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Coordinated Regional Climate Downscaling Experiment

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ABSTRACT BOOK



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**WELCOME TO
THE INTERNATIONAL CONFERENCE ON REGIONAL CLIMATE CORDEX 2019
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14-18 OCTOBER 2019**

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World Climate Research Programme

**Parallel Session A:
Advances in regional downscaling**

A1: Uncertainties and added value

ORAL PRESENTATIONS

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

Multi-domain intercomparison and potential conflicts from CORDEX simulations: An example for the Mediterranean region

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The Coordinated Regional Climate Downscaling Experiment (CORDEX) has made available an enormous amount of regional climate simulations and projections in different domains across the world. Despite being crucial for the development of better adaptation strategies and policy making, it is difficult for a typical user of this kind of information to understand the differences that may be expected across the different data sources available for a given region (different domains, GCM/RCM ensembles, resolutions, etc.). This is the case for a number of regions of particular interest which are covered by more than one CORDEX domain. A relevant question in those cases is the consistency and potential conflicts which may arise for the projections provided by different domains. This work addresses this hot topic by focusing on the Mediterranean region, a first illustrative case-study which is encompassed by the EURO-, AFR- and MED-CORDEX domains.

To do so, we first assess the performance of a common multi-domain set of RCMs to simulate a number of precipitation-related indicators (accounting for spells and high-order moments) when driven with ERA-Interim data. Preliminary results from this “perfect” validation experiment indicate that the effect of the choice of domain is in general small. Second, to assess whether or not these small differences become relevant when the RCMs are driven by GCMs, we also inter-compare the climate change signals projected by the full ensemble of GCM/RCM combinations available for the EURO-, MED- and AFR-CORDEX domains, as well as for those obtained for the common set of simulations available for the three domains. This allows to better characterize the uncertainty that is present in CORDEX climate change simulations, covering not only the main factors which have been traditionally analyzed (choice of GCM, RCM, scenario) but also a new one which has not been taken into account before (the choice of domain). The results from this study will help different users’ communities to better frame their decisions for impact applications.

Moreover, we plan to broaden this study by applying the same methodology to other regions of the world where RCM-based simulations coming from different CORDEX domains are also available.

Keywords: CORDEX domains, regional uncertainty, climate change projections, dynamical downscaling

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

CORDEX-SEA projection of temperature and precipitation and their time of emergence in Vietnam

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In Vietnam, reliable information about future climate conditions under different climate change scenarios is particularly important for adaptation efforts due to the high level of vulnerability of Vietnam to future climate changes. However, such information is still lacking in the region or generally based on global climate models (GCMs) that may have large uncertainties in a complex region such as Vietnam. In order to fill the gap, the Southeast Asia Regional Climate Downscaling /Coordinated Regional Climate Downscaling EXperiment - Southeast Asia (SEACLID/CORDEX-SEA) project was established and had successfully gathered members from several countries to carry out a high resolution multi-model regional climate downscaling experiment (RCMs).

In this presentation, a summary of the recent findings of the SEACLID/CORDEX-SEA activities in Vietnam is firstly introduced. Next, we address how simulations of present-day climate are influenced by the choices of various physical parameterizations in order to determine which schemes are well suited to simulate the climate over the region. The added values of the RCMs versus the GCMs were shown for the 7 climatic sub-regions of Vietnam, particularly for temperature. Lastly, we analyzed the Time of Emergence (ToE) of temperature and precipitation in Vietnam. ToE is defined when a climate change signal starts to exceed the noise range of projection uncertainty. Results showed that the ToE of temperature was earlier for the RCMs than for the GCMs by ~3-5 years and also earlier for the RCP8.5 scenarios than for RCP4.5 by ~10 years. As there were high uncertainties in the projected rainfall in Vietnam, the patterns of rainfall TOE were shown to have high variability in the region.

Keywords: Time of Emergence, CORDEX-SEA, Vietnam

**Parallel Session A: Advances in regional
downscaling
A1: Uncertainties and added
value**

**Present day bias and future change signal of temperature over China in a
series of multi-GCM driven RCM simulations.**

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Simulation of surface air temperature over China from a set of regional climate model (RCM) climate change experiments are analyzed with the focus on bias and change signal of the RCM and driving general circulation models (GCMs). The set consists of 4 simulations by the RCM of RegCM4 driven by 4 different GCMs for the period of 1979-2099, under the RCP4.5 (Representative Concentration Pathway) scenario. Results show that for present day conditions, the RCM provides with more spatial details of the distribution and in general reduces the biases of GCM, in particular in DJF. The bias patterns show some correlation between the RCM and driving GCM in DJF but not in JJA. Similar patterns of biases among the RCM simulations are found, which can be attributed to the large internal model physics of it. For change signals, dominant forcing from the GCM is evident both for magnitude and large scale distribution in the regional scale, as well as the inter-annual changes. In general no clear relationships are found between the model bias and change signal, both for GCM and RCM. Reduced warming is projected by the RCM, more significant in DJF. Furthermore, large differences of the change distribution are found in the sub-regional scale (river basins) between the RCM and driving GCM. In DJF, profound warming over the Tibetan Plateau is simulated by the RCM but not GCMs.

Keywords: model bias, change signal, regional climate model, China

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A global overview of present and future climate over CORDEX domains by RegCM4

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The study provides an assessment of the ensemble climatologies for surface air temperature and precipitation across nine domains (North, Central and South America, Europe, Africa, East, South and South-East Asia and Australasia). All simulations were carried out within the Coordinated Regional Downscaling Experiment (CORDEX) framework using the ICTP regional model (RegCM4), driven by four global climate models (GCMs; HadGEM2-ES, MPI-M-MPI-ESM-MR, NCC-NorESM1-M, NOAA-GFDL-ESM2M). Model evaluation over present day (1995 – 2014) is assessed against various observational datasets; afterwards an analysis over near (2041 – 2060) and far future (2080 – 2099) climate projections under RCP 2.6 and 8.5 scenarios is investigated. A comparison of the climate change signal between RegCM4 and its driving GCMs shows the consistency and differences between the two ensemble projections. Finally, a more in-depth investigation about causes and variability of the climate change signal is carried out across regions with strong and consistent signal.

Keywords: high resolution simulations, Dynamical Downscaling, CORDEX CORE

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

Projected Changes in Temperature over Southeast Asia in the CORDEX-SEA Simulations

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We investigate future changes in temperature over Southeast Asia in terms of trends and changes, and shifts using the Southeast Asia Regional Climate Downscaling (SEACLID)/Coordinated Regional Climate Downscaling Experiment – Southeast Asia (CORDEX-SEA) simulations using the RCP4.5 and RCP8.5 scenarios. In particular, we focus our analysis on: a) model validation and applying a weighted ensemble of models; b) the added value of using Regional Climate Models (RCMs); and c) projected changes in temperature. We performed a weighting ensemble approach (Knutti et al., 2017) wherein models that agree poorly with observations for a selected set of diagnostics and models that largely duplicate existing models get less weight. Our results show that Global Climate Models (GCMs) have larger biases over mountainous regions compared to the downscaled model results. The comparison between weighted and unweighted downscaled model ensemble show that the weighted ensemble reduces the cold bias found in mainland Southeast Asia, Malaysia, and Indonesia. Further, the weighted ensemble has less bias with greatest improvement during the boreal summer season. Modeled climate variability in the weighted ensemble is also closer to observation than the unweighted ensemble. A potential added value approach (Di Luca et al., 2013) is applied to both unweighted and weighted ensemble and we find that more regions over Southeast Asia appear to have improved with weighted ensemble results. For the projected climate, we find a greater increase in temperature for GCMs than in RCMs especially in the RCP 8.5 scenario. In a seasonal timescale, there is greater warming in boreal and austral winter and summer. Temperature shifts analyzed through probability density functions (PDFs) show that there are similar climate shifting patterns over Southeast Asia regions that are within similar latitudes. The greater shifts into warmer distributions are found over the Maritime Continent, while minimal shifts in climate are seen over the mainland Southeast Asia.

Keywords: Regional climate modeling, climate variability, CORDEX-SEA, multi-model ensemble, near-surface air temperature, climate projections

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

Contrasting global and regional climate models over Europe and Africa

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Analysis of regional climate model (RCM) simulations generated within the Coordinated Regional climate Downscaling Experiment (CORDEX) reveals that at regional scale, future climate change in RCMs can be quite different, or even contrasting to, changes in their driving global climate models (GCMs). Moreover, it was found that different RCMs downscaling the same GCM may also produce contradicting future projections. Taking such contradictions into account, one can argue that dynamical downscaling increases the range of uncertainties in climate projections. An alternative interpretation is that such contradictions in climate projections provide a useful insight into uncertainties in future regional climate change. In case of contrasting messages between RCMs and their driving GCMs, local-scale processes defined by RCM parameterisations can be much more important than large-scale drivers dictated by the driving GCMs. Using the Euro- and Africa-CORDEX RCM ensembles we first document consistent and contradicting messages between the CORDEX RCMs and their driving GCMs. For a deeper understanding of the drivers of regional climate change, a more comprehensive analysis of relevant processes is required and we try to identify what processes are responsible for the contradicting messages. Our results show that excluding GCMs and using only RCMs, a commonly established approach, can significantly change the message on future regional climate change.

Keywords: RCM,GCM,contradictions,CORDEX,climate change

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

Uncertainty and inter-model variations in CORDEX Southeast Asia multi-model simulations of precipitation

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CORDEX Southeast Asia 25 km x 25 km simulations comprise of 15 members with 7 RCMs and 12 CMIP5 GCMs. Evaluation of individual model performances showed that two members needed to be excluded due to failure in capturing the monsoon circulations during historical period as well as showing very obvious climate drift relative to the GCM in the projection period. With 13 simulation members, the performance of ensemble mean, uncertainty and intermodal variations were evaluated. Generally, the model ensemble reasonably captured the precipitation spatial and its seasonal dependency over the region during historical periods. However, the performances over sub-regions vary with a tendency for large biases in area comprises of small and multiple islands. Two key findings on the projected changes of mean rainfall. The most striking one is the drying tendency over Indonesia especially over Java, Sumatra and Kalimantan during boreal summer by middle and end of 21st century, especially under RCP8.5. Such changes can be traced to enhance subsidence over the region. During boreal winter, Indochina region is projected to be wetter. Despite the ensemble mean indicating a particular tendency of change, analysis of inter-model projections reveals large inter-model variations. This paper discusses on how such information can be conveyed to the users.

Keywords: CORDEX Southeast Asia, Precipitation, Uncertainty, Inter-model variations

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

What can we know about future precipitation in Africa? Robustness, significance and added value of projections from a large ensemble of regional climate models

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We employ a large ensemble of Regional Climate Models (RCMs) from the COordinated Regional-climate Downscaling EXperiment (CORDEX) to explore two questions: 1) what can we know about the future precipitation characteristics over Africa? and 2) does this information differ from that derived from the driving Global Climate Models (GCMs)?

By taking into account both the statistical significance of the change and the models' agreement on its sign, we identify regions where the projected climate change signal is robust, suggesting confidence that the precipitation characteristics will change, and those where changes in the precipitation statistics are non-significant.

Results show that, when spatially averaged, RCMs results are usually in agreement with those of the GCMs ensemble: even though the change in seasonal mean precipitation may differ, in some cases, other precipitation characteristics (e.g., intensity, frequency, and duration of dry and wet spells) show the same tendency. When the robust change (i.e., the value of the change averaged only over the land points where it is robust) is compared between the CGMs and RCMs, similarities are striking, indicating that, although with some uncertainty on the geographical extent, GCMs and RCMs project a consistent future.

The impact of the heterogeneity of the GCM-RCM matrix on the results has been also investigated; we found that, for most regions and indices, where results are robust or non-significant, they are so independently on the choice of the RCM or GCM. However, there are cases, especially over Central Africa and parts of West Africa, where results are uncertain, i.e. most of the RCMs project a statistically significant change but they do not agree on its sign. In these cases, especially where results are clearly clustered according to the RCM, there is not a simple way of subsampling the model ensemble in order to reduce the uncertainty or to infer a more robust result.

Keywords: CORDEX-Africa, Future precipitation characteristics, Regional Climate Models

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A spatial representation of an Added Value Index for Regional Climate Models

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In the past decades, Regional Climate Models (RCMs) have undergone substantial development, resulting in increasingly reliable high-resolution simulations. Despite this, Global Climate Models (GCMs) can sometimes perform better in regions of low topographic complexity and thus, it is important to quantify the added value of a RCM. While a number of studies describe different methods to quantify this added value, here, a new quantification method for the added value of RCMs is introduced and tested.

This method compares the Probability Distribution Function of a RCM, a GCM, and a high-resolution observation source for any parameter. The comparison is performed using the sum of probability difference, and repeating the method on every grid cell in order to obtain a spatial representation of the added value. An ensemble of RCMs is used to demonstrate and test this method on the EURO-CORDEX region. The primary focus of the analysis was daily precipitation and tail fraction of the distribution, but the additional fractions, CORDEX regions, and Convective Permitting simulation data may soon be used for a broader-scale test of this new method.

Keywords: Added Value, RCM, CORDEX

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

Uncertainties in CORDEX simulations over Central Africa and climate change at 1.5°C, 2°C and 3°C global warming levels

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The uncertainties in regional climate models (RCMs) are evaluated over Central Africa during present-day climate (1989-2008) by analysing outputs data of five RCMs (REMO, CRCM5, RegCM4, CCLM4 and RCA4), each one is forced by ERA-Interim reanalysis and MPI-ESM general climate model. Spatial and quantitative analysis over some selected climatic subregions of Central Africa for the mean climatology, the inter-annual variability of temperature and rainfall, as well as low-level circulation have show that the RCMs have systematic biases which are independent from different forcing datasets. Biases in RCMs are not consistent with the biases in the driving fields and the models show similar spatial patterns after downscaling by different global datasets. The annual cycle of temperature and rainfall is well simulated by the RCMs, however the RCMs are not able to capture the inter-annual variability over in the Congo Basin and countries located in the Atlantic coast. We also found that the RCMs simulations are generally able to capture the observed values of extreme rainfall indices in many cases. For the future climate analysis, MPI-ESM is downscaled under RCP4.5 and RCP8.5 emission scenarios. The climate change signal is consistent between MPI-ESM and RCMs but the regional warming differ considerably for 1.5°C, 2° C and 3°C global warming levels. Compared to changes in temperature, changes in rainfall are more heterogeneous and climate model simulations indicate of lack consensus across the region, though there is tendency towards decrease of seasonal rainfall over north eastern Cameroon, Gabon and Democratic Republic of Congo.

Keywords: Regional climate model, Uncertainty, Central Africa, Global warming levels, Climate change

**Parallel Session A:
Advances in regional downscaling**

A1: Uncertainties and added value

POSTER PRESENTATIONS

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Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-01

Evaluation of the Climate Forecast System version 2 over Iran

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Skillful seasonal prediction of the surface temperature and precipitation is needed to mitigate the impact of extreme climate events such as floods and droughts. Using a continuous multi-decadal simulations over the period 1981-2010, subseasonal to seasonal simulations of the Climate Forecast System version 2 (CFSv2) over Iran against the Climatic Research Unit (CRU) dataset are evaluated, focusing on forecasts of 2-m temperature and precipitation. CFSv2 shows cold biases over northern hillsides of the Alborz Mountains with the Mediterranean climate and warm biases over northern regions of the Persian Gulf and the Oman Sea with a dry climate. Magnitude of the model bias for 2-m temperature over different regions of Iran varies by season, with the least bias in temperate seasons of spring and autumn, and the largest bias in summer, and the model bias decreases as temporal averaging period increases from seasonal to annual. The forecast generally produces dry and wet biases over dry and wet regions of Iran, respectively. In general, 2-m temperature over Iran is better captured than precipitation, but the prediction skill of precipitation is generally high over western Iran. Averaged over Iran, observations indicated that 2-m temperature has been gradually increasing during the studied period, with a rate of approximately 0.5°C per decade, and the upward trend is quite well simulated by CFSv2 (with a rate of approximately 0.6°C per decade). Averaged over Iran, both observations and simulation results indicated that precipitation has been decreasing in spring, with averaged decreasing trends of 0.8 mm (observed) and 1.7 mm (simulated) per season each year during the period 1981-2010. Observations also indicated that the maximum increasing trend of 2-m temperature has occurred over western Iran (nearly 0.7°C per decade), while the maximum decreasing trend of annual precipitation has occurred over western and parts of southern Iran (nearly 45 to 50 mm per decade).

Keywords: Climate Forecast System version 2 (CFSv2), Seasonal Prediction, Model bias, CRU dataset

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-02

Performance of downscaled convective and stratiform precipitation over the Philippines during the East Asian Winter Monsoon

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We investigate the disagreement in the convective and stratiform pentad precipitation between the 0.25° x 0.25° Global Precipitation Measurement (GPM) Microwave Imager (GMI) and the 0.75° x 0.75° European Centre for Medium-Range Weather Forecasting (ECMWF) Reanalysis Interim (ERA-Interim) datasets. The study focuses on the East Asian Winter Monsoon period from 2014 to 2017 over the Philippine region. The ERA-Interim reanalyses are then downscaled to match the GMI resolution using the Regional Climate Model version 4.7 (RegCM4.7) with the MIT-Emanuel and Tiedtke cumulus parametrization schemes. Rainfall over ocean is better captured using the Tiedtke scheme although rainfall over land is generally overestimated for both schemes. Wet bias of stratiform rainfall is observed over the Cordilleran mountain range especially for the Tiedtke scheme.

Keywords: Dynamical downscaling, Rainfall, Philippines, East Asian Winter Monsoon

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-03

Large-scale consistency with driving GCM and fine scale details in the present-day climate simulated by the EuroCORDEX RCM integrations

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The analysis of the consistency of RCMs with the driving boundary conditions at the larger scale, implicitly assumed to be satisfied in the "one-way" nesting approach, has been analysed for the EuroCORDEX 12km set of simulations.

The results indicate that the consistency with driving conditions is very high, and its dependence on the GCM formulation could be neglected as a first order approximations, supporting the assessments of the multi-model uncertainty based on experimental design whereby RCM and GCM are treated as independent factors (GCM/RCM matrices). Additional investigation of the factor influencing the GCM/RCM consistency will be presented at the conference.

Keywords: Experimental design, One-way nesting, Large scale consistency

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-04

The influence of regional nudging over South America on the simulation of the Southern Hemisphere extratropical circulation

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This work presents new modeling evidence showing the added value of high-resolution information from South America (SA) in the simulation of the Southern Hemisphere extratropical circulation. LMDZ, a coarse-resolution atmospheric global general circulation model constitutes the main tool for this investigation. Parallel to the control (CTR) simulation, a two-way nesting (TWN) simulation of LMDZ is performed with an interactive coupling to the same model, but with a higher-resolution zoom over SA. The third simulation (fERAi) is a perfect boundary simulation for which re-analysis information from ERA-Interim is used to nudge LMDZ, but only over SA. Results indicate that enhanced resolution over SA improves the representation of the low-level circulation over the continent and, thus, simulates better the meridional transport of energy from the tropics into extratropics. The local improvement of the low-level circulation is followed by a better representation of the global extratropical circulation, especially in austral summer. The regional climate enhancement over SA has positive effects on simulation of the midlatitude jet position during the austral summer by significantly reducing the bias of the mean zonal kinetic energy outside the nudged zone. On the other hand, the wintertime general circulation outside the nudged-zone shows a limited bias-reduction for the regional-driven simulations, especially in the case of the TWN system. However, improvements of the TWN system compared to the control experiment are noticed in early stages of cyclone lifecycle, as it is identified in a better simulation of transient meridional transport and transient kinetic energy intensity. The findings of the present study suggest, thus, that improvements in resolution over SA effectively excite the simulation of the mean atmospheric circulation in the Southern Hemisphere.

Keywords: Two-way nesting system, Extratropical circulation, Southern hemisphere, Influence of South American regional climate

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-05

The potential added value of Regional Climate Models in South America using a multiresolution approach

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This work aims to identify those regions within the South American continent where the Regional Climate Models (RCMs) have the potential to add value compared to their coarser-resolution global forcing. For this, we distinguished the mesoscale climatic signal present in atmospheric surface fields from observed data and 6 RCM simulations belonging to the CORDEX Project. We used a spatial-scale filtering method based on the wavelet theory and kept those scales that can be explicitly simulated by the RCM and not by its driver. Once the longer wavelengths were filtered, we focused on analyzing the spatial variability of extreme rainfall and the spatiotemporal variability of maximum and minimum surface air temperature on a daily basis. The results obtained suggest essential differences in the spatial distribution of the mesoscale signal of extreme precipitation between TRMM and regional models, together with a large dispersion between models. While TRMM registers a large signal throughout the continent, the RCMs place it over regions with complex topography or areas where convective systems dominate. Surface air temperature has a large mesoscale stationary component over regions characterized by complex topography, such as the Andes Cordillera and the Brazilian Highlands, and the coasts of the continent. The transient part is much smaller than the stationary one, except over la Plata Basin where they are of the same order of magnitude. Also, the RCMs and CRU showed a large spread between them in representing this variability. The results confirm that RCMs have the potential to add value in the representation of extreme precipitation and the mean surface temperature in South America. However, this condition is not applicable throughout the whole continent but is particularly relevant in those terrestrial regions where the surface forcing is strong, such as the Andes Cordillera or the coasts of the continent.

Keywords: Added value, South America, Wavelet

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-06

Intercomparison of observed and simulated climatic trends in the CORDEX-CAM (Central America, Caribbean and Mexico) domain

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An intercomparison of three regional climate models (RCMs) was performed over the Coordinated Regional Dynamical Experiment (CORDEX) - Central America, Caribbean and Mexico (CAM) domain to determine their ability to reproduce observed temperature and precipitation trends during 1980-2010. PRECIS-HadRM3P, RCA4, and two versions of RegCM4 were forced with ERA-Interim Reanalysis. Observations from the Climate Research Unit (CRU) and ERA-Interim show a generalized warming over most of the domain. The most significant warming trend ($\geq 0.33^{\circ}\text{C decade}^{-1}$) is observed in the North American monsoon (NAM) region, which is moderately captured by the three RCMs, but with less intensity; each decade from 1970 to 2016 has become warmer than the previous ones, especially during the summer. Moreover, since the 1990s the 95th percentile threshold of summer temperatures in the NAM has also significantly increased. The warming trend is also observed in the 1950-2017 period and appears to be partially related to the positive phase of the Atlantic Multidecadal Oscillation (+AMO).

There is a good agreement between observations (CRU, GPCP and CHIRPS) showing annual decreases of precipitation (less than -15% decade $^{-1}$) in parts of the Southwest United States and Northwestern Mexico, including the NAM, and a positive trend (5% to 10% decade $^{-1}$) in June-September in eastern Mexico, the mid-summer drought (MSD) region, and northern South America, but observed longer trends (1950-2017) in the NAM and the MSD are not statistically significant. Some of the observed regional trends of precipitation are captured by the RCMs. During 1980-2010, observations and RCMs show a good consistency in the wintertime precipitation trends in most of the domain. However, summer precipitation trends from GPCP show opposite sign to those of CRU and CHIRPS over the Mexican coasts of the Gulf of Mexico, the Yucatan Peninsula, and Cuba, possibly due to data limitations and differences in grid resolutions. Summer precipitation trends from the RCMs also show more regional differences than during winter. Our results show the importance of evaluating several observational datasets and RCMs to determine the regions and seasons that show less uncertainty.

Keywords: Trends, CORDEX-CAM, Intercomparison, Regional models

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-07

Frequency analysis of annual maximum rainfall over Thailand under changing climate

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Regarding to climate change affected to the changes in local hydrology which caused to more frequency of flood and drought. These impacts obviously influence the frequency and severity of floods and droughts experienced in many countries around the world. In the vulnerable areas might obtains more disaster with unavoidable. Especially the flood risk areas have more chances to encounter the uncertain of heavy rainfall. Therefore, one of adaption measure should be provided the future climate information to make awareness to people to cope with the changes. This study aims to analyze the changes in frequency of annual maximum rainfall using multi bias corrected GCM under CMIP5 project. Ten sets of bias corrected GCM precipitation datasets under the Representative Concentration Pathway (RCP4.5 and RCP8.5) are used to calculate annual maximum rainfall. The Gumbel, General Extreme Values, Weibull, Log normal, Log Pearson Type III distribution are used to analyze frequency of maximum rainfall and the goodness of fit tests are evaluated the appropriate distribution of maximum rainfall. The resulting of maximum rainfall with return period can be used to identify the flood risk area under changing climate.

Keywords: climate change, frequency analysis, Gumbel, General Extreme Values, Weibull, Log normal, Log Pearson Type III

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-08

Evaluation of added value of CORDEX-SA experiments in representing Indian summer monsoon characteristics

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In recent times, there has been a growing debate on benefit of dynamical downscaling that is applying regional climate models (RCMs) over their coarser counterparts- global climate model models (GCMs). In light of this new area of research in climate modeling, the following study aims at investigating the added value (AV) of a suite of RCMs over their respective forcings that is, GCMs in simulating Indian summer monsoon (ISM) features. These RCM simulations are part of Coordinated Regional Climate Downscaling Experiment- South Asia (CORDEX-SA) initiative. To evaluate the AV, the skill of RCMs and their respective parent GCMs is compared for the present day climate (1970–2005) against observations and reanalysis datasets with respect to different ISM characteristics- the spatial pattern of mean precipitation, the evolution of vertical shear of westerlies and the onset of ISM. The RCMs show a definite improvement over their driving GCMs in representing the chief spatial features of ISM precipitation with drastic reduction in bias over some regions in India, for example the orographic precipitation along Western Ghats is well captured by RCMs. This improvement mainly comes in the form of reduction in dry biases shown by GCMs. In terms of simulation of onset timing, a few RCMs show a marked improvement, particularly, RegCM4 driven by IPSL- CM5A- LR. The general conclusion is that the present set of CORDEX- SA RCM experiments do indeed add value to their parent GCMs for a number of characteristics associated with the ISM precipitation but this value depends on the region, the driving GCM and the specific feature of ISM under study.

Keywords: CORDEX- South Asia, Added value, RCMs, GCMs, Indian summer monsoon

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-09

How European projections have changed through 20 years of multi-model ensemble projects

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For more than 20 years, coordinated efforts to apply regional climate models to downscale GCM simulations for Europe have been under way. European research projects like RACCS and MERCURE in the '90s were first. Here, the foundation for today's advanced worldwide CORDEX approach was laid out with some of the first coordinated multi-RCM simulation collections aiming to assess regional climate change for Europe in a robust way. The first public multi-model collection of climate change data was created in the PRUDENCE project (2001-2004). Additional coordinated efforts involving ever increasing numbers of GCMs and RCMs followed in ENSEMBLES (2004-2009) and currently CORDEX, specifically Euro-CORDEX, for the area covered during the prior projects. Simulations have increased their standard resolution from 50km (PRUDENCE) to about 12km (CORDEX EUR-11) and from time slice simulations (PRUDENCE) to transient experiments (ENSEMBLES and CORDEX); from one driving model and emission scenario (PRUDENCE) to several (Euro-CORDEX). This wealth of simulations have been used to assess and frame the potential impacts of future climate change in Europe providing a baseline change as defined by a multi-model mean change with associated uncertainties calculated from model spread in the ensemble.

Here we investigate how the overall picture of state-of-the-art regional climate change projections changed over this period of almost two decades. By scaling with global temperature change we identify robust results from the various emission scenarios having been used about the projected future European temperature and precipitation changes, which confirm the basic findings of PRUDENCE. The large-scale patterns of change show remarkable agreement across model resolution, ensemble strategy and emission scenario.

A comparison with observed European temperature and precipitation trends since 1950 shows good agreement with the simulations measured with root mean square distance, though precipitation only shows clear trends in limited areas.

With an EOF analysis in model/signal space of all simulations we quantify and discuss the patterns of main differences between the multi-model ensembles of these projects.

Keywords: Multi-model ensembles, European climate change

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-10

Climatology and trend of cyclones over the South Atlantic Ocean simulated by global and regional climate models

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Synoptic scale cyclones affect the weather and the climate of many regions of the globe by producing clouds, precipitation, temperature changes and intense winds. Over South Atlantic Ocean, cyclones occur throughout the year with greater frequency in austral winter. In this work, a tracking algorithm based in relative vorticity at 925 hPa is applied to identify cyclones in the present (1979-2005) and future (2020-2050, 2070-2099) climates under RCP8.5 scenario. These systems were identified in: (a) three global climate models (GCMs) of CMIP5 (HadGEM2-ES, MPI-ESM-MR and GFDL-ESM2M) and in their respective downscaling's with the regional climate model RegCM4 (RegHad, RegMPI and RegGFDL); (b) Era-Interim reanalysis. Preliminary results show that in the present climate the models represent the cyclogenetic density over southwestern South Atlantic Ocean with similar patterns observed in Era-Interim reanalysis. However, there are some differences as: GFDL-ESM2M presents a general underestimation of the cyclogenetic density; HadGEM2-ES simulates a more intense cyclogenetic core in southern Argentina. On the other hand, the RegCM4 downscaling improves some results, for example, it decreases the cyclogenetic density in southern Argentina that is simulated by HadGEM2-ES. Models tend to overestimate the trajectory density of the cyclones in the longitudinal belt of 30o-20oW and underestimate the velocity of cyclones compared to Era-Interim with GFDL-ESM2M presenting greater underestimation. In terms of trend, at the end of the century (2070-2099) the GFDL-ESM2M and MPI-ESM-MR project a change in the meridional location of the storm tracks region compared to the present climate, while HadGEM2-ES projects a gradual increase of the cyclones in the subtropical sector of South Atlantic. Complementary analyses of the trends are being developed.

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-11

The Regional Climate Model evaluation system: A systematic evaluation of CORDEX simulations using Obs4MIPs

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Observation-based evaluations of global climate models (GCMs) have been a key element for identifying systematic model biases that can be targeted for model improvements and for establishing uncertainty associated with projections of global climate change. However, GCMs are limited in their ability to represent physical phenomena which occur on smaller, regional scales, including many types of extreme weather events. In order to help facilitate projections in changes of such phenomena, simulations from regional climate models (RCMs) for 14 different domains around the world are being provided by the Coordinated Regional Climate Downscaling Experiment (CORDEX; www.cordex.org). However, although CORDEX specifies standard simulation and archiving protocols, these simulations are conducted independently by individual research and modeling groups representing each of these domains often with different output requirements and data archiving and exchange capabilities. Thus, with respect to similar efforts using GCMs (e.g., the Coupled Model Intercomparison Project, CMIP), it is more difficult to achieve a standardized, systematic evaluation of the RCMs for each domain and across all the CORDEX domains. Using the Regional Climate Model Evaluation System (RCMES; rcmes.jpl.nasa.gov) developed at JPL, we are developing easy to use templates for performing systematic evaluations of CORDEX simulations. Results from the application of a number of evaluation metrics (e.g., biases, centered RMS, and pattern correlations) will be shown for a variety of physical quantities and CORDEX domains. These evaluations are performed using products from obs4MIPs, an activity initiated by DOE and NASA, and now shepherded by the World Climate Research Program's Data Advisory Council. In order to facilitate reproducibility, evaluation configurations and results for each CORDEX domain are published on our website (rcmes.jpl.nasa.gov).

Keywords: obs4mips, Model Evaluation, RCMES

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-12

Exotic Uncertainties in North America CORDEX

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A number of simulations have been produced for the North-American component of the Coordinated Regional Downscaling Experiment (NA-CORDEX). The simulations are based on a wide range of regional and global climate models (RCMs and GCMs). The RCMs include: WRF, RegCM4, RCA4, HIRHAM5, CRCM5 (with and without nudging), and the CanRCM4. The driving GCMs include: MPI-ESM-LR, MPI-ESM-MR, HadGEM2-ES, GFDLES2M, EC-EARTH, and CanESM2. These GCMs fully span the equilibrium climate sensitivity (ECS) of the GCMs that make up the CMIP5 suite of simulations. Simulations have also been produced at both 50km and 25km and in some cases for both RCP8.5 and RCP4.5.

We present some interesting analysis results and the uncertainties they address or create. To start, the effect of spanning GCM ECS in the NA-CORDEX ensemble of projections will be illustrated and GCM sampling uncertainty will be presented. Additionally, we examine the effect of including Shared Socioeconomic Pathway (SSP)-based land-use and land-cover change (LULCC) along with the RCP-based green-house-gas-induced climate changes and the projection uncertainty overlooked by neglecting LULCC in traditional NA-CORDEX regional climate simulations. Time-permitting, a brief overview of additional results from an ongoing study on the role of extratropical cyclones in winter precipitation uncertainty over the east-south-central U.S. will also be discussed.

Keywords: North America CORDEX, Exotic uncertainties

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-13

Climate change projections in RegCM CORDEX-CORE simulations via Koeppen-Trewartha climate classification

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The analysis of climate patterns can be performed for each climatic variable separately or the data can be aggregated using e.g. a kind of climate classification. The advantage of such a method, in our case Koeppen-Trewartha classification, is putting together the most important variables, i.e. temperature and precipitation, considering not only annual means, but through monthly values the annual course as well. These classifications usually correspond to vegetation distribution in the sense that each climate type is dominated by one vegetation zone or eco-region. This way climate classifications also represent a convenient tool for the assessment and validation of climate models and for the analysis of simulated future climate changes.

The RegCM results of CORDEX-CORE experiments over nine CORDEX domains are analysed using selected CMIP5 simulations (mostly HadGEM, MPI and NorESM) driving the RegCM. Validation based on ERA-Interim driven runs compared to CRU database (E-OBS for higher resolution in Europe) shows some systematic biases in different types. Through the analysis of the control experiments together with the performance of driving GCMs we can assess the sources of the biases in present conditions as well as to see the added value, which comes mainly from the better description of topography in higher resolution and thus appearance of mountaineous tundra type, as well as better representation of coastal region and thus separating maritime and continental subtypes. Finally, for two scenarios RCP8.5 and RCP2.6 we show the projections of the individual types' area changes, individual transformations of types or their shifts in CORDEX domains (e.g. decrease of boreal and tundra type area, their shift to the higher latitudes and altitudes, increase of temperate climate, deserts, savana, more significant for RCP8.5). We compare the changes with the signal of climate change for driving GCMs to identify the added value of higher resolution RCM simulations.

Keywords: Koeppen-Trewartha climate classification, climate change projections, CORDEX-CORE experiment

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-14

Performance evaluation of all subsets from the CMIP5 multimodel ensemble used in each CORDEX region: Representation of the present climate and uncertainty range of climate change projections

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Region-specific subsets selected from the full set of CMIP5 multimodel ensemble have been used in CORDEX. Do the subsets have enough ability to represent the observed climatological state, and project a consistent tendency of the climate change with the full set? How extent do the subsets capture the uncertainty in the projections by the full set? To provide increased credibility for the scientific outcomes by answering these questions, we evaluated the performance of all subsets used in CORDEX. Regarding the climate change projection, compared with the possible subsets generated using 10,000 random samples, we investigated whether the subsets showed higher coverage of the uncertainty than the others when using the same sample size. The spreads of the biases and Taylor's skill scores obtained from the CORDEX subsets extend beyond the spread from high performed 24 models of the full set for the regional means of temperature and precipitation. Therefore, despite using models that performed acceptably, a subset exists that would have less biases than the current subsets. Compared with the random samples, CORDEX uses subsets with low coverage of the uncertainty range from the full set for the temperature change in the regions where more models are used. On the other hand, for the precipitation change the coverage is lower than that from the random samples in half of the regions. However, in the regions that used nine models or more, good coverage (>50%) is evident for the projections of both temperature and precipitation. Therefore, the subsets can a relative-widely cover the uncertainties, but it depends on the number of models used. In contrast to the subsets used in CORDEX, we also conducted the evaluation on a globally consistent model subset consisting of four models used in ISIMIP. As the result, the subset indicates difficulty in capturing uncertainties in the regional precipitation change with widely covering that in the temperature.

Keywords: Performance evaluation, Uncertainty range, Model subset

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-15

Assessment of future climate change over India and Hindu Kush Himalayan regions using CORDEX South Asia Regional Climate Model projections

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The World Climate Research Programme (WCRP) regional activity Coordinated Regional Climate Downscaling Experiment (CORDEX) provided an ensemble of high resolution (50 km) regional climate change projections for South Asia. These future projections of climate till the end of 21st century were developed by dynamical downscaling methods using regional climate models (RCMs) forced with a subset of global climate models (GCMs) that contributed to the fifth phase of the WCRP Coupled Model Intercomparison Project (CMIP5). The CORDEX initiative provided an opportunity for assessing the range of uncertainties in regional climate change within South Asia associated with varying forcing from the CMIP5 GCMs and the future greenhouse gas scenarios based on three representative concentration pathways (RCPs), and from the use of multiple RCMs. The interim report on climate change over India released by the Government of India in mid 2017 found that the CORDEX South Asia RCM ensemble based future projections were useful to better quantify the regional climate change uncertainties in the near-surface air temperature, precipitation, and in extreme events. The Hindu Kush Himalayan (HKH) Monitoring and Assessment Programme (HIMAP) report coordinated by the International Centre for Integrated Mountain Development (ICIMOD) assessed the future climate change signal in seasonal mean temperature and precipitation over the HKH region using an ensemble of CMIP5 GCMs and CORDEX South Asia RCMs. This presentation will provide an overview of the main findings in these future climate change assessments over the South Asia region.

Keywords: CORDEX South Asia, India, Hindu Kush Himalaya

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-16

Projected changes in the relationship between Precipitation, African Easterly Jet and African Easterly Waves under global Warming

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An ensemble of regional climate analysis projections is carried out with Theoretical Physics Regional Climate Model (RegCM4) over West African domain. The RegCM4 is driven by three CMIP5 Global Climate Models (GCMs) under two greenhouse gas concentration pathways such as RCP8.5 and RCP4.5 to assess regional changes in temperature, precipitation and West African Monsoon (WAM) dynamical features. In particular, we examine and inter-compare the models performance with their ensemble-mean in simulating the mean climatology and the response of African Easterly Jet (AEJ) and African Easterly Waves (AEWs) to increasing greenhouse gas concentrations by the end of the 21st century. The covariance analysis is used to investigate the nature of the relationship between WAM features and precipitation. Using an ensemble of regional climate models, much of model simulations project a widespread change of precipitation associated with decreased of AEJ (in term of location and intensity) and AEWs activity in the 2–10 days period and affecting their relationship. The seasonal mean precipitation events decrease in the future scenarios with largest and more extensive drying condition over the Sahel and wetter condition over the Gulf of Guinea while some models project a drier condition along the both region. This dry condition delayed the onset of the rainy season, anticipated the retreat of the rainbelt and reducing and strengthening of the Intertropical Convergence Zone (ITCZ) band. The change is consistent in all global and regional model projections, although with different spatial detail. The results suggested that changes in AEJ and AEW characteristics could play a critical role in shaping the response of WAM to elevating anthropogenic greenhouse gas (GHG) forcing.

Keywords: Monsoon precipitation, Regional climate models, Circulation dynamics

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-17

Multi-resolution investigation of long term regional/local trends in temperature and precipitation from observations and NA-CORDEX regional climate simulations

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Assessment of long-term temperature and precipitation trends is one of the most fundamental tasks for studying climate change. While the global temperature on Earth has significantly increased in the last several decades, regional trends in temperature and precipitation are not spatially uniform. Using the Global Historical Climatology Network monthly observations and regional climate models (RCMs) that participated in the North America CORDEX (NA-CORDEX) program, we investigated the spatial variability of the temperature, precipitation, and their long term trends over the contiguous United States (CONUS) using the Regional Climate Model Evaluation System (RCMES). RCMES is an open source software suite developed jointly by NASA's Jet Propulsion Laboratory and the University of California, Los Angeles. RCMES facilitates multi-model, multi-variate evaluation over any CORDEX domain using ground-based observation and NASA remote sensing datasets. The recent development of RCMES includes the hierarchical data analyzer that can show the added value of high-resolution datasets from observations and models. Our analysis of observations indicates that using temperature and precipitation observations whose spatial resolution is finer than 50 km is important in studying their temporal trends. However, NA-CORDEX RCM simulations forced by ERA-interim reanalysis data do not show expected performance in simulating the spatial structures in observed temperature and precipitation trends. Specifically, the simulated trends do not represent the fine-scale variability, which is important for supporting decisions and management plans to address the impacts of regional climate change.

Keywords: Added value of high resolution RCMs, temperature and precipitation trends, North America CORDEX

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-18

Ten years of CORDEX - a review

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The Coordinated Regional Downscaling Experiment (CORDEX) entered its tenth year in 2019 and this paper reviews the impact of CORDEX in the scientific peer-reviewed literature. We investigate the uptake of CORDEX data in peer-reviewed articles and quantify the geography of the papers (which region are the papers reporting on), in which scientific community the papers belong to (climate, health, energy, etc.), what proportion of CORDEX work is open access and report on the inclusion of CORDEX literature in the IPCC assessment cycles. A particular assessment of the climate science literature quantifies the number of studies with themes including extreme events, added value and detection-attribution. We also attempt to report on how CORDEX data is used in post-graduate studies and in government white papers or reports line National Adaptation Plans. We conclude with an assessment of how CORDEX activities align with the WCRP strategic plan and programmes within the WCRP and make some suggestions about this.

Keywords: CORDEX, Review paper

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-19

Investigating sea surface temperature representation and its potential influence in SEACLID/CORDEX-Southeast Asia regional climate simulations

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Sea Surface Temperature (SST) characteristics and its regional influence may not be well represented in climate models and these can result to biases in the downscaled climate output. Southeast Asia Regional Climate Downscaling (SEACLID)/Coordinated Regional Climate Downscaling Experiment – Southeast Asia (CORDEX-SEA) historical climate simulations showed biases in temperature and rainfall. This study examines SST representation in climate models to investigate whether this can potentially contribute to the resulting model biases. This is done by: a) describing the historical SST over Southeast Asia (SEA) from observations in terms of spatial patterns and temporal variability; b) analyzing the Coupled Model Intercomparison Project Phase 5 (CMIP5) Global Climate Model (GCM) representation of SST over SEA and its potential influence on modeled climate over the Philippines; and c) assessing the possible effect of SST representation in CMIP5 GCMs on the downscaled regional climate output. Results show that four GCMs that best represent SSTs also have good representation of GCM model climate. Particular GCMs that do not represent SST well also produce climate simulations that are far from observed data. There are also GCMs that do not show any statistical relationship between SST representation and the resulting climate simulation. Over regions of Southwest Monsoon influence including South China Sea where the SST seasonal variability is captured well, temperature, rainfall, moisture, and wind speed are also adequately represented by the models. Results suggested that negative biases in land temperature, and positive biases in precipitation and wind speed, in both global and regional climate models, are associated with negative model biases in SST. Findings give a better understanding on how SST potentially influences modeled climatology in SEA and can help improve regional climate models for better future climate projections used for adaptation and impact studies.

Keywords: regional climate modeling, climate variability, CORDEX-SEA, sea surface temperature

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-20

Assessing the value of climate information for local government officials in South Africa

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A significant amount of work has been done by national as well as international academic, research and other institutions to produce climate change information that intended to support decision making and planning. This includes the work by the Intergovernmental Panel on Climate Change at international level and the Council for Scientific and Industrial Research and the Climate Systems Analysis Group at the national level. However, it is anticipated in the traditional way of producing knowledge that when CORDEX data is generated and disseminated the targeted users will automatically start using it but this is not always the case. In an effort to understand the factors that are required to support uptake of climate change information in South Africa, this study uses two municipalities in South Africa namely Capricorn District Municipality in Limpopo and Amathole District Municipality in the Eastern Cape. The two provinces are considered to be amongst the most vulnerable to climate change in South Africa as a result of socioeconomic drivers such as poverty, dependence on primary economic sectors such as agriculture and high levels of unemployment.

Participatory methods were used to engage decision makers in the two municipalities who are involved in climate change and air quality management. The study found that knowledge about climate change risks and adaptation has improved amongst local government officials. This is a result of national efforts through programmes such as the South African Risk and Vulnerability Atlas and the Department of Environmental Affairs Local Government Climate Change Support Programme. Research and academic institutions in South Africa have been able to provide down-scaled projections that have informed the development of adaptation strategies at local level. However, there is still need for local government focused climate change products other than projections that can address the usability gaps. Other barriers to use of climate change information include issues relating to communication, accessibility, relevance and limited capacity of users to interpret information in projections and implement in different sectors. The study also found that decision making at local government is not easily influenced by the provision of information, tools and frameworks as other factors play a role and need to be acknowledged as part of that system.

Decisions to act on adaptation are often blocked by institutional and psychological factors especially on difficult, transformational and long lifetime decisions. There is also pressure amongst individuals and groups especially when worldviews/values between the scientists and non-scientific community are different. Further to this, uptake of climate information at municipal level is also affected by the level of top down management, control risk management and local self-organised adaptation. District municipalities in South Africa are responsible for key service delivery areas such as water, sanitation, electricity, municipal health services and other district-wide functions for the municipalities in the district. Human and financial resources at these district as well as their local municipalities are often under-resourced and struggle to integrate climate change with other service delivery activities. These constraints help in understanding the instances where climate change information is available to inform potential climate change impacts and responses but the decisions taken on what and how actions are implemented do not always match the recommendations from science (Adger et.al., 2007).

There are increasing calls for co-production and co-implementation of knowledge to enhance the value and use of scientific information including climate information. However, there is need to acknowledge

that institutions such as local governments are complex systems whereby multiple actors play a key role in decision making while the institutions regulations and culture; technology; individual identity and values among other factors influence the adaptation activity space (Pelling et.al.,2014). As such, knowledge producers need to find the different entry points and packaging options for climate change information to meet the different expectations that decision makers at local government as they use information in different ways. Further to this local government officials need guidance on the use and limitations of CORDEX data in the different sectors that they operate in. To conclude, the study recommends that information needs and support for local governments need to be ongoing process as adaptation is an continuous learning process that needs regular monitoring to meet the changing needs/values.

Keywords: climate information, local government, South Africa, adaptation

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-21

Climate analog and future appearance of novel climate in Southeast Asia

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This study identified the analog locations of five big cities and the future appearance of novel climate in Southeast Asia (SEA) at the end of the 21st century under the Representative Concentration Pathways 8.5 (RCP8.5) and 4.5 (RCP4.5) scenarios. A modified version of an existing formulation to estimate climate distance is introduced, using the monthly means of temperature and precipitation from six regional climate experiments and from six global climate models (GCM). Results showed that regional downscaling allowed a more accurate representation of temperature but displayed a higher variability in rainfall over SEA compared to those of the GCMs. The ensemble mean (ENS) experiment had a relatively better performance compared to each individual experiment in representing the monthly time series of temperature and precipitation. The common tendency of climatic relocation towards warmer regions for the five big cities in SEA (Hanoi, Bangkok, Manila, Kuala Lumpur and Jakarta) was prominent with the regional ENS experiment. At the end of the 21st century, the ratio of novel climate areas over SEA, mainly located in low elevation, coastal, equatorial regions and islands, was less than 2% under RCP4.5 and increased to 24% and 21% under RCP8.5 for the ensemble regional and global experiments, respectively.

Keywords: climate analog, novel climate, regional climate model, CORDEX-SEA

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-22

On the sensitivity of seasonal and diurnal precipitation to cumulus parameterization over CORDEX-EA-II

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The ability of the Weather Research and Forecasting (WRF) model in simulating the seasonal and diurnal cycles of rainfall over the Coordinated Regional Climate Downscaling Experiment East Asia Phase II (CORDEX-EA-II) domain is validated against the Tropical Rainfall Measuring Mission (TRMM) datasets. A focus is placed on the role of convective parameterization (CP) schemes. A set of numerical experiments at a 25km resolution for 1998-2009, using six different CPs, is performed to evaluate the physic-dependency of results. All CPs simulate realistic summer mean precipitation and its northward propagation, with the best performance in the Simplified Arakawa-Schubert (SAS). The biases in the seasonal march of rainfall are related to the deficiency in simulated low-level winds and the northward propagation of the cyclonic vorticity. The simulated earlier peak time in other CPs is delayed by about 1-2 hours by the Kain-Fritsch with a modified trigger function (KFMT), although this scheme shows a disadvantage in the magnitude. The performance of different CPs in simulating diurnal rainfall cycles is dependent on regions, and none of them performs better than the others for all sub-regions. The initiation of simulated convection is weakly physic-dependent. However, the timing and magnitude of stratiform precipitation differ among the six simulations. A further analysis shows that the dry biases over the lower Yangtze River basin are a result of the weakened southwesterly water vapor transport, while the excessive afternoon rainfall in the Kain-Fritsch (KF) simulation is attributed to the largest positive perturbation in the lower level atmosphere, especially the enhanced vertical transport of humidity.

Keywords: Regional climate model, convective parameterization schemes, precipitation

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-23

The potential of CORDEX to capture long term extreme events over Guinea Coast

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We analyze the performance of a group of six regional climate models (RCMs) along with the ensemble mean of their statistics in simulating long term extreme events in daily precipitation and temperature over Guinea Coast for the period of 1961–2005. The models are run at 45km grid interval and is driven by GCM reanalysis lateral boundary conditions. A comparison made with observation data demonstrates that the model performs reasonably well in simulating the frequency of daily precipitation events as well as the precipitation intensities, with the exception of the highlands. Substantial differences are observed among the RCMs which are attributed to the wide range of estimates of high-order statistics like frequency, intensity and the convective schemes employed. This is attributed mainly to the relatively coarse representation of topography across the area of the Guinea Coast and the high variability in the precipitation pattern over the region. The model underestimates daily maximum temperature in the warmer seasons. The performance of the model improves in the simulation of daily minimum temperature. In order to apply CORDEX to the simulation of extreme events over the complex terrain for Guinea Coast, it is recommended that a higher resolution is used in order to better describe the topography of the Guinea Coast and that the daily maximum temperature bias is reduced.

Keywords: Cordex, Guinea Coast, extreme

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-24

Variability and trends of atmospheric moisture in recent West African monsoon season and the CORDEX-Africa projected 21st century scenarios

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The interannual variability and trends of atmospheric moisture flux convergence (MFC) and the flux transport and their roles in wet season rainfall variability during the West Africa monsoon have been investigated using the Climate Research Unit observational datasets and the National Center for Environmental Prediction reanalysis 2 from 1979 to 2016, and the Coordinated Regional Downscaling Experiment (CORDEX)-Africa model outputs. Particular emphasis has been placed on the three rainfall zones: the Western Sudano Sahel, the Eastern Sudano Sahel and the Guinea Coast. The MFC shows largest variability and impact on rainfall in the Western Sudano Sahel, followed by the Guinea Coast, but there is no significant impact in the Eastern Sudano Sahel. The MFC shows significant positive trends at the Sahelian locations but not at the Guinea Coast. The CORDEX-Africa models adequately simulate the climatology and spatial patterns of the mean June to September atmospheric moisture; however, differences exist in the magnitude and signs of the temporal trend. The model ensemble mean is presented, which better represents the atmospheric moisture during WAM rainfall variability. A mean bias-corrected projection of the atmospheric moisture shows a consistent enhanced variability of the Guinea Coast in the RCP 4.5 and RCP 8.5 at the end of the 21st century.

Keywords: West African monsoon, CORDEX-Africa, atmospheric moisture, rainfall, variability

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-25

How important is the climate change signature in inputs to hydrological models in 2050 and 2100?

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Developing projections of Australia-wide hydrological variables can be approached in a number of different ways. Earlier efforts (ISI-MIP: Hempel et al. 2013; Victoria: Hope et al. 2017; Potter et al. 2018) have used an ensemble of opportunity, based upon the availability of climate model simulations, downscaled data and relevant variables required to run hydrological models. In some cases relatively simple statistical shifts in the mean were applied to represent the climate change signal. However, for many variables important to hydrology (precipitation, temperature, wind and radiation), changes due to anthropogenic climate change can not be expressed as a simple shift in the mean. The tails and shape of the distribution might also be expected to change. In this work, we aim to retain as much of the information about the modelled shift in the full distribution as possible, within the constraints of providing inputs to off-line hydrological models. In this presentation we outline the change simulated by climate models relevant to key variables for hydrological projections and detail the range of bias-correction methods that can account for their inter-relationships. These results will then guide our choice of bias correction and downscaling methods to be used in the Bureau of Meteorology's hydrological projections project.

Keywords: Bias correction, Downscaling, Hydrological modelling

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-26

Inter-comparison of temperature trends in CORDEX models and CMIP5 models

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Temperature trends is an important parameter to measure the state of climate. And it provides evidence of green house gases (GHG) impact. The data used in the estimation of temperature trends include but not limited to meteorological station data, satellite observations and model data such as reanalysis products. Global climate models (GCMs) and regional climate models (RCMs) are tools used to investigating potential changes in the future climate. However, projections from RCMs and GCMs can differ, particularly in the case of rainfall. To gain more confidence in both GCMs and RCMs climate projections is important first to analyse how trends are captured in the past climate. Yet such analysis using a suit of GCMs and RCMs hasn't been done over southern Africa. Here we compare trends in the Coordinated Regional Climate Models Experiment (CORDEX) regional climate models and the driving boundary conditions from CMIP5 to check for consistency or lack of it. Furthermore, the mechanisms driving these trends are also explored in order to provide robust message for decision making. In general the spread in temperature trends between different RCMs forced by the same GCM (boundary condition) is small compared to the spread due to the difference in GCM boundary condition. There is typically greater warming over the sub-continent than surrounding oceans, but models show substantial differences in regional detail within this broad pattern. The model projections analysed here indicate a strong agreement for increased (summertime) surface air temperatures over southern Africa over the century. The continental heat low was identified as the main mode of variability and influencing these trends.

Keywords: Temperature trends, southern Africa, models

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-27

Assessment of the CORDEX-Atlas Africa simulations added value and uncertainty of the climate change signal

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Within the CORDEX-Atlas effort, RegCM4 has been used to downscale 3 GCMs (HadGEM-ES, MPI and NorESM) over the African domain for the two scenarios RCP2.6 and RCP8.5 with a resolution of 25 km. The CORDEX Africa domain has been also the central domain of the previous CORDEX Phase 1 experiment, therefore there are available many regional climate model simulations for the same scenarios at the lower resolution (50 km).

The aim of this work is to put the new CORDEX-Atlas projections in the context of the available literature.

The added value of the new high-resolution simulations is assessed for both mean climate and extreme over specific climatic regions for sub-daily to interannual time scales.

In addition, mean temperature and precipitation change, together with the change of extreme temperature and precipitation indexes are computed for the mid and far future time slices for both 25 and 50 km simulations.

Keyword: CORDEX-Africa, CORDEX-CORE

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-28

Application of the quantile mapping and probability density functions approach using CORDEX data for drought and flood frequencies in Pakistan

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Abstract: Statistical Downscaling from the global to the regional scales always leave uncertainties due to the lack of fine resolution climate data incorporated at the local scale. To overcome this difficulty up to some extent, the quantile mapping (QM) approach based on observed data collected from meteorological stations were incorporated to remove the systematic biases in the regional scale simulations of the CORDEX South Asia data for maximum temperature, minimum temperature and precipitation. Due to the limited computational capacity of climate cluster, the domain size was kept to cover Pakistan area only. The output of the simulations on all the three selected parameters was modelled into probability density functions (PDFs) to indicate the anomalies of the baseline climate patterns in various statistical moments for temperature, the lowest and highest extremes while for precipitation, the driest and the wettest. The PDF-based analysis of the thermal regime identified negatively skewed patterns in projected temperatures as compared to the baseline pattern which forced shifting of percentiles and means largely towards extreme highs and relatively showing less impact on lows. However, the PDF-based analysis for precipitation produced lower kurtotic values with fatter and longer tails in the projected amounts as compared to baseline which are indicating higher frequencies of the dry and wet extremes to occur in future. Both the flood and the drought frequencies are in the matching contrast in the PDF-based output.

Keywords: CORDEX, Probability Density Functions, Statistical Downscaling, Drought and Flood, Uncertainties

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-29

Assessment of future cyclones activity in the CORDEX Southern Hemisphere domains following a Multi-Model Ensemble approach

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This work aims at analyzing present and future cyclone activity in three CORDEX Southern Hemisphere domains (South America, Africa and Australia) using an ensemble of simulations based on the Regional Climate Model (RegCM4) system driven by global climate models (GCMs) HadGEM2-ES, MPI-ESM-MR and NOR-ESM1-M. RegCM4 has a horizontal resolution of 22 km and uses the Community Land Model (CLM4.5) as scheme for the land surface processes. The analysis includes both extratropical and subtropical cyclones which have been identified using an objective procedure based on the nearest-neighbor approach on mean sea level pressure gridded fields produced by the simulations. Historical period (1995-2014) of the simulations were validated through comparisons ERA-Interim reanalysis. RegCM4 simulates a cyclone frequency more similar to the reanalysis than GCMs ensemble. Resulting storm tracks and cyclone features for the period 2080-2099 (based on RCP8.5 scenario) in RegCM4 and GCMs have been compared with those of the historical period (1995-2014). Both GCMs and RegCM4 ensemble show in the future a decrease in the cyclone frequency over South America and Australia domains. No significant changes have been identified in the cyclone intensity over South America, while for Australia a slight decrease in the intensity of the systems has been found. Simulations for Africa are still in processing.

