Using Arctic and high-latitude observations at the Swedish Meteorological and Hydrological Institute

Research Department

(presented by Ralf Bennartz, University of Wisconsin)


Ulrika Willén /Torben Königk **- Climate research, Rossby Centre**

David Gustafsson  - Hydrology

Abhay Devastahle  - Atmospheric remote sensing

Magnus Lindskog  - Meteorology

Joakim Lagner  - Air quality

Ye Liu /Lars Axell   - Oceanography

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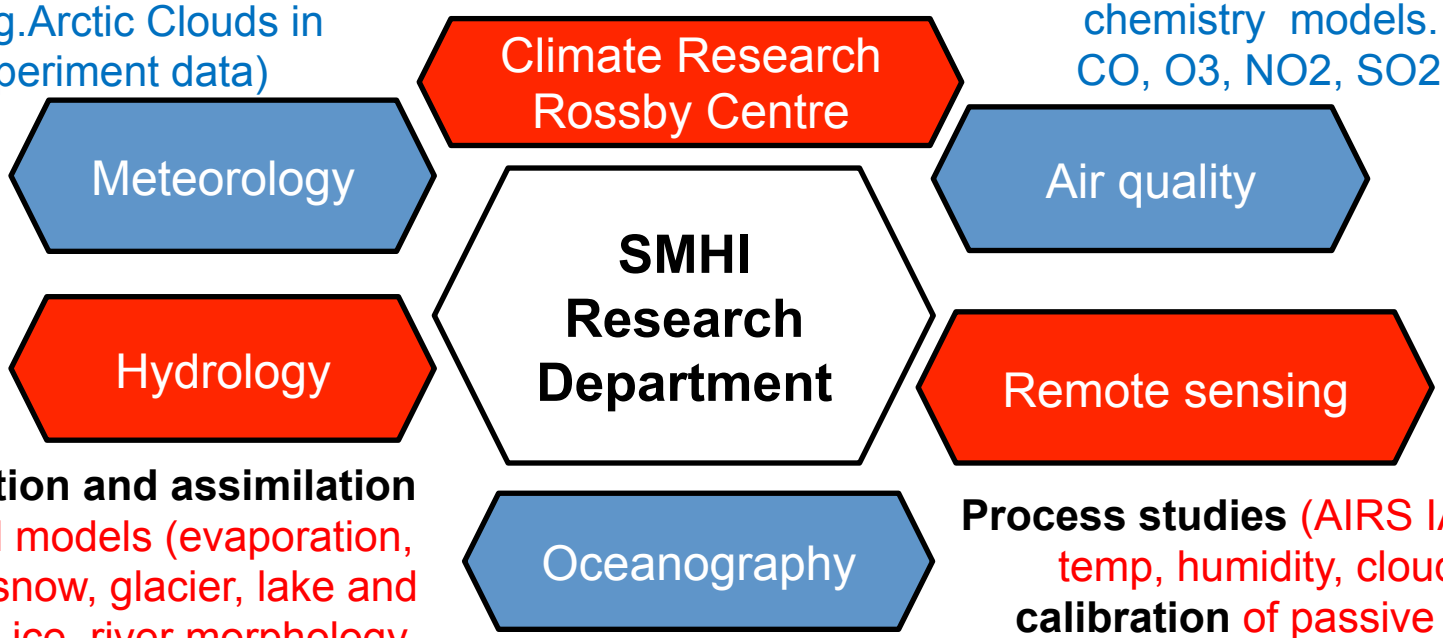
Arctic, High latitude observations used for

Process studies, evaluation of global and regional climate models (temp, humidity, clouds, radiation, soli misutre, LAI, snow, albedo, SST, ice). **Initial conditions** (SST, ice) for seasonal and decadal predictions.

Assimilation of upper air data and soli-moisture in regional NWP forecasts and reanalysis. **Evaluation** (e.g.Arctic Clouds in Summer Experiment data)

Monitoring of atmospheric composition. **Evaluation** of chemistry models. (CH4, CO, O3, NO2, SO2, AOD)



Input, calibration and assimilation in hydrological models (evaporation, soil moisture, snow, glacier, lake and river temp and ice, river morphology, vegetation index, land use)

Process studies (AIRS IASI CrIS temp, humidity, clouds), **calibration** of passive cloud retrievals (Calipso/CloudSat data)

Assimilation of ice edge data, sea-ice concentration and SST in operational ocean forecasting. **Evaluation** of biogeochemical model (ocean colour).

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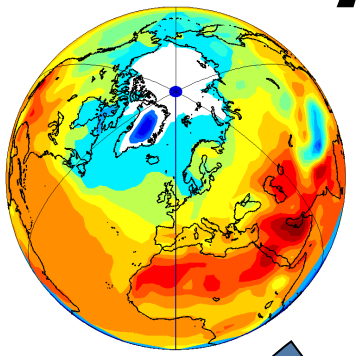
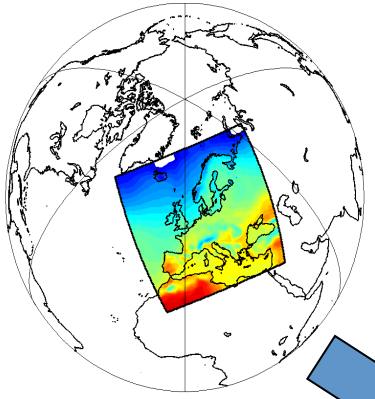
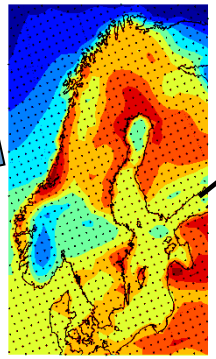
Activites at the Rossby Centre

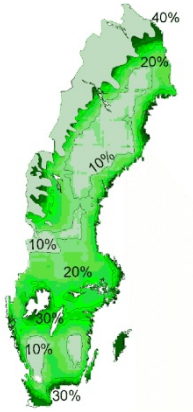


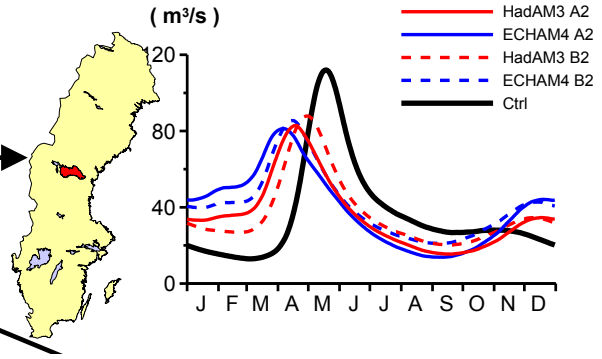
Global scenarios and climate prediction: EC-Earth, 100 → 25 km



Regional downscaling :
50→1 km resolution

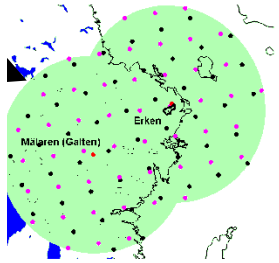






- Developing and running climate models
- Analysing climate scenarios
- Support for impact and adaptation studies

