

Greenland ice sheet elevation change derived from ERS-1 and ERS-2 satellite altimeter data and its relation with climate parameters

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Actuality

Satellite altimeter measurements of Greenland Ice Sheet elevation changes

- **method of direct mass balance determination**
- **orbits of ERS-1 and 2 satellites allow to study the whole area of Greenland ice sheet**

Study of polar ice sheets mass balance is critical for:

- **understanding of their response to climate change**
- **determination of their contribution to sea level rise**

Greenland Ice Sheet is of particular interest because:

- **Greenland being located on the path of cyclones, is a good indicator of changes in the atmospheric circulation system**
- **summer melting occurs over 1/4 to 1/3 of Greenland Ice Sheet surface**

Data processing and approach

Data sources and corrections

ERS-1 (1992-1996) and ERS-2 (1995-2003) satellite altimeter data are provided from Goddard Space Flight Center (NASA)

Dataset includes altimeter waveform product and the following corrections are to be applied:

Leading edge tracker

(10% threshold retracking correction)

Tides (solid, ocean, and load)

Atmospheric (wet, dry, ionospheric)

Satellite orbits (DGM-E04)

ESRIN corrections for

Ultra stable oscillator (USO) drift and the scanning point target response (SPTR) bias jumps

Approach

Crossover analysis was used for ice sheet elevation change estimation

Dataset of all available crossover points was created

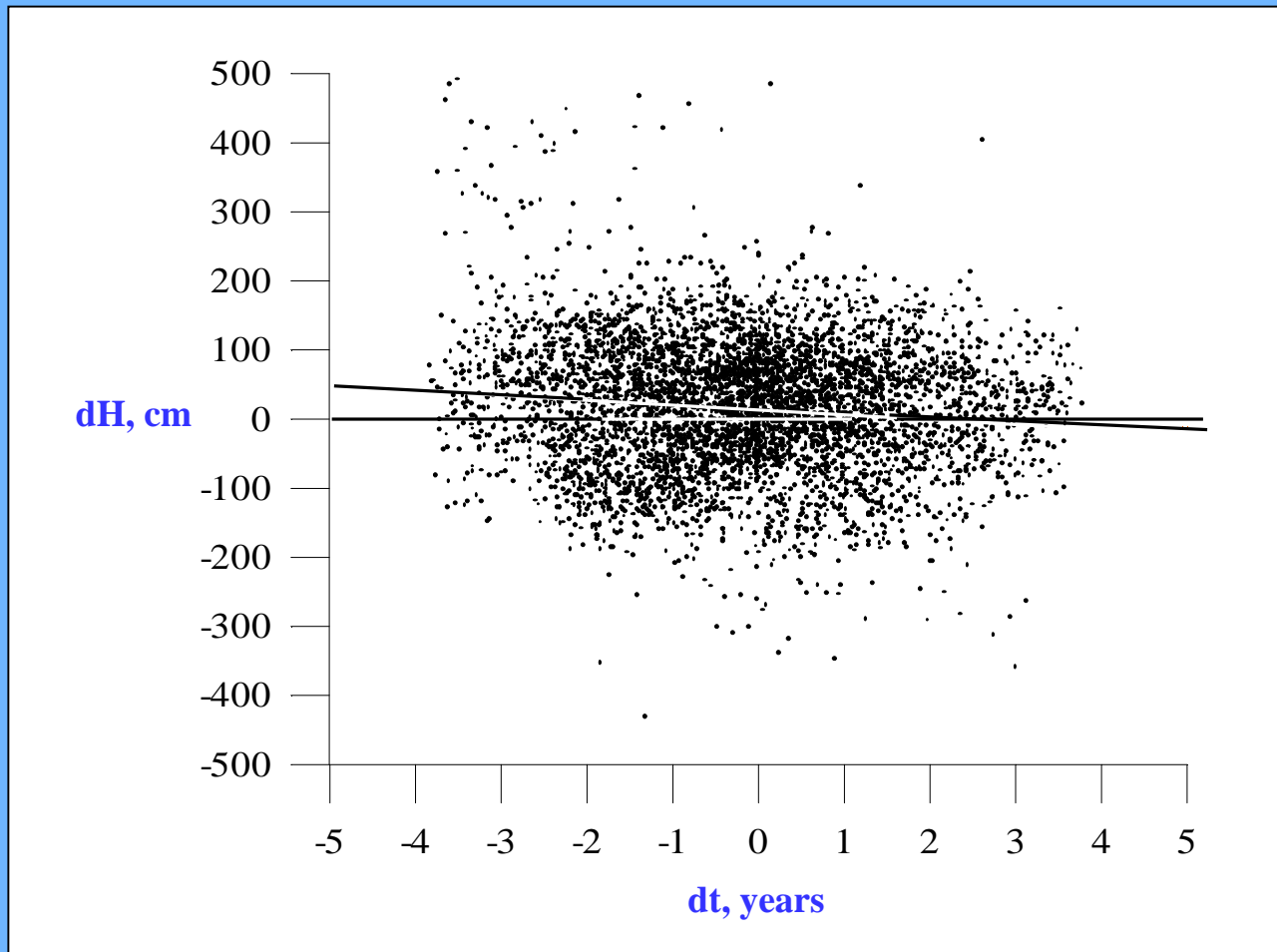
Only crossovers with ice-mode ranged were used in calculations

