
The Moon meets Venus during the polar night (Photo: Sophie Rosenburg Uni Leipzig).


Polarstern in the ice during ArcWatch 2 / VAMPIRE (Photo: Linnu Bühler, Uni Cologne).

Transregional Collaborative Research Center on Arctic Amplification

(AC)³ Newsletter

December 2024
18th Issue

EDITORIAL

Dear readers of the (AC)³ newsletter,

Once again we can report on many exciting things that have happened in our project since last summer. In particular, it was very nice to see how many (AC)³ Early Carreer Researchers (ECRs) successfully defended their PhD theses. In total 11 PhD candidates have completed their theses. This is always one of the biggest rewards for all the effort and work we have put into our project. In addition, we maintain to be very efficient in publishing the results of our work. A highlight in this regard was the paper workshop on analyzing the data from the HALO-(AC)³ aircraft campaign. The online meeting took place on November 11. It included not only the (AC)³ community, but also involved ECRs and researchers from the HALO (High Altitude and Long Range Research Aircraft) Priority Program (SPP 1294). We heard a total of 16 presentations with concrete publication plans. These planned papers will be in addition to the 11 already published in a Special Issue (SI) of Atmos. Chem. Phys. journal on the results of the HALO-(AC)³ aircraft campaign (https://acp.copernicus.org/articles/special_issue1272.html). We are curious to see how this SI will develop; it is still open until the end of June 2025.

Another important meeting, this time in person, took place in Leipzig on November 12 and 13. It was an Advanced Training Module (ATM) initiated by the Leipzig Graduate School for Clouds, Aerosols, and Radiation (LGS-CAR). The topic was "Arctic-Midlatitude Linkages". The meeting was open to the LGS-CAR, HALO, and (AC)³ ECR communities and was indeed very well attended (about 45 ECRs were registered). We managed to attract excellent keynote speakers from the US, UK, and Germany, including one of our (AC)³ Mercator Fellows (Judah Cohen). Practical work was planned prior to the meeting and participants seemed to enjoy the ATM very much.

Thanks to all of us for keeping our exciting (AC)³ project active and fruitful. Enjoy the upcoming Christmas holidays and have a good start into 2025!

Yours,
Manfred and Marlen.

TOPICS IN THIS ISSUE

KICK OFF MEETING REPORT

REPORT ON JOINT (AC)³ IRTG AND LGS-CAR ADVANCED TRAINING MODULE ON 'ARCTIC MIDLATITUDE LINKAGES'

by Christa Genz (IRTG coordinator) & Awadesh Pant (PhD student in E04)

From November 12 to 13, 2024, the Leipzig Institute for Meteorology (LIM) hosted a joint Advanced Training Module (ATM) organized by the (AC)³ IRTG in collaboration with the Leipzig Graduate School for Aerosols, Clouds, and Radiation (LGS-CAR). The event brought together approximately 45 doctoral researchers and a distinguished lineup of speakers, including international experts such as Judah Cohen (Atmospheric and Environmental Research, USA), Marilena Oltmanns (National Oceanography Centre, UK), Jonathon Preece (University of Georgia, USA), Reinhard Schiemann (University of Reading, UK), and Matt Shupe (University of Colorado, USA). The scientific program was further enriched by contributions from (AC)³ project leaders Dörthe Handorf (AWI Potsdam) and Marlene Kretschmer (Leipzig University), who also played pivotal roles in shaping the workshop's structure and focus, jointly with Manfred Wendisch.

Fig. 1: The interested ATM participants listen intently to Judah Cohen's presentation (Photo: Christa Genz, Uni Cologne).

Fig. 2: Group picture of all participants (Photo: Christa Genz, Uni Cologne).

The workshop kicked off with a welcome by Manfred Wendisch, who provided an overview of (AC)³, setting the stage for the central theme: Arctic-Midlatitude linkages. Judah Cohen opened with a detailed exploration of the interactions between Arctic extremes and jet stream patterns, highlighting their implications for global weather anomalies, such as cold spells in midlatitude regions. His presentation was followed by Jonathon Preece, who examined atmospheric rivers and blocked flows as drivers and outcomes of Arctic amplification. Marilena Oltmanns concluded the first day's lectures with a focus on North Atlantic climate dynamics, particularly the interplay between ice sheets, ocean currents, and atmospheric variability.

The afternoons were dedicated to hands-on group exercises led by the speakers, offering participants practical experience with topics like Arctic warming, atmospheric blocking, and teleconnections. Teams worked on projects ranging from the impact of snowfall on extreme weather to ENSO-blocking interactions, utilizing observational data and model simulations.

Day two began with Reinhard Schiemann's presentation on atmospheric blocking patterns and their simulation in global climate models, which was followed by Marlene Kretschmer's analysis of sea ice loss and its subtle yet significant influence on midlatitude winter extremes. Dörthe Handorf rounded out the talks with an in-depth discussion of Scandinavian-Ural blocking and its role in Arctic-midlatitude linkages. These insights were complemented by group project presentations, where participants shared findings, sparking vibrant discussions and showcasing the collaborative spirit of the event.

The ATM concluded with a social gathering at L'Osteria Leipzig, providing an opportunity for informal networking. Participant feedback was overwhelmingly positive, praising the workshop's organization, the quality of lectures, and the balance between theoretical and practical components. While some noted the intensity of group work, the overall sentiment emphasized the value of the training for building networks and deepening understanding of complex climate processes.

The event underscored the collaborative ethos of $(AC)^3$ and left participants inspired and better equipped to tackle the challenges of Arctic-midlatitude linkages in their research.

News from the modelers

A YEAR IN LES: DAILY SIMULATIONS OF THE ARCTIC BOUNDARY LAYER DURING THE MOSAIC DRIFT

by Niklas Schnierstein, Jan Chylík & Roel Neggers (PhD, Postdoc and PI in A01)

Local, small-scale processes that shape the Atmospheric Boundary Layer (ABL) play a key role in the central Arctic climate system. These processes include turbulence, clouds in multiple phases, radiation, and surface-atmosphere exchange - just to name a few. Measuring these processes simultaneously at high resolutions and across a large area is not feasible. To virtually fill this data gap, we have utilized the wealth of observational data collected during the MOSAiC drift expedition during 2019-2020 to create a library of daily Large-Eddy Simulations (LES) of the lower atmosphere, as observed near the Polarstern Research Vessel (RV).

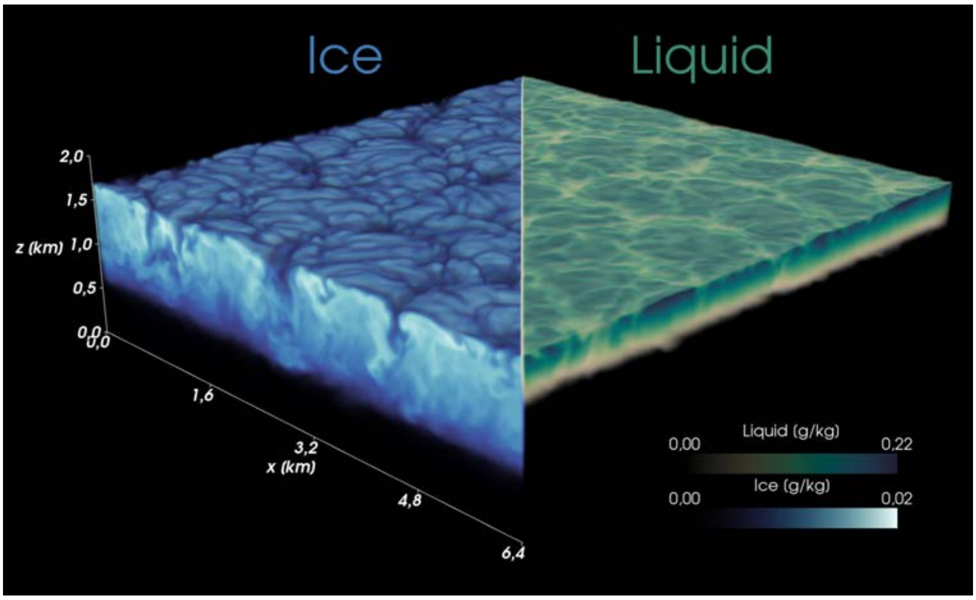

Fig. 3: 3D rendering of the mixed-phase cloud simulated on November 1st, 2019.

