(AC)^3

ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms

http://ac3-tr.de/

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Areas of contribution

Polar atmospheric processes

Modelling and forecasting

Polar-lower latitude linkages

Observations

Sea ice processes

Outreach

Summary

Within the last 25 years a remarkable increase of the Arctic near–surface air temperature exceeding the global warming by a factor of two has been observed. This phenomenon is commonly referred to as Arctic Amplification. The warming results in rather dramatic changes of a variety of Arctic climate parameters. For example, the Arctic sea ice has declined significantly. To study processes leading to Arctic Amplification we combine the scientific expertise and competency of three German universities (Leipzig, Bremen, Cologne) and two non–university research institutes (AWI, TROPOS) in the framework of a Transregional Collaborative Research Centre TR 172 (http://ac3-tr.de/) funded by the German Research Foundation (DFG). The first approved funding period (Jan 2016 to Dec 2019) covers the time frame of YOPP. The project will deliver a major German contribution to MOSAiC. Observations from instrumentation on satellites, aircraft, tethered

balloons, research vessels, and a selected set of ground–based sites will be integrated in dedicated campaigns, as well as being combined with long–term measurements. The field studies will be conducted in different seasons and meteorological conditions, covering a suitably wide range of spatial and temporal scales. They will be performed in an international context and in close collaboration with modelling activities. The latter utilize a hierarchy of process, meso–scale, regional, and global models to bridge the spatio–temporal scales from local individual processes to appropriate climate signals. The models will serve to guide the campaigns, to analyse the measurements and sensitivities, to facilitate the attribution of the origins of observed Arctic climate changes, and to test the ability of the models to reproduce.

Description

The overarching scientific objective of (AC)3 is to identify, investigate, and evaluate the key processes contributing to Arctic Amplification, improve our understanding of the major feedback mechanisms, and quantify their relative importance for Arctic Amplification. In Phase I (Jan 2016 to Dec 2019, approved) of (AC)3 the research will focus on atmospheric and surface processes, because the ongoing rapid changes in the Arctic climate imply that mechanisms involve important atmospheric influences. In Phases II and III (2020-2028, anticipated after evaluation of Phase I) the interactions between oceanic and atmospheric components in Arctic Amplification and related global aspects will be addressed in more detail. The planned combination of observational and modelling studies within (AC)3 aims to improve future projections of Arctic climate development.
Altogether 19 individual scientific sub-projects plus one coordination and one data management project with 27 Principal Investigators are involved in (AC)3.
Data will be collected during (i) dedicated, short–term field campaigns using ground stations, ship, balloon, and aircraft, and (ii) intensive, long–term observations from the ground (at super sites) and satellites for the circum Arctic region. The temporary, intensive field campaigns will be performed in different seasons to cover various cloud, aerosol, sea ice, and meteorological situations. They aim at detailed process studies with a focus on atmospheric and surface properties and feedback mechanisms driving Arctic Amplification. The long–term observations target on trends and spatio–temporal variability during longer time periods (up to the last 3.5 decades). The short–term intensive campaigns are embedded in the long–term data sampling. Different temporal and spatial scales will be covered by using diverse observational platforms. The collected data will have some overlap and complementarity, which assures coherence. The measured data will be stored in the Publishing Network for Geoscientific & Environmental Data (PANGAEA), that is hosted by the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI).
In May-June 2017 a joint field campaign using the research vessel Polarstern and two research aircrafts from AWI will perform closely collocated measurements at the ice edge North of Spitsbergen. Two more aircraft campaigns are planned during the end of the Arctic winter seasons of 2018 and 2019. We will also contribute to the MOSAiC campaign, and additionally plan measurements with the German research aircraft HALO (High Altitude and Long Range Research Aircraft) in March/April 2020.
Satellite data are essential to bridge the different scales in time (from short-termed field campaigns to decades covered by some of the satellite instruments) and space (from point measurements to the whole Arctic). Satellite observations are especially valuable for the evaluation of GCM parameterizations due to the large spatio–temporal statistics. The long time series of satellite data investigated and used in (AC)3 facilitate the identification of trends in model results and data. Many different geophysical parameters are retrieved by inverting passive or active remote sensing measurements made in the spectral range from the Ultra– Violet (UV) to microwave and in different observation geometries and modes (passive/active). The satellite platforms used in (AC)3 fly in sun–synchronous orbits and their instrumentation provide latitude–dependent diurnal

