Earth System Monitoring and Modelling

SIBERIA-II
Multi-Sensor Concepts for Greenhouse Gas Accounting in Northern Eurasia

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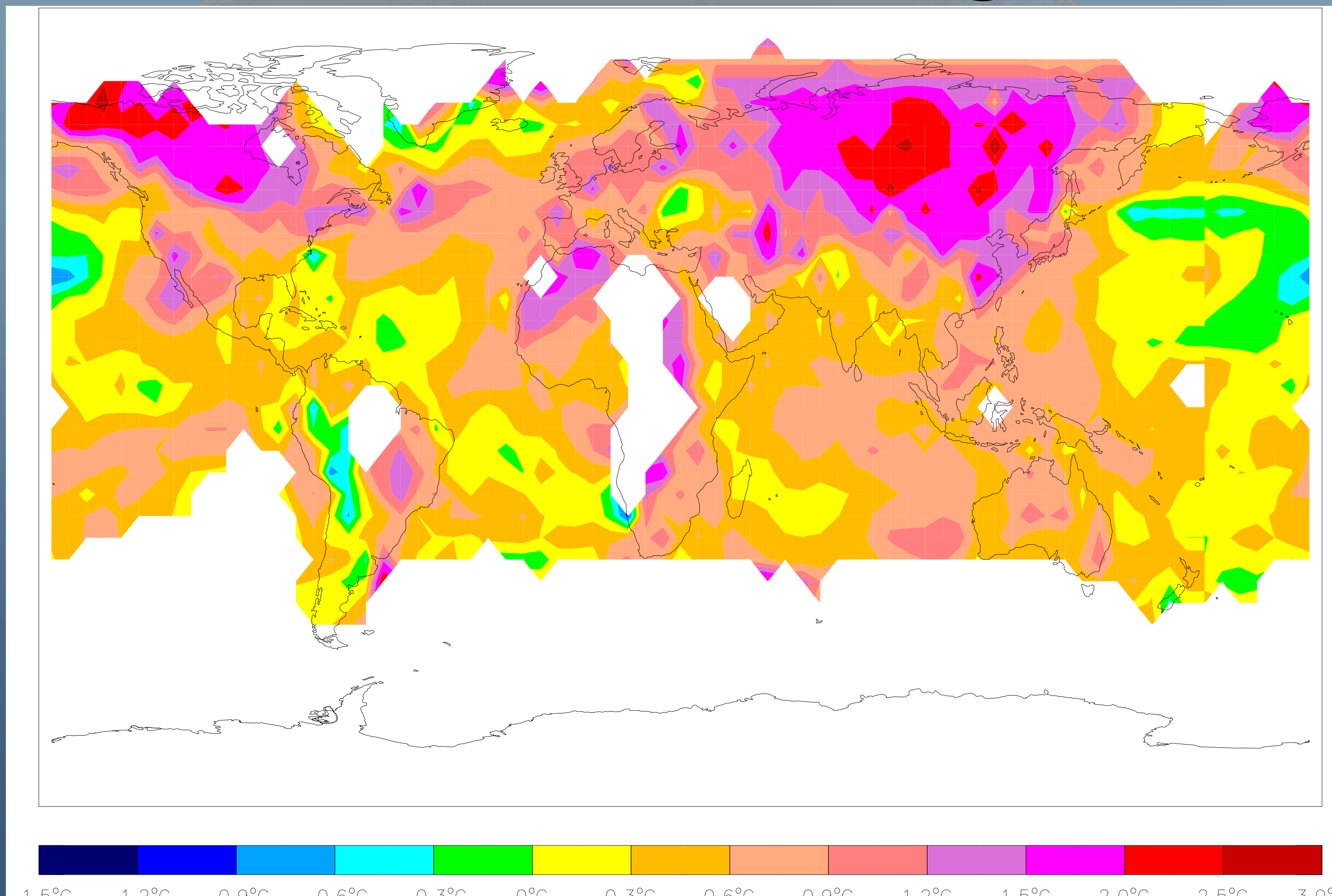
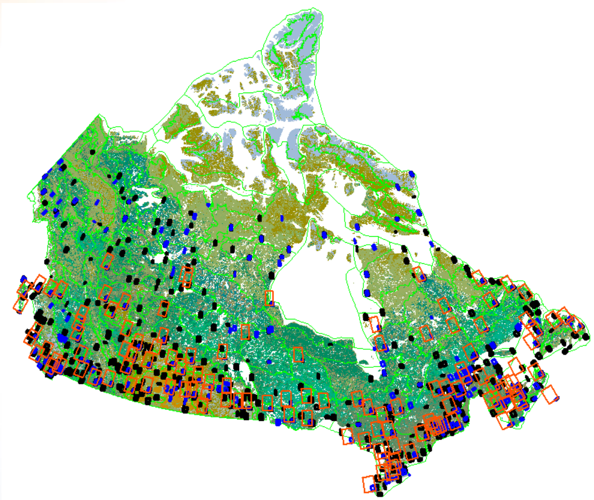
Mean Temperature Change 1965 to 2002 over the globe

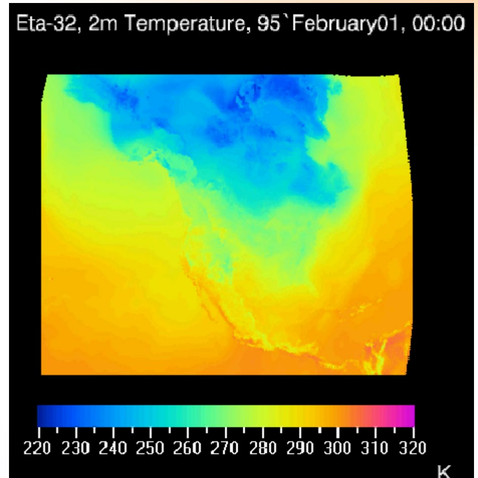


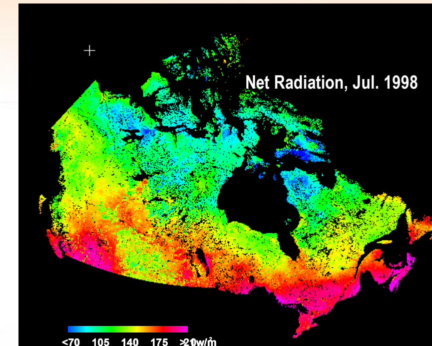
Data source: http://www.cru.uea.ac.uk/cru/data/temperature/

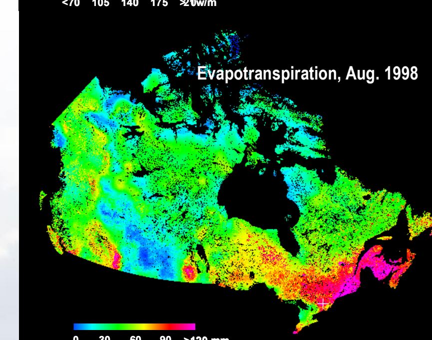
Processed by the U.S. NCDC Global Climate at the Glance Mapping System

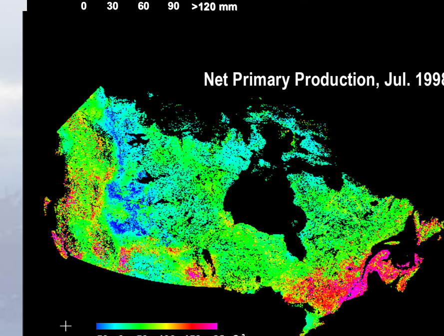
Canada Wide Observations and Modelling

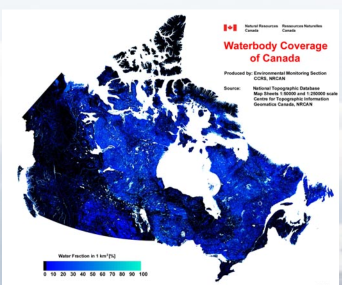


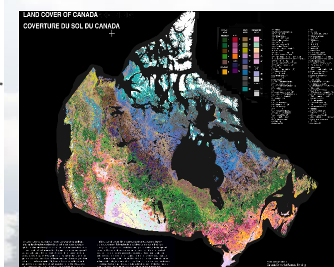


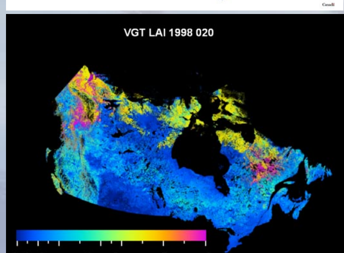


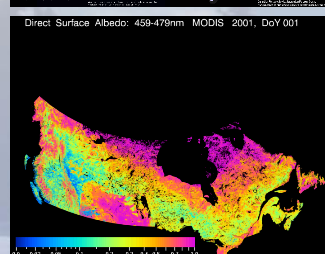


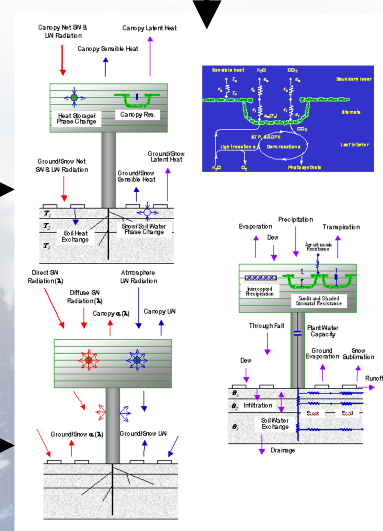






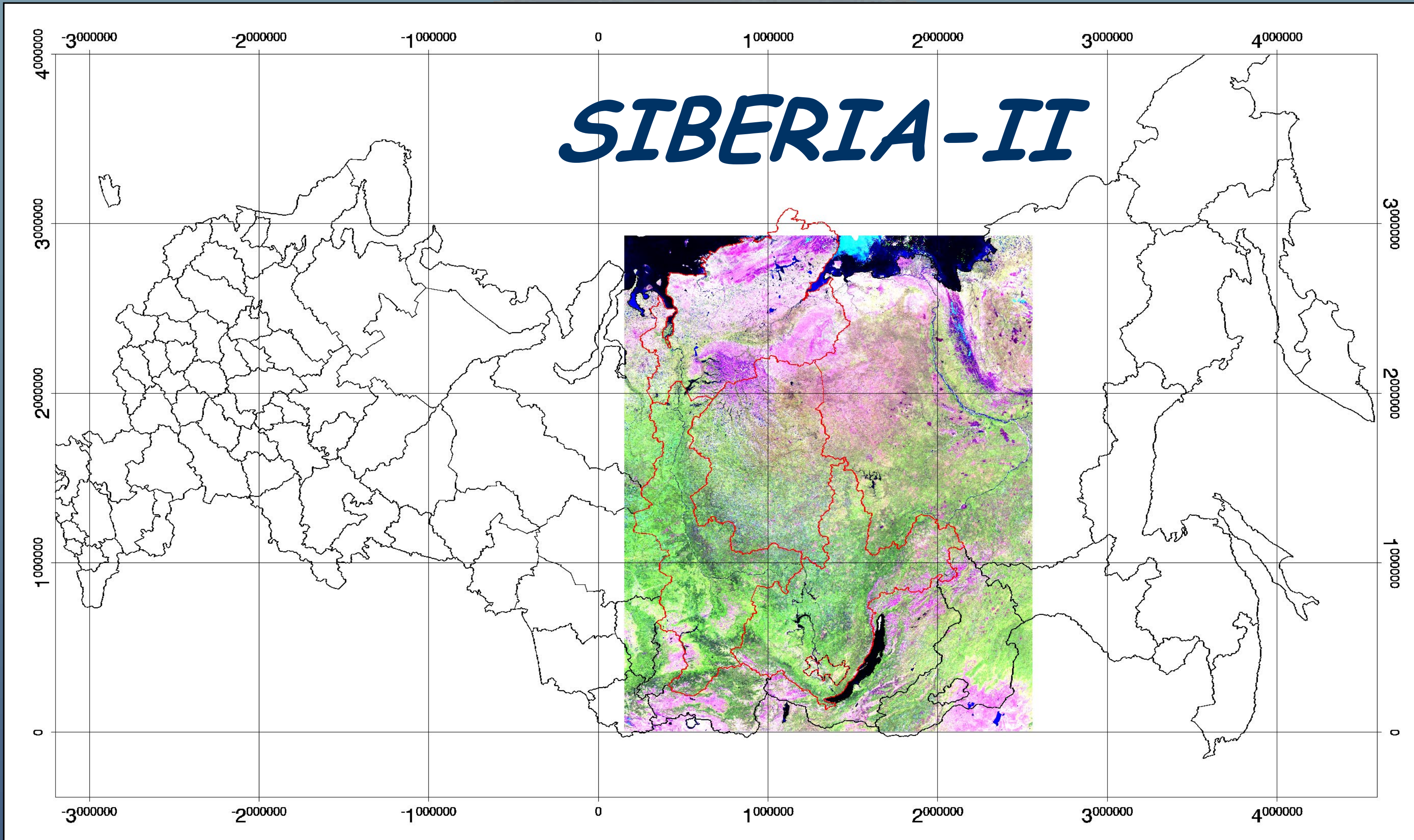






Source: Wang, Fernandes

SIBERIA-II



Multi-Sensor Concepts for Greenhouse Gas Accounting of Northern Eurasia

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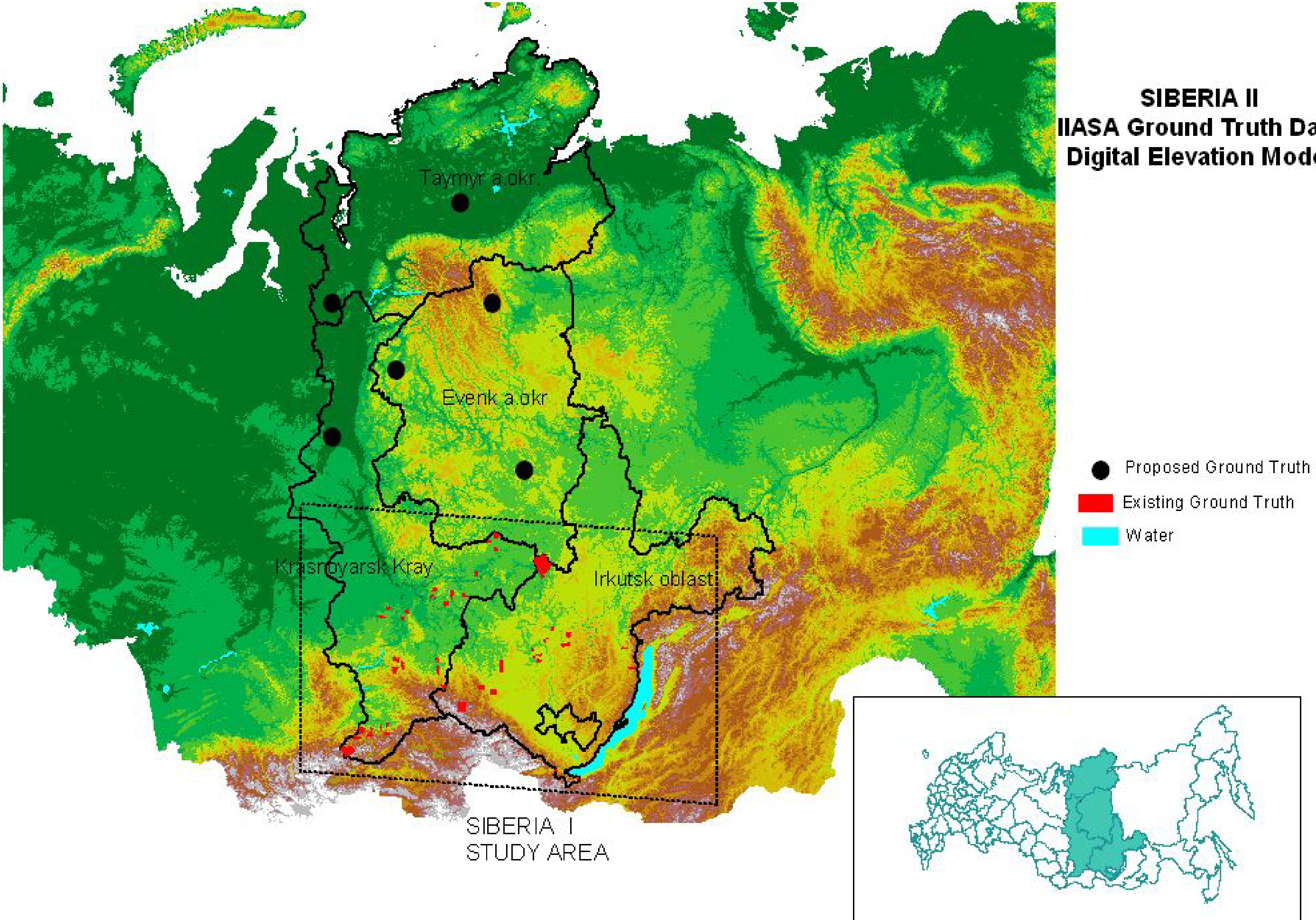
SIBERIA II
IIASA Ground Truth Dat
Digital Elevation Model
Taymyr a.okr.
Evenk a.okr
Krasnoyarsk Kray
Irkutsk oblast
Proposed Ground Truth
Existing Ground Truth
Water
SIBERIA I
STUDY AREA

Location of SIBERIA-I Classification within SIBERIA-II

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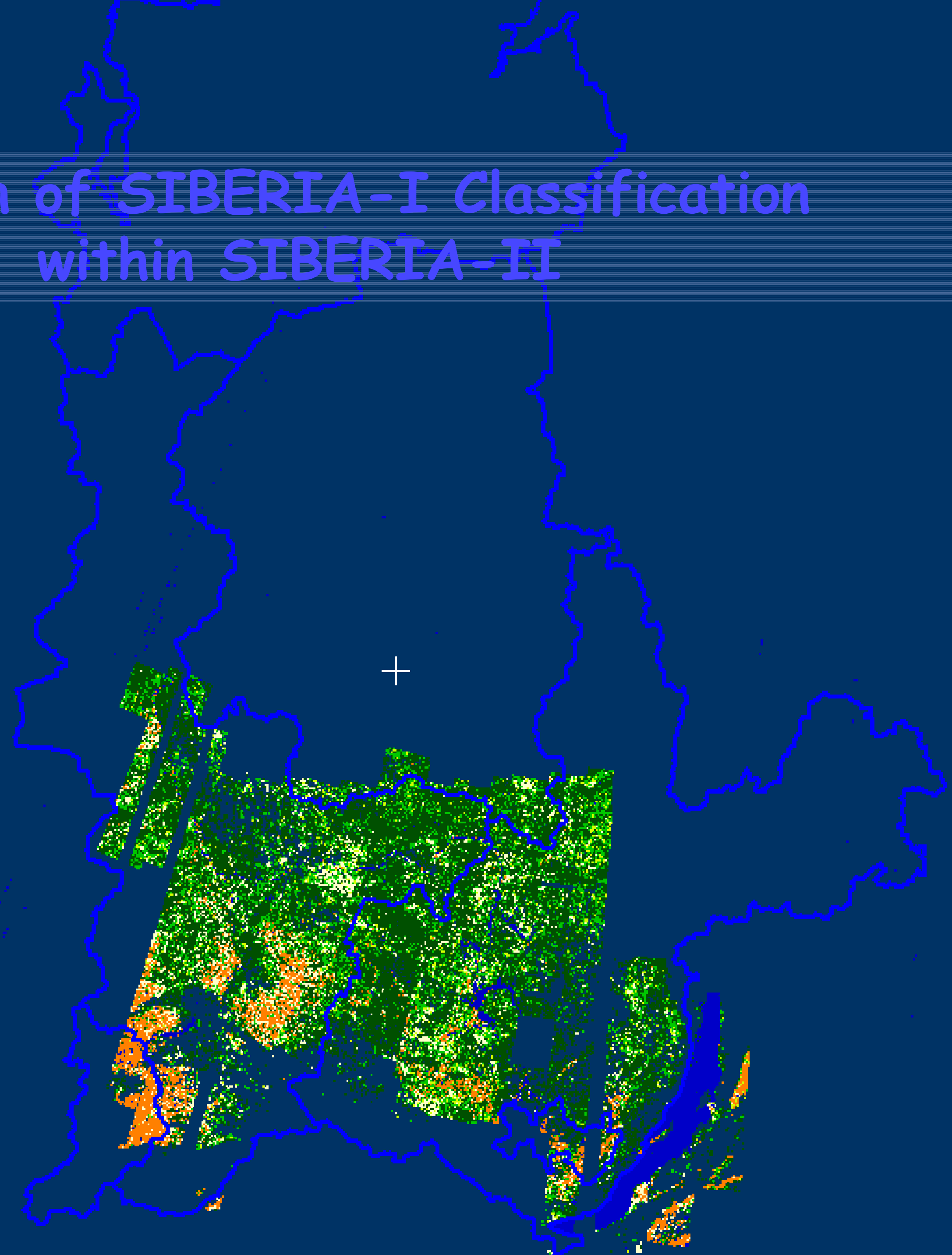
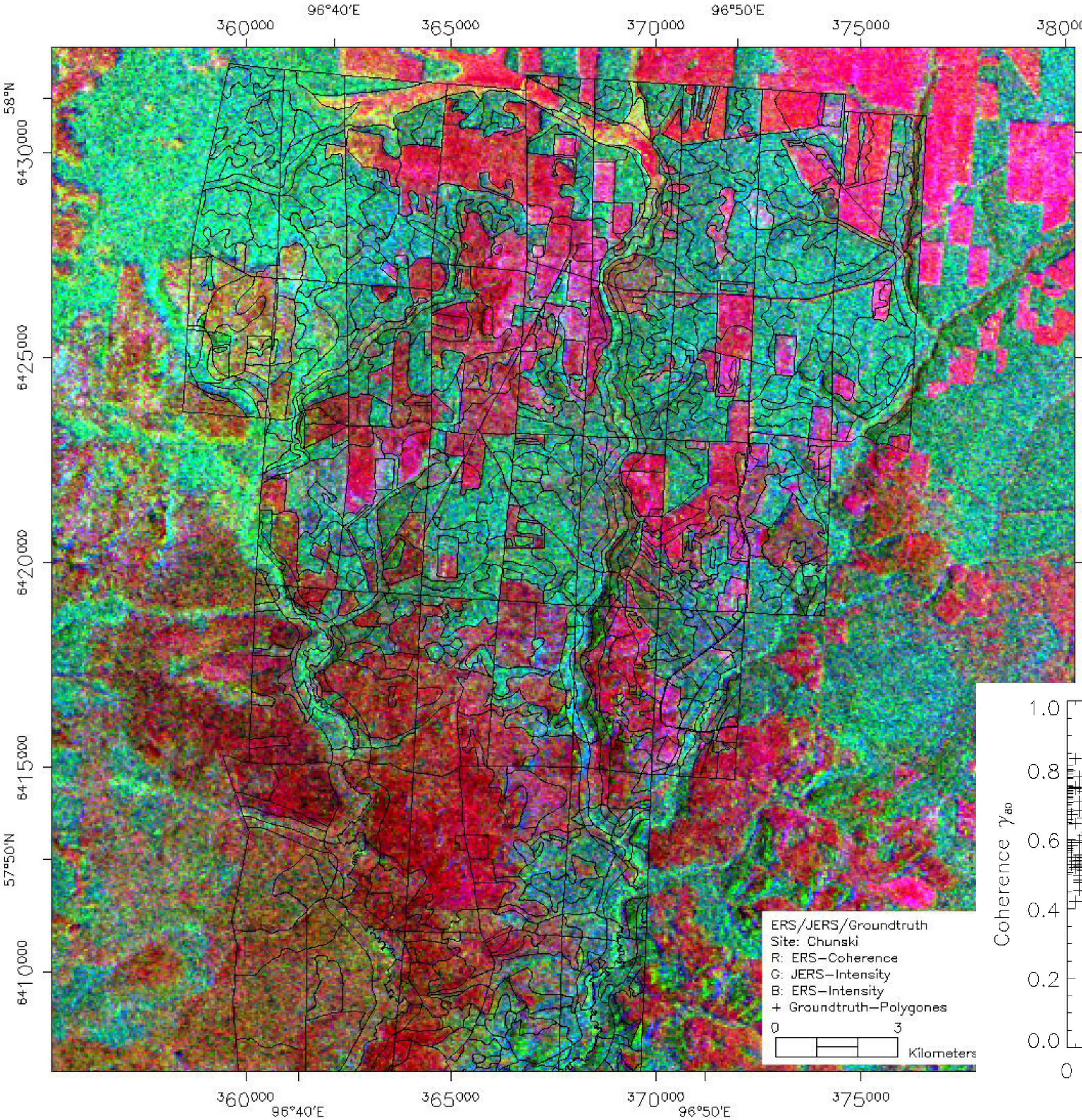
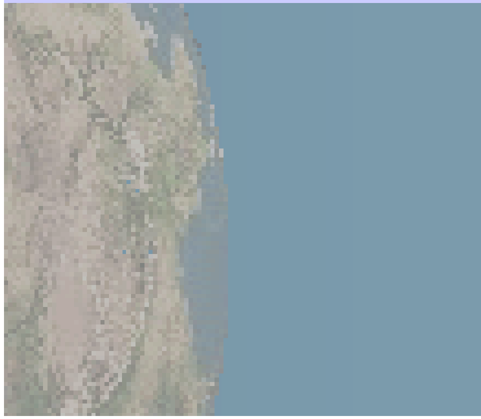
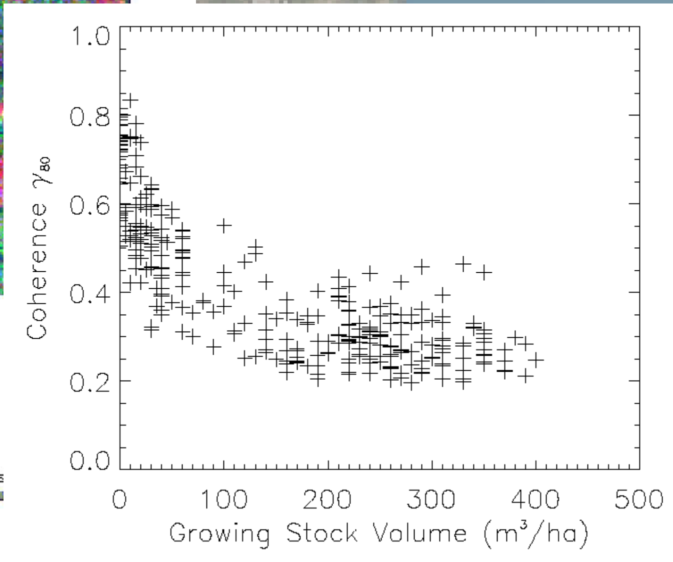
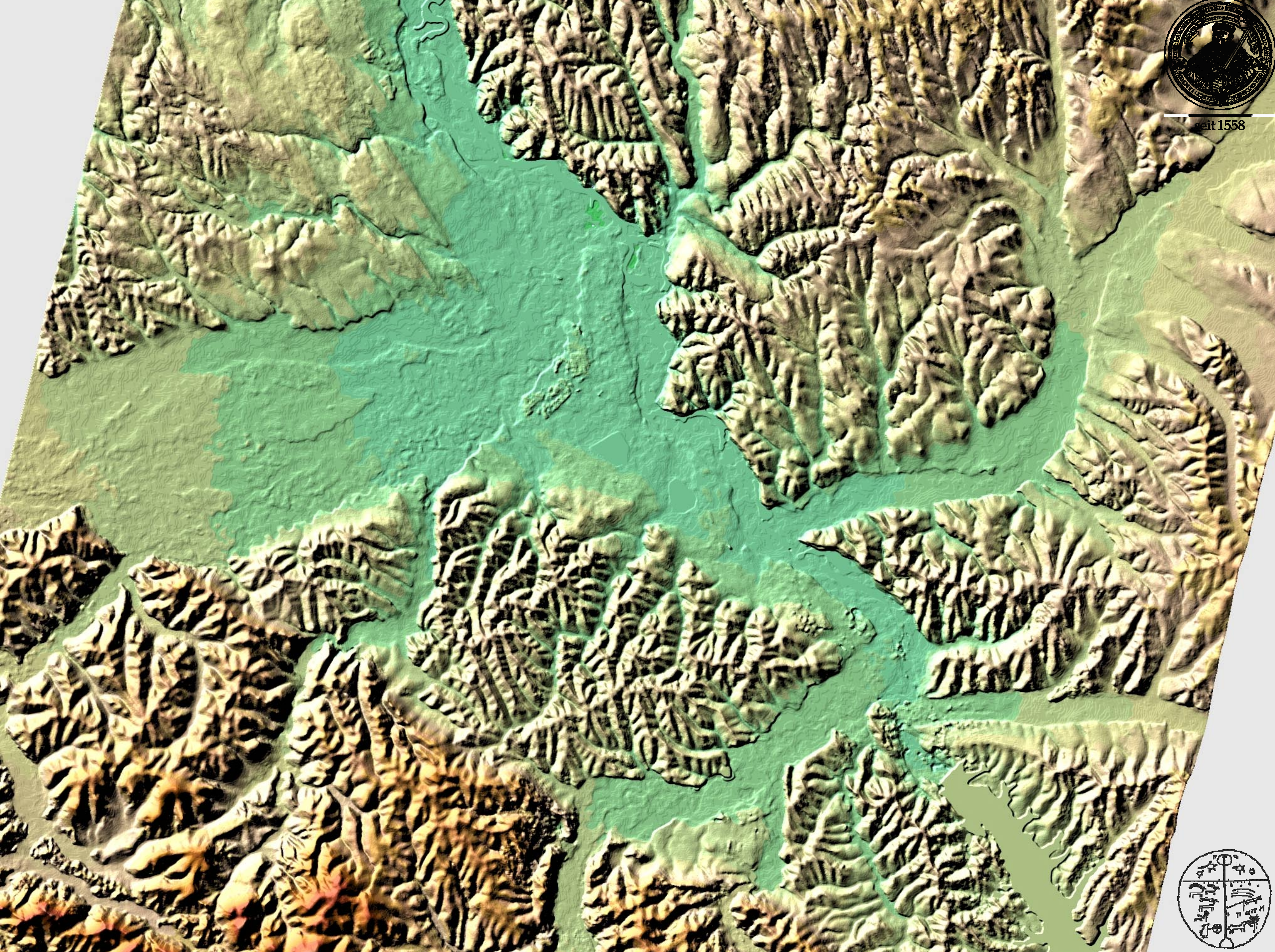


