Draft Programme – Blockseminar „Polar Processes II“

13 July, AWI Bremerhaven,
Gebäude F, Glaskasten

09:00 – 09:10	Welcome and Logistics (Renate Treffeisen)

Aerosol and clouds

09:10 – 09:30	Larysa Istomnia (IUP Bremen): Remote sensing of aerosols in Arctic region
09:30 – 09:50	Luca Lelli (IUP Bremen) Clouds characteristics from satellite spectral measurements in the Oxygen A-Band

Sea Ice

09:50 – 10:30	Rüdiger Gerdes (AWI Bremerhaven) Changing Arctic sea ice and consequences for ocean and atmosphere
10:30 – 10:50	***Coffee Break***
10:50 – 11:10	Cornelia Köberle (AWI Bremerhaven) Atlantic water melting Arctic Sea Ice - now or in the future?
11:10 – 11:30	Wolfgang Dorn (AWI Potsdam) Arctic Sea Ice Development 1948-2009: Insights from coupled regional climate model simulations
11:30 – 11:50	Sandra Schwegmann (AWI Bremerhaven) The importance of large scale sea ice drift and ice type distribution on ice extent in the Weddell Sea
11:50 – 12:10	Georg Heygster (IUP Bremen) Sea ice types and properties inferred from satellite sensors

12:10 – 13:40	***Lunch break***
13:40 – 14:00	Alexander Kokhanovsky (IUP Bremen) The retrieval of snow grain size from a satellite
14:00 – 14:20	Heidrun Wiebe (IUP Bremen) Large scale application of snow grain size retrieval with optical satellite data from MODIS
14:20 – 14:40	Anja Rösel (Uni Hamburg) Comparison of different techniques for melt pond determination for Landsat and MODIS satellite data on arctic sea ice
14:40 – 15:00	Nina Maaß (Uni Hamburg) First preliminary results of sea ice thickness retrieval using SMOS data
15:00 – 15:20	***Coffee Break***

Ocean

15:20 – 15:40	Daniel Zitterbart (AWI Bremerhaven) Local mapping of sea-ice coverage and marine mammal detection using ship-based thermal imaging
15:40 – 16:00	Reiner Steinfeldt (IUP Bremen) Inventory changes in anthropogenic carbon in the Atlantic Ocean
16:00 – 16:20	Sven Kranz (AWI Bremerhaven) New approaches to assess the responses of phytoplankton to Global Change
16:20 – 17:00	Closing remarks / open discussion

ca. 17:00 end of the seminar

ABSTRACTS

Remote sensing of aerosols in Arctic region

L. Istomina, W. von Hoyningen-Huene, A. Kokhanovsky, V. Rozanov, and J. P. Burrows

Aerosols affect climate in two ways by direct and indirect climate forcing. In Arctic aerosols can also affect the albedo of the surface by deposition on snow and ice. These effects result in changing of atmospheric circulations and melting of snow and ice coverage, and this has a lot of consequences on both local and global scales. To understand the scale of these consequences one should know the amount of aerosols and details of their transport in Arctic. Remote sensing can provide necessary data, but aerosol retrival over very bright surface is a difficult task due to possible large error in the retrieved aerosol amount which can be caused by even small inaccuracy in accounting for surface reflectance.

In this work a dual-view algorithm to retrieve the amount of aerosol in Artic region has been established and validated. The algorithm consists of two main steps: 1. cloud/snow/ocean determination 2. AOT retrieval over cloud free snow and ice scenes. The first step is performed using spectral analysis of data pixels in 7 wavelengths from VIS to TIR, using the difference in spectral behaviour of snow, clouds and ocean in these channels. The second step solves the equation for top of atmosphere radiance in order to retrieve the aerosol optical thickness. For such bright surfaces the advantage of AATSR observations, the dual-viewing geometry (nadir view 0° and forward view 55°), is used. The albedo of snow is highly variable and depends on grain size of snow, soot concentration, humidity, age and can change in time and in space. Using the two views simulatiously makes it possible to exclude the snow albedo from the retrieval, and only account for snow bidirectional reflection function (BRDF) shape. In order to take the most realistic shape of snow BDRF, we use measured radiances of the whole system „surface + atmosphere“ to weight a preassumed snow model. This also lets us diminish the contamination of the retrieval by the relief of the surface.

