UP 12: Atmosphäre - Labor

Time: Thursday 9:30–12:00 Location: MAG 100

Invited Talk UP 12.1 Thu 9:30 MAG 100

Laser filament induced secondary ice multiplication under cirrus cloud conditions — Thomas Leisner[1], Denis Duft[1], Harald Saathoff[1], Martin Schnaiter[1], Stefano Henin[2], Kamil Stelmaszczyk[3], Massimo Petrarca[2], Raphaëlle Delagrange[2], Zuoqiang Hao[3], Johannes Lüder[1], Yannick Petit[2], Philipp Rohwetter[3], Jérôme Kasparian[2], Jean-Pierre Wolf[2], and •Ludger Wöste[3] — [1]Institute for Meteorology and Climate Research, KI, 76131 Karlsruhe, Germany — [2]GAP, Université de Genève, CH 1211 Genève 4, Switzerland — [3]Institut für Experimentalphysik, Freie Universität Berlin, Arnimallee 14, 14195 Berlin, Germany

The interaction of artificial plasma channels with water and ice clouds was investigated in the large cloud simulation chamber AIDA. Under the conditions of a typical storm cloud, where ice and supercooled water coexist, no influence of the plasma channels on the ice formation could be detected. Under conditions typical for thin cirrus ice clouds however, the plasma filaments induced a surprisingly strong effect of ice multiplication. Here, the laser action led to a strong enhancement of the total ice particle number density in the chamber by up to a factor of 100, even though only a 10-9 fraction of the chamber volume was exposed to the laser filaments. The newly formed ice particles quickly reduced the water vapor pressure to ice saturation thereby increasing the cloud optical thickness by up to three orders of magnitude. A model relying on the complete vaporization of ice particles in the laser filament and the condensation of the resulting water vapor on plasma ions reproduces our experimental findings [1].

UP 12.2 Thu 10:00 MAG 100

Growth amplification of small ice particles in saturated sucrose and sodium silicate solutions — •Patricia Handmann[1] and Thomas Leisner[2] — [1]Karlsruher Institut für Technologie, Karlsruhe, Baden-Württemberg — [2]Karlsruher Institut für Technologie, Karlsruhe, Baden-Württemberg

Reliable detection of particle phase state in clouds, containing water droplets and ice crystals, is a very challenging task. Furthermore the ability to discriminate between liquid and frozen cloud compounds is essential for understanding cloud glaciation and providing reliable parameterization for climate models. A vast number of optical instruments have been developed over the last decades to solve this task in field and laboratory experiments. In this presentation we revisit the old method of ice crystal growth amplification (Bigg 1956) and demonstrate its advantages and drawbacks in a more modern setup.

Within this approach we exploit the property of ice crystals to grow to easily detectable sizes in the supercooled aqueous solutions of sucrose and sodium silicate solutions. In contrast to this, liquid droplets dissipate upon contact with the surface of such solution. We will show video records of the laboratory experiments and will discuss the applicability of the method for phase detection of secondary particles emitted by droplets during freezing.

Cited References:

BIGG, E. K. A new Technique for Counting Ice-Forming Nuclei in Aerosols Tellus, Blackwell Publishing Ltd, 1957, 9, 394-400

UP 12.3 Thu 10:15 MAG 100

Laboratory measurements on ice multiplication processes observed in individual cloud droplets — •Thomas Pander[1,2], Patricia Handmann[2], Alexei Kiselev[2], and Thomas Leisner[1,2] — [1]Ruprecht-Karls-Universität Heidelberg — [2]Karlsruher Institut für Technologie

Phase transitions in clouds have a profound influence on their radiative properties and lifetime. While it is common knowledge that water freezes at 0°C, cloud droplets can easily remain in a supercooled liquid state above -36°C. Heterogeneous freezing at warmer temperatures may be initiated by a suitable ice nucleus, ice itself being the ideal nucleus. As under typical conditions only a 10^{-5} fraction of the atmospheric aerosol particles are good ice nuclei, any multiplication processes of atmospheric ice particles are potentially relevant to the physics of the atmosphere. We present high-speed video evidence of such processes: a droplet may burst and emit several ice particles while freezing. The growing pressure in a liquid core surrounded by a growing ice shell can also be released by the pressing of water and dissolved gases through cracks in the shell, leading to bubbles on the outside of the droplet. If those bubbles burst, ice particles might be produced. The key influence of solid aerosol inclusions on these processes is explored and quantified.

