

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

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Motivation

- * **ISM** is one of the most spatially extensive and temporally consistent monsoon systems in the world.
- * Nearly 1/5th of world population depend, directly and indirectly, on the rainfall associated with **ISM attaches importance** to its variability **even on minor spatiotemporal scales**.
- * It is undergoing a period of 'enhancement' following a land-warming trend since the **beginning of the 21st century**.
- * Frequencies of **heavy rainfall events** and their **contribution** to the total **seasonal** rainfall are investigated to elucidate the overall variability in the seasonal rainfall.
- * Also, the goal of this talk is to introduce the **global ocean-regional atmosphere coupling** concept over CORDEX SA region.
- * To show the potential benefits of this model system to simulate present-day climate and especially the future.

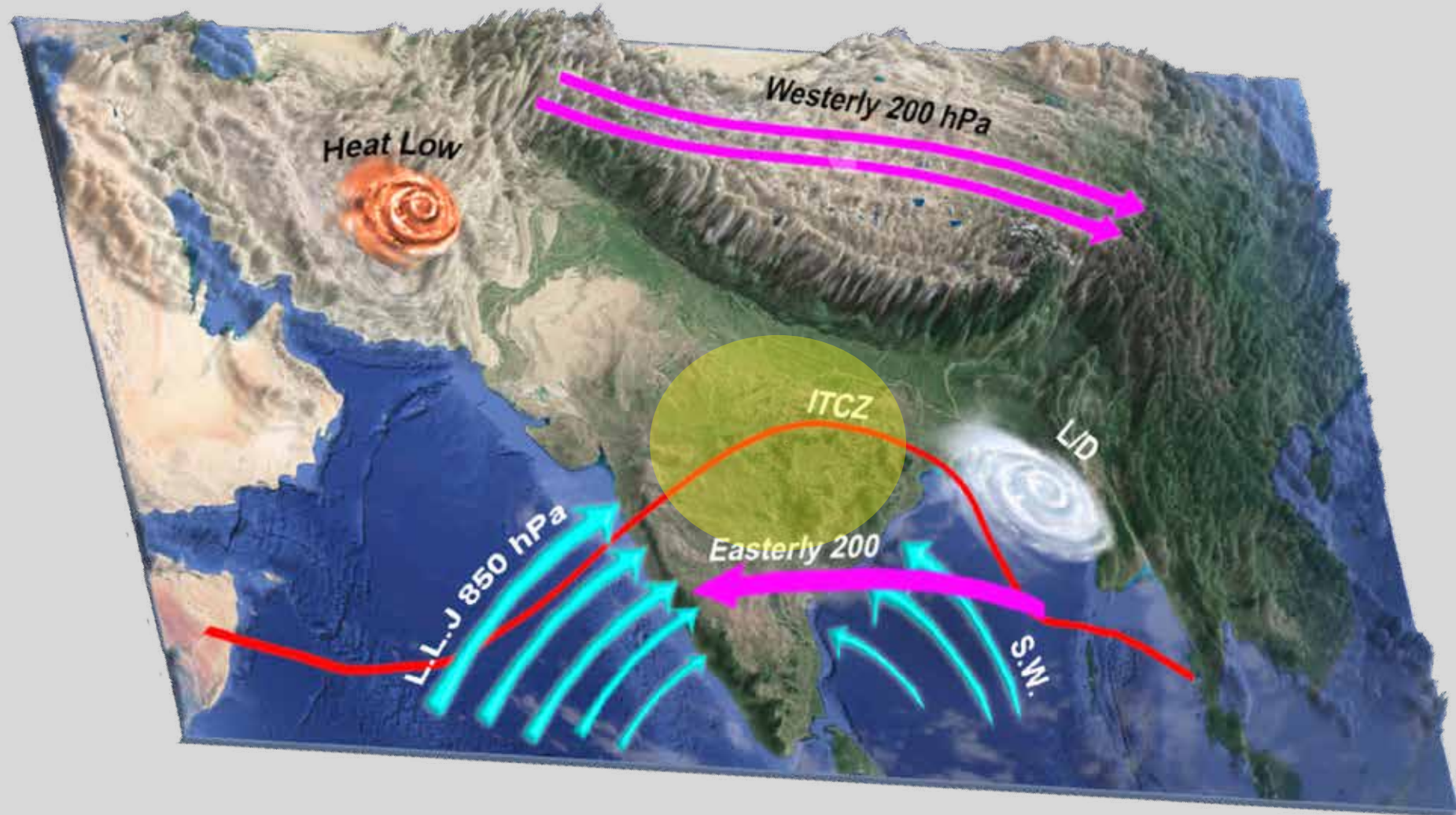


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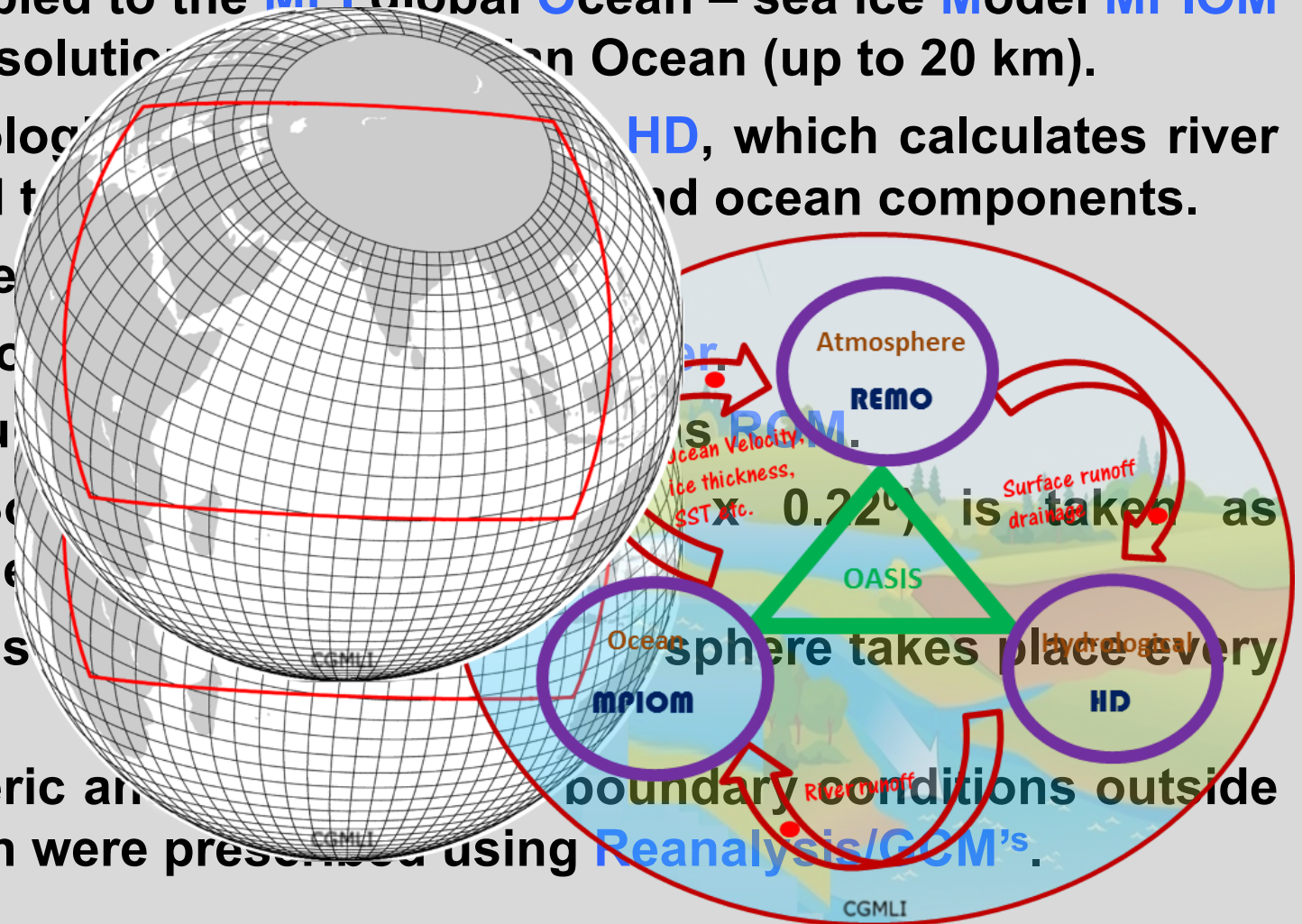
ISM: Indian Summer Monsoon (JJAS) Salient Features



