Remote sensing observations of low-arctic vegetation green-up

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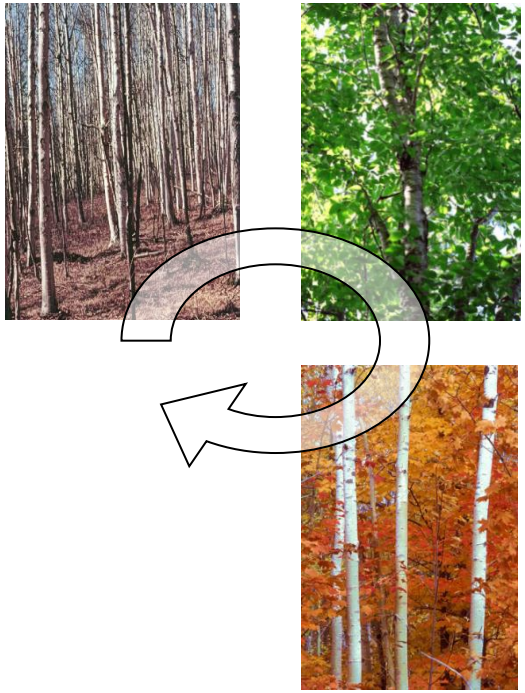
"The 12th International Circumpolar Remote Sensing Symposium", May 14-18, 2012, Levi, Finland

Introduction

Date of leaf appearance



- Picard, G., Quegan, S., DELBART, N., Lomas, M.R., Le Toan, T., Woodward, F.I., (2005) Phenology modelling in Siberia and its impact on the carbon budget, *Global Change Biology, 11*, 2164-2176.
- DELBART, N., L. Kergoat, T. Le Toan, J. L'Hermitte and G. Picard (2005), Determination of phenological dates in boreal regions using Normalised Difference Water Index. *Remote Sensing of Environment, 97*, 26-38.
- DELBART, N., Picard, G., Le Toan, T., Kergoat, L., Quegan, S., Woodward, I, Dye, D., and Fedotova, V. (2008), Spring phenology in boreal Eurasia in a nearly century time-scale, *Global Change Biology*, 14, (3), 603-614.
- DELBART, N., T. Le Toan, L. Kergoat, V. Fedotova (2006), Remote sensing of spring phenology in boreal regions: a free of snow-effect method using NOAAAVHRR and SPOT-VGT data (1982-2004), *Remote Sensing of Environment, 101*, 52-62.
- DELBART, N. and Picard, G. (2007), Modeling the date of leaf appearance in low-arctic tundra, *Global Change Biology*, *13*, 2551-2562.
- Vicente-Serrano, S., DELBART, N., Le Toan, T., Grippa, M. (2006), Niño-Southern Oscillation Influences The Inter-Annual Variability Of Leaf Appearance Dates In Central Siberia, *Geophysical Research Letters*, 33, L03707, doi:10.1029/2005GL025000.

- Ongoing projects :
  - Annett Bartsch, **PAGE21**.
  - Ottlé Catherine, **CLASSIQUE** project.

Introduction

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Community and ecosystem responses to recent climate change

Gian-Reto Walther

Phil. Trans. R. Soc. B 2010 **365**, 2019-2024
doi: 10.1098/rstb.2010.0021

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Why does phenology drive species distribution?

Isabelle Chuine

Phil. Trans. R. Soc. B 2010 **365**, 3149-3160
doi: 10.1098/rstb.2010.0142

review article

Ecological responses to recent climate change

Gian-Reto Walther*, Eric Post†, Peter Convey‡, Annette Menzel§, Camille Parmesan||, Trevor J. C. Beebee¶, Jean-Marc Fromentin#, Ove Hoegh-Guldberg☆ & Franz Bairlein**

Journal of Animal Ecology
British Ecological Society
Journal of Animal Ecology 2009, **78**, 73–83 doi: 10.1111/j.1365-2656.2008.01458.x

Climate change and unequal phenological changes across four trophic levels: constraints or adaptations?

Christiaan Both[1]*, Margriet van Asch[2], Rob G. Bijlsma[1], Arnold B. van den Burg[3] and Marcel E. Visser[2]

Fingerprints of global warming on wild animals and plants

Terry L. Root*, Jeff T. Price†, Kimberly R. Hall‡, Stephen H. Schneider§, Cynthia Rosenzweig|| & J. Alan Pounds¶

Canopy duration has little influence on annual carbon storage in the deciduous broad leaf forest

MICHAEL A. WHITE* and RAMAKRISHNA R. NEMANI†
*5210 Old Main Hill, Department of Aquatic, Watershed & Earth Resources, Utah State University, Logan, UT 84322-52
†Numerical Terradynamic Simulation Group, School of Forestry, University of Montana, Missoula, MT 59812

A globally coherent fingerprint of climate change impacts across natural systems

Camille Parmesan* & Gary Yohe†
* Integrative Biology, Patterson Laboratories 141, University of Texas, Austin, Texas 78712, USA
† John E. Andrus Professor of Economics, Wesleyan University, 238 Public Affairs Center, Middletown, Connecticut 06459, USA

Introduction

Definition for this presentation: **timing of leaf / needle appeareance of deciduous species**.

In Siberia and most of the Northern Hemisphere :

Greening trend: earlier « spring ». It has been observed by:

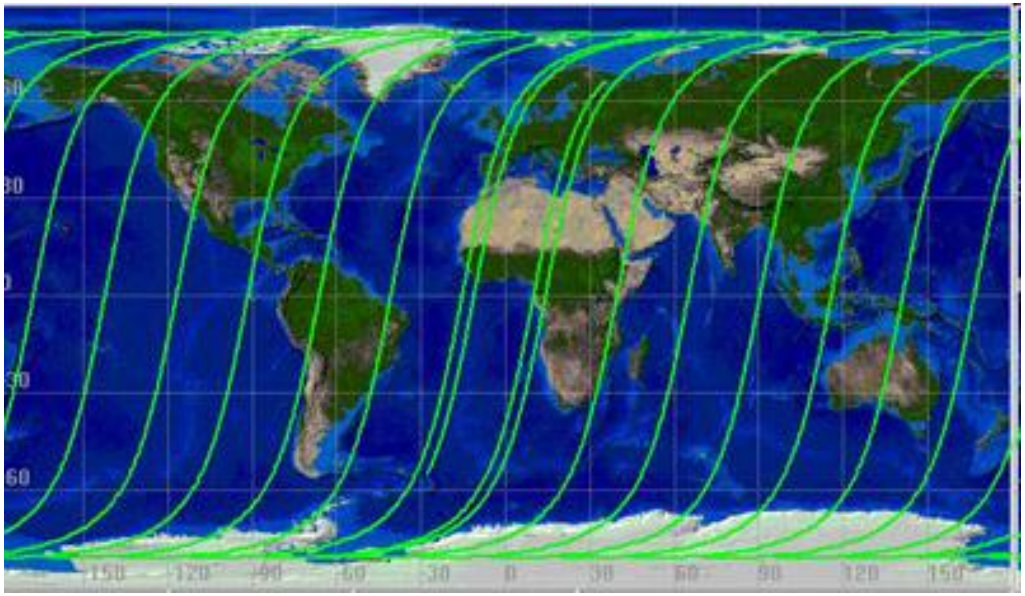
- **Remote sensing**. E.g.: Myneni (1998). Drawbacks: 1/ only from 1982. 2/ What is really detected?

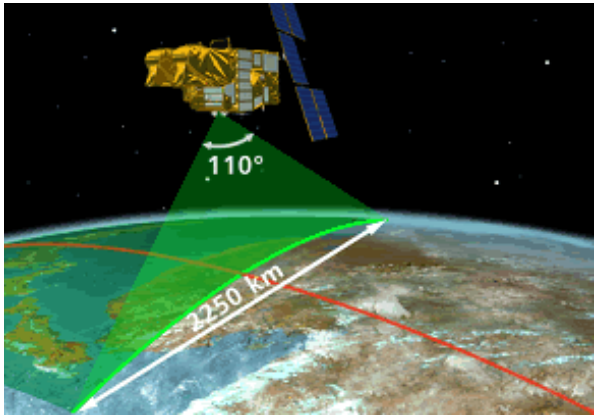
- Other methods :**In situ measurements** (Schaber and Badeck, 2005) ; **Modeling**. E.g.: Schwartz (2005).

Methods

1 Remote sensing methods to measure spring phenology date in boreal region (removing snow effect) **SPOT-VEGETATION** (using the middle infra-red band) and **NOAA-AVHRR**

