

Greenland Ecosystem Monitoring

**Inter-disciplinary long-term research
in
high and low arctic Greenland**

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**Science Vision Workshop for Toolik Field Station
DoubleTree Hotel, Portland, Oregon
2–4 August 2012**

Greenland Ecosystem Monitoring

Subjects:

1. General description

- a) History*
- b) NERO and Nuuk Basic*
- c) ZERO and Zackenberg Basic*

2. The conceptual framework

3. National and international cooperation

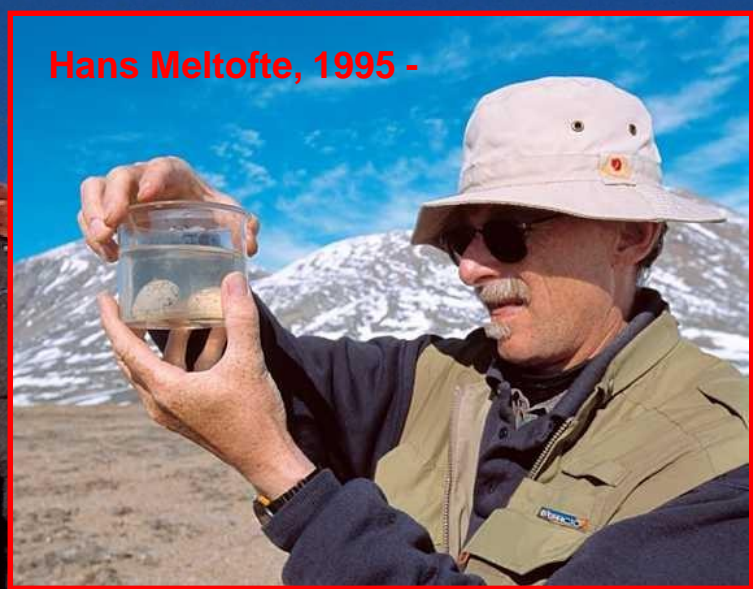
Zackenberg, 1991



Zackenberg, 1991

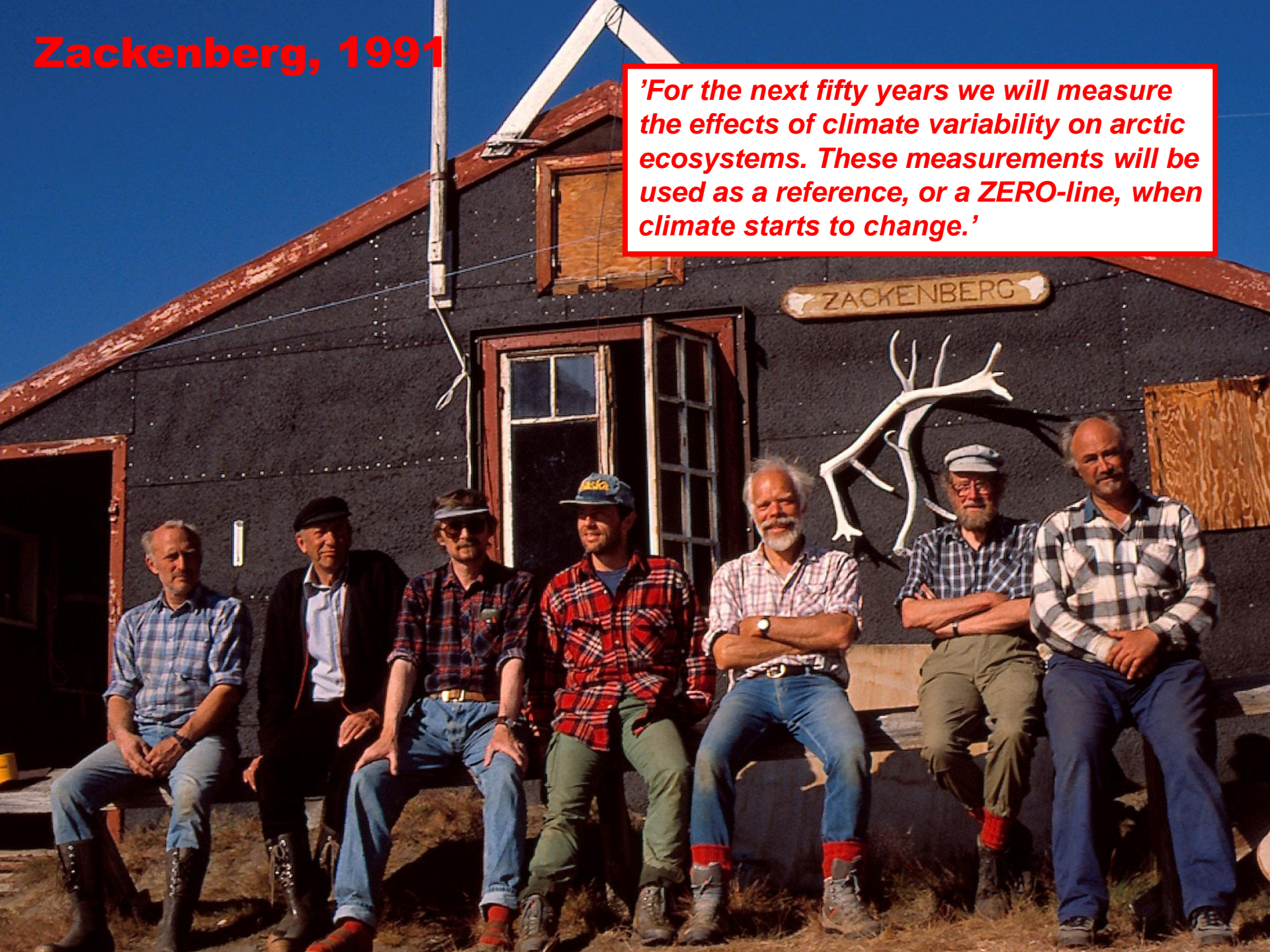


Hans Meltofte, 1995 -

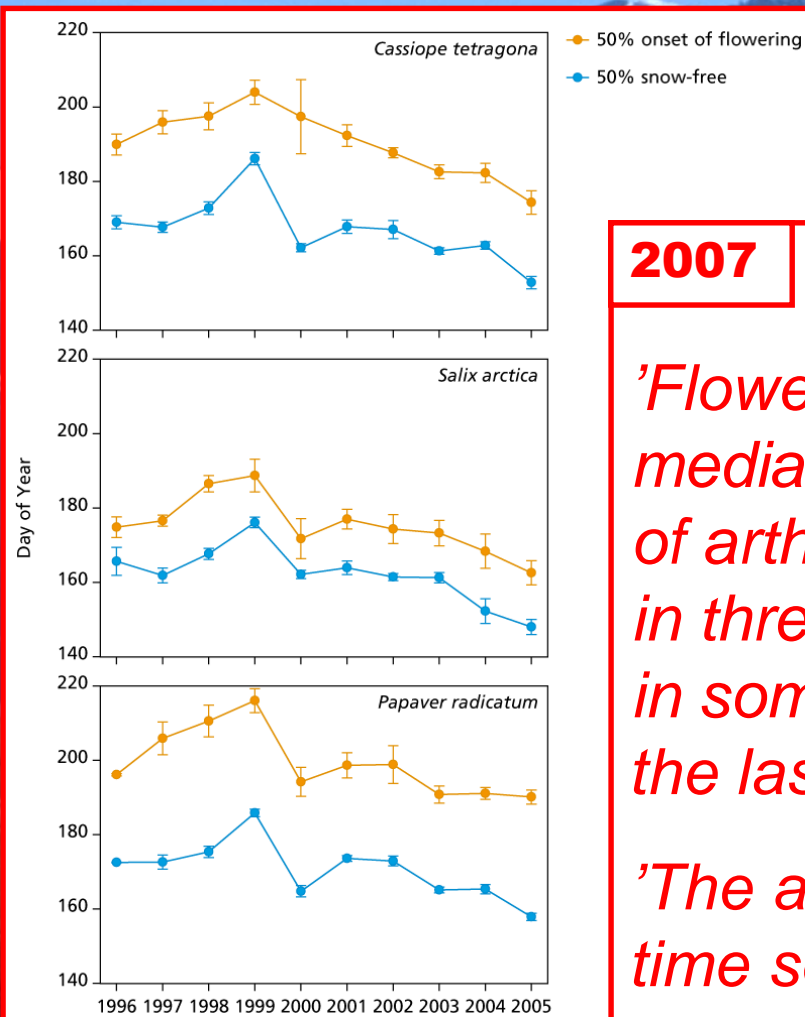


Zackenberg, 1991

'For the next fifty years we will measure the effects of climate variability on arctic ecosystems. These measurements will be used as a reference, or a ZERO-line, when climate starts to change.'



Greenland Ecosystem Monitoring



2007

'Flowering dates in six plant species, median emergence dates of twelve taxa of arthropods, and clutch initiation dates in three species of birds have advanced, in some cases by over 30 days during the last decade'

'The average advancement across all time series was 14.5 days per decade'

Hoye et al. 2007: *Current Biology* 17(12), 449-51.



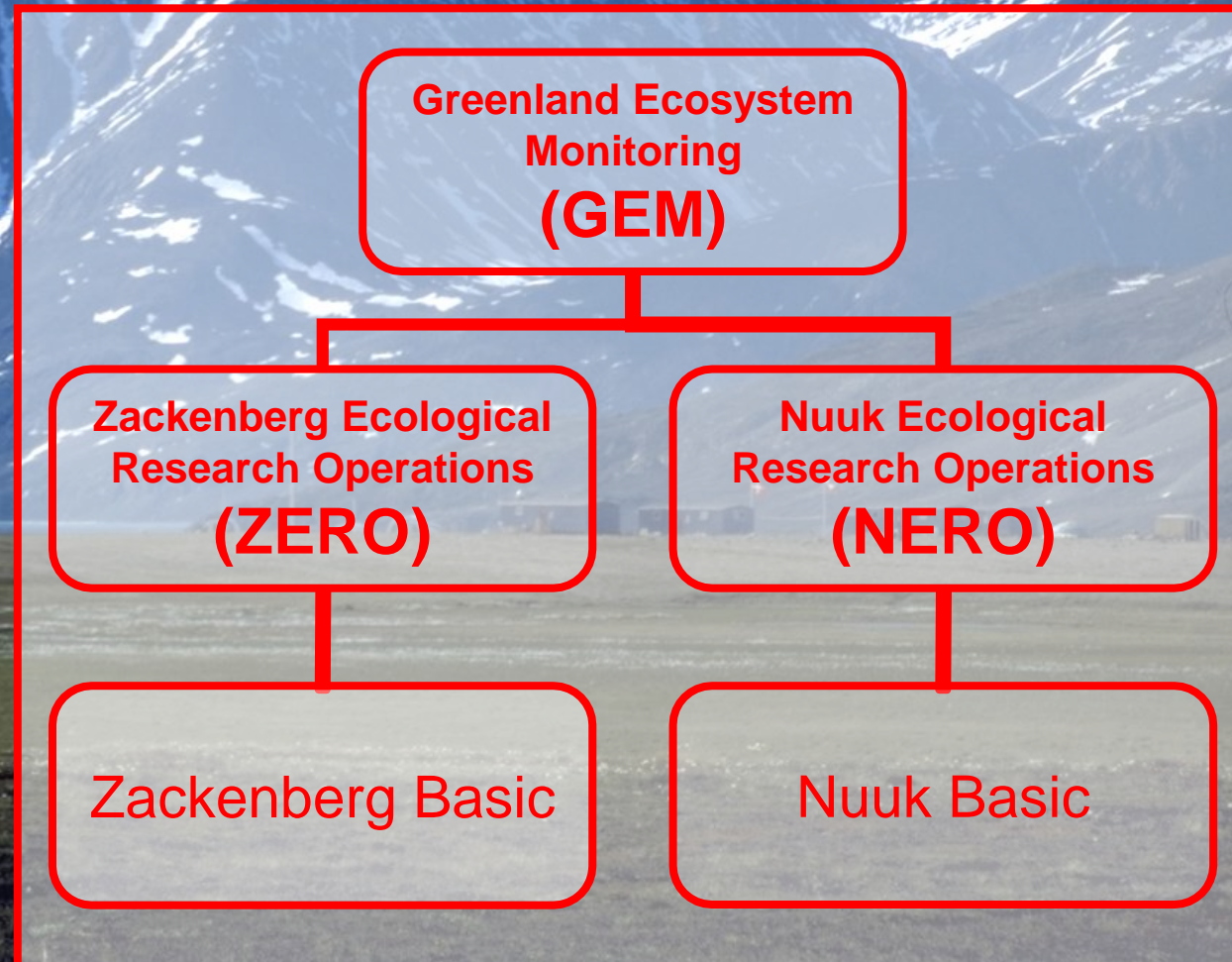
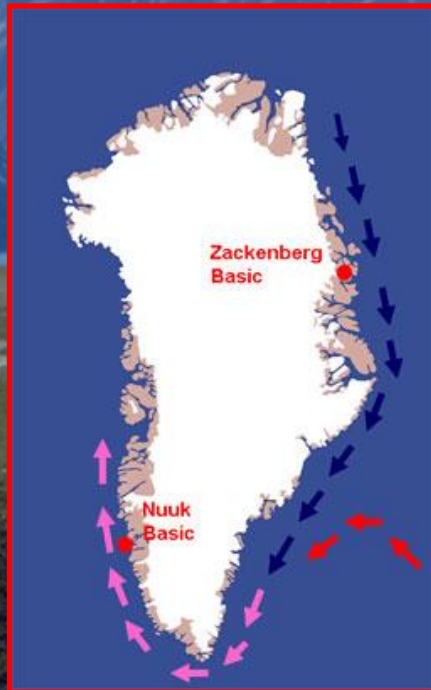
History

- 1991: First ZERO expedition to Zackenberg
- 1995: Zackenberg Basic established
- 1996-7: Five houses build at Zackenberg (300 m²)
- 1997: The station officially opened