Measurements with noise waveforms and data outliers of elevation differences in crossovers were discarded

Elevation change was estimated for 1° longitude by 0.5° latitude cells

Methods of elevation change calculation (1st method)

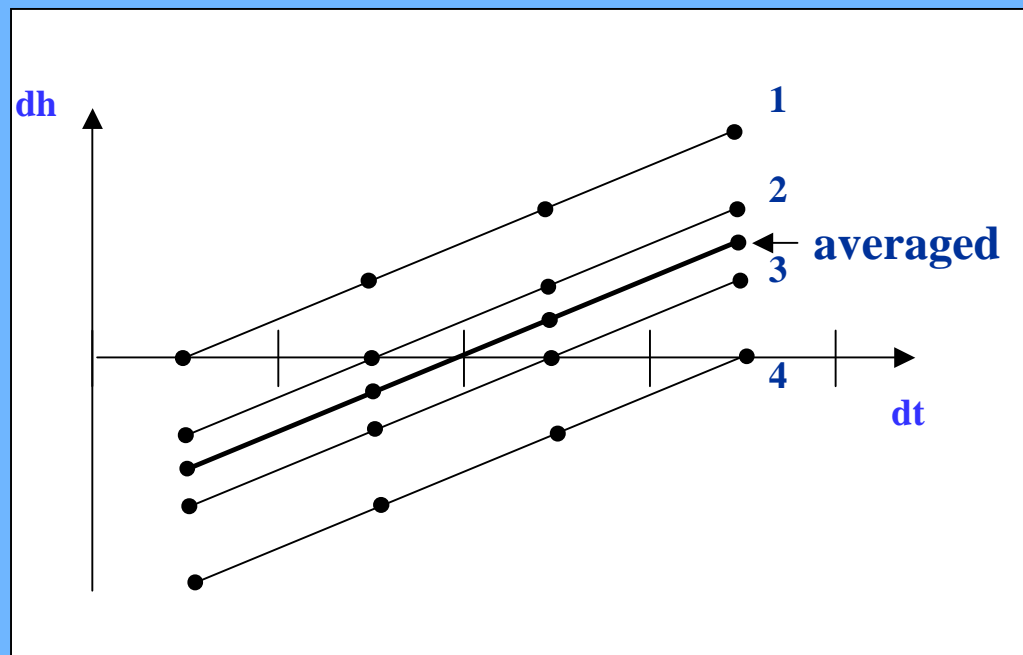
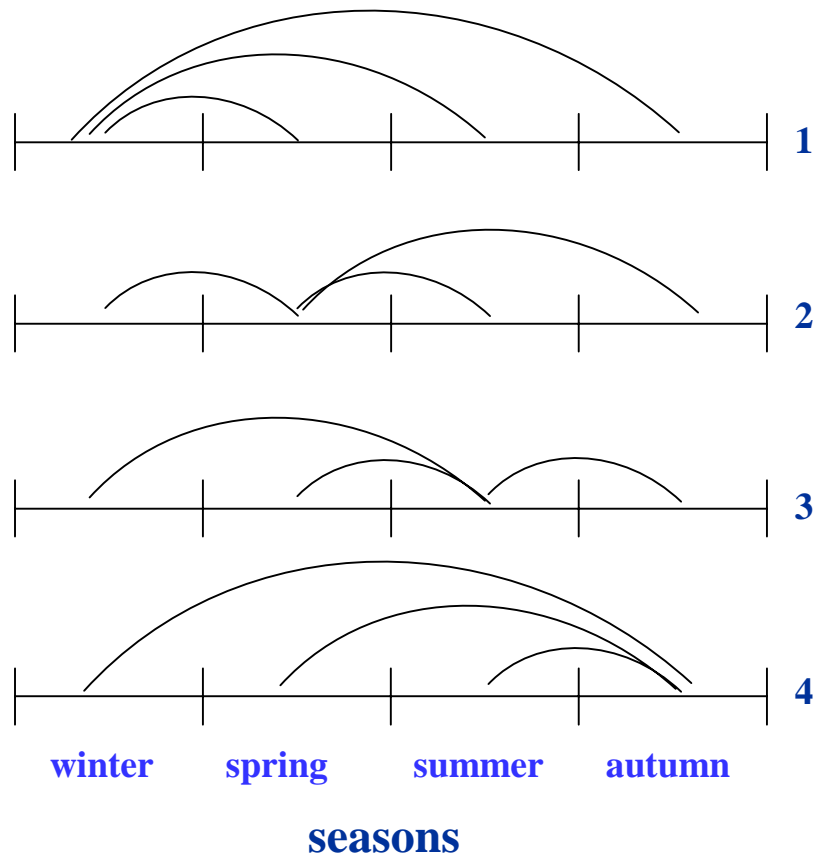
dH/dt -method



