UP 6: Upper Atmosphere, Polar Chemistry and Volcanic Aerosols

Upper-atmosphere, polar processes, volcanic aerosols, remote sensing, and dynamics.

Time: Wednesday 9:30–11:00 Location: MER/0002

UP 6.1 Wed 9:30 MER/0002

Twofold Chemical Properties of Premelting at Ice Surfaces — •Thorsten Bartels-Rausch[1], Jérôme Gabathuler[1], Yanisha Manoharan[1], Luca Artiglia[1], Markus Ammann[1], Rawan Abouhaidar[2], Céline Toubin[2], and Ivan Gladich[3] — [1]Paul Scherrer Institute, Villigen, Switzerland — [2]Universite de Lille, Lille, France — [3]University of Urbino, Urbino, Italy

The physical properties of ice surfaces are a longstanding subject of intense research motivated by their relevance in glacial flow, thunder, (anti-)freezing, and on-water catalysis. How water molecules rearrange at the surface to minimize energy, going as far as evolving liquid-like features in premelting, is under ongoing investigation. Less elusive remains the impact of this disorder on chemistry. This is problematic considering the role of ice and snow interfaces in chemical processes, such as global geochemical cycles. This work presents hexylamine adsorption as a means to investigate the chemical characteristics of the ice- and water-air interface. By analyzing the X-ray photoemission spectra of the adsorbate at the air-ice interface against those at the air-water interface, we discovered experimental evidence indicating differing chemical interactions at these two interfaces. Molecular dynamics and core binding calculations linked these spectroscopic differences to an active interfacial proton transfer.

UP 6.2 Wed 9:45 MER/0002

Bromine Explosion signals in Arctic snow — •Stefanie Falk[1], Hogo El-Mansi[2], Ariane Le Cardinal[1], Luca Reissig[1,4], Bianca Zilker[3], Andreas Richter[3], Hans-Werner Jacobi[2], and Björn-Martin Sinnhuber[1] — [1]Karlsruhe Institute of Technology, Institute of Meteorology and Climate Reseach, Atmospheric Trace Gases and Remote Sensing, Karlsruhe, Germany — [2]nstitute of Environmental Geosciences (IGE), Université Grenoble Alpes / CNRS / Grenoble INP / INRAE / IRD, Grenoble, France — [3]University of Bremen, Institute of Environmental Physics, Bremen — [4]German Weather Service, Offenbach, Germany

Ozone (O_3) volume mixing ratios (VMR) below 5 ppb are frequently observed during springtime in the polar boundary layer. The destruction of O_3 is caused by reactive halogen compounds, likely dominated by bromine (Br_2) released from salty ice and snow. The driving mechanism leads to exponential growth in Br_2 VMR during so-called Bromine Explosions (BEs). Increased vertical column densities (VCD) of bromine monoxide (BrO) are regularly observed by remote sensing. Long-term observations of O_3 at Arctic coastal sites and BrO indicate emerging signals of a changing climate. We also compare modeled bromine deposition on snow to bromide concentrations determined in snow samples taken at Spitsbergen in 2024. To this end, we use the ECHAM/MESSy Atmospheric Chemistry (EMAC) model, including a treatment of bromine release, recycling on ice and snow-covered surfaces, and parameterized emissions from sea salt aerosols. We discuss implications for the assumed sources of Br_2 in the Arctic.

UP 6.3 Wed 10:00 MER/0002

Polar 6 airborne in situ aerosol and turbulence measurements in the Arctic and Antarctica — •Laura Köhler[1], Stephan Borrmann[2], Jörg Hartmann[1], Zsofia Juranyi[1], Christof Lübkes[1], Jonas Schäfer[3], David Simon[3], Frank Stratmann[3], and Andreas Herber[1] — [1]Alfred-Wegener-Institut, Bremerhaven, Germany — [2]Max Planck Institute for Chemistry, Mainz, Germany — [3]Leibniz Institute for Tropospheric Research, Leipzig, Germany

We present three aircraft campaigns conducted with the research aircraft Polar 6, all using similar configurations for in situ aerosol and turbulence measurements. Two campaigns, BACSAM I (autumn 2022) and BACSAM II (spring 2024), were carried out in the Arctic from Longyearbyen. The third campaign, SANAT, will take place in early 2026 from Neumayer III Station in Antarctica. These measurements provide one of the first aerosol profile datasets collected in the vicinity of Neumayer III.

