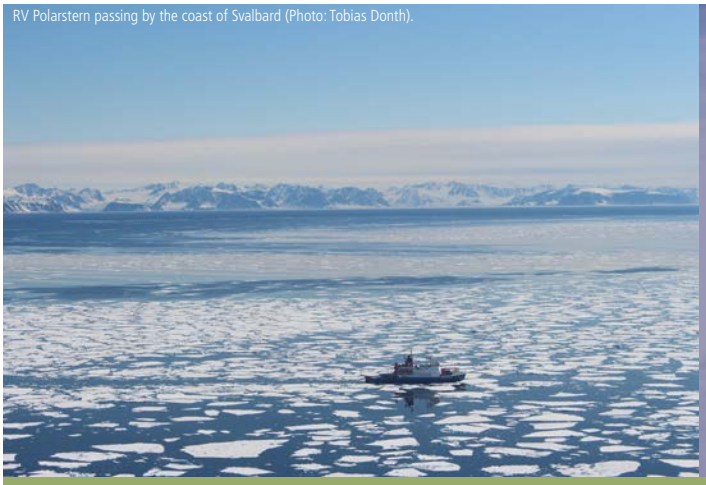


RV Polarstern passing by the coast of Svalbard (Photo: Tobias Donth).

Polar 6 close before touching into the clouds (Photo: André Ehrlich).

Transregional Collaborative Research Center on Arctic Amplification

(AC)³ Newsletter

July 2017
3rd Issue

EDITORIAL

Dear Reader,

It is incredible how time flies. Another half year has passed since the release of the second issue of our Newsletter and in the meantime our project progressed significantly with two undisputable highlights: (1) Proceeded by a Winter School on the Observation and Modeling of High-latitude and Arctic Clouds, in Finnland, on March 26th – 28th, 2017 we conducted our "First (AC)³ Science Conference on Arctic Amplification" hosted by the University of Bremen. (2) After the conference the hot phase of preparation for the first two major, combined field campaigns ACLOUD and PASCAL started (see two contributions in this issue for more information). In May and June we successfully performed both campaigns.

The conference in Bremen illustrated first significant scientific results of (AC)³. 18 oral presentations were given, mostly by young PhD students from (AC)³. Numerous posters were discussed. The conference also demonstrated the close links of (AC)³ with the international Arctic science community. Renewed international scientist gave keynote presentations. The members of our international Scientific Advisory Board (SAB) evaluated the current status of our project and gave valuable hints for the future. After the conference several internationally recognized experts in Arctic climate research gave lectures on general Arctic-related topics, which inspired in particular (but not exclusively) our PhD students.

The measurement campaigns ACLOUD and PASCAL turned out to be extremely successful. The project teams worked hard and eventually all of us are very relieved and highly satisfied with the campaign outcome. Besides the needed luck, the careful preparatory work indeed paid off. The Polarstern and the related ice camp were in reachable proximity of Longyearbyen (Spitzbergen), where the two AWI aircraft Polar 5 & 6 were stationed. The aircraft and ship, as well as the instrumentation withstood the harsh Arctic conditions and worked properly almost all the time during the campaigns. The weather situation was quite favorable for the intended cloud measurements; we encountered extended cloud fields with interesting ice features quite frequently. We met Polarstern and several satellites even more times than we had imagined. With these successful measurements our students and scientists have nice data to evaluate and to answer questions related to our project. We are very happy and cannot wait to look into the data and combine them with models, as envisioned in our project proposal. Stay tuned …

Manfred Wendisch, Speaker of (AC)³; Marlen Brückner, Scientific Coordinator.

TOPICS IN THIS ISSUE

CONFERENCE REPORT
1ST (AC)³ SCIENCE CONFERENCE ON ARCTIC AMPLIFICATION

On 26 to 28 of March 2017 we had our first (AC)³ Science Conference on Arctic Amplification kindly hosted by the University of Bremen, Institute for Environmental Physics (IUP). This conference had the occasion to discuss the results of the first year of our work within the TR172 on "ArctiC Amplifiaction: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms (AC)³". We were particularly pleased that more than 100 interested project members and guests accepted our invitation. We were excited that almost the complete Scientific Advisory Board (SAB) could come to the conference to give interesting keynote presentations and to discuss scientific results and perspectives, but in particular to advice and inspire for our young PhD students.

