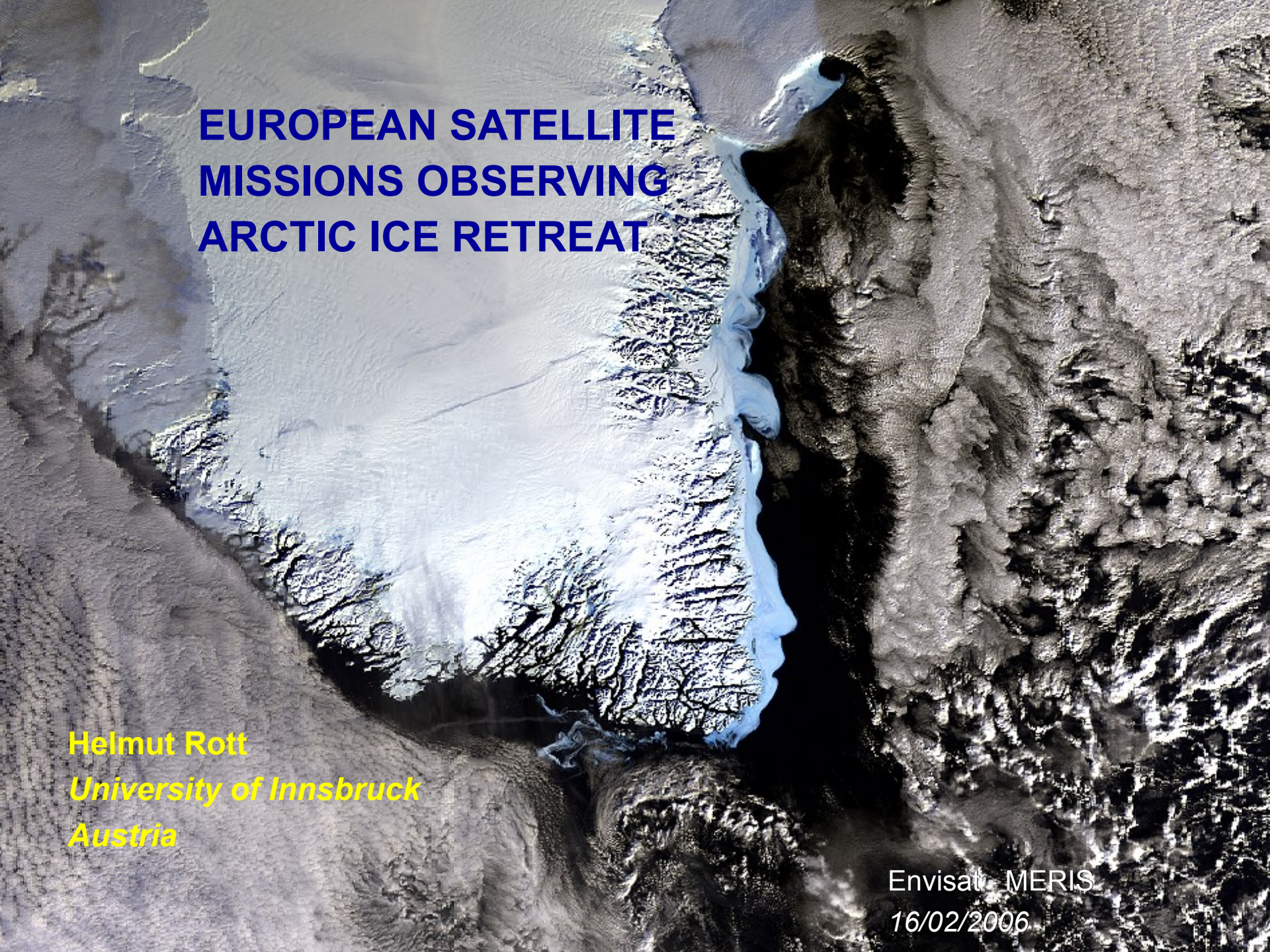
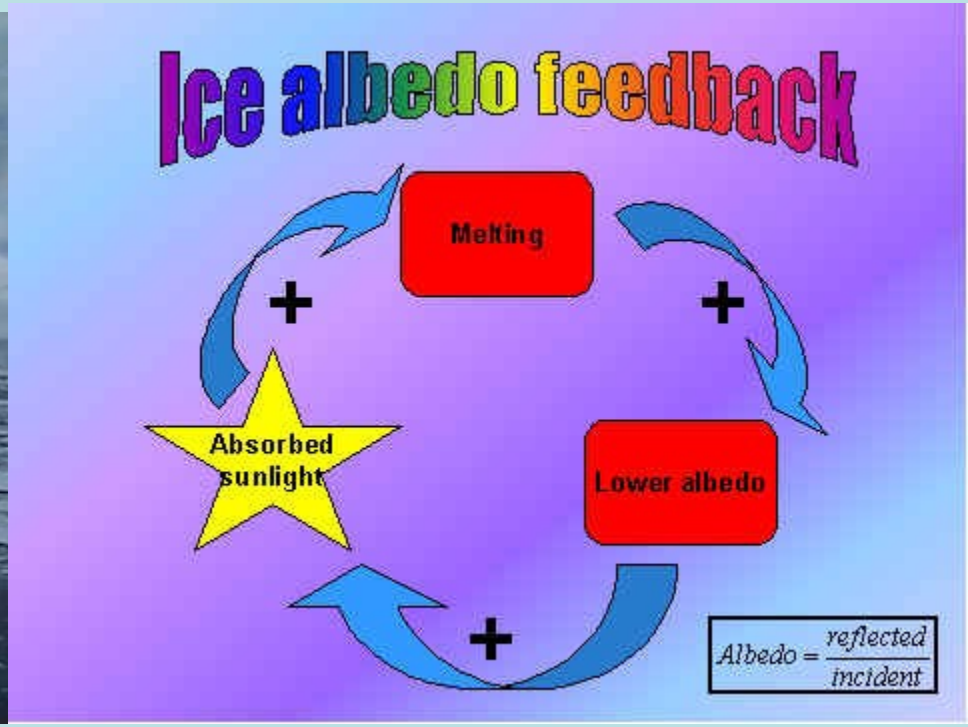
EUROPEAN SATELLITE MISSIONS OBSERVING ARCTIC ICE RETREAT

Helmut Rott
University of Innsbruck
Austria



Envisat MERIS
16/02/2006

The Role of Snow and Ice in the Global Climate System → Ice – Albedo Feedback Accelerates Warming



Positive Feedback – Accelerates Climate Change

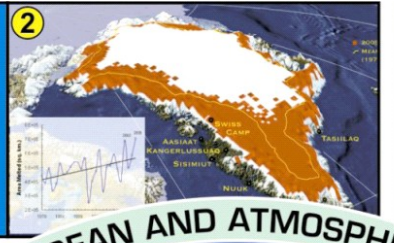
Decrease of snow, glacier, and sea ice areas → Increased absorption of solar radiation on the Earth's surface → Higher temperature → → Increased melting

Cryosphere Processes

Climate Change

SNOW COVER
Melting and retreating increases radiation absorption; a radiative feedback. Also large impacts on snow-based wildlife

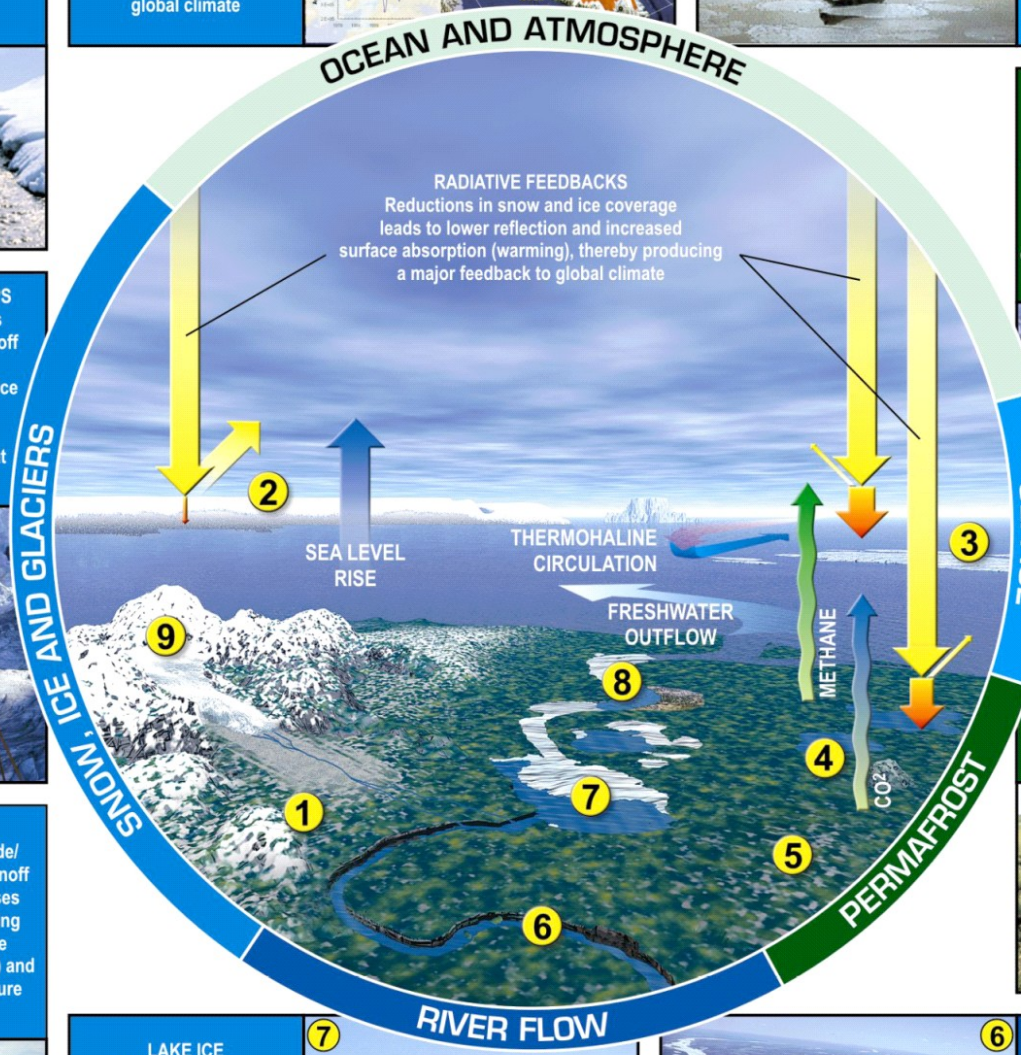
ICE SHEET
Melting of large ice sheets contributes to sea level rise and freshwater flux with potential effects on thermohaline circulation and global climate



SEA ICE
Retreating sea ice contributes to increased radiative absorption and the loss of habitat for mammals such as polar bears and seals

GLACIERS/ICE CAPS
Retreating glaciers initially increase runoff but lower flows eventually result as ice masses diminish. Impact example: reduced fish habitat and water supply

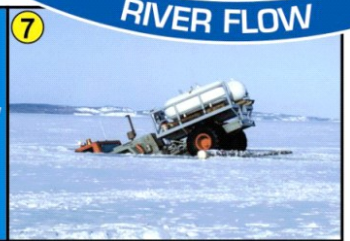
RIVER ICE
Changes in magnitude/ timing of snowmelt runoff and river-ice processes modify ice-jam flooding with related positive (e.g., aquatic recharge) and negative (infrastructure damage) impacts



TRACE GASES
With enhanced surface ponding as permafrost degrades, methane production increases. With wetland drying, CO^2 emissions increase as organic materials oxidize. Both processes can be significant climate feedbacks.

