Quantification and Analysis of Icebergs Distribution around Greenland using Sentinel SAR images

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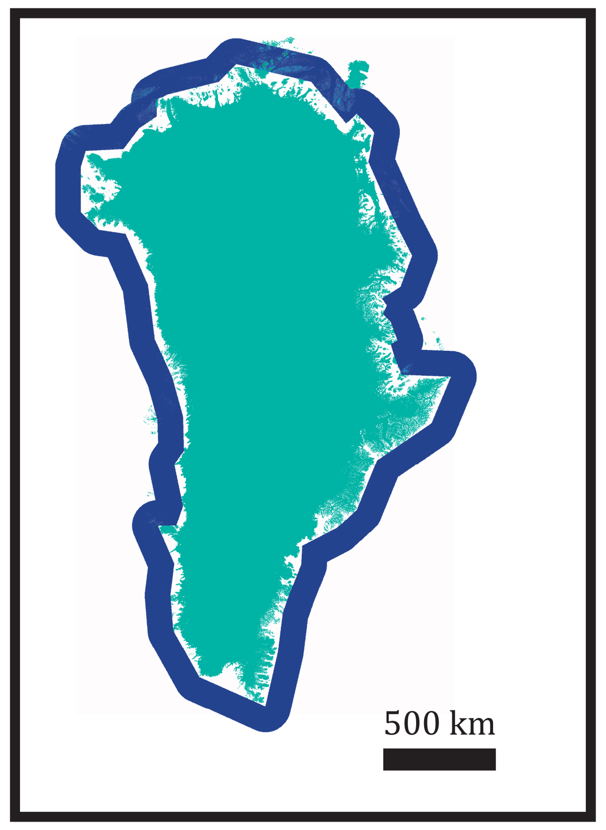
Introduction

Icebergs transport freshwater from the Greenland Ice Sheet to the surrounding fjords and ocean basins at rates that are poorly quantified.

The rate of iceberg production is largely modulated by ice sheet dynamics, and the rate at which they melt can influence fjord circulation. As a result, when climate models do not include variable iceberg properties, they poorly constrain the atmosphere-ice sheet-ocean relationship.

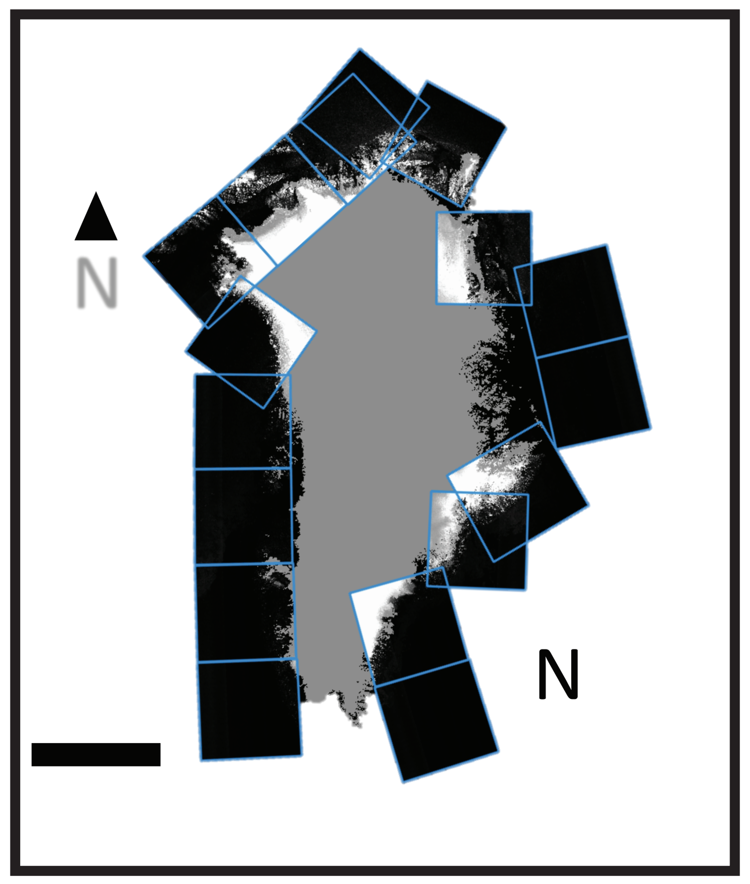


Here, we investigate how iceberg distributions vary both spatially and temporally. We apply a new iceberg detection algorithm to satellite radar imagery within 100 km of the Greenland coastline (Figure 1).
Results can then be incorporated into coupled ice sheet-climate models.