A standardized model setup was developed, adopting a resolution of 10 m vertically and 20 m horizontally that enabled to resolve small-scale ABL processes to a high degree. A key science objective was to make the LES represent the observed conditions as accurately as possible. To this purpose a variety of time-continuous MOSAiC datasets was integrated into the model forcing, initial- and boundary conditions, including radiosonde profiles, surface- and tower measurements, cloud profiles from remote sensing, and aerosol measurements. This significant effort proved of key importance, and could not have been successful without close collaboration with instrument mentors. A library of 190 LES cases was produced, covering a wide range of atmospheric conditions.

Figure 3 shows a three-dimensional rendering of a simulated mixed-phase cloud layer on 1 November 2019. The spatial heterogeneity of cloud ice and liquid water, shaped by turbulent updrafts and downdrafts, is clearly visible. The full library of simulations was evaluated against independent year-long data, revealing encouraging skill in reproducing low-level meteorology, clouds and radiation. This justifies future scientific use of the LES data, for example for contextualizing measurements at lower dimensionality and frequency. Some systematic model weaknesses were also identified, mainly concerning surface exchange and the representation of cloud ice at very low temperatures during Arctic winter. In that sense this effort will also help in further improving LES model realizations in this climate regime. All results and setup files have been made available to the community to support further research.

This work has been recently published in the Journal of Advances in Modeling Earth Systems (JAMES): Schnierstein et al. (2024), Standardized Daily High-Resolution Large-Eddy Simulations of the Arctic Boundary Layer and Clouds During the Complete MOSAiC Drift, doi.org/10.1029/2024MS004296. You can also find the abstract in this newsletter (Page 8).

A YEAR IN LES: DAILY SIMULATIONS OF THE ARCTIC BOUNDARY LAYER DURING THE MOSAIC DRIFT

(continued)

Lead impacts on the lower atmosphere

The year-long library of LES realizations opens exciting research opportunities. A first ongoing follow-up study concerns the impact of leads on the ABL in the central Arctic. These openings in the sea ice enhance the surface exchange of heat and water vapor. Previous research has shown that these effects can be locally significant, however their wider, regional impact remains less well understood. Most previous LES studies of leads were also highly idealized, in particular concerning the meteorological conditions. Using a subset of cases from the library of LES for MOSAiC allows to overcome this limitation, by studying lead impacts under a broad range of realistic (measured) atmospheric conditions. An example is shown in Figure 4, in which the lead increases liquid water content and connects the two-layered cloud system observed in the control run. Analysis of leads introduced in a dozen MOSAiC cases reveals that the influence of leads is strongly dependent on the temperature difference between the atmosphere and sea ice, as well as low-level stability. For example, we find that lead-driven plumes can overcome stable layers below decoupled clouds, enhancing mixing in the air mass and affecting its transformation. Also, under fully stable conditions, leads can form thin near-surface cloud layers. Finally, we reproduce previous research findings that leads can also remove near-surface thin clouds, accelerating their lifecycle by quickly dissipating them. Such cloud impacts have a significant impact on the surface energy budget; the novelty is that they are here reproduced under realistic conditions.