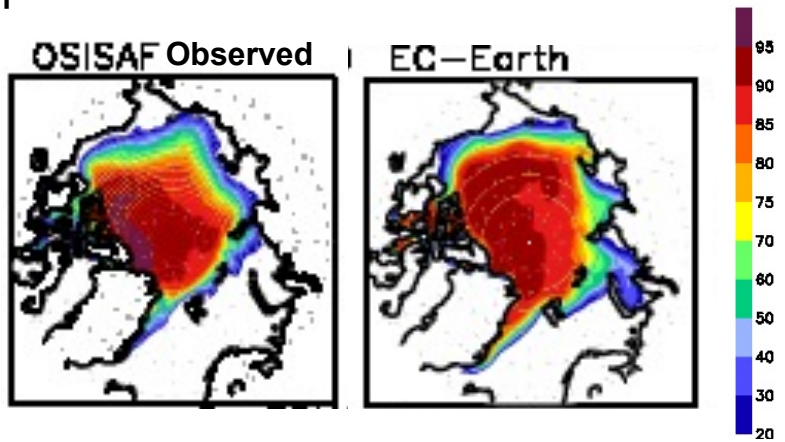
Impact modelling/studies
Hydrology, Forestry,
Infrastructure, Health
The Baltic Sea & The North Sea



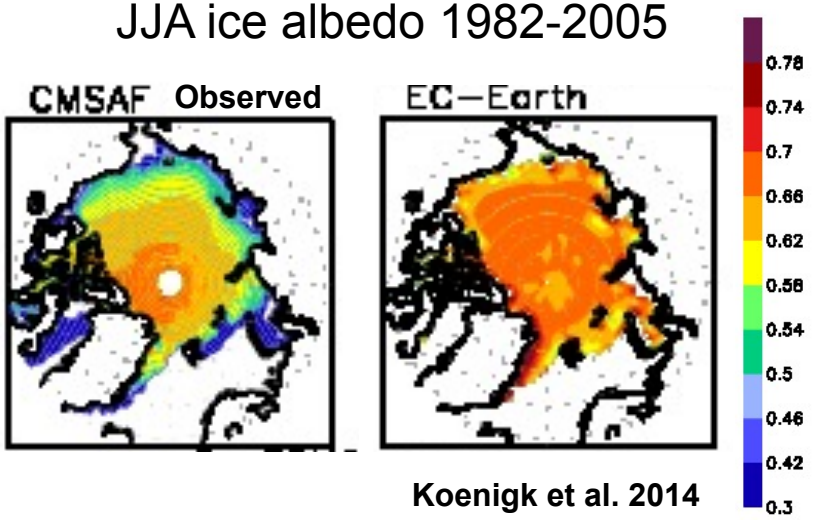
EC-Earth (7 scenarios): Arctic ice extent/albedo study