- 2000: Zackenberg Research Station was invited to join SCANNET
- 2001: Zackenberg Agreement signed
- 2003: Magrethe II at Zackenberg
- 2006: Ownership transfered to Greenland Home Rule
- 2007: Extension of station with 300 m² at Zackenberg and 150 m² in Daneborg
- 2007: Nuuk Basic and Greenland Ecosystem Monitoring (GEM) established
- 2007: *'Carbon cycling in Arctic marine ecosystems: Case study Young Sund'* published
- 2008: *'High-Arctic Ecosystem Dynamics in a Changing Climate. Ten years of monitoring and research at Zackenberg Research Station, Northeast Greenland'* published
- 2010: Extension of station with 150 m² at Daneborg and 50 m² at Zackenberg
- 2010: GEM takes co-lead in INTERACT
- 2011: First course at Aarhus University in *'Arctic System Science'*

Greenland Ecosystem Monitoring

Zackenberg Ecological Research Operations

Nuuk Ecological Research Operations



Mission and Vision 2011-15

Mission

- To contribute to a coherent and scientific sound description of the state of the environment, including its biodiversity in Greenland and the Arctic in relation to climatic changes with focus on ecosystem responses and on global impacts related to the feedbacks processes.
- To provide science-based input on the state of the environment in Greenland and the Arctic for Danish, Greenlandic and international policy development, adaptation and administration.
- To provide a platform for cutting-edge inter-disciplinary research on the structure and function of arctic ecosystem.