Co-registered Forest-GIS Polygons









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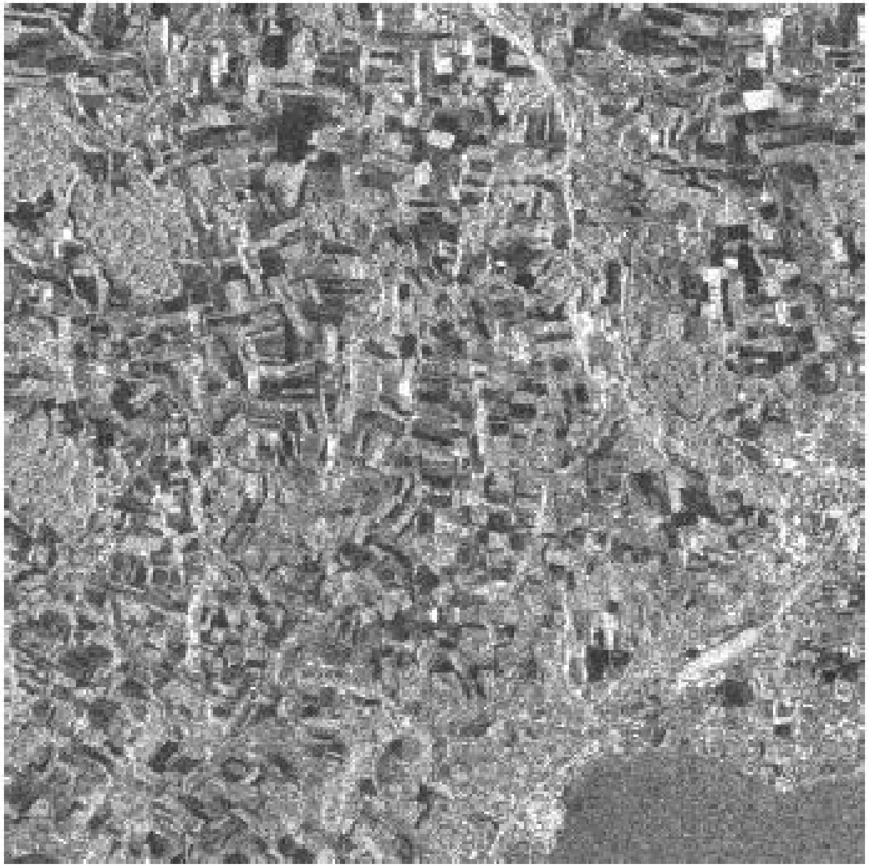
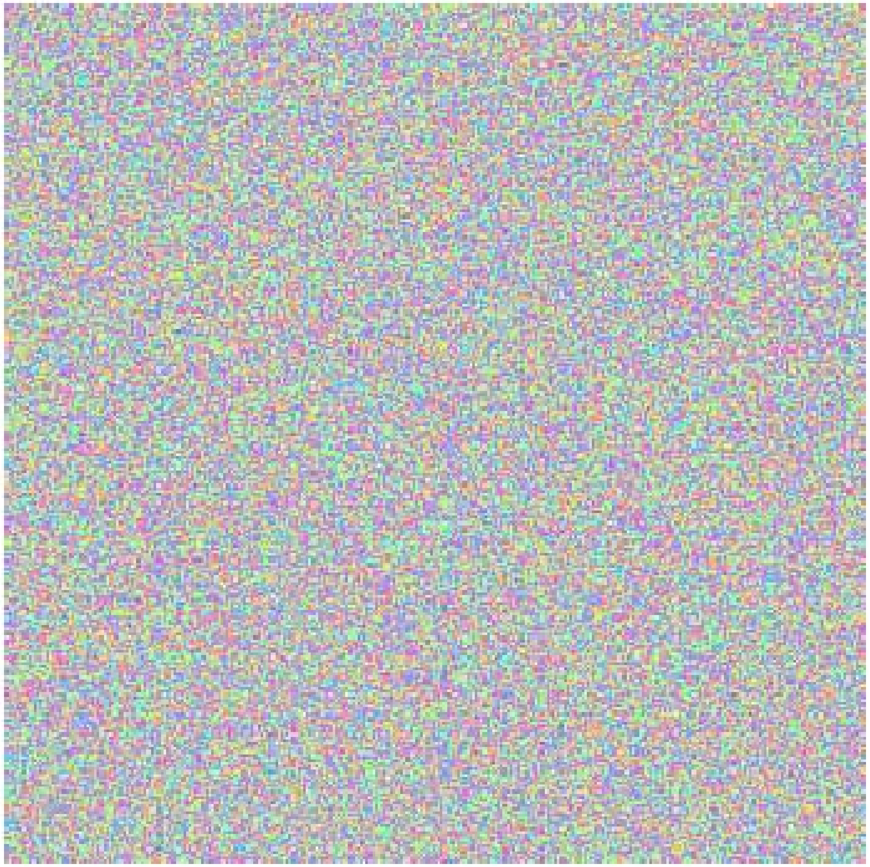
SAR images



Magnitude: backscattering intensity
many scatterers → speckle



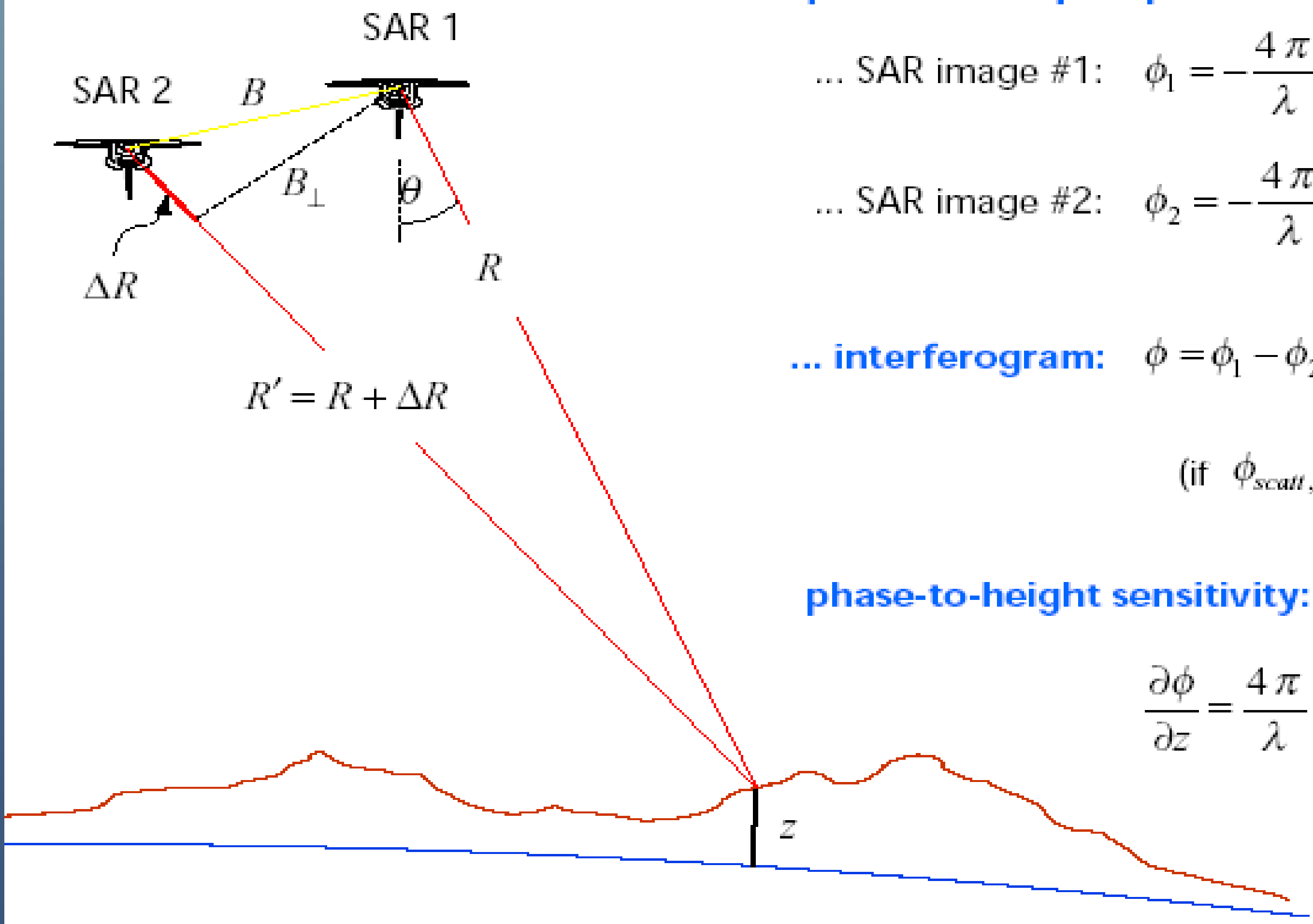
Phase: propagation time + scatter term
only known modulo 2π → white noise

Strozzi, T., InSAR Sommerschule 2002

SAR Interferometry ....

... combines two or more complex-valued SAR images to derive more information about the imaged objects (compared to using a single image) by exploiting phase differences.

⇒ Images must differ in at least one aspect (= "baseline")



phase of complex pixel in ...

... SAR image #1: $\phi_1 = -\frac{4\pi}{\lambda} R + \phi_{scatt,1}$

... SAR image #2: $\phi_2 = -\frac{4\pi}{\lambda} (R + \underline{\Delta R}) + \phi_{scatt,2}$

... interferogram: $\phi = \phi_1 - \phi_2 = \frac{4\pi}{\lambda} \Delta R$

(if $\phi_{scatt,1} = \phi_{scatt,2}$!)

phase-to-height sensitivity:

$$\frac{\partial \phi}{\partial z} = \frac{4\pi}{\lambda} \frac{B_\perp}{R \sin\theta}$$

Bamler, R., InSAR Sommerschule 2002

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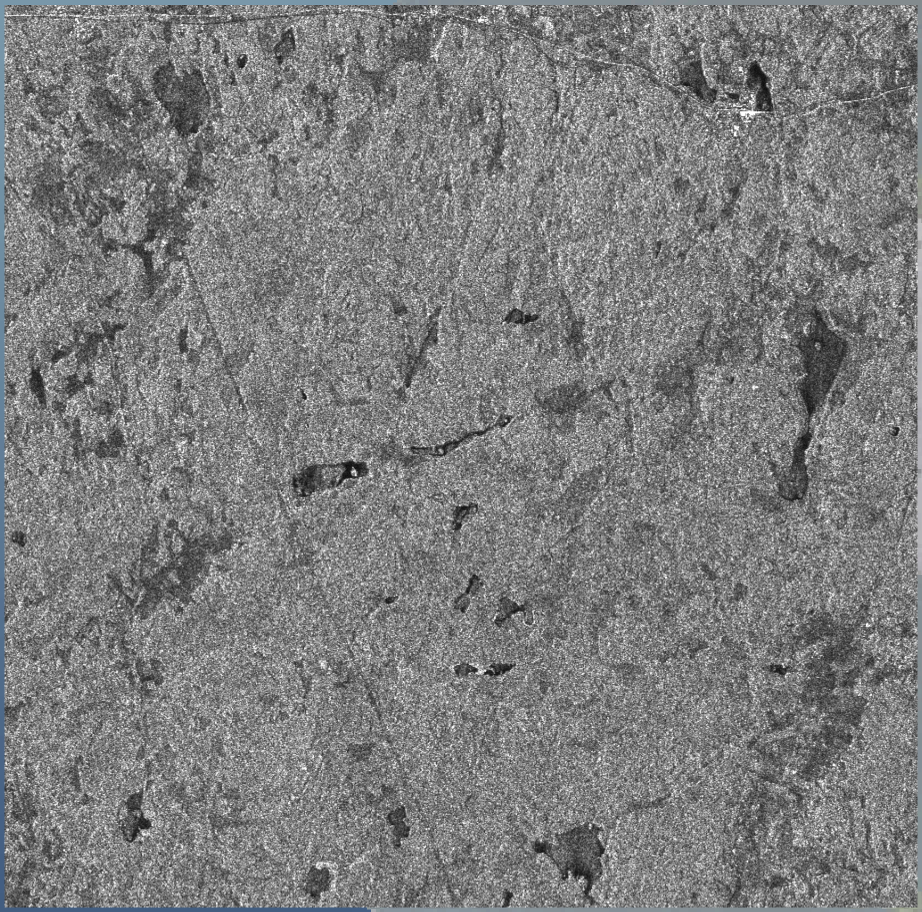
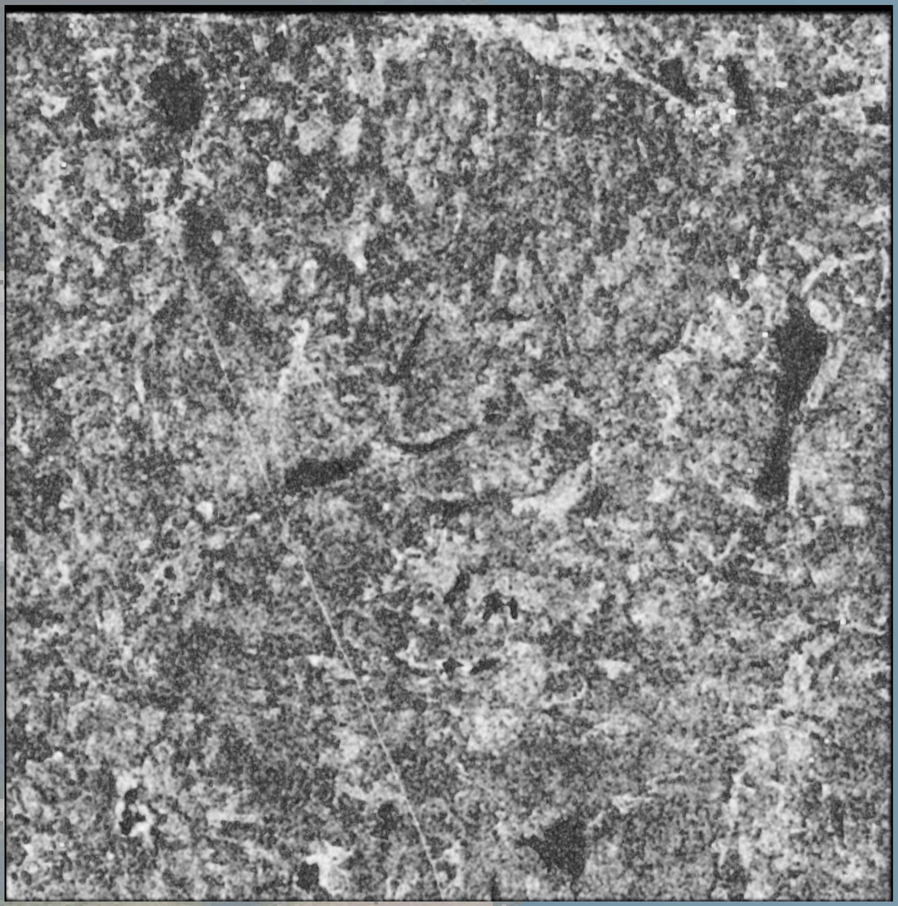
SAR and InSAR images

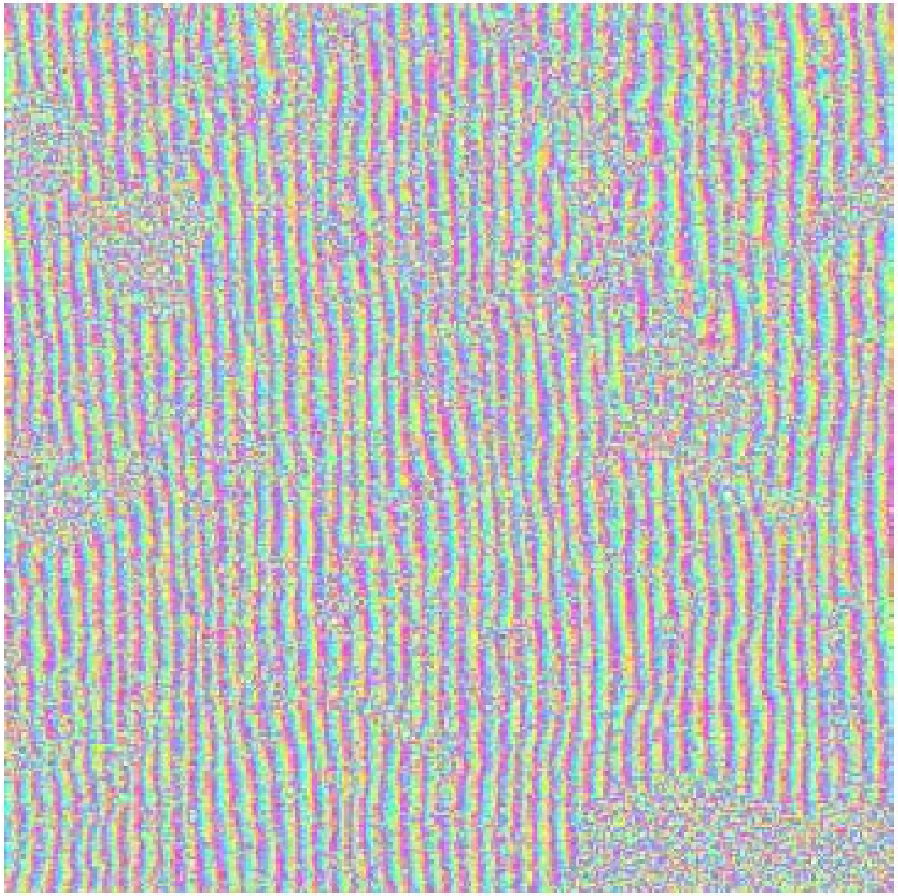


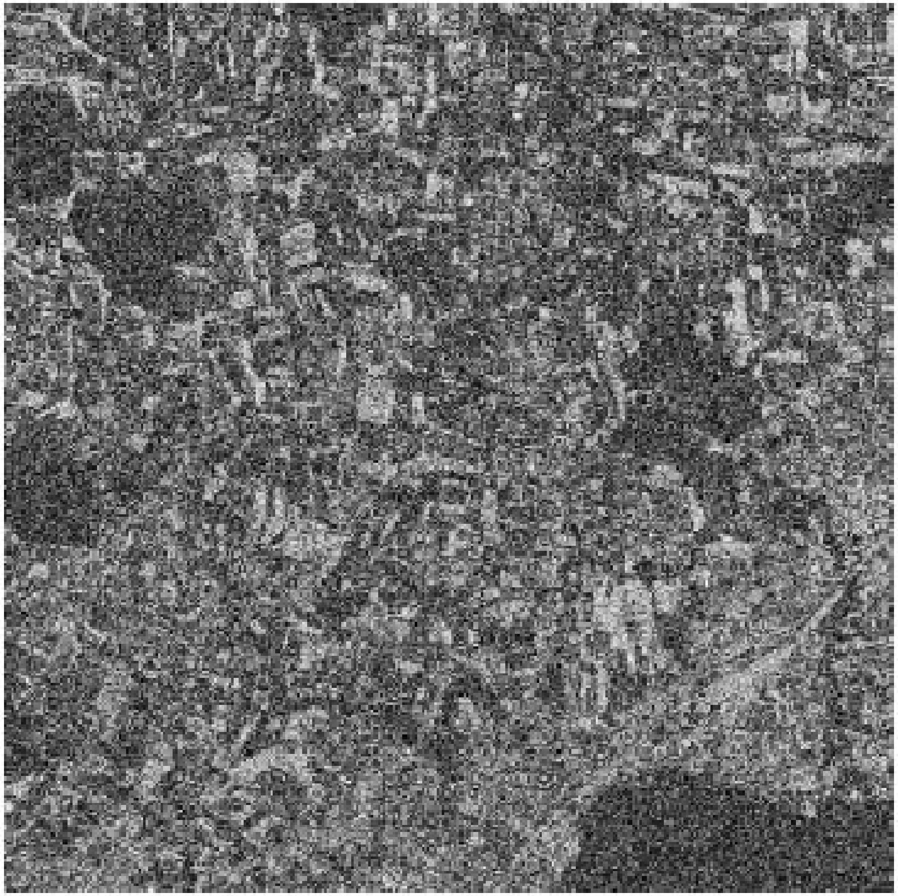
ERS backscatter



ERS „tandem“ coherence

InSAR images

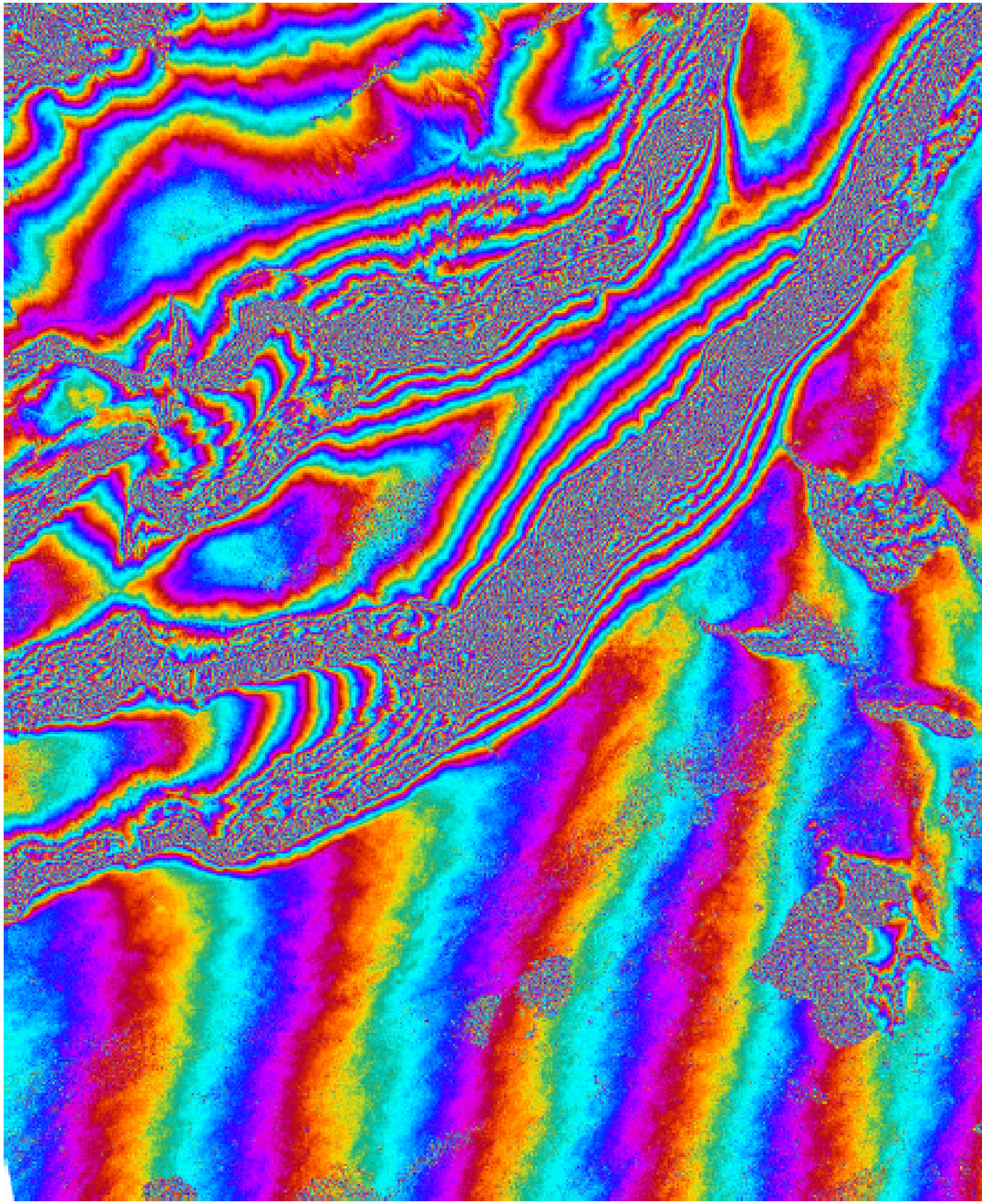




ERS InSAR phase

ERS „tandem“ coherence

Strozzi, T., InSAR Sommerschule 2002



Interferometric Phase

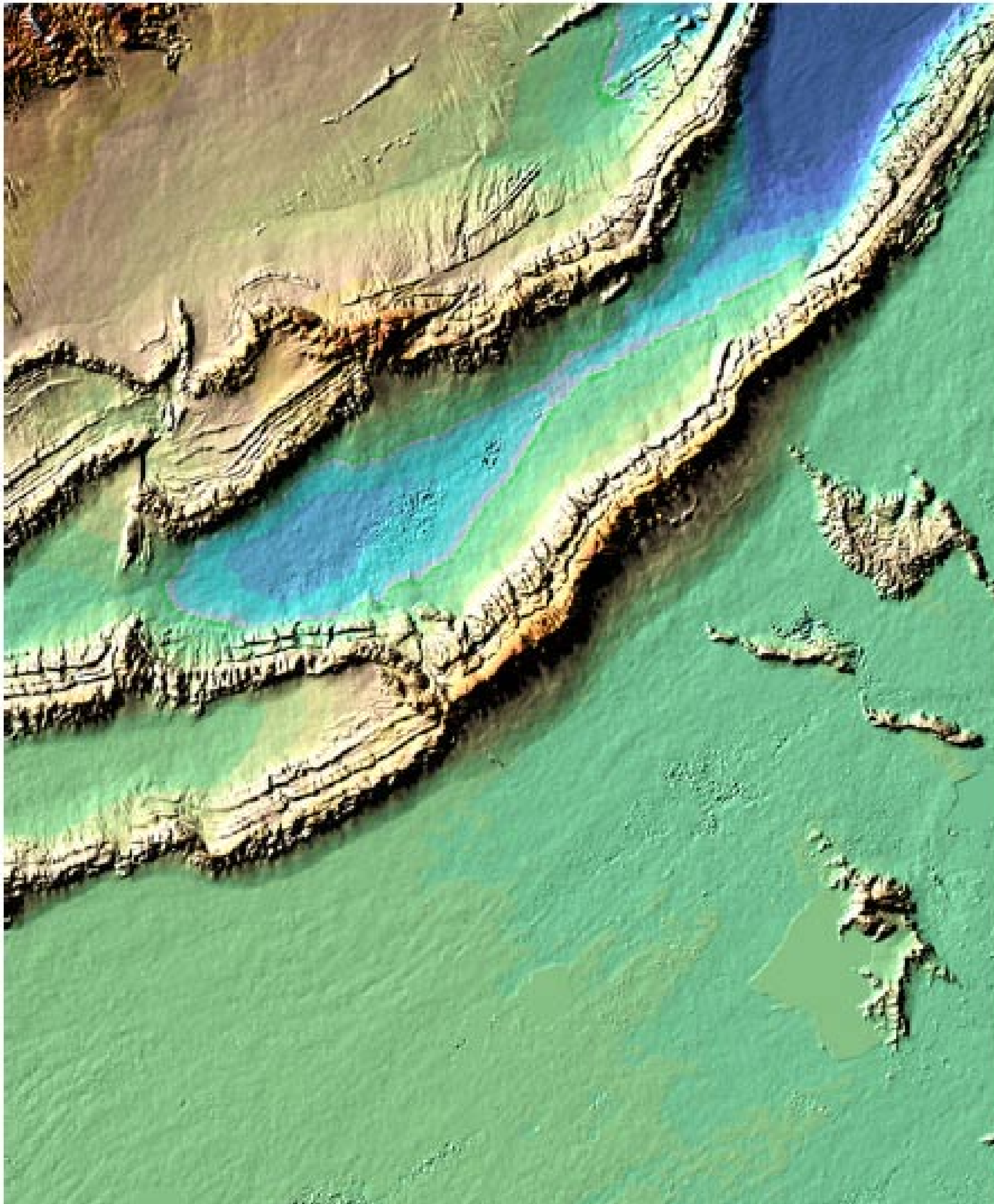
Bachu, China

approx. 100 km × 80 km

ERS-1/2 data © ESA

DLR

Bamler, R., InSAR Sommerschule 2002



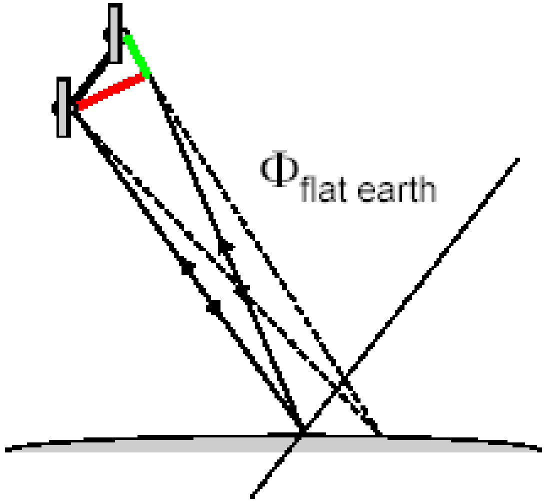
InSAR DEM (ERS-1/2)

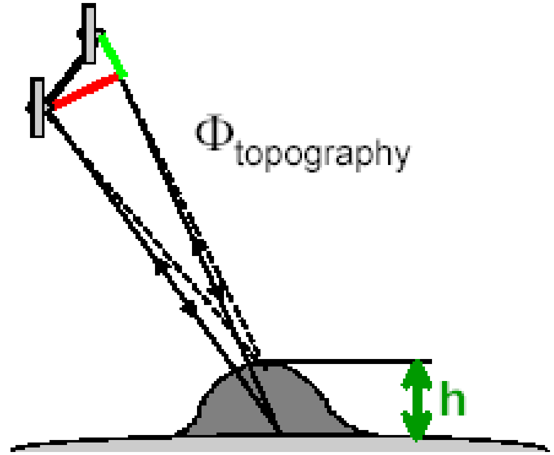
Bachu, China

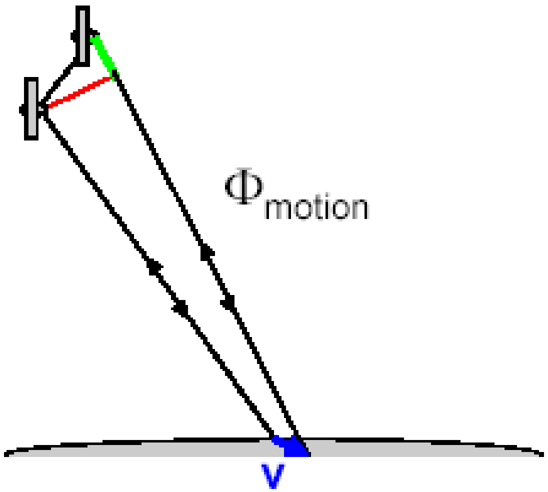
approx. 100 km × 80 km

Bamler, R., InSAR Sommerschule 2002

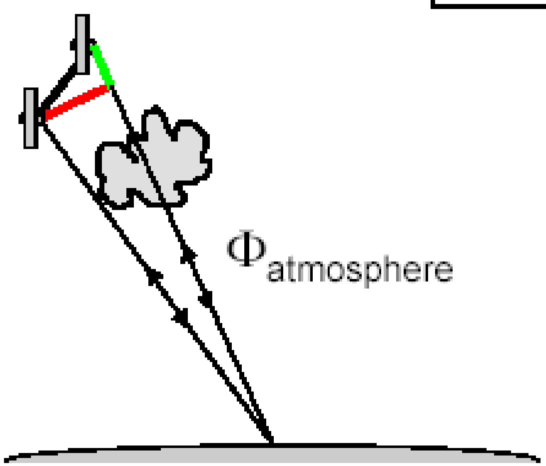
Beiträge zur interferometrischen Phase







$$\Phi = \Phi_{flat earth} + \Phi_{topography} + \Phi_{motion} + \Phi_{atmosphere} + \Phi_{noise}$$



$$\Phi_{flat\ earth} = \frac{4\pi B_{\parallel}}{\lambda}$$

$$\Phi_{topography} \approx \frac{4\pi B_{\perp}}{\lambda} \frac{h}{r \sin\theta}$$

$$\Phi_{motion} = \frac{4\pi}{\lambda} \langle \mathbf{n}_{LOS} \cdot \mathbf{v} \Delta t \rangle$$

Coherence contributions

The coherence depends on sensor parameters, parameters related to the imaging geometry and target parameters:

$$|\gamma| = \gamma_{thermal} \cdot \gamma_{spatial} \cdot \gamma_{temporal}$$

$\gamma_{thermal}$: influence of the signal-to-noise ratio

$\gamma_{spatial}$: spatial decorrelation related to the imaging geometry (interferometric baseline, local incidence angle)

$\gamma_{temporal}$: temporal decorrelation

Strozzi, T., InSAR Sommerschule 2002

SIBERIA Methodological Objectives

Analysis of the available radar data with the help of ground data
- **to define the forest information provided by the radar data,**
- **to develop efficient and effective methods to extract that information.**

The methods needed to be:

automatic — because of the large amount of data to be handled (550 ERS and 890 JERS scenes)

adaptive — because of changes in image properties between scenes, caused by imaging geometry and environmental variations

consistent — so that the assignment of information would not be scene dependent

validated — so that some degree of confidence could be assigned to the results

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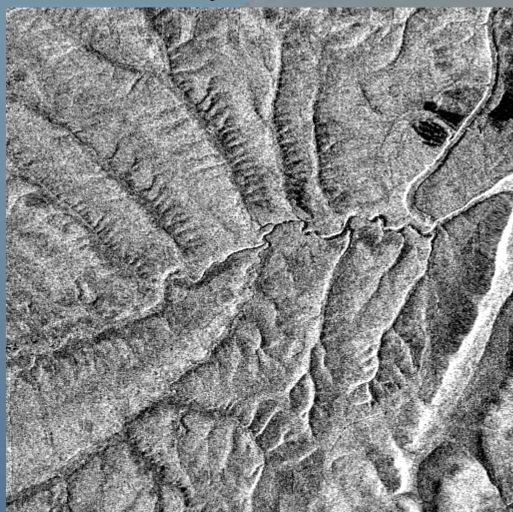
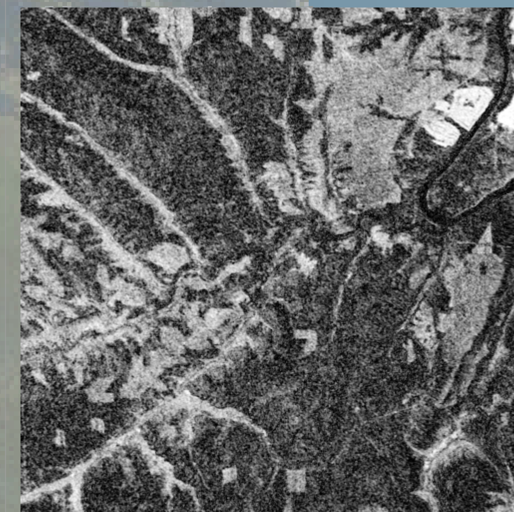
Classification Source Data

