



Global and Regional Atmosphere – Land Surface Modelling at the University of Oslo: Vegetation, Permafrost and Snow Surfaces

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Strategic Research Initiative 2015-2019

Land-Atmosphere Interactions in Cold Environments

The role of Atmosphere – Biosphere – Cryosphere – Hydrosphere interactions in a rapidly changing climate

LATICE

Coordinator: Lena M. Tallaksen

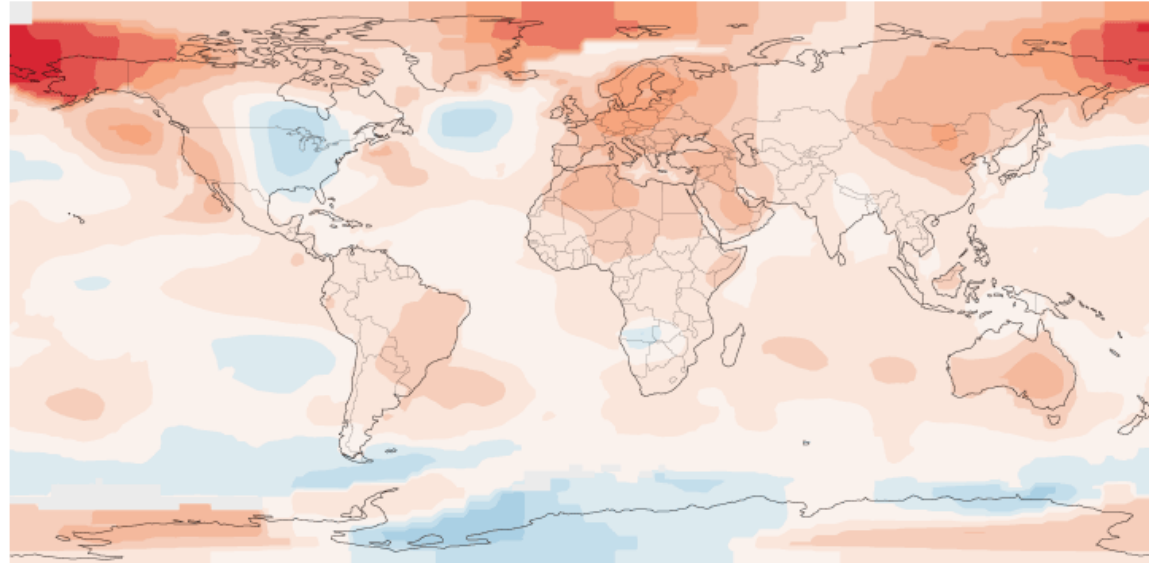
Co-leaders: Frode Stordal, John Burkhart

Motivation

- Global warming
- Arctic amplification
- Major impacts in cold environments
- The role of the land-surface

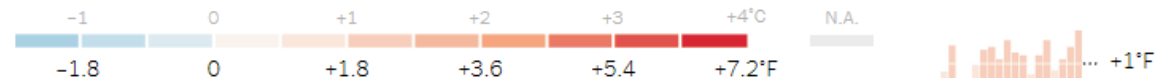
The Warmest Year on Record

Parts of the eastern United States were cooler than average last year, but globally 2014 was the warmest year in recorded history.



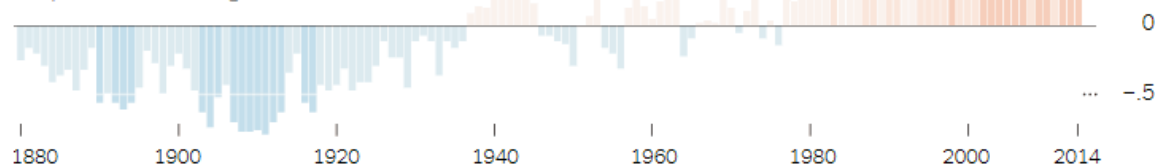
How far above or below average temperatures were in 2014

Compared with the average from 1951 to '80



Average global surface air temperature

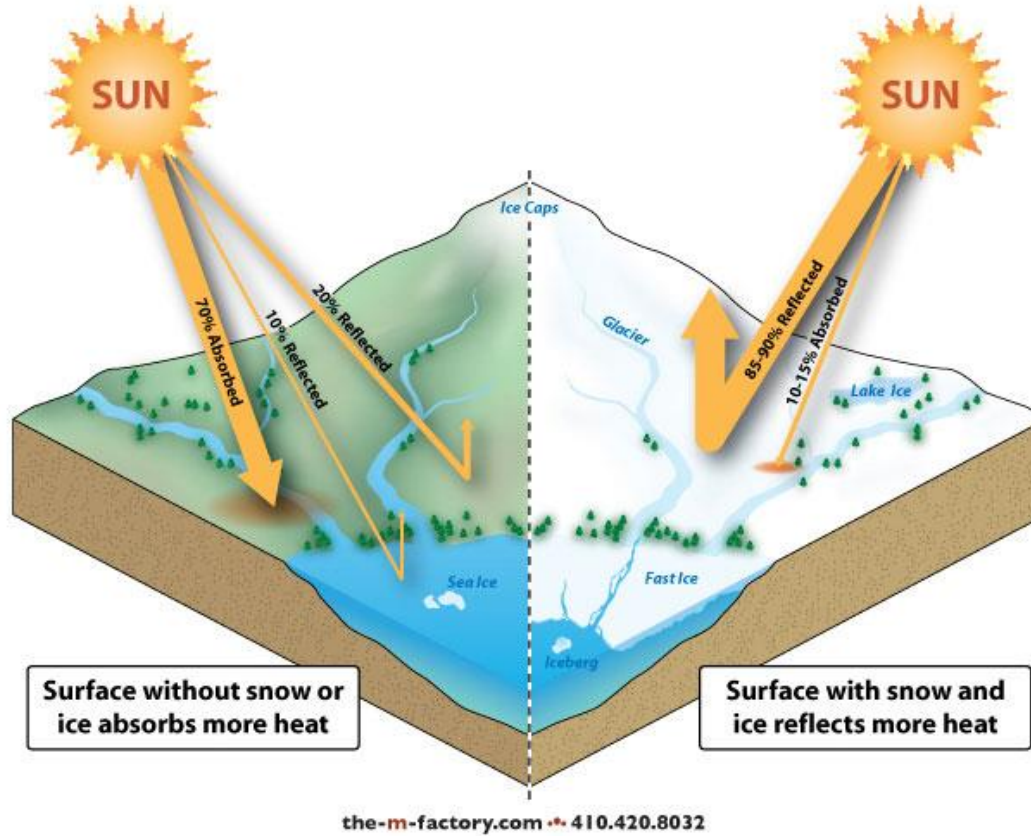
Compared with the average from 1901 to 2000



