

# Forecasting in the Arctic - Adventure and challenge

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## Introduction

The Alfred-Wegener-Institute for Polar and Marine Research (AWI) in Bremerhaven and the Maritime Competence Centre of the German Weather Service (DWD) based in Hamburg have forged a reliable and trusted partnership, successfully working together for a number of decades studying and monitoring our earth systems. One of their most recent and ambitious ventures was the Multidisciplinary drifting Observatory for the Study of Arctic Climate (MOSAiC) project conducted in 2020.

## MOSAiC

The MOSAiC expedition was a € 140 Million scientific research project, designed by an international consortium of leading polar research institutions, to investigate the physical, chemical and biological processes that coupled the Arctic atmosphere, sea ice, ocean, and ecosystem during the freezing to melting season in the Arctic circle. The MOSAiC project was a 1 year study that used a modern research icebreaker ship, the Polarstern, laden with scientific instruments to conduct this study.

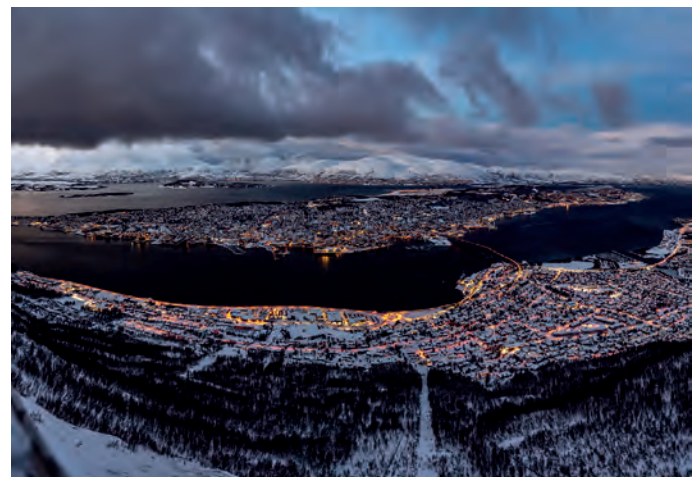
An experienced team of weather forecasters and scientific technicians formed part of the crew on board the expedition the MOSAiC expedition, launching radiosonds, controlling data, maintaining sensors and providing a variety of advisory forecasting products.

It was a win-win situation for both the forecasters and the scientists. The forecasting team provided meteorological advice and guidance to maintain colleague safety on board and allowed scientists to plan future fieldwork activities more effectively, saving time and money. In turn, the forecasters onboard were able to gain real time verification of their own maritime and aviation forecasts seeing for themselves as the changes occurred.

The MOSAiC project was divided into six parts (legs) due to extreme weather conditions. Together with my partner Christian Rohleder, we participated in the Leg 3 of the expedition, running from the end of January until beginning of April 2020.

## Transit to Polarstern

At the end of January 2020, we gathered in Tromsø, Norway in order to get the final instructions before departure. It was the first meeting from all the different disciplines with institutes coming from Europe, Asia and the US. I've never been in Tromsø before and must admit I was really impressed. Coming from a mild winter in Frankfurt (Germany) it felt great waking up in a winter wonderland and snow was a great introduction to the wintery conditions to come during our upcoming trip.



▲ Figure 1: View on Tromsø in the late afternoon, 24.01.2020

Before we even started we had our first unexpected delay. The ship we expected to take on the expedition was not available and in its place *Kapitan Dranitsyn* ship normally used for tourist trips on Russian rivers during winter was swiftly arranged on short notice as an alternate for us. During this

time we met with a number of Russians who were very friendly and polite. In fact, we had a lot of fun with them, competing with them in tough and sweaty table tennis matches. Unfortunately, surreal and unimaginable nowdays...

After one week we went to sea. It was so bumpy a lot of people got seasick. Learning from previous experience, I placed a special plaster behind my ear, which dims the balance feeling and reduces the sickness. One and a half days later we reached the ice edge and the waves stopped immediately. Communication was very restricted. We could WhatsApp, but if you intended to chat, you had to wait. Large photos and videostock a full day or more to come through and this became quite annoying.

During this time when communication was limited, it was best to fill your time with sports, quiz evenings, presentations and movies. The general mood was good and the team spirit grew over time. You could take a walk out on deck but you had to cover your face during these walks as the outside air temperature was less than -20 degrees! It was

permanently dark during the polar night and this made us all very tired. We slept on average 10 to 14 hours per day.

Approximately 200 km away from the North Pole at around 88°N we finally saw a dimmed light near the horizon. That was amazing, we had not seen any light during winter season. On first view the bright spot was rather small but getting closer we realized that we finally made it to the *Polarstern*!

As soon as we disembarked the *Kapitan Dranitsyn* we conducted the meteorological handover with our colleagues from leg 2. They outlined the advantages and disadvantages of the models and shared their experiences in different weather situations which was crucial for our future success in Leg 3. We were now in charge and it got serious!



▲ Figure 3: Handover of the forecasters Leg 2 (Julia Wenzel/DWD) to Leg 3 (Robert Hausen/DWD), 02.03.2020

## On the floe

It was the coldest period of the entire MOSAiC expedition during our leg, and it lasted until the middle of March. The air temperatures fell below -40 degrees centigrade at 2 meters above ground (the all-time record at the "MET-City" part of the Ice Camp was -42.3 degrees on the 4<sup>th</sup> of March).

Due to a very strong inversion close to the surface the temperatures in the crow's nest (29 m from the ship surface) there was 5 Kelvin difference between the air temperature at 2 m above the ground surface and the air temperature up in the crows nest, with the nest being warmer.

◀ Figure 2: *Kapitan Dranitsyn* in the Arctic during polar night on the way to *Polarstern*, 06.02.2020

Despite almost calm conditions, the wind chill was between -50 and -60 degrees (minimum -61.2 degrees) causing frost nips and bites within only a few minutes on unprotected areas of skin. The extremely cold temperatures were threatening cargo and scientific operations and it was challenging for people. The Pistenbullies and Skidoos were not working properly anymore, the oil became solid and stuck. Crane operations were halted below -30 degrees and Helicopters were not able to fly at temperatures below -35 degrees as their temperature operating limits had been reached.

a PowerPoint presentation for the science meeting and an update on the development in the next days had to be made. You'll never get bored. Day-offs were rare and only happened if you had agreement with the master and chief scientist.

Two types of storm tracks were the most common. Either a storm over the Atlantic Ocean took a swing via Svalbard or Franz-Josef-Land into our direction or it turned southwards from the Bering Strait and passed over northern parts of Canada. No matter the track, it always caused a widespread storm field, horizontally extending over several hundreds of kilometers, which was very impressive. During these storms it took a while for the winds to die down and for blown snow to settle on the ground once more. It was important to carefully consider the winds in the surrounding areas and how they might develop whilst forecasting as these had a direct and major impact on visibility both on the ground and in the air.

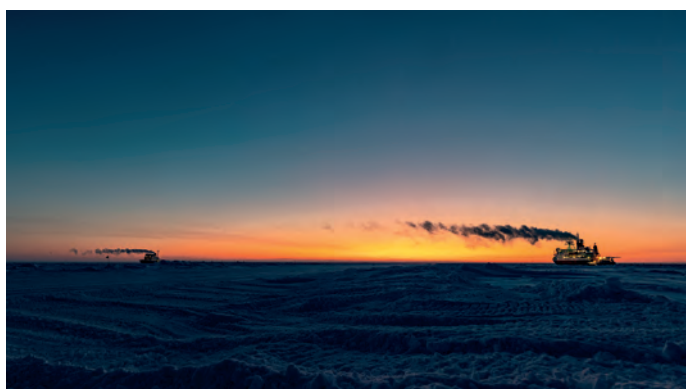
## COVID-19 and other challenges

One day an unusual and shocking message from home arrived on the ship. Usually, we received the daily news from the day before through a common newspaper or via download video of german TV news ('Tagesschau'). But this kind of message changed everything. It was the speech of the former german chancellor Mrs. Angela Merkel explaining the serious spread of a new virus called COVID-19 or CoronaVirus. Regions with higher numbers of infections back home were being locked down causing major restrictions on everyones human rights.

It seemed so surreal as we sat on board our ship at the end of the world hearing how infections and fatalities were increasing day by day. Some people were kidding that we would be the only ones who would survive. Unbelievable!

After a while we realized that this pandemic would have far reaching consequences even affecting us. The spread of the virus heavily affected our planned return. One by one our planned transport home by either plane or icebreaker boats were cancelled due to this global crisis.

◀ *Figure 5: View on Polarstern with Helideck (green), in behind logistic area und measurements on the floe, 22.03.2020*



▲ *Figure 4: Exchange between Kapitan Dranitsyn (left) and Polarstern (right) Leg2 to Leg 3 in spring, 05.03.2020*

As we moved into spring, the stormy season started very early. As a result, there was a high demand on weather information on board and we became very busy. Each day started at 6 AM in order that we could successfully prepare materials for the big weather briefing scheduled for quarter past 8 with the captain, chief scientist, logistic managers and pilots. The amount of met work in the morning depended on the planned activities and current weather conditions. After a short break for lunch the evening report with graphical outputs,





We did get some luck. A short part of the runway was repaired during the stable winter season that allowed Twin Otter aircraft to land and were able to evacuate a small number of people that had very urgent issues to return back home immediately. Organizing this evacuation event was a challenge and a masterpiece by all involved authorities.

At the same time as this emergency pick up, the weather conditions had been very challenging. An almost stationary intense low near Spitsbergen caused strong NEly winds of Bft 6 to 7 with multilayered clouds and long-lasting snowfalls were occurring.

The wind speeds exceeded the threshold of 25 knots, causing drifting snow to become blowing snow. This in combination with the snowfall already falling caused whiteouts. Any weather improvements were not expected for days and everybody involved was put on standby which was very stressful and frustrating for some.



▲ Figure 6: 'Evacuation' of heavy equipment from the floe with helicopter, 25.03.2020



▲ Figure 7: Open leads with sea smoke around Met City, 23.03.2020

As the end of our leg came closer, large amounts of technical equipment on the floe was recovered. There were three weeks of delays in picking up the equipment and as a result some autonomously measuring instruments were left on the floe for Polarstern to take care during leg 4. Helicopters were used to evacuate the heavy huts and to do the final scientific flights.

On Wednesday 13<sup>th</sup> of May, only a few days before the scheduled departure, a powerful storm hit. The pressure fell to 965 hPa over Spitsbergen. In terms of extreme weather events during MOSAIC it was the dramatic end of the extended leg 3 beating all previous records.

Average 10-minute wind speeds recorded during leg 1 were: of 22.9 m/s (Bft 9) on the 16<sup>th</sup> of November 2019, and during leg 2: 21.4 m/s (Bft 9) on the 1<sup>st</sup> of February. We easily exceeded those values with 25.1 m/s (low Bft 10) in the morning hours on the 13<sup>th</sup> of May.

At this time, persistent easterly winds moved mild and maritime air masses towards the floe, clearing the cold pool over the central Arctic. This was the beginning of the summer season with temperatures now between 0 and -4 degrees. Due to a positive radiation balance the lower troposphere was now only able to produce temperatures above -10 degrees. This rapid increase in temperature caused the breakup of the ice and led to an enhanced risk of fog.

## Return

On our journey to Svalbard an extended zone of high pressure caused only weak winds and enhanced risk of fog and low stratus. Coming closer to the end of May a well-defined low pressure complex established from Iceland towards the Frame Street. Located in front of that system, mo-

derate winds from southeast came up and moved mild air masses with origin west of the Hebrides toward us. Therefore the temperatures rose to positive values with maximums around 2.5 degrees.

Observed precipitation turned from solid into liquid more and more often. Melt ponds formed and the snow layer became heavier but also thinner. It was essential to provide information concerning the ice situation based on satellite images in the visible channel with emphasized contrasts during that period of time. Unfortunately, often cloudy conditions inhibited an undisturbed view to the surface of the ice.

On Tuesday 2<sup>nd</sup> of June PM, we reached the ice edge and the day after we entered the Isfjord to meet and swap places with our leg 4 colleagues who were waiting on the research vessels 'Sonne' and 'Maria S. Merian'. After a few days handing over to our successors and refilling food and fuel the 'Polarstern' headed off to the MOSAiC floe once more, now filled with fresh scientists and crew on board.

The journey back to the floe for leg 4 was now much easier than it had been for us as the ice started to melt. Leg 4 returned to the original floe and proceeded to collect data until the floe reached the ice edge and finally dissolved finally at the end of July after 300 days of continuous scientific measurement

In the meantime, we headed for home. After a bumpy start with a sharp and nasty trough at the edge of a low near Svalbard coinciding with the scheduled mandatory rescue boat deployment safety exercise. I thought: "Today of all days!". But luckily the rest of our trip home was calm and we enjoyed the sunset view after numerous dark polar days. As we had no more (urgent) tasks to do, all the pressure and stress of the past month released leading into tiredness without any energy. That's why we spent those days watching movies, playing games and extended periods of sleeping. Then it was finally done! We entered the port of Bremerhaven on Monday, the 15<sup>th</sup> of June 2020 and were sent back to our families and friends. We had originally planned to be absent from home for 2.5 months, but this had turned into nearly 5 months! It was an overwhelming feeling to hug my family after such a long period of time. After a few hours it felt like I've never been away before, but it took a while to adopt and get used to the 'new life' with COVID-19 and all these circulating restrictions.

After we returned home, further north, Leg 5 seized the remaining time at the end of the arctic summer and beginning of autumn to investigate the area around the North Pole more closely, especially in terms of new freezing processes. They returned on the 12<sup>th</sup> of October which indicated the official end of the MOSAiC campaign.

▲ *Figure 8: View on MOSAiC floe during summer near 82°N, 30.06.2020*





## Summary

During the entire expedition approximately 150 Terabytes of data with more than 10,000 samples of ice, snow, water and air were collected and are under evaluation and will still be analyzed in numerous scientific disciplines and studies. This will take another couple of years. However some initial early conclusions were able to be drawn and were revealed in 2021:

- 25% reduction in ozone concentration, especially in April at 20 km height no ozone was measured
- Sea ice is melting rapidly
  - Thickness has halved compared to 1880
  - Extent has halved compared to a few decades ago

It hurts to experience the unique environment of the Arctic that closely, knowing that it will most likely be a lost in this rapidly changing region of the world. Despite of all these circumstances, we will never forget this expedition and especially the positive memories, experiences and impressions will remain.


From my experience as a forecaster during leg 3 (March-May 2020): I outline the following pros and cons of the IFS (ECMWF) and ICON (DWD) models for forecasting weather in the extreme northern hemisphere.

### References

<https://mosaic-expedition.org/expedition/>


photos: ©Christian Rohleder (technician and meteorological assistance on board/DWD)






### temperature:

- ,radiation weather': **ICON not bad, first guess  $T \sim Td\_model$ , IFS too mild (partly  $\sim 10$  K)**
- **Low pressure/warm intrusion: IFS significantly better, ICON too cold (partly  $\sim 10$  K)**




### clouds:

- **High und med clouds generally very good captured**
- **Low stratus (ice): ICON rather good, IFS mostly overestimated**
- **Low clouds (water): IFS very good, ICON mostly underestimated**



### wind/pressure:

- **Short range: in general satisfying performance from all the models**
- **Medium range: highest reliability and consistency from IFS, ICON jumping**



### precipitation:

- **IFS almost nothing – fits most, but higher intensities systematically underrated**
- **ICON very good – some cm with severe events, but volatile**