Rossby Centre and Remote sensing group

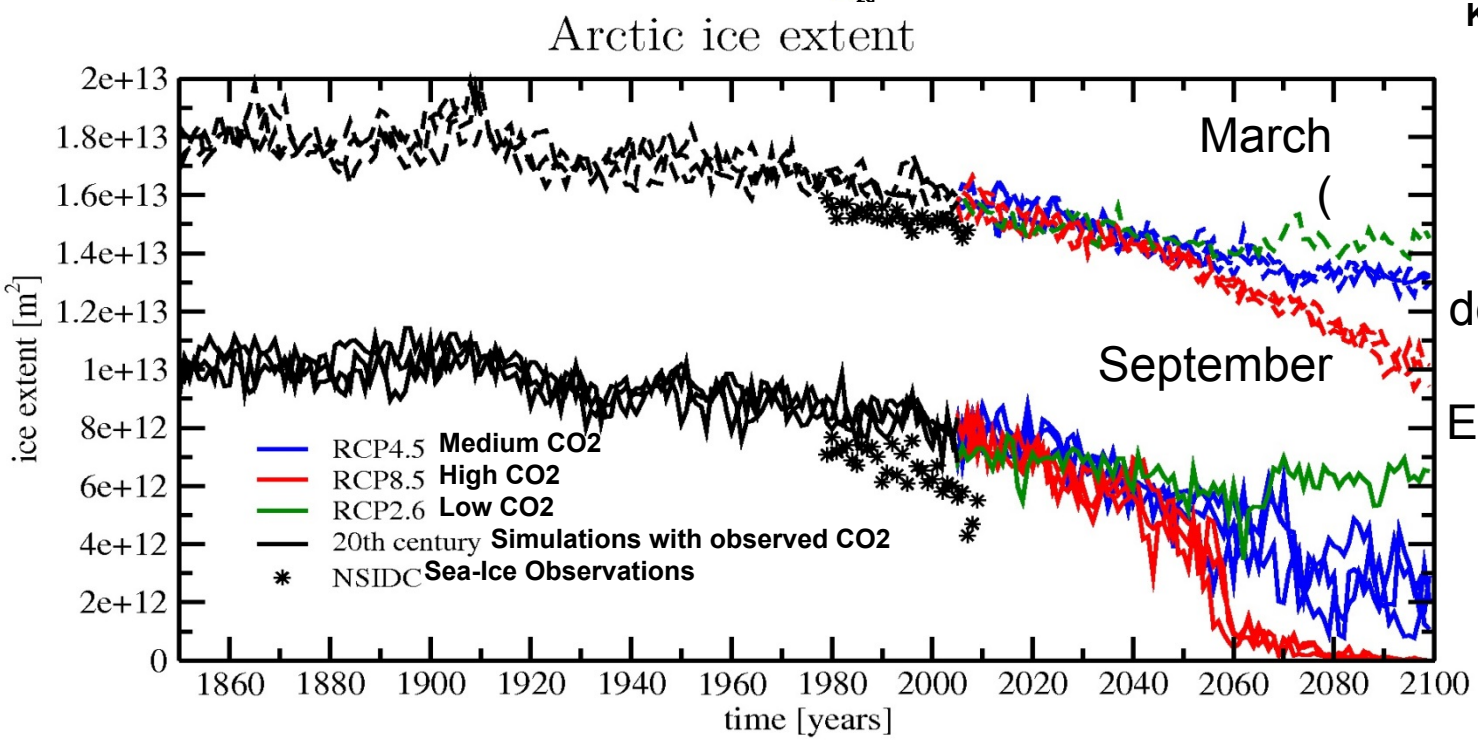
Sep sea ice concentration 1982-2005



JJA ice albedo 1982-2005



Koenigk et al. 2014



Observed sea-ice decline (black dots) faster than all EC-Earth scenarios

Koenigk et al. 2013

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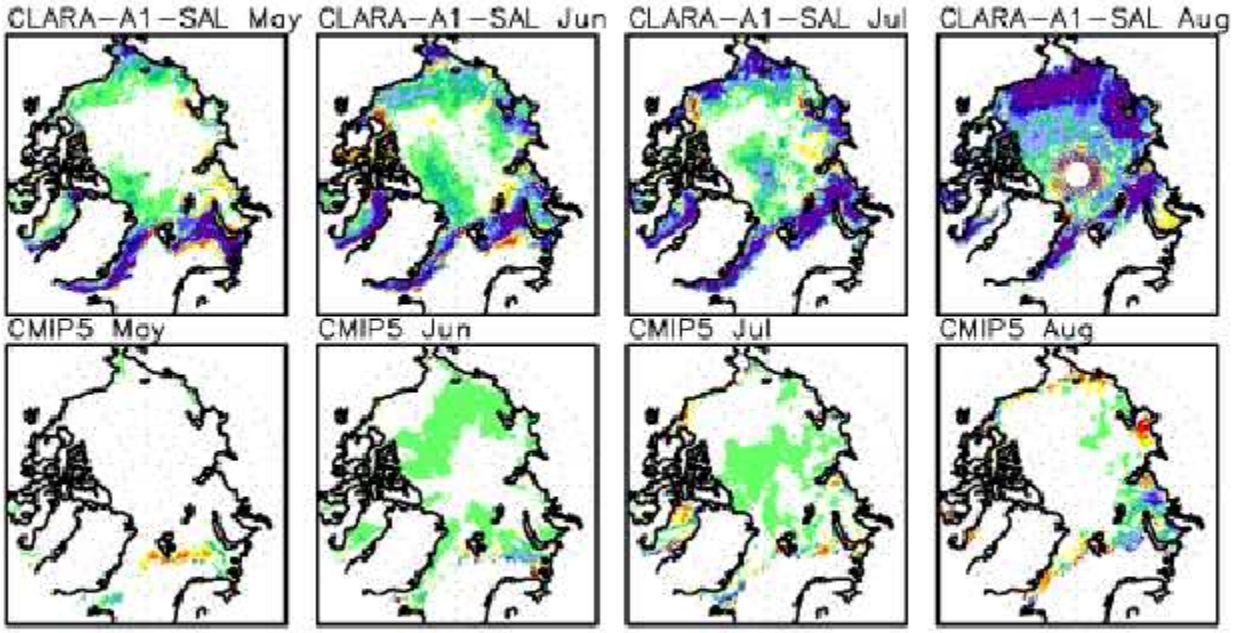
Do CMIP5 models show the decreasing trend in sea-ice albedo?

Rossby Centre and Remote sensing group

An example using CLARA sea-ice albedo data set (1982-2005)



Königk et al 2014

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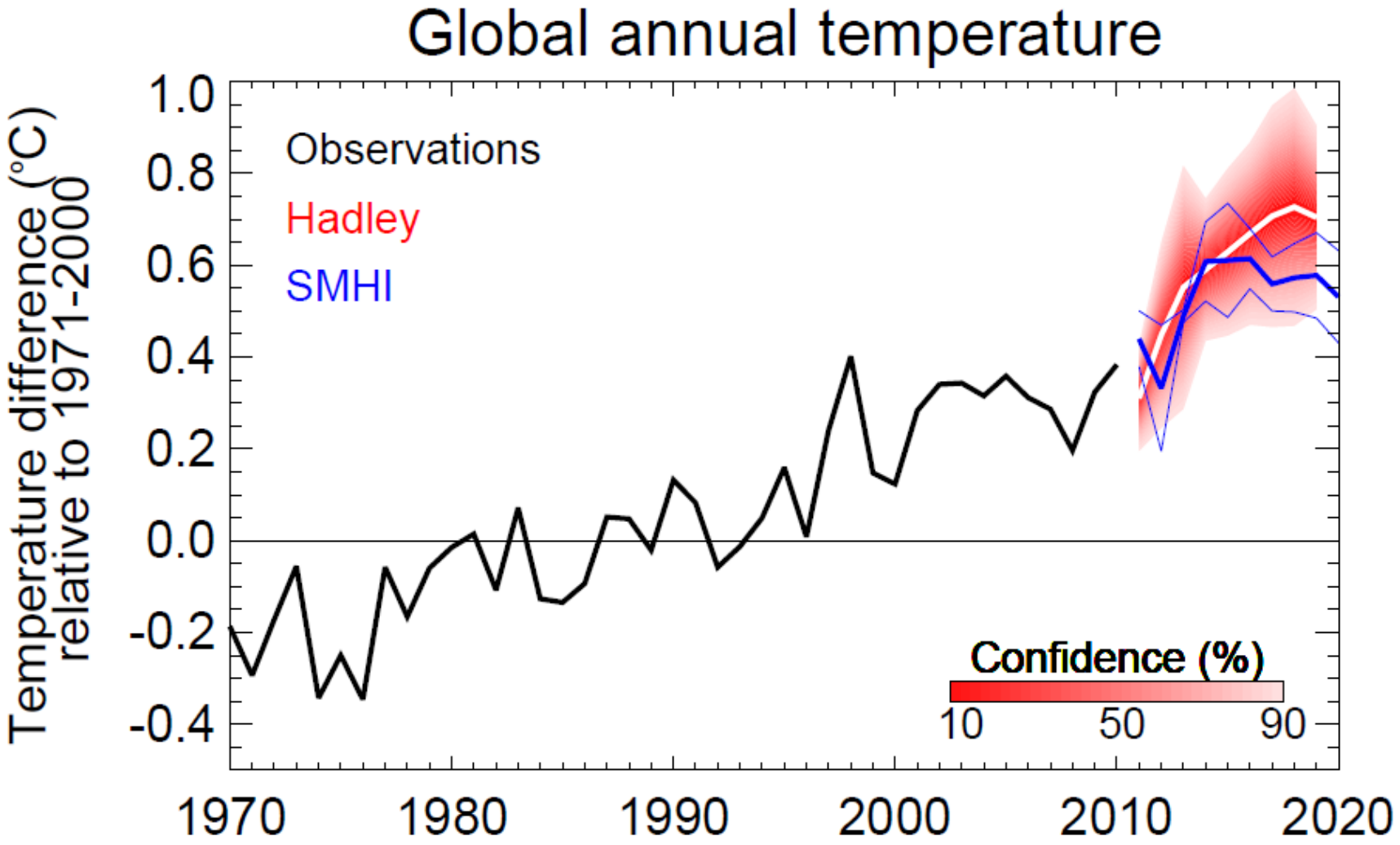
Decadal predictions with EC-Earth and UK MetOffice Hadley model



We need a reliable and consistent observational data set for initialization of the ocean – sea ice system.

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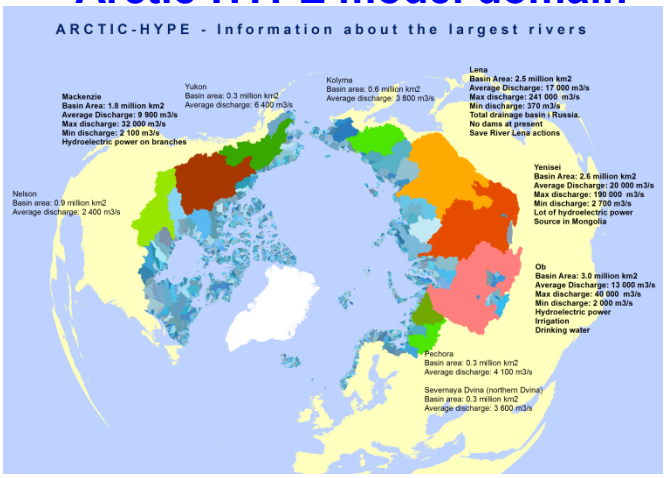
Activites in the hydrology group

HYPE is a multi-basin large scale hydrological model used for short term forecasts, long-term hind casts, climate change impacts and predictions. A pan-Arctic application **Arctic-HYPE** is used in WMO Arctic-HYCOS, ESA CCI CMUG projects.