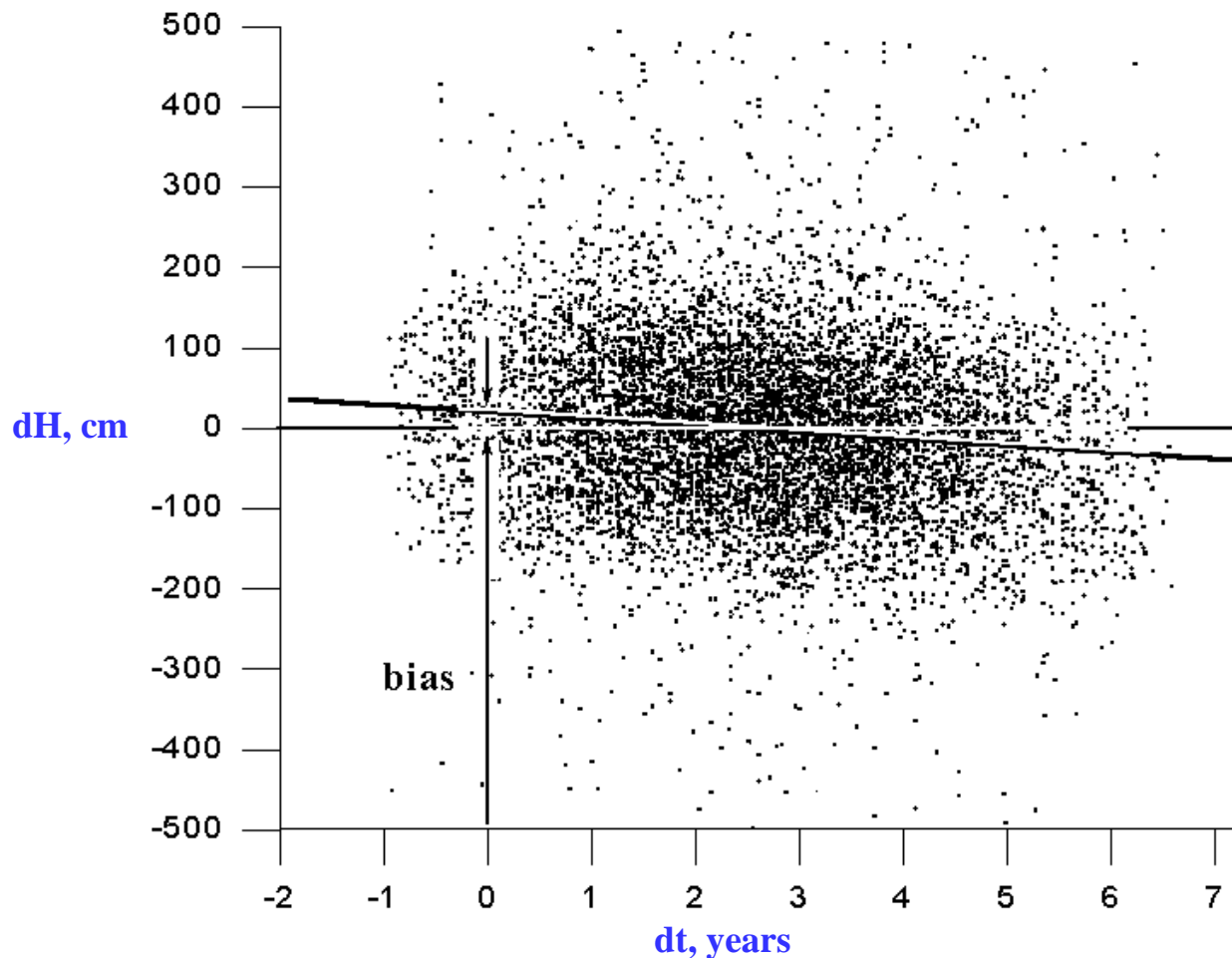
Methods of elevation change calculation

(2nd method)

Time series method



Methods of ERS-1/ERS-2 bias determination

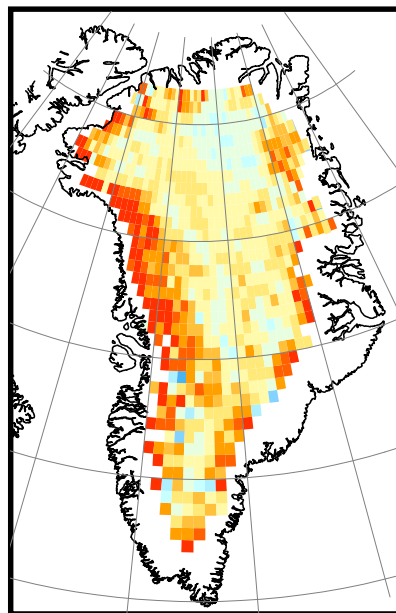


For all ERS1 \times ERS-2 crossovers the 40.9 cm offset was subtracted from ERS-1 elevations to account for the different characterization parameter used for ERS-2 (Femenias, P., ERTNRS-RA-0022, 1997.)

