Investigation of ice nucleating particles with the Fast Ice Nucleus Chamber (FINCH)

D. Rose¹, F. Frank¹, B. Nillius¹², R. Kohl¹, U. Bundke¹³, P. Artaxo⁴, and J. Curtius¹

¹ Institute for Atmospheric and Environmental Science, Goethe University of Frankfurt am Main, Germany
² now at: Multiphase Chemistry Department, Max Planck Institute for Chemistry, Mainz, Germany
³ now at: Institute for Energy and Climate Research (IEK-7), Forschungszentrum Jülich, Germany
⁴ Physics Institute, University of São Paulo, Brazil

Atmospheric aerosol particles influence the formation of clouds and precipitation and thus have an important impact on the Earth’s climate and the hydrological cycle. The formation of ice crystals is a basic process in cloud formation that leads to precipitation. Ice crystal formation through spontaneous freezing of supercooled aqueous solution droplets (homogeneous nucleation) is only possible at temperatures below approx. -40°C. At warmer temperatures, however, ice crystals can only form by heterogeneous nucleation, which involves aerosol particles as seeds on which the ice grows, so-called ice nuclei (IN). Typical sources of ice nuclei are mineral dust and carbonaceous particles originating from combustion processes (soot) or from biological sources (e.g., pollen, bacteria, fungi). For temperatures ≤ -15°C number concentrations of IN vary mostly in the range of 1-10 L⁻¹ with increasing values for decreasing temperatures (DeMott et al., 2010). The IN number concentration affects the initial cloud formation and thus the development of precipitation (Lohmann and Feichter, 2005). Since the spatial distribution of IN as well as their sources are highly variable it is necessary to perform measurements at various locations and atmospheric conditions to improve the incorporation of IN in meteorological weather and climate models.

With the fast ice nucleus chamber (FINCH; Bundke et al., 2008) we are able to measure the number concentration of IN at different freezing temperatures and supersaturations with respect to ice. In FINCH the sample flow of ambient aerosol is mixed with a warm moist as well as a cold dry airflow. By changing the flow rates and/or temperatures of the individual airflows the freezing temperature and ice saturation can be varied relatively quickly (within the order of seconds to a few minutes). Ice nucleating particles are activated, grow while flowing through the chamber, and are counted in an optical particle counter (OPC). The OPC used in this instrument is able to distinguish between water droplets and ice crystals by analyzing the polarization ratio of the scattered circular polarized light (P44/P11 ratio of the scattering matrix; Hu et al., 2003). Also, the auto-fluorescence resulting from the excitation of the grown particles with UV light is detected (Bundke et al., 2010), which is an indication for biological particle material.

FINCH has been operated successfully during one field campaign (INUIT-JFJ/CLACE 2013) at the high-alpine research station Jungfraujoch in Switzerland and will be operated soon at the ML-CIRRUS mission aboard the research aircraft HALO (High Altitude and Long Range Research Aircraft). At the ACRIDICON-CHUVA workshop first results from these two campaigns will be presented.
During the ACRIDICON-CHUVA campaign in Brazil we will operate the FINCH instrument on board the HALO aircraft again. We will measure the number concentration of IN and biological IN at different ice supersaturations and freezing temperatures in tropical deep convective cloud systems. For cloud conditions our instrument shall be connected to a counterflow virtual impactor (CVI) inlet to investigate the re-activation of ice particle residuals. On the other hand, outside clouds, FINCH will measure behind the HALO aerosol submicrometer inlet (HASI) to investigate the ice nucleating behavior of ambient aerosol particles in the submicrometer size range.

Acknowledgements:

This work is supported by the German Research Foundation, DFG Grant: BU 1432/3-2 BU 1432/4-1 in the framework of INUIT (FOR 1525) and SPP 1294 HALO.

References:


