National Institute of Meteorological Sciences
책임운영기관

Regional Climate Model Performance in Simulating Present-Day Mean Climate Using CMIP5 & CMIP6 GCMs

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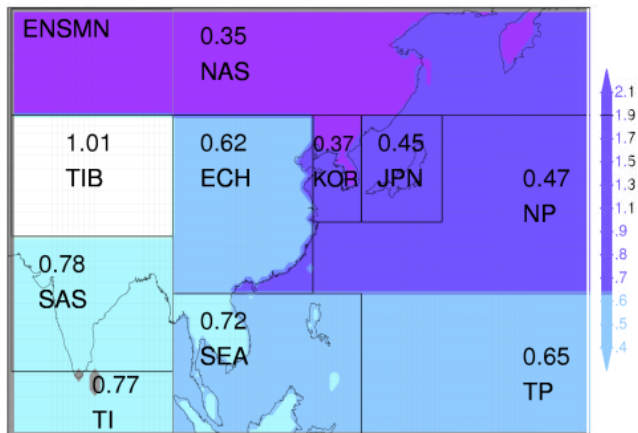
Climate Research Division, NIMS, KMA

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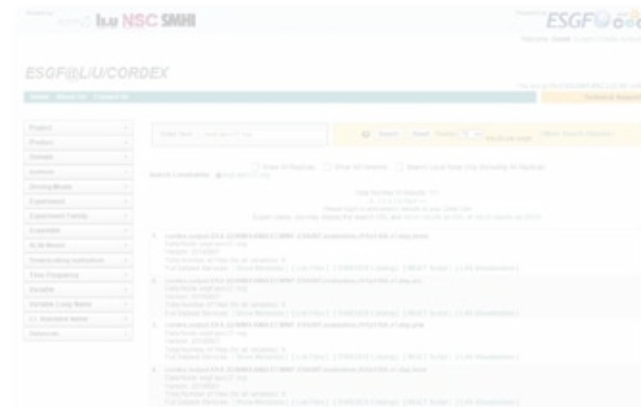
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1. Performance of RCMs

2. Current Status of CORDEX-EA data

Introduction

✓ **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. CORDEX-core recommended each RCM should downscale a minimum of 3 GCMs.**

✓ **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 in CORDEX-EA.**

CORDEX Coordinated Output for Regional Evaluations (CORE)

