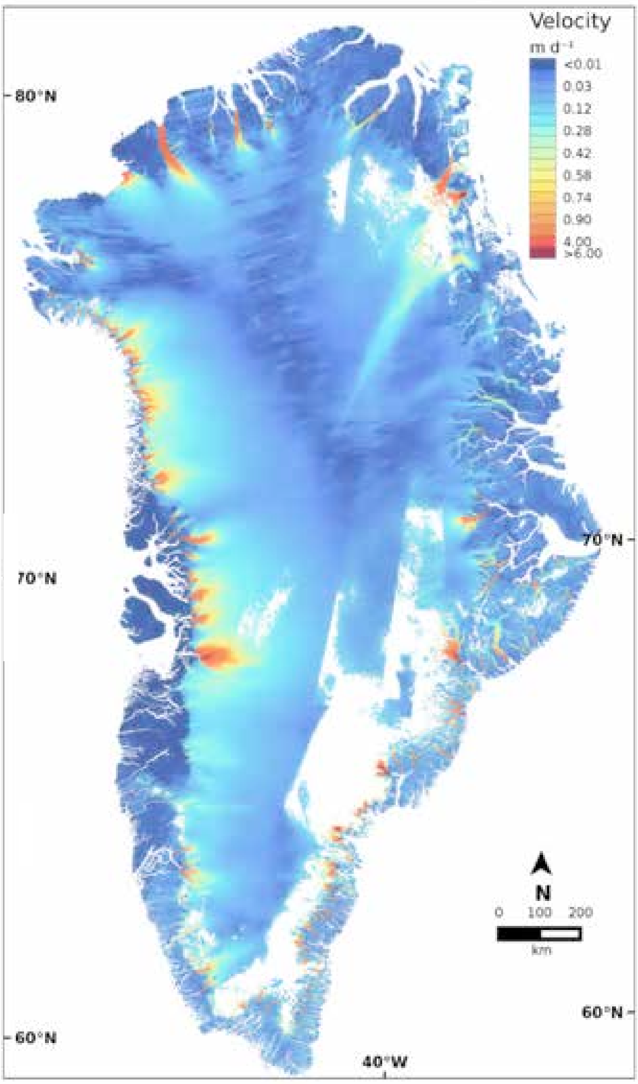
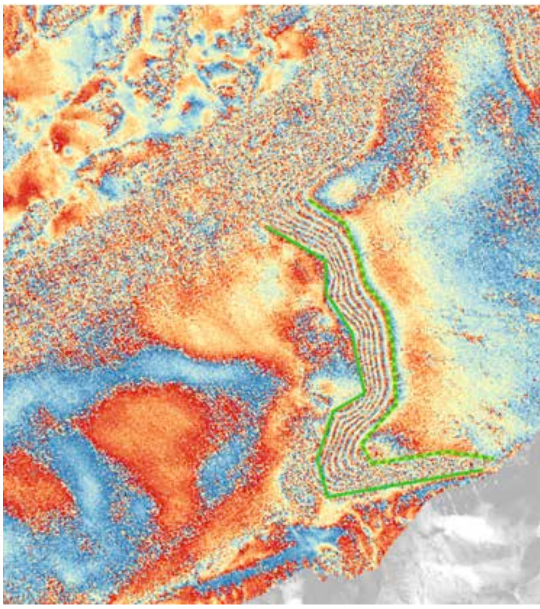
climate change initiative

→ GREENLAND ICE SHEET NEWSLETTER

Special Issue: COP-21 | September 2015





In this issue:

LEFT: Ice velocity map (magnitude) of the Greenland Ice Sheet derived from SAR onboard of Sentinel-1A operating in Interferometric Wide Swath Mode, acquired in the period January and March 2015. Credit: ENVEO

ABOVE: Detail from the Grounding Line Location product (see p. 4 for more details)

Greenland Ice Sheet CCI Releases Data Products

The ESA Greenland_Ice_Sheet_cci project was initiated in 2012 to investigate essential climate variables related to changes in the Greenland ice sheet. The results are now available.

