Plenary session during the 2nd (AC)$^3$ Science Conference on Arctic Amplification in Bremerhaven.

# (AC)$^3$ Newsletter

December 2018
6th Issue

## TOPICS IN THIS ISSUE



## EDITORIAL

Dear Reader,

we are approaching the end of the third year of (AC)$^3$, and it is high time to summarize what we have learned so far. And this is quite impressive! That became evident during the "2nd (AC)$^3$ International Conference on Arctic Amplification" that took place in Bremerhaven in November. The conference turned out to be the undisputed highlight of our project work within the last half year. We succeded to invite several distinguished keynote speaker from around the world to the meeting. Actually, it was not a big deal to attract them to the conference; they were curious to see what we have achieved and happily accepted our invitations to join us. Together with the members of the (AC)$^3$ Scientific Advisory Board they had a very close look at our results obtained in the first three years of (AC)$^3$. We have not received their written evaluation report yet, but from what we have heard, the board agreed that we performed quite well. We think the discussions during the conference both, among us as well as with our international guest, was extremely useful. Many thanks go to the local organizers in Bremerhaven; we truly enjoyed the conference and the nice side program (ice breaker, museum).

In July we held our first PI meeting to set the stage for the second phase of our project. We have learned quite a lot during the first phase of (AC)$^3$, based on our achievements we will assemble a convincing proposal for the upcoming second phase to be submitted in July next year. However, competition between SFBs is tough. We need to put all our efforts and power into the continuation proposal to succeed.

We also had some productive smaller meetings (e.g., HALO-(AC)$^3$ Planning Meeting, SYNARC) and conferences (e.g., POLAR 2018) within the last half year, which are briefly reported in this Newsletter. And we are preparing for the AFLUX campaign next spring, the third in a row of (AC)$^3$ aircraft campaigns based in Spitzbergen.

Please enjoy reading this Newsletter! And have a nice Christmas time and a perfect start into the New Year!

Manfred Wendisch, Speaker of (AC)$^3$, Christa Engler, Scientific Coordinator.

CONFERENCE REPORT

# 2nd (AC)³ INTERNATIONAL SCIENCE CONFERENCE ON ARCTIC AMPLIFICATION

by Christa Engler (University of Leipzig)

On 12 to 14 November 2018 our second (AC)³ Science Conference on Arctic Amplification took place at Klimahaus Bremerhaven. During the conference, the results of the first three years of work within (AC)³ have been presented and discussed. We were very pleased to welcome more than 110 project members and guests following our invitation to join the conference. In particular, we were excited that four members of the Scientific Advisory Board (SAB) and four invited speakers were able to come and give interesting keynote presentations and discuss the scientific results and perspectives. The advice and inspiration especially for our early-career researchers is pretty much appreciated.

Group picture during the 2nd (AC)³ Science Conference.

The conference was structured in five sessions representing the five clusters of (AC)³. Each session was chaired by a PhD student together with a more experienced scientist, and most of the oral presentations were given by PhD students and young PostDocs as well. During two afternoon poster sessions almost 50 posters were presented and discussed with the community. Furthermore, a video and diashow kindly provided by the AWI media office communicated impressions from the PAMARCMiP measurement campaign, which was conducted in Greenland in spring 2018.

Some of the conference participants during the poster session.

The most attractive posters were awarded by the "(AC)³ Distinguished Young Investigators Prize".

The conference was a big success and we are very much looking forward to publish all the impressive results in peer reviewed articles in the coming months.

## (AC)³ YOUNG INVESTIGATORS PRIZE - WINNERS

**Ana Radovan, University of Cologne**
**Ilias Bougoudis, University of Bremen**
**Jan Kretzschmar, University of Leipzig**

Winners of the (AC)³ Young Investigators Prize: Jan Kretzschmar, Ana Radovan, Ilias Bougoudis (from left to right).