ERS intensity



JERS intensity

ERS Tandem Coherence



- Small dynamic range
- Variable response to water
- Variable response to open areas
- Can be used as indicator of environmental effects effecting the coherence

•Medium dynamic range

•Stable response to water

•Possible to identify agricultural fields

•Higher frame to frame variations

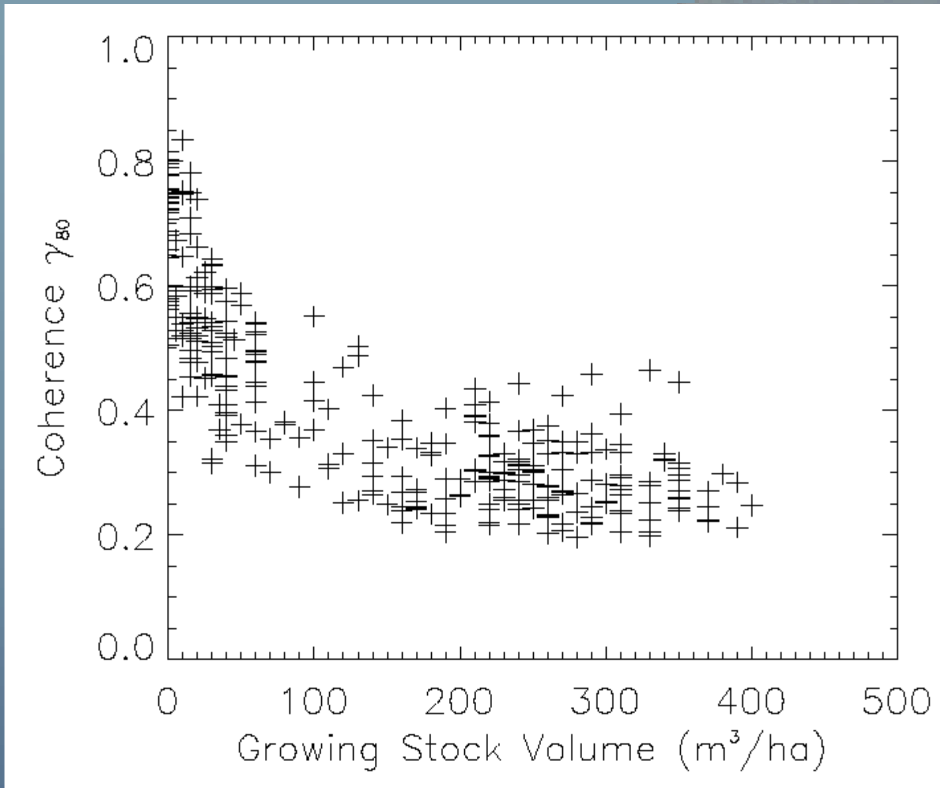
•Higher contrast between forest/non forest

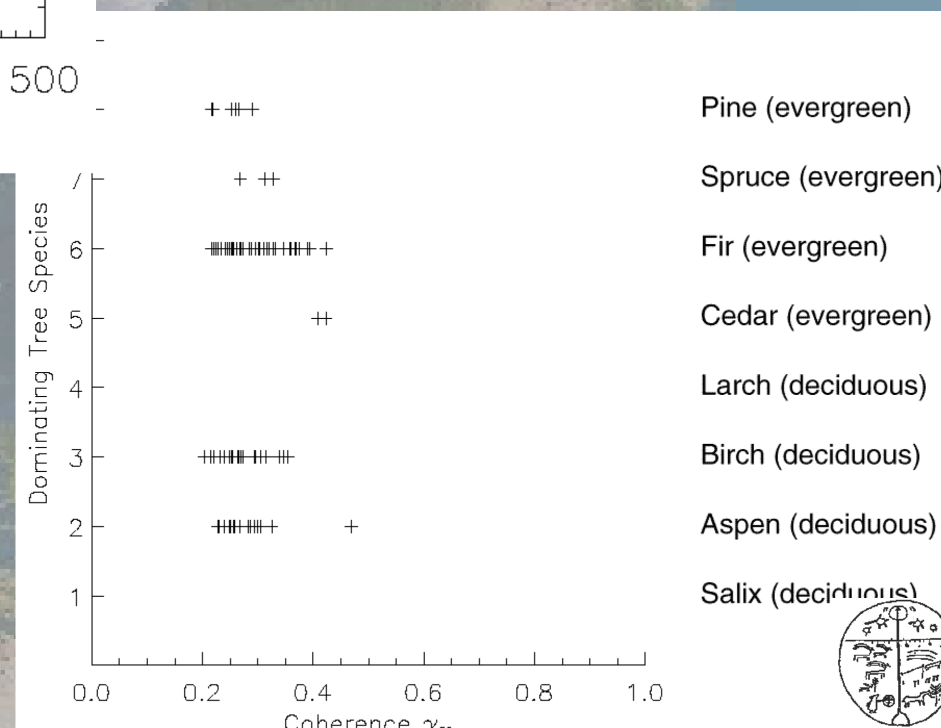
•Higher sensitivity to forest volume

•Confusion between water and dense forest

•Frame to frame variations

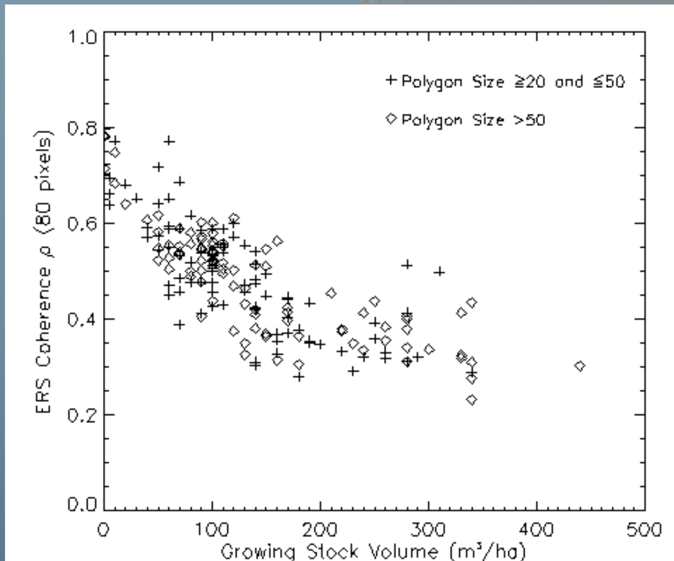
(L. Eriksson)

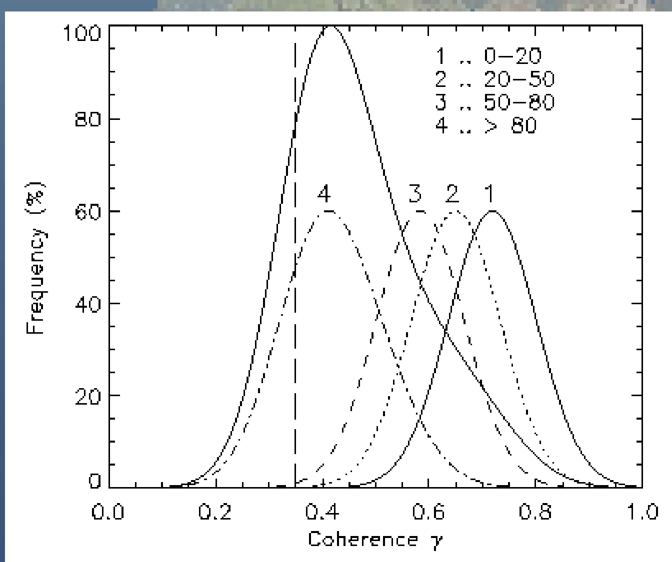

1.0
0.8
0.6
0.4
0.2
0.0
Coherence γ80
0
100
200
300
400
500
Growing Stock Volume (m³/ha)


Pine (evergreen)
Spruce (evergreen)
Fir (evergreen)
Cedar (evergreen)
Larch (deciduous)
Birch (deciduous)
Aspen (deciduous)
Salix (deci
Dominating Tree Species
1
2
3
4
5
6
0.0
0.2
0.4
0.6
0.8
1.0
Coherence γ80

Model definition for coherence

(Wagner, Vietmeier et al.)





$$\gamma(v) = \gamma_\infty + (\gamma_0 - \gamma_\infty) \cdot e^{-\frac{v}{V_\gamma}}$$

$$\gamma_\infty \approx \gamma_{75}$$

$$\gamma_0 = a_\gamma + b_\gamma \cdot \gamma_{75}$$

$$\gamma(v) = \gamma_{75} + \left(a_\gamma + (b_\gamma - 1)\gamma_{75}\right) \cdot e^{-\frac{v}{V_\gamma}}$$

$$\gamma(v) = \gamma_{75} + \left(0.330 + 0.581 \cdot \gamma_{75}\right) \cdot e^{-\frac{v}{122.1}}$$

v = growing stock volume

γ_0 = coherence at v = 0 m^3/ha (non-forest)

γ_∞ = coherence for asymptotic values of v (corresponding to dense forest)

γ_{75} = value where the coherence distribution reach 75% of the maximum value (see fig.)

V_γ = characteristic v value where the exponential function has decreased by e^{-1}

Correspondence Siberia Land Category and Radar retrieved Land Category

Forest classes:

Natural stand

Unclosed natural forest

Low productivity forest

Forest plantationsparse forest

Burned forest

Clearcut area

Non forest

Bogs

Agriculture, hay

Agriculture, pasture

Smooth fields, sand bars

Lake, stream

Forest Volume class:

>80 m3/ha

50-80 m3/ha

20-50 m3/ha

0-20 m3/ha

Non forest

Open

Smooth open areas

Water

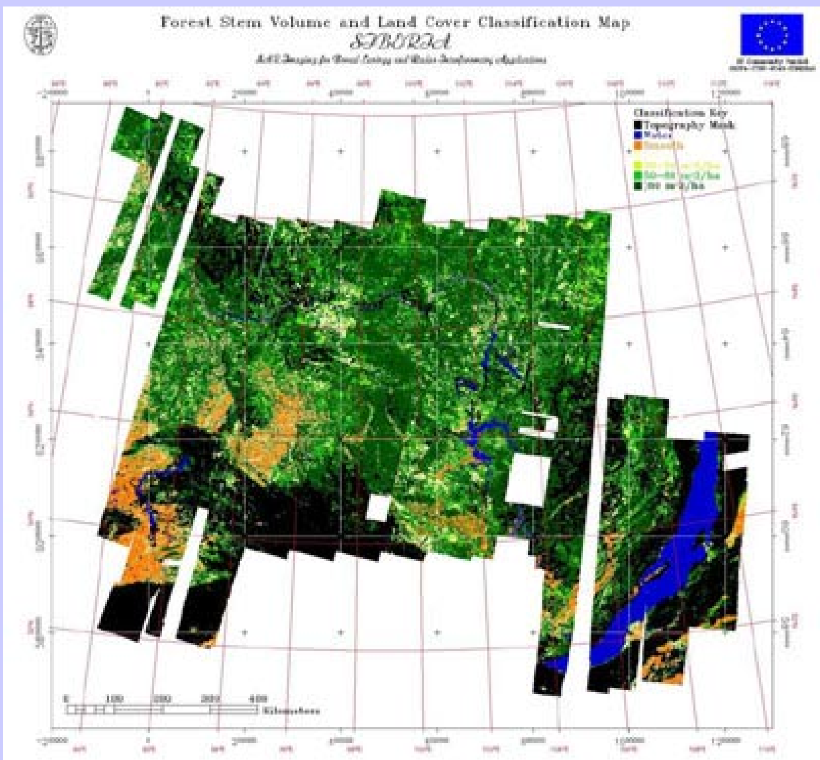
Independent Russian Field Data

	Ground validation					
Earth Obs. Results	<20 m3/ha	20-50 m3/ha	50-80 m3/ha	>80 m3/ha	Total	User accuracy
<20 m3/ha	908	36	5	9	977	93 %
20-50 m3/ha	76	576	39	15	707	81 %
50-80 m3/ha	12	33	881	58	984	90 %
>80 m3/ha	0	9	120	2182	2311	94 %
Total	1016	655	1045	2264	5232	95 %
Producer accuracy	89 %	88 %	84 %	96 %	95 %	91%

Pooled confusion matrix for the 7 Russian test areas. $\kappa_w = 0.94$.

Vegetation Data Resources

Above Ground Biomass



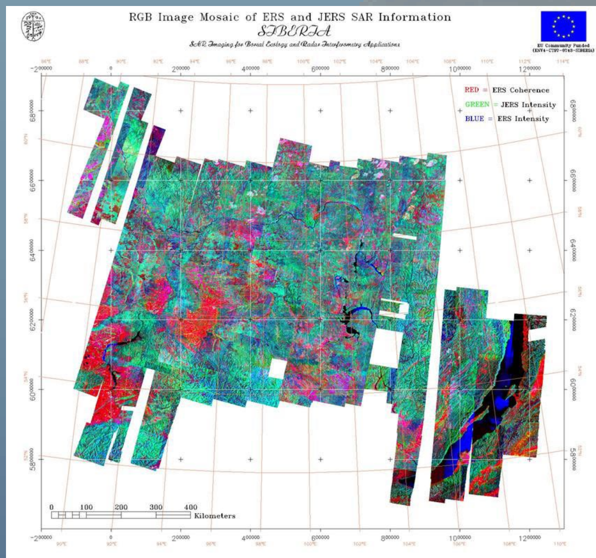
Nothing as yet global and accessible as Above Ground Biomass

Regional - SIBERIA (1mio km^2 at 50m, 1998) based on SAR Interferometry

Future - SIBERIA-II (from 2002-5)
Other SAR methods
ESSP VCL?

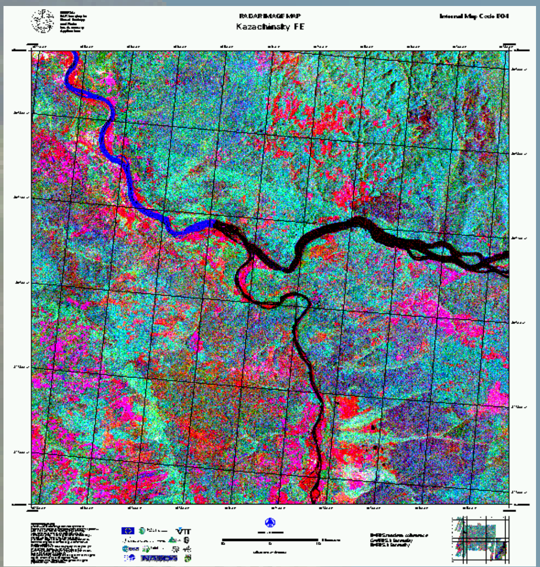
http://pipeline.swan.ac.uk/siberia/

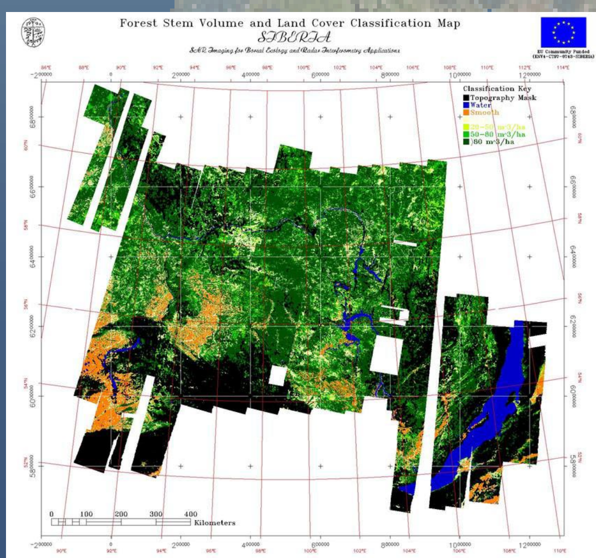
Products



Radar Image Mosaic

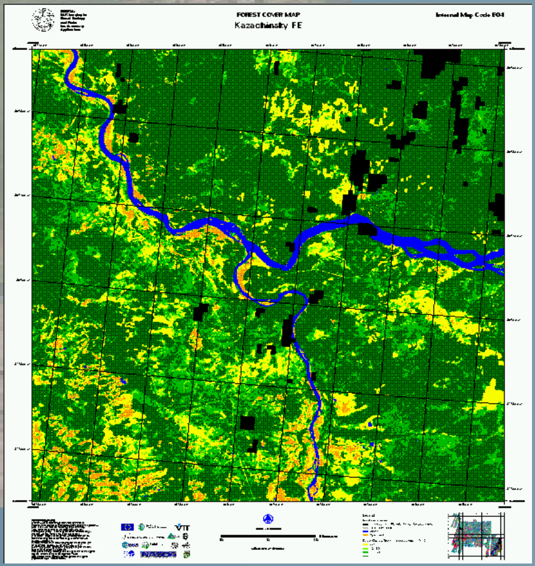
111 Radar Image Maps





Forest Cover Mosaic

96 Forest Cover Maps



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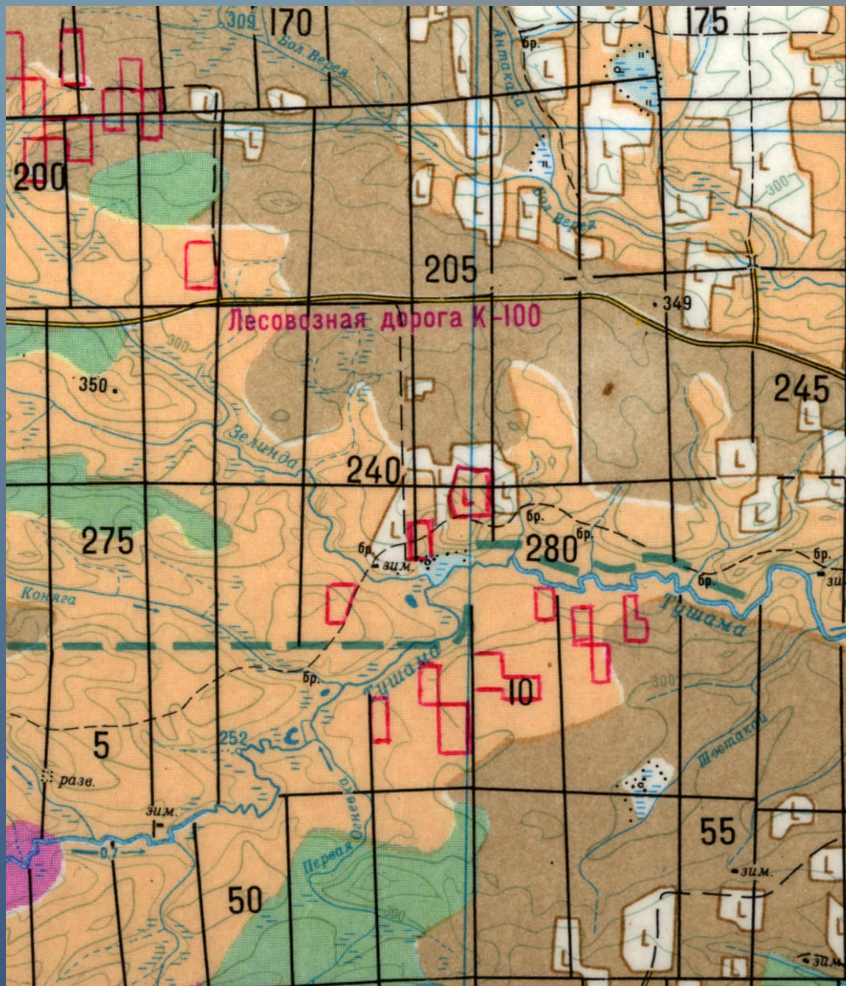
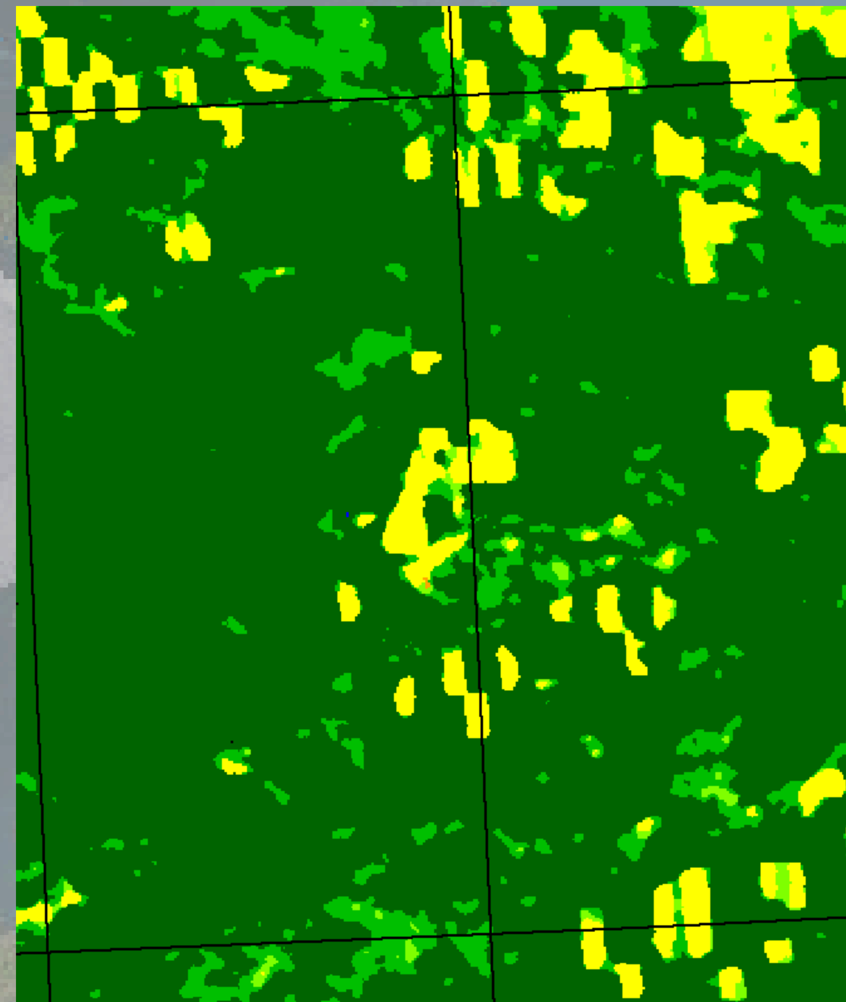
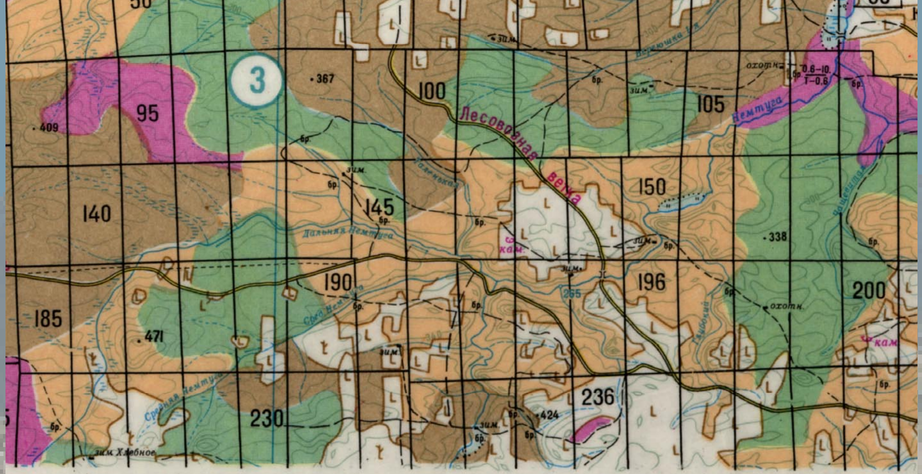
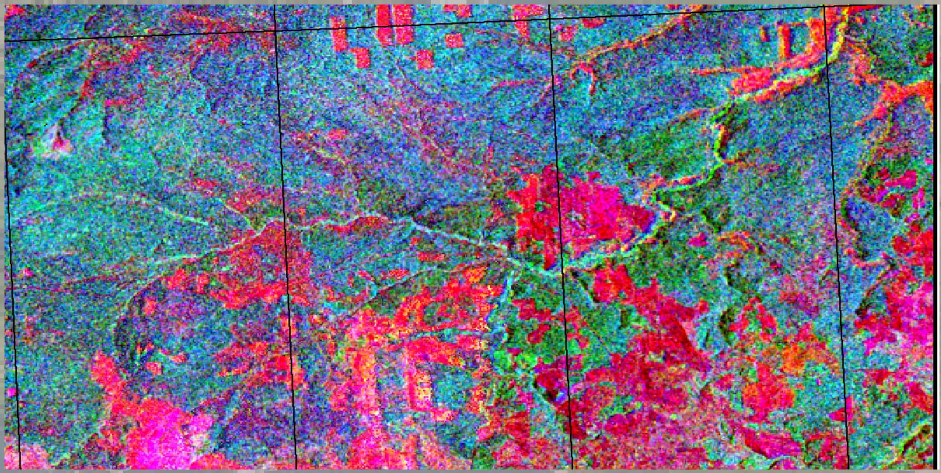
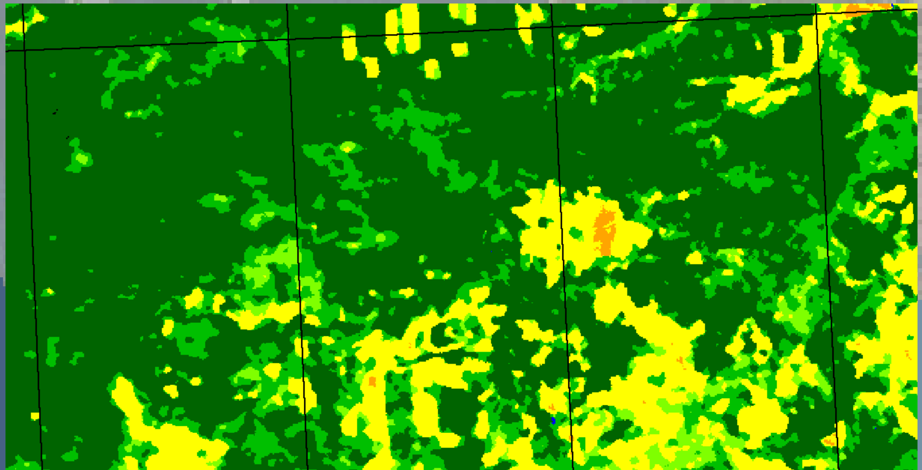




