Title:	Enhanced Simulation of the Indian Summer Monsoon Rainfall Using Regional Climate Modeling and Continuous Data Assimilation
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Abstract:	This study assesses a Continuous Data Assimilation (CDA) dynamical-downscaling algorithm for enhancing the simulation of the Indian summer monsoon (ISM) system. CDA is a mathematically rigorous technique that has been recently introduced to constrain the large-scale features of high-resolution atmospheric models with coarse spatial scale data. It is similar to spectral nudging but does not require any spectral decomposition for scales separation. This is expected to be particularly relevant for ISM, which involves various interactions between large-scale circulations and regional physical processes. Along with a control simulation, several downscaling simulations were conducted with the Weather Research and Forecasting (WRF) model configured over the Indian monsoon region at 10 km horizontal resolution using CDA, spectral (retaining different wavenumbers) and grid nudging for three contrasting ISM rainfall seasons: normal (2016), excess (2013), and drought (2009). The simulations are nested within the global NCEP Final Analysis data available at 1 × 1° horizontal resolution. The model outputs are evaluated against the India Meteorological Department (IMD) gridded precipitation and the fifth generation ECMWF atmospheric reanalysis (ERA-5). Compared to grid and spectral nudging, the simulations using CDA produce enhanced ISM features over the Indian subcontinent including the low-level jet, tropical easterly jet, easterly wind shear, and rainfall distributions for all investigated ISM seasons. The major ISM processes, in particular the monsoon inversion over the Arabian Sea, tropospheric temperature gradients and moist static energy over central India, and zonal wind shear over the monsoon region, are all better simulated with CDA. Spectral nudging outputs are found to be sensitive to the choice of the wavenumber, requiring careful tuning to provide robust simulations of the ISM system. In contrast, control and grid nudging generally fail to well-reproduce some of the main ISM features.
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