Report on Case 1: Orographic mixed-phase stratiform cloud

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The key issues of this case study center around the initiation of ice by heterogeneous ice nucleation and on the liquid to ice mass partitioning in orographic clouds. Since aerosols are important for cloud droplet nucleation and heterogeneous ice nucleation a further objective is to investigate the sensitivities of orographic precipitation to changing aerosol conditions. In particular, the effect of aerosols on the orographic precipitation distribution, the total orographic precipitation budget, the orographic spillover factor and the drying ratio. In view of observational studies the effect of aerosols on different microphysical processes (e.g., autoconversion, accretion, riming) is analyzed.

This case study is composed of two parts. Part 1 is an orographic cloud and precipitation system simulated using stable upslope flow impinging on an idealized bell-shaped mountain. Sensitivity is easily tested by varying the initial thermodynamic conditions and mountain height to produce either a blocked flow or a hydrostatic wave. Microphysical sensitivities are tested by varying aerosol number concentrations and aerosol constituents. Part 2 of this case is a 2D simulation of an observed orographic precipitation event in the Swiss Alps on 08 March 2004. Initial aerosol values are provided based on actual field campaign observations. Other observations include precipitation, radar reflectivity, cloud droplet/ice crystal number concentrations and liquid/ice water content for evaluation of simulation results.

In total 15 participants attended the break-out sessions with some of them presenting model simulations. The contributing numerical models included state-of-the-art weather prediction models and various research models from different institutions (e.g., COSMO, Meso-NH, WRF, Clark, UWMNS). The microphysical parametrizations of the participating models varied in their degree of complexity and ranged from single-moment or double-moment bulk-microphysical schemes to bin-microphysics and ice habit prediction.

All models developed orographic clouds in the simulations. However, the liquid to ice partitioning varied among the models which translated into different orographic precipitation distributions and total precipitation. The reasons for differences in the model need

further investigation but may to some extent be tied to the parametrization of riming and the treatment of snow and graupel in the models. Results on the sensitivity of orographic precipitation with respect to varying aerosol number concentrations varied quantitatively between the models but all simulated a tendency to decrease precipitation with increasing cloud condensation nuclei (CCN). Furthermore, all modeling approaches showed sensitivities of the CCN effect on orographic precipitation with respect to the dynamical flow regime and temperature.