ERS-1/ERS-2 bias of altimeter measurements over Greenland Ice Sheet

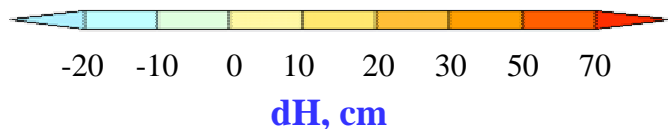
Used dataset: ERS-1 \times ERS-2 crossovers (ERS-1: 1992-1996, ERS-2: 1995-1999)

ERS-1/ERS-2 bias

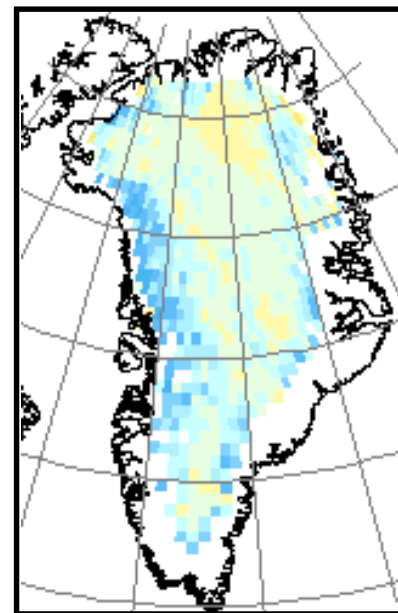


21.5 ± 1.2 cm

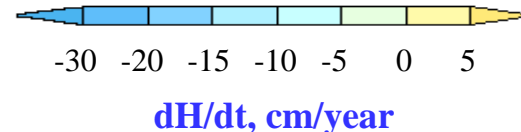
Std. err. of bias estimation is 6.3 cm



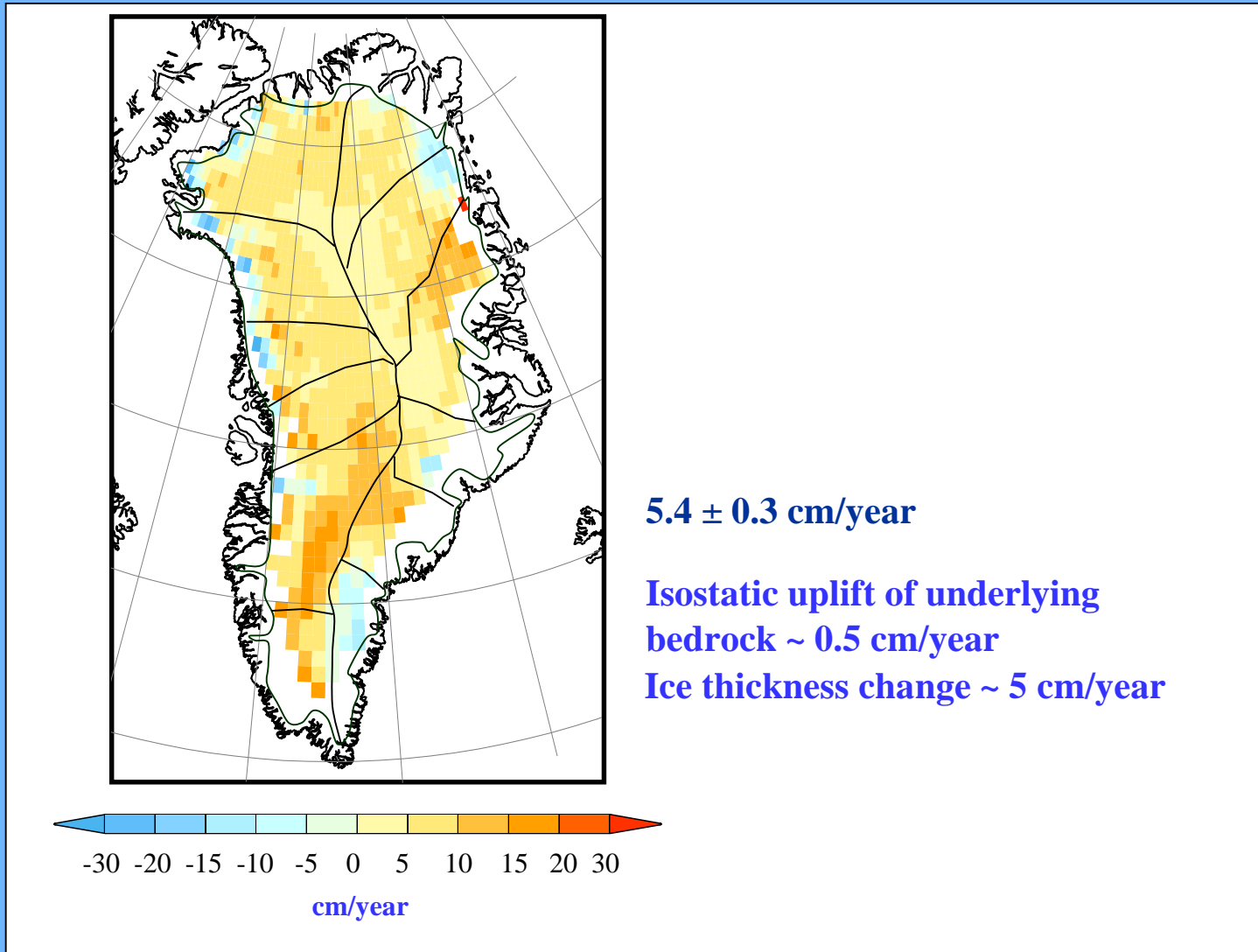
(ERS-2 – ERS-1) – (desc. – asc.)
(effect of bias on elevation
change estimation)



