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GLOBSNOW

esa

ESA DUE GlobSnow

Project manager: Kari Luojus (FMI)

Principal investigator: Jouni Pulliainen (FMI)

Technical officer: Simon Pinnock (ESA)

ESA/EUMETSAT Workshop on European Satellite Snow Monitoring Perspectives
Darmstadt, 4 December 2012

GAMMA REMOTE SENSING

enveo

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

UNIVERSITÄT BERN

ZAMG

norut NORTHERN RESEARCH INSTITUTE TROMSØ

NR Norsk Regnesentral

SYKE

Environment Canada Environnement Canada

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ESA DUE GlobSnow

- ESA DUE GlobSnow project: Production of novel **hemispherical snow extent** (SE) and **snow water equivalent** (SWE) climate data records.

- Generation of long time-series employing FMI supercomputing facilities at Helsinki (daily, weekly and monthly maps of **SE** and **SWE** for northern hemisphere) **+ NRT demonstration**

- Consortium members: Finnish Meteorological Institute (FMI) with ENVEO IT GmbH (Austria), GAMMA Remote Sensing (Switzerland), Norwegian Computing Center, Finnish Environment Institute (SYKE), and Environment Canada (EC). + Univ. Bern, MeteoSwiss, ZAMG & Norut

- GlobSnow-1: 11/2008 – 01/2012 (3 years)
- GlobSnow-2: 05/2012 – 05/2014 (2 years)

- Details and products available at **www.globsnow.info**

esa enveo GAMMA REMOTE SENSING NR Norsk Regnesentral SYKE Environment Canada Environnement Canada

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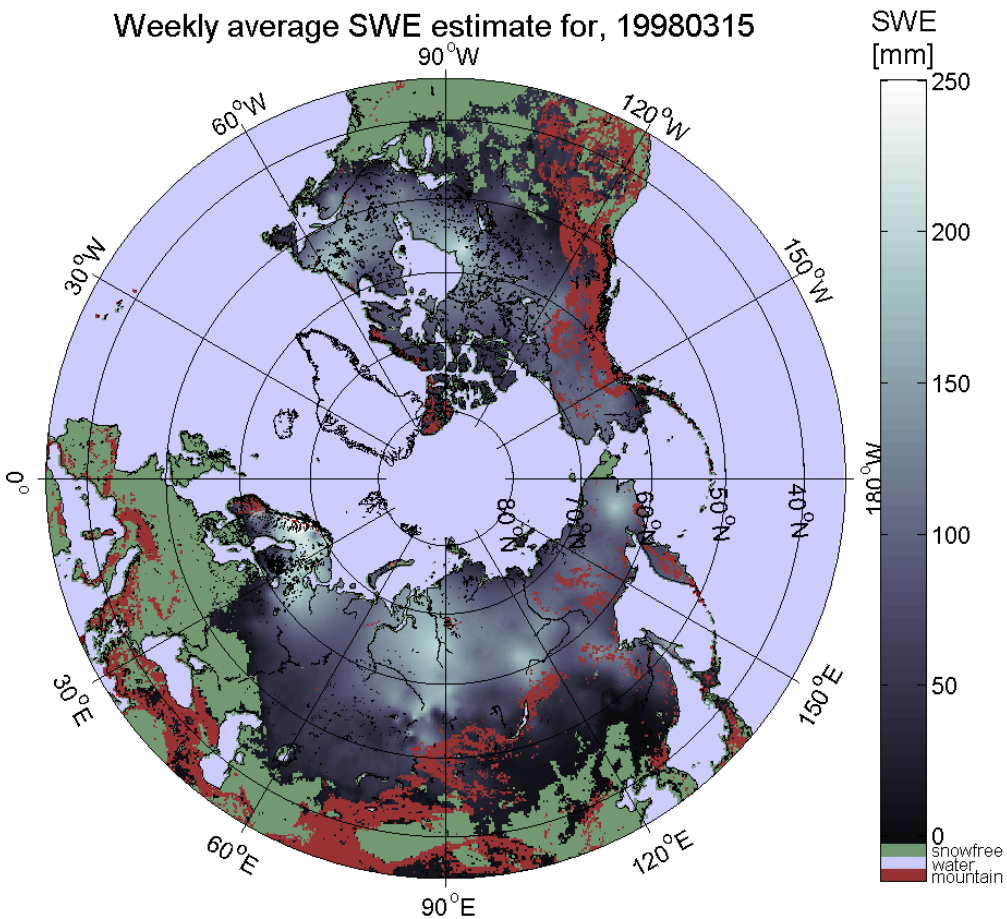
30 year-long CDR time-series on snow conditions of Northern Hemisphere (ESA-GlobSnow SWE)

- 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 1979-2011
- Passive microwave radiometer data combined with ground-based synoptic snow observations
  - Variational data-assimilation
- Available at open data archive (www.globsnow.info)
- Demonstration of NRT processing started on October 2010
- Greenland, glaciers & mountains masked out



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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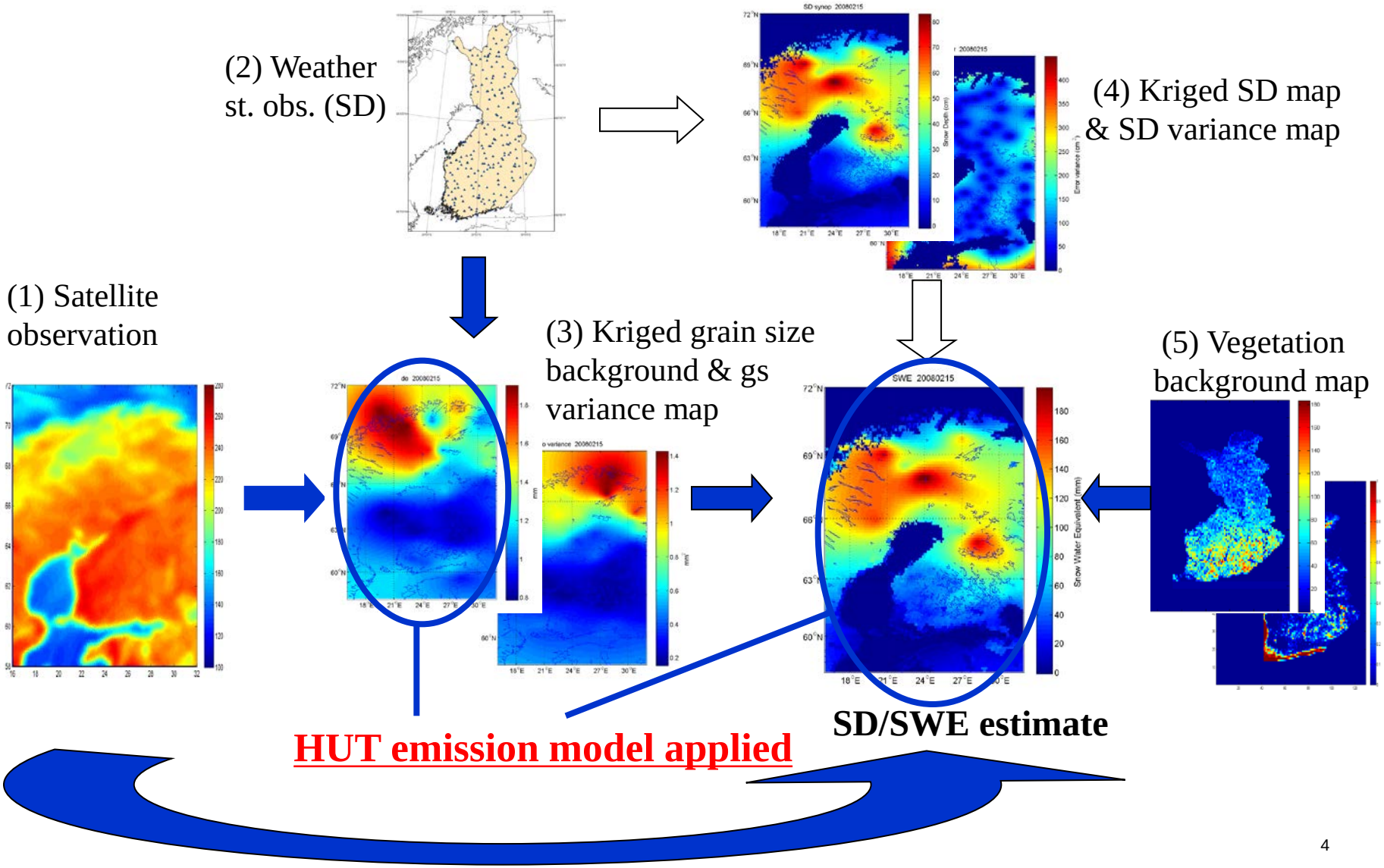
HUT snow emission model within SWE retrieval