Regional-Earth System Model for South Asia

Experiment Setup

- The **REgional atmosphere MOdel REMO** with 25km horizontal resolution is coupled to the **MPI global Ocean – sea ice Model MPIOM** with increased resolution in the Indian Ocean (up to 20 km).
- The global Hydrological Model **HD**, which calculates river runoff, is coupled to the atmospheric and ocean components.
- Marine Biogeochemistry Model **MBG** is coupled to the ocean component.
- The models are coupled via a common interface **OASIS**.
- Hereafter this coupled model is referred to as **REMO-MPIOM-HD**.
- The **CORDEX South Asia** atmospheric model is used for the atmospheric component.
- Exchange of fields between the models takes place every three hours.
- Lateral atmospheric and ocean boundary conditions outside the REMO domain were prescribed using **Reanalysis/GCM's**.



RESM: Simulation Table

(under DST-RSA joint project)

S. No.	Forcing	Observations /Scenarios	Resolution (Deg)	Period
1	ERA-Interim	Reanalysis	0.22	1980-2017
2	AWI-CM-HR	Historical	0.22	1951-2014
3	MPI-ESM-LR	Historical	0.22	1951-2014
4	AWI-CM-HR	RCP2.6/RCP4.5/RCP8.5	0.22	2015-2100
5	MPI-ESM-LR	RCP2.6/RCP4.5/RCP8.5	0.22	2015-2100

