



**Russian Academy of Sciences
Space Research Institute**

Overview on Land Cover and Land Use Monitoring in Russia

Sergey Bartalev

Joint NASA LCLUC Science Team Meeting and GOFC-GOLD/NERIN, NEESPI Workshop

Monitoring land cover and land use in boreal and temperate Europe

August 25-28, 2010, Tartu, Estonia

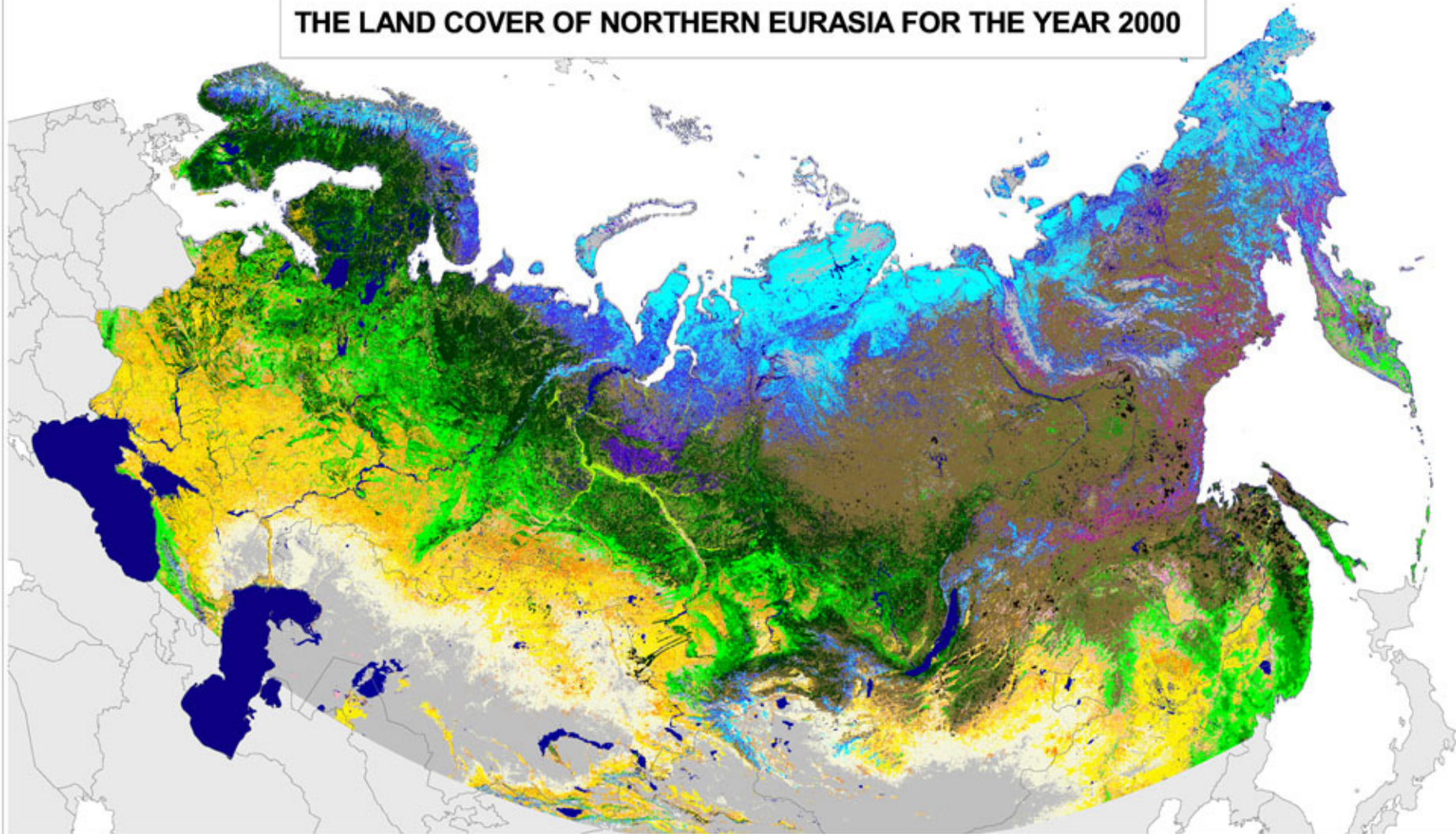
Russian Academy of Sciences' activity related to LCLU satellite monitoring

- land cover mapping using MODIS data and LAGMA method;**
- agricultural monitoring with focus on arable land and crops mapping;**
- burnt area mapping and severity assessment using MODIS and high-resolution optical data;**
- TerraNorte Information System**

Some features of R&D at IKI

- ❑ Focus is on national (entire Russia) and sub-continental (Northern Eurasia) monitoring
- ❑ Primary sources of EO data are moderate resolution satellite instruments (mainly MODIS and SPOT-VGT), while the role of high-res. (e.g. Landsat-TM, SPOT-HRV/HRVIR, RapidEye) data for national monitoring is rapidly increasing
- ❑ Focus on long-term time-series data analysis for land cover mapping and monitoring
- ❑ Development of automatic satellite data processing chains to perform monitoring in the routine and repeatable manner

THE LAND COVER OF NORTHERN EURASIA FOR THE YEAR 2000



LEGEND / РЕГИОНА	
FORESTS / ЛЕСА	WETLANDS / ВОДНО-БУКТОВАЯ КОМПЛЕКСНОСТЬ
European Hardwood Forest Northern Hardwood Forest	Wetland Hardwood Forest
European Broadleaf Forest Northern Broadleaf Forest	Wetland Broadleaf Forest
European Coniferous Forest Northern Coniferous Forest	Wetland Coniferous Forest
Deciduous Hardwood Forest Hardwood in Shrubland	
OTHER VEGETATION TYPES AND COMPLEXES / ДРУГИЕ РАСТИТЕЛЬНОСТНЫЕ ЦЕЛЫ И КОМПЛЕКСЫ	WATER-BODIES / ВОДНЫЕ ТЕЛА
Forest Steppe Forest-Steppe Complex	Open Water Bodies Coastal Water Bodies
Forest-Steppe Complex Forest-Steppe Complex	Coastal Water Bodies Coastal Water Bodies
NON-VEGETATED LAND COVER TYPES / НЕРАСТИТЕЛЬНОСТЬ	
Barren and Rock Perpetually Snow-Covered Perpetually Ice-Covered	
Barren and Rock Perpetually Snow-Covered Perpetually Ice-Covered	

MAP INFORMATION

Scale: 0 200 400 km

Projection: Albers Equal-Area Conic, Spheroid: WGS-84, Central Meridian: 97° E, Reference Latitude: 0° N, Standard Parallel: 1° 30' N, Standard Parallel 2: 30° N

This map of Northern Eurasia's land cover has been created at European Commission's Joint Research Centre in partnership with Russian Academy of Sciences' Centre for Forest Ecology and Productivity. The mapping has been performed as part of Global Land Cover 2000 project with use of data obtained by the VEGETATION sensor on board the Earth Observation satellite SPOT-4. Land cover classes have been identified with series of advanced data products, derived from VEGETATION data, in order to characterize phenology of vegetation, water content of surface, directional reflectance properties and snow duration.

CONTACT DETAILS

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Global datasets can be downloaded from: <http://www.dinamic.jrc.ec.europa.eu>
Derived as part of the Global Land Cover 2000 project, coordinated by the Global Vegetation Monitoring Unit of the European Commission Joint Research Centre.



 

GLC2000 legend for Northern Eurasia

FORESTS

-  Evergreen Needleleaf Forest
-  Deciduous Broadleaf Forest
-  Needleleaf / Broadleaf Forest
-  Mixed Forest
-  Broadleaf / Needleleaf Forest
-  Deciduous Needleleaf Forest

SHRUBLANDS

-  Needleleaf Evergreen Shrubs
-  Broadleaf Deciduous Shrubs





GRASSLANDS

-  Humid Grasslands
-  Steppe

WETLANDS

-  Bogs and Marsh
-  Palsa Bogs
-  Riparian Vegetation






TUNDRA

-  Barren Tundra
-  Prostrate Shrub Tundra
-  Sedge Tundra
-  Shrub Tundra

OTHER VEGETATION TYPES AND COMPLEXES

-  Recent Burns
-  Croplands
-  Forest - Natural Vegetation Complex
-  Forest - Cropland Complex
-  Cropland - Grassland Complex

NON-VEGETATED LAND COVER TYPES

-  Bare Soil and Rock
-  Permanent snow / ice
-  Inland water bodies
-  Urban
-  Salt-pans

Main features of GLC2000 Northern Eurasia land cover map

1-km resolution SPOT-Vegetation data for year 2000

Mapping method involves:

- i. set of advanced spectral-temporal and spectral-angular indexes to distinguish various land cover types
- ii. clustering and significant human input for labelling and decomposing of ambiguous semantic clusters

Advantages:

- large number of mapped land cover types
- high level mapping accuracy

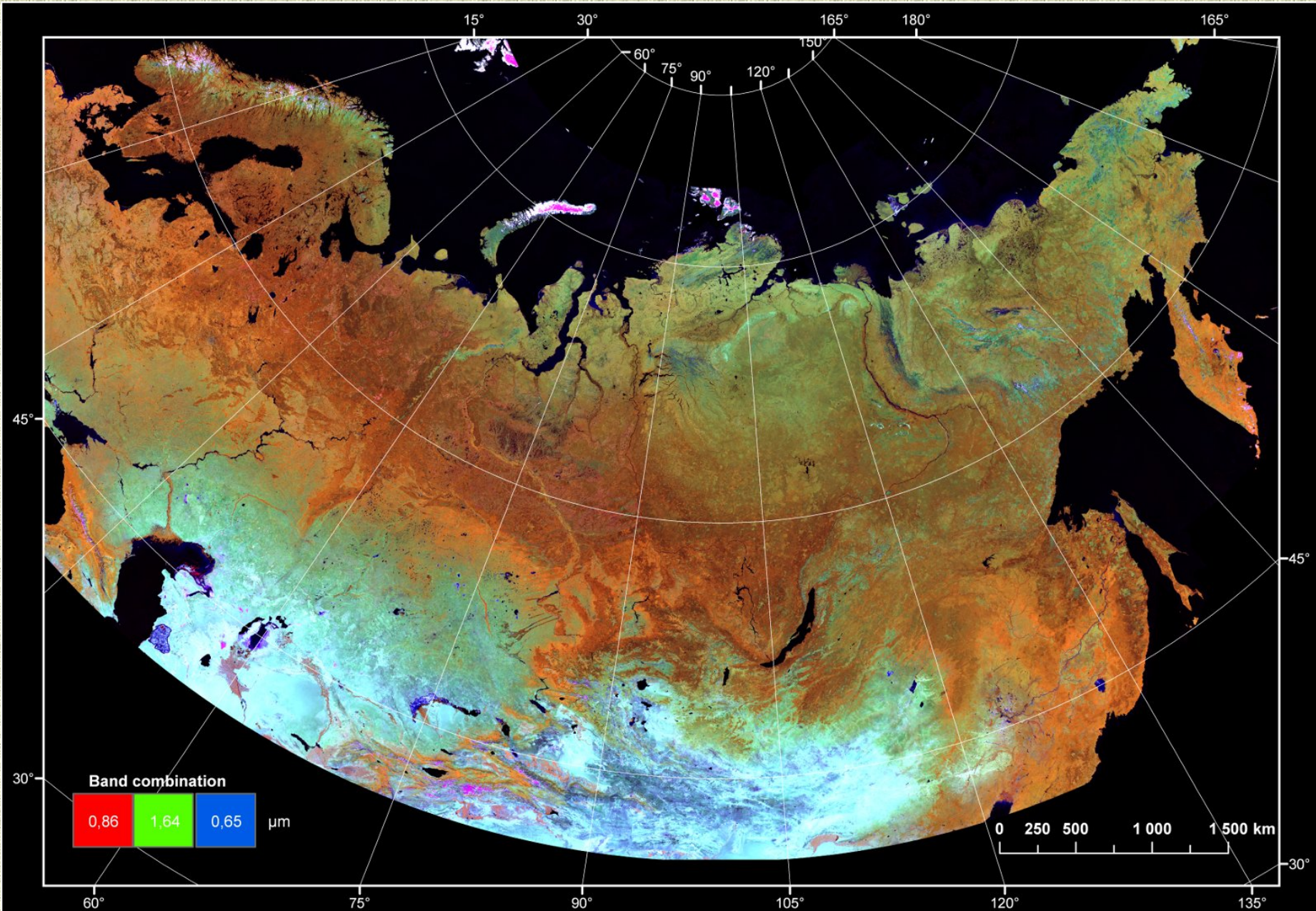
Disadvantages:

- limited repeatability

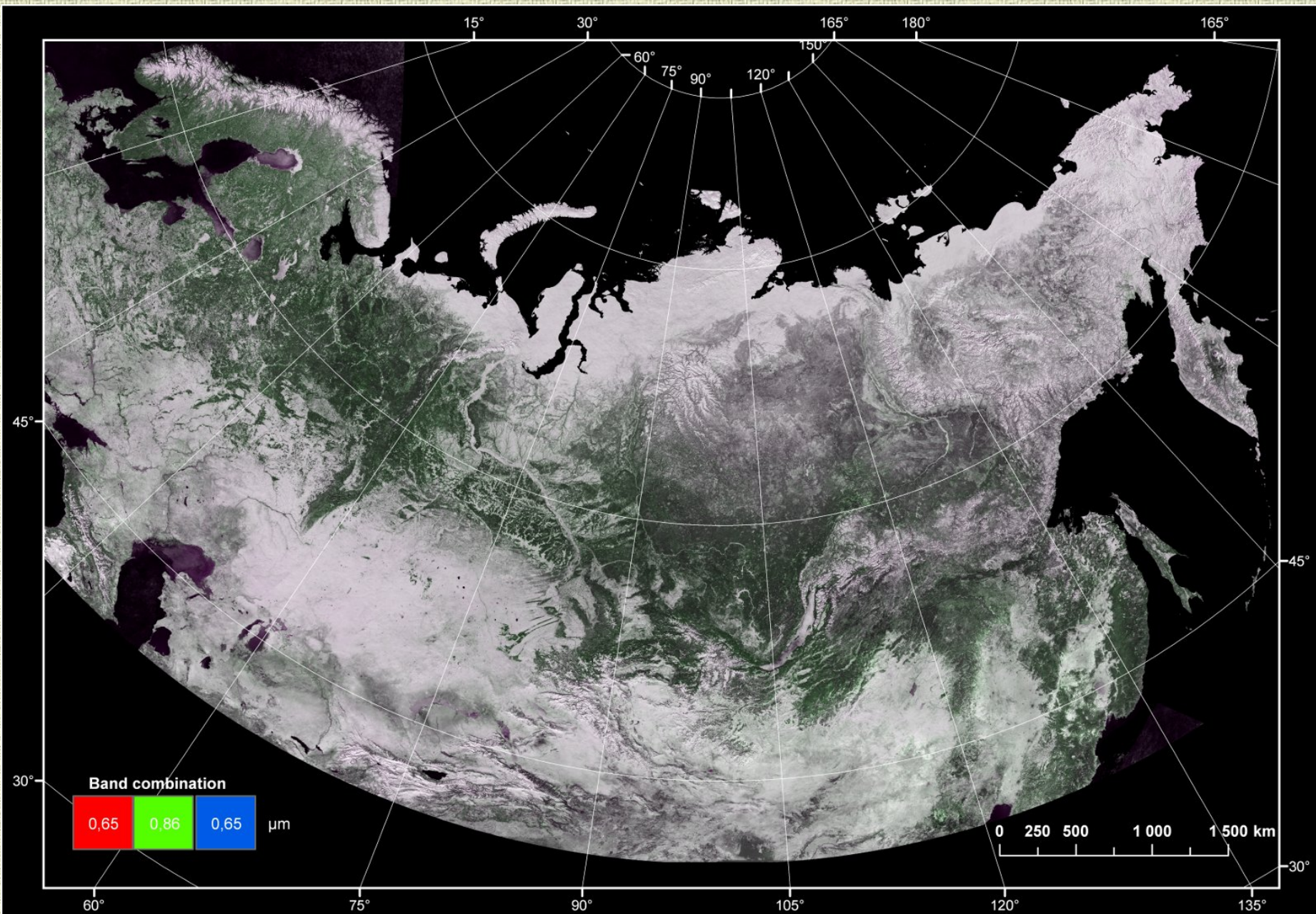
Towards better land cover mapping: main directions of consideration

- **spatial resolution** of mapping according to satellite sensors ability (1 km => 250 m)
- mapping **accuracy**
- mapping **repeatability** (annual as the target)
- possibility to **modify mapping legend** (e.g. to increase number of thematic classes)

