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.