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Arctic sea level change over the past 2 decades from GRACE gradiometry and multi-mission satellite altimetry

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The main goal of the iAREA project is to quantify the impact of the vertical profile of absorbing aerosols on direct radiative forcing in the European Arctic. This will be made through the experimental studies of various physical processes involving absorbing aerosols (mainly soot from human-made and natural sources, mineral dust and volcanic) and by numerical modelling of aerosols and by developing of a methodology to retrieve vertical profiles of the aerosol single-scattering properties.

The scope of the work within the project facilitates the determination of the degree of the impact, which man-made aerosols over the European Arctic have on the total radiative forcing. Finally, we want to show that the estimation of the impact of absorbing aerosols on the climate system requires an integrative approach which combines the actual observations of vertical variability with the global circulation/transport model simulations.

This research has been made within the scope of the iAREA program of the Polish-Norwegian Funding Program.

TP3-P-02: Changes in Temperature and Radiation at the Arctic Station Ny-Ålesund (79°N, 12°E)

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The Arctic is considered to be most sensitive to climate change, with warming in the Arctic occurring considerably faster than the global average. Several positive feedback mechanisms contribute to the ‘Arctic amplification’, including e.g. the snow/sea ice – albedo feedback. Moreover, clouds, water vapour and their radiative feedbacks are recognised as important issues in the arctic climate, and atmospheric circulation changes augment the meridional transport of water vapour to the Arctic. All of these processes impacting arctic climate are important concerning local feedbacks with the underlying surface but also global feedbacks on the energy balance of the planet. Altogether, radiative fluxes play a key role in the complex Arctic region. At Ny-Ålesund (78.9°N, 11.9°E), Svalbard, surface radiation measurements of up- and downward short- and longwave radiation are operated since August 1992 in the frame of the Baseline Surface Radiation Network (BSRN), complemented with surface and upper air meteorology since August 1993. Over the 21-year observation period, ongoing changes in the Arctic climate system are reflected. Particularly, the observations indicate a strong seasonality of surface warming and related changes in different radiation parameters. The annual mean temperature at Ny-Ålesund has risen by +1.3 ± 0.7 K per decade, with a maximum seasonal increase during the winter months of +3.1 ± 2.6 K per decade. In the recent warmer winters, precipitation has often occurred in the form of rain rather than snow. At the same time, winter is also the season with the largest long-term changes in radiation, featuring an increase of +15.6 ± 11.6 W*m^{-2} per decade in the downward longwave radiation. Furthermore, changes in the reflected solar radiation during the months of snow melt indicate an earlier onset of the warm season by about one week compared to the beginning of the observations.

TP3-P-03: Retrieving sea ice concentrations from 1.4 GHz brightness temperature measurements

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Arctic sea ice is one of the components of the climate system reacting most sensitively to the warming climate. The sea ice concentration is of special interest for physical reasons as it governs the heat exchange between ocean and atmosphere, for biological reasons as lower sea ice concentrations allow higher photosynthesis rates and for economic reasons as possible ship routes may open in an ice-free Arctic in summer. However, existing high-frequency microwave products of sea ice concentration have suffered from large sensitivities towards the state of the atmosphere and from large uncertainties regarding the sea ice concentration range between 0 and 50%. We applied an existing algorithm to retrieve sea ice concentrations from the low-frequency microwave 1.4 GHz brightness temperatures measured by ESA‘s Soil Moisture and Ocean Salinity (SMOS) satellite. We demonstrated that the wide range between the emissivities of open water and sea ice at 1.4 GHz causes a high sensitivity towards sea ice concentrations between 0 and 50%. Additionally, the atmospheric influence at 1.4 GHz is small. Our results do show physically plausible sea ice concentrations below 50% during the melting period 2012, which are not shown by high-frequency sensors. A validation with the Multisensor Analysed Sea Ice Extent (MASIE) product showed good agreement for the area enclosed by at least 15% of sea ice during the Arctic Cyclone in August 2012. These are important achievements because we show that it is possible to retrieve reliable and plausible sea ice concentrations between 15 and 50 % from SMOS data which have not been displayed by high-frequency microwave sensors. During winter, the sea ice concentration retrieval from SMOS data is difficult because the brightness temperature is more sensitive towards sea ice thickness than towards sea ice concentration.

