Russian Academy of Sciences
Space Research Institute (IKI)

Forest mapping and monitoring in Russia using EO data: R&D activity overview

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11.09 – 13.09.2017, 3rd User Workshop of the GlobBiomass project, FAO, Rome, Italy

Limitations of “traditional” forest data

Limited availability

- The available data at the forest stands level are fragmented (the unified country-wide database do not exist)
- The publically available country-wide forest statistics related to Russian Federation subjects level

Outdating

- Most of the data more than 15-20 years old

Inconsistency

- Data accuracy are significantly varying across the country

Main components of the VEGA Platform

(I) Multi-annual EO data archive (daily update):

- MODIS Surface Reflectance (2000 - ongoing)
- PROBA-V (2014 – ongoing)
- Landsat-TM/ETM+/OLI (2001 – ongoing)
- Sentinel-2 (2016 – ongoing)
- Sentinel-1 (2015 – ongoing)
- DEIMOS (update follows data delivery)
- KMSS, Canopus, RESURS-P (update follows data delivery)

(II) EO data pre-processing:

- cloud screening, cloud-free image compositing, VI time-series reconstruction

(III) Web-based User data analysis tools

- Multi-spectral and multi-temporal colour composition
- NDVI and other VI temporal profiles extraction
- Supervised and unsupervised image classification

VEGA Service
http://pro-vega.ru/

VEGA-PRO
satellite based service for vegetation monitoring

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Username: bartalev [Exit]

Analysis of vegetation condition

- Fields list
- Fields area statistics [rus]
- Map

Analysis of vegetation condition in the region

- Information bulletins
- Statistics data [rus]

Fire situation

- Daily reviews of wildfires in Russia[rus]

Identified anomalies in the state of vegetation (press-release)

- Condition of winter crops season 2014.[rus]

Welcome to VEGA-PRO!

> **VEGA-PRO** - professional information service for monitoring of renewable biological resources based on satellite data analysis.

VEGA-PRO Service is created based on long-term developments of the Russian Academy of Sciences' Space Research Institute - IKI (Department of Satellite Monitoring Technologies) in the field of automated methods and technologies for satellite data collection, processing and dissemination. The **VEGA-PRO service was created** with support of the Skolkovo Foundation. At present, the **VEGA-PRO** service development is provided by IKI jointly with the Institute for Space Research of the Earth (IKIZ Ltd.). The VEGA-PRO service is maintained by IKIZ, participating company of Skolkovo space technologies and telecommunications Cluster.

VEGA-PRO is information service for professional operations with in near-real-time updated satellite data archives and other geospatial information to provide solutions for wide range applications focused at assessment and monitoring of renewable biological resources primarily related to agriculture, forestry and forest industry.

VEGA-PRO Features

VEGA-PRO service is based on updated in near-real-time data on state of vegetation in Russia and neighboring countries acquired by satellite remote sensing instruments. There are daily updated data archives for any area of Northern Eurasia region from the beginning of the twenty-first century to the present.

The service performs automated satellite data processing, which allows carrying out daily information update.

In particular, **VEGA-PRO** service is facilitated to analyze the vegetation cover state (for example, agricultural crops and forests) using vegetation indices time-series based on its seasonal and multi-annual dynamics for every single point or user-specified polygon. Information can also be integrated at the level of administrative districts for any region of Russia.

News

2016-05-20
Add a map of winter crops of the season 2015-2016 as of May 11, 2016.

2016-04-22
Add a map of winter crops of the season 2015-2016 as of April 5, 2016.

2016-02-29
Add a land cover map and land covered with forest map for 2015 season.