Vision

Focusing on Greenland, GEM will contribute substantially to the basic scientific understanding of arctic ecosystems and their responses to climatic changes and variability as well as the potential local, regional and global implications of changes in Arctic ecosystems. GEM will maintain and strengthen its position as an internationally leading integrated long-term monitoring and research program.

Funding and institutions involved

- The programme is financed by the Danish Energy Agency, the Danish Environmental Protection Agency, the Danish Research Agency and the Greenland Government. Establishment of infrastructure was mainly financed by Aage V. Jensen Charity Foundation
- The programme is operated as a centre-without-walls with participation of Greenland Institute of Natural Resources, Asiaq, Aarhus University, Copenhagen University, and Geological Survey of Denmark and Greenland
- The programme is coordinated by a secretariat at Aarhus University
- Annual budget is c. 3.5 mio. EURO

Nuuk Ecological Research Operations (NERO)

Nuuk Basic



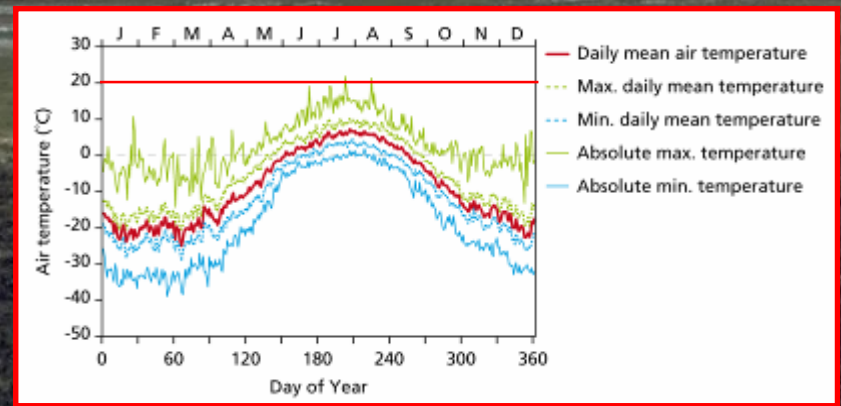
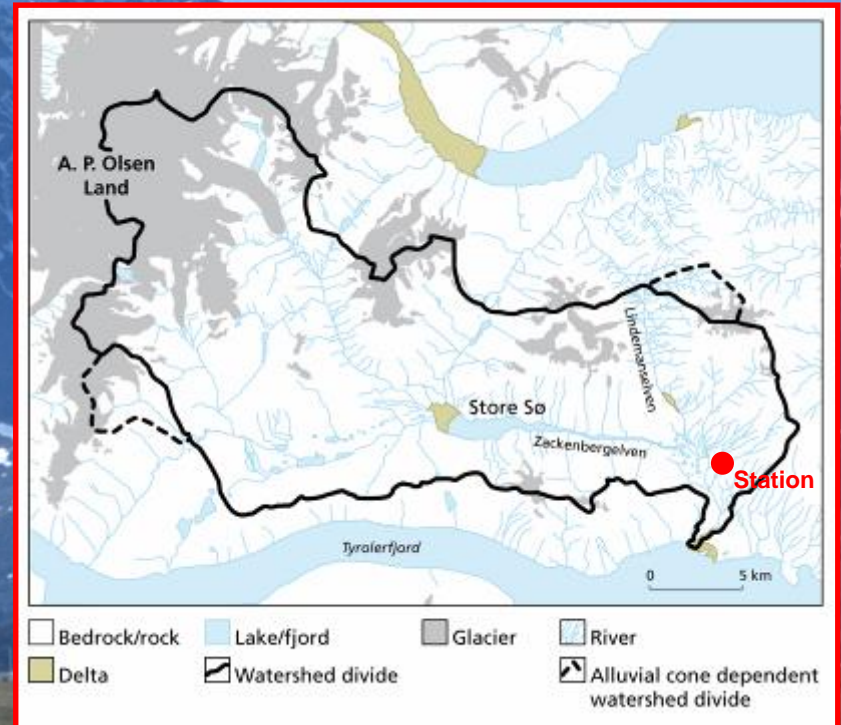
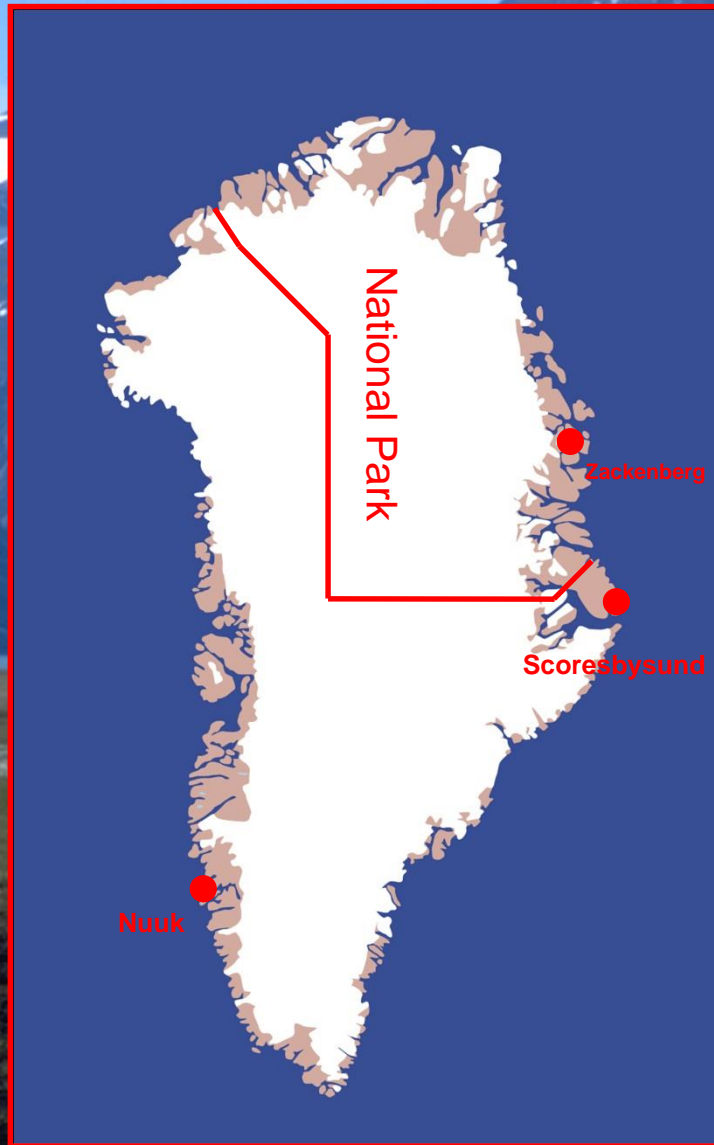
NERO and Nuuk Basic:

- Established in 2007
- Study area consists of the fjord Kobbefjord (25 km²) and a drainage basin (32 km²) in the bottom of the fjord
- Low arctic setting
- No permafrost – sporadic permafrost
- Study area 25 km from Nuuk
- Four subprogrammes: Climate Basis, GeoBasis, BioBasis and MarineBasis
- Approximately 3,500 different parameters
- Staff: 7 scientists, 1 logistician and a number of field assistants
- Annual budget: c. 1.5 mio. EURO
- Close cooperation with the newly established Greenland Climate Research Center
- Future plan is to establish an educational component for secondary and high school students in Greenland
- Approximately 5 peer reviewed papers per year



Zackenberg Ecological Research Operations (ZERO)

Zackenberg Basic



Zackenbergl Research Station



Terrestrial facility at Zackenberg



Marine facility at Daneborg



Zackenbergl Research Station

Airstrip

Accommodation

Fuel



Power station,
Workshop and
garage

Logistics

Monitoring

Shelter's

Accommodation

Offices

Waterworks

Laboratories

Cantine

Toilet

Drinking
water



ZERO and Zackenberg Basic:

- Established in 1995
- Study area consists of the fjord system Young Sund/Tyrolerfjord (390 km²) and a drainage basin (520 km²) at Zackenberg
- High arctic setting
- Continuous permafrost
- Study area 450 km from nearest town, Scoresbysund
- Five subprogrammes: Climate Basis, GeoBasis, BioBasis, MarineBasis and GlacioBasis
- Approximately 3,500 parameters
- Staff: 8-9 scientists, 2 logistician and a number of field assistants
- Annual budget: c. 2.0 mio. EURO
- Besides being the observatory for ZERO and Zackenberg Basic, Zackenberg Research Station also hosts c. 25 international research projects per year
- The research station at Zackenberg was in 2010 extended with a marine facility with accommodation facilities, laboratories, boat house etc. in Daneborg c. 20 km south of Zackenberg
- Approximately 40 peer reviewed papers per year



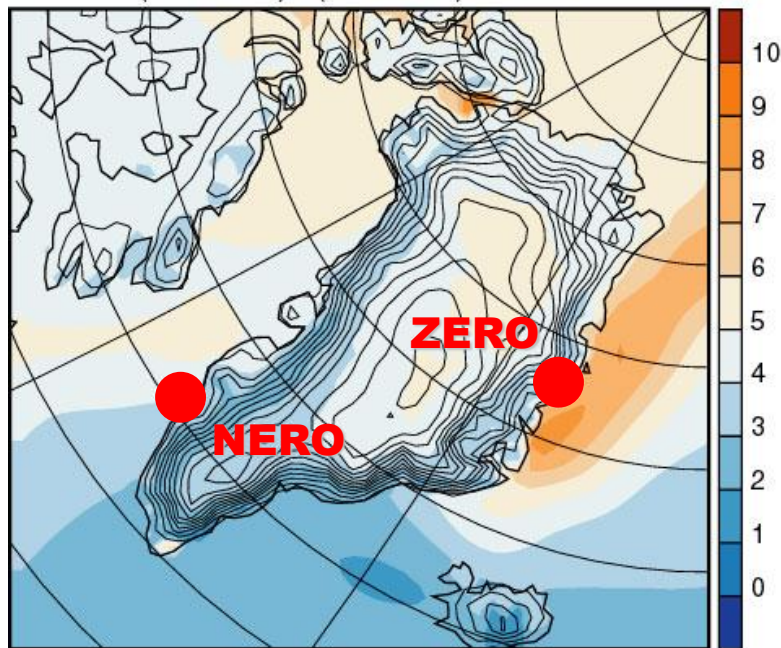
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Future climate in Greenland

Temperature and precipitation. 2071-2100 minus 1961-1990

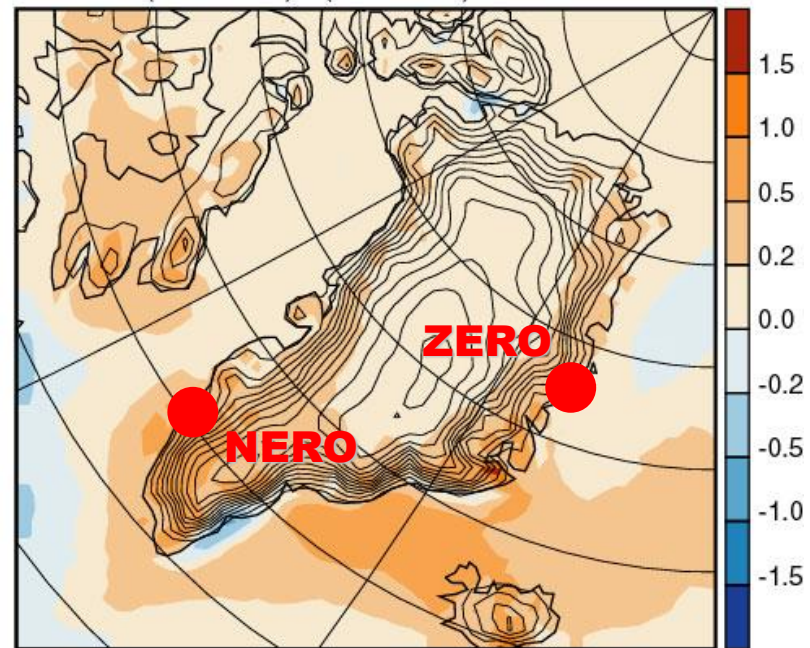
Temperature

HIRHAM4 (2071-2100) – (1961-1990) scB2



Precipitation

HIRHAM4 (2071-2100) – (1961-1990) scB2



Greenland Ecosystem Monitoring

Subjects:

1. General description

- a) *History*
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- c) *ZERO and Zackenberg Basic*