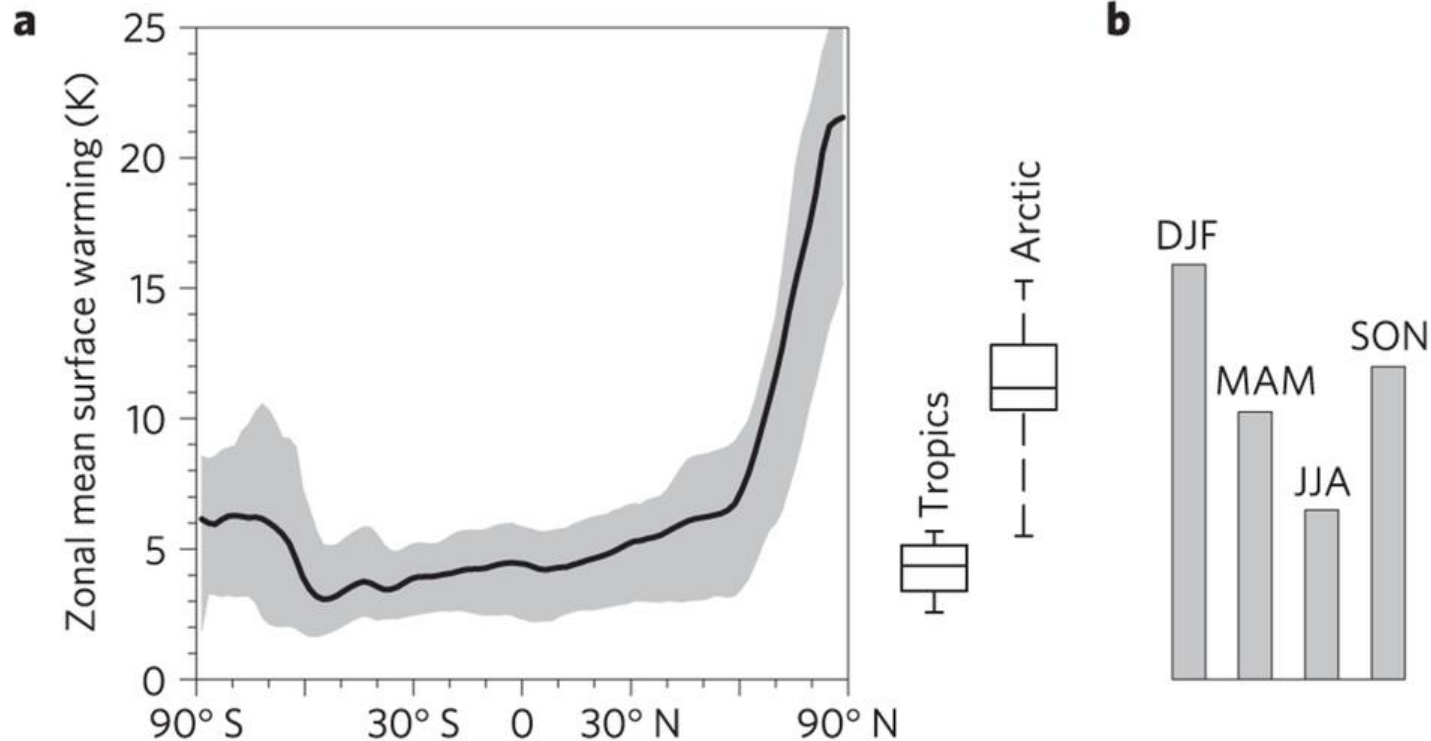
Sources: NASA; National Oceanic and Atmospheric Administration

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Arctic amplification: Albedo feedbacks

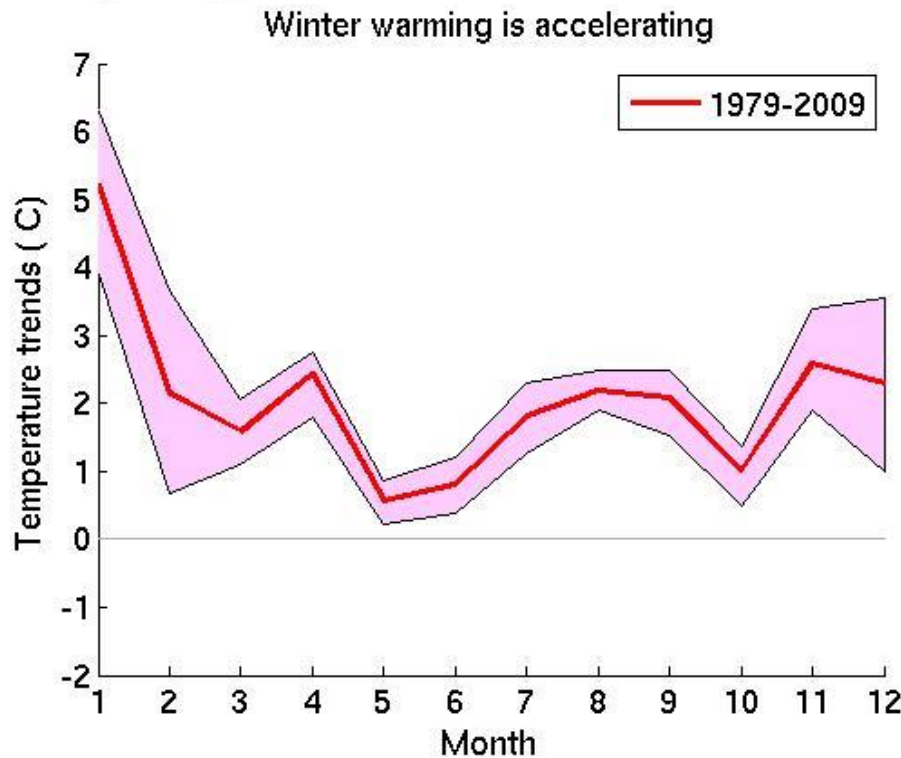


Arctic amplification: Temp. feedbacks

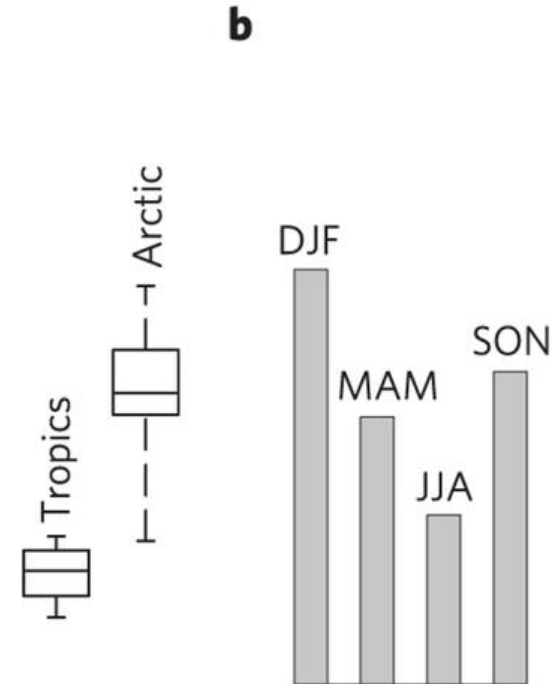


Arctic amplification dominated by temperature feedbacks in contemporary climate models. Pithan & Mauritsen, *Nature Geoscience* 7, 181–184 (2014)

Arctic amplification: data from seNorge



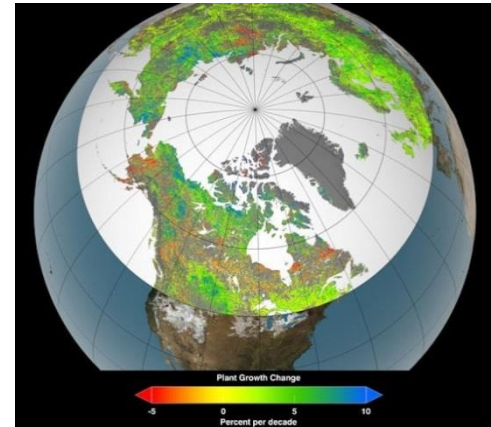
Brox-Nilsen & Tallaksen, EGU (2014)