Magenta: Finished; Blue: In machine; Black: Yet to start

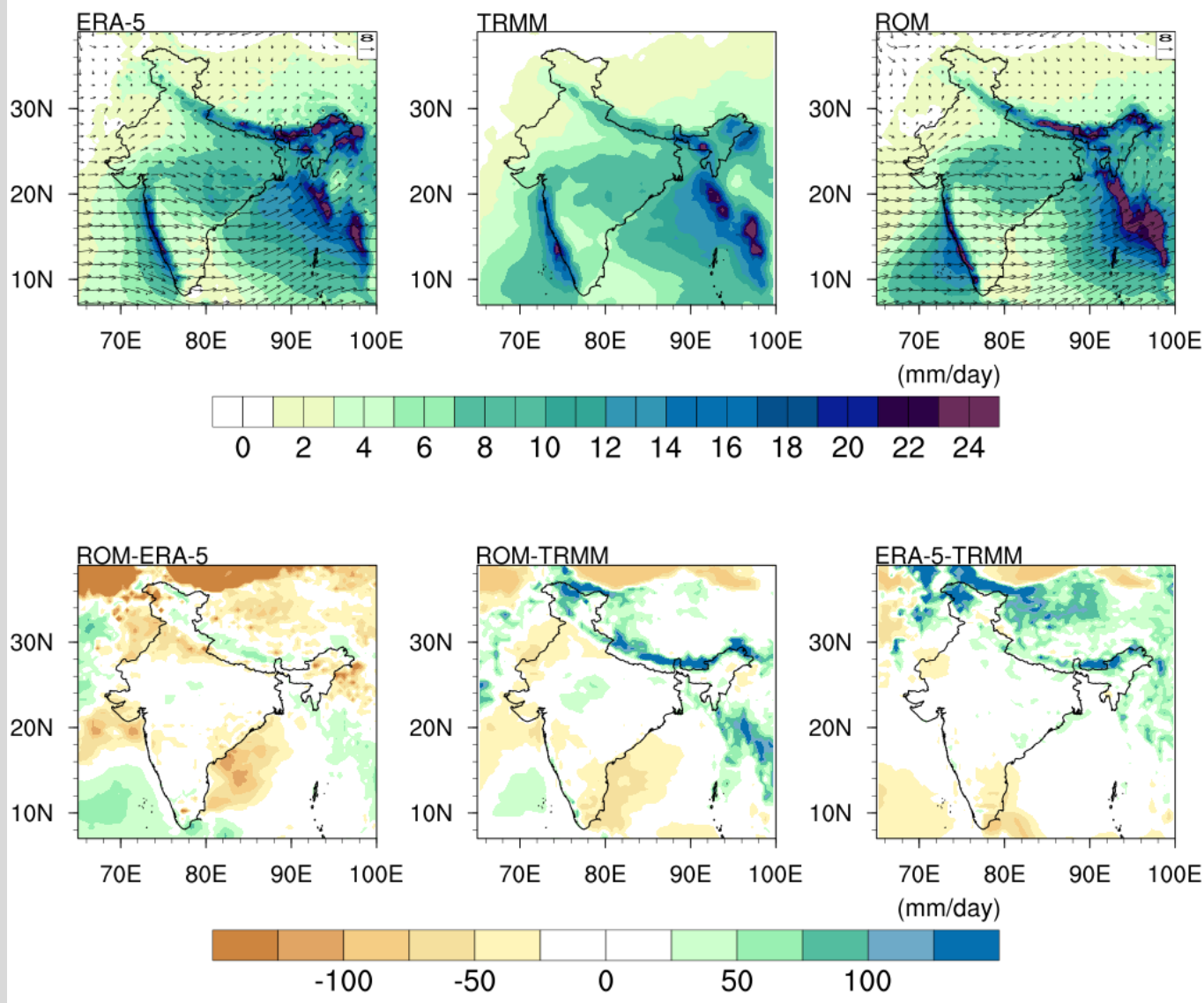


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Results

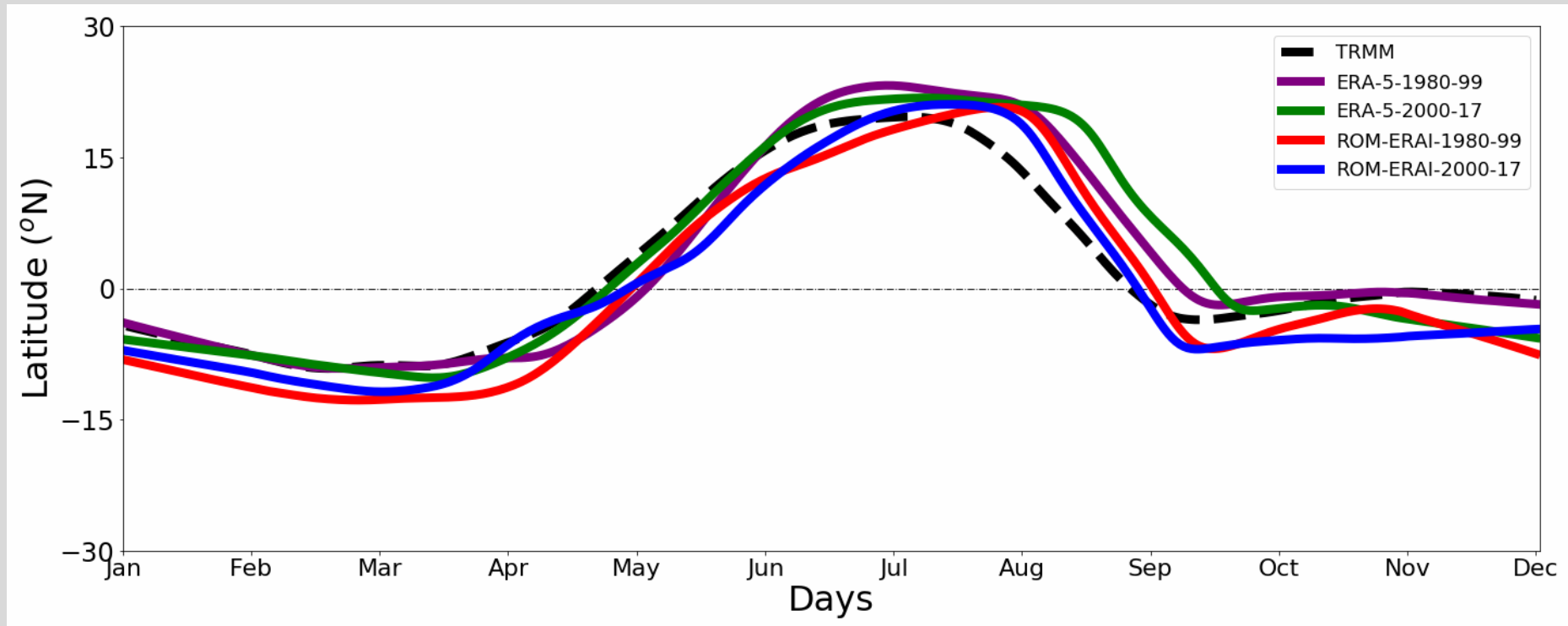


Upper panel:
JJAS Precipitation
climatology, 1998-2017.