Keywords: cyclones, climate projections, CORDEX domains

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-30

Potential future climate regimes based on an ensemble of CORDEX-CORE simulations using REMO

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Based on the IPCC Special Report on the impacts of global warming of 1.5 degree C above pre-industrial levels, the temperature extremes on land are projected to warm more than the observed monthly global mean near-surface temperature with high confidence. The potential impacts of this significant climate change vary regionally as such that in most land regions, the current climate conditions would probably shift to a different climate regime. In this study, we are investigating how the regional climate zones of ten CORDEX regions will potentially shift in dynamically downscaled high-resolution projections forced by selected global climate models (GCMs) and two representative concentration pathway (RCP) scenarios (low- and high-end scenario). The high resolution climate change simulations from the regional climate model REMO are a part of the WCRP Initiative on CORDEX Coordinated Output for Regional Evaluation (CORDEX-CORE) Framework.

The latest version of the regional climate model REMO, which is developed and maintained at the Climate Service Center Germany (GERICS), was used to simulate the present and future climate of ten out of the fourteen CORDEX Domains: Europe, South America, Central America, North America, Africa, South Asia (formerly called West Asia), Australasia, East Asia, Central Asia, and Southeast Asia. Following the CORDEX-CORE setup, the model was run on a spatial resolution of 0.22° (about 25 km) with 27 hybrid vertical levels. The CORDEX-CORE simulations are composed of ERA-Interim-driven simulations for the evaluation period from 1979 to 2017, and GCM-driven simulations for the historical time period from 1950 to 2005 as well as for the two RCPs scenarios, RCP2.6 and RCP8.5, each for the time period 2006-2100 driven by three GCMs (MPI-ESM-LR, HadGEM2, and NorESM).

For the evaluation period, the mean precipitation and temperature biases were analysed using the latest CRU version TS 4.02 during the evaluation period (1981 to 2010). The climate zones were defined based on the fourteen climate types from the Koeppen-Trewartha Climate Classification. We will investigate how the fourteen climate zones are projected to vary in the future. In addition, we will identify how the population of the regions might be exposed to the changes in the climate zones.

Keywords: future climate regimes, CORDEX CORE, Koeppen-Trewartha Climate Classification

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-31

Modelling potential impacts of future climate on barley (*Hordeum vulgare* L.) productivity in eastern Tigray, northern Ethiopia

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Crop growth and productivity is principally a function of temperature if water is available to the ideal satisfaction. The objective of this research was to analyze the future climate of the study area and simulate the potential impacts of climate change on barley (*Hordeum vulgare* L.) productivity. The climate prediction was made from NT up to the end of the century (NT=near term (2010-2039) MT=midterm (2040-2069) and ET=end term (2070-2099)) using two Representative concentration pathways (RCP: RCP 4.5 and RCP 8.5) and 20 Global Circulation Models (GCM's). To capture the uncertainties in prediction associated with inter-model differences and model parameter assumptions, only under and over predicting GCMs were selected and used. Barley productivity under future climate was simulated using APSIM after thorough calibration using five years' (2013-2017) phenology data. The performance of APSIM was assessed using Relative Root Mean Square Error (RRMSE) and coefficient of determination (R²). The downscaled climate of the study area revealed that precipitation is likely to increase in a range of 20.9% to 30.3% in Atsbi Wenberta and 26.1% to 27.0% in Kilte Awulaelo (the range being the uncertainty). As well, the future temperature is predicted to increase and change in minimum temperature exceeded that of maximum temperature in ET. An output from calibrated and evaluated APSIM model showed a general grain yield decline relative to the baseline, especially during ET RCP 8.5. Relatively lower percentage yield losses resulted from early sowing (05 June) of barley cultivars as opposed to normal and late sowing (23 June and 05 July respectively). Extreme temperatures under future climate is expected to decrease yield as higher temperature is likely to increase evapotranspiration, shorten pollination and grain filling period. We therefore recommend better soil and water conservation practices to minimize evapotranspiration, early sowing and breeding for improved barley cultivars with combined traits such as heat-stress tolerance, early heading and longer grain filling period.

Keywords: Global Circulation Model, Climate Change

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-32

Uncertainty in climate change projections over India using two dynamical downscaling techniques

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Uncertainty in future climate projections at regional and sub-regional scales is an issue of concern for the research and policymaker communities. Over regional scales, dynamic downscaling is still a preferred approach to produce useful information. The use of RCMs and high-resolution AGCMs are two approaches that are popular. In this study, we investigate the impact of various dynamical downscaling methodologies (using a RCM and AGCM) on the mean change and associated uncertainty over India. We use 9 selected CMIP5 AOGCMs downscaled (to 0.5°x0.5° resolution) using the Regional Climate Model (RCM) for the South Asia domain using the Rossby Center regional Atmospheric version (RCA4) by the Swedish Meteorological and Hydrological Institute (SMHI) as a part of CORDEX. We also downscaled the same 9 AOGCMs using NCAR's Community Atmosphere Model (CAM5.3 – the atmospheric component of CESM1.2.2, at 0.9°x1.25° resolution). We compare the downscaled outputs from RCP4.5 and RCP8.5 scenarios against relevant CMIP5 model output over the homogenous climatic zones of India. Spatial and seasonal features of present-day climate over Indian region are reasonably well simulated by both the RCM and AGCM with the signature of downscaling models evident in the biases. We analysed the impact of two dynamical downscaling on mean change and associated uncertainty over the regional and sub-regional scale and also investigated how the uncertainty is fundamentally different from AOGCMs.

Keywords: Dynamical Downscaling, Regional Climate Change, Uncertainty, Regional Climate Model, AOGCMs

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-33

Validation for the tropical belt version of WRF: Sensitivity tests on radiation and cumulus convection parameterizations

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Version 3.9 of WRF-ARW is run with a tropical belt configuration for a period from 2012 to 2016 in this study. The domain covers the entire tropics between and with a spatial resolution of about 45 km. In order to verify two radiation schemes and four cumulus convection schemes, eight experiments are performed with different combinations of physics parameterization schemes. By analyzing the basic features of 2m temperature, precipitation and zonal wind at 10m, and the diurnal cycle of precipitation in boreal summer, the following main conclusions are drawn :

- (1) Eight experiments present reasonable spatial patterns of surface air temperature and precipitation in boreal summer, with the spatial correlation coefficient (COR) between simulated and observed temperature exceeding 0.95, and that between simulated and observed precipitation ranges from 0.65 to 0.82.
- (2) The four experiments with the RRTMG radiation scheme show a better performance than the other four experiments with the CAM radiation scheme. In the four experiments with the RRTMG radiation scheme, the COR between simulated and observed surface air temperature is about 0.98, and that between simulated and observed precipitation ranges from 0.76 to 0.82.
- (3) Comparatively, the two experiments using the new Tiedtke cumulus parameterization scheme can simulate better diurnal variation of precipitation in boreal summer than the other six experiments. In particular, for the diurnal cycle of precipitation over land and ocean, the experiment using the RRTMG radiation scheme and the new Tiedtke cumulus convection scheme shows that the peaks of precipitation rate appear at 0400 LST and 1600 LST, in agreement with observation.

Keywords: Parameterization Scheme, Diurnal cycle of precipitation

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-34

CORDEX multi-RCM hindcast over Central Africa: Evaluation within observational uncertainty

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This work investigates the performance of ten RCMs hindcasts from CORDEX over Central Africa during the period 1998-2008, with focus on monthly rainfall and surface temperature. Downscaled simulations are nested within the ECMWF Interim Re-Analysis (ERA-Interim) over the period 1998–2008 and over a common area at 0.44° (~50km) of resolution. Many observational datasets are used to assess model performances over four subregions. Throughout the work a measurement of observational uncertainty is made and we discuss whether or not the models are truly within or outside the range of observational uncertainty. We also discuss the added value of the RCMs over ERA-Interim, the uncertainty in ensemble mean of RCMs and how treating all simulations equally matters or not. Results indicate that in general, RCMs relatively simulate well rainfall and temperature basic features over the four subregions, though important biases exist and vary for models and seasons. Wet biases are quasi-systematic features in the northern and southern part of the domain, and in regions with higher topography. Dry biases are common features for few RCMs over the Congo basin. From one season to another, most of the RCMs and sometime along with their average fail to simulate rainfall and temperature by underestimating or overestimating the range of observational uncertainty. However, RCMs show a good spread of grid points where added value is found, except UC-WRF and UCT-PRECIS. This could explain why whatever the time scale of variability (seasonal, annual and interannual), UC-WRF is generally found to be one of the worst among RCMs. We can not really say the multimodel generally outperform individual model, but it is found within observational uncertainty when most models are also found inside. This highlight the fact that the ensemble mean, built from the equal treatment of RCMs is not really different from most of the RCMs and put question on the way it was built.

Keywords: Central Africa, CORDEX-RCMs, Observational uncertainty, Multi-model average, Added value

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-35

Uncertainties in detecting tropical cyclones in Regional Climate Model simulations over the CORDEX-Southeast Asia domain

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The possible sources of uncertainties in simulating the historical tropical cyclone (TC) climatology such as the model-dependent threshold values per criteria, the detection method algorithm, and the domain size are examined and compared using the three downscaled simulations of Southeast Asia Regional Climate Downscaling / Coordinated Regional Climate Downscaling Experiment – Southeast Asia (SEACLID/CORDEX-SEA) and the two downscaled datasets of Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA). The study analyzes the characteristics of TC climatology in terms of pattern, intensity, frequency, and lifetime. Sensitivity tests for the detection method criteria threshold values were conducted to determine the optimum threshold configuration for each CORDEX-SEA simulation and PAGASA simulation. Model simulations underestimated the total number of TCs and the average TC days for the 1986 to 2005 period compared with the best tract dataset of Joint Typhoon Warning Center (JTWC). The detection method of Phan et al. (2015) and Hodges (1994) displayed differences in the TC count and detected maximum wind speed. However, both detection methods showed a northwestward shift of TC track density in the region. Model simulations are also affected by domain size and location of the lateral boundaries that contributes to uncertainty in simulating TC climatology.

Keywords: CORDEX, tropical cyclones, regional climate modeling, uncertainty

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-36

Harnessing the economic benefits under uncertainty: Evidence from the Teesta river basin of Bangladesh

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Climate change will increase the frequency and intensity of extreme events such as floods, riverbank erosion, and drought in both near-term and long-term which may lead further uncertain future to the poor and marginal people in the Teesta basin of Bangladesh. The farmers practicing adaptations in Teesta basin experience reduced loss and damage involves different costs and benefits. This study aimed at assessing the most promising adaptation practices, their economic cost and return, and social welfare through the cost-benefit analysis approach. The study revealed few adaptation practices with high costs but generating low benefits to the farmers and vice versa. The study found among the adaptations, shallow tube-well (STW) based irrigation practice in both sandy and loamy soil has the highest marginal adaptation cost (MAC) but the lowest benefit-cost ratio (BCR). Deep tube-well (DTW) based irrigation practice generates superior benefit to the farmers compared to the STW based farming due to the initial establishment by the government which cost a large amount. Maize farming as alternate cropping generates nearly five times higher economic benefits than the costs which can be acknowledged as a most profitable and resilient adaptation option in the Teesta basin. Though MAC is the least for the short-duration variety (SDV) rice among the promising adaptations, it's economic profitability is 36% lower than that of the maize cultivation. However, having lower BCR the SDV rice produces US\$51 higher social welfare than the maize cultivation which may enhance the SDV rice over the maize cultivation. Strategic adaptation planning and subsidized resilience building may encourage the farmers to take up adaptation options which may reduce climate-induced loss and damages of the farmers and build socio-economic resilience in the Teesta basin and other similar areas of South Asia.

Keywords: Climate vulnerability, Adaptation benefit, Teesta river basin, Socio-economic resilience

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-37

High resolution simulations and projections over most of North America: achievements and on-going work

Jiali Wang, Argonne National Laboratory, United States

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In this presentation, we will talk about our achievements using dynamic downscaling (using WRF) over most of North America (7200km x 6192km) at a spatial resolution of 12km; we will also talk about our on-going work over a slightly larger domain than CORDEX-NA at a spatial resolution of 4km. For the 12km WRF, we developed six ensemble members, with one 30yr of WRF simulations driven by NCEP-R2, and five ensemble members of simulation and projection using three different Coupled Model Intercomparison Project Phase 5 Earth system models (ESMs): GFDL-ESM 2G, HadGEM2-ES, and CCSM4 to represent the range of the sensitivities of all ESM responses to doubled CO₂. Our ensemble is made up of one simulation that uses HadGEM2-ES boundary conditions; two simulations that use GFDL-ESM 2G as boundary conditions—one with spectral nudging and one without; and two simulations that use CCSM4 as boundary conditions—one with bias correction and one without. For most of the ensemble simulations we ran each of the lateral boundary conditions with two scenarios, each for two future time periods: (1) historical simulations (1995–2005), (2) RCP 4.5 (2045–2054), (3) RCP 4.5 (2085–2094), (4) RCP 8.5 (2045–2054), and (5) RCP 8.5 (2085–2095). The model output have been extensively evaluated and studied, especially for temperature and precipitation and their extreme features. The output were also applied by statisticians, infrastructure engineers, hydrologist, crop modelers, and biologist to study the spatio-temporal features of the climate change effect on infrastructure, water cycle, crop yields, and even insect pathogen! We have published a dozen of journal articles directly out of this project. There are also scientific reports, and PhD thesis that have used this model output. Some results will be highlighted in this presentation.

One of the most recent successful applications of this project is to provide future extreme climate information (e.g inland and coastal flooding as well as strong winds) to AT&T's network infrastructure over southeastern US. A white paper is published by AT&T and dozens of new articles are written to report this application. Key outcomes from this project will be presented.

With the needs of high resolution data growing, and the fact we found from our previous study, a convective-permitting spatial resolution (less than 4km grid spacing) can significantly improve model performance, especially for extreme features. We are currently testing the feasibility and scale up capability of a 4km simulation over most of North America (similar domain as CORDEX-NA, but covers entire Alaska and Puerto Rico). There are 140 millions of grid cells (horizontally and vertically) for the domain. This project will conduct similar time periods considering different emission scenarios using GCMs as we did for the 12km. Once this dataset is generated, there will be immediate benefits for many other research topics. For example, high resolution wind data will serve better for fire risk study, coastal flooding study; high resolution precipitation will provide much better dataset for hydrological modeling (such as WRF-Hydro®); finer resolution will capture the details of complex topography and generate better precipitation over western US (such as snow over Sierra Nevada). We will present the challenge of this on-going work and the added value we found through several previous studies.

Keywords: High resolution simulations, convective-permitting

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-38

Identifying added value of RCMs for simulated precipitation in Africa

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We investigate impacts of horizontal resolution and model formulation on the climatology of simulated precipitation over Africa by conducting a number of sensitivity experiments at different horizontal resolutions by different RCMs. First we downscale the ERA-Interim reanalysis (about 80 km resolution) by two RCMs (SMHI-RCA4 and HCLIM-ALADIN) over Africa at about 25, 50, 100 and 200 km resolution for the historical period (1981-2010) for the evaluation of model performance and identify possible added value compared to the reanalysis. Second, to attribute changes by RCMs on climate change signals, we downscale two global models from 1950 to 2100 (EC-EARTH and MIROC5 under the RCP8.5 scenario) by two versions of SMHI-RCA4 over Africa at the standard CORDEX 0.44° (50 km) resolution and at the spatial resolution of the driving GCMs (about 1.1° for EC-EARTH and 1.4° for MIROC5). Focusing on precipitation we find that added value of increasing resolution can be found with regards to the forcing reanalysis and GCMs, but varies depending on region and season. We also note that some of the identified added value are common to the RCMs regardless of which GCM that is downscaled. This study may give useful implication to the utility of RCMs, especially when it comes to the theme of climate services.

Keywords: Added value, Africa, RCA4, HCLIM, precipitation

Parallel Session A: Advances in regional downscaling

A1: Uncertainties and added value

A1-P-39

Evaluation of multi-RCM high-resolution hindcast over the CORDEX East Asia Phase II region

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Based on the Coordinated Regional Downscaling Experiment-East Asia second phase (CORDEX-EA-II) with higher resolution, model results driven by ERA-Interim reanalysis using WRF, RegCM4 and CCLM are evaluated against the observational datasets including CN05.1, CRU and GPCP during the period of 1989-2009. The results show that the RCMs have the capability to simulate the annual and seasonal mean surface air temperature and precipitation, however, some biases are produced. The biases are highly dependent on the geophysical locations and the RCMs applied, and CCLM agrees better with the observed precipitation over ocean. CCLM also outperforms the other two RCMs in simulating the interannual variations of temperature and precipitation in most sub-regions, which can be attributed to its better presentation of the interannual variation of large scale circulation. Generally, all the three RCMs can well reproduce the seasonal cycles of the surface air temperature in most sub-regions, however, only in the northern regions of China can the RCMs well reproduce the seasonal cycles of precipitation.

Key words: CORDEX; Regional climate model; East Asia

Under the same framework, we are going to investigate and evaluate the RCMs' performances in simulating extreme temperature over CORDEX-EA-II region in the period after the submission of abstract. We focus on the climate extreme indices developed by ETCCDI and the relevant model performances to detect what reasons cause the biases and uncertainties in the simulations. So we may add these part of study into my oral presentation if this abstract will be accepted as we hope. On the basis of these procedures, we can better understand the underlying physical mechanisms in the regional dynamical downscaling modelling.

Keywords: CORDEX-EA-II, Regional Climate Model

**Parallel Session A:
Advances in regional downscaling**

A2: Convection permitting modelling

ORAL PRESENTATIONS

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A surrogate warming experiment on summertime extreme precipitation events in Europe comparing a convective permitting model to coarser scale RCMs

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***Erik Kjellström, Petter Lind, Danijel Belusic**, SMHI, Sweden;
Geert Lenderink, KNMI, Netherlands*

We compare a very high resolution (≤ 3 km grid spacing) convection permitting regional climate model (CPRCM) with a standard high-resolution (12 km grid spacing) convection parameterized regional climate model (RCM) simulate precipitation extremes for four different regions covering Europe in today's climate and in a climate representing a warmer world. Simulations forced by reanalysis are performed for ten months from the last two decades representing summer conditions with large amounts of precipitation. In addition, a surrogate climate change experiment was made in which the boundary conditions for the RCMs were synthetically changed to represent a two-degree warming. We show that the convective permitting model outperforms the intermediate standard-resolution (12 km) regional climate model in representation of hourly precipitation statistics and that added value is obtained, not just at the very high resolution, but also aggregated to the 12 km grid scale. The surrogate climate change experiments indicate that precipitation and precipitation extremes increase in the two-degree warmer climate. Changes in precipitation mostly follow the Clausius-Clapeyron relationship with about a 6-7% increase in precipitation per degree of temperature increase. An exception to this relates to high-intensity precipitation events where high-end (above 90%) percentiles (based on hourly data) show stronger increase up to twice the Clausius-Clapeyron relation. We analyse differences between different parts of Europe with respect to different regional forcing factors such as moisture availability. The experimental design of our surrogate climate simulations, with a relatively large number of events sampled through a number of month-long simulations, shows some benefits in interpreting "Future Weather" simulations in terms of climate change compared to studies based on single events.

Keywords: Convective permitting model, Precipitation extremes

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

(When) is convection permitting resolution important in the northern latitudes?

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Danijel Belušić, Petter Lind, David Lindstedt, SMHI, Sweden; ***Erika Toivonen***, FMI, Finland; ***Rasmus A. Pedersen***, DMI, Denmark; ***Erik Kjellström***, SMHI, Sweden; ***Oskar Landgren***, MET Norway, Norway; ***Fuxing Wang***, SMHI, Sweden; ***Ole B. Christensen***, DMI, Denmark

We examine new climate simulations over the Nordic region, performed with the HCLIM38 regional climate model at both convection permitting and coarser scales, searching for benefits of using convection permitting resolutions. The Nordic climate is influenced by the North Atlantic storm track and characterised by large seasonal contrasts in temperature and precipitation. It is also in rapid change, most notably in the winter season when feedback processes involving retreating snow and ice lead to larger warming than in many other regions. This makes the area an ideal testbed for regional climate models. We explore the effects of higher resolution and better reproduction of convection on various aspects of the Nordic climate, such as snow in the mountains, lake snow effects, coastal winds, urban climate, as well as convective storms and precipitation with a special focus on extreme events.

Keywords: Nordic climate, convection permitting modelling

Parallel Session A: Advances in regional downscaling A2: Convection permitting modelling

Future precipitation changes over the Alpine region in a multi-model convection-permitting ensemble: a first look

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the Bjerknes Centre for Climate Research, Norway

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Changes in precipitation at local to regional scales in a warmer world remain highly uncertain. This is especially true of both moderate and high extremes (e.g. > 90%-iles and > 99.9%-iles, respectively). While a relationship between increasing model resolution and increasing precipitation (both means and extremes) appears to be present for both GCMs and RCMs there are conflicting results when convection-permitting scales are reached. These differences can be region as well as model dependent. A project under the auspices of the World Climate Research Program's (WCRP) Coordinated Regional Downscaling Experiments Flagship Pilot Studies program (CORDEX-FPS) was established to investigate these, and other issues. This initiative aims to build first-of-their-kind ensemble climate experiments using convection permitting models to investigate present and future convective processes and related extremes over Europe and the Mediterranean. In this presentation we offer a first look at the scenario simulations (Historical 2000-2009 and RCP8.5 2090-99 timeslices) and an analysis of precipitation changes and their drivers over various sub-regions of a large domain, which cover the Alps, parts of central Europe and the Mediterranean and Adriatic coasts (0-17E x 40-50N). To maintain consistency and compatibility to earlier studies we first examine changes in percentiles, seasonality and wet day frequency before moving on to an investigation of changes in the full distribution using e.g. intensity-duration metrics. Finally we employ process-based metrics using vorticity and vertical velocity to split precipitation into stratiform, orographic and convective categories. This new approach focuses on the physical processes leading to precipitation of a certain type rather than use the circular reasoning of employing the result to determine the cause. We conclude with a discussion of the changes to the underlying physical processes driving convective and other types of precipitation at highly localized scales.

Keywords: Convective extremes, Regional change, Precipitation, Convection permitting modeling

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

The effects of switching-off parameterized convection at grey-zone resolutions

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The grey-zone of convection is defined as the range of horizontal grid-space resolutions in atmospheric models in which some convective processes might be explicitly represented by the dynamics of the model. In these range of resolutions (from around a few km to about a few hundred meters), either using parameterizations for convective processes or relaying on the model dynamics to represent them explicitly could lead to systematic model biases. Here, we explore the effect of parameterizing or not deep and shallow convection in year-long climate simulations over a Pan-European domain using different horizontal resolutions ranging from 50km to 2.2km with a non-hydrostatic model. We find that across the range of horizontal resolutions tested, model biases tend to differ more due to the representation of convection than due to changes in resolution when looking at precipitation intensities and the diurnal cycle of summer precipitation. The short-wave net radiative balance of the atmosphere is the variable most strongly affected by resolution changes from the ones we studied. The results suggest that an explicit representation of convection can be used at much coarser resolutions than previously thought. We will also present results on how the representation of convective processes at grey scale resolutions affect simulated climate change projections.

Keywords: convection-permitting, parameterized convection

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

Convection permitting regional climate simulations over the Arabian Gulf Region

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A high-resolution (4 km) regional climate simulations over a 10-yr period (1990-1999) is conducted to study the cloud and precipitation climatology in the Arabian Gulf Region (AGR). WRF is employed to dynamically downscaled the climate of the AGR at fine spatial and temporal scale using GCM data. The initial and boundary conditions were generated by the Community Climate System Model-Version 4 (CCSM4), whose outputs are bias-corrected using an ERA-Interim driven WRF benchmark simulation. The results are evaluated against the Tropical Rainfall Measuring Mission (TRMM) and ground-based station data. The WRF simulation captures the precipitation distribution and amount well, especially during winter. The AGR experiences wet winter and dry summer in general. The cloud occurrence frequency in AGR is the highest during summer, but the precipitation amount is small.

The future climate for 2065-2074 under the representative concentration pathway 8.5 (RCP8.5) emission scenario is simulated using a bias-corrected dynamic downscaling approach. The climate perturbations are derived from the bias-corrected CCSM4 outputs. The simulation provides an estimate of average changes in the atmospheric conditions and precipitation distribution in fine scale over the AGR. The primary results indicate that increases in temperature due to global warming leads to higher precipitation intensities, but fewer precipitation events.

Keywords: convection permitting, Arabian Gulf Region, regional climate simulations

Parallel Session A: Advances in regional downscaling A2: Convection permitting modelling

Sensitivity of summer precipitation simulation to microphysics parameterization over eastern China: Convection-permitting Regional Climate Simulation

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***Ziyue Guo, Jianping Tang**, School of Atmospheric Sciences, Nanjing University, China*

This study presents a 6-year (2009-2014) summer climate simulation using the Weather Research and Forecasting (WRF) model at convection-permitting (CP) resolution (4 km grid spacing). To investigate the effect of precipitation characteristics on the microphysics parameterization (MP) schemes, we choose the Lin (single bulk MP), WSM5 (one-moment and mixed-phased MP), and Thompson (two-moment and mixed-phase MP) scheme. The model results are evaluated through a comparison with the CMORPH and ERA-interim data. The CP model can well reproduce summer precipitation amount and associated large-scale atmospheric circulations, which are insensitive to the choice of MP schemes. The simulations of all MP schemes are able to capture the precipitation timing but overestimate the precipitation amount especially for heavy rainfall, and this may due to the systematic bias, which may not decrease significantly by using different MP schemes. Moreover, all simulations also can capture the major features of precipitation diurnal variation and their transition characteristics, but they significantly overestimate (underestimate) the precipitation frequency (intensity). Thompson scheme creates more snow particles (less graupel) than WSM5 (Lin) scheme, and produces the least precipitation amount that best matches the CMORPH.

Keywords: Convection Permitting scale, solid hydrometeors

Parallel Session A: Advances in regional downscaling A2: Convection permitting modelling

How does the rainfall change over Hawaii in the future? Convection permitting regional climate simulations of the Hawaiian Islands

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Two high-resolution (a 1.5 km grid spacing domain nested within a 4.5 km grid spacing domain) 10-year regional climate simulations over the entire Hawaiian archipelago have been conducted at the National Center for Atmospheric Research (NCAR) using the Weather Research and Forecasting (WRF) model version 3.7.1. The historical simulation driven by the ERA-Interim reanalysis data that validates very well against various observations serves as the basis to assess the rainfall changes through comparing the model results of the simulation in a pseudo globe warming (PGW) scenario. The detailed validations of the historical simulation and the analysis of rainfall changes in PGW simulation will be discussed. The importance of the trade wind inversion and its interaction with complex terrain in controlling the rainfall distributions is emphasized. The high-resolution simulation data are available for researchers to tackle other science questions.

Keywords: convection permitting regional climate simulation, orographic precipitation

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

Case study reproducibility in a convection-permitting WRF multi-physics ensemble: the role of internal variability

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Alvaro Lavin-Gullon, **Jesus Fernandez**, University of Cantabria, Spain; **Sophie Bastin**, Institute Pierre Simon Laplace (IPSL), France; **Rita M. Cardoso**, Instituto Dom Luiz, Universidade de Lisboa, Portugal; **Theodore M. Giannaros**, National Observatory of Athens, Institute for Environmental Research and Sustainable Development, Greece; **Klaus Goergen**, Research Centre Juelich, Institute of Bio- and Geosciences, Germany; **Stergios Kartsios**, **Eleni Katragkou**, Aristotle University of Thessaloniki, Greece **Torge Lorenz**, Bjerknes Centre for Climate Research, Norway; **Josipa Milovac**, University of Cantabria, Spain; **Stefan Sobolowski**, Bjerknes Centre for Climate Research, Norway; **Pedro M. M. Soares**, Instituto Dom Luiz, Universidade de Lisboa, Portugal; **Kirsten Warrach-Sagi**, University of Hohenheim, Germany

In the framework of the CORDEX FPS on Convective phenomena at high resolution over Europe and the Mediterranean (FPS-CEM, Coppola et al., 2018), a convection-permitting multi-model ensemble was used to simulate high-impact weather events over the Alps. This experiment resulted in noticeable discrepancies between models in representing selected heavy precipitation events. The groups using the Weather and Research Forecasting (WRF) model organized a multi-physics ensemble, suited to identify the processes behind those discrepancies. In this work we analyze the uncertainty arising from internal variability in this multi-physics ensemble at one-month and one-year timescales. To distinguish the uncertainty due to the use of different parameterizations from that of the internal variability, a set of simulations with perturbed initial conditions was performed. We measured quantitatively the uncertainty arising from both sources using inter-member variances. For circulation variables, the results suggest that uncertainties from multi-physics and internal variability have comparable magnitude, exhibiting an annual cycle with higher values in summer than in winter. The spatial distribution of the uncertainties show similar patterns, with higher values over the northeastern part of the domain. These patterns are in agreement with previous studies which conclude that internal variability increases where the inflow of the boundary information is less dominant: that is, in summer when the boundary forcing is not able to overcome the local-scale processes, and far from the westerly flow coming from the north Atlantic. The behaviour of uncertainty also depends on the variable. Surface variables are more affected by parameterized processes (soil physics, boundary layer, clouds, etc.), hence the uncertainty associated to the parameterizations has more decisive role for these variables than for circulation variables.

Keywords: Internal Variability, RCM, Physical parameterizations, Uncertainty

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

Assessment of the synoptic forcing associated with extreme precipitation events over Southeastern South America as depicted by RCMs at convective permitting resolution performed within a CORDEX FPS

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Southeastern South America (SESA) is one of the regions of the world where the deepest and most intense convective storms develop. Initiated over the lee side of the Andes, these storms propagate further eastward as they grow up to the mature stage into mesoscale convective systems, fed by moisture provided by a strengthened South American Low Level Jet, the development of a low level pressure on the lee side of the Andes and a mid-level trough. In the context of the ongoing Flagship Pilot Study endorsed by CORDEX focused on extreme precipitation events over SESA, a series of RCM (regional climate model) simulations at convective permitting resolution (4 km) has been produced. The aim of this study is to assess the capability of these simulations in capturing the synoptic forcing associated with the occurrence of extreme precipitation events over SESA. For that purpose, three individual storms of extreme characteristics were selected during the spring to summer season 2009-2010. Simulations were driven by the ERA-Interim reanalyses at two resolutions: 20 km and 4km. Two types of simulations were performed: the “weather mode”, based on 72-hours simulations of the individual cases, and the “climate mode”, based on 6- months-length simulations for the period from October 2009 to March 2010. The RCMs included in this first assessment are: RegCM4 (Univ. of Sao Paulo -Brazil), WRF3.8 (Univ. of Cantabria- Spain) and WRF3.9 (Univ. of Buenos Aires/CIMA-Argentina). The comparison among the convective permitting and parameterized convection simulations in terms of the triggering mechanisms associated with the extreme precipitation events is discussed. It was found that one of the largest differences among the two groups of simulations is in the low- level moisture flux convergence field, suggesting that the low-level wind and moisture fields are affected by the occurrence of convection and they are sensitive to how convection is captured in the models.

Keywords: CORDEX FPS SESA, extreme precipitation events, convective permitting simulations

**Parallel Session A:
Advances in regional downscaling**

A2: Convection permitting modelling

POSTER PRESENTATIONS

LAST NAME	FIRST NAME	TITLE	POSTER NUMBER
BASTIN	Sophie	Multi-model analysis of triggering of precipitation: impact of model resolution and convection representation, and evolution in a warmer climate	A2-P-01
DA ROCHA	Rosmeri	Initial results of the CORDEX FPS on extreme precipitation events in Southeastern South America: dynamical downscaling at convection-permitting resolution	A2-P-02
FALL	Cheikh Modou Noreyni	Characterization and predictability of rainfall convective systems in the Sahel focus on Senegal	A2-P-03
FEIJOÓ	Martín	Assessment of the capability of the WRF-ARW model at convective permitting resolution to reproduce extreme precipitation events over Southeast South America: A Case Study Approach	A2-P-04
FITA	Lluís	Exploration of new insights of land-atmosphere interaction using FPS Alps convection permitting experiment	A2-P-05
GOERGEN	Klaus	Soil moisture-temperature coupling in a CORDEX FPS convection-permitting WRF RCM ensemble	A2-P-06
JIANG	Zhiyu	Simulated climate extremes in the Yangtze River Basin, using the regional climate model WRF	A2-P-07
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Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-01

Multi-model analysis of triggering of precipitation : impact of model resolution and convection representation, and evolution in a warmer climate

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Despite their horizontal resolution higher than global models, regional climate models still present biases for the simulation of precipitation extremes for both sides of the distribution, with a tendency to simulate too often light precipitation and to underestimate heavy precipitation, making them unreliable for the estimation of future extremes (droughts and flash floods) over the Mediterranean area. In this study, we use a multi-variate statistical relationship between temperature, humidity and precipitation - derived from colocated observations at the supersite SIRTa near Paris - to investigate the triggering of precipitation over the site in several regional climate simulations performed in the framework of Hymex/Med-CORDEX, EURO-CORDEX and the FPS Convection. We test the sensitivity of the triggering to the model resolution - from 50 to 3 km, including convection-permitting simulations. In particular, we evaluate how much the spread between models is modified by the absence of parametrization of deep convection in the simulation. We also assess the spatial variability of the relationship and how it evolves in a warmer climate.

Keywords: Triggering of precipitation, Convection-permitting simulation

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-02

Initial results of the CORDEX FPS on extreme precipitation events in Southeastern South America: dynamical downscaling at convection-permitting resolution

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The CORDEX Flagship Pilot Study (FPS) on extreme precipitation events in Southeastern South America (SESA) aims at studying multi-scale processes and interactions leading to extreme precipitation events. It will foster cooperation with the impacts and user community to obtain actionable climate information from different sources, including both statistical and dynamical downscaling. Regarding the latter, we designed an experimental setup exploring the uncertainties arising from the use of (1) different regional climate models and configurations (ETA, RegCM4, WRF3.8, WRF3.9), (2) different resolutions, with an intermediate resolution nest (20km) to reach convection-permitting resolution (4km) over the target area, (3) different heavy precipitation events and (4) different simulation setups, comparing a “Weather-like” mode, benefiting from predictability arising from initial conditions as in NWP, and a “climate mode”, where predictability arises only from the lateral boundary conditions. These driving boundary conditions are taken in all cases from the ERA-Interim reanalysis, in order to compare with observations and leave out global climate modelling uncertainty.

In this work, we present some initial results focusing only on precipitation and exploring the above mentioned uncertainty sources. In particular, we focus on the ability of the models to represent the diurnal cycle of precipitation, total precipitation amount and spatial distribution as compared to the driving reanalysis and several station and gridded observational datasets over the region.

Keywords: convection-permitting simulations, precipitation, diurnal cycle, sensitivity study

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-03

Characterization and predictability of rainfall convective systems in the Sahel : focus on Senegal

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In West Africa, rainfall is a determining factor for the global population consists mostly of rural living on agriculture. In this area, the water cycle has a high variability on all spatial and temporal scales and depends on the dynamics of the system of the West African monsoon. Rainfall is generated by Mesoscale convective systems and squall lines (Mesoscale convective systems multicellular), but also with local storm systems of any size, such as isolated thunderstorms. The spatial and temporal distribution of the seasonal cumulative rainfall depends on the number of occurrence of these various convective systems.

This work highlights the rainfall characteristics at a small scale including that of Senegal center area. Using the synoptic observation network of ANACIM (National Agency of Civil Aviation and Meteorology) to and IRD (Institute of Research for Development) to 12 stations in center of Senegal, Thies, Fatick, Kaolack, Diourbel, Mbour, Bambey from 1960 to 2011. We generally observe a high spatial and temporal variability of the annual total and descriptors of the rainy season. including the onset, wet and dry spells and high impact rainfall or extremes events.

This high spatial and temporal variability is observed between separate stations a few kilometers. Indeed, Diourbel recorded a rain deficit in 2007 season, while for the same year was in surplus Kaolack. We showed the high frequency nature for the short dry and wet spells while the long dry and wet spell are low frequencies and strongly modulate the seasonal accumulation of rain. Consequently, to understand this high rainfall variability in the Sahel, it is necessary to distinguish between local systems and meso-scale convective systems (MCSs). Thus, we first made a climatology of different types of convective systems observed in the Sahel from satellite data (TRMM), observations and radar (NPOL). This classification allowed us to properly quantify the contribution of each type of system on the cumulative rainfall in the area. The originality of this study lies in the characterization of convective activity via OLR (Outgoing longwave radiation) data just before and after a long dry and wet spell. Indeed, the duration of such extreme breaks will dry the soil which helps to decrease the latent flux to increase the sensitive flux, which will warm the atmosphere. Thus, the mesoscale convective systems (MCS) and the squall lines can not be supplying moisture and therefore they will dissipate.

Keywords: Rainfall, MCSs, Squall lines, Dry and Wet Spell

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-04

Assessment of the capability of the WRF-ARW model at convective permitting resolution to reproduce extreme precipitation events over Southeast South America: A Case Study Approach

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Southeastern South America (SESA) is one of the regions in the world most affected by extreme mesoscale convective systems and their associated extreme precipitation. Many authors have studied the mesoscale forcings that trigger convection on the region, being the Andes mountain range and the South American Low Level Jet key factors in the development of convective storms. The small spatial scale of these systems and the fact that the intensity of extreme precipitation has been increasing over SESA due to global warming during the last decade, reveals the importance of understanding how these systems may change in the future. Several studies show that high resolution convective permitting Regional Climate Models (RCMs) improve the representation of the diurnal cycle and intensity of precipitation associated with deep convection, compared to coarser convection parameterized RCMs. In this context, the aim of this study is to assess the capability of the WRF-ARW at convective permitting (CP) resolution in representing the precipitation associated with these events over SESA, compared with RCMs, in two ways. First, in order to determine if the CP improves the results of RCMs and second, if increased spatial resolution in a CP model improves the results, taking into account the computational cost of high resolution simulations. Three extreme precipitation events have been selected over the region and three simulations have been carried out, one with parameterized convection at 12 km spatial resolution, and two simulations at 4 km and 2.4 km in which convection was not parameterized but resolved explicitly. The simulated precipitation was compared against CMORPH satellite estimations and the ability of the simulations was measured using the Fractional Skill Score. The results show that CP simulations have better agreement with the observations (diurnal cycle and intensity) than RCM simulations. No significant difference was found between the 4 km and 2.4 km simulations.

Keywords: SESA, Convective permitting simulations, extreme precipitation events, high resolution

Parallel Session A: Advances in regional downscaling A2: Convection permitting modelling

A2-P-05

Exploration of new insights of land-atmosphere interaction using FPS Alps convection permitting experiment

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The CORDEX FPS Alps experiment establishes a first-of-its-kind in regional climate dynamic downscaling experiments by using the models at cloud resolving resolution. This should enable the study of the land-atmosphere interaction under the unprecedented paradigm of the very high resolution for a multi-year period. This resolution should allow the study of different land-atmospheric processes which were unresolved at previous similar lower resolution exercises.

In this study we present a preliminary exploration of the suitability of this new paradigm to study various land-atmosphere interaction processes. The main focus is to analyze the impact of the heterogeneity of the surface fluxes on the development of convection during summer, while other subjects are the representation of katabatic/anabatic winds and the land/sea-breeze. The study attempts to analyze some of these different features in terms of: (1) how they are represented in the simulations, (2) fit-for-purpose of the resolution (3) and suitability of the complexity of the physical parameterizations.

This study aims to explore, open and discuss the new opportunities that (should) arise from this kind climate exercises. Which land-atmosphere dynamics or other interactions can be expected to be properly resolved and which aspects are still required to be improved from the modeling community in order to properly represent and analyze the unresolved ones.

Keywords: Convection Permitting, Land-atmosphere interaction

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-06

Soil moisture-temperature coupling in a CORDEX FPS convection-permitting WRF RCM ensemble

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High-resolution, convection-permitting regional climate models (CPRCMs), with a more detailed representation of land surface properties and an explicit treatment of deep convection, have shown improvements in the simulation of meteorological and climate system processes. Using an ensemble of CPRCM evaluation simulations for a central European domain, this study investigates results from the application of drought- and heatwave-related indices in the context of soil-moisture temperature coupling as part of the terrestrial segment of the land-atmosphere coupling. Analyses focus on differences (i) between the nested convection-permitting resolution 3km runs and their reference 15km driving runs, and (ii) among 11 members of a multi-physics evaluation experiment. A higher resolution leads not only to different precipitation timings, distributions and amounts; the larger heterogeneity at the surface and subsurface, as well as the larger orographic variance, lead, e.g., to altered terrestrial water cycle processes, which in turn affect the coupling. The CPRCM base data used in this study are from an ERA-Interim driven evaluation experiment from 2000 to 2009 that is part of the WCRP CORDEX Flagship Pilot Study (FPS) "Convective phenomena at high resolution over Europe and the Mediterranean". Here we use 11 WRF ensemble members from 11 international FPS participant groups, as a subset of the overall FPS ensemble. The WRF models are run in a one way double-nesting setup, with a joint 15km European and a FPS 3km Alpine domain. To allow for a clear separation of cause and effect relationships, these runs were done in a highly constrained setup, using the same spin-up, initial and boundary condition files and a common model configuration with systematically altered microphysics, boundary layer, surface layer, aerosol, and shallow cumulus convection schemes as well as different land surface models.

Keywords: CORDEX FPS, L-A coupling, convection-permitting, WRF RCM

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-07

Simulated climate extremes in the Yangtze River Basin, using the regional climate model WRF

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Abstract : A 9-yr(2005-2013) Weather Research and forecast(WRF) Model regional climate simulation was evaluated over Yangtz River Basin (YRB). The analysis assesses the spatial and temporal characteristics of climate extremes, using a selection of climate indices. Two nested domains at 9- and 1.5-km resolution are examined over the research area, using convection parameterization scheme or convection permitting scheme, separately . The simulation results are compared with the observed temperature and rainfall to verify mode suitability. The results show that: 1) At both coarse and fine resolutions, WRF can simulate the temporal and spatial distribution of precipitation and temperature, including extreme climate events; 2) convection permitting significantly improves the simulation results for precipitation; 3) the model has a good reproduction of the average temperature, but the simulation of high temperature and low temperature is not ideal, and high resolution did not show improvement in results. Based on these consequences, the authors believe that the WRF model has reliable climate simulation results in Yangtz River Basin, including the spatial and temporal distribution of climate extremes, and the convection permit model in this region is better than the convective parameterization scheme for precipitation simulation. This study provides a high-resolution climate description for impact studies and will also provide a reference for climate simulation driven by general circulation models.

Keywords: Convection-permitting model, Regional Climate Model, Extreme climate, Yangtz River Basin

Parallel Session A: Advances in regional downscaling A2: Convection permitting modelling

A2-P-08

Testing of non-hydrostatic core of RegCM and microphysics over the Carpathians

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This study is about testing of non-hydrostatic core of RegCM and microphysics over the Carpathian Mountains. Carpathians are a mountain range across the Eastern and Central Europe forming an arc of ~1,500 km long, with eastward continuation of Alps. The region of study comprises of the Carpathians with the Hungary-Slovakia domain at 4 km resolution for the years 2006-2015. The two setups with non-hydrostatic dynamical cores and microphysics under moisture scheme were made. Setup 1 used Kain-Fritsch for cumulus convective scheme while it is kept off for the setup 2. Average daily temperature and daily precipitation over the study region (Hungary-Slovakia) for 10 km observations and 20 km coarse domain were observed. Both setups and 20 km coarse resolution shows higher values of daily temperature over the Hungary as compared to observations whereas it shows lower values of precipitation as compared to observations. Similarly, both setups show higher values for daily temperature over Slovakia whereas lower values of precipitation as compared to observations. The results and comparisons show that the model performs better with the Slovakia domain. A larger domain for the high-resolution simulation may improve the results over the Carpathians. The long-time span experiments may show better results.

Keywords: microphysics, non-hydrostatic, temperature, precipitation, Carpathians

Parallel Session A: Advances in regional downscaling A2: Convection permitting modelling

A2-P-09

Sensitivity of temperature and precipitation to physical parameterization schemes of RegCM4 over Mindanao, Philippines

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The island of Mindanao, Philippines is key agricultural region of the country known to be vulnerable to extreme climate events whose extent and dynamics are still poorly understood. As part of the Southeast Asia Regional Climate Downscaling/Coordinated Regional Climate Downscaling Experiment-Southeast Asia (SEACLID/CORDEX-Southeast Asia) project, this study first examines the sensitivity of simulated temperature and rainfall of Mindanao using 18 different cumulus parameterization schemes of the ICTP Regional Climate Model (RegCM) version 4.3 at 25km resolution for the period 1990-2007. The best-performing cumulus scheme is then used for simulations using RegCM 4.3.7 over the same domain at a finer 5km resolution and compared with output from the newly-introduced nonhydrostatic configuration. The observation datasets APHRODITEv1808 and CHIRPSv2 was used as basis for temperature and precipitation, respectively. For all configurations at 25km, consistent cold bias (1-4°C) and large rainfall RMSE values (>5mm/day) are observed over mountainous areas while warm bias (1-2°C) exists over southern coasts of the island. The parametrization that recorded the least bias and best metrics is Grell over land and Emanuel over ocean with Zeng ocean roughness parameter $\text{iocnrough}=2$. On the other hand, configurations using Grell over both land and ocean and the Kuo scheme ranked lowest among all metrics.

Keywords: Philippine climate, cumulus parametrization, nonhydrostatic model, CORDEX SEA

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-10

Analysis of hazardous events environment in present and future scenario by multi-models approach in convection permitting mode

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Withdrawal

Severe precipitation events in Europe, together with other weather and climate related hazards, have large impact on people's life, economy and ecosystem. This is particularly true in the Mediterranean area because of its complex morphology, where it is expected that a warmer climate will increase thermal instability and frequency of severe precipitation events.

One method for assessing trends about occurrence and intensity of wet hazards is to study environment conditions favorable to their development by using correlated quantities such for example CAPE, available from model simulations.

Even if the dynamical downscaling community made enormous advances to overcome the limitation of too coarse resolution in representing subscale mechanisms, the convection parameterizations, even at high resolution, still have the issue of underestimating instability processes outside of cloud columns. In this context the new generation of climate simulations at the convection permitting scale represent one suitable mean for the application of proxy methods, for their ability in representing explicitly mesoscale initiation of convective processes.

We will present the results of a convection-permitting multi models ensemble belonging to the CORDEX-FPS convection, analyzing some proxy variables correlated to potential initiation of convection to assess the ensemble ability to represent the present climatology of severe wet hazards over central Europe and Mediterranean.

The study of present trends provides a baseline for the interpretation of results carried out in the perspective of a future climate scenario (RCP8.5), providing a picture of the change of severe events over the Mediterranean regions.

Keywords: convection permitting modeling, climate change, precipitation hazards

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-11

Simulated precipitation in convection permitting scales using REMO-NH

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Moving towards convection permitting simulations up to few kilometers scale are emerging solutions to the challenge and complexities in simulating different convective phenomena especially over mountainous regions. This study is motivated to identify the regions where convection permitting model at 3 km have a higher skill in simulating precipitation compared to its coarser driving model of about 12 km. Under the framework of the Horizon2020 European Climate Prediction (EUCP) Project, convection permitting simulations using the non-hydrostatic regional model REMO-NH have been performed for several European regions in the ERA-Interim period 2000-2009. The REMO-NH model has a horizontal resolution of 0.0275 degree and 49 vertical levels and was driven by the REMO model from the EURO-CORDEX Ensemble. During the conference, we will show results of three domains covering the northern, central, and Alpine regions of Europe. We made a first evaluation of the precipitation for the Central European domain that covers Germany and the Alps. The fine resolution of REMO-NH shows much more details in the precipitation field in comparison to the corresponding EURO-CORDEX REMO run at 0.11 degree resolution. This result was especially true in the Alps and the German mid-range mountains where higher precipitation arises. A comparison with the REGNIE dataset of the German Weather Service revealed that the EURO-CORDEX simulation has some biases in the mountainous regions and underestimates the precipitation in the Black Forest throughout the whole year. The convection permitting REMO-NH simulation reduced these biases to some degree. However, a wet bias appears in eastern part of Germany during the DJF and MAM seasons. The Brier Skill Score has been used to evaluate the time series of daily precipitation totals of simulations compared to the observational datasets. It was found that REMO-NH has added value in many regions during the DJF and JJA season and in the upper Rhine Valley throughout the whole year. The absence of added value in most regions during the MAM and SON seasons can likely be explained by the wet bias and the higher noise in simulations without convective parameterization.

Keywords: precipitation, convection permitting model, REMO

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-12

Evaluation of WRF regional climate model at a convection-permitting resolution over eastern China

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Convection-permitting (CP) simulation using the Weather Research and Forecasting (WRF) model at 4-km resolution are analyzed to understand the diurnal characteristics of rainfall over eastern China. The model produces accurate representations of the observed mean rainfall and the upper-troposphere circulations. The low-tropospheric wind and the surface cyclone convergence contribute more to the seasonal precipitation. Compared to the CN05.1, the wet day intensity of summer precipitation in CMORPH dataset is much stronger, however, the model results are more in line with the later. The CP simulation produces a single diurnal peak of annual precipitation amount over land at around 1700LST, which is 1 h ahead than CMORPH and tends to overestimate the peak value. As for the summer diurnal variation features, CMORPH shows the higher frequency over the intense precipitation areas. The model can simulate the land-sea diurnal phase contrast well but overestimates the diurnal variations of precipitation amount, precipitation frequency and precipitation intensity. In generally, the modelled diurnal precipitation shows good agreement with CMORPH, albeit with a little timing and some intensity differences. The maximum of precipitation amount and precipitation frequency in model evidently occur earlier 1-2h than CMORPH but the modeled diurnal phase of precipitation intensity is less coherent. Though the CP simulation cannot catch the secondary morning peak of PI and midnight peak of PF, the eastward propagating convection is well captured.

Keywords: Convection-Permitting resolution, diurnal variation

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-13

Gray-zone simulations of rainfall over the UAE and Arabian Peninsula

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A cloud permitting simulations are tested using Weather Research and Forecasting (WRF) model over United Arab Emirates (UAE) and Arabian Peninsula at the so-called gray-zone resolution, about at 9-km for multiple years. Such resolution is both too coarse to accurately simulate convective updrafts, and too fine to rely on the underlying averaging approximation that are inherent to most cumulus parameterization for deep convection. Yet, many studies have demonstrated that cloud permitting model at the gray-zone resolution can capture many regional precipitation patterns, including the Madden Julian Oscillation and the Indian Summer Monsoon.

In this study, a regional configuration of the WRF model is shown to capture the spatial distribution of precipitation over the Arabian Peninsula as well as the timing of occurrences of precipitation with respect to TRMM3B42 and GPM observations. Circulation features are also realistic in WRF. Wintertime precipitation events are credibly captured by the WRF, but systematic dry biases occur during summer precipitation. Wintertime precipitation events are for the most part initiated by extratropical intrusions. Mid tropospheric potential vorticity anomalies induce southerly wind over the Arabian Peninsula, which trigger a moisture transport from the Arabian and Red Seas. This inflow of moisture feeds precipitation over the frontal region. In contrast, Summer time precipitation over the UAE is strongly tied to the local land-sea contrast and its interaction with regional topography. While the 9-km configuration is unable to reproduce the Summer time rainfall, it does capture the variability in precipitable water and other cloud properties. This suggests that the coarse resolution is insufficient to capture the convective initiation of summertime precipitation events. A 10-years long simulations with the WRF model is used to investigate the variability of the precipitation over the Arabian peninsula and also its sensitivity to the change in large scale atmospheric patterns.

Keywords: Grey zone resolution, winter precipitation, moisture transport

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-14

Sensitivity of monsoon precipitation to physical parameterizations in a cloud permitting regional model

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Simulations with a high-resolution cloud permitting atmospheric model have been shown to accurately capture many features of the Indian Summer Monsoon (ISM) including the timing of the onset and the intra-seasonal variability. Such simulations are however highly sensitive to the physical configurations of the models. In particular, we investigate here how changes in the parameterization used for cloud microphysics (MP) and planetary boundary layer (PBL) can severely affect the precipitation patterns over India.

In this study, the ISM is simulated with the Weather Research and Forecast (WRF) model at a horizontal resolution of 9km over the south-east Asian monsoon region (39 E – 111 E & EQ – 38 N) for three different years, i.e. 2007, 2008 and 2015, which are representative of an early, normal and delayed monsoon onset respectively. Two different PBL (ACM2 and MYNN) and MP (Thompson and WDM6) schemes are tested over the 3 years. It is shown that the choice for the PBL scheme has a dramatic impact on the ISM. Indeed, while simulations performed with ACM2 captures most of the circulations and precipitations patterns over India, simulations using MYNN, lead to a very substantial reduction in rainfall and an overall weakening of the atmospheric circulation. In contrast, the impacts of the microphysical schemes are much less pronounced. Simulations with the Thompson scheme being better able to capture the rainfall over the Western Ghat regions and Arabian Sea, while the WDM6 schemes produced excess rainfall over Northern India and the Himalayan Foothills.

To assess how changes in physical parameterization affects the over rainfall over South Asia, we analyze both the energy and water budgets of the subcontinent. It is shown here that the changes in precipitation are not directly driven by local changes in evaporation. Rather, changes the regional distribution of the energy sources and sinks modify the atmospheric circulation, which in turns affects the distribution of rainfall. It is argued here that systematic study of the energy and water budget can provide important guidelines for understanding the sensitivity of precipitation patterns in regional climate models.

Keywords: cloud permitting model, evaporation, energy and water budget

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-15

Model validation methodology of short-duration precipitation extremes

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The estimation of the impact of climate change on short-duration rainfall extremes is especially relevant in an urban context. Indeed, due to surface impermeability, cities are highly susceptible to intense precipitation events and can cause flash floods with high socio-economic impact.

However, to estimate the climate-change impact, one requires the availability of long time series of sub-hourly data from convective-permitting model runs. Moreover for model validations corresponding observations are required. All such data is scarce such that the estimation of extreme rainfall is associated with large uncertainties. Within the URCLIM project that aims to provide climate services, different uncertainties related to extreme precipitation and their projections are quantified. To achieve this goal, different qualitative features of extreme precipitation are addressed. These are tested on both observational datasets across Western and North Europe, and on climate model ensembles (CORDEX/CORDEX.be).

More specifically we focus on Intensity-Duration-Frequency (IDF) curves with multi-scaling characteristics and the Clausius-Clapeyron (CC) scaling between extreme rainfall and temperature. The uncertainties associated with the statistical modeling are quantified. The statistical modelling and uncertainty estimation of (i) the IDF-characteristics is done in a Bayesian framework (Van de Vyver, 2015, 2018), and (ii) the scaling properties is done with quantile regression and associated information criteria. The latter allows to study the deviations from the CC scaling that have recently been found for hourly extreme precipitation.

Keywords: extreme rainfall, precipitation, model validation, IDF, Clausius-Clapeyron

Parallel Session A: Advances in regional downscaling

A2: Convection permitting modelling

A2-P-16

Synergistic effect of high resolution and orographic drag parameterization to reduce WRF simulated precipitation bias in central Himalaya

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Current climate models usually have significant wet biases in the Tibetan Plateau and have particular difficulties in representing the role of the Central Himalaya (CH), where the topography is very steep and terrain is very complex. In order to quantify precipitation bias and improve climate modeling in this region, a network consisting of 14 rain gauges was set up at elevations > 2800 m a.s.l. along a CH valley. Numerical experiments with Weather Research and Forecasting model (WRF) were designed to investigate the effect of mesoscale and microscale terrain on water vapor transport and precipitation. The control case uses a high resolution (0.03o) to explicitly resolve the mesoscale terrain and switches on a Turbulent Orographic Form Drag (TOFD) scheme to represent sub-grid microscale terrain effect. As a result, this case has the lowest bias in the simulated precipitation. The roles of the resolution and the TOFD scheme were then analyzed through comparison with sensitivity cases that either use a lower resolution (0.09o) or switch off the TOFD scheme. It is found that the simulations with the high resolution can not only increase the spatial consistency (correlation coefficient: 0.84-0.92) between the observed and simulated precipitation, but also considerably reduce the wet bias by more than 200%. Therefore, resolving mesoscale terrain plays a leading role in precipitation modeling for this terrain-complex region. The TOFD scheme also reduces the precipitation bias at almost all stations in the CH; it functions to reduce precipitation intensity and reduces more heavy precipitation (>10 mm hr⁻¹). Both high resolution and TOFD enhance the orographic drag to slow down wind; as a result, less water vapor is transported from lowland to the high altitudes of CH, causing more precipitation at lowland south to the CH and less at high altitudes of CH. Therefore, for this highly terrain-complex region, it is crucial to use a high resolution to depict mesoscale complex terrain and a TOFD scheme to parameterize the drag effect due to microscale complex terrain.

