Proceedings of the Eighth (1998) International Offshore and Polar Engineering Conference
Montréal, Canada, May 24-29, 1998

ISBN 1-880653-34-6 (Set); ISBN 1-880653-37-0 (Vol. III)

Extraction of Sea Ice Parameters from Satellite Radar Images

Mohammed E. Shokr
Atmospheric Environment Service
North York, Canada

ABSTRACT

Sea ice parameters operate at different spatial scales ranging from millimetres to hundreds of kilometres. The Synthetic Aperture Radar (SAR) aboard the operational satellites ERS and RADARSAT has been successful in capturing some of those parameters, with limitations linked to their spatial scale. In this study, results from *in-situ* measurements of ice physical properties are used with coincident SAR images to evaluate the utility of the images in retrieving ice parameters. The parameters are grouped into the following scale-based categories: sub-pixel, intermediate, and mesoscale. The sub-pixel scale parameters (e.g. brine volume and brine pockets geometry) are difficult to retrieve from single channel SAR data. The intermediate scale parameters (e.g. ridges and floe definition) can be identified when the incidence angle of the radar beam is relatively large. The mesoscale parameters (e.g. ice types and concentrations) can be retrieved using an empirical approach that links them to the observed backscatter.

Key words: sea ice, SAR, ice monitoring, ice remote sensing

INTRODUCTION

Since the beginning of this decade, the spaceborne Synthetic Aperture Radar (SAR) has been the main source of information for sea ice monitoring. At present, there are two operational satellite platforms with SAR on board: the European ERS and the Canadian RADARSAT. Sea ice information originally envisaged as being retrievable from SAR data encompassed a wide range of parameters which operate at scale levels ranging from a few millimetres to hundreds of kilometres. During four years of experience with ERS-1 SAR images (1992-1995) in the operational ice monitoring program of the Canadian Ice Service (CIS), and through several field validation programs designed to relate observed backscatter to ice and snow parameters, more realistic perception of retrievable parameters has been realized.

The scales of the geophysical processes at which ice parameters operate vary from a few millimetres to hundreds of kilometres. For the purpose of this study, the parameters are grouped into three categories according to their relevant scale. The first is the sub-pixel scale which includes physical and electrical properties as well as surface roughness. The pixel spacing in SAR is typically a few tens of meters. Those parameters are important in determining the thermal and the mechanical behaviour of the ice. Surface roughness is less important from the climatic and marine operations view points, although it is the dominant scatterer in case of saline first year ice (Hallikainen and Winebrenner, 1992). The second is the intermediate scale, between o.1 and 5 km, which includes ice features such as ridges, ice floes, leads and deformed ice zones. Retrieval of those parameters is discussed in Li et al. (1995) and Johannessen et al. (1994). The third is the mesoscale (> 5 km) which includes ice type and concentration, edge location and large-scale leads. Those parameters are particularly important for ship navigation and for thermodynamics of ice/ocean interactions in synoptic scale climate models.

The purpose of this paper is to highlight potentials and limitations of using spaceborne SAR images in retrieving ice parameters within the above spatial scale context. The study includes first-year and younger ice types only. It revolves more around the question of what can be extracted rather than how it can be extracted.

DATA ACQUISITION AND ANALYSIS METHODS

Field Programs

Results from two field programs: Labrador'94, and SIMMS'95 are presented. The first was carried out in early March of 1994, offshore of Cartwright near the Labrador shelf in the Canadian east coast waters (around 54°30'N and 57°15'W location). Ice thickness and concentrations increased with increasing distance from the shore until the main pack was encountered at about 50 km offshore. The SIMMS'95 program was conducted in Lancaster Sound in the Canadian eastern Arctic during the first three weeks of May 1995. The first-year ice in the study area was relatively flat and uniform in thickness (average 1.79 m). Multi-year ice thickness varied from 1.75 m to over 6.0 m. Details of the field program are included in Misurak et al. (1995).

Measured and derived Parameters

The main objective of the field programs was to collect baseline data to characterize the physical, electrical and crystalline structure parameters of first-year ice and relate them to the backscatter observed in ERS-1 SAR images. Ice cores were extracted from selected areas based on their signatures in ERS-1 SAR images. Profiles of measured temperature, salinity, density and the complex dielectric constant (permittivity and loss) were obtained. Temperature was measured immediately after core extraction. Salinity was measured using an optical refractometer and density was measured by weighing slices of known volume. Thin sections