Electronics help predict global warming

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Earth's vast polar ice caps reflect sunlight, keeping the planet cool. As they melt, global warming accelerates. The Intergovernmental Panel on Climate Change predicts that the ice-packed caps may disappear between 2050 and 2100, but the panel admits that its prediction of the year they completely melt is only a guess. Now, by making detailed measurements of the polar ice's permeability, using models originally conceived for solid-state semiconductors, scientists are refining global warming predictions. University of Utah mathematician Ken Golden is currently on an Australian research ship in the Antarctic, pioneering the electronic modeling of ice permeability.

"Here in the Antarctic sea ice pack, we are doing experiments on the permeability of sea ice," Golden said. "We are doing DC resistivity measurements to obtain conductivity profiles of the ice, and we saw a dramatic illustration of the percolation threshold yesterday."

The percolation threshold of ice is being modeled by Golden, using the solid-state semiconductor mathematical model of effective conductivity in a random resistor network. There the threshold value determines the time at which a transition occurs toward rapidly increasing conductivity. In the ice pack version of the model, the percolation threshold determines the time at which the transition to rapidly increasing global temperatures occurs.

"Now that we have a much firmer understanding of how permeability depends on the variables of sea ice, namely temperature and salinity, our results can help to provide more realistic representations of sea ice in global climate models, helping to hone the predictions for world climate and the effects of warming," Golden said.

When Golden recently presented his claims to the American Geophysical Union, the AGU responded by calling Golden's work "a unified theory of sea ice permeability and its effect on global warming."

White sea ice ordinarily reflects sunlight at the poles, but the open water now there is absorbing light instead. The question is when the point will be reached at which global warming accelerates dramatically. Every spring, melting sea ice creates ponds that absorb sunlight. The drainage of these spring melt ponds is controlled by the permeability of the ice that Golden is modeling with the help of solid-state electronics models.

"A broad range of problems in the physics of materials involve disordered media whose effective behavior depends critically on their connectedness, or percolation properties," Golden noted. "Examples include doped semiconductors, thin metal films, smart materials such as piezoresistors and thermistors, radar absorbing composites, cermets, and porous media. We use the random resistor network, which was introduced in the late 1960's as a model for impure semiconductors."

Effective conductivity in a random resistor network depends on the threshold value where the transition to rapidly increasing conductivity occurs, including an exponent describing how fast the transition occurs. This formula, Golden explained, also describes the permeability of sea ice as a function of brine volume near the percolation threshold. Golden has measured the exponent describing how fast the transition occurs and found it to be 2, also the universal lattice value for semiconductors.

"We have also exploited the similarities between sea ice microstructure and the microstructure of some radar absorbing composites to predict the threshold value," Golden said. "We have also used ideas of critical path analysis developed originally to study hopping conduction in impure semiconductors to estimate the scaling factor for the permeability of sea ice."

Golden claimed that similar porous materials exist throughout the universe, including ice on other worlds, such as Jupiter's icy, ocean-covered moon, Europa. Golden performed his work with Jingyi Zhu, an associate professor of mathematics, as well as with colleagues at the University of Alaska in Fairbanks and University of Utah chemistry graduate student Amy Heaton.

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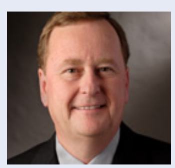

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