The remotely piloted system ALICE

## (AC)³ NEWS

- Announcement - **Evaluation of (AC)³** in Leipzig, 11 to 12 September 2019. Further details at http://www.ac3-tr.de/meeting/evaluation-of-ac3/
- Our Special Issue in ACP/AMT is now open for submission. Please check out https://www.atmos-chem-phys.net/special_issue971.html
- Stay informed: if you want to receive this newsletter regularly, you can subscribe online at http://ac3-tr.de

News from the Modelers

# LARGE-SCALE DYNAMICS AND SURFACE AIR TEMPERATURE

by Daniel Mewes, D01 (University of Leipzig)

Increasing temperatures in the Arctic have an influence on the general circulation of our planet, while in turn the large-scale dynamics influences Arctic climate variability. As the Arctic is warming faster than the rest of the planet, the temperature difference between the low-latitude and Arctic regions has reduced over the last 30 years. This temperature difference is the main driver of the general circulation. At higher mid-latitudes, a key parameter within the general circulation is the jet stream, a large and strong eastward wind pattern in the upper troposphere, which plays a significant role in the mid-latitude weather system and heat transport into the Arctic. A strong jet stream implies more zonal transport while a weaker jet stream is more likely to meander and, thus, create more meridional transport. Generally speaking, the larger the temperature difference between the Arctic and low latitudes the stronger is the jet stream. Due to Arctic Amplification this temperature difference is decreasing, and with that, it is suggested that the jet stream is weakening. Due to the weaker jet stream, warmer air from lower latitudes can more easily access the Arctic region and, thus, can also increase the temperatures there. This in fact might increase the Arctic Amplification itself, which in turn might weaken the jet stream even further and resulting in a positive feed-back.

The project D01 "Large-scale dynamical impacts on regional Arctic climate change" is dealing with the change of large-scale dynamics due to Arctic Amplification and vice versa. Currently, we analyze to which degree distinct heat transports into the Arctic are related to surface air temperatures. For that, we used ERA-Interim reanalyses of the European Center for Medium-Range Weather Forecast (ECMWF) for the winter months 1979 to 2016. We group tropospheric horizontal transport of moist static energy using a simple neural network called "Self-Organizing Map" (SOM). The SOM extracts a user-defined amount of patterns from the data and arranges them in a two-dimensional field of maps. This provides information, which day of the time series corresponds to which pattern that was extracted from the SOM. In this way we can also relate other meteorological fields to the grouped data due to this assignment of each day to a distinct pattern derived from the SOM.

The top panel of Fig. 1 shows the refined result of the SOM. The SOM algorithm was used to find twelve distinct pattern of the daily tropospheric horizontal transport of moist static energy during winter. The patterns emerging from the SOM that showed similar features were manually grouped into three major pathways, which are presented in Fig. 1. The left-most pathway we called Atlantic Pathway due to the main transports into the Arctic through the North Atlantic sector; it occurs about 32 % of the time. The Continental Pathway features transports into the Arctic through Siberia or northern Canada, and it occurs about 25 % during the analyzed time intervals. The Pacific Pathway is connected to transports originating from the North Pacific, and it is most common during the last decades (42 %). The lower panels of Fig. 1 show the composite of the two meter air temperature anomalies corresponding to the grouping of the pathways. This helps to understand how the transports are connected to air temperature. The Atlantic Pathway is connect-

