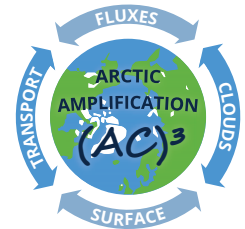## Transregional Collaborative Research Center on Arctic Amplification

(AC)³ Newsletter

EDITORIAL

Dear Reader,

it is our great pleasure to present the first issue of the Newsletter of the Transregional Collaborative Research Center (TR 172) on "ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms" with the acronym (AC)³. We plan to make this a biannual regular publication, with the general intention to update the interested public and our scientific colleagues twice a year about the progress of the (AC)³ project in a concise and comprehensible manner. We will share recent highlights of the work we are doing, and report about plans for the coming months. Furthermore, we will introduce 3-4 (AC)³ fellows in each issue. The letter will be published and distributed via our website (http://ac3-tr.de/). Because it is directed to a broader audience of non-specialists; no detailed previous knowledge will be required to comprehend the scientific content of the (AC)³ Newsletter. We will spare complicated details and try to write catchy, brisk and readable, in order to quickly get to the point.

August 2016
1st Issue

TOPIC IN THIS ISSUE

In the current issue we begin with a summary of the kick-off meeting of (AC)³ performed in May 2016. This event was intended to get the ball rolling, to welcome the new PhD students and PostDocs, to introduce them to the general topic of (AC)³, and to get them excited and motivated. After the kick-off the PhD students did not waste any time. It was amazing to see how quickly and independently they organized themselves. They initiated and performed a workshop to jointly learn about computational tools to conduct their work more efficiently. From what we have heard this meeting was extremely useful (see the respective report in this Newsletter).

Besides several outreach activities, two scientific highlights have already been achieved in the first six months of the project run-time. The cloud radar became operational by the end of June at the AWI station of Ny Ålesund, and the modelers improved the representation of Arctic climate using a coupled model. Both scientific activities are reported in the present (AC)³ Newsletter. Furthermore, we have achieved a first high-impact publication (K. Dethloff co-authored a Nature Climate Change paper).

Altogether, (AC)³ became operational quite fast and is running on full force and at full speed already. There is much work ahead of us, and time is flying. It is safe to say, the coming months, as usual (no complaint!), will be an extremely busy but also very exiting time.

Have fun while reading the first issue of the (AC)³ Newsletter.

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

$(AC)^3$ KICK-OFF MEETING

On 30 May to 1 June 2016, the $(AC)^3$ project kick-off meeting was held at Kloster Nimbschen (nearby Grimma, 35 km southwest from Leipzig) with about 75 participants. This meeting gave ample opportunities to get to know each other and to establish collaborations between the sub-projects of $(AC)^3$. Representatives of all 21 sub-projects (ordinary members, PhD students and Postdocs) participated in the kick-off meeting. Additionally, Stefan Kneifel from University of Cologne, who recently received an Emmy Noether award from DFG, presented his ideas for a collaboration with $(AC)^3$.

Fig. 1: Group photo (Swen Reichholdt)

This meeting turned out to be a big success. During the first two days we introduced the general topic of $(AC)^3$, which was particularly important for the young PhD students. Each $(AC)^3$ project cluster including all 21 sub-projects used the opportunity to introduce their research and present some first results. During the last day of the meeting we discussed further steps in the upcoming extensive field campaigns. One of the milestones in the next year will be the joint expedition of the research vessel Polarstern from Alfred-Wegener Institute for Polar and Marine Research (AWI) and the AWI aircraft (Polar 5 and 6). More than 50 researchers will collect measurements in the Arctic for four weeks. The ship-based and aircraft measurements will be accompanied by satellite and ground-based observations in Ny-Ålesund.

Furthermore, we discussed the modelling activities within $(AC)^3$. With a hierarchy of models working on different scales we want to close the gap between current existing Arctic climate models which are still not able to reproduce the rapid Arctic climate changes.

