YOPP YEAR OF POLAR PREDICTION

International Coordination Office (ICO) for Polar Prediction

AWI PPP WORLD METEOROLOGICAL ORGANIZATION

Find more information at www.polarprediction.net

#18 PolarPredictNews

August 2021

Photo: Christian Paulmann, DWD

Addicted to Antarctic Weather
One of the stations in Antarctica manned year-round is the Neumayer III in Queen Maud Land (or Dronning Maudl Land DML). DML extends from 65°S to 85°S and from 20°W to 45°E and covers an area of approximately 5 million km^2. Neumayer III is only reachable in austral summer, when supplies and new station team members come by air or sea. But even at that time of the year, the weather decides whether this is possible or not. All the logistics are protected by the German Weather Service (DWD), which monitors the DML all year, either from Cape Town or, from late November to early February, directly from Neumayer III. The challenge for meteorologists: the whole of DML only has ten weather stations. To compensate, DWD uses, for example, data from daily radiosonde ascents and images from polar-orbiting weather satellites.
Read more on ***page 26****.*

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Content

ART + SCIENCE

The Year of Polar Prediction (YOPP) is a major international activity that was initiated by the World Meteorological Organization as a key component of the Polar Prediction Project (PPP).
The overarching goal of YOPP is to significantly advance our environmental prediction capabilities for the polar regions and beyond.
As an internationally coordinated period of intensive observing, modelling, prediction, verification, user-engagement, and education activities involving various stakeholders, YOPP contributes to the knowledge base needed to manage the opportunities and risks that come with polar climate change.

Dear Colleagues,

In this 18th issue of *PolarPredictNews*, it is great to see Zack Labe's story on Arctic science communication through data visualizations (p. 5). As an experienced user of social media platforms, Zack proposes the many but yet underexplored ways for the polar community to display their data so that the public can easily follow the changes in the polar regions and beyond.

Marvin Kähnert's idea for an article in *PolarPredictNews* emerged during the YOPP Session of the Arctic Science Summit Week earlier this year. Marvin who is a PhD candiate collaborating with MET Norway has now summarized various interesting tools of the YOPP-endorsed Alertness project to enhance numerical weather prediction capabilities for the Arctic (p. 10).

In his article, Lorenzo Zampieri asks whether a complex sea-ice model is better than a simple one (p. 18). Based on his work at the Alfred Wegener Institute, he suggests strategies for successfully dealing with the ever-rising complexity in sea-ice modelling.

I also recommend looking at the summary on Alaska's current weather and climate trends (p. 13) and the interview with Rick Thoman (p. 16), who has fostered the dialogue with local Alaskan communities for many years in support of decision-making.

This spring, the YOPP-endorsed APPLICATE project came to an end – hence the ICO invited us, i.e. our APPLICATE project manager Luisa Cristini and myself as PI, to review the project efforts and success stories (p. 44). I would like to use this opportunity to once again thank all project members for their manifold contributions to APPLICATE.

Finally, I am most happy to invite the polar prediction community to the YOPP Final Summit, which is scheduled to take place from 1–4 May 2022 in Montreal, Canada, At the moment, we are planning for an in-person meeting, to bring YOPP to a successful closure and ensure a strong legacy.

Happy reading,
Thomas Jung

photo: Martina Buchholz/ Alfred Wegener Institute

Art + Science
FEATURED IN THIS ISSUE:

MOSAiC Leg 4 in Water Colours by Amy MacFarlane

by Amy MacFarlane, WSL Institute for Snow and Avalanche Research and Mayleen Schlund, WMO WWRP International Coordination Office for Polar Prediction, Alfred Wegener Institute

During her first five-month trip during leg 3 on board Polarstern, Amy MacFarlane, PhD student at the Snow and Avalanche Research Institute in Switzerland, extended her stay for another three months to join leg 4 of the MOSAiC campaign. Luckily, Amy did not abandon her previously pursued hobby and continued to paint to capture more moments from the MOSAiC adventure.

Amy MacFarlane extended her stay during the MOSAiC field campaign for another leg (photo: Delphin Ruché).

After collecting all my thoughts to return home, I was asked to extend my stay for another three months. Of course, I did not hesitate to agree to continue working on Polarstern and unpacked my brushes and paint again, being excited to watercolour even more memories from the field.

During leg 4 of MOSAiC, the ice floe that once had the character of a fortress had already disintegrated into a mosaic of ice floes. After Polarstern got back to the ice camp in July with the new team of which I was a member now, I continued my research on seasonally Arctic snow changes, both physically and chemically. I returned to the regular daily work schedule and relaxed in the evening hours by painting my watercolour drawings. In the field, it was always busy with so many teams and observational stations which I tried to capture as much as possible, with many little iconic situations.

In the picture (full size shown at page 22/23), I have drawn the special moment when an interested polar bear came close to the ice edge. Polar bears often visited us at night when no scientists were on the ice, which was lucky. But on a few occasions, just like the one drawn here, we had to evacuate the ice, leaving our instruments behind and retreating to the ship. The polar bears were very curious about the infrastructure we had installed on the ice. Understandably since we had entered their home.

One of my favorite drawings are the balloons that hover above the ice floe. The big orange balloon that is used to attach various instruments for measuring atmospheric conditions, is called "Miss Piggy". The other one, called "The Beluga" due to their iconic shape and colour is used to measure vertical dispersion of aerosol particles in about 1 km height.

After spending eight months in total in the Arctic, I am currently busy working on the data collected and a side project which is measuring the impact of the expedition in the hope to highlight possible changes of future expeditions to improve their sustainability. The painting has taken a backseat but I hope to return to these painting projects when communicating my scientific findings later in my research career.

If you want to explore my other picture creations from leg 3, then check out the ***PolarPredictNews #15***.

01

Sharing Data-Driven Stories of Arctic Climate Change

by Zachary Labe, Colorado State University, @ZLabe

Zachary Labe is a postdoctoral researcher at Colorado State University in the Department of Atmospheric Science. His research considers signal-to-noise problems in large-scale climate variability, especially related to the Arctic. He is also very passionate about improving science communication, accessibility, and outreach through engaging data visualizations.

Zack Labe (photo: private).

The Arctic is a region of dramatic change. It's an area that continues to warm at a rate of nearly three times the global average temperature – otherwise known as Arctic amplification (Richter-Menge and Druckenmiller, 2020). But communicating the causes and consequences of Arctic climate change is still rather difficult.

For one thing, it's a far and remote place, which very few people have the opportunity to visit. In that sense, the Arctic almost holds an aura of mystery. But for others, the image of a polar bear floating on a tiny piece of sea ice across a wide-open ocean is synonymous with the words global warming.

In many ways, the Arctic is the canary in the coal mine. It's a region that is already experiencing numerous direct and indirect effects of climate change, which continue to bring new challenges to local communities and their surrounding environmental ecosystems. It's also a warning for the rest of the planet as to the many interconnected ways that climate change affects society and the entire Earth system. While there have been an increasing number of efforts to focus on sharing indigenous knowledge and perspective, the far-ranging impacts of Arctic amplification still remain elusive to most people. Therefore, it's really important that we start talking about it (even more).

One of the biggest challenges for science communication (and climate change communication) is that there is no right answer on how to do it. Science communication can depend on the audience, the goal of the main message, the communication channel (e.g., social media, print/radio/tv media, blogs, public lectures, etc.), and some creativity. To my (initial) surprise, I've found

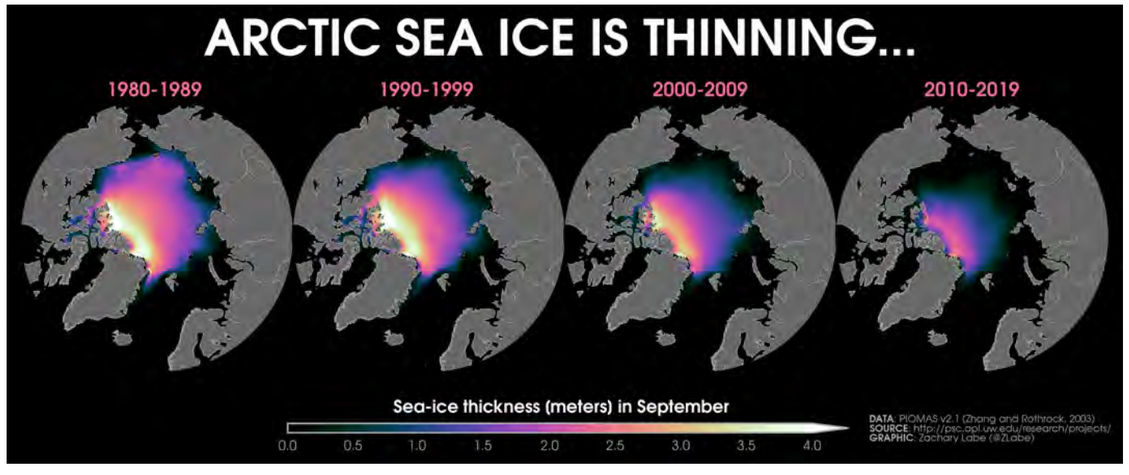
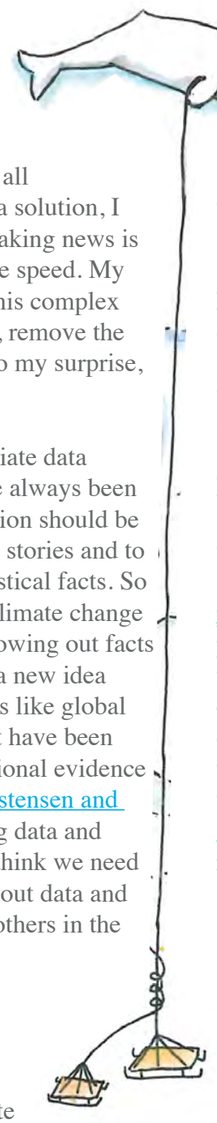


Figure 1: Visual of decadal changes in September Arctic sea-ice thickness. Data are taken from the Pan-Arctic Ice-Ocean Modeling and Assimilation System (PIOMAS; Schweiger et al. 2011).

that data visualization can be a powerful form of science communication that is both accessible and engaging for a broad audience. In particular, I believe that sharing visualizations of climate change indicators is an effective form of science communication that allows us to tell Arctic climate change stories and form conversations in real-time.

Data Visualization is Storytelling

Just a few years ago, I started my literature review of research surrounding Arctic climate change in the first year of graduate school. Paper after paper showed how climate change can have impacts locally (within the Arctic) and remotely (across the mid-latitudes and tropics). The issue for communicating this fact is that scientific journal articles are not really accessible ways of sharing information to broad audiences. Moreover, the changes in the Arctic were/are happening in real-time, and the scientific process is not geared at all for that type of short turnaround. As a solution, I turned to Twitter – a place where breaking news is condensed and shared at an incredible speed. My goal was to create visualizations of this complex data related to Arctic climate change, remove the jargon, and monitor it in real-time. To my surprise, it has been a tremendous success.



However, it took me a while to associate data visualization with storytelling. I have always been told that climate change communication should be done through a lens of human-driven stories and to generally avoid data and lists of statistical facts. So initially, I saw my visualizations of climate change indicators as just another form of throwing out facts and abstract numbers. It also wasn't a new idea either. Graphs of changes in measures like global temperature and Arctic sea-ice extent have been used for decades to provide observational evidence of climate change to the public (Christensen and Nilsson, 2017). As a scientist, sharing data and graphs comes naturally to me. But I think we need to re-evaluate our way of thinking about data and its incredible potential for engaging others in the scientific process.

Data visualization is a form of storytelling. In particular, data-driven stories can be a powerful form of communicating Arctic climate change. Let me provide some examples.

It is well-established that Arctic sea ice is both thinning and shrinking in extent. One way we can show this information is by drawing a line. Perhaps the line graph shows changes in Arctic sea-ice extent during the annual minimum (September) over the satellite-era (1979 to 2020). While the line is obviously going down, it still retains the appearance of looking like a standard scientific graph. Instead, what if you show an actual visual of the shrinking sea-ice cover broken down by decade? Figure 1 is an example of allowing the appearance of the data to tell its own climate change story, rather than focusing on the abstract data measurements. While the exact data values are still shown (in this case, meters), the brighter colours focus on the overall decrease in sea-ice thickness across time and space. The labels also remove any jargon or acronyms (e.g., "SIT" for sea-ice thickness or "m" for meters), and the title provides an accessible and short caption to accompany the figure. However, the source of the actual data itself can still be found (bottom right-hand corner), which helps to add to the credibility of the visualization. Here, the graphic is really interested in communicating the message of long-term changes in sea ice across the entire Arctic Ocean.

Figure 2 is another example of taking complex data and turning it into a story. This graphic highlights the unprecedented lack of sea ice in the Laptev Sea during the summer of 2020 as a result of the persistent warmth over Eurasia. Here, colour [from purple (older years) to white (recent years)] is used to highlight the long-term trend of declining sea-ice extent in the Laptev Sea compared to anomalous conditions in a single year (2020 - red line). While there already are some recent studies investigating this extreme event, graphics like this were shared across Twitter while the event was happening in real-time. Although this graph retains the same scientific data (daily sea-ice extent from 1979 to 2020), the use of colour and use of storytelling helped to attract widespread media attention and initiate more climate change conversations all throughout last year.

Keep It Simple, But Be Bold

When re-thinking visualizations of scientific data, it's important to keep a few points in mind. First, it's important to consider the power of colour. In telling stories about climate change, colour can hold important meaning (e.g., red = warmer temperatures, blue = colder temperatures). As the scientific community transitions away from potentially misleading colour scales, there are a growing number of open-source colormap packages for the geosciences. "Scientific colour maps" and "cmocean" are two examples of colourmap resources that use perpetually-uniform scales and are designed to be readable for colour-vision deficient people (Thyng et al., 2016; Crameri et al., 2020). It's important to consider colourmaps that are both accessible and relevant for the data (e.g., do not choose a diverging scale of green and brown for showing temperature anomalies). A recent article in EOS provides a great overview of the role of colour in scientific research and communication (Zeller and Rogers, 2020).

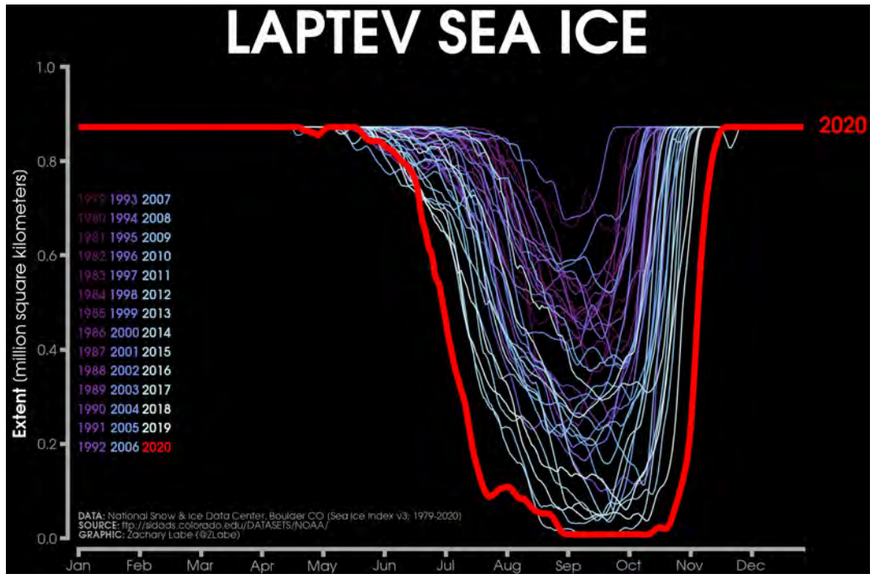


Figure 2: Visual of daily Arctic sea-ice extent in the Laptev Sea for each year from 1979 to 2020. Data are taken from the National Snow and Ice Data Center (NSIDC; Sea Ice Index, v3).

