Cold Calculus: Modeling Heat Exchange in the Arctic

A new model captures the flow of heat from ocean water into floating ice, providing an important input for efforts to predict future melting in the Arctic.

By Michael Schirber

Arctic ice is shrinking at a rate of 12% per decade, according to satellite data. “The evolving Arctic sea ice cover is an eye-catching indicator of a changing climate,” says Srikanth Toppaladoddi of the University of Leeds, UK. One of the main drivers of this melting is heat rising from the ocean below, but measuring this heat flux is difficult, Toppaladoddi says. Now he and Andrew Wells from the University of Oxford have modeled the heat flow and how much it varies, offering an important input for predicting the fate of the Arctic ice cover [**1**].

The upper layers of the Arctic Ocean are heated each summer when sunlight shines through open-water gaps in the ice. Some of this stored energy is released into the ice, offsetting some of the refreezing that occurs during the cold months. Previous models of this heat exchange have only been able to estimate the mean flux. Toppaladoddi and Wells have applied statistical methods to capture the mean as well as the fluctuations.

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The researchers started with a simplified model of the temperature and velocity fluctuations in the water below the ice, based on observations made with underwater probes. By incorporating this model into a theory of turbulent flows, they were able to determine the heat flowing into the ice from the water below. This heat flux varies, averaging around 15 watts per square meter (W/m^2) in summer months, but on rare occasions jumping to over 500 W/m^2. In addition to quantifying these statistics, the researchers showed that water movements are mostly independent of water temperature gradients—a fact that could simplify computational efforts to predict the future evolution of the ice cover.

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REFERENCES

1. S. Toppaladoddi and A. J. Wells, “Stochastic model for the turbulent ocean heat flux under Arctic sea ice,” **Phys. Rev. E 111, 025101 (2025).**