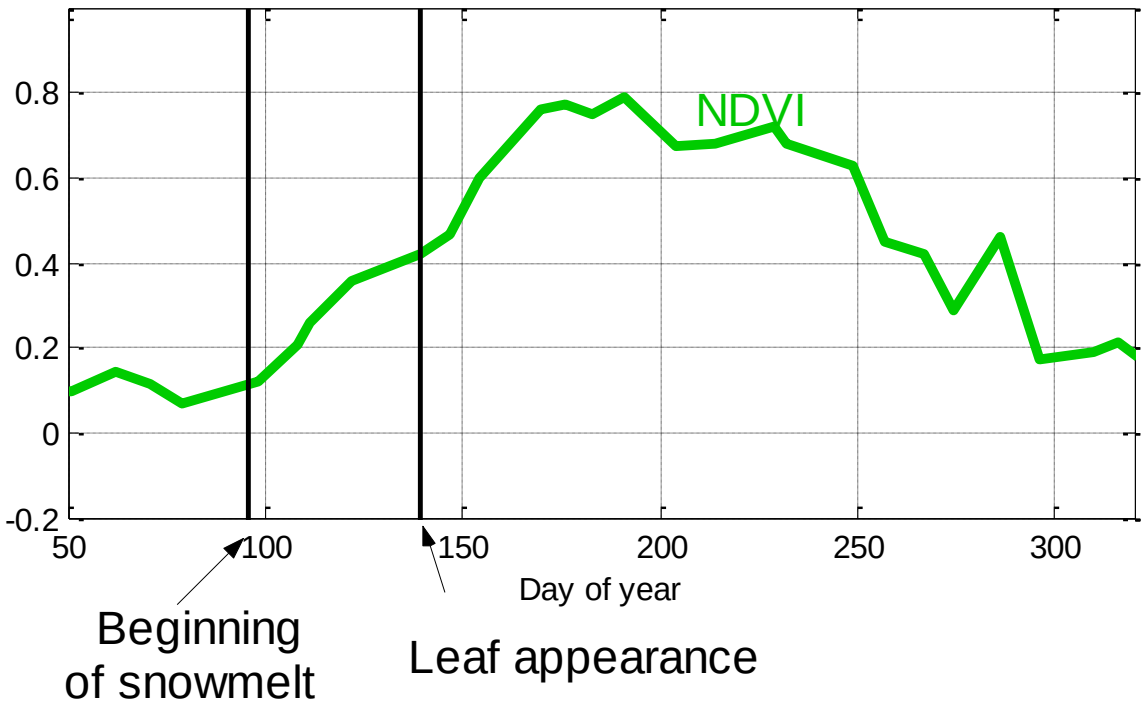
SPOT-VEGETATION





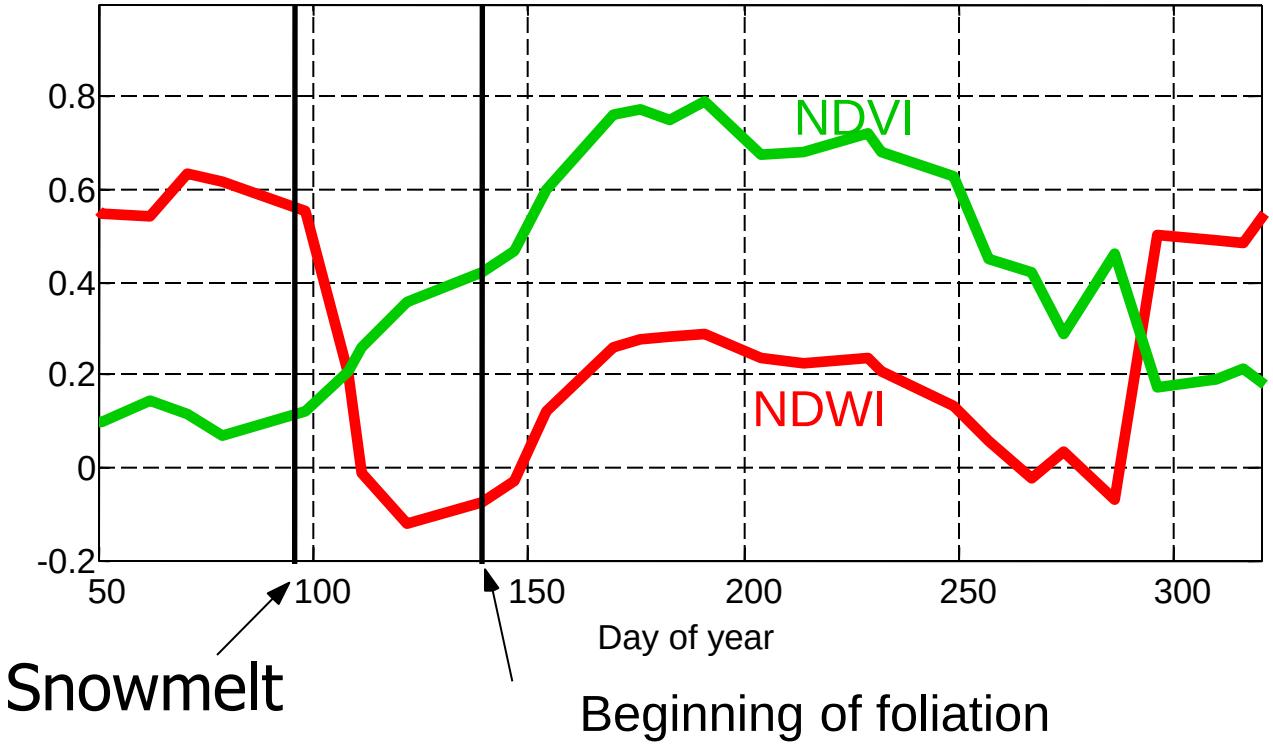
10 day composite S10 product.

SPOT-VEGETATION



Melting snow reveal the soil -> NDVI increases.
Confusion between snowmelt and foliation.
(Moulin et al. 1997, Dye et al., 2003, Shabanov et al., 2002, White et al., 2005)

SPOT-VEGETATION



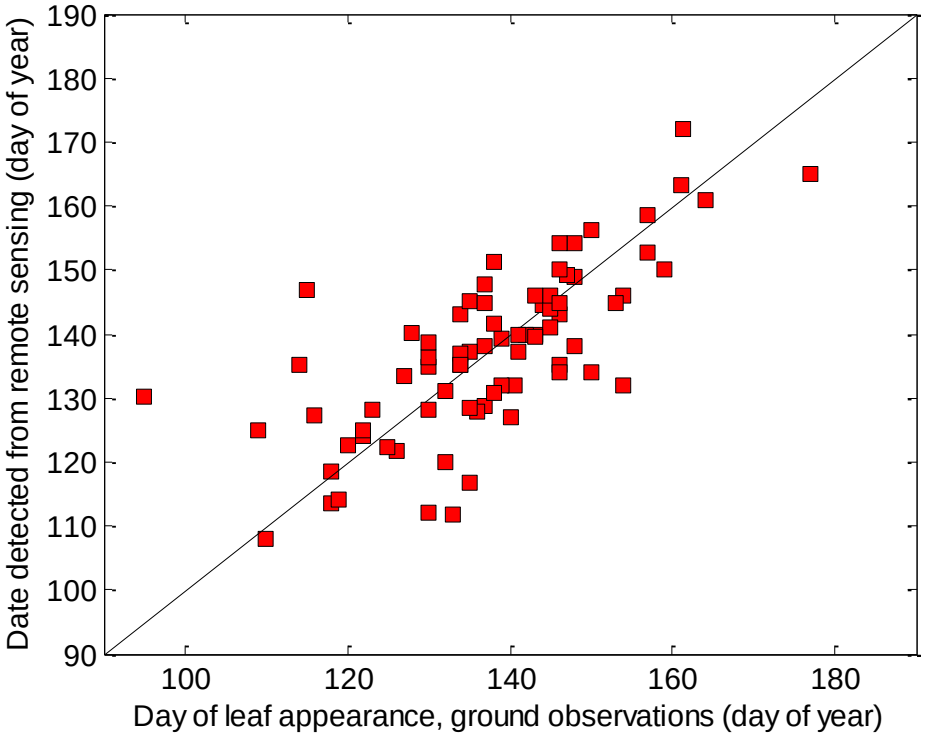
$$NDVI = \frac{NIR - R}{NIR + R}$$

$$NDWI = \frac{NIR - MIR}{NIR + MIR}$$

(**Delbart, N**., et al. (2005), Determination of phenological dates in boreal regions using Normalised Difference Water Index. *Remote Sensing of Environment, 97*, 26-38.)

SPOT-VEGETATION

Field observations of date of foliation (Komarov Institute de Saint Petersbourg, project Plantwatch, Ahas et al. 2002...)

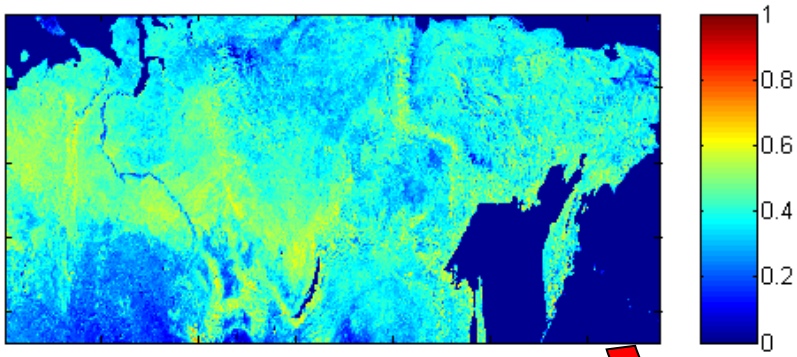


RMSE≈ 8 days

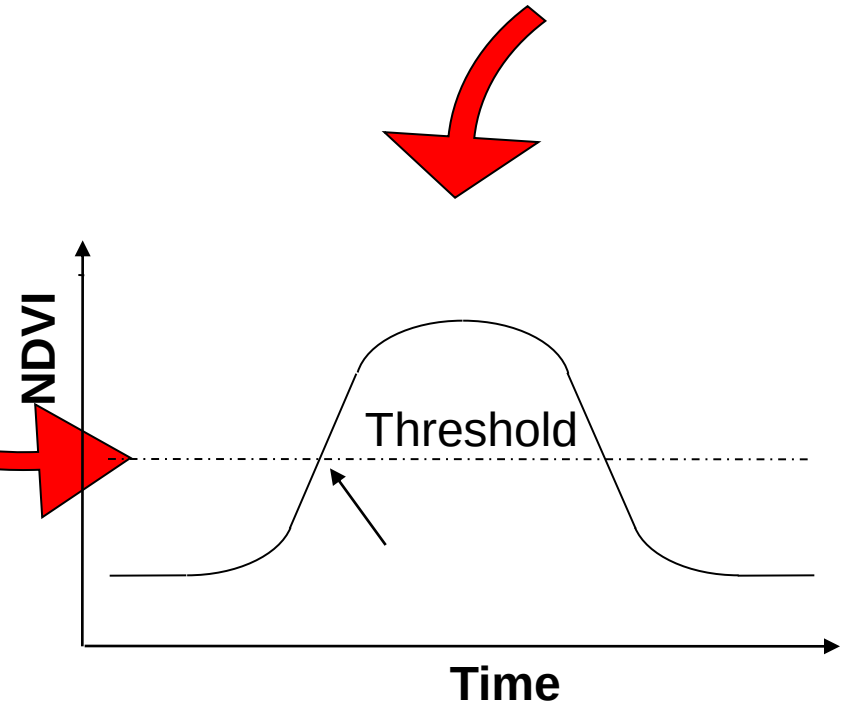
NOAA-AVHRR Pathdinder

1982-2001

Threshold Map



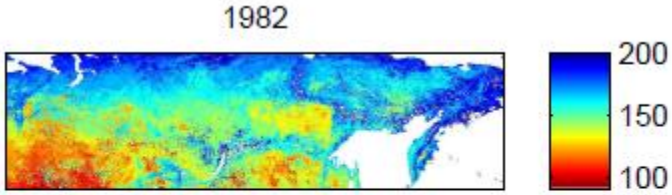
NOAA-AVHRR NDVI



The threshold map is calibrated for each pixel independently.

