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Environmental observations over Arctic areas – potential for monitoring the spread of infectious diseases

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ARKTIKO Seminar, Helsinki, 10-11 May 2016

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Climate-change effects on the epidemiology of infectious diseases and the impacts on Northern Societies (CLINF)

Project manager

Professor Birgitta Evengård, University of Umeå

Participating institutes

Umeå University (SE)
National Veterinary Institute (SE)
Swedish University of Agricultural Sciences (SE)
University of Sheffield (UK)
Stockholm University (SE)
University of Nordland (NO)
Northern Federal University (RU)
Statens Seruminstitut (DK)
Finnish Meteorological Institute (FI)
Norut (NO)

Project

Aug 2016-Dec 2020
CLINF Nordic Centre of Excellence (NCoE)
NordForsk

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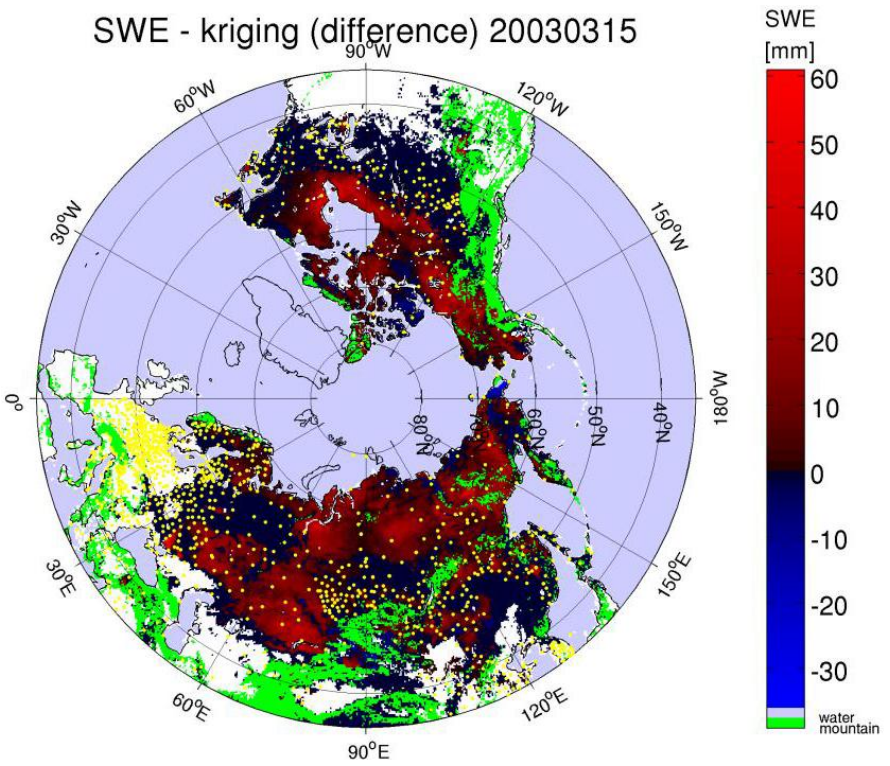
Climate-change effects on the epidemiology of infectious diseases and the impacts on Northern Societies (CLINF)

- Rate and magnitude of climate change strongest in the Arctic
- Climate-induced ecological alterations will affect *geographical boundaries of micro-organisms* with capacity to cause diseases in humans and animals
- Northern societies face challenges concerning *health, livelihood and traditional culture*.
- CLINF will address these threats by contributing valuable information on strategies to ensure socio-economic development and viable communities in the North.
    - Climate change, human & animal health statistics
    - Economic impacts
    - Societal impacts

Remote epidemology

- Operational observation networks (e.g. synoptic weather stations) in Arctic areas are sparse
- Satellite remote sensing offers an important tool in monitoring and recording environmental processes related to climate at Northern Latitudes
- Environmental parameters can be applied as *proxy indicators* in models predicting the risk of epidemics
- Relevant parameters in the Arctic:
  - Extent and duration of snow cover
  - Soil moisture and soil freeze/thaw processes
  - Vegetation health (LAI, NDVI)

