YEAR OF POLAR PREDICTION

International Coordination Office (ICO) for Polar Prediction

WORLD METEOROLOGICAL ORGANIZATION

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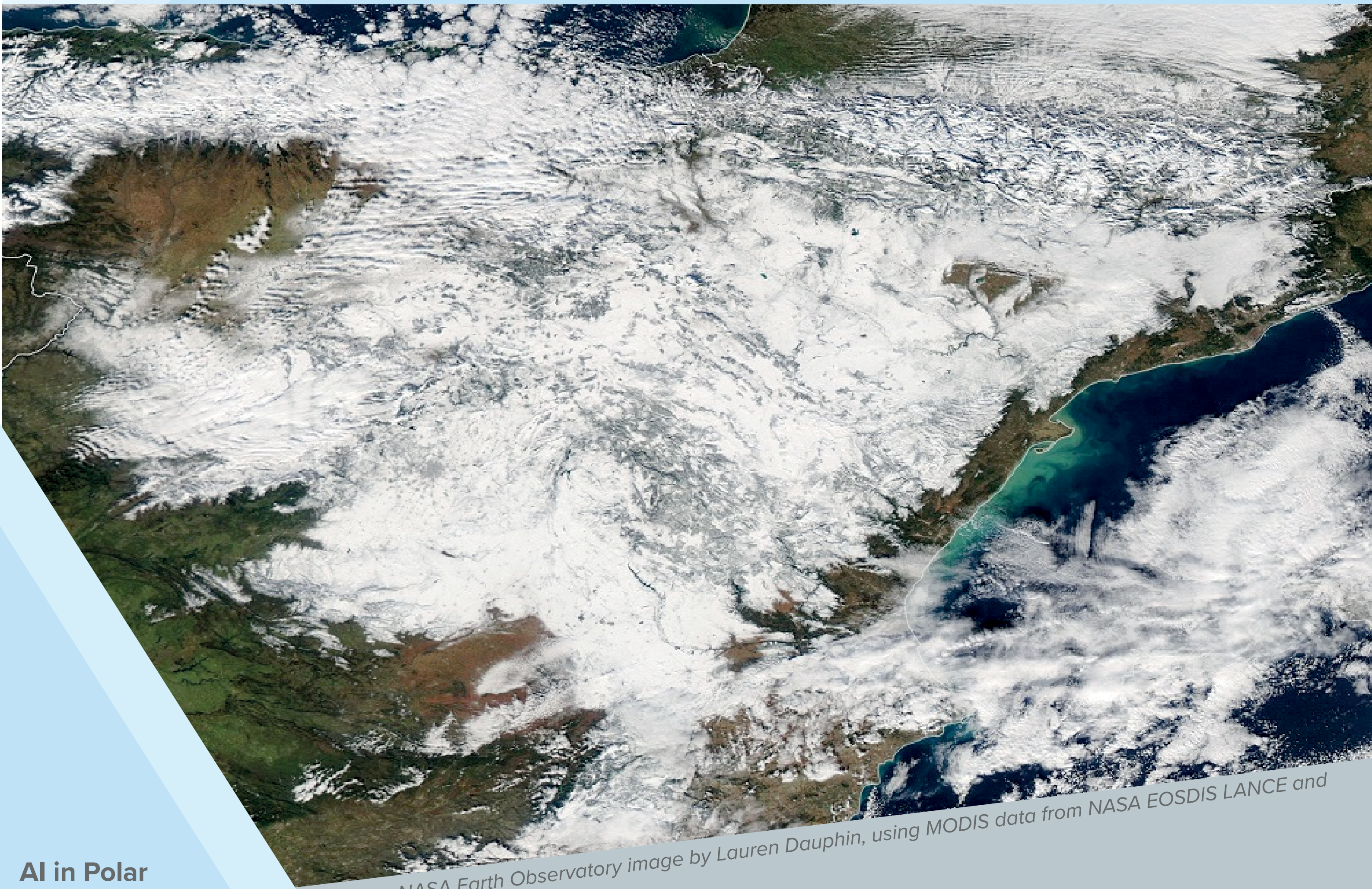
#17

PolarPredictNews

February/March 2021



(photo: NASA Earth Observatory image by Lauren Dauphin, using MODIS data from NASA EOSDIS LANCE and GIBS/Worldview.)

The first two weeks of this year saw the storm Filomena bringing severe winter weather to Spain. Vast amounts of snow blanketed much of the country. The State Meteorological Agency (AEMET) declared this snowfall "exceptional and most likely historic". It was the most significant Spain has seen since 1971. In León, in northern Spain, temperatures fell to −35.8 °C, a record low for the country. Filomena occurred during a negative phase of the North Atlantic Oscillation (NAO) pattern. During an NAO negative phase, the polar low-pressure system (polar vortex) is weaker, letting cold Arctic air push down into the mid-latitudes and influencing large-scale weather patterns there. In this new issue of PolarPredictNews, we elucidate the mechanisms of the polar vortex and its influence on mid-latitude weather.

YOPP YEAR OF POLAR PREDICTION

International Coordination Office (ICO) for Polar Prediction

Find more information at www.polarprediction.net

Content

The Year of Polar Prediction (YOPP) is a major international activity 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, verfication, user-engagement, and education activities which involves various stakeholders, YOPP contributes to the knowledge base needed to manage the opportunities and risks that come with polar climate change.

Dear Colleagues,

We are happy to present to you the 17th issue of PolarPredictNews. In this latest issue, Matthew Shupe, co-coordinator of MOSAIC, who has always played a key role in shaping the YOPP-MOSAiC partnership, talks about the efforts it took to bring MOSAiC into life. What are next steps of MOSAiC and YOPP? In this context, PPP Steering Group member Gunilla Svensson on behalf of the YOPP Processes Task Team has provided an overview how the data generated through the MOSAiC expedition as one of the major supersites for YOPP will be taken up by the PPP task teams to make them available for the PPP Community. I am sure that the YOPPSiteMIP efforts (see also Jonny Day and colleagues, p. 14) and the development of the Merged Observatory Data Files are main PPP/YOPP success stories that contribute to the legacy of the Polar Prediction Project.

In this issue, you will also find an in-depth review about the consequences that a weakened polar vortex might have onto large-scale patterns of our weather in the mid-latitudes of Europe and North America. This is a particularly timely topic given the strong meandering of the jet stream and associated extreme weather events during this winter.

Furthermore, I would like to highlight the scientifc artwork by Thomas Rackow that is featured in this PolarPredictNews issue. I discussed with Thomas about a year ago the warming stripes by Ed Hawkins and we came up with the idea to turn these into sea-ice melting stripes. The outcome of this discussion is presented in this newsletter – a straighforward and very accessible way to display the observed sea-ice melting or lack thereof in Arctic and Antarctic regions, respectively, over the last view decades.

Happy reading,
Thomas Jung

photo: Martina Buchholz/ Alfred Wegener Institute

FEATURED IN THIS ISSUE:

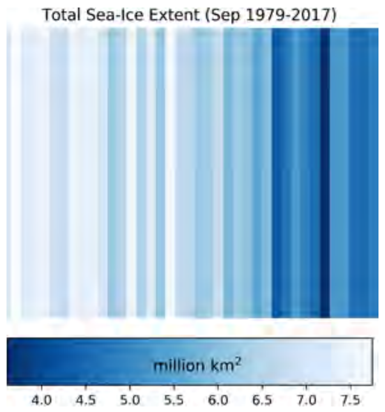
The Melting Sea-Ice Stripes by Thomas Rackow

by Thomas Rackow, Alfred Wegener Institute (@thomas_rackow)

Thomas Rackow is a postdoctoral scientist at the Alfred Wegener Institute. But he also has a creative side: a children's story he illustrated is nearing publication. Inspired by Ed Hawkins' warming stripes, he recently applied the concept of using stripes in graphics to the cryosphere: melting sea-ice stripes, representing the September sea-ice extent in different regions of the Arctic and Antarctic from 1979–2017.

Photo: Sam Cornish, University of Oxford, UK.

"Warming stripes", a style of graphic conceived by climate scientist Ed Hawkins at the University of Reading (@ed_hawkins), emerged in May 2018 and went viral. Right away, I liked the simple aesthetic without any scientific legends or labels. It is an intuitive way to communicate climate change to the public. Stripes for various regions and countries are available at the website *showyourstripes.info*. The original stripes have been built upon since then, for example to include projections from coupled climate models based on potential future greenhouse gas emissions pathways. Arguably, it can be difficult to compare the rate of change among different regions using stripes without colour bars, since the ranges and the minimum and maximum values might not be the same for each location. So, besides providing geographic context, this issue of our newsletter also includes a map with an overview of all colour bars applied to the various "melting stripe" design elements. But wait a second: "melting stripes"?



September total Arctic sea-ice extent from 1979 to 2017 (source: Thomas Rackow).

I think the idea of using stripes to represent sea-ice melt originally came from our YOPP captain, Thomas Jung. He wondered whether one could translate the warming stripes into "melting" stripes – shaded from white to blue – for Arctic and Antarctic sea ice. So I generated an initial set of Arctic summer sea-ice stripes representing September values and *tweeted them in April 2019*. I chose the standard "Blues_r" Python colormap, which intuitively changes from very light shades (ice) to deep blue (ocean) over time in the Arctic. Applying only shades of blue is also friendly towards colour vision deficiency. Melting stripes for the Antarctic *followed in July 2019*, where the multi-decadal trend looked close to neutral in contrast to the Arctic. It was great timing: Just two months later, I got to see the Arctic sea ice in September with my very own eyes, during Leg 1a of MOSAiC. We set up the Distributed Network around Polarstern, with the 20 young international scientists participating in the MOSAiC School. (I had the honour of giving the WMO/YOPP lecture on modelling.) The thickness of the ice we experienced on site in September and October of 2019 was exceptionally thin in comparison to what the data show for the last 26 years. I can still remember feeling apprehensive as we set down the first multi-ton blue container on the sea ice. We may have experienced a new normal for Arctic conditions (*Krumpen et al., 2020*) and I think the Arctic Ocean melting stripes clearly reflect this. The different behaviours of the (modelled) Arctic and Antarctic sea ice still fascinate me and figure into my latest research.

Find the sea-ice melting stripes throughout this newsletter with further explanations, and the corresponding polar regions and legend on pages 30/31.

01

The Polar Vortex and Its Influence on Mid-Latitude Winter Weather

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

These days, forecasts of extreme winter weather often generate headlines like *The Washington Post*'s recent "The polar vortex is splitting in two, which may lead to weeks of wild winter weather". Are winter weather stories about the polar vortex scientifically accurate?

Searching the news for longer-term forecasts for this boreal winter, one is sure to find mention of the "polar vortex". You might even say the term in recent years has become prominent, as many winter extremes are associated with this particular feature of the atmospheric circulation. For instance, the heavy snowfalls in Spain caused by storm Filomena in early January 2021 could be related to a polar vortex weakening, although the exact relationship is unclear. This uncertainty shows how easily the term can be overused, sometimes leading to misconceptions about what a polar vortex actually is and how it affects the weather (see *Waugh et al., 2017*). It's no surprise: The physical processes affecting the polar vortex are complex. To better understand the connections between the polar vortex and mid-latitude weather, we spoke with Thomas Jung and Doug Smith, both of whom became polar vortex experts while working at internationally renowned operational forecasting centres and have published numerous studies on the topic.

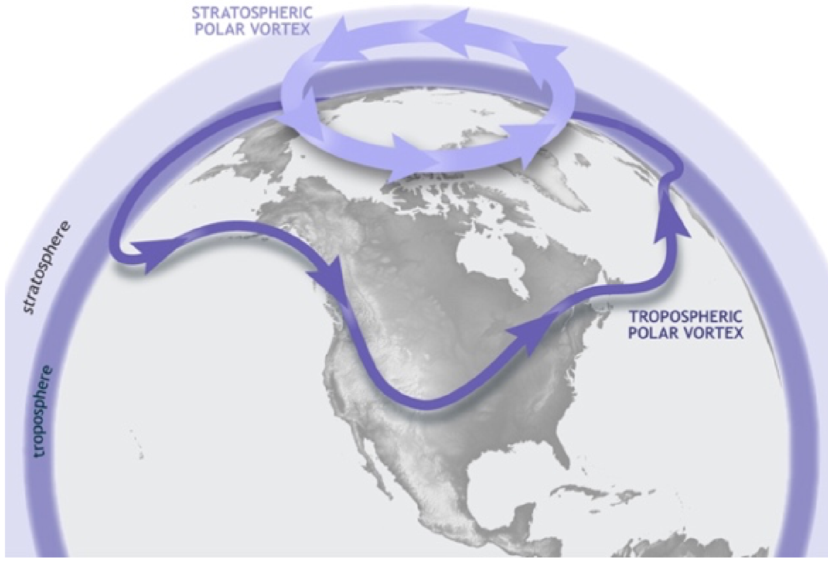


Illustration of the polar vortices in the northern hemisphere. Schematic is by NOAA Climate.gov and is adapted from Waugh et al., 2017, Figure 1.

What is a Polar Vortex?

The polar vortex, or frequently the "stratospheric polar vortex", is a large low-pressure zone of cold air that sits above the tropopause over the poles. The tropopause is the boundary between the troposphere (the bottom layer of the atmosphere) and the stratosphere. The stratospheric vortex can extend into the mesosphere, reaching altitudes of over fifty kilometres. The cold air masses over the poles are being encircled by a band of strong westerly winds, which is the acutal stratospheric polar vortex. These high-altitude winds are also called the "polar night jet" because the stratospheric polar vortex is strongest when no sunlight reaches the poles. This upper-level jet stream acts as a barrier to the cold air inside the vortex, isolating it from the surrounding atmosphere. Yet there is another polar vortex found at lower altitudes, in the troposphere, and it is associated with a different feature of atmospheric circulation: the polar jet stream. In the northern hemisphere, the polar jet stream often determines the routes of commercial flights seeking faster travel from the US to Europe.

These two distinct features of atmospheric circulation – the stratospheric and tropospheric polar vortices – are closely coupled. "*Changes in the tropospheric vortex have an impact on the stratospheric polar vortex. Each can actually cause the other to collapse*", says Thomas Jung, professor of physics of the climate system at the University of Bremen and steering group chair of the Polar Prediction Project. "*But the connections are more pronounced in the upward direction. The stratospheric vortex is more stable than the jet stream, which is characterized by large undulations. The stratospheric vortex would probably* *hardly vary at all if it weren't for anomalies in the tropospheric jet streams – so called Rossby waves – propagating into the stratosphere, where they break and lose velocity in the stratospheric polar vortex*", explains Jung. The stronger the Rossby waves, the more likely they are to cause a disruption of the stratospheric polar vortex. A disturbed stratospheric polar vortex is associated with a greater likelihood of various kinds of extreme weather in the mid-latitudes.

Sudden Stratospheric Warmings

Upward-propagating Rossby waves thus play an important role in disruptions of the polar vortex. Rossby waves are planetary-scale air waves resulting from the temperature gradient between the equator and the poles. Due to the Earth's rotation (Coriolis-force), the south-north balancing motion of Rossby waves also gets a west-east component. Large-scale weather patterns such as the El Niño Southern Oscillation (ENSO), can also influence the direction of these waves. Sometimes, upward-propagating Rossby waves run up against the stratospheric polar vortex, where they tend to break just like waves on a beach. They can disrupt the stratospheric vortex, shifting its centre or even splitting it into two or more separate vortices. The surrounding jet then shifts from a westerly to an easterly flow, causing the air masses inside the vortex to converge towards the centre, where they descend and become compressed. This compression leads to a sudden stratospheric warming event, with temperatures there increasing by up to 50 °C in a matter of days. The propagation of the resulting easterly flow down into the tropopause in turn affects the tropospheric polar vortex, causing more pronounced meanders in the jet stream.

In the southern hemisphere, the polar vortex is more stable. "*Since the beginning of observational data from the stratosphere, the southern-hemispheric vortex has broken down only twice, as opposed to something like once a year on average in the northern hemisphere*", says Jung. The greater stability of the Antarctic vortex is due to there being fewer land masses and thus less topography in the south, so Rossby waves there are relatively infrequent. "*If you had a planet entirely covered by oceans – as in so-called 'aquaplanet' models – I wouldn't expect many at all of these breakdowns in the stratospheric vortex*".

The teleconnection between the two vortices is described mathematically by the Arctic and Antarctic Oscillation (AO/AAO) Index, also called the Northern Annual Mode (NAM) and Southern Annual Mode (SAM), respectively. Positive index values indicate a robust stratospheric vortex and a stable polar jet stream, whereas negative values suggest a weaker stratospheric vortex and greater likelihoods of a stratospheric warming event. The modes typically show annual variation, but phase transitions can also occur within a few days.

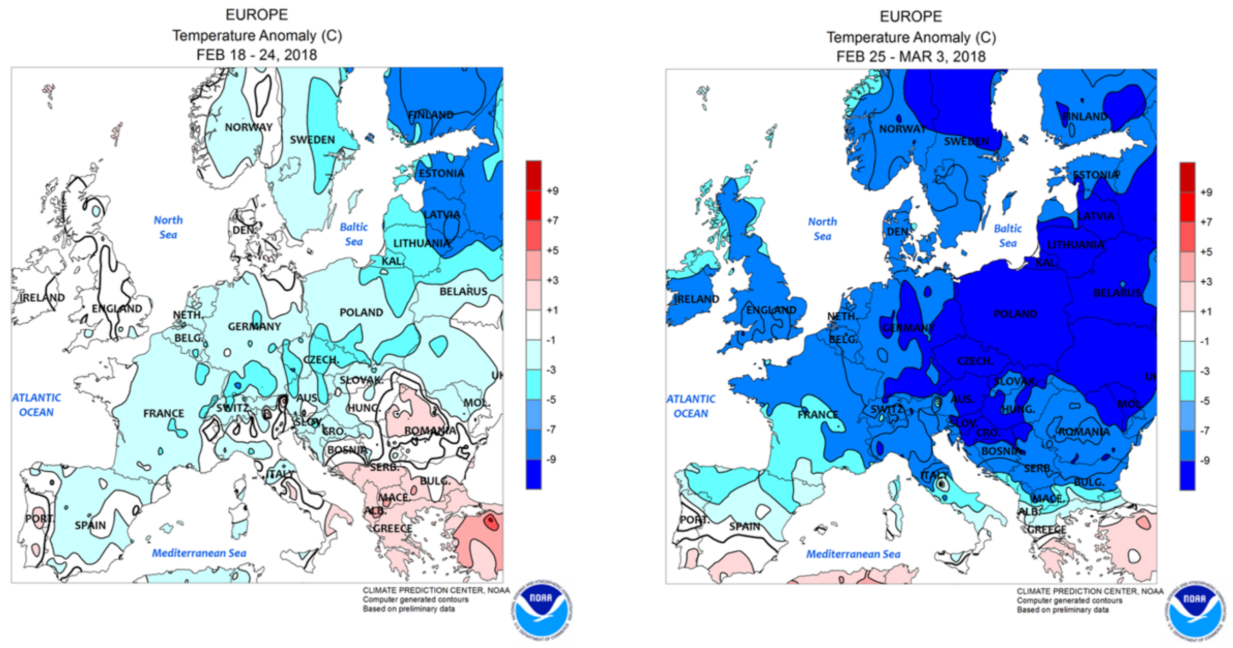
Extreme Weather Events in the Mid-Latitudes

But how do the polar vortices affect weather in the mid-latitudes? "*In the mid-latitudes, extreme weather events are almost exclusively determined by the behaviour of the jet stream*", explains Thomas Jung, who spent more than nine years at the European Centre for Medium-Range Weather Forecast (ECMWF) before joining the Alfred Wegener Institute. "*In Europe for instance, when we had a very zonal, not-very-wavy jet stream, we would frequently observe windstorms*". When the jet stream is meandering, the situation is markedly different: "*There are 'cold air outbreaks' of cold northern air moving south as mild air masses move north*". Also, the jet stream affects mid-latitude weather conditions differently from place to place. "*Depending on how heavily the jet stream is breaking, in summer we would see heat waves and a tendency for flooding hundreds of kilometres further up- or downstream. So basically windstorms, cold air outbreaks, flooding events and persistent heat waves can all be traced back to the behaviour of the jet stream*".

