Satellite-observed start of vegetation active season in Finland and comparison with estimates from biosphere model

Kristin Böttcher, Geoinformatics Research Unit, Geoinformatiikan tutkimuspäivät, 20.-21.05. Helsinki
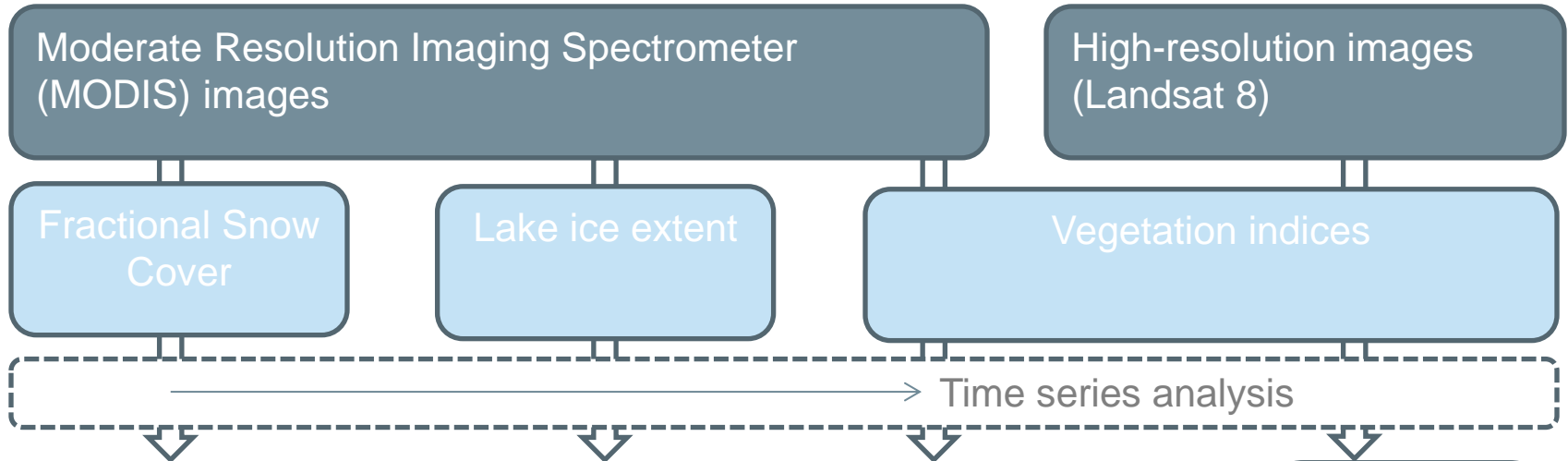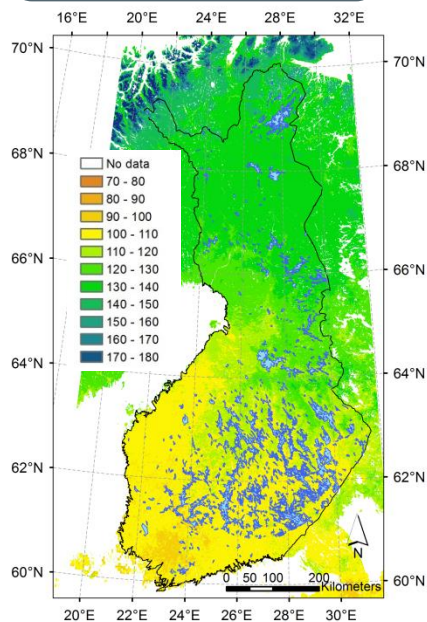
Contributors: Tiina Markkanen, Mika Aurela

Outline

- SYKE activities related to satellite time series analysis

- Background and motivation for vegetation phenology studies

- Remote sensing of start of vegetation active season

- Evaluation of biosphere model estimates
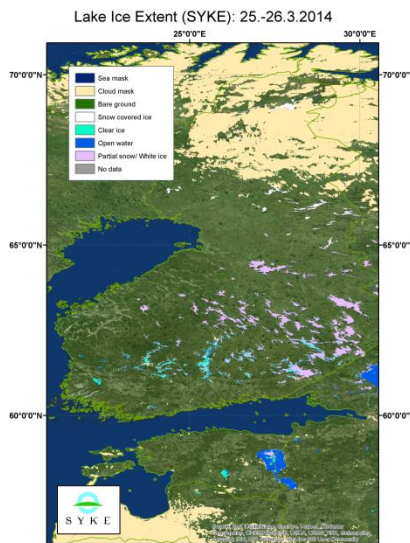
- Summary and outlook