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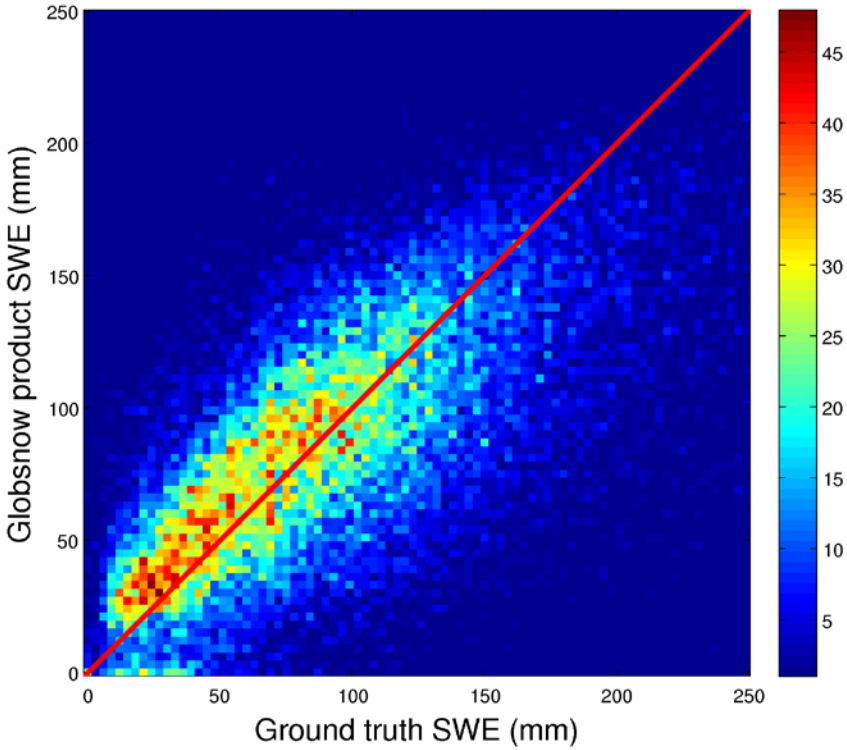
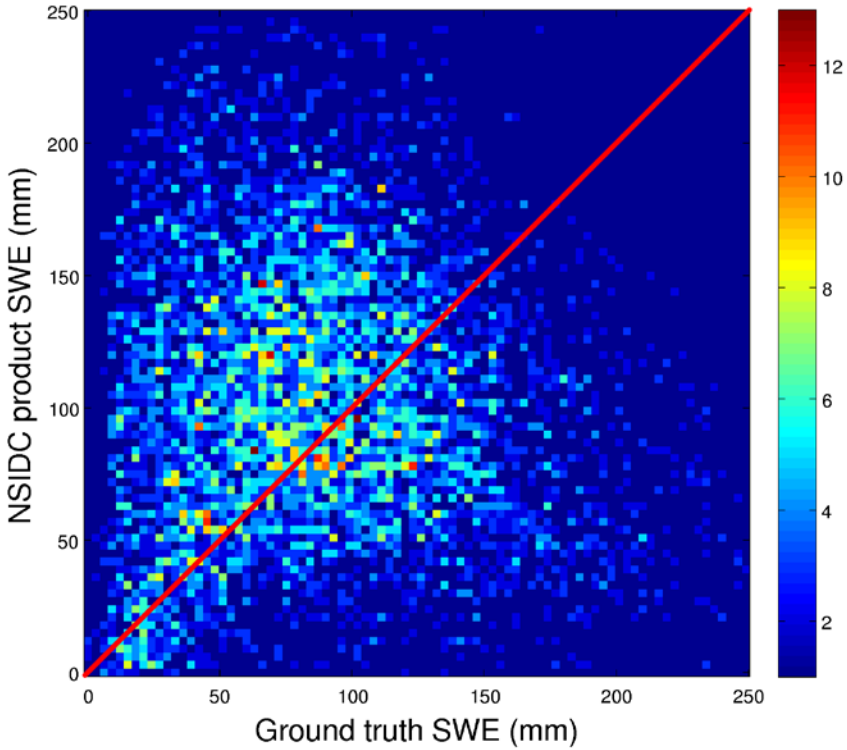
SWE retrieval (data assimilation vs. channel diff.)

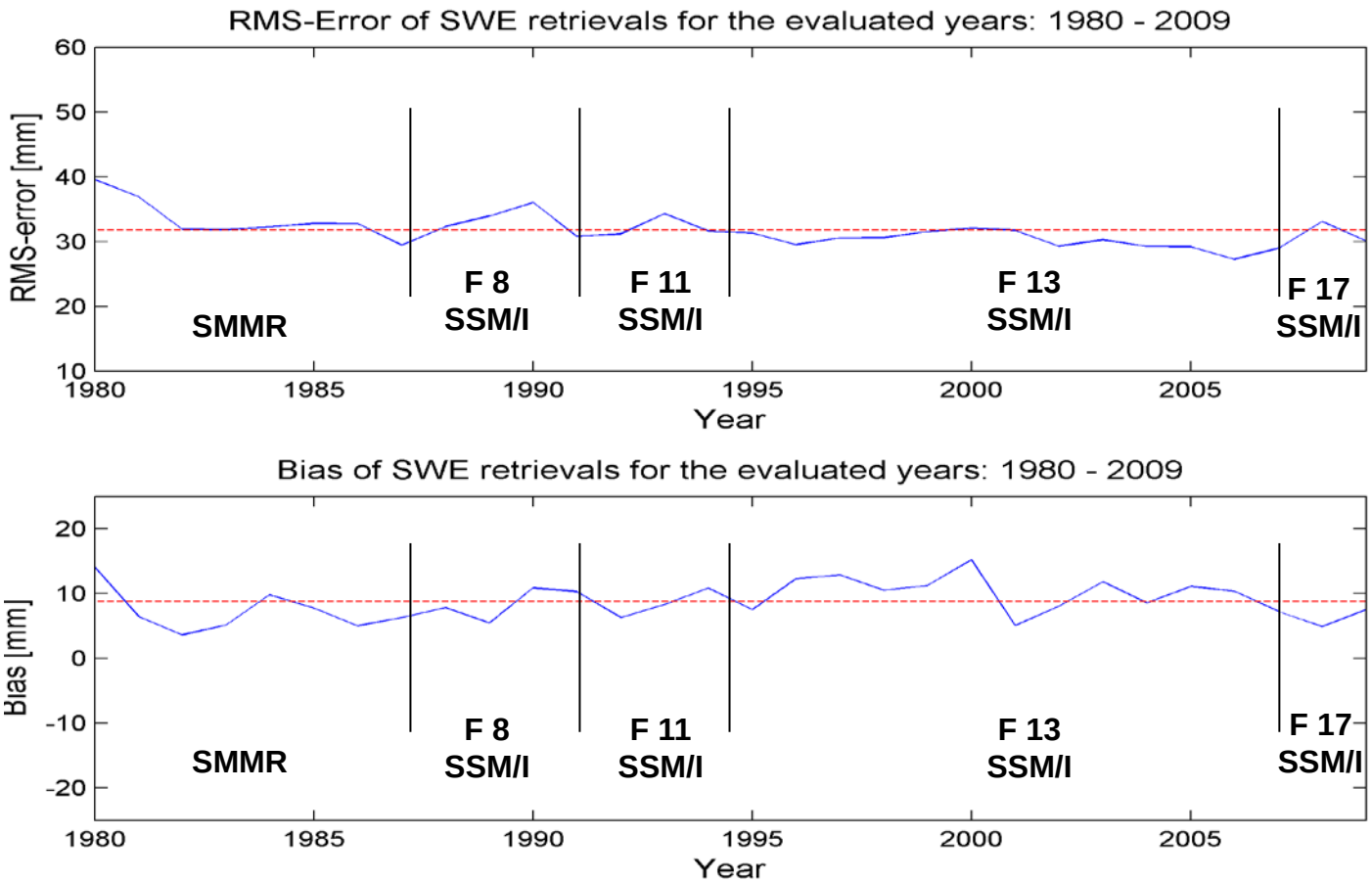
- **Density scatterplot (assimilated vs. satellite only SWE)**
- **Ground truth data is INTAS SCCONE SWE transect data**





Consistency of SWE retrieval 1980 - 2009

- RMS error and retrieval bias calculated independently for each year 1980-2009
- Reference data: snow transects from Russia (INTAS-SCCONE)



SWE<150 mm

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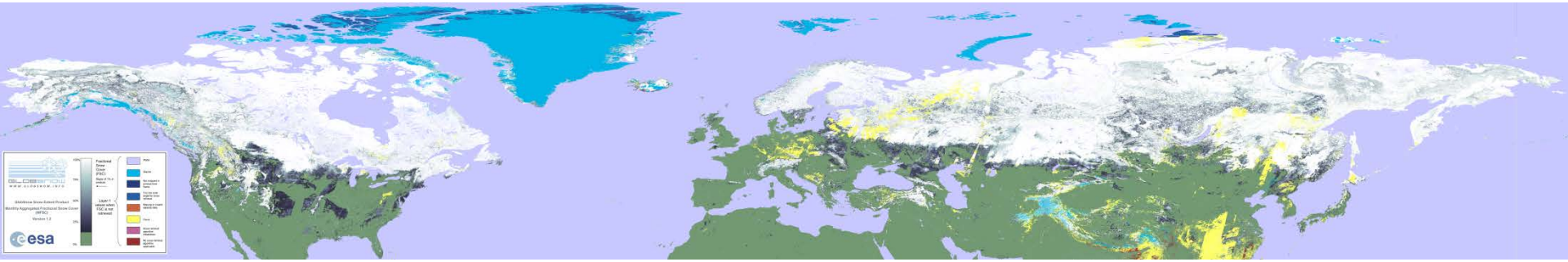
GlobSnow Snow Extent (SE) dataset