During the kick-off meeting we enforced our bylaws, and elected the representatives and bodies of the TR 172, as well as the members of our external Scientific Advisory Board (SAB). Team building was exercised during a bowling contest, a relaxed soccer match (luckily nobody got injured), echelon running with almost 35 highly motivated sportsmen (with real medals for the winning teams), a classic barbeque and a vespertine campfire.

Fig. 2: Manfred Wendisch talks to the curious audience in the impressive facilities of Kloster Nimbschen. (Swen Reichholdt)

(AC)³ KICK-OFF MEETING (continued)

On the third and fourth days the young PhD students and Postdocs came together to get acquainted with each other in a separate workshop. They had an exciting workshop on how to organize and manage their PhD work. The unchallenged highlight of this PhD student workshop was the poster session performed on the third evening of the kick-off meeting.

It was more than obvious that the entire staff of (AC)³ returned excited, equipped with new ideas, and highly motivated to implement them back to work at their home institutes.

News from the Field Observations
REVEALING THE SECRETS OF ARCTIC CLOUDS AT NY-ÅLESUND

by Kerstin Ebell, University of Cologne (PI of E02)

Atmospheric observations have a long history at the German/French Arctic research station AWIPEV far in the North at Ny-Ålesund, Svalbard (78°55'24" N, 11°55'15" O). Observations by a German station of the Alfred Wegener Institute (AWI) already started in 1991. Since 2003, AWI and the French Polar Institute Paul Emile Victor (IPEV) jointly operate the research base AWIPEV. The core facility is the Atmospheric Observatory which encompasses various instrumentation mainly dedicated to thermodynamic, aerosol, trace gas and surface radiation observations. Detailed cloud measurements have not been performed so far. While other Arctic cloud observatories already exist, e. g. at Barrow (Alaska), Eureka (Canada) and Summit (Greenland), continuous cloud observations in the warmest part of the Arctic are still sparse. In order to improve the knowledge on Arctic clouds sub-project E02 „Ny-Ålesund column thermodynamic structure, clouds, aerosols, radiative effects" of (AC)³ will provide long-term, vertically resolved cloud data.

A first significant step forward was recently taken by (AC)³ collaborators of the University of Cologne. Beginning of June 2017, Nils Küchler and Lisa Dirks (sub-project B03) came to the North to install the new 94 GHz cloud radar JOYRAD94. JOYRAD94, which was already tested at the Jülich Observatory for Cloud Evolution, will be operated at AWIPEV for about one year. Lifted by a huge crane, the cloud radar was set up on the roof of the AWIPEV observatory and is now located in close distance to other remote sensing instruments.

Fig. 3: The radar attached to the hook. (René Bürgi)

MEET THE (AC)³ FELLOWS

My name is Arantxa María Triana Gómez, and I moved from Valencia (Spain) to Germany to start my PhD with (AC)³ three months ago. In my hometown, I recieved the degrees of a Bachelor in Physics and a Master in Remote Sensing. Within (AC)³ I am working in sub-project B05 to estimate precipitable water vapor (PWV) (i.e. vertically integrated) from microwave remote sensing data (imagers AMSR-E or AMSR-2 and sounders AMSU-B or MHS). The general aim of B05 is to determine how water vapor changes temporally and regionally over the last decades, so we can analyze the relative effects on radiation, clouds and temperature from a significant database.

My first goal will be to merge two different PWV datasets to obtain a daily dataset of 50 km resolution with seamless coverages from the high Arctic to mid-latitudes, starting in 2002. From that, I will analyze monthly and seasonal regional PWV patterns, as well as inter-annual variability changes and trends.

I was elected as the representative of the PhD students within (AC)³.

Thanks to the amazing help provided by the AWIPEV onsite staff, the installation was realized without complications within one day. Since June 10, 2017, measurements are now continuously taken. Quicklooks of the radar measurements can be found at http://gop.meteo.uni-koeln.de/~Hatpro/dataBrowser/dataBrowser1.html?site=Ny-Alesund&date=0&UpperLeft=Joyrad94_Overview.