$-6,7 \pm 0,4$ cm/year



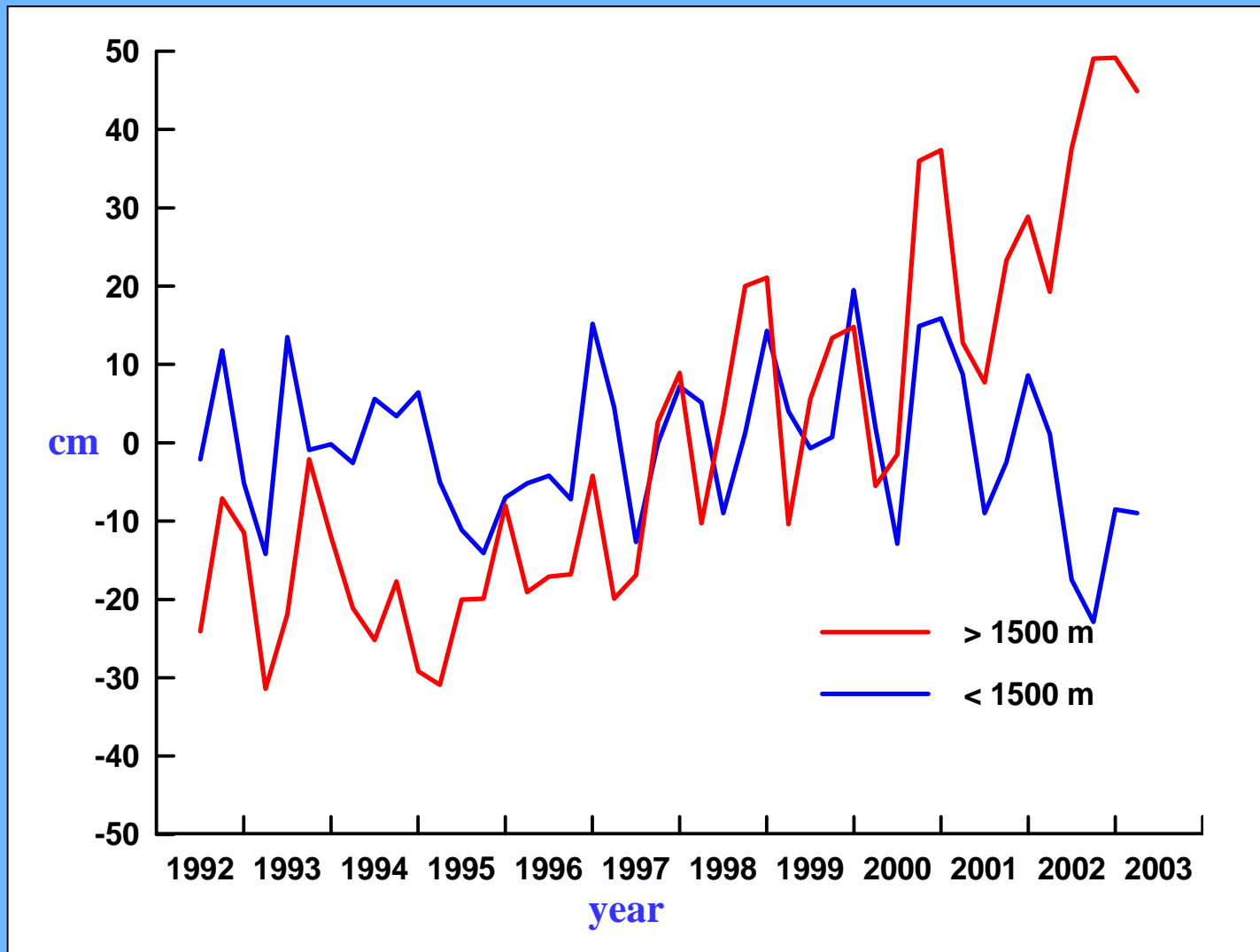
Elevation changes from 1992 to 2003 derived from merged ERS - 1 and ERS - 2 measurements



