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Top-level Research Initiative

SVALI

Monitoring the Accelerating Mass Loss of Arctic Glaciers

Stability and **V**ariations of **A**rctic **L**and **I**ce (SVALI)
Nordic Center of Excellence

Top-level Research Initiative:
Interaction between Climate Change and the Cryosphere

18 Nordic partners, 2011–2016

René Forsberg
National Space Institute, Technical University of Denmark (DTU-Space)

Jon Ove Hagen, project leader
Department of Geosciences, University of Oslo, Norway

Tómas Jóhannesson, co-project leader
Icelandic Meteorological Office, Iceland

www.ncoe-svali.org

SVALI focuses on the area around the North Atlantic
Greenland, Iceland, Scandinavia, Svalbard

Image from Jyrki Hokkanen @csc.fi

Glaciers in the Nordic countries

- Range in size from **small mountain glaciers**, through the **intermediate-size ice caps of Svalbard and Iceland** to the **Greenland Ice Sheet**, the second largest body of ice on Earth
- Many are easily accessible for studying processes that are important for the global response of the cryosphere to climate changes
- **Large settled areas in the Nordic countries are affected by climate-change induced variations in glaciers**

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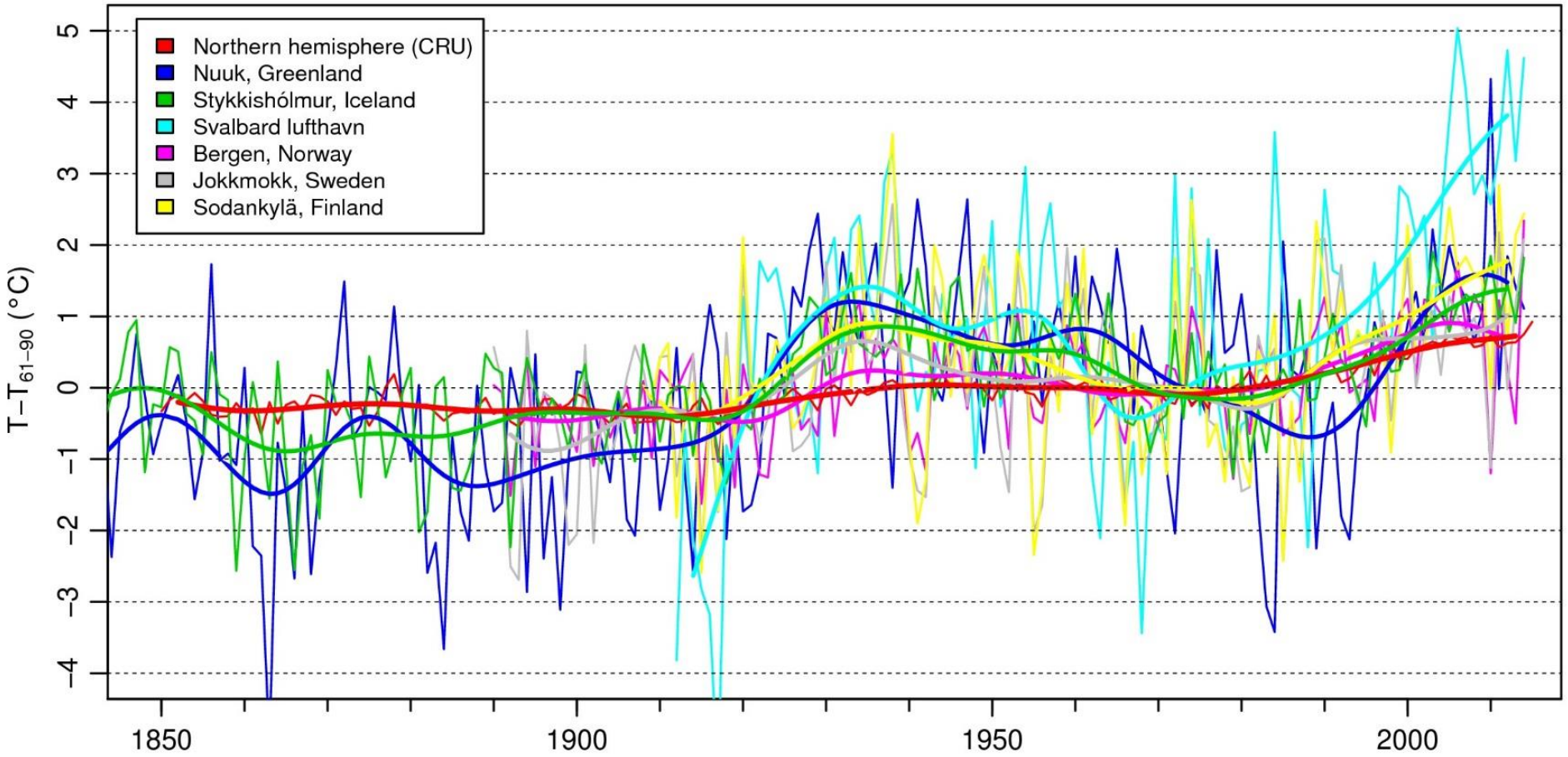
The climate in the Nordic area is characterized by large variations in temperature



Glaciers are sensitive indicators of variations in climate

Langjökull, W-Iceland
Photo: O. Sigurðsson

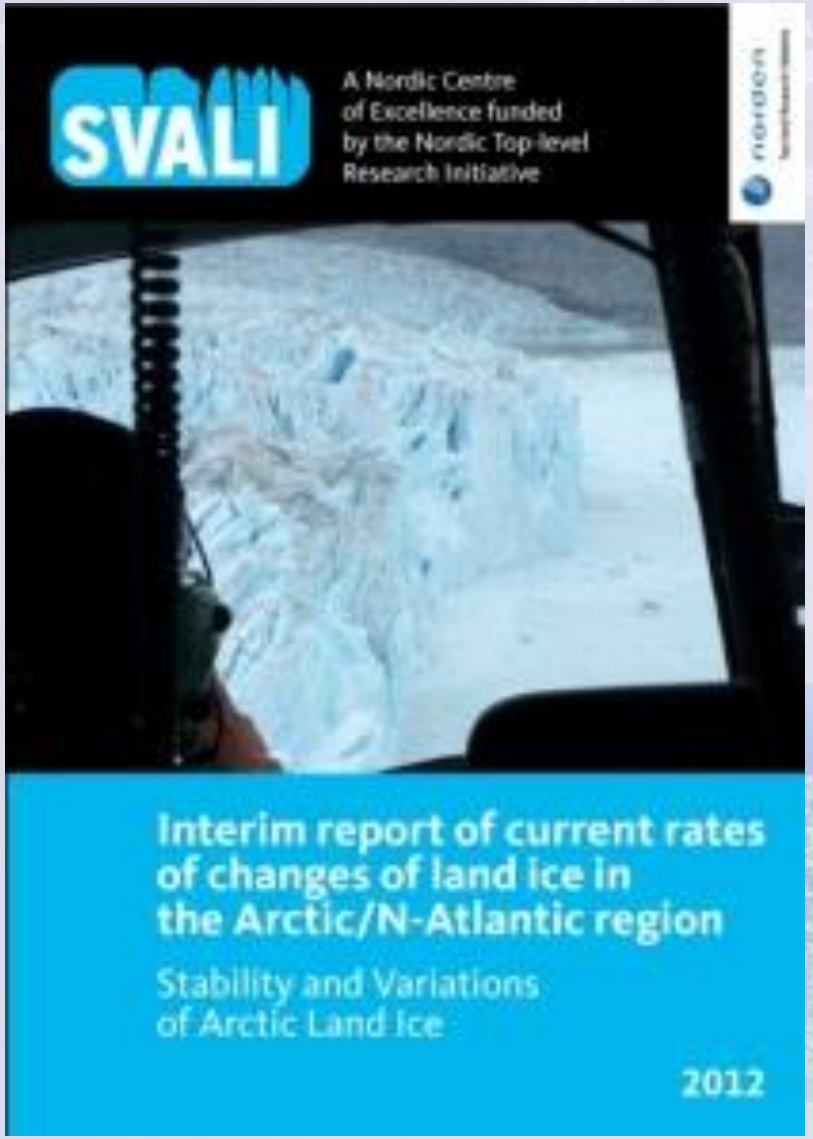
SVALI is based on three pillars

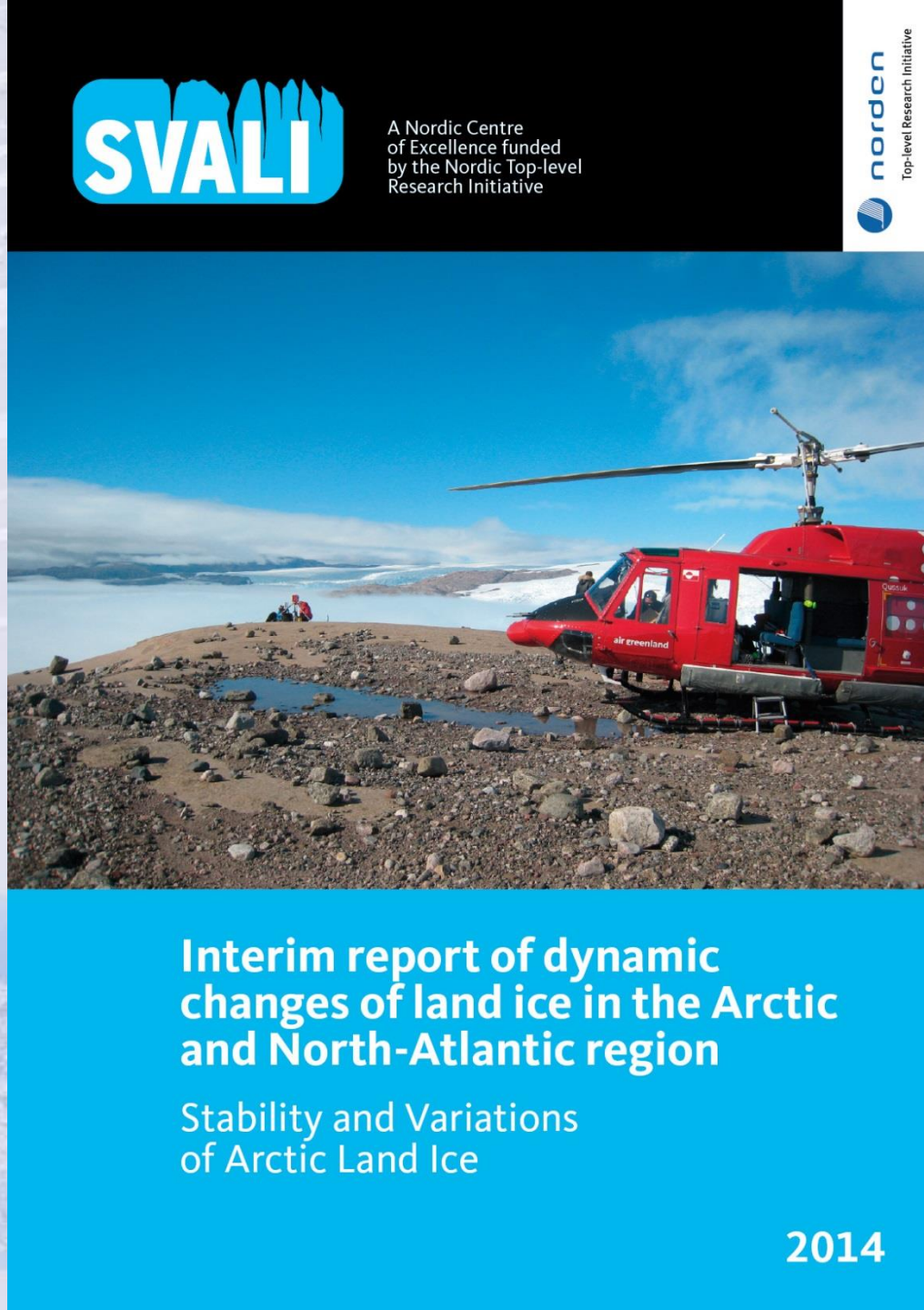
1. Science – cooperation between 19 Nordic universities and research institutes
2. Education – PhD school
3. Outreach

Science Themes

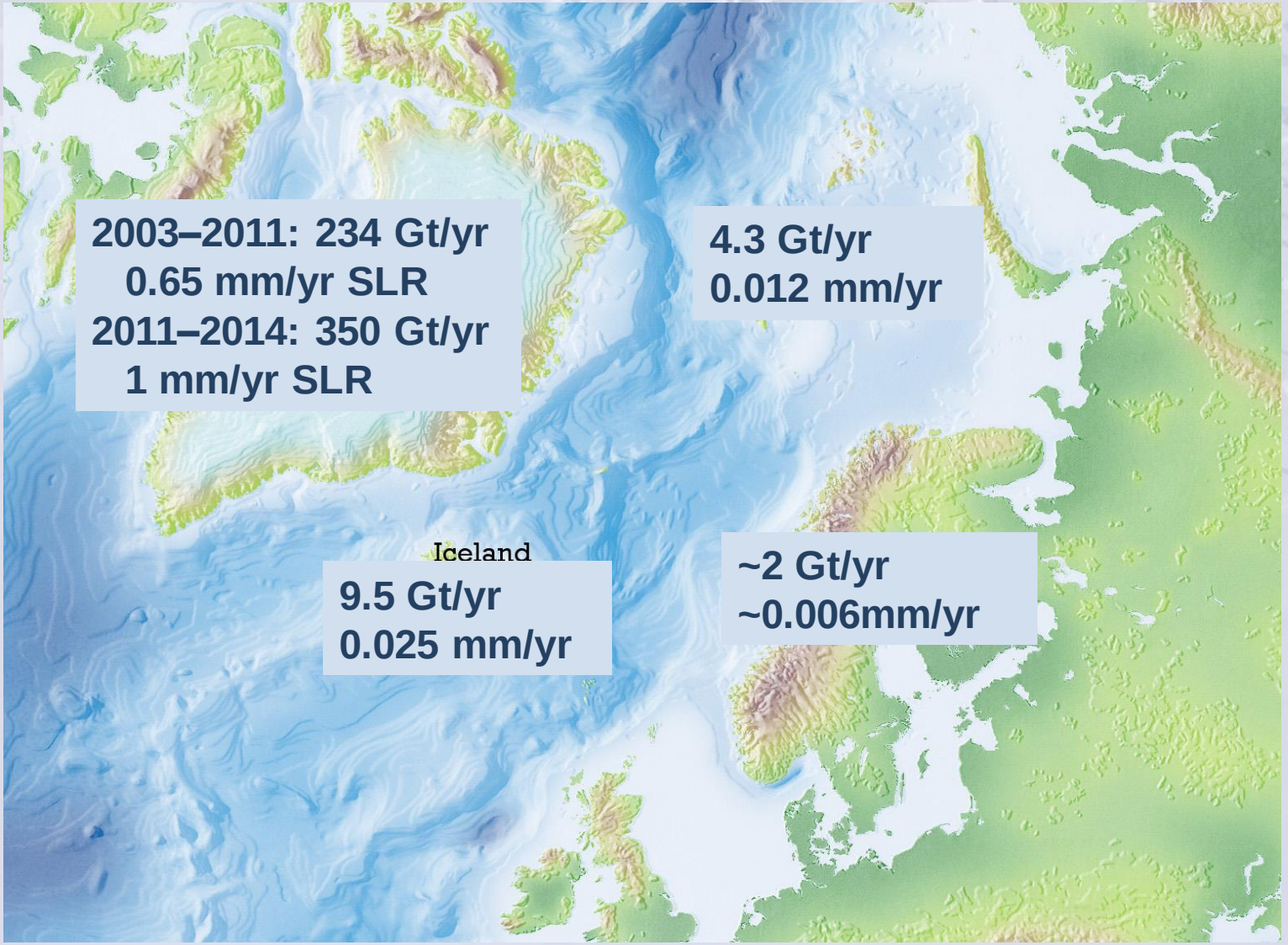
1. **Observing the present – baseline and changes**
   - Ice volume / mass changes
   - Changes in ice dynamics
   - Surface mass balance
2. **Understanding the physical processes**
   - Hydrology/subglacial processes
   - Calving
   - Surface/atmosphere interactions
3. **Understanding present changes and predicting the future**
   - Several different modelling approaches
   - Earth Systems Models
   - Future changes

SVALI Interim reports





Rate of ice loss after 2000



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Ice volume/mass changes: Development of improved algorithms for processing of satellite remote sensing data

