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From EO Services to carbon cycle modeling support

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Content

- **Land cover data for carbon balance modeling**
- **Model validation with satellite information**
  - Snow cover
  - Start of the growing season

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Land Cover Data - Background

- **Land cover/ land use affect the regional climate (REMO) by affecting the surface meteorology and hydrology**
  - The effects are described with surface parameters
- **Land cover/ land use affect the carbon cycle (JSBACH) through different vegetation types**
  - Described by plant functional types
- **In the standard version of REMO model, land cover is described using Global Land Cover Characteristics Database (USGS, 1997) according to definitions by Olson** (1994a, 1994b)
  - Old Global data set: Based on EO data received in early 1990
  - Used also in **JSBACH** model for spatial distribution of plant functional types (PFTs)

→ **Updated land cover/land use distribution needed for Northern Europe**

U.S. Geological Survey, 1997. Global land cover characteristics data base
http://edc2.usgs.gov/glcc/glcc.php
Olson, J. S. 1994a. Global Ecosystem Framework 1. Definitions. Report GPC94.1, USGS
Olson, J. S. 1994b. Global Ecosystem Framework 2. Translation Strategy. Report GPC94.2, USGS.

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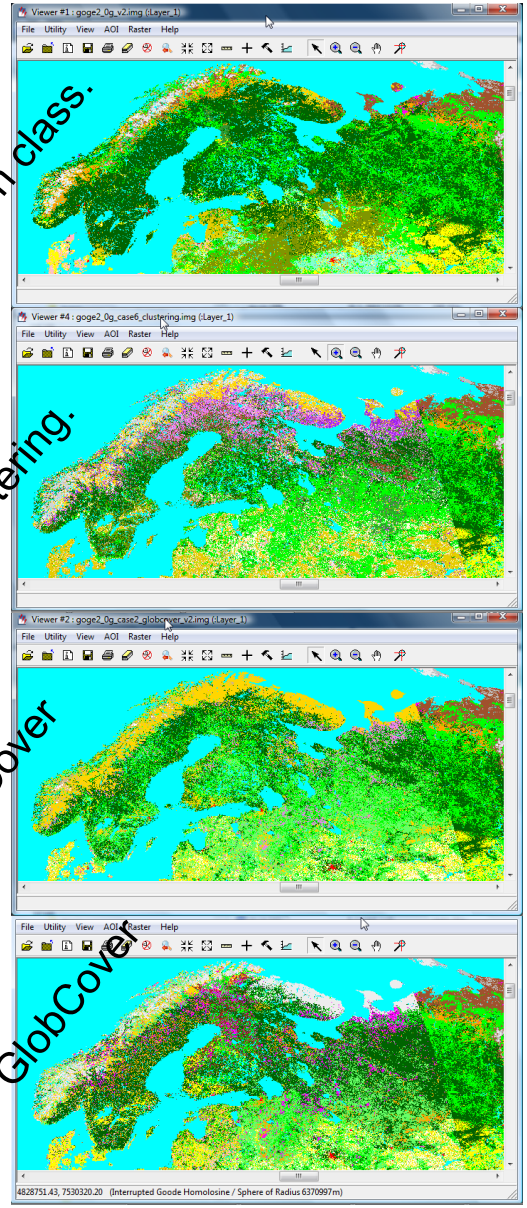
Alternative Land Cover Datasets

- **Comparison of class descriptions in different data sets**
  - Global Land Cover Characteristics/ Olson classification (AVHRR)
  - Clustering of MODIS products
  - GLOBCOVER V2.2 (MERIS)
  - European CORINE Land Cover (CLC2000,CLC2006)
  - Finnish National CORINE Land Cover
- **Comparison of surface parameters of Olson classes with local data covering Finland**

→ The combination of Finnish National Corine, European Corine Land Cover and GlobCover was selected for describing the land cover in Northern Europe.



