

Name of research institute or organization:

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**Institut für Atmosphäre und Umwelt, Universität Frankfurt,  
Germany**

Title of project:

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Volatile organic compounds (VOC) in air, snow and ice crystals and super-cooled droplets at high alpine research station Jungfrauoch during CLACE 4

Project leader and team:

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Project description:

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Naturally occurring emissions and continuously rising levels of anthropogenic emissions are responsible for the presence of volatile organic compounds (VOC) in the atmosphere. Due to vertical transport processes chlorinated and aromatic hydrocarbons were detected at higher altitudes (Prévot et al., 2000, Reimann et al., 2004). Secondary aerosols are formed from biogenic and anthropogenic VOC (Barthelmie & Pryor, 1997). An important process affecting the fate of VOC in the atmosphere is their removal by wet deposition (Czuczwa et al., 1988). Most of the precipitation falling to the surface at midlatitudes originates as ice in mixed phase clouds at higher altitudes. One possible uptake mechanism for VOC by ice crystals could be the uptake of gaseous VOC during crystal growth by vapour deposition (Huffmann & Snider, 2004).

During the Cloud and Aerosol Characterization Experiment CLACE 4 in February-March 2005 quasi-continuous measurements of VOC in air, snow, ice crystals and super-cooled droplets were carried out at the Sphinx laboratory at the alpine research station Jungfrauoch (3580 m asl). The measurements were focused on C<sub>2</sub>-C<sub>12</sub> nonmethane hydrocarbons (NMHC).

*Air.* VOC in air were measured with two different analytical methods. One method was based on an online-gas chromatographic system (AirmoVOC) with a temporal resolution of 240 min. The equipment was calibrated by a parent gas standard (National Physical Laboratory, UK) containing 28 VOC (alkenes, alkanes, aromatics) at a concentration of 5 ppb. The second method based on a preconcentration of VOC on activated charcoal followed by gas chromatography/mass spectrometry (GC/MS). Outside air was passed through glass sampling tubes packed with activated charcoal (Dräger, Germany). Samples were taken simultaneously to the AirmoVOC measurements. Sampling time was 240 min. After trapping VOC the cartridges were transported to the laboratory. Subsequently, compounds were desorbed by adding 750 µL of carbon disulfide (CS<sub>2</sub>) to the activated charcoal. One-micro liter aliquot of each CS<sub>2</sub> extract was manually injected into the GC-injector kept at 260 °C. Quantification was done by adding 25 µl of octylchlorid (200 µg ml<sup>-1</sup>) as an internal standard.

*Snow and ice crystals, super-cooled droplets.* Simultaneously to air sampling airborne snow and ice crystals and super-cooled droplets were collected during different snow events. Therefore, two self-constructed snow collectors were installed at the Sphinx laboratory. In addition, we installed a stain- less steel panel to collect super-cooled

droplets. After four hours of sampling snow and ice crystals and super-cooled droplets were removed and filled into 10 ml glass vials sealed with an aluminium coated septum (Supelco). The frozen samples were transported to the laboratory in a freezing box and melted right before analysis. Toluene D8 was added to each sample as an internal standard. Concentrations of VOC in the melted ice were determined by a sensitive method based on a self-controlled Solid-Phase-Dynamic-Extraction (SPDE) followed by gas chromatography /mass spectrometry (GC/MS). VOC were allowed to adsorb on a syringe coated with a bonded organic phase. After extraction the syringe was drawn into the GC injector and analytes were desorbed thermally at 260 °C.

A sustainable monitoring allows us to evaluate the impact of biogenic and anthropogenic emissions on the free troposphere. Preliminary results during CLACE 4 show that alkenes, alkanes and aromatic hydrocarbons are present in the gas phase at the Jungfraujoch area at high altitudes. The results of our measurements are a contribution to the continuous gas phase measurements of the EMPA group at Jungfraujoch. The propane concentration variations match very well with the predicted propane concentrations by the weather forecast model MATCH developed by Lawrence et al (1993). The propane measurements at Jungfraujoch confirmed that the model is a useful tool to detect episodes with high hydrocarbon concentrations.

Since we detected concentrations of VOC also in airborne snow and ice crystals our results are also a contribution to the evaluation of the role of the ice phase in the troposphere on the global transport of organic compounds. The occurrence of those compounds in precipitation at high altitudes is an indication for the importance of in-cloud scavenging on the removal of VOC by wet deposition from the atmosphere. With a comparison of the concentrations of VOC in snow, ice crystals and super-cooled droplets we will be able to distinguish the uptake of VOC via riming from the uptake during vapor to ice growth by diffusion.

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Key words:

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Organic compounds, SPDE, snow, GC/MS, air

Internet data bases:

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<http://www.meteor.uni-frankfurt.de/b8.htm>

Collaborating partners/networks:

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Universität Mainz, MPI Mainz, Technische Universität Darmstadt

Scientific publications and public outreach 2005:

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**Refereed journal articles**

Fries, E., Starokozhev, E., Auras, S., Sieg, K., Püttmann, W and Jaeschke, W. Volatile organic compounds in air at the high alpine research station Jungfraujoch during CLACE 4; in prep. For submission to Atmospheric Environment.

**Conference papers**

E. Fries, E. Starokozhev, W. Püttmann and W. Jaeschke Volatile organic compounds (VOC) in air, snow and ice crystals and super-cooled droplets at high alpine research station Jungfraujoch during CLACE 4. Presented at the European Aerosol Conference (EAC). Ghent, 28 August - 2 September, 2005.

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