SIBERIA – Inventory Map Comparison, Irkutsk Forest Service

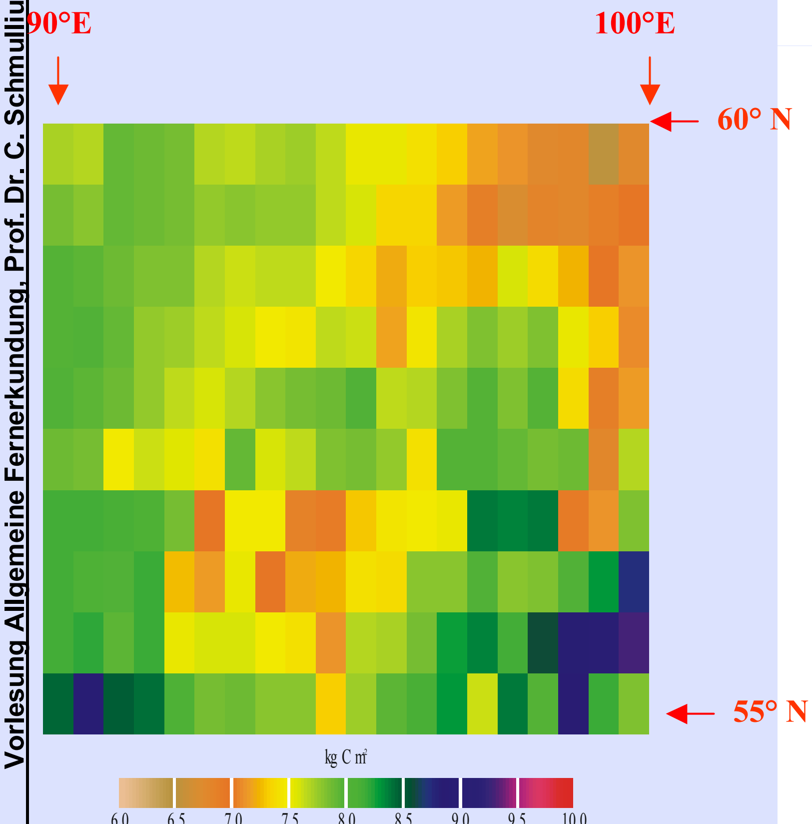

3
95
100
105
140
145
150
185
190
196
200
230
236



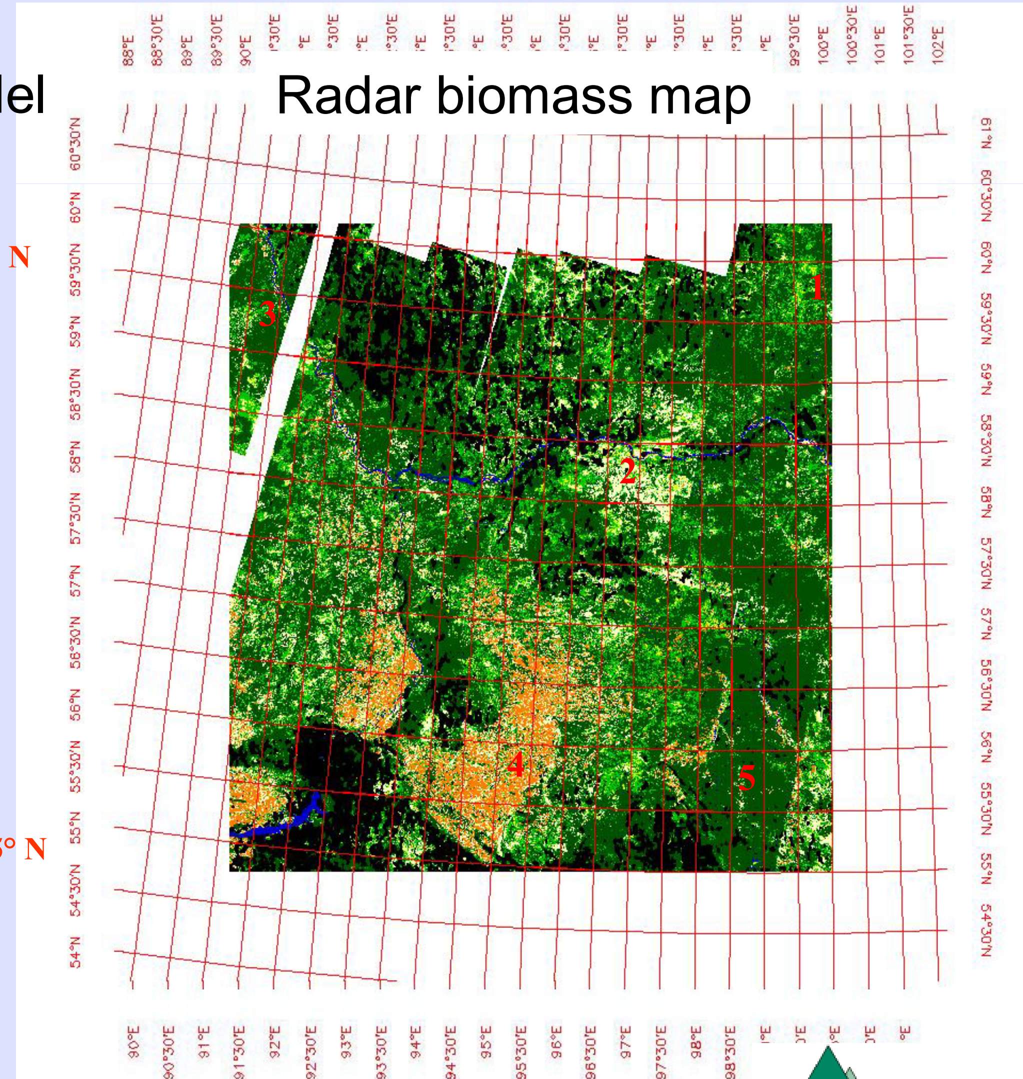


Testing with Earth Observation

Sheffield Dynamic Vegetation Model



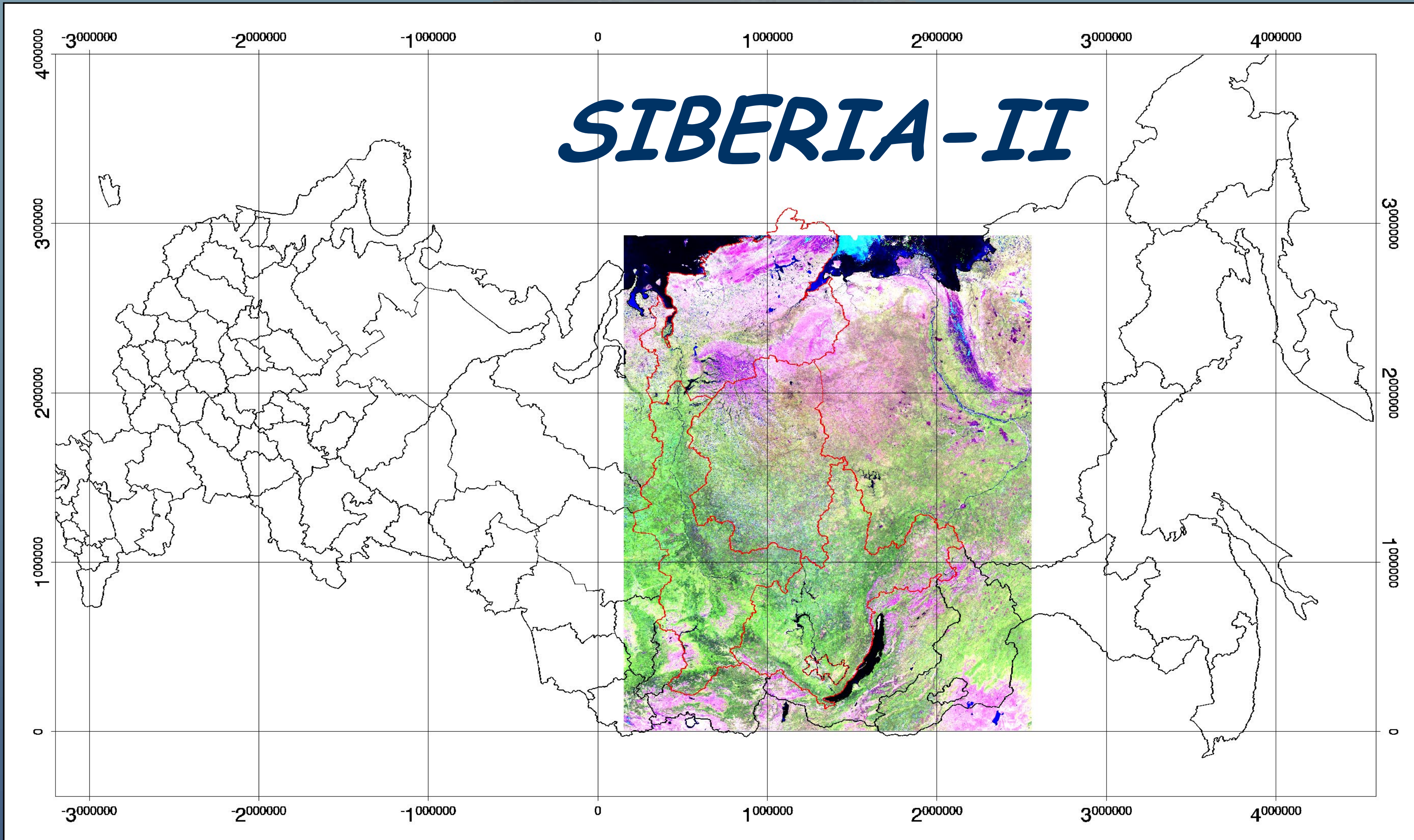
Radar biomass map



Le Toan et al., 2004
J. of Climatic Change

seit 1558

SIBERIA-II



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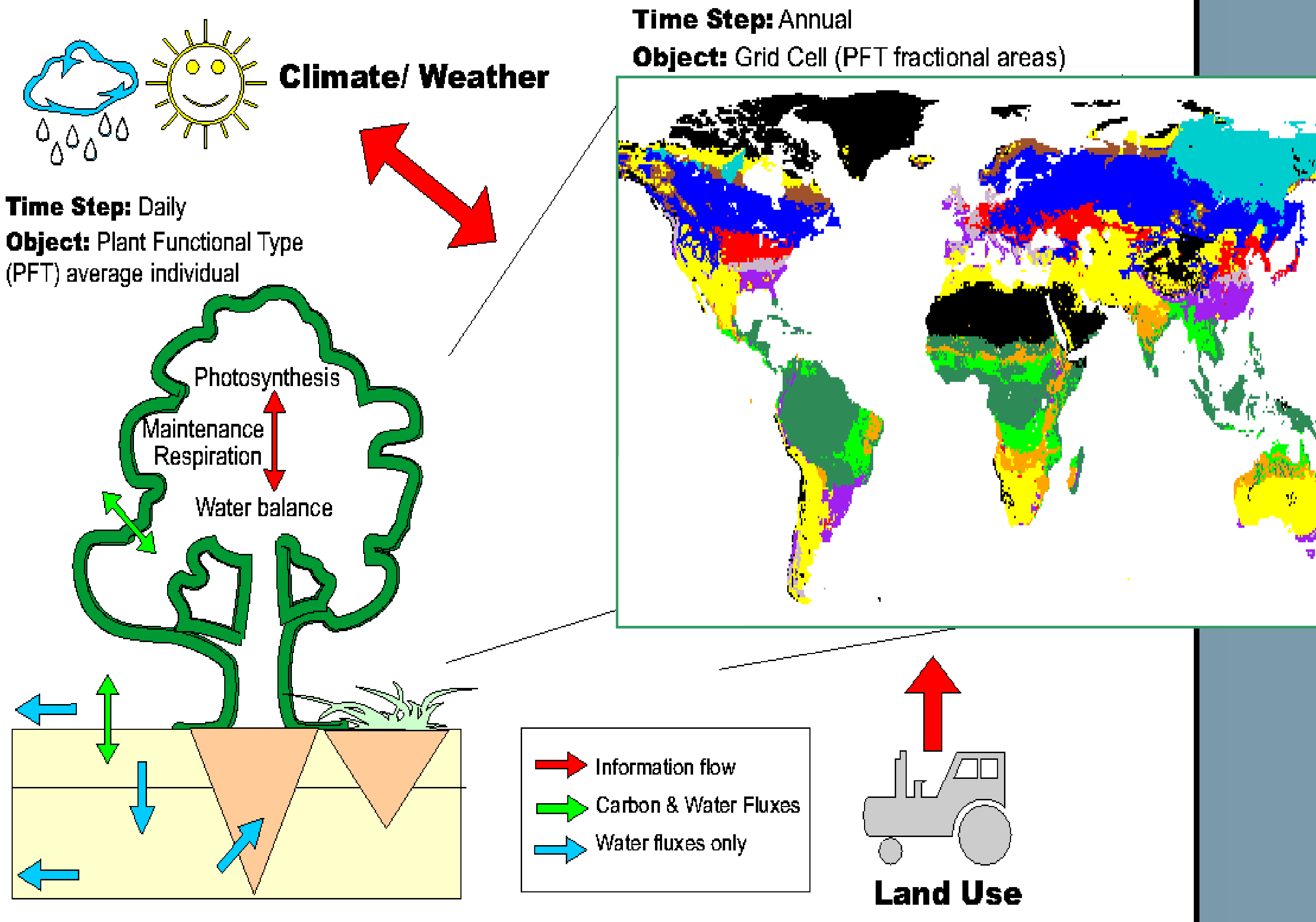
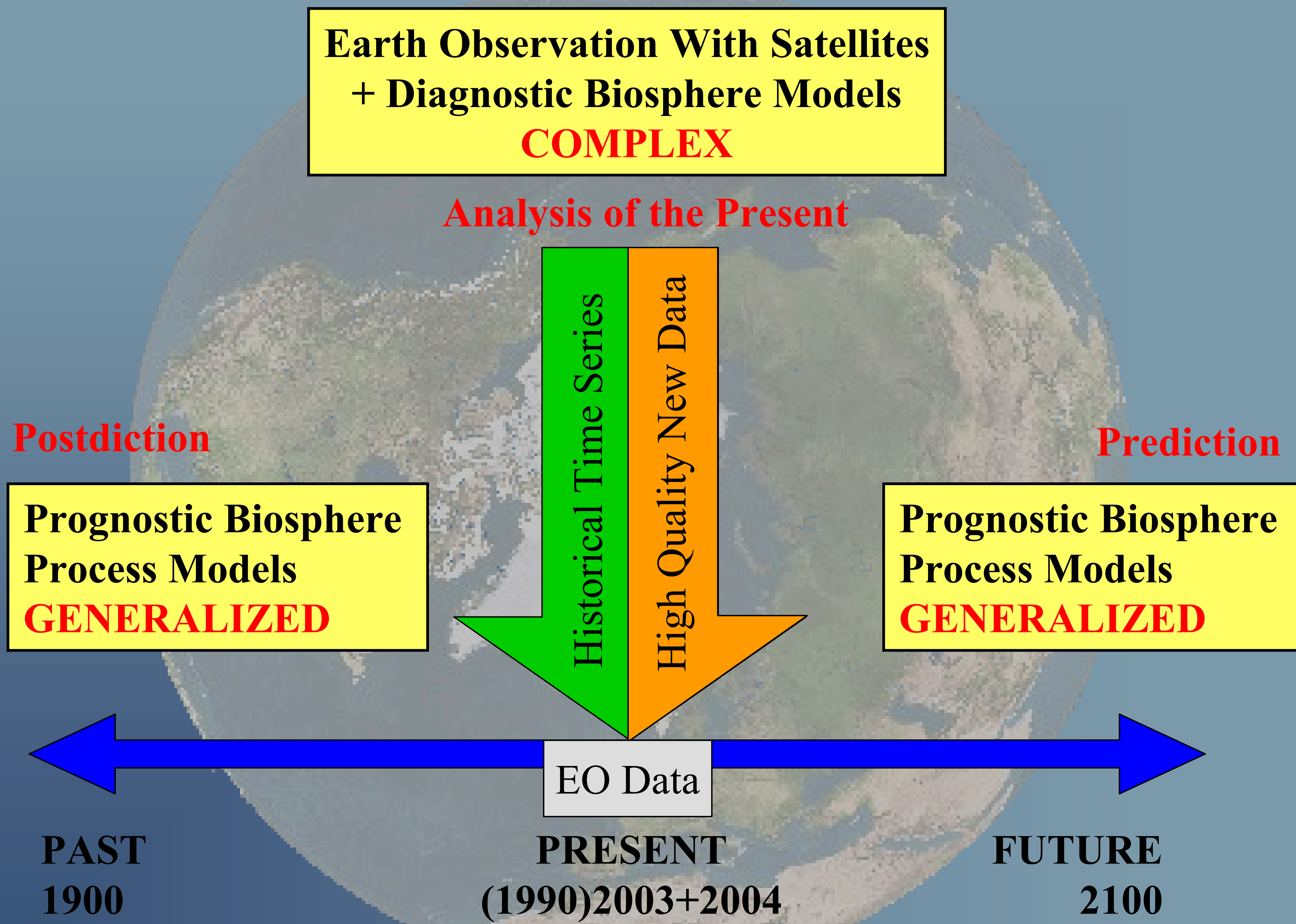
EO - Model Interfaces

Two main classes of potential interface:

1. Land cover and structure (boundary conditions):
   - land cover
   - fire extent
   - freeze-thaw, snow cover
   - species
2. Vegetation status (functioning):
   - fAPAR (foliar chemistry)
   - phenology
   - LAI
   - biomass

The Lund-Potsdam-Jena Dynamic Global Vegetation Model (DGVM)





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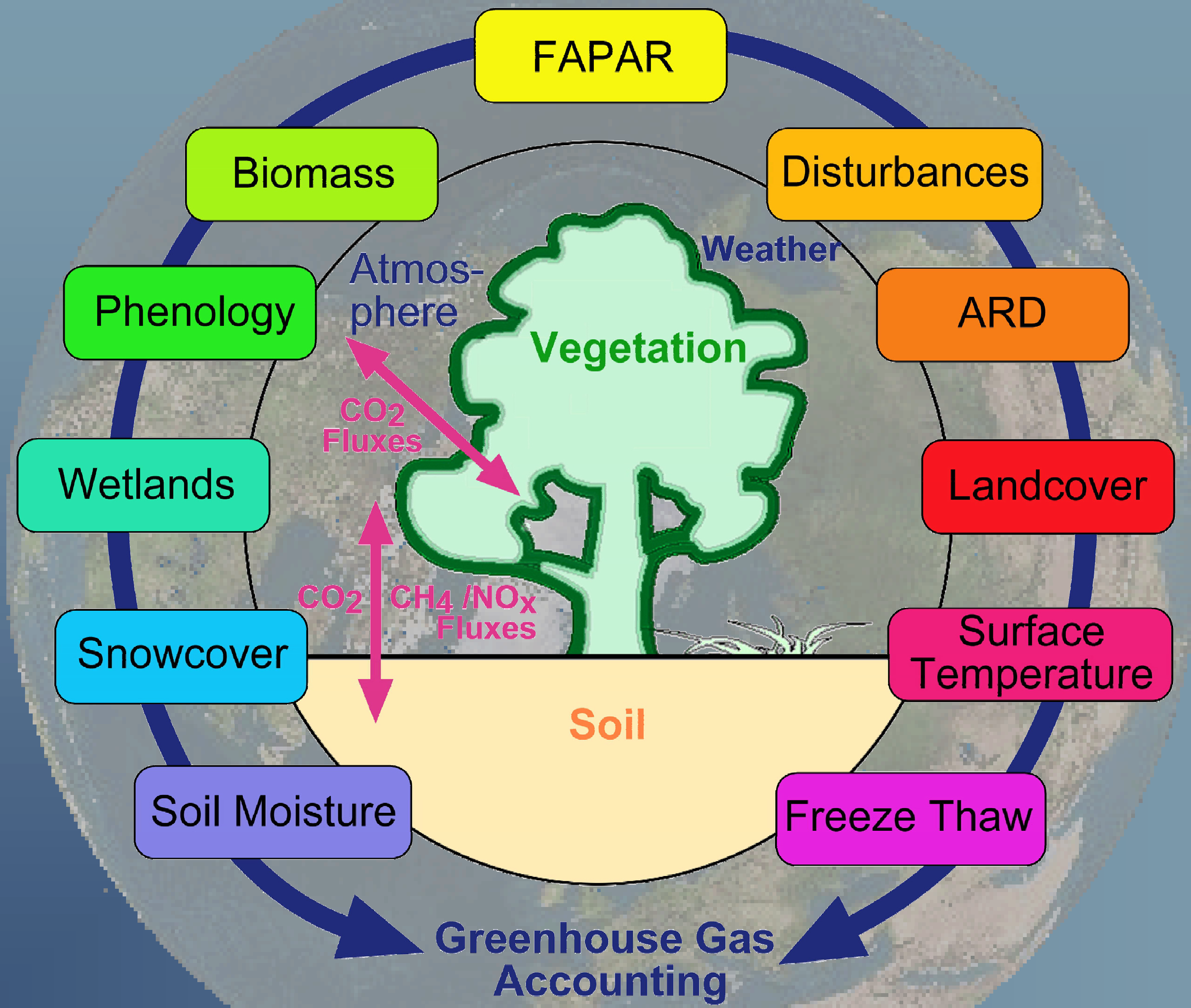
SIBERIA-II Greenhouse Gas Parameters



Vegetation Models in SIBERIA-II:
LPJ-DVM, SDVM, IIASA GIS-Approach

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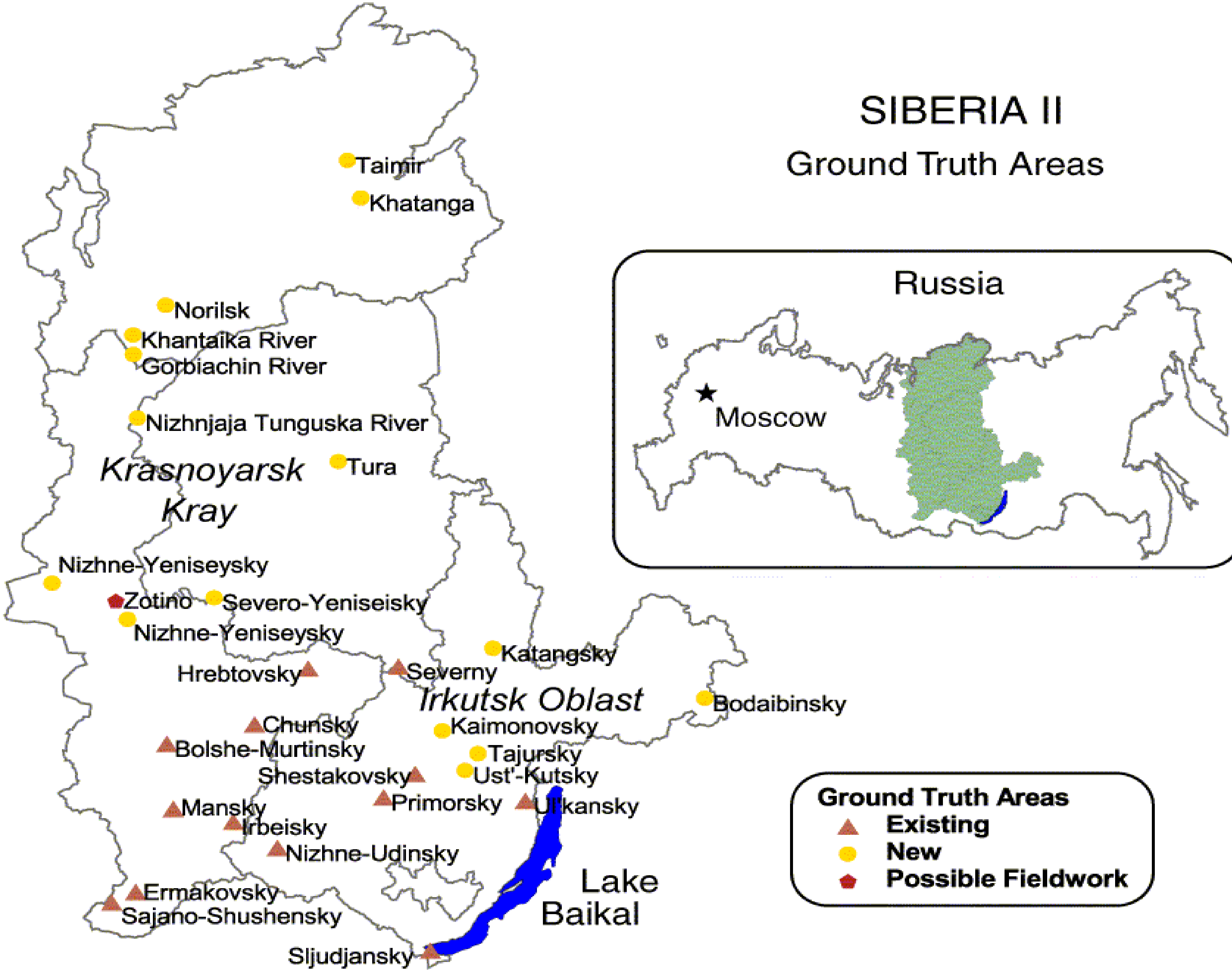


SIBERIA II
Ground Truth Areas
Russia
Moscow
Taimir
Khatanga
Norilsk
Khantaika River
Gorbiachin River
Nizhnjaja Tunguska River
Krasnoyarsk Kray
Tura
Nizhne-Yeniseysky
Zotino
Severo-Yeniseisky
Nizhne-Yeniseysky
Katangsky
Hrebtovsky
Severny
Irkutsk Oblast
Bodaibinsky
Chunsky
Kaimonovsky
Bolshe-Murtinsky
Tajursky
Shestakovsky
Ust'-Kutsky
Primorsky
Ul'kansky
Mansky
Irbeisky
Nizhne-Udinsky
Lake Baikal
Ermakovsky
Sajano-Shushensky
Sljudjansky
Ground Truth Areas
Existing
New
Possible Fieldwork

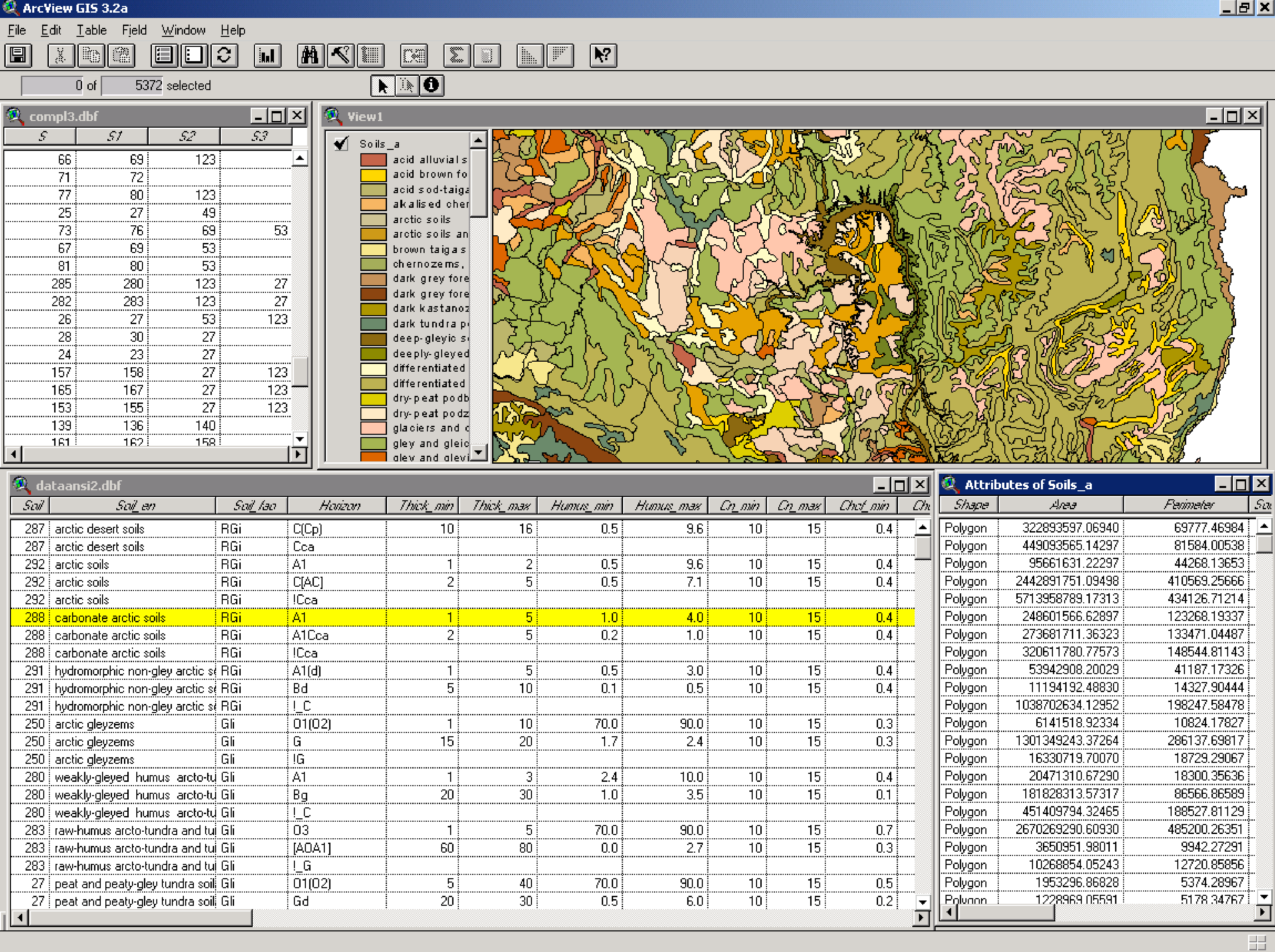
GROUND TRUTH

- 70 test areas distributed over 7 bio-climatic zones
- Test areas range from 40,000 to 150,000 ha and include 700 to 5-7,000 primary land cover polygons
- GIS components include maps at scales 1:50,000 and 1:100,000 and corresponding attributive databases

Dr. Leonid Vashchouk,
Irktustk Regional Forest Service

Database:Forests

- Forested areas
- 1. Code of dominant species N3, dimensionless
- 2. Share of growing stock of dominant species N2, dimensionless
- 3,5,7,9. Code of admixture species (maximum 4) N3, dimensionless
- 4,6,8,10. Share of growing stock of admixture species N2, dimensionles
- 11. [Average] age [age class] of dominant species N3, year
- 12. Type of age structure N1, dimensionless
- 12-15. Average age of admixture species N3, year
- 16-17. Average height/diameter of dominant species N2, m/ N2, cm
- 18-25. Average height/diameter of admixture species N2, m/ N2, cm
- 26. Site index [bonitet class] – average height in 100 year N2.1, m
- 27. Relative stocking N0.2, dimensionless
- 28. Average growing stock N3, m3 ha-1
- 28-32. Phytomass of dominant species by 4 major fractions N0.4, Mg C m-3
- 33-40. Phytomass of admixture species by 4 fractions N0.4, Mg C m-3
- 41-44. Phytomass of undergrowth (incl. green forest floor) N0.4, Mg C m-3
- 45. Coarse woody debris (1-5 decay stages) N3, Mg C ha-1
- 46. Dead roots N3, Mg C ha-1
- 47. Net growth N2.2, m3 ha-1
- 48. Gross growth N2.2, m3 ha-1
- 49. Net Primary Production (by 4 fractions) N4, g C m-1
- 50. Seasonal course of Leaf Area Index N2.2, m2 m-2
- 51. On-ground litter N2.1, Mg C ha-1
- 52. Soil type N3, dimensionless
- 53. Texture class N1, dimensionless
- 55. Depth of active layer N3, cm
- 56-59. N:C ratio in phytomass by fractions (green parts, stems,
- branches, roots) N0.3, dimensionless 60-61. N:C ratio in dead organic (CWD, on-ground litter) N0.3, dimensionless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0 of 5372 selected
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66 69 123
71 72
77 80 123
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73 76 69 53
67 69 53
81 80 53
285 280 123 27
282 283 123 27
26 27 53 123
28 30 27
24 23 27
157 158 27 123
165 167 27 123
153 155 27 123
139 136 140
View1
Soils_a
acid alluvial s
acid brown fo
acid sod-taiga
alkalised cher
arctic soils
arctic soils an
brown taiga s
chernozems,
dark grey fore
dark grey fore
dark kastanoz
dark tundra p
deep-gleyic s
deeply-gleyed
differentiated
differentiated
dry-peat podb
dry-peat podz
glaciers and c
gley and gleic
dataansi2.dbf
Soil Soil_en Soil_fao Horizon Thick_min Thick_max Humus_min Humus_max Cn_min Cn_max Chcl_min
287 arctic desert soils RGi C(Cp) 10 16 0.5 9.6 10 15 0.4
287 arctic desert soils RGi Cca
292 arctic soils RGi A1 1 2 0.5 9.6 10 15 0.4
292 arctic soils RGi C[AC] 2 5 0.5 7.1 10 15 0.4
292 arctic soils RGi !Cca
288 carbonate arctic soils RGi A1 1 5 1.0 4.0 10 15 0.4
288 carbonate arctic soils RGi A1Cca 2 5 0.2 1.0 10 15 0.4
288 carbonate arctic soils RGi !Cca
291 hydromorphic non-gley arctic s RGi A1(d) 1 5 0.5 3.0 10 15 0.4
291 hydromorphic non-gley arctic s RGi Bd 5 10 0.1 0.5 10 15 0.4
291 hydromorphic non-gley arctic s RGi !_C
250 arctic gleyzems Gli O1(O2) 1 10 70.0 90.0 10 15 0.3
250 arctic gleyzems Gli G 15 20 1.7 2.4 10 15 0.3
250 arctic gleyzems Gli !G
280 weakly-gleyed humus arcto-tu Gli A1 1 3 2.4 10.0 10 15 0.4
280 weakly-gleyed humus arcto-tu Gli Bg 20 30 1.0 3.5 10 15 0.1
280 weakly-gleyed humus arcto-tu Gli !_C
283 raw-humus arcto-tundra and tu Gli O3 1 5 70.0 90.0 10 15 0.7
283 raw-humus arcto-tundra and tu Gli [AOA1] 60 80 0.0 2.7 10 15 0.3
283 raw-humus arcto-tundra and tu Gli !_G
27 peat and peaty-gley tundra soil Gli O1(O2) 5 40 70.0 90.0 10 15 0.5
27 peat and peaty-gley tundra soil Gli Gd 20 30 0.5 6.0 10 15 0.2
Attributes of Soils_a
Shape Area Perimeter
Polygon 322893597.06940 69777.46984
Polygon 449093565.14297 81584.00538
Polygon 95661631.22297 44268.13653
Polygon 2442891751.09498 410569.25666
Polygon 5713958789.17313 434126.71214
Polygon 248601566.62897 123268.19337
Polygon 273681711.36323 133471.04487
Polygon 320611780.77573 148544.81143
Polygon 53942908.20029 41187.17326
Polygon 11194192.48830 14327.90444
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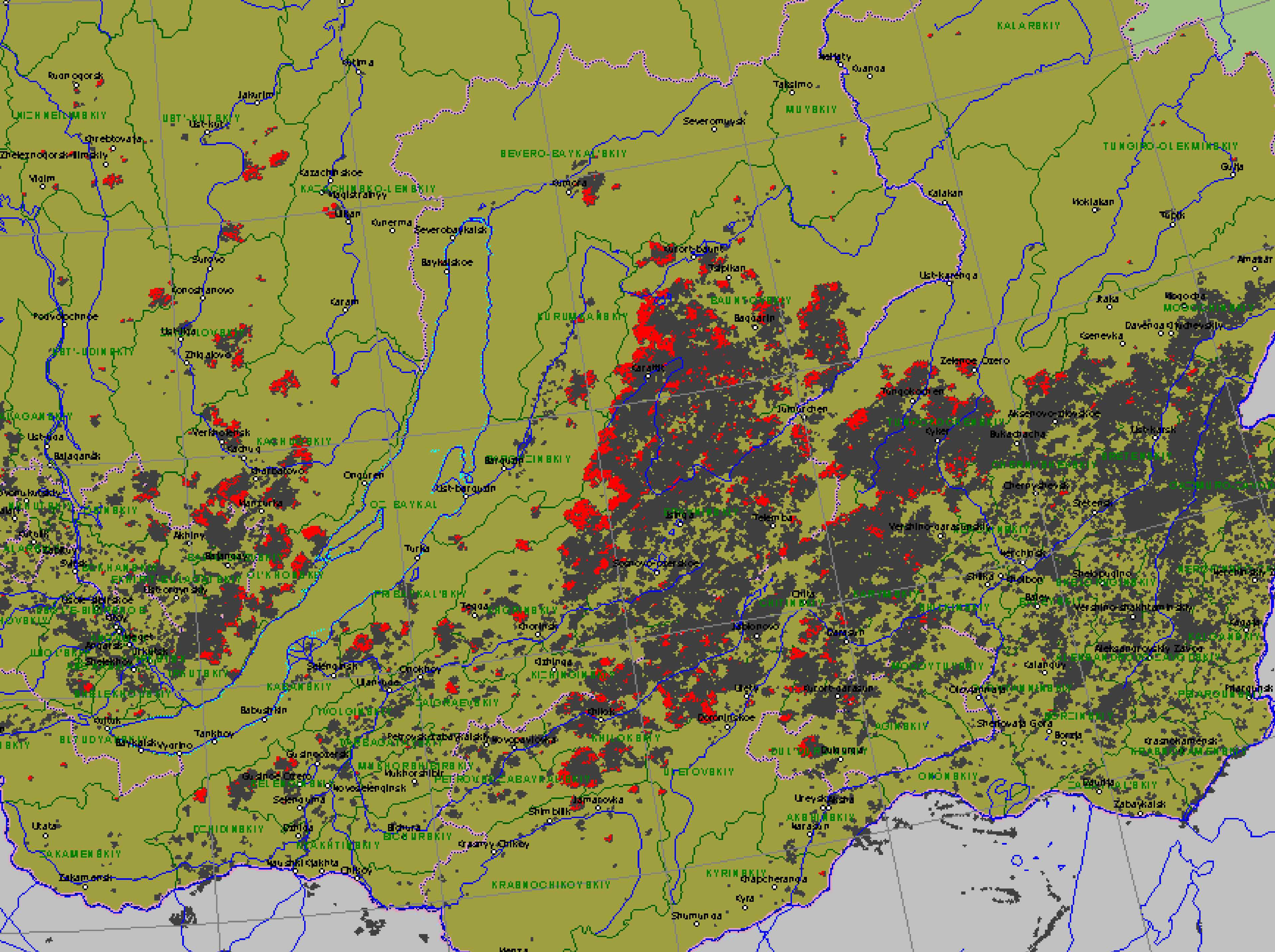
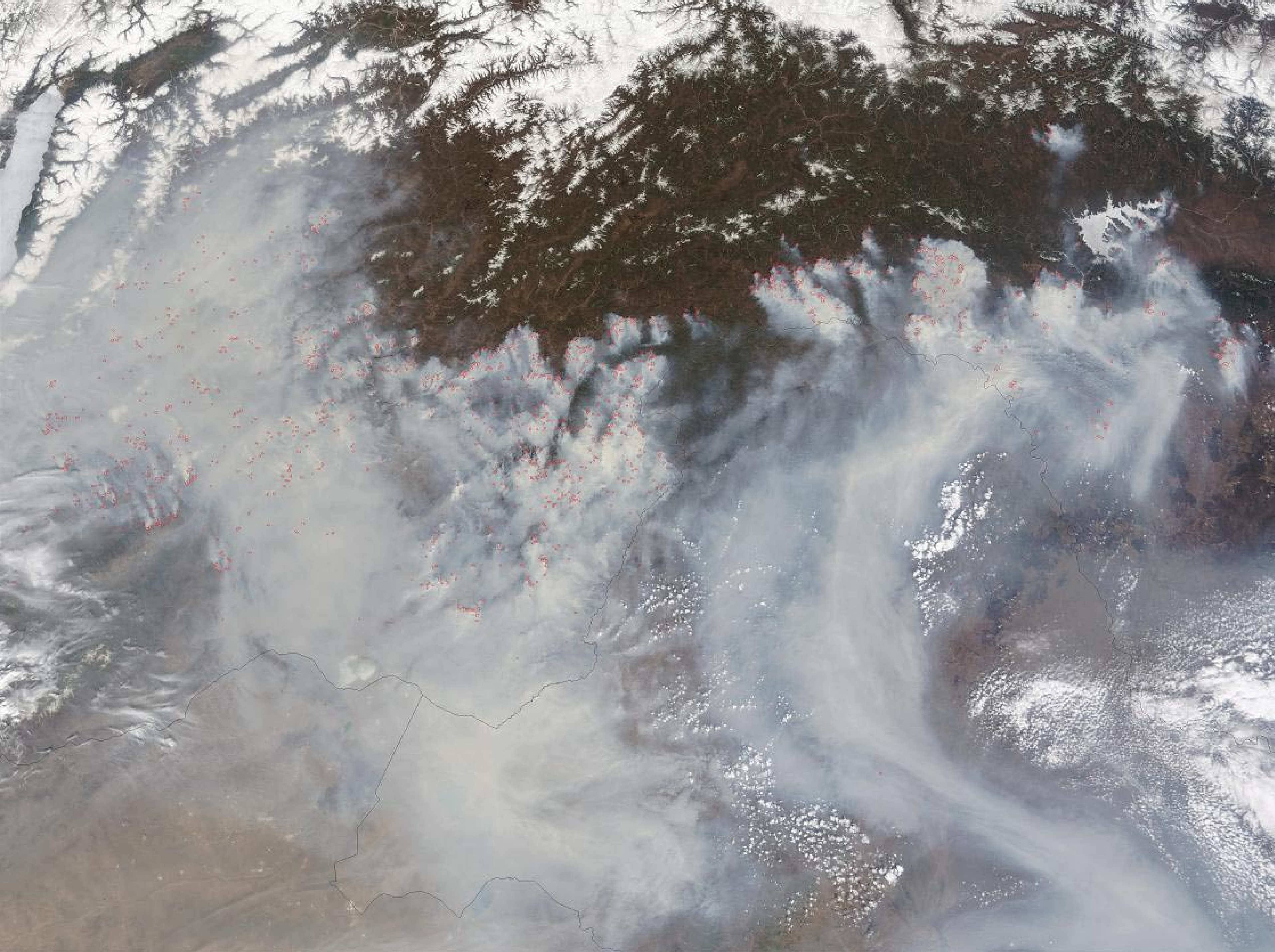
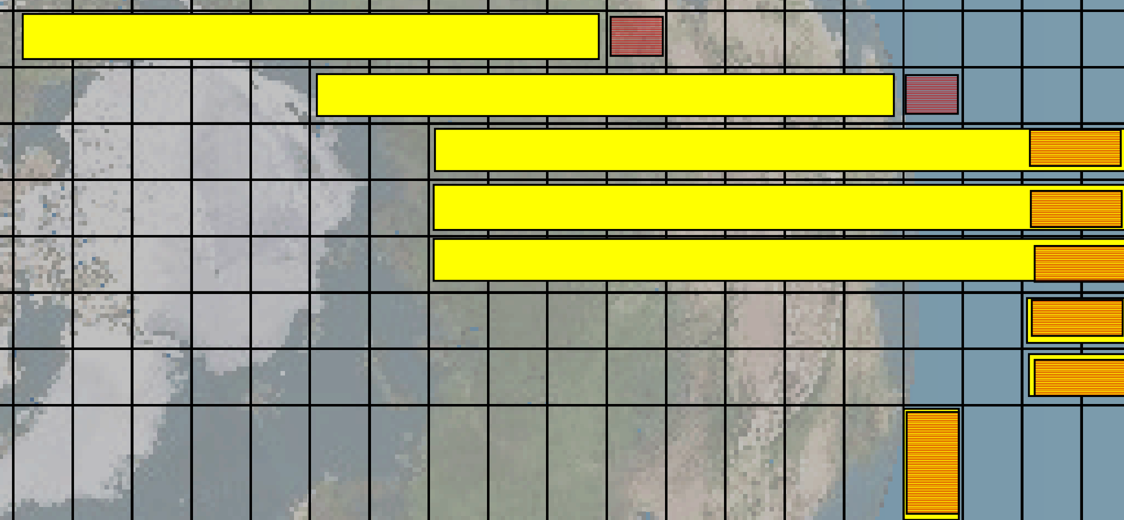


