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Monsoon precipitation biases in storm-resolving NextGEMS Earth System Models

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Global Earth System Models at storm-resolving resolutions (SR-ESM, with horizontal resolutions of ~4km) are being developed as part of the nextGEMS collaborative European EU's Horizon 2020 programme. Within the Storms & Ocean theme, we are exploring how resolving convective storms, ocean mesoscale eddies, and air-sea interaction on these scales influences tropical circulations and associated precipitation, and their variability.

In this talk, we evaluate the representation of the characteristics of the wet season over core monsoon regions in these SR-ESM, which include assessment of the seasonal cycle of precipitation, the timing of monsoon onset and retreat, and the total accumulated precipitation. These existing biases are compared to those seen in CMIP6 models and interpreted through the lens of both local and remote moist energy diagnostics based on modern theories of monsoons. Local diagnostics include relative moist static energy (MSE) defined as the difference between local and tropical-mean near surface MSE, which has been recently introduced as a simple measure of the lower and upper-level influences on convective stability and shown to correlate well with monsoon onset dates in both CMIP6 simulations (Bombardi and Boos 2021) and idealized aquaplanet simulations we have conducted. The influence of possible remote biases, such as those of extratropical origin, are explored through analysis of the equator-to-pole MSE gradient. This contrast is central to vertically integrated energy budget frameworks that link changes in monsoonal precipitation to changes in meridional energy fluxes, which in turn scale with the meridional near-surface MSE gradients under diffusive approximations. Biases in this gradient result in smaller or greater advection of low-level MSE into monsoon regions, hence resulting in wet or dry biases, respectively, in monsoonal rainfall.