The (AC)³ team during the General Assembly 2017 in Cologne.

Transregional Collaborative Research Center on Arctic Amplification

(AC)³ Newsletter

EDITORIAL

Dear Reader,

we havput together another interesting issue of our (AC)³ Newsletter for you. The present fourth edition includes a report of the weather forecast team of the ACLOUD campaign by Jacob Schacht, two articles from PhD students (Daniel Mewes, Philip Rrostosky) working in modelling projects of (AC)³, a report on the PhD workshop after the recent General Assembly in Cologne, and a summary of the first paper in the framework of (AC)³ with a PhD student as the first author (Sandro Dahlke).

It is already half–time of our first project phase! Time to have a look back and think about how to move forward during the next two years and beyond. This was more or less the major topic of the discussion during our recen General Assembly (GA), which took place in Cologne from 27–28 November 2017. During the GA we heard a lot of interesting talks mostly by our PhD students and Post-Docs reporting about the progress of their work. We would like to take this opportunity to thank our young scientists for their enthusiasm, dedication, and hard work, which obviously starts to pay off already. You are the heart of (AC)³!

During the GA in Cologne we also heard about the crosscutting activities, in particular with respect to the ACLOUD and PASCAL campaigns. It was awesome to see how both modelers and observational project partners join forces to exploit these valuable data from the campaigns. During the GA we also outlined the roadmap to prepare the proposal for the second phase of (AC)³. All in all, the GA was a very fruitful meeting, which no doubt fostered the communication among the different (AC)³ projects.

Besides the GA, there were several other meetings within the past half year, which brought together the project partners. One highlight was the Advanced Training Module for our PhD students with the topic of "Polar–Mid-Latitude Linkages Caused by Arctic Amplification", which took place in Leipzig in October 2017.

Have fun reading the Newsletter, enjoy the Christmas time, and have a healthy and successful New Year 2018!

Manfred Wendisch, Speaker of (AC)³; Marlen Brückner, Scientific Coordinator.
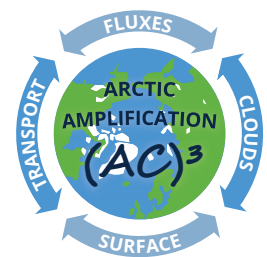
TOPICS IN THIS ISSUE

(AC)³ NEWS

- **Our campaign work during ACLOUD in Svalbard was accompained by the artist Kerstin Heymach. The result is a book including traditional expedition drawings with pencils and chalks and interviews from the researchers reporting on their work in the field. Order at http://edition.lammerhuber.at/buecher/klima-aufzeichnungen**

- **First exhibition of paintings from Kerstin Heymach during celebration of the 25th anniversary of AWI Potsdam.**

- **Stay informed: if you want to receive this newsletter regularly, you can subscribe online at http://ac3-tr.de**

Jacob Schacht (PhD student in sub-project D02) reports on

WHAT WILL THE WEATHER BE LIKE?

A question that you hear more often than you want to answer it as a person with a degree in meteorology. Sometimes it is justified, or even important. It allowed me to travel to a place, that not many people will ever visit: Svalbard.

During part of the ACLOUD campaign I was "the weather guy". A job I never envisioned doing. I knew that I learned everything I needed at the university, or did I? I was nervous, how important would my forecast be? What would depend on it?

When I arrived at the local airport I was picked up and immediately felt welcome. Things were off to a good start. People had already done more than one week of successful measurements and Bernd, who was the first to do the meteorological support felt comfortable at what he was doing.

So, I was right in the middle of my first day, in the conference room of the hotel, that I would end up spending most of my time in. Downloading weather charts of all important meteorological parameters, always trying to focus on the thing it was all about: clouds.

At first it was hard to distinguish what was important and what not, but things became more clear by later. It always came down to the question: When should we fly, and what would be the best flight patterns and instrumentation for the upcoming day? It was important to know when to expect clouds and where. Is icing on the planes to be expected?

It all went quite well, until one day when another flight towards Polarstern was planned. Like every day I got up early to have a quick look at the newest satellite images. It looked like the forecast said: Clear sky near the island, low clouds starting close to the ice edge.

