Great Lakes Ice Cover Mapping with Satellite Scatterometer Data

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In this paper, we present the potential use of satellite scatterometry for applications to Great Lakes ice cover mapping. Ice cover mapping over the Great Lakes is a regional-scale problem that requires a satellite sensor with a large swath to provide data with large and frequent coverages. We first present the scattering physics that is employed to develop a technique for lake ice identification with dual-polarized Ku-band scatterometer measurements. To demonstrate the use of scatterometry for lake ice mapping, we use data collected by the spaceborne NASA Scatterometer (NSCAT) over the Great Lakes in conjunction with surface observations obtained during our 1997 field experimental campaign. NSCAT was operated at approximately 14 GHz on the Advanced Earth Observing Satellite (ADEOS) from June 1996 to July 1997 covering the entire ice season over the Great Lakes. NSCAT had double-sided swaths, each with a coverage of 600 km spanning a range of incidence angles within 10° to 70°. There were 3 beams with the vertical polarization and 1 beam with the horizontal polarization on each side. The relative accuracy of backscatter measurements was estimated at about 0.3 dB. We use the subswath with incidence angles larger than 40° in center dual polarized beams for Great Lakes ice mapping. The 1997 field experimental campaign was a collaboration between the Jet Propulsion Laboratory and the Great Lakes Environmental Research Laboratory with ship, helicopter, and ground support by the U.S. Coast Guard to collect data for development and validation of lake ice mapping with satellite radar data. During the field campaign in February and March, we measured physical and environmental data for various ice types from USCG Mackinaw and Biscayne Bay icebreakers, while NSCAT concurrently collected data over the Great Lakes. In addition, ice charts produced at the U.S. National Ice Center (NIC) for the same time period were also selected for comparisons. The results from NSCAT lake ice mapping are in good agreements with field observations and NIC ice charts. NSCAT mapping results show that western Lake Superior was frozen up while the eastern part was still open water, and that Lake Erie (at lower latitude) was mostly frozen solid while the upper lakes were only partially ice covered. This ice coverage behavior is related to the lake bathymetry. Such ice cover trend profoundly impacts the heat fluxes (both sensible and latent) between lake water and the atmosphere, and thus influences the local and regional climate patterns. The current limitation of the scatterometry is its low resolution, which needs to be improved in the future generation of advanced spaceborne scatterometers. We also discuss the study of an ultra wideswath high resolution scatterometer appropriate to Great Lakes ice mapping.