

Eos

A Nearly 100-Year-Old Physics Model Replicates Modern Arctic Ice Melt

The model was previously used to describe the behavior of ferromagnets in the presence of external magnetic fields.

By Rachel Crowell

2 August 2019



The team simulated patterns of Arctic melt ponds and sea ice. Credit: Kenneth Golden

It might seem bizarre to modify a physics model originally used to study the behavior of ferromagnets to explore patterns of melt ponds on Arctic sea ice. However, this approach makes intuitive sense to [Kenneth Golden](#), a mathematician at the University of Utah in Salt Lake City.

Golden said that he and his collaborators have been “really surprised with the response” to their [New Journal of Physics study](#) published on 21 June. Their study modifies the almost 100-year-old Ising model, which researchers have already adjusted to study diverse topics, including [trees in pistachio orchards](#), [urban segregation](#), [language change](#), [economic opinions](#), and more. He wasn’t expecting the flurry of interest and coverage for research connected to such a widely studied model. In particular, he has been asked many variations on one question: How did he first realize the connection between the patterns of melt ponds on the Arctic sea ice and the Ising model?

Making the Connection

Golden’s fascination with sea ice dates back to when he was in high school. During his senior year, he used mathematics and satellite imagery to study arctic sea ice with [Jay Zwally](#), now chief cryospheric scientist at NASA’s Goddard Space Flight Center in Greenbelt, Md. Golden’s varied [research interests](#) in “sea ice, the climate system, composite materials, statistical physics,” and more have taken him on 7 trips to Antarctica and 11 trips to the Arctic.

So it’s unsurprising that his mathematical physics research intersects with the study of melt ponds on Arctic sea ice. However, Golden said the actual connection described in the paper between “the melting sea ice and the resulting patterns of light and dark regions on its surface” and the Ising model came to him as a bit of an epiphany while he was walking on sea ice and coming across alternating patches of water and ice.

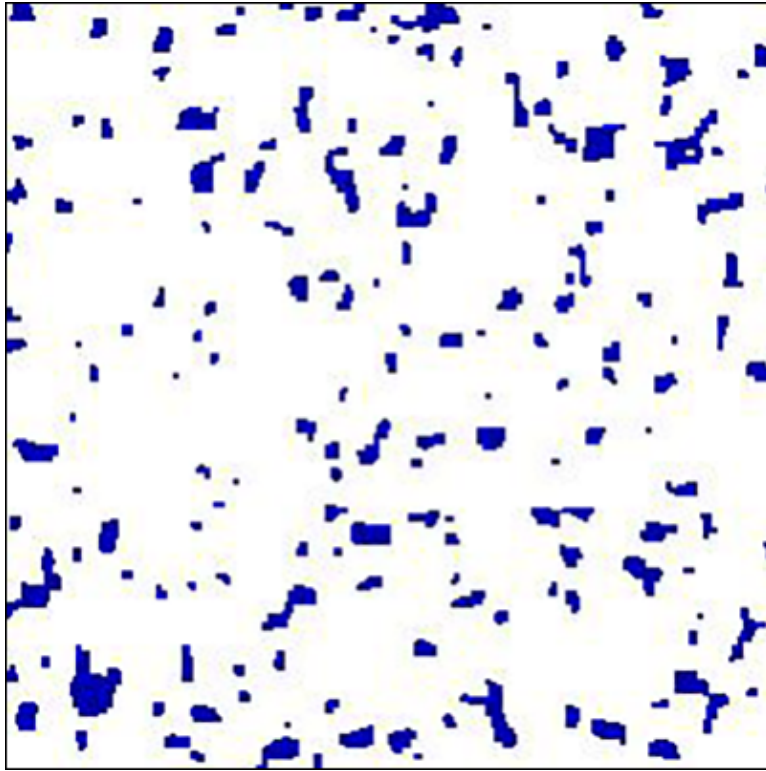
“

“It really struck me that ‘oh my god, these melt ponds look like islands of spin.’”

“When I finally started looking...It really struck me that ‘oh my god, these melt ponds look like islands of spin,’” a realization that helped him connect what he was seeing to the Ising model.

In the Ising model, researchers imagine an infinite, two-dimensional lattice, Golden said. Atoms or molecules, each with a spin variable, are found at every vertex in the lattice. Researchers can calculate how much energy is required for the spin of each atom to align or antialign with that of an external magnetic field, he said. In principle, each atom’s spin can also be influenced by interactions with all other atoms in the lattice.

However, the “brilliant assumption of the model” is that researchers can instead focus only on the influence that each atom’s four nearest neighbors have on any given atom’s spin, Golden said. Using this assumption, researchers study what happens when the system has different thermal energies, which sometimes drive atoms toward a tendency to align their spins with their neighbors, creating “islands of spin.”



A simulation of Arctic melt pond formation. Blue areas represent melted sea ice, whereas white areas represent frozen sea ice. Credit: Yi-Ping Ma [CC-BY-3.0](#)

eye,” Golden said.

“It was really an intriguing study” using a “powerful tool” that could have applications in other climate models, said [Donald Perovich](#), a sea ice geophysicist at Dartmouth College in New Hampshire who wasn’t involved with the study.

—Rachel Crowell ([@writesRCrowell](#)), Science Journalist

Citation:

Crowell, R. (2019), A nearly 100-year-old physics model replicates modern Arctic ice melt, *Eos*, 100, <https://doi.org/10.1029/2019EO129555>. Published on 02 August 2019.

Text © 2019. The authors. [CC BY-NC-ND 3.0](#)

Except where otherwise noted, images are subject to copyright. Any reuse without express permission from the copyright owner is prohibited.

When applying the model to simulating patterns of Arctic sea ice and melt ponds, Golden and his colleagues “envision a square lattice of surface patches or *pixels* of melt water or ice, corresponding to the classical spin up or spin down states, respectively. They are collectively influenced by an external forcing field, and interact only with their nearest neighbors,” they wrote in the paper.

The researchers were able to study the energy of the melting sea ice system. “Pond-like configurations, or connected regions of ‘up spins,’ result from a series of energy reducing updates of an initially random state,” they wrote. They were also able to estimate how much time it takes for spin to flip within the system, leading to freezing or melting surface patches.

However, they “are not using the present model to directly describe the time evolution of ponds over the melt season,” they noted. The results of their simulations “really look like melt ponds— strikingly so—to my

