Friedrich-Schiller-University Jena
Institute of Geography – Department of Earth Observation

seit 1558

Integrated Forest Observations in Boreal Ecosystems

Results of the EC projects SIBERIA-I and –II EC, and ESA projects FEMINE, GMES Forest Monitoring and the GOFC-GOLD Land Cover Project Office in Jena

Chris Schmullius, Sergey Bartalev, and Anatoly Shvidenko

Overview

1. Climate Change Background and EO

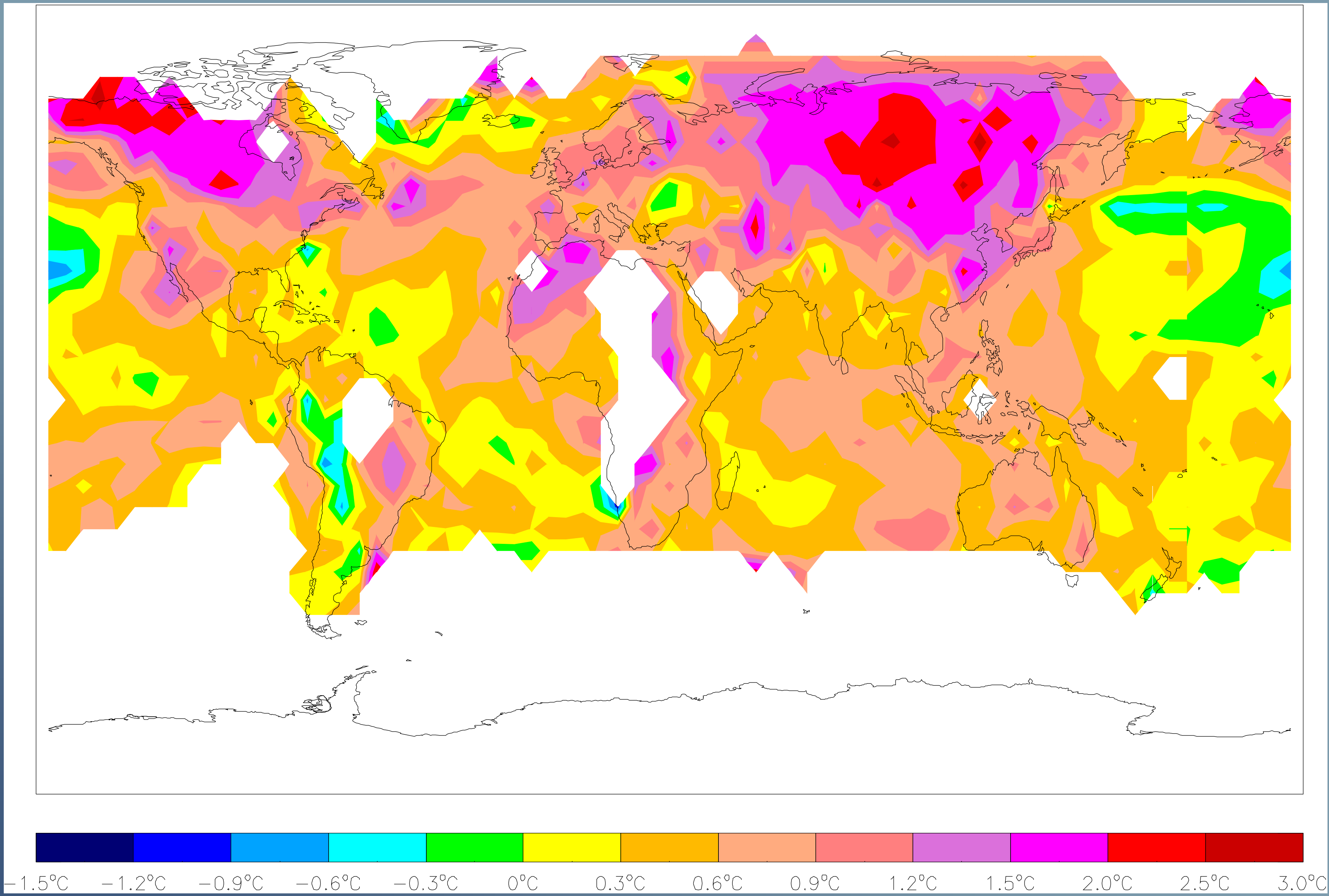
2. SAR Imaging for Boreal Ecology and Radar Interferometry Applications

3. SIBERIA-II: Multi-sensor Concepts for Greenhouse Gas Accounting

4. New Possibilities: ALOS and TerraSAR-X

5. Sib-ESS-C:
   Siberian Earth System Science Cluster

Mean Temperature Change 1965 to 2002



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

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

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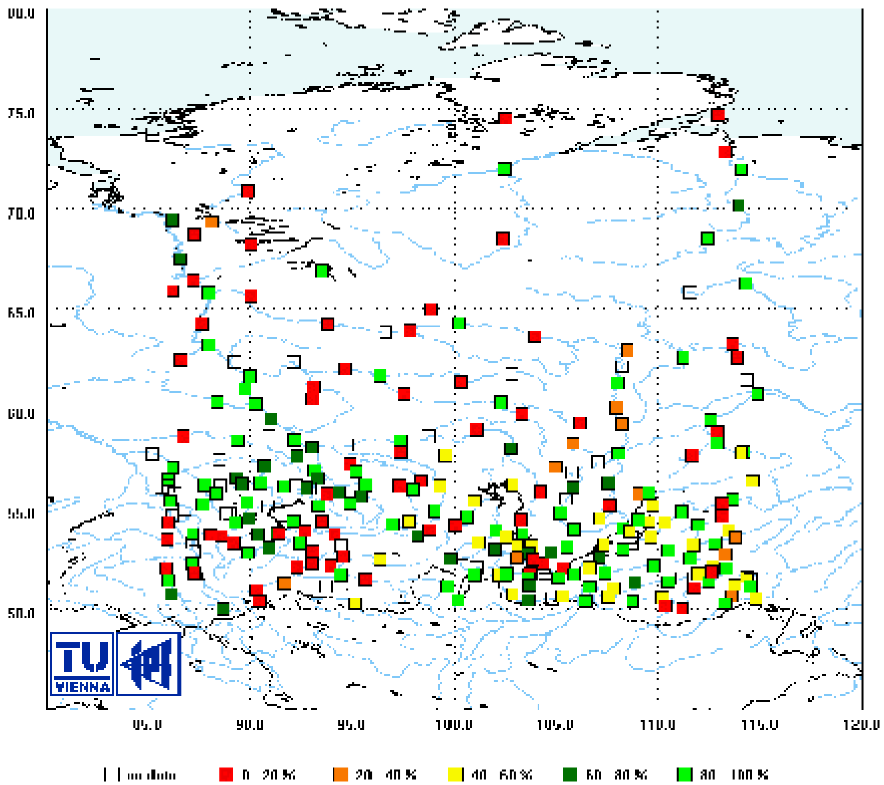
Northern Hydrologic Systems are Changing

- Carbon cycle is closely linked with energy & water cycles
- Observed changes in Northern Hydrology
  - § River discharge ↑
  - § Spring discharge peak ↓
  - § Length of ice-free season ↑
  - § Snow covered area ↓
  - § Active layer depth ↑
  - § Etc.
- But distributed hydrologic processes can only be poorly quantified due to the lack of data



% of non-missing precipitation data 1994-2004 over SIBERIA II region

http://www.siberia2.uni-jena.de

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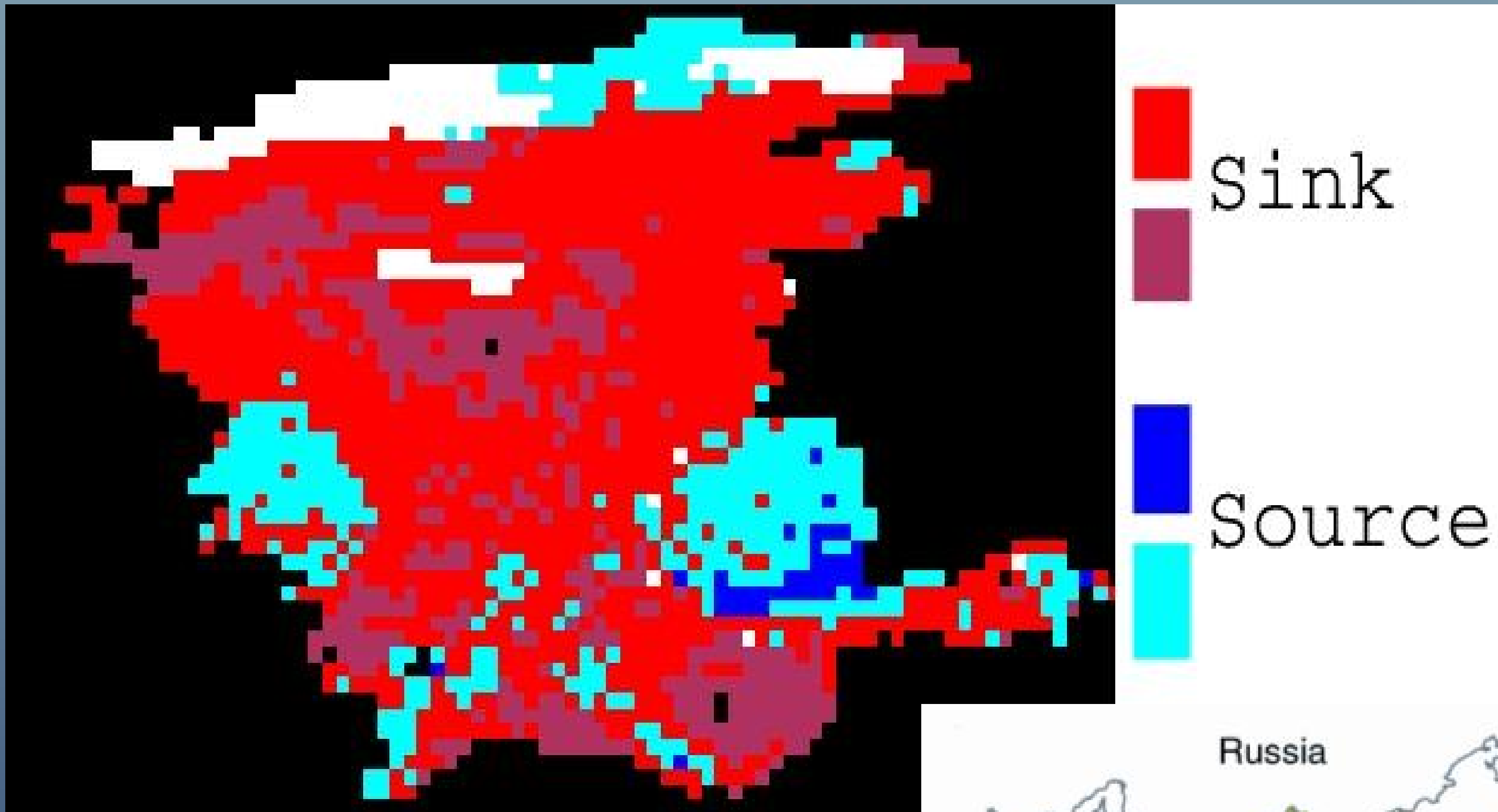
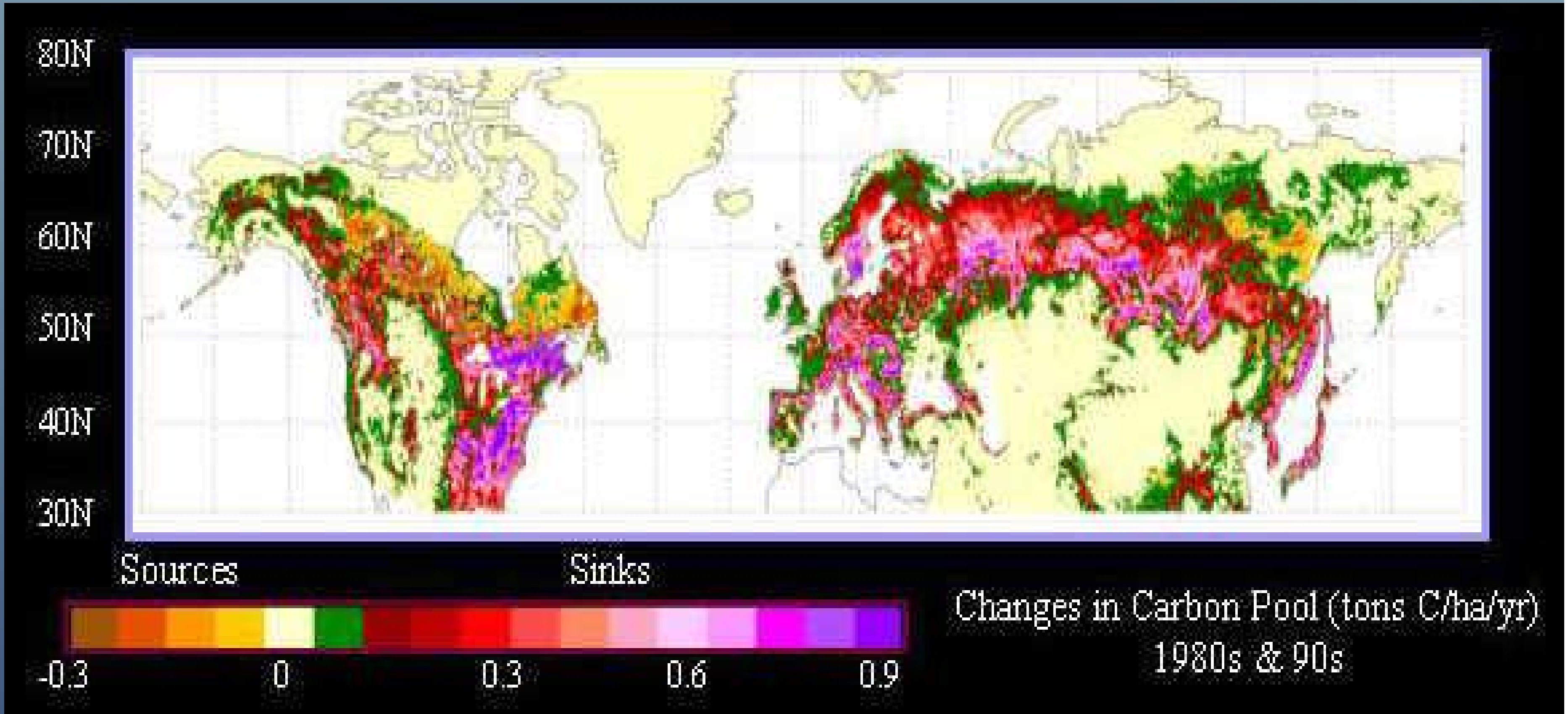
SIBERIA-II : LPJ Carbon Bilance 2002-2003



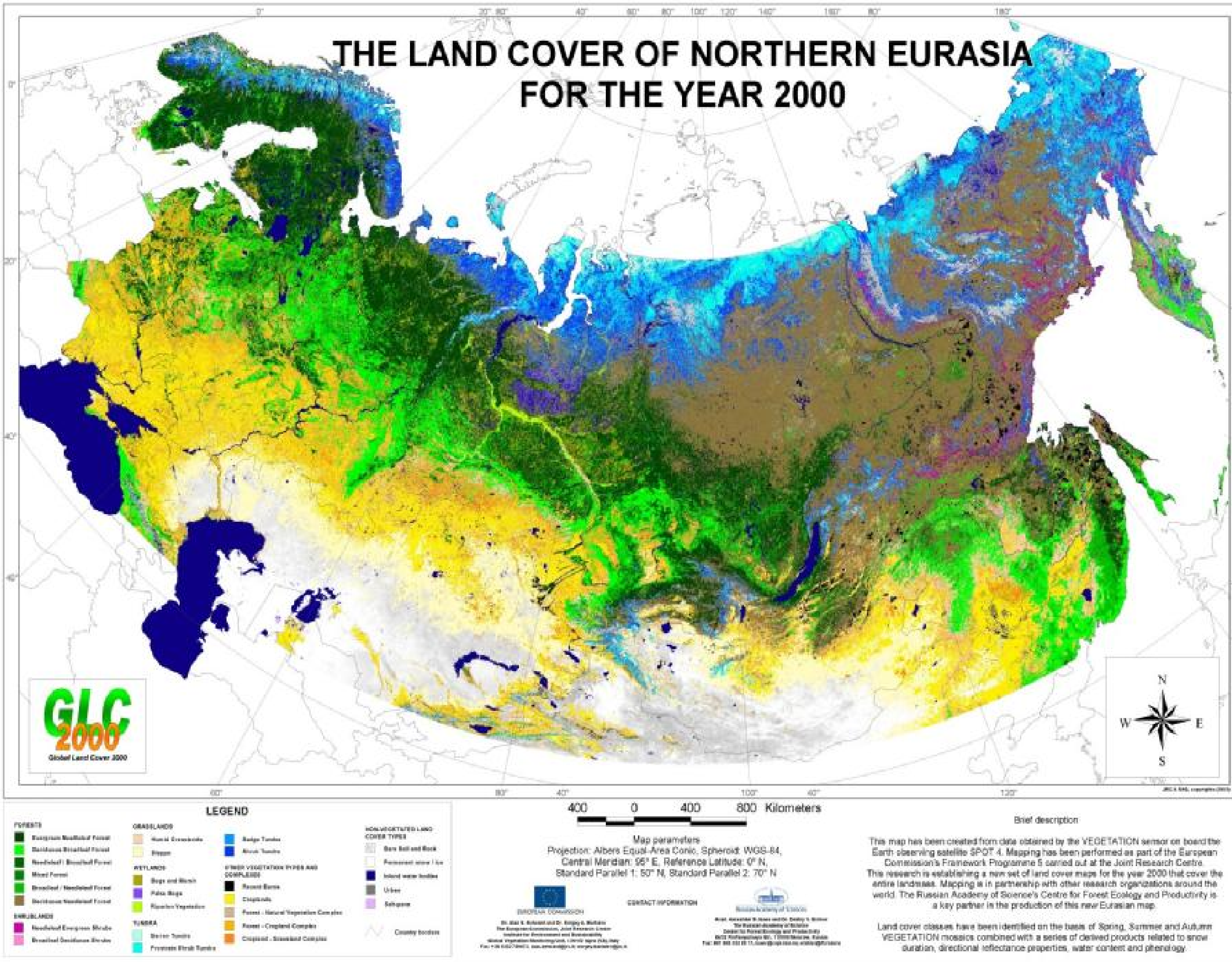
LPJ-LC estimates the SIBERIA-II region as a sink of CO_2 of –12 gC/m²/a on average during 2002 and 2003 (unbublished results C. Beer 2005).

Biomass of Northern Eurasia has been Changing in Recent Decades



From Myneni et al. (2001)

THE LAND COVER OF NORTHERN EURASIA FOR THE YEAR 2000



Map parameters
Projection: Albers Equal-Area Conic, Spheroid: WGS-84,
Central Meridian: 95° E, Reference Latitude: 0° N,
Standard Parallel 1: 50° N, Standard Parallel 2: 70° N

EUROPEAN COMMISSION

CONTACT INFORMATION

Russian Academy of Sciences

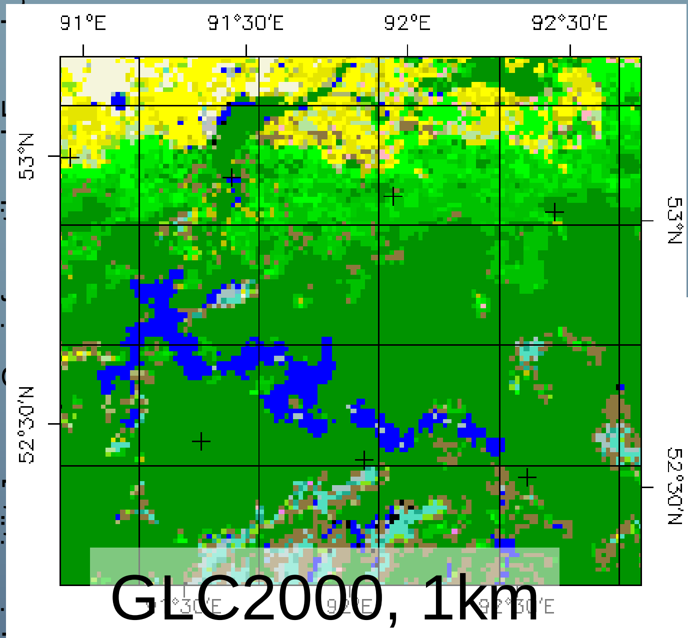
Brief description

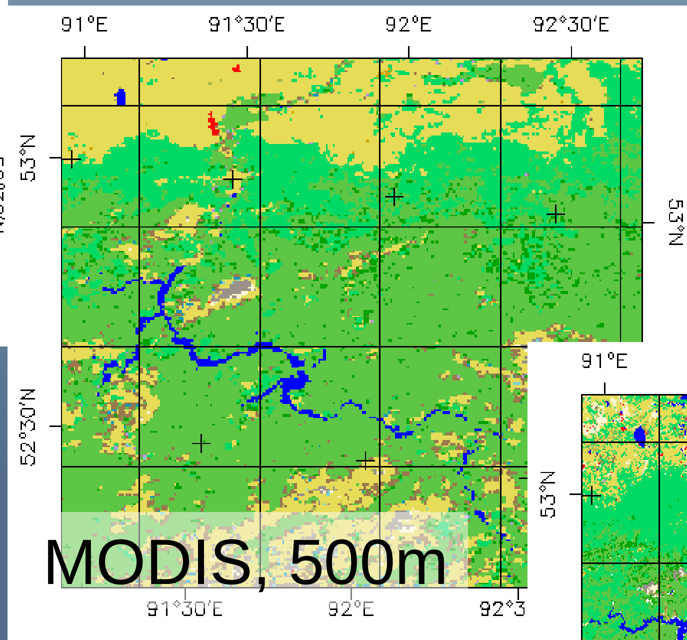
This map has been created from data obtained by the VEGETATION sensor on board the Earth observing satellite SPOT 4. Mapping has been performed as part of the European Commission's Framework Programme 5 carried out at the Joint Research Centre. This research is establishing a new set of land cover maps for the year 2000 that cover the entire landmass. Mapping is in partnership with other research organizations around the world. The Russian Academy of Science's Centre for Forest Ecology and Productivity is a key partner in the production of this new Eurasian map.

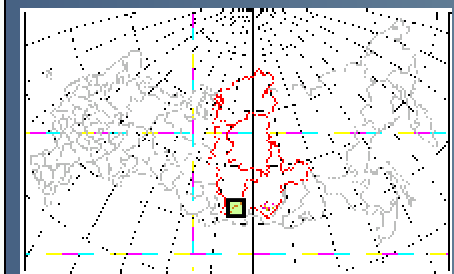
Land cover classes have been identified on the basis of Spring, Summer and Autumn VEGETATION mosaics combined with a series of derived products related to snow duration, directional reflectance properties, water content and phenology.

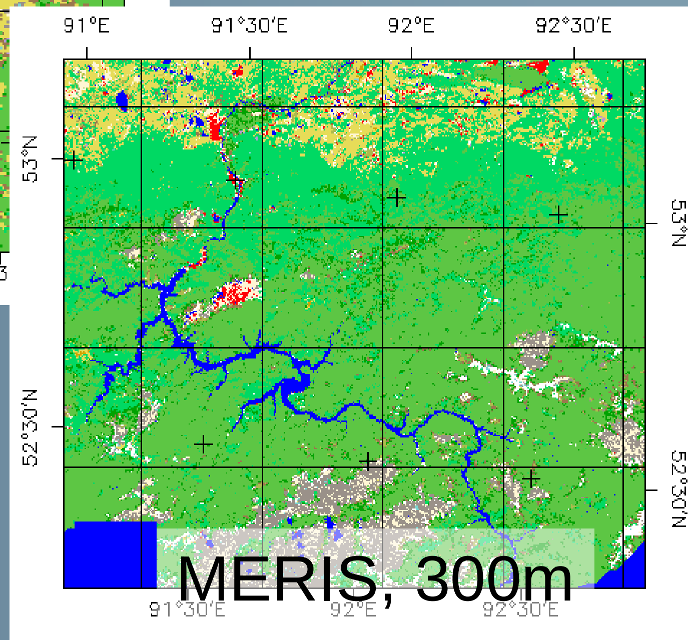
Classifier Results

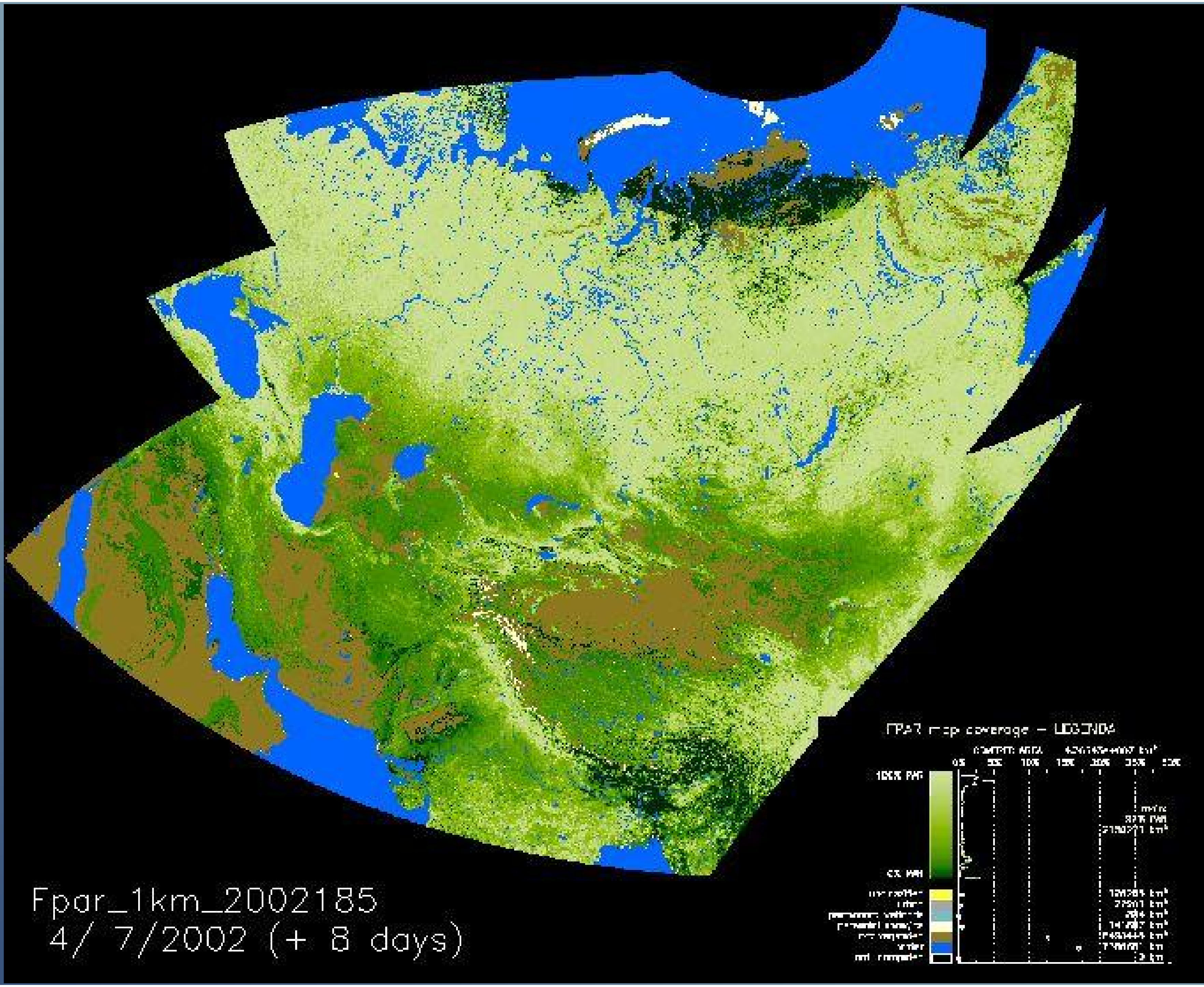
Spatial resolution issue









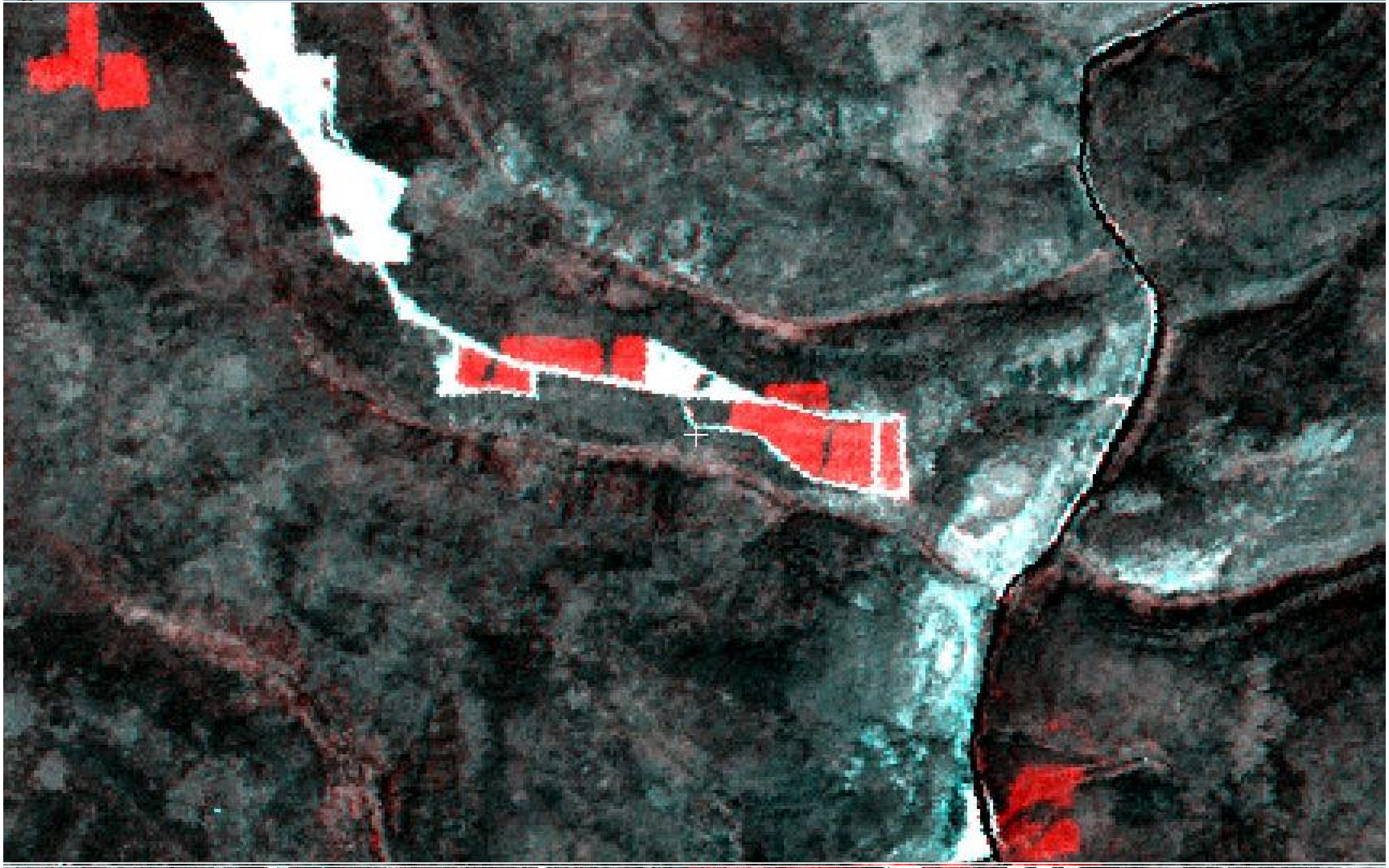

FPAR map coverage - LEGENDA
Fpar_1km_2002185
4/ 7/2002 (+ 8 days)

Requirements for Kyoto ARD Forest Change Mapping – a Challenge:

- Changes appearing between 1989(1950) and 2000
- Identification of underlying causes of specific changes
- Identification of specific landuse change

-> development of a change detection system for

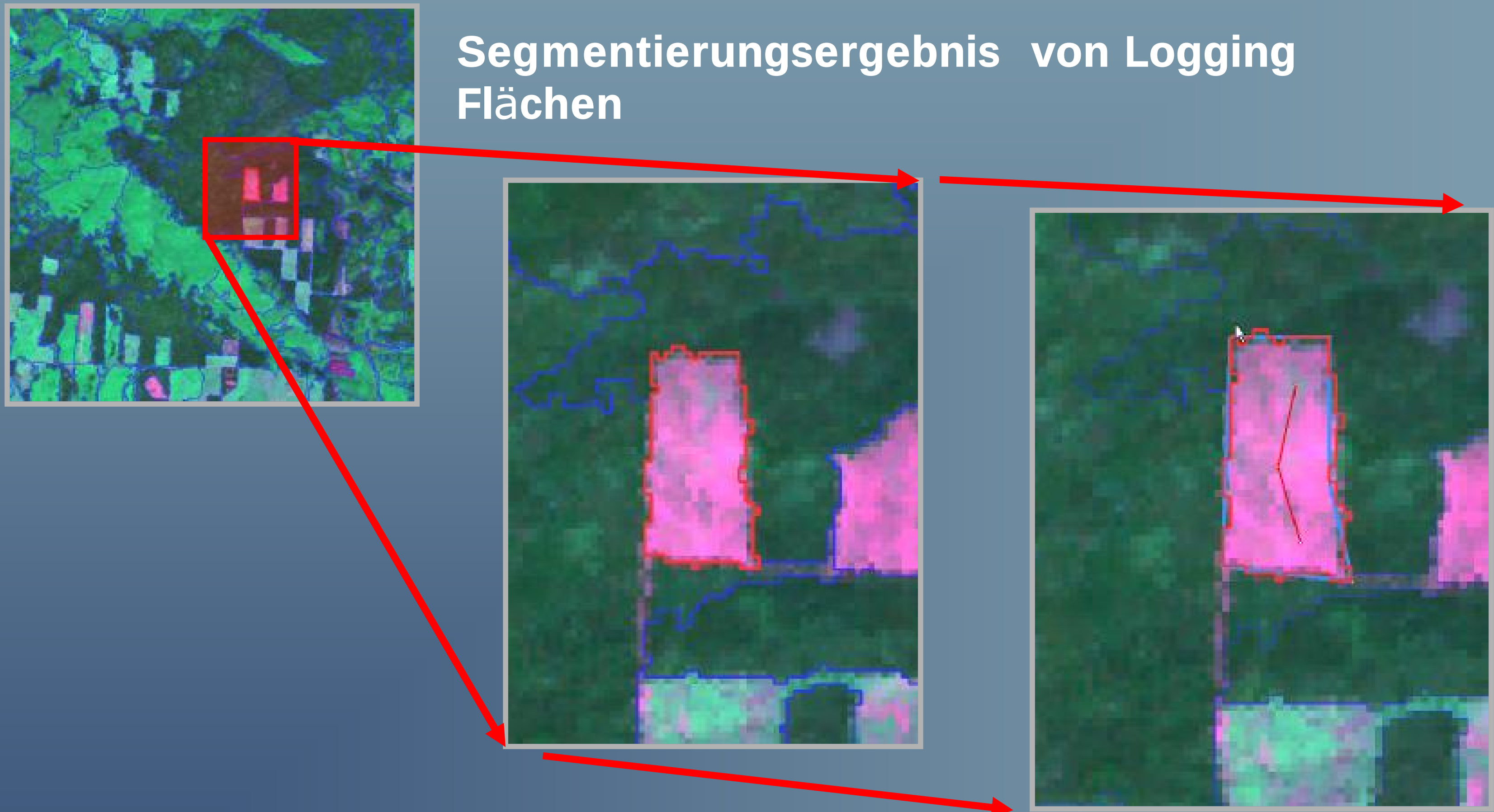
1. landuse change detection (Afforestation)
2. Forest cover change detection and
3. secondary feature classification (context classification/object shape classification)



ARD mapping 1990 vs. 2000 in Central Siberia, Bratsk region with Landsat

Objektformeigenschaften (Logging)

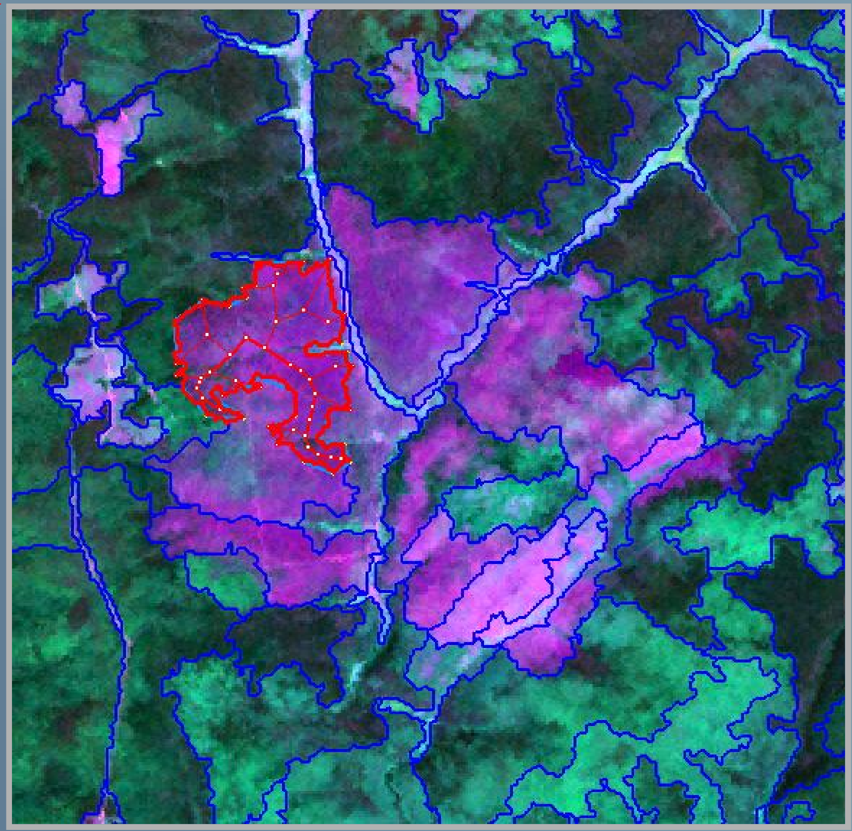
Segmentierungsergebnis von Logging Flächen



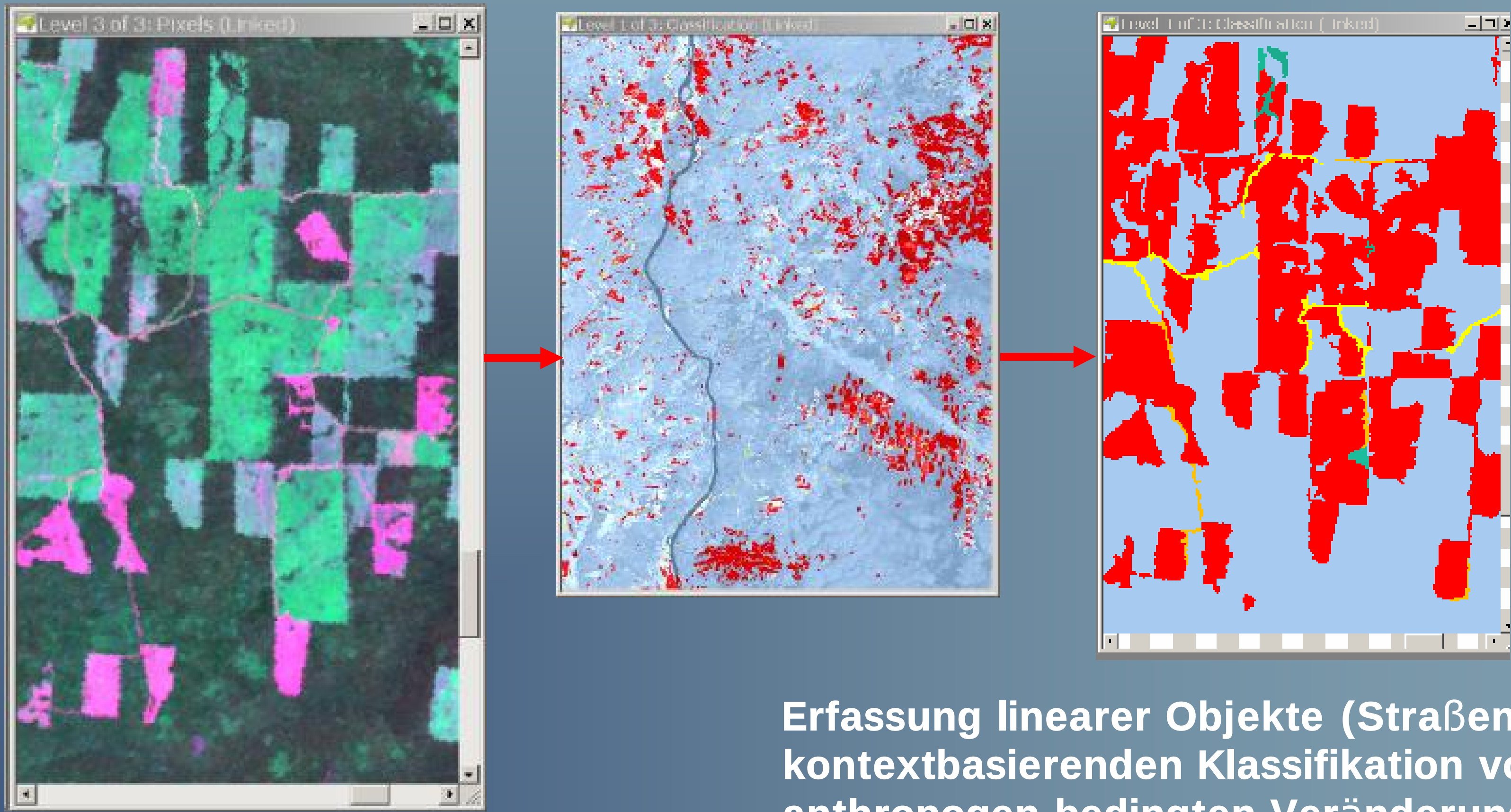
Objektformvereinfachung und Darstellung der inneren Objektstruktur

Objektformeigenschaften (Fire Scars)

Fire Scar Objekte zeigen eine sehr viel komplexere Form (auch der inneren Polygonstruktur)



Objekt-Kontextinformation I



Erfassung linearer Objekte (Straßen) zur kontextbasierenden Klassifikation von anthropogen bedingten Veränderungen.