PERMAFROST
Thawing permafrost changes geomorphic/ geochemical processes and fluxes. Impact example: changes to flow systems and aquatic ecology

LAKE ICE
Shrinking ice cover produces numerous ecological impacts generally leading to greater productivity but can also affect surface transport

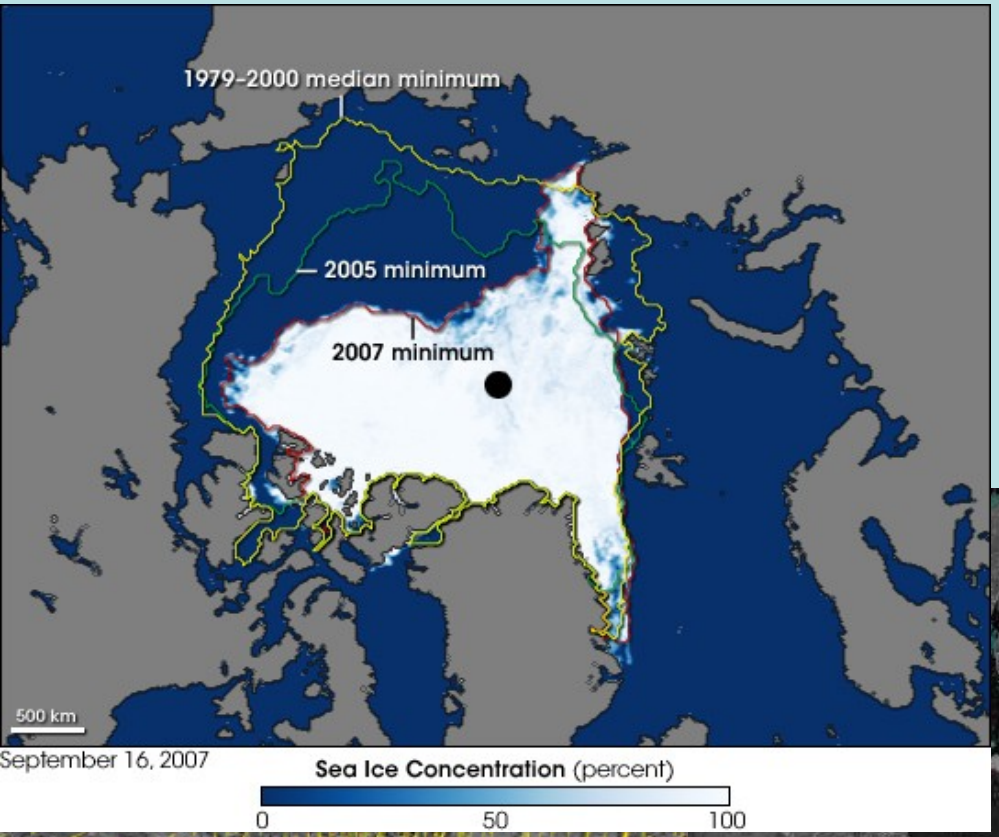


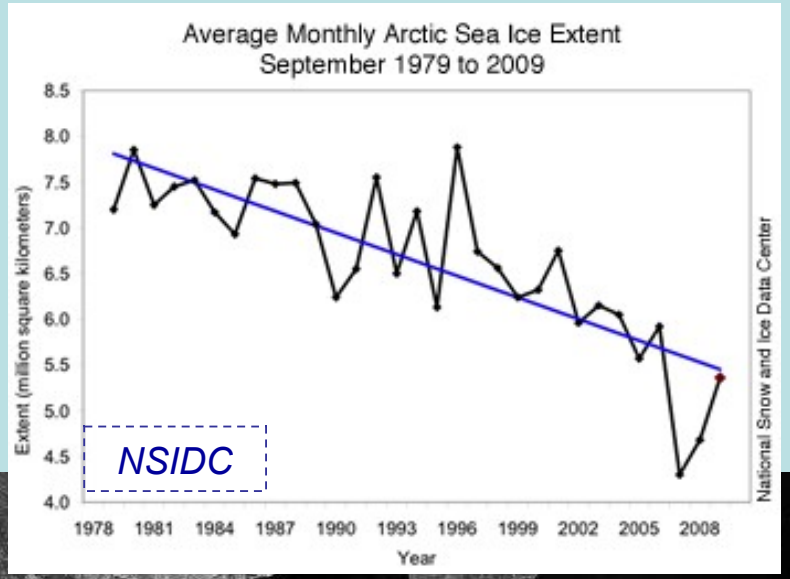
RIVER FLOW
Increasing precipitation plus melting snow & ice increases arctic river flow although summer flows may decrease with enhanced evaporation. Changes in freshwater flux may affect thermohaline circulation and global climate