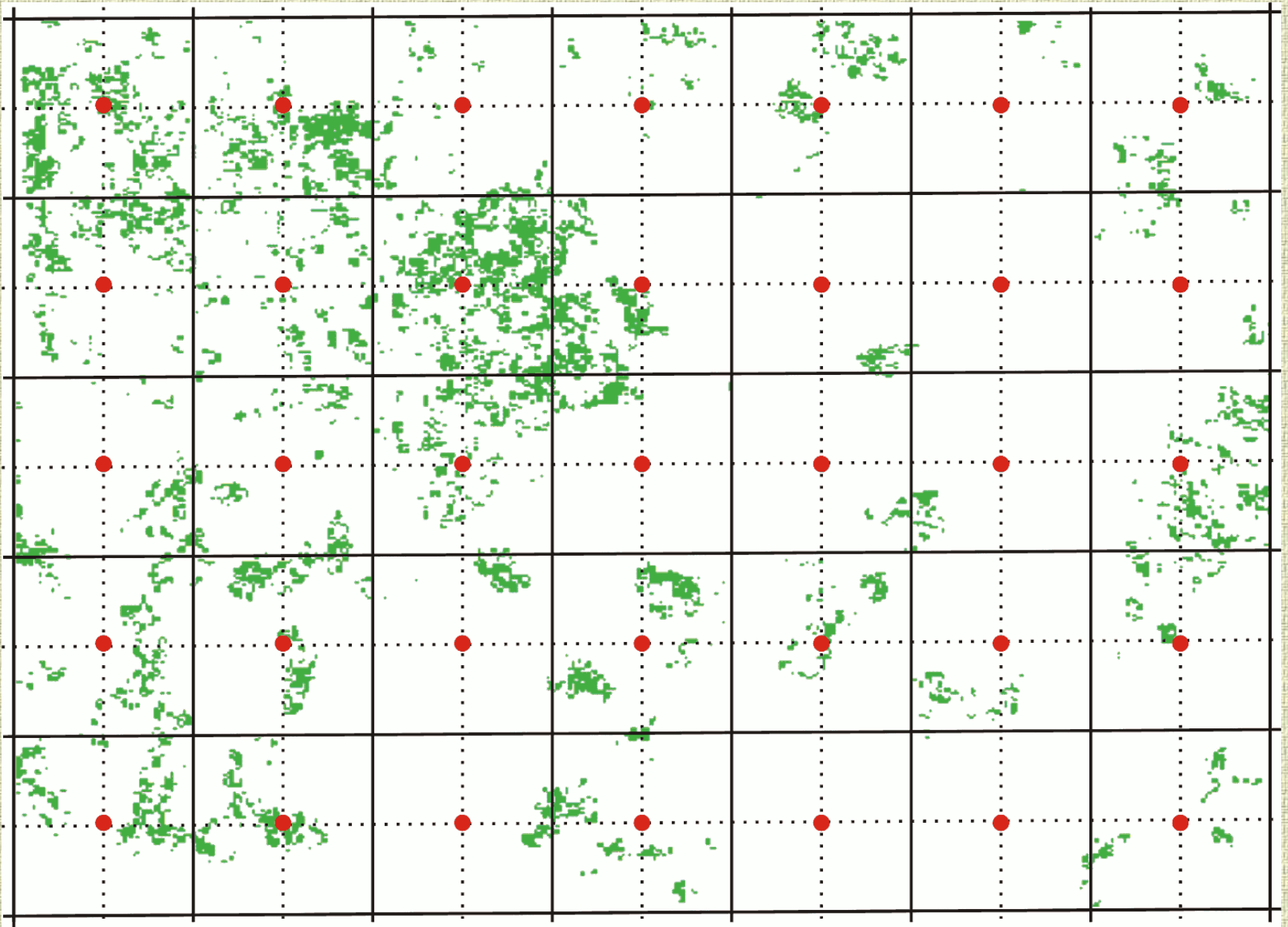
Cloud-free summer MODIS composite



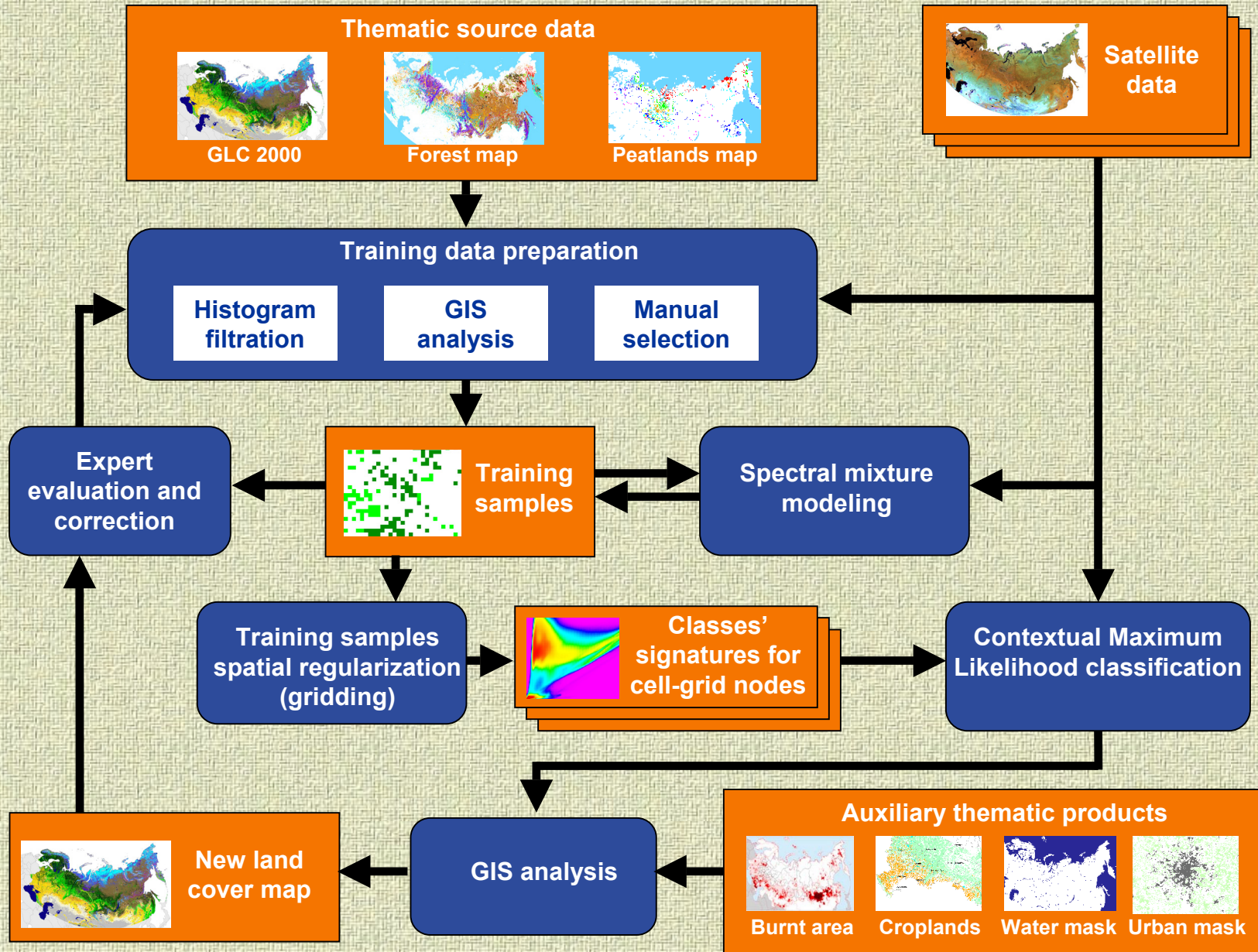
Cloud-free winter MODIS composite



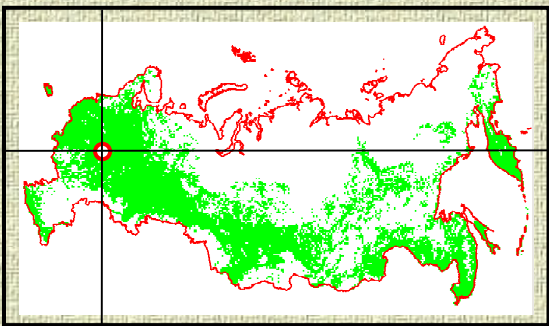
Classification based on LAGMA method



TerraNorte RLC mapping method

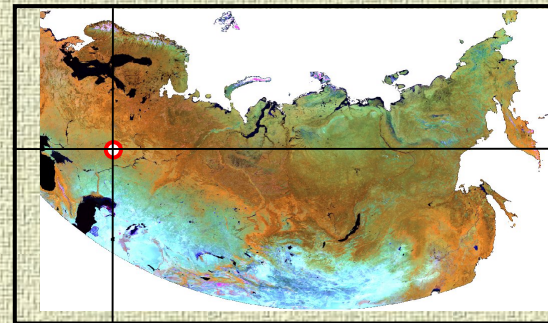


Contextual Maximum Likelihood Classification



Local spectral-temporal signatures of classes

Σ_i	\bar{a}_i	n_i
Covariation of metrics	Average of metrics	Number of samples



Spectral-temporal MODIS data composites

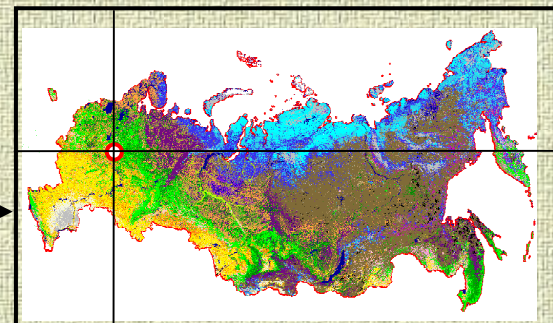
\bar{x}

Metrics for the pixel

Maximum likelihood classifier









$f_i(\bar{x})$

Probabilities for classes



LEGEND




FOREST

-  **Evergreen Dark Needle-leaf**
Forest ecosystems consisting of spruce (picea), fir (abies) and siberian pine (pinus sibirica) for at least 80% of the forest canopy.
-  **Evergreen Light Needle-leaf**
Forest ecosystems consisting of pine (pinus sylvestris) for at least 80% of the forest canopy.
-  **Broadleaf**
Forest ecosystems consisting of birch (betula), aspen (populus tremula), oak (quercus), tilia, ash (fraxinus), maple (acer), elm (ulmus) for at least 80% of the forest canopy.
-  **Mixed with Needle-leaf Majority**
Forest ecosystems consisting of the needle-leaf species for 60% to 80% and the broadleaf species for 20% to 40% of the forest canopy.
-  **Mixed**
Proportions of the needle-leaf and the broadleaf species in the forest canopy are approximately equal (40% to 60%).
-  **Mixed with Broadleaf Majority**
Forest ecosystems consisting of the broadleaf species for 60% to 80% and the needle-leaf species for 20% to 40% of the forest canopy.
-  **Deciduous Needle-leaf**
Forest ecosystems consisting of larch (larix) for at least 80% of the forest canopy.
-  **Sparse Deciduous Needle-leaf**
Single trees of sparse tree canopy of larch (larix) having less than 20% density.



