THE UNIVERSITY OF CHICAGO

COMPUTATIONAL AND APPLIED MATHEMATICS STUDENT SEMINAR

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Drainage Through Holes Drives Arctic Sea Ice Melt Ponds to the Critical Percolation Threshold

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Jones 226, 5747 South Ellis Avenue

ABSTRACT

During the summer, vast regions of the Arctic sea ice are covered by meltwater ponds that significantly lower the ice reflectivity and accelerate melting. Despite their importance, melt ponds are still not well-understood. Ponds develop over the summer melt season through an initial stage of rapid growth followed by drainage through macroscopic holes. Recently, we showed that ponds after drainage resemble percolation clusters near a critical percolation threshold. Understanding the physical mechanism behind this previously-unrecognized constraint on pond evolution provides an unprecedented opportunity to improve representation of ponds in large-scale climate models. Here, we show that organization towards the percolation threshold is a consequence of pond drainage through macroscopic holes. The threshold, a tractable statistical property of ice topography, sets the upper limit and scales the pond coverage throughout its evolution after the beginning of drainage. Furthermore, we show that, after rescaling, pond coverage fraction as a function of number of open holes follows a universal curve. This curve governs pond evolution during and after pond drainage, which allows us to formulate an equation for pond coverage evolution that captures the dependence on physical properties of the ice. Our work reveals some of the fundamental properties of melt pond physics. As such, it can be used in large-scale models to create a reliable albedo parameterization and improve predictions of Arctic sea ice's response to warming.

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