In 2012, the Greenland_Ice_Sheets_cci joined the CCI with the intention to provide high quality science and climate products for the Greenland ice sheet. The ice sheet ECV parameters provide a consistent, long term data set for climate modelling and sea level changes, based primarily on ESA satellite sensors. The data extend back in time to the first ERS measurements in 1991, and they provide continuity with future satellite missions such as those of the Sentinel programme.

The following Essential Climate Variable (ECV) parameters are tracked:

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

Products are available for download from: http://products.esa-icesheets-cci.org/

Fill in the simplified registration form by clicking on 'register', then enter the following information about yourself:

- Your name in the following form: First name.Lastname,
- Your organisation, and
- Your email address.

Choose your password and click 'Register'. Click 'log in' and provide (again) your name on the form Firstname.Lastname, and the password you previously picked. The SEC, IV, CFL and GLL data products may now be downloaded.

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Ice Velocity (IV) Data products

Within Phase 1 of the CCI Greenland Ice Sheet project, ice velocity maps have been generated by applying offset tracking techniques to both ERS-1/2, ENVISAT ASAR and ALOS PALSAR data.

Large-scale maps have been generated covering:

- ◊ The margin of the Greenland ice sheet: winter 1995/1996
- ◊ The margin of the Greenland ice sheet: winters 2006-2011
- ◊ The Northern Drainage Basins: winter 1991/1992
- ◊ The Upernavik Glacier (time series)
- ◊ The Jakobshavn Glacier (time series)

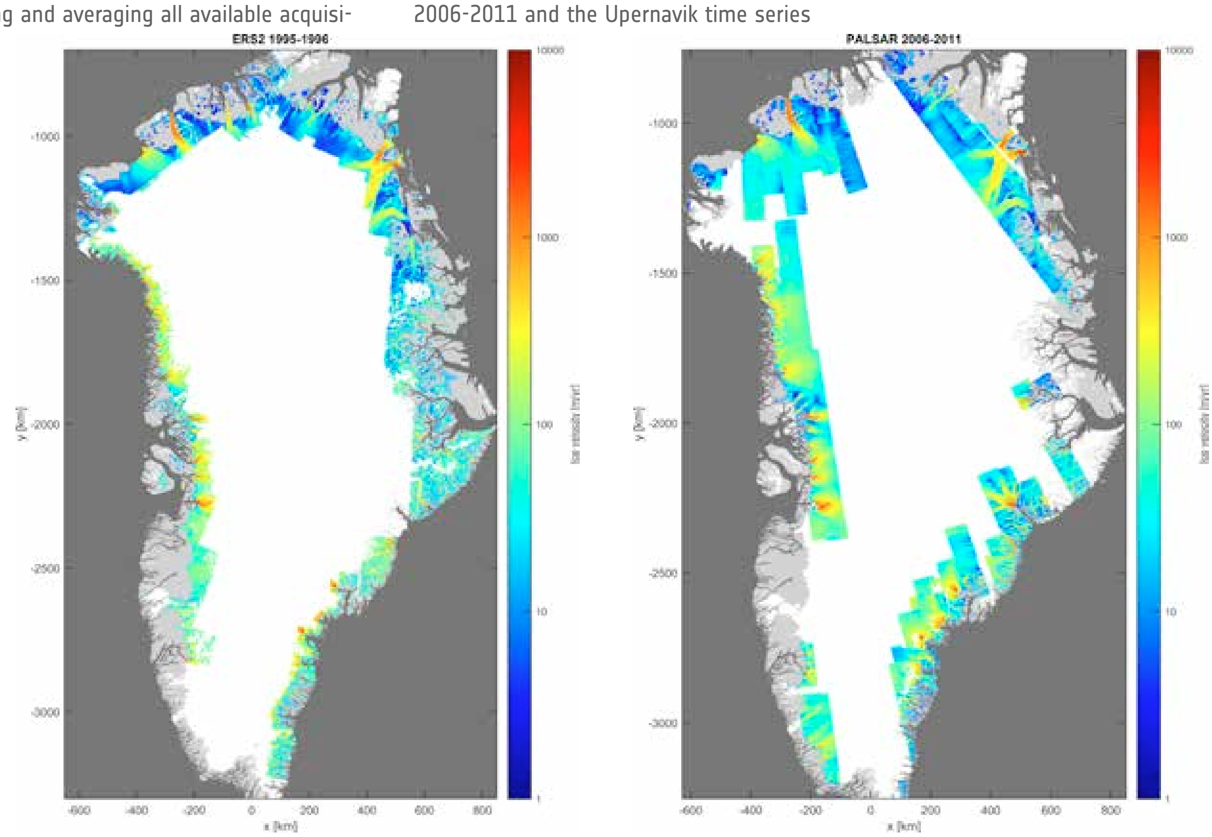
The velocity maps are accompanied by quality maps, i.e. the estimated standard deviation of the velocities on a pixel basis. The 1995/1996 map of the margin is based on ERS-1/2 data with a repeat cycle of 35 days and the 2006-2011 maps are based on ALOS PALSAR data with a repeat cycle of 46 days (see below).

