

# Arctic Research and Operational Activities in Greenland and Denmark related to PRCC-Arctic

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René Forsberg, National Space Institute (DTU-Space )  
Morten Skovgaard Olsen, Danish Energy Agency



## Denmark and Greenland in a Nordic and Arctic context

- Strongly involved in Nordic collaboration



Each nation in the Arctic region has a different approach towards climate services

- National authorities have different duties and obligations
- Geography and environment
- Culture and people
- Infrastructure
- Capabilities

However:

A need for an open **pan-Arctic source of underpinning data** for climate services:

Operational services, climate projections and climate observations

## Greenland - in particular – the ice cap

- the changing ice cap (mass, albedo)
  - calving ice bergs
  - year round sea ice
- Global, as well as regional and local climate impacts



Many international research projects in Greenland

Small community – huge geographical areas

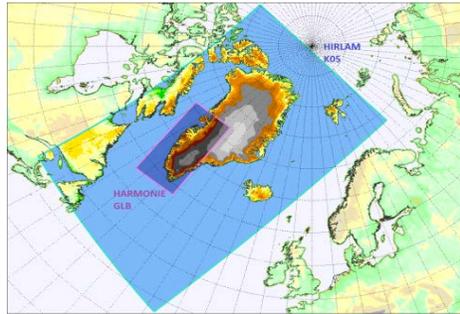
- Expensive infrastructure
- Many institutions in Greenland and Denmark involved in climate services
- Government of Greenland



# Earth System Modelling at DMI

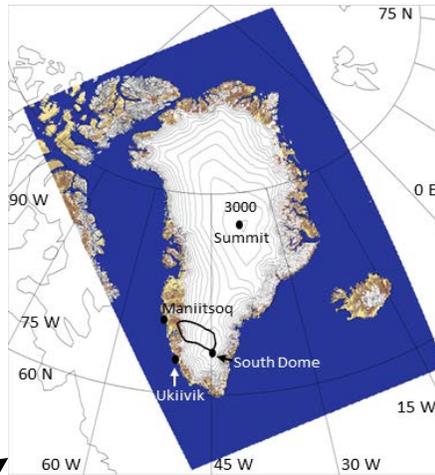
## Surface mass balance

**Weather forecast model (HIRLAM)**

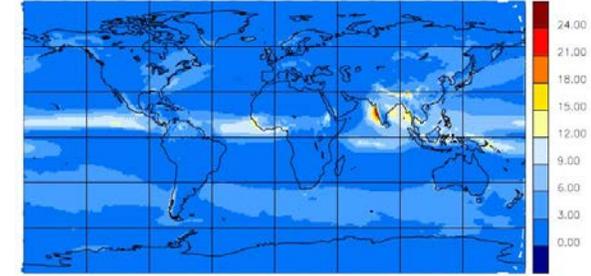


**Forces snow model from RCM for SMB**

**Regional Climate Model (HIRHAM)**



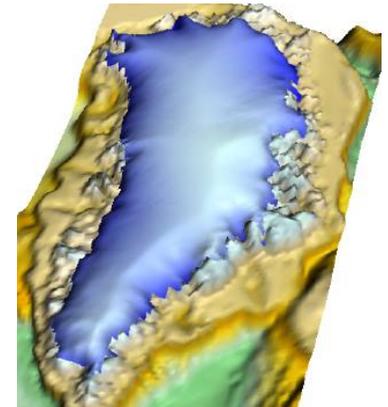
**Global Climate Model (EC-EARTH)**



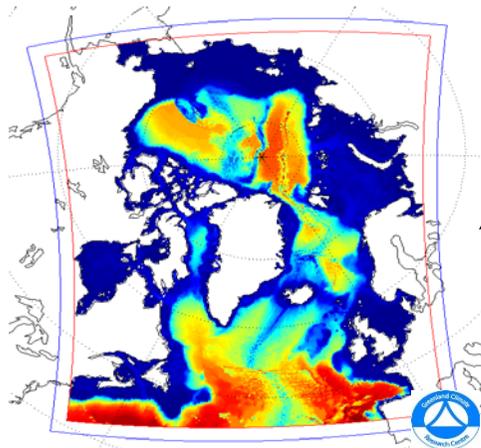
**GCM forces RCM**

**dynamic coupling**

**Ice Sheet Model (PISM)**



**Regional Ocean – Sea Ice Model (HYCOM - CICE)**



**dynamic coupling**

**RCM forces ISM (on and offline)**

# Polar Portal

<http://polarportal.dk/en/home/>

- National collaboration bringing together main Danish and Greenlandic actors on Arctic geophysical issues, centered on Greenland



**POLAR PORTAL**  
MONITORING ICE AND CLIMATE IN THE ARCTIC

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## GREENLAND



Welcome to the new arctic monitoring web-site  
The Danish Arctic research institutions present updated knowledge on the condition of two major components of the Arctic: The Greenland Ice Sheet and the sea ice

[Surface conditions](#)

[Glacier front positions](#)

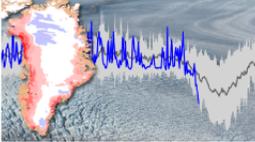
[Total mass change](#)

[Understanding the Greenland Ice Sheet](#)

[More ice-monitoring products](#)

[Links](#)

### Surface conditions



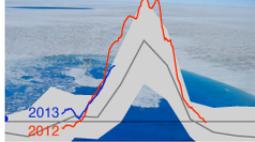
Daily updates on the surface conditions on the Greenland Ice Sheet. See where it is melting and where the ice sheet is growing – and compare with the total melt from the surface in previous years. See also satellite measurements of the surface reflectivity.

### Glacier front positions



See animations of satellite images of major outlet glaciers of the Greenland Ice Sheet. You can compare the updated images with the positions of the glaciers in the mid-1980s and in the year 2000.

### Total mass change



Follow the total mass balance of the Greenland Ice Sheet. Weekly updates on the contribution to global sea-level. See animations that show how the ice sheet grows and diminishes through the year.

### Reports from the Greenland ice sheet

[2013 Season report](#)  
*All in all, 2013 has been a year with large melting from both the Greenland Ice Sheet and the Arctic sea ice – but not nearly as large as the record-setting year of 2012.*  
November 18, 2013.

[Ice Sheet Melt Above Long Term Average for July.](#)  
*Ruth Mottram, Jason E. Box, Peter L. Langen, Polar Portal.*  
July 29, 2013

[Greenland ice sheet climate before summer 2013.](#)  
*Jason E. Box, Peter L. Langen, Signe Bech Andersen, Polar Portal.*  
June 18, 2013

© 2014 - DMI, DTU, GEUS

DMI DTU GEUS

Mest besøgte I gang med Firefox



Welcome to the new arctic monitoring web-site  
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Surface conditions