Figure 1: Map of Greenland with a 100 km buffer region around the coastline.

Dataset and Initial Processing

For this study we use Sentinel Synthetic Aperture Radar (SAR) images which are freely available through the European Spac Agency.



DataSet configuration:

- Satellite: Sentinel-1A
- Sensor Mode: Extra Wide Swath (EW)
- Swath Width: 400km
- Polarization: HH+HV
- Product Type: GRD
- Spatial Resolution: 40 m
- Band: C-band

Figure 2: Mosaic of Greenland Ice Sheet(GrIS) created using Sentinel SAR images.

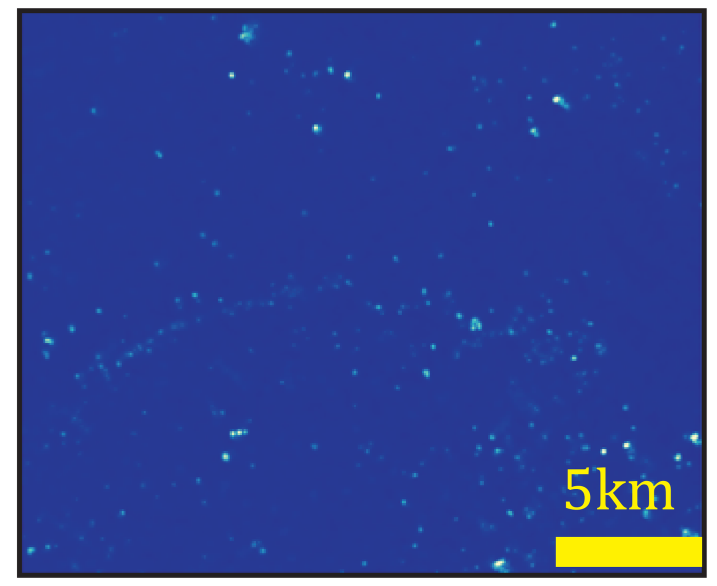
Initial Processing is done on raw Sentinel SAR images using ESA's SNAP toolbox. This initial processing helps to improve the image by removal of thermal noise, speckle filtering and terrain correction. After the initial processing the scenes are mosaicked together(figure 2) and clipped at a 100 km buffer from the coast of Greenland(figure 1).

Algorithm and Initial Results

We modified the Constant False Alarm Rate (CFAR) algorithm to automate the identification of icebergs around the coast of Greenland. The CFAR algorithm isolates icebergs from surrounding open water or sea ice based on brightness threshold (T).

False alarm rate value helps to nullfy the effect of noise in data and thus improves the accuracy of iceberg detection.

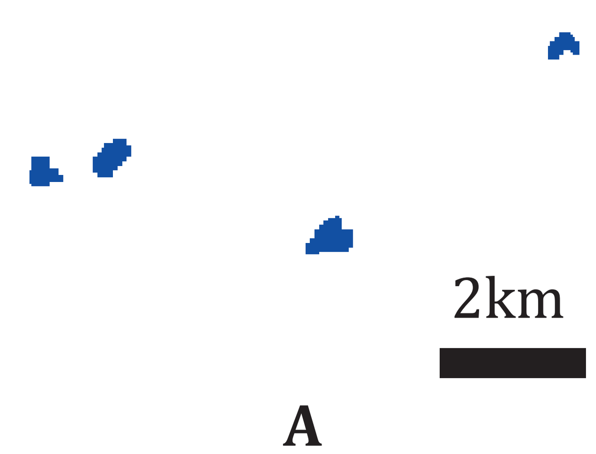
where $T = -\mu \ln\alpha$
α = *false alarm rate (0.001)*
μ = *mean of 2D image array.*

