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New research provides unprecedented look at what influences sea ice motion in the Arctic

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Local tidal currents strongly affect the movement of sea ice in the Arctic ocean and the makeup of the seafloor causes some of the most abrupt changes. Credit: Daniel Watkins.

A new study led by researchers at Brown University offers fresh insights into the forces above and beneath the ocean surface that influence how sea ice moves and disperses in the Arctic Ocean, which is warming at over twice the rate of the global average.

The in-depth analysis reveals how local tidal currents strongly affect the movement of the ice along its journey and provides an unprecedented look at how the makeup of the sea floor is causing some of the most abrupt changes.

Data from the study can be applied to improve complex computer simulations used for forecasting Arctic sea ice conditions, and in the long-term, the results may help clarify how climate change is altering the Arctic and inform future climate predictions.

"The ice is clearly feeling the influence of the bottom of the ocean," said Daniel Watkins, a postdoctoral researcher at Brown and lead author of the new study published in *Geophysical Research Letters*. "The landscape at the ocean floor, like canyons and continental shelves, affects tides and other ocean currents. And as it drifts, the sea ice passes over many different undersea features. We see sharp changes in the dynamics of the sea ice as soon as it gets to those undersea features."

Using data from the largest ever drifting sea-ice buoy array, along with 20 years of satellite images, the researchers examined sea ice motion as it drifted from the Arctic Ocean through a deep-water passage called the Fram Strait and eventually into the Greenland Sea. The analysis revealed the sea floor's impact on some of the most abrupt changes affecting the sea ice, like dramatic gains in speed or motions that force the ice to pack in close together or even break apart.

"What we see with this data set is a transition from the central Arctic, where the ice is mostly moving as a whole and following wind patterns, to areas where we're seeing much stronger impacts of ocean currents," Watkins said.

The Arctic is the fastest warming part of the globe and it has long been understood that sea ice in the region plays an important role in the planet's climate. For instance, the ice acts like a reflective surface deflecting how much sunlight is absorbed by Earth. As it disappears, more sunlight is absorbed, leading to a warmer planet. Many scientists also expect that as Arctic ice vanishes, weather across the Northern Hemisphere will be impacted, producing periods of bitter cold, punishing heat waves and disastrous floods.

With the study, the researchers wanted to delve deeper into the changes happening in this critically important part of Earth. Much of the data for the study was gathered during the largest polar expedition in history—the Multidisciplinary drifting Observatory for the Study of Arctic Climate.

Comprehensive research reveals sudden increases in ice speed

During the expedition, teams of researchers took turns spending a year drifting with the sea ice aboard a massive German icebreaker in the Arctic Ocean. Watkins was there for two weeks in October 2019 to help install a network of autonomous sensors around the base camp. While there, Watkins coordinated helicopter flights to remote patches of sea ice, worked with analysts to find suitable sites for instruments and buoys, and deployed them on the ice.

Throughout the year-long expedition, 214 buoys were deployed, including 51 during Watkins' tenure on the expedition. The study is based on GPS data transmitted from a set of 108 of the buoys that drifted from the central Arctic through the Fram Strait and into the Greenland Sea.

The major focus was on what are known as marginal ice zones in the Greenland Sea and Fram Strait, which is the transition zone between the open, ice-free ocean and the pack ice of the central Arctic.

As part of their analysis, the group also analyzed satellite measurements taken from 2003 to 2020 to put the data the buoys gathered over the year adrift into historical context. The satellite data helped confirm sharp changes in ice velocity and ice motion that could only be explained by the sea floor's influence on the sea ice.

For instance, looking at the data from an area northeast of Svalbard, Norway, the researchers noticed the speed of the ice suddenly increased even though the wind hadn't changed. That meant the ice was getting pushed by the ocean currents, so the team delved deeper to find where this happens and how.

They found that the sea ice speeds up where the Transpolar Drift Stream, one of the Arctic's Ocean major currents, ends and the fast-moving East Greenland Current, which forms due to a combination of Earth's rotation and the edge of the continental shelf on the sea floor, begins. The analysis shows how the sea ice responds to different ocean currents and that the sea floor plays a role.

"In the beginning of this journey, there was almost no difference in the drift speed across the whole set of buoys," Watkins said. "Then there's essentially one day where the wind died down and the ice ran into that boundary current and it just took off. It was like a one-day-to-the-next change in what was pushing the ice."

As next steps, the researchers plan to work with model developers to help implement the data from the study into forecasts of how the ice will move and where it will end up. They also plan to further develop an ice floe tracking tool to track the motion of individual pieces of ice. The tool would help researchers see details of ice motion that are invisible to standard approaches.

"We're hoping to understand the changing ice physics in a warming

Arctic and use it to help make our models of those physics better," Watkins said.

Along with Watkins, other researchers involved with the study included Monica Martinez Wilhelmus, an assistant professor of engineering and a senior author on the study, as well as Angela C. Bliss from NASA's Goddard Space Flight Center and Jennifer K. Hutchings from Oregon State University.

More information: Daniel M. Watkins et al, Evidence of Abrupt Transitions Between Sea Ice Dynamical Regimes in the East Greenland Marginal Ice Zone, *Geophysical Research Letters* (2023). DOI: 10.1029/2023GL103558

Provided by Brown University

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