Landsat RGB; Linear „change“ objects in yellow, other change objects in red. (logging activities and new road features)

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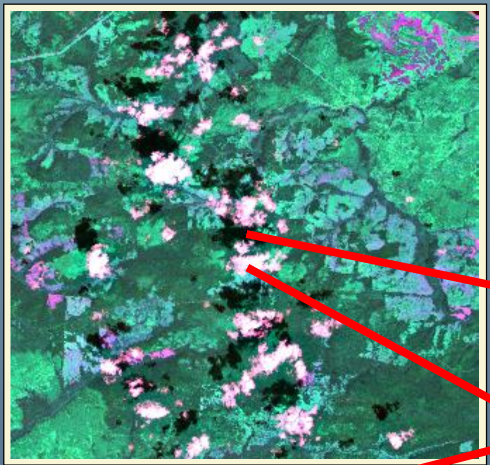
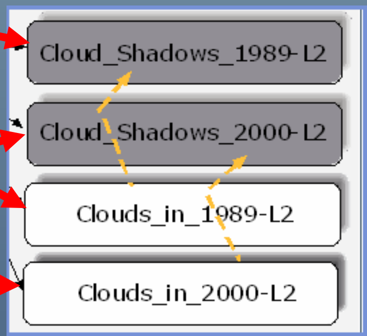
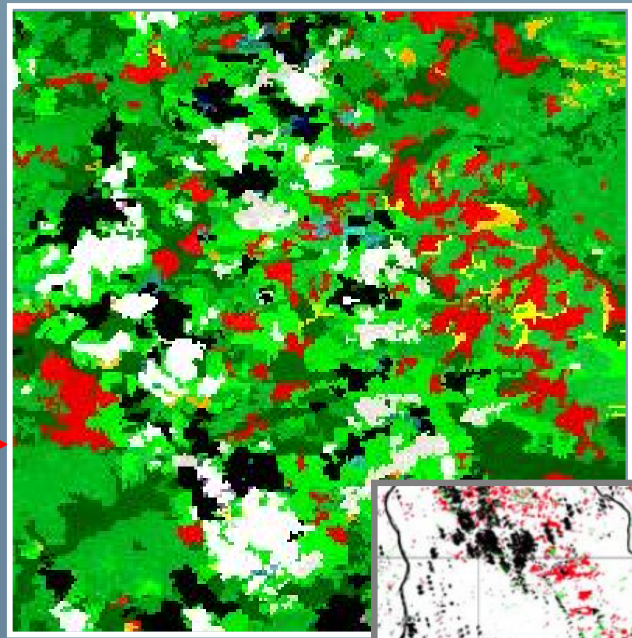
Objekt-Kontextinformation II



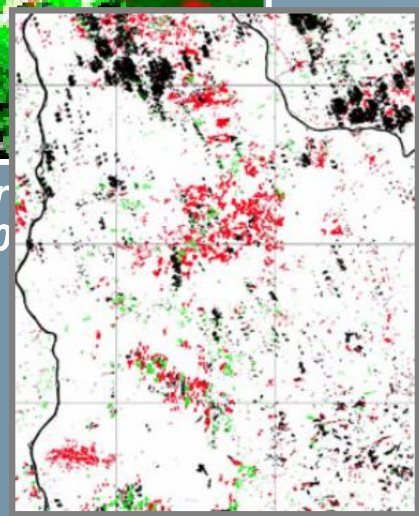
Wolken und Wolkenschatten in 1989



Kontextinformation: Schattenabstand zu Wolken



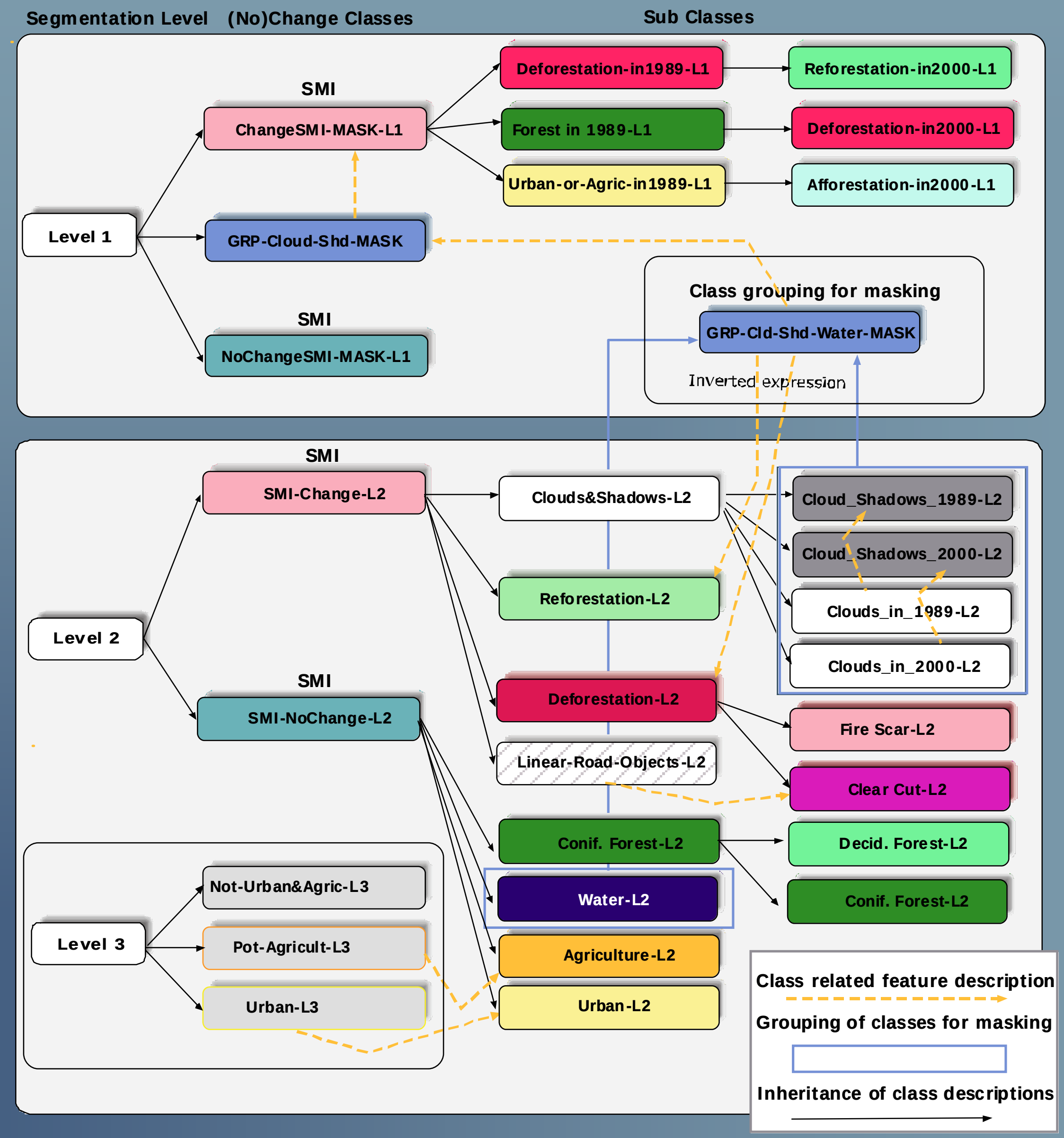
Zuordnungsr (1989&20



Maskierung von Wolken und Wolkenschatten

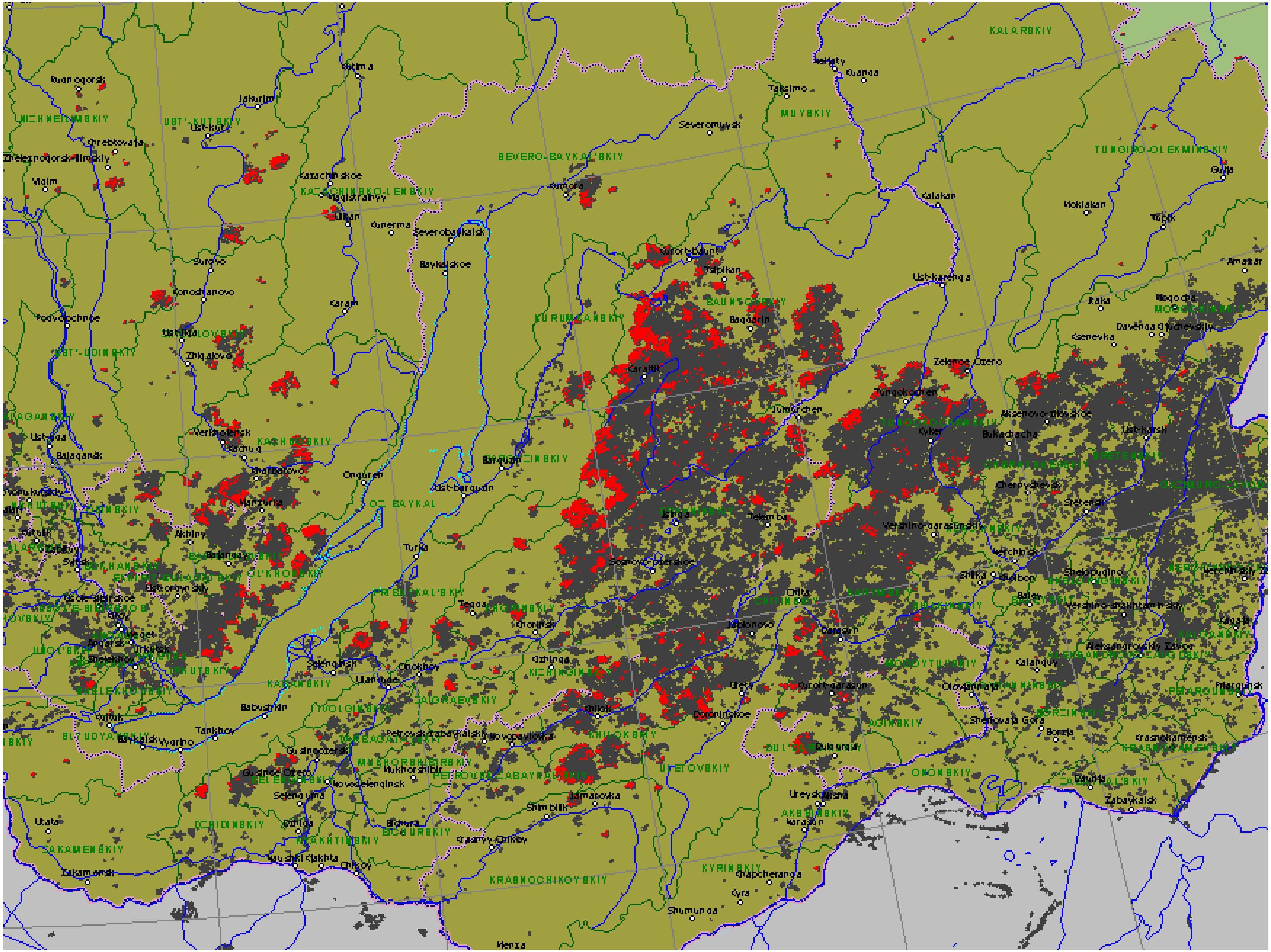
Wolken und Wolkenschatten in 2000

Klassifikation



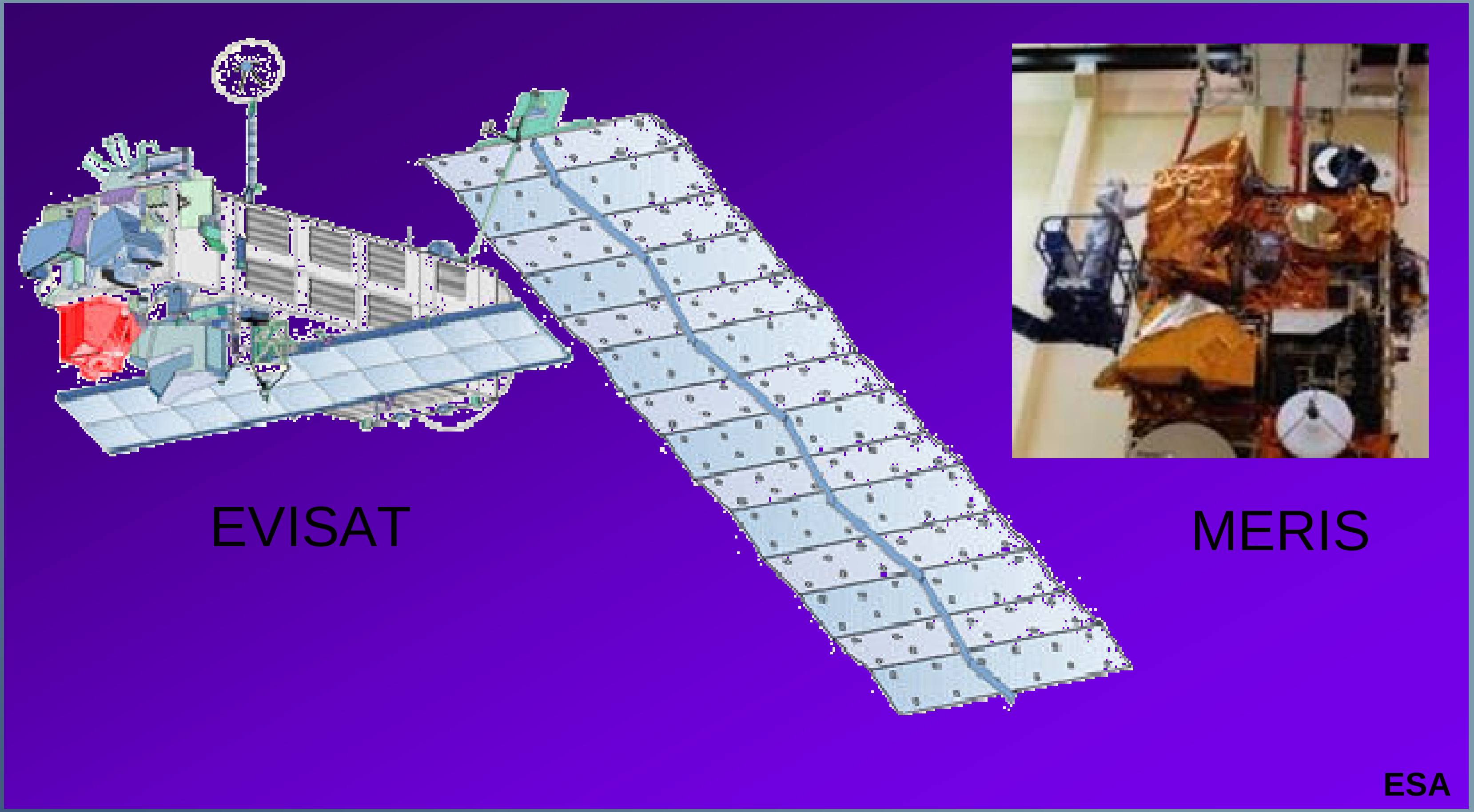
Summary / Lessons Learned

- ARD (im Sinne der Kyoto Definition) ist nur schwer mit hoher Genauigkeit klassifizierbar
- Komplizierte auf Objektform basierende and kontextbasierende Verfahren sind nicht direkt übertragbar auf große Datensätze -> Bedarf für neue Normalisierungsansätze ! (z.B. Shape–Template-Matching ?).
- Objekt orientiertes Konzept jedoch sehr viel versprechend für die zukünftige Methodenentwicklung



KALARSKIY
MUYSKIY
SEVERO-BAYKAL'SKIY
TUNGIRO-OLEKMINSKIY
Taksimo
Severomuysk
Kalakan
Kazachinskoe
Ust-Kut
Zhigalovo
Kachug
Baykalskoe
Kurort-Baunt
Bagdarin
Tungokochen
Jumurchen
Karam
Onguren
Ust-Barguzin
Turka
Mogocha
Ksenevka
Zelenoe Ozero
Aksenovo-Zilovskoe
Bukachacha
Chernyshevsk
Sretensk
Nerchinsk
Shilka
Baley
Chita
Yablonovo
Ulety
Khilok
Petrovsk-Zabaykalskiy
Novopavlovka
Ulan-Ude
Selenginsk
Kabansk
Babushkin
Tankhoy
Baykalsk
Kultuk
Gusinoozersk
Gusinoe Ozero
Novoselenginsk
Mukhorshibir
Bichura
Kyakhta
Jamarovka
Shimbilik
Krasnyy Chikoy
KRASNOCHIKOYSKIY
Kyra
Shumunda
Ust-Karsk
Kalanguy
Olovyannaja
Borzya
Krasnokamensk
Zabaykalsk
Duldurga
Aksha
Kyakhta
Alexandrovskiy Zavod
Nerchinskiy Zavod

ENVISAT MERIS
(Medium Resolution Imaging Spectrometer)



MTCI vs. REP

- REP by MERIS:

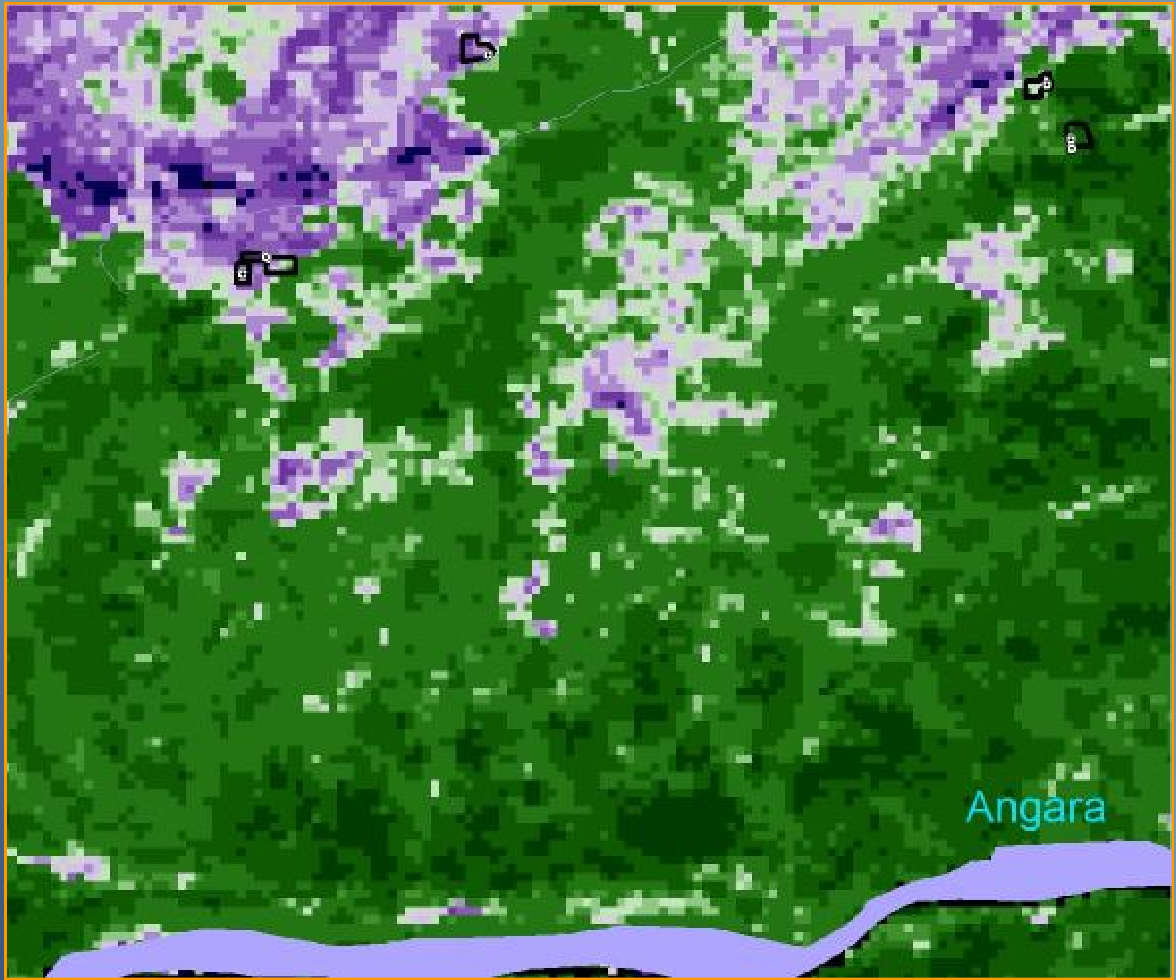
$$REP(MERIS) = 708.75 + 45 \frac{(R_i(MERIS) - R_{Band9})}{(R_{Band10} - R_{Band9})}$$

$$R_i(MERIS) = \frac{(R_{Band7} + R_{Band12})}{2}$$

- MTCI (MERIS Terrestrial Chlorophyll Index):

$$MTCI = \frac{R_{Band10} - R_{Band9}}{R_{Band9} - R_{Band8}}$$

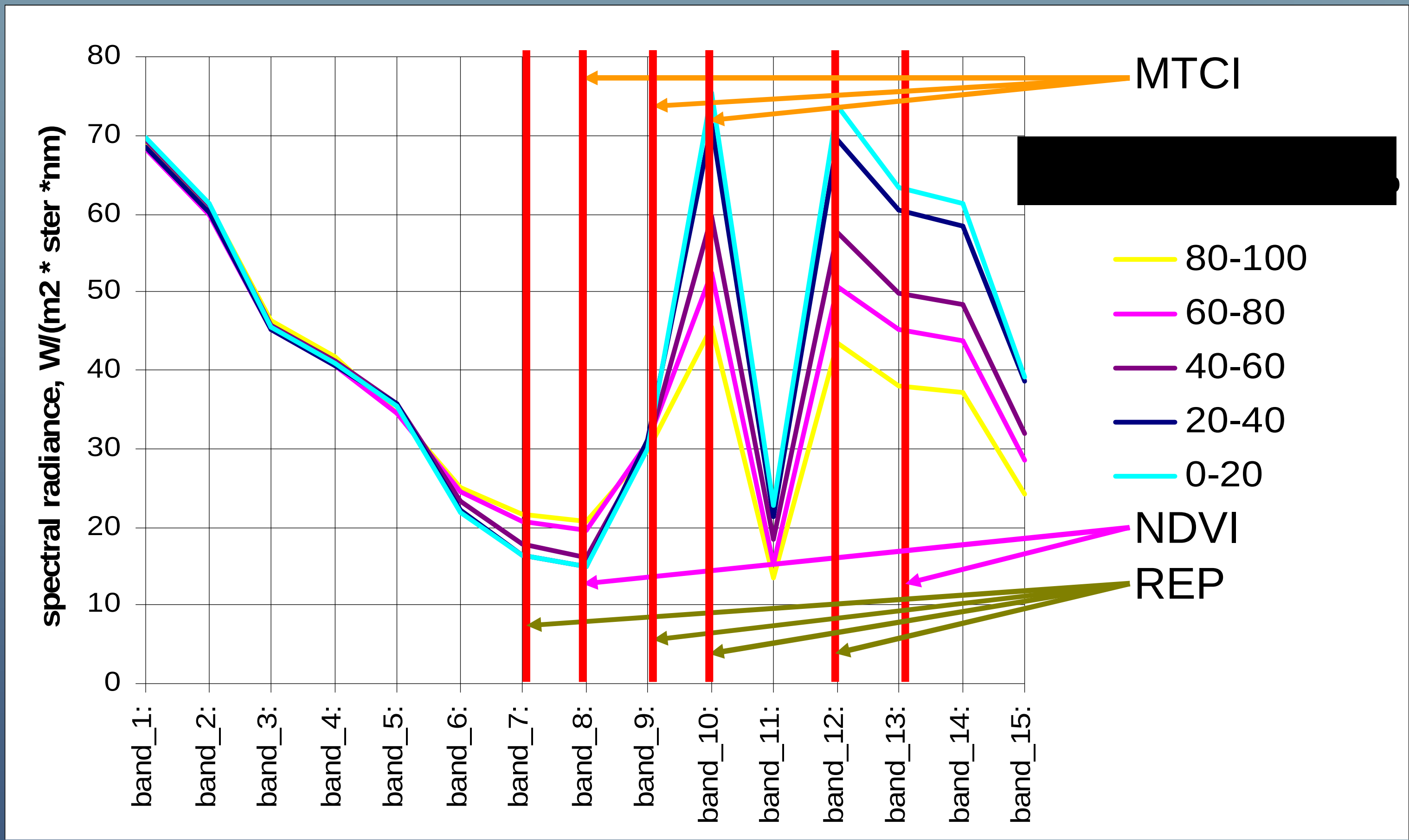
NDVI, REP and MTCI Calculation



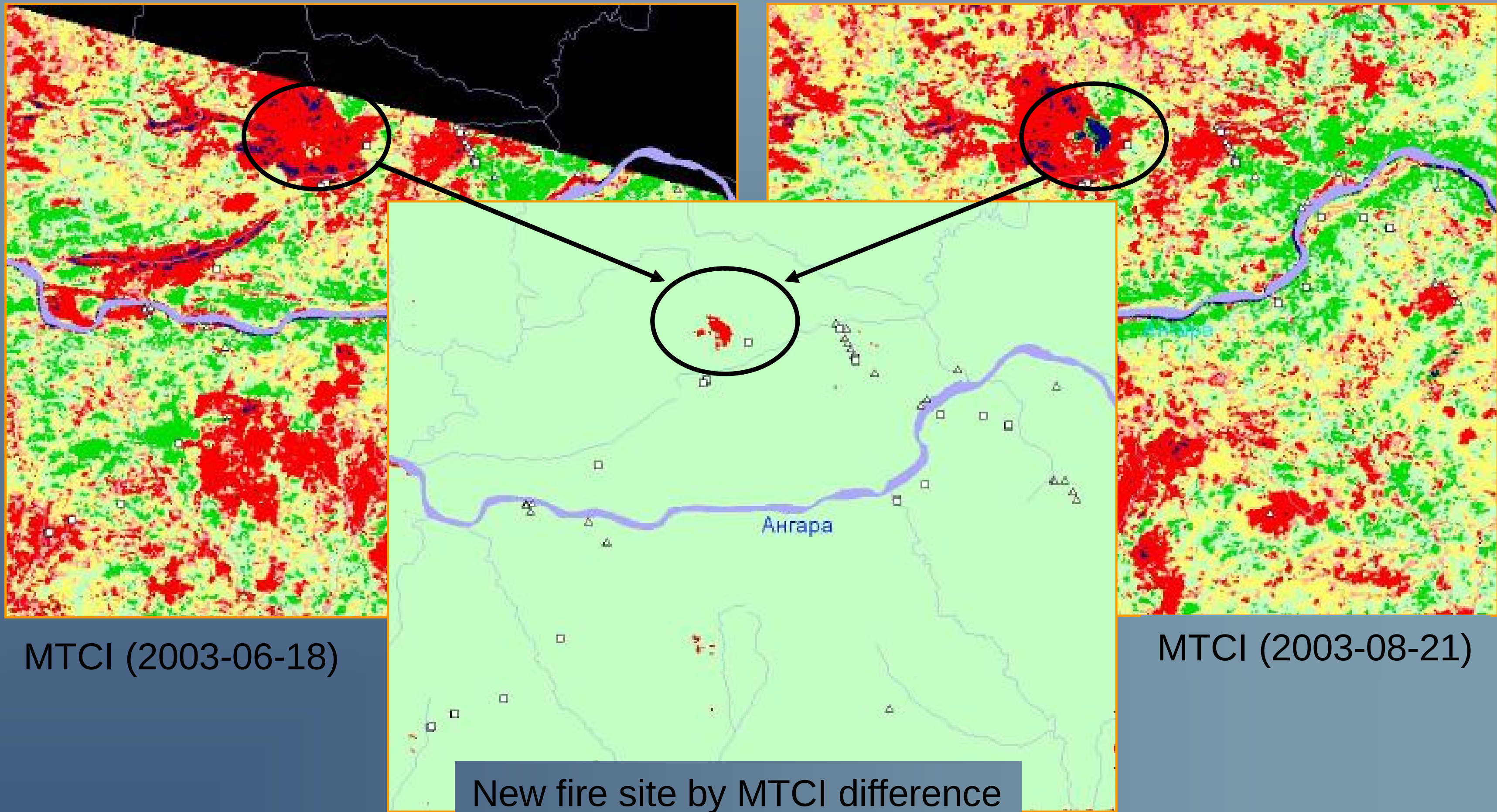
MTCI (2003/06/18)

	0 - 1
	1.1 - 1.2
	1.2 - 1.3
	1.3 - 1.4
	1.4 - 1.5
	1.5 - 1.6
	1.6 - 1.7
	1.7 - 1.8
	1.8 - 1.9
	1.9 - 2
	2 - 2.5
	2.5 - 3
	3 - 4

The Selective Spectral Profiles of the Fire Sites with different severity



New Fire Sites Detection



MTCI (2003-06-18)

MTCI (2003-08-21)

New fire site by MTCI difference
of 2003-06-18 and 2003-08-21

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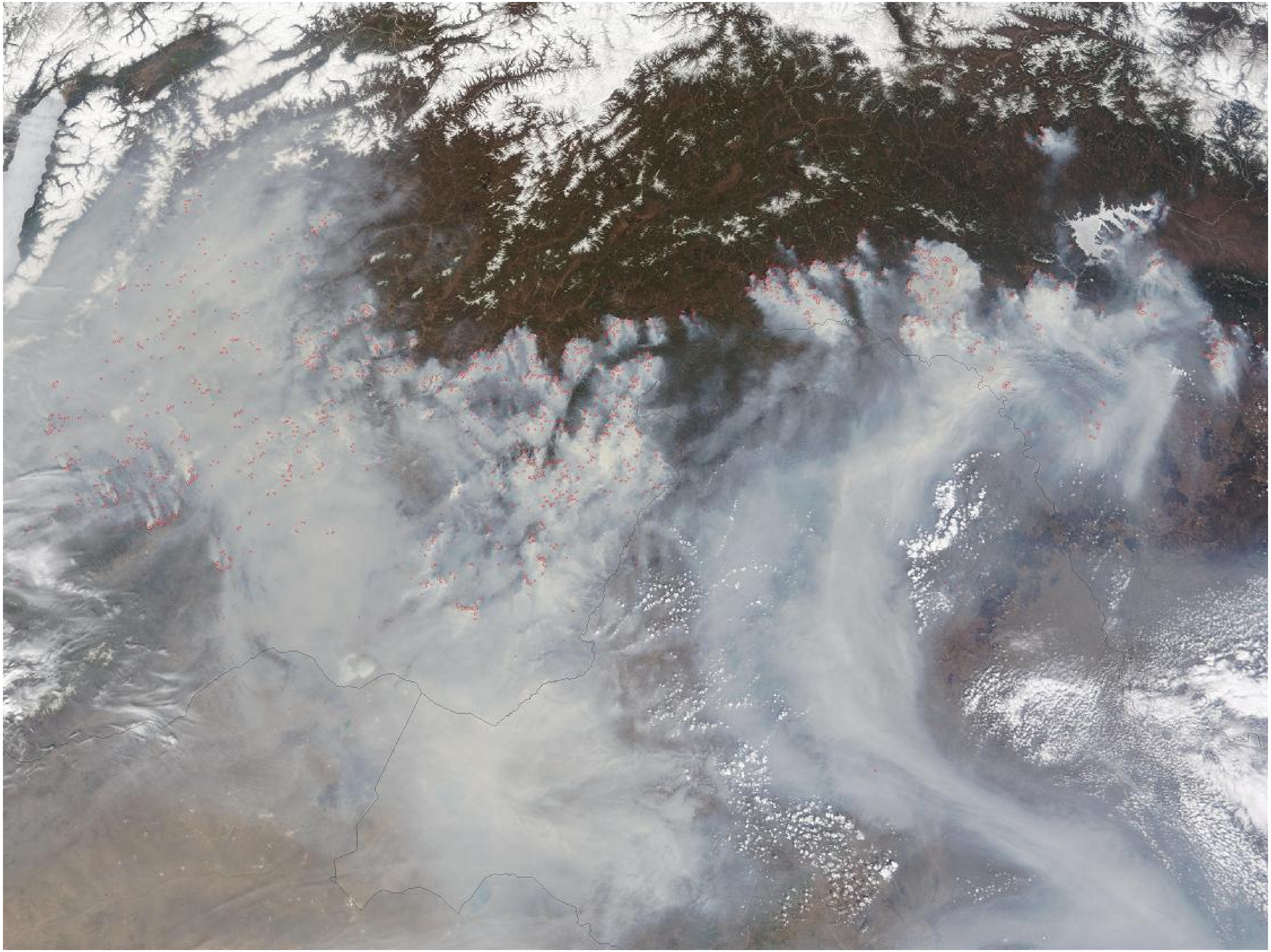
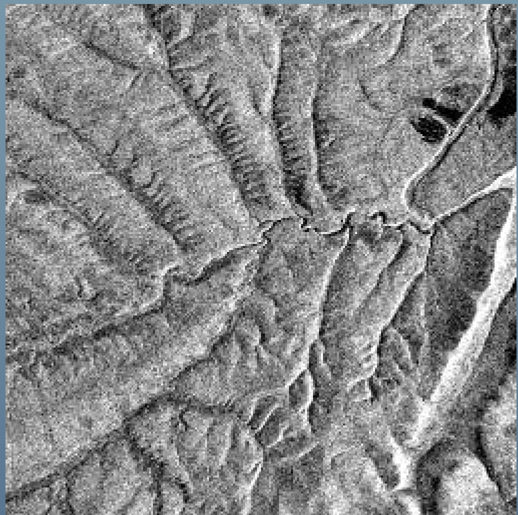
The Main Results

- The ENVISAT MERIS instrument shows the good sensitivity for the forest degradation estimation
- The simple form and linear relationship between MTCI and forest degradation makes it more preferable than NDVI and REP for degradation mapping
- The use of MERIS Terrestrial Chlorophyll Index (MTCI) can approximate the forest degradation with RSME below 20%



Classification Source Data

ERS intensity



JERS intensity

ERS Tandem Coherence

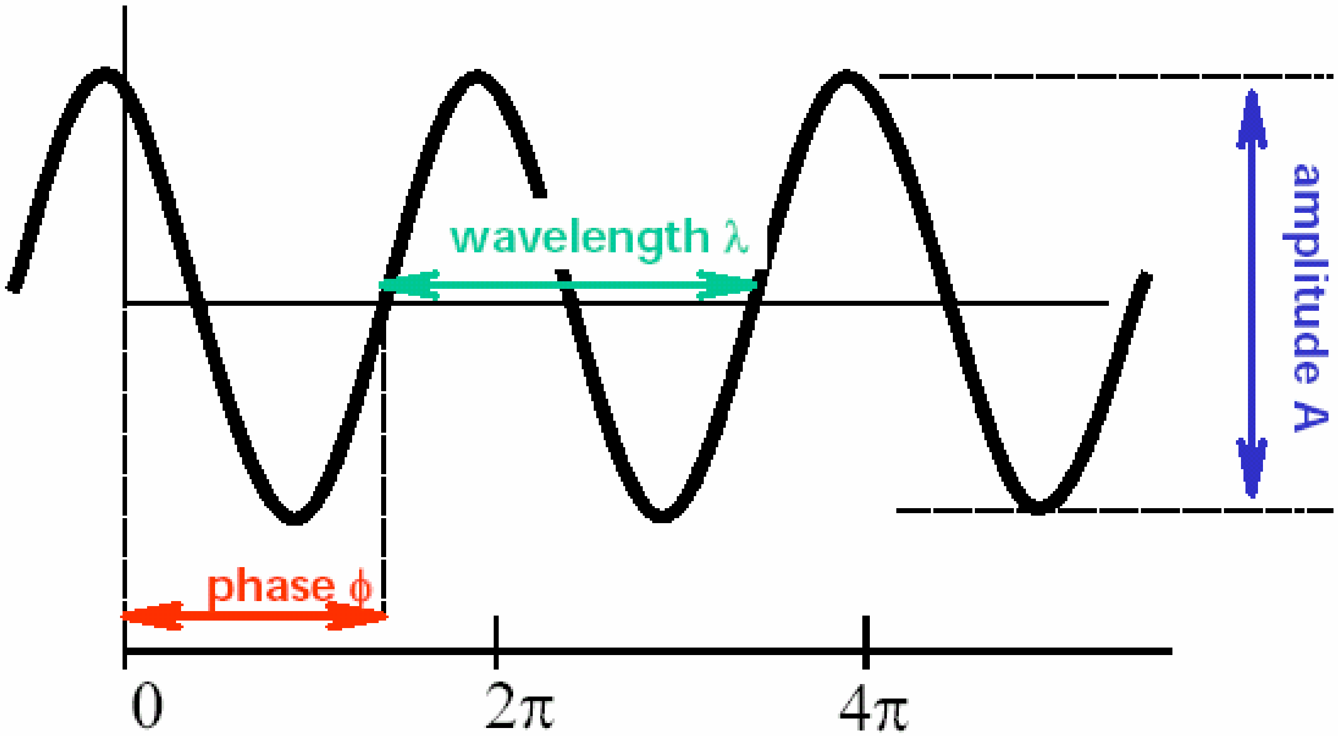
- Small dynamic range
- Variable response to water
- Variable response to open areas
- Can be used as indicator of environmental effects effecting the coherence

- 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)

Wellen: Amplitude und Phase

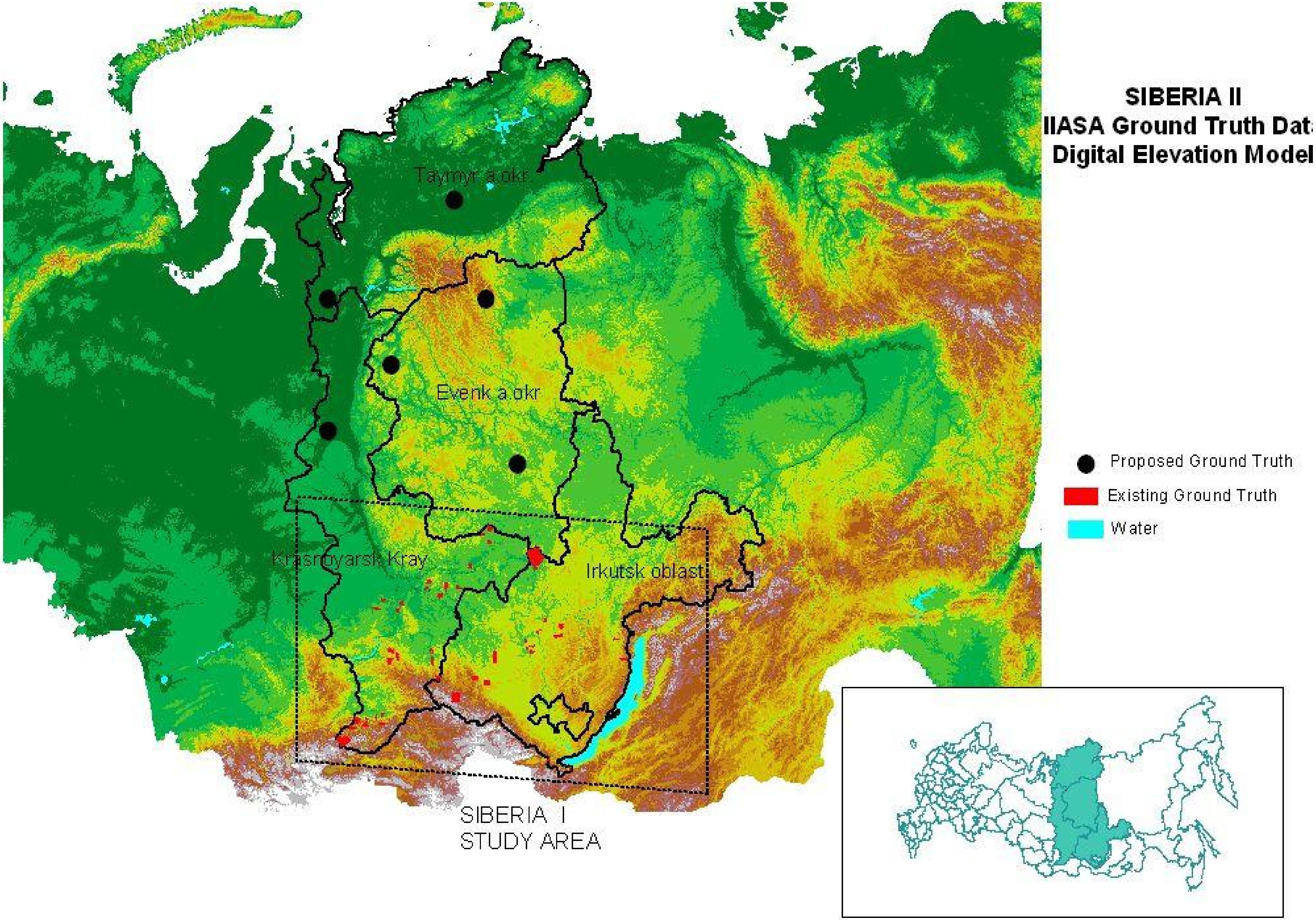


A. Roth, MFFU Sommerschule 2000

What are the scatterers in the volume scattering?

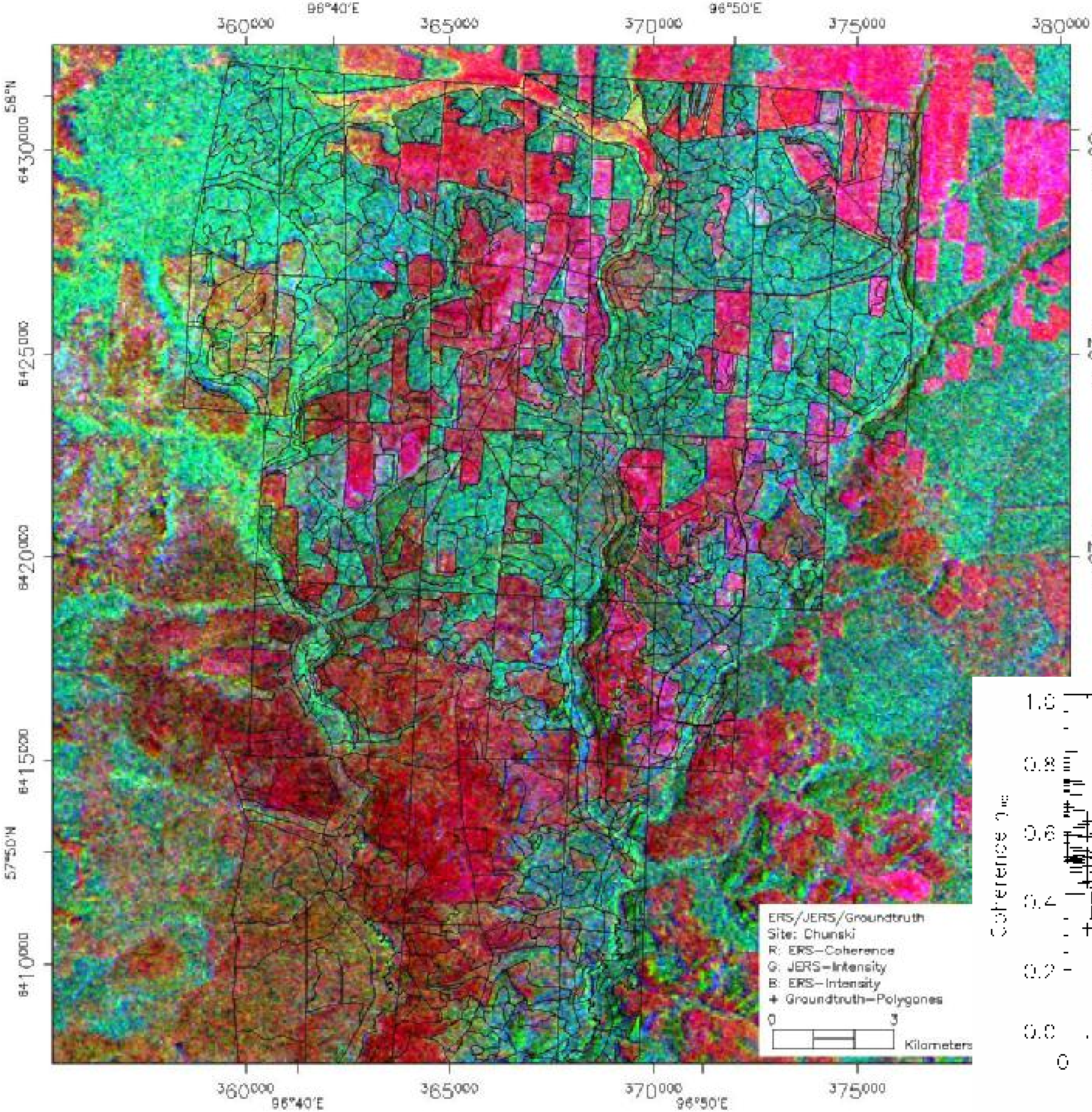
Austrian pine	X band	L band	P band	VHF
	$\lambda = 3$ cm	$\lambda = 27$ cm	$\lambda = 70$ cm	$\lambda > 3$ m

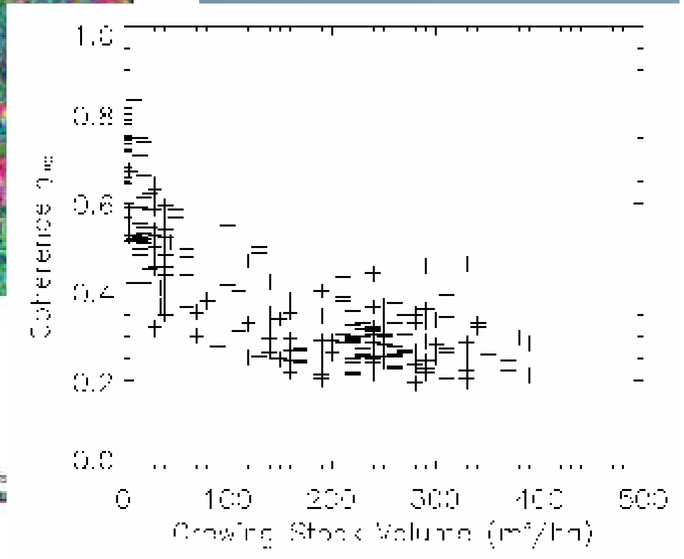
The main scatterers in a canopy are the elements having dimension of the order of the wavelength

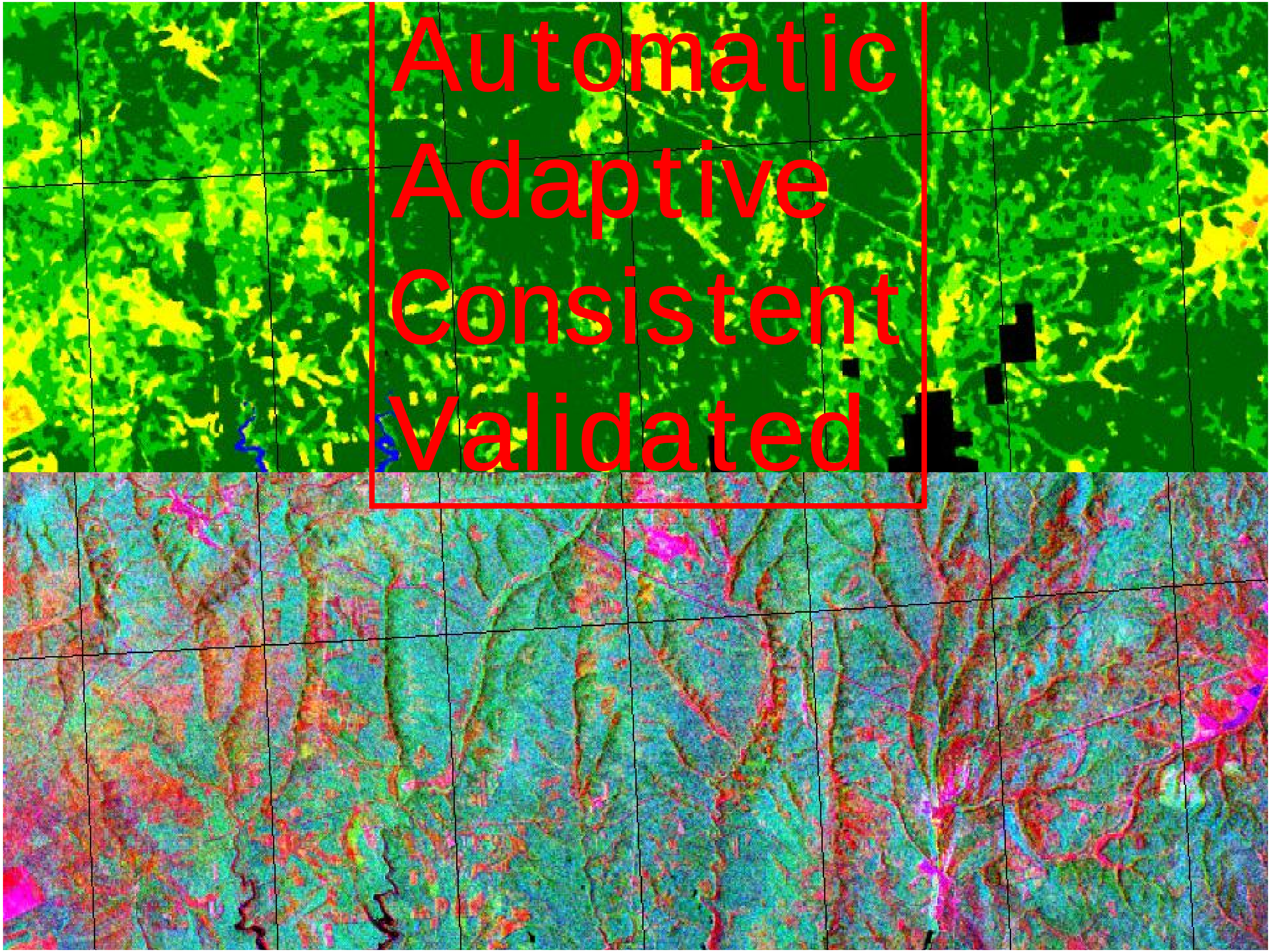


SIBERIA II
IIASA Ground Truth Dat
Digital Elevation Model
Taymyr a.okr.
Evenk a.okr
Krasnoyarsk Kray
Irkutsk oblast
SIBERIA I
STUDY AREA
Proposed Ground Truth
Existing Ground Truth
Water

Co-registered Forest-GIS Polygons

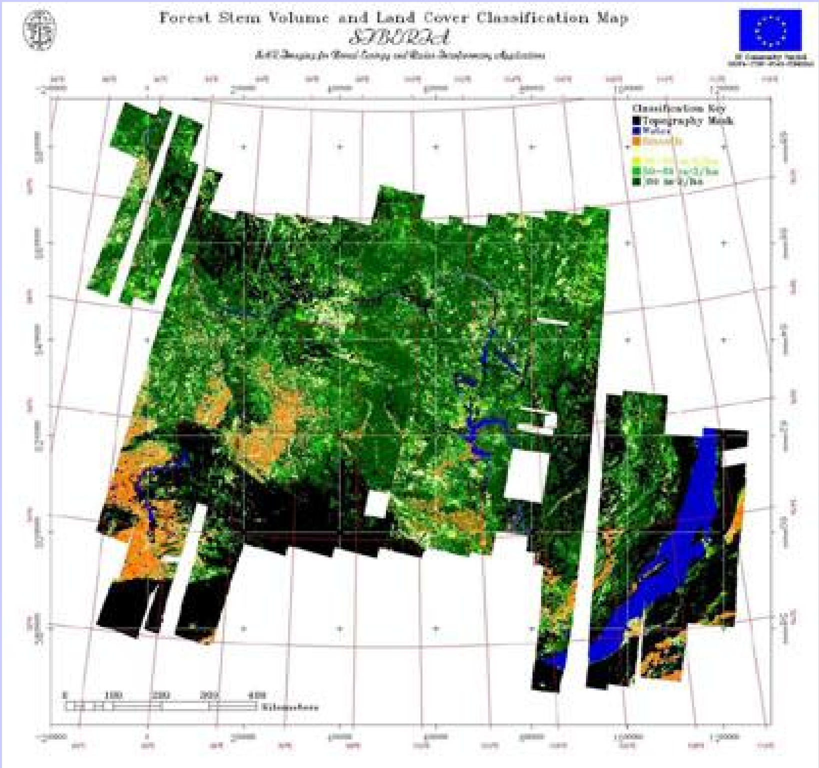





Automatic
Adaptive
Consistent
Validated

Vegetation Data Resources

Above Ground Biomass

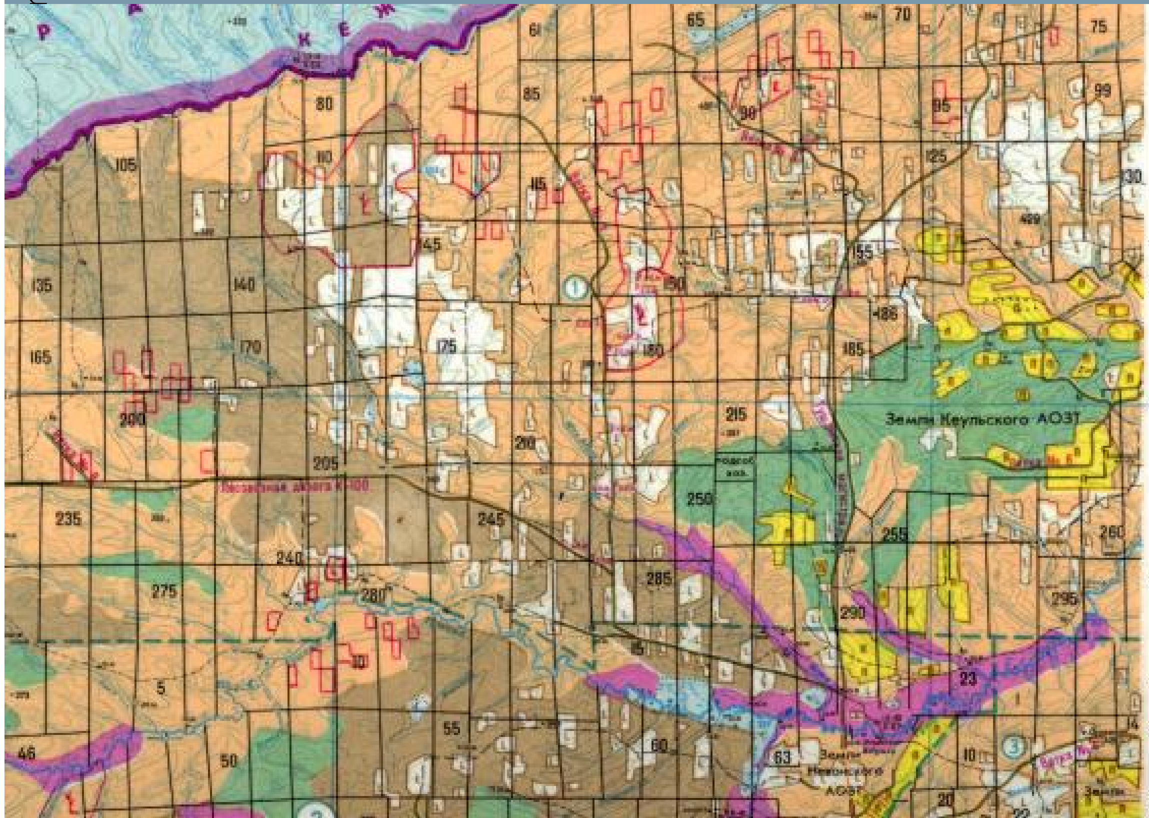


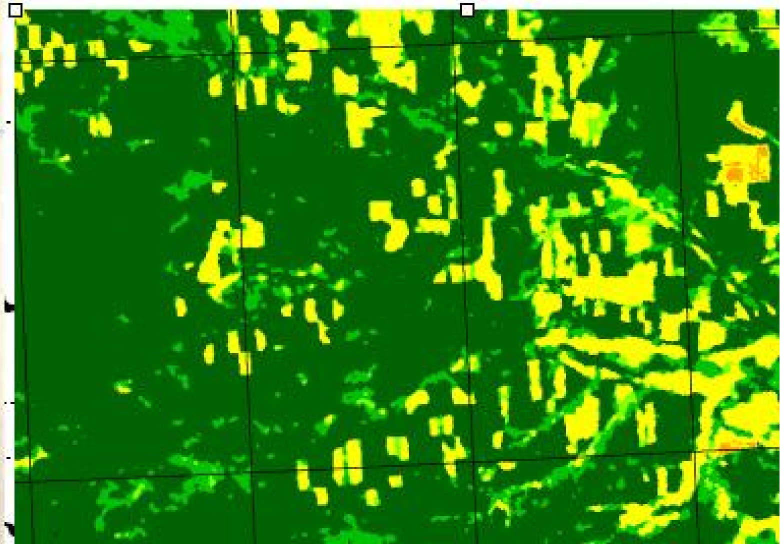
Nothing as yet global and accessible as Above Ground Biomass

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/





SIBERIA – Inventory Map Comparison, Irkutsk Forest Service

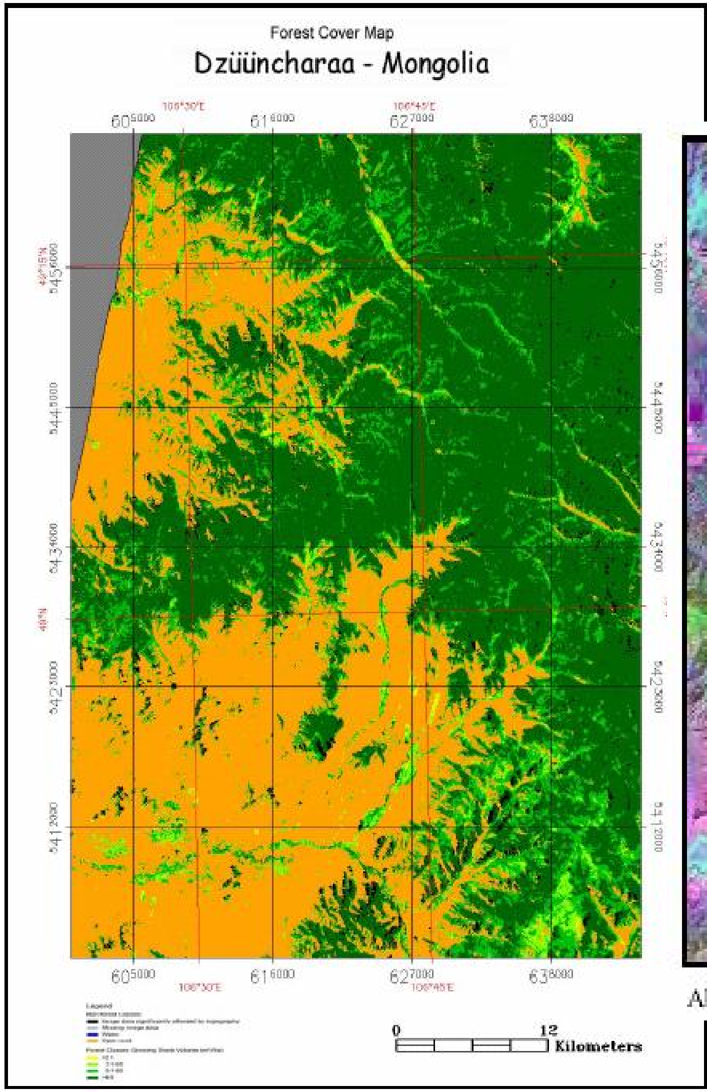


Abbildung 27: Klassifikation des Testgebiets

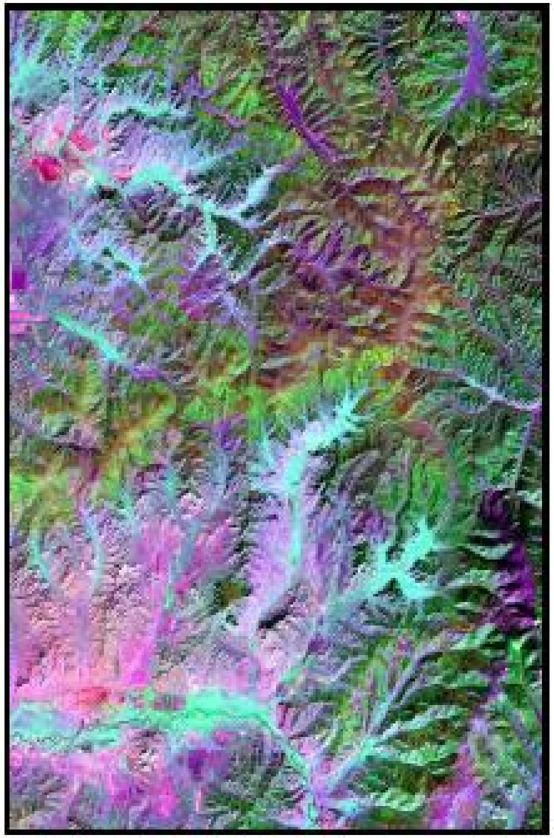


Abbildung 32: Landsat-Szene Dzuuncharaa

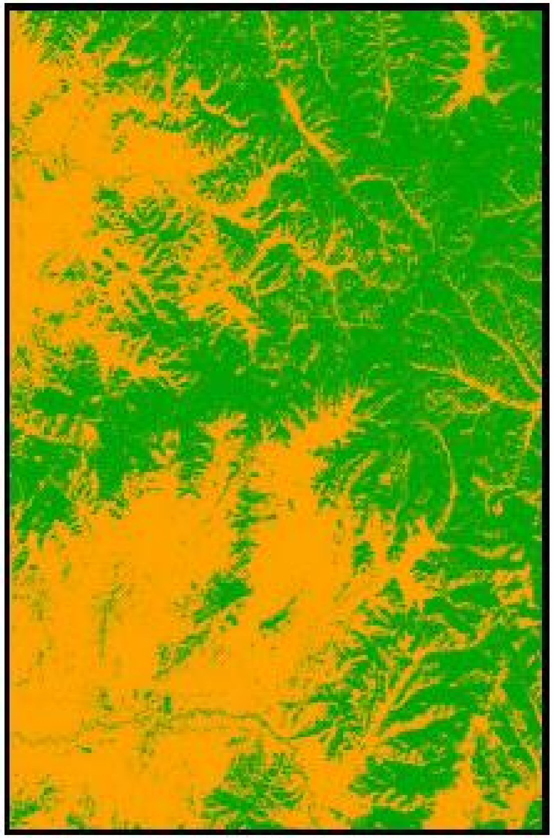
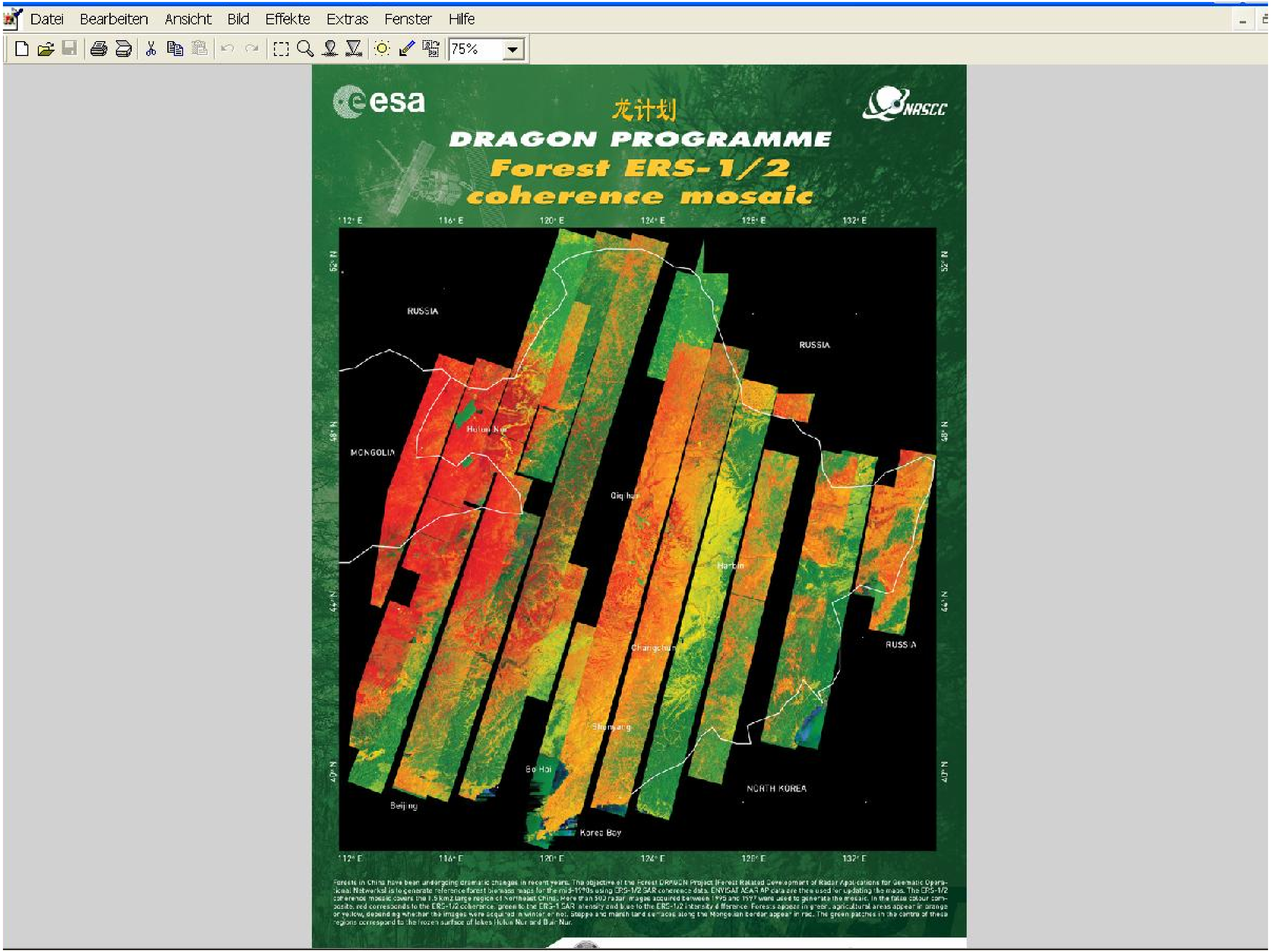


Abbildung 33: NDVI-Waldmaske Dzuuncharaa

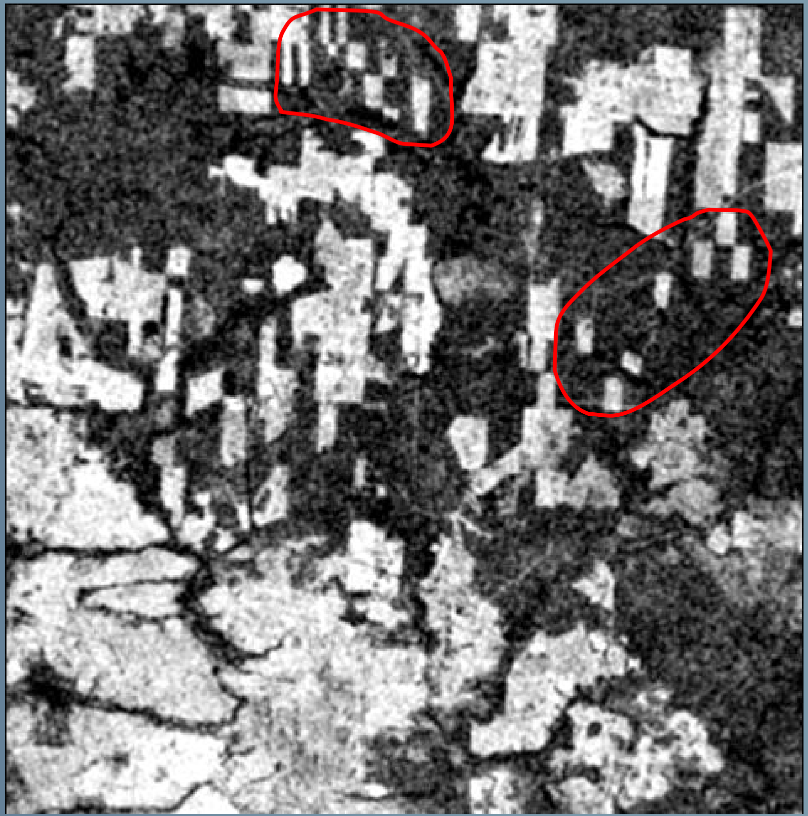
SIBERIA algorithm application in Mongolia (FAO Participatory Forestry Proj.)



Datei Bearbeiten Ansicht Bild Effekte Extras Fenster Hilfe
75%
esa
龙计划
NRSCC
DRAGON PROGRAMME
Forest ERS-1/2
coherence mosaic
112° E
116° E
120° E
124° E
128° E
132° E
52° N
48° N
44° N
40° N
RUSSIA
RUSSIA
RUSSIA
MONGOLIA
Hulun Nur
Qiqihar
Harbin
Changchun
Shenyang
Bo Hai
Beijing
Korea Bay
NORTH KOREA
Forests in China have been undergoing dramatic changes in recent years. The objective of the Forest DRAGON Project (Forest Related Development of Radar Applications for Geomatic Operational Networks) is to generate reference forest biomass maps for the mid-1990s using ERS-1/2 SAR coherence data. ENVISAT ASAR AP data are then used for updating the maps. The ERS-1/2 coherence mosaic covers the 1.5 km2 large region of Northeast China. More than 500 radar images acquired between 1995 and 1997 were used to generate the mosaic. In the false colour composite, red corresponds to the ERS-1/2 coherence, green to the ERS-1 SAR intensity and blue to the ERS-1/2 intensity difference. Forests appear in green, agricultural areas appear in orange or yellow, depending whether the images were acquired in winter or not. Steppe and marsh land surfaces along the Mongolian border appear in red. The green patches in the centre of these regions correspond to the frozen surface of lakes Hulun Nur and Buir Nur.