The maps have been generated by mosaicking and averaging all available acquisition pairs within the period. Consequently the maps are best interpreted as average ice velocities for the entire winter period, although the dispersed temporal coverage of the available acquisitions means that different parts of the maps may be based on different acquisitions within the period.

The time series of the Upernavik glacier complex in West Greenland is based on ERS-1/2, ENVISAT ASAR and ALOS PALSAR data. Data from the period 1992 to 2011 have been processed. The ice velocity time series of Jakobshavn glacier is based on ENVISAT ASAR data with 35 days repeat acquisitions from 2002 to 2010. The frequency of maps varies with data availability.

In-situ GPS measurements overlapping in time and space were available for the margin of the Greenland ice sheet: winters 2006-2011 and the Upernavik time series and were used for validation. Results of the validation yield generally good agreement and may be seen in the Product Validation and Intercomparison Report (PVIR) document.

The map of the Northern Drainage Basins is based on ERS-1/2 data from the 3-days ice phase in 1991/1992. With a repeat cycle of 3 days, full coverage is not obtained, only 'fingers' of data. In this case all available acquisition pairs have not been mosaicked and averaged, as the 3-days pairs have been excluded. Due to severe solar activity during the winter 1991/1992, the Northern Drainage Basin maps are highly affected by ionospheric interference, mainly apparent as streaks in the along-track velocity component. The 3-days pairs are excluded in order to increase the ratio of the true ice displacements to the apparent displacements induced by the ionosphere.



LEFT: IV Map of margin from 1995/1996 ERS+1/2 data. The colour-scale is shared between the two plots.

RIGHT: IV Map of margin from 2006-2011 ALOS PALSAR data.

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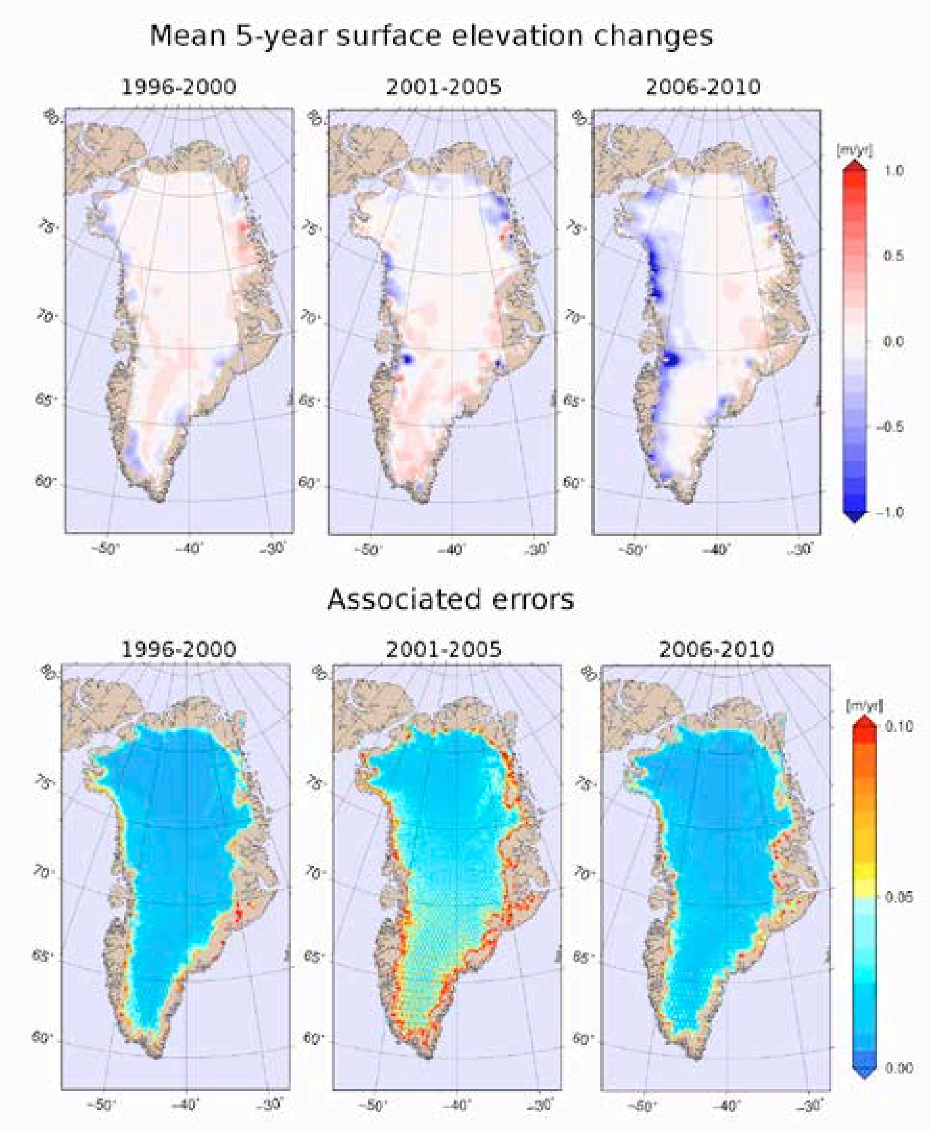
Surface Elevation Change (SEC) Data products