Keywords: WRF, precipitation in central Himalaya, orographic drag parameterization, high resolution

**Parallel Session A:
Advances in regional downscaling**

**A3: Downscaling tools and
methods**

ORAL PRESENTATIONS

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

Statistical downscaling with deep learning: A contribution to CORDEX-CORE

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Machine learning is nowadays a very active research area in many disciplines and major breakthroughs have been recently obtained with deep convolutional neural networks in many complex problems. This is due to the ability of deep learning to efficiently treat high-dimensional spatiotemporal inputs extracting high-level feature representations with convolutional layers. Moreover, the technological advances boosted by data science applications provide efficient computational frameworks (e.g. TensorFlow) to transparently train these models on modern computing infrastructures using big datasets. As a result, deep learning provides an efficient alternative for statistical downscaling over wide domains, and some preliminary successful applications have been already reported. However, the robustness and extrapolation capability of these models has yet to be tested for plausible applications in climate change problems.

In this work we analyze the potential of deep learning, and particularly convolutional neural networks, as suitable statistical downscaling techniques for climate change applications. In particular, we analyze cross-validation (using ERA-Interim predictors) and extrapolation (using GCM outputs) capabilities of different configurations of increasing complexity (starting from simple convolutional models) obtaining the best configurations to downscale precipitation and temperature. This validation study is first performed over the EURO-CORDEX domain, and it is then extended to other CORDEX domains to test transferability of the results. Finally, we describe the contribution to CORDEX-CORE and the resulting public dataset which is available to the downscaling community for intercomparison studies.

Keywords: deep learning, machine learning, statistical downscaling, climate change, CORDEX-CORE

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

Reproducible Statistical Downscaling with the climate4R R-Based Framework: The downscaleR package

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climate4R (<https://github.com/SantanderMetGroup/climate4R>) is an R-based open framework for climate data access, harmonization and post-processing. The framework allows for comprehensive end-to-end sectoral reproducible applications through the interoperability of different specific R packages. One of the core packages is loaderR, the climate4R catalog- and subset-oriented data access tool from either local or remote (OpenDAP) data sources, which is transparently linked to the Santander Climate Data Service (UDG), providing a wide catalogue of popular datasets (incl. CMIP and CORDEX) to climate4R users. As part of the climate4R ecosystem, the package downscaleR provides tools for bias adjustment and statistical downscaling, covering the most popular techniques (e.g. analogs, LMs and GLMs, and neural networks), and allowing for multiple experiment configurations and cross-validation options. climate4R was used to contribute to the VALUE intercomparison experiment, and will be used in ongoing experiments in the framework of EURO-CORDEX.

In order to illustrate the functionalities of downscaleR and climate4R, we present a fully reproducible worked example from the VALUE contribution, obtaining local climate change projections for a set of 86 stations over Europe. We first replicate the VALUE 1A Experiment (with reanalysis predictors) using an extended set of methods. Then, we describe ongoing work with GCM predictors to compute the climate change signal for the late XXI century and analyze the spread resulting from the ensemble of statistical downscaling methods used.

Climate data processing typically involves complex error-prone operations. In this sense, climate4R provides a unique framework where common tasks such as statistical downscaling can be straightforwardly performed in a few lines of code. The development of climate4R is a community effort boosted by the contribution to several international initiatives, such as the IPCC WGI activities of the Atlas Chapter.

Keywords: R package, statistical downscaling, reproducibility, VALUE experiment, climate services

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

Challenges of statistical-dynamical downscaling of euro-cordex regional climate models for impact studies at the city scale

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Today, the spatial resolution of Regional Climate Models (RCM) is getting more and more precise. It is nonetheless insufficient for impact studies at city scale and urban climate services adapted to the needs of urban planning stakeholders. In addition, urban issues of urban heat island mitigation, improvement of thermal comfort, energy efficiency, or water management, require specific urban climate models to be run. Multiple approaches to spatially downscale the RCM simulations have been developed over the years, each with different pros and cons.

We developed a statistical-dynamical downscaling method specific to urban studies to spatially refine the atmospheric fields coming from RCM projections, while adding the city's signature in the low levels of atmosphere. The approach is based on a correction method of RCM's atmospheric fields by local weather types (WT, Hidalgo et al., 2014) for each of which the urban heat island is expected to have specific structure and intensity. Some representative days of each WT were simulated previously at 250-m resolution with the atmospheric model Meso-NH and an urban climate model to characterize the effect of city on atmospheric fields of temperature, humidity and wind (Schoetter et al., in rev).

Using Paris area as a case study, the method is currently implemented and tested for 9 couples of GCM/RCM projections from EURO-CORDEX but first the methodology is tested over an evaluation period against both a dynamically downscaled simulation and a set of urban observations.

Different methodological aspects are looked into such as: (1) The urban model sensitivity to different forcing time steps; (2) The method needed to reconstruct atmospheric conditions above the urban canopy level from the surface; (3) The connection between the WT in the RCM and the WT in the urban simulation in present climate; and (4) The evolution of WT in future climate in term of intensity and frequency.

Keywords: statistical-dynamical downscaling, weather type, urban climate, impact studies

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A comparison of statistical downscaling techniques for daily precipitation: Results from the CORDEX Flagship Pilot Study in South America

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Southeast South America (SESA) is one of the regions of the planet where extreme precipitation events occur and have high impact on human activities. These extreme events result from the complex interactions of a broad range of scales, therefore their study, modelling and projections in a changing climate continue to be a challenging task. The CORDEX Flagship Pilot Study in South America (FPS-SESA) addresses this topic in order to advance in the understanding and modelling of extreme precipitation events based on coordinated experiments using different downscaling approaches. In this work we present the results from the collaborative action to intercompare different statistical downscaling techniques in simulating daily precipitation in SESA with special focus on extremes. To this end, seven statistical downscaling models based on the regression and analog families were evaluated over SESA. The sensitivity to the different predictor and predictand datasets were tested using two reanalyses (ECMWF ERA-Interim and Japanese 55-year Reanalysis JRA-55) and two daily precipitation (station data and MSWEP) datasets. The models were calibrated and cross-validated during the 1979-2009 period and also evaluated in the independent warm season of 2009-2010. This season, with record of extreme precipitation events, is the target season chosen in the FPS-SESA to perform the dynamical downscaling simulations as well, and therefore it allows for comparisons between both approaches. The results show that the methods are more skillful when combined predictors including circulation variables at middle levels and local humidity at low levels of the atmosphere are considered. The performance of the models is also sensitive to reanalysis choice. The methods show overall good performance in simulating daily precipitation characteristics over the region, but no single model performs best over all validation metrics and aspects evaluated.

Keywords: Flagship Pilot Study, Precipitation extremes, Statistical Downscaling

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A hybrid statistical downscaling approach based on nonstationary time series decomposition

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Downscaling techniques are effective to bridge the scale gap between global circulation models (GCMs) and hydrological models. Statistical downscaling methods are prevalent due to their advantages of high computational efficiency and accuracy. However, statistical downscaling methods are based on an assumption that the statistical relationships between outputs of large-scale climatic model and climatic observation of regional areas will remain constant in the future. Such statistical relationships may become less reliable under changing climatic conditions where the relationships between large-scale and fine-scale weather patterns would be non-stationary. Addressing the non-stationarity of downscaling climatic data is crucial to regional climate studies. How to effectively characterize dynamic statistical relationships facing non-stationary weather information is challenging. In this study, a hybrid statistical downscaling method was developed through integration of bivariate empirical mode decomposition (BEMD) which is an adaptive non-stationary time series decomposition technique and machine learning into a general framework to address the non-stationarity. The proposed method can reduce the effects of non-stationarity on statistical downscaling by decomposing climatic data into different independent components at multiple time-frequency resolutions. It was applied to downscale CanESM2 monthly precipitate and temperature for two weather stations in California, USA from 1950 to 2005 to verify its accuracy. Although not all components were stationary after disaggregating, the main stationary weather pattern was captured and the interactions of different non-stationary components were separated. The performance of downscaling temperature was satisfying ($R^2 > 0.9$), but the performance of downscaling precipitate was not very satisfying. This is partly the result that precipitation is more sensitive to instantaneous weather patterns. Further improvements are needed for BEMD to realize perfect disaggregating. The proposed method can provide a viable option to deal with the non-stationary in statistical downscaling.

Keywords: downscaling, GCMs, bivariate empirical mode decomposition, machine learning, nonstationary

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

Combining global and regional models to “fill the matrix”

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The COPERNICUS project PRINCIPLES is a major undertaking to supplement the already large collection of EUR-11 high-resolution CORDEX simulations over Europe. Before the start of the project in 2017 a total of 60 simulations existed with data publicly available in the ESGF, distributed over the emission scenarios RCP2.6, RCP4.5 and RCP8.5.

The 9 partners of PRINCIPLES (SMHI, GERICS, KNMI, DMI, IPSL, MF, ETHZ, UKMO and ICTP) have 9 different regional climate models available (RCA4, REMO2015, RACMO22E, HIRHAM5, WRF381P, ALADIN63, CcrCLM, HadRM3-GA7.05 and RegCM4.6.1). The project funding makes possible a rough doubling of the pre-existing multi-model ensemble with the addition of 66 simulations.

In this poster, the thoughts behind assigning slots in the GCM-RCM-Scenario matrix for this considerable amount of additional simulations will be described, and the resulting schedule of simulations will be presented. In quite general terms, the choice stands between aiming for a homogeneous distribution of simulations in the matrix and aiming for completion of 2d sub-slices in the 3d matrix. The resulting choice leans towards the latter of the two options. Mainly because this strategy facilitates analyses of GCM, RCM, and scenario influence on the resulting climate change, but also because the evolution of both global and regional models and hence the constant addition of new models will eventually make any initially homogeneous matrix less homogeneous.

Keywords: Euro-cordex, copernicus, GCM/RCM matrix

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

RCMES-based Statistical Downscaling of CORDEX South Asia RCM output over India

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The statistical downscaling toolkit provided as a part of the Jet Propulsion Laboratory (JPL)'s Regional Climate Model Evaluation System (RCMES) is utilized to develop a web-based interactive application for statistically downscaling the WCRP Coordinated Regional Climate Downscaling Experiment (CORDEX) South Asia regional climate model (RCM) output to the fine-scale required for local climate impact assessments. This web-application is useful to downscale daily maximum and minimum temperature and precipitation over selected locations in India. This web-application will address the users need for correcting the errors in the RCM output that deviates from observations, using four statistical downscaling methods viz., the delta addition, delta correction, quantile mapping, and asynchronous linear regression. This user-friendly application will also enhance the visibility and utilization of CORDEX South Asia RCM outputs in the climate impacts community.

Keywords: Region Climate Models, Statistical Downscaling, Climate change

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

FESOM2.0 in climate simulations: from global to regional scales

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In this work, we present a set of climate simulations using a hierarchy of AWI climate models: the global AWI-CM2 (FESOM2/ECHAM6) and the regionally coupled AWI-RCM1 (FESOM2/REMO). The main advantage and novelty of these models is its common next generation ocean component FESOM2, which use unstructured meshes. FESOM2 allows to simulate the global ocean circulation on eddy-resolving spatial scales for the climate simulations with throughput of 5-10 model years per day.

We begin with the description of results from the global model AWI-CM2 where an eddy resolving FESOM2 mesh is coupled to the global atmospheric model ECHAM6 with ca. 100 km. resolution. The FESOM2 mesh is globally adjusted to the quarter of the baroclinic Rossby radius with 2 km fine and 20 km coarsest resolution. This simulations are then downscaled with the regionally coupled climate model AWI-RCM2. In this case FESOM2 setup remains unchanged, but the resolution of the atmospheric component regionally increases from 100 to 12 km due to the use of REMO. This approach allows to avoid problem with boundary conditions for the ocean model as well as long ocean model spin-up.

We investigate the impact of using an eddy-resolving ocean model and increased atmospheric resolution on the representation of the North Atlantic and European climate. In particular, our strategy allows us to explore the impact that the explicit simulation of the mesoscale activity of both the ocean and the atmosphere has on the representation of many aspects of the regional climate, especially the ocean circulation and sea-ice variability.

Our results are discussed with a special emphasis on the perspectives regarding the use unstructured ocean models in high-resolution climate simulations.

Keywords: climate modelling , downscaling, FESOM2

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

Future changes in water balance components across irrigated lands of Central Asia as projected by a high-resolution modeling system

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The economy of arid regions in Central Asia is based largely on irrigated agriculture, which critically depends on the amount of regional water deficit. The insufficiency of water resources requires an accurate estimation of water balance components from irrigated lands in order to develop the optimal strategy of water consumption across Central Asia. This is particularly important for irrigated areas with typical spatial scales several kilometers, not captured by the majority of up-to-date RCMs and thus requiring an explicit description of subgrid processes. Here, a series of climate simulations using MGO RCM (25 km resolution) and a 150-level atmospheric boundary layer model (ABLM) is carried out to downscale the temperature and water balance components (notably evapotranspiration) over the irrigated lands. Besides, a sensitivity study has been conducted in order to assess the impact of the changes in the Aral sea mirror during the second half of the 20th century – early 21st century on regional heat and moisture balance using the RCM-ABLM system.

A 30-member ensemble of regional climate change projections by 2050-2059 relative to 1990-1999 has been carried out using RCM-ABLM chain under IPCC RCP8.5 scenario. The analysis shows that the deficit of moisture over the irrigated areas is projected to increase by the mid-21st century during the growing season. This implies that the conditions for cultivating traditional agricultural crops in the region will deteriorate if the irrigation water supply remains unchanged in the future.

The study is supported by the Russian Science Foundation (grant №16-17-00063) and the Korean Meteorological Administration under contract “Analysis of extreme climate change using RCP scenarios (V)”.

Keywords: ensemble climate projection, downscaling water balance

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

Recent progress of Japan's regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

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As a Japan's national project, SI-CAT develops reliable technologies to find climate change adaptation measures in collaboration with researchers of geoscience, social science and humanities, and officials of local governments from the beginning of the project to avoid and reduce various threats of climate change.

We conducted dynamical downscaling experiments with horizontal grid spacing of 5km and 2km to reproduce regional climate information. We examine the performance of the regional climate model (NHRCM) to represent severe precipitation events occurred around Gifu and Nagano region. To examine the performance in ungauged mountainous regions, the runoff analysis was conducted. It indicates the overestimation of precipitation. We conduct the ensemble downscaling experiments using database for Policy Decision making for Future climate change (d4PDF) to detect the climate change impact in this region.

Multi-model large ensemble regional climate scenarios over Japan and CORDEX Asia are developed by using CMIP5 GCMs (RCP2.6 and RCP8.5) and a statistical downscaling (Bias Corrected Spatial Disaggregation (BCSD)) to investigate uncertainty of projected change associated with structural differences of the GCMs for the periods of historical climate (1950-2005) and near future climate (2026-2050). Uncertainty range information of the regional climate scenarios support various regional adaptation measures and informed decision making. Based on the SI-CAT experiences, the CORDEX Asia ESD group enhances and integrates the science and application of downscaling activities in Asia by sharing and exchanging data, knowledge, and techniques.

Keywords: Dynamical downscaling, Statistical downscaling, Multi-model ensemble, CORDEX, Asia

**Parallel Session A:
Advances in regional downscaling**

**A3: Downscaling tools and
methods**

POSTER PRESENTATIONS

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Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-01

Trends and variability of surface temperature over the Olifants River catchment

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This study examines trends in temperature using historical observation and model daily minimum and maximum temperature data over the Olifants River catchment for the period 1951–2005. An ensemble of regional climate model (RCA4) simulations, forced with CMIP5 models under the “Business as usual” climate scenario RCP 8.5 was performed for the catchment for future period of 2006-2060. All the simulations were obtained from the CORDEX Africa. Trends and the statistical significance of the annual and seasonal series were calculated using the modified Mann-Kendall test in the R package. The results indicate that the catchment has experienced increase in the frequency of warm temperature, although no significant change in the shapes of the historical and future distributions are discernible. The results further indicate that warm temperature extremes are expected to increase significantly, continuing from already significant historical trends in the mean temperature as well as extremes. Seasonally, the frequency of warming in minimum temperature is stronger in the Summer season of December, January, February (DJF) and Spring season of September, October, November (SON) compare with Winter season of June, July, August (JJA) and Autumn season of March, April, May (MAM). The results of this study provide an understanding of the characteristics of changing temperature, in the context of the present anthropogenic global warming and are relevant for decision-making process, especially for sustainability of the River catchment and its resources.

Keywords: Trends, Projections, Temperature, Rainfall

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-02

Changes in moisture dynamics as potential drivers of precipitation change in the Central African region under global warming of 1.5°C and 2°C

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Anthropogenic climate change is anticipated to influence the frequency and intensity of climate extremes in vulnerable regions. This study examines the effects of global warming levels (GWLs) of 1.5°C and 2°C on future changes of moisture fluxes to constrain modeled change in Central Africa (CA) rainfall, using an ensemble of transient projections from the regional climate model RCA4 in the framework of the coordinated regional climate downscaling experiment over Africa (CORDEX-Africa). RCA4 is nested within eight General Circulation Models (GCMs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) under the Representative Concentration Pathways (RCPs) 4.5 and 8.5. Results indicate that regional scale responses to anthropogenic forcings vary across GWLs and seasons. Seasonal changes of precipitation and moisture divergence are correlated; more pronounced in March-May, relative to September-November; and larger for 2°C GWL relative to 1.5°C GWL. Whilst most forcings seems to show a projected decrease precipitation over major areas in MAM, there is rather a tendency to localised decreases or increases in SON. There is a substantial increase of zonal moisture divergence fluxes in upper atmospheric layers (>700) under RCP8.5 compared to RCP4.5 leading to large changes in the moisture transport. Moreover, it's found that additional warming of 0.5°C will change Central Africa hydrological cycle with modification of water availability, which means serious problems to water resource management in agriculture, hydro-power generation, breeding, sanitary and other ecosystems.

Keywords: Central Africa, RCA4, CMIP5, global warming levels, moisture flux convergence

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-03

Dynamical and statistical downscaling: intercomparison in three extreme temperature events in southern South America

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Global Climate Models are the main tools used to generate weather and climate predictions at different time scales. However, it is well recognized that these models are unable to provide information at the spatial scale required by many stakeholders. Hence, dynamical and statistical downscaling (RCM and ESD) approaches are necessary for adapting the global model predictions to smaller spatial scales, providing suitable products for a range of applications. Despite of the large number of works that applied these techniques, in South America the comparison of strengths and weaknesses of ESD and RCM has not comprehensively been performed yet, especially in the simulation of extreme events.

In this context, the aim of this work is to compare ESD and RCM in representing extreme temperature events in central-eastern Argentina. To this end, three hot summers in which record heat wave events occurred were selected: 2002-2003, 2013-2014 and 2015-2016.

For the comparison of the two downscaling methodologies, the WRF RCM was used with two different configurations, in which the soil physics were altered. Jointly three ESD models based on linear regression and analogues were considered. All models were driven by ERA Interim. Also, to train the ESD models and to evaluate the downscaling approaches, daily station data from Argentina was used. Two different bioclimatic indices based on the wet bulb temperature were also simulated and compared.

The results show that both approaches are able to reproduce the persistence and spatial distributions of the extreme events as well as the seasonal characteristics of each hot summer. The spread in the simulation of the intensities of the heat waves varies depending on the particular event, the region and the simulation considered. They also showed a good performance in simulating the bioclimatic indices highlighting the importance of the generation of detailed climate information for impact assessment.

Keywords: Dynamical and Statistical Downscaling, Heat waves, Center-eastern of Argentina

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-04

Inter-comparing grid resolution impacts in WRF and RegCM4 simulations for 2004-year over South America

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To understand the impact of fine resolution in the regional climate (RCM) simulations, the climatology of two RCMs over South America (SA) CORDEX domain is investigated. The special interest is drawn into the evaluation of simulated rainfall and near-surface wind over southeastern South America (SESA) and southeastern of Brazil (SDE), which are two of the main cyclogenetic areas of SA. Therefore, for the 2004-year, the Regional Climate Model (RegCM, version 4) and the Weather Research and Forecasting model (WRF, version 3.9) were integrated using two different horizontal grid spacings and strategies. WRF simulations are two-way nested with grid spacings of 27 and 9 km and used spectral nudging to synoptic waves (2000 km). RegCM4 used 25 and 12.5 km of grid spacings without two-way nesting and forced only in the boundaries. Both simulations were nested in the CFSR reanalysis and the WRF run used SST updates from the NOAA OISST. The simulated rainfall is compared with different TRMM rainfall and 10-m height winds are compared with ERA5 reanalysis. For annual mean, the simulated spatial pattern of rainfall is similar to the observed one, but there is an underestimation of rainfall over the tropical sector of the domain. For the SESA region, both RegCM4 and WRF simulate the annual cycle of rainfall similarly to the observation. In SDE area, WRF tends to overestimate the rainfall while the opposite occurs with RegCM4. In both regions, it is noted a small impact of the grid resolution in both the phase and intensity of the simulated rainfall. For the SDE and SESA areas, the simulated 10-m height wind is more intense than the observed one, with WRF presenting smaller overestimation of wind than RegCM4. In the annual cycle of wind, it is noted also a small impact of grid resolution. An analysis of grid resolution impact in daily rainfall and wind is also presented.

Keywords: model grid resolution, South America, WRF and RegCM4

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-05

Analysis of observations-simulations-projections and scenarios production in Guinea

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Forecasting at reduced scales (downscaling) is still insufficient because of insufficient observations and duration; early warning systems are unreliable due to lack of technical means, information and consistent data. Even some climate models are difficult to validate on the African continent (IPCC, 2007). Models do not show a consistent enough trend for tropical Africa (Cook and Vizi 2006, Biasutti et al., 2008), which makes medium and long-term planning difficult. However, tropical Africa, like Guinea, is one of the areas where populations, resources and natural ecosystems are the most vulnerable to climatic hazards (Brassard et al., 2007, Tsalefac et al., 2007; 2009, Sultan 2011).

To evaluate and validate the performance of the multi-model approach used in the study area, several climate simulation data were analyzed. The results were compared with observations and analyzes for the main elements controlling climate in tropical Africa (Kamga and Buscarlet, 2006).

It is in fact a data processing of IPCC climate projections and complete the historical analyzes for the plausible scenarios for the period 2020-2050 on our study area.

In this work we used CMIP5 & CORDEX AF simulation data that we then evaluate using data from our observation stations to be able to scenarios (projection RCP)

Keywords: Cordex, RCP

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-06

Present climate and climate trends using the regional model RegCM4 over regions of complex topography of the Andes.

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This study used three simulations of RegCM4 forced by three different global models (GFDL, HadGEM2 and MPI) of CMIP5 (Coupled Model Intercomparison Project Phase 5) to evaluate the present climate (1981-2005) and future scenario RCP8.5 (2006-2096) over regions of complex topography like the Andes. The evaluation of the performance of the model in over Andes (CA) was made through comparisons with data from meteorological stations and interpolated data (CHIRPS) in four sub-regions, obtained by cluster analysis. In the present climate, the three RegCM4 simulations overestimate the precipitation in regions located at heights between 3000 and 4200 m. In general, in the Andes mountains, the amplitudes of annual precipitation cycles are higher in RegCM4 than in observations. It indicates that RegCM4 simulates high availability of water vapor in the atmosphere, resulting in higher precipitation rates, especially when the wet period occurs (December, January and February). In terms of circulation, in the present climate the 850 hPa winds through the Low Level Jet (JBN) indicate a strong mass convergence on the Andes favoring intense upward movements that would be contributing to the increase of precipitation in the models and a displacement towards the west compared to the reanalysis (ERA-Interim). These factors contribute to explain the overestimation of rainfall in the region in the simulations. The simulations represent the interannual variability of temperature and precipitation, but in general, an intensification of this signal is observed in comparison with the observations. Future latitudinal projections were analyzed over a 30-year period (2030-2060) and show a predominance of warming trend at all latitudes and rainfall reduction in the future, except for the simulation of RegCM4 forced by MPI. For air temperature, the probability density functions of (PDF) show a shift to the right in the future climate (2030-2060), with consequent increase of extreme events which can affect the hydrological cycle in the CA.

Keywords: Andean Region, statistical analysis , climate trends, RegCM4

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-07

The Earth System Grid Federation Data Node in India for CORDEX South Asia and CMIP6 Data Dissemination

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The climate research collaboration for understanding and predicting climate change and extreme weather events need advanced tools to archive, manage, access, analyze, visualize, and process enormous and distributed climate change projection data sets. The Earth Grid Federation (ESGF) meets this challenge by an international collaboration for the software designed and maintained by research institutions around the globe that powers most global climate change research. The ESGF was a partnership of climate modeling centers created to provide secure, web-based, distributed access to the World Climate Research Programme (WCRP) Coupled Model Intercomparison Project Phase 5 (CMIP5) climate model data that contributed to the Intergovernmental Panel on Climate Change (IPCC) fifth assessment report (AR5).

The Centre for Climate Change Research (CCCR) established at the Indian Institute of Tropical Meteorology (IITM) under the Ministry of Earth Sciences, Government of India has joined the ESGF as a data node peered with the Swedish Meteorological and Hydrological Institute (SMHI) ESGF index node for sharing the climate model outputs generated at CCCR-IITM from the climate simulation experiments conducted for contributing to the WCRP initiative COordinated Regional climate Downscaling Experiment (CORDEX) over South Asia. This ESGF data node is also being utilized for disseminating the IITM Earth System Model (ESM) outputs generated at CCCR-IITM for contributing to the sixth phase of CMIP (CMIP6), which will serve as a basis for the forthcoming IPCC sixth assessment report (AR6). This presentation will provide an overview of the different components in the ESGF infrastructure and the software tools implemented that make the climate data easily accessible to the users for detailed analysis and application studies over the Indian region.

Keywords: CORDEX South Asia, ESGF, Data Dissemination

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-08

High-resolution temperature projections from PRECIS in different regions across China

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Average and extreme temperatures, i.e., mean temperature (T_m), maximum temperature (T_{max}), minimum temperature (T_{min}), diurnal temperature range (DTR), frost days (FD) and heat wave days (HD), are derived from Providing Regional Climates to Impact Studies (PRECIS) at a fine resolution (25km) across China. It is obvious that these temperatures exhibit well performance in PRECIS than its originated GCM (i.e., HadGEM2-ES), with a exception of HD. However, some biases (e.g. a bias exceed ± 3 oC for $T_m/T_{max}/T_{min}/DTR$ and ± 5 d for FD/HD) are still declared in some regions, western regions in especial. It is thus necessary to correct bias fro raw outputs. Mapping quantile is used to correct the bias, taking observation as reference. After that, reproduced temperatures are performed much well than raw simulation. Most regions is reported in a bias within ± 0.2 oC for $T_m/T_{max}/T_{min}/DTR$ and ± 2 d for FD/HD. Given the acceptance of the bias-corrected outputs, potential temperatures changes are explored. It is clear that northern and western regions are expected to experience higher warming trend of $T_m/T_{max}/T_{min}$. Though national DTR is detected in no obvious trend, it is interesting to note that DTR rises in central-southern regions, indicating a faster increment in T_{max} than T_{min} . Northern and western regions express a decreasing value of FD, which decrement during 2071~2100 relative to 1961~1990 under RCP8.5 is twice as much as that during 2071~2100 under RCP4.5. Central-southern regions endure an increasing HD, with an increment during 2071~2100 under RCP8.5 over 2 times than that under RCP4.5.

Keywords: temperature projections, Providing Regional Climates to Impact Studies (PRECIS)

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-09

Projection of future water cycle in East China with an ensemble of climate downscaling simulations

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The ensemble approach is an essential methodology to gain confidence for future climate projection at both global and regional levels. International initiatives, such as CMIP and CORDEX, clearly showed added value of the multi-model ensemble approach. Nevertheless, MME still remains very heavy to actually conduct. Especially for the commonly-used downscaling approach that employs a regional climate model forced by high-frequency boundary conditions (usually every 6 hours) from global climate model, it is indeed very rare to see ensemble simulations in a same regional climate model forced by different global models. In this work, an alternative methodology is proposed and consists of adding a global atmospheric model between the coupled climate system model and the regional climate model. Within this methodology, only monthly-mean global sea-surface temperature and sea-ice extension are necessary and sufficient to propagate climate signal from the global model to the regional one. This hypothesis was approved to be a very reasonable one for climate downscaling purposes, as reported in Krinner et al. (2014, J of Climate) and Hernandez-Diaz et al. (2017, Climate Dynamics) for the Antarctic and Africa respectively. A similar regional downscaling study in East China is reported here with LMDZ-regional, the regional version of the climate model LMDZ. The coarse-resolution global version of LMDZ, noted as LMDZ-global plays the role of intermediate model to pass global climate information to regional scale. Within this framework, climate scenarios from about ten CMIP5 models are used to perform climate downscaling in East China. All of them cover the historical period from 1951 to 2005 and the RCP8.5 scenario from 2006 to 2100. Water cycle is the main focus of this study. Precipitation, evaporation and runoff are carefully examined, especially for the major rivers in the region, such as the Yangtze river and the Yellow river.

Keywords: climate downscaling, water cycle

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-10

Multi-scale Simulation of East Asian Climate

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Traditional global climate models (GCMs) with coarse resolution usually have deficiency in simulating realistic regional weather because of the difficulties to resolve complex orography at regional scales. Experimental global high-resolution models show some benefits but also raise much computational burden, while variable resolution (VR) models with unstructured mesh can provide comparable results and require less computational resources. In recent years, a VR dynamical core Model for Prediction Across Scales (MPAS) has been incorporated into the Community Atmosphere Model Version 5 (CAM5) and shows promising results. Here the MPAS dynamical core and CAM5 physics package are used to evaluate the effect of regional refinement over East Asia on the climate mean state, with the resolution from 30 km to 120 km. The VR simulation is evaluated against a 20 km regional climate model simulation, observations and ERA-Interim reanalysis data for surface temperature, large-scale circulation and precipitation. The analysis is performed for the whole year and summer, over the 30-year period from 1979 to 2009.

Keywords: MPAS, Variable resolution, East Asia

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-11

Meteorological drought magnitude duration, intensity and frequency in the future climate of Eastern Tigray, Northern Ethiopia

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Precipitation deficit and its daily, seasonal and annual vacillations are intrinsic features of Ethiopian's climate. This study aimed at analyzing meteorological drought and its characteristics in future climate of eastern Tigray, northern Ethiopia, with the principal goals of enhancing an early warning and better drought disaster response mechanisms. To predict the climate of the study area, the delta scenarios were generated from CMIP5 GCMs and BCSD using the R-software to create 120 delta-adjusted data files (3 times scales [NT=near term (2010-2039) MT=midterm (2040-2069) and ET=end term (2070-2099)] * 2 RCPs [4.5 and 8.5] * 20 GCMs). The meteorological droughts events under future climate of the study area were analyzed using a 4- and 12-months SPI and SPEI. The two-parameter gamma (α , β) probability and log-logistic distributions (α , β and γ) were used to compute SPI and SPEI respectively. In the future, the duration and magnitude of short-term drought will increase in Fatsi but the mean intensity will drop slightly below the baseline. Wukro and Atsbi will probably experience a slightly lower mean intensity of drought relative to the baseline but an increase in duration and magnitude was noticed. Moderate drought frequency will increase in all time segments. Regardless of the predicted increase in mean annual rainfall, some years will still experience deficit that will tantamount in to drought events coupled with higher evapotranspiration. Moreover, the predicted increase in precipitation under the future climate will have uneven temporal characteristics/variability. We therefore recommended better soil and water conservation practices to minimize evapotranspiration.

Keywords: Global Circulation Model, Climate Change, Drought

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-12

Modeling the current atmospheric parameters trends for Sinai Peninsula using RegCM4.7

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Surface air temperature, sea level pressure, surface wind, surface heat fluxes, and total precipitation are considered as the most important components to describe the Sinai recent climate. The current research presents a three-step downscaling of these atmospheric parameters over Sinai from 1991—2016 using f-nest technique within RegCM4.07 model. The results indicate that the simulated surface air temperature, sea level pressure, and surface wind closely follow the observations. In addition, simulated surface heat fluxes and total precipitation have a significant correlation (over 0.8) with available reanalyze data. In general, the third step downscaling with 10 km grid resolution shows more relevant results incomparable to the first downscaling step with 30 km grid resolution. Generally, the data for Sinai, 1991–2016, display a significant positive trend for surface air temperature (0.45°C decade⁻¹) together with significant negative trends for total precipitation (-0.028 mm day⁻¹ decade⁻¹), and sea level pressure (-0.32 mbar decade⁻¹).

Keywords: Regional modeling, Air temperature, Total precipitation, fnest

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-13

How well do RCMs and ESDs reproduce the occurrence of extreme precipitation events over Southeastern South America? A case study approach

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Individual extreme precipitation events over Southeastern South America (SESA) during the spring and summer time are responsible of more than 40% of the total accumulated seasonal precipitation. These extreme events are associated with the occurrence of organized convection in the region. Given the mesoscale features involved in their development, modelling their main features and lifecycles is challenging. In this work we gather different modelling strategies, including several Empirical Statistical Downscaling (ESD) models, several CORDEX Regional Climate Models (RCMs) for the South American domain at various horizontal resolutions and several convective permitting simulations performed with the WRF model for selected case studies to assess the capability of different methodologies in capturing the spatial distribution of rainfall during the occurrence of an extreme event. The evaluation of different methodologies also allows identifying their capability in capturing (or not) the associated physical forcings triggering extreme events. Ten individual events were selected based on data from the TRMM dataset and the CPC-Unified gridded dataset for the period 1979-2015 satisfying the following criteria: daily precipitation exceeding the 95th percentile and with a coverage of more than 10% of grid points within SESA. Due to the large observational uncertainty, we also included several observational datasets to characterize the main features of the individual cases evaluated, which include station data, gridded products (CPC-Unified data) and several precipitation estimates based on satellite data (CHIRPS; MSWEP; TRMM; PERSIANN; CMOPRH). For each individual event, evaluation RCM simulations from the CORDEX database at 50 km and 25 km resolutions; 72-hours simulations performed with the WRF model driven by ERA-Interim reanalysis at roughly 20km, 12 km and 4 km, and several ESD models based on different techniques and different predictor variables were compared.

Keywords: downscaling techniques, extreme precipitation events, Southeastern South America

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-14

Orographical modulation of regional fine scale precipitation change signals - European examples

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High number of regional climate model (RCM) experiments have been accomplished over different sub regions of the globe in the framework of the international initiative called the COordinated Regional Downscaling Experiment (CORDEX). Being the European branches of the CORDEX program: EURO-CORDEX and Med-CORDEX provide RCM simulations targeting Europe (for Med-CORDEX: being the Mediterranean region in focus) at grid resolutions of 0.44° (medium resolution) and of 0.11° (high resolution). Detailed investigation of ensembles of driving GCM and nested RCM simulations for the late 21st century with respect to late 20th century from the CMIP5, EURO-CORDEX, and Med-CORDEX experiments are presented at high resolution, with a special focus on the Alps and the Carpathian region. Present work gives an overview on how the fine-scale RCM downscaling can modulate the GCM produced precipitation change signal in future climate projections over the regions of interest. Our findings point to the fact that the topographically induced fine scale precipitation signal is mostly of dynamical nature in winter, while is more thermodynamic in nature during summer, thus the high-resolution representation of topography in climate models is crucial for the provision of fine scale precipitation projections in mountainous regions.

Keywords: regional climate modeling, precipitation change

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-15

Future projection of heat waves over China under global warming within the CORDEX-EA-II project

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Driven by four global climate models (GCMs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5) (i.e., CNRM-CM5, EC-EARTH, GFDL-ESM2M and MPI-ESM-LR) under the Representative Concentration Pathway 8.5 (RCP8.5) scenario, projections for future changes in heat waves over China are performed by Weather Research Forecasting (WRF) model simulations for future (FTR, 2031–2055) and present (1981–2005) periods. Six heat wave indices are applied to characterize heat waves based on their frequency, duration, magnitude, intensity, accumulated occurrence days and severity. Analyses show that notable increases in heat wave indices cover all of China. More areas will endure more frequent, longer lasting and more severe heat waves in the coming decades. The increasing tendencies of heat wave indices in the FTR period are more significant than those at present, indicating that heat waves will intensify more rapidly in the future. The impacts of climate changes on the accumulated properties of heat waves are more substantial than those on the individual aspects of heat waves. It is also projected that stronger heat waves with prolonged durations and more severe magnitudes will occur more often in the FTR period, whereas relatively weaker heat waves would occur less often. Hence, the occurrence of extreme heat waves shows a more remarkable increase than the occurrence of moderate heat waves. The changes in heat waves can be largely explained by the changes in the dominating high-pressure systems.

Keywords: Heat Waves, WRF, CORDEX-EA-II, Future projection

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-16

A Case Study for the Impact of Nudging Parameters in WRF over CORDEX East Asia Phase II Domain

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In the study, we investigate the sensitivity of the Weather Research and Forecast model (WRF) to the nudging parameters in simulating JJA precipitation by applying sixteen experiments over CORDEX-EA-II domain. The effects of various nudging parameters in spectral nudging (SN) and grid nudging (AN) experiments were explored, including wavenumbers, relaxation time, nudging levels and nudging variables for SN and relaxation time and nudging variables for AN.

Results showed that both the two interior nudging methodologies can improve the WRF model's ability to reproduce the JJA precipitation and large-scale fields.

- 1) Spectral nudging shows an advantage over grid nudging in simulating heavy rainfall and low-level circulation.
- 2) Nudging both kinematic and thermodynamic variables can simulate the JJA precipitation better for both SN and AN simulations.
- 3) The effect of spectral nudging parameters is dependent on the regions of interest in simulating JJA precipitation.
- 4) In SN simulations, the options of wave number display larger effects on JJA precipitation when nudging solely the kinematic variables compared to both kinematic and thermodynamic variables over wet sub-regions.
- 5) The application of small wavenumber can decrease the improvement from both kinematic and thermodynamic variables in simulating large-scale fields and sub-seasonal variations of precipitation.
- 6) Nudging coefficient has an effect on the performance obviously in grid nudging.

Generally, the experiment adopting spectral both kinematic and thermodynamic variables, 1h relaxation time and four or eight wavenumbers captures the characteristics of summer precipitation more reasonably.

Keywords: precipitation, interior nudging

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-17

Optimization of CMIP5 results based on machine learning algorithm

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Machine learning algorithms have been widely used in various subject areas including geosciences. However, there are still quite few studies on weather forecasting and climate prediction. At the same time, most GCMs underperform in some regions than the others, particularly in areas with complex underlying surface such as the Tibet Plateau. This paper uses the 'online learning' algorithm to evaluate climate model performance (2meter temperature and precipitation) in the Tibetan Plateau based on output from CMIP5. With the help of the algorithm, we could explore the ability of each model at different times and different grid points, on which optimal weight allocation scheme will be developed to reduce the error between the multi-model ensemble and the observation value as small as possible. Hopefully the algorithm will be applied for future projections in order to optimize the model ensembles.

Keywords: machine learning, GCMs, Tibetan Plateau

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-18

Assessment of the boundary layer height simulation by CAM-MPAS over East Asia

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Planetary boundary layer (PBL) plays an important role in climate and air quality simulations. Conventional global climate models (GCMs) and regional climate models (RCMs) still have some limitations in simulating multi-scale interactions between PBL and large-scale processes. Large uncertainties remain in PBL height (PBLH) simulations among different models. The development of variable resolution GCMs (VR-GCMs) models provide a great opportunity to combine the advantages of GCMs and RCMs to perform global simulation in representing the global processes with high resolution in regions of interest. In this study, radiosonde data and ERA-Interim reanalysis data are applied to evaluate PBLH simulations over China in the variable resolution CAM-MPAS compared with uniform resolution global models. The sensitivity of PBLH simulations to different model parameterizations are further explored. Our results show that, lower PBLH is simulated with grid refinement over East Asia, especially in winter. Our results also show that PBL schemes have significant impact on simulating PBLH. It is further revealed that the CAM-MPAS model is unable to reproduce the observed seasonal cycle of PBLH even with grid refinement. Reasons for model deficiency in simulating PBLH are further explored.

Keywords: Planetary boundary layer heights, CAM-MPAS

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-19

Regional climate modelling of the Central Asia: Consistencies and uncertainties of the driving GCM's bias correction

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Global climate models (GCMs), typically on horizontal scales of around 100 km, decently simulate Earth's climate system. Nevertheless, the space resolutions of GCMs are in general too coarse for regional climate studies. Regional climate models (RCMs) are therefore introduced to dynamically downscale the GCM output, producing more details of climate variables on finer scales. A GCM with biases that are negligible on planetary scales, however, can possibly lead to severe inconsistencies when employed as boundary conditions for the RCM. While diverse approaches to performing bias correction for the GCM data are proposed, the effect of these corrections on the performance of RCM still remains unclear. As a result, we aim for a thorough discussion on the consistencies and uncertainties of a GCM bias correction with a geographical focus on the Central Asia. The GCM data used in this study is the CCSM3 model data bias-corrected by the ERA-Interim reanalysis data, following Bruyère et al. (2014)'s method based on Reynolds decompositions. The RCM being selected here is the WRF model, with the CORDEX region of Central Asia set as the coarser parent domain, and a region fully covering all five countries in the Central Asia, i.e. Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan, defined as the finer nest one. Through a comprehensive comparison between the numerical simulations and the observations in terms of several climate variables, e.g. temperature and precipitation, we present the strengths and weaknesses of the regional modelling of the Central Asia driven by the bias-corrected GCM data. The conclusion of our research may offer practical guidance to climate scientists in robustly determining GCM bias correction protocols for the conduction of dynamical downscalings.

Keywords: Regional climate modelling, GCM bias correction, Central Asia

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-20

Statistical significance tests for the difference of performance between two climate models

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With the increasing emergence of climate models, it becomes more and more important to evaluate and compare the performance of different climate models objectively, quantitatively and comprehensively is more and more important. Although a number of methods are proposed to evaluate different aspects of model performance for both scalar and vector fields, these methods do not consider the difference of performance between two models. Thus, significance test is necessary when you want to know whether the difference of model performance between different models, or the difference before and after the improvement of the model is significance, significance test for the difference of performance is necessary. To the end, we proposes statistical significance test for the difference of performance between two climate models. Statistical significance test includes the test on correlation coefficient, standard deviation, root-mean-square difference and absolute mean difference. Statistical significance test can quantify to what extent one climate model differs from the other model in different aspects. The significance test is based on bootstrap and has no restriction on the distribution of tested data. In addition, the significance test can be used for both scalar fields and vector fields. The significance test would provide new perspective to the evaluation of model performance, and useful information for model developers.

Keywords: model performance, significance test

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-21

Projected mean and extreme temperature and precipitation over Central Asia results from dynamical downscaling and CCSM4

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Limited by availability of high resolution and quality climate data, the climate change and its ecosystem responses and feedback over Central Asia has not been thorough comprehension. In this study, the optimized WRF is used to downscale the ERA-Interim reanalysis data and CCSM4 outputs, producing a new regional dataset of 30×30 km spatial resolution covering 1986–2100. The results show that Noah-MP Parameterization is more suitable for WRF to conduct the dynamic downscaling over CA than Noah, and there is significant improvement for the mean and extreme climate simulation in dynamic downscaling compared to CCSM4 model. The projections by dynamic downscaling and CCSM4 model are very similar to each other, especially for temperature and temperature related extremes. Related to 1986-2005, a significant rise trend shown by the annual and seasonal temperature during 1971-2100 with about 2°C and 5°C increasing under RCP4.5 and 8.5 scenario respectively. The maximum value of daily maximum temperature, the minimum value of daily minimum temperature and annual total number of days with minimum temperature greater than 25°C will also increase significantly, the annual total number of days with minimum temperature less than 0°C will decrease significantly with more GHGs emissions and more significant trend. Therefore, reducing greenhouse gas emission should be a priority to mitigate warming over CA. Significant differences and different change trends are shown in the projection of precipitation and precipitation related extremes over CA by dynamic downscaling and CCSM4 model, and the impact of GHGs emissions is not obvious. The simulations for global and regional precipitation by earth system model and regional model are not reliability, resulting in large deviation of the dynamic downscaling results. In the future, the simulation of global and regional precipitation by the earth system model and regional model needs to be improved to further improve the reliability of the predicted results of climate change.

Keywords: Central Asia, Dynamic Downscaling

Parallel Session A: Advances in regional downscaling

A3: Downscaling tools and methods

A3-P-22

Projected temperature and precipitation changes on the Tibetan Plateau: Results from dynamical downscaling and CCSM4

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The regional climate of the Tibetan Plateau (TP) was simulated by dynamically downscaling reanalysis data and the Community Climate System Model version 4 (CCSM4) and comparing trends of temperature and precipitation with gridded observations. Then, future CCSM4 projections under high and low emission scenarios were downscaled and compared with CCSM4 projections. Observations showed a marked upward trend in temperature and precipitation since 1979. The spatiotemporal distribution of temperature and precipitation in the TP were well represented by the reanalysis data. Downscaled simulations of ERA-Interim and CCSM4 were able to reproduce the spatial distribution of temperature in the TP; however, a cold bias was apparent in the central and western regions. Compared to precipitation observations, the downscaled CCSM4 simulation showed markedly different precipitation trends. Future climate projections indicated that temperatures will increase markedly in the TP, especially under the high emission RCP8.5 scenario. Under RCP4.5, both CCSM4 and the downscaled simulation projected a 1.5 °C increase in annual temperatures during 2006–2050, while under RCP8.5, the downscaled simulation projected an increase greater than 2.5 °C, and CCSM4 projected an increase of 2.0 °C. Emission scenarios had no apparent impact on projections of future precipitation. Therefore, to mitigate warming over the TP, reducing greenhouse gas emission should be a priority.

Keywords: Tibetan Plateau, Dynamic downscaling, CCSM4

Parallel Session B: Coupled Models

B1: Atmosphere-land

ORAL PRESENTATIONS

Parallel Session B: Coupled Models

B1: Atmosphere-land

Providing high-resolution land-use change information for ensemble simulations within EURO-CORDEX and the LUCAS framework

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Land-use and land cover (LULC) are continuously changing due to environmental changes and anthropogenic activities. The bio-physical impacts of these changes on the regional climate in Europe are currently extensively investigated within the CORDEX Flagship Pilot Study LUCAS - "Land Use and Climate Across Scales". An ensemble of different regional climate models (RCMs) coupled with land surface models (LSMs) was already set up to perform idealized experiments with extreme LULC changes (LULCC). Based on these results, the sensitivity of the individual RCM-LSM combination was analyzed.

However, to investigate the impact of realistic LULCCs, observed historic LULCCs and plausible future LULCC scenarios are required as input for the RCM-LSM simulations. Therefore, the land-use change information from the land-use harmonized dataset (LUH2), which is also used for CMIP6 experiments, is applied to derive realistic LULC distributions on high spatial resolution and annual timestep from 1950 to 2100. We start with the current LULC distribution (~300 m) from the GLOBCOVER 2009 dataset (GLC2009). Based on GLC2009, a map of 16 plant functional types (PFTs) is derived using observed climate data (i.e. biotemperature and precipitation) in combination with the Holdridge ecosystem classification scheme. The LUH2 dataset is applied to derive annual PFT maps for Europe starting from the LULC distribution for the year 2009 back to 1950, and forward to 2015. From 2016 on, annual maps for future scenarios based on LUH2 are derived for different SSP/RCP combinations. The resulting datasets will be provided to the EURO-CORDEX community, and can be applied as land surface forcing to the LUCAS RCM-LSM ensemble to investigate the impact of both past and future LULCCs on high resolution climate change simulations.

The method, used for the construction of the dataset, and simulation results with the coupled RCM-LSM REMO-iMOVE employing the newly derived LULCC information will be presented.

Keywords: LUCAS, Land-use change, high-resolution dataset, REMO-iMOVE, EURO-CORDEX

Parallel Session B: Coupled Models

B1: Atmosphere-land

Land-atmosphere feedbacks in a high-resolution RCM: sensitivity to the land-surface forcing

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Within the framework of CORDEX-FPS on convective phenomena over Europe and the Mediterranean (FPS-CEM), a multi-model ensemble of regional climate models (RCMs) on convection permitting (CP) resolution is being produced for the first time. In these high resolution RCMs the accuracy of static input information, such as land use and soil texture, are becoming more relevant, and may impact not only surface fluxes, but also the representation of boundary layer evolution and precipitation. In this study we investigate the sensitivity of the Weather Research and Forecasting (WRF) model to land-surface static data by applying the extended case-study experimental design of FPS-CEM (Coppola et al. 2018). Apart from the default WRF static information based on MODIS land use and FAO soil texture, we adapted higher resolution and up-to-date data for WRF based on CORINE land use and HWSD/BÜK top soil texture info, which have been used by all WRF groups involved in FPS-CEM. Combining these 4 data sets for a summer and a winter case, with 2 WRF physical parameterization settings, we generated two 8-member ensembles. We focus here on the model representation of land-atmosphere (LA) feedback processes over the CP Alpine domain, and its sensitivity to (1) land-surface static forcing, (2) season, and (3) WRF configuration. We investigate correlation between the strength of the LA coupling and the model sensitivity to the land-surface static data, and we explore the impact of land-surface changes on the potential for convection and precipitation occurrence. To quantify the strength of LA coupling we use coupling metrics appropriate for monthly time scales (e.g. mixing diagram).

Keywords: Land-atmosphere feedbacks, RCM, WRF, Land use, Soil texture

Parallel Session B: Coupled Models

B1: Atmosphere-land

Land-atmosphere coupling strength in dependence of the land-cover in European climate simulations

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The land surface is an important driver in the earth system. Increasingly, natural changes in land-cover as well as changes in the human land use modify land surface properties and the feedback to the climate system. Land-cover dependencies and strength of land-atmosphere feedbacks are spatially and temporally variant. The underlying biogeophysical feedback mechanisms are still not completely understood. Three ERA-Interim driven regional climate simulations were conducted in the framework of the WCRP FPS 'Land-Use and Climate Across Scales' (LUCAS) in order to investigate the impact of theoretical maximum afforestation and deforestation, respectively, on feedbacks and potential implications for precipitation patterns in Europe. Model outcome of the Weather Forecast and Research (WRF) model coupled to NOAH-MP was evaluated with respect to the magnitude and variability in land-atmosphere coupling strength at seasonal time scales and in dependence of land cover. Data from 1986-2015 were used to identify potential feedback hotspots and estimate the coupling strength based on the CTP-Hilow framework (Findell and Eltahir, 2003a,b) and the Two-legged metric (Dirmeyer, 2011). It was found that the strongest coupling (max. 48.5% of days/season) occurs in the summer months over the Eastern European Plain. Especially in strongly coupled regions, afforestation causes an increase in atmospheric instability (CTP) and humidity deficit (Hilow) of in average +20.5 J/kg and +1.0°C, respectively, on land, resulting in a weakening of the coupling strength and less pronounced potential for local positive feedbacks between soil moisture, evapotranspiration, and precipitation. Conversely, deforestation yields the opposite effect (-18.5 J/kg and -0.75°C on land). Generally, the results indicate that besides direct impacts on exchange fluxes, especially in summer, changes at the land surface modify the atmospheric background conditions and hence, the strength of land-atmosphere feedbacks.

Keywords: Land-atmosphere coupling strength, Land-cover change, Biogeophysical feedbacks

Parallel Session B: Coupled Models

B1: Atmosphere-land

Integrated simulation of the terrestrial water cycle with the fully coupled Terrestrial Systems Modelling Platform (TSMP)

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Water resources and security are intricately linked to complex interactions and feedbacks between the groundwater, land surface and atmosphere, and strongly affected by climate change as well as human water use. To better understand the drivers and processes behind hydroclimatic extremes (droughts, heatwaves), the related two-way feedbacks (soil moisture-temperature or precipitation coupling), and to lay the foundation for more informed adaptation and mitigation options, we use the multi-scale, fully coupled, physically consistent Terrestrial Systems Modelling Platform (TSMP) (COSMO + CLM + ParFlow, OASIS3-MCT) in EURO-CORDEX compliant experiments at 12km resolution over Europe. In coupled ERA-Interim driven TSMP sensitivity and process studies, with closed terrestrial water and energy cycles, a more realistic groundwater representation (full 3D groundwater vs. free drainage) leads, e.g., to altered soil moisture-temperature feedbacks, with an alleviation of air temperature extremes during the 2003 European drought and heatwave of up to 1K. An ensuing 30-year continental TSMP evaluation run shows, e.g., an improved representation of the spatio-temporal variability of RCM air temperature anomalies when compared to observations, complementing the existing EURO-CORDEX RCM ensemble. The associated pristine (i.e., no human interference) groundwater climatology, consistent with the atmospheric forcing, may serve as a baseline dataset to assess future hydro-climatic extremes and the impact of human water use. In a pilot study, using TSMP with and without human water use, systematic atmospheric feedbacks can be induced by groundwater abstraction and irrigation that lead to a change in the strength of the continental sink for atmospheric water and these feedbacks are in turn drivers for terrestrial water storage changes, which may aggravate the drying of arid watersheds.

Keywords: CORDEX, TSMP, groundwater-to-atmosphere, coupled modeling, water resources

Parallel Session B: Coupled Models

B1: Atmosphere-land

Quantifying the evolution of agriculture impact on climate in Europe by observation and regional climate model simulations

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Agricultural sector is an important part of the anthropogenic land use change which plays a prominent role in stabilizing global mean temperature rise to 2 °C or less. Changes in the extent and magnitude of local-to-regional climate by agriculture evolution are still not explored. In this study, we simulate and analyze the climate response to different ranges of agricultural area changes with a regional climate model (WRF v.3.9.1) in EURO-CORDEX (European branch of the international Coordinated Regional climate Downscaling Experiment-CORDEX initiative) domain. Different experiments are envisioned in this study, including a control run and simulations based on idealized extensive cropland loss or cropland gain. The simulations also include more realistic agricultural area changes across different land cover classes. The investigated parameters will be the changes of temperature, precipitation, and frequency of temperature extremes at both the entire EURO-CORDEX domain (regional scale) and the changed grids (local scale). Results will also be compared to observation data gathered from satellite retrievals. In the grid cell affected by land cover change, we expect to find climate changes that are more significant than in non-affected areas. A latitudinal pattern and seasonal variability should also emerge. Of particular interest will be the understanding of the spatial patterns of the climate response to the transition between cropland and other types of land cover changes, their sensitivity to space and location, and the analysis of possible correlations with different kinds of cropland and climate parameters. As biophysical effects from agriculture evolution shape European climate in different ways, further developments and better understanding of land-climate interactions can ultimately assist decision makers to modulate land management strategies at different scales in light of climate change mitigation and adaptation.

Keywords: land use/cover change, regional climate mode, biophysical mechanisms, cropland, EURO-CORDEX

Parallel Session B: Coupled Models

B1: Atmosphere-land

Do uncertainties in the reconstruction of land cover affect the simulation of air temperature and rainfall in the CORDEX Region of East Asia?

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Shuyu Wang, **Congbin Fu**, Nanjing University, China*

Land cover type reconstructions, required in climate models, commonly utilize remote sensing products. There are inevitable misclassifications in land cover reconstructions due to the retrieval process. We use the Weather Research and Forecasting model to determine whether these misclassifications can affect the simulations of air temperature and rainfall over the Coordinated Regional Climate Downscaling Experiment (CORDEX) East Asia region, where the accuracy of the land cover classification is low. The Moderate Resolution Imaging Spectroradiometer land cover map is used for the control simulations and is then replaced by the most likely alternative land cover type at pixels where the classification confidence is below various threshold values. Results show that misclassification-induced land cover change can affect key biogeophysical characteristics (albedo, leaf area index, and roughness length) and these can affect the sensible and latent heat fluxes at regional scales. However, the impact on air temperature is very limited and is restricted to the Tibetan Plateau where warming of up to 2 °C occurs associated with the replacement of barren or sparsely vegetated land to grassland. The impact on rainfall is negligible, and most changes are likely caused by model internal variability rather than land cover change. Overall, uncertainties in the reconstruction of land cover have negligible impacts, and the Moderate Resolution Imaging Spectroradiometer land cover product can be used in regional simulations over East Asia. However, we note that land cover change experiments incorporating uncertainties must utilize large numbers of simulations if air temperature and rainfall changes are to be examined robustly.