Glacier front positions

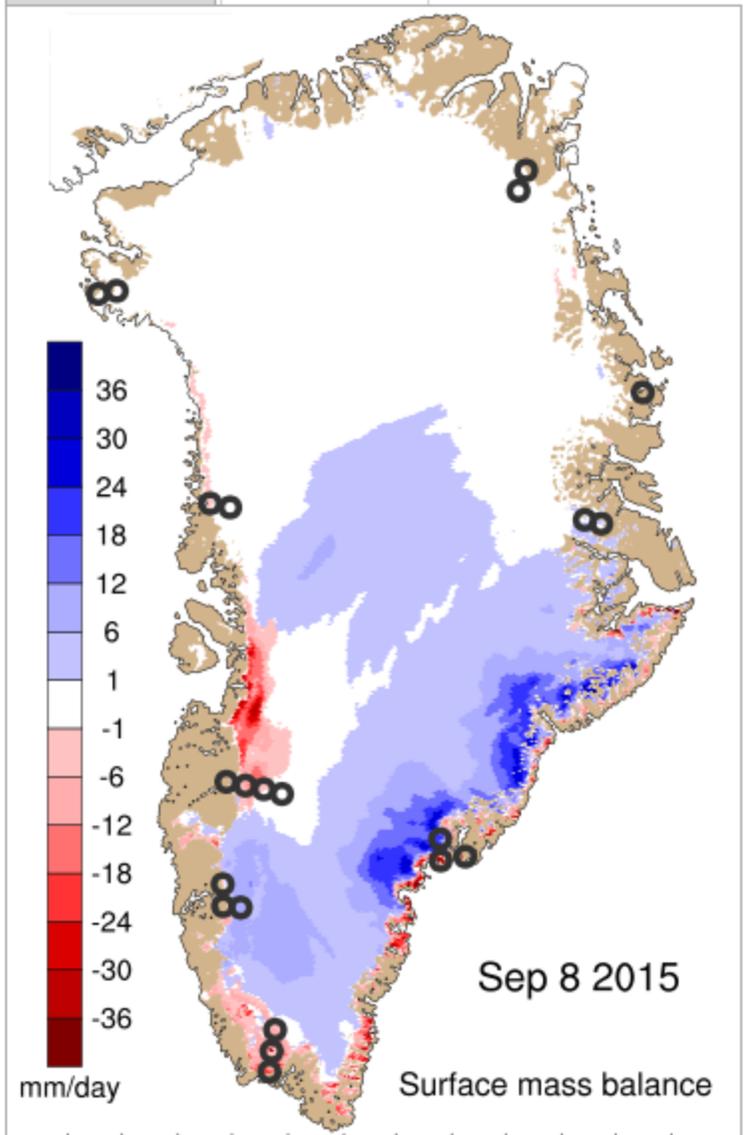
Total mass change

Understanding the Greenland Ice Sheet

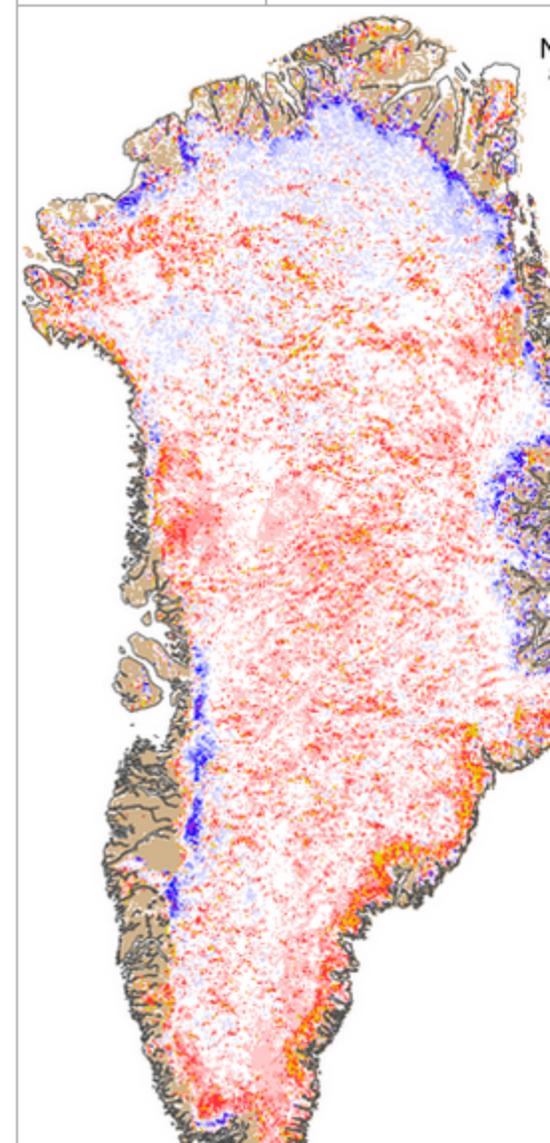
More ice-monitoring products

Links

Daily change Accumulated



Albedo anomaly



Welcome to the new arctic monitoring web-site  
The Danish Arctic research institutions present updated knowledge on the condition of two major components of the Arctic: The Greenland Ice Sheet and the sea ice