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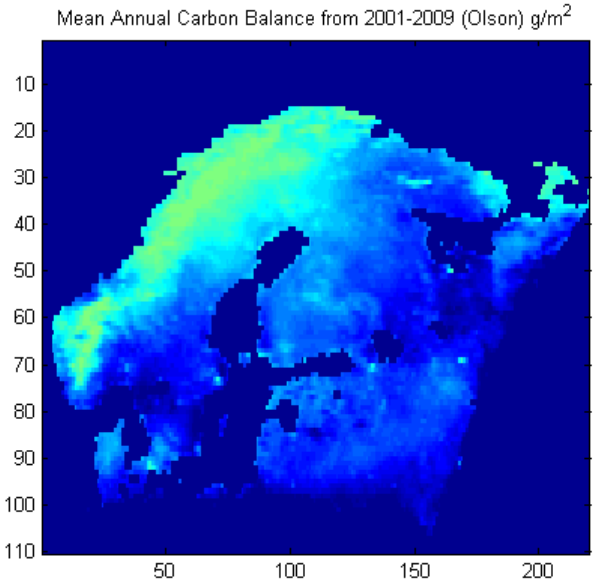
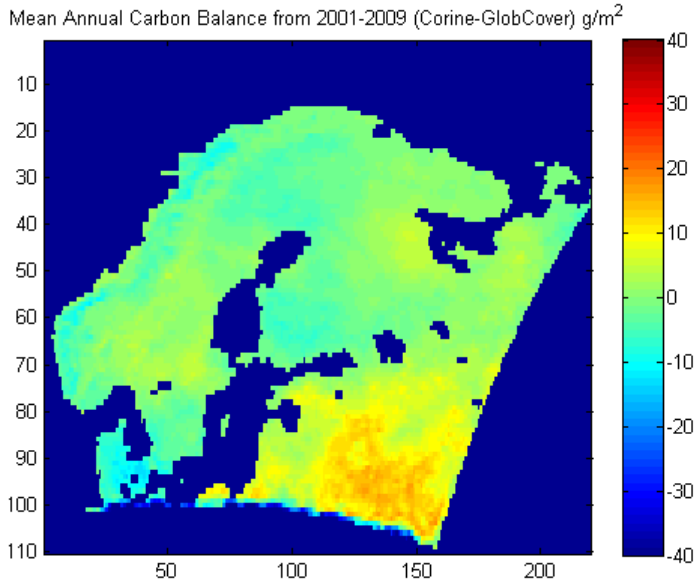
Effects of Land Cover on Carbon Balance

- **Comparison of mean annual carbon balances for years 2001-2009 –Olson classification and combination of National / European CORINE land cover and GlobCover:**
  - Domination of Boreal coniferous forest → largest carbon uptake
  - Alternative land cover dataset produced more release of carbon, especially in the area of Baltic Countries and Belarus



Olson classification



Corine – GlobCover combination

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Model validation with satellite information - Background

- **Sparse observation network for validation of model results**
- **Need to generalize information provided by *in situ* sites**
- **Provide time-series of vegetation indices and snow cover for the evaluation of the performance of JSBACH model**
- **Assessment of snow-related variables of JSBACH**
- **Definition of proxy indicators for ecosystem functioning (e.g. start of growing season) from remote sensing data**

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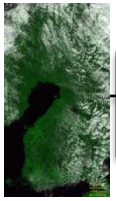
Satellite time-series

- **Processing of daily time-series of satellite-indices derived from Terra/ Moderate Resolution Imaging Spectrometer (MODIS) 2001-2010**
  - Normalized Difference Vegetation Index (NDVI), 250 m
  - Normalized Difference Water Index (NDWI), 500 m
  - Snow Covered Area (SCA), 500 m