The conference offered five sessions representing the five project clusters of (AC)³. Most of the oral presentations were given by PhD students and young Post-Docs working within (AC)³. With more than 50 posters also the two afternoon poster sessions were a big success and gave the opportunity to discuss recent scientific results with the Arctic community. Furthermore, we had invited several speakers representing the German partners of (AC)³. A particular highlight of the conference was the evening talk by Sebastian Gerland from the Norwegian Polar Institute at the "Haus der Wissenschaften" in downtown Bremen.

We have prized the best PhD oral presentations and the most attractive posters by the "(AC)³ Young Investigator Award".

This conference turned out to be a big success and we are very much looking forward to our next (AC)³ Science Conference in 2018.

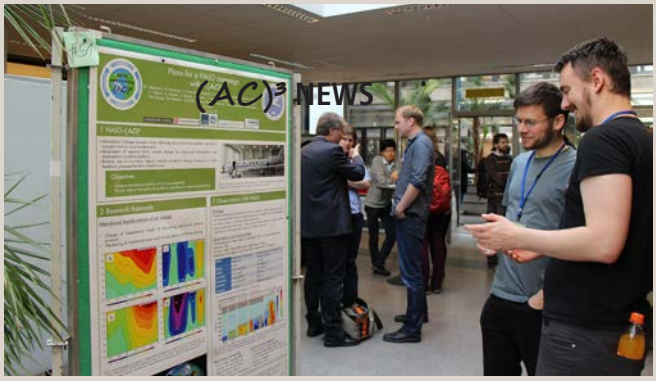


Fig. 1: Some meeting impressions from the (AC)³ Conference in Bremen. Top left: The conference group picture. Left: Lively discussions during the afternoon poster sessions.

(AC)³ YOUNG INVESTIGATOR AWARDS - WINNER

Best oral presentation:

- **Felix Lauermann, University of Leipzig**
- **Sandro Dahlke, AWI-Potsdam**

Best poster presentation:

- **Franziska Köllner, MPI-C Mainz**
- **Ulrike Egerer, TROPOS**
- **Yufang Ye, University of Bremen**

(AC)³ NEWS

- **Several upcoming (AC)³ workshops on aircraft activities, snow properties and Xcutting activities in autumn/winter. Check out online at http://www.ac3-tr.de/news-events/**
- **Stay informed: if you want to receive this newsletter regularly, you can subscribe online at http://ac3-tr.de**

News from the Field Observations - Aircraft

SIX WEEKS OF VERY SUCCESSFUL AIRCRAFT MEASUREMENTS IN ARCTIC CLOUDS

by André Ehrlich & Manfred Wendisch (University of Leipzig) & Christof Lüpkes (AWI-B)

At the end of June, after six weeks of intensive measurements, the first aircraft field campaign ACLOUD (Arctic CLoud Observations Using airborne measurements during polar Day) using the AWI aircraft Polar 5 & 6 has successfully been completed. Just recently, the (AC)³ students and scientists returned home to start analyzing the terrabytes of data collected during the campaign. In May and June both AWI research aircraft were operated from Longyearbyen at Spitzbergen to investigate Arctic boundary layer clouds by in situ and remote sensing measurements. With an impressive set of about 50 individual instruments, also other aspects on the list of scientific question of (AC)³ not directly related to clouds were addressed, such as the aerosol distribution and composition in different Arctic synoptic regimes, the variability of turbulent fluxes in the boundary layer over sea ice, the marginal ice zone and open sea water, and sea ice albedo and reflectivity in cloudless conditions.

The general synoptic conditions were almost ideal during the campaign: the sea ice edge was unexpectedly far south and in easy reach for the aircraft. On the other hand, the temperatures were still in the winter mode producing widespread clouds containing numerous ice crystals. These favorable meteorological circumstances prevailed over almost the entire campaign period and allowed to reach the sea ice edge, the research vessel Polarstern (PASCAL), and the respective ice camp in only about 1 hour flight time.