Change detection

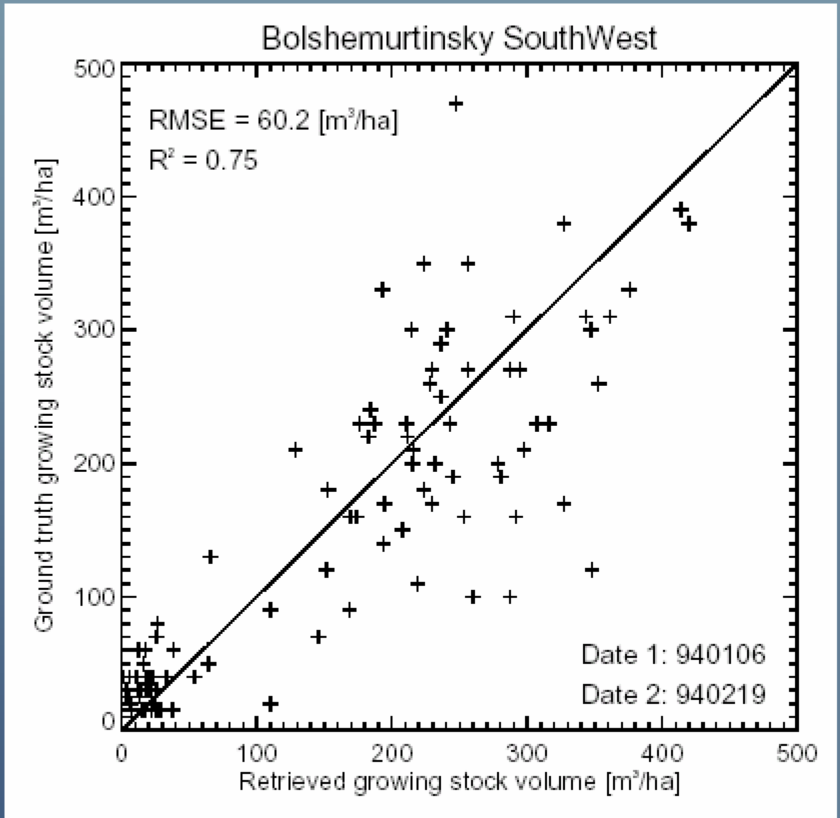
JERS Coherence 1993-12-29 – 1994-02-11



JERS Coherence 1996-01-17 – 1996-03-01

Leif Eriksson, ForestSat 2005

Stem volume retrieval – Results



Best results for JERS-1:

RMSE = 60 m³/ha

Relative RMSE = 43 %

$R^2 = 0.75$

Best results for ERS-1/2:

RMSE = 57 m³/ha

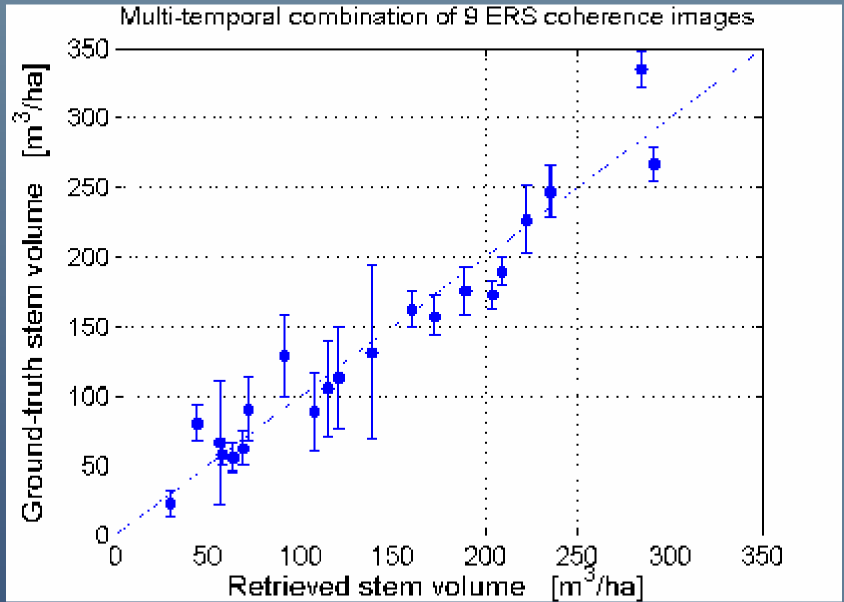
Relative RMSE = 37 %

$R^2 = 0.73$

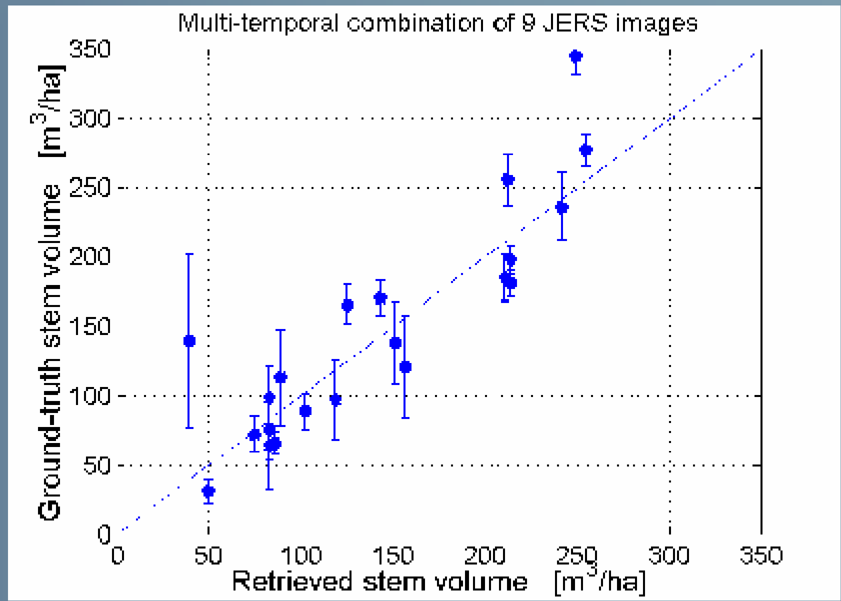
Leif Eriksson et al., ForestSAT 2005

3. Multi-temporal combination

ERS „tandem“ coherence
RMSE: 10 m³/ha
Relative RMSE: 7 %



JERS backscatter
RMSE: 33 m³/ha,
Relative RMSE: 22 %



Santoro et al., RSE, 2002

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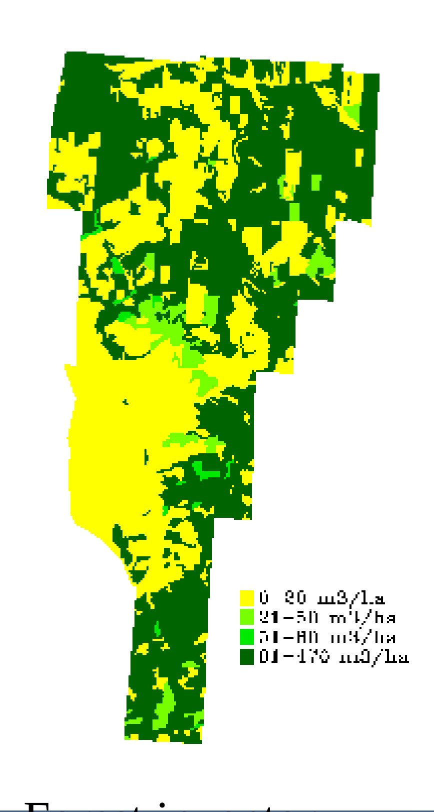
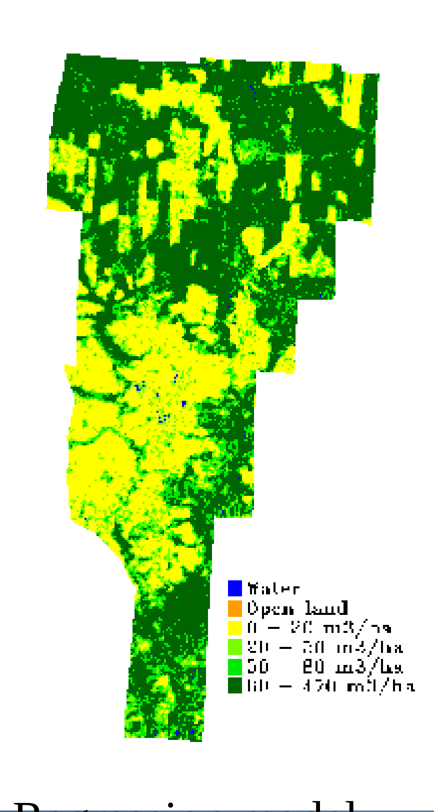
Stem volume map - Preview



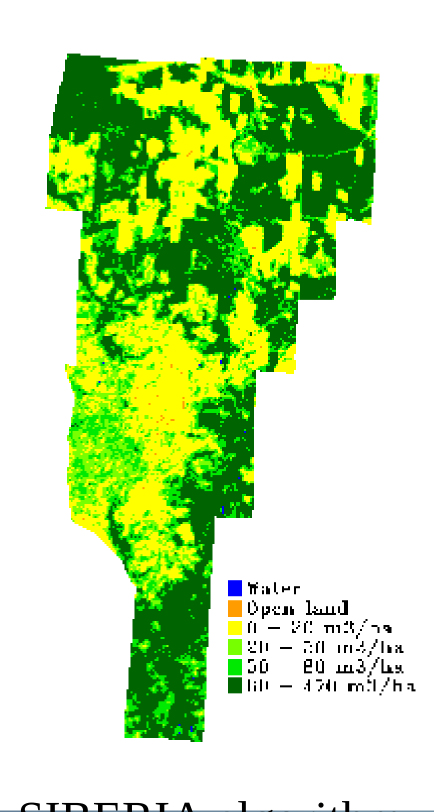
Forest inventory



Regression model

JERS-1 coherence

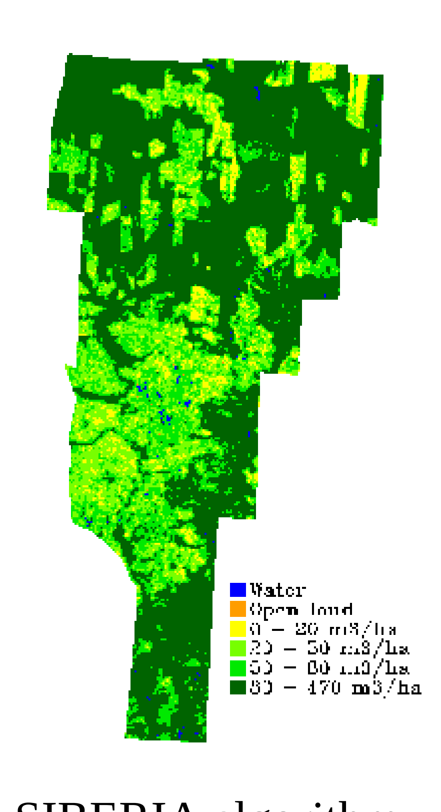
JERS-1 backscatter



SIBERIA algorithm

ERS-1/2 coherence

JERS-1 backscatter



SIBERIA algorithm

JERS-1 coherence

JERS-1 backscatter

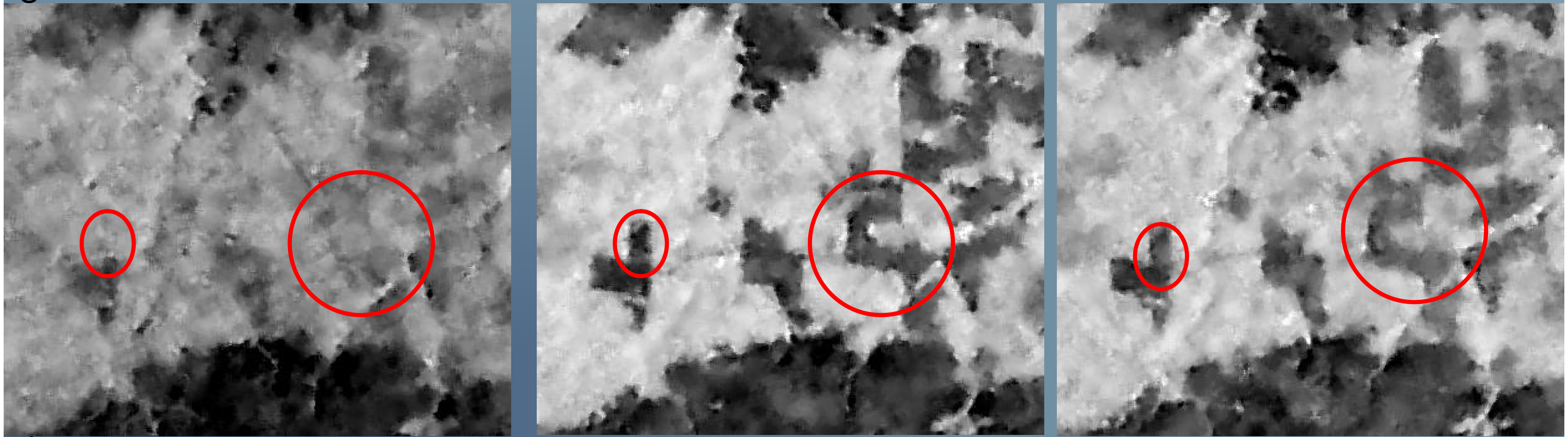
The ENVISAT Mission:

Deforestation

05.01.1996 (ERS-2)

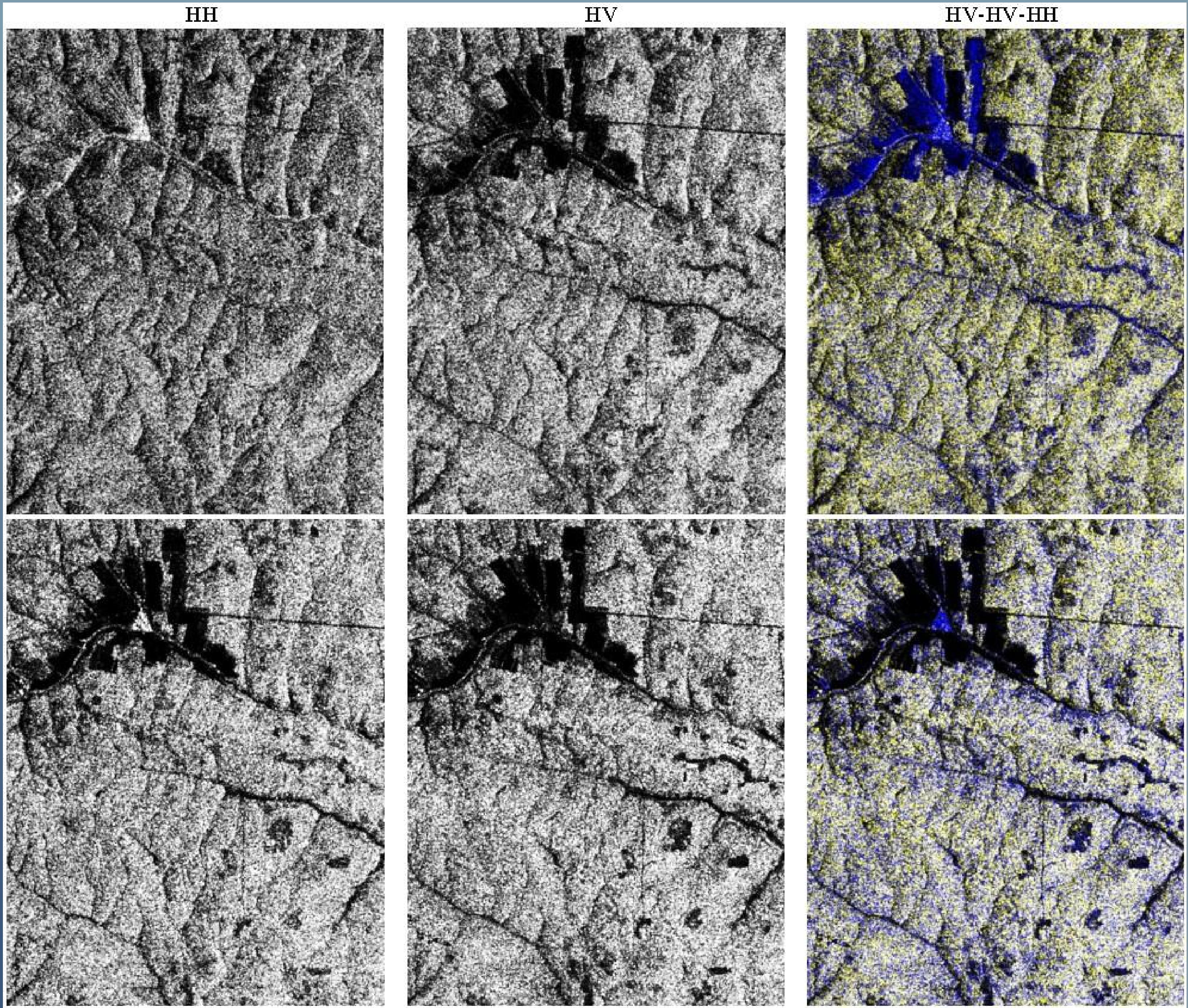
29.12.2000 (ERS-2)

27.02.2004 (ASAR IM)



C-Band VV Time Series to detect changes for ARD, Afforestation-Deforestation-Reforestation, Article 3.3 of the Kyoto Protocoll.

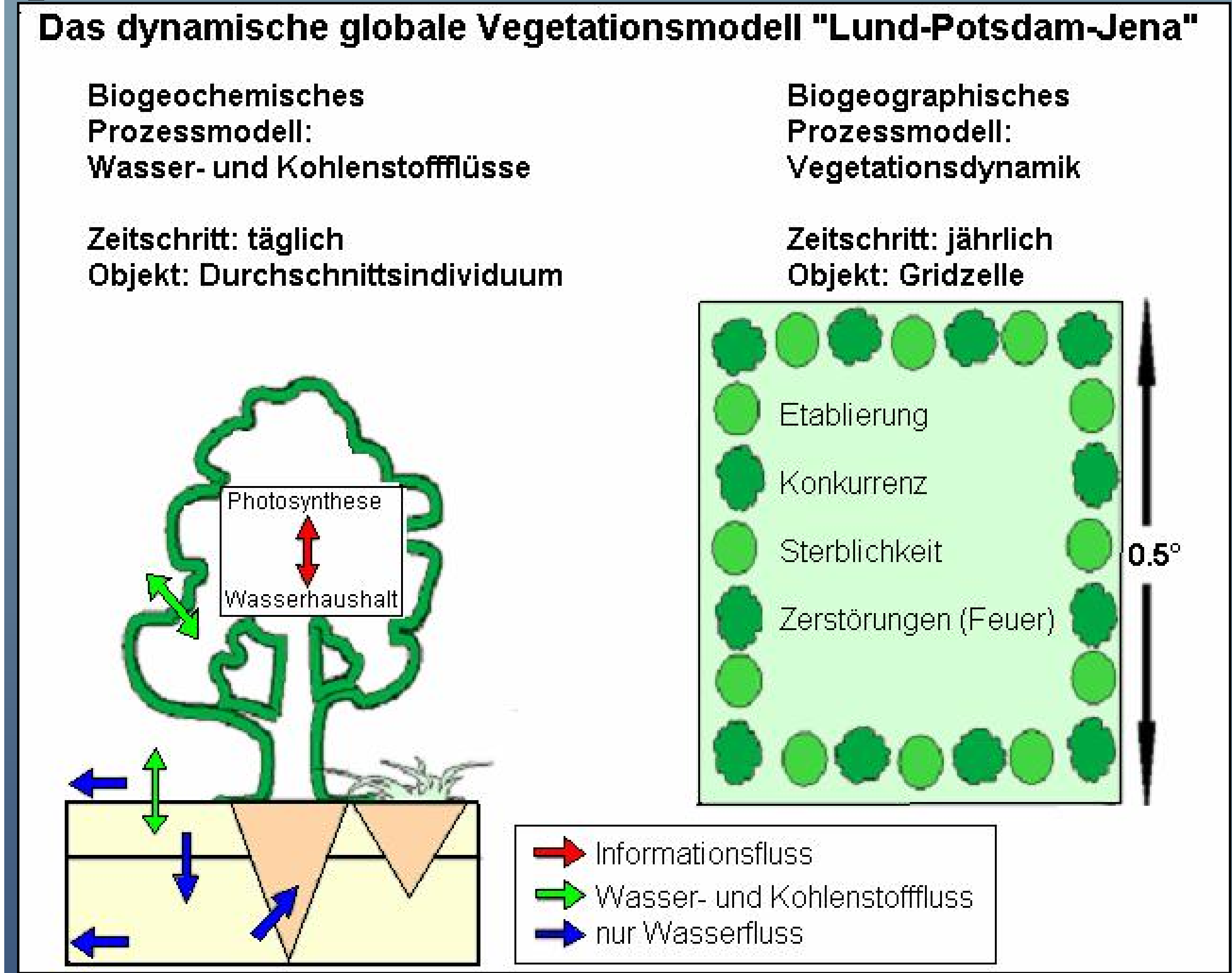
M. Santoro 2004



IS2

IS7

Das Lund-Potsdam-Jena-DGVM (LPJ-DGVM)



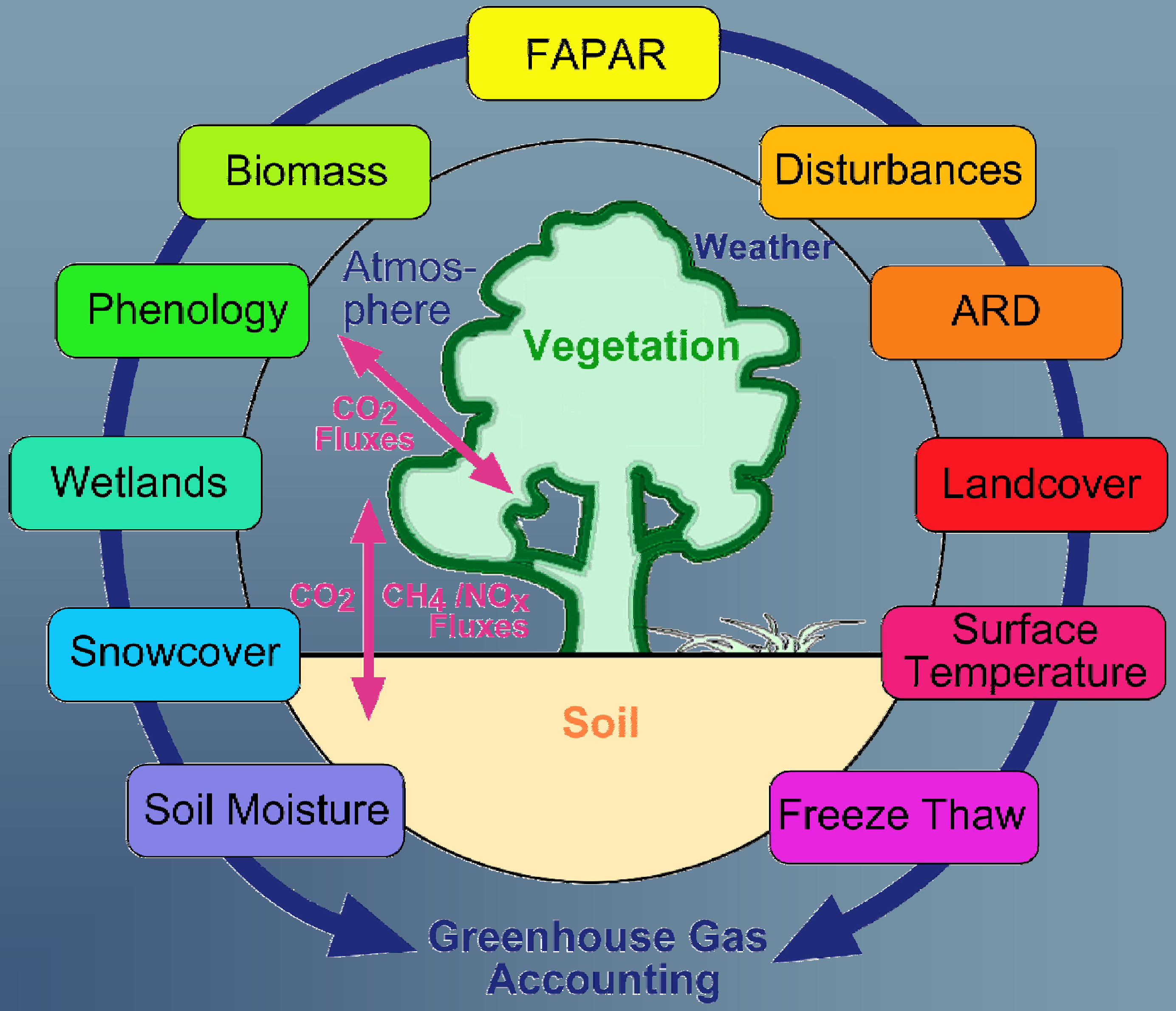
<u>0.5° Input, monatlich 1901-2003:</u>
Lufttemperatur, Niederschlagsmenge, Bewölkungsgrad, Anzahl der Regentage (CRU/PIK: New et al., 2000; Oesterle et al., 2002)

<u>0.5° Input / zeitlich konstant:</u>
Bodenart (FAO)

<u>Globaler jährlicher Input 1901-2003:</u>
CO_2-Konzentration der Atmosphäre (McGuire et al., 2001)

Sitch, et al. (2003)

SIBERIA-II Greenhouse Gas Parameters



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

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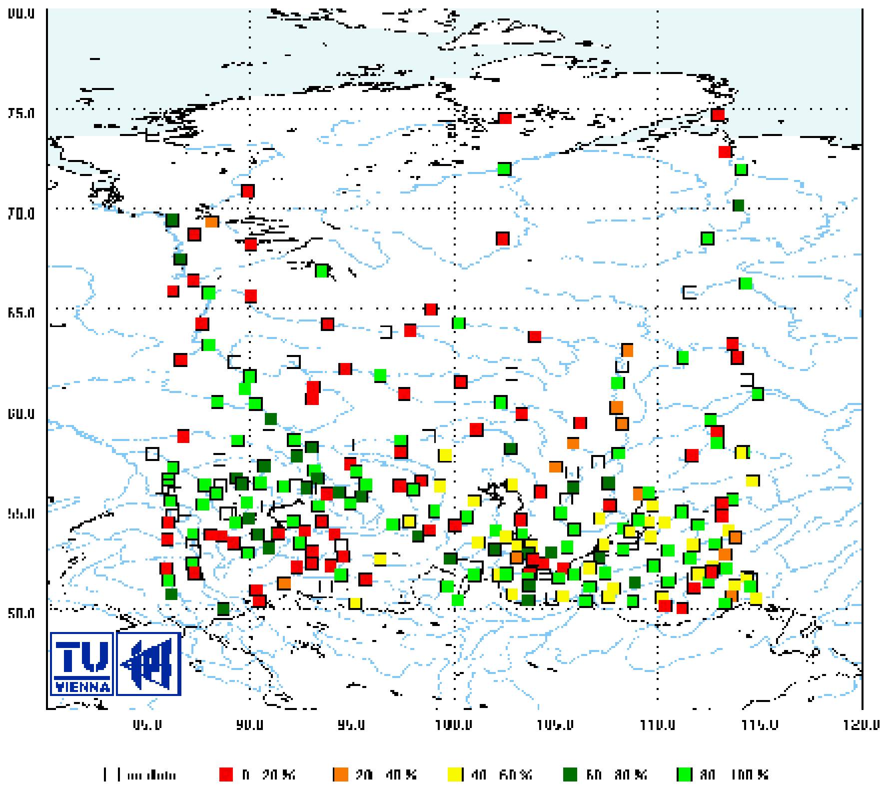
Northern Hydrologic Systems are Changing

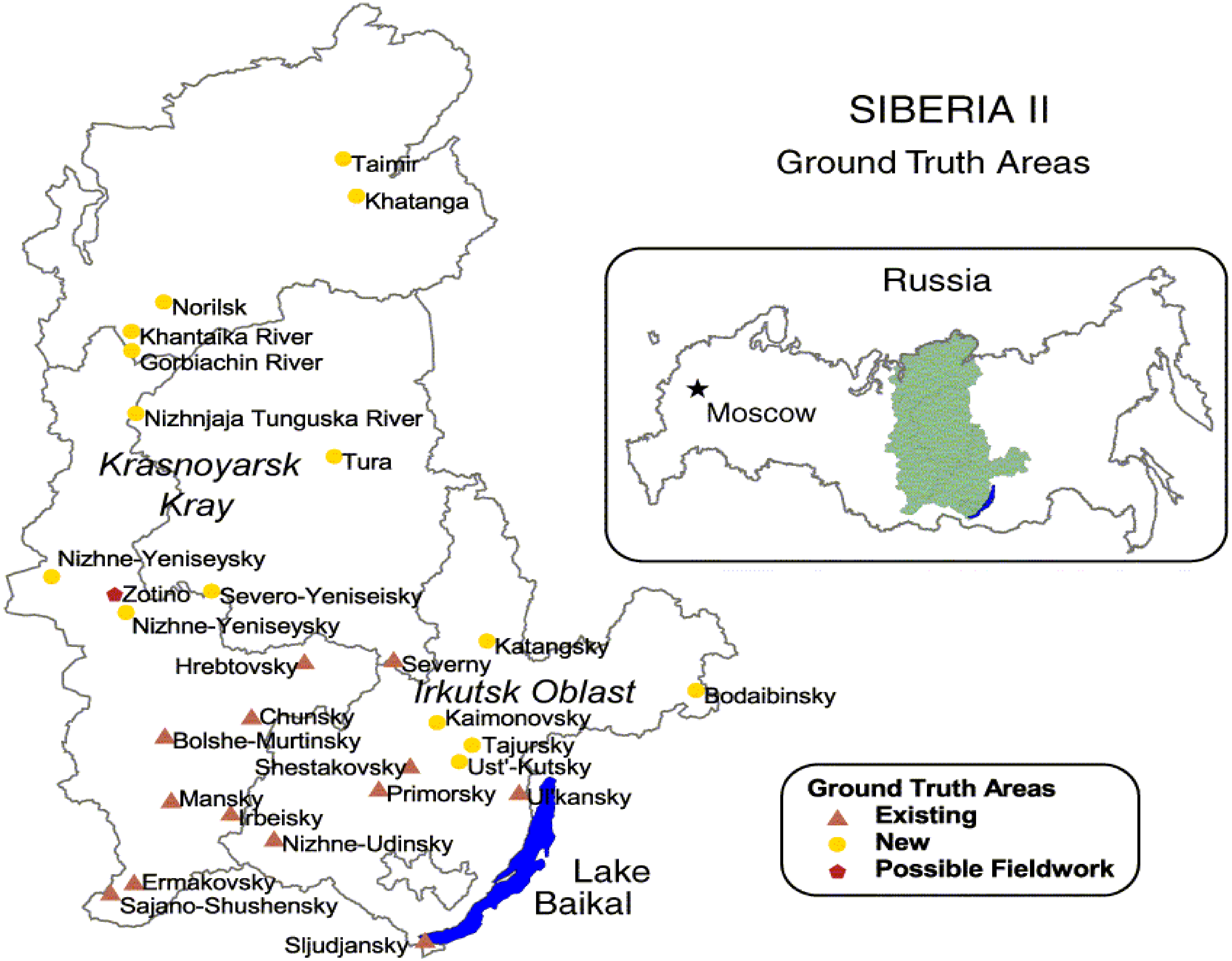
- Carbon cycle is closely linked with energy & water cycles
- Observed changes in Northern Hydrology
  - § River discharge ↑
  - § Spring discharge peak ↓
  - § Length of ice-free season ↑
  - § Snow covered area ↓
  - § Active layer depth ↑
  - § Etc.
- But distributed hydrologic processes can only be poorly quantified due to the lack of data

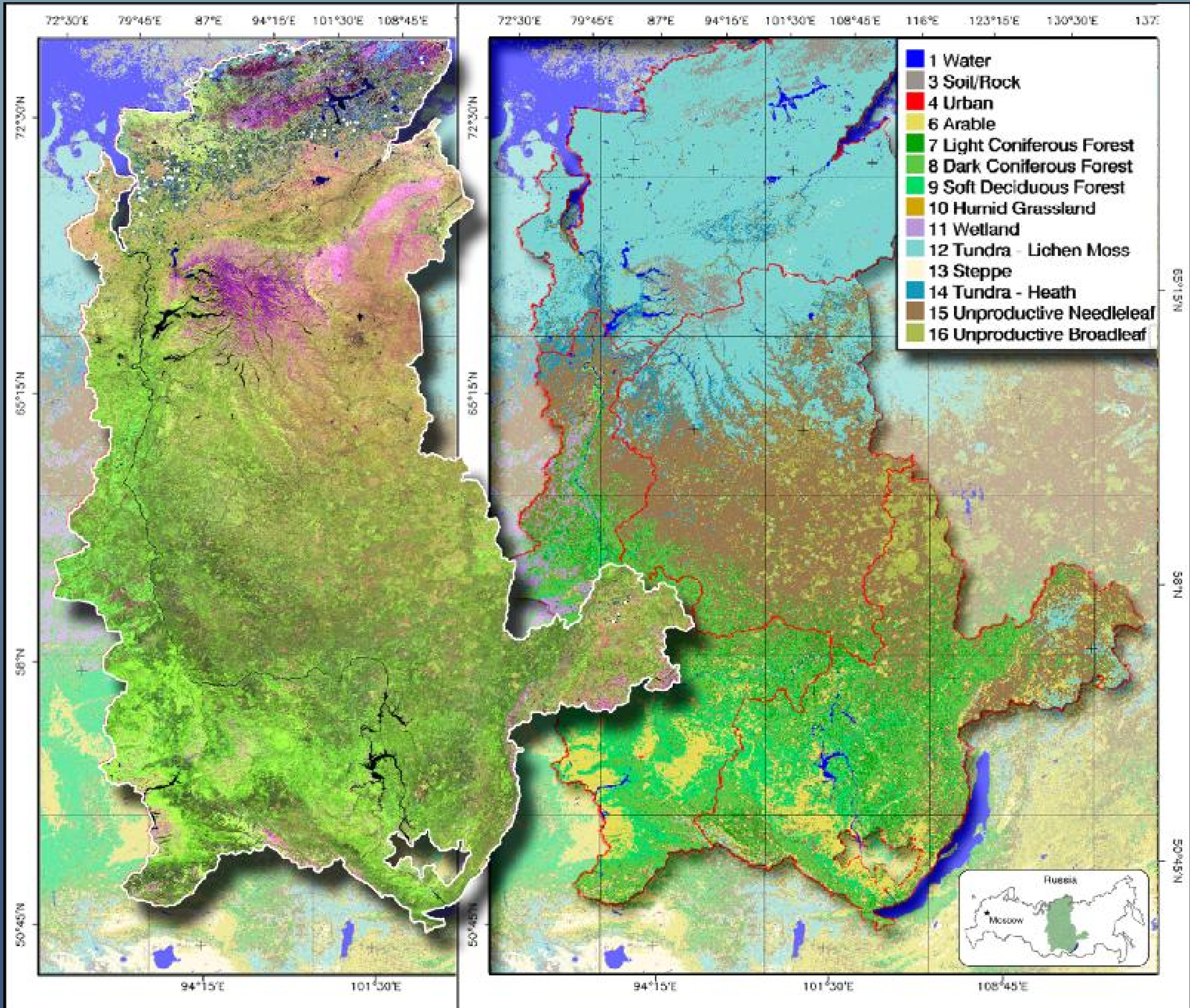


% of non-missing precipitation data 1994-2004 over SIBERIA II region

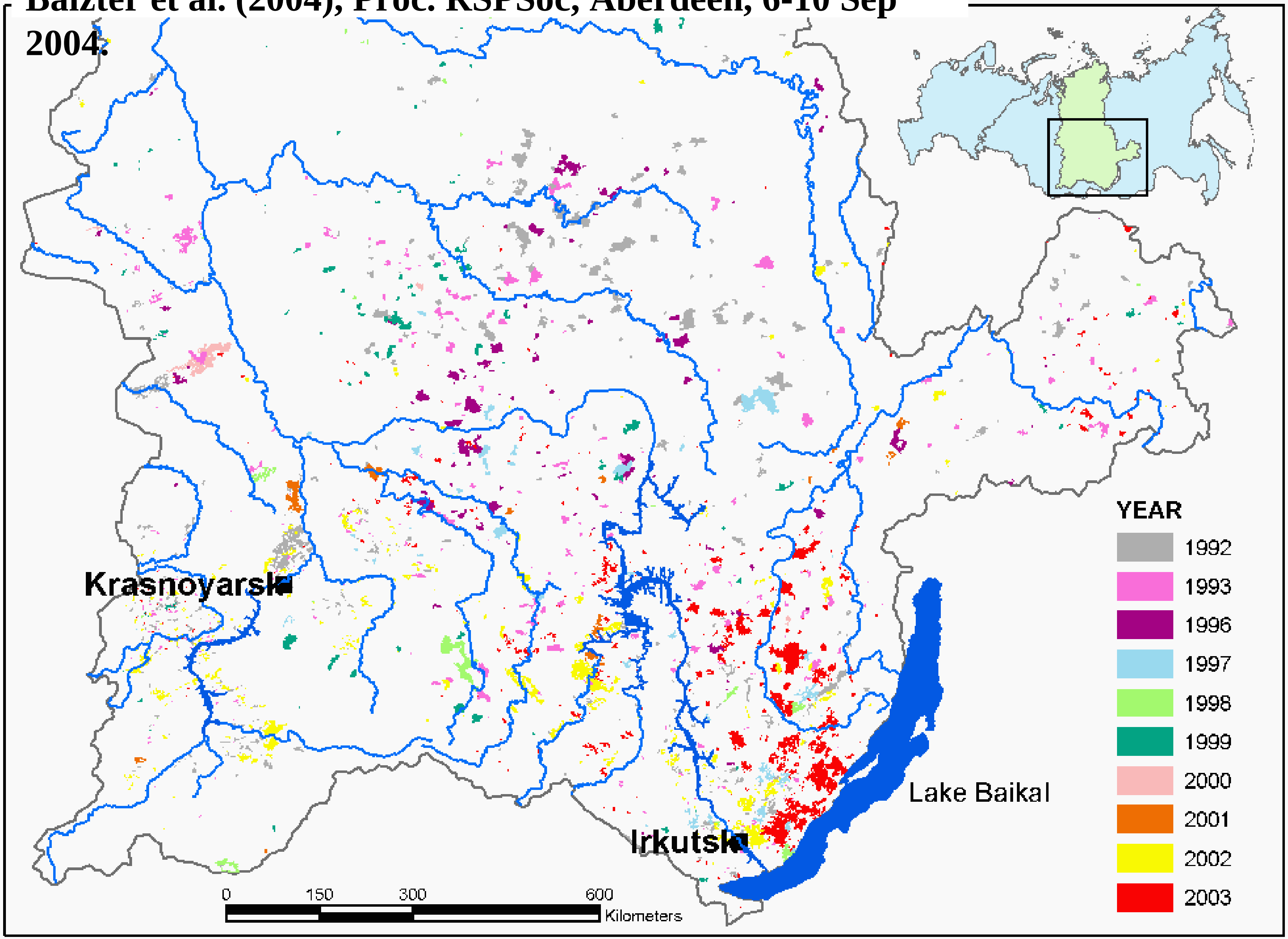
http://www.siberia2.uni-jena.de

Passive Optical Sensors		NOAA AVHRR
		ENVISAT AATSR
		ENVISAT MERIS
		TERRA MISR
		ERS ATSR-2
		TERRA MODIS
		TERRA ASTER
		Landsat TM 5
		Landsat ETM
		SPOT Vegetation
		DMSP OLS
		DMSP SSM/I
		Resurs-01 (MSU-SK)
Active Optical Sensors (Laser)		none - (although interest in VCL - Vegetation Canopy Lidar - Mission)
Active Microwave Sensors	SAR	ENVISAT ASAR
		ERS-2 SAR
		ERS-1 SAR
		JERS-1 (historical data)
	Scatterometer	QuikScat SeaWinds
		ERS AMI-SCAT
Passive Microwave Sensors		(SMMR, ADEOS-II AMSR)


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
Hrebtovsky
Severny
Katangsky
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

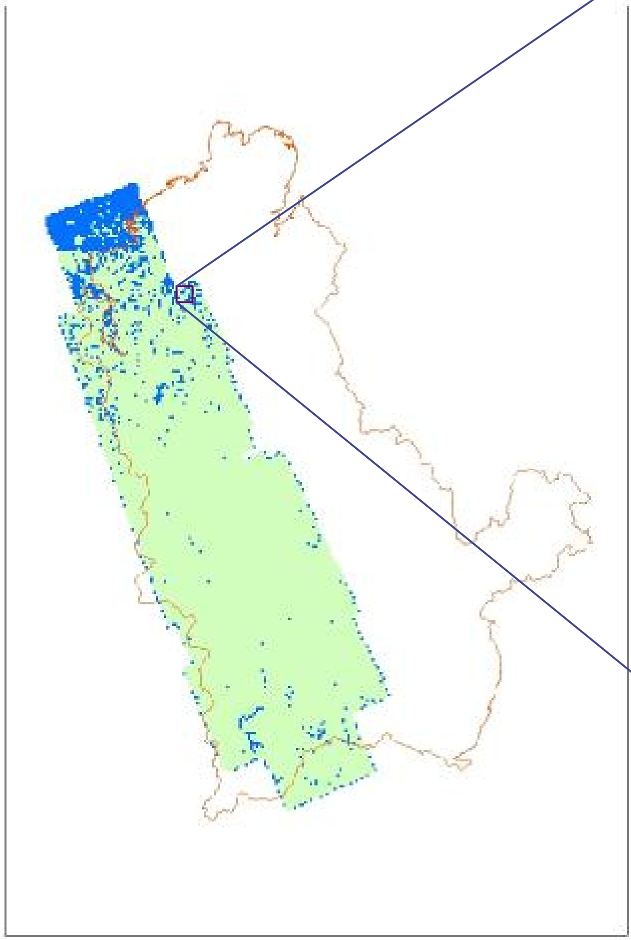

72°30'E
79°45'E
87°E
94°15'E
101°30'E
108°45'E
116°E
123°15'E
130°30'E
72°30'N
65°15'N
58°N
50°45'N
1 Water
3 Soil/Rock
4 Urban
6 Arable
7 Light Coniferous Forest
8 Dark Coniferous Forest
9 Soft Deciduous Forest
10 Humid Grassland
11 Wetland
12 Tundra - Lichen Moss
13 Steppe
14 Tundra - Heath
15 Unproductive Needleleaf
16 Unproductive Broadleaf
Russia
Moscow

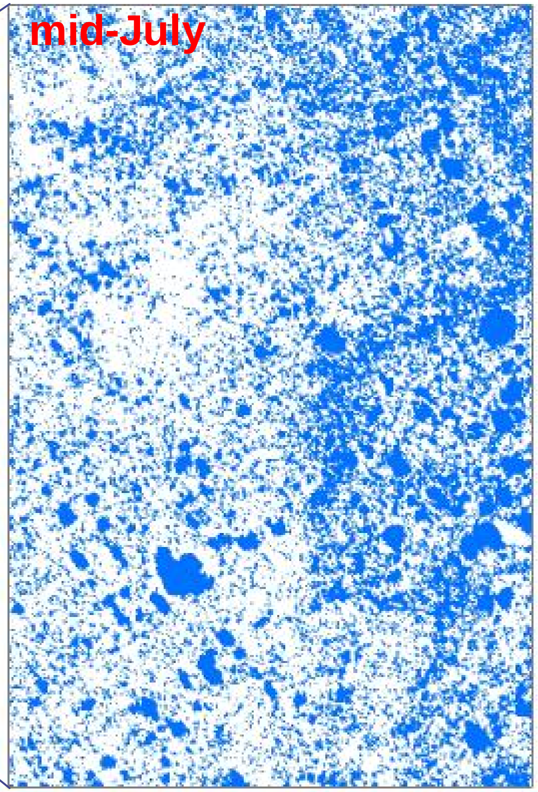
Balzter et al. (2004), Proc. RSPSoc, Aberdeen, 6-10 Sep 2004.