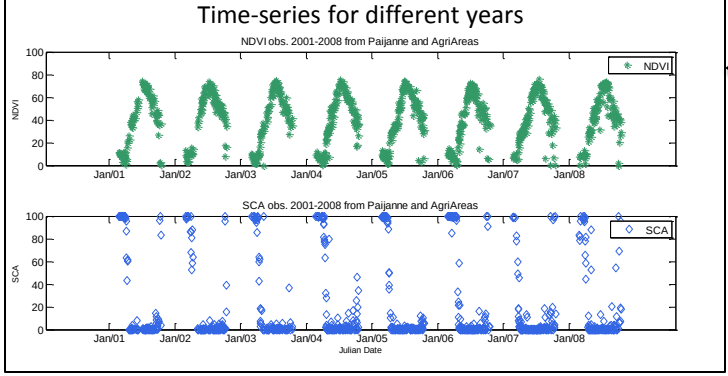
Sat. Data

Pre-processing, Cloud masking

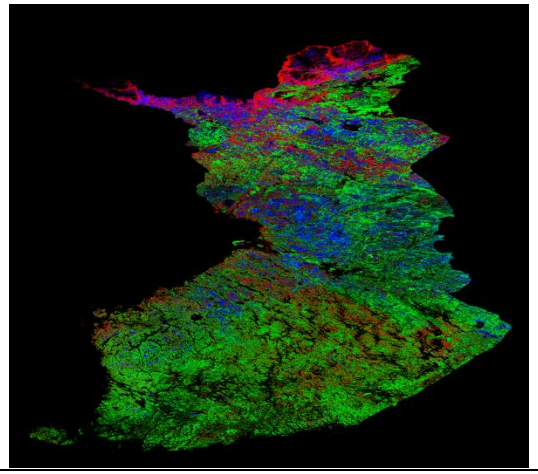
Snow cover and vegetation estimates

Extraction of time-series

Time-series for different years



Pixel-based land use information



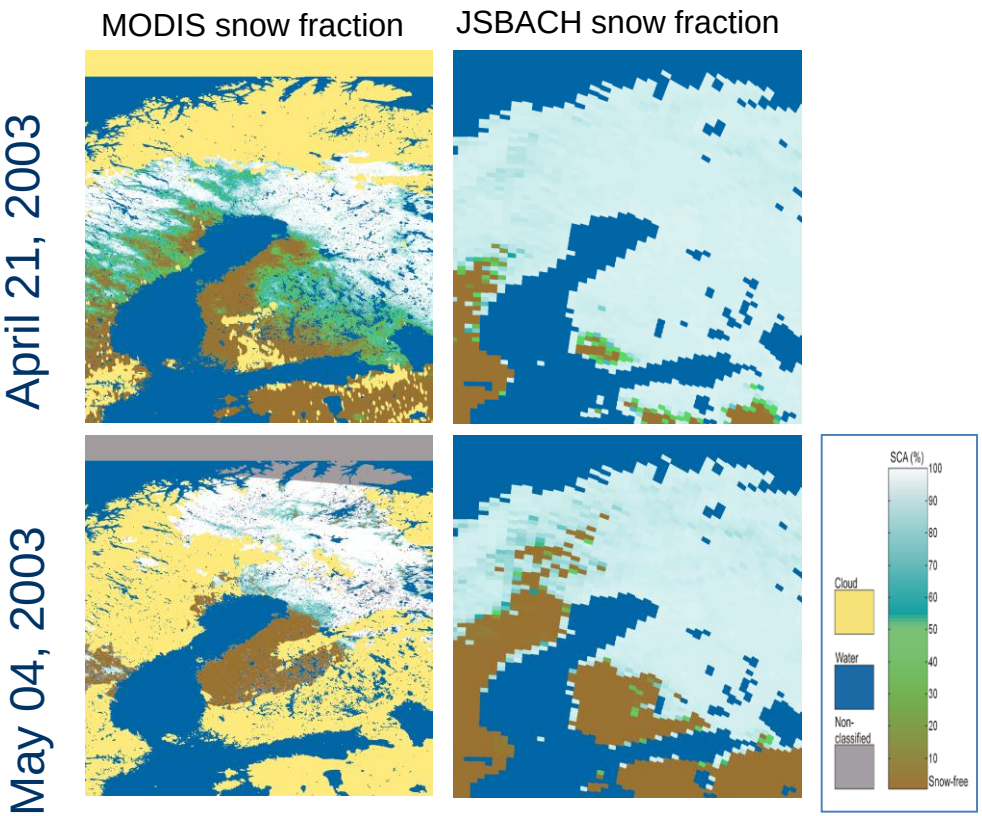
Fraction of coniferous forest (green), broadleaf deciduous forest (red), open bogs (blue)