How?

- 1998-2001 : SPOT-VGT and Pathfinder.
- We record the AVHRR NDVI value at the greenup date given by SPOT-VGT method.
- Average over 1998-2000.


1982
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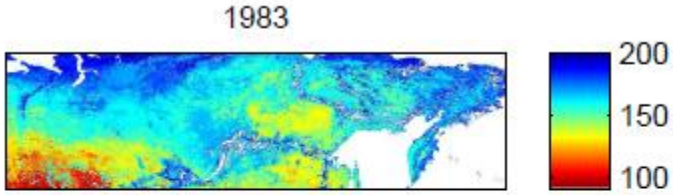
1983
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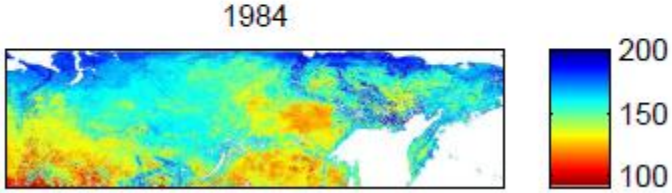
1984
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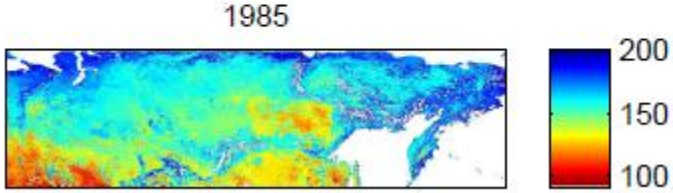
1985
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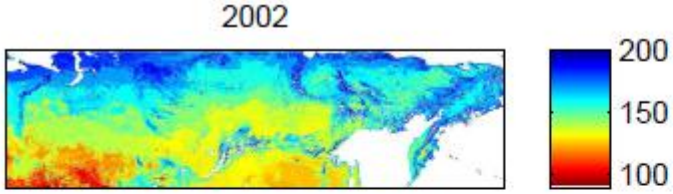
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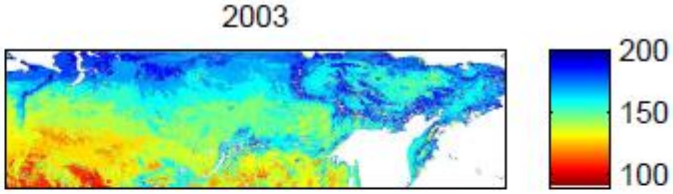
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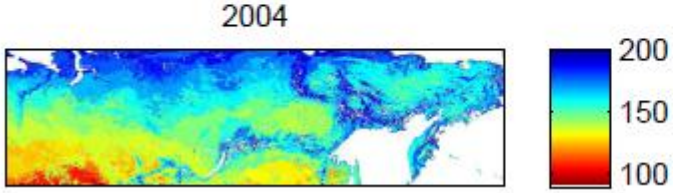
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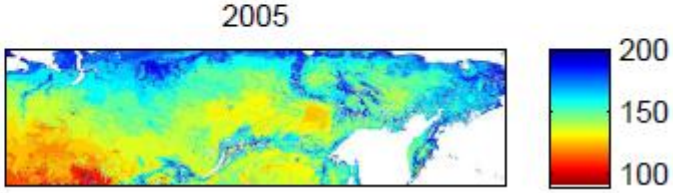
2005
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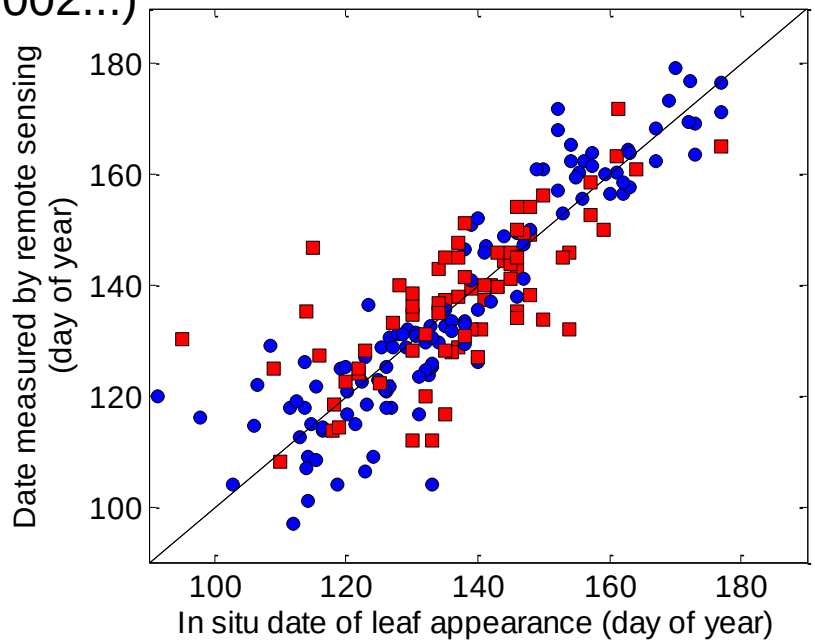
Validation of remote sensing

Field observations of date of foliation (Komarov Institute de Saint Petersbourg, project Plantwatch, Ahas et al. 2002...)



Methods

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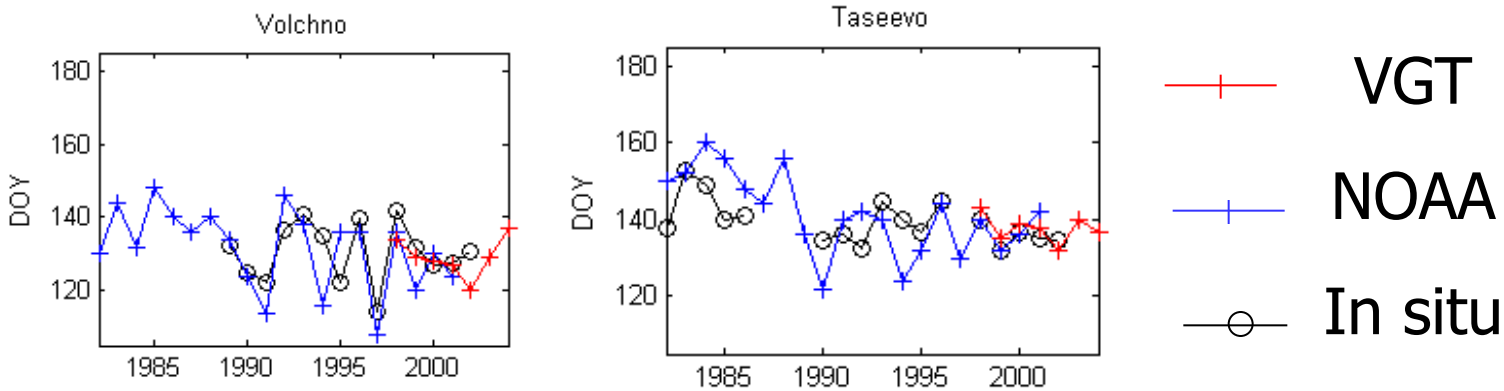
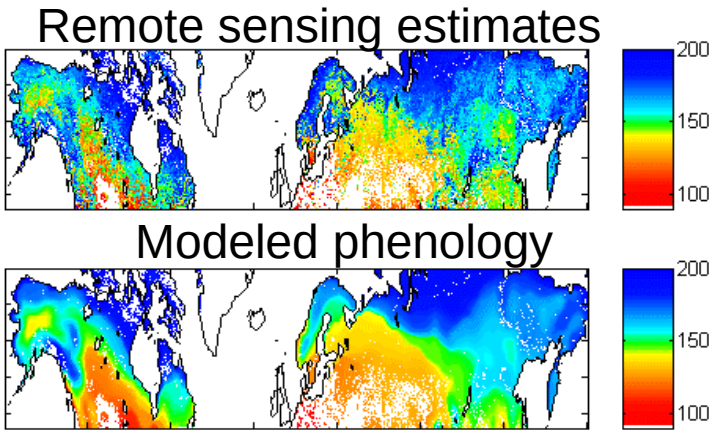
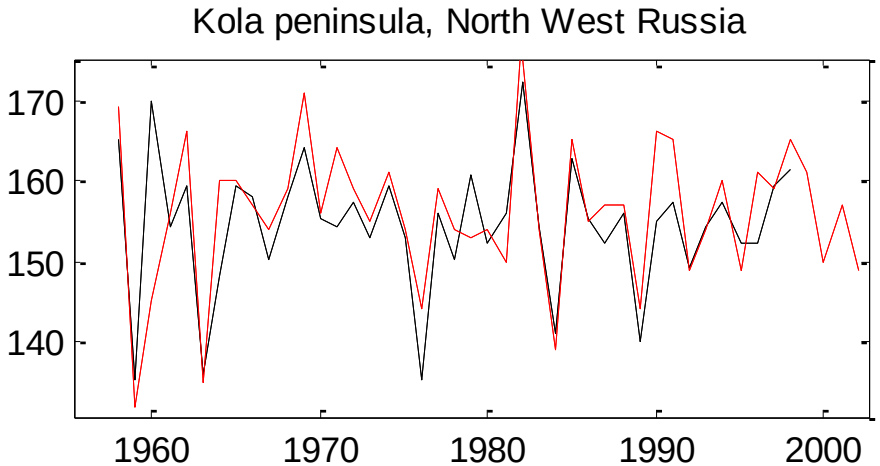
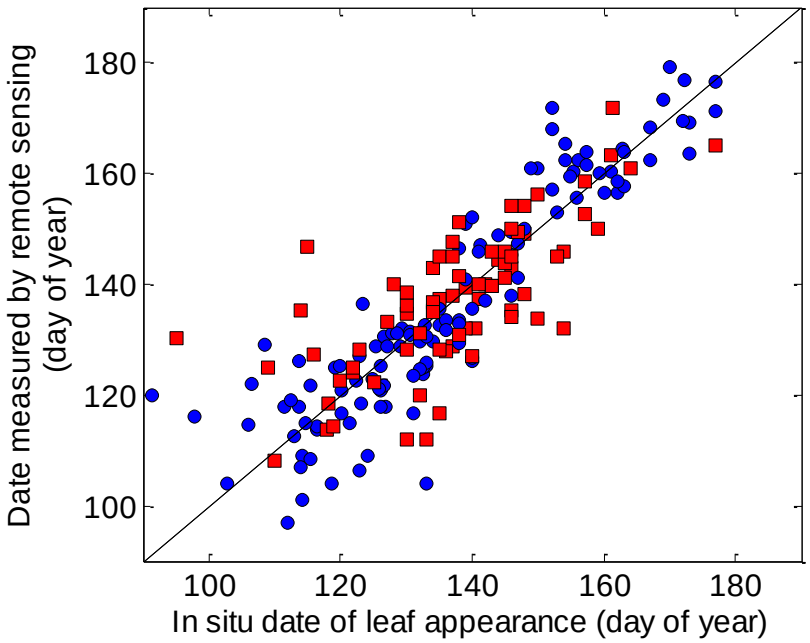


