Environmental Physics Division
Fachverband Umweltphysik (UP)

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Overview of Invited Talks and Sessions

(Lecture halls: MOL/0213, ZEU/0160 and HSZ/AUDI; Posters: HSZ OG1)

Plenary Talk of the Environmental Physics Division

PV V	Tue	9:45–10:30	HSZ/AUDI	**The European Destination Earth initiative – a paradigm change for weather and climate prediction** — •Peter Bauer

Invited Talks

UP 2.1	Wed	11:00–11:30	MOL/0213	**Volcanic radiative forcing: past and future** — •Anja Schmidt
UP 7.1	Thu	11:00–11:30	MOL/0213	**Towards monitoring of anthropogenic greenhouse gas emissions from satellites** — •Hartmut Bösch, Antonio Di Noia, Neil Humpage, Alex Webb, Harjinder Sembhi, Robert Parker, Michael Buchwitz, Max Reuter, Oliver Schneising, Stefan Noel, Heinrich Bovensmann
UP 8.1	Thu	14:00–14:30	MOL/0213	**Destabilization of carbon in tropical peatlands by enhanced weathering** — •Alexandra Klemme, Tim Rixen, Moritz Müller, Justus Notholt, Thorsten Warneke
UP 8.2	Thu	14:30–15:00	MOL/0213	**Widespread forest decline in central Europe following three extreme summers in 2018-2020** — •Ana Bastos

Invited Talks of the joint Symposium Strange Clouds – from the Earth to Exoplanets (SYSC)

See SYSC for the full program of the symposium.

SYSC 1.1	Tue	11:00–11:20	HSZ/0004	**Not all clouds are created equal – strange clouds in our solar system** — •Thomas Leisner
SYSC 1.2	Tue	11:20–11:45	HSZ/0004	**Clouds to the Edge of Space** — •Gerd Baumgarten, Ronald Eixmann, Jens Fiedler, Michael Gerding, Mykhaylo Grygalashvyly, Franz-Josef Lübken, Ashique Vellalassery, Christian von Savigny, Robin Wing
SYSC 1.3	Tue	11:45–12:10	HSZ/0004	**The dynamic clouds of Venus** — •Javier Peralta
SYSC 1.4	Tue	12:10–12:35	HSZ/0004	**Observational constraints of exoplanet clouds** — •Nicolas Iro
SYSC 1.5	Tue	12:35–13:00	HSZ/0004	**Gemstone clouds in JWST target exoplanets** — •Dominic Samra, Christiane Helling

Sessions

UP 1.1–1.5	Tue	16:45–18:00	ZEU/0160	**Clouds in Planetary Atmospheres (joint session EP/UP)**
UP 2.1–2.5	Wed	11:00–12:30	MOL/0213	**Volcanic Effects on Atmosphere and Climate**
UP 3	Wed	13:00–14:00	MOL/0213	**Members' Assembly**
UP 4.1–4.6	Wed	14:00–15:30	MOL/0213	**Aerosols & Hydrological Cycle**
UP 5.1–5.4	Wed	16:00–17:00	MOL/0213	**Measurement Techniques and Simulations**
UP 6.1–6.4	Wed	17:30–19:00	HSZ OG1	**Poster**

UP 7.1–7.4	Thu	11:00–12:15	MOL/0213	**Greenhouse Gases: Remote Sensing**
UP 8.1–8.3	Thu	14:00–15:15	MOL/0213	**Carbon Cycle & Climate Change**

Members' Assembly of the Environmental Physics Division

Wednesday 13:00–14:00 MOL/0213

- Report on last year's activities
- Election
- Any other business

UP 1: Clouds in Planetary Atmospheres (joint session EP/UP)

Time: Tuesday 16:45–18:00 Location: ZEU/0160

UP 1.1 Tue 16:45 ZEU/0160

Wellen und Wolken in der Atmosphäre über den südlichen Anden gemessen mit einem Rayleigh-Lidar — •Natalie Kaifler, Bernd Kaifler, Andreas Dörnbrack und Markus Rapp — Deutsches Zentrum für Luft- und Raumfahrt e.V., Institut für Physik der Atmosphäre

Das CORAL-Lidar misst seit November 2017 in Tierra del Fuego, Argentinien (54°S) die Temperatur der Atmosphäre bis in 100 km Höhe. In der Stratosphäre treten über den südlichen Anden durch Gebirgswellen verursachte Temperaturstörungen von über 20 K Amplitude auf. In den kalten Phasen der Wellen können auf diese Weise polare Stratosphärenwolken auch in mittleren Breiten entstehen. In größeren Höhen, am oberen Rand der Mesosphäre, ist die Temperatur im Sommer kalt genug für die Bildung von Eiswolken, den sogenannten leuchtenden Nachtwolken. Sie werden durch die Gezeitenwinde beeinflusst, sind stark durch Schwerewellen moduliert, und treten in der Südhemisphäre nicht seltener auf als in der Nordhemisphäre, was man aufgrund der höheren Hintergrundtemperatur der südlichen polaren Mesosphäre erwarten könnte. Wir zeigen eine Übersicht und ausgewählte Beobachtungen von Wellen und Wolken in der mittleren Atmosphäre aus mehr als fünf Jahren Lidar-Messungen.

UP 1.2 Tue 17:00 ZEU/0160

Preferential adsorption of para and ortho water molecules on charged nanoparticles in planetary ice clouds — •Johanna Weidelt[1], Thomas Dresch[2], Denis Duft[2], and Thomas Leisner[2,3] — [1]Ultrafast Science Research Unit, University of Bielefeld, Germany — [2]Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, Germany — [3]Institute of Environmental Physics, University of Heidelberg, Germany

In the Earth mesopause, nanometer-size singly charged particles form by condensation of evaporated meteorite material. They exhibit an enhanced water adsorption cross section due to the strong charge-dipole-interaction. In this work, we study how the nuclear spin state of water molecules affects this enhancement and whether there are conditions that could lead to the formation of spin-polarized ice. Due to symmetry constraints on the total molecular wavefunction, ortho (proton spins parallel) and para (spins antiparallel) water occupy different rotational states, resulting in a different average dipole orientation in electric fields. Therefore, we expect ortho and para water to exhibit distinct adsorption enhancement factors onto charged nanoparticles. Based on Stark-shifts of individual rotational states of water, average dipole orientations of a molecular ensemble and the resulting collision cross section was calculated for various temperatures and particle sizes. We found that in the mesosphere of the Earth (T~150K) the adsorption enhancement of ortho- and para- water is approximately equal while at lower temperatures prevailing around ice giant planets and their moons, significant spin polarizations up to 15% occur.

