UP 2: Clouds and Aerosols

Time: Thursday 14:00–16:10 Location: H3

Invited Talk UP 2.1 Thu 14:00 H3

BLUESKY - Atmospheric Composition Changes during the Corona Lockdown 2020 — •Christiane Voigt[1,2], Jos Lelieveld[3], Johannes Schneider[3], Daniel Sauer[1], Ralf Meerkötter[1], Silke Gross[1], Ulrich Schumann[1], Mira Pöhlker[3], Laura Tomsche[1], Mariano Mertens[1], and Hans Schlager[1] — [1]Deutsches Zentrum für Luft und Raumfahrt, Institut für Physik der Atmosphäre, Oberpfaffenhofen, Germany — [2]Universität Mainz, Institut für Physik der Atmosphäre, Mainz, Germany — [3]Max-Planck Institut für Chemie, Mainz, Germany

Worldwide regulations to control the COVID-19 pandemic caused significant reductions in ground and airborne transportation in spring 2020, which provided the unique opportunity to directly measure the less perturbed atmosphere, notably near the tropopause. The BLUESKY mission employed the high-altitude, long-range research aircraft HALO and the DLR Falcon together with satellite observations and models to study the atmospheric composition changes. From 16 May to 9 June 2020, the 2 research aircraft performed 20 flights over Europe. Profiles of trace species were measured with an advanced insitu trace gas, aerosol and cloud payload from the boundary layer to 14 km altitude. I will present an overview and selected highlights of the campaign. Continental aerosol profiles show significant reductions in aerosol mass in the boundary layer and lower organic aerosol mass fractions in the free troposphere. The reduced aerosol optical thickness above Germany has also been detected by MODIS and contributes to the observed *blue sky* during the lockdown period 2020.

UP 2.2 Thu 14:20 H3

Thermal imaging of freezing drizzle droplets: pressure release events as a source of secondary ice particles — Judith Kleinheins[1], Alexei Kiselev[2], Alice Keinert[2], Matthias Kind[2,3], and •Thomas Leisner[2,4] — [1]Department of Environmental Systems Science, ETH Zürich, Zürich, Switzerland — [2]Institute of Meteorology and Climate Research - Atmospheric Aeorosol Research, Karlsruhe Insitute of Technology, Karlsruhe, Germany — [3]Institute of Thermal Process Engineering, Karlsruhe Institute of Technology, Karlsruhe, Germany — [4]Institut für Umweltphysik, Universität Heidelberg, Heidelberg, Germany

The freezing of supercooled water droplets freely falling through a mixed-phase clouds is an ubiquitous natural process fundamental for the formation of precipitation. During the freezing of a droplet a solid ice shell grows from the outside inwards, leading to a pressure increase inside the liquid core, which can result in violent rupture of the ice shell and the production of secondary ice particles. To investigate this process of ice multiplication, the evolution of the droplets surface temperature during the second freezing stage was measured with a high-resolution infrared thermography system (INFRATEC). Drops of about 300 micrometer in diameter were levitated in an electrodynamic trap under controlled conditions with respect to temperature, humidity and ventilation. Combining experimental results and comprehensive process modelling, we explore the thermodynamic conditions beneficial for secondary ice production upon freezing of freely falling drizzle droplets.

UP 2.3 Thu 14:35 H3

Cracking the problem of atmospheric ice nucleation: chemically induced fracturing of alkali feldspar makes it a better ice-nucleating aerosol particle — •Tilia Gädeke[1], Alexei Kiselev[1], Alice Keinert[1], Thomas Leisner[1], Christoph Sutter[2], Elena Petrisheva[3], and Rainer Abart[3] — [1]KIT, IMK-AAF, Karlsruhe, Germany — [2]Universität Heidelberg, IFU, Heidelberg, Germany — [3]University of Vienna, Department of Lithospheric Research, Vienna, Austria

Feldspar is a major constituent of magmatic, metamorphic, and sedimentary rocks on the Earths* surface. Consequently it is also an abundant constituent of the solid aerosol particles and induces heterogeneous freezing in cloud droplets. The freezing process changes cloud properties and precipitation formation. The mineralogy of feldspar has a crucial effect on its ability to induce freezing of water. The mechanisms relating the microstructure of feldspars and enhanced ice nucleation (IN) efficacy are not known and are currently debated.