Pithan & Mauritsen, Nature
Geoscience 7, 181–184 (2014)

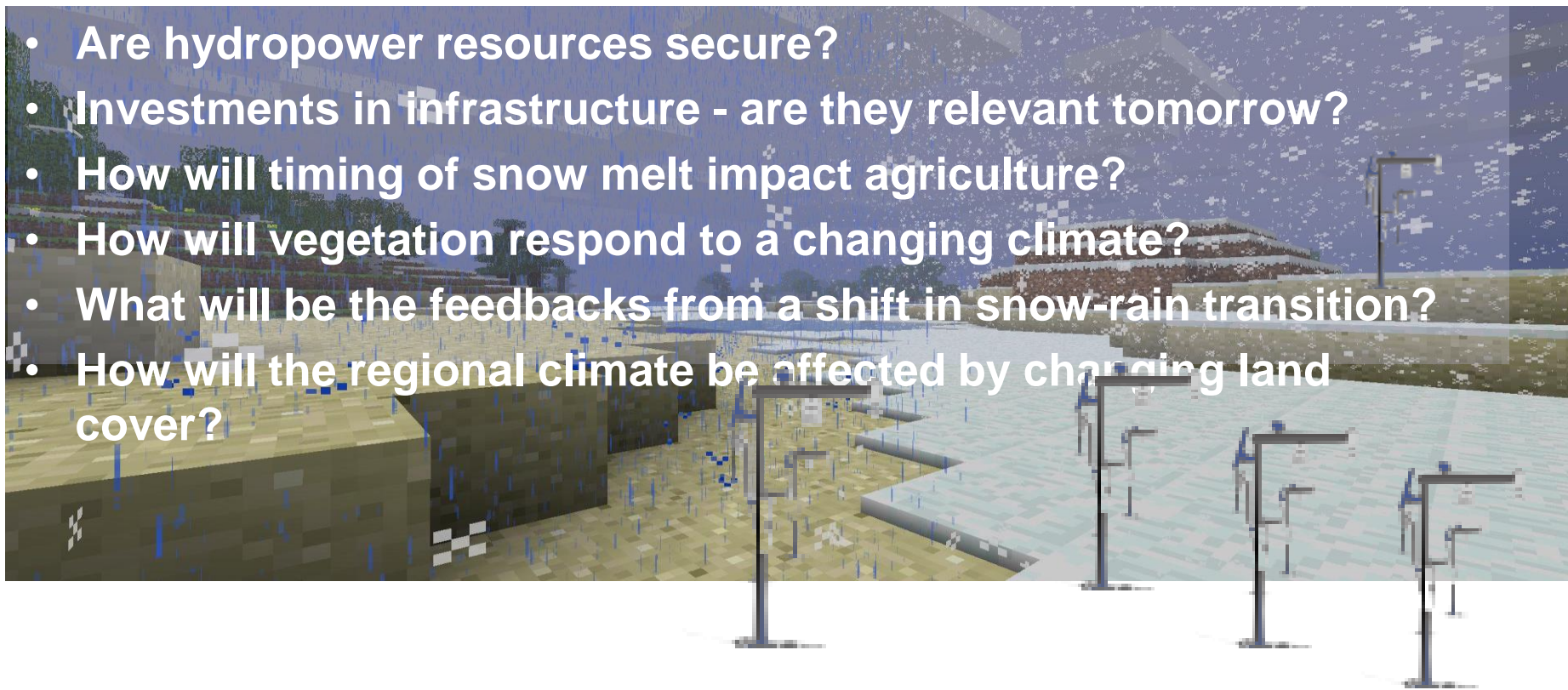
Impacts – Cold environments

- Greening of the arctic
- Reduced snow cover
- Thawing of frozen ground
- More extreme events
- New and emerging hazards
- Uncertain ecosystem changes



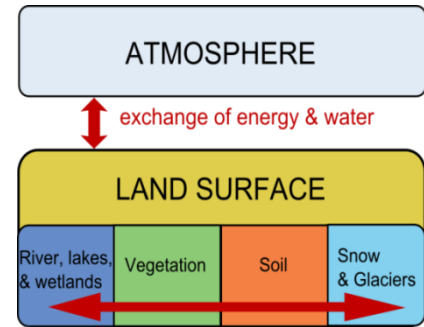
Is our understanding sufficient?

- Are hydropower resources secure?
- Investments in infrastructure - are they relevant tomorrow?
- How will timing of snow melt impact agriculture?
- How will vegetation respond to a changing climate?
- What will be the feedbacks from a shift in snow-rain transition?
- How will the regional climate be affected by changing land cover?



Objective

To establish an interdisciplinary team of Earth System scientists to address critical knowledge gaps in current climate assessments through:



- Improved parameterizations of processes in earth system models
- Assess **feedbacks** resulting from land surface changes through an observational-based modelling approach
- Integrate remote earth observations with in-situ data and instrument networks
- Develop novel observational products
- Bridge the scales between atmosphere and terrestrial model systems through targeted field efforts and network design

LATICE – Who are we?

GEOFAG (GEO)

Atmosphere

Terje Koren Berntsen
Jón Egill Kristjánsson
Kirstin Krüger
Frode Stordal

Cryosphere

Bernd Etzelmüller
Jon Ove Methlie Hagen
Andreas Käab
Thomas V. Schuler
Sebastian Westermann

Hydrosphere

John Burkhart
Lena M. Tallaksen
Chong-Yu Xu
Kolbjørn Engeland (II)

NATURHISTORISK MUSEUM (NHM)

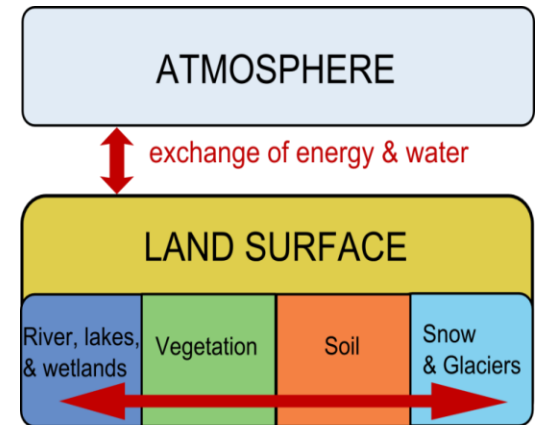
Biosphere

Anders Bryn
Rune Halvorsen
Vegar Bakkestuen (II)

IFI

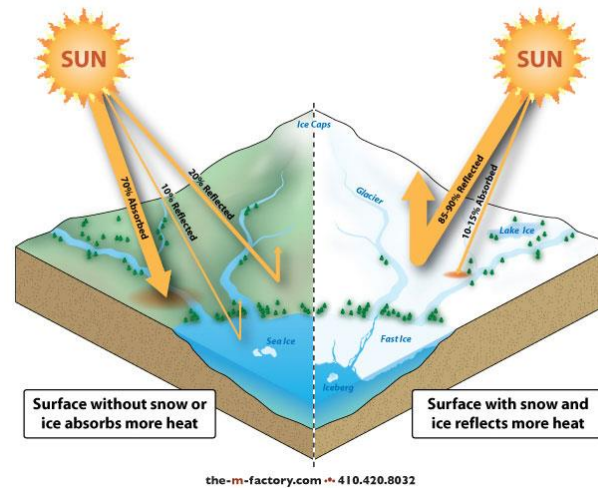
Environmental sensors

Tor Sverre Lande
Svein Erik Hamran (II)
Dag Wisland (II)