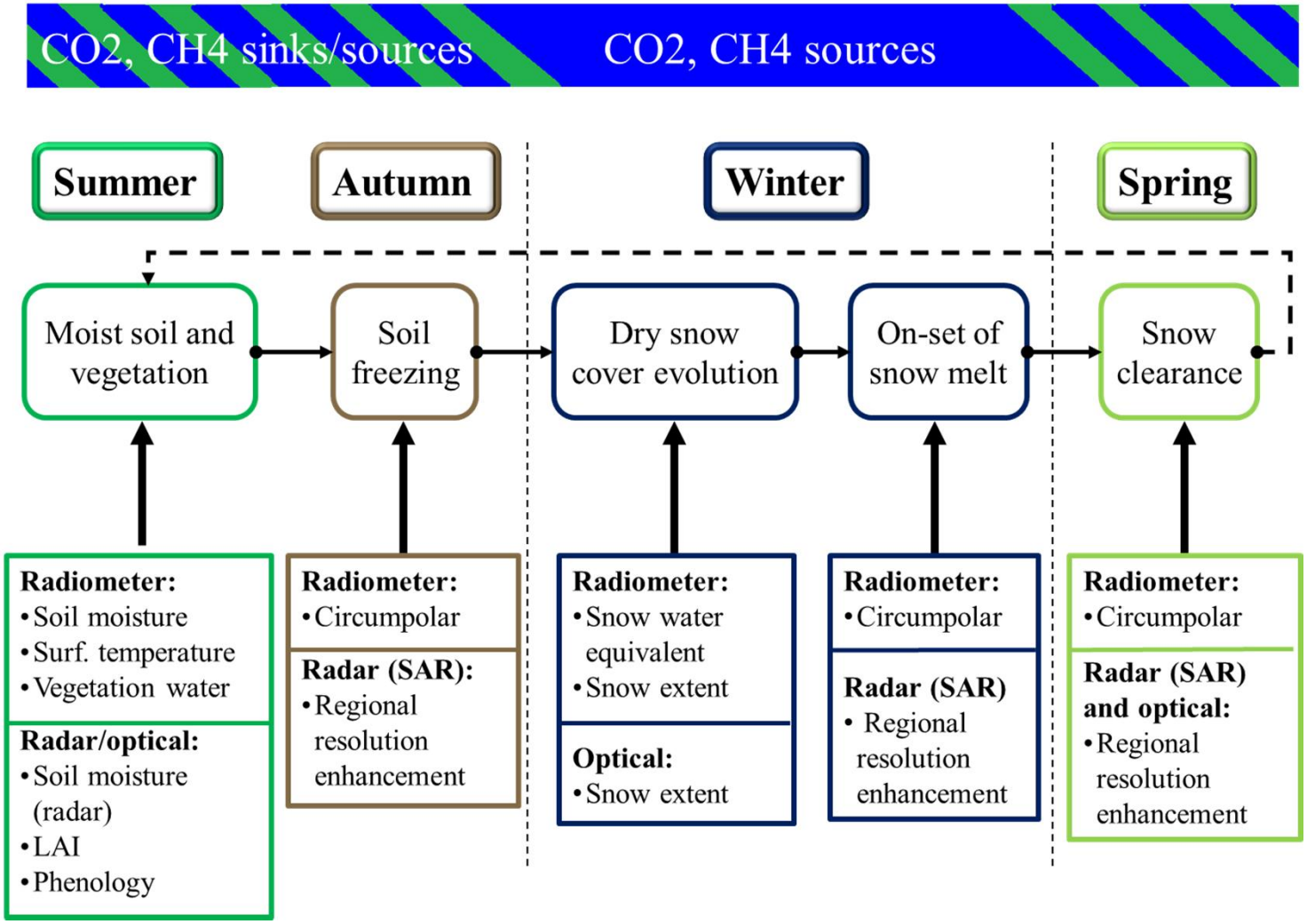


Difference of satellite observation (ESA GlobSnow) and interpolated estimate based on synotic weather station for Snow Water Equivalent (Takala et al., 2011)

Integrated view on the terrestrial cryosphere: snow and soil processes

Use of diverse satellite data allows Full seasonal view on phenomena relevant to e.g. *carbon exchange* and annual balance at high latitudes

Relevance for other *biological/ecological* processes, including spread of infectious disease?



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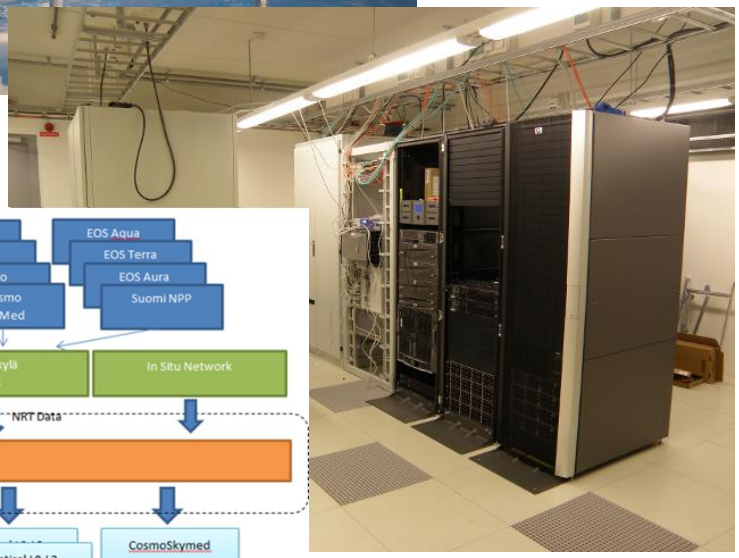
Sodankylä National Satellite Data Centre

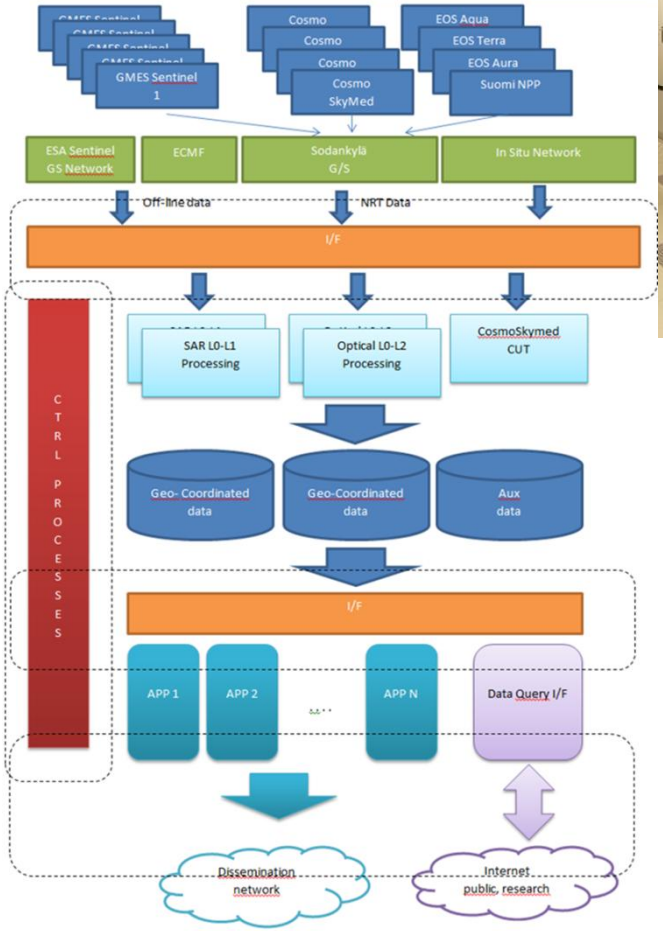



National satellite data center providing satellite data reception and data processing services to Finnish and international partners

Computing facilities at Sodankylä



- **Full scale computer building for processing of satellite, in situ (CAL-VAL) and ground based remote sensing data**
- **Security and Safety standards according to ESA data processing requirements.**
  - UPS + backup generator
  - Dual cooling and air-conditioning
  - Fire extinguisher system
- **High speed 10 Gbit /s network connection between Sodankylä and Helsinki**
- **Open data delivery systems**



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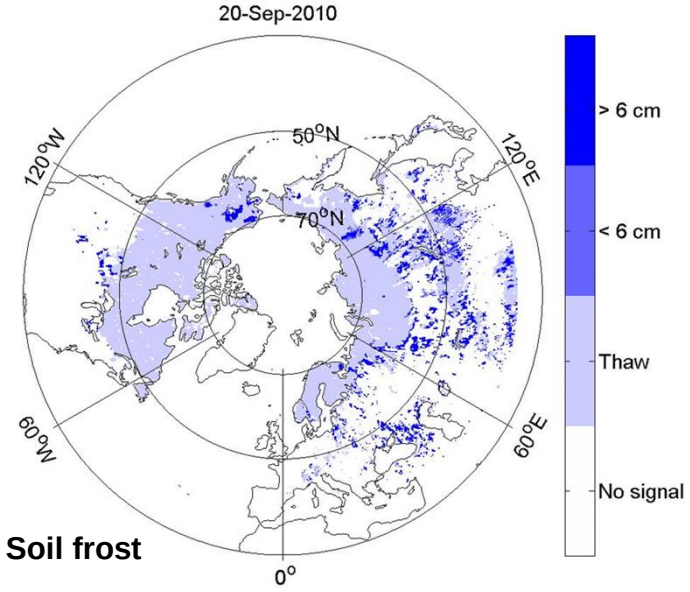
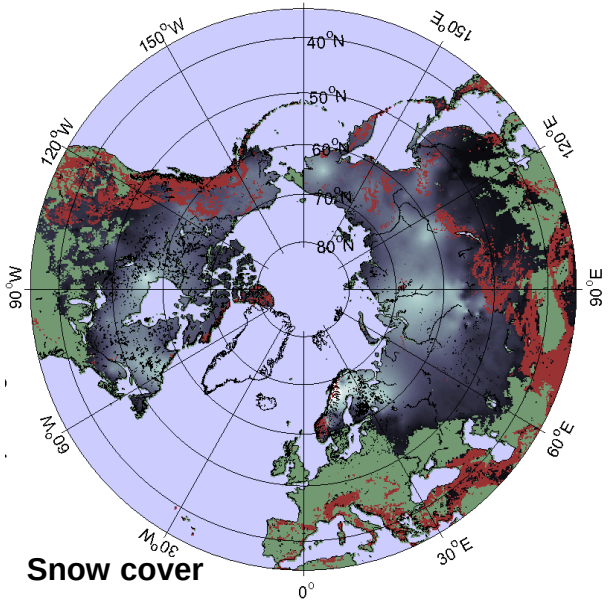
Satellite data at FMI-ARC for monitoring of the environment