UP 12.4 Thu 10:30 MAG 100

Laboratory experiments on ice nucleation and growth rates on meteoric smoke particles at mesospheric conditions — •Mario Nachbar[1], Denis Duft[2], Markus Eritt[2], and Thomas Leisner[1,2] — [1]Institute for Environmental Physics, Ruprecht-Karls-University Heidelberg, Germany — [2]Institute for Meteorology and Climate Research, Karlsruher Institute of Technology (KIT)

Ice particles have been detected at the polar mesopause region (height of 80-90 km) during summer term by radar measurements as polar mesospheric summer echoes (PMS). If large enough, they can be observed by eye as noctilucent clouds (NLC). Heterogeneous nucleation on nanometer sized (< 2nm) meteoric smoke particles (MSP) is believed to be one of the major nucleation processes taking place. PMSE and NLC could be used as a probe for the extreme physical and thermodynamical conditions of the mesopause region. In addition, long term trends due to the influence of anthropogenic greenhouse gas emissions could be validated. Therefore, the microphysical processes need to be understood in detail. We produce charged nanometer sized particles in a microwave resonator at 60 mb and transfer them into the TRAPS apparatus in order to examine ice nucleation as well as growth rates. Our new quadrupol ion trap allows us to store these particles under controlled mesospheric temperature and water vapor saturation conditions. Ice nucleation and growth processes are examined by analysing the mass distribution of the particles with a time of flight spectrometer as a function of the trapping time. In this talk, first measurements using the new setup will be presented.

Kaffeepause, 30 min

Invited Talk UP 12.5 Thu 11:15 MAG 100

Contact freezing induced by mineral dust particles — •Nadine Hoffmann, Manfred Schäfer, Denis Duft, Alexei Kiselev, and Thomas Leisner — IMK-AAF, KIT, Karlsruhe, Germany

The contact freezing of supercooled cloud droplets is one of the potentially important and the least investigated heterogeneous mechanism of ice formation in tropospheric clouds [1]. On the time scales of cloud lifetime the freezing of supercooled water droplets via contact mechanism may occur at higher temperature compared to the same IN immersed in the droplet. In our experiment we study single water droplets freely levitated in an Electrodynamic Balance [2]. We have shown previously that the rate of freezing at given temperature is governed only by the rate of droplet-particle collision and by the properties of the contact ice nuclei [2, 3]. Recently, we have extended our experiments to potassium reach feldspar (Microcline), being one of the most abundant components of the atmospheric mineral dust particles [4]. We have dispersed feldspar particles from the water suspension and as dry powder and compared their freezing properties. In this presentation we will present these results and discuss their possible implication for elucidation of contact freezing mechanism.

[1] Ladino et al., Atmos. Chem. Phys., 13, doi:10.5194/acpd-13-7811-2013, 2013. [2] Hoffmann et al., Atmos. Meas. Tech., doi:10.5194/amtd-6-3407-2013, 2013. [3] Hoffmann et al., Faraday Discuss., doi: 10.1039/C3FD00033H, 2013. [4] Atkinson et al., Nature, 498, doi:10.1038/nature12278, 2013.

UP 12.6 Thu 11:45 MAG 100

Characterization of ice crystals in the AIDA cloud chamber — •Paul Vochezer, Ahmed Abdelmonem, and Martin Schnaiter — KIT IMK-AAF, Karlsruhe, Germany

Clouds remain a major source of uncertainty for both weather forecasts and climate models. These uncertainties are strongly linked to the occurrence and development of ice particles in clouds. Our group is currently involved in field and laboratory measurements to quantify and qualify ice particles in clouds.

In our contribution we present measurements obtained by two cloud particle probes during a series of laboratory based AIDA cloud chamber experiments with ice containing clouds in a temperature range from -20°C to -60°C. The PHIPS-HALO instrument includes a stereo microscope which takes real images of individual cloud particles at a resolution of 3μm/pixel. The PPD2-K instrument acquires high resolution 2D scattering patterns of individual cloud particles in forward direction $5°$-$25°$. Asphericity of the particles leads to deviations from the Airy pattern and allows the discrimination between droplets and ice particles. Symmetric ice particles like columns or plates generate symmetric scattering pattern which are filtered and analyzed habit by habit.

The data sets of PHIPS-HALO and PPD2-K are analyzed to determine the fraction of cloud ice particles and the occurrence of certain ice particle habits. Furthermore the transverse and longitudinal growth rates of airborne columnar ice particles are derived.