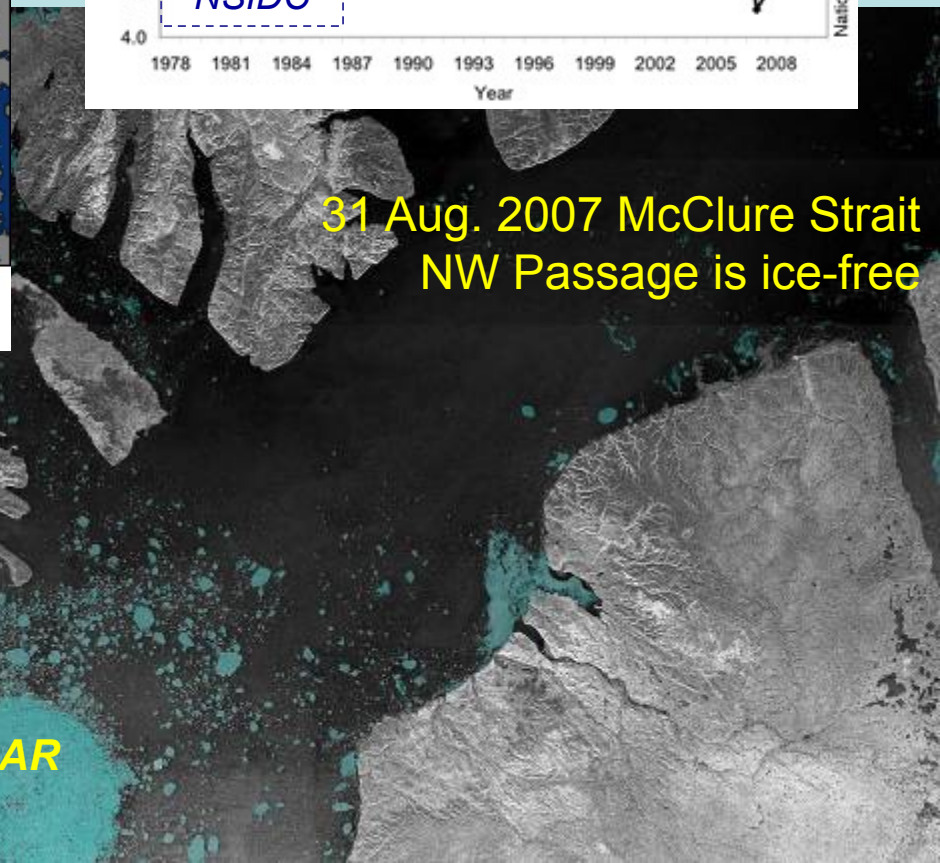
Euro

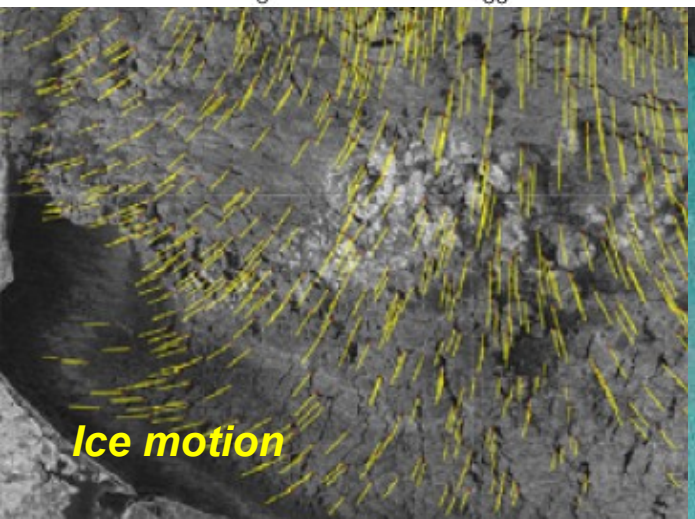
WCRP·SCAR·IASC CliC

Arctic Ocean: Strong Decrease in Sea Ice Area

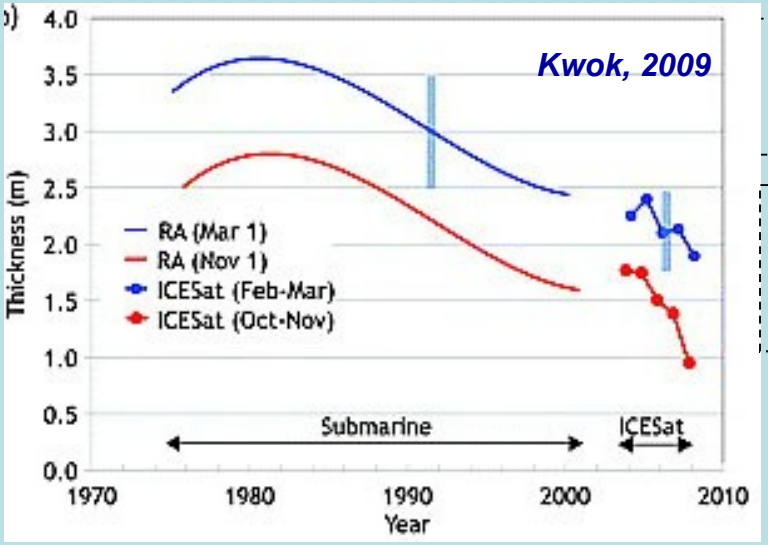






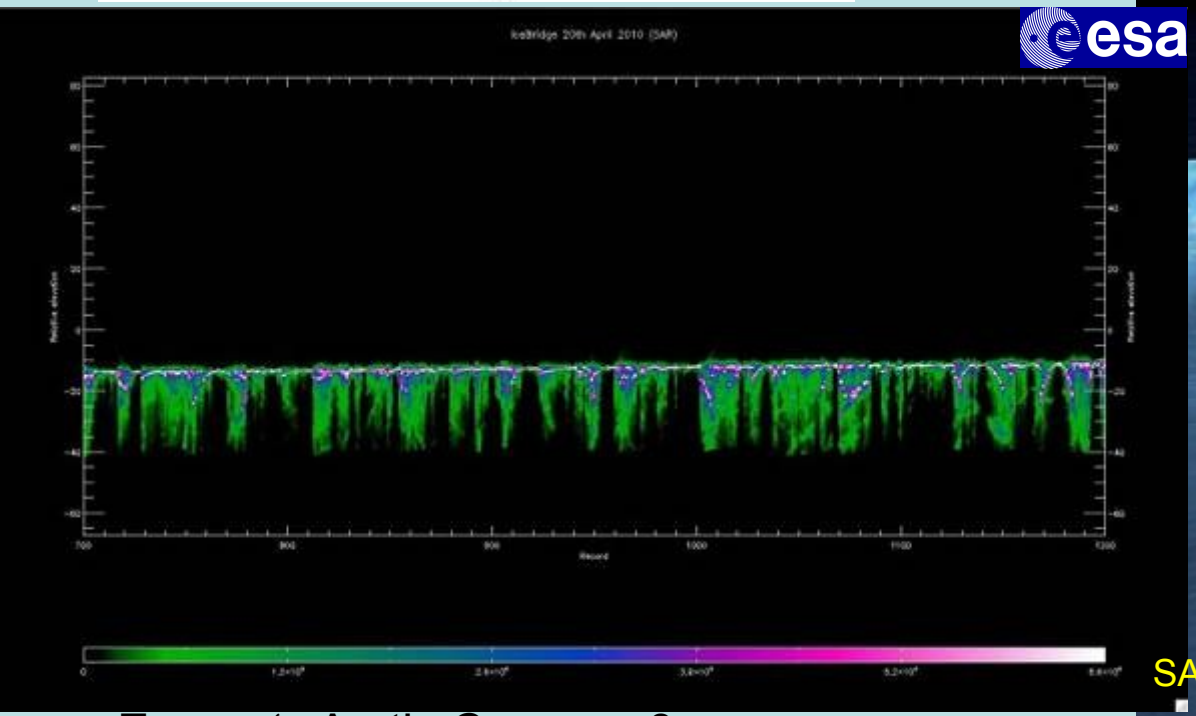


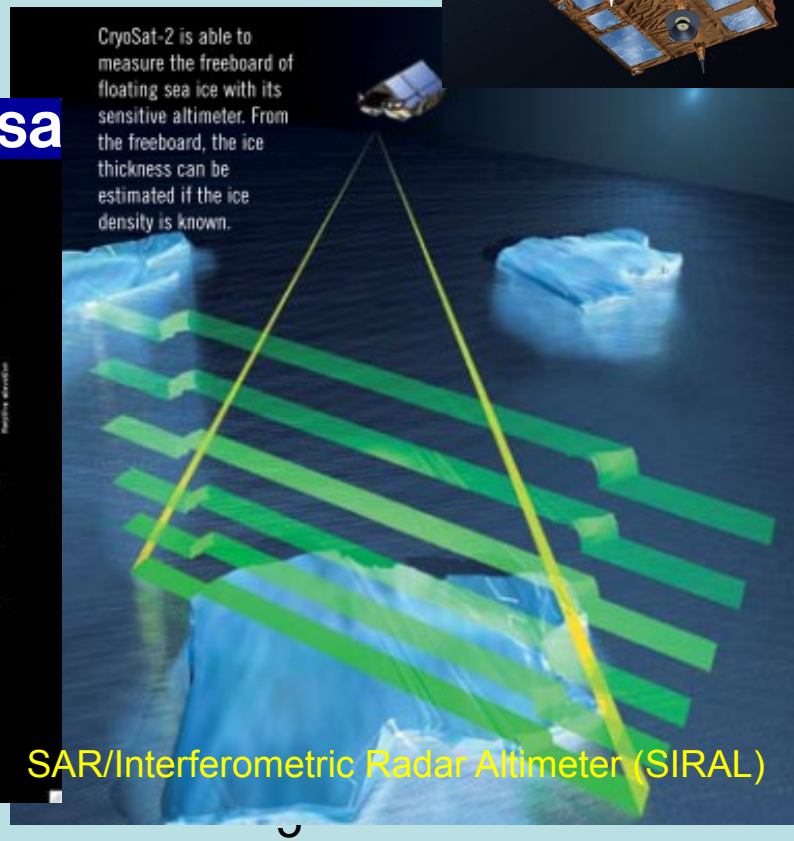
Arctic Ocean: Decrease in Sea Ice Thickness



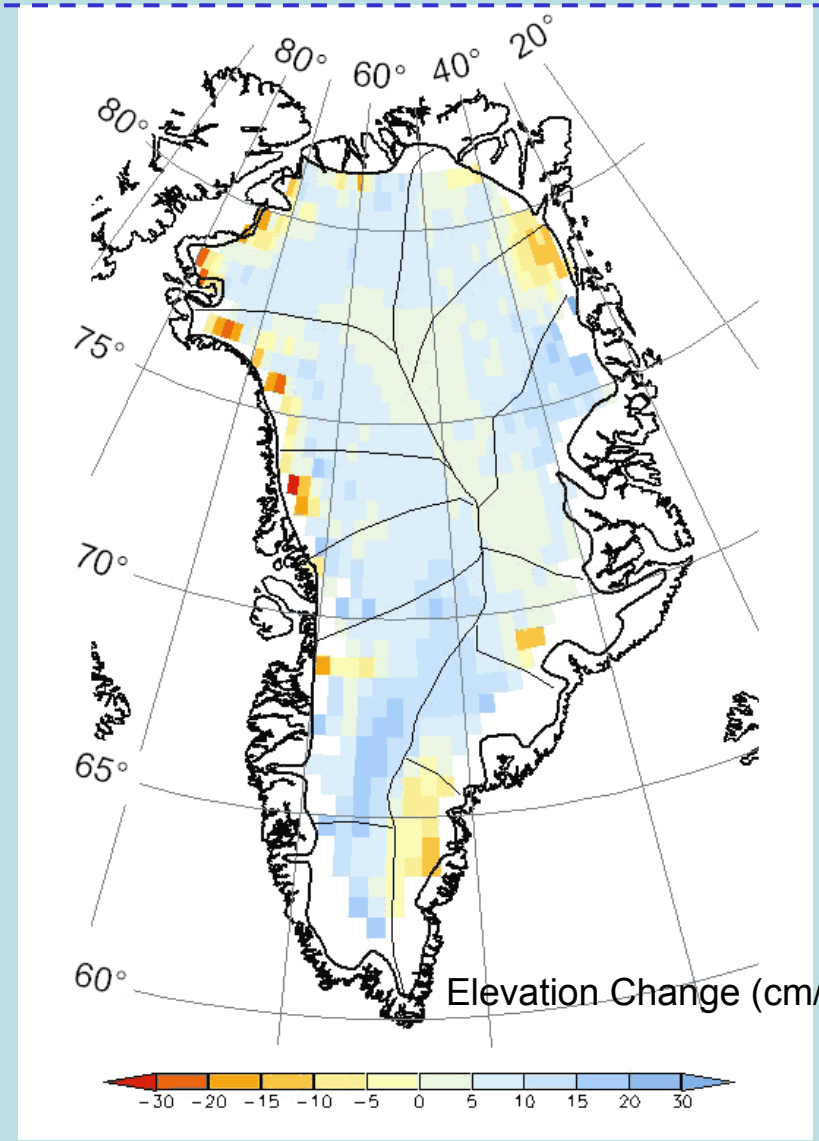
←Decrease in mean thickness
1978 (Submarine) – 2003/08 (Altimetry)

CryoSat-2: Improved Precision in measuring sea ice freeboard and estimating ice thickness