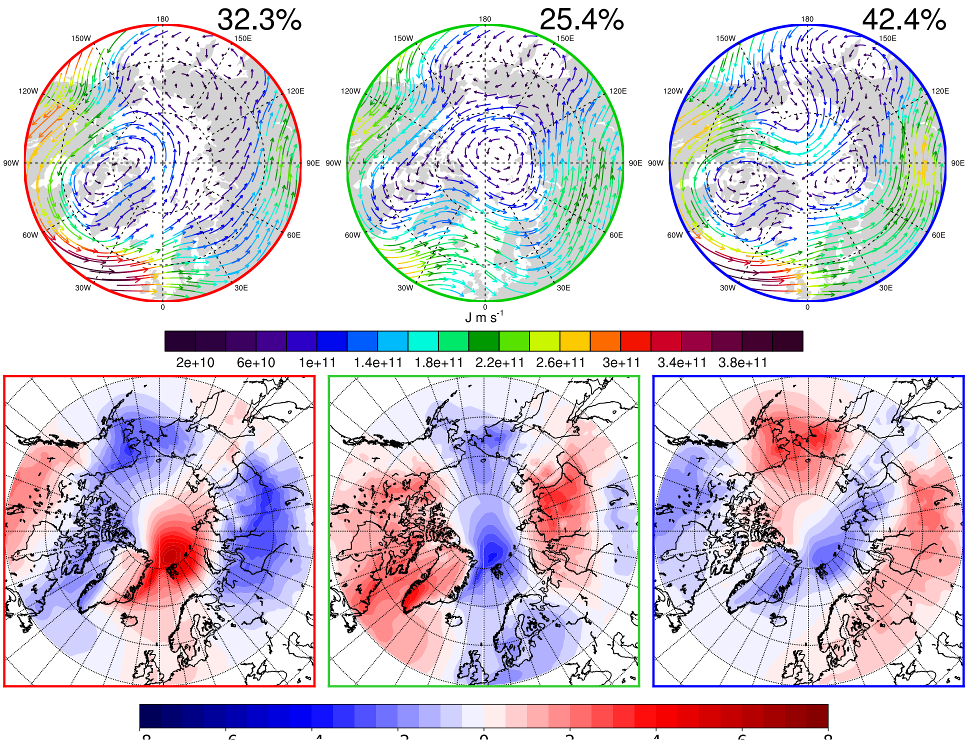



Fig. 1: Top: Transport pathways extracted from SOM analysis. Reddish and bluish colours correspond to stronger and weaker transports, respectively. The percentages on the top right of each pattern corresponds to their relative occurrence in the winters 1979-2016. Bottom plot shows the temperature anomaly composites corresponding to the pathways above, red colours show positive anomalies and blue colours show negative anomalies compared to the mean of 1979-2016.

## LARGE-SCALE DYNAMICS AND SURFACE AIR TEMPERATURE (continued)

ed to positive temperature anomalies over the central Arctic ocean, Barents and Kara Sea, and to negative temperature anomalies over central Siberia. The Continental Pathway shows positive temperature anomalies over the Siberia and North America, and negative anomalies over the central Arctic Ocean, Northern Europe, and the Bering Strait. The Pacific Pathway is connected to higher temperatures than usual in the Bering Strait and continental Europe, and lower temperatures over Greenland, North America and Svalbard Region. Further, we found that cases corresponding to the Atlantic Pathway are likely getting more frequent during the last three decades with an increase of about 4 % per decade, while the Pacific Pathway is getting less frequent.

With our analysis we could distinguish three major pathways of tropospheric horizontal transport of moist static energy. We can conclude that a warmer Arctic is related to a stronger northward heat transport through the North Atlantic while a colder Arctic is related to heat transport over Siberia into the Arctic. Additionally, the Atlantic Pathway is getting more frequent during the last decades which implies that the corresponding warmer temperatures in the Arctic that occur simultaneously might also get more frequent.

PhD students workshop in Bremerhaven

## (AC)³ STATISTICAL METHODS

by Sandro Dahlke (AWI Potsdam)

From November 15-16, 24 PhD students participated in the two-day workshop on „Statistical methods in Climate Sciences". The workshop was held by Prof. Dr. Inga Koszalka from GEOMAR, including a fabulous view on the river Weser from the lecture hall. In order to accomplish resilient and meaningful scientific results for us PhDs, it is vital to apply appropriate statistical methods to our data, regardless whether it is about modelling or observational data. The course made an excellent effort to deliver this message. Covering a broad palette of topics, the workshop consisted of equal amounts of theoretical lectures and practical exercises with relevant climate data from the Arctic. A review of basic notions such as probability distributions and statistical estimators was followed by presenting commonly used statistical tools for climate data analysis, such as (auto)correlation, linear regression, hypothesis testing, bootstrap and cross-validation. The students were working in groups on the exercises, and everyone could apply the appropriate functions, that were given as tools in the Python programming language. The course also pointed towards common pitfalls in applying either method, and certainly helped the students in their perspective to conduct excellent science. Regardless of the previous level of expertise in the field, the workshop offered highly relevant input for each of the participating students. We wish to thank Prof. Koszalka for teaching the course and (AC)³ for funding this event.