measurements at high latitudes due to meridional convergence towards the north pole.
In order to make full use of the planned unique observations, accompanying and adequate modelling activities are mandatory. Models will guide the planning and performance of field campaigns; they will be used as testbeds to evaluate different parameterizations, analyse and quantify feedback mechanisms in sensitivity studies and assess the importance of processes for Arctic climate and their interaction with dynamics and climate change.
The hierarchy of models employed within (AC)3 ranges from high–resolution process models to meso–scale, regional, and global models. The employment of these model types is subdivided into ’down-scaling’ and ’up-scaling’ approaches. In our down–scaling approach large–scale simulations with climate models are used to identify systematic errors on the daily, seasonal, inter–annual and decadal time scale and to quantify contributions of individual processes relevant for Arctic Amplification. Within (AC)3 we apply on the one hand atmospheric regional and global climate models with resolutions of about 13-130 km. On the other hand we run a coupled atmosphere–ice–ocean regional climate model and analyse coupled global climate model simulations from CMIP5/6. Further, we include simulations with a coupled ecosystem–ocean global model.
High–resolution modelling studies with prescribed large–scale forcing, that allows the comparison with the observations being performed on the same scale, will improve our understanding of these processes and uncertainties. This is the up–scaling approach, which improves climate simulations from the perspective of the small–scale processes. The mesoscale model will be applied with different resolution (5, 15, 50 km) on its domains and will serve as the tool to test parameterizations relevant for the RCM and GCM scales. The process models (RTM, SCM, LES) are tied to the campaign data with the aim to develop and evaluate parameterizations (particularly of clouds and ABL processes). However, it is emphasized that all modelling activities use the observational data in the process- and climate-oriented evaluation and helping in data interpretation. In scientific practice both approaches complement each other; our goal is to deploy the associated models such that we can benefit from the advantages of both approaches, which serves synthesis and integration.

Timeline

2016-01-01 - 2020-12-25

User relevant aspects

not applicable

Regional emphasis

Northern hemisphere: Yes

Southern hemisphere: No

Key project deliverables

Observational data from a multitude of field campaigns and long-term observations:
- Dynamic thermodynamic parameters (temperature, pressure, humidity, wind)
- Energy fluxes (turbulence, heat, radiation)
- Cloud and aerosol measurements
- Gas phase parameters, in particular water vapor
- Radiation

Model output from a variety of different model types covering wide temporal and spatial scales.

Data management

Publishing Network for Geoscientific & Environmental Data (PANGAEA), hosted by the Alfred–Wegener-Institut, Helmholtz–Zentrum für Polar– und Meeresforschung (AWI).

Is data provided to WMO Global Telecommunication System

No

Real-time provision

Radiosoundings from Polarstern for data assimilation

Timelines

Location	Latitude	Longitude	Start date	End date	Activity
Ny Ålesund	78° 56' N	11° 57' E	2016-01-01	2020-12-25	Continuous measurements (ground–based) will be conducted at the German/French research site (AWIPEV) in Ny–Ålesund (Svalbard) throughout the entire duration of (AC)3 (CONCORD). The overarching goal of CONCORD is to characterize the thermodynamic structure, clouds, aerosols, trace gases and radiative effects in the atmospheric column on a long–term basis exploiting the synergy of various remote sensing instruments. The analysis will be based on the established routine observations at the research station; new instrumentation will be installed within (AC)3, which will turn Ny-Ålesund into a complete atmospheric supersite providing also vertical cloud information. The long–term column characteristics at Ny–Ålesund and its variability will be connected to the large–scale and local meteorology, and the representativeness will be assessed. Data from other stations (Eureka in Canada, Summit in Greenland, Barrow in Alaska) will be involved.

Location	Latitude	Longitude	Start date	End date	Activity
North of Svalbard	78° 56' N	11° 57' E	2017-05-01	2017-06-25	Major combined observational campaigns of RV Polarstern (PASCAL), tethered balloon measurements from an ice–floe camp (ABEX) and AWI aircraft Polar 5 & 6 (ACLOUD, based in Longyearbyen, Svalbard) are scheduled to be performed at the same time in May/June 2017. The coupling of sea ice, clouds and aerosol in the transition zone between open ocean and sea ice will be investigated. The instrumentation on board of RV Polarstern provides standard and additional spectral radiation measurements to determine the surface energy budget and a detailed characterization of surface, cloud and aerosol properties. Similar measurements will be provided by CONCORD close to the open ocean. Observations of both surface stations will be coordinated with the airborne ACLOUD activities operating between Svalbard and the actual location of RV Polarstern along the sea ice edge. Airborne observation will be supplemented by ABEX measurements of the boundary layer structure (turbulent and radiative energy fluxes) from a tethered balloon.
Greenland-based	81° 43' N	17° 47' W	2018-01-01	2018-04-25	During an aircraft campaign in 2018 Polar 5 based at Station Nord (Greenland), airborne observations of snow, sea ice and aerosol optical properties will be conducted. Measurements are embedded in PAMARCMiP, a long–term airborne research programme of AWI. The standard instrumentation of the aircraft will be extended by an improved remote sensing package. Key instruments are spectral imaging sensors and specific new instruments for remote sensing of snow properties (e.g., albedo, grain size, roughness, black carbon concentrations). Remote sensing will be supported by airborne in–situ and ground–based aerosol measurements. Continuous observation within the 2nd and 3rd phases of (AC)3 enable to detect trends and to extend the observation area, e.g., to the Russian Arctic where the impact of ship traffic (North–East-Passage) and forest fires is expected to grow significantly. Additionally, process studies for the Canadian Arctic along the North–West–Passage are planned during future activities within PAMARCMiP.
Greenland-based	81° 43' N	17° 47' W	2019-03-01	2019-05-25	A third aircraft campaign (AFLUX), based at the Station Nord (Greenland), with one of the two AWI aircrafts is planned for 2019. The objectives and instrumentation are similar to ACLOUD, although somewhat reduced because probably only one aircraft will be available.