In addition to colour, it's important to consider design. Let the data tell its own story. Be creative, but keep it simple. A few easy changes that I have found effective include decreasing the brightness of the axes (e.g., changing from black to gray), eliminating jargon (spell out SI units), and removing unnecessary labels. There is also power in animation, especially for Arctic climate change, where the data are clearly showing long-term trends in the land, ocean, cryosphere, and atmosphere.

Don't Be such a Scientist

One of the most important messages (and one I have to keep reminding myself of) is to stop thinking like such a scientist. This is particularly relevant when considering how to design visualizations that are honest to the science, but also understandable for all audiences. The "Climate Spiral" and "Climate Stripes" (both designed by Dr. Ed Hawkins) are striking examples of creative ways to use complex climate change data for storytelling. The Climate Spiral has been viewed by millions of people around the world, yet it still uses the same data as a typical global mean surface temperature anomaly line graph found in most all communication presentations (Hawkins et al., 2019). While it's important to use your skills in evaluating and interpreting the raw scientific data, still, don't be such as scientist.

Improving Engagement through Accessible and Open Science

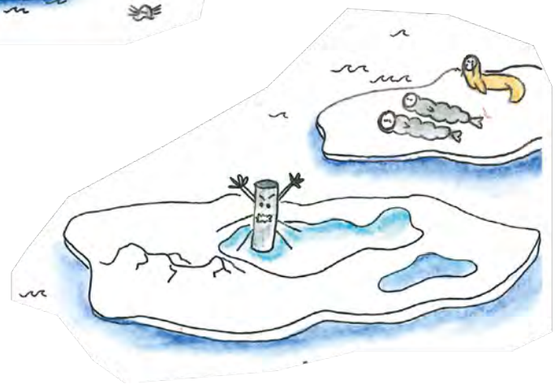
Accessibility in data visualizations extends well beyond just appropriate colourmaps for colourblindness. Some suggestions I have include removing jargon (e.g., use "human-caused" instead of "anthropogenic" climate change), adding alternative text to images and animations, placing labels directly with the data (e.g., mark 2020 next to the red line in Figure 2), using high contrast colour ratios, avoiding flashing GIFs, using figure titles as effective captions, avoiding too many data overlays (e.g., complicated surface

maps in meteorological analysis), and providing references/links to the original data. By including information on the original data, we can educate others on the scientific process and engage them with the data and methods of analysis. Again, to my (initial) surprise, I've found that many people are really interested in how climate change data is obtained and processed. Therefore, through sharing additional context with our visualizations, we can get others involved and excited about science!

While many of my suggestions are related to science communication, I also believe that they extend to scientific research and journal publications. By considering accessibility and the meaning of our data, we can improve the readability, dissemination, and interpretation of graphs and maps in peer-reviewed studies. This also can help improve the transparency, reproducibility, and innovation in striving for a future of open science.

Lastly, keep telling stories. Talking about climate change is one of the easiest and most effective ways to aim for a better future. There are many resources, such as the National Snow and Ice Data Center, OSI SAF, World Meteorological Organization, and Polar Portal, that provide visualizations and data of Arctic climate conditions in real-time. These can be useful starting points for data-driven stories. We can all create our own climate change conversations by sharing simple and bold visualizations.

Find out more about Zack at *https://sites.uci.edu/zlabe/*



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02

PolarPredictNews – Call for Polar Prediction "Art & Science"

The International Coordination Office for Polar Prediction and the Association for Polar Early Career Scientists (APECS) are inviting the polar prediction community to share creative or artistic renderings of polar prediction research output to be considered for publication in PolarPredictNews, the newsletter for the Year of Polar Prediction.

The last four issues of *PolarPredictNews* have had scientific artwork integrated into the design of the newsletter. "Art & Science" connects polar prediction-related science with the polar prediction community's creative and artistic work. We, the International Coordination Office for Polar Prediction (ICO), thereby aim to provide a platform for the PPP community to share sides of their research that go beyond pure science to involve impressions, emotions and creative or aesthetic modes of displaying scientific results. The platform offers a way to view the science from a slightly different angle, which in some cases may make it even more accessible than it would be from reading a paper or grasping particular x-y plots.

Thomas Rackow's melting sea-ice stripes were published in the previous edition of *PolarPredictNews*. Other contributors have been *Taneil Uttal* (Pieceful Pictures of the Day from MOSAiC Leg 2), *Amy MacFarlane* (Watercolour Drawings from MOSAiC Leg 3), and *Friederike Krüger and Thomas Rackow* (The Drawn Distributed MOSAiC Network). You can find all issues of PolarPredictNews at *https://www.polarprediction.net/news/polarpredictnews/*.

As we would like to continue to highlight artistic pieces resulting from the YOPP's and PPP's scientific achievements, we warmly invite you to share with us your creative output, which we will consider for publication in a future PolarPredictNews issue. Whether you have already done something or always needed the motivation, now is your chance to show it to your colleagues. Be it a result of your latest field work

experience or an outcome of your newest model the weather-forecasting skills of which you captured in pencil, oil or photography – even if transferred into knitwork – we are open to pretty much anything that relates to your research contributing to improved Arctic and Antarctic weather and sea-ice forecasts. Please submit samples of your artwork along with a short description of how it relates to your polar prediction research and to YOPP in particular, in PDF format, to the International Coordination Office for Polar Prediction, via email to *office@polarprediction.net*. After a committee has reviewed your submission, we'll get back to you with a decision.

03

Enhancing Capabilities of Numerical Weather Prediction in the Arctic – Tools of the Alertness Project

by Marvin Kähnert, University of Bergen, Bjerknes Centre for Climate Research

Norway's YOPP-endorsed project Alertness aims to improve AROME-Arctic, the weather forecast model which recently entered into service at MET Norway. As an operational convection-permitting model system dedicated to the European Arctic, it is one of YOPP's core models. As part of a collaborated effort within Alertness, PhD student Marvin Kähnert employs a number of tools to enhance Arctic NWP capabilities.

Many endeavours in the Arctic, from tourism to transportation to exploitation of natural resources require access to accurate weather forecasts. Yet, numerical weather prediction (NWP) models generally display comparatively low predictive skill at these high latitudes. The sparse conventional observation network over the ocean and sea ice as well as the pronounced impact of unresolved processes (surface fluxes, radiation, cloud microphysics) on Arctic weather events pose particularly large challenges for numerical modelling. Norway's YOPP-endorsed Alertness project, led by Jørn Kristiansen of the Norwegian Meteorological Institute and Marius O. Jonassen (University Centre in Svalbard UNIS), aims to tackle these key, specifically Arctic challenges, while exploiting the Year of Polar Prediction's opportunities in terms of field campaigns, observations and modelling efforts. The operational forecast systems AROME-Arctic form the methodological basis of the Alertness project's work. One of its dedicated aspects under the supervision of Harald Sodemann (University of Bergen) is to enhance the capabilities and diagnostics of AROME-Arctic. For this, members of the University of Bergen, the Nansen Environmental and Remote Sensing Center (NERSC), and the Norwegian Meteorological Institute have teamed up to employ a variety of tools that permit deeper insight into the "inner workings" of the NWP models. This article briefly introduces these tools and their utility.

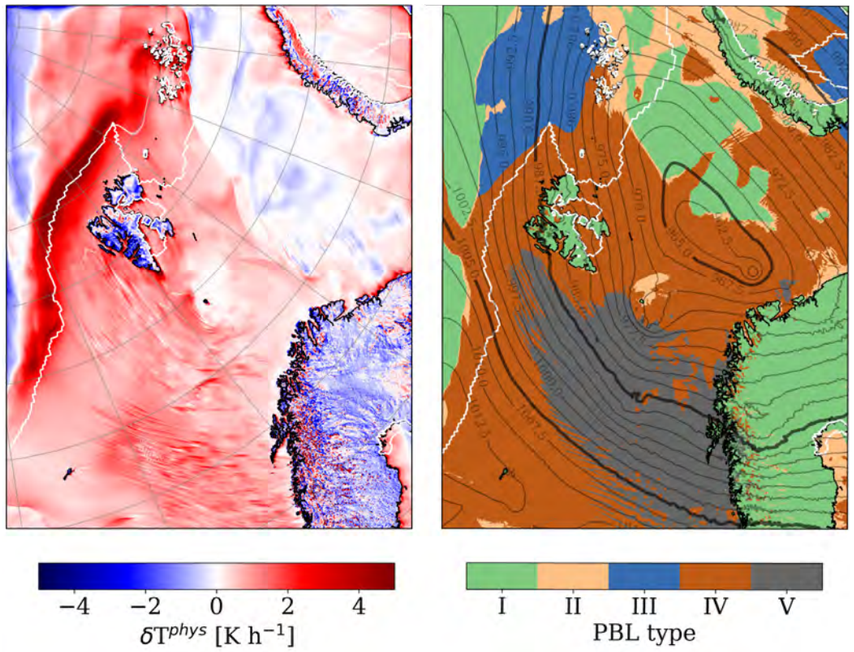


Figure 1: Physical tendency for temperature (left) of the lowest model level. Diagnosed planetary boundary layer (PBL) types in AROME-Arctic (right): I stable stratification, II dry convective, III stratocumulus topped, IV shallow cumulus topped, V deep convection. Northern Scandinavia is located in the bottom right corner, Svalbard is located near the middle of the model domain. White line is sea-ice edge (source: M. Kähnert).

1. Inspecting how the model advances from one time step to the next

The essence of a weather forecasting model is to calculate changes in atmospheric variables such as temperature, pressure or wind over time. In our models, these changes can be divided into two main contributions: model dynamics and model physics. Model dynamics refers to the large-scale transport of air masses by the wind, the model can fully resolve. Model physics on the other hand represents processes such as turbulence, radiation or cloud physics, that are too small to be resolved by the model grid despite AROME-Arctic's 2.5 km grid spacing. As a consequence, these processes need to be represented by simplified formulations, so-called parameterizations.

All of these parameterized processes contribute to e.g. temperature or wind change in our model. We refer to these contributions as *individual tendencies*. Investigating these tendencies enables targeted studies of the otherwise "hidden" activity and interplay of the model's physics. Figure 1 demonstrates this utility. Shown on the left is the physical tendency (sum of all parameterization schemes) for temperature close to the surface (the lowest model level) during a day with major cloud formation. The physics actively warm most of the model domain (red shading). However, this warming is not uniform, and distinct spatial patterns emerge. These patterns can be attributed to environmental factors such as the sea-ice edge (white line) or to model-internal factors. We found that boundary layer types play an important role (Fig. 1). Boundary layer types help the model to adjust its physical package towards the plethora of atmospheric regimes that it needs to represent, such as a cloud-free winter night or an autumn storm. Together with Wim de Rooy (Royal Netherlands Meteorological Institute), we use the new perspective obtained from tendency output to investigate the impacts of a new boundary layer package.

2. Inspecting processes in the MUSC single columns model

Enhancing Arctic NWP capabilities also includes improving the representations of the model's error-prone processes such as low-level fog (being addressed by Teresa Valkonen of the Norwegian Meteorological Institute), or the stable boundary layer (being tackled by Igor Esau of NERSC). For this, we employ MUSC (Modèle Unifié Simple Colonne), which is the single-column model (SCM) of the HARMONIE-AROME model. An SCM isolates a vertical column from the full, three-dimensional model-system, but retains all of the physics and algorithms. Since it only investigates a single vertical column, the calculations are very fast, making MUSC an ideal tool for implementing new physical parameterizations or conducting sensitivity tests. Figure 2 exemplifies how liquid precipitation is sensitive to a parameter buried

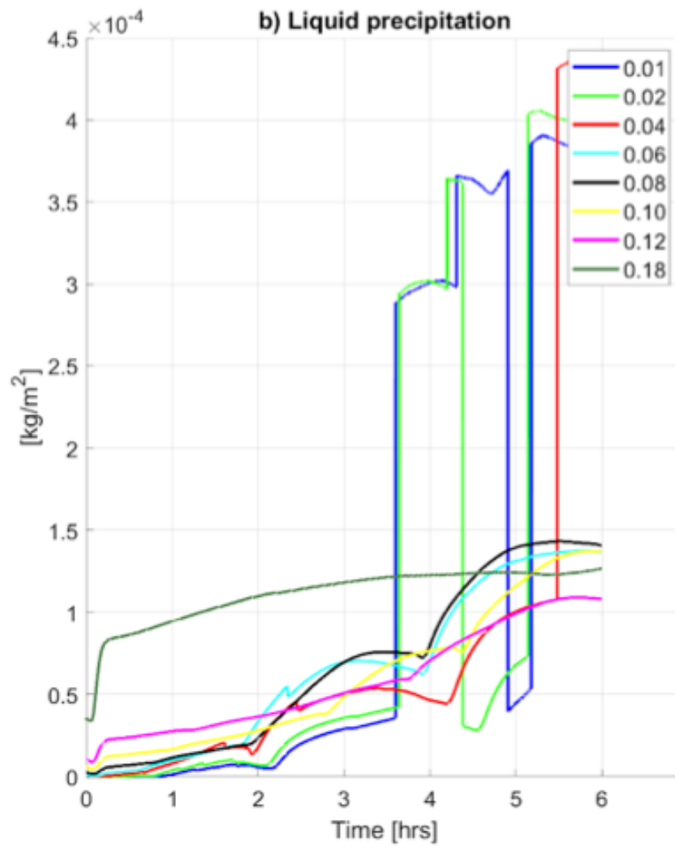


Figure 2. Sensitivity of liquid precipitation to different saturation limit values in MUSC. Figure by Petter Ekrem (UiB).

within the parameterization schemes for cloud microphysics. Stephen Outten (NERSC) set up MUSC as a virtual machine at the beginning of the project, making it very accessible and easy to work with, also for educational purposes.

3. Gaining high-resolution insight into the model with DDH

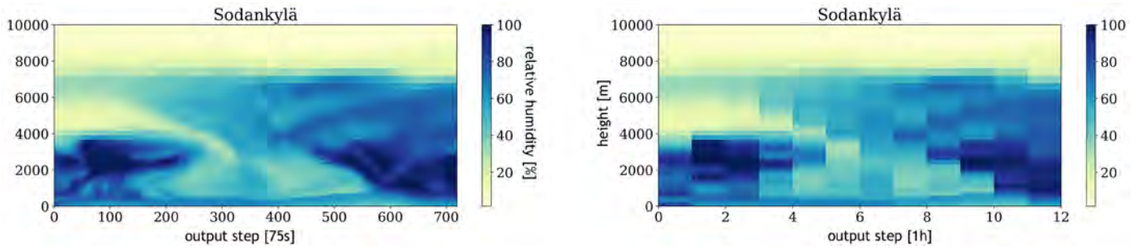
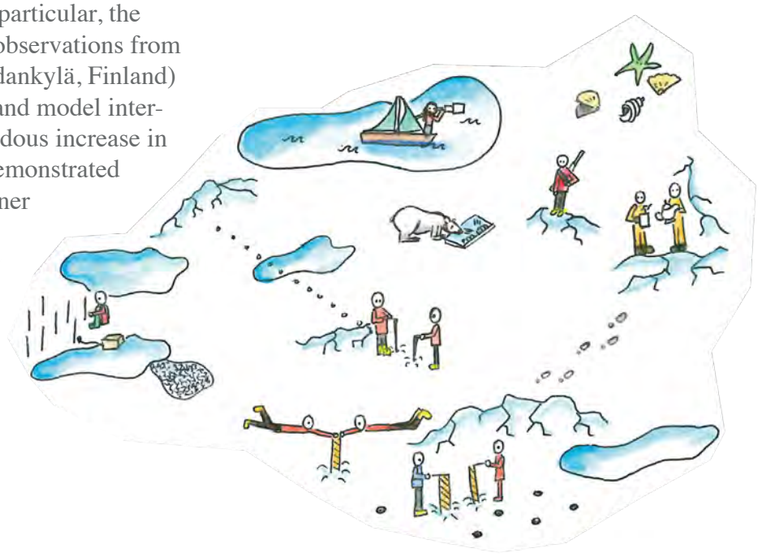


Figure 3. Comparison of output provided by the DDH tool (left, x-axis in 75 seconds model time steps) against the conventional 1h-output interval on the right. Shown is relative humidity for the closest grid point to the Sodankylä measurement site. Y-axis shows height in meter (source: M. Kähnert).

