IUP-AWI Blockseminar

Human Impact on the Earth System

February 6, 2015, University of Bremen, room S1360

10:00 – 10:20	Helmut Fischer	IUP	Anthropogenic radioisotopes in the environment
10:20 – 10:40	Maren Walter	IUP	Ecological aspects of deep-sea mining - Sediment plume dilution and dispersal
10:40 – 11:00	Steven van Heuven	AWI	The invasion of anthropogenic carbon dioxide into the Weddell Gyre and adjacent Atlantic sector of the Southern Ocean
11:00 – 11:30	Coffee break		
11:30 – 11:50	Georg Heygster	IUP	Analysis and trends of Arctic and Antarctic sea ice concentration time series 1979-2013
11:50 – 12:10	Paul Gierz	AWI	To what extent is coupled ice sheet-climate model development useful for understanding climate change and ocean circulation in the coming centuries?
12:10 – 12:30	Lisa Kattner	IUP	Monitoring shipping emissions and the impact of new regulations trying to reduce them
12:30 – 14:00	Lunch break		
14:00 – 14:20	Andreas Hilboll	IUP	Rapid economic growth leads to boost in NO2 pollution over India, as seen from space
14:20 – 14:40	Max Reuter	IUP	Trends of anthropogenic CO2 and NO2 emissions derived from the satellite instrument SCIAMACHY
14:40 – 15:00	Denise Müller	IUP	Lateral carbon fluxes and CO2 outgassing from a peat-draining river in Southeast Asia
15:00 – 15:20	Elpida Leventidou	IUP	Tropical tropospheric ozone from satellite observations with the Convective Clouds Differential (CCD) technique
15:20 – 15:40	Kai Pong Tong	IUP	Preliminary investigation of angular dependence of artificial light at night upwelling towards VIIRS-DNB

Anthropogenic radioisotopes in the environment

Helmut Fischer (IUP Bremen)

Radioisotopes are common in the environment ever since, their origin being either cosmogenic (like ^{14}C) or primordial (like ^{238}U). During the last century, mankind has added a third category by understanding and applying nuclear processes like fission: anthropogenic radionuclides. Some of these, like ^{137}Cs or ^{239}Pu, have become a serious radiological problem, especially after their massive atmospheric dispersion by nuclear bomb tests and nuclear power plant accidents. Others are less well-known, have different sources and are, fortunately, less dangerous in most cases. They can be detected in a variety of environmental media if appropriate techniques are applied. The talk will give a brief overview of man-made radionuclides, covering origin, properties and dangers, but also their potential usefulness in environmental science.

Ecological aspects of deep-sea mining - Sediment plume dilution and dispersal

Maren Walter (IUP Bremen)

Marine mineral resources, such as polymetallic nodules, crusts and submarine-exhalative sulphides have recently become the target of policy makers, mining companies and deep sea researchers. The lack or limited availability of certain high tech elements or minerals in terrestrial ore deposits, essential for the electronics industry, future transportation concepts, or the new generation of alternative energies, have made raw materials from the marine environment a target for future mining operations. However, commercial deep-sea mining will always cause a major impact on local ecosystems. The collector unit gathering nodules will destroy the top few centimetres of the seabed, causing major disturbance and disruption of the flora and fauna in the mining tracks. In addition, the propulsion system of the collector will stir up sediments, and the tailings will be discharged in the water column. This sediment redistribution will result in artificial rapid redeposition and bottom blanketing in the vicinity of the mine site in the near-field, which may result in the burial of meiobenthos, the clogging of respiratory surfaces of filter feeders, and the coverage and dilution of food supply (organic material), as well as the possible long-range vertical and lateral dispersion of fine-grained particles by ocean currents in the far-field. To minimize human impact on the benthic community, long term studies of environmental consequences prior to any mining activities are essential.

The invasion of anthropogenic carbon dioxide into the Weddell Gyre and adjacent Atlantic sector of the Southern Ocean

Steven van Heuven(1), Mario Hoppema(1) and Oliver Huhn(2)

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Using cruises spanning several decades, we investigated the time rate of change of TCO_2 in the Weddell Gyre along the Prime Meridian, on the continental slope near the tip of the Antarctic Peninsula, and in the Weddell Sea interior. A strong and significant increase was observed in the surface layer, while for other variables no significant changes were found; this is unequivocal evidence for the invasion of anthropogenic CO_2. In the Weddell Sea Bottom Water at the Prime Meridian, the spatial distribution of the increase in TCO_2 bears a high resemblance to that of CFCs, suggesting that the changes in TCO_2 have been propagated from the surface. However, other variables like dissolved oxygen and silicate also show trends through time, pointing to non-steady state conditions which might also affect the derived CO_2 increase. Near the tip of the Peninsula, the coldest and most recently ventilated waters, hugging the continental slope, exhibit increasing TCO_2 over time. In the bottom layer of the Weddell Sea interior, however, the mean values of TCO_2 have remained essentially stable, suggesting that only a slight ventilation of these waters has taken place over the time scale of observations. This finding is in line with the low levels of CFCs at this location. Additionally, results are shown of the rate of storage of anthropogenic CO_2 (C_{ant}) in the South Atlantic Ocean, estimated from measured data of the oceanic CO_2 system and ancillary variables from 56 research cruises spanning 35 years. The time rate of change of C_{ant} is assessed using an adaptation of the Time Series Residuals method (Van Heuven et al., 2011).

