Environmental Physics Division
Fachverband Umweltphysik (UP)

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Overview of Invited Talks and Sessions

(Lecture halls H3 and H7; Poster P)

Plenary Talk of the Environmental Physics Division

PV X	Fri	9:45–10:30	Audimax	**How does the heat get to the ice? - Comprehensive year-round observations of ocean-ice-atmosphere interactions in the high Arctic Ocean** — •Christian Haas, MOSAiC Team

Invited Talks

UP 2.1	Thu	14:00–14:20	H3	**BLUESKY - Atmospheric Composition Changes during the Corona Lockdown 2020** — •Christiane Voigt, Jos Leliefeld, Johannes Schneider, Daniel Sauer, Ralf Meerkötter, Silke Gross, Ulrich Schumann, Mira Pöhlker, Laura Tomsche, Mariano Mertens, Hans Schlager
UP 2.4	Thu	14:50–15:10	H3	**Nucleation and growth of atmospheric aerosol particles: Recent results from CLOUD at CERN** — •Joachim Curtius
UP 5.1	Fri	14:00–14:30	H7	**Ozone in the troposphere responds to reduced precursor emissions during the COVID-19 pandemic** — •Wolfgang Steinbrecht

Invited talks of the joint symposium What makes an exoplanet habitable (SYEP)

See SYEP for the full program of the symposium.

SYEP 1.1	Wed	14:00–14:30	Audimax	**Requirements for Earth-like habitats** — •Helmut Lammer
SYEP 1.2	Wed	14:30–15:00	Audimax	**Geological drivers of habitability** — •Raymond T. Pierrehumbert
SYEP 1.3	Wed	15:00–15:30	Audimax	**Space Weather from an Active Young Sun and Its Impact on Early Earth** — •Vladimir Airapetian
SYEP 1.4	Wed	15:30–16:00	Audimax	**Habitable zones around stars and the search for extraterrestrial life** — •James F. Kasting

Sessions

UP 1.1–1.7	Thu	11:00–12:45	H3	**Oceanography and Climate Modelling**
UP 2.1–2.8	Thu	14:00–16:10	H3	**Clouds and Aerosols**
UP 3	Thu	18:00–19:00	MVUP	**Annual General Meeting**
UP 4.1–4.6	Fri	11:00–12:30	H7	**Measurement Techniques & Miscellaneous**
UP 5.1–5.6	Fri	14:00–15:45	H7	**Atmospheric Trace Gases**
UP 6.1–6.8	Fri	16:30–18:30	P	**Poster Session**

Annual General Meeting of the Environmental Physics Division

Thursday 18:00–19:00 Link will be provided by e-mail

UP 1: Oceanography and Climate Modelling

Time: Thursday 11:00–12:45 Location: H3

UP 1.1 Thu 11:00 H3

On the Serious Limitations of Current Field Measurements and Measuring Techniques for Air-Sea Gas Exchange — •Bernd Jähne — HCI am IWR, Universität Heidelberg — Institut für Umweltphysik, Universität Heidelberg

Despite half a century of field measurements of the gas transfer velocity across the air-ocean interface, it is still not possible to provide a reliable relation between the gas transfer velocity and the parameters driving the exchange process from these measurements. The basic limitations are two-fold. Firstly, the data mainly cover only medium wind speeds and show discrepancies which are not yet understood. Secondly, none of the existing field measuring techniques is really suitable for low-wind speeds. Mass balance methods suffer from the long time constants and eddy covariance measurements from too low fluxes. Active thermography does not work either, because of the need to heat a too large patch at the water surface. The floating chamber technique is not suitable at all to measure gas transfer velocity because it cuts off the wind shear at the water surface, sensible and latent heat transfer and disturbs the wind-wave field.

In consequence, novel field measuring techniques need to be invented, which avoid the disadvantages and shortcomings of the existing technique. In addition, laboratory measurements must be performed, which simulate the oceanic conditions in an appropriate way, close the fetch-gap and wave-age gap and give direct insight into the mechanisms.

UP 1.2 Thu 11:15 H3

Thermohaline circulation - the role of advection in dynamics and stability — •Leonie Neitzel and Edeltraud Gehrig — RheinMain University of Applied Science, Germany

In recent years ongoing research of climate and environmental problems reveal the importance of thermohaline circulation on climate changes. The large-scale ocean circulation is driven by density gradients created by global surface salinity and temperature distributions. It can be modelled with box-models for the polar and equatorial regions of the earth. The boxes are coupled by deep water currents and surface currents that, in turn, depend on the parameter values of salinity and temperature. The dynamic system represented by the boxes and the currents typically exhibits a characteristic dynamics including e.g. bifurcations revealing critical regimes and consequently abrupt changes in the climate. In our approach we couple the model quations to an advection equation describing the changes in the density distribution within a box. This allows to investigate the role of local density changes induced by e.g. environmental influences or pollution. Our results demonstrate that local density changes created by e.g. an initial perturbation enter the thermohaline circulation via the currents and additionally affect the dynamics and stability of the system. Our comparative study of selected box models (Stommel, Marotzke and Welander model) reveals an influence of the dynamics on advective processes as well as dependencies on parameters and model approach.

