

**AWI-IUP-Seminar WiSeS 2019/20
Layers and Fluxes in Earth System
Program**

Where: Seminar room, NW1, S1360, Otto Hahn Allee 1, 28359 Bremen

When: 03 February 2020, Start: 09:00, Finish: around 16:00

09:00, Prof. Dr. Ulrich Platt (Uni Heidelberg):
" Atmospheric Cycles of Ozone and Reactive Halogen Species"

10:00, Dr. Leonardo Alvarado Bonilla (IUP):
"Unexpected long-range transport of glyoxal and formaldehyde observed from the Copernicus Sentinel-5 Precursor satellite during the 2018 Canadian wildfires"

10:30-10:45: Coffee break

10:45, Dr. Tim Rixen (ZMT):
" Tropical Peatlands; Climate and Coastal Seas"

11:45, Dr. Reiner Steinfeld (IUP):
" Role of the Atlantic ocean in the global carbon cycle"

12:15-13:15: Lunch break

13:15, Prof. Dr. Dieter Wolf-Gladrow. (AWI):
"Carbon Cycle & Negative Emissions"

14:00, Dr. Gregor Kieseewetter (IIASA):
" Source contributions to and mitigation pathways for ambient PM2.5 in Asia"

14:30, Prof. Dr. Claus Lämmerzahl (ZARM):
" Fluxes and Gravity"

Abstracts

Atmospheric Cycles of Ozone and Reactive Halogen Species

Ulrich Platt

Heidelberg University, Institute of Environmental Physics, Heidelberg, Germany

Ozone (O_3) is one of the most important species in our atmosphere. The ozone layer generates the stratosphere and shields us from dangerous UV-radiation, while in the lower atmosphere (troposphere) O_3 is the source of free radicals cleaning the air we breathe. We examine the sources and sinks of O_3 , some techniques to measure its abundance, and its role in various parts of the atmosphere.

Closely related to O_3 are reactive halogen species (RHS, e.g. X, X_2 , XO, HOX, where X denotes one of the halogens F, Cl, Br, or I), which are abundant in many parts of the troposphere (as well as in the stratosphere), these 'halogen compartments' include polar regions, coastal areas, vicinity of salt pans, parts of the free troposphere, and volcanic plumes. RHS have been shown to have a profound impact on tropospheric chemistry, for instance they deplete O_3 and change the hydrogen radical chemistry. During recent years much progress has been made with respect to elucidating the spatial and temporal distribution of RHS, their origin, and their chemical interactions in these compartments as well as in the theoretical understanding of these processes. However unanswered questions remain.

We give an overview of ground-, aircraft-, and satellite- based observations and recent advances in modelling and identify common features of the RHS-related processes in the different compartments and derive answers to some of the questions.

Unexpected long-range transport of glyoxal and formaldehyde observed from the Copernicus Sentinel-5 Precursor satellite during the 2018 Canadian wildfires

Leonardo M. A. Alvarado, Andreas Richer, Mihalis Vrekoussis, Andreas Hilboll, Anna B. Kalisz Hedegaard, Oliver Schneising, and John P. Burrows

University of Bremen, Institute of Environmental Physics (IUP)

Glyoxal (CHO.CHO) and formaldehyde (HCHO) are intermediate products in the tropospheric oxidation of the majority of Volatile Organic Compounds (VOC). CHO.CHO is also a precursor of secondary organic aerosol (SOA) in the atmosphere. CHO.CHO and HCHO are released from biogenic, anthropogenic, and pyrogenic sources. CHO.CHO and HCHO tropospheric lifetimes are typically considered to be short during the daytime at mid-latitudes (e.g. several hours), as they are rapidly removed from the atmosphere by their photolysis, oxidation by OH, and uptake on particles or deposition. At night and at high latitudes, tropospheric lifetimes increase to many hours or even days. Previous studies demonstrated that CHO.CHO and HCHO vertical column densities, VCDs, are well retrieved from space-borne observations using the differential optical absorption spectroscopy, DOAS. In this study, we present CHO.CHO and HCHO VCDs retrieved from measurements of the TROPOMI instrument, launched on the Sentinel-5 Precursor (S5P) platform in October 2017. We observe strongly elevated amounts of CHO.CHO and HCHO during the 2018 fire season

in British Columbia, Canada, where a large number of fires occurred in August. CHO.CHO and HCHO plumes from individual fire hot-spots are observed in air masses travelling over distances of up to 1500 km, i.e. much longer than expected for the relatively short tropospheric lifetime expected for CHO.CHO and HCHO. Comparison with simulations by the particle dispersion model FLEXPART indicates that effective lifetimes of 20 hours and more are needed to explain the observations of CHO.CHO and HCHO if they decay in an effective first order process. FLEXPART used in the study calculates accurately the transport. In addition an exponential decay, in our case assumed to be photochemical, of a species along the trajectory is added. We have used this simple approach to test our assumption that the CHO.CHO and HCHO are created in the fires and then decay at a constant rate in the plume, as it is transported. This is clearly not the case and we infer that CHOCHO and HCHO are either efficiently recycled during transport, or continuously formed from the oxidation of longer-lived precursors present in the plume, or possibly a mixture of both. We consider the best explanation of the observed CHO.CHO and HCHO VCD in the plumes of the fire is that they are produced by oxidation of longer-lived precursors, also released by the fire and present in the plume.