The particularly high IN activity of alkali feldspar has been attributed to structural similarities between specific prism planes of ice and feldspar. In this study, the gem quality K-rich alkali feldspar was shifted towards more Na-rich compositions. The cation exchange induces parallel cracks with an orientation close to (100). Droplet freezing assay experiments performed on the cation-exchanged feldspars, revealed an increase of freezing efficacy with respect to the untreated feldspar. This contribution demonstrates how the natural complexity of rock-forming minerals can have a direct impact on Earth's climate.

Invited Talk UP 2.4 Thu 14:50 H3

Nucleation and growth of atmospheric aerosol particles: Recent results from CLOUD at CERN — •Joachim Curtius — Institut für Atmosphäre und Umwelt, Goethe Universität Frankfurt, Frankfurt am Main, Germany

Atmospheric aerosol particles influence cloud formation, climate and human health. A large fraction of the atmospheric aerosol forms by nucleation from the gas phase. In order to understand and predict atmospheric new particle formation it is of importance to perform experiments under well-controlled laboratory conditions to investigate the details of the formation of molecular clusters. By performing more than 2200 individual experiments over the past decade, the CLOUD project at CERN has studied the most relevant chemical systems for a large range of atmospheric conditions at unprecedented precision. It allows the direct and simultaneous measurement of all relevant variables at atmospheric conditions. The physico-chemical mechanisms (e.g. ion-induced vs. neutral path) for the formation and initial growth of molecular clusters are determined. For example, the nitric acid-sulfuric acid-ammonia system has been studied recently that is predicted to cause nucleation in such diverse conditions as East Asian megacities in winter or in the upper troposphere above the Indian monsoon. Overall, a greatly improved understanding has been reached for the role of new particle formation in the atmosphere and for characterizing the various factors that act as boosters or inhibitors for the nucleation and growth processes. An overview of the current understanding, including its role for cloud formation and climate is given.

UP 2.5 Thu 15:10 H3

A bird's eye view on the invisibile, unprecedented levels of ultrafine particles and the hydrological cycle — •Wolfgang Junkermann[1] and Jorg Hacker[2] — [1]Karlsruhe Institute of Technlogy, IMK-IFU — [2]Airborne Research Australia, Parafield, SA

Airborne measurements from small, slow flying aircraft have been used to identify and characterize major sources of ultrafine particles (UFP) and to quantify their contribution to the global aerosol number budget. UFPs are relevant as cloud condensation nuclei (CCN), with respect to size and number emission. State of the art fossil fuel flue gas cleaning techniques following clean air legislation are turning power stations into efficient UFP generators, doubling global primary number emissions. The subsequent enhancement of (CCN) modifies cloud microphysics, decreases droplet sizes and delays raindrop generation, suppressing certain types of rainfall, increasing cloud droplet evaporation and affecting the hydrological cycle. A subsequent transport of water vapour as latent energy into mid altitudes of the lower troposphere, in turn enhances torrential rain events, and via increased residence time of H2O in the atmosphere, might contribute to larger than regional scale climate warming through effects on the infrared radiation budget.