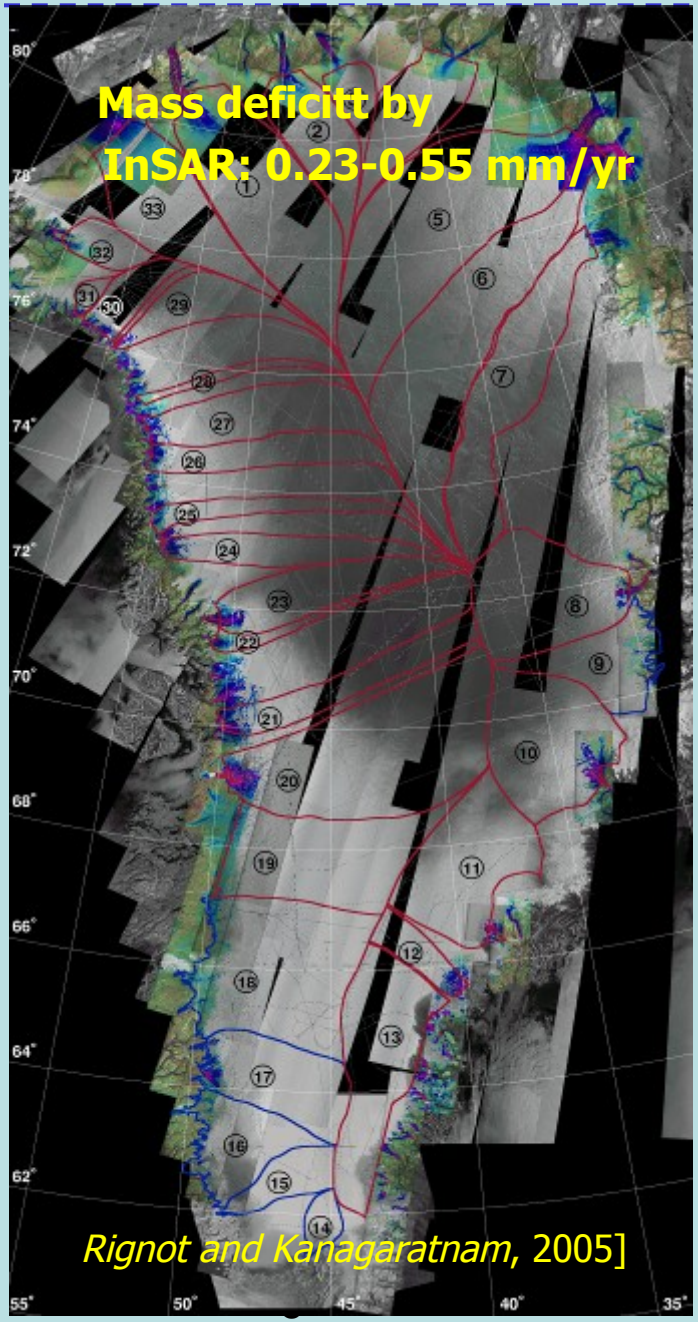


Greenland Sea Level Contribution



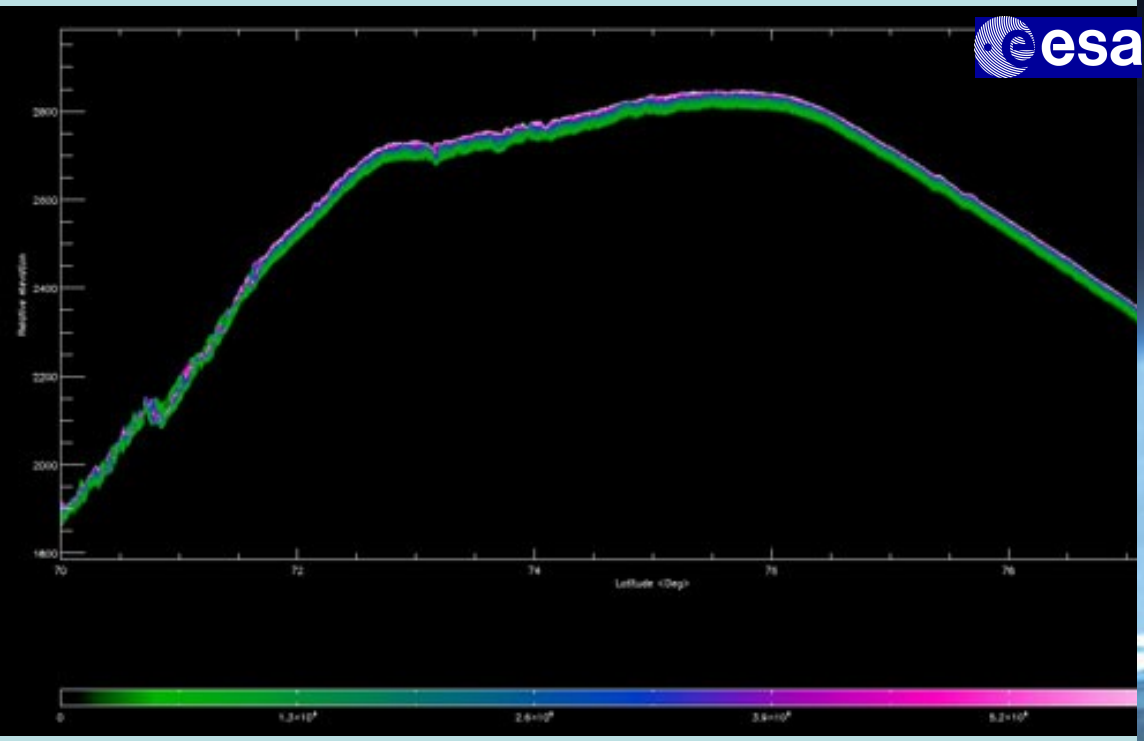
1992 -2003 ERS-1/2 Altimetry

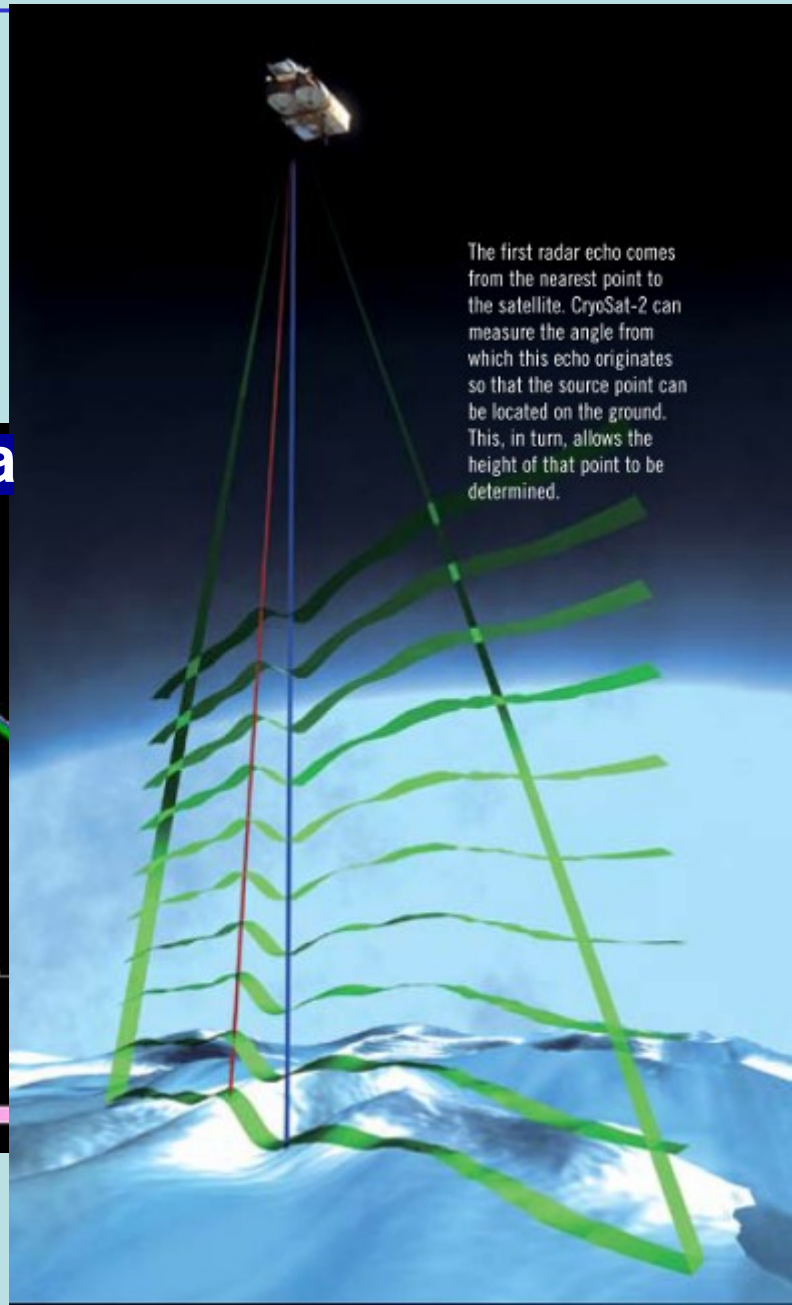
O.M. Johannessen et al. 2005



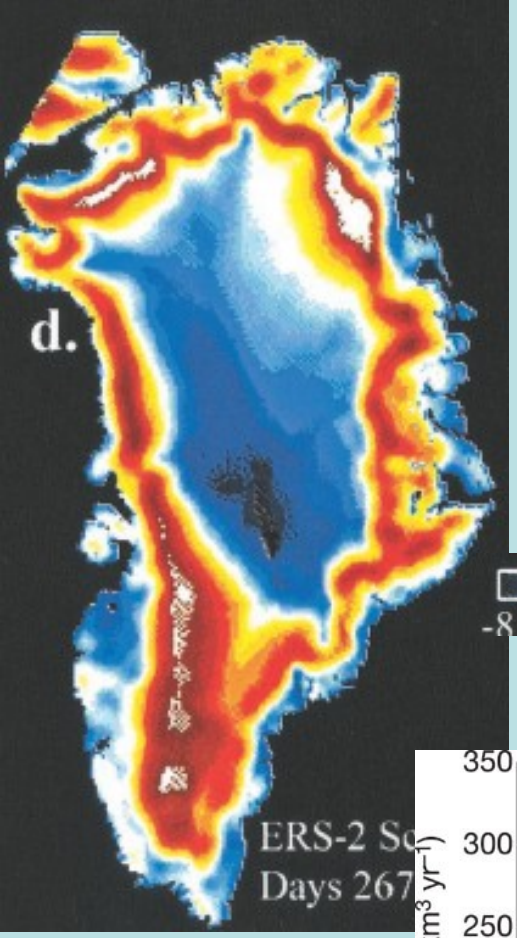
Croysat-2: Improved Precision for Ice Sheet Topography

SAR-Interferometric Mode, SARIn: Major improvements on slanting surfaces.
The location of the echo is determined by means of phase measurement