UP 1.3 Thu 11:30 H3

Horizontal Wave Number Spectra in the Upper Ocean — •Jan Eric Stiehler, Christian Mertens, and Maren Walter — Institut of Environmental Physics, University of Bremen

Even though the spectra of motions in the atmosphere are well known, the same does not hold for the ocean. This has a quite simple reason: velocity measurements in the atmosphere are way more available compared to ocean current measurements as a result of the large amount of airplanes. Resolving temporal and spacial time scales is also easier in the atmosphere due to planes being able to cover much greater areas in the same time compared to ship based measurements. Those motions can be divided into a horizontally rotational part which corresponds to vortex motions in geostrophic balance and a divergent part which resembles internal gravity waves. This is accomplished by calculating and decomposing the spectra of measured shipboard underway ocean current velocity sections and velocity data from a gravity wave resolving ocean general circulation model. The shapes of the resulting model spectra compare well to the observational spectra even though they have approximately an order of magnitude less energy. Both roughly follow a k^{-3} power law at scales of 50 km to 200 km and k^{-2} at scales larger than 200 km. The results will also be used to look further into the limits of applicability of this method.

UP 1.4 Thu 11:45 H3

A Virtual Field Campaign along the MOSAiC track — •Rajka Juhrbandt[1], Suvarchal K. Cheedela[1], Nikolay Koldunov[1,2], and Thomas Jung[1,3] — [1]Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung (AWI), Bremerhaven, Germany — [2]MARUM - Center for Marine Environmental Sciences, Bremen, Germany — [3]Institute of Environmental Physics, University of Bremen, Bremen, Germany

The recently completed Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) can serve as reference to evaluate current and future ocean state of the Arctic Ocean. With this premise, we perform a virtual MOSAiC expedition in historical and ssp370-scenario experiments in data generated by CMIP6 models. Results for other paths are presented additionally.

The timespan covered ranges from preindustrial times (1851-1860) through present-day up to a 4K world (2091-2100). Preliminary results using AWI-CM model suggest that for scenario simulations a thinning of the colder surface layer and a warming of the layer between 200 and 1200 m along the MOSAiC path can be expected, while there is no significant change in temperature below this depth.

The Python-centric tool used for the analysis simplifies preprocessing of a pool of CMIP6 data and selecting data on space-time trajectory. It exposes an interface that is agnostic to underlying model or its grid type. The tool's ease of use is presented to demonstrate the potential for similar virtual field campaigns using past observations and arbitrary trajectories

UP 1.5 Thu 12:00 H3

Arctic amplification: The role of moisture — •Felix Pithan — Alfred Wegener institute, Helmholtz Centre for Polar and Marine research, Bremerhaven

Global climate change is amplified in the Arctic mostly because of the surface albedo feedback and the stable stratification of the Arctic (wintertime) lower troposphere trapping most warming near the surface. While the water vapour feedback is much stronger at low than high latitudes, moist processes do have important implications for Arctic climate and climate change which will be discussed in this presentation. Much of the wintertime transport of moisture into the Arctic occurs in discrete intrusion events that substantially alter atmospheric profiles and the surface energy budget. Weather and climate models struggle to represent the air-mass transformations associated with such intrusions, causing important biases in temperature structures and surface fluxes. In a warmer climate, the amount of latent heat convergence in the Arctic increases at the expense of dry energy convergence. The corresponding increase in precipitation is substantially stronger than in the global mean, even when normalized by the regional warming. Improving the understanding and model representation of moist processes in the Arctic is necessary to better constrain projections of future Arctic warming and the associated sea-level rise and sea-ice retreat.

UP 1.6 Thu 12:15 H3

Water tracers in the general circulation model of intermediate complexity PlaSim — •Oliver Mehling[1], Elisa Ziegler[1], Heather Andres[2], Frank Lunkeit[3], Martin Werner[4], and Kira Rehfeld[1] — [1]Institute of Environmental Physics, Heidelberg University, Germany — [2]Memorial University of Newfoundland, St. John's, NL, Canada — [3]CEN, Institute of Meteorology, University of Hamburg, Germany — [4]Alfred Wegener Institute, Bremerhaven, Germany

Atmospheric water tracers provide a powerful tool to examine source-sink relations of water vapor in atmospheric general circulation models (GCMs). In particular, they offer insight into the variability of moisture transport and sources of precipitation. However, water tracers are computationally expensive, and allow only for short simulations or a small number of tracers in state-of-the-art models.

Here, we present the implementation of water tracers in a GCM of intermediate complexity, the Planet Simulator (PlaSim), which permits for millennial-length simulations with water tracers. We first show that the model can reproduce present-day precipitation patterns reasonably after tuning, and discuss the validation and remaining biases

of the tracer-enabled model.

The water tracer framework is then applied to study moisture export from the Arctic in idealized experiments of warm and cold climate states using simulations forced by sea surface temperatures and sea ice concentrations from comprehensive Earth system models. We discuss the contributions of moisture evaporated in the Arctic to precipitation at high latitudes, both in the mean state and during extreme events.