(AC)³ GUESTS

## DR. CHANTAL CLAUD (LMD/IPSL, CNRS) AT UNIVERSITY OF COLOGNE

by Ana Radovan (University of Cologne)

Dr. Chantal Claud from LMD/IPSL, CNRS and Ecole Polytechnique Université Paris-Saclay Palaiseau and director of astronomical observatory Versailles Saint-Quentin-en-Yvelines Observatoryin in France, visited (AC)³ and the Integrated Remotes Sensing research group at the Institute of Geophysics and Meteorology (University of Cologne) from 7 to 8 November. Her research interests are in detection of storm convection, its microphysics and precipitation from both, passive and active satellite instrumentation. As a long term expert in research on severe cyclones such as polar lows, as a part of hers visit, she gave a talk on this topic. In addition she also shared latest research that has been done in her group. This research considers development of retrievals algorithms of a snowfall from satellites with passive microwave instruments Advanced Microwave Sounding Unit (AMSU) and Microwave Humidity Sounder (MHS) and from the active ClaudSat. In her recent study the amount of total column water vapor from MODIS, GPS, SCIAMACHY and AIRS over Arctic region has also been investigated. This made it for a very interesting and fruitful latest research exchange between participants of our group that are part of (AC)3 subprojects E04 and B05. We mostly discussed possibilities and limitations of snowfall retrieval from AMSU-B/MHS in comparison with ClaudSat and CALIPSO satellites and ground based Micro Rain Radar (MRR).

## Workshop in Berlin
## The 1st HALO-(AC)³ PLANNING MEETING

by Bernd Heinold (TROPOS)

Observing Arctic air mass transformations will be the aim of a new Lagrangian-type experiment with the High Altitude and Long Range Research Aircraft (HALO) in spring 2021.

At a first planning meeting of the aircraft campaign called HALO-(AC)³ in Berlin on 28th of June 2018, mission PI Manfred Wendisch (University of Leipzig) and observationalists and modelers from different German Universities and research institutes discussed scientific questions as well as details of the instrument setup and related modeling activities.

HALO-(AC)³ will investigate meridional atmospheric transports between Arctic and Northern Hemisphere mid-latitudes, more specifically intrusions of warm/moist air and cold air outbreaks, and the associated transformation of air masses. This will advance understanding the links between amplified Arctic warming, mid-latitude weather, and related atmospheric teleconnections.

In a Langrangian manner, and equipped with a remote sensing package, dropsondes, and nose boom instruments, HALO will measure vertical profiles of meteorological, aerosol, cloud, and radiation budget parameters and their changes during meridional transport over the ice-covered and open Arctic Ocean. The flights are scheduled for four weeks from the beginning of March 2021 with the operational base in Kiruna, Sweden. The target area will be the North Atlantic Sector of the Arctic.

Eventually, the collected data will become a valuable source for research within (AC)³ and beyond. In particular because of their so far unprecedented spatial coverage, the HALO-(AC)³ observations will be best suited to evaluate climate models, which then can be applied to further investigate the atmospheric teleconnections between warming Arctic and mid-latitude weather more accurately and in more detail.

