Representation of physical processes in IMDAA regional reanalysis during boreal summer monsoon

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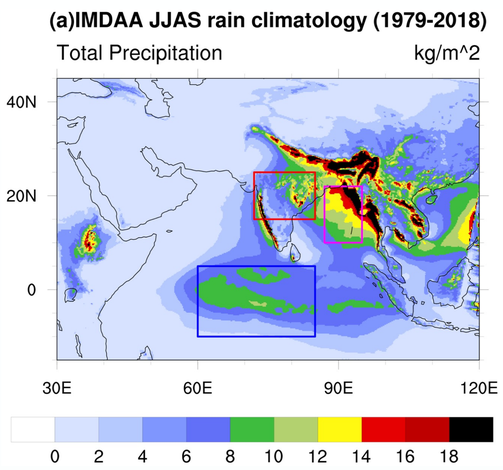
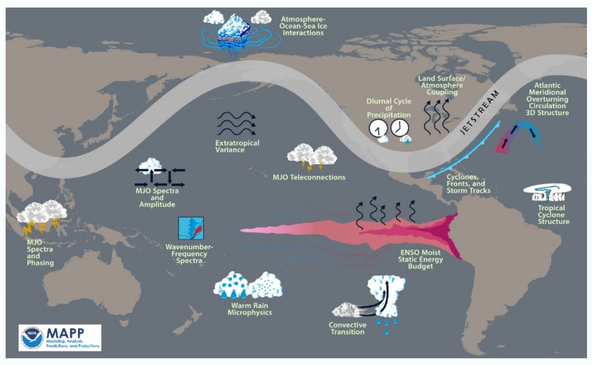
Background

- ✓ Indian monsoon, from June to September during boreal summer season, is considered as one of the largest monsoon systems in the world.
- ✓ Rainfall maxima (heat sources) present over several regions of South Asia (Bay of Bengal, Central India, Indian Ocean, tropical west pacific).
- ✓ Mutual interaction of these heat sources dictates monsoon variability at several time scale.
- ✓ Presence of large systematic errors in the simulation of basic state is one of the major drawbacks in monsoon modelling (Sperber et al 2013, Martin et al 2021)



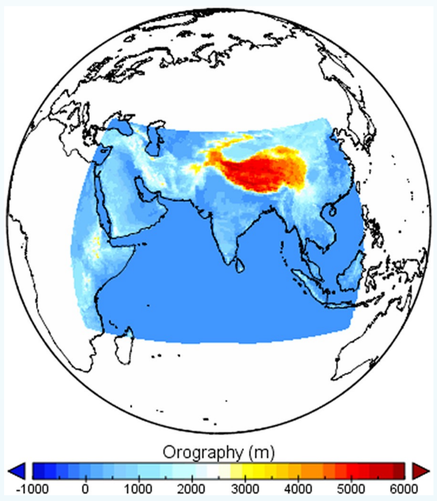
Motivation and scientific issue



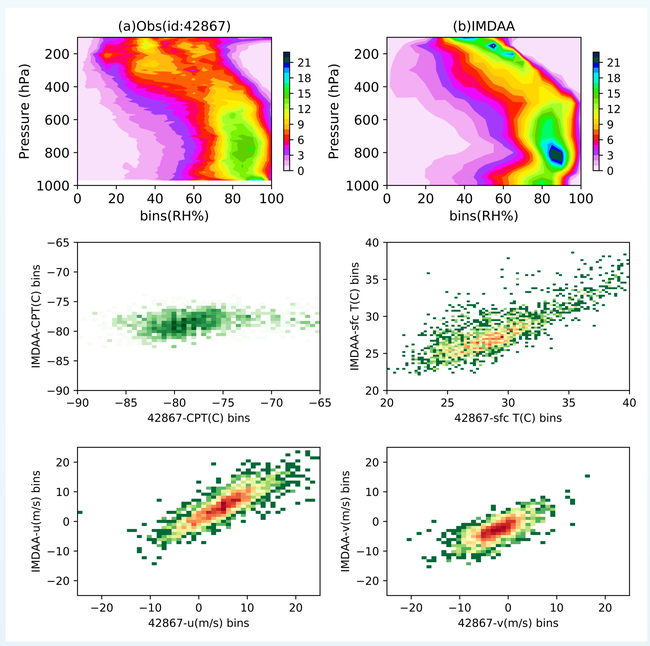
- Assess IMDAA's performance in representing key processes associated with boreal summer monsoon
- Applied process-oriented diagnostics that are designed to inform parameterization improvements to address long-standing model biases [Maloney et al. 2019]

