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The New ESA Earth Observation Science Strategy: Finnish Perspective

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Earth Observation Science Strategy for ESA

A new era for scientific advances and for societal benefits

Previous strategy: Challenges driving science missions and their requirements

5 Challenges of the Atmosphere

5 Challenges of the Cryosphere

4 Challenges of the Land Surface

6 Challenges of the Oceans

5 Challenges of the Solid Earth

Formulated in 2006, ESA-SP-1304

Following the 2011 EOEP Science Review, Recommendation to "…review and update periodically the Changing Earth…"

53 leading community Scientists were consulted on the validity of the 25 Living Planet Challenges of "The Changing Earth" for 5 Themes

European Space Agency

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Finnish perspective: An example of proposed research activities to achieve the goals of ESA EO Science Strategy

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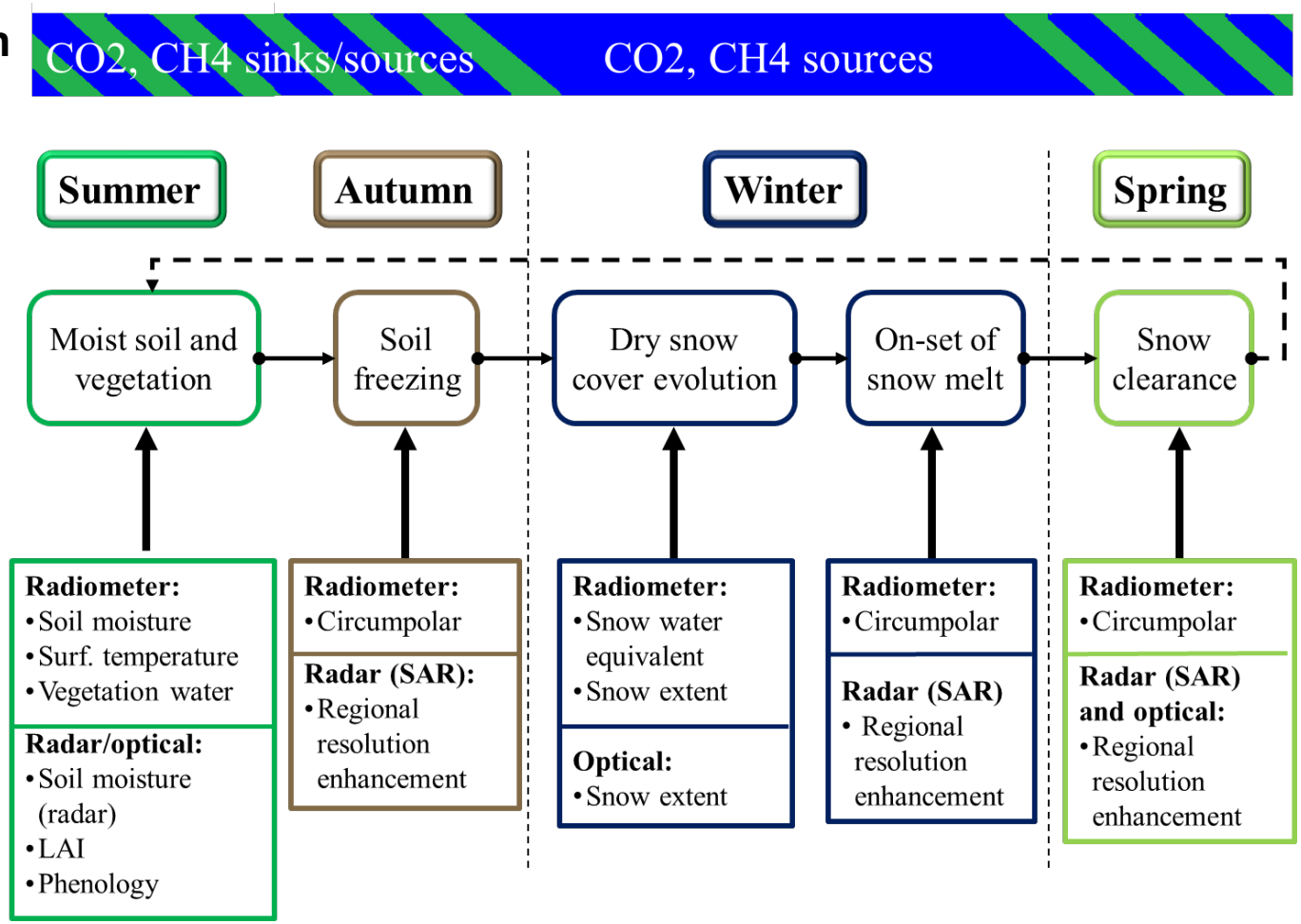
Integrated view on the land cryosphere: snow and soil processes

