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D2.3.1: Time series of satellite altimetry height changes of the Greenland ice sheet, year since 1992 expressed as height change grids.

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RE	Restricted to a group specified by the consortium (including the Commission)	
CO	Confidential, only for members of the consortium (including the Commission)	

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SUMMARY

Measurements of radar altimeters from a series of European satellites (ERS-1, ERS-2, and Envisat) allow the investigation of the surface elevation changes of the Greenland ice sheet from 1992 to present, excluding some ice sheet marginal areas, where the measurements are sparse due to rougher sloping surface.

We have derived time series of surface elevation changes of the Greenland ice sheet for the time span April 1992 – December 2008. Measurements from different satellites were merged through determination and applying intersatellite biases. Adjustment of elevation time series for its dependence on backscatter coefficient was performed to account for changes in properties of the ice sheet surface.

Ice sheet growing and shrinking for the high and low elevation areas respectively from 1992 to 2008 are indicated. Increases in surface elevation from 1995 observed over the high-elevation regions of Greenland are followed by an elevation decrease from 2006. In contrast, over low-elevation areas below 1500 m the surface elevation decrease that started from 2000 has continued.

The grid contains elevation time series of the Greenland Ice Sheet. The elevation changes observed by satellite radar altimeters are not corrected for signals that are not related to the ice sheet mass balance (such as GIA and firn densification). Relevant corrections must be applied by the user.

The elevation change grid is provided in the file: dH_ERSEnvisat_1992-2008.txt
Available at: http://monarch-a.nersc.no/node/61

MONARCH - A CONSORTIUM

Participant no.	Participant organisation name	Short name	Country
1 (Coordinator)	Nansen Environmental and Remote Sensing Center	NERSC	NO
2	The University of Sheffield	USFD	UK
3	Universität Hamburg	UHAM	NO
4	Centre National de la Recherche Scientifique	CNRS	FR
5	Scientific foundation Nansen International Environmental and Remote Sensing Center	NIERSC	RU
6	Universitetet i Bergen	UiB	NO
7	Danmarks Tekniske Universitet	DTU	DK
8	Institut Francais de Recherche pour l'Exploitation de la Mer	IFREMER	FR

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1.1 Grid file

The grids contain elevation time series of the Greenland Ice Sheet from 1992-2008 derived from merged ERS-1, ERS-2 and Envisat satellites radar altimeter data.

The elevation changes observed by satellite radar altimeters are not corrected for signals that are not related to the ice sheet mass balance (such as GIA and firn densification). Relevant corrections must be applied by the user.

The elevation change grid is provided in the file: dH_ERSEnvisat_1992-2008.txt

Available at: http://monarch-a.nersc.no/node/61

File format: lat, lon, dH_1, dH_2 ,… , dH_{199} [cm]
The resolution of the grid is 0.5° latitude x 1° longitude
Given coordinates are the lowest latitudes and longitudes for each cell (i.e. lower left corner of the cells)
Time series are created with one month step and every points of the time series represents 3-months averaged elevation change. Time series contain 199 points starting from interval April to June (AMJ) 1992 and ending with the interval October to December (OND) 2008. Missing values are represented by -999.9. The three-point gap of no data from FMA to AMJ 2006 is due to Envisat radar altimeter sensor anomaly from February 8 to June 22.

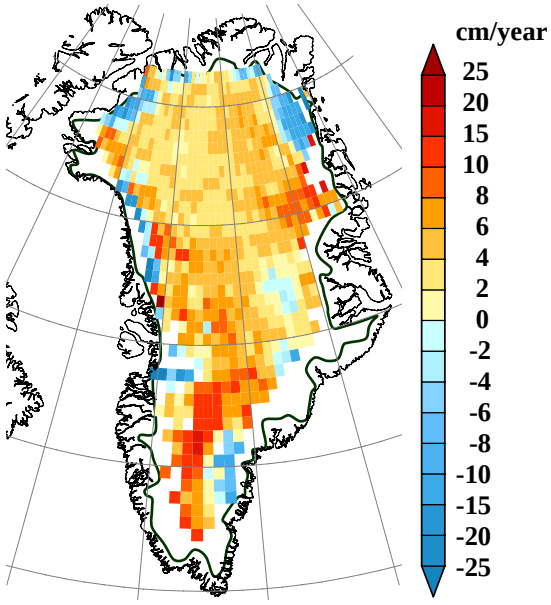

Fig. 1. Distribution of elevation change rates derived fromERS-1, ERS-2 and Envisat satellite altimeter measurements from 1992 to 2008.