Beast from the East

A recent example of a cold air outbreak was the so-called "Beast from the East" which struck Europe during the winter of 2018. Overland et al. (2020) studied this particular cold spell, identifying a weakening of the stratospheric polar vortex in mid-February, initiated by Rossby-wave propagation from the troposphere into the stratosphere. The Rossby waves ascending into the stratosphere caused a split in the polar vortex, shifting its centre toward North America and creating a secondary centre over Siberia. While the North American vortex remained strong, a sudden stratospheric warming event over Siberia caused a cold snap over much of Europe in March. The "Beast from the East" resulted in 84 deaths and thousands of traffic accidents across Europe, for an economic loss in the billions of Euros.

Central Arctic Ocean



Temperature anomalies during the Beast from the East event over Europe (source: Climate Prediction Center. NOAA).

Wildfires in the South

Although the stratospheric polar vortex in the southern hemisphere is generally much more stable and less variable, there are some links between a weakened stratospheric vortex and changing weather patterns in the southern mid-latitudes. A recent study by Lim et al. (2019) found that a weaker, warmer Antarctic stratospheric polar vortex significantly increases the likelihood of hot-and-dry extreme weather across subtropical eastern Australia in austral spring and early summer. As a consequence, it contributes to the spread of wildfires.

Despite these relationships, not every cold air outbreak is linked to a weakened stratospheric polar vortex. It's rather that the likelihood of such events is greater when the stratospheric polar vortex is weak.

Are Models Misleading?

The internal variability of the atmosphere (among other factors) means that some polar vortex breakdowns may be easier to predict than others. "*That's why we run ensemble forecasts, which paint different scenarios but are based on more or less the same initial conditions. Ensemble predictions tell us how predictable an event is. We can forecast these breakdowns in the stratospheric vortex probably about 7 to 14 days in advance*", says Jung. "*On the other hand, once a polar vortex has broken down, its persistence is represented very well in our models. Our ability to simulate the stratospheric polar vortex in models has improved substantially in the last twenty years*", Jung points out. "*But some colleagues argue that basic processes are still missing from our models. Interesting studies by Doug Smith and others at the UK Met Office suggest that the models are not yet responsive enough to certain perturbations in sea ice and sea surface temperature, and that there might be something fundamentally wrong with them.*"

Doug Smith, an expert on decadal climate prediction at the Met Office, shares Jung's assessment. "*Models have recently been improved to represent the stratosphere much better, both by increasing the height of the top level and by increasing the number of vertical levels. Nonetheless, current models appear to still underestimate the magnitude of the predictable fraction of the total variability*". Smith is currently co-chairing the Polar Amplification Model Intercomparison Project (PAMIP), which (among other important work) is running coordinated numerical model experiments to compare how different climate models represent the polar vortex as the climate changes.

Tug of War

Indeed, scientists disagree about the likely impact of current climate change on the behaviour of the polar vortex. In their review paper, Cohen et al. find that observational and modelling studies diverge. Observational studies tend to support a link between the Arctic amplification (an aspect of warming) and increased likelihood of severe mid-latitude winter weather. Most modelling studies indicate less of a connection. The authors of the review note that better representation of the stratosphere in future models may eventually help to resolve the discrepancies between model and observational studies.

The atmosphere itself, naturally highly variable, poses a challenge when it comes to detecting forced signals. "*In fact, one of the problems is what we sometimes call a 'tug of war'. The tropics are warming up. They're trying to push the jet stream north, even as the warmer Arctic is pushing it south. So, air masses are being sort of pushed in opposite directions. And it's not quite clear who is going to win*", says Jung.

Can Additional Observations in the Arctic Improve Polar Vortex Forecasts for Europe?

According to Jung, it's a complex picture because weather over Europe is driven mainly from a westerly direction rather than by the Arctic: "*Our studies from the Polar Prediction Project suggest that having more observational data from the Arctic would aid forecasting for Russia, Japan and China more than it would for Western Europe, where the winds come not from the Arctic but are south-westerly. Observations from North America are really what improves weather forecasts for Europe, not observations from across the Arctic. That's information about conditions not moving directly towards us.*" Increasing the number of observations gathered in the Arctic will nonetheless be crucial to better understanding processes that influence the polar vortices in the Northern Hemisphere. They will also help forecasters to link the stratospheric polar vortex to the polar jet stream, as the latter is what influences the weather over Europe.

So, far from being unusual, the polar vortices are a natural, constant feature of atmospheric circulation. When talking about weather, it is important to differentiate between the stratospheric polar vortex and the tropospheric polar vortex. While the high-altitude, stratospheric polar vortex does not by itself influence our weather, several mechanisms – many of them not yet fully understood – couple it to the troposphere. Even though the record-setting storm Filomena occurred during a negative phase of the NAO, and a polar vortex weakening happened a few days before it, those two signs should not be taken for a grant of cold winter weather in general. How climate change and loss of sea ice in particular will affect the polar vortex requires further study. Forecast models must take those factors into account to better represent atmospheric conditions.

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02

MOSAiC was Designed for the Needs of the Modeling Community

Interview: Kirstin Werner and Sara Pasqualetto, WWRP International Coordination Office for Polar Prediction/Alfred Wegener Institute
Transcription and written interview: Laura Hüßner, Kirstin Werner and John A. Foulks

Matt Shupe served as the co-coordinator on the MOSAiC expedition, the German research icebreaker Polarstern's year-long drift through the ice of the central Arctic Ocean. A senior research scientist with the University of Colorado's Cooperative Institute for Research in Environmental Sciences (CIRES) and NOAA's Physical Sciences Laboratory, Shupe was aboard for the first and fourth of the expedition's five legs. In our interview with him for *The IcePod* podcast, he talks about the origins of the expedition, some of its challenging aspects, mysteries whose answers may lie in the data and measuring clouds during the polar night.

Dr Shupe, you co-led the MOSAiC expedition with Markus Rex from the Alfred Wegener Institute in Germany. MOSAiC was carried out on a German research vessel, the Polarstern. But you work for the United States' National Oceanic and Atmospheric Administration. How did you get involved? Can you recall a first encounter?

Multiple paths came together. Basically, I've been working on MOSAiC since 2008, when I went near the North Pole on board the Swedish ice breaker Oden. We were studying many of the same processes as I later did during MOSAiC. And I thought that this expedition with Oden wasn't long enough. There was just not enough time for me to understand where the sea ice had come from and where it was going. It was striking for me to realize that we need to go to the Arctic at least for an entire year – ideally multiple years. So, I started working on a concept for this interdisciplinary project. In 2011, I met my German colleague Klaus Dethloff, who had some similar ideas. At that point, we started some serious discussions. We both wanted to engage the international community and bring a lot of people together. When Klaus was at retirement age, Markus Rex from the Alfred Wegener Institute took over.

It took more than eight years to plan this huge polar expedition. What were your tasks as a co-lead?

The early part was mostly focused on designing the science and bringing together a team of experts who could put this together. For me, the interdisciplinary part was one of the key ingredients; we had to put all these different parts together, because that's the Arctic system. You cannot study just one part in the Arctic, such as the atmosphere. It only works if you study that part together with the sea ice, the ocean, the biology and the chemistry, because that is what changes. My role was helping to design the science and to bring the right people to the table to talk about how the coupled-system-science pieces fit together. Following that, we had to think about what we would need to measure and how. I felt I was constantly cheerleading to bring the people together.

What in your view was hardest from an organizational point of view?

The hardest part was to overcome a certain scepticism at the beginning – to get people into a common mindset of what it takes to be in the central Arctic for a year. Most people involved had some kind of experience of the Arctic, but only very few people actually had the experience of being out there in all seasons of the year, especially in wintertime. For a lot of us, it was quite a challenge, because we weren't necessarily fully prepared for what this year would all entail. I think that's part of a normal process, but that was a challenging piece.

Your scientific work is focused on clouds, and this is also what you studied during MOSAiC. How do you measure clouds during the polar night?

For our instruments it doesn't matter if it's a pitch-black night or a sunny day. We use radars that scan vertically and LIDARs, which send out signals seen as green lights. The signal bounces off targets in the atmosphere and comes back. The radar and LIDAR signals together tell us something about the properties of clouds, the phase of the cloud, and the shape of its particles – a liquid drop is spherical, while an ice crystal looks like the snowflakes we know. Based on the particles' shape and the phase of the cloud, we get a different return signal. There are other sensors as well that will help us to quantify how much liquid water is there or other properties of the cloud. So, together this suite of instruments does an awesome job of telling us about the clouds.

Was there anything you discovered during MOSAiC that came as a surprise?

Yes, at various levels! For example, aerosols. We had time periods when there were no aerosols in the atmosphere at all. Where were they? It would be fascinating to understand the role of these kinds of events. There are some hints about the processes that might control the evolution of particles in the atmosphere. We still need to learn so much about it.

MOSAiC and the Year of Polar Prediction basically were planned in tandem, since advancing forecast capabilities in the Arctic depends heavily on better understanding the processes and gathering more observations to feed into numerical models. Originally, MOSAiC was supposed to take place during the actual Year of Polar Prediction 2017–2019. What were the really important key measurements for YOPP?

MOSAiC was designed for the needs of the modelling community, so we can feed the new knowledge into the models. YOPP and MOSAiC are natural partners. The international community of modelers is really counting on the information generated during MOSAiC. The interaction with the Polar Prediction Project really helped to design MOSAiC from the very beginning.

One important aspect for modelling was the distributed network that was set up at a radius of about fifty kilometres around Polarstern and its Central Observatory ice camp. It is one thing to put one ship out and have one point of measurement; most of the modelling community will laugh at that. For models which go global or regional, one point is not enough. Rather, we need spatial understanding. A model has to represent a grid cell – a spatial domain. What happens within this domain is what we call sub-grid-scale processes. For models, we need to understand how to represent what happens within those grid domains, specifically the variability. With the MOSAiC distributed network, we aimed to have multiple points across the domain which looks like a model grid box.

From very early on, this was the most appealing aspect to the PPP community, because it will help to provide the link from observations to process understanding and modelling.

Canadian Arctic Archipelago

You returned to Boulder after leg 4 having completed the MOSAiC field work. Are you happy with the results?

Yes, I am happy, for multiple reasons. We did get this fantastic data set unlike any before it. And it is going to enable a lot of great science. I'm also happy because MOSAiC is done – at least the field part. It has been such a lot of work over many years, and I'm kind of happy to have arrived at the end of that part and at the transition into analysis. I'm a scientist, I like science, I like to look at numbers and make plots. For the last decade, I have slowed down my science in order to focus on MOSAiC, developing the science for MOSAiC, pulling together international partners. It's not the same as doing science, and I look forward to turning my attention back to the analysis and to the mysteries that might reveal themselves within the data. I have so many questions that I would still like to try and address by looking at, and understanding, the data.

So, what's next? What are the next steps for MOSAiC now?

The next step is to now integrate the information we gained. At the moment, we are working very hard to get the MOSAiC data into a state that can be used in models. We are working to create data products that are matched with model output along the drift path of Polarstern so that we can compare the data in space and time. The aim is to produce a fantastic observational data set that can be used to evaluate the processes in the models. In short: We want to make sure we have solid data, packaged in the right way, to then actually do a process-level evaluation of the models.

photo: Marcel Nicolaus/Alfred Wegener Institute; photo page 9: MOSAiC.

After a MOSAiC year in the Arctic, collecting an incredible amount of data and a unique dataset where previously almost no data about the polar night had been available, what will be the next big thing?

I would challenge us as a community to use what we have. We have this amazing data set from MOSAiC, and from other projects like SHEBA or the Russian drifting stations. How does this great MOSAiC data set relate to the data from the other projects? What is the data telling us about the innate aspects of the Arctic system versus those that are currently changing? And how do we put those together? This requires a synthesis. And synthesis requires data over a long time, but also models and a modelling perspective, because they hold together the big picture. There is so much that hasn't been analysed yet.

But surely there will be a next project. Towards the end of MOSAiC, a lot of the early-career scientists asked me, "What are we going to do next?". In the end, it takes people to work really hard and persistently to make something like that happen; but anybody could do it. So, I challenge those early-career scientists: the next one is on you.

The interview was edited for length and clarity. The full podcast interview with Matt will be published as the final episode of The IcePod's season 1.

03

East Greenland is the Opposite of New York

by Laura Hüßner, WWRP International Coordination Office for Polar Prediction/Alfred Wegener Institute

With its nearly 2,000 residents, Tasiilaq on the south-eastern coast of Ammassalik Island is the biggest town in East Greenland. In 1983, the South Tyrolean mountaineer Robert Peroni traversed the Greenland ice sheet at its widest point and never wanted to leave again. He bought a house and turned it into *The Red House*, a hotel where he welcomes anyone willing to stay at least a week. We interviewed Robert Peroni about weather forecasts and decision-making to ensure sustainable tourism in Greenland.

Mr Peroni, you offer your guests certain activities, for example dog sledge tours, skiing or kayaking on the fjords. These activities can be dangerous in bad weather. Where do you obtain forecasts when you need to decide whether to go out or not?

We get our forecasts from the Danish Meteorological Institute (DMI). They provide a special forecast service for our area. We also use Windy.com, which is very accurate, for a more general forecast for Greenland.

Over the years, I have gotten to know our micro-climate here in Tasiilaq. On the ice sheet, for example, the cold air moves down and shifts the katabatic wind to the edges – which is one of the reasons forecasts for all of East Greenland do not cut it for our island here. But the more accurate forecasts by the DMI take into account the peculiarities of the different regions of Greenland.

Wind is the most difficult element; the forecasts still struggle with it. We have two different wind directions here in Tasiilaq: one from the east, the so-called "women's wind" or Nakajaq, and another from the north-west, the "men's wind" or Piteraq. The Piteraq is the brutal one. It can reach up to 300 km/h. For sea ice, until recently I would still collect different weather maps and forecasts and cobble them together to make our particular forecast for Tasiilaq. But nowadays we receive satellite images, which are very helpful as a way for me to learn about the ice conditions from six hours ago.

Have you and your guests ever had it happen that the forecast was wrong and you found yourselves in a dangerous situation?

Of course, that has happened and still happens. Sometimes we really get surprised by the Piteraq. But nowadays we are more careful. In Tasiilaq there is a little but important weather station that puts out warnings when the Piteraq is coming. The hunters and fishermen then know they have to get home in time. If they don't, the wind will blow them away and farther out onto the open sea to where they won't be able to come back.

How have ice conditions in Greenland, and in East Greenland in particular, changed in the last three decades?

The amount of ice that arrives from the central Arctic has decreased greatly in the last few years – which is dramatic because, if the river of ice that comes to our area with the East Greenland Current weakens, the ice no longer slows the ocean waves. The waves instead destroy the ice near the coasts, the fjord ice. However, if the ice in the fjords is destroyed, then people, especially poorer ones, cannot go fishing. And their families will go hungry. Also when the ice is very weak, fewer seals and polar bears appear, which happened last winter. On the other hand, the new thin-ice conditions permit more supply vessels to reach us here as they can break through the ice more easily.

You have been running The Red House guesthouse since 1986 with a team now of about seventy local employees. Guests are unable to book only one night at The Red House. Instead, you expect your guests to stay in Tasiilaq for at least a few days. What is the reason for this?

The Red House is more than just a normal hotel. If people were to come here and stay for just a day, they would have to take the same long flight either way. But the travel for that one day would produce more CO_2 than staying with us for seven days. So, this is our way of making travel sustainable – we only offer accommodation to people who plan to stay with us for at least one week. On average, our guests stay six or seven nights here.

In addition, we make sure that people are informed about the problems, conventions and activities here in East Greenland and on Ammassalik Island. This is neither Crete nor Egypt. One time, somebody arrived here without so much as a jacket. They wore a plastic bag instead. We want to teach our guests how to travel slowly, how to stand still and how to listen to the environment. Ice mountains are not just white – they are colourful. The ice moves, it makes noises, little splashes as it floats in the water. Greenland is the exact opposite of, say, New York, where everything is noisy.

What in your view makes Greenland, particularly East Greenland, so special?

For me, the east is the treasure of Greenland. The people here are unique. The first white human came to East Greenland only 120 years ago, but on the west coast they arrived as early as a thousand years ago. If you want to see the real Greenland, you have to come to us. It's a fascinating world. People often associate Greenland with rugged wilderness and alcoholism, but it's not true. The people here are so friendly and welcoming. Of course, they are a little shy because they are not used to tourism; but everyone would invite you into their house for coffee or tea.

If you could, what would you change about tourism in Greenland?

It should be mandatory for everybody to stay for at least seven days so visitors take their time seeing and experiencing Greenland. Travel should not be about a cheap souvenir to bring home or the trash left behind the houses. Tourists need to ask themselves why they really want to come to Greenland. Or whether the beauty of their home countries isn't enough for them. When the big cruise ships arrive down at the harbour, about five hundred passengers overrun a village of only eighty residents. Naturally our residents often hide from the tourists, because some of [the tourists] don't seem aware of boundaries and take pictures of everything they can find. Or they say things like "there's nothing here". Well, yes – there is nothing there if you have your eyes closed. It's a bad development I would like to see change.

