Icebergs in Sea Ice: Detection and Iceberg-Ship Discrimination With RADARSAT-2 Full Polarimetric Data

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ABSTRACT

Information on icebergs and ice islands is important for climate science and for various marine operations in the Arctic and Antarctic. The detection of icebergs in sea ice and discriminating them from ships is required for search and rescue operations, offshore industries and ship navigation. The authors investigated capabilities of polarimetric RADARSAT-2 data acquired in Fine Quad and Fine Quad Wide modes with several iceberg detectors. The detection results were verified with the information extracted from very high and medium resolution electro-optical satellite data including stereo datasets. The false alarm rates produced by detection algorithms were computed using RADARSAT-2 data acquired over first- and multi-year ice with icebergs. The receiver operational characteristics indicated that iceberg detection performance depends on polarimetric information, parameters of detection algorithm and sea ice types. An improvement of detection results for icebergs in pack ice was achieved using combinations of Pauli decomposition components, span and advancing detection algorithm.

The second task was to discriminate the detected icebergs from ships. The selection of a suitable classification technique was based on examining the statistical properties of the training data and analyzing feature dimensionality reduction. The following classification techniques were considered in this research: Decision Tree (DT), Linear Discriminant Analysis (LDA), Quadratic Discriminant Analysis (QDA), Neural Network (NNet), Support Vector Machine (SVM), and K-Nearest Neighbors (KNN). The validated iceberg and ship targets were used in a supervised training approach where features were tested and evaluated as input into the classifiers’ models. Considering that there were 49 features available, a feature selection methodology (exhaustive search) was used to optimize the classification technique based on criteria of performance accuracy and algorithm robustness.

Classification techniques were used to calculate classification error for the selected targets (icebergs and ships) using Leave-one-out cross validation technique. The error was calculated as an average value of classification loss, which is the rate (with maximum 1) of misclassification for targets not used for training. It was observed that for the selected targets the error less than 0.01 (1%) can be achieved using DT, KNN, SVM, QDA and NNet. The minimal error 0.0017 (0.17%) was achieved using SVM and zero error was achieved by combining classifiers using the majority vote rule.