UP 1.7 Thu 12:30 H3

Bayesian parameter estimation for EBMs: What can we learn about climate variability? — •Maybritt Schillinger[1,2], Beatrice Ellerhoff[1], Kira Rehfeld[1], and Robert Scheichl[2] — [1]Institute of Environmental Physics, INF 229 — [2]Institute of Applied Mathematics, INF 205, 69120 Heidelberg, Germany

Reliable climate projections in the face of global warming require an improved understanding of the internally-generated and externally-forced variability of Earth's climate. To this end, energy balance models (EBMs) provide a conceptual tool for studying climate dynamics. However, EBMs are typically based on a set of parameters with considerable uncertainties across empirical data and model hierarchies. To incorporate these uncertainties, we describe the global mean temperature as an inverse problem: We model the observed data as a function of the unknown parameters, given through the EBM's solution, and stochastic noise, representing the internal variability. With a Bayesian approach and a MCMC algorithm, we estimate the parameters as well as the best model fit to the data. In particular, we investigate how this estimate depends on the strength of internal variability compared to the response to external forcing. We discuss results for the zero-dimensional linear EBM and possible extensions with time-dependent feedback parameters. Our approach represents an application of state-of-the-art analytical and numerical techniques to the complex dynamics of Earth's climate. It can help to elaborate the potential, but also limitations, of the inverse problems approach and be readily applied to other dynamical systems with uncertain parameters.

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 Leliefeld[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 in-situ 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.

UP 3: Annual General Meeting

Time: Thursday 18:00–19:00 Location: MVUP

Annual General Meeting

UP 4: Measurement Techniques & Miscellaneous

Time: Friday 11:00–12:30 Location: H7

UP 4.1 Fri 11:00 H7

Imaging of Formaldehyde in the Atmosphere — •Alexander Nies[1], Christopher Fuchs[1], Jonas Kuhn[1,2], Nicole Bobrowski[1,2], and Ulrich Platt[1,2] — [1]Institute of Environmental Physics, Heidelberg University, Germany — [2]Max Planck Institute for Chemistry, Mainz, Germany

Monitoring of atmospheric traces gases by imaging techniques is essential for the understanding of physical and chemical dynamics of the atmosphere. Hyperspectral imaging in the UV-VIS range allows highly selective measurements of several trace gases simultaneously, but scanning is necessary for image acquisition resulting in a low spatio-temporal resolution. Non-dispersive imaging techniques, e.g. SO2 cameras, reach high spatial and temporal resolution, but due to their strongly restricted spectral information they are limited to high abundances of SO2 only. Combining the benefits of both approaches using a Fabry-Perot-Interferometer in a filter camera setup enhances spectral information by matching its periodic transmission to the narrowband absorption structures of the target trace gas and leading to reduced cross interferences. The technique has been demonstrated for SO2 and we present a case study for HCHO in the atmosphere with

a sensitivity of $4.7 \cdot 10^{-16} \frac{molec}{cm^2}$. Because of the similar absorption structures of HCHO and BrO in the UV wavelength range, the same instrument can be used for BrO measurements (for instance, highly abundant in volcanic plumes). Usually HCHO and BrO have no common sources, and therefore, potential cross sensitivities are only a minor problem. The calculated sensitivity for BrO is $1.6 \cdot 10^{-14} \frac{molec}{cm^2}$.

UP 4.2 Fri 11:15 H7

Fabry-Perot interferometer correlation spectroscopy - A novel technique for the imaging of atmospheric trace gases — •Jaro Heimann[1], Alexander Nies[1], Christopher Fuchs[1], Jonas Kuhn[1,2], Nicole Bobrowski[1,2], and Ulrich Platt[1,2] — [1]Institute of Environmental Physics, Heidelberg University, Germany — [2]Max Planck Institute for Chemistry, Mainz, Germany

Imaging of trace gases by optical remote sensing provides insights into the dynamics of physical and chemical processes within the atmosphere. However, dispersive techniques cannot resolve many processes on their intrinsic spatial and temporal scale, e.g. Imaging DOAS. Non-dispersive imaging techniques, e.g. SO_2 cameras, reach high spatial and temporal resolution, but due to their strongly restricted spectral information they show cross-interferences with other trace gases (e.g. O_3), aerosols, and clouds. We introduce a novel imaging technique for atmospheric trace gases, based on the application of a Fabry-Perot interferometer (FPI). The FPIs periodic transmission is matched to the periodicity of the vibronic narrowband absorption structure of the target trace gas absorption yielding high trace gas selectivity and thereby allowing a more precise determination of gas emission fluxes. The instrument response can be modelled using absorption cross sections and a solar atlas spectrum from the literature thereby avoiding additional calibration procedures, e.g. using gas cells. We present recent measurements which were performed at Mt. Etna for SO_2 with an imaging Fabry-Perot interferometer correlation spectroscopy (IFPICS) instrument with a detection limit of 3e17 molec/cm^2.