After the breakfast and morning meeting everybody was eager to go and off they flew. It was a sunny and "warm" day in June, almost 10° C. It was melting everywhere, the water was running down the streets, that were steaming because of that. In the afternoon, something unforeseen happened. Very low clouds were forming over the open water. They had not shown up in any forecast and they were soon covering the airport area, making the lading very hard. I was shocked, but was told that this was not my error and not my responsibility.

Still, it shows that the Arctic clouds are so complicated, neither the models nor the meteorologist at the local airport saw them coming. The very reason we were on Svalbard made the work hard and dangerous.

Fig. 1: Low cloud forming over the open water, like the ones obstructing the view at the airport (Photo: Jacob Schacht).

News from the Modelers
CHANGE OF LARGE-SCALE DYNAMICS
by Daniel Mewes (PhD student in sub-project D01, University of Leipzig)

Increasing temperatures in the Arctic influence 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 globe, 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 midlatitudes, 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. So generally speaking, the larger the temperature difference between the Arctic and low latitudes the stronger is the jet stream. But 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 more resulting in a positive feedback.

The sub-project D01 is dealing with the change of large-scale dynamics due to Arctic Amplification and vice versa. Currently, we analyze to which degree the change of surface air temperature is related to the heat transport into and out of the Arctic. For that, we are using the ERA-Interim reanalyses of the European Center for Medium-Range Weather Forecast (ECMWF) for the winter months 1979 to 2005. We group the temperature data using a simple neural network called "Self-Organizing Map" (SOM). The SOM extract a user-defined amount of patterns from the data and arranges them in a 2-dimensional field of maps. This provides information which day of the time series corresponds to which pattern that was extracted from the SOM. So 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.

Fig. 1 shows the result of the SOM. The SOM algorithm was delegated to find three distinct pattern of the daily mean surface temperature data, shown as deviation from the 1979-2005.
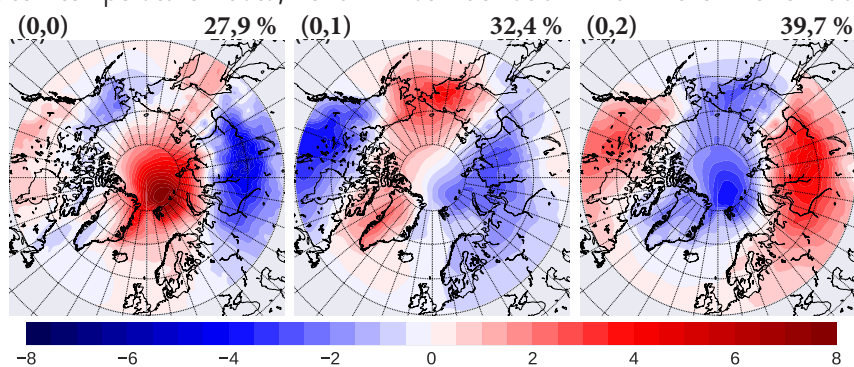

Fig. 2: The three temperature pattern extracted from SOM analysis as a deviation from the mean of the analyzed time frame in Kelvin. Red colors correspond to higher than usual temperatures and blue colors correspond to lower than usual temperatures. The percentages on the top right of each pattern corresponds to the relative occurrence for the winters from 1979-2005, the numbers on the top left is for naming purposes.

MEET THE (AC)³ FELLOWS

I'm Rosa Gierens and I grew up in Turku, a coastal town in southern Finland. The winters there are warm and wet, with much less snow than most of Finland enjoys. I studied Meteorology at the University of Helsinki (another wet and windy city by the sea). On my second year I got the possibility to visit Svalbard and I fell in love with the harsh beauty of the high Arctic. Later, during a semester at the University Centre in Svalbard (UNIS) I found out that I prefer living in a more pleasant climate. Therefore, last year I moved to Cologne for a PhD.

In (AC)³ I'm studying mixed phase clouds (clouds containing both super-cooled liquid water and solid ice) using ground based remote sensing. The measurements are running continuously at the AWIPEV station in Ny Ålesund, Svalbard, and part of my daily work is to make sure that the cloud radar is operating and the data is transfered without problems. I aim to combine different remote sensing observations with in situ cloud measurements made during the ACLOUD campaign to explore some of the complex microphysics in these clouds. I find the topic truly fascinating because there are so many things we don't understand about these clouds. For the new year, I have an exciting challenge in the role of representing the PhD students in (AC)³ - with all the great people I'm really looking forward to this!

