climate change initiative

GREENLAND ICE SHEET NEWSLETTER

Issue n. 9 | June 2018

Greenland_Ice_Sheet_cci - New Data Products are released

The Greenland_Ice_Sheet_cci project (2015-2018) is now closing in on final activities in June 2018. The ESA Greenland CCI project started in February 2012, and has provided consistent and validated data on a number of Essential Climate Variables for the Greenland ice sheet (elevation changes, ice velocities, mass changes, outlet glacier calving fronts and grounding lines), for time series up to 25 years duration.

The ECV time series are based on multiple satellite mission data, and are available for downloading at the CCI web site, http://products.esa-icesheets-cci.org/, as well as the ESA CCI common data portal http://cci.esa.int/content/cci-open-data-portal.

The generation of selected main products will continue under the Copernicus Climate Service (https://climate.copernicus.eu/) in the coming years, with some supplementary ECV data generated by an upcoming CCI+ ESA project.

This newsletter gives an updated on recently released products.

In this issue:

SAR Ice Velocity (IV) - 2012-2014 time series for Jakobshavn glacier

Time series based on offset-tracking of 4-day repeat COSMO-SkyMed image pairs.

Since June 2012, the COSMO-SkyMed constellation has regularly been acquiring high resolution SAR images of selected glaciers in Greenland at high revisit rates. We present a time series of ice velocity for the Jakobshavn glacier outlet area based on offset-tracking of 4-day repeat COSMO-SkyMed image pairs. The time series consists of 13 ice velocity maps covering the period from June 2012 to December 2014. The high spatial resolution and short revisit rate allow ice velocity to be measured all the way to the calving front. Figure 1 shows the velocity map from June 2012. The accompanying time series plot shows the significant temporal variation of the ice velocity at points 1-9 along the glacier centerline.

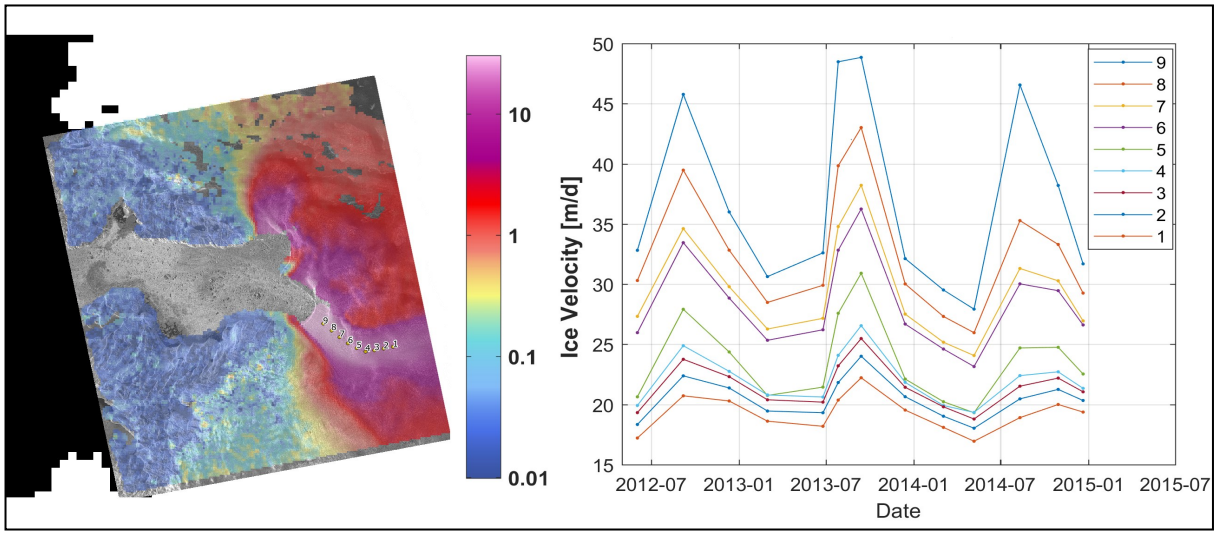


FIGURE 1: **(Left)** Jakobshavn ice velocity, June 2012; **(Right)** Velocity time series on centerline points

SAR Ice Velocity (IV) - Ice sheet wide velocity maps 2014-2018

Within the framework of the ESA CCI program a system for automatic generation of ice velocity maps from repeat pass Sentinel-1 data was developed, fundamentally changing the way scientists are able to monitor the polar ice masses.