UP 4.3 Fri 11:30 H7

Moisture and humidity dependence of the above-ground cosmic-ray neutron intensity revised — •Markus Köhli[1,2], Jannis Weimar[1], Martin Schrön[3], and Ulrich Schmidt[1] — [1]Physikalisches Institut, Heidelberg University — [2]Physikalisches Institut, University of Bonn — [3]Helmholtz Centre for Environmental Research-UFZ, Leipzig

The novel method of Cosmic-ray neutron sensing (CRNS) allows non-invasive soil moisture measurements at a hectometer scaled footprint. Up to now, the conversion of soil moisture to a detectable neutron count rate relies mainly on the equation presented by Desilets et al. (2010). While in general a hyperbolic expression can be derived from theoretical considerations, their empiric parameterisation needs to be revised for two reasons. Firstly, we find a 3-parameter equation with unambiguous values equivalent to the 4-parameter equation. Secondly, high-resolution Monte-Carlo simulations revealed a systematic deviation of the count rate to soil moisture relation especially for extremely dry conditions as well as very humid conditions. That is a hint, that a smaller contribution to the intensity was forgotten or not adequately treated by the conventional approach. Investigating the above-ground neutron flux by a broad simulation campaign revealed a more detailed understanding of different contributions to this signal. The packages MCNP and URANOS were used to derive a function including the detector-specific response. The new relationship has been tested at three exemplary measurement sites and its remarkable performance allows for a promising prospect of more comprehensive data quality.

UP 4.4 Fri 11:45 H7

Energy Storage in Concentration Gradients — •Ulrich Platt and Florian Dinger — Universität Heidelberg, Inst. für Umweltphysik

Reliable systems for energy storage are a central component of energy supply systems with a high fraction of renewable energy. Here we propose energy storage using two reservoirs of water with different salt concentrations. Storage of excess energy takes place by reverse osmosis increasing the salt concentration in one reservoir. The produced fresh water will be stored in a second reservoir or discarded, e.g. in a river. Release of the stored energy by an osmosis power station (OPS), exploiting the osmotic pressure of the high concentration reservoir. Energy storage density can reach 8 kWh/m3, up to one order of magnitude higher than in typical pumped-storage hydroelectricity (PSH) at comparable efficiency. Besides the described onshore application using fresh water, an OPS can also be installed at the coast or offshore utilizing the still large concentration gradient between ocean water and saturated salt solution. The technology of such a system is readily available: Reverse osmosis for production of fresh water from ocean water is in widespread use and the technical components (large area membranes, pressure exchangers) are commercially available. Also, the principle of OPS was realized in a demonstration plant in 2009. Compared to PSH our new approach requires no altitude difference of reservoirs, therefore large storage capacities can be realized very economically. A series of different realization schemes and sample calculations of power and energy densities are provided.

UP 4.5 Fri 12:00 H7

Using the limits of photosynthesis to understand planetary habitability — •Axel Kleidon — MPI für Biogeochemie, Jena, Germany

Photosynthesis is the dominant process which supports life on Earth with the chemical energy it needs to sustain its metabolic activities. Here, I evaluate the factors that limit photosynthesis, focusing on terrestrial ecosystems, as these include the most productive ecosystems on Earth. I first use satellite-based datasets of gross carbon uptake by terrestrial ecosystems and solar radiation to show that the median efficiency of photosynthesis of terrestrial ecosystems of converting energy is less than 1%, consistent with long-standing ecological observations, but far below the maximum efficiency derived from thermodynamics. I show that this low efficiency can be explained by the thermodynamic limit on gas exchange, as ecosystems need to take up carbon dioxide from the atmosphere to produce chemical energy in form of glucose, and inevitably lose water when doing so. Gas exchange is limited by turbulent transport within the lower atmosphere, which in turn is limited by the heating of the surface. I show that the geographic variations of this gas exchange with respect to water can be explained by the thermodynamic limit of maximum power very well. What this implies is that the photosynthetic activity of the most productive ecosystems on Earth appear to be strongly constrained by thermodynamics through gas exchange. For habitability, this interpretation emphasizes the importance of mass exchange to sustain high levels of chemical activity that are needed to sustain life in planetary environments.

UP 4.6 Fri 12:15 H7

Does the solar 27-day variability influence the Madden-Julian oscillation in the tropical troposphere? — •Christoph G. Hoffmann and Christian von Savigny — Institut für Physik, Uni Greifswald, Deutschland

The solar irradiance is subject to variations on different time scales including the 27-day cycle. These variations are known to introduce variability in the upper and middle atmosphere. Implications for the troposphere are currently under discussion.

The Madden-Julian oscillation (MJO) is a major source of intraseasonal variability in the troposphere. We analyze whether the temporal evolution of the MJO phases could be linked to the solar 27-day cycle. We basically count the occurrences of particular MJO phases as a function of time lag after the solar 27-day extrema in about 38 years of MJO data.

We find indications for a synchronization between the MJO phase evolution and the solar 27-day cycle, which are most notable under certain conditions: MJO events with a strength greater than 0.5, during the easterly phase of the Quasi-biennial oscillation, and during boreal winter. The MJO appears to cycle through its 8 phases within 2 solar 27-day cycles. However, these results strongly depend on the used MJO index.

We point out that we do not claim to unambiguously prove this relationship; neither in a statistical, nor in a causal sense. Instead, we challenge these unexpected initial findings ourselves in detail by varying underlying datasets and methods.