Keywords: MODIS land cover map, Air temperature, Rainfall, WRF model, CORDEX East Asia

Parallel Session B: Coupled Models

B1: Atmosphere-land

Effects of vegetation fraction variation on regional climate over eastern China

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The interactions between the atmosphere and vegetation are of major importance for the climate change. Terrestrial vegetation can regulate the local weather and climate through modifying the surface energy budget and exchanges of heat, water, and momentum with the atmosphere. The main purpose of this study is to investigate on the influence of vegetation variations on regional climate simulation over Eastern China. Therefore, three 30-year simulations from 1982 to 2011 with the WRF model coupled with the Noah land surface model have been performed as follows: a control experiment (CTL) with NOAA climatology green vegetation fraction (GVF) during 1982-2011, a sensitive experiment (CLMV) with WRF default climatology GVF during 1985-1991, and a sensitive experiment (DYNV) with dynamic vegetation during 1982-2011 derived from the NOAA GVI system. It is detected from the climatology difference between CTL and CLMV and the linear trend difference between DYNV and CTL that the increase of vegetation will decrease the temperature and vice versa, and no clear relation is found between precipitation and GVF change. In response to GVF change, the climatic precipitation responses are clearly insignificant and heterogeneous, and the vegetation-precipitation feedback mainly determined by the complicated moisture feedback, dominating over the radiation and momentum feedback. The change of GVF data also alters extremes and heat wave. Over regions south of the Yangtze River, the DYNV simulation of the interannual variation for the extremes such as maximum of daily maximum temperature (TXx), warm spell days (WSDI) and heat wave indices have been improved. However, it also introduces new biases on the minimum of daily minimum temperature (TNn) and cold spell days (CSDI) as well as in the Eastern coastal regions and Northeastern China.

Keywords: vegetation variations, extremes

Parallel Session B: Coupled Models

B1: Atmosphere-land

The role of soil texture in local and non-local land surface–atmosphere interactions

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The land surface is inextricably linked to the atmospheric circulation as it dictates the location and strength of land–atmosphere coupling mechanisms via controls on surface fluxes. Arguably, one of the most fundamental components of the land surface is the texture of the soil (i.e., the proportions of sand, silt or clay). In modern numerical weather and climate prediction, it is necessary to prescribe a distribution of soil texture classifications within the land surface model, which acts as the lower boundary condition for the atmospheric model. Comparison of two widely used soil texture databases, the USDA State Soil Geographic database (STATSGO) and Beijing Normal University's global 1-km soil texture database, Global Soil Dataset for use in Earth System Models (GSDE), over Southern North America at 15-km horizontal grid spacing, reveals that only 33% of terrestrial classifications are in common. Seasonal WRF simulations were conducted to assess the impacts of changing the soil texture database.

Changes in the soil texture databases influence the simulation of thermodynamic variables (i.e., temperature, humidity profiles). At the surface in the late afternoon, changes of the order of 45–50 W/m² are noted in the latent and sensible heat fluxes. Seasonal-averaged temperature changes are approximately 1–2 K over most of the domain with the positive and negative values mirroring the changes in soil texture categories. Further, changes in texture have dynamical effects, affecting the boundary layer structure and evolution and the orientation and strength of the Great Plains Low Level Jet (GPLLJ). Using the GSDE database increases the GPLLJ seasonal-average by 1–2 m/s and consequently the corresponding moisture fluxes. Resulting changes in precipitation are observed, and changes may become as large as the average total rainfall over some important agricultural regions of the United States.

Keywords: land-atmosphere interactions, soil properties

Parallel Session B: Coupled Models

B1: Atmosphere-land

The impact of the land use and land cover (LULC) change on regional climate in China simulated with WRF model

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The WRF model is employed in this study to simulate how the LULC change makes an impact on temperature and precipitation in the area of China. First, we carried out the climate downscaling simulation, in which, the reanalysis data from ECMWF and climate scenario data from Norwegian global model (NorESM) as the meteorology input data respectively. The MODIS data of the year 2001 is used in all the simulation as LULC. Based on the used MODIS data of LULC, we repeated the WRF simulation with artificially modifying LULC, in three cases as all LULCs being the forest, grassland, and bare land respectively. The result shows that both forest and grassland would increase precipitation, with bare land reducing precipitation in China. On the other hand, the grassland did not alter temperature significantly, however, the forest and bare land robustly increase the temperature. The forest mainly increases winter temperature, while the bare land mainly increases the summer temperature, which leads to a smaller temperature difference between winter and summer for forest experiment and larger temperature difference for the bare land experiment. Therefore, the simulation experiments manifest that the LULC change will change the regional climate significantly.

Keywords: WRF simulation, land use land cover change

Parallel Session B: Coupled Models

B1: Atmosphere-land

Integrating Remote Sensing Data with WRF model for Improve 2 m Temperature and Humidity simulations in China

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The data sets of fraction of green vegetation coverage (GVF) estimated by remote sensing and used in Weather Research and Forecasting (WRF) Model, was produced many years ago, and its representation is gradually deteriorating. The latest Moderate Resolution Imaging Spectroradiometer (MODIS) products can be used to update the underlying surface static data sets in WRF. In this study, The default GVF data was replaced by the estimated GVF, which was calculated by the Normalized Difference Vegetation Index (NDVI) of MODIS in the WRF model. We compared the result of meteorological elements, such as 2 m temperature, and specific humidity between WRF model control run experiment (WRF-CTL), and modified WRF simulations (WRF-MODIS) and observations from 824 weather stations in China. The results show that 2 m temperature and specific humidity from WRF-MODIS is improved compared with The WRF-CTL, and has effectively reproduced the observed pattern. The correlation coefficient of 2 m temperature and specific humidity between observations and WRF-MODIS is increased compared to WRF-CTL. The RMSE and bias of specific humidity is also reduced in WRF-MODIS. However, WRF-MODIS overestimates the specific humidity in South China in summer. The overestimated specific humidity in South China may be due to a higher GVF in WRF-MODIS simulations.

Keywords: WRF model, MODIS-NDVI, temperature, specific humidity

Parallel Session B: Coupled Models

B1: Atmosphere-land

POSTER PRESENTATIONS

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GILES	Julian	Diurnal cycle of precipitation and atmospheric humidity flux in South America: role of land-atmosphere interactions	B1-P-02
HIRSCH	Annette	Land surface contributions to the amplification of Australian heatwaves via local land-atmosphere coupling	B1-P-03
HOFFMANN	Peter	Response of LUCAS-models to forestation and afforestation in Europe under dry, wet and hot climate conditions	B1-P-04
KUMAR	DHIRENDRA	Indian Summer Monsoon in a coupled land-atmosphere regional downscaling experiment	B1-P-05
LIU	SILIANG	Regional climate impact assessment of vegetation change in Loess Plateau: combining WRF-Noah model and long time series satellite observations	B1-P-06
MAOSHAN	Li	The study of the surface roughness length and its application in the NoahMP on the northern of the Tibetan Plateau	B1-P-07
MARGARYAN	Pargev	Probable deviations of air temperature in the surface layer of arid regions of Armenia in the context of global climate change	B1-P-08
MARGARYAN	Varduhi	Dynamics change of annual number of atmospheric precipitation of Ararat physical geographical arid region in global climate change context	B1-P-09
NTOLE	Romain	Forecast of Planting Calendar for Sorghum (Sorghum bicolor) from Downscaling Method in Kivu Mountain, DR Congo	B1-P-10
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SILVA	Maria Elisa	Climatic impact over South America caused by the Amazon deforestation during distinct Pacific Decadal Oscillation phases	B1-P-13
SINGH	Charu	An analysis of extreme rainfall events over the Himalayan region using coupled models	B1-P-14
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WANG	Xuejia	Characterization of air and surface temperature coupling over the Tibetan Plateau: Results from multi-source reanalyses	B1-P-16
YAN	Yan	Assessment of the Uncertainties of Options in the Noah-MP Land Surface Model Simulations over China	B1-P-17
ZACHARIAH	Johnson	Impact of Equatorial and Northern Bay of Bengal SST's on the Indian summer monsoon rainfall	B1-P-18

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-01

Contribution of Urban Heat Island on Landscape Composition and Its Impact to the Land Surface Temperature (Case Study on Palembang City-Indonesia)

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Palembang as the capital of South Sumatra Province, and also famous as the host of the Asian Games 2018 has high development activities along with the increasing population. Development carried out through the diversion of land functions into built-up land causes an increase in surface temperature which triggers the urban heat island phenomenon. This study aims to discuss the phenomenon of Urban Heat Island in Palembang City and its relation to land composition and population density on surface temperatures obtained from the processing of multi-temporal Landsat Images in 1989, 2001, 2018, with the specification of cloud-free (clear sky) using the Land Surface Temperature (LST) algorithm and guided classification (supervised). The results of surface temperature, population density, and land composition were then carried out simple regression tests. The distribution of the UHI phenomenon is obtained by classifying LST to obtain the UHI threshold. The results showed a link between changes in surface temperature, population density and land composition. The value of the determinant coefficient (R^2) between the relationship of changes in surface temperature which is directly proportional to the increasing population, the increase in the area of each open land and built-up land reached 62.6%, 86.3%, and 55.0%. Conversely, there is a negative link between surface temperature and dense vegetation with a determinant coefficient reach 90.4%. The affected area of UHI is located in the center of Palembang, reaching 33.5 km² of the total area of Palembang City in 2018. It is necessary to have an ideal city mitigation and arrangement by calculating the green area with the increasing population in Palembang City.

Keywords: Urban Heat Island, LST, Landsat

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-02

Diurnal cycle of precipitation and atmospheric humidity flux in South America: role of land-atmosphere interactions

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Model accuracy of the timing of precipitation in its diurnal cycle is as important as that of the daily mean to correctly represent climate, but nevertheless it is often overlooked. We analyzed the diurnal cycles of precipitation (DCP) and convergence of atmospheric humidity over South America in the wet season (October through March), using two regional climate models (RCA4 and LMDZ). The simulations were compared with two satellite-derived products and one reanalysis. Consistent with previous results, these RCMs have a wrong representation of the DCP because precipitation is being unrealistically triggered too easily. Both models showed qualitatively similar errors in the DCP compared to reference data. However, the humidity flux convergence - a necessary condition for a correct rainfall simulation - and its diurnal cycle at the continental scale were satisfactorily captured compared to the reanalysis. We speculate that the boundary layer evolution and its thermodynamic properties could be sensitive to the coupling between the soil and the atmosphere. In order to explore if the diurnal cycles of convection and different properties of the boundary layer are sensitive to the land-atmosphere coupling, an additional run was performed with each RCM: an Uncoupled experiment that shares the same set-up as the control (coupled) one, except that its soil-moisture evolution at each day is replaced with the climatology of the control for that day, uncoupling the land surface from the atmosphere. The main results of this experiment will be presented during the conference.

Keywords: diurnal cycle, south america, precipitation, atmospheric humidity flux convergence, land-atmosphere coupling, soil moisture

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-03

Land surface contributions to the amplification of Australian heatwaves via local land-atmosphere coupling

Annette Hirsch, CLEX/UNSW, Australia (presented by J. Evans)

Annette Hirsch, Jason Evans, CLEX/UNSW, Australia; ***Giovanni Di Virgillio***, UNSW, -; ***Sarah Perkins-Kirkpatrick***, UNSW, -; ***Daniel Argüeso***, U. Balearic Islands, -; ***Andrew Pitman***, CLEX/UNSW, -; ***Claire Carouge***, CLEX/UNSW, -; ***Jatin Kala***, Murdoch Uni,-; ***Julia Andrys***, Murdoch Uni, -; ***Paola Petrelli***, CLEX/UTAS, -; ***Burkhardt Rockel***, Helmholtz-Zentrum Geesthacht

Climate change is likely to increase the frequency, intensity and duration of heatwaves, particularly over Australia. Heatwaves pose a significant risk to ecosystem and human health as evident in the impacts of several well documented case studies, including the 2003 European heatwave, the 2010 Russian heatwave and the 2012/2013 summer in Australia. Heatwaves are generally associated with the clear skies, increased subsidence, warm air advection and prolonged heat arising from persistent quasi-stationary high-pressure systems. However, land surface conditions have been shown to have an influence on amplifying the surface temperatures experienced during a heatwave. Most analyses to date focus on the role anomalous soil moisture conditions preceding exceptional events (e.g. the 2003 European heatwave). However, in general it is not known how much the rate of land surface drying, through land-atmosphere interactions, both before and during a heatwave contributes to the intensity of these extreme events. Therefore, in this study we examine how the rate of land surface drying preceding a heatwave event contributes to heatwave intensity. Here we focus on Australian heatwaves using both observational data and model output from the CORDEX AustralAsia project. We find that rate of land surface drying prior to a heatwave event influences the magnitude of temperature anomalies experienced but only over regions where there is strong coupling between the land and the atmosphere. We also find that heatwaves are triggered more frequently over regions where there is strong land-atmosphere coupling. Time permitting, we will also present new results distinguishing between dynamical and non-local land surface contributions.

Keywords: land-atmosphere interactions, heatwaves

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-04

Response of LUCAS-models to forestation and afforestation in Europe under dry, wet and hot climate conditions

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Within the CORDEX Flagship Pilot Study LUCAS - "Land Use and Climate Across Scales", the bio-physical impacts of land-use and land cover changes (LULCCs) on the regional climate in Europe are currently extensively investigated. An ensemble of different regional climate models (RCMs) coupled to diverse land surface models (LSMs) has been set up to perform idealized experiments with extreme LULCC scenarios for the EUR-44 domain driven by ERA-Interim. In the first scenario, Europe is covered with forest where trees can realistically grow (FOREST), while in the second scenario all forests are turned into grassland (GRASS). An evaluation run (EVAL) with the individual model land surface distributions was also conducted for each participating RCM-LSM. The responses of the RCM-LSM ensemble to the two extreme LULCC scenarios show robust seasonal signals for some regions and some variables but also disagreements between the different RCM-LSM.

In this study, the influence of atmospheric conditions on the responses to the extreme LULCC is investigated to understand the inter-model differences and to assess the robustness of the responses. This is done by analyzing differences between the FOREST and GRASS simulations under dry, wet, and hot climate conditions. Dry and wet climatic conditions are detected using two different methods. For the first method, the five wettest and five driest years are determined in the EVAL runs for each PRUDENCE region and season. The second method is based on the standardized precipitation index

(SPI), computed from the monthly precipitation in the EVAL runs. Months with a low (high) SPI over the majority of the corresponding region are defined as dry (wet) conditions. Regional scale hot conditions are detected using the hot season definition. The differences in near-surface variables between the FOREST and GRASS simulations are then averaged for the different climatic conditions and compared to the average response computed for the whole period.

Keywords: LUCAS, Land-use and land cover change, extreme climate conditions

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-05

Indian Summer Monsoon in a coupled land-atmosphere regional downscaling experiment

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One of the visions of the CORDEX project is to evaluate and improve different regional climate downscaling techniques through testing different models over a common area. In this regard, the capability of regional climate model RegCM4 forced with two different GCMs and three different land-surface parameterization schemes (i.e. BATS, CLM4.5, and Subgrid-BATS) in simulating the mean features of Indian Summer Monsoon is tested for the present climate (1975-2005). The selection of the GCMs (MIROC5 and CCSM4) were made on the basis of their ability in representing the seasonal mean, inter-annual and the intra-seasonal variability of monsoon over the Indian region based on the available literature. In total, 6 different long term simulations were carried out and assessed in terms of seasonal mean near surface air temperature, precipitation and low level wind fields for June-September season over CORDEX-South Asia domain. Among all the experiments, MIROC-RegCM-CLM4.5 experiments outperform others in simulating the JJAS seasonal mean precipitation and wind climatology with comparatively less dry bias over the Indian region. The model performance were assessed in terms of Taylor's metric (for seasonal mean precipitation, temperature, zonal wind, meridional wind and total cloud fraction), mean annual cycle, Index of Agreement, Normalized Root Mean Squared Deviation, and Probability distribution function over the Indian landmass region. The model experiments were found to simulate the moderate precipitation events more accurately than higher intensity precipitation events when compared with IMD observations. The inherent biases in the model simulations are attributed to the weaker meridional wind simulation in the experiments along with restrained vertical motion during monsoon especially in case of those forced with CCSM4 GCM. This emphasizes the importance of appropriate GCM forcing as well as land surface parameterization scheme for the simulation of a coupled land-ocean-atmosphere system such as Indian Summer Monsoon.

Keywords: RegCM4, CLM4.5, CORDEX-South Asia, Monsoon, Downscaling

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-06

Regional climate impact assessment of vegetation change in Loess Plateau: Combining WRF-Noah model and long time series satellite observations

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Loess Plateau (LP), a pilot region with arid and semi-arid climate in China, has undergone significant vegetation change since the launch of the 'Gain for Green' Program (GGP) in 1999. As the aim of GGP to increase forest cover and control soil erosion, parts of agriculture land have converted to forests and grassland. The net warming or cooling effect of afforestation in this region is still uncertain, depending on the competing contributions of albedo and evapotranspiration as well as background climate. Further, it is reported that vegetation change has altered the rainfall distribution and frequency in LP.

With the availability of decades of satellite observations, the transition of land cover types and change of vegetation status can be represented realistically. Through incorporating this information into the static field of coupled atmosphere-land regional climate model, it is expected to quantify the climate effects due to vegetation change.

The objective of this study is to investigate how surface air temperature and precipitation response to vegetation change due to government policy in LP, through combining multiple long time series satellite products from 1982 to 2016 and WRF-Noah model. To highlight the effect of GGP and avoid sensors calibration issue, the whole temporal range is divided into two periods: 1982-1999 and 2000-2016. Contrasting sensitivity experiments are conducted using real vegetation observations and static vegetation background to isolate the effects of vegetation change.

Keywords: Vegetation Change, Climate Effects

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-07

The study of the surface roughness length and its application in the NoahMP on the northern of the Tibetan Plateau

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This study focuses on the temporal and space variation of the roughness length on the northern of the Tibetan Plateau. The figures show that there is the distribution of the surface aerodynamic roughness of 40000km² around BJ site (BJ site is in the center, time is taken on the 15th of each month). It can be seen from the figure that the surface roughness of the area shows a decreasing trend from January to February, which may be due to snowfall and other reasons, resulting in a small surface roughness and a continual decrease in surface roughness. From February 15 to March 15, the z0m has recovered somewhat in a month as figure C is basically consistent with figure A, it indicates that the z0m has reached to its lowest, it could indicate by snowfall must begin to melt, and the contribution of the complex underlying surface environment to z0m is enhanced. On March, April, May z0m continues to increase, and the vegetable low growth in these three months, the monthly chart changes are not large. These figures show the coverage of the surface is indicating the complexity of the surface, whether the surface or vegetation will have an important impact on the z0m. From March until August, z0m has been on a rising trend. Corresponding to the obvious changes of relative humidity, temperature and pressure brought by the summer monsoon mentioned above, the height and coverage of surface vegetation are all increasing. Therefore, z0m is also constantly increasing, reaching its peak in August. It is noteworthy that the change from May to June is very significant. This may be due to the start of the corresponding plateau summer monsoon in June, which will lead to the increase of precipitation. After the precipitation increases, the growth of vegetation will accelerate and the z0m will rapidly increase. June, July, August three months, due to continuous precipitation and other reasons, leading to plant growth is very strong, but grow to the maximum no longer grow, corresponding to the map is the maximum surface roughness has not changed, but due to the abundant water, the z0m gradually expanded in the past three months and reached the maximum area in August. From September to December, with the decline of plateau monsoon, some changes have taken place in temperature and relative humidity, compared with the prevailing summer monsoon, which are no longer suitable for the growth of vegetation. From this month, the vegetation contribution to z0m is gradually weakened, and the height and coverage area of z0m gradually decrease. Therefore, z0m also decreases continuously and the range begins to decrease. In December, the z0m area near BJ site sudden decrease may be due to snowfall.

It can also be seen from the above simulation that the z0m changes not only impress with the time scale but also with the spatial scale. From these figures of the characteristics trend, we can see that the underlying surface has different complexity, the trend of the z0m is different. After inverting the satellite remote sensing data, we also get the variation of z0m of 40000 km² around the BJ station at northern Tibetan Plateau in 2008, which shows the data decrease from Jan. to Feb. It reaches its peak in Aug. and then decrease again. This annual variation is to some extent related to the plateau summer monsoon and snowfall. Besides, the vegetation height in dry seasons is low, so the z0m is determined mainly by the relief of land surface in dry season. On the other hand, improved roughness length was

applicated in the NoahMP simulation process and the simulated results were evaluated using observation.

Keywords: the roughness length,numerical simulation,Tibetan Plateau

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-08

Probable deviations of air temperature in the surface layer of arid regions of Armenia in the context of global climate change

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Today the effects of climate change are felt around the world and Armenia is not an exception. Armenia is characterized by vulnerable mountainous ecosystems, arid climate, an active process of desertification and natural disasters are often observed, which makes the country more vulnerable the impacts of climate change. The air temperature has a main role in the forming of atmosphere circulation, evaporation and moisture regime of territory. That is why the air temperature study is an important task and caught our attention. So, clarifying and estimation of regularities of temporal distribution of air temperature importance, especially for more accurate definition of thermal balance, for productive using of thermal resources.

For solving of suggested problems as a theoretical base have been used appropriate researches, as a raw material - actual data of long-term observations of air temperatures the meteorological station of the territory of republic for last 100 years, which are kept in fond Armstatehydromet. In work have been applied methods: mathematic-statistical, geographical, extrapolation, analysis, correlation, complex.

Average data of air temperature observations in Armenia at meteorological stations for the period of 1935-2017 has been analyzed.

In study area the values of average annual air temperature are within 14.3 °C (Meghri) and -2.6 °C (Aragats). During the year the warmest months are July-August, with average monthly temperature 9.0...27.0 °C, and the coldest month are January with average monthly temperature -12.7...1.5 °C.

In Armenia air temperature changes have been estimated for different periods, and results have been used in first and second national messages of Climate Change of RA. The results show, that during last ten-years period in Armenia observes increasing of air temperature. During 1935-96 period for comparison to basic period (1961-1990) average annual temperature increased on 0.4 °C, in 1935-2007 period – 0.85 °C, in 1935-2012 period - on 1.03 °C. It means that the temps of temperature increasing increased. Since 1994 the deviations of average annual temperature in comparison with average temperature in 1961-1990 were only positive.

By the forecasts of ECHAMS, GFDL, GISSER, HadCM3 models in Armenia predicts annual increase of air temperature for 1.1-1.5 °C in 2011-2040, 2.0-3.0 °C in 2041-2070, and 3.5-5.5 °C – in 2071-2100. So, in the results of studies we have the following conclusions and suggestions:

In perennial observations notes a tendency of increase of annual average values of air temperature;

- have been made many researches, but there are not studies systemized of reasons of air temperature change yet, and existed are just for some sides of it. So, is better to continue studies and to develop future forecasts, using new models;

- estimation of problems of air temperature dynamics change will get right solving, when will be known the relations, which it have with other components of nature area complex in conditions of direct influence of human.

Is necessary:

- providing of meteorological stations with modern equipment (especially automatic);
- evaluation of the vulnerability of ecosystems as a result of changes in air temperature;
- realization legal-organization, institutional, technical arrangements for adaptation of economy to new natural conditions and soften of climate change consequences;
- strengthening of scientific studies of climatic problems and implementation of new technologies;
- working out of real climatic scenarios;
- working out of the programs for softening the negative effects of air temperature change;
- financial satisfy support from government and other donor organizations made implementations must be visible for society, directed for realization of specific programs and have control by some organs;
- providing of modern ways of availability and outspread of information;
- working out and implementation of qualification programs, organization of studying processes, development of specialists' qualification;
- realization and providing international scientific-educational cooperation, strengthening of inter-agency cooperation.

Keywords: air temperature, arid regions, probable deviations, global climate change, Armenia

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-09

Dynamics change of annual number of atmospheric precipitation of Ararat physical geographical arid region in global climate change context

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The atmospheric precipitation change is a reason of different dangers ecological situations manifestations. Need to study the cause-and-effect relationships of precipitation change became more vital since the late 20th century, when it became clear that the sustainable development of the society due to climate components protection

So, considering the above, studied and evaluated the dynamics change of annual precipitation of an important agricultural region of the republic, Ararat valley, clarified the distribution patterns, revealed the challenges of sphere.

For solve these problems as a theoretical and informative basis served appropriate studies, published works, decisions of the Armenian government, reports, development programs, projects, working plans. As a starting material used actual data of long-term observation of atmospheric precipitation (1935-2015) of meteorological stations of Armstatehydromet of MES of RA of study area, as well as climatic reference-books. As a methodological basis used geographical, mathematics-statistical, extrapolation, matching, comparison, analysis, correlation methods.

The tasks of atmospheric precipitation change discussed and studied by the results of actual data of separate meteorological stations. As a result of the study revealed, that in the region observes regular spatial distribution of dynamics change of the number of precipitation during the year. Thus, at the territory of Ararat valley is noticed increase of amount of annual precipitation until 1300m height, and on greater heights-tendency of decrease. But it does not means, that humidification and artificial irrigation issue of valley are resolved. The reason is, that at low zone due to high air temperature and its increase tendency is great the evaporation, therefore, the loss of precipitation also. On the other hand, on the territory of the RA the river runoff is formed at 1800m and more heights mainly. And in this zone observes only a decrease tendency of precipitation. So, it is necessary to manage and use right the water resources from atmospheric precipitation, especially in the context of the global climate change.

According to regional climatic models (Armstatehydromet) in Armenia is expected an increase of annual temperature on 1.1-1.5°C in 2011-2040, 2.0-3.0°C - in 2041-2070, 3.5-5.5°C – in 2071-2099 and decrease of annual precipitation appropriately on 5-10%, 10-15%, 15-25%.

Thus, in the result of such change of atmospheric precipitation will observed a violation of natural ecosystem balance, particularly an aridity of climatic conditions, soil degradation, biodiversity violation. So, it is necessary to evaluate precipitation change with ecosystem approach, by separate physical-geographical regions or river basins, to work out appropriate programs of consequences mitigation and adaption events, taking into account local features of any area.

In the result of studies we came to following conclusions and proposals:

- The atmospheric precipitation belongs to that meteorological elements, which characterized with more local features of spatiotemporal distribution;
- The number of precipitation regularly increases from low regions of valley to south-eastern slopes of Aragats. Maximum annual number of precipitation(988 mm), in the Republic also, observes at Aragats meteorological station, minimum number (166 mm) – at Taronik meteorological point;
- On the result of study has negative effect a circumstance, that in study area meteorological stations and points are located until 1200m height mainly, at 1300-2000 m height their number is 2;
- Until 1300 m height is observed a tendency of increase of annual number of precipitation, and more higher – a tendency of decrease;
- In the conditions of conservation of such cause of precipitation change, probably, will be growth of aridity of the region, intensive soil degradation.

It is necessary

- Providing of continuous comprehensive and systematic scientific studies of dynamics change of precipitation, investment of new programs and technologies;
- Providing of homogeneity, continuity and reliability of observations of actual data series;
- Training professionals, organizing of training courses continuously;
- Improving of information and notification systems;
- Evaluation of vulnerability of ecosystems due to precipitation change;
- Reserving of water of small streams and rivulets of upland areas during humid period for irrigation relatively dry areas in dry season in low areas;
- Mitigation of legal-organizational, institutional, technical events for softening of effects of atmospheric precipitation change and adapting of economy to new natural conditions.

Keywords: atmospheric precipitation , global climate change, Ararat physical geographical, arid region

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-10

Forecast of Planting Calendar for Sorghum (*Sorghum bicolor*) from Downscaling Method in Kivu Mountain, DR Congo

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Assessing impact of climate change on Sorghum production and analysis of future adaptation measures bears enormous advantages in general and in South Kivu in particular, owing to the country's low adaptive capacity. The analysis shows that climate change will reduce Sorghum production in South Kivu Mountain through time horizons i.e till the year 2030s, 2050s and 2080s. This study was conducted to characterize climate, assess its impact on Sorghum production and identify management options for the climate future dates in South Kivu Mountain DR Congo. Daily climate data, normalized large scale Hadley Centre coupled Model version 3 model predictors and crop and soil data were analyzed. Past and present climate variability characterization was assessed through seasonal rainfall amount, monthly rainfall statistics and dry spell length using R analytical tool and INSTAT climate guide. Temperature variability was examined in terms of pattern and trend. For future projection, Climate change scenarios for rainfall, minimum and maximum temperatures were developed for the period 2001-2099 by using the Hadley Centre coupled Model version 3 under A2a and B2a Special Report on Emission Scenarios using Statistical Downscaling Model version 4.1 software. Decision Support System for Agro-technology Transfer, crop model was used to simulate future changes in Sorghum and to determine best adaptation measures in Kivu area under modified environment. Seasonal rainfall amount was found to decrease with significance for 42 years period ($P < 0.05$) while monthly rainfall statistics showed a high variation (CV of 80.6 to 34.4 % across months). Minimum and maximum temperatures showed an increasing trend at inter annual scale (0.21°C per decade and 0.14°C per decade respectively). The future projection analysis showed a decreasing trend of annual rainfall and increasing trend for temperatures during the period from 2001-2099. Accordingly, the average annual minimum temperature was found to rise in 2020, 2050 and 2080s for A2a and to decrease for B2a emission scenarios. While maximum temperature was predicted to increase in 2020, 2050s and 2080s under both emission scenarios. In 2080s, the average annual maximum temperature increment would be high for B2a scenarios. The crop model simulation indicated a positive impact on the cultivars across climate change scenarios relative to baseline due to climate change by 2100s. As adaptation options under changed climate conditions, And best agricultural practices have been found to be a combination of late planting date, high plant population and high fertilizer application rate. The cultivar has been found to be more sensitive on high fertilizer application rate. Therefore, growing cultivar under future climate condition with improved management options such as high fertilizer application rate, improved soil water and planting in third dekad of July could ensure high yields during a good rainy season. Likewise, good yield could also be observed during a poor rainy season.

Keywords: Downscaling, scenarios, Crop Model, Sorghum

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-11

Land surface temperature in high resolution simulations with RegCM over Southeastern Brazil

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With the refinement of the horizontal resolution of the regional climate models, satellite observations have become a source of information to validate the simulations. In this context, land surface temperature (LST) from Moderate-Resolution Imaging Spectroradiometer (MODIS) was used to validate two Regional Climate Model (RegCM) version 4.6.1 simulations for southeastern Brazil. LST-MODIS is registered only in clear-sky conditions. Here, we used the LST from merging the products from the satellites TERRA and AQUA with 1 km of horizontal resolution for 2010-year. RegCM was driven by ERA-Interim reanalysis and was integrated with 5 km of horizontal grid spacing, using the Emanuel cumulus convection scheme and with different land-surface schemes: the Biosphere–Atmosphere Transfer Scheme (BATS) and the Community Land Model (CLM). These simulations were denominated RegBATS and RegCLM, respectively. Considering the whole simulation domain, RegBATS (RegCLM) has a tendency to underestimate (overestimate) the LST registered by MODIS. Focusing on the large urban centers of southeast Brazil (São Paulo, Rio de Janeiro, Belo Horizonte and Vitória), both simulations reproduce the LST annual cycle in agreement with MODIS. The greatest similarity in LST values between RegCM and MODIS occurs in the coastal regions (Rio de Janeiro and Vitória). For example, in Rio de Janeiro the LST mean annual bias is 0.9oC (-0.6 oC) in RegCLM (RegBATS). In São Paulo, RegCLM (bias of 0.6 oC) is closer to the MODIS, while in Belo Horizonte smaller bias is found in RegBATS (bias of -0.4 oC). The biases over these urban centers are relatively small since they are less than $\pm 1\text{oC}$.

Keywords: land surface temperature, RegCM,MODIS

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-12

Projected trends of precipitation regime in Ukraine during the period of 2020-2050

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The projected spatiotemporal distribution of precipitation in different regions of Ukraine under the climate scenario RCP8.5 was defined. The data of the regional climate modelling project CORDEX EUR-44 have been used for construction time series of projected precipitation. For the Steppe and Forest-Steppe areas, trends of projected climate extreme indices for precipitation were assessed.

The analysis showed that the projected amount of summer precipitation will decrease over the territory of Ukraine, but unevenly in different decades. In the period of 2020-2030 precipitation amount will not change in the northern, central and western regions, but in the Crimea and the Carpathians will decrease by 17% and 38% respectively. In the southern and eastern regions precipitation amount will increase by 17-25%. During the period of 2030-2040 projected precipitation amount will decrease by 7–46% throughout the country, except for the western regions. In decade 2040-2050 an increase in precipitation by 13-15% is expected in the northern and central parts and in the Crimea. In the other regions the amount of precipitation will decrease by 5-38%.

The analysis of time series of the ALTCDD index shown that the number of dry days in all areas will increase and reach up a maximum in 2044-2045. During this period, is projected from 30 dry days in Forest-Steppe to 51 dry days in the southern Steppe.

According to projected trends of the SDII index the precipitation intensity will weakly increase in all regions. The highest intensity up to 5 mm/day will expected in the northern Forest-Steppe at the end of 2040s, when the general decrease of precipitation sums is expected.

The analysis of time series of the R95pTOT index showed that the amount of extreme precipitation will increase during the study period. A maximum amount is projected in the central and south-western Steppe regions, where it range from 115 mm/year in 2020s to 150 mm/year in 2038–2039.

Keywords: climate scenario, precipitation regime, climate extreme index

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-13

Climatic impact over South America caused by the Amazon deforestation during distinct Pacific Decadal Oscillation phases

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Numerical simulations indicate specific changes in the precipitation patterns, mainly during the summer period, over South America due to deforestation scenarios of Amazonian forest: precipitation decrease over adjacent and deforested areas, and, on the other hand, precipitation increase over the eastern South America sector. Diagnostic studies indicate a dipole-like precipitation pattern over the eastern side of South America during the positive and negative Pacific Decadal Oscillation, PDO, phases. In this study we verified the ability of the regional climatic model RegCM new version, RegCM4, in simulate the climatic variability on the decadal scale over South America, from 1970 to 2003.. Additionally, we sought to evaluate the climatic impact over South America due to the extrapolated Amazon deforestation for the year 2050, for the distinct PDO phases. The RegCM4 model was able to represent the precipitation dipole pattern observed over South America for the three PDO phases, although the dipole pattern is displaced southward than the obtained with the NCEP-NCAR reanalysis I precipitation. The deforestation experiment using extrapolated Amazon landuse provided a stronger increase of air temperature and precipitation over South America on the positive PDO phase if compared with the negative PDO phases. The next steps will allow quantifying the climatic impacts during El Niño events occurred on the distinct PDO phases.

Keywords: Amazon deforestation, regional model RegCM4, decadal variability

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-14

An analysis of extreme rainfall events over the Himalayan region using coupled models

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North-West Himalayan (NWH) region in Indian is highly vulnerable to extreme rainfall events. Due to intricate topography, the observational network is sparse in this region. Owing to the limitations with the satellite derived rainfall data sets over the mountainous region, it poses several challenges to the scientific community to analyse and monitor the heavy rainfall events. In a climate changes scenario, a substantial increase of heavy rainfall events over the NWH region is anticipated (Menon et al., 2013; Bharti et al., 2016 and references therein). Therefore, it becomes essential to improve forecasting skills of the regional models to minimise the disastrous impact of the extreme rainfall events on the livelihood of the region, however due to the availability of limited observational data sets, a comprehensive evaluation of the model derived rainfall forecast may not be carried out. Regional models those participated in the CORDEX project uses the boundary conditions derived by coupled climate CMIP5 models. Hence, it is also imperative to assess the coupled climate models in estimating the heavy rainfall events over the NWH region. In the present study 4 CMIP5 models are utilised for analysing the extreme rainfall events for various future warming scenarios (i.e. representative future warming scenarios: RCPs) for present years and towards the end of the 21st century. Present analysis suggests a substantial change in the extreme rainfall events distribution over the NWH region under the warmest future warming scenario RCP 8.5.

Keywords: North-west Himalayan region, extreme rainfall events, regional model, RCP 8.5

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-15

Institutionalization of Climate Adaptation Practices: A Case Study of Planned city of Chandigarh, India

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Cities seem to be very vulnerable to disasters and climate related risks occurring more frequently in recent past. The potential risks of disasters are putting pressure on city governments for devising knowledge based innovative tools to cope with the emerging challenges. Chandigarh, the most attractive planned city in Northwestern India has initiated very remarkable and participatory initiatives for improving environmental conditions in poor neighborhoods and institutionalize climate adaptation practices. The major climate friendly initiatives of the city are introduction of Garbage Bin Free Scheme, Sahej Safai Kendras (Easy Sanitation Centres), Scientific Landfill of Waste, Setting up of Waste to Energy Plant, revitalization of green belts, parks and roundabouts, opting for energy saving street lights, augmentation of secondary and tertiary treatment of liquid waste, SCADA for water management, construction of dedicated bicycle lanes, switchover to CNG/ LPG based automobiles, modernization of fire services and a very important initiative of making solar energy systems compulsory in the larger housing units, institutions and offices etc. The results of the initiatives in Chandigarh have been remarkable. The city has been adopted as a model city for the solar energy and it has been moving very fast in making city a 'solar city'. It has also been adjudged the greenest city in the country. Chandigarh has received awards for providing quality sanitation in 2010, best performance award for providing water supply, waste water management and drainage in 2008, an award for increasing forest and tree cover in 2010 and six award on e-governance during last five years. The paper based on some studies by the author is an effort to describe the initiatives of Chandigarh towards institutionalization of climate adaptation practices.

Keywords: Institutionalization , Climate Adaptation

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-16

Characterization of air and surface temperature coupling over the Tibetan Plateau: Results from multi-source reanalyses

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Tibetan Plateau (TP), known as Earth's "Third Pole", exerts a tremendous influence on regional and even global weather and climate systems through its mechanical and thermal-dynamical forcing. Land-atmosphere interactions are key parts of Earth climate systems. Near-surface air temperature (T_a) and surface temperature (T_s), two crucial parameters of land-atmosphere interactions and climate change, both exhibit significant increasing trends on the TP, however with diverse magnitudes. Yet it is still unclear whether and how the two variables couple with each other along with their involved physical processes. In this regard, this study attempts to analyze the variation characteristics of two individual variables at seasonal and inter-annual scales and detect the distributions and trends of their contrast ($T_s - T_a$) using four latest reanalysis datasets ECMWF family (ERA-Interim and ERA5), MERRA2, and JRA-55, together with gridded observations. Possible forcing mechanisms are explored and discussed furthermore. The present findings will provide insight into regional climate modeling improvement and advance study of land-atmosphere interactions over the TP.

Keywords: Tibetan Plateau, Air temperature, Surface temperature, Temperature contrast, Reanalysis dataset

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-17

Assessment of the Uncertainties of Options in the Noah-MP Land Surface Model Simulations over China

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The interactions between the atmosphere and the land surface is believed to have significant impacts on the climate change. Land surface influences both regional climate and mesoscale atmosphere through exchanges in heat, water and momentum with the atmosphere. The main purpose of this study is to assess the impact of the Noah-MP land surface model options on regional climate simulation over China. Therefore, we have performed 4 groups of simulations during summer and winter seasons of 2007 and of 2015 with the WRF model coupled with the Noah-MP land surface model. Each group contains 5 experiments: NOAHMP, ALB with the BATS snow surface albedo scheme, BTR with CLM stomatal resistance scheme using matrix potentials as function of soil type, DVEG allowing annually constant vegetation fraction and time-varying LAI and SAI from lookup tables, ROUOFF adopting a simple groundwater parameterization based on the TOPMODEL runoff scheme. From the comparison of the mean distribution between observation and experiments, high CORRs and relatively low RMSEs are detected for the temperature. During summers in 2007 and in 2015, warm biases are generally found in the north, while cold in the south. The experiments also underestimate winter temperature in general. However, relative low CORRs for precipitation with larger RMSEs (wet biases) are found in summer. For the intraseasonal variations, the comparisons between the NOAHMP and observation show high CORRs and low RMSEs for the mean surface air temperature in summer and relative large RMSEs in winter. For precipitation, the WRF model shows relatively poor performance in intraseasonal variability with low correlations and large RMSEs especially in summer. The intercomparisons of experiments will be discussed in the future.

Keywords: Noah-MP, options

Parallel Session B: Coupled Models

B1: Atmosphere-land

B1-P-18

Impact of Equatorial and Northern Bay of Bengal SST's on the Indian summer monsoon rainfall

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The influence of East equatorial Indian Ocean and the northern Bay of Bengal SST's on the rainfall pattern over monsoon core zone during Indian summer monsoon is investigated. During Indian summer monsoon, rainfall over monsoon core zone and the SST at the East equatorial Indian Ocean are negatively correlated, whereas it is positively correlated with Northern Bay of Bengal. A new index, the summer monsoon SST index from the SST difference between the East equatorial Indian Ocean and the Northern Bay of Bengal regions is formulated. Summer monsoon SST index shows strong correspondence with the intraseasonal oscillation of Indian summer monsoon and, rainfall over Monsoon core zone varies in coherent with the increasing/decreasing periods of summer monsoon SST index. The rising limb of the monsoon Hadley cell and the associated atmospheric convection shows north-south shifting according to the increasing/decreasing trends of summer monsoon SST index. This coherent variation of rainfall over monsoon core zone with summer monsoon SST index suggests that SST's at East equatorial Indian Ocean and Northern Bay of Bengal are teleconnected with Monsoon core zone and consequently modulate the rainfall pattern over Monsoon core zone

Keywords: Monsoon core zone, Summer monsoon SST index, Indian Summer monsoon

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

ORAL PRESENTATIONS

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Advancing Decadal Climate Predictability in the North Atlantic

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The Earth's climate is fundamentally chaotic and highly sensitive to initial conditions, which imposes limits on the prediction of the climate system. Over the last several decades, great progress has been made in seasonal climate prediction with the steady evolution of climate modeling, but how to make robust decadal prediction remains a challenge in the climate community. In this study, we perform a suite of coupled climate model simulations and experiments to estimate decadal climate variability and predictability in the North Atlantic. The aim is to diagnose the mechanisms behind decadal predictability and to further advance the near-term climate prediction in the North Atlantic. Simulations with the interactive ensemble coupling strategy is applied to reduce the internal atmospheric noise at the air-sea interface, allowing an assessment of how noise affects predictability. We also compare simulations of eddy-parameterized ($1^\circ \times 1^\circ$) and eddy-resolved ($0.1^\circ \times 0.1^\circ$) ocean component models, the purpose of which is to investigate the role of resolved mesoscale ocean features in variability, predictability and air-sea interactions at decadal timescales. The results show that with resolved eddies and mesoscale features, we obtain more realistic estimates of the North Atlantic decadal variability and predictability that are more consistent with the observational estimates. The interactive ensemble can significantly reduce decadal variability but can either increase or decrease decadal predictability depending on the locations, as discussed from the Hasselmann framework. Applying the interactive ensemble can further amplify the role of the mesoscale ocean features especially in ocean eddy rich regions, and advance our understanding of the decadal climate predictability in the North Atlantic.

Keywords: Coupled Model, Decadal Predictability, Interactive Ensemble

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Changes in tropical cyclones and their associated precipitation over North and Central America from a set of RCA simulations under the RCP8.5 scenario

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We evaluate the spatial representation, intensity and duration of Tropical Cyclones (TCs) over the Central America and Mexico (CAM) CORDEX domain on a set of simulations performed with the Rosby Centre Atmospheric (RCA) model forced by 10 CMIP5 General Circulation Models. A process-based evaluation relevant for tropical cyclones is presented, highlighting the features that allow the model to have a good representation of the spatial distribution of TCs, like SST, windshear, etc. We also assess the skill of the different simulations to represent the percentage of total precipitation that is due to tropical cyclones within the domain. Our results show that the RCA ensemble shows an overestimation of TCs over the North Atlantic, and an underestimation over the Eastern Tropical Pacific. The TCs-associated precipitation is comparable with observations, especially on those showing good representation of TCs spatial distribution.

For the future period under the RCP8.5 pathway, the RCA ensemble shows a decrease of precipitation over Mexico and Central America, which is robust across ensemble members (8/10). This decrease appears to be due to a more intense easterly winds over the Caribbean and therefore an increased vertical wind shear.

The density of TCs in the future show a change towards a higher concentration towards the North subtropical Atlantic ocean, and a decrease over the Tropical Atlantic. Similarly it is found a higher TC concentration away from the Mexican coasts and a decrease of TC concentration close to coastal regions.

Although the total precipitation shows a decrease all along Mexico, the TCs-associated precipitation shows an increase (almost double the amount of the historical period) over Northwest Mexico, especially over the Gulf of California, increasing the contribution of TCs-associated precipitation to total precipitation over that region.

Keywords: Tropical cyclones, North and Central America, RCP8.5

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Assessing the water cycle in the MED-CORDEX simulations of the IPSL regional Earth system model

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The regional Earth system model of the Institut Pierre Simon Laplace (RegIPSL) couples the WRF atmospheric model, the ORCHIDEE land surface model and the NEMO ocean model. It has been configured for the Mediterranean region following the MED-CORDEX protocol with an atmospheric resolution of about 20km and ocean resolution of 6-8km. In this model, the water cycle is fully coupled as the river flows simulated by ORCHIDEE are provided to the estuaries in NEMO. The only open boundaries are in the atmosphere, the straight of Gibraltar and the Nile river. Furthermore ORCHIDEE is run with a fully interactive vegetation which allows to represent on the continents the feedbacks between the water cycle and the plant development, a critical aspect of the semi-arid climate of the Mediterranean. For this study we will focus on the 37 year hindcast which covers the period 1979-2016 and allows to sample some of the strongest droughts observed during the past decades. The model was executed either coupled to the ocean or forced with the sea surface temperature to evaluate the role of feedbacks.

The proposed analysis focuses on the water cycle simulated by RegIPSL. In recent years a debate has been ongoing on the amount of fresh water which flows from the continents into the Mediterranean sea and how much is exchanged with the Atlantic through the straight of Gibraltar. We will show where the model stands in the proposed range of values and how far the systematic biases of the model can explain the discrepancy with the various observational based estimates. The inter-annual variability of these fluxes will be analyzed with a particular focus on the contribution of the coupling to the ocean and dynamical vegetation to the extremes which are reproduced by the model.

Keywords: Regiona Earth System model, Water cycle

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Spatiotemporal variability characteristics of Indian Summer Monsoon Rainfall in the twenty-first century - a regional ocean-atmosphere coupled climate model perspective

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A weakening of the land-ocean temperature contrast had been causing a decline in the ISM rainfall in the latter half of the twentieth century. However, since the start of the current century, this gradient has been known to be on the rise again due to the warming of the land. In this study, changes in the interannual to the intraseasonal variability of ISM rainfall have been explored in such a warming scenario. A recorded increment in rainfall following a land-warming trend, however, does not ensure uniform spatiotemporal increases. Temporally, a significant rise in the September rainfall and spatially, rainfall increments in the southern and north-western regions of India act as the influential contributors of the rainfall intensifications in recent years. Spatial variability of rainfall increases with an increase in rainfall magnitudes due to a surge in the heavy rainfall contribution to the seasonal sum. A land-warming induced development of a region of ascent over the northern Indian latitudes accompanied by a weakening of dry air subsidence over these latitudes strengthen the Hadley circulation over the monsoon sector which in turn increases the rainfall associated with ISM.

A regional coupled ocean-atmosphere model within the CORDEX framework has been used with reanalysis forcing over south Asia and the results prove that the model performs very well in replicating the regional variability of ISM rainfall in response to land-ocean temperature contrast changes. A set up of the sort has the potential to assess future changes in the air-sea interactions and the subsequent repercussions in ISM rainfall variability.

Keywords: Coupled Ocean-Atmosphere Modelling, Indian Summer Monsoon Rainfall

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Coupled long-term wave simulations based on Regional Earth System Model over the Mediterranean sea

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We investigate wave climatology over the Mediterranean Basin using reanalysis/observations (ECMWF's ERA5 and MyOCEAN) and coupled Regional Earth System Model (RegESM). The RegESM model is run in coupled (RegCM4 coupled with ROMS and WAM) and uncoupled mode (atmosphere – land only) for 1979-2017 period driven by Era-Interim Reanalysis over the Med-CORDEX domain prescribed under the CORDEX framework. Additionally, the standalone simulation of the wave model (WAM) has been forced by the RegCM wind field (12 km horizontal resolution) for the Mediterranean Sea. We compared simulated mean SWH (Significant Wave Height) results with both the MyOCEAN gage data (SKYRO, 61277, KALAM, LESVO and MYKON) in temporal scale and ERA5 in spatial scale. Comparisons show that temporal variability of the mean SWH is highly consistent with the observations and spatial distribution of the mean SWH is very well captured. Moreover, we compare three model configurations to investigate the role of air-sea interaction in the simulation of key processes that govern wave climate variability over the study area. Our results reveals that the recently developed modeling system RegESM incorporates atmosphere, ocean and wave components and thereby is better capable to improve the understanding of coupled climate system processes. In addition to that, results highlight the importance of atmosphere-ocean-wave coupling in accurate representation of physical processes that influence wave climatology at seasonal timescale over the Mediterranean region.

Keywords: Regional Earth System model, Med-CORDEX, CORDEX, Wave climatology

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Impact of regional air-sea coupling on the simulation of the Iberian Peninsula current climate

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The climate of the Iberian Peninsula (IP) is characterized by great temporal and spatial variability. Changes in the position and intensity of the Azores High cause air masses of different origins to influence the weather over Western Europe, and hence, on the IP, at regional and local scales. The interaction of this variety of air masses with a particularly complex topography and the existing land-sea contrasts produces a range of differentiated regional climates. Moreover, the Iberian climate is also influenced by the large-scale North Atlantic ocean circulation, especially by the Gulf Stream and the North Atlantic Current. In this context, the use of high-resolution atmosphere-ocean coupled models (AOGCMs) is potentially necessary to achieve a correct representation of the IP climate and its variability. However, current oceanic and atmospheric components of state-of-the-art global AOGCMs generally have a resolution which is too coarse to represent adequately the circulation patterns of the North Atlantic, a key region for global climate.

The aim of this study is to examine the role of air-sea coupling processes in the representation of the present-day climate of the Iberian Peninsula. To that end, we perform a series of ocean-atmosphere coupled and atmosphere-only simulations that expand from 1980 to 2012. We adopt the regional atmospheric model REMO (Jacob, 2001) and the regionally-coupled model ROM (Sein et al. 2015). In our experiments, the atmospheric model is run with a horizontal resolution of 25 km. The horizontal resolution of the ocean model reaches up to 10 km (eddy permitting) within the IP and decreases gradually, reaching a minimum of 100 km in the southern seas. Outside the coupled domain, simulations are driven by ERA-Interim reanalysis, with a horizontal resolution of 75 km. Additionally, the role of forcing resolution in the representation of the climate of the IP is assessed by the examination of a series of simulations forced with data from MPI-ESM (Giorgetta et al. 2013). The MPI-ESM RCP85 simulation used as boundary conditions has T63 (c.a. 1.9°), 47 levels in the atmosphere, 1.5° resolution (near the equator) and 40 vertical z-levels in the ocean. Our results show that air-sea coupling magnifies winter temperature and precipitation errors relative to the E-OBS gridded observational database due to drawbacks in the representation of the North Atlantic ocean circulation. However, in summer, when large-scale circulation patterns only influence the IP climate to a small extent, air-sea interactions reduce biases. In this season, the influence of the Mediterranean Sea plays a role in the improvements observed.

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Keywords: Regional air-sea coupling, Atmospheric circulation, Ocean circulation, Climate of the Iberian Peninsula

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Performance of a high resolution regional ocean-atmosphere coupled model over western North Pacific region: Sensitivity to cumulus parameterizations

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We developed a high-resolution regional ocean-atmosphere coupled model, based on RegCM4 and a North Pacific Ocean model, through the OASIS3 coupler. The horizontal resolution of the atmospheric component (oceanic component) was set to 15 km (0.1°). With the motivation to customize the model over western North Pacific (WNP) region, the sensitivity to three cumulus parameterization schemes (MIT-Emanuel, Tiedtke, Kain-Fritsch) was investigated. The results indicated that a simulation with the Tiedtke scheme exhibited the relatively best performance over this region in terms of sea surface temperature (SST), rainfall, and circulation. Fifty percent of the model grids had biases of SST (rainfall) within ± 0.5 °C (± 2 mm/day) over WNP. In addition, the simulation with the Tiedtke scheme reasonably captured the shape and magnitude of the monsoon trough rainfall, the northward movement of the rainband and the associated circulation changes over WNP. However, the apparent heat source (Q1) and moisture sink (Q2) in the simulation with the MIT-Emanuel (Kain-Fritsch) scheme were nearly half (double) those of the observed measurements, especially in the lower troposphere over the monsoon trough region. The too weak (too strong) diabatic heating favored a weaker (stronger) ascending motion, which led to the underestimation (overestimation) of vertical moisture advection over the monsoon trough, thus resulting in evident dry (wet) biases. Our analysis suggested that the improved performance using the Tiedtke scheme could be attributed to the improved simulated vertical profile of diabatic heating, the inclusion of the effects of large-scale forcing in the cumulus parameterization, and the reasonable simulated relationship of precipitation with low-level vertical velocity.

Keywords: Regional ocean-atmosphere coupled model, monsoon

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Impact of climate change on sea surface wind speed over the Southeast Asia : results from a RegCM4 dynamical downscaling of CNRM-CM5 in the CORDEX-SEA framework.

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South East Asia climate system shows a large range of variability scales, from extreme events to interannual variability. Understanding its answer to climate change is of primary scientific and socio-economic importance, the IPCC-AR5 however pointed the considerable lack of knowledge in regional climate change and its impact in this region. In particular very little is known about the answer of wind to climate change, though it is a major ingredient of ocean circulation. We investigated the impact of climate change on sea surface wind speed, examining changes in daily and extreme event scales, interannual variability and climatological average. For that we used the RegCM4 regional atmospheric model to perform a dynamical downscaling of CMIP5 simulations done with the CNRM-CM5 global climate model. Comparisons with QuikSCAT satellite data show that the downscaled simulations perform overall better than the global simulations. Both models produce regionally and seasonally contrasted results in terms of daily wind speed evolution between the XXth and XXIst centuries. Global simulations produce mostly weak and non significant changes, only suggesting an intensification of northeast winter monsoon in the northern part of the domain. Conversely regional simulations suggest from March to November in the northern SCS and PAC and in the SEA south equatorial region a weakening of wind speed at all temporal scales, for regions and periods of initially strong wind speed values. This decrease of daily variability and extreme wind speeds is associated with a -40% and to -50% decrease of TC frequency.

Keywords: CORDEX-SEA, Dynamical downscaling, surface wind, climate change, tropical cyclones

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

Can ocean-atmosphere climate change at the coastal scale be achieved? The example of the Adriatic Sea

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With the aim to study the impact of climate change on the processes driving the Adriatic thermohaline circulation (i.e. Adriatic-Ionian Bimodal Oscillating System, dense water formation, etc.) and its manifestation in coastal regions, the ultra-high resolution (3-km for the atmosphere and 1-km for the ocean) Adriatic Sea and Coast (AdriSC) Climate component was developed in the framework of the Croatian funded ADIOS project. The main challenges posed by such an approach are (1) the relative slowness of the modelling suite (1 month of simulation per day), and (2) the low temporal and spatial resolutions (only few vertical levels for daily or monthly data) of the coupled Regional Climate Models (RCMs) available to provide boundary conditions for the AdriSC models. In consequence, the classical climate change approach (consisting in 30-year evaluation, 50-year historical and 100-year scenario runs) could not be implemented within our study and the surrogate climate change approach was used instead. This approach was developed and well tested for atmospheric studies only. It mostly consists in adding a climatologic differential (derived from the difference between scenario and historical results of a given RCM for a given period) to the forcing of a 30-year high resolution evaluation run. In this study, we will present (1) the set-up of the AdriSC Climate component and the first results of the evaluation run performed for the 1987-2017 period and (2) the methodology used to adapt the surrogate climate change approach to the coupled ocean-atmosphere model.