The radar is a frequency modulated-continuous wave (FM–CW) cloud radar which observes clouds with a maximum vertical resolution of 5 m up to a height of 10 km. Moreover, the instrument is equipped with an 89 GHz passive channel, receiving information on the liquid column over the instrument while using the same antenna as the radar. This is a novel design for radar/radiometer observations combining active and passive measurements to derive vertical cloud property profiles not only at the same point in time but also by combining active and passive information originating from the identical atmospheric volume. It is expected that the high vertical resolution and the perfect time and beam matching increases the accuracy of retrieval algorithms for cloud vertical profiles. The detailed analysis of the cloud radar Doppler spectra will enable to better understand processes of mixed-phase clouds which often occur in the Arctic.

In order to further improve the vertical information on the cloud macro- and microphysical properties of Arctic clouds, the cloud radar measurements will be combined with the collocated observations from the remote sensing instrumentation at AWIPEV, e.g. microwave radiometer, lidar/ceilometer and infrared interferometer. As a first step, the Cloudnet target classification algorithm will be implemented which will classify the backscattering hydrometeor types in terms of the occurrence of liquid water droplets, ice, rain and mixed phase particles. Subsequently, corresponding retrieval algorithms will be applied to describe liquid/ice amount and cloud droplet/ice particle sizes. The knowledge of the cloud composition is crucial to understand cloud processes and their interaction with terrestrial and solar radiation.

The JOYRAD94 cloud radar will be continuously operated until summer next year. Afterwards it will be replaced by the MiRAC cloud radar/microwave radiometer, which will fly on the Polar 5 aircraft during the ACLOUD campaign. The cloud observations will thus be continued at AWIPEV for a longer time period and will present a benchmark for model evaluation, a reference and validation data set to satellite and airborne retrieval algorithms, and complement in-situ experiments performed within $(AC)^3$.
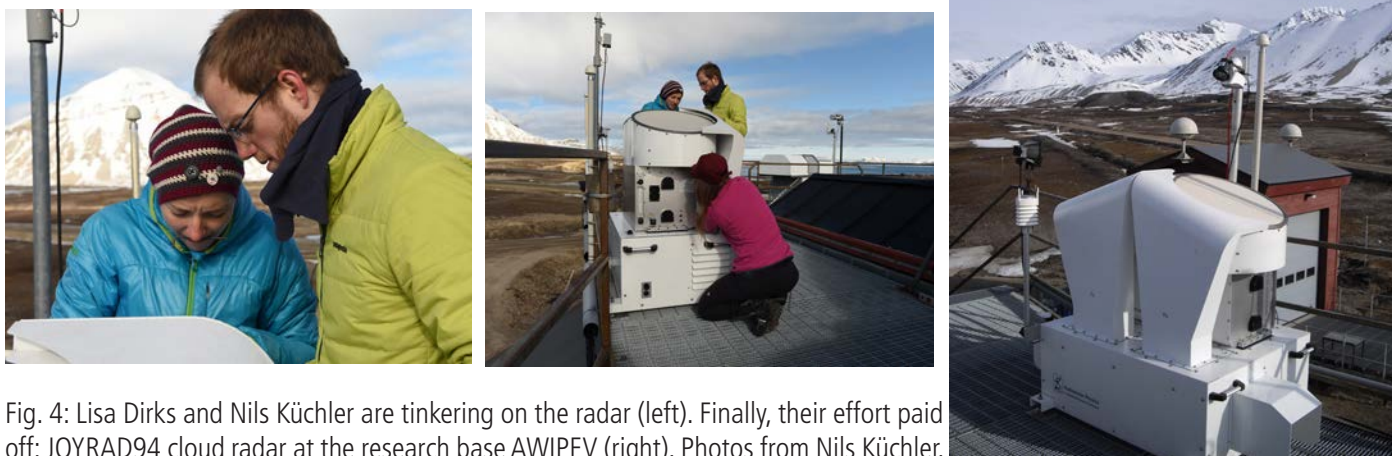

Fig. 4: Lisa Dirks and Nils Küchler are tinkering on the radar (left). Finally, their effort paid off: JOYRAD94 cloud radar at the research base AWIPEV (right). Photos from Nils Küchler.