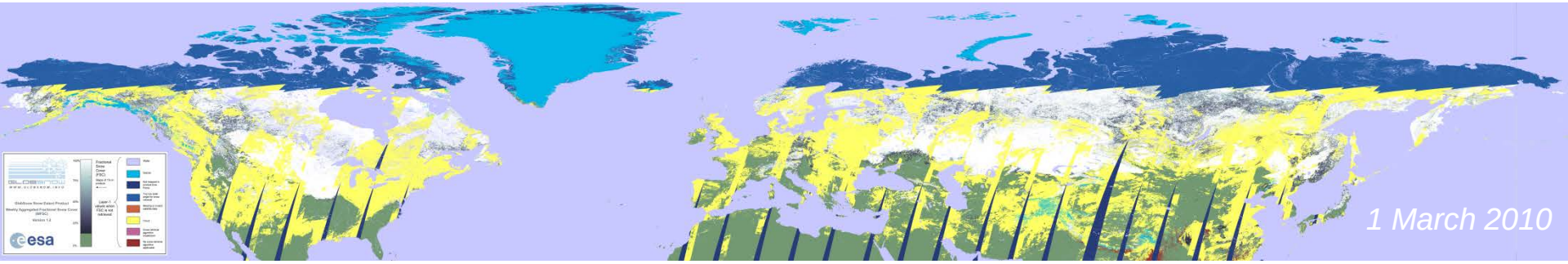
- 17 years SE data record produced using optical imagery from ESA ATSR-2 (1995-) and AATSR (2002-2012) on a hemispherical scale.
- SYKE's SCAmod method for fractional snow cover mapping implemented for Northern hemisphere covering all non-mountainous terrain, mountains estimated using NLR algorithm developed by NR
- A novel Cloud detection algorithm by SYKE & ENVEO (snow – cloud discr.)
- Retrieval methodology developed especially for forested regions – basically a challenge for optical methodologies

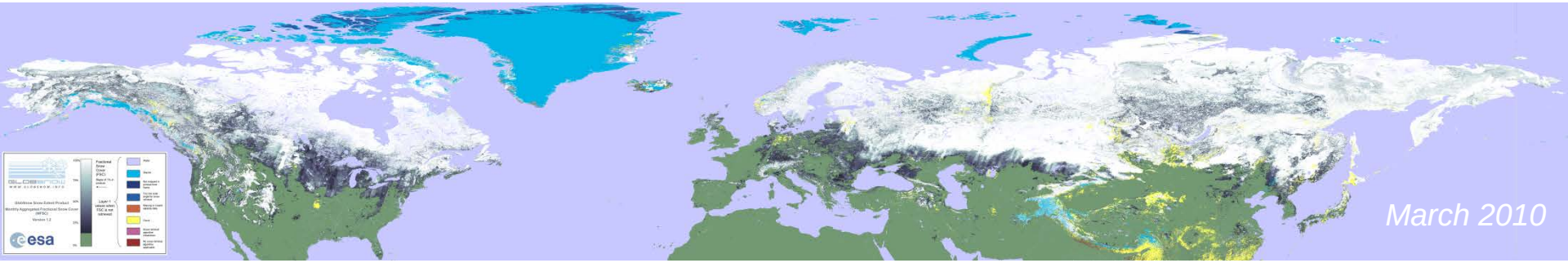


Operational data production at the Finnish Meteorological Institute (FMI)

Daily, weekly and monthly products

Optical data ~ 1km spatial resolution





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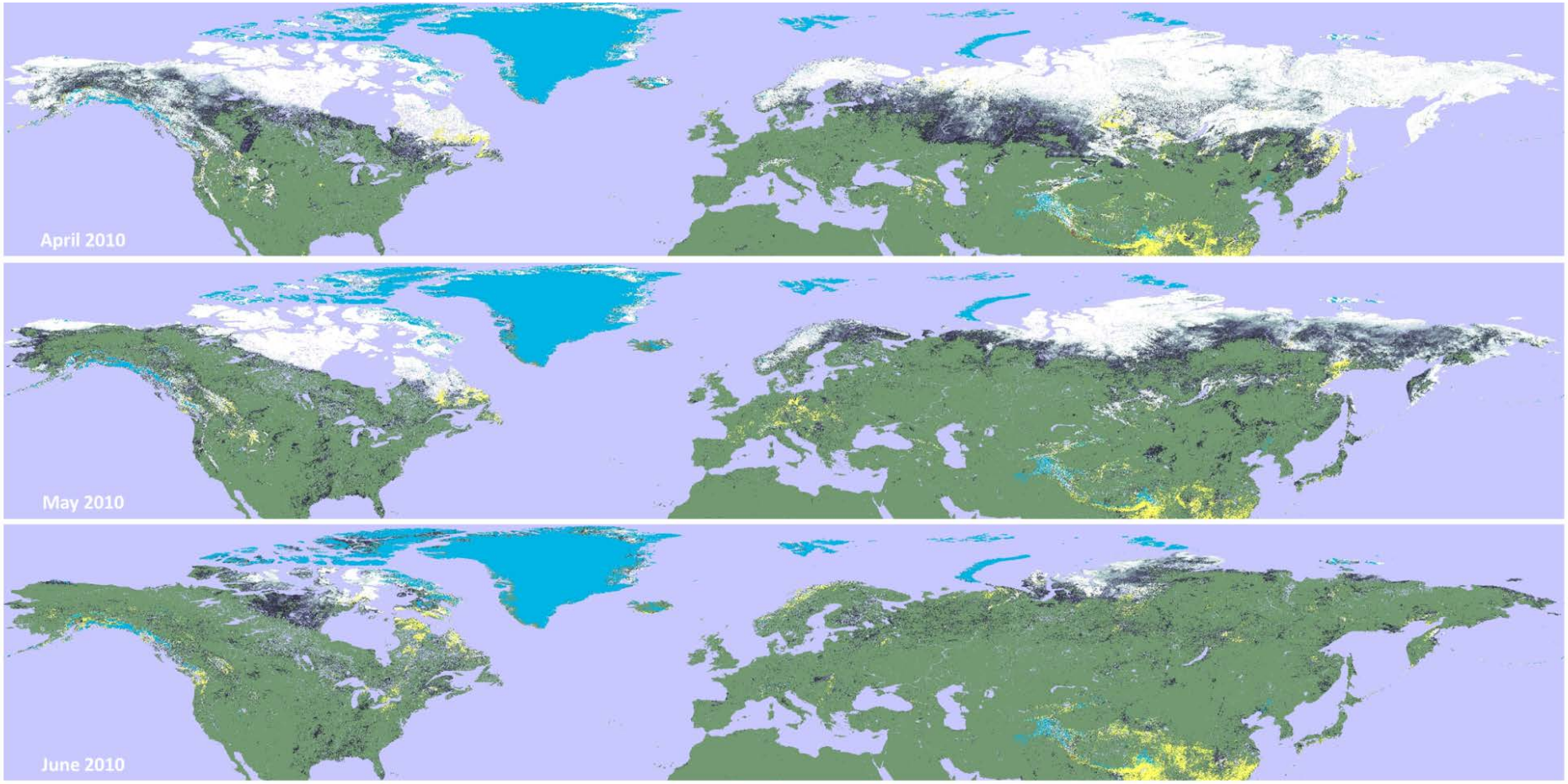
Examples of monthly products, 2010



GlobSnow Snow Extent Product

Monthly Aggregated Fractional Snow Cover (MFSC)

Version 1.2

Fractional Snow Cover (FSC) - Steps of 1% in product

100% 75% 50% 25% 0%

Layer-1 values when FSC is not retrieved

Water | Glacier | 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

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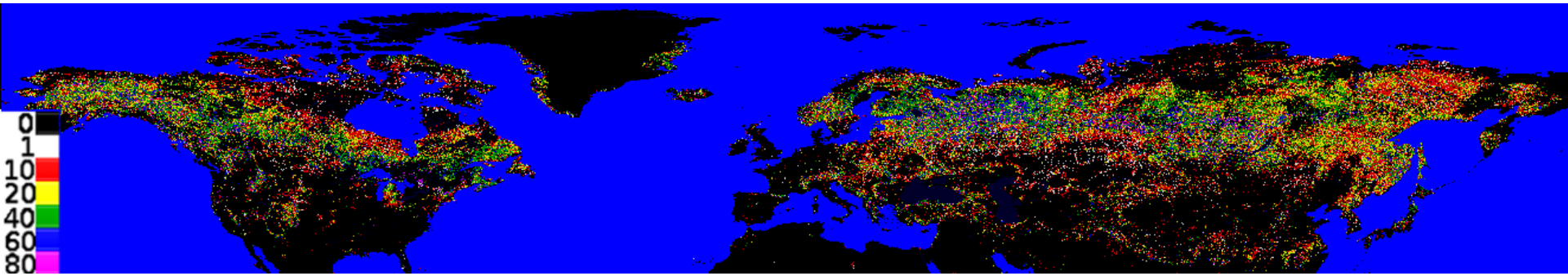
Difference between GlobSnow & NASA MODIS products

Key essential difference seen on forested regions!

(NASA product handicapped)



Mean difference between GlobSnow and NASA products

Forest map

Published in: 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.