Total Area: 23 x 106 km2
Number of subbasins: 30 777
Discharge to sea: 3300 outlets
Average area of subbasins: 756 km2
Number of individ. lakes: 1800

Arctic-HYPE model domain



Recent projects using Earth Observations in HYPE:

geoland2

Fraction of green and brown vegetation, LAI, water and snow fraction, soil water index, soil sealing, land use cover

Lake Surface temperature (from MODIS) ESA STSE North Hydrology

CryoLand

Snow water equivalent (SWE) (passive microwave, same as ESA GlobSnow) Snow cover fraction (FSC) optical and multi-sensor. River ice mapping high resolution SAR (ice jam monitoring). MODIS Potential evapotranspiration product. ESA GlobSnow SWE and FSC products

Main research questions:

- To what extent can earth observation data increase our knowledge about hydrological system and hydrological system change?
- IF and how do we need to modify our hydrological models in order to make better use of EO data, for different purposes (short term forecasts, seasonal forecasts, or longterm monitoring of hydrological change?)

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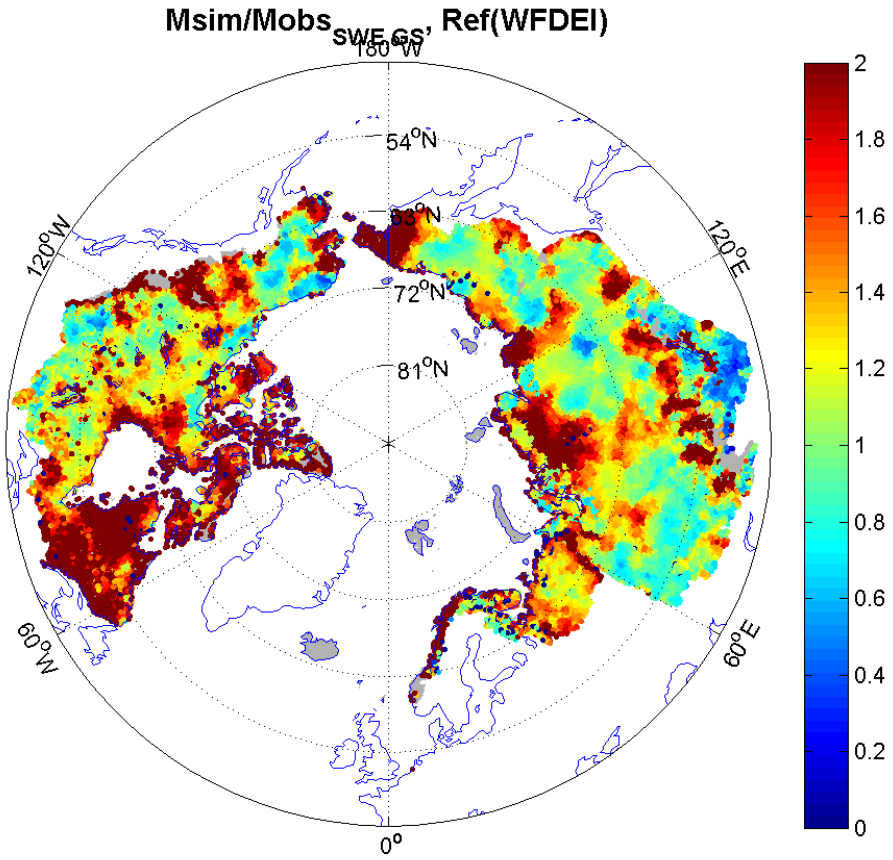
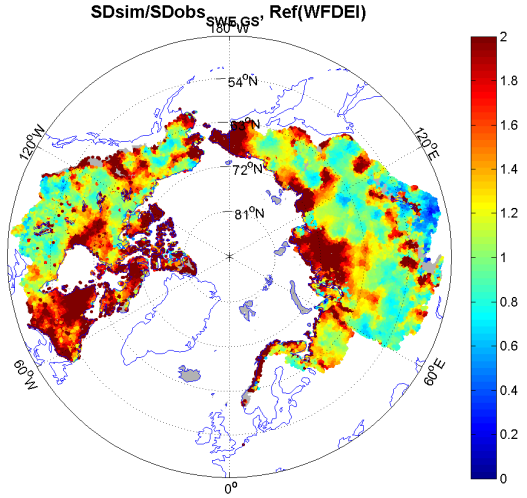
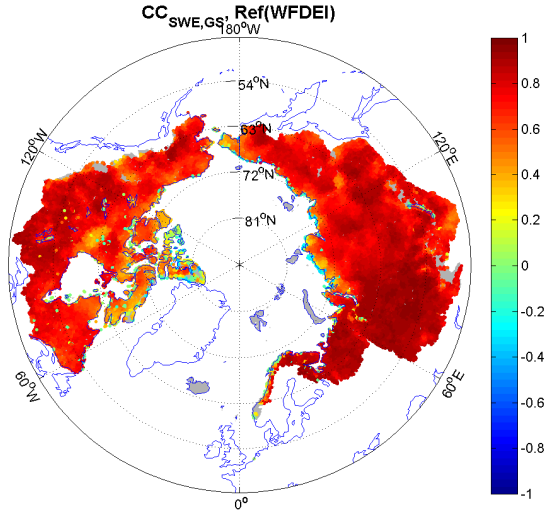
Arctic-HYPE Evaluation activities

GlobSnow satellite based snow water equivalent SWE calibration/evaluation:

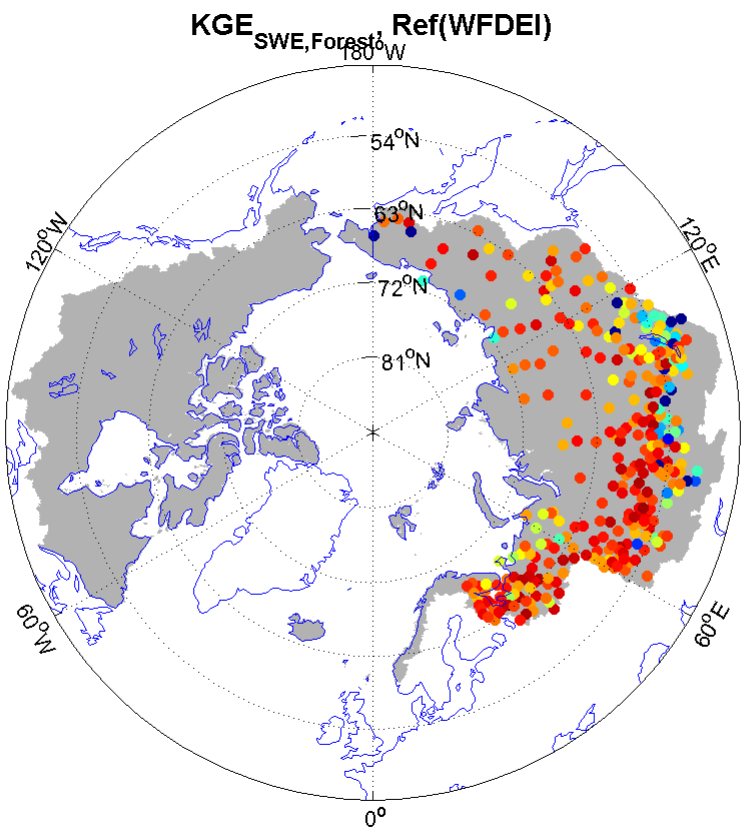




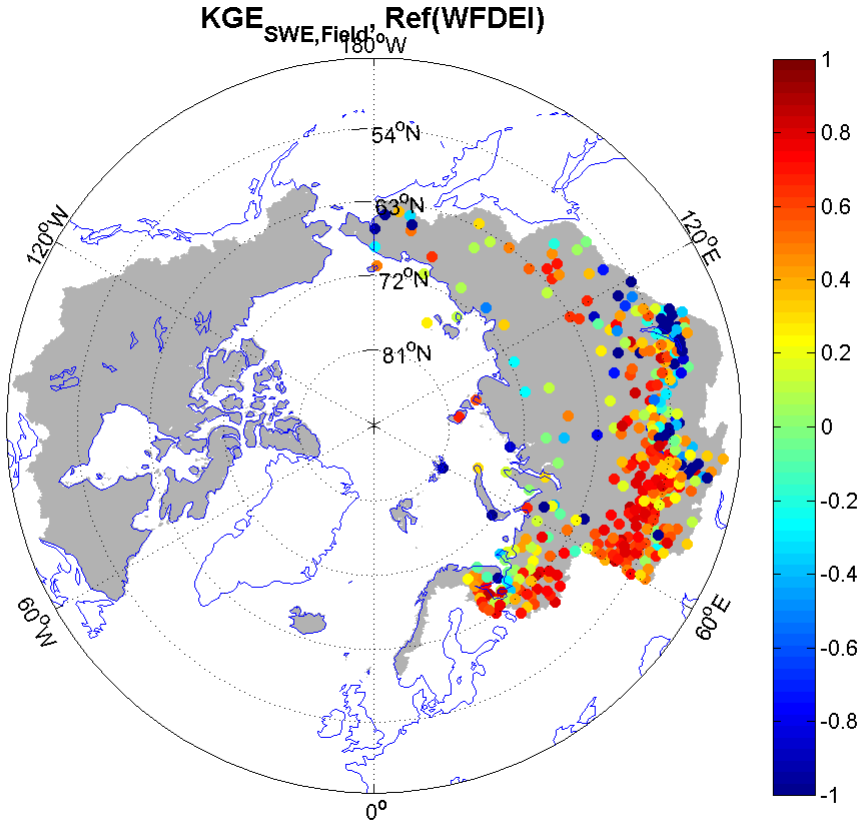


Arctic-HYPE Evaluation activities

FSUS snow evaluation (~400 stations, 1979-1996)



Forest



Field

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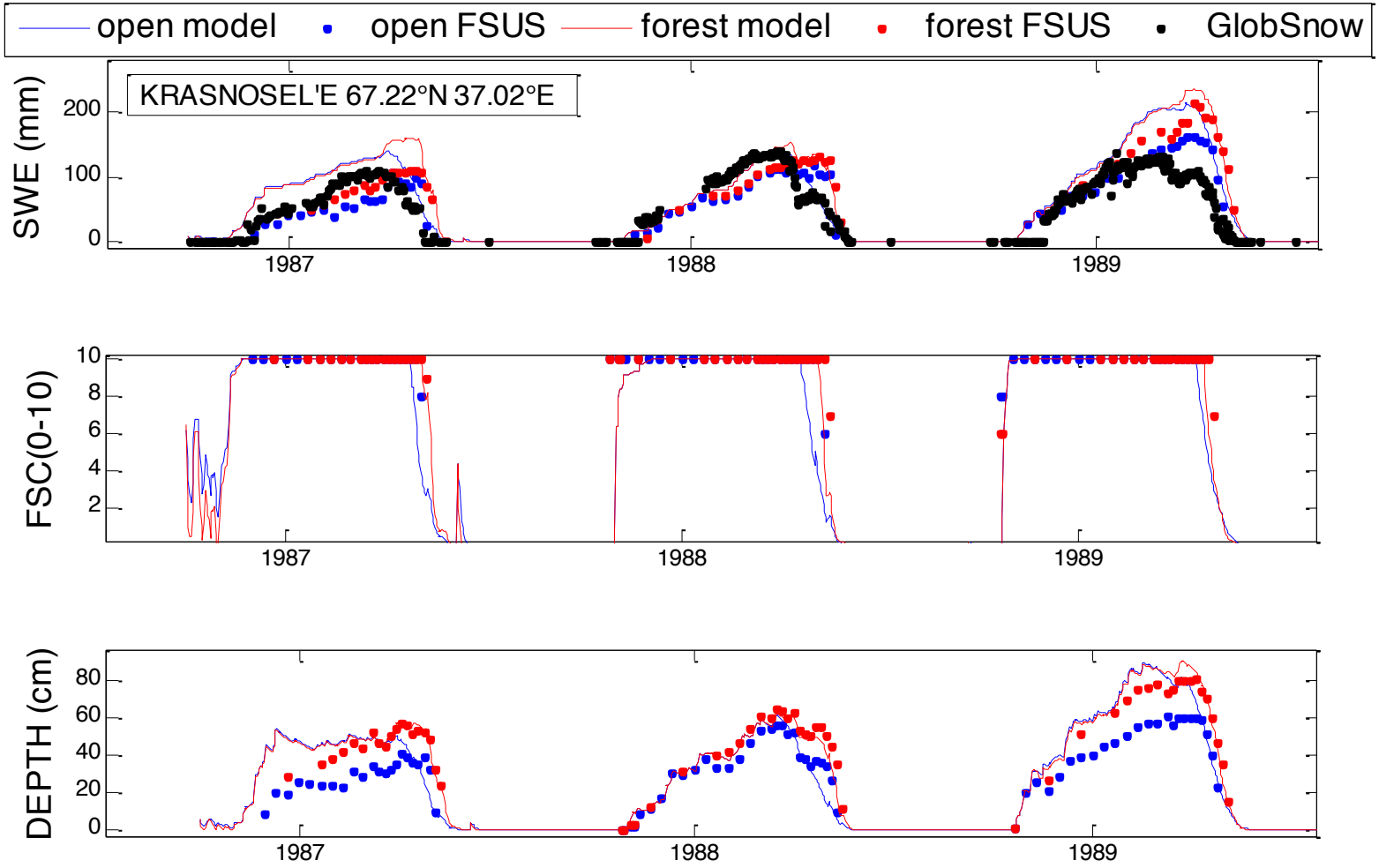
FSUS snow data from forest and open fields:

In-situ data from forest and open vegetation areas are very informative for calibration and evaluation of hydrological models.

