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High-resolution simulations of orographic precipitation – sensitivity tests

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The sensitivity of numerically simulated precipitation across a mesoscale mountain range to horizontal resolution, cloud condensation nuclei (CCN) spectrum, initiation of cloud ice, numerical treatment of horizontal diffusion and initial and boundary conditions is investigated. The fifth generation Penn State/National Center for Atmospheric Research (PSU/NCAR) Mesoscale Model (MM5) is used in the study, in which the model is run at 8, 4 and 2 km horizontal resolutions and with a number of microphysical and numerical configurations. The model simulated precipitation is compared to the observed precipitation over the Reykjanes mountain ridge during the Reykjanes Experiment in Southwest Iceland in the autumn of 2002.

Improvements in representation in topography at increasing horizontal resolutions yield large improvements in the accuracy of the simulated precipitation. At 8 km horizontal resolution the simulated maximum precipitation is too low, but the simulated precipitation upstream of the mountains is too high. The absolute values and the pattern of the precipitation field improve stepwise when going from horizontal resolutions of 8 km to 2 km, with the main contribution being when going from 8 km to 4 km. Calculations of diffusion and ice initiation do not seem to have a large impact on the simulated precipitation, but it is on the other hand quite sensitive to the CCN spectrum. The simulations underestimate the precipitation over the downstream slopes of the mountain ridge by factors of 23. There are indications that this underestimation may be associated with a systematic overestimation of downslope winds, and possibly descending motion, by the model.