When working with NWP models, end-users are normally provided with hourly to three-hourly output intervals. Even though today's NWP models internally calculate in time steps of about 60 seconds or so, the sheer number of grid points on a typical model grid (~10^8) makes it simply not feasible to store every single time step. The DDH- (diagnostics on horizontal domains) tool developed at Météo-France provides an elegant solution. It allows model output to be written for every single model time step within a specified sub-domain. This enables a highly detailed investigation of process representations in the full, three-dimensional model. In particular, the combination of such output with observations from super-sites (such as the one in Sodankylä, Finland) has great potential for validation and model inter-comparison purposes. The tremendous increase in detail the DDH tool achieves is demonstrated in Figure 3. DDH reveals much finer structures in the development of relative humidity in the model for the Sodankylä measurement site.

Such high-resolution output enables much more detailed process studies of the stable boundary layer and testing of the new parameterization scheme than would otherwise be possible.

Equipped with these tools, we are working on improving high latitude weather forecasting. Yet our methodology is by no means restricted to the HARMONIE-AROME model or to NWP in the Arctic; but can be applied to other NWP models and geographical locations. A paper, demonstrating the utility of the individual tendency output is currently under review at *Weather and Forecasting*.



04

Alaska's Weather and Climate - Call for Change in Consciousness?

by Nikoleta Petridi, Kirstin Werner and Sara Pasqualetto, WMO WWRP International Coordination Office for Polar Prediction, Alfred Wegener Institute

A number of severe storms struck Alaska's coasts in March 2021 – a cause for concern, according to many news articles. Climate and weather specialist Rick Thoman from the Alaskan Centre for Climate Assessment & Policy (ACCAP) provides regular weather briefings to inform about Alaska's current weather and climate trends.

Alaska is part of the polar and peripolar area. Climate change hits hard here, leading to imbalances in the natural system. In nature, everything has its own timeline – during spring, the ice in the rivers breaks up, wildfires break out in summer, and storms usually occur in fall and winter. During the last few decades, global climate changes have started to disrupt the natural balance, e.g. by shifting the onset of seasons or changing their duration. At the same time, higher temperatures and increased greenhouse gasses in the atmosphere pose a substantial threat, not only to the polar regions' sea ice and glaciers, but also to nature in its current state, its terrestrial wildlife and vegetation, and the marine fauna and phytoplankton essential to maintaining the global food chain.

Alaska on a spring night (photo: Winfried Hoke)

Rick Thoman works at the Alaskan Centre for Climate Assessment & Policy (ACCAP)at the University of Alaska Fairbanks. An Alaskan climate specialist by training, he is one of the weather scientists trying to understand the ongoing dramatic changes in northern North America. He collaborates with organizations from the World Meteorological Organization and the National Oceanic and Atmospheric Administration to private companies such as the World Climate Service, and colleagues at the International Arctic Research Center. Together, they provide monthly and seasonal forecasts to the Alaskan community. For his online weather briefings, he puts complex information from the latest climate and sea-ice predictions into a format that non-scientists can use to stay informed about the next few weeks' expected weather conditions. An important part of these briefings is his kick-off with last month's weather conditions. He then compares them with the coming weeks' forecast and historical data, looking for trends and general shifts in Alaska's climate.

Following Rick Thoman's weather briefing in March, in which he envisioned a sustainable and safer Arctic, some important trends and key messages are summarized below.

Jumping into the Unknown? – From Sea Ice...

Sea ice is a vulnerable element of Alaska's environment, and it has changed dramatically during recent years. As a natural regulator of temperature, moisture, food webs, and also many human activities, sea ice plays a vital role in the climate, economy and the environment. According to Rick, "*this February,*

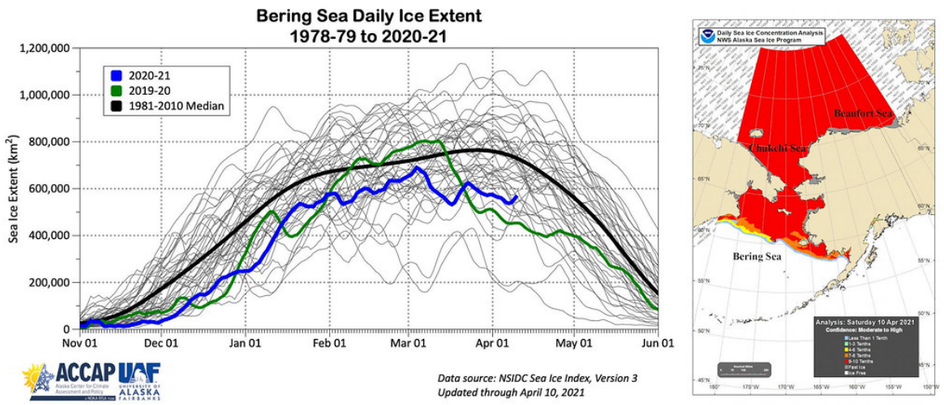


Figure 1: Daily Sea-Ice extent from 1978-1979 to 2020-2021 in the Bering Sea. By Rick Thoman

the average ice volume was the third lowest in the satellite era reconstruction from 1979 to 2021". Ice thickness has also been affected: during March 2021, ice thickness was substantially lower than the long-term average, especially along northern Greenland and the northern Canadian islands. As mentioned in a report Rick Thoman and John Walsh published in 2019, the typical summer sea-ice extent in the Chukchi Sea, for example, was only 10% of what it was in the early 1980s, allowing for a much longer period of open water. But more open waters mean an extended period of heat exchange and circulation between the atmosphere and the deep ocean, thereby amplifying the effect of sea-ice melting. "*This recent winter's ice-extent never got to the 'normal' values but was still well above the minimum of 2017–2018 and 2018–2019*", explains Rick Thoman in his March 2021 weather briefing.

ACCAP, together with the University of Alaska Fairbanks, developed a sea-ice atlas for Alaska and the Arctic, showing sea-ice data from 1850 to the present (http://www.snap.uaf.edu/tools/sea-ice-atlas).

...to Wildlife Fires

But Alaska is a place of extremes, and so the concerns are not limited to sea-ice melting only. According to Alaska's interagency fire management organization, the wildfire season has been extended by an entire month, with a dramatically increased frequency of large wildfires. According to the 2019 report by Thoman and Walsh, the amount of smoke has increased significantly in the country, with a mean annual value of approximately 15 days of reduced visibility during the summer (see also a recent article on a wildfire study by the YOPP-endorsed APPLICATE project in ***Polar Prediction Matters***). Not only do wildfires burn local habitats, they also affect air pollution and release greenhouse gasses. Additional greenhouse gasses may originate through permafrost melting in the heated soil layers.

More Heat Contributes to a Positive Feedback Loop

Winter temperatures in Alaska have been rising since the 1970s. Thoman's and Walsh's report mentions that record temperatures have been observed in the past five years that were warmer than any prior year, with an average annual increase of 3 °C – 4 °C. At the same time, the number of extremely cold winter days has been decreased; during the past decade, less than 30 days were extremely cold, compared to more than 40 days before 1960. Still, February, 2021, "*was the coldest February in the thirty-year reference period from 1991 to 2021 in the center and northern Alaska*". On the other hand, "*the south of Alaska, the lower Alaska Peninsula had among the warmest Februarys on record. The temperature difference was dramatic with much of the mainland, with southwest Alaska being kind of a battle zone. They had big flips from day-to-day temperatures but at a monthly scale they evened out*".

What about the Ocean?

Ocean warming has been altering the seas globally; Alaska is no exception. Sea surface temperatures are rising annually, absorbing most of the heat resulting from global warming. An example explained in the above-mentioned report is the so-called Pacific "blob", a pool of warm water that developed off of Alaska in 2013 that expanded south until the end of 2015, when it shut down, with devastating effects on marine life. After this occurence in the Northern Pacific Ocean, marine heat waves and sea-ice loss culminated in the loss of the "cold pool" in the Bering Sea – a boundary for southern and northern species. This winter, sea surface temperatures have been above normal in the southern Bering Sea and the Gulf of Alaska.

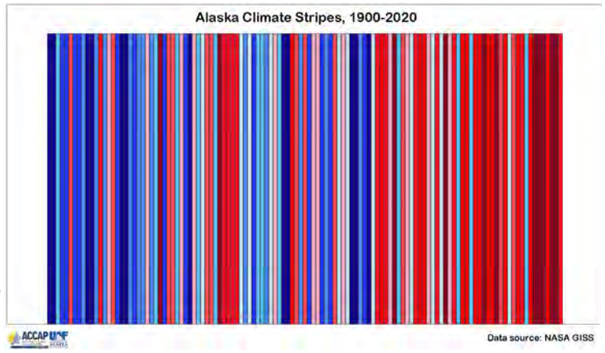


Figure 2: Ed Hawkins's warming stripes showing the average monthly temperatures from 1895-2020 in Alaska (source: Ed Hawkins).

But Where does all this Data Come from?

SNAP, the Scenarios Network for Alaska and Arctic Planning, provides downscaled climatic data for the areas around Alaska and Canada and is working together with the international Arctic Research Centre and the University of Alaska Fairbanks. The network makes use of various models and scenarios, usually extracting the average value. Still, artifacts and uncertainties do occur, which available data and model improvement could limit.

Listening to the Community, Listening to Nature

Communities who lived in and adapted to previous "normal" conditions have been facing drastic challenges these past few decades. Hunting and traveling has become more and more difficult for indigenous people. Providing reliable and accurate forecasts for the upcoming season has become crucial to communities planning their daily routines. For locals, knowing (for example) when the sea ice will melt, or how thick it will be can be a vital; during winter, sea-ice roads often are the only roads available.

Traditional knowledge transferred from one generation to the next in local and Indigenous communities is an invaluable source of information. Often, it used to be the primary source of information that not only local communities but also scientific observations relied on. Many times, locals notice tiny changes in environmental conditions, which are essential to their understanding and predicting weather and ice conditions – changes a stranger wouldn't think of or wouldn't even realize were happening. But with ongoing climate changes, these early weather signs have become harder to read, such that improved forecast services become all the more important to the local communities instead. Fostering collaboration and communication between local communities and forecasters can thus help to enhance dialogue about Alaskan weather forecast users' requirements and wishes.

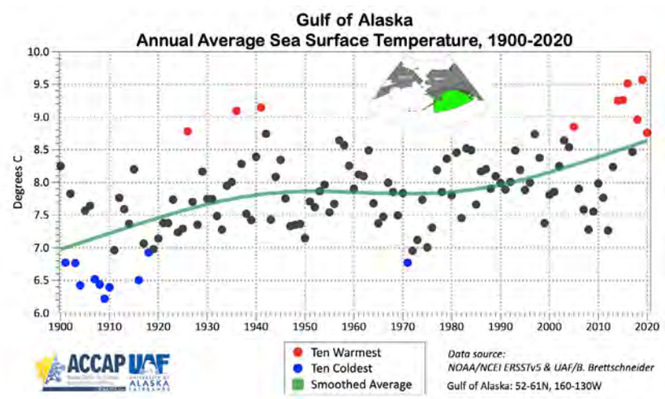


Figure 3: Annual average sea surface temperature in the Gulf of Alaska from 1900-2020. By Rick Thoman.

Ilarion K. Merculieff, founder and president of the Global Centre for Indigenous Leadership and Lifeways, once said, "*You can't change the problems with the same consciousness that created the problems*". In this very same spirit, Rick Thoman translates scientific knowledge into accessible information that is easy to understand for everyone. Having done his graduate work in Athabascan linguistics, Thoman minimizes the gap between academia and the communities, strengthening local collaborations. Following his example of taking a somewhat non-traditional view of science can generate benefitial social and scientific impact, bringing to Alaska the change it needs for a sustainable future.

For more see also the ***Polar Prediction Matters blog*** published by Rick Thoman and Gita Ljubicic in 2019.

05

"Alaska of the Late 21st Century Will Be Somewhat Different" – Interview with Rick Thoman

Interview: Nikoleta Petridi, WMO WWRP International Coordination Office for Polar Prediction, Alfred Wegener Institute

In his work, Alaska climate and weather expert Rick Thoman bridges between climate modeling, weather and sea-ice forecasting and Alaska communities. In our interview, he shares his perspective on the challenges and opportunities to work with Alaskan communities to support them in getting the weather and sea-ice information they need.

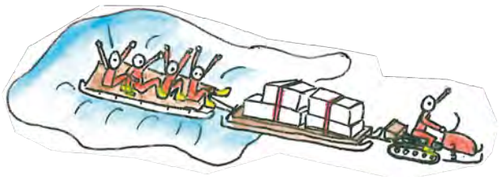
Photo: private

Rick, you have been monitoring Alaska's climate for the past few years and making seasonal forecasts. What are the difficulties you face in your work?

RT: Difficulties fall into two categories. One is having the types of climate and environmental information and forecasts that communities say they want and can use in their decision making. The second category is the difficulty getting information to individuals and communities in rural areas, where Internet connectivity is unreliable and has limited bandwidth even when functioning.

What data do you use? Where would you like to see improvement (modeling, data assimilation, observations etc.)?

Remote sensing information from satellites and modern high-resolution computer model reanalysis (such as the ERA5 from ECMWF/Copernicus) and the data derived from them are vital for monitoring ongoing and recent conditions. In Alaska and nearly all of the Arctic, there are many fewer traditional in-situ weather and climate observations than in the mid-latitudes. This increases the importance of the observations we do have. Snow information, such as depth and water equivalent, is critical for many human and ecosystem activities in the Arctic, but in large parts of Alaska and Canada there is less snow data available now than there was 50 years ago. This is the direct result of the automation of basic weather observations and neglected by national agencies on replacing these important measurements. However, citizen science participation can bridge some of this gap and provide information at the local scale that is impossible to obtain remotely, such as sea-ice quality and stability.



What changes worry you the most?

Seasonal changes in sea-ice extent, thickness and stability have already brought extraordinarily rapid ecosystem changes to the Bering Sea and are poised to do the same in the Chukchi Sea. In the longer term, ocean acidification is going to be a big problem for Alaska and the Arctic.

What scientific work is, in your opinion, missing from Alaska and the peripolar regions?

One of the big uncertainties in climate projections is the role thawing permafrost and warming Arctic soils may play in the release of greenhouse gases (methane and carbon dioxide). As important, though, is the urgent need to bring together information from different science disciplines into a holistic view of the changes and the potential impacts to individuals, communities and businesses. Scientists are often hesitant to provide those kinds of syntheses until "we know for sure", but we all make decisions everyday with incomplete and uncertain information, and Arctic change should be no different.

How are the people responding to your forecasts? Have you noticed a change in habits? – Do you think people rely more on weather forecasts nowadays?

I think (hope?) that people and organizations in Alaska are gradually coming to realize that there is much more information about weather and climate that they can potentially use to help make decisions than is readily available on cell-phone apps. And, that this applies to all time scales, from decisions regarding activities planned for today to costly decisions regarding infrastructure investments that can be expected to remain in use into the 22nd century.