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

The SEC consortium has processed satellite radar altimetry data from the ERS-1, ERS-2 and Envisat satellites. The ERS-1 and ERS-2 data were provided following successful completion of the Reprocessed ESA ERS Altimetry (REAPER) project. The altimetry data were analysed using two different methods: the repeat-track method and the crossover method. These two were subsequently merged using kriging/collocation. The result is a dH/dt estimate for five-year intervals spanning the time frame 1992-2012.

Shown below are three such time periods as an example. The top row shows the change of the surface whilst the bottom row shows the associated errors. Errors are largest in coastal areas, where the altimeter struggles with steep topography. Errors are also large in between satellite tracks. Over flat terrain, the errors are lower.

For the first period, 1996-2000, some thickening can be seen in the northeast and the central south of the ice sheet. Thinning appears moderate.



For the second period, 2001-2005, pronounced thinning is visible in the west of the ice sheet. This is the location of the Jakobshavn Isbræ glacier which is known to be melting at an increased speed.

By the final period, 2006-2010, widespread thinning can also be observed along the northwest coast of Greenland. This area comprises in excess of twenty glaciers. In addition, parts of south-eastern Greenland also show an accelerated thinning signal. This area is home to the Helheim glacier, one of the largest outlet glaciers in SE Greenland. The signal in NE Greenland is more complex. An area of accelerated thinning, comprising the 79 Fjord and the Zachariæ Ice Stream, is located north of an area thickening. This thickening signal comes from the Storstrømmen glacier which experienced a large surge between 1978 and 1984 and which is thickening at present in response to this surge.

The SEC product represents a major advancement in our understanding of the behaviour of the Greenland Ice Sheet, providing an unprecedented level of detail reaching all the way to the margin of the ice sheet. The dH/dt estimates indicate that the surface of the Greenland Ice Sheet is thinning at increasing rates along large coastal areas. If this pattern of thinning persists, the associated ice melt will have a large effect on sea level rise in the 21st century. It is envisaged that the SEC product will be incorporated into ice sheet models used for predicting changes in polar areas.

After successful completion of Phase 1 of the CCI project, in Phase 2 new data sources will be incorporated into the SEC product such as Cryosat-2 and Sentinel-3.

LEFT: Mean 5-year surface elevation changes and their associated errors.

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Seasonal and Interannual variations of the Calving Front of Greenland Outlet Glaciers

Time series of calving front locations (CLF) are used in modelling the ice dynamics of ice sheets, areal changes of outlet glaciers. Long term trends in the CFL provides first insights into the mass balance of outlet glaciers.