UP 1.3 Tue 17:15 ZEU/0160

On the colour of noctilucent clouds — •Christian von Savigny[1], Anna Lange[1], Gerd Baumgarten[2], and Alexei Rozanov[3] — [1]Institute of Phyics, University of Greifswald, Greifswald, Germany — [2]Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany — [3]Institute of Environmental Physics, University of Bremen, Bremen, Germany

Noctilucent clouds, also known as polar mesospheric clouds, are a polar summer mesopause phenomenon and they are typically characterised by a silvery-blue or pale blue colour. In this contribution, we investigate the reasons for this colour using the radiative transfer model SCIATRAN in combination with the CIE (International Commission on Illumination) colour-matching functions in order to the determine the resulting colour impression in an objective way. Different processes and parameters potentially affecting the colour of NLCs are investigated, i.e. the size of the NLC particles, the abundance of middle atmospheric O3 and the importance of multiply scattered solar radiation. We confirm earlier studies indicating that absorption of solar radiation in the O3 Chappuis bands can have a significant effect on the colour of the NLCs. It is, however, found that for sufficiently large NLC optical depths O3 plays only a minor role for the blueish colour. The simulations also show that the size of NLC particles affects the colour of the clouds. Cloud particles of unrealistically large sizes can lead to a reddish colour. Furthermore, the simulations show that the contribution of multiple scattering to the total scattering is only of minor importance, providing additional justification for the earlier studies on this topic, which were all based on the single-scattering approximation.

UP 1.4 Tue 17:30 ZEU/0160

Exoplanetary clouds: The potential of high-precision polarimetry — •Moritz Lietzow and Sebastian Wolf — Institute of Theoretical Physics and Astrophysics, Kiel University, Germany

The reflected flux from planets is polarized due to scattering in their atmosphere. While polarimetry is used to study objects in the Solar System, it has also been proposed for detection and characterization of extrasolar planets. In particular, the reflected polarized flux depends not only on the planetary phase angle and observed wavelength, but also on the atmospheric composition, allowing to distinguish between various cloud compositions. Given the accuracy of existing high-precision polarimeters, scattered light polarimetry indeed has the potential to become a powerful tool to characterize exoplanetary atmospheres. First measurements of planet-induced polarization were reported during recent years. To provide the basis for theoretical studies and the interpretation of dedicated polarization measurements, we developed a radiative transfer simulation software that contains all relevant continuum polarization mechanisms for the comprehensive analysis of the polarized flux resulting from the scattering in the atmosphere, on the surface, and in the local planetary environment. In addition, we investigated the impact of the cloud composition and exoplanetary rings on the scattered light polarization.

UP 1.5 Tue 17:45 ZEU/0160

Retrieval of cloud properties using spectropolarimetric simulations of Earthshine — •Orsolya Pari[1], Claudia Emde[1], Michael Sterzik[2], and Mihail Manev[1] — [1]Ludwig-Maximilians-Universität, München, Germany — [2]European Southern Observatory, Garching bei München, Germany

In order to be able to interpret future observations of the atmospheres of Earth-like planets and detect signatures of life, it is important to understand Earth's atmospheric and surface properties. Observations of Earthshine, which is sunlight scattered by Earth to the Moon, and then reflected back to Earth, make it possible to study Earth as an exoplanet.

We use the Monte Carlo radiative transfer model MYSTIC to simulate polarized spectra in the atmosphere of the Earth for Ocean and Lambertian surfaces. A water or an ice cloud layer is included and we vary the cloud parameters (cloud altitude, cloud optical thickness, effective droplet radius).

The focus is on the $O_2 - A$ and H_2O bands, where the degree of polarization can be higher or lower than the adjacent continuum. To quantify this behavior we use the equivalent width, which is the area in the passband between the absorption line and the simulated spectrum without absorption across a specific spectral region.

We find that the equivalent width is highly sensitive to cloud altitude and cloud optical thickness.The simulations are compared to the observations of Earthshine obtained by FORS2 at the VLT for different Sun-Earth-Moon phase angles.

UP 2: Volcanic Effects on Atmosphere and Climate

Time: Wednesday 11:00–12:30 Location: MOL/0213

Invited Talk UP 2.1 Wed 11:00 MOL/0213

Volcanic radiative forcing: past and future — •Anja Schmidt — Institute of Atmospheric Physics (IPA), German Aerospace Center (DLR), Oberpfaffenhofen, Germany — Meteorological Institute, Ludwig Maximilian University of Munich, Munich, Germany — Yusuf Hamied Department of Chemistry, University of Cambridge, Cambridge, United Kingdom

Volcanism is a major driver of climate variability and has played a critical role in the long-term evolution of Earth*s atmosphere and habitability through the release of gases including sulfur species, water, carbon dioxide, and halogens. In this talk, I will summarize my work on volcanic radiative forcing exerted by volcanic eruptions of different magnitudes in the past and in the future. The general mechanisms by which volcanic eruptions affect climate are well understood today. Until recently, research efforts have mainly been focused on the direct radiative, dynamical and chemical effects of sulfate aerosol particles formed by large-magnitude explosive eruptions such as Mt. Pinatubo in 1991. However, eruptions much smaller in magnitude than 1991 Mt. Pinatubo routinely decrease the transparency of the stratosphere to a degree that a cooling effect is discernible in upper tropospheric temperature measurements. I will make a case for the need to include these small-magnitude eruptions in climate model simulations. In addition, I will show that global warming can affect both eruptive column dynamics and the volcanic sulfate aerosol lifecycle and thus the radiative forcing and climate effects of future volcanic eruptions.

