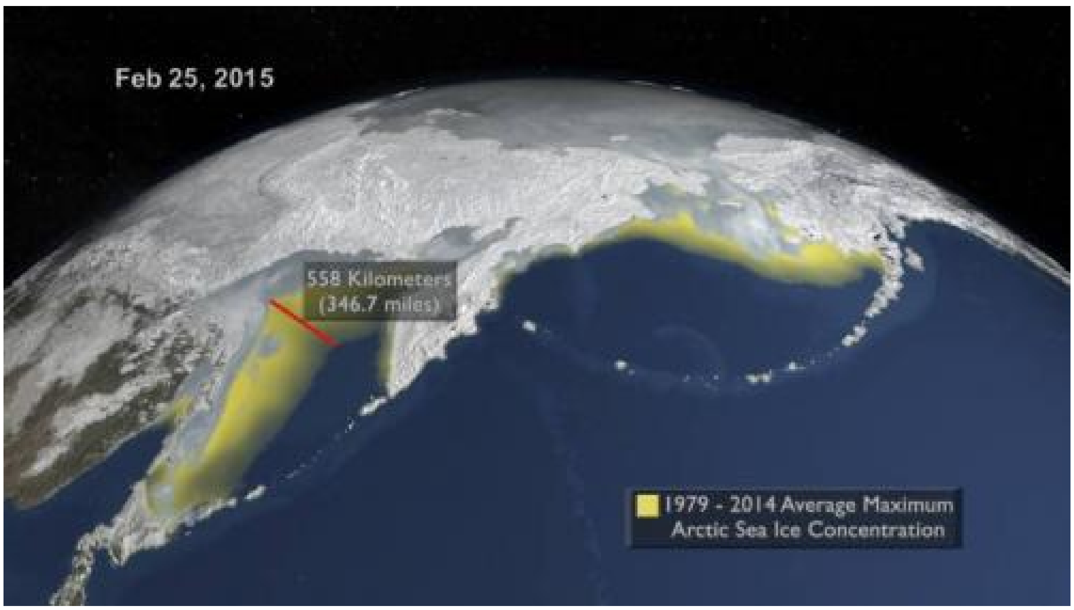
Ice-tethered devices to collect more data on the Arctic Ocean

March 27 2015, by Cassie Martin



Here the 2015 maximum is compared to the 1979 to 2014 average maximum (shown in yellow). A distance indicator shows the difference between the two in the Sea of Okhotsk north of Japan. Credit: NASA's Goddard Space Flight Center

Last week, the National Snow & Ice Data Center announced winter ice covering the Arctic Ocean reached its annual peak, ushering in the spring melting season. But the extent of sea ice cover was the smallest since record-keeping began in 1978. Covering approximately 5.6 million square miles of the northern seas, the ice was 425,000 square miles below the average recorded between 1981 and 2010, and about 50,000 square miles below the previous lowest maximum recorded in 2011.

As ice disappears, the ocean underneath absorbs more heat, further accelerating melting. Sea ice loss already affects the entire Arctic ecosystem, including organisms such as polar bears and phytoplankton that depend on the ice, the ocean environment, and even weather patterns across the Northern Hemisphere. But to what extent is the ecosystem impacted, and what might it look like in the future?

Scientists have been working for years to answer these questions, but the Arctic's harsh environment often prohibited the gathering of long-term data. Until recently, satellites and sampling from ships and submarines were the only sources of information on this ice-covered region, and provided only snapshots of small areas. Now, thanks to an innovative device designed to drift around the Arctic on sea ice, researchers are closing critical data gaps and gaining a better understanding of how the Arctic Ocean is responding to climate change.

"Ice-tethered profilers (ITPs) are helping us on two fronts," says John Toole, an oceanographer at Woods Hole Oceanographic Institution (WHOI) and ITP designer. "One is trying to better understand the ocean's role in shrinking ice cover and the other is thinking about what the implications are for the upper ocean and the ecosystem in the Arctic."

