Name of research institute or organization:

Institute for Atmospheric and Climate Science, ETH Zurich

Title of project:

Field measurements of atmospheric ice nuclei and properties of mixed phase clouds

Project leader and team:

Dr. Jan Henneberger, Zamin Kanji and Prof. Ulrike Lohmann, project leaders
Yvonne Boose and Monika Kohn, PhD students

Project description:

Aerosol-cloud interactions are responsible for the largest uncertainty in radiative forcing. The level of understanding of mixed-phase clouds (MPCs) is low because of their complicated structure and dynamics. There is a lack of observations of the microstructure of MPCs with a high temporal and spatial resolution. With our holographic device HOLIMO II, a single cloud-particle imager, the microstructure of MPCs has been measured with high spatial resolution of the cloud phase and low uncertainty in small ice crystal number concentration.

In 2013, HOLIMO II was deployed at the Jungfraujoch (JFJ) during the CLACE 2013 campaign. The data set of MPCs at JFJ was extended and comparison with other cloud particle in-situ instruments, which were measuring simultaneously, allowed further validation of HOLIMO II. The data set of MPCs at JFJ showed that for northerly wind cases intermediate ice water content to total water content ratios (IWC/TWC) are more frequently observed than for southerly wind cases (Figure 1). The hypotheses for these results are either higher vertical velocities due to orographic lifting form the north or that the MPC is not well mixed but consists of pockets of pure water or pure ice, where the pockets of pure water indicate a lack of IN.

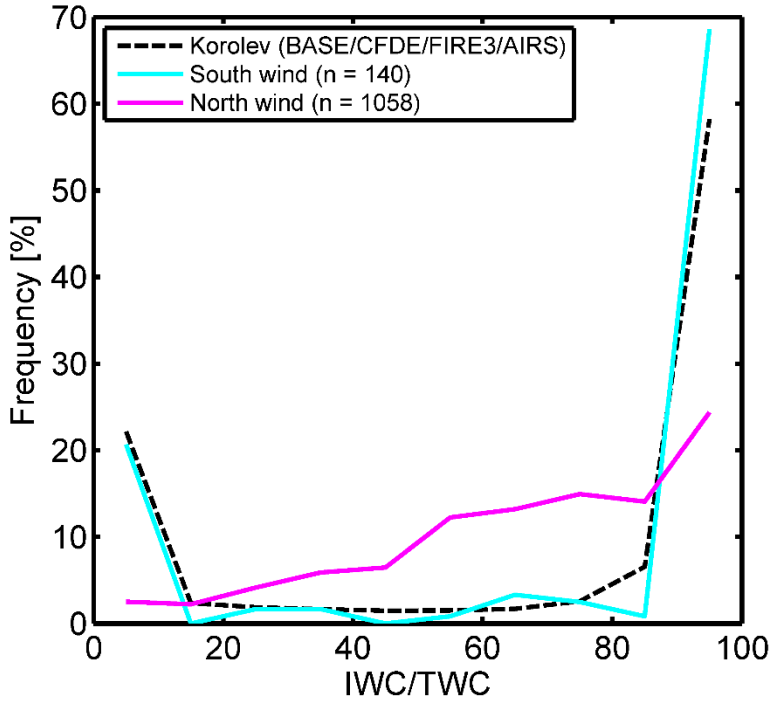

Figure 1. Frequency of occurrence of the IWC/TWC ratio in % in MPCs. Measurements of HOLIMO II obtained at Jungfraujoch (solid lines) are compared to insitu aircraft measurements in frontal systems in Canada by Korolev et al. (2003) (dashed lines).

The second part of the project focuses on aerosols acting as ice nuclei (IN). Very few aerosol particles have the ability to nucleate ice at temperatures warmer than required for homogeneous freezing (-38°C), which causes an experimental challenge to detect their ambient concentration.

Measurements of IN concentration in the deposition mode, at a temperature of 241K and a relative humidity with respect to ice (RH_i) of 127%, were performed with the portable ice nucleus counter (PINC) during the CLACE 2013 campaign in January and February as shown in Figure 2. A new adiabatic lens (ADL) concentrator was applied to enrich particle concentration and thus detect the very low IN concentration (often below 1 IN per liter) found in winter in the free troposphere. Comparison measurements with the Frankfurt Ice Nuclei Deposition FreezinG Experiment (FRIDGE) were also performed. First results show a good agreement at a temperature of T = -25°C and a relative humidity RH_i = 110%, RH_i = 123% and RH_i = 127%.