Analysis and trends of Arctic and Antarctic sea ice concentration time series 1979-2013

Georg Heygster and Malte Gerken (IUP Bremen)

Time series of Arctic and Antarctic sea ice concentrations are investigated in view of large- and small-scale trends. For the Arctic, an average reduction of the sea ice area of (45000 ± 15000) km 2 /a is found, while in the Antarctic it is a small increase of (17000 ± 4600) km 2 /a. The monthly trends show the largest Arctic decrease in the months of low ice extent (August, September, October) while in the Antarctic the monthly trends are more homogeneous. The regional distribution shows an increasing Arctic trend in the Bering Sea which is line with the regionally decreasing temperatures and with the Pacific Decadal Oscillation index. The principal components (PC) of the sea ice concentration maps decrease slower than in other PC analyses, showing the high variability of the sea ice distribution.

To what extent is coupled ice sheet-climate model development useful for understanding climate change and ocean circulation in the coming centuries?

Paul Gierz (AWI Bremerhaven)

Global warming has the potential to influence sea surface and sea ice conditions as well as the melting rates of ice sheets. These changes can impact the ocean's ability to generate deep water, thereby affecting the strength of the Atlantic Meridional Overturning Circulation (AMOC). With the emerging recognition of the importance of ice sheets, a detailed study of the interactive role of dynamic ice sheets on the AMOC and therefore on global climate is required. We utilize a coupled atmosphere-ocean model in combination with a dynamic ice sheet model specifically to investigate changes to the AMOC and North Atlantic climate in response to several IPCC scenarios. It is demonstrated that the inclusion of a dynamic ice sheet component has the effect of drastically freshening the North Atlantic, enhancing high latitude haloclines in a similar way as in a scenario initially proposed by Bryan, and effectively weakening the AMOC. Cumulatively, incorporating a bi-directionally coupled dynamic ice sheet results in relatively reduced warming over Europe contemporaneous with a slight warming over South America and Africa, implying that previous studies, having not included a dynamic ice sheet, may have misestimated future warming patterns

Monitoring shipping emissions and the impact of new regulations trying to reduce them

Lisa Kattner, Barbara Mathieu-Üffing (IUP Bremen, BSH), André Seyler, Folkard Wittrock (IUP Bremen)

Air pollution from shipping emissions contributes to overall air quality problems and has direct health effects on the population especially in coastal regions and harbor cities. In order to reduce these emissions the International Maritime Organisation (IMO) has tightened the regulations for air pollution from ships. Since January 1st 2015, the allowed amount of sulfur in shipping fuel which is responsible for SO2 emissions, has dropped from 1% to 0,1% in the Emission Control area (ECA) that combines the North Sea and Baltic Sea. This effectively excludes the use of heavy fuel oils by ships in this area. However, until now there is no regular monitoring system available to verify that ships are complying with these new regulations. The project MeSMarT (Measurements of shipping emissions in the marine troposphere) has been established as a cooperation between the University of Bremen and the German Bundesamt für Seeschifffahrt und Hydrographie (Federal Maritime and Hydrographic Agency) to estimate the influence of shipping emissions on the chemistry of the atmospheric boundary layer and to establish a monitoring system for main shipping routes. Within the project, several hundred ships have been monitored with focus on their sulfur fuel content, which is estimated by the ratio of SO2 and CO2, both measured with in-situ instruments from measurement stations near the passing ships. It is shown how well ships have been complying to the sulfur content regulation so far and which ships and how many are affected by the new regulations. First results from very recent measurements of 2015 will be presented to show how the new regulations are implemented and how this will result in reduced SO2 and thus better air quality.

Rapid economic growth leads to boost in NO_2 pollution over India, as seen from space

A. Hilboll, A. Richter, and J.P. Burrows (IUP Bremen)

Over the past decade, the economy of India has grown at an exceptionally pace. This economic growth was accompanied by a strong increase of the Indian population. Consequently, traffic, electricity consumption, and industrial production have soared over the past decade, leading to a strong increase in fuel consumption and thus pollutant emissions.

Nitrogen oxides ($NO+NO_2$) are a major anthropogenic air pollutant, playing key part in reaction cycles leading to the formation of tropospheric ozone. They are mainly emitted by fossil fuel combustion; other sources include lightning, biomass burning, and microbial activity in soils.