Greenland Ice Sheet
2010–2014

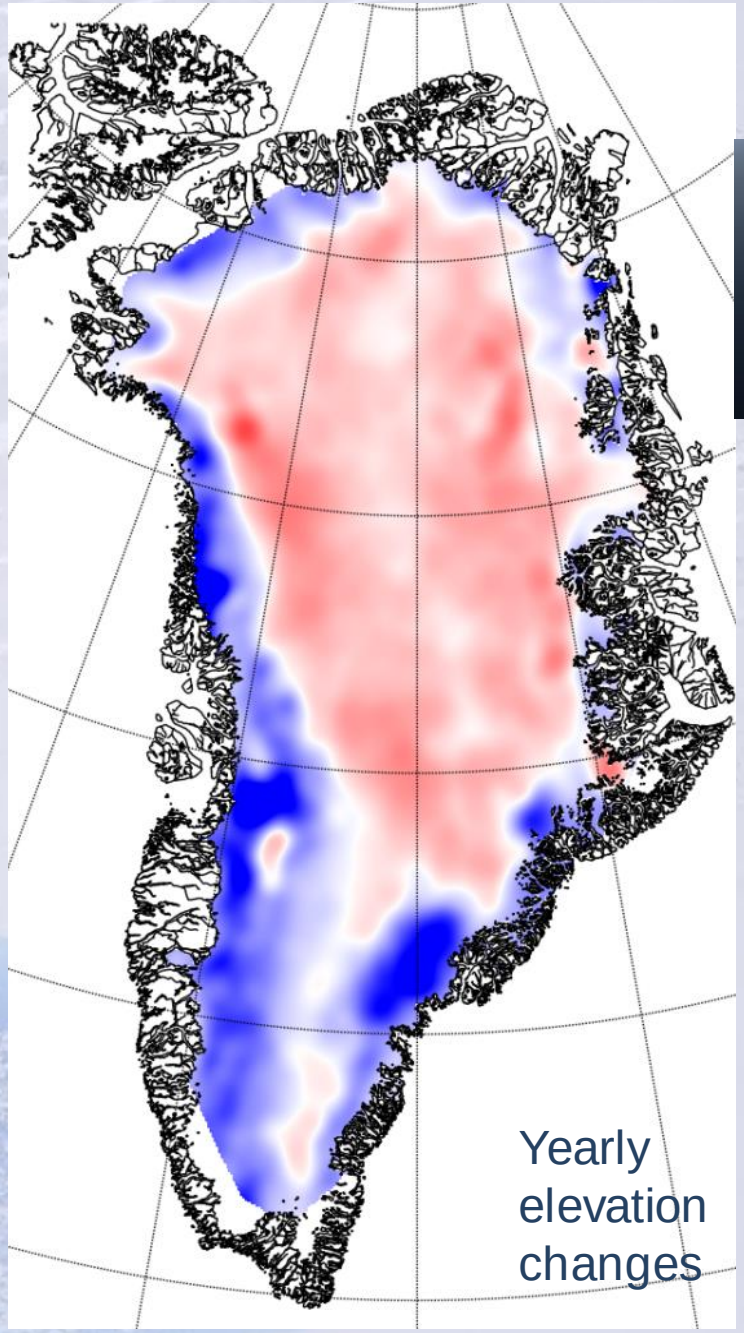
CryoSat-2 dH/dt

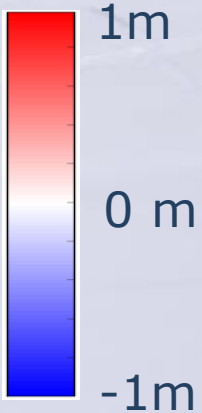
$$\delta V = \int_A \delta h / \delta t$$

$\Delta M = \partial V/\partial t * \rho$

$\Delta M = -240 \pm 28$ Gt/yr

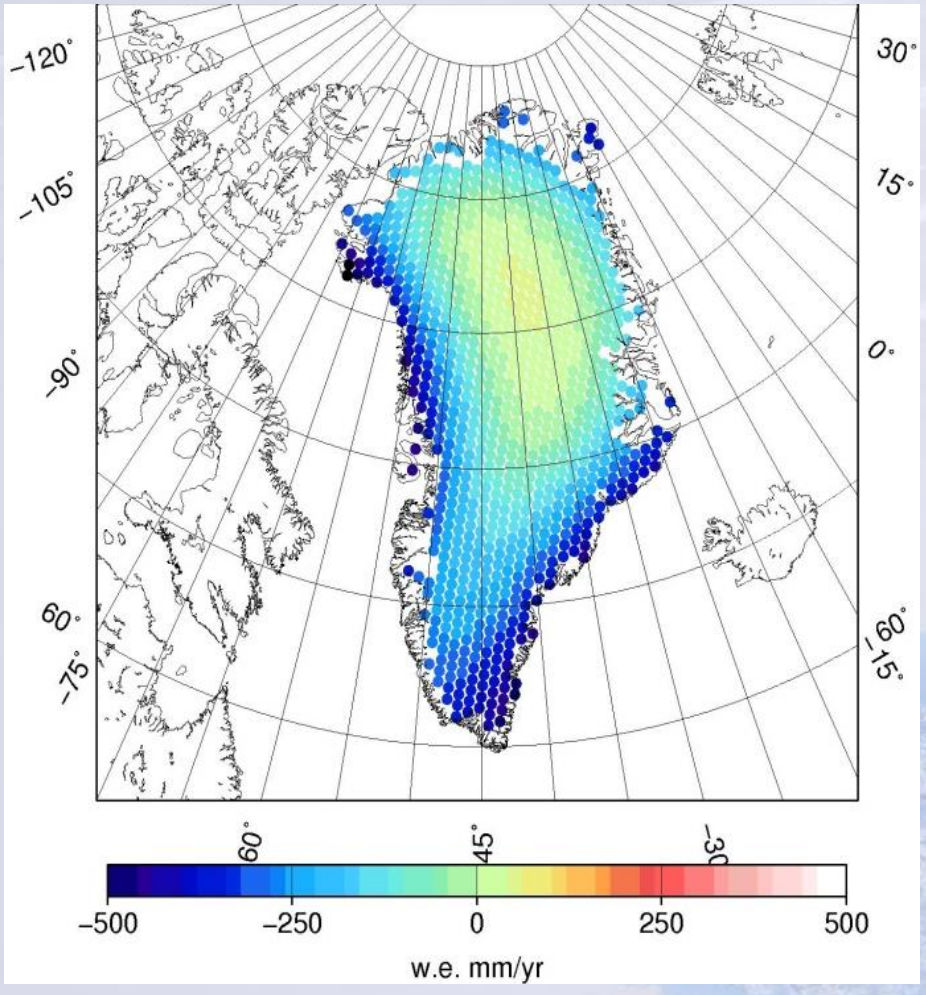
or 0,66 mm SLR/yr

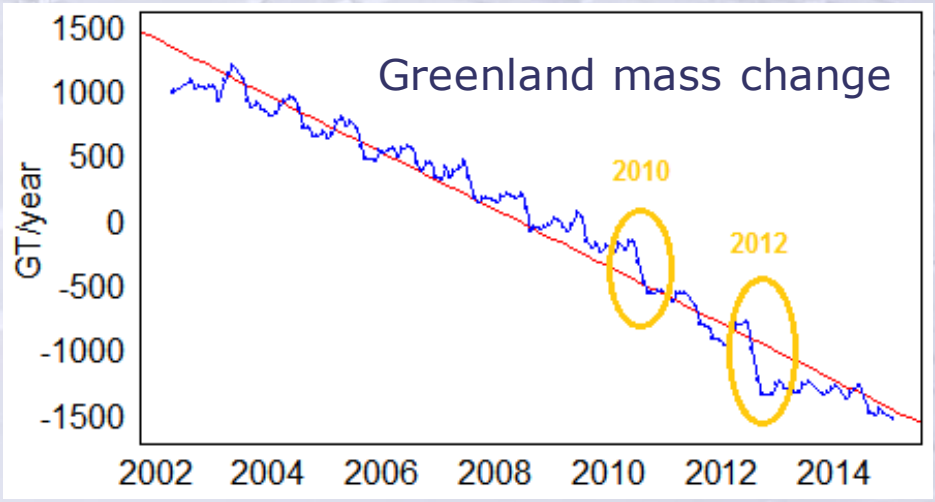




Johan Nilsson, PhD, DTU-Space

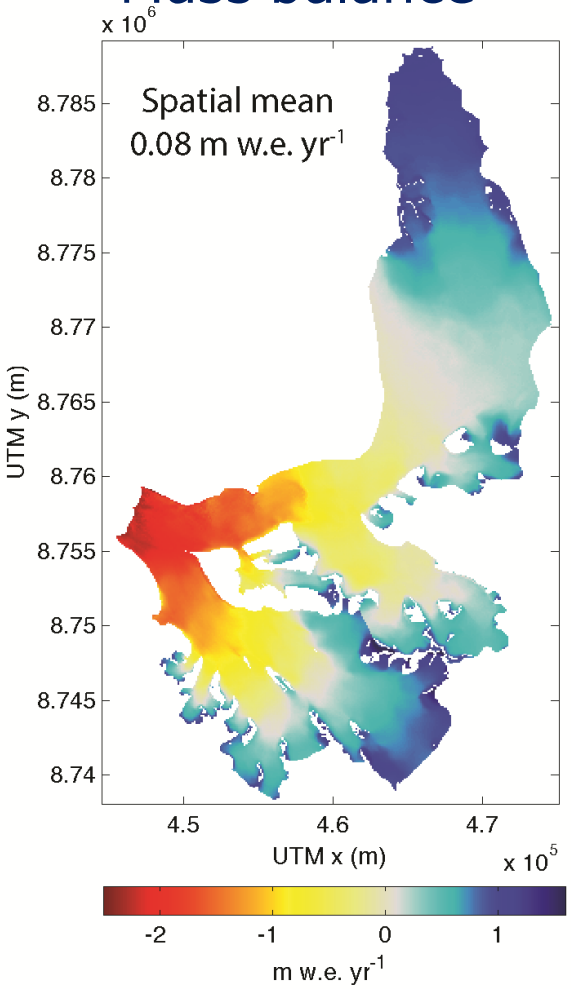
Ice mass changes: Direct measurement by the GRACE satellite mission (DTU Space)