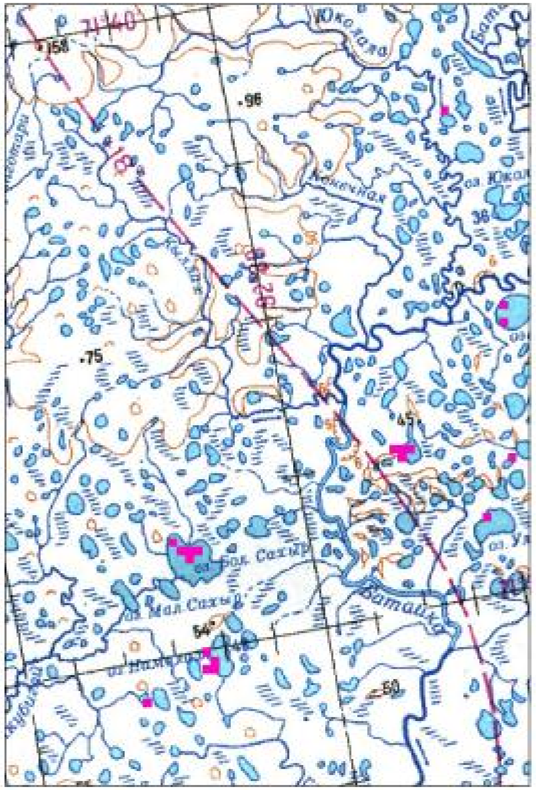


Water bodies – accuracy assessment

Current extent of water bodies mask





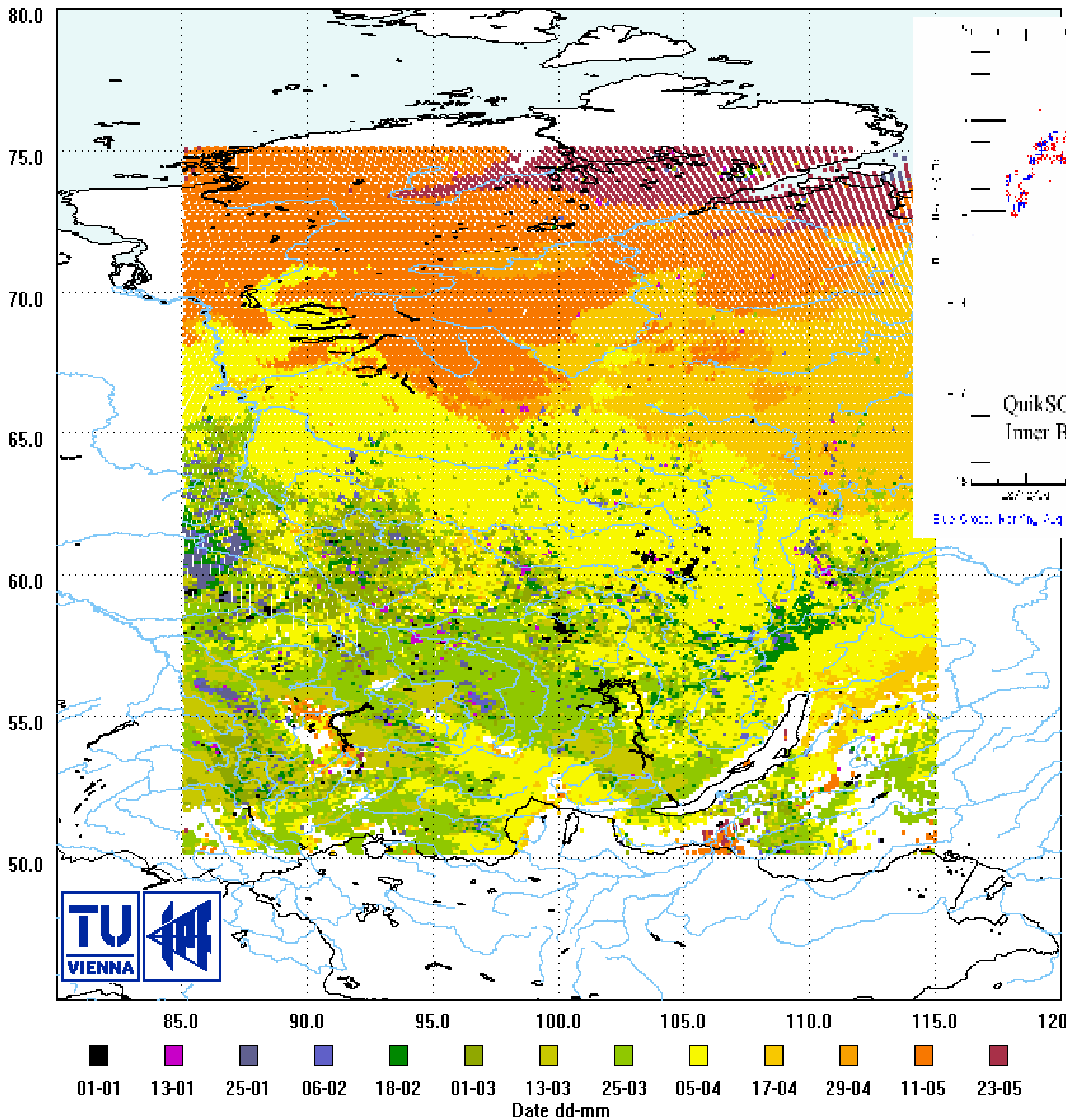


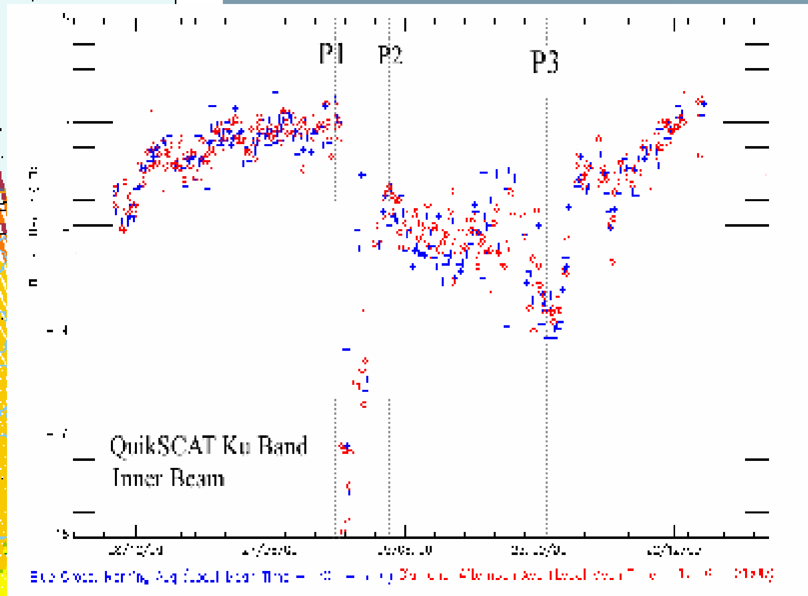
20 km

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

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

SIBERIA II Start of Thaw Indicator - 2000



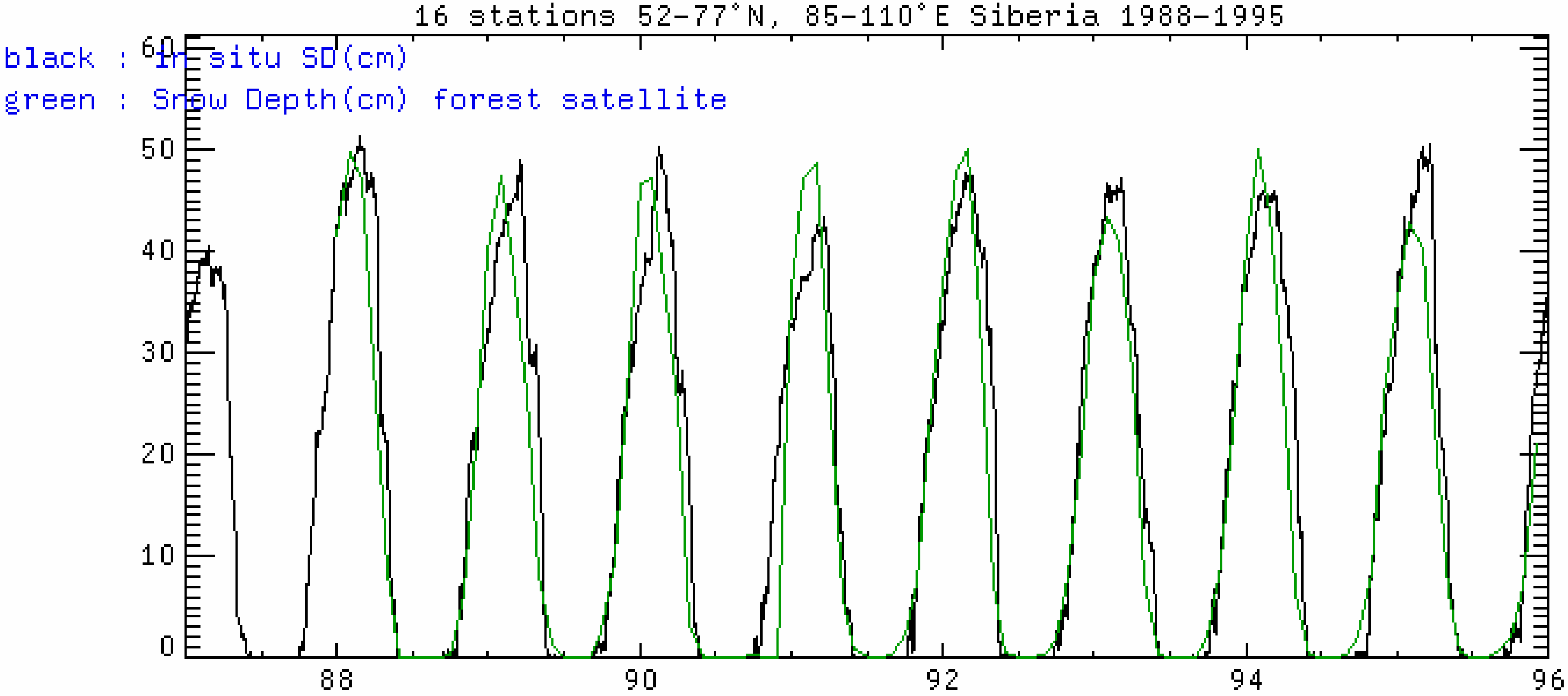


P1. **Start of Thaw**
change in surface
wetness during day

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

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

Comparison snow depth satellite- weather stations Siberia 88-95



SIBERIA-II: CESBIO, Toulouse

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

SIBERIA-II Greenhouse Gas Parameters

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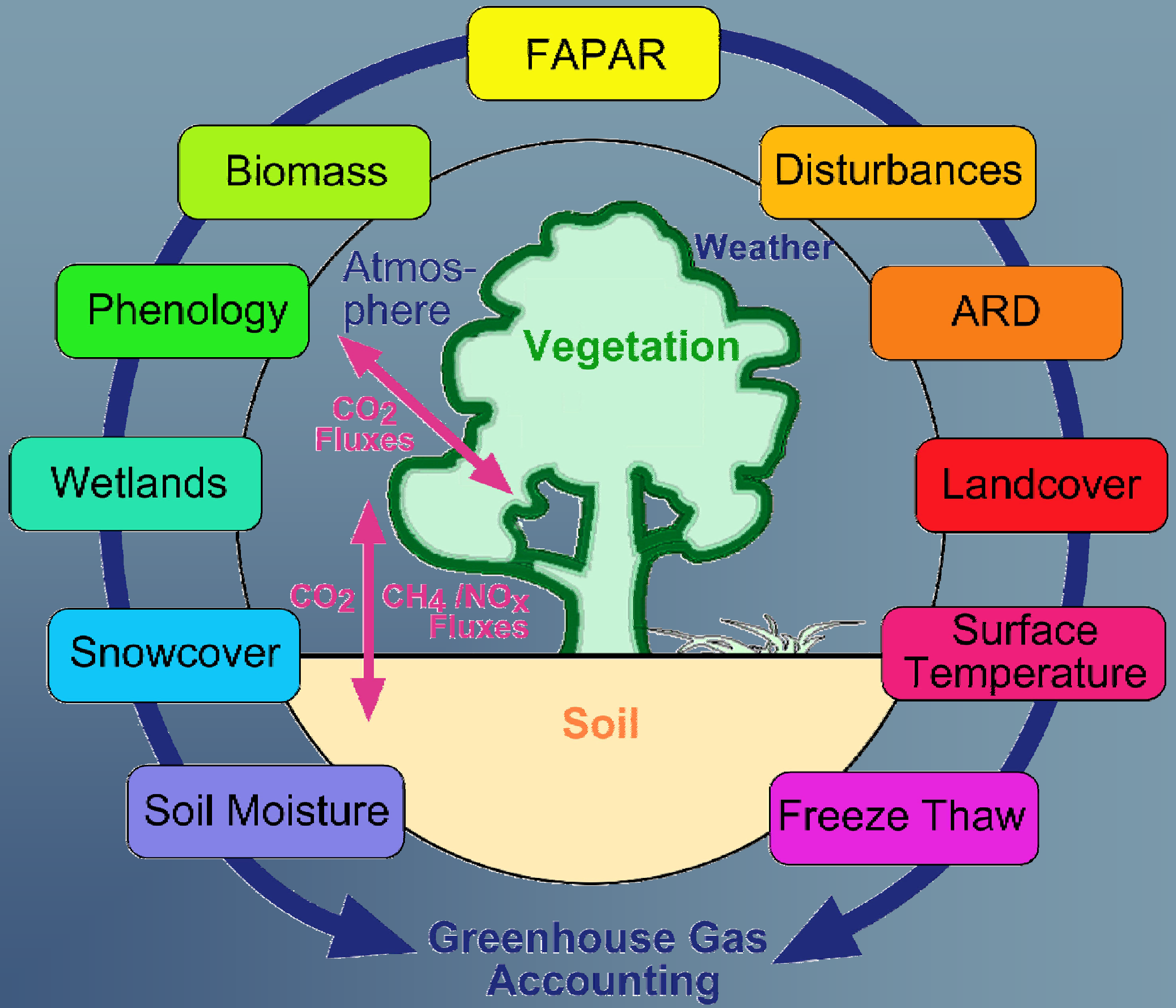
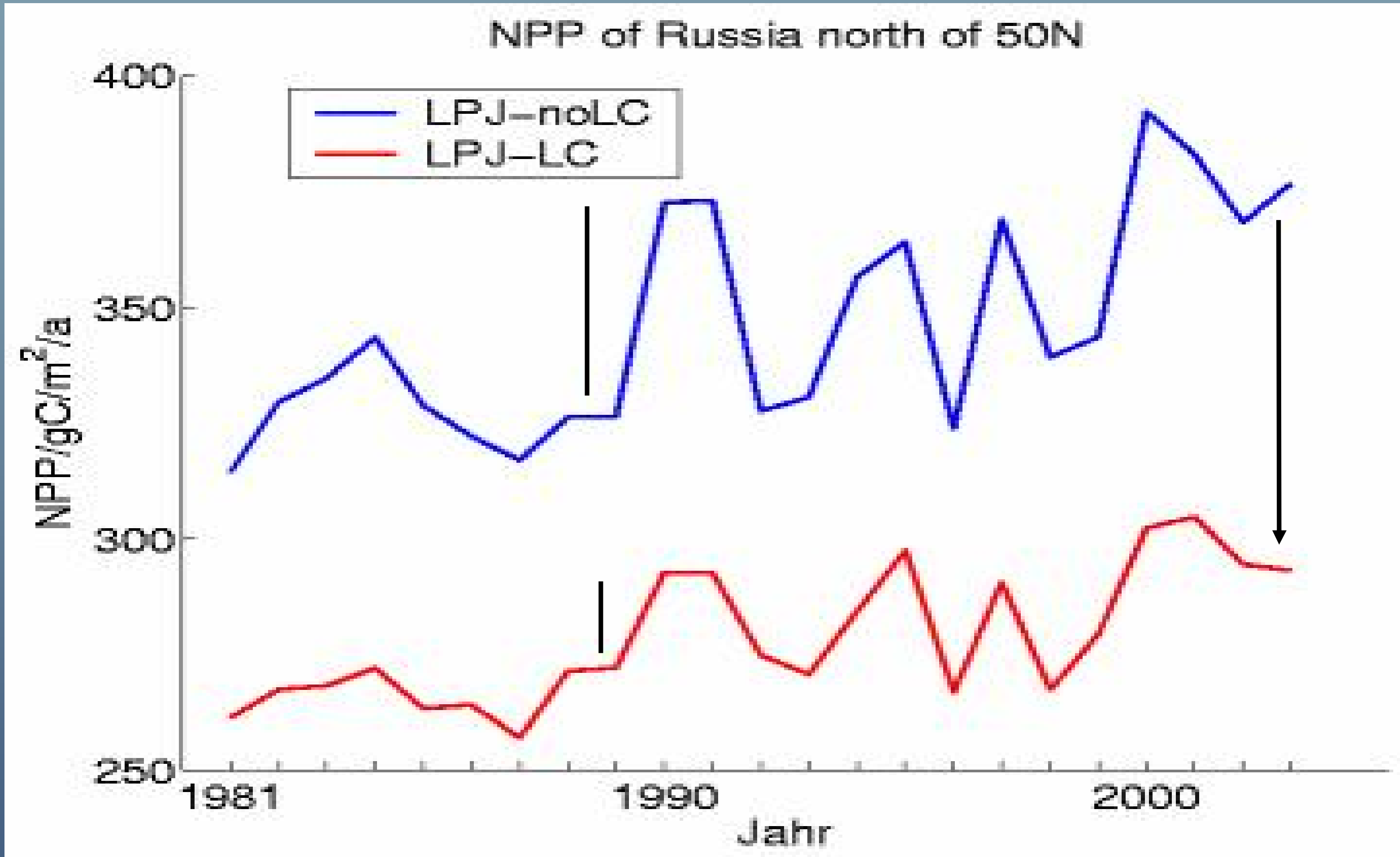


Vegetation Models in SIBERIA-II:
LPJ-DVM, SDVM, IIASA GIS-Approach

SIBERIA-II Major Outcome 1= NPP reduction



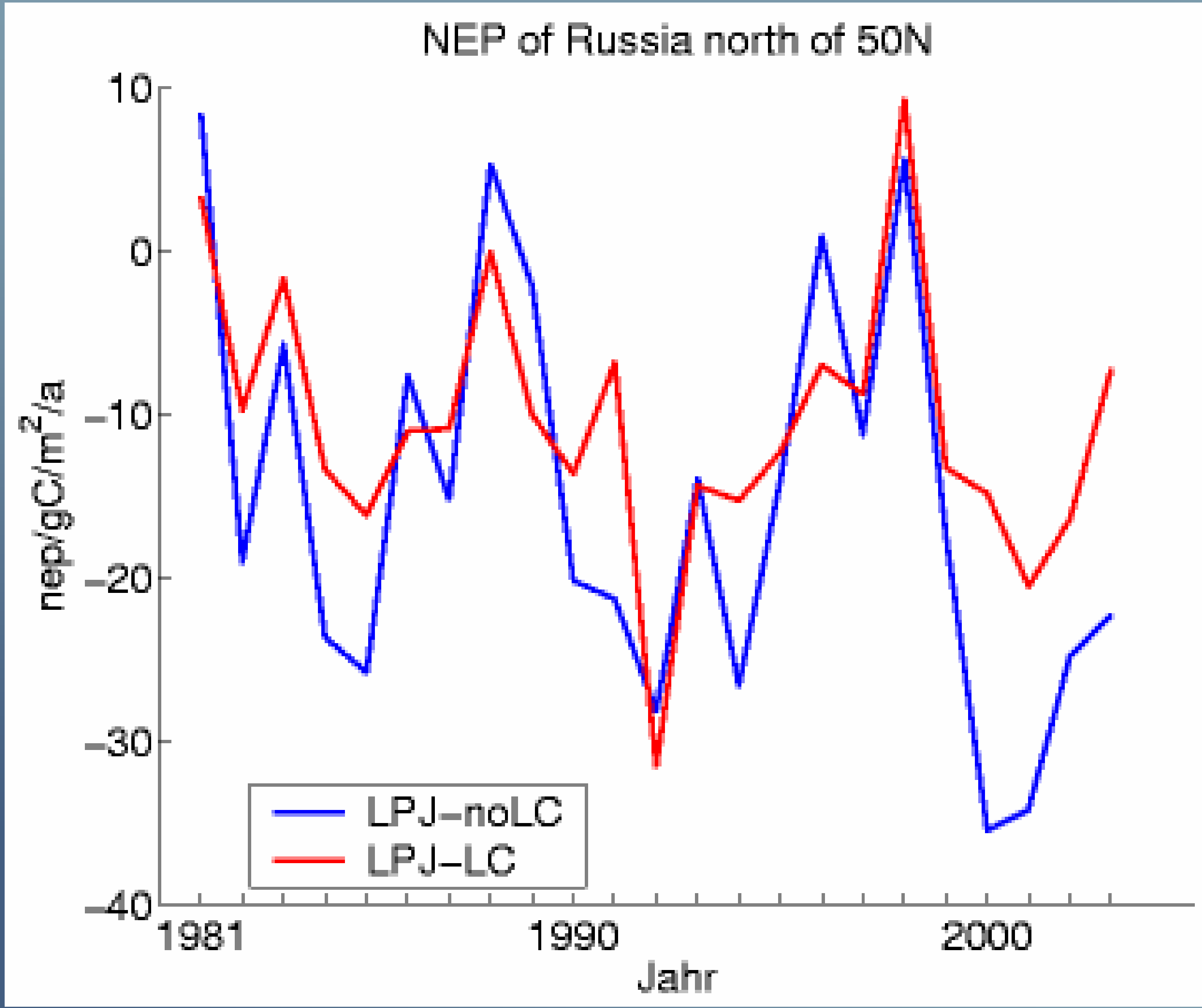
Less interannual variability.

Reduction in NPP results.

SIBERIA-II Major Outcome 2: NEP sink-to-source

Source

Sink



Spatial Modelling of Greenhouse Gas Compartments for GIS-based Terrestrial Carbon Accounting in Boreal Ecosystems

Daniela Knorr[1], Anatoly Shvidenko[2], Christiane Schmullius[1]

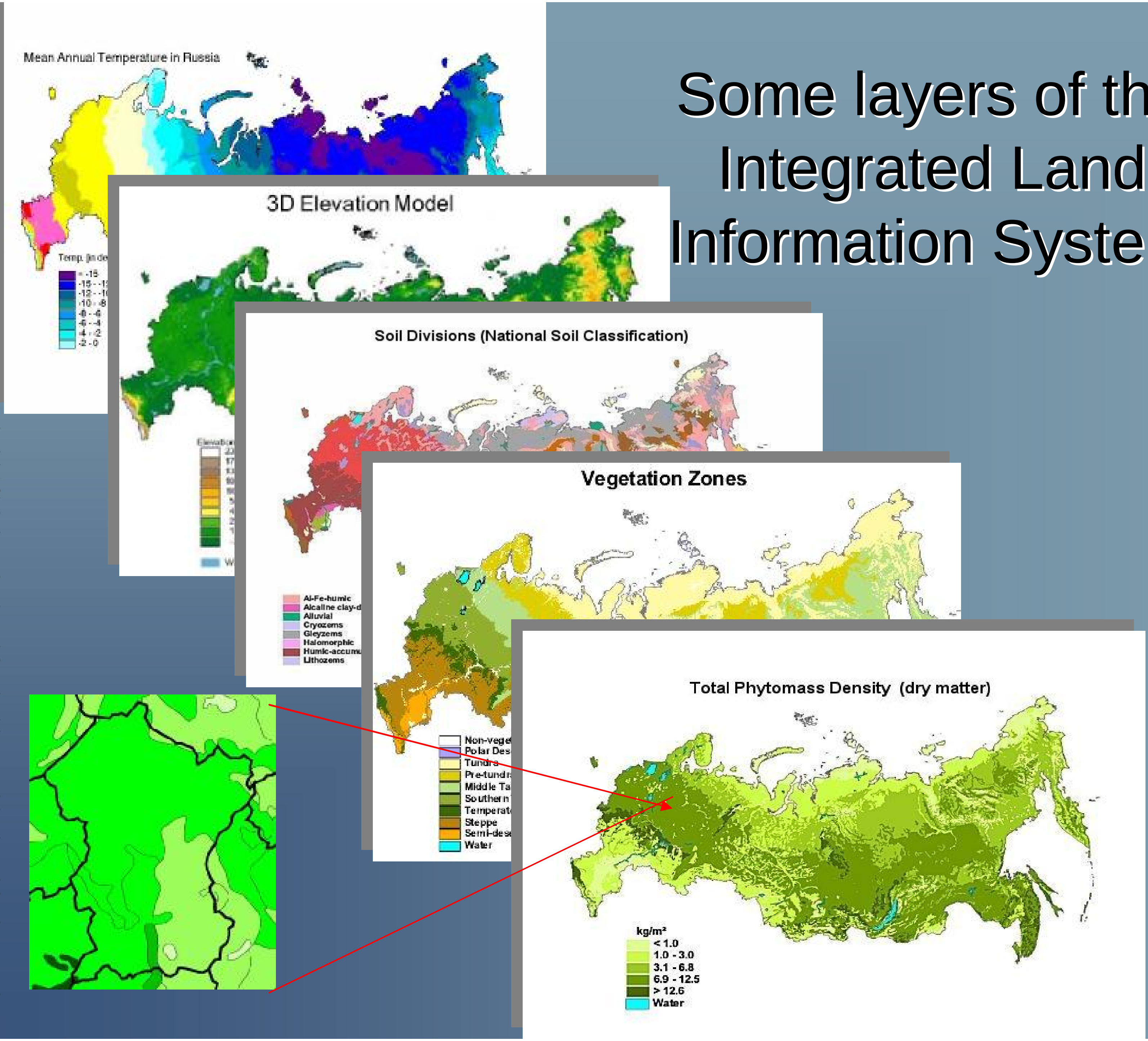
(1) Friedrich-Schiller-University, Jena/Germany
(2) International Institute of Applied Systems Analysis, Laxenburg/Austria

Background – SIBERIA-II

Study region:

~ 3 Mio km²
in Central-Siberia
(85 -115° E; 52 - 75° N)

Some layers of the Integrated Land Information System



Background – IIASAs Landscape Approach

GIS-based landscape ecosystem model
provides diagnostic predictions of the carbon storage and GHG fluxes

Model input
Polygon based vegetation map 1: 1 Mio with attributive database holding all information needed for a terrestrial biota full carbon accounting (FCA)

Generation of IIASA data base
Manual digitizing in GIS by Russian regional vegetation experts who identified and delineated homogenous polygons based on
- field data
- forest inventory
- remote sensing data (landsat scenes)
- soil and landscape maps

Background – IIASAs Landscape Approach

Problems

- labour and time consuming
- data is strongly aggregated
- practical implementation of delineation and aggregation rules are not completely clear
- estimation of uncertainties of the process of delineation is not possible
- forest inventory is only conducted every 10 to 15 years and only in the forested middle and southern parts of the study region

↓

snapshot land cover description for the year 2003

↓

! extension of data base to other years is not possible !

Objectives

Remote Sensing

Ground data

repeatable
rule-based method
automated

- yearly information on vegetation distribution, and
- high classification depth down to species level

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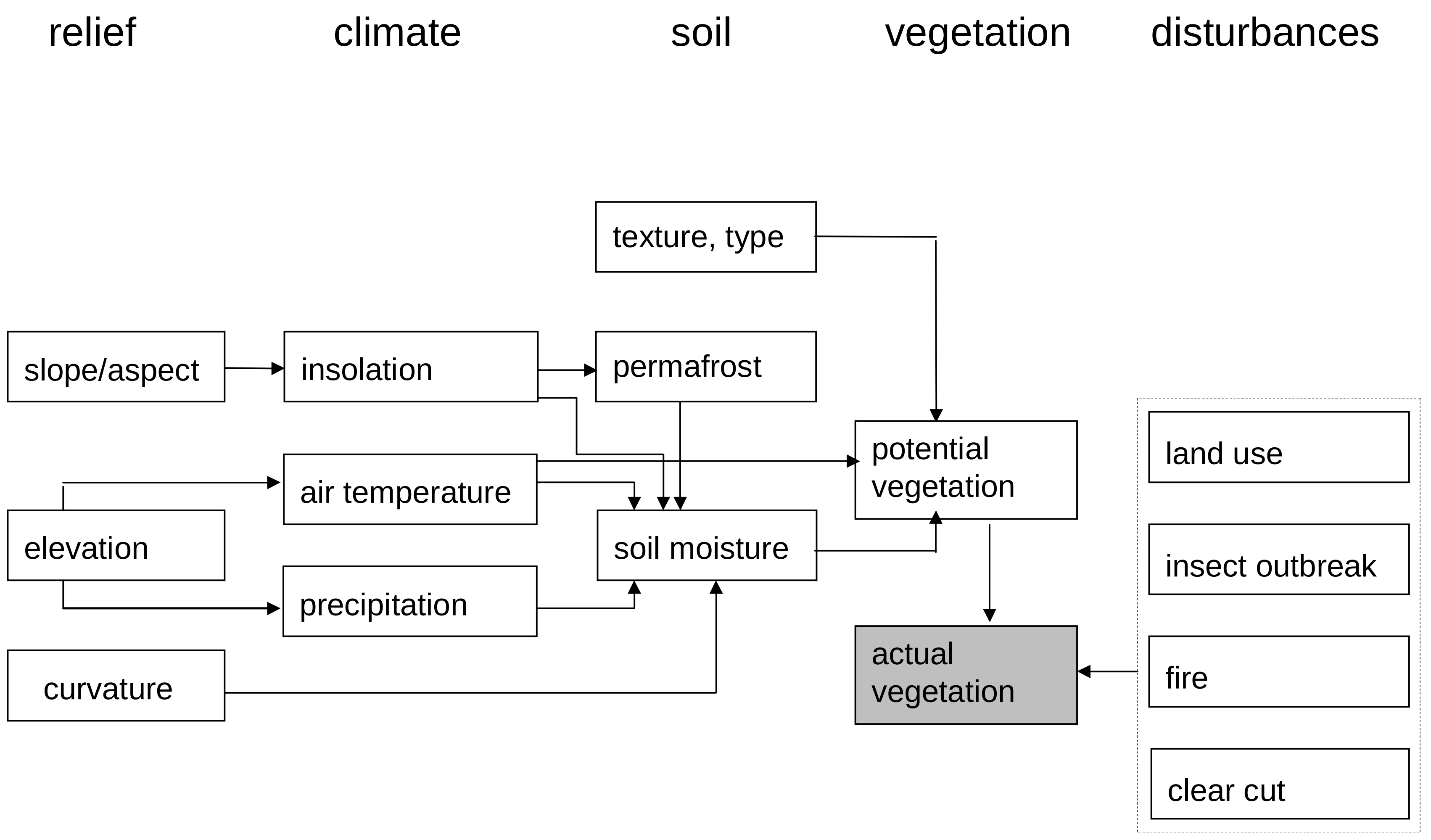
Concept – Landscape ecology



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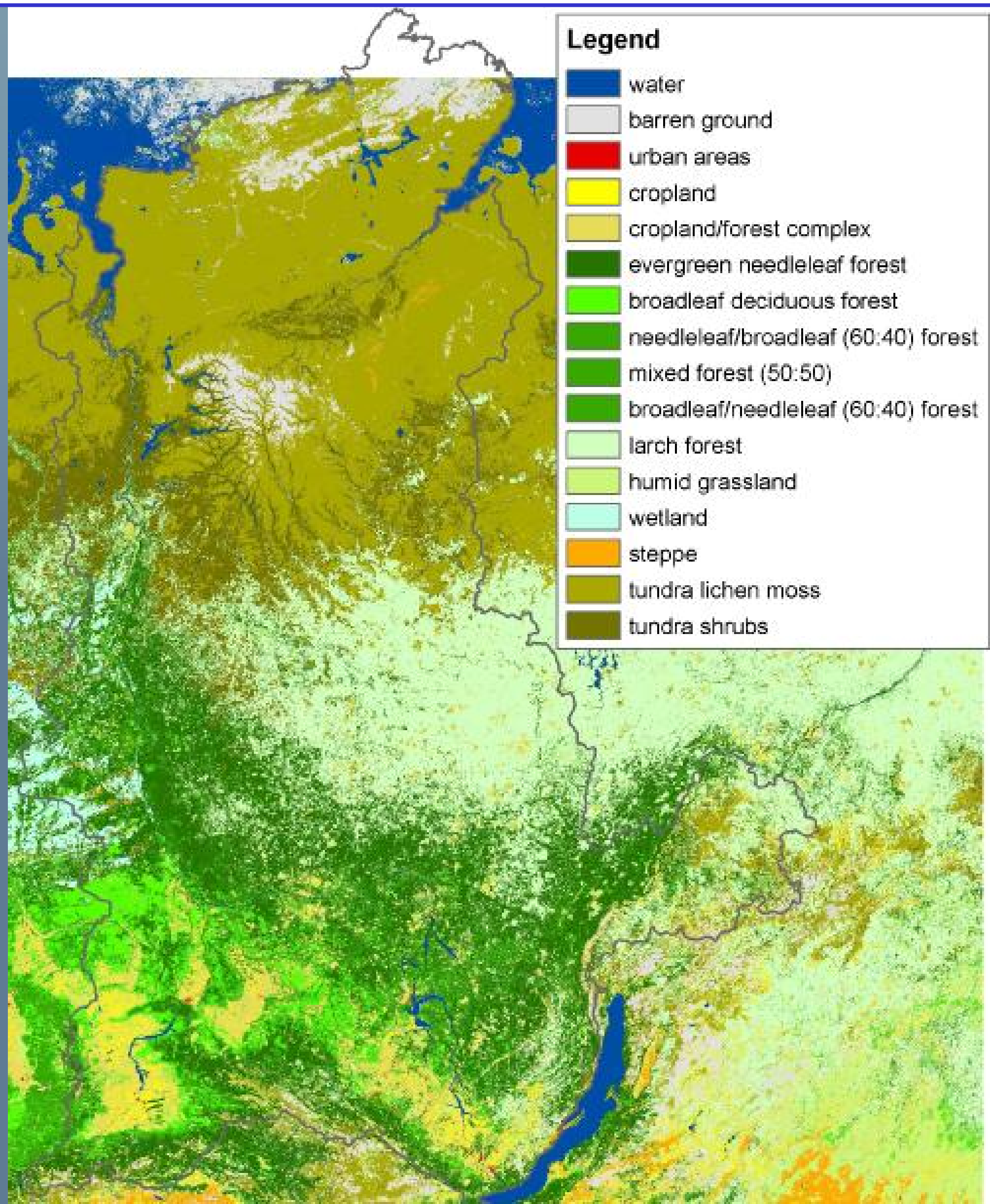
Methodology

- Postclassification of SIBERIA-II land cover map



Land cover 2003
(500 m MODIS, Skinner & Luckman 2003)

Methodology

- Postclassification of SIBERIA-II land cover map
- Rule based data fusion of different independent EO-products and maps

Methodology

- Postclassification of SIBERIA-II land cover map
- Rule based data fusion of different independent EO-products and maps
- Rules of desicion tree are
  - based on natural regularities or/and
  - trained with IIASAs vegetation map (1:1 Mio) and forest inventory test sites (1:50.000, 1:100.000)

Methodology

- Postclassification of SIBERIA-II land cover map
- Rule based data fusion of different independent EO-products and maps
- Rules of desicion tree are
  - based on natural regularities or/and
  - trained with IIASAs vegetation map (1:1 Mio) and forest inventory test sites (1:50.000, 1:100.000)
- Fuzzy classification scheme using VCF to derive 3 layers:
  - forest layer
  - non forest classes
  - bare rock (unproductive) layer

Decision Rules

ecoregions

different rules
for different regions

Decision Rules

ecoregions

↓

land cover

reclassification after plausibility rules

SIBERIA-II land cover (MODIS, 500m, 2003)

