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Simulations of Orographic Mixed-Phase Clouds at Mountain Range Site using COSMO-ART-M7

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Aerosol-cloud interactions constitute the highest uncertainties in radiative forcing estimation since preindustrial times. Clouds living in temperature range between 0° C and -38° C may contain supercooled water drops as well as ice particles formed by heterogeneous freezing. The coexistence of the three water-phases: vapor, liquid and ice in mixed-phase clouds (MPCs) leads to an enhanced number of microphysical processes that further complicates the estimation of radiative effects furthermore and challenges models on every scale. Due to a lower saturation pressure over ice than over water ice growth is favoured and a rapid glaciation of MPCs is expected. Even though MPCs are considered unstable, observations have shown that they can persist over long periods up to several hours. In-situ measurements at the high altitude research station Jungfraujoch (JFJ) show the occurrence of MPCs under certain conditions. In addition to the longevity of MPCs an unexpected high ice crystal concentration exceeding the number of ice nuclei was also observed. Due to the lack of information about updraft velocities in this complex orographic region and the constraint of measurements on a single location it is not fully understood how MPCs can persist over such a long time in this region, whether microphysical or dynamical processes are dominantly determining their longevity and what causes the high ice crystal concentration.
The measurements taken at JFJ delivering mass content as well as number concentration of particles on one hand require a detailed model study to fully understand processes of mixed phase clouds and on the other hand deliver a great opportunity to study the performance of the newly developed COSMO version: COSMO-ART-M7 on the kilometer-scale in comparison with measurement results. Furthermore it has to be proven whether a resolution of 1 km is sufficient enough to capture relevant processes in MPC.
First model simulations with COSMO, including the two-moment microphysics scheme, show the occurrence of MPCs in accordance with the measurements with mass concentration of liquid and ice phase on the same order of magnitude as observed but the high ice number concentration observed at JFJ can not be captured by the simulations with the current setup. As the processes leading to such high ice concentration are not well understood yet it is not clear if they are considered by the model. The correlation between updraft velocities and occurrence of liquid water content found in the measurement results can also be seen in the first simulations with COSMO for some chosen days in February and April 2013 based on the measurements. Nevertheless the simulations also confirm that occurrence of MPC can not exclusively be explained by updraft velocities. Further simulations with modified aerosol concentrations and coupled to the ART-M7 module will explore influences of aerosols on clouds at JFJ.