A simulation framework in support of IPCC AR6
CORDEX Scientific Advisory Team

5. Driving GCMs and scenarios
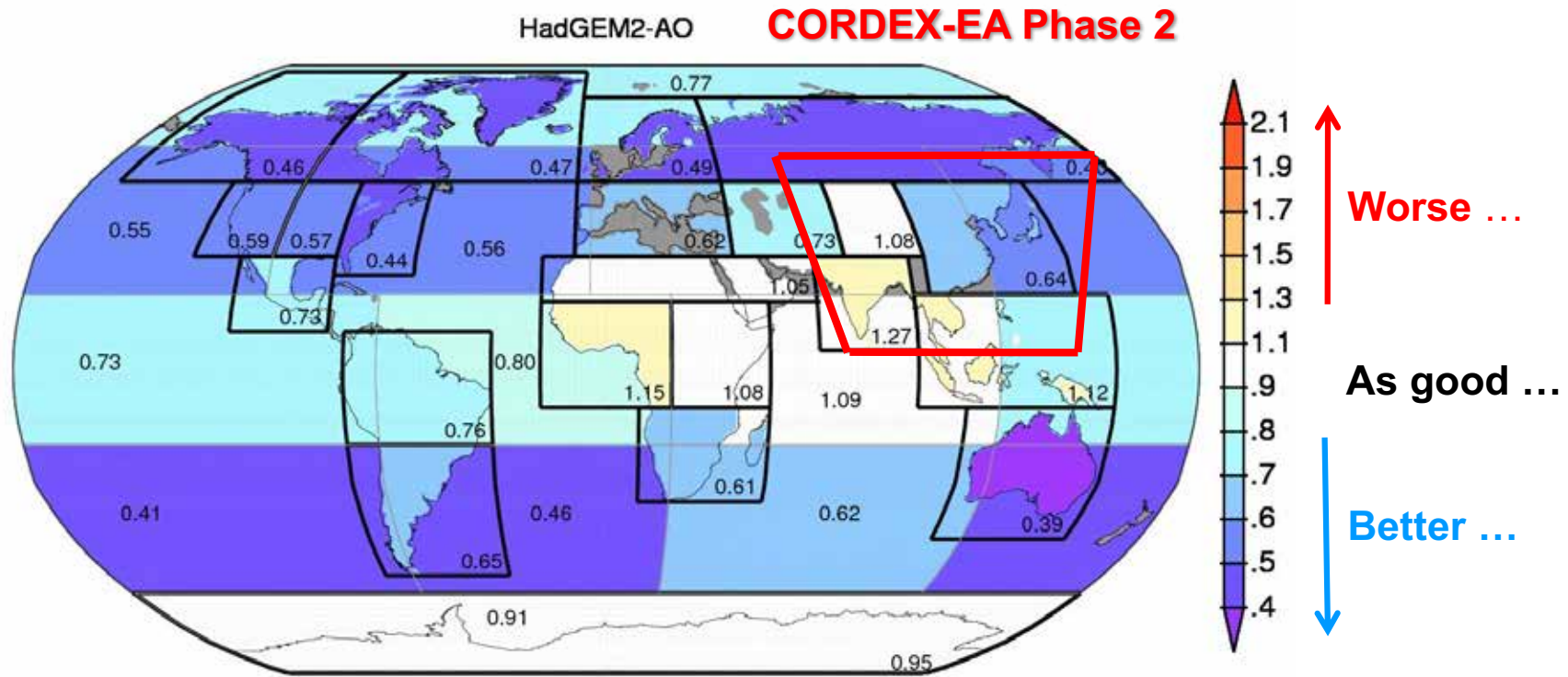
To participate in CORDEX CORE, each RCM should downscale a minimum of 3 GCMs for 2 scenarios, RCP8.5 and RCP2.6. The two scenarios more or less cover the full IPCC range. The number of 3 for the GCMs is a minimum, ideally 5-6 GCMs would be better, if feasible.

6 June 2018

Methodology

Normalized error variance

- **Reichler and Kim 2008, BAMS, JGR** → **Global Performance skill**

✓ To evaluate the agreement between RCM and observation, we quantify an error using an index for performance by Reichler and Kim (2008).

✓ In the CORDEX-EA domain, the average performance is expressed as 1.

✓ A performance index of less than 1 implies good performance.

Methodology

Normalized error variance

- **Reichler and Kim 2008, BAMS, JGR**

1. Normalized RMS error

$$E = \sqrt{\sum_{n=1}^{N} w_n \left(\frac{\overline{s_n} - \overline{o_n}}{\sigma_{n,o}} \right)^2}$$ **NRMS**

S_n : simulated climatology
O_n : observed climatology
$\sigma_{n,o}$: interannual variance from the validating observations

2. Regional error index

$$I_r^2 = \frac{E_r^2}{\overline{E_{ea}^2}^M}$$ **< 1 : Better than average**

I_r : error for each region
E_r : averaged error for each region
E_{ea} : averaged error for CORDEX-EA region

3. Overall performance index

$$I^2 = \overline{I^{2v}}$$

- ✓ **First, calculated for each model and variable a normalized error variance E by squaring the grid-point differences between simulated and observed climate.**
- ✓ **I_r^2 is error for each region normalized by error mean of all models for East Asia.**
- ✓ **The final model performance index (I^2)was formed by taking the mean over all climate variables for regions.**

Data

RCM Data (GCM Historical LBC)

