

Satellite-derived ice velocity maps for the Greenland ice sheet

The Programme for Monitoring of the Greenland Ice Sheet (PROMICE) is now capable of deriving ice velocities for the Greenland ice sheet on a routine basis (Van As *et al.* 2017). An important step forward in ice velocity mapping has been made by the introduction of Sentinel-1 satellite data, yielding an improved PROMICE product of Greenland-wide maps at a high temporal resolution.

The Sentinel-1 satellites have a repeat cycle of twelve days, and due to their constellation, each track has a six-day repeat cycle. We produce a Greenland-wide product that spans two repeat cycles of Sentinel-1A. The product is a mosaic of all the ice velocity maps produced from all the tracks from Sentinel-1A and -1B covering Greenland during those two cycles, and the product thus has a total time span of 24 days. The left hand side of Figure 1

shows the tracks that regularly enter into the product. The two-satellite constellation makes it possible to produce maps every six days. It is, however, computationally very expensive to do this for all of Greenland, and for this reason the PROMICE product mainly consists of 12-day repeats from both satellites.

The high temporal resolution often comes at the expense of many gaps in data as well as a lower signal-to-noise ratio depending on region and season. When the appearance of the surface changes significantly between images for instance due to large snowfall, high melt rates or fast flow, it is no longer possible to track features from one image to the next. In South-East Greenland, all three processes combined make it inherently difficult to get complete coverage. To improve our ice velocity maps, six-day repeats are included for three tracks covering the southern margins of the ice sheet (Figure 1, left). An example of the benefit of including six-day repeats along those tracks

is shown in Figure 1, where the improved coverage is very clear in southeastern Greenland.

The main PROMICE product is thus a velocity mosaic with spatial resolution of 500 x 500 m for the entire Greenland margin. The products span 24 days (two cycles) with a frequency of either 6 or 12 days based on SAR data from Sentinel-1A and -1B. Due to the higher frequency of the maps compared to the temporal coverage, some pairs in one map are also included in the following map. Figure 2 provides examples of the ice velocity product for each month in 2017.

The campaign in winter where the interior is also covered is evident in the December, January and February examples. The example maps from June and July have a clear band with no data on the west coast, which is probably due to melt-induced changes of the surface appearance. It is also clear from Figure 2, that South-East Greenland is the most chal-

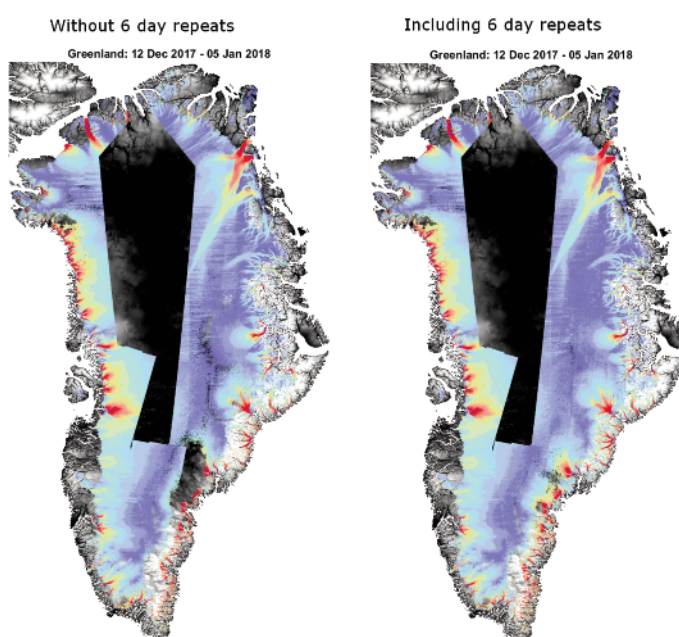
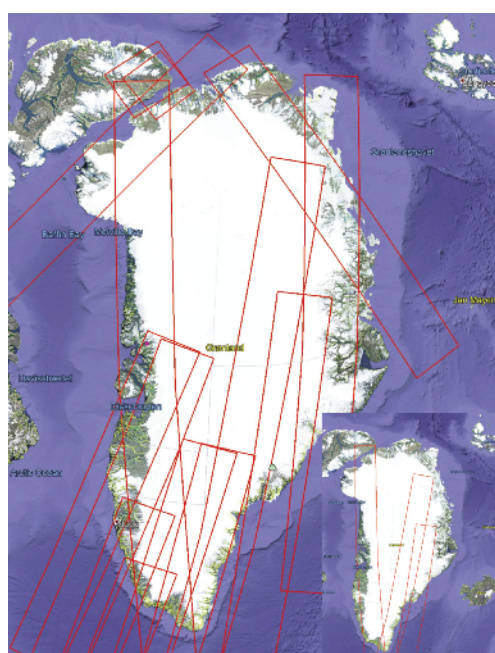


Figure 1: Left: Map showing the regular Sentinel-1 image acquisition coverage over Greenland forming the basis for the PROMICE product. The small inset map shows the tracks where six-day repeats are included in the product. Right: Two maps of ice-velocity showing the impact of including six day repeats along the tracks shown in the inset on the left. The coverage is significantly improved in South-East Greenland.