Tropical Peatlands, Climate and Coastal Seas

Tim Rixen

University of Bremen, Leibniz Centre for Tropical Marine Research (ZMT)

Today, about half of the tropical peat swamps are located in Indonesia, mainly on the coasts of Sumatra, Borneo and Irian Jaya. In the past peats were important carbon stores but as early as 2008, about 90% of the peatlands in Indonesia were no longer in their original condition. Due to drainage and deforestation peat decomposes into CO₂, and literally dissolves into air. Net CO₂ emissions from peat lands amount to about 105 million tonnes of carbon per year representing about 10% of the annual global CO₂ emissions from land-use change. Leaching further increases the carbon losses of peat by about 44 million tonnes of carbon per year. This enhances CO₂ emission from peat draining rivers and leads to acidification that affects the growth of calcifying organisms in the coastal seas. These problems, which were recognized in the past, pose the question of what to do with this ecosystem in future?

The global carbon cycle and negative CO₂ emissions

Dieter Wolf-Gladrow

Alfred Wegener Institute for Polar and Marine Research (AWI), Bremerhaven

Atmospheric CO₂ has increased from 280 ppm (parts per million) before the start of the industrial revolution (about 1750) to more than 400 ppm mainly by burning of coal, gas, and oil. In order to understand the past and future development of atmospheric CO₂ one needs to know the structure and functioning of the global carbon cycle. Large fluxes of CO₂ between the atmosphere on the one side and ocean and land biosphere on the other result in a very short residence time of atmospheric CO₂. Various processes like, for example, the physical and biological carbon pumps have kept atmospheric CO₂ at a relative low level. I will discuss two questions: (1) How will these processes respond to anthropogenic perturbations? (2) Can we enhance certain natural processes in order to remove CO₂ from the atmosphere?

Role of the Atlantic ocean in the global carbon cycle

Reiner Steinfeldt, Monika Rhein, Dagmar Kieke
University of Bremen, Institute of Environmental Physics (IUP)

At present, the ocean takes up about 30% of the global emissions of anthropogenic CO₂ (Cant). Cant enters the ocean at the surface by air-sea gas exchange and is transferred into the ocean's interior by the formation and spreading of denser water masses. Due to the presence of recently formed North Atlantic Deep Water, the Atlantic has higher Cant column inventories compared to the Pacific and Indian Ocean.

Both the air-sea carbon fluxes and the total carbon concentration in the ocean are dominated by natural processes, e.g. the physical/solubility and the biological carbon pump. The anthropogenic part of the carbon fluxes and interior concentrations only makes up a small fraction. Here we make use of anthropogenic tracer data to infer the Cant concentrations in the Atlantic and compare its distribution and decadal variability with the total and biogenic carbon. We also contrast the spatial distribution of the oceanic Cant storage with the pattern of air-sea CO₂ fluxes. This highlights the role of the Atlantic Meridional Circulation (AMOC) for the Cant uptake and storage. The upper limb of the AMOC advects Cant enriched lighter water masses to the subpolar/polar regions, where they are transferred into dense water by surface cooling. We will investigate, how the variability of deep water formation in the North Atlantic is reflected in the change of the Cant storage rates.

Source contributions to and mitigation pathways for ambient PM_{2.5} in Asia

Gregor Kiesewetter
Air Quality and Greenhouse Gases Program
International Institute for Applied Systems Analysis, Laxenburg, Austria

Exposure to ambient fine particulate matter (PM_{2.5}) is currently considered the largest environmental risk factor worldwide, with several million cases of premature deaths attributed to it every year. While PM_{2.5} trends in Europe and the US have been decreasing thanks to tightening emission control legislation, concentration levels in many developing countries have been increasing or stagnant, creating a serious health hazard for citizens. Many Asian cities, particularly in India and China, rank among the most polluted places in the world. Currently, policy responses often happen very locally and on an ad-hoc basis during high pollution episodes. For designing sustainable and efficient pollution mitigation strategies, however, understanding the contributions of different sources – in terms of economic sectors, pollutants, and spatial origin – is crucial.

Here we present findings of an Asia-wide assessment of air pollution, as well as examples of work at national and city level for India, Vietnam and China. Based on emission and chemistry-dispersion calculations of the GAINS model, we quantify emission trends, source contributions to current levels of ambient PM_{2.5}, and their likely evolution under future emission scenarios. We analyse the effectiveness of recent policies and sketch out measures to improve the situation, while decreasing greenhouse gas emissions and attaining sustainable development goals at the same time.

Fluxes and Gravity

Claus Lämmerzahl

Center for Applied Space Technology and Micro Gravity (ZARM), Bremen

While Newtonian gravity is insensitive to fluxes, within the framework of General Relativity fluxes create their own gravitational field. This field does not possess a Newtonian analogue. After a short down-to-Earth introduction to basics of General Relativity, the gravitational field of fluxes will be sketched. This gravitational field has some analogies to the magnetic field of electrodynamics and, thus, is often called the gravitomagnetic field. Past and future measurements of this particular gravitational field will be described. In a further step it is shown that on purely mathematical reasons the full gravitational field of the earth can be decomposed into a rest-mass part and a flux part which both are directly accessible to geodetic measurements and interpretation using gravimetry, clocks, spinning tops, laser and atom interferometers. The presentation aims to be on a generally understandable level.