$(AC)^3$ NEWS

- **$(AC)^3$ has been officially endorsed by Year of Polar Prediction (YOPP).**
  Further details can be found on http://www.polarprediction.net/yopp/yopp-endorsement/ .

- **John Burrows (PI of B01, B02, and C03) was promoted to a Fellow of the Royal Society, our Corresponding Member Klaus Dethloff was elected as a member of Leibniz Sozietät der Wissenschaften zu Berlin. Congratulations to both of them!**
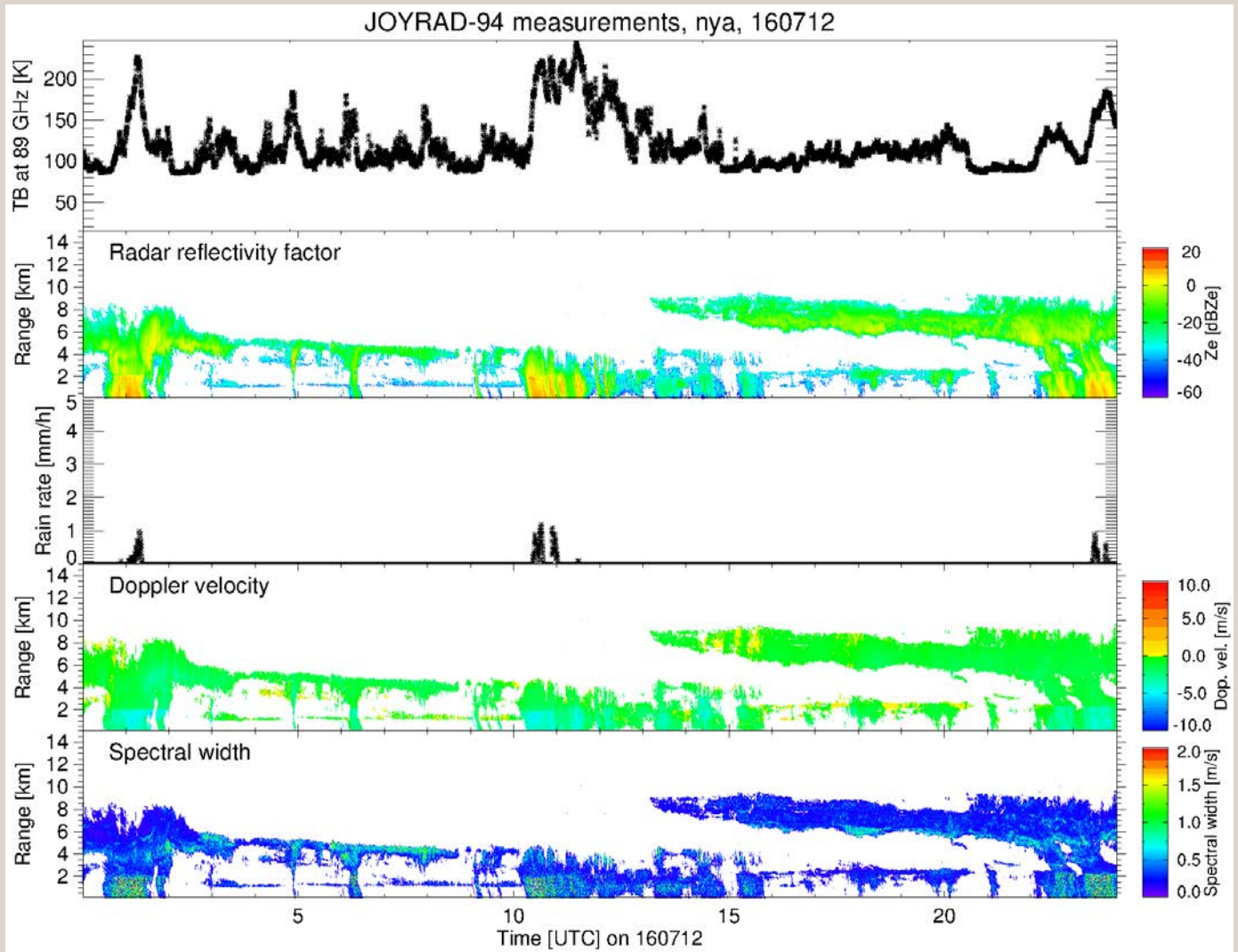
Fig. 5: Measurements of JOYRAD-94 cloud radar on 12 July 2016 at AWIPEV. From top to bottom: time series of brightness temperature at 89 GHz, radar reflectivity factor, rain rate of rain sensor, mean Doppler velocity and Doppler spectral width. On 12 July 2016, multi-layer clouds up to 10 km height were present at AWIPEV with intermittent periods with precipitation. The melting layer can be nicely seen at about 2 km height. High brightness temperatures at 89 GHz reveal the existence of liquid water in the atmospheric column. (University of Cologne)