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SYKE activities related to satellite time series analysis

Moderate Resolution Imaging Spectrometer (MODIS) images

High-resolution images (Landsat 8)

Fractional Snow Cover

Lake ice extent

Vegetation indices

Time series analysis

Melt-off date

Ice break-off

Vegetation phenology
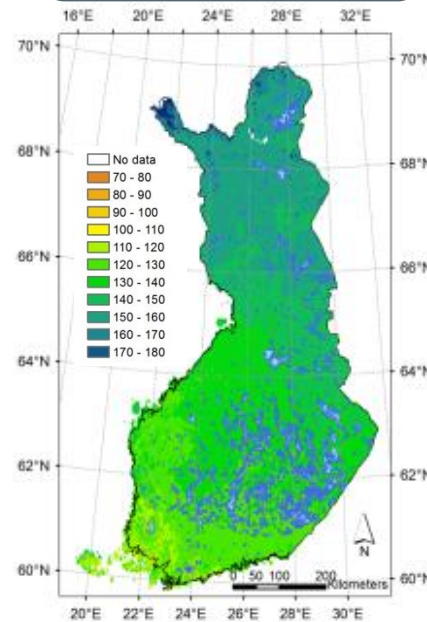
Agricultural fields
- Winter coverage
- Crop type

Lake Ice Extent (SYKE): 25.-26.3.2014
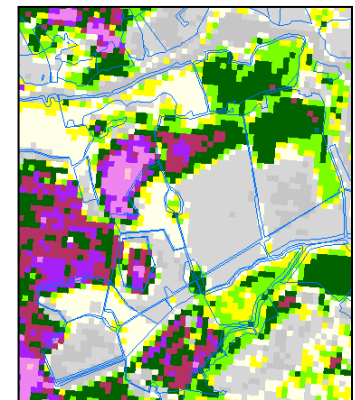
Background and motivation

- Ecosystem processes are directly influenced by vegetation phenology: carbon, water and nutrient cycle

- Phenology is an important indicator for long-term biological impacts of climate change on terrestrial ecosystems (Menzel and Fabian 1999, Richardson et al. 2013)

- Phenology is suggested as essential biodiversity variable (EBV) (Pereira et al. 2013)

Menzel A. & Fabian P. 1999. *Nature 397: 659-659.*
Richardson et al. 2013. *Agricultural and Forest Meteorology 169: 156-173.*
Pereira *et al.* 2013. *Science 339: 277-278.*

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Start of vegetation active season (1/2)

Boreal evergreen coniferous forest

- Photosynthetic recovery in evergreen coniferous forest occurs before canopy changes, mainly driven by air temperature

- Locally observed from *in situ* measurements of CO_2 fluxes with the eddy covariance technique
    - A fixed fraction of peak growing season gross primary production is used as a threshold value for the start of season
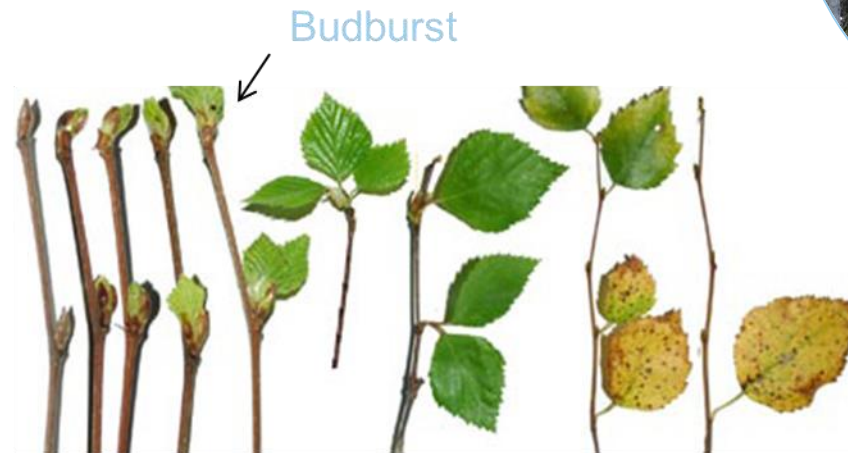
SYKE
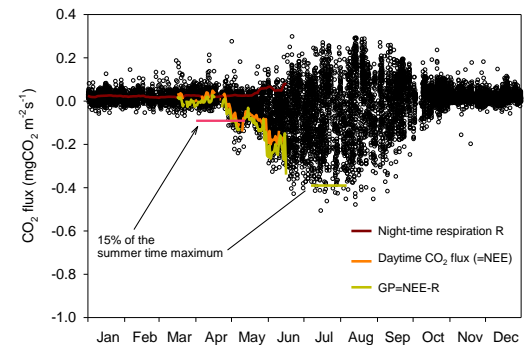
Start of vegetation active season (2/2)