- **Period: 1981.01. ~ 2000.12. mean climate**

- **Domain: CORDEX-EA Phase2 domain**

- **8 RCMs - CMIP5 (7), CMIP6 (1)**

Phase 2
(0.25˚ X 0.25˚)
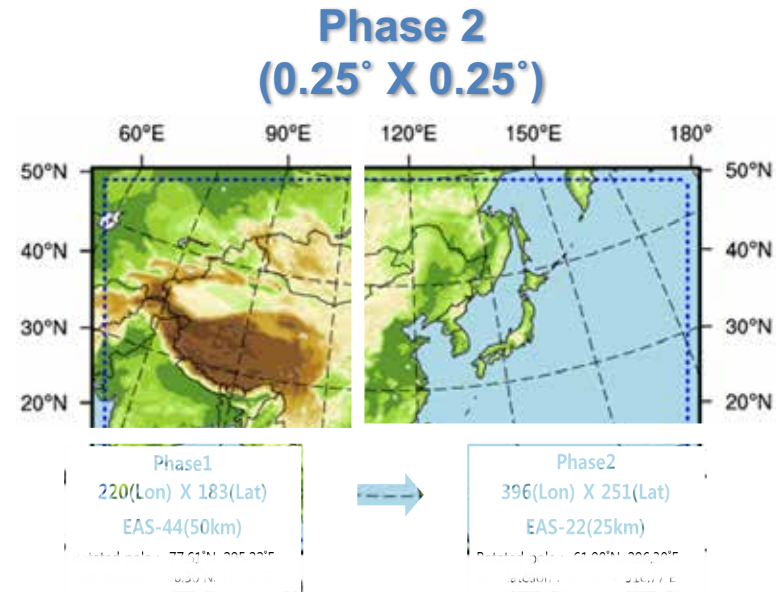
GCM \ RCM	HadGEM3-RA (NIMS)	SNU-RCM (UNIST)	CCLM (POSTECH)	WRF (PNU)	RegCM4 & GRIMs (KNU)
HadGEM2-AO	●	○	●		●
MPI-ESM-LR	●	○	●	●	
GFDL2M				●	○
UK-ESM	●	○	○	○	○

Data

Validation Data

- **ERA-Interim & ERA5 (0.25˚ X 0.25˚)**

No	Quantity v	Acronym
1	surface air temperature	tas
2	Maximum temperature	tasmax
3	Minimum temperature	tasmin
4	Evaporation	evspsbl
5	Surface Downwelling Shortwave Radiation	rsds
6	Surface Downwelling Longwave Radiation	rlds
7	Surface Sensitive Heat Flux	hfss
8	Surface Latent Heat Flux	hfls
9	sea level pressure	psl

No	Quantity v	Acronym
10	precipitation	pr
11	Convective Precipitation	prc
12	specific humidity 850 hPa	hus850
13	temperature 850 hPa	ta850
14	zonal wind 850 hPa	ua850
15	meridional wind 850 hPa	va850
16	geopotential 500 hPa	zg500
17	temperature 200 hPa	ta200
18	zonal wind 200 hPa	ua200
19	meridional wind 200 hPa	va200