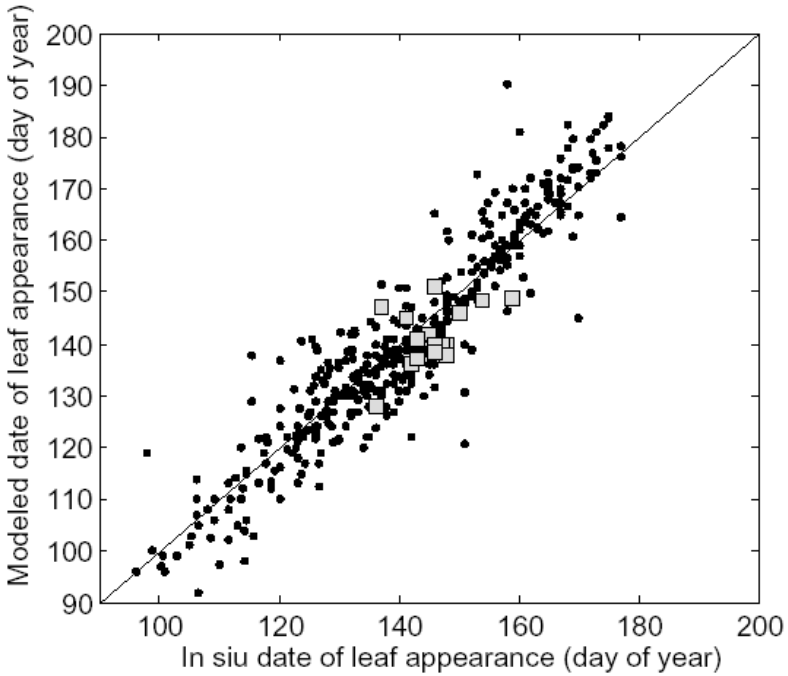
2 Modelling phenology from temperature. Degree.day model. Calibration using remote sensing results in Central Siberia in 1998-2002.