The retrieval has been applied to sequences of data for various Arctic haze events at some Artic sites such as Spitsbergen and Alaska. The retrieved AOT has been compared to ground-based measurements. The developed cloudscreening method has been validated against Micro-Pulse Lidar Network data.

Clouds characteristics from satellite spectral measurements in the O2A-band

L. Lelli, A.A. Kokhanovsky, V.V. Rozanov, M. Vountas, and J. P. Burrows
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Almost 70% of the earth's surface is covered by clouds at any given time. Clouds can both cool or heat the troposphere. Clouds shield the incoming sunlight cooling the troposphere and, on the other hand, infrared radiation emitted by earth's surface is absorbed by cloud particles, which causes a heating of the troposphere. Therefore the determination of their properties is essential in the assessment of the earth's radiative forcing and routine calculation of trace-gases columns. The characterization of spatial and temporal behavior of clouds can be achieved combining radiances derived from different instruments. Datasets from several platforms are ingested in SACURA (Semi-Analytical CloUd Retrieval Algorithm), which exploits the absorption of oxygen in the near-infrared region, and properties as cloud-top-height and albedo as well as cloud optical thickness are retrieved. Moreover we investigate the spectral sensitivity of different instruments with respect to the cloud-top- and bottom-height determination with two approaches. The findings suggest that the increase in information content moderately improves the retrieval with both analytical and exact radiative transfer algorithm (deployed through the SCIATRAN environment). The error and sensitivity analysis for several scenarios and the qualitative comparison with the cloud-top-height from ATSR-2 (Along Track Scanning Radiometer) and ground-based measurements are presented.

Changing Arctic sea ice and consequences for ocean and atmosphere

Rüdiger Gerdes

Sea ice is an important component of the climate system in high latitudes. It influences the radiation balance and the ocean – atmosphere exchanges of heat and water. The surface conditions affect the pathways and intensity of storms. The fresh water transport by the sea ice impacts the ocean circulation through its effect on the stability of the water column in downstream regions. The fresh water transport with the sea ice is also an important part of the fresh water balance of the Arctic Ocean. Through the regulation of light transmission into the ocean, the provision of a distinct habitat and through its influence on the upwelling of nutrient rich water, sea ice also has an effect on the biological productivity in the Arctic Ocean.

Relative to its surface area, the Arctic Ocean receives a disproportionate amount of freshwater, mainly through river run-off and precipitation. In equilibrium, the Arctic Ocean exports as much freshwater as it receives from various sources. Main export pathways are through Fram Strait and the Canadian Arctic Archipelago. Freshwater is exported both as liquid freshwater and as sea ice. Climate model scenario calculations show declining sea ice export for the 21st century. This implies a larger need for liquid freshwater export and an intermittent increase in freshwater storage in the Arctic Ocean. The recent decline in ice thickness of the ice exported through Fram Strait has probably already impacted the sea ice export from the Arctic Ocean.

The summer sea ice extent anomalies of 2007 and 2008 represented a massive change in the lower boundary conditions for the atmosphere. Not only was the highly reflective snow and ice surface replaced by the dark ocean. The ocean mixed layer heated through the absorption of solar radiation and sea surface temperatures were 4K higher than the long term mean in large areas of the Arctic Ocean. Applying the 2007 Arctic surface anomalies in the Arctic to a atmospheric general circulation model we find a warming of the lower atmosphere and significant changes in sea level pressure. There are indications of a possible positive dynamical feedback between atmospheric circulation and sea ice.

Atlantic water melting Arctic Sea Ice - now or in the future?