Keywords: ocean-atmosphere, coastal scale, Adriatic Sea

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

POSTER PRESENTATIONS

LAST NAME	FIRST NAME	TITLE	POSTER NUMBER
ALIZADEH CHOOBARI	Omid	Contribution of the El Niño-Southern Oscillation on the strength and duration of the Indian summer monsoon	B2-P-01
CHEN	Lin	The Response of ENSO Asymmetry to Global Warming	B2-P-02
CHEN	Lin	Causes of the Asymmetric SSTA Zonal Spatial Pattern between Strong El Niño and La Niña	B2-P-03
CHEN	Lin	Cause of ENSO period simulation biases in coupled models	B2-P-04
GAOL	Adelina	Simulation of Dahlia Tropical Cyclone Impact on Atmospheric Dynamic and Ocean in Sunda Strait Using DELFT-3D Model	B2-P-05
LI	Delei	An atmosphere-wave regional coupled model over the East China Sea: skills assessment of simulated wind and wave	B2-P-06
MANDAL	Shailendra	Effect of sea level rise on metro city: lessons from urban coastal communities from India	B2-P-07
YANG	Minghao	Influence of cumulus convection schemes on winter North Pacific storm tracks in the Regional Climate Model RegCM4.5	B2-P-08

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-01

Contribution of the El Niño-Southern Oscillation on the strength and duration of the Indian summer monsoon

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As a quasi-periodical natural phenomenon, the El Niño-Southern Oscillation (ENSO) is one of the main driving forces of the Indian summer monsoon. Using the European Centre for Medium-Range Weather Forecasts (ECMWF) reanalysis Interim (ERA-Interim) data for the period 1979-2016, impacts of different phases of ENSO on the Indian summer monsoon are investigated, with an emphasis on different responses of the Indian summer monsoon to the eastern and central Pacific El Niños. Our analysis indicated that El Niño and La Niña are associated with weakening and strengthening of the Indian summer monsoon and associated moist southwesterly winds over the Indian subcontinent, respectively. It is also found that there is a higher possibility for the occurrence of the positive phase of the Indian Ocean Dipole (IOD) during the eastern Pacific El Niño, which causes cooler water and drier conditions in the eastern Indian Ocean, and warmer water and higher precipitation in the west. The Hadley circulation also responds to different phases of ENSO, such that anomalous subsidence establishes over most parts of the Indian subcontinent during both the eastern and central Pacific El Niños, causing shorter duration of the Indian summer monsoon. The impact of the central Pacific El Niño on the Hadley circulation is stronger than that of the eastern Pacific El Niño. A strong correlation between sea surface temperature anomalies in the tropical Pacific Ocean and the mid-tropospheric geopotential height anomalies over the Indian subcontinent is identified during the pre-monsoon month of April, with positive and negative geopotential height anomalies during El Niño and La Niña, respectively. This implies that the mid-tropospheric geopotential height anomalies in April can be used as an indicator to predict the strength of the upcoming Indian summer monsoon.

Keywords: El Niño-Southern Oscillation, Indian summer monsoon, Hadley circulation

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-02

The response of ENSO asymmetry to global warming

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How the ENSO amplitude asymmetry respond to global warming (GW) gradually becomes a hot topic. However, the projected changes in ENSO amplitude under global warming are divergent. In this work, we choose a representative model, CCSM4, to explore the possible mechanisms of ENSO asymmetry changes in the future (since the CCSM4 exhibits outstanding performance in representing positive ENSO skewness in the present-day simulation, while the majority of current the CMIP5 models are still struggling with simulating ENSO amplitude asymmetry reasonably). This model from NCAR simulates present-day's (PD's) ENSO skewness reasonably, and it exhibits obviously weakening in ENSO amplitude asymmetry in future. Specifically, the amplitude of El Niño becomes weakened significantly in future whereas the change in the amplitude of La Niña is minor, leading to the weakening in ENSO amplitude skewness in future. Based on thorough diagnoses, we find the physical reasons for the asymmetric changes in El Niño and La Niña amplitudes primarily arises from the asymmetric changes in anomalous precipitation response to SSTA. The asymmetry in the anomalous precipitation response between El Niño and La Niña leads to the asymmetric changes in the zonal wind stress anomaly response to SSTA. The zonal wind stress anomaly response for the warm events becomes weaker and shows markedly westward shift in GW than its counterpart in PD, while the zonal wind stress anomaly response for the cold events only becomes slightly stronger and shows no obvious changes in east-west distribution in GW. This causes the asymmetric changes in the oceanic thermocline response to zonal wind stress anomaly between the warm and cold events in GW, with weaker thermocline response for El Niño and changeless thermocline response for La Niña. Consequently, the zonal advective feedback and thermocline feedback for El Niño is significantly weakened whereas the counterparts for La Niña show minor changes, leading to the significantly weaker El Niño but changeless La Niña in future. Thus, the ENSO amplitude exhibits weaker skewness in future.

Keywords: ENSO asymmetry, asymmetric precipitation response, asymmetric thermocline response

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-03

Causes of the asymmetric SSTA zonal spatial pattern between strong El Niño and La Niña

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Observed sea surface temperature anomaly (SSTA) in equatorial eastern Pacific exhibits an asymmetric zonal spatial pattern between strong El Niño and La Niña: Strong El Niño events tend to be located more in the eastern Pacific with SSTA center around 125°W, whereas strong La Niña events tend to be located more in the central Pacific centered around 148°W. So far, the physical mechanism of the spatial pattern of strong El Niño (warm event) being eastward shifted compared with that of strong La Niña (cold event) is unclear. The physical mechanism of the production and evolution of the asymmetric SSTA zonal spatial pattern between strong ENSO events are investigated through composite analysis, quantitative diagnosis and numerical sensitivity experiments. We design one set of atmospheric general circulation model (AGCM) experiments with two symmetric SSTAs, which have equal amplitude and same spatial pattern but opposite sign. The result shows that both dynamic feedback (surface wind stress anomaly) and thermodynamic feedback (short wave radiation and latent heat flux anomaly) during El Niño are eastward shifted compared with those during La Niña, which are forced by two symmetric SSTAs. Further, three sets of oceanic general circulation model (OGCM) sensitivity experiments are performed respectively with the surface wind stress anomaly, short wave radiation heat flux anomaly and latent heat flux anomaly obtained from the AGCM experiments above. It is confirmed by the OGCM experiments that both asymmetric dynamic feedback and thermodynamic feedback contribute to the zonal spatial pattern asymmetry between strong El Niño and La Niña and these two feedback processes are equally significant. This work revealed for the first time that the asymmetric SSTA zonal spatial pattern between strong El Niño and La Niña is caused by both the asymmetric ENSO dynamic process (surface wind stress - SSTA feedback) and asymmetric ENSO thermodynamic process (short wave radiation heat flux - SSTA feedback, latent heat flux - SSTA feedback).

Keywords: ENSO, Zonal spatial pattern, Asymmetry, Numerical sensitivity experiment

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-04

Cause of ENSO period simulation biases in coupled models

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To investigate the cause which leads to biases of ENSO period simulation in coupled models, four interesting coupled models are used to analyze their ENSO period. Specifically, these four models are constructed by cross-coupling the atmospheric component and oceanic component of two commonly used coupled models. Based on the comparison between the ENSO period in the observation and model simulations, the four parent models are separated into two groups according to their atmospheric components: Grid-point Atmospheric Model of IAP LASG Version 2 (GAMIL2)-based models whose ENSO period are shorter than observation, and Community Atmosphere Model Version 4.0 (CAM4) -based models whose ENSO amplitudes are longer. Wyrтки index analysis on ENSO period shows that the meridional structure of zonal wind stress is the critical factor to determine the period simulation among these coupled models. The longer period in CAM4-based models is attributed to broader meridional width of zonal wind stress, while a short period in GAMIL2-based models is caused by the narrower meridional width. Different patterns of precipitation responses to ENSO in two groups of models show many influences onto meridional structures of wind zonal stress. The bias of climate mean SST simulation is the root cause which modulates the structures of precipitation anomalies, and the extra-tropical central Pacific may be the key region.

Keywords: Cross-coupled models, Wyrтки index, simulation bias of climate mean state

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-05

Simulation of Dahlia Tropical Cyclone impact on atmospheric dynamic and ocean in Sunda Strait using DELFT-3D Model

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The Dahlia Tropical Cyclone occurred during the period November 27th until December 2nd, 2017, with increasing strength in the West Indian Ocean near the Bengkulu Sea. Altimetry satellite data was used to determine the condition of sea level anomaly and showed an increased sea level anomaly of about 0.3-0.4 meters, but experienced a less significant change from the previous conditions caused by the distance of cyclone trajectories which are quite far from the verification station area. Delft-3D simulation modeling was conducted to determine the condition of the ocean and atmospheric dynamics during the Dahlia Tropical Cyclone phase. The peak of the significant wave height reached a value of 3.24 meters at the Ciwandan Station which was caused by wind induction from the Dahlia tropical cyclone. The peak of swell height reached a value of 3.0 meters with the direction of propagation towards the Sunda Strait. Automatic weather system data shows that wind direction is mostly from the Southwest with speeds reaching 11-17 knots during Dahlia Tropical Cyclone. The study presented here proves the important rule of wind induction on swell propagation from tropical cyclones which causes maximum significant wave heights and sea level anomalies. The Delft-3D model results compare favorable with observations from the Geospatial Information Agency revealing a strong correlation of 0.86 indicating that the Delft-3D model in this case provides trustworthy predictions.

Keywords: Delft-3D, sea level anomaly, tropical cyclone

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-06

An atmosphere-wave regional coupled model over the East China Sea: Skills assessment of simulated wind and wave

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The coupling of models is a commonly used approach when addressing the complex interactions between different Earth System components. This study focuses in the non-linear interaction between the waves and atmosphere models. Several sensitivity experiments have been performed to investigate the impact of atmosphere-wave coupling on the simulated wind and wave over the East China Sea. These experiments include stand-alone regional atmosphere model (CCLM) simulation, stand-alone spectral wave model (WAM) simulations driven by the regional atmosphere model CCLM or ERA5 reanalysis wind, and two-way (CCLM-WAM) coupled simulations. The two-way coupling is done interactively using OASIS3-MCT libraries. The frequency of the exchange between CCLM and WAM is set to 6 minutes for the coupled run. We compared the simulated wind speed and significant wave height against in-situ and remote sensing data for 2010. Results show that the coupled model can be better in capturing the significant wave height during typhoon events than ERA5. Considering the wave-induced stress led to improving the model skills during extremes, especially in the near-coastal areas. The validations of wind speed/significant wave height against satellite observations showed that the two-way model outperforms/underperforms both the stand-alone CCLM/WAM and ERA5 reanalyses. On the other hand, a comparison with wave buoy observations in the coastal areas demonstrates improvement of the two-way simulations in respect to stand-alone model or ERA-5 reanalyses. High-horizontal-resolution coupled model intensifies the simulation of storms compared to ERA-5 re-analyses. We demonstrate the differences between the different experiments in capturing the surface pressure, wind speed, roughness length field and vertical profiles (temperature, pressure and wind speed) to find out the interaction mechanism between atmosphere and wave.

Keywords: East China Sea, Atmosphere-wave coupling, CCLM, WAM

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-07

Effect of sea level rise on metro city: lessons from urban coastal communities from India

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Societies have lived with the vibrant nature of land and coastal environments for ages. Vulnerability of coastal areas to climate change is an important issue, which has gained attention recently. Faced with rising sea levels and the likelihood of increasing storminess, coastal communities are on the front line of climate change impacts. Coastal areas face multiple risks and stresses related to climate change and variability. Impacts of sea level rise are expected to have predominantly adverse effects on natural and human systems. Coastal communities are highly vulnerable to climate change impacts, mainly because of three main reasons, high resource dependency, high exposure and limited adaptive capacity. This raises concerns about coastal community's sustainability. India has a 7,517 km long coastline with many low-lying and densely populated areas with nearly 260 million people living within 50 km of the seacoast. These highly vulnerable areas house a network of infrastructures. It is highly pertinent to start climate adaptive infrastructure and services, given the climate sensitive nature of the existing infrastructure systems in the coastal area. It could be maintained and managed in such a way that it is prepared to withstand sea level changes impacts.

This paper discusses on approaches that can increase resilience of infrastructure and the services in coastal urban areas of developing nations. It also highlights the Identification of vulnerable hot spots in the coastal areas, recommendations for climate proofing infrastructure and services and methodology for vulnerability assessment of coastal communities to climate variability and sea-level changes. It also recommends appropriate policy and institutional reform, capacity building and improved knowledge management towards increasing the resilience and adaptive capacity of these coastal communities to current and future sea level changes.

Keywords: Climate change, Sea level rise, Coastal communities, Vulnerability mapping, Climate adaptive infrastructure

Parallel Session B: Coupled Models

B2: Ocean-Ice-Atmosphere

B2-P-08

Influence of cumulus convection schemes on winter North Pacific storm tracks in the Regional Climate Model RegCM4.5

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The simulation ability of the regional climate model itself and the choice of the parameterized scheme configuration of various physical processes are particularly important. Based on the regional climate model RegCM4.5 driven by National Centers for Environmental Prediction (NCEP) reanalysis, the influence of cumulus convection schemes (CCSs) on the winter North Pacific storm track (WNPST) is investigated. It is found that the climatology, interannual variation, spatial modes and characteristic indices of the WNPST are extremely sensitive to the choice of CCS. Among the selected CCSs, WNPST climatology and interannual variation in the Kuo scheme are better than in other CCSs, with a smaller root mean square error (RMSE). The WNPST spatial modes and strength indices in the Kuo and Grell schemes are more consistent with NCEP reanalysis. The Kuo scheme has a stronger ability to simulate the WNPST latitude index and the interannual variation of winter characteristic indices. In addition, we attempt to reveal the possible reasons for the different performances of CCSs from the viewpoint of baroclinic energy conversion (BCEC). It is found that the energy conversion from the mean available potential energy to the eddy available potential energy (BCEC1) has no significant difference among the Kuo, Grell and Emanuel schemes, while energy conversion from the eddy available potential energy to eddy kinetic energy (BCEC2) in the Kuo scheme is obviously better than other CCSs, which means that the differences in BCEC2 among these CCSs may be one of the key reasons affecting the simulation results of the WNPST.

Keywords: cumulus convection scheme, regional climate model, storm track, interannual variation, baroclinic energy conversion

Parallel Session B: Coupled Models

B3: Biogeochemical processes

ORAL PRESENTATIONS

Parallel Session B: Coupled Models

B3: Biogeochemical processes

Evaluation of the Mediterranean climate and marine biogeochemistry with the Regional Earth System Model RegCM-ES

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We evaluate the skills of a new version of the Regional Earth System model RegCM-ES in reproducing the climate and the marine biogeochemistry of the Mediterranean region. Novel aspects of this coupled system include a new version of the atmospheric module RegCM (version 4.6.1) and the marine biogeochemical model, BFM, online coupled to the ocean circulation model MITgcm. The evaluation of RegCM-ES performances with respect to available datasets shows that the model is able to capture spatial patterns, inter-annual and inter-monthly variabilities and mean climate in the region together with horizontal and vertical patterns of chlorophyll-a, dissolved nutrients and oxygen and mean values of net primary production in the marine environment. Some improvements are found in the representation of the surface temperature over the land in winter and fall, of the precipitation and evaporation over the sea and of sea surface temperature. The model, despite some persistent biases such as a warm and dry bias over the land in summer, the overestimation of short wave during summer, evaporation from the sea, sea surface salinity and vertical mixing in the some parts of the basin, is able to capture some key aspects of the regional Mediterranean climate and its marine biogeochemistry.

Keywords: RegCM-ES, Mediterranean region, Chlorophyll-a, Net primary production, Dissolved nutrients, Dissolved oxygen

Parallel Session B: Coupled Models

B3: Biogeochemical processes

Analysis of a dust storm event of May-June 2018 using NWP model

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Dust storms, are considered as one of the potent extreme environmental events and are responsible to affect human life in various sectors. Dust storm is the emanation or transport of dust in the atmosphere from the surrounding areas, which can reduce visibility, affect the respiratory system of human being, cause the reduction of agriculture production, and further affect various socioeconomic sectors. Dust storm responsible for its huge contribution to increase in the pollution over urban areas. During spring time due to increase in the soil temperature there is a decrease in the soil moisture over desert areas. Low moisture availability in the soil and weather conditions such as speed of winds leads to release of dust particles into the atmosphere. A dust storm is a meteorological phenomenon common in arid and semi-arid regions. West Asia is mostly arid or semiarid region and such conditions makes it vulnerable as one of the important source region of dust emission under favorable meteorological conditions. A dust storm originated over Iran, Turkmenistan, Afghanistan, and Pakistan on late-May 2018, due to a strong upper level storm system that tracked north of the region. The event was so severe that it swept a larger region extending from west Asia to the Indian subcontinent. In the present study, we attempted to analyse this extreme dust episode using Weather Research and Forecasting (WRF) model coupled with Chemistry for the purpose to evaluate the model performance in capturing the entire cycle of event for e.g. emission, transportation, suspension and dissipation. Model performance throughout the event period has been assessed using ground based and satellite derived estimates. It is noted based on the statistically robust test that WRF-Chem can simulate extreme dust episode reasonably well. Present study has implications for improved forecasting of episodic dust events.

Keywords: Dust storm, air quality, west Asia, WRFF-Chem ,Dust storm, air quality, west Asia, WRFF-Chem

Parallel Session B: Coupled Models

B3: Biogeochemical processes

POSTER PRESENTATIONS

LAST NAME	FIRST NAME	TITLE	POSTER NUMBER
KHAN	Rehana	Assessment on the variability in optical and radiative effects of key aerosol types over IGP and NCP regions: Temporal heterogeneity and source identification	B3-P-01
TARIQ	Salman	Spatio-temporal Distribution of Aerosol Optical Depth over South Asia using MODIS data	B3-P-02

Parallel Session B: Coupled Models

B3: Biogeochemical processes

B3-P-01

Assessment on the variability in optical and radiative effects of key aerosol types over IGP and NCP regions: Temporal heterogeneity and source identification

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Radiative forcing due to aerosols is a key parameter in quantifying their crucial impacts on climate change. It largely depends on chemical, optical and microphysical characteristics of aerosols. In order to understand the temporal evolution, properties, and effects of atmospheric aerosols over the IGP (Indo-Gangetic Plain) and NCP (North China Plain), considered as aerosol hotspot regions located in Asia, significant knowledge on the aerosol heterogeneity have been well established from individual observations over different sites in the two regions using limited span of measured data. To the best of our knowledge and existing literature, we understand that none of the researchers have studied and compared the aerosol characteristics utilizing the existing long-term AERONET data over these large aerosol regions. To achieve an in-depth understanding in the aforementioned, the present study aimed to identify and classify the major aerosol types following the very important clustering techniques adapted by several authors (e.g., Russell et al., 2012) and investigate the possible implications to radiative forcing over the regions based on the AERONET's sun photometer measured data during 2007-2018.

Differentiation of aerosol types over the selected sites in two regions was made using the appropriate thresholds for size-distribution of aerosols (i.e. fine-mode fraction, FMF) and radiation absorptivity (i.e. SSA440 and EAE). A detailed knowledge on the dominant absorption aerosol types was also investigated to unravel the mechanisms of aerosol radiative forcing and improve the accuracy of satellite remote sensing. Four different aerosol types were identified, viz., pure dust (PUD), polluted dust (POD), polluted continent (POC), mostly absorbing (MAB i.e., black carbon) and mostly non-absorbing (MNA i.e., organic carbon), in which the contribution of MAB type was found higher in Beijing and Lahore followed by POC to the total aerosols. However, Sacol and Karachi sites were found affected mostly with PUD, POD and POC. To detect the presence of specific emission sources that enhance the pollution over receptor sites, the conditional bivariate probability function (CBPF) and concentration weighted trajectory model are employed in the present study. Besides, the spectral dependencies of optical properties for these aerosol types differed considerably, with low variations for the dust and absorbing type of aerosols in AOD and SSA, respectively. The results will be further used to assess and quantify their radiative implications over the study regions. It is revealed that the higher atmospheric forcing was observed for MAB aerosol type at Beijing followed by POD type in Lahore, Karachi and Sacol along with the corresponding higher atmospheric heating rates. Whereas, the lowest was found for the POC aerosol type in Kanpur and Lahore during the study period.

Keywords: AERONET, Aerosol types, Optical and radiative effects, Multivariate statistical analysis, Asia

Parallel Session B: Coupled Models

B3: Biogeochemical processes

B3-P-02

Spatio-temporal distribution of Aerosol Optical Depth over South Asia using MODIS data

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Aerosols play an important role in climate of the region. In this paper an effort has been made to study the spatio-temporal trends of aerosol optical depth (AOD) over South Asia. For this purpose, we have used AOD at 550 nm from Moderate Resolution Imaging Spectroradiometer (MODIS) during the period September 2002-August 2015. We have also compared AOD from Aqua-MODIS with those of Terra-MODIS, MISR and SeaWiFS. The highest value (0.973) of correlation coefficient (R) was found between Terra-AOD and Aqua-AOD while for MISR and SeaWiFS, values of R were found to be 0.711 and 0.520 respectively. During winter, the highest values (~ 1) of AOD were recorded over eastern part of Indo-Gangatic Belt (IGB) while during monsoon, highest values (~ 1) of AOD were found over western part of IGB consisting of Indus river basin in Pakistan. AOD anomaly were also calculated for the study region. Maximum values (~ 0.4) of AOD anomaly were detected over western parts of IGB in monsoon season. Time series of monthly deep blue Aqua-AOD over South Asia showed increasing trend with $\Delta AOD = 9.75\%$. Annual mean AOD was found to be 0.290 ± 0.048 with maximum value in the month of June and lowest in September.

Keywords: Aerosols, Remote sensing, South Asia

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

ORAL PRESENTATIONS

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Ubiquitous increase of extreme heat stress under global warming from CORDEX-CORE climate projections

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Global mean temperature is projected to increase in response to elevated greenhouse gas concentrations. In alignment with global warming, the risks of heat stress will be likely to increase in the future. However, the change in the global mean temperature does not linearly disaggregate into regional to local impacts on extreme heat stress in a straightforward manner. While regional to local extremes do not necessarily scale with global mean changes, heat stress may not linearly respond to temperature only and the change in relative humidity and temperature is often negatively correlated under global warming due to the limited moisture sources at the regional scale. In this study, we investigate the changes in characteristics of extreme heat stress under RCP2.6 and RCP8.5 scenarios using the enormous regional climate projections generated within the CORDEX-CORE framework. RegCM4 with 25 km horizontal resolution, whose physical parameterizations are optimized for individual domains, is used for the dynamical downscaling of multiple GCMs over the nine selected CORDEX domains including North, Central and South America, Europe, Africa, East, South and South-East Asia and Australia. The wet-bulb temperature and Heat Index, which represent the combined effects of temperature and humidity, are used to measure the human thermal comfort. The analysis will be focused on identifying regionally emerging severity and the risk of heat stress that are considered upper boundaries on human heat tolerance. The comparison of results between RCP2.6 and RCP8.5 scenarios will provide a valuable insight for possible benefits of global warming mitigation even at regional scales. This study will help to enhance public awareness of the potentially drastic effects of climate change.

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Keywords: extreme heat stress, CORDEX-CORE

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Putting distillation into practice: co-developing climate services to build resilience across South Asia

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Despite the risks posed by climate change to the South Asia region, the uptake and use of available regional future climate projections is currently limited. Multiple national projects, regional research programmes, and international initiatives have produced climate change projections for the region, using different models and methods. Combining and communicating this range of information to different stakeholders presents significant scientific and practical challenges.

The Climate Analysis for Risk Information and Services in South Asia (CARISSA) project is part of a new four-year Asia Regional Resilience to a Changing Climate (ARRCC) programme funded by the UK Department for International Development. The project aims to improve the utility and uptake of regional climate information, including CORDEX South Asia data through collaboration with IITM, to support decision-making, through enhanced regional coordination with a focus on four countries; Afghanistan, Bangladesh, Nepal and Pakistan. This presentation will provide a summary of the CARISSA project as part of the ARRCC programme, highlighting joint research with ICIMOD as key collaborators on the project. We will outline our approach to distilling the existing body of regional climate information for key sectors, including assessing climate change impacts on the hydropower sector. The approach aims to extract relevant messages to inform decision-making and the co-development of climate services to build resilience to a changing climate.

Keywords: climate projections, regional climate impacts, regional climate change, climate services

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Compound climate extremes and exposed population in Africa at different global warming levels using CORDEX-CORE projections

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Africa is considered to be one of the most vulnerable continents due to its high exposure and low adaptive capacity related to climate change (Niang et al., 2014). Furthermore, Africa is the second most populous continent in the World after Asia, with high rates of population growth, such that the UN DESA projects that the population of the African continent, will double by the middle of this century.

Africa, and the African population, is already exposed to many climate risks including heatwaves, drought and intense rainfall events, which can lead to flooding. Despite wide recognition and acceptance within the global community of the need to urgently and drastically reduce global carbon emissions to meet the goals of the Paris Agreement, the evidence is that our emissions continue to rise. As such, the Earth will continue to warm, and changes in these kinds of extremes will likely occur, placing the African population at increased risk of harm. The level of risk faced will ultimately depend on what kind of pathway our carbon emissions develop along.

In our presentation, we will analyze compound climate extremes such as heat waves combined with droughts and/or extreme precipitation, and the exposed African population to those climate extremes under two different global warming levels. In detail, we will discuss the intensity, frequency and duration as well as the co-occurrence of climate risks with focus on sub-Saharan regions. For the analysis, we will exploit the newly performed ensemble of CORDEX-CORE simulations for Africa at a spatial resolution of 25 km, and spatial maps of population distributions based on scenarios consistent with the Shared Socioeconomic Pathways (SSPs).

Reference:

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Keywords: compound climate extremes, population, Africa, global warming levels, CORDEX-CORE

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Implementation of a new aging parameterisation scheme in RegCM4

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Black carbon (BC) is an important short-lived climate pollutant (SLCP) and the second largest contributor to global warming after CO₂. With a simplistic aerosol scheme and fixed aging of 1.15 day (~27.6 hours) RegCM4 does not capture the dynamic aging of BC as a function of coagulation and condensation. When freshly emitted, soot is hydrophobic, but aging of soot due to condensation and coagulation changes its hygroscopic and optical properties. Neglecting these processes leads to large uncertainty in BC forcing and feedback processes. In this work, a reduced aging parameterization scheme has been implemented in RegCM4, to improve its BC representation. RegCM4 has been simulated over the South-Asian CORDEX domain with anthropogenic aerosols for the year 2010 to understand the impact of the new aging scheme. Our study domain is India, being an important contributor of global BC burden. Two sets of simulation has been performed for this study: (i) control simulation i.e considering the fixed aging scale of 1.15day and (ii) simulation with new dynamic aging scheme. Our study showed that the aging timescale from hydrophobic to hydrophilic occurs is less than 20 hours over less polluted regions and is less than 10 hours over polluted regions of India, especially over Indo-Gangetic basin (IGB). These aging scales vary with months but is always less than the fixed aging value over majority of India. Secondly with the new scheme the BC columnar burden and surface mass concentration has increased by almost 7-10%, most pronounced during the drier season (Jan–Feb) when washout is negligible. This can be attributed to more hydrophilic BC formation whose depositional velocity is much less than hydrophobic BC, based on particle size.

Keywords: Aging parameterisation, RegCM4, Black carbon

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

End of 21st Century Projections of Precipitation Extremes in Southeast Asia based on multi-model CORDEX-SEA simulations

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Based on the ensemble of 8 members of the 25 km x 25 km simulations of CORDEX Southeast Asia (CORDEX-SEA), which comprise of 7 GCMs and 4 RCMs, this paper presents the end of 21st century projection of seasonal precipitation extremes over Southeast Asia region under RCP4.5 and 8.5. We utilize the indices of the Expert Team on Climate Change Detection and Indices (ETCCDI) of Consecutive Dry Days (CDD), the precipitation extreme intensity (RX1day) and the precipitation extreme frequency of R10mm and R20mm. The performances of the ensemble during the historical period (1986 – 2005) compared to the Tropical Rainfall Measuring Mission (TRMM) 3B42 version 7 based on the grid-by-grid are considered reasonable although biases can be notable. The probability density function of the anomaly of indices indicates the model ensemble reasonable approximation of the precipitation extreme distribution. A number of significant and robust changes are projected by the end of 21st century (2081 – 2100). The most striking one is the drying tendency during boreal summer, especially over Indonesian region. Significant and robust CDD changes prevail especially under RCP8.5 over Sumatra, Java, Kalimantan and Sulawesi. Other regions including Peninsular Malaysia, Cambodia and Vietnam also are projected to experience increased CDD. On the other hand, Myanmar, northern Thailand and Laos are projected to have increased precipitation extreme intensity during boreal winter especially under RCP8.5. In some areas, significant changes are projected in all three indices.

Keywords: Precipitation Extremes, CORDEX, Southeast Asia

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

Evaluation of the effects of a multiphysics ensemble on the simulation of an extremely hot summer in 2003 over the CORDEX-EA-II Region

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The performance of multi-physics ensemble of WRF model is assessed and evaluated for the JJA extreme precipitation and temperature in 2003 over the CORDEX-EA-II domain. While relatively larger biases of model precipitation and temperature are evident over the sub-regions where the effects of mesoscale processes are important, the combinations of WRF physical schemes also show dependency on geographic location and climate regimes. Comparably, the cumulus and microphysical schemes have substantial influences on the simulation of precipitation, and the land surface models and cumulus schemes play crucial roles in the surface temperature. The combination of Noah for the land surface process, Lin for the microphysics, G3D for the cumulus parameterization and CAM for the radiation scheme can provide the most reliable reproduction of both precipitation and temperature extremes over China. The wind fields at low-to-middle atmospheric levels, which is closely connected to model's ability to reproduce regional extremes, are sensitive to the model treatment of land surface and cumulus convective process, and the impact of the land-atmospheric interaction on regional extremes can be greatly modulated by convective activity. In conclusion, the model simulated temperature and precipitation extremes are sensitivities to the model physical processes, displayed as relatively large ensemble spread.

Keywords: regional extremes, WRF model, multi-physics ensemble analysis

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Using dynamically downscaled output for climate change risk analysis: results from an application to southeastern USA

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In this presentation we will talk about the application of dynamically downscaled climate output for a high impact of climate change risk analysis on critical infrastructure for support of AT&T, a communication company.

Our dynamic downscaling (using WRF) covers most of North America (7200km x 6192km) at a spatial resolution of 12km. We developed six ensemble members, with one 30yr of WRF simulations driven by NCEP-R2, and five ensemble members of simulation and projection driven by three different Coupled Model Intercomparison Project Phase 5 Earth system models (ESMs): GFDL-ESM 2G, HadGEM2-ES, and CCSM4, to represent the range of the sensitivities of all ESM responses to doubled CO₂. For most of the ensemble simulations we ran each of the lateral boundary conditions with two scenarios — RCP4.5 and RCP8.5, each for one historical period and two future time periods — 2045–2054 and 2085–2094. The model output have been extensively evaluated and studied, especially for temperature and precipitation and their extreme features. We have published a dozen of journal articles directly out of this project, in addition to several scientific reports and a PhD thesis.

This presentation will focus on southeastern US (north Carolina, south Carolina, Georgia, and florida), looking at inland flooding due to heavy precipitation, coastal flooding due to storm surge from tropical cyclone and hurricanes, as well as high-intensity wind speeds. The 12km WRF output were used as input for all these three tasks. We modeled the historical and future inland flooding using WRF-Hydro® (Version 5) at spatial resolution of 200 meters. The input provided by WRF include 3hourly precipitation, temperature, wind, solar radiation, surface pressure, vegetation fraction, as well as relative humidity. We modeled the historical and future coastal flooding using ADCIRC (which has a unstructured mesh) with finest resolution of 50m along the coastal area. The input provided by WRF include sea level pressure and 10m wind speed and direction. All the future scenarios were projected at mid-21st century considering a business-as-usual scenario (RCP8.5). We also conducted general extreme value (GEV) analysis using these model output to generate 10-yr, 30yr and 50yr return levels of surface water depth and wind speeds.

Results shows that due to the increase of heavy precipitation under climate change, the surface water level are increased by more than 5% in the southeastern regions. The extremes are increased even greater. For example, a once-every-50 yr event will produce water depth up to 10 feet along the coastal areas along southeastern Georgia. The sea level rise signal associated with warming projections consistent with the RCP8.5 scenario appear to be the largest driver of future warm-season flooding and increases nuisance-level flooding events and severe flooding along the four priority states. While the wind speed changes vary across regions and seasonal, southern Florida tends to show the greatest change in maximum sustained wind conditions. For example, once-every-50yr wind speeds can go up to 90 mph for a large part of the southern Florida coastal region by mid-century.

Keywords: climate change impact, infrastructure

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Future projections in tropical cyclone activity over multiple CORDEX domains using RegCM4.7

Jose Torres, ICTP, Italy

Jose Torres, Erika Coppola, Filippo Giorgi, ICTP, Italy; Kevin Hodges, Department of Meteorology, and National Centre for Atmospheric Science, University of Reading, Reading, United Kingdom; Sushant Das, Taleena Sines, Graziano Giuliani, ICTP, Italy

Under the CORDEX initiative, simulations were performed using the latest version of the ICTP Regional Climate model (RegCM4.7) at a spatial resolution of 25 km and over three different domains (Australasia, Central America and South Asia). These simulations cover the 130-year period, 1970–2099, for two representative concentration pathways, 2.6 (RCP2.6) and 8.5 (RCP8.5) emission scenarios, and were driven by three General Circulation Models (GCMs) from phase 5 of the Coupled Model Inter-comparison Project (CMIP5). Additionally, a simulation that covers the near-present period of 1980 to 2014 is produced. This experiment is driven by ERA-interim (RegCM4.7-ERA-Interim) fields to validate the GCMs. In these simulations, the potential changes in tropical cyclone (TC) activity for future climate conditions are investigated, using an objective algorithm to identify and track the TCs. The RegCM4.7 simulations driven by GCMs are evaluated for the period of 1971–2005 by comparing with the RegCM4.7-ERA-Interim and the observed TC data from the International Best Track Archive for Climate Stewardship (IBTrACS); then the changes in the future period (2070–2099) relative to the baseline period (1976–2005) are analyzed for RegCM4.7 simulations driven by GCMs. Preliminary results show that RegCM4.7 simulations driven by GCMs are capable of most of the features of the observed TC climatology and the future projections show an increase in the frequency of the strongest TCs in all the basins.

Keywords: Climate Change, Regional Climate Model, RegCM4.7, Tropical Cyclones

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Hydroclimatological variables in the South America CORDEX domain for La Plata River Basin

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La Plata Basin represents the second largest hydrological basin in the world after Amazon basin. In this basin most of agro-industries of Argentina, Brasil and Uruguay are located; therefore the analysis of hydrometeorological variables in this region is of paramount importance for planning that can account for half of the GDP of the three countries. Our first aim is to study the representation of precipitation and evapotranspiration of the Regional Climate Model RCA4 v3 driven by nine Global Climate Models available for South America domain in CORDEX in La Plata Basin. The second objective is to analyze future projections on hydrological cycle, under RCP8.5 scenario. The performance of the models is compared with two datasets: GPCC for monthly precipitation and GLEAM for monthly evapotranspiration, for the IPCC model verification period 1986-2006. Accounting for long term means of the variables, annual cycle is well represented. Particularly, there is underestimation of precipitation that can reach up to 74% (by IPSL-CM5A-MR) during dry season (austral winter) and overestimation in the order of 50% (by CanESM2) for wet season (austral summer), depending on the model. In the case of evapotranspiration, overestimation is higher in the wet season reaching up to 10% (by NorESM1-M) and for dry season there is no agreement between models, presenting both over and underestimation. Additionally, the spatial distribution of the RMSE presents higher values to the north for evapotranspiration and to the southeast for precipitation. Finally, projections present increase in annual amplitude for both variables under the most severe climate change scenario. With the results so far we can conclude that CORDEX models can be used for assessment of hydroclimatological conditions of the basin taking into account the results from validation process, contributing to the design of strategies of adaptation at regional scale to the projected increase in the hydrological cycle.

Keywords: RCMs validation ,water cycle,impact on agriculture and hydrological sectors

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

Coastal flooding due to extreme events in the Mediterranean coast of Spain

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pdf file available at

http://icrc-cordex2019.cordex.org/wp-content/uploads/sites/2/2019/09/C1_9_Andrea-Lira-Loarca1.pdf

Keywords: coastal flooding, EURO-CORDEX, storm surge, waves

Parallel Session C: Climate Change Impacts

C1: High impact regional phenomena

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Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-01

Seasonal and interannual variations of the ITCZ in the Indian Ocean

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Parya Adibi, Omid Alizadeh-Choobari, *Institute of Geophysics, University of Tehran, Iran*

The climate of tropical regions on the monthly and longer time scales is significantly affected by migration of the intertropical convergence zone (ITCZ), while the ITCZ position depends on the cross-equatorial atmospheric energy transport (AET) and the equatorial net energy input (NEIO). Using the ERA-Interim dataset for the period 1980-2018, the ITCZ position in the Indian Ocean and its migration on the seasonal and interannual time scales are investigated. In addition, the cross-equatorial AET and the NEIO in the Indian Ocean are analyzed to determine position of the ITCZ based on the atmospheric energy balance. Results indicated that the annual mean position of the ITCZ in the Indian Ocean is in the Southern Hemisphere (approximately at 5.5°S), while in some seasons, a double ITCZ forms. It is also found that during the period 1980-2018, the annual mean position of the ITCZ in the Indian Ocean is migrated toward the equator by approximately 1° . The largest meridional migration of the ITCZ in the Indian Ocean occurs with the period of 1 year, showing seasonal migration of the ITCZ associated with the monsoon circulation. Our analysis indicated that position of the maximum precipitation in the Indian Ocean is different from the energy flux equator (EFE, where the column-integrated meridional energy flux vanishes), such that the EFE is always located at north of the position of maximum precipitation. It is found that variations of the cross-equatorial AET and the ONI are not consistently correlated, while variations of the NEIO in the Indian Ocean and the ONI are quite consistent. Variations of the cross-equatorial AET dominate interannual variations of the ITCZ position, while variations of the NEIO dominate seasonal variations of the ITCZ position in the Indian Ocean.

Keywords: ITCZ, cross-equatorial atmospheric energy transport, equatorial net energy input, energy flux equator, Indian Ocean

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-02

Empirical Assessment of Climate Impact on the Population of the Oil palm Leaf miner

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The leaf miner (*Coelaenomenodera elaeidis*) is the most serious insect pest of the oil palm. It breaks out in epidemic proportions periodically, resulting in severe leaf defoliation and consequently low fresh fruit bunch (ffb) yield. This study analyses patterns in leaf miner abundance, and elucidates climatic factors influencing leaf miner abundance. The leaf miner sampling records during 2009-2010 in oil palm fields and records from previous surveys from 1976-1980 were utilized. The study analyses temperature, rainfall and relative humidity between 1961 and 2010 in the main station of the Nigerian Institute for Oil Palm Research (NIFOR). Data on temperature, rainfall and relative humidity were obtained from NIFOR meteorological unit. Decadal variation in air temperature indicated increase in air temperature between 1961-1970 and 2001-2010 while variation in rainfall and relative humidity indicated a decrease. It was also observed that there was temperature increase across seasons with highest increase in the dry season, and suitable for leaf miner control. Relationship between mean weather factors (temperature, humidity and rainfall) and leaf miner insect stages (larvae, pupae and adult) between 2009 and 2010 showed significant relationship ($P \leq 0.05$). This could be attributed to relatively higher weather values and higher leaf miner population. The need for continuous monitoring has great potential for control of insect pests in oil palm growing areas.

Keywords: Climate variability, Insect population, Climate impact

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-03

Can the CORDEX- SEA historical simulations capture the observed spatiotemporal characteristics of the drought signal over the Philippines?

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Drought has been a recurrent hazard in the Philippines. Gaining an understanding of the spatiotemporal characteristics of drought in the Philippine setting is needed to frame appropriate mitigation measures. Meteorological thresholds leading to drought conditions differ on regional scales. The Standard Precipitation Index (SPI) is used to characterize drought through frequency, duration and seasonality. This study uses five gridded reanalysis observational datasets: CHIRPS, CRU, JRA, PERSIANN and UDEL to compare with the results from CORDEX-SEA historical simulations. The CORDEX-SEA simulations were downscaled using the RegCM4 model and driven by different GCMS: CNRM, CSIRO, EC-EARTH, HADGEM2 and MPI.

SPI values are computed over 3 and 6 month timescales representing seasonal and semiannual rainfall contexts. For both SPI3 (agricultural) and SPI6 (hydrological) droughts, results show that droughts are more frequent over the largest islands (Luzon and Mindanao) with a clear west-east difference. Generally, there are more droughts in the western half of the Philippines. Furthermore, results show that Luzon experiences more distributed number of droughts over all duration lengths (2, 3, 4, 5 months or greater), compared to Mindanao. Luzon experiences more frequent 3-month droughts while Mindanao droughts are seen to be split equally, lasting from 2 to 3 months, with generally no droughts lasting 5 months or longer. In terms of seasonality, SPI3 droughts start most commonly between December and February, while SPI6 starts between February and April over all areas. By assessing the performance of CORDEX-SEA historical simulations in replicating the drought signal exhibited by observation datasets, application of the same methodology on future downscaled projections can be contextualized and assessed properly.

Keywords: Drought, Standard Precipitation Index, climate variability, CORDEX-SEA

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-04

Quantification of future climate risks and onset of extreme weather events to metropolitan cities in Asia

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More than 50% (~3.5 billion) of the global and 49.6% Asian population is living in cities becoming increasingly urbanized, and population in Asia is equivalent to 59.66% of the total world population. Current growth simulations indicated that the relative magnitude will increase to 58% by 2030, and by 2050 nearly 6.3 billion out of an estimated global population of 9.1 billion will live in urban territory. Cities consume 75% of the world's energy use and produce more than 76% of all CO₂. Warming of just 1.5 degrees Celsius could bring on the most severe consequences of climate change. During 2010 to 2018 people's lives were disrupted by heat waves, floods, drought, erratic rains and sea level rise. Changes in temperature, precipitation, sea level, and coastal storms will likely increase the vulnerability of infrastructure across the Asia. Each city has its own particular reaction under the stress of extreme weather events, and weather poses one of the biggest risks to human health and economy. Cities have direct linkages with climate change, and urban centers are major drivers of global warming because they concentrate transportation, industries, households and many of the emitters of greenhouse gases. Already, a third of the urban population in developing countries is living in slum, this usually implies a lack of safe drinking water, sanitation, and highly vulnerable to natural disasters. In Asia more than 18% of urban population living in Low Elevation Coastal Zone that is less than 10 meters above sea level (Mumbai, Karachi & Jakarta). Marginalized urban residents such as labor migrants in, for instance Manila, Colombo and Dhaka are forced to live in highly exposed locations which are highly susceptible to extreme weather. Using regional research and to analyze vulnerability, impacts, and adaptation practices, this paper estimates impacts to human health, economy, coastal properties, and urban infrastructure and investigates sensitivity to varying greenhouse gas emission scenarios and climate sensitivities. The study will provide better understanding to policy makers to rethink what and where a central business district is in the 21st century to reduce our GHG emissions by 45% before 2030 and reach net zero emissions by 2075.

Keywords: Climate Warming, Extreme Weather, Future Risks, Urbanization

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-05

Response of regional monsoons at various levels of radiative forcing in RegCM4-CORDEX simulations

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Using an ensemble of RegCM4 simulations over various monsoon domains, including North America, South America, Western Africa, South Asia, East Asia and Australia, we investigate changes in the regional scale monsoon dynamics in response to changes in the radiative forcing, and its impact on precipitation distribution over monsoon regions. All regional monsoon simulations are conducted at 25km horizontal grid spacing using lateral and lower boundary forcing from three CMIP5 GCMs, each covering 1970 to 2100 under two Radiative Concentration Pathways (RCP2.6 and RCP8.5) in the 21st century projections period. We make use of Lagrangian based moisture back trajectory analysis to understand the variations in moisture sourcing from contributing oceanic and terrestrial sources, dynamic and thermodynamics drivers of those variations, and their impacts on the precipitation distribution at varying time-scales. Additionally, we compare results from each of the regional monsoons to understand the commonalities and dissimilarities in the regional precipitation responses, including those related with the monsoon onset, precipitation seasonality and extremes, and the timing of emergence when projected changes are permanently above the baseline variability. Use of centennial-scale, multiple RCP and multi GCM driven RegCM4 simulations provide an opportunity to understand the robustness as well as the sensitivity of projected fine-scale regional monsoon changes to various levels of radiative forcing.

Keywords: global monsoons, RegCM4

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-06

Investigation and projection of Human Thermal Comfort Stress over West Bengal, India using observations and CORDEX climate model experiments

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Numerous studies feature the extreme human bio-meteorological conditions in terms of human thermal comfort index in India for the last few decades. This research highlights the human bio-meteorological conditions and its variability in West Bengal (one of the densely populated state of India) for the last 50 years by using Universal Thermal Climate Index (UTCI). The meteorological variables from meteorological stations in West Bengal are used to calculate UTCI and the computed UTCI is also compared with the UTCI calculated from the regional climate model from the CORDEX-south Asia experiments. The results showed increasing trend of UTCI in almost all the stations of West Bengal during the study period. In addition, future human thermal comfort is projected for Kolkata and its neighbouring districts (capital city of West Bengal) under the scenarios of RCP4.5 and RCP8.5. The future projection of UTCI in Kolkata and its rural outskirts with climate change taken into account suggests that annual aggregate of heat stress days will increase significantly while the no thermal stress days or cold stress days will reduce.

Keywords: Urban Heat Island, Human Thermal Stress

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-07

Predicting Dengue cases in Kolkata, India based on variation of climate using Zero-Inflated Regression Model

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Dengue is one of the most serious vector-borne infectious diseases in Kolkata, India and its viruses and their vectors are sensitive to climate change. The widespread characteristics of dengue in Kolkata are identified with some key meteorological factors such as maximum temperature, minimum temperature, relative humidity and rainfall on the basis of statistically significant cross-correlation coefficient values. The statistical model on dengue cases was framed with the key factors for the first 120 months of the data set from 2005-2016. The remaining months were used to validate the model. Finally, climate variables from the Coordinated Regional Climate Downscaling Experiment (CORDEX) for South Asia region were input into the developed statistical model to project the occurrences of dengue infections under different climate scenarios (RCP2.6, RCP4.5, and RCP8.5). It has been estimated that from 2020-2100, dengue cases will always be higher from September to November with more cases in RCP8.5 (871 cases per year) than RCP4.5 (530 cases per year). This study further evaluates that from December to February, increases in carbon dioxide concentration under RCP8.5 leads to warmer weather conditions essential for the survival and multiplication of vectors, with more than two times the dengue cases than in RCP4.5.

Keywords: Mosquito borne disease, Dengue

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-08

Hydroclimatological variables in the South America CORDEX domain for the Amazon River Basin

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Introduction: With 7.0 x 10⁶ km² the Amazon River basin represents the most important hydrological region in South America. The Amazon discharges approximately 200,000 m³ s⁻¹ becoming the main source of fresh water from the continent to the Atlantic Ocean. Methodology and data: Our aim is to study the representation of precipitation and evapotranspiration of the Regional Climate Model RCA4 v3 driven by the nine Global Climate Models available for the South America domain in CORDEX. For that purpose, we selected as comparison period the verification period of the IPCC model verification, between 1986 and 2006 at a monthly time scale. The performance of the models is compared with two datasets, the one from GPCC for monthly precipitation and the one from GLEAM for monthly evapotranspiration. Results: Accounting for the long term means of the variables in the period of analysis, models underestimate precipitation by 19% and underestimate evapotranspiration by 4%. When analyzed by wet (January) and dry (July) seasons we find that for precipitation there is underestimation during the dry season that can reach up to 70% and underestimation in the order of 60% for the wet season consistently in model CSIRO. In the case of evapotranspiration, the higher underestimations are of approximately 30% in model CSIRO. However, as for the spatial distribution of the RMSE, the northeast of the Amazon presents the highest errors for evapotranspiration and the north of the Amazon for precipitation. Finally, projections present increase in annual amplitude for both variables under the most severe climate change scenario. Conclusions: With the results so far we can conclude that CORDEX models can be used for assessment of hydroclimatological conditions of the basin taking into account that there is a general underestimation of both variables and that CSIRO is amongst the nine models the one with the lower performance in order to represent the analyzed variables.

Keywords: Amazon River Basin, SAM-CORDEX, Hydroclimatology, Water resources planning

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-09

Energy simulation of social housing in Argentina: how extremes and climate change impact on the energy demand

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Because one-third of the total energy demand in Argentina corresponds to the residential sector, there is an urgent need to define criteria and implement measures, including the labeling of energy efficiency of buildings, the rational use of energy, and the sustainable construction. Energy simulation of buildings is a working area that is at the center of the problem and an essential resource for estimating the energy consumption associated with the use of housing. This requirement is also strongly dependent on the climatic conditions of the place where the house is located and considering the comfort conditions required for each climate.

The occurrence of extreme events and changes in its characteristics (e.g., increase, intensification and/or changes in the frequency of occurrence of warm spells) will have an impact on the energy sector. To estimate it, we perform a series of experiments using a buildings' energy simulation platform (Energy Plus) to evaluate the hygrothermal behavior of social houses in Rosario City (Argentina), forced by boundary conditions from CORDEX models. Aim of this work is to (i) study the hygrothermal behavior of social houses, (ii) define design improvements and estimate changes in the average energy demand, and (iii) analyze the impact of the occurrence of extreme events and (iv) the impact of the climate change on the peaks of energy demand due to consumption from the residential sector.

Keywords: Energy demand, residential sector, confort conditions, extreme events, Rosario City, Argentina

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-10

Multi-model projections of climate change hotspots in the Philippines

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Given the impacts of future climate change, the identification of potential climate change hotspots (i.e. areas highly responsive to changes in climate) is useful for risk assessment, in order to prepare contextualized adaptation strategies. In the Philippines, previous analyses of observation records have shown significant trends and changes in climate in particular areas. Using the multi-model, multi-scenario projections of SEACLID/CORDEX Southeast Asia, this study aims to examine how these climate change hotspots will change in the future, as well as to identify potentially new hotspots due to significant changes in magnitude and/or variability. Changes in climate means and extremes in the Philippines are analyzed for three time periods (2016–2035, 2046–2065, 2080–2099) under RCP 4.5 and RCP 8.5 scenarios, relative to the 1986–2005 baseline period. Initial results show warming that can reach 4°C on average at end of the 21st century under the RCP 8.5 scenario. Models generally agree on the direction of change in the temperature extreme indices, but also show differences in spatial extent, frequency of occurrence, and duration of warm/cold spells. Future drier conditions are also projected in most parts of the Philippines, as indicated by decreases in annual rainfall and heavy wet days, and increases (decreases) in consecutive dry (wet) days, but with more intense rainfall events. Compared to temperature, there is more variability in projected changes in precipitation extremes, in terms of direction of change and spatial distribution. For example, some models project northwest Luzon to be wetter, and Mindanao island to be drier, which would have serious impacts on these vulnerable agricultural regions.

Keywords: climate extremes, hotspots, Philippines, CORDEX Southeast Asia

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-11

Evaluation of the numerical model with CORDEX Regional Climate Models for heavy precipitation in the Meghna Basin region

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Prediction of heavy precipitation (HP) induced flood incidents is challenging when they happen on the high terrain of Meghalaya Plateau and nearby areas. Improving the simulation of the Pre-monsoon (March-May) mesoscale convective systems (MCSs) is important as such events routinely result in rainstorms, flash flood, flooding events and significant loss of lives and properties over Bangladesh, Indian eastern, northeastern region and neighborhood. The influx of moisture from the Bay of Bengal (BoB) energizes these rainstorms systems as it passes over Meghalaya and northern parts of Bangladesh and thus produces heavy convective and stratiform rain over Meghalaya and the surrounding areas. Although extreme precipitation and runoff are the root causes of the flash flood, the stretches of valley and highland plateaus of Indo-Bangla region play an important role in the weather system due to its extraordinary geography and climate. The valley and plateaus of Indo-Bangla region is the wettest place on planet earth. It is important to predict heavy precipitation precisely for assessing floods and flash flood over the region of the Meghna basin. The global precipitation products are helpful for understanding rainfall pattern over a data scarce region. For the regional study, the mesoscale numerical model Advanced Research version of the Weather Research and Forecasting (WRF-ARW) is used for estimating heavy precipitation in a finer resolution for the HP event of pre-monsoon season 2004, 2010, 2016 and 2017. Sensitivity analyses of different parameterization schemes are applied in this study. The model simulated precipitation is assessed with the available rain gauge observation along with India Meteorological Department (IMD) Global Precipitation Measurement (GPM) mission merged datasets. The best and worst performing parameterizations combination schemes are identified after doing statistical analyses. In the study, the WRF model simulated precipitation are evaluated with the Coordinated Regional Climate Downscaling Experiment (CORDEX) models data for a better understanding of regional analysis. To understand the influence model grid resolution, global to regional (g2r-1:3) and global to convection-permitting (g2c-1:9) scale ratios are tested in the present study.

Keywords: Heavy precipitation, flood, Parameterization, WRF ARW, CORDEX models

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-12

EPICC – a cross-sectoral and cross-regional intercomparison of climate impacts and adaptation options

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The impacts of climate change and accordingly adaptation options vary strongly regionally and have to be assessed context-specifically. The East Africa - Peru - India Climate Capacities (EPICC) project investigates these impacts for three tropical countries - Tanzania, Peru, India - that differ strongly from each other in terms of geography as well as their vulnerability to a changing climate. In dialogue with partners from policy making, the private sector, civil society and science, EPICC has identified local demands for climate change impact assessments and for testing adaptation options.

Based on observations, global climate projections as well as high-resolution regional climate projections from CORDEX, we investigate these climate change impacts and adaption options across different sectors. Climate data from the CORDEX simulations will be bias-adjusted and statistically downscaled to the local level to allow for local analyses with particular focus on extreme events. These high-resolution climate simulations provide the basis for assessments for the agricultural as well as the hydrological sector, using a suite of statistical and process-based impact models.

Results feed into assessments of migration in the context of climate change, primarily internal migration related to changes in subsistence agriculture productivity. This project enables intercomparisons of regional studies across different sectors and different tropical locations and contexts, using the same approaches, models and statistical tools, always focusing on local user-demands.

Keywords: climate adaption, climate impacts, cross-sectorial

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-13

Extreme winter precipitation vs. model resolution across the Upper Mississippi River Valley

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As we continue to see an increase in extreme precipitation anomalies during winter months across the United States, it is important to focus on how to simulate better these events. These events can cause substantial flooding that can severely erode soil and weaken energy-transmission infrastructure. One way to better understand and simulate these extreme precipitation events is to assess how resolution in regional climate models affects processes leading to extreme precipitation. During winter months, synoptic dynamics play an important role in extreme precipitation events and should be fairly well resolved in regional climate models.

This study focuses on extreme sub-daily precipitation in the Upper Mississippi River Valley during the months of December, January, and February (DJF). We analyze extreme, 6-hourly precipitation as simulated by RegCM4 and WRF using ERA-Interim boundary conditions for the period 2002 through 2012 at grid spacings of 12, 25 and 50 km. We compare composites of simulated 6-hourly extreme events with those occurring in NOAA Stage IV quantitative precipitation for the same period. In addition, we compare composite 6-hourly fields of 2m temperature, 500hPa geopotential height, 10m wind, and 2m specific humidity for the simulated events with composites of the same fields during Stage IV events, using the North American Regional Reanalysis. We evaluate how changing resolution in the two models affects the intensity of extreme events versus Stage IV events as well as how the circulation and thermodynamics of the events changes with resolution, highlighting factors are most sensitive to resolution and their impact on replicating observed behavior.

Keywords: Extreme precipitation, model resolution

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-14

Climate change impacts on hydrology and water resources of Upper Awash Sub-Basin, Ethiopia

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The Awash River basin is the most irrigated area in Ethiopia facing critical water resources degradation due to climate change. Climate change alters regional hydrologic conditions impacting water resource systems. Such hydrologic changes will affect almost every aspect of human well-being. Agriculture is the mainstay of Ethiopian economy. The growing population and efforts to meet the food security of the country will call for expanding irrigation on top of the rain-fed agriculture which in turn will depend on available freshwater resources. As the most irrigated basin in the country, the availability of water in the Awash River basin has declined because of the increased water abstractions for various uses. The main objective of this study is to assess the impacts of climate change on surface water availability of Upper Awash River Basin by using Soil and Water Assessment Tool (SWAT) hydrological model and Regional Climate Model (RCM). Regional climate model (ECHAM5 with A1B emission scenario) and meteorological variables at local scale were applied for three time periods (2020s, 2050s and 2080s). Bias-correction methods have been applied to individual climate variables to adjust RCM data. RCMs bias correction methods was used for scenario generation to estimate average changes in annual temperature and rainfall. The bias correction approach applied in this study gave the reasonable results. SWAT was calibrated and validated to simulate future hydrologic variables in response to changes in precipitation and temperature. The results of calibration and validation model indicated that SWAT simulated monthly flow well. This was showed by the Nash-Sutcliffe simulation efficiency (ENS) and Coefficient of determination (R²), which were 0.80 and 0.85 for the calibration and 0.78 and 0.83 for the validation, respectively. The results showed that the projected climate change scenario increase in rainfall for the time period of 2020s, whereas reduces in rainfall for the time periods of 2050s and 2080s and the projected temperatures increase for all three time periods. The SWAT model results show that the annual stream flow of Upper Awash Sub-Basin was reduced by 2.46% and 18.14% in 2050s and 2080s, respectively, while the stream flow increased in 2020s by 4.90% for A1B scenario. The simulated flow at 2050s and 2080s, with A1B scenario from RCM, showed reduction of runoff by 1.52% and 3.50%, respectively in the Sub-Basin and it was directly related to the reduction in precipitation, while the annual runoff increases in 2020s by 8%. Thus, precipitation being the main driver in the water balance computation, its variability both annually and seasonally has a direct impact on the other simulated water budget components. Model result showed that about 44.36% of annual rainfall contributes to stream flow as surface runoff. Generally, the results revealed that changes in climatic variables, such as reduction in rainfall and change in both minimum and maximum

temperature would have a significant impact on the stream flow and surface runoff, causing a possible reduction on the total water availability in the Sub-Basin. The results obtained in this study can provide useful information for future water resource planning and management in the face of climate change in the upper Awash Basin. It is concluded that future climate change by the end of the 21st century are most likely to produce significant impacts on the surface runoff and stream flow.