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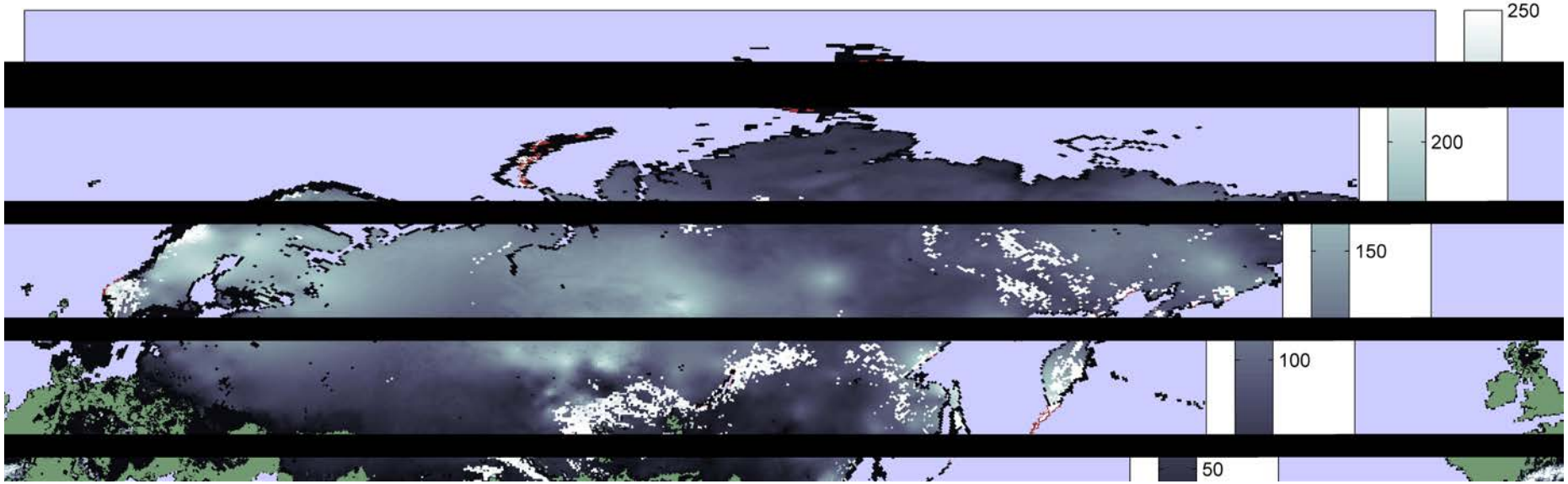
ESA GlobSnow-2

further enhancing SE & SWE retrieval methodologies

- Algorithm development: emission model, variable snow density, homogenization of WS data on SWE; new sensors for SE, etc…
- Combining PMW SWE product with high resolution SE data
- Reprocessing of long term SE & SWE time series
  - SWE algorithm developmen of GS-2 -> H-SAF & CryoLand projects

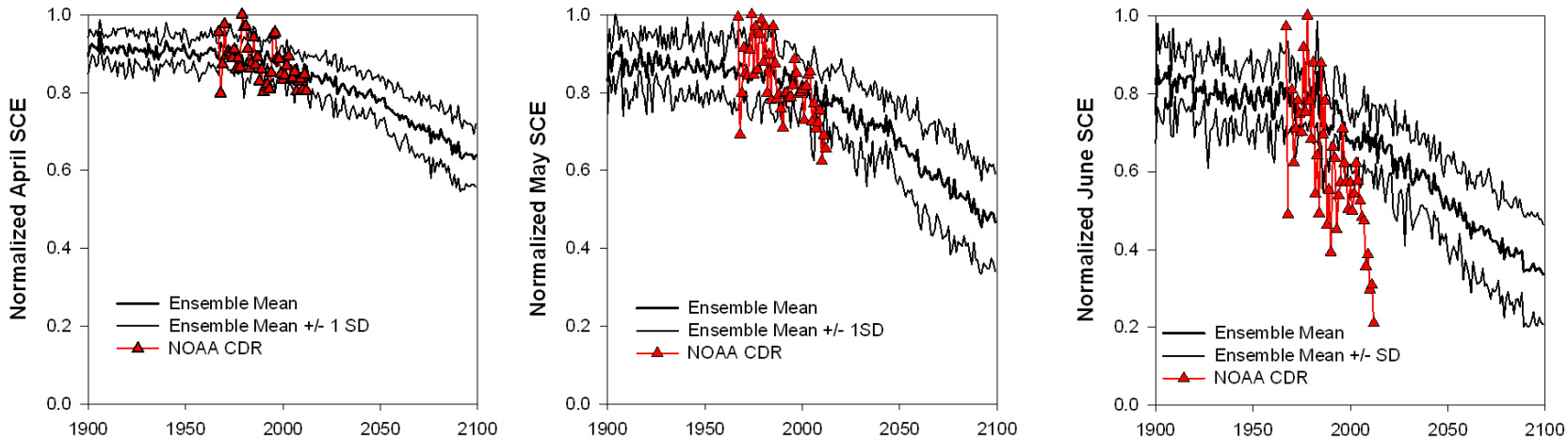


GlobSnow – data for **climate research** purposes

requirements: **long term** & **hemispherical**

- slides by:
  Luojus, Pulliainen, Takala, Ikonen (FMI)
  C. Derksen, R. Brown (EC)

Simulated vs. Observed Arctic Snow Cover – CMIP5



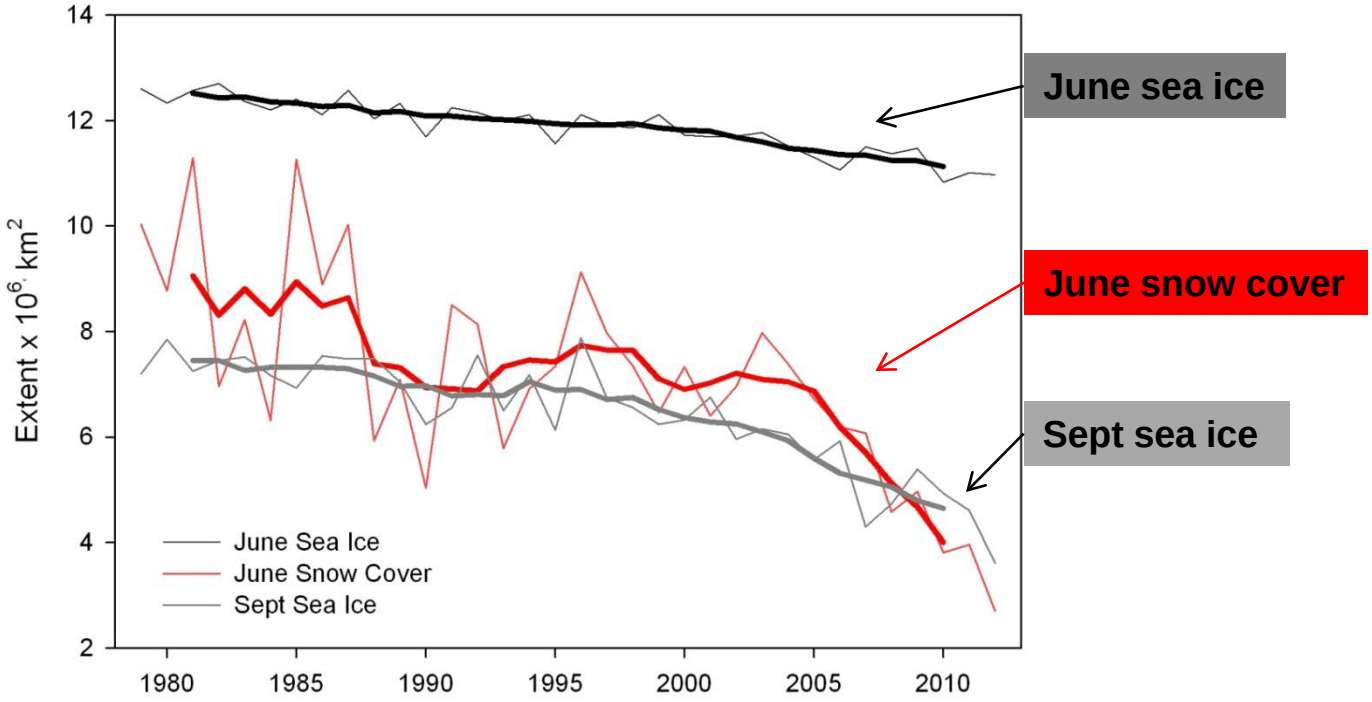
Historical + projected (**8 CMIP5 models; rcp85 scenario**) and observed (**NOAA snow chart CDR**) snow cover extent for April, May and June for land areas north of 60°. Snow covered area is normalized by the maximum area simulated by each model.

- NOAA observations are mostly within ±1 standard deviation of the multi-model ensemble in April and May, but start to diverge from the model consensus in recent years.
- Marked reductions in June SCE observed since 2005 fall below the zone of model consensus defined by +/-1 standard deviation from the multi-model ensemble mean.

Derksen, C Brown, R (2012) GRL

Changes in Snow vs. Sea Ice Extent

Northern hemisphere June snow cover and Arctic sea ice extent, 1979-2012



- For 1979–2012, June SE decreasing at rate of -17.6% per decade (relative to 1979-2010 mean)
- September sea ice extent is decreasing at -13.0% per decade. ***Derksen, C Brown, R (10.10.2012) GRL***

- **Estimated decay in radiative forcing (cryospheric cooling) receive nearly equal contributions from land snow cover and sea ice**
  (Flanner et al. 2011 – *Nature Geoscience Letters, March 2011*)