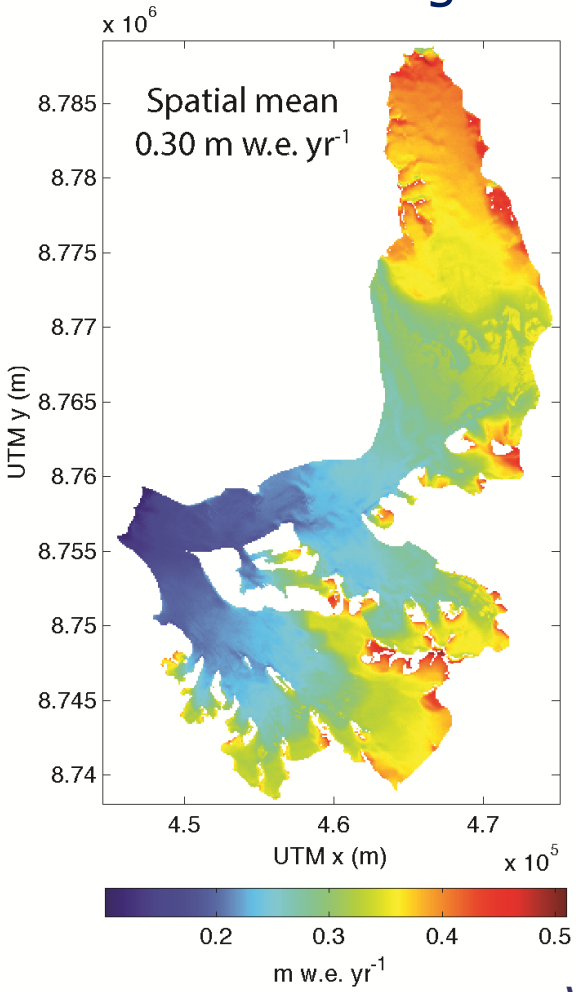


Study of mass balance components
Svalbard, Kongsbreen
1961–2012 mean

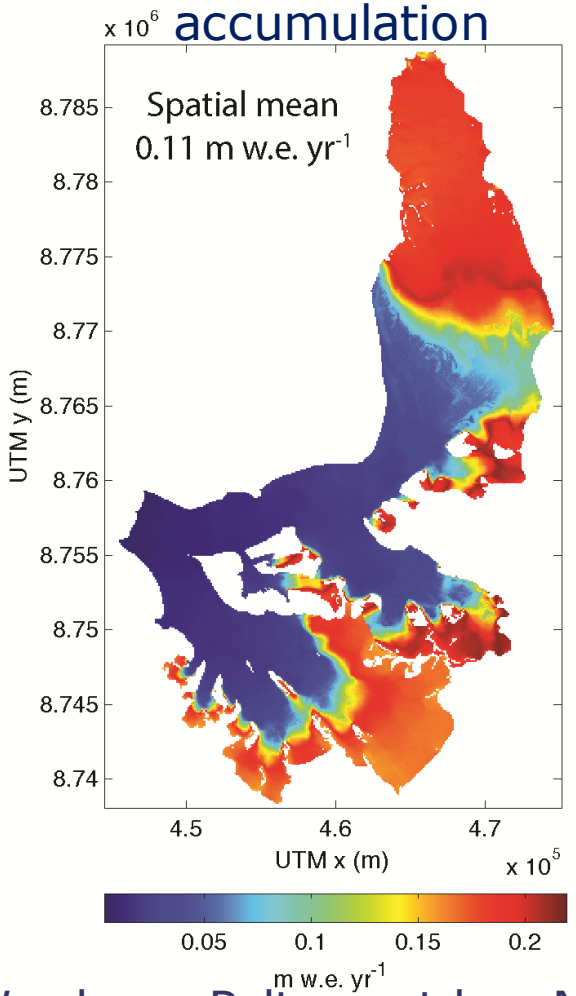
Mass balance



Refreezing



Internal accumulation



Ward van Pelt, postdoc, NPI

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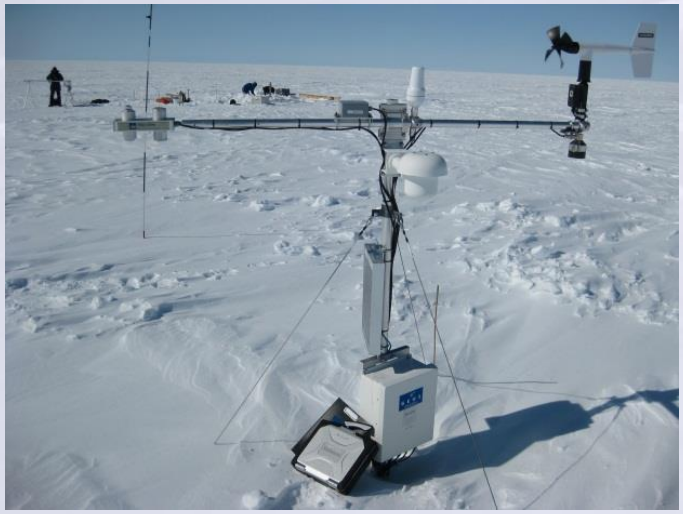
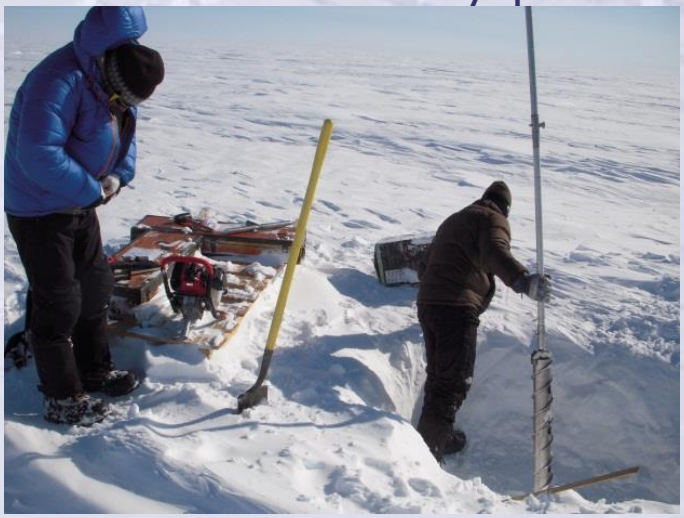
SPLAZ – SVALI field campaign