UP 2.2 Wed 11:30 MOL/0213

Reduction of average stratospheric aerosol size after volcanic eruptions — •Felix Wrana[1], Ulrike Niemeier[2], Sandra Wallis[1], and Christian von Savigny[1] — [1]Institute of Physics, University of Greifswald, 17489 Greifswald, Germany — [2]Max Planck Institute for Meteorology, 20146 Hamburg, Germany

The evolution of the size distribution of stratospheric aerosols after volcanic eruptions is still not understood very well, due to the temporal sparsity of in situ measurements, the low spatial coverage by ground based observations and the difficulties to derive aerosol size information from satellite measurements. To contribute to this ongoing research, we show data from our aerosol size retrieval using SAGE III/ISS solar occultation measurements. Using a three wavelength extinction approach the parameters of assumed to be monomodal lognormal particle size distributions are retrieved.

Surprisingly we find that some volcanic eruptions can lead to a decrease in average stratospheric aerosol size, in this case the 2018 Ambae eruptions and the 2019 Ulawun eruptions, while other eruptions have a more expected increasing effect on the average particle size, like the 2019 Raikoke eruption. We show how different parameters like the median radius, the absolute mode width and the number density evolve after the mentioned eruptions.

Additionally, as a part of our ongoing research to understand the underlying mechanisms controlling the observed aerosol size reduction, we show simulations of the aforementioned volcanic eruptions using the aerosol-climate model MAECHAM5-HAM.

UP 2.3 Wed 11:45 MOL/0213

A miniaturized chemiluminescence ozone monitor for drone-based measurements in volcanic plumes — •Maja Rüth[1], Ellen Bräutigam[1], Jonas Kuhn[1], Nicole Bobrowski[1], Ulrich Platt[1], and Christopher Fuchs[2] — [1]Institute for Environmental Physics, Heidelberg University, Germany — [2]ETH Zürich, Switzerland

Volcanic plumes contain reactive halogen species, especially bromine monoxide (BrO), which catalyzes ozone (O3) destruction. Therefore, local O3 depletion is commonly assumed inside volcanic plumes and has also been measured to varying degrees at different volcanoes in several studies. However, a calculation comparing atmospheric mixing with the rate of O3 destruction suggests no significant reactive halogen catalysed O3-loss (1% or less) in the plume. So far, O3 and its distribution in volcanic plumes have only been insufficiently determined since commonly used ultraviolet (UV) absorption O3 monitors show interference with sulphur dioxide (SO2), an abundant volcanic gas.

This problem can be overcome by using a chemiluminescence (CL) O3 monitor, which has no known interference from trace gases abundant in volcanic plumes. However, field measurements with former CL O3 monitors are challenging, as they were heavy and bulky.

Here we report on a lightweight version of the instrument (1 kg, shoebox size), which can be mounted onto a drone. In particular, we describe the design advances making the reduction in weight and size possible and present first test measurements. By allowing the instrument to be carried by a drone into the plume, this opens up completely new measurement strategies.

UP 2.4 Wed 12:00 MOL/0213

Highly resolved volcanic SO2 emission flux measurements with imaging Fabry-Perot interferometer correlation spectroscopy — •Jaro Heimann[1], Alexander Nies[1,2], Christopher Fuchs[1,3], Jonas Kuhn[1], Nicole Bobrowski[1,4], and Ulrich Platt[1] — [1]Institute of Environmental Physics, Heidelberg University, Germany — [2]CNRS/University Orleans, France — [3]ETH Zurich, Zurich, Switzerland — [4]INGV, Catania, Italy

Imaging Fabry-Perot interferometer (FPI) correlation spectroscopy (IFPICS) is a robust and mobile imaging technology, to study volcanic trace gas emissions with high temporal resolution and accuracy. The FPI provides a periodic transmission spectrum which is matched to the periodic narrowband absorption structure of the target trace gas (due to vibronic excitations in the UV). From the resulting data an image of trace gas column density can be inferred via an instrument model. Since the image acquisition takes about 2.4s for an image, it is possible to calculate emission fluxes on this timescale.
Here we present SO2 flux measurements from July 2022 at Mt. Etna with an IFPICS instrument with a detection limit of $\approx 5e17\, molec/cm^2$ at 4 Megapixel spatial and 2.4s temporal resolution, e.g. a mean flux of 418 $\pm$ 138 t/day^{-1} for the 15th of July 2021 between 08:17 and 10:13 UTC. We will furthermore discuss uncertainties and challenges of the technique.

UP 2.5 Wed 12:15 MOL/0213

Impact of a strong volcanic eruption on the summer middle atmosphere in UA-ICON simulations — •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

Explosive tropical volcanic eruptions are able to inject large amounts of sulfur dioxide into the stratosphere. Sulfur dioxide mostly converts to sulfate aerosols that can increase the temperature of the lower stratosphere and subsequently alter the stratospheric circulation. This was directly observed after the strong Pinatubo eruption in 1991. The impact on the mesosphere is less well understood, mainly because of a lack of strong eruptions during the satellite era and sparse observations of the middle atmosphere before. Few measurements, however, hint to an increase in mesospheric temperatures after the Pinatubo eruptions. We investigate dynamical mechanisms that could explain such observations by simulating the response of the middle atmosphere to an idealized tropical eruption that emitted twice as much sulfur dioxide as the Pinatubo in 1991 using the upper-atmospheric icosahedral nonhydrostatic (UA-ICON) model. We focus on the first austral summer after the eruption and find a significant warming of the polar summer mesopause of up to 15-21 K. Our study indicates that this mesospheric warming is mainly due to vertical coupling through wave-mean flow interaction in the summer hemisphere and potentially enhanced by interhemispheric coupling (between the winter stratosphere and the summer mesosphere).

UP 3: Members' Assembly

Time: Wednesday 13:00–14:00 Location: MOL/0213

All members of the Environmental Physics Division are invited to participate.