Lower panel: %age
change

**Added value: ROM is able
to simulate the all the
major spatiotemporal
rainfall regimes amicably.**

ITCZ

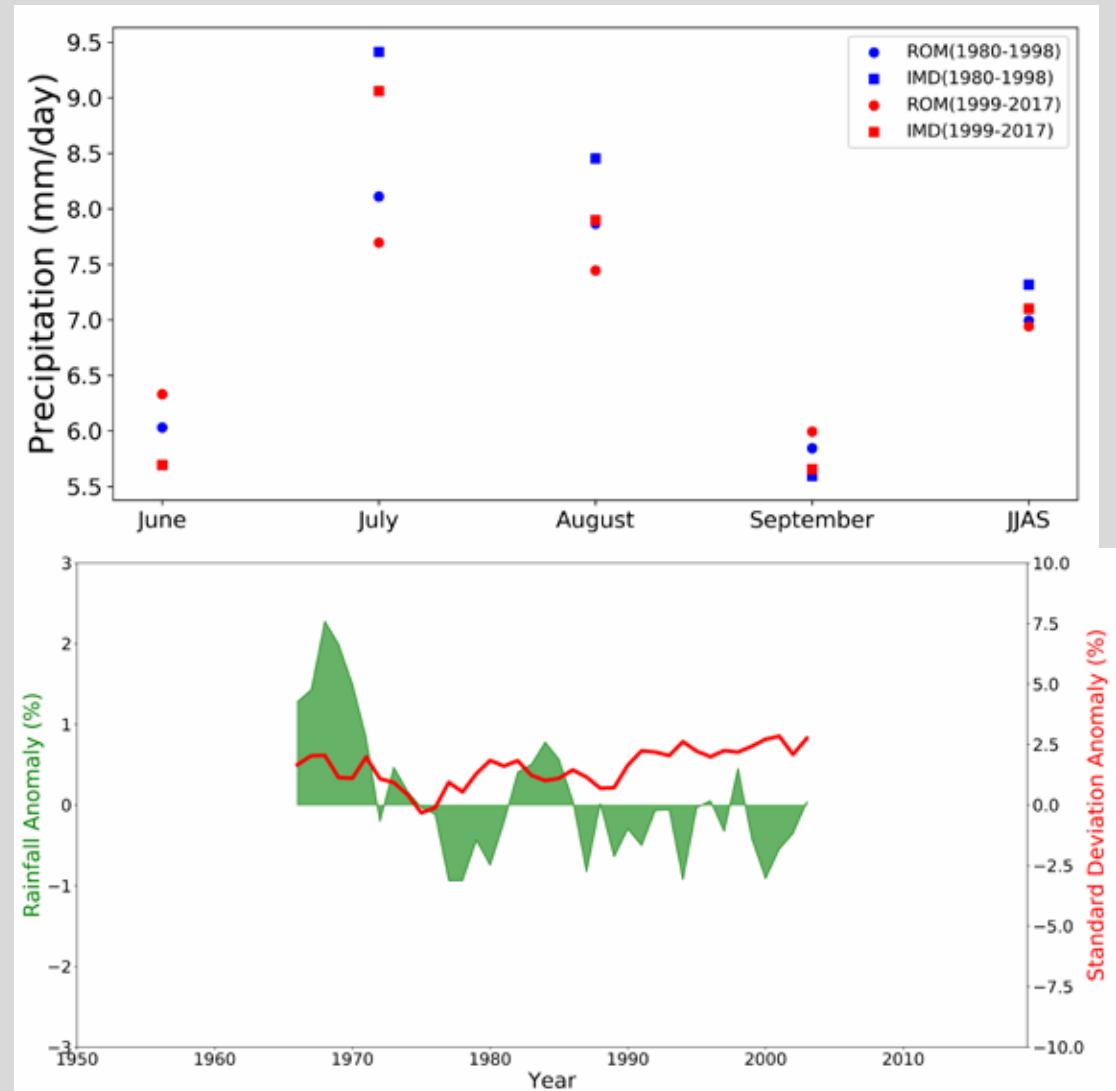


Meridional migrations of the zonally averaged ($70^{\circ}\text{E} - 90^{\circ}\text{E}$) precipitation maxima derived from the TRMM and ROM-I data. It is smoothed using a locally-weighted linear regression (LOESS) and the years indicate the centre of a 3-year moving average.

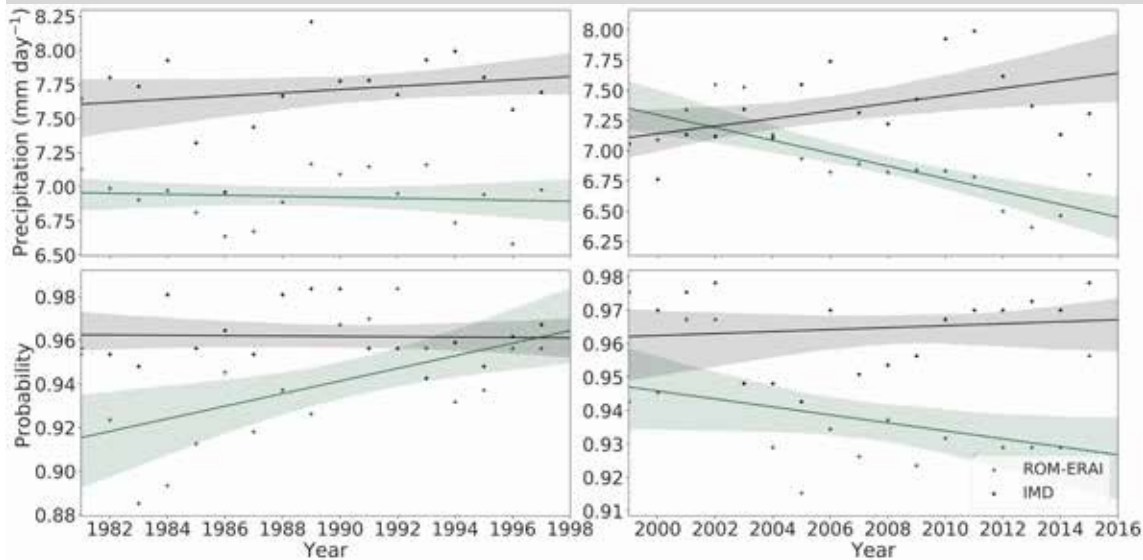
No Change in JJAS mean monthly precip over India: 1980-1998 (blue) vs 1999-2017 (red).
IMD ■ and ROM-i ●

*Frequencies of heavy rainfall events and their contribution to the total seasonal rainfall are investigated to elucidate the overall variability in the seasonal rainfall.

*Secondly, the goal of this talk is to introduce the global ocean-regional atmosphere coupling concept over CORDEX SA region.



Probability and magnitude of rainfall

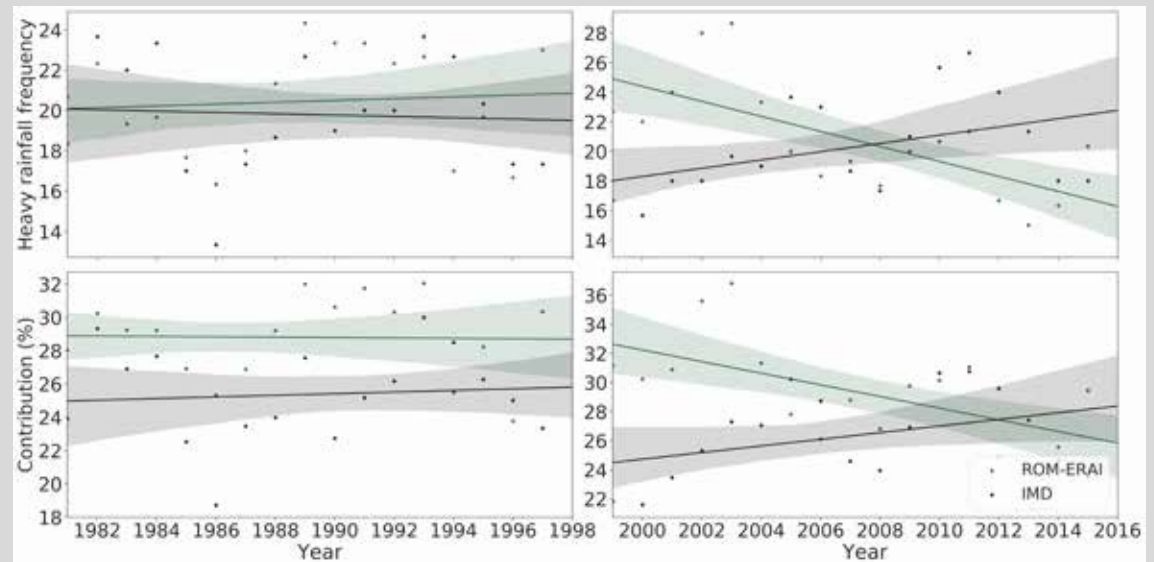


JJAS precipitation IMD (black) & ROM-i (green) and. Individual values are results of a 3-year moving average and are indicated by filled circles. Solid lines indicate the linear trend and the translucent bands indicate a 95% confidence interval.