Sea ice extent and thickness

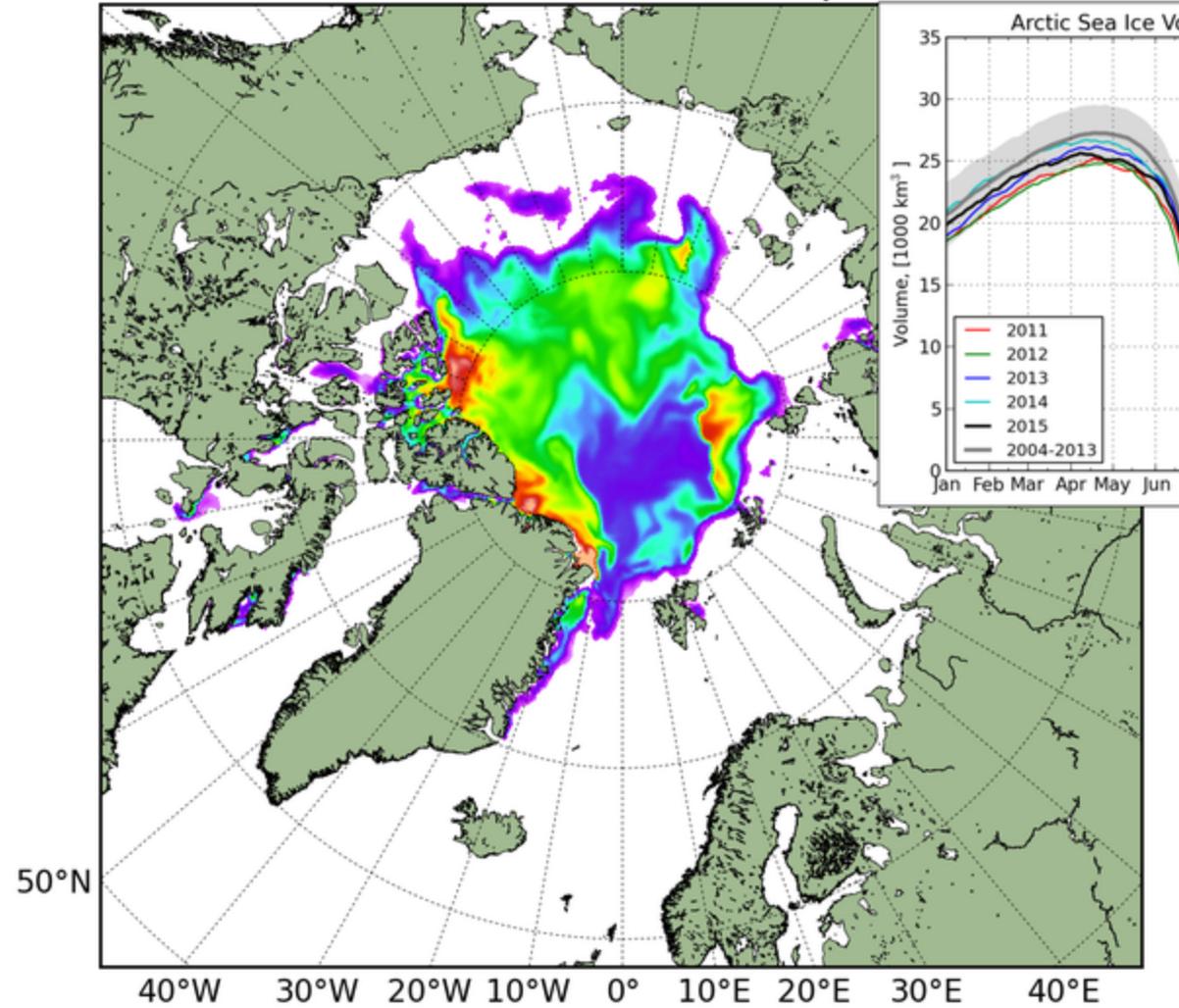
Sea ice temperatures

Understanding the Arctic sea ice

More ice-monitoring products

Links

### Sea Ice Thickness, 08-Sep-2015



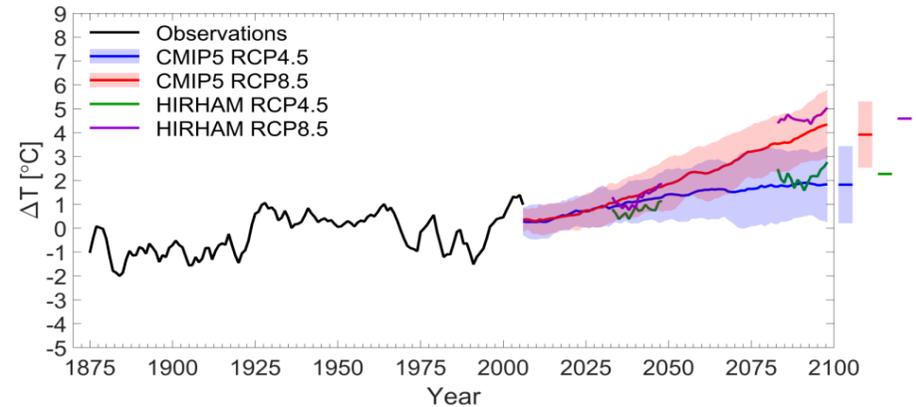
# Climate services

- Making high resolution scenarios for the Greenland Government

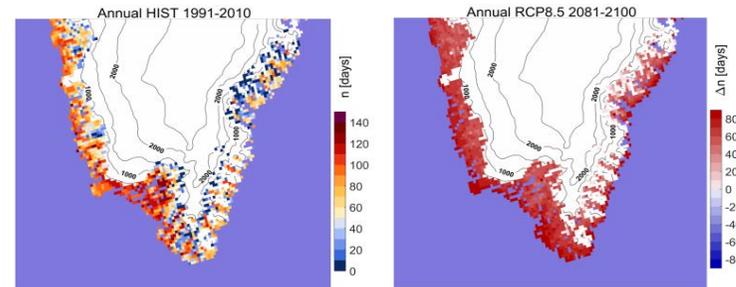


- Processed climate information

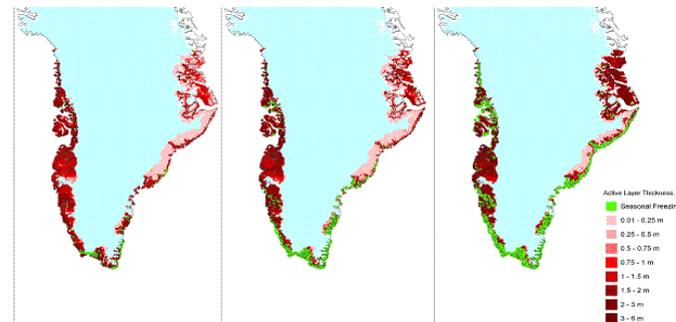
Annual mean temperature anomalies wrt. 1985-2005



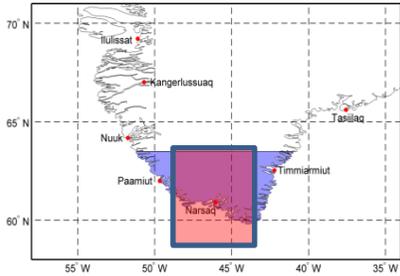
Growing season



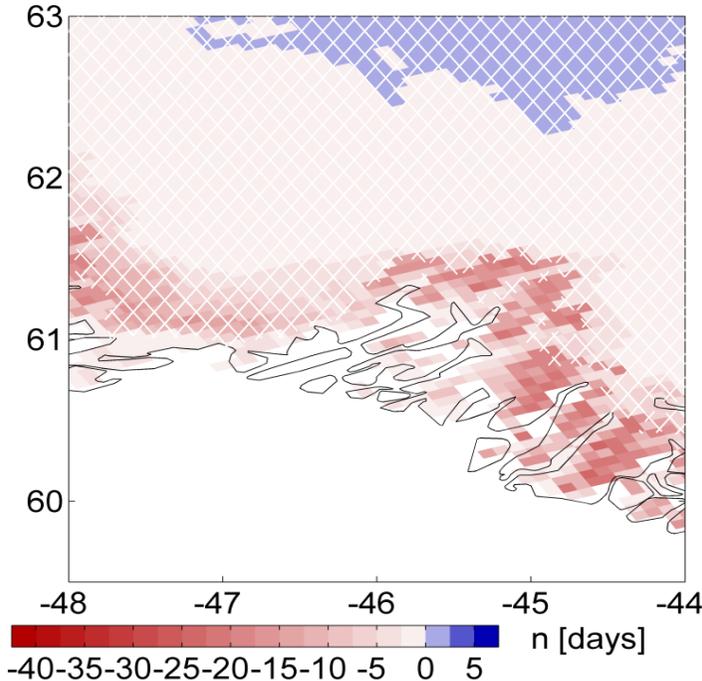
Permafrost



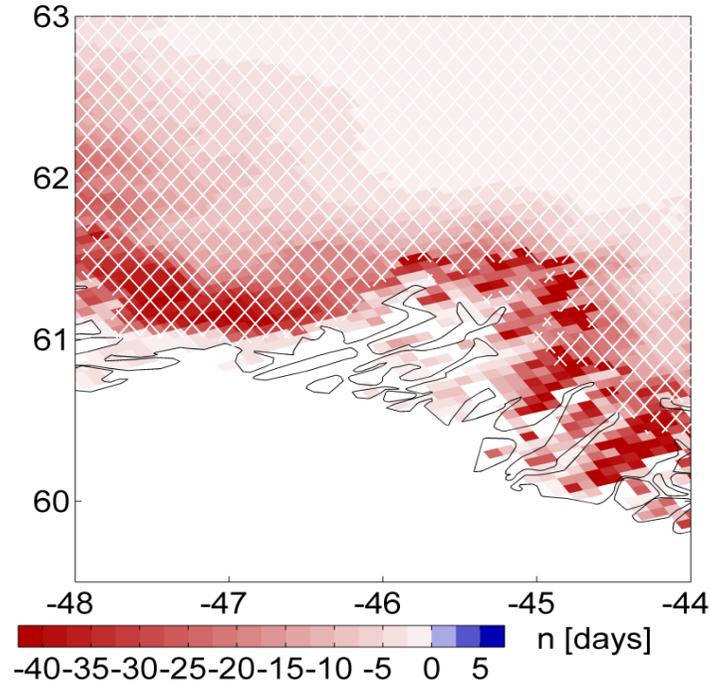
# Change in number of frost days in June-July-August



JJA RCP8.5 2031-2050



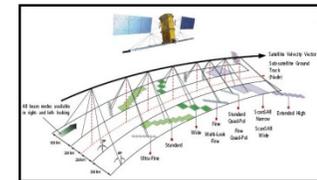
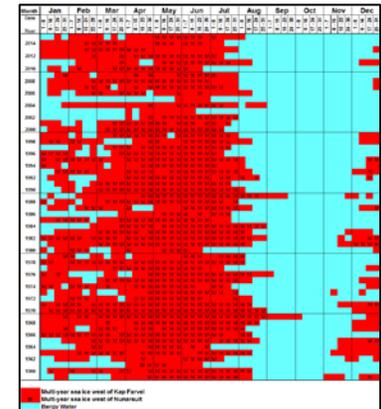
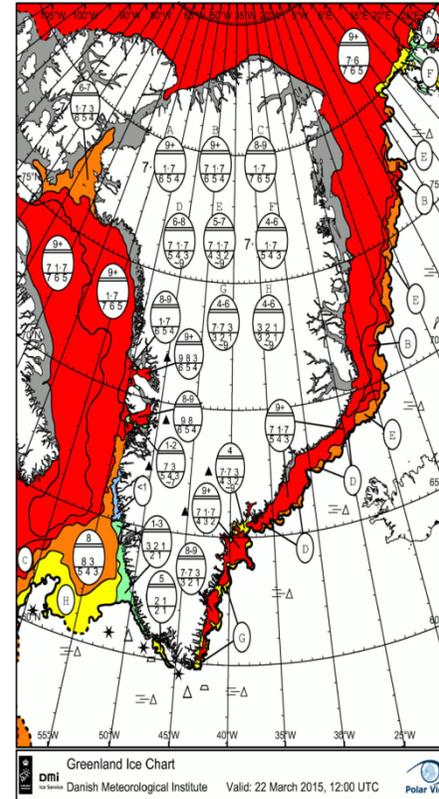
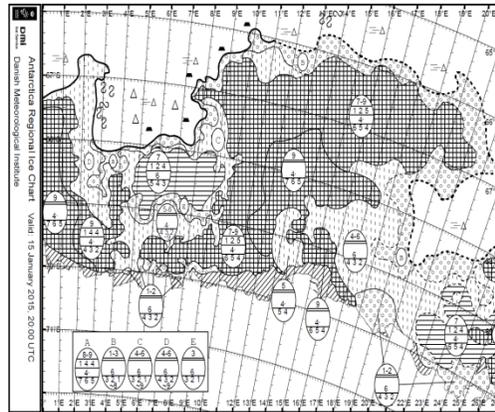
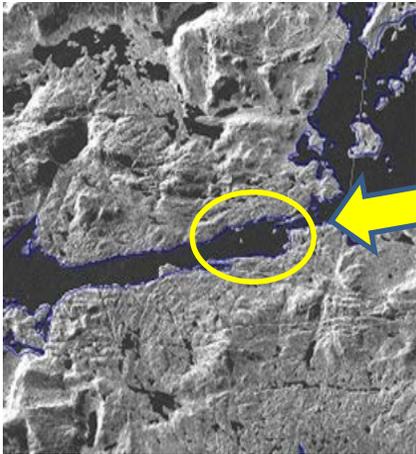
JJA RCP8.5 2081-2100