Cornelia Koeberle

At the moment the Arctic ice is shielded from the warm Atlantic water at mid-depth by a well-developed halocline. If the heat content of the Atlantic layer would become available to the surface of the ocean, that could impact the development of the ice cover enormously. Coupled climate models contributing to the 4th assessment report of the IPCC project an ice free Arctic until the end of this century with this halocline either intact or even thickened. However, given the large sea ice extent reductions in recent years and the apparent inability of most climate models to reproduce the recent sea ice decline, we trace the in-flowing Atlantic water in an ocean-sea ice model (NAOSIM) and try to find mechanisms that could weaken or even dissolve the halocline within a few decades.

Arctic sea-ice development 1948-2008: Insights from coupled regional climate model simulations

Wolfgang Dorn, Klaus Dethloff, Annette Rinke, Rüdiger Gerdes, Dörthe Handorf

The simulation of the Arctic sea-ice cover with coupled atmosphere-ocean-sea ice models still comprises large uncertainties, which are very likely attributable to poor representation of feedback processes between the atmosphere and ocean-sea ice components of the coupled models. One of the major processes for the sea-ice retreat during the Arctic summer is the ice-albedo feedback. Due to the combination of improved parameterizations for ice growth, ice albedo, and snow cover on ice, a more realistic representation of this feedback process in the coupled regional climate model HIRHAM-NAOSIM has been achieved, by which the simulation of the summertime sea-ice extent is significantly improved.

Ensemble simulations with the improved version of HIRHAM-NAOSIM show that the interannual variability of the sea-ice cover is associated with differences in the atmospheric circulation. A realistic simulation of the atmospheric circulation is a necessary, but not sufficient prerequisite for the reproduction of the observed sea-ice extent in summer. The ensemble simulations also demonstrate that internal variability is important in summer, whereas the external atmospheric forcing of the regional model system dominates the interannual variability in winter. Furthermore, there are indications that the large-scale atmospheric forcing induces a pronounced multi-decadal variability in sea-ice volume, with rather thin ice in the 1950s and 1960s and thick ice in the 1980s and 1990s. However, the coupled model is still not able to reproduce the observed downward trend in summer ice extent. The contact with reality of the multi-decadal variability is therefore uncertain.

The importance of large scale sea ice drift and ice type distribution on ice extent in the Weddell Sea

S. Schwegmann, C. Haas, R. Timmermann, R. Gerdes, P. Lemke

In austral winter large regions of the Southern Ocean are covered by seasonal sea ice which disappears in summer. Only in few regions sea ice persists during the summer and becomes second year ice. Most of this second year ice is located in the Weddell Sea, making this region particularly interesting. The variation of the ice covered area modifies the exchange of heat, mass and momentum between ocean and atmosphere. Therefore knowledge of ice extent and its variability is necessary for an adequate simulation of those fluxes and thus for climate modelling.

The goal of this study is the observation of interannual and seasonal ice extent variations and their underlying causes in the Weddell Sea. Variability is analysed by using microwave satellite data. Results are correlated with satellite derived sea ice drift data to determine the impact of ice drift variations on sea ice extent.

An additional cause for variations of ice extent might be different ice type distributions, i.e. the contribution of first and second year ice to the total ice covered area. These ice types are determined on monthly time scales from scatterometer satellite data for the years 2000 to 2007.

Ice class distribution and sea ice drift variability are compared with the characteristics and variability of meteorological behaviour to evaluate the relative importance of different sea ice parameters for shaping Weddell Sea ice extent and its variability.

The determination of snow grain size using spaceborne optical measurements

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The changes of cryosphere have profound climatic consequences because of their contribution to global warming of the planet. Therefore, the task to monitor snow and ice parameters using spaceborne observations is of special importance. The main parameters of interest are as follows: snow cover, snow pollution, snow depth, snow grain size, snow water equivalent, snow temperature, snow and ice albedo, ice concentration, ice extent and thickness.

In this work we present selected results related to monitoring of snow cover parameters derived with MERIS and AATSR data. In particular, a newly developed algorithm for the determination of snow grain size is described in detail. The algorithm is implemented in the BEAM satellite data processing software for MERIS and AATSR. The applied method includes a comprehensive cloud screening and ice/snow detection procedures.

