EGU2020-1376
https://doi.org/10.5194/egusphere-egu2020-1376
EGU General Assembly 2020

Sensitivity of high-resolution precipitation to physics parameterization options in WRF over equatorial regions

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Precipitation patterns and climate variability in East Africa and Western South America present high heterogeneity and complexity. This complexity is a result of large-scale and regional controls, such as surrounding oceans, lakes and topography. The combined effect of these controls has implications on precipitation and temperature, and hence, on water availability, biodiversity and ecosystem services. This study focuses on the impact of different physics parameterization in high-resolution experiments performed over equatorial regions with the Weather Research and Forecasting (WRF) model, and how these options affect the representation of precipitation in those regions.

As expected, weather and climate in equatorial regions are driven by physical processes different to those important in the mid-latitudes. Hence, it is necessary to test the parameterizations available in the WRF model. Several sensitivity simulations are performed over Kenya and Peru nesting the WRF model inside the state-of-the-art ERA5 reanalysis. A cascade of increasing grid resolutions is used in these simulations, reaching the spatial resolutions of 3 and 1 km in the innermost domains, and thus, convection permitting scales. Parameterization options of the planetary boundary layer (PBL), lake model, radiation, cumulus and microphysics schemes are changed, and their sensitivity to precipitation is tested. The year 2008 is simulated for each of the sensitivity simulations. This year is chosen as a good representative of precipitation dynamics and temperature, as it is neither abnormally wet or hot, nor dry or cold over Kenya and Peru. The simulated precipitation driven by the ERA5 reanalysis is compared against station data obtained from the WMO, and over Kenya additionally against observations from the Centre for Training and Integrated Research in ASAL Development (CETRAD).

Precipitation is strongly underestimated when adopting a typical parameterization setup for the mid-latitudes. However, results indicate that precipitation amounts and also patterns are substantially improved when changing the cumulus and PBL parameterisations. This strong increase in the simulated precipitation is obtained when using the Grell-Freitas ensemble, RRTM and the Yonsei University schemes for cumulus, long-wave radiation and planetary boundary layer, respectively. During some summer months, the accumulated precipitation is improved by up to 100 mm (80 %) compared to mid-latitudes configuration in several regions of the domains

(near the Andes in Peru and over the flatlands in Kenya). Additionally, because the 1- and 2-way nesting options show a similar performance with respect to precipitation, the 1-way nesting option is preferred, as it does not overwrite the solutions in the parent domains. Hence, discontinuous solutions related to switching off the cumulus parameterization can be avoided.