Hatching for inland ice

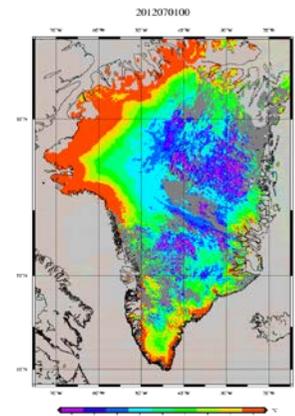
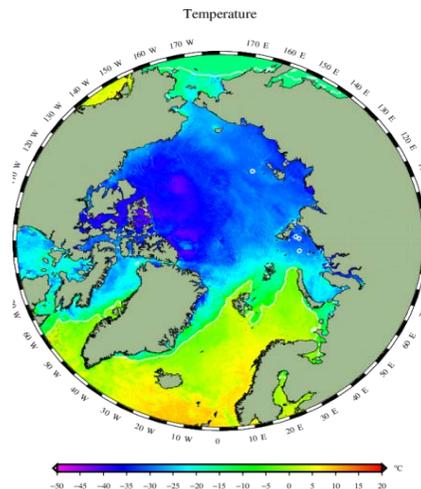
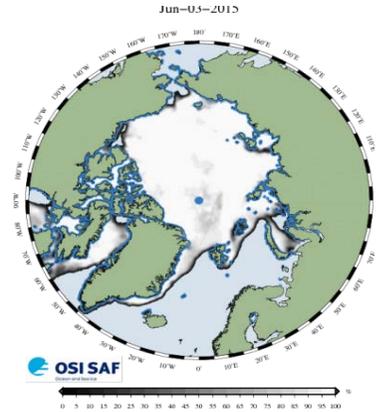


DMI provides tailored solutions for planning, safety and efficient operations in ice-infested waters



# DMI Arctic ocean and Ice products

- Ocean and Sea ice SAF sea ice concentration
  - Operational product
  - Reanalysis from 1978-2014
  - Sea ice climatology
- Sea surface and ice surface temperature products
  - Including Greenland and Antarctic ice sheets
  - Gapfilled Arctic SST, MIZ and IST product (at [polarportal.dk](http://polarportal.dk))
  - Operational 1 km from Metop AVHRR 4 km reanalysis (1982-2009) from AVHRR GAC



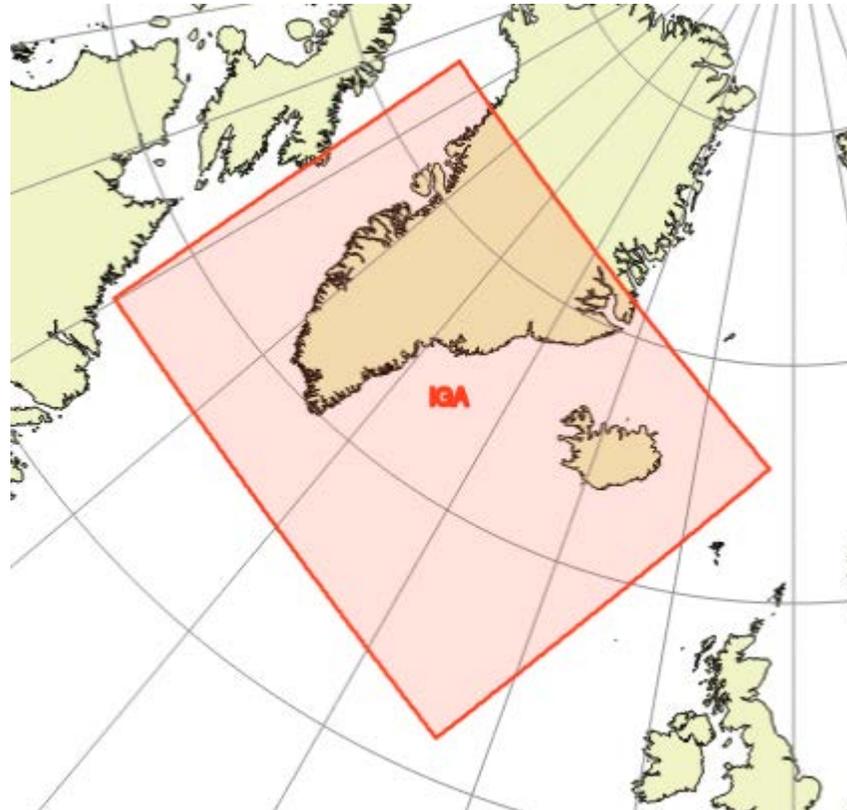
- Field campaigns with observations for validation

## DMI – IMO collaboration

DMI installs its new HPC Cray XC30 cluster on IMO headquarter at Reykjavik (2016-2020)

Joint DMI-IMO operational NWP for south Greenland and Iceland using mesoscale HARMONIE model with 2.5 km grid size.

Research collaboration on weather forecasting, climate and storm surge



# PROMICE

Programme for Monitoring of the Greenland Ice Sheet

## PROMICE goals

- Provide a consistent long-term dataset of observations
- Calculate the mass loss using the budget method
- Understand the mass loss