Automatic weather station for melt modelling



Firn cores for density profiles

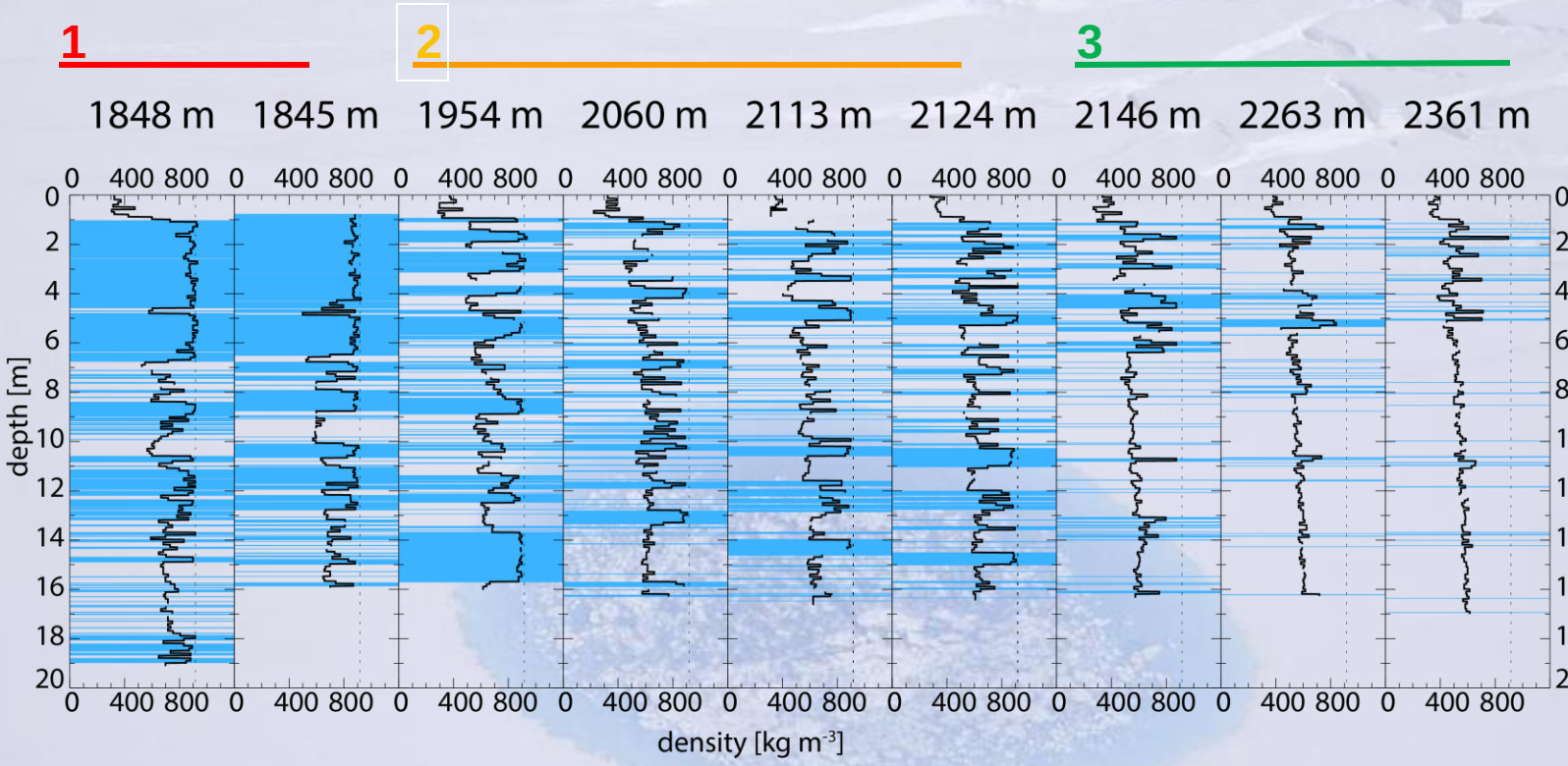


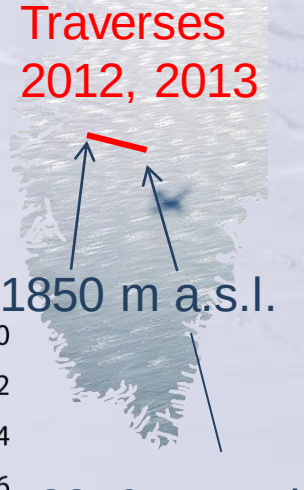
Snow pits for accumulation

Firn core for studying refreezing

Melt water retention on the Greenland ice sheet

- *Retention in firn limits runoff and is one of the least understood components of surface mass balance*
- *Impermeable layers / deep percolation / shallow percolation*





Horst Machguth, postdoc, ARTEK

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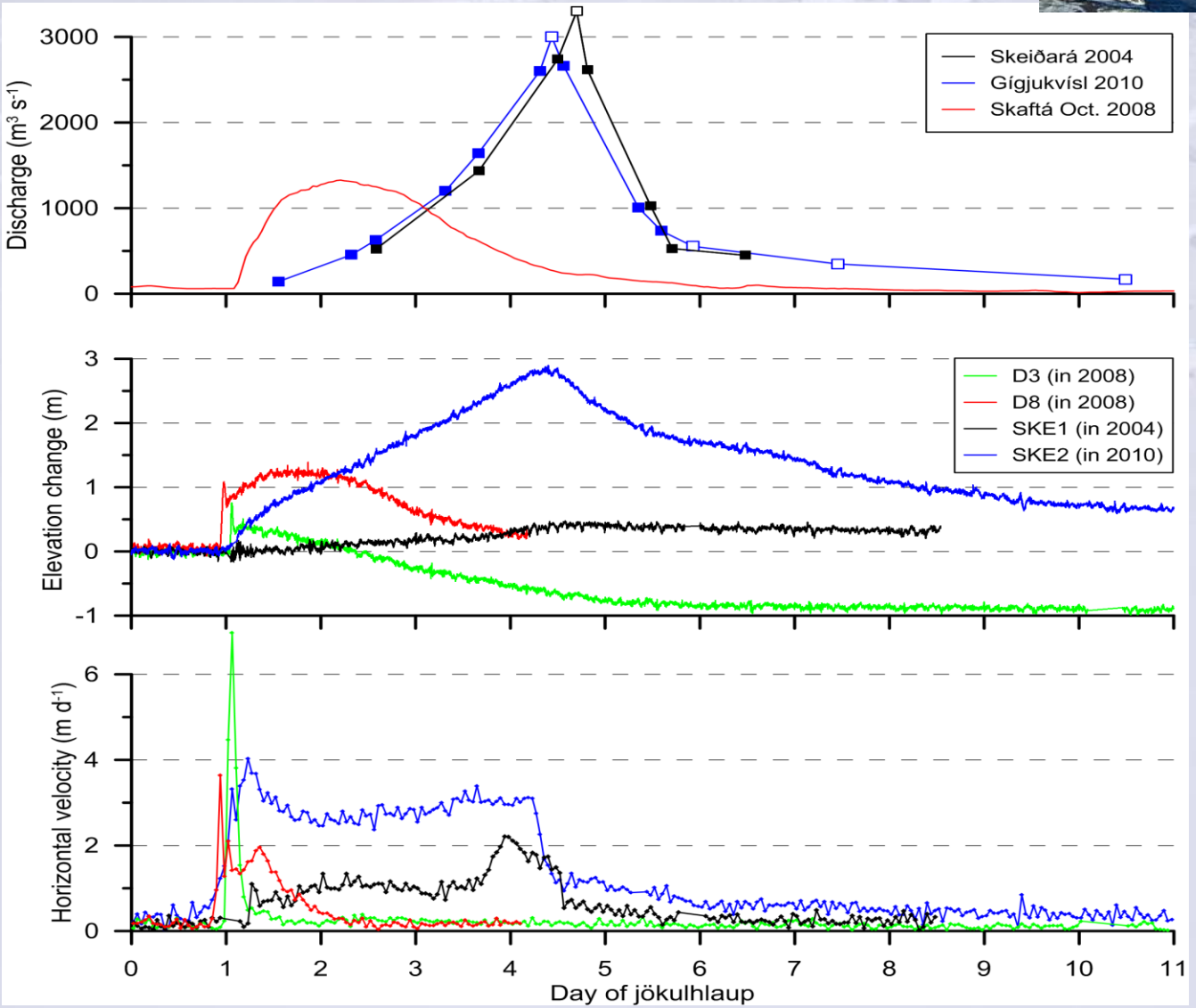
Effect of jökulhlaups in Iceland on glacier motion measured with GPS



