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**Arctic sea ice melt pond fractal dimension - explained**

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As Arctic sea ice starts to melt in the summer, pools of melt water quickly form on its surface, significantly changing its albedo, and impacting its subsequent evolution. These melt ponds often form complex geometric shapes. One characteristic of their shape, the fractal dimension of the pond boundaries, D, when plotted as a function of pond size, has been shown to transition between the two fundamental limits of D = 1 and D = 2 at some critical pond size. Here, we provide an explanation for this behavior. First, using aerial photographs, we show how this fractal transition curve changes with time, and show that there is a qualitative difference in the pond shape as ice transitions from impermeable to permeable. Namely, while ice is impermeable, maximum fractal dimension is less than 2, whereas after it becomes permeable, maximum fractal dimension becomes very close to 2. We then show how the fractal dimension of a collection of overlapping circles placed randomly on a plane also transitions from D = 1 to D = 2 at a size equal to the average size of a single circle. We, therefore, conclude that this transition is a simple geometric consequence of regular shapes connecting. The one physical parameter that can be extracted from the fractal transition curve is the length scale at which transition occurs. We provide a possible explanation for this length scale by noting that the flexural wavelength of the ice poses a fundamental limit on the size of melt ponds on permeable ice. If this is true, melt ponds could be used as a proxy for ice thickness.