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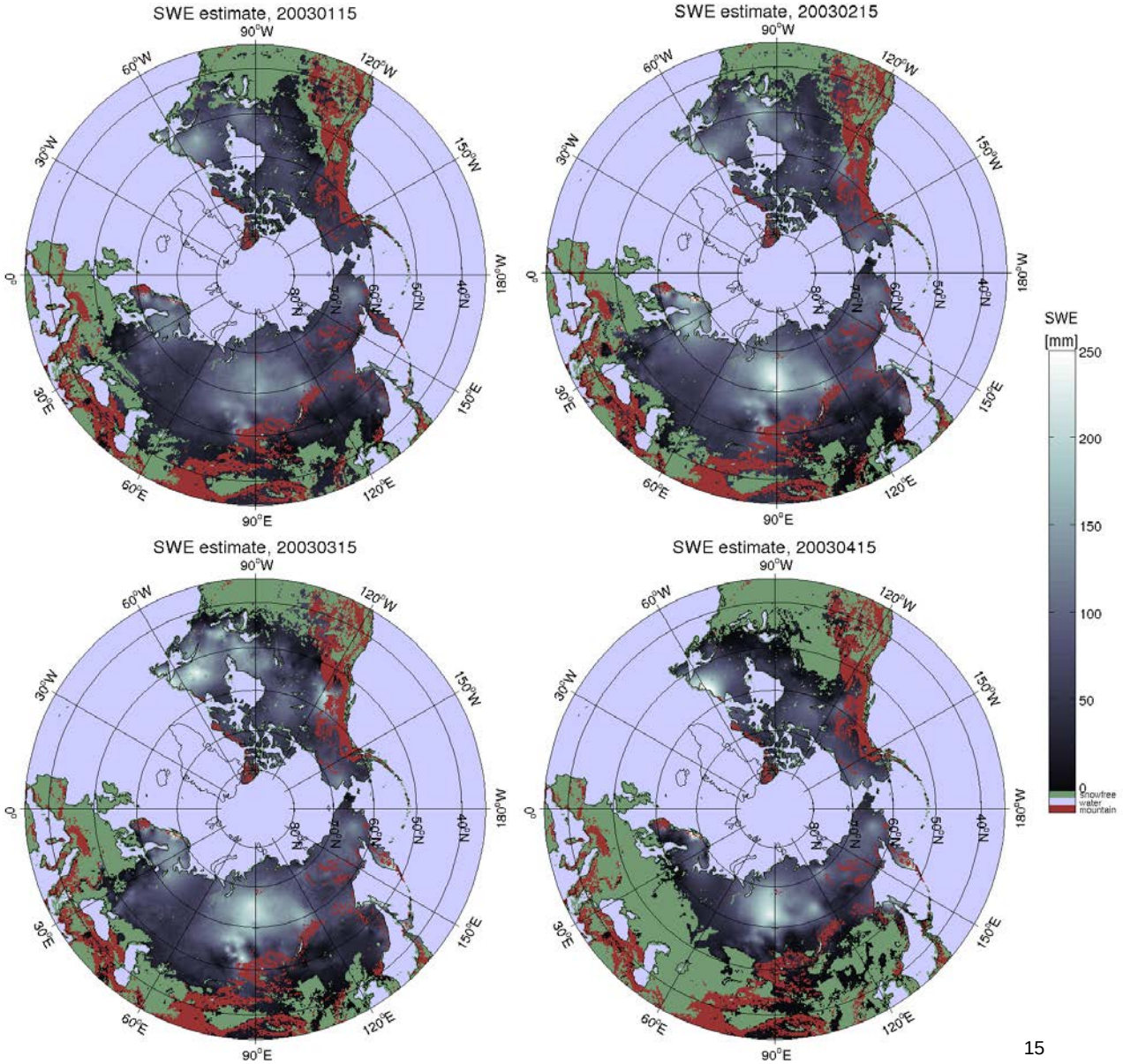
GlobSnow SWE ”observation data” available as daily/weekly/ monthly products



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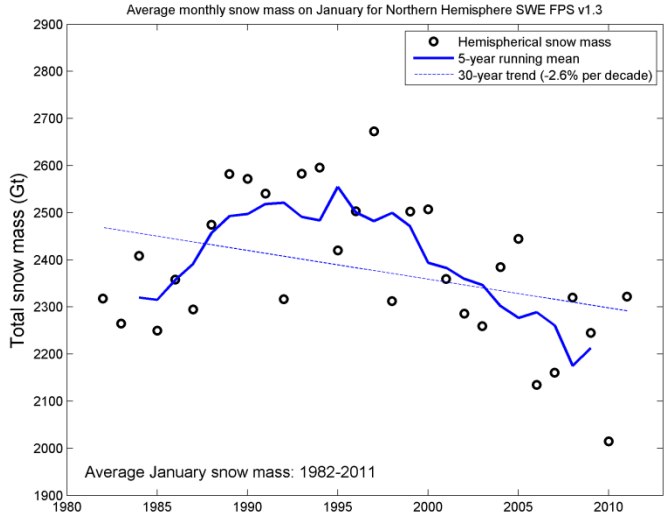
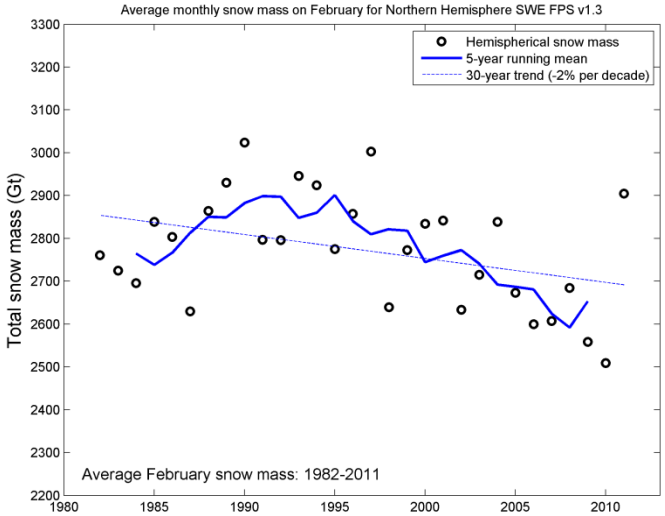
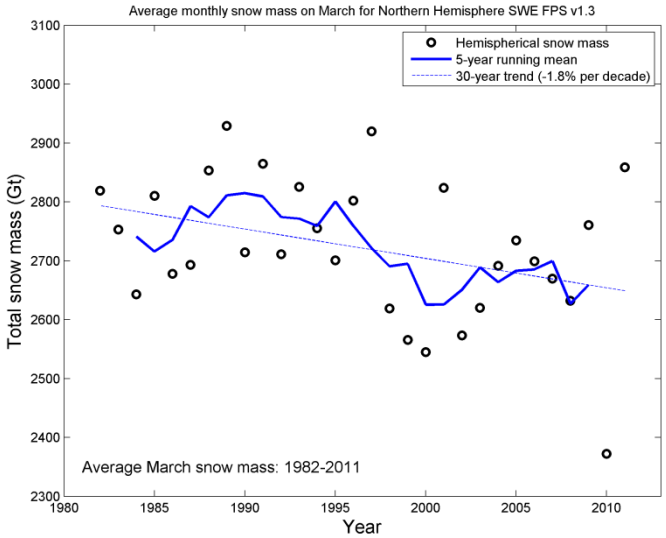
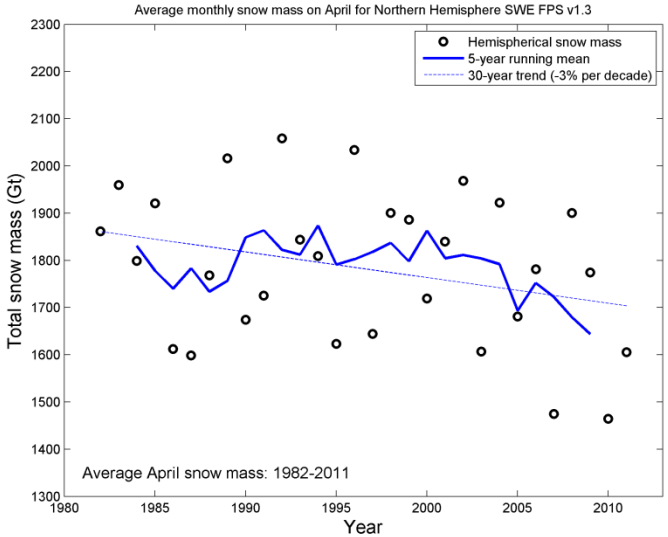
Hemispherical trends of snow mass (January – April)



