climate change initiative

GREENLAND ICE SHEET NEWSLETTER

Issue n. 6 | June 2016

Greenland_Ice_Sheet_cci – New Data Products are released

The Greenland_Ice_Sheet_cci project (2015-2018) has now passed Year 1 of Phase 2.

The project investigates essential climate variables on the Greenland Ice Sheet CCI. This newsletter coincides with new products now available on the CCI data server:

http://products.esa-icesheets-cci.org/

- Ice Velocities from Radarsat-2 and Sentinel 1 (two more years, Greenland-wide; and time series for 9 major ice streams)

- Gravimetric Mass Balance from GRACE (2002-present), both for Greenland as whole and for 8 main drainage basins

- Surface elevation change from CryoSat (2-year and 4-year means)

- Updated data on Calving Front Locations and Grounding Lines for Greenland Glaciers

The Greenland Ice Sheet ECV parameters, produced as part of the ESA CCI project, provide consistent, long term data sets for climate modelling and sea level changes. The data series goes back to the first ERS measurements in 1991, or whenever data available for particular ECV's.

The following Essential Climate Variable (ECV) parameters are computed and updated at regular intervals:

- Surface Elevation Change (SEC),
- Ice Velocity (IV),
- Grounding Line Location (GLL),
- Calving Front Location (CFL),
- Gravimetric Mass Balance (GMB).

GMB is the new parameter in Phase 2.

In this issue:

Surface Elevation Change (SEC) - from Cryosat-2

Twenty years of processed radar altimetry reveals a speed-up of thinning in the coastal areas of Greenland.

In December 2015, the first version of surface elevation changes for Greenland from Cryosat-2 was published on the Greenland CCI website. In the second released version, advantage is taken of the longer time span of operation of Cryosat -2. Data are provided in two-yearly means for the periods 2011-2012 until 2014-2015. A composite trend for the period 2011-2015 is also available. The trends and their associated errors are provided in both ASCII and netCDF formats.

The algorithms used to derive the products are explained in detail in the Algorithm Theoretical Baseline Document v3.0 which can be downloaded from the project website.

In the approach used here, the slope within each grid cell is accounted for by subtraction of the GIMP DEM; the data are corrected for both backscatter and leading edge width; and the LSM is solved at 1 km grid resolution (2 km search radius) and averaged in the post-processing to 5 km grid resolution with an underlying smoothing at the 10 km level.

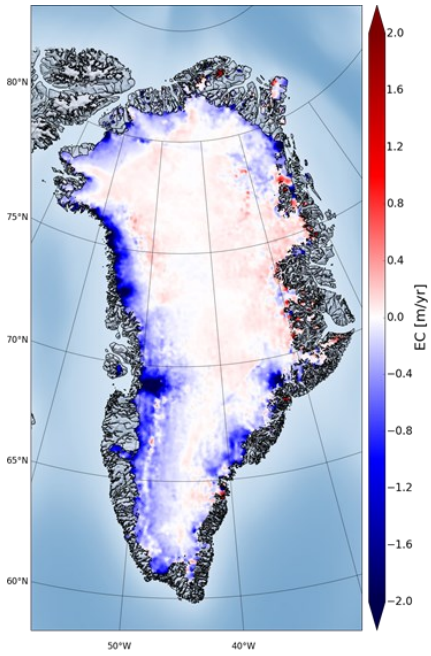


FIGURE: The figure shows Cryosat-2 derived elevation changes for the period 2011-2015. Large areas of thinning are observed particularly on the north-western edges of the ice sheet, including the Jakobshavn Glacier drainage system. The thinning of both the Helheim and Kangerlussuaq glaciers in the southeast of Greenland are also well-resolved. Also well-visible are the strongly varying SEC trends of the 79 and Zachariae glaciers in the northeast, as well as the thickening of Storstrømmen due to stagnation. The used algorithms has to a large degree reduced the effects of the 2012 Greenland-wide melt anomaly.