- **Soil and vegetation processes in addtion to snow cover**
- **Full seasonal view on phenomena relevant to carbon exchange and annual balance at the high latitudes**



Current topics in the remote sensing of cryosphere

- **Evolution of the seasonal snow cover**
  - ECV time-series for climate research including the validation and parametrization of General Circultion Models/Earth System Models
    - Snow mass evolution (SWE): until recently reliable global information has not exist
    - Need of combined products describing all characteristics of snow cover (**SWE**, **Snow Extent** (SE), **Fractional Snow Cover** (FSC))
- **Effect to carbon cycling and radiation balance**
  - CO2 and CH4 cycling
    - For example, methane emissions on wetlands during winter are affected by the snow cover; changes in permafrost regions active layer characterist6ics related to changes in snow cover
- **Hydrological and meteorological forecasting**
  - Consideration of snow cover and lake ice
  - Data assimilation

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esa due data user element GLOBSNOW

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 processing**

• 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

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

ZAMG

UNIVERSITÄT BERN

esa enveo GAMMA REMOTE SENSING SYKE norut NORTHERN RESEARCH INSTITUTE TROMSØ Norsk Regnesentral Schweizerische Eidgenossenschaft Confédération suisse Confederazione Svizzera Confederaziun svizra Federal Department of Home Affairs FDHA Federal Office of Meteorology and Climatology MeteoSwiss Environment Canada Environnement Canada

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EUMETSAT: H-SAF

- Near real-time snow mapping services for Europe
  - SWE mapping approach is based on the further development of GlobSnow approach

EC: CryoLand and Sen3App

- Multi-national EC Copernicus projects also linked to ESA GlobSnow
  - Development of operational satellite-based snow & land ice products
  - Sentinels 1, 2 and 3

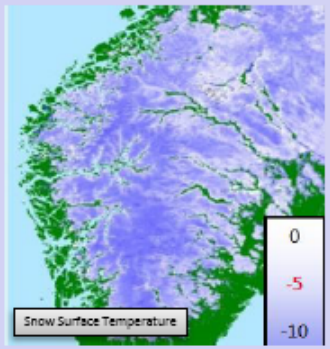
CryoLand

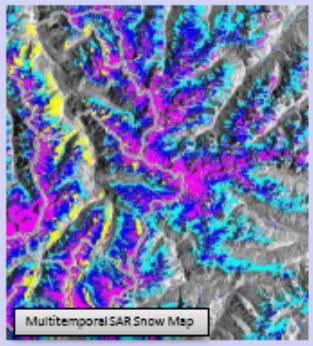
GMES Service Snow and Land Ice

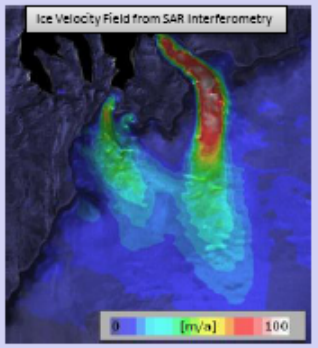
Proposal for a GMES Downstream Service in response to the Call
FP7-SPACE-2010-1 Activity 9.1 Space-based applications at the service of European Society
1. Stimulating the development of downstream GMES services.

