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Comparing modelled and measured ice crystal concentrations in orographic clouds during the INUPIAQ campaign

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At temperatures between -35°C and 0°C, the presence of insoluble aerosols acting as ice nuclei (IN) is the only way in which ice can nucleate under atmospheric conditions. Previous field and laboratory campaigns have suggested that mineral dust present in the atmosphere act as IN at temperatures warmer than -35°C (e.g. Sassen et al. 2003); however, the cause of ice nucleation at temperatures greater than -10°C is less certain. In-situ measurements of aerosol properties and cloud micro-physical processes are required to drive the improvement of aerosol-cloud processes in numerical models.

As part of the Ice NUcleation Process Investigation and Quantification (INUPIAQ) project, two field campaigns were conducted in the winters of 2013 and 2014 (Lloyd et al. 2014). Both campaigns included measurements of cloud micro-physical properties at the summit of Jungfraujoch in Switzerland (3580m asl), using cloud probes, including the Two-Dimensional Stereo Hydrometeor Spectrometer (2D-S), the Cloud Particle Imager 3V (CPI-3V) and the Cloud Aerosol Spectrometer with Depolarization (CAS-DPOL). The first two of these probes measured significantly higher ice number concentrations than those observed in clouds at similar altitudes from aircraft.

In this contribution, we assess the source of the high ice number concentrations observed by comparing in-situ measurements at Jungfraujoch with WRF simulations applied to the region around Jungfraujoch. During the 2014 field campaign the model simulations regularly simulated ice particle concentrations that were 3 orders of magnitude per litre less than the observed ice number concentration, even taking into account the aerosol properties measured upwind.

WRF was used to investigate a number of potential sources of the high ice crystal concentrations, including: an increased ice nucleating particle (INP) concentration, secondary ice multiplication and the advection of surface ice or snow crystals into the clouds. It was found that the influence of these processes on the ice particle concentrations could not explain the observations. We also assessed whether the inclusion of a surface flux of hoar crystals into the WRF model could account for the increased ice concentrations in the orographic clouds found at Jungfraujoch. By including a simple parameterisation based on the surface wind speed, the inclusion of the surface crystal flux provided good agreement with the measurements at Jungfraujoch. A summary of these results will be presented at the meeting.

References

Lloyd, G., et al., 2015. The origins of ice crystals measured in mixed-phase clouds at the high-alpine site Jungfraujoch. Atmos. Chem. Phys., 15, 12953–12969.

Sassen, K., et al., 2003. Saharan dust storms and indirect aerosol effects on clouds: Crystal-face results. Geophys. Res. Lett., 30, 1633–1636.