IN-situ data also important for evaluation of EO data



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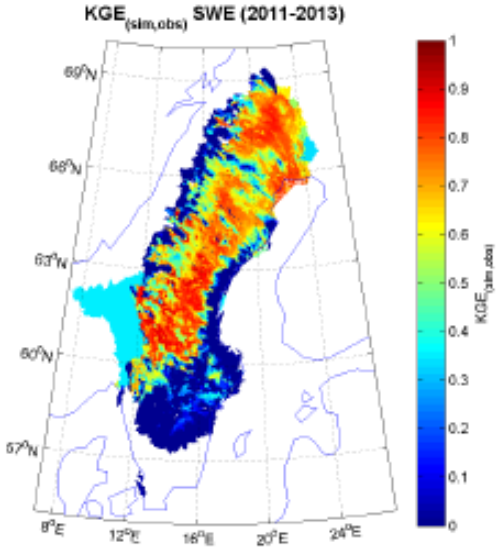
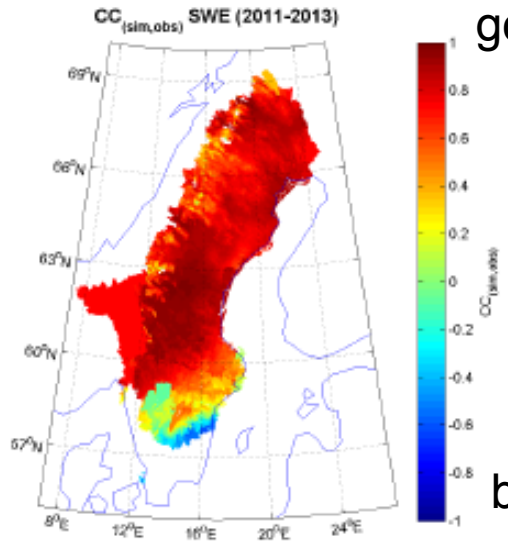
Assimilation of satellite snow data: Test cases in Sweden with Sweden-HYPE. Satellite data from EU FP7 CryoLand. Snow water equivalent (SWE), Fractional snow cover (FSC), Model state updating using EnKF





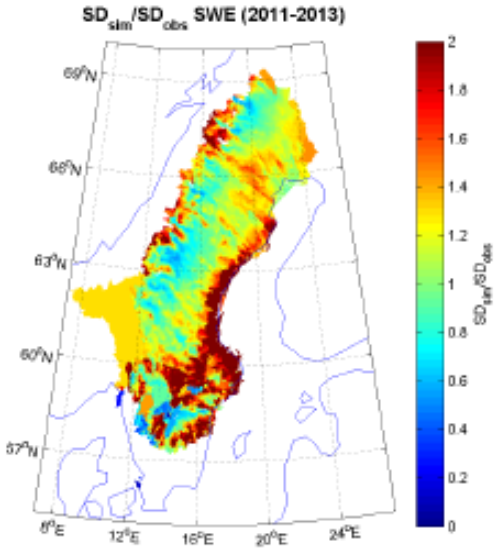
good

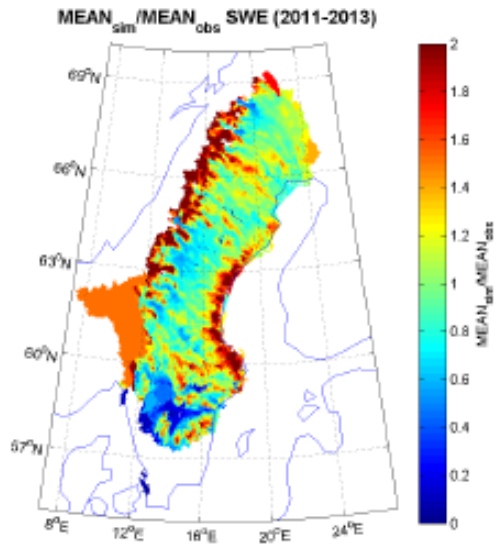
bad

Model-data comparison: SWE

KGE model efficiency index

Summarize model agreement with the observations in terms of **mean value, standard deviation and correlation**





SWE product agrees well with model in central Sweden (flat forest areas)

Poor agreement in mountains and in coastal and southern Sweden

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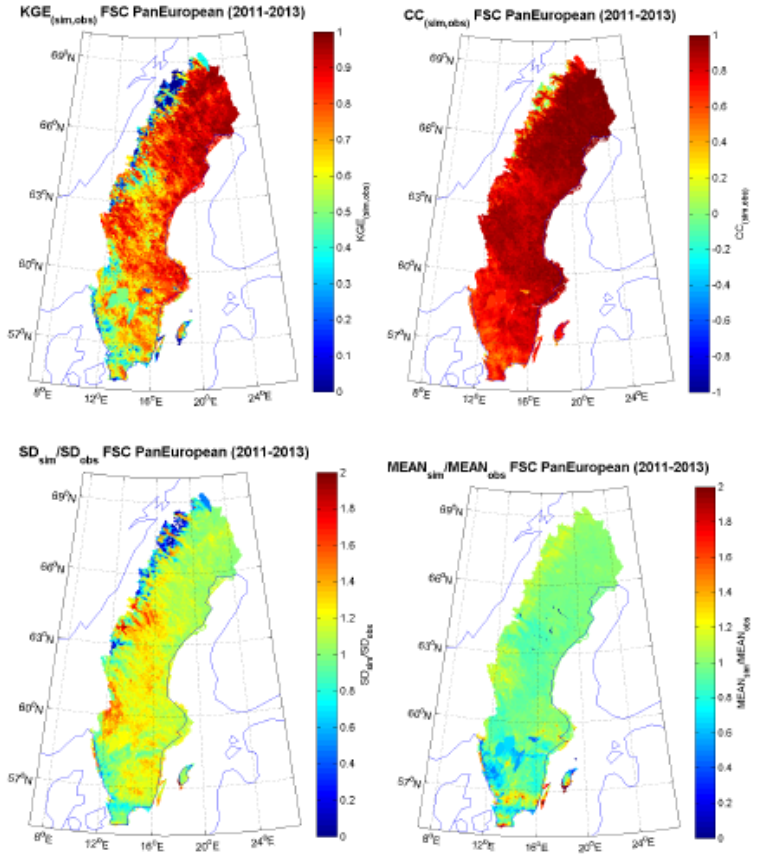
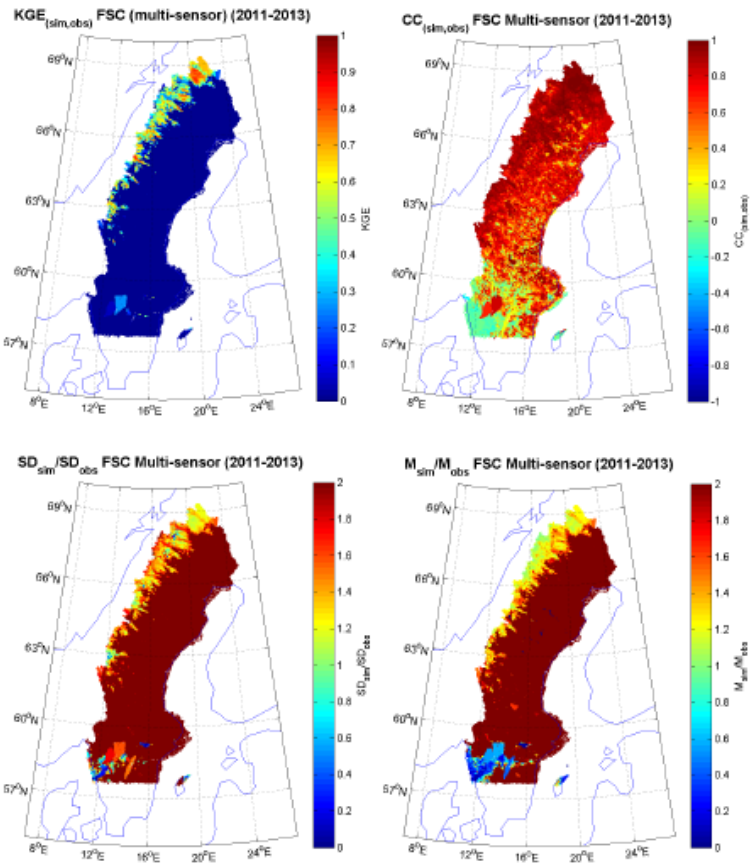
Model-data comparison: Fractional Snow Cover (FSC)

