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In-situ measurements of orographic mixed-phase clouds in a High Alpine Environment using Digital in-line Holography

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Mixed-phase Clouds (MPCs), consisting of an unstable mixture of ice particles and supercooled liquid droplets, are found in many seasons of the year over broad stretches of the earth. In particular for orographic MPCs in complex High Alpine terrains the level of understanding is low because auf their complicated structure and dynamics.

In-situ measurements of MPCs at the high altitude research station Jungfraujoch (JFJ), Switzerland were taken with the digital holographic imager HOLIMO II (Henneberger et. al, 2013) during the winters of 2012 and 2013 (within the CLACE campaign). Each HOLIMO II image (the so called hologram) yields single particle information like size and shadowgraph for hundreds of particle within a well-defined sample volume (which can be up to a few hundreds). Advancements in data processing software now offer phase-resolved size distributions, concentrations, and water contents, with a sampling rate that sees variations in these parameters on a 25m length-scale in a MPC. The HOLIMO II measurements are compared to commonly used cloud instrumentation, which were simultaneously operated at the JFJ by the University of Manchester.

The field data reveal the unstable co-existence of water droplets and ice crystals, i.e. the presence of an only partially-glaciated MPC maintained at the JFJ for over several hours. At the JFJ a larger frequency of intermediate glaciation conditions were found than in in-situ aircraft observations of MPCs associated with frontal systems by Korolev et al. (2003). The higher longevity of these intermediate glaciation conditions of MPCs at the JFJ suggests that higher updraft velocities, and therefore higher water-vapor supersaturations, prevent the quickly glaciation of the MPCs. The JFJ location has a steeper topography for northerly winds meaning higher updraft velocities than for southerly winds. And the measurements show more intermediate values of glaciation from the North with the higher updraft velocities than from the South which has consistently either fully-glaciated or almost no glaciation in its MPCs.

In addition to the longevity of MPCs unexpected high ice crystal concentrations were observed; two order of magnitude larger than the simultaneously measured ice nuclei concentrations by the Portable Ice Nucleation Chamber (PINC). This discrepancy indicate than a large fraction of the ice crystal are not via primary ice nucleation, but whirled up snow or secondary-ice mechanism have a significant influence.

For putting this single point measurements to a broader picture the measurement days were simulated with a regional model COSMO-ART-M7 with a resolution of 1 km. First result of the simulations confirmed the measured occurrence of MPCs, but could not capture the high observed ice crystal concentrations.

Henneberger, J., Fugal, J. P., Stetzer, O., and Lohmann, U.: HOLIMO II: a digital holographic instrument for ground-based in-situ observations of microphysical properties of mixed-phase clouds, Atmos. Meas. Tech., 6, 2975–2987, 2013.

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