In 2020, due to the pandemic, tourists could not travel to Tasiilaq. This has also has affected The Red House, which recently launched a crowdfunding campaign in order to survive.

photos: (upper left) Ulrike Fisch;
(below): *The Red House*

04

The YOPP Site Inter-Comparison Project

by Jonathan Day (ECMWF, UK), Gunilla Svensson (Stockholm University, Sweden), Barbara Casati (ECCC, Canada), Taneil Uttal (NOAA, USA)

This article was first published in the [autumn 2020 ECMWF Newsletter]. It is re-published in PolarPredictNews #17 under the [Creative Commons licence]

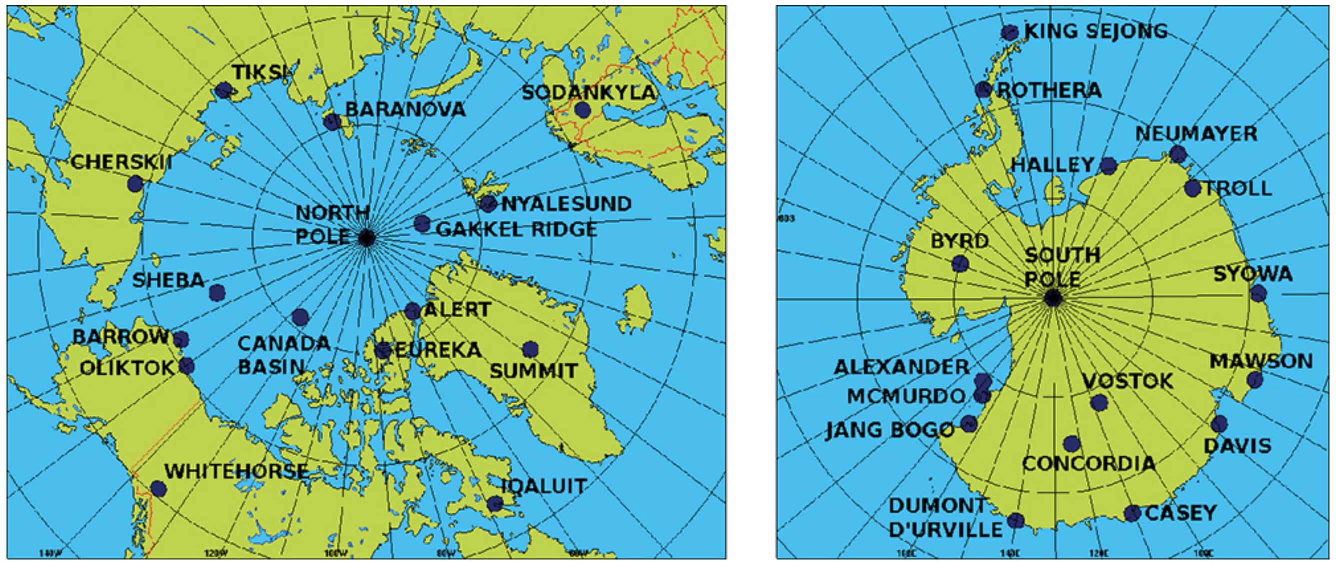
A team of modelers, observationalists and data scientists collaborating under the umbrella of the World Meteorological Organization's Year of Polar Prediction (YOPP) have been working through the complex details of synergistically combining information from Arctic observatories and numerical weather prediction (NWP). They aim to further our understanding of polar meteorology and to assess and improve process representation in the polar regions. The project, known as YOPPsiteMIP, is an international effort and has to date produced forecast data from eight NWP systems (including ECMWF's Integrated Forecasting System) at 41 polar terrestrial observatories. A number of these systems are also providing output at the MOSAiC ice camp as part of the MOSAiC-Near Realtime Verification Project. The dataset is archived at the YOPP portal, hosted by Met Norway.

Although the quality of weather forecasts in the Arctic is improving, it still lags behind the quality of forecasts in lower latitudes. Arctic regions pose specific challenges related to processes which are historically difficult to model (stable boundary layers, mixed-phase clouds, and atmosphere-snow-ice coupling). Moreover, so far there has been relatively little effort to evaluate processes in weather models using in-situ datasets from the terrestrial Arctic and Antarctic, compared to the situation in mid-latitudes. YOPPsiteMIP aims to address this gap.

While the concept of model inter-comparison is not new, there are novel challenges associated with the YOPPsiteMIP activity:

(1) The focus is on coupled NWP models, assessing their performance at a process level in the polar environments. This requires the development of consistent time series at specific grid-points, with high frequency to model time-step outputs from different NWP centres.
(2) The observatory data, which includes variables originating from scores of instruments, researchers, institutions, archives and portals, need to be organised into consistent Merged Observatory Data Files (MODFs).

Initially efforts will focus on the YOPP special observing periods (SOP1: Feb–Mar 2018, and SOP2: Jul–Sep 2018, SOP–Southern Hemisphere: Nov 2018–Feb 2019) and the MOSAiC year (Sep 2019 to Sep 2020).



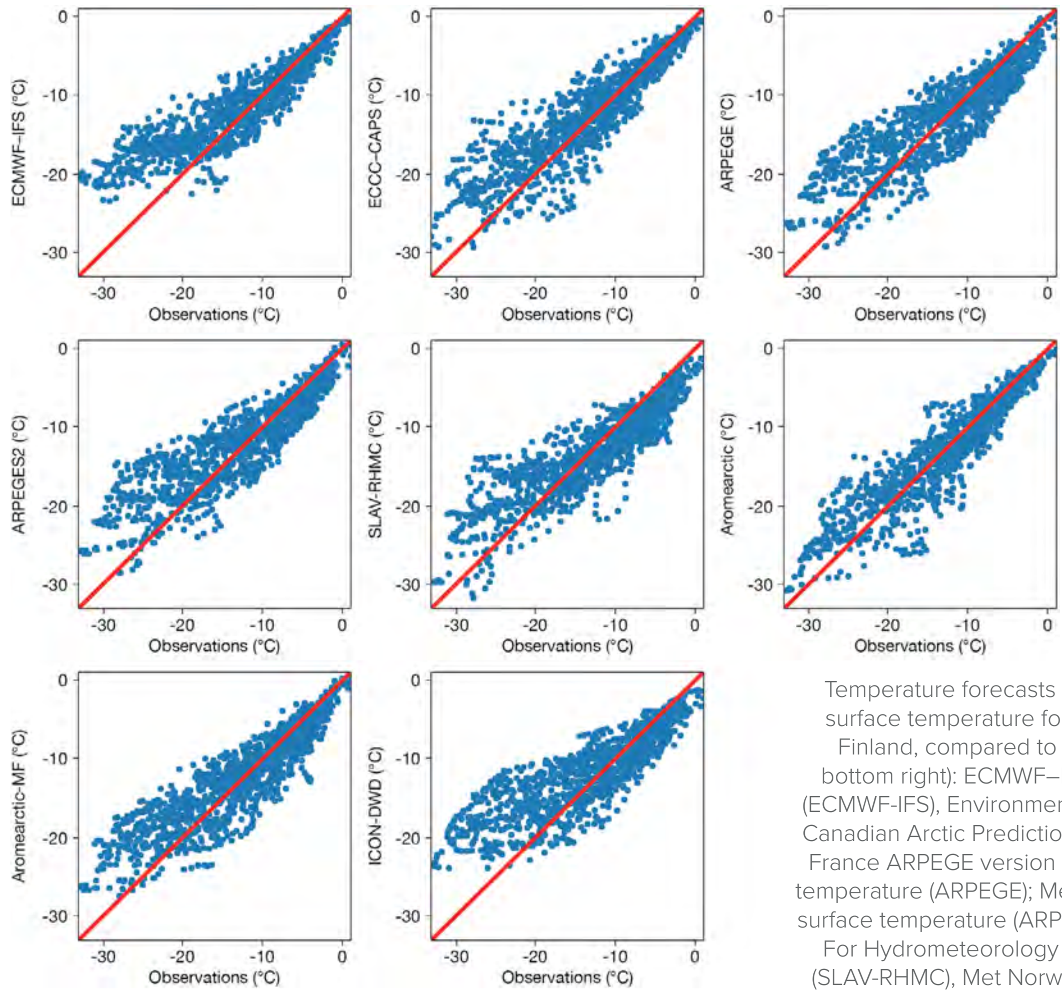
Polar observatories. Maps of polar observatories included in YOPPsiteMIP (source: [ECMWF autumn 2020 newsletter]).

The YOPPsiteMIP dataset complements the ECMWF-YOPP dataset, which contains spatial fields, albeit at a lower temporal resolution.

An initial evaluation across the models already provides some interesting results. For example, most of the forecast systems exhibit a warm bias in extremely cold conditions. This can be seen in both northern Europe (as illustrated in the second figure) and northern Alaska. Finding common issues like this across models and attributing these to certain processes/parameterizations, which can then be tackled in community efforts, is a key theme. For example, in all the NWP systems shown, terrestrial snow is represented by a single thermal layer. Recent work at ECMWF, as part of the *[APPLICATE]* project, has shown that this bias is partly caused by this simple representation of the snow. Including a multi-layer snow model can improve, but not completely solve, this error in the IFS. Understanding whether this is the case for all the contributing systems would obviously help inform model development choices across the community.

Future Plans

The next steps for YOPPsiteMIP are to produce MODFs for each of the sites and to use these in a process-oriented evaluation of the forecasts. The NWP centres, including ECMWF, have been providing input into the design of these files. This is designed to ensure a fair comparison with the forecasts themselves. However, producing standardised MODFs for the observatories is much more challenging than for the forecasts, since it requires bringing together a mixture of routine and research grade observations. A prototype MODF has been produced for Utqiagvik (formerly Barrow) Alaska by the US National Oceanic and Atmospheric Administration (NOAA), and a team has been assembled to begin producing these for other sites according to this template. Once completed, it is expected that the MODFs produced for the polar observatories will provide a valuable resource for benchmarking NWP and climate models, from a process perspective, for many years to come. Further model evaluation using these is planned as part of upcoming projects, including ECMWFs contribution to *[INTERACTIII]*.



Temperature forecasts and observations. Hourly near surface temperature forecasts for day 1 at Sodankylä, Finland, compared to observations from (top left to bottom right): ECMWF–Integrated Forecasting System (ECMWF-IFS), Environment and Climate Change Canada–Canadian Arctic Prediction System (ECCC–CAPS), Metéo-France ARPEGE version without variable sea-ice surface temperature (ARPEGE); Metéo-France with variable sea-ice surface temperature (ARPEGES2), Russian Federal Service For Hydrometeorology and Environmental Monitoring (SLAV-RHMC), Met Norway (Aromearctic), Metéo-France (Aromearctic_MF) and the German national weather service (ICON-DWD).

Kara & Barents Sea, Arctic

05

Artificial Intelligence May Usher In the Next Revolution in the Arctic

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

Artificial intelligence (AI) means tasks normally requiring human intelligence being performed by machines. Its presence in our everyday lives is growing. It has applications in healthcare and public transportation, speech recognition and language translation, decision-making and visual perception. It simplifies many complex data management processes. Weather forecasting is no exception: in coming years, machine-learning approaches are expected to substantially enhance satellite-based remote sensing and numerical weather prediction (NWP). Sea-ice warnings for shipping will also benefit from the advantages of coming AI applications.

The means of scientific observation and measurement have continuously advanced since the middle of the last century. Back in the "old days" – not even a hundred years ago – the only way to obtain data in the Arctic was by staging shipboard expeditions that were possible only during summer when thin sea ice made the icescape navigable. Cold-war era submarine operations were the first to investigate the Arctic Ocean from below the surface. (They noticed a decline in sea ice in certain regions.) The advent of satellite observations over the Arctic in 1979 was game-changing: for more than forty years, seamless observations of ice extent in the Arctic, or of cloud conditions or algal blooms there, have been available. We may now be at the cusp of another revolution in data retrieval with AI algorithms for weather and sea-ice forecasts.

Artificial intelligence describes a range of computing techniques that let machines and computer programs simulate human intelligence. One common method to achieve AI is to apply machine learning (ML) algorithms. Machine learning-based systems are able to learn from data and improve on their own – without explicit programming. This requires the system to go through a "learning phase" in order to educate the model to recognize certain patterns in datasets. The training algorithms can be supervised, unsupervised or semi-supervised. In supervised learning, a model will be trained with labelled data, meaning that input and output variables are already defined. This can be compared to a student taking a test under the supervision of a teacher. Unsupervised learning on the other hand deals with unlabelled data, allowing the system to discover information and recognize patterns completely on its own. Each technique has its advantages and disadvantages depending on the area of application. Both can be useful. Deep learning is a special approach to machine learning based on artificial neural networks. These involve multiple processing or "hidden" layers which can extract features from datasets. Deep learning algorithms are thus capable of processing unstructured data such as that contained in pictures, text, audio and video.

Operational weather centres so far have been able to make reliable predictions on timescales from hourly to seasonal by using a variety of observational datasets to initialize forecasts. But even though we draw on an already-huge volume of observational data, the capabilities of numerical weather prediction (NWP) models are still limited by the performance of the available hardware. That's where recently developed ML methods come in handy. They already appear to be highly beneficial where integrated into the work of operational weather centres. For instance, the European Centre for Medium-Range Weather Forecasts (ECMWF) uses several ML applications at every stage of the NWP process. This demonstrates the great potential of implementing AI into the workflow, from correcting bias in satellite observations to apprehending model error within data assimilation, local downscaling of model output to improve predictions, and many other applications.

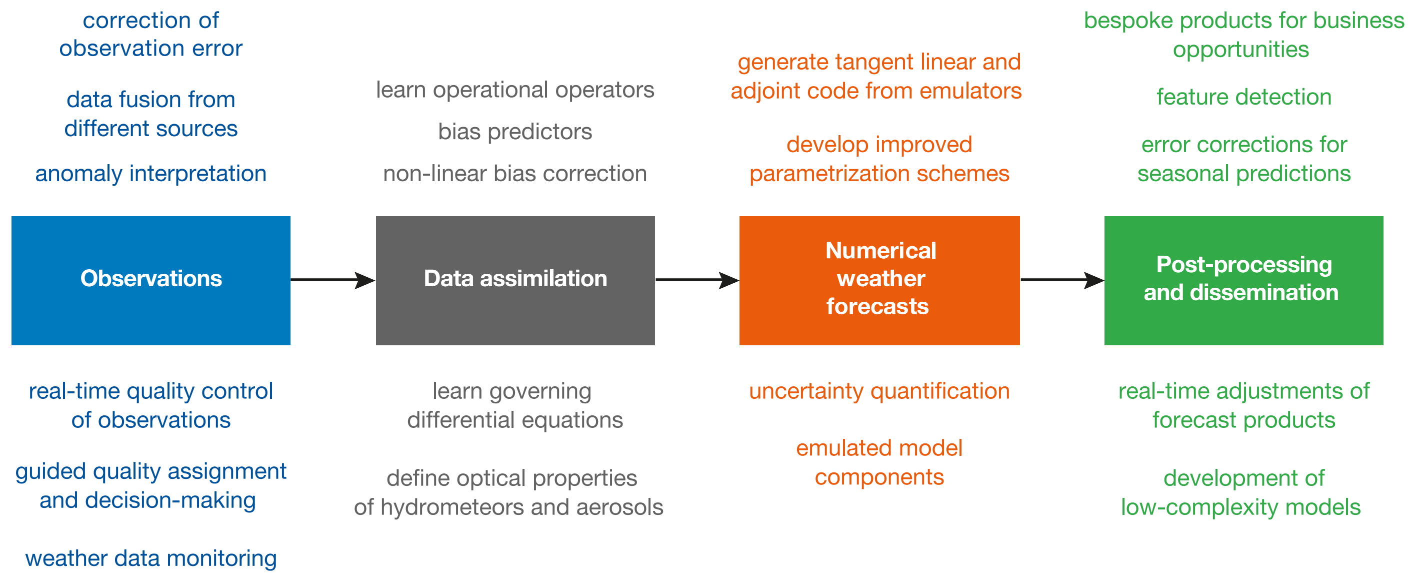
Potential for On-Board Application

Operational weather centres are not the only beneficiaries of AI. Safely navigating in the Arctic Ocean crucially depends on reliable weather and sea-ice forecasts. Researchers need them to plan scientific activities and operations there. Securing reliable navigational guidance can be very time-consuming since accurately depicting the state of the sea ice requires so many processing steps. According to Thomas Viguier, an expert on global and Arctic shipping and maritime industries, the complex procedures of data processing, accessibility and interpretation can interfere with decision-making on the bridge: "If a tool is not intuitive or is too complex, it will not be taken into account for decision-making as it would be too time-consuming to analyse and extract useful data." ([Polar Prediction Matters, 21 July 2020](#)). What's more, sea-ice forecasting for shipping routes cannot be carried out directly on board as no vessel currently carries the bandwidth and computational capacity needed to run a dynamic sea-ice model at a reasonable resolution. (This is partly due to limited satellite availability in polar regions.) The progressive implementation of integrated bridge systems (IBS) and sea-ice and weather forecast software on ice-navigating vessels may be helpful in getting and processing accurate sea-ice and weather data on board. But that does not make it usable per se. "Often there is no way for the crew to enter manually observed data in the software, sacrificing a crucial and basic aspect in navigation: human in-situ observation", explains Viguier in his contribution to Polar Prediction Matters. Weather conditions can change even within a few minutes in the Arctic Ocean, so the sole use of satellite data for forecasts will not always be accurate.

Automated Sea-Ice Products

The European Space Agency (ESA), the Danish Meteorological Institute (DMI), the Technical University of Denmark and the maritime service provider Harnvig Arctic & Maritime have launched a project in which they are collaborating to develop an automated sea-ice products (ASIP) service that incorporates novel ML techniques for data fusion and synthetic aperture radar (SAR) imagery interpretation and processing. The ASIP service automatically merges imagery from Sentinel-1 satellites with related satellite information such as advanced microwave scanning radiometer (AMSR2) and Copernicus imaging microwave radiometer (CIMR) data. Their deep learning model so far has achieved very good results in the form of high-resolution sea-ice maps for Arctic maritime uses. The developers of the ASIP service are planning to expand model capabilities to produce reliable outputs for further parameters such as sea-ice type and concentration. More information on ASIP can be found at their *website*.