Pan-European Optical



Scandinavian Multisensor



Pan-European FSC agree much more with model than SWE product
Scandinavian Multi-sensor product, which is better in mountains (and not developed for forests)

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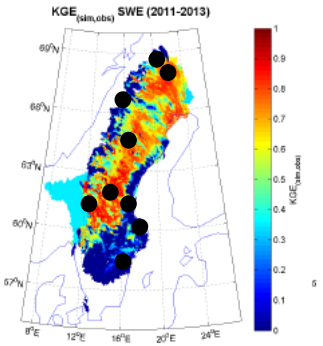
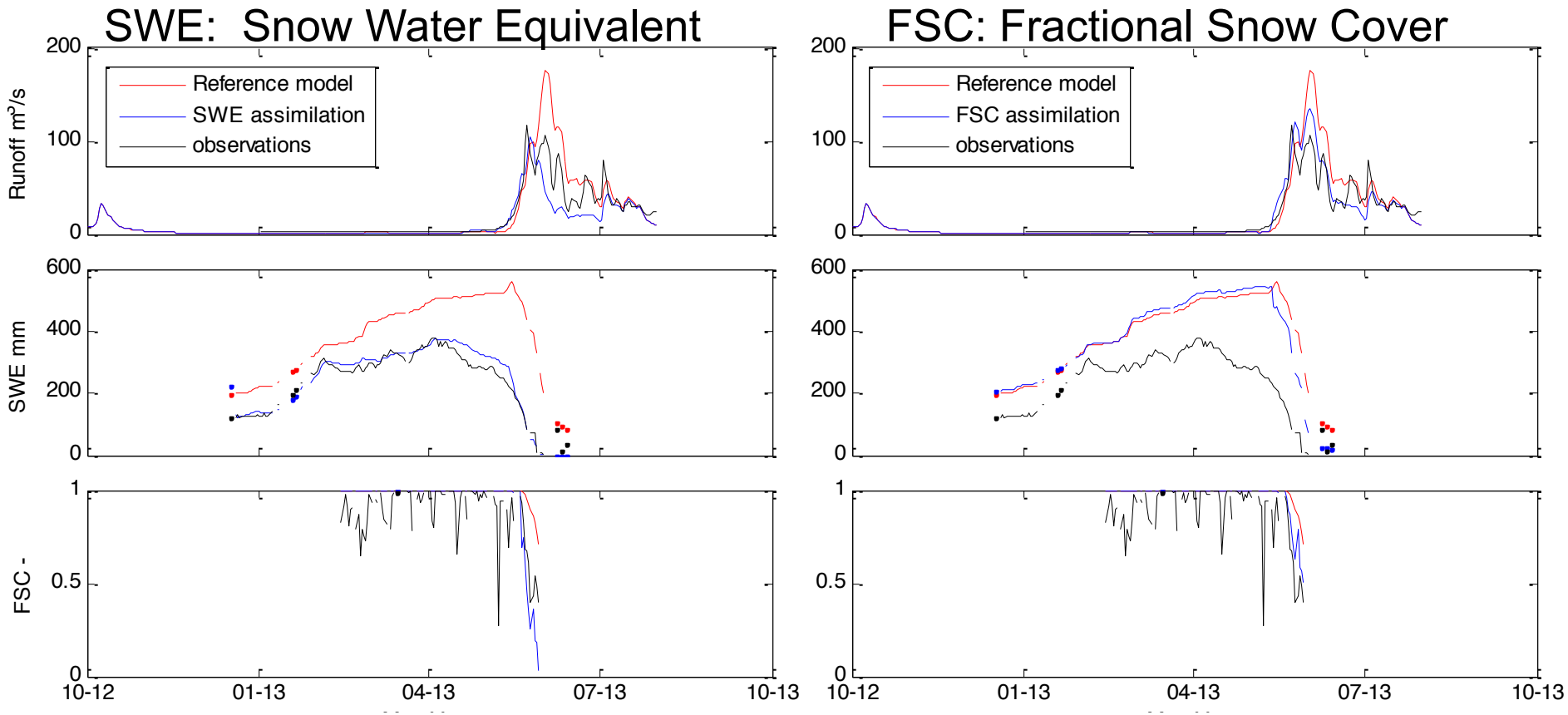
Assimilation results

Good example: Abiskojokki, northern Sweden.
Both SWE and FSC data improve stream flow simulations



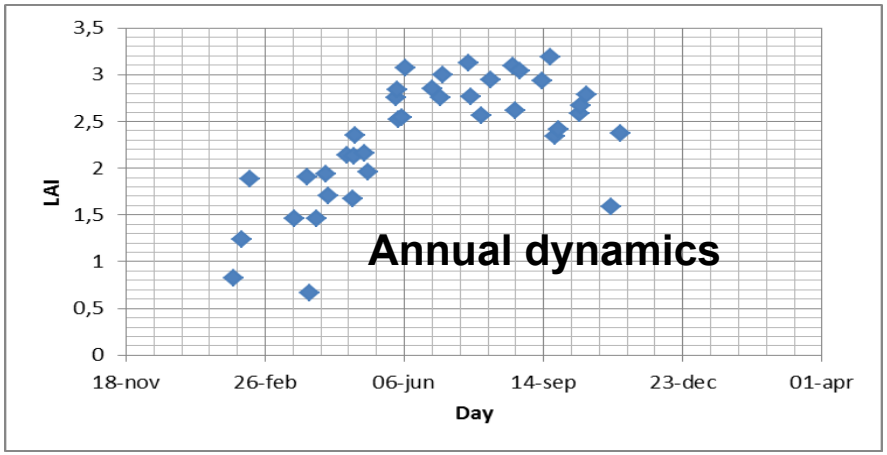


LAI (BioPar) Evaluation

The Leaf Area Index (LAI)

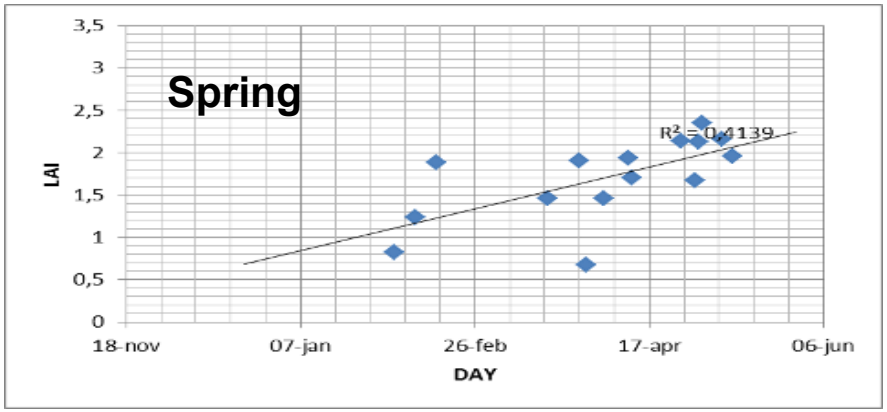
= half the developed area of photosynthetically active elements of the vegetation per unit horizontal ground area