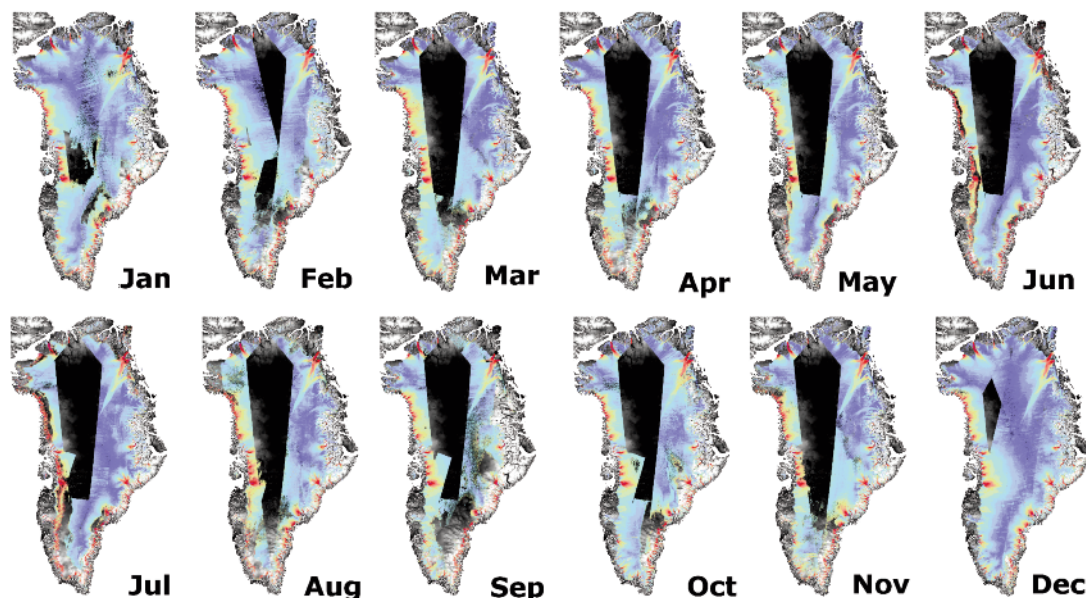


Figure 2: Examples from each month in 2017 of the PROMICE ice velocity product.

lenging place to produce ice-velocities using offset tracking. So far, 13 maps from 2016, 55 maps from 2017 and 3 maps from 2018 are available from promice.org. The primary use of the ice velocity maps in PROMICE is the potential for calculating ice-dynamic mass loss across flux gates for all marine-terminating glaciers in Greenland. However, the processed data included in the 24-day mosaics are also an important source of data, when studying outlet glacier dynamics at a high temporal resolution. This is especially the case for glaciers covered by more than one track, like the outlets of the North-East Greenland ice stream. This was exploited in Rathmann *et al.* (2017), studying the dynamic response of Zachariæ Isbræ and Nioghalvfjerdsfjorden glacier to seasonal surface melt.

For other purposes, the cost of the high temporal resolution is too high in terms of spatial coverage in data, and mosaics spanning longer periods are preferred. In winter, the satellites also acquire images over the interior of the ice sheet, providing full Greenland cov-

erage. Figure 3 shows an example of combining several cycles over winter to produce a map with nearly full coverage.

PROMICE continues to improve and automate the production chain associated with the generation of the ice velocity maps, so that all velocity products can be used on routine basis for e.g. research or educational purposes. All PROMICE data is freely available from promice.org.

References:

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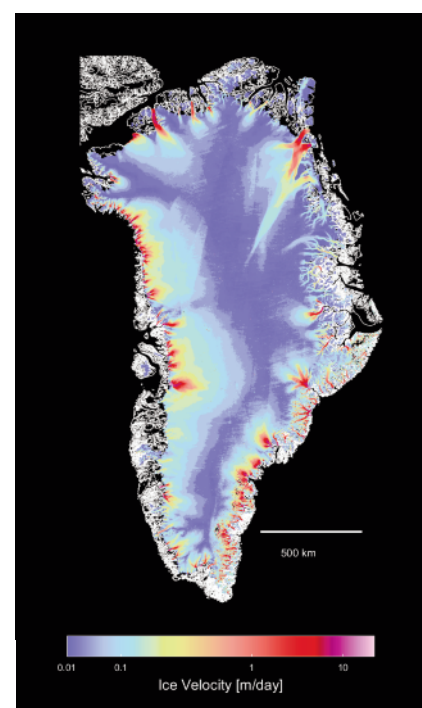


Figure 3: Ice-velocity map for winter 2017–2018 using data from the period: 30 Nov 2017–6 Mar.

Further information

<http://www.promice.dk>

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PROMICE

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- The purpose of PROMICE is to monitor the mass loss of the Greenland ice sheet, both the melting on the surface and the volume of icebergs discharged into the sea

- PROMICE is headed in Denmark by GEUS in cooperation with DTU Space and Asiaq in Greenland. Furthermore the programme collaborates with the Danish Meteorological Institute and foreign universities and authorities.
- Read more about PROMICE on promice.org, where you can find photos and videos, get direct access to measuring data from the ice sheet and the PROMICE outreach material. On the website you can also subscribe to our newsletter.
- Information can also be found on polarportal.org a new website where Danish research institutions display the results of their monitoring of the Greenland ice sheet and the sea ice in the Arctic.



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