KALARSKIY
Taksimo
MUYSKIY
Severomuysk
SEVERO-BAYKAL'SKIY
TUNGIRO-OLEKMINSKIY
Gulja
Kalakan
Moklakan
Tupik
Amazar
Ust-Karenga
Mogocha
Kazachinskoe
Kunerma
Severobaykalsk
Baykalskoe
Jalturim
Ust-kut
Ust-Ilimsk
Vigim
Surovo
Konoshanovo
Podvolochnoe
Zhigalovo
Karam
Taipikan
Bagdarin
Karaftit
Zelenoe Ozero
Tungokochen
Jumurchen
Aksenovo-zilovskoe
Bukachacha
Ust-karsk
Chernyshevsk
Sretensk
Verkholensk
Ust-Uda
Balaganask
Onguren
Barguzin
Ust-Barguzin
OZ BAYKAL
Turka
Telemba
Vershino-darasunskiy
Sosnovo-ozerskoe
Shelopugino
Chita
Jablonovo
Darasun
Tegda
Khorinsk
Kizhinga
Usole-Sibirskoe
Angarsk
Shelekhov
Babushkin
Tankhoy
Selenginsk
Ulan-ude
Onokhoy
Gusinoozersk
Gusinoe Ozero
Novoselenginsk
Petrovsk-Zabaykalskiy
Novopavlovka
Khilok
Doroninskoe
Kurort-darasun
Olovjannaja
Sherlovaja Gora
Borzja
Krasnokamensk
Zabaykalsk
Kalanguy
Aleksandrovskiy Zavod
Priargunsk
Duldurga
Aginskoe
Jamarovka
Shimbilik
Bichura
Krasnyy Chikoy
Kyakhta
Chikoy
Zakamensk
Ukata
Mogoytuy
Nerchinsk
Shilka
Balej
Kyra
Shumunda
Chapcheranga
KYRINSKIY
KRASNOCHIKOYSKIY
ONONSKIY
ULETOVSKIY
KHILOKSKIY
KABANSKIY
SELENGINSKIY
DZHIDINSKIY
KYAKHTINSKIY
BICHURSKIY
ZAKAMENSKIY



Temporal & spatial coverage

Sensor	Spatial coverage: Res.	Spatial coverage: Extent	Temporal coverage: 85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03
ATSR-2	1km	Full																			
SPOT VEGETATION	1km	Full																			
AATSR	1km	Full																			
MODIS	500m	Full																			
TM	30m	test sites																			
ASAR global mode	500m	Full																			
ASAR image mode	50m	test sites																			
GLOBSCAR GBA2000	1km	Full																			



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NATURAL ENVIRONMENT RESEARCH COUNCIL

Results: Image segmentation

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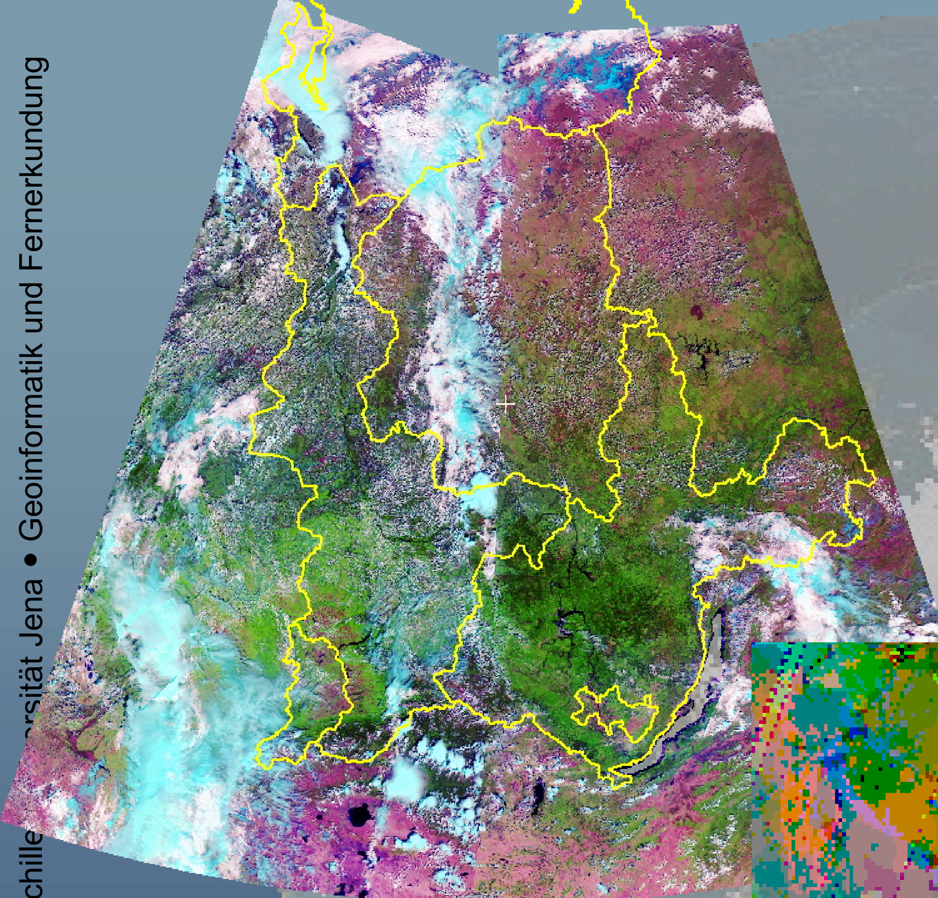
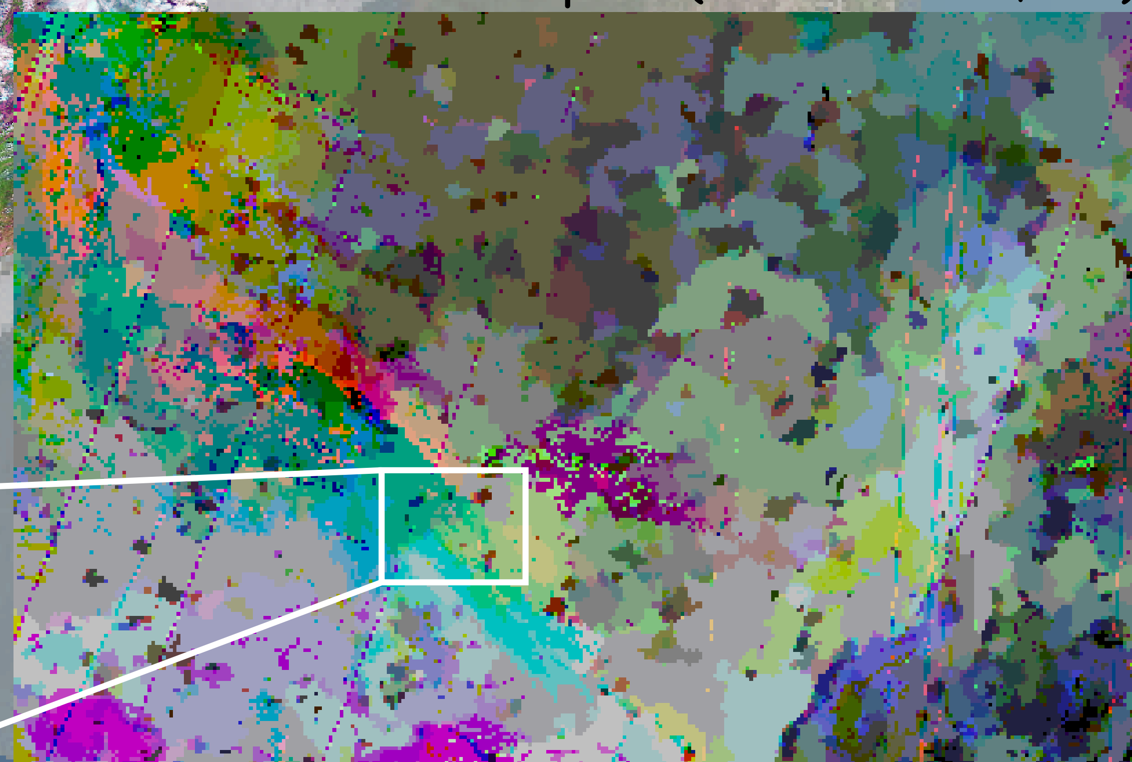
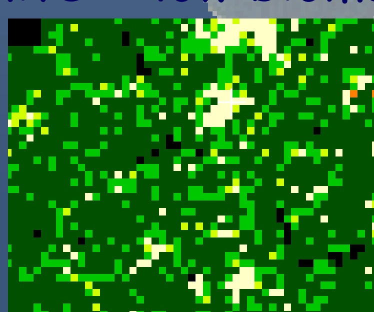


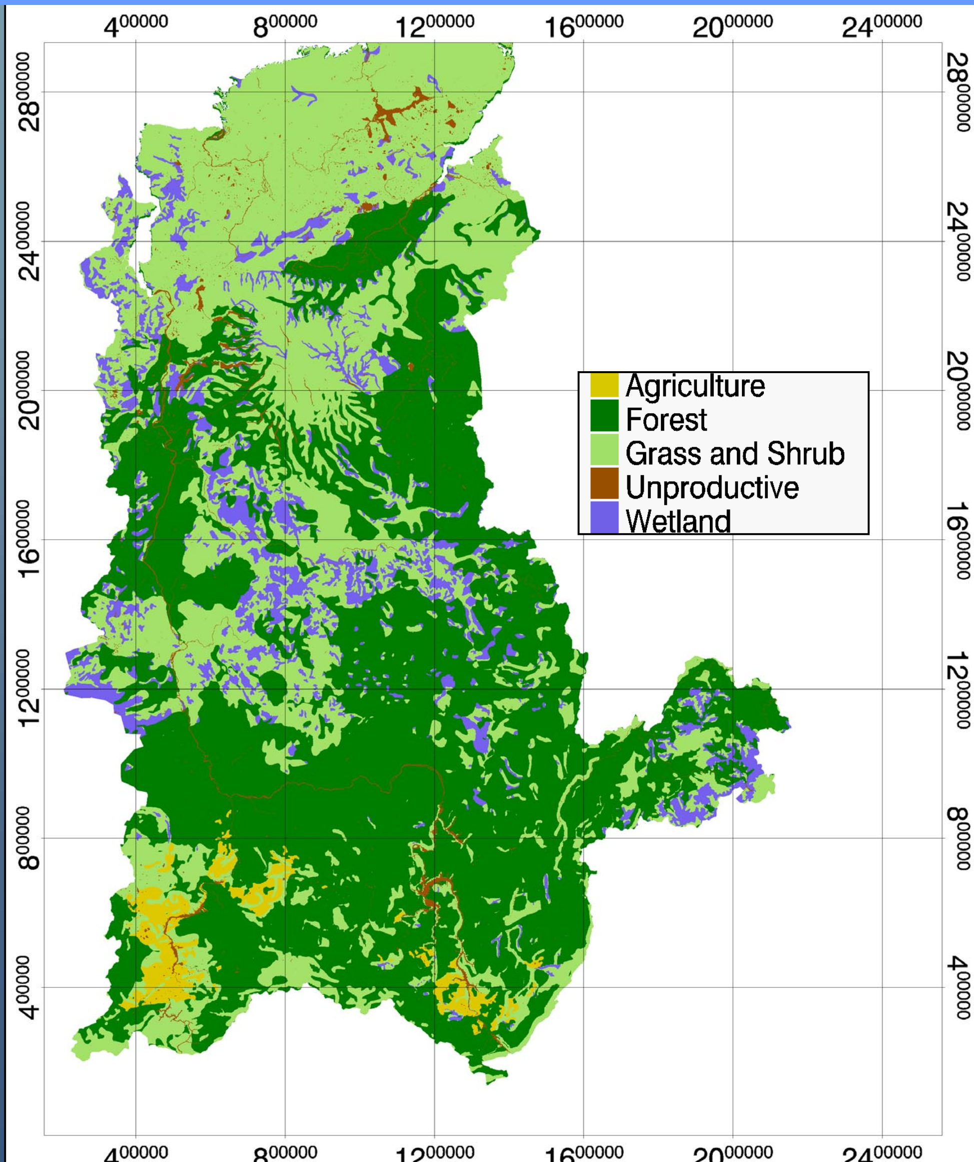
Segmentation of SPOT VGT
18th, 19th, 23rd Aug 2000
ATSR-2 hotspots (summers '96, '97)

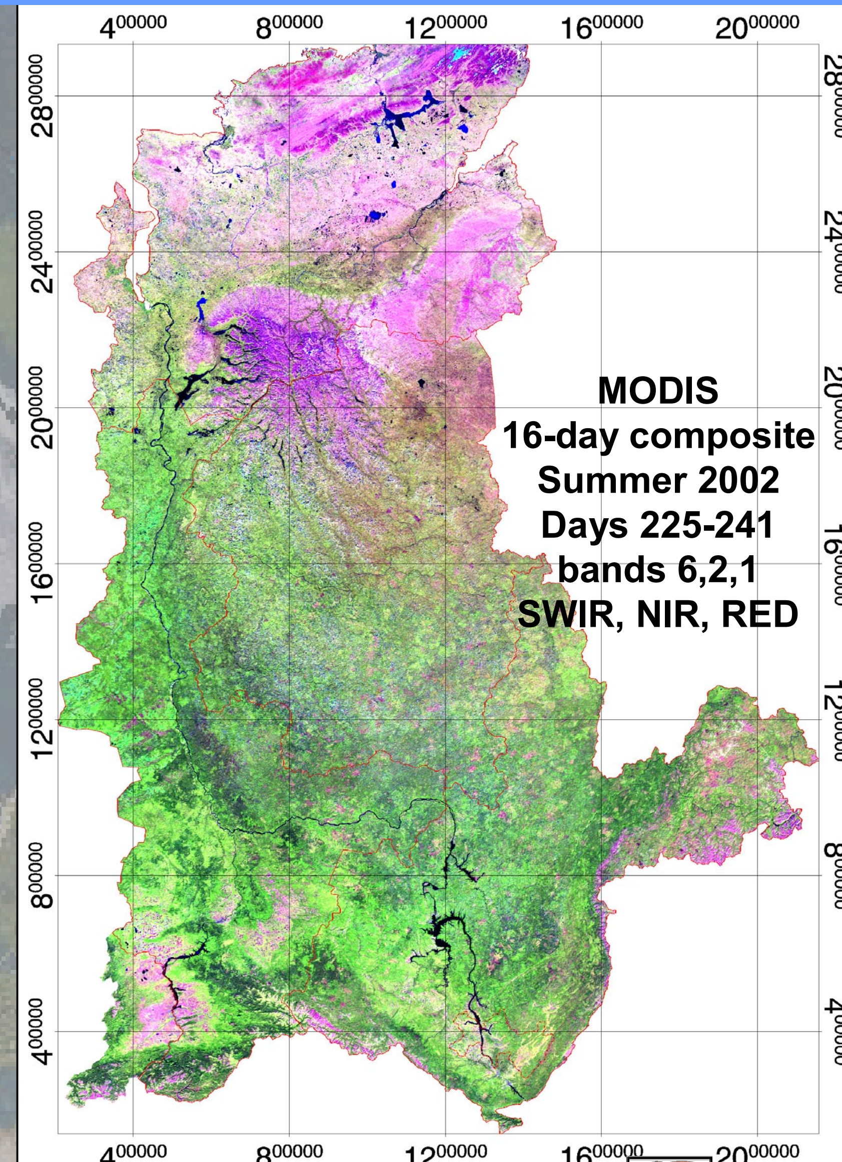


SIBERIA-I, 1km pixels
(1997/98)
'white' = low biomass



Level 1 comparison





Prof. D

University of Wales Swansea

Land cover

Level 1

- 1 Unproductive land
- 2 Agricultural land
- 3 Forest land
- 4 Wetlands
- 5 Grasslands and shrubs

Level 2

1 Unproductive land
- 11 Water
- 13 Barren
- 14 Urban

2 Agricultural land
- 21 Cropland
- 22 Cropland/Forest Complex

3 Forest land
- 31 Light Coniferous
- 32 Dark Coniferous
- 33 Soft Deciduous
- 35 Sparse Needle-leaf Forest
- 36 Sparse Broadleaf Forest

4 Wetlands
- 41 Wetlands

5 Grasslands and shrubs
- 51 Tundra – Lichen Moss
- 52 Tundra - Heath
- 53 Steppe
- 54 Grasslands

Level 3

Forest Species

Aspen, Birch, Ceder, Fir, Larch, Pine, Spruce

Multiple Species

Evergreen Needleleaf
Deciduous Broadleaf
Mixed Forest

Land cover classification method

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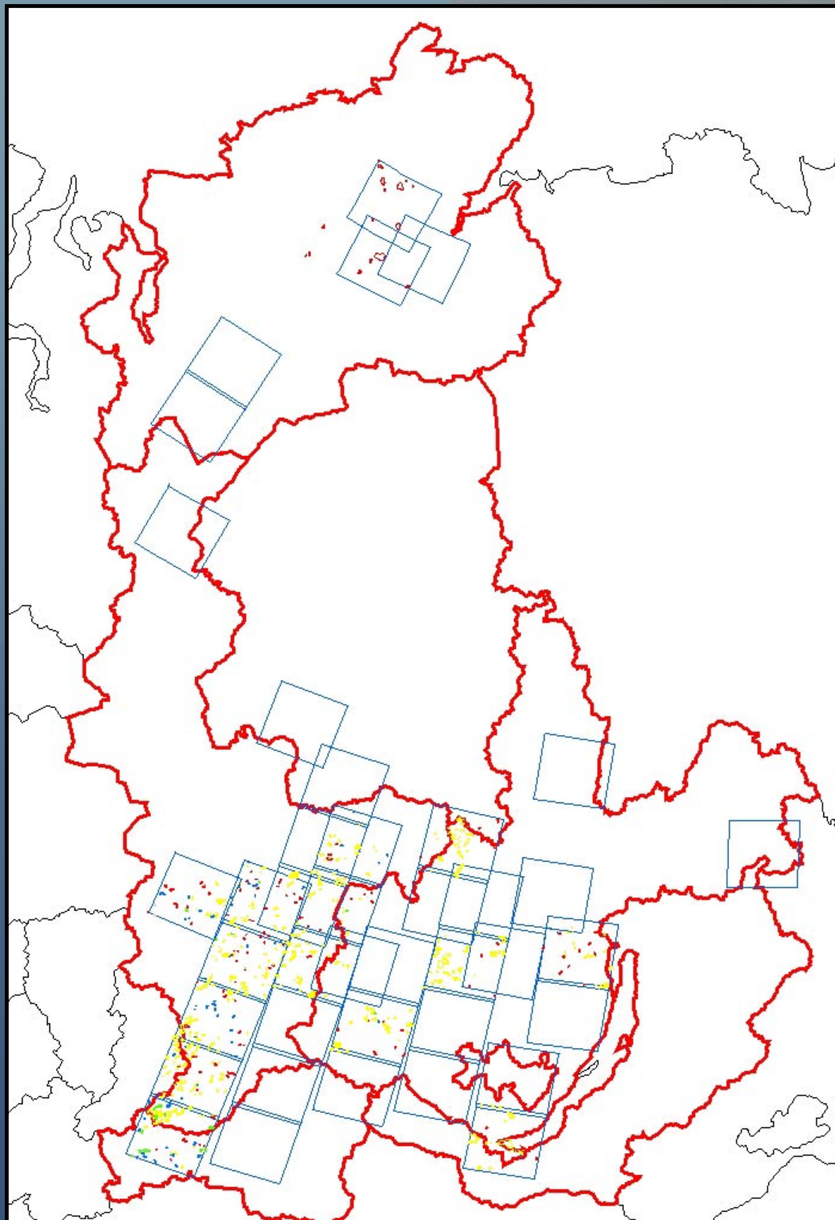
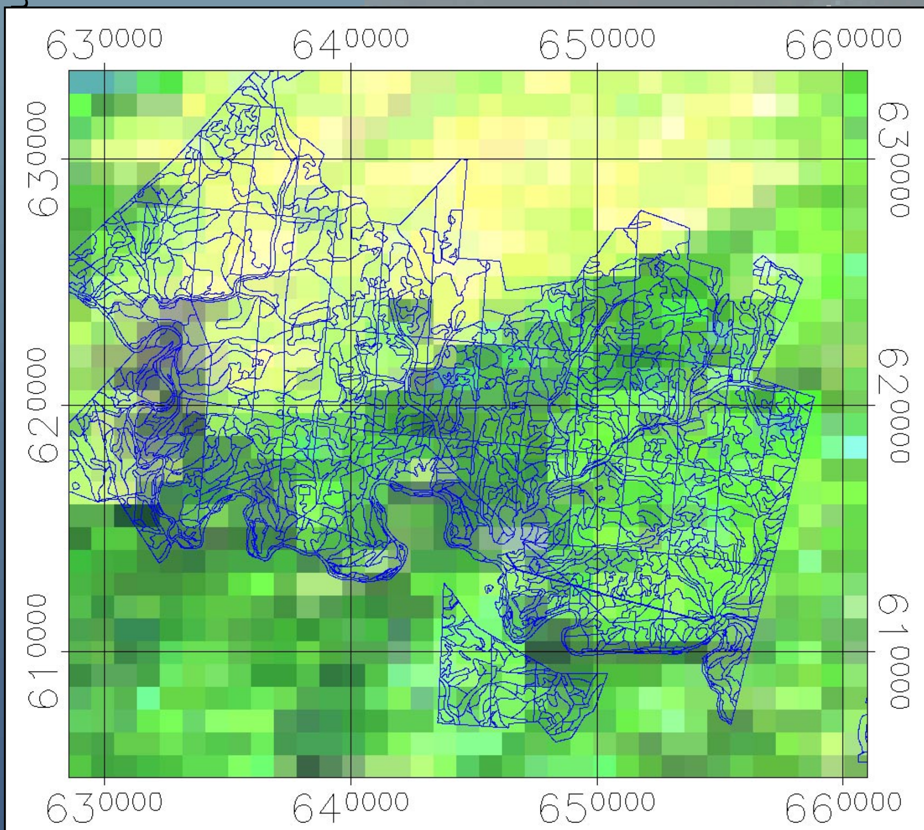
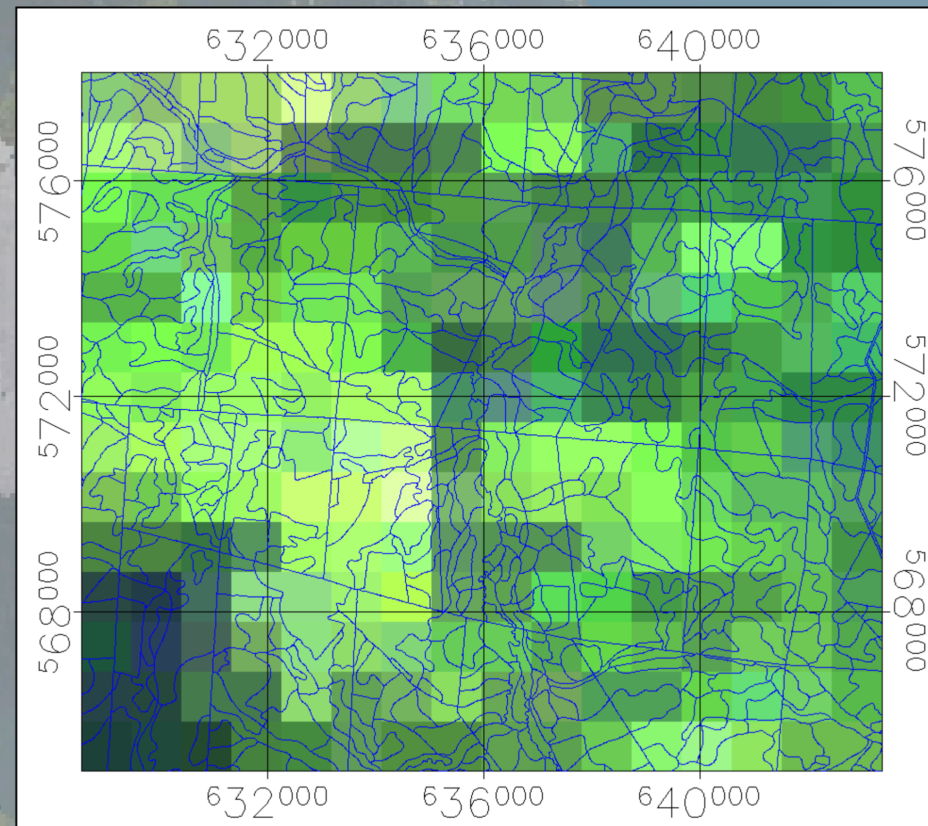


- Supervised classification
  - C5.0 (decision tree)
- Training areas
  - Expert knowledge
    - Russian colleagues
  - Landsat TM analysis
    - Blue rectangles
  - Some classes from GLC2000
  - 1000 training polygons

