ANALYSIS OF C-BAND POLARIMETRIC RADAR BACKSCATTER FROM MELT POND COVERED FIRST-YEAR SEA ICE

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1. INTRODUCTION

Understanding regional changes in Arctic sea ice, in particular during summer, has imposed the need for enhanced sea ice monitoring techniques using high-resolution remote sensing data. During summer melt, the formation of melt ponds on the sea ice surface enhances the absorption of shortwave energy into the ice-ocean system, accelerates seasonal ice decay, and leads to a decrease ice volume in successive years [1]-[2]. The development of a robust methodology for identifying spatio-temporal variations in the fractional coverage of melt ponds will aid in determining linkages with other competing interactions that lead to regional changes in sea ice extent and volume during the critical summer melt period.

While passive microwave radiometers (e.g., AMSR-E) and radar scatterometers (e.g., QuikSCAT) provide daily, coarse-scale Arctic sea ice information throughout most of the year, melt ponds during summer present a significant source of error for conventional extraction algorithms [3]. Data from optical sensors (e.g. MODIS and AVHRR), which provide information on ice concentration and the ice surface energy balance, are limited by the ubiquity (up to 80%) of cloud cover during summer [4]. Synthetic aperture radar (SAR) data enable monitoring local and regional sea ice conditions irrespective of daylight or cloud cover, and at metre-scale spatial resolution – making it an attractive tool for observing polar oceans. The advent of spaceborne polarimetric SAR from recently launched sensors TerraSAR-X and RADARSAT-2 has further expanded the scientific potential of SAR through the addition of several dimensions of data available for exploitation from a single scene.

This paper reports C-band (5.3 GHz) radar scattering signatures and derived polarimetric discriminants collected using a portable, surface-based, fully-polarimetric, FM-CW radar scatterometer deployed over melt pond covered first-year sea ice in the Canadian Arctic [5]. Scattering signatures of surface features are used to demonstrate the potential of wide swath SAR data for the inversion of melt pond fraction and the proxy estimation of climatological albedo from Arctic first-year sea ice. The optimal combination of polarimetric discriminants and radar parameters for achieving this technique using fully polarimetric C-band SAR data, e.g. from the recently launched RADARSAT-2, is outlined.

2. METHODS

Data were acquired during the POL-ICE – a joint Canada-Finland remote sensing program focused on improving the extraction of sea ice information from multipolarization SAR – field campaign near Resolute Bay, NU in June-July 2006 and during the Circumpolar Flaw Lead System Study (CFL) – a Canadian Government funded IPY project devoted to understanding climate change in the Arctic – field study in the Beaufort Sea in May-June 2008. The radar scatterometer was deployed at various locations on the ice, and fine-resolution polarimetric backscatter measurements were made of melt ponds, sea ice, and composite surfaces over incidence angles ranging from 20° to 60°. Ice and melt pond property data were acquired during the same period, including salinity, thickness, and qualitative assessments of ice structure.

Scatterometer samples were processed to yield angular response functions for copolarized and cross-polarized backscatter (σ^o_{vv}, σ^o_{hh}, and σ^o_{hv}) as well as phase information. Second-order polarimetric discriminants were derived for each sample, including: copolarized ratio (r_{co}), depolarization ratio (r_{depol}), copolarized correlation coefficient (ρ_{vvhh}), and copolarized phase difference (φ_{vvhh}).

3. RESULTS TO DATE

During some wind events, the wind induced surface roughness of melt pond waves can lead to indistinguishable copolarized and cross-polarized backscattering signatures from that of the decaying first-year sea ice. When this occurs, the r_{co} is useful for discriminating high dielectric melt ponds from the sea ice at medium to high incidence angles (>35º). This behavior agrees with modeling predictions which show that the separation between polarizations is greater for melt ponds than ice due to the Brewster angle. Changes in φ_{vvhh} with incidence angle show that decaying first-year sea ice behaves as expected from an isotropic scatterer (i.e. φ_{vvhh} close to zero), while melt ponds transition from single bounce to double bounce scattering (i.e. φ_{vvhh} rapidly increased with incidence angle) when waves are present on the surface.

4. REFERENCES

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