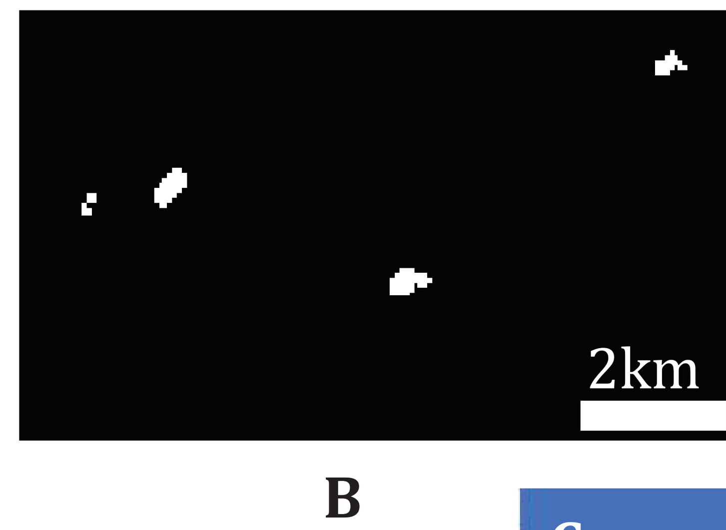


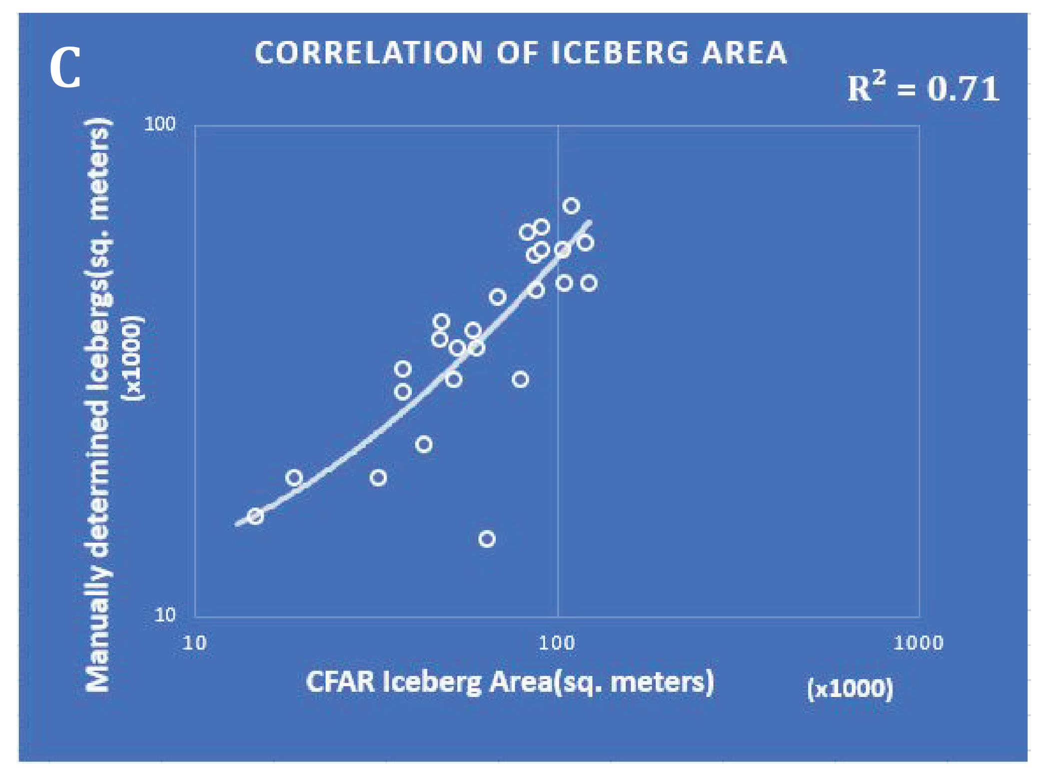
The threshold is compared against each pixel(Pi).

if (Pi > T):
Pi = iceberg pixel
else:
Pi = ocean water

To assess the accuracy of our CFAR technique, we compare the CFAR detected icebergs with a selection of those we manually detected.







Our technique successfully identifies all the icebergs in our test scene and delineates the area with a correlation of $R^2 = 0.71$

Figure 3:A Image with manual trace. B) CFAR detected icebergs. C) Correlation between manually traced icebergs and CFAR detected icebergs.

Conclusion and Future Analysis

The initial results show that:

i) The CFAR algorithm correctly identifies all of the icebergs in our test scenes.
ii) The CFAR algorithm calculates iceberg area with correlation value of 0.71 .

Future Work:

i) Time-series analysis of iceberg distribution.
ii) Changes in iceberg distribution due to characterstics.
iii) Estimate freshwater flux based on the iceberg distribution.

Acknowledgement

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