## PASCAL conference in Delmenhorst, 22 - 24 October 2018
## SYNARC

by Andreas Macke (TROPOS)

The main objective of the SynArc workshop was to bring together scientists studying the complex interplay between atmospheric physics, ocean dynamics, marine biology, and biogeochemistry in the coupled Arctic system. A large part of the workshop aimed at fostering cross-disciplinary scientific research of the research projects PASCAL (Physical feedbacks of Arctic PBL, Seaice, Cloud And Aerosol) and SiPCA (Survival of Polar Cod in a Changing Arctic Ocean) as well as related atmospheric, sea ice physics and physical oceanography projects, all contributing to the expedition PS106. Beyond that, the conference included participants from previous Arctic expeditions, such as TRANSSIZ, N-ICE, as well as representatives of the coming one-year ice-drift MOSAiC (Multidisciplinary drifting Observatory for the Study of Arctic Climate) of RV Polarstern. 45 senior scientists and PhD students from Germany, Spain, Sweden, Norway, and Canada attended the workshop. We specifically acknowledge financial and logistic support from the DFG (project number 412850984), TROPOS, AWI and the conference

### MEET THE (AC)³ FELLOWS


Hi, my name is Hannes Griesche. I have received a bachelor degree in Geophysics at the University of Münster. After that, I moved to Leipzig to do my master in meteorology at the University of Leipzig. In my master thesis, I have studied the influence of atmospheric dust on the predictability of numerical weather forecast models using ground-based remote sensing observations.

In April 2017, I started a PhD position in the subproject A01 within (AC)³ at TROPOS dealing with remote sensing observations of aerosols and clouds. In order to do so I use measurements from lidar and cloud radar made during the Polarstern cruise PASCAL in summer 2017. My first challenge in advance to the cruise was to prepare a motion stabilized cloud radar with the aim to minimize the influence of Polarstern's pitch and roll on the cloud radar measurement. To reduce the effect of the vertical velocity of the RV, I corrected the data also for the heave rate subsequent to the cruise. Now I am working on combining the remote sensing observations we have made in the scope of PASCAL with high resolved models in order to test their ability to simulate the Arctic clouds. A second application of these measurements is to use them as input for radiative transfer models in order to quantify the effects of clouds and aerosols on the Arctic climate.

location Hanse-Wissenschaftskolleg Delmenhorst.

The workshop started with overview presentations on the TR 172 "ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms: (AC)³", the current status of the atmospheric projects ACLOUD and PASCAL, both parts of (AC)³, an overview on the MOSAiC Programme as well as topical presentations along all scientific fields. Among several areas discussed during SynArc the following central and overarching topics will be presented exemplarily in order to foster future work in (AC)³:

*1) Proposed showcase study on connections between biological, physical and chemical processes relevant in ocean, sea ice and atmosphere*

It was proposed to engage in a showcase study based on data from PS106 that explores the linkages between the three major disciplines on board. A potential starting point of the study could be that INPs, especially in warm clouds, would not function without biological / biochemical compounds at their surface. The study could provide an overview on relevant biogeochemical processes and links to physics in ocean, sea ice and atmosphere, and identify key aspects that should be considered on MOSAiC.

*2) Cross-disciplinary studies on biogeochemical processes linking atmosphere, sea ice and ocean*

A large data series collected during PS106.1-2 has been identified that could be used to characterize the microbial loop and the subsequent escape of molecules into higher trophic levels. Specifically, it is suggested that the nutrient data, primary productivity rates, POC and chlorophyll, carbohydrates, eukaryotic DNA and fungal biomass data, and RNA samples could be co-analyzed to create a narrative that characterizes the activity of the microbial realm in relation to available organics and inorganics.

*3) Aerosol & cloud physics and biogeochemistry*

The occurrence of ice particles at warm temperatures as warm as -7°C is striking and requires reconsidering our understanding of ice formation in the atmosphere. We will try to put observational data from in-situ INP measurements to vertical wind profiles into a LES model to see to what extend observed INP can explain ice formation under realistic thermodynamical conditions. State-of-the-Art LES models are able to run CCN and INP as prognostic variables. Thus, observed CCN and INP will be able to feed the model with realistic ambient aerosol conditions. Chemical and biological (DNA) analysis will provide insights to what extend marine biological processes are responsible for effective INP in the atmosphere.