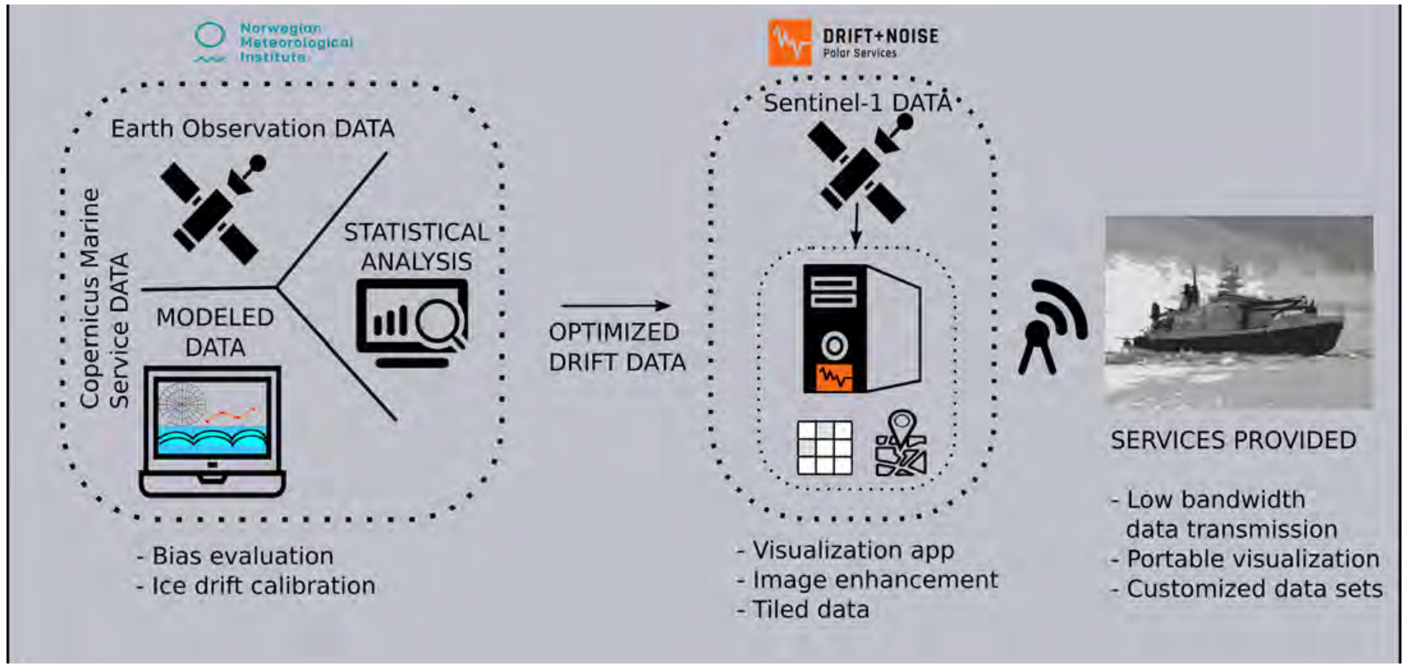
Similarly, the German start-up Drift+Noise Polar Services GmbH, a spin-off company of the Alfred Wegener Institute, provides user-friendly ice information applications for on-board nautical decision makers. Cooperating with four partners, they recently launched the *Eisklass2* project to develop a different set of automated sea-ice information products by means of deep learning approaches. Another of their current projects also takes advantage of AI integration: the *MAP-BORealis project*, a collaboration with the working group Optimization and Optimal Control and a maritime research lab



Areas of application for machine learning (from https://www.ecmwf.int/en/newsletter/163/news/ai-and-machine-learning-ecmwf).

of the German aerospace centre, DLR, both at the University of Bremen. This project aims to optimize shipping routes by creating automated sea-ice classifications from satellite images with the help of machine learning. They are employing a similar approach in their *IcySea project*, which provides near-real-time sea-ice maps for the general vicinity of Svalbard. The maps are merged from Sentinel-1 satellite imagery and high-resolution model output. The IcySea application incorporates machine-learning techniques developed at the Development Centre for Weather Forecasting of the Norwegian Meteorological Institute (MET Norway). Combining these with Copernicus Marine Service operational data sets allows for a significant reduction in ice-drift speed and angle biases. It also ensures that the application can run on low-bandwidth connections. Use of the IcySea app is free of charge. It can be found *here*.

A similar approach featured in a recent publication in which *Fritzner et al. (2020)* compared a regular dynamical sea-ice model with two statistical ML models. The results indicated that the forecast accuracy of the novel statistical ML models was similar to that of the dynamical sea-ice model. The latter relied on data assimilation, but the ML models required much less computing power. This novel, ML-based method enables sea-ice models to run on a regular laptop – or rather, more practically, directly aboard an icebreaker or research vessel.



Framework of the IcySea App developed by Drift+Noise and partners (source: Drift+Noise).

AI-backed models still face challenges. To the extent they have relied exclusively on historical data, performance has been satisfactory for less drastic changes in the sea ice. But when sea-ice variability increases, for instance in an extreme melting phase, AI models still have difficulty interpreting such unusual events, and dynamical assimilative models here are more accurate. Nonetheless, the pace at which AI has improved over the last decade is beyond astonishing – so the future of AI-assisted models in the Arctic looks bright.

Fritzner, S., Graversen, R. and Christensen, K. H. (2020) "*Assessment of High‐Resolution Dynamical and Machine Learning Models for Prediction of Sea Ice Concentration in a Regional Application*" JGR Oceans, 125(11), e2020JC016277. doi: 10.1029/2020JC016277

06

New ECMWF Blog Article – Insights into Polar Observing Systems

by Laura Hüßner, WWRP International Coordination Office for Polar Prediction/Alfred Wegener Institute

In the new post on the *Science Blog of the European Centre for Medium-Range Weather Forecasts* (ECMWF), Irina Sandu, ECMWF Physical Processes Team Leader, and François Massonnet, F.R.S.-FNRS Research Associate at the Université Catholique de Louvain, Belgium, emphasize the importance of improved prediction skills and monitoring capabilities in the polar regions. The authors are calling for contributions to the *special collection in QJRMS*, to gather studies highlighting the impact of polar observations on predictive skill in polar regions and beyond.

Conventional observations such as radiosonde launches and surface observations are less common in polar regions. But sounding satellites sample the polar regions more frequently than any other region on the globe, due to the fact that polar-orbiting satellites pass over the pole at each orbit. These observations are a key ingredient for accurate predictions from hours to years ahead.

Irina Sandu currently represents ECMWF in the PPP Steering Group, while François Massonnet, who leads the Antarctic Sea Ice Prediction Network SIPN South, is active in the YOPP Southern Hemisphere Task Team. The blog describes how coordinated numerical experimentation with coupled prediction systems helps to identify the impact of atmospheric observations on short- and medium-range weather forecasts (hours to days), and the impact of sea ice initialization on sub-seasonal to seasonal forecasts (weeks to months ahead).

Key to enhancing future prediction capacities in polar regions are synergistic investments in observing and numerical prediction systems. As *APPLICATE* and the Polar Prediction Project (PPP) have demonstrated, numerical models can be used to show the impact of current observing systems on predictive skill, identify ways to maximize their uptake in numerical weather prediction (NWP) systems, and guide the design of future observing systems. "*The clear message is that investment in observing systems must be carried out synergistically with the investment in numerical prediction systems*", according to the authors.

For the *special collection in QJRMS*, the Quarterly Journal of the Royal Meteorological Society is currently welcoming manuscripts covering Observing System Experiments on a range of time scales (from a few days to sub-seasonal or seasonal) as well as studies that use numerical experimentation to explore the possible added value to predictive skill of recently available or hypothetical observations (see *#08)*.

Find the blog article *here*.

07

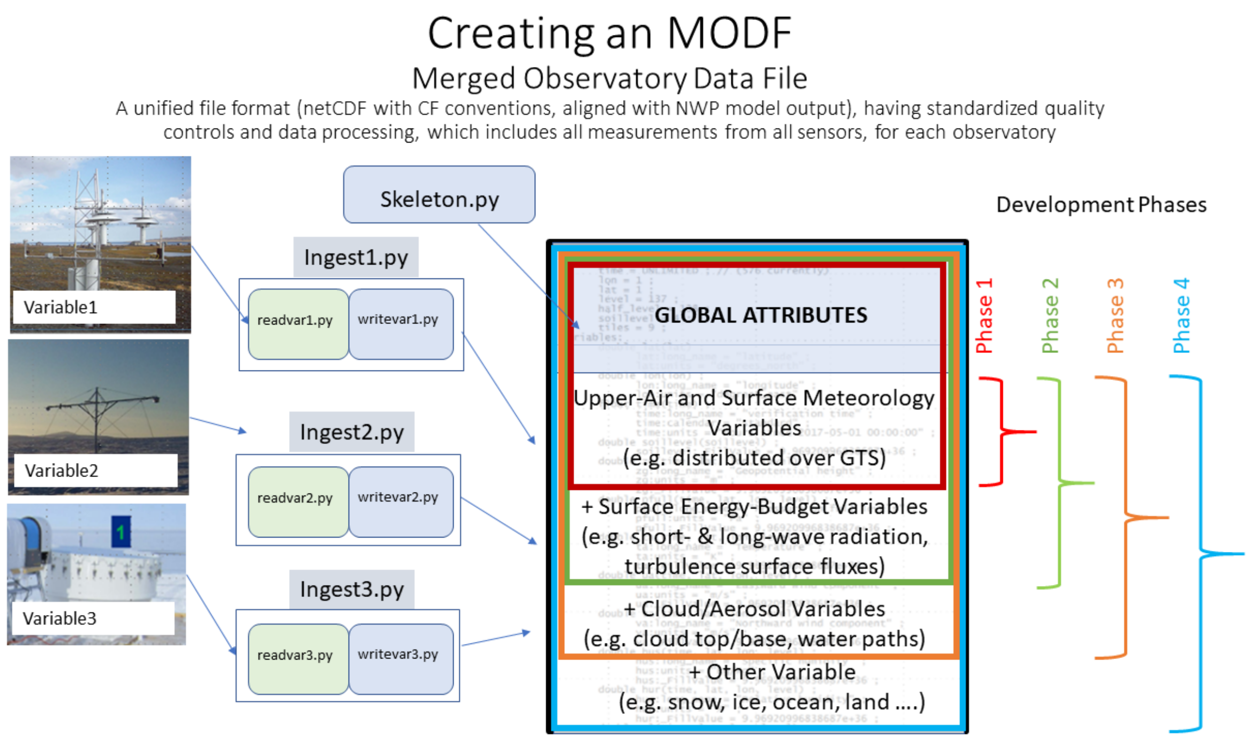
MOSAiC Data for Process-Based Model Evaluation – When and How?

by Gunilla Svensson, Stockholm University, on behalf of the YOPP Process Task Team

With the extra attention on environmental prediction in the polar regions over the last decade, the polar prediction community is very excited about the observational data that was collected during the MOSAiC expedition. This extraordinary Arctic field campaign, led by atmospheric scientist Markus Rex, and co-led by Klaus Dethloff and Matthew Shupe, was completed successfully with the return of the research icebreaker Polarstern to Bremerhaven in October 2020. With 389 operating days and numerous observations gathered by scientists studying the atmosphere, ocean, sea ice, ecosystems and biogeochemistry, MOSAiC will provide a wealth of data for many years to come.

It is important to realize that terabytes of data were gathered by nearly five hundred scientists directly involved in the expedition and more than three hundred colleagues participating additionally in the background. Although the data is collected for the benefit of science – and all data will be available for the community eventually – it is important to recognize the importance for the MOSAiC scientists to first work with their hard-earned data. They need time for processing, quality assurance and publication of descriptive science studies. The MOSAiC Data Policy states that the all data will be freely and publicly available on 01 January 2023. However, a significant amount of data will be publicly available well before that date, and some significant data is already available.

The Process, Data and Verification Task Teams of the WMO WWRP Polar Prediction Project are actively trying to facilitate the community's access to this unusual and extremely valuable data by several means to pave the way for making the observational data accessible also for modelers. In this effort, our focus is to work together with MOSAiC scientist, on collaboration projects and in continued dialogue



The creation of a merged observatory data file is facilitated by Python scripts that convert the observed variable name to the standardized one with all the needed netCDF attributes. Usability is thereby enhanced as the files for every observatory have the same structure and variable names. The files are developed in phases that successively include data from more instruments and parameters for more advanced process evaluation (source: Gunilla Svensson).

about how to improve the integration of process observations into numerical weather prediction and coupled models, while offering co-authorship to scientists responsible for observations and with proper acknowledgements following the MOSAiC Data Policy.

Already up and running is the verification of numerical weather prediction (NWP) prime variables lead by Amy Solomon, mainly using the observations distributed over the Global Telecommunication System (GTS) thus primarily weather-station and radiosonde data. The exchange of model data is accomplished using the standards developed by the three tasks teams together within the framework of the the *YOPP Supersite Modelling Intercomparison Project*, in short YOPPsiteMIP. The goal of YOPPsiteMIP is to facilitate process evaluation of models by organizing observational data at so-called YOPP supersites – with MOSAiC being of of the important supersites for YOPP.

Merged Observatory Data Files

Producing observational files of process-oriented data for modelers is a complicated task that takes time, more than anticipated when the Task Teams embarked on this route. But we find this effort extremely important as it is trying to break a barrier so more observations can be used to better understand the biases in terms of processes in models. Even if Merged Observatory Data Files (or MODFs) were created for all supersites now available in the world, it is still an extremely limited part of the global surface that is covered by measurements. However, if we manage to do this for all YOPP supersites around the Arctic Ocean including MOSAiC, this joint activity can already have a substantial impact for model development work for years to come. The MOSAiC site is exceptional, as it will eventually include information on the atmosphere, sea ice, and ocean jointly. The most important characteristics of the MODFs is that all supersites follow the same data protocol so that it is easy to add more locations to model evaluation (Figure left).

At the moment, we are trying to accelerate the creation of MODFs, with a specific focus on the YOPP supersites Utqiagvik (former Barrow) in Alaska, Sodankylä in Finland, and the two Canadian sites Whitehorse and Iqaluit where data has been gathered during the YOPP Arctic winter Special Observing Period (NH-SOP1; from 01 February to 31 March, 2018). This data will be analyzed and transferred into MODFs along with data from the MOSAiC site for the winter season (October 2019 to March 2020). We anticipate that first versions of data, i.e. Phase 1/2 MODFs (see left Figure) will be available on the *YOPP Data Portal* by the end of February 2021. Updated versions with increased quality and additional parameters will follow eventually, with the next deadline tentatively set to end of March 2021.

As mentioned above, the additional data generated from MOSAiC can be used for specific projects in collaboration with observationalists. As part of the YOPPsiteMIP activitiy, which is endorsed by MOSAiC, interesting periods will be selected for multi-model process evaluation and detailed analysis.

Anyone interested in contributing with model results or coordinate an intercomparison case, please contact Gunilla Svensson *gunilla@misu.su.se*.

08

The Impact of Polar Observing Systems on Forecast Accuracy – A Special Collection of the RMetS' Quaterly Journal

The Royal Meteorological Society (RMetS) has issued a call for manuscripts for a special collection of their Quarterly Journal to gather various studies on the impact of polar observations on predictive skill at the poles and beyond.

The RMetS Quarterly Journal (QJRMS) is one of the world's leading peer-reviewed meteorology journals. It has now opened a special issue to collect studies that document the impact of polar observing systems on the accuracy of predictions from hours to months ahead as well as on climate monitoring capabilities. The special issue will also provide recommendations for how to increase the uptake of existing polar observations into prediction systems and guidance for designing future observing systems in polar regions. Some of the studies to be published in the Quarterly Journal's special collection will rely on the extensive numerical experimentation performed within the Year of Polar Prediction (YOPP) and the YOPP-endorsed H2020 project *APPLICATE*.

Part of the special issue will rely on so-called "observing system experiments" (OSEs), for which certain observations are withheld from or denied to the data assimilation system used to create initial conditions for weather forecasts. As part of this effort – about which *articles are already available* – the first coordinated OSEs withholding observations for polar regions were performed at several operational weather centres, including *ECMWF*, *Environment and Climate Change Canada*, *German Weather Service* (DWD) and *MET Norway*. Results were analysed for a better understanding of how the observations affect short and medium range forecast skill. Some OSEs covered the YOPP Special Observing Periods of 2018 and 2019 in both the Arctic and Antarctic.

The RMetS Quarterly Journal special issue also welcomes OSE studies at longer timescales, for instance such as would analyse the impact of degrading initial oceanic and sea-ice conditions on predictive skill at sub-seasonal to seasonal timescales or explore through numerical experimentation the potential of newly available or hypothetical observations (those for which instruments are not yet deployed) to achieve better predictive skill.

Submissions are due by 31 December 2021. Further information, including the link for manuscript submission, is found *here*. *(is/lh/kw)*

09

ECMWF Global Coupled Atmosphere, Ocean and Sea-Ice Dataset for the Year of Polar Prediction

A detailed description of the global ECMWF-YOPP dataset has just been released in the Nature Research journal Scientific Data. The dataset is expected to spawn novel research ideas, generate more funding opportunities and promote inspiring master's and PhD theses. It is publicly available at the YOPP Data Portal (*https://yopp.met.no/*).

Alongside all the field campaigns and numerical experiments that have been part of the Year of Polar Prediction so far, the European Centre for Medium-Range Weather Forecasts (ECMWF) has produced a unique dataset to monitor the state of the coupled system across several seasons in the polar regions. In addition to the entire model output on the atmosphere, ocean and sea ice, the resulting (and extensive) database contains specific information on individual physical processes. This allows scientists to investigate how the state of the system is affected for example by dynamic transport, radiation or cloud microphysics.

Peter Bauer and co-authors have now published an article in Scientific Data entitled "ECMWF global coupled atmosphere, ocean and sea-ice dataset for the Year of Polar Prediction 2017–2020". In it, they describe the ECMWF-YOPP dataset, which contains initial condition and forecast model output from the operational global coupled numerical weather prediction system. The dataset, freely accessible through the YOPP Data Portal *https://yopp.met.no*, offers atmosphere, ocean and sea-ice output from the world's leading global medium-range numerical weather prediction system. *(lh)*

Greenland Sea, Arctic

Bauer, P., Sandu, I., Magnusson, L. et al. (2020) *ECMWF global coupled atmosphere, ocean and sea-ice dataset for the Year of Polar Prediction 2017–2020*. Sci Data 7, 427. https://doi.org/10.1038/s41597-020-00765-y

10

New YOPP-Endorsed Project ISLAS – Isotopic Links to Atmospheric Water's Sources

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

YOPP has *endorsed* a new research project investigating the local water cycle in the Nordic Seas region by means of stable isotope-measuring instrumentation deployed on the ground as well as aboard research aircraft. ISLAS, or "Isotopic Links to Atmospheric Water's Sources", will substantially contribute to better representation of the water cycle in operational weather prediction models. This will help to address such variables as ocean evaporation, cloud cover and mixed-phase precipitation.

Significant uncertainties still limit our understanding of the hydrological water cycle. Especially clouds and water vapor persist as the largest sources of error in weather predictions and climate models. The reason for this uncertainty is that many processes in the water cycle occur at smaller-scale resolutions than the model grids and thereby heavily limit the skill of the models at predicting extreme hydrological events.

However, the stable isotopes found in water – hydrogen-2 (^{2}H) and oxygen-17 and -18 (^{17}O, ^{18}O) – can provide us with information on the phase changes and moisture transport history of water throughout the hydrological cycle. ISLAS was designed to take advantage of recent technological advances in isotope measurement and in-situ sample collection that now permit researchers to gather a high-resolution, high-precision data set on the distribution of these isotopes. Being able to measure their distribution should contribute to overcoming the related model uncertainties. By improving understanding of the hydrological cycle, the collected data will help researchers set new benchmarks for better weather prediction and climate models.