A comprehensive suite of aerosol instruments enables measurements of aerosol parameters such as number concentrations and size distributions, while the aircraft*s nose boom provides high-frequency (100 Hz) meteorological and turbulence data. During all three campaigns, the Turbulence-Bird (T-Bird) was also deployed up to 80 m below the aircraft, carrying additional aerosol and turbulence sensors allowing for simultaneous observations at two altitudes.

This unique setup enables investigations such as airborne particle fluxes. We present the three campaigns, outline the measurement setup, and show examples of the atmospheric conditions encountered.

UP 6.4 Wed 10:15 MER/0002

Stratospheric aerosol size evolution after the Ruang volcanic eruptions in 2024 — •Felix Wrana, Christian von Savigny, and Sandra Wallis — Institute of Physics, University of Greifswald, Greifswald, Germany

The size of stratospheric aerosols is an important factor in their effect on Earth's radiative balance and on atmospheric chemistry. On April 17th and 30th 2024, the Ruang volcano (2.3 °N, 125.37 °E) had two eruptions with a volcanic explosivity index (VEI) of 4, both reaching the stratosphere. Although each eruption injected only around 0.26 Tg of SO_2, they had a considerable effect on the stratospheric aerosol size in the Junge layer, that was at that point in time still affected by the exceptional Hunga eruption of 2022. The evolution of the stratospheric aerosol size from before to after the Ruang eruptions is shown, based on a multi-wavelength retrieval from the satellite solar occultation measurements of the Stratospheric Aerosol and Gas Experiment III on the ISS (SAGE III/ISS). Similarities and differences with other volcanic eruptions that reached the stratosphere in the previous years are shown and discussed, adding to our current understanding of the main driving factors behind observed aerosol size increases vs decreases after volcanic eruptions. Also, the satellite retrieval is validated with balloon-borne in situ measurements.

UP 6.5 Wed 10:30 MER/0002

How long does H2O from a strong tropical volcanic eruption need to reach the polar summer mesopause? — •Sandra Wallis[1], Hauke Schmidt[2], and Christian von Savigny[1] — [1]University of Greifswald, Greifswald, Germany — [2]Max Planck Institute for Meteorology, Hamburg, Germany

It is assumed that the historic 1883 Krakatoa volcanic eruption emitted a large amount of water vapour into the tropical middle atmosphere (20 - 100 km). According to a prominent hypothesis, this volcanic water vapour might have been transported to the polar summer mesopause resulting in the first ever sighting of noctilucent clouds (NLC) two years later. This discussion was recently revived after the 2022 Hunga eruption. We used simulations from the Hamburg Model of the Neutral and Ionized Atmosphere (HAMMONIA) to determine the transport time of water vapour from the tropics to the summer polar mesopause for different volcanic injection seasons and heights. The results suggest that a 1.5 to 2 year transport time period is plausible, strengthening the Krakatoa-NLC hypothesis.

UP 6.6 Wed 10:45 MER/0002

Is there a stratospheric airglow layer caused by the chemiluminescent reaction of NO and O_3? — •Christian von Savigny[1], Christoph G. Hoffmann[1], Wuhu Feng[2,3], and John Plane[2] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]School of Chemistry, University of Leeds, Leeds, UK — [3]National Centre for Atmospheric Science, Leeds, UK

Airglow, i.e. non-thermal emissions caused directly or indirectly by solar radiation, is a ubiquitous phenomenon in the Earth's atmosphere and also other planetary atmospheres. Most airglow emissions in the terrestrial atmosphere occur in the mesosphere and thermosphere, but some emissions can also extend down to below the stratopause. The most prominent example is the $O_2(^1\Delta)$ dayglow emission at a wavelength of about 1270 nm. Another potential stratospheric emission is a nightglow emission by excited NO_2 that was reported three decades ago by Evans and Shepherd (1996) based on nightglow measurements with the Wind Imaging Interferometer (WINDII) on UARS and model simulations. This emission has not yet been confirmed in other studies. In this contribution we use nightglow simulations based on input from the Whole Atmosphere Community Climate Mode (WACCM) to investigate, (a) how intense the NO + O_3 chemiluminescence is at

stratospheric altitudes, and (b) whether it can likely be identified with a satellite limb viewing spectrometer. Our results indicate that the $NO + O_3$ volume emission rates are orders of magnitude weaker than suggested earlier.