Comparison of model output and RS data

- **Model produced snow cover was compared with satellite snow information**
  - The spring melting produced by the model is late, when comparing to satellite derived snow information

→ Something wrong with surface meteorology or insufficient description of snow processes?

→ Needs to be considered in the interpretation of results and in the development of the model.



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Extraction of start of season

- **Spring vegetation phenology is important parameter influencing the terrestrial carbon balance (Richardson et al. 2010)**
- **Existing methods for satellite-retrieval of greening-up**
- **Photosynthetic recovery in evergreen coniferous forest occurs before canopy changes**
- **Aim to develop new satellite-derived start of season indicator calibrated to *in situ* observations at CO_2 flux measurement sites**

Richardson et al.(2010). Influence of spring and autumn phenological transitions on forest ecosystem productivity. *Philosophical Transactions of the Royal Society B: Biological Sciences, 365, 3227-3246*

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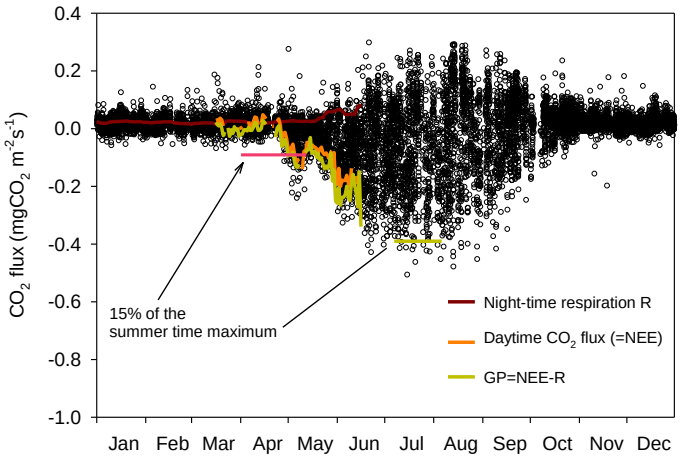
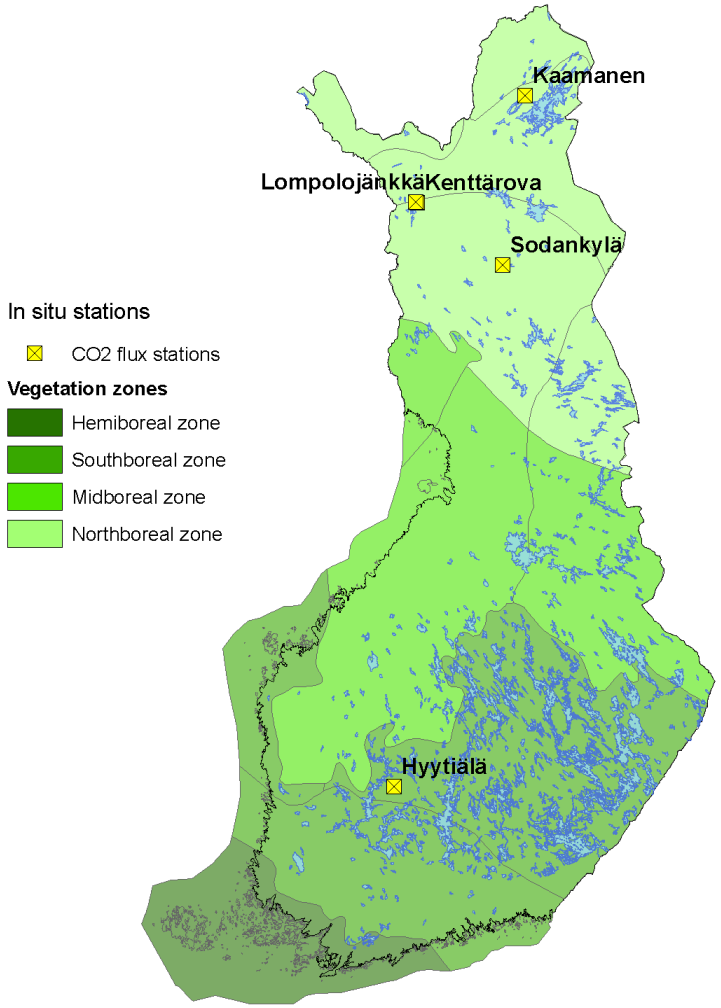
In situ observations for the start of season