- Development and distribution of long term (10-38 yr) datasets and data products, e.g.
  - Fractional Snow Cover area
  - Snow Water Equivalent
  - Snow melt state
  - Terrestrial snow albedo (FMI-UHA)
  - Vegetation LAI (FMI-UHA)
  - Soil freeze/thaw
- Near real-time Earth Observation datasets
  - EU Copernicus Program (Sentinel satellites):
    - Participation in development of Copernicus Core Land Services
    - Hosting of Collaborative Ground Segment for data downlink and distribution
  - Direct downlink, processing lines and archiving capability of satellite data CosmoSKYMED, TerraSAR-X, EOS Terra, EOS Aqua
- Data distribution via National Satellite Data Centre hosted by FMI



Soil frost



Snow cover

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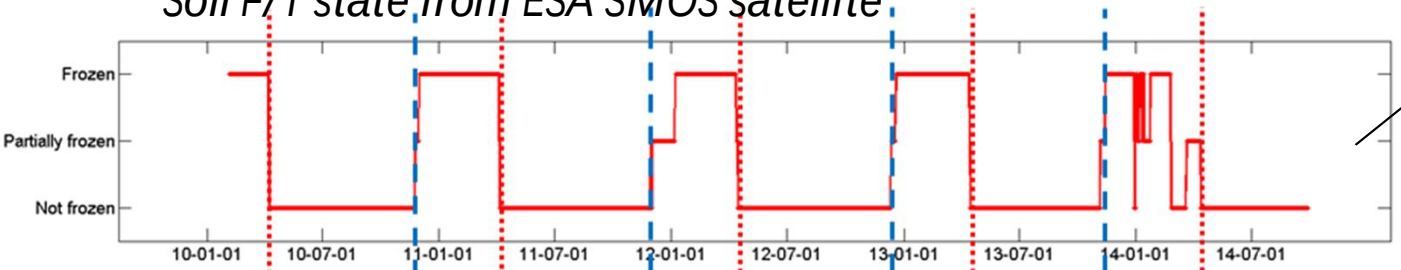
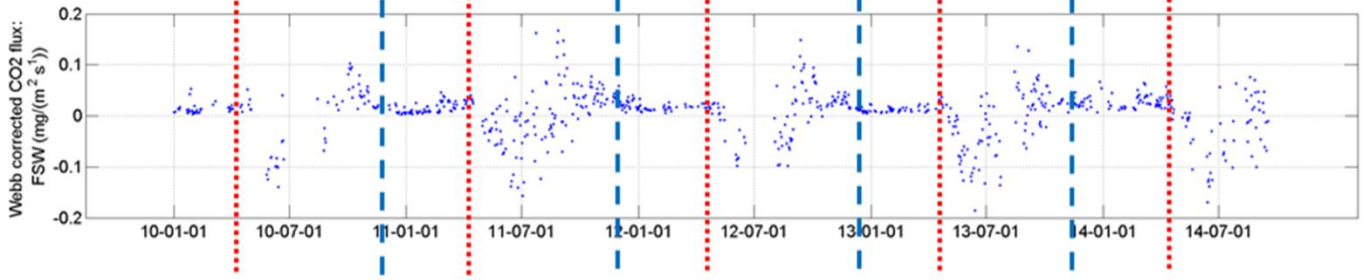
Science drivers: why soil freezing?