greenland ice sheet cci

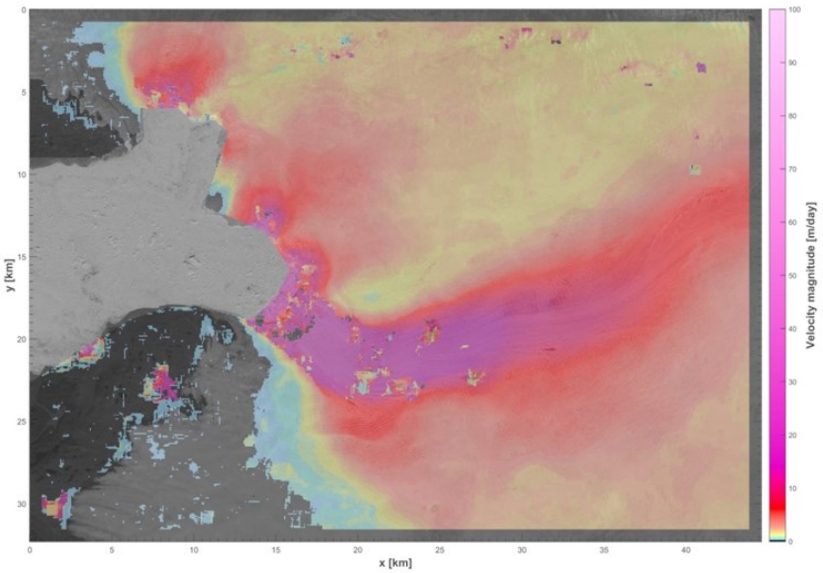
Ice Velocity (IV) - Optical vs SAR Comparison for Jakobshavn Glacier

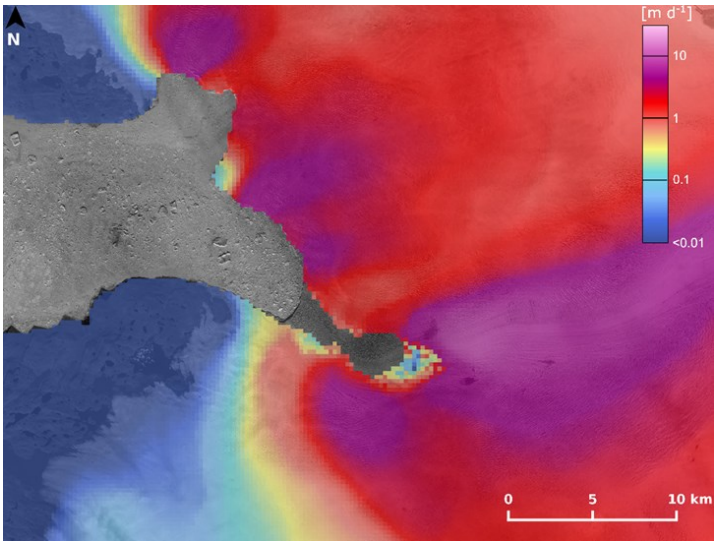
The operational ice velocity monitoring using Sentinel-1 SAR is complemented by including also high resolution optical satellite data from Sentinel-2 and Landsat-8.

During summer and cloud free conditions optical data help to densify the time series of ice velocity observations of outlet glaciers and supports closing data gaps in the annual ice sheet wide velocity maps. The figure shows the ice velocity map derived from Landsat-8 images from 15 to 31 July 2015 applying image cross-correlation. The main ice stream is clearly visible with typical ice speed of about 30 m/d and peaks of up to 40m/day near the calving front. Surface lakes forming during the summer due to strong melting can be clearly detected as local discontinuities in the ice velocity map.

First analysis of ice velocity data from SAR and optical satellite data show a good agreement opening the synergistic use of both data sources.

The potential of synergistic use of Sentinel-1 SAR and Sentinel-2 Multispectral Instrument (MSI) for monitoring ice dynamics of Greenland outlet glaciers will be further investigated in the project.





ABOVE LEFT: Speed of horizontal ice velocity of the terminus of Jakobshavn glacier, Greenland, applying image correlation techniques on Landsat-8 MSI scenes acquired on 15th and 31st July 2015.