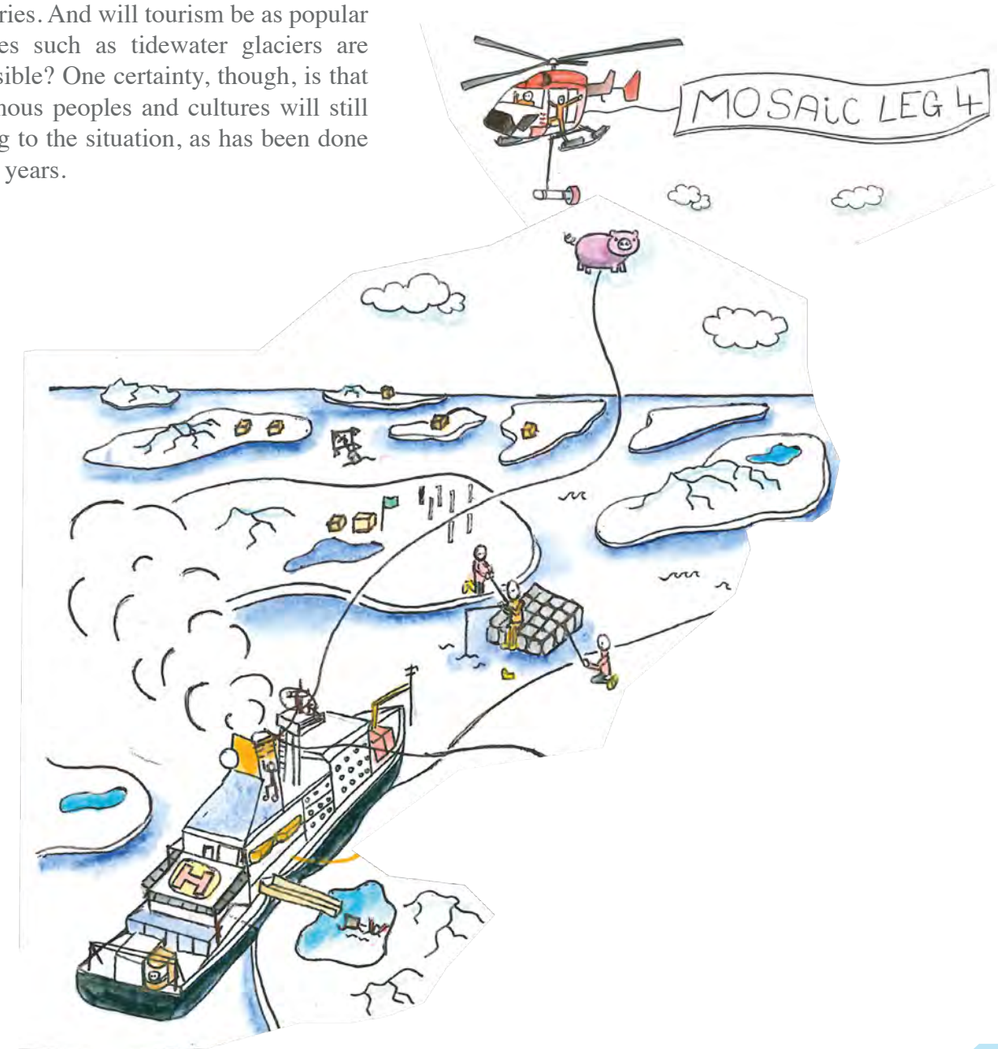
How do you see the future for Alaska?

Alaska in the late 21st century will be, in some ways, quite different than in the late 20th century. An economy based on crude oil extraction will be long gone, although large scale industrial mining for metals will likely persist. A big unknown will be the state of fisheries. And will tourism be as popular if iconic features such as tidewater glaciers are gone or inaccessible? One certainty, though, is that Alaska's Indigenous peoples and cultures will still be here, adapting to the situation, as has been done for thousands of years.

Do you envision any new opportunities arising along with the changing conditions?

There are always opportunities, but the question will be whether the benefits of new opportunities will accrue to outside interests or Arctic residents. Increased opportunities for agriculture could dramatically improve food security by reducing the reliance on foods produced far away and requiring long-distance shipping. Some changes will result in mixed impacts: higher winter temperatures reduce heating costs for people but have compounding ecosystem effects. Less sea ice is already allowing for increasing commercial and industrial shipping but may well contribute to increasing winter snows and more frequent rain-on-snow episodes, both of which can be costly for societies.

Follow Rick *@AlaskaWx* on Twitter for regular updates on Alaska's weather and climate.



06

Is a Complex Sea-Ice Model Better for Your Simulations?

by Lorenzo Zampieri, Alfred Wegener Institute

In addition to satellite observations, in-situ measurements or experiments in the lab, the study of sea ice is nowadays also carried out through the employment of sophisticated mathematical models. The ultimate goal of these models is to quantitatively simulate the behavior of the sea ice, its evolution and its interactions with other components of the climate system. Whether a complex model produces better results than a simpler model remains an open question.

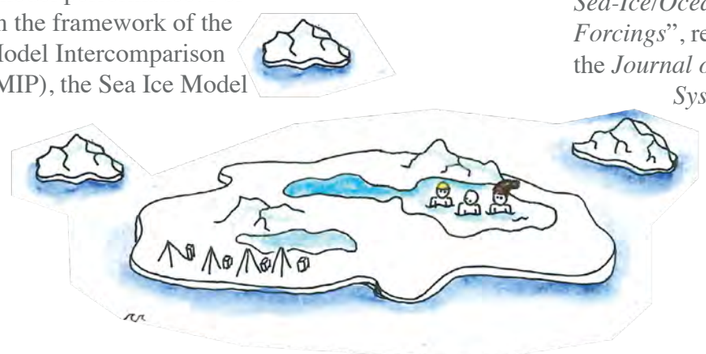
When discussing the evolution of sea ice in models, we cannot refrain from connecting major developments in sea-ice modeling to fundamental advances that have been made in the field of sea-ice observations. The understanding of heat conduction in sea ice, which led to the first mature sea-ice model by Maykut & Untersteiner (1971), would not have been possible without the data collected during the *International Geophysical Year* in 1957–58. Before the first satellite observations were available, the "Arctic Ice Dynamics Joint Experiment" (AIDJEX) – a series of experimental campaigns carried out during the 1970s – laid the foundation for understanding sea-ice motion in the Arctic. This contributed to the formulation of the first dynamical and thermodynamic model of sea ice by Hibler (1979), featuring a viscous plastic (VP) sea-ice rheology. Observations from the "Surface Heat Budget of the Arctic" (SHEBA) campaign added radiation to our understanding of the interactions between sea ice and snow, resulting in a series of more physically realistic parameterizations being added to sea-ice models. The recently concluded "Multidisciplinary drifting Observatory for the Study of Arctic Climate" (MOSAiC) – arguably the largest Arctic expedition in history – can be considered the next step on this pathway. MOSAiC was explicitly designed to build a solid understanding of sea-ice processes that will have a major impact on the future of sea-ice modeling. In this respect, future modeling improvements are expected through the description of the snow layer on top of the sea ice, the representation of its biochemical processes, and ultimately through the exchange at the interfaces between the sea ice, ocean, and atmosphere.

Improved Access to Computational Resources

The development of numerical sea-ice models has been driven not only by the growing quality of observations but also by the increasing availability of computational resources for running the models and for analysing the results. The first mature model of sea ice by Maykut & Untersteiner (1971) was too detailed and too sophisticated for the computing capabilities available at the time and had to be simplified by Semtner (1976) so that it could be employed over larger domains and for climate applications. An energy-conserving multi-layer sea-ice model for pan-Arctic setups was not implemented until almost three decades later by Bitz & Lipscomb (1999). Nowadays, sea-ice simulations feature very high spatial resolutions that reach the kilometer scale.

How complex must a sea-ice model be?

Despite many decades of model development efforts, the modeling community still has not agreed on the required degree of model complexity needed to obtain good sea-ice numerical simulations. In simpler terms, there is still debate: Does a more physically detailed sea-ice model formulation lead to better sea-ice simulations? Some studies suggest that a more sophisticated description of the sea-ice physics leads to simulations that agree better with sea-ice observations. Others, however, fail to establish a link between complex model formulations and improved model performance. For example, in the framework of the Coupled Model Intercomparison Project (CMIP), the Sea Ice Model Intercomparison Project (SIMIP) community shows that it is unclear to what degree differences between CMIP6, CMIP5 and CMIP3 sea-ice simulations are caused by better model physics versus other changes in the forcing.



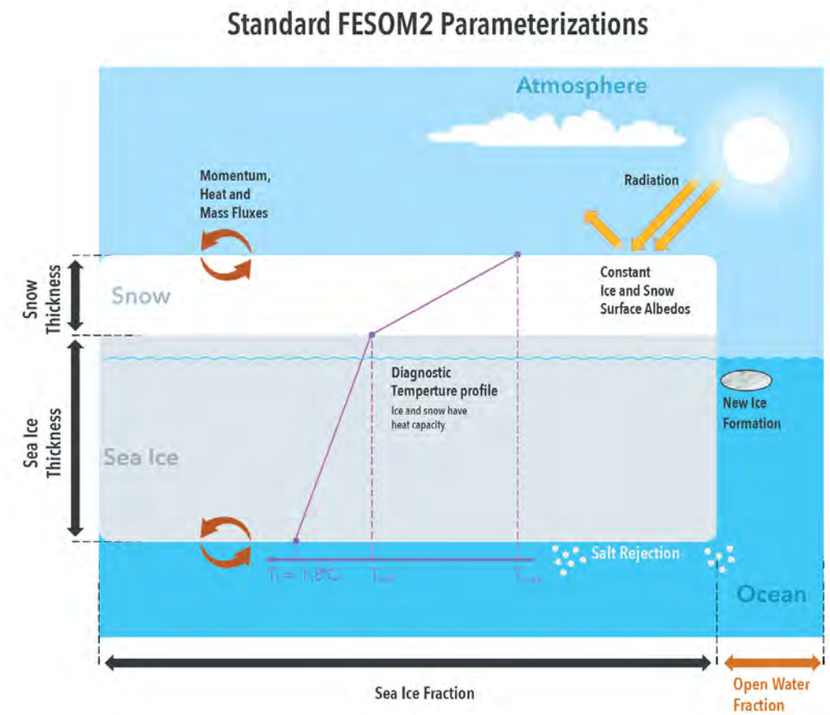


Figure 1: Schematic representation of the dynamical and thermodynamical processes used in the standard formulation of the Finite-volumE Sea ice ocean Model version 2 (FESOM2) (credit: Lorenzo Zampieri and Martin Künsting, copyright: CC BY 4.0).

In the field of subseasonal and seasonal sea-ice forecasting, simple dynamical models exhibit predictive skills comparable to, or even better than, those of more complex forecast systems, suggesting that the year-to-year variability, the skill of the atmospheric models and the quality of initial conditions dominate the variation in prediction success.

In the paper "*Impact of Sea-Ice Model Complexity on the Performance of an Unstructured-Mesh Sea-Ice/Ocean Model under Different Atmospheric Forcings*", recently published open-access in the *Journal of Advances in Modeling Earth Systems*, we investigate this open question by analysing a set of sea-ice simulations performed with a revised and improved sea-ice model that features substantial modularity in terms of model complexity.

As the first step, we equipped the unstructured global sea-ice and ocean model FESOM2 with a set of physical parameterizations derived from the single-column sea-ice model Icepack. The simple 0-layer sea-ice and snow thermodynamics have been replaced with a set of multi-layer parameterizations that take the enthalpy and salinity of the ice into account. The new system can simulate prognostic thickness and floe-size distributions (also jointly), accounting for sea-ice ridging and processes regulating the break-up and healing of sea-ice floes. A sophisticated delta Eddington multi scattering solar radiation parameterization and three prognostic melt-pond schemes are also available. To fairly compare eventual improvements or drawbacks associated with the changing model complexity, we optimized a subset of the parameter space of each tested model configuration by applying a Green's function optimization technique. The results indicate that a complex model formulation leads to better agreement between the modeled and the observed sea-ice concentration and snow thicknesses while differences are smaller for sea-ice thickness and drift speed. However, the choice of the atmospheric forcing used as the boundary condition for the sea-ice model also impacts the agreement between

simulations and observations, with NCEP-CFSR/CFSv2 being particularly beneficial for the simulated sea-ice concentration and ERA5 for sea-ice drift speed. Furthermore, the results indicate that the parameter calibration can better compensate for differences among atmospheric forcings and for model deficiencies in a simpler model setting (where sea ice has no heat capacity) compared to more realistic formulations with a prognostic ice thickness distribution.

Modularity and Community

In light of the previous considerations, we propose two simple strategies for dealing successfully with the heterogeneous and rapidly evolving field of sea-ice modeling. These strategies can be summarized by the words "modularity" and "community".

Modularity is a key requirement for present and future sea-ice modeling infrastructures, as it allows one to tailor the model setup to specific scientific applications, optimizing at once the use of computational resources and storage space dedicated to model simulations. In this respect, modularity is the compass we followed when designing the upgrade of the thermodynamic sea-ice component of FESOM2 by integrating into it the single-column model Icepack.

Working in close collaboration with the rest of the sea-ice modeling community is a second strategy that has the best chances of developing a healthy, well-performing modeling infrastructure. In this respect, having implemented the Icepack subroutines in FESOM2 by following a modular approach guarantees that model updates and corrections wil be received in an efficient and timely manner. Furthermore, sharing one modeling infrastructure with hundreds of scientists around the world maximizes synergies, which translates into more direct applicability and assimilation of major scientific advances and a larger reach for our findings and developments.

More information:

Zampieri, L. (2020). Sea-ice prediction across timescales and the role of model complexity, Ph.D.Thesis, University of Bremen. https://doi.org/10.26092/elib/446

Zampieri, L., Kauker, F., Fröhle, J., Sumata, H., Hunke, E. C., & Goessling, H. F. (2021). Impact of sea-ice model complexity on the performance of an unstructured-mesh sea-ice/ocean model under different atmospheric forcings. Journal of Advances in Modeling Earth Systems, 13, e2020MS002438. https://doi.org/10.1029/2020MS002438

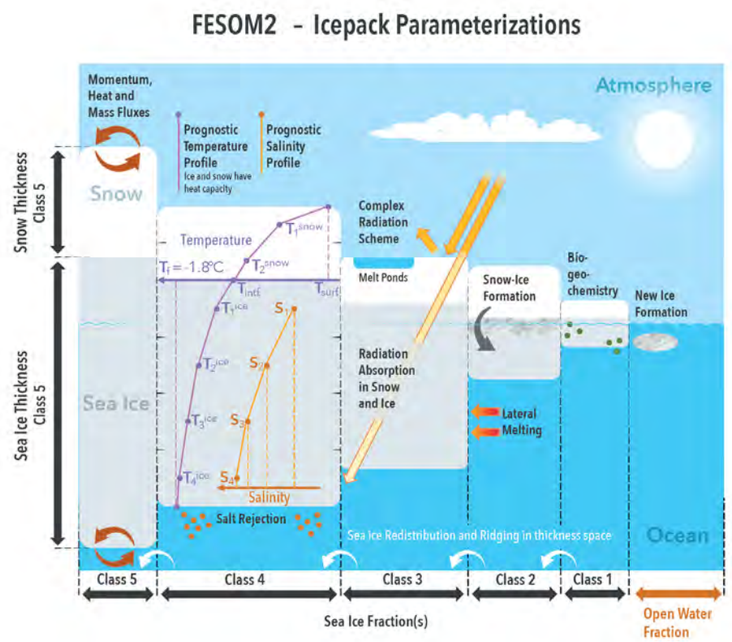
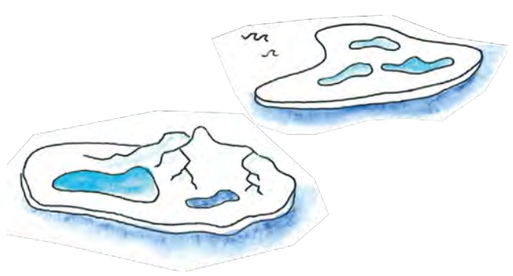


Figure 2: Schematic representation of the dynamical and thermodynamical processes used in the Icepack sea-ice column physics package, recently implemented in the Finite-volumE Sea ice ocean Model version 2 (FESOM2) (credit: Lorenzo Zampieri and Martin Künsting, copyright: CC BY 4.0).