UP 5: Atmospheric Trace Gases

Time: Friday 14:00–15:45 Location: H7

Invited Talk UP 5.1 Fri 14:00 H7

Ozone in the troposphere responds to reduced precursor emissions during the COVID-19 pandemic — •Wolfgang Steinbrecht — Deutscher Wetterdienst, Hohenpeissenberg, Germany

The COVID-19 pandemic has provided an accidental global air-quality experiment, which tests observational capabilities, and also our understanding of atmospheric chemistry and transport. Measures to curb spreading of the COVID-19 pandemic have reduced world-wide fuel consumption and associated emissions. Air-traffic and surface transportation were the sectors with the largest emission reductions, up to 80%. Both sectors are important sources of nitrogen oxides and volatile organic compounds (VOC), the main precursors for photochemical production of ozone in the troposphere. In spring and summer 2020, observations of ozone in the free troposphere show an unprecedented reduction by about 7%, over much of the Northern Hemisphere. Model simulations reproduce this ozone reduction. In addition, they attribute about one third each of the observed reduction to reduced air-traffic, reduced surface transportation, and 2020 meteorological conditions (including the exceptional ozone hole of the Arctic stratosphere in spring 2020). Different from the ozone reduction observed in the free troposphere, data from polluted urban and industrial regions often show increased ozone during the pandemic - consistent with well-known non-linearities in tropospheric ozone chemistry (NOx saturation).

UP 5.2 Fri 14:30 H7

Charakterisierung der subarktischen Ökozone hinsichtlich der Modellierung von Ozonverschmutzung und Klimarisiken — •Stefanie Falk[1], Ane Victoria Vollsnes[2], Aud Eriksen[2], Lisa Emberson[3], Connie O'Neill[3], Frode Stordal[1] und Terje Koren Berntsen[1] — [1]Department of Geosciences, University of Oslo, Oslo, Norway — [2]Department of Biosciences, University of Oslo, Oslo, Norway — [3]Department of Environment and Geography, Stockholm Environment Institute, University of York, UK

Die Vegetation der subarktischen Ökozone wird durch die Verlängerung der Wachstumsperiode bei gleichzeitigem, steten Anstieg der troposphärischen Ozonkonzentration vermutlich mehr schädliches Ozon akkumulieren. Zur Untersuchen der Wechselwirkung subarktischer Vegetation mit Luftverschmutzung bedienen wir uns einer Klimaanalyse und Risikoabschätzung mittels Modellierung. Im Fokus stehen die Jahre 2018/19. 2018 war ein ungewöhnlich warmes Jahr mit überdurchschnittlich vielen Sonnentagen im Frühling und Sommer. Die gemessenen Ozonkonzentrationen zeigen eine Häufung von Spitzenwerten über 40 ppb im selben Zeitraum. Als mögliche Ursache identifizieren wir Waldbrände in Teilen Schwedens. Unter Verwendung des DO3SE-Modells untersuchen wir die Auswirkung des Wetters und Pflanzentypisierung (PFT) auf das Schadensrisiko. Die Verwendung von optimierten, subarktischen PFTs deutet auf eine mögliche Unterschätzung des Biomassenverlustes von 2.5–17.4 %. Maßgeschneiderte PFTs für die subarktische Ökozone haben daher das Potenzial biogeochemische Kreisläufe in regionalen und globalen Modellen zu verbessern.

UP 5.3 Fri 14:45 H7

Ermittlung von SO2 und NOx Emissionsraten fahrender Schiffe aus Langpfad-DOAS Messungen — •Kai Krause[1], Folkard Wittrock[1], Andreas Richter[1], Stefan Schmitt[2], Denis Pöhler[2], Andreas Weigelt[3] und John P. Burrows[1] — [1]Institut für Umweltphysik, Universität Bremen — [2]airyx GmbH, Heidelberg — [3]Bundesamt für Seeschifffahrt und Hydrographie (BSH), Hamburg

Schiffe sind eine wichtige Emissionsquelle von SO2 und NOx. Die Überwachung dieser Emissionen erfolgt üblicherweise über In-situ-Messungen am Ufer, nahe der Schifffahrtslinie. Diese Systeme sind auf günstige Windbedingungen angewiesen, unter denen die Abgase der vorbeifahrenden Schiffe zur Messstelle transportiert werden. Fernerkundung erlaubt die Messung dieser Emissionen auch bei ungünstigen Windverhältnissen und kann daher ergänzend zu den üblichen Messverfahren eingesetzt werden.

Im Rahmen des Projekts MESMART (Measurements of shipping emissions in the marine troposphere) wurden ein Jahr lang Langpfad-DOAS Messungen an der Elbe in der Nähe von Hamburg durchgeführt. In diesen Messungen wurden kurzzeitig erhöhte Konzentrationen (Peaks) von SO2 und NO2 detektiert und mit Hilfe von AIS-Daten einzelnen Schiffen zugeordnet. Mithilfe eines Gauß-Fahnenmodells lassen sich aus den Peakhöhen die Emissionsrate von SO2 und NO2 bzw. NOx ermitteln.

Die Höhe der ermittelten Emissionsraten korreliert dabei mit der Größe der Schiffe und der Geschwindigkeit über Grund. Des Weiteren zeigen Binnenschiffe und Seeschiffe unterschiedliche Emissionsraten.

