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WRF model performance and sensitivity to model physics in a medium- and high-resolution downscaling experiment for West Africa

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In order to develop and improve a Regional Climate Model (RCM) system for the West African region, we aim for an optimization of the Weather Research and Forecasting (WRF) model driven by ERA-Interim (ERA-I). The model provides numerous tuning options and physical parameterizations. It is well known that different model configurations and spatial resolutions have a strong impact on the simulation results. So far, there is a lack of studies addressing these questions in detail for the WRF model in this region. Therefore, an important first step is to test the model's performance and sensitivity for various model physics and for different spatial resolutions.
The rainy seasons of 1999 (wet) and 2002 (dry) are simulated at a medium resolution of 24 km over a domain enclosing the West African Monsoon (WAM) system. Different combinations of model physics (cumulus, microphysics and planetary boundary layer parameterizations) are tested. Simulation results are compared to observational data (Tropical Rainfall Measuring Mission (TRMM), Climatic Research Unit (CRU), Global Precipitation Climatology Centre (GPCC) and station data of national meteorological services) and analyzed in terms of parameterization-specific differences and their causes. Our results show that the choice of model physics significantly influences the dynamics and hence the representation of the WAM transition. With respect to TRMM, the average precipitation bias in 1999 ranges from -3.3 to 1.4 mm/day at the Guinean Coast and from -1.8 to 2.7 mm/day in the Sahel. The latitudinal position of the African Easterly Jet during the WAM strongly depends on the strength of simulated monsoonal westerly winds. For August 1999, the average position of the southern edge of its core ranges from 9.5°N to 14°N between the various simulations, introducing a marked dry or wet regime in the Sahel, respectively, emphasizing the sensitivity of the model results on the physics choice. In comparison to ERA-I, the downscaling improved the representation of strong precipitation events and reduced the bias in the Volta basin region from -1.1 to -0.1 mm/day. A group of well-performing configurations is identified for further analysis in high-resolution simulations at 4 km. It is shown, that regional modeling at convection resolving scales can greatly improve the representation of mesoscale convective systems, which is of major importance for capturing precipitation extremes in this region.