Deciduous broadleaved forest

- Photosynthetic recovery is linked to development of leaves
- Budburst: more than 50% of buds have broken throughout the tree crowns
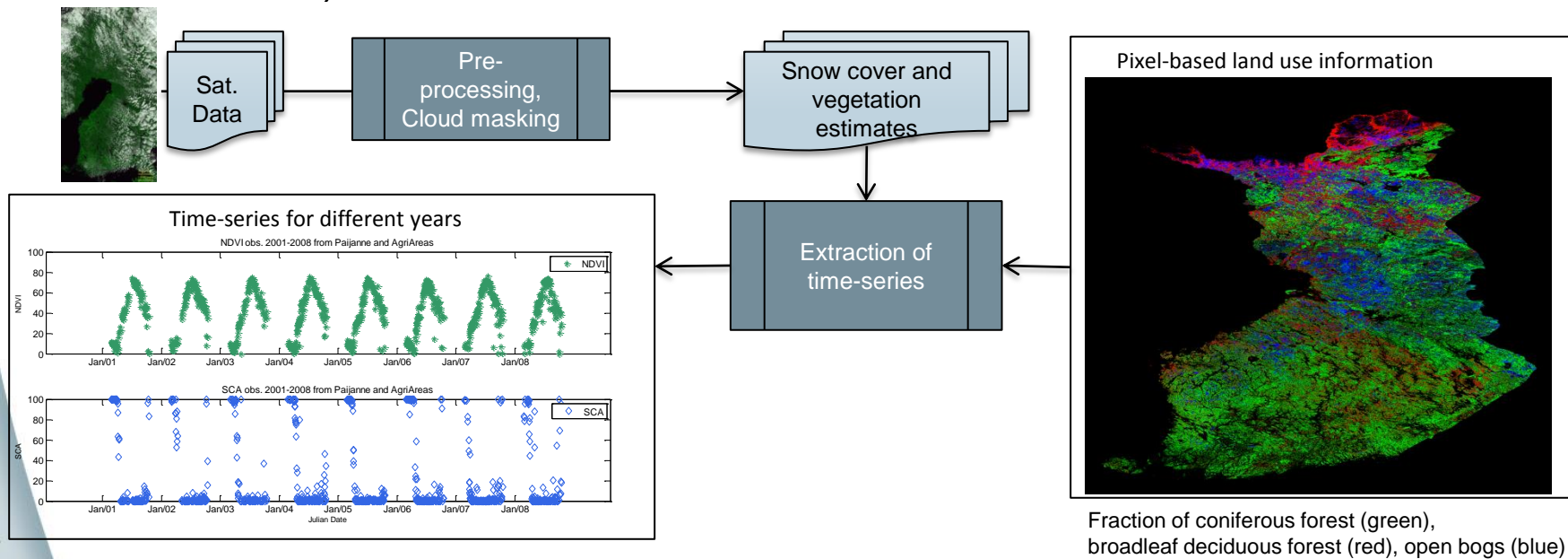
Budburst

Photo: Marja-Leena Nenonen

Phenological stages of birch trees

Source: Kubin et al. (2007). *Fenologisen havaintoverkon seurantaohjeet*: METLA

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Remote sensing methods (1/3)

Daily time-series of satellite-indices derived from Terra/ Moderate Resolution Imaging Spectrometer (MODIS) 2001-2012

- ○ Normalized Difference Vegetation Index (NDVI), 250 m
- ○ Normalized Difference Water Index (NDWI), 500 m
- ○ Fractional Snow Cover (FSC), 500 m (Metsämäki et al., 2012)

Sat. Data → Pre-processing, Cloud masking → Snow cover and vegetation estimates

Pixel-based land use information

Extraction of time-series

Time-series for different years

NDVI obs. 2001-2008 from Paijanne and AgriAreas

SCA obs. 2001-2008 from Paijanne and AgriAreas

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

Metsämäki et al. 2012. Remote Sensing of Environment, 123, 508-521.

