The north-Alpine flooding events of May 1999 and August 2005: Microphysical and multi-scale dynamical aspects of orographic precipitation enhancement

G. Zaengl

Meteorological Institute, University of Munich (guenther@meteo.physik.uni-muenchen.de)

Interactions of atmospheric dynamics and cloud microphysics with the Alpine orography are investigated for two north-Alpine flood cases (20–22 May 1999 and 22–23 August 2005) with the aid of high-resolution MM5 simulations. Both cases were related to a deep cyclone propagating slowly eastward along the Alps, advecting moist air of Mediterranean origin towards the northern side of the Alps. Sensitivity experiments with flattened Alpine orography indicate that the heavy precipitation encountered in the Alps was primarily related to orographic lifting, and that the orographically induced precipitation enhancement extends at least 100 km into the northern foreland. In addition, the east-west extent of the precipitation field is enlarged by the presence of the Alps, even in the foreland where no direct orographic influence is present. This is related to the upstream influence of the Alps, leading to blocking and deflection around the Alps of the low-level airflow. Since the airflow approaching the Alps from the north is lifted over the blocked low-level air, precipitation enhancement already starts farther in the north. Moreover, the precipitation field is found to be shifted eastward due to the Alpine influence. On the scale of single Alpine mountain ridges, the formation of a marked local precipitation maximum (more than 300 mm of storm-total precipitation) at a valley location is investigated. It is found that the downstream advection of precipitation hydrometeors generated in an orographic feeder cloud is essential for the development of the valley maximum. Strong ambient winds and, due to the fall-speed difference between snow/graupel and rain, a low freezing level favor a large distance of the precipitation maximum from the upstream mountain ridge. In addition, the processes leading to a negative height gradient of precipitation (systematically more rainfall along the valley bottom than over the adjacent mountain ridges) in an inner-Alpine valley system are examined. Apart from the downstream advection of hydrometeors, the fall-speed difference between snow/graupel and rain is found to be of great importance for this feature. If the ambient flow penetrates into the valley, the melting-induced increase of the fall velocity leads to a locally intensified fallout of hydrometeors and thus to a maximum in the precipitation rate.