## (AC)³ GUESTS

## PROF. BRUNO TREMBLAY (MCGILL UNIVERSITY, MONTREAL) AT UNIVERSITY OF LEIPZIG

by Heike Kalesse (University of Leipzig)


Prof. Bruno Tremblay from McGill University, Montreal, Canada was an (AC)³ visiting scientist at the University of Leipzig from Nov 20 to 23, 2018. His research is centered on Arctic sea ice at the interface between the ocean and the atmosphere using Global Climate Models and observations. He is working on forecasting of pan-Arctic and regional Arctic sea ice on time-scales of month to seasons.

In a colloquium presentation at the University of Leipzig he introduced his pan-Arctic forecast of the minimum sea ice extent using a Lagrangian approach. Specifically, he showed that the position of the minimum sea ice extent ice edge in the Arctic is well correlated with the previous winter's coastal divergence. The maximum correlation is obtained when the synthetic ice edge is backtracked from May to February. While the pan-Arctic net ice divergence could be correlated with the winter mean Arctic Oscillation index, a regional analysis requires sea ice drifts in order to calculate the winter mean ice divergence along the coasts. This finding supports the need for continuous production of real-time satellite-derived sea-ice velocity vectors, which can now be used for observation-based regional forecasting. Other potential predictors include ocean heat fluxes, first year ice area, as well as cloud amount and cloud phase. He plans to cooperate with Jun.-Prof. Heike Kalesse in a project studying cloud amount and phase as Arctic minimum sea ice extent predictor to be applied for in the planned second phase of (AC)³.

CONFERENCE REPORT - POLAR2018, Davos

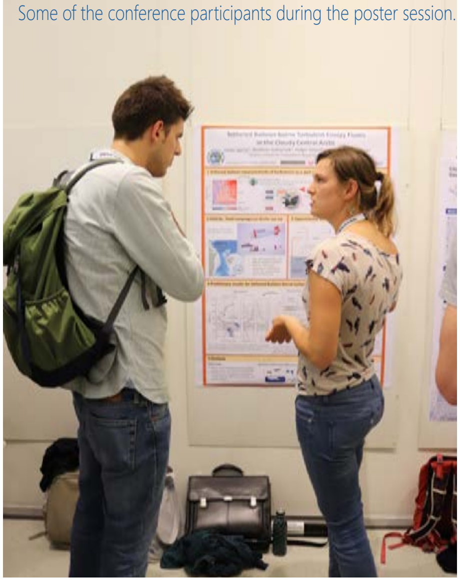
# (AC)$^3$ MEETS THE POLES

by Matthias Gottschalk (University of Leipzig)

The train winds up the slope, a steep valley to the left. Mountains rise on the other side of the valley. Soon we enter a tunnel. The conductor announces: „next stop Davos Dorf". I finally arrive at 1560 m. I get out of the train and most people have a poster roll in their hand. It's time for POLAR2018, a joined meeting by the Scientific Committee on Antarctic Research (SCAR) and the International Arctic Science Committee (IASC) with the slogan: where the poles come together. This conference lasts from 19.06.- 23.06. But some of the (AC)$^3$ PhD students already arrived a day earlier to join the APECS (Association of polar early career scientists) World Summit. We discussed about the different fields climate, marine, terrestrial and on different political and organisational aspects of early career scientists.

The next day at 8:00 POLAR2018 is officially opened. In total more than 2000 polar scientist take part and 2400 abstracts have been submitted. (AC)$^3$ takes his share with nine talks and ten posters. (Sadly, we did not manage to win the APECS-poster prize for Europe, as Sandro did not join.) Also 24,000 croissants were eaten, hence roughly 10 per day, per person.

Some of the conference participants during the poster session.



The conference is structured in different thematic sessions, while Arctic climate and BE have been the biggest ones. There have been a lot of interesting talks. Unfortunately, some of them were in parallel sessions. Thus, session hopping was a common sport for a lot of participants. It was interesting to see the similarities of the science on both poles. Furthermore, the third pole (high alpine areas, such as Andes or Himalayas) was also present. Thus, I attended sessions on Arctic clouds and aerosols, dynamical features such as Polar lows and Foehn. But also on sea ice, volcanism and science communication.