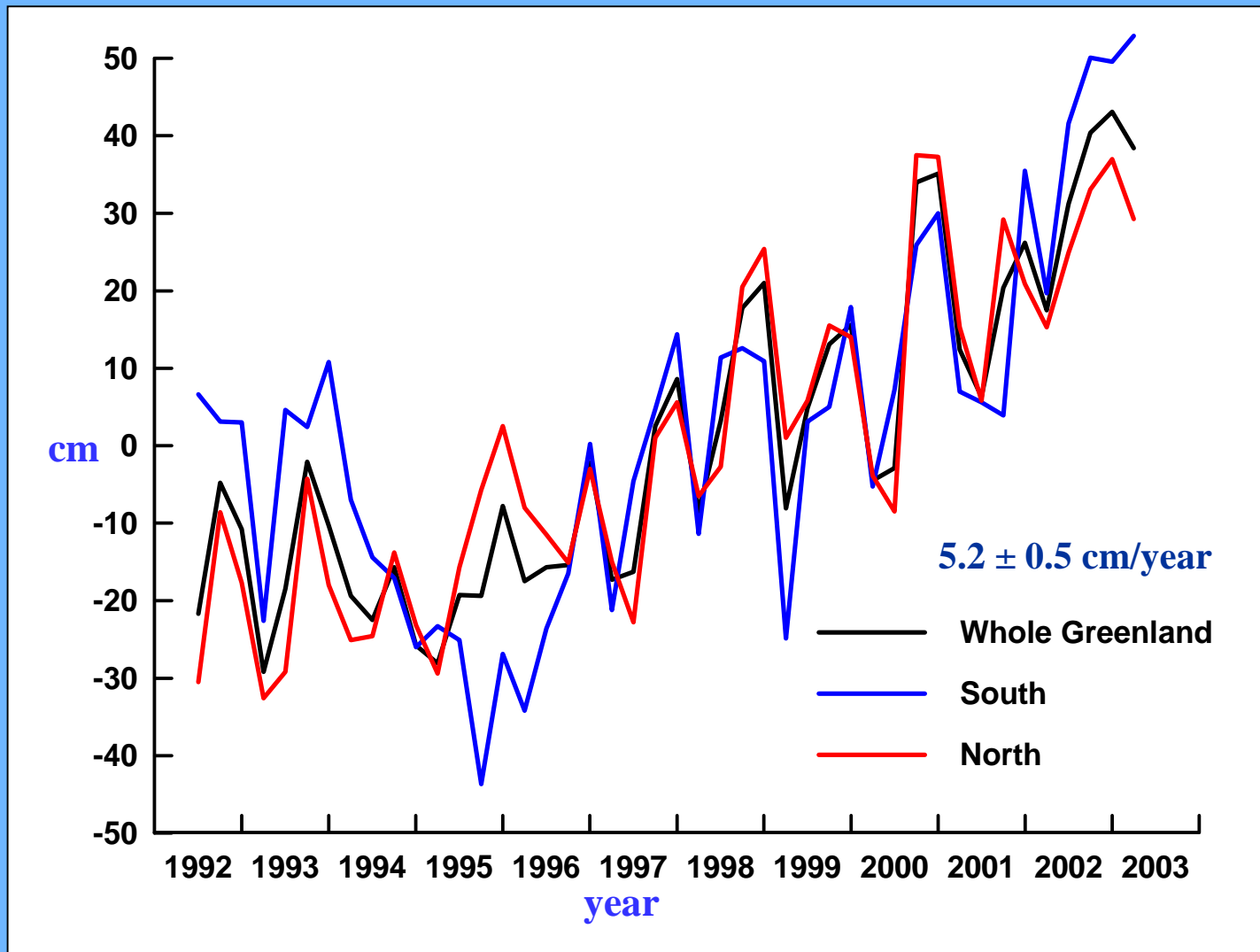
Elevation change rate over different elevation bands

Elevation band, km	dh/dt, cm/year	Std. err. cm/year	Area, 10³ *km²
<1.5	-2.0 ± 0.9	0.4 ± 0.04	155.1
1.5-2	5.6 ± 0.5	0.3 ± 0.03	228.2
2-2.5	7.0 ± 0.4	0.2 ± 0.02	398.9
2.5-3	6.4 ± 0.3	0.2 ± 0.01	458.3
>3	5.5 ± 0.3	0.1 ± 0.01	140.3
Whole Greenland	5.4 ± 0.3	0.2 ± 0.01	1380.7

