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Spatial and Temporal Variations in RADARSAT Backscatter from Subarctic Lake Ice (Churchill, Manitoba)

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EXTENDED ABSTRACT

Lakes are important components of many ecosystems, including northern boreal and tundra environments, where lakes and standing water occupy a significant fraction (~25%) of the total land cover (Goodison *et al.* 1999). Lakes influence local energy and water exchanges, and the freezing and thawing of lake ice has important consequences for physical, chemical, biological, and hydrological processes (Heron and Woo 1994; Vincent *et al.* 1998). Lake ice break-up date, in particular, has shown to be a good proxy indicator for local–regional climate variability and change investigations. According to Morris *et al.* (1995), shallow lakes represent promising sites for long-term monitoring and the detection of changes related to global warming and its effects on the polar regions.

In this study, a time-series of winter (1997–1998) RADARSAT C-HH Standard Beam Mode images of the Churchill, Manitoba, region was acquired. Measurements on snow and ice cover characteristics made during three field campaigns (February, March, and May 1998), which coincided with RADARSAT overflight dates, were used in the interpretation of changes in backscatter as a function of time and incidence angle (S1 to S7).

Results from this very first investigation on the use of multi-incidence angle spaceborne SAR imagery for monitoring lake ice conditions from shallow lakes can be summarized as follows:

1. As reported in other ice cover investigations from shallow arctic/subarctic lakes using ERS-1 C-VV data (Jeffries *et al.* 1994; Morris *et al.* 1995; Duguay and Lafleur 1997; Duguay *et al.* 1999), RADARSAT data also showed a strong dependence in backscatter intensity with time related to ice growth and decay processes, including the development of tubular bubbles and bottom freezing.
2. Backscatter intensity in RADARSAT images varied considerably with incidence angle for ice with few air inclusions. Differences of as much as 6.5 dB were noted for the same ice cover when observed at smaller (20°–35°) compared to larger (35°–49°) incidence angles.
3. During the early stages of ice growth and when the ice volume contained a small amount of tubular bubbles, backscatter intensity from the floating ice measured at larger incidence angles (S4-S7 beam positions) was similar to that observed from the grounded ice (–12 to –16 dB) at any incidence angle (S1-S7).
4. During spring thaw, the strong decrease in backscatter could be explained by the microwave signal being absorbed by the wet snow cover and by specular reflection from the standing water (ponds) on the lake ice surface. Significant differences in backscatter intensity were also observed between small and large incidence angles during the thaw period.

In conclusion, due to its frequent revisit cycle (every 1–2 days at high latitude sites using all available beam modes), the RADARSAT Standard Beam Mode configuration offers an improved temporal coverage over ERS-1/2, thus making it possible to determine more precisely freeze-up and break-up dates, and timing of bottom freezing. However, due to large differences in backscatter with

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incidence angle under certain ice conditions, the revisit time may best be once every 5 days to a week instead of once every 1–2 days. This would reduce the possible confusion between floating ice with few air inclusions and grounded ice, both of which showed similar backscatter values.

Key words: Lake ice, RADARSAT, incidence angle, subarctic tundra and forest.

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