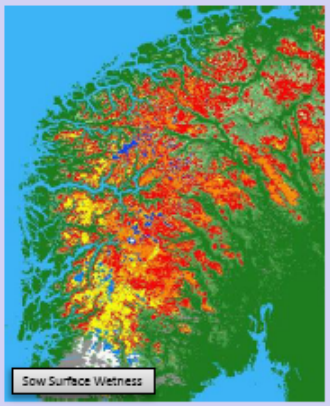
Service Goals

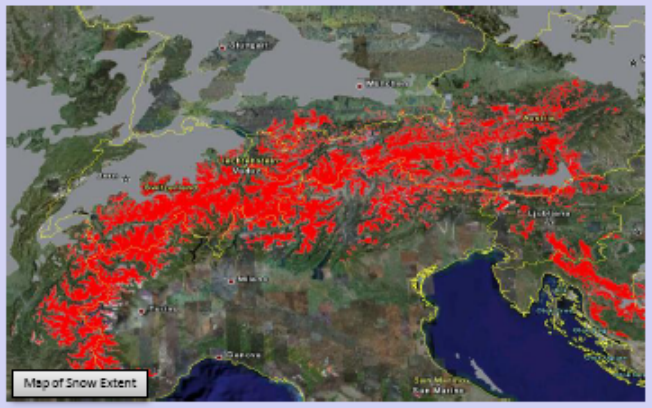
- Develop and validate a pan-European satellite-based snow and land ice service delivering highly needed products to the user society.
- Integrate and operationalise existing snow and land ice services
- Prepare the tools for offering snow and ice services world-wide
- Perform full verification and real time demonstration of the service
- Complement GeoLand Land Cover Products
- Prepare the basis for the Cryosphere Component of a GMES Global Land Monitoring Service
- Conform to INSPIRE/GEOSS standards
- Make available products via state-of-the-art online services
- Issue guidelines for stakeholders and for service deployment operations











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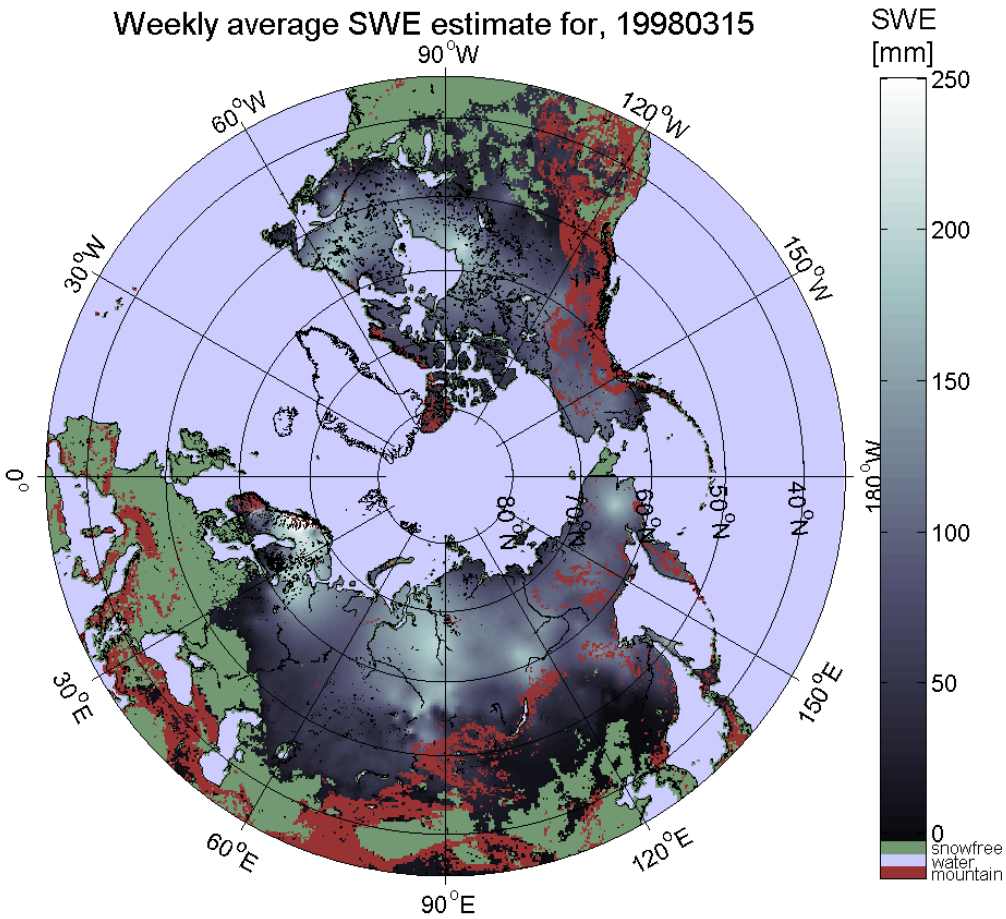
esa due data user element GLOBSNOW