UP 5.4 Fri 15:00 H7

Enhanced levels of nitrous acid during daytime derived from MAX-DOAS measurements during the AQABA campaign in late summer 2017 — •Steffen Dörner[1], Sebastian Donner[1], Lisa Behrens[2], Steffen Beirle[1], Sergey Osipov[1], Roland Rohloff[1], and Thomas Wagner[1] — [1]Max Planck Institute for Chemistry, Mainz, Germany — [2]University of Bremen, Science Institute of Environmental Physics, Bremen, Germany

During the Air Quality and Climate Change in the Arabian Basin (AQABA) campaign a MAX-DOAS instrument was set up on board of the Kommandor Iona. The ship route covered a variety of regions with different atmospheric compositions: Clean air in the Mediterranean and the Arabian Sea, anthropogenic air pollution near the oil fields in the Arabian Gulf or in areas of dense ship traffic like the Suez Channel or the dust clouds of the nearby deserts in the Red sea. The measured spectra in the UV/VIS spectral range (302 to 467nm) provide sufficient information for the retrieval of aerosol and trace gas profiles. In this study, we focus on evidences of direct nitrous acid emission sources in harbor areas around Jeddah and Kuwait. Since HONO daytime chemistry is debated in recent literature and missing sources are being discussed, we compared the results of the MAX DOAS measurements to WRF-Chem model output in order to identify potential daytime sources in maritime/harbor regions.

UP 5.5 Fri 15:15 H7

Analysis of global trends of total column water vapour from multiple years of OMI observations — •Christian Borger, Steffen Beirle, and Thomas Wagner — Max Planck Institute for Chemistry, Mainz, Germany

Atmospheric water plays a key role for the Earth's energy budget and temperature distribution via radiative effects (clouds and vapour) and latent heat transport. In this context, global monitoring of the water vapour distribution is essential for numerical weather prediction, climate modelling, and a better understanding of climate feedbacks.

Total column water vapour (TCWV) can be retrieved from satellite spectra in the visible "blue" spectral range (430-450nm) using Differential Optical Absorption Spectroscopy (DOAS). The UV-vis spectral range offers several advantages for monitoring the global water vapour distribution: for instance, it allows for accurate, straightforward retrievals over ocean and land even under partly-cloudy conditions.

To investigate climate changes in the global TCWV distribution, we make use of the long-term observations of the Ozone Monitoring Instrument (OMI) on board NASA's Aura satellite and present a global analysis of TCWV trends retrieved from multiple years of OMI measurements (2005-2020). Additionally, we put our results in context to trends of other climate data records of TCWV and surface air temperature and investigate if the changes in TCWV follow a Clausius-Clapeyron response. Moreover, we demonstrate that the OMI TCWV data set can also give insights into changes of the global atmospheric circulation.

UP 5.6 Fri 15:30 H7

Globale Betrachtung von Brommonoxid in Vulkanfahnen mit Hilfe von Sentinel-5 Precursor/TROPOMI — •Simon Warnach[1,2], Holger Sihler[1], Christian Borger[1], Nicole Bobrowski[1,2], Moritz Schöne[1,2], Steffen Beirle[1], Ulrich Platt[2] und Thomas Wagner[1] — [1]Max-Planck-Institut für Chemie, Mainz, Deutschland — [2]Institut für Umweltphysik, Heidelberg, Deutschland

Das Halogenradikal Brommonoxid (BrO) spielt in vielen chemischen Prozessen in der Atmosphäre eine Rolle. Neben dem wichtigen Einfluss von aus Vulkanen emittiertem Brom auf die Ozonchemie der Atmosphäre, ist das molare Verhältnis von Brom und Schwefel des Vulkangases eine wichtige vulkanologische Kenngröße für Magmazu-

sammensetzung und dem eruptivem Verhalten eines Vulkans.

In dieser Studie präsentieren wir die Ergebnisse einer globalen Übersicht des BrO/SO2 Verhältnisses von Vulkanfahnen über einen drei-Jahres Zeitraum von TROPOMI Daten ermittelt mit Hilfe der Differentiellen Optischen Absorptions Spektroskopie (DOAS). Über den Zeitraum der Studie gelang die erfolgreiche Bestimmung eines BrO/SO2 Verhältnisses bei 84 dieser Eruptionen von 14 unterschiedlichen Vulkanen. Dies sind fast fünf Mal so viele erfolgreiche Messungen verglichen mit Messungen vorheriger Satelliten (GOME-2), da die feine räumliche Auflösung (von bis zu 3.5kmx5.5km) des S5-P/TROPOMI Instrumentes die Bestimmung eines BrO/SO2 Verhältnisses auch bei mittelgroßen Ausbrüchen ermöglicht.

UP 6: Poster Session

Time: Friday 16:30–18:30 Location: P

UP 6.1 Fri 16:30 P

Charge induced enhancement of water adsorption on nanoparticle ions — Mario Nachbar[3], •Thomas Dresch[1], Denis Duft[1], and Thomas Leisner[1,2] — [1]Institute of Meteorology and Climate Research, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany — [2]Institute of Environmental Physics, University of Heidelberg, 69120 Heidelberg, Germany — [3]current address: Bruker AXS GmbH, 76187 Karlsruhe, Germany

Water and other polar molecules experience an attractive force in the inhomogeneous electric field of small molecular ions or charged nanoparticles. This charge induced attractive force increases the collision cross section, and, hence, impacts the adsorption rates compared to neutral particle interactions. While ion-molecule interactions have been studied extensively, experimental data are still lacking regarding the interaction of polar molecules with nanoparticles whose radii exceed the Langevin capture radius. Precise knowledge of this effect is crucial, e.g. for describing the formation and growth of atmospheric nanoparticles and for understanding the role of charged particles in cloud formation. We present experimental results for the charge induced enhancement of the collision cross section between H2O molecules and singly charged nanoparticles with radii between 1.4 nm and 3 nm. The enhancement factor Γ with respect to the geometrical cross section increases with decreasing particle size. We also present a new model for Γ based on Stark effect adiabatic dipole orientations, which is in excellent agreement with the experimental findings.