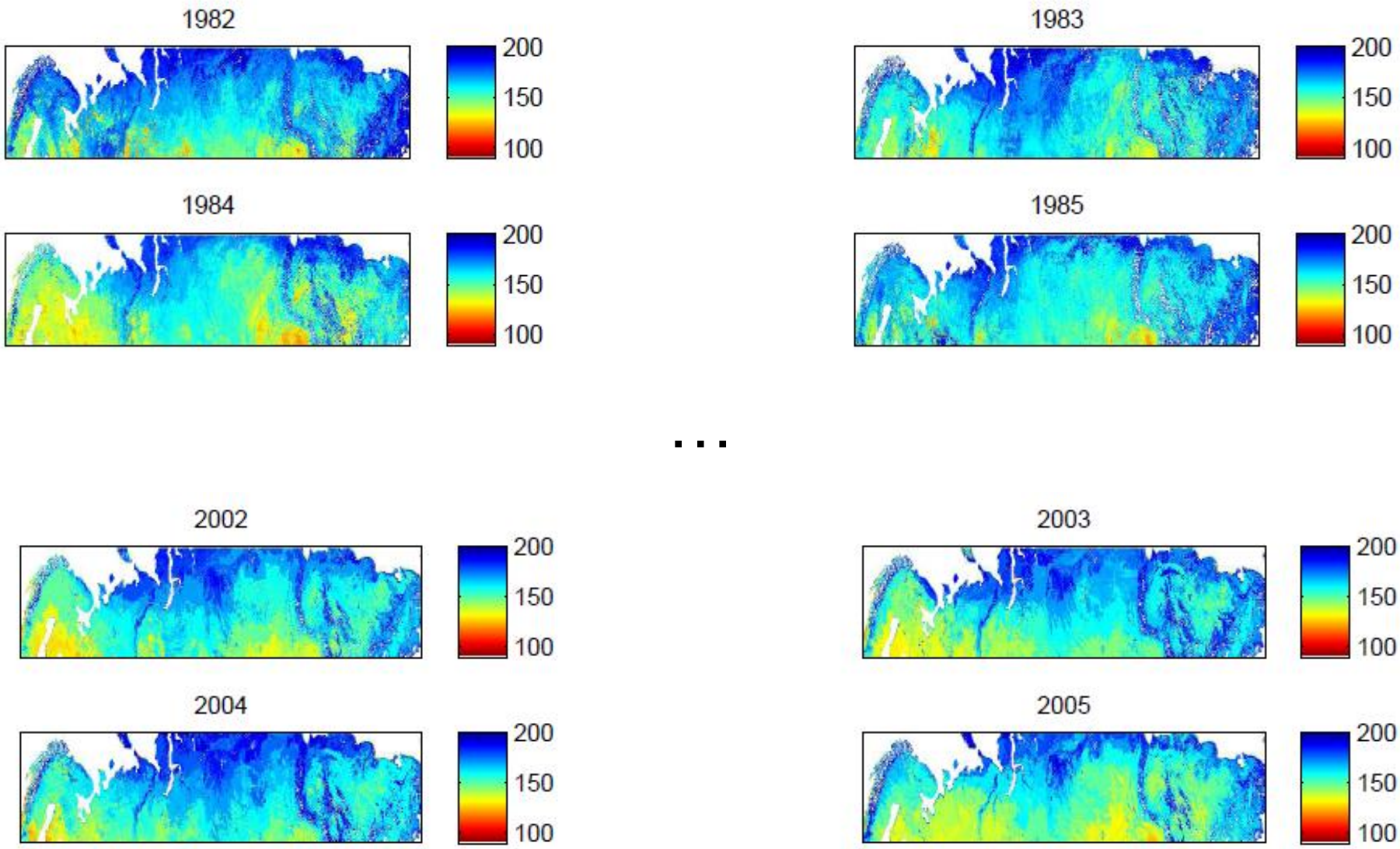
Validation of remote sensing and model





Phenology in tundra

Tundra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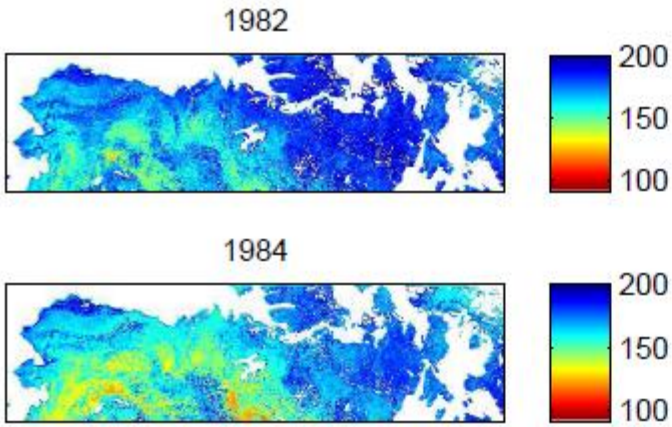
Tundra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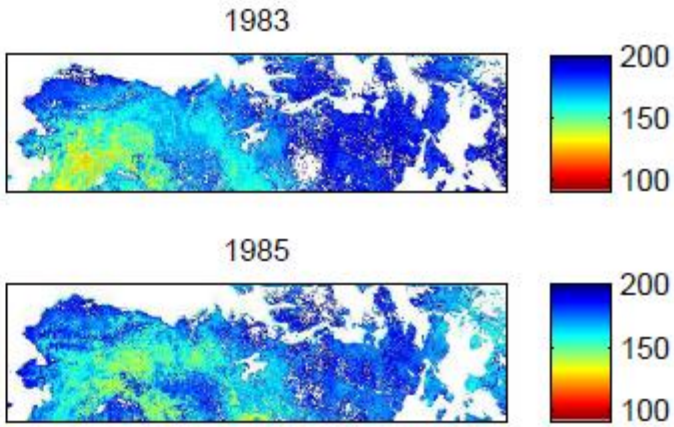
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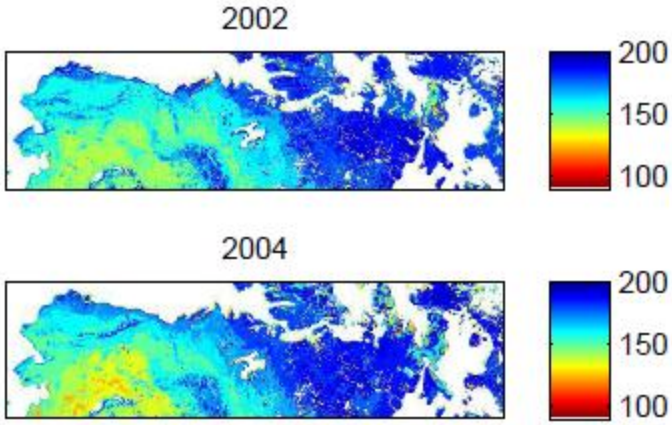
2002
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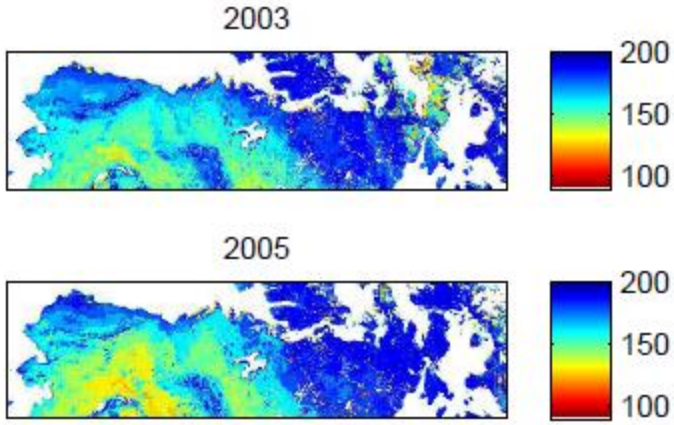
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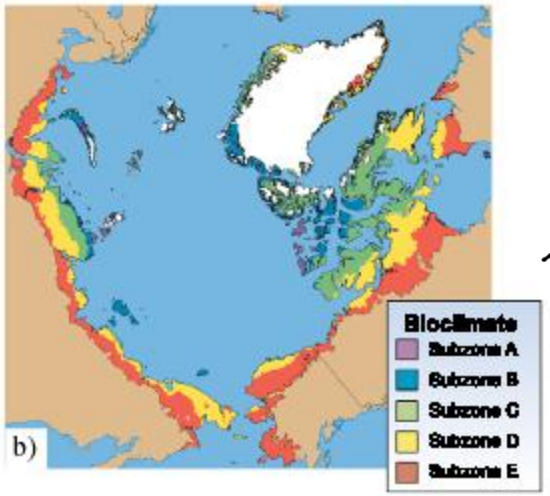
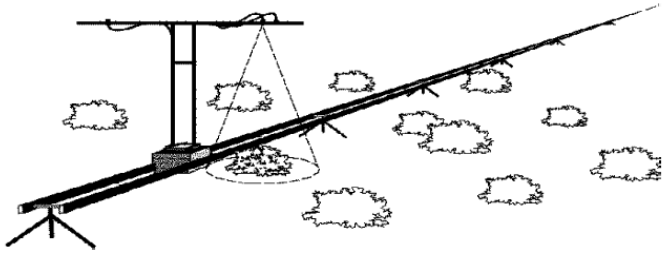
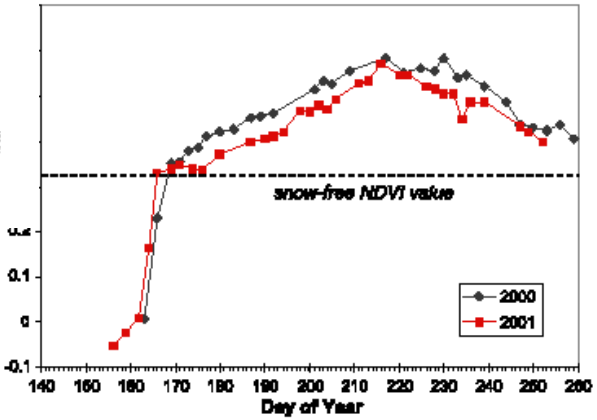
Tundra

Stow et al. 2004







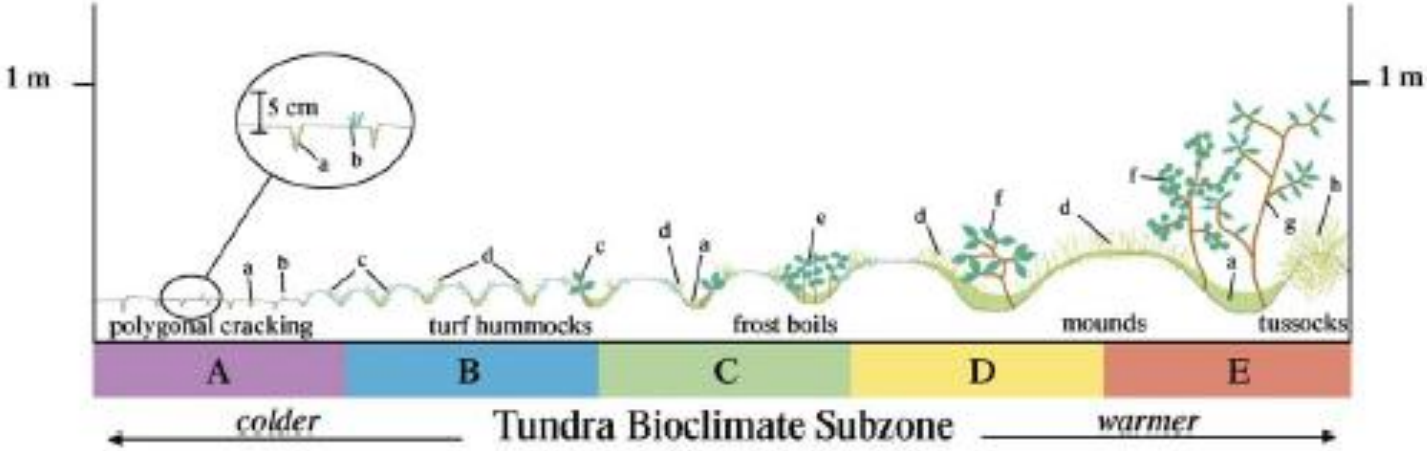


Fig. 2. Plant physiognomy occurring in different Tundra Bioclimate Subzones: A — mosses, liverworts and lichens, B — forbs, C — prostrate dwarf-shrubs, D — non-tussock graminoids, ehemiprostrate dwarf-shrubs, F — erect dwarf-shrubs, G — low shrubs, H — tussock graminoids.

Raynolds et al. 2006

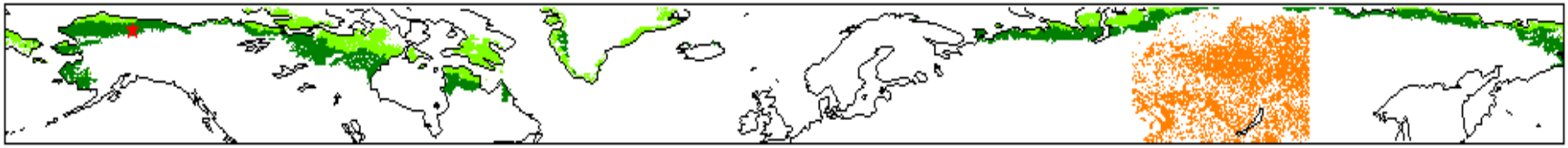
Tundra

- Can we explain the spatial gradients and the temporal variations of the remote sensing greenup date with temperature?

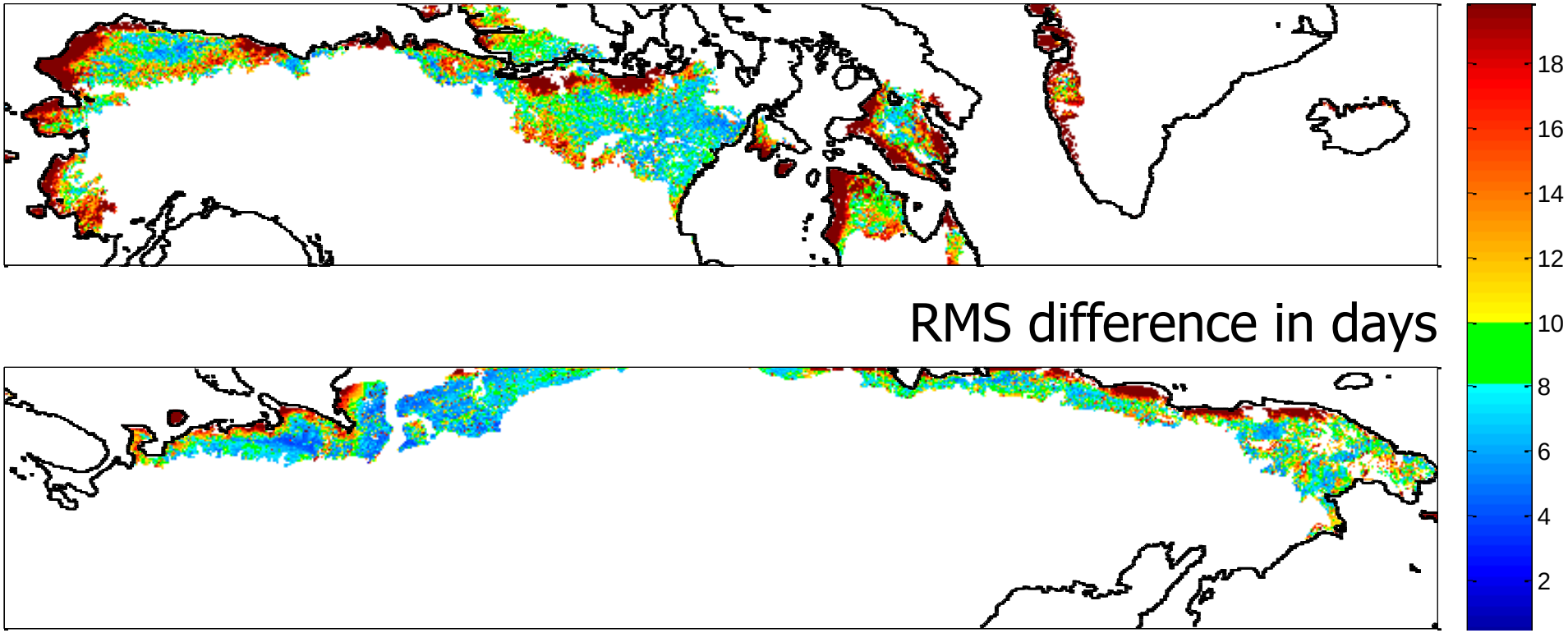
- Approach : comparison of the remote sensing time series to our temperature based lef-out model.