Data and Methodology

- Long term IMDAA data (1981-2020) is used in the present analysis.
- IMDAA system based on 4-D Var assimilation scheme and UM model (Davis et al 2005; Brown et al 2012).
- It uses 6 hourly DA cycle with spatial resolution – 12 km and vertical levels-63
- Lateral boundary conditions are taken from ERA-Interim (Rani et al 2021; Ashrit et al 2020).
- Also used observed precipitation (TRMM, GPCP, IMERG) and ERA-5 reanalysis.



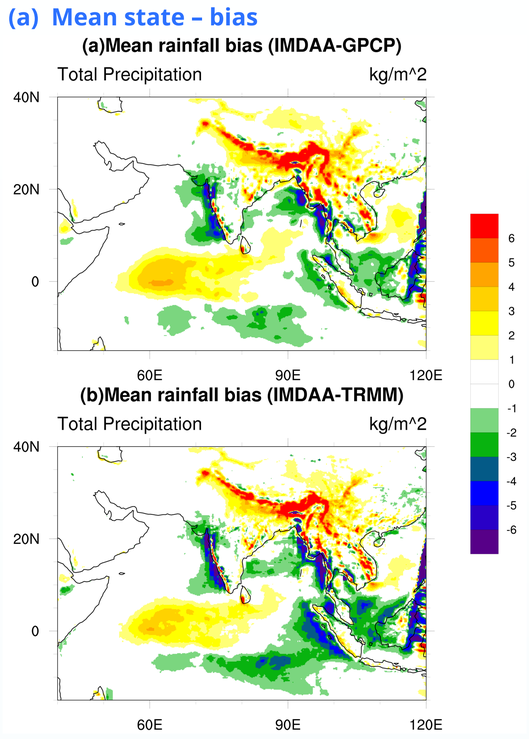
IMDAA vs Radiosonde



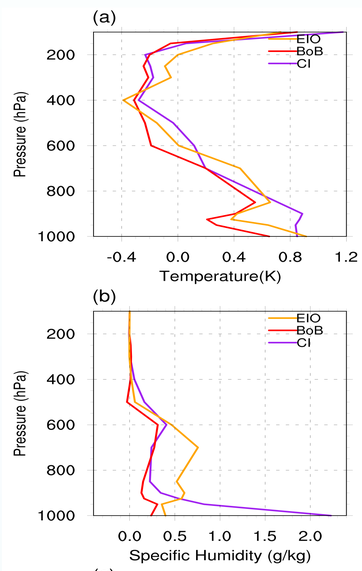
- CFAD's structure computed from IMDAA data vs radiosonde exhibits a good correspondence above boundary layer heights.
- Relatively large RH values are seen above 200hPa (miss representation of radiative processes)?
- A very good association in sonde derived winds and thermal parameters, an encouraging aspects in IMDAA.
- ***Sonde data source** : daily long-term (1981-2018) IGRAv2 over Nagpur 21.1N 79.05E)*

Results

(a) Mean state – bias



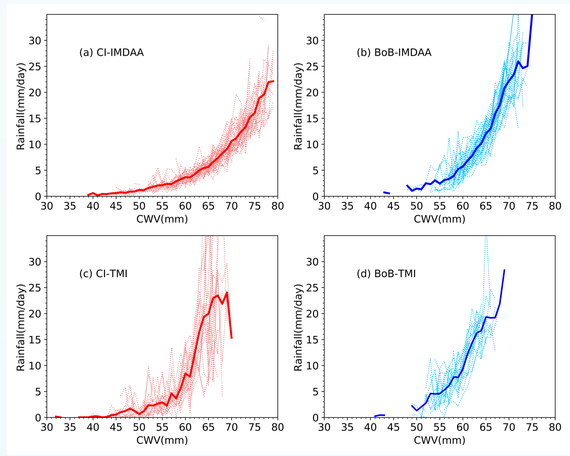
- Observed Wet bias over tropical western Equatorial Indian Ocean (EIO) as reported in earlier studies [Sperber et al 2013, Martin et al 2021].
- Does this excessive precipitation over EIO induces Local Hadley cell descent over CI! (Kelvin-Rossby wave activity?).
- Dry bias is seen over West, Arakkan coast (upwelling regions) and Bay of Bengal.
- The spatial structures seen in IMDAA are coherent [Annamalai et al. 2017, Zhao et al 2018].
- Despite of magnitude biases rainfall annual cycle was well represented in IMDAA.