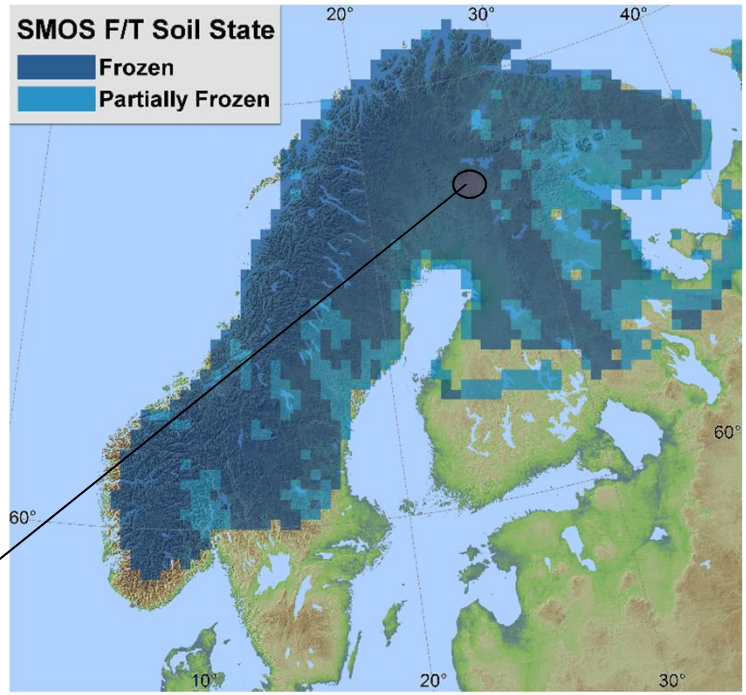
- ~49 % of land areas in NH undergo seasonal soil freezing
- Soil freeze/thaw state has an effect on
  - surface energy balance
  - surface and subsurface water flow
  - exchange rates of carbon with the atmosphere
  - photosynthetic activity of plants
  - microbial activity within soils
  - ***Spread of disease? Perhaps!***
    - ***spread and survival of e.g. ticks (ixodes persulcatus) -> Lyme disease, babesiosis, encephalitis***

Soil F/T state from ESA SMOS satellite



Daily NEE (CO_2 flux)

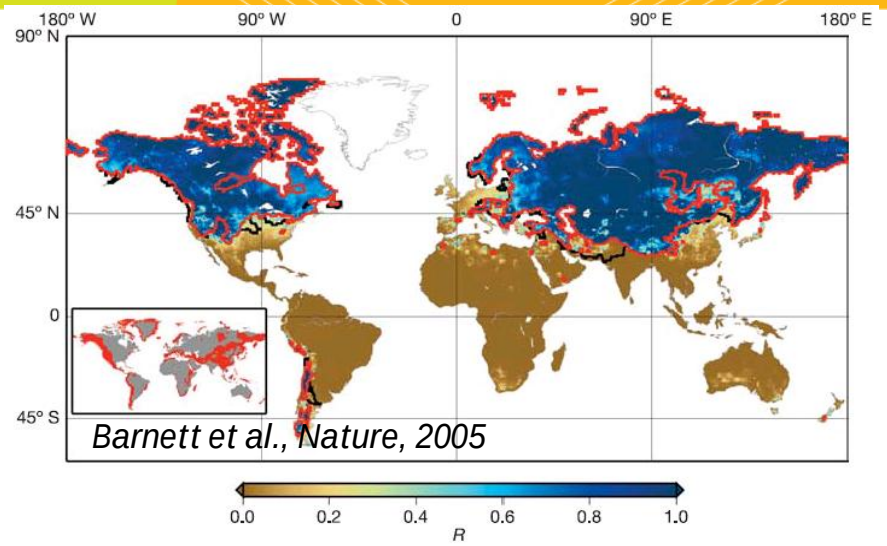




FMI product on soil freeze-thaw state based on ESA SMOS observations (coverage since 2010 -> present)

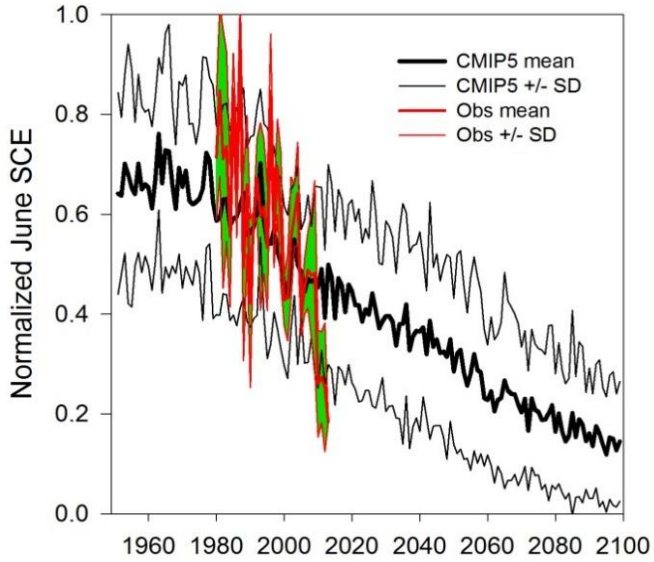
Science drivers: why snow cover?