Since 2004, WHOI has deployed more than 80 profilers, and tries to maintain approximately 20 profilers across the Arctic at all times. Large, bright yellow buoys anchored atop ice floes support weighted cables that extend 800 meters down into the freezing water. Attached to the cables are motorized "profiler" units. Equipped with a variety of sensors, these profilers move along the entire length of the cables measuring anything from temperature, pressure, and salinity to dissolved oxygen content, ocean currents, and fluorescent chlorophyll produced by phytoplankton. The data are sent to electronics in the buoys, which wirelessly transmit the information back to WHOI in near real time.

Profilers collect and send data for up to three years, after which their batteries fail, underwater components break, or ice crushes them. Researchers are able to recover and refurbish some units if it's cost effective, but many are too damaged, or lost to the depths of the Arctic Ocean. Still, researchers find that three years' worth of continuous data is a vast improvement. "ITPs in that sense are revolutionizing arctic research and polar research in general," says Patrick Heimbach, a principal research scientist in MIT's Department of Earth, Atmospheric and Planetary Sciences (EAPS), and in the Program in Atmospheres, Oceans, and Climate.

Modeling the Arctic's future

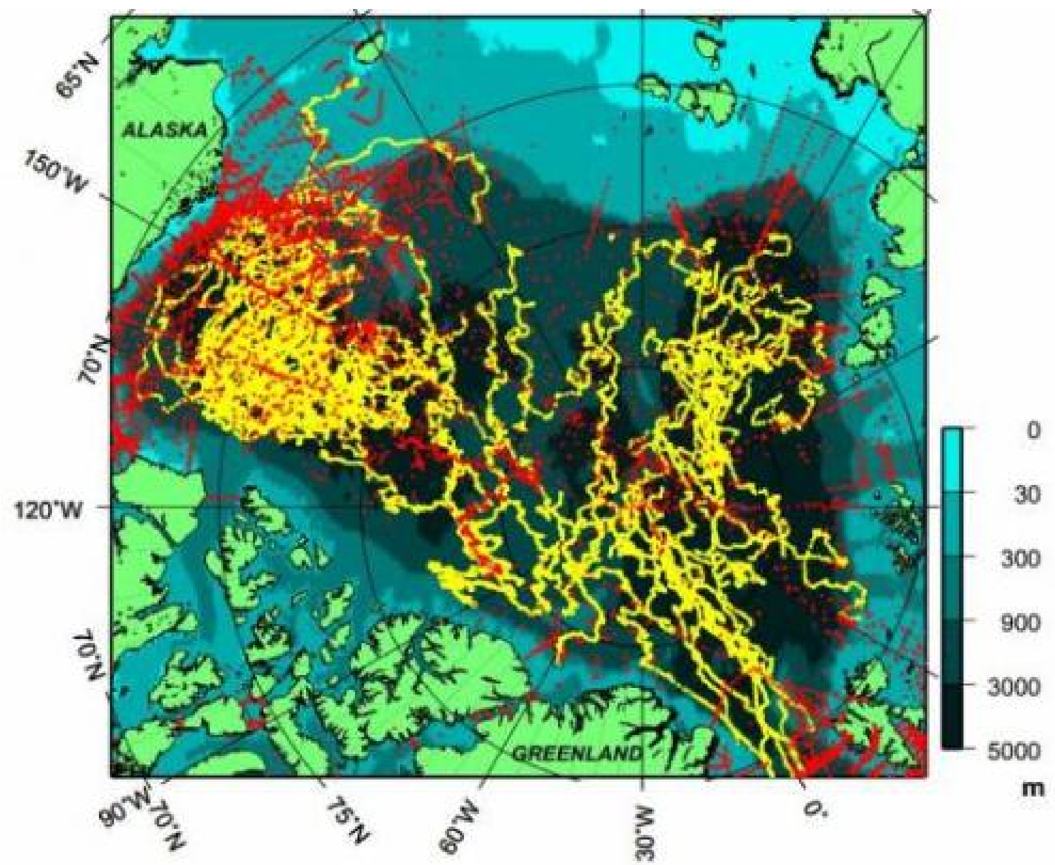
Heimbach mainly focuses on ocean circulation and its role in the global climate system. However, he also uses modeling to investigate the dynamics of Arctic sea ice, polar ice sheets, and polar oceans. "For us, the main importance is really that we start to constrain what the ocean has actually been doing, how it's changing under the ice, and how its changes may be affecting the ice," he says. "And ITPs are helping us do that." In other words, he uses the data collected by ITPs to fit models within real-world parameters. But it's not as easy as it sounds.

