Systematic errors in monsoon simulation: a way forward

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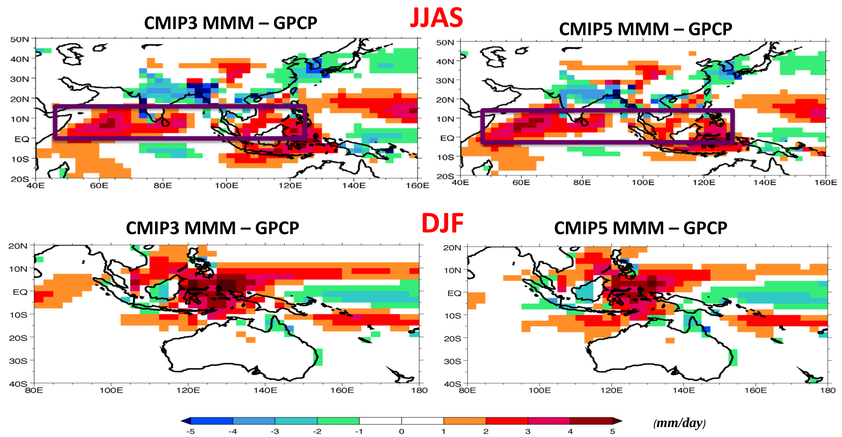
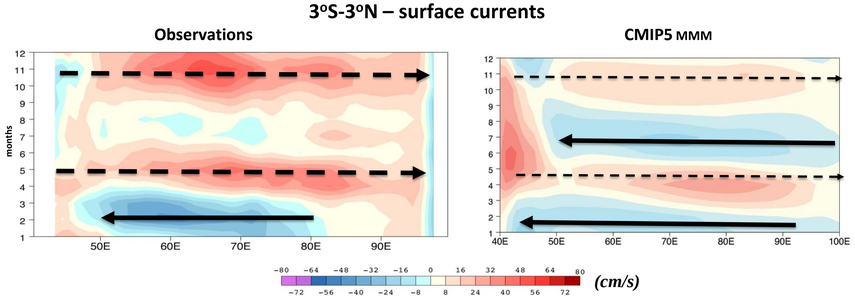


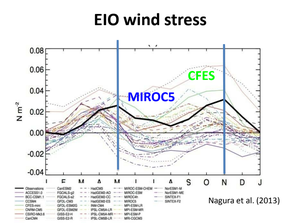
In climate models, simulating the monsoon precipitation climatology remains a grand challenge. Compared to CMIP3, the multi-model-mean (MMM) errors for Asian-Australian monsoon (AAM) precipitation climatology in CMIP5, relative to GPCP observations, have shown little improvement. One of the implications is that uncertainties in the future projections of time-mean changes to AAM rainfall may not have reduced from CMIP3 to CMIP5. Despite dedicated efforts by the modeling community, the progress in monsoon modeling is rather slow. This leads us to wonder: ***Has the scientific community reached a "plateau" in modeling mean monsoon precipitation?***

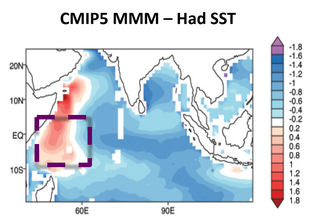
Way forward

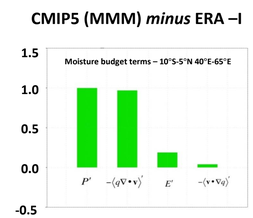
A systematic and well-coordinated approach in the identification and improved understanding of coupled air-sea interactions that govern the monsoon precipitation over the open oceans (where large-scale errors persist) are needed: On this front, we propose: (i) coupled model experiments; (ii) process-oriented diagnostics and (iii) direct observations.

3°S-3°N – surface currents









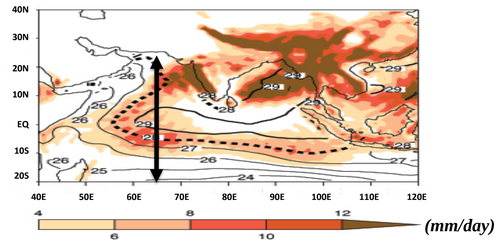
Hypothesis

Errors in representing the equatorial Indian Ocean (EIO) processes, particularly from processes that lead to weaker-than-normal, eastward, equatorial currents, the Wyrtki Jets (WJs) during inter-monsoon seasons could impact the monsoon simulation.

