Automatic Iceberg Detection in the Barents Sea for Icebergs in Open Water, Fast Ice and Pack Ice

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/ BACKGROUND AND AIM

Iceberg detection is crucial to achieve safe maritime operations in the Arctic. Spaceborne Synthetic Aperture Radar (SAR) data can provide information about iceberg location independent of weather and light conditions. Marino et al. (2016) introduced an iceberg detector for icebergs in floating sea ice outside Greenland. Together with the Constant False Alarm Rate (CFAR) method for calculating the thresholds the detector showed promising results. However, icebergs are much smaller in the Barents Sea compared to e.g. Greenland, and the detector thus needs to be adapted and tested also for these smaller icebergs, as well as for different backgrounds.

Aim: To develop an automatic iceberg detection algorithm for icebergs in the Barents Sea by applying the DPolRAD-detector and using the Constant False Alarm Rate (CFAR)-method to calculate the optimal threshold. The goal is to make the algorithm universal for any type of environment surrounding the iceberg.

/ STEP 1: DATA AND SOFTWARE

The automatic detection algorithm is performed on Sentinel-1 EW SAR images. They are covering the Barents Sea up to twice per day with a swath-width of 420km and a resolution of ~30m.

Optical images with high resolution are used for better understanding in the learning process of the detection algorithm, and to validate detection results.

The algorithm is written in Python, and Google Earth Engine is used to manually detect icebergs in optical images.

/ STEP 2: MODIFIED DPOLRAD

The DePolarization Ratio Anomaly Detector (DPolRAD) is used to enhance bright pixels and reduce background clutter by extracting useful information from both co- and cross-polarization channels:

\[ I = \frac{|HV|^2_{\text{test}} - |HV|^2_{\text{train}}}{|HH|^2_{\text{train}}} \]

The \( I \) means using a boxcar filter over a smaller test area and \( I \) means using a Gaussian filter over a larger background/train area.

The map to the left shows the result of applying \( I \) to the HH and HV polarizations from the image in Step 1. In addition to removing land it is here also removed glaciers that are apparent over both sea/ice and land.

/ STEP 3: BLOB DETECTION

To reduce computation time we first select plausible iceberg pixels by using blob detection. A blob is a region/connection of pixels that cover the approximate same properties. The blob-detection is performed using a Laplacian of Gaussian method, which is simply taking the gradient of a Gaussian filter on the image.

Because only blob-detected pixels will be included in the final detection, it is important that the blob-detector retrieves as many true iceberg-pixels as possible. Thus, the blob-detector has been tested for different thresholds and standard deviations to get the optimal result.

/ STEP 4: CFAR

The threshold for detection, \( T \), is calculated from a given probability of false alarm, \( P_f \) such that

\[ P_f = 1 - \int f(x) dx \]

where \( f(x) \) is the probability density function (PDF) of the local (minor window) background clutter. The threshold is calculated analytically or numerically for every blob-detected pixel.

A good PDF is necessary to get an accurate threshold from CFAR. Here is the histogram of the DPolRAD data in a local window overlayed by the Gamma and Normalized Inverse Gamma (NIG) PDFs.

/ SUMMARY AND FUTURE WORK

• This algorithm combines the DPolRAD filter, blob detection, and CFAR to do iceberg detection.
• With the given parameters, the iceberg detector has a successrate of 37% with respect to the total number of icebergs.
• The result show many false alarms and many missed icebergs which are numbers that need to be reduced!
• At this stage one needs to compromise whether few false alarms or few missed icebergs are more important.
• Need to check also for icebergs in open water and pack ice.

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More questions? Email: ingsoldal@nersc.no