RCMs Performance

CORDEX-EA Phase2 Performance

ENSEMBLE mean

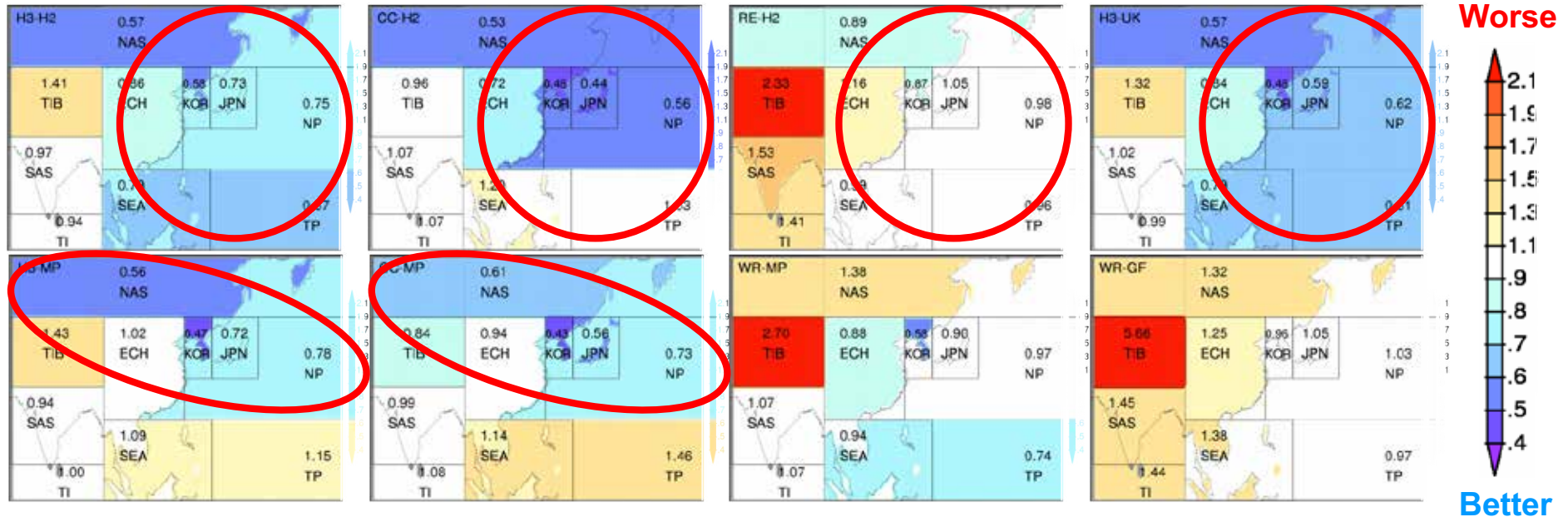Worse / Better
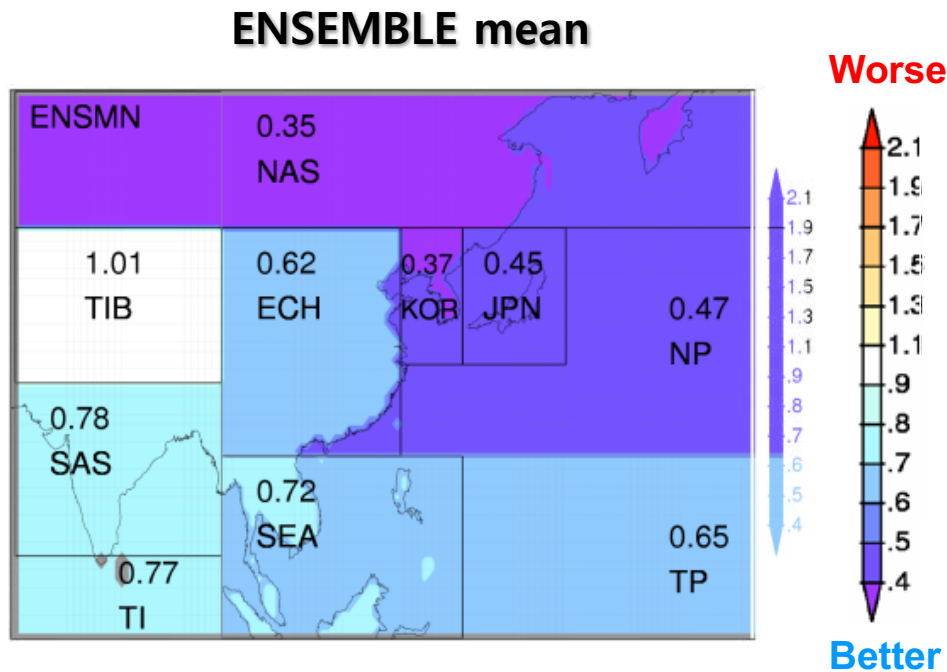
- ✓ **Regional performance results are generally divided into East and West. The east shows good performance, the west shows bad performance.**

- ✓ **It has lower simulation performance in Tibetan Plateau.**

- ✓ **Very well simulates East Asia, including East China, Korea, and Japan.**
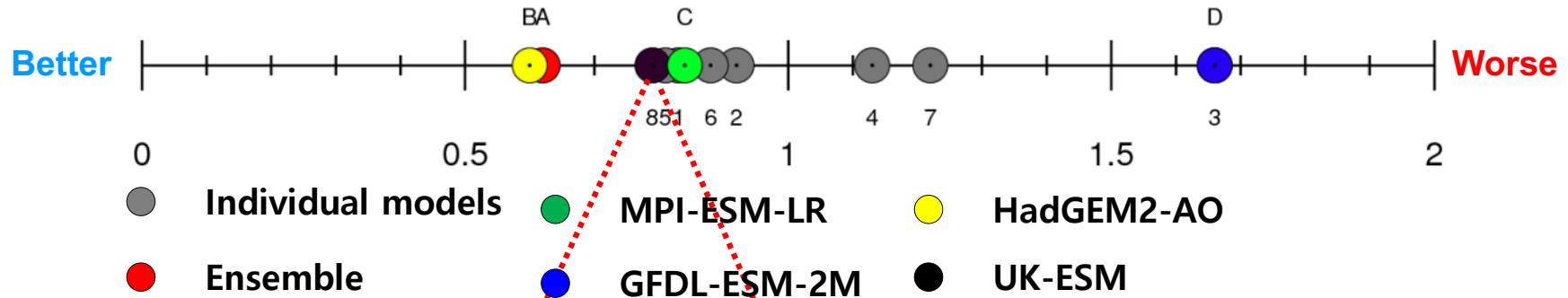
RCMs Performance

