MOSAiC

Multidisciplinary drifting Observatory for the Study of Arctic Climate

Sea Ice Ticker

Information on the state of the sea ice and the work of Team ICE as part of the MOSAiC expedition

20 August 2019 – 12 October 2020

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Sea Ice Ticker

On 20 September 2019, the icebreaker Polarstern will set sail for the MOSAiC expedition, and a year-long drift in the Arctic sea ice. The 'Sea Ice Ticker' provides the latest information on the sea ice, presented in various forms so that you can track the ice conditions.

Sea Ice Ticker Nr. 57, 12 October 2020: An entire year of the MOSAiC expedition! … meereisportal.de covered it all for you.

On 20 August 2019 meereisportal.de began its regular coverage of the MOSAiC expedition, which officially began in Tromsö, Norway, on 20 September 2019 and will soon end, 387 days later, on 12 October 2020 in Bremerhaven. As an information and data portal on the topic of sea ice, meereisportal.de worked from Bremerhaven to offer the public accompanying news items on the sea-ice-related research conducted during the expedition, up-to-the-minute sea-ice maps, and information on the expedition and the importance of the drift. As a result, anyone interested in sea ice had the opportunity to follow the work being done on board the Polarstern, and to learn about the initial findings gleaned on the unparalleled expedition.

A total of 57 Sea Ice Ticker instalments were prepared; released on a weekly basis, they reported on the sea-ice-related data gathered, or described the changing sea-ice situation throughout the drift. This broad range of information was only possible thanks to the close collaboration with various colleagues on board RV Polarstern and in Bremerhaven, for which we on the meereisportal.de team would like to offer our heartfelt thanks. Taking the time out to help us in addition to their taxing daily duties was anything but self-explanatory, and shows the importance that the participating researchers attach to knowledge transfer. It also underscores the importance of meereisportal.de as a product for knowledge transfer at the AWI, one that not only seeks to provide information, but also, through carefully prepared data and maps, to promote a dialogue and discourse with societal actors.

Moreover, meereisportal.de introduced another product for the expedition: the DriftStories. In a total of ten instalments, once a month we offered a more in-depth look at the sea-ice research conducted on the expedition, providing detailed information on the work being done on site and its role in the MOSAiC expedition as a whole, to complement the weekly Sea Ice Ticker texts. Working together with science journalist Sina Löschke, this approach yielded unique stories that allowed readers to share not only in the challenges involved – authentically, up close and personal – but also the fascination of this unprecedented expedition, in various facets and with the aid of breath-taking photos. Given the highly positive feedback received on the DriftStories, meereisportal.de now plans to publish them in print. We'll provide information at meereisportal.de concerning the release date and purchasing options as it becomes available.

In closing, all that is left to do now is to express our sincere thanks to everyone who contributed to the success of these instalments. Thanks to their personal commitment and desire to share their research, they have helped to clarify the causes and effects of climate change in the polar regions, and in so doing, have fostered the necessary transformation into a more sustainable society. They are all part of the extended meereisportal.de team!

And last but not least, we'd like to thank you, dear readers, for choosing meereisportal.de as a scientifically objective source of information, and making yourselves 'knowledge spreaders' regarding the effects of climate change on our planet in the process.

Best regards, on behalf of the whole meereisportal.de team,
Renate Treffeisen and Klaus Grosfeld

The following individuals contributed to the Sea Ice Ticker texts and/or the DriftStories: *Luisa von Albedyll, Stefanie Arndt, Jakob Belter, Gerit Birnbaum, Giulia Castellani, Sandro Dahlke, Klaus Grosfeld, Sebastian Grote, Helge Gössling, Christian Haas, Stefan Hendriks, Clara Hoppe, Mario Hoppmann, Monica Ionita-Scholz, Annekathrin Jäkel, Bennet Juhls, Arttu Jutila, Lars Kaleschke, Christian Katlein, Daniela Krampe, Frank Kauker, Thomas Krumpen, Sina Löschke, Ilkka Matero, Khalid El Maghawry, Christian Melsheimer, Marcel Nicolaus, Kai Nierula, Ian Raphael, Robert Ricker, Kathrin Riemann-Campe, Janin Schaffer, Axel Schweiger, Farzaneh Shams, Julia Sokolova, Anja Sommerfeld, Gunnar Spreen, Renate Treffeisen, Daniel Watkins, Marietta Weigelt and Katrin Weiß.*

meereisportal.de *was jointly launched as an independent information and data platform by the Climate Initiative 'Regional Climate Change' (REKLIM) and the Climate Office for Polar Regions and Sea Level Rise at the Alfred Wegener Institute.*

Sea Ice Ticker No. 56, 2 October 2020: The spotlight is on the new MOSAiC floe … even without RV Polarstern

Those of you who've been following the news on the MOSAiC expedition regularly will already know that a new ice floe for RV Polarstern had to be found in August 2020, after the original MOSAiC floe had traversed the Central Arctic faster than anticipated. From the ending position of the initial drift in the northern Fram Strait, RV Polarstern returned to the Russian sector via the North Pole, reaching the position of the 'MOSAiC floe 2.0', near the Pole, on 22 August. Just like on the first floe, the participants in the last leg of the MOSAiC expedition soon deployed a host of scientific instruments on the ice around the icebreaker in order to document the onset of the season in which temperatures in the lightless Arctic gradually sink farther and farther below the freezing point.

In order to supplement the readings taken on site, numerous satellite images of the new MOSAiC floe were taken on a daily basis. Just as in the past, some of the high-resolution 'SAR' images had to be ordered two days in advance, and the request had to include information that was as precise as possible on where the floe would be when the satellite passed overhead. To provide that information, drift forecasts were once again called for; in this regard, the experts relied on the 'Sea Ice Drift Forecast Experiment' (SIDFEx), which had already proven its value during the first drift. What sets SIDFEx apart: instead of using just one model, the forecasts of several internationally operating forecasting centres are continually gathered and combined into consensus forecasts, which provide not only the most likely drift trajectory, but also an uncertainty corridor (see the figure).

Roughly a month later, on 20 September, RV Polarstern then had to bid farewell to its new floe – not because it began disintegrating, like its predecessor did, but because the expedition was drawing to a close. And apparently, just before the ship left, Walt Disney sent his regards to the North Pole by talking the floe into taking on the characteristic shape of one of his beloved characters' heads. Can you find the cartoon character we're talking about in the figure? But back to the research, which is hardly over simply because the ship weighed anchor. For one thing, the fate of the new floe will continue to be monitored by a handful of instruments left behind for that purpose, and by satellite. Accordingly, until further notice, new SIDFEx forecasts will also be provided on a daily basis. You can always find the latest forecast for the new MOSAiC floe here; for more information on SIDFEx, please click here. In the 7-day forecast for 19 – 26 September, the MOSAiC floe 2.0 largely drifted to the west. The forecast (solid line) matches the actual drift trajectory (dotted line) very closely. Although the north-south drift at the end of the 7-day period wasn't predicted, this movement lies completely within the 90% confidence interval for the various projected trajectories. For the 120-day forecast, we largely expect to see a southwest drift that generally follows the Transpolar Drift Stream.

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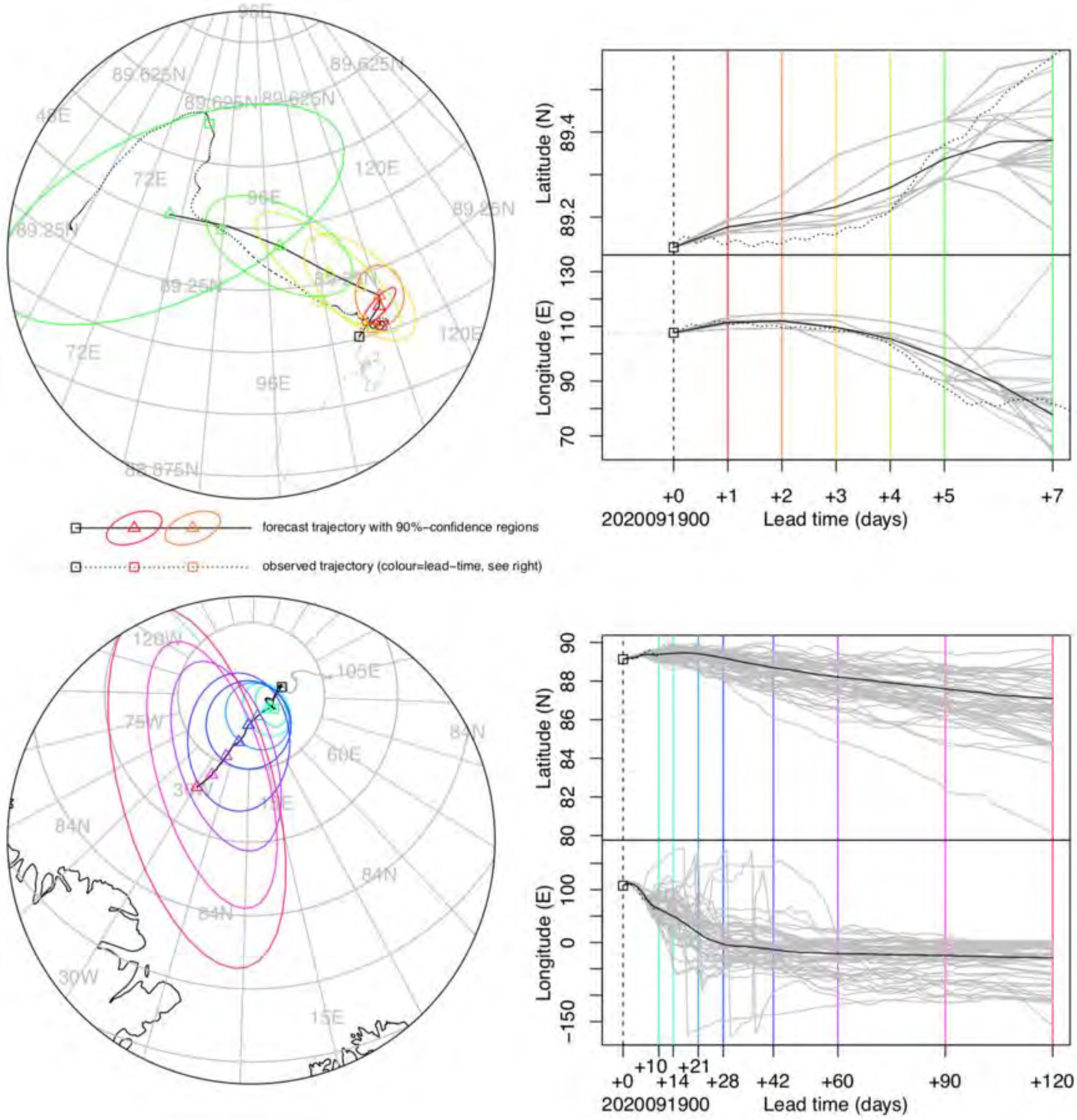

Figure: SIDFEx consensus forecast for the drift trajectory of the new MOSAiC floe from 19 September 2020, 00:00 UTC. The forecast for the next 7 days is shown above; the forecast for the next 120 days is shown below. The actual drift trajectory to date is shown in dotted curves and squares.

Sea Ice Ticker Nr. 55, 25 September 2020: Data for MOSAiC's second year

When the MOSAiC floe began disintegrating on 31 July 2020, we said goodbye to the old observatory and departed on board RV Polarstern, leaving behind only a handful of autonomous monitoring stations (buoys). Some of these stations are still transmitting data today, e.g. on the floe's position. Consequently, we know that the remnants of the floe are now scattered over hundreds of kilometres, and that some of the fragments we installed monitoring systems on actually survived the summer melting. These buoys have since served as waypoints for aeroplane- and helicopter-based aerial surveys, which were used to continue monitoring the characteristics of the ice and atmosphere. We also continue to track these fragments of the old camp by satellite.

On 21 August the MOSAiC Team set up a new Ice Camp for the fifth leg of the expedition at ca. 87° 43' North and 104° 30' East, just eleven nautical miles from the route that the original floe followed in January 2020. On 20 September we then left (were forced to leave) the second floe. Here, too, a network of autonomous buoys, smaller than the first, was deployed on the main floe and in its vicinity, and was once again left behind. These buoys will now continue the drift in our stead, and provide us with valuable data on the atmosphere, sea ice, and ocean from MOSAiC's second year.

On the central floe, the Sea Ice Team deployed three sets of buoys, outfitted with complex systems for observing various parameters: in "Met City" there are snow and ice buoys, as well as a buoy for monitoring flows and turbulences, from the ocean to the atmosphere. A second station, set up on level ice, focuses on energy flows and optical properties, as well as the mass balance for snow and sea ice. We also installed buoys in the pressure ridge near the ship's bow, which are above all used to compare the distribution of snow there to the distribution on level ice. There are also three cameras among the buoys, which offer us a daily record of the conditions on site.

Beyond the main floe, 28 buoys were installed on smaller individual floes: 20 in its immediate vicinity (up to 10 km away) and the remainder as far as 40 km away. One of the buoys was deployed at the North Pole itself, and another near the sea-ice edge.
Now we'll keep our fingers crossed that our systems survive the autumn and winter, and are eager to see what the second year holds in store. "Besides the dynamic ice conditions as a potential threat to the buoys' survival, we hope that the local polar bears have lost interest in them by now, and won't take a closer look or use them as their 'playground' now that we're gone," explains Dr Marcel Nicolaus, Coordinator of the Sea Ice Team on the MOSAiC expedition.

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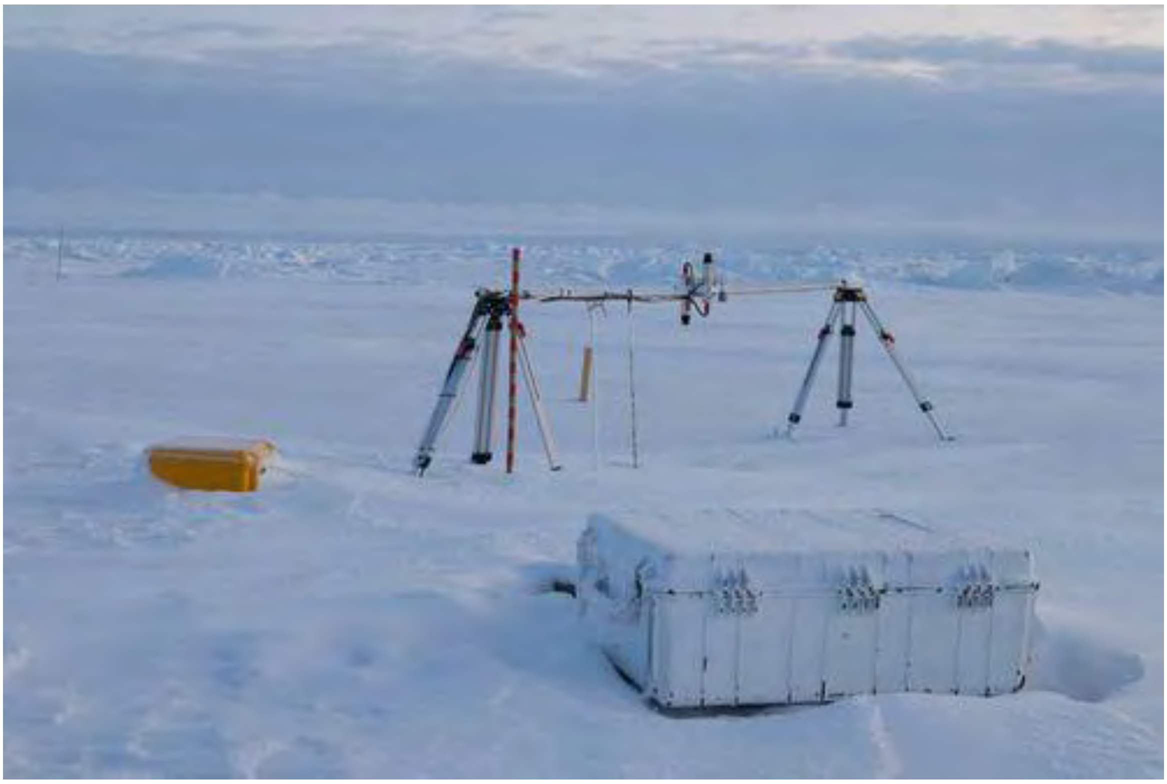
Radiation monitoring buoy 2020R21 in a frozen-over meltwater pool (photo: Marcel Nicolaus, AWI)



iBOB systems installed on level ice (photo: Marcel Nicolaus, AWI)

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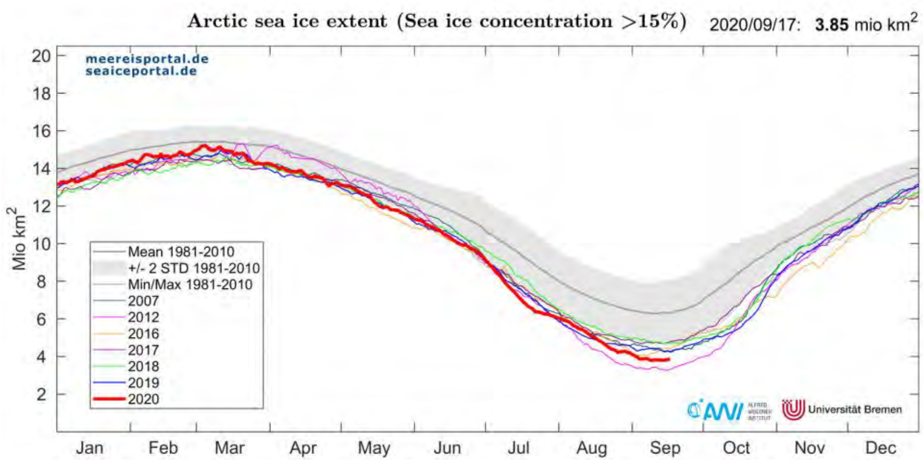
Sea Ice Ticker Nr. 54, 18 September 2020: Sea Ice Minimum extent reached

After the summer months June and July 2020 had yielded minimum values in the 42-year time series of sea-ice extent, the trend continued in September, underscoring the importance of Arctic warming as an early-warning system for global climate change. The mean value in August was 5.03 million km^2, making it the third-lowest extent (after 2012 and 2019) since 1979. The extent on 31 August was 4.19 million km^2 and had declined by ca. 1.85 million km^2 – an area roughly the size of about 5 times the size of Germany – in the course of the month alone. Though sea-ice retreat slowed somewhat in late July and early August, from 6 August it accelerated.

In the second half of August and until mid of September, a strong ice retreat was observed in the Canadian Basin, which led so far to the lowest ice extent of 3.784 million km^2 on 09 September this summer. This value has stabilized in the last few days and we expect that this year's minimum has been reached. This means that 2020 is the year of the second lowest ice extent in the Arctic since 1979 and was 510,000 km^2 above the historical low of 2012. Eight of the ten lowest ice extents have occurred since 2010!

One cause of the significant sea-ice retreat: the meteorological conditions in July and August, which included a distinct temperature anomaly over the Central Arctic. Over the course of the summer, the anomaly produced fluctuations in air temperatures at 925 hPa (ca. 760 m) of more than 6° Celsius above the long-term average for the years 1981 to 2010. These conditions in the Central Arctic manifested in a stable, substantial pressure anomaly, especially in July, when the high-pressure cell was directly over Siberia and the Central Arctic. The accompanying air currents pushed the warm continental air masses over Siberia into the Central Arctic. Since the ice was already quite thin at the edges by this time of year, this could have been conducive to melting. The melting was also influenced by the warm ocean surface temperatures, which were above the long-term average in the Barents, Kara and Laptev Seas, as well as the Siberian Sea.



Sea Ice Ticker Nr. 53, 11 September 2020: Sea ice from a biological perspective

Sea ice is home to many organisms; most of them can only be seen with a microscope. In this regard, algae are an essential part of the Arctic food web, because they are a staple for larger organisms: the zooplankton. During our time on the MOSAiC ice floe, we took measurements to understand how much of these algae were actually present and what percentage was eaten by the zooplankton.

Once a week, usually on Monday, we performed sea-ice coring. These coring days were always long days out on the ice; we had to collect several ice cores to measure not only the abundance of algae, but also many other parameters that are important to characterizing the entire microbial system in the sea ice. We also measured how much of the sunlight penetrated the sea ice, because algae are photosynthetic organisms and need sunlight to grow.

After the cores were extracted, we measured the length, described the characteristics of the ice, and then cut the cores into small sections. Once back on board the ship, we melted the ice cores prior to storage. Most of the analysis will be conducted at home, so once the cores were melted we filtered them and stored the filtered contents at -80°C until they could be shipped back to researchers' home institutions. In the last few weeks, we saw some of the filtered samples turning bright green, a sign for the presence of algae.

In addition, under most of the ice we saw long strands of a specific type of ice-associated algae, Melosira Arctica. Melosira lives attached to the bottom of the ice and grows into the water column by producing very long filaments, measuring 1 m or more. During the past week, the ice began melting at the bottom, and most of the Melosira detached from the ice and started floating at the surface or appearing in cracks and holes in the ice.

We also used nets attached to a remotely operated vehicle (ROV) that can dive under the ice. With the aid of these nets, we caught many of the small organisms that live at the interface between the ice and the ocean surface. These animals will be shipped home, where we will analyze their stomach content to understand how much and which types of algae they eat. But that's not the end of the story: these small organisms themselves can be found in the stomachs of the fish that we caught while on the MOSAiC floe. This shows that sea ice is not merely ice, but also an important source of life for the entire Arctic marine food web.

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Figure 1: Copepods with stomachs full of algae

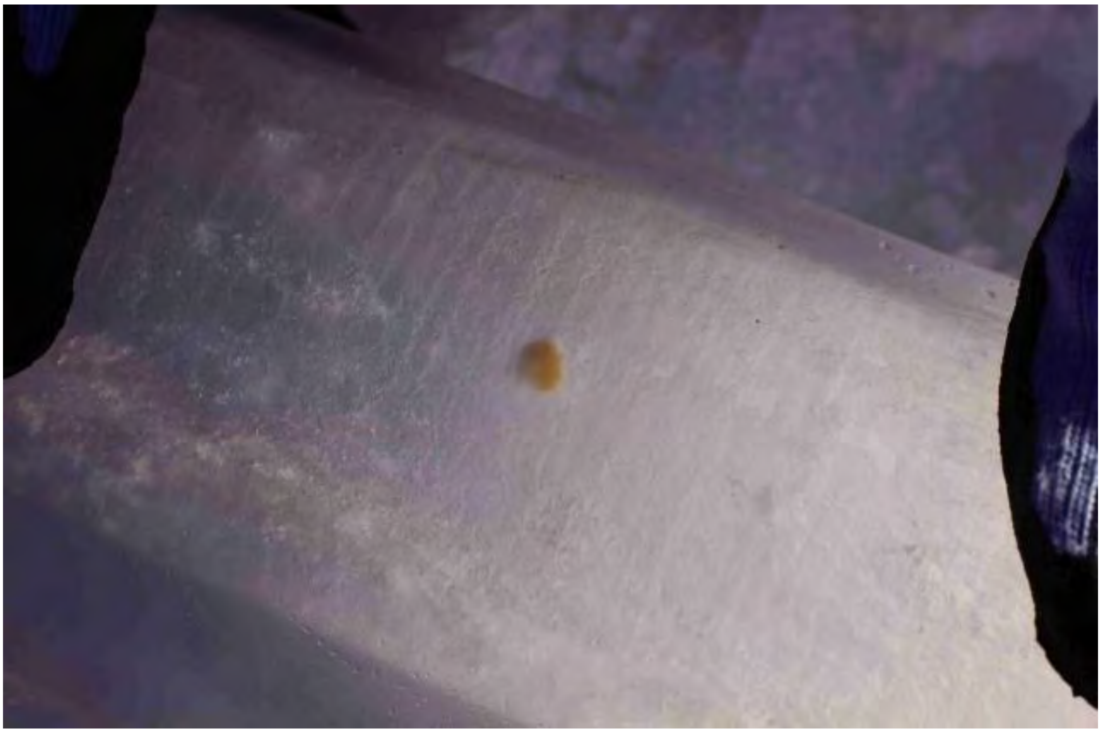

Figure 2: Algae in the sea ice

Sea Ice Ticker Nr. 52, 4 September 2020: IceBird – Large-scale surveying of the Arctic sea ice in the MOSAiC year

Parallel to the MOSAiC expedition with RV Polarstern, the Alfred Wegener Institute for Polar and Marine Research (AWI) will also conduct aerial survey flights with the research aircraft Polar 5 and Polar 6. Polar 5 is equipped with a host of meteorological monitoring instruments, and will investigate the atmospheric conditions in the extended vicinity of the ship. The second research aircraft, Polar 6 , will document the thickness and surface characteristics of sea ice in Fram Strait and the central Arctic Ocean. These flyovers are part of IceBird, an AWI ice-measuring programme that takes place twice per year: in summer and winter, when the sea-ice extent and thickness reach their minimum and maximum values, respectively. For the ice-thickness measurements during IceBird, the EM-Bird will be used: a torpedo-shaped electromagnetic measuring sensor, which is towed behind and beneath the plane at a height of 50 feet / 15 metres above the ice's surface. Due to the coronavirus pandemic, this year the flights will begin somewhat later than originally planned, and use a different base of operations: whereas in the past, the Stations 'Nord' (Greenland) and 'Alert' (Canada) were the point of departure for flights over the sea ice in August, respectively, this year they will exclusively launch from Longyearbyen, Svalbard, and take place in the first two weeks of September. In addition to the routine documentation of the sea-ice thickness and condition, the exciting question this year is how the MOSAiC ice compares to that seen in past years: in other words, was it generally thicker or thinner than the ice observed over the past two decades? Did the high summer temperatures significantly affect it, producing more meltwater pools on the surface than usual? Did the ice's high drift speed have an effect on the formation and frequency of pressure ridges? Following the campaign, the Meereisportal will release an accompanying DriftStory on these questions.

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Image 1: The polar aircraft Polar 5 and Polar 6 can be fitted with a torpedo-like electromagnetic sensor, the EM-Bird, which is stowed away in a 'nest' on the ship's underside for take-off and landing. Once over the sea ice, the sensor is towed behind the plane on a 70-m-long cable, measuring the thickness of the ice from a height of 15 metres above its surface (photo: Jan Rohde, AWI).

Image 2: This year's aerial survey campaign will take place parallel to MOSAiC. But RV Polarstern is currently so far to the north that flyovers like this one (in Longyearbyen, from 2016) are unlikely (photo: Thomas Krumpen, AWI).

Sea Ice Ticker Nr. 51, 28 August 2020: Sea ice situation in the Arctic: August 2020

Text On 19 August the RV Polarstern reached the North Pole during the MOSAiC expedition. Her journey there was very different to what could normally have been expected for this region. One reason was the route chosen, which had significantly less ice than in previous years – with the exception of 2018, when the ice conditions were similar to this year (see Figure 1). In both years, the sea-ice area along the route was significantly below the average for the years 2012 to 2019. On her way to the North Pole, RV Polarstern encountered very little thick, multiyear ice, many stretches of open water, and particularly so-called 'rotten' ice. This ice has a honeycomb structure, its ice crystals are only loosely connected and it is riddled with meltwater and seawater.

This year, we continue to see less ice in the Siberian Arctic than in previous years. If we examine the ice area in the sector from 60° – 180° East more closely, in July there was a historical record low, which remained below the previous record low levels for this region in 2012 and 2019 up to mid-August (see Figure 2). The other two sectors of the Arctic (Canadian and Atlantic sectors) did not show particularly low sea-ice levels compared to previous years (Figure 3). It will be interesting to see how the ice area in this region develops up to the September sea-ice minimum.