(AC)³ GUESTS
PROF. XIANGDONG ZHANG (IARC/ UAF) AT AWI-POTSDAM

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

Xiangdong Zhang from the International Arctic Research Center (IARC) / University of Alaska Fairbanks (UAF) visited the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research (AWI-P), and gave a seminar on "Modeling Studies on Linkage Between Arctic Change and Mid-latitude Climate and Weather".

As a co-chair of the US CLIVAR Working Group on Arctic Change and Possible Influence on Mid-latitude Climate and Weather, he presented an overview of current existing knowledge on such links including weather extremes. Xiangdong's associated research includes Arctic climate variability and change, storm track dynamics, and air-ice-sea interaction.

Additionally to Xiangdong Zhang, we welcomed his two PhD students Yang Yang and Liran Peng. During their visit, they all had extensive discussions with several (AC)³ members about their work. In particular, we discussed the continuation of our collaboration on storm-sea ice interaction, which is part of the D03 project. We compiled a first joint paper draft on "Arctic regional modeling investigation of summer storm – sea ice – ocean interactions". We discussed results of the analysis of ensemble simulations of our regional coupled atmosphere-ice-ocean model HIRHAM-NAOSIM with respect to cyclone characteristics and how it might be affected by the underlying surface (e.g. sea ice extent). We also discussed specific details of the set up of our planned new model simulations when we plan to store additional oceanic model output for future analyses.
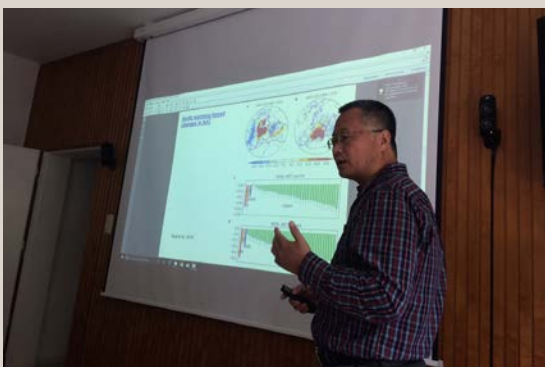
News from the Models
CHANGE OF LARGE-SCALE DYNAMICS (continued)

The left most pattern (0,0) corresponds to temperature distributions with high temperatures in the central Arctic, Barents and Kara Sea, and lower temperatures over central Siberia. The right most pattern (0,2) shows the opposite: a central Arctic that is colder, and continents (Eurasia and North America) that are warmer than usual. The middle pattern (0,1) shows lower temperatures than usual over North America, Siberia, Barents and Kara Sea, and warmer temperatures over the Bering Strait and Greenland. The percentages of occurrence of each pattern show that during the analyzed time period 40 % of the days corresponds to a lower temperature over the central Arctic, while only 28 % of the days corresponds to higher temperatures compared to the mean of the analyzed time period. Fig. 2 shows the time development of the occurrence frequency of the patterns. For this, the occurrence was analyzed separately for each winter from 1979 to 2005. Afterwards, a 5-year running mean was applied. In particular after 1997 the pattern (0,0) is getting more and more frequent and, thus, was the most frequent pattern for the last analyzed winters. At roughly the same time the pattern (0,2) starts to decrease in frequency. These trends are supporting the observations that the Arctic is getting warmer.

Based on grouping of data using SOM we can analyze which mean heat transport is connected to specific patterns. It was found that the mean horizontal heat transport corresponding to pattern (0,0) is on average directed through the North Atlantic over the central Arctic and south through northern Canada, while heat transport is directed for the other two patterns (0,1) and (0,2) either through East Siberia or Central Siberia over the central Arctic.