- Terrestrial snow cover is a strong indicator for climate change
- A vital freshwater resource over a large fraction of northern hemisphere land areas
- Snow cover affects energy and GHG exchange in the terrestrial Arctic and sub-Arctic; strong feedback to climate via terrestrial albedo
- CMIP5 models underestimate the significant reductions in spring snow cover extent observed during the satellite era



Barnett et al., Nature, 2005

Accumulated annual snowfall divided by annual runoff over global land regions



Derksen and Brown, GRL, 2012

June NH snow cover extent from observational snow analyses and CMIPS models (historical + rcp8.5 scenario)

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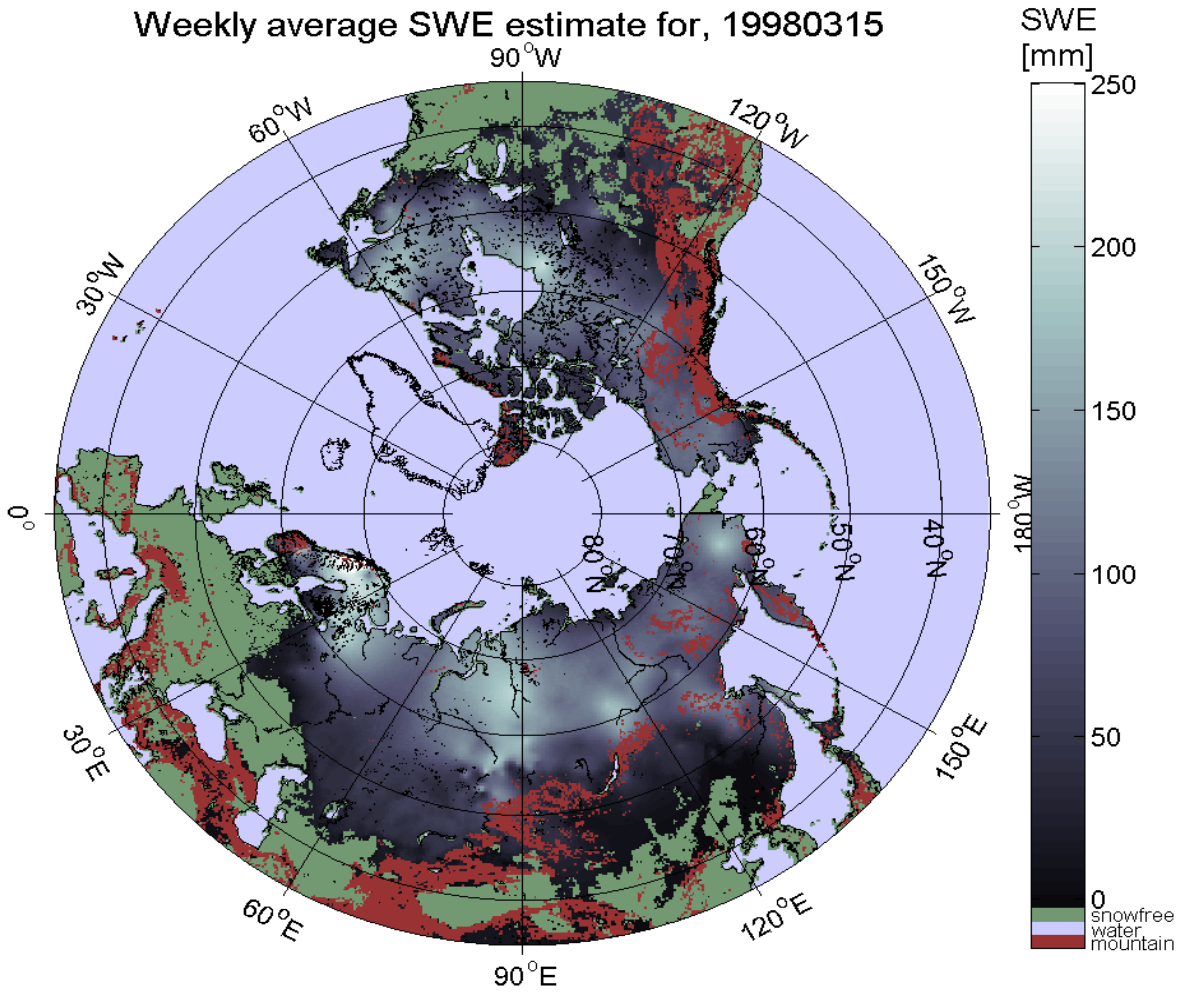
esa due data user element GLOBSNOW