Tundra

The model calibrated in taiga (orange area) was applied in tundra (green area):

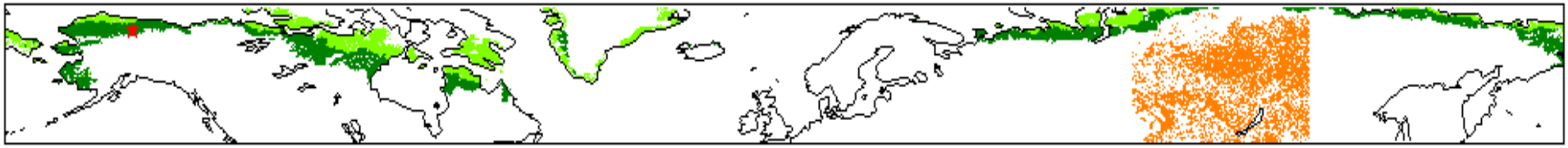


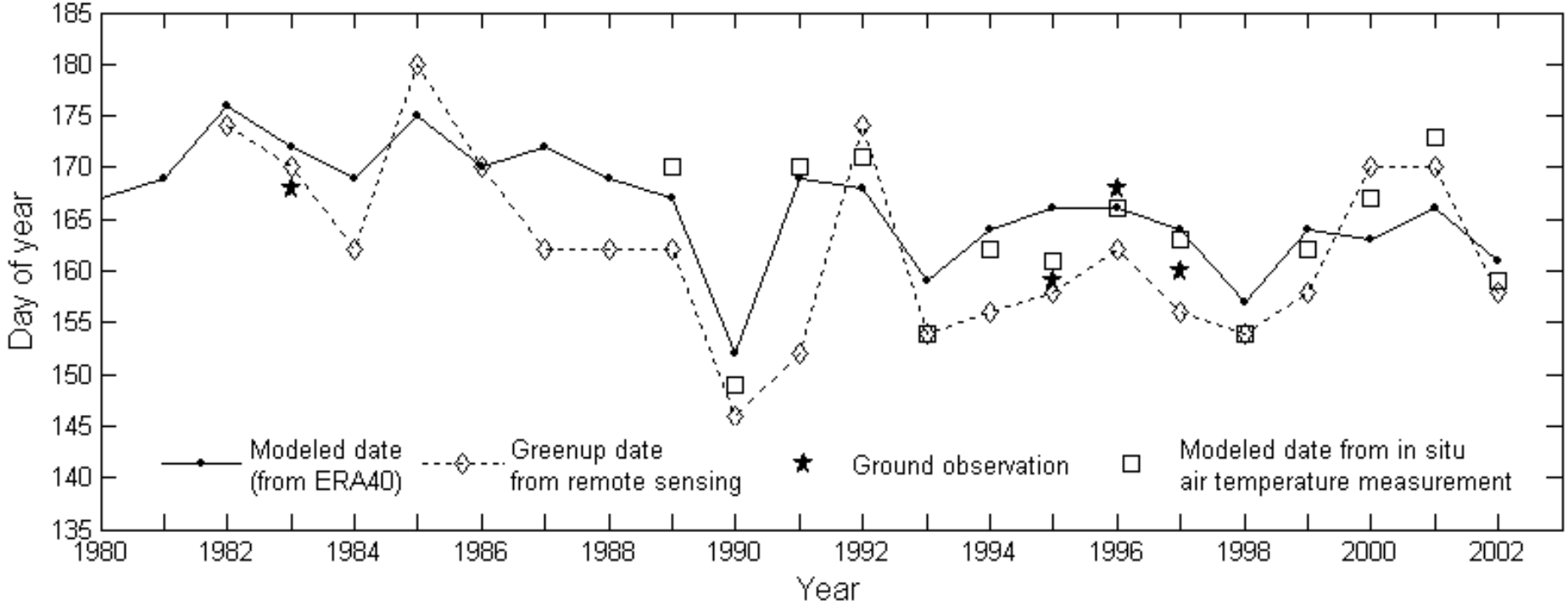
We compare the modeled dates with the dates detected using remote sensing:



Tundra: field station

Location: Toolik station, Alaska.





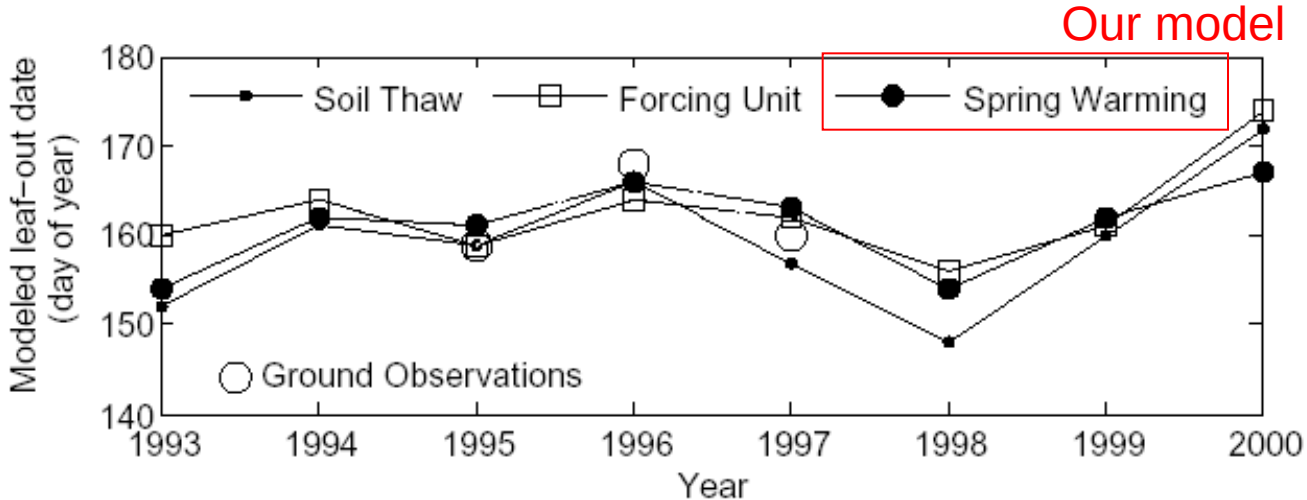
Tundra: field station

The simulated dates are compared to two models calibrated at the Toolik field stations.

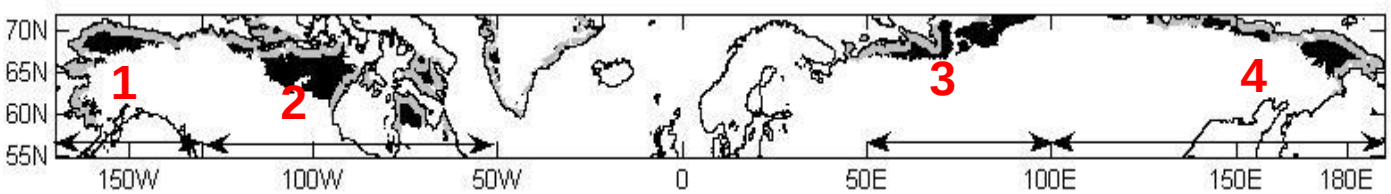
The Soil Thaw Model (VanWijk et al 2003) is a physical model which simulates the heat echanges between air and soir through snow. The soil temperature is the trigger for leaf appearance.

The Forcing Unit Model (Pop et al. 2000) is an empirical model based on air temperature. It differs from our model in its formulation.