The Sentinel-1 mission is the flagship SAR mission of the Copernicus Earth observation program, consisting of the twin satellites Sentinel-1A and Sentinel-1B. One of the unique aspects of the satellite mission has been the systematic acquisition planning of polar regions, designed to cover nearly the entire Greenland and Antarctic ice sheet margin at intervals of 6 to 12 days, providing excellent capabilities for operational monitoring of ice flow velocity. In the Greenland Ice Sheet CCI Sentinel-1 SAR images acquired in Interferometric Wide (IW) swath mode are used to derive ice flow velocity in Greenland on a regular basis. The dense velocity time series of outlet glaciers provide essential information for studying temporal fluctuations and long-term trends, improving future predictions of ice flow and sea level rise in response to climatic changes. Dedicated ice sheet wide winter mapping campaigns augment the continuous time series of the margins and provide a detailed snap shot of ice flow velocity in Greenland. Data, acquired during this winter's campaign, has now been processed to provide the 4th consecutive ice sheet wide velocity map generated in the Greenland Ice Sheet CCI project. The latest map is derived from more than 1800 Sentinel-1A and 1B scenes acquired from late December 2017 to late February 2018 and is available for download in the CCI (http://products.esa-icesheets-cci.org/) and Cryoportal databases (http://cryoportal.enveo.at/).