From B. Einarson, IMO, and E. Magnússon, UI

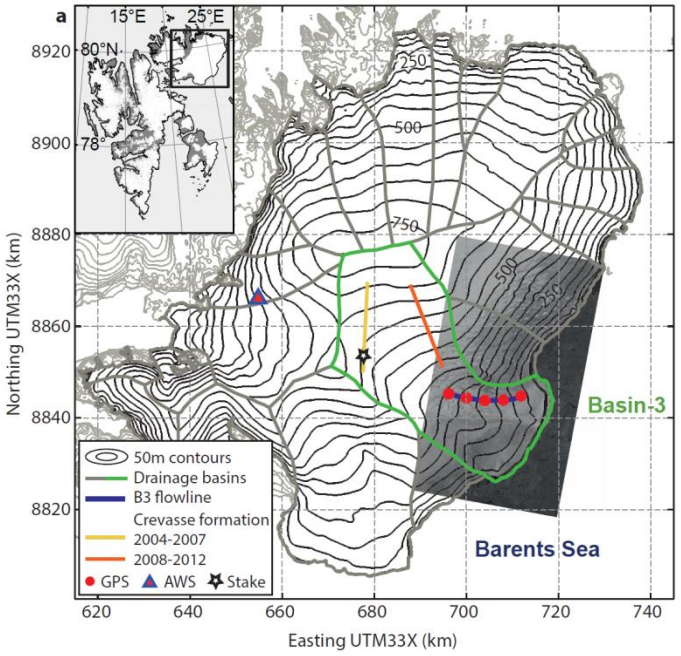
Model improvements

Improve the underlying physical processes

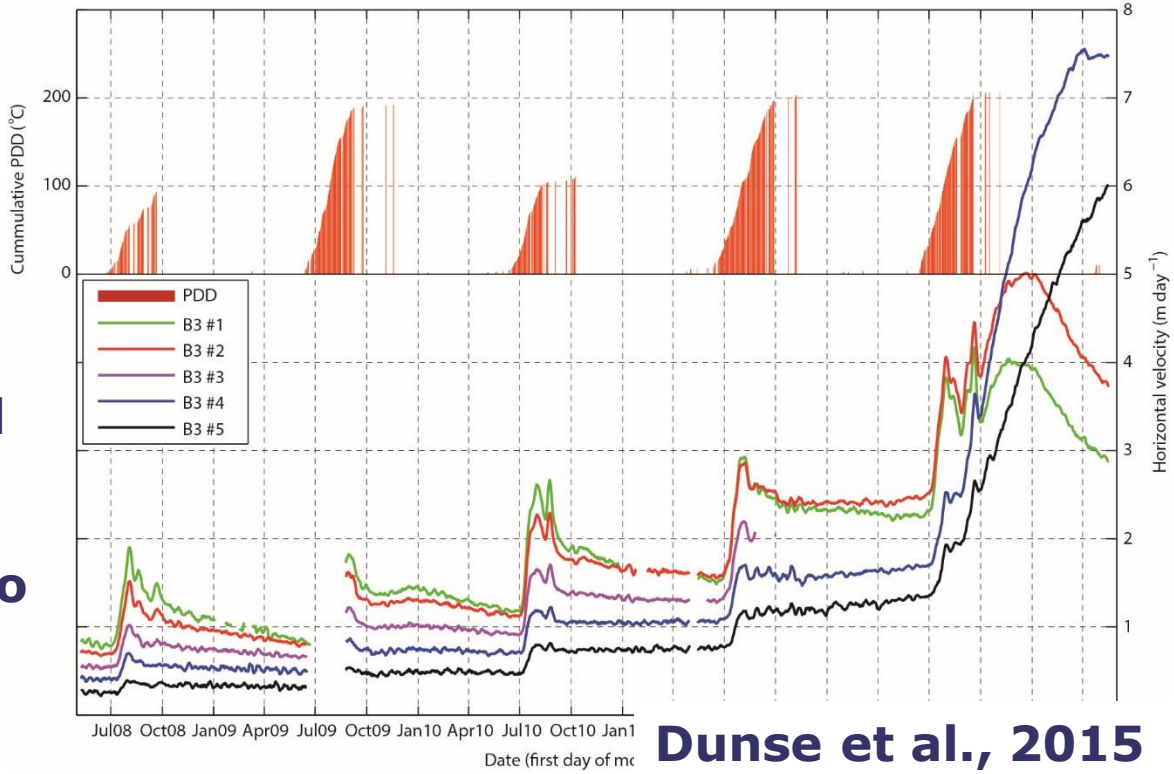
DMI, ARTEK, GEUS, UU, FMI, UH,UL, UI

- **Albedo**
  - Sensitivity tests and updates
  - Implementation of updated albedo scheme in HIRHAM5
  - Snow albedo study in WRF.
- **Water retention**
  - Implement results from measurements
  - Implementation and testing of retention and refreezing in HIRHAM5
  - Evaluation of refreezing parameterization in RCMs.
- **Model comparisons**
  - HIRHAM5 Regional Climate Modelling (P-T): Greenl. and Svalb.at 5km
  - HIRHAM model, ESM EC-Earth, RACMO model at IMAU (Netherlands)

Understanding dynamics is crucial to constrain uncertainties in projections



- Surge initiation of Basin-3, Austfonna, observed by GPS (and satellite radar)
  - annual summer melt drives multi-annual stepwise acceleration

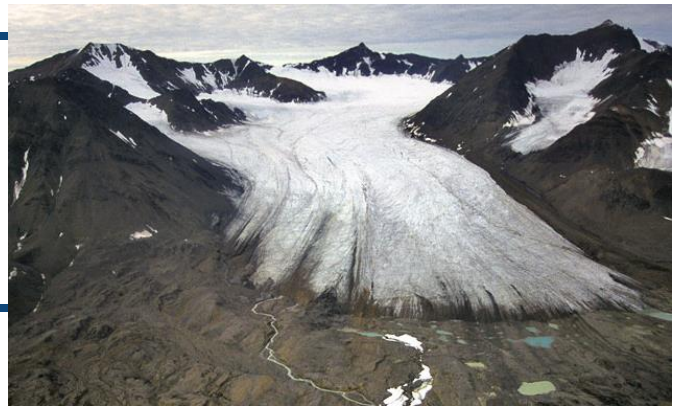


Meltwater effects not limited to hydraulic lubrication

➢ **cryo-hydrologic warming contributes to thermal regulation of Basin-3 surge**

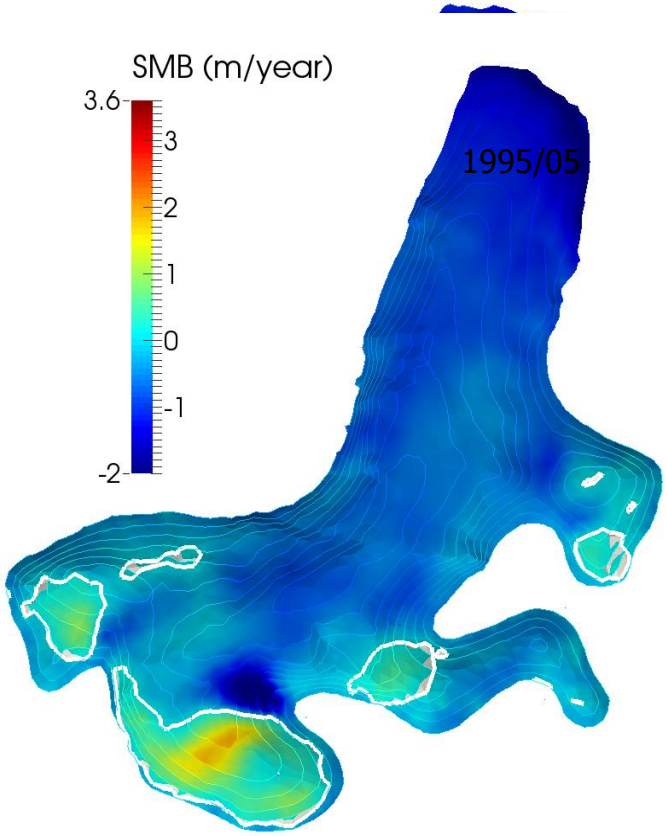
Dunse et al., 2015

Midtre Lovénbreen, Svalbard



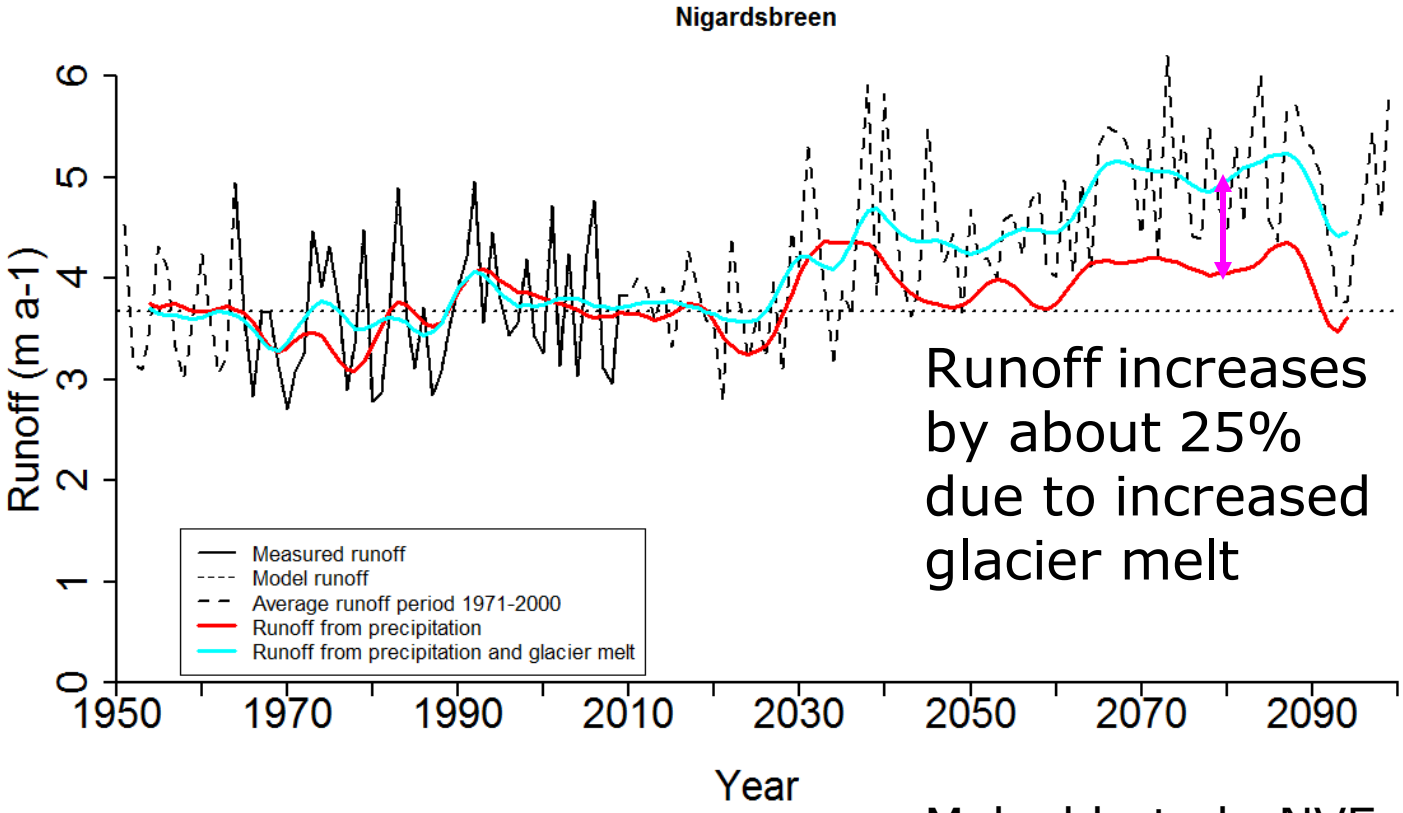
- Elmer/Ice full Stokes prognostic simulation (Zwinger & Moore, 2009)
  - Starting from 1977 DEM + 53 years
  - Conservative SMB forcing: averaged stake measurements 1968 – 2002 (Kohl et al. 2002)
  - Temperature field 1977 steady state conditions (Wadham & Nuttall, 2002)
  - Accounting for refreezing using a P_{max} model (Wright et al., 2007)
- Current investigation (I. Välisuo, FMI):
  - diagnostic simulations using average of 2 DEM's to obtain $\frac{\partial h}{\partial t}$, h, $\frac{\partial h}{\partial x}$, $\frac{\partial h}{\partial y}$, (u, v, w)
  - Inversely obtaining SMB