07

The United Nations Ocean Decade in A Polar Context

by Daniel Butkaitis, WMO WWRP International Coordination Office for Polar Prediction Alfred Wegener Institute

The United Nations Decade of Ocean Science for Sustainable Development 2021–2030 (in brief: "the Ocean Decade") aims to foster scientific and societal efforts toward sustainable ocean management in the coming years. To provide Arctic and Antarctic stakeholders with a shared agenda to support the goals of the Ocean Decade from a polar perspective, action plans for the respective regions are currently being developed.

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Considering accelerating climate change, the need for more enhanced efforts in the generation of ocean data and knowledge for sustainable ocean management is pressing. To address this, the United Nations proclaimed an Ocean Decade, starting this year, to enhance international collaboration in ocean science and create more robust-science policy interfaces. The Ocean Decade's goals are defined in seven Societal Outcomes (SOs), which can be found in the Ocean Decade Implementation Plan.

Based on the recommendations in the Implementation Plan, a series of workshops to develop regional implementation plans were organized throughout last year. For the Arctic, it was part of the January, 2020 Arctic Frontiers conference at which the Research Council of Norway hosted a Policy-Business-Science Dialogue Meeting. Later, the Danish Centre for Marine Research organized a series of online workshops in October and November 2020, where more than three hundred participants discussed the barriers and challenges for sustainable development in the Arctic. This resulted in the creation of an Arctic Action Plan that aims to identify actions and priorities in the Arctic in order to achieve the Ocean Decade's Outcomes.

Cross-Cutting Barriers in Polar Research

To create collaborative momentum for polar science and sustainable development in the region, the Arctic Action Plan aims to provide Arctic stakeholders with a common agenda. The Action Plan identifies several cross-cutting barriers to progress. These can be translated into the three different types of challenges the plan is structured around: i) research challenges concerning scientific gaps in understanding and data availability; ii) organizational challenges in terms of efficient international coordination; and iii) uptake challenges to foster the societal benefits of ocean science and solutions. For each of these areas, the Action Plan provides a dedicated agenda of specific challenges and research foci. The collection, management and sharing of data as well as the need to involve Indigenous people in Arctic science and policy processes are further issues.

A similar Action Plan for the Southern Ocean is currently being developed. The Scientific Committee on Antarctic Research (SCAR) has coordinated the setup of a Southern Task Force to work on the Southern Ocean Action Plan. In February of last year, the first Southern Ocean Meeting was held in San Diego (USA), where key research priorities for the region were defined. The next step will include an open survey so Antarctic stakeholders can provide information on their current activities and interests. Once the survey concludes, different working groups for each of the Decade's Societal Outcomes will work on transferring its findings into an Antarctic context. A final Southern Ocean Action Plan version can be expected by September 2021, when the second Southern Ocean Regional Workshop will take place in The Hague (NL).

More information on the United Nations Ocean Decade can be found at https://oceandecade.org.
More information on the Arctic Action Plan can be found here: https://www.oceandecade.dk/.
More information on the Southern Ocean Action Plan can be found here: https://www.sodecade.org/

PolarPredictNews #18

08

On Kitchen Scales and Drifting Icebergs – Antarctic Diary

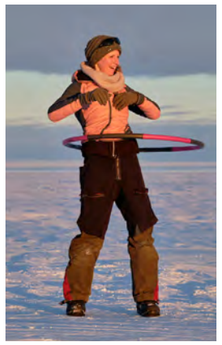
by Stefanie Arndt, Alfred Wegener Institute, and Mayleen Schlund, WMO WWRP International Cordination Office for Polar Prediction, Alfred Wegener Institute

Stefanie Arndt is a sea-ice physicist at the Alfred Wegener Institute in Bremerhaven, Germany. Her passion is snow; she loves to work with Antarctic sea ice. In February and March, Steffi joined the most recent expedition to the Antarctic on board the research icebreaker RV *Polarstern*. Expedition PS124 was special in several ways, and carrying out a research expedition under pandemic conditions was challenging on its own. She shared her experiences with *PolarPredictNews* in the form of a diary.

28 January 2021: Hotel, Bremerhaven

For the past 13 days, I have been isolated in my hotel room. It's quarantine time! The most strenuous part is over for now, though. After the second round of negative coronavirus tests a couple of days ago, the expedition team entered what I would call group therapy! Since then, we have been spending parts of our days together.

Held only virtually over the past weeks and months, team meetings are now also taking place in person in the hotel's seminar rooms. We're eating together, and we can do some outdoor activities in a fenced-off area, so I can now swing my hula hoop without having to clear the entire desk in my room. Tomorrow we'll face the last round of coronavirus tests before leaving for Antarctica.



All Photos: Stefanie Arndt

04 February 2021: RV Polarstern, Falkland Islands

Yesterday, we finally reached *Polarstern* lying at anchor close to Port Stanley in the Falkland Islands. After two weeks of quarantine in Bremerhaven and the longest-ever passenger flight in the history of Lufthansa aircraft, I am happy; we are now heading for the Drake passage and ultimately for Antarctic waters. It is fantastic to be back on board again; after eight cruises with the old lady, she has really become my third home after Berlin and Bremerhaven.

18 February 2021: RV Polarstern, Antarctica

We have been in the ice with *Polarstern* for one week now. A great feeling. And it means we are also in our ice-station routine. Whenever the weather allows, we fly out with the helicopter and do our ice work. We measure (among other things) snow depth with a snow probe and ice thickness with a device that we tow behind us on a sled while walking in a large triangle across the floe. I also take a very close look (in truest sense) at the snow layer. Here, I not only look at the size and shape of individual snow crystals but also weigh individual snow layers with my kitchen scales to determine its density.

Some other "kitchen practices" are when I taste snow every now and again – all for science, of course ☺. When sea ice forms, most of the salt from the ocean does not get incorporated into the ice's lattice structure. The snow on top, on the other hand, is actually tasteless fresh water - unless it has come into contact with salt water. But I still take samples of course, which I use to correctly measure its salinity in the laboratory on board. My colleagues also bring many samples back on board: many, many drilled ice cores.

03 March 2021: RV Polarstern, Antarctica

Every day is pretty much the same at the moment. And the schedule aboard *Polarstern* is strict. Breakfast is between 07.30 and 08.30 a.m. Then we meet in the ship's weather office: Can we take the helicopter towards the pack ice? If the weather conditions are good, we leave around 9.30 a.m. The flight to the floes usually takes about 5–15 minutes. By noon, it's all about digging holes and surveying the snow and ice. Today, we had another visitor, an Antarctic native: a penguin. After the work is done, the helicopter takes us back to *Polarstern*. By then, in most cases we have just missed lunch between 11.30 am and 12.30 pm. (Too bad.) But there is always food in the fridges in the mess rooms on board – lovely, because when we get back from the ice, we have to take care of our samples first anyway. They can't be allowed to thaw and need to be taken directly to the –20 °C cold room. Until dinner, we digitize our readings from the ice floe or analyse the samples we brought back to the ice lab. Here, we look at the ice crystal structure in polarized light and then melt the ice cores for salinity measurements.

The evening meeting is at 7.30 p.m. Here, I like to listen to what the other teams have done to get a good overview of what's going on. Before I go to bed, I prepare all our equipment again for the next ice station – because maybe we'll be going out on the ice again tomorrow?! I hope so!

13 March 2021: RV Polarstern, On a piece of fast ice north of the new A74 iceberg

Wow, what an experience when your only protection on the ice is a helicopter! But first things first. Most of today was a usual day on the ice. But a whiteout hit our site in the last hour of work. After a while, we all looked like snowmen (and women); the wind was whipping around our ears at, well, probably about 30 knots or so. We sought protection in the helicopter and waited for the weather to get better, but the world around us just receded into a grey-silver. The pilot decided conditions were too bad to fly back to *Polarstern*; instead, the ship set course to pick us up. So, we walked into the ship's direction with the helicopter sliding behind us the whole way. Once the helicopter managed to hop onto the ship with all our equipment and samples, we were picked up by the ship's mummy chair. It was a long day; but now we are happy to be back on board with both the helicopter and our equipment. Maybe I'll go to bed earlier tonight. Maybe.

14 March 2021: RV Polarstern, A74 iceberg

A few weeks ago, iceberg A74 broke off from the Brunt Ice Shelf. Since we were in the vicinity with *Polarstern*, it represented the opportunity for us to sail into the gap (now more than a mile wide) between the ice shelf and the iceberg and explore the life above this "fresh" ocean floor. Observing it carefully together with the captain, we decided to sail through. What an impressive moment. And it remained exciting, because the iceberg was already moving a lot due to tides and wind. But everything went well, and the view of the sometimes jagged, sometimes completely flat ice edge was striking. We could only think how loud it must have been when the iceberg broke away.

20 March 2021: Neumayer III, North Pier/ Atka bay

Twenty-four more people with three tons of luggage and (additionally) a lot of garbage are now on *Polarstern*. Ten days ago, we set course for Atka Bay, about 8 km from Germany's Neumayer III Station. The plan was to pick up the last wintering team, the summer guests, and everything the station no longer needed. But such as it is with plans, things turned out differently. While we were loading the ship, it experienced a fair jolt accompanied by an odd, lingering sound. Sea ice was pushing the ship against the ice shelf. Action had to be taken, so the captain decided to leave the north pier of Atka Bay to escape the situation. The next day, the helicopter brought all the passengers and their luggage on board – and just one container of garbage was left behind. It will be removed next year. Exciting times on board!

27 March 2021: Atka Bay

Now in the final days of the expedition, it feels as if the entire expedition has just slipped away. Having crammed in 18 ice stations, dug 24 snow pits totaling 761 cm, taken 184 snow samples and walked about 20 km of transects over the ice flows, the expedition was a success, and we are setting course for home. The last evening on the ice was emotional. I realized that I don't know if I will ever come back to my third home in Antarctica; it was hard to say goodbye. On Friday, we will return to the Falkland Islands and then fly home. Hopefully I will be able to come back to this beautiful Antarctica!

Want to know more? Listen to ***The IcePod*** bonus episode #1 and episode #8 with Stefanie Arndt.


MOSAiC LEG 4
Amy Macfarlane

09

YOPP Final Summit 1-4 May 2022 – Save the Date

The Year of Polar Prediction (YOPP) Final Summit will take place in Montreal (QC), Canada, 01–04 May 2022. The conference will bring together the polar prediction community, from operational centres and academia, to environment services and polar prediction users and northern communities, to showcase the successes of YOPP and contribute to the legacy of the Polar Prediction Project.

Topics to be discussed during the meeting will be on the representation of polar processes in numerical models, especially coupling of the atmosphere, ocean & sea ice; ocean and sea-ice modelling and services; the MOSAiC expedition and polar observation campaigns; supersite multi-variate observations and process studies (YOPPsiteMIP); Observing System Experiments and reanalyses in polar regions; teleconnections linking polar weather to mid-latitudes predictability; science to services: tailoring polar forecasting products and services to meet user needs; societal and economic implications of accessible, relevant, and useable forecasts; participation of early career scientists is warmly encouraged, to shape the future of polar science.

Further information will be available in late summer when registration and abstract submission opens. For updates, please check at *https://www.polarprediction.net/meetings-workshops-and-science-sessions/*

10

Two New Contributions to *Polar Prediction Matters*

by Kirstin Werner, WMO WWRP International Cordination Office for Polar Prediction, Alfred Wegener Institute

Two new *Polar Prediction Matters* contributions have been added to the dialogue platform for users and providers of polar forecast services. In "Climate Service for the Chief Snowmaker", Martin Coath from the YOPP-endorsed Blue-Action project and Carlo Carmagnola from the H2020 PROSNOW project write about the opportunities and challenges that come with climate services for winter tourism management. In the contribution "Addicted to Antarctic Weather – What Queen Maud has to do with Germany's National Weather Service (DWD)", Gertrud Nöth, deputy head of media and public relations at DWD, writes about the role of Germany's national weather service in Antarctic weather prediction.

Climate Service for the Chief Snowmaker

Will there be enough snow on this slope for Christmas? Do I need to make more snow? And how much water do I need to make the snow? These are questions, a manager of a winter tourist resort might be asking. The two projects, PROSNOW and Blue-Action, looked into them and came up with easy-to-use solutions for how to predict snow-making conditions and indicate uncertainty, with the ultimate goal of aiding decision-making.

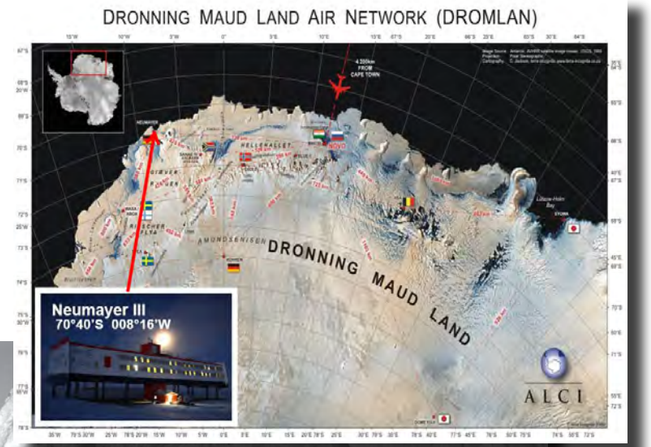
A new contribution of *Polar Prediction Matters*, the dialogue platform for providers and users of forecasting services, presents the outcome of the PROSNOW and Blue-Action studies. Martin Coath from Blue-Action and Carlo Carmagnola from PROSNOW discuss the projects' differences and shared challenges between two projects looking at climate services for winter tourism. Amongst others, the co-designing process and close collaboration with stakeholders from different ski resorts has been "*a key benefit and challenge*" at the same time. While any software application should ultimately be easy and simple to use, "*it was a difficult process to simplify so much complexity*", says Carlo Carmagnola.

Addicted to Antarctic Weather – What Queen Maud has to do with Germany's National Weather Service DWD

Antarctica is subdivided into four weather prediction regions. Germany provides the forecasting services for Queen Maud Land, where various countries maintain research stations, some of them year-round. The stations can only be accessed and supplied by air or sea from late October to early March. But in Antarctica, weather is always the limiting factor. Deutscher Wetterdienst (DWD), Germany's national weather service, provides meteorological information to ensure safe operations to and from all stations in the Queen Maud Land area.

In a contribution by the DWD to *Polar Prediction Matters*, Gertrud Nöth, deputy head of DWD's media and public relations, writes about weather forecaster Christian Paulmann's meteorological work, DWD's role in Antarctica and about how the COVID-19 pandemic has complicated weather forecasting in the high southern latitudes.

Find the two new contributions at ***https://blogs.helmholtz.de/polarpredictionmatters/***.



Photos from upper left to lower right: Carlo Carmagnola; Veera Vihervaara/RUKA Ski resort ; ALCI, Kapstadt, modified by Christian Paulmann, DWD; Christian Paulmann, DWD.

Polar Prediction Facts Week

Concept & Design: Mayleen Schlund, WMO WWRP International Cordination Office for Polar Prediction, Alfred Wegener Institute

The Association of Polar Early Career Scientists (APECS) brought the Polar Weeks to life to raise awareness and see the importance of the polar areas. Polar Week is celebrated twice a year around the equinoxes in March and September – the only time when everywhere on Earth the day length is twelve hours, a perfect opportunity to celebrate the poles on a global scale! In suport of the Polar Week, the YOPP International Coordination Office organised this March its first Polar Prediction Facts Week. For this, we invited some of you to share your most exciting but also fun facts which we posted on Instagram and Twitter during 15 to 20 March 2021. Find our Twitter and Instagram accounts @polarprediction.