Analysis
Usefulness for Europe-HYPE input-data of:
Spatial variability of vegetation growth over time



Test Areas

1. Motala Ström: 15500 km², South Eastern Sweden.
2. Sventoji River: 472 km², Lithuania



Results

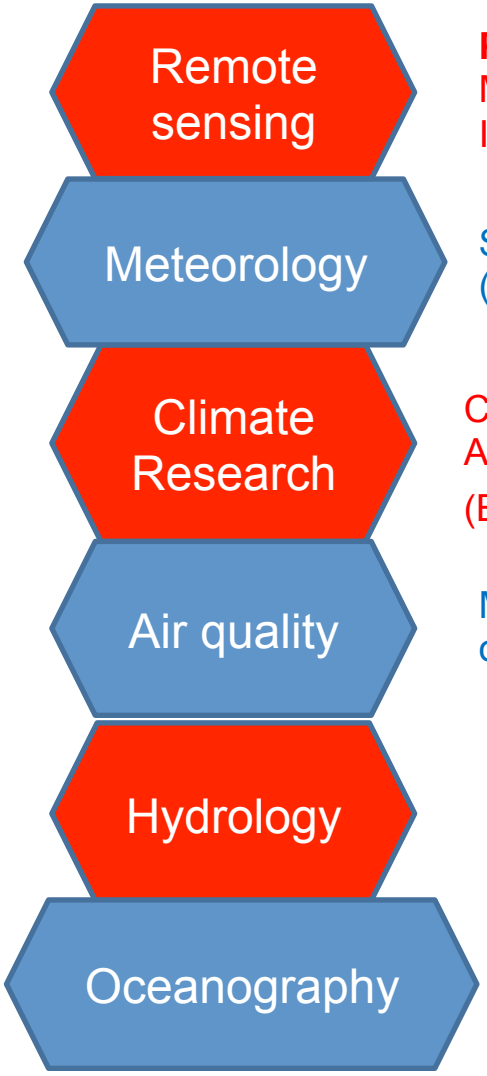
Four seasons could roughly be distinguished.

Conclusion

- LAI is usefull to determine vegetation dynamics over large areas.
- Higher temporal resolution and longer time series would make the results more robust.

Arctic and High latitude observations: Whish List

Long and consistent data sets with (small), well documented uncertainties. Integration of different satellite measurements, in situ and campaign data available via common site. Data with easily accessible format (netcdf, geotiff, CMIP5/Obs4MIP format).



PCW: Polar Communication and **W**eather Satellite. Two satellite constellation in Molniya orbit (or similar HEO) = continuous views of Arctic and down to 50-45°N. IR sounders (AIRS IASI CrIS) for process studies, continuous VIRS type sensors

Supports PCW and more cloud observations, surface variables for assimilation (soli moisture, temperature, humidity, snow)

Cloud (ice/water phase) and radiation, profiles (active instruments). Albedo, Sea-ice thickness. Ground based measurements SW/LW, energy fluxes (BSRN stations). In situ profiling instruments as the ARM/CloudNet sites

More/Improved measurements of CH4, CO, O3, NO2 and SO2. AOD and other optical prpoerties is of interest. Vertical resolved properties.

Lake and river ice, soil moisture, water temp, water surface areas, permafrost. Corresponding lower level products for data assimilation (e.g permafrost, snow)

Retrievals optimised for Brackish water (Baltic Sea), SST, Ocean colour. Better resolution, e.g. OSI-SAF SIC has too large footprint to be useful for the Baltic Sea region.

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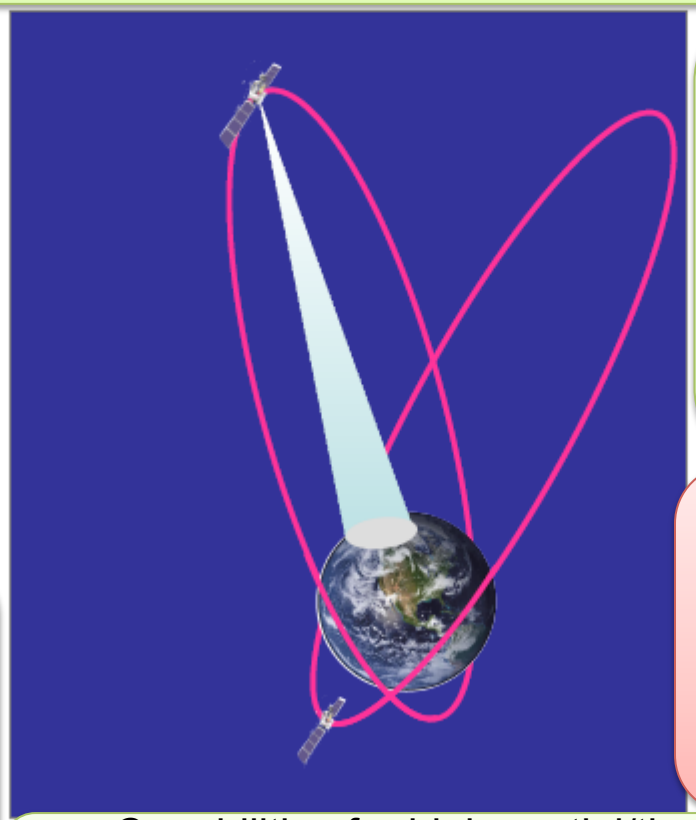
Improved Arctic and subarctic observing system

PCW: Polar Communication and **W**eather Satellite
2 satellite constellation in Molniya orbit (or similar HEO)
= continuous views of Arctic and down to 50-45°N

Environment Canada is looking for partners, PCW satellite system not fully financed yet (lauch 2022?)

Real time access to PCW should significantly improve Nowcasting and regional weatherforcasts!

Addition of a hyperspectral IR Sounder as IRS would significantly enhance NWP (global and regional) and Climate applications



Capabilities for high spatial/time resolution sea ice charting, cloud analysis, wind retrieval, and studies of arctic climate and environmental system

Imager performance as for new generation of geostationary satellites with resolution of 0.5-1km (MTG, GOES-R)

Addition of a day/night band as on S-NPP/ VIIRS would improve capabilities in polar winter for cloud analysis and sea ice charting

Canada

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Ice conditions in the Bay of Bothnia seen from the VIIRS Day Night Band

- **For a significant part of the lunar cycle a combination of IR and DNB gives superior cloud and ice analysis as compared to IR only**
- **About 10% of days ice charting at SMHI is done only using VIS/IR information due to restricted radar data availability. With high temporal coverage from HEO this portion is expected to increase, and would allow to better adapt to rapidly changing ice conditions.**
- **At low lunar illumination DNB allows Aurora monitoring, continous imaging capabilities would advance our understanding in this field**