1.2 Satellite radar altimeter data

ERS-1 (1992-1996), ERS-2 (1995-2003) and Envisat (2002-2008) data used for creating elevation time series were provided by NASA/GSFC.

Level-2 product provides geolocated and time tagged ice sheet surface elevation estimates with all instrument, atmospheric, tide, slope and retracking corrections, while Level-1 gives altimeter signal parameters including backscatter coefficient. Measurements in ice mode from ERS-1 and ERS-2 and in fine mode from Envisat were used.

1.3 Method

A procedure of creating time series is based on crossover analysis and described in (Li and Davis, 2006) and (Khvorostovsky and Johannessen, 2009).

A methodology for determining intersatellite biases was developed and applied in order to merge measurements from different satellites and to create continuous and consistent time series (Khvorostovsky, 2011).

Adjustment of elevation time series for its dependence on backscatter coefficient (σ^0) is performed on the basis of the approach used by Davis and Ferguson, 2004 and Zwally et al., 2005 in order to account for the changes in the ice sheet surface properties. The sensitivity of measured elevation to changes in σ^0 was estimated by using the differences between adjacent points of time series as in (Khvorostovsky, 2011). Temporal variations of this sensitivity and adjustment of elevation time series for dependence on other waveform shape parameters are not taken into account here.

1.4 Results

Ice sheet growing and shrinking for the high and low elevation areas respectively from 1992 to 2008 are indicated (Fig.1). Temporal variations show that increases in surface elevation from 1995 observed over the high-elevation regions of Greenland were followed by an elevation decrease from 2006 (Johannessen et al., 2005; Khvorostovsky, 2011). In contrast, over low-elevation areas below 1500 m the surface elevation decrease that started from 2000 has continued (Fig. 2). Dataset presented here gives an average elevation change rate of 3.2 ± 0.2 cm/year from 1992 to 2008 over 76% of the Greenland ice sheet area. However marginal areas are not completely measured by radar altimetry and substantial thinning rates over these areas could offset the observed average elevation change. At the same time spatio-temporal analysis reveals large interannual elevation variability over western and south-eastern regions.

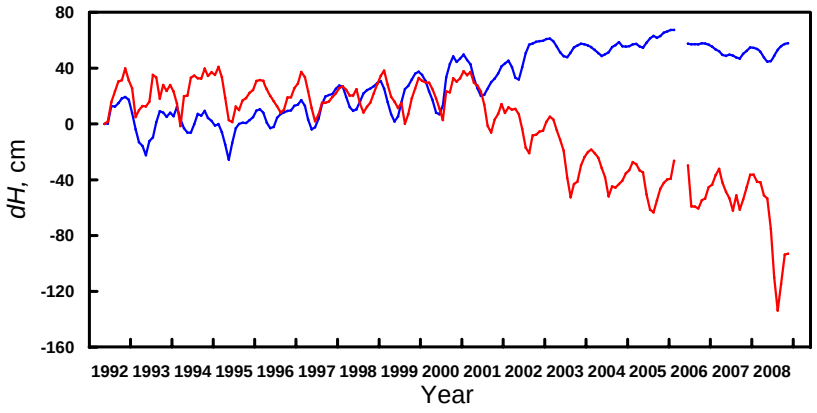

Fig. 2. Elevation time series over the areas above (blue) and below (red) 1500 m obtained by merging ERS-1, ERS-2 and Envisat satellite altimeter measurements from 1992 to 2008.

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