- **Reference dates for onset of growing season for coniferous forest determined from CO_2 flux measurements**
- **A fixed fraction of peak growing season gross primary production (GPP) was used as a threshold value for the growing season onset (start of flux growing season, FGS)**





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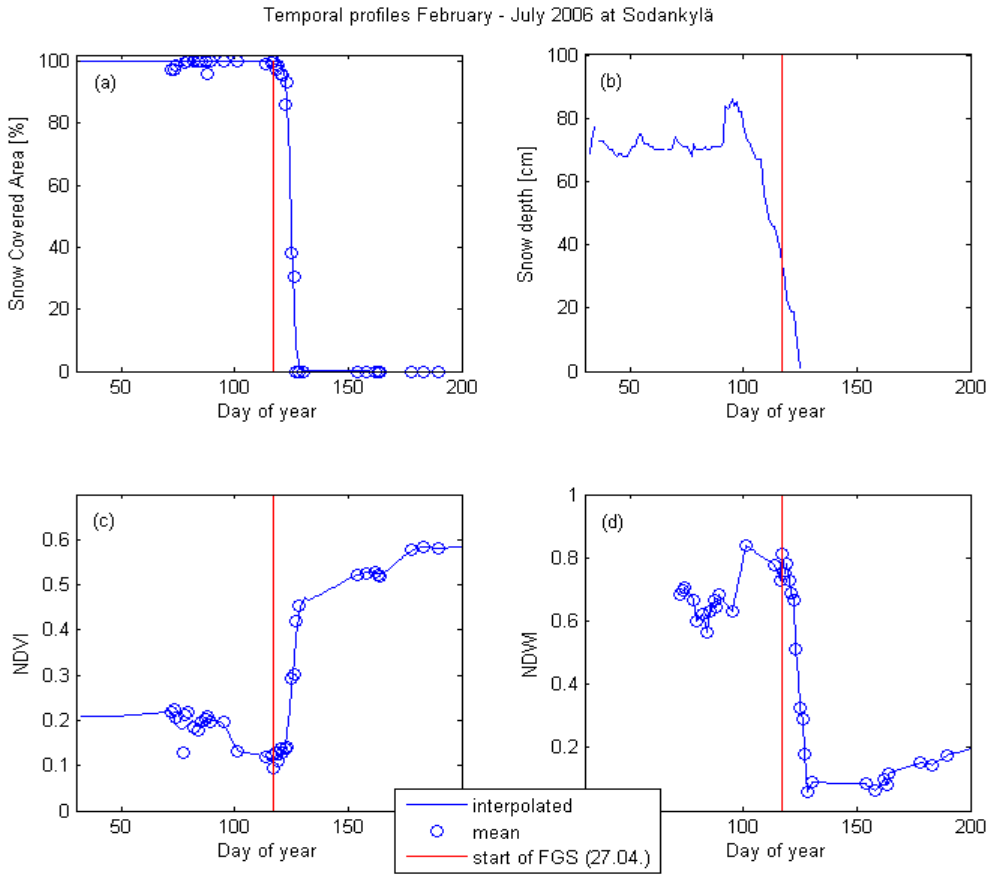
Sodankylä: Coniferous forest