35 year-long CDR time-series on snow conditions of Northern Hemisphere

- First time reliable daily spatial information on SWE (snow cover):
  - Snow Water Equivalent (SWE)
  - Snow Extent and melt (+ grain size)
  - 25 km resolution (EASE-grid)
  - Time-series for 1979-2014
- Passive microwave radiometer data combined with ground-based synoptic snow observations
  - Variational data-assimilation
- Available at open data archive (www.globsnow.info)
- **Daily NRT production** since 2010



Takala, M., Luojus, K., Pulliainen, J., Derksen, C., Lemmetyinen, J., Kärnä, J.-P, Koskinen, J., Bojkov, B., "Estimating northern hemisphere snow water equivalent for climate research through assimilation of spaceborne radiometer data and ground-based measurements", Remote Sensing of Environment, Vol. 115, Issue 12, 15 December 2011, doi: 10.1016/j.rse.2011.08.014

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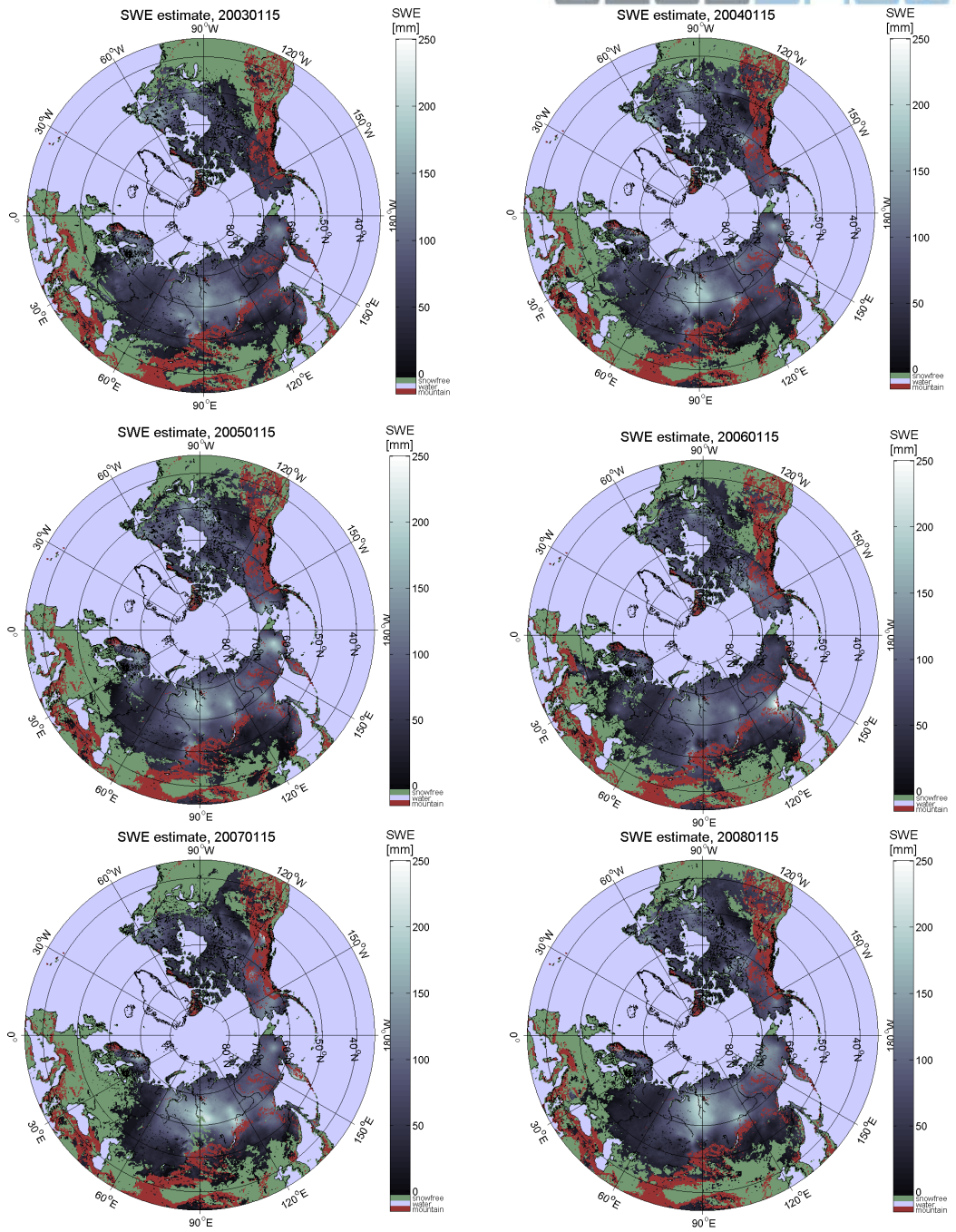
GlobSnow SWE time series (FCDR)