CORDEX-EA Phase2 Performance

- ✓ **Although each model is somewhat different, the results are similar to the ensemble mean.**

- ✓ **Common to all RCMs are lower simulation performance in Tibetan plateau. On the other hand, they commonly best simulate Korea.**

- ✓ **RCMs using HadGEM2-AO and UK-ESM GCM forcing have relatively good simulation performance in the east side. MPI performs slightly better at the top right.**

- ✓ **Of the models, the HadGEM3-RA driven by UK-ESM has the best performance.**

RCMs Performance

Best model combination (GCM-RCM)

GCM \ RCM	HadGEM3-RA (NIMS)	SNU-RCM (UNIST)	CCLM (POSTECH)	WRF (PNU)	RegCM4 & GRIMs (KNU)
HadGEM2-AO	0.85		0.82		1.24
MPI-ESM-LR	0.93		0.89	1.61	
GFDL2M				1.12	
UK-ESM	0.80				

CMIP6

✓ **The ensemble mean shows higher performance than the individual RCMs**

✓ **The HadGEM3-RA and UK-ESM combination shows the best performance of all individual models.**

✓ **Among CMIP5 GCM driven models, the CCLM driven by HadGEM2-AO has the best performance.**

RCMs Performance

Climate elements

CORDEX-EA domain
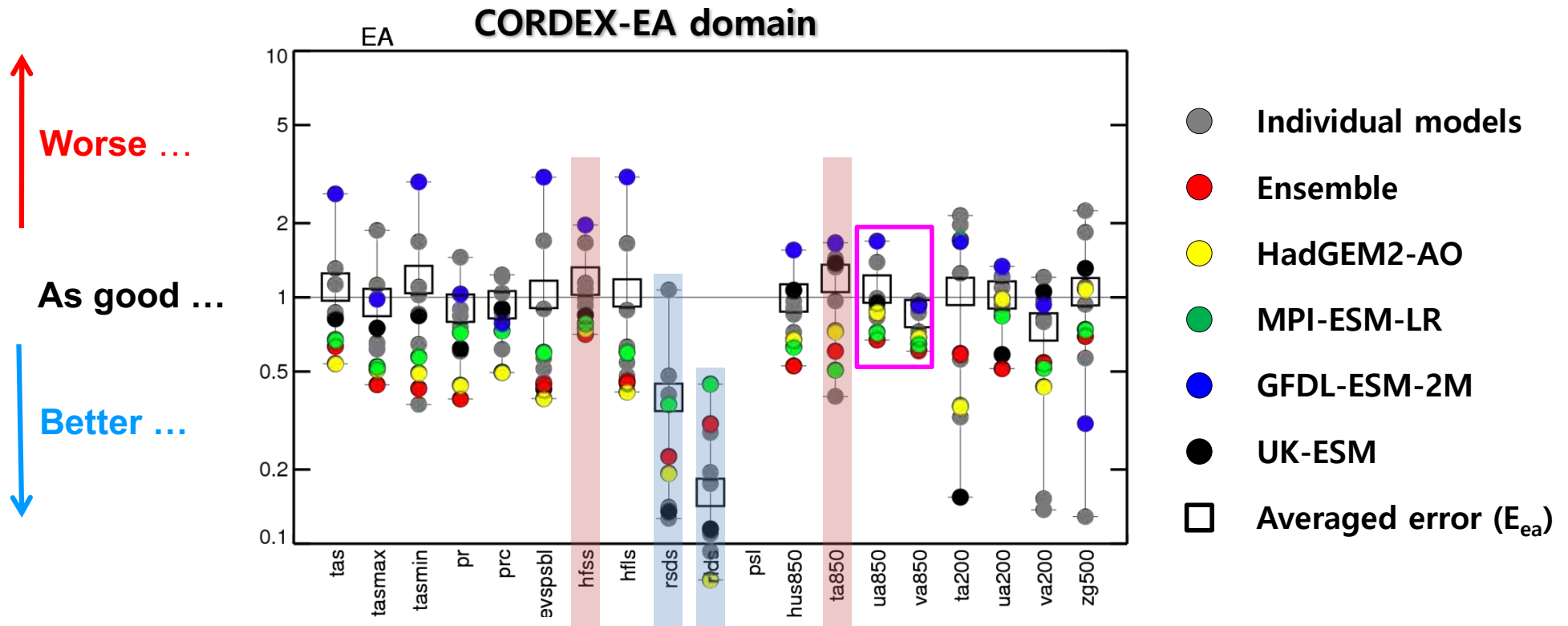
- ✓ **The ensemble mean and HadGEM2-AO GCM forcing usually good performance.**
- ✓ **rlds and rsds most faithfully**
- ✓ **There are no variables whose simulated performance is significantly poor**
- ✓ **The lower atmosphere wind field has the smallest difference in simulation performance between models**