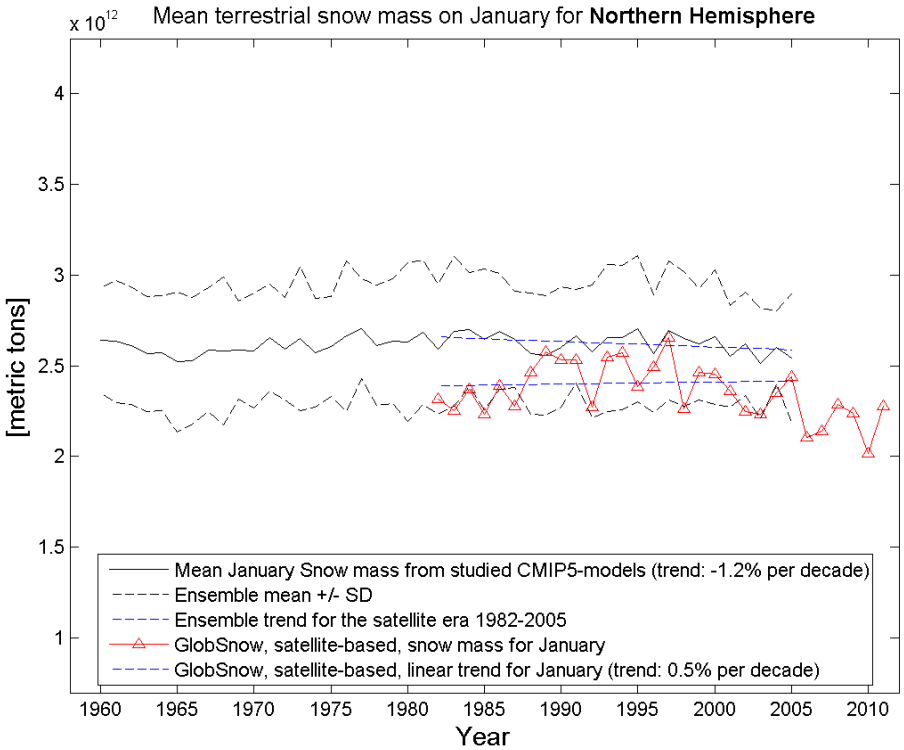


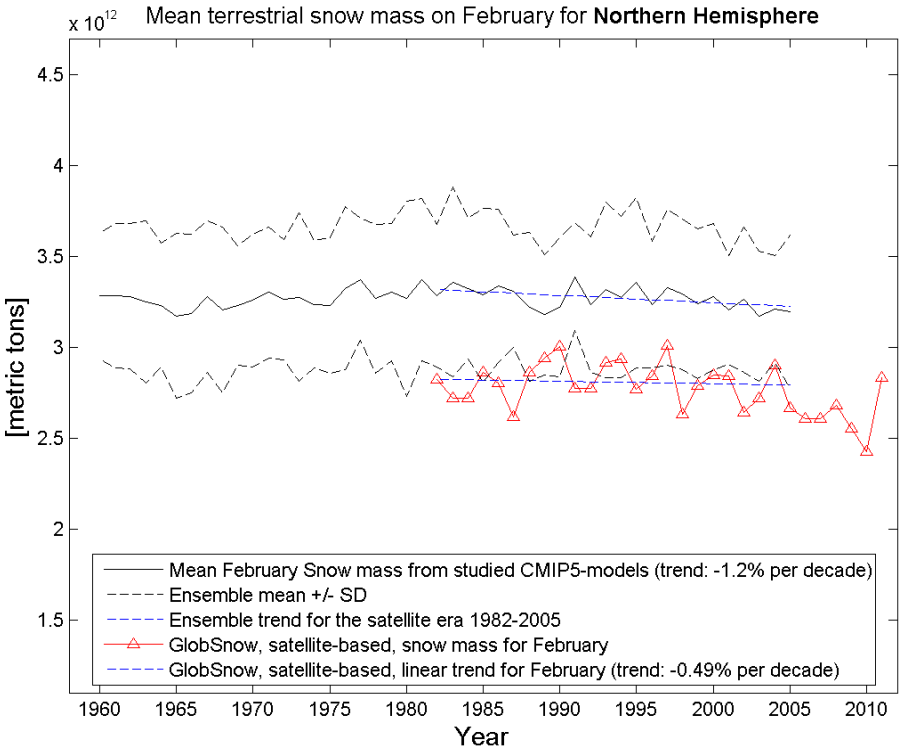
Average decrease of -7% in Snow Mass for 30-years



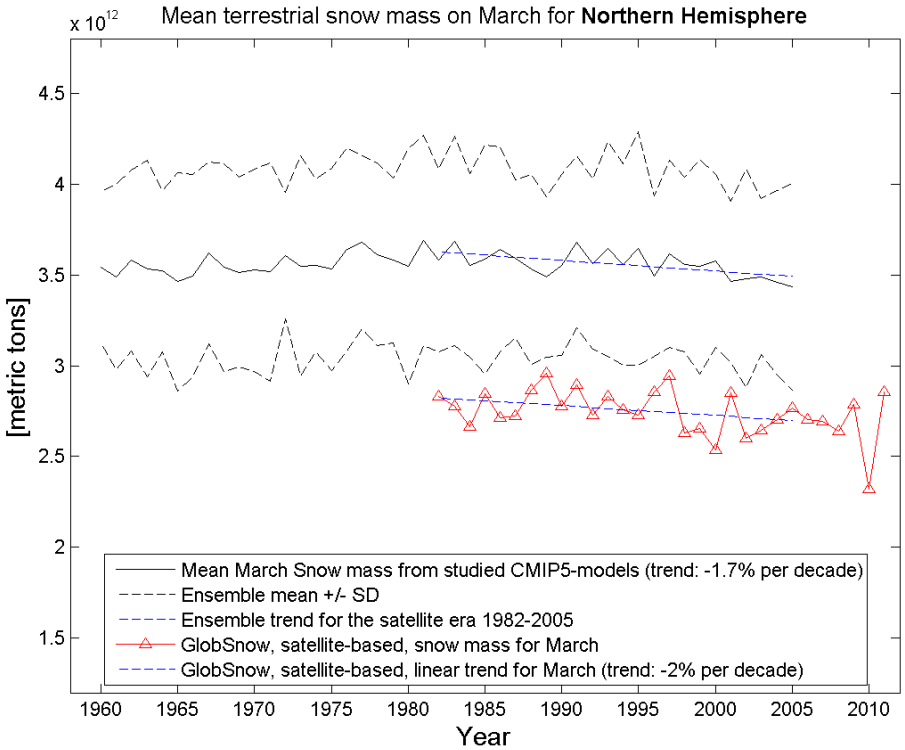


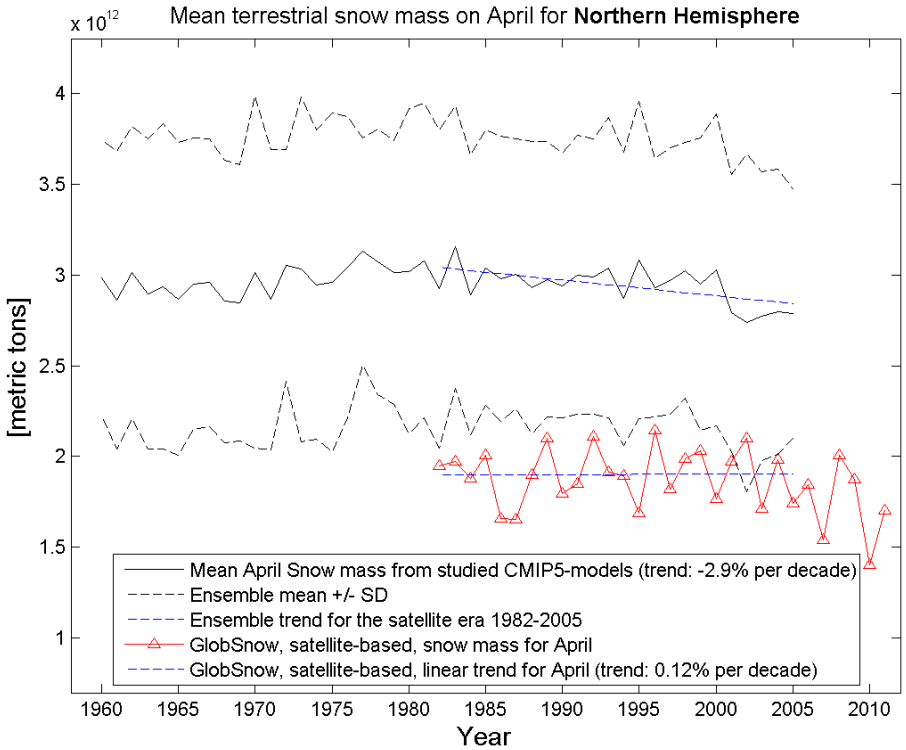
CMIP5 vs. GlobSnow SWE (January & February)





CMIP5 vs. GlobSnow SWE (March & April)





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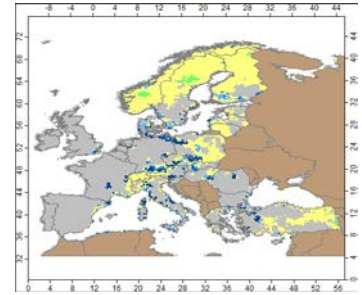
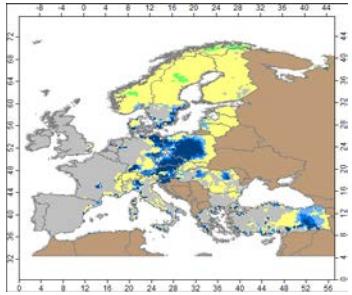
Indexes for climate change and hydrology:
Use of SWE information in regional scale