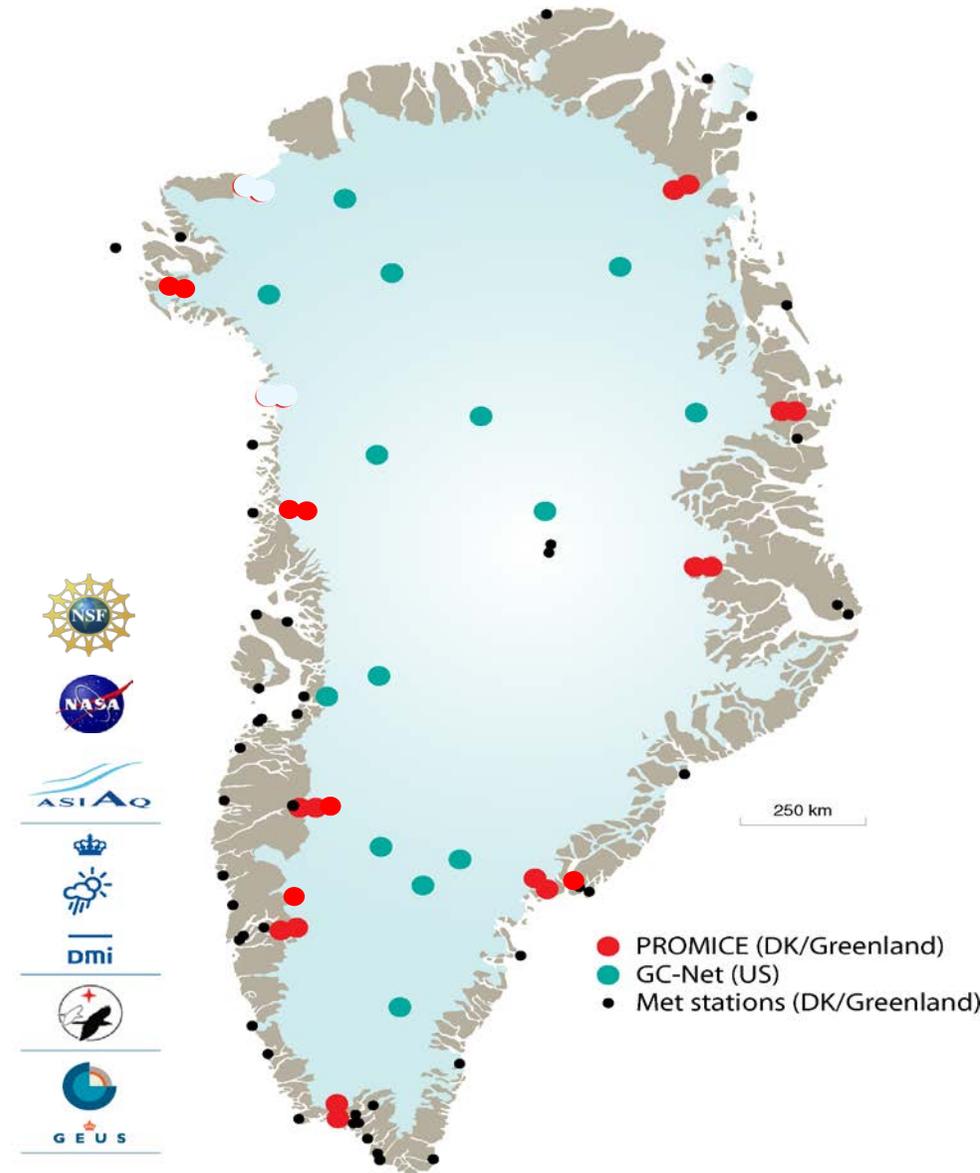
# PROMICE

Programme for Monitoring of the Greenland Ice Sheet

## Measurements



## Automatic weather stations in Greenland



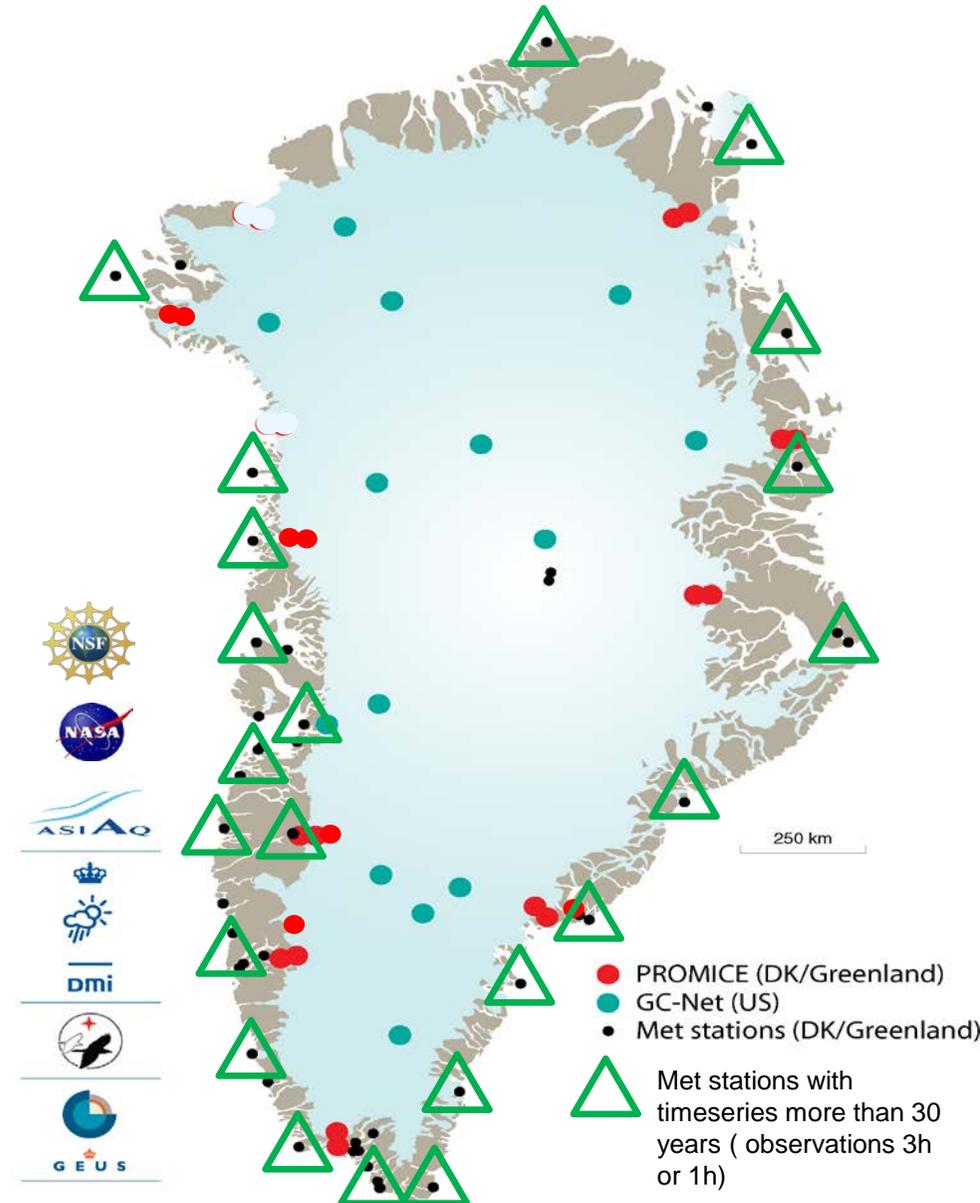


# Long term meteorological observations

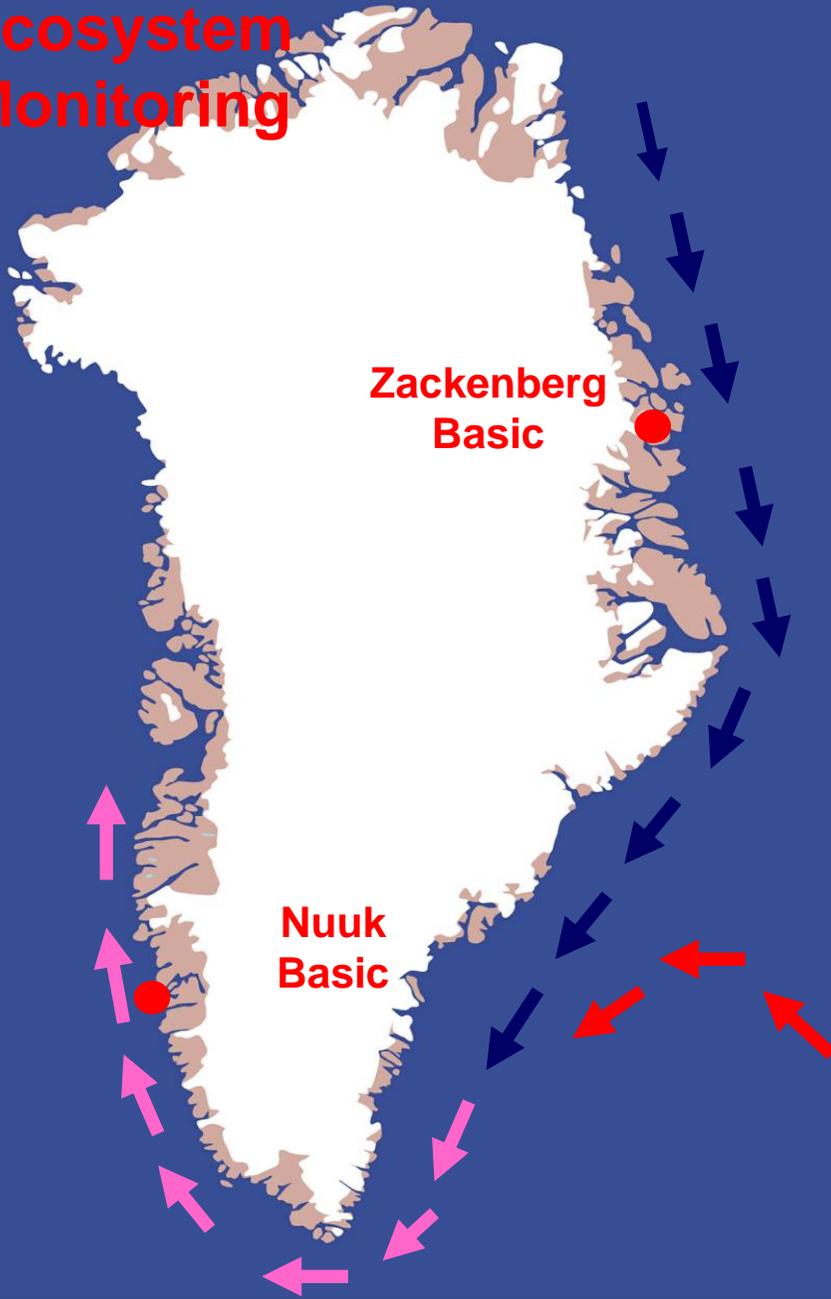
- Since 1784 composite monthly series
- Since 1873 monthly & annual series
- Since 1877 daily series
- Since 1958 observations from all national Greenland weather stations
- Since 1980/85 timeseries observations each 3h or 1h (some even starting earlier)