In comparison with earlier performed measurements at comparable measurement conditions in winter, the IN concentrations in January and February 2013 were significantly lower. Additional measurements will be performed in January and February 2014 to further investigate the annual variability of free tropospheric IN concentrations at the JFJ.

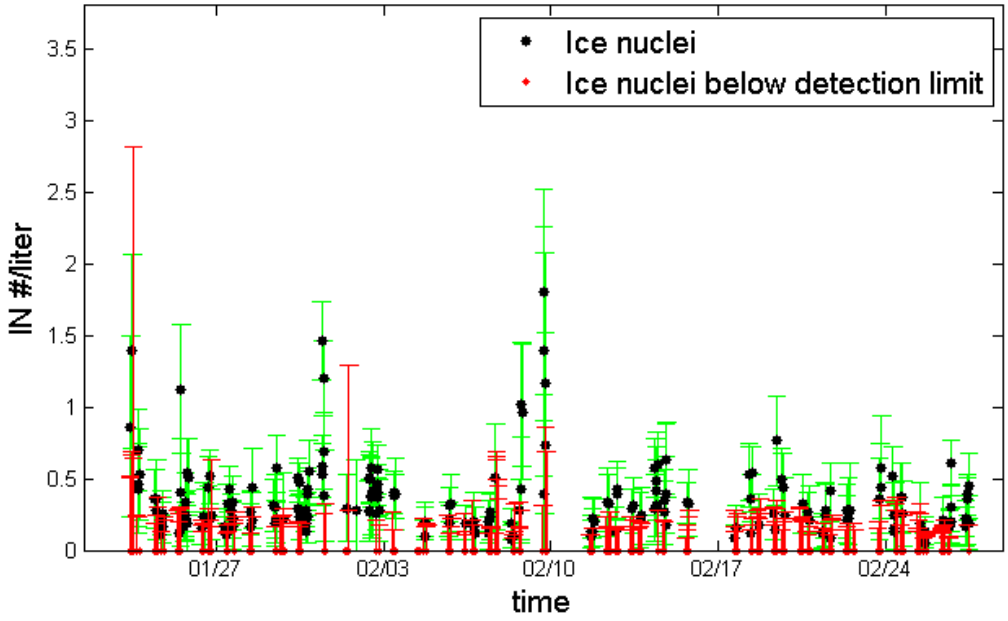

Figure 2. IN concentration at T=241K and RH_i= 127% during January and February 2013. The ADL concentrator allowed an improvement of the detection limit. However, as the IN concentration was so low several data points are still below the detection limit (in red).

Key words:

Ice nuclei, heterogeneous nucleation, aerosol particles, clouds, ice crystals, mixed-phase clouds, holography, cloud particle imager

Internet data bases:

http://www.iac.ethz.ch/groups/lohmann

Collaborating partners/networks:

Christiane Schulz, Heinz Bingemer, Goethe University Frankfurt a.M.
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Jacob Fugal, MPI Mainz
Paul Connolly, Gary Lloyd, University of Manchester

Scientific publications and public outreach 2013:

Refereed journal articles and their internet access

Henneberger, J., J.P. Fugal, O. Stetzer and U. Lohmann, HOLIMO II: a digital holographic instrument for ground-based in situ observations of microphysical properties of mixed-phase clouds, Atmos. Meas. Tech., **6**, 11, 2975-2987, doi: 10.5194/amt-6-2975-2013, 2013.
http://www.atmos-meas-tech.net/6/2975/2013/amt-6-2975-2013.pdf

Conference papers

Henneberger J., O. Stetzer and U. Lohmann, In-situ measurements of the microphysical properties of mixed-phase clouds with a digital holographic instrument, DACA-13 conference, Davos, Switzerland, July 8-12, 2013.

Theses

Henneberger, J., Mountain-top in-situ observations of mixed-phase clouds with a digital holographic instrument, PhD thesis, ETH Zurich, 2013.

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