The **probability** of rainfall events is defined as the fraction of days in concerned period having an amount of rainfall greater than 1 mm/day

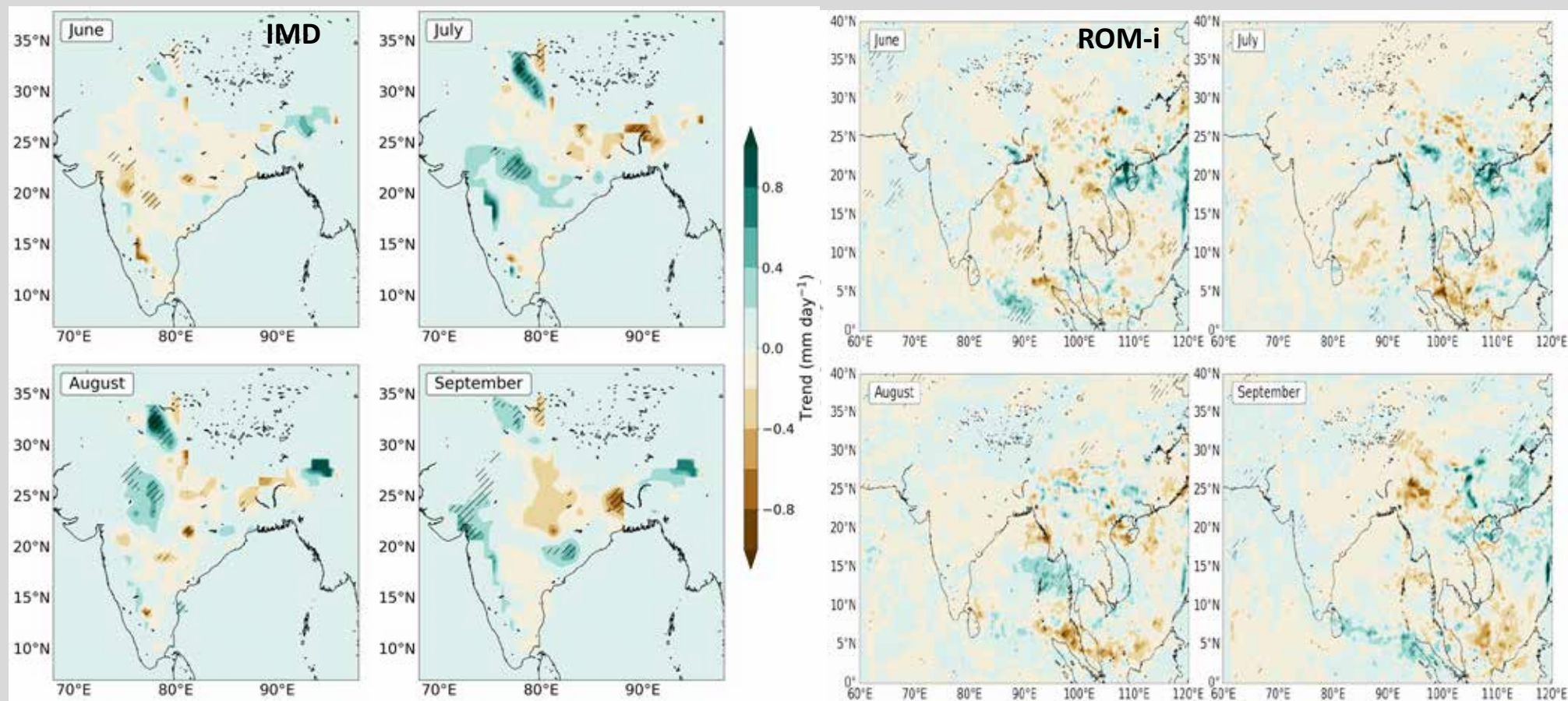
Yearly heavy rainfall frequency and its contribution in total precipitation per year.

Heavy rainfall frequency is defined as the days having precipitation greater than 1 of standardized anomaly.



Trends of rainfall in the summer months

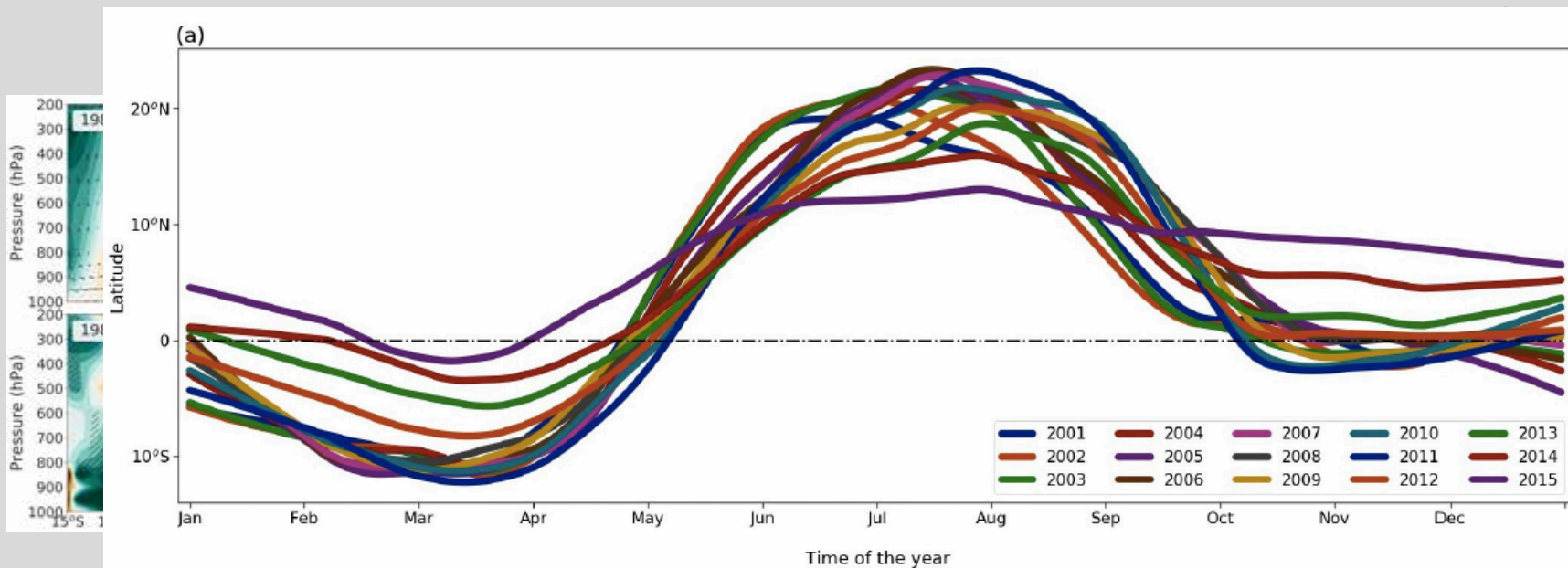
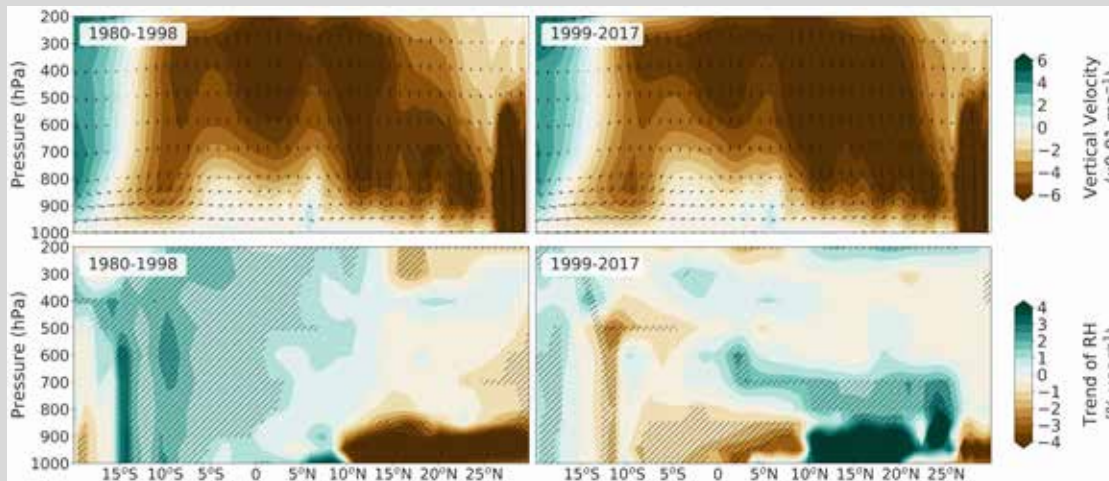
Hatches show 95% significance trend: recent decades western part and central India is receiving more especially August and September, 1998-2015.