## Automatic weather stations in Greenland



# Greenland Ecosystem Monitoring



## Sub-programmes:

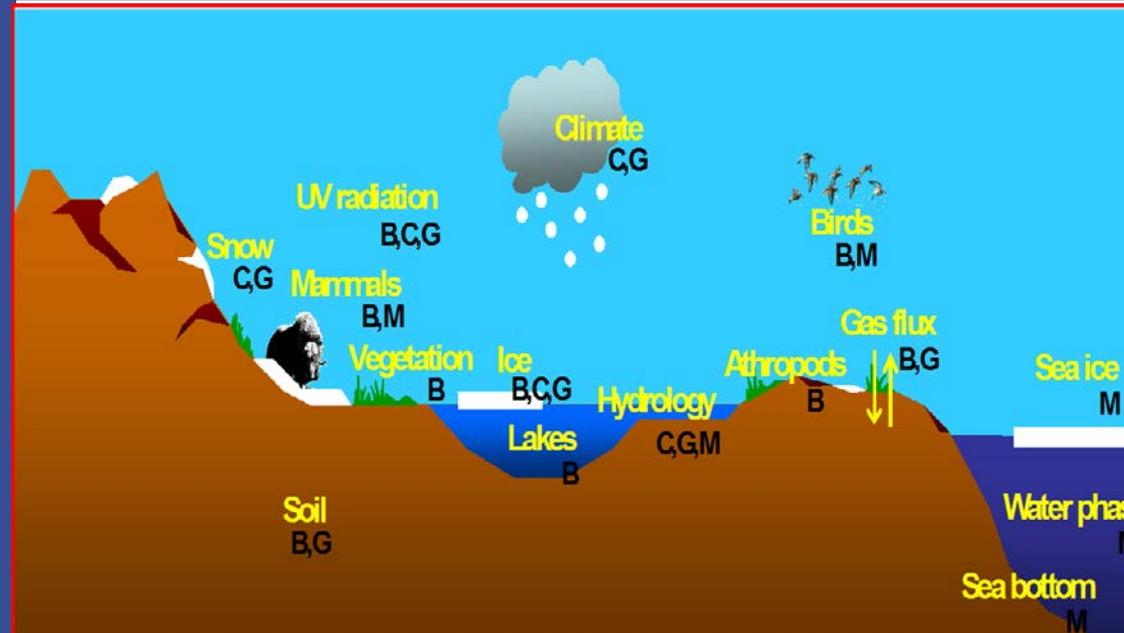
ClimateBasic

GlacioBasic

GeoBasic

BioBasic

MarineBasic



# New portal on logistics and research launched april 2015

☰ Menu

ISAAFFIK

📍 Map

## Isaaffik Arctic Gateway

Connecting Arctic Research, Education,  
Consultancy and Logistics within the Kingdom of  
Denmark

Isaaffik Arctic Gateway

**RESEARCH**  
Upcoming events and latest  
articles about Arctic research

**EDUCATION**  
Plans and news about Arctic  
education and courses

**CONSULTANCY**  
Scientific consultancy services  
and public outreach

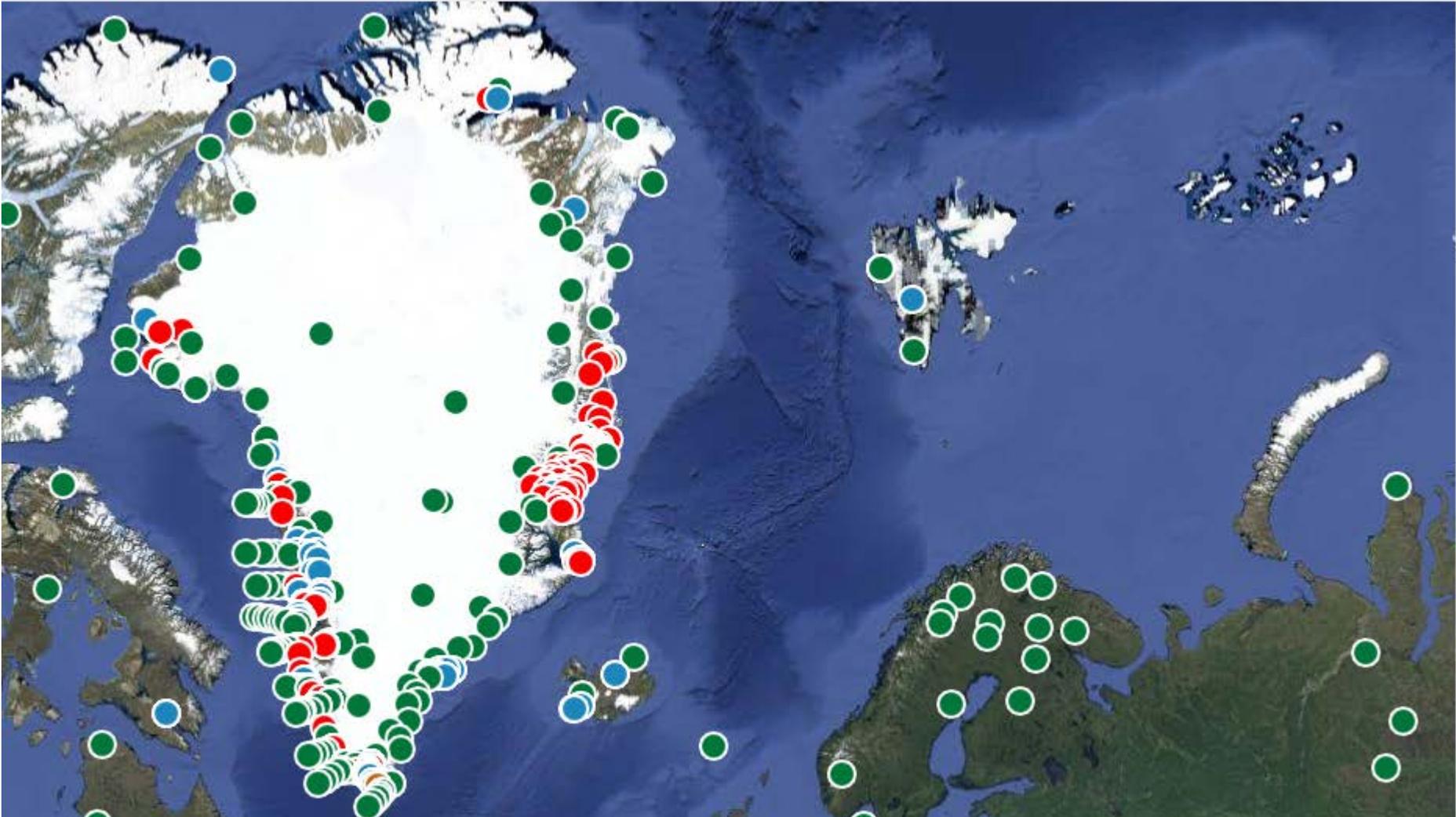
**LOGISTICS**  
News and events concerning Arctic  
logistics

Itinerary	Departure	Area 	Transport 	Status 
Zackenberg/Daneborg	2015, Week 38	NE Greenland	Aircraft	Closed

# Isaaffik.org

ISAAFFIK

Map



# Suggestion

## Greenland Climate Data Hub

Data center for climate projections and observations

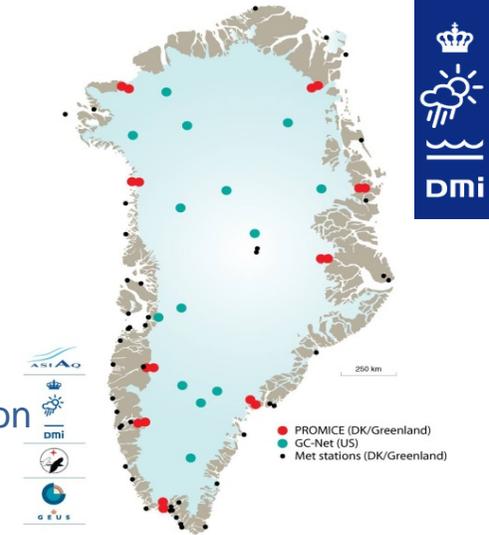
as an underpinning facility for promotion of national based climate services in the Arctic region

- Open
- Joint
- Pan-Arctic
- PRCC-Arctic node

Besides the basic national meteorological & climatological observation activities, a widespread and often less coordinated weather and climate observation and data collecting activities takes place in Greenland as part of other tasks, research projects and investigations. Most often data are not shared/available to others due to the lack of a mechanism to host and share climate data from Greenland.