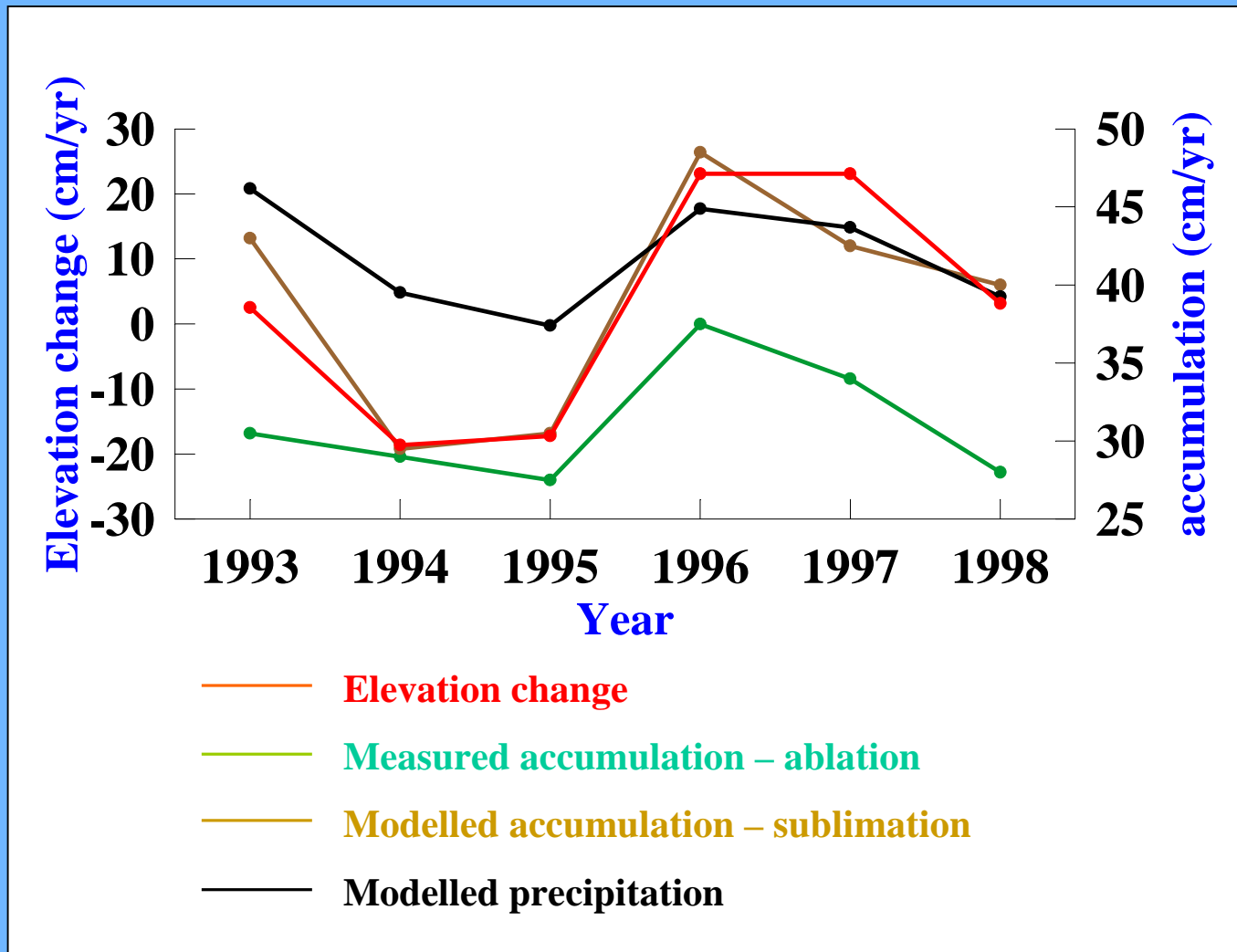
Seasonally averaged time series of elevation change