GRASSLANDS AND SHRUBLANDS

-  **Humid Grasslands**
Grasslands having vegetative season over 5 months long and sufficient humidification. The species composition consists mainly of perennial plant, particularly of cereals and sedges. Forest and shrub canopy area is less than 20%.
-  **Steppe**
Herbaceous canopy is mainly composed of drought-resistant perennial bunchgrass, including mat-grass, fescue, mugwort and others. There is also a diversity of steppe shrubs and subshrubs, with short-blooming ephemeral and ephemeroïd plants.
-  **Evergreen Needle-leaf Shrubs**
Scrublands or low forest of mountain pine (pinus pumila).



TUNDRA

-  **Prostrate Shrub**
Dry tundra with sparse vegetation consisting mainly of Alpine and Arctic dwarf-shrub species less than 15 cm high. Moss, lichen and forbs can also be found.
-  **Sedge**
Tundra consisting of various herbs and mosses vegetating on wet soil and making up continuous cover. Dwarf-shrubs up to 40 cm high can also be found.
-  **Shrub**
Shrubs including dwarf birch (betula nana), willow (salix) over 40 cm high, sometimes mixed with juniperus, высотой более 40 см, иногда с примесью можжевельника, ольхи или кедрового стланика.





WETLANDS

-  **Peatlands**
Overhumidified lands covered mainly with moss, lichen, reed and sedge. Sometimes sparse tree canopy (up to 20%) can be found.
-  **Riparian Vegetation**
Hydrophilic, periodically flooded herbaceous, shrub and forest vegetation along the coastlines.

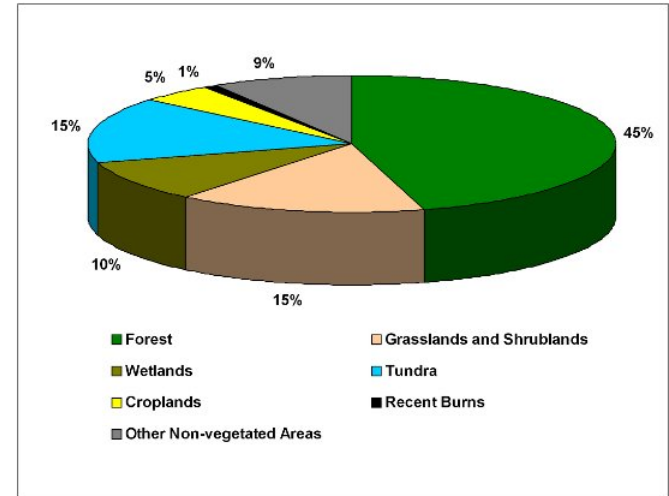
OTHER VEGETATION

-  **Recent Burns**
Tree cover or tundra seriously damaged by fire or dead.
-  **Croplands**
Arable lands regularly cultivated for at least 5 recent years.

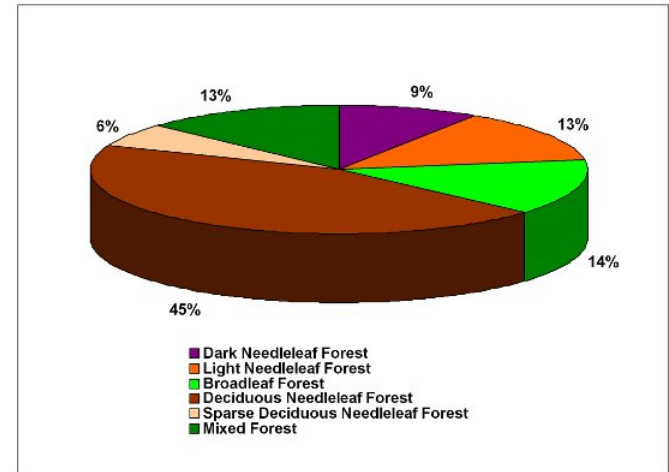
NON-VEGETATED AREAS

-  **Permanent Ice and Snow**
Land covered by ice or snow for the whole year.
-  **Bare Soil and Rock**
Lands having total vegetation canopy less than 20%.
-  **Water Bodies**
Open water bodies including seas, lakes, reservoirs and rivers.
-  **Urban Area**
Populated areas, roads, industries and other anthropogenic objects.

TERRESTRIAL ECOSYSTEMS

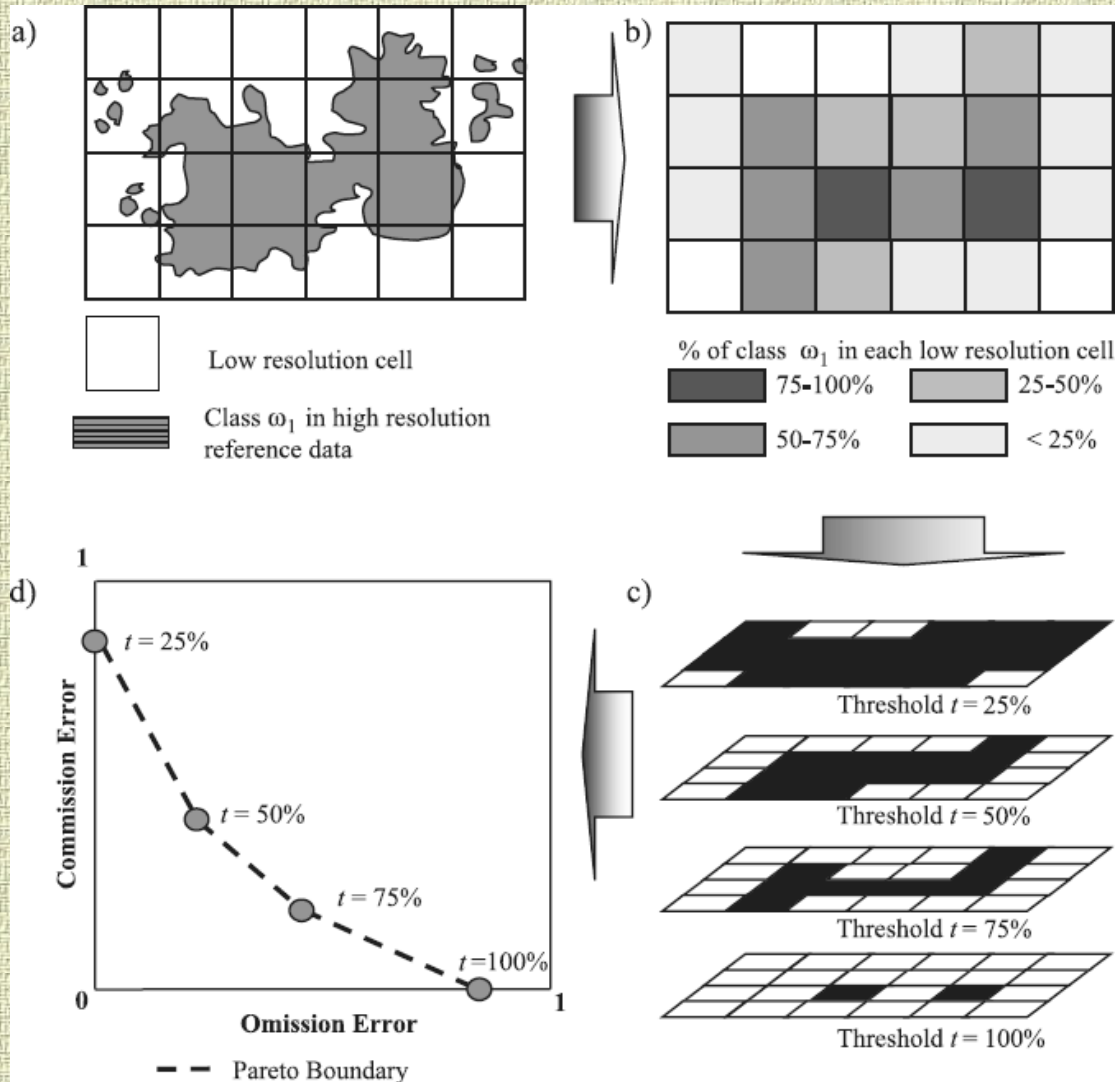


FOREST

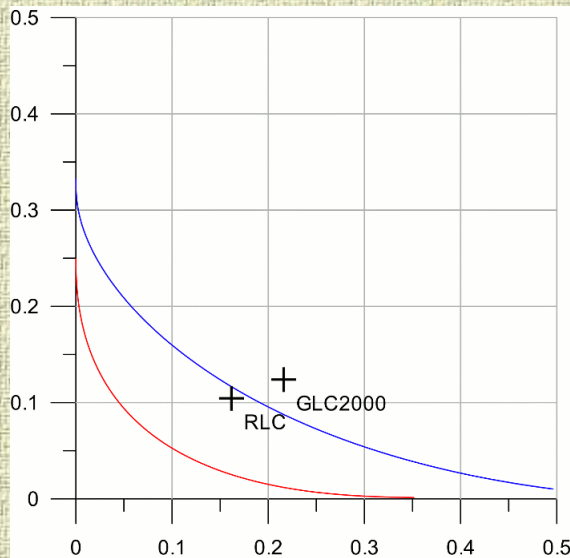
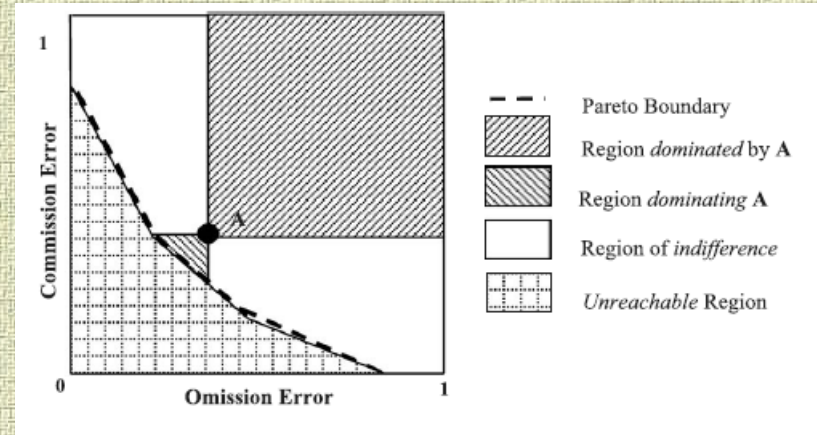


The Legend of TerraNorte RLC Map

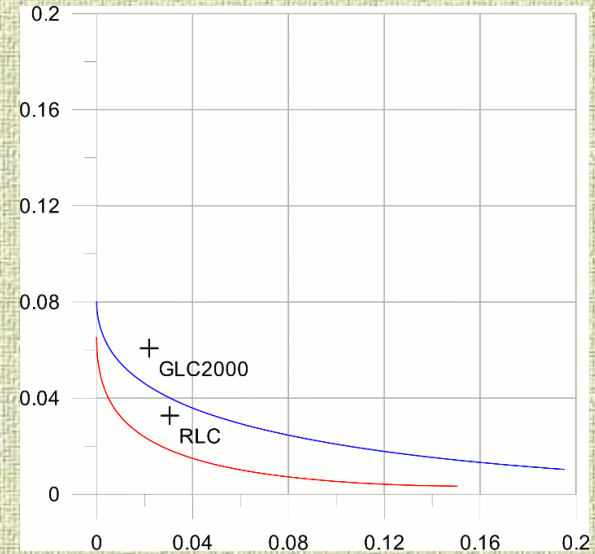
The Pareto Boundary method to estimate accuracy of the land cover map



TerraNorte RLC accuracy assessment for two test sites



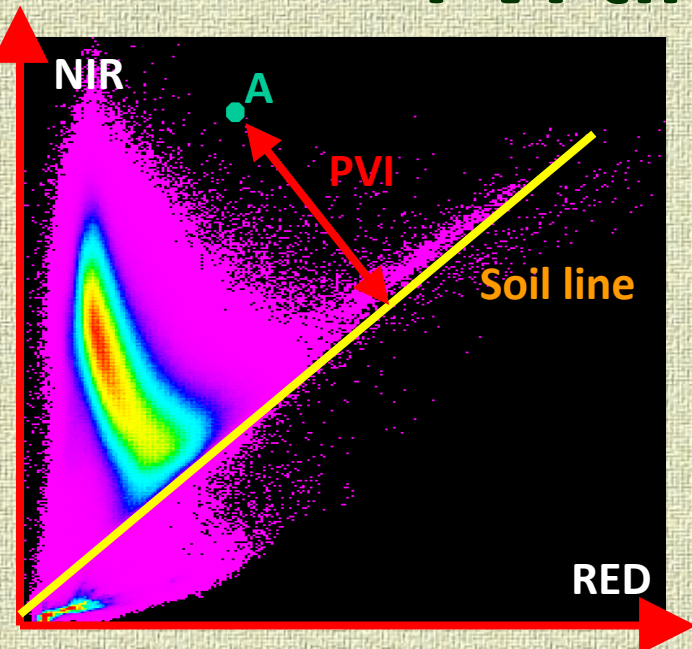
Site 1: Karelia Republic



Site 2: Komi Republic

Pareto optimum: — for 250 m resolution
— for 1000 m resolution

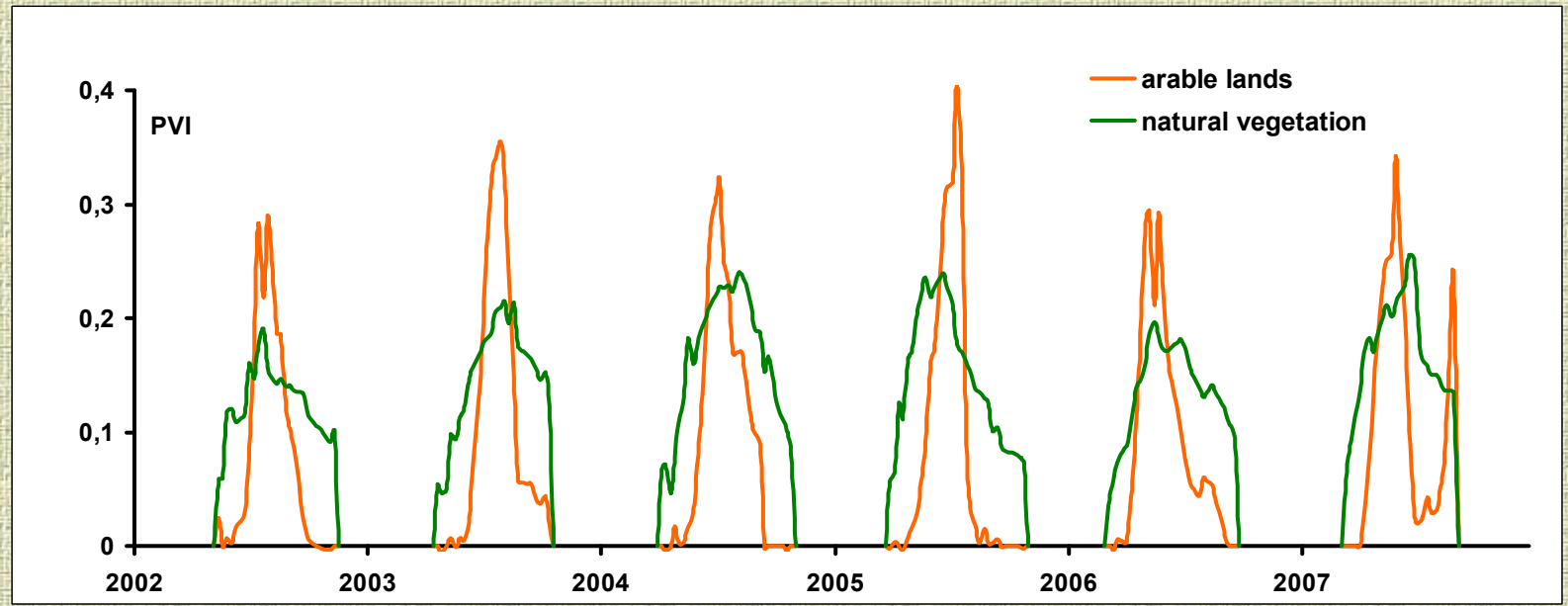
PVI time-series analysis



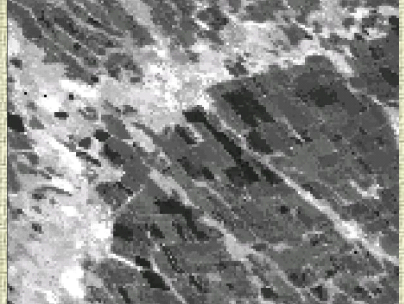
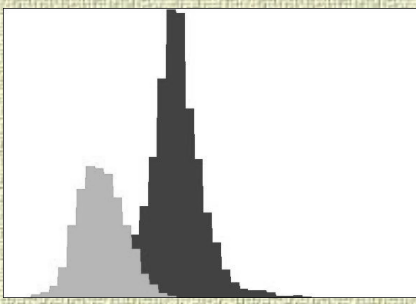
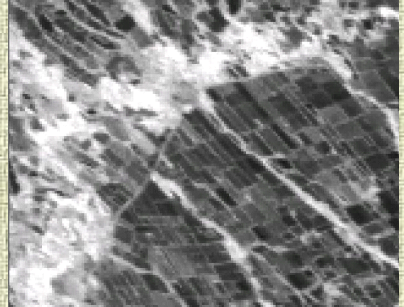
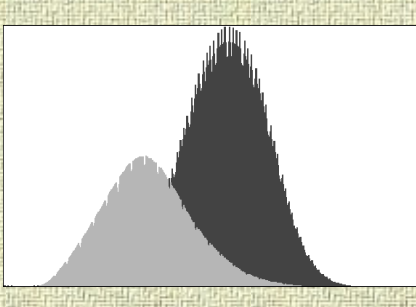
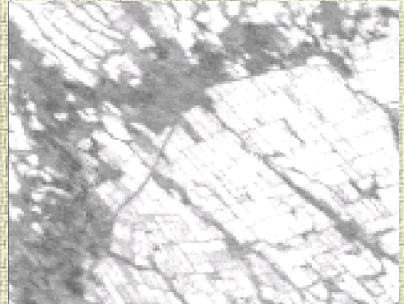
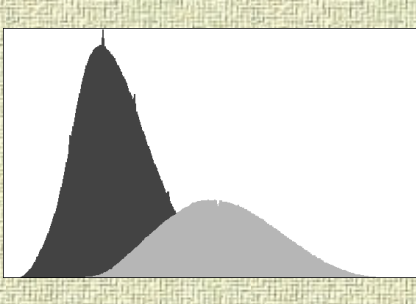
$$PVI = \text{Distance (A, Soil line)}$$

$$PVI = -0.83 * RED + 0.56 * NIR - 0.005$$

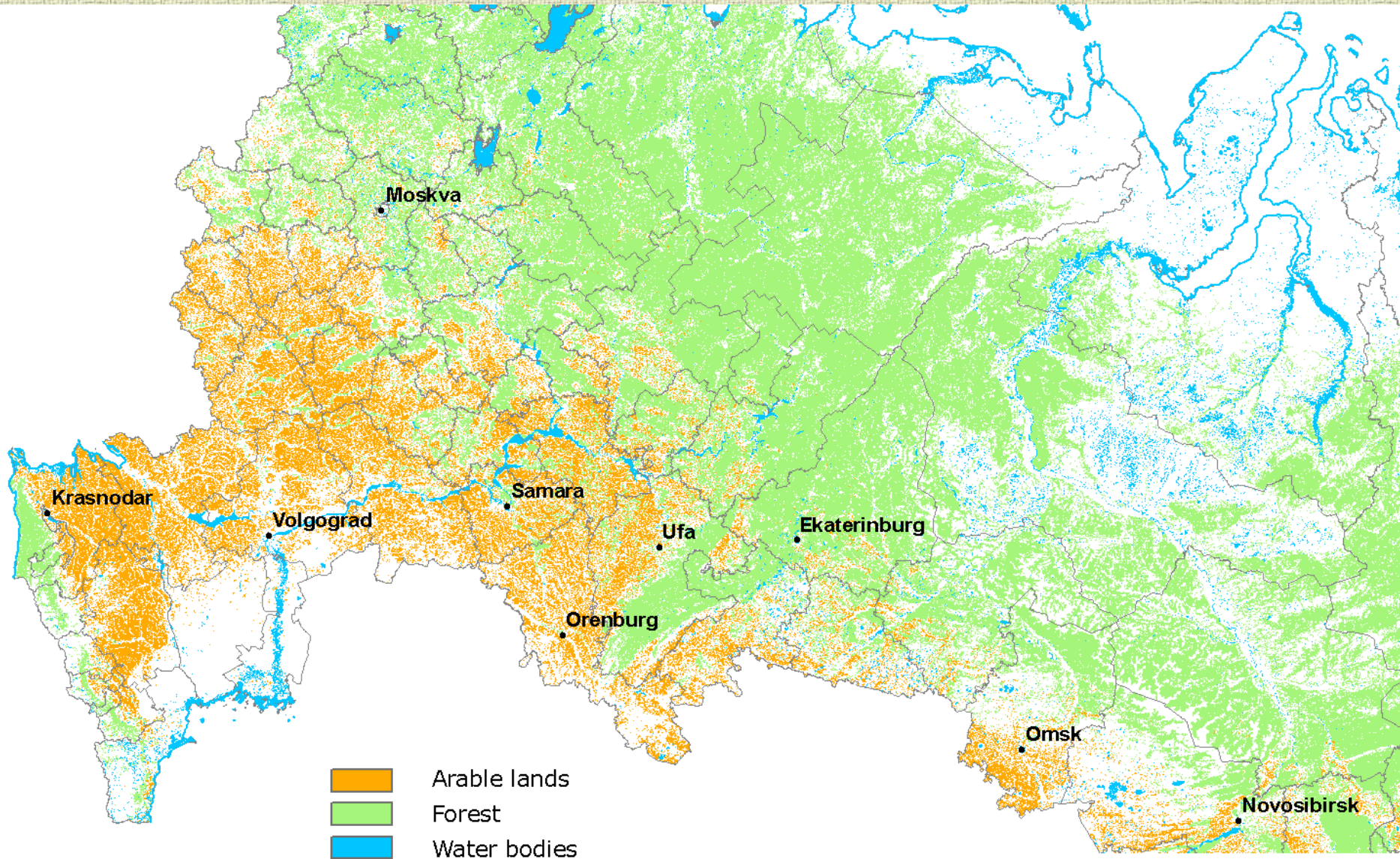
Inter-annual PVI dynamic similarity analysis and multi-annual phenological features retrieval



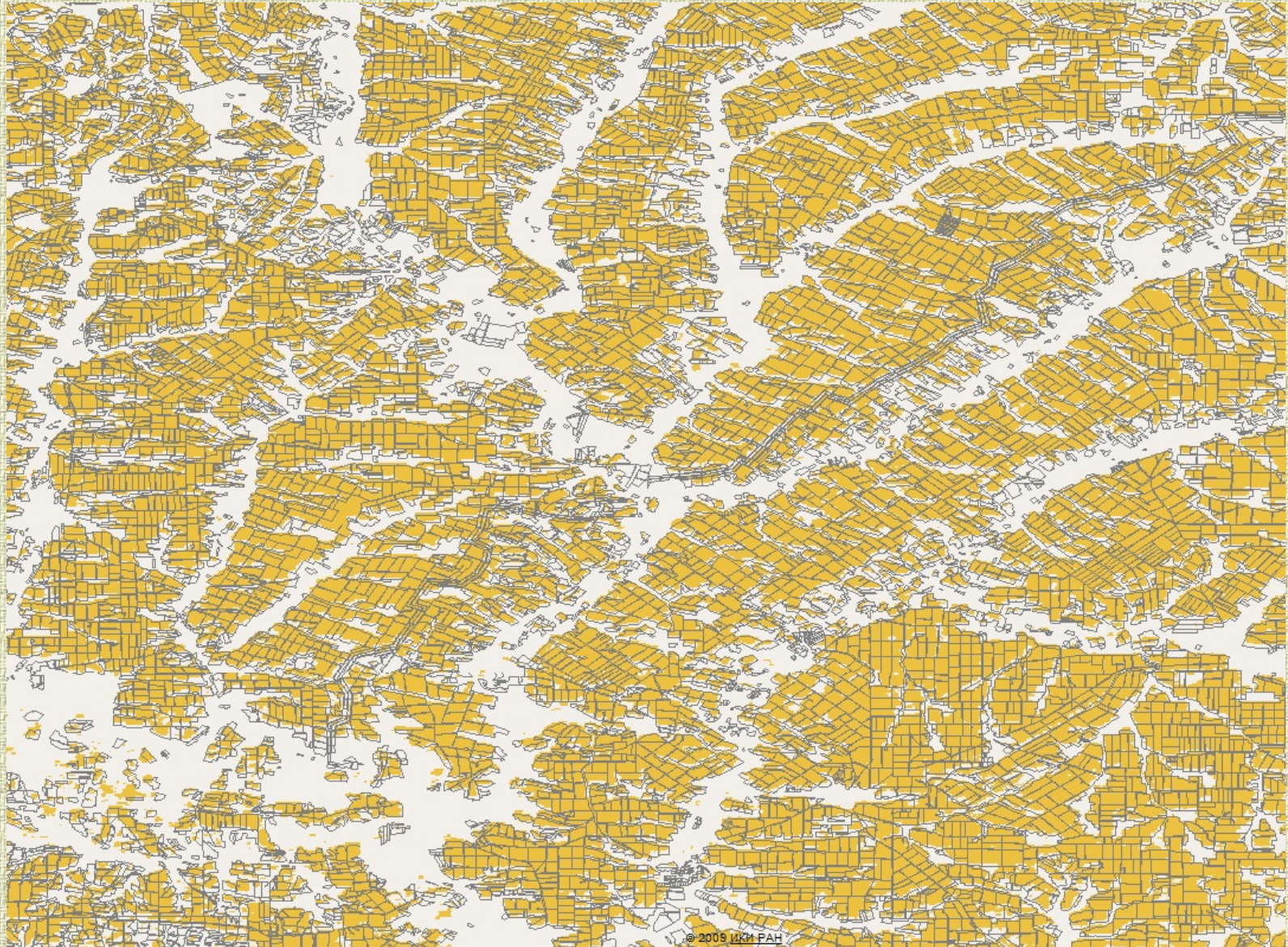
The features for arable lands mapping with MODIS multi-annual data time-series

Features Description	Formula	Feature Image	Histograms
Index of shortest vegetation period	$L_{1/2} = \min_{j=1..N} (t_L^j - t_F^j),$ $PVI(t_L) = PVI(t_F) = \frac{PVI_{max}}{2},$ $t_L > t_{max}, t_F < t_{max}$		
Index of vegetation spring development	$MSI = \min_{j=1..N} \sum_{i \in spw} PVI_{ij}$		
Index of seasonal biomass decrease	$NSMI = const - \frac{\sum_{j=1}^N PVI_j^{\min \in sw}}{\sum_{j=1}^N \sum_{i \in sw} PVI_i}$		

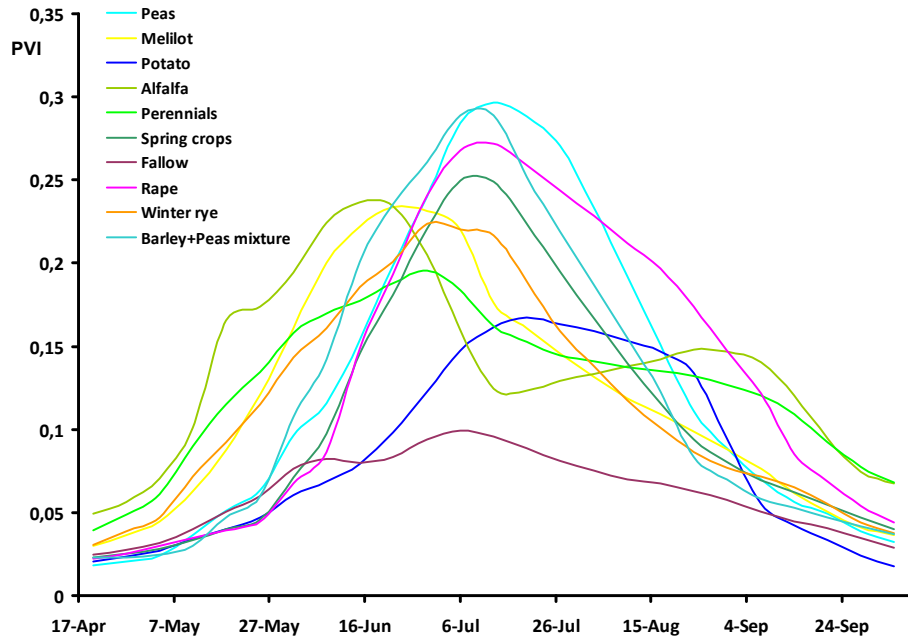
Arable lands map based on MODIS



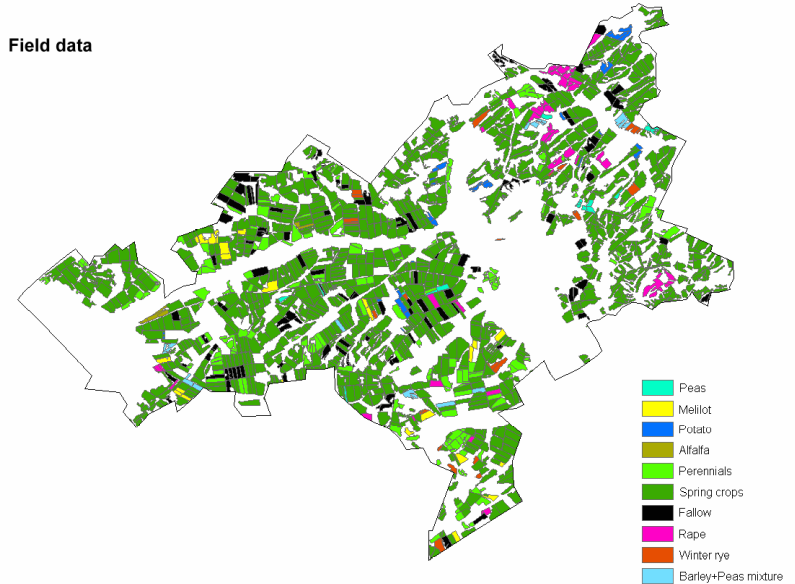
MODIS derived arable lands map vs. HR imagery based fields' limits



Crop types classification using MODIS



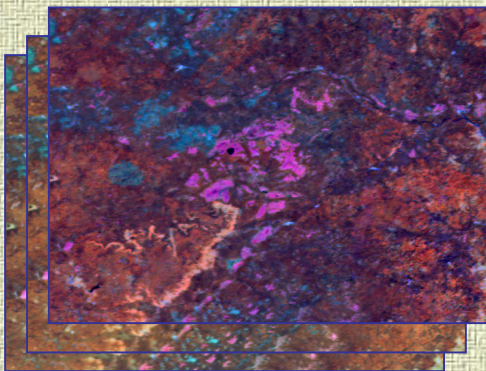
Field data



		Ground-truth										Omission (%)
		1	2	3	4	5	6	7	8	9	10	
Classification	1	58	0	0	0	0	11	0	0	0	0	5,9
	2	0	127	0	0	3	34	0	0	3	1	24,4
	3	0	0	101	0	0	10	7	1	0	0	15,1
	4	0	0	0	26	0	0	0	0	0	0	0,0
	5	0	0	1	1	797	116	17	8	1	0	15,3
	6	2	3	3	0	2	5822	9	6	4	4	0,6
	7	0	1	7	0	2	49	574	4	0	0	9,9
	8	0	0	0	0	0	127	0	175	1	0	42,2
	9	0	0	0	0	0	14	7	0	72	0	22,6
	10	0	0	0	0	0	42	0	0	0	46	47,7
Commission (%)		3,3	3,1	9,8	3,7	0,9	6,5	4,5	9,8	11,1	9,8	93

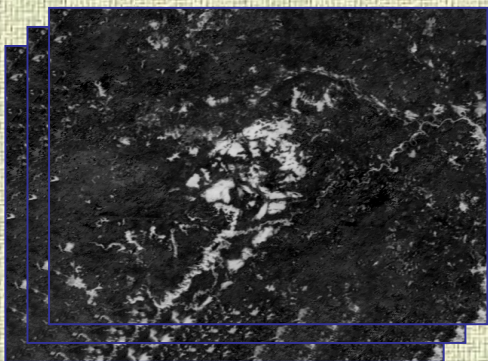
Burnt area mapping using MODIS

Multi-annual MODIS data

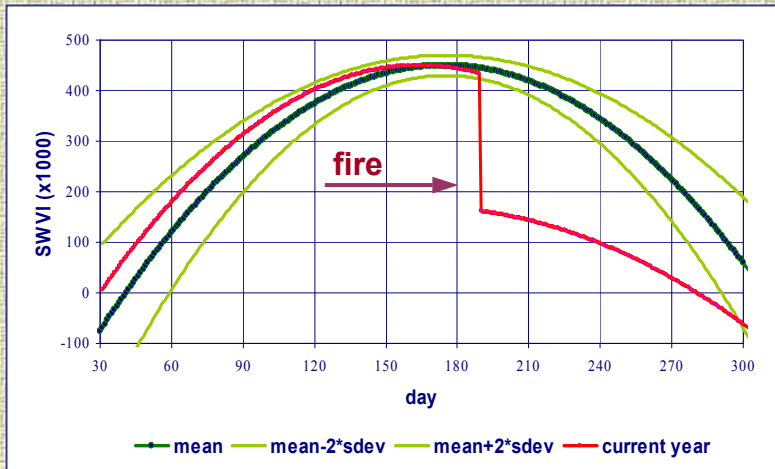


Contaminated pixels detection

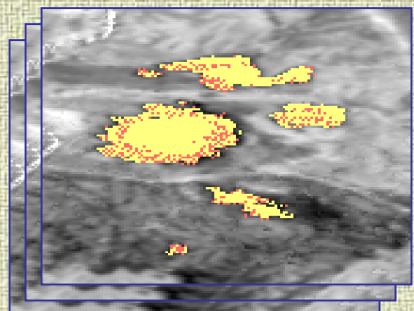
SWVI time-series restoration



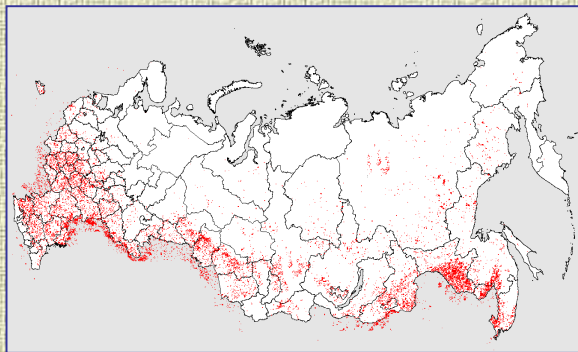
SWVI time-series



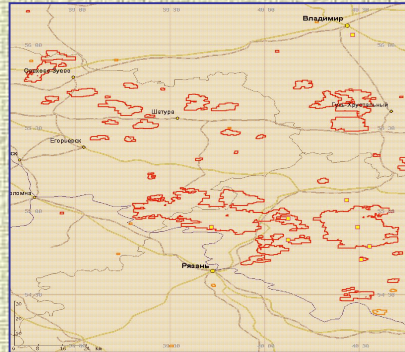
Detection of SWVI statistical anomalies



Combined SWVI and thermal anomalies



Burnt area maps



Thermal anomalies

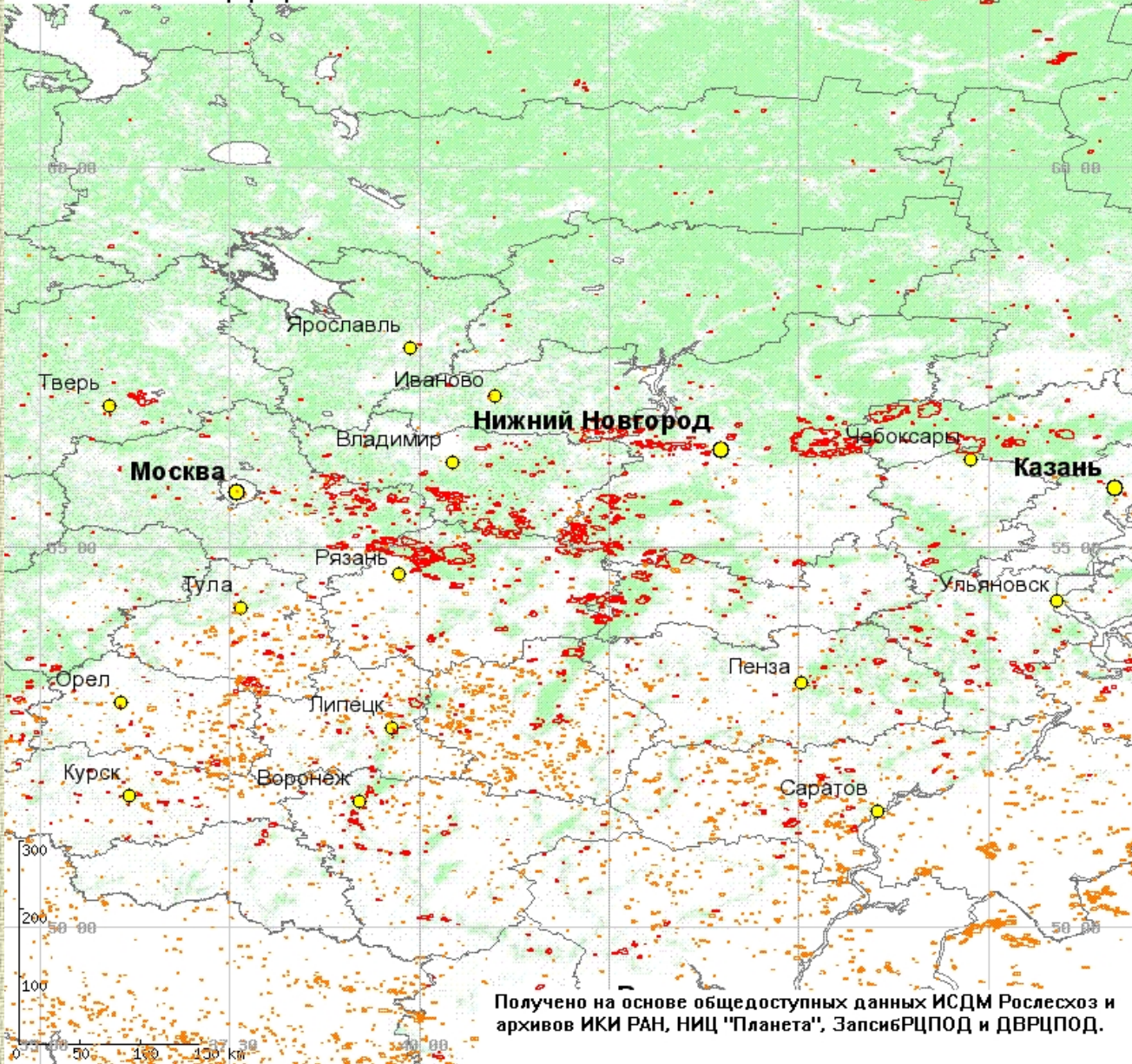
Burnt area for year 2009



Fires in Central European Russia in 2010

Пожары наблюдавшиеся прибором MODIS (спутники Terra и Aqua), действовавшие в период с 1.07.2010 по 21.08.2010.
Сформировано 21.08.2010

<http://smis.iki.rssi.ru>



The fires have been mapped using MODIS data and MOD14 thermal anomalies detection algorithm implemented within the Satellite Monitoring Information System of Russian Forest Service

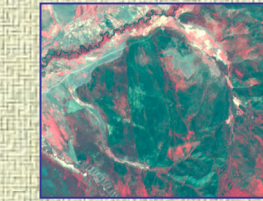
The considered period:
July 1 – August 21, 2010

Forest burns severity assessment

Ground-truth collection using HR data samples



Field measurements

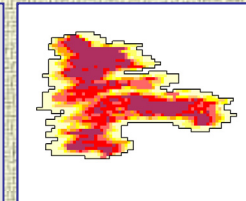


HR Satellite images

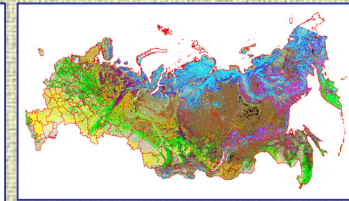
Burns severity assessment using MODIS data



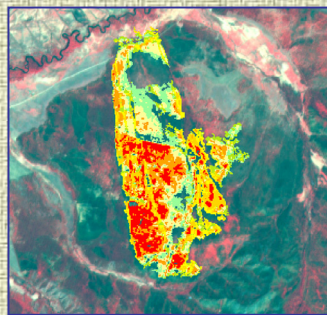
Burnt area mapping



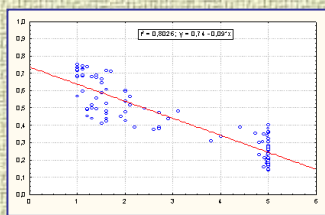
Burns severity assessment



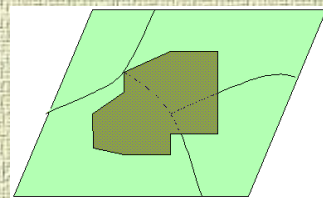
Land cover



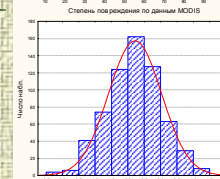
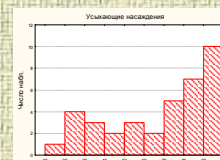
Data analysis



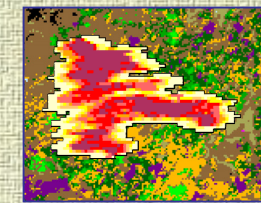
Statistical relationships



Burn severity assessment



Statistics on forest mortality



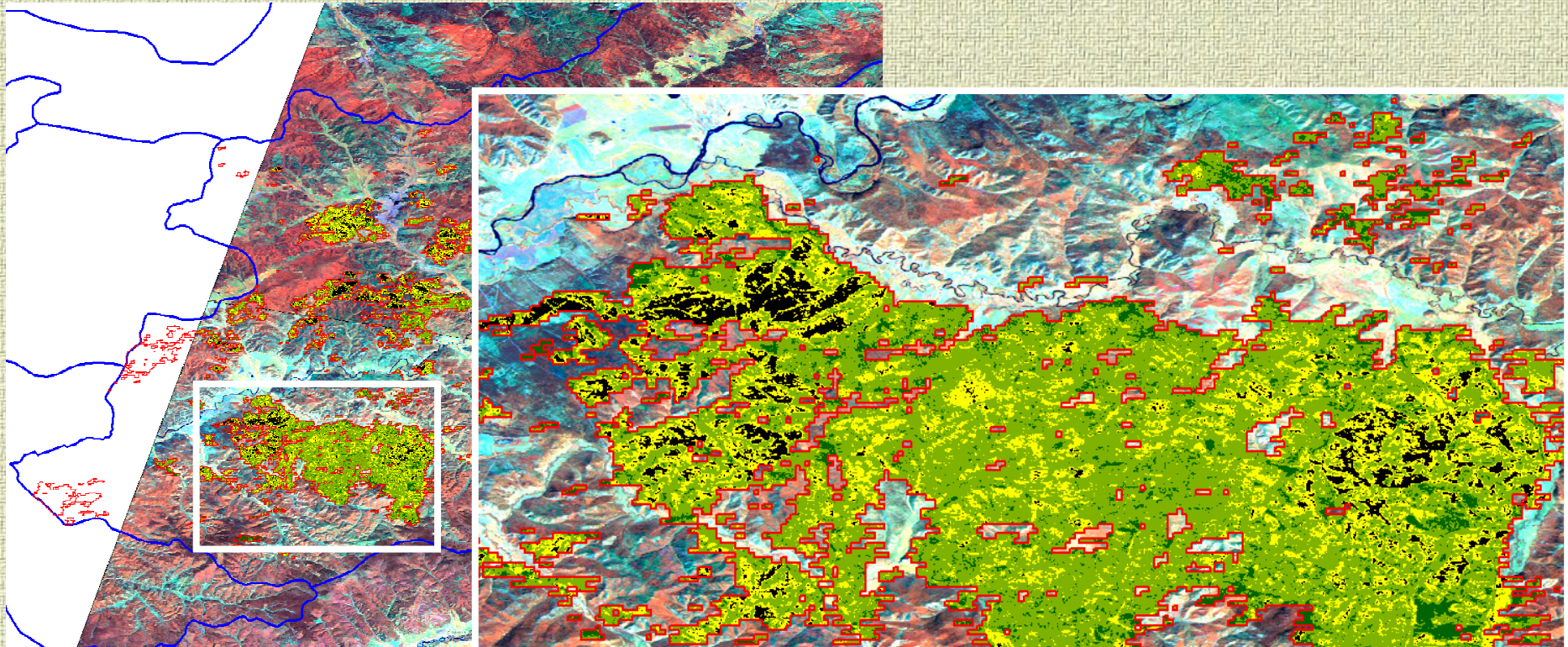
Burns severity by forest types

№ п/п	Наименование объекта (наименование населенного пункта, территории, территории)	Площадь, га	Степень повреждения	Площадь, га	Площадь, га
1
2
3
4
5
6
7
8
9
10

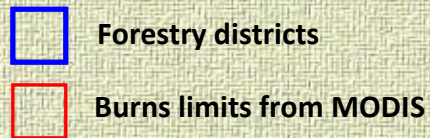
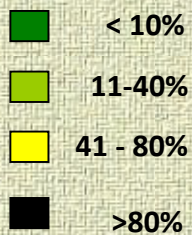
Lost forest area assessment

Post-fire assessment of trees mortality

Landsat-TM 07.09.2009; RGB:NIR-SWIR-Red



Trees mortality



TerraNorte: Data Products on-line

TerraNorte
the information system of the boreal ecosystems monitoring

News Information products **On-line maps** Press catalogue Links About Русский

Preview

Map control

Legend

- State Boundaries
- Tree Cover, broadleaved, closed
- Tree Cover, broadleaved, open
- Tree Cover, needle-leaved, evergreen
- Tree Cover, needle-leaved, deciduous
- Tree Cover, mixed leaf type
- Mosaic: Tree Cover / Other natural vegetation
- Tree Cover, burnt
- Shrub Cover, closed-open, evergreen
- Shrub Cover, closed-open, deciduous
- Herbaceous Cover, closed-open
- Sparse herbaceous or sparse shrub cover
- Regularly flooded vegetation
- Cultivated and managed areas
- Mosaic: Cropland / Tree Cover / Other natural vegetation

<http://terranorte.iki.rssi.ru/>