UP 4: Aerosols & Hydrological Cycle

Time: Wednesday 14:00–15:30 Location: MOL/0213

UP 4.1 Wed 14:00 MOL/0213

Mineralstaub - Vom Feldexperiment ins Labor und zurück ins Feld — •Moritz Haarig, Ronny Engelmann und Albert Ansmann — Leibniz Institut für Troposphärenforschung, Leipzig

Mineralstaub stellt den größten (Massen-)Anteil des atmosphärischen Aerosols. Er wird von den großen Wüsten der Erde emittiert und über mehrere tausend Kilometer weit transportiert. Dabei beeinflusst er Wolken- und Niederschlagsbildung und den Strahlungshaushalt der Erde. Mittels Lidartechnologie können die Staubwolken höhenaufgelöst beobachtet werden. Das Leibniz Institut für Troposphärenforschung (TROPOS) betreibt Lidargeräte unter anderem auf den Kapverden, in Zypern und Tadschikistan. Die Messung des Depolarisationsverhältnisses erlaubt eine Trennung des Staubes von anderen Aerosolen, da Mineralstaubpartikel durch eine irreguläre Form gekennzeichnet sind. Die multispektrale Depolarisationsinformation enthält weitere Informationen über die Partikelform und Größenverteilung. Allerdings erschwert es die unregelmäßige Form eines Staubpartikels, seine Streueigenschaften zu modellieren und von optischen auf mikrophysikalische Eigenschaften zu schließen. Für ein besseres Verständnis sind Labormessungen dringend erforderlich, um so die optischen Partikelmodelle zu verbessern. Im Rahmen einer Leibniz Junior Research Group wird ein solches Labor am TROPOS aufgebaut. Größenselektierte Staubproben aus verschiedenen Wüsten sollen vermessen werden. Die Messung bei genau 180° Rückstreuung stellt große Herausforderungen an den optischen Aufbau, ist aber zwingend notwendig für ein besseres Verständnis der Lidarmessungen vom Boden und aus dem Weltraum.

UP 4.2 Wed 14:15 MOL/0213

50 Jahre Lidar-Messungen in Garmisch-Partenkirchen: Langzeit-Meßserie des stratosphärischen Aerosols — •Thomas Trickl, Helmuth Giehl, Horst Jäger und Hannes Vogelmann — Karlsruher Institut für Technologie, IMK-IFU, Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen

Bald nach der Erfindung des Lidars wurde 1973 am IFU in Garmisch-Partenkirchen das erste Aerosol-Lidar-System in Betrieb genommen. Ab 1976 wurde mit diesem eine Langzeit-Meßserie des stratosphärischen Aerosols erstellt, welche seit 2016 am Schneefernerhaus auf der Zugspitze fortgesetzt wird. Die verbesserte Empfindlichkeit des neuen Systems erlaubt es, Messungen nun bis in über 45 km Höhe durchzuführen. Das stratosphärische Aerosol reicht über Mitteleuropa meist bis in knapp 30 km Höhe. In Einzelfällen wurden jedoch schon Beiträge bis fast 40 km nachgewiesen. Die Partikel in der Stratosphäre stammen von starken Vulkanausbrüchen, massiven Waldbränden, Wüstenstaub, aber auch vom Flugverkehr. Im Falle von tropischen Eruptionen bleiben die Aerosole mehrere Jahre in der Stratosphäre, sonst nimmt die Belastung innerhalb eines Jahres stark ab. In den vergangenen Jahren haben die Beiträge von hochreichenden Pyro-Kumulonimbus-Ereignissen deutlich zugenommen. Die Ursachen hierfür sind noch nicht klar.

UP 4.3 Wed 14:30 MOL/0213

Aerosol measurements in the Tropo- and Stratosphere by spectral splitting of Rayleigh and Mie signals with mobile lidar system VAHCOLI. — •Ronald Eixmann[1], Gerd Baumgarten[1], Jan Froh[1], Josef Höffner[1], Alsu Mauer[1], Mense Mense[1], Bernd Jungbluth[2], Alexander Munk[2], Sarah Scheuer[2], and Michael Strotkamp[2] — [1]Leibniz Institute of Atmospheric Physics, Kühlungsborn, Germany — [2]Fraunhofer Institute for Laser Technology, Aachen, Germany

By combining a novel diode-pumped alexandrite ring laser with a narrow bandwidth (FWHM ∼3 MHz) and a tuned interferometer (FWHM ∼7.5 MHz), a separation of the atmospheric molecular and aerosol backscatter in the receiver of the mobile Lidar system (VAHCOLI) is possible. Matching the frequency of the pulsed laser from pulse to pulse with sub-MHz accuracy relative to the interferometer enables Doppler aerosol measurements with a largely reduced Rayleigh signal. This enables aerosol measurements from the ground up to an altitude of ∼25 km as well as Doppler wind measurements from the Doppler shift. The technical specifications of the VAHCOLI Lidar system ($1m^3$) allow background-free measurements during the day and 24/7 measurement operation in the future.

UP 4.4 Wed 14:45 MOL/0213

Simulating green volcanic sunsets — •Christian von Savigny and Anna Lange — Institute of Phyics, University of Greifswald, Greifswald, Germany

Volcanic sunsets are usually associated with extended and enhanced reddish colors as well as purple colors higher up. Both of these effects are well understood and can be simulated with radiative transfer models based on appropriate assumptions. However, in some cases eyewitness accounts include reports of clear and distinct green colors in the evening sky. This was particularly the case after the 1883 eruption of Krakatoa. To our best knowledge no studies exist attempting to provide an explanation for this unusual phenomenon. In this contribution we employ radiative transfer simulations to provide an explanation for green sunsets. They can be explained with plausible assumptions by anomalous scattering on stratospheric aerosols having a suitable particle size distribution with sufficiently large mean particle size and a preferably narrow width. We investigate the sensitivity of the twilight colors to relevant parameters such as aerosol optical depth, the parameters of the particle size distribution and the amount of ozone. Apart from a specific particle size, a sufficiently large aerosol optical depth is required to explain green sunsets.