$$\mathrm{SMB} = \left(\frac{\partial h}{\partial t} + u\frac{\partial h}{\partial x} + v\frac{\partial h}{\partial y} - w \right)$$



Runoff changes for Nigardsbreen, Norway

In 2100 glacier area is reduced by 70%

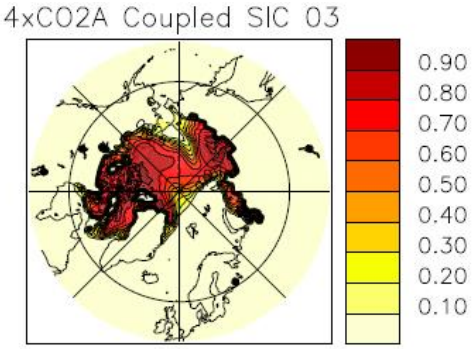


Runoff increases by about 25% due to increased glacier melt

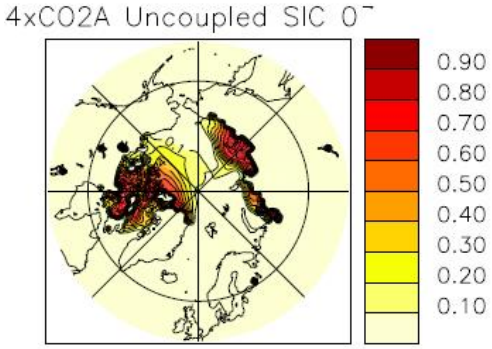
Melvold et al., NVE

Important to include a dynamic ice Sheet in Earth System Models

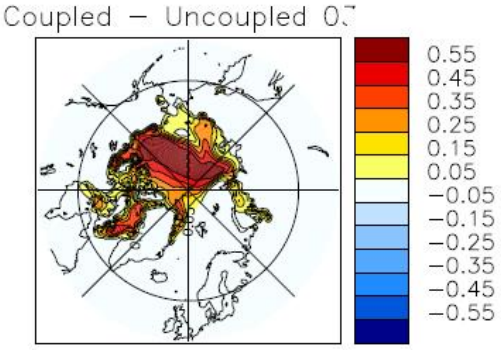
EC-EARTH – PISM



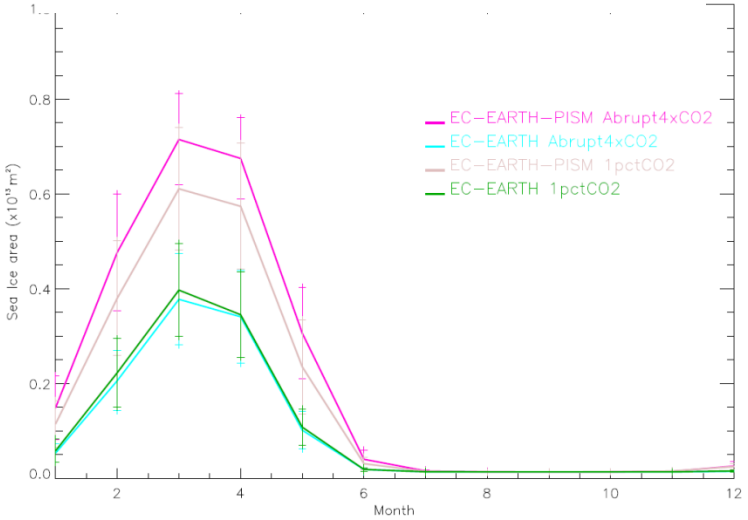
EC-EARTH



EC-EARTH – PISM
minus
EC-EARTH

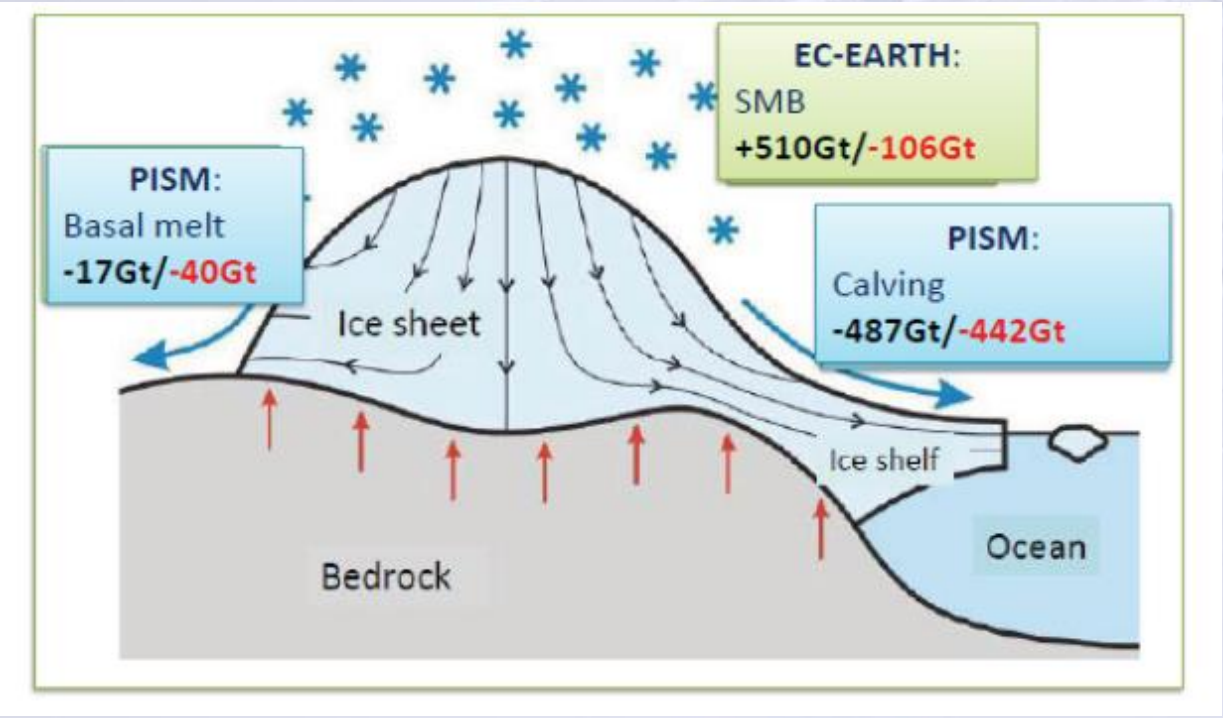


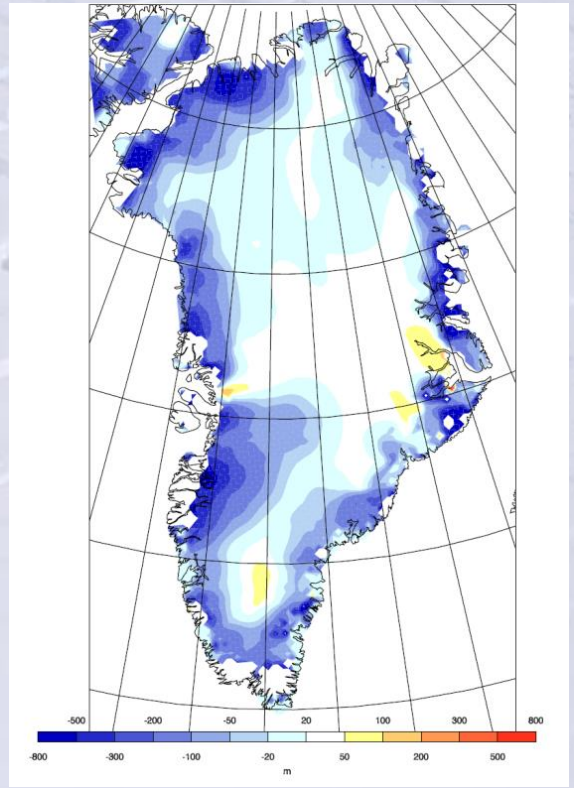
Seasonal variability in sea ice



In the uncoupled model the winter sea is much less in a warmer scenario

EC–Earth–PISM Mass Balance





- Pre-industrial conditions (**black**) ice volume is nearly constant.
- Abrupt4xCO2 (**red** numbers), the surface melt increases more than the precipitation
- 1% /yr to 4xCO2

- Maximum ice losses at the margins (up to 500m).
- Ice thickness increases in some areas (more P)

Madsen et al, DMI

The SVALI Graduate School

http://ncoe-svali.org/phd_school

- 10 PhD students and 7 Pos.docs paid by SVALI. + 14 associated PhD-students PhD courses
- 17 joint SVALI PhD-courses are listed in 2013/2014
- Workshops, Summer schools and special courses
- The PhD programme will exceed the lifetime of SVALI. A Graduate School Agreement was signed by all 9 SVALI universities in 2013

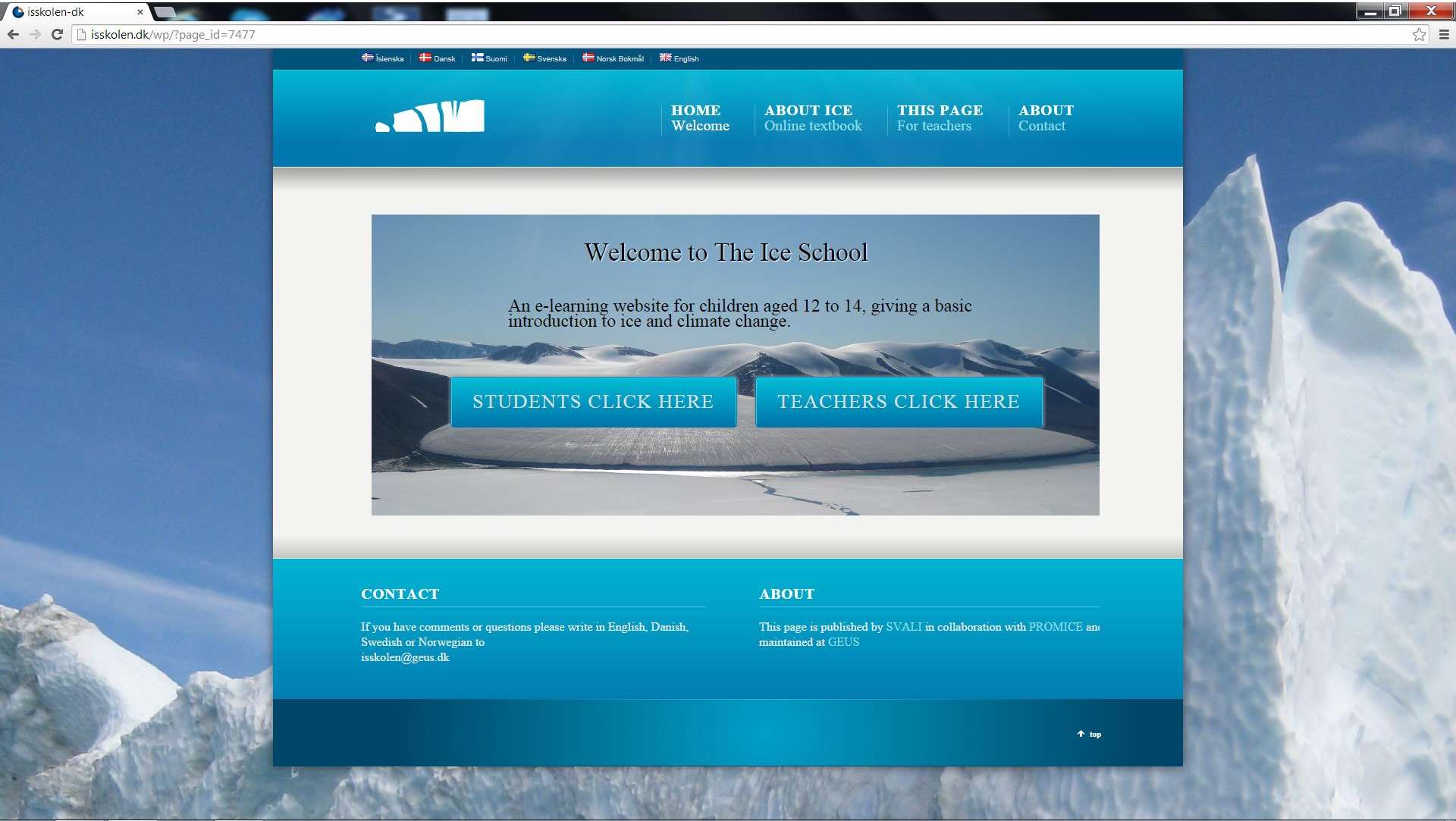
Outreach: The Global Cryosphere Watch

www.polarportal.org

Inform the public!

- Websites
- Social media
- Media contact
- Newsletters
- Press releases
- Talks

Outreach: Isskolen.dk/wp



Ice on land

You have probably heard about glaciers before. A glacier is a large volume of ice on land, but the word glacier is actually just one of many for ice on land.

This is Gigjökull, a glacier in Iceland. We will come back to Gigjökull in a moment…