The retrieval code is based on the asymptotic solution of the radiative transfer equation valid for weakly absorbing scattering media. This enables fast runs, which is essential element of operational procedures. The results of retrievals are accompanied by validation using the ground measurements. A thorough sensitivity analysis for the retrieval of individual parameters based on the numerical solution of direct and adjoint radiative transfer equations in the framework of SCIATRAN is presented as well.

Large scale application of snow grain size retrieval with optical satellite data from MODIS

Heidrun Wiebe IUP Bremen

For climate modelling, the snow grain size and soot pollution are important parameters to determine the snow albedo, which in turn affects the energy balance of the Earth. It requires regular observations of the snow on a global scale, which can only be achieved by means of satellite remote sensing. The type of electromagnetic radiation that is applicable for detecting the snow grain size and soot concentration is optical and near IR radiation (400 nm – 1400 nm), as the grain size influences the reflectance characteristics in this wavelength range. Furthermore, optical and near IR data are available from various satellite sensors at a high spatial resolution in the order of 10 m – 1000 m.

In this presentation, the large scale application of the snow grain size retrieval SGSP (Snow Grain Size and Pollution) is presented for the Ross ice shelf, which is a rather level and homogeneous region. The SGSP algorithm uses optical data (here MODIS channels 2, 3, and 5 with wavelengths 860, 470, 1240 nm) to calculate the size of snow grains and the soot. It uses a snow reflectance model based on radiative transfer theory and geometrical optics for single-scattering characteristics. The new approach of the SGSP algorithm is the usage of three channels (conventionally two channels are used) in order to determine the two parameters, snow grain size and soot concentration, and to reduce the influence of the bi-directional reflectance distribution function (BRDF) from the retrieval. The BRDF defines how light is reflected at an opaque surface and strongly depends on the particle shape. The SGSP algorithm does not use assumptions of spherical snow particles, which is important, as snow grains have various kinds of shapes (plates, columns, fractals). Most existing snow grain size algorithms assume spherical snow particles, which may lead to incorrect results as snow grains are mostly not spherical.

Comparison of different techniques for melt pond determination for Landsat and MODIS satellite data on arctic sea ice

Anja Roesel, Lars Kaleschke

Melt ponds are regularly observed on the surface of arctic sea ice in late spring and summer. They reduce strongly the surface albedo and accelerate the decay of arctic sea ice. Until now, the spatial extend of melt ponds on arctic sea ice is only explored sporadically by field campaigns. Satellite based analysis have been done only for a few individual cases. The knowledge of the melt pond distribution on the entire arctic sea ice would be a solid basis for the parametrisation of melt ponds in existing sea ice models. Due to different spectral properties of snow, ice and water a multispectral sensor like the Landsat 7 ETM+ (Enhanced Thematic Mapper plus) generally is applicable for the analysis of the distribution of melt ponds. The very high spatial resolution of 30m*30m is an additional advantage. We developed an algorithm, based on a Principal-Component-Analysis (PCA) of two spectral channels, for the determination of the melt pond fraction. The PCA allows a proper differentiation of melt ponds and other surface types like snow, ice or water. The spectral band~1 with a central wavelength at 480 nm and band~4 with a central wavelength at 770 nm are used as they represent the differences in the spectral albedo of melt ponds.

For this analysis, we selected a Landsat 7 ETM+ scene from July 19, 2001, located in the northern Beaufort Sea, to apply the PCA. The comparison of the melt pond fraction determined from the PCA method with a method developed by Markus (2003), yields a different spatial distribution of the ponded areas: The fraction calculated with the PCA in areas with an apparently high melt pond distribution is more compact and areas dominated by open water show a lower fraction than the results of the method by Markus. Furthermore, a MODIS (MODerate resolution Image Spectroradiometer) subset from the same date and area is analysed by a method developed by Tschudi (2008). The comparison of different techniques and satellite data shows, that both classification methods for Landsat data give consistent results for the melt pond fraction. The classification of MODIS data results in a higher melt pond fraction as compared to both Landsat classifications.