Monday

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

If we wanted to counteract the global mean sea level rise of ~ 3 mm /yr, every single human on Earth would need to scoop out a glass of seawater (25cl) every minute.

POLAR PREDICTION FACTS WEEK

WHAT IS THE FINGER OF DEATH?

When brine is rejected during sea-ice formation, the very salty water underneath the sea ice can freeze during sinking to a so-called brinicle, also called the "finger of death", or "ice finger". Once it reaches the ground, it freezes anything too close to death!

POLAR PREDICTION FACTS WEEK

THANKS TO **FRANÇOIS MASSONNET** FOR SHARING THESE POLAR PREDICTION FACTS WITH US

François Massonnet is a researcher and lecturer at @UCLouvain focusing on climate variability, polar regions, climate model evaluation, visualization and statistics.

Tuesday

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

People use weather information in Antarctica and the sub-Antarctic to **plan** and **schedule tasks, find weather windows** (times of suitable weather conditions), and **manage safety.**

POLAR PREDICTION FACTS WEEK

TOP SOURCES OF WEATHER INFORMATION

In Antarctica and the sub-Antarctic, peoples' top sources of weather information are **websites, station intranets, forecasts, current weather displays,** and **meteorological professionals.**

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

No matter peoples' jobs or location in Antarctica or the sub-Antarctic, the most useful information for their weather-related decision-making was **wind** information, closely followed by **short-term forecasts** and **advice from trained weather professionals.**

POLAR PREDICTION FACTS WEEK

THANKS TO **VICTORIA HEINRICH** FOR SHARING THESE POLAR PREDICTION FACTS WITH US

Victoria Heinrich worked as a weather observer and is doing her Ph.D. at the University of Tasmania in Hobart.

Wednesday

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

During her drift, Polarstern reached 88°36' North, just 156 km from the North Pole.

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

It takes approx. 25 minutes every time to get fully dressed for going out on the ice.

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

Basic equipment during the winter season was a headlamp and during the summer season, it were sunglasses.

THANKS TO **ANJA SOMMERFELD AND MOSAIC** FOR SHARING THESE POLAR PREDICTION FACTS WITH US

Anja Sommerfeld is the project manager of MOSAIC. She is also an atmospheric scientist at AWI. More about Anja in **The IcePod** episode 5.

Thursday

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

The team of the Spanish Meteorological Agency (AEMET) which developed the Mobile Automatic Weather Station (M-AWS) met once during lunch break at a polar symposium in Madrid to test the components of the M-AWS. It was then put into a zero-emission windsled to measure meteorological conditions in Antarctica.

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

During the Year of Polar Prediction - Southern Hemisphere (YOPP-SH) Special Observing Period, the Mobile Automatic Weather Station (M-AWS) recorded data over a distance of 2536 km around Dome Fuji station, which is one of the remotest places in the world.

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

An Automatic Weather Station (AWS) usually includes a data logger and measuring devices to record several meteorological variables like temperature, wind speed, humidity, and atmospheric pressure.

POLAR PREDICTION FACTS WEEK

ZERO-EMISSION WINDSLED

POLAR PREDICTION FACTS WEEK

THANKS TO **SERGI GONZÁLEZ** FOR SHARING THESE POLAR PREDICTION FACTS WITH US

Dr. Sergi González is an atmospheric scientist and meteorologist at the Spanish Meteorological Service (AEMET) and a member of the Association of Polar Early Career Scientists (APECS).

Friday

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

Sea ice is **more** than "ice"? It contains many **small pockets** and channels, filled with very **salty water** or **air**, in which many **biological communities** thrive.

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

"Fast" ice is the slowest sea ice. In shallow seas, sea ice can ground on the seafloor, becoming **immobile** for many months. This sea ice type is called landfast ice, or more often, fast ice (from fastened).

POLAR PREDICTION FACTS WEEK

THANKS TO **LORENZO ZAMPIERI** FOR SHARING THESE POLAR PREDICTION FACTS WITH US

Lorenzo Zampieri is a Postdoctoral Researcher of the Climate Dynamics Section at Alfred Wegener Institute. His research focus lays on Sea ice modelling and Sea ice predictions.

Saturday

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

Model studies suggest that September Arctic sea-ice extent can be forecast in early July with expected errors only 40% of a climatological forecast. Real forecasts have a long way to get there.

POLAR PREDICTION FACTS WEEK

DID YOU KNOW?

Arctic sea ice, normally about 1-2 meters thick, could be grown 60 meters thick ... you only need to find a way to pump trillions of tons of sea water onto the ice each winter!

POLAR PREDICTION FACTS WEEK

THANKS TO **HELGE GOESSLING** FOR SHARING THESE POLAR PREDICTION FACTS WITH US

Helge Goessling works as a researcher at the Alfred Wegener Institute and his current research focus is on Sea Ice Prediction, Climate Physics Modelling and Data Assimilation.

Find us @polarprediction

11

The IcePod Episodes Ten and Eleven

by Sara Pasqualetto and Kirstin Werner, WMO WWRP International Cordination Office for Polar Prediction, Alfred Wegener Institute

Binoculars Are My Weapons

For the tenth episode of The IcePod, we jump from the scientific part to the logistical aspects of the expedition. Carrying out research in the polar bears' living room requires people who take care of keeping everybody safe. "*The binoculars are my weapons*", says Laura Schmidt, a member of the Safety and Logistics Team during MOSAiC leg 4.

Laura grew up in an alpine environment in Southern Germany, which easily paved her way into the Arctic. Studying geography was a way for her to merge scientific curiosity with a passion for outdoor activities. And, Greenland was her first love; while a master's student, she went on an excursion to the frozen super-island and always wanted to go back.

And that's what she did. She's been working as a self-employed guide, leading tourists into the extreme Greenlandic outdoors, home to the Inuit. "*In Greenland, everything is much different. Here, nature tells you what to do*." One has to be able to read and feel the landscape in order to enjoy it and get home safely. It's an ability that also helps against a pretty tough enemy for anyone exploring Arctic environments: fog.

Safety is also the keyword of Laura's role aboard *Polarstern*. The polar bear watch was one of a number of responsibilities to make sure the scientists and crew could carry on with their jobs. But shooting a polar bear would only have been an option of very last resort. Many tactics would come first, explains Laura in the episode. such as retreating or using a flare gun: "*I would never want to be the person who shoots a polar bear*."

It would be normal to wonder if Laura ever feels afraid when working in such an extreme environment. But for her, fear is part of the job; and at the right dosage, it is actually a key to staying aware of her surroundings and alert to changes and dangers around her.

Sharing the same home as a close-knit team of researchers and professionals for three months, Laura occasionally had an opportunity to step out of her logistics role and contribute to other activities in the MOSAiC camp. That's how she came to feel she was part of the atmosphere team, launching weather balloons and sending off messages into the blue Arctic skies.

Zoe and the Quiet Ocean

Number Eleven! It's the ocean episode. As we finally enter the last leg of the MOSAiC expedition, we get to talk to Zoe Koenig, an Arctic physical oceanographer at the University of Bergen and the Norwegian Polar Institute in Tromsø. Zoe led team Ocean during leg 5, which differed clearly from the previous legs. That's because the original MOSAiC ice floe had disintegrated, and *Polarstern* was now looking for a new home.

Zoe always had a close relation to the ocean. She grew up in Brittany and spent her childhood vacations with her family, sailing off the coasts of France. So to her, the ocean has always been a special place of freedom. And even if for some people it's just a blue-in-blue, she will always find a different shade of blue. In the Arctic, where sea ice covers and calms the ocean's motion; white adds to the blue; but what fascinates Zoe is the quiet.

It wasn't Zoe's first time drifting in the Arctic – as a PhD student, she joined the Norwegian Young Sea Ice (N-ICE) experiment aboard the vessel Lance. And so she brought to MOSAiC all this experience of how to measure the ocean's speed, tempeature, and salinity. Team Ocean was small but busy. To make sure no one got bored taking the same measurements over and over, Zoe introduced a rotating system so that everyone could run the different instruments. On the last leg, they only built a pared-down version of the former ice camp, but Zoe and her team still had to work hard to keep the various holes in the ice (for plunging instruments into the ocean) from refreezing.

During the last part of the cruise, *Polarstern* suffered a shortage of cheese and chocolate. But Zoe and her team made it back healthy and in time to be heartily welcomed in Bremerhaven in October last year. But, sadly, with the pandemic ongoing, it felt odd to come back to a world of people hidden behind masks and without hugs.

Find the latest and all previous IcePod episodes e.g. on Spotify, Apple Podcast, Castbox (no sign-up needed) or on our website theicepodcast.home.blog

#TheIcePod is the podcast about polar science and the people. We'll talk to scientists who went on board Polarstern, the German research icebreaker, for the biggest-ever research expedition to the Arctic. The IcePod is produced in collaboration with the Alfred Wegener Institute and Radio Weser.TV, where the full episode, with music, will air at *www.medialabnord.de/radio-livestream/*. For dates, check in with *polarprediction@gmail.com*.

Editorial responsibility:
Kirstin Werner and Sara Pasqualetto

Photos both pages: Lianna Nixon

12

Support for the YOPP International Coordination Office

Four more interns and a new staff member have been supporting the International Coordination Office for Polar Prediction over the last few months.

Mayleen Schlund studies physical geography at the Leibniz University Hannover, Germany, where she is currently in the final semester of her bachelor's program. From 22 February until 27 May 2021, Mayleen has assisted the International Coordination Office (ICO) for Polar Prediction as well as supporting the YOPP-endorsed project APPLICATE and the Advanced Earth System Modelling project (ESM), a Helmholtz initiative.

Nikoleta (Niki) Petridi is a geology student from the University of Athens, Greece, who is spending her last semester as an ERASMUS student at the University of Bremen, Germany. Niki is interested in various climate-change related topics. From 15 March until 09 May 2021, she has been supporting the YOPP International Coordination Office and the APPLICATE and ESM project offices.

Two new interns had joined the YOPP Coordination Office in May and June. **Patrick Hansen** studies environmental sciences at the Technical University in Brunswick, Germany. From 10 May until 2 July 2021, he has been supporting the YOPP International Coordination Office as well as the project offices of APPLICATE and ESM.

Jakob Hafner studies physical geography in his last semester at the Friedrich-Alexander-University Erlangen-Nürnberg. He stayed with us from 1 June to 9 July 2021.

Former PPP ICO intern **Daniel Butkaitis** has joined us as a student assistant. Daniel studies water resources management at the University of Applied Forest Sciences Rottenburg, near Stuttgart, Germany. *(kw)*

Photos: all private, except last PhotoArt Manuela Hund

13

All Across the Globe – PPP Steering Group Annual Meeting #12

by Jeff Wilson, WMO WWRP International Cordination Office for Polar Prediction

The twelfth annual meeting of the Polar Prediction Project Steering Group (PPP-SG) was held online due to travel restrictions caused by the global COVID-19 pandemic. The session took place from 08 to 12 March 2021 at different times of the UTC day to allow for different time zones of the PPP-SG members' locations. Discussion around each agenda item was kept to a maximum of 90 minutes.

The PPP-SG #12 session specifically focused upon reviewing progress in the Year of Polar Prediction (YOPP) Consolidation Phase: YOPP education activities and plans for the 2022 Polar Prediction Spring School; outreach and communication activities; considering options for the PPP evaluation and suggestions how parts of the content produced during PPP can be kept public available beyond the end of the project; planning for the Targeted Observing Periods during Antarctic winter from mid-April to mid-June 2022; reviewing the outcomes from the Targeted Observing Period in the Northern Hemisphere (NH-TOP1); reviewing plans for activities by the PPP Societal and Economic research Applications (PPP-SERA) group; examining the benefits and outcomes from PPP's collaboration with MOSAiC (Multidisciplinary drifting Observatory for the Study of the Arctic Climate); reviewing progress with the sea-ice prediction activities; reviewing progress with the YOPP Data Portal and the YOPP Supersite Model Intercomparison Project (YOPPSiteMIP); and, planning for the Final YOPP Summit as well as general coordination and administrative matters.

Progress with PPP and YOPP Activities

Prof Jung noted his pleasure in the progress to date with PPP and YOPP activities and the very positive outcomes associated with the collaboration of PPP with the MOSAiC expedition. Thomas Jung stated that the next twelve months would be critical for PPP as individuals and institutions furthered their research and prepared results for publication and discussion at the YOPP Final Summit. Thomas Jung also called on all PPP-SG members to seek further support for the PPP Trust Fund to enable the YOPP Final Summit and major activities such as the YOPP Data Portal and YOPPSiteMIP to be successfully completed before the end of 2022.
In summarizing the session, Thomas Jung recalled that the session had made a range of tactical decisions related to: the YOPP education activities and the Polar Prediction Spring School; the desirability of continuing the strong partnership with MOSAiC, particularly for YOPPSiteMIP and coupled modelling; to retro-actively define a Special Observing Period (SOP) from mid-December 2019 to mid-April 2020 to act as a focus for collecting the MOSAiC and wider YOPP observation and modelling data for further priority analysis; investigating the option for holding a second Northern Hemisphere Targeted Observing Period (TOP) in-conjunction with the HALO-AC3 campaign in March and April 2022; request YOPP projects and endorsed projects to check that their YOPP publications are included the YOPP Google Scholar list; to include lessons learnt in the YOPP evaluation brochure; and consider the number of submissions for presentations at the YOPP Final Summit when confirming the final room bookings to allow as many speakers as possible to present.

Upsides and Downsides of the Online Format

In closing the session, the chair of PPP-SG, Thomas Jung noted that the online format had worked well for much of the discussion while we, however, did not get the added benefits of the many side chats and out-of-session discussions that occurred during face-to-face meetings; it was also difficult to run "brain storming" activities. Additionally, it was challenging to reach out to all PPP-SG members and invited guests considering the different time zones of the participants' locations; therefore, recordings of all sessions were provided to all members who had the opportunity to comment and contribute to the discussion of an agenda item at a later stage.

The full report is available ***here***.

Photo: The twelfth annual meeting of the Polar Prediction Project Steering Group (PPP-SG) was held online from 08–12 March 2021 at different times of theUTC day to allow for different time zones of the PPP-SG members' locations (photo collage: Mayleen Schlund, Sara Pasqualetto).

14

Virtual Meetings on YOPP in the Southern Hemisphere and Antarctic Meteorology and Climate

The 16th Workshop on Antarctic Meteorology and Climate (WAMC) is held virtually from 21 to 23 June 2021. Anyone interested in Antarctic research, operations and logistics with a focus in Antarctic meteorology and forecasting and related disciplines is welcome to join the sessions to share and discuss their results. Along with WAMC goes the sixth meeting of the Year of Polar Prediction in the Southern Hemisphere (YOPP-SH) community on 24 and 25 June 2021. Focus will be to discuss plans and contributions to the Antarctic Targeted Observing Periods (TOPs) scheduled for Antarctic winter 2022.

The virtual 16th WAMC and the 6th YOPP-SH meeting are organized by the Byrd Polar and Climate Research Center at The Ohio State University, Columbus, Ohio, USA. **WAMC** takes place from the 21 to 23 June 2021. It brings together those interested in Antarctic research and operations/logistics to share their latest results and discuss future concepts to better understand atmospheric, oceanic and sea-ice processes relevant to enable numerical weather, climate and sea-ice predictions. Contributions to the workshop in the field of Antarctic meteorology and forecasting and related disciplines are welcome to be submitted (see information below).