UP 4.5 Wed 15:00 MOL/0213

Sediment transport in Indian rivers high enough to impact satellite gravimetry — •Alexandra Klemme[1], Thorsten Warneke[1], Heinrich Bovensmann[1], Matthias Weigelt[2], Jürgen Müller[2], Tim Rixen[3], Justus Notholt[1], and Claus Lämmerzahl[4] — [1]Institute of Environmental Physics, University of Bremen, Germany — [2]Institute of Geodesy, Leibniz Universität Hannover, Germany — [3]Leibniz Center for Tropical Marine Research, Bremen, Germany — [4]Centre of Applied Space Technology and Microgravity, University of Bremen, Germany

Satellite gravimetry is used to study the global hydrological cycle. It is a key component in the investigation of groundwater depletion on the Indian subcontinent. Mass loss by sediment transport in rivers is assumed to be below the detection limit of current gravimetric satellites like GRACE-FO. Thus, it is not considered in the calculation of terrestrial water budgets from gravimetric data. However, the Indian subcontinent is drained by some of the world's most sediment rich rivers and mass loss by sediment transport will impact long term gravimetric anomalies. We estimate the impact of sediment mass loss within different river catchments on gravimetric estimates of trends in terrestrial water storage. For the Ganges-Brahmaputra-Meghna catchment, our results indicate that sediment transport could account for $(6 \pm 3)\,\%$ of the gravity anomalies attributed to groundwater depletion. For erosion-prone Himalaya regions, we find an average sediment mass loss of $2\,\mathrm{kg\,m^{-2}\,yr^{-1}}$ which is almost 20 % of the observed gravity anomaly.

UP 4.6 Wed 15:15 MOL/0213

Validation potential for Remote Sensing soil moisture products using Cosmic-Ray Neutron Sensing — •Markus Köhli, Jannis Weimar, and Ulrich Schmidt — Physikalisches Institut, Heidelberg University

The novel method of Cosmic-ray neutron sensing (CRNS) allows for non-invasive soil moisture measurements at a hectometer scaled footprint. This technique relies on the measurement of neutrons originating from cosmic-ray induced air showers. The key characteristic of the method is the exceptionally high moderation strength of hydrogen. It slows down fast neutrons whereas other heavier elements independent of the chemical composition rather reflect them. The result is an inverse relation of the above-ground neutron intensity to soil moisture. Due to neutrons being transported over the air over hundreds of meters, the measurement is representative for an area on the scale of hectares. In the recent years the interest was set to understanding neutron transport by Monte-Carlo simulations for complex environmental topographies. Its remarkable performance in signal interpretation allows for a promising prospect of more comprehensive data quality. This especially addresses mobile applications, which is the current focus of development. With roving it is possible to cover the scale of one square kilometer per day with one instrument. Satellite-based products can specifically profit from data assimilation of CRNS-based representative measurements of soil moisture. With its large integral footprint and its penetration depth of several decimeters, high-quality data sets can be obtained as ground truthing for remote sensing products.

UP 5: Measurement Techniques and Simulations

Time: Wednesday 16:00–17:00 Location: MOL/0213

UP 5.1 Wed 16:00 MOL/0213

Concept of a Raman-based microfluidic system for measuring trace substances in the field of wastewater treatment — •Simon Jansen, Jan Berk, Sebastian Mammitzsch, and Martin Reufer — Hochschule Ruhr West, Institut Naturwissenschaften

In wastewater treatment plants, sewage is cleaned in various purification stages. But not all impurities are removed in this process. In particular, easily water-soluble substances and those that are difficult to biodegrade, such as pharmaceutical residues, are present in low but nevertheless environmentally harmful concentrations ($\sim \mu g/l$). To reduce the residual amount of these substances, an additional (fourth) purification stage is currently implemented in the wastewater treatment plants. The efficiency of this purification stage can be determined and controlled on the basis of the so-called lead substances with classical analytical methods like gas chromatography-mass spectrometry or indirectly by proof of a sum parameter. We demonstrate a measurement concept suitable for an inline approach, based on a microfluidic system. This concept provides for a concentration of the lead substances by specific binding to surface-activated magnetic beads and a subsequent determination of the concentration. The approach for concentration measurement is based on Raman spectroscopy, due to the distinguishable fingerprint of the different trace elements. This measurement concept is advantageous because the purification process will be monitored and optimised based on the concentration of the lead substances. First results of the particle concentration in the microfluidic system and the subsequent analysis are presented.

UP 5.2 Wed 16:15 MOL/0213

Optimization of excitation and detection windows for the optical detection of microplastics via photoluminescence — •Stefan Brackmann, Srumika Konde, Katharina Gejer, Marina Gerhard, and Martin Koch — Department of Physics and Material Sciences Center, Philipps-Universität Marburg, Renthof 5, 35032 Marburg, Germany

Current microplastics research utilizes subjective hand-picking of particles to identify plastic particles. Recently the first methods using visible photoluminescence to detect plastic particles have been publicized. Here, we investigate the excitation and detection wavelength range suitable to 12 common virgin polymer types. Based on our findings, we recommend a range from 270 to 320 nm for the excitation and 320-425 nm for the detection window. We further show that plastics have unique UV-PL signatures that may be suitable for identifying microplastic particles. This approach may lead to a low-cost alternative to the established methods.

UP 5.3 Wed 16:30 MOL/0213

Time-resolved simulations of wind speed fluctuations across atmospheric boundary layers using a stochastic forward model — •Marten Klein and Heiko Schmidt — BTU Cottbus-Senftenberg, Cottbus, Germany

Atmospheric boundary layers (ABLs) govern the atmosphere–surface coupling and are therefore of fundamental relevance for Earth's weather and climate system. Time-resolved numerical simulations of ABLs are challenging due to intricate interactions of inertial, Coriolis, buoyancy, and viscous forces on all relevant scales of the turbulent flow. Small-scale processes, albeit potentially nonuniversal, are typically not resolved due to cost constraints but modeled based on physically justified relations with the resolved scales, neglecting expensive backscatter. This lack in modeling is addressed here by utilizing a dimensionally reduced stochastic modeling approach. The model aims to reproduce turbulent cascade phenomenology by a stochastic process, respecting fundamental physical conservation principles. Momentary wind velocity and temperature profiles evolve autonomously in time for an ensemble of initial conditions. By comparison with available high-fidelity reference numerical simulations, reanalysis, and observations, it is shown that the model captures various relevant flow properties, exhibiting limitations mainly in a delayed relaminarization under very stable conditions. Forthcoming research aims to contribute to a better understanding of polar boundary layers, requiring predictive modeling capabilities, high resolution, and numerical efficiency to perform long-time simulations.