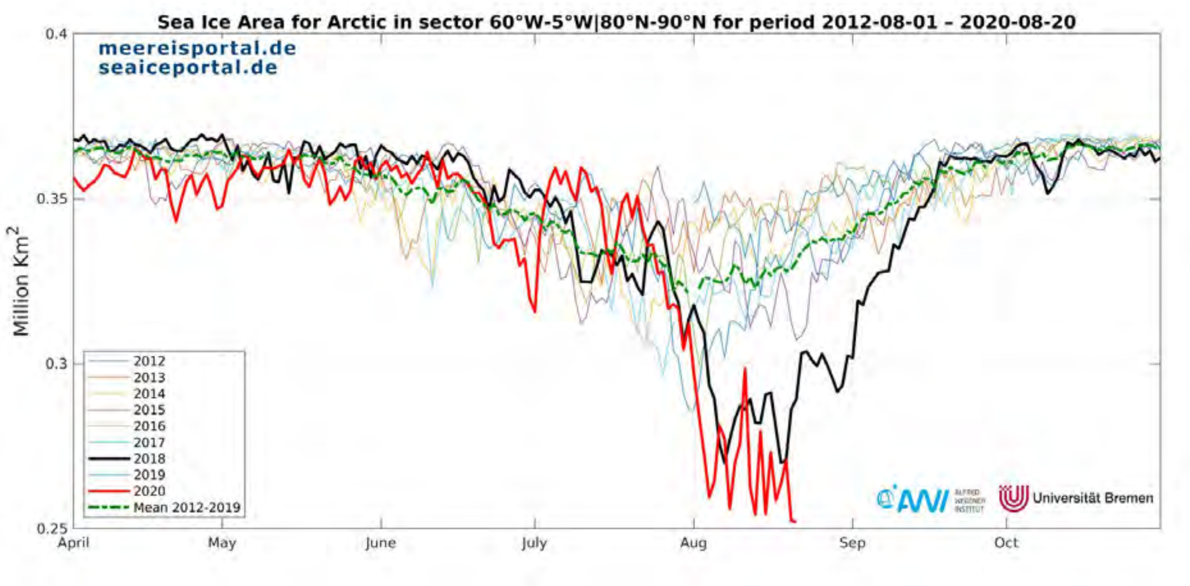

Figure 1: Average sea-ice area in the sector of the Arctic from 60°W – 5°W / 80°N – 90°N (the sector roughly matching Polarstern's route to the North Pole; data.meereisportal.de/maps/mosaic/latest/sic_MOSAIC_last.png) for the period 1 to 20 August 2020. The sea-ice area describes the effective area of the ocean that is covered with ice, taking into account the ice concentration. Only areas with ice concentrations > 15% are considered to be ice-covered.

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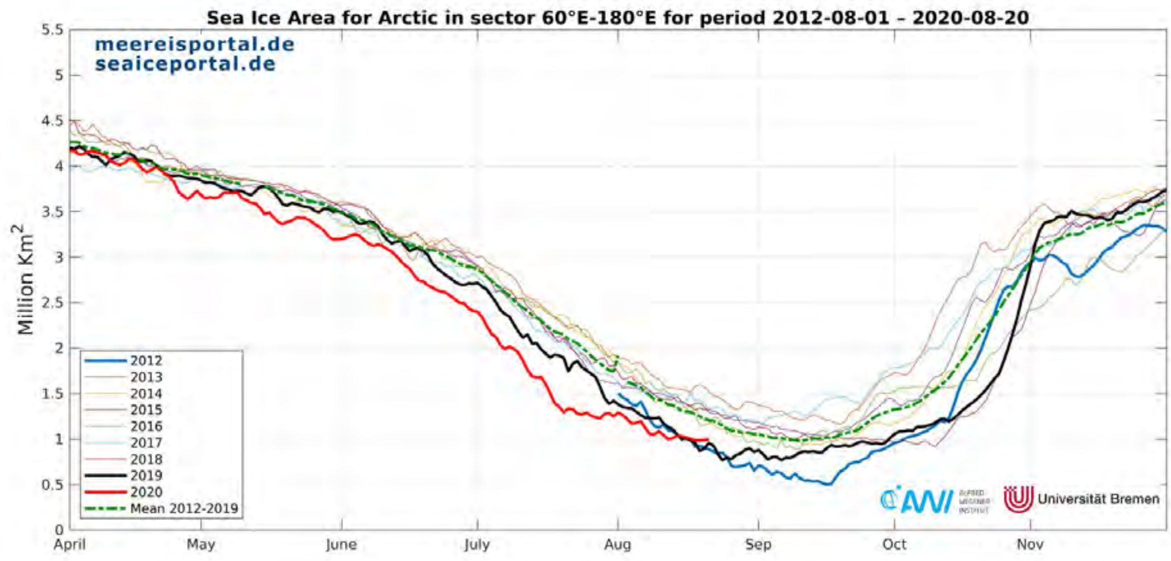

Figure 2: Map of the sector 60°E – 180°E: Ice area up to 20 August 2020 (red) and for the years 2012 – 2019.

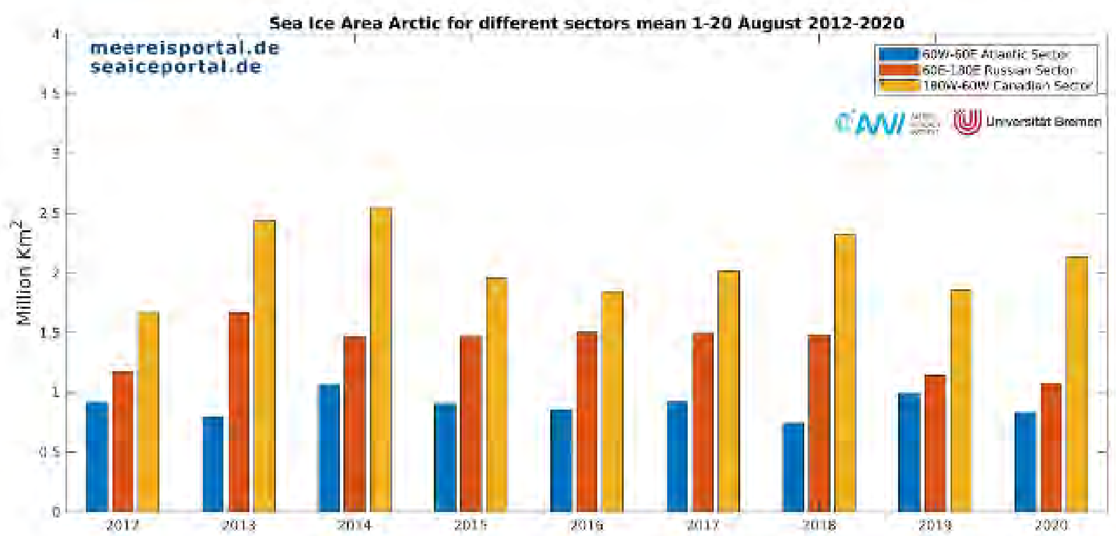

Figure 3: Overview of the sea-ice area in the three sectors of the Arctic: the Atlantic sector (60°W – 60°E), Russian sector (60°E – 180°E) and American / Canadian sector 180°W – 60°W.

Sea Ice Ticker Nr. 50, 21 August 2020: MOSAiC microwave remote sensing of and on the sea ice

Text The aim of the MOSAiC research programme was to better understand sea-ice physical processes and to more accurately measure sea-ice characteristics from space. Accordingly, the sensors we used on the ice were similar to current and future satellite sensors. The MOSAiC campaign provided a unique opportunity to obtain in-situ ice information together with remote sensing measurements of the same location.

MOSAiC Leg 3 covered a period of particularly significnt changes in environmental conditions. The change in surface air temperature from below -40°C to above the melting point, and the associated change in the sea ice and snow surface properties, was observed using various active and passive instruments. These stationary measurements form the basis for a subsequent analysis of the temporal variability. A relocation experiment towards the end of the time series allowed us to assess the spatial variability within the remote-sensing site, which was influenced by large artificial snow dunes in the lee of the instruments. Lastly, we used a customised snow-removal experiment to investigate the influence of the snow cover on the microwave brightness temperature. The remote-sensing measurements were supplemented by measurements of the dielectric permittivity; ice cores; snow pits; aerial and terrestrial laser-surface elevation and underwater ROV surveys; GEM sea-ice thickness and magnaprobe snow-depth tracks; and thermistor string installations.

The extensive dataset collected will be useful for validating sea-ice microwave radiative transfer models and various sea-ice and snow physics parameterisations that are essential to improving satellite retrieval algorithms for key sea-ice and snow parameters.

The SSMI radiometer (PI Julienne Stroeve) is a passive microwave sensor that measures at frequencies of 19 GHz to 89 GHz, the same frequencies as the SSMI satellite series. The SSMI satellites provide us with the longest climate data record of Arctic and Antarctic sea-ice area and extent. A preliminary analysis of the data collected during Leg 3 showed that warming events and associated changes in the snow surface can lead to an underestimation of the ice concentration.

Temperatures close to the melting point altered the snow surface characteristics and reduced the surface roughness. In the panorama photograph (Fig 1.) this can be seen in the strong specular surface reflection in the direction of the sun. The specular surface produced an increased polarisation of the reflected electromagnetic waves, which also applied to the microwave emissivity.

The photograph also reveals major challenges for the subsequent interpretation of the data: the influence of the instruments themselves on the observed scenery. The sledges and boxes trapped blowing snow, leading to the accumulation of large snow dunes in their lee. Therefore, the observed environment cannot be considered a natural, pristine snow and sea-ice surface.

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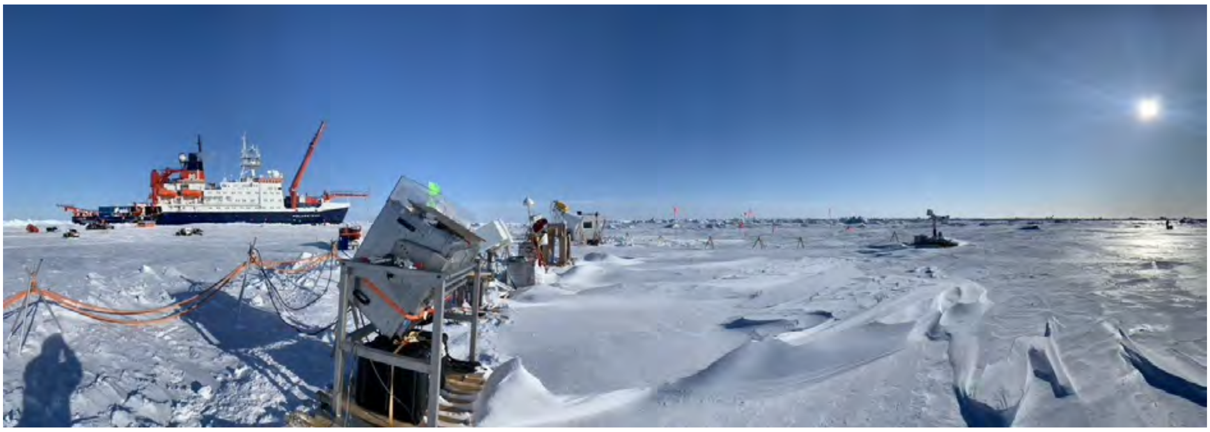

Fig 1.: Panorama photograph from 23rd April 2020 showing the Leg 3 remote-sensing site. Instruments from left to right: HUTRAD, SSMI, GNSS-R, ELBARA, thermal infrared and hyperspectral camera in front of the hut, and C-Scat. (Photo: Lars Kaleschke)

Sea Ice Ticker No. 49, 14 August 2020 - The Big Melt

Text When Leg 4 arrived at the MOSAiC floe, summer had already started, and we observed widespread surface melting. On the first walkabouts around the floe, we came across the first melt ponds, a few of which were open, while the others were covered with a thin layer of snow and ice. The snow was already slushy and wet, but still a few tens of centimetres deep. Compared to surrounding ice floes, ours stood out from the rest, thanks to its high abundance of melt ponds (Fig. 1).

Since then, air temperatures have been close to or above 0° degrees and the floe began melting from the top, but also from the bottom. The snow disappeared except in heavily ridged areas, where the snow crystals resembled giant jewels. We observed these slow but unstoppable processes with our various tools for measuring the ice thickness.

On our transects – regular walks across the floe, always following the same route – we measured ice thickness with the GEM (ground-based electromagnetic sensor), which uses the large conductivity difference between ice and seawater to detect the interface between ocean and ice (Fig. 2). We recorded a gradual decrease in the average ice thickness: a drop of approximately one metre over the course of July. At the same time, pond depths began increasing, until the first holes appeared in the melt ponds through which the meltwater poured into the ocean below. In some ponds, we recorded spectacular depths of more than 150 cm.

While the transect measurements reflect the decrease in thickness, ablation stakes allow us to distinguish between the melting below and melting above. An ablation stake is essentially a ruler frozen into the ice paired with a hotwire thickness gauge (Fig. 2). We used the ablation stake to measure the position of the snow and ice surfaces, and the hotwire to measure the position of the ice bottom. We measured an average of ~85cm of ice thinning across our stakes sites from 26 June to 30 July. Surface ablation accounted for seventy-five percent of that thinning, while bottom melting made up the remaining twenty-five percent.

The remotely operated underwater vehicle (ROV) "Beast" surveys the ice from below and uses its multi-beam sonar to create maps of the underwater topography. Comparing the maps produced over several dives showed that not all the ice melted at the same speed. Especially the deep keels that extended more than 8 metres into the comparably "warm" ocean were eroding quickly. In some parts of the ridged ice, keel depth decreased by up to 2 metres in just the first 14 days.

Digital thermistor chains (Fig. 3) are another essential tool for measuring changes in ice and snow thickness over time. Over 30 of these units were deployed across MOSAiC's Central Observatory, which allowed us to monitor the hourly temperature evolution in different ice and snow layers spread out around the floe. Though the data is still being processed, the legs of the DTC unit in the photo (Fig. 4) illustrate the progressive ice surface melting: the tops of the white tubes were initially installed level with the ice surface.

In the end, the decreasing thickness, pre-existing weaknesses, and numerous thaw holes in melt ponds made the floe unstable and less able to withstand ocean swell and collisions with surrounding floes. Many cracks appeared, and eventually, our one big floe broke apart into many smaller ones, which will now continue to melt until they disappear completely.

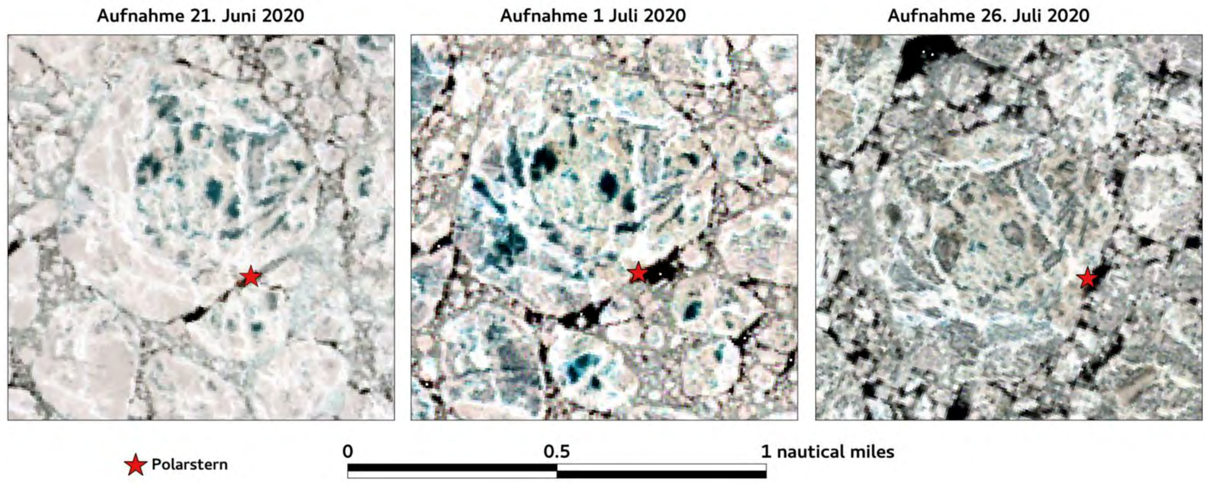

Figure 1: Changes of the MOSAiC ice floe during ~1 month observed with Sentinel-2 satellite images. (Graphics: Bennet Juhls)

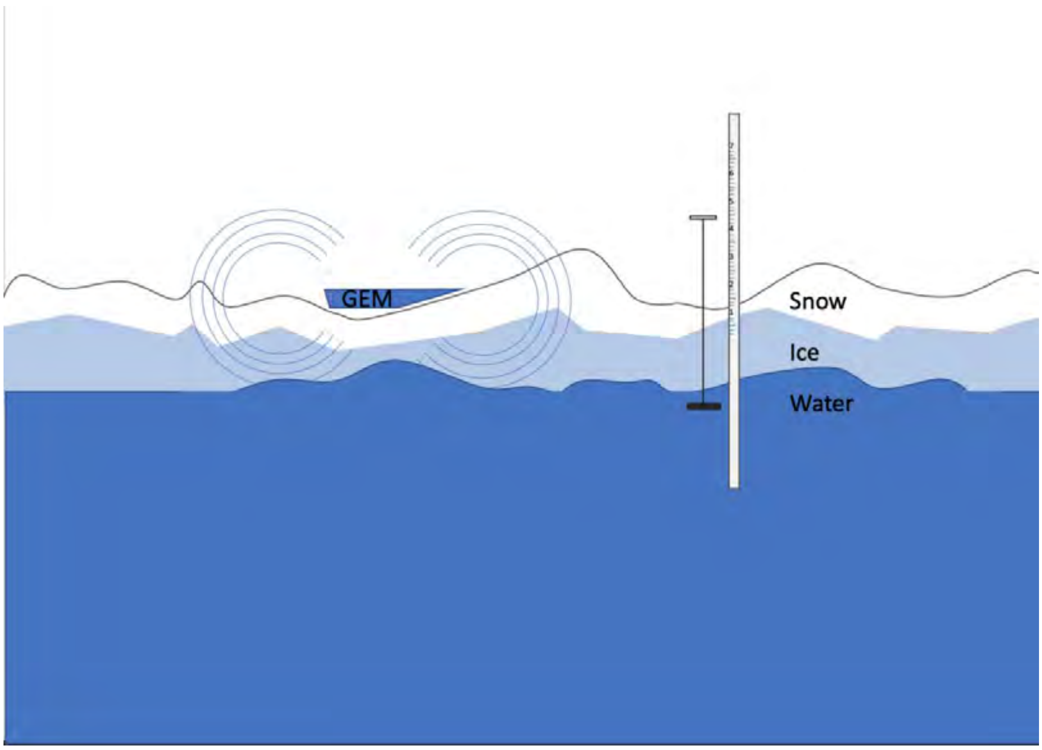

Fig. 2: Diagram of the GEM and an ablation stake & hotwire thickness gauge. The highly mobile, sledge-based GEM can measure total thickness change across a large spatial scale, while the stakes offer us data on snow-ice-water interface changes at individual points. We measured the snow and ice surfaces directly against the stake, and by pulling up the hotwire, we could tell how much the ice bottom had melted. On the basis of these three measurements, we were able to determine how the snow and ice thicknesses were changing. (Figure: Ian Raphael

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Fig. 2 Figure 3: A digital thermistor chain unit in the old Central Observatory on 21 July. (Photo: Ilkka Matero)

Sea Ice Ticker Nr. 48, 7 August 2020: Back to the MOSAiC floe! Interview with Dr Marcel Nicolaus, sea-ice physicist at the AWI

Text **meereisportal.de:** You were on the first leg of the expedition, and will also be part of the final one – from a scientific point of view, how different are the two legs?

Marcel Nicolaus: For us, the final leg of the voyage marks the close of the annual cycle, since we have now experienced, observed and measured all the seasons on our ice floe in the Arctic. On the one hand it represents the end of the expedition, but on the other hand, since we'll be observing the transition from summer to autumn, in a sense, it is actually the beginning of the time series. Last year we weren't able to monitor the early freezing phase, when the melting turns to freezing, since the MOSAiC drift didn't start until October. Our measurements at the end will bring us back to where we started a year ago. In some ways the legs are very similar, even though the 24-hour daylight at the start of Leg 5 will present a completely different Arctic than the 24-hour darkness at the end of Leg 1 – in this respect the contrast couldn't be greater.

meereisportal.de: In terms of sea-ice related measurements, how will this phase of the expedition differ?

Marcel Nicolaus: To begin with, everything will still be warm and in the process of melting. Then, first the surface will freeze, since the air will cool very quickly but the ocean will remain warm. As a result, the ice will simultaneously freeze from above and continue to melt from below. But eventually, everything will freeze: the melt pools will freeze over, new ice will form in the open water, the individual floes will freeze together, creating a seamless ice cover, and then the first snow will fall. During the course of the coming leg we will experience the annual minimum ice cover in the Arctic. These changes have a major influence on the energy flows between the ocean and the atmosphere. This is a very exciting phase for me, since it relates specifically to my scientific field, and my personal research question.

meereisportal.de: What are you looking forward to on this leg?

Marcel Nicolaus: First, it's a great opportunity for me to get back to the ice and return to the RV Polarstern, back to the Arctic and the work there. Because the old floe has reached the end of its lifespan, we will engage in a small second drift, which will become part of the overall drift. We will look for another floe from which we can observe the transition from summer to autumn. There we will set up a new camp and intensively gather measurements before heading back to Bremerhaven, marking the end of the one-year-long expedition. I'm curious to see, using our underwater robot (ROV), how the sea ice forms and how the porous summer ice becomes thicker and more compact. The first snowfall will significantly alter the surface characteristics of the sea ice. All in all, I'm really looking forward to my second leg of the expedition, because there are always surprises. Moreover, that is what makes our work so exciting and unique.

Dr Marcel Nicolaus working with the ROV (Source: AWI Sea Ice Physics)

Sea Ice Ticker Nr. 47, 31 July 2020: Sea-ice measurements by helicopter

Text Since the start of the MOSAiC expedition, we haven't just collected data on climate-relevant sea-ice conditions using measurements on the ground; we've also used instruments installed in or on RV Polarstern's two helicopters. Regular flights over the MOSAiC floe and the Distributed Network of automated monitoring systems are carried out in particular spatial patterns. On the one hand this allows us to observe temporal changes in the ice conditions across an area larger than the floe itself over an entire year. On the other hand, the measurements provide insights into the spatial variability of the sea-ice conditions within a radius of up to 150 km from RV Polarstern, and into how representative the surface conditions of the MOSAiC floe are for this area.

During the Polar Night, with its extreme temperature differences between ice of various thicknesses and areas of open water, a laser scanner and infrared camera were used to determine the topology and thickness of the ice, as well as the size distribution of ice floes and leads. Following the return of daylight, and particularly in the current summer period, the so-called EM Bird will be used to measure the ice-thickness distribution, along with the laser scanner, two SLR cameras, a hyperspectral camera and other radiation meters. These will allow us to determine the following parameters e.g. for the meltwater pools that have formed on the ice: their percentage of the total area / coverage on the ice, their size distribution, depth, shape and the extent to which the pools are interconnected, as well as their influence on the ice's mean reflectivity of sunlight (albedo).

This will allow us to put the ground-based measurements on the MOSAiC floe in a broader spatial context. At the same time they will help us to validate data on sea-ice characteristics gathered during the helicopter-based measurements. In turn, the helicopter-based measurements offer a good basis of data for validating satellite-based products, since with helicopters we can cover a greater spatial area than with individual measurements on the ground.Lastly, the helicopter-based measurements will supplement their ground-based counterparts to provide extensive data on sea-ice characteristics that significantly shape exchanges of momentum and energy between the atmosphere, ice and ocean, and covering the entire annual cycle. This data will help to validate and refine the algorithms used in numerical climate models.

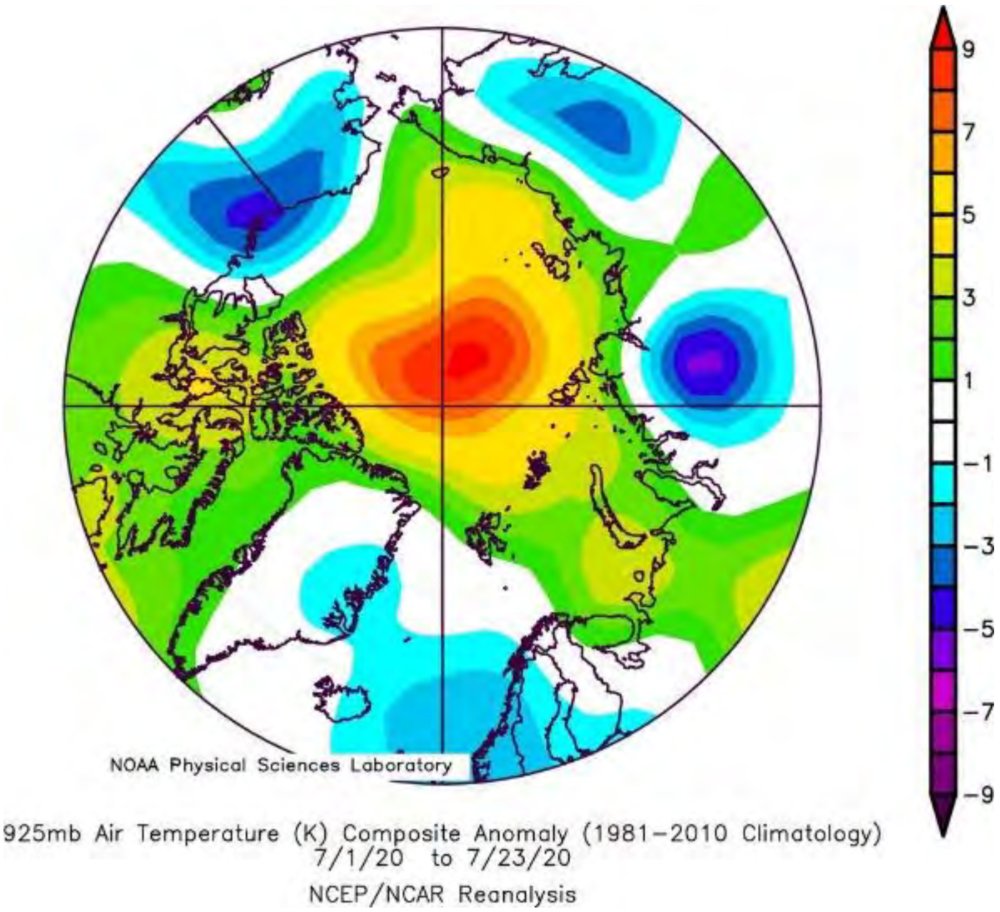
Meereisticker (20 August – 12 October 2020)

MOSAiC ice floe on 30 June 2020. (Photo: Markus Rex)

AWI meteorologist Dr Gerit Birnbaum on bord the Polarstern-Bordhelicopter. (Photo: Lianna Nixon)

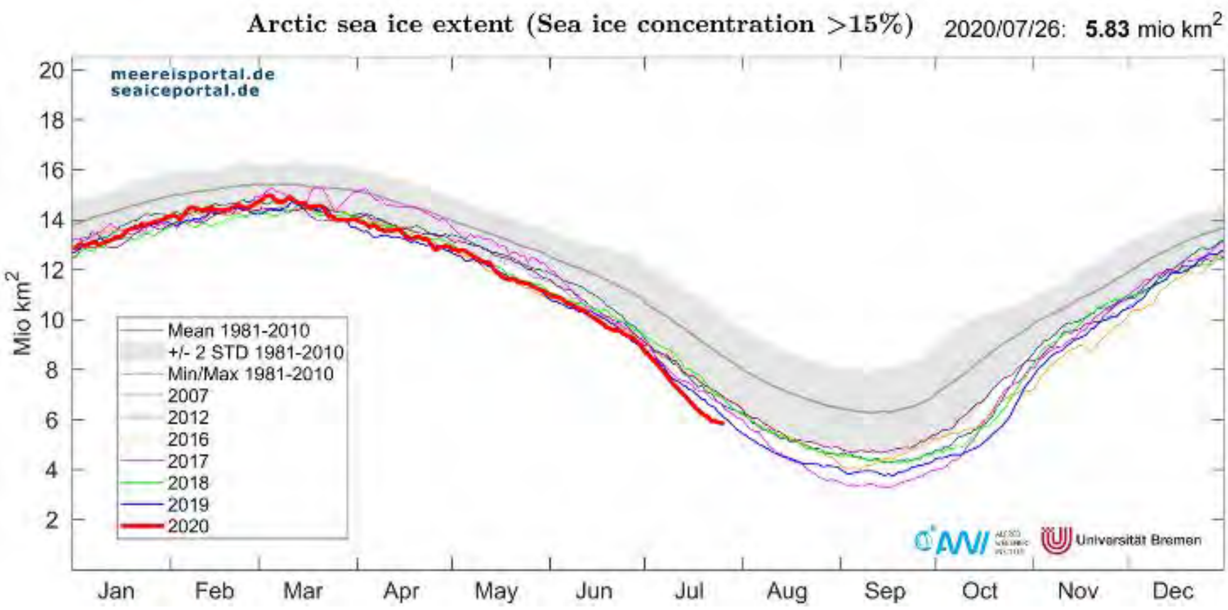
Sea Ice Ticker No. 46, 27 July 2020: Central Arctic much too warm for July

Text The Central Arctic is currently much warmer than the long-term mean, continuing the trend that has been apparent since June this year. Average air temperatures at the 925 mb level (roughly 760 m above sea level) for the first half of July were unusually high over the central Arctic Ocean – up to 10 degrees Celsius. These above-average temperatures were connected to high sea-level pressure centred over the East Siberian and Chukchi Seas. Arctic temperatures along the Russian coast were near or slightly above average. This represents a significant change from June, when temperatures along the Siberian coast of the eastern Laptev Sea were up to 8 degrees Celsius above average. It is likely that these high temperatures, combined with ice movement away from the coast, initiated early ice retreat along the Russian coast, and the opening of the North-East Passage. At present, the ice extent is extremely low – the lowest level for this time of year since the beginning of satellite observation. Sea-ice extent in the Arctic has been at a historically low level since 1 July 2020. On 19 July, the ice extent was 570,000 km^2 lower than the former record low in 2019. This sea-ice loss is represents an area roughly the size of France. 26 July this difference reaches still a value of circa 260.000 km^2. The coming weeks will show how this will affect the overall ice development and the MOSAiC expedition.