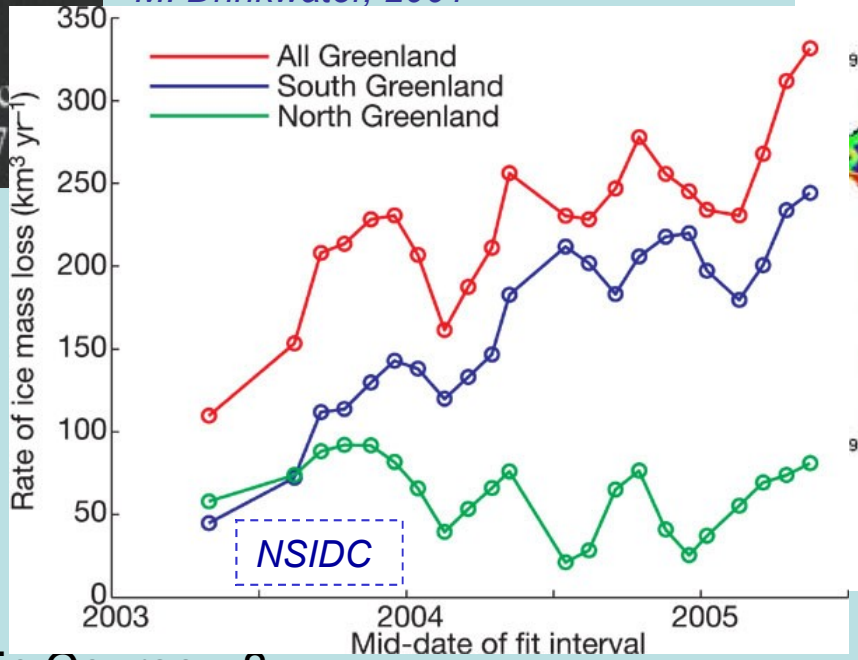


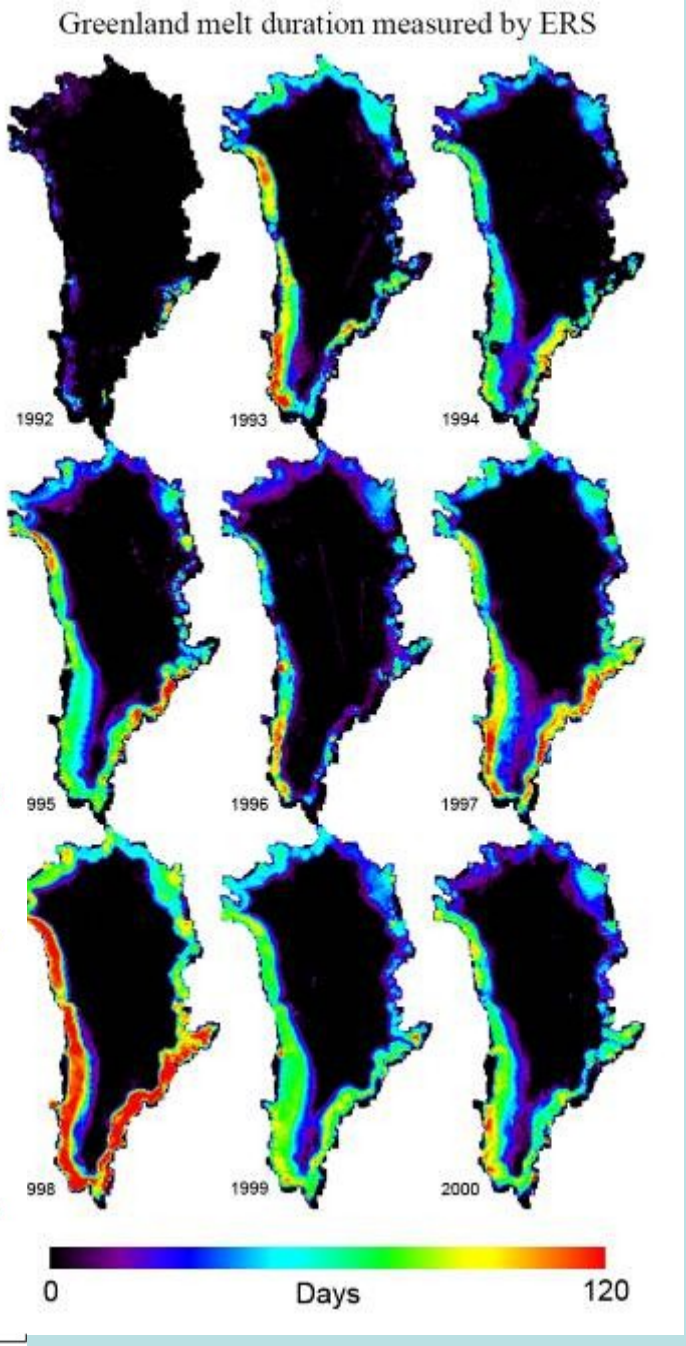


Greenland: Summer Melt Increases

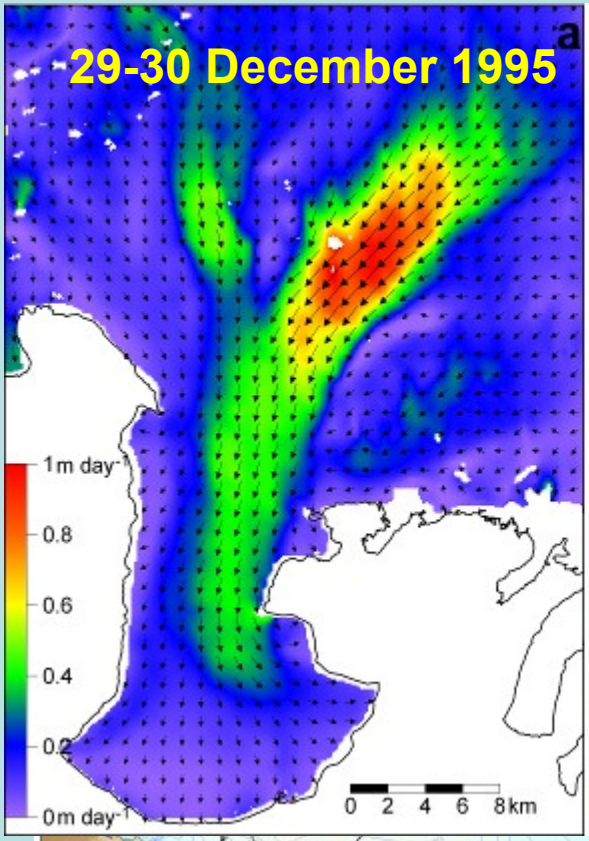


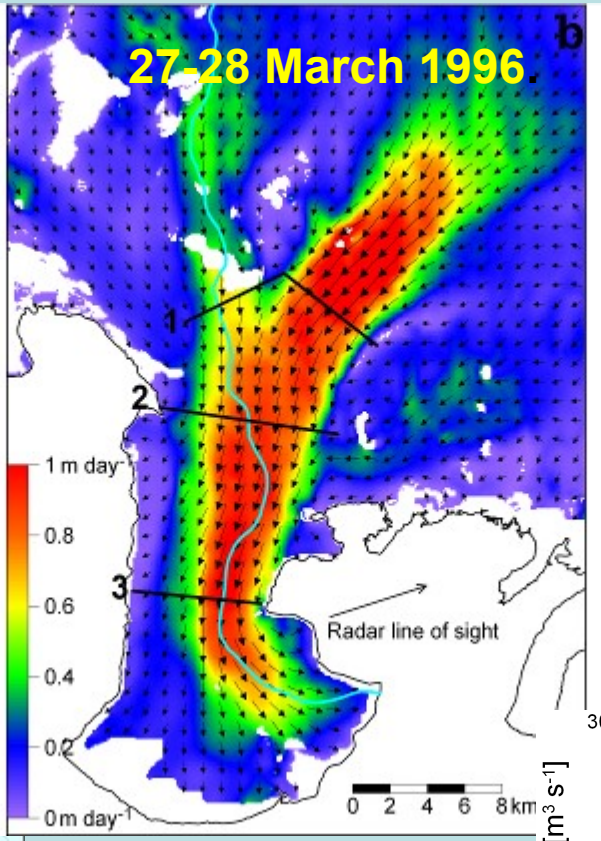
←ERS Scatterometer
M. Drinkwater, 2001

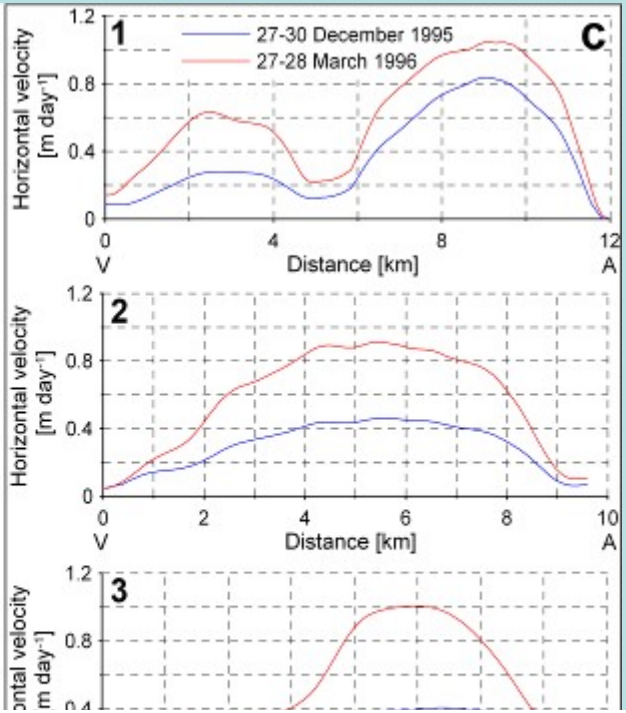


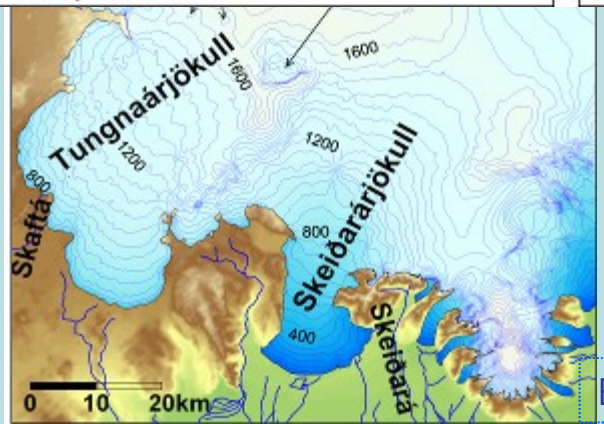


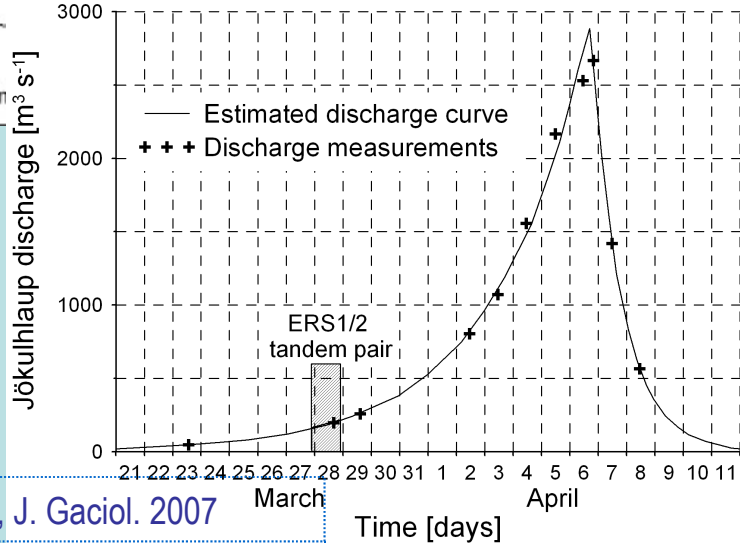
ERS – InSAR: Dynamic Response of Glaciers
Detection of Precursor to Water Outbreak – Acceleration of Ice Flow











E. Magnusson, H. Rott, H. Björnsson, J. Gaciol. 2007

ESA COOPERATION WITH SCIENTIFIC ORGANIZATIONS AND PROJECTS

Climate and Cryosphere Project Goals and Themes

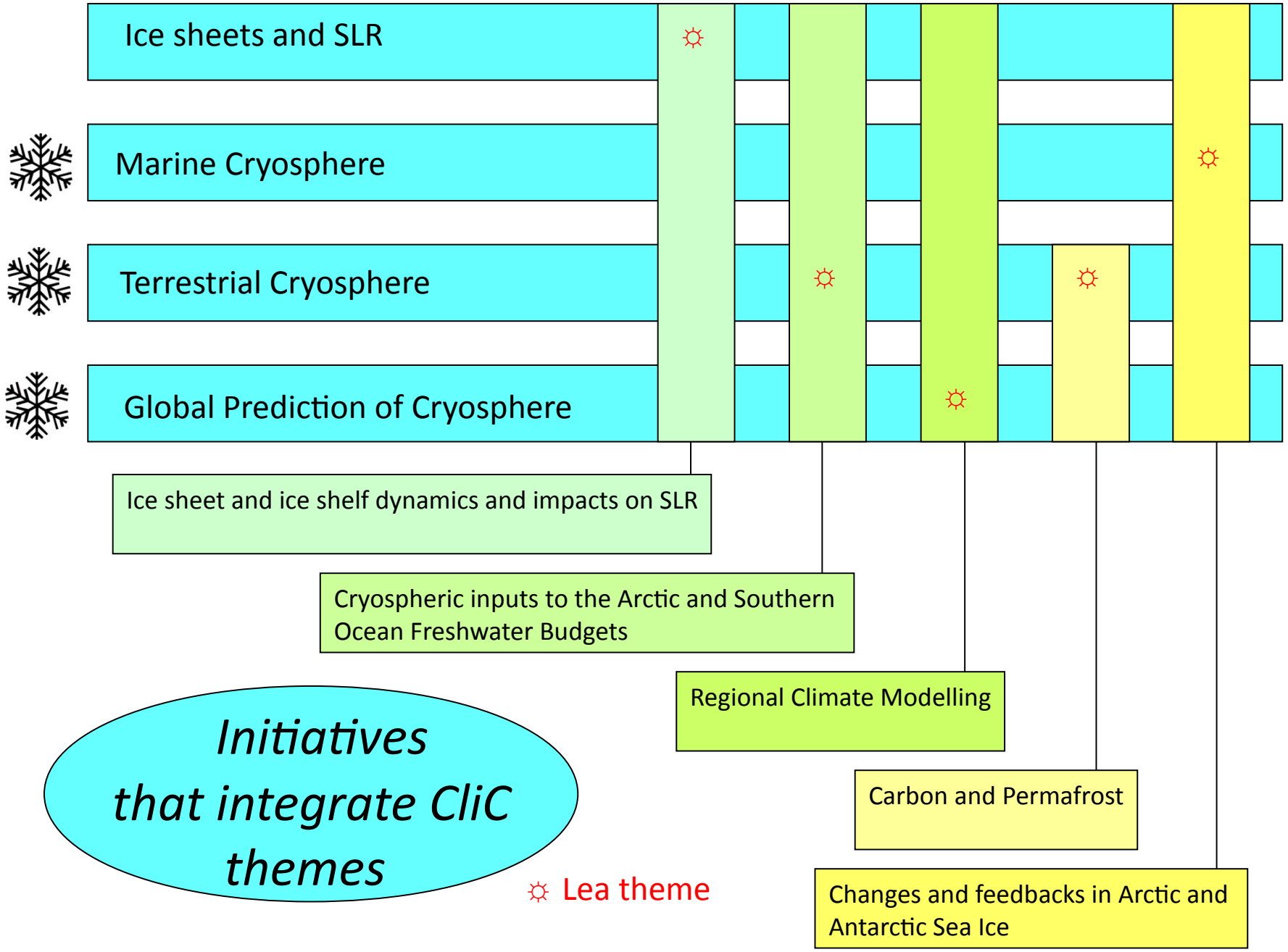
WCRP-SCAR-IASC

Principal Goal:

- To assess and quantify the impacts that climatic variability and change have on components of the cryosphere and the consequences of these impacts for the climate system.
- In addressing this aim, CliC also seeks to determine the stability of the global cryosphere.

CliC focuses its activities through the following **Themes**:

1. Terrestrial Cryosphere and Hydrometeorology of Cold Regions (TCHM)
2. Ice Masses and Sea Level (IMSL)
3. Marine Cryosphere and Climate (MarC)
