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South Asia: a case for high-resolution climate modeling frameworks

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This study focuses on the need of high-resolution modeling frameworks in the simulation of the processes that govern South Asian summer monsoon dynamics. A recent GCM based study suggests that orographic insulation provided by the Himalayas and adjacent mountains predominantly controls South Asian monsoon, debating the previously recognized role of the Tibetan plateau as a dominant thermal forcing. However, at a typical GCM resolution, neither the Himalayas and the Plateau are distinguishable nor the topographic gradient is correctly represented. Therefore, it is imperative to test the reproducibility of these results with the high-resolution modeling frameworks. Using the Weather Research and Forecasting Model (WRF), we revisit the role of Plateau heating versus the role of orographic insulation. We perform ultra high-resolution South Asian summer monsoon simulations with and without modifications in the topography. In order for the orographic insulation to be the dominant factor in South Asian summer monsoon development; we expect to find comparable results with and without the availability of Plateau heating. However, our results indicate that absence of Plateau strongly modulates the thermodynamic structure in the upper-troposphere, which substantially reduces the strength of Tibetan High and meridional tropospheric temperature gradient. These changes inhibit northward progress of summer monsoon through weakening of vertical easterly shear and reduction of moist southwesterly flow over South Asian landmass. Our results suggest that orographic insulation provided by Himalayas is incapable of producing a normal monsoon at its own and depends on the moisture transport through the strong meridional temperature gradient that is critically controlled by the presence of Tibetan Plateau as a heat pump. Further, we show that majority of the CMIP5 GCMs are not able to simulate the strength of meridional tropospheric temperature gradient, leading to little to no skill in the simulation of monsoon onset, annual monsoon cycle and intra-seasonal monsoon varability. These results highlight the need for high-resolution modeling frameworks and skill-based selection of GCMs for dynamic downscaling over South Asia.