Since the mid-1990s, space-borne measurements of tropospheric nitrogen dioxide (NO_2) have been conducted by the GOME, SCIAMACHY, GOME-2, and OMI instruments. These instruments perform hyperspectral measurements of scattered and reflected sunlight and apply differential optical absorption spectroscopy (DOAS) to yield vertically integrated columnar trace gas abundances.

In this talk, I will present the results of almost 20 years of NO_2 measurements over India. After showing the spatial distribution of NO2 pollution over India, I will present time series for individual states and urban agglomerations. These time series will then be related to various indicators of economic development. Finally, I will highlight several instances where single industrial pollution sources and their development can clearly be identified from the NO_2 maps.

Trends of anthropogenic CO_2 and NO_2 emissions derived from the satellite instrument SCIAMACHY

Maximilian Reuter, Michael Buchwitz, Andreas Hilboll, Andreas Richter, Oliver Schneising, Michael Hilker, Jens Heymann, Heinrich Bovensmann, and John Burrows (IUP Bremen)

Global CO_2 emission inventories are currently mainly based on bottom-up estimates. These rely, e.g., on reported fossil fuel consumptions and fuel types. The associated uncertainties propagate into CO_2-to-NO_x emission ratios being an important measure for pollution monitoring and into biospheric carbon fluxes derived with inverse models. Co-located simultaneous SCIAMACHY satellite retrievals of XCO_2 and NO_2 from the years 2003-2011 are used as input for a top-down estimate of emission and emission ratio trends. In East Asia, the analysis reveals an increasing trend (4.2+/-0.9%/a) of the CO_2-to-NO_x emission ratio. This results from a large positive trend of CO_2 emissions (9.8+/-0.7%/a) primarily driven by the growing Chinese economy exceeding the positive trend of NO_x emissions (5.8+/-0.3%/a). The results confirm that the newly installed and renewed technology (power plants, transportation, etc.) is significantly cleaner in terms of NO_x emissions. In North America and Europe negative CO_2 trends balance similarly large negative NO_2 trends so that no significant trends of the emission ratios are observed.

Lateral carbon fluxes and CO_2 outgassing from a peat-draining river in Southeast Asia

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Tropical peatlands play an important role in the global carbon cycle due to their immense carbon storage capacity. However, pristine peat swamp forests are vanishing due to deforestation and peatland degradation, especially in Southeast Asia. It has already been shown that soil CO_2 emissions increase once peatlands are deforested and drained, and that consequently, this efficient carbon sink is slowly turning into a source. These warning signals might also be observed in the adjacent aquatic system. Rivers flowing through tropical peatlands seem to reflect the vulnerability of those ecosystems by increased export of formerly stored organic carbon. As a consequence, CO_2 emissions from tropical peat-draining rivers are thought to increase as well; however, this has been mere speculation so far. We present for the first time total organic carbon (TOC) and CO_2 data from a tropical blackwater river draining an intact peat dome in Sarawak, Malaysia. Our measurements in the Maludam national park reveal that the lateral carbon flux dominates over CO_2 outgassing in an undisturbed system. Our study serves as a reference for future studies on changing carbon dynamics in peat-draining rivers due to anthropogenic disturbance.

Tropical tropospheric ozone from satellite observations with the Convective Clouds Differential (CCD) technique

Elpida Leventidou (IUP, Bremen)

Ozone influences most of the chemical reactions in the Troposphere. Its abundance can be retrieved from space-borne observations of vertically integrated ozone measurements and cloud cover. The CCD technique takes advantage of the frequent occurrence of convective clouds in the western Pacific region by subtracting the above-cloud from the clear-sky ozone measurements to derive a monthly mean tropospheric amount. An important assumption here is that the above-cloud ozone in the western Pacific simulates the stratospheric ozone and that this amount is invariant with latitude; which is approximately true in the tropics. A CCD algorithm has been developed and is applied to optical remote sensing observations from three satellite instruments (1995-2012), so that a unique long-term record of monthly averaged tropical (20°S, 20°N) tropospheric vertically integrated ozone is created. First results of the CCD application, including validation by comparisons with ozone data from balloon-borne instruments, will be presented.

Preliminary investigation of angular dependence of artificial light at night upwelling towards VIIRS-DNB

Kai Pong Tong (IUP Bremen)

In order to accurately understand and model skyglow patterns, it is important to know how various factors affect the propagation of artificial light at night. One of these significant but less studied variables is the angular distribution of upwelling artificial light. In this study, the incidence angle dependence of the night-time moonless radiance data of Leipzig and its surroundings taken by the VIIRS-DNB sensor on board the Suomi NPP satellite is investigated. The urban area of Leipzig and several isolated towns and villages near are selected for a quantitative analysis of the angular dependence of the upwelling artificial light. Moreover, the relationship between satellite incidence angle and overflight time over a given point on earth is used to analyse the temporal change of the amount of artificial light. The results of the analysis will be presented and implications for skyglow forward modelling and artificial light determination from VIIRS-DNB data will be discussed.