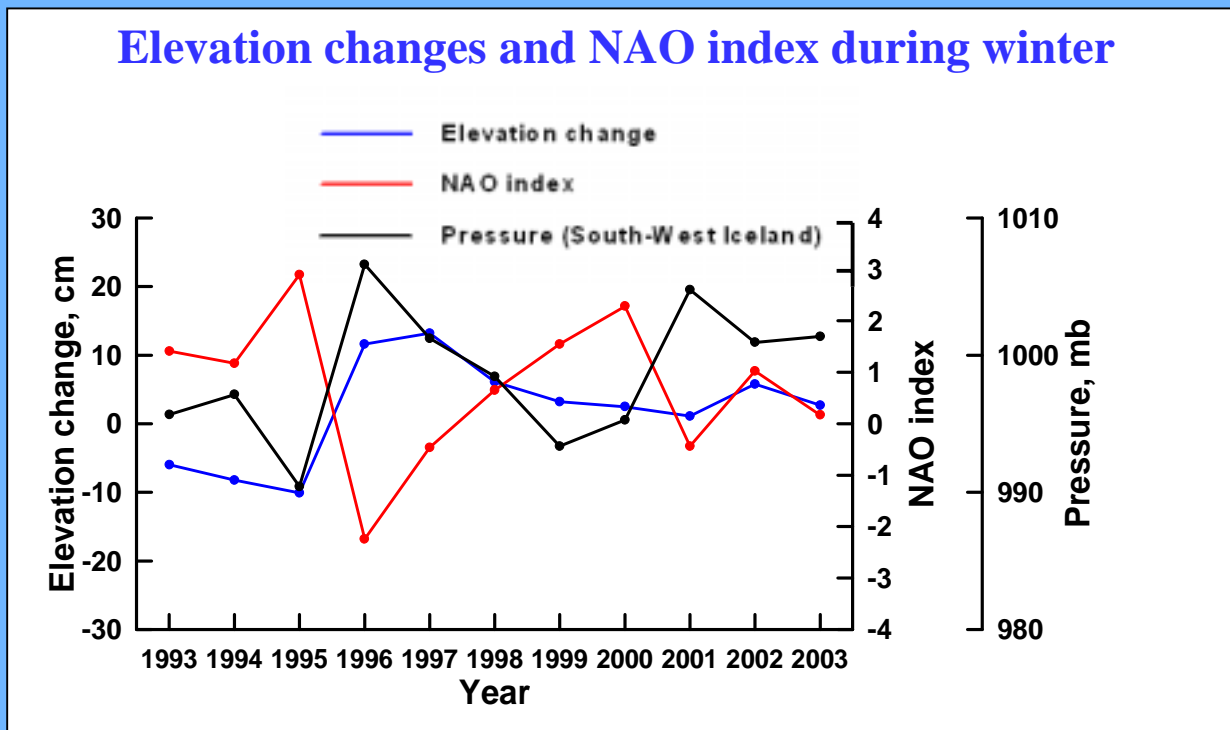
Seasonally averaged time series of elevation change



Annual changes of elevation and snow accumulation over higher parts of southern Greenland

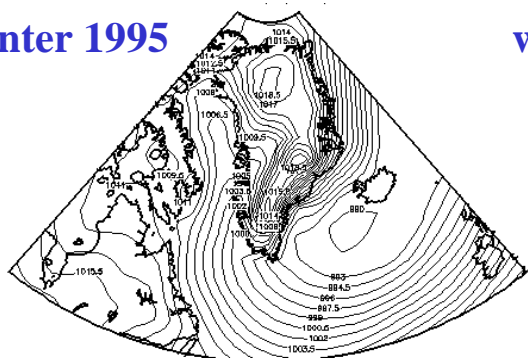


Seasonal changes of Greenland Ice Sheet elevation and their relationship with atmospheric circulation

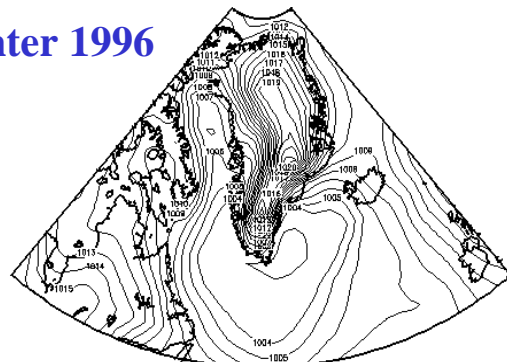


Seasonally mean sea level pressure fields

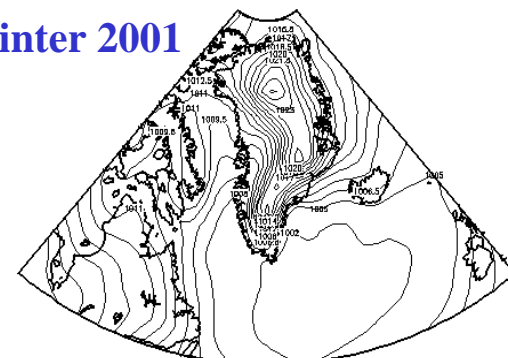
winter 1995



winter 1996



winter 2001



Conclusions

- ➔ **Spatially averaged rate of Greenland Ice Sheet elevation changes over 1992-2003 is assessed at 5.4 ± 0.2 cm/year (ice thickness change ~ 5 cm/year if adjusted for isostatic uplift)**
- ➔ **Elevation growth is indicated over most of interior regions, while over margin areas ice sheet thinning is revealed.**
- ➔ **South areas are characterized by rapid change of elevation change rate in 1995, and over northern part growing with stable rate was observed**
- ➔ **Interannual elevation changes are in accord with data on snow accumulation in Greenland**
- ➔ **Location of Icelandic low pressure is an important factor of Greenland Ice Sheet elevation change mostly pronounced in winter**