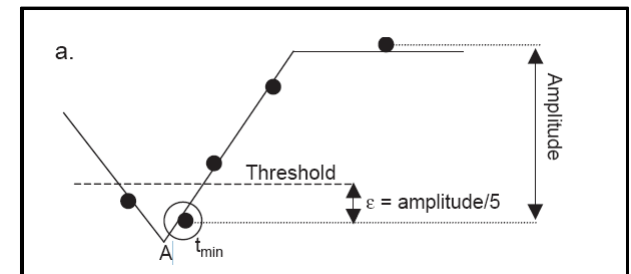# Remote sensing methods (2/3)

- **Evergreen forest**
  - Time when Fractional Snow Cover decreases can be used as proxy for start of season
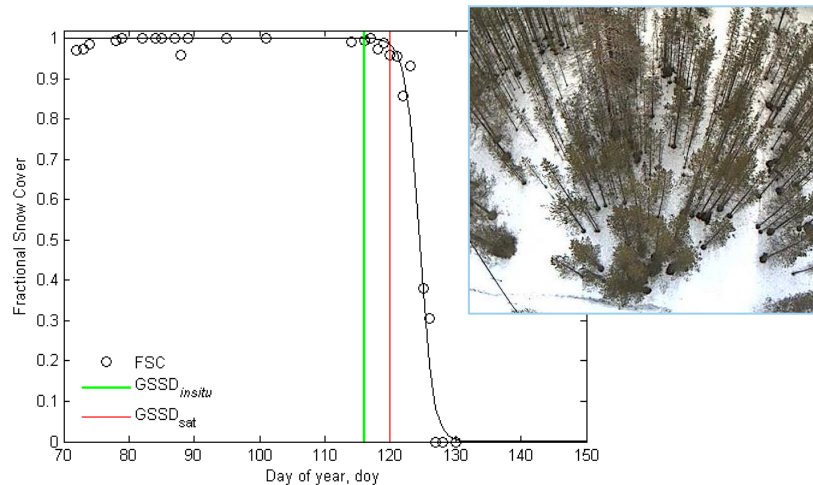
Böttcher *et al.* 2014. *Remote Sensing of Environment 140: 625-638.*
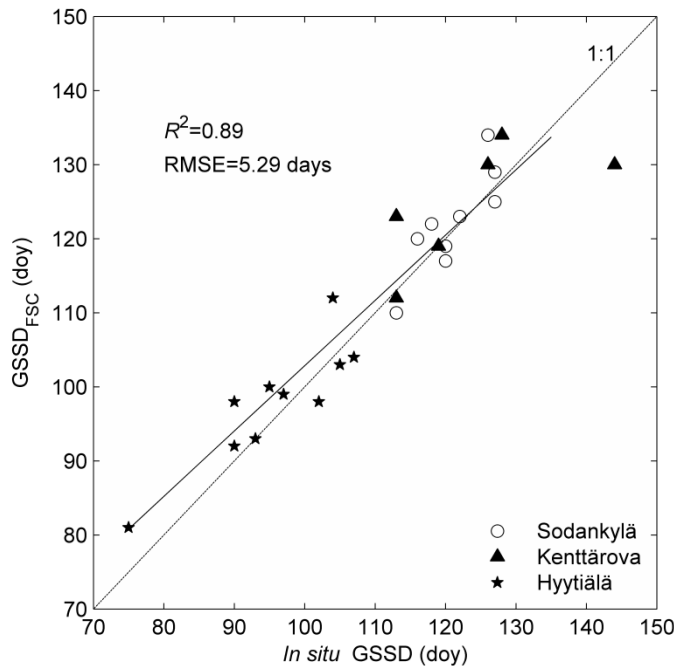
Deciduous forest
  - Start of season (greening-up) in the boreal region can be determined from time series of Normalized Difference Water Index

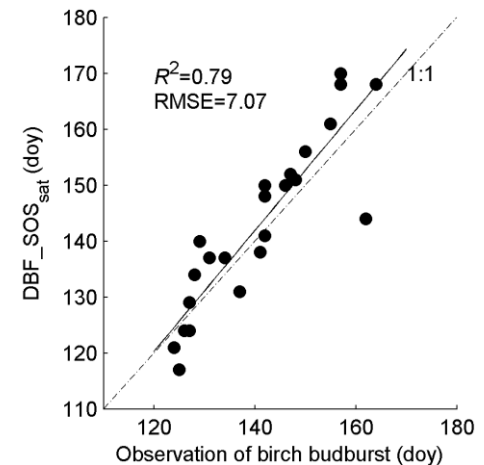Source: Delbart *et al.* 2005. *Remote Sensing of Environment 97: 26-38.*