Land-atmosphere interactions and feedbacks

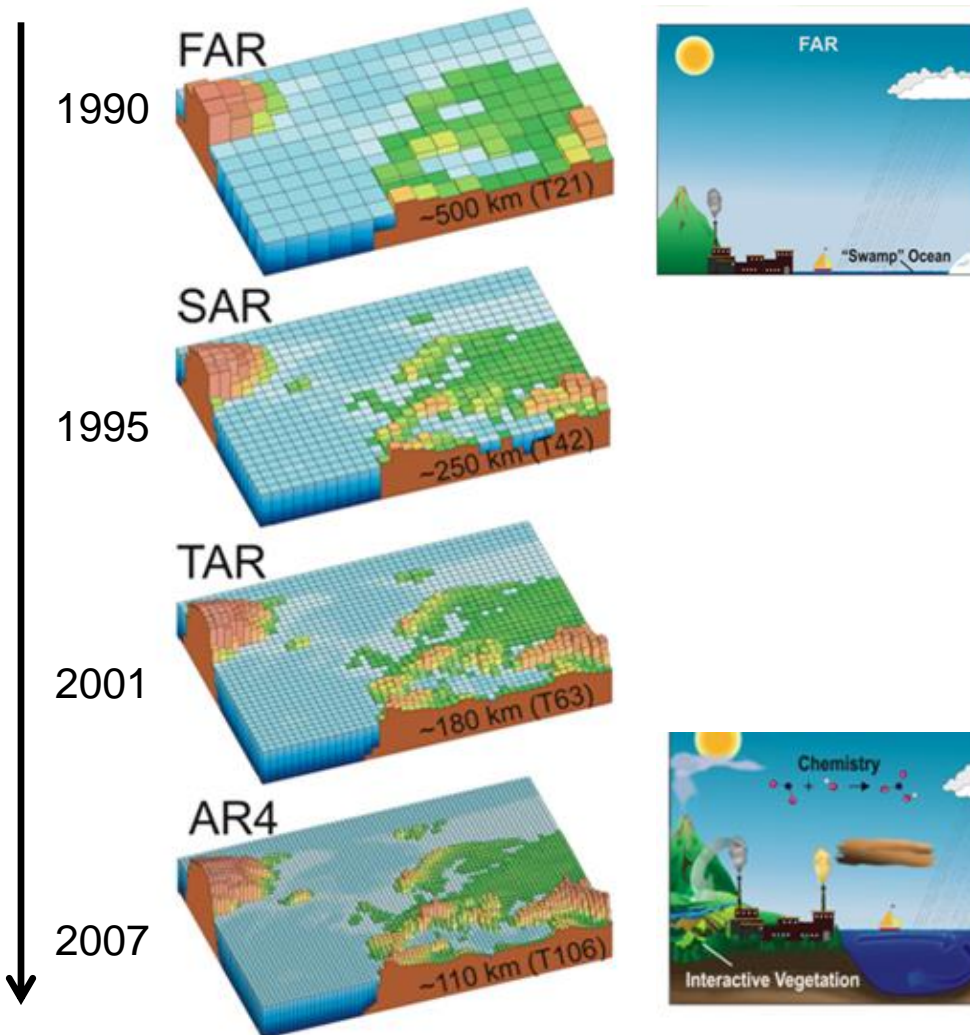
- Albedo
- Surface temperature



- Soil moisture
- Permafrost
- Vegetation



NorESM – An integrating tool



The **Norwegian Earth System Model (NorESM)** will be used as a common tool to study interactions across processes and scales.

- WRF – regional weather and climate model
 - Distributed terrestrial models

Observations

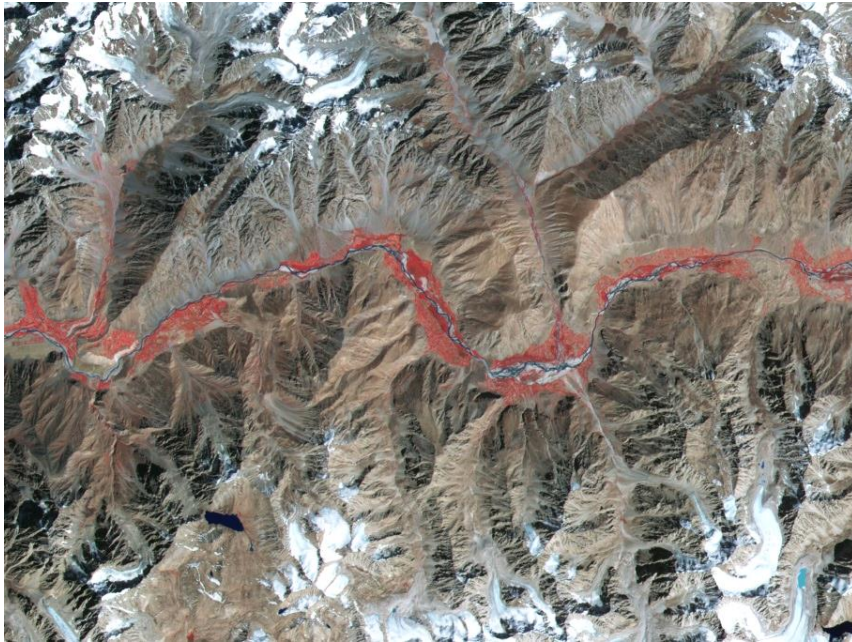
Observations are fundamental for improving Earth System Models

*Colin Jones, Head UK Earth System
Modeling Project*

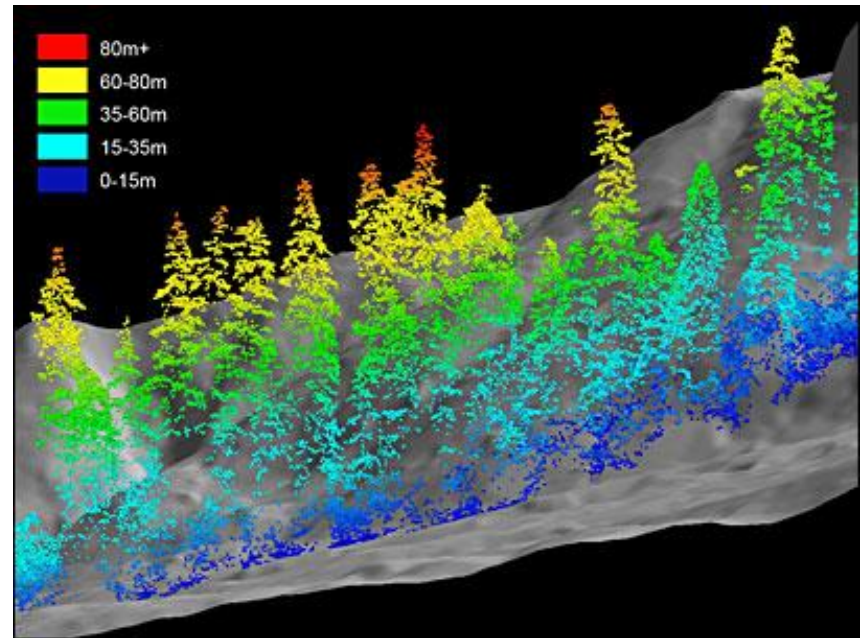
- Analyse and map recent changes
- Verify earth observations (ground truth data)
- Model development and verification