The main data collection activities will be a set of field experiments to measure the isotope composition of atmospheric vapour and precipitation. After an initial ground-based campaign in boreal spring 2020, an airborne campaign is planned for March/April 2021. The observations will be analysed by a unique palette of sophisticated model tools. A probabilistic short-term forecast system will be developed and shared with MET Norway and other scientific aircraft operators. Also planned are several model sensitivity experiments to test the isotope-enabled, regional numerical weather prediction model COSMO-iso as well as the AROME Arctic model.

More information on ISLAS can be found at their *website*.

Measuring the stable isotope composition of the lower 2 m above snow, sea ice and open water at Ny Ålesund in February 2020 (photo: Harald Sodemann).

11

Is Alaska Prepared for Extreme Wildfires? – New Polar Prediction Matters Article

by Sara Octenjak, Barcelona Supercomputing Center

Polar Prediction Matters is a platform for dialog among users and providers of polar weather and sea-ice forecasts. A *new post* by researchers from the YOPP-endorsed EU 2020 Horizon *APPLICATE* project introduces a case study of Alaska's extreme 2019 wildfire season and related forecasting.

The work described in the post is part of a series of case studies the YOPP-endorsed project is undertaking to examine the relationship between weather, climate and sea-ice forecasting and specific events that have significantly affected certain communities or economic sectors. This particular one focuses on the local and global impacts of wildfires in Alaska as well as on APPLICATE scientists' contributions to forecasting such extreme events. The aim is to enable those affected to better prepare for the future.

Vast areas of multiple Arctic regions, in Siberia, Canada and Greenland, burned in the summer of 2019. Alaska in particular experienced a severe drought and heatwaves during July and August. Scientists recorded some of the highest temperatures and lowest moisture levels since recordkeeping began in 1952; the risk of fire from April to September was above average. More than seven hundred wildfires consumed over a million hectares of land in 2019 and sent smoke across an even larger area, polluting the atmosphere with fine particles of black carbon. The polluted air harmed humans and ecosystems across the region. The numerous large wildfires will also have exacerbated climate change by contributing to the release of a large quantity of CO_2 that was stored in soil and permafrost throughout the region.

The severe impact of the fires, according to the case study, emphasizes the need to use and improve systems that allow communities to predict and better prepare for extreme fires. Scientists from ECMWF and other participating institutions in the APPLICATE consortium have been working nonstop to predict essential climate variables, such as temperature and precipitation. They are also improving the predictive skill of the Extreme Forecast Index (EFI) for regions where potentially anomalous, extreme or severe weather conditions are forecast to deviate from the local climate. The forecast climate variables and the EFI are closely connected to the risk of wildfire, and they can help authorities make more efficient risk management decisions. For instance, numerical weather prediction models (which forecast the next few days' weather) predicted extremely high temperatures for 07–09 July – one week in advance of the dry spell. Concurrently, a high-resolution fire danger forecast warned of increased risk of fire six days in advance. Such warnings can help authorities reposition firefighting resources so they are available when and where needed.

In summary, wildfire management in boreal forests is not only crucial to the local environment but also globally relevant, since successfully managing wildfires can contribute to limiting greenhouse gas emissions. APPLICATE scientists are therefore working on further improvements to the forecasting systems that contribute to better wildfire management.

Find the Polar Prediction Matters contribution on extreme wildfires in Alaska *here*.

(Photo above: Pixabay)

12

Three New Episodes of *The IcePod*

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

In three further episodes of the podcast *The IcePod*, we spoke with Robert Hausen from the German Weather Service DWD, with Stefanie Arndt who is a sea-ice scientist at the Alfred Wegener Institute, and with the MOSAiC data manager Antonia Immerz.

Episode #7 – The Weather Man

Made your hobby into a profession? Everybody tries; Robert Hausen has succeeded. For the seventh episode of The IcePod, we met with Robert Hausen, a forecaster with the German Weather Service (DWD) who participated in leg three of the MOSAiC expedition.

Ever since childhood, Robert has always waited for snow. He grew up wondering about all kinds of weather phenomena. And where did he end up? Aboard the Polarstern. MOSAiC was his first Arctic cruise. He usually sails the Antarctic, which actually qualified him for the coldest leg that MOSAiC had to offer its participants.

Part of his job aboard the Polarstern was to inform people – every day at 8 a.m. – about that day's weather. For this, Robert had to examine various weather forecasts and choose the best fit for, well … we aren't going to reveal that here, so go listen to the episode!

He was eventually rewarded with a helicopter flight across the Arctic sea ice. This may also have been some consolation for not being able to return home to Germany for his daughter's birthday at the end of April. The third leg of MOSAiC ended up being the longest because of the upheaval caused by the COVID-19 pandemic. Another highlight for him was the crusted lamb served on Easter Sunday to the science team and crew. Robert helps us debunk some weather myths: "sheepy" clouds don't actually produce rain; red skies at night are not always a sailor's delight.

Episode #8 – Snowflakes, Pee Bottles and a MOSAiC of Floes

In episode eight of *The IcePod*, we hear back from Stefanie Arndt, who spoke with us prior to leaving for the Arctic (*[Bonus Episode One](#)*). Stefanie Arndt is a sea-ice scientist at Germany's Alfred Wegener Institute, and she has a "Smilla's" sense of snow. After 145 days away from home, she tells us all about the third leg of the MOSAiC expedition. Though Antarctic snow was her first love, this time Steffi ventured onto the fields of the north and flirted with Arctic snowflakes.

At the end of the passage aboard the Russian icebreaker Kapitan Dranitsyn, which carried leg 3 to the ice camp just as the sun returned, her stash of muesli she had brought from home ran out. But she survived to lead "Team Ice" through challenging times: not only was it the coldest leg of MOSAiC; there was also great uncertainty due to some very dynamic ice conditions. In addition, this leg of the voyage was extended because of the pandemic. Flights from Svalbard that were supposed to carry out the exchange with leg 4 were cancelled. But Steffi and her team adapted well to the new circumstances, studying spring conditions much longer into the season than they'd expected. As the days lengthened, the sea-ice energy and ice albedo changed. Eventually, the MOSAiC ice floe itself became a mosaic of ice floes…

What do you do when the urge to go gets urgent out on the ice? In case you didn't already know about the no-pee policy for MOSAiC field work, Steffi shares some little-known insights into some of the expedition's less majestic challenges. That's right – pee bottles were a thing.

Even polar scientists are not immune to Arctic temperatures, so you need a strategy for sampling snow at −40 °C. MOSAiC's own Smilla had a pretty elaborate system that involved warming pads and two layers of gloves beneath the plastic gloves needed to avoid contaminating the snow. Another way to keep warm was to "walk five hundred miles" over ridges of ice. Luckily, there was always hot tea for those returning from a long day out at the work camp, to a warm and cosy home called Polarstern.

Even as COVID-19 affected life on land, Steffi and the team of leg 3 could still stock up on hugs before leaving the ice to go home. It gave her strength she would be able to draw on for months to come...

Episode #9 – Hugs, Dips in Melt Ponds, and WiFi on the Ice

If anybody can wrap their mind around the innumerable data points collected during the MOSAiC expedition's icy year-long drift, it can only be Antonia Immerz. MOSAiC's data manager was on the Polarstern for the first and fourth legs. She is one of the lucky few – maybe we should call them "brave" – souls who took a bath in an Arctic melt pond. In this ninth episode of *The IcePod*, we slightly change perspectives by looking at MOSAiC from a "data point" of view.

Antonia started coordinating the data collecting activities and infrastructure for the Arctic ice drift at the Alfred Wegener Institute in 2018. We have uncovered in Antonia the perfect career path for a data scientist to be involved in such a huge project. Taking on this role meant things came together very well for her. She spent her childhood snorkelling the tropical beaches in Papua New Guinea, followed her childhood dreams about the marine world, and ended up at the right place and time to combine her technical skills with her fascination for the ocean.

The data is where the magic happens. Two hundred terabytes of it, and about 15,000 actions to retrieve it. And Antonia knows much more is available from this comprehensive central Arctic study that ended this past October. Now that everybody wants to analyse the data, the work for her and her team has reached a new level of intensity. Every success relies on the human factor, and communication is key to making it work – these are some of Antonia's "lessons learned" when it comes to efficiently supporting the MOSAiC members now working with the data. If you listen carefully, Antonia even telegraphs some not-so-secret tricks for potentially getting access to the data even if you weren't involved in the project before.

The fourth leg got nicknamed "the hugging leg" – it was probably the only place on Earth where one hundred people were still allowed to have physical contact while the rest of us, our faces half covered by masks, were making a huge effort to eye-smile at the cashier at the supermarket or the lady at the post office. Meanwhile, they were having a good old time on the Polarstern, having "art-and-wine nights", acting, knitting, wood carving or jamming. As a special treat for this IcePod episode, you get to hear the MOSAiC song composed by Matt Boyer, Ingo Schuffenhauer und Felix Linhardt, which they performed during the last CTD cast during leg 4. Antonia was lucky enough to turn a year older in the Arctic with great music and a hundred people at her party – seeking some harmony, peace, and "love in the time of COVID".

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

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The IcePod 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 research expedition in the Arctic. It is produced in collaboration with the Alfred Wegener Institute and Radio Weser.TV where the full episode with music will be played at www.medialabnord.de/radio-livestream/. For dates check back with polarprediction@gmail.com.

Photos (from left to right): Christian Rohleder/German Weather Service DWD; Stefanie Arndt/Alfred Wegener Institute; Marcel Nicolaus/Alfred Wegener Institute.

YOPP in 2020

2020 has been a year far from being normal. But community efforts to advance polar predictive skill were ongoing. Here's a summary of PPP activities and deliverables made available through the YOPP International Coordination Office

Jan

The IcePod #02 with **Thea Schneider - The Set-Up Scene**

Feb

17-18 February: YOPP Science Workshop and Icebreaker with Panel Discussion on „Decision-Making and Polar Prediction", German Maritime Museum, Bremerhaven, Germany

19-21 February: Polar Prediction Project Steering Group Meeting #11 at the Alfred Wegner Institute (AWI), Bremerhaven, Germany

The IcePod #03 with **Stefan Hendricks - The Moon Episode**

Mar

Version 3.0 of Year of Polar Prediction Implementation Plan released

Launch of ***MOSAiC Near Real-Time Verification Project***

Apr

Special Issue in Advances in Atmospheric Sciences: ***Antarctic Meteorology and Climate: Past, Present and Future***

Year of Polar Prediction Arctic Targeted Observing Period (TOP)

The IcePod #04 with **Gunnar Spreen - How do you like your eggs?**

PolarPredictNews #14

May

EGU General Assembly 2020

Silent but Busy - Sharing Geoscience Online: **Joint YOPP-APPLICATE Session** at ***EGU 2020*** via live chat

PolarPredictionMatters: Risks and Reward: Assessing the Ocean Risks Associated with a Reducing Greenland Ice Sheet

The IcePod Bonus #02 with **Markus Rex**

June

The IcePod Bonus #03 with **Gunilla Svensson** & ***#04*** with **Thomas Jung**

July

Special Issue in Polar Geography: ***Societal Value of Improved Forecasting***

Polar Prediction Matters: Ice and Weather Forecast Software Onboard Merchant Vessels

The IcePod #05 with **Anja Sommerfeld - 77 Luftballons**

PolarPredictNews #15

Aug

YOPP session at APECS-SCAR Workshop "Antarctic Science: Global Connections"

First live session of ***The IcePod Bonus*** with **Vicki Heinrich - Paid to look at the Clouds and Play with Balloons**

Sept

The IcePod #06 with **Taneil Uttal - Measuring the Zeros**

PolarPredictNews #16

Oct

Polar PredictionMatters: Is Alaska Prepared for Extreme Wildfires?

The IcePod #07 with **Robert Hausen - The Weather Man**

Overview Paper in BAMS by Bromwich et al. **The Year of Polar Prediction in the Southern Hemisphere (YOPP-SH)**

Polar Prediction Matters: In Antarctica, the Weather Comes First

YOPP DATA PORTAL YouTube

New Video Tutorial How to Search for Data in the YOPP Data Portal

Nov

Paper in Scientific Data by Bauer et al. **ECMWF global coupled atmosphere, ocean and sea-ice dataset for the Year of Polar Prediction 2017-2020**

The IcePod #08 with **Stefanie Arndt - Snowflakes, Pee Bottles and a Mosaic of Floes**

Dec

The IcePod #09 with **Antonia Immerz - Hugs, Dips in Melt Ponds, and WiFi on the Ice**

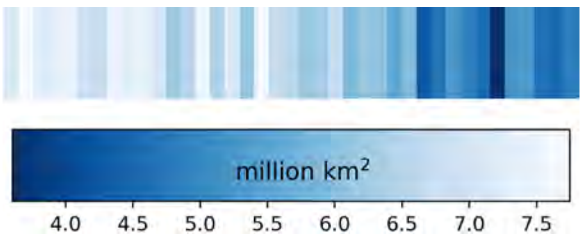
Photo credits: Stefanie Arndt, Martina Buchholz, Stefan Hendricks, Mario Hoppmann, Esther Horvath, Marcel Nicolaus, Sara Pasqualetto, Thomas Rackow, Nadine Wieters (all), Christian Rohleder, Steffen Schröter, Julia Wenzel (all German Weather Service DWD), Eva Dalin (Stockholm University),Peter Hargreaves, Michael Gallager (NOAA), Graham Oakley, Darrel Swift (University of Sheffield), Advances in Atmospheric Sciences, American Meteorological Society, Polar Geography, Pixabay, Royal Arctic Line.,Springer Nature, YouTube.

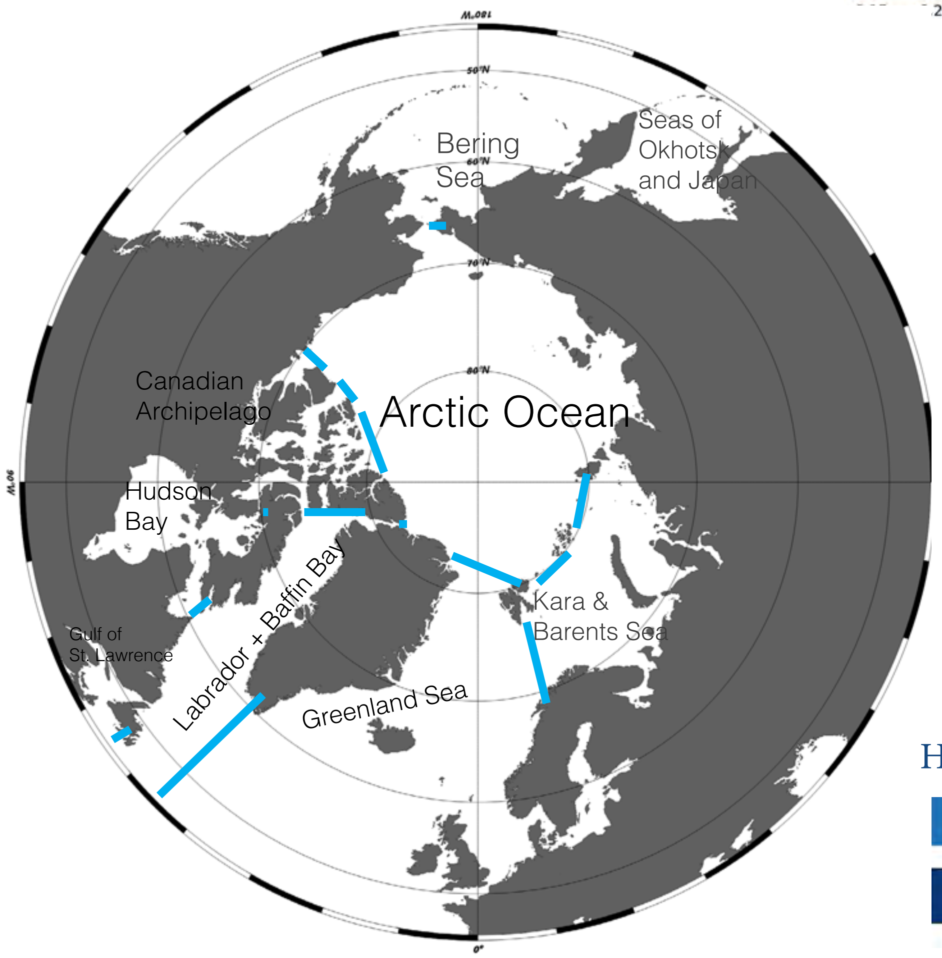
Art + Science

The Melting Sea-Ice Stripes by Thomas Rackow

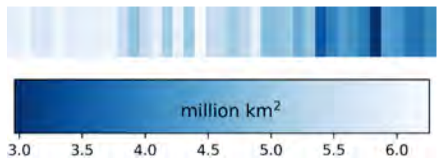
On this page, you‘ll find an overview of Thomas Rackow‘s melting sea-ice stripes (see also p. 1) We give the according colorbars and ranges for all „melting stripe“ design elements in this issue of PolarPredictNews. One can clearly see that while September Arctic sea ice declines quickly from 1979 to 2017, Antarctic sea ice is relatively stable over the multi-decadal timescale shown here (we chose also September for illustration). It is only in the last four years that Antarctic sea ice shows strong negative anomalies, and the causes and likely future evolution of Antarctic sea ice is focus of ongoing research.