RCMs Performance

Climate elements

Good Performance Area

Bad Performance Area
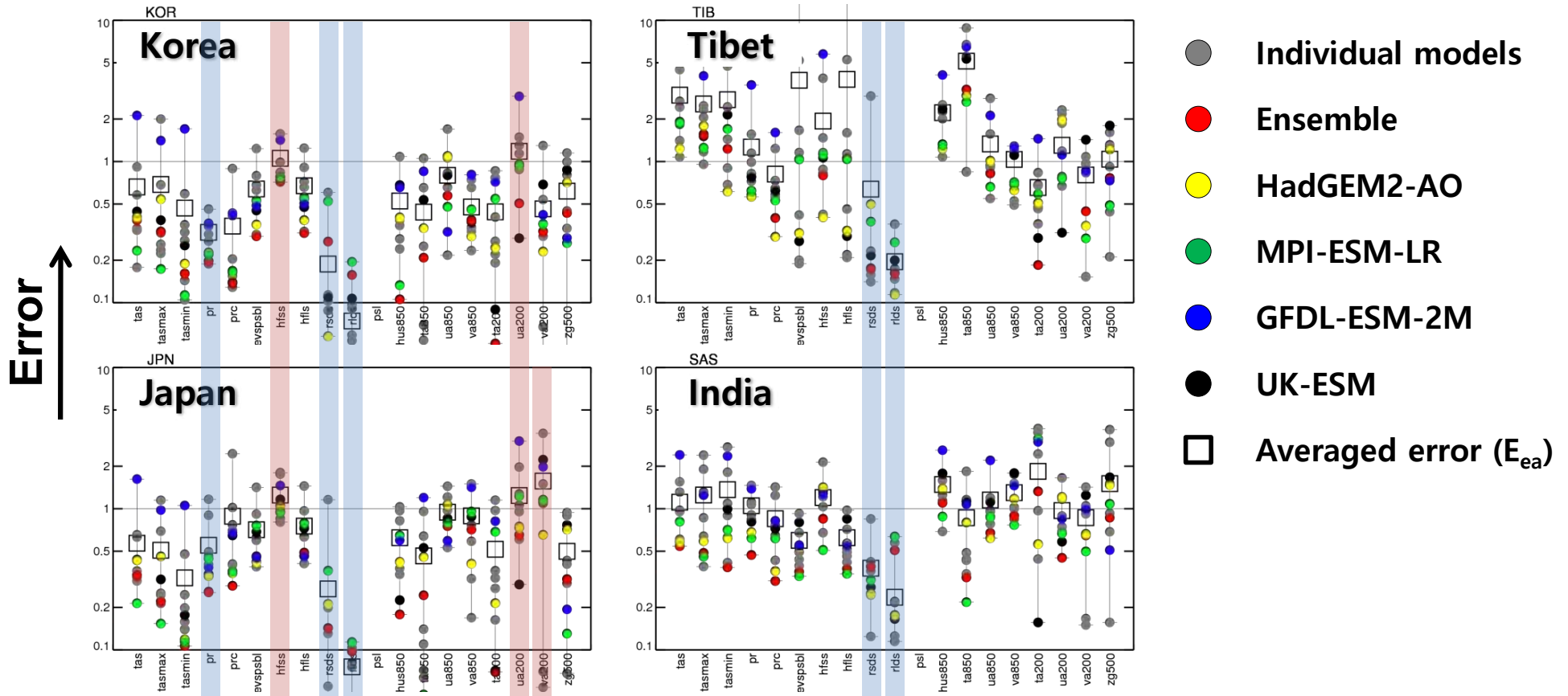
- ✓ **In Korea and Japan where performance is good, most variables have performance index lower than 1. However, higher atmosphere meridional-wind is rather low.**
- ✓ **Tibet and India, which have bad performance, have a performance index exceeds 1 in most variables. However, radiation variables are most faithfully**