(a) Mean Snow Covered Area and interpolated profile;

(b) Snow depth measurement station Sodankylä;

(c) Mean NDVI and smoothed profile;

(d) Mean NDWI and linear interpolated profile.

- **Onset of growing season in coniferous forest coincides with decrease of fractional snow cover and beginning of spring-rise of NDVI**

Start of season 07.05.2010

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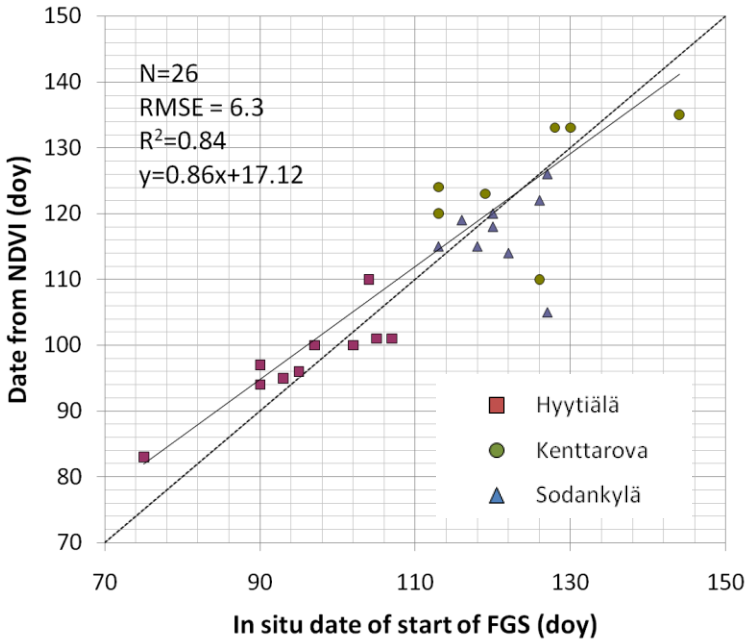
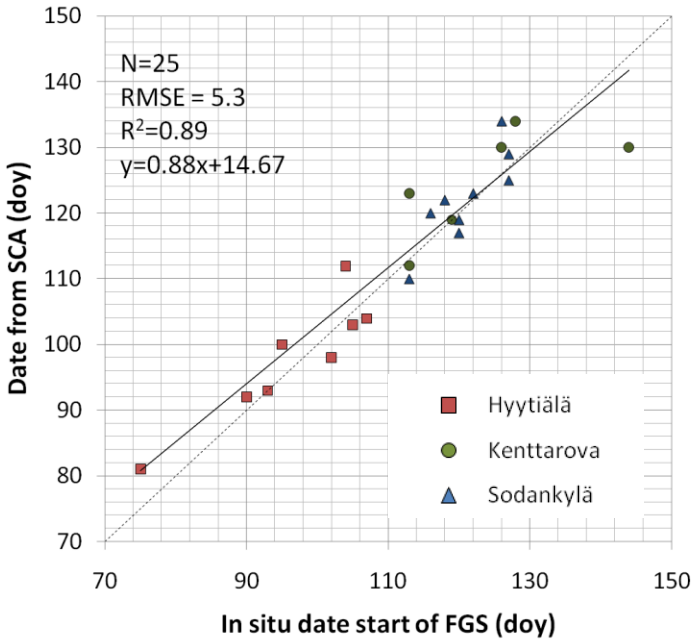
Satellite-derived start of season