As in previous years, the **YOPP-SH meeting** is aligned with WAMC, this year taking place on 24 and 25 June, in a virtual world. Over the past year, the YOPP-SH community has met online on a regular basis to discuss interest and potential contributions to the Antarctic Special Observing Period that is scheduled during mid-April and mid-July 2022. During the sixth YOPP-SH meeting, national commitments will be coordinated amongst the different action teams that look at various Antarctic regions to develop the Targeted Observing Periods (TOPs) that explore the predictability of impactful atmospheric phenomena such major oceanic cyclones and Atmospheric Rivers. In addition, results from the summer Special Observing Period (SOP) in 2018-2019 will be presented to guide the planning and execution of the Antarctic winter TOPs.

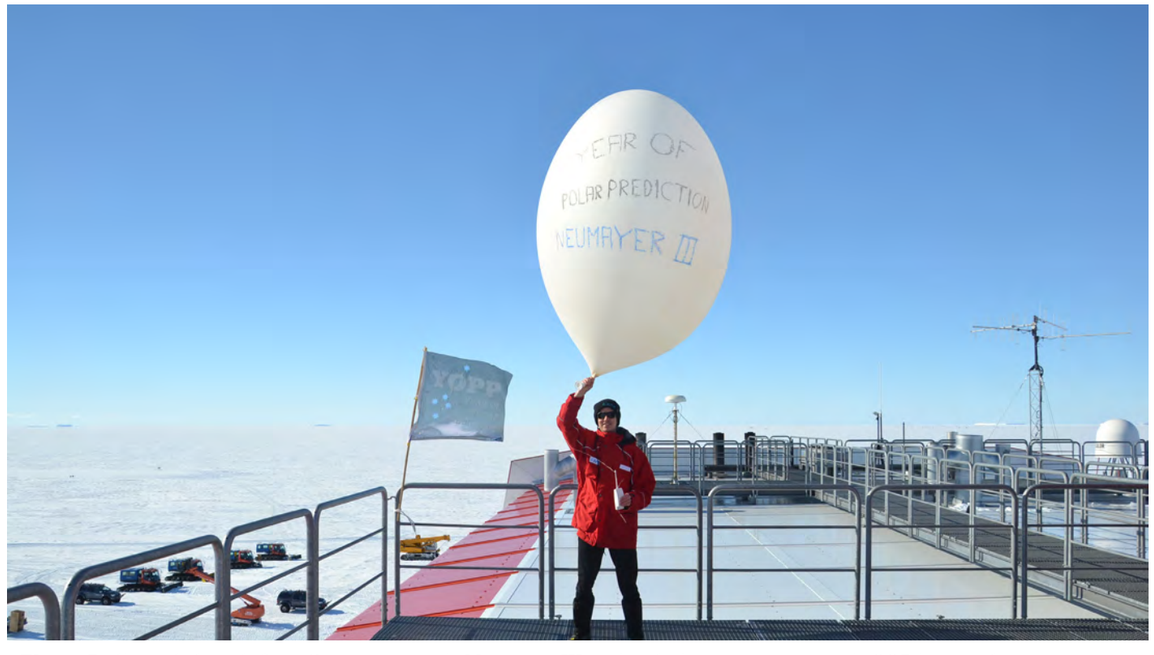


Photo: Radiosonde launch from German Antarctic Neumayer III station during summer Antarctic SOP in austral summer season 2018/2019 (photo: Mikko Sipilä/University of Helsinki, Finland).

15

Introducing the YOPP Task Teams – The YOPP Southern Hemisphere Task Team (YOPP-SH)

Interview: Daniel Butkaitis, WMO WWRP International Cordination Office for Polar Prediction, Alfred Wegener Institute

The YOPP Southern Hemisphere Task Team (YOPP-SH) is responsible for the planning and execution of research activities within YOPP in the Southern Ocean. In an interview with YOPP-SH Task Team lead Prof. David Bromwich, he told us about the typical workflow within the group, plans for an upcoming winter Special Observing Period in Antarctica, and about the future of the YOPP-SH task team.

Photo: private

David Bromwich is an expert in polar meteorology and climatology and senior research scientist at the Byrd Polar and Climate Research Center in Columbus Ohio, USA. Early in the duration of PPP, he joined the PPP Steering Group and participated in the planning of the first YOPP Special Observing Periods in the Southern Hemisphere. Since 2015, he leads the YOPP-SH Task Team as a driving force for the planning and coordination of YOPP activities in the South. We talked to David about his work within the YOPP-SH Task Team.

How many people are involved in the YOPP-SH Task Team?

We have something like 70 names on the email distribution list. For our regular online meetings (see below), we have 25-30 participants.

How often do you meet? How does a typical meeting look like?

Every 1-2 months online. We have two sessions per day to accommodate all the different time zones.
We have a yearly scientific/planning meeting, the latest one was 24–25 June 2021, entirely online: *https://byrd.osu.edu/events/yopp-sh*.

Are you working together with other Task Teams? How good are you interconnected?

We have representatives from other Task Teams that provide the close connections.

Which YOPP-endorsed projects are closely connected to the YOPP-SH Task Team?

We have representatives from various YOPP-endorsed projects. For example, Vito Vitale is an active participant and he links us with several Italian projects like IAMCO-YOPP. SIPN-South under François Massonnet is a very active participant in our Task Team.

Where is your special focus in the Task Team now?

We are planning the upcoming winter Special Observing Period in mid-April to mid-July 2022. This effort will be centered on ~4 Targeted Observing Periods in 2-3 regions around Antarctica. We had to delay one year because of the pandemic. Our winter Special Observing Period was originally planned for mid-April to mid-July 2021. It was delayed until 2022 because of COVID-19 restrictions on Antarctic field work.

You mentioned already the SOP scheduled for the Antarctic Winter 2022. Can you tell us more about the exact plans? Why is this SOP needed?

The Targeted Observing Periods will be separately scheduled for 2-3 broad regions around Antarctica. The focus will be on major oceanic cyclones affecting the coast and atmospheric rivers. The TOPs will be ~ 5 days in duration each and there will likely be 4 of them per region. This SOP investigates the atmospheric predictability during the colder part of the year when the sea ice cover is rapidly expanding. The prior SOP considered the predictability during the austral summer. We also upload the minutes from all online sessions on our website: *http://polarmet.*

YOPP in the Southern Hemisphere meeting in 2016 at the Byrd Polar and Climate Research Center, in Columbus, OH, USA (photo: Wesley Haines, BPCRC).

osu.edu/YOPP-SH/

YOPP is going to be concluded by next year. Is the work for you and your team also done then, or is there any follow-up activity planned already?

The winter SOP will occur near the end of PPP-YOPP. The analysis and publication of the research will continue beyond 2022. YOPP-SH is scheduled to end December 2024.

What would you describe as the biggest success story within your Task Team?

The active participation by many Antarctic nations resulted in a very successful summer Special Observing Period, as summarized in our publication in the Bulletin of the American Meteorological Society: https://journals.ametsoc.org/view/journals/bams/101/10/bamsD190255.xml.

What would you describe as the biggest challenge within your Task Team?

We try hard to ensure participants from around the world and across many time zones are given equal consideration and equal opportunity to contribute.

16

PPP-SERA Online Annual Meeting 2021

by Daniela Liggett, University of Canterbury, Christchurch, New Zealand

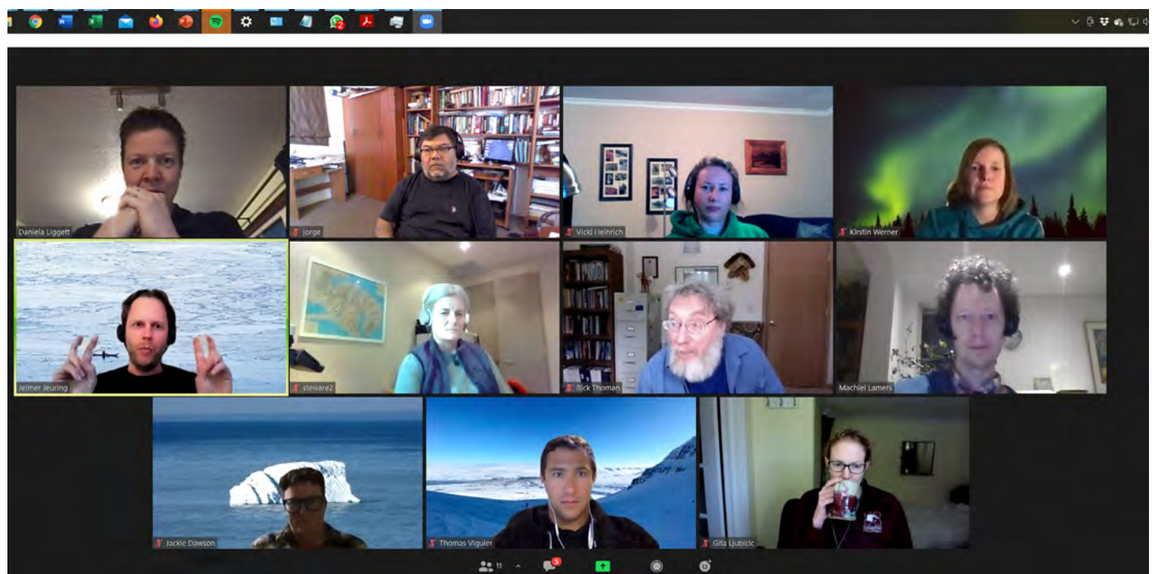
In a series of Zoom sessions from 12–16 April 2021, the Societal and Economic Research and Applications group of PPP (PPP-SERA) met to discuss their work over the last one-and-a-half years and plan for the year ahead, leading up to the YOPP Final Summit in May 2022.

While it was a juggling act to bring together a team of people from eight different time zones, the PPP-SERA team was able to progress their understanding and agreement on a range of topics, including PPP-SERA contributions to the YOPP Final Summit, to the YOPP Legacy and Evaluation efforts, and the third Polar Prediction School.

The task team also agreed on pursuing two joint publications. The first is a synthesis paper with the goal of summarizing and evaluating the key outcomes PPP-SERA achieved, with a particular focus of the team's interactive Open Sessions that engaged a range of PPP stakeholders in tourism, research, fishing or government operations in the polar regions. The second publication is a high-level commentary paper exploring the impact of improved polar prediction and WWIC services on operational risk. Considerable time was spent at the meeting to discuss the foci of these publications, and PPP-SERA team members are presently working on developing these publications further.

Similarly, the team had in-depth discussions about how best to contribute to the YOPP Final Summit, which the team views as an ideal conduit to showcase the diversity and impact of PPP and YOPP efforts over the last eight years. PPP-SERA strongly endorse an integrated approach to some of the sessions that bring together user and producer perspectives in the form of paired presentations, which serve as capacity-building exercises in their own right and are woven throughout the entire Final Summit.

PPP-SERA co-chairs Machiel Lamers and Daniela Liggett took turns chairing the four days of engaged and vibrant discussions, which all PPP-SERA members contributed to.



Shown in the screenshot are the meeting participants, in order from left to right: (upper row) Daniela Liggett, Jorge Carrasco, Vicki Heinrich, Kirstin Werner, (mid row) Jelmer Jeuring, Emma Stewart, Rick Thoman, Machiel Lamers, (lower row) Jackie Dawson, Thomas Viguer, Gita Ljubicic (absent Yulia Zaika) (photo: Emma Stewart).

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Virtually Connected – The 2021 Online Arctic Science Summit Week

by Clare Eayrs, New York University, Adu Dhabi, Mayleen Schlund and Kirstin Werner, WMO WWRP International Cordination Office for Polar Prediction, Alfred Wegener Institute

This year's Arctic Science Summit Week (ASSW) 2021 was organized by Portugal. While it was initially planned for everyone to convene in Lisbon, the meeting was eventually held online from 19 to 26 March 2021. The virtual conference gathered international Arctic researchers to discuss interdisciplinary topics framed by the overarching theme "The Arctic: Regional Changes, Global Impacts". The virtual meeting included both science and business meetings, as well as a cultural day and a science symposium. A joint APECS-YOPP-YESS workshop took place during the weekend part of the conference.

The conference kicked off at the weekend with a series of business and community meetings. During the week, scientists presented their recent results from various initiatives and projects. The conference offered high-level discussions on how to transfer Arctic and Antarctic knowledge into operations and development. Despite the online nature of the conference, the organizers managed to bring some of Lisbon's rich cultural heritage to the attendees through a series of videos and recordings.
As part of the business meetings, the International Coordination Office for Polar Prediction and the YOPP Education Task Team led by Dr Clare Eayrs collaborated with the Association for Polar Early Career Scientists (APECS) and with the Young Earth System Science (YESS) network to host a workshop for Early Career Researchers on "Polar Prediction and Collaboration in the Arctic". The workshop comprised three sessions from which recordings are now available at the Polar Prediction YouTube channel.

In the session, **"Home Office (Fatigue) and Zoom Networking – COVID-19 and ECRs"**, a lively discussion followed five brief presentations on recent national and international surveys. These discussions highlighted the experiences of researchers, and especially early career researchers, during the pandemic and described the variety of ways in which scientific work and researcher's lives have been impacted.

The broad scope of the five presentations in the session entitled **"The 4 Essential Cs - Coordination, Communication, Community, and Collaboration"**, examined the various ways in which these '4 Cs' are crucial to polar research. From finding ways to use your data to translate it into an engaging story for the public, through coordinating and fostering international, interdisciplinary, and even transdisciplinary cooperation and collaboration, this session highlighted the importance of Arctic research and the need to engage and motivate all aspects of the community.

In the session, **"Predict and Predictability - The Arctic YOPP"**, researchers associated with the Year of Polar Prediction and working within a number of YOPP-endorsed projects introduced their research activities aiming to improve predictive skill for the Arctic; also modelling datasets were introduced. This session provided a good overview about opportunities for ECRs to engage with the YOPP/PPP community including a number of upcoming education activities.

Part of the science part of ASSW 2021 was the session **"Arctic climate change and its Impacts on Weather and Climate in the Midlatitudes"**. Here, the YOPP-endorsed project APPLICATE highlighted their contribution to better understand Arctic atmospheric and sea ice processes to enable the development of of improved prediction services.

The next Arctic Science Summit Week 2022 is planned to be held in Tromsø, Norway from 26 to 31 March 2022.

Follow the link below for more information about this year's ASSW:
https://assw2021.pt

18

Big in Japan but Virtual – Third Arctic Science Ministerial Meeting

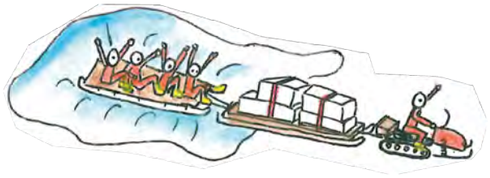
by Mayleen Schlund and Kirstin Werner, WMO WWRP International Cordination Office for Polar Prediction, Alfred Wegener Institute

From 08–09 May 2021, the Arctic Science Ministerial Meeting 2021, co-hosted by Japan, Iceland and the European Polar Board, took place. Since fall 2020, the European Polar Board had organized a webinar series to call for input from the Arctic research community, stakeholders and Indigenous people and engage with Arctic science and proposed operations.

With the aim of increasing cooperation in Arctic science, two earlier Arctic Science Ministerial meetings, one in 2016 in Washington D.C. and the other in 2018 in Berlin, Germany, had already been held. The Third Arctic Science Ministerial was scheduled for 08–09 May 2021 in Tokyo, to be co-hosted by Iceland and Japan. The meeting aimed to use the well-established foundation of the Ministerial as a means to take action on coordinated Arctic observation and research in an open and transparent format which included all Arctic stakeholders.