Conclusion

- In this study, we evaluate the performance of each model of the East Asian group participating in CORDEX. Performance index is useful to compare RCMs and to track model changes.

- Regional performance results are generally divided into East and West. Common to all RCMs is lower simulation performance in Tibetan plateau.

- Multi-model mean outperforms even the best individual model.

- The combination of CCLM & HadGEM2-AO, and HadGEM3-RA & UK-ESM have the best performance.

- Among the variables, surface downwelling longwave radiation and surface downwelling shortwave radiation performance is excellent. On the other hand, Minimum temperature and Surface Sensitive Heat Flux have low performance.

- In the future, observational data as well as reanalysis data will be used for model evaluation.

1. Performance of RCMs
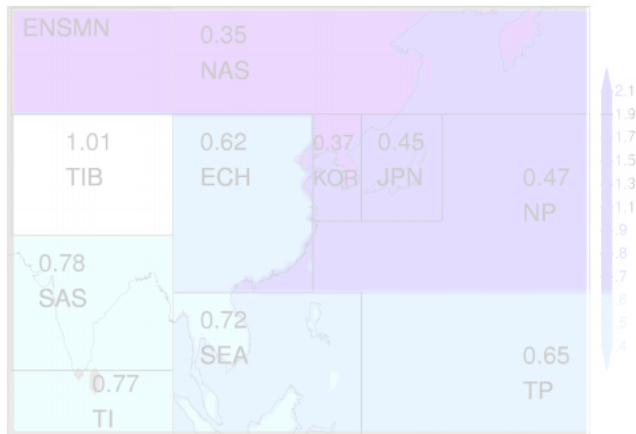
2. Current Status of CORDEX-EA data

Current Status of RCM in NIMS

CORDEX-EA Data Center

- **Data Center (2013~): CORDEX-EA Intercommunication Channel**

  - **Notice, Model information, Publications, News, Data download (phase 1)**

Current Status of RCM in NIMS

CORDEX-EA Data Center

- **CORDEX-EA data declined in 2017-2018, but has recently increased again**

- **Asia accounted for 86.4% of the total downloads**

- **Download by variable: pr(4.3%), tasmin&max(2.8%), tas(1.6%), sfcWind(1.3%) …**

CORDEX Phase1 downloads

Year	Downloading
2013	69,130
2014	89,413
2015	120,395
2016	87,346
2017	23,197
2018	12,103
2019	81,898
Total	483,482

Download by County

Year	2018	2019	Total
Asia	97.1	84.8	86.4
Other regions	2.9	15.2	13.6
China	79.4	65.4	67.2
South Korea	4.4	9.7	9.0
India	0.9	6.0	5.4
Indonesia	0.0	2.4	2.1
Thailand	12.5	0.5	2.0
Japan	0.0	0.8	0.7
Bangladesh	0.0	0.0	0.0
Vietnam	0.0	0.0	0.0

Current Status of RCM in NIMS

ESGF data node

- **ESGF node (May 2019~): Data download (phase 2)**

- Launched phase 2 data download service in the spring using ESGF node.

  - Currently, only evaluation data is available.

- We plan to upload RCMs driven by GCM forcing from early 2020 after post-

  processing & QC.