Keywords: A1B Emission Scenario, Climate Change, RCM, Hydrology, Water Resource

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-15

Spatiotemporal dynamics of rainfall, temperature, and vegetation greenness for Dhidhessa River Basin, Ethiopia

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Understanding the spatiotemporal dynamics between climate variables and vegetation greenness can be beneficial to design climate change adaptation strategies. However, such a study is lacking in many basins of Ethiopia. The objective of this study was to analyze the past and future temperature and rainfall trends, and determine their spatial relationship with vegetation greenness, characterized using Normalized Difference in Vegetation Index (NDVI), for the Dhidhessa River basin. Quality checked high spatial resolution satellite datasets were used for the study. Mann-Kendall test and Sen's slope method were used for the trend analysis. The spatial relationship between climate dynamics and NDVI was analyzed using Geographically Weighted Regression (GWR) technique. Past and future climate trend analysis generally showed wetting and warming for the Dhidhessa River basin where the degree of trends varies for different time and spatial scales. A seasonal shift in rainfall was also observed for the basin. These findings informed that there will be negative impact on rain-fed agriculture and water availability in the basin. NDVI trends analysis showed significant increasing trends for dry season and annual timescales and decreasing trend for the main rainy season. Spatially, a significant increase in NDVI trend was observed only for the warm moist climatic zone. The increasing NDVI trends could be due to agroforestry practices but does not necessarily indicate improved forest coverage in the basin. A declining NDVI during the main rain season indicates expansion of agricultural land by clearing forest and shrubland. The NDVI dynamics is positively correlated to rainfall ($r^2=0.62$) and negatively correlated to minimum ($r^2=0.58$) and maximum ($r^2=0.45$) temperature. The study revealed strong interaction between the climate variables and vegetation for the basin that further influences the biophysical terrestrial processes like hydrologic responses of a basin. This study provides helpful information to device climate change adaptation strategies at local scales.

Keywords: Spatiotemporal climate dynamics, Vegetation greenness, Mann-Kendall test, Sen's slope method, Dhidhessa River basin

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-16

Using CORDEX data to estimate future hydro-ecological conditions in North-Western Black Sea coast

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The future hydro-ecological conditions in small watersheds of Southern Ukraine were estimated using the outcomes from the CORDEX Project – the 14 runs of 5 regional climate models (RCM). In the nearest future, 2021–2050, the rising temperature (about 0.8 °C per 30 years) and steady precipitation (~470 mm per year) during 2021-2050 in Southern Ukraine will be probably observed. Let's note that precipitation will usually decrease in Ukraine and the southern region is rather an exception to the rule. In this Figure, we can see (i) changeable increase of temperature and a sharp decrease of precipitation during the 2023-26; (ii) sharp increase of temperature following a decrease of precipitation during the 2028-31; and (iii) sharp decrease of temperature against the steady precipitation background during 2037-40. We used the standardized precipitation evapotranspiration index (SPEI) to investigate spatiotemporal droughts variability caused by climate change. The SPEI is the multi-scalar drought index and allows determining the onset, duration and severity of drought conditions on different time scales. It is common practice to assess the hydrological droughts on the time scale 13–24 months. The analysis of nearest-future SPEI time series showed that the trend to drier conditions will be expected in North-Western Black Sea coast – the next long and severe droughts can be registered about 2025 and after 2030. Moreover, we can expect in all likelihood that the period 2031-2040 will be driest, and duration of drought in that region will be a few years. We also considered a connection between time series of the SPEI on the 24-month time scale and annual runoff on a few hydrological sites in some small watersheds. The temporal features of water flow changes are in close agreement with the SPEI24 during the nearest future – all years with high water flows were registered during the wet years, i.e. the absence of atmospheric droughts.

Keywords: Temperature, Droughts, Runoff

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-17

An analysis of the abnormal flood and its impact on environment and socio-economic conditions in Kerala

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Climate change and its impact are evident in the State of Kerala in India. In August 2018, abnormally heavy monsoon rains lead to the worst flooding in a century, killing around 500 people and thousands of livestock, displacing one million people and damaging 50000 houses, roads and other infrastructures. Estimated losses amount to more than US \$3 billion. Seasonal rainfall was 42% above normal and rainfall during 1 to 19 August was 164% above normal. Around 414 mm rainfall occurred during August 15-17, which led to severe flooding. Steep slopes and destruction of wetlands added to its severity. All 39 major dams had reached their full reservoir level by the end of July, and were incapable of absorbing the torrential volumes in August. After flood, surface water bodies, especially rivers are drying up fast because of abnormal landslides and sedimentation. Around 8 to 10% of all reservoirs were already filled with sand because of deforestation and urbanization. As a result of the loss of surface soil and failure of northeast monsoon, groundwater level in the state fell by 3 metres and the state experienced serious water crisis in the beginning of 2019 itself. Destruction of check dams and erosion and deepening of rivers allow fast flow of groundwater towards the sea. Decrease in runoff now permits salinity intrusion far inland. State was not prepared to cope with the unexpected situation and flood initiated several socio-economic issues such as shortage of reliable water, hiking price of food and water, conflicts over allocation, spread of contagious diseases and large investment to rebuild infrastructure and rehabilitate the displaced population. This study analyses the hydrometeorological extremes in Kerala during 2018, trends in extremes and their impacts on different facets of life. Results show an increasing trend in extremes in near future. Guidelines for developing a better climate policy and adaptation strategy have been provided.

Keywords: Climate change, Kerala, flood, socio-economic, adaptation

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-18

Numerical simulation of synoptic to quasi-biweekly disturbances involved in the summer 2003 heavy rainfall in East China

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During the Meiyu season of summer 2003, the Yangtze and Huai River Basin (YHRB) encountered anomalously heavy rainfall, and the northern YHRB (nYHRB) suffered a severe flood because of five continuous extreme rainfall events. A spectral analysis of daily rainfall data over YHRB reveals two dominant frequency modes: one peak on day 14 and the other on day 4, i.e., the quasi-biweekly and synoptic-scale mode, respectively. Results indicate that the two scales of disturbances contributed southwesterly and northeasterly anomalies, respectively, to the Meiyu frontal convergence over southern YHRB (sYHRB) at the peak wet phase. The passages of five synoptic-scale disturbances finally led to the severe flooding over the nYHRB region. In this study, a 29-day (June 15 – July 13, 2003) regional climate simulation is conducted using the Weather Research and Forecast (WRF) model. The simulation reproduces reasonably well the spatial distribution and temporal evolution of the rainfall over both regions, especially the frequent heavy rainfall events over the nYHRB regions. In addition, both the quasi-biweekly and synoptic-scale disturbances are clear in the simulation results, which well match the raw simulated rainfall peaks.

Keywords: synoptic to quasi-biweekly disturbances, heavy rainfall, numerical simulation

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-19

Features of spatiotemporal distribution and management issues of dangerous meteorological phenomena on the territory of the Republic of Armenia

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Dangerous meteorological or heliogeographysical phenomena (dangerous phenomena) are natural phenomena arising in the atmosphere and hydrosphere that are dangerous for the life, health and property of the population by their importance, intensity duration or time of occurrence, and can cause significant material damage to different branches of the economy. Dangerous meteorological phenomena are those that can or have already led to natural disasters and emergencies.

Statistics show that the number of human casualties and material losses due to hazardous meteorological phenomena is growing. In recent decades, the number of dangerous phenomena and their climatic extremes has also increased, and the zone of their impact has increased. Dangerous meteorological phenomena can also intensify or contribute to other disasters, for example, the spread of infectious diseases, desertification, the accumulation of toxic gases in the atmosphere, the invasion of locusts, radiation accidents and so on. So their observations and studies are very important for research, weather forecasts, as well as for the correct and effective organization and development of works of a wide range of sectors of the economy. Consequently, the purpose of this work: to discuss and analyze the dynamics of changes in the hazardous meteorological phenomena of the study area, the patterns of spatial distribution to assess the vulnerability and risk of the territory of the republic in relation to hazardous dangerous phenomena.

For the solution of the tasks the theoretical basis was the relevant scientific and research works. As a source material, actual observations data of the Ministry of Emergency Situations of the Republic of Armenia “Service for Hydrometeorology and active influence on atmospheric phenomena” and the data of the RA National Statistical Service have been used. In the work methods are applied: geographic, general scientific, characteristics, statistical, analysis and correlation.

We note that more than 100 natural hazards and dangerous phenomena inherent in the territory of Armenia can be identified about 10, the most frequently recurring. These include: earthquakes, landslides, mudslides, floods, destruction, fall of stones, thunderstorms, hail, high groundwater level, forest fires and so on.

As a result of the research it was found out that in the republic there are different trends in the change of dangerous meteorological phenomena, different degrees of vulnerability to this or that dangerous phenomena. Thus, it is necessary to create a database of dangerous meteorological phenomena and make it accessible to the population, to develop and implement a local detailed study of hazardous meteorological phenomena, to hold frequent meetings with the public, to conduct a sociological survey among the general population, to develop mechanisms for effective management policies.

Keywords: dangerous meteorological phenomena, spatiotemporal distribution, change, management

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-20

Method of calculation of maximum runoff of spring flood for ungauged rivers case study the Desna river basin

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All modern methods used to calculate the runoff of rivers, both in Ukraine and abroad, are based on the assumption of the stationary nature of the formation of a long-term annual runoff. It is believed that the design value of water discharges the rare probability of exceedance, obtained by statistical processing over the past years, will remain the same in the future. But at the present stage there is already a statistical non-stationarity of hydrometeorological processes, which is confirmed by instrumentally warming of the climate.

As the calculated method used a modified version of the operator model, that allows considering "climate amendment" for the maximum snow supplies, precipitation and runoff coefficients during the flood.

The modified variant of the operator model takes into account the process of the transformation of the slope influx in to channel runoff through two transformation functions and is proposed as a calculation method for determining on the plain territory of Ukraine the maximum runoff during the spring period for ungauged rivers.

The proposed variant of determining the maximum runoff of spring flood is implemented for the rivers of the Desna basin. Consideration of possible climate change is made using the data of the regional climate model RACMO2 and scenarios RCP4.5 and RCP8.5. Analyzing the results obtained, it should be noted that the results are not significantly different, namely, in the RCP4.5 scenario, it is forecasted by the decrease of the maximum modules of spring flood resources by 2050 at the level of 5-10%, and in the more rigorous scenario (RCP8.5) - 10- 15%.

Keywords: spring flood, ungauged rivers, scenarios RCP4.5 and RCP8.5

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-21

Scientific and methodological approaches to taking into account the influence of climate change on the minimum rivers runoff

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In order to account for climate changes in calculations of maximum runoff, the author had proposed to introduce "climate corrections" to the calculated values of maximum water discharges. A similar approach can be applied to the minimum runoff of rivers. Such research was carried out on the example of the Transcarpathian rivers. If we have the predicted values of air temperature and precipitation, for example during a warm period, and the dependence of these values on the present day on the elevation (because it the mountain region), "climate corrections" can be introduced to the values of the minimum runoff in the future.

With purpose to obtain the calculating equations of relation between the minimum runoff and the predicted values of temperature and precipitation, on the one hand, and local factors runoff on the other, the method of multiple linear regressions is applied. As predictors, all available factors were used, namely: average annual air temperature, rainfall for cold and warm periods of the year, latitudinal coordinates, catchment area, forest area, length, and slope of rivers. The average height of the catchment was not used in the calculations, because its influence is represented by the calculated values of temperature and precipitation. The most optimal equations were further used to determine the predicted values of the minimum runoff under different scenarios.

Another possible option considering the impact of climatic changes on minimal rivers runoff is its interconnection with the drought index, for example, SPEI. The time series of the SPEI index on different scales for the steppe zone of Ukraine, in particular for the basin of the Southern Bug River, were analyzed for the period 1950-2010. Estimation of the statistical connection between SPEI at different time scales and different phases of the river flow of the Southern Bug River during the period 1950- 2010 showed that the obtained dependencies are significant, which opens up the possibility of using the index of drought in the modelling of hydrological processes in the steppe zone of Ukraine.

Keywords: minimal runoff, climate change, drought index

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-22

Capturing Co-Behavior Modes in CORDEX regional climate models over Southern Africa

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We examine how co-behavior of climate processes is represented in CORDEX regional climate models. Co-behavior does play a crucial role in how the regional climate of southern Africa is influenced as established in our earlier research. Self-Organizing Map (SOM) technique is used to classify circulation patterns over the region. In order to identify strongly associated patterns across the data to explore how identified synoptic types relate to the co-behavior of three important large-scale drivers; El Niño Southern Oscillation (ENSO), Antarctic Oscillation (AAO) and Inter-Tropical Convergence Zone (ITCZ), a varimax rotated Principal Component Analysis (PCA) is employed and the statistical significance of these patterns are determined by bootstrapping. The nature of co-behavior in CORDEX models in relation to already identified co-behavior modes from observation dataset is assessed. We then explore regional precipitation and surface temperature response to these modes of co-behavior to improve regional climate understanding.

Keywords: regional climate models, large-scale processes, co-behavior

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-23

Rainfall and temperature scenarios over Bangladesh based on RCP scenarios using RegCM

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Rainfall and surface temperature are the most important climatic variables in the context of climate change. Thus, these variables simulated from ICTP RegCM models have been compared against observed (raingauge) data and projected for the middle of twenty first century under the Representative Concentration Pathway (RCP) 4.5 emission scenario. Through calibration and validation of RegCM was adapted for Bangladesh for generating rainfall and temperature scenarios. The model generated rainfall was calibrated with ground based observed data in Bangladesh during the period of 1981-2000. Better performance of RegCM obtained through validation process increased confidence in utilizing it in the future rainfall and temperature projection for Bangladesh. Rainfall, maximum and minimum surface air temperature projection for Bangladesh is experimentally obtained for the period of 2041-2060. This work finds that the RegCM simulated Rainfall and temperature are not directly useful in application purpose. However, after validation and calibration, acceptable performance is obtained in estimating annual rainfall and maximum and minimum surface air temperature in Bangladesh. Change of rainfall is projected about -1.2 percent in pre-monsoon (MAM), -1.4 percent in monsoon season (JJAS), 1.90 percent in post-monsoon Season (ON) and 0.46 percent in winter season (DJF) during the period of 2041-2060. Similarly, change of maximum and minimum surface air temperature is projected about 1.4 and 1.5 degrees Celsius for the same period.

Keywords: Rainfall forecast, temperature forecast, climate change, calibration, validation

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-24

Impact of regional climate model projected changes on maize yield over Southern India

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Maize is one of the major cereals grown in southern state of Tamil Nadu, India and produces about 1.2 million tones which contribute 14 percent to total cereal production in Tamil Nadu. There was an increasing demand for maize grains for poultry feed and also for human consumption due to structural changes of consumption pattern. In Tamil Nadu, about 43 percent of cropping area under rain fed and nearly 40 percent of maize production comes from rainfed regions. Presently, global warming has become a great challenge for the agrarian economy of India. Among various factors, maize yield depends on the vagaries associated with rainfall and surface temperature. These two primary climate variables are expected to change in a warmer climate. To understand the projected monsoon changes impact on maize production is carried out by performing high-resolution regional model climate simulations (IPRC_RegCM) with multiple lateral forcing, and the climate variables from regional model serve as input into economic model. To predict the impact of climate change on maize yield in the future, we used the coefficients of Indian Meteorological Department (IMD) data and European Reanalysis Interim (Era-Interim) data as baseline and predicted the current yield. The projections taken from CCSM4 (Community Climate System Model) forced high-resolution regional model climate simulations and computed the climate change impacts on maize yield. This paper predicts the maize yield for the RCP6.0 scenario under the CCSM4 model by employing the panel data regression model. The model estimates the impact of maize yield is projected to decrease by 11 and 23 percent for the IMD and Era-Interim reanalysis data respectively during end of the 21st century. However, we have compared the IMD maize yield projections with ERA-Interim reanalyses outputs which is also a proxy for observations, both the models projects in similar trend gives more confidence and precise estimate on our projections.

Keywords: Climate change impact, Maize yield, Southern India

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-25

Understanding precipitation extremes over CORDEX South Asia: A regional earth system model assessment

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The impact of climate change will be mainly felt through changes in the intensity and frequency of extreme events rather than changes in mean climate. It is expected that precipitation extremes will enhance over tropics in the 21st century. Within the CORDEX South Asia framework, a high-resolution Regional Earth System Model is used to understand the precipitation extremes over south Asia focusing on different homogeneous regions, as well as the future return period frequency and intensity of extreme events will be presented with uncertainty assessment.

We use a high-resolution regional coupled model setup, which will comprise of the Max Planck Institute Ocean Model, including sea ice, and the Hamburg Ocean Carbon Cycle model (MPIOM/HAMOCC) is coupled via OASIS coupler to the Regional atmosphere Model (REMO), and the Hydrological Discharge model (HD). This system has the distinctive feature that its global ocean module provides the possibility to reduce the grid size in the region of interest to provide high resolution there and not to set the lateral boundary conditions in the ocean.

Historical and climate change simulations were performed to understand and analyze various aspects of extreme event conditions in India along with the study of Indian Ocean biogeochemistry, including phytoplankton blooms, (focusing on the Bay of Bengal) and, particularly, climate change influence on sea surface temperature (SST) which strongly effects Indian monsoons and corresponding extreme events.

Keywords: Regional Modeling, South Asia, Climate change, Extreme events

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-26

Modern spatiotemporal distribution of squalls on the territory of Ukraine

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According to last studies in Ukraine, since the 1990s there is a general increase in number and intensity of weather phenomena associated with the convection development. Squall is a strong wind characterized by a sudden onset, duration of the order of minutes and accompanied by changes in its direction. The Ukrainian meteo service use the next criteria of a squall: first hazard level with a wind speed of 15-24 m/s; a strong squall with a wind speed of 25-34 m/s; and an extreme squall with a wind speed more than 35 m/s.

In this study, the spatiotemporal distribution of squalls over the territory of Ukraine during warm period of 2013-2018 was analyzed. The observations data at the meteorological stations in all regions of Ukraine were used. During the study period 384 cases of squalls of varying intensity were recorded. Squalls of the first hazard level are prevailed (91%). Strong squalls were observed in 15 cases and only one squall reached an extreme criterion. This squall with a wind speed of 40 m/s was recorded in Henichesk on 29 June 2013. Most of strong squalls occurred in air masses under conditions of thermal convection, and an extreme squall formed on the cold front. In the annual distribution, the maximum of 133 cases of squalls were observed in 2013. In the other years, the total number of squalls varied between 30-70 cases per year. The maximum frequency of squalls is in the summer months. The earliest and latest squalls were recorded in 2017 on April 3 and on October 29, respectively. The largest number of squalls was observed in the southern regions (24% of all cases), most of them (18%) were in the Odessa region. The least frequency of squalls is in the western part of Ukraine. Comparison of the frequency of squalls in Ukraine with the base period 1961-1990 showed that in the western part of the country the number of squall cases decreased. In the other regions, the number of squalls has increased significantly, and in the Odessa region almost doubled.

Keywords: squall, wind speed, convection phenomenon

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-27

Features of the regional atmospheric circulation, leading to formation of dry winds in Ukraine

Withdrawal

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Dry and hot wind named as “sukhovey” is a widespread high impact phenomenon, which reduces the crop yields in Ukraine. According to criteria of the Ukrainian meteoservice dry wind is fix, if at least in one term of observation values of three meteorological parameters simultaneously amounts: air temperature 25°C and higher, wind speed at 10 m height is 5 m/s and more, and the relative air humidity is 30% or lower.

The aim of the study is to determine the synoptic conditions that led to formation of dry winds in Ukraine during the period 1995-2015.

According to observations from 24 stations of Ukraine for in all agroclimatic zones maximum frequency of dry winds observed in August: from 129 days in Steppe to 21 days in Mixed Forests. Analysis of high-level pressure fields shown that during dry wind period over Europe a meridional atmospheric circulation is establish. The upper-level trough is under Western Europe and upper-level ridge prevailed under Eastern Europe.

Analysis of HYSPLIT backward trajectories shown that at the SLP air flows from the north-east, west and east have the equal frequencies (19-20%). In 16% cases relatively short trajectories formed directly over Ukraine. At the level of 1500 m flows from the west have most frequency (30% cases). The flows from north-west, north and east directions are observed in half of all cases. At the level of 3000 m air particles trajectories from the west prevailed (45% cases). Along moving trajectories the air temperature was increased at all observed levels. The largest heating was 17-23°C per 120 hours at the level of 1500 m. At the same time, downward air moving from the upper levels was observed, which led to adiabatic heating of the air mass. The assessment of lapse rate showed that, on average, it was 0.98°C/100 m in the layer of 0-1500 m and 0.68°C/100 m in the layer of 1500-3000 m. So, during the dry wind formation the lapse rates close to dry adiabatic value in the lower troposphere that leads to maximum heating and drying.

Keywords: dry wind, backward trajectory, adiabatic heating

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-28

Synoptic conditions and frequency of heavy rainfalls in Belarus

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In recent decades in Belarus the question of the impact of weather conditions on the development of economic sectors and life of the population has become acute. The maximum damage to the country's economy is caused annually by very intense heavy rainfalls (67 %).

In this study it was analyzed the synoptic conditions and frequency of heavy rainfalls in Belarus during the period of 1995-2018. All cases of heavy rainfalls were divided into 3 groups: 1)very heavy showers (the amount of precipitation not less than 30 mm for a period of not more than 1h) – 26 cases; 2)very heavy rains (not less than 50 mm for a period of not more than 12h) – 309 cases and 3)prolonged very heavy rains (not less than 100 mm for a period of 12-48 h) – 22 cases.

It was found that heavy rainfalls of all types were observed in the warm period of the year – from May to early October. The maximum number of cases occurred in the summer months – June-August (315 cases), with the largest number in July – 182 cases.

The average number of heavy rainfalls during the warm period of the year ranged mainly from 3 to 9 cases, with a maximum of 12 cases in 2006. In some years (2008, 2012, 2014-2015) their number didn't exceed 1-2.

Trend lines showed that the frequency of intense rainfalls in the warm period decreased, but it was a positive dynamics in July during the studied period.

The active cyclonic circulation or low-gradient unstable fields caused intensive precipitation in Belarus. At night, they were mainly associated with the influence of the warm fronts near the center of surface cyclones, and in the daytime the intensity of precipitation was determined by the cold fronts with waves and severe convection.

The backward trajectories (120 h) were calculated using the HYSPLIT model. It was found that there are two main sources of air masses bringing abundant rainfalls in Belarus: the Mediterranean and the Black Sea. In rear cases the humid air masses are transported from the Atlantic region.

Keywords: rainfalls in Belarus, synoptic conditions, backward trajectories, humid air masses

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-29

Intensification of heavy precipitation events in continental-scale climate-change simulations with kilometer-scale resolution

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Climate models and observations show that heavy precipitation is intensifying with a warmer climate, and these changes are very often put in the context of theoretical expectations from Clausius-Clapeyron relation with regard to the (near-) surface temperature. However, the intensification of heavy precipitation is very sensitive to the investigated region and model, and to the analysis method, and thus often shows departures from Clausius-Clapeyron rate.

Here we employ a high-resolution model at convection resolving resolution of 2.2 km over a pan-European domain, and analyze scaling of heavy precipitation in response to warming over different regions. The increase of heavy precipitation with near-surface temperature in most of the regions is around Clausius-Clapeyron rate, except for the British Isles where it exceeds this rate for heavy daily and hourly precipitation. We show that the lower troposphere, which contains the most of moisture, warms faster than the surface, especially over oceans. Thus it can contain more moisture than expected from the increase in surface temperature, and leads to above Clausius-Clapeyron increase in heavy precipitation. These results indicate that the changes in the surface precipitation are largely controlled by the changes in the temperature of the lower-troposphere, and not by changes in the (near-) surface temperature.

Keywords: heavy precipitation, convection resolving scale

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-30

Can reanalysis products with only surface variables assimilated capture MJO characteristics?

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The Madden-Julian Oscillation (MJO), as a dominant mode of tropical intraseasonal oscillation, plays an important role in the variability of global weather and climate. However, current state-of-art atmospheric circulation models have difficulty in reproducing observed MJO characteristics when forced by observed daily sea surface temperature alone. An important practical question is how much data a model needs in assimilation in order to reproduce real MJO events? By analyzing ERA-20C and NOAA-20CR reanalysis data, the authors tried to figure out whether a model could reproduce observed MJO events by assimilating the observed surface signal alone.

The phase propagation and vertical structure associated with MJO were compared between the reanalysis data and observations during 1979-2010. A total skill score considering both temporal correlation and spatial standard deviation were defined. The result showed that both ERA-20C and NOAA-20CR could reproduce the observed MJO characteristics very well, with the former superior to the latter, regardless of MJO intensity. Thus, a minimum requirement for an operational atmospheric model for MJO prediction is the assimilation of the observed surface signals.

Keywords: MJO, Reanalysis data, data assimilation

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-31

Evaluation of the effects of a multiphysics ensemble on the simulation of an extremely hot summer in 2003 over the CORDEX-EA-II Region

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The performance of multi-physics ensemble of WRF model is assessed and evaluated for the JJA extreme precipitation and temperature in 2003 over the CORDEX-EA-II domain. While relatively larger biases of model precipitation and temperature are evident over the sub-regions where the effects of mesoscale processes are important, the combinations of WRF physical schemes also show dependency on geographic location and climate regimes. Comparably, the cumulus and microphysical schemes have substantial influences on the simulation of precipitation, and the land surface models and cumulus schemes play crucial roles in the surface temperature. The combination of Noah for the land surface process, Lin for the microphysics, G3D for the cumulus parameterization and CAM for the radiation scheme can provide the most reliable reproduction of both precipitation and temperature extremes over China. The wind fields at low-to-middle atmospheric levels, which is closely connected to model's ability to reproduce regional extremes, are sensitive to the model treatment of land surface and cumulus convective process, and the impact of the land-atmospheric interaction on regional extremes can be greatly modulated by convective activity. In conclusion, the model simulated temperature and precipitation extremes are sensitivities to the model physical processes, displayed as relatively large ensemble spread.

Keywords: regional extremes, WRF model, multi-physics ensemble analysis

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-32

The sensitivity to initial soil moisture for three severe cases of heat waves over Eastern China

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Using Weather Research and Forecasting model (WRF) simulations with different initial soil moisture (ISM) conditions, we investigate the sensitivity to ISM for the three severe heat wave events that dominated eastern China in 2003, 2007, and 2013. The control simulations are able to reproduce the spatial distributions and the daily evolutions for each of the three heat waves but apparently underestimate their amplitudes, intensities, and spatial extensions. The decreased ISM could cause an enhancement on heat waves with increased amplitudes, extents and intensities, while it has insignificant influence on the spatial distributions and temporal variations. The responses of heat waves are generally decreasing with the increasing ISM, controlled by different regimes in the surface soil moisture-temperature relationship. Through enhanced sensible flux as well as reduced latent cooling, the initial soil dryness locally strengthens the surface warming and the further drying of the soil. The three heat waves were all dominated by high-pressure systems in the mid-troposphere. The reduced ISM forces positive anomalies of geopotential height at mid-troposphere and negative anomalies at lower levels, leading to an enhanced thickness of the atmosphere. Such a thickened atmosphere can strengthen the anomalous high-pressure systems, favoring the maintenance of severe heat waves. This acts as a positive feedback between atmospheric circulation, surface warming, and soil dryness.

Keywords: initial soil moisture, heat waves, WRF, soil moisture-temperature relationship

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-33

Quantifying anthropogenic contribution to the 2017 earliest summer onset in Korea using large-ensemble RCM simulations

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During May 2017, South Korea experienced the hottest recorded temperature since 1973 which was the culmination of four consecutive years of record-breaking May temperature. The warmer May temperature were observed across South Korea, with the station mean being 1.5°C warmer than climatology (1987-2010). The hottest May coincides with the earliest summer onset about 8 day earlier than climatology, exerting huge societal impacts for health, economy, and leisure activities. To examine the human contribution to the 2017 extreme May temperature and the earliest summer onset, this study assesses extreme events under real world and counterfactual world conditions using high-resolution (50 km) large-ensemble (>1000 members) regional climate model (RCM, weather@home) over CORDEX-East Asia Phase I domain. Results are compared with those from atmospheric global climate model (GCM, CAM5.1) simulations and CMIP5 coupled GCMs with a coarse resolution. The anthropogenic contribution is quantified by using risk ratio (RR) which indicates a change in extreme event probability due to human activities. Both large-ensemble RCM and GCM simulations show that the probability of occurrence of the extreme events like the 2017 May case increases by two-three times when including anthropogenic forcing (mainly due to greenhouse gas increases). Further analysis of differences in the attribution results among different boundary SSTs (or GCMs) suggests that the inter-model difference is closely related to the model's response to the aerosol forcing, supporting previous findings. Our multi-model assessment based on RCM and GCM simulations provides a convincing evidence that human influence has contributed to the stronger and earlier spring heat wave in Korea by better considering inter-model uncertainties.

Keywords: RCM, Summer onset, anthropogenic contribution

Parallel Session C: Climate Change Impacts

C1: High Impact regional phenomena

C1-P-34

Response of tropical terrestrial gross primary production to the super El Niño event in 2015

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The Gross Primary Production (GPP) in tropical terrestrial ecosystems plays a critical role in the global carbon cycle and climate change. The strong 2015–2016 El Niño event offers a unique opportunity to investigate how GPP in the tropical terrestrial ecosystems responds to climatic forcing. This study uses two GPP products and concurrent climate data to investigate the GPP anomalies and their underlying causes. We find that both GPP products show an enhanced GPP in 2015 for the tropical terrestrial ecosystem as a whole relative to the multi-year mean of 2001–2015, and this enhancement is the net result of GPP increase in tropical forests and decrease in non-forests. We show that the increased GPP in tropical forests during the El Niño event is consistent with increased photosynthesis active radiation as a result of a reduction in clouds, while the decreased GPP in non-forests is consistent with increased water stress as a result of a reduction of precipitation and an increase of temperature. These results reveal the strong coupling of ecosystem and climate that is different in forest and non-forest ecosystems, and provide a test case for carbon cycle parameterization and carbon-climate feedback simulation in models.

Keywords: gross primary production, El Niño-Southern Oscillation, tropical terrestrial ecosystems, light use efficiency, extreme events

**Parallel Session C:
Climate Change Impacts**

C2: High mountain environments

ORAL PRESENTATIONS

Parallel Session C: Climate Change Impacts

C2: High mountain environments

The Experimental Studies on the Land-Atmospheric Interactions over the Source Region of the Three Rivers

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The land-atmospheric interaction is an important component of the Earth Climate System. Although the numerical model and satellite remote sensing are the main means to study the land-atmospheric interaction process, the field observation experiments are still essential. The land-atmospheric interaction process in the source area of Three Rivers has important impacts on climate change and water cycle in this region and even in the whole eastern Asia region. This investigation will focus on a series of the land-atmospheric interaction field experiments in the source area of the Three Rivers. Special attention has been paid to the observations of the water heat exchange between the land-atmospheric interaction field experiments, the establishment and data analysis of soil moisture observation network, and the ground based microwave remote sensing experiment. The important research progress based on this experiment is to be introduced, and the future prospect of the data is prospected.

Keywords: land-atmospheric interaction; experiment; moisture; remote sensing

Parallel Session C: Climate Change Impacts

C2: High mountain environments

Is dynamically downscaled CORDEX-SA domain model able to simulate Rainfall pattern: A case study of north-west Himalayan region?

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The climatic phenomena over the Indian region are highly influenced by monsoon. As a great physiographic divide, the Himalayas defends rain-bearing south-west monsoon to give up maximum precipitation in that region during the monsoon season (rainy season). According to the scientific concurrence, it can be said that rainfall in North-West Himalayan Region (NWH) become more unpredictable as there is a considerable variation between the duration of monsoon and the amount of rainfall in the different places of that region. According to the socio-economic point of view, the rainfall over the NWH region is very closely related to the loss of human beings, destruct architectures and food crops. In that context, the present study has been planned to investigate the Coordinated Regional Climate Downscaling Experiment over the South Asia region (CORDEX-SA) domain model is able to capture rainfall intensity at daily scale over NWH region compared to the ground-based IMD gridded rainfall data properly or not? To serve that purpose, some selected CORDEX-SA domain models like MIROC5, MPI-ESM-LR, GFDL-ESM2M, and IPSL-CM5A-LR, etc. have been utilized according to their simulation capability of the spatio-temporal distribution of rainfall at daily scale over the NWH region during the time period 1976 to 2000 in the principal rainy season. It is noted from the analysis, that the models like MIROC5 and MPI-ESM-LR provide the best spatial distribution of rainfall, although CORDEX-SA domain models are unable to capture the rainfall intensity at daily scale compared to IMD data over the NWH region. More discussion will be held at the time of conference.

Keywords: Rainfall, CORDEX-SA, NWH region EURO-CORDEX, climate projections, snow cover

Parallel Session C: Climate Change Impacts

C2: High mountain environments

Observations and Modelling of Precipitation in High Mountain Regions

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Within the Global Energy and Water Exchanges Project (GEWEX) of the World Climate Research Programme (WCRP) several new activities are being developed to address the issues regarding observations and modeling of precipitation in high mountain regions. Several Regional Hydroclimate Projects (RHPs) are being developed in the high mountain regions of the world (ANDEX, AsiaPEX) that will focus on the issue of improving our observations both in situ as well as using remote sensing and modeling of precipitation with convection permitting modeling. A special activity that cross cuts these RHPs is now being developed to address precipitation in these challenging environments in particular. In this presentation, the various approaches and ideas within this new project will be presented.

Keywords: Precipitation, High Mountains

Parallel Session C: Climate Change Impacts

C2: High mountain environments

European snow cover in a changing climate: Evaluation and projections of the EURO-CORDEX regional climate model ensemble

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Surface snow cover plays a vital climatic role in mountainous and high latitude regions around the globe, where snow-atmosphere feedbacks can strongly influence near-surface atmospheric conditions. In addition, human activities strongly depend on snowfall and snow cover in many of these places. In Alpine regions, for instance, freshwater supply partly relies on the availability of meltwater originating from the surface snowpack. Also winter tourism often heavily depends on the availability of natural snow. Recent studies of past snow cover trends using observational datasets show a decrease in snowfall days and snow depth in many regions.

In order to anticipate future changes in snow cover and its implications for human activities and water availability, regional climate models (RCMs) can be used. These models aim at representing the most relevant processes for climatic conditions in a region on time scales of decades to centuries and, among others, incorporate snow parameterization schemes of differing complexity to simulate the snow cover response to climate change and climate variability. They thus allow for an approximate representation of snow-atmosphere feedbacks.

In this study, we exploit the state-of-the-art multi-model EURO-CORDEX RCM ensemble to validate past and to analyze future snow cover conditions on a European scale and at a horizontal resolution of ~12 km. We first investigate the capability of the model ensemble to represent historical snow cover conditions in different regions of Europe in re-analysis and GCM-driven simulations. Model results are evaluated against satellite derived and surface-based observational datasets. Overall, the analysis indicates a good representation of past snow cover variability by the RCMs. However, important biases can arise especially at high-elevation regions due to a constant accumulation of snow in some models.

Second, projected future changes in European snow conditions for three different greenhouse gas scenarios (RCP2.6, RCP4.5 and RCP8.5) are analyzed. We find an important reduction of both mean winter snow depth and of snow cover duration over most regions of Europe. The relative loss of snow cover is most pronounced in high emission scenarios (RCP4.5 and RCP8.5) and at low elevations where present-day winter temperatures are already close to or even above the melting point. Also snow cover duration is projected to importantly reduce. Overall, the results are largely consistent with regional studies employing offline snow cover models forced by RCM atmospheric input, indicating the general applicability of RCM-simulated snow cover for large-scale studies.

Parallel Session C: Climate Change Impacts

C2: High mountain environments

Future changes in snowfall and snow cover at high Japanese mountain ranges

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The Japanese high mountain ranges along the Sea of Japan receive heavy snowfall in winter. The northwesterly from the continent obtains a large amount of moisture from the Sea of Japan and causes heavy snowfall along the Sea of Japan coast. This mechanism is the same as the sea effect of the Baltic Sea or the lake effect of Great Lakes in the US. The topographic updraft enhances snowfall and results in enormous amount of snow cover over the high mountainous areas in Japan. Since the Japanese mountain ranges have complex topography, a high-resolution regional climate model is required to reproduce the mountainous snowfall and snow cover in Japan.

We have already conducted the large ensemble regional and global climate simulation, which is called the database for Policy Decision making for Future climate change (d4PDF), using the non-hydrostatic regional climate model (NHRCM) with 20 km grid spacing and atmospheric general circulation model (MRI-AGCM) with about 60 km grid spacing. In this study, the dynamical downscalings from d4PDF are conducted using NHRCM with 5 km and 1 km grid spacing (NHRCM05 and NHRCM01) in the selected years to focus on the future changes in snowfall and snow cover over the complex Japanese mountains.

In the end of 21st century under the RCP8.5 scenario, winter total snowfall is comparable to that in the present climate over the high mountainous areas. NHRCM01 indicated that snowfall will increase from late December to early February although snowfall will decrease in the early winter and late February. NHRCM01 also indicates that the frequency of heavy daily snowfall will increase in the future climate. These changes are clearly found in the heavy snowfall years. In the light snowfall years, total snowfall dramatically decreases due to global warming. Our results indicate that the interannual variation of snowfall become large at the Japanese high mountainous areas in the future climate.

Keywords: mountainous snow, global warming, regional climate change, Japanese mountain ranges, ensemble experiments

Parallel Session C: Climate Change Impacts

C2: High mountain environments

The relation between CORDEX precipitation and model orography in the northwest Ethiopian highlands

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The Ethiopian highlands go up to 4500m and feature very complex patterns of precipitation that are important to the large local population? However, due to the sparse observational network, understanding the rainfall variability can be achieved by the use of climate models. Modelling rainfall in the Ethiopian Highlands is challenging due to the complex orography, the presence of Lake Tana and the seasonal and predominantly convective rainfalls.

Here, the available CORDEX models from different CORDEX domains that cover northwest Ethiopia are evaluated against multiple sets of gridded observational data sets (Van Vooren et al. 2018). Such model validation is required to get confidence in climate projections that assess the response of precipitation and associated impacts such as agriculture, with respect to global climate change.

The results indicate that, although CORDEX overestimates rainfall, observations generally lie within the range of the model ensemble. We underline the relation of the model orography to the model performance. More specifically, we find an overestimation of the elevational sensitivity in the sense that CORDEX rainfall is too high at high elevations and too low at low elevations. Models featuring the most smoothed model orography perform best although this relation could be due to their very poor orographic representation. Six other models, also featuring a poor orographic representation, have the strongest precipitation overestimation at high elevations. Given their strong elevation–precipitation correlation even larger biases could be expected in case these models incorporate a correct orography. Results are also shown that show the contrast between rainfall falling at the windward and rainfall at the lee-side of the mountains

Reference:

Van Vooren, S., Van Schaeybroeck, B., Nyssen, J., Van Genderachter, M., & Termonia, P. (2019). Evaluation of CORDEX rainfall in northwest Ethiopia: sensitivity to the model representation of the orography. Accepted to International Journal of Climatology 39, 2569-2586, doi:10.1002/joc.5971.

Keywords: orography, precipitation, convection

Parallel Session C: Climate Change Impacts

C2: High mountain environments

Topography effects on projected rainfall change in mid-latitude mountain regions

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Change to precipitation in a warming climate holds many implications for water management into the future, and an enhancement of a precipitation decrease or increase on or around mountains would have numerous impacts. Here we show that recent observed trends and two high-resolution model ensembles agree on an enhanced precipitation decrease over the Australian Alps compared to surrounding regions in winter and spring, consistent with theory and model studies of idealised mountain ranges. The ensembles disagree on an enhanced precipitation decrease in autumn. Intermediate resolution modelling suggests that this enhanced response is present over other mid-latitude mountain ranges in winter. The projected change in summer rainfall over mountains depends on processes such as convection that are parameterised even in current regional climate models. We find that parameterised rainfall drives an enhanced rainfall increase over the inland slopes of the Australian Alps compared to surrounding regions in summer, partly consistent with previous findings over the European Alps. We also find that an increase in parameterised rainfall determines the sign of total rainfall change in many regions in summer, only some of which are on or near mountains. The results represent regional-scale added value in the climate change signal of projections from high resolution models in cooler seasons, but suggest that the specific model components such as convection schemes strongly influence projections of summer rainfall change. Confidence in the simulation of change in convective rainfall, or convection-permitting modelling may be needed to raise confidence in summer rainfall projections over mountains.

Keywords: regional climate models, added value

Parallel Session C: Climate Change Impacts

C2: High mountain environments

The investigation of glacier-hydrological impacts under climate change by an integrated atmosphere-glacier-hydrological modeling system: a case study of a Norwegian glacier

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Glaciers provide natural storage and regulation of water supply to rivers, which, in turn, contribute to water supply for domestic and industrial consumption, irrigation and hydropower, especially in Norway. There is a critical and pressing need to better understand the effects of climate change on glaciers, and the local-to-regional hydrological impacts these changes induce, in a holistic manner. However, the regional processes, mass balance and/or other glacial processes, are still poorly understood. Further, the impacts these changes have on water resources are typically investigated via a one-way chain of discrete models, which often mismatches in temporal and spatial resolution.

Our study aims to investigate the future climate projection and its glacier-hydrological impacts for a well-monitored Norwegian glacier (Hardangerjøkulen) complex by a newly developed integrated atmosphere-glacier-hydrological modelling system, i.e. WRF-HydroGlac. First, a convective-permitting simulation (1km over the Hardangerjøkulen region and its surrounding watersheds, and 100 m for the hydrological/glacier system) of hindcast 10 years (1995-2005) was conducted by the WRF-HydroGlac modeling system and evaluated based on the observations. Second, the Pseudo-global-warming (PGW) climate change approach is applied to focus on the forced response of the future climate system at the middle of the century (2055-2065) and we made a future projection, which has the same domain set and resolution as the hindcast simulation. At last, we investigated and summarized the climate and glacier-hydrological projections for the Norwegian glacier region by the WRF-HydroGlac modelling system.

Keywords: Glacier, Hydrological impact, modelling, regional climate, convective-permitting, climate change

Parallel Session C: Climate Change Impacts

C2: High mountain environments

Results of a new methodology for the analyze the climate change uncertainty on a high step mountain range. Application at the Andes

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Multi-model climate change analysis over mountainous regions is a complex topic due to the models' different representations of the mountains. The Andes Mountains produces a huge disturbance of the atmospheric circulation of South America with large differences in the climatic response that occur on the windward and lee side of the range. Due to different representations of the mountain, the windward and lee sides will differ among the models. Moreover, the climate along the mountain range will present a strong dependence on the topographical high of the grid point, also differing among models, and its distance from the Equator. In order to take under consideration all these elements, we present the first results of a methodology which allows us to objectively classify the domain of simulation following three different criteria: latitudinal bands, topographical height and W-E side along the range. The methodology is applied to analyze the climate change projection and its uncertainty of all over the South American Andes mountain range. This range encompasses a large variety of climates along its North-South distribution and presents also strong W-E climate differences due to its blocking effect to the large-scale circulation. The databases used include a sub-set of CMIP5 runs, available CORDEX runs, and some re-analysis in order to provide a robust measure of the uncertainty spanned by these models presented at different, latitudes, heights and sides of the mountains.

Keywords: Climate uncertainty, Mountaineous areas

**Parallel Session C:
Climate Change Impacts**

C2: High mountain environments

POSTER PRESENTATIONS

LAST NAME	FIRST NAME	TITLE	POSTER NUMBER
DAHAL	Piyush	Application of CORDEX South Asia climate product to assess the impacts of climate change on water availability in Karnali River Basin of Nepal Himalaya.	C2-P-01
DHAKAL	Subodh	Climate change vulnerability in different parts of the Nepal Himalaya	C2-P-02
MADHAV	Giri	Impacts of climate change on the mountainous indigenous communities of Nepal	C2-P-03

Parallel Session C: Climate Change Impacts

C2: High mountain environments

C2-P-01

Application of CORDEX South Asia climate product to assess the impacts of climate change on water availability in Karnali River Basin of Nepal Himalaya.

Piyush Dahal, *The Small Earth Nepal, Nepal*

Piyush Dahal, Jeeban Panthi, Madan Lall Shrestha, *The Small Earth Nepal/Nepal Academy of Science and Technology, Nepal*

The Himalayas are water towers for Asia and water source to major rivers which provide water for about 1.3 billion people inhabiting the mountain and downstream. Basin-level water availability assessment in the context of climate change is now a major concern for many regional planners and decision makers in this area. The main objective of this research is to evaluate the projected impacts of climate change on water availability in Karnali River Basin of Nepal Himalaya. We applied the Soil and Water Assessment Tool (SWAT), a basin-level hydrological model to determine future water availability based on climate scenarios. We used an ensemble product of CORDEX South Asia future climate data for 2040-2069 and 2070-2099 for 2 emission scenarios – RCP4.5 and RCP8.5. Results indicate that the average annual temperature could rise by at least 1.4°C by the mid-21st century (2040-2069) and can exceed by 3.4°C by the late 21st century (2070-2099) under a high-emissions scenario compared to the baseline 1971-2000. The warming trend is projected to be stronger in northern highland than lowland. Our analysis shows that precipitation will increase during the monsoon but decrease during the winter, indicating increasing extreme events. Annual precipitation could increase by 12% and 30% under RCP4.5 RCP8.5 scenarios respectively. This change in precipitation has been reflected in streamflow change. An increase in streamflow is expected for both the mid- and late-century compared to the baseline period in pre-monsoon (March-May) and monsoon (June-September) seasons and that flooding will become more extreme and projected to decrease streamflow during the early winter.

Keywords: Climate Change, Water Resource, Hydrological Model, Himalaya

Parallel Session C: Climate Change Impacts

C2: High mountain environments

C2-P-02

Climate change vulnerability in different parts of the Nepal Himalaya

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Due to the great variation of topography, the climatic variability and its impact are not homogeneous in Nepal. This paper identifies the vulnerabilities associated with the climate change in the High Mountains to the plain areas of Nepal focusing on glacial retreat in the high mountains, water resources in the Middle Mountain and crop production in the plain area. The primary data were collected from the direct field study and social survey. The secondary data were collected from the satellite images and the relevant agencies of the Nepal government. The climatic and crop yield trends were determined using Mann–Kendall tests and quantified using Sen's slope method.

When comparing the aerial extent of the glaciers in the Langtang Valley, the total loss of glacial coverage area within the past 30 years is 24%. The horizontal and vertical retreat of glaciers in this watershed is found to be 40 m/year and 3 m/year respectively. As a consequence, the vulnerability of debris flow, shortage of water resources and adverse impact in agriculture were reported. Study in the middle mountain of Salyantar area for last 30 years revealed that maximum temperature was increasing at the rate of 0.039 degree Celsius/year and annual precipitation was decreasing at the rate of 22.99 mm/year with statistically significant trend. Number of local ponds has been reduced and the soil moisture has been decreased continuously. Water coverage has been decreased from 28.93% to 6.47% within the same period. Study in plain areas of Nepal in Rautahat district revealed that the annual average rainfall is decreasing at the rate of 10.21 mm/year and the annual mean temperature is increasing at a rate of 0.020 degree Celsius/year over the last 30 years. Despite this trend, the yield of major crops showed increasing trend which is statistically significant. This is attributed to the adaptation measures like enhanced irrigation systems, hybrid seeds and increased access to fertilizers and pesticides.

Keywords: Climate change, Vulnerability, Glacial retreat, Crop production

Parallel Session C: Climate Change Impacts

C2: High mountain environments

C2-P-03

Impacts of climate change on the mountainous indigenous communities of Nepal

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Climate change is fast pushing the communities, particularly the most poor and marginalized in the developing countries. Erratic rainfall patterns and changing seasons are upsetting agricultural cycles and drought events are leaving many to struggle to feed their families. This study was undertaken to assess adaptation practices by Surel and Thami mountain indigenous and marginalized communities of Nepal.

The study was conducted based on the data gathered from both the primary and secondary sources. The primary data were collected using questionnaire survey of 104 households of marginal communities in Lapilang and Surel village of Dolakha, mountain district of Nepal along with key informant interviews in May – June 2018. Meteorological data were collected from Department of Hydrology and Meteorology.

There was increment of mean annual temperature by 0.02040C per year. Similarly, data confirmed an increment trend of annual rainfall at the rate of 7.574mm per year. There was increased in Maize production and increased Mosquito problem due to increased in temperature. Both the communities are facing emergence of diseases and pests in their farmland and livestock.

It was found that the farmers are practicing some adaptation options such as shifting from large animals to smaller ones, introduction of new varieties of commercial vegetables, crop rotation, surface channels for irrigation, artificial ponds and water tank for the storage of water. However, strong institutional supports are required to build resilience of poor and marginalized community to strengthen the adaptive strategies and practices.

Keywords: Climate change, Impact, Adaptation, Mountain, Indigenous

Parallel Session C: Climate Change Impacts

**C3: Implications for renewable
energy**

ORAL PRESENTATIONS

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

Future projections of wind speed and wind power over CORDEX-East Asia

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Delei Li, Institute of Oceanology, Chinese Academy of Sciences, China; Baoshu Yin, Institute of Oceanology, Chinese Academy of Sciences, China; Beate Geyer, Institute of Coastal Research, Helmholtz Zentrum Geesthacht, Geesthacht, Germany

China has set ambitious goals for the development of wind energy to meet the increasing energy demand. Many studies have assessed the potential wind energy in Chinese continental areas for historical periods. However, few studies have focused on future projections of climatology and variability of wind speeds and wind power in China. We analyze ensemble simulations of regional climate model CCLM over CORDEX-East Asia at 50 km resolution, focusing on wind speed and wind energy potentials. The analysis is based on 3-hourly 10 m wind speeds from four GCM-CCLM Chain simulations during 1950 - 2100. The quality of historical wind speeds during 1981-2005 reconstructed by CCLM was assessed by a comparison with ERA5 reanalysis dataset. Quantile mapping based on Weibull distribution has been used to bias-correct simulated to the ERA5 reanalysis dataset. The climatology, variability, and extreme climate of wind and wind energy over the BYS are spatially and temporally investigated, including mean changes in annual and seasonal wind energy.

Keywords: wind energy, future projection, CORDEX-East Asia, Bias Correction

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

Effect of aerosol-radiation and aerosol-cloud interactions in the simulation of photovoltaic and wind power using regional climate models

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Sonia Jerez, Jose María López-Romero, Blas Lajarin, Raquel Lorente-Plazas, Laura Palacios-Peña, Pedro Jiménez-Guerrero, Juan Pedro Montávez, Universidad de Murcia, Spain

Regional Climate Models are powerful tools allowing in-depth characterizations of the variable renewable wind and solar resources abundance and variability and the climate change impact on these, among others. Their suitability to provide both surrogate climate databases to overcome the limitations of the observational records and to assess regional impacts of the global warming is well known. However, they still miss some important physical-chemical processes, mainly due to their high computational cost. As this latter is increasingly assumable, an evaluation of the effects and actual importance of these processes, such as aerosol-radiation (ARI) and aerosol-cloud (ACI) interactions, is key to advance in the optimal design of new regional climate model experiments. Here we assess the extent at which the climatologies of the wind and the solar resources are sensitive to the costly inclusion of the aerosols effects. Euro-Cordex compliant ERA20C-driven WRF and WRF-CHEM (including fully two-way ARI and ACI) simulations for the period 1991-2010 are compared for the purpose. Results depict non-negligible signals, larger for the solar resource, indicating a general decrease in the resource availability and usability when evaluated from the most complex simulation despite the fact that ACI effects were found to offset part of the sensitivity signals to the ARI effects, a novel finding itself.

Keywords: Regional climate model, aerosol

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

Impact of climate change on future potentials of solar electricity generation over West Africa

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Solar power generation or utilization is highly dependent on the availability of adequate solar radiation which is strongly influenced by weather and climate. To examine the impact of climate change on the future solar energy resource potentials over West Africa during 2020-2060. We analyze multi-model ensemble of the Africa-CORDEX regional climate simulations. We found that under two greenhouse gas concentration scenarios that annual solar resource ranges from 300 Wm⁻² in the northern extremity to 160 Wm⁻² in the Guinea Coast region. Additionally, it is observed that the solar radiation trends increased significantly in the region. This suggest that future climate scenarios appears not to affect the stability of solar electric power generation over West Africa.

Keywords: Solar radiation,Future projection,West Africa

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

Characterizing the Historical and Projected Wind Energy Resource in the Philippines Using CORDEX-SEA Simulations

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Wind energy is a viable resource for power generation in the Philippines, but the wind resource will likely change over time due to climate change. This study determined the historical and projected trends in both wind speeds and available wind energy in established and potential wind farm locations in the Philippine region. The wind resource was assessed using an ensemble model output from the Coordinated Regional Climate Downscaling Experiment – Southeast Asia (CORDEX-SEA). Large positive biases in the modeled surface wind speeds of up to 200% with respect to ECMWF Re-Analysis (ERA)-Interim dataset, especially in mountainous regions, were observed and later bias-corrected using the Quantile Mapping Method. Seasonally for all periods, wind power peaks during January-December and August, coinciding with peaks of the Northeast and Southwest monsoons, respectively. Both Representative Concentration Path (RCP)4.5 scenarios for the 2046-2045 period show an increase in wind power density with respect to 1986-2005 values over the whole Philippine domain, with stronger increase during Southwest monsoon months. Analysis of several regions in the Philippines reveal that Palawan and Quezon, which were identified in previous studies to be areas with excellent wind resources, remain to be viable wind farm locations. However, potential sites (Northeast and West Luzon, Mindanao, Celebes Sea) that show large and significant ($\alpha = 0.05$) projected increase in wind resources were determined to be poor wind farm locations, as both the available and extractable wind power are still quite low despite this large increase.

Keywords: CORDEX-SEA, Philippines, Wind Energy, climate change, RegCM4.3

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

A study on civic engagement into energy transition since Fukushima and its impact on renewable energy policy in South Korea

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Hyun-Chin Lim, Suk-Ki Kong, *Seoul National University Asia Center, South Korea*

This paper tries to explore how the Fukushima disaster in 2011 had an unfathomable impact on the whole Korean society into reflecting the national energy policy as well as promoting energy transition. Awakened by the Fukushima disaster, the hibernating Korean citizens on nuclear issues regathered for denuclearization and climate change. Various civic groups are converging on energy transition by carrying out science-based campaigns. Recently, those threatened by the risk of particulate matters(micro-dust), are actively supporting for energy transition to renewable energy. The Fukushima disaster has begun to crack down on the four-party alliance: the nuclear industry, interest groups, government agencies, and expert groups. To examine the dynamic process, this paper focuses on the full-fledged frame conflict and competition surrounding the energy transition policy. Especially, we highlight the bottom-up process of how grassroots citizens plan, lead and practice participation to promote local governance towards energy transition. Since the Moon Jae-in government was launched in May 2017, the government declared denuclearization policy and recently promised not to construct any nuclear power plant but to increase renewable energy ratio up to 30-35% by 2040. Given the new political opportunities, the trilateral competition and conflict on energy policy are getting intense. Notably, citizens fearing climate crisis have actively engaged in practical alternatives such as energy-saving campaigns and solar power plant cooperatives. This paper examines how post-nuke groups develop their specialty equipped with more scientific and reliable evidence to persuade others. Arguably, such energy transition efforts push the government to prioritize renewable energy policy over fossil fuel industry causing climate change. This analysis suggests practical and scientific clues on how the government resolves frame conflicts and develops renewable energy policies towards energy transition. It is hoped that the findings from the present analysis has no small implications for policy choices not only in Northeast Asian countries but in all developing countries.