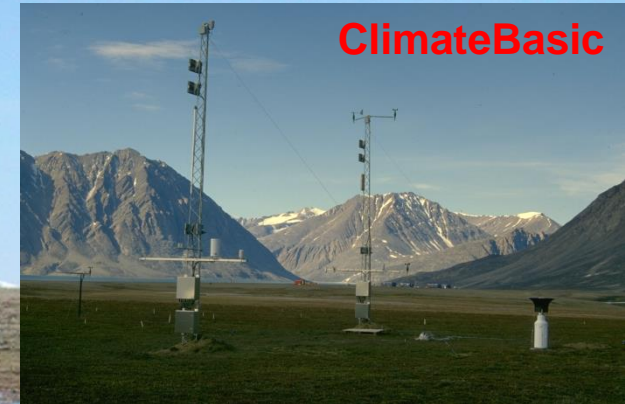
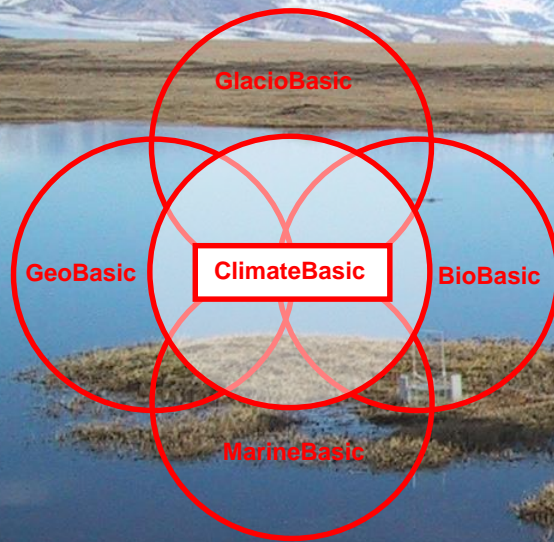
2. The conceptual framework

3. National and international cooperation

Greenland Ecosystem Monitoring

Major questions:

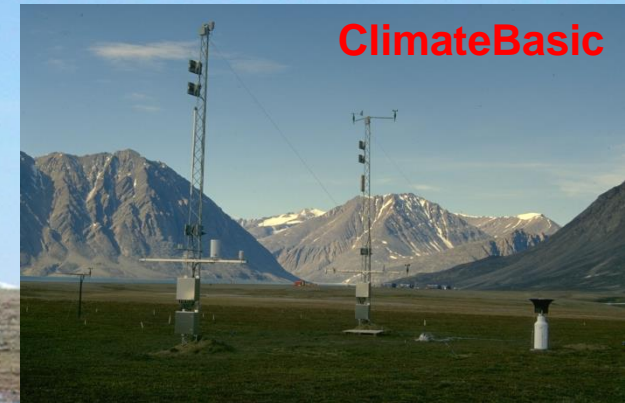
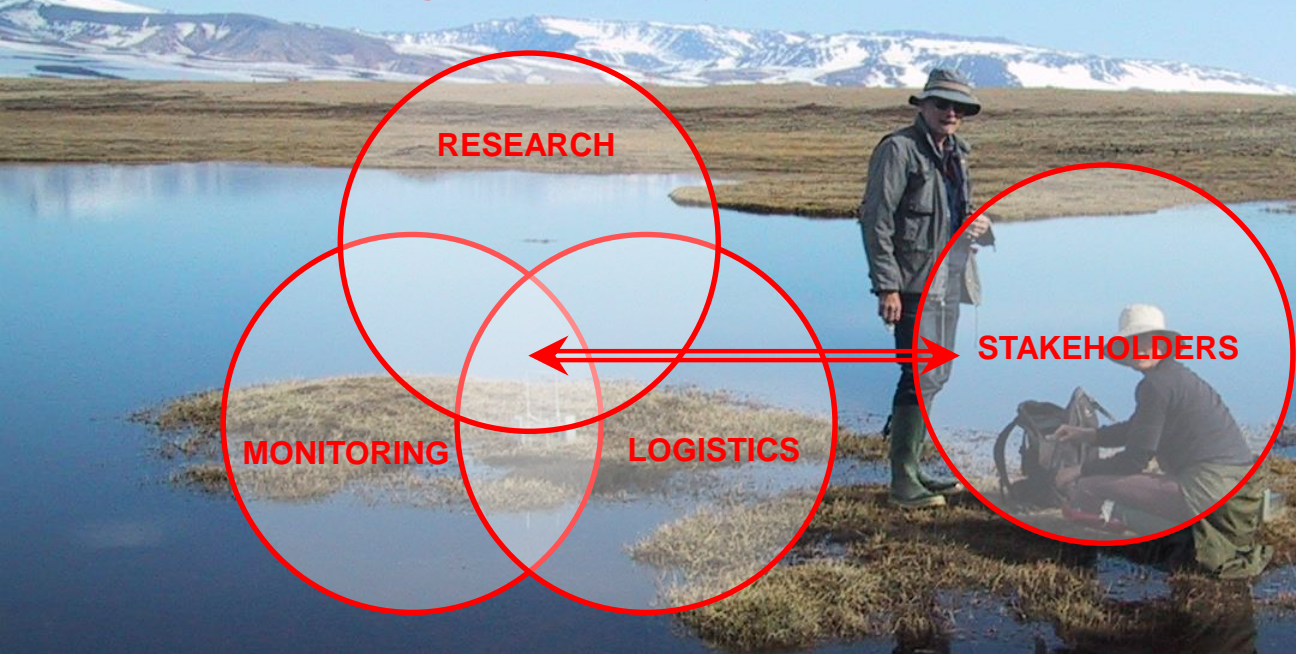
1. How and why does climate variability influence the dynamics of high arctic ecosystems?
2. How do high arctic ecosystems affect climate?