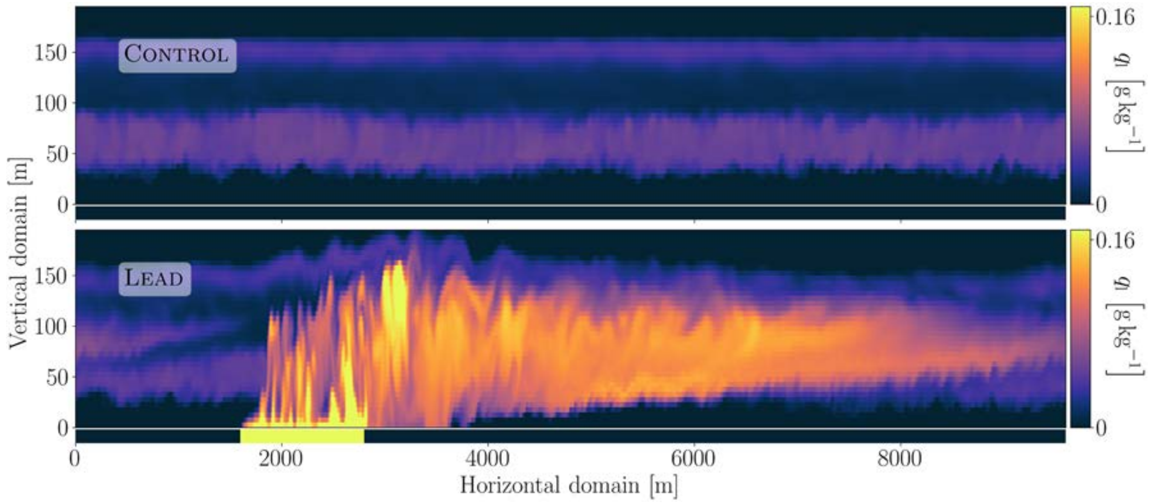

Fig. 4: Crosssection of liquid water content for two simulations. Control without lead representing condidtion on January 24th, 2020 and Lead showing the lead impact.

(AC)³ NEWS

(AC)³ IS GROWING:

- A new subproject proposal (A04) of PI Nikki Vercauteren (University of Cologne) within (AC)³ has been approved by DFG. The title of the new subproject: "Effective representation of surface-atmosphere fluxes above heterogeneous sea-ice cover for use in climate models"
- Read more about it in the next newsletter!

SAVE THE DATES:

- 3rd (AC)³ Winter School in Hyytiälä, Finland, 24 - 30 March 2025
- (AC)³ General Assembly in Bremen, 3 - 5 February 2025
- (AC)³ General Assembly in Potsdam, 23 - 25 September 2025
- 4th (AC)³ Science conference on Arctic Amplification in Cologne, 23 - 27 February 2026

News from the observations

UNEXPECTED RESEARCH FLIGHTS INTO THE ARCTIC

by André Ehrlich (PI in B03 at Uni Leipzig) & Sophie Rosenburg (PhD in B03 at Uni Leipzig)

As part of the PERCUSION campaign, in November, the research aircraft HALO was on a mission to validate EarthCARE satellite. $(\mathcal{AC})^3$ scientists joined this mission together with the remote sensing instrumentation already operated during HALO-$(\mathcal{AC})^3$. As it turned out during the planning of the research flights, a suitable area for validating EarthCARE is in the high latitudes of the Arctic. This is where the EarthCARE tracks of the successive orbits (orbit duration of 92.5 min) are rather close to each other and thus allow HALO to catch EarthCARE twice during one flight. In the end, five research flights headed from Oberpfaffenhofen far North up to 76°N (Figure 5a). The flight on 14 November was designed and led by Sophie, who was well supported by Mika. There are several exiting features of this flight: i) that far north it soon became dark making the measurements of our thermal imager even more important (Figure 5b-c). Similar conditions we expect for the future CONIDA campaign. ii) the flight directly crossed a strong low-pressure system north of Scandinavia that included lot of precipitation. iii) clouds of a cold air outbreak in autumn conditions could be sampled. iv) Mika got a lot of cookies and enjoyed being back in the Arctic (Figure 5d-e).