Comment:

Land-warming and the changes in meridional circulation

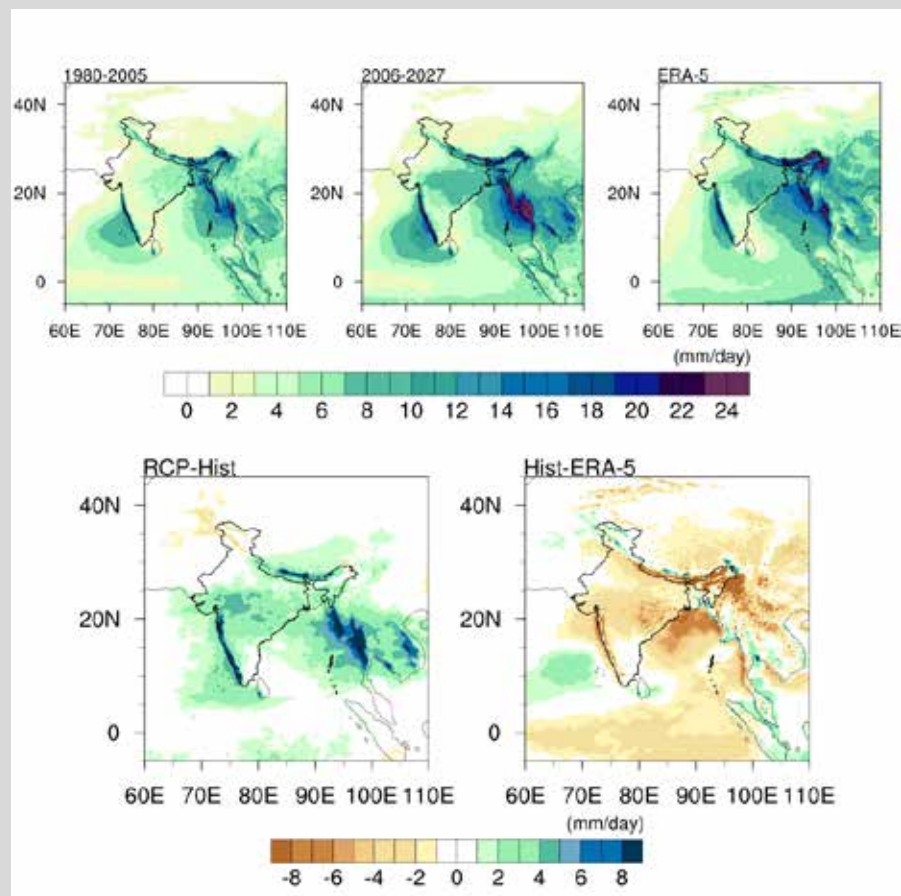
(top panel) Two periods of equal length (1985 – 2000 and 2000 – 2015) are considered to examine the differences imposed by the land-warming which is reported to be in effect from the beginning of the century. Hadley cell circulation time-means between 20°S and 30°N for the two periods are determined