Greenland Ecosystem Monitoring

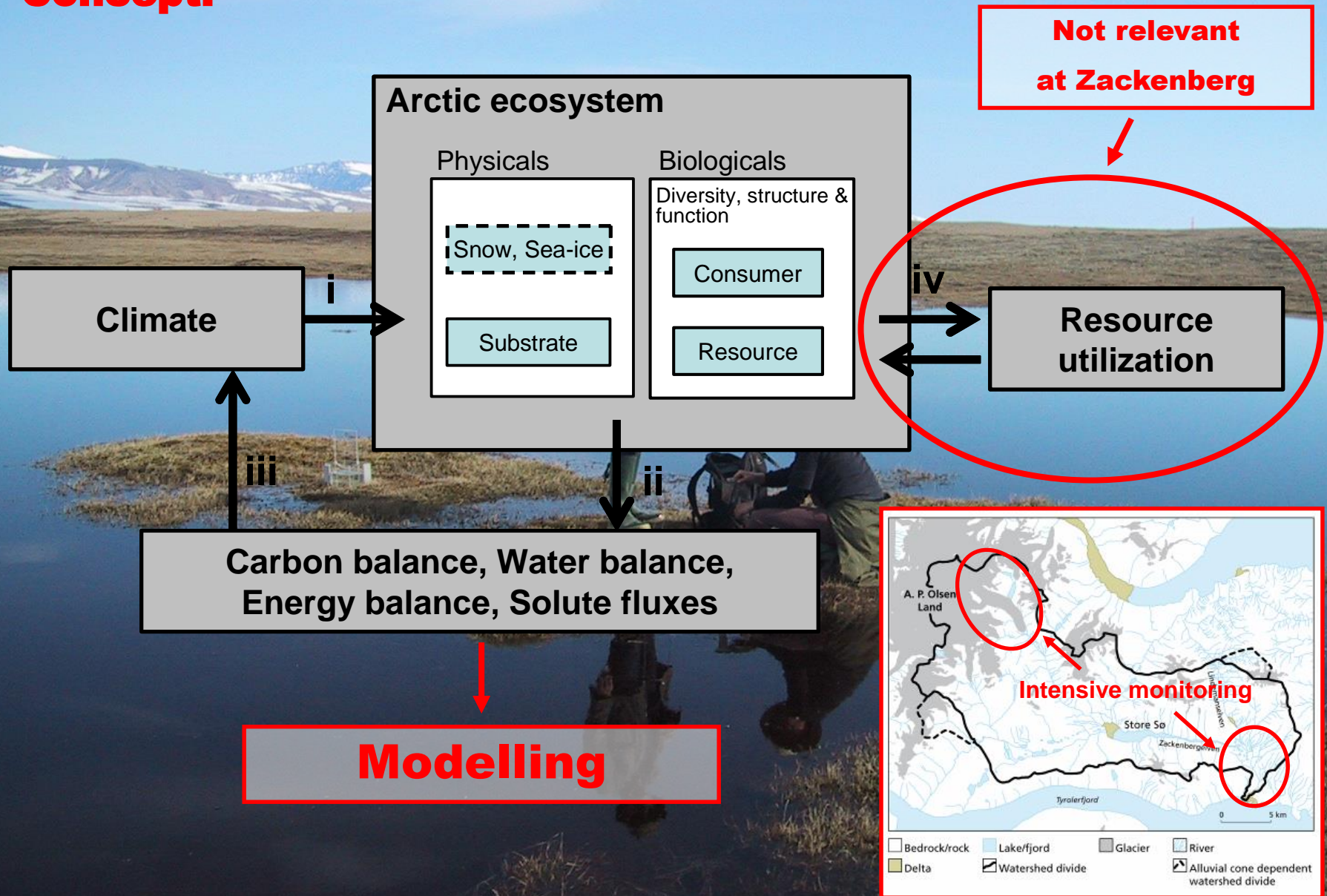
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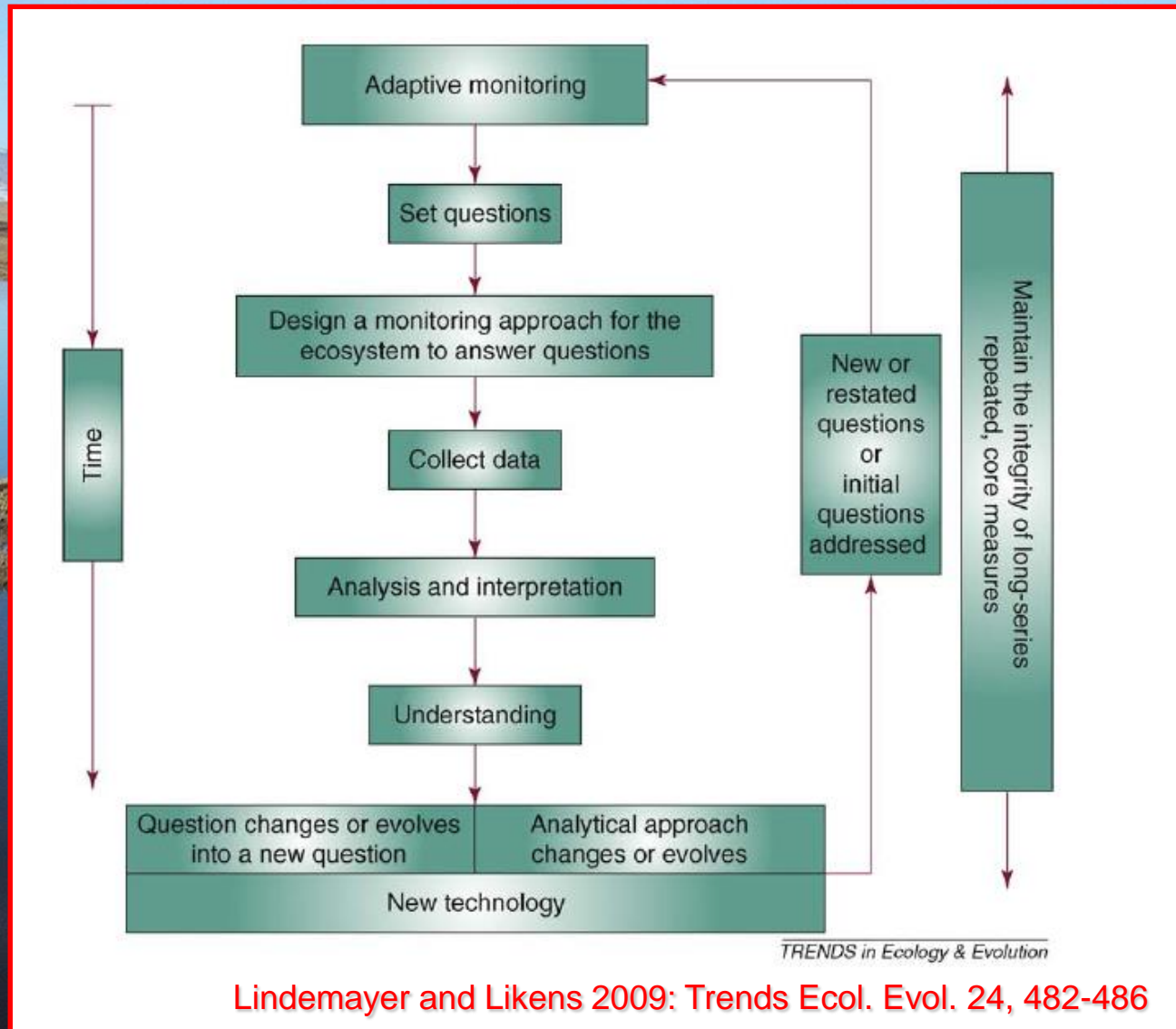
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Concept:



Greenland Ecosystem Monitoring

Adaptive monitoring:

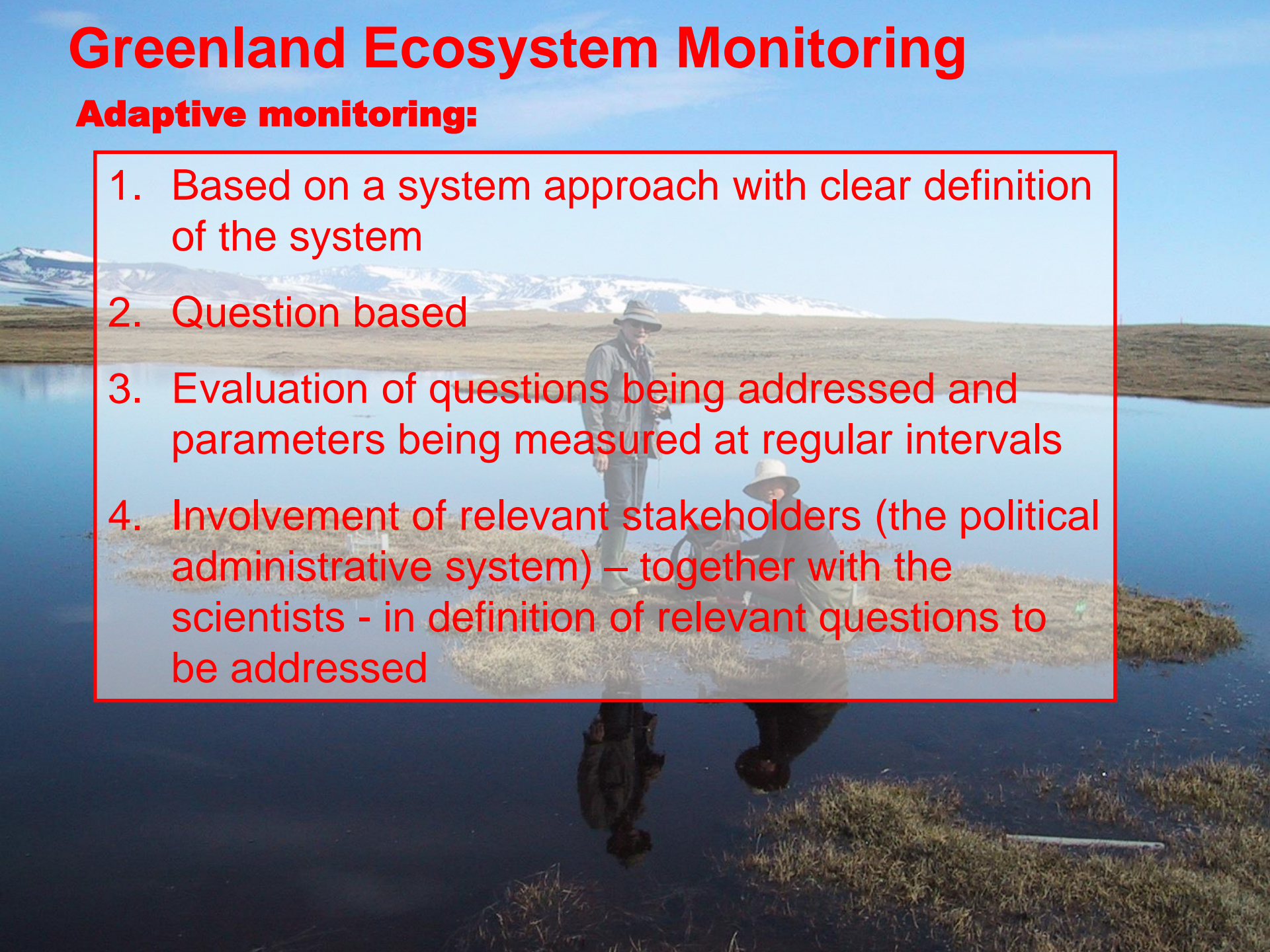


Lindemayer and Likens 2009: Trends Ecol. Evol. 24, 482-486

Greenland Ecosystem Monitoring

Adaptive monitoring:

1. Based on a system approach with clear definition of the system
2. Question based
3. Evaluation of questions being addressed and parameters being measured at regular intervals
4. Involvement of relevant stakeholders (the political administrative system) – together with the scientists - in definition of relevant questions to be addressed



Greenland Ecosystem Monitoring

GEM Strategy 2011-15:

13 questions to be addressed during 2011-15:

Greenhouse gas exchange with the atmosphere and nutrients balance

1. How does climate change and variability control the annual and seasonal exchange of greenhouse gasses (H₂O, CO₂, CH₄ and N₂O) between arctic terrestrial ecosystems and the atmosphere?
2. How does climate change and variability affect the CO₂ exchange between arctic marine ecosystems and the atmosphere?

Ecosystem function and resilience

3. How does global change, incl. stronger climatic variability and change, affect the species composition and function of arctic ecosystems?
4. Are there important thresholds in arctic ecosystems that might lead to sudden and significant shifts of their overall biodiversity and function?

Water balance, incl. glaciology and water circulation in the marine environment

5. How does climate variability and change affect the water balance (incl. availability of water in terrestrial ecosystems, glacier mass balance and extreme run-off events) of arctic ecosystem?
6. How does climate variability and change affect the discharge of sediments, organic matter, solutes and carbon from the terrestrial to the marine compartments of arctic ecosystems?
7. How does river water discharge affect the water circulation in arctic fjord systems?

Snow and ice, incl. effects on phenology, energy and carbon balance

8. How does climate induced changes and variability of snow, lake-ice and sea-ice distribution change the biodiversity and function of marine, terrestrial and limnic ecosystems in the Arctic?
9. How does the energy balance of arctic ecosystems (marine, terrestrial and limnic) change with climate change and variability?
10. How does climate induced changes of permafrost affected landscapes/soils (mainly thickness of active layer, thermal and moisture regime) affect the function of arctic ecosystems and specifically their carbon balance?

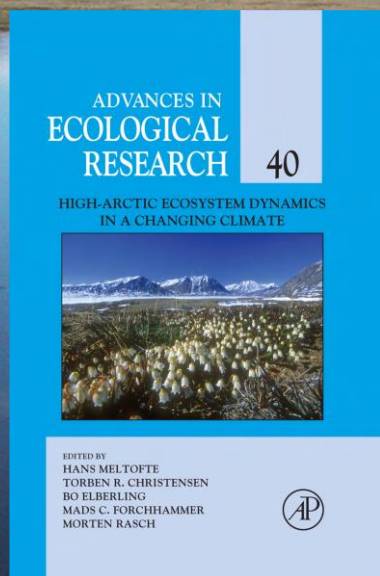
Up-scaling, modelling and prediction

11. To what extent can results from GEM be used for up-scaling and prediction to address the questions above on a regional scale covering Greenland and the sea around Greenland (now and for the future) and what are the constraints for such up-scaling and prediction efforts?
12. What models shall be developed in to address the questions above on a regional scale (Greenland and surrounding sea)?
13. How can current monitoring and long-term research efforts in GEM most effectively be adjusted to meet current and future scientific needs and policy-related demands?

Greenland Ecosystem Monitoring

Measurements, data and publication:

- Data are provided free-of-charge to anyone being interested in using the data
- Data from Zackenberg and Nuuk are thoroughly reported each year to the ZERO and NERO Annual Report's and a number of scientific papers
- Reporting of the first ten years of monitoring and research at Zackenberg was published in Monographs on Greenland (marine ecosystems) in 2007 and in Advances in Ecological Research in 2008 (terrestrial ecosystems).



Scientific theme	Description
Climate	Temperature (air, surface and soil), wind, radiation, humidity, precipitation
Snow	Cover, thickness, distribution
Hydrology	Water balance, sediment and solute transport
Glacier ice	Glacier mass balances, iceberg production in Godthåbsfjord
Sea ice	Cover, thickness, distribution, biological activity
UV radiation	Strength, seasonal and interannual variations, ecosystem effects
Soils	Active layer development, temperature, water chemistry, soil arthropods, decomposition
Vegetation	Species diversity, growth, reproduction, phenology, parasitism, distribution of vegetation types, UV radiation effects
Gas flux	Carbon dioxide, methane, water vapour, laughing gas, interactions with structure and function of herbivore-plant interactions
Lakes	Chemistry, carbon balance, abundance and production of plankton and fish
Athropods	Insect abundance, reproduction and phenology
Mammals & Birds	Selected terrestrial, freshwater and marine species, species diversity, abundance, distribution, reproduction, phenology
Water phase	Temperature, salinity, currents, chemistry, carbon balance, plankton, crustacean, fish.
Sea bottom	Chemistry, carbon balance, growth, abundance and distribution of benthic animals



Greenland Ecosystem Monitoring

Data policy:

ZackenbergGIS/DataPage - Windows Internet Explorer

http://dmugisweb.dmu.dk/zackenberggis/datapage.aspx

File Edit View Favorites Tools Help

Google Søg Del Sidewiki Kontroller Oversæt AutoFyld Log ind

ZackenbergGIS/DataPage

Denne side er på Engelsk. Oversæt den ved hjælp af Google Toolbar? Ikke på Engelsk? [Hjælp os med at blive bedre](#)

Oversæt Slå Engelsk oversættelse fra

ZackenbergGIS [MapPage](#) [DataPage](#) [Help](#) Zackenberg.dk | NERI | Aarhus University

Data from Zackenberg

Welcome to the ZackenbergBasic database.