Heterogeneity

- Mismatch in spatial scale
- Scaling issues





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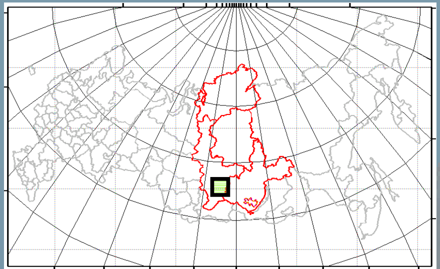
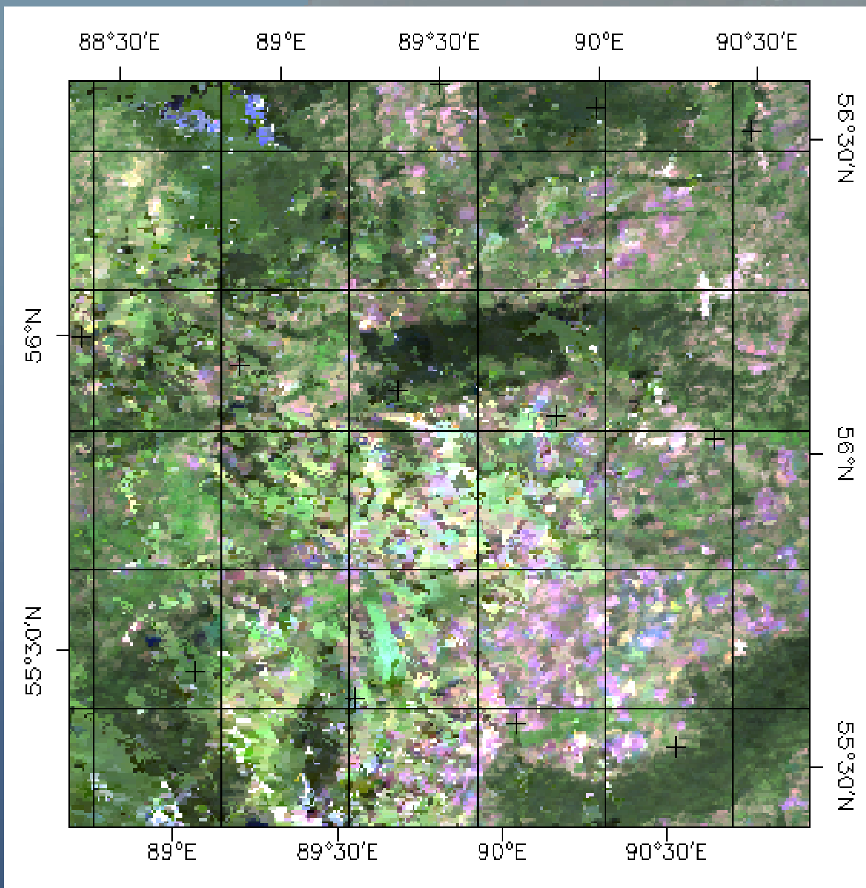
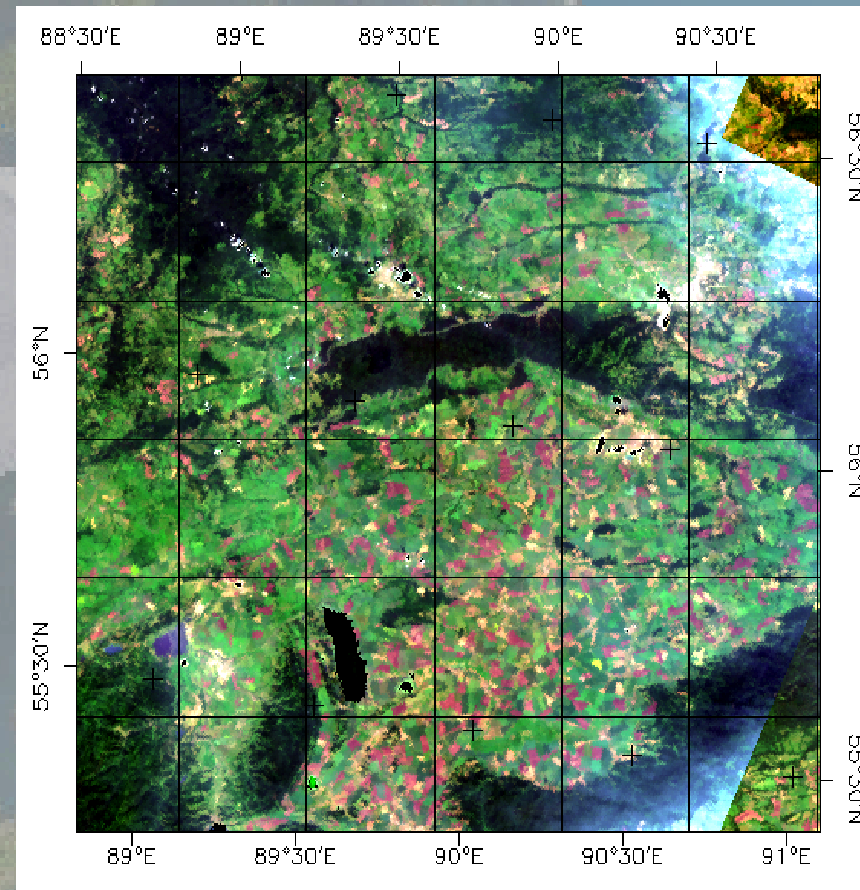
Advantages of MERIS





MODIS, 500m

R:Red, G:Green, B:Blue



MERIS, 300m

R:Red, G:Green, B:Blue

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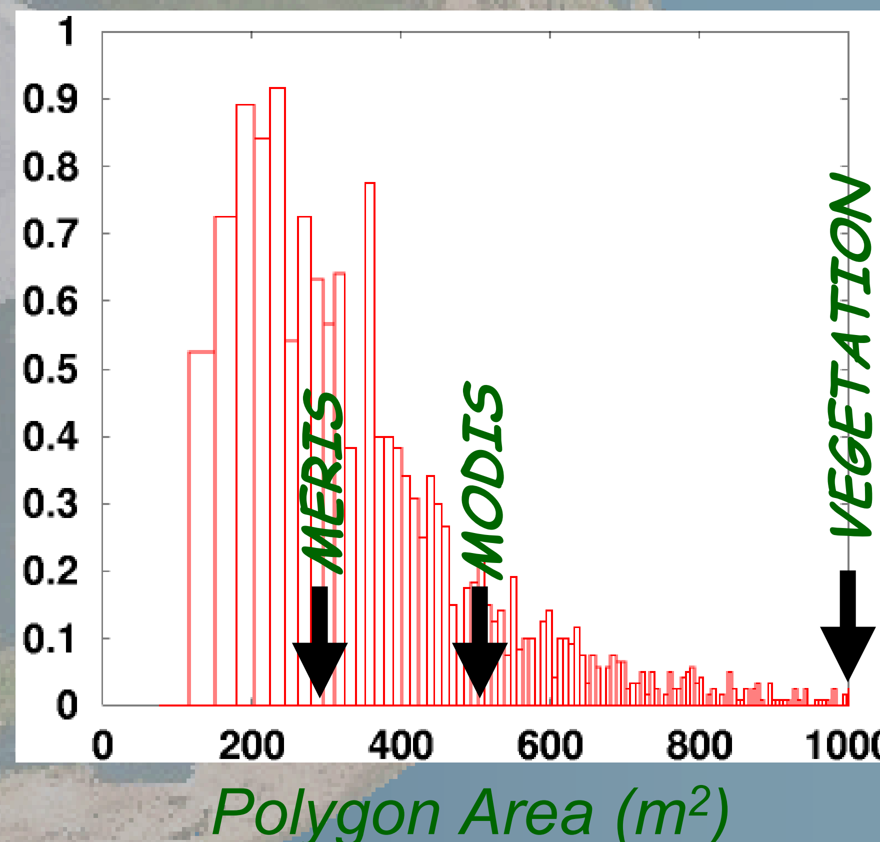
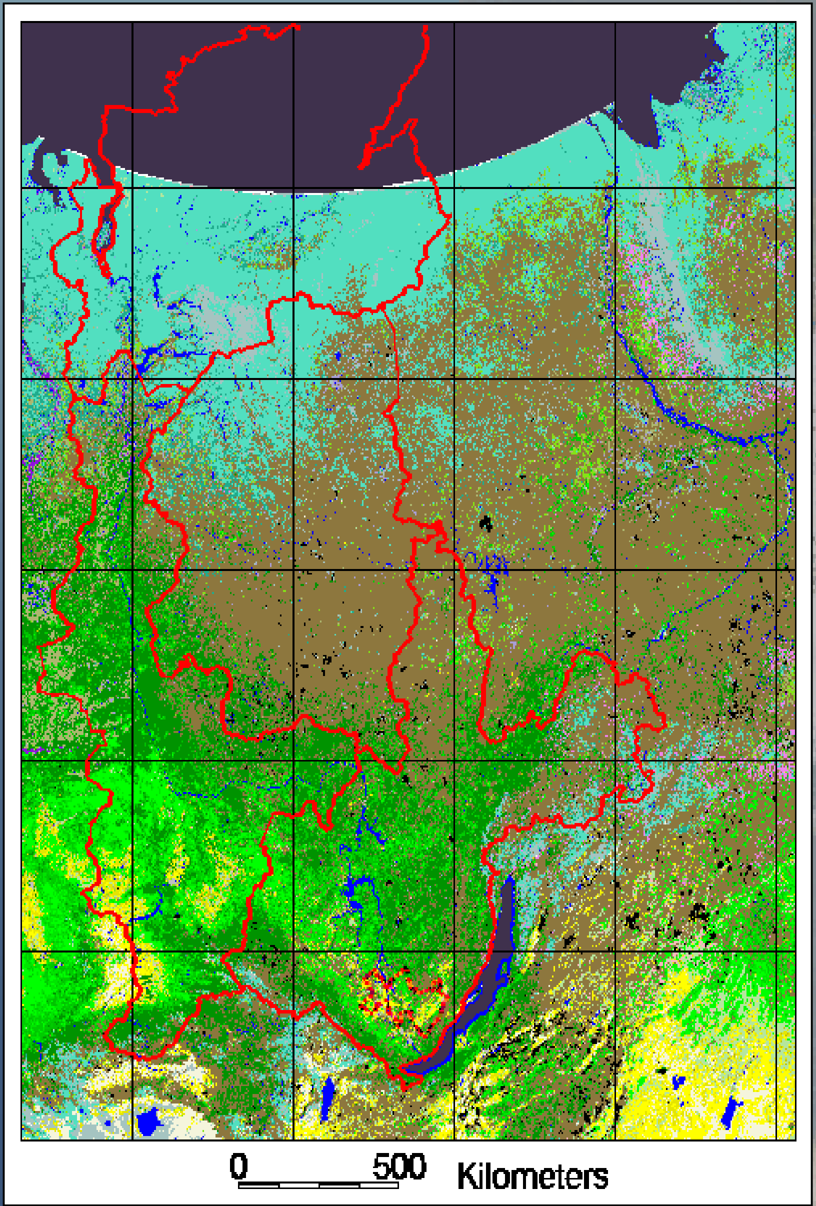
MERIS and land cover

- MERIS Advantages:
  - European sensor
    - Future data availability
  - More appropriate spatial resolution for land cover

Histogram of forestry polygon sizes in S. Lake Baikal region



State of the Art



- E.g. GLC 2000
- Continental or global in coverage
- Hard Classification
- Kilometre pixel size
- Temporally static

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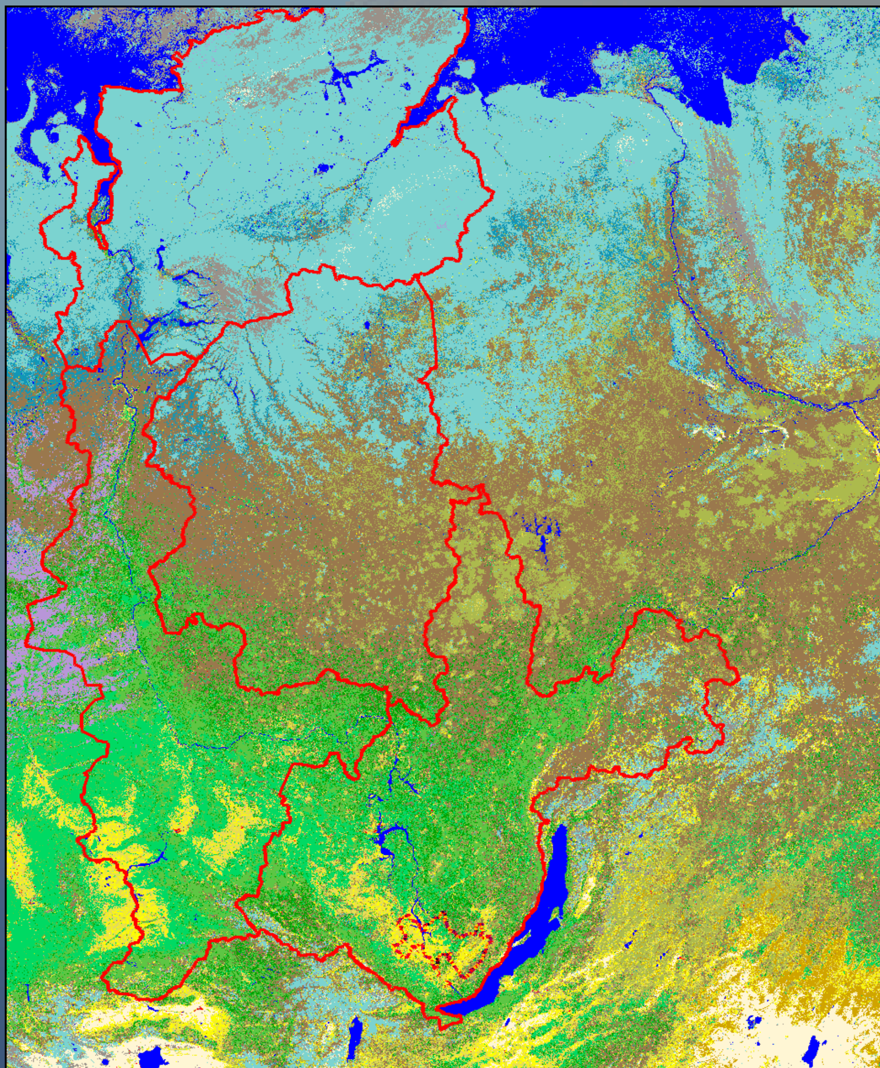
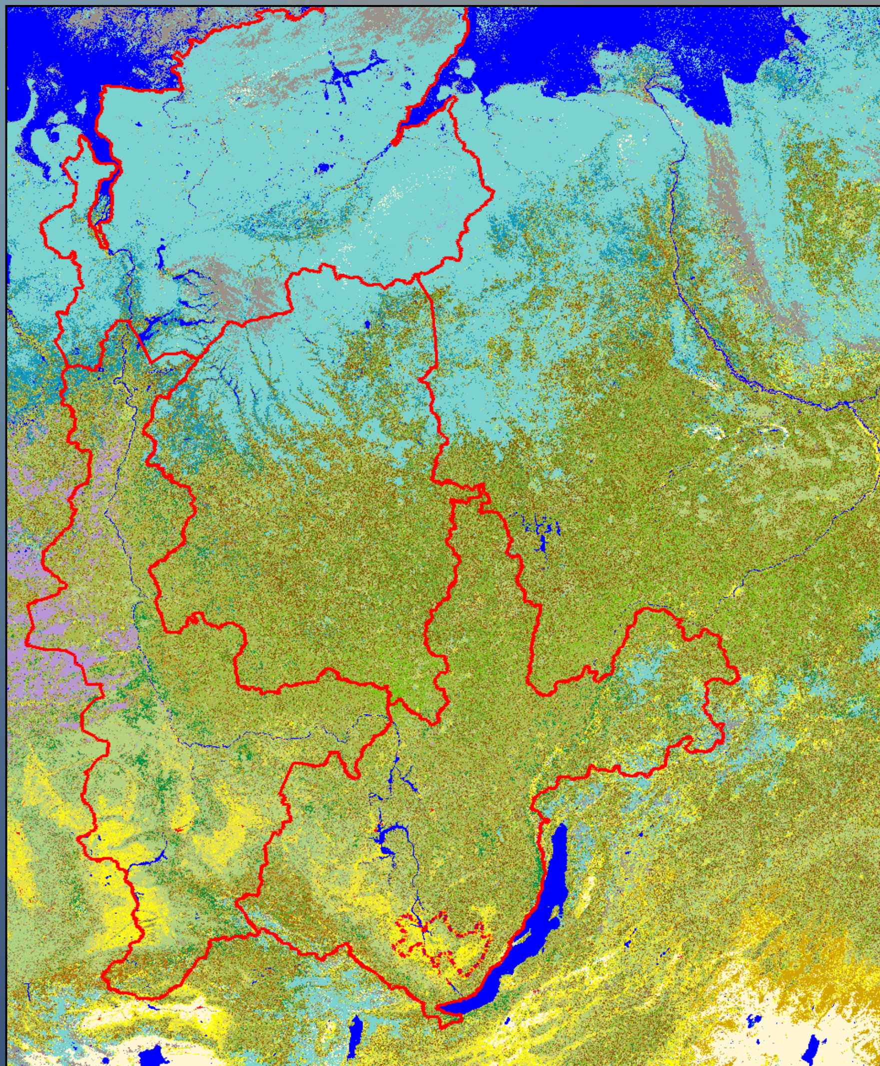
Siberia-II Level 2 results



- 500m pixel size
- 3 LC maps (2001, 2002, 2003)
- 2004 to be derived
- 16 Classes identified
- Results similar to previous efforts (GLC, UMD, IGBP)

SibII Level 3 results



- Same as the level 2 LCmap, except:
  - New forest classes added

    Aspen Birch Ceder

    Fir Larch Pine

    Spruce

    Mixed Evergreen Needleleaf

    Mixed Deciduous Broadleaf

    Mixed Forest

Accuracy (Siberia-II Level 2)

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	vs Training Data		vs New test sites		vs GLC2000	
	Prod.	Users	Prod.	User	Prod.	User
Water	100.0	99.61	83.22	92.77	50.85	77.37
Soil/Rock	84.34	99.91	45.71	67.95	37.60	53.51
Urban	95.38	99.2	-	-	29.33	24.12
Cropland	100.0	70.28	-	-	20.86	15.91
Crop/Forest	94.92	90.18	-	-	18.12	12.92
Light Conif.	100.0	91.81	51.66	78.21	58.85	72.56
Dark Conif.	100.0	91.87	85.01	74.71	-	-
Soft Decid.	100.0	89.03	84.93	73.64	62.22	52.80
Light Needleleaf	100.0	67.37	-	-	61.56	72.20
Light Broadleaf	100.0	89.39	-	-	-	-
Grassland	90.67	99.94	-	-	31.40	37.70
Wetland	99.72	99.72	-	-	21.42	48.63
Tundra Moss	100.0	77.03	95.58	48.76	84.63	62.68
Tundra Heath	76.61	99.96	-	-	21.95	20.04
Steppe	97.27	87.08	99.18	63.77	64.92	35.70
	Overall	92.18	Overall	73.87	Overall	58.68
	Kappa	0.91	Kappa	0.64	Kappa	0.48

Earth Observation and the Kyoto Protocoll

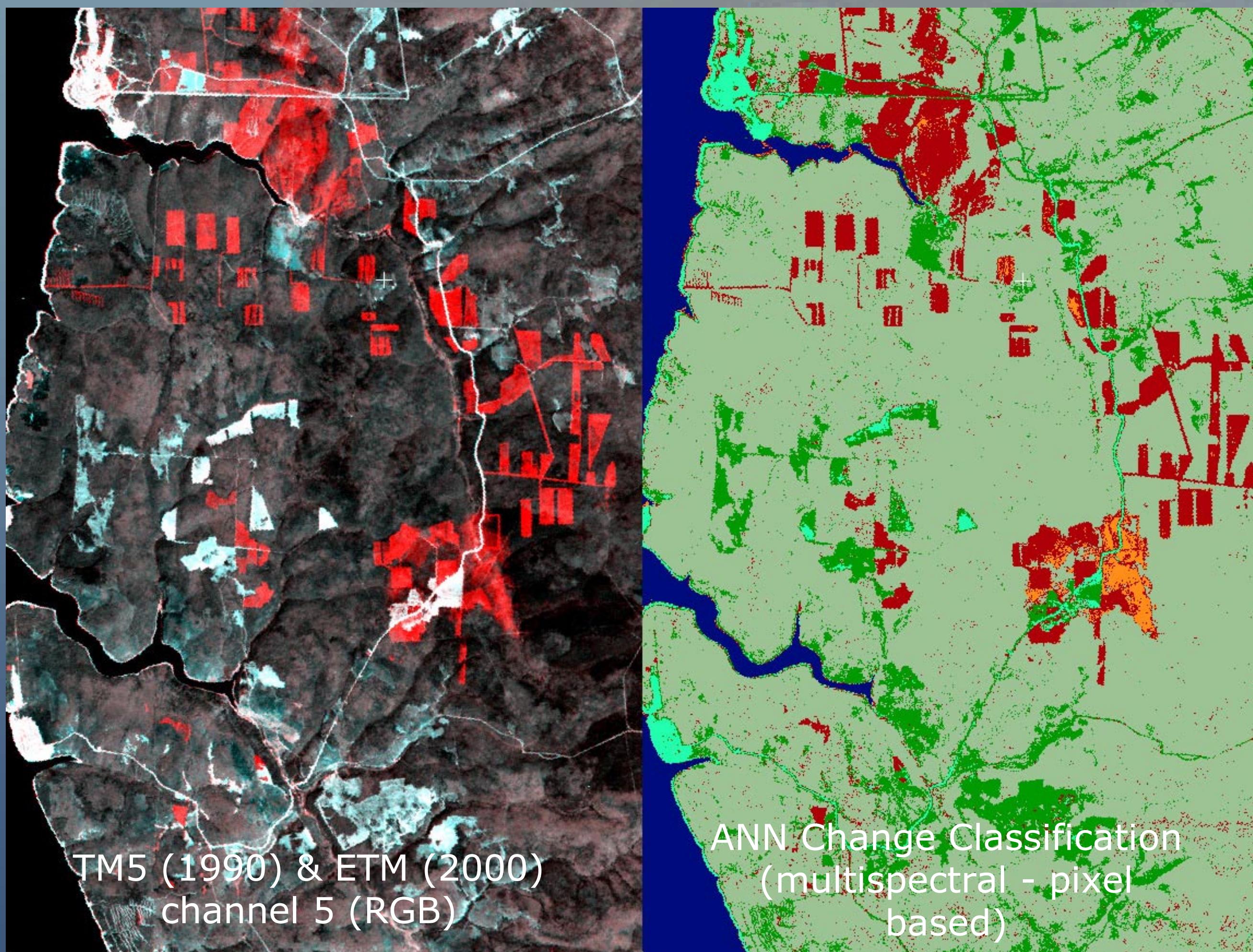
Five areas were identified where remote sensing technology may be applied, partly or fully, toward facilitating the treaty:

- Provision of systematic **observations of relevant land cover** (Art. 5, Art. 10);
- Support to the **establishment of a 1990 carbon stock baseline** (Art. 3);
- **Detection and spatial quantification of change in land cover (Art. 3, Art. 12); (→ Senken -> ARD)**
- **Quantification of above-ground vegetation biomass stocks** and associated changes therein (Art. 3 Art 12);
- Mapping and monitoring of sources of **anthropogenic CH4** (Art. 3, Art. 5, Art. 10);

seit 1558

ARD Classification

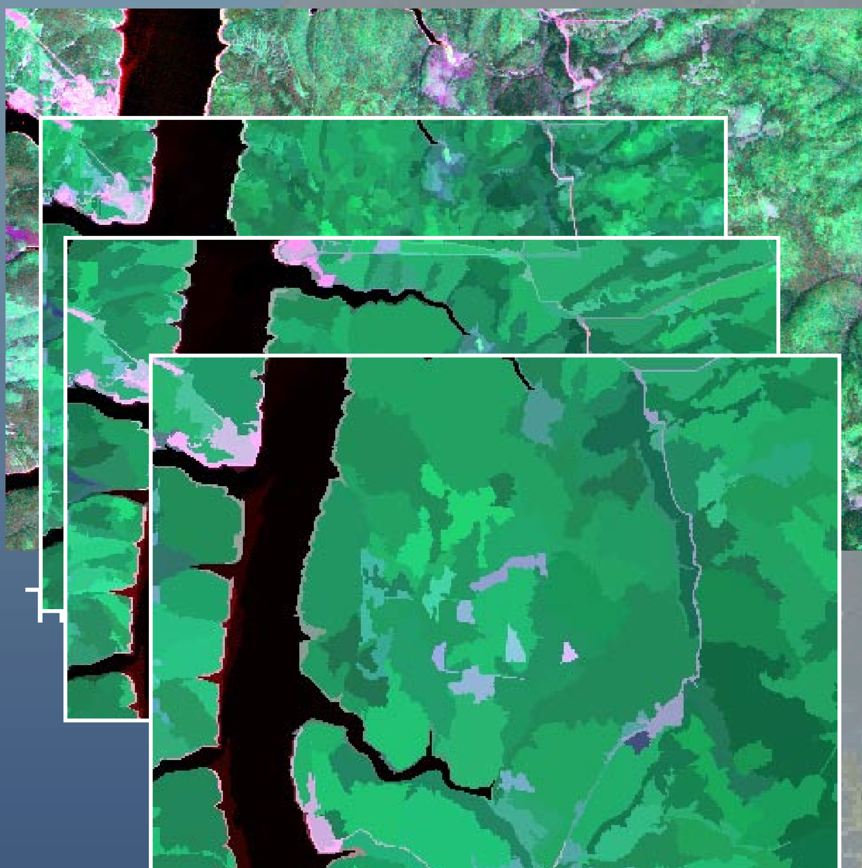
Deforestation and Reforestation



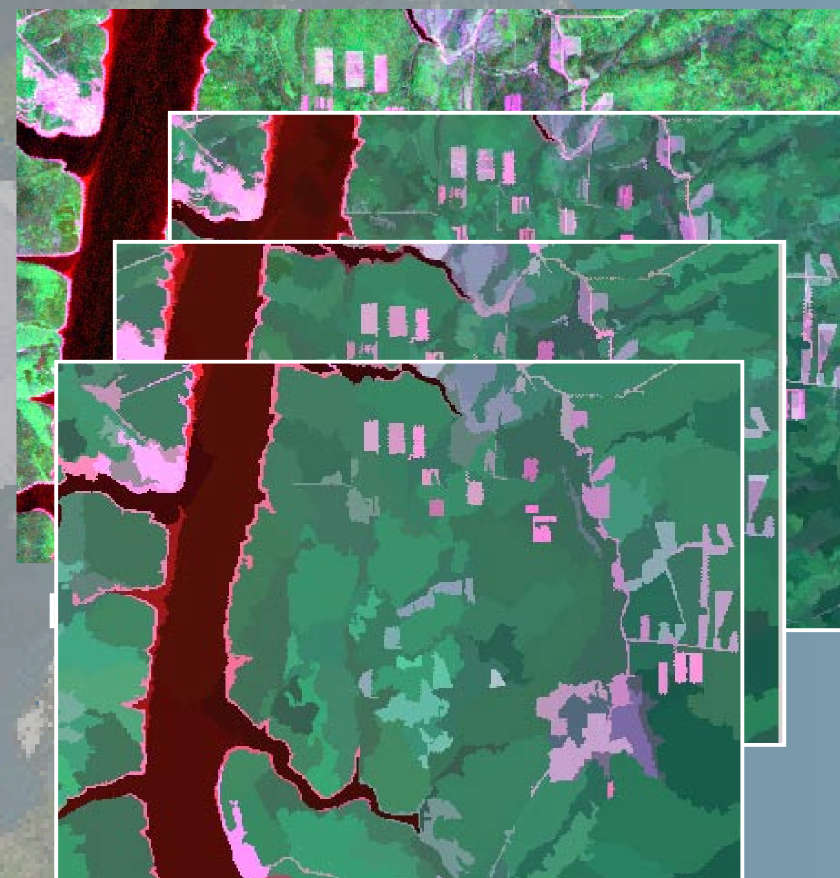
- deforestation
- fire scars (deforestation)
- forest no changes
- reforestation
- urban / industrial areas
- water