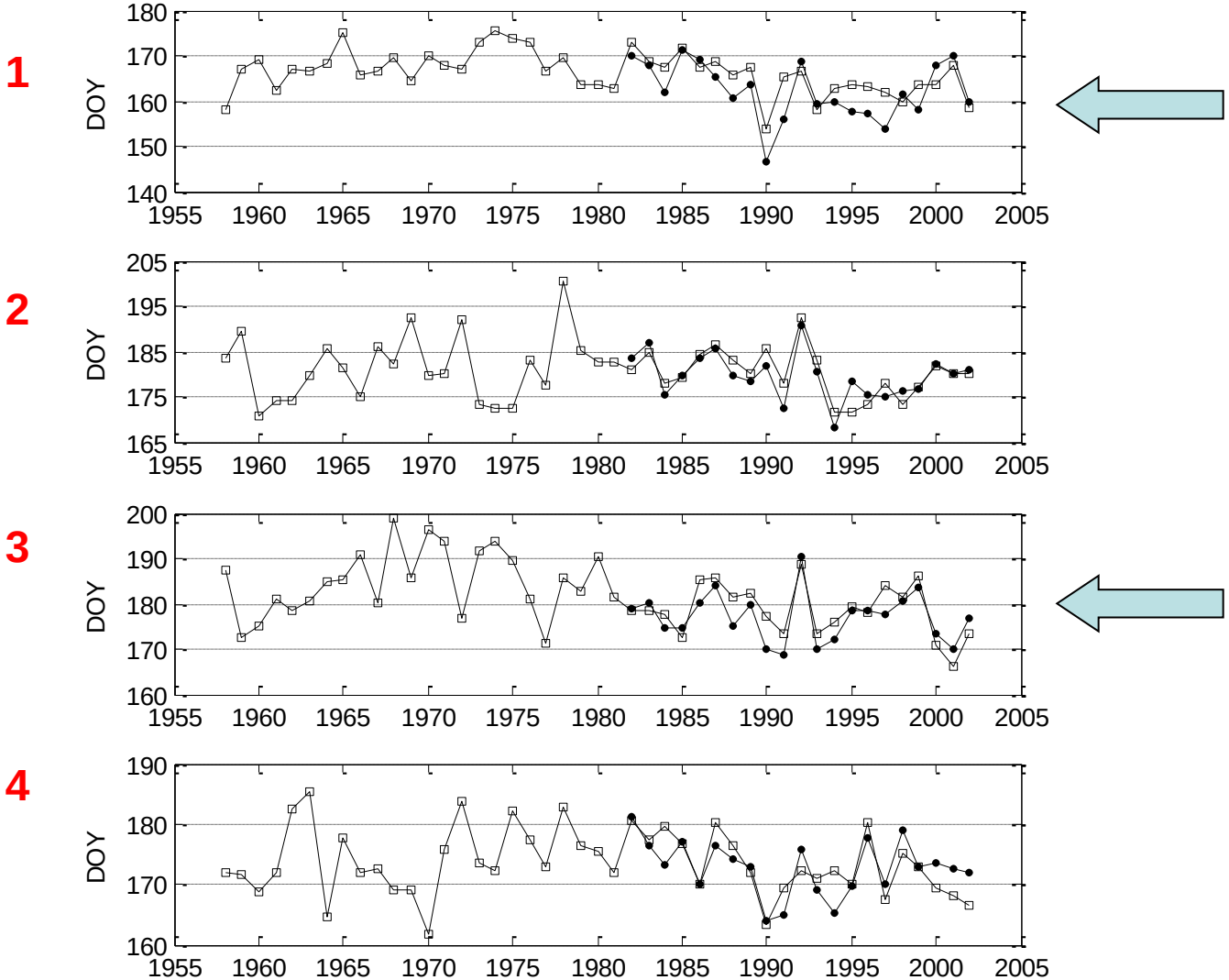
The results of the three models are very close although our model was calibrated in a different ecosystem.



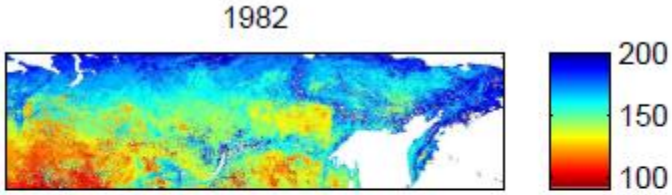
Variation in the green-up timing in tundra 1958-2002



RMSD	R
4.54 days	0.79
2.85 days	0.85
3.64 days	0.82
3.41 days	0.74



Phenology in Eurasian Taiga


1982
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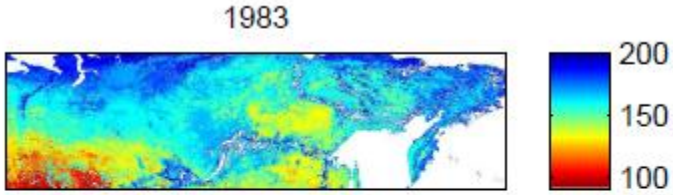
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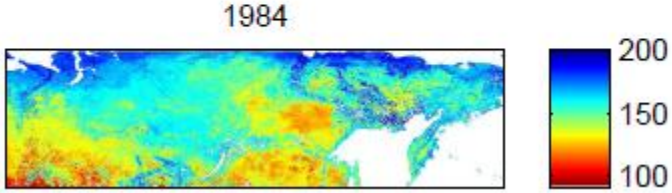
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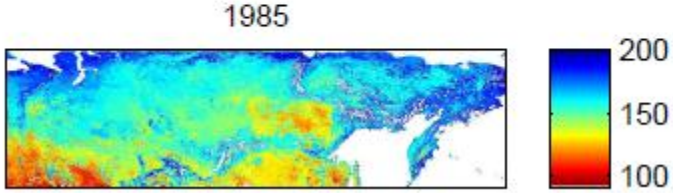
1985
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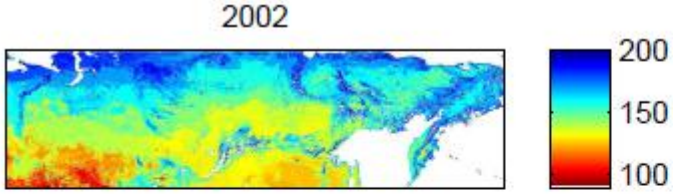
...


2002
200
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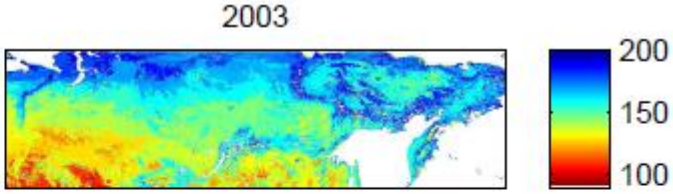
2003
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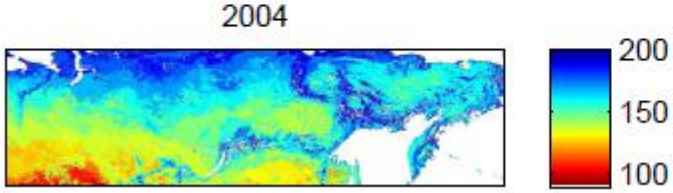
2004
200
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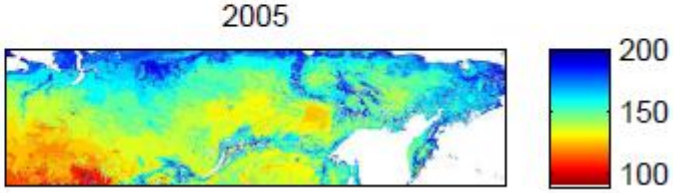
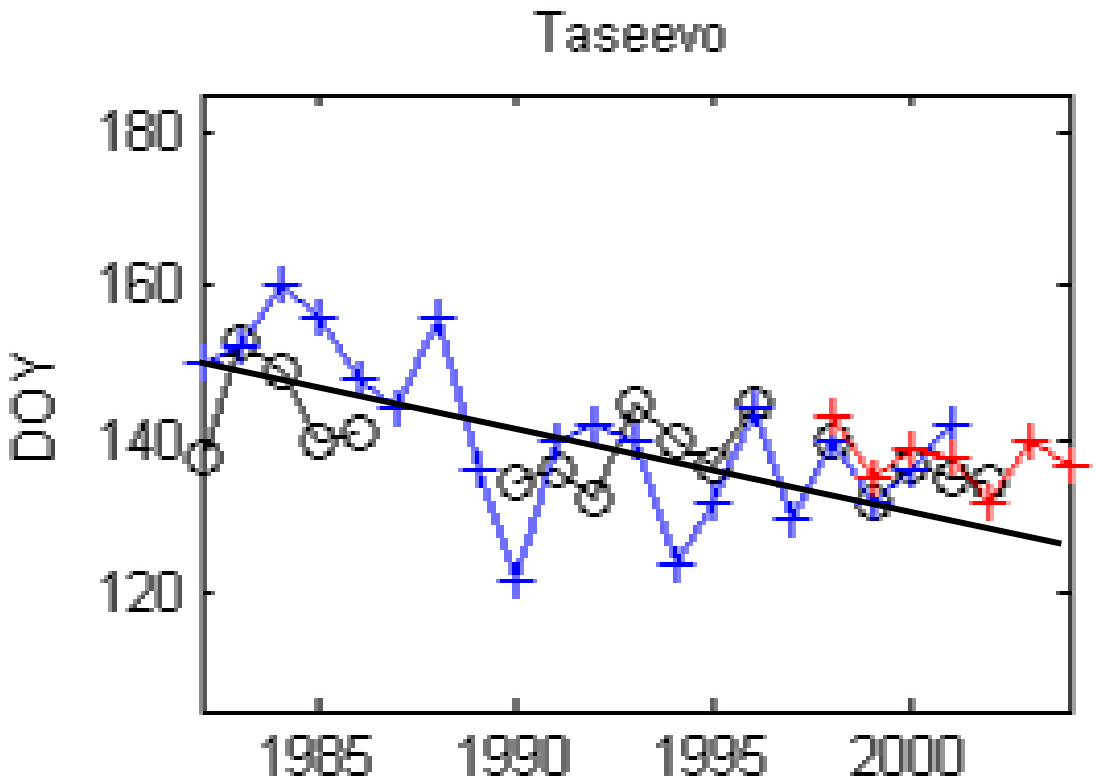
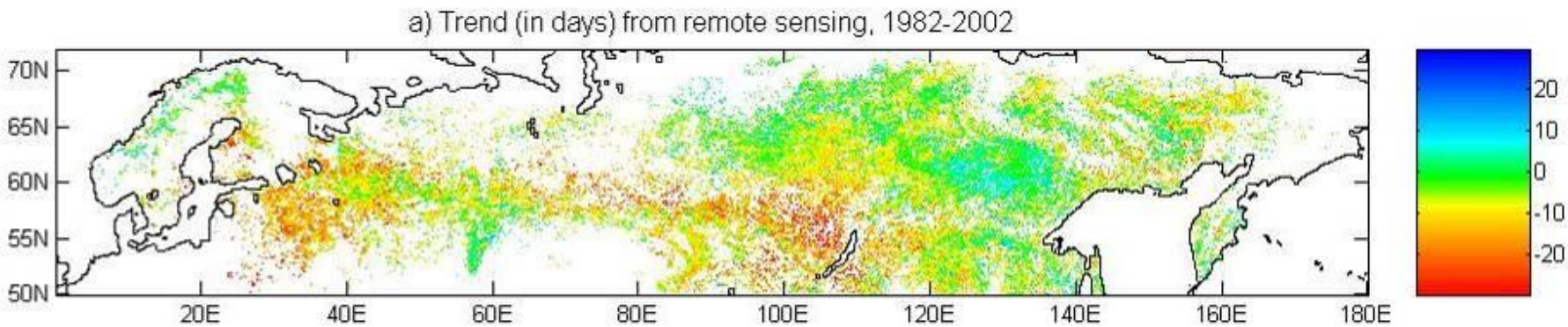
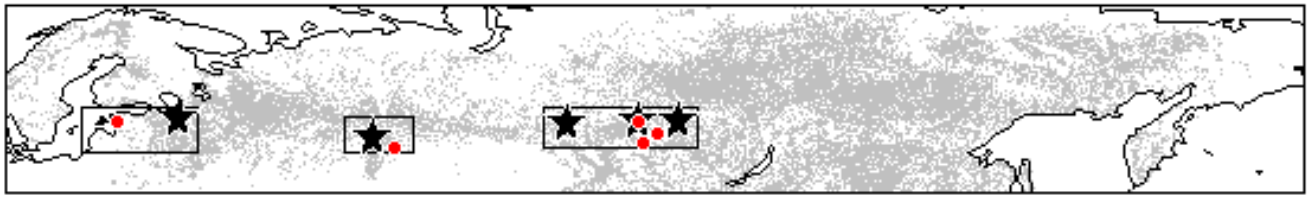