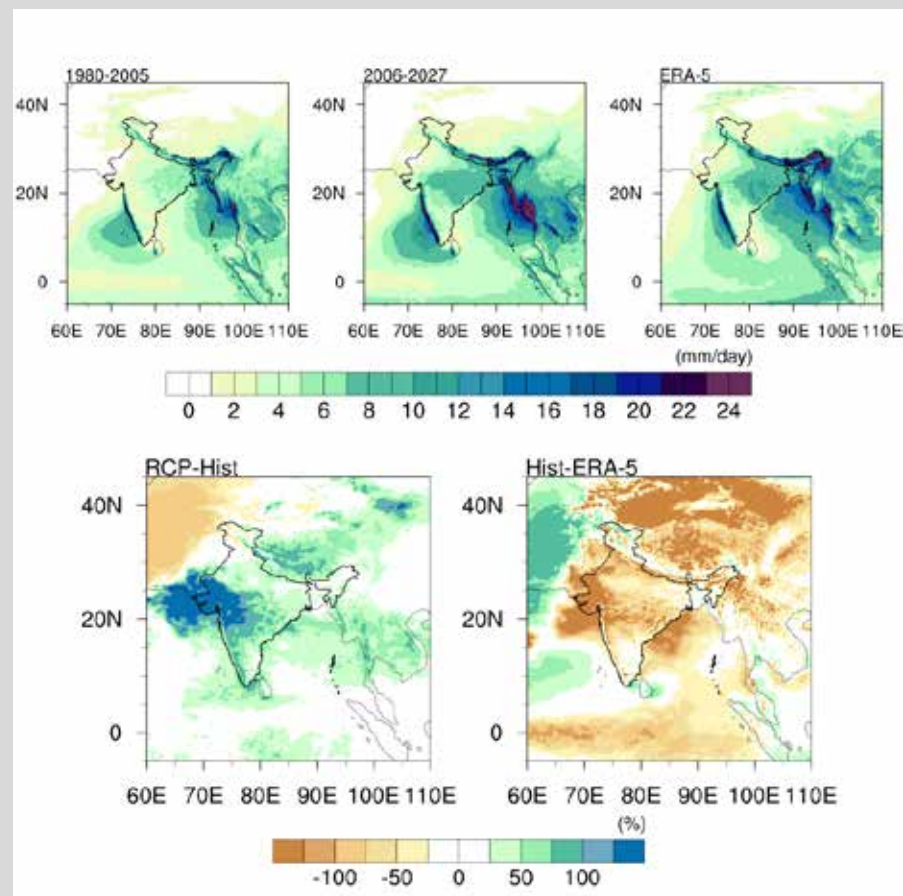
between 70°E
meridional

trends of
– 90°E)
the pre-
– June)
Hatches
statistical

ROM-hist: (forcing MPIESM-LR), 1980-2005

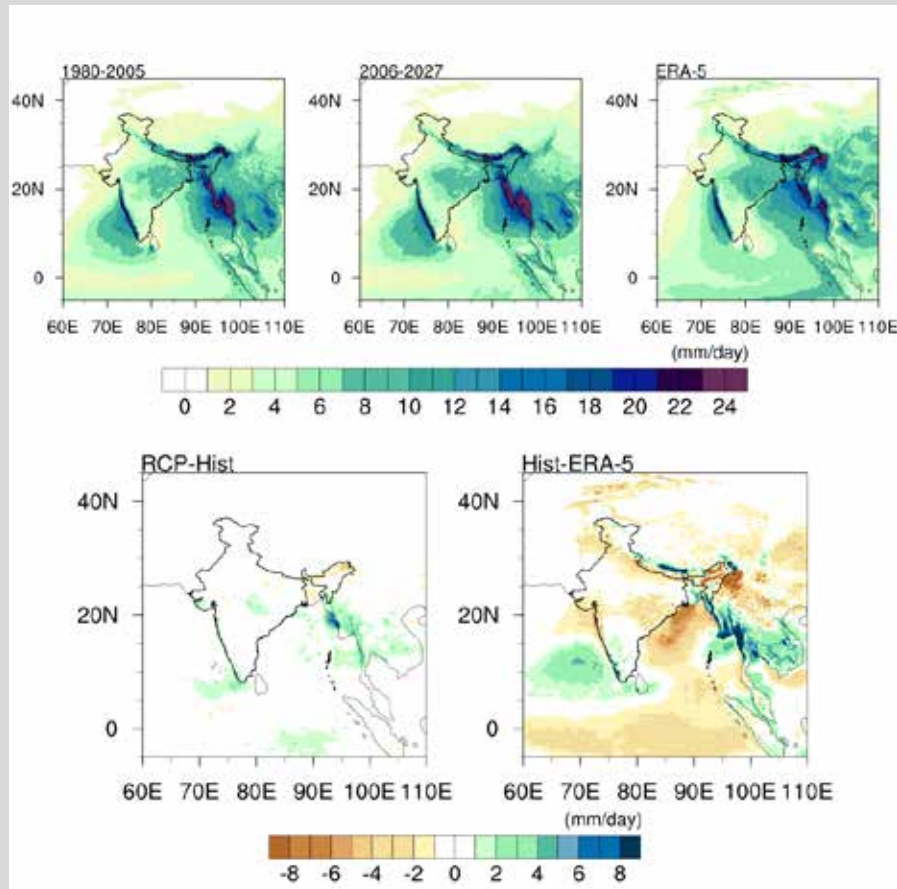


ROM-RCP8.5: (forcing MPIESM-LR), 2006-2027

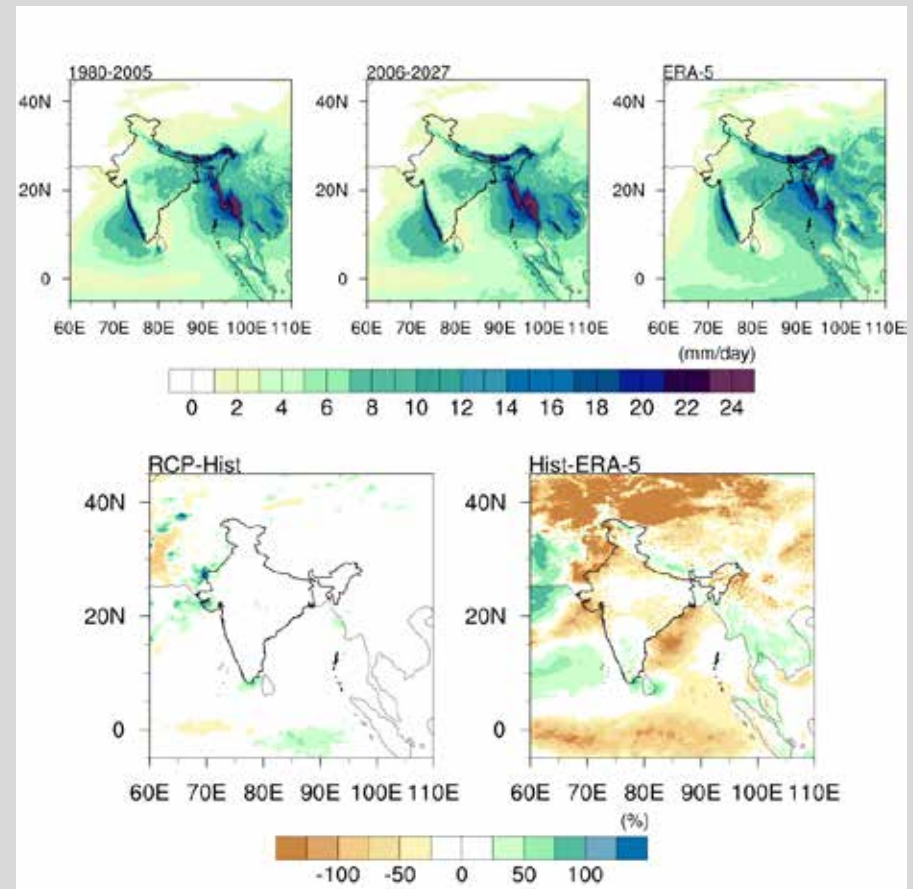


ROM-BGC_hist

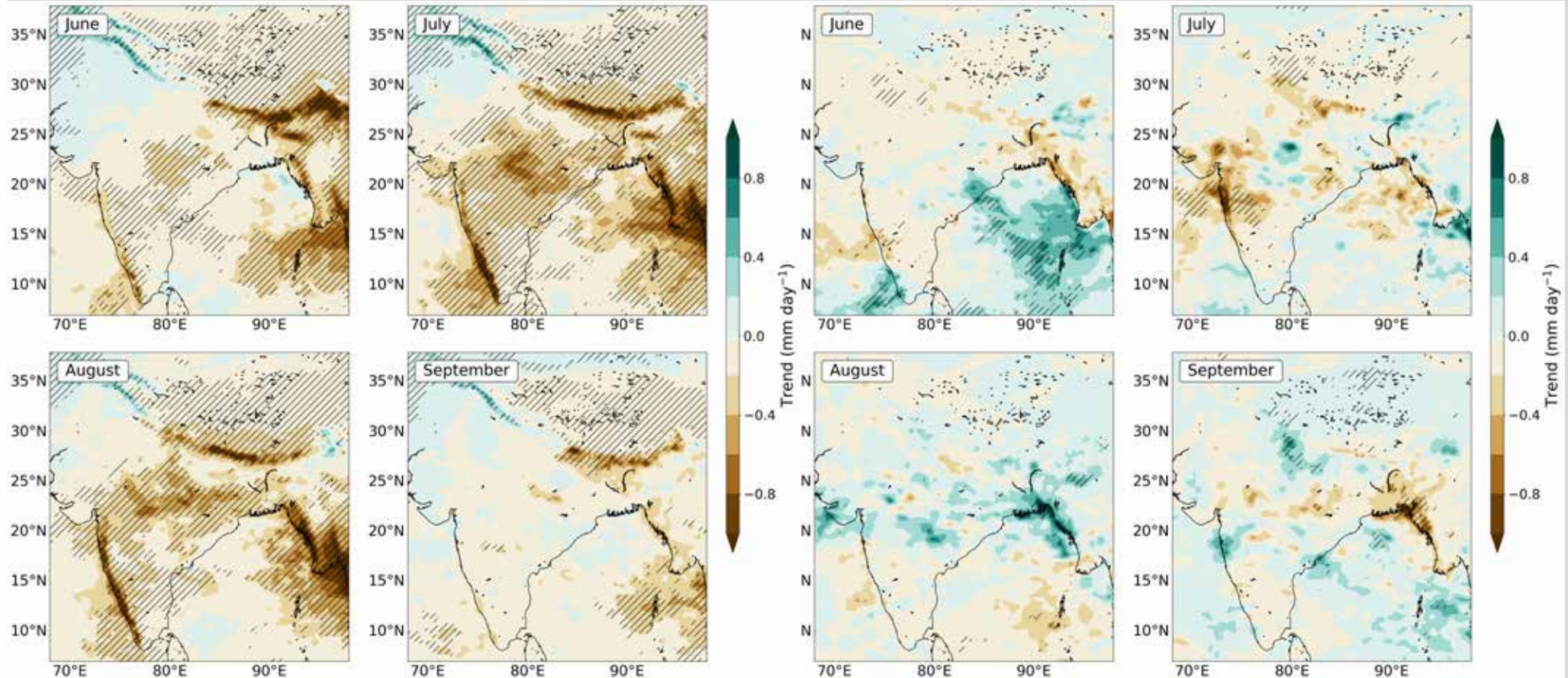
ROM-hist: (forcing MPIESM-LR), 1980-2005



ROM-RCP8.5: (forcing MPIESM-LR), 2006-2027



ROM-hist: JJAS monthly mean precipitation: recent decades
western part and central India is receiving more especially
August and September.



MPIESM-LR-hist: 1980-2005

RCP8.5: 2006-2027

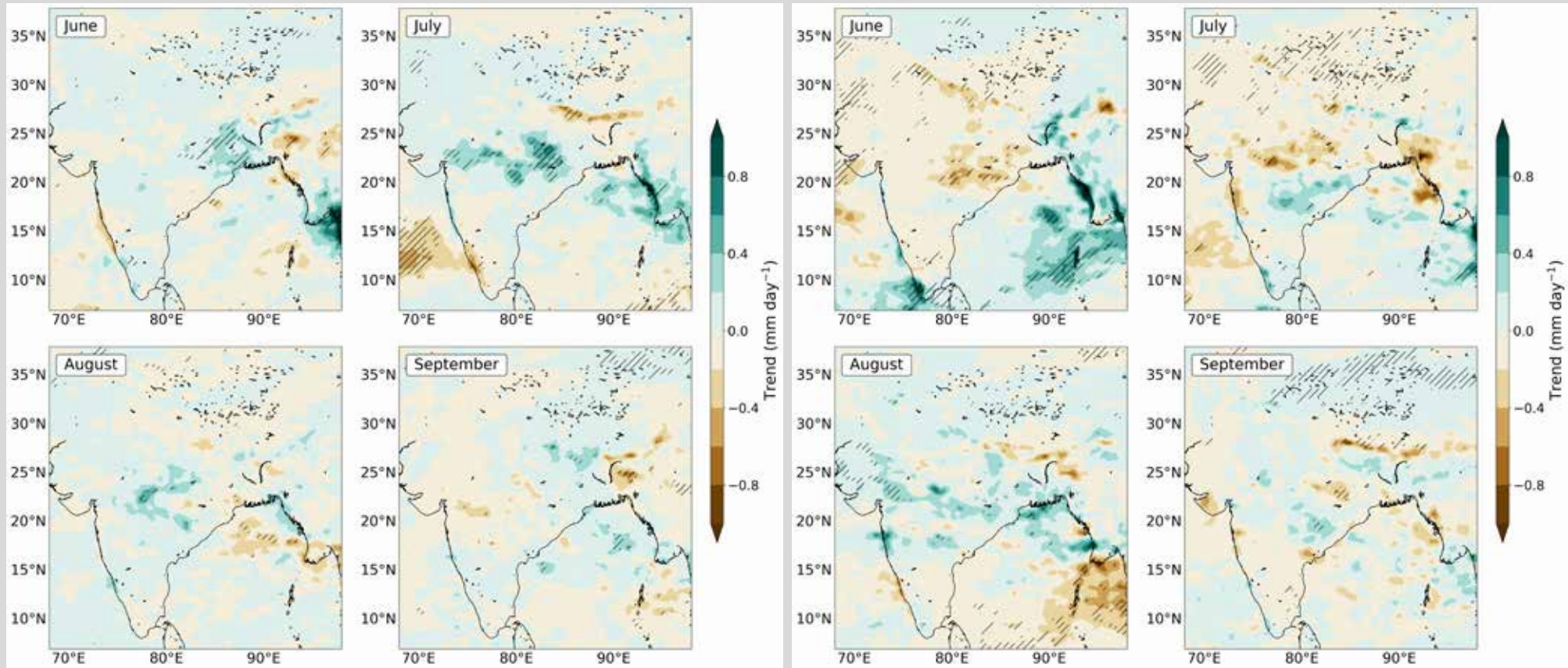


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ROM-BGC_hist: : JJAS monthly mean precipitation: recent decades western part and central India is receiving more especially August and September.



MPIESM-LR-hist: 1980-2005

RCP8.5: 2006-2027

Summary

- ISM rainfall is undergoing a period of 'enhancement' following a land-warming trend since the beginning of the twenty-first century.
- A reported increase in rainfall magnitudes is not homogeneous spatiotemporal increments.
- September rainfall contributes the most to an overall increasing trend in the ISM rainfall in recent years.
- SW and Peninsular regions of India act as the major contributors.
- Interestingly, the spatial variability of rainfall increases with an increase in rainfall magnitudes due to a rise in the heavy rainfall contribution to the seasonal sum.
- A land-warming induced enhancement in the moisture convection approximately between 10° N and 25° N creates an ascending limb of moist air that limits the Intertropical Convergence Zone from migrating further northwards.
- The result is an increase in rainfall over south India as well as the equatorial Indian ocean and adjacent continental regions.
- Regional coupled model is able to capture this signal largely.



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Thank You for your attention!



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