UP 6.2 Fri 16:30 P

Modelling optical twilight phenomena: Earth's shadow and the Belt of Venus — •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

During clear civil twilights it is possible to see a combination of two optical phenomena above the antisolar horizon: The earth's shadow and the Belt of Venus (or antitwilight arch). Simulations with the radiative transfer model SCIATRAN and colour modelling based on the CIE (International Commission on Illumination) colour matching functions and CIE chromaticity values reproduce the phenomena accurately. Investigations on the influence of ozone show that it has a strong impact on the colours of both twilight phenomena. Although the Chappuis bands are clearly visible in the spectra of all segments, the colour of the earth's shadow differs from the sky above the antitwilight arch. Furthermore, a low optical depth in the troposphere is necessary to simulate the reddish colour of the Belt of Venus.

UP 6.3 Fri 16:30 P

Detektion von lokal erhöhten Methankonzentrationen durch Analyse von Sentinel-5 Precursor Satellitendaten — •Steffen Vanselow, Oliver Schneising, Michael Buchwitz und John P. Burrows — Institut für Umweltphysik (IUP), Universität Bremen FB1, Bremen, Deutschland

Methan (CH_4) ist ein wichtiges Treibhausgas und dessen steigende Konzentration in der Atmosphäre tragen signifikant zur globalen Erwärmung bei. Satellitenmessungen des vertikal gemittelten Mischungsverhältnisses (XCH_4) können für die Detektion und Quantifizierung von Methanemissionen genutzt werden. Dies ist wichtig, da die Emissionen vieler Methanquellen eine große Unsicherheit aufweisen und einzelne Emissionsquellen noch nicht bekannt sind.

Der im Oktober 2017 gestartete Sentinel-5 Precursor (S5P) Satellit gestattet u.a. die Messung von XCH4 mit einer räumlichen Auflösung von $7 \times 7\,km^2$ und einer täglichen globalen Abdeckung.

Der an der Universität Bremen entwickelte WFM-DOAS Retrieval-Algorithmus erzeugt ein XCH_4-Datenprodukt mit einer Genauigkeit von ca. 1 %. Um lokal erhöhte Methankonzentrationen zu detektieren, die im Zusammenhang mit Emissionsquellen stehen, analysieren wir dieses Datenprodukt für die Jahre 2018-2020. Unser Detektionsalgorithmus identifiziert zeitlich stabile lokale XCH_4-Erhöhungen relativ zur Umgebung, indem verschiedene Filterkriterien, wie z.B. Schwellenwerte für die Methananomalien, verwendet werden.

Es werden der Algorithmus und erste Ergebnisse zur Detektion von lokalen Methanerhöhungen vorgestellt.

UP 6.4 Fri 16:30 P

Challenges and progress in the analysis of satellite-based measurements of methane in the Arctic — •Jonas Hachmeister, Matthias Buschmann, Justus Notholt, John P. Burrows, Oliver Schneising, and Michael Buchwitz — Universität Bremen, Deutschland

With the launch of the Sentinel-5 Precursor mission, carrying the TROPOMI instrument, an unprecedented high spatio-temporal resolution of the column-averaged mole fraction of various gases was made possible, e.g. methane (XCH4). Especially in the northern high-latitude regions, where few ground stations and in-situ measurements are available, this data promises new ways of understanding the methane distribution and variation on large scales. In addition to the operational Copernicus S5P XCH4 data product developed by SRON, the scientific WFMD algorithm data product was generated at the Institute of Environmental Physics at the University of Bremen. Comparisons of both products show significant differences, which are not yet well understood and their evaluation proves difficult due to the limited opportunities of validation because ground-based measurements, e.g. from TCCON and NDACC, are sparse in the Arctic. In this poster contribution we show comparisons with measurements from ground-based stations and different satellite XCH4 data products.

UP 6.5 Fri 16:30 P

Direct measurement of methane radiative forcing in Ny-Ålesund — •Lukas Heizmann, Mathias Palm, Justus Notholt, and Matthias Buschmann — Universität Bremen, Bremen, Germany

Methane is an important greenhouse gas with significant increase in concentration between pre-industrial times and today, corresponding to an associated estimated increase in radiative forcing of $+0.48 W/m^2$ compared to $+2.83 W/m^2$ for all well-mixed greenhouse gases (IPCC 2013). However direct measurement of the radiative forcing attributed to methane proved to be difficult. Feldmann et al. (2018) presented a a first study using ground-based measurement at a single location (ARM Southern Great Plains atmospheric observatory). We investigate the feasibility of such measurements in the Arctic using a calibrated FTIR emission spectrometer in Ny-Ålesund, Spitsbergen. Due to nearby water vapor absorption lines, methane radiative forcing is mediated by the thermodynamic state of the atmosphere. We thus retrieve water vapor and methane profiles simultaneously to produce counterfactual spectra in which the only difference from the true atmosphere consists in the methane mixing ratio. By differencing the true with the counterfactual spectra and integrating over the entire spectral range we obtain a measurement of the radiative forcing of methane.