Within Phase 1 of the Greenland Ice Sheet cci project we analysed time series of SAR data in order to monitor the interannual variation of 28 major tidewater glaciers of the Greenland ice sheet (preferably during summer). In addition, seasonal variations of the frontal position was mapped for 6 main outlet glaciers of the Greenland ice sheet. The main input data are SAR data acquired by ERS SAR and ENVISAT ASAR operating in Image Swath Mode, providing a time series from 1992 to 2010, depending on the SAR data availability. With the launch of Sentinel-1A in April 2014 a new era for monitoring ice sheets started. First CFL products from Sentinel-1A have been produced and included in the data package. Data gaps in the time series of CFL product result from missing SAR data.

The CFL production includes automatic extraction and geocoding of the SAR data covering the glacier termini and applies a manual delineation of the glacier front within a GIS system. The CFL product are stored as vectors in shape file format, and includes detailed metadata information on geographical coordinates and map projection, the SAR data used to generate the product. In addition, the material in front of the glacier terminus, which can be open water sea ice, sea ice melange, is annotated as it might affect the manual delineation accuracy of the frontal position.

Grounding Line Location (GLL)

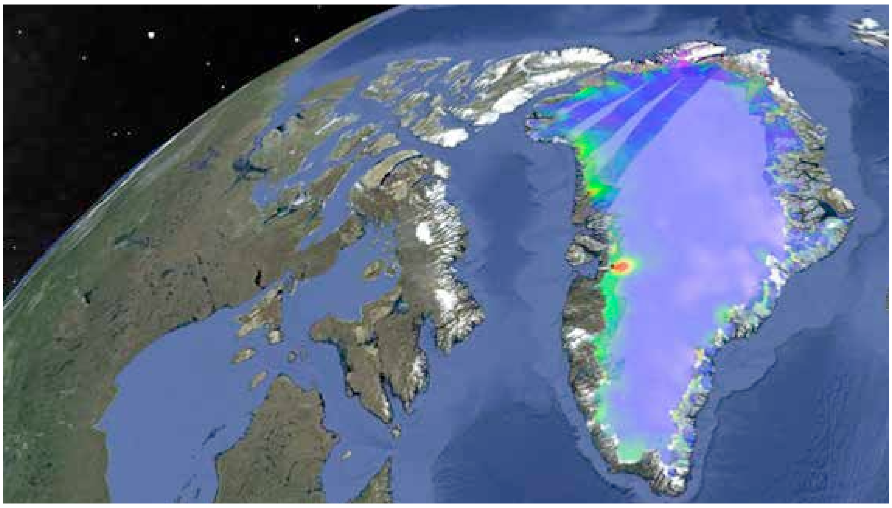
The location of the transition from grounded to floating ice (the grounding zone) of marine terminating glaciers and its temporal variation is of high interest for icesheet modelling, and for understanding the response to ice masses to changing oceanic and atmospheric boundary conditions.

From Earth observation the grounding zone can be mapped only indirectly by observing ice surface features related to the position of the grounding line. Phase-1 of the Greenland ice sheet CCI project focussed on SAR interferometry for mapping the sea and landward limit of tidal deformation, which is related directly to the change from grounding to floating of the ice. The method requires repeat pass SAR data acquired within a short period of a few days only (e.g. ERS Tandem Phase with 1 days repeat acquisitions). Based on the formed double differenced interferograms the delineation of the sea and land-wards limit of the tidal deformation zone is carried out manually. The GLL products are stored as vector files in shape file format and included metadata information on used SAR images and processing system.

Data product visualisation in Google Earth

In the visualisation, Surface Elevation Change (SEC) data and Velocity (IV) data are shown as partly transparent overlays. Calving Front Location (CFL) data is show as polygons. The user may navigate and zoom using the relatively familiar Google Earth interface. The Google Earth application must be installed to view the file.

The data is temporal in nature. Different time intervals may be set and an animation of the data evolution in time can also be viewed. Available for viewing and download at http://www.esa-icesheets-cci.org/



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Newsletter published by Science [&] Technology AS | Editor: Dag Evensberget