(b) Vertical structure

- Relatively "warm (cold) below (above) 600 hPa level and large amounts of boundary layer moisture over **land (CI region).**
- over EIO 'q' is more at free troposphere levels which is sensitive to deep convection [Bretherton et al 2006; Halloway and Neelin 2009].
- Allt the three regions exhibit "top heavy" vertical velocity profile indicates combined latent heating effect of shallow and deep convection.
- Bias in large descent (ascent) in 'w' profile over CI (BoB). Need to study the mechanisms causing this *ascent and descent(local or remote responses?)*

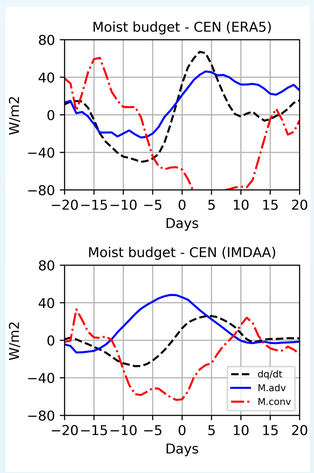
(c) Convection - transition statistics



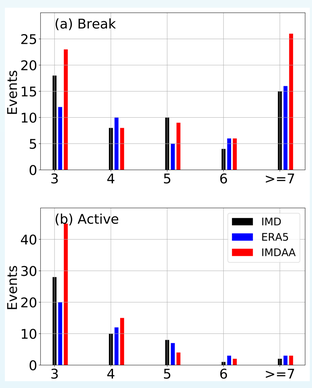
- Monotonous increase in rainfall – CWV bins (1mm) indicates the CWV vs precipitation relation is relatively good.
- "pick-up" in precipitation is slow over land steep over Ocean
- The discrepancies found in the relationship gives us hint in Short comings in microphysics!

Sub-seasonal variability and Moisture budget

- Extended rainfall events in IMDAA - double than the observed. Short active events are also large in number.
- Hyperbola structure - during break and Exponential decrease - Active (Prasanna and Annamalai 2012; Mohan and Annamalai 2018)



- Moisture budget is applied to the active/break events identified in IMDAA Over CI region.
- Among the major components Moisture convergence and precipitation alignment is better in IMDAA corroborating with the earlier reports (Prasanna Annamalai 2012; Mohan et al 2018).
- Dryness as seen in the moisture advection leads rainfall over CI by ~7-8days. However, the leading time is relatively large in ERA5 (~14 days).



Conclusion

- ✓ Presence of large systematic error in climate model's mean state during Asian summer monsoon is a long-standing problem and efforts are still ongoing to find out the physical processes responsible for these errors. With the aim of understanding and identifying these errors we have applied few process-oriented diagnostics onto the long term IMDAA reanalysis data generated at NCMRWF.
- ✓ A prominent wet (dry) biases are evident in IMDAA over oceanic and land regions. It is found that convection is more sensitive to surface instabilities in IMDAA and pick-up in precipitation is very slow over land indicating the shortcomings in microphysical processes in IMDAA. Leading moisture budget terms shows the association with ERA5.
- ✓ This study not highlights the importance of process-oriented diagnostics in checking the fidelity of the IMDAA but also indicates the merits-demerits for better understanding of monsoon processes.

Acknowledgements

This work is supported by National Centre for Medium Range Weather Forecasting (NCMRWF) Ministry of Earth Sciences(MoES), Govt. of India under the "UM Partnership" of Met Office-UK, BoM/CSIRO-Australia, KMA-South Korea, NIWA-New Zealand and MoES/NCMRWF-India