Keywords: Renewable Energy Policy, Energy Transition, Civic Engagement, Climate Change, South Korea

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

Sustainability of the hydropower generation capacity of Pakistan in changing climate conditions

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***Hazrat Bilal, Mazlin Mokhtar, Chamhuri Siwar**, The National University of Malaysia, Malaysia*

Pakistan's hydropower sector depends heavily on glacier and snowmelt water that originate from the Upper Indus Basin (UIB). It is expected that climate change will have adverse effects on future hydropower generation capacity as a result of fluctuations in the magnitude, seasonality and hydrological extremes of the Indus River runoff. The possible effects of climate change on the Indus River flow had been investigated through the use of Snowmelt-Runoff Model (SRM) along with the Moderate Resolution Imaging Spectroradiometer MODIS snow product and daily ground-based hydro-meteorological data. The results had indicated a significant increase in the annual and seasonal runoff, hence suggesting more water availability in the future. As a stronger increase of seasonal runoff had been shown under the RCP4.5 rather than the RCP8.5 scenario, this difference had, therefore, revealed a significant possible loss of permanent snow and glacier masses by early warming. However, the rise of annual and seasonal river flow is expected to increase the electricity generation capacity of future hydropower projects since the overall generation capacity had been projected to increase between 25% to 69% under the RCP4.5 and RCP8.5 scenarios, respectively. As a case in point, the hydroelectric generation capacity of the Diamer Basha hydropower project is expected to increase from the respective current power generation capacity of 6053 GWh to 7748 GWh and 10224 GWh under the RCP4.5 and RCP8.5 setups by the end of the 21st century. Since the increase of runoff during peak river flow has now become a great concern, there is a pressing need for better water conservation through the building of more robust dams in catering for extreme weathers as well as to supply adequate water for hydroelectric power generation during low flows. As such, apart from improving the storage capacity of future hydropower projects, the spillway discharge capacity of future dams should also be upgraded to deal with peak flows. Likewise, reforestation and afforestation in the upstream areas can help regulate water flow and reduce siltation, while the construction of more dams can mitigate flood risks in downstream areas, hence increasing the resilience of hydropower sector to climate change.

Keywords: Climate Change, Hydropower, Upper Indus Basin, Snow, SRM

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

The Future of Africa's Wind Energy Sector under 1.5° and 2° global warming.

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Africa relies mainly on petroleum imports and hydropower to meet its ever increasing domestic and commercial energy requirements. Wind energy is expected to substantially contribute to the gross generated global energy production, especially in Africa where less than half of its population have access to electricity. Wind energy resource is naturally a function of the climate system, susceptible to variations in climate and hence vulnerable to climate variability and change. In this paper, we investigate potential effect of mean global temperature increases under 1.5oC and 2oC Global Warming Levels above pre-industrial levels on changes in surface wind speeds over Africa with a focus on eight regions with ongoing large-scale wind energy projects, using downscaled multi-model simulations from the Coordinated Regional Climate Downscaling Experiment (CORDEX). The capability of multi-model simulations to reproduce past wind characteristics over the eight regions was evaluated against ERA-Interim reanalysis dataset. Models give realistic simulation of wind characteristics over these regions, and in most cases, the magnitudes of the simulation biases are within the observation uncertainties. Based on multi-model projections, wind energy potential for the eight regions is likely to persist under both 1.5oC and 2oC Global Warming Levels, thus sustainability of ongoing projects is guaranteed.

Keywords: Wind energy, 1.5°C and 2°C global warming

Parallel Session C: Climate Change Impacts

**C3: Implications for renewable
energy**

POSTER PRESENTATIONS

LAST NAME	FIRST NAME	TITLE	POSTER NUMBER
AYOOB KHAN	Afsal	Possibilities of renewable energy technologies to address the pollution hazard due to backwater tourism in Kuttanad area of Kerala, India	C3-P-01
RAHAMAN	Muhammad	Climate Information Services and Its Potential on Adaptation and Mitigation, Local Adaptation Plan of Action (LAPA), Intended Nationally Determined Contributions (INCD) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP): Experience from Flood Affected Region of Bangladesh	C3-P-02

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

C3-P-01

Possibilities of renewable energy technologies to address the pollution hazard due to backwater tourism in Kuttanad area of Kerala, India

Afsal Ayoob Khan, Kerala Agricultural University, India

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Background of the Study: Climate Change is emerged as the major threat to the environment. However, its negative impacts are primarily affected by the poor peoples in the developing countries because they mainly rely on the natural resources for their livelihood. Furthermore, tourism is an important sector among the other climate sensitive economic sectors. The study location Kerala state comprises of a unique geographical features that have made it one of the most exclusive tourist destinations in Asia. Even though there is positive impact on the economy, however environmental pollution is the major problem associated with this industry. The improper and irresponsible way of houseboat tourism development affecting the water quality, ecosystems, agricultural production and traditional livelihoods. Further, the seepage of oil, sewage and other engine driven waste from the houseboats are directly discharged into the agricultural land. Moreover, the farmers were affected by the incidences of health problems when prolonged contact with polluted water.

Objectives: The study was conducted to analyze the pollution hazard due to backwater tourism in Kerala state of Southern India

Keywords: Climate Change, Backwater Tourism, Environmental Pollution, Renewable Energy, Green Economy

Parallel Session C: Climate Change Impacts

C3: Implications for renewable energy

C3-P-02

Climate Information Services and Its Potential on Adaptation and Mitigation, Local Adaptation Plan of Action (LAPA), Intended Nationally Determined Contributions (INCD) and Bangladesh Climate Change Strategy and Action Plan (BCCSAP): Experience from Flood Affected Region of Bangladesh

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Climate services are the use of climate knowledge and information in climate-smart development. The study aims to explore the understanding and level of resilience at community level, potentials of climate information services in promoting INDC, BCCSAP, LAPA and also adaptation and mitigation paradigm with smart mobile phone along with internet scheme via SMS, Outbound Dial (OBD), Apps and Call Centre services on agriculture, agro meteorology, weather forecast and early warning system. The study was conducted in South Kharibari village of Dimla upazila under Nilphamari district in where 100 climate vulnerable households are using customized system for increasing resilience in household level through climate information services. The study was conducted through explanatory methods including case studies, best practice documentation, FGD, KII and PVA (household vulnerability index). The study reveals that climate information plays a vital role in climate resilient development at household level of the study area through increased women's participation in participatory action research and formulation of LAPA, helps to strengthen their leadership role in food security and energy sector which are the major focus area of INDC and BCCSAP. It also helping climate vulnerable women to adapt with changing climate through resilient crop farming, homestead gardening, fisheries, livestock, horticulture and poultry and helps them to develop resilient planning for alternate energy sources in cooking, lighting and another purpose which meets the mitigation needs at household levels.

Keywords: Climate service, adaptation, mitigation, INDC, BCCSAP, LAPA

**Parallel Session D:
Domain/cross-domain meetings,
Convection permitting models**

**D1: Third Pole Environment: high
resolution simulation/reanalysis
and its implication/application**

ORAL PRESENTATIONS

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D1: Third Pole Environment: high resolution
simulation/reanalysis and its implication/application**

Challenges for high resolution simulation over the Himalayas

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Technology, Japan*

The latent heat release from cloud convections over the Himalayas and Tibetan Plateau has been known to play an important role for Asian monsoon and sub-continental scale weather variabilities. Over the slopes and foothills of Himalayas, nocturnal precipitation is observed as well as the daytime orographic precipitation. To simulate cloud-precipitation process over the Himalayas and to understand its physical processes, we conducted a numerical experiment using the Weather Research and Forecasting model (WRF) with cloud-resolving resolution. Initial and boundary conditions were provided from ERA-interim. The experiment was set up with 50 layers and a horizontal resolution with 10km for outer domain and 2km for inner domain. For the outer domain, a cumulus parametrization (CP) was used.

According to the merged-IR dataset, the daytime cumulus convection prevails over the plain region (~200 m topography) and the nocturnal and morning clouds occur over south of the Himalayas. The WRF with 2km horizontal resolution could simulate the nocturnal precipitation peak over the south of Himalayas, which did not clearly find in the simulation using 10km horizontal resolution. The diurnal variation of simulated precipitation in the inner domain tended to be affected by that in the outer domain. Comparing with the experiment with CP for the outer domain, diurnal variation in simulated precipitation is better over the plain region in an experiment without the CP both of the outer and inner domains, while the nocturnal precipitation peak over south of Himalayas cannot be captured well. We will conduct the experiment using ERA5 reanalysis dataset, in which the reanalysis would be directly downscaled to 2km horizontal resolution to avoid the effect of atmospheric conditions simulated in the outer domain. Then, we will investigate the topography resolution impact on the precipitation simulation and will discuss the physical processes to cause nocturnal precipitation over the Himalayas.

Keywords: cloud resolving simulation, the Himalayas

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D1: Third Pole Environment: high resolution
simulation/reanalysis and its implication/application**

Convection-permitting modeling over the Tibetan Plateau

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Based on the regional climate model, dynamical downscaling is an useful tool to provide local climate information at fine scale, in particularly for areas with sparse observation. Tibet Plateau is the unique typical region with scarcity in observation. Therefore, we conducted a series of dynamical downscaling historical (1979-2011) and future simulations (2006-2100) centered over the Tibetan Plateau (Gao et al. 2014, 2015a, 2015b, 2016, 2017, 2018) with the horizontal resolution of 30km. The downscaling was found added values in three aspects. 1) The great overestimated precipitation was reduced 35% averaged over the TP. 2) The observed elevation dependent warming and 3) the dryness-wetness contrast between northwest and southeast were better captured compared to its large scale forcing. Although the advantages of the 30km dynamical downscaling, the profound overestimation in precipitation still exists. Study in the United States (Rasmussen et al 2011; Liu et al. 2016) claimed that convection-permitting modeling could highly improve simulation performance. Hence, a convection-permitting dynamical downscaling with the resolution of 4km was performed for one year due to the computing consumption. Simulated precipitation will be evaluated compared to in-situ observations and multiple remote sensing datasets as well as 30km dynamical downscaling.

Keywords: Tibetan Plateau, Convection-permitting modeling

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D1: Third Pole Environment: high resolution
simulation/reanalysis and its implication/application**

High resolution simulation over the third pole region

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Accurate description of precipitation over mountainous is crucial in the hydrological and disaster studies. Global reanalysis datasets could not satisfy the requirements in these studies due to the coarse resolution, while the calibrated satellite products may also have systematic errors over the station sparse region, especially over the Tibetan Plateau. Simulation with regional numerical models provides an alternative and is expected to provide a more accurate description on the temporal and spatial pattern in precipitation. The complex topography and some meso-micro scale processes should be mostly resolved with high horizontal resolution. This work will conduct a high resolution simulation (up to about 3km) over the Tibetan Plateau and its surrounding. The simulated precipitation is expected to give a more detailed description of the precipitation, which would be beneficial for the hydrological and disaster studies.

Keywords: WRF, Tibetan Plateau

**Parallel Session D: Domain/cross-domain meetings,
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simulation/reanalysis and its implication/application**

**Simulated diurnal cycle of summer precipitation over the Tibetan Plateau
at gray-zone grid spacing**

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Tinghai Ou, Deliang Chen, *University of Gothenburg, Sweden*; **Xingchao Chen**, *Pennsylvania State University, United States*; **Changgui Lin**, *University of Gothenburg, Sweden*; **Kun Yang**, *Tsinghua University, China*; **Hui-Wen Lai**, *University of Gothenburg, Sweden*; **Fuqing Zhang**, *Pennsylvania State University, United States*

The Tibetan Plateau (TP), also referred to as the “Third Pole” of the earth, is the “water tower of Asia”. The Weather Research and Forecast model (WRF) with spectral nudging has been used to simulate warm-season precipitation of 2014 over the TP at the gray-zone grid spacing (9 km), and to evaluate the model’s ability in simulating the diurnal cycle of precipitation. Two groups of experiments have been undertaken: 1) simulations driven by two different global reanalyses without a cumulus scheme (CU), namely the high resolution latest version of global reanalysis of the European Centre for Medium-Range Weather Forecasts (ECMWF), ERA5, and its previous version, ERA-Interim (ERA-I); 2) simulations with different CUs, including Grell-3D Ensemble (Grell), New Simplified Arakawa-Schubert (NSAS), and Multiscale Kain-Fritsch (MSKF). Evaluated against radiosonde observations, it is found that the ERA5 has better ability to reproduce upper-level relative humidity during the summer months (June -August) compared to that of the ERA-I. However, this has little impact on the simulated summer precipitation over the TP. All the three simulations with CU, especially the Grell and NSAS, overestimate summer precipitation with an early peak of hourly precipitation frequency during a day. Both no-CU experiment and experiment with a scale aware CU, namely the MSKF, have their advantage in simulation the diurnal cycle of summer precipitation over the TP, with the no-CU experiment capture better the diurnal cycle of precipitation frequency and the MSKF experiments better reproduced the diurnal cycle of precipitation intensity.

Keywords: Tibetan Plateau, gray-zone, regional dynamical downscaling, diurnal cycle, cumulus scheme

**Parallel Session D: Domain/cross-domain meetings,
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**Effects of planetary boundary layer parameterizations on high resolution
regional climate simulation over Tibe Plateau**

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The Tibetan Plateau (TP), with an average altitude of over 4000 m, has a profound impact on the weather and climate. However, due to its complex terrain, the observation stations over the TP are spare and unevenly distributed, making it difficult to represent the spatial variability of local climate, especially for precipitation. Many studies have shown that with the improvement of horizontal resolution, the regional climate simulations can be improved. To better understand the precipitation variability, the Weather Research and Forecasting (WRF) model is used to simulate the summer precipitation of 1998 and 2006 over the TP. The year 1998 is the peak year while 2006 is the valley year of precipitation. To investigate the sensitivity of summer precipitation to boundary layer schemes, different boundary layer schemes are compared in this study. The regional climate simulations are compared with both high-resolution CMORPH satellite data and in-situ observations. To evaluate the performance of WRF model over the TP, two statistics, CORR (correlation coefficient) and RMSE (root mean square error), are calculated at different spatial and temporal scales to compare the differences between model simulations and observations. The most suitable boundary layer scheme for precipitation simulation over the TP is obtained.

Keywords: high resolution, planetary boundary layer, regional climate simulation

**Parallel Session D: Domain/cross-domain meetings,
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**Simulation of monsoon precipitation over the
North Western Himalaya using WRF**

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The Himalaya, also known as the third pole plays an important role in deriving the climate of Indian sub-continent. The high mountain ranges affect the local convective systems which in turn affect the precipitation intensity and distribution of this region. The North Western Himalaya (NWH) hosts some of the highest mountain peaks which force orographic ascent and orographic blocking of moisture-laden air which leads to cloudburst and heavy rainfall events. Many of the major rivers of the sub-continent like Ganga, Indus and Yamuna originate in the NWH and therefore make the study of precipitation in this region very important. Due to the rugged topography, the rain gauge network in the Himalaya is very poor therefore making it difficult to study the rainfall in this region. Also, the high elevation makes it difficult for remotely sensed data to accurately represent rainfall. In such a context, the use of the high-resolution regional model to study the rainfall appears to be a viable option. The Numerical Weather Prediction models with its forecasting skills will also prove useful for the socio-economic development of the region. Therefore, the present study employs, National Center for Atmospheric Research (NCAR) Weather Research and Forecasting (WRF) model to assess its capability to simulate rainfall over the North Western Himalaya. Simulations were carried out for the monsoon season of 2017 over the NWH using multiple nested domains of 45, 15 and 5 km resolution extending from 65° E to 92° E and 18° N to 40° N. Reanalysis data from NCEP/NCAR are used for the initial and boundary conditions along with High-resolution topographic datasets. The model outputs are compared with the daily gridded rainfall product provided by IMD at 0.25°x0.25° resolution and the satellite-based GPM IMERG and INSAT-3D derived HE rain. All the data is resampled to the model resolution of 5 km. The results showed a good correlation between the simulated and observational data. Also, a relationship between topography and rainfall was established with more rainfall occurring over the windward as compared to the leeward side but tends to overestimate the intensity of rainfall over higher elevations. However, the WRF simulation was able to capture the fine-scale structure of rainfall satisfactorily over the NWH region. The study, therefore, suggests that the WRF model is capable of modelling the orographic rainfall with reasonable accuracy over rugged terrain.

Keywords: Orographic rainfall, North Western Himalaya, WRF, GPM IMERG, Topography

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simulation/reanalysis and its implication/application**

**Observation-model integration for simulating water cycle in the
Tibetan Plateau**

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Asian water tower understanding is constrained by the lack of high-resolution and high-accuracy precipitation data, but current GCMs and RCMs much over-predict precipitation. Our overall goal is to build a regional climate modeling system to simulate precipitation realistically for the Tibetan Plateau. In this talk, we present our field experiments that measure precipitable water vapor, lake temperature profile and rainfall. With these measurements, high quality data and improved simulations are presented, including selecting lake model through model inter-comparisons, implementing orographic turbulent drag scheme and optimizing high-resolution simulations for complex terrain of Himalaya Range. Finally, we propose an integrated strategy to improve plateau climate simulation capability.

Keywords: complex terrain, lake effect

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POSTER PRESENTATIONS

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LAI	Hui-Wen	Downscaled summer convective activities and precipitation over the Tibetan Plateau through ensemble-based data assimilation	D1-P-02
THOMAS	Liby	Sensitivity of soil moisture to rainfall simulations associated with western disturbances over north India	D1-P-03
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**Parallel Session D: Domain/cross-domain meetings,
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D1-P-01

**Classification of precipitation features associated with meso-scale
convective systems in the Third Pole region**

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Jianping Tang, Nanjing University, China*

The Third Pole (TP) refers to the Tibetan Plateau and all the mountain ranges that surround it, as it acts as the world's largest freshwater storage after the Arctic and Antarctica. The region is characterized by faster warming rates compared to global average, which has led to vigorous hydroclimatic changes during the past decades. These changes include changes in large-scale atmospheric moisture transport, a generally increasing precipitation trend and an accelerated hydrological cycle through increased local moisture recycling. Since the plateau is marked by intensive surface heating and sufficient moisture supply through mid-latitude westerlies and the monsoon circulation, convection is a key component for the water cycle. Furthermore, the TP has a clear seasonal cycle of convective clouds and precipitation, which is primarily due to the impact of the large-scale atmospheric circulation. During the summer monsoon season between May and September, meso-scale systems such as Tibetan Plateau vortices (TPV) and Tibetan convective systems (TCS) have been found to be the major precipitation-producing systems in the region. These systems are therefore directly linked to river runoff and water resources, as well as to severe storm and flooding events which affect downstream located societies. Furthermore, meso-scale weather systems in the TP region encompass systems at different spatial and temporal scales which originate from various thermodynamic processes. Yet, no clear relationship between precipitation characteristics and the different systems has been established. For example, it is unknown which system types have the largest environmental impact of persisting heavy precipitation. In addition, there is a lack of knowledge about how these organized forms of convection are linked to the synoptic background conditions and surface features.

In order to draw more robust conclusions about hydroclimatic changes in the TP region, it is thus crucial to understand what role precipitation induced by meso-scale systems has in comparison to small-scale convection and how possible changes in large-scale circulation would affect these systems. Using different high-resolution satellite and reanalysis precipitation products, we identified and tracked areas of meso-scale precipitation based on contiguity, rain rates and time persistence. We then segmented these tracked precipitation areas into different groups and analyzed the spatial and temporal patterns of precipitation features, in order to evaluate the possible linkage to meso-scale weather systems. In addition to the segmentation, we performed a cluster analysis and compared the results to clusters of large-scale and convective precipitation in the recently created regional reanalysis for China (CNRR), to see how much of the precipitation in general can be attributed to convection.

This work provides the first step for a more comprehensive analysis of the synoptic environment which favors meso-scale weather systems and associated precipitation. In order to establish a more clear

relationship between different types of meso-scale convective systems and extreme precipitation In the TP region, additional parameters from the regional reanalysis will be included in the analysis by linking the precipitation segments and clusters to vorticity, updraft, pressure and wind fields.

Keywords: extreme precipitation, mesoscale convective systems

**Parallel Session D: Domain/cross-domain meetings,
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D1-P-02

**Downscaled summer convective activities and precipitation over the
Tibetan Plateau through ensemble-based data assimilation**

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Summer convective systems and associated precipitation over the Tibetan Plateau (TP) are crucial for the regional hydrological cycle and water management. They could also affect the large-scale circulation, such as mid-level troughs, jetstreaks and the Asian monsoon. The TP has experienced amplified warming in recent decades which could change the convective systems, but exactly how the convective system and precipitation have changed and what mechanisms behind the changes remain to be determined and understood. In situ observations are sparse in this region and current global reanalysis datasets have too coarse spatial and temporal resolutions to accurately represent the mesoscale convective systems over this high mountainous area. To better understand the convective activities over the complex terrain, we use a high-resolution numerical weather model to study synoptic- and mesoscale circulation including the convective systems and related precipitation and over the TP region. We used the convection-permitting Weather Research and Forecasting (WRF) model and a regional data assimilation system based on the ensemble Kalman filter (EnKF) that assimilates observations from the Global Telecommunication System to build a high-resolution regional reanalysis with a grid spacing from 30 km down to 10 km. Here we will present preliminary results from the WRF-EnKF reanalysis for the summer months (June through August) of 2015. The reanalysis results are evaluated against independent observations and compared with two global reanalyses, namely ERA-Interim and ERA-5. We focus our analyses on the characteristics of convective systems over the TP and their physical mechanisms.

Keywords: Mesoscale convective systems, Tibetan Plateau, WRF, Data assimilation

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simulation/reanalysis and its implication/application**

D1-P-03

**Sensitivity of soil moisture to rainfall simulations associated with
western disturbances over north India**

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Winter precipitation over north India is important for agriculture, horticulture, transport, domestic use and power generation. North India mainly gets winter precipitation mainly from the Western Disturbances (WDs). The sensitivity of soil moisture to the simulation of rainfall during eight WDs are investigated using Weather Research and Forecasting model. For this purpose one control experiment is done for each of eight cases of WDs with the suitable combination of parameterization schemes. Then the simulations are repeated with 10 % increase and 10 % decrease in the soil moisture respectively. The area averaged rainfall encompassing domain (72° E-83° E to 27.5° N-38.5° N) from model simulations are compared with the TRMM observations. Results indicate that there is 1.7% increase in precipitation from the control simulation by the enhancement of 10% soil moisture. The rainfall is decreased by 1.4% when soil moisture is reduced by 10%. Model simulated values of rainfall are also compared with corresponding India Meteorological Department observed values at different stations. It is observed that the simulated rainfall corresponding to station observations increase with the enhancement in soil moisture and rainfall decreases with the reduction in soil moisture. The winds at various levels, mean sea level pressure and relative humidity patterns are reasonably well simulated by model.

Keywords: western disturbances, rainfall, soil moisture

**Parallel Session D: Domain/cross-domain meetings,
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D1-P-04

**From GCM'S to river flow: Linking patterns to processes
over the western Himalayas**

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Studies have shown that the Himalayan climate system is sensitive to global warming and climate change. Most of the snowfall over this region comes from wintertime precipitation. This precipitation, in turn, helps in maintaining the glaciers, which serve as the vast storehouse of freshwater supply to millions of people downstream throughout the year through rivers of western Himalayan origin. Therefore, for a country like India that gets more than 50% of its fresh water supply from the rivers of Himalayan origin, the question arises what would happen to regional hydrology and the downstream water flow in a warming environment? So to answer this question an integrated approach based on linking patterns to processes is applied here. The aim of the present study is in three-folds. Firstly, to access the predictive skill of state-of-the-art CMIP5 models and identify forecast windows of opportunity. Secondly, to reproduce the patterns of the GCM at higher spatial resolution, both dynamical (ICTP-RegCM nested with HadGEM3-ES2 at 25 km resolution) and statistical downscaling (based on Canonical Correlation Analysis) approaches with bias correction have been applied. Thirdly, a hydrological model (SWAT) has been used to simulate the Satluj river streamflow for the present and future climate using the bias corrected downscaled data obtained from RegCM. Finally, why process based investigation and its implementation is important and how CORDEX framework has played a key role in addressing such issues is highlighted.

Keywords: Western Himalayas, Hydroclimate, Coupled dynamical system

**Parallel Session D:
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**D3: Regional responses to global
warmings of 1.5 and 2°C**

ORAL PRESENTATIONS

**Parallel Session D: Domain/cross-domain meetings,
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D3: Regional responses to global warmings of 1.5 and 2°C**

**Projected changes in seasonal precipitation extremes in Malaysia under
global warming of 2°C and 4°C**

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This study provides assessment impact of climate change on projected changes in seasonal precipitation extremes in Malaysia at warming levels of 2°C and 4°C based on the multi-model simulations of the Southeast Asia Regional Climate Downscaling / Coordinated Regional Climate Downscaling Experiment Southeast Asia (SEACLID/CORDEX-SEA). Three indices of extreme precipitation are considered i.e., are the consecutive dry days (CDD), the number of days daily precipitation exceeded 20mm (R20mm) and the maximum 1-day precipitation total (RX1day). The ensemble mean of 10 simulations showed reasonable performance in simulating observed characteristics of extreme precipitation during the historical period of 1986–2005. The year 2041 was taken as the year when global mean temperature reaches 2°C and year 2084 for 4°C warming above pre-industrial level under unmitigated climate change scenario based on Karmalkar and Bradley (2017). Results indicate that both period (2031–2051 and 2074–2094) have large significant prominent changes especially during the period of 2074–2094. Robust increases in CDD imply impending drier condition over both Peninsular and East Malaysia and enhanced under 4°C global warming. Increases in RX1day suggest more intense rainfall events over most of Malaysia and intensified under 4°C global warming especially over East Malaysia during JJA and MAM seasons. Both Peninsular and East Malaysia are projected to experience increases in CDD, R20mm and RX1day, suggesting Malaysia may face more serious repercussions in future.

Keywords: Precipitation Extremes, regional climate downscaling, multi-model ensemble, future changes, Global warming

**Parallel Session D: Domain/cross-domain meetings,
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D3: Regional responses to global warmings of 1.5 and 2°C**

**Modelling of vulnerability and adaptive capacity of Caribbean small island
developing states**

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One of the biggest challenges for Small Island Developing States (SIDS) to Climate Change is the disproportional impact that those changes pose to the islands. The modelling of the dynamism of climate change vulnerability for SIDS should therefore consider the transformation of the intricate interactive processes (socio-economic, political, and environmental conditions) that are unique to the individual SIDS. Some vulnerability and capacity assessments tools and methodologies have been developed to assist in the understanding of those implications. Notwithstanding, it has become evident that the dynamic approach to providing current information and establishing continuity is not always a significant feature and the consideration of the SIDS' contextual vulnerability and the integration of inherent characteristics of domain are often minimal. This research presents a more comprehensive approach to addressing this gap, through the development of a Climate Change Vulnerability and Capacity Assessment Model for Caribbean Small Island Developing States (CC-VCAM-CaribSIDS). This method consolidates some of the different methodologies to ultimately provide a visualization of the vulnerability and capacity assessment within the specified SIDS and the creation of a wide-ranging tool which could provide information to policy holders, technocrats and even the average interested enthusiast. By defining a baseline normal using observed and modelled data; integrating climate projections; development and categorisation of vulnerability profiles using Geographic Information Software; and the integration of risk and vulnerability equations into the model, the user is presented with a more comprehensive output with particular relevance to the peculiarities of the SIDS. It is expected that the CC-VCAM-CaribSIDS will make a significant contribution to understanding the vulnerability of Caribbean SIDS, specifically to climate change scenarios. It is further expected that this will serve as a fundamental model to assist in guiding the process towards sustainability and viability, as it provides the foundation for the identification of the optimum restorative action to reduce impacts through effective implementation.

Keywords: climate change, vulnerability, modelling, adaptive capacity, SIDS

**Parallel Session D: Domain/cross-domain meetings,
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D3: Regional responses to global warmings of 1.5 and 2°C**

**Projection and possible causes of summer precipitation in Eastern China using
self-organizing map**

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Self-organizing map (SOM) is applied to downscale the summer daily precipitation over Yangtze-Huaihe river basin in Eastern China in this study, including evaluation, ensemble projection and physical explanations. The evaluation shows that SOM can evidently promote the ability of simulation in terms of probability distribution of daily rainfall and spatial distribution of rainfall indices, as well as the consistency of multi-model simulation, demonstrating the "added value" to raw outputs from GCMs. In the 21st century under RCP4.5 Scenario, daily rainfall at roughly 75% sites is projected to shift towards large value. In the early 21st century (2016-2035), the precipitation in central basin can be increase, yet the significant decreases occur over the middle reaches as well as partial southeast basin. In the middle stage (2046-2065), the area of raising precipitation expands to the middle Yangtze River. As to the last stage (2081-2100), the mean and extreme precipitation experiences an overall increase, leading significant raises of extreme indices by almost 30%. Moreover, the total precipitation in lower reaches and south of it may increase from 8% at 1.5°C global warming to 15% at 2°C, while the intensity enhancement is more clearly in the middle reaches due to 0.5°C additional warming. Based on the analysis of possible causes of precipitation change, the regional synoptic patterns in the future are found with high stability, suggesting precipitation change in interested region is mainly related to the frequency variation of regional patterns. The overall intensification of large-value precipitation in 21st century is linked to the raise of extreme wet pattern with closely South Asia High and westward Western Pacific Subtropical High, as well as the reduction of extreme dry pattern with far-away Subtropical High and South Asia High.

Keywords: Statistical downscaling, Self-organizing map, Precipitation projection

**Parallel Session D: Domain/cross-domain meetings,
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D3: Regional responses to global warmings of 1.5 and 2°C**

Frequency of extreme El Niño and La Niña events under global warming

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The El Niño-Southern Oscillation (ENSO) is a quasi-periodical natural phenomenon occurring in the tropical Pacific whose characteristics can be influenced by global warming. Using outputs of 14 general circulation models (GCMs) participating in the Coupled Model Intercomparison Project Phase 5 (CMIP5), the number of extreme El Niño and La Niña events are analyzed for the 50-year period in the future (2050-2099) under the RCP4.5 and RCP8.5 scenarios relative to that during the historical period 1950-1999. Analyses are based on the Oceanic Niño Index (ONI) and the modified Cai index that is defined in this study. Our approach deviates from that of Cai et al. (2014) and Cai et al. (2015b) who used rainfall and sea surface temperature (SST) thresholds to identify extreme El Niño and La Niña events, respectively. Analysis of SST and rainfall in the tropical Pacific indicated that under global warming the eastern equatorial Pacific warms faster than the surrounding ocean waters, which is accompanied with an increase of rainfall in the eastern equatorial Pacific. Thus, changes in the mean state of the tropical Pacific climate will be like an El Niño pattern under global warming. By applying the ONI, it is found that the number of very strong El Niño events slightly increases under global warming and the rate of increase in the number of extreme La Niña events is greater than that of extreme El Niño events. Applying the modified Cai index shows a slight decrease of extreme El Niño events and a slight increase of extreme La Niña events under global warming. Thus, results of several previous studies which concluded that the number of extreme El Niño events nearly doubles under global warming are not supported by results of this study.

Keywords: El Niño-Southern Oscillation, Extreme El Niño, Extreme La Niña, Global Warming, CMIP5

**Parallel Session D: Domain/cross-domain meetings,
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D3: Regional responses to global warmings of 1.5 and 2°C**

**Changes in extreme temperature in China under 1.5 and 2.0 °C global
warming scenarios as simulated by HAPPI multi-model ensemble**

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Zhihong Jiang, Cenxiao Sun, Wei Li, NUIST, China

The 1.5°C global warming target proposed by the Paris Agreement has raised worldwide attention. However, previous studies are mainly based on Representative Concentration Pathways (RCP) simulations, which can be considered as ‘transient simulations’ and cannot reflect the response of climate when global warming stabilized at 1.5°C relative to pre-industrial level directivity. In this study, we use datasets from ‘Half a degree Additional warming, Prognosis and Projected Impacts’ (HAPPI) project, to analyze the response of extreme temperature in China to stabilized 1.5°C and 2.0°C global warming. The results are as follows: (1) When global warming stabilizes at 1.5°C/2.0°C, the area-averaged mean temperature over China increases by about 0.94°C/1.59°C relative to the historical climate (2006-2015). Areas with more extreme temperature increase are mainly located in Northwest and Northeast China, while the warm spell duration increases mostly in Southeast China. Under an additional 0.5°C warming, the changes of mean temperature and all extreme indices are larger in transient simulations than in stabilized simulations, indicating that previous studies based on transient simulations may overestimate the response to an additional 0.5°C warming; meanwhile the uncertainty ranges of extreme indices are narrower in stabilized simulations. (2) When global warming stabilizes at 1.5°C/2.0°C, the return period of area-averaged 100-year extreme hot event over China in the historical climate is 6 year/1.73 year, and the return period of area-averaged 10-year extreme cold event is 50 year/238 year, which may not happen basically. And the uncertainties of the risks for area-averaged extreme events obviously reduce in stabilized simulations compared to transient simulations results. On regional scale, the risks for extreme hot events and cold events mainly change in the Tibetan Plateau, and the risks for extreme cold events also reduce obviously in Northeast and Southeast China.

Keywords: 1.5°C global warming, Extreme temperature, HAPPI, China

**Parallel Session D: Domain/cross-domain meetings,
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D3: Regional responses to global warmings of 1.5 and 2°C**

Projected change of mean and extreme climate events over China under 1.5°C and 2°C based on machine learning

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Four machine learning approaches, random forest (RF), support vector regression (SVM), neural networks (NN), and linear regression (LR) are used for CMIP5 multi-model ensembles to investigate the change of mean and extreme temperature and precipitation events over China (relative to 1986–2005) under 1.5°C and 2°C warming levels (relative to 1861–1900) under RCP 8.5 scenarios. During the verification period, compared to multi-model ensemble mean (MME), the cases based on machine learning achieved significant improvements in simulating temporal and spatial pattern, which Taylor skill scores exceed 0.9 and Interannual variability indicators are significantly lower. Among them, random forest outperforms all other ensembles.

For future projection under 1.5°C and 2°C warming, results show that the increases in mean (TAS) and extreme temperature (TXx, TNn) over China higher than global mean, will increase about 1/1.6°C, 1.2/1.8°C, 1.1/1.9°C, particularly over Northwest China, Northeast China and the Tibetan Plateau. These regions are also climate change sensitive areas to an additional 0.5°C warming. The main difference between machine learning approaches and MME is the inconsistent warming response in different regions over China, the projected increases of temperature in TAS, TXx and TNn are obviously lower except the climate change sensitive areas. For the mean (PR) and extreme precipitation (R95P, RX5DAY), results show a significant increase in mean and wet extreme indices, but the increasing amplitude and sensitive areas are not identical for different machine learning approaches and MME. For annual average precipitation (PR), four machine learning approaches show the change in West and Northeast China can exceed 20%, but the dryer areas are inconsistent (Eastern coastal area projected by RF, North China projected by SVM and NN, but Yangtze River basin projected by MME). For extreme precipitation (R95P and RX5DAY), the change projected by NN is -10%--10%, some areas in northwestern China will become dryer; but all other machine learning cases show the change will be increased by 10%--40%, similar to MME.

Keywords: 1.5°C and 2 °C warming, multi-model ensemble, machine learning, mean and extreme climate events

**Parallel Session D: Domain/cross-domain meetings,
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D3: Regional responses to global warmings of 1.5 and 2°C**

European climate change at different global warming levels as derived from a large ensemble of EURO-CORDEX simulations.

Erik Kjellström, SMHI, Sweden

Erik Kjellström, Grigory Nikulin, Gustav Strandberg, SMHI, Sweden

EURO-CORDEX has contributed to an unprecedented number of regional climate model simulations at high horizontal resolution (12.5 km grid spacing) for Europe. Here, we present results from related to a number of impact-relevant indices. The results indicate considerable near-surface warming already at 1.5°C global warming exceeding that of the global mean in most parts of Europe. Changes are becoming increasingly more pronounced and more robust within the ensemble at 2°C and at higher levels of global warming. For some indices and parts of Europe, however, there are no robust changes even at higher warming levels. Notably for winter, the changes in many indices are shown to be modulated by changes in mean sea level pressure indicating a strong relationship with the large-scale circulation and its internal variability as given by the choice of global climate model. For some other indices and in other seasons, however, we find stronger dependency on the choice of regional climate model indicating that local and regional processes have a strong impact on the simulated climate change. In this context, it is also clear that the RCMs can alter the climate change signal from the GCM in a significant way. By comparing to a larger ensemble of CMIP5 GCMs we find that the RCMs can alter the results leading either to attenuation or amplification of the climate change signal in the underlying GCMs.

Keywords: Climate indices, Global warming levels

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D3-P-01

Detecting regions highly sensitive to extreme events in China under 1.5°C and 2°C warming scenarios: analysis of NCAR CESM low-warming experiments

***Yipeng Cao**, School of Atmospheric Science, Nanjing University, China*

***Yipeng Cao**, School of Atmospheric Science, Nanjing University, China; **Runqi Wu**, School of Atmospheric Science, Nanjing University, China; **Weidong Guo**, School of Atmospheric Science, Nanjing University, China*

In 2015, the Paris Agreement proposed a goal to pursue efforts to keep global temperatures below 2 °C above preindustrial levels and better below 1.5 °C by the end of twenty first century. As this target is worldwide accepted, it is crucial to assess the difference in global climate changes under 1.5°C and 2°C warming conditions. Extreme weather and climate events have a greater impact on both the natural environment and the human society, so it is necessary to assess the changes in extreme events under different warming scenarios over China.

In 2017, the Community Earth System Model (CESM) low-warming experiment for the first time simulated the process of global mean temperature achieving the 2°C and 1.5°C goals in line with the Paris targets in the late twenty-first Century. We analyzed the output data from the CESM Low-Warming experiment. Our results show that the frequency and intensity of extreme high temperature events in China will increase under the background of global warming. The Tibetan Plateau and semi-arid areas in northern China will be more likely to suffer extreme high temperature events with higher intensity and frequency. While controlling warming below 1.5 °C can significantly reduce the influence of extreme high temperature events in these areas. It indicates that the Tibetan Plateau and semi-arid areas in northern China are very likely the regions highly sensitive to extreme high temperature events. In contrast, extreme precipitation events show large spatial heterogeneity over China. The largest increase in extreme precipitation events occurs over the Middle-Lower Yangtze plain under both warming scenarios. At the same time, the difference in extreme precipitation events between 1.5°C and 2°C is also the largest for this region. It suggests the Middle-Lower Yangtze plain could be the regions highly sensitive to extreme precipitation events in China.

Keywords: 1.5°C and 2°C warming, CESM, Temperature extremes, Precipitation extremes, Precipitation extremes; Regional sensitivity

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D3-P-02

Contributions of solar radiation management to Caribbean climate

***Leonardo Clarke**, University of the West Indies, Jamaica*

***Leonardo Clarke, Michael Taylor, Jayaka Campbell, Tannecia Stephenson,**
University of the West Indies, Jamaica;
Abel Centella, Instituto de Meteorologia, Cuba*

Small Island Developing States (SIDS), such as those in the Caribbean, have had some success in advocating that the continued rise in global mean surface temperature (GMST) be held to a maximum of 1.5°C above preindustrial levels. To this effect the 1.5°C target was included in the Paris Climate Agreement of 2015. There is however much pessimism as to whether the 1.5°C or even the upper 2.0°C long term target goal (LTTG) set under the agreement are truly attainable. Recent studies indicate that based on the current trends in CO₂ emissions, the likely increase in GMST would be between 2.0°C to 4.9°C. Geoengineering is actively being investigated for its worth and likely impact globally and regionally if it is used as a possible mechanism to contain the rise in GMST. This study uses existing runs from the Geoengineering Model Intercomparison Project (GeoMIP) to investigate the possible effects on Caribbean climate of solar radiation management (SRM). Changes in mean precipitation and temperature are examined for the cases of the G3 (sulphate aerosol is injected into the atmosphere at a location on the equator or uniformly globally to counteract temperature rise that would be cause by a RCP4.5) and G4 (sulphate aerosol is injected into the lower stratosphere (16 to 25km in altitude) at a location on the equator at a constant rate of 5Tg of SO₂ per day) experiments. Results are presented.

Keywords: Geoengineering, Solar Radiation Management

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D3-P-03

**Future extreme temperature changes over West Africa
linked global warming intensity**

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Ohaji, Nigeria*

Victor Dike, Colman Ibe,
Energy, Climate, and Environment Science Group, Imo State Polytechnic Umuagwo, Ohaji, Nigeria

Based on CORDEX-Africa high resolution daily dataset, we investigate future (2020-2060) changes in temperature extremes given that the global mean temperature increased persistently under two greenhouse gas concentration scenarios. Results indicate that during 2020-2060, temperature extreme increased significantly over West Africa as compared with the conditions during the preindustrial era. Warm extremes seems to be more persistent, this is an indication that heat waves will be more frequent in the region. More intense warming is observed over the drier West African Sahel, and the wetter Guinea Coast regions. Additionally, warm temperature extremes scales linearly with changes in the 1.5oC and 2.0oC global warming magnitude. This further demonstrates that changes in temperature extremes are related to global mean temperature changes. In a broader social context, this region is home to over 200 million people and thus protective measures are required to lessen the effect of the projected warm temperature extremes on the populates.

Keywords: Extreme temperature, Future changes, West Africa

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D3-P-04

**Assessment of thermal stress adaptability in commercial layer production
in hot and humid climate**

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Withdrawal

A hot and humid climate is one of the important stressors affecting commercial poultry production in tropical and sub-tropical regions. Thus, the effect of high ambient temperature and resultant thermal stress on the performance of commercial egg-laying stocks, need to be assessed. This study was designed to evaluate the effect of thermal stress on the production performance of two strains of commercial layer chickens (Isa Brown and Bovan Nera) in a humid tropical environment.

Data on two strains of layer chickens (Isa Brown and Bovan Nera) were obtained from farm records of Funtuna Farms, Ogere- Remo, in Southwest, Nigeria. The data included egg-laying performance traits and climatic variables. Performance traits include age at point of lay, mortality pattern and egg-laying performance. Climatic variables include temperature and relative humidity from which temperature-humidity index (THI) was derived. The THI was grouped into 3 classes: <26, 26-29, and >29 to show the degree of thermal stress variation in the chicken houses the birds were exposed to. Effect of threshold of thermal stress levels and the associated rate of decline in egg production and mortality were estimated. Egg-laying records of 4,000 pullets on each strain were analyzed to quantify the effect of thermal stress function in a fixed effect model on performance. Effect of thermal stress, genotype, and age of layers on production efficiency, were studied. The data was analyzed using descriptive statistics, linear regression modeling of production function, analysis of variance and the general linear model of SAS®.

Results revealed that egg production was significantly affected by genotype ($P < 0.05$), THI and age of birds ($P < 0.001$). Hen-housed egg production for Isa Brown and Bovan Nera were 4.98 ± 0.21 and 5.20 ± 0.21 per hen per week respectively. There was however, significant effect ($P < 0.001$) of THI on production. The thermal stress function developed showed a threshold at $THI = 27.5$ and the associated rate of decline were 0.35 eggs per unit increase in THI (Egg Production = $-0.35THI + 6.3$). Bovan Nera recorded lower rate (0.32eggs/THI) as against Isa Brown (0.37eggs/THI). On seasonal effects, the early rain (ER) was best (13.23 ± 1.75) followed by late rain (18.04 ± 1.76), early dry (19.19 ± 1.75) and late dry (20.85 ± 1.79). Further, a highly significant effect ($P < 0.001$) of thermal stress was recorded on mortality. Isa Brown recorded higher mortality (24.19 ± 1.25) per month of lay than Bovan Nera (14.46 ± 1.25) during the study period.

In conclusion, the production performance of the two strains (IB and BN) was influenced by thermal stress, genotype and age of bird. Bovan Nera was superior to Isa Brown as it showed hardiness and better production adaptability, which are desirable characteristics in commercial poultry industry. There exists variability in heat tolerance among the strains and temperature-humidity index (THI) can be used to account for the effects of thermal stress on production performance of commercial layers in hot and humid climate

Keywords: thermal stress, adaptability, commercial layer, hot climate, production

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D3-P-05

**Potential impact of 1.5°C , 2°C and 3°C global warming on planting season
and crop suitability over West Africa**

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Temitope Samuel Egbeyi, University of Cape Town, South Africa, South Africa; ***Olivier Crespo***,
University of Cape Town, South Africa, South Africa; ***Chris Lennard***, University of Cape Town, South
Africa, South Africa

West African rainfed agriculture is highly vulnerable to climate variability and change. This study examines the potential impact of 1.5, 2 and 3°C global warming (GWL15, GWL20 and GWL30) on crop growth suitability and planting/growing season in West Africa under RCP8.5 scenarios. Climate variables from 10 CMIP5 GCMs that participated in the Coordinated Regional Downscaling experiment (CORDEX) were downscaled by regional climate model, RCA4. These variables were then used in driving crop suitability model, EcoCrop for six crops pearl millet maize (cereals); groundnut, cowpea (legumes) and cassava and plantain (root and tuber). The robustness of GWLs impacts were assessed using two conditions; first if at least 80% of the simulations agree on the sign of change and secondly that signs of change are statistically significant at 99% confidence interval level, using t-test with respect to climate variability of the historical period. The result showed a spatial distributions of decreasing crop suitability from south to north across the three agroecological zones (AEZs) in West Africa in the historical climate with marginal cropping suitability are observed around lat. 14°N for all crops except for plantain which is approximately at 12°N. Higher suitability is observed to the south of the marginal for all the crops across showing the guinea zone is most suitable across all crops and the Sahel to be unsuitable. The simulations project a robust increase in crop suitability and planting period with increasing GWLs for the six crops. Crop suitability is projected to increase from marginal suitability to being suitable in the central Sahel for cereals and legumes and over the savanna for root and tuber, plantain while a decrease in suitability is projected for cassava across the AEZs and for plantain in guinea zone with increasing GWLs. Cassava is the most impacted crop with increasing GWLs due to contraction of the suitable area the crop can be grown. Our findings have application in reducing the impacts of global warming on food security over West Africa.

Keywords: Crop suitability, Planting season, Global warming levels, Ecocrop, West Africa

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D3-P-06

**Ensemble projection of temperature and precipitation under the
1.5°C warming in East Asia using regional climate models**

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Twenty-eight regional climate model (RCMs) projections at a resolution of ~50 km are employed to investigate the future climate change over East Asia under the 1.5°C global warming. Emission scenarios include SRES A1B, RCP4.5, and RCP8.5, with the respective time periods corresponding to 1.5°C global warming are identified from the driving global climate model (GCMs) simulations. Range of the projected changes and the uncertainty across this multi-model ensemble for this level of global warming are investigated. The results indicate that the East Asian land will experience robust and significant warming (1.3°C on average relative to 1986-2005) which is greater than the global average (0.9°C relative to 1986-2005). The annual mean warming is more pronounced over Northwest China, Tibetan Plateau, and Mongolia, and to a less extent over Southeast China. The annual mean precipitation will also increase over most regions (2.3% on average relative to 1986-2005) but with large uncertainties. Highest and statistical significant increases locate at Northwest China and North China, while lowest and statistical insignificant ones locate at Tibetan Plateau and Japan. If the target changes from 1.5°C to 2°C, the warming and precipitation increasing will continue. Comparisons between the RCMs and driving GCMs are also provided.

Keywords: 1.5°C warming, East Asia, regional climate model

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D3-P-07

**Evaluation of CMIP5 wind-vector fields and its relationship with precipitation
in the Asian-Australian monsoon region**

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Vector winds play a crucial role in shaping regional climate and the lateral atmospheric boundary conditions (LBC) of regional models. Model simulated precipitation may largely be determined by simulated vector winds. Nudging the wind field in the process of model integration may effectively improve the model capability to simulate precipitation. In this study, we evaluate 37 CMIP5 models and their multi-model ensemble (MME) in terms of vector winds and their relationship with precipitation in the Asian-Australian monsoon region. Unlike previous model assessments those mostly assessed meridional and zonal wind separately, we treat vector wind as a whole by employing a recently developed vector field evaluation (VFE) method. The results are summarized as follows: 1) in terms of climatological means of wind-vector field, the MME exhibits the best performance, followed by CESM1-CAM5 model and three MPI-ESM models. In summer and autumn, precipitation is generally better simulated in the models those can well reproduce vector wind fields, which indicates that model simulated vector wind field may strongly affect the simulation of precipitation. 2) The MME, CESM1-CAM5 and three MPI models are still the leading models in reproducing the annual cycle of vector winds. Correlation analysis suggests that the annual cycle of precipitation is likely affected by the vector wind field in the northwest Pacific and the southern Arabian region. 3) CMIP5 Models generally overestimate the interannual variation of the 850-hPa vector wind field. The interannual variation of vector wind fields can also modulate the interannual variation of precipitation in South Asian monsoon region in spring.

Keywords: Asian monsoon circulation, Vector Field Evaluation, vector wind, precipitation, model performance

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D3-P-08

Contribution Assessment of Multiple Bias Correction for Summer Extreme Precipitation in BCC-CSM1.1-m over Yangtze-Huaihe River Basin in China

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For the BCC-CSM1.1-m, four statistical bias correction methods, which including the Linear scaling (LS), Quantile mapping (QM), Distribution mapping (DM) and Cumulative distribution function transform (CDFT), are introduced to evaluate their performance in correcting summer daily precipitation, especially extreme rainfall over Yangtze-Huaihe River Basin (YRB) in China. BCC-CSM1.1-m has much better performance in climate simulation over China, but still has evident deviation in the daily rainfall especially extreme precipitation in YRB. After the multiple bias correcting, the simulating ability can be significantly improved, but with different performance in different sides. Of which, the QM has the most significant improvement in the probability distributions of daily precipitation and area mean rainfall, and CDFT comes second. For the spatial consistency of six extreme precipitation indices, LS, QM and CDFT have better simulation capabilities in the total precipitation and moderate rainy days. Meanwhile, only QM can well correct the rainfall days, precipitation intensity and 95% quantile precipitation. For example, the averaged relative errors for 95% quantile precipitation are reduced from -57.8 to -2.8%, and the spatial correlation coefficients are increased from -0.12 to 0.64. It is noted that the continuous dry days, overall, are failed to be well corrected.

Keywords: Bias Correction, Statistical Downscaling, Extreme Precipitation

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D3-P-09

**The southern African climate under 1.5 °C and 2 °C of global warming
as simulated by CORDEX regional climate models**

Genito Maure, *Eduardo Mondlane University, Mozambique*

Results from an ensemble of 25 regional climate model simulations from the Coordinated Regional Downscaling Experiment Africa initiative are used to assess the projected changes in temperature and precipitation over southern Africa at two global warming levels (GWLs), namely 1.5 °C and 2.0 °C , relative to pre-industrial values, under the Representative Concentration Pathway 8.5. The results show a robust increase in temperature compared to the control period (1971–2000) ranging from 0.5 °C –1.5 °C for the 1.5 °C GWL and from 1.5 °C –2.5 °C , for the 2.0 °C GWL. Areas in the south-western region of the subcontinent, covering South Africa and parts of Namibia and Botswana are projected to experience the largest increase in temperature, which are greater than the global mean warming, particularly during the September–October–November season. On the other hand, under 1.5 °C GWL, models exhibit a robust reduction in precipitation of up to 0.4 mm day⁻¹ (roughly 20% of the climatological values) over the Limpopo Basin and smaller areas of the Zambezi Basin in Zambia, and also parts of Western Cape, South Africa. Models project precipitation increase of up to 0.1 mm day⁻¹ over central and western South Africa and in southern Namibia. Under 2.0 °C GWL, a larger fraction of land is projected to face robust decreases between 0.2 and 0.4 mm day⁻¹ (around 10%–20% of the climatological values) over most of the central subcontinent and parts of western South Africa and northern Mozambique. Decreases in precipitation are accompanied by increases in the number of consecutive dry days and decreases in consecutive wet days over the region. The importance of achieving the Paris Agreement is imperative for southern Africa as the projected changes under both the 1.5 °C , and more so, 2.0 °C GWL imply significant potential risks to agricultural and economic productivity, human and ecological systems health and water resources with implied increase in regional water stresses.

Keywords: 1.5 degree, CORDEX, Southern Africa, Global warming

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D3-P-10

onset variation under 1.5 and 2.0 degree

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In this work we are looking the variation of the onset date on a single pick rainy season under 1.5 and 2 degrees C. We used the downscaled CORDEX data simulated by multimodel ensembles over Senegal. Results show a shift of the onset dates and the frequency of dry spells after the onset dates.

This has implication on agricultural activities over west africa which depends most of the population and thus an impact on the economy which relies mostly on rainfed agriculture.

Keywords: onset, agriculture

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D3-P-11

Enhanced dryness and drought over Indonesian region under global warming of 2°C and 4°C and possible combined effects of climate change and El Niño

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Indonesian region, especially Sumatera and Kalimantan, is known to experience drought in months of June to October during El Niño. During strong El Niño, the anomalous Consecutive Dry Days (CDD) can be more than 50% compared to normal years. While we experience such dry condition inter-annually in the current climate because of El Niño-induced condition, in future such dryness is projected to occur annually in months of June through October if climate change is not fully mitigated. Under RCP 4.5 and 8.5, CDD of multi-model simulations of CORDEX Southeast Asia showed Indonesian region is projected to experience robust and significant increase in dryness when global mean temperature reaches 2°C above pre-industrial level. The level of dryness is projected to further increase when global mean temperature increase reaches 4°C. While the inter-annually occurring dryness and drought experienced during El Niño in the current climate exerted tremendous environmental and socio-economic implications, the annually occurring dryness and drought because of climate change would cause much greater impacts. However, in future years when El Niño is also occurring, the combined effects of unmitigated climate change and El Niño could enhance the dryness and drought over Indonesia to unprecedented level.

Keywords: CORDEX Southeast Asia, dryness and drought, Consecutive Dry Days, El Nino, Indonesia

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D3-P-12

**Climate Change projection for the Uttarakhand, India
using CORDEX South Asia model**

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Neetu Tyagi, Tripti Jayal, Mukesh Singh,
State Climate Change Centre, Forest Department, Dehradun, Uttarakhand, India

The possible consequences of climate change are yet to be understood as it's a major global environmental and developmental problem. It is now established that adverse impacts are likely from an increased frequency of extreme weather and extreme climate variability where natural calamities such as Landslide, Flood, Cloud Burst, Flash flood, Drought etc.

In this study, climate change projections for the Uttarakhand State is carried out using outputs of high resolution Regional Climate Models (RCMs) from the Coordinated Regional Climate Downscaling Experiment program (CORDEX). It represents the trend of temperature and precipitation with their comparison. The resolution of both gridded data is 0.25 x 0.25 at global level where the CORDEX South-East Asia modelled climate data includes 12 models. The study is based on selected parameters Precipitation, Maximum Temperature, Minimum Temperature & Mean Temperature. The RCP 4.5 (moderate emission) and RCP8.5 (high emission) scenarios is to be used in this study. The processed climatic data represents Mid-Century (2021-2050) and End-Century (2070-2099) with respect to the Base-Line (1976-2005). For both emission scenarios, increase in annual and seasonal minimum temperature is projected for Uttarakhand and its district towards MC and EC. Heavy and extreme precipitation is projected to increase for majority of districts towards MC and EC as compared to BL.

The socio-economic development in developing country like India is partially effected by impact of Climate Change. Local adaptation is the only possibility for reducing those impacts. Scientific study helps in formulation of effective adaptation strategies. This study will be use in policy making and adaptation & mitigation strategies for the state of Uttarakhand.

Keywords: Representative Concentration Pathways (RCP's), Temperature, Precipitation, Adaptation, Mitigation

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D3-P-13

**Changes in the land-atmosphere interaction in the Congo Basin:
processes driving the decline of precipitation recycling ratio
under 1.5°C and 2°C global warming levels in CORDEX Model**

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This study investigates precipitation recycling in the Congo Basin (CB) using Swedish Regional Climate Model RCA4. The model was driven by eight General Circulation Models (GCMs) from the Coupled Model Intercomparison Project Phase 5 (CMIP5). Responses to the global warming of 1.5°C and 2°C levels under the representative concentration pathways (RCPs) 4.5 and 8.5 were analysed. Results indicate that RCA4 captures reasonably well patterns and modes of variability of CB recycled precipitation although some uncertainties exist between observed and simulated fields. Existing seasonal biases thought to be due to combined effects of boundary conditions and the RCM inherent errors. Empirical Orthogonal Functions show that the spatial pattern of the recycling rate (RR) displays a dipole in the CB, explaining two distinct mechanisms that control the recycling process. Over the northern sector (2°S-5°N; 12-30°E), the soil moisture seems to control the RR whereas on the southern part (2-10°S; 12-30°E), the solar radiation is found to be the main driver of the precipitation recycling. The CB will experience a general decline of the RR, more robust under RCP8.5 and larger amplified at 2.0°C of global warming.