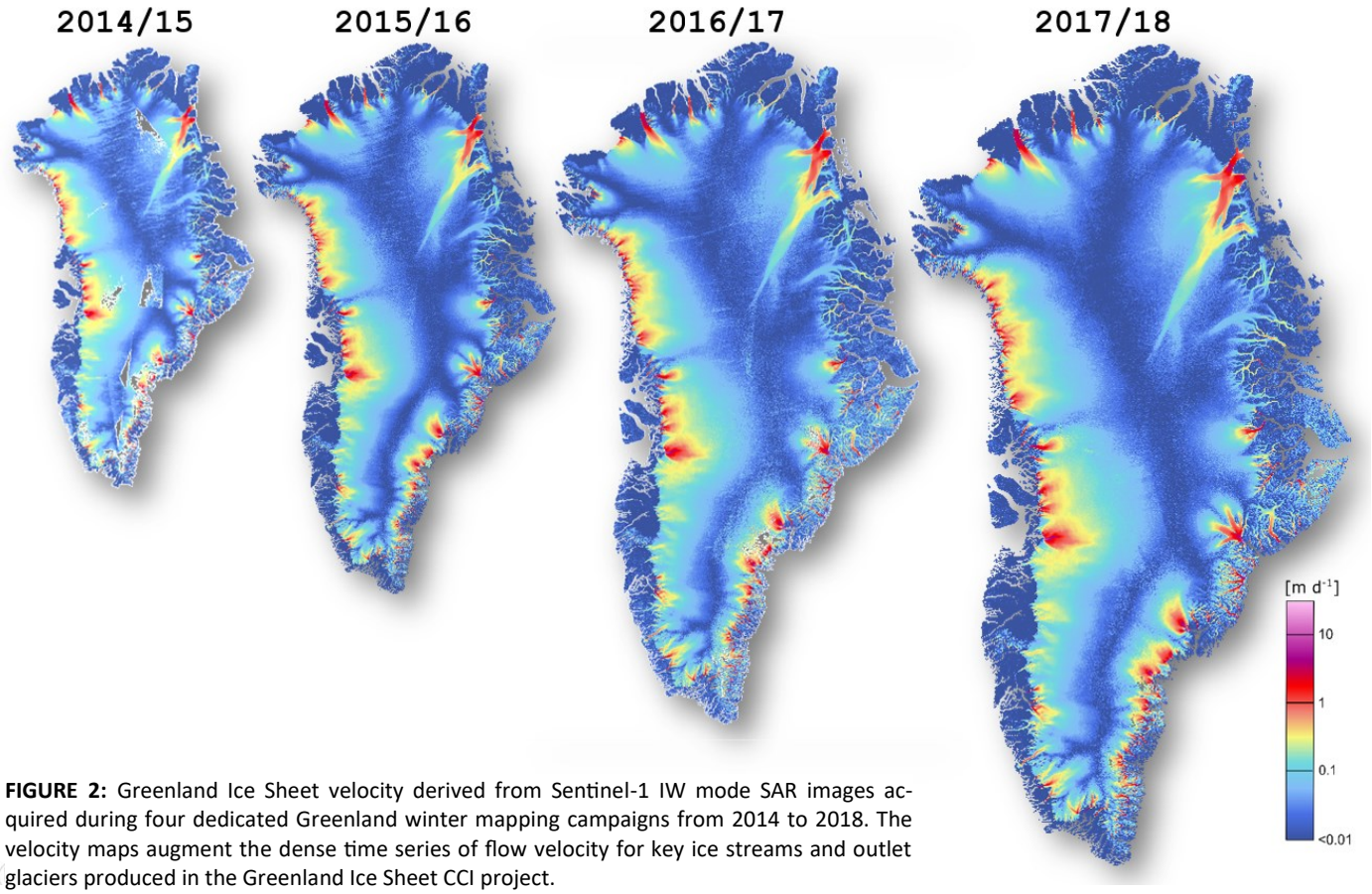


FIGURE 2: Greenland Ice Sheet velocity derived from Sentinel-1 IW mode SAR images acquired during four dedicated Greenland winter mapping campaigns from 2014 to 2018. The velocity maps augment the dense time series of flow velocity for key ice streams and outlet glaciers produced in the Greenland Ice Sheet CCI project.

Gravimetric Mass Balance (GMB) - GRACE comes to the end

GRACE processing centers started to release their latest reprocessed monthly gravity field solutions.

The Center for Space Research (CSR), University of Texas at Austin, published monthly solutions of release 06 (RL06) for the period 2003-01 – 2016-08.
Residuals of the gravity field coefficients w.r.t. to a linear, seasonal and quadratic model may serve as a measure for the noise level of the monthly solutions. Figure 3a shows the temporal median of the degree amplitudes, i.e. the power per spherical harmonic degree, of these residuals. It becomes evident that the noise level of the CSR RL06 data set was clearly reduced compared to its precursors, CSR RL05. The noise level of the latest CSR product is comparable to the latest product from TU Graz (ITSG-Grace2016). Hence, GMB products derived from both GRACE data sets exhibit a high level of agreement (Figure 3b). GMB products based on CSR RL06 are now available for downloading at the CCI web site and serve as an alternative to the already available ITSG-Grace2016 -based products.
On May 22, the follow-on mission GRACE-FO was successfully launched. First gravity field solutions are expected to be available in about six months' time and will allow to continue the GRACE time series.