Automated whale detection and local, high resolution ice mapping using a 360° ship-based thermal imager

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Ship borne visual observations are the predominant method to detect whales in the context of cetacean research and mitigation efforts during noise producing anthropogenic marine activities. Detections in most cases rely on spotting the whales' blow, which is frequently of low contrast and visible for a few seconds only, requiring utmost concentration of the observer. Hence, to reliable conduct such observations for multi-week periods on a 24h per day basis, large teams of observers are necessary to compensate for observer fatigue and the limited human field of view. Moreover, visual observations are restricted to daylight hours.

For high-latitude regions, a whale's blow contains fluid droplets which are significantly warmer than the polar environment, making thermal imaging a promising detection method for both day- and night-time. Here we present first results from a ship-borne, 360°, thermal imager, FIRST-Navy (RDE, Germany), which provides a continuous video stream of the ship's perimeter. The imager is mounted in the crow's nest of RV Polarstern and comprises a fully stabilized gimbal and a high resolution, 8-12 µm cooled infrared scanner.

Video data collected near Spitsbergen reveal that whale blows were clearly visible up to a distance of at least 1.5 km, even under relatively warm water conditions of 6°C. With decreasing water temperatures, detections ranged up to 3 km. Currently, automated detection algorithms are under development, with first results from an ongoing Antarctic cruise to be presented at this conference.

In addition, the IR video data may be used to generate a high resolution infrared map of the ship's immediate surrounding (approximately 1km). In particular, such images directly represent the local ice coverage in real time. This may be used for research applications, such as the calibration of satellite-based ice imagers or navigational purposes (finding leads or avoiding growlers), particularly at night.

Inventory changes in anthropogenic carbon in the Atlantic Ocean

R. Steinfeldt, M. Rhein, J. Bullister, and T. Tanhua

The formation of North Atlantic Deep Water (NADW) is a unique fast track for transporting anthropogenic carbon (Cant) into the ocean's interior, making the deep waters in the Atlantic rich in Cant. Thus the Atlantic is presently estimated to hold 38 % of the oceanic Cant inventory, although its volume makes up only 25 % of the world ocean. Between 1997 and 2003, the column inventory of Cant in the deep water formation regions, especially in the North western Atlantic, lacks the expected increase due to rising atmospheric CO2 concentrations. It is demonstrated that this decrease in Cant uptake is directly linked to the variability of the formation of (Upper) Labrador Sea Water, whereas the contributions of the overflow water masses show smaller fluctuations. The decline of Cant storage in the subpolar North Atlantic compared to 1997 reaches its maximum in 2007. Afterwards, the deeper convection in the Labrador Sea in the winter 2007/2008 led to an increase of the inventory of anthropogenic carbon. Compared to the global annual oceanic uptake of anthropogenic carbon of about 2 Pg C/yr, the annual changes in the subpolar North Atlantic are quite small.

New approaches to assess the responses of phytoplankton to Global Change

Sven Kranz

Global Change will affect phytoplankton in many and different ways, altering the complex balance of biogeochemical cycles and climate feedback mechanisms. Predictions of how phytoplankton may respond to these perturbations at the cellular and ecosystem levels are a major challenge in global change research. We investigate the responses of different phytoplankton groups (diatoms, coccolithophores, cyanobacteria, dinoflagellates) to environmental factors which will be altered by Global Change (CO_2/pH, irradiance, macro-/micro-nutrients). Interactive effects of these factors on key processes (growth, elemental composition, photosynthesis, calcification, N_2-fixation, toxin-production) are studied. Using a combination of mass-spectrometric and fluorimetric techniques, different *in vivo* assays are applied in laboratory and field experiments to develop a process-based understanding of cellular responses. Measurements are accompanied by analysis of protein and gene expression as well as microarrays. Working on different phytoplankton groups and specific oceanic regions, complementary issues are addressed. First results imply major changes within all phytoplankton functional groups on the physiological level affecting community structures and biogeochemical cycling.