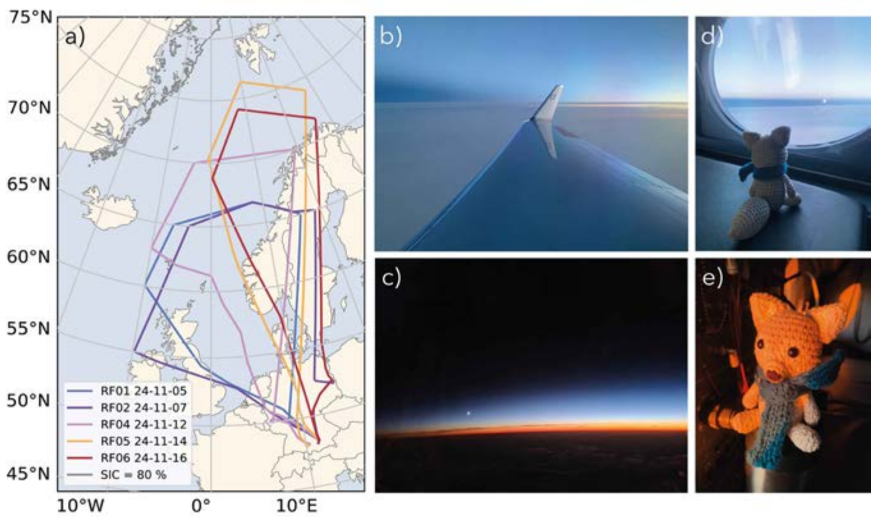

Fig. 5: a) Flight tracks reaching the Arctic including the 80 % contour of sea ice concentration (SIC) on 24-11-16. b) HALO between day and night, c) beautiful twilight colors, d-e) Mika enjoying the moonrise and the sunset (Photos: Sophie Rosenburg).

With help of the observations from these flights, we hope to learn more about the capabilities and limitations of the EarthCARE instruments in these high latitudes. And we will investigate if there are differences in cloud properties compared to the springtime measurements of HALO-$(\mathcal{AC})^3$.



By the way: our snowflakes are real! Observed with the VISSS instrument in Hyytiälä, Ny-Alesund, the MOSAiC expedition and the measurement campaign in the Rocky Mountains.

MEET THE $(\mathcal{AC})^3$ FELLOWS

Hey everyone,
I'm Max, I'm from Nuremberg in Germany and a new PhD student in project C01 as of this September. I did my BSc and MSc in Meteorology at the University of Hamburg, focusing early on (satellite) remote sensing of clouds. My studies included a semester on polar meteorology and oceanography at the University Centre in Svalbard (UNIS) and participation in the HALO-$(\mathcal{AC})^3$ airborne campaign in Kiruna. Both experiences piqued and fueled my fascination for polar research and remote sensing.

After graduating, I spent a year working as a research assistant at the University of Cologne, working on airborne and satellite cloud observations from various $(\mathcal{AC})^3$ campaigns. Now, as a doctoral researcher in the Remote Sensing of Polar Regions group at the University of Bremen, I study satellite observations of sea ice albedo and melt ponds. My research combines satellite data and field observations to analyze sub-satellite footprint variability and the spatio-temporal trends of melt ponds and albedo over the past two decades.

I'm looking forward to meeting and working with all of you in $(\mathcal{AC})^3$ over the coming years!

MEET THE $(AC)^3$ FELLOWS

Hello! I'm Fathima Cherichi Purayil, and I recently moved from Kerala, a state in India, to Germany to begin my PhD within the $(AC)^3$ project. I hold a Bachelor's and Master's degree in Physics. By the last phase of my masters degree, I became more interested in applying my skills as a physicist to real-world problems like climate change. This led to my Master's thesis, where I explored how aerosol-cloud interactions influence the Indian Monsoon rainfall.

Now, as a PhD researcher in the D02 project, I'm diving into a fascinating aspect of climate science: how aerosols from mid-latitudes affect the Arctic climate. My first goal is to apply the polar aerosol atmospheric river detection algorithm to track extreme aerosol transport into the Arctic over the last 43 years. Lateron, I will examine how these aerosol flows influence Arctic clouds and precipitation patterns. I am also interested in tackling how these mechanisms might change as the future climate warms and emissions shift. To accomplish this, I will use a combination of active remote sensing, reanalysis data, and advanced modeling. I'm incredibly excited to contribute to our understanding of aerosol's role in Arctic amplification and to explore how these findings can shape our future.