Object Based Post Classification

1990

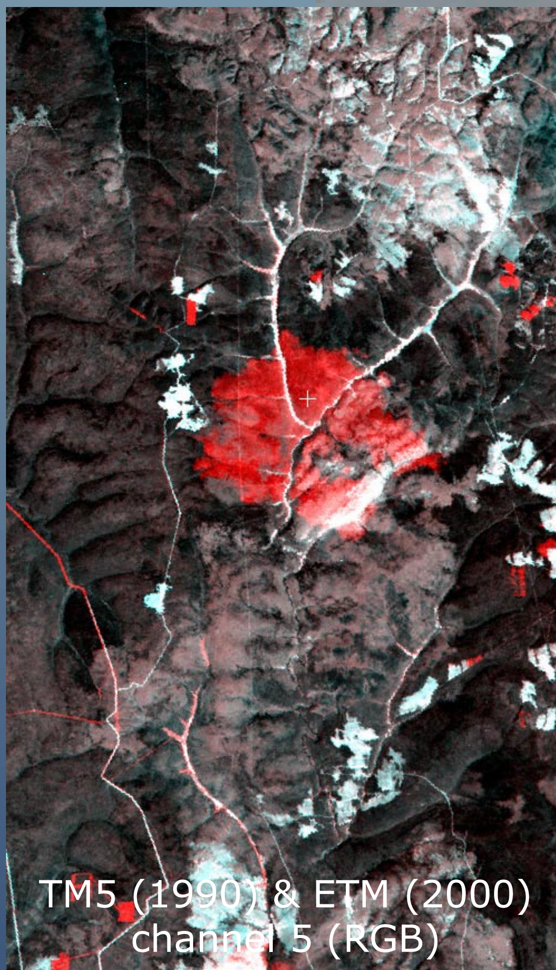


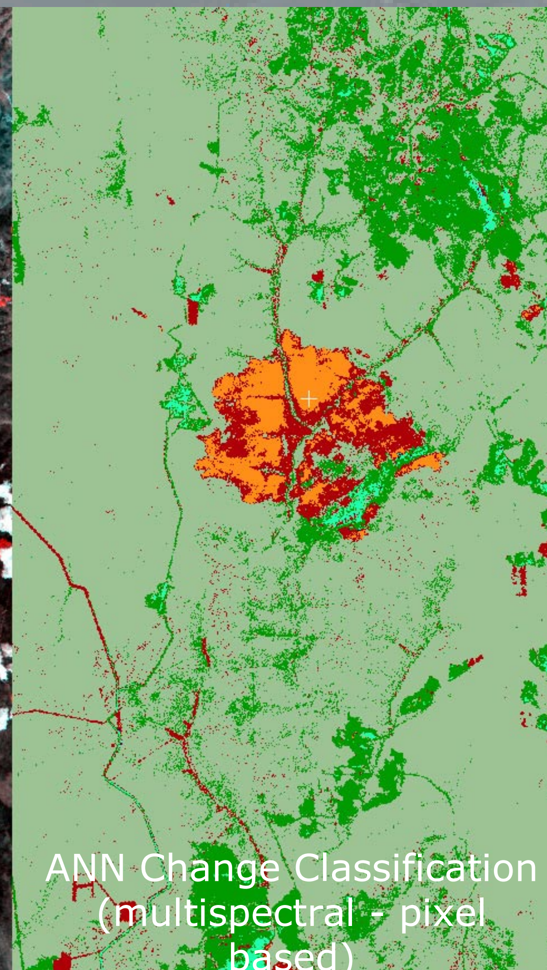
2000



1. Step: multi-scale segmentation

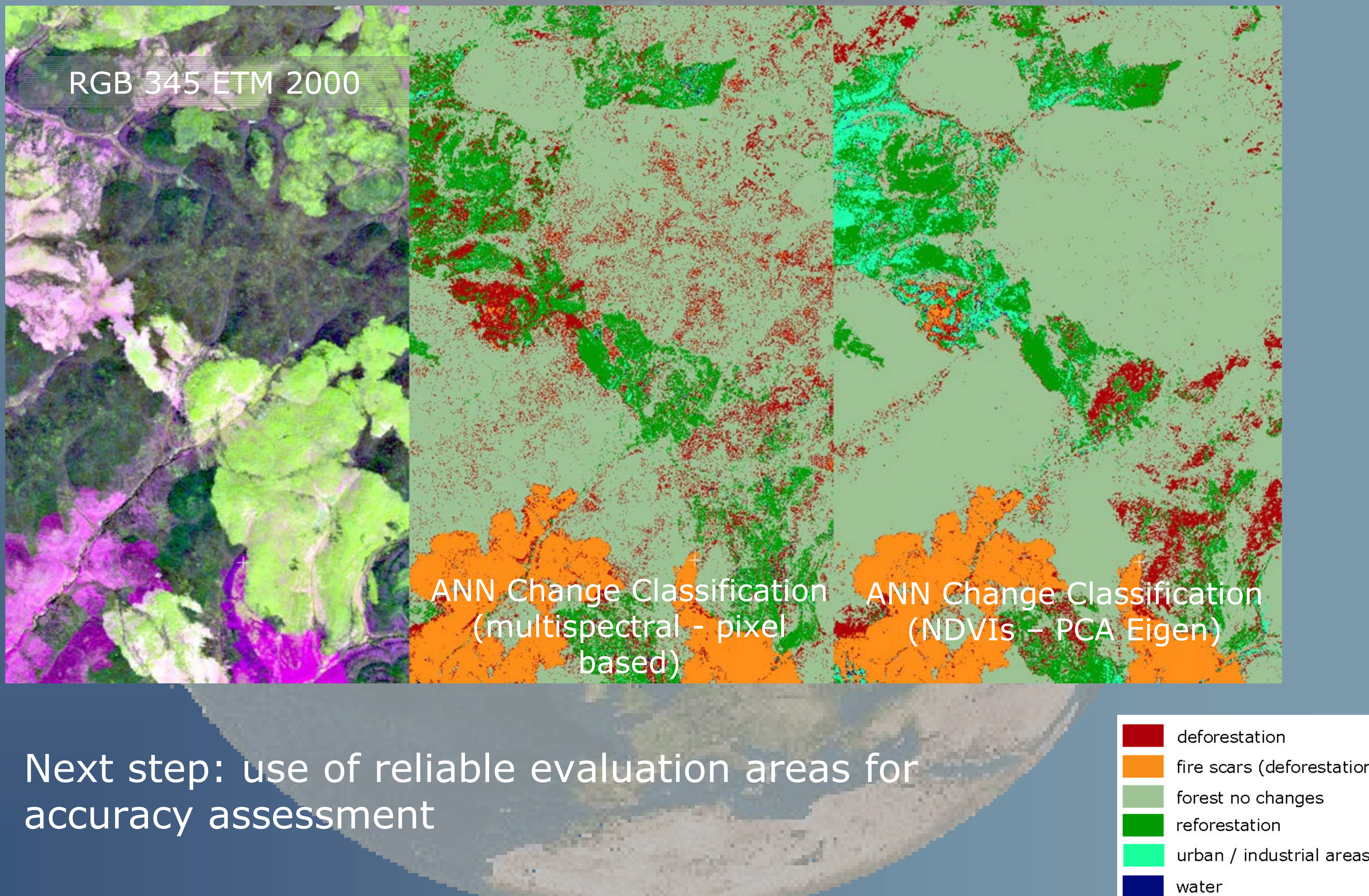
ARD Classification





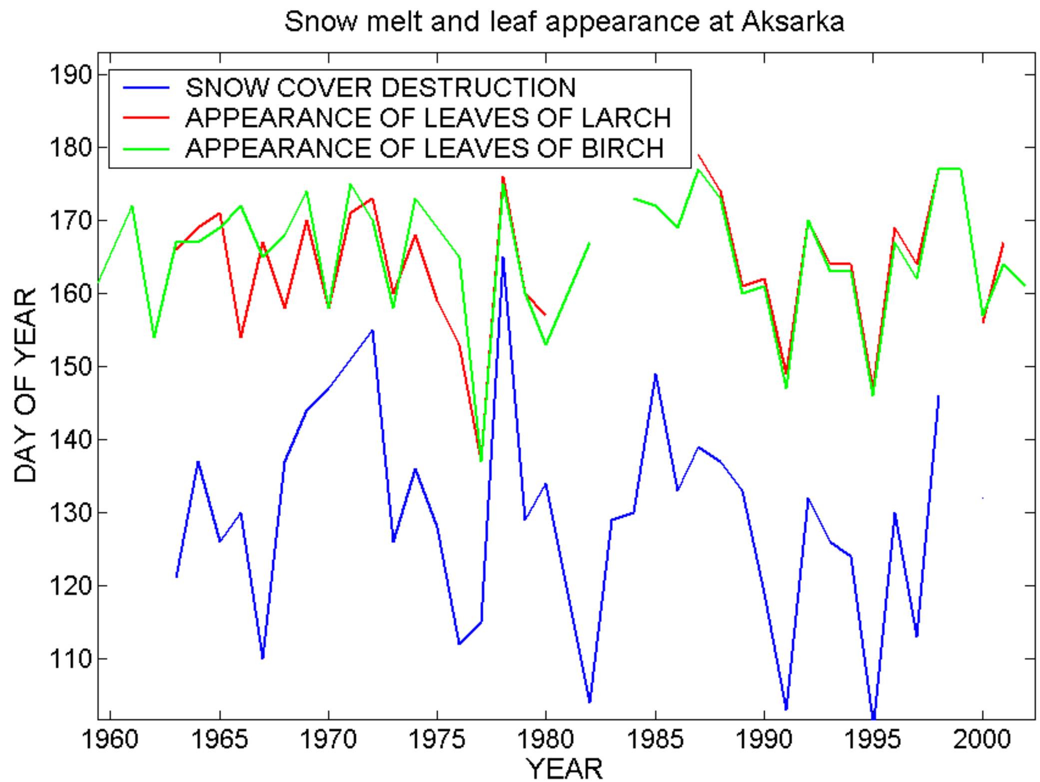
Differentiation of human induced Deforestation and fire disturbances is problematic

ARD Classification



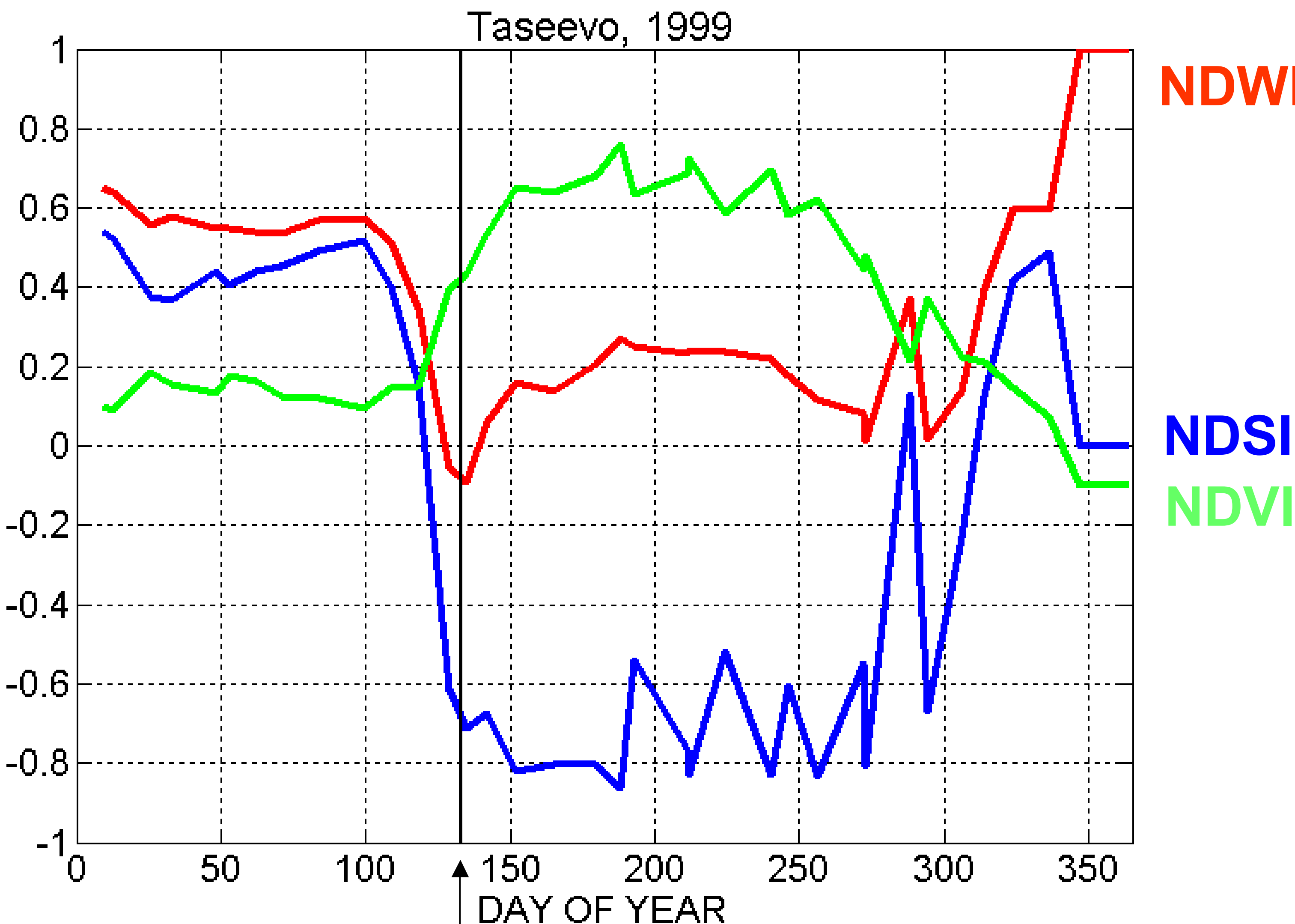
Next step: use of reliable evaluation areas for accuracy assessment

Analysis of in-situ data



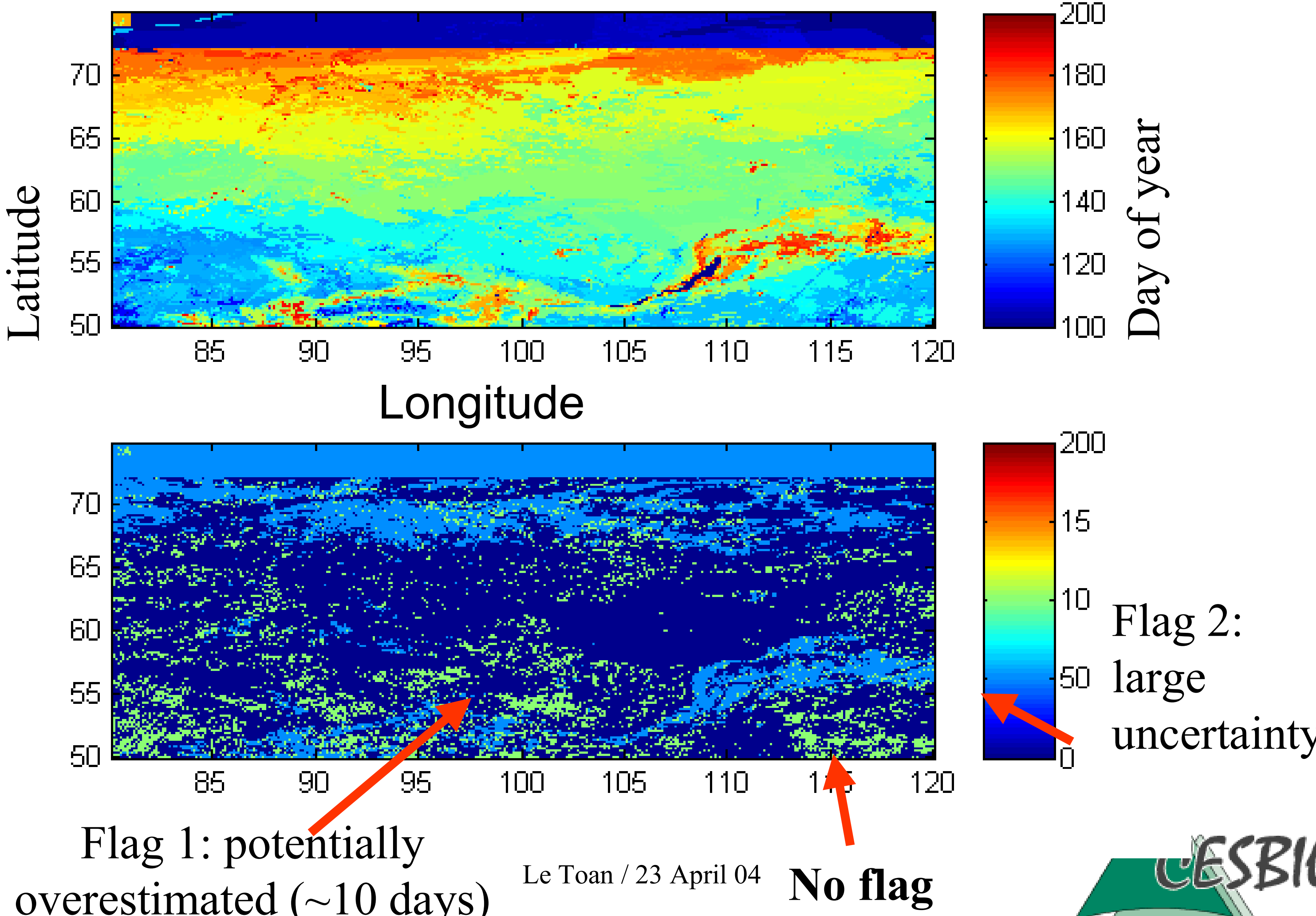
- Leaves appear after the beginning of the snowmelt. Variable time lag between both events.
- Close dates of leaf appearance for deciduous species.
- Mean leaf appearance interannual variability at one given place: 30 days.
- Variation of budburst dates from north to south: approximately one month

Analysis of spectral indices

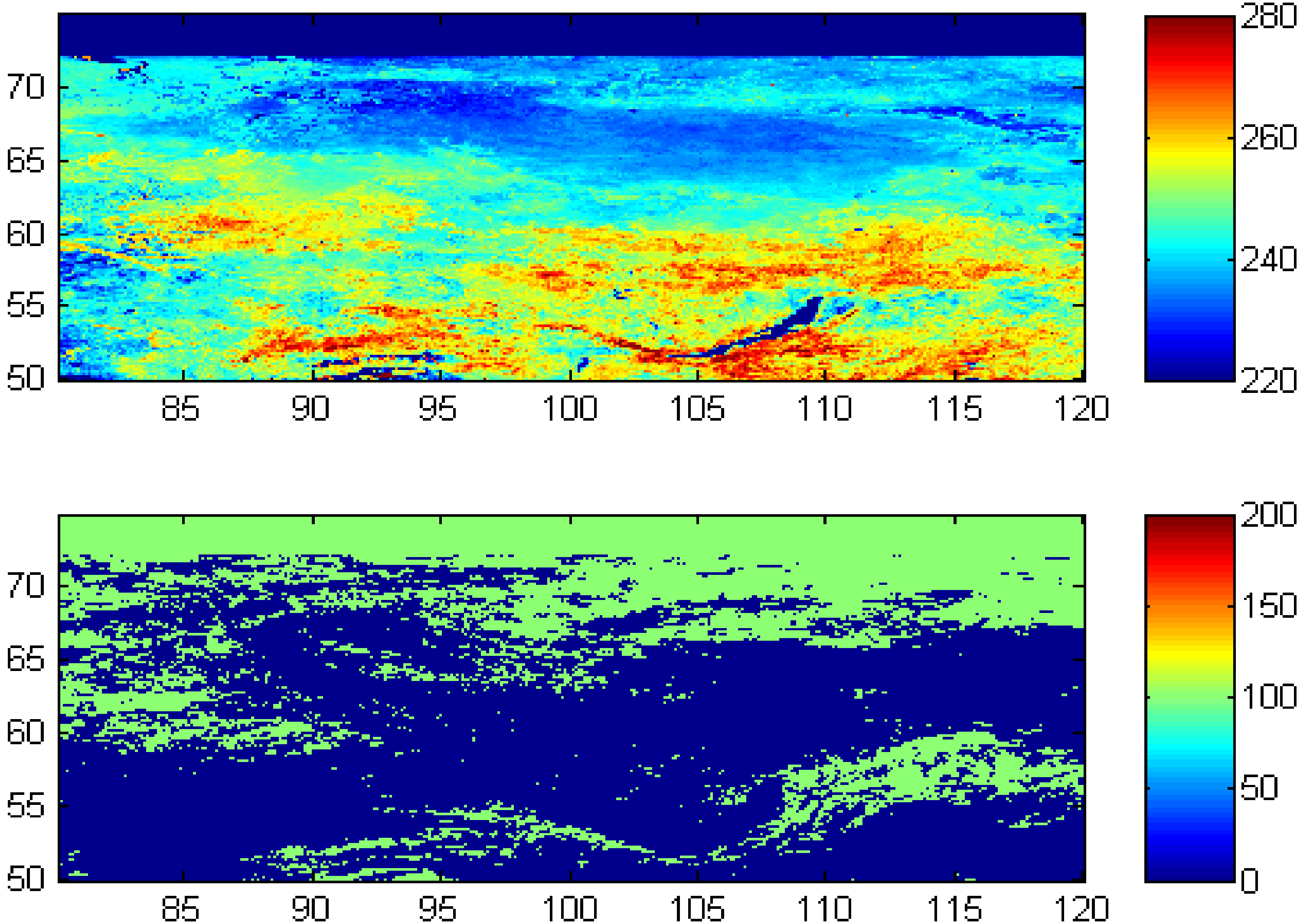


Appearance of birch first leaves

Map of budburst dates over Siberia in 2001, res: 0.1°

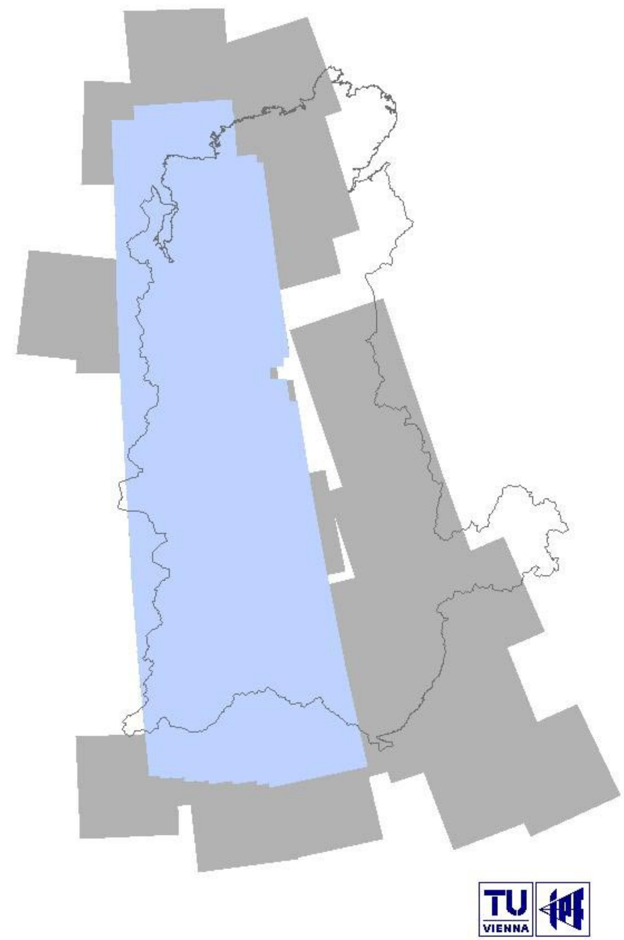


Map of phenological dates over Siberia:



ASAR WS availability

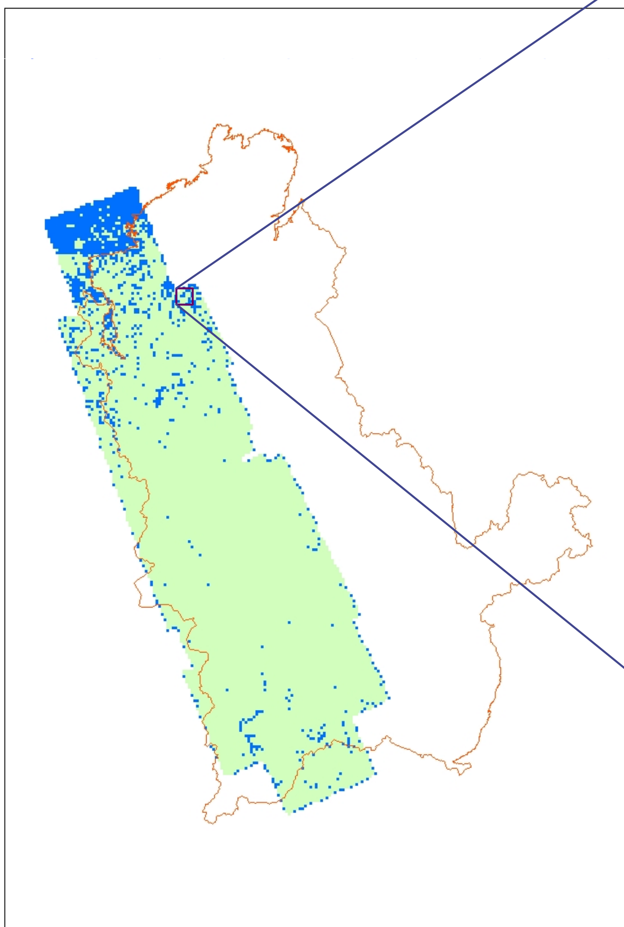
- Summer data from 2003 cover western part of Siberia II area
- Time period important for permanently by water covered surfaces: Summer (July-mid September)
  - Most of the region will be covered

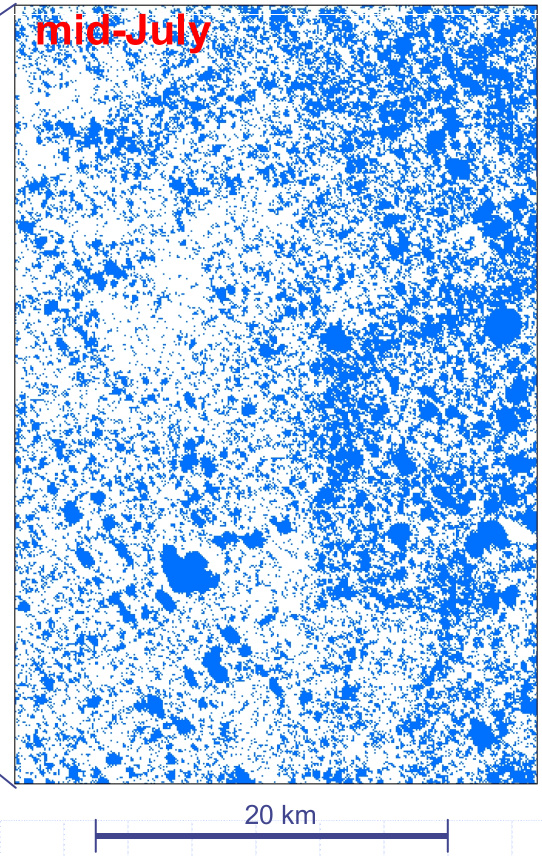


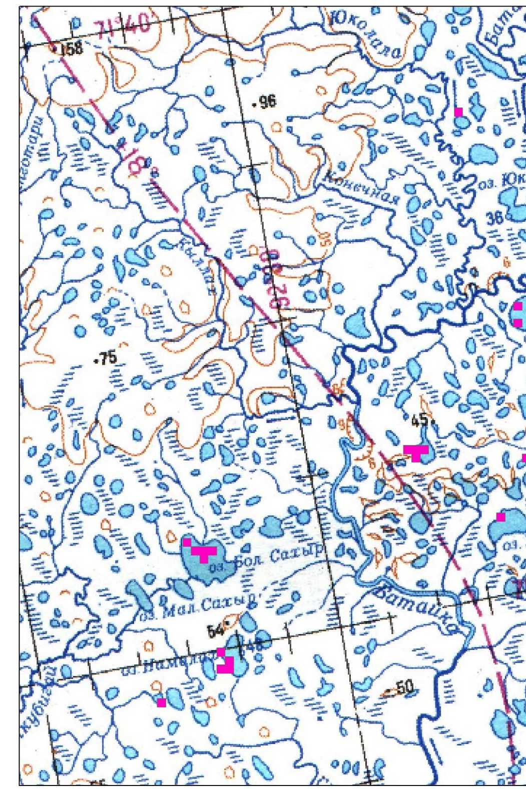
Complete (grey) and Summer coverage (blue)

Water bodies – accuracy assessment

Current extent of water bodies mask





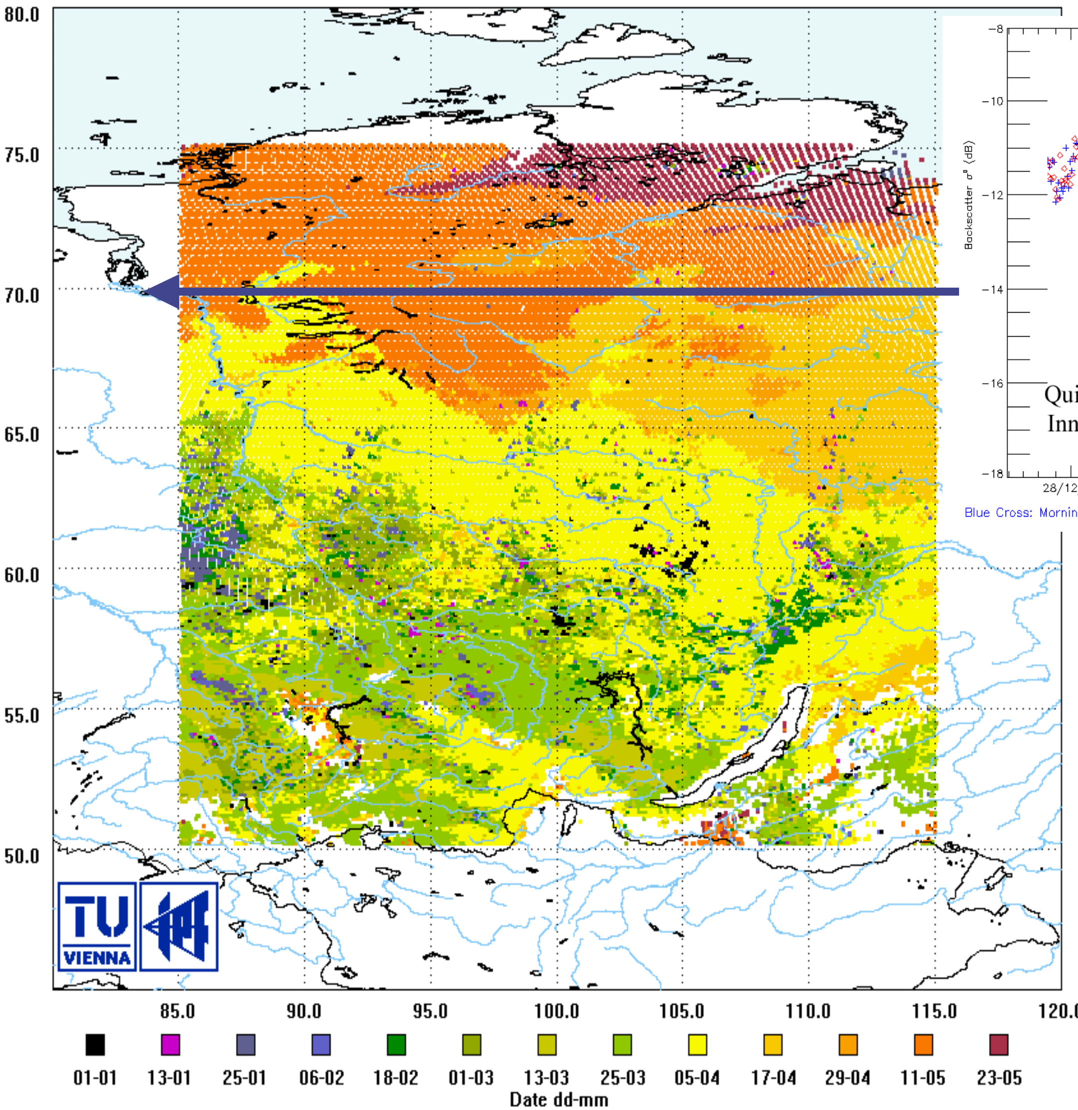


- No water bodies in the corresponding IIASA GIS layer for this area

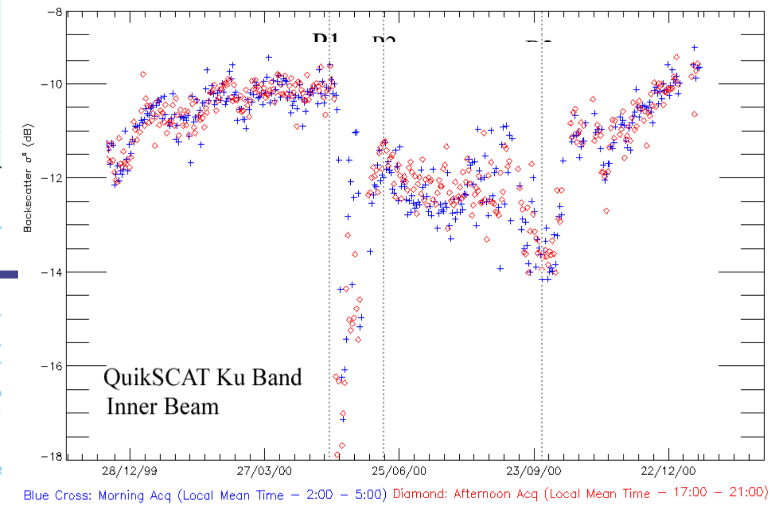
- pink areas: MODIS water class (all other area classified as tundra)

Brief Review – Product Rationale

SIBERIA II Start of Thaw Indicator - 2000



Lichen Moss Tundra



P1. **Start of Thaw**
change in surface wetness during day

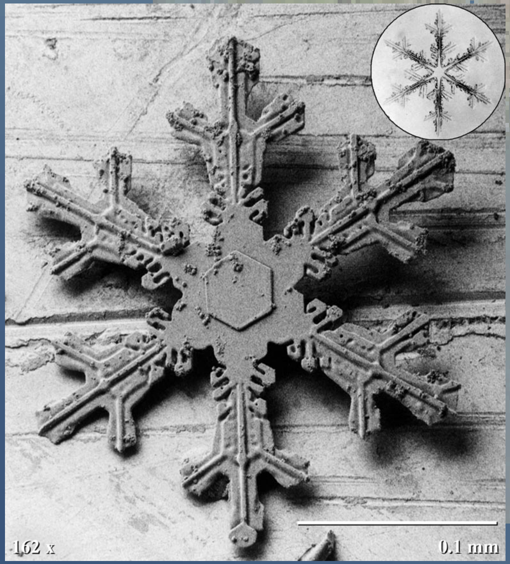
P2. **End of Thaw**
Disappearance of snow, or flooding?

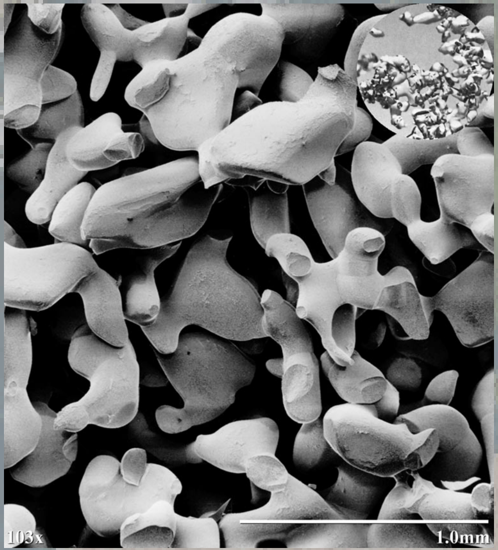
P3. **Start of Freeze**
apparent “drying up” of surface

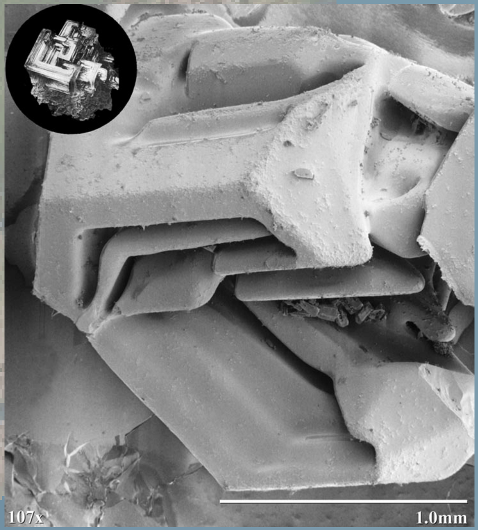
New Dynamic Algorithm

(Mognard & Josberger 2002)

- Dense media Radiative transfer theory
- Mie scattering
- Takes in to account snow grain size metamorphism in time and space.
- Requires surface air temperature information.