Remote sensing methods (3/3)

- **Evergreen forest**

Böttcher *et al.* 2014. *Remote Sensing of Environment 140: 625-638.*
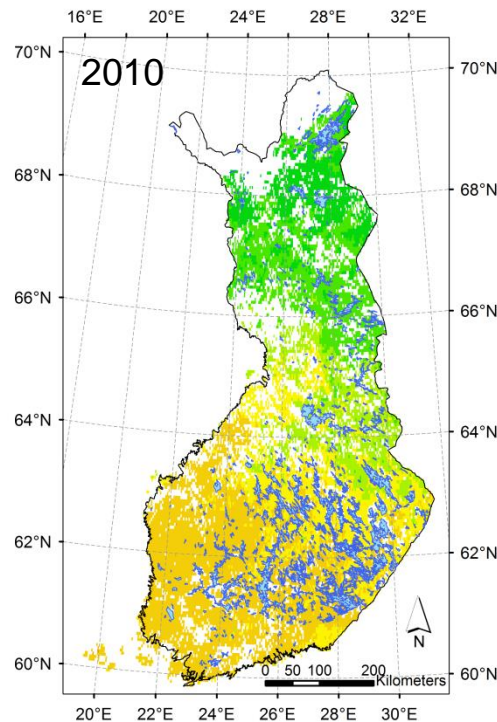
Deciduous forest

- Budburst of birch, larch, aspen in Siberia: RMSE 6.7 days and negligible bias (Delbart *et al.* 2006)
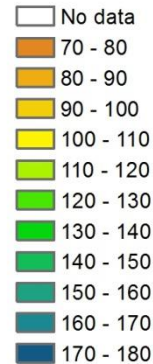- Budburst of birch in Finland: RMSE 7 days, bias 2 days (2003 – 2008)

Start of season in Finland (1/2)

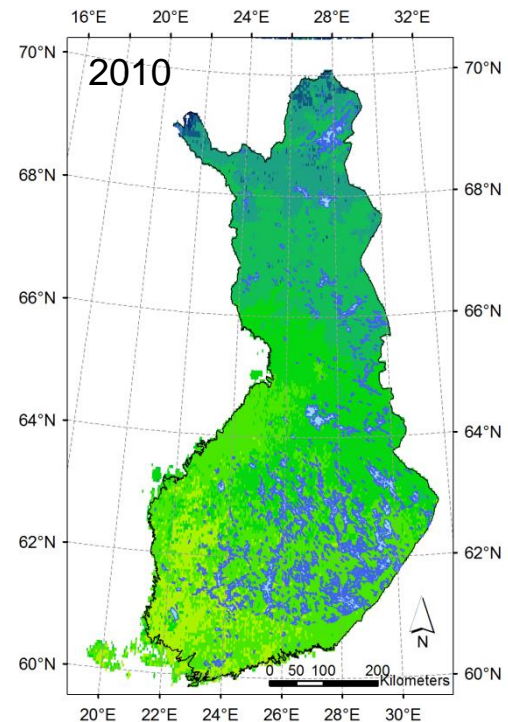- Mapping of start of season for pixels with dominance of coniferous forest and deciduous vegetation