- SSPI: Standardized SnowPack Index as indicator for drought

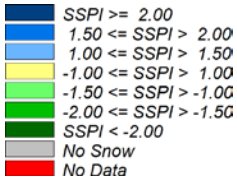
Monthly Average SSPI Winter 2005 - 2006

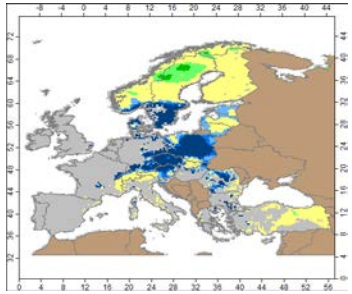


December 2005

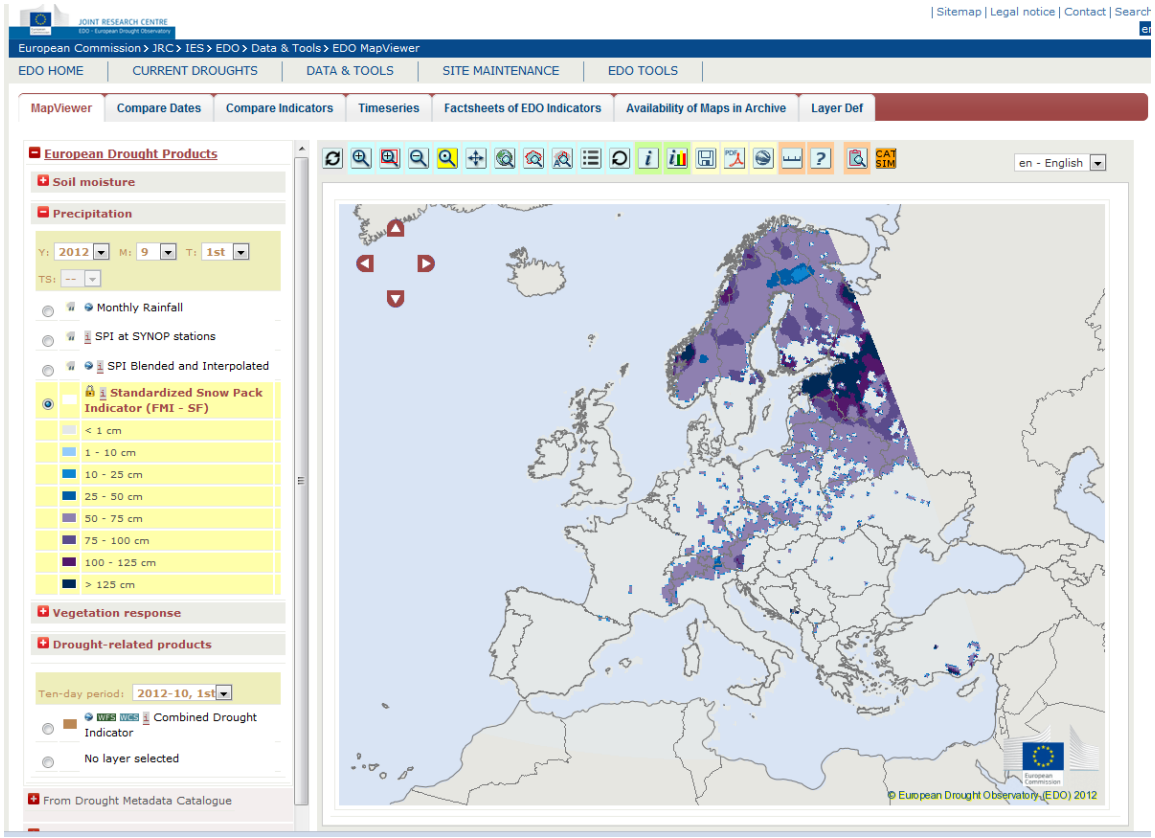


January 2006

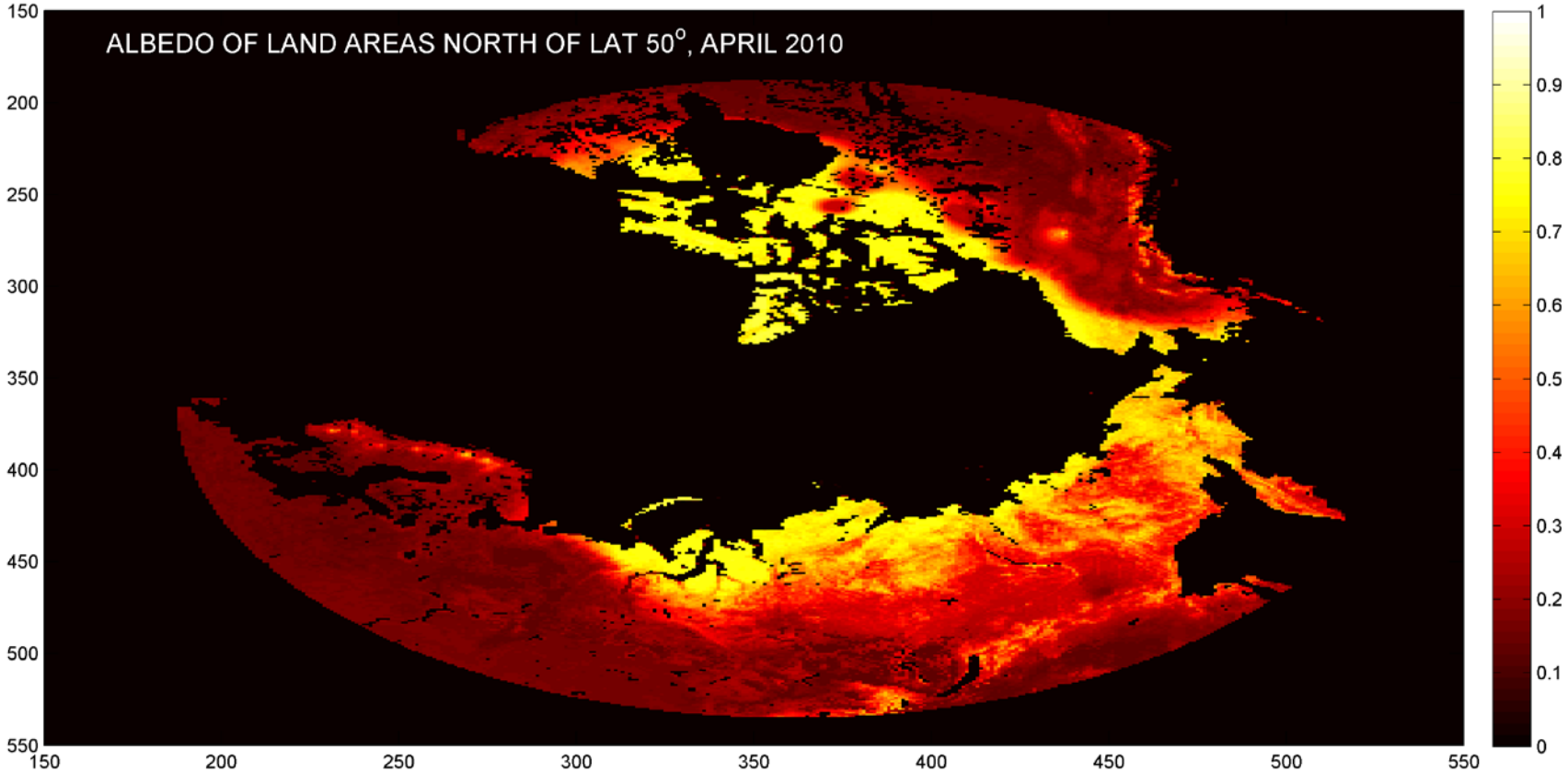




March 2006



- **Albedo determined from GlobSnow SWE using the albedo formulation of ECHAM-5 climate model (MPI Hamburg)**
  - Results for 30-years time frame
  - Input data: GlobSnow microwave Snow Water Equivalent (SWE), SYKE forest transmissivity maps, GlobCover land use, terrain topography, 2 m temperature



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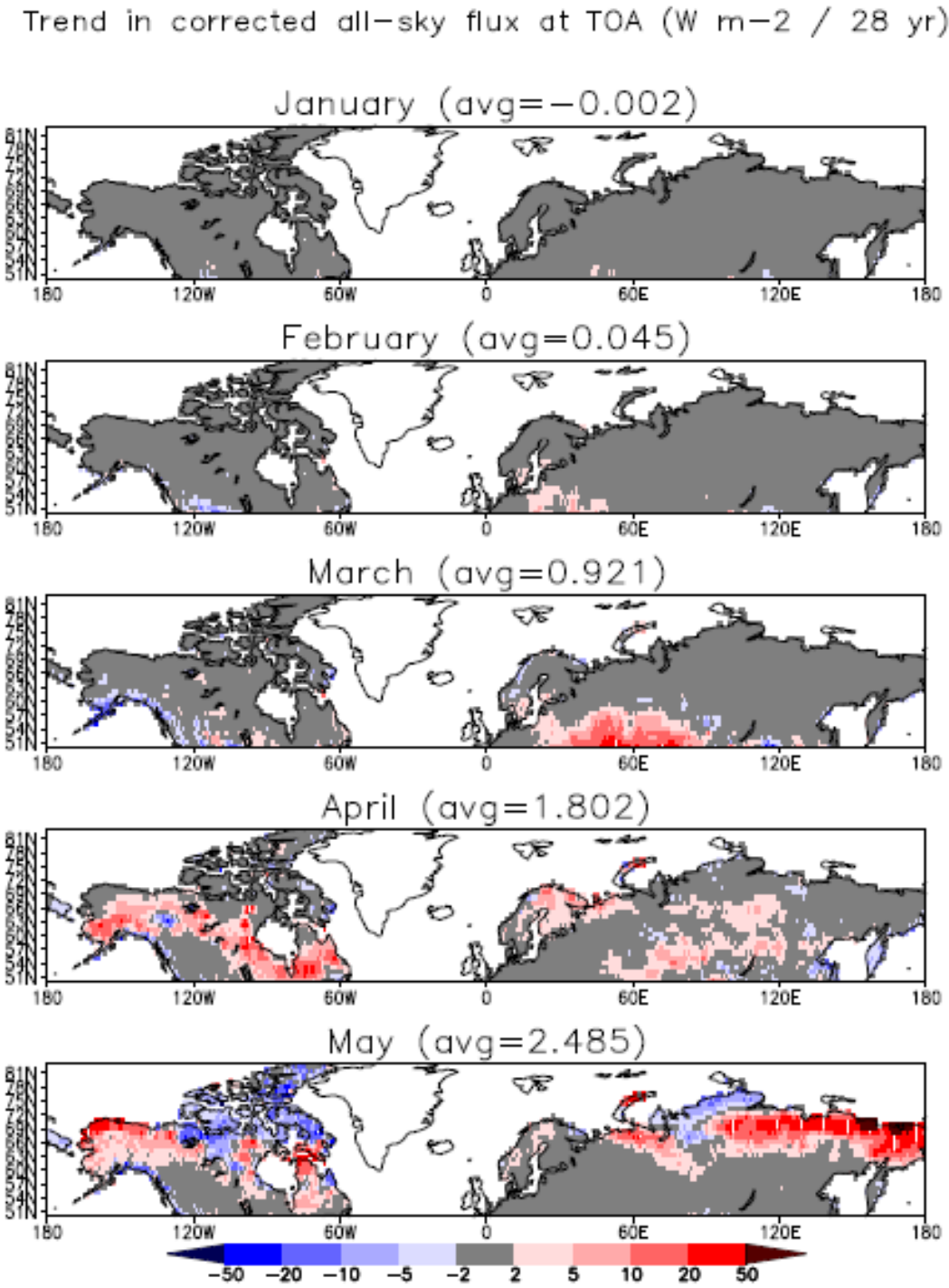
Example on GS product use:

Change of radiation flux at the top-of-the-atmosphere as estimated by ECHAM-5 simulations based on GlobSnow input