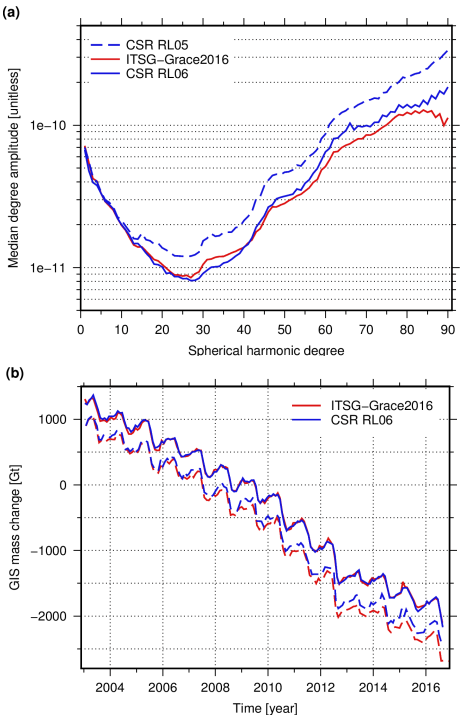


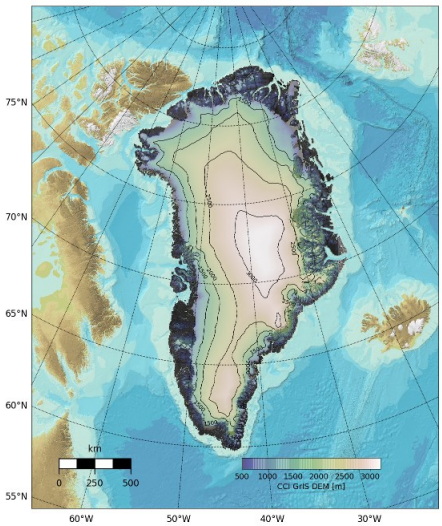
FIGURE 3: (a) Median of monthly degree amplitudes for residual gravity field coefficients w.r.t. to a linear, seasonal and quadratic model shown for different GRACE solutions. **(b)** Time series of ice-mass changes based on GRACE monthly solutions provided by TU Graz (red) and CSR (RL06, blue) derived by TU Dresden (solid) and DTU Space (dashed). Note: the time series from both institutions are shifted to increase readability.

Surface Elevation Change (SEC) - 25 years continuous time series available

Greenland SEC grids from Cryosat-2. 2-yr and 5-yr means for 2011-2017.

The CryoSat-2 surface elevation changes have been updated until 2017 in the latest data release. As for the earlier years, both 2-year and 5-year mean of elevation changes in m/year are provided, and merged with ERS and EnviSat time series provide a 25 year continuous data series of elevation changes in Greenland. The SEC data highlights the variability of the Greenland changes (the last years have been relatively cold in Greenland), and a new Greenland DEM, based on CryoSat-2 data, have also been released.

Experiments with merging CryoSat-2 Ku-band radar data with AltiKa Ka-band radar data has shown that the SEC ECV are highly dependent on the radar frequency, and that making a unified multi-frequency combined radar product is presently not possible in practice; the corresponding AltiKa SEC product from 2013 onwards has earlier been posted.



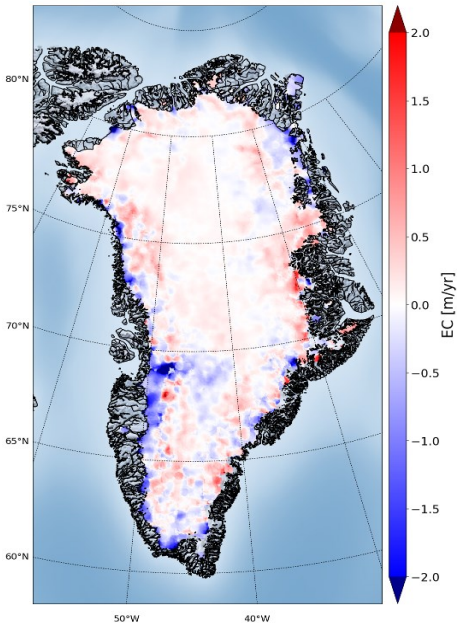


FIGURE 4: (Left) Greenland time-tagged CryoSat DEM (height model of Greenland); **(Upper):** CryoSat SEC ECV 2011-17 (m/yr).

Optical Ice Velocity (Opt-IV) - 2017 outlet glaciers products

Products of 8 major outlet glaciers generated by S[&]T applying offset-tracking to ESA Sentinel-2 data.

Sentinel 2-B, Sentinel 2-A's "twin brother", was launched in March 2017. The combination of the two satellites, which are located at the opposite sides of a common orbit, has allowed the observation of the Greenland ice sheet at regular intervals of 5 to 10 days.

The increase in the data availability allows for regular monitoring of ice velocity in the optical wavelengths. Within ESA Greenland CCI project, S[&T has developed a new 50m-resolution Optical Ice Velocity product, applying an offset-tracking algorithm to the ESA Sentinel-2 data.

Processing data acquired over the 2017 summer campaign, detailed Opt-IV time series have been generated for 8 major outlet glaciers: Jakobshavn, Petermann, Hagen, 79Fjord, Zachariæ, Kangerlussuaq, Helheim glaciers and the Upernavik region. Examples of the products are presented in Figure 5.

Opt-IV is a powerful supplement to SAR ice flow velocity maps. It helps both in the coverage of time periods and areas where SAR data is not available and in the independent verification. Furthermore, it has the merit of providing a complementary and independent calculation of ice velocities.

