

Backscatter Identification of the Full Frost Flower Coverage Condition

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Abstract

Observations from spaceborne SAR show a backscatter enhancement from 2 to more than 10 dB for young lead ice in the Arctic. Such an enhancement has been associated with the growth of frost flowers and the capture of blowing snow by the flowers on the sea ice surface. However, it is not known from these observations, even approximately, the level of backscatter increase that can be used to indicate the full growth of frost flowers corresponding to the full areal coverage of the flowers. We carried out a laboratory experiment on the response of C-band radar backscatter to frost flowers growing on the surface of newly-formed saline ice. The experiment took place in a 5 m by 7 m by 1.2 m deep saline water pool located in a two-story indoor refrigerated facility at the Cold Regions Research and Engineering Laboratory. Sodium chloride ice was grown in this pool at an air temperature of 28°C. The frost flowers first appeared on the ice surface as dendrites, then changed to needles as the ice sheet grew thicker and the surface temperatures became colder. The frost flowers reached a height of 1.0-1.5 mm, and beneath each cluster of frost flowers, a slush layer formed to a thickness of approximately 4 mm. Far-field radar measurements of the backscatter from the ice were made at incident angles from 20° to 40°, and at approximately 6-hour intervals throughout the 3-day period of the experiment. A backscatter minimum occurred early in the flower growth at the time coincident with an abrupt doubling in the ice surface salinity. Once the full flower coverage was achieved, we removed first the crystal flowers, then the slush layer from the ice surface. The results for these cases show that the crystals have little impact on the backscatter, while the underlying slush patches yield a backscatter increase of 3-5 dB over that of bare ice. The laboratory results suggest that this relative backscatter increase of approximately 5 dB can be used as an index to mark the full areal coverage of frost flowers.