The aim of PRCC-GCDH is to collect, host and provide access to all climate data measured in Greenland. A “one-stop” Greenland Climate Data Hub.

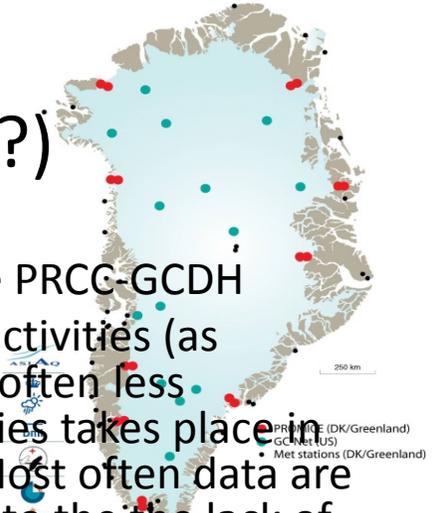
The strong basis in GCDH is formed by the very comprehensive (both historical and realtime) data collection provided by DMI, comprising time series from selected locations since 1784, the entire collection of national weather observations collected since 1958, as well as hourly update with real time data.



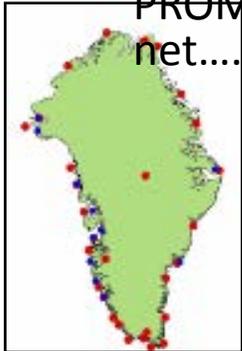




# Polar Regional Climate Center Greenland Climate Data Hub(/Center?)



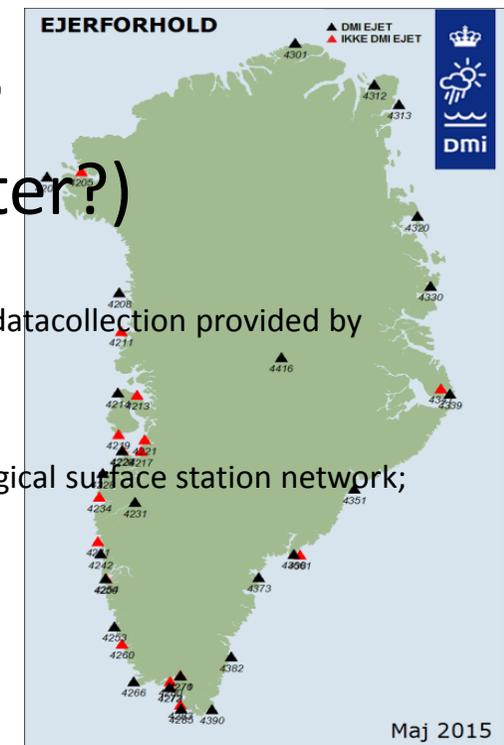
- Together with Greenland xxx & xxx DMI will form, host and operate the PRCC-GCDH
- Besides the basic national meteorological & climatological observation activities (as carried out by DMI and exchanged within the WMO), a widespread and often less coordinated weather and climate observation and data collecting activities takes place in Greenland as part of other tasks, research projects and investigations. Most often data are not shared/available to others (that the specific project/institution) due to the the lack of a mechanism to host and share climate data from Greenland
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- The strong basis in GCDH is formed by the very comprehensive (both historical and realtime) datacollection provided by DMI, comprising timeseries from selected locations since 1784 , the entire collection of national weather observations collected since 1958, as well as hourly update with realtime data.
- The forming partners (GEUS, ..... ) will supplement this basis with the datacollections from PROMICE ..... as well as research international projects will make there data available (GC net.....)





# Polar Regional Climate Center Greenland Climate Data Hub(/Center?)

- The strong basis in GCDH is formed by the very comprehensive (both historical and realtime) data collection provided by DMI, comprising:
  - timeseries since 1784 ,
  - the entire collection of national weather observations since 1958,
  - as well as hourly/daily update with data from the longterm baseline meteorological/climatological surface station network; radiosounding station network, and unique reception of polar orbiting satellite data
- **Since 1784 composite SW Greenland monthly temp. series**
- **From 1873:**
  - -Monthly & Annual series, 10 stations
  - -Daily series, 2 stations starting 1877-
  - -Observations of atmospheric air pressure (msl) 1 station starting 1894-
- **From 1958: Observation dataset Greenland Dataset (all weather stations)**
- Hourly update of realtime measurements from a total of 42 meteorological stations, including the **longterm baseline 17 station country wide stationnetwork**, from worlds most northern landpoint (Kap Morris Jessup) to the southern tip (Angisoq) – from the most western point (Carey Islands) to the most eastern part (Itiq). And the presnet **25 station wide network of measurements** from towns and settlements including the **update of the historical long-timeseries of climate data**
- Data from PROMICE, GC net..... (når vi begynder at få data.....en dag.....)





# POLAR PORTAL

MONITORING ICE AND CLIMATE IN THE ARCTIC



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Welcome to the new arctic monitoring web-site  
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[Surface conditions](#)

[Glacier front positions](#)

[Total mass change](#)

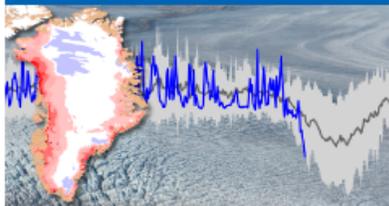
[Understanding the Greenland Ice Sheet](#)

[More ice-monitoring products](#)

[Links](#)

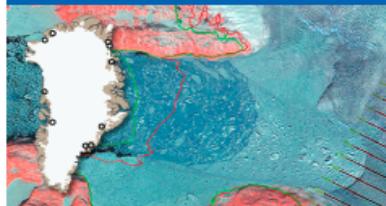
## GREENLAND

### Surface conditions



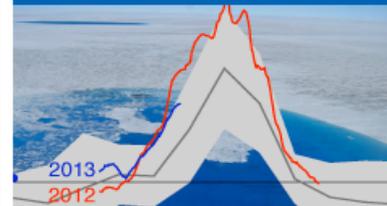
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See animations of satellite images of major outlet glaciers of the Greenland Ice Sheet. You can compare the updated images with the positions of the glaciers in the mid-1980s and in the year 2000.

### Total mass change



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*All in all, 2013 has been a year with large melting from both the Greenland Ice Sheet and the Arctic sea ice – but not nearly as large as the record-setting year of 2012.*

*November 18, 2013.*

#### Ice Sheet Melt Above Long Term Average for July.

*Ruth Mottram, Jason E. Box, Peter L. Langen, Polar Portal.*

*July 29, 2013*

#### Greenland ice sheet climate before summer 2013.

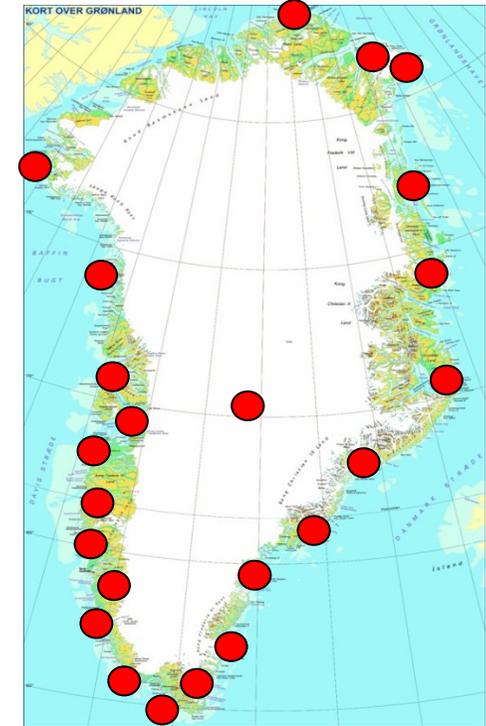
*Jason E. Box, Peter L. Langen, Signe Bech Andersen, Polar Portal.*