4. Global Prediction of the Cryosphere (GPC)


Ice sheets and SLR
Marine Cryosphere
Terrestrial Cryosphere
Global Prediction of Cryosphere
Ice sheet and ice shelf dynamics and impacts on SLR
Cryospheric inputs to the Arctic and Southern Ocean Freshwater Budgets
Regional Climate Modelling
Carbon and Permafrost
Changes and feedbacks in Arctic and Antarctic Sea Ice
Initiatives that integrate CliC themes
Lea theme

ESA STSE Support to Science Element

http://dup.esrin.esa.int/stse/

Objective: Maximise the scientific return of ESA EO missions; respond to scientific challenges of Living Planet Programme; support science bodies.

Action Lines:

- ***Future Mission Concepts***
- ***Strategic Actions***
- ***Novel Observations and Products***

  SAR IceConstellation

  Develop the basis for multi-mission based SAR constellations for operational and scientific monitoring of sea ice (strategies and techniques)

  SnowRadiance

  Techniques for retrieval of snow / ice properties from passive imaging instruments operating in the UV to TIR spectral range.
- ***Support to Earth Science***

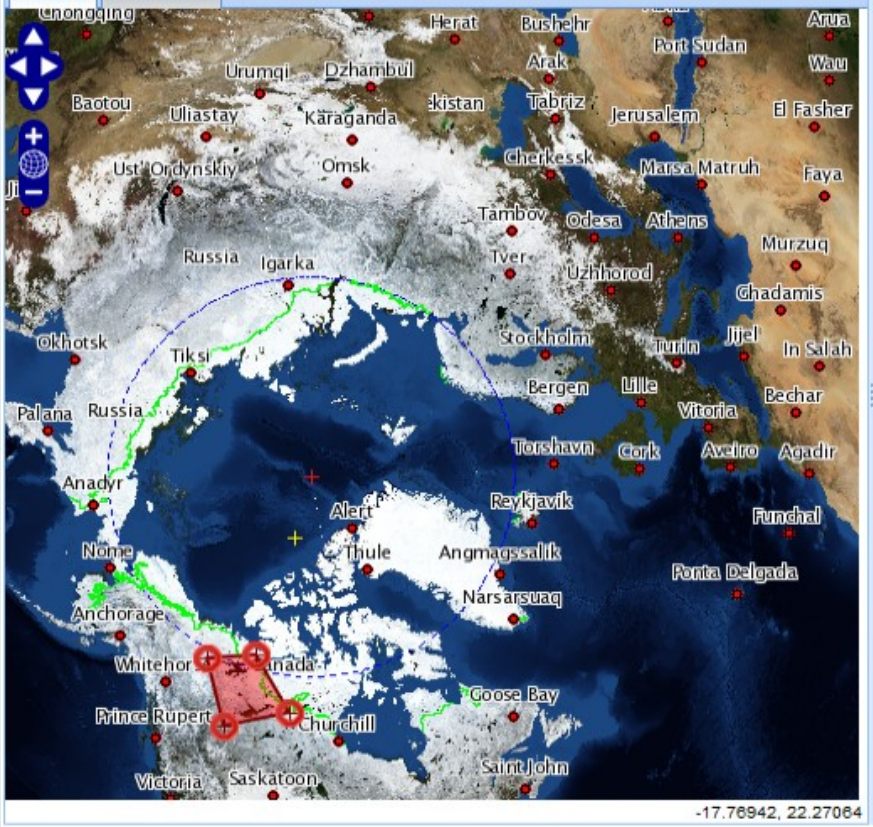
  North Hydrology Collaboration with ***CliC*** to define Scientific requirements.