UP 5.4 Wed 16:45 MOL/0213

Simulated outdoor efficiency and performance ratio of a III-V-on-Si solar panel for direct solar hydrogen production — •Johannes Grabenstein[1,2], Moritz Kölbach[3], Matthias M May[3], Klaus Pfeilsticker[1], and Kira Rehfeld[1,2] — [1]Institut für Umweltphysik, Universität Heidelberg, Germany — [2]Geo- und Umweltforschungszentrum, Universität Tübingen, Germany — [3]Institut für Physikalische und Theoretische Chemie, Universität Tübingen, Germany

Tandem solar cells might play a substantial role in future energy systems and in negative emission technologies, both for electricity- and direct hydrogen generation. In a tandem solar cell, photocurrent mismatch between the absorber layers due to variation in the spectral irradiance distribution induces efficiency losses. Together with the temperature-related efficiency modulation, this effect gives rise to its sensitivity to climatic conditions. Here, the performance of an AlGaAs-on-Si tandem solar cell that is either used for electricity production or directly connected to an anion exchange membrane electrolyzer is evaluated for different locations on earth using numerical modeling. The ratio between the outdoor harvesting efficiency and efficiency at standard conditions [1] lies within 0.86 and 0.95 for electricity- and within 0.91 and 0.95 for hydrogen production. This study allows to improve performance predictions and highlights how tuning the top absorber band gap to the prevailing spectral irradiance composition can enhance the harvesting efficiency, depending on the location. [1] Kölbach et al., Sustainable Energy Fuels, 2022, **6** DOI:10.1039/D2SE00561A

UP 6: Poster

Time: Wednesday 17:30–19:00 Location: HSZ OG1

UP 6.1 Wed 17:30 HSZ OG1

Straylight characterization of airborne imaging remote sensing instruments of the MAMAP2D family for greenhouse gas observations — •Oke Huhs, Konstantin Gerilowski, Sven Krautwurst, Jakob Borchardt, Heinrich Bovensmann, and John P. Burrows — University of Bremen, Institute of Environmental Physics, Otto-Hahn-Allee 1, 28359 Bremen, Germany

Airborne measurements of atmospheric column enhancements of methane (CH_4) and carbon dioxide (CO_2) from anthropogenic point sources were performed with the Methane Airborne MAPer (MAMAP) since 2007, which delivers 1D spatial data by measuring the spectrum of backscattered solar radiation. To measure 2D spatial data from a single overflight, a new generation of passive airborne imaging remote sensing grating spectrometers is being developed and built by IUP Bremen. The MAMAP2D-Light instrument was already successfully flown during the COMET 2.0 Arctic campaign in Canada in summer 2022 measuring CO_2 and CH_4 enhancements in a short-wave infrared band around 1.6 μm. The MAMAP2D instrument, which has an additional near-infrared O2A-band channel and a higher spectral resolution, has delivered measurement data in a laboratory environment. For the characterization of remote sensing instruments, straylight is one important quantity. Straylight occurs due to reflections and scattering within the spectrometer and must be characterized well to establish a straylight correction. Therefore, straylight was characterized down to 7 orders of magnitude below the integrated incident illumination level for MAMAP2D and MAMAP2D-Light.

UP 6.2 Wed 17:30 HSZ OG1

Calibration of an Air Data Probe to complement airborne in-situ Flux Measurements — •Josua Schindewolf — Institut für Umweltphysik, Universität Bremen, Deutschland

Airborne in-situ measurements of greenhouse gases (GHG) contribute to the increasingly important task of monitoring the changing greenhouse gas emissions and attribution of the sources. For the quantification of GHG sources, not only observations of precise atmospheric concertation gradients are needed, but also accurate measurements of the corresponding wind fields. This is because, the computation of the emissions and their uncertainties have linear dependencies on wind speed and direction. In 2022 we installed and calibrated a new turbulence probe to the underwing pod of the research aircraft of the Jade University Wilhelmshaven to complement future airborne flux measurements with high accuracy wind data. A series of flights were conducted to carry out the in-flight calibration procedure recommended by the manufacturer. Additionally, a meteorological observation tower was used for a series of fly-by manoeuvres, providing ground-based reference wind data. The calibration exhibits a mean difference in wind speed of 0.3 m/s and in wind direction of 4° over ten such calibration flights. The tower comparison showed a mean difference in wind speed of 0.5 m/s and in wind direction of 20°. In summary, the results indicate that more calibration flights are required for a further evaluation, which will focus on the comparison with the ground based met tower observations. This is challenging, because of the high variability of the wind fields at low flight altitudes.

UP 6.3 Wed 17:30 HSZ OG1

On the twilight phenomenon of the green band — •Anna Lange[1], Alexei Rozanov[2], and Christian von Savigny[1] — [1]Institute of Physics, University of Greifswald, Germany — [2]Institute of Environmental Physics, University of Bremen, Germany

The twilight sky is usually characterised by the well-known reddish/orange colours close to the horizon and the blue colours above. However, in many cases a green or greenish band forms between the blue and reddish parts of the sky, and it is essentially not documented in the literature. In this study, the green band phenomenon is simulated using the radiative transfer model SCIATRAN and subsequent colour modelling based on the CIE colour matching functions and chromaticity values. Different parameters and processes that have a potential influence are investigated. In addition, a possible contribution by airglow emissions is discussed. The simulations show that it requires just the right intensities in the blue, green, and long-wave spectral regions to produce a green colour. The total ozone column has the comparatively largest influence. This study is, to the best of our knowledge, the first detailed investigation of the green band phenomenon.