News from the Modeling Groups
COUPLING THE FAST STRATOSPHERIC OZONE SCHEME SWIFT TO THE CLIMATE MODEL ECHAM6 IMPROVES THE REPRESENTATION OF POLAR CLIMATE

by Markus Rex, AWI Potsdam (PI of D01)

Interactions in the coupled tropo-/stratosphere system play an important role for the variability and long term evolution of Arctic climate. The importance of stratospheric ozone as a climate active gas is well recognized and feedbacks between stratospheric ozone and climate are particularly strong in polar regions. Mechanisms related to ozone/ climate feedbacks can provide an important amplification factor for climate change in northern high latitudes. A major goal of $(\mathcal{AC})^3$ is to include these feedbacks in climate models and use such fully coupled models to investigate the role of ozone/climate feedbacks in Arctic Amplification.

Hello, my name is Tobias Donth. I was born in Zeitz, a small town in the southern part of Saxony-Anhalt, on April 17, 1991. I have studied meteorology in Leipzig from 2010 until November 2015. I have written my bachelor thesis as well as my master thesis in the working group of Prof. Manfred Wendisch. During my master thesis, I analyzed different spectral radiation quantities from ground-based measurements in China to derive aerosol optical properties in a highly polluted region.

Since February 2016 I am working on the sub-project C02, as a PhD at the University of Leipzig. This sub-project basically deals with black carbon particles in the Arctic region. I will use spectral radiation measurements from aircraft and ground-based observations to derive surface reflection properties. Currently, I am working on an algorithm to derive black carbon concentrations in snow, using spectral albedo measurements. In 2017 we will participate in the ACLOUD campaign. Our second measurement dataset will be collected during the PAMARCMIP campaign, which will take place at Station Nord in Greenland, in 2018. I am really looking forward to gain experiences in terms of field work in the Arctic region.

News from the Modeling Groups

COUPLING THE FAST STRATOSPHERIC OZONE SCHEME SWIFT TO THE CLIMATE MODEL ECHAM6 IMPROVES THE REPRESENTATION OF POLAR CLIMATE (continued)

Detailed, state-of-the-art chemical transport models of the stratospheric ozone layer are now mature and reproduce the stratospheric ozone layer appopriately. But their computational effort is prohibitively large.

Hence, stratospheric ozone is typically prescribed in modern climate models. The international modelling community is in desperate need of a method for including ozone interactively within climate models but avoiding the huge computational overhead implicit in coupling a full chemistry module.