- Northern Hemisphere
  - 1980 to 1987 (SMMR)
  - 1988 to 2013 (SSM/I, SSMIS)
  - *FPS v1.0 2003 to 2011 (AMSR-E)*
- Daily, weekly, monthly products
- Includes error estimates (statistical std of the SWE estimate in mm)
- Data format HDF4 & NetCDF CF
- EASE-Grid projection (~25km resolution)
- snow grain data provided as well
- Glaciers, mountains & Greenland masked out

- Versions: 1.0; 1.3 and 2.0 (current)



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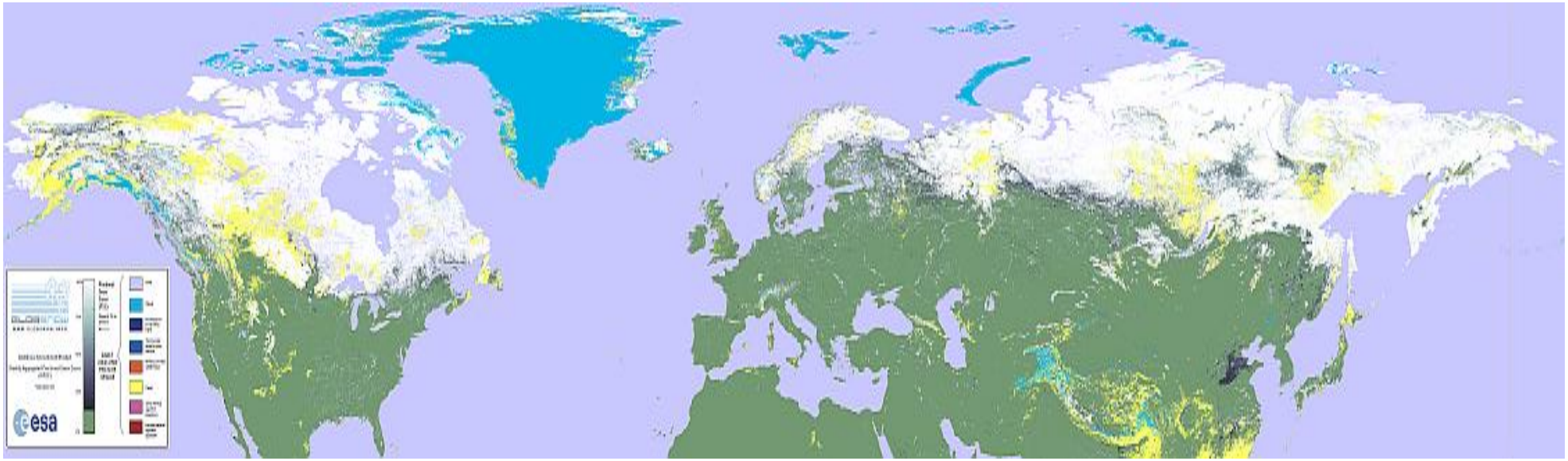
GlobSnow Snow Extent (SE) dataset

- 17 years SE data record has been produced using optical imagery from ESA ATSR-2 (1995-) and AATSR (2002-) on a hemispherical scale. NPP VIIRS from 2012-
- ~1km spatial resolution, daily hemispherical coverage



- Methodology developed especially for forested regions – basically a tough challenge for optical retrieval of Snow Extent
- Uncertainty estimate provided for each grid cell, data available as NetCDF CF
- Operational data production at the Finnish Meteorological Institute (FMI)

Metsämäki, S., Mattila, O.-P., Pulliainen, J., Niemi, K., Luojus, K., Böttcher, K. "An optical reflectance model-based method for fractional snow cover mapping applicable to continental scale", Remote Sensing of Environment, Vol. 123, August 2012, pp. 508-521, doi: 10.1016/j.rse.2012.04.010.

Thank you for your attention!