2005
200
150
100


Taseevo
DOY
180
160
140
120
1985
1990
1995
2000

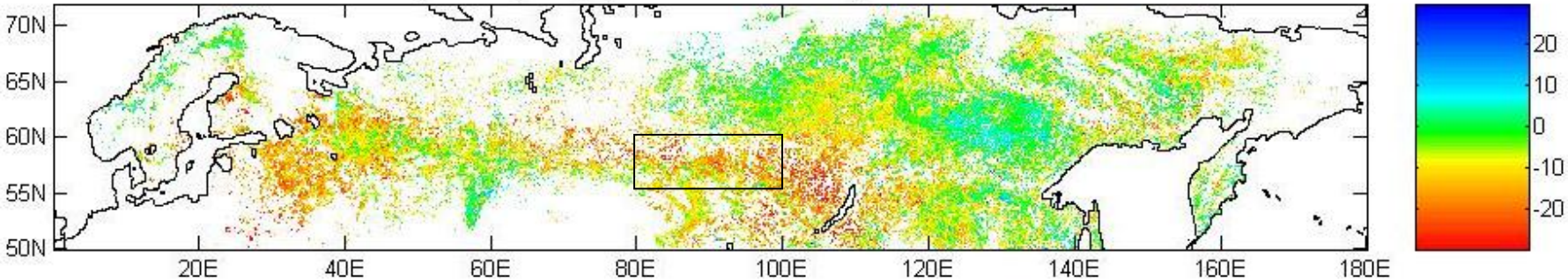

a) Trend (in days) from remote sensing, 1982-2002
70N
65N
60N
55N
50N
20E
40E
60E
80E
100E
120E
140E
160E
180E
20
10
0
-10
-20

Phenology in Central Siberia, 1920-2005

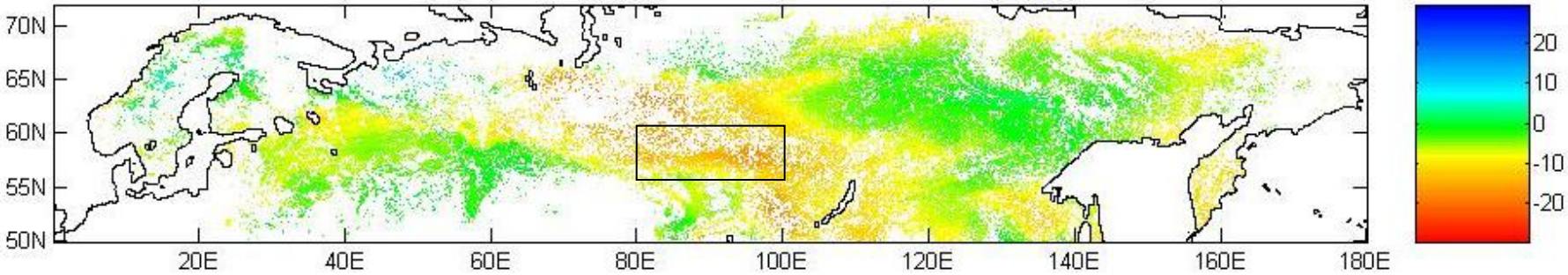
e)



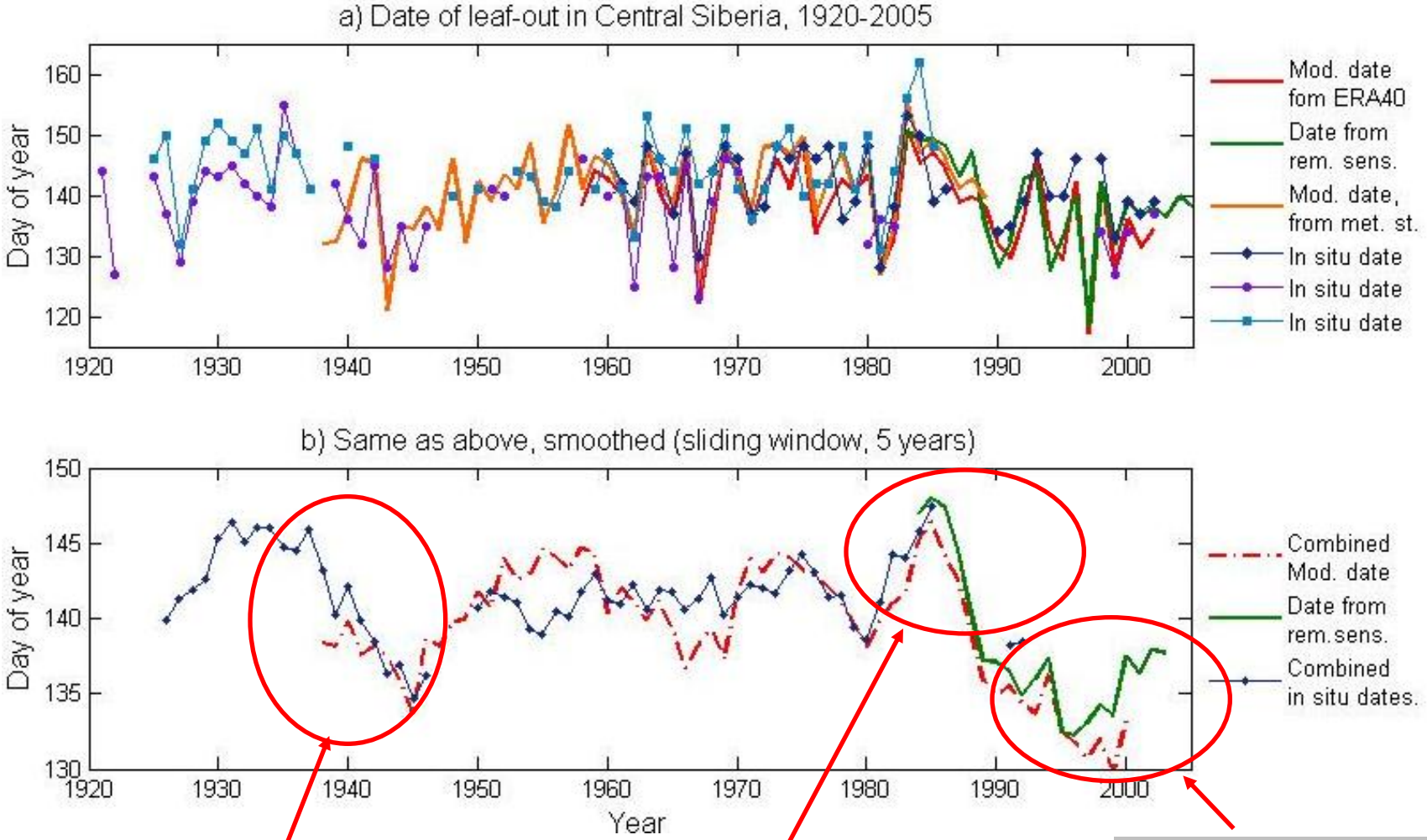
a) Trend (in days) from remote sensing, 1982-2002



b) Trend (in days) from model, 1982-2002



Phenology in Central Siberia, 1920-2005



Another "greening trend" in 1938-1944

The greening trend in 1982-1990 is partially due to exceptionally late leaf appearance in 1983-1984

The dates in the 1990's have been the earliest since 1921

Contribution to ongoing projects

- CLASSIQUE : climate, agriculture, society in Siberia.
- Remote sensing of Phenology : calibration of vegetation model.

Thanks!