30 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 1979-2012
- 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 since 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

Motivation: CO2 EMISSIONS ARE GROWING

Additionally, natural (ecosystem) sinks an sources are changing due to climate change

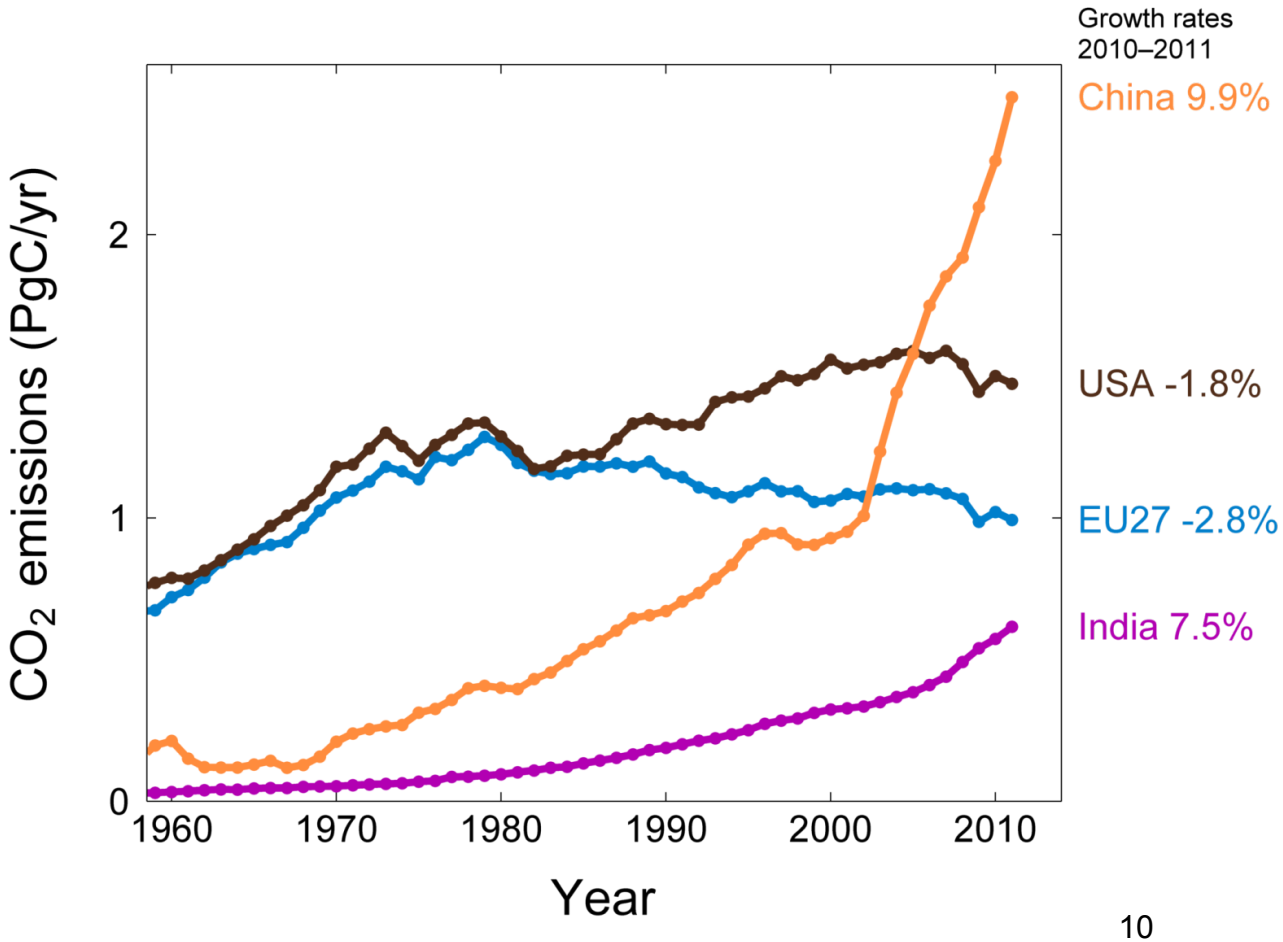
Top four emitters in 2011 covered 62% of global emissions