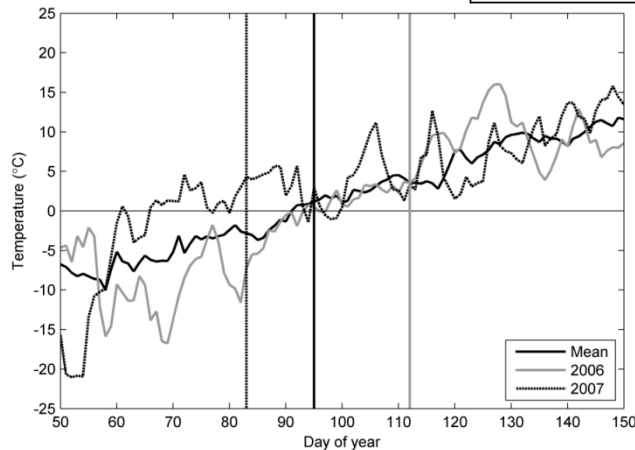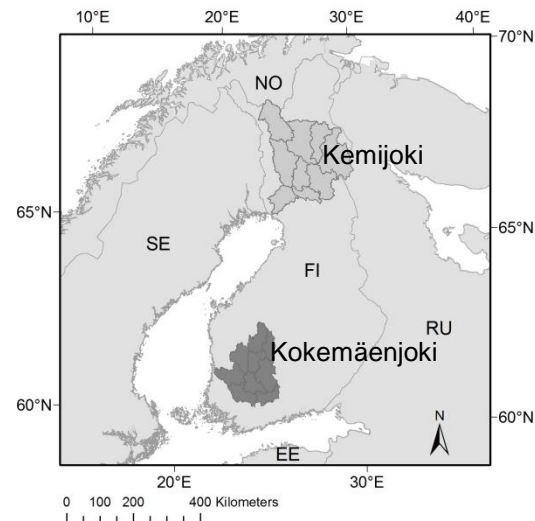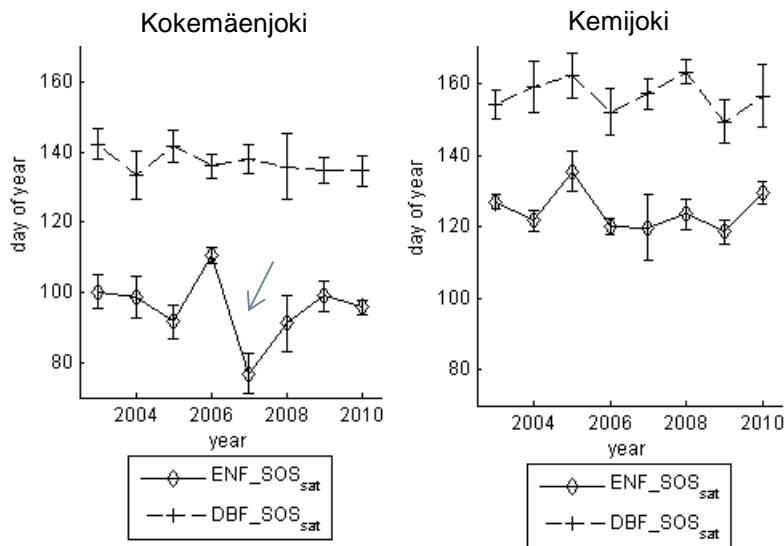- **Evergreen forest**   **Deciduous vegetation**

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Start of season in Finland (2/2)

- Interannual variability of start of season in two large drainage basins in southern and northern Finland

Evaluation of biosphere model estimates

- Seasonal cycle of vegetation is currently not well represented in global terrestrial biosphere models (Richardson et al. 2012)

- Sparse observation network for model validation

- Satellite-derived maps serve for spatio-temporal evaluation of the modelled phenology

Richardson et al. 2012. *Global Change Biology 18: 566-584.*

Modelled start of vegetation active season

- JSBACH (Jena Scheme for Biosphere-Atmosphere Coupling in Hamburg) is a biosphere model of an Earth system model run by FMI

- Process-based model that calculates the exchange of carbon, water and energy between land surface and atmosphere

- JSBACH biosphere model run with bias-corrected meteorological data from REgional climate MOdel (REMO)

- Start of season is determined from JSBACH model output
  - GPP threshold for evergreen coniferous forest
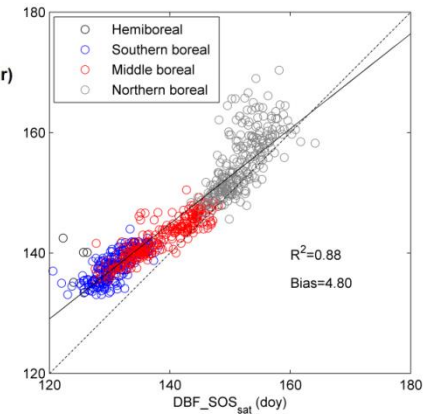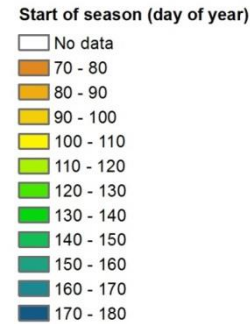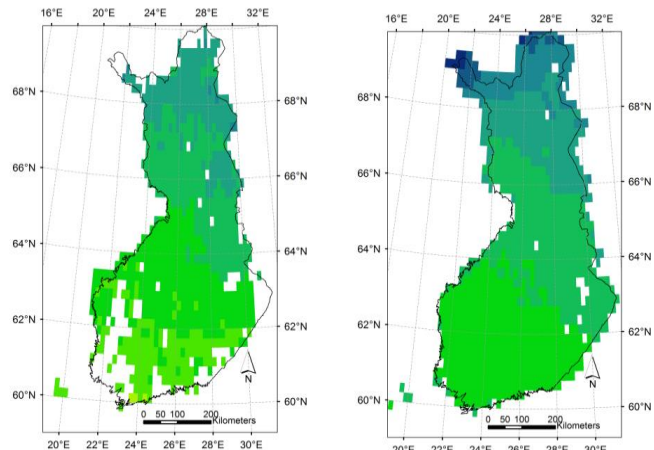 - Increase of Leaf Area Index for deciduous broadleaved forest