SWIFT consists out of polar-SWIFT, a module for the stratospheric ozone chemistry in polar winter and extrapolar-SWIFT, a module for the extra-polar regions, which is also used in polar regions during summer. The reason for this separation is that the chemical mechanisms affecting ozone are very different during polar winter. While the families of chemical species that affect ozone are fairly close to photochemical equilibrium for most of the stratosphere, this is not the case for polar winter.

To study the role of ozone/climate interactions for Arctic Amplification we are developing the fast stratospheric ozone scheme SWIFT and couple it to the climate model ECHAM6. Ensemble studies with the resulting Chemistry Climate Model (CCM) will be used to distinguish internally generated atmospheric variability from trends forced by ozone changes and increasing greenhouse gas levels as well as by interactions between both.

Coupling a prototype version of polar-SWIFT to ECHAM6 has resulted in an extremely fast CCM. ECHAM6-SWIFT is only a few percent slower than ECHAM6 alone but is able to fully account for the main feedbacks resulting from ozone-climate interactions in polar regions. Including stratospheric ozone chemistry interactively has improved ECHAM6's ability to reproduce polar climate and has reduced biases in temperature and dynamics. Particularly the improvements in the representation of dynamical vertical coupling in the atmosphere will allow us to achieve one goal of $(AC)^3$: To better understand the role of dynamical coupling between the stratosphere and the troposphere for Arctic Amplification.
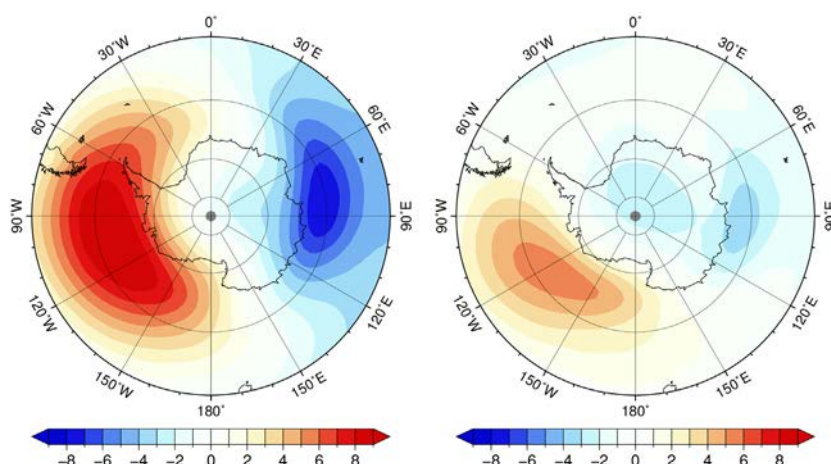

Fig. 6: 50hPa temperature biases of ECHAM 6 (left) and ECHAM 6 − SWIFT (right) in Kelvin, compared to the ERA-interim meteorological data set, which is based on assimilating observations in a numerical weather prediction model. The figure is based on a decade long test integration of the coupled model set-up.

MEET THE $(AC)^3$ FELLOWS

My name is Lisa Dirks and I am working in sub-project B03 of $(AC)^3$ at the University of Cologne.

I obtained my Master degree in Geoecology (Environmental sciences) with a focus on environmental physics. In my Master thesis I investigated the influence of boundary layer processes on snow surface temperatures.

The topic of my PhD work is the characterization of Arctic mixed phase clouds by airborne remote sensing. I will investigate these clouds with a Microwave Radar/ Radiometer for Arctic Clouds (MiRAC) on board of the AWI research aircraft Polar 5. MiRAC is a combination of Radar (94 GHz with a 89GHz passive channel) and radiometer (183 GHz, 243 GHz, 340 GHz) tailored to investigate the vertical and horizontal distribution of ice and liquid water in Arctic mixed phase clouds.

