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High-resolution atmospheric modeling over complex terrain: the effects of spatial resolution and land use in WRF in the Nepalese Himalaya

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Currently available gridded datasets strongly underestimate precipitation over the Himalaya, due to their relatively low spatial resolution (25-75 km2) and thus poor representation of the complex topography in this region. Dynamical downscaling of these products can improve the accuracy and quality of available climate data for the Himalaya. In theory, simulations at higher spatial resolution resolve the climatological features better than coarser simulations; however, in reality the benefits of increasing the spatial resolution are not endless, as specific parameterizations may not be suitable for high resolution.

In this study, the WRF (Weather Research and Forecasting) model is used to determine the optimal spatial resolution for modeling of the Langtang catchment, located in the Nepalese Himalaya. Previous work for this catchment has shown that near-kilometer resolution is required to capture meteorological variability, however here we evaluate the role of sub-kilometer grid scale modelling. For this assessment, WRF is set up for two time periods; one typical summer monsoon period (17th to 27th of July 2014) and one winter event (10th to 20th of February 2014). Four grid spacings are tested in WRF-LES mode: 500, 300, 200 and 100 meters. As a basis, three nests are set up with a resolution of 25, 5 and 1 km, wherein the higher spatial resolutions (500-100 meters) are nested separately in the 1-km domain with the nest-down approach in WRF. This method ensures that the forcing for each domain is consistent. The results of these simulations are compared to observational data obtained from automatic weather stations, pluviometers and tipping buckets located in the Langtang catchment. The optimal resolution is determined as a compromise between the agreement with observations, computational time and the resolution of the input product data sets (e.g. topographic and land use).

Secondly, the effects of using a more accurate land use dataset on atmospheric key variables are investigated. The default land use data set in WRF (USGS) greatly underestimates the extent of glaciers and forested area in the Langtang catchment. Therefore, a new land use classification is made with the use of satellite imagery and based on the FAO (Food and Agriculture Organization of the United Nations) classification. Results show that the new land use classification has large effects on the distribution and magnitude of precipitation amounts in the catchment, likely due to processes acting on a local scale, such as changes in evapotranspiration and surface roughness.