Data products can be downloaded at: http://products.esa-icesheets-cci.org/

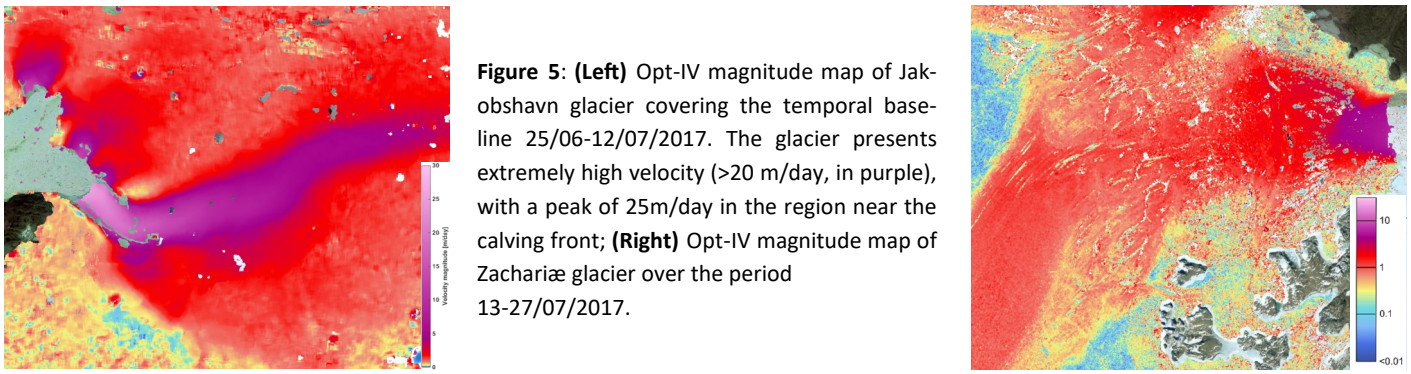


Figure 5: **(Left)** Opt-IV magnitude map of Jakobshavn glacier covering the temporal baseline 25/06-12/07/2017. The glacier presents extremely high velocity (>20 m/day, in purple), with a peak of 25m/day in the region near the calving front; **(Right)** Opt-IV magnitude map of Zachariæ glacier over the period 13-27/07/2017.

Data Product Traffic & Outreach

Since 2015 the number of downloads of CCI_gis data products has constantly increased.

Overall, on the official project data product website we have overtaken 5000 visitors, for a total of almost 1800 downloads of our data products since the first products were released in 2016. These numbers demonstrates the constant interest of the users and the appreciation for the products' quality.

Several scientific outputs have been released or are in press and/or preparation, including scientific papers, news items and presentations in international conferences. The last scientific output in order of time is the paper "25 years of elevation changes of the Greenland Ice Sheet from ERS, Envisat, and CryoSat-2 radar altimetry", published on *Earth and Planetary Science Letters* by Sørensen, LS et al. in May 2018.

(DOI:10.1016j.epsl.2018.05.015)

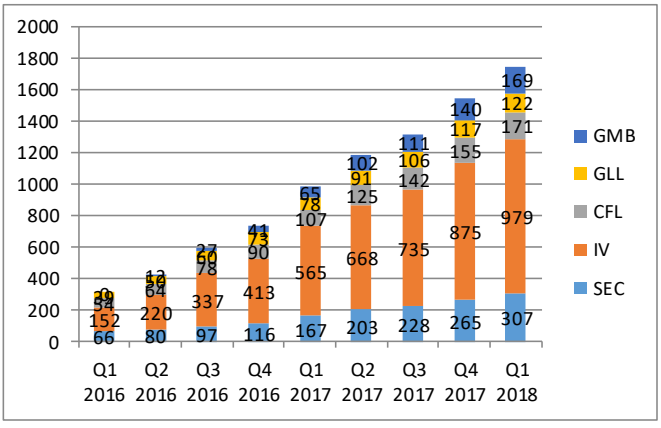


Figure 6: The figure gives an overview of the accumulated downloads per data product. On the official project data product website.

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Contributors: Project science team. Editor: D. Fantin, fantin@stcorp.no