Source: www.esrl.noaa.gov/psd/products

Meereisticker (20 August – 12 October 2020)



Sea Ice Ticker No. 45, 17 July 2020: Sea-ice forecasts in the Arctic: what ice conditions are likely for the MOSAiC experiment in July, August, and September?

Text Sea-ice forecasts based on numerical modelling represent an important tool for estimating the sea- ice conditions in the Arctic and Antarctic in advance. The Arctic forecast for sea-ice conditions in July, August, and September 2020 could be an essential component in planning the continuation of the MOSAiC expedition after it was interrupted in May 2020. Therefore, a tried-and-tested method was applied, which is normally used for the AWI's contribution to the Sea Ice Prediction Network-Phase2 (SIPN) annual September Sea Ice Outlook (see here for details). The system used here for the MOSAiC forecasts differs from the September minimum system in that a) there is no bias correction and b) a higher model resolution is used.

While the forecasts of the sea-ice extent in September (15 % ice concentration) are based on lessons learned in connection with the Sea Ice Outlook (SIO) over the last decade, the forecasts regarding 80 % ice concentration and 1 m ice thickness are experimental and should be used with caution. Nonetheless, these two parameters provide important information for the continuation of the MOSAiC expedition at the chosen floe, because they ensure the ice is sufficiently thick for the research teams and the planned investigations and observations.

The model system starts with an analysis of the sea-ice conditions in March and April, which is produced by 'fusing' observational data and model simulations ('data assimilation'). The data used includes forcing parameters like satellite-based observations of daily ice concentrations and ocean surface temperature, as well as daily snow thickness. An important element for the success of the method is the assimilation of CryoSat-2 ice-thickness data during the calibration period. In the next step, ensemble simulations with forcing data from the years 2010 – 2019 are run.

While in 2018, the 80 % ice concentration and 1 m ice thickness contour lines were located further to the north, the forecast indicates that the ice conditions for the remainder of the MOSAiC expedition will be fairly similar to those in 2019, making them favourable for a maximum possible observation period.

Meereisticker (20 August – 12 October 2020)

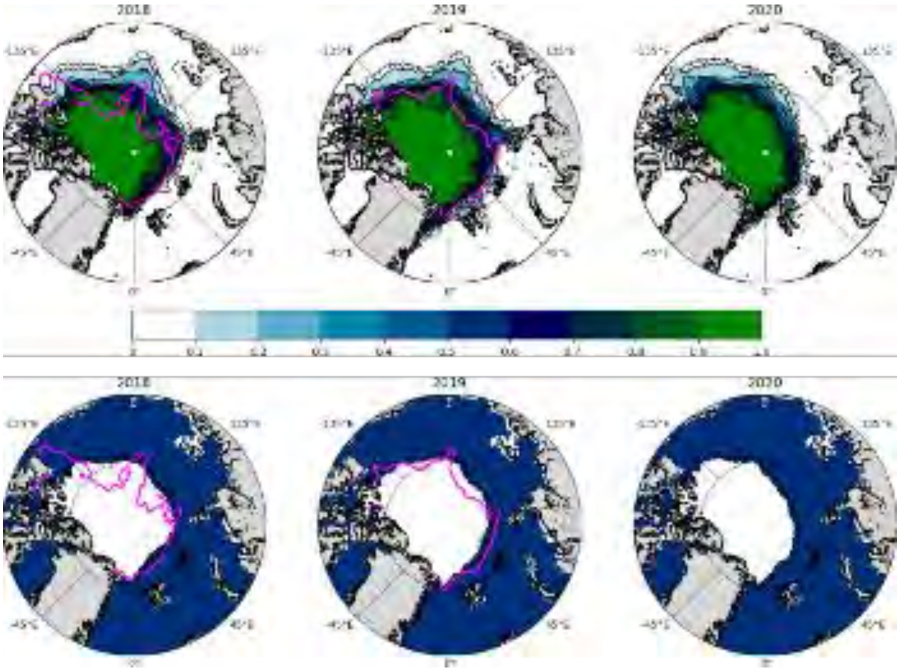


Figure 1: Validation sequence for the forecasting system for the years 2018 and 2019 (left and middle column) and the forecast for September 2020. Forecast of the likelihood (top) and the ensemble mean likelihood (bottom) of encountering an ice concentration of 80 % or greater. The actual observed isoline (OSI SAF) indicating a concentration of 80 % is marked in magenta for 2018 and 2019.

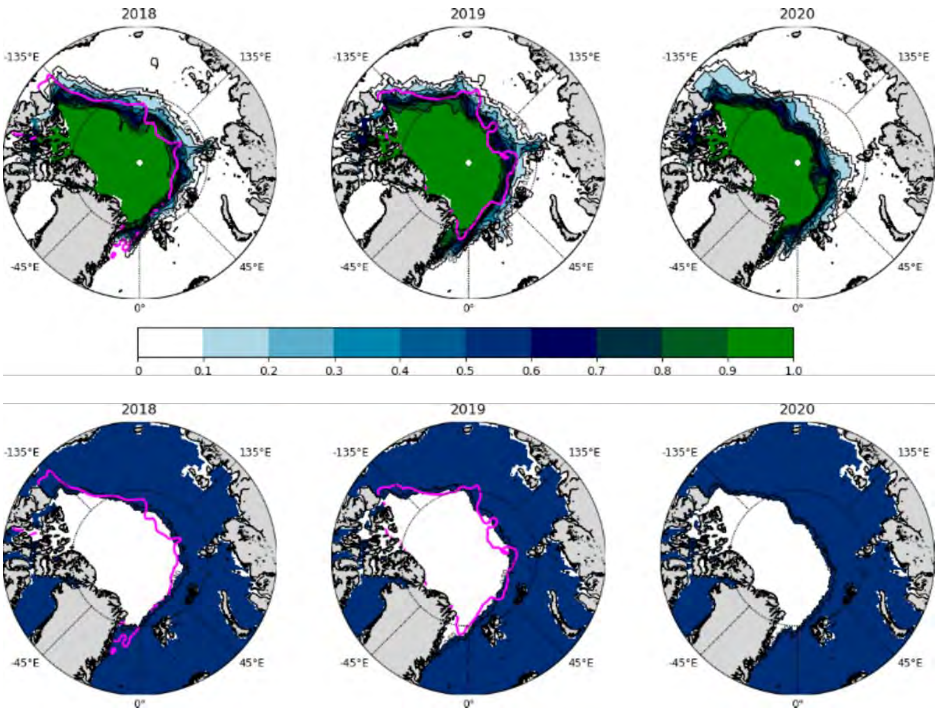


Figure 2: Validation sequence for the forecasting system for the years 2018 and 2019 (left and middle column) and the forecast for 2020 for 15th to 21st October: Forecast of the likelihood (top) and the ensemble mean likelihood (bottom) of encountering an ice thickness of 1 m or greater. The actual observed isoline (CS2SMOS) indicating a thickness of 1m is marked in magenta for 2018 and 2019.

Sea Ice Ticker Nr. 44, 10 July 2020: Drilling and digging – an ecosystem under observation

Text The Central Arctic is a largely unexplored ecosystem, yet one that is seriously threatened by climate change and sea-ice retreat. MOSAiC offers us a once-in-a-lifetime chance to investigate this unique ecosystem over the course of an entire year. This is particularly exciting with regard to the Arctic winter and spring, seasons that we still know very little about. Despite the considerable logistical challenges, from October 2019 to May 2020 biologists on board RV Polarstern tirelessly gathered samples of the organisms and their habitat within and below the ice.

Questions that they hope to answer with the help of MOSAiC include what the flora and fauna do during the long and cold Polar Night, how active they are and what they feed on. Another very interesting question: at what point the returning sunlight is sufficiently powerful to penetrate the dense layers of snow and ice and allow photosynthesis. They also hope to determine which microalgae have adapted better to these low-light conditions: those living in the sea ice, or those in the water column. To find the answers to these and countless other questions, every week of the expedition they gathered a large range of samples.

For example, they measured the available food sources for microalgae, as well as the chemical composition and nutritional value of these lower trophic levels (life forms that are on the lower end of the food chain) for fish and crustaceans. The biologists also studied the biomass, diversity and species assemblage of bacteria, microalgae, zooplankton and fish, and measured their activity. To gather samples from the sea ice, they drilled out ice cores; to investigate the aquatic ecosystem, they used water samplers. Since many of the specimens they gathered can only be effectively analysed in the lab, they're now returning home with very few answers, but with freezer boxes filled to bursting, and can't wait to see the first results. In the meanwhile, the next team of biologists are now on the MOSAiC floe, where they'll gather additional samples in an effort to better understand the transition to summer, the most productive phase for the Arctic ecosystem.

Collecting a sea-ice core sample to study the biomass, diversity and species assemblage of bacteria and microalgae (photo: Calle Schönning).

Sea Ice Ticker No. 43, 03 July 2020: Visual observation – an important task during sea-ice navigation

On the 16th of June, just over a week after departing from Svalbard, RV Polarstern reached the MOSAiC floe. On the way through the ice, we experienced moderate ice conditions compared to those on the way from the MOSAiC floe to Svalbard. Visual observations of ice conditions offer valuable support for research and navigational operations in sea-ice-covered regions, and they were done from the ship during transit from and back to the floe. Since these ice observations are standard procedure on vessels transiting through ice, our observations will contribute to a large dataset that is used to assist navigation in ice, to establish the seasonal and regional climatology of sea ice characteristics, and to verify satellite-based measurements.

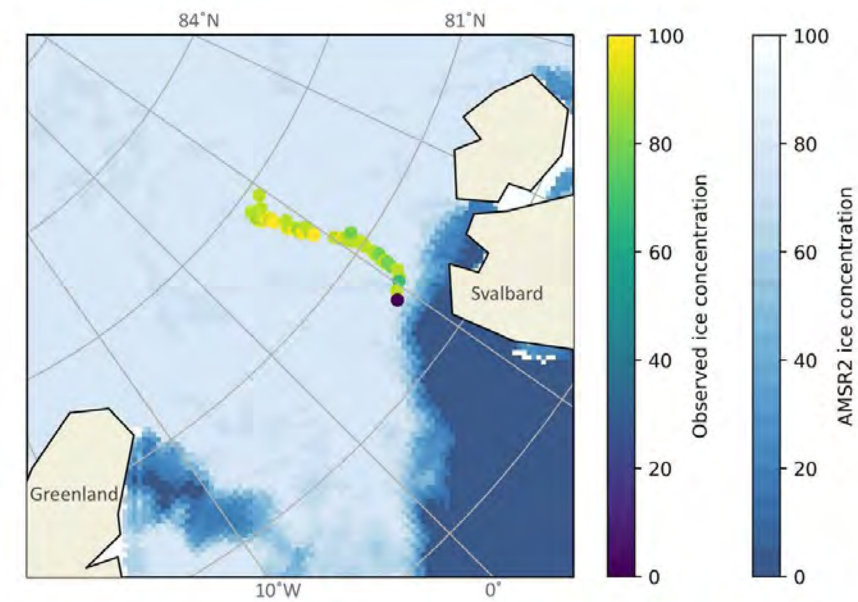
The journey back to the floe was significantly faster than the outbound transit just a few weeks earlier (8 days compared to 18 days). Our transit was made easier by the fact that in the nearly four weeks that we were away from the floe, it had drifted roughly 70 nautical miles (ca. 130 km) further to the south. The shorter travel time was likely also a result of lower ice pressure, which allowed us to pass through the ice faster. This can be seen quantitatively in the ice observations, which generally show lower ice concentrations on the return transit, and the presence of wider leads. Ice pressure is created by wind and ocean currents pushing the ice together. We generally had favourable northerly winds on our transit, compared to the southerly winds that caused the earlier compaction. However, we did still encounter considerable ice pressure, which kept us at a standstill for just under two days (13-14 June). We made use of the time to take some quick readings on the ice in the area.

During our observations, we found ample evidence of a high ice dynamic in the area. The ice was heavily deformed, with ridges up to two meters in thickness. This was also a result of the ice pressure created by wind and ocean currents.

As summer approaches, the melting season is now beginning. On the way out of the ice, the observers saw the formation of melt ponds on the surface. Decreasing temperatures paused this melting, so we primarily observed re-frozen melt ponds throughout our trip north. However, melting happens from both above and below, and we also observed some rotten ice and thaw holes – evidence that the melting from below has been accelerating due to warm ocean temperatures.

Meereisticker (20 August – 12 October 2020)

Heavily ridged sea ice seen off the bow of the ship during ice observations on 14 June (Photo: Luisa von Albedyll / AWI).



Total ice concentration observed along ship's transit out of and back into the ice, based on visual observations, and overlaid with ice concentration data from the AMSR2 satellite product (16 June).

Sea Ice Ticker Nr. 42, 26 June 2020: Is Fram Strait inevitable?

Especially in February and March, the MOSAiC floe, and RV Polarstern along with it, was driven by unusually powerful winds toward Fram Strait. As a result, the expedition is now closer to this main outlet for Arctic ice than we expected it to be. Analyses of the sea-ice drift in past years, conducted long before MOSAiC began, indicated that the expedition's course would most likely take it to Fram Strait and therefore the ice export along the eastern coast of Greenland. But is it now inevitable that the floe will exit the Arctic somewhere between Svalbard and Greenland, or are there still alternatives?

If this question had been raised at the end of April, consulting the latest projections from the Sea Ice Drift Forecast Experiment (SIDFEx, see its website) would have left the answer anyone's guess: in the course of April, the floe had drifted southeast toward Svalbard, thanks to a low-pressure wedge that spanned from Novaya Zemlya in the east to the North Pole and beyond (Fig. 1, top).

Based on the floe's position at the end of April, it seemed just as likely that it would come out in the Barents Sea to the east of Svalbard, instead of following in the footsteps of Nansen's Fram. Yet the month of May had other plans for the temporarily abandoned floe: a powerful high-pressure front, which pushed the low-pressure wedge out of the Arctic and reached from the rejuvenated Beaufort Gyre to Fram Strait, pushed the floe toward Greenland (Fig. 1, top).Since then, three weeks – predominantly characterised by a southern course, and later an eastern course – have passed; and most recently the floe appears to have begun 'dancing', as can be seen in the corkscrewing twists and turns in Figure 2 (upper left, dashed drift path), but that's a different story. The latest drift forecast, which can also be seen in Figure 2, indicates a continuing eastern course, but one that will only last two more days before heading back to the west. In the longer term (drift forecast for the next 120 days), Fram Strait appears to be a likely destination, as reflected in the ellipses in Fig. 2 (bottom left), which represent the forecast's spatial uncertainty and shift to the southwest. However, the wind-driven pull in Fram Strait tends to be fairly weak in late summer, which means the jury is still out.To see the latest SIDFEx forecast for the MOSAiC drift, click here .

Meereisticker (20 August – 12 October 2020)

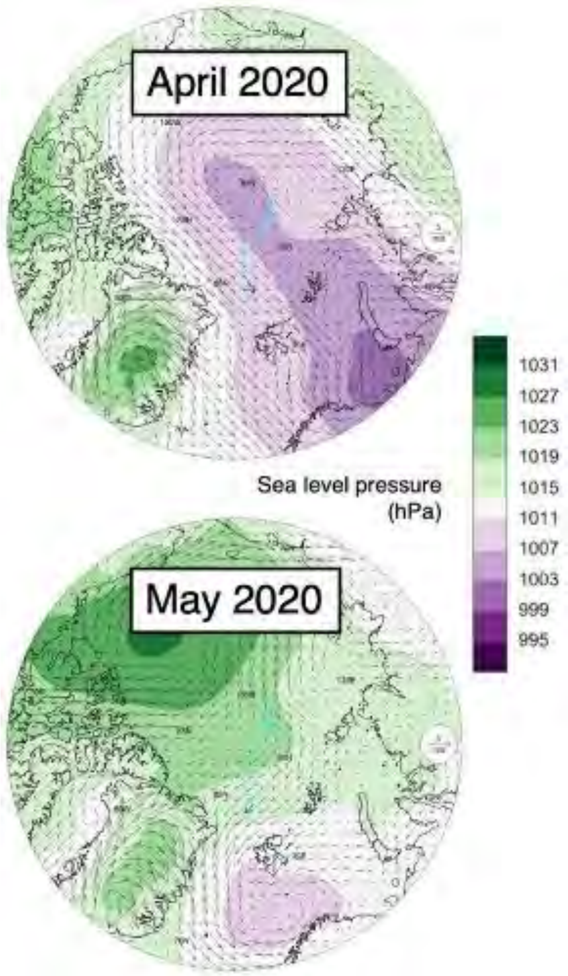


Figure 1: Pattern of sea-level pressure (colour scale) and winds at 10m height (arrows), as well as the entire MOSAiC drift path to date (light-blue curve) and monthly drift path (blue arrow) in April (top) and May (bottom). Pressure and wind data are based on the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA5 reanalysis.

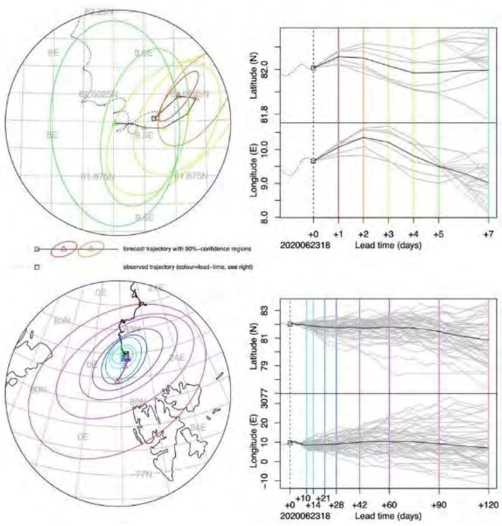


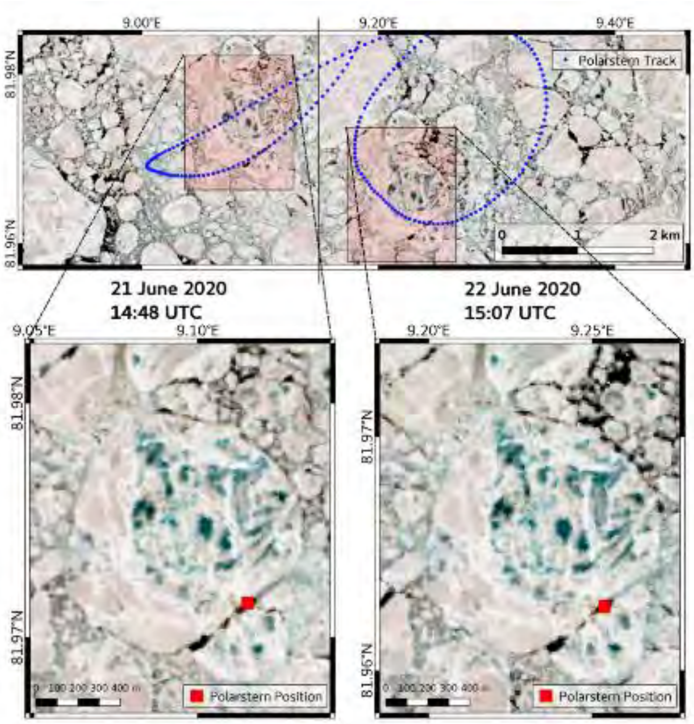
Figure 2: SIDFEx consensus forecast for the drift path of the MOSAiC floe, valid from 23rd June 2020 at 6:00 pm UTC. The next 7 days are displayed at the top; the next 120 days are shown at the bottom.

Sea Ice Ticker Nr. 41, 26 June 2020: A floe covered in pools: First high-resolution satellite images show the melting process

Since the return of the research vessel Polarstern to the MOSAiC floe, the expedition has been within range of high-resolution optical remote sensing satellites. On 21 and 22 June, the Sentinel 2 satellite from the European Union's Copernicus programme captured these images of the MOSAiC floe. Thanks to the spatial resolution of ca. 10 m per pixel (a pixel is the smallest physical point in a raster image), many details can be recognised, e.g. the shapes of the larger pressure ridges. But we can also see meltwater pools, which formed on the surface with the onset of the melting season and are now becoming larger by the day (see the image compari-son from 21 and 22 June).

Compared to other floes in its extended vicinity, the MOSAiC floe is characterised by an unusually high meltwater pool concentration, making it the ideal candidate for investigating the pools' formation and development by means of various sensors. The blue colour is produced by the underlying ice, and is a hallmark of meltwater pools on sea ice.

The images were processed and interpreted by Bennet Juhls. As a PhD candidate at the Freie Universität Berlin's Institute for Space Sciences, he is currently studying material and carbon flows from land to ocean in the Arctic with the aid of optical remote sensing, working in close collaboration with the AWI Potsdam (permafrost section).



Images produced by the MultiSpectral Instrument (MSI) on board the Sentinel 2 satellite, part of the European Union's Copernicus programme, on 21 and 22 June. The first meltwater pools have now formed on the MOSAiC floe and are rapidly growing. Modified Copernicus Sentinel data [2020] ; scihub.copernicus.eu

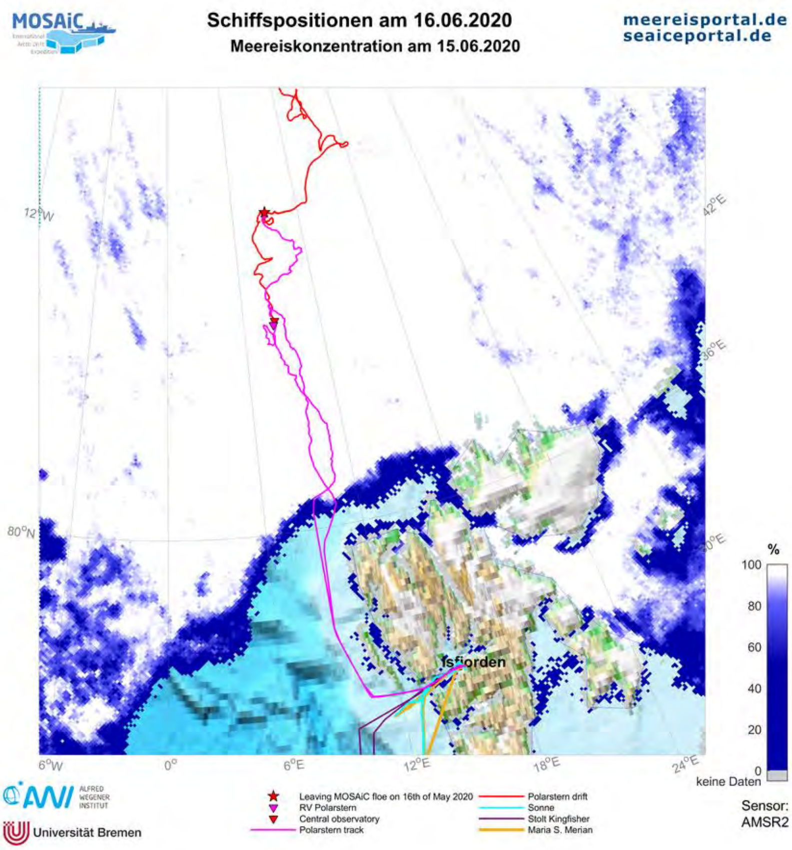
Sea Ice Ticker No. 40, 17 June 2020: Sea ice drift through Fram Strait

Text The RV Polarstern is currently on her way back to the MOSAiC floe, which she left on 16 May for a personnel and crew exchange in Isfjorden near Svalbard. The journey involved passing through part of Fram Strait, the region lying between Greenland and Svalbard, where a large percentage of the pack ice leaves the polar waters and melts. Some of the ice that ships encounter here is several years old and has been transported across the Arctic by one of the two main currents. One of them is the Beaufort Gyre, which circulates the ice north of Alaska in a clockwise direction. The other significant current, the Transpolar Drift, transports ice that has formed e.g. on the Russian Shelf across the Central Arctic to Fram Strait, a journey that normally takes two to three years. During the MOSAiC experiment, RV Polarstern has taken advantage of this 'conveyor belt'. Ice leaving Fram Strait today is about 30 percent thinner than 15 years ago. This is due on the one hand to the rising winter temperatures in the Arctic and the fact that the melting season now begins much earlier. On the other hand, this ice is no longer formed in the shelf seas, but instead much farther north. This means that it has significantly less time to drift through the Arctic and grow into thicker pack ice (read more here).

On her southward journey, RV Polarstern encountered both pressure ridges and more compacted ice cover, as a result of which she sometimes only made a few nautical miles of headway per day. Traversing the ice was difficult, especially due to the enormous pressure produced by compression.

Since the start of the expedition, the MOSAiC floe has drifted at an average speed of 0.43 km/hour, and since leaving the floe on 16 May, she has been transported with the general drift ca. 108 km south toward Fram Strait (and a total distance of 213 km). On her return journey almost four weeks later, the advancing summer in the Arctic had broken up the ice further, allowing RV Polarstern to progress more easily and rapidly, and reached the MOSAiC floe today. The MOSAiC drift can now continue with RV Polarstern. We are eager to see what developments there have been there in the last four weeks.

Meereisticker (20 August – 12 October 2020)



Sea Ice Ticker No. 39, 10 June 2020: Satellites provide helpful guidance for navigating

The satellites Sentinel-1 a and Sentinel-1 b take daily images of Fram Strait and provide helpful guidance for navigating in the ice. Radar images are similar to photographs, but instead of visible light, they are created using microwaves with a wavelength of approximately 4 - 7.5 cm, which is much longer than the visible light that we can see with our eyes. The main advantage of microwaves is that we can take pictures unaffected by clouds and even in the absence of sunlight, e.g. during the (Polar) night.

The varying shades of grey on the radar image (see Figure 1 left) indicate how much of the outgoing radar pulse was scattered back to the satellite's antenna. The strength of the backscatter depends on various physical properties of the sea ice, but a very important one is the surface roughness. A smooth surface, like open water without any waves, acts like a mirror and the microwaves are reflected away from the satellite. This means the satellite can't see the reflected waves, which is why these areas appear as dark spots in the image. Ice ridges that consist of jagged chunks pointing in different directions scatter more radiation back to the satellite, and therefore appear brighter in the radar image.

While the satellite images are used on board to plan the general route, the ship's radar offers real-time support with navigating in the ice (Figure 1 right). Just like the satellites, the radar uses microwaves and can scan the ice in a radius of 3 nautical miles, unaffected by the lighting conditions or fog. This is extremely helpful when visibility is poor. The differences in brightness in the ship's radar images make it possible to distinguish between deformed ice (bright) that consists of broken chunks and flat, undeformed ice floes (dark). Leads, i.e., channels of open water that can serve as a fast route through the ice, appear black, often with a clearly visible edge separating them from the surrounding ice. The radar continuously scans the ship's surroundings, allowing us to monitor how the ice moves, and how new leads and ridges are formed.

Meereisticker (20 August – 12 October 2020)

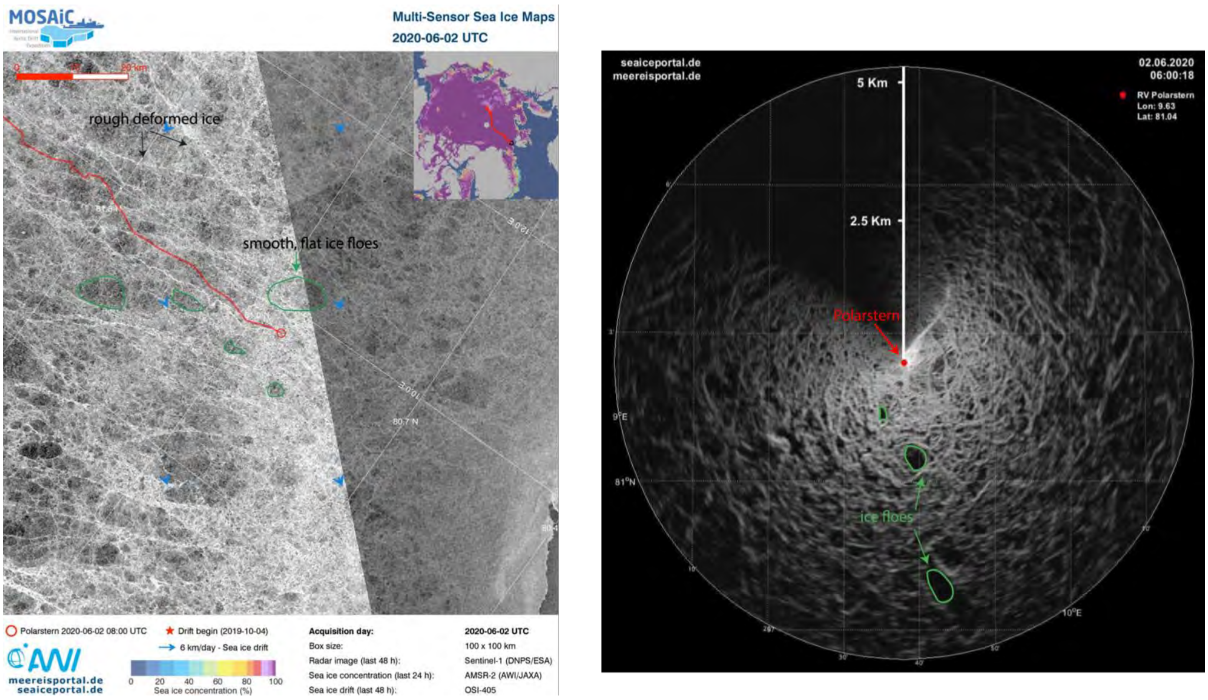


Figure 1: (Left) Flat, undeformed ice floes (outlined in green), which show up as dark oval-shaped areas in the Sentinel-1 image are crisscrossed by bright, thin lines that correspond to deformation zones where the sea ice has been broken up. The ship navigates around the large floes instead of ploughing through them, because doing so could slow it down. (Right) In this ship's radar image, RV Polarstern (red dot) is surrounded by bright structures that represent broken chunks of ice. The darker areas outlined in green are most likely undeformed, flat ice floes. The officers on the bridge use these images to decide on the best way to navigate through the ice, while avoiding the large floes.

Textfoto

Sea Ice Ticker No. 38, 05 June 2020: Black carbon - small particles that produce major effects, or essentially harmless?

Black carbon (BC) refers to carbon particles produced by incomplete combustion. Sources include forest fires, emissions from ships, diesel engines, and combustion of fossil fuels.

The particles can be transported through the atmosphere for days or even weeks before finally settling on the surface. When the dark BC particles land on snow, they reduce the reflectiveness (albedo) of its otherwise white surface. As a result, snow absorbs more sunlight and warms up more intensively.

To date, the processes and effects of BC particles in snow have yet to be thoroughly investigated; we still lack reliable readings collected over an extended timeframe and covering a large spatial area. Using data gathered during MOSAiC, AWI researchers plan to quantify the BC content in snow over the course of a year, and to investigate how this darkening and atmospheric feedback affect the melting of snow cover on sea ice.

For this purpose, on the MOSAiC floe, snow samples are collected in small vials (50 ml) at various distances from RV Polarstern, and in the surrounding Distributed Network, throughout the year-long drift. At the end of the expedition, the samples will return to Bremerhaven on board the RV Polarstern. Once there, they'll undergo laboratory testing, and the results will be combined with other data, e.g. the weather conditions and snow properties. In the next step, all of the data gathered will be fed into a snow model, in order to gain new insights into the effects of BC particles on radiative forcing, and accordingly, on sea ice.

AWI doctoral candidate Daniela Krampe collects samples to measure the black carbon content in the snow (Photo: Matthias Jaggi).

Sea Ice Ticker No. 37, 02 June 2020: RV Polarstern is gone, but the research continues!

On 16 May RV Polarstern had to leave the MOSAiC floe, in order to complete a transfer of research personnel and crew, and to bunker fuel and provisions, despite the coronavirus crisis. Having to leave the floe now of all times is a bitter setback for many of the participating researchers. When the spring comes and the melting begins, there's much to see on the sea ice: the snow cover melts, and the water collects in melt ponds. At the same time, the ice becomes more and more transparent, and the algae underneath it start growing.

Unfortunately, for the next few weeks there won't be anyone on site to study these changes in detail. But now, one of the ice researchers' tactics is especially paying off: over the course of the last several months, a host of automatic monitoring stations have been installed on the ice – and they continue to transmit their readings to Bremerhaven by satellite, allowing us at the AWI to follow the changes 'live'. The webcams impressively show how the surface melting is rapidly progressing and the first meltwater ponds have formed. Further, the sensors on our monitoring buoys indicate that the snow thickness is declining and the algal content in the water is on the rise. Needless to say, this remote sensing is no substitute for detailed on-site investigations, but at least this approach allows us to stay in the loop and keep up with what's happening on the MOSAiC floe while the experts are away. By the way, nearly all of our buoy data is freely accessible at our meereisportal.de.

Series of images from the webcam on our radiation monitoring buoy 2020R12 for three consecutive days from 26 to 28 May 2020 (Photo: automatic webcam, AWI).

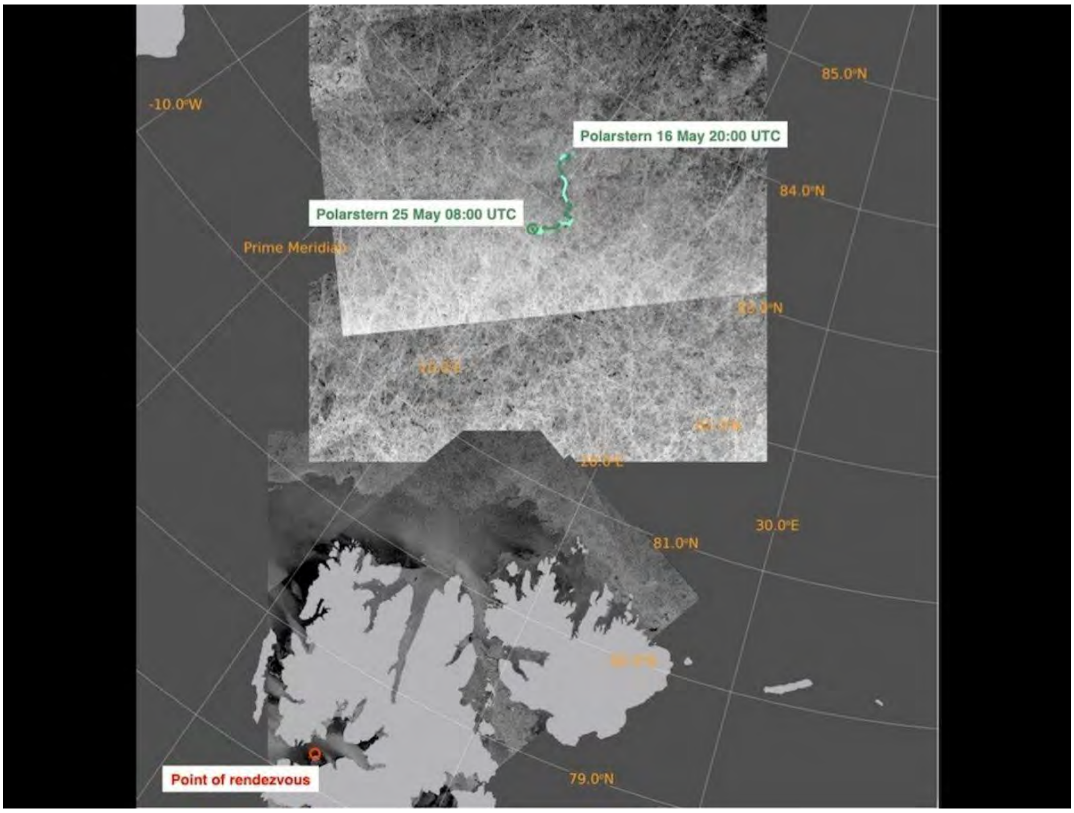
Sea Ice Ticker No. 36, 29 May 2020: The ice in Fram Strait – bound for a rendezvous

On 17 May, RV Polarstern left the MOSAiC floe to rendezvous with the German research vessels Maria S. Merian and Sonne in Isfjorden near Svalbard. Once there, the three ships will engage in the transfer of personnel for Legs 3 and 4 of the expedition, as well as provisions. Yet, due to adverse ice conditions, the FS Polarstern is making very slow headway. There are currently no sizeable ice-free stretches running north and south that she could use as an "autobahn" to more quickly reach the ice margin and open water. The ship is currently ploughing through two-year-old fast ice, which can still be up to two metres thick (referred to as 'level ice'), despite the recent melting processes.

The aerial photograph shows that, in some places, the pack has broken up into smaller floes. Nevertheless, the sea ice continues to be under substantial pressure, making it harder for the FS Polarstern to break through and push it aside. Between the small floes, there are large quantities of mixed ice fragments ('rubble ice'), which are also difficult to press through. On the bridge of the RV Polarstern, the crew constantly survey the ice concentration and thickness, snow thickness, average floe size, and the percentage of pack ice hummocks on the ice. During the transit to Isfjorden, Svaldbard , images from the ship's on-board radar system will continue to be transmitted back to Bremerhaven several times a day. This sequence of radar images shows the FS Polarstern departing from the Central Observatory on the MOSAiC floe and heading south, pushing through an area filled with smaller ice floes and numerous pack ice hummocks along the way.

It's important to bear in mind that these ice conditions are nothing unusual for the region and time of year; in fact, they're fairly typical and were to be expected. Arctic sea-ice is thickest in the spring. In addition, the ship is headed in the direction of Fram Strait, the central outflow region for southbound ice, especially two-year-old ice. In brief: normally it's advisable to avoid traversing two-year-old ice in mid-May, but in this phase of the expedition and under the current circumstances, there was no other choice.

Meereisticker (20 August – 12 October 2020)



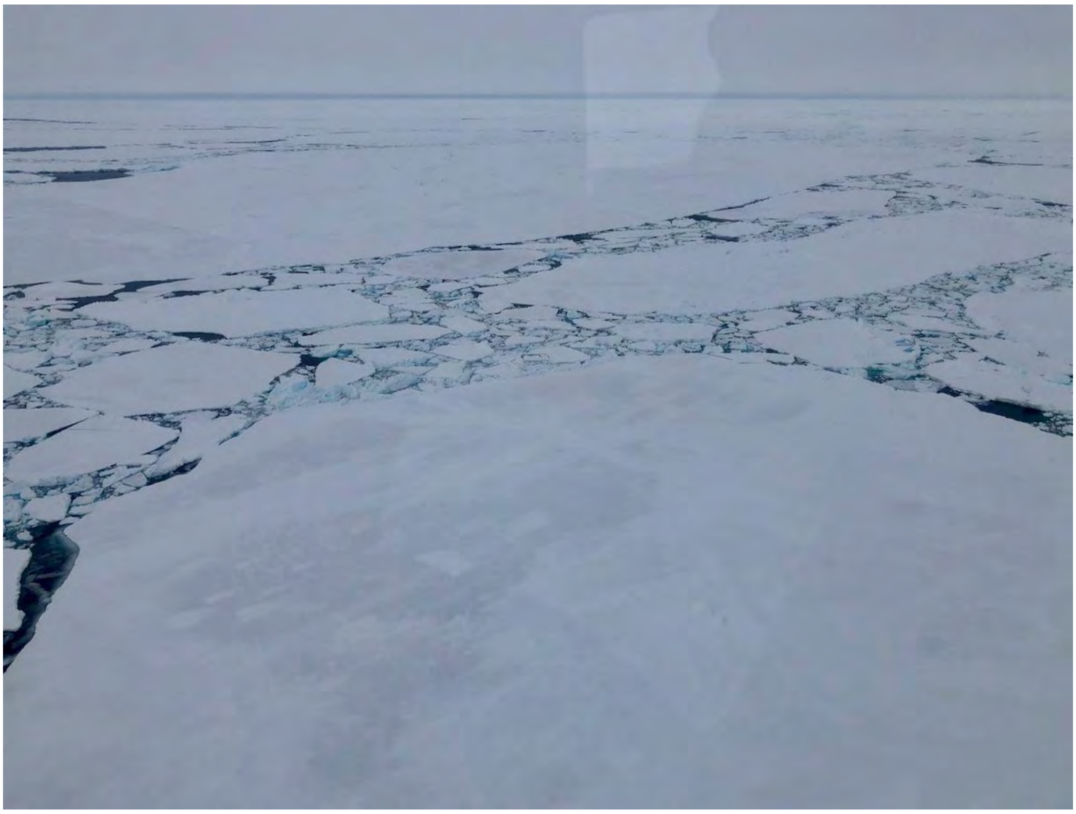


Photo: Robert Ricker

Sea Ice Ticker Nr. 35, 20 May 2020: Personnel transfer becomes a unique rendezvous for the German research fleet

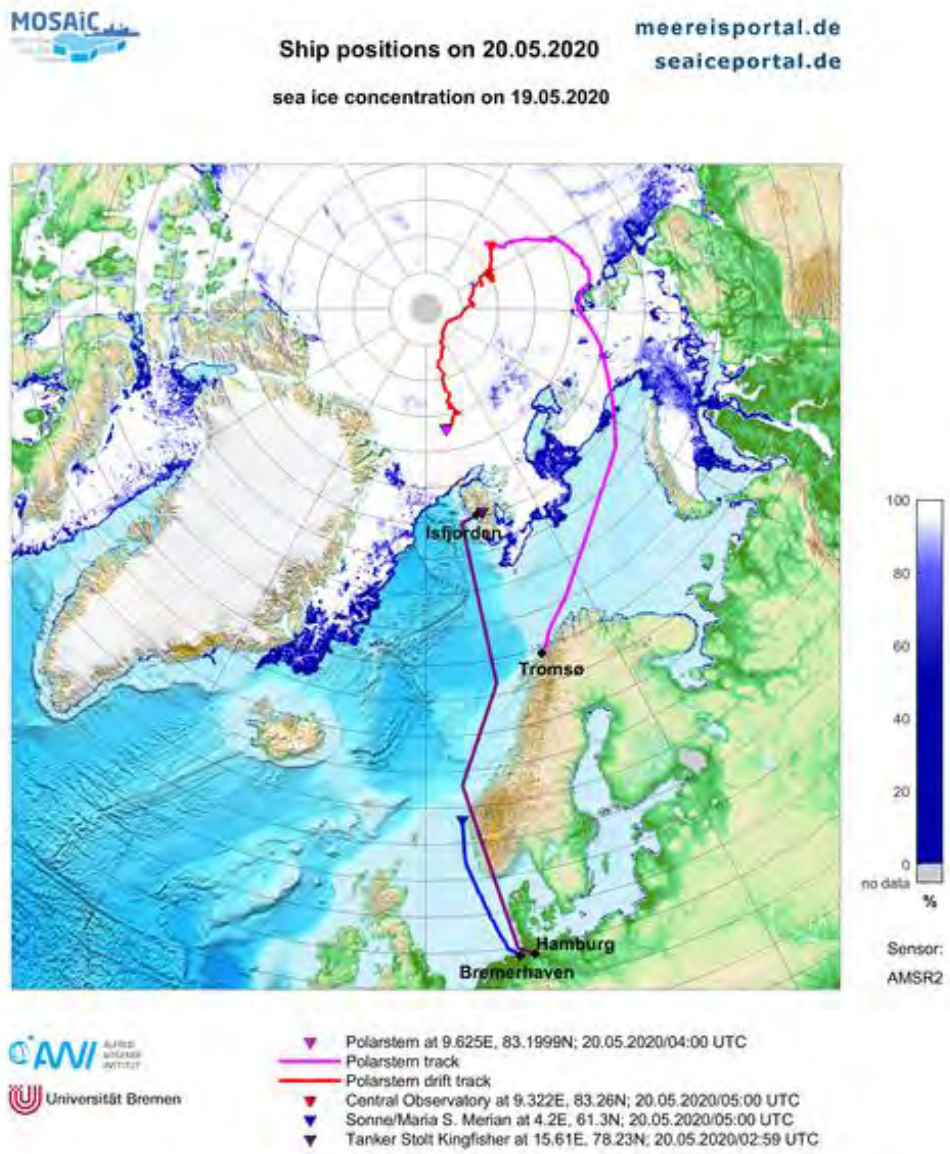
For weeks now, the researchers and crewmembers on board the RV Polarstern have been waiting for the next personnel transfer in the MOSAiC expedition, originally slated for the first half of April, to take place. But due to the global coronavirus pandemic, it has been impossible to relieve the staff for the expedition's third leg (Leg 3) as planned; the transfer via aeroplane had to be cancelled, since no flights were permitted to or from Norway or Svalbard. As a result, the entire team for Leg 3 is still working on the MOSAiC floe today.

In the meantime, thanks to an unprecedented level of cooperation, an alternative plan has been devised, which will for the first time bring together three German research vessels at sea. The global pandemic forced the RV Sonne and RV Maria S. Merian to abort their ongoing expeditions and return to Germany. Since neither ship was currently engaged in operations, the German Research Fleet Coordination Centre, together with Germany's Federal Ministry of Education and Research, decided to deploy them for the MOSAiC personnel transfer.

On 18 May 2020, after a two-week-long quarantine period at Bremerhaven-based hotels, a total of 56 researchers and 37 crewmembers began their journey to the Arctic. Accompanied by a refuelling tanker, the Sonne and Maria S. Merian will follow a course along the European coast bound for Svalbard, and will rendezvous with Polarstern at the fjord Isfjorden from 23 May. Since none of the three supporting ships is designed for operating in pack ice, RV Polarstern departed from the MOSAiC floe on 16 May, in order to leave the ice, carry out the personnel transfer and bunker ca. 14 metric tons of supplies, not to mention fuel.

The four ships will remain in the area for ca. three to five days, after which RV Polarstern will return to the MOSAiC floe, where the researchers will continue their drift and field work as long as possible. RV Sonne and RV Maria S. Merian will return to Bremerhaven with the participants from Leg 3 on board. In this animation of the ship's route, you can track the courses of the ships, plus the drift of the MOSAiC floe, on a daily basis.

Meereisticker (20 August – 12 October 2020)



Sea Ice Ticker Nr. 34, 15 May 2020: MOSAiC's eyes in the sky

Airborne measurements are an essential tool for the areal, high-resolution acquisition of sea ice parameters on a medium scale, between in-situ measurements and large-scale observations by satellite. The two BK 117 helicopters on board RV Polarstern can be equipped with a diverse range of scientific instruments for airborne surveys, from various types of camera to a laser scanner, and even a towed torpedo-shaped EM-Bird. The aim of the surveys is to investigate the temporal evolution and spatial variability of sea ice parameters like thickness distribution, freeboard, topography, surface temperature, floe size distribution, and the properties of leads and meltwater ponds, so as to better understand the processes governing them. For the duration of MOSAiC, the flights take place on a weekly basis, depending on the weather conditions, which can be challenging in the polar regions, and cover various spatial scales, from the Central Observatory up to a distance of 80 nautical miles from RV Polarstern.

During the second leg of MOSAiC, stretching through the dark mid-winter months, only the airborne laser scanner (ALS) and the infrared camera were used for airborne surveys. In addition to several of the scientific objectives listed above, the ALS served a more practical purpose. Since the scientists of leg 2 arrived at RV Polarstern on 13 December, i.e., already deep in the Polar Night, they had never seen the surrounding MOSAiC floe by daylight. The surface elevation data from the ALS was processed into quicklook products already onboard Polarstern to produce topographic maps of the floe. This offered the scientists a way to "switch on the light" in the darkness, to get an accurate representation of their surroundings, and to ensure safe working conditions on the ice. (See e.g. Sea Ice Ticker Nr. 15 and the MOSAiC blog).

The airborne surveys were flown at an altitude of 300 m, which also roughly matches the width of a single line on the ground as measured by the ALS. Therefore, covering a sufficiently large area to capture the Central Observatory and its immediate surroundings required multiple parallel passes. This was easier said than done in total darkness, where GPS coordinates quickly became obsolete as the sea ice underneath drifted and the only visual reference points left were the lights of RV Polarstern. The solution: "backseat driving" by the scientific instruments' operator, who had a live view of the covered track on their computer screen. Successful missions thus called for seamless cooperation and communication between the science operator and the pilot through clear commands such as "ten degrees to the right", "five degrees to the left", "maintain heading", and "increase rate of turn".

Long-exposure photo of the helicopter during a lead event survey on 23 January 2020 (Photo: Steffen Graupner)

Sea Ice Ticker Nr. 33: 08 May 2020: Building a runway on the sea ice

During the first few months of the MOSAiC drift we were farther away from any land or civilisation, from which an emergency evacuation could be carried out in a few hours, than the astronauts on the International Space Station ISS. Accordingly, in an emergency, for example for medical reasons, reaching the RV Polarstern in the middle of the Polar Night would have taken several days by plane, and even then, only if there were a landing strip near the ship. It was therefore an important goal during Leg 2 to build a suitable runway for emergency use. But how do you find a suitable, i.e., sufficiently thick and level, location in the permanent darkness? We used airborne laser scanning (ALS) to map the area surrounding RV Polarstern by helicopter. We were lucky to find an extended smooth area only a few hundred metres away from the ship. Then we towed an electromagnetic (EM) ice thickness sensor along the surface of the prospective runway to confirm that it was thick enough. Once we knew that the ice was consistently thicker than one metre and therefore safe for landing, we brought a snowcat (tracked vehicle) to the site to flatten a few small ridges and to remove the snow. In early January, three weeks after our arrival at the floe, and after just one day of ploughing, we had a smooth, 500 m long runway suitable for landing a small Twin Otter aeroplane, on wheel skis if needed. Luckily, we never had any medical emergencies and the runway initially remained unused.

However, in preparation for the planned crew exchange in early April, we successively expanded the runway to 1 km long and 60 m wide, making it suitable for larger airplanes like the AN74, which can carry up to 40 passengers. Unfortunately, the crew exchange never took place due to the closure of the airport in Svalbard in the wake of the COVID19 pandemic, and therefore no larger aircraft ever used our runway.

During March and April, several ice fracture events damaged parts of the runway, reducing its useable length to 400 m. Then, on 22 April the big day came when two Twin Otter planes landed near RV Polarstern to exchange some personnel. This event marked the crowning success of the construction of the sea ice runway.

Two Twin Otters have safely landed and are parked on the sea-ice runway near RV Polarstern on 22 April 2020. (Photo: Christian Rohleder, DWD)

Meereisticker (20 August – 12 October 2020)

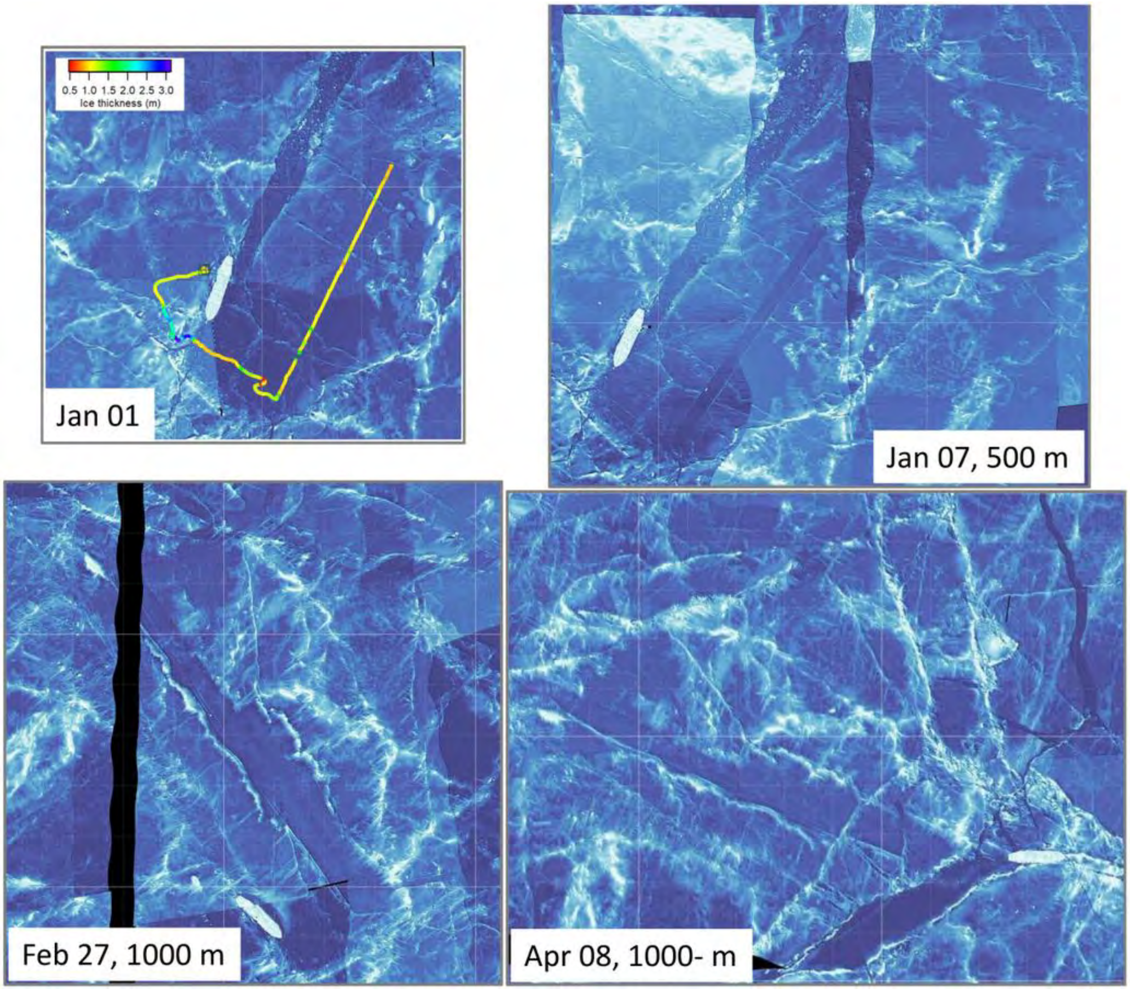
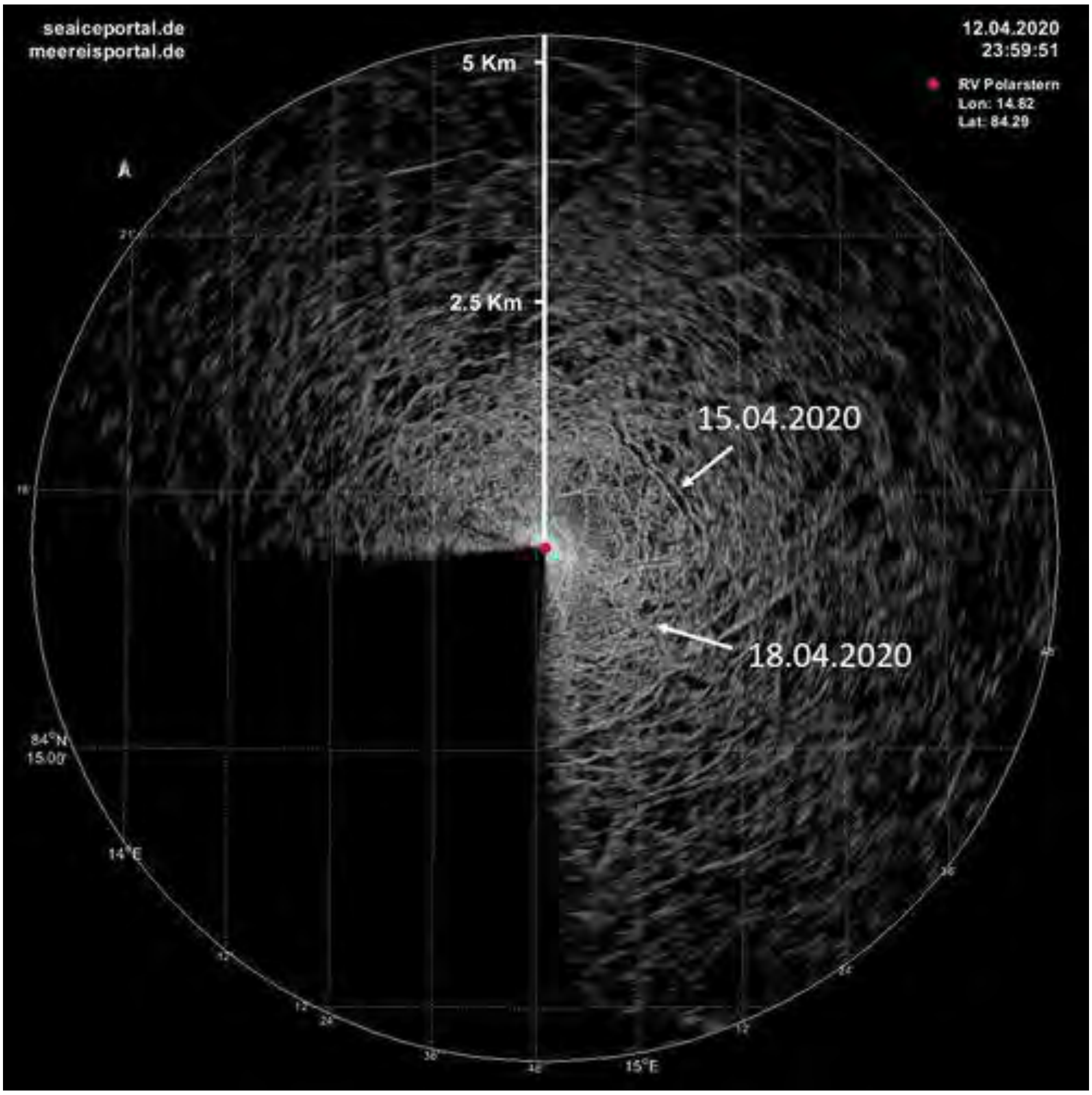


Figure: Airborne laser scanner maps of different stages of the runway. The maps show the freeboard, with higher elevations, e.g. pressure ridges and RV Polarstern, depicted in brighter tones. The runway can be recognised by its smooth surface and the snow banks to the sides. Top left: the initial electromagnetic ice thickness survey. Top right: the initial 500 m long medevac runway. Bottom left: the runway after being extended to 1000 m to accommodate BT67 and AN74 aircraft. Bottom right: the situation in April, after the runway had been cracked and shifted by deformation events in March, and only approximately 400 m on the left-hand side remained useable. This was the section on which two Twin Otter aircraft landed on 22 April. Note: in the four maps, the runway seems to rotate; this is due to the fact that in all maps North is up, but North turned relatively by at least 100° as the floe drifted from approximately 120°E in early January to approximately 14°E in April.

Sea Ice Ticker Nr. 32: 30 April 2020: Ice dynamics in the ship's surroundings & MOSAiC Camp

The MOSAiC Camp is currently drifting with the sea ice at a rate of ca. 10-15 km per day, predominantly heading south toward Spitsbergen, and we continue to see highly dynamic conditions in its own floe and neighbouring floes. Though the month of March was colder than the long-term average in the Central Arctic and the ice concentration chart for the region shows nearly 100 % ice cover, the small-scale ice conditions are highly dynamic. The MOSAiC floe (at 83° 56′ N and 15° 38′ E) is now entering a region where satellite images no longer indicate solid ice cover, but also areas with less than 90 % cover. But it's impossible to say what that means on a small scale using satellite images with a resolution of 6.25 km. In this regard, RV Polarstern's on-board radar offers a good means of monitoring the relative motion of both the ship and nearby floes.

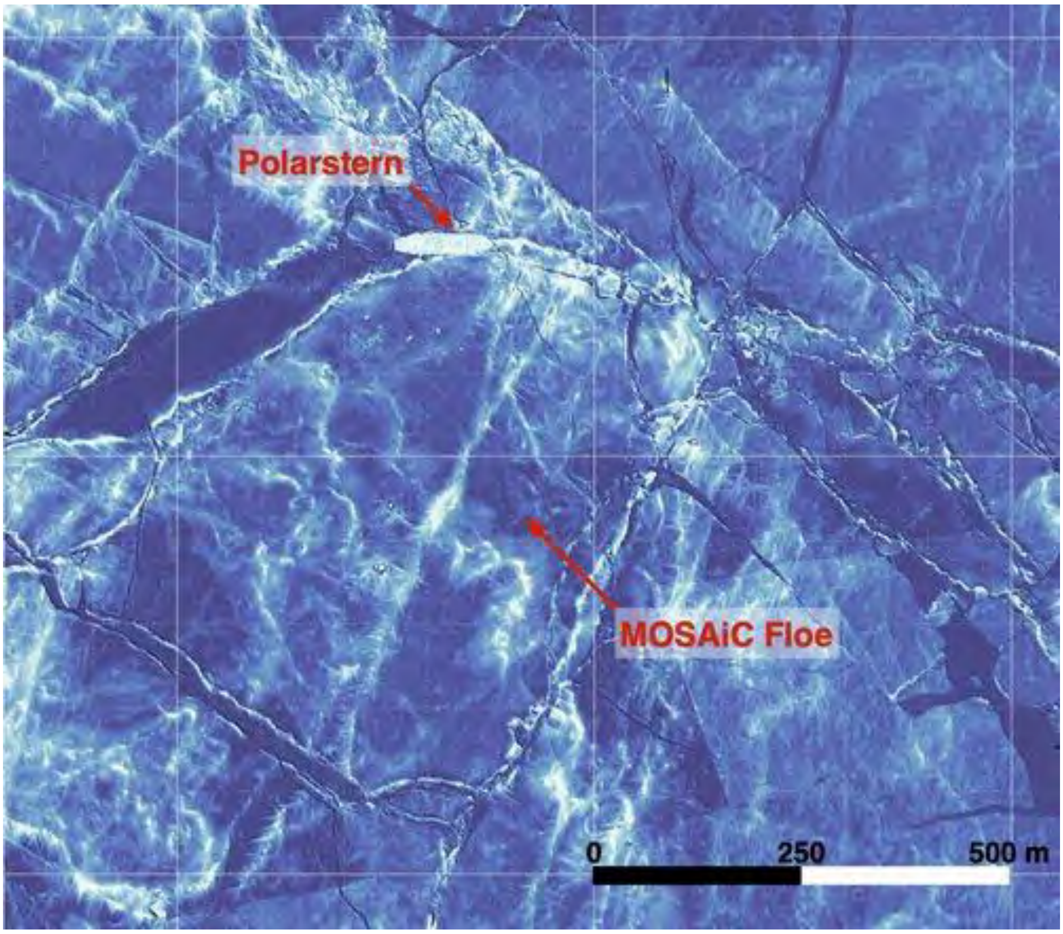
The ice has been in constant motion since mid-March, and extensive systems of cracks and leads have formed in the Camp area. Not only can broad leads and lakes be seen, but also pack-ice hummocks produced by colliding ice floes; the latter have made on-site fieldwork much more difficult, in some cases cutting off monitoring stations' power supplies, or even making them inaccessible. As a result, new solutions have to be found on a daily basis in order to continue the work at the observatories. In this 14-day animation, composed of radar images of the ship's immediate vicinity from 8 April to 21 April 2020, we can see how RV Polarstern, at the centre of the screen, moves relative to its geographical surroundings, and how leads and cracks form and disappear. For example, on 15 April we observed a relative movement of a large floe edge to the northeast of Polarstern, and another on 18 April to her southeast, both of which produced significant shifts within the span of 6 – 12 hours. This poses a constant challenge for research and logistics, but also for the measuring instruments and equipment installed on site.


seaiceportal.de
meereisportal.de
12.04.2020
23:59:51
RV Polarstern
Lon: 14.82
Lat: 84.29
5 Km
2.5 Km
15.04.2020
18.04.2020
84°N
15.00'
14°E
15°E

Sea Ice Ticker Nr. 31: 24 April 2020: A 3D map of the MOSAiC floe

The thickness and internal structure of sea ice are important parameters for sea-ice physics and the long-term development of the sea-ice cover, especially with regard to the course of the MOSAiC expedition. With the helicopters on RV Polarstern, we can accurately measure physical ice parameters in order to characterise both the MOSAiC floe and its surrounding area. One helicopter is equipped with nadir-looking cameras and a laser scanner, which allows us to map the surface topography down to the nearest centimetre.

The figure above is a scan image from 8 April 2020. White patches indicate higher elevations, such as pressure ridges. Dark blue areas indicate lower elevations, such as leads or cracks in the ice. The picture clearly shows how the MOSAiC floe is embedded in its surroundings, and where huge crevasses and areas of open water have formed. Within the floe, pressure ridges as well as small channels and cracks can clearly be seen. The ice's surface is highly dynamic and can change within just a few hours. Thanks to these regular measurements, we can capture changes in the ice topography, which is an important aspect of MOSAiC.



Sea Ice Ticker Nr. 30: 17 April 2020: Investigating the world beneath the MOSAiC floe

The underside of sea ice and the water layer directly below it are an important part of the Arctic ecosystem. Single-celled algae living in the water column (phytoplankton) and in the ice (ice algae) are the main primary producers in the frigid waters. They transform inorganic carbon into organic material through photosynthesis, and thus form the basis of the food web in the ice-covered Arctic Ocean. Primary production is heavily dependent on the availability of light, which is currently increasing as the sunlight again reaches the MOSAiC floe after the long Polar Night.

In addition to the dramatic seasonal variability, the light conditions under the ice are also characterised by a high degree of spatial variability. The thickness of the snow cover, cracks in the ice, leads, melt ponds and inherent sea ice properties all influence how much light penetrates to the bottom, resulting in differences on orders of magnitude within the area of a single ice floe. Mobile platforms like the Remotely Operated Vehicle (ROV) “Beast” make it possible to investigate this spatial variability underwater in great detail.

In addition to measuring irradiance and radiance, the “Beast” has a suite of sensors for measuring water column properties, several cameras and a multibeam scanning sonar that allows it to produce 3D topographical maps of the ice’s underside. By combining bottom topography data from regular dives together with surface laser scans, meteorological observations and snow measurements, researchers can monitor the development of the sea ice and snow cover at both interfaces. Further, the high level of detail allows them to identify connections between the observed changes in the ice-and-snow matrix and developments in the world beneath the ice.

The ROV also offers a unique ‘seal’s-eye view’ of the beautiful underwater realm, as shown here in a screenshot from an HD video camera mounted on the “Beast”. The device at the bottom of the image is the ROV’s manipulator arm, which allows it to grasp and move objects underwater.

Sea Ice Ticker Nr. 29: 9 April 2020: The MOSAiC Buoy Network

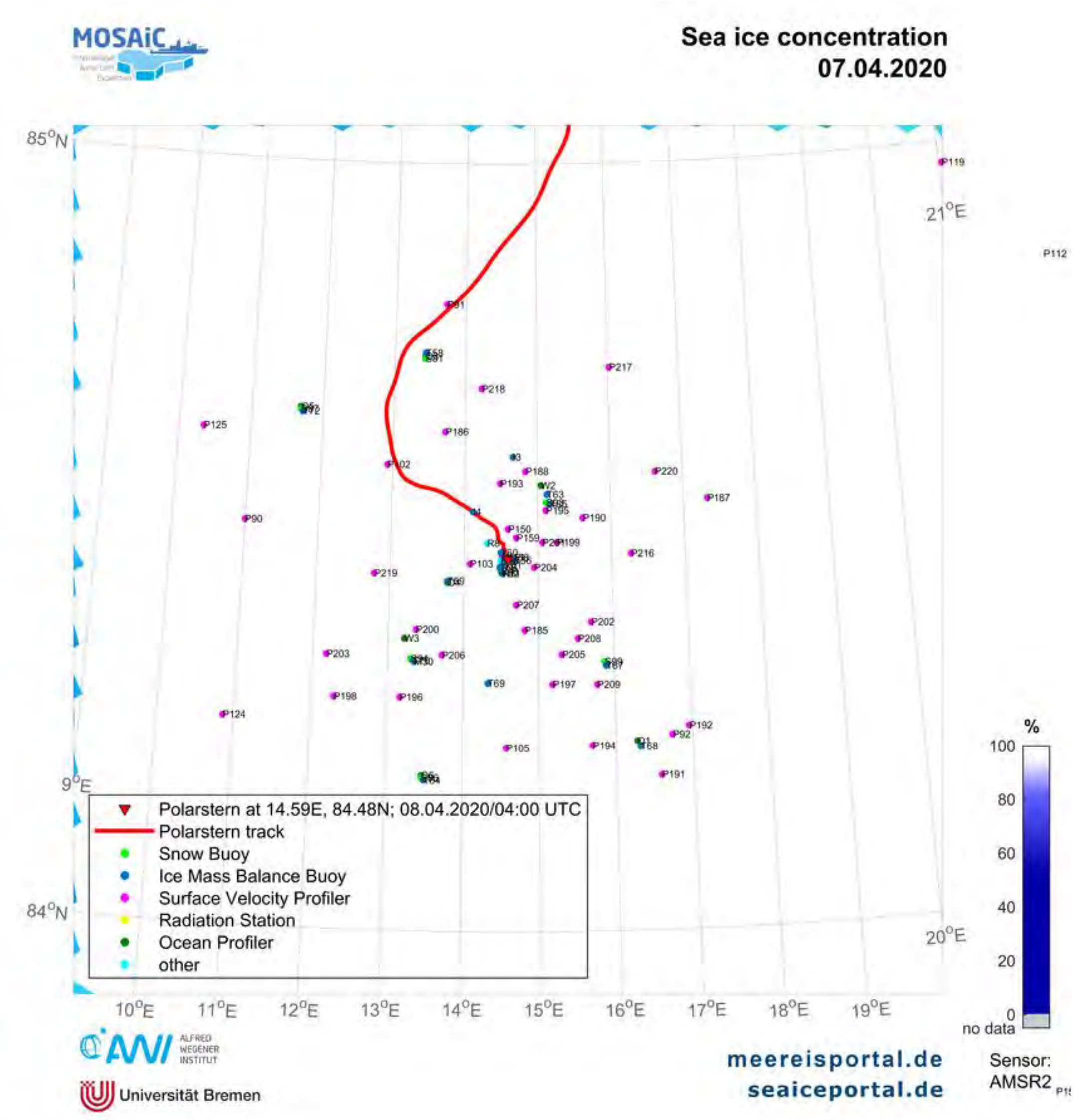
The extensive observations and readings gathered in the course of the MOSAiC expedition are complemented by a large-scale grid of buoys, officially known as the "Distributed Network (DN)" (cf. Sea Ice Ticker Nr. 9 and Nr. 20). 141 buoys have been deployed for the DN to date, and more are planned. Of all the buoys deployed, 118 are still transmitting their data by satellite several times a day to the mainland, where it is made available to the public, e.g. at meereisportal.de. The drifting sea ice to which the buoys are moored is constantly in motion; as a result, the effects of wind and currents can compress it into what are known as pack-ice hummocks. One such hummock was formed right beside snow buoy 2019S92, crushing it.

The buoys in the DN aren't distributed at random. Many of them are part of task-specific groups, the goal being to cover as many observational parameters as possible. Further, the types of buoy differ in terms of what they measure; ice mass balance buoys, for example, gauge the temperature directly above and within the snow cover, throughout the layers of the ice floe, and in the topmost metres of the ocean below it. In contrast, radiation stations measure the incoming and reflected solar radiation at the ice's surface, as well as the amount that penetrates the ice and is absorbed by the ocean. Buoys designed to measure the ice's drift speed (drift buoys) are relatively common. There are also buoys that measure the characteristics of the ocean surface (ocean buoys) or the amount of snow cover (snow buoys), as well as buoys that are combinations of the previously mentioned types (other). The distances between the respective monitoring stations and the other buoys were selected to facilitate the observation of various ice qualities, e.g. age, thickness, mobility and natural variability.

As soon as they're deployed, all buoys are added to the data portal at meereisportal.de and the first time series of their sensor data are presented in near real-time. The current position and data of each individual buoy are available to the public and can be accessed in graphic form here. The buoys can also be displayed by type or by their respective station.

The figure shows the current position of the research Polarstern and its buoy network, the "Distributed Network (DN)". The different buoy types are colour-coded. At buoy stations, the buoys are so close to one another that their markers overlap. The figure of the DN is updated on a daily basis, and can be accessed.

Meereisticker (20 August – 12 October 2020)

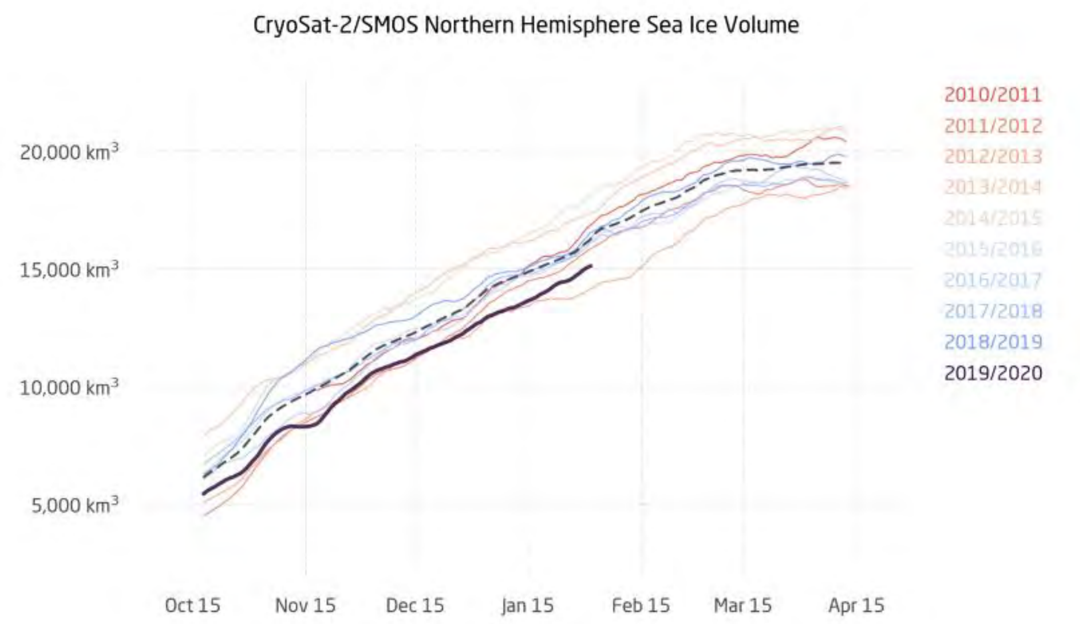


SEAICE Portal

Sea Ice Ticker No 28: 03 April 2020 Sea-ice volume in the Arctic – an important parameter describing the sea ice situation

Combining satellite observations of sea-ice area and thickness allows us to compute the total amount of sea ice in the Arctic. The standard unit used for the sea-ice volume is thousands of cubic kilometres, and offers a better measure of the state of Arctic sea ice than the extent, since the volume includes the thickness of the ice layer and not merely its total area. In recent years, changes in sea-ice volume have typically ranged from 5,000 cubic kilometres for the minimum extent in October, to 20,000 for the maximum extent in April. In the latest seaiceportal.de news, Dr Stefan Hendricks, a sea-ice physicist at the AWI, shares the results of his recent data analysis for January 2020. The low ice volume is a product of moderate sea-ice extent and wider stretches of below-average thicknesses in the central Arctic Ocean. Only in the winter of 2011/2012was there less ice in the Arctic. The lowest sea-ice extent ever recorded followed in September 2012.

The Arctic sea-ice will most likely gain an additional 5,000 cubic kilometres of volume before the start of the melting season. We won't be able to make a final assessment of the current season until June, when all the CryoSat-2 and SMOS data is available.



Observed sea ice volume between October and April since the winter season of 2010/2011. The dashed line indicates the average since the beginning of observations.

Sea Ice Ticker No 27: 27 March 2020 Wintry snow and ice conditions on the MOSAiC floe

Once it reaches a certain age, sea ice is covered with snow. Measuring and assessing the snow's thickness and structure is similarly difficult to measuring ice thickness. Yet the heterogeneous snow cover is a crucial parameter in various climate-relevant processes. One essential characteristic of the snow is its high albedo, i.e., the extent to which it backscatters short-frequency solar radiation. Accordingly, the snow on sea ice is an important factor in the Earth's energy budget. In addition, when the snow melts in the summer, it represents an important source of fresh water, which affects the density and salinity of seawater in the ocean. Snow cover also poses problems for aircraft-based and satellite-based ice monitoring, as it determines the surface characteristics of sea ice and is a major source of uncertainty.

Especially in winter, the thickness and features of the snow cover are decisive factors in the thermodynamic growth of sea ice: the thicker the snow cover is, the greater its insulating effect is, reducing the temperature contrast and thermal flow between the ocean and atmosphere. This flow of heat toward the atmosphere is critical for the growth of sea ice, and therefore, for its thickness.

In today's Sea Ice Ticker, Dr Stefanie Arndt (a sea-ice physicist at the AWI) reports from the MOSAiC camp on the snow-monitoring work she's now doing in the Central Arctic. "The snow and ice conditions on our MOSAiC floe are fairly dynamic – in a number of different ways. The increasing formation of cracks and leads within the central observatory (CO), on the one hand, promoted the persistent (thermodynamic) growth of new thin ice. At the same time, ice was pressed together in other parts of the floe, resulting in an increased formation of ice ridges. The extensive lead system around the ship might produce further movements within the CO in the days and weeks to come."

"Also, the snow's surface reflects these dynamic processes. Since the end of February, we have observed an increase in the formation of characteristic snow dunes and sastrugi, produced by high wind speeds in the area." (Explanation: Wavelike grooves and ridges sculpted in snow are referred to as sastrugi. These steep, irregular and parallel ridges are formed on snow-covered surfaces by wind erosion and deposition. On mobile pack ice, the ridges are parallel to the direction of the prevailing winds at the time of their formation.) "Thus, the upper part of the snowpack is highly compacted and stable. In the lower part, we've found beautiful depth hoar crystals, which formed due to the substantial temperature gradient between the snow/ice and air/snow interfaces." These observations can be clearly seen in this photo, taken by Michael Gutsche on 18 March 2020.

Meereisticker (20 August – 12 October 2020)

Photo: Michael Gutsche

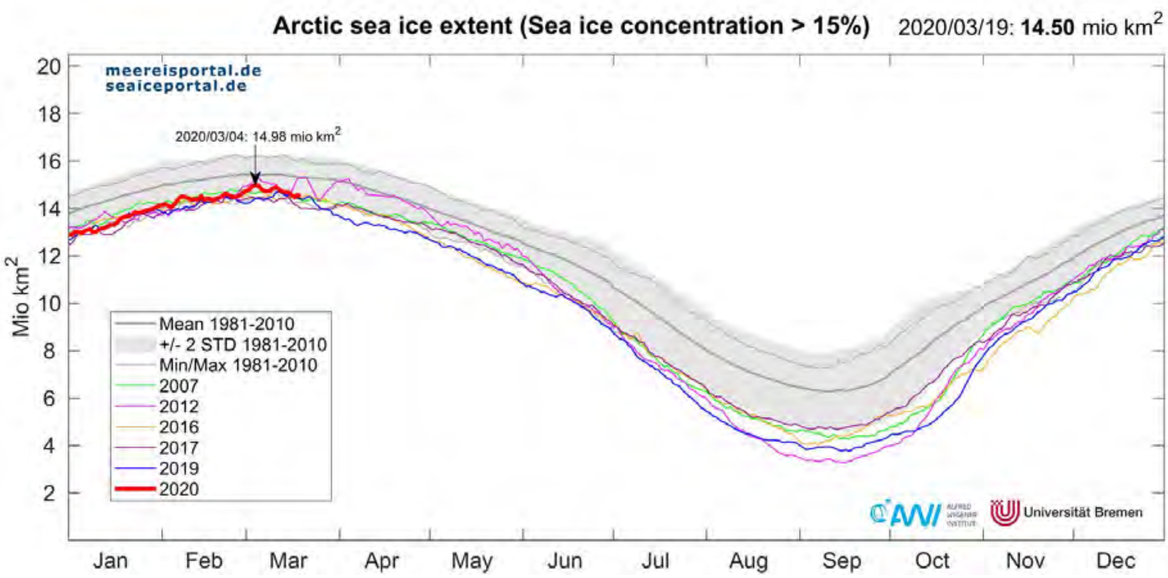
Meereisticker (20 August – 12 October 2020)

Sea Ice Ticker No 26: 20 March 2020 Winter maximum sea-ice extent reached

The seasonal variability in sea-ice extent reflects the scope of the seasons' influence on ice formation. To a considerable degree, the position of the sun and solar radiation dictate the energy input in the polar regions, which is a central driver for sea-ice growth and melting. On 4 March 2020 the Arctic sea-ice extent reached a total area of 14.98 million km^2; that number includes all ice-covered regions with an ice concentration of at least 15%.

Sea-ice growth and melting primarily constitute the near-surface ocean's response to changing seasonal conditions. The sea-ice cover controls the flows of heat, moisture and mass across the boundary layer between the atmosphere and ocean, but is also shaped by these flows. Since sea ice is comparatively thin, it can be affected by even minor disturbances in the ocean-atmosphere system; the consequences are significant changes in its area and thickness. Moreover, the yearly freezing and melting of the ocean surface in the polar regions are extremely important, especially for the energy and radiation budget on the Earth's surface. Consequently, sea ice interacts with various components of the climate system, and many of the connections and processes involved still aren't fully understood. Addressing these gaps is one of the ICE Team's main goals. To do so, they will gather extensive data on the forces responsible for ice movement (drift and deformation), as well as its growth and melting processes (thermodynamics), throughout the MOSAiC expedition. This data will help improve future climate models, allowing them to more accurately reflect the complex interrelations between the ocean, sea ice and atmosphere.

Since early March, winter has begun drawing to a close at the MOSAiC camp, too. The sun is now just six degrees below the horizon, producing the first hints of twilight. These conditions are technically referred to as "civil twilight" and offer sufficient light to e.g. read a book outside. For the researchers working at the camp, it means they can now see their monitoring stations and their immediate surroundings without artificial light, and can much more clearly identify the snow and ice conditions. Update: Since 12 March, the sun has finally climbed above the horizon: an exhilarating feeling after nearly six months of total darkness!

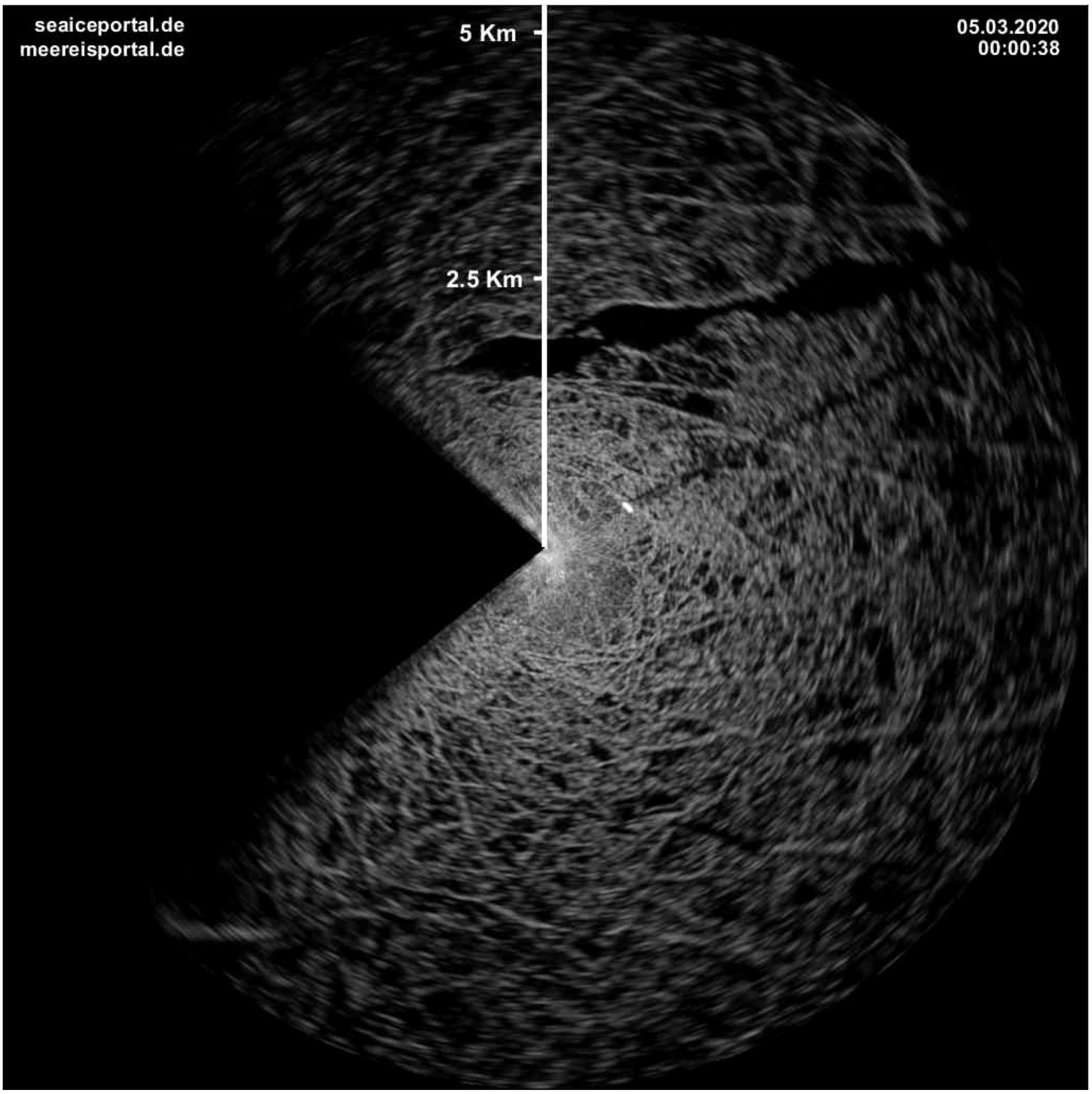


Sea Ice Ticker No 25: 13 March 2020 Second transfer of research personnel and crew successfully completed

It was a long and bitter struggle with the winter ice in the Arctic, but the transfer of research personnel and crewmembers was ultimately a success. From the outset, the transition from the second to the third leg of the MOSAiC expedition, scheduled for mid-February, was likely to involve difficult ice conditions, since it would take place at the end of the polar winter. The Russian icebreaker Kapitan Dranitsyn had left the port of Tromsø on 28 January, departing on her second resupply mission, with 83 researchers and crewmembers on board, plus 43 metric tons of cargo. Not long after setting out, rough weather in the Barents Sea forced the ship to drop anchor and wait five days in a fjord north of Tromsø – and the remainder of the journey was no easier, with challenging ice conditions including several-metre-tall pack ice hummocks. Time and time again, the ship had to turn back and seek new routes through newly opened channels in the ice. This situation aptly demonstrated the importance of good cooperation at the international level: thanks to the provision, analysis and interpretation of various satellite imaging products and high-resolution infrared satellite images of new channels, kilometre by kilometre, Kapitan Dranitsyn neared her goal. Though alternative options for the transfer involving air support were carefully considered, the ship finally managed to break through, and the new team reached the MOSAiC drift camp on 27 February 2020. Images from RV Polarstern's on-board radar show how the resupply icebreaker approached on 28 February and moored ca. 800 m from camp. They also show the formation of a large channel in the sea ice on 4 March, which disappeared again two days later. You can find regularly updated animations of the on-board radar here.

Since Kapitan Dranitsyn consumed more fuel than planned on the journey through the fast ice, another Russian icebreaker, Admiral Makarov, is now underway from Murmansk to refuel the ship on her return journey, amidst the Arctic sea ice. The successful completion of the mission represents a logistical masterstroke and shows once again the unique challenges involved in the MOSAiC expedition.

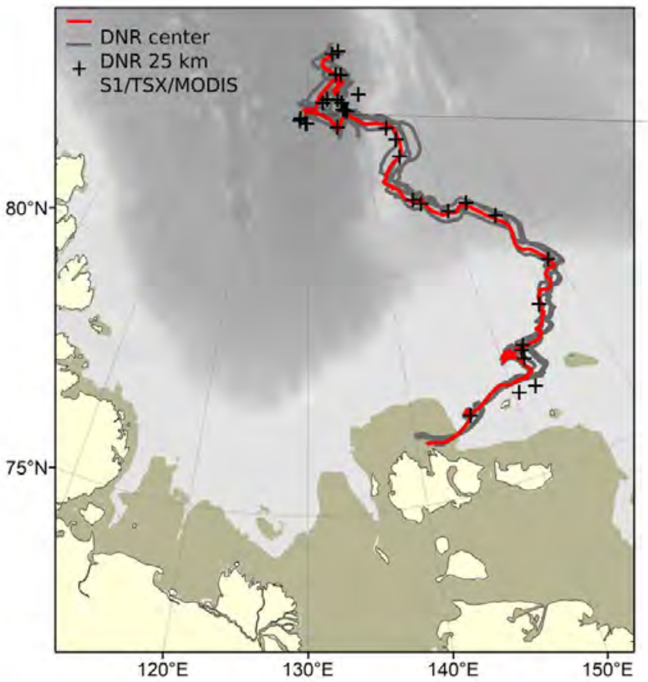
Meereisticker (20 August – 12 October 2020)



Sea Ice Ticker No 24: 6 March 2020 A history of the MOSAiC ice floe

The results of the initial analysis were sobering: the ice in the starting region was less than a year old, had a mean thickness of only 30 centimetres, and had undergone substantial melting during the summer, as a result of which it showed heavy weathering and was littered with meltwater pools. The ice's life story read like a string of negative records. The summer of 2019 was the warmest in the Russian Arctic since the beginning of weather observations on Kotelny Island, back in 1935. Air temperatures over the Laptev Sea and East Siberian Sea beat the previous record high by two to four degrees Celsius. Since the previous winter had been one to three degrees Celsius warmer than the average in the reference period 1981 to 2010, the ice that formed in the 'nursery' for Arctic sea ice – the Laptev Sea and adjacent East Siberian Sea – was far thinner than in the past. Strong offshore winds then rapidly blew it out to open sea. When the air temperature quickly rose in the spring of 2019, this extremely thin ice melted so rapidly and extensively that we not only saw the earliest break-up of the ice cover since 1992, but also the rapid and unexpected northward retreat of the ice edge.

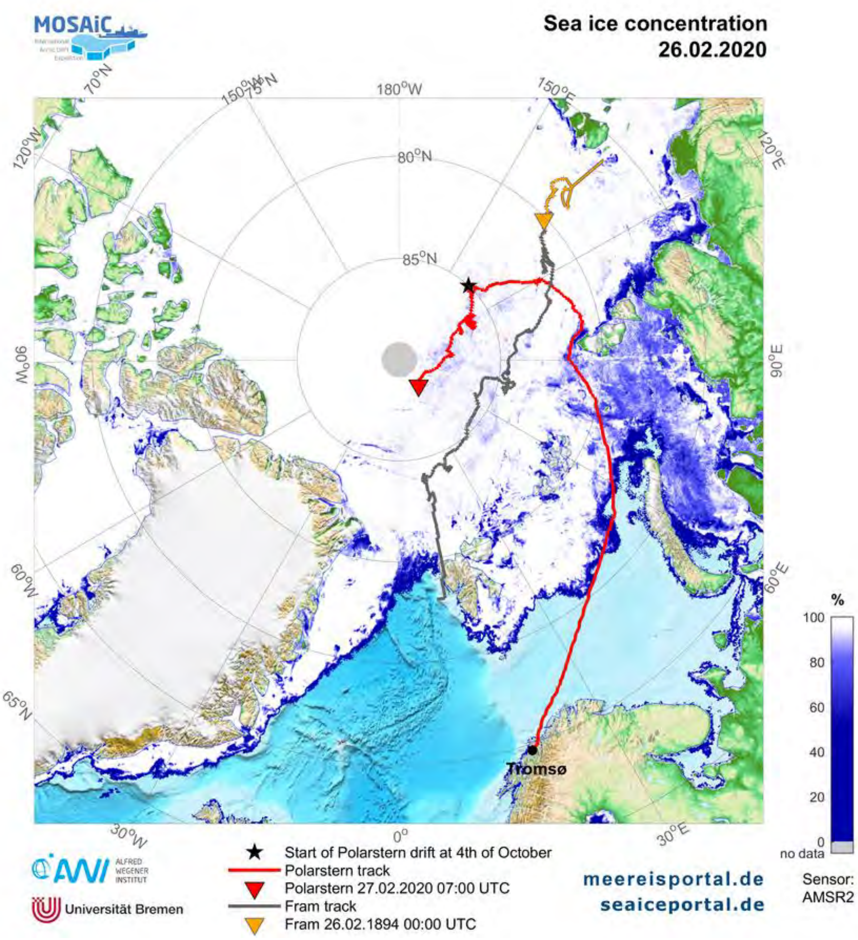
Once these initial conditions had been established the work began to trace the course of the pack ice in the starting region back to its point of origin. To do so, a time series of high-resolution satellite data was used, which allowed to identify the MOSAiC floes and therefore reconstruct their journey from the marginal seas of the Arctic Ocean to the Central Arctic – down to the exact day. The ice floes that was set up the MOSAiC monitoring network on were formed off the northern coast of the New Siberian Islands on 5 December 2018, and in a shallow region with a depth of less than ten metres. When RV Polarstern dropped anchor at one of the floes, on 4 October 2019, the ice was exactly 318 days old and had travelled a total distance of 2240 kilometres, on a zigzagging course determined by the wind. The whole story can be read in the new DriftStories of seaiceportal.de.



Sea Ice Ticker No 23: 28 February 2020 MOSAiC now just a stone's throw away from the North Pole

Many people following the drift of the MOSAiC expedition are on the edge of their seats; they can't wait to see just how far north the drift will continue! Careful planning prior to the expedition helped predict how the drift would progress, and which course the MOSAiC camp would follow. This was only possible thanks to numerous drift-route calculations, based on satellite observations, meteorological and climate data from the past 20 years. Yet even with the advanced climate models and supercomputers available today, there's no 100% guarantee. MOSAiC's projected drift corridor included potential routes that could take the camp either to the west or east of the North Pole, or ideally right across it.

During their drift 125 years ago, Fridtjof Nansen and his crew crossed the northernmost parallel at 85° 57' North on 17th November 1895, roughly 450 km from the North Pole. On 24 February 2020, RV Polarstern reached her northernmost point to date (88° 35' North), putting her only ca. 150 km from the Pole and significantly closer to Nansen's goal. However, the latest forecasts indicate that the westward drift will now increasingly be influenced by a southward component, as a result of which the Transpolar Drift will slowly begin taking the MOSAiC camp further from the North Pole and toward Fram Strait. Drifting across the North Pole was never the expedition's declared goal; rather, it was to improve our understanding of the Arctic climate system and arrive at more accurate reflections of it in global climate models.



Sea Ice Ticker Nr. 22: 20 February 2020 Microwave radar measurements from satellite of seaice during the MOSAiC-Expedition

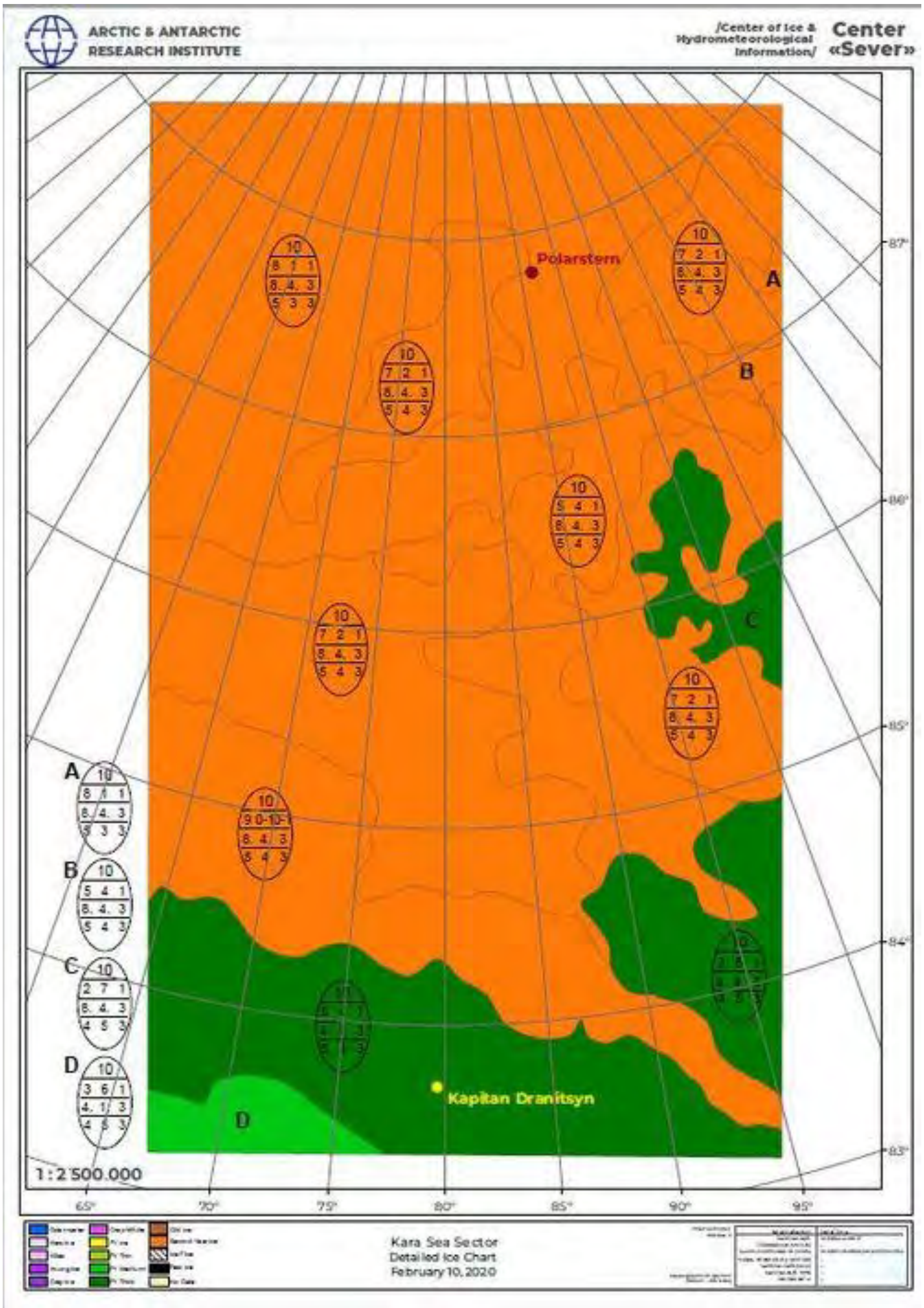
Satellite data offers valuable insights into the Arctic sea ice. Thanks to the more than 40-year-long time series on the sea-ice extent, based on microwave data from satellites, researchers have been able to clearly show the dramatic reduction in Arctic sea ice that has taken place over the past few decades, and to prove the existence of climate change in the Arctic. Today, with the aid of new satellites and monitoring methods we can use satellite data to determine not only the sea-ice extent, but also e.g. the ice thickness, type of ice, and amount of snow cover. In order to refine and improve these methods, remote sensing readings are being taken throughout the MOSAiC drift experiment. Instruments that are comparable to the sensors used in satellites were installed directly on the surface of the ice. Taken on a windy day, the image above shows several microwave radiometers (in the background), some of which are aimed at the snow and ice, while others are pointed toward space. An infrared camera and video camera, which are used to monitor the surface temperature, are in the foreground. At the same time, a host of physical snow and ice parameters like snow grain size, salinity and temperature are monitored. Combining all of these readings helps us to understand the signals received by the satellites, and to produce better satellite maps of e.g. the sea-ice thickness or snow thickness. These maps can then be used on their own, or together with models, to arrive at a better grasp of the Arctic climate system – which is MOSAiC's primary objective.

Equipment used to monitor and determine the microwave characteristics of the snow and ice conditions in the vicinity of the MOSAiC ice camp (Photo: Gunnar Spreen / IUP Bremen).

Sea Ice Ticker Nr. 21: 14 February 2020 Using ice charts to assess the ice situation near the MOSAiC camp

In order to support navigation in the ice and help plan research activities on RV Polarstern during the MOSAiC expedition, not only satellite data, but also the ice charts provided by national sea-ice information services are used. These charts summarise the results of comprehensive analyses of satellite and model-based data. The chart from 10 February 2020 reflects the current ice situation in the vicinity of the MOSAiC expedition. It also shows the positions of both RV Polarstern and Kapitan Dranitsyn, a Russian resupply icebreaker that is en route to Polarstern to exchange personnel. For the past few days, the Russian ship has been operating to the north of Franz Josef Land; here patches of multiyear ice, which the ship had to overcome on her way to Polarstern, can be recognised. These charts were prepared by the Arctic & Antarctic Research Institute in St Petersburg (AARI) for use on the MOSAiC expedition, in keeping with the established international standard. Yellow represents 'open ice' with an ice concentration of 4/10 – 6/10; orange stands for 'close ice' (7/10 – 8/10); and red stands for 'very close ice' (9/10 – 10/10). In the oval grids, the ice concentrations are described in greater detail: the second line shows the respective concentrations of the thickest, second-thickest and third-thickest ice. The line below it (middle line) provides information on the ice's developmental stage, i.e., how thick it is. The bottommost line indicates the ice's form, e.g. whether it is pancake ice (0), a large (500 m - 2 km; 5) or a massive ice floe (> 10 km; 7). These charts are provided on a regular basis at meereisportal.de.

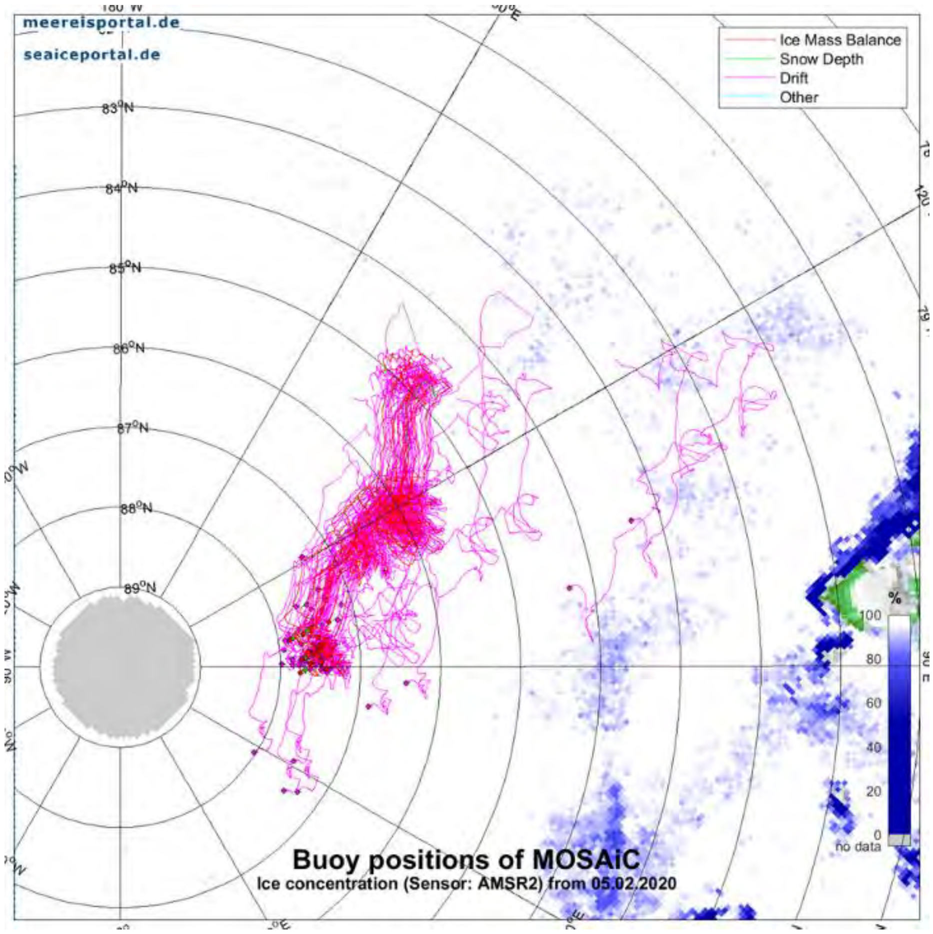
Meereisticker (20 August – 12 October 2020)



Sea Ice Ticker 20: 7 February 2020 Autonomous Monitoring of Sea-ice Characteristics-Buoys

Buoys, or in more general terms, 'ice-based observation platforms' – which autonomously and continually monitor the physical characteristics of the sea ice, snow and the uppermost layers of the ocean, as well as atmospheric parameters like the air temperature and barometric pressure – are essential sea-ice physics tools, used to prepare important time series on the sea ice and its development throughout the MOSAiC expedition.

Data collected by buoys deployed on the ice can be used to determine e.g. the thickness and temperature of the sea ice or the snow cover atop it, as well as sea-ice movement. Some types of buoy also monitor the surface layer of the ocean in order to measure the water temperature and currents. The sample map below shows the current positions of all active buoys involved in the MOSAiC expedition. The majority of them were deployed by the RV Polarstern upon her arrival, or near the starting position of the MOSAiC floe by the resupply icebreaker Kapitan Dranitsyn. To date, 126 buoys have been deployed for MOSAiC. Data and time series from 87 buoys are now available at meereisportal.de, including 14 thermistor buoys, 6 snow buoys, 2 radiation stations, 59 surface velocity profilers, 5 ocean CTD buoys, and 1 mass balance buoy. All buoy data is also supplied to the International Arctic Buoy Program (IABP).

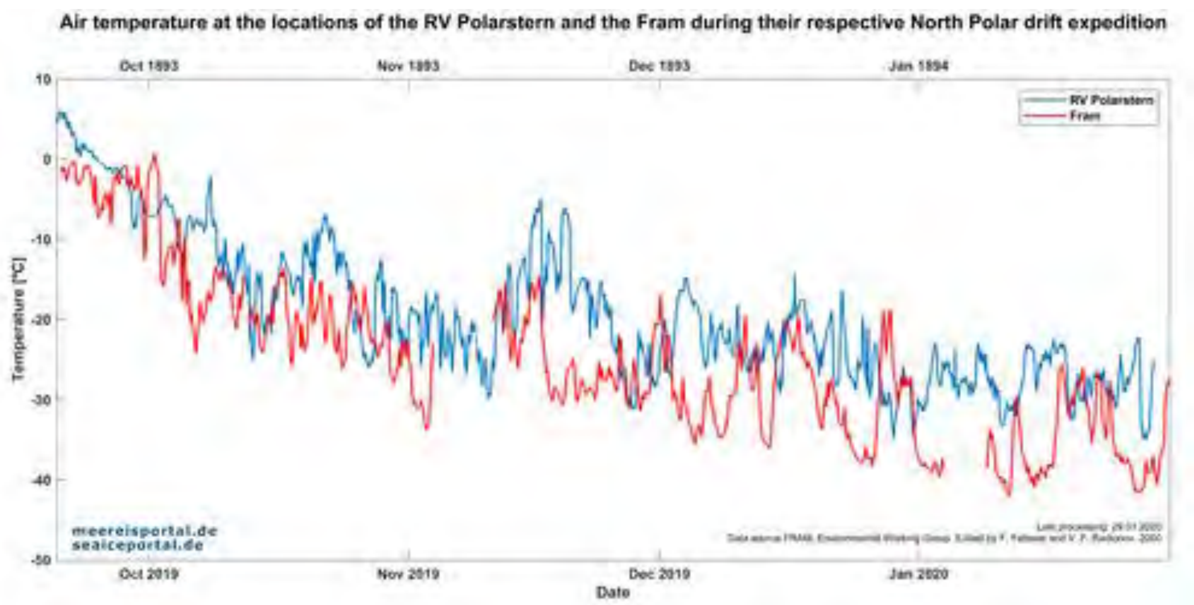


Sea Ice Ticker 19: 31 January 2020 Temperature development on the MOSAiC floe – and what Fridtjof Nansen encountered 126 years ago

The temperature development in the Central Arctic is to a great extent shaped by the prevailing wind systems and the advection of warm air from the middle latitudes. In the winter months a powerful polar vortex, i.e., an upper-level low-pressure area over the polar ice caps, is formed. The result of a negative radiation balance, the vortex is characterised by a pronounced mass of cold air. This process also intensifies the polar jet (high-altitude wind), which separates the air masses of the middle and northern latitudes. When this air current weakens, it begins meandering, which makes it easier for warm air masses to penetrate the Central Arctic, while also opening the door for cold air intrusions into e.g. Europe or the USA. Current temperatures at the MOSAiC base camp are ca. -25° to -30° C, i.e., normal conditions for this time of year. With the exception of a phase in mid-November, during which temperatures rose above -10° C, this winter the temperatures have generally ranged from -20° to -30° C (blue curve in the figure).

The red curve in the figure shows the temperatures that Fridtjof Nansen and his 12-man crew encountered on their expedition, 126 years ago. At this time of year, they had to endure temperatures roughly 10° C colder (-30° to -40° C) during their drift.

In the current era of global warming, particularly the Arctic winters have generally grown milder, as can be clearly seen in the continuous readings gathered over the past 25 years at our AWIPEV station on Spitsbergen. Temperature data from the MOSAiC drift experiment is updated on a daily basis.



SEAICE Portal

Sea Ice Ticker No 18: 24 January 2020 Snow-related Activities during MOSAiC

Snow is important for sea ice in a number of ways: the insulating layer of white makes the surface of the ice brighter. By increasing the ice’s albedo (reflectivity), it ensures that the majority of incoming sunlight is reflected back into the atmosphere. But it also insulates the sea ice from the frigid atmosphere. As a result, the temperature gradient between the ice / snow interface and ice / ocean interface is weakened, reducing the ice’s thermodynamic growth. In contrast, if the snow cover becomes too thick, its weight can push the ice / snow interface below the surface, allowing water to cover the ice. When this water refreezes, ‘snow-ice’ is formed, and the ice floe grows in thickness from above. In addition, there are a number of seasonal processes that take place within the snow cover: the snow can be compacted, e.g. by blowing winds or heavy snowfall; or brief warm-air intrusions in the Arctic can cause it to briefly melt – but then rapidly freeze again, producing e.g. ice lenses in the snow. Understanding all of these internal structures and qualities is not only necessary in connection with their influence on the energy and mass budget of Arctic sea ice, but can also support the accurate interpretation of remote sensing data.

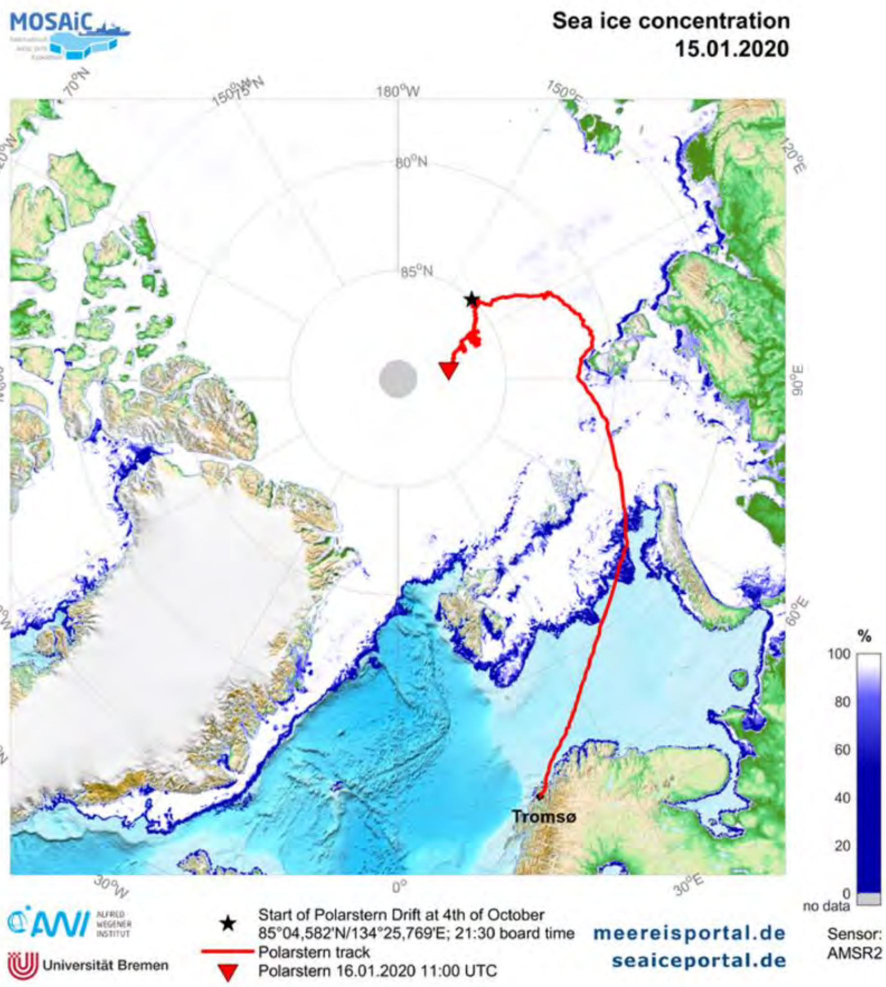
For MOSAiC researchers, these aspects are extremely important. Accordingly, they are intensively engaged in measuring a broad range of snow characteristics. In addition to snow distribution on the floe, this includes precisely analysing physical traits like snow density, temperature, and snow grain size and types. Moreover, they’re collecting a wealth of snow samples for subsequent physical, chemical and biological laboratory analyses.

Sea Ice Ticker No 17: 17 January 2020 Winter sea-ice growth

In the course of the winter, the extent and thickness of sea ice steadily increase throughout the Arctic, until they reach their winter maximum, normally in late February / early March. By this time, the sea ice cover extends to the coastline at nearly all latitudes, at which point it can't expand any farther. The only regions in which the extent continues to grow – i.e., where expansion is not precluded by land – are the Bering Sea, Sea of Okhotsk, eastern Greenland Sea and Barents Sea.

The ice of the MOSAiC floe has now grown to more than one metre thick, which has made it possible to prepare a 500-metre-long landing strip so that, in the event of an emergency, help can be flown in (search and rescue). RV Polarstern's current position is 87° 33′ N and 100° 47′ E, or ca. 300 kilometres from the North Pole. The mean ice thickness for the expedition area as a whole is currently ca. one metre. Making more precise descriptions is difficult, since the ice frequently breaks up, new ice and ice hummocks are formed, and the ice is in constant motion.

Current temperatures at the MOSAiC camp are now as low as -35°C, which, combined with wind speeds of several metres per second, can produce wind chill temperatures down to -48°C: challenging conditions for the researchers and their equipment alike.



Sea Ice Ticker No 16: 10 January 2020 Changeover of teams at the MOSAiC camp: Christian Hass is the expedition leader for the second leg (Leg 2)

On 13 December 2019, day 85 of the MOSAiC expedition, the Russian supply icebreaker Kapitan Dranitsyn reached the MOSAiC station's ice floe, located at 86° 35′ North and 119° 17′ East. Roughly 100 people traded places between the RV Polarstern and the Kapitan Dranitsyn, which embarked on its return journey to Tromsø on 18 December. This changeover also brought a change in expedition leaders; Prof Markus Rex, who had been responsible for selecting the ice floe, determining the drift experiment's starting position, and setting up the MOSAiC camp since the start of the expedition in Tromsø, handed over the reins to Prof Christian Haas, head of the Sea Ice Physics section at the Alfred Wegener Institute and a sea ice physicist with extensive expedition experience. Haas, who has spent more than three year participating in various expeditions on board ship and at research camps, describes his expectations as follows: "From a research standpoint, I hope we'll get to see some of the Arctic winter's unique processes. For example, the warm air intrusions that are becoming more frequent in the Central Arctic, and can lead to rain at the North Pole even in mid-winter. This would give us the once-in-a-lifetime opportunity to investigate how such events affect the snow on the ice floe or even thaw it, causing dramatic changes in the snow's microwave characteristics, which are important when it comes to interpreting satellite data." A particular challenge for Christian Haas and the new team is the fact that they arrived in the polar winter, in an environment that they have never seen in daylight, which makes orientation difficult. "We have to learn to see using technology rather than our eyes. Laser scanners and infrared cameras, satellite images and ship-based radar systems will help us to do so and get our bearings on the ice floe in the middle of the Polar Night. This second leg could be the most gruelling stage of MOSAiC, with the darkest, coldest and windiest conditions. It may also take us to the northernmost point in the drift."

Current temperatures at the MOSAiC camp are now as low as -35°C, which, combined with wind speeds of several metres per second, can produce wind chill temperatures down to -48°C: challenging conditions for the researchers and their equipment alike.

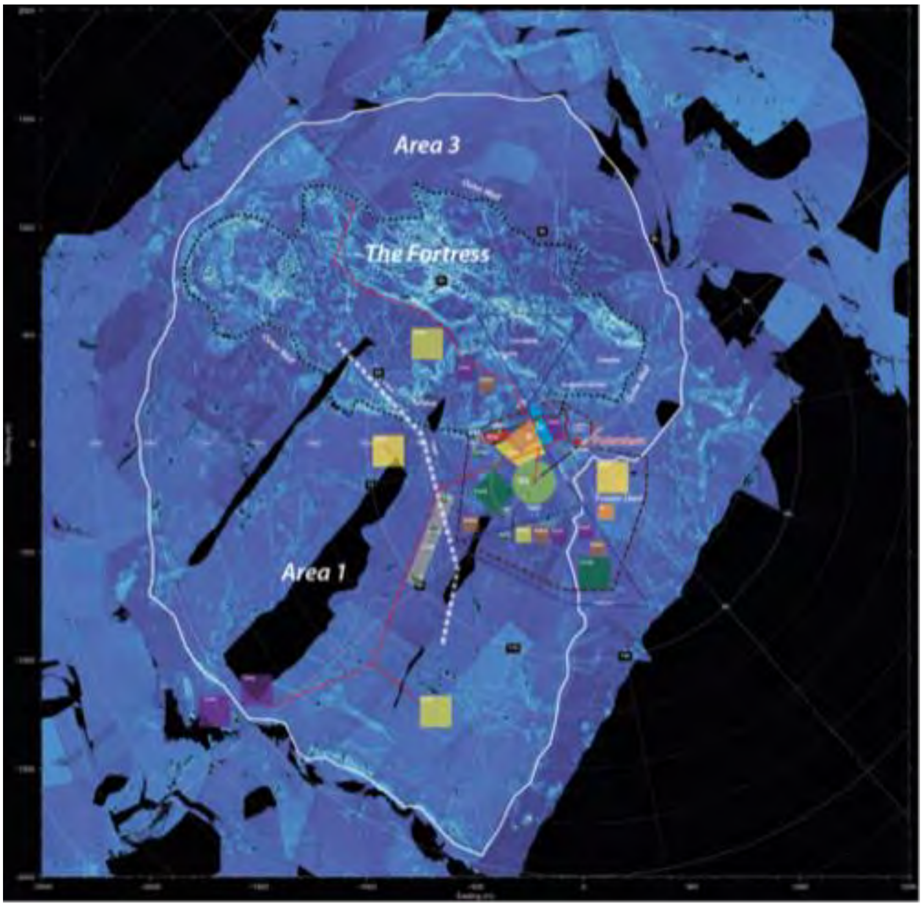
The new expedition leader for MOSAiC Leg 2, Prof Christian Haas (right), a sea ice physicist and head of the Sea Ice Physics section at the Alfred Wegener Institute in Bremerhaven, during a daily briefing on site. Photo: Lars Barthel (AWI)

Sea Ice Ticker No 15: 18.10.2019 MOSAiC Reaches its First Goal!

With the mooring of the ship to an ice floe on 4 October 2019, nothing stood in the way of setting up the research camp around the RV Polarstern. Since then, a great deal of the initial work has been completed, and the 'distributed network' has been successfully installed.

With the aid of the ship's seasoned crew and skilled helicopter pilots, the international team of researchers on board the Russian icebreaker Akademik Fedorov deployed a complex system of buoys and monitoring equipment in a radius of up to 50 km around the RV Polarstern, which will now serve as the central observatory, field laboratory, and home for a total of 600 researchers. In the course of an entire year, these experts will conduct their ongoing tests and take measurements at various sites (coloured areas in the figure below) on the ice floe.

And that marks the end of our coverage from the sea ice ticker, which accompanied the first phase of the MOSAiC expedition. For the remaining legs of the journey, meereisportal.de will continue to provide exclusive coverage of the sea-ice-related measurements taken, and of course also report on other important findings and stages of the drift experiment. In addition, you can use the MOSAiC app or the MOSAiC website to follow the expedition's progress on a daily basis. Thank you for using the sea ice ticker!



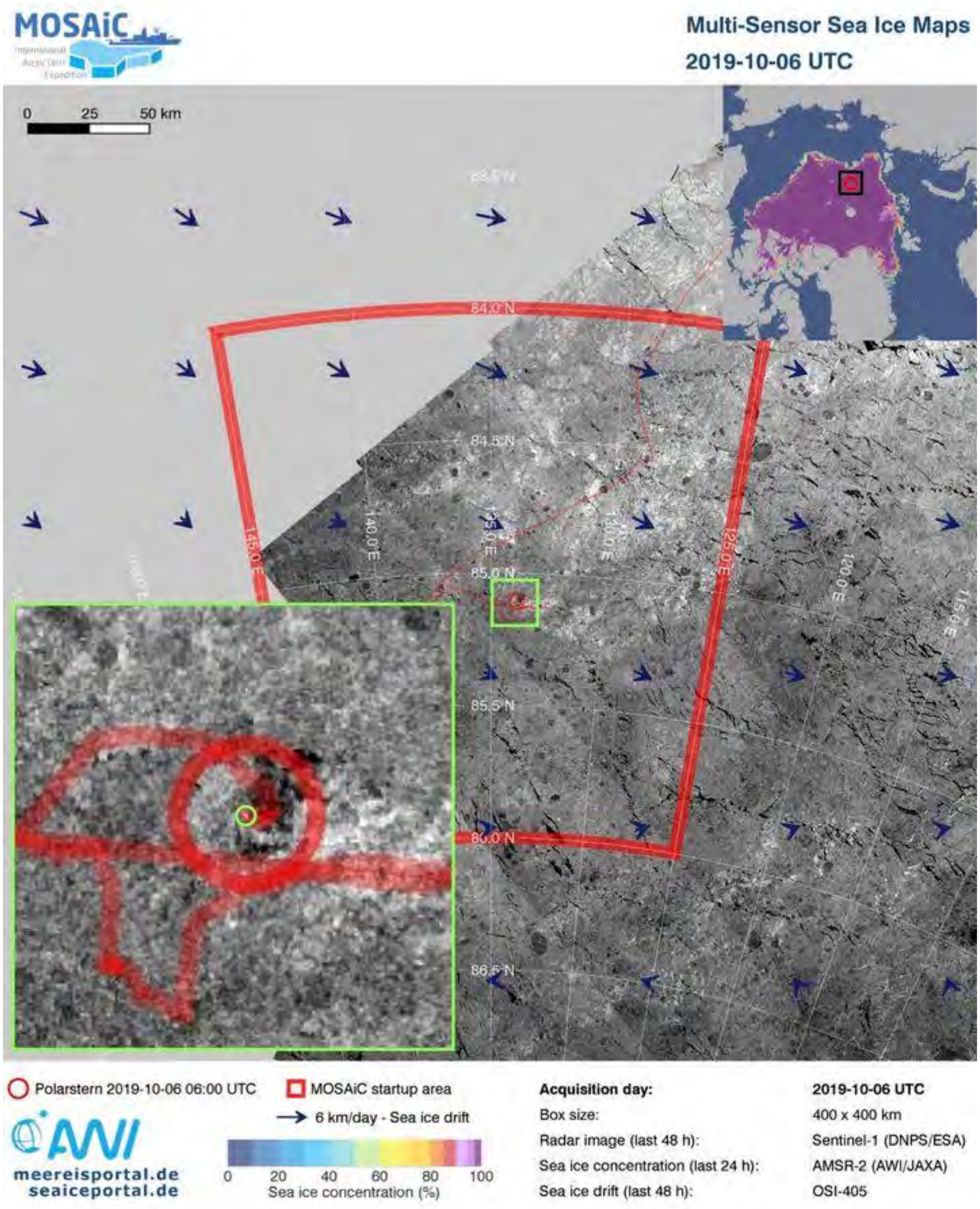
Sea Ice Ticker No 14: 8.10.2019 The Search for the Ideal Ice Floe is a Success Story!

Since last week, RV Polarstern has been carefully making her way through the Arctic sea ice, all the while searching for the ideal ice floe to set up camp on. To aid her in this task, helicopters regularly took off from and landed on the accompanying Russian icebreaker Akademik Fedorov, taking aerial measurements with a sensor dubbed the EM-Bird. The device, which measures ice thickness in the direction of flight, makes it possible to initially survey potential ice floes, after which the ships can take a closer look at the most promising candidates. Once the floe had been found, additional tests and measurements were taken directly on its surface, using a variety of methods. In this regard, its thickness and stability were the most crucial parameters; after all, the floe will serve as the basis for an extensive ice research camp for more than a year.

Our multi-sensor sea ice maps show the sector for the starting region and route, as well as RV Polarstern's current position (see figure). From the 'zigzag' route to date (red line), we can see that Polarstern neared a number of individual floes to assess their suitability. With the beginning of the winter season, the majority of the target sector is now home to sea ice, though in some cases it is only a few centimetres thick.

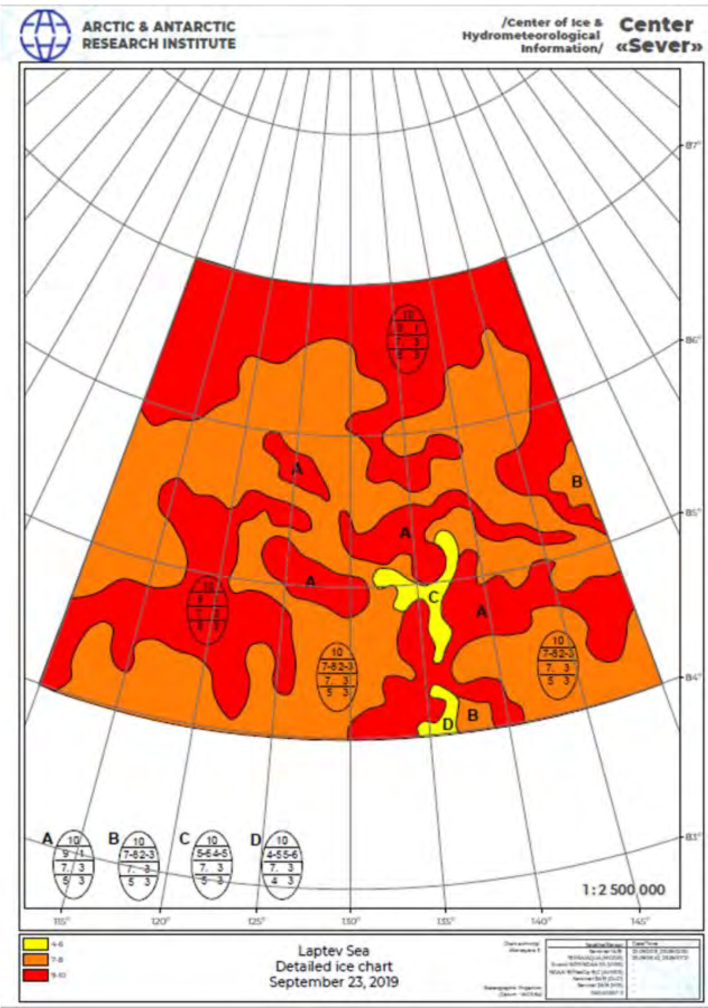
At 9:30 pm ship's time on 4 October 2019, the time had come: the target floe had been identified and moored to, the ship's engines were shut down, and Polarstern's immediate vicinity could now be explored on foot! At the coordinates 85° 04.582' north and 134° 25.769' east, the researchers and crew can now begin with the actual heart of the expedition: the drift experiment! On the latest map, the area around Polarstern is also shown at magnification (green box). Since the icebreaker is a strong reflector for radar signals, it can also be recognised as a small white dot on the map.

Meereisticker (20 August – 12 October 2020)



Meereisticker (20 August – 12 October 2020)

Sea Ice Ticker No 13: 1.10.2019 Ice Maps from the Russian Research Institute AARI
In order to support navigation in the ice and help plan research activities, not only satellite data, but also the ice charts provided by national sea-ice information services are essential. These charts summarise the results of comprehensive analyses of satellite and model-based data, which are visually conducted by ice analysts. Throughout the MOSAiC expedition, ice charts will be provided by the Arctic and Antarctic Research Institute in St Petersburg (AARI). The ice information is presented in keeping with the established international standard: yellow indicates 'open pack ice' with an ice concentration of between 4/10 and 6/10, orange is 'close pack ice' (7/10 – 8/10), and red represents 'very close pack ice' (9/10 – 10/10). In the ovals, the ice concentration is described in more detail. The second column shows the respective concentrations of the thickest, second-thickest and third-thickest ice. Information on the ice's developmental stage, i.e., how thick the ice is, can be found below the column. The last column offers data on the form of the ice, e.g. whether it is pancake ice (0), a large floe (500 m - 2 km; 5), or a massive floe (> 10 km; 7). These charts are provided at meereisportal.de on a regular basis.

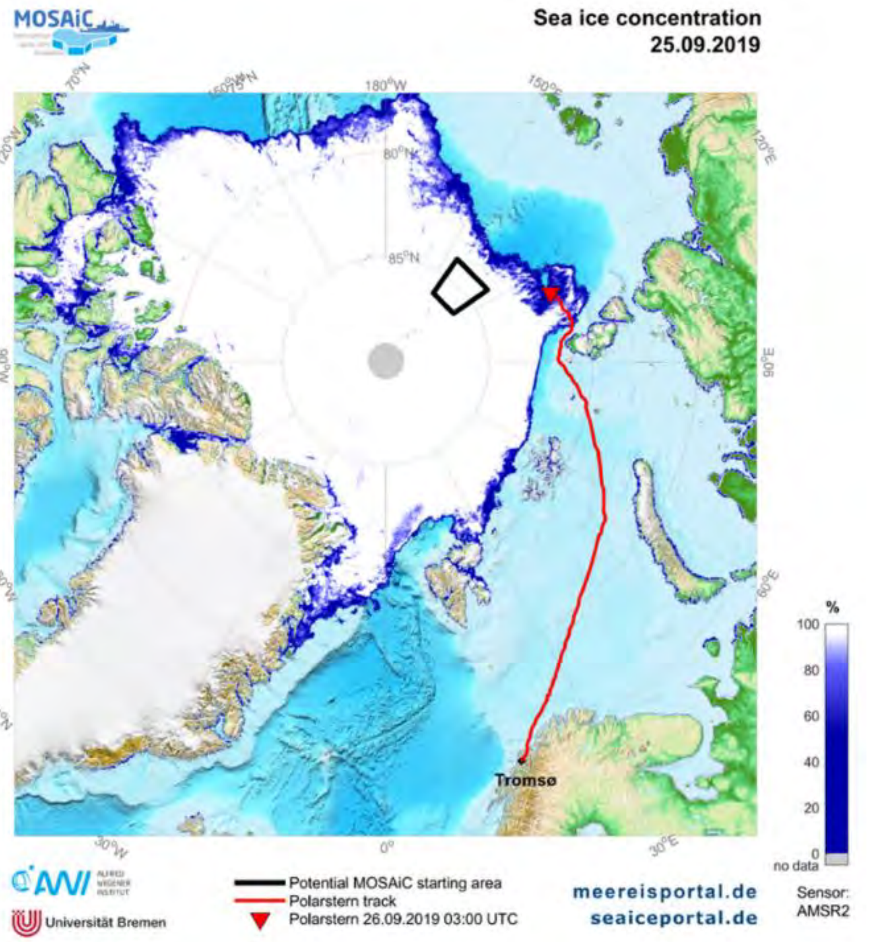


Detailed ice map of the Laptev Sea from 23 September 2019.

Sea Ice Ticker No 12: 27.09.2019 Ice Concentration in MOSAiC's Starting Region

After the successful launch of the MOSAiC expedition from the port of Tromsø at 8:30 pm on 20 September 2019, RV Polarstern is now on a direct course to the planned starting region in the Russian Sector of the Central Arctic. On 15 September 2019 the sea-ice extent in the Arctic reached its lowest total area this year; in the next few weeks, the freezing season will begin again. This is the time when the first layer of ice, referred to as frazil ice, is formed; in turn, nilas appears in the pancake ice, and eventually accumulates to form floes and first-year sea ice. Accordingly, it's very important that the expedition reach the target region as early as possible, and begin looking for a suitable floe to erect the ice camp on.

Although the route to the target region is currently ice-free, the region itself is characterised by compact ice with a concentration of over 90%. Once there, the research icebreaker RV Polarstern will only be able to reach the final starting position by ramming her way through the ice. By 8 October 2019, roughly two weeks from now, the sun will no longer rise in the starting region, and the Polar Night will begin. When it does, the residual light from the sunset, reflected by the white snow, will be the only natural light source. By then, the camp should have been set up, and all preparations for the drift experiment completed.



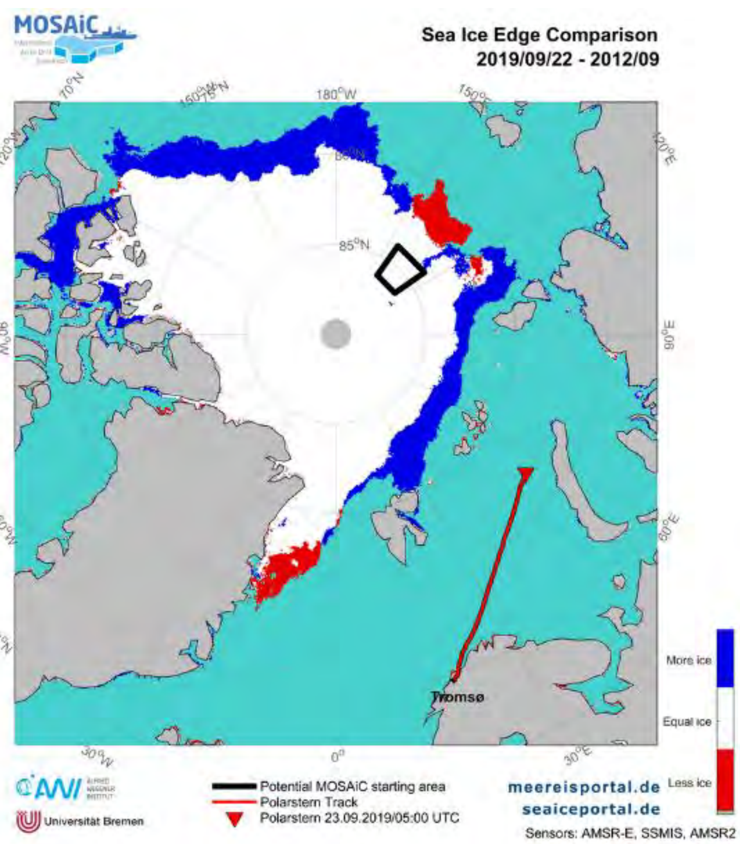
Detail map of the ice concentration on 25 September 2019 with the RV Polarstern's route (in red) and the target region for the MOSAiC drift experiment (outlined in black).

Meereisticker (20 August – 12 October 2020)

Sea Ice Ticker No 11: 24.09.2019 Comparison Map of the Sea Ice Edge Position

In order to make meaningful statements on changes in the sea-ice concentration in different regions for different days, months and years, the differences are portrayed on a comparison map. In this regard, data on the sea-ice concentration from meereisportal.de can be used to calculate the daily position of the ice edge (15% sea-ice concentration). The differences to e.g. the long-term average (from 2003 to 2014) or to the monthly mean for the same month in any year can be displayed. Regions that gained sea ice (blue) and those that lost it (red) can be clearly recognised.

The map shows the differences in the sea ice edge position from 23 September 2019 in comparison to the monthly mean position for September in 2012, the year with the lowest summertime sea-ice extent since the beginning of satellite observation in 1979. Generally speaking, we can see a larger extent in all regions of the Arctic, although September 2019 was characterised by the second-lowest sea-ice extent ever observed. However, we can also see that there is now substantially less ice in the northern Laptev Sea, the planned starting region for the MOSAiC expedition (outlined in black on the map); there is also much less ice in the southern Greenland Sea this year. In the expanded data section created especially for MOSAiC on meerreisportal.de, new comparison maps will be provided on a daily basis, and in two versions (one in comparison to the year 2012, and one in comparison to the long-term average), helping us put the current sea-ice situation in perspective.



Comparison map: sea ice edge position from 23 September 2019 in comparison to the monthly mean position in September 2012.

Sea Ice Ticker No 10: 20.09.2019 Kick-off for the MOSAiC Expedition in Tromsø

Text Today MOSAiC, the greatest Arctic expedition of all time, will begin, and the RV Polarstern will depart for her one-year-long overwintering experiment in the drifting polar ice. Over the course of an entire year, more than 600 experts from 60 research institutes and 19 nations will investigate the exchange processes between the ocean, ice and atmosphere. Though the Arctic regions have a tremendous influence on our climate, that influence remains only poorly understood. New data gathered during the expedition will allow us to better grasp how the Arctic climate is evolving; moreover, together with the new insights gained, it will enhance our current climate models, helping us make more accurate forecasts regarding our weather and future climate developments.

The official launch will be tonight at 8:00 pm Central European Summer Time, when many years of careful preparation will finally pay off, and the adventure will begin!

meereisportal.de will here intensively accompany the expedition with a focus on sea ice aspects, and would like to take this opportunity to wish everyone participating the best of luck, great new findings, and safe travels!

RV Polarstern, ready to cast off in Tromsø! (Photo: Marcel Nicolaus)

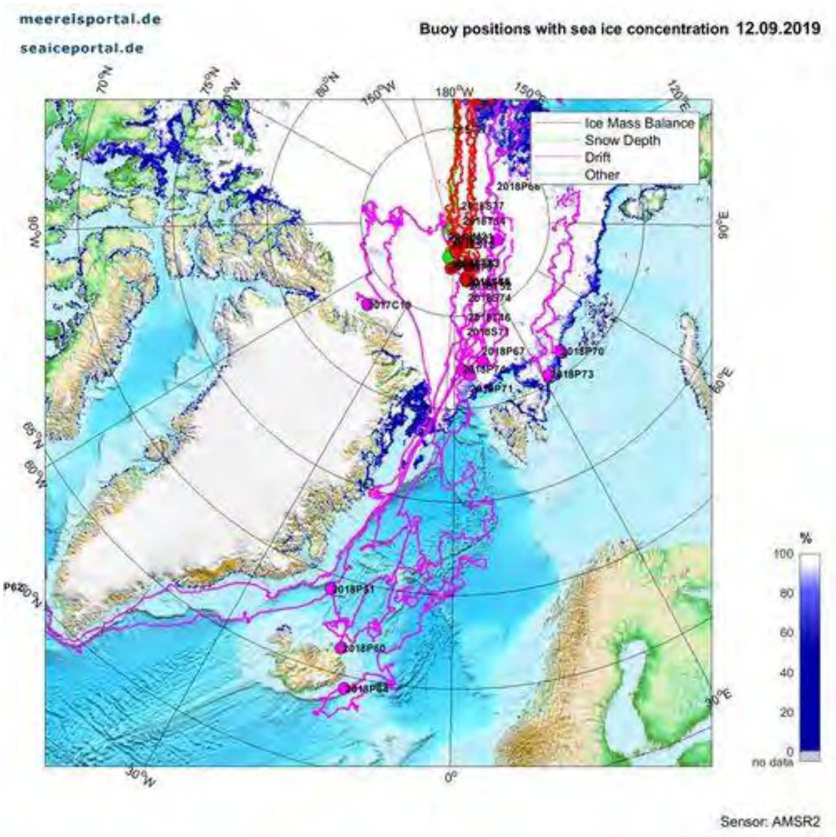
Meereisticker (20 August – 12 October 2020)

Sea Ice Ticker No 9: 17.09.2019 Sea-ice Buoys

Buoys are independent measuring platforms, which are used to autonomously gather climate-relevant data in the world's oceans and send it via satellite directly to a base station. They are particularly used in the ice-covered oceans in the polar regions to obtain valuable measurements in the winter months. Braving the extreme (Ant)Arctic weather conditions during this time is a major challenge for marine expeditions or other manned missions. There are numerous types of buoys that can measure the physical and biological properties of the atmosphere and the sea ice as well as the underlying ocean.

This technology will play a crucial role in the unique MOSAiC expedition. While most of the participating researchers will focus on taking measurements on the main ice floe, up to 160 measuring buoys will be installed on other ice floes over a radius of several dozen kilometres around this 'central observatory'. To install this network of buoys, the RV Polarstern will initially be escorted by a second icebreaker and several helicopters, which will be used to allow the international research team to erect their instruments on the ice. The experts hope that this data will enable them to extend the insights from the measurements on the 'main floe' to a larger area. Furthermore, the unprecedented number of buoys working in parallel will provide new insights into the movements of the ice floes in relative to each other, which will then be used, among other things, to improve climate models.

The measurements from the buoys can be followed live on meereisportal.de. From October, we will also provide an easy-to-use, interactive map to present the buoy date on meereisportal.de more quickly and simply.

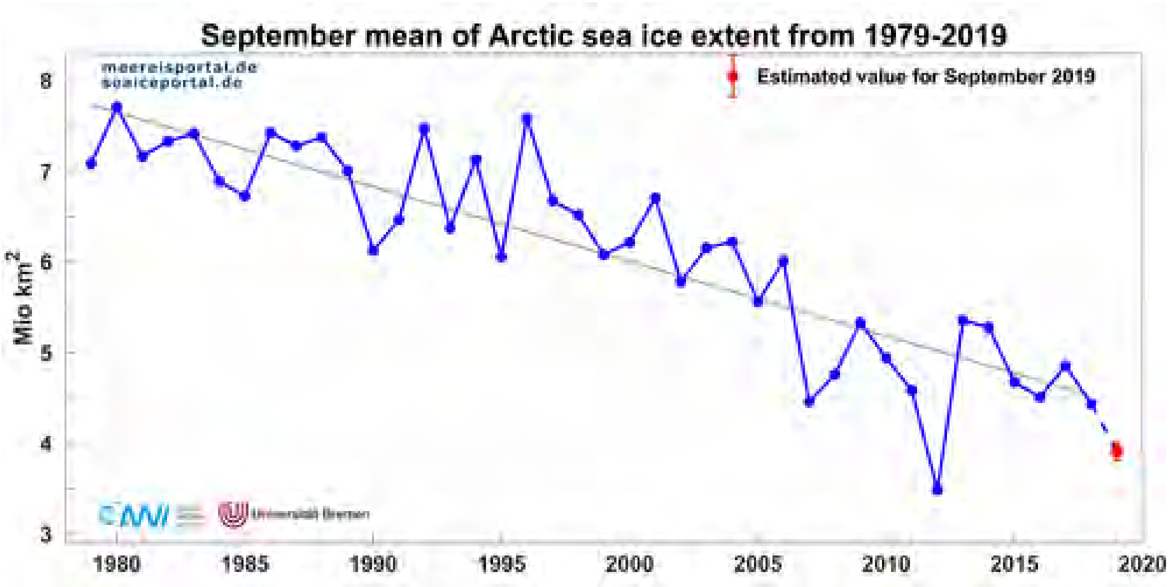


SEAICE Portal

Meereisticker (20 August – 12 October 2020)

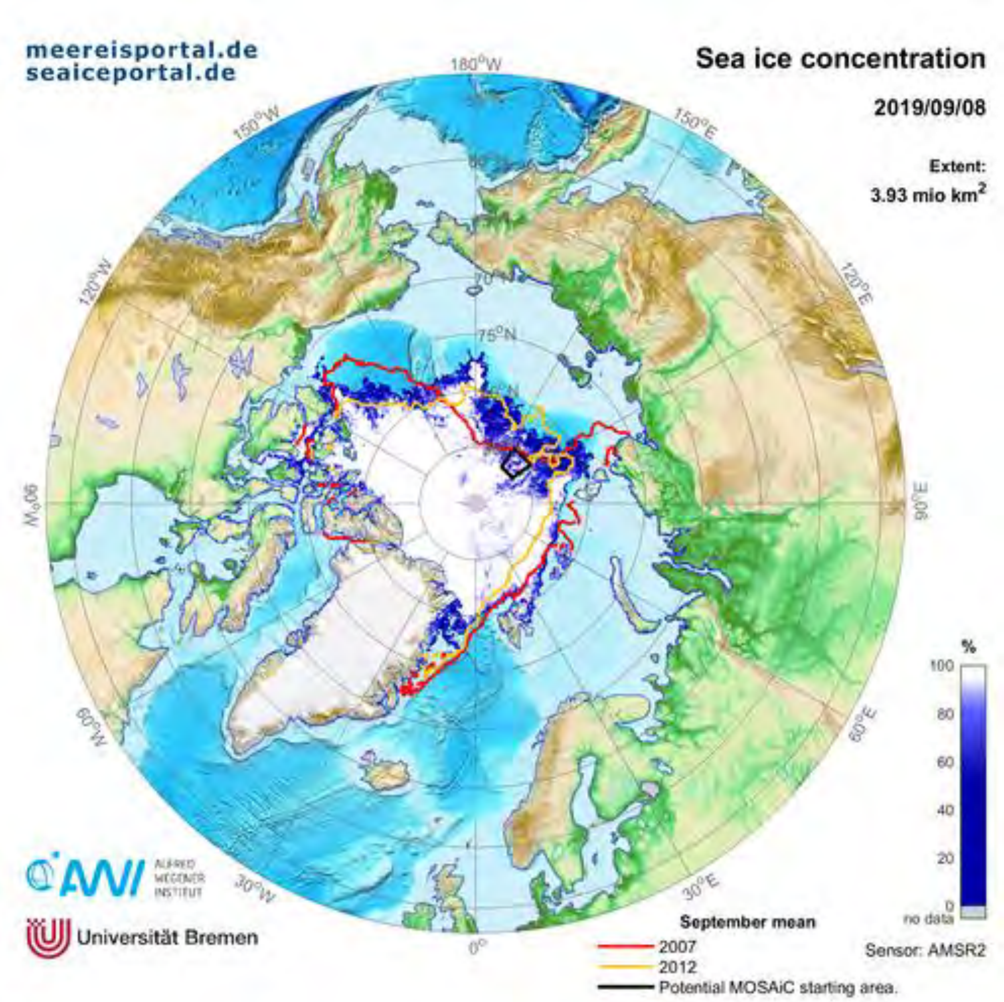
Sea Ice Ticker No 8: 13.09.2019

The summer sea-ice minimum in the Arctic is an indicator of the global effects of progressing climate change. The September ice extent has been decreasing since 1979. This is the month that marks the end of the melt season, when the lowest absolute ice extent, as well as the lowest monthly mean, is reached. There has been a reduction in this of circa 12 % per decade, and in all probability this year will see the second-lowest level ever. Despite variations in the ice melt from year to year, this year, since the beginning of the melt season in March, the average monthly ice extent has been low (in parts, the lowest ever). Looking at the average ice concentration and extent for the first third of the month, we can expect the monthly mean ice extent in September to be 3.9 ± 0.1 million km^2, assuming similarly progressing weather conditions. This extensive melting is also linked to a reduction in the mean ice thickness, which means that RV Polarstern's search for a suitable ice floe (a thickness > 1.2 m, to provide a safe base to set up camp on) to serve as a "home port" won't be easy.



Sea Ice Ticker No 7: 10.09.2019

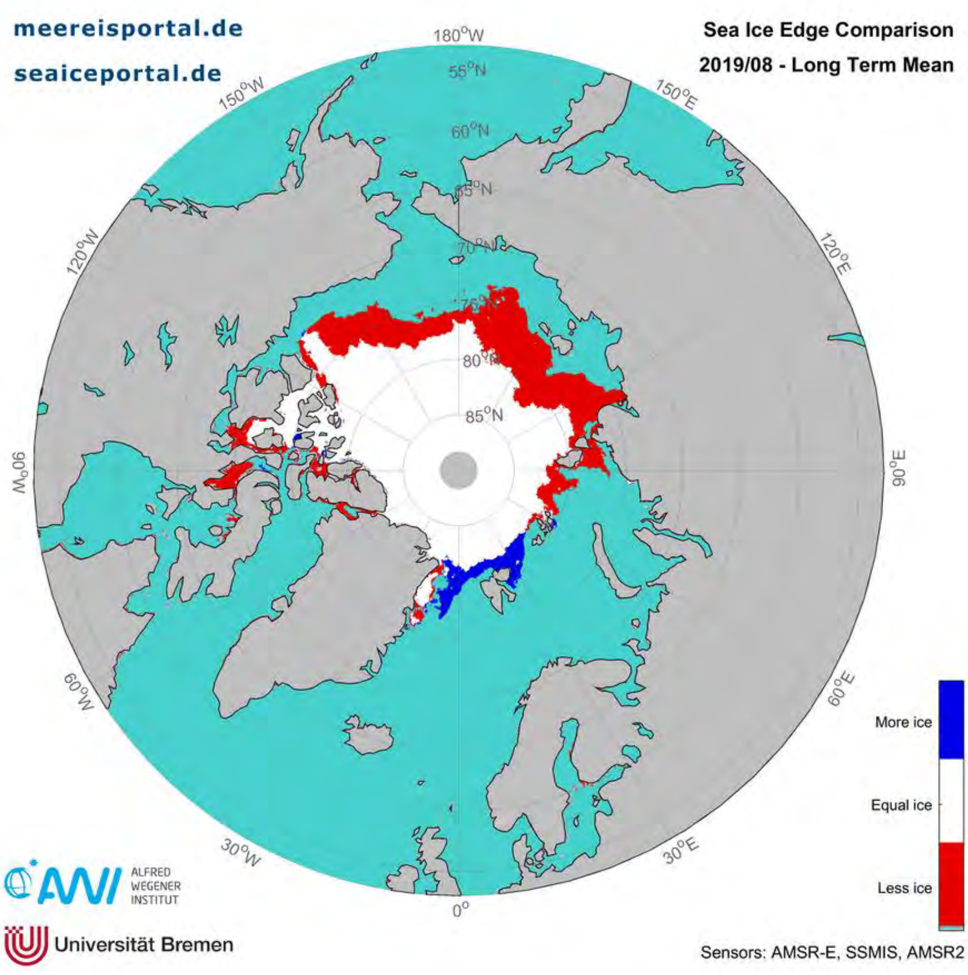
We're gradually approaching this summer's sea ice minimum. This map shows us the sea ice concentration on 9 September, and it can clearly be seen that large parts of the Northwest Passage are free of ice. Although the surface melt is almost over, the ice continues to melt since there is still sufficient warmth in the ocean. Winds can also reduce the sea ice by pushing it together. For comparison the ice edges in 2007 (red) and 2012 (yellow) are shown. In both years the sea ice concentration reached record lows. If the ice isn't further compacted by strong winds, the sea ice extent in 2019 will near the second-lowest value since the beginning of continuous satellite observation in 1979.



Meereisticker (20 August – 12 October 2020)

Sea Ice Ticker No 6: 06.09.2019

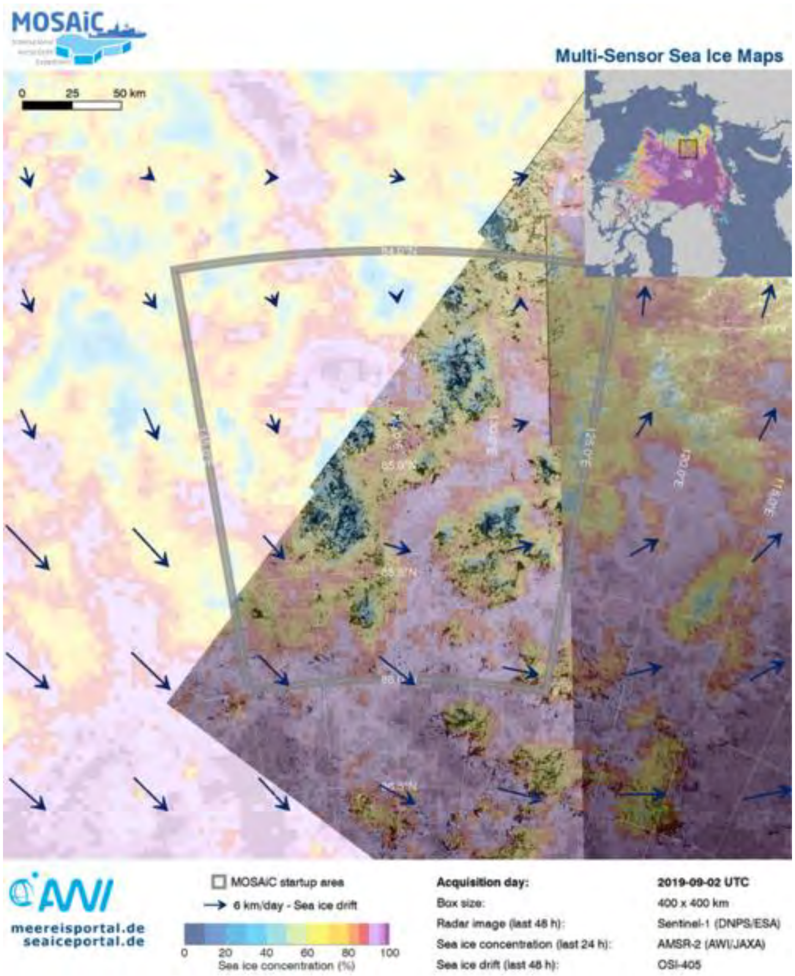
Comparing the current sea ice extent in the Arctic with reference time points in the past allows us to better estimate the current sea ice situation. In order to compare the changes in the sea ice concentration in various regions and for different months and years, the differences in the ice edge are represented on a map. To do this, data on the sea ice concentration is used to determine the position of the ice edge (15 % sea ice concentration) and the difference between this and the long-term average (from 2003 to 2014) for the same month. This makes regions with an increase in sea ice (blue) and a reduction in sea ice (red) clearly visible. In August 2019, there was significantly less ice in the entire Siberian and Canadian continental shelf region than the average for the period 2003 – 2014. Only in small areas of the Greenland Sea (Fram Strait) and in the northern Barents was there slightly more ice. In particular, the ice in the planned starting position for the MOSAiC expedition has declined sharply, making it a favourable point for the RV Polarstern to set off from on its way to the target region.



Sea Ice Ticker No 5: 03.09.2019

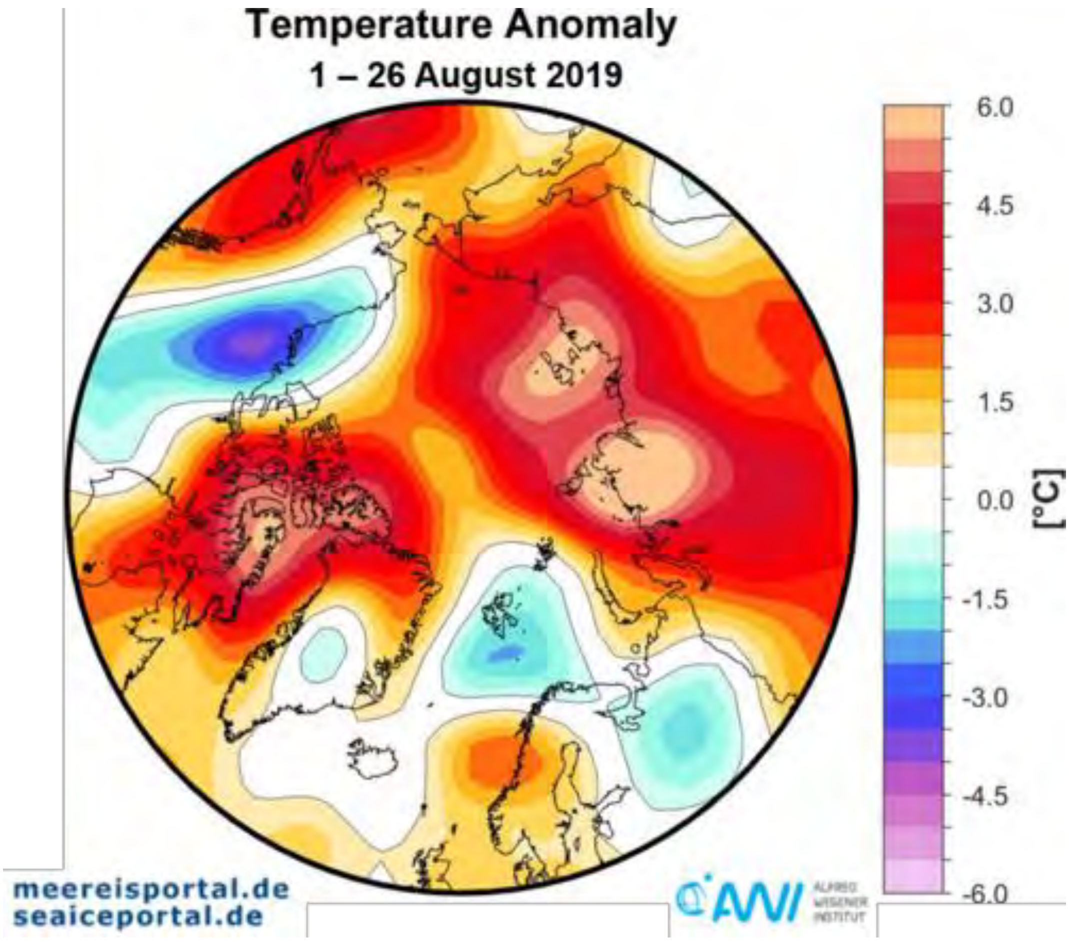
Satellite remote sensing is an effective tool for recording sea ice parameters. In order to assess the sea ice situation in the MOSAiC starting region, multiple types of information from satellite observations are used to obtain a better estimate of the sea ice situation in the area. The most important parameters include ice concentration, ice movement and the general condition of the ice surface. In the AWI's newly developed multi-satellite product for MOSAiC, radar satellite images of the sea ice surface with a resolution of 50 m are combined with ice concentration data with a spatial resolution of 3 km and drift information on the ice movement. This allows us to gain an accurate picture of the ice characteristics in the potential starting region, which makes the preparatory investigations and route planning easier and also depicts the ice conditions during the MOSAiC drift.

The region is currently marked by a fragmented sea ice surface with a sea ice concentration of 20 -100 %. Everything from compact ice to open water can be found here. However, recent weeks have shown how quickly the situation can change, depending on the weather. In the last 48 hours, the ice drift was mainly in a westerly direction. From today, this and other sea ice maps and derived products for MOSAiC will be available in a new section on meereisportal.de.



Sea Ice Ticker No 4: 30.08.2019

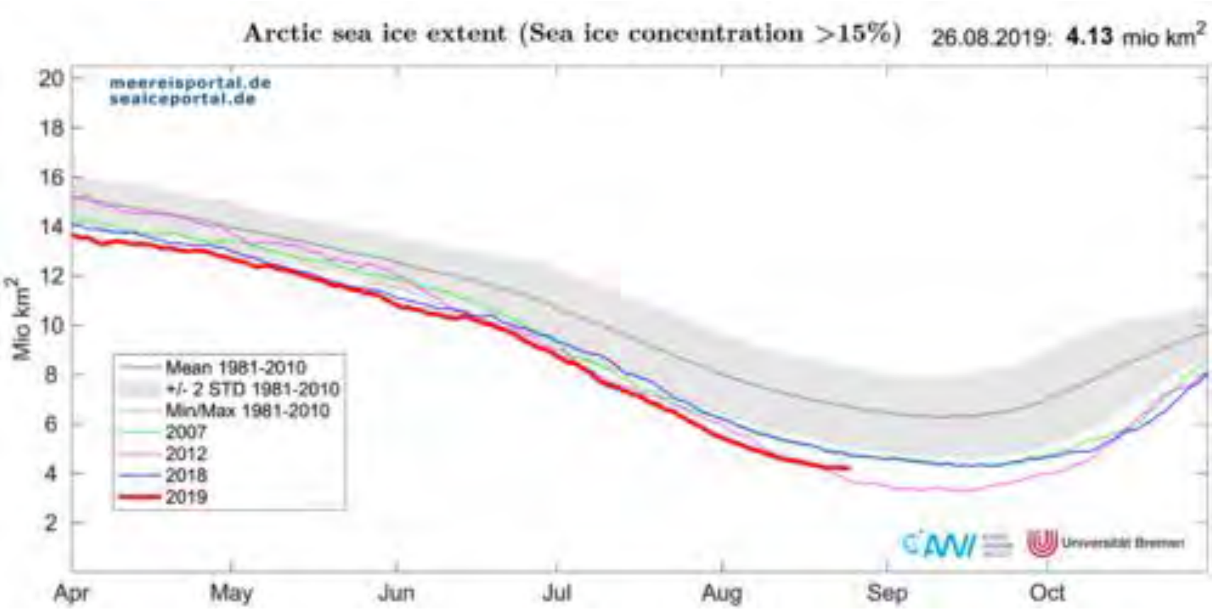
Climatalogical maps help us gain a better understanding of the current Arctic sea ice situation. This map shows the temperature anomalies at an altitude of 925 hPa (roughly 760 m) over the Arctic, depicted as deviations from the long-term average from 1971 to 2000. Red indicates a positive deviation and blue a negative deviation. We can clearly see that in the period from 1 to 26 August, wide areas of the Arctic were far too warm. Particularly along the Siberian coast, the temperatures were up to 6 degrees higher than the long-term average, and the situation was similar over the Canadian Arctic Archipelago. Warmth from the atmosphere, together with the wind field and the ocean temperature, is an important factor in the development of the sea ice situation up to the summer minimum in the coming month. You can read more about the effect of these factors on the current sea ice situation here.



Temperature anomaly Arctic from long-term mean 1971 to 2000.

Sea Ice Ticker No 3: 27.08.2019

This 'fever chart' allows us to follow the daily changes in the total sea ice concentration in the Arctic. The red line shows us the values for 2019, while the grey line shows the mean value for the years 1981 – 2010, bordered by an area depicting the span of two standard deviations for all the observed values in the same period (grey band). If we look at the trend for this year, we can see that after a record low in July, it has gradually settled above the line for 2012 – the year with the lowest sea ice extent since the beginning of continuous satellite observations in 1979. The weather in the coming weeks will be crucial to how this curve develops. The distribution of high and low-pressure areas and the effect of warm air masses from the lower latitudes will determine the distribution of the sea ice and the total ice cover. We're following the situation in the planned MOSAiC starting region with bated breath.

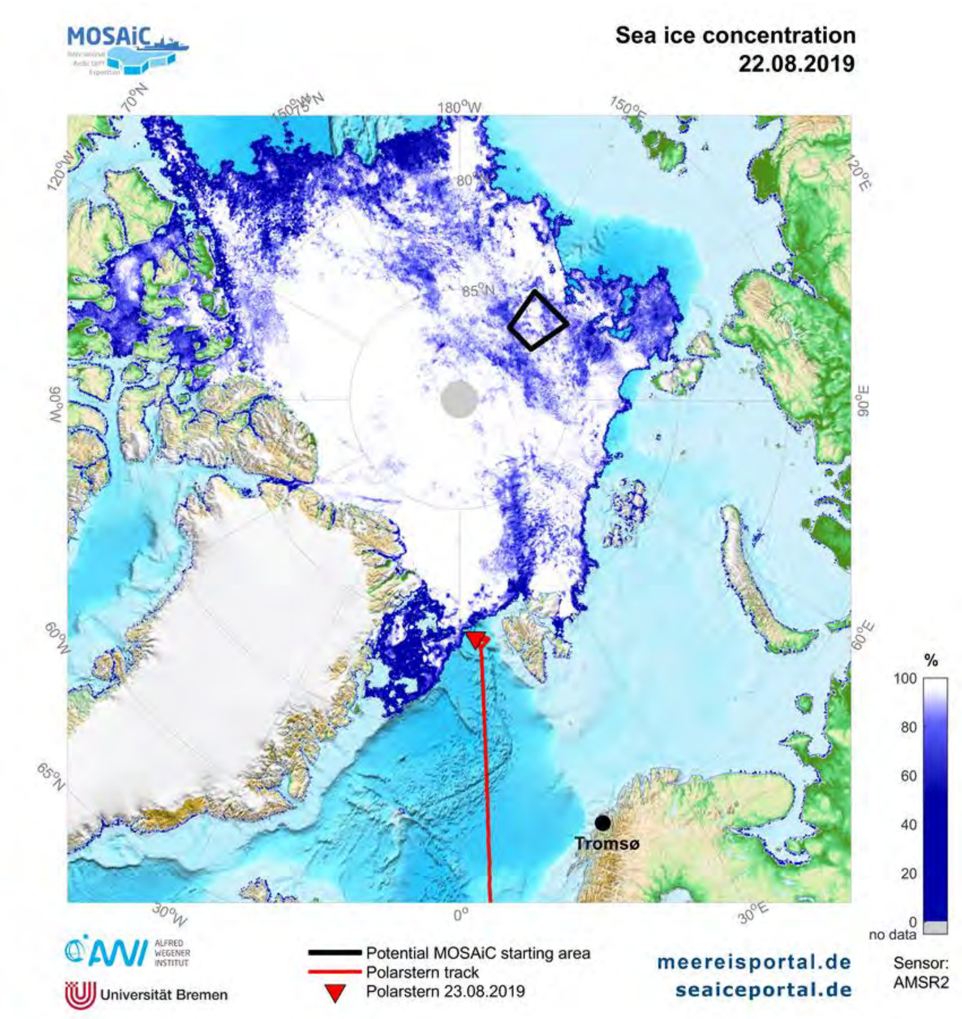


Actual sea ice concentration in the Arctic 26.08.2019.

Meereisticker (20 August – 12 October 2020)

Sea Ice Ticker No 2: 23.08.2019

Today's map shows the likely area in the Arctic from which the research icebreaker RV Polarstern's MOSAiC expedition will start its drift (section outlined in black). The RV Polarstern will sail from Tromsø/Norway on 20 September, cross the Barents and Kara Seas and then set course for Novaya Zemlya and Severnaya Zemlya in order to reach the starting area in the Laptev Sea. The sea ice in this region has retreated significantly this year, and the ice concentration is between 50 % and 80 %. It will only be possible to select an ice floe with the necessary size and thickness for the drift station to anchor at once the starting region has been reached. You can find detailed maps of the sea ice concentration on the DataPortal of seaiceportal.de. RV Polarstern is currently on another mission – Expedition PS121.

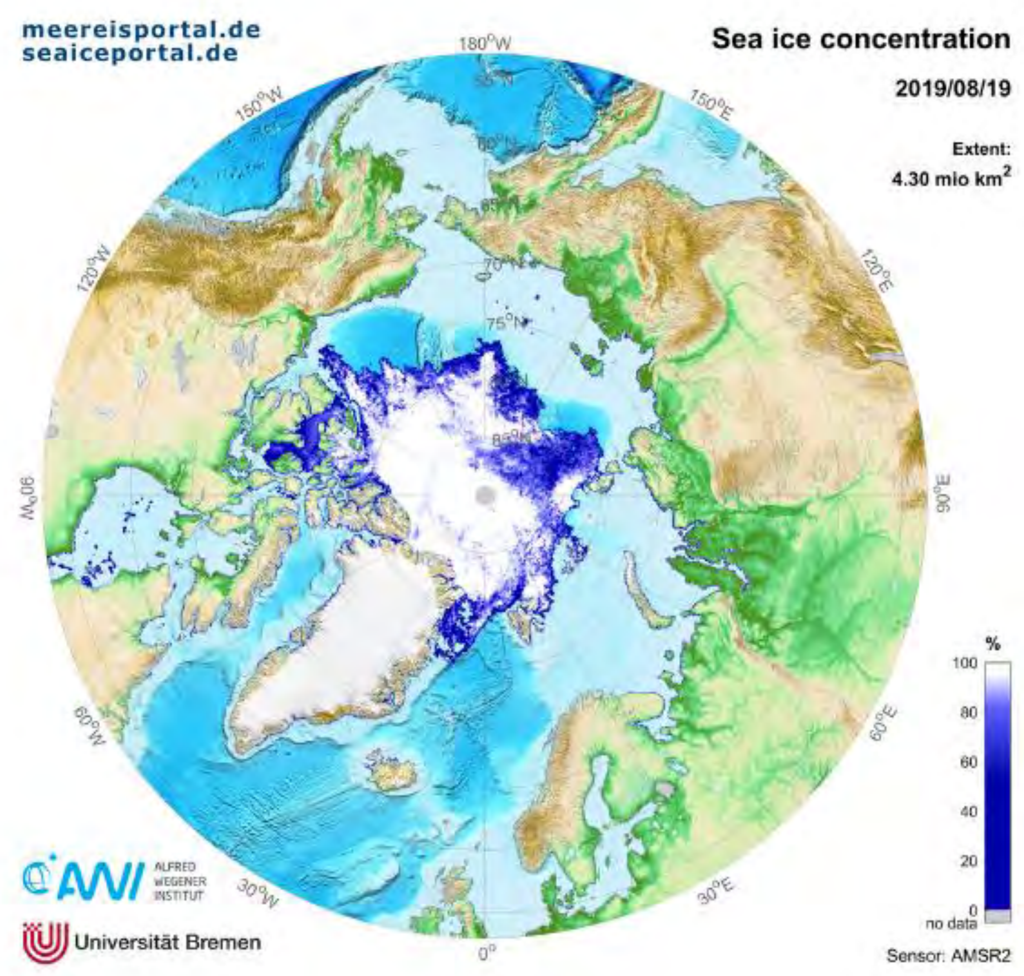


Detail map of the Arctic including the potential starting region of the MOSAiC expedition 23.08.19.

Meereisticker (20 August – 12 October 2020)

Sea Ice Ticker No 1: 20.08.2019

Today's map of the sea ice concentration and extent in the Arctic marks the launch of the "AWI Sea Ice Ticker". In preparation for the start of the major MOSAiC expedition in Tromsø/Norway on 20 September 2019, twice a week we will present new maps of the sea ice situation in the Arctic, showing the current sea ice development, and so follow the preparations in the lead-up to the expedition. We're all eagerly awaiting the start of MOSAiC – why not join us?



Sea ice concentration in the Arctic 19 August 2019.