ABOVE RIGHT: Sentinel-1 ice velocity map (magnitude) of the same area of the Jakobshavn glacier presented in Fig. 1. The map was generated using images acquired by Sentinel-1 collected in 2015/16.

Ice Velocity (IV) - Rapid Velocity Changes on Greenland Outlet Glaciers

In the last two decades scientists have witnessed large and rapid velocity changes on Greenland outlet glaciers.

In the Greenland Ice Sheet CCI both archived and new repeat SAR data, such as from Sentinel-1, are used to derive ice flow velocity (IV) to study and monitor these changes. The Sentinel-1 mission has opened up new opportunities for operational monitoring of glacier and ice sheet velocities at high spatial and temporal resolution. From January to March 2015 the first ice sheet wide campaign on Greenland was completed resulting in a detailed and nearly complete IV map. During last winter the second Greenland IV mapping campaign was carried out yielding a completer picture of ice sheet velocity. Besides the ice sheet wide campaigns, Sentinel-1's acquisition scheme allows for regular repeat observation of the entire ice sheet margin every 12 days. It is along these margins where velocity fluctuations are most pronounced. For a number of key regions and outlet glaciers velocity time series are produced enabling glaciologists to study seasonal fluctuations. Combined, the produced data sets allow for a unique assessment of ice sheet velocity and short term outlet glacier fluctuations in recent years.

See figure on the top on next page.

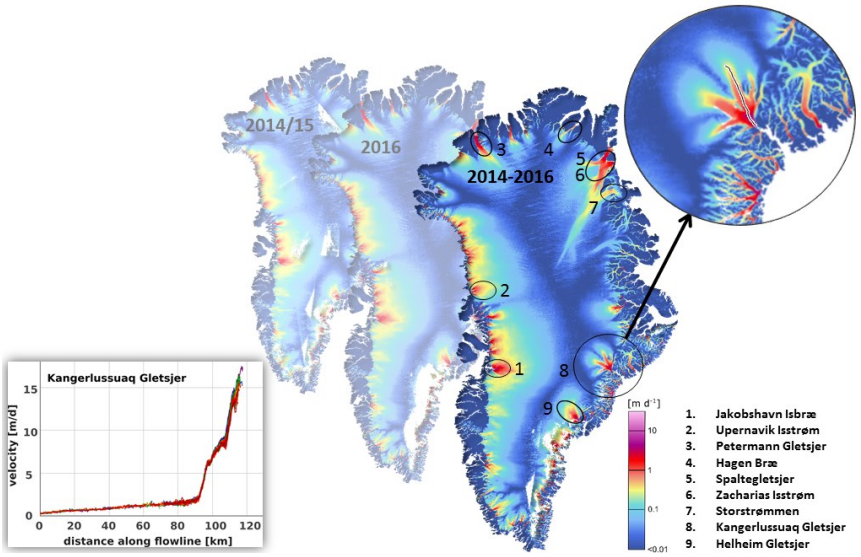


FIGURE:

Greenland Ice Sheet velocity derived from the 2014/2015 and 2016 Sentinel -1 winter campaigns. Indicated are key outlet glaciers for which IV time series are produced. Inset shows IV profile time series along a central flowline of Kangerlussuaq Gletsjer marked in the close up.

Carving Front Location (CFL) - Extended data with Sentinel-1

The calving front location (CFL) marks the terminus position of a tide water glacier and is subject to variations as the ice advances or breaks off.

The CFL is basic glacier parameter used for mapping glacier length or area change or for computing mass fluxes at the calving gate. From time sequences of CFL's the iceberg calving rate can be computed which is a direct measure of ice mass lost to the ocean. Monitoring the CFL is important as prolonged retreat of the calving front can indicate changing boundary conditions and instability. In the new version of the CFL data package the CFL's of 28 key Greenland outlet glaciers are further extended up to the winter of 2015/16. The new calving front locations are derived by carefully delineating the ice ocean boundary using Sentinel-1A SAR images within a GIS system. The selected dates include the most retreated and advanced location of the terminus position. The CFL's are available as annotated shapefiles, including detailed metadata information on the SAR data used to generate the product, and can be downloaded from the Greenland Ice Sheet CCI database.