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Spatial correspondence (1/2)

- Mean modelled start of season was compared with mean dates from satellite data (years 2003-2010)

Evergreen coniferous
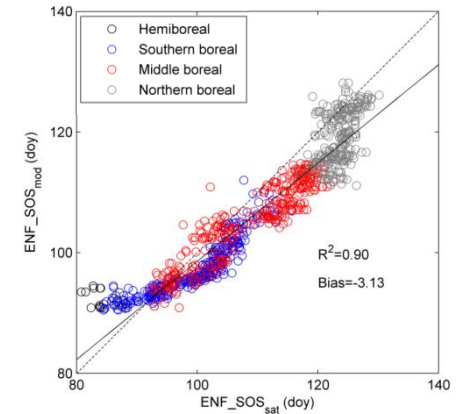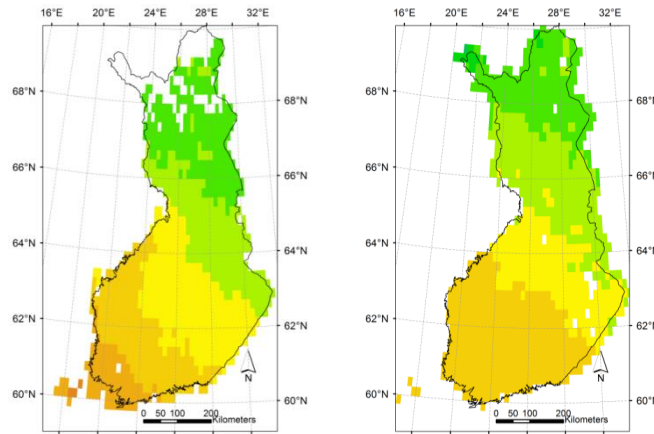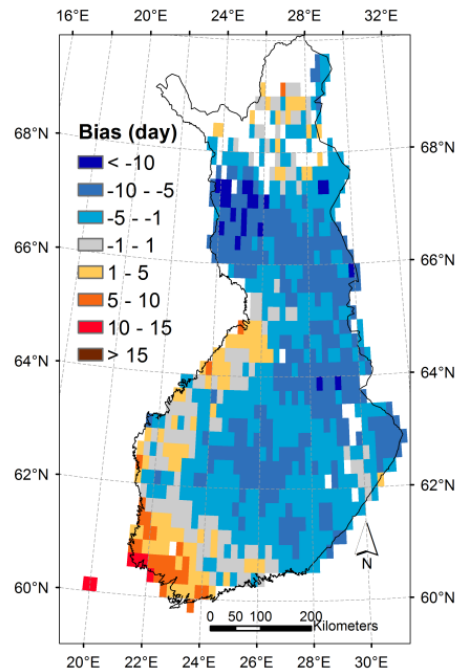
Deciduous broadleaved
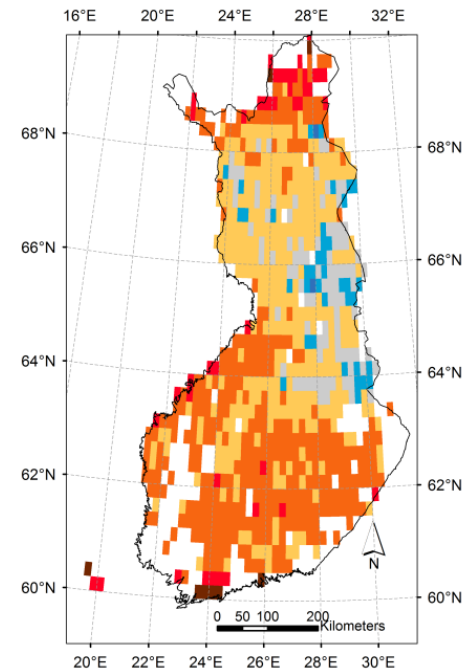

Satellite   JSBACH model

Spatial correspondence (2/2)