China (28%),

United States (16%),

EU27 (11%),

India (7%)



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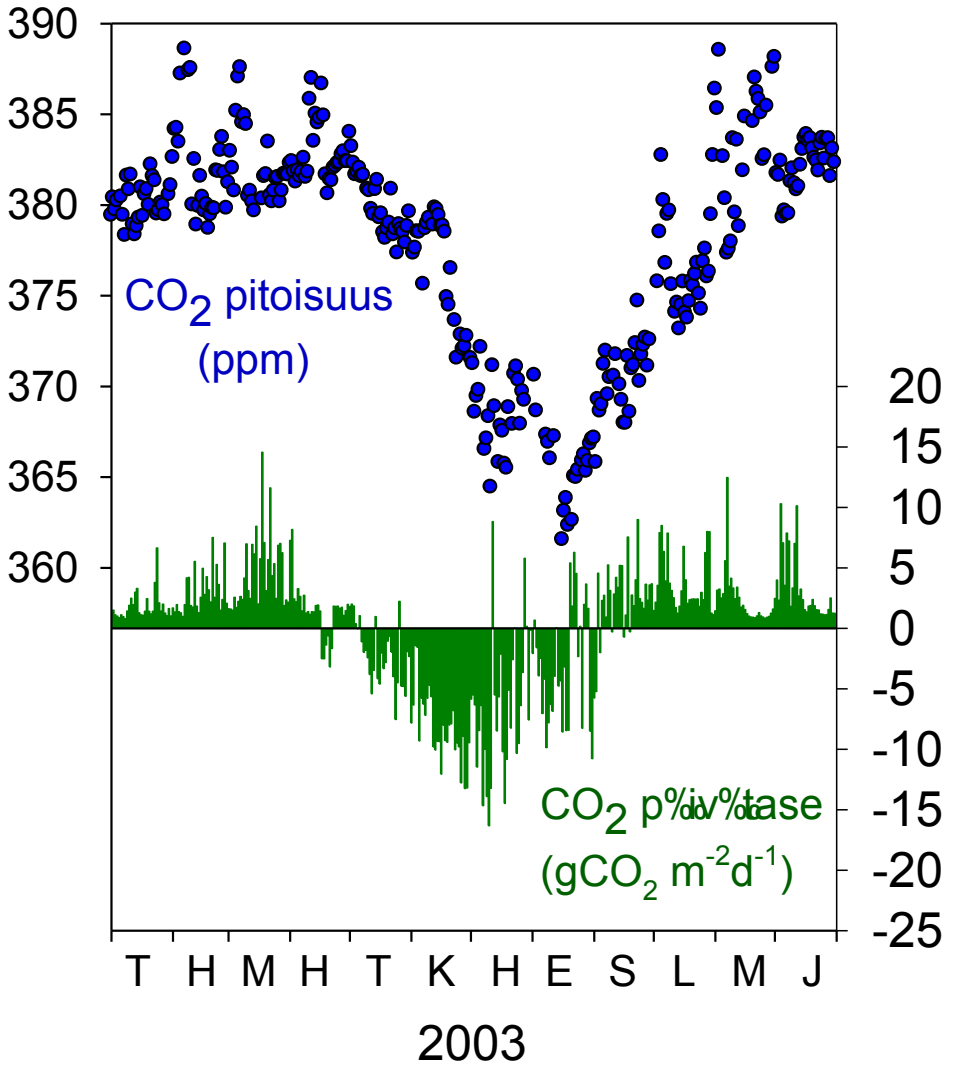
CO_2 concentration and daily fluxes are observed at different ecosystems in FMI Sodankylä-Pallas Supersite



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FMI Sodankylä satellite CAL-VAL program:

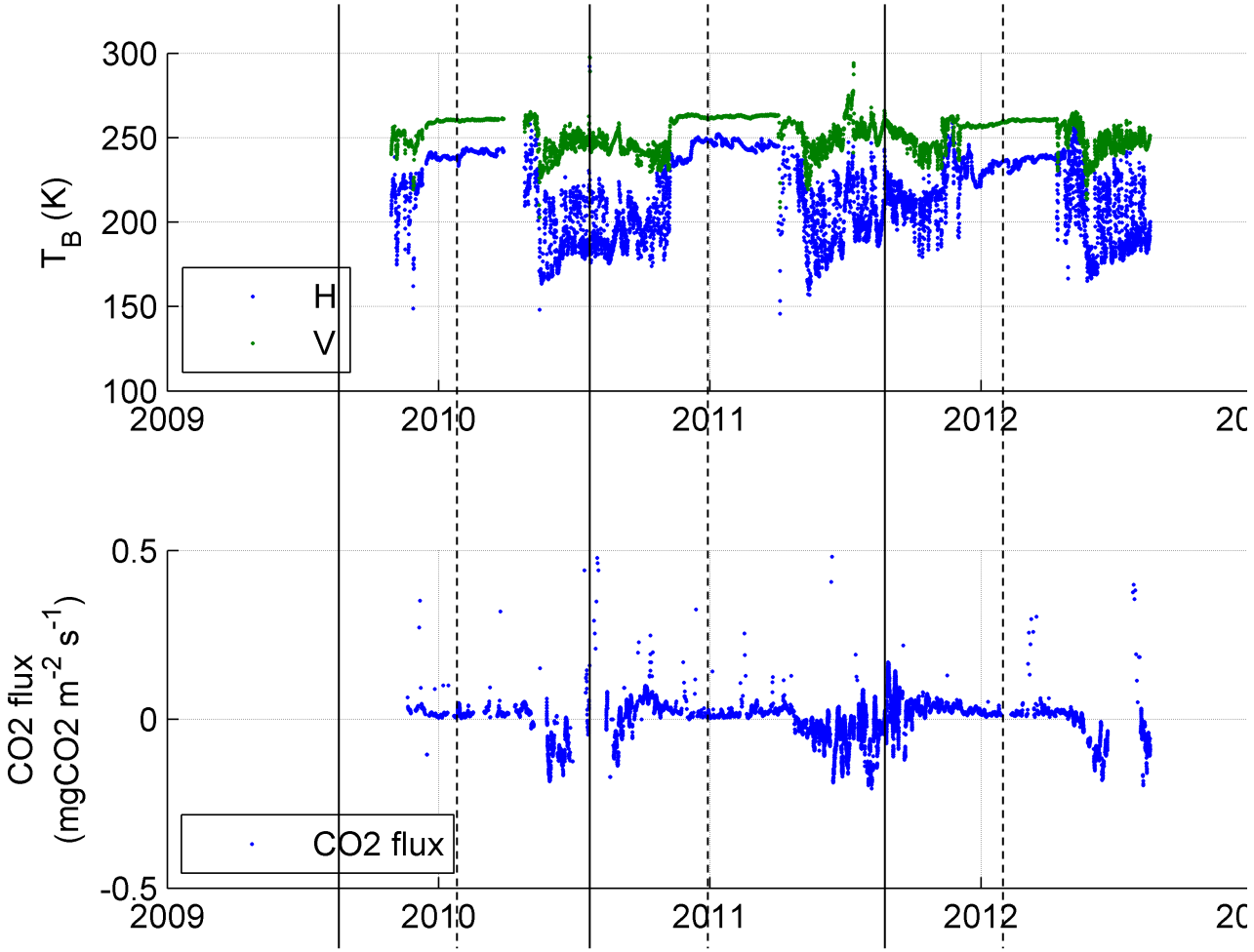
Among key topics: Development of satellite data retrieval algorithms to map ***snow*** and ***soil state characteristics***, and their relation to ***carbon cycle (CO2 and CH4 fluxes)***

ESA SMOS

CO2 flux in forest and its relation to L-band brightness temperature

Three-year time series of ELBARA-II in forest opening (top) and concurrent CO2 net flux (below)

- **After snow melt-off a CO2 sink** due to photosynthesis
- During autumn a clear **CO2 source before soil freezing** (weak source during winter)