Earth observations

Satellite and LIDAR



Satellite mapped vegetation area
(A. Kääb)

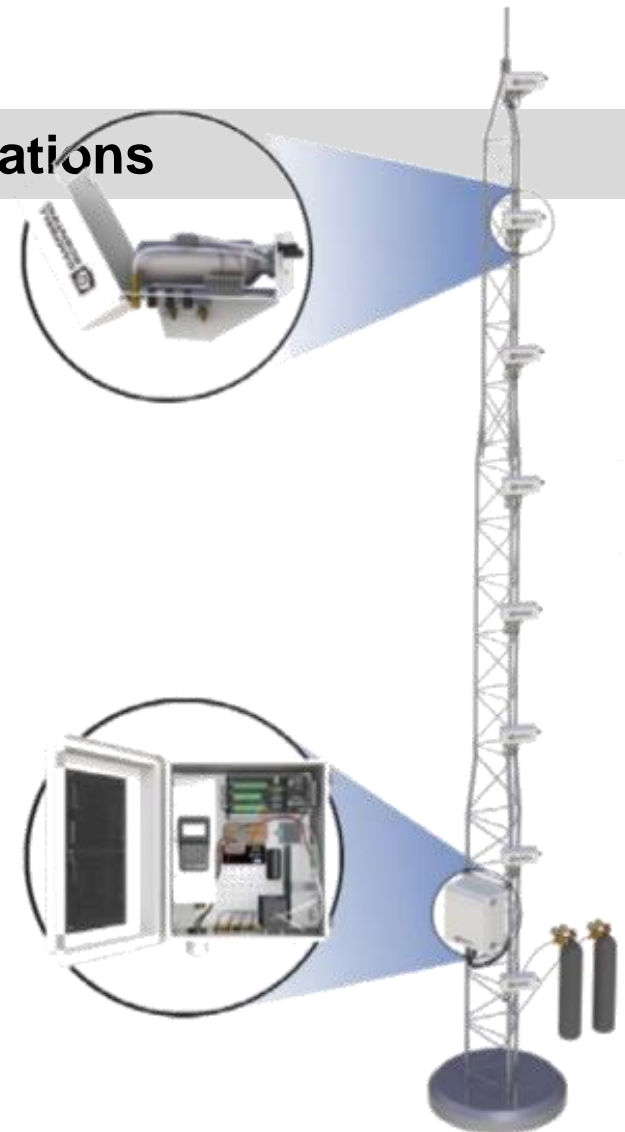
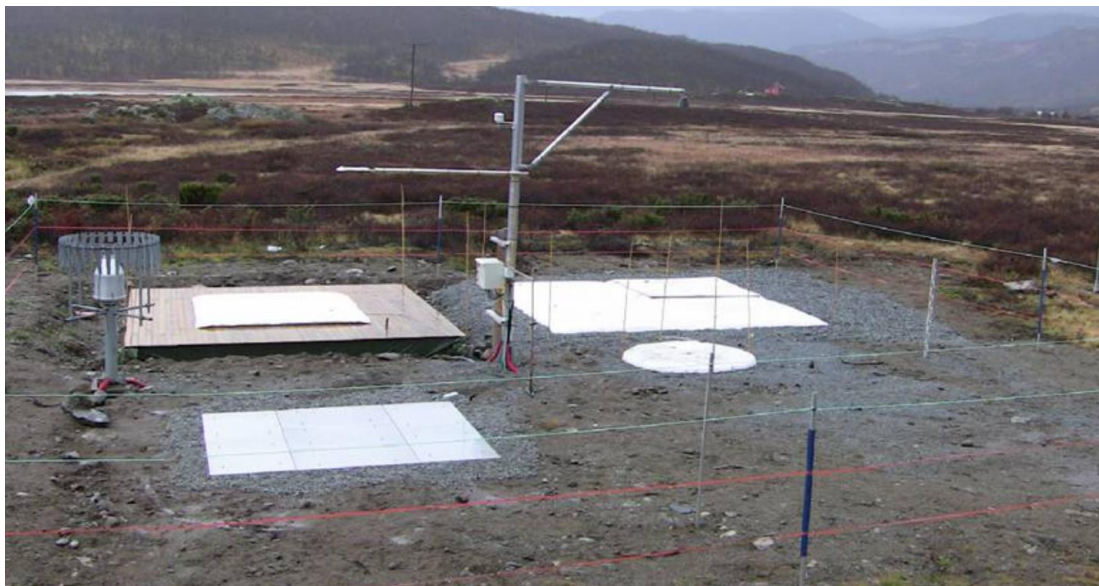


Lidar mapped canopy layer (biomass)