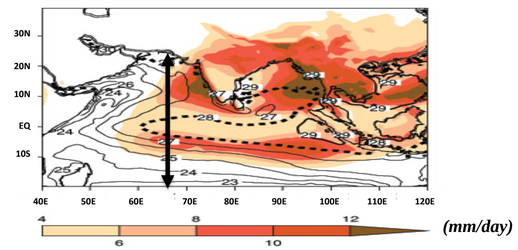
Coupled model (CFES) basic state

Precipitation errors noted in CMIP5 are hypothesized to arise from errors due to fast atmospheric processes, a view supported by simulations performed with atmosphere only models (e.g. Ma et al., 2014). To understand this monsoon precipitation and SST climatology in the AFES and CFES control simulations are shown. Note that in both runs, the atmospheric model component is the same except that AFES is forced with daily-varying, observed SST for the period 1979-2010. Similar to the CMIP5 models, the simulated precipitation in AFES is erroneous with higher precipitation (> 4-8 mm/day) over WCIO (~west of 65°E). In the CFES solutions, however, this erroneous feature is clearly rectified by the coupling, implying the need for realistic representation of EIO coupled processes.

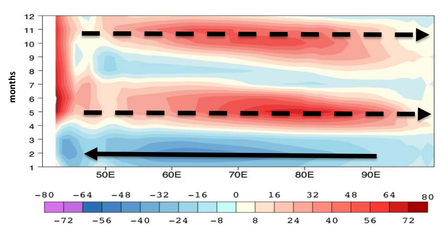
AFES – JJAS Precipitation / SST



CFES – JJAS Precipitation / SST

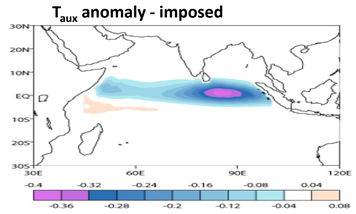


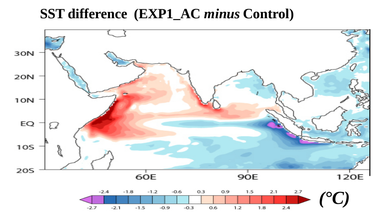
3°S-3°N – surface currents CFES



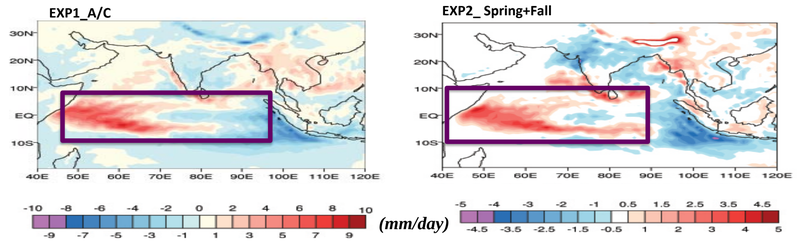
Coupled model sensitivity experiment

The fact that CFES realistically simulates the Asian monsoon and tropical Indian Ocean basic states makes it a useful "laboratory" for testing hypotheses. We carried out two experiments designed to isolate the impact of the WJs in monsoon dynamics and coupled processes along the EIO.



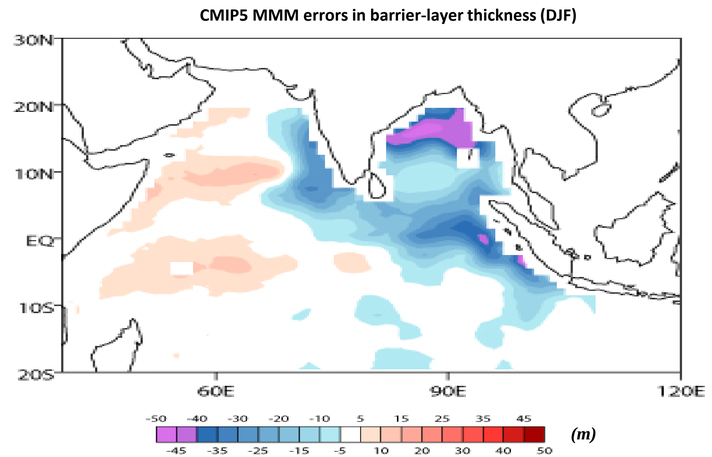


JJAS Rainfall difference (CFES sens expt *minus* ctl)



Our results demonstrate that the monsoon-Indian Ocean climate systems are tightly coupled in that misrepresentation of coupled processes in the EIO can have profound impact on monsoon simulations. However, systematic errors over the Bay of Bengal appear insensitive to EIO processes and may be related to errors in representing fresh-water forced salinity stratification, and its subsequent impact on local SST.

Outstanding Issue



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