We are now going to learn about the three most important forms of ice on land:

- Ice sheet
- Ice cap
- Glacier

NEXT

Jää kuivalla maalla

Olet varmaan kuullut jäätiköistä aiemminkin. Jäätikkö on suuri määrä jäätä kuivalla maalla, mutta jäätikkö on itse asiassa vain yksi monista termeistä, joilla jäämuodostumia kuivalla maalla kutsutaan.

Kuvassa on Gigjökull, jäätikkö Islannissa. Palaamme siihen tuota pikaa…

Opit kohta lisää kolmesta tärkeimmästä jäämuodostumasta kuivalla maalla. Ne ovat:

- Mannerjäätikkö
- Lakijäätikkö
- Jäätikkö

SEURAAVA

Ice-school

- E-learning to be used by the pupils in schools
- An introduction to glaciology
- Available in all Nordic languages, incl. Greenlandic, plus English, German and French
- Focusing on glaciers in the SVALI countries
- Interactive quiz based learning
- Meet the PhD students

Outreach:
Ilulissat Climate Days, June 2-5

Greenland Minister Mala Høy Kuko

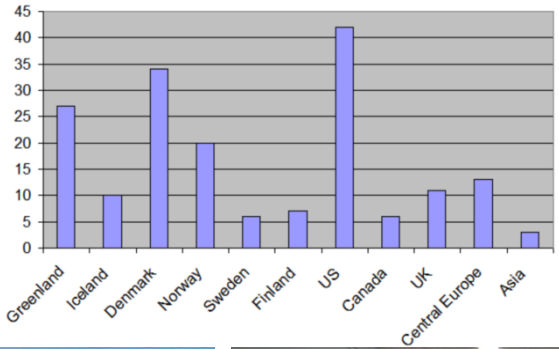
- Changes of the Greenland ice sheet (ice sheet, glacier and sea ice changes), and impact on society
- SVALI Nordic Center of Excellence – final conference

Attracted 180 scientists, ph.d. students, stakeholders …

http://www.polar.dtu.dk/english/Ilulissat-Climate-Days

Sessions:

- Cryosphere changes: Observations and Impact on Society
- Climate Change and Society
- Greenland, Arctic and Antarctic Ice Cap Changes
- Space Measurement of Cryosphere Changes
- Observations and Models
- Stability and Variations of Arctic Land Ice



Participant distribution (total: 179)

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The future of SVALI

1. SVALI will be continued as a network of Nordic institutes involved with cryosphere research and monitoring
2. The network will strengthen the international role of Nordic research in glaciology
3. The Nordic Graduate School in glaciology will be continued as a joint PhD program of the participating universities
4. The outreach ice-school will be maintained

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Thank you for listening