Hello everyone!

I am Awadhesh, part of Project E04 in $(AC)^3$ from the Institute of Geophysics and Meteorology, University of Cologne. I started as a PhD student in September 2024. I come from India and have a bachelor's degree in Environmental Sciences. I then moved on to a master's in Atmospheric and Oceanic Sciences. In my master's, I did my thesis on Arctic Marine Cold Air Outbreaks, and ever since, I have been curious to learn about dramatic changes occurring in the Arctic.

My project, E04, focuses on the effects of warm and moist air intrusions from the lower latitudes to the Arctic. The changes the Arctic might see due to this can be large regarding precipitation regimes. I would also focus on how the precipitation patterns in the Arctic are changing. It is a well-known fact that understanding precipitation helps us comprehend the overall state of the Arctic; it would be extremely important to diagnose this change and then further learn about how these changes, in turn, affect the Arctic. A brief idea would be to see if the precipitation regime is shifting from snowfall to rain.

PYTHON COURSE OF THE IRTG AND THE INF PROJECTS

by Johannes Röttenbacher & Matthias Buschmann (Data steward & PI in INF)

Efficient research data management and reproducible workflows are essential for studying Arctic amplification, especially for PhD students working with $(AC)^3$ data. To support this, the Information Infrastructure (INF) project and IRTG organized Python courses in both Phases 2 and 3 of $(AC)^3$.

The Phase 2 workshop, held over four days, concluded with a hackathon that produced Jupyter notebooks showcasing $(AC)^3$ data use, now available on GitHub: AC3 Notebooks.

For Phase 3, a continuous learning format was adopted, with workshops held regularly based on participants' schedules and chosen topics. So far, sessions have covered Python modules, reproducible workflows, and Git for version control. About 15 PhD students attended the first three online sessions in late 2024, which blended theory with hands-on exercises using Jupyter notebooks.

Future topics include multiprocessing, parallel program execution, and advanced plotting with Cartopy. Suggestions and contributions are welcome via the Mattermost channel or email (data@ac3-tr.de). These workshops aim to improve programming skills and foster collaboration within the $(AC)^3$ community.

Exciting news: Mia’s Klimatagebuch is live again!

MIA’S KLIMATAGEBUCH IS BACK IN ACTION!

Mia’s Klimatagebuch (https://mias-klimatagebuch.de/) is a blog designed especially for kids, where the adventurous Mia and her trusty polar fox, Mika, answer questions about weather, climate, climate change, and much more. Mia’s mission is to share her passion for climate research with young minds through Mia’s and Mika’s fun and educational stories!

Fig. 6: Our Mia’s Klimatagebuch Team.

This fantastic project is part of the $(AC)^3$ initiative, and right now, blog posts are written by dedicated $(AC)^3$ scientists. We’d love to invite all interested colleagues to join us! It would be amazing if some of you could contribute a blog post. Our team, Fathima, Marie, Patrizia, Sophie, Nina, and our student assistant Leonard, take care of illustrations, ensure everything is kid-friendly, and publish the posts on the website.

Do you want to spark curiosity and share your research with kids? Whether it’s about weather, climate, field campaigns, or other fascinating topics, your insights can make a big impact! We still have many unanswered questions and would love to hear your fresh topic ideas too. Let’s inspire the next generation of climate explorers together!

MEETING REPORT

PhD Kick off

by Fathima Cherichi Purayil, PhD student in D02 at Uni Leipzig

The ‘Start-up Your PhD’ workshop took place on 14 and 15 of November at the Leipzig Institute for Meteorology, designed to help PhD students kickstart their doctoral journey with strong strategies for success. Led by Dr. Andrea Perino, a seasoned PhD coach, the workshop offered valuable tools and insights for those of us entering the third phase of the $(AC)^3$ project. The goal was clear: to equip us with the mindset and practical approaches needed to navigate the long and often challenging road toward earning a PhD.