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Spaceborne

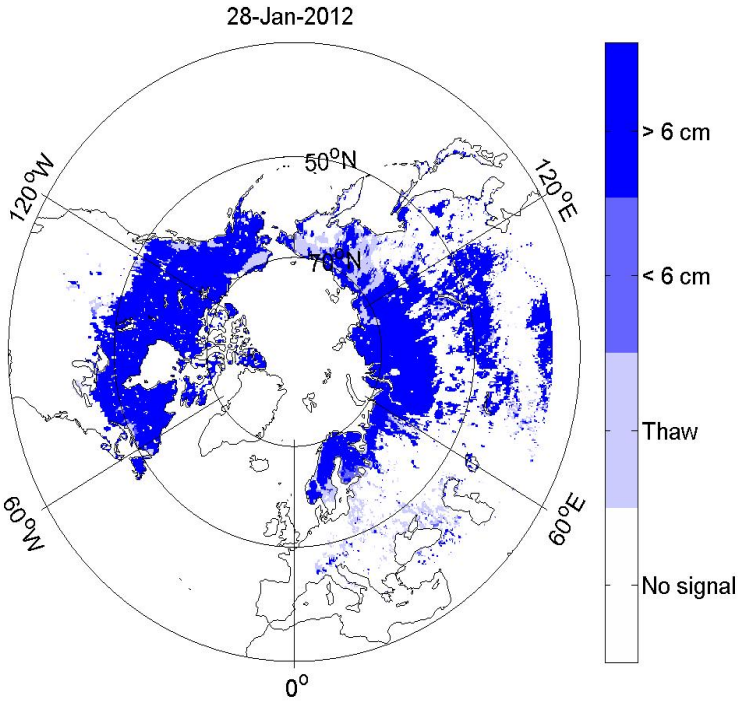
Prototype retrieval algorithm for space-borne L-band observations have been successfully demonstrated

