Name of research institute or organization:

ETH, Zurich, Institute for Atmospheric and Climate Science

Title of project:

Studies of the Chemical Compostion of Aerosol in Mixed Phase Clouds

Project leader and team:

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Project description:

Aerosols, both natural and anthropogenic, are important factors with respect to the radiation budget of the atmosphere.
Ice nuclei in mixed phase clouds are not sufficiently investigated. The high alpine research station on the Jungfraujoch is an ideal site to study mixed phase clouds. In order to investigate only ice nuclei in mixed phase clouds, a special inlet was applied. Droplets and interstitial particles are removed in this inlet, such that only ice particles of a certain size range remain in the sampling lines. The chemical composition of the ice residues was analyzed with a bipolar single particle mass spectrometer, the Aerosol Time-of-Flight Mass Spectrometer (ATOFMS, TSI Model 3800). Thus spectra for both polarities were optained simultaneously. In order to also investigate the ambient aerosols a total inlet was applied before the ATOFMS.The aerodynamic diameter of the ice nuclei detected in the mass spectrometer were found to range from approximately 0.14 µm to about 1.67 µm. The particles were found to be internally mixed. Compared to the background, a higher fraction of mineral dust, fly ash and metals was found in the ice residues. Outstanding compared to the background is also the discovery that there was hardly any sulfate present in the ice nuclei and if there was sulfate then mostly only traces. Furthermore, another interesting finding is the presence of rather strange particles containing phosphates. The origin of these particles is not yet known. Also, a quite large fraction of ice nuclei contained chlorine. These particles might contain sea salt or could origin form an industrial process involving sodium chloride or chlorine in another form. The particles measured were grouped according their assignment of their spectra. The largest fractions are from mineral dust, fly as or metal particles and from salt-like particles (contain sodium chloride). Furthermore, there were biomass burning particles and the above mentioned phosphates found.
Another important property is the ability of an aerosol particle to take up water which can have an impact on aerosol optical properties and cloud formation. To date little is known about how aerosol water uptake depends on the chemical composition of the aerosol. In this study an in-situ measurement setup to determine the chemical composition of atmospheric aerosols as a function of hygroscopicity is presented. This has been done by connecting a custom-built Hygroscopicity Tandem Differential Mobility Analyzer (HTDMA) and an ATOFMS. Thus, single particle bipolar mass spectra from aerosols leaving the HTDMA could be obtained as a function of hygroscopic growth factor. For these studies the HTDMA was deployed at a relative humidity of 82% and particles with a dry diameter of 260 nm were selected. This novel setup was laboratory-tested with mixed hydrophobic and hygroscopic aerosols. Subsequently, several sets of field experiments were performed during the last year. One datasets was obtained during wintertime 2007 at the remote high alpine station

Jungfraujoch. There, due to low particle concentrations, a long sampling period was required. During the measurements two different growth factor modes were observed. First results from this location show that most aerosols were generally internally mixed. A large contribution of organics and biomass combustion was found in the non-hygroscopic growth mode particles. Refractory material (e.g. metals, mineral dust, fly ash elements) was also highly enhanced in the non-hygroscopic particles. Sulfate was found to be a constituent in almost all particles independent of their growth factor.

Key words:

Aerosol chemical composition, hygroscopicity, ice nucleation

Collaborating partners/networks:

Pacific Northwest National Laboratories

Scientific publications and public outreach 2007:

Conference papers

Keller, L., Herich, H., Cziczo, D., and U. Lohmann, The composition of ice residue in clean mixed phase clouds, European Aerosol Conference, Salzburg, Austria; September 2007.

Cziczo, D., Herich, H., Keller, L., and U. Lohmann, The Chemical Composition of Ice Nuclei in Ice and Mixed-Phase Clouds : Studies at a High Altitude Research Station in Switzerland, Washington State University Environmental Seminar Series, Pullman, WA, January 2008.

Cziczo, D., Herich, H., Keller, L., and U. Lohmann, The Chemical Composition of Ice Nuclei in Ice and Mixed Phase Clouds", University of Washington Atmospheric Science Colloquium, Seattle, WA, January 2008.

Cziczo, D., Herich, H., Keller, L., and U. Lohmann, What have we learned about the indirect effect by studying aerosol composition?", PNNL Atmospheric Science and Global Change Seminar, Richland, WA, January 2008.

Cziczo, D., Herich, H., Keller, L., and U. Lohmann, A Comparison of Ice Nucleation in Ice and Mixed Phase Clouds", International Union of Geodesy and Geophysics Meeting, Perugia, Italy, July 2007.

Herich, H., Keller, L., Cziczo, D., and U. Lohmann, A Rapid In-Situ Technique for Aerosol Chemical Composition as a Function of Hygroscopic Growth, AGU, San Francisco, USA, December 2007.

Herich, H., Keller, L., Cziczo, D., and U. Lohmann, Aerosol Chemical Composition and Hygroscopic Growth - first results from field studies, ETH-Conference on Combustion Generated Nanoparticles, Zurich, Switzerland, August 2007.

Magazine and Newspapers articles

D. J. Cziczo, A Nice Place To Ski, But How About To Study Clouds?, Particle Distributions (2007).

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