On 20 May, without any delay, both aircraft arrived in Longyearbyen and were immediately ready for the first science missions. Altogether 19 flights with Polar 5 and 18 flights with Polar 6 were accomplished until the end of June. Surprisingly, almost all of the instruments worked almost perfectly over the entire time period of the campaign, it was astonishing that the instrumentation worked so well in such tough Arctic conditions. That was the result of careful planning and preparation of the measurements by the involved students, scientists, engineers and technicians who did a great job in fixing all problems. That's why we achieved a data coverage of almost 100 %; hundreds of gigabytes of data were saved on our hard drives.

Fig. 2: ACLOUD group picture at Svalbard airport in front of Polar 6 & 5.

MEET THE (AC)³ FELLOWS

My name is Soheila Jafariserajehlou and I'm a new member of the (AC)³ project and a PhD student at University of Bremen, IUP, since October 2016. Originally I was studying geomatics engineering and my main focus was on remote sensing, in particular atmospheric correction in Radar Interferometry which was also the subject of my master thesis. It was my first experience in this field, which changed my view towards atmospheric science and motivated me to gain a deeper insight leading me to cluster B02 of the (AC)³ project.

In my current position, my aim is to establish and investigate changes of aerosol properties and surface spectral reflectance (SSR) in the solar spectral region, their origins and impact on Arctic Amplification using satellite-borne instrumentation. To achieve this goal, I will investigate the temporal changes in aerosol loading, type and SSR between 60° N and 90° N over the past two to three decades using data from a series of nadir sounding spectrometers. My research focuses on the determination of the SSR and aerosol optical properties for cloud free scenes.

Since cloud masking is the first step in aerosol retrieval, I initially applied an existing cloud mask method to specifix satellite datasets and could already show that the method needs improvement in the case of discriminating thin clouds from clear snow and ice.

(AC)³ GUESTS
GUEST STAY OF DR. RODRIGO CABALLERO (MISU) AT AWI-POTSDAM

by Annette Rinke, AWI-Potsdam (Cluster Speaker D & PI)

Rodrigo Caballero from the Department of Meteorology in Stockholm University (MISU) visited the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI-P) for two days. He gave a seminar talk on "The role of moist intrusions in winter Arctic warming and sea ice decline". There is increasing observational evidence that the Arctic winter climate is strongly controlled by filamentary intrusions of moist, warm air which cross the entire Arctic basin. He discussed how the distribution of these intrusions is affected by large-scale atmospheric circulation, particularly mid-latitude storm track activity, blocking events, and possibly by interaction with the stratosphere.

All AWI-Potsdam (AC)³ members working in clusters D and E had extensive and fruitful discussions with Rodrigo about this topic in general and specific links with our projects, particularly with D03, E02, and E04. For the latter also our (AC)³ colleagues from University of Cologne took part in the discussion via telecon. We discussed future topics of collaboration within our (AC)³ projects. The application of his intrusion algorithm can help us to better understand the spatial patterns of temperature, precipitation and storminess trends from reanalyses and our regional climate model simulations. Also, this will help to discuss the peculiarity of climate change at Ny-Ålesund/Svalbard, which is strongly affected by moisture intrusions, compared to observational sites in other Arctic regions.

News from the Field Observations - Aircraft
SIX WEEKS OF VERY SUCCESSFUL AIRCRAFT MEASUREMENTS IN ARCTIC CLOUDS (continued)

The measurements covered different atmospheric conditions with variable cloud regimes, different sea ice concentrations, a weak cold air outbreak, strong warm air advection and clouds touching the ground. Actually, fog at the airport kept the aircraft grounded for a couple of days; it was interesting to see how the fog slowly moved into the fjords of the island.

To be prepared for the different weather situations and to file the flight plans, we arranged regular weather briefing and flight planning meetings in our campaign headquarters at the Spitsbergen Hotel. These activities were supported by several (AC)³ members, including modelers, doing a great job with the weather forecast. Similar holds for the logistic support by AWI and all involved institutes making the campaign running smoothly from start to the end.