UP 6.6 Fri 16:30 P

Influence of cruise ship emissions on local air quality in Ny-Ålesund, Svalbard — •André Seyler, Folkard Wittrock, Anja Schönhardt, Lisa K. Behrens, Tim Bösch, Andreas Richter, and John P. Burrows — Institute of Environmental Physics (IUP), University of Bremen, Germany

The IUP Bremen has performed Differential Optical Absorption Spectroscopy (DOAS) measurements in Ny-Ålesund, Svalbard, since 1995, when the first simple zenith-viewing instrument was installed. It was enhanced to a Multi-Axis-DOAS (MAX-DOAS) instrument in 1999 (1

off-axis direction), replaced with a newer instrument in 2002 (4 off-axis directions) and again replaced in 2011 with the current system with a pant-tilt-head allowing for measurements in multiple azimuth directions (Wittrock et al., 2004; Peters, 2013).

Shipping, a sector which featured enormous growth rates in the last decades, is one of the major contributors to air pollution, especially in coastal regions and harbor towns. In the last decade, the sea cruise industry has been a booming market with strong increases in the number of ships and and the size of the ships. Also the number of cruise ships operating in the Arctic is on the rise.

Ny-Ålesund, located at 79°N, is a remote location with many cruise ship calls and nearly no land-based pollution. This study investigates the influence of cruise ship emissions on the local air quality in Ny-Ålesund using MAX-DOAS Measurements of NO_2 and SO_2 taken from the roof of the AWIPEV observatory.

UP 6.7 Fri 16:30 P

Auswertung eines bodengestützen OH-(3-1) Rotations-Schwingungs-Spektroskopie-Datensatzes zur Bestimmung der Mesopausentemperatur — •Lukas Depenthal, Christian von Savigny und Julia Hoffmann — Universität Greifswald

Seit Anfang 2015 wird an der Universität Greifswald mit Hilfe eines Andor Shamrock SR-163 Infrarotspektrometers die OH-Meinel-Bande im Wellenlängenbereich von 1500 nm bis 1600 nm gemessen. Die mittlere Emissionshöhe beträgt dabei circa 87 km. Anhand der relativen Intensitäten der OH(3-1)-Linien werden mit Hilfe der Boltzmann-Methode Rückschlüsse auf die Mesopausentemperatur gezogen und hinsichtlich ihrer Variabilität untersucht. Dabei werden auch mögliche dynamische Prozesse in die Untersuchungen einbezogen. Aufgrund der zeitlichen Auflösung des Spektrometers von 15 s können Wellensignaturen mit Perioden von wenigen Minuten gemessen werden. Hierbei konnten mit Hilfe von Fourier-Transformations- und Wavelet-Analysen Variationen mit Perioden von ca. 5-20 Minuten festgestellt werden.

UP 6.8 Fri 16:30 P

COVID-19 in Berlin: Epidemische Wellen und Sommer 2020 — •Peter Carl — ASWEX - Angewandte Wasserforschung, Berlin

Der COVID-19 Ausbruch in Berlin ist auffällig korreliert mit der regionalen Dynamik des Saisonwechsels im Frühjahr 2020. Der Shutdown schuf eine 'Laborsituation', in der vor allem regionale extrinsiche Bedingungen die intrinsische Dynamik des epidemischen Systems beeinflussten. Um dies nutzbar zu machen, wurde ein SEIR-Modell aufgesetzt, das unmittelbar zwei Typen der Systemantwort auf den Eintrag Infizierter zeigte: (i) eine epidemische Welle, die in *Zero-COVID* mündet, und (ii) eine gedämpfte Schwingung mit zwei Wellen, die in einen endemischen Zustand übergeht. Ein solches Systemverhalten war zu erwarten. Das Durchforsten sinnvoller Parameter-Einstellungen nach weiteren Lösungstypen wird begleitet von einer Struktur- und Funktionsanalyse, die innere Zyklen aufdecken und ihren dynamischen Einfluss bewerten kann. Neben der raschen Reaktion auf die Maßnahmen des Shutdown zeigt das Modell nämlich eine wesentlich längere Zeitskala der dynamischen Response, die zu dem Schluss führt, dass der epidemiologisch 'ruhige' Sommer 2020 ein Ergebnis des Shutdown vom März war. Eine frühere Intervention mit denselben Maßnahmen hätte das Modell-System zudem auf dem *Zero-COVID* Pfad gehalten und die Dauer der epidemischen Lage deutlich verkürzt. Die Wechselwirkung der Eigendynamik des Systems mit einem strukturierten Saisonverlauf wird anhand des Beobachtungsmaterials diskutiert. Die Aufklärung seiner Lösungsvielfalt ist jedoch vorrangige Bedingung für das Verständnis der Saisonalität und Dynamik von COVID-19.