Data Center (NIMS)   **ESGF (APCC)**

Current Status of RCM in NIMS

Current Status

- **Each RCM should downscale using two different CMIP5 GCMs and one common CMIP6 GCM forcing.**

- **NIMS completed Historical and Scenario experiments using on two CMIP5 GCMs forcing.**

- **The goal of NIMS is to complete RCM based on three GCMs by the early 2020.**

	Evaluation **Completed**	**ERA-Interim** → providing
HadGEM3-RA	**CMIP5 GCMs** **Completed**	**HadGEM2-AO** **MPI-ESM-LR** → Quality Control
	CMIP6 GCM **20%**	**UK-ESM** → Simulating
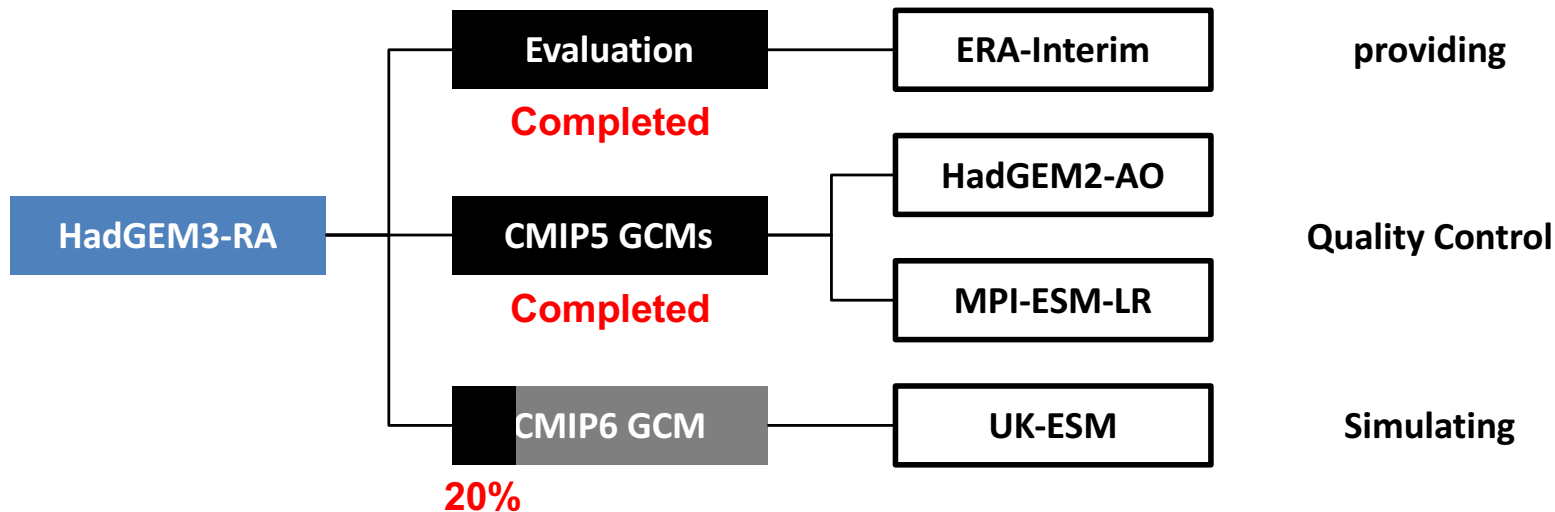
Thank you

for your attention!

No	Quantity v	Acronym	현재
1	surface air temperature	TAS	CRU, ICOADS, NOAA
2	surface radiation_short_down	RSDS	CERES
3	surface radiation_short_up	RSUS	CERES
4	surface radiation_long_down	RLDS	CERES
5	surface radiation_long_up	RLUS	CERES
6	TOA outgoing shortwave radiatin	RSUT	CERES
7	TOA outgoing longwave radiatin	RLUT	CERES
8	precipitation	PR	CMAP, GPCP
9	precipitable water	PRW	HOAPS3
10	sea level pressure	PSL	ERSLP, HADSLP, ICOADS
11	surface sensible heat flux	HFSS	GSSTF3, HOAPS3, ICOADS, JOFURO, OAFLUX
12	surface latent heat flux	HFLS	GSSTF3, HOAPS3, ICOADS, JOFURO, OAFLUX
13	surface skin temperature	TS	ERA-interim
14	zonal wind 200hPa	U200	ERA-interim
15	meridional wind 200 hPa	V200	ERA-interim
16	temperature 200 hPa	T200	ERA-interim
17	geopotential 500 hPa	Z500	ERA-interim
18	zonal wind 850 hPa	U850	ERA-interim
19	meridional wind 850 hPa	V850	ERA-interim

⋮