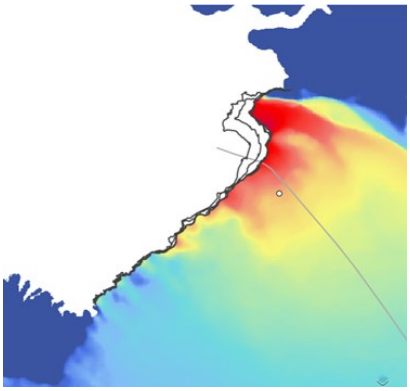


FIGURE: Calving front locations for Humboldt Gletsjer, Greenland, extended up to winter 2015/16 using Sentinel -1 A SAR imagery.

Grounding Line Location (GLL) - New data product on Petermann Glacier

The grounding line marks the transition from grounded to floating ice and is a sensitive indicator of ice sheet stability.

Locating the grounding line is critical to determine the mass flux of a marine based outlet glacier or ice sheet and monitoring changes in grounding line positions allows to identify instable regions. In reality the grounding line can better be envisioned as a grounding zone, as it undergoes daily fluctuations depending on ocean tides and bed slopes. The tidal deformation of the ice can be detected using InSAR as they show up as distinct fringe patterns in interferograms.

In Phase 1 of the Greenland Ice Sheet CCI repeat pass data of the ERS-1 and ERS-2 satellites from 1995 were used to map the grounding zone of the Petermann Glacier in north Greenland. Now we use SAR data of the Sentinel-1A mission to remap the grounding zone and added it to the database. The double difference interferogram is derived from 3 Sentinel-1A images acquired at 2, 14 and 26 October 2015 and clearly shows the fringes indicating the grounding zone. Advanced interferometric processing was applied in the formation of interferograms from Sentinel-1 TOPS mode data in order order to account for the 12 day image acquisition interval and high ice speed (about 3 m/day) of the float part of the glacier. With the recently launched Sentinel-1B, repeat acquisitions is reduced to 6 days enhancing the possibility of delineating the grounding line by means of interferometry.

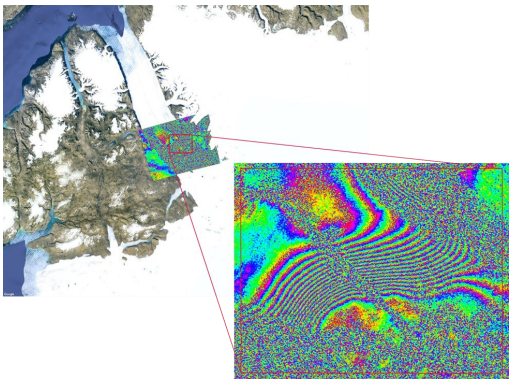


FIGURE: Interferogram of the terminus of Petermann Glacier in north Greenland derived from repeat pass SAR data of Sentinel-1A acquired at 2, 14 and 26 October 2015. The grounding zone can be recognized as a distinct band of fringes in the interferogram that is caused by tidal deformation.

Gravimetric Mass Balance (GMB) - First Data Products Released

A user consultation highlighted the interest in gravimetric mass balance (GMB) products for the ice sheets.

In Phase 2 of the project, the following products are therefore provided: basin-wide time series of mass changes obtained from the GRACE (Gravity Recovery and Climate Experiment) satellite mission for the period 2002 – present, as well as a time series for the entire Greenland Ice Sheet. In addition, users can find five-year running means of mass change grids for nine time periods from 2003 until 2015 (to aid in comparison with existing 5-year running means of SEC).

The GMB ECV product is based on GRACE Level-2 products provided by the Technical University of Graz ((ifg.tu-graz.at/ITSG-Grace2016). The new ITSG2016 gravity field solutions are provided up to degree and order 90, and form the core of a future European Gravity Service for Improved Emergency Management. The Greenland GMB setup is based on the point mass inversion method, where a direct estimate of mass changes is derived in a least-squares generalised inverse processing. This method secures a better and more explicit separation of Greenland mass changes from the mass changes from adjacent ice caps, especially northern Canadian ice caps in Ellesmere, Devon and Baffin Island.