- **Comparison of satellite-derived start of growing season for evergreen coniferous sites with *in situ* dates**

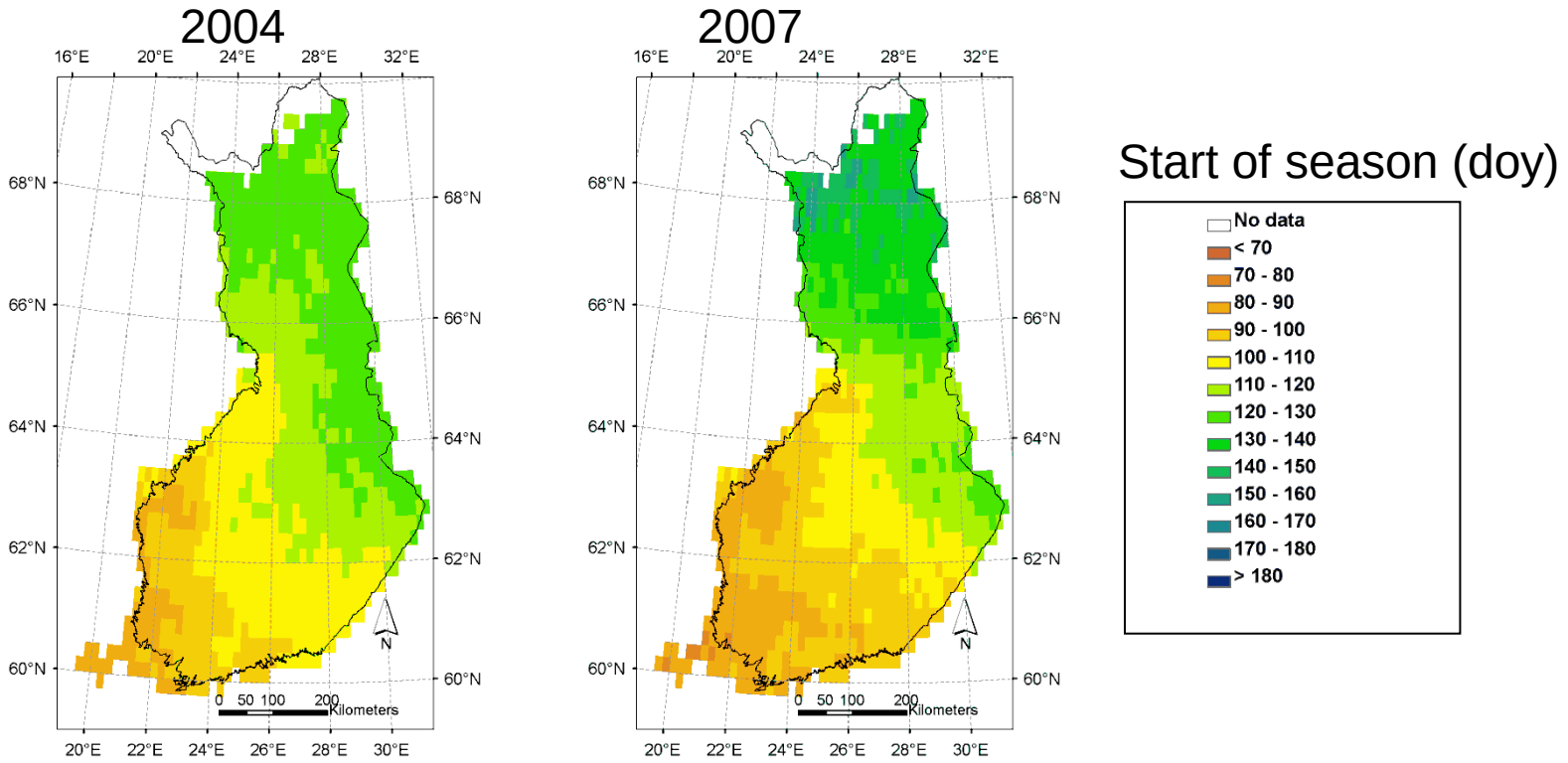




FGS: Flux Growing Season. Doy: day of year.