For the last few years, Heimbach, together with EAPS research scientist An Nguyen and his team, has been developing an Arctic-focused version of their global ocean modeling and state estimation system, called ECCO (Estimating the Circulation and Climate of the Ocean)—a computationally intense endeavor that requires the use of NASA supercomputers. "We are just getting to the stage of looking into the details of what the trajectory we are computing tells us," he says. "It's complicated in that it involves not just the forward model, but a model that essentially runs backwards in time." This backwards model acts as a fact-checker, comparing the forward model's data against observed past conditions. If the differences are too large, the system methodically adjusts uncertain variables, such as surface forcing and other model parameters, so the forward model better fits the data.

In order to get a more complete picture of Arctic Ocean and sea ice changes from their model, Heimbach and Nguyen also incorporate satellite data, limited data sets collected by researchers out in the field, and more robust data sets from moorings that stay in the water for extended periods of time. "We're trying to see whether all of the different data sets tell a consistent story, and what story the model tells us about unobserved parts," Heimbach says. Their team is just beginning to see results.

This ITP was installed in the Beaufort Sea in March 2014 to collect data on complex air-ice-ocean interactions that govern sea ice formation and retreat. Credit: John Kemp/WHOI

Data from profilers aren't just used to model the Arctic Ocean of the future; WHOI researchers and others from around the world use it to understand changing dynamics happening right now. For example, Toole and colleagues recently published studies that used ITP data to examine eddies, and ice flow, internal waves, mixing, and turbulent fluxes underneath sea ice, to name a few. These findings not only tell scientists about the current state of the Arctic Ocean, but also give a boost to modelers such as Heimbach and Nguyen by providing them with highly detailed, small-scale observations they can incorporate into their models.



This figure shows ITP (yellow) and ship/aircraft (red) locations in the Arctic from 2004 to 2014. There were approximately 60,000 profiles obtained with ITPs versus 19,000 by manned ships and aircraft. Credit: Rick Krishfield/WHOI

The road ahead

Although ITPs provide researchers with unprecedented access to the Arctic, the technology has a few drawbacks. Profilers rely on ice to carry them around the Arctic Ocean, but as ice cover shrinks so does the devices' range. "Now that we have thinner ice and less ice, we need extensive measurements in areas that are now in open ocean," Nguyen says, adding, "At the moment, ITP data set offers an incomplete picture because it only takes measurements underneath relatively thick ice." But even those under-ice measurements are limited—important ocean-ice interactions take place within the first few meters of ocean underneath sea ice, but profilers cannot measure water properties there because they could potentially be crushed.

Researchers recover an ITP from the Arctic Ocean. Credit: John Toole/WHOI

However, Toole and WHOI engineers are working to fix some of these issues. Not only are profilers able to float should ice melt, Toole says, but "in fact, we have now deployed several on open water and they have survived fall freeze up and went on to function like conventionally-deployed systems." And, thanks to a growing monitoring network, where ITPs fall short, other technologies such as moorings and satellites are there to fill in the gaps. "Given the dramatic changes that have already occurred this century, including the record maximum ice extent just reported by NSIDC, we must continue to observe the oceans to document what those changes are and their consequences," he says.

More information: "Veering, Internal Waves, and Turbulence Observed under Arctic Sea Ice." *J. Phys. Oceanogr.*, 44, 1306–1328. doi: dx.doi.org/10.1175/JPO-D-12-0191.1

"Characterizing the eddy field in the Arctic Ocean halocline," *J. Geophys. Res. Oceans*, 119, 8800–8817, DOI: 10.1002/2014JC010488

This story is republished courtesy of MIT News (web.mit.edu/newsoffice/), a popular site that covers news about MIT research, innovation and teaching.

Provided by Massachusetts Institute of Technology

Citation: Ice-tethered devices to collect more data on the Arctic Ocean (2015, March 27) retrieved 26 April 2024 from https://phys.org/news/2015-03-ice-tethered-devices-arctic-ocean.html