The first steps of my work are to get familiar with radar and radiometer measurements and do some pre-simulations for the measurements in the Arctic with a radiative transfer model (based on radio sonde data). Furthermore, I am participating in an aircraft campaign in Island (HALO) to get acquainted with aircraft measurements in general. Besides this I already helped to set up our new cloud radar in Ny Alesund (picture).
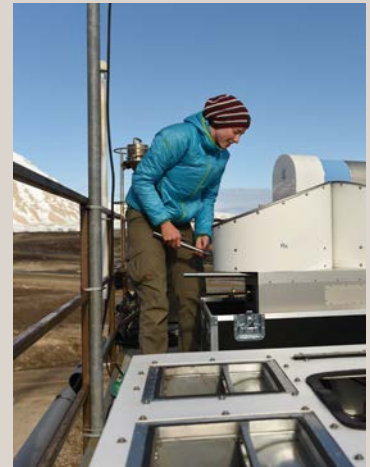
PhD Workshop in Leipzig
AN INTRODUCTION INTO LINUX/ UNIX AND PROGRAMMING WITH FORTRAN

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

The workshop took place in Leipzig from 14 - 17 of July 2016 and was organized by the $(AC)^3$ PhD students. The aim was to introduce Linux, especially the terminal, to the new PhD students as most of us will perform calculations on computing clusters operated with Linux. In total nine students from the Universities of Bremen and Leipzig, as well as from the TROPOS and the AWI-Potsdam met on Thursday. During the first day, we learned how to navigate through the Linux terminal and how to write shell-scripts which help to automate processes. On Friday, we learned the basics of FORTRAN, i.e. compiling programs and how to perform basic calculations as well as how to use logical branching, loops and arrays. A feedback was given on Saturday.

Further aims of this workshop were to strengthen the network of the PhD students and introduce Leipzig. Thus, board game nights were organized as well as the obligatory sightseeing tour in the city center of Leipzig. Special thanks goes to Jacob Schacht, TROPOS and Daniel Mewes, University of Leipzig, for organizing the workshop.

Fig. 7: Some impressions from the students workshop in Leipzig. (Matthias Gottschalk)

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$(AC)^3$ Publications
BOUNDARY-LAYER DEVELOPMENT AND LOW-LEVEL BAROCLINICITY DURING HIGH-LATITUDE COLD-AIR OUTBREAKS: A SIMPLE MODEL

Abstract

A new quasi-analytical mixed-layer model is formulated describing the evolution of the convective atmospheric boundary layer (ABL) during cold-air outbreaks (CAO) over polar oceans downstream of the marginal sea-ice zones. The new model is superior to previous ones since it predicts not only temperature and mixed-layer height but also the height-averaged horizontal wind components. Results of the mixed-layer model are compared with dropsonde and aircraft observations carried out during several CAOs over the Fram Strait and also with results of a 3D non-hydrostatic (NH3D) model. It is shown that the mixed-layer model reproduces well the observed ABL height, temperature, low-level baroclinicity and its influence on the ABL wind speed. The mixed-layer model underestimates the observed ABL temperature only by about 10 %, most likely due to the neglect of condensation and subsidence. The comparison of the mixed-layer and NH3D model results shows good agreement with respect to wind speed including the formation of wind-speed maxima close to the ice edge. It is concluded that baroclinicity within the ABL governs the structure of the wind field while the baroclinicity above the ABL is important in reproducing the wind speed. It is shown that the baroclinicity in the ABL is strongest close to the ice edge and slowly decays further downwind. Analytical solutions demonstrate that the e-folding distance of this decay is the same as for the decay of the difference between the surface temperature of open water and of the mixed-layer temperature. This distance characterizing cold-air mass transformation ranges from 450 to 850 km for high-latitude CAOs.

Chechin, D. G. and **Lüpkes, C.**, 2016: Boundary-layer development and low-level baroclinicity during high-latitude cold-air outbreaks: A simple model, Boundary-Layer Meteorol., **2016**, 1-26, doi:10.1007/s10546-016-0193-2.

$(AC)^3$ PROJECT PARTNERS