We managed to spend more than 160 flight hours in the air, almost equally distributed between Polar 5 & 6. We conducted 17 collocated flights of Polar 5 & 6, visited Polarstern ten times, overflew the CONCORD station in Ny Ålesund 11 times, catched six A-Train overpasses in close collocation with the Cloudsat and Calipso tracks, during one flight even two in a row. All scientists are looking forward to analyzing the very promising data set in the coming months and years.

Fig. 3: Almost endless, homogeneous cloud layers close to Svalbard as seen from Polar 5 (Photo: André Ehrlich).

Fig. 4: Polar 6 flying over broken sea ice. On the horizon typical thin clouds over sea ice and some ice clouds are obvious (Photo: Tobias Donth)

IN 4 WEEKS FROM BREMERHAVEN INTO THE ARCTIC & BACK TO LONGYEARBYEN

by Andreas Macke (TROPOS, Fahrtleiter PS106.1) & Marlen Brückner

On May 24 the research vessel (RV) Polarstern left Bremerhaven to its first Arctic expedition PS106.1 in 2017. This cruise leg was called Physical feedbacks of Arctic PBL, Sea ice, Cloud and AerosoL (PASCAL). 20 out of altogether 48 scientists on board were part of $(AC)^3$. Our aim was to take the shortest route into the Arctic sea ice north of Svalbard, and to perform physical, chemical and biological measurements of the atmosphere, the sea ice and the ocean. The major goal was to look for a suitable ice floe at around 82.5°N and 15°E and to install an ice camp for two weeks.

On our way to the marginal ice zone we performed numerous atmospheric observation continuously on board Polarstern. Vertical profiles of aerosols, cloud and ice water, temperature and humidity are retrieved from lidar, radar, solar-, infrared-, and microwave radiometers. So far, most of these remote sensing devices were operated on Polarstern during Atlantic transit cruises. So we were excited to see how they work under Arctic conditions. The daily highlights on the transit was the zodiac operations, where we performed sea surface microlayer and radiation measurements.

Shortly after passing Svalbard we already reached the sea ice margin. After one week on the ocean we suddenly arrived in a completely different world. Very impressing! Also impressing is the scientific information on the ship: the latest high-resolution satellite images, ice concentration and ice drift maps, local sea ice radar, several meteorological analysis from the ships meteorologist every day, and many more.

On the early morning of June 2 we passed a suitable ice floe, decided to conquer it, and in the morning the ship was fixed to the ice. As the gangway touched the ice the first exploitation was carried out, always carefully observed by the bear watch on the bridge. Flags were set to mark our station positions that we have discussed during several meetings prior to and during the cruise to the ice. Already on the same day, the first science teams installed the first instruments. We actually needed two full days to set up the meteorological station 200 m away from the ship around a very visible red shelter hut we call the "tomato": several radiation stations, a 10 m turbulence mast and the tethered balloon for profiling of the Arctic boundary layer. There is a special sledge for mobile snow albedo measurements. All over the station several holes have been drilled through the ice for regular sampling of oceanographic and biological properties underneath the ice.

While we experienced during the transit in the ice beautiful clear skies, we have hardly seen any sun since we arrived at the ice floe. Mostly low-level, thin clouds with occasional snow fall were observed. This turned out to be good conditions for our cloud remote sensing team, but othes were hoping for better weather for remote sensing flights and melt pond surveys.

Fig. 5: Left: RV Polarstern attached to the ice floe seen from the helicotpter. Several flags mark the different observations sites such as the meteorological site including the balloon and the red tomato, as well as different coring and snow probe sites (Photo: Niels Fuchs); Right top: Polar 5 and Polarstern (Photo: Marlen Brückner); Right bottom: Polar 5 is passing by the ship close to the surface measuring typical Arctic low level clouds (Photo: Andreas Macke).

IN 4 WEEKS FROM BREMERHAVEN INTO THE ARCTIC & BACK TO LONGYEARBYEN (continued)

Almost every day the two AWI research aircrafts Polar 5 and Polar 6 visit our new sea ice observatory around Polarstern for horizontal and vertical profiling of the atmosphere and to conduct surface observations.