Total Arctic Ocean

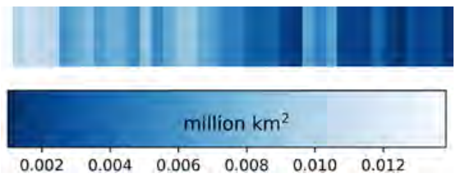




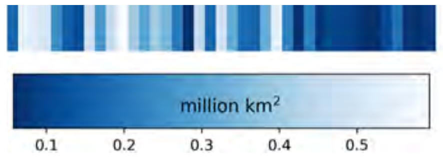
Central Arctic Ocean



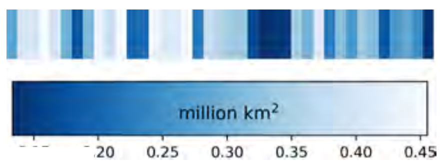
Bering Sea



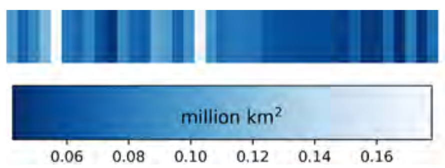
Kara & Barents Sea



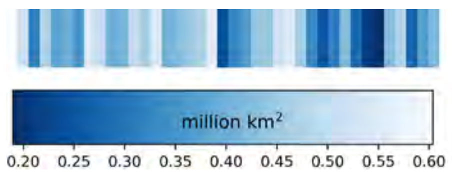
Greenland Sea



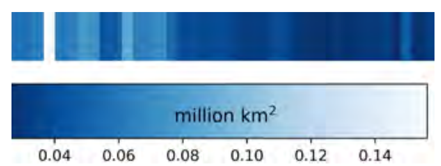
Baffin Bay & Labrador Sea



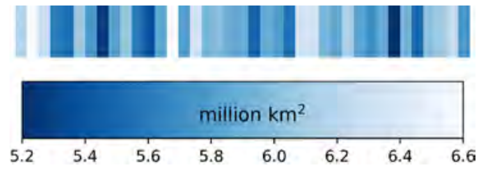
Canadian Arctic Archipelago



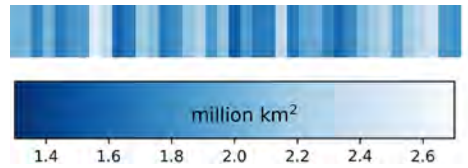
Hudson Bay



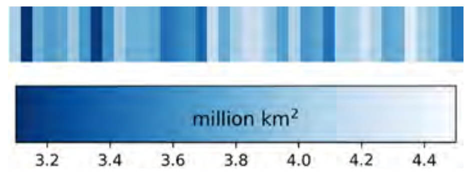
Weddell Sea



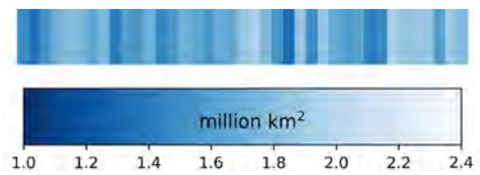
Bellingshausen & Amundsen Seas



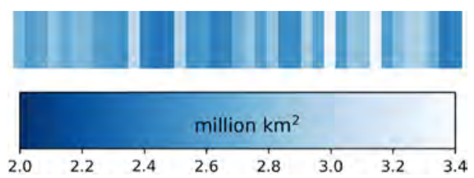
Ross Sea

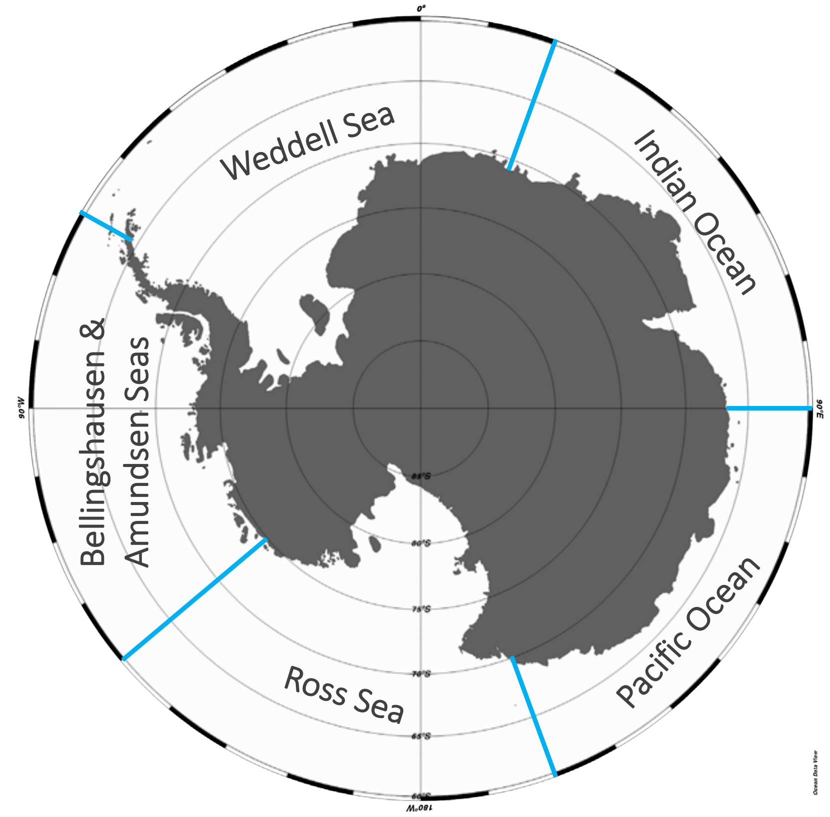


Western Pacific Ocean

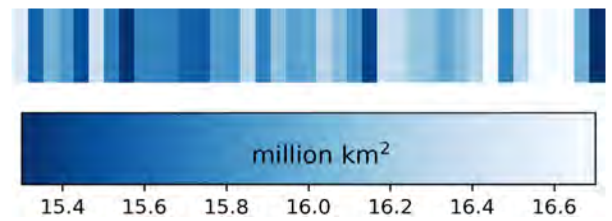


Indian Ocean





Total Antarctic Sea Ice



The Antarctic melting stripes all have a range of −0.7 to +0.7 million square kilometres around their respective mean sea-ice extents (in the middle). With [data from NASA](#) (1979–2017), which splits the Antarctic into five pie-piece sectors, it becomes possible in principle to compare among trends. However, note that the different sectors vary somewhat in size, and ice cover around Antarctica is not zonally symmetric. For the Arctic, the minimum and maximum values of the colour bars as well as their ranges vary from region to region. Since the size of the regions as defined by NASA also varies much more in the Arctic than in the Antarctic, one cannot easily intercompare melting stripes and rates of change from one region to another this way. If one of our readers has a good idea for a more inter-comparable definition, please reach out to Thomas Rackow (thomas.rackow@awi.de). To give it a go, the original scripts are openly available on [GitHub as Jupyter notebooks](#).

13

What's Happening This Year? – PPP/YOPP (Virtual) Meetings 2021

PPP Steering Group Annual Meeting #12 – All Virtual

From 8–12 March 2021, the twelfth annual PPP Steering Group will take place virtually. In order to facilitate participation by all PPP Steering Group members, time slots of two to three hours per day will be carefully chosen to cover time zones around the globe. Key topics to be discussed and reviewed at the meeting will be the final two years of the Polar Prediction Project (in particular the self-evaluation of PPP/YOPP), the third Polar Prediction School and the YOPP Final Summit to be held in Montreal, Canada, in May 2022.

PPP/YOPP Participation in Other Conferences and Meetings

Arctic Science Summit Week
20–22 March 2021
Together with the Association for Polar Early Career Scientists (APECS) and the Young Earth System Science (YESS) network, the International Coordination Office for Polar Prediction is organizing an early career researchers (ECR) workshop. It will consist of three sessions during the 2021 virtual *Arctic Science Summit Week*. Amongst others, an overview of a number of Arctic YOPP-endorsed activities will be highlighted. One of the sessions will also be on the impact of COVID-19 on early career scientists, including the polar prediction community.

16th Workshop on Antarctic Meteorology and Climate (WAMC) & YOPP in the Southern Hemisphere Meeting (YOPP-SH)
21–25 June 2021
An online version of the annual WAMC will take place on 21–23 June 2021. The workshop invites the community active in research and operational/logistical interests in Antarctic meteorology and forecasting and related disciplines. This workshop also is a forum for current results and ideas in Antarctic meteorology, observations, automatic weather stations, numerical weather prediction, and weather forecasting, from contributors around the world. There will be discussions on the relationships among international efforts and Antarctic forecasting, logistical support, and science.

As in previous years, the YOPP-SH meeting will occur in conjunction with WAMC. The virtual meeting aims to feature research resulting from the summer Special Observing Period (SOP) in 2018-2019 along with plans for participation in the upcoming winter SOP mid -April to mid-July 2022. More updates will follow through the YOPP-SH email list and on the *PPP website*.
(kw)

14

Keen for Even More Screentime? – Upcoming (Online) Meetings

17 March 2021
ASM3 Theme 3, Respond: Sustainable development; Evaluation of vulnerability and resilience; Application of knowledge
Online

20 – 26 March 2021
Arctic Science Summit Week (ASSW) 2021
YOPP-APECS-YESS joint workshop (21/22 March 2021) during *Business Meetings Program*
Online, hosted by Portugal

06-11 April 2021
One Health, One Future
Online, hosted by the University of Alaska, Fairbanks

07 April 2021
ASM3 Theme 4, Strengths: Capacity building; Education; Networking; Resilience - prepare the next generation
Online

15 – 17 April 2021
50th International Arctic Workshop
Online, hosted by INSTAAR, Boulder, CO, USA

19 – 30 April 2021
EGU General Assembly 2021
Online

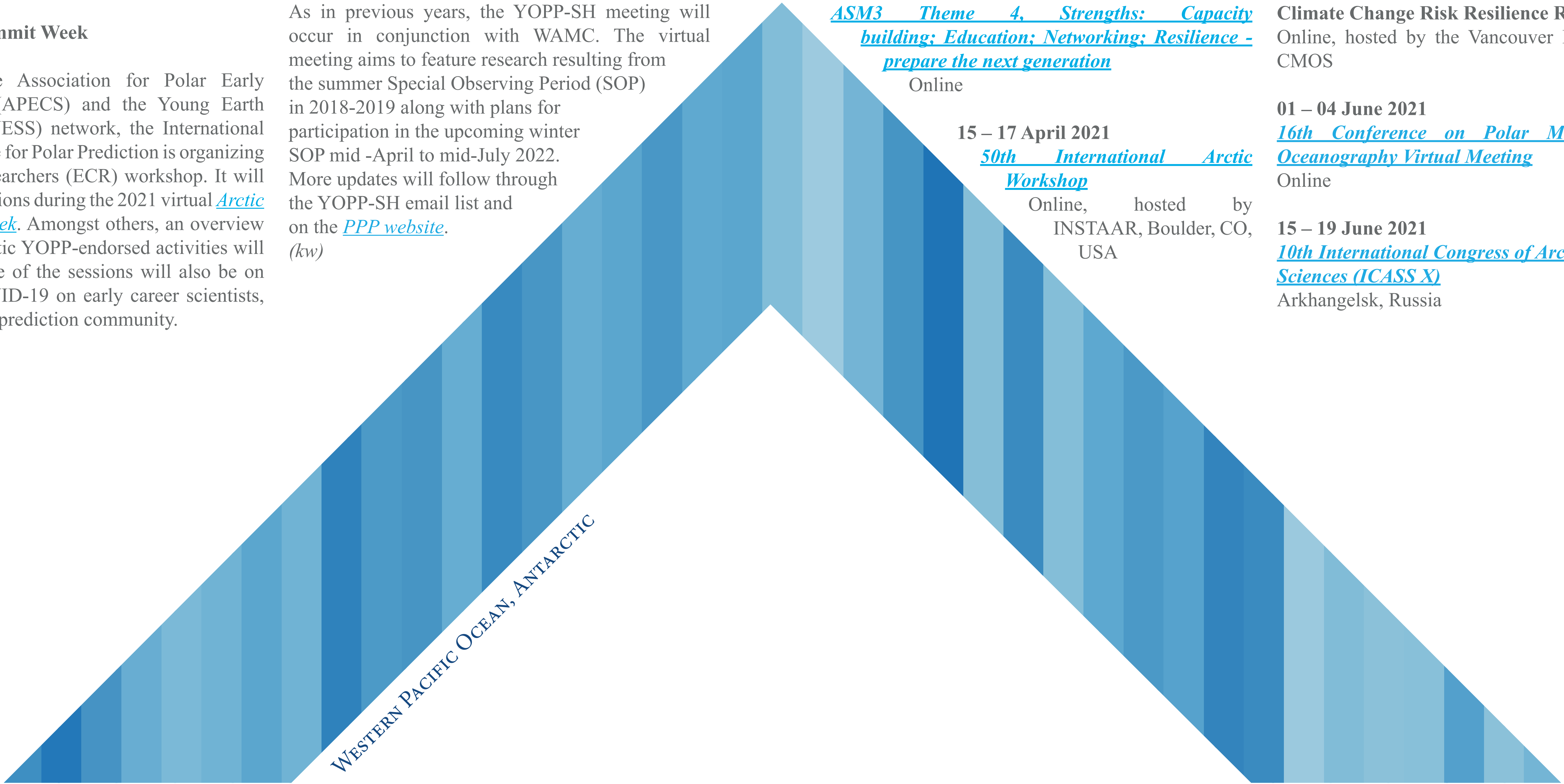
08 – 09 May 2021
3rd Arctic Science Ministerial
Tokyo, Japan

13 – 15 May 2021
38th International Polar Symposium "Environmental Changes in Polar Regions: New Problems - New Solutions"
Toruń, Poland

31 May – 11 June 2021
55th Canadian Meteorological and Oceanographic Society (CMOS) Congress
Climate Change Risk Resilience Response
Online, hosted by the Vancouver Island Centre of CMOS

01 – 04 June 2021
16th Conference on Polar Meteorology and Oceanography Virtual Meeting
Online

15 – 19 June 2021
10th International Congress of Arctic Social Sciences (ICASS X)
Arkhangelsk, Russia



15

Operational Satellite Microwave Products for High Latitude and Polar Area Models – EUMETSAT-YOPP Workshop

In order to foster the utilization of satellite microwave data in weather, climate, ocean and sea-ice prediction services at high latitudes, EUMETSAT and YOPP organized an all-virtual joint workshop on 23/24 February 2021.

The use of satellite microwave observations has become essential to weather prediction and climate projection services. This pertains especially to polar regions, where the conventional observational network is generally sparse compared to the rest of the world. Satellites provide important information that benefits both coupled and stand-alone atmosphere-ocean-sea-ice models in numerical weather prediction (NWP) systems. But numerical experiments within the framework of YOPP, amongst other projects, have shown for example that the use of observations from microwave sounders still does not yield optimal performance.

To address the lag, YOPP and EUMETSAT organized an online workshop entitled "The Optimal Use of Satellite Microwave Products for High Latitude and Polar Area Models". It brought together experts from the full breadth of fields that contribute to weather, water, ice and climate (WWIC) information services, from satellite product development, coupled NWP or climate modelling, data assimilation, radiative transfer and in-situ observations. The workshop took place on a Tuesday and Wednesday, from 23 to 24 February 2021. Like most meetings these days, this scientific workshop has been fully virtual.

The workshop included several panel discussions with a number of experts who identified current issues with the usage of satellite microwave products. This fed into an important discussion about the most promising approaches to effectively increasing the uptake of microwave observations in NWP and climate systems.

For further information, please check the workshop's website. *(db)*

16

Second Virtual EGU General Asssembly 2021 – #vEGU21: Gather Online

The 2021 European Geoscience Union (EGU) General Assembly will take place from 19 to 30 April 2021, virtually now for the second time. Building on last year's "EGU2020: Sharing Geoscience Online", the virtual EGU 2021, or #vEGU2021, has been reconceived to let participants attend remotely from all around the globe. Registration is open through 31 March 2021.

The European Geoscience Union (EGU) is Europe's leading organization for Earth, planetary and space science research. EGU fosters fundamental geoscience research alongside applied research that addresses key social and environmental challenges.

Since opportunities for scientists to network and inspire one another in 2020 were so limited, and with the majority of researchers now working from home, EGU is trying to counteract the ongoing situation by hosting, now for the second time, a virtual platform for geoscientists from around the world to engage with one another. #vEGU21 is holding nearly seven hundred geoscience sessions, the bulk of them taking place from 26 to 30 April.

Multiple sessions will be relevant to the polar prediction community. For example, Irina Gorodetskaya and colleagues, who are involved in the YOPP-Southern Hemisphere Task Team, have put together one called "Clouds, moisture, and precipitation in the Polar Regions: Sources, processes and impacts". A list of all sessions related to PPP and YOPP can be found here. The complete #vEGU2021 programme is available here.

Haven't registered yet? It's possible to do so through the end of the conference. Early registration rates are available until 31 March 2021; registration fees are found here. Standard registration rates apply from 01 April 2021 through the end of the conference. The event is free of charge for undergraduate and master's students.

Questions or concerns about #vEGU21 can be submitted through the provisional format page or emailed to egu21@copernicus.org. *(lh/db/kw)*

17

All Aspects of Human Existence in the Arctic – The 10th International Congress of Arctic Social Sicneces (ICASS X)

The 10th International Congress of Arctic Social Sciences (ICASS X) is set to take place 15 to 19 June 2021 in Arkhangelsk, Russia. A PPP-SERA session there will address the economics and social sciences aspects of the Polar Prediction Project.

Approximately four million people of numerous ethnicities inhabit the Arctic. Indigenous peoples make up more than ten percent of the total Arctic population.

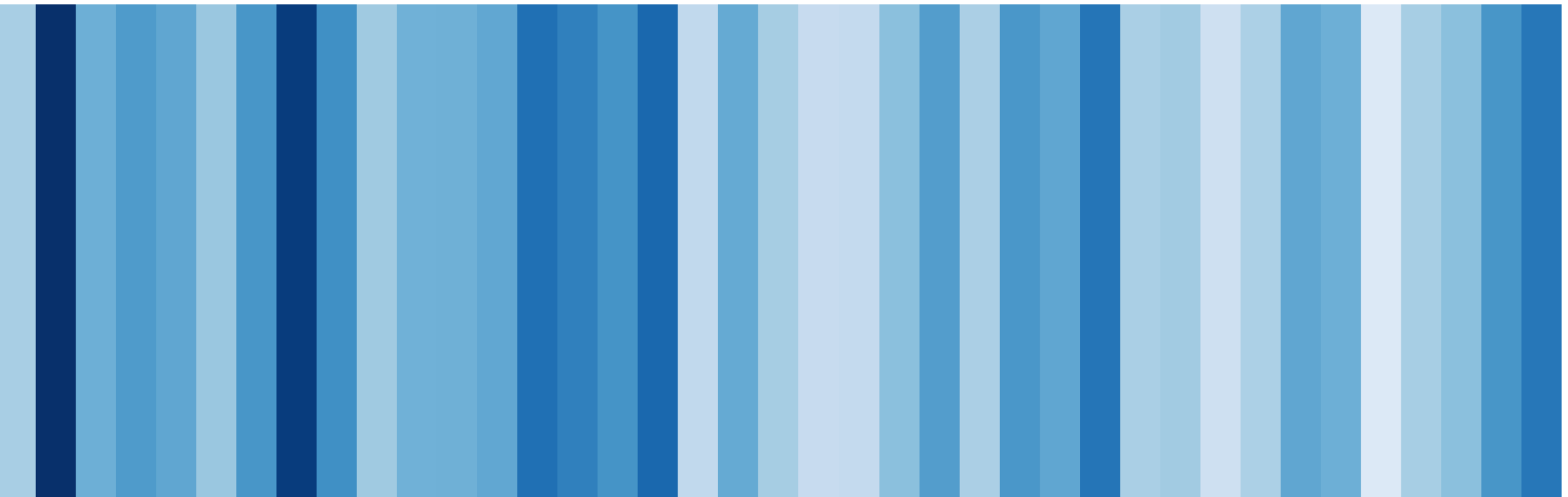
The 10th International Congress of Arctic Social Sciences (ICASS X) will focus on all aspects past, present and future – social, cultural, historical, economic, political and linguistic to name a few – of human existence in the Arctic. The topic is nothing less than the history and future of Arctic peoples, and ways to make their environment sustainable for generations to come. Co-production of knowledge together with holders of Indigenous knowledge and other Arctic stakeholders will be an important issue.