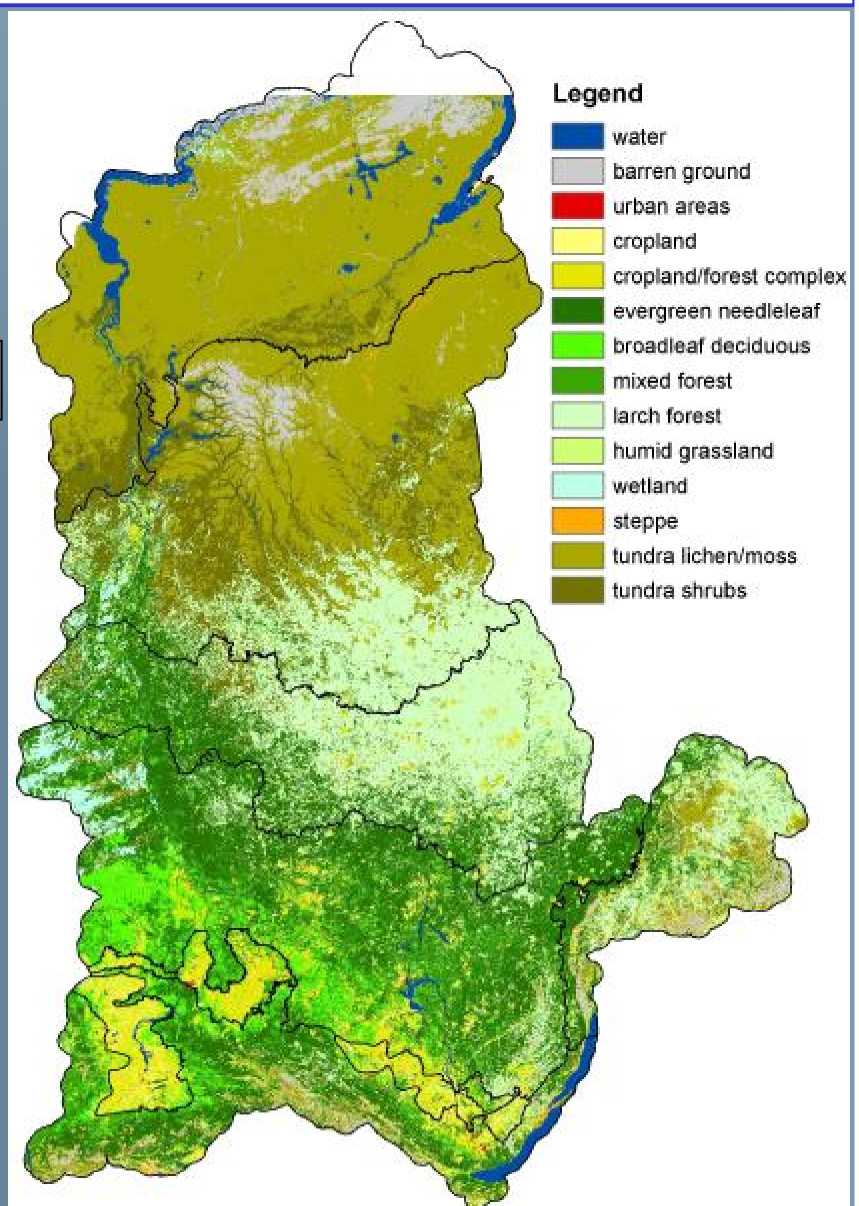
tundra

↓

steppe

↓

tundra or barren ground



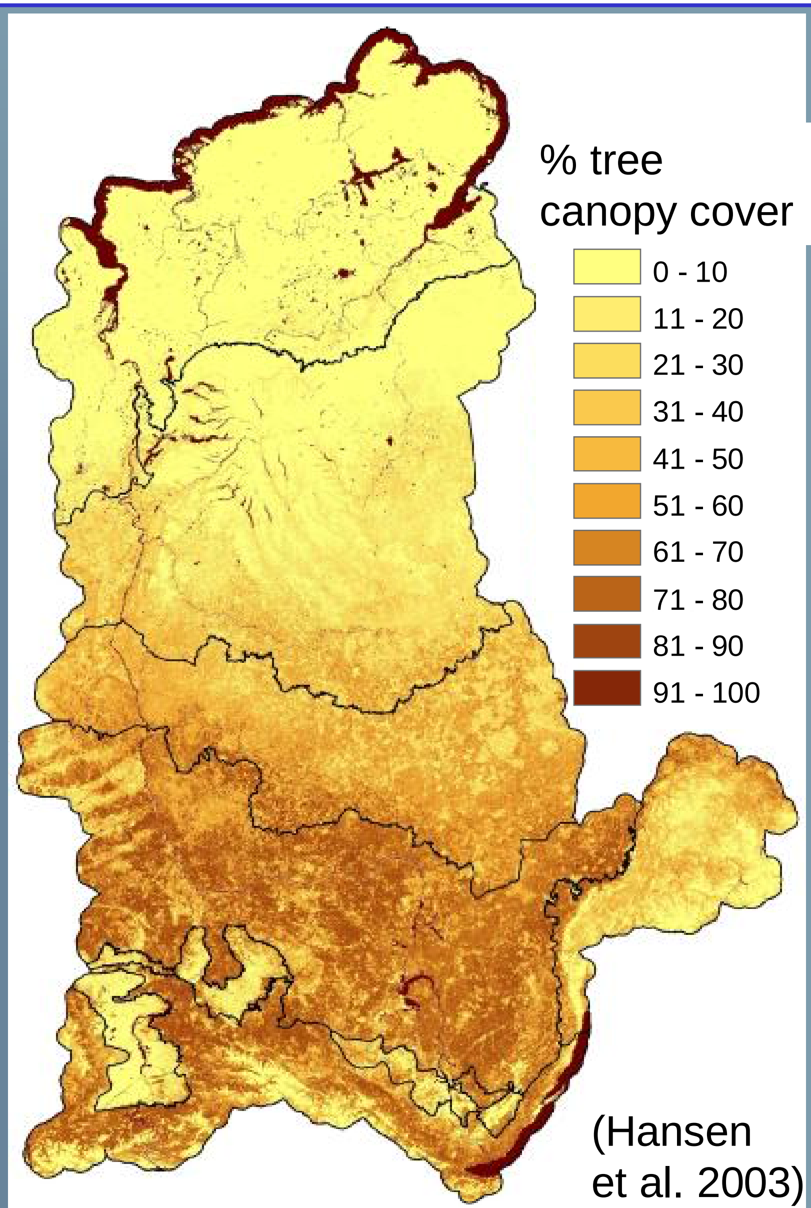
Decision Rules

ecoregions → land cover → VCF

MODIS VCF, 500m, 2001

tundra → steppe

- barren ground < 95% tree cover < 5% → tundra
- tree cover > 5% → larch + tundra
- barren ground > 95% → barren ground



Decision Rules

ecoregions

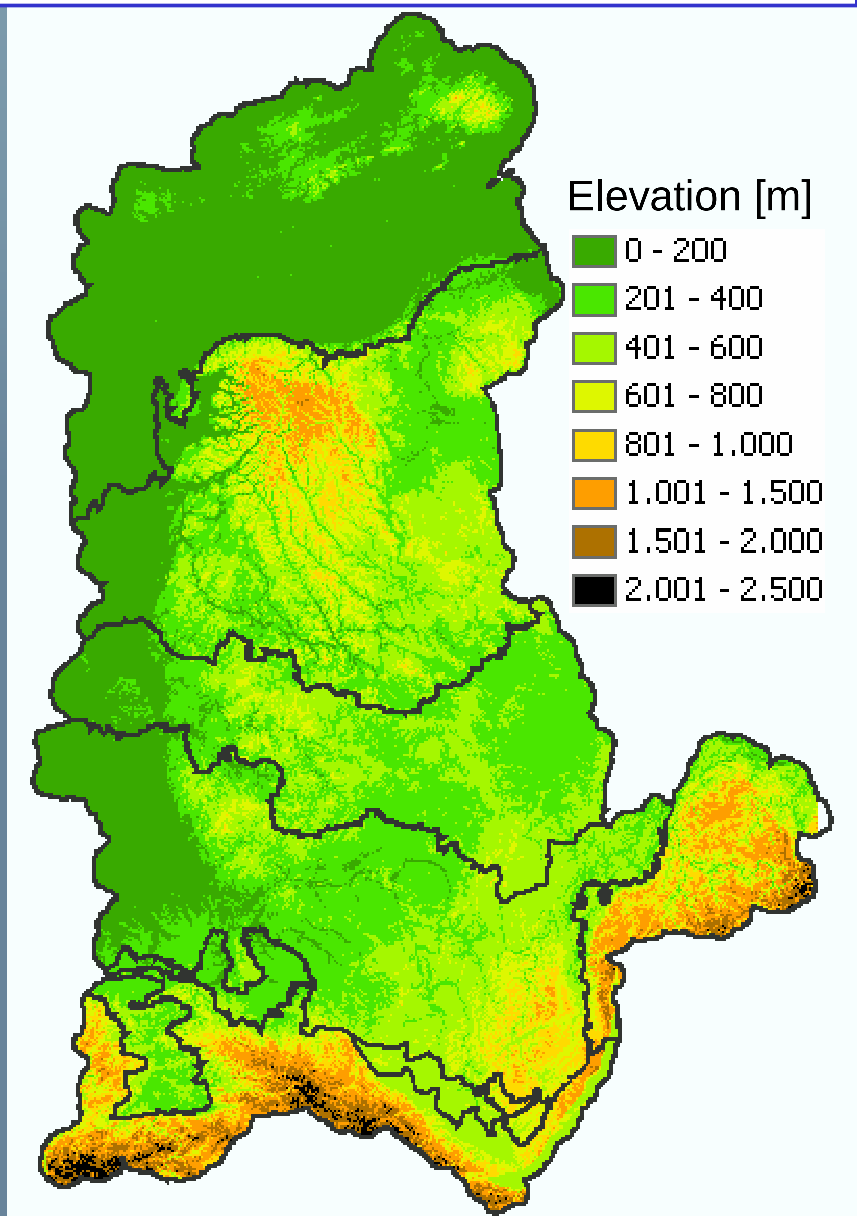
land cover

VCF

topography

SRTM, 500m

elevation belts, for differentiation of tree species, wetland types

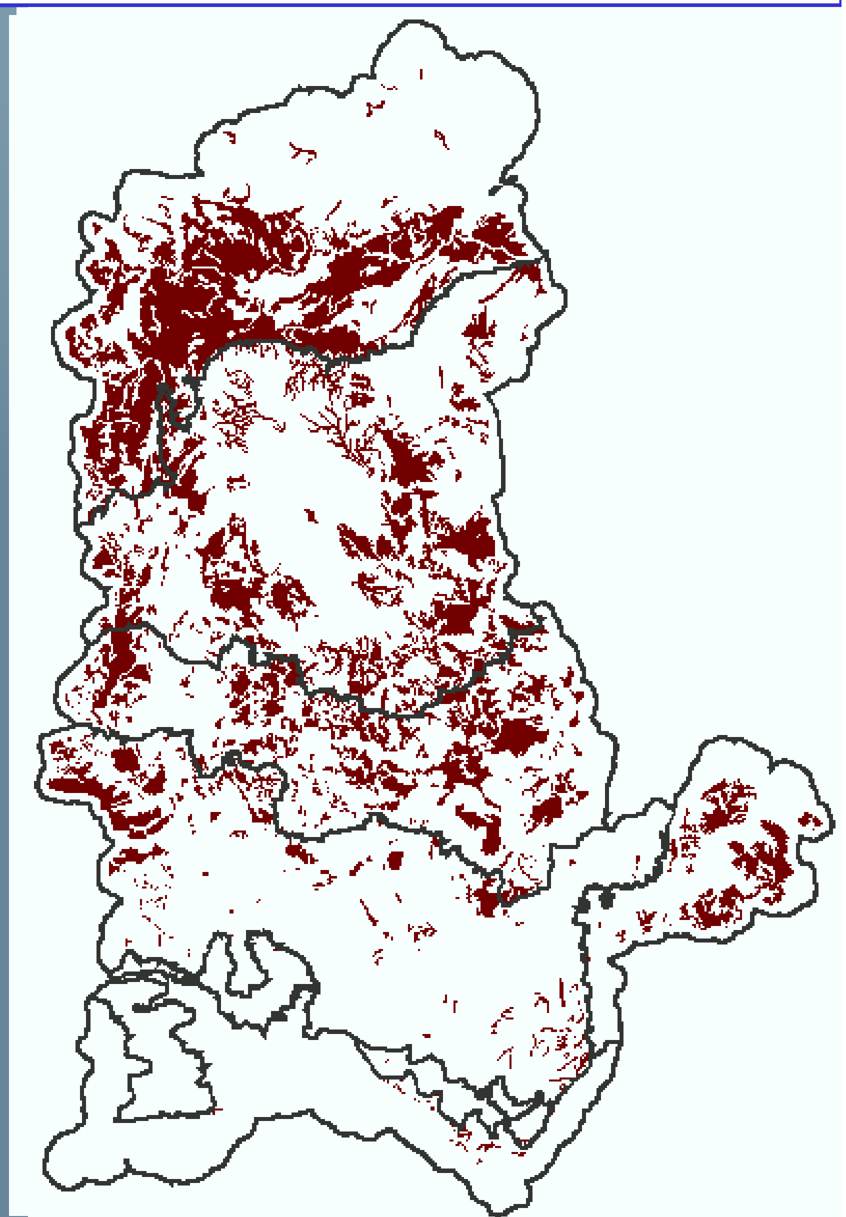


Decision Rules

ecoregions
↓
land cover
↓
VCF
↓
topography
↓
soil

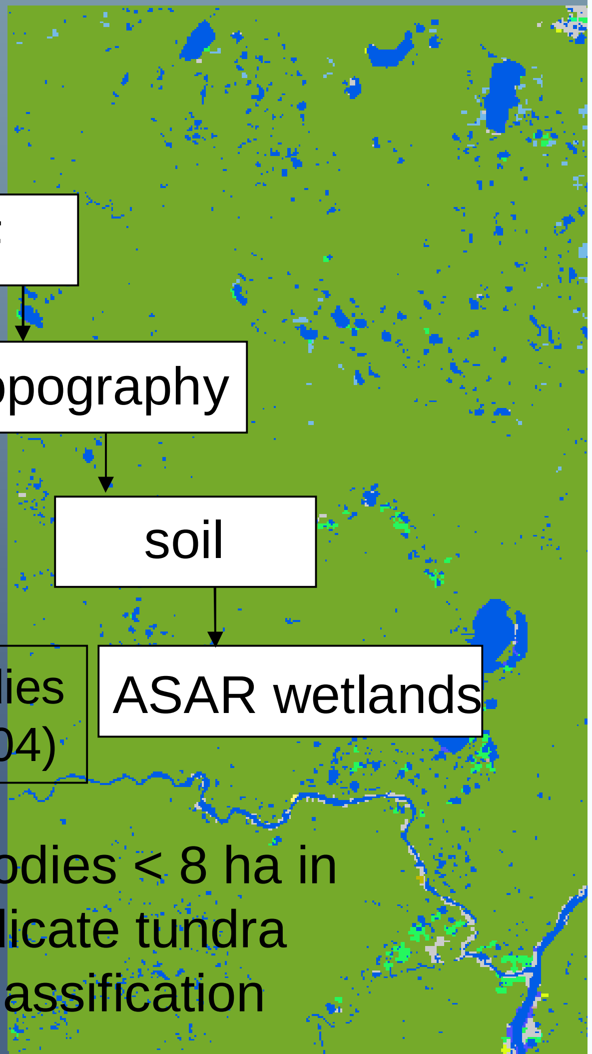
IIASA soil database, 1:1 Mio

1. special soil types for differentiation between tree species
2. peaty horizon > 40cm for decision about wetlands,



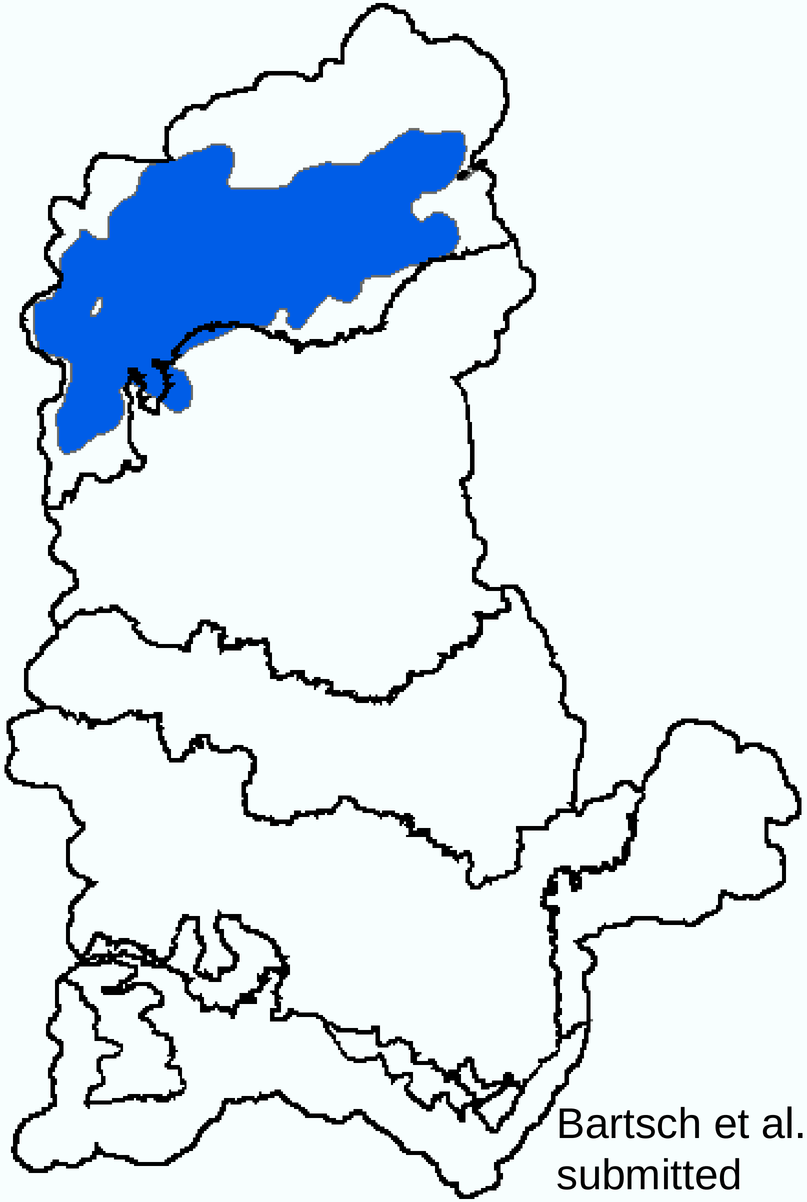
Decision Rules

ecoregions → land cover → VCF → topography → soil → ASAR wetlands



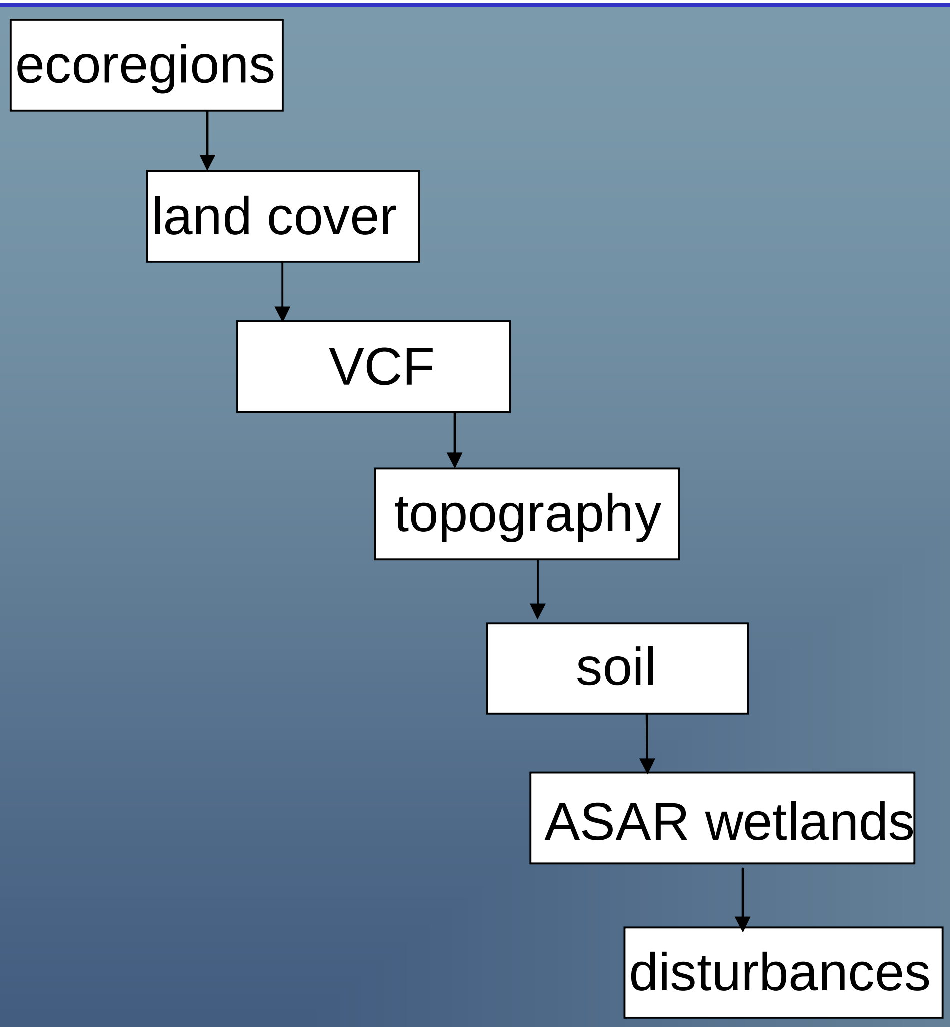
SIBERIA-II water bodies
(ASAR, 150m, 2003/04)

- permanent water bodies < 8 ha in subartic regions indicate tundra wetland (Ramsar classification scheme)

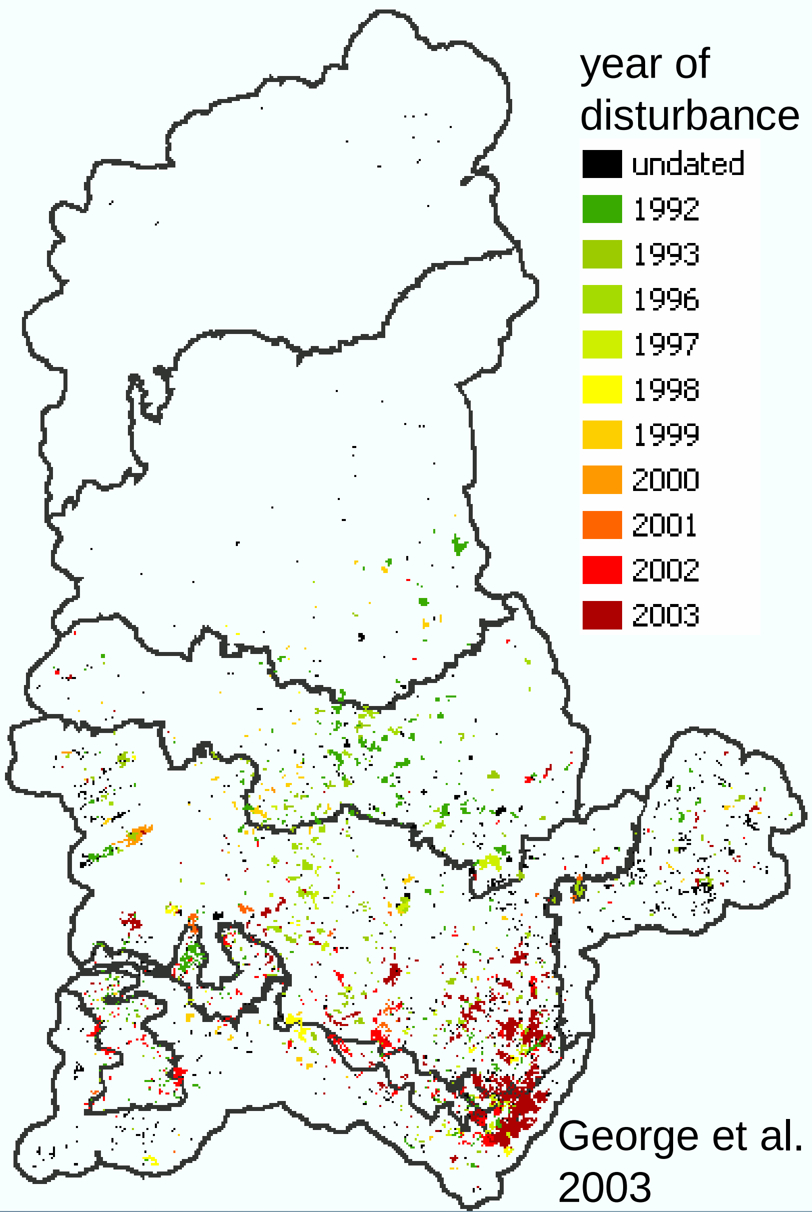


Bartsch et al., submitted

Decision Rules



SIBERIA-II disturbance map (SPOT-VGT, MODIS, AVHRR, ATSR, 1000m, 1992-2003)



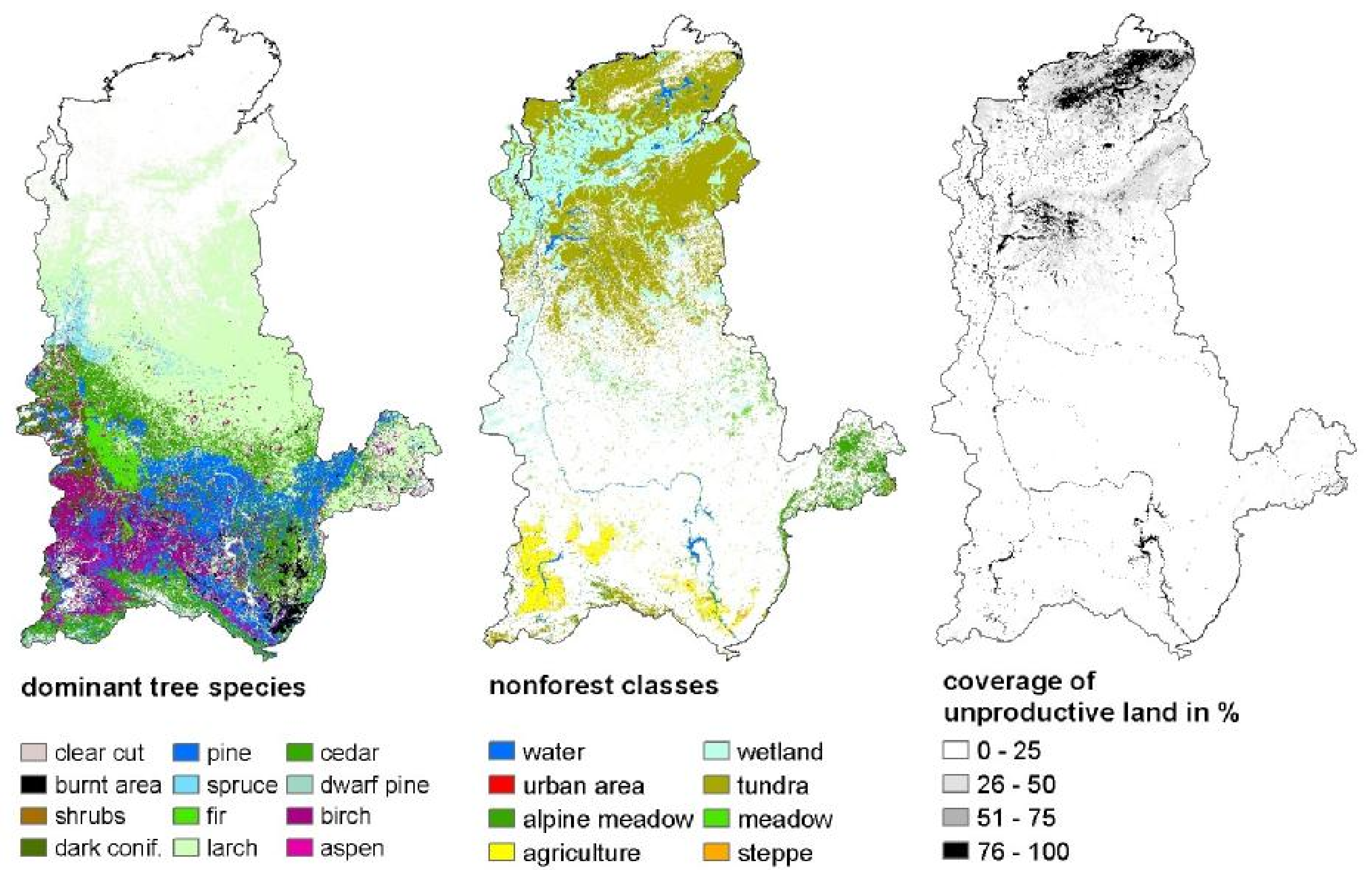
George et al. 2003

Decision Rules

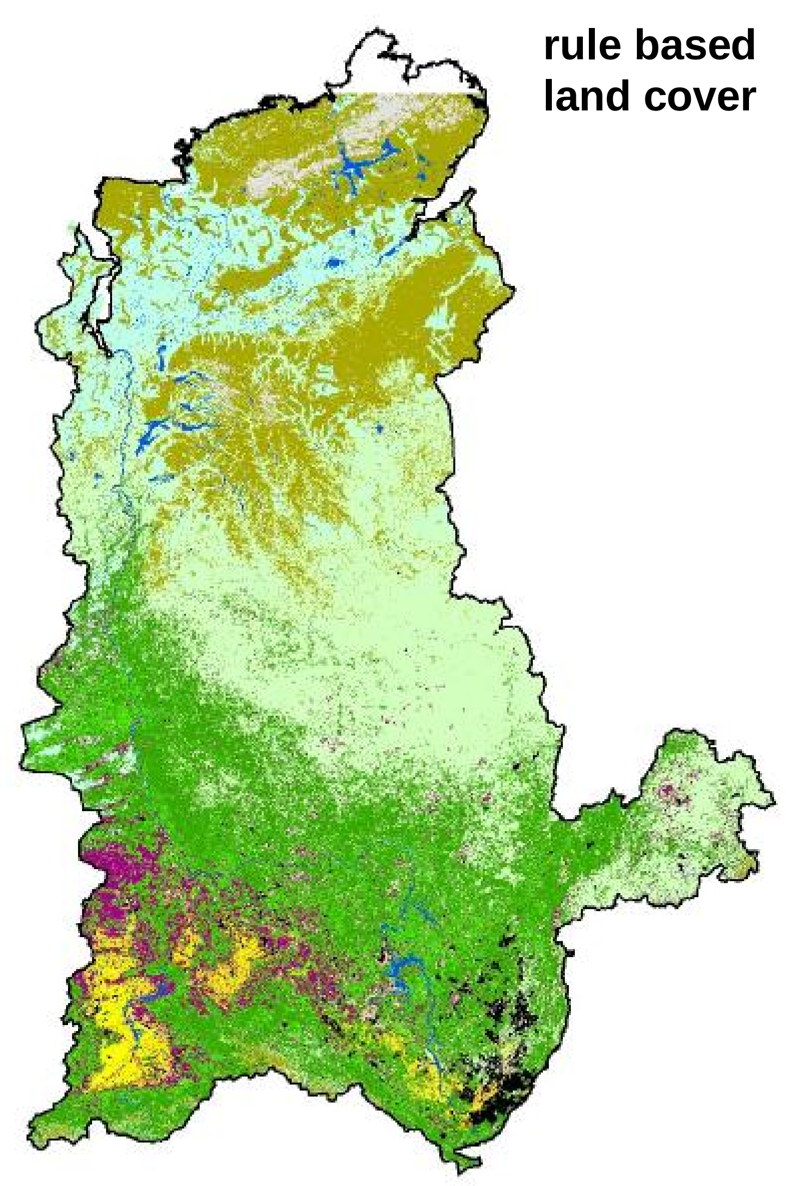
ecoregions
↓
land cover
↓
VCF
↓
topography
↓
soil
↓
ASAR wetlands
↓
disturbances
↓
ASAR water bodies and topographic map

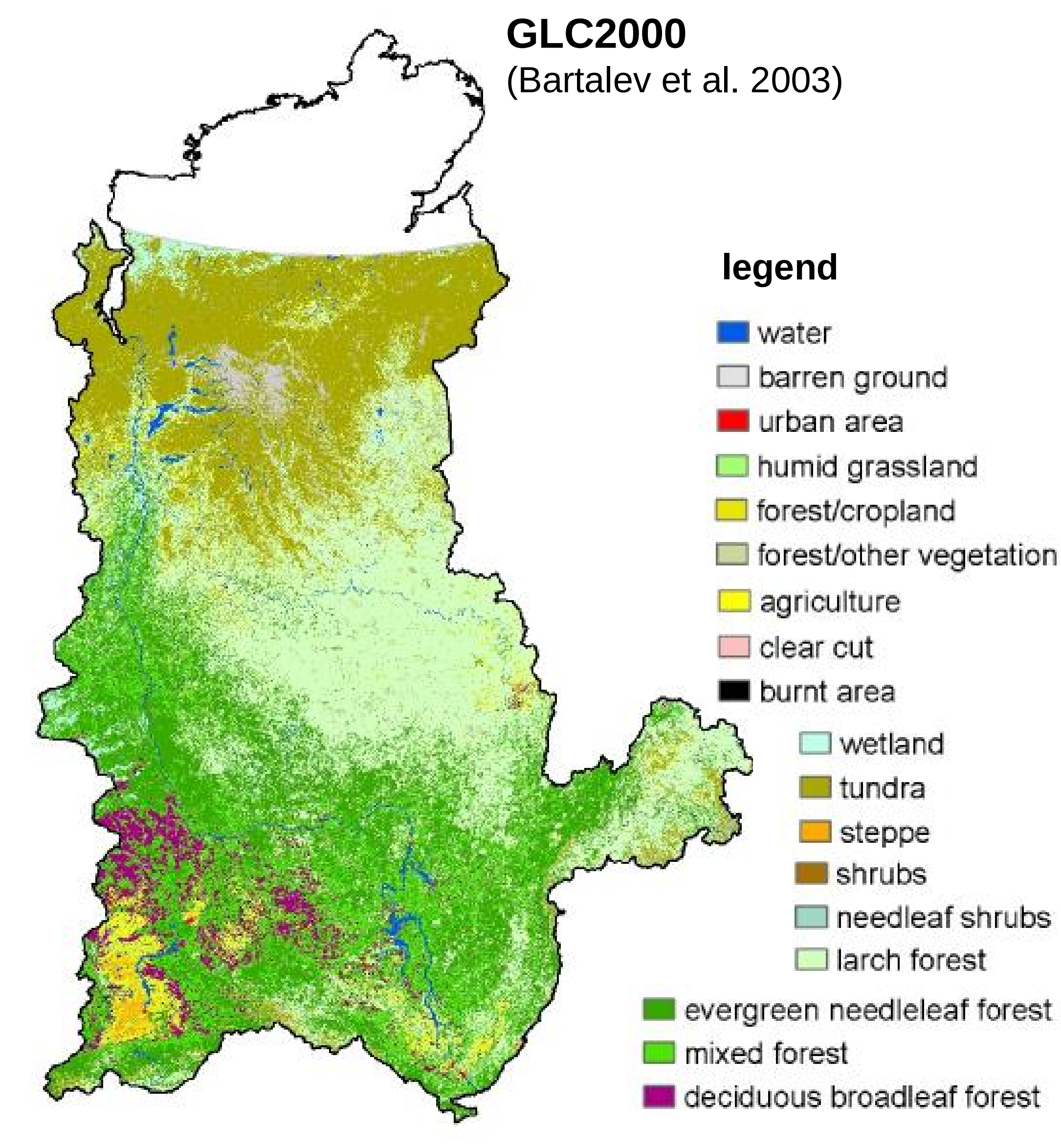
Data fusion and implementation of desicion rules in AML