We conclude from the analysis using the SOM, 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. In future we use the SOM algorithm to analyze different patterns of horizontal transports and how they correspond to the Arctic temperature. With this we will be able to analyze both: how temperature determines the transport and how transport itself is determining the temperature. This will help us to understand different dependencies of the circulation and surface parameters.
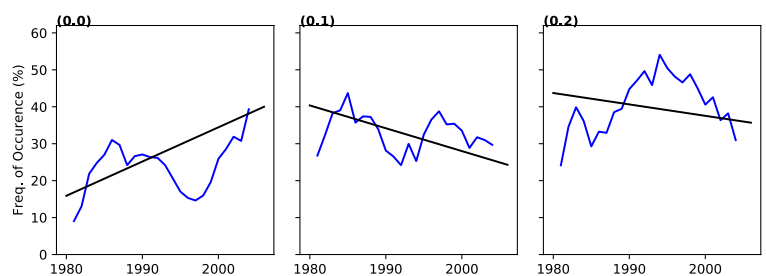

Fig. 3: The 5-year running mean time series of frequency of occurrences, for each winter the relative occurrence of each pattern was derived from daily data. The black line shows the linear trend.

News from the Modelers
MODELING THE MICROWAVE EMISSION OF SNOW ON ARCTIC SEA ICE

by Philip Rostosky (PhD student in sub-project D03, University of Bremen)

In order to describe and understand changes in the Arctic climate system, knowledge about the snow depth on Arctic sea ice is crucially needed. Snow is a very good isolator (ten times as good as sea ice), and therefore, even a shallow snow layer on top of the sea ice strongly influences the heat exchange between the ice/ocean and the atmosphere. Thus, the snow has a strong influence on the sea ice growth and melt. Due to its high albedo, snow reflects a large fraction of the incoming solar radiation and therefore strongly influences the Arctic energy budged.

Observations from satellites are the only tool to obtain information about the snow depth on a panarctic scale on a daily basis. The most common snow depth retrieval uses observations from satellite radiometers, which measure the microwave radiation emitted by the Earth. The quantity observed by those satellites is called microwave brightness temperature. Through scattering the observed brightness temperature is influenced by snow on top of the sea ice surface and from this it is possible to draw conclusions about the snow depth. However, besides the depth also other snow properties like grain size, density and liquid water, salt in the snow influence the observed signal. Additionally, also the sea ice beneath the snow affect the signal.

In this study, the influence of snow properties on the observed brightness temperature is analyzed. For that purpose, a microwave emission model for snow (MEMLS) is fed with detailed snow and ice observations from snow pits and ice-cores. The measurements were taken during a five-month field campaign in winter and spring 2015 (N-ICE2015) north of Svalbard led by the Norwegian Polar Institute.

Figure 1 and 2 show the key results of the modeling study. In Figure 1 the results using all available snow pit measurements are shown (39 snow pits). The quantity GR is the gradient ratio of two simulated brightness temperatures (T_b) at different frequencies (i.e. GR (37/19) uses brightness temperatures at 37 GHz and 19 GHz):

$$GR\,(37/19) = \frac{T_b\,(37) - T_b\,(19)}{T_b\,(37) + T_b\,(19)}$$

This quantity is traditionally used in snow depth retrievals based on satellite observations. However, in Figure 1 no clear correlation between the observed snow depth and neither GR (19/7) nor GR (37/19) can be found (correlation coefficient -0.23 and -0.11). This would mean that GR cannot be used to directly infer snow depth. For a more detailed analysis the snow pits are separated into four different classes and the influence of these classes on the GR is discussed. The classes are chosen with respect to different snow conditions that were observed during the N-ICE2015 campaign.

1. Blown snow or freshly fallen snow (stars in Fig. 1): This snow type has usually very small grains and is almost transparent in the microwave region. Therefore, the resulting GR will be close to 0.
2. Warm (and wet) snow (squares in Fig. 1): When the snow becomes warmer than -5°C a substantial amount of liquid water can be found within the snow. In case of this "wet" snow the GR is almost independent of the snow depth and approaches values close to 0.
3. Depth hoar (triangles in Fig. 1): In late winter and spring, so called depth hoar often develops close to the snow/ice interface as a result of snow metarmorphism. Depth hoar has very big grains and usually a high density. This results in very low GR and can therefore be misinterpreted as deep snow.
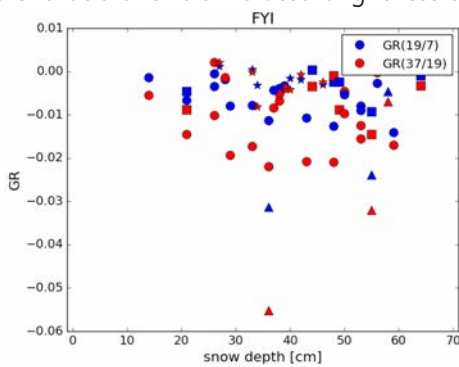4. All remaining cases (circles in Fig. 1)