Discrimination into thawed, frozen and partially frozen states

SMOS – ESA's Soil Moisture and Ocean Salinity –mission

Coverage: whole Northern Hemisphere

Methodology also applicable to NASA SMAP



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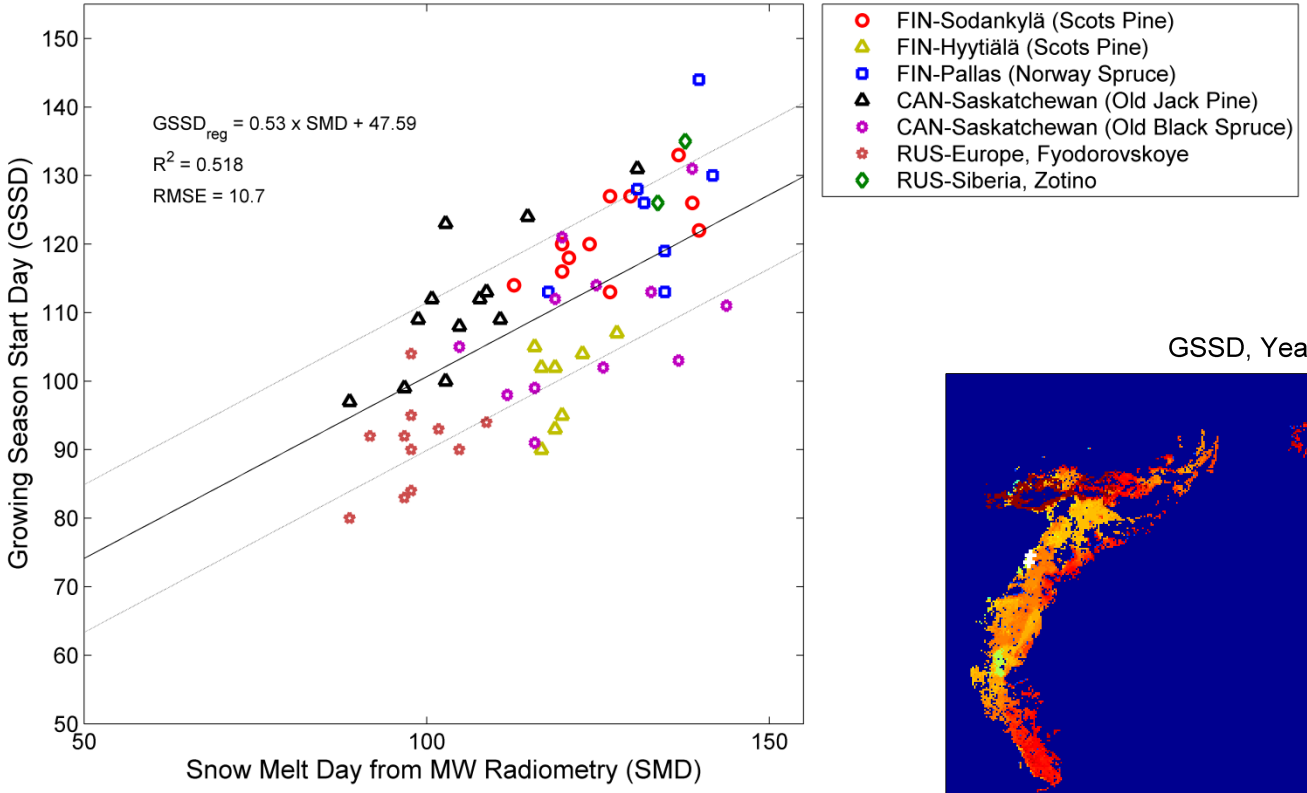
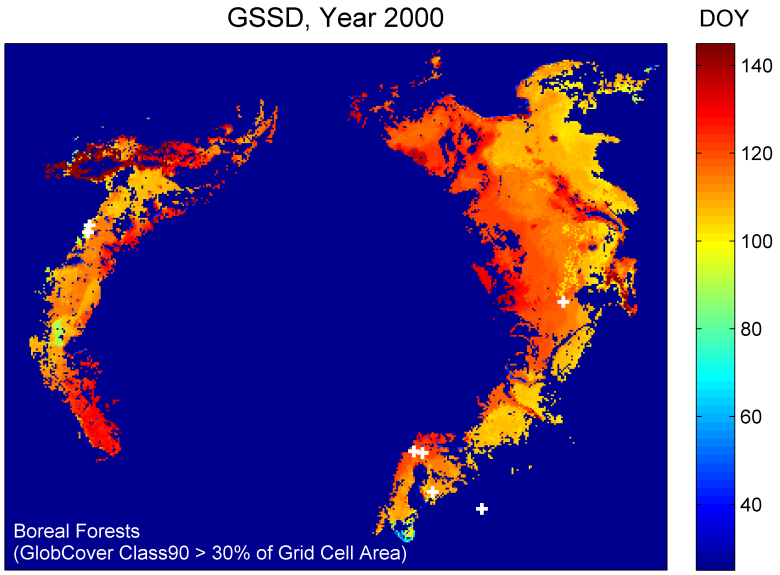
Direct use of satellite products as proxy indicators

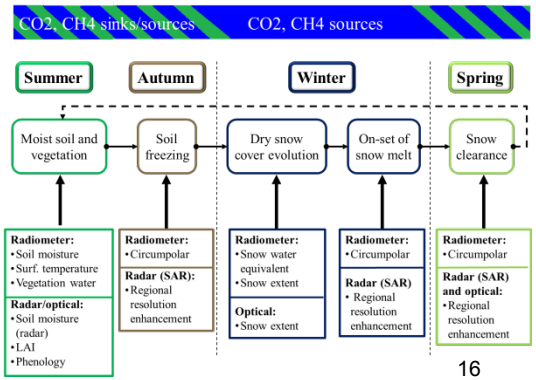
- Example: Detection of Start of the Growing Season from space-borne data derived snow melt (GlobSnow product)





Way forward: Combined products to monitor the seasonal cycle of carbon exchange related phenomena

- **Relevant microwave and opticl satellite instruments/missions**
  - SSMI/I, AMSR-E (2), SMOS, Envisat ASAR, TerraSAR-X, MODIS, AATSR, MERIS, Sentinel 1, Radarsat-1/2, Chinese FY-series …
  - Future missions: Sentinels 2 and 3, NASA SMAP
- **Combination of snow , soil and vegetation products**
  - Monitoring of all C-relevant processes of the land cryosphere
- **Combined use with *in situ* data and assimilation with models**
  - Proxy indicators (developed with *in situ* data)
  - Use with LSM




Thank You *for* Your Attention!
Kuva: Matias Takala