Instrument clusters

Flux tower + in-situ data + routine observations

- Data analyses
- Verification



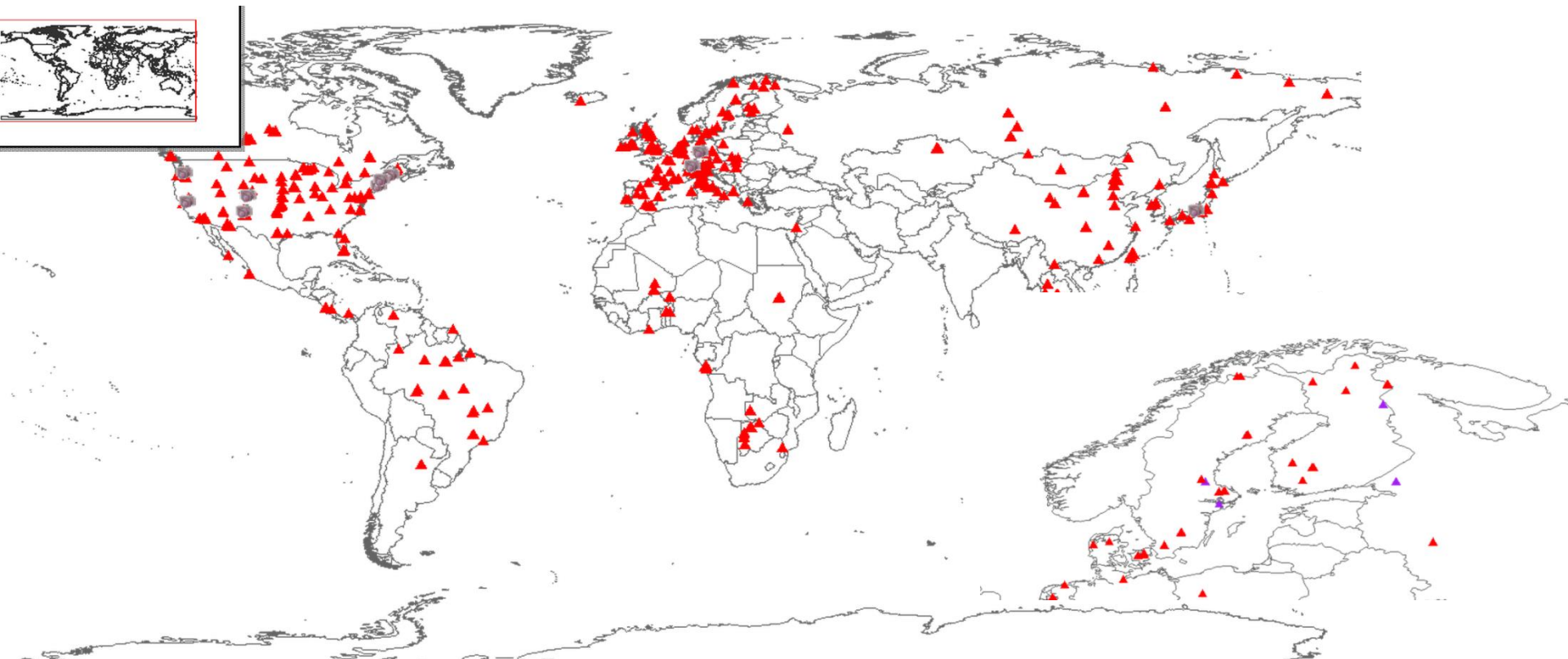


Integrating
Worldwide CO₂,
Water and Energy
Flux Measurements



FluxNET

a "network of regional networks," coordinates regional and global analysis of observations from micrometeorological tower sites



LATICE-Flux



Primary* & Portable Tower:

LI-7500A Open Path CO₂/H₂O

Analyzer

Biomet System 4 – Tower (net radiation, humidity, soil heat flux, precipitation sensor, soil temperature/moisture)

4 component radiation

Sonic anemometer

Wireless Sensor Network (distributed measurements)

Snow depth

Snow/precipitation radar platform

Soil temperature/moisture

piezometers (?)

Net radiation

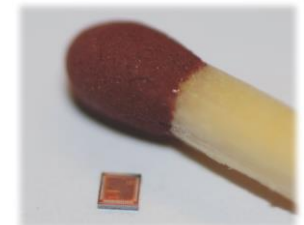
Temperature / Humidity

Environmental sensing



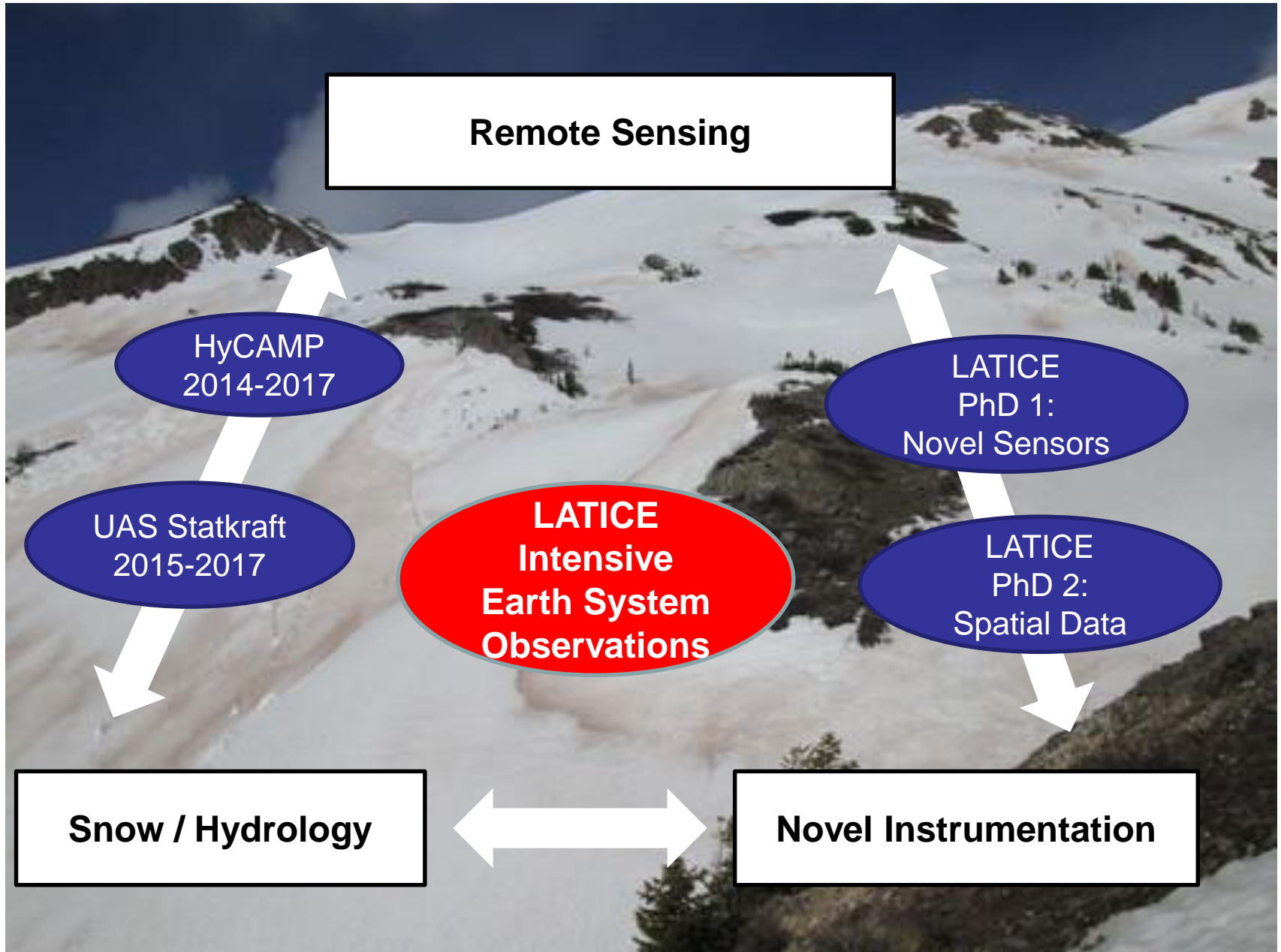
New radar sensor technology

- RADAR Sensors FFI/IFI
 - Ground Penetrating Radar (GPR)
 - Monitoring soil conditions
 - Surface sensing
 - Snow and moisture monitoring
- Stationary surface radar
- Miniaturized radar
 - Distributed systems (≈ 100 nodes)
 - Remote long-term operation

