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Role of land-atmospheric processes in CFSv2 monsoon rainfall dry bias over India

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Dynamical model simulations of the Indian monsoon are challenging due to the limitations in understanding and model representation of land-atmosphere-ocean interactions that modulate the monsoon and its variability. Coupled Global Climate Models (GCMs) exhibit biases in the mean monsoon rainfall and are also unable to capture the observed historical trend of monsoon rainfall over the Indian landmass. The operational dynamical model for seasonal prediction of Indian Summer Monsoon, the Climate Forecast System version 2 (CFSv2), exhibits a dry bias over Central India, prominently over the Ganga basin. This bias in monsoon rainfall restricts the use of model output in hydrological simulations and forecasts. The dry bias over Central India seen in CFSv2 simulations is not unique and is reported in many Coupled Model Intercomparison Project Phase 5 (CMIP5) GCMs as well. Literature indicates that errors in SSTs alone cannot account for the model biases and points to missing process representations associated with aerosols or land surface process as likely culprits. In this study we explore the role of land surface processes in the dry bias of CFSv2 simulated monsoon rainfall over the Ganga Basin.

We perform coupled and uncoupled land-atmosphere regional simulations using the Weather Research and Forecasting Model (WRF) to dynamically downscale CFSv2 free run outputs over the Indian monsoon region. The coupled land-atmosphere regional simulations show substantial reduction in the CFSv2 dry rainfall bias over the Ganga basin. To understand the reasons behind the reduction of rainfall bias we perform a source-sink analysis of the atmospheric moisture in the model simulations using the Dynamical Recycling Model. The analysis reveals that the coupled regional model is able to capture (a) the moisture contribution from Western Indian Ocean and (b) local moisture recycling, over the Ganga basin better. We find that the representation of land and near surface processes are important for monsoon simulations through its effect on both the recycled precipitation and the regional circulation that transports moisture from remote sources over the Indian landmass. Our findings are consistent across two land surface models coupled with WRF. These results have important implications in the operational hydro-climatic prediction system in India.