While drifting, attached to the floe, we conducted a variety of measurements from the helicopter and on the ice to characterize properties of melt ponds and the surrounding sea ice. Since the ponds alter the albedo of the sea ice, which means the amount of reflected sunlight, they tend to warm up the sea ice system. Conducting many measurements at and in melt ponds, we aim to learn more about how they alter the surface properties of the sea ice during the melting season. We have been lucky because melt ponds started to appear quite in time when we were occupying the floe. In the framework of our physical observations of the sea ice and its snow load we have focused our investigations on the changes with respect to snow and ice melting during the last weeks. How does the energy (mostly solar irradiance) effect and change the snow and sea ice? To this end the thickness of snow and ice was measured along kilometer wide profiles along the entire floe. The additional probing of snow and sea ice with respect to aerosols and their interaction with the atmosphere was an essential part of this work. As we are in the middle of the melt season, strong changes could be observed within the past two weeks that could also be sorted into different types of ice. Especially the snow load on the sea ice did melt away drastically and the sea ice became significantly warmer and thinner.

After we covered a total distance of 2.373 nm within 4 weeks we finally reached Longyearbyen on June 21 and returned with tons of data and many impressions from the beauty of the Arctic.

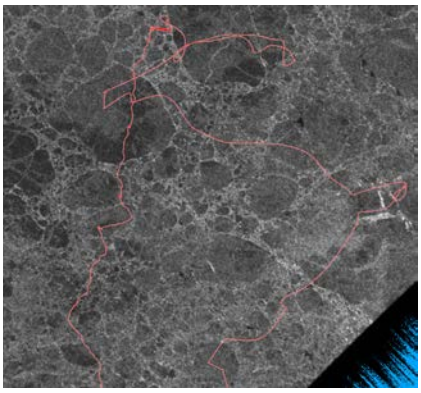


Fig. 6: Left: PASCAL group picture in front of Polarstern. Right: Cruise track of Polarstern ice drift with Sentinel satellite image of Arctic sea ice.

MEET THE (AC)³ FELLOWS

Hi, I am Philipp from the University of Bremen. I obtained my Master in Physics with emphasis on Environmental Physics and Solid State Physics in Bremen. My Master thesis dealt with the formation of discharges in the mesosphere, so called sprites. In (AC)³ I work in the sub-project B06 and the topic of my work is the latitudinal variability of water vapor, aerosols and thin clouds in the Arctic. For this, I was part of the PASCAL campaign on RV Polarstern. First part of my work was the setup of our lab container containing two FTIR spectrometer. One of these instruments works in solar absorption mode and measures the solar radation, the other one measures the emission of the atmosphere. With these devices I will record spectra in the mid-infrared region, from which parameters such as water vapor can be retrieved, also aerosols and cloud properties like liquid water path and effective droplet radius can be obtained from the shape of the spectra. The results of the solar absorption measurements will be compared the collected at Ny-Ålesund. For this, I will work on an improvement of the experimental setup.

News from the Field Observations - Balloon

TETHERED BALLOON MEASUREMENTS IN THE ARCTIC

by Matthias Gottschalk, University of Leipzig (PhD student in A02)

08:15: airborne activity meeting and weather briefing.
08:30: ice activity meeting.

09:00, it is time to get the equipment and leave the ship via the gangway.

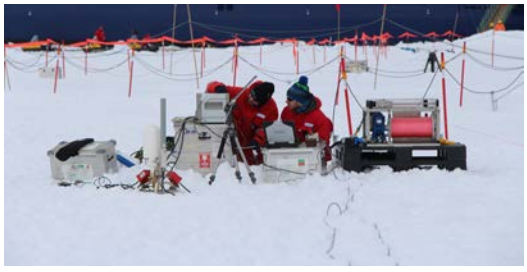
The crane lowers down the instruments and the winch on the sledge. We attach the scooter, the rifle is half-loaded and via VHF you can hear: "Bear watch, bear watch for Tomato", "Bear watch is listening", "Tomato is leaving to the Met-area". Slowly the scooter moves the 250 m towards the tethered balloon site and roughly one hour later the balloon is ready for the measurements.