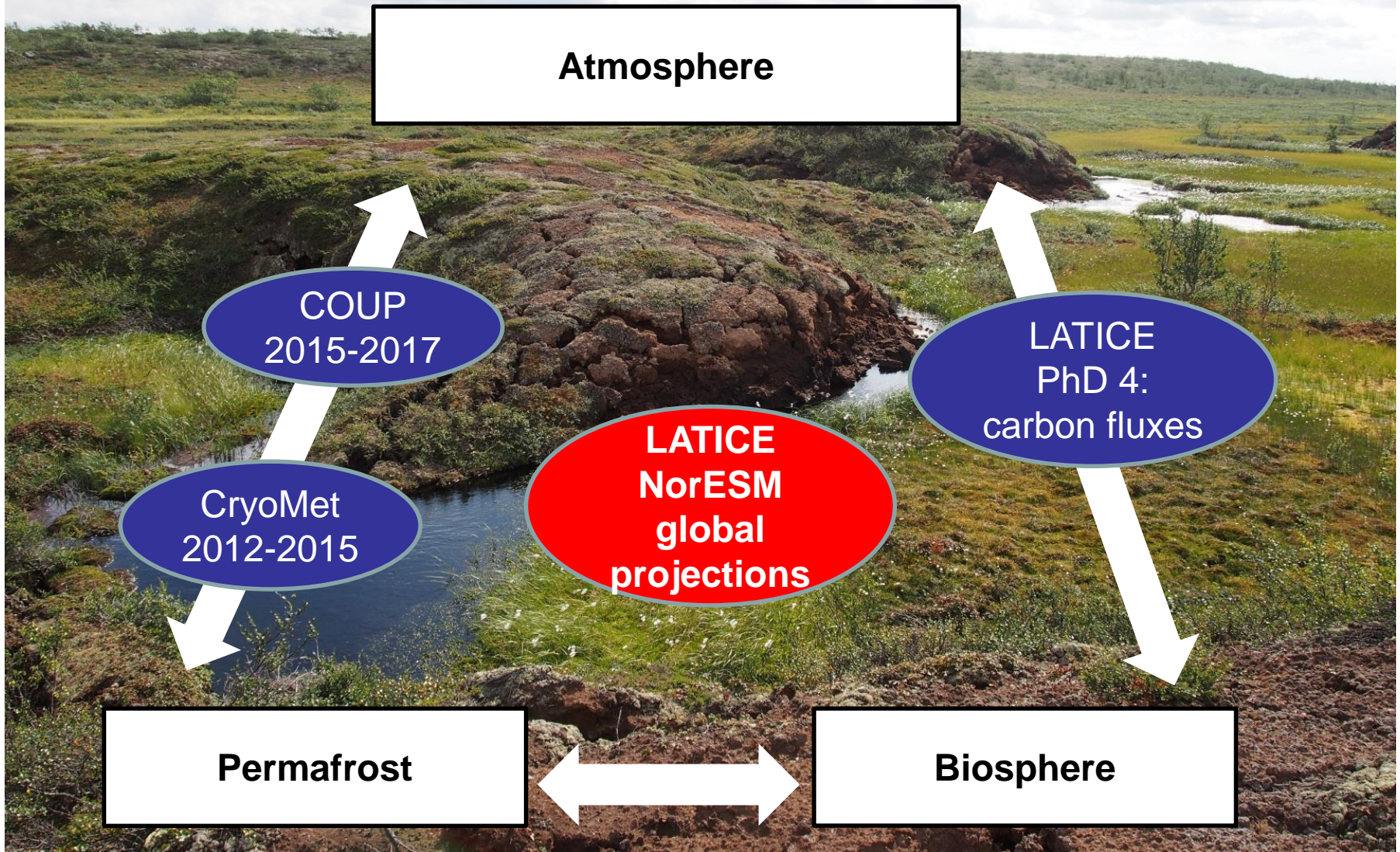


Novelda AS
single-chip radar

High resolution Earth System observations



Permafrost degradation and carbon feedback



2014: Degrading permafrost mire in Finnmark, Norway

Boreal and Arctic Vegetation feedbacks

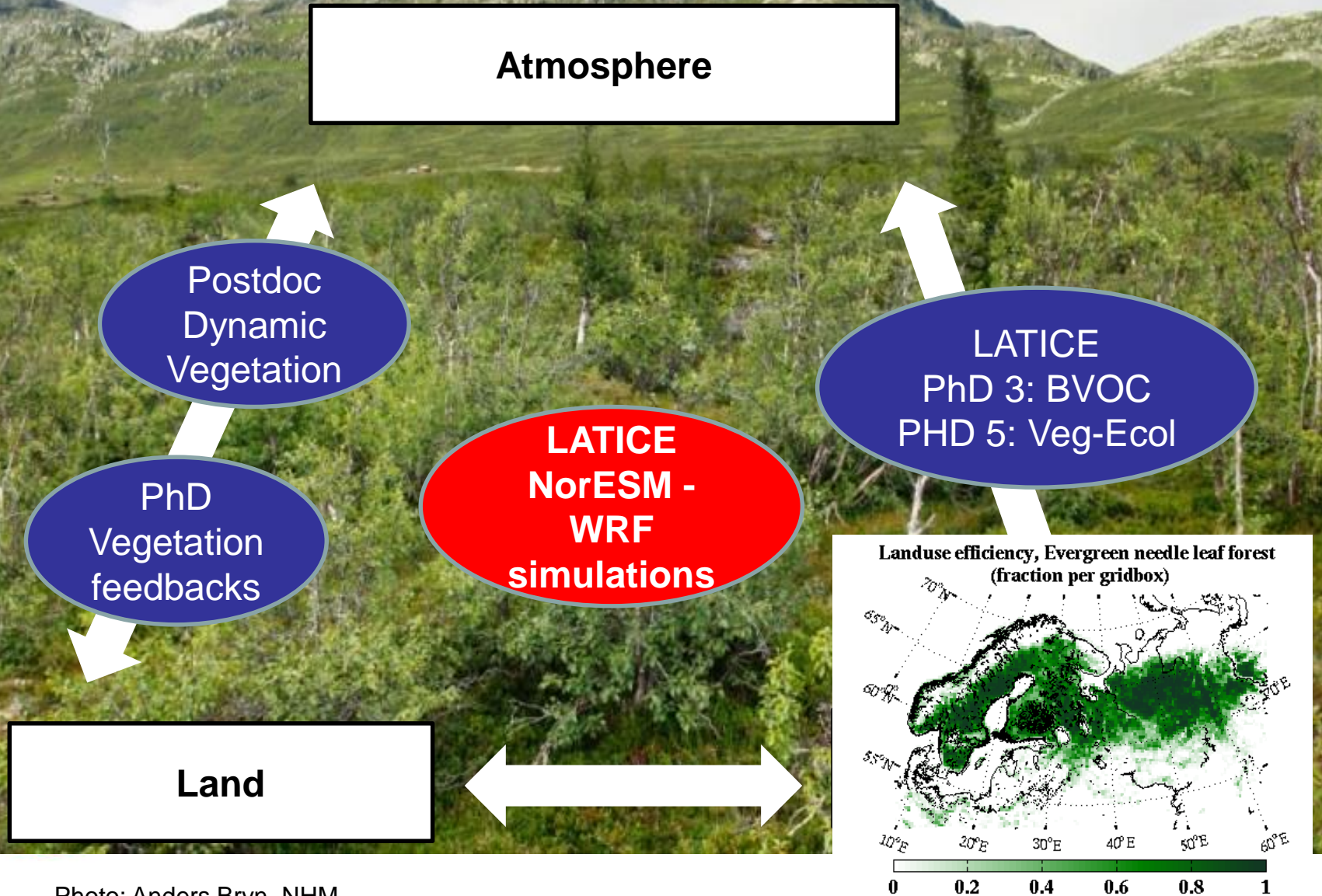


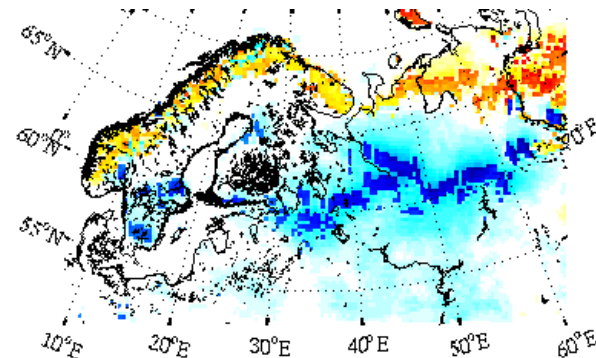
Photo: Anders Bryn, NHM

Two examples - ongoing PhDs

- *Johanne Rydsaa*

Feedbacks to regional boreal climate due to structural vegetation changes:

WRF modelling



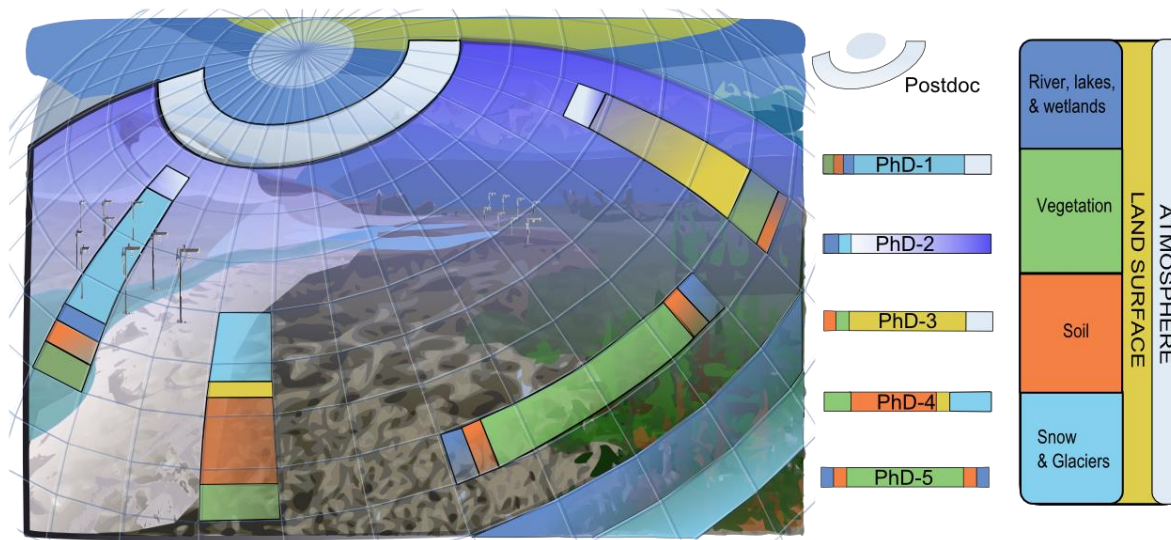
- *Kjetil S. Aas*

Simulation of surface energy balance at the Svalbard archipelago plus sub grid scale snow distribution:

WRF modelling



Integration of LATICE PhD projects



Postdoc-1:
Model sensitivity to changes in surface conditions

- **PhD-1:** Advanced sensor technologies for eco/cryo/hydrologic studies
- **PhD-2:** Datascares: spatial data sensitivity and representativeness in models.
- **PhD-3:** Biogenic emissions of particle and ozone precursors
- **PhD-4:** Carbon turnover sensitivities to permafrost and snow dynamics in ESMs.
- **PhD-5:** Vegetation-ecology modelling

Poster



LATICE - Land-ATmosphere Interactions in Cold Environments

The role of Atmosphere - Biosphere – Cryosphere – Hydrosphere interactions in a changing climate



Climate change is impacting the high latitudes more rapidly and significantly than any other region of the Earth. A warmer climate has already led to thawing of permafrost, reduced snow cover and a longer growing season; changes, which in turn influence the atmospheric circulation and the hydrological cycle.

LATICE aims to advance the knowledge base concerning land atmosphere interactions and their role in controlling climate variability and climate change at high northern latitudes through:

- Improving parametrizations of processes in earth system models controlling the interactions and feedbacks between the land (snow, ice, permafrost, soil and vegetation) and the atmosphere at high latitudes, including the boreal, alpine and arctic zone.
- Assessing the influence of climate and land cover changes on water and energy fluxes.
- Integrating remote earth observations with in-situ data and suitable models to allow studies of finer-scale processes governing land atmosphere interactions.
- Addressing observational challenges through the development of novel observational products and networks.





Sensors - Design

LATICE will aim at the development of sensors and algorithms to address eco/cryo/hydrological applications using microsensors and high frequency data collection. At the same time, the project will address the development of Wireless Sensor Networks (WSN) enabling the deployment of dense clusters of instruments. LATICE will also study how to scale up high resolution information across a single catchment for the use in regional modeling scenarios and how such information may be incorporated into physically based models. Further, LATICE aims at creating value from the datascape generated from multimode sensor networks and evaluating model sensitivity to the spatial and temporal coverage of the data.

Positions to fill:

- PhD: Advanced sensor technologies for eco/cryo/hydrologic studies;
- PhD: Spatial data sensitivity and representativeness in models (Datascape).

Snow - Permafrost

Snow is one of the most important factors for the hydrological regime, glacier mass balance and permafrost distribution in the Nordic area. LATICE will address and enhance the representation of snow in Earth System Models (ESMs), and associated permafrost/mass balance models. The impacts of a reduction in snow cover resulting from climate change will have a further feedback on biogeochemical cycles, thus the project will focus also on the characterization of snow distribution in ESMs, and conduct sensitivity studies on permafrost distribution in order to evaluate impacts to carbon turnover (GHG emissions) within the ESMs.

Position to fill:

- PhD: Carbon turnover sensitivities to permafrost and snow dynamics in ESMs.

Vegetation

LATICE will map and model distributions of selected nature types and will use these models for projecting nature-type distributions to different climate change scenarios. Dynamic vegetation modelling will be performed using global and regional climate models. Remote sensing techniques will be used to monitor vegetation types and their potential migration across large regions. LATICE will also study how Biogenic Volatile Organic Compounds (BVOCs), emitted by vegetation and leading to the formation of aerosols and ozone, will impact atmospheric chemistry and physics, in particular cloud formation. The project will include also analysis of the relation with anthropogenic VOC emissions. At the same time the uptake of ozone in plants will be studied.

Positions to fill:

- PhD: Vegetation ecology modelling;
- PhD: Climate impacts of biogenic emissions.

LATICE is recognized as a strategic research area by the Faculty of Mathematics and Natural Sciences at the University of Oslo who has provided funding for five PhD and one Postdoc during the period 2015 - 2019.

UiO : Department of Geosciences

Tanja Kovan Bernsten, John Barltun, Bernd Eitzinger, Jon Ole Munnich Hagen, Andreas Kohn, Jon Egil Kristiansen, Rolf Hagen, Thomas Wilhelms-Schnee, Ingrid Jostad, Lene Merete Tallaksen, Sebastian Westermann, Chang Su Xu

UiO : Department of Informatics

Tor Steinar Lund, Svein-Erik Henriksen, Dag Wilund

UiO : Natural History Museum

Anders Bryn, Rana Halvorsen

Use the QR-code for more information



NHR 3rd conference on Modelling Hydrology, Climate and Land Surface Processes

7-9 September 2015, Lillehammer

Thank you for your attention!

LATICE: <http://mn.uio.no/latice>