Fig. 5: Scatterplot of simulated gradient ratio (GR) of brightness temperatures (y-axis) and measured snow depth for all snow pits (x-axis). Stars: fresh fallen or blown snow; Squares: wet snow; Triangles: depth hoar; circles: all remaining cases.
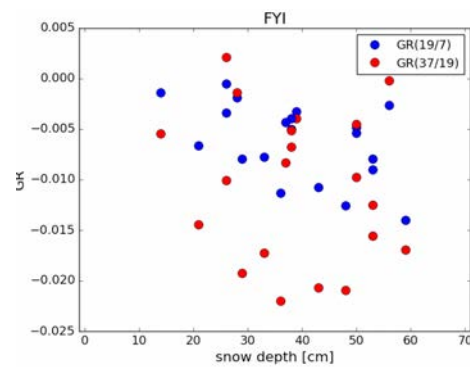

Fig. 2: Scatterplot of the simulated GR and the measured snow depth for the filtered Snow pits. Only snow pits with "regular" snow are shown. GR decreases with increasing snow depth.

In Figure 2, all snow pits that belong to the three classes 1 - 3 are removed. For the remaining 20 snow pits both *GR* show a reasonable sensitivity to the measured snow depth. On average, both GR decrease with increasing snow depth (Anti-correlation of -0.54 and 0.45). For such "regular" snow cases the snow depth can be retrieved from microwave radiometer observations (within some error margin).

The results of this study highlight the importance of the snow properties for snow depth retrievals based on satellite observations. In order to improve the accuracy of those retrievals, additional information about the weather conditions and the snow metamorphism are needed. Microwave emission models, like MEMLS used here, can help to correct for different environmental conditions to retrieve the most accurate snow depth based on the available information.
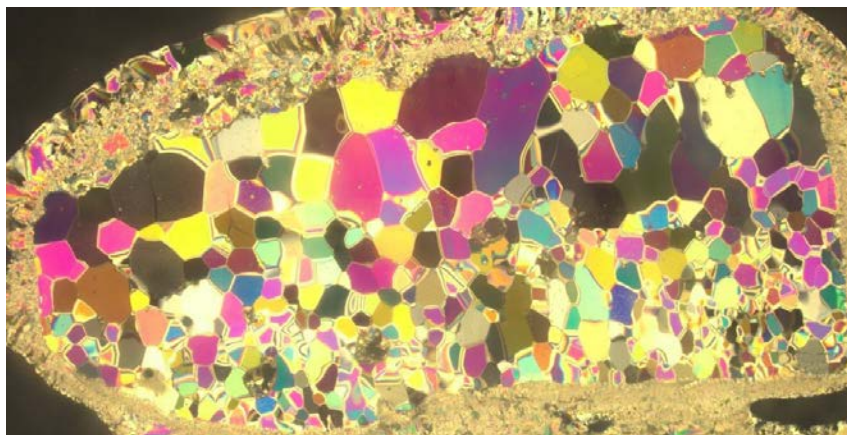

Fig. 6: Example of an ice-core thin section (top 5 cm of the ice core) photographed under polarized light. Statistical information about the air-bubbles within the ice (dark features) are used as input data for the model.

MEET THE $(AC)^3$ FELLOWS

My name is Ilias Bougoudis. I was born in a small town in the northern part of Greece. During my Bachelor I studied Computer Science at Aristotle University, while during my Master I worked in Environmental Informatics at Democritus University, focusing on air quality. The reason for this shift towards environmental studies is, that I want to apply all the theoretical background from informatics to more interesting, substantial real life problems, like climate change.

Since July 2016, I am working in the $(AC)^3$ project, sub-project C03. My role is to investigate how Arctic Amplification alters the chemical composition of the Arctic troposphere. For this purpose, I use satellite remote sensing in order to obtain a 20-year time series of halogens, which play a key role in the formation of the Arctic atmospheric composition, as they rapidly deplete ozone, changing the oxidizing capacity of the atmosphere. Moreover, I will study the relation of halogens to sea ice conditions and meteorological parameters in order to better understand their release mechanisms to the atmospheric boundary layer. Finally, I will link halogen observations to phytoplankton satellite retrievals and their changes, to gain a better picture regarding the effect of Arctic Amplification on the atmospheric composition and ocean biochemistry of the Arctic.