Result of land cover classification

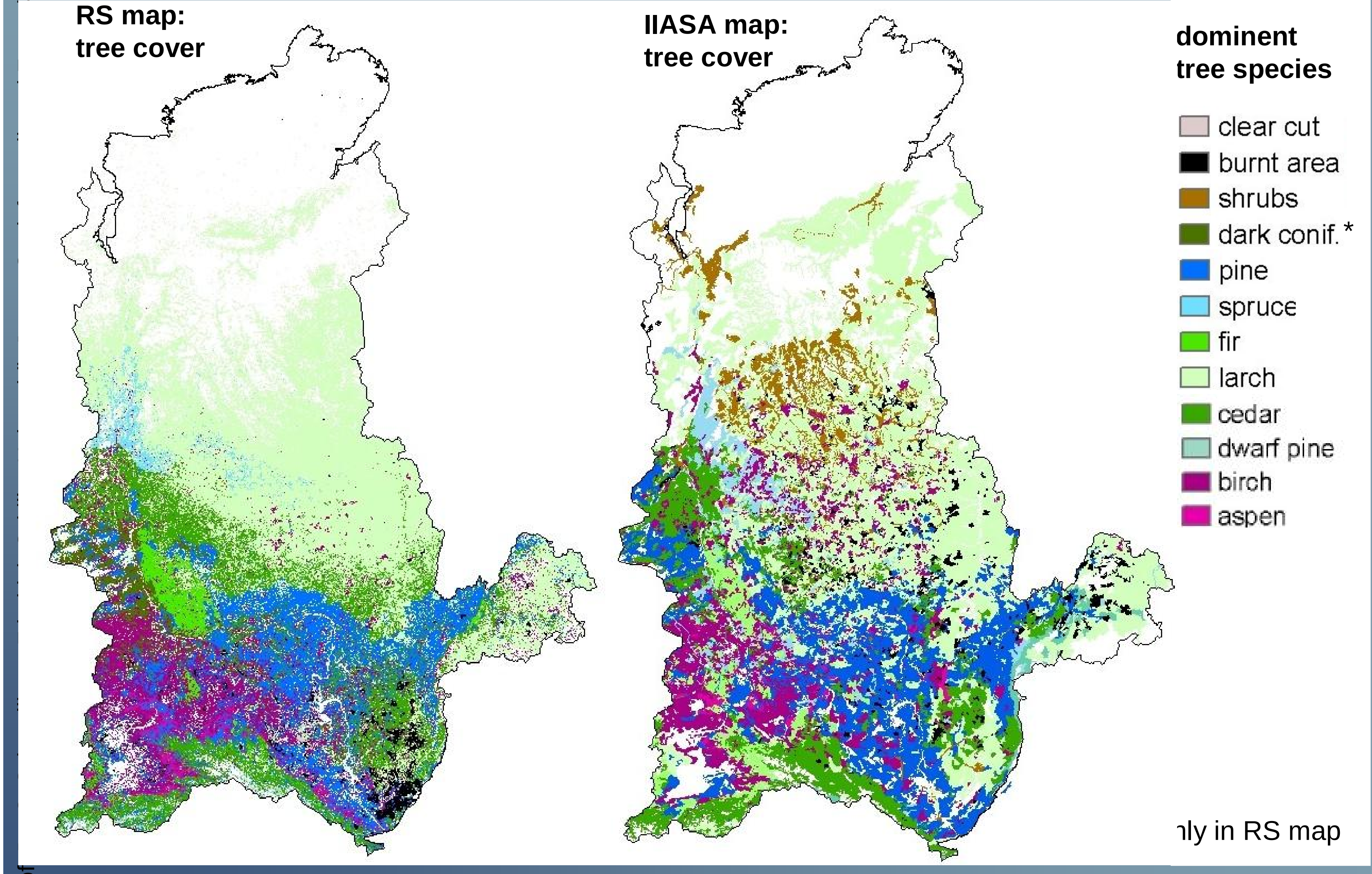


Result of land cover classification



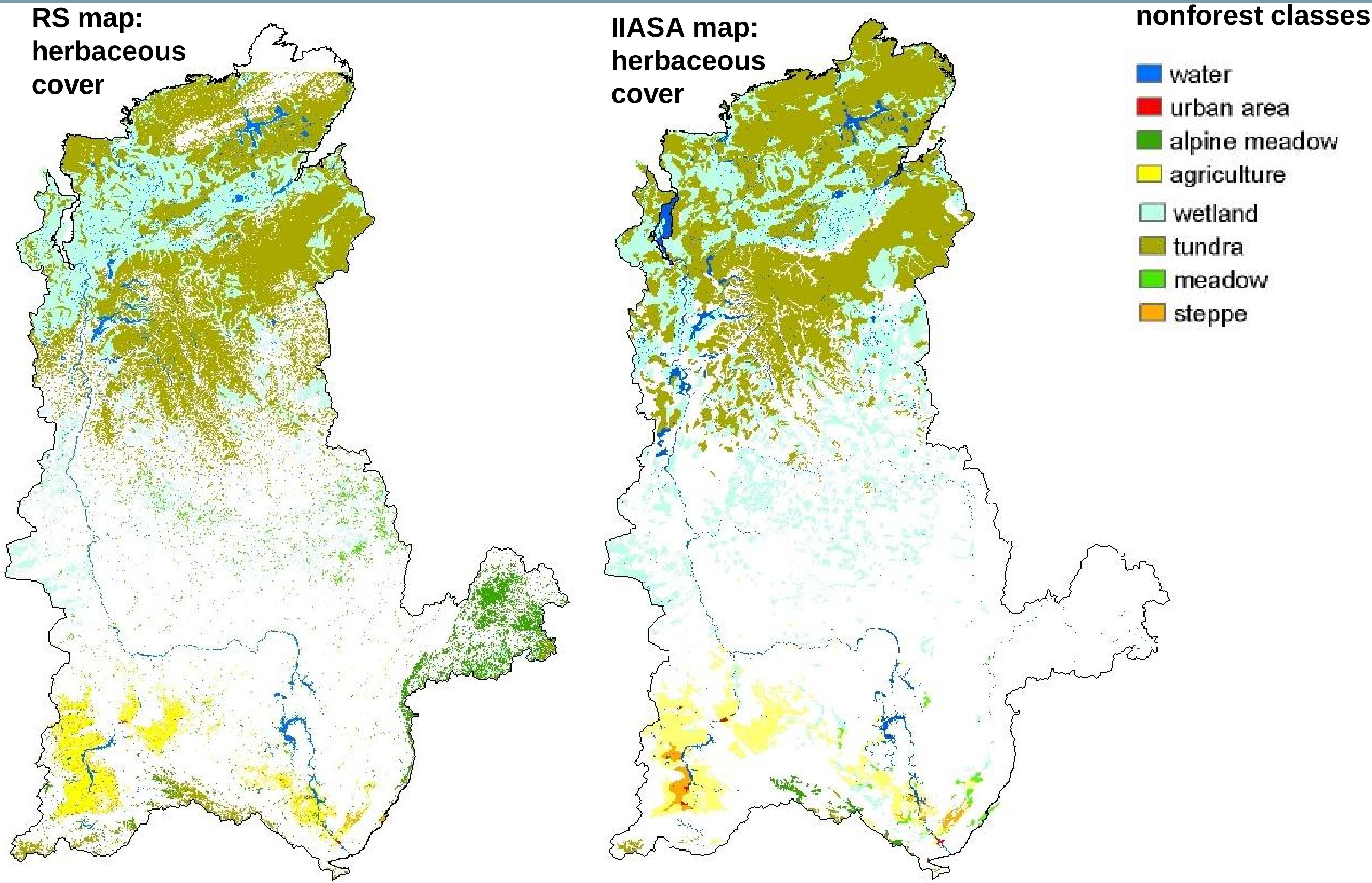


Result of land cover classification



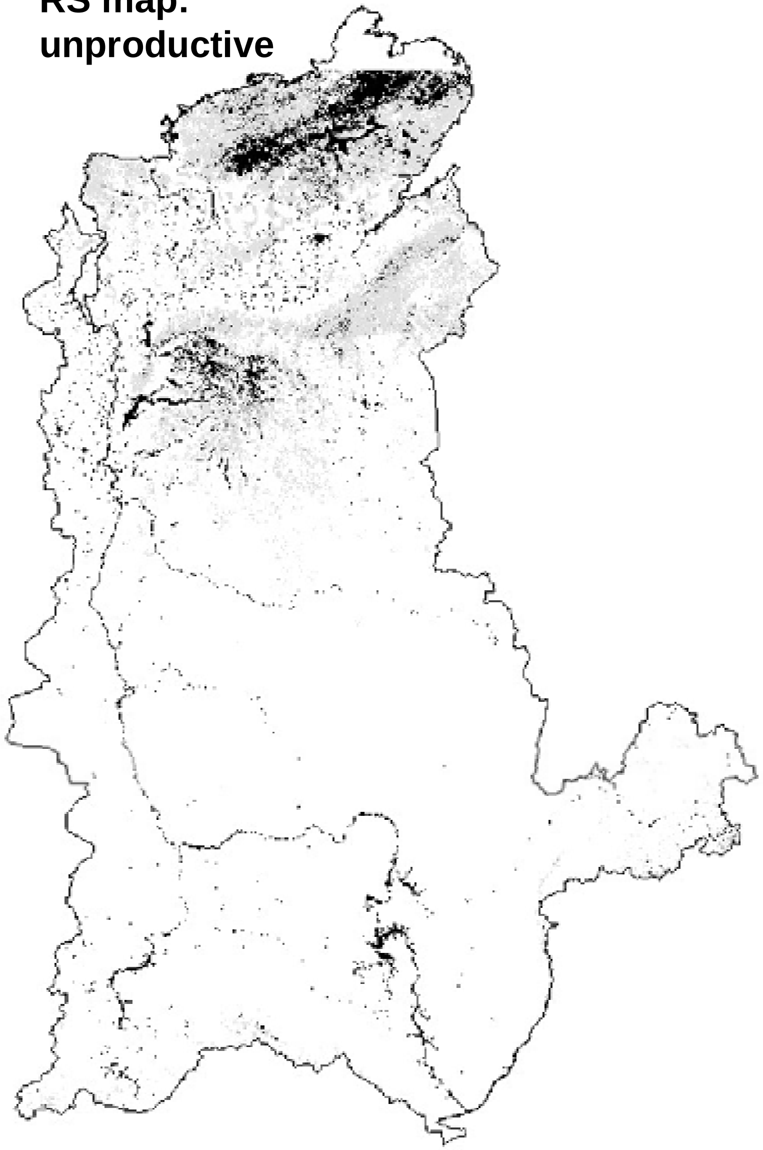
Prof

Result of land cover classification

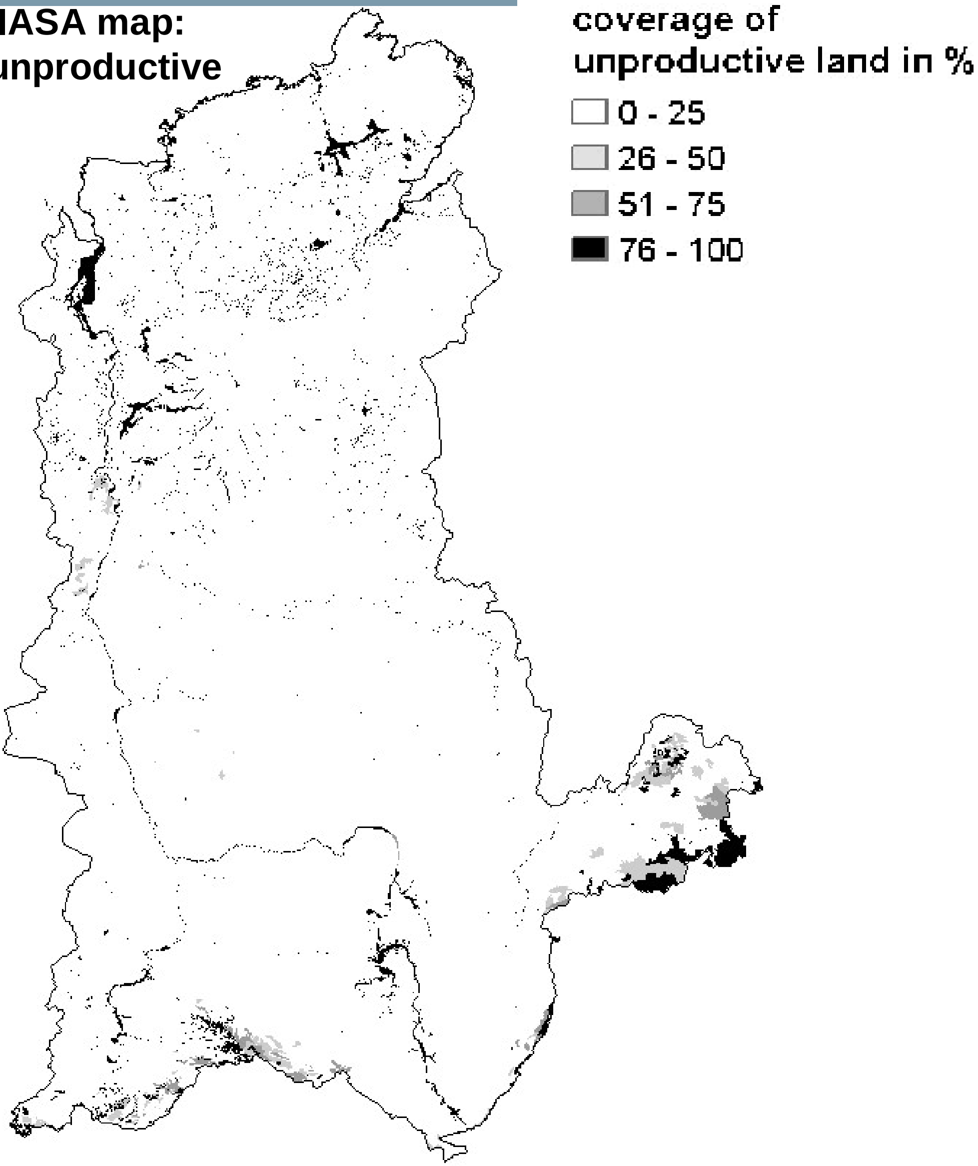


Result of land cover classification

RS map: unproductive



IIASA map: unproductive

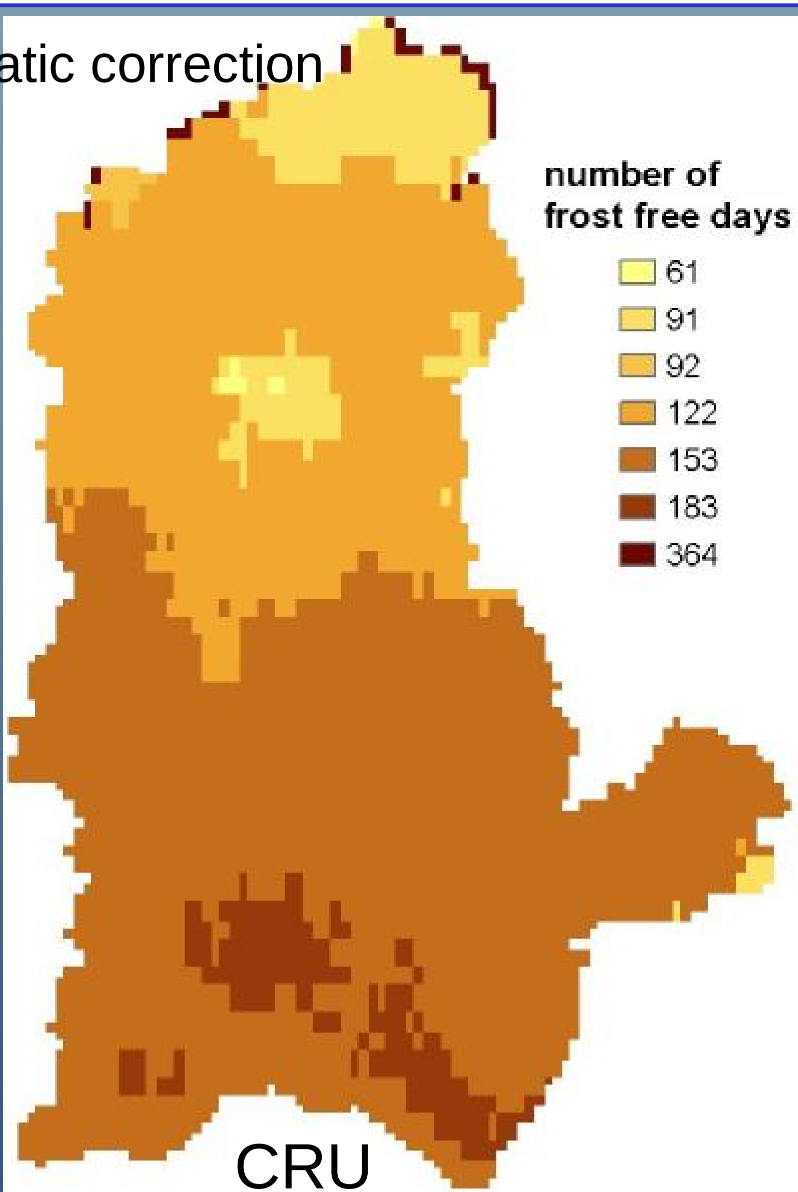


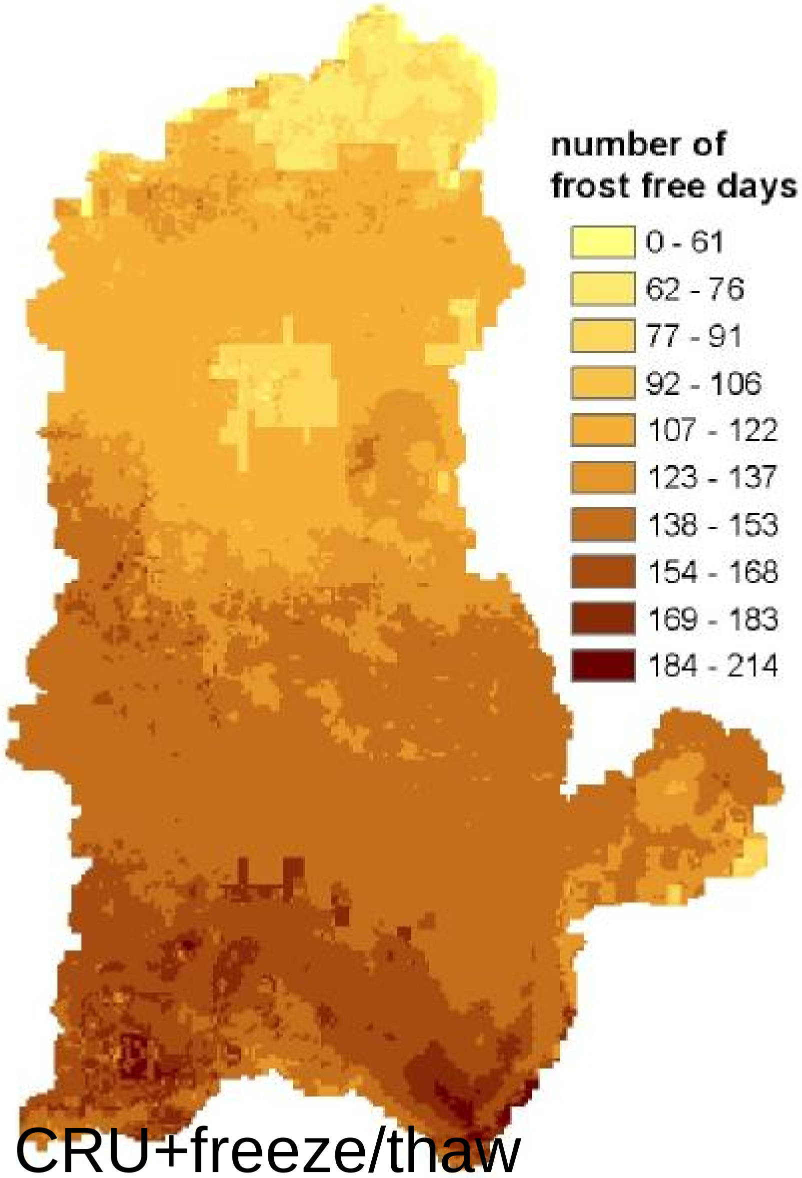
Other input parameters for IIASA model

parameters	derived from
Soil data: - carbon stored in first 1m - carbon stored in litter	IIASA data base, soil data base
Forest inventory parameters: - site index - growing stock, - relative stocking - age	IIASA data base VCF **à** height and DBH mean values for ecoregions
Climate data: - number of days with temperature > 0°C - sum of temperature > 0, 5 and 10°C - sum of precipitation of days with temp. > 0, 5, 10°C	CRU data + freeze/thaw

Other input parameters

Climatic correction





Other input parameters

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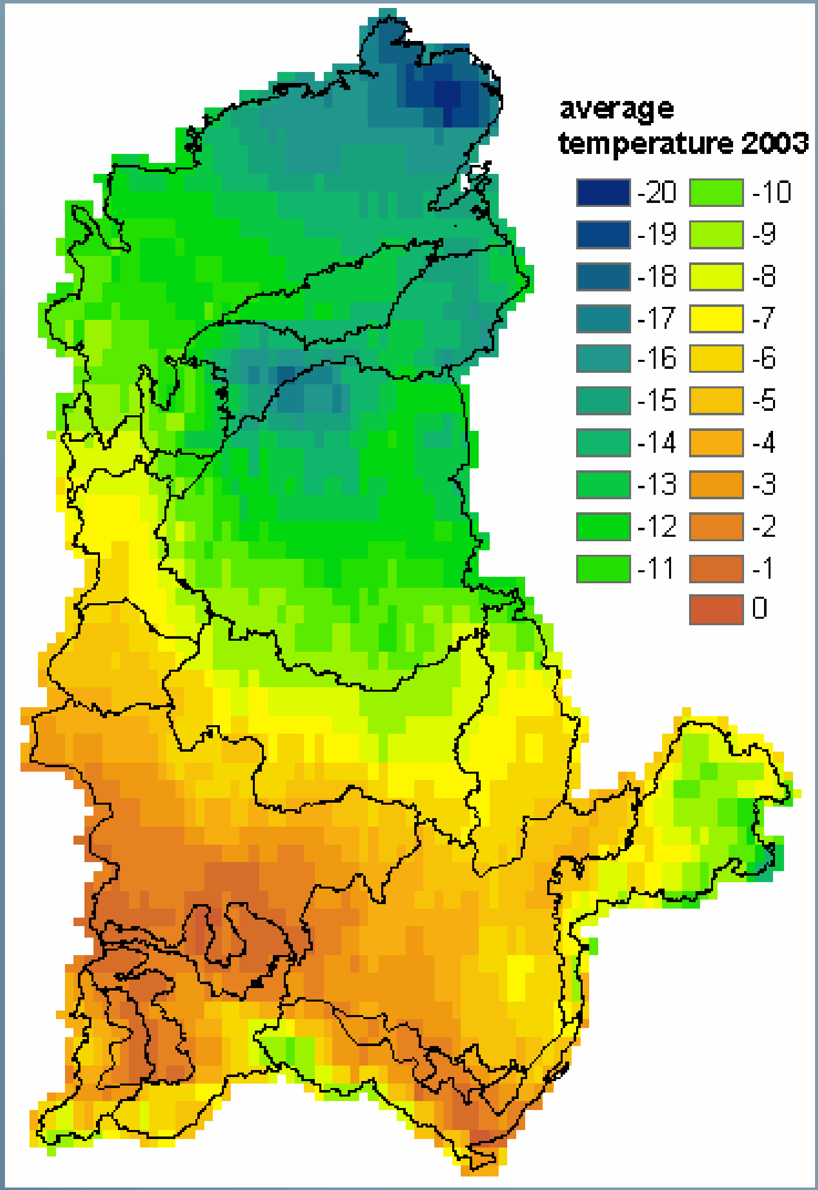
Climatic correction

IIASA uses averages over each ecoregion

We use averages over GGCs



Greenhouse Gas Compartments

GGC = a region consisting of pixel with the same
- vegetation
- soil type and
- bioclimatic zone

Based on these regions all other parameters are regionalised
à A mean value over this region is used

Other input parameters

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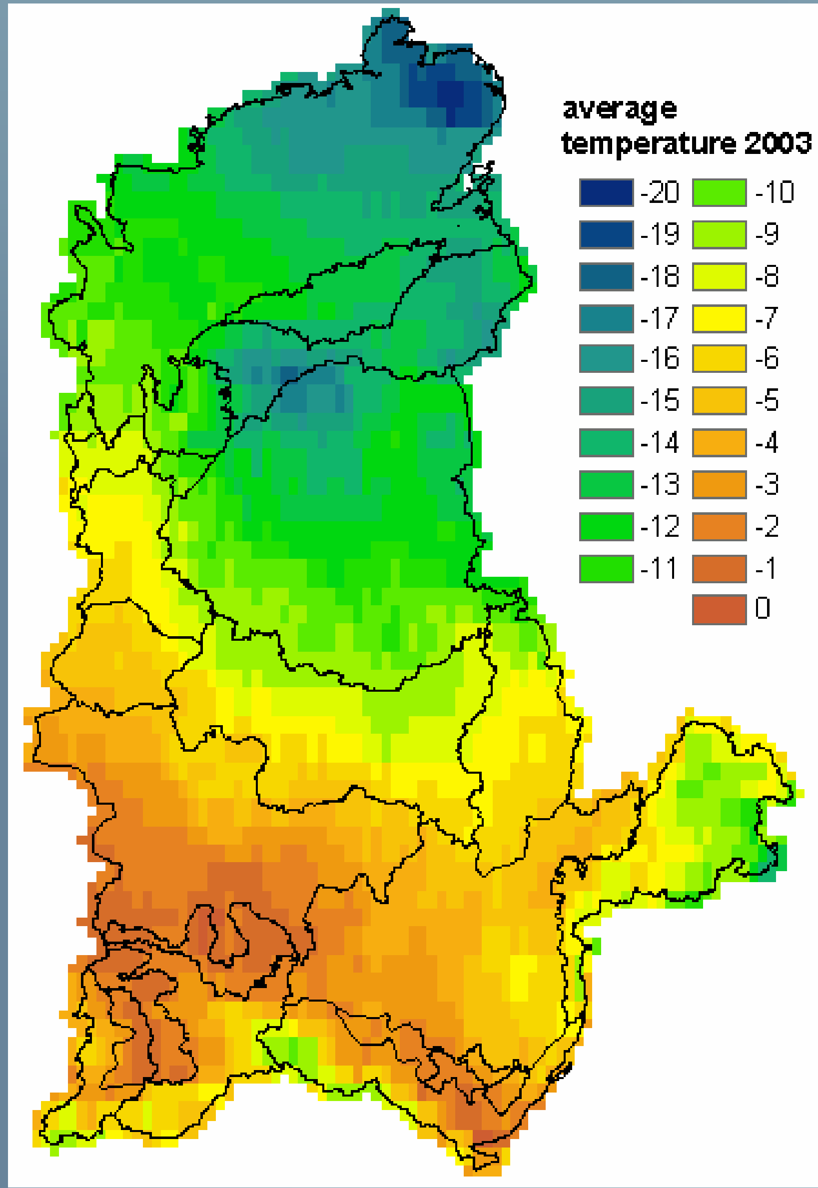
Climatic correction

IIASA uses averages over each ecoregion

I use averages over GGCs



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Introduction to SIB-ESS-C

Where do we go from here?

- need to preserve the achievements of SIBERIA-II

- need for public access to data products

- need for more structure and documentation

- need to continue dataset generation to build up time series

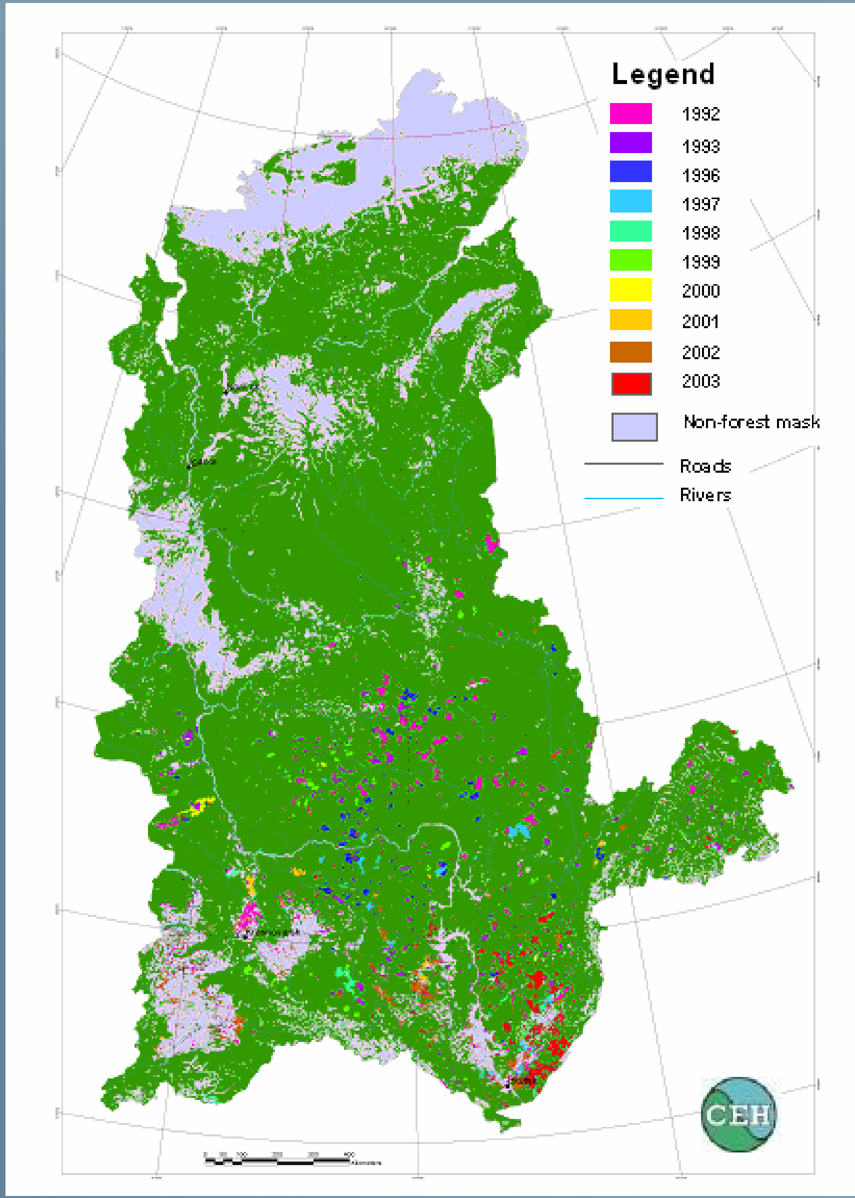
Need for an: Earth Science Information Infrastructure*
= Siberian Earth System Science Cluster

* J. Frew, UCSB

Disturbances

Product Summary

- **Annual fire disturbances from 1992 to 2003**
- **“historic” data derived from MODIS & SPOT_VGT using NDSWIR Index in combination with thermal anomaly data from AVHRR, ATSR-2 and MODIS**
- **“current” fires (2002-03) derived from MODIS 16-day hotspot and NDVI differencing synergy**



Reference

Balzter, H. et al. (2004): Forest fires in Central Siberia and their impact on emissions of greenhouse gases. Proceedings of RSPSoc, Aberdeen, 6-10 September, CD-ROM

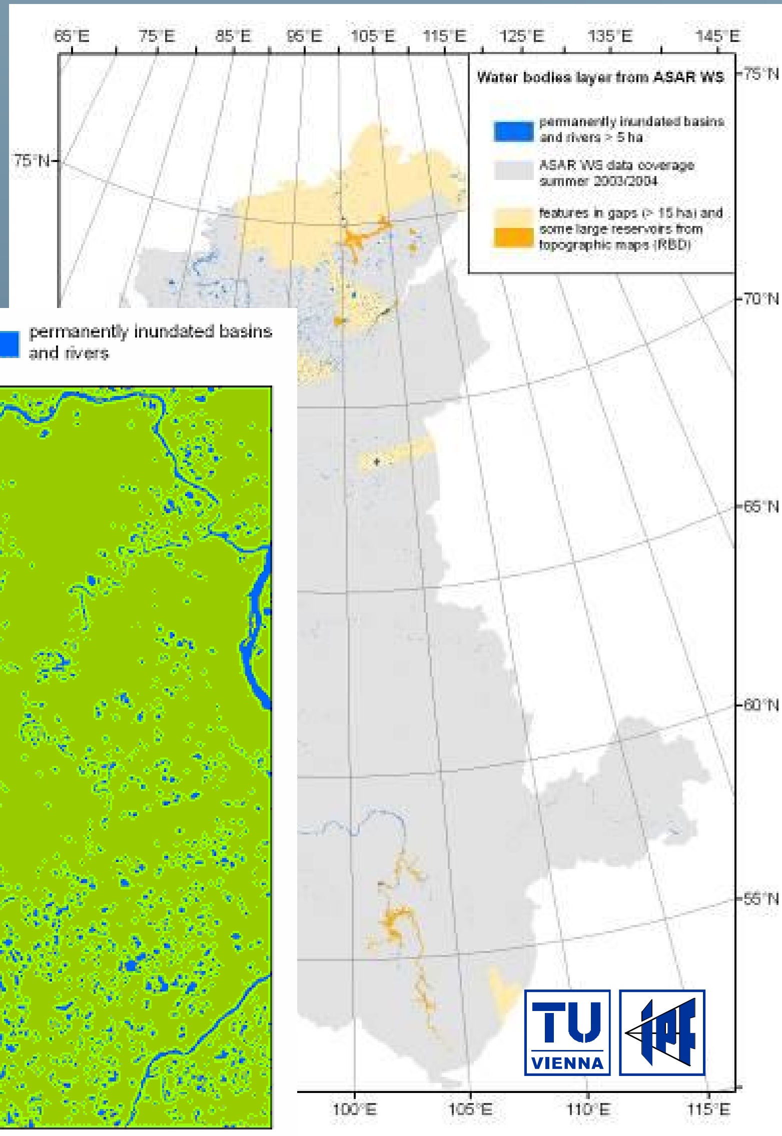
Waterbodies

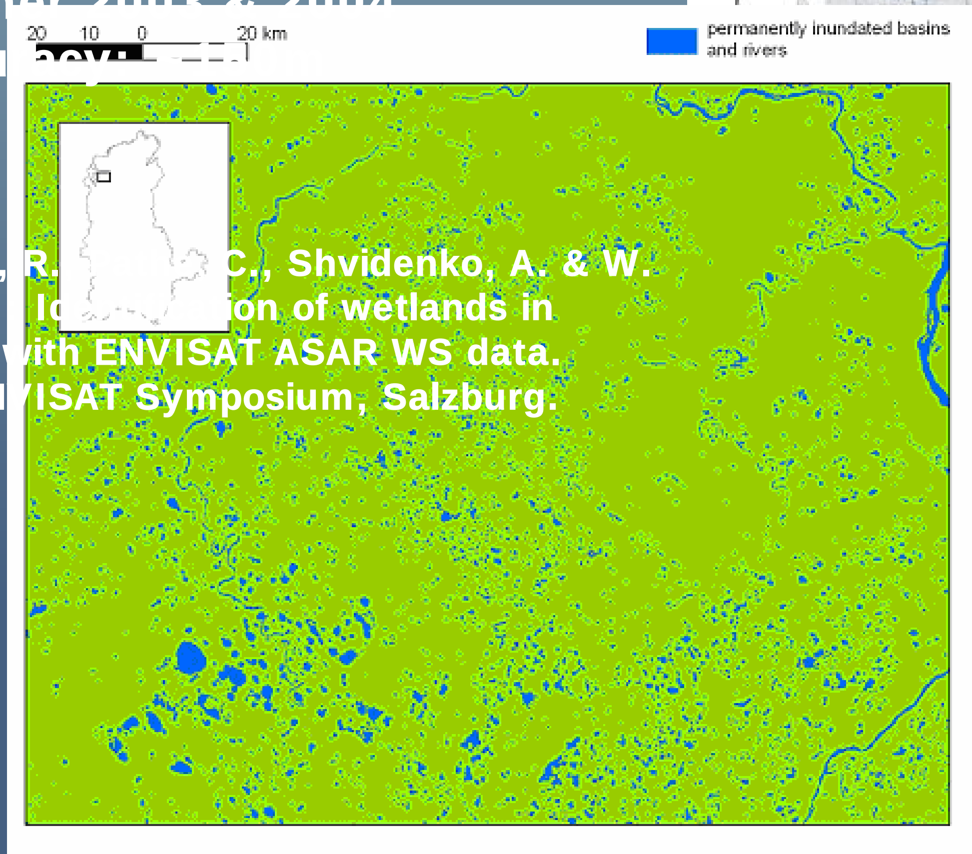
Product Summary

- Permanent open water bodies > 5 ha (15 ha) derived from ENVISAT ASAR WS data (C-Band)
- Spatial resolution: 150m
- Date: summer 2003 & 2004
- Spatial accu

Reference

Bartsch, A., Kidd, R. ... C., Shvidenko, A. & W. Wagner (2004) Identification of wetlands in central Siberia with ENVISAT ASAR WS data. Proceedings ENVISAT Symposium, Salzburg.

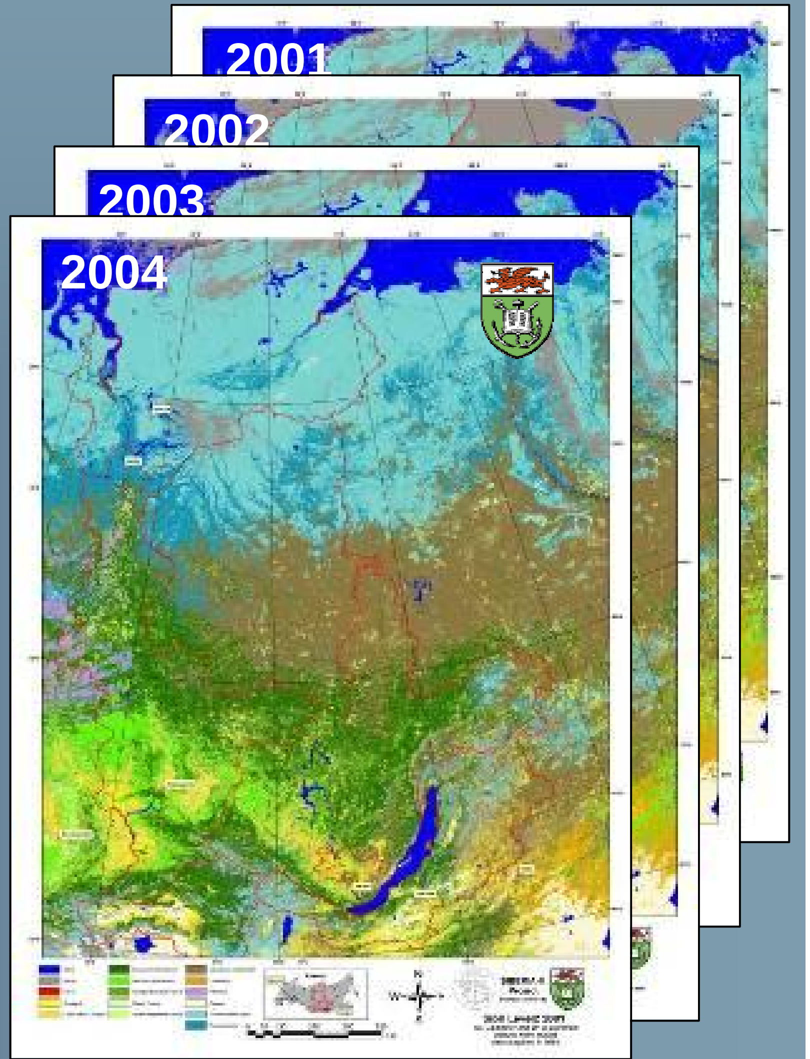




Land Cover

Product Summary

- annual land cover maps for 2001-2004 derived from MODIS 8-day surface reflectance (MOD04A)
- Spatial resolution: 500 m
- 16 classes adopted from GLC2000
- Input data acquired for growing season (June-October)
- Supervised classification scheme using C5.0 decision tree classifier



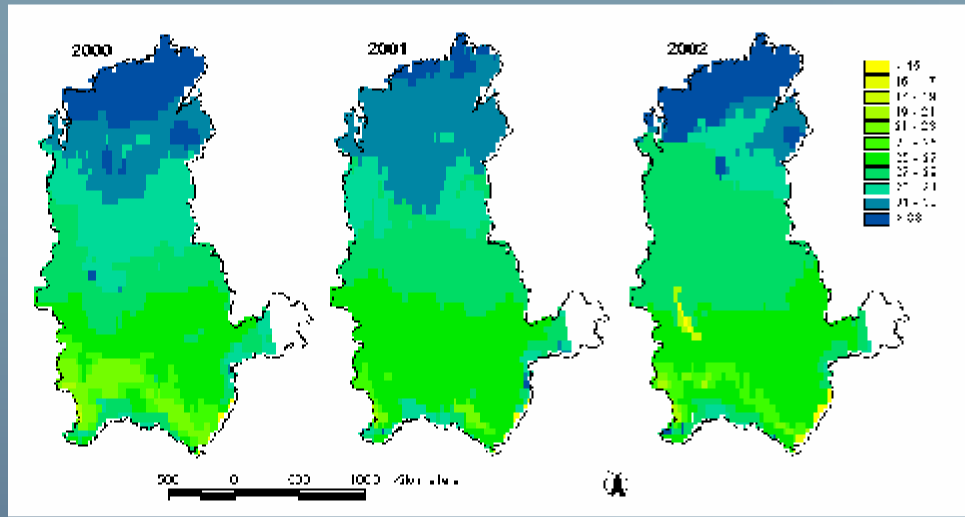
Reference

SKINNER, L., and LUCKMAN, A. (2004): Introducing a land cover map of Siberia derived from MERIS and MODIS data. Proceedings of IGARSS'04, Anchorage, 20-24 September, pp. 223-226.

