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Intercomparison of four cloud microphysics schemes in the Weather Research and Forecasting (WRF) model for the simulation of summer monsoon precipitation in the Langtang Valley, Himalayas

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Better understanding of regional-scale precipitation patterns in the Himalayan region, and how these are affecting snow and ice, is critically required to increase our knowledge of the impacts of climate change on glaciers and snowpacks. This study examines how 4 different cloud microphysical schemes (Thompson, Morrison, WRF Single-Moment 5-class (WSM5; which is the WRF default scheme), and WRF Double-Moment 6-class (WDM6)) simulated precipitation in the Langtang Valley, Himalayas during the summer monsoon in the Weather Research and Forecasting (WRF) model. The precipitation is simulated for a ten-day period during July 2012 at high spatial-resolution (1.1 km) so as to simulate the local conditions in great detail. The model results are validated through a comparison with precipitation and radiation measurements made at two observation sites located on the main Langtang Valley floor and the mountain slopes. Analysis of water vapour and hydrometeors from each of the 4 schemes are also investigated to elucidate the main microphysics processes. The results show that the choice of microphysics scheme has a strong influence on precipitation in the Langtang Valley, with the simulated precipitation exhibiting large inter-model differences and significantly different day-to-day variability compared to measurements. The inter-model differences in simulated radiation were less marked, although under cloudy conditions all schemes demonstrated a significant positive bias in incoming radiation. However, overall the Morrison scheme showed the best agreement in terms of both precipitation and radiation over the ten-day period, while the poorest performing scheme is WDM6. Analysis of microphysics outputs suggested that 'cold-rain processes' is a key precipitation formation mechanism. The good performance of the Morrison scheme is consistent with its double-moment prediction of every ice-phase hydrometeor, which is ideally suited to represent this mechanism. By contrast, WDM6 is most likely the poorest performing scheme due to its double moment prediction of 'warm-rain process' which did not occur, as well as excessive evaporation near the ground. A recommendation of this study is therefore that improved modelling of ice-phase process is a critical criterion for a realistic representation of clouds and precipitation in the Langtang Valley region, and by extension throughout the wider Himalayan region.