Keywords: precipitation recycling, Congo basin, global warming levels, Regional Climate Model RCA4

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D3-P-1'

**Detecting regions highly sensitive to drought events in China based on
multiple soil moisture data**

Yixin Wang, School of Atmospheric Sciences, Nanjing University, China

Yixin Wang, Weidong Guo, School of Atmospheric Sciences, Nanjing University, China

Drought events have great impacts on agricultural production, social economy and human life. The frequency and intensity of drought events shows large spatial heterogeneity, thus the regions which are highly sensitive to drought events needs to be identified. In this paper, multiple long-term soil moisture products are evaluated in comparison to in-situ measurements in China, then the product with highest quality is selected to explore the location and evolution of the regions highly sensitive to drought events in China. The evaluation of the soil moisture products is conducted at both local and regional scale from 1992 to 2013. According to the Brunke ranking method, ESA CCI performs best among the evaluated soil moisture products, followed by ERA-Interim, NCEP/DOE-R2 and NOAA/CIRES-20CR. Soil moisture drought (SD) events were then defined using ESA CCI soil moisture data. Results show that SD events occur more frequently in the semi-arid and some parts of arid area of China, and have increased significantly since 1987. Flash drought (FD) is an extreme event that comprehensively reflects the characteristics of drought and heat wave. From 1979 to 2014, FD events increased by more than 115% in China. The high temperature driven FD is more likely to occur in wet and semi-humid areas, while the low soil moisture driven FD are more frequent in arid and semi-arid areas.

Keywords: climate change, soil moisture, soil moisture drought, flash drought, China

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D3-P-15

**Impact of global warming levels on photovoltaic power generation
over West Africa**

Sawadogo Windmanagda, WASCAL, Burkina Faso

Sawadogo Windmanagda, WASCAL, Burkina Faso; ***Babatunde Abiodun***, University of Cape Town, South Africa; ***Emmanuel Okogbue***, Federal University of Technology, Akure, Nigeria

Many West African countries are plagued with poor electricity. An abundance of solar irradiance over the region makes solar energy an attractive solution to the problem, but there is a dearth of information on how the ongoing global warming and solar dimming at a specific level may alter the solar energy over the region in the future. This study investigates the impact of climate change on photovoltaic power generation potential (PVP) over West Africa under various global warming levels. Fourteen regional climate model simulations from the Coordinated Regional Climate Downscaling Experiment (CORDEX) were analysed for the study. The capability of the simulations to reproduce climate variables (surface-downwelling shortwave radiation, R_s ; air temperature, T_s ; wind speed, W_s ; and relative humidity, R_h) over West Africa was quantified. The simulated PVP were also compared with the observed. The impact of climate change on simulated PVP over West Africa was examined at four global warming levels (1.5°C ; 2.0°C ; 2.5°C and 3.0°C) under the Representative Concentration Pathways 8.5 (RCP8.5) climate change scenario.

The results show that the CORDEX simulation ensemble captures the spatial distribution of climate variables (R_s , T_s , W_s and R_h) and PVP over West Africa, though with few biases. It also reproduces the annual cycle of these variables over the different climatic zones. The simulation and observation agree that PVP over West Africa ranges from 8% along the Guinea zone to 25% over the Sahel zone, and that the annual cycle of PVP is influenced by the seasonal variation of the monsoon system. The simulation ensemble projects a decrease of PVP over West Africa in the future and indicates that the magnitude of the decrease grows with warming levels. The decrease in PVP is attributed to a decrease in R_s (solar dimming) and an increase in ambient temperature induced by global warming. Nevertheless, the spatial and temporal distribution of the PVP changes are more influenced by R_s changes than by T_s changes, such as at GWL1.5, an increase in PVP is projected over all zones during the rainy season when an increase in R_s is projected. A decrease in projected PVP is also projected over all the countries. Nevertheless, the maximum decrease in PVP projected over any country or zone in the region is less than 3.8% even at GWL3.0. Hence, the study suggests that ongoing global warming may have an influence on PVP over West Africa.

Keywords: Solar Energy, Global warming

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D3: Regional responses to global warmings of 1.5 and 2°C**

D3-P-16

**Fine structure and sensitive areas in China under 1.5/2.0°C warming as
indicated by extreme climate events**

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The Paris Agreement aims to keep global average temperature rise well below 2.0°C and better to limit the temperature increase no more than 1.5°C above pre-industrial levels by the end of this century. To detect the regions highly sensitive to extreme events under 1.5/2.0°C warming scenarios, we perform dynamic downscaling using output data from CESM low-warming experiment and Weather Research and Forecasting model (WRF). Our results show that arid and semi-arid regions such as North, Northwest and Northeast China are more sensitive to extreme temperature events under 1.5/2.0°C scenarios. Extra 0.5°C warming restriction can significantly reduce the risk of extreme temperature events. WRF simulated frequency and intensity of extreme temperature events in China under 1.5/2.0°C warming scenarios is larger than that simulated by CESM. At the same time, WRF shows that larger risks of extreme temperature events can be avoided from controlling extra 0.5°C warming, suggesting that the benefit of extra warming control tends to be estimated by CESM. WRF results show that more frequent and intense extreme precipitation events occurs over the Tibetan Plateau, Southwest China and Northeast China under 1.5/2.0°C warming scenarios. While the bias in the extreme precipitation events between WRF and CESM as well as between 1.5°C and 2.0°C scenarios show a large spatial heterogeneity among all analyzed indices, indicating a large uncertainty remains in the extreme precipitation events.

Keywords: 1.5/2.0°C warming, Sensitive Areas, downscaling, WRF

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D3: Regional responses to global warmings of 1.5 and 2°C**

D3-P-17

**Peak forecast of carbon emissions under climate change background:
A case study**

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The Paris Agreement sets the target of controlling the increase of the global average temperature within 2 degree by 2050 comparing to pre-industrial level, which will push the carbon discharges peak coming as early as possible at global and regional level. IPCC has set the new Shared Socio-economic Pathways (SSPs) to realize the climate targets by different combination of climate adaptation and mitigation options in social and economic developments. Anhui Province is chosen as a regional case study to discuss how regional carbon emission peaks under different SSPs framework, as it is a major energy production and consumption province in China. This paper uses ridge regression to fit the expanded STIRPAT carbon emission model in Anhui Province, and selects five indicators: population size, per capita GDP, energy intensity, urbanization rate and secondary industry ratio. Under the five scenarios of sustainable path (SSP1), intermediate path (SSP2), regional competition path (SSP3), unbalanced path (SSP4) and fossil fuel-based development path (SSP5), the future Carbon discharges peak value and time of Anhui Province from 2016 to 2030 are predicted and analyzed respectively. Relevant policy suggestions are put forward to ensure the smooth implementation of Anhui Province's low-carbon development plan and sustainable development.

Keywords: Carbon emissions, Peak prediction, STIRPAT model, SSPs

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D3: Regional responses to global warmings of 1.5 and 2°C**

D3-P-18

**Projected change of precipitation over China under 1.5°C and 2°C
based on model performance and independence**

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***Lilong zhao, Zhihong Jiang, Tong Li**
Nanjing university of information science & technology, China*

A weighting scheme which considering both model performance and independence (PI-based weighting scheme) was applied to investigate the change of average and extreme precipitation over China under the 1.5°C and 2°C warming above preindustrial. Compared to the Rank-based ensembles and the simple arithmetic mean ensemble, the PI-based ensembles achieved significant improvements to simulate temporal and spatial patterns in precipitation simulation, especially in western China. Averaged bias over china was decreased in all climate index (PRCTOT:9%, RX1day:5%, RX5day:5% R95p:11%).

The model projected tendencies of PRCTOT, RX1DAY, RX5DAY and R95P values increase for both the 1.5 °C and 2 °C warming levels under RCP 4.5 and 8.5 scenarios by three different schemes across the whole China. The spatial distribution of PRCTOT for the three schemes follow a similar pattern, but PI-based scheme shows large percentage increases at the Southwest for both 1.5 °C and 2 °C warming levels under two scenarios. The PI-based scheme shows an average 4 percent increase in PRCTOT for the whole China. Northwest and middle part of the study region in both scenarios show a bigger decline in precipitation than Rank-based and MME results. Similar results can be found in RX1DAY, RX5DAY and R95P. Comparing to 1.5 °C , PRCTOT \RX1DAY\RX5DAY\R95P increase more obviously at 2 °C warming levels, especially on west and northwest. All indices decrease in middle region and west marginal region. There is a bigger increase in R95P under 0.5 difference with the maximum value exceeding 20%.

Keywords: 1.5 /2.0°C global warming, precipitation projection, CMIP5 model

**Parallel Session D:
Domain/cross-domain meetings,
Convection permitting models**

**D4: Urban environment and regional
climate**

ORAL PRESENTATIONS

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

Urbanization in high resolution RCM – do we need it?

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Czech Republic;*

To assess the impact of cities and urban structures on weather, climate and air-quality, modelling approach is commonly used and the inclusion of urban parameterization in land-surface interactions is of primary importance to capture the urban effects properly. This is especially important when going to higher resolution, which is common trend in operational weather forecast, air-quality prediction as well as regional climate modeling. As the most of population is living in the cities and the ratio is increasing, we need proper description of urban processes for proper assessment of impacts within the cities and of the effectiveness of adaptation and mitigation options applied in cities in connection with climate change as well as the urban heat island itself. Thus, it is valid not only for extreme heat waves impact prediction, but as well in air-quality prediction and in long term perspective in connection to climate change impacts. This provides the background for the project within Operational Program Prague - The Pole of Growth "Urbanization of weather forecast, air-quality and climate scenarios for Prague", shortly URBI PRAGENSI.

We demonstrate the importance of urban parameterization in the high resolution simulations comparing WRF and RegCM with different urban parameterization options in 10 km resolution. There are differences in the impacts, but basically all are able to capture the effects of urban heat island in these simulations, which can be quite significant especially under heat waves and achieve up to about 8-10 °C difference between the city and its vicinity for large cities during night time. More detailed analysis of the effects in terms of energy balance in the city and remote areas in high resolution simulations will be presented. Experiments in convection permitting resolution of 3 km will be compared in weather like mode.

Keywords: urban heat island, urban parameterization, regional climate modelling, convection permitting modelling, energy balance

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

**High-resolution regional climate modelling with CNRM-AROME to study the
urban climate of Paris (France) area and its evolution with climate change**

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CNRS/Meteo-France*

Regional climate models, that are driven by general circulation models to simulate more accurately regional-scale climate evolution, as well as environmental impacts, do not include explicit modelling of urban areas. Nonetheless, the very high spatial resolutions they are able to reach enhance the need and relevance to take into account a specific representation of the cities.

The urban canopy model TEB is now running inline with the French convection-permitting regional climate model CNRM-AROME. This configuration makes it possible to realistically represent urban processes at the surface/atmosphere interface and phenomenons such as urban heat islands, but also to simulate the potential feedback of local urban effects on regional-scale climate. Different refinement levels can be activated in TEB to study the urban issues of heat stress conditions, energy demand for heating and cooling, or urban vegetation management.

This new configuration is here applied over the Paris region and evaluated over the past period 2000-2008. CNRM-AROME is running at 2.5 km resolution, driven by the 12-km resolution ALADIN model, and by using ERA-interim reanalyses as boundary conditions. The evaluation is based on spatialized observed data of air temperatures, surface temperatures, and rainfall with the aim of investigating the model's ability to reproduce Paris' urban climatology through spatio-temporal indicators (especially for intensity and spatial extension of the urban heat island). The evolution of these urban climate indicators with climate change will then be studied. For this, CNRM-AROME is driven by ALADIN that is itself driven by the ARPEGE global circulation model. The historical period 1995-2005 and future period 2040-2050 will be compared according to the emission scenario RCP8.5.

Keywords: Urban environment, High-resolution regional climate model

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

**From regional scale to city scale by correction of dynamical downscaling
simulations**

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François Duchêne, *Royal Meteorological Institute of Belgium, Belgium*; ***Steven Caluwaerts***, *Ghent University, Department of Physics and Astronomy, Ghent, Belgium, Belgium*; ***Rozemien De Troch***, ***Rafiq Hamdi***, ***Piet Termonia***, ***Bert Van Schaeybroeck***, *Royal Meteorological Institute of Belgium, Belgium*

Within the URCLIM project, the goal is to develop urban climate services based on high-resolution climate data. There is indeed a strong need for climate services at the city level related to the impact of climate change on the urban environment, required for adequate adaptation measures. Reliable and high-resolution climate data, however, are scarce and atmospheric climate models are typically at resolutions of 10 to 150 km. Therefore, supplementary steps are required to translate data of low resolution to the city-scale resolution.

The aim here is to devise a methodology to produce urban climate time series based on CORDEX downscaling simulations. These will be used as input for the land use model (LSM). As such, ensembles including different models and scenarios will allow to sample uncertainty at the city scale. For an adequate translation from the regional to the city scale, a supplementary downscaling step is required using an RCM coupled to a land-surface model (Hamdi et al., 2014). However, such climate-scale model runs are computationally extremely expensive and therefore a method is designed to skip this step based on a limited set of additional downscaling simulations. The innovative step consists of correcting the forcing data of the LSM. We present a validation of the methodology the Brussels Capital Region supplemented with an in-depth study of the initialization methods. We use ALARO-0 as RCM and SURFEX-TEB as LSM, with boundary forcing from reanalysis ERA-Interim data. We focus our validation on temperature, heat-wave characteristics, the urban heat island and multivariate indices of human comfort. Our method will allow to downscale climate urban scenarios forced with a large set of RCM models such as from the CORDEX project, to sample the uncertainty.

Keywords: urban heat island, heat wave, calibration, downscaling

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

**Increases in anthropogenic heat release from energy consumption lead to
more frequent extreme heat events**

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With economic development and rapid urbanization, increases in GDP and population in fast-growing cities since the turn of the 21st Century have led to increases in energy consumption. Anthropogenic heat flux from energy consumption released to the near-surface atmosphere has led to changes in the urban thermal environment and severe extreme temperature events. To investigate the effects of energy consumption on urban extreme temperature events, including extreme heat and cold events, a dynamic representation scheme of anthropogenic heat release (AHR) was implemented in the Weather Research and Forecasting model (WRF), and anthropogenic heat release (AHR) data were developed based on energy consumption and population density in a case study of Beijing, China. Two simulations during 1999–2017 were then conducted using the developed WRF model with 3-km resolution with and without the AHR scheme. It was shown that the mean climate temperature increased with the increase of AHR, and more frequent extreme heat events were produced, with an annual increase of 0.02–0.19 days, as well as less frequent extreme cold events, with an annual decrease of 0.26–0.56 days based on seven extreme temperature indices (ETIs) in the city center. AHR increased the sensible heat flux and led to surface energy budget changes, strengthening the boundary atmosphere dynamic processes that reduce AHR heating efficiency more in summer than in winter. The similar simulation can be applied to other cities to get a global result. In addition, it was concluded that suitable energy management might help to mitigate the impact of extreme temperature events in different seasons.

Keywords: energy consumption, anthropogenic heat release, extreme temperature events, Weather Research and Forecasting model

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

**Diurnal temperature range trend over rural and urban regions of the world
and its human induced effects on climate**

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The Diurnal Temperature Range (DTR) is an important parameter in terms of assessing the long term climate change of surface temperature. Studies point out that both maximum temperature and minimum temperature is being increased due to global warming and thus the DTR is decreased as a long term over China. Here in this study, the long term trend, as well as interannual and interdecadal variability of maximum temperature, minimum temperature, Diurnal temperature range (DTR) etc, is analysed in detail with long term climatic data (1901-2015) of surface temperature of daily maximum and minimum temperature using Climate Research Unit (CRU) data. Different economic regions over the globe have been classified on the basis of gridded GDP Per capita data during the long term period. The entire grid was divided into three different types on the basis of economic performance. Also, the rural and urban regions of the different parts have been identified. This is done by utilizing the quartiles obtained from whisker and box plot and thus classifying the global grid in terms of rich, poor and transition areas. After this, the entire type grids were examined for the DTR, maximum temperature and minimum temperature trends and analysed the results thoroughly. The effects on minimum temperature changes and its trends due to the urbanization over different parts of the globe have been examined. It is also proposed to examine the effects of minimum temperature during the winter period due to the human-induced heating over cities.

Keywords: DTR, Temperature, rural/urban environment, trend

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

**Future integrated climate trajectories for major cities in the World from the
RegCM4 CORDEX-CORE projections**

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Data from the RegCM4 CORDEX-CORE projections, covering 9 CORDEX domains, are used to assess how the climate of the most populous cities in the World will change under the RCP8.5 and RCP2.6 scenarios. First, a city climate index is defined based on percentiles of observed mean annual temperature and precipitation for a region covering all land areas between 60 S and 65 N, i.e. the region encompassing most large cities in the World. Then a climate change anomaly is added based on the RegCM4 CORDEX-CORE projections, and the new climate of cities is calculated in terms of the present day percentiles. This results in an effective migration of cities in climate space. The calculations are then repeated with the inclusion of present day and future population scenarios, resulting in cities migration in climate-population space. It is shown how, under the high end RCP8.6 scenarios cities will potentially undergo substantial migrations in climate and climate-population space, not only within the same continent, but also to different continents, and for some cases, in a climate, or climate-population, space not experienced by any city today. This type of analysis may be useful for the development of planning and adaptation measures for major cities to cope with possible future climates.

Keywords: CORDEX-CORE, Climate and cities

Parallel Session D:
Domain/cross-domain meetings,
Convection permitting models

**D4: Urban environment and regional
climate**

POSTER PRESENTATIONS

LAST NAME	FIRST NAME	TITLE	POSTER NUMBER
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CAI	Peng	Numerical study of the interaction between oasis and urban areas within an arid mountains-desert system in Xinjiang, China using ALARO-SURFEX	D4-P-02
FATHI	Najlaa	Urbanization and surface climate case study: Morocco.	D4-P-03
GOZO	Emilio	Impact of climate change on extreme rainfall events on coastal cities in the Philippines	D4-P-04
HAN	Zhenyu	Convection-permitting simulations of urban heat island during a hot-weather case using “weather-like” simulation mode of RegCM4.7/CLM4.5	D4-P-05
LANGENDIJK	Gaby	Urban areas under climate change: what does the EURO-CORDEX ensemble tell ? - A case study investigating near surface humidity in Berlin	D4-P-06
MANDAL	Shailendra	Urban environment and regional climate change: A Case study of Indian metropolitan city	D4-P-07
ZHANG	Miao	Effects on local temperature and energy of urban expansion located in oasis in arid desert area	D4-P-08

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

D4-P-01

**Coastal urban climate change adaptation and disaster risk reduction:
Policy, programme and practice for sustainable planning outcomes**

Emmanuel Tolulope Busayo, *University of Fort Hare, South Africa*

Emmanuel Tolulope Busayo, Ahmed Mukalazi Kalumba,
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Coastal urban areas are centre of attraction to humans in developing countries of the world based on the various opportunities that abound in these areas, for example sea transportation, marine natural resources, seafood, place of tourist and it also serves as a point for resort and relaxation. However, almost a quarter of the world's population resides within a distance of 100km from the coast and less than 100m above sea level therefore making coastal settlements growing rapidly over the years. Consequently, the impacts of climate change on coastal urban areas are intensifying with significant effects on populaces, environment and ecosystems. This study focused on East London, Eastern Cape, South Africa as a case study using a mixed method approach in data collection. Public perspectives under three groups of identified enablers; policy; programme and practice are discussed. Based on the findings, a framework is proposed to enhance planning systems to maximise synergies between the fields of climate change adaptation and disaster risk reduction to minimise the vulnerability of communities to extreme weather events in coastal urbanised regions. Additionally, findings from this study show that the development of risk descriptions is paramount in the integration of CCA and DRR in achieving a sustainable urban planning development and outcomes.

Keywords: Climate change adaptation, Disaster risk reduction

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

D4-P-02

**Numerical study of the interaction between oasis and urban areas within an
arid mountains-desert system in Xinjiang, China using ALARO-SURFEX**

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The rapid oasis expansion and urbanization that occurred in Xinjiang province (China) in the last decades have greatly modified the land surface energy balance which influences the local circulations, mainly the oasis-desert and urban-rural breezes, in the context of the arid mountains-desert system in the north slope of Tianshan mountains. In this study, we first evaluated, during the summers 2001-2013, the ALARO regional climate model coupled to the land surface scheme SURFEX at 4 km spatial resolution using 53 national meteorological stations distributed within Xinjiang. We found that at 4 km resolution the model simulates the daily variation of 2 m temperature and relative humidity correctly although it overestimates relative humidity and underestimates the daily mean temperature. A 4-day clear sky period (9-12 June 2016) has been simulated in order to study both circulations and their mutual interactions. The results from both observations and model simulations show that the low level divergence over oasis appears only between 19:00 and 21:00 Beijing Time (BJT) when the background mountain-plain wind system is weak during the late afternoon transition period. The model simulates a synergistic interaction between Oasis-desert breeze and urban-rural breeze from 16:00 until 22:00 BJT with a maximum effect at 20:00 BJT when the downdraft over oasis (updraft over urban) areas increases by 0.3×10^{-3} (0.2×10^{-3} Pa s⁻¹). The results show that the oasis expansion decreases the nocturnal urban heat island in the city of Urumqi by 0.8°C, while the impact of urban expansion on the oasis cold island is negligible.

Keywords: Oasis-desert breeze circulation, Urban-rural breeze circulation, Urban heat island, TEB

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

D4-P-03

Urbanization and surface climate case study: Morocco.

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Morocco*

Urbanization is a major form of land use that affects surface energy, carbon and hydrology in a way that alters local-to-regional climate. It changes the natural land surface by reducing the fraction of vegetation which induces a reduction in photosynthesis and transpiration and thus leads to a surface warming.

The building material such as masonry, asphalt and concrete affects the local energy balance by absorbing, storing, and reradiating more solar energy than vegetation and natural soil typical in rural areas creating thus the so-called 'urban heat island' (UHI), which is a differential heating generated by building material within the city core as compared to the surrounding vegetated area. This urban heat, combined with warming due to climate may have impacts in term of energy use and human health.

During the last decades, the world has experienced unprecedented urban expansion and Morocco has experienced demographic increase such that the majority its population lives in urban areas. In 2013, about 57% of the total population lived in cities and this rate is expected to reach 75% within the next 10 years.

In this study we will use MODIS land surface temperature (LST), normalized vegetation index NDVI and the land use land cover , and Landsat 8 data in a spatial analysis to assess the urban heat island generated by buildups, its amplitude and its size for largest cities in Morocco. A temporal analysis will then be performed to quantify how change in climate may exacerbate urban heat islands.

The results of this study will facilitate the development of a set of mitigation and adaptation measures for decision makers and urban planners to create socially and environmentally sustainable cities.

Keywords: Urbanization, Climate, Urban heat Island

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
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D4-P-04

**Impact of climate change on extreme rainfall events on
coastal cities in the Philippines**

Emilio Gozo, *Manila Observatory, Philippines*

Emilio Gozo, Faye Abigail Cruz,
Manila Observatory, Philippines

Developing country such as the Philippines, are highly vulnerable to flooding caused by extreme rainfall events such as the enhanced Southwest Monsoon (SWM) and typhoons. Major cities especially those that are in the coastal region, are even more vulnerable primarily because of how this kind of land cover can modify heat and moisture fluxes in the area. With the continued growth and development of these cities along with increasing population, it is very important to understand how these climate hazards will change in a globally warmer future. The aim of this study is to analyze the projected changes in extreme rainfall events due to climate change for the major cities in the Philippines. Historical and future multi-model projections from two scenarios (Representative Concentration Pathway 4.5 and 8.5) from the Southeast Asia Regional Climate Downscaling (SEACLID) / Coordinated Regional Climate Downscaling Experiment (CORDEX) Southeast Asia project is used in the climate change analysis. Comparison of the intensity, frequency and duration of rainy days from the reference period (1971 to 2000) to early (2016 to 2035), middle (2046 to 2065), and late (2080 to 2099) future periods is carried out in this study. Finally, extreme rainfall shifts particularly at return periods of 50 and above is measured and analyzed.

Keywords: climate change, urbanization, extreme rainfall, regional climate models

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

D4-P-05

Convection-permitting simulations of urban heat island during a hot-weather case using “weather-like” simulation mode of RegCM4.7/CLM4.5

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Due mainly to computational limitations and costs, decade-long simulations over China with convection permitting regional climate modeling (CP-RCM, with grid spacings under 4 km) have been seldom conducted. The previous studies show that CP-RCM simulations have positive indirect effects on the representation of regional climate through various feedback mechanisms such as soil moisture—temperature and urban effects. In this study, a hot-weather case from 2 July to 6 July 2010 over the North China plain is selected to evaluate the RCM—RegCM4.7/CLM4.5 using “weather-like” simulation mode, prior to launching into expensive decade-long simulations. Especially the urban heat island (UHI) effect over Beijing was analyzed. Except the control run, an idealized simulation with all the urban surface replaced with bare ground and vegetation and four other sensitivity simulations were also performed. Based upon these experiments results, the effect of urban extent, urban categories, anthropogenic heat release (AHR) due to removing heat by air conditioning and energy consumption by the air conditioners were discussed.

The results show that, the RegCM4.7/CLM4.5 model reasonably reproduced the majority of the observed spatial and temporal characteristics of the 2-m temperature field over the simulation period. Strong UHI effects can cause intensification and expansion of the areas experiencing extreme heat stress. In the simulation, an average temperature increase of 0.67 °C in the city center (averaged over the six-ring area of Beijing) was observed under high urbanization conditions. Comparisons among the results of six runs showed that urban land use, classification of urban subcategories, and consideration of AHR respectively contributed 46.3% (0.31°C), 67.2% (0.45°C), and 17.9% (0.12°C) to the simulated UHI effects. The AHR can be further be decomposed into cooling indoor temperature, waste heat due to removing heat by air conditioning, and waste heat due to energy consumption by the air conditioners, which contribute -433.3% (-0.52°C), 250.0% (0.30°C), and 100.0% (0.12°C) to total AHR effect, respectively. It indicates that if waste heat from air conditioning systems is effectively recovered, the AHR effect on UHI can be largely reduced. The UHI peak reached a maximum value of 0.94 °C at 2000 LST around sunset. Analysis of the surface energy balance was also conducted. The results showed that the UHI is mainly caused by a greater heat storage in the urban fabric during the day and the release of this heat in the evening.

Keywords: urban heat island, convection permitting

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

D4-P-06

Urban areas under climate change: what does the EURO-CORDEX ensemble tell? A case study investigating near surface humidity in Berlin

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Urban areas are prone to climate change impacts. There is an increasing need to equip decision makers with useful climate information to adapt adequately. Though, many of the urban climate models and regional climate models are currently either not scale compliant for cities, or do not cover essential parameters and/or urban-rural interactions. Furthermore, although e.g. the urban heat island may be better understood, other phenomena such as moisture change are little researched. This research aims to improve the understanding of the change in moisture and temperature variables under climate change. Available EURO-CORDEX 0.11° simulations for RCP8.5 are analysed for relative and specific humidity, as well as for temperature variables throughout the century. Berlin is taken as a case-study. The results show that all the models simulate a difference between Berlin and its surroundings for the variables. There is a water vapor deficit in Berlin and it is generally warmer. The outcomes are similar between the model simulations and observations, though there is a slight overestimation of the water vapor deficit in Berlin by the models. The running mean over 30 years shows a divergence throughout the century for relative humidity between Berlin and its surroundings, with Berlin getting dryer over time, validated by the Mann-Kendall test. The Mann-Whitney-Wilcoxon test for relative humidity indicates a robust climate change signal in Berlin. Berlin is dryer and warmer for all months with the largest difference compared to its surroundings in the summer. Results of the regional climate model REMO is studied to gain further understanding in the processes supporting the findings. This study presents promising results to understand moisture change and related variables under long-term climate change in urban areas, potentially interesting to urban studies in other CORDEX domains.

Keywords: Urban, Humidity, EURO-CORDEX, Berlin, Climate Change

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

D4-P-07

**Urban environment and regional climate change:
A case study of Indian metropolitan city**

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India is experiencing rapid urbanisation, and consequently water demand in urban areas is escalating rapidly. The metropolitan city of India is amongst the oldest surviving cities in the world. Despite the fact that city is located on the banks of the River Ganga, residents are primarily dependent on groundwater aquifers for domestic water supply. The decline in the piezometric head of the deeper aquifer during the previous two decades is another concern. This raises concerns about the security of metropolitan city's water supply, and, hence, the economic vitality and sustainability of the city.

In this environment, with already existing pressures on water availability and use, climate change puts further stress on water management and the sustainability of water supplies. Climate change is already having impacts on temperature. Trends in temperature also interact with non-climatic factors, which complicate planning for water supply and demand and increases water insecurity. Moreover, regional annual average monthly maximum temperatures are projected to increase 2.5°C by 2049, based on the ensemble average of 41 CMIP5 models and assumptions of moderate future increases in greenhouse gas emissions. These projected increases in temperature will put further stress on water supplies. In addition, the increasing exposure to climate change, described above, will be superimposed on existing vulnerabilities.

In order to address these vulnerabilities, and to increase the resilience of metropolitan city of India in the face of projected climate changes, the study recommends several measures, which includes incorporating climate information in urban planning and development processes. The study concludes that these rudimentary measures, which are needed just to address metropolitan city's non-climate water management concerns, are necessary as a stepping-stone to transformative pathways for addressing the uncertainties associated with climate change.

Keywords: Urban environment, Urban water supply, Regional climate change, Projected climate change, Groundwater resource

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D4: Urban environment and regional climate**

D4-P-08

**Effects on local temperature and energy of urban expansion located in oasis
in arid desert area**

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The land surface model SURFEX 7.3 was used to study climate effect of urban expansion located in oasis in arid desert area by surface and 2-m urban heat island (UHI) intensity and available energy ratio (B). We performed a true regional development scenario and four assumed scenarios simulations in 1978, 1993, 2004 and 2014. The results show that simulated 2-m temperature in true scenario was well consistent with observation. 2-m UHI always displays positive twin peaks during whole day, while surface UHI only displays a positive single peak with several hours during daytime at four seasons in the four years. Moreover, 2-m UHI intensity during night is higher than that during daytime, indicating that UHI intensity is contributed more by “trap effect” from urban complex geometry or anthropogenic heat and that surface UHI according to land surface temperature cannot reflect UHI comprehensively. The oasis-urban development resulted in local warming and increasing of B, and compared with original undeveloped environment, local climate in study area was in a relatively balanced state in 1978 and 1993 due to “heating effect” of urban and “cooling effect” of oasis, but the offsetting effect from oasis would become weaker in 2004 and 2014.

Keywords: Urban heat island, Climate effect, Arid area

Parallel Session D:
Domain/cross-domain meetings,
Convection permitting models

**D5: Introduction and application
of ESGF in CORDEX-EA domain**

ORAL PRESENTATIONS

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

Current status of CORDEX-EA data center and its future role

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National Institute of Meteorological Sciences, South Korea*

CORDEX-EA Data Center has been managed and operated during several years by Korea Meteorological Administration (KMA) and National Institute of Meteorological Sciences (NIMS) since CORDEX Phase I data sets were released in 2013. CORDEX Phase I data sets consist of outputs of 5 Regional Climate Models (RCMs) which include evaluation runs with reanalysis data (ERA-Interim and/or NCEP DOE data) and GCM-driven forcing run using HadGEM2-AO model. CORDEX data is in demand steadily from 2013 when the first data was released to the present day. According to statistics, for 6 years from 2013 to 2018, about 4 hundred thousand files have been downloaded by researchers, scientists, and the others in universities, institutes and industrial sectors through data center web (ftp site).

Recently, CORDEX group has started Phase II activities, linked with IPCC AR6 schedule, and many research institutes and universities have begun to run regional climate model through CORDEX protocol for model run and data requests. Therefore, NIMS started to make a plan to improve functionalities of data center including renovation of web site (<http://cordex-ea.climate.go.kr>). Also, construction of ESGF data node connected with Data Center web page has started with APEC Climate Center (APCC) for release of new data sets published by CORDEX Phase II activities. In this session, future role of CORDEX-EA Data Center with its current status will be discussed in fostering regional activities such as regional climate studies, data sharing, and application of climate information.

Keywords: CORDEX-EA, Data Center, Regional Climate, Climate Information

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

**How to generate and distribute the CORDEX-EA metadata through ESGF Data
Node in APEC Climate Center**

Jeongmin Han, APEC Climate Center, South Korea

Jeongmin Han, Jaewon Choi, APEC Climate Center, South Korea

Related experiments are increasing rapidly to produce the scenario data necessary for global climate change response. The regional climate change scenario model has been improving in resolution, and the volume of data is also continuously increasing. To facilitate the sharing of vast climate change forecast data used in the IPCC (The Intergovernmental Panel on Climate Change) future climate change scenario reporting, countries around the world are forming associations that distribute, service and store data in a standardized structure.

In this study, we analyzed the system structure of the distributed storage and data exchange standard system supported by ESGF (Earth System Grid Federation), the support for international climate change response and climate service, participated in the establishment of international standard system, to support the response and participate in climate service, the APEC Climate Center has established an international standards data clustering design and foundation for climate data exchange. It has been certified as a data node of ESGF for international joint use of CORDEX-EA data which is a regional climate model.

In order to distribute the CORDEX-EA Metadata to the world, we have to use ESGF index node of Sweden. ESGF data node of the APCC (APEC Climate Center) has been certified from ESGF (Earth System Grid Federation) to connect with index node. Because, only systems certified by ESGF are allowed to transfer metadata. It will be explained how to distribute and download data using APCC's data node.

Keywords: ESGF in KOREA, CORDEX-EA, APEC Climate Center, APCC

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

**Establishment of ESGF data node in the APEC Climate Center for providing
CORDEX-EA data**

Jeongmin Han, APEC Climate Center, South Korea

Choi Jaewon, Jeongmin Han, APEC Climate Center, South Korea

Climate-related study is one of the most overwhelming field which affected by the Big Data era, as climate data continues to grow exponentially. Especially, it is very challenging to manage such ever-increasing data sets, including model simulations, observations, reanalysis products and satellite data.

The Earth System Grid Federation(ESGF), which is multi-agency, international collaboration of people and institutions working together, had been launched and overcome unprecedented limitations as mentioned previously. The APEC Climate Center was established to provide customized climate information for APEC region and is giving efforts to manage a data node for providing CORDEX-EA data more systematically after being certified from the ESGF which is composed of four types of node ; Data node, Index node, Identity Provider node and Compute node. In order to ensure a stable operation and satisfy requirements of the ESGF Tier-2 nodes, the data node has been equipped with service system of high availability, early stage service storage as well as backup storage. In addition, various security equipment has been associated with the system to provide more reliable service.

In conclusion, it is essential to collect data through several nations in order to provide more rich CORDEX-EA data to users, policy makers or stakeholders. Additionally, an index node of the ESGF representing the Asia region should be considered to improve metadata transfer environment between data and index node, and to promote mutual technical exchanges.

Keywords: CORDEX-EA, ESGF, data node, APCC

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

**Regional Climate Model Performance in Simulating Present-Day Mean
Climate Using CMIP5 & CMIP6 GCMs**

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Climate models are sophisticated tools designed to simulate the regional climate system and the complex interactions between its components. However, climate models are not perfect and contains uncertainty. In particular, regional climate models may include not only errors of their own, but also errors of the input data, GCM. To complement this, CORDEX framework is conducting multiple GCM-RCM experiments. To analyze climate change through multiple GCM-RCM experiments, it is necessary to analyze the characteristics of each model and evaluate its performance. In this study, we evaluate the performance of each model of the East Asian group participating in CORDEX. We also compare the performance of the CMIP6 GCM forcing (UK-ESM) experiment and the CMIP5 GCMs forcing experiment.

To objectively quantify the agreement between model and observation, we use the method of Reichler and Kim (2008) composed of the normalized RMSE about 30 different key climate variables. The models to be evaluated are CORDEX-EA RCM models using CMIP5 GCM and CMIP6 GCMs forcing. We used a number of observational and reanalyses such as ERA-I, CRU, CERES, and ISCCP for RCM evaluation. The base period of the observations was 1979~2005. The models were compared against present (1979~2005) climate.

Keywords: CORDEX-EA, RCM, model performance, CMIP6 forcing

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

**Added values by dynamical downscaling for high impact weather simulations
over CORDEX East Asia domain**

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Dong-Hyun Cha, Gayoung Kim, Minkyu Lee, Dong-Hyuck Yoon, *Ulsan National Institute of Science and Technology*
Dong-Kyou Lee, *Korea Meteorological Administration, Korea*; ***Joong-Bae Ahn***, *Pusan National University*, ***Myoung-Seok Suh***, *Pohang University of Science and Technology*; ***Seung-Ki Min***, *Pohang University of Science and Technology*

CORDEX East Asia Experiments in Korea supported by the Korea Meteorological Administration have been conducted using 5 RCMs since 2009. In this study, we investigate the added values by dynamical downscaling for high impact weather simulations under CORDEX East Asia Experiments by comparing the results of Phase I and II experiments. In general, RCMs with higher-resolution more reasonably capture the spatial distribution of precipitation over the Korean Peninsula compared to those with lower-resolution. In particular, large precipitation regions related to complex mountain ranges are well simulated due to detailed topography in RCMs with higher-resolution. The difference between RCMs with dissimilar resolutions is relatively robust for extreme precipitation during summer season indicating that higher-resolution and detailed topography lead to more realistic simulation of heavy precipitation related to mesoscale processes. Also, increasing model resolution results in improved simulation of typhoon activity over the western North Pacific. Although simulated typhoon activity is significantly affected by model configurations, higher-resolution RCMs in Phase II generally reproduce more realistic typhoon intensity compared with lower-resolution RCMS in Phase I, in particular for strong typhoon with above 40 m s⁻¹ maximum wind speed. Therefore, large precipitation amount over the Korean Peninsula for the late summer and early fall associated with typhoon activity can be properly captured by higher-resolution RCMs in Phase II. In addition, RCMs in Phase II have an ability to reduce systematic cold bias of surface air temperature for heat wave cases due to more detailed topography and improved simulation of regional processes such as the Foehn effect. In summary, higher-resolution RCMs in Phase II can improve the simulation of high impact weather and climate compare with lower-resolution RCMs in Phase I.

Keywords: CORDEX-East Asia, Added Value

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

**Projection of future changes in extreme precipitation indices over South
Korea**

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In this study, the regional climate of the Korean Peninsula is dynamically downscaled using a high-resolution regional climate model forced by two representative concentration pathway scenarios of Hadley Centre Global Environmental Model version 2-Atmosphere and Ocean (HadGEM2-AO) using multiple regional climate models. Changes in extreme precipitation indices are investigated. Through the evaluation of the present climate, a multi-model ensemble reasonably reproduces the long-term climatology of extreme precipitation indices over South Korea despite some systematic errors. Both mean and extreme precipitation intensities for 80 years in the future (2021–2100) increase compared to those of the present. However, the increasing rates of indices related to precipitation intensities are different according to sub-period, season, and emission scenarios. Mean and extreme precipitation intensities of the future climate increase during the summer when most extreme precipitation events occur over the Korean Peninsula. Also, abnormal extreme precipitation can increase during future summers due to increasing variances of indices related to extreme precipitation intensity. Increasing extreme summer precipitation over South Korea is proportional to the increases in convective precipitation compared to non-convective precipitation. This indicates that future changes in summer precipitation, with regard to intensity and frequency, over South Korea, among representative concentration pathway scenarios, are more related to a change in convective instability rather than the synoptic condition.

Keywords: climate change, extreme precipitation, South Korea, regional climate model, STARDEX, multi-RCM, HadGEM2-AO

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

**Future change in tropical cyclone activity over the western North Pacific in
CORDEX-East Asia Multi-RCMs forced by HadGEM2-AO**

Minkyu Lee, UNIST, South Korea

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Hyeonjae Lee, ***Tahyung Kim***, ***Dong-Hyun Cha***, UNIST, South Korea; ***Dong-Kyou Lee***, Seoul National
University, South Korea; ***Myoung-Seok Suh***, Kongju National University, South Korea; ***Song-You
Hong***, Korea Institute of Atmospheric Prediction Systems, South Korea; ***Hyun-Suk Kang***, Korea
Meteorological Administration, South Korea

Future changes in tropical cyclones (TCs) activities over the western North Pacific (WNP) are analyzed using four regional climate models (RCMs) within the Coordinated Regional Climate Downscaling Experiment (CORDEX) for East Asia. All RCMs are forced by the HadGEM2-AO under the historical and Representative Concentration Pathway (RCP) 8.5 scenarios, and are performed at about 50 km resolution over the CORDEX-East Asia domain. In the historical simulations (1980–2005), multi-RCM ensembles yield realistic climatology for TC tracks and genesis frequency during the TC season (June–November), although they show somewhat systematic biases in simulating TC activity. The future (2024–2049) projections indicate an insignificant increase in the total number of TC genesis (+5%), but a significant increase in track density over East Asia coastal regions (+17%). The enhanced TC activity over the East Asia coastal regions is mainly related to vertical wind shear weakened by reduced meridional temperature gradient and increased sea surface temperature (SST) at mid-latitudes. The future accumulated cyclone energy (ACE) of total TCs increases significantly (+19%) because individual TCs have a longer lifetime (+6.6%) and stronger maximum wind speed (+4.1%) compared to those in the historical run. In particular, the ACE of TCs passing through 25°N increases by 45.9% in the future climate, indicating that the destructiveness of TCs can be significantly enhanced in the mid-latitudes despite the total number of TC number not being changed greatly.

Keywords: tropical cyclone, CORDEX-East Asia, RCP scenario, climate change

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D5: Introduction and application of ESGF in CORDEX-EA
domain**

**Asian summer monsoon changes at different levels of global warming:
A multi-RCMs study**

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***Donghyun Lee, Seung-Ki Min**, POSTECH, South Korea*

This study investigates summer precipitation changes over Asia at different global warming levels from Paris Agreement (+1.5 and 2.0°C, relative to pre-industrial level) and stronger warming (+2.5 and 3.0°C) using multi-RCM simulations from CORDEX East Asia Phase II experiments. Five RCMs (RegCM4, SNU-MM5, WRF, CCLM, HadGEM3-RA) were dynamically downscaled driven by three CMIP5 GCMs (GFDL-ESM2M, HadGEM2-AO and MPI-ESM-LR) under 8.5 scenario simulations. 10-year periods corresponding to the global warming levels were selected from boundary GCMs, by assuming recent 10 years (2006-2015) as +0.87°C warmer than pre-industrial level (IPCC, 2018). RCMs can reproduce overall characteristics of Asian summer monsoon precipitation, but with systematic bias patterns resembling those from boundary GCMs. Large inter-RCM differences are found in mean precipitation changes. However, extreme precipitation (upper 99%ile of summer precipitation) show good agreement across RCMs, which is intensified as global warming levels increase. This indicates that global warming mitigation benefit will manifest itself more strongly in extreme precipitation over Asian region, supporting previous studies. Physical mechanisms (dynamical and thermodynamic effects) and quantification of uncertainty sources (GCMs and RCMs) will be further discussed

Keywords: CORDEX-East Asia, Paris Agreement, Asian summer monsoon, Extreme precipitation

**Parallel Session D:
Domain/cross-domain meetings,
Convection permitting models**

**D6: Hybrid downscaling methods:
How can CORDEX benefit from
statistical approaches?**

ORAL PRESENTATIONS

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D6: Hybrid downscaling methods: How can CORDEX benefit
from statistical approaches?**

The best of both worlds: Processed-based and data-driven regional climate

Ethan Gutmann, NCAR, United States

*Ethan Gutmann, Roy Rasmussen, Trude Eidhammer, NCAR, United States;
Jeffrey Arnold, USACE, United States*

While dynamical regional climate modeling is appealing to the physical scientist, its computational cost is objectionable to the applied scientist. In contrast, while simple statistical downscaling tools are appealing to stakeholders for their ability to generate large ensembles, the physical and applied scientists recognizes the implausibility and physical inconsistencies in such methods. We have been developing a regional climate approach starting from physical processes, and incorporating a simple form of data assimilation to keep the simplifications in one area of the model from harming others. We will discuss the Intermediate Complexity Atmospheric Research model (ICAR), a simplified atmospheric model capable of running 100-1000 times faster than a traditional regional climate model. ICAR relies on physics and first principals where it is currently computationally possible, for example for orographic precipitation, and simpler physical parameterizations aided by data driven stochastic processes to provide a convective parameterization applicable at what would ordinarily be considered "convection resolving" grid scales (< 6km). We show that this approach captures many of the expected changes in regional climate signals such as the snow albedo feedback, wind and rain/snow fall speed driven orographic precipitation shifts, and increases in extreme precipitation. In addition, because we are able to examine a large ensemble of climate projections we can also understand how compensatory changes can interact. For example, increases in high elevation precipitation can counter increased temperature driven melting of snow and minimize the snow albedo feedback effect.

Keywords: quasi-dynamical, orographic precipitation, snow albedo feedback, mountain

**Parallel Session D:
Domain/cross-domain meetings,
Convection permitting models**

**D7: Climate Services developments
in the frame of CORDEX
and their transferability**

ORAL PRESENTATIONS

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D7: Climate Services developments in the frame of CORDEX
and their transferability**

Regional climate simulations for the impact of climate change over the CAS-CORDEX domain

Sara Top, Ghent University, Belgium

***Sara Top**, Ghent University, Belgium; **Svetlana Aniskevich**, Latvian Environment, Geology and Meteorology Centre, Latvia; **Leonid Bobylev**, Nansen International Environmental and Remote Sensing Centre, Russian Fed; **Steven Caluwaerts**, Ghent University, Belgium; **Lesley De Cruz**, Royal Meteorological Institute of Belgium, Belgium; **Philippe De Maeyer**, Ghent University, Belgium; **Rozemien De Troch**, Royal Meteorological Institute of Belgium, Belgium; **Natalia Gnatiuk**, Nansen International Environmental and Remote Sensing Centre, Russian Fed; **Anne Gobin**, Flemish Institute for Technological Research (VITO), Belgium; **Rafiq Hamdi**, Royal Meteorological Institute of Belgium, Belgium; **Lola Kotova**, Climate Service Center Germany, Germany; **Arne Kriegsmann**, Climate Service Center Germany, Germany; **Armelle Reza Remedio**, Climate Service Center Germany, Germany; **Abdulla Sakalli**, Iskenderun Technical University, Turkey; **Andrey Sirin**, Institute of Forest Science Russian Academy of Sciences, Russian Fed; **Piet Termonia**, Royal Meteorological Institute of Belgium, Belgium; **Hans Van De Vyver**, Royal Meteorological Institute of Belgium, Belgium; **Bert Van Schaeybroeck**, Royal Meteorological Institute of Belgium, Belgium; **Andris Viksna**, Latvian Environment, Geology and Meteorology Centre, Latvia*

The AFTER project was initiated to investigate the “Impact of climate change and climate extremes on the Agriculture and Forestry in the Europe-Russia-Turkey Region”. In this context high-resolution climate data was produced by running the RCMs ALARO-0 and REMO at a resolution of 25 km over the Central Asia (CAS)-CORDEX domain. The models were evaluated by comparing the output of ERA-Interim driven runs with CRU data over the 1980-2017 period. Different climate variables that will be used later as input for crop and vegetation models are validated.

First validation results show that both RCMs reproduce realistic spatial patterns for temperature and precipitation, with biases in an acceptable range. Similar precipitation biases appear for both models with a strong wet winter bias in the east and a dry summer bias in the south-western part of the CAS-CORDEX domain. In contrast, there are differences between the RCMs in terms of spatial bias patterns for air temperature. For both variables large biases are observed over the mountainous areas but these could be largely attributed to the observational error.

The climate change results over the CAS-CORDEX domain using CMIP5 driven simulations enable an assessment of climate impacts and extreme events. The REMO model is driven by three GCMs (MPI-ESM, HadGEM and NorESM), while ALARO is driven by CNMR-CM5. The comparison of the historical period with the future model output up to 2100 allows to estimate the response of the climate over Central Asia under the scenarios RCP2.6, RCP4.5 (only for ALARO) and RCP8.5.

The AFTER consortium bridges the gap between supply and demand of climate information by implementing the newly created climate data directly into crop and vegetation models. For specific sub-regions of Latvia, Turkey and major crop areas of Russia detailed studies will be done. In addition stakeholders from different countries in the CAS-CORDEX domain are involved in discussing the scientific results.

Keywords: ALARO,REMO,climate change impact,CAS-CORDEX,RCM

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D7: Climate Services developments in the frame of CORDEX
and their transferability**

**CORDEX data in the Climate Data Store (CDS) of the Copernicus Climate
Change Service (C3S): current status and plans**

Andras Horanyi, ECMWF, United Kingdom

Andras Horanyi, Anca Brookshaw,; Cedric Bergeron, Carlo Buontempo, ECMWF, United Kingdom

The Copernicus Climate Change Service (C3S) implemented by ECMWF on behalf of the European Union provides authoritative climate service information about the past, present and future climate in Europe and elsewhere through its Climate Data Store (CDS). Climate data for the future decades are provided by global and regional climate projections. The regional climate projections accessible from the Climate Data Store are taken from the CORDEX database through the Earth System Grid Federation (ESGF) data and computing nodes. The presentation is going to summarise the main objectives of C3S, the content of the CDS with special emphasis on the details of the CORDEX regional climate projection information and plans for the extension of CORDEX datasets in the CDS.

Keywords: Copernicus Climate Change Service, Climate Data Store

**Parallel Session D:
Domain/cross-domain meetings,
Convection permitting models**

**D7: Climate Services developments
in the frame of CORDEX
and their transferability**

POSTER PRESENTATIONS

LAST NAME	FIRST NAME	TITLE	POSTER NUMBER
CHRISTENSEN	Ole	The need for flexible selection of climate simulation sub-ensembles for impact assessment in a climate service	D7-P-01
ESABU	Anthony	Smallholder farmers' perceptions and adaptations to climate change and variability in Katakwi district, Uganda	D7-P-02
FITA	Lluís	Climate change estimations of fluvial discharge from the main Andean rivers	D7-P-03
GLEIXNER	Stephanie	The East Africa - Peru - India Climate Capacities (EPICC) project is co-developing climate services for and with partners from the water, agriculture and related sectors.	D7-P-04

**Parallel Session D: Domain/cross-domain meetings,
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D7-P-01

**The need for flexible selection of climate simulation sub-ensembles for
impact assessment in a climate service**

***Ole B. Christensen**, Danish Meteorological Institute, Denmark*

***Ole B. Christensen**, Danish Meteorological Institute, Denmark; **Marianne S. Madsen**, Danish Meteorological Institute, Denmark; **Rasmus Benestad**, Met. Norway, Norway; **Andreas Dobler**, Met. Norway, Norway; **Kajsa M. Parding**, Met. Norway, Norway; **Olle Räty**, University of Helsinki, Finland; **Jouni Räisänen**, University of Helsinki, Finland; **Kimmo Ruosteenoja**, Finnish Meteorological Institute, Finland; **Peter Ukkonen**, Finnish Meteorological Institute, Finland; **Harilaos Loukos**, The climate Data Factory, France; **Elisabeth Viktor**, Climate Service Centre Germany, Germany; **Juliane Otto**, Climate Service Centre Germany, Germany; **Gabriella Zsebeházi**, Hungarian Meteorological Institute, Hungary; **Peter Szabó**, Hungarian Meteorological Institute, Hungary; **Antti Mäkelä**, Finnish Meteorological Institute, Finland; **Hilppa Gregow**, Finnish Meteorological Institute, Finland*

DECM (C3S_51_Lot4, Data Evaluation for Climate Models) was a COPERNICUS project in the Evaluation and Quality Control block dealing with climate model results and how to evaluate simulations for the COPERNICUS Climate Data Store (CDS), which is currently being developed at the ECMWF.

DECM had a strong focus on the relation between user requirements, data inventory and scientific quality assurance in order to recommend user-friendly and fit-for-purpose tools and services for the Evaluation and Quality Control framework of the COPERNICUS Climate Data Store, which will contain both regional (CORDEX) and global (CMIP) data..

This poster will present general findings and recommendations from the work on scientific model assessment and gap analysis of the relation between user needs and data availability. We present the main conclusions identified in this project related to the very important challenge of how to perform selection of sub-ensembles of climate model simulations. For advanced use, e.g. as input to quantitative impacts models, it is frequently necessary to select smaller sub-ensembles of larger existing ensembles. This is increasingly important as CMIP and CORDEX model simulation collections constantly grow.

Keywords: sub-ensemble selection, climate model uncertainty

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D7: Climate Services developments in the frame of CORDEX
and their transferability**

D7-P-02

**Smallholder farmers' perceptions and adaptations to climate change and
variability in Katakwi district, Uganda**

Anthony Esabu, Farm Africa Uganda, NGO, Uganda

The effects of climate change have highly challenged the productivity of the agricultural sector. The increasing temperatures and erratic rains, as well as diseases and pests have significantly reduced crop yields in the arid and semi-arid regions of Uganda. Though climate change has been the talk of the day, many farmers in the grassroots have hardly adopted any response options and have continued to suffer losses from the inherent effects of climate change. The present study sought to assess the perceptions of small scale farmers on climate change in selected sub counties in Katakwi district and identify adaptation measures adopted by the farmers in response to climate change. Descriptive survey design was used. A total of 177 households were randomly selected to constitute the study sample. Data was coded and analyzed using SPSS version 20. The results showed that most farmers had perceived a changing climate with 74% and 100% of the respondents in Kapujan and Toroma sub counties respectively, reporting an increase in temperature over the years. Regarding precipitation, 100% and 97% of the respondents in Kapiujan and Toroma sub counties respectively, had noticed a decrease in the average annual rainfall over the last two decades. Further, the results indicated that 76% and 88% of the respondents in Toroma and Kapujan subcounties respectively had adopted various adaptation options in response to the decreasing rainfall and the unpredictable onset of rains. The study established that farmers in drier areas perceived climate change more and had adapted more to climate change and variability as compared to those in wetter areas. More resources in terms of credit facilities, access to climate change information and extension services should be availed to farmers in areas affected more by climate change and variability to increase their resilience.

Keywords: Arid and semi-arid lands; Crop yields; Climate change; Drought resistant crops; Perceptions ,Arid and semi-arid lands; Crop yields; Climate change; Drought resistant crops; Perceptions

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D7: Climate Services developments in the frame of CORDEX
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D7-P-03

Climate change estimations of fluvial discharge from the main Andean rivers

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Freshwater resources are essential for sustaining ecosystems and human activities. The Andean mountain range is an elongated series of mountains stretching from north to south all along the South American continent. In this study we present estimation of the projected changes in discharge from all major river basins in South America. These estimations are developed in a simple way by performing 'off-line' simulations with the routing scheme of the ORCHIDEE land model forced by CORDEX dynamical regional downscaled datasets. Our results are the first attempt to provide a depiction of the evolution of the water resources for the entire region making use of a simple, limited but reliable methodology.

Keywords: Fresh water, Climate projection

**Parallel Session D: Domain/cross-domain meetings,
Convection permitting models
D7: Climate Services developments in the frame of CORDEX
and their transferability**

D7-P-04

**The East Africa - Peru - India Climate Capacities (EPICC) project is
co-developing climate services for and with partners from the water,
agriculture and related sectors.**

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Funded by the International Climate Initiative (IKI) the project starts from a clear statement of demand by a national agency (ministry) in the respective partner country. Through this initial link, EPICC has established dialogues with a network of partners from policy making, the private sector, civil society and science in Tanzania, Peru and India, with national meteorological services playing a central role. Jointly with these partners, EPICC identifies local user-demands for climate services and capacities. In doing so, we recognize the different contexts, vulnerabilities, adaptation options and demands for capacity development across the three partner countries, at national and sub-national level.

Based on scientific products such as seasonal forecasts, climate scenarios and hydrological and agricultural impact assessments, EPICC assesses integrated adaptation options that strengthen climate resilience, help to achieve national development goals and potentially reduce migration pressure. Methods employed include statistical and process-based modeling, field surveys, data synthesis, advanced visualization techniques, web platforms, local workshops and training sessions and other formats.

Challenges that EPICC is facing include the need for continuous interaction, for establishing methods and structures that last beyond the project period, and to bridge the often large gap between science and policy- and decision-making. For that we closely cooperate with related projects, with other climate services initiatives, with various national and sub-national institutions and also with development cooperation. In an iterative process the concept of climate services is explained to partners and operationalized, that way overcoming concerns that EPICC (like other projects in the past) might want to exploit the national partners and their data without tangible benefit for them and their countries. This joint definition of relevant issues, research questions, products and eventually building of trust takes time.

Keywords: Climate Services, Co-development