Snowmelt dates

Product Summary

- Spring snow melt date for 2000-2002
- derived from SSM/I data
- spatial resolution: 25km x 25km
- temporal resolution: 5 day interval



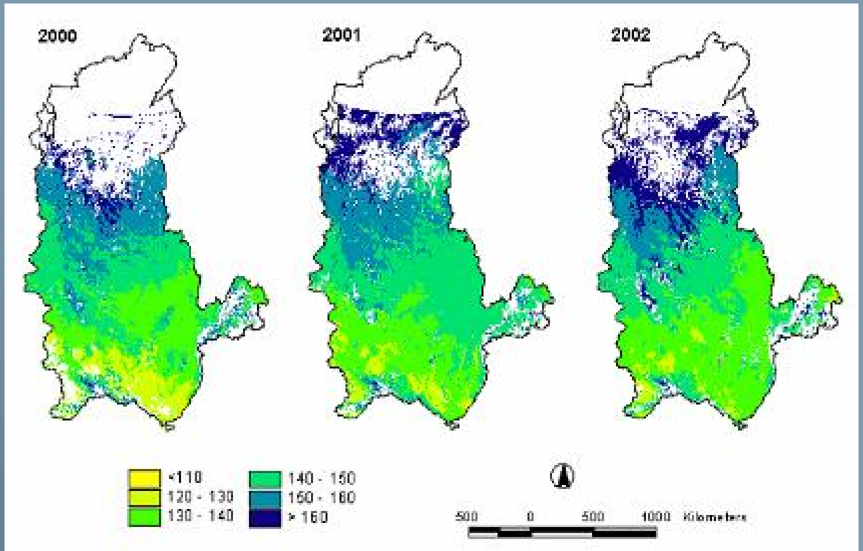
Reference

Grippa M., N. M. Mognard and T. Le Toan, 2005a, Comparison between the interannual variability of snow parameters derived from SSM/I and the Ob river discharge, Remote Sensing of Environment, 98, pp 35-44.

Phenology

Product Summary

- spring phenology dates for 2000-2003
- Derived from SPOT-VGT 10-day composite data using Normalised Difference Water Index (NDWI)
- Spatial resolution: 1km x 1km



Reference

Delbart N., L. Kergoat, T. Le Toan, J. L'Hermitte and G. Picard, 2005, Determination of phenological dates in boreal regions using normalized difference water index, Remote Sensing of Environment, 97, 1, pp. 26-38.

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.

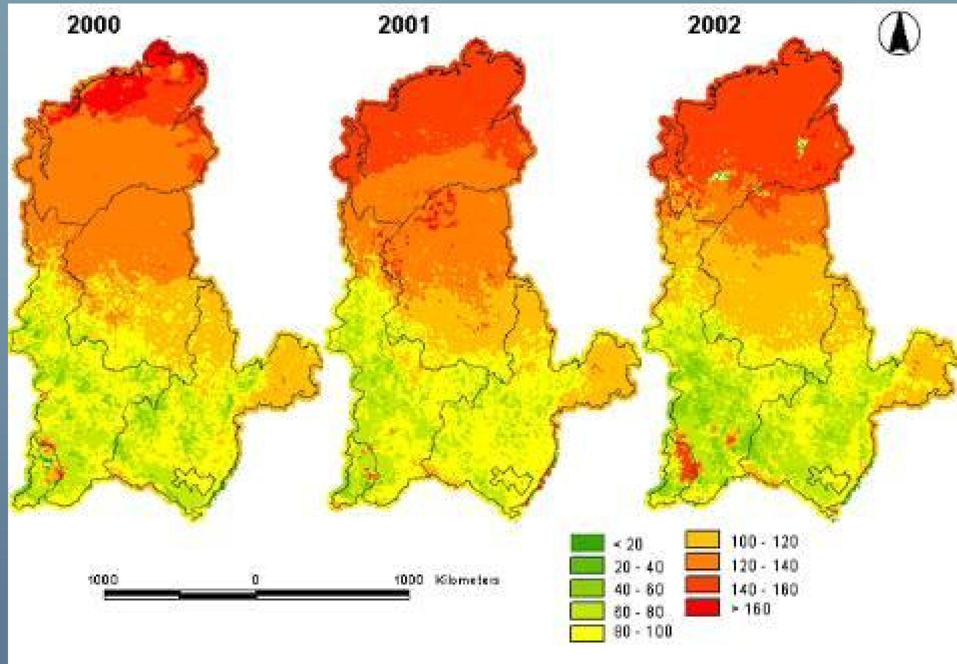
Freeze/ Thaw

Product Summary

- Derived from QuikSCAT (1 Terabyte) Ku Band Scatterometer
- Spatial resolution: 25km (product 10km)
- Temporal resolution: daily

Products for 2000-2003 inc.

- Onset of Thaw/refreeze period
- Duration of Thaw/refreeze period



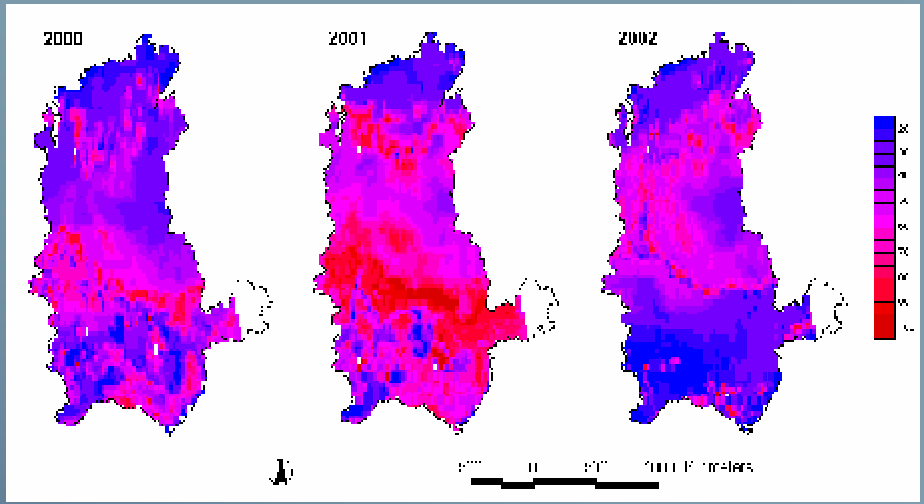
Reference

KIDD, R., BARTSCH, A., and WAGNER, W. (2004): Development and validation of a diurnal difference indicator for freeze-thaw monitoring in the Siberia II Project, Proceedings of 2004 ERS & Envisat Symposium, Salzburg, 6-10 September, SP-572, CD-ROM.

Snowdepth

Product Summary

- monthly snow depth for 2000-2002
- derived from SSM/I data using a new combined dynamic and static algorithm
- spatial resolution: 25km x 25km



Reference

Grippa, M., N.M. Mognard, T. Le Toan and E.G. Josberger 2004a “Siberia snow depth climatology derived from SSM/I data using a combined dynamic and static algorithm, Rem. Sens. Envir. 93:30-41.

Grippa M., N. M. Mognard and T. Le Toan, 2005a, Comparison between the interannual variability of snow parameters derived from SSM/I and the Ob river discharge, Remote Sensing of Environment, 98, pp 35-44.

Dynamic Vegetation Models

DGVMs (Dynamic Vegetation Models)

- **Lund-Potsdam-Jena Digital Global Vegetation Model (LPJ-DGVM).** ***Potsdam Institute for Climate Impact Research (PIK) – Prognostic Process Model***
- **Sheffield Digital Global Vegetation Model (SDGVM).** ***Sheffield Centre for Earth Observation Science (SCEOS) – Prognostic Process Model***
- **Terrestrial Biota Greenhouse Gas Accounting (TBGHGA).** ***International Institute for Applied Systems Analysis (IIASA) – Static Regression Model***

State-of-the-art

What is currently available?

Universal connectivity
- **Internet**
- **Web**

Comprehensive analysis environments
- **GIS (ArcGIS, ...)**
- **Matrix manipulation (IDL, MATLAB, ...)**

Standards
- **Metadata (FGDC, ISO 19115, ...)**
- **Data (HDF, GeoTIFF, SHP, ...)**
- **Services (OGC, ...)**

SIB-ESS-C Overall Objectives

- **Develop a spatial data infrastructure to facilitate earth system science studies in central Siberia**
- **Set up a web interface to provide access to data products created during the SIBERIA-II project**
- **Continue remote sensing data acquisition and product generation to build up time series**
- **Provide online geo-visualization tools for integrated data analysis**
- **Integration of biosphere modelling algorithms into SIB-ESS-C (external access via web-interface to trigger model runs)**
- **initiate additional projects to complement SIB-ESS-C**

Implementation strategy

Stage 1: *"getting the SIBERIA-II products online"*

- establish a catalogue service providing information about SIB-ESS-C data holdings and services
- establish a coverage service for direct data access and download

Stage 2: *"equip SIB-ESS-C with processing power for continuous product generation"*

- Setting up a PC cluster for operational data processing
- implement tools for data archiving, storage management and automatic metadata creation

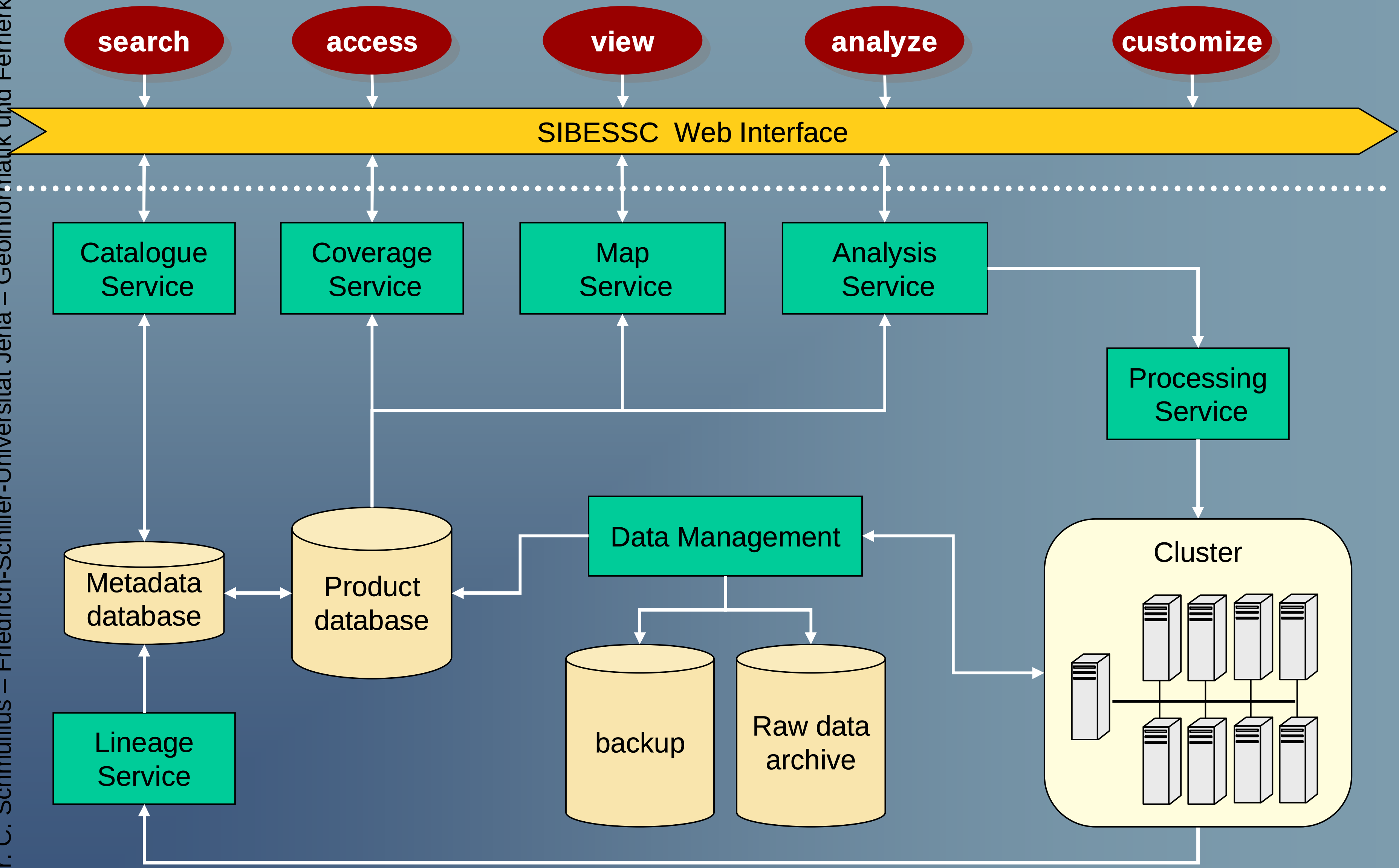
Stage 3: *"from data providing to scientific data analysis"*

- implement interactive visualization tools for spatio-temporal analysis

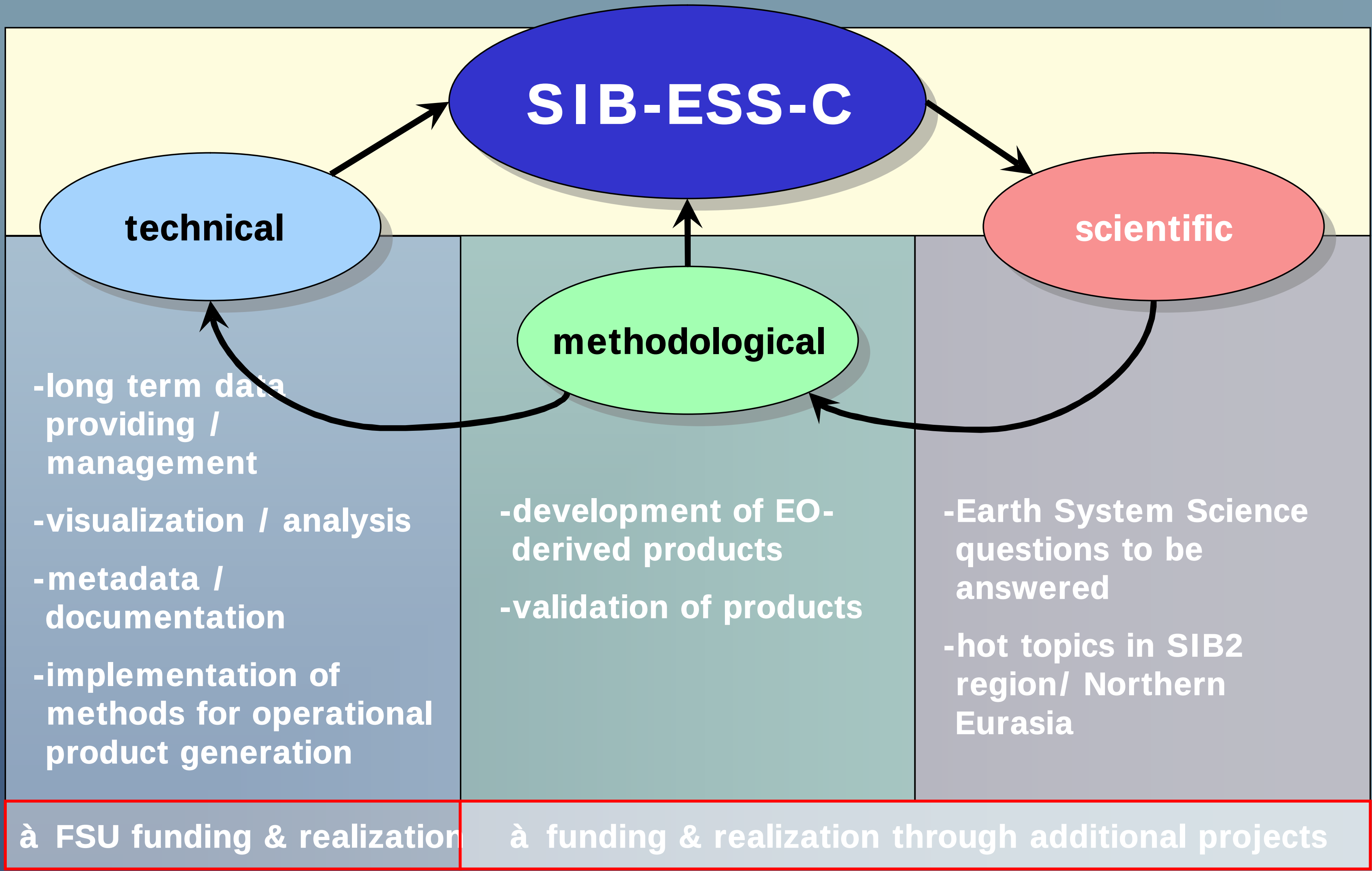
Stage 4: "*integrating SIB-ESS-C into a global network of distributed Earth Science Clusters*"

- offer data/services to external systems
- implement external data/services into SIB-ESS-C

SIB-ESS-C Architecture



SIB-ESS-C - Conceptual View



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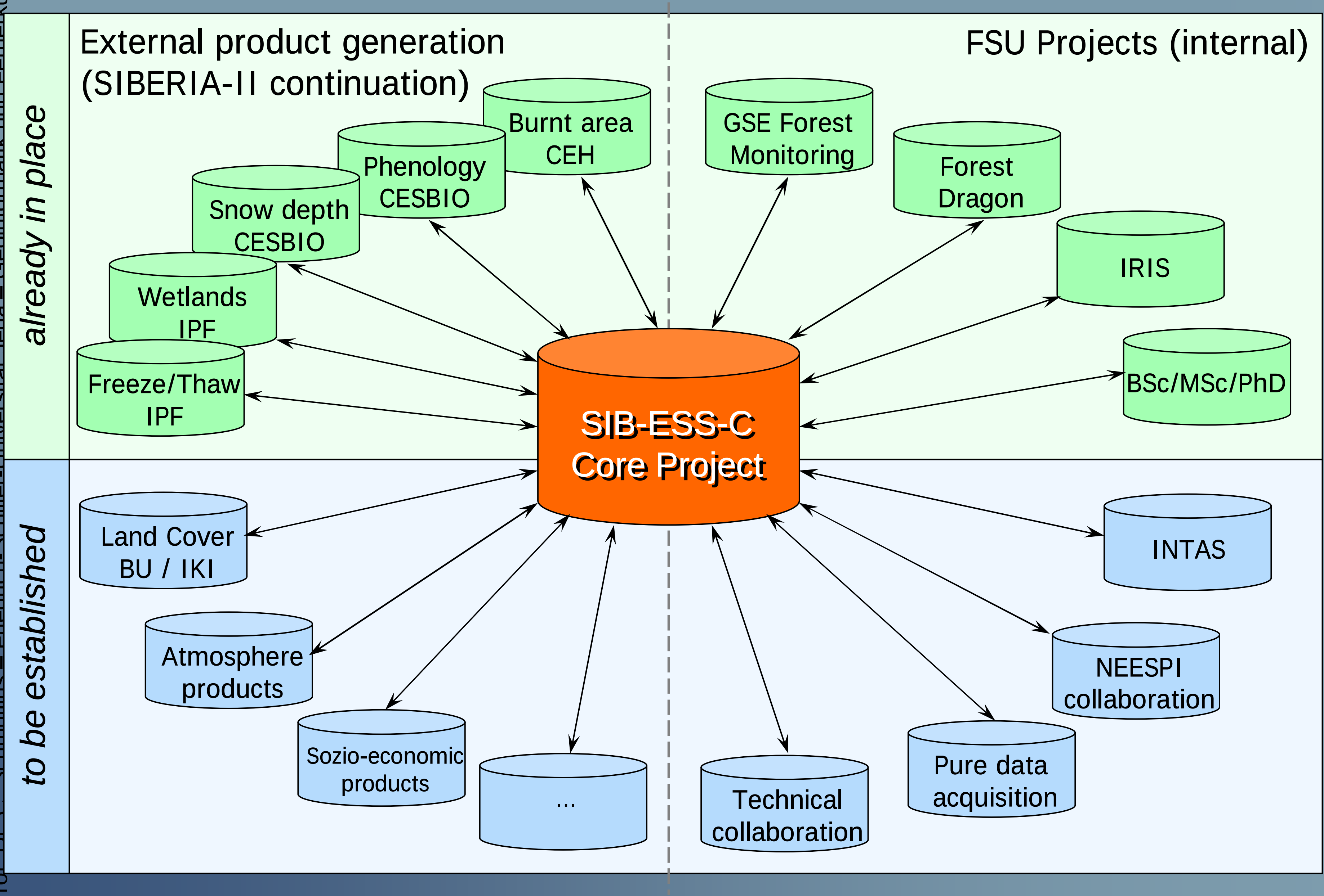
Supporting projects

- SIB-ESS-C core project is to develop a Earth Science Information Infrastructure
- Supporting projects are to be established in 3 areas:
  - thematic (science / application driven)
  - methodological (EO-product developm
  - technical (software, system architectu
- supporting projects can be:
  - internal (within FSU Jena or FSU coor
  - external (through collaboration)

Supporting Elements



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Fully polarimetric L-band meets high resolution fully polarimetric X-band

ALOS Advanced Land Observing Satellite

PALSAR
L-band

Commercial acquisition starts
November 2006

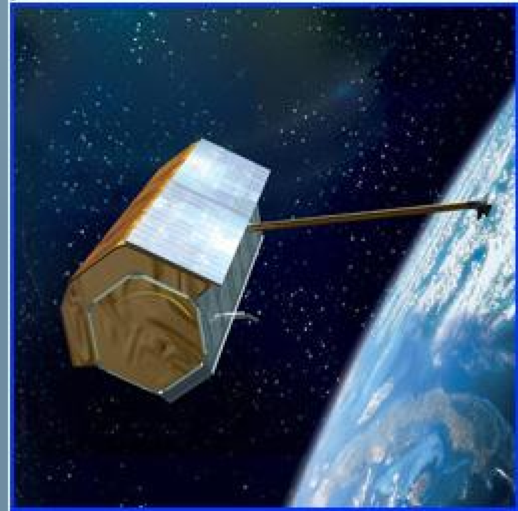
Fine Resolution Mode
8.0-60.0 deg.
HH or VV / HH+HV or VV+VH
7.0-44.3m / 14.0-88.6m
40-70km / 40-70km

ScanSAR Mode
18.0-43.0 deg.
HH or VV / 100m / 250-350km

Polarimetric Mode
8.0-30.0 deg.
HH + HV + VH + VV
24.1-88.6m / 20-60km

+

TerraSAR-X



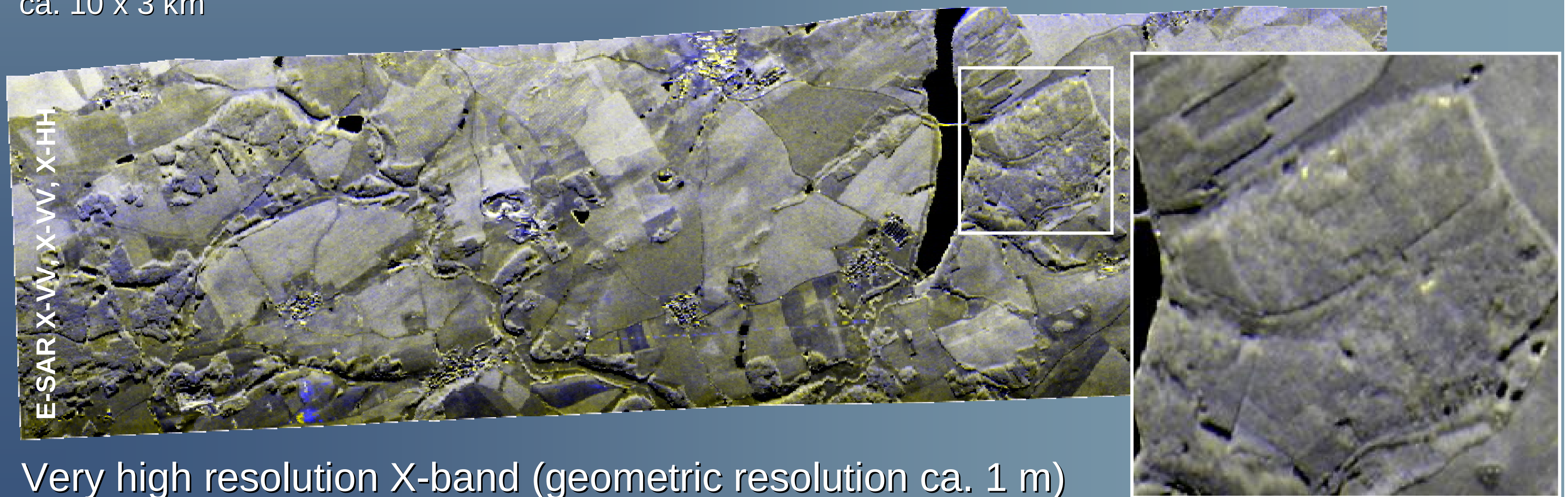
Launch **31. October 2006**

Standard Imaging Mode

	Spotlight	StripMap	ScanSAR
Geometric Resolution	1 m	3 m	16 m
Image Swath Width	10 km	30 km	100 km
Maximum Length per Image	5 km	3000 km	3000 km

Sensor Synergy: Very high dynamic range (L-band) plus very detailed texture (X-band)

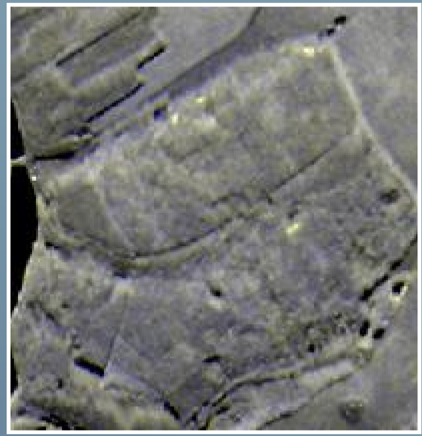
Fully polarimetric L-band (geometric resolution ca. 25 m)
ca. 10 x 3 km



Very high resolution X-band (geometric resolution ca. 1 m)

Sensor Synergy: Very high dynamic range (L-band) plus very detailed texture (X-band) -> image transformation

+



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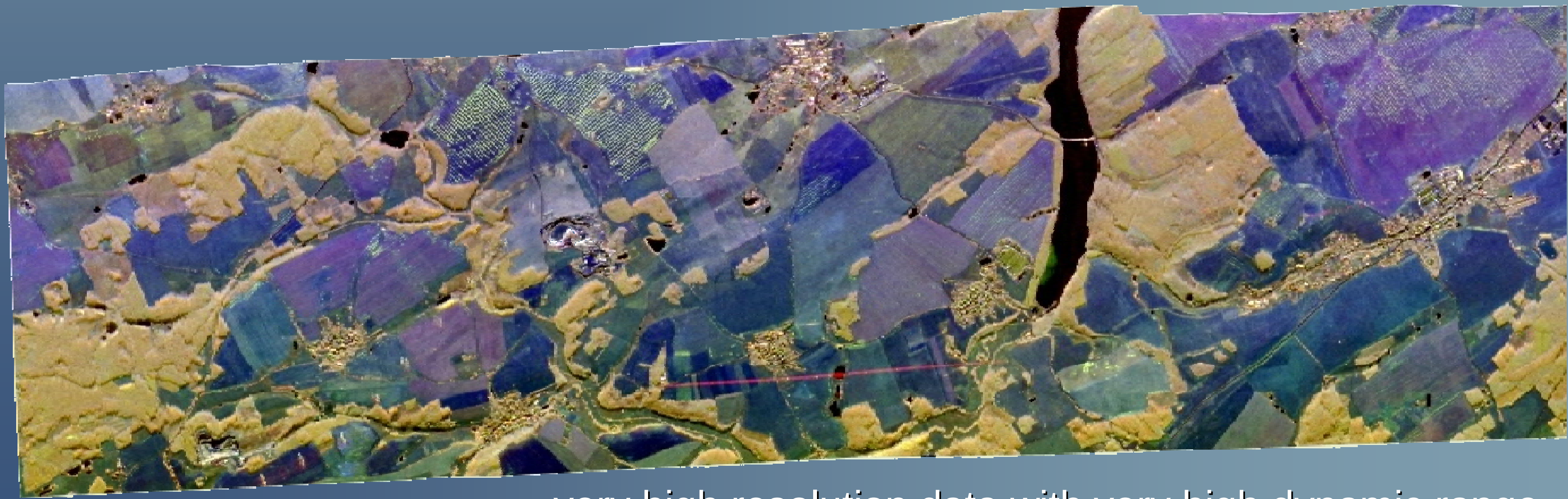
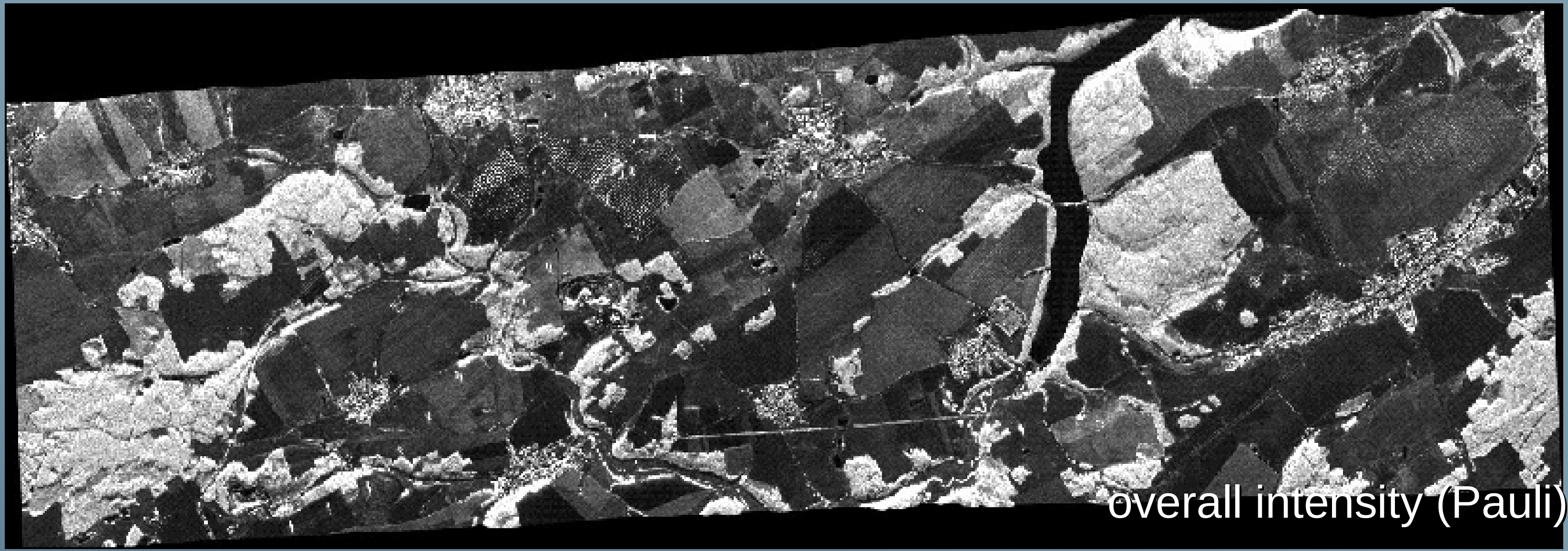


ca. 10 x 3 km

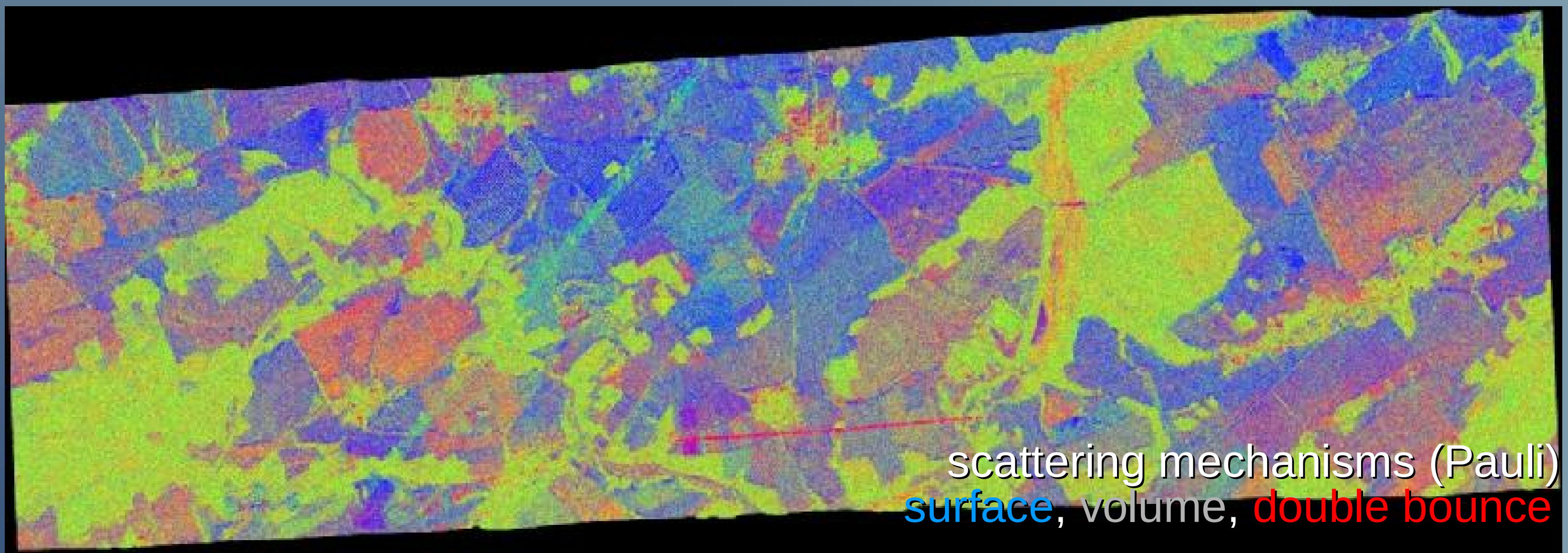
very high resolution data with very high dynamic range

Additional polarimetric information (L-band and X-band)



E-SAR L-band

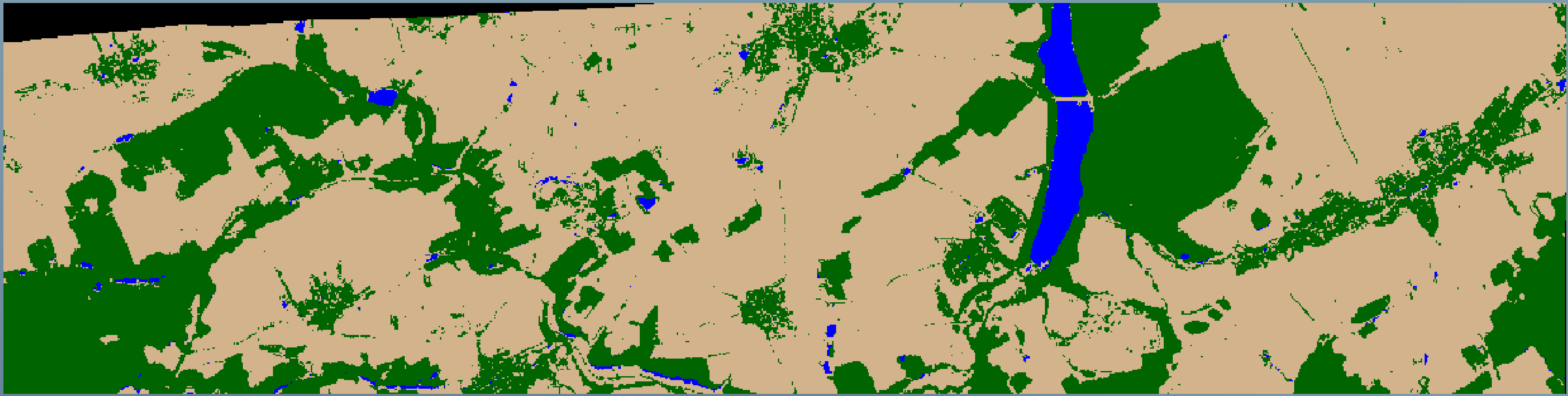
ca. 10 x 3 km



E-SAR L-band

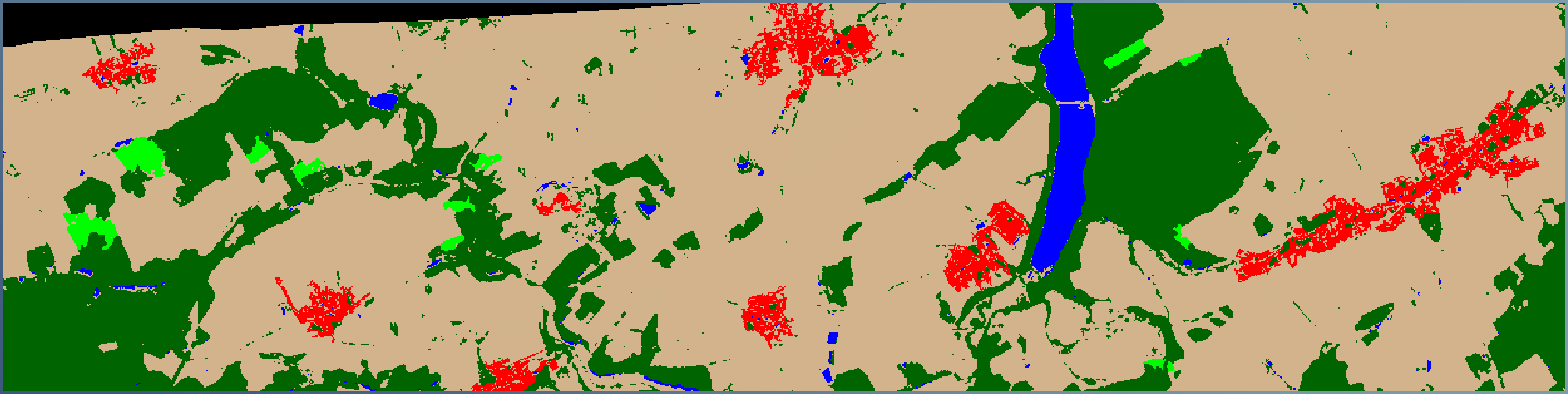
ca. 10 x 3 km

Application area image classification / forest detection



ca. 10 x 2,5 km

Unsupervised classification using L- and X-band intensities
water/shadow, forest/settlements, other



ca. 10 x 2,5 km

Supervised classification using intensities & polarimetric information
water/shadow, forest (high density), forest (low density), settlements, other

Thank you