Such a conference is also a good opportunity to meet people again from campaigns or winter schools. During one break we went up on a mountain and enjoyed the stunning view on Davos. But even on that hut 800 m above the conference, you recognized persons you just have met an hour ago giving a talk.

Now I sit in the train, which climbs down the serpentines towards Zurich. I sort my notes and thoughts about this successful conference, where I learned a lot and look forward to our 2nd (AC)$^3$ Science Conference.

## MEET THE (AC)$^3$ FELLOWS

My name is Konstantina Nakoudi and I come from Greece. I am a new member of the (AC)$^3$ project, working at AWI-Potsdam since May 2018. I decided to study Physics from an early age, since I was really amazed by the way it explains the world around us. During my Bachelor studies in the University of Athens, I attended a wide variety of courses from Nuclear Physics to Astrophysics. However, Environmental Physics was the most impressive field to me, as it is related to issues that strongly affect humanity, such as air pollution and extreme meteorological phenomena. Therefore, I followed a Master in Meteorology, where I focused on retrieving the Planetary Boundary Layer height using atmospheric aerosols as tracers. This was my first experience in analyzing lidar data, which made me realize how powerful lidar systems are, since they can provide information of various atmospheric parameters, with high spatial and temporal resolution.

In the B06 sub-project of the (AC)$^3$ project, I found the best platform to continue working on the lidar technique. The goal of my PhD topic is to quantify the contribution of aerosols to the amplified Arctic climate change. Currently, I investigate the spatial and temporal variability of aerosols in the inner Arctic using ground-based and air-borne lidar systems. As a next step, I will assess the radiative forcing of aerosols in the atmosphere and on the ground using a radiative transfer code. In January 2019, I will travel to Ny-Ålesund, Spitsbergen, so as to perform measurements in the AWIPEV research station. Without doubt, this is a great opportunity to gain experience in operating a lidar system and with this knowledge I hope to contribute to the MOSAiC expedition. I can't wait for this field trip I hope to come back with more knowledge and experience in my suitcase...

## ACKNOWLEDGEMENTS

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DFG Deutsche Forschungsgemeinschaft

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## (AC)³ Publications

### ROLE OF AIR-MASS TRANSFORMATIONS IN EXCHANGE BETWEEN THE ARCTIC AND MID-LATITUDES

### Abstract

Pulses of warm and moist air from lower latitudes provide energy to the Arctic and form its main energy source outside of the summer months. These pulses can cause substantial surface warming and trigger ice melt. Air-mass transport in the opposite direction, away from the Arctic, leads to cold-air outbreaks. The outbreaks are often associated with cold extremes over continents, and extreme surface heat fluxes and occasional polar lows over oceans. Air masses advected across the strong Arctic-to-mid-latitude temperature gradient are rapidly transformed into colder and dryer or warmer and moister air masses by clouds, radiative and turbulent processes, particularly in the boundary layer. Phase changes from liquid to ice within boundary-layer clouds are critical in these air-mass transformations. The presence of liquid water determines the radiative effects of these clouds, whereas the presence of ice is crucial for subsequent cloud decay or dissipation, processes that are poorly represented in weather and climate models. We argue that a better understanding of how air masses are transformed on their way into and out of the Arctic is essential for improved prediction of weather and climate in the Arctic and mid-latitudes. Observational and modelling exercises should take an air-mass-following Lagrangian approach to attain these goals.

F. Pithan, G. Svensson, R.. Caballero, **D. Chechin**, T.W. Cronin, A.M.L. Ekman, **R. Neggers**, **M.D. Shupe**, A. Solomon, M. Tjernström ,and **M. Wendisch**, 2018, Nature Geoscience, doi:10.1038/s41561-018-0234-1, https://www.nature.com/articles/s41561-018-0234-1

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