UP 2.6 Thu 15:25 H3

Occurrence of Polar Stratospheric Clouds as derived from ground-based zenith DOAS observations — •Bianca Lauster[1,2], Steffen Dörner[1], Udo Friess[2], Myojeong Gu[1], Janis Pukite[1], and Thomas Wagner[1] — [1]Max Planck Institute for Chemistry, Mainz, Germany — [2]Institute of Environmental Physics, University Heidelberg, Heidelberg, Germany

Polar Stratospheric Clouds (PSCs) are an important component of ozone depletion in the polar stratosphere. Although satellite observations already yield high spatial coverage, continuous ground-based measurements with high temporal resolution can be a valuable complement. Since 1999, a MAX-DOAS (Multi AXis-Differential Optical Absorption Spectroscopy) instrument has been operating at the German research station Neumayer (70° S, 8° W), Antarctica. Although typically used to retrieve slant column densities of trace gases such as BrO or OClO, this study investigates the so-called colour index (CI). Defined as the ratio between the observed intensities of scattered sun light at two wavelengths, it enables to monitor the occurrence of PSCs during twilight even in the presence of tropospheric clouds. Using the radiative transfer model McArtim, the analysis of CI variations with solar zenith angle enables the detection of PSCs. Here, it is advantageous that measurements are available in the UV and visible spectral range which allows a more extensive comparison of the wavelength choice. The aim is to improve and evaluate the potential of this method. It is then used to infer the occurrence of PSCs throughout the measurement time series of more than 20 years.

UP 2.7 Thu 15:40 H3

Satellite observations of volcanic eruptions leading to smaller average stratospheric aerosol sizes — •Felix Wrana[1], Christian von Savigny[1], and Larry W. Thomason[2] — [1]Institut für Physik, Universität Greifswald, Greifswald, Germany — [2]NASA Langley Research Center, Hampton, Virginia, USA

We present surprising results of our stratospheric aerosol size retrieval which is using the SAGE III/ISS solar occultation measurements, that started in 2017. Due to the broad wavelength spectrum covered by the instrument a robust and simultaneous retrieval of the median radius and mode width of monomodal lognormal size distributions is possible. We focus on three small to mid-intensity volcanic eruptions that were observed by SAGE III/ISS and that reached and perturbed the stratospheric aerosol layer: The Ambae eruptions (15.3°S) in spring of 2018 and the Raikoke (48.3°N) and Ulawun (5.05°S) eruptions, both in June 2019. While the Raikoke eruption led to an increase in the median radius of the stratospheric aerosols, which was to be expected and is in line with previous observations, the Ambae and Ulawun eruption had the opposite effect. After both eruptions the average aerosol size decreased, with lower median radii and narrower size distributions, while the number density increased strongly. The observation that volcanic eruptions may lead to smaller average stratospheric aerosol sizes, as also recently discussed by Thomason et al. (2021), is a novel one and should be of great interest to the modeling as well as remote sensing community. In our talk, we will present the temporal and spatial evolution of the size distribution parameters.

UP 2.8 Thu 15:55 H3

Estimating the impact of tropical volcanic eruptions on the thermal structure of the mesosphere by analyzing HALOE temperature data and UA-ICON simulations — •Sandra Wallis[1], Christoph Hoffmann[1], Hauke Schmidt[2], and Christian von Savigny[1] — [1]University of Greifswald, Greifswald, Germany — [2]Max Planck Institute for Meteorology, Hamburg, Germany

She et al. [1] published a paper in 1998 that analyzed Na lidar temperature profiles and reported an episodic warming of the mesopause region (up to 12.9 K in 100 km altitude) that they attributed to the 1991 Pinatubo eruption. Our study analyses temperature data for the middle atmosphere from the Halogen occultation experiment (HALOE) on the Upper Atmosphere Research Satellite that started its scientific observation 4 months after the eruption. A regression was performed including a volcanic term suggested by She et al., but it did not confirm the significantly higher values reported previously for the lidar measurements. An alternative fit is proposed that approximates the Pinatubo signature with an exponential decay function having an e-folding time of 6 months. We conclude that the HALOE time series probably captures only the decay of a Pinatubo-induced mesospheric warming and that the mesospheric response is more rapid than reported by She et al. The impact of a tropical volcanic eruption on the mesosphere was further investigated by simulations using the upper-atmosphere icosahedral non-hydrostatic (UA-ICON) general circulation model. [1] She et al. Geophys. Res. Lett., 25(4):497-500, 1998.