During the first and second ASM meetings, the Year of Polar Prediction (YOPP) and the international Multidisciplinary Drifting Observatory for the Study of Arctic Climate (MOSAiC) were prominent examples of voluntary international cooperation focused on increasing predictive capabilities for weather and climate in the Arctic and beyond.

The goal of this year's Arctic Ministerial meeting was to foster observations (networking and data sharing), process understanding (local and global impact), response (sustainable development), and strengthening (capacity building, education, resilience) of collaborations in Arctic research. The meeting also aimed at ensuring education opportunities and building sustainable capacity for future generations.



Due to the ongoing pandemic, the meetings were fully set to take place online. While previous ASM meetings had aligned a science day for the research community to come together for discussions, this year's meeting consisted only of the Ministerial. However, the research community had been able to contribute to discussions since fall 2020 during a webinar series organized by the European Polar Board. The latest webinar on 15 April discussed "Theme 3, Respond: Sustainable development; Evaluation of vulnerability and resilience; Application of knowledge". It presented a series of projects aiming to increase Arctic sustainability and resilience and protect the local communities, culture and environment. Input to feed into ASM3 discussions was also collected through two conferences last year, ISAR 6 (March 2020), and ASSW 2020 (March/April 2020).

More information about this year's ASM Meeting and the recordings from the European Polar Board webinar series are available here.

NEW PUBLICATIONS
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Relative Impact of Observations on Arctic Weather Forecasts

In a new study, Randriamampianina et al. investigate the relative impact of different observation types on weather forecasting in the Arctic during the YOPP Special Observing Periods.

The rapidly changing Arctic has opened up opportunities for more ship traffic and tourism; however, these require more accurate Arctic weather reports. While there is good satellite observation coverage in the Arctic, the temporal and spatial resolution of conventional observations is sparse. To better understand and improve the numerical weather forecasting capability in the Arctic, it is necessary to know the relative impact of the already-existing observations on forecasting skill.

Randriamampianina et al.'s study was carried out in the first and second Arctic Special Observing Periods during the Year of Polar Prediction (February–March 2018 and July–September 2018). Results from the observing-system experiments (OSE) carried out by the European Centre for Medium-Range Weather Forecasts (ECMWF) were used as lateral boundary conditions (LBC) to evaluate the impact of Arctic conventional and satellite observations on regional short-range weather forecasts. These experiments involved removing these observations when setting up the initial conditions for the forecasts. MET Norway's AROME-Arctic regional mesoscale numerical weather prediction system was used to conduct parallel regional OSEs. A careful combination of the observation removal in global and regional OSEs allows their relative impacts on forecast skill to be evaluated through regional data assimilation (DA) and the LBCs. It also allows evaluation of their total impact of observations on the regional forecasts.

As far as total impact is concerned, the observations that get assimilated into the global model that issues the LBCs can dominate upper-air forecasts for up to 48 hours; for the winter period, regional DA can dominate surface fields for up to 36 hours. Because of their total impact on forecast skill, conventional observations and infrared radiances have the largest impact on all upper-air parameters except humidity; here, microwave radiances have the largest impact. In terms of observation impact through regional DA, conventional observations are most important for upper-air temperature and geopotential; here too, microwave radiances have the largest impact on upper-air humidity. Atmospheric motion vectors and Infrared Atmospheric Sounding Interferometer (IASI) have a large effect on wind forecasts. In addition, regional DA of conventional observations is also the most helpful at improving surface fields. *(ph)*

Randriamampianina, R., Bormann, N., Køltzow, M. A. Ø., Lawrence, H., Sandu, I., & Wang, Z.Q. (2021). Relative impact of observations on a regional Arctic numerical weather prediction system. Q J R Meteorol Soc., 1– 21. https://doi.org/10.1002/qj.4018

20

Evaluation of Sea-Ice Thickness in the Weddell Sea

In a new study, Qian Shi et al. look into contemporary monthly sea-ice thickness in the Weddell Sea intercomparing four ocean-sea-ice coupled models with observations.

Sea-ice thickness is a significant parameter for the ocean-ice system as it determines the storage of heat and fresh water. In addition, the Weddell Sea is of central significance for sea-ice production and perennial sea-ice formation and is a source of Antarctic Bottom waters with a fundamental role in the global circulation system.

This study focuses sea-ice thickness performance across four reanalyses system models: the German contribution, of the project Estimating the Circulation and Climate of the Ocean Version 2 (GECCO2); the Southern Ocean State Estimate (SOSE); the Ensemble Kalman Filter system based on the Nucleus for European Modelling of the Ocean (NEMO-EnKF); and the Global Ice-Ocean Modeling and Assimilation System (GIOMAS).

Each models is compared with satellite and in-situ observations using the correlation coefficients and the root mean square errors. Each reanalysis underestimated ice thickness near the western Weddell Sea when compared to satellite data, while in other parts of the Weddell Sea, the models exhibited maximum performance. *(np)*

Shi, Q., Yang, Q., Mu, L., Wang, J., Massonnet, F., & Mazloff, M. R. (2021). Evaluation of sea-ice thickness from four reanalyses in the Antarctic Weddell Sea. The Cryosphere, 15(1), 31–47. ***https://doi.org/10.5194/tc-15-31-2021***

21

The Regional Ice Ocean Prediction System V2: A Pan-Canadian Ocean Analysis System

In this study, Greg Smith et al. are presenting the first pan-Canadian operational regional ocean analysis system. It is part of the second version of the Regional Ice Ocean Prediction System (RIOPSv2), developed by the Canadian Centre for Meteorological and Environmental Prediction (CCMEP).

The model incorporates both satellite observations of sea-level anomalies (SLA) and sea-surface temperatures (SST) as well as in-situ temperature and salinity measurements. A spatial filtering of model fields is part of the observation operator for SSTs; for the SLA, the inverse barometer effect has been removed.

The paper compares RIOPSv2 with GIOPS, the Global Ice Ocean Prediction System, which has also been implemented by the CCMEP and provides Canada's first operational global ocean assimilative capacity with sub-seasonal predictions. It also discusses the modifications, improvements and innovations incorporated into RIOPSv2. Compared to GIOPS, RIOPSv2 shows improved representation of mesoscale features, such as eddy fields and a higher grid and more effective resolution. Furthermore, RIOPSv2 has a higher-resolution background error mode and includes tidal movements; a tidal harmonic analysis is part of the observation operator. The two systems overall exhibit similar innovation statistics with regional variations.

Important applications for the model include sea-ice predictions and emergency response along the Canadian coastline. *(np)*

Smith, G. C., Liu, Y., Benkiran, M., Chikhar, K., Surcel Colan, D., Gauthier, A.-A., Testut, C.-E., Dupont, F., Lei, J., Roy, F., Lemieux, J.-F., & Davidson, F. (2021). The Regional Ice Ocean Prediction System v2: a pan-Canadian ocean analysis system using an online tidal harmonic analysis. Geoscientific Model Development, 14(3), 1445–1467. ***https://doi.org/10.5194/gmd-14-1445-2021***

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"It's Really the Whole Package" YOPP-endorsed! – The APPLICATE Project

Interview and Text: Mayleen Schlund, Sara Pasqualetto and Kirstin Werner, WWRP International Coordination Office for Polar Prediction, Alfred Wegener Institute

For the past four and a half years, Thomas Jung and Luisa Cristini, of Germany's Alfred Wegener Institute, have been coordinating the YOPP-endorsed European project APPLICATE. APPLICATE stands for "*A*dvanced *P*rediction in *P*olar regions and beyond: modelling, observing system design and *L*inkages associated with a *C*hanging *A*rctic clima*TE*". The project includes a multinational and multidisciplinary team of 15 partner institutions in eight European countries, with the aim of enhancing weather and climate prediction capabilities in the Arctic and beyond and of bringing together the expertise of different research partners, e.g. universities, meteorological and oceanological institutes or research centres. APPLICATE wrapped up in April 2021. We spoke with Luisa and Thomas about the project's achievements and success stories.

What is the APPLICATE project about?

Thomas Jung (TJ): The APPLICATE project is about developing improved predictive capacity for polar regions on timescales from days out to the end of the twenty-first century. It is about being able to better predict environmental sea-ice conditions in polar regions. The main focus lies on how climate change in the polar regions affects the mid-latitudes where we live. When we started the project, there were major knowledge gaps that we wanted to close.

Luisa Cristini (LC): An additional objective of APPLICATE is knowledge transfer; that means translating project outcomes into useful information that can inform not e.g. policy makers and private businesses as well as educate the public.

Where did the funding come from? Who is on the team?

TJ: The project has 15 European partners and two additional partners from Russia. The team members include universities such as Stockholm University and the Catholic University of Louvain and operational centres such as the Norwegian Meteorological Institute, the Met Office, Météo France and ECMWF. In addition, research institutes such as the AWI contribute to the success of APPLICATE. The European Commission funded the project under the Horizon 2020 programme.

What are the most interesting results of APPLICATE? And how does APPLICATE contribute to improving the polar prediction system?

TJ: Basically, all APPLICATE work packages contributed to the goals of the Polar Prediction Project. For example, we provided a dedicated modelling dataset, that is, a YOPP forecast-and-analysis dataset including process tendency. APPLICATE made quite some progress toward understanding the impact of observations on predictions in the Arctic and beyond. Critical, it turns out, are investments in the uptake of observations into the forecast system, both in terms of getting more skillful predictions as well as for scientists carrying out prediction-relevant research.

Additionally, by developing the Polar Amplification Model Intercomparison Project (PAMIP) protocol, we contributed to understanding model linkages to the mid-latitudes. The results will help to close the gulf between observational (strong link, but causality may be mistaken) and modelling studies (weak link).

LC: Also, regarding the coordination with other projects and general community building, the APPLICATE and YOPP teams learned from each other. For example, we collaborated on a joint publication looking at the challenges and opportunities of project and community management in polar sciences; it received really good feedback from the community. And this is definitely something that will remain: beyond being able to say we have have run a successful project, we have contributed to improving management practices. YOPP has also helped the polar community to become aware of the APPLICATE project and to amplify our results.

What are the next big questions to be answered regarding Arctic-midlatitude linkages?

TJ: We still don't understand why the impact of Arctic sea-ice decline is relatively low in models versus what observations indicate. The link could be large, but the causality in the observations might be mistaken. In the end, it may very well turn out that the strong Arctic sea-ice decline has relatively little impact on the behaviour of the jet stream in mid-latitudes.

There is also merit in further studying linkages from a prediction perspective: to better understand the impact of improved weather and climate forecasts in the Arctic on mid-latitud forecasts and vice versa is also certainly an area that still needs further exploration.

What were the main challenges in collaborating with many different centres across Europe?

TJ: I would really summarize our collaboration as being great fun. Especially in terms of coordination and management, the work package leaders happened to worked super-fast and delivered results before we even asked. It was an advantage that the project was very clearly structured and had well-defined goals. It helped that people understood what the project was about. But of course, there were also challenges; we were set back by delays in delivering certain data sets, for example those related to CMIP6.

LC: I agree that collaboration across Europe, and in particular with so many different people from so many institutions and countries, is both fun and challenging. On one hand, it is exciting because you get to work with different people, and diversity is what makes science more useful as you generate more ideas mutually. But on the other hand, the more partners you have, the more challenging it is to bring all these people together while you try to take all their needs into account – people at different career stages, students (of course), not to mention

From left to right: APPLICATE Finance Manager Nancy Lange, PI of APPLICATE project Thomas Jung, and APPLICATE project manager Luisa Cristini during the APPLICATE General Assembly 2018 in Barcelona (photo: APPLICATE cornsortium).

the senior scientists on the Executive Board.

What were the most exciting parts in the project for you personally? Is there something you are particularly proud of (e.g., in terms of project management)?

TJ: It is the whole package I was most happy with. If pressed to single out one activity, I would mention our work on Arctic–mid-latitude linkages. There, we went well beyond what our proposal originally promised: We moved from a small set of coordinated simulations to a full CMIP6-endorsed protocol (PAMIP).

Furthermore, I am really excited about the work, led by Irina Sandu and François Massonnet, on recommendations for developing the Arctic observing system.

Managing EU projects is actually quite challenging. However, the feedback we've received from our project officer at the European Commission and the two external reviewers for the third and final review by was very positive; they were happy with the way we did things, and it was a great moment.

LC: I agree with Thomas in that it's really the whole package. For me, it is always important to learn new things and to go beyond my personal comfort zone, and in the project there were many occasions for learning – for example, how to design and develop impactful knowledge transfer activities and how to address the bigger question of a project's impact. The team and the general cooperation performed very well, and after so many years of APPLICATE, the social side played an important part, too. The team grew together and bonded beyond the professional level. Personally, I got to know some fantastic people with whom I want to keep in touch. It was a lot like working with friends, and this should be counted as a success story, too.

Have you achieved all goals during the project's duration?

TJ: APPLICATE did not necessarily achieve all goals. During the course of the project, some things had to be adjusted; new topics were picked up, and certain activities received more attention than originally planned. Together with the European Commission and our reviewers, we decided to increase our contribution in order to stay flexible in terms of implementations, becoming more dynamic overall.

Where can the YOPP community access the data and also get more information about APPLICATE?

TJ: I can highly recommend visiting our website *applicate-h2020.eu*.

How did the COVID-19 pandemic affect the workflow and the project management?

LC: Even before COVID-19, the various work packages were coordinated online, so that didn't change much. What we had to move online were all the coordinating-team meetings. In some ways, the project members got to communicate even more and met more regularly with the subgroups. So, I think we adapted the management to the situation.

TJ: The project was in some ways more fortunate than other EU projects, because by the time the pandemic started, we had already sufficiently matured and were in our last year; many simulations were already complete or were just finishing. We were also lucky in that we were able to meet in person for our last annual assembly in January 2020, shortly before the first shutdown. We communicated very well online. And finally, a lot could be accomplished remotely because it was a modelling project.

Will there be a follow-up project to pick up where APPLICATE left off?

TJ: APPLICATE is around 80 percent YOPP, and it greatly contributed to the goals of PPP. At the moment, there are ideas and discussions on its legacy. Part of it is, What comes after the Polar Prediction Project? There seems to be an appetite for a bit of an extension of research projects like APPLICATE. And in principle, there are good reasons to do it.

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Upcoming (mostly Online) Meetings

03-10 September 2021
2021 Annual Meeting of the European Meteorological Society
Online

06-10 September 2021
SIOS Training course on Hyperspectral Remote Sensing
Online

20-24 September 2021
Polar Data Forum IV
Online

27-29 September 2021
26th International Symposium on POlar Sciences: Respoding to Climate Cristis: Contributions of POlar Science and Technology
Incheon, South Korea (with option to move online)

05-07 October 2021
Arctic CCS: Community and Citizen Science in the Far North
Online

10-14 October 2021
28th International Polar Conference
Potsdam, Germany

18-22 October 2021
International MOSAiC Science Conference/ Workshop 2021
Potsdam, Germany

14–17 October 2021
Arctic Circle Assembly
Reykjavik, Iceland

03–05 November 2021
ACUNS Student Conference on Northern Studies: Adaptation, Resilience and Change in the North
Online

08 November 2021
Linking multidisciplinary observations from Svalbard with the MOSAiC campaign
Online

18–20 November 2021
38th International Polar Symposium "Environmental Changes in Polar Regions: New Problems –New Solutions"
Torún, Poland

18–19 November 2021
2021 SCAR SC-HASS Biennial Conference – The Global Antarctic
Kobe, Japan & Online

06–10 December 2021
ArcticNet Annual Scientific Meeting
Online

13–17 December 2021
AGU Fall Meeting
New Orleans, USA & Online

YOPP FINAL SUMMIT 2022

01–04 May 2022
The Centre Mont-Royal
Montreal, Quebec, Canada

More information at
https://yoppfinalsummit.com/

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FINAL SUMMIT
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2022

YOPP YEAR OF POLAR PREDICTION

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