- Large bias (>10 days) observed
  - in south-western coastal areas and western Lapland for coniferous forest and
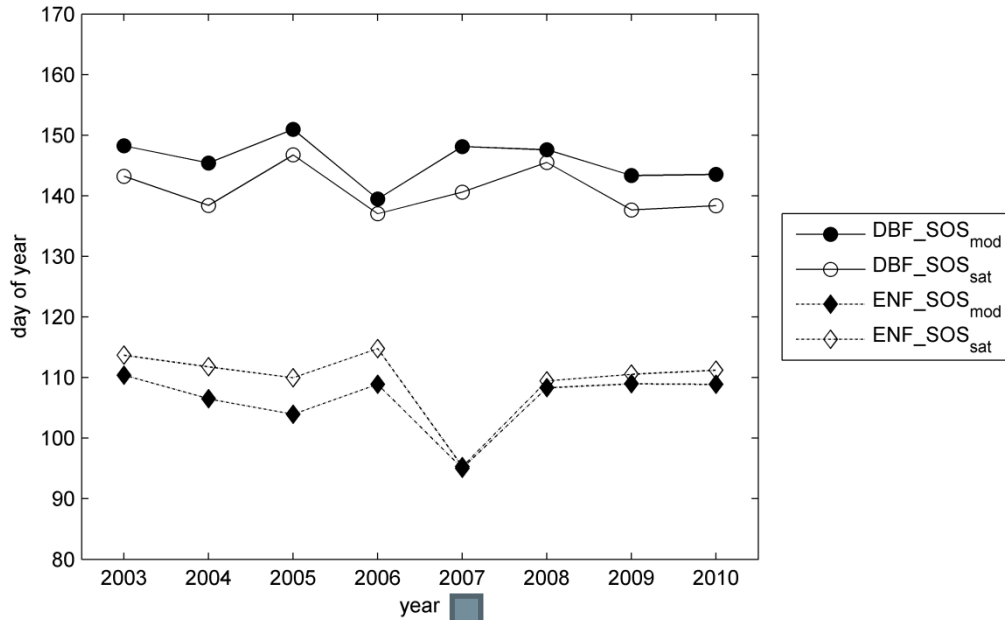 - in northern Lapland for deciduous forest

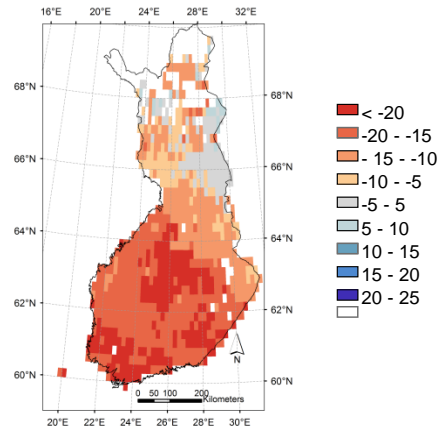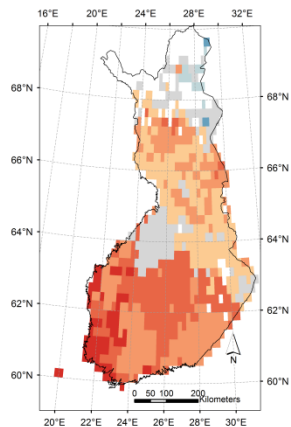**Evergreen coniferous**

Deciduous broadleaved

Interannual variability in Finland

JSBACH modelled   Satellite-observed

Summary

- Remote sensing observations of start of season with dedicated methods for boreal coniferous and deciduous forest

- Satellite-derived information was used to assess model performance

- Good correlation between two data source was obtained

- Modelled start of season of deciduous forest too late

- Deviation in boreal sub-region results are likely related to difference in acclimation of forest to different temperature regimes

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Outlook

- Further work on end of season indicators ongoing in EU Life+ project Monimet

- Monimet project is implementing web-camera network for monitoring the seasonal cycle of forests and wetlands in Finland

- New source for validation of satellite information on vegetation phenology and snow cover

Latest Camera Images:

Punkaharju Spruce Landscape Camera
Last image time: 15.05.15 - 14:45:32

Punkaharju Spruce Crown Camera
Last image time: 15.05.15 - 15:01:38

Sodankyla Pine Ground Camera
Last image time: 15.05.15 - 15:01:39

Kenttarova Spruce Canopy Camera
Last image time: 15.05.15 - 12:00:00

See all cameras

http://monimet.fmi.fi/

Thank you!

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