Maps of the start of season

- **Extraction of start of season based on SCA for pixels with dominance of coniferous forest**
- **Aggregation of results for comparison with JSBACH land surface model-derived start of season**



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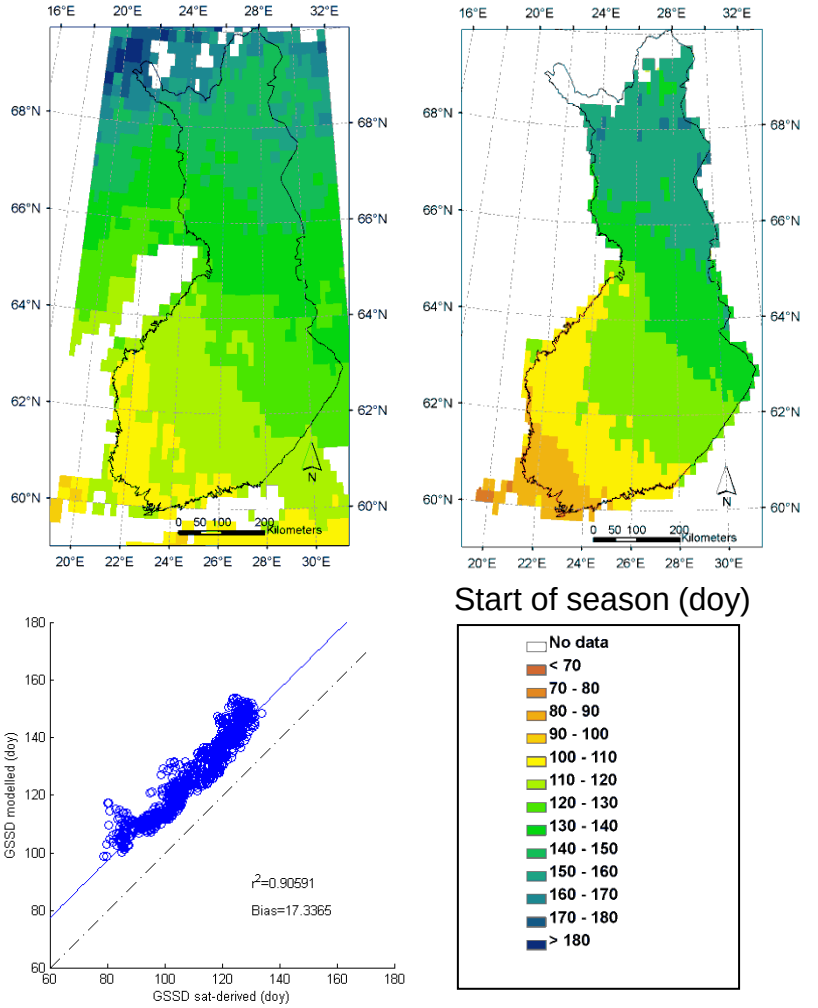
Indirect model validation

- **Model produced start of season was compared with dates extracted from satellite data for years 2003-2008:**
  - The correlation between the two datasets was good (r^2=0.91), arising from good agreement in the spatial domain, but there is a systematic delay of ~ 2 weeks in the start of the growing season.



Mean start of season for years 2003-2008. REMO-JSBACH Modeling results (top-left). SCA derived start of season (top-right). Correlation between the two (bot-left).

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Summary

- **Satellites can provide important information for generating up-to-date land cover information for supporting carbon balance modeling.**

- **Satellite derived surface parameters can be used to validate internal processes in the models to find ways of improving the process descriptions, e.g. the dynamics of snow cover.**

- **Satellite datasets can provide proxy information on the performance of the model, both in temporal and spatial scales.**