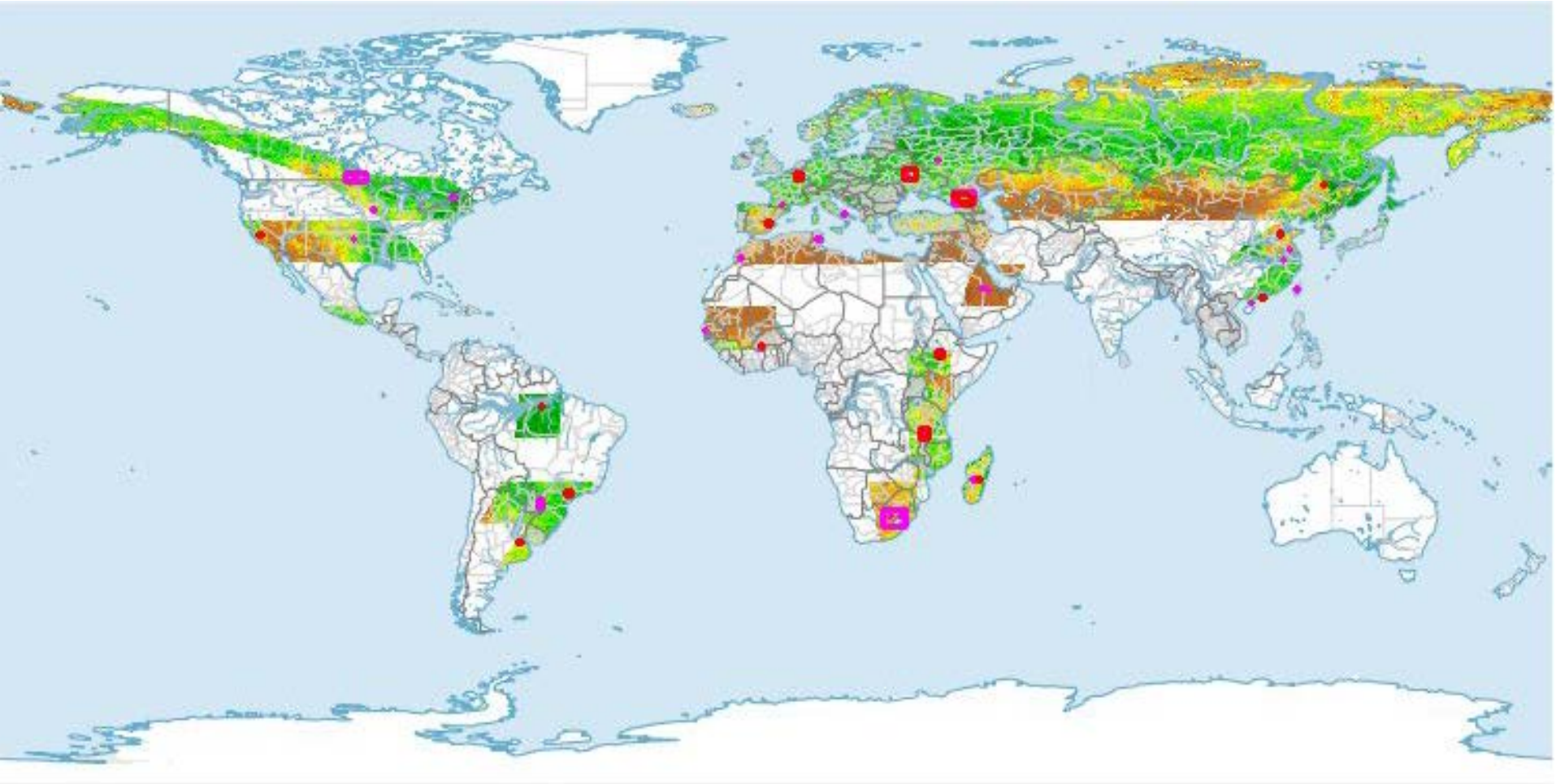
2016-02-12
Add a map of arable lands for 2010-2015 years and a map of clean fallow for 2015 season.

2016-01-26
Add a final autumn map of winter crops of the season 2015-2016.

2015-11-13
Sample data of the European satellite **Sentinel-2A** become available in the map interface.

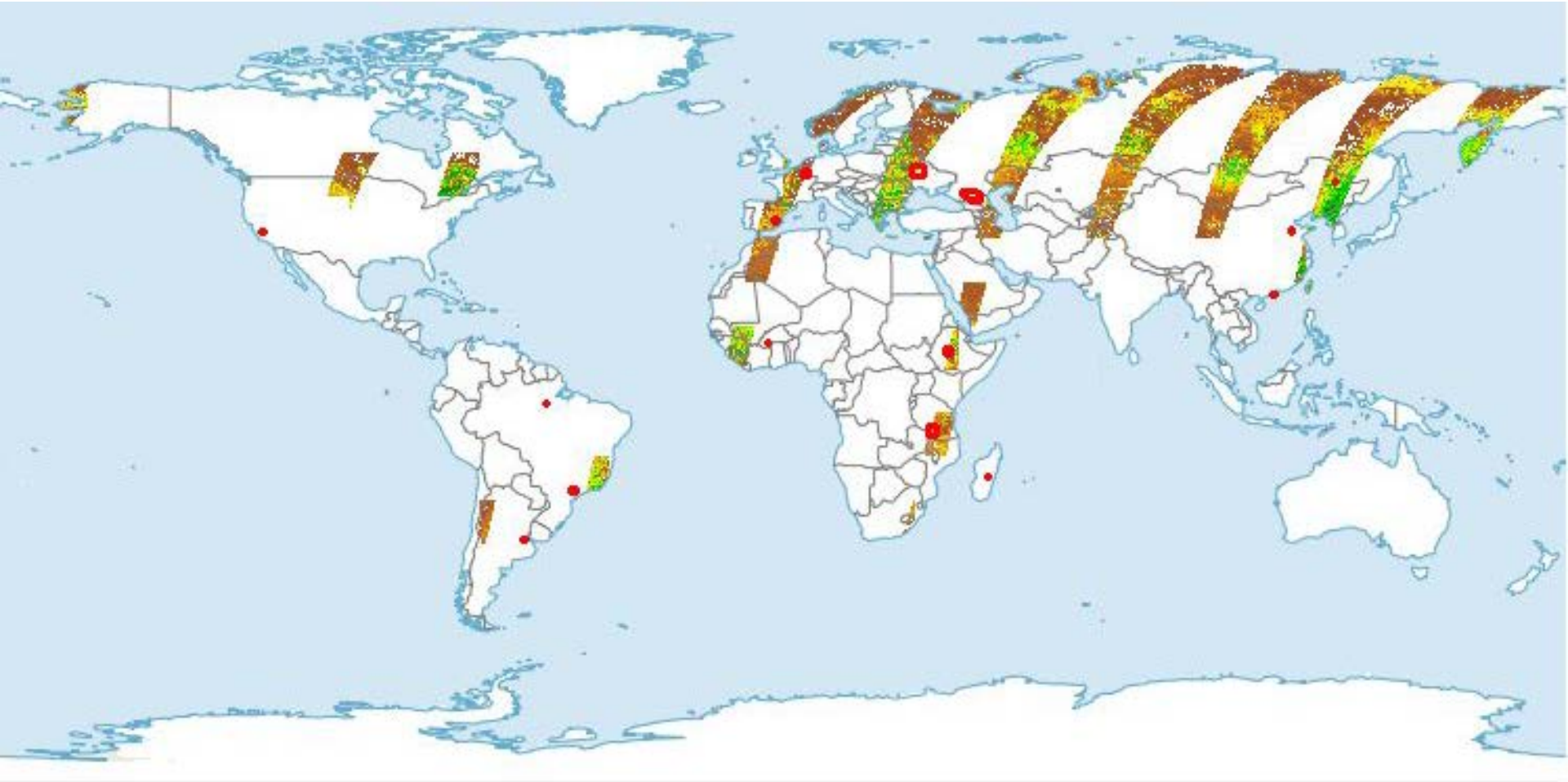
VEGA-PRO - professional information service for monitoring of renewable biological resources based on EO data analysis developed by the Russian Academy of Sciences' Space Research Institute.

MODIS coverage



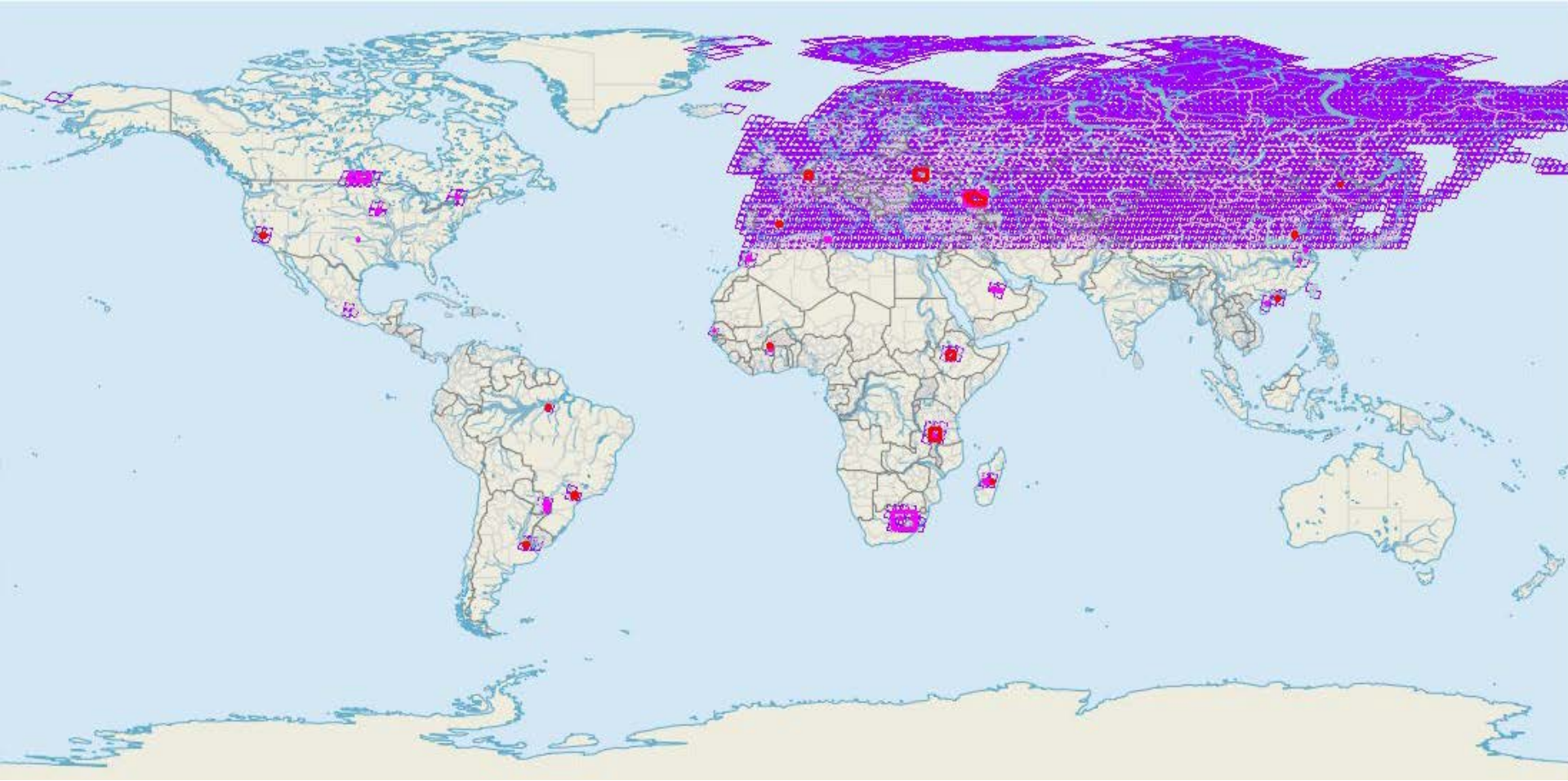
VEGA-GEOGLAM - web-based analysis system
Time of generation 15:07:07 15/11/2015

An example of Proba-V daily coverage



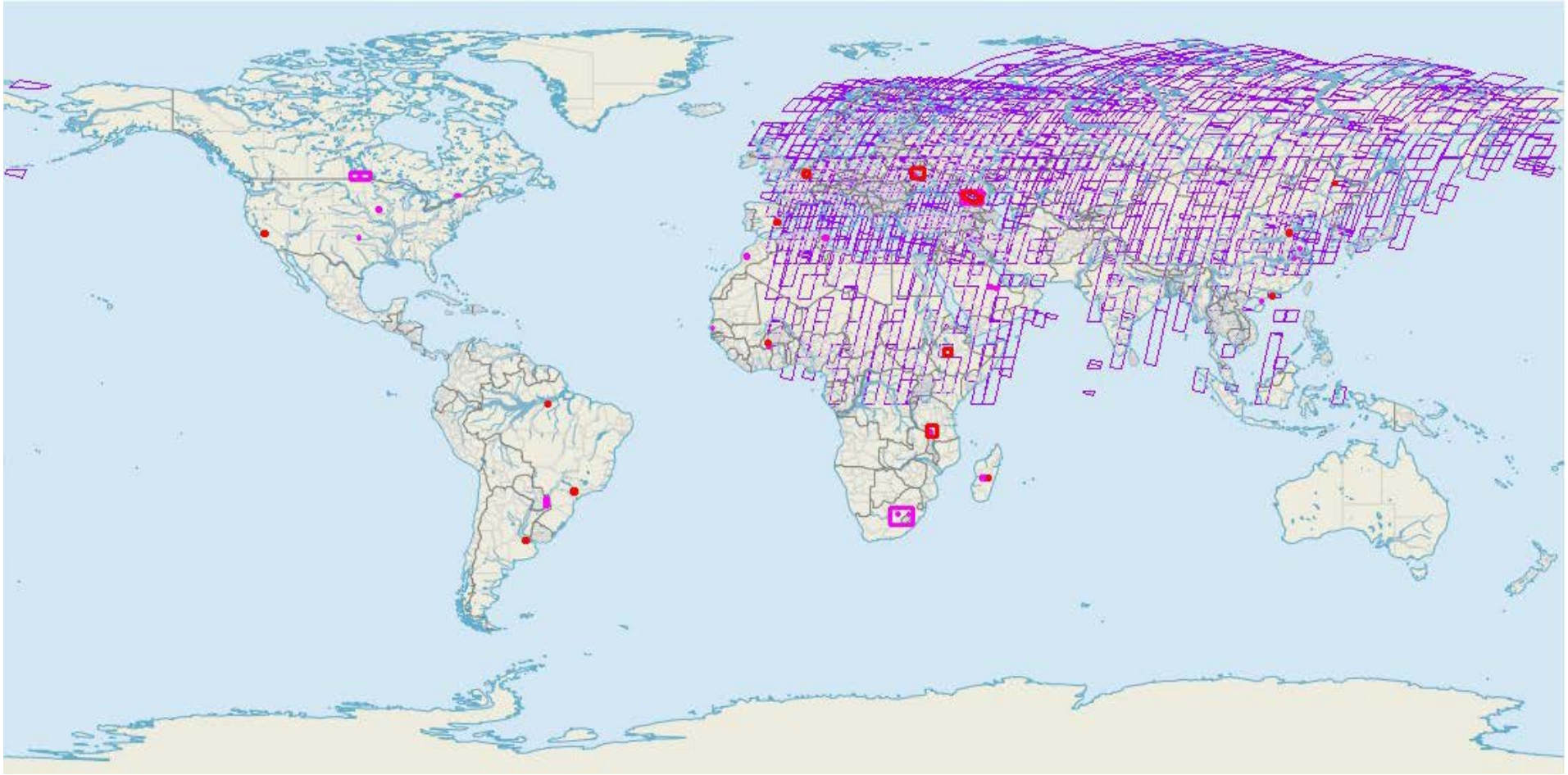
VEGA-GEOGLAM - web-based analysis system
Time of generation 17:45:43 15/11/2015

Landsat coverage



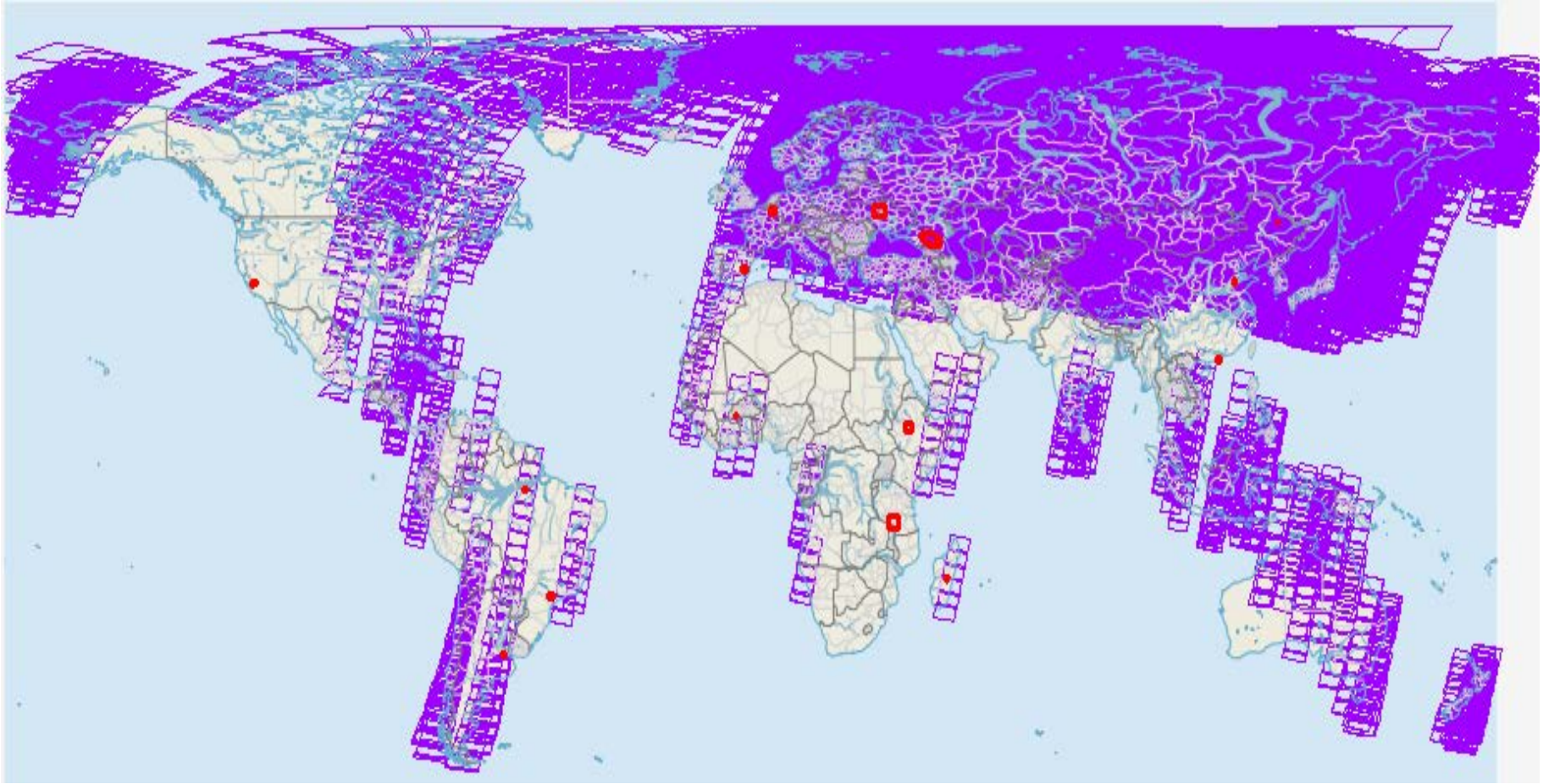
The Landsat data coverage for the period Jan 1- March 27, 2016, The Landsat data archive contains data for the period since year 2000 with daily update.

Sentinel-2 coverage



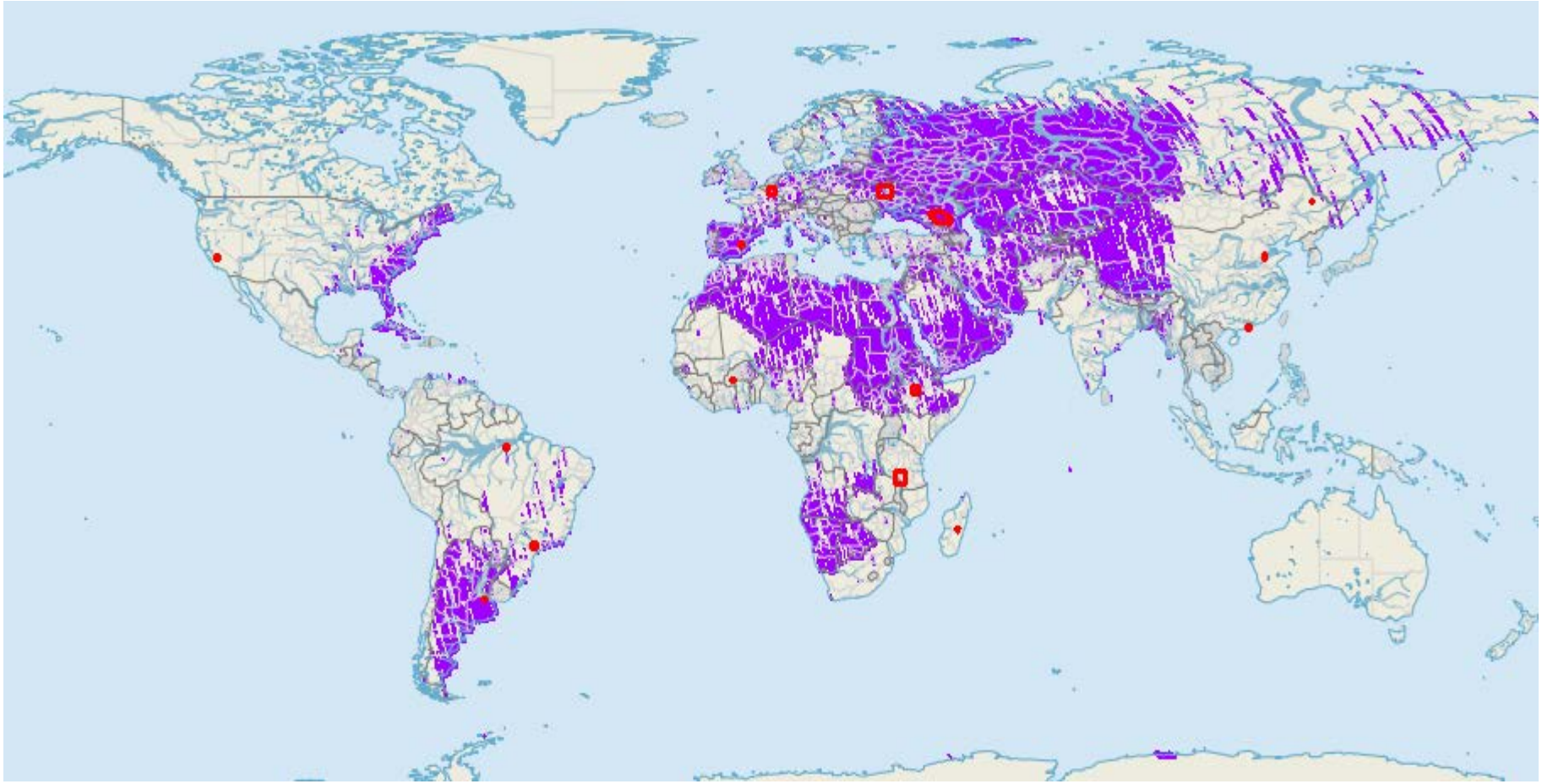
The Sentinel-2 data coverage for the period Jan 1 – March 27, 2016, The Sentinel-2 data archive is of daily update.

KMSS Meteor-M coverage



The Meteor-M data (for both, № 1 and № 2) coverage for the period June 1, 2015 - September 1, 2015. The Meteor-M data archive contains data for the period since year 2011 with daily update. Also it is available for visualization, classification and downloading.

Canopus-V coverage



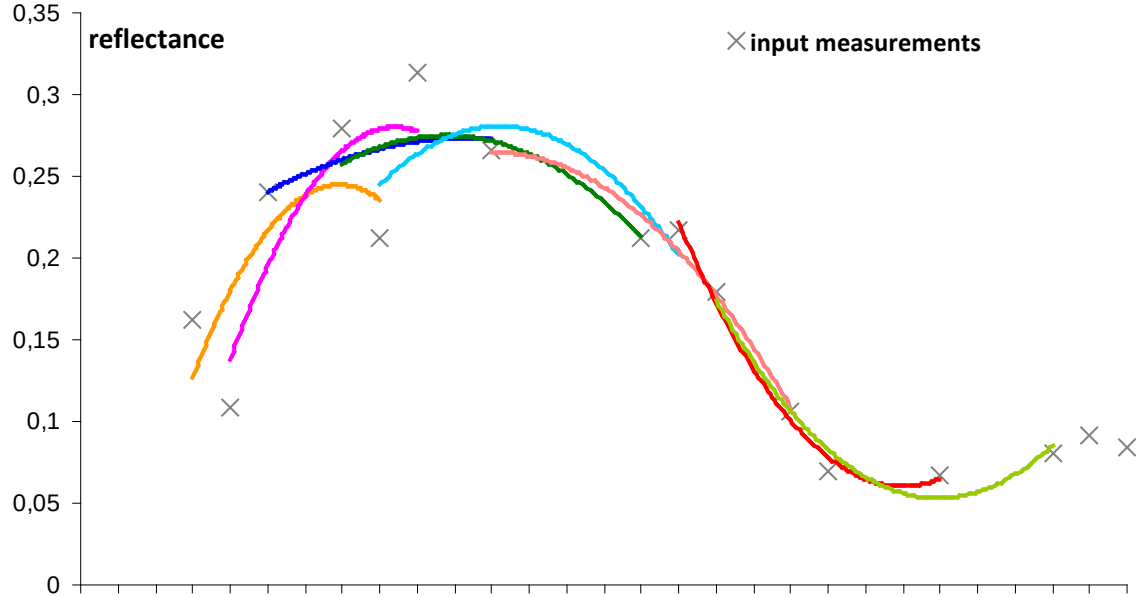
The Canopus-V data (MSS and PSS) coverage from 23 January, 2013 up to now.
It is available for visualization only.

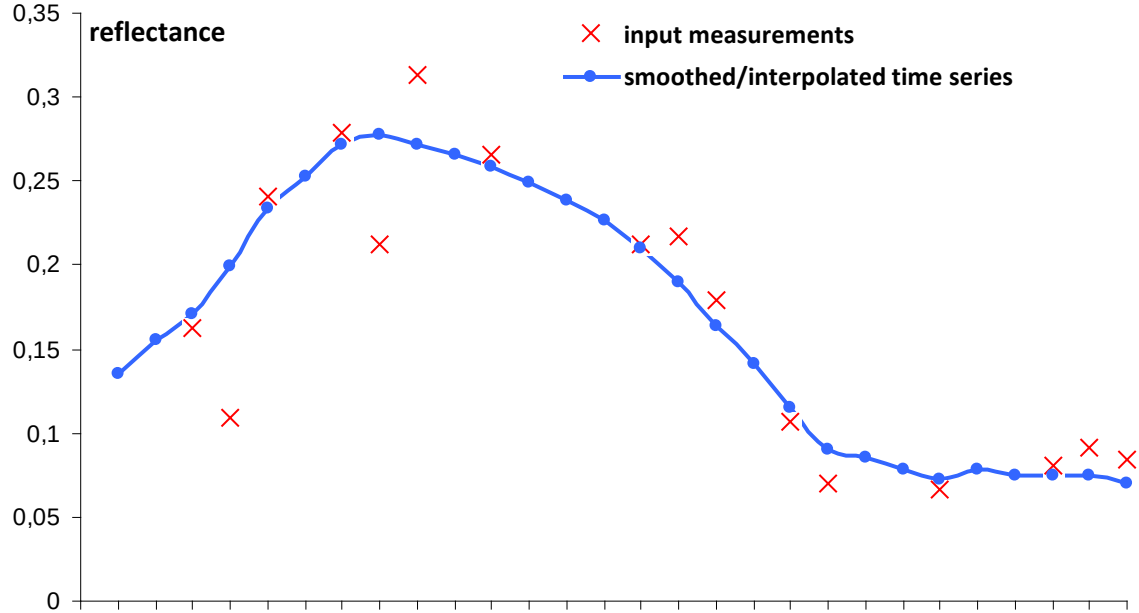
EO data preprocessing

Cloud screening

Time series reconstruction

Images compositing



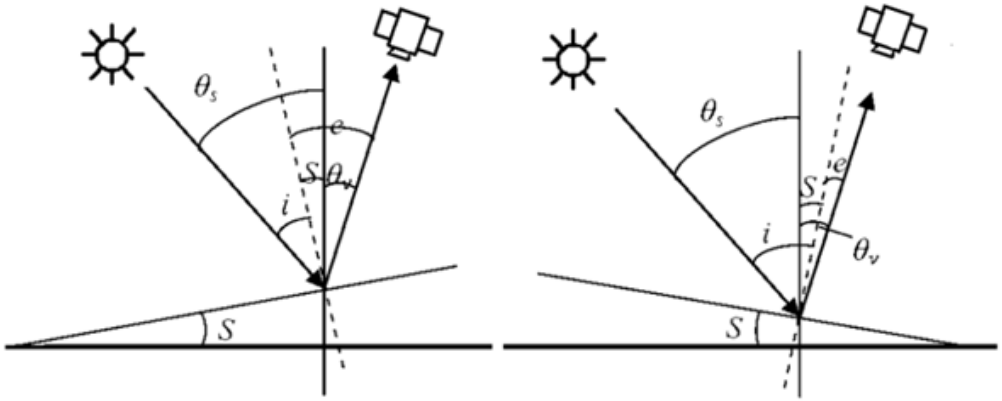


EO data topographic normalization

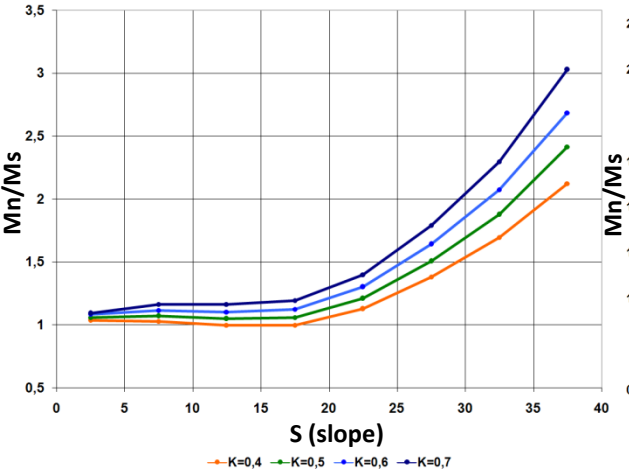
Minnaert model:

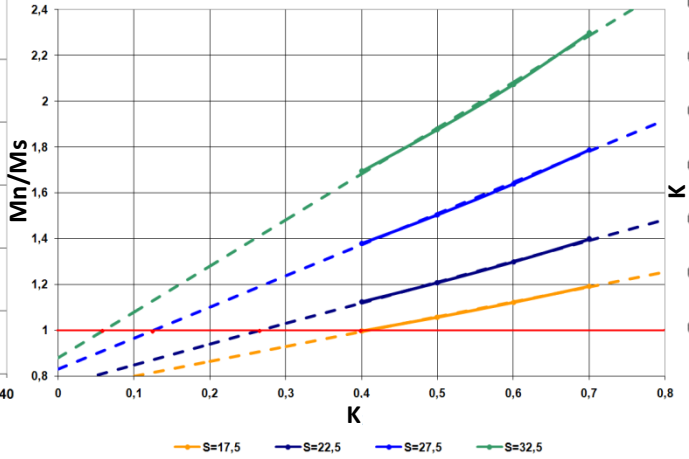
$$R_n = R \cdot \left(\frac{\cos(e)}{\cos^K(i) \cdot \cos^K(e)} \right)$$

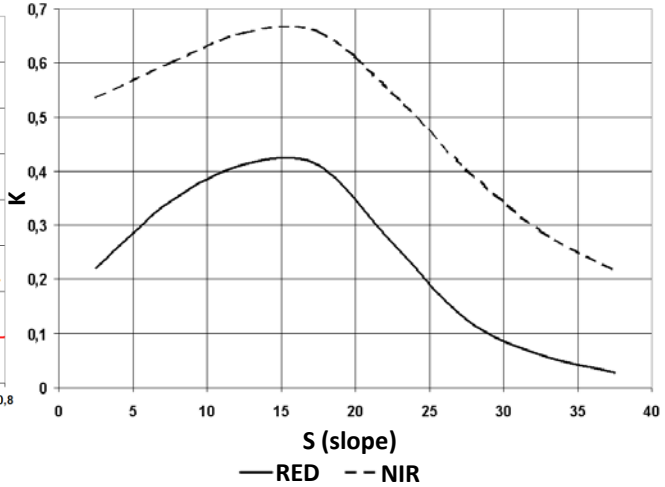
R – reflectance
K – Minnaert coefficient



K is chosen so that mean reflectances of the same LC types on dark/north (**Mn**) and light/south (**Ms**) slopes are equal:

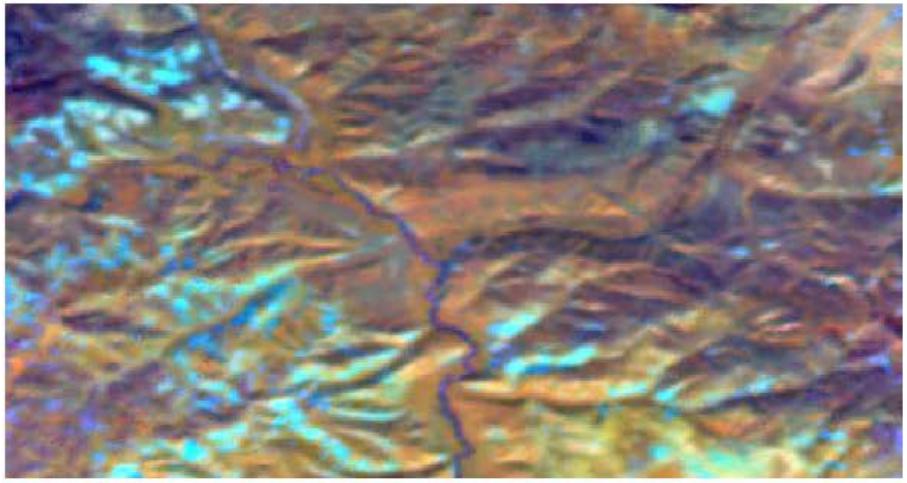


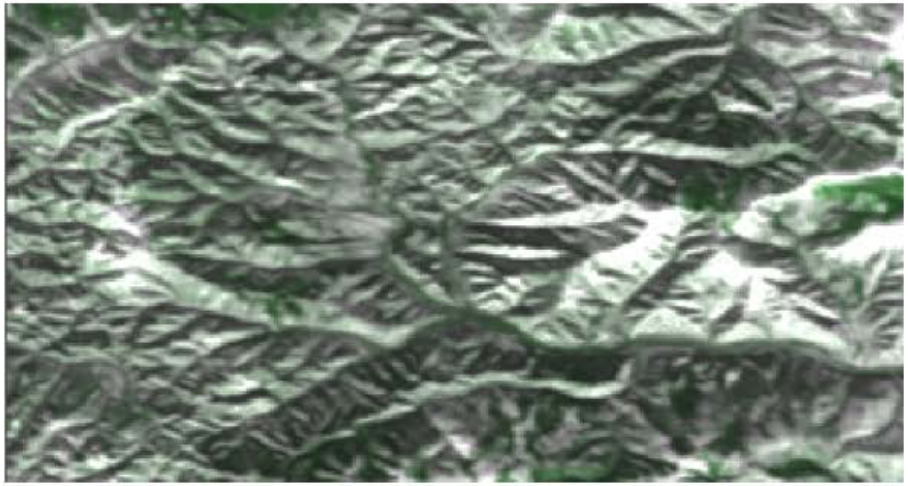




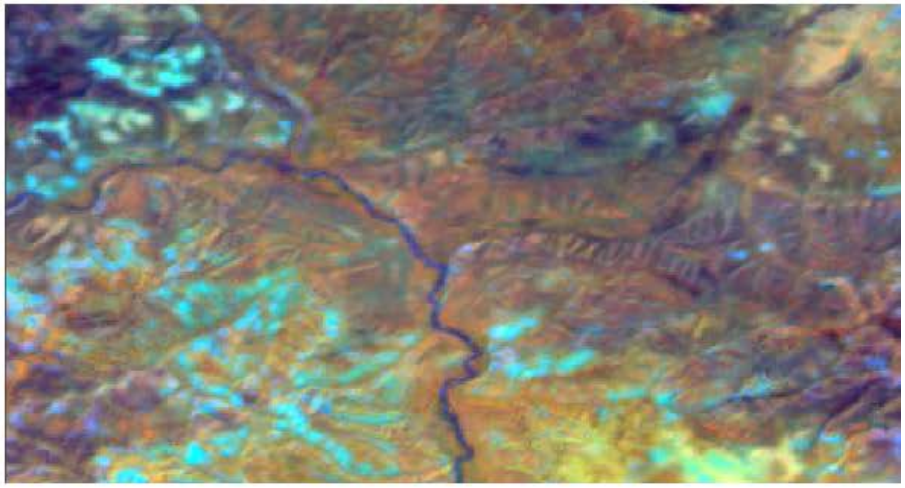
Topographic normalization effects

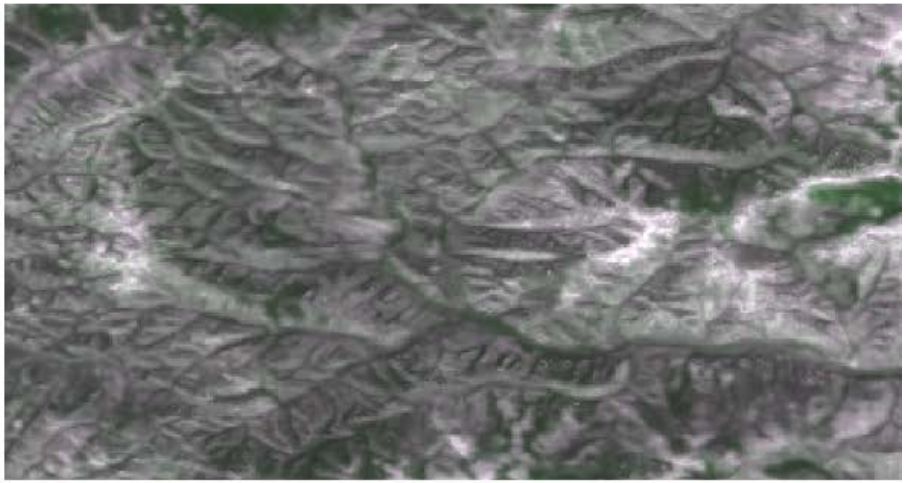
no topographic normalization