UP 6.4 Wed 17:30 HSZ OG1

Investigation of a method to analyse OH(3-1) Mesopause temperature and two-dimensional imager data of the OH-airglow layer — •Lukas Depenthal[1], Christian von Savigny[1], Christoph Hoffmann[1], and Philipp Mattern[2] — [1]Institute of Physics, University of Greifswald, Greifswald, Germany — [2]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany

The University of Greifswald operates two instruments to measure airglow emissions at an altitude of about 87 km. The Andor Shamrock SR-163 Infrared spectrometer is used to detect OH-Meinel bands at 1500 nm - 1600 nm as OH(3-1) rotational-vibrational spectroscopy. Based on the relative intensities of the OH(3-1)-lines, conclusions about the mesopause temperature are drawn and examined with regard to their variability. Based on these investigations, dynamic processes in the mesopause can be investigated. Since the spectrometer has a temporal resolution of 15 s, variations with periods of about 5-20 minutes can be determined. The ongoing measurements started in 2015.

In addition, a Xenics Cheetah 640CL infrared camera is used as an OH airglow imager to visualize spatial structures and gravity wave signatures within the OH airglow layer. With a resolution of 640 x 512 pixels, wavelengths of several kilometers can be observed. These measurements started in August 2020 and have continued since then. Using principal component analysis, it is possible to determine periods of about 5-20 minutes, as in the spectrometer data. Due to the side by side installation of the instruments, the data can be compared with each other.

UP 7: Greenhouse Gases: Remote Sensing

Time: Thursday 11:00–12:15 Location: MOL/0213

Invited Talk UP 7.1 Thu 11:00 MOL/0213

Towards monitoring of anthropogenic greenhouse gas emissions from satellites — •Hartmut Bösch[1,2], Antonio Di Noia[1], Neil Humpage[1], Alex Webb[1,3], Harjinder Sembhi[1], Robert Parker[1], Michael Buchwitz[2], Max Reuter[2], Oliver Schneising[2], Stefan Noel[2], and Heinrich Bovensmann[2] — [1]University of Leicester, Leicester, UK — [2]IUP, University of Bremen, Bremen, Germany — [3]Oklahoma University, Oklahoma, USA

To limit global warming to well below 2C compared to pre-industrial levels requires a decarbonization of the economy and many countries have pledged to reach net-zero emissions by 2050 but progress has been slow so far. Satellite observations of CO2 and CH4 will play a key role for tracking progress towards emission reduction targets and for verifying the effectiveness of mitigation policies. Satellites also provide information on natural sinks which store large amounts of carbon and play a potentially important role in the pathway towards net-zero emission.

In this presentation, I will introduce the key concepts for satellite observations of CO2 and CH4 and present examples how we use current, dedicated satellite missions to quantify regional surface fluxes of natural and anthropogenic sources. I will discuss how such dedicated missions can be complemented by hyperspectral satellites with high spatial resolution that allow constraining individual emission sources. The presentation will end with an outlook to the upcoming Copernicus CO2 Monitoring (CO2M) Mission, the space component of the European anthropogenic CO2 Monitoring & Verification Support Capacity.

UP 7.2 Thu 11:30 MOL/0213

Seasonal and Interannual Variability of Australian Carbon Fluxes Seen by GOSAT — •Andre Butz[1], Eva-Marie Metz[1], Sanam Vardag[1], Sourish Basu[2], Martin Jung[3], and Stephen Sitch[4] — [1]Institut für Umwetlphysik, Universität Heidelberg, Germany — [2]NASA Goddard Space Flight Center, University of Maryland, USA — [3]Max Planck Institute for Biogeochemistry, Jena, Germany — [4]University of Exeter, Exeter, UK

The semi-arid Australian continent significantly influences the interannual variability of the global terrestrial carbon sink. The sparsity of in-situ CO2 and flux measurements, however, leads to large uncertainties in estimated carbon fluxes for the continent. Satellite measurements of CO2 offer an independent and spatially extensive source of information about the Australian carbon cycle. Here, we examine the decadal data set (2009-2018) of atmospheric CO2 mole fractions delivered by the Greenhouse Gases Observing Satellite (GOSAT). We find previously undected CO2 pulses at the end of the dry season that we attribute to the quick onset of respiration after the dry period. These pulses dominate the seasonal and the year-to-year variability of Australia's carbon balance.

UP 7.3 Thu 11:45 MOL/0213

Emission estimates of carbon dioxide and methane with a ground-based imaging spectrometer — •Marvin Knapp[1], Leon Scheidweiler[1], Felix Külheim[1], Ralph Kleinschek[1], Jaroslaw Necki[2], Pawel Jagoda[2], and Andre Butz[1] — [1]Institute of Environmental Physics, Heidelberg University, Im Neuenheimer Feld 229, 69120 Heidelberg — [2]Faculty of Physics and Applied Computer Science, AGH University of Science and Technology, Krakow, Poland

Carbon dioxide (CO_2) and methane (CH_4) emissions into the atmosphere are the strongest anthropogenic drivers of global climate change. Mitigation strategies rely on precise knowledge of the strength and distribution of these greenhouse gas sources. Spectroscopic techniques emerge that enable imaging of atmospheric CO_2 and CH_4 plumes from

strong point sources and thus, facility-scale emission estimates.
We show results of CO_2 and CH_4 emission plume images from ground-based observations with a NEO HySpex SWIR-384 hyperspectral camera. The camera takes images of sky-scattered sunlight in the shortwave-infrared range (1-2.5 μm) at kilometer distance to point sources. An adapted matched filter retrieval is used to calculate atmospheric enhancements of CO_2 and CH_4 from their 2 μm absorption bands. We present CO_2 emission plumes of a medium-sized power plant (>4.9 MtCO2/yr), which we detect reliably in hourly averaged spectral images. Furthermore, we successfully observed methane plumes from a coal mine shaft in Silesia, Poland, with a temporal resolution of roughly 1 minute, discovering emission dynamics on time scales from minutes to days.