PhD students workshop in Cologne
IMPROVISATION INSTEAD OF IRRITATION

by Narges Khosravi, University of Bremen (sub-project B01)

The workshop was held on 29th and 30th of November in Cologne. The focus of the workshop was to utilize games and activities to understand human interactions and to provide potential solutions for the daily work/personal challenges. Through a various range of physical and mental activities we encountered (potentially) uncomfortable situations and came up with creative ways to handle them.

The first day of the workshop was mainly on learning how to interact. We were engaged in group activities in which we had to work together as a team, in order to finish a task or win a game. There have been games that winning was possible only by helping everyone else to win. There have been moments in which we had to face failure or rejection (in a controlled environment) and handle it. There have been activities by which we could only contribute by build up on others opinions and contributions. Through these activities we had to be creative, flexible, positive and accommodating in order to successfully finish the tasks. It was an interesting experience to view a situation from different points of view and "understand before being understood". Additionally, some team-work skills have been practiced to identify problems, propose solutions, put them in to action, assess the outcome and adjust the further actions based on these outcomes.

At the end of the day we moved to activities which were focused on self-understanding and analyzing. We assessed and discussed our individual tendencies while reacting to inner and outer expectations. This theme is also continued to the second day. We spend the second day mostly analyzing our own feelings and thoughts and getting in touch with our personal tendencies and characteristics.

Fig. 7: Some impressions from the interactive group activities during the PhD workshop in Cologne (Photos: Dr. Benjamin Hartwig/Neuroplay).

MEET THE (AC)³ FELLOWS

My Name is Benjamin Segger and I am part of sub-project E04 of $(AC)^3$.

I obtained my Diploma in Physics with emphasis on Atmospheric Physics and Geophysics at the University of Potsdam. In my Diploma thesis I analyzed extratropical cyclones and their connection to Arctic sea ice. After graduating from university, I worked on stochastic convection parameterizations at the Institute of Meteorology of the Freie Universtität Berlin.

Since February 2017 I am at the Alfred Wegener Institute in Potsdam and investigate snowfall, snow cover, and related feedback mechanisms. This means, I study how snowfall influences the growth and melting of sea ice and vice versa. Despite its importance, there are very few circum-Arctic stations measuring precipitation. Moreover, there are almost no observations from the Central Arctic. Therefore, simulations are often the only source to get information about precipitation events.

My first goal is to investigate how reliable model simulations are in terms of precipitation and how different assumptions in the microphysics scheme of the atmospheric models influence the results.

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(AC)³ Publications

CONTRIBUTION OF ATMOSPHERIC ADVECTION TO THE AMPLIFIED WINTER WARMING IN THE ARCTIC NORTH ATLANTIC REGION

Abstract

Arctic Amplification of climate warming is caused by various feedback processes in the atmosphere-ocean-ice system and yields the strongest temperature increase during winter in the Arctic North Atlantic region. In our study, we attempt to quantify the advective contribution to the observed atmospheric warming in the Svalbard area. Based on radiosonde measurements from Ny-Ålesund, a strong dependence of the tropospheric temperature on the synoptic flow direction is revealed. Using FLEXTRA backward trajectories, an increase of advection from the lower latitude Atlantic region towards Ny-Ålesund is found that is attributed to a change in atmospheric circulation patterns. We find that about one-quarter (0.45 K per decade) of the observed atmospheric winter near surface warming trend in the North Atlantic region of the Arctic (2 K per decade) is due to increased advection of warm and moist air from the lower latitude Atlantic region, affecting the entire troposphere.

Dahlke, S. and **Maturilli, M.**, 2017: Contribution of Atmospheric Advection to the Amplified Winter Warming in the Arctic North Atlantic Region, Adv. Meteorol., doi: 10.1155/2017/4928620, https://www.hindawi.com/journals/amete/2017/4928620/.
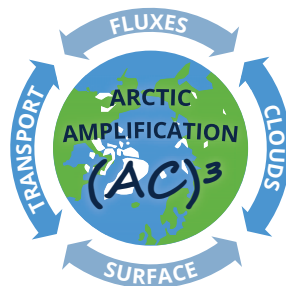
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