  Themes 1) Novel multi-mission river and lakes ice products (study initiated) 2) improving ice sheet mass balance estimates (upcoming)

North Hydrology Science Data Portal

North Hydrology Science Geospatial Search — Home | Help Manual — Version 2.0

Arctic | Antarctic



NHS Search | Results | Metadata | Data

North Hydrology Science Search

Choose a different data collection...

All fields are mandatory

Area of Interest (Click on the map to make a box or enter coordinates)

Latitude	Longitude	
65.4719917453	-129.53997996	Apply Changes
58.8332262433	-119.09586577	Delete Last
62.0607818661	-105.27667946	
68.1121380374	-117.11971556	Clear All

Start Date January 1 2008

End Date December 31 2009

Lake/River Ice Product Lake ice: cover/open water extent

- Lake ice: cover/open water extent
- Lake ice: concentration
- Lake ice: types
- Lake ice: thickness
- Lake ice: snow depth
- Lake surface temperature

Only the first 250 results will … earch | Clear

Quick Search

Reference ID
Example: 89059

Search

IC3 | University of Waterloo | CliC | esa

ESA Data User Element – Cryosphere Projects

http://dup.esrin.esa.int/

Objective: Foster relationships between User communities and Earth Observation.

The information products developed in the projects respond to the requirements of users actively involved in the project (GCOS etc.).

DUE GlobGlacier (Pi Univ. Zürich)

- Improvement of techniques for retrieval of glacier properties from EO data (***glacier outline, topography, snow/ice area extent, surface motion***)
- Producing data sets for selected glacier regions world wide

DUE GlobSnow (PI Finnish Meteo Service)

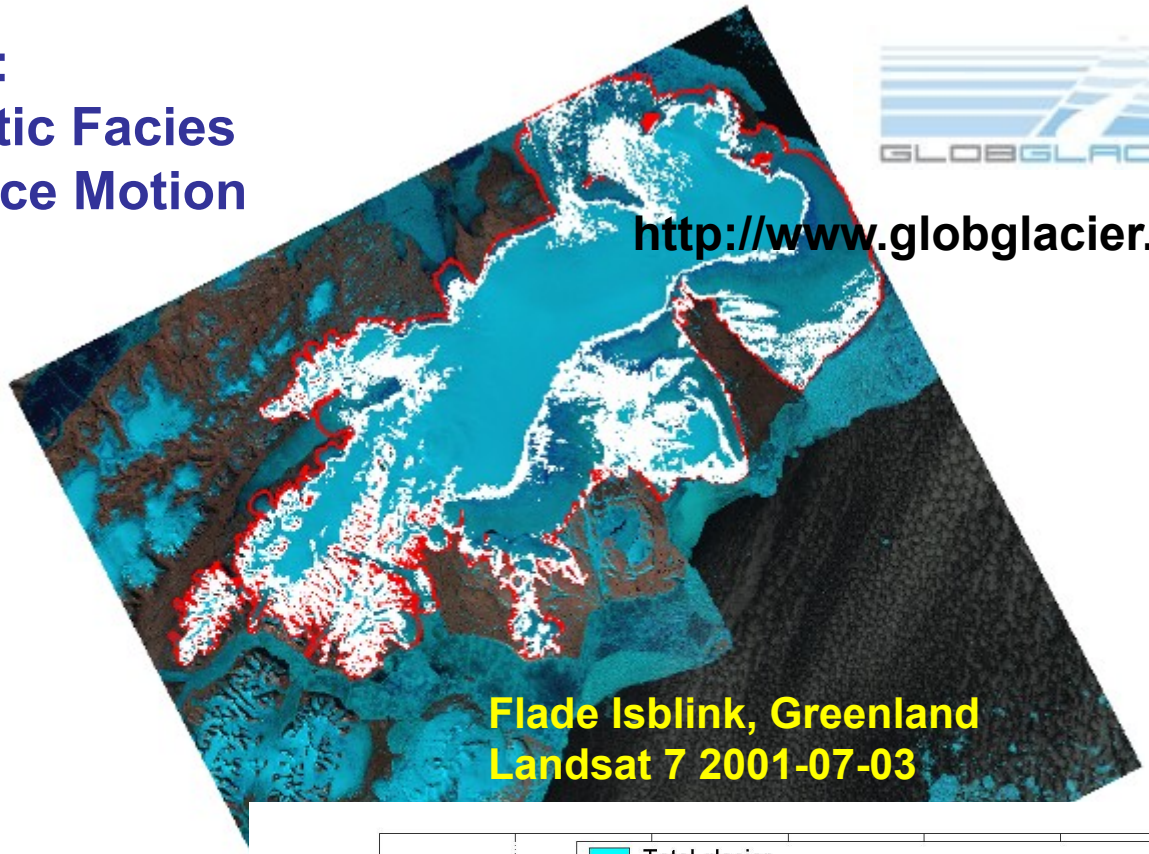
Creating a ***global database of snow parameters (snow extent, snow water equivalent)*** for climate research purposes; 15, 30 years time series

DUE Permafrost (PI TU Vienna)

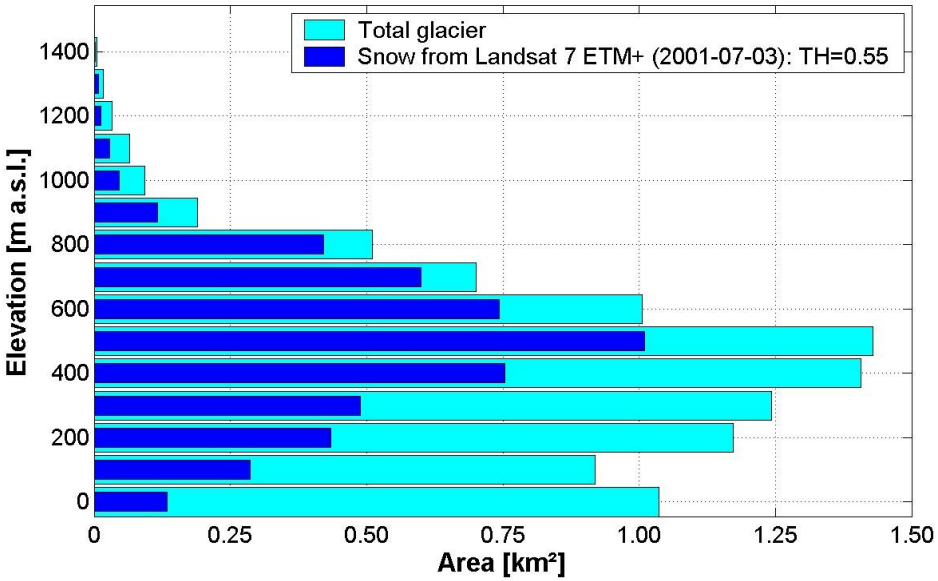
Define, demonstrate and validate a permafrost information service from local to large scale, based on satellite observations. Global permafrost extent, change and related products.

GlobGlacier Products:
Glacier Area, Diagenetic Facies
Surface Topography, Ice Motion