The PPP Societal and Economic Research and Applications (SERA) task team is going to hold a session there called "Tailoring Environmental Forecasting Information and Services to Diverse Polar Needs". Its organizers, Daniela Liggett (University of Canterbury), Machiel Lamers (Wageningen University) and Yulia Zaika (Kola Science Center of the Russian Academy of Sciences), aim in particular to present the economics and social sciences aspects of the Polar Prediction Project. Presentations of research on the need for and uses of environmental information are encouraged, including ones relating to decision-making by the diverse range of polar actors as well as to providers of environmental information. The PPP-SERA task team is seeking to encourage communication between providers and users of polar weather and ice information.

ICASS X is being put on by the International Arctic Social Sciences Association (IASSA) and co-hosted by the ARCTICenter at the University of Northern Iowa (USA) and the Northern Arctic Federal University (Russia). Indigenous peoples, northern residents, decision-makers, politicians and academics are all encouraged to participate.

More information is available on https://icass.uni.edu/. *(lh)*

Ross Sea, Antarctic



18

Capture the State of the Art of Co-Production Approaches in European Arctic Research – A PPP-SERA Arctic Stakeholder Workshop

The PPP Societal and Economic Research and Applications (PPP-SERA) task team hosted a special services projects workshop on 25 January 2021. Bringing together relevant stakeholders involved in weather, water, ice and climate (WWIC) information services, this online workshop aimed to capture the state of the art of co-production approaches in European Arctic research.

Now that they face a changing Arctic, communities, researchers and economic stakeholders across the circumpolar north are eager to learn about sophisticated environmental forecasting. All these constituencies rely heavily on valuable weather, water, ice and climate (WWIC) information. In light of this, a growing number of information providers are now calling for advanced approaches to co-producing WWIC information services.

On 25 January 2021, an online workshop took place entitled "Co-Production in the European Arctic Weather, Water, Ice and Climate Services". Organized by PPP-SERA members Machiel Lamers and Jelmer Jeuring, it aimed to bring together researchers and representatives from past and present projects in the European Arctic region. The workshop focused on co-production of WWIC information services for the benefit of communities and economic sectors. By facilitating an exchange of information about their experiences and challenges, this workshop will contribute to a better understanding of the diversity of approaches to co-production as well as to the creation of a roadmap for future activities. Experts offered insights into a number of fields that relate to WWIC services. Among the presenters were Kirstin Werner (PPP), Annette Scheepstra (EU-PolarNet), Marta Bruno Soares (University of Leeds), Berill Blair (SALIENSEAS) and Marta Terrado (APPLICATE). Various breakout sessions provided for interactive engagement and joint discussion by all participants. (*db*)

Photo: Machiel Lamers/Wageningen University.

19

Arctic Change 2020 Session Brought Together Producers and Users of WWIC Data and Services

by Jackie Dawson, University of Ottawa and Daniel Butkaitis, WWRP International Coordination Office for Polar Prediction/Alfred Wegener Institute

During the Arctic Change 2020 conference, a special session on weather, water, ice and climate (WWIC) services took place, co-chaired by members of PPP-SERA. The session brought together WWIC users and providers from different industries and institutions all around the globe. Outside the presentations, the importance of end-user engagement and collaboration with local communities was discussed and highlighted.

2020 was a year like no other for Arctic research, and ArcticNet's Arctic Change conference was no exception. It is generally held every three years at different locations in Canada. This year, the global COVID-19 pandemic shifted the international conference to a virtual setting, with 1,600 attendees tuning in online from across Canada and around the world. This year, there were 327 Northern participants and dozens of international delegates representing Arctic and non-Arctic nations around the globe.

Of the 320 virtual presentations with live question and answer sessions, many were highly relevant to exploring and better understanding the need for enhanced and improved weather, water, ice, and climate (WWIC) services and service delivery. Topical and plenary sessions covered everything from innovation in satellite technology for marine and terrestrial environmental systems observation to the role of Indigenous knowledge in science.

A special session on WWIC services was co-chaired by members of the Polar Prediction Project's Societal and Economic Research Applications group (PPP-SERA): Gita Ljubicic from McMaster University, Canada and Jackie Dawson from the University of Ottawa. International presenters in the session discussed innovations in and needs of WWIC service provision and use in the polar regions. Presentations were given by, amongst others, Marta Terrado (Barcelona Supercomputing Center), Victoria Heinrich (Australian Bureau of Meteorology), Rick Thoman (Alaska Center for Climate Assessment and Policy) and Lynn Moorman (Mount Royal University, Canada). The session was attended by more than sixty participants representing a variety of service providers and end users from the shipping, oil and gas, tourism, fisheries, aviation and education sectors.

A rich question and answer session revealed the importance of engagement with Indigenous persons from the Arctic to enhance WWIC services and service provision to ensure safe local mobility. Similarly, the need to connect with end users and experts to enhance safe navigation in the Antarctic was emphasized.

A special session and side meeting focused on WWIC are being planned for the December 2021 ArcticNet meeting to be held in Toronto, Canada (or virtually depending on COVID restrictions).

Further information on the Arctic Change conference 2020 can be found *here*.

20

Meet the Demand for Environmental Data from All Sectors of Society – A WMO Data Conference

by Øystein Godøy, Norwegian Meteorological Institute

A *WMO Data Conference* was held from 16 to 19 November 2020 as a fully virtual conference. The purpose of the data conference was to engage a wide community in discussions of WMO data policy. WMO adopted an open data policy early on that was effectively implemented in three different WMO data policy resolutions that helped form the basis for the open data policy of the International Polar Year 2007–2008. The data policy is now under review. This data conference was part of the stakeholder engagement portion of the review process.

Since the establishment of WMO in 1950, the traditional WMO community has expanded its involvement of communities external to the organization, seeking to meet the demand for weather, climate, water and other environmental data in all sectors of society. Among these communities are both consumers and providers of relevant data and services. The conference was thus organized around four themes: *The changing landscape of weather, climate and water data*; *Business models and data policy issues*; *Filling the gaps in global data coverage*; and *Data exchange for Earth system monitoring and prediction*. Participants were drawn from a wide range of communities including WMO Members, space agencies, the private sector, global data users, academia, development partner organizations and other United Nations agencies and international organizations. For an introduction to the conference, a number of workshops were arranged that explored details of the conference's themes from stakeholders' perspectives.

The conference was designed to achieve several particular outcomes: *Common understanding among all sectors of data exchange and its role in supporting the goals laid out in the WMO convention and the global agenda as articulated in the UN Sustainable Development Goals*; *improved understanding of the role of the private sector in data provision; stronger links between the private and public sectors; identification of the main obstacles to increased exchange of data and specific opportunities or activities to try to overcome them*; and *recommendations for decision-making at the WMO Executive Council and the World Meteorological Congress in 2021*.

The conference and the preceding workshops provided valuable input to the review process from communities both within as well as outside WMO. In particular, strong support was expressed for WMO maintaining a free and open data policy as well as for the development of a unified WMO data policy to include all Earth System disciplines. In this context, it was decided that the three existing data policy resolutions mentioned earlier will be replaced by a single resolution as a way to simplify the data policy issue for WMO activities and programmes. It was also noted that while advances in technology will help to implement the data policy, technology should and will not define the policy. Participants voiced some concern about the potential for conflicting national data policies among WMO Members to limit the capabilities of environmental monitoring and prediction. On the topic of gaps in Earth system observations, participants highlighted an increased level of engagement between National Meteorological and Hydrological Services and partnering communities, emphasizing the mutual benefits of data exchange and collaboration. This latter element is particularly important in the polar regions, where many monitoring efforts are undertaken by the academic community.

WMO, through efforts of the WMO Secretariat and the Study Group on Data Issues and Policy, is currently analysing the outcomes of the WMO data conference and related workshops as well as their meaning for WMO Data Policy.

For more information, please visit *https://public.wmo.int/en/events/WMO-Data-Conference*.

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Third Arctic Science Ministerial – A Webinar Series

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

In order to nurture scientific exchange between Arctic researchers even under pandemic conditions, the organizers of the third Arctic Science Ministerial (ASM3) have launched a webinar series. Scientists, Indigenous peoples and other Arctic stakeholders are invited to stay engaged in the scientific process in the run-up to the third Arctic Science Ministerial meeting to be held in Tokyo in May 2021.

Mitigating the impacts of climate change in the Arctic may be one of the biggest challenges our society nowadays faces. International cooperation and science-based policy will be essential to counteracting global warming, which is affecting the livelihoods of Arctic communities all over the circumpolar north, where its effects are most noticeable. Bolstering cooperation amongst Arctic scientists has therefore been a key goal of the Arctic Science Ministerial meetings. The first two were hosted by the United States of America in Washington, D.C. in 2015 and by the European Commission, the Republic of Finland and the Federal Republic of Germany in Berlin in 2018.

Ongoing travel restrictions because of the pandemic forced a postponement of the third ASM meeting, which was to take place in November 2020. It is now scheduled for 08–09 May 2021 in Tokyo. Co-hosts are Iceland and Japan. To keep scientific dialogue open, the European Polar Board launched a monthly webinar series to get ready for the ASM3 meeting. Everyone interested is invited to participate in the meetings and workshops that will be taking place online through June 2021. The webinars aim to increase the transparency of the ASM science process and to on-board all Arctic stakeholders including scientists, Indigenous communities and other groups living or working in the Arctic.

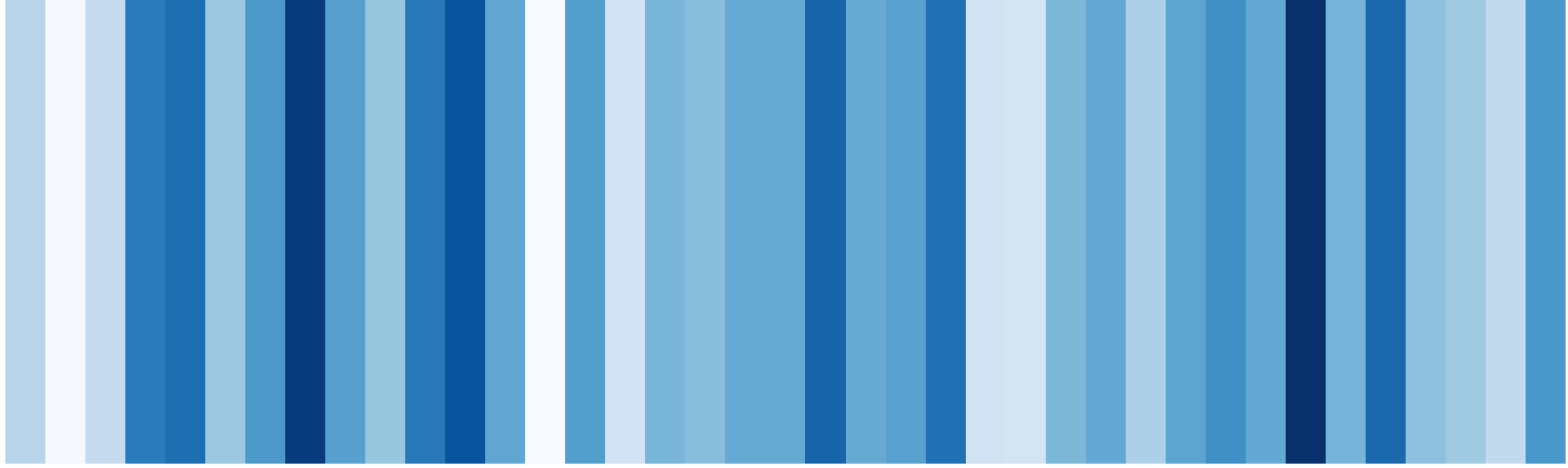
Gaps and Barriers in International Arctic Research

The second online seminar, held on 11 November, focused on current gaps in and barriers to international Arctic research. Over 130 participants from all over the world logged into the Zoom meeting. Participants stressed the need for more international cooperation but also highlighted opportunities in Arctic research. A panel of five speakers presented their work as well as synthesis reports from recent research projects, giving best-practice examples of international cooperation. MOSAiC project manager Anja Sommerfeld spoke, elaborating on lessons learned during the one-year ice-drift mission and why MOSAiC is a shining example of fruitful international cooperation. After the presentations, attendees met up in various breakout sessions to specify what needs to be done to improve international cooperation. Their conclusions will be part of the final report of the ASM3 meeting.

Two more webinar sessions will take place on 17 March and 07 April, all 1300–1400 UTC. There will also be a post-ministerial webinar, taking place on 09 June 2021, 1300–1500 UTC.

The online platform the ASM3 webinars use is Zoom. Each session will be recorded and uploaded on the European Polar Board [YouTube-Channel]().

For more information and registration for the sessions see https://asm3.org/webinar-series/.



Weddell Sea, Antarctic

22

First Integrated European Polar Research Programme Published

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

EU-PolarNet has recently wrapped up its work on an integrated European polar research programme to guide future research in response to current and future needs and expectations of European societies in changing polar regions. Two new white papers have been released under the new programme.

After five years of thrilling collaborative work, EU-PolarNet has now published the new European Polar Research Programme (EPRP). The new programme will contribute to a better understanding of societal and environmental vulnerabilities in both polar regions. Six overarching research issues have been identified that will require close collaboration with local stakeholder groups. Answering the research questions posed in the EPRP will further improve our knowledge of the interactions between natural and social sciences. The EPRP also emphasizes the need for a campaign of polar observation to "build upon and extend the Year of Polar Prediction effort".

EU-PolarNet has also published two new white papers. One, the "White Paper on Status of Stakeholder Engagement in Polar Research", offers evidence-based advice on best-practices for communication and engagement with polar stakeholders. The other, the "White Paper on European Polar Infrastructure Access and Interoperability", discusses how to improve access and interoperability and comes with a plan for implementing EPRP to enhance prospects for the success of future polar operations.

EU-PolarNet began in 2015 as the world's largest consortium for polar research. Its expertise and infrastructure were provided by 22 of Europe's leading Arctic research institutions. The initiative received € 2,000,000 in funding from the EU Horizon 2020 programme. Throughout the last five years, the consortium's ambition has been to advance international cooperation as well as cooperation with stakeholders; to advise policymakers regarding the polar regions; and to identify the social relevance of polar research needs.

EU-PolarNet 1 came to an end in June 2020. But its work is not finished. Rather, we are already at the doorstep of the second phase of the consortium, EU-PolarNet 2. EU-PolarNet 2 has grown remarkably beyond the first phase. It now numbers 25 partners and includes all European countries. EU-PolarNet 2 will continue to build upon the polar framework that has crystalized over the last few years. It will develop a platform where participants can mutually advance future polar research activities.

For more information about EU-PolarNet 2, have a look at the "Kick-Off Event", which took place during the 2020 European Polar Science Week. A video of the event is still up and can be found here.

To access the European Polar Research Programme and white papers, visit the EU-PolarNet web page: https://www.eu-polarnet.eu/.

 NEW PUBLICATIONS

23

High-Resolution Ensemble Prediction Systems Over the Antarctic

In a new study by Gonzalez et al., the high-resolution Ensemble Prediction System (EPS) γSREPS recently developed by the Spanish Meteorological Organization (AEMET) has been validated in comparison with the ECMWF EPS. Their findings show that γSREPS presents added value over ECMWF EPS and will benefit future logistics activities and general safety in the Antarctic Peninsula.

Increasing logistics activity means skillful weather predictions are becoming crucial to the safety and security of scientific operations on the Antarctic continent. But the low density of assimilated weather observations in most high-latitude areas of the southern hemisphere limits the performance of numerical weather prediction (NWP) systems. In order to improve forecast skill for future logistics at the Spain's Juan Carlos I (JCI) research station, the Spanish Meteorological Agency (AEMET) has developed the first operational convection-permitting limited area model ensemble prediction system (LAM-EPS) over Antarctica. It goes by the name γSREPS. It uses four mesoscale NWP models, each driven by three different global NWP models as boundary conditions (BCs). That is, it runs on three different global assimilations to account for southern hemisphere mesoscale and synoptic uncertainties and, as a result, consists of twelve ensemble members. It has a horizontal resolution of 2.5 km and 65 vertical levels.

During Spain's Antarctic campaign of 2018/2019, which coincided with the YOPP Southern Hemisphere Special Observing Period, γSREPS was integrated at 0000 UTC for up to 48 hours over the Antarctic Peninsula (where the JCI research station is located) and operationally integrated into daily forecasting. Over the course of the campaign, forecasters subjectively assessed its performance very positively and perceived added value over ECMWF EPS, especially with respect to mesoscale wind and visibility features around Livingston Island. The authors objectively verified γSREPS in comparison with ECMWF EPS through a particular focus on 2 m temperature (T2m), 10 m wind speed (S10m) and visibility (vis). In this context, γSREPS improved forecast skill for all assessed variables except sea-level pressure.

A number case studies were also carried out. One of them, conducted during a low-level cloud event on 5 March 2019, compared the probability values for visibility and ceiling as determined by either ensemble. The results confirmed that γSREPS, due to its high resolution, better represents the orography of the Antarctic Peninsula. Thanks to the better articulated results of γSREPS predicting good-enough visibility, forecasters could confidently recommend that planned scientific operations be carried out that day, where ECMWF EPS would not have permitted it.

γSREPS shows that high-resolution EPSs will be the way forward for precise short-range weather predictions. Its approach, combining multi-boundary conditions with different NWP models, is somewhat unique and suited to studying the sources of uncertainty in polar prediction by segmenting outputs by BC and NWP. γSREPS will stay in operation during future campaigns. More members are to be added to the EPS. *(db)*

Gonzalez, S., Callado, A., Martínez, M., & Elvira, B. (2020). *The AEMET-γSREPS over the Antarctic Peninsula and the impact of kilometric-resolution EPS on logistic activities on the continent*. Advances in Science and Research, 17, 209–217.
https://doi.org/10.5194/asr-17-209-2020

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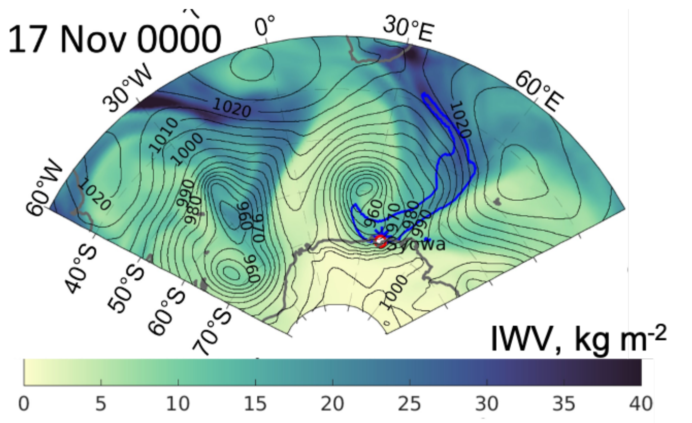
Atmospheric River Events in East Antarctica

In a new study, Gorodetskaya et al. analyse atmospheric river events over East Antarctica based on additional radiosonde measurements over Queen Maud Land during the YOPP Southern Hemisphere Special Observing Period during austral summer 2018/2019.