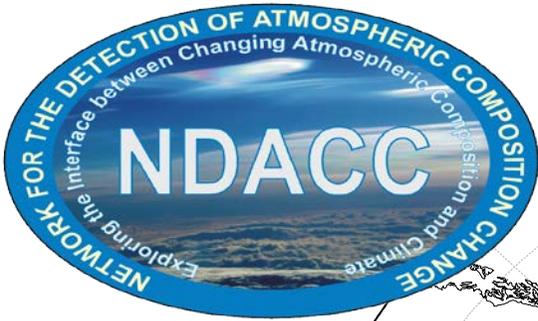
*June 18, 2013*



# Meteorological stations network

- 1 Weather service center Kangerlussuaq
  - 7 Met stations in rural districts
  - 18 Met stations at remote locations
  - 5 Radiosounding stations





# Ozone, other trace gases and aerosols



World Ozone and Ultraviolet Radiation Data Centre  
 Meteorological Service of Canada



Service météorologique du Canada  
 Centre Mondial des Données sur l'Ozone et le Rayonnement Ultraviolet

- Dobson/Brewers
- FTIR
- Microwave
- UV-Vis
- O3-sondes
- Lidar



# PROMICE

Programme for Monitoring of the Greenland Ice Sheet

## Programme for Monitoring of the Greenland Ice Sheet

 DTU Space  
National Space Institute



# Greenland Ecosystem Monitoring

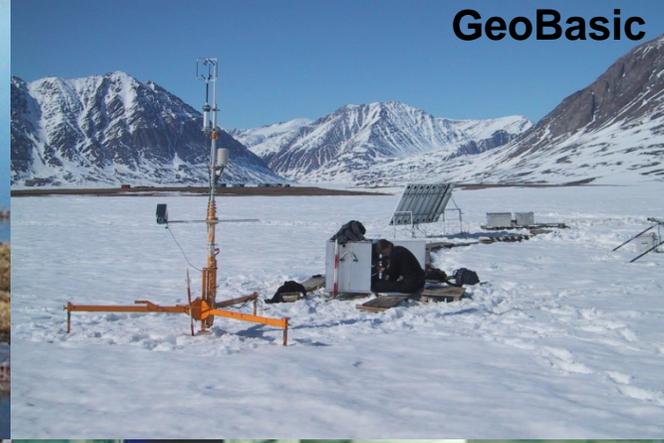
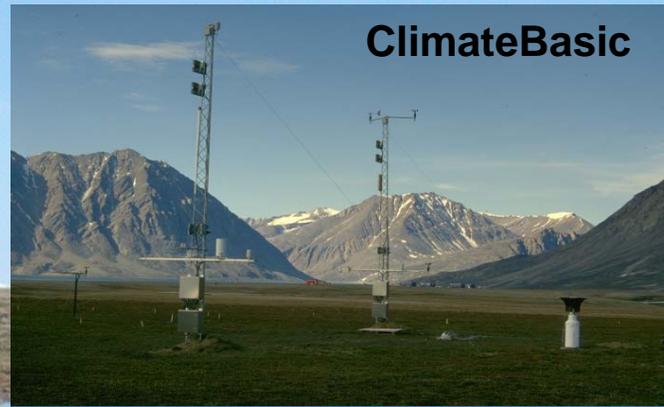
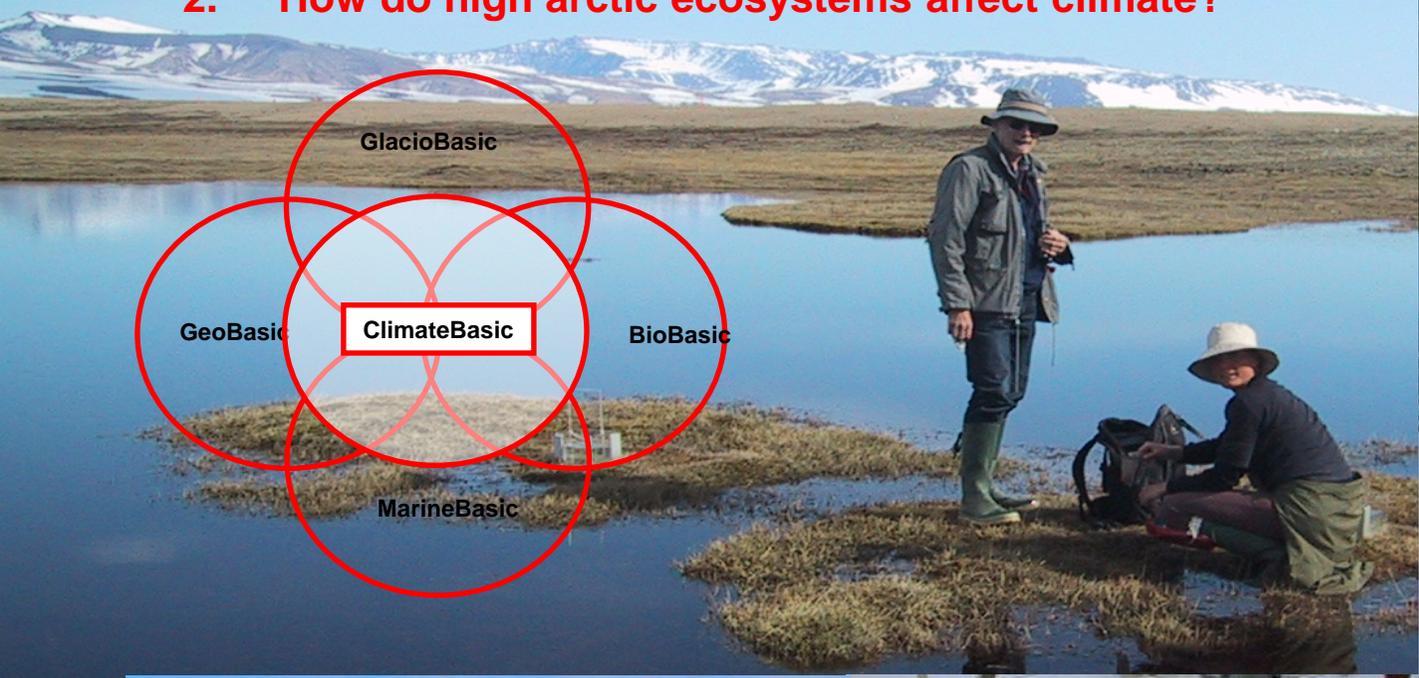
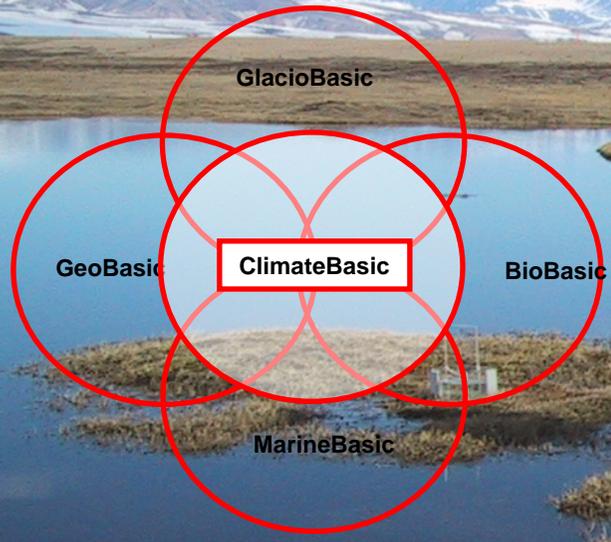
- Integrated ecosystem monitoring currently at two sites in Greenland.
- Zackenberg Basic since 1996
- Nuuk Basic since 2007

# GEM charecteristics

- Long term site-specific interdisciplinaty monitoring
- Common stategy and workprogramme
- Common monitoring protocols
- Common open access database
- Common secretariate
- Coordinating management structure

# Example Zackenberg Basic – monitoring at Zackenberg Research Station

1. How and why does climate variability influence the dynamics of high arctic ecosystems?
2. How do high arctic ecosystems affect climate?



# Kingdom of Denmark

## Strategy for the Arctic 2011-2020

- A peaceful, secure and safe Arctic
- Respect for the Arctic's fragile climate, environment and nature
- Self-sustaining growth and development
- Close cooperation with our international partners

*These strategic headlines are Operationalized by approx. 75 concrete goals and targets that have been approved politically*

*Inventory of progress made annually with a view to updating and adjusting goals and targets*