The trend map (an example for the period 2007-2011) shows large, dark-blue areas of mass loss in the northwest and southeast of the Greenland Ice Sheet.

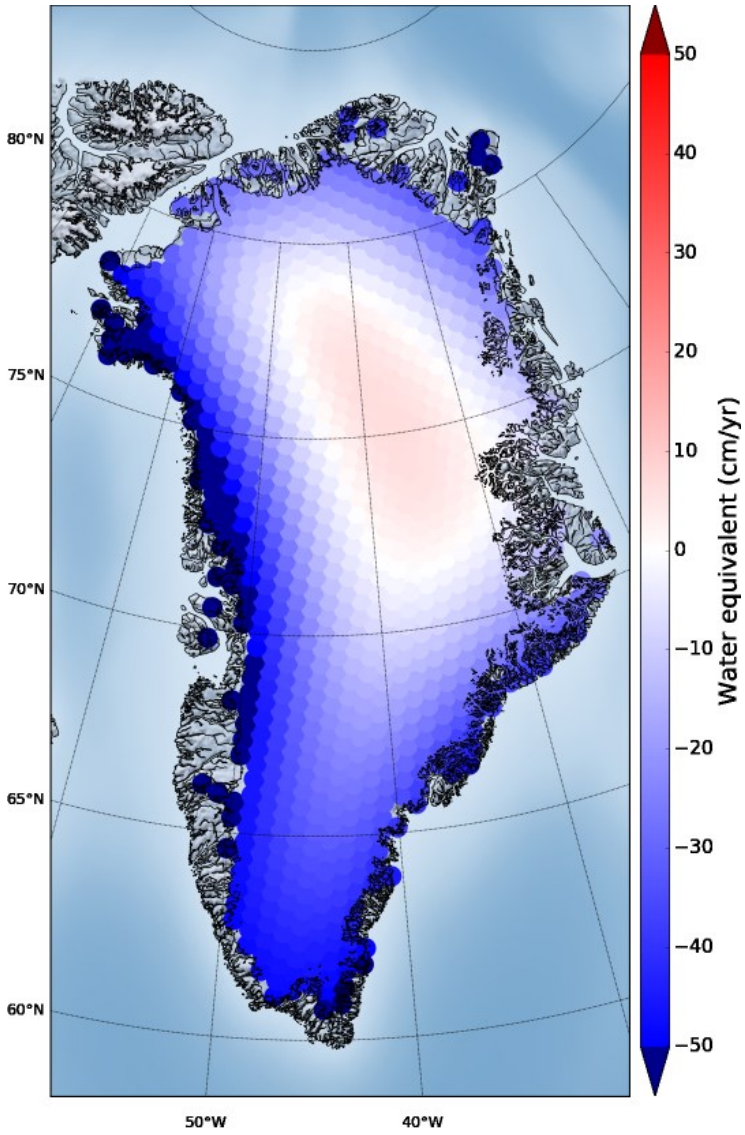


FIGURE: Example of GMB changes 2007-11 (cm water equivalent/year).

Download Data Products

This is a brief instruction on how to download the data products ...

Enter the Greenland_Ice_Sheet_cci project website; **http://www.esa-icesheets-greenland-cci.org/** and click on the ***Data Products*** under the ***Direct Link*** heading or go directly to the data product websiste; **http://products.esa-icesheets-cci.org/**

Detailed instructions on registration and maneuvering within the data products websiste are found in the "Product User Guide";
Enter the Greenland_Ice_Sheet_cci project website; **http://www.esa-icesheets-greenland-cci.org/** and click on the ***Product User Guide*** under the ***Direct Link*** heading located just below the Data Products link.
For download assistance please contact Science [&] Technology AS, Arnoud Jochemsen on **jochemsen@stcorp.no**

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