http://www.globglacier.ch/

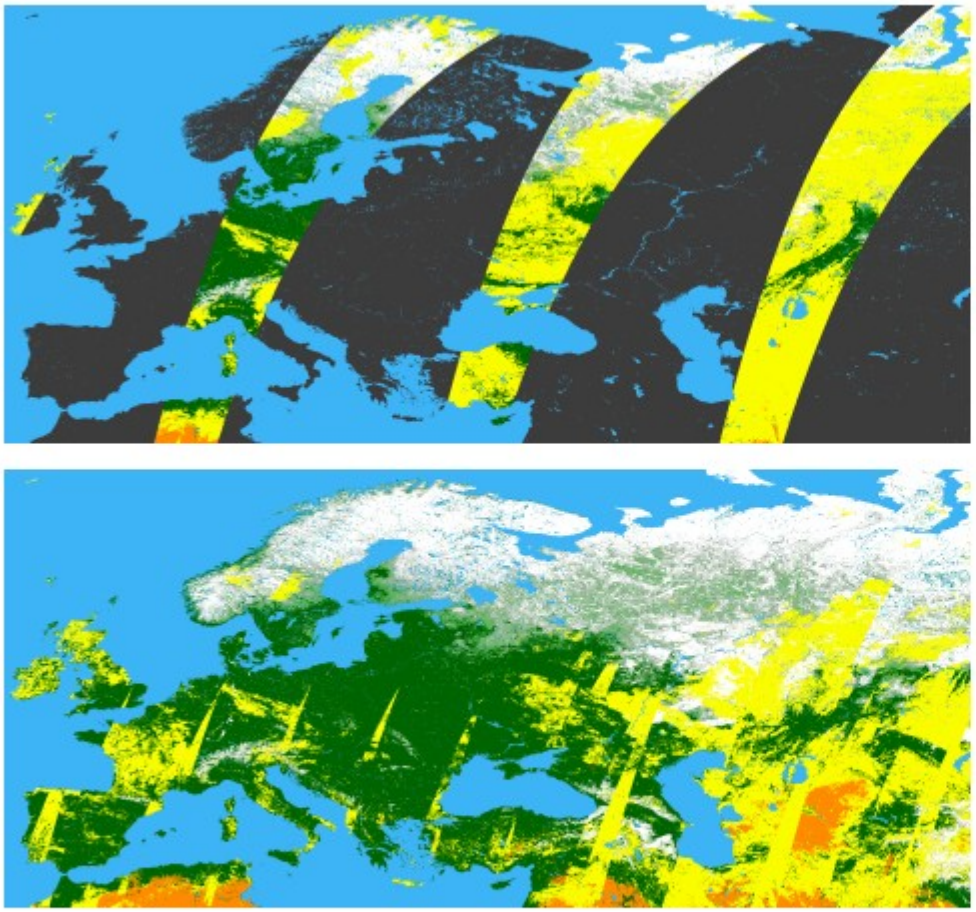


Flade Isblink, Greenland
Landsat 7 2001-07-03



Improved Services on Glacier Monitoring
→Sentinel 2

GlobSnow – Prototype Snow Map



Outside mapping area

Water

Not mapped in product time frame

Too low solar angle for snow retrieval

Missing or invalid satellite data

Cloud

Snow retrieval algorithm breakdown

No snow retrieval algorithm applicable

0%

50%

100%

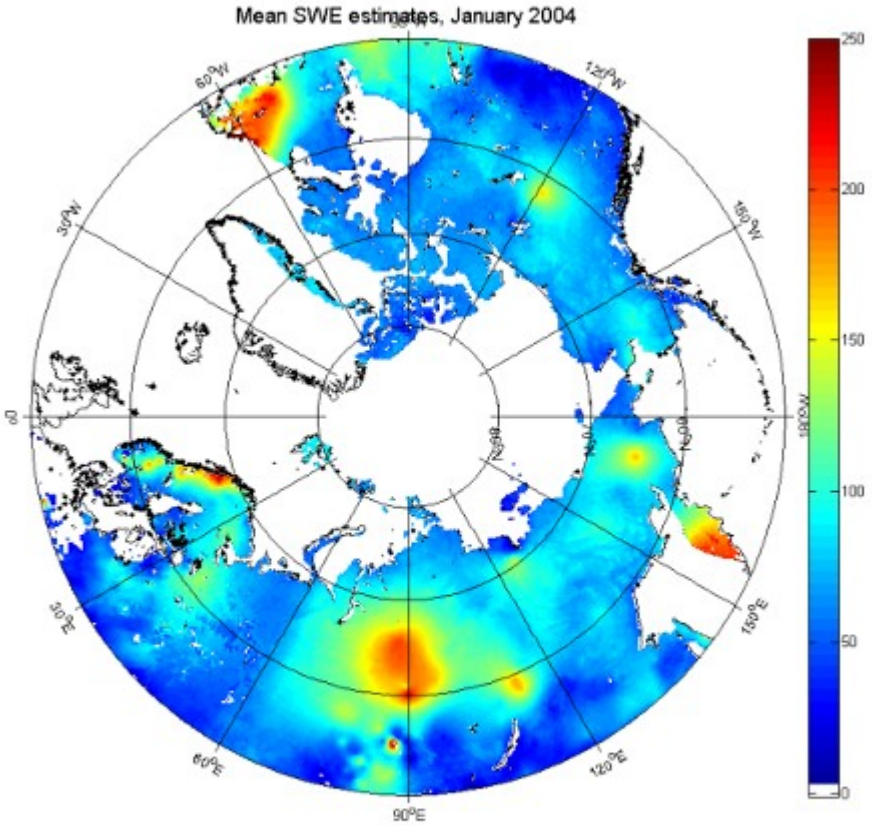
Fractional snow cover

Steps of 1% in product, steps of 10% in colour legend

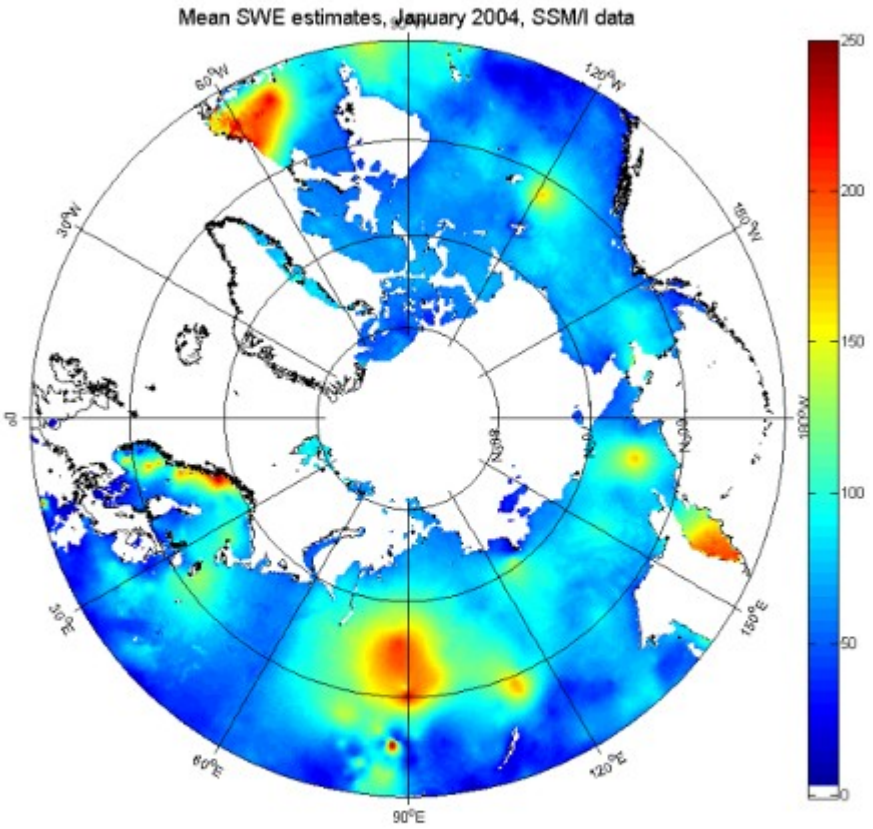
Data base: ATSR & AATSR (ERS-2, Envisat)

GlobSnow – Map of Snow Water Equivalent

Baseline: AMSR-E derived SWE product
(both AMSR-E and SSM/I data available from 2002->)



SSM/I derived SWE product
(SSM/I data used for 1987-2002)



ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

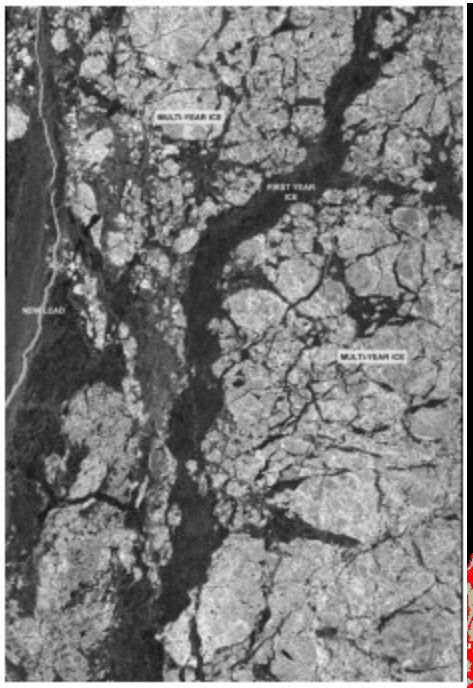
http://www.globsnow.info/

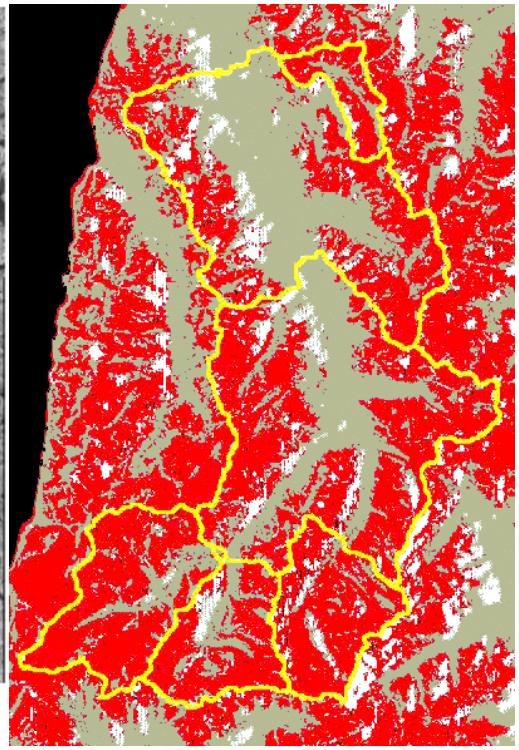
GLOBSNOW

S-1: Cryosphere Applications

http://www.esa.int/gmes

- **Global sea-ice monitoring**
  - Extent/type/drift
- **Iceberg monitoring**
  - Detection/drift
- **Ice sheet/glacier monitoring**
  - InSAR- topography
  - InSAR- ice movement
- **Land snow cover monitoring**
  - Melt area
- **River and Lake ice monitoring**
- **Ocean monitoring**
  - Waves
  - Surface winds
  - Ocean currents
  - Frontal structures

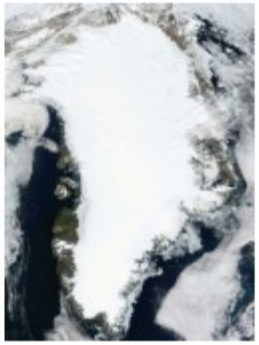


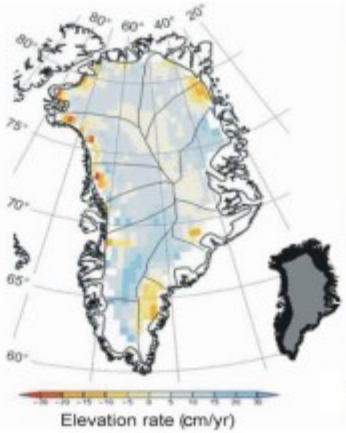


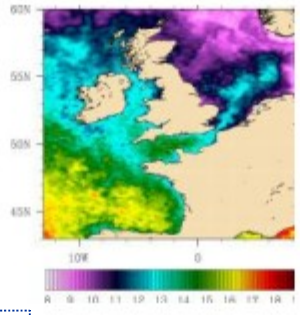
Sensor: C-band SAR, 250 km swath
12 day repeat (6 d with 2 sat)

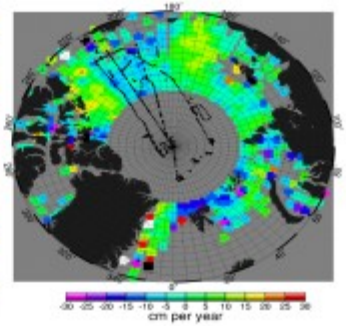
S-3: Cryosphere Applications

- **Surface Topography**
  - Sea-ice elevation/thickness
  - Land Ice elevation
- **Surface Temperature**
  - Snow/ice
  - Land surface
- **Ocean & Land Colour**
  - Snow/Sea ice extent
- **By-products**
  - Clouds
  - Albedo









Sensors:

OLCI Ocean & Land Colour Instrument
21 bands, 300 m and 1.2km res.

SLST (IR, ViS, 9 bands) AATSR – follow on

SRAL Altimeter: CryoSat heritage