Danmarks Meteorologiske Institut

DMI Report 22-27
Icebergs and freshwater fluxes from Greenlandic Glaciers

Final scientific report of the 2021 National Centre for Climate Research Work Package WP3.4 Icebergs and freshwater fluxes from Greenlandic glaciers

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1. Scientific summary

Short description of work package

The volume of freshwater (solid and liquid) exported from glaciers to the ocean is important for the global climate system, as an increase in the freshwater content can slow down the large-scale thermohaline circulation and change the mass balance of the glaciers. Thus it has become increasingly important to quantify the amount of icebergs calving into the oceans. The solid part of the freshwater is exported as icebergs calving from the marine terminating glaciers. Because of this, the iceberg distribution around Greenland is directly linked to the glacier surface velocities. Here we present iceberg size and volume distribution from SPOT-6/7 optical images for a case study in the Upernavik Fjord system, West Greenland, in the open water season 2020. A total of 179,355 icebergs were detected of which over 75% were found to be growlers and bergy bits. Our preliminary satellite based results show that at the end of the summer of 2020 there were about twice as much ice (in the form of icebergs) as expected.

The work package

In connection with previous field studies, we have taken pictures (from ship) of a number of icebergs of different sizes and types in the Upernavik area. The icebergs have been photographed from several angles, which enables us to calculate 3D models of the photographed icebergs; i.e. determine their volume above the sea surface. These results have been used to derive a function to calculate similar volumes of icebergs only knowing their horizontal surface areas (as seen from satellite). The full volume (above +below the sea surface) of the icebergs can then be calculated using the density-ratio between “iceberg-ice” and seawater.

By analyzing the velocities of the Inland Ice's outlet glaciers through "flux gates" into the Upernavik Fjord, we have estimated the volume of icebergs calving into the fjord over a fixed period of time (corresponding to the expected iceberg residence time in the fjord); and compared it to our satellite based estimate of the total iceberg volume in the fjord. The ice velocities are from Program for Monitoring of the Greenland Ice Sheet (PROMICE); derived from Sentinel-1 Synthetic Aperture Radar (SAR) satellites imagery.

Our preliminary satellite based results (from SPOT-6/7 high res. imagery) show that at the end of the summer of 2020 there were about twice as much ice (in the form of icebergs) as expected from our calculations. This difference may be due to the fact that the terminal glaciers transport more ice (in the form of icebergs) into the fjord than calculated. However, there is also uncertainty associated with the calculations, which need to be studied in more detail. To achieve a more certain result, the next steps will be to look further into: iceberg volume calculation methodologies, iceberg residence times, fluxgate estimates; and finally include other fjord systems around the Greenlandic coasts (see Figure 1). This figure shows the areas where we have SPOT imagery available in sufficiently high resolution to make similar studies.

Further studies will include similar analyses covering other coastal regions of Greenland (Figure 1). We expect to be able to use these extended studies together with DMI's ongoing iceberg monitoring program, which is based on Sentinel-1 SAR satellite imagery. The advantage of SAR images is that they are independent on sunlight, are insensitive to cloud cover and have more frequent coverage. However, the spatial resolution of the SAR imagery is significantly coarser than the SPOT imagery. Thus in the SAR resolution, smaller icebergs are not detected, but the more frequent coverage allows for a more ongoing monitoring of the iceberg distribution around Greenland. By combining the results from our studies with SAR based iceberg detection, we thus expect to be able to correct the iceberg observations from the SAR images and thus get a better and more accurate ongoing iceberg monitoring.

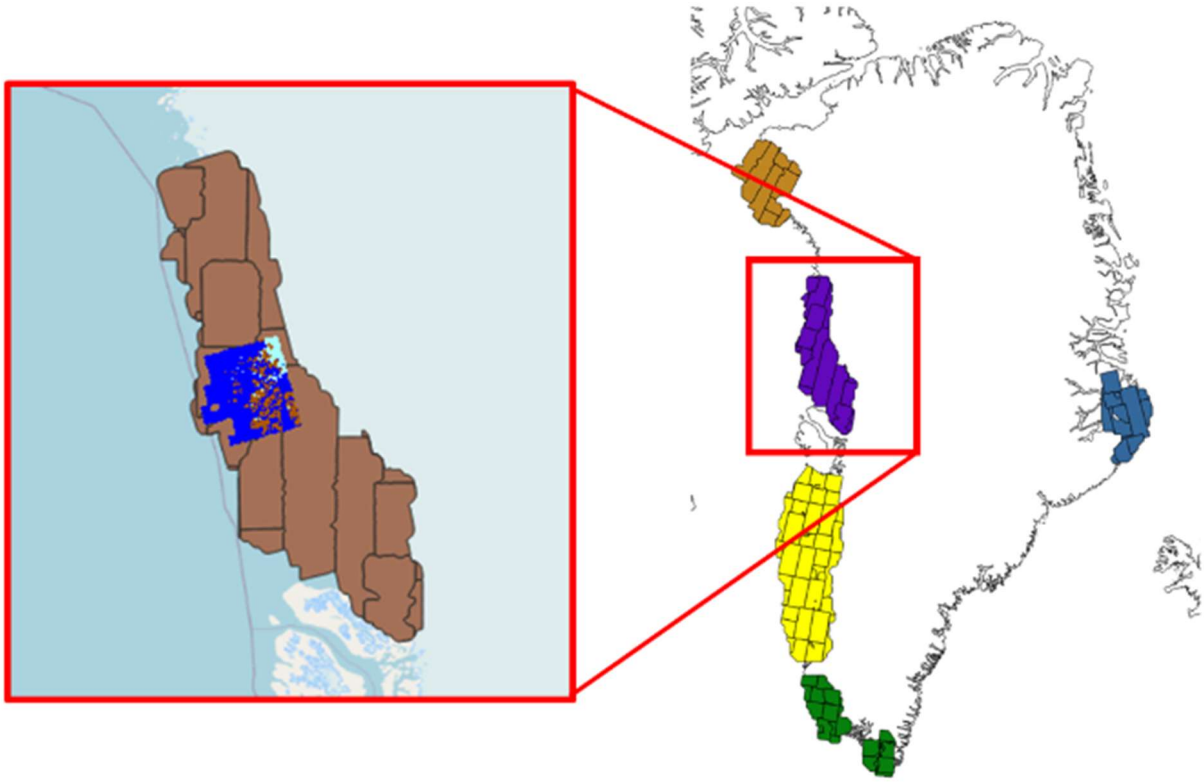

Figure 1. The colored areas show coverage of available SPOT 6- and 7 satellite imagery in 1.6 m spatial resolution. The blue area in the zoomed view shows the coverage (open water only) of SPOT-images applied for Upernavik in this study.

2. Scientific publication

A manuscript is planned for submission in summer 2022.

Linking iceberg detection and ice sheet discharge: A case, study in Upernavik Isfjord, North-West Greenland *(tentative titel)*

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