TP3-P-04: Arctic sea level change over the past 2 decades from GRACE gradiometry and multi-mission satellite altimetry

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The Arctic is still an extremely challenging region for the use of remote sensing for sea level studies. Despite the

availability of 20 years of altimetry, only very limited sea level observations exist in the interior of the Arctic Ocean. However, with Cryosat-2 SAR altimetry the situation is changing and through development of tailored retrackers dealing with presence of sea ice within the radar footprint, we can now develop sea surface height and its variation in most of the Arctic Ocean. We have processed 3 years of Cryosat-2 data quantified as either Lead or Ocean data within the Cryosat-2 SAR mask in the Arctic Ocean. By carefully reprocessing and reediting conventional altimetry from ERS-1/ERS-2 and Envisat, we have now been able to derive a multi-decadal time series using far more remote sensing data in the interior of the Arctic Ocean than ever before.

Through recently acquired gradiometer observations from the ESA GOCE mission, we are now able to derive a mean dynamic topography of the Arctic Ocean with unprecedented accuracy to constrain the Arctic Ocean circulation controlling sea level variations in the Arctic. We present both a new estimation of the mean ocean circulation and new estimates of large scale sea level changes based on satellite data and perform an estimation of the freshwater storage increase over the last decade using temporal gravity changes from the GRACE satellite.

TP3-P-05: Thermophysical properties of seawater for climate change

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The global warming, melting of ice, greenhouse gas effect, the Gulf Stream and other processes in nature, in oceans and atmosphere play an important role for climate change. These processes directly depend on the properties of seawater. The majority of water on earth is seawater from a sea or ocean. The density of seawater changes in dependence on the depth below sea surface because of the pressure dependence from the depth of sea.

Some of the important atmospheric gases are added to seawater from the atmosphere through the constant movement of the sea surface by wind and waves. Compared to the other atmospheric gases, the amount of carbon dioxide dissolved in saturated seawater is unusually large. Direct storage and sequestration of captured CO_2 in the deep ocean has been considered as a means to mitigate global warming.

During many years the Institute of Technical Thermodynamics of University of Rostock together with the department of Heat and Refrigeration Techniques of the Azerbaijan Technical University analysed thermophysical properties of seawater samples from various parts of the earth, e.g. from the North Atlantic Ocean, Pacific Ocean, Mediterranean Sea, Caspian Sea, Baltic Sea, Dead Sea, Black Sea, Bosporus etc. An empirical equation of state for the calculation of various thermophysical properties (density, vapour pressure, solubility, isothermal compressibility, isobaric thermal expansibility, differences in isobaric and isochoric heat capacities, thermal pressure coefficient, internal pressure, secant bulk modulus etc.) of seawater was constructed.

TP3-P-06: POLYAR - Process of Organic transport to the Lakes of the Yamal Region

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Climatic and environmental fluctuations in the permafrost zone lead to activation of various cryogenic processes. This activation results in a strong impact on redistribution of substances and changes in biochemical composition of the water bodies. Lakes in the Arctic are good indicators of changing natural conditions. These indicators are expressed in both areal changes of thermokarst lakes, and changes in biochemical composition of water.

In this regard, the main purpose of the study is the development of the model of processes influencing the cDOM concentrations in Arctic lakes in permafrost landscapes. The model is based on in-situ measurements of aquatic parameters and land parameters, remote sensing of aquatic parameters and land parameters and topographical data. The key sites, where water samples were previously collected and more sampling is planned are: coastal zone of Yamal and Gydan, Central Yamal with tabular ground ice in the geological section. As Yamal peninsula is a very specific territory, comparison with data collected from the Lena delta is planned as well. The work is the joint research of staff from Arctic and Antarctic Research Institute, Alfred Wegener Institute and Earth Cryosphere Institute SB RAS.

TP3-P-07: Ice, water, fire: Changes in the permafrost landscape of central Yakutia, 2000-2011

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The focus of this research has been on detecting changes in lakes vegetation, land surface temperatures, and snow