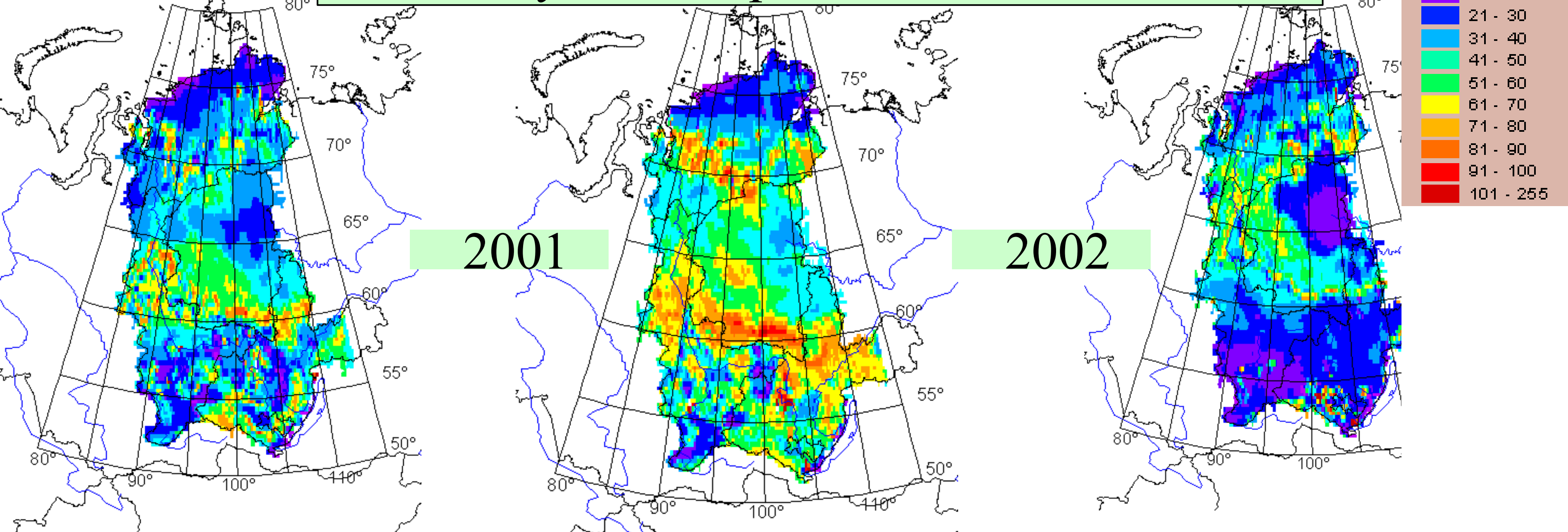




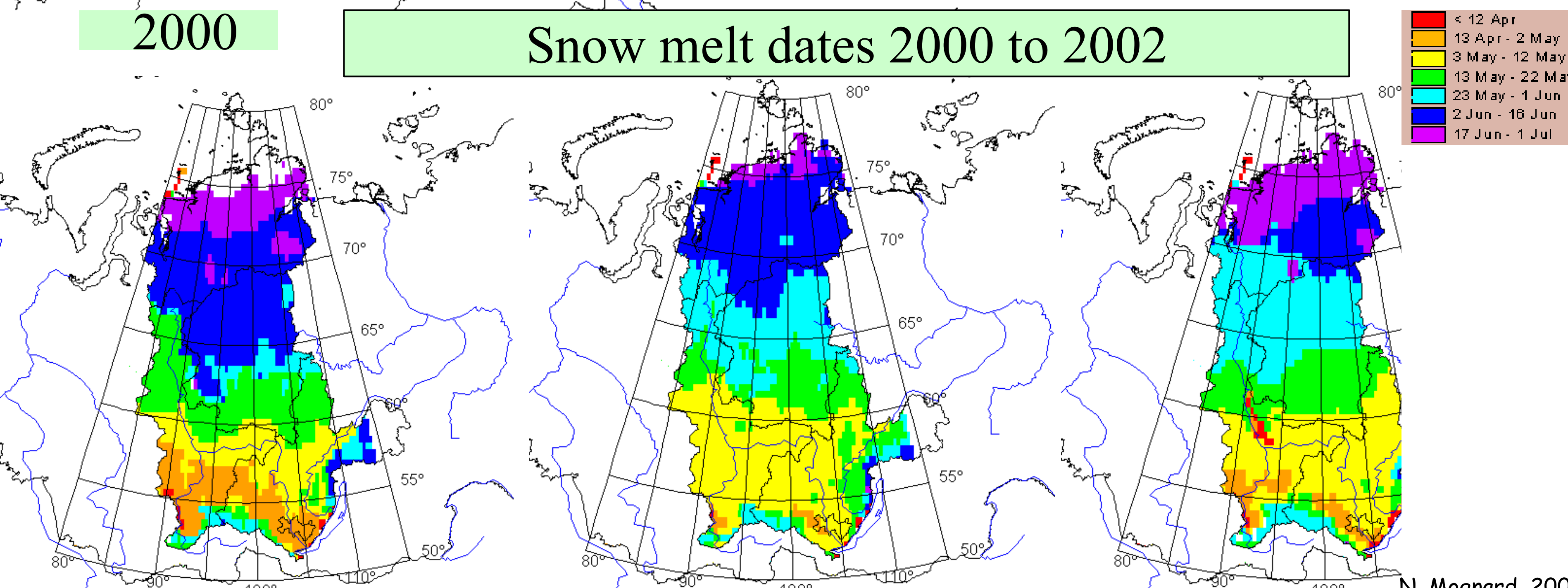


CESBIO

Monthly snow depth March 2000 to 2002

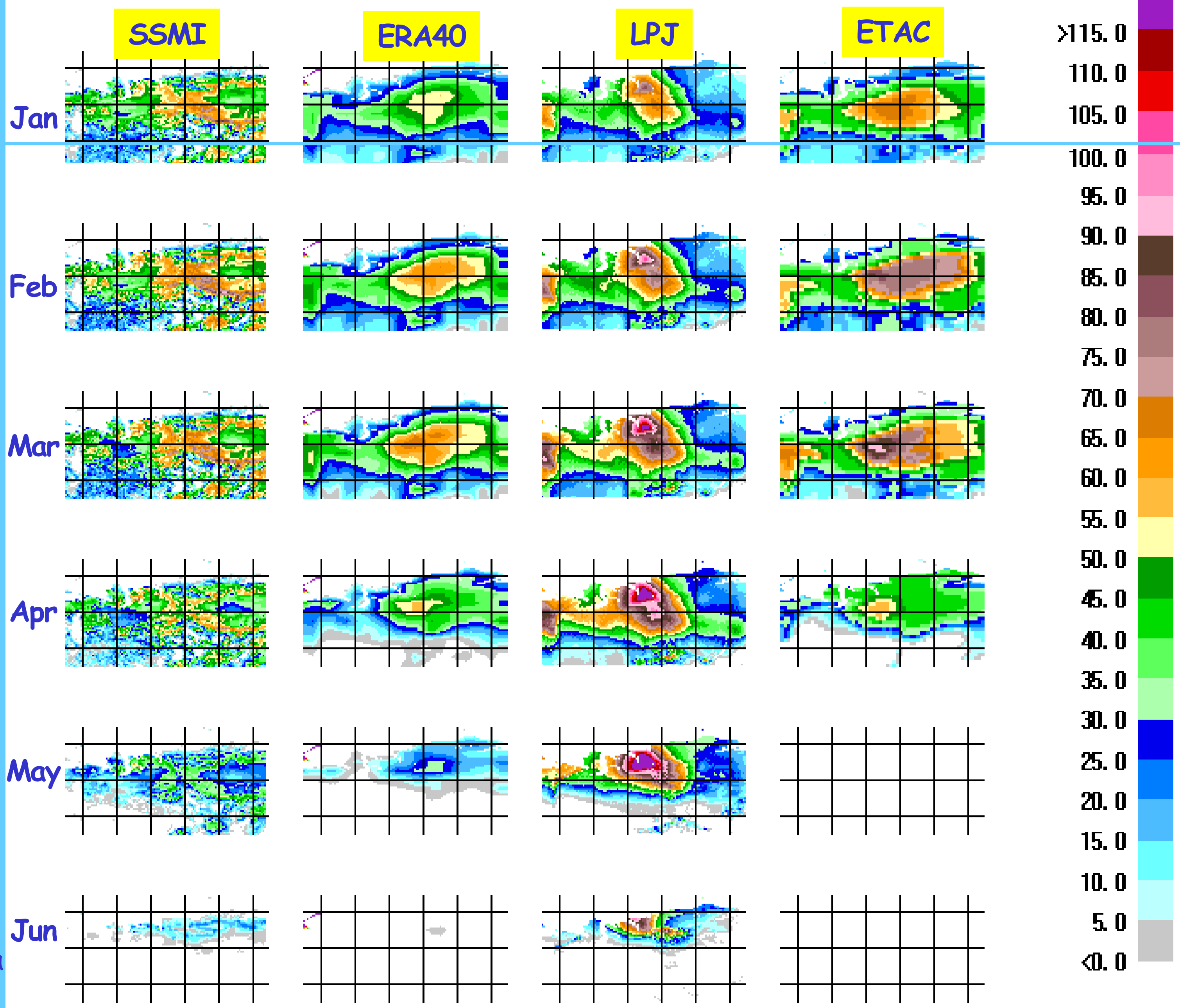


Snow melt dates 2000 to 2002



N. Mognard, 2004

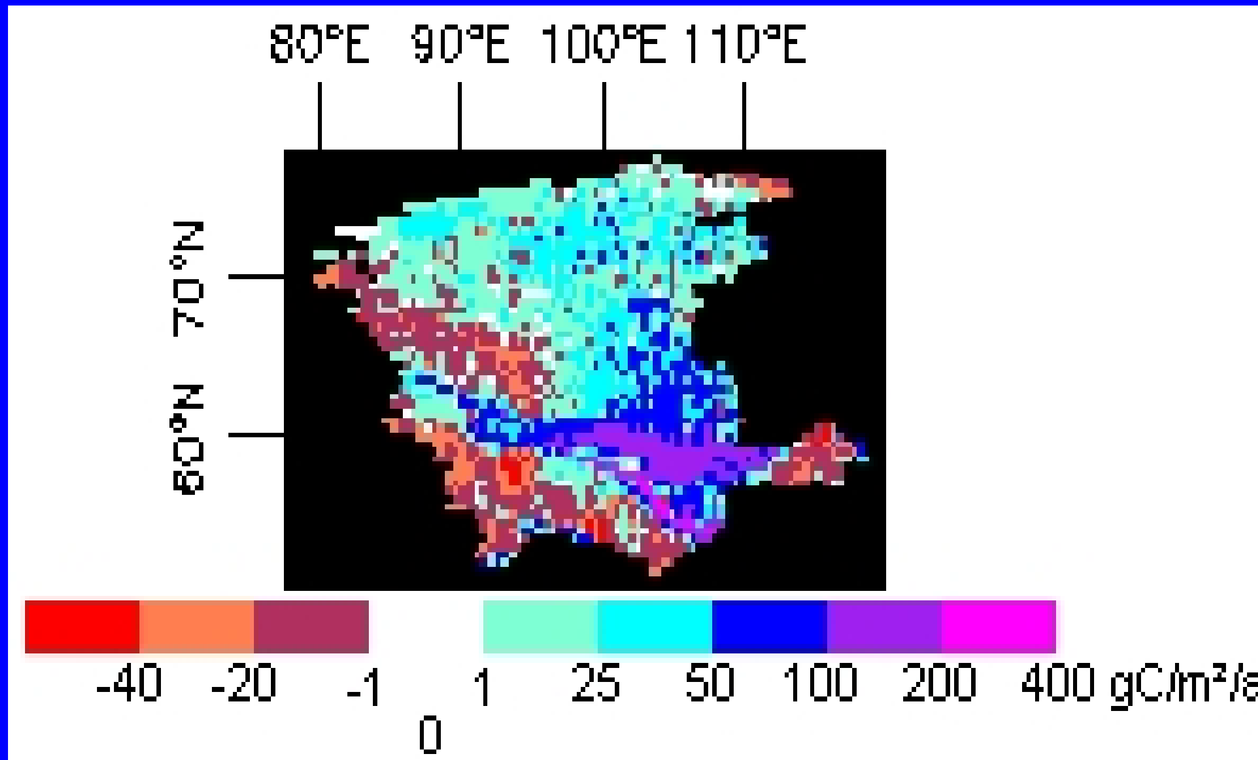
Mean monthly values averaged between 1988-1998



M. Grippa

CESBIO

Net carbon flux (NBP)

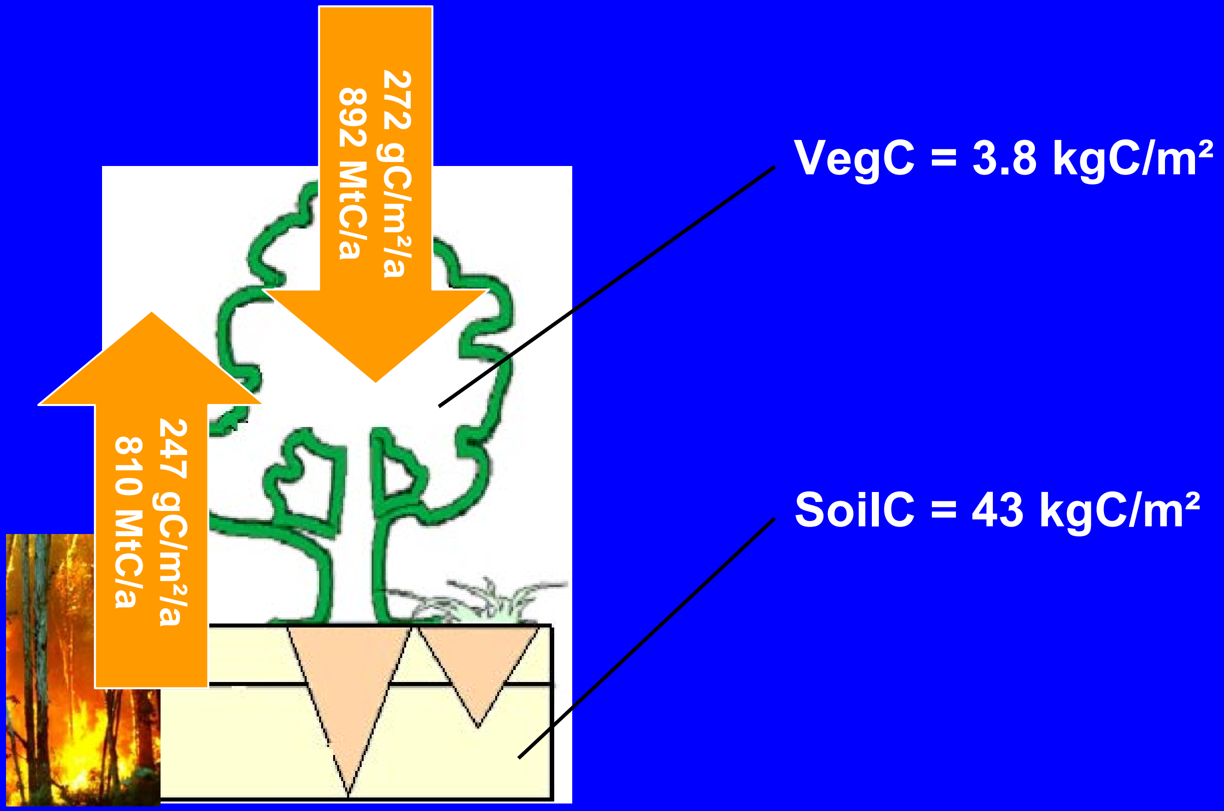


Mean net carbon flux (NBP) 1988-1992

NBP = NPP + Rh + FireC Negative values: Flux to the atmosphere

	NBP [gC/m²/a]
LPJ	+25

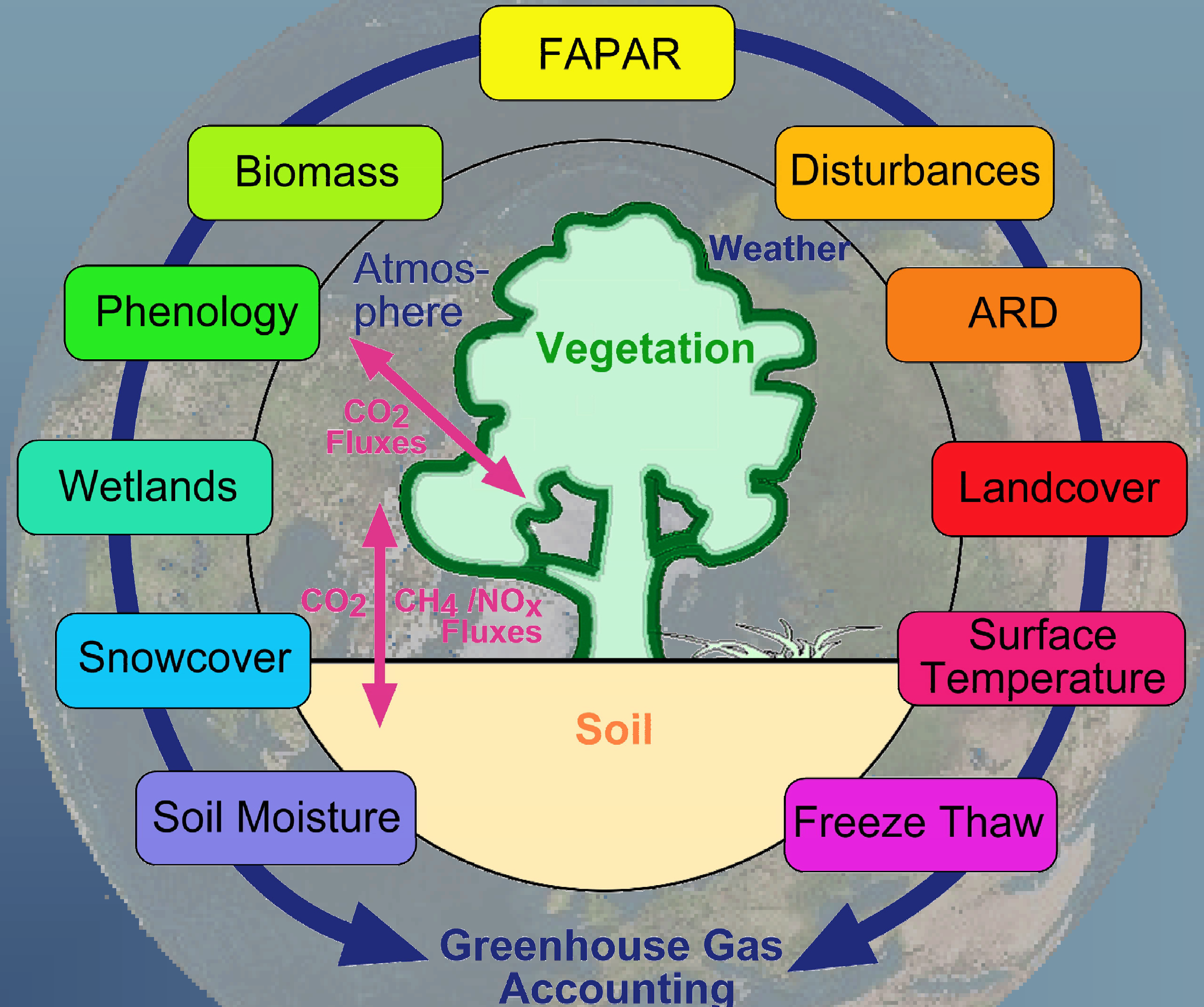
Summary of annual carbon balance of SIBERIA-II region, 1988-1992



NBP = +25 gC/m²/a = 82 MtC/a

SIBERIA-II region: 328 Mio ha

SIBERIA-II Greenhouse Gas Parameters



Vegetation Models in SIBERIA-II:
LPJ-DVM, SDVM, IIASA GIS-Approach

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SIBERIA-II Operational EO-Products for Greenhouse Gas Accounting

Greenhouse Gas Parameter = EO Product	Parameter Synergies	Main Sensor **Operational!**	Sensor Synergies (incl. Up- & Downsscaling) **Improvement!**	Source Years for SIBERIA-II	Pixel Size
ARD (only testsites)	Disturbances Landcover	Landsat TM	Multitemp. AVHRR ASAR ; JERS-1	90 vs. 2000	25m to 2km
Biomass	None	None	SIBERIA(-1) Map ASAR AP and repeat-pass coherence; NDVI (97-03)	1997/8 (Envisat03 / 04)	50m to 8km
Disturbances	ARD Landcover SnowCover	SPOT VGT	SIBERIA(-1) Map Multitemp. ASAR; AVHRR; ATSR-2, MODIS, MERIS	1990-2002, 2003 on a monthly basis	300m to 1km
FAPAR + LAI		MODIS	AVHRR, MERIS, VGT	2002, 2003	1km to 10km
Phenology	Landcover Snow Cover	MODIS	ASAR WS, AVHRR, MERIS?, SSM/I, VGT	98-03	1km to 10km
Freeze/ Thaw	Snow Extent Phenology, (Permafrost)	Quickscatt	(ASAR WS), MODIS, MERIS	1999-ongoing	(75m to) 10km
Land cover	Disturbances Waterbodies Biomass Phenologoy	MODIS	AATSR ASAR WS MERIS	2001-2004	300m to 1km
Snow Depth & Date of Snowmelt	Landcover Phenology	SSM/I	MODIS VGT	1988-02	1km to 25km
~~Soil-moisture~~ (not operational)		Scatterometer	ASAR WS	92-2000	25km
~~Wetlands~~ Waterbodies	Landcover (Permafrost)	ASAR WS	SSM/I	2004 (2003/04)	75

EXPECTED KEY IMPROVEMENTS FOR GREENHOUSE GAS ACCOUNTING FROM EO

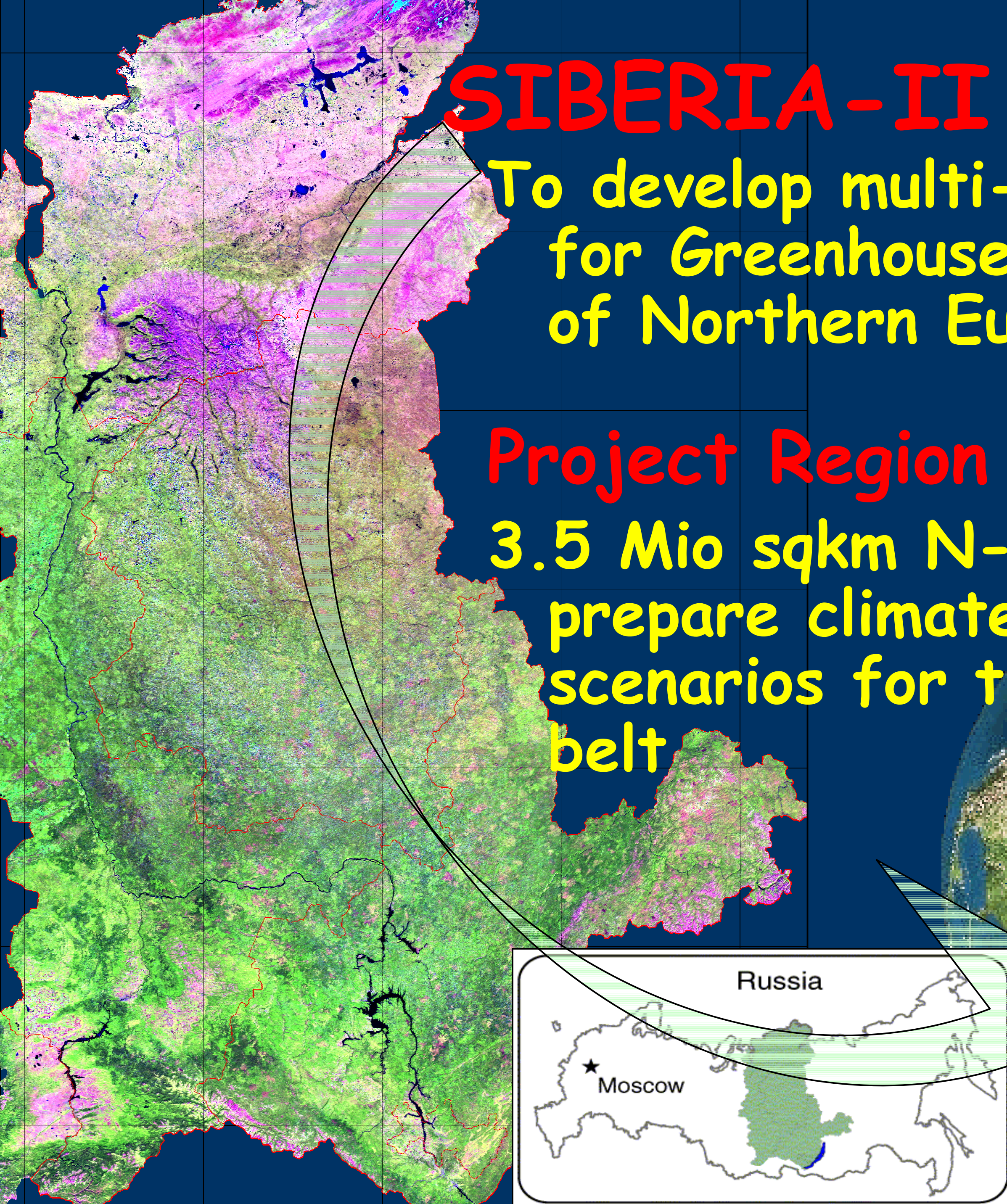
Compiled by W. Lucht and the SIBERIA-II EO-Model Interface Splinter Group, ESRIN, Nov. 7, 2003	LPJ-Model **(Lund Potsdam Jena Dynamic Veg.Model)**	SDGV Model (Sheffield Dynamic Global Vegetation Model)	IIASA GIS Account (Int. Inst. of Applied System Analysis Geoinformation Syst.)
BASELINE “pre-SIBERIA-II”	stand-alone runs 1900-2100	stand-alone runs 1900-2100	previous results for 1990 (1988-92 av.)
EO-MODEL COMPARISONS → PROCESS IMPROVEMENT	Permafrost (from Freeze/Thaw) Snow PFT parameters	Permafrost (from Freeze/Thaw) PFT (Topography)	● New semiempirica models (eg for NPP) ● Process blocks include landscape properties
EO-ASSIMILATION INTO MODELS I → IMPROVEMENT OF SPATIAL CONSTRAINT “Land Cover (LC) vs. PFT*) ***plant functional type**	Force LC (for improved biomass patterns and C-balance)	Force LC (for improved biomass patterns and C-balance)	LC Disturbance pattern (incl. EO-fire) Wetland pattern
EO-ASSIMILIATION INTO MODELS II → IMPROVING SPATIAL-TEMPORAL CONSTRAINTS	fPAR assimilation (recent climate data crucial!)	fPAR assimilation (recent climate data crucial!)	Direct and indirect use of fPAR and LAI

SIBERIA-II Objective

To develop multi-sensor concepts for Greenhouse Gas Accounting of Northern Eurasia

Project Region

3.5 Mio sqkm N-S transect to prepare climate change scenarios for the pan-boreal belt



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©Boreas Machine Potsdam Meeting, June 2004

Major Effects – observed already now or of concern for the near future

Changes in permafrost/ice

- hydrology / ocean salinity
- vegetation / GHG balance (soils)
- infrastructure

Changes in vegetation & snow cover patterns

- impact on albedo climate feedback
- impact on carbon/GHG/H_20 balance

Changes in C, N, H_20 … (GHG) stores/fluxes

- impact on regional/global climate
- stress effects on ecosystems
- human use impacts (eg water use, biomass/wood potential)

Changes in fire regime

- management
- vegetation composition
- GHG & aerosol emissions

Changes in socioeconomics

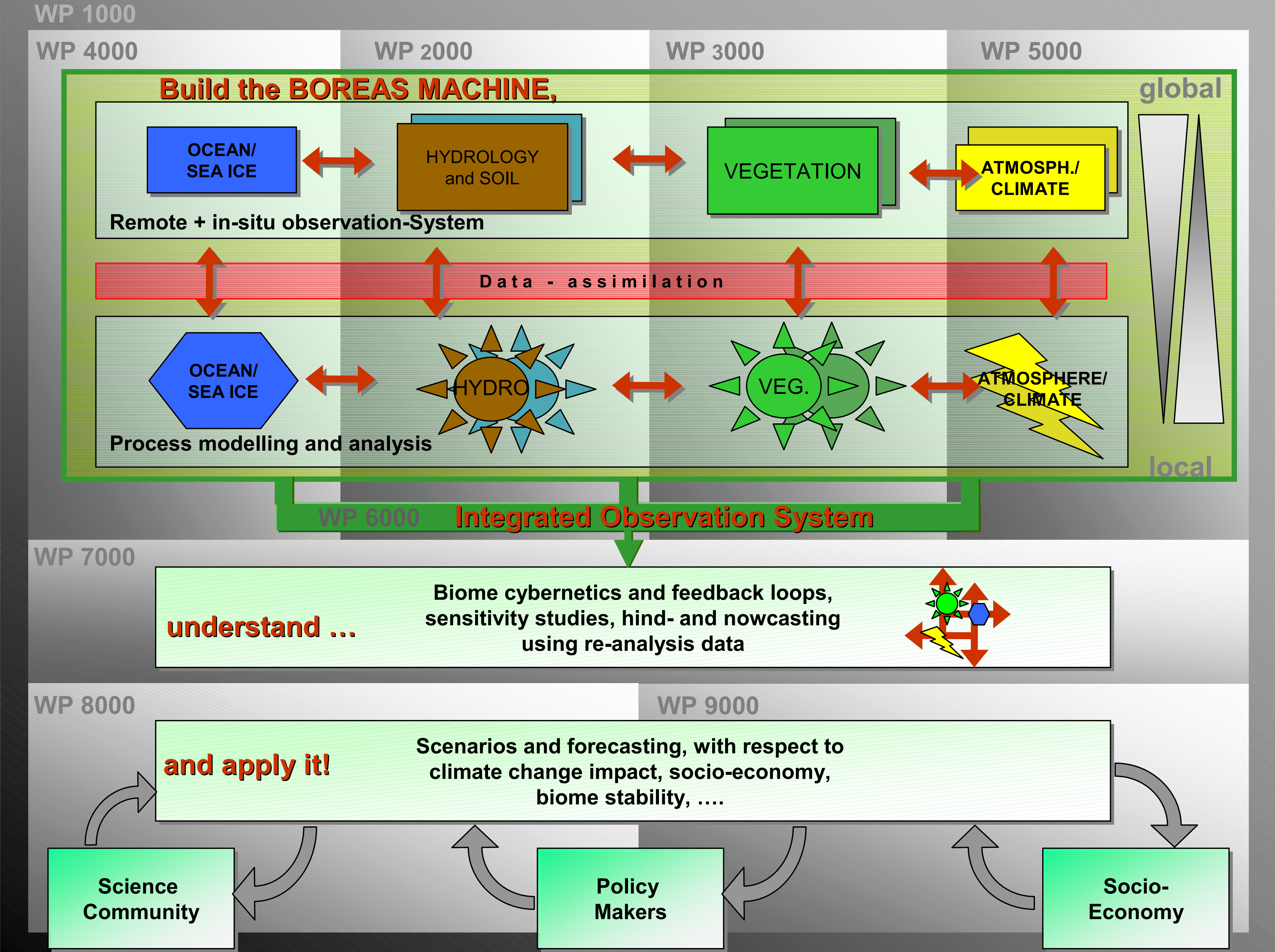
- impact of infrastruct. changes (pipelines, transp.) on ecosyste
- impact of land use change on hydrology, GHG balance

Changes in sea ice

- impact on coastal zone (transport, livelihoods)
- impact on reg./global circulation (climate, water cycle, veg)

Changes in atmospheric chemical composition

- arctic haze
- ozone (tropospheric and stratospheric, UV effect)


WP 1000
WP 4000
WP 2000
WP 3000
WP 5000
Build the BOREAS MACHINE,
global
OCEAN/ SEA ICE
HYDROLOGY and SOIL
VEGETATION
ATMOSPH./ CLIMATE
Remote + in-situ observation-System
Data - assimilation
OCEAN/ SEA ICE
HYDRO
VEG.
ATMOSPHERE/ CLIMATE
Process modelling and analysis
local
WP 6000
Integrated Observation System
WP 7000
understand …
Biome cybernetics and feedback loops, sensitivity studies, hind- and nowcasting using re-analysis data
WP 8000
WP 9000
and apply it!
Scenarios and forecasting, with respect to climate change impact, socio-economy, biome stability, ….
Science Community
Policy Makers
Socio-Economy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