Every morning, this was the procedure for the two weeks ice floe camp during the RV Polarstern cruise (PS106.1). The idea is to measure vertical profiles of energy fluxes through the cloud layer and compare them with surface and aircraft measurements. One advantage of tethered balloon measurements are the slow vertical speed compared to the airplane and the ability to measure stationary. To achieve these measurements, the balloon team of the University of Leipzig and TROPOS developed different packages to measure three-dimensional (3D) and one-dimensional (1D) turbulence, broadband irradiance, spectral radiation and standard meteorological parameters. In addition, we installed similar instrumentation on the surface close to the balloon site.

Every day we started with a complete profile to test the conditions, estimate the inversion and cloud top height. This information is crucial to place our instruments in the best position. The task was challenging but we managed it well with our backup systems. The main instruments, sonic anemometer and broadband irradiance, performed well.

We were surprised by the amount of icing we collected on the instruments and the rope. The accumulating ice, hence extra weight, made it hard to stay at the same height during some flights. The second limiting external factor are polar bears. Low, thick clouds decrease the visibility and thus the ability to see polar bears. Hence, we had to stop our sampling in case of low visibility and miss some thick clouds.

In general, the campaign was successful. Now it is time to look closely in the data and check the quality in detail and make science out of it.



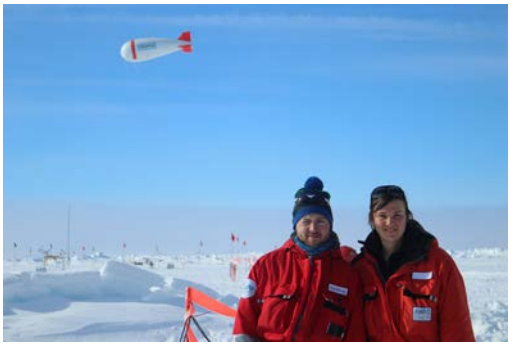


Fig. 7: Left: The meteorological measurement site including several turbulence and radiation instruments at the ice camp. Above everything floats the tethered balloon. The balloon group anxiosly monitors the position of the balloon, which is attached to a winch (Photos: Marlen Brückner). Right: The two $(AC)^3$ A02 PhD students Matthias and Ulrike with their working tool. Thomas tries to free the balloon rope and the broadband radiation sonde from ice (Photos: Matthias Gottschalk).

ACKNOWLEDGEMENTS

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DFG Deutsche Forschungsgemeinschaft

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(AC)³ Publications

UNDERSTANDING CAUSES AND EFFECTS OF RAPID WARMING IN THE ARCTIC

Abstract

For meteorologists and climate scientists, the Arctic is one of the most interesting regions on Earth. There climate changes currently take place at an unprecedented pace and intensity, and the reported dramatic changes have not been completely anticipated. The Arctic is warming more rapidly than the rest of the world, a process referred to as the Arctic amplification. Over the past 25 years, scientists have observed a remarkable increase of near-surface air temperatures, which exceeds the global warming by a factor of 2 to 3. To find out why this is happening, in January 2016 the German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) launched a new Transregional Collaborative Research Center (TR 172) called "Arctic Amplification: Climate Relevant Atmospheric and Surface Processes, and Feedback Mechanisms."
This effort, known by the abbreviation (AC)³, has as its overarching scientific objectives the identification, investigation, and evaluation of key processes involved in Arctic amplification; improving the understanding of the major feedback mechanisms; and quantifying the relative importance of these mechanisms. Our current understanding of the rapid changes in the Arctic climate implies that atmospheric processes likely dominate the short-term warming mechanisms involved. Thus, research in (AC)³ has an atmospheric focus during Phase I, which was approved to obtain funding by DFG from January 2016 to December 2019. In Phases II and III (planned for January 2020 to December 2027) the researchers of TR 172 plan to investigate the interactions between oceanic and atmospheric components more thoroughly.

Manfred Wendisch, **Marlen Brückner**, **John P. Burrows**, **Susanne Crewell**, **Klaus Dethloff**, **Kerstin Ebell**, **Christof Lüpkes**, **Andreas Macke**, **Justus Notholt**, **Johannes Quaas**, **Annette Rinke**, and **Ina Tegen**, Understanding Causes and Effects of rapid Warming in the Arctic, *EOS,* 98, 2017, https://doi.org/10.1029/2017EO064803. Published on 17 January 2017.

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