From here, you can download data from the monitoring at Zackenberg.

For details about the data available, please contact the relevant [programme managers](#).

In case you need data for 2008 and onwards, please also contact the relevant programme manager.

NOTE about GeoBasis data: Due to implementation of a new data handling and validation tool in GeoBasis (WISKI), data until fall 2006 are currently only available in the database. However, data have been validated up to 2009 and are available. Please contact Charlotte Sigsgaard (cs@geo.ku.dk) or Mikkel P. Tamstorf (mpt@dmu.dk) for access.

Manuals

Manuals are available as PDF files for the [BioBasis](#), [GeoBasis](#), [GlacioBasis](#) and [MarineBasis](#) programmes.

Select programme, subprogramme and data

Programme:

Subprogramme:

Data:

Programme description

Title	Arctostaphylos
Description	For details about this BioBasis dataset, please refer to the BioBasis Manual (pdf-file, 2 MB)
Min_Date	19980831
Max_Date	20060813
No_Records	425

Variable description

Column name	Data type	is_nullable
Date	int	yes

Data, protocols
and manuals on:

www.zackenberg.dk
www.nuuk-basic.dk

Greenland Ecosystem Monitoring

Subjects:

1. Relevance

2. General description

- a) *History*
- b) *NERO and Nuuk Basic*
- c) *ZERO and Zackenberg Basic*

3. The conceptual framework

4. National and international cooperation

Greenland Ecosystem Monitoring

National Cooperation:

Centres, groups and projects

Arctic Research Centre, Aarhus University – Arctic Science Partnership

Greenland Climate Research Centre – Arctic Science Partnership

Polar Science Centre, University of Copenhagen

The Climate Modelling Group, Danish Meteorological Institute

The Ice Group, University of Copenhagen

The Marine Group, University of Southern Denmark

The Remote Sensing Group, Technical University of Denmark

DEFROST, Nordic Council of Ministers

Research Stations and Institutions

Greenland Institute of Natural Resources

Arctic Station, University of Copenhagen

Sermilik Station, University of Copenhagen

Kangerlussuaq International Science Support

Greenland Ecosystem Monitoring

International Cooperation:

Centres, groups and projects

The Carbon Group, Lund University

The Snow Modelling Group, Colorado State University

The Population Dynamics Group, Pennsylvanian State University

The Ecology Group at Sheffield University

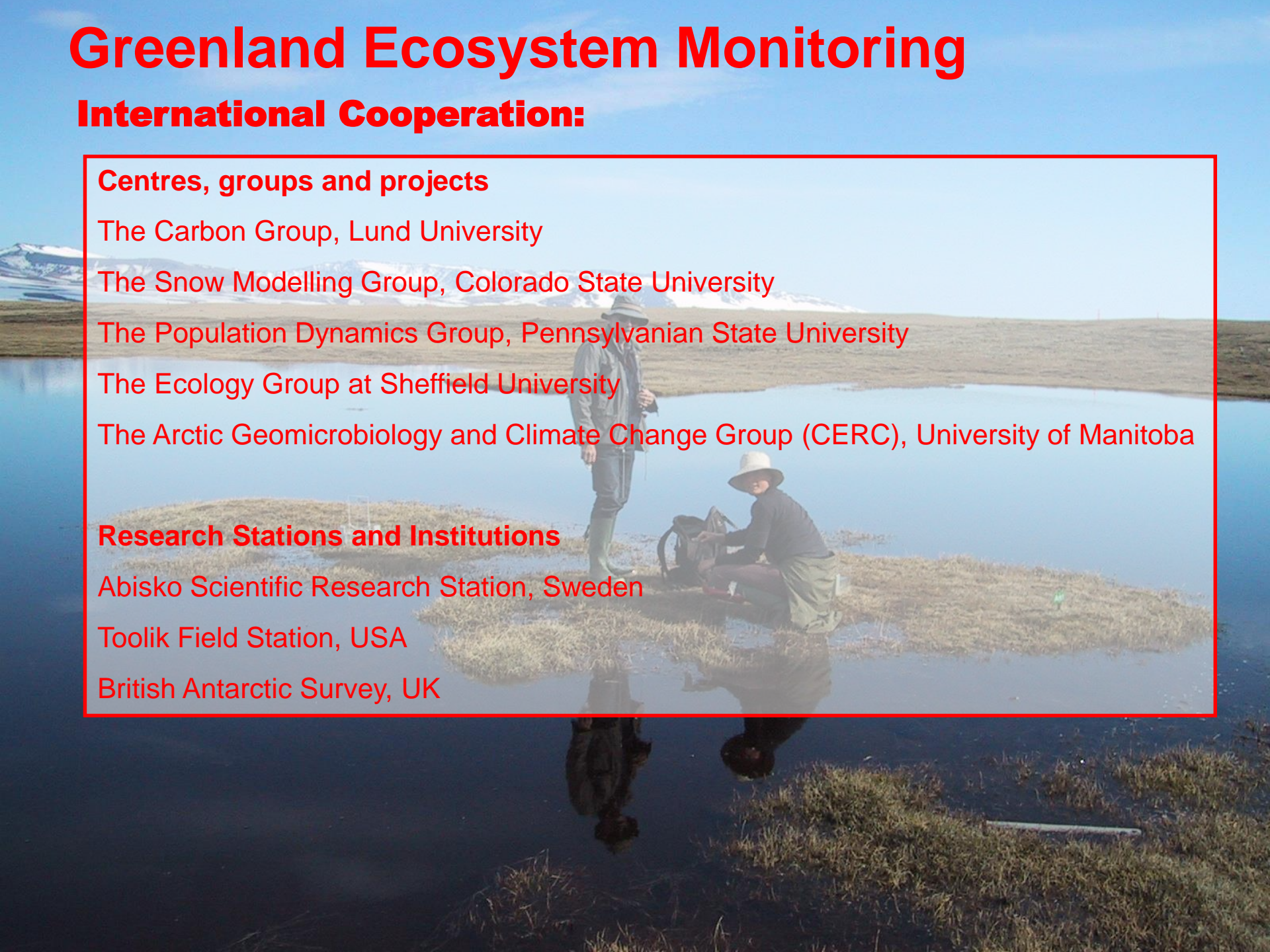
The Arctic Geomicrobiology and Climate Change Group (CERC), University of Manitoba

Research Stations and Institutions

Abisko Scientific Research Station, Sweden

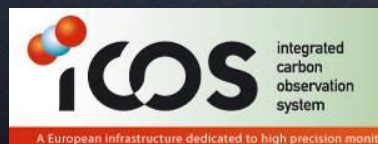
Toolik Field Station, USA

British Antarctic Survey, UK



Greenland Ecosystem Monitoring

International Cooperation:



**All good cooperation starts
with people enjoying each
others company**





Thank You



More information:
www.g-e-m.dk
www.zackenbergs.dk
www.nuuk-basic.dk