Atmospheric rivers (ARs) are narrow corridors consisting of air masses with high moisture and heat content. Forming at lower latitudes in the southern hemisphere, they are important in atmospheric moisture transport towards Antarctica and eventually add to the Antarctic ice sheet's surface mass balance. A group of scientists led by Irina Gorodetskaya from the Centre for Environmental and Marine Studies (CESAM) at the University of Aveiro, Portugal, have studied some salient past AR events that have affected the Neumayer III and Syowa research stations in East Antarctica. The team analysed radiosonde data gathered during the YOPP Southern Hemisphere Special Observing Period from 16 November 2018 to 15 February 2019 to identify high-moisture events that caused strong increases in humidity extending through the mid-troposphere and fed into strong low-level jet streams. Over Neumayer III on the Ekström Ice Shelf, moisture inversions have been observed at peak levels between 800–900 hPa, with the low-level jet concentrated below 900 hPa. Further to the east, at Japan's Syowa station, such humidity increases were usually less pronounced, with peaks near the surface. However, a substantial increase in wind speed occurred at heights between 825–925 hPa.

Both the ERA-interim and ERA5 reanalysis data effectively captured moisture transport within the vertical profile during AR events at the Neumayer III station, but they badly underestimated it at Syowa.



Atmospheric river affecting Syowa during YOPP on 17 November 2018 (source: Gorodetskaya et al., 2020).

Studies of enhanced moisture transport events from 2009 to 2019 show that they usually represent an extreme state of the lower-tropospheric profile compared to median values of temperature, humidity, wind speed and (thus) moisture transport. The authors emphasize the need for high temporal- and vertical-resolution radiosonde observations to better understand how these rare AR events contribute to total moisture transport over Antarctica. Such observations could also help improve representation of AR events in numerical weather prediction models. *(lh)*

Indian Ocean, Antarctic

Gorodetskaya, I. V., T. Silva, H. Schmithüsen, and N. Hirasawa (2020) *Atmospheric river signatures in radiosonde profiles and reanalyses at the Dronning Maud Land coast, East Antarctica*. Adv. Atmos. Sci., 37(5), 455–476.
https://doi.org/10.1007/s00376-020-9221-8

25

Wind-Induced Errors in Snow Observation – Verification of Snow Forcasts in Norway

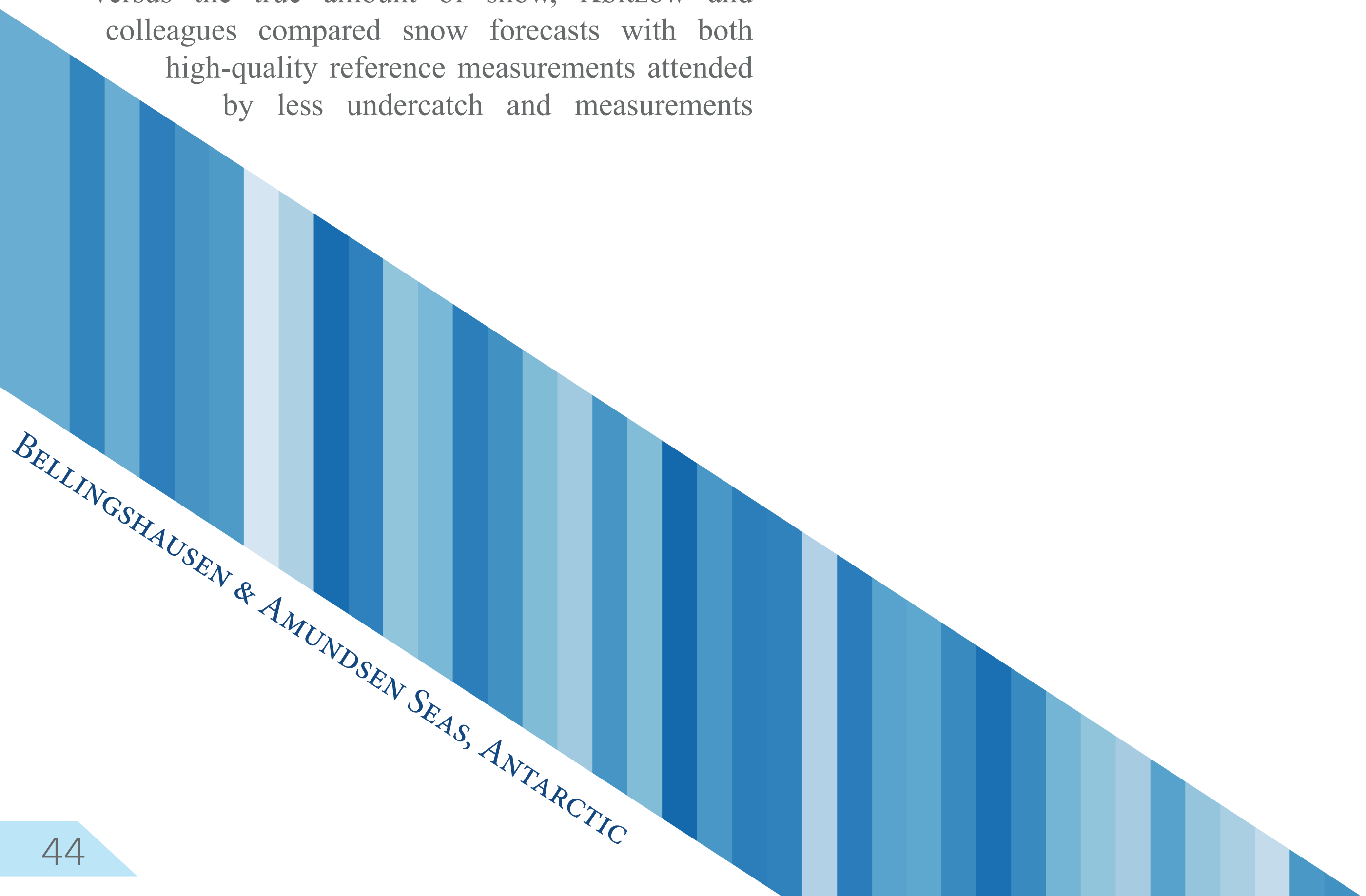
In their new study, Morten Køltzow et al. investigate how wind-induced undercatch in measuring solid precipitation affects weather forecast verification and discuss the impact of inaccuracies in snow measurement on the verification of precipitation forecasts for Norway.

All precipitation observations come with uncertainties. One of the largest uncertainties is caused by wind-induced undercatch hampering solid precipitation gauge measurements, where wind blows away snow which then cannot collect and be quantified at the gauge. Precipitation gauges are key not only to verifying weather forecasts. They also provide input to gridded precipitation products and help to ground-truth precipitation estimates from radar and satellite products. Even at moderate wind speeds, wind-induced undercatch of solid precipitation at precipitation gauges can be substantial. Undercatch makes it difficult to quantify actual precipitation amounts and hence to numerically assess the true quality of weather forecasts.

To overcome the discrepancy between the undercatch versus the true amount of snow, Køltzow and colleagues compared snow forecasts with both high-quality reference measurements attended by less undercatch and measurements from simpler, commonly available equipment that is vulnerable to substantial undercatch. Measurements were taken at the Norwegian observation site Haukeliseter. In a second step, the authors incorporated all Norwegian observation sites into their verification approach to test whether a transfer function would successfully adjust for any missing amounts of snow.

Their results show that wind-induced undercatch of solid precipitation has a substantial impact on the verification results. Furthermore, applying transfer functions to adjust for wind-induced undercatch of solid precipitation gives a more realistic picture of true forecast capabilities. But the transfer functions themselves introduce uncertainties that need to be taken into account. The authors conclude by recommending ways to verify solid precipitation forecasts. *(lh)*

Køltzow, M., B. Casati, T. Haiden, and T. Valkonen (2020) Verification of Solid Precipitation Forecasts from Numerical Weather Prediction Models in Norway. Wea. Forecasting, 35, 2279–2292. https://doi.org/10.1175/WAF-D-20-0060.1



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„The Use of Probabilistic Ice Forecasts is Still at an Early Stage" YOPP-endorsed! – The *SALIENSEAS* Project

Interview: Kirstin Werner and Laura Hüßner, WWRP International Coordination Office for Polar Prediction/ Alfred Wegener Institute

The YOPP-endorsed European SALIENSEAS project "Enhancing the Saliency of Climate Services for Marine Mobility Sectors in European Arctic Seas" is studying the specific needs of end users of Arctic climate information. The team made up of social and natural scientists working with experts from the Danish and Norwegian meteorological institutes (DMI and MET Norway) and end users of forecast services is jointly developing novel, customized, high-quality Arctic climate information products to serve users' needs. SALIENSEAS directly involves end users and other stakeholders in co-producing the knowledge needed to supply operational and strategic decision makers with weather and climate information. We spoke to PPP Steering Group member and PPP-SERA co-chair Machiel Lamers, associate professor with the environmental policy group at Wageningen University & Research and PI of SALIENSEAS.

Dr Lamers, what is the YOPP-endorsed project SALIENSEAS project about?

The SALIENSEAS project has taken action on multiple fronts to improve the quality of Arctic marine climate services and make them accessible to maritime end users in the European Arctic. For example, we have surveyed the needs of various shipping sectors in specific operational and planning contexts and developed new demonstration services for sub-seasonal sea-ice and iceberg forecasts. Demonstration services are niche information services developed in the context of a research project and made available temporarily for demonstration and user testing, but are not yet part of the permanent, publicly available service portfolio. All this work has been done by a transdisciplinary team of social scientists and natural scientists from the Danish and Norwegian meteorological institutes and end users in an iterative research and co-production process.

What exactly does co-production mean when working with providers and users of weather, water, ice and climate (WWIC) services and information?

Co-production is a popular term in science and technology projects. It refers to the ways and levels of collaboration among scientists, technicians, end users and stakeholder representatives. The idea is that early, regular collaboration on key choices about the approach to and outcomes of such projects will improve the relevance of the products and services that come out of them as well as their uptake by end users.

For the SALIENSEAS project, we've arranged such a collaboration by involving a stakeholder advisory group consisting of leaders from industrial organizations and operational centres. We have also employed innovative, participatory social-science research methods. It should be noted that such collaboration typically does not start with a project but rather is an ongoing process. In other words, ongoing interactions or insights from previous projects are highly relevant to aligning *scientific with practical agendas. Regular exchange of ideas among researchers, services providers and practitioners can be driven by concrete projects, but it can also be part of the organizational culture.*

SALIENSEAS started in 2017. What kinds of studies have been carried out since then, and what methods have they used?

SALIENSEAS is an interdisciplinary project with widely differing studies and approaches: developing probability-based sub-seasonal to seasonal sea-ice forecasts using statistical methods; surveying users' informational needs and the challenges they face with the help of spatially explicit online tools and in-depth interviews of operational service personnel; holding scenario-building and simulation workshops with a variety of participants. The project aims both to advance the respective natural- and social-science research agendas in the field of polar meteorology and to further the uptake of information services. It also aims to achieve social learning and a reciprocal relationship between products and outcomes.

Group discussions at the SALIENSEAS scenario workshop, organized in November 2018 at DMI in Copenhagen (photo this and previous page: SALIENSEAS).

How have these iterative research and co-production processes been working out?

Concretely, it has meant that plans, contents of surveys, interview rounds and demonstration services were all co-designed, carried out and regularly discussed within the transdisciplinary team. The resulting demonstration services were part of innovative simulations in which their use was tested during a serious game.

What is a serious game?

Serious games are games that have a purpose beyond pure entertainment, such as collecting data or promoting learning or behavioural change. Serious games can be used to experiment with new social, spatial, temporal or informational settings, such as exposing maritime users to new sea ice forecasts.

Did you have to adjust your goals during the project's duration?

Since SALIENSEAS was a co-production project, its goals by design could be adapted to new insights and decisions. Overall the project has been able to deliver on all its objectives, except that the number and level of co-production workshops in the project's final year were curtailed as a consequence of COVID-19. Plans for several on-site simulation sessions with end-user groups had to be cancelled, and an alternative trajectory had to be formulated to generate valuable insights regarding the use of innovative WWIC services across the product value chain. The alternative in this case took the form of an online survey.

Who is involved in SALIENSEAS, and how is it funded?

SALIENSEAS was funded by ERA4CS through the Joint Call on Researching and Advancing Climate Services Development. ERA4CS is a European programme (a joint planning initiative) to boost the development of efficient climate services in Europe by supporting research into better tools, methods and standards for the production, transfer, communication and use of reliable climate information. The point is to cope with current and future climate variability. As is often the case with a joint planning initiative, the funding comes from a select number of dedicated European funding agencies with additional funds from the European Commission.

SALIENSEAS was funded as a project dedicated to Arctic marine challenges. It was among 26 other projects focused on a wide range of climate related issues such as drought, flooding, wildfires, algal blooms and sea level rise. Among the core partners working on SALIENSEAS are Wageningen University & Research (Netherlands), Umea University (Sweden), Arctic University of Tromsø (Norway), the Norwegian Meteorological Institute (Norway) and the Danish Meteorological Institute (Denmark) along with a range of core stakeholder advisors including the Association of Arctic Expedition Cruise Operators (Norway), Maritimt Forum Nord SA (Norway), Hurtigruten (Norway), Oceanwide Expeditions (Netherlands), Greenland Pilot Service (Greenland), Royal Arctic Line (Greenland) and Greenland Fishing and Hunting Association, KNAPK (Greenland).

SALIENSEAS
CO-PRODUCING CLIMATE SERVICES

SALIENSEAS brings together a team of social and natural scientists, MetOcean service personnel and end users. How did you manage to keep together such a big group of stakeholders and end users? What do you think it takes to successfully manage the community?

With just five core partner institutes, the SALIENSEAS project is actually quite modest, especially compared to large European Arctic cluster projects. The group of stakeholder advisors were managed by organizing regular annual meetings to discuss plans and approaches. These stakeholder advisors played a pivotal role reaching out to end users for the social science research (surveys, interviews and workshops). Successful community management requires clear, open communication and genuine participation.

What about the project design (from planning to execution) worked out as you expected? What surprised you?

What worked out as expected was the impact of the early stakeholder advisory meeting on the direction of the project. In the beginning, it hadn't been determined what services were going to be developed even though the research team understood the opportunities as well as the expectations of the ERA4CS programme with its focus on climate services.

The stakeholder advisors as well as the user survey convinced us at the outset that sea-ice dynamics were a key area for service development. But not in the way we anticipated. It turned out that stakeholders saw the greatest need for higher-resolution, tailored, dynamic sea-ice products. They were not calling for longer-range sea-ice forecasts. The stakeholder advisory meeting also made clear that the service needs of different parts of the European Arctic were quite various, for example around Svalbard and in West Greenlandic waters. The various needs were subsequently picked up separately by the Danish and Norwegian MET partners, the call for higher-resolution, dynamic sea ice products in follow-up projects.

What results from SALIENSEAS are most exciting? And what was the most exciting part for you personally?

Exciting was that SALIENSEAS is a social science-led project in a natural science-dominated field. The co-production approach allowed the social science-led activities to have a major impact on the course of the project, because they aimed to combine user-need survey results with demonstration services work (for instance, scenario and simulation workshops). I am therefore most excited about the results of the simulation workshops, in which we tested the usefulness and usability of the sub-seasonal sea-ice forecasts developed by MET.no by bringing them into a decisional context. We organized a workshop in Tromsø last January where experienced mariners from the cruise industry played a serious game in which they were asked to run a Svalbard-and-Greenland itinerary at critical times of the season. The sub-seasonal forecasts were brought into the decisional matrix and discussed in an extensive debriefing. This brought deep insights for both improvement and uptake of the service and the serious game.

What are these insights? Can you summarize in few sentences?

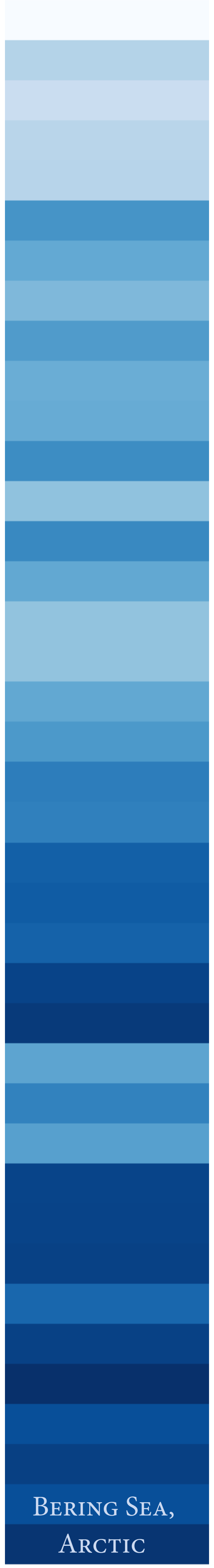
For example, it becomes clear that the uptake and use of probabilistic ice forecasts is still in an early stage. Even when participants were brought into a situation where such a forecast could be beneficial, their lack of experience with it made them hesitate and trust more in their experience. Particularly the different layers of probabilities in a sub-seasonal to seasonal ice forecast, some relating to the ice concentration itself and others to the reliability of the forecast, remain challenging to interpret. In many ways, these are still services looking for operations, instead of the other way around. Participants also expressed concerns about the effects of these information systems on policy-driven safety standards in the coming years. In other words, the development of sub-seasonal ice services may not necessarily impact operational and planning services directly but may do so indirectly, through policy and finance or insurance-related constraints.

What can the polar prediction community learn from SALIENSEAS about improving weather and sea-ice predictions for the Arctic?

The increasing availability of data as well as improvements in forecasting skill is leading to major innovations in servicing the Arctic maritime sectors. If and how those users find these services useful and usable is largely unknown and will depend on many contextual factors. Our simulations of sub-seasonal sea ice clearly show this. SALIENSEAS demonstrates that the value of social science research lies in understanding how to use WWIC services in such decision-making contexts. SALIENSEAS also shows the value of inter- and transdisciplinary collaboration in improving weather and sea-ice predictions for the polar regions.

Where can we find more information about SALIENSEAS?

All the results of the project are collected and linked to on the project's website, http:\\salienseas.com. There is also a @SALIENSEAS Twitter account from where information is linked.



YOPP YEAR OF POLAR PREDICTION

International Coordination Office (ICO)
for Polar Prediction

WORLD METEOROLOGICAL ORGANIZATION

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