UP 7.4 Thu 12:00 MOL/0213

Ozonmessungen auf der Zugspitze 1978-2020: Woher stammt der Ozonanstieg? — •Thomas Trickl[1], Cédric Couret[2], Ludwig Ries[2] und Hannes Vogelmann[1] — [1]Karlsruher Institut für Technologie, IMK-IFU, Kreuzeckbahnstr. 19, 82467 Garmisch-Partenkirchen — [2]Umweltbundesamt II 4.5, Schneefernerhaus, 82475 Zugspitze

Die Meßserie des troposphärischen Ozons auf der Zugspitze (2962 m) von 1978 bis 2011 zeigt bis 2003 einen deutlichen Konzentrationsanstieg auf, der im Vergleich mit anderen Langzeit-Serien besonders herausragt. Die Erklärung hierfür liegt an einer Zunahme des Absinkens von Stratosphärenluft, die mit einem Austrocknen der freien Troposphäre einhergeht. Kaum verzögert zum Rückgang der Sonnenaktivität seit ca. 20 Jahren hat der Ozonanstieg deutlich abgenommen. Die Messungen am 0.3 km tiefer gelegenen Schneefernerhaus (2660 m) haben die Trendänderung bis 2020 bestätigt. Ferner wurde eine klare Abnahme des troposphärischen CO gefunden, wohingegen der Trend für CO aus der untersten Stratosphäre leicht positiv ist. Die CO-Abnahme bestätigt die Verbesserung der Luftqualität in der Troposphäre.

UP 8: Carbon Cycle & Climate Change

Time: Thursday 14:00–15:15 Location: MOL/0213

Invited Talk UP 8.1 Thu 14:00 MOL/0213

Destabilization of carbon in tropical peatlands by enhanced weathering — •Alexandra Klemme[1], Tim Rixen[2], Moritz Müller[3], Justus Notholt[1], and Thorsten Warneke[1] — [1]Institute of Environmental Physics, University of Bremen — [2]Leibniz Center for Tropical Marine Research, Bremen — [3]Faculty of Engineering, Computing, and Science, Swinburne University of Technology Sarawak Campus

Southeast Asian peatlands represent a globally significant carbon store. Recent land use changes destabilize the peat, causing increased leaching of peat carbon into rivers. Despite resulting high river organic carbon concentrations, field data suggests only moderate carbon dioxide (CO2) emissions from rivers. We offer an explanation for this phenomenon by showing that carbon decomposition is hampered by the low pH in peat-draining rivers, and we find that enhanced input of carbonate minerals increases CO2 emissions by counteracting this pH limitation. One potential source of carbonate minerals to rivers is the application of enhanced weathering, a CO2 removal strategy that accelerates weathering-induced CO2 uptake from the atmosphere via the dispersion of rock powder. The effect of enhanced weathering on peatland carbon stocks is poorly understood. We present estimates for the response of CO2 emissions from tropical peat soils, rivers and coastal waters to enhanced weathering induced changes in soil acidity. The potential carbon uptake associated with enhanced weathering is reduced by $18-60\,\%$ by land-based re-emission of CO2 and is potentially offset completely by emissions from coastal waters.

Invited Talk UP 8.2 Thu 14:30 MOL/0213

Widespread forest decline in central Europe following three extreme summers in 2018-2020 — •Ana Bastos — Max Planck Institute for Biogeochemistry, Hans Knöll Str 10, 07745 Jena

Among the ten hottest summers in Europe since 1880, only two happened before 2010 (2003 and 2006). In Europe and other temperate regions, summers like 2003 and 2010 were extremely rare in the past, but are projected to happen every few years in the coming decades. Since they are stochastic to some extent, this means such extreme events do not necessarily happen at regular intervals, and they may cluster in time and/or space.

Together with that of 2003, the summers of 2018, and 2019 were exceptionally hot and dry in central Europe. In 2020, drought conditions persisted over a large region. Such a sequence of three exceptionally hot and dry summers is unprecedented in the observation-based record since 1950 and triggered a series of cascading effects that resulted in large-scale forest decline and tree mortality.

It is unclear to which extent this large-scale tree mortality event, driven by three consecutive extreme summers, reveals an anthropogenic fingerprint or whether these could have happened due to natural climate variability and disturbance interactions. This talk will discuss the conceptual and practical challenges of answering this question. Then, recent work addressing different aspects of this question from both data-driven and process-based modeling perspectives will be presented.

UP 8.3 Thu 15:00 MOL/0213

STEPSEC: Update und erste Ergebnisse — •Stefanie Falk für die STEPSEC-Kollaboration — Ludwig-Maximilians-Universität München (LMU)

Um sowohl nationale als auch internationale Klimaschutzziele einhalten zu können und den globalen Temperaturanstieg zu begrenzen, sind massive Reduktionen des CO_2-Ausstoßes notwendig. Da die bisherigen Maßnahmen zur Emissionsreduktion weltweit nicht ausreichend sind, müssen Wege gefunden werden, mehr Treibhausgase zu binden, als ausgestoßen werden. Wir führen eine robuste und vergleichende Bewertung der Potenziale der gängigsten Methoden landgebundener Kohlenstoffdioxidabscheidung (CDR_L) und ihrer Auswirkungen auf das Erdsystem unter der Annahme sozio-ökologischer Randbedingungen durch.
Unter Verwendung von drei dynamischen globalen Vegetationsmodellen (DGVMs) vergleichen wir Aufforstung, Waldbewirtschaftung und Bioenergie mit Kohlenstoffabscheidung und -speicherung. Dies erlaubt es das CDR_L-Potenzial mit hohem ökologischen Realismus zu untersuchen. Da gesellschaftliche Zwänge wichtige Hindernisse für die Umsetzung von CDR_L darstellen können, werden auch sozio-ökonomische Gesichtspunkte, basierend auf sozio-ökonomischen Pfaden und agentenbasierten Modellen, für die Landnutzungsentscheidungen Eingang finden.
Diese umfassende und interdisziplinäre Untersuchung von CDR_L Methoden wird eine fundierte Entscheidungsfindung ermöglichen.