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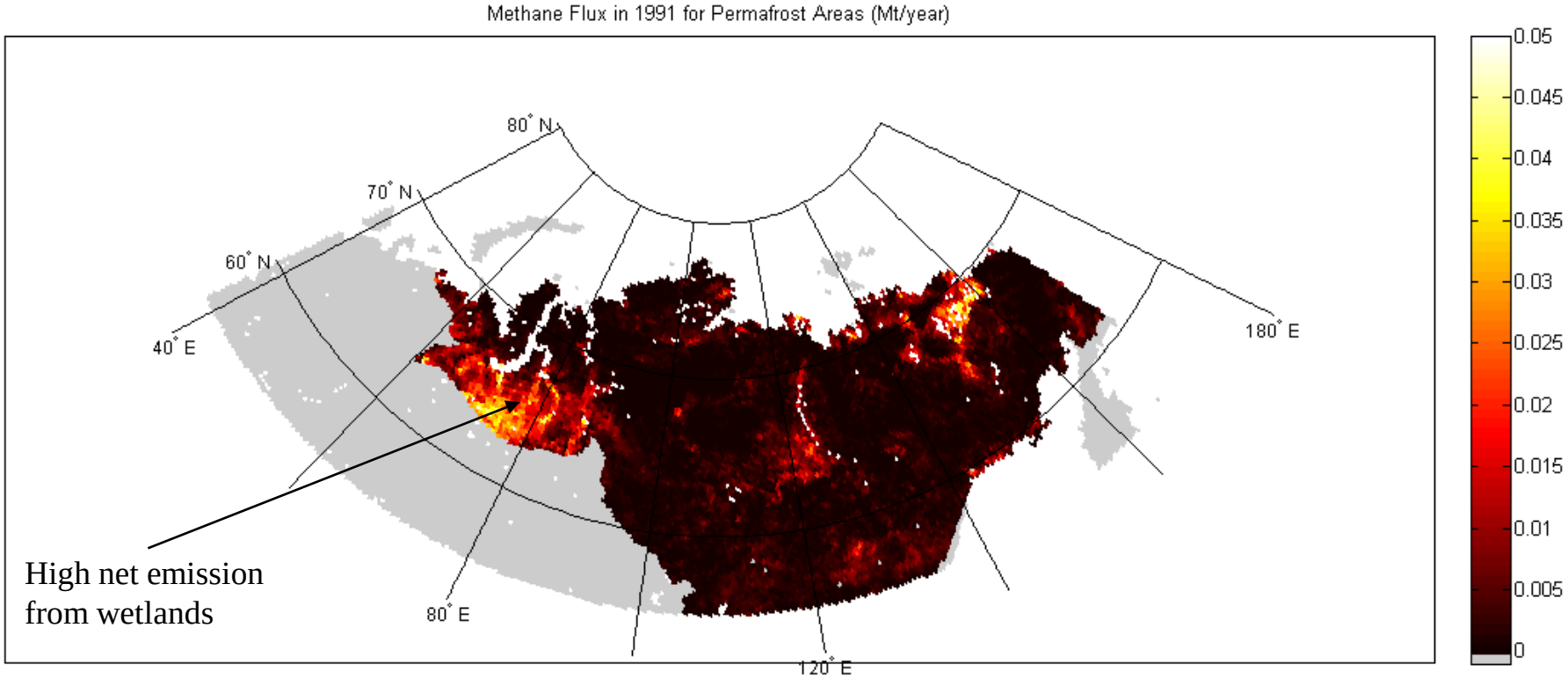
Annual estimated methane emission from Siberian permafrost areas

* By combining satellite data on snow melt and land cover with model/re-analysis data on near surface air temperature (annual flux from wetlands for 625 km^2 pixels)



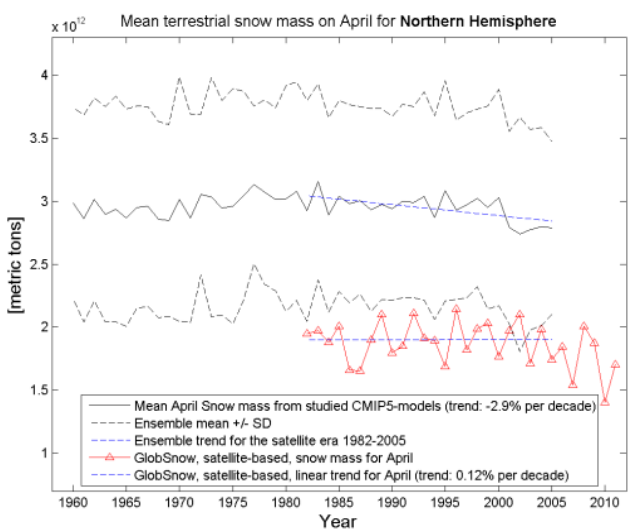
Sustainability ?

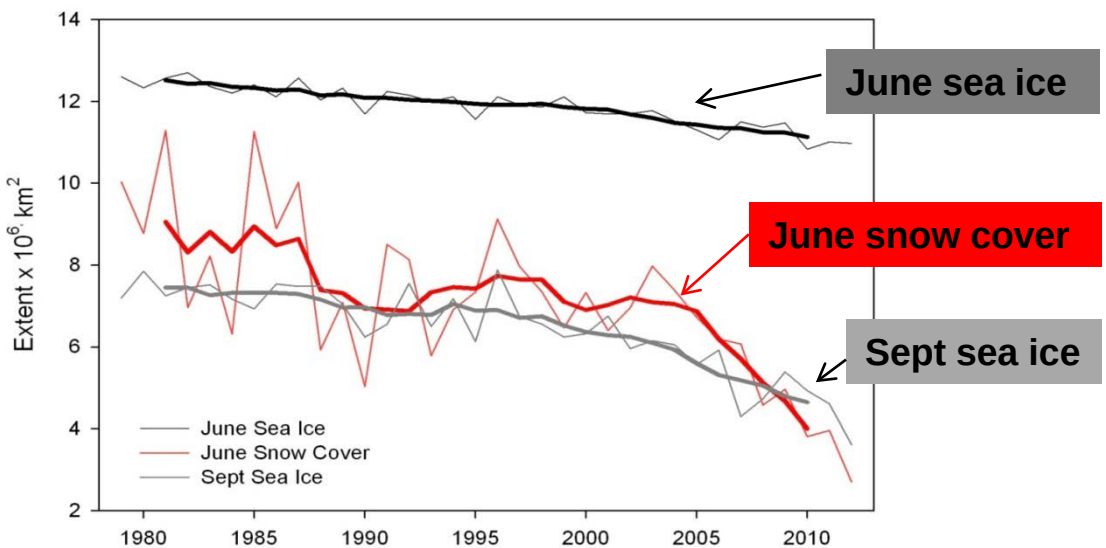
- GlobSnow is the only effort in Europe working on long-term RS records of snow cover, (other initiatives -> NRT focused)
- After the end of GS-2 (~May 2014)
  - The existing GS-derived datasets will be hosted by FMI
  - No further development of methodologies dealing with long term dataset issues, e.g. sensors changes, homogeneity of data, reprocessings of long term FCDRs (Petabytes of data)
  - GlobSnow SWE record is widely recognized outside Europe as well: Canada, US & Chinese collaboration
- Need for RS-based ECVs: validation/assessment of climate models, climate change monitoring, water resource monitoring

ESA DUE GlobSnow
Global, Climate research

Questions?

(! Check ESA front page: www.esa.int)





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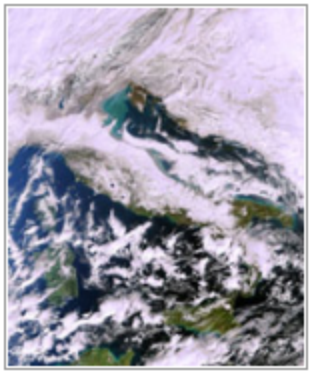


Snowy Italy

Snow cover hits record lows

3 December 2012

Santa Claus may someday need wheels for his sleigh – satellites show a decreasing amount of snow in the Northern Hemisphere.

A new analysis of snow cover observed by satellites shows record lows in Eurasia for June each year since 2008. In addition, three of the past five years have seen record low cover in North America.

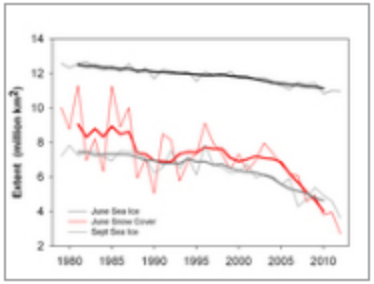
This is the lowest June snow extent since satellite observations began some 45 years ago. June snow cover is found to be falling much faster than expected from climate models, and is disappearing even quicker than summertime Arctic sea-ice.

These results, published in Geophysical Research Letters in October and based on snow chart data from the US National Oceanic and Atmospheric Administration (NOAA), are consistent with indications of a decline in monthly-average snow mass, published last year as part of ESA's GlobSnow project.

The results show that the maximum amount of snow across the Northern Hemisphere is slowly falling, while spring snow – particularly at high latitudes – is melting significantly earlier.

GlobSnow produced a long time-series of snow mass from 1979 to 2012, as well as a time-series of snow cover from 1995 to 2012.

The snow mass time-series is the first daily dataset of its kind for the Northern Hemisphere that extends over 30 years and is from satellite sensors measuring Earth's microwave emissions.



Changes in snow cover and sea-ice

Information on snow mass and area is used to monitor and understand changes in seasonal snow cover that are important

Related links
- GlobSnow
- GlobSnow Newsletter
- Workshop on European Satellite Snow Monitoring Perspectives
- Climate Change, Impacts and Vulnerability in Europe 2012

In depth
- Spring snow cover extent reductions in the 2008–2012 period exceeding climate model projections
- Estimating northern hemisphere snow water equivalent for climate research through assimilation of space-borne radiometer data and ground-based measurements

Space for our climate