The first day of the workshop focused on time management. Dr. Perino introduced us to a range of strategies to efficiently manage the complex demands of our research projects. Among the highlights was backward planning, a method where we start with our end goal and work backward to break down tasks into actionable steps. This was paired with the Eisenhower Matrix, a framework for prioritizing tasks based on urgency and importance, which resonated with many of us. These methods will undoubtedly become key components of our daily routines.

The second day shifted focus to more personal aspects of the PhD work. We began by noting down the hurdles we face, whether it’s managing our workload, dealing with isolation, or coping with stress. With her guidance, we had an open and fruitful discussion on how to address these challenges. It was reassuring to realize that many of us share similar struggles, and hearing others’ strategies for overcoming them was helpful.

Overall, the workshop was an enriching experience that not only helped us refine our approach to time management and productivity but also allowed us to share experiences. As we continue with our PhDs, the strategies and insights gained during these days will serve as a solid foundation for tackling the challenges ahead. We would like to thank Dr. Perino and $(AC)^3$ for this nice workshop :)

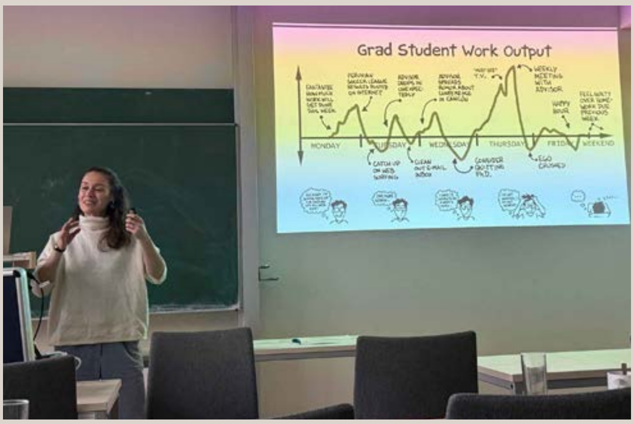

Fig. 7: Dr. Andrea Perino illustrates the ups and downs of a PhD work (Photo: Fathima Cherichi Purayil).

ACKNOWLEDGEMENTS

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Deutsche Forschungsgemeinschaft

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(AC)³ Publications

STANDARDIZED DAILY HIGH-RESOLUTION LARGE-EDDY SIMULATIONS OF THE ARCTIC BOUNDARY LAYER AND CLOUDS DURING THE COMPLETE MOSAIC DRIFT

Abstract

This study utilizes the wealth of observational data collected during the recent Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) drift experiment to constrain and evaluate close to two-hundred daily Large-Eddy Simulations (LES) of Arctic boundary layers and clouds at high resolutions. A standardized approach is adopted to tightly integrate field measurements into the experimental configuration. Covering the full drift represents a step forward from single-case LES studies, and allows for a robust assessment of model performance against independent data under a range of atmospheric conditions. A homogeneously forced domain is simulated in a Lagrangian frame of reference, initialized with radiosonde and value-added cloud profiles. Prescribed boundary conditions include various measured surface characteristics. Time-constant composite forcing is applied, primarily consisting of subsidence rates sampled from reanalysis data. The simulations run for 3 hours, allowing turbulence and clouds to spin up while still facilitating direct comparison to MOSAiC data. Key aspects such as the vertical thermodynamic structure, cloud properties, and surface energy fluxes are well reproduced and maintained. The model captures the bimodal distribution of atmospheric states that is typical of Arctic climate. Selected days are investigated more closely to assess the model's skill in maintaining the observed boundary layer structure. The sensitivity to various aspects of the experimental configuration and model physics is tested. The model input and output are available to the scientific community, supplementing the MOSAiC data archive. The close agreement with observed meteorology justifies the use of LES for gaining further insight into Arctic boundary layer processes and their role in Arctic climate change.

N. Schnierstein, J. Chylik, M.D. Shupe & R.A.J. Neggers, 2024: Standardized Daily High-Resolution Large-Eddy Simulations of the Arctic Boundary Layer and Clouds During the Complete MOSAiC Drift, *Journal of Advances in Modeling Earth Systems*, 16, e2024MS004296. https://doi.org/10.1029/2024MS004296

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