Drifting through the ice on board a polar climate research vessel

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Credit: EPFL/J.Schmale

More than two months ago, EPFL researcher Julia Schmale joined the crew of the Polarstern, a German research icebreaker that has been drifting slowly through the frozen waters starting north of Siberia towards Svalbard since September last year. The vessel is carrying an international team of scientists on a year-long research expedition, working in unusual and often challenging conditions: changeable weather, temperatures plummeting as low as –40°C, interminable darkness giving way to endless daylight, and ice as far as the eye can see.

The crew is carrying out research as part of a major expedition titled Multidisciplinary drifting Observatory for the Study of Arctic Climate, or MOSAiC for short, which aims to gain fundamental insights into conditions in the Arctic, the impact of climate change on the region and vice versa the region's influence on global climate change.

Schmale, an atmospheric scientist, is leading the observatory's atmospheric research team. She had planned a mid-April return to Switzerland, where she was recently appointed head of the brand-new Extreme Environments Research Laboratory at EPFL, but the COVID-19 crisis means she will remain on board until early June. Schmale is no stranger to polar environments, having taken part in the Antarctic Circumnavigation Expedition (ACE) in 2017. Her role in this latest expedition is to study how airborne molecules and particles influence cloud formations in the Arctic. In this interview, she talks to us from the front line about living and working in this extreme environment, what it's like to head out onto the ice floe, and the aims and methods of her research. The complete interview is soon to be read on the EPFL Out there website.

What's it like living and working on the ice?

"Unpredictable. The icescape changes frequently and new cracks, leads and ridges form overnight, often preventing us from reaching our research sites on the ice. Depending on how severe the changes are, we might need to go scouting for a new route or reschedule whatever activities we had planned. Sometimes the ice becomes dynamic during the day while we're out. When that happens, we either have to keep a close eye on our path back to the ship or we get called back by the bridge, where the on-board team coordinates and monitors activities out on the ice. Before we head out, we always complete a trip log detailing who's going where, what gear they're carrying and—importantly—who's acting as the polar bear guard. Most of us are qualified polar bear guards, a role that involves keeping a permanent lookout while our colleagues are working. We carry a flare gun to scare any bears away, as well as a rifle to use if an animal approaches us too quickly. On 23 April, we saw the first bear on our floe since we arrived in early March.

The environment is just beautiful. It was still dark when we arrived, with only a slither of daylight on the horizon. The research sites on the floe looked far away, but they were easy to reach across flat ice. Now, with the sun up 24 hours a day, everything seems much closer. But moving about is much harder because many leads and cracks have formed, especially between the ship and our team's main research site. With temperatures at around –20°C, open leads freeze over relatively quickly—about 6 cm in one day. Sometimes, ridges form when open leads close and we can end up surrounded by ice rising up to 6 meters high in just a couple of hours. On occasion, we can hear the ice moving and, if it happens fast, we can also see it. It's also fascinating to watch frost flowers grow. We sample them to learn about their biogeochemistry.

Credit: EPFL/J.Schmale

And what about the weather?

We've experienced the full range of Arctic weather conditions in our time here. We've had persistent low temperatures of –40°C, which makes working outdoors very challenging and renders some of ship's equipment unusable. March was particularly stormy, with strong winds and a few complete whiteouts. Conditions have settled down recently, though. We have clear skies, sunshine and light winds—very much like winter in the Alps. Now that we've drifted below 84°N, warm air mass intrusions from the Atlantic are pushing temperatures as high as 0°C, bringing surface melt and rain.

What samples are you collecting and why?

I'm studying the extent to which natural and human emissions modify low-level Arctic clouds. These clouds play a vital role in maintaining the Arctic's energy and mass balances because they reflect and absorb radiation, and because they contribute to snow cover through precipitation. In general, clouds only form in the presence of cloud condensation nuclei or ice nucleating particles. These are a subset of aerosol particles that can originate from natural sources such as sea spray, phytoplankton emissions or blowing snow, but also from human activities such as fossil-fuel combustion, other industrial emissions and agriculture.

We can use our on-board instrumentation to characterize aerosol particles in terms of their microphysical and chemical properties. Variables such as number concentration, particle size distribution, hygroscopicity, chemical composition and fluorescence help us to understand their origin—natural or human—and their potential effects on clouds. Our end goal is to understand how far natural versus human-made processes contribute to cloud formation and to the energy balance in the Arctic, and how this might change as the so-called "New Arctic" evolves and human emissions change in the future. Ultimately, this information can be used in Arctic climate change scenarios.

Credit: EPFL/J.Schmale

What have you learned about the Arctic air so far?

By looking at the data, I get an almost real-time picture of the composition of the atmosphere. When air masses come from the north—from the High Arctic—the aerosol population is aged, meaning several days to weeks old, and consists mainly of sulfuric acid. This is a common winter phenomenon known as Arctic haze, when sulfur dioxide emissions—mostly from human activity in the mid and high latitudes—accumulate over the wintertime. The haze began forming back in November. Initially, the concentration was about 50 particles per cubic centimeter. Now it's risen to 200.

During stormy conditions, salty snow is lifted into the air where it forms aerosol particles. The number of particles depends on several factors, including the microstructure of the snow, how wind-pressed it was, and its surface roughness. Because these particles make up a significant share of the overall aerosol population, they likely play an important role in cloud formation.

When air masses arrive from the south, however, all these variables are different. The particles have been processed by clouds, and differ in origin, size and chemical composition. Mid-April is the time when phytoplankton blooms happen in the Atlantic. These blooms emit dimethyl sulfide, which is transformed to methanesulfonic acid—a tracer that we're now seeing in the aerosol particles. We've also found halogens—iodic acid and bromine—in the aerosol population. These are more local in origin, and are connected to snow chemistry and UV radiation. And, of course, we also see exhaust particles from the ship, skidoos and helicopters. They carry a distinctive signature that sets them apart from other aerosol types.

Credit: EPFL/J.Schmale

Have you personally observed changes in the Arctic climate?

That's a difficult question. I don't have a reliable benchmark because this is the first time that I, like many other members of the team, have been this far north at this time of year. Generally speaking, we didn't anticipate observing so much mobile ice so early in the year. We expected to see a much more consolidated ice pack. But this might not necessarily be a sign of climate change. What was striking, however, was that precipitation fell as rain instead of snow when Atlantic air masses arrived in mid-April.

Is the COVID-19 crisis affecting life on an Arctic research vessel?

Yes, definitely. It's affecting us in two main ways. First, we're all hearing news from home about how the world has changed and what it means for our families, friends and colleagues. It's a real cause for concern and we talk about the pandemic a lot. Second, the outbreak has disrupted the crew changeover schedule. It's taken us several weeks to figure out our options, given the travel restrictions in force around the world. Despite the delays and uncertainty around when we'll return home, I'm happy to report that crew morale is high. We've grown together as a fantastic team of scientists who communicate openly and look out for each other. It's also made my job much easier, as one of the five science team leaders on board.

As someone who's used to spending long periods on boats, how are you coping with living under lockdown?

I'd hardly call this a lockdown. We have a lot more freedom than people back at home. We can still work, go out, hold social gatherings, exercise and eat together. Of course, we can't travel far from the ship and our activity options are limited. But you don't really notice those things when you're surrounded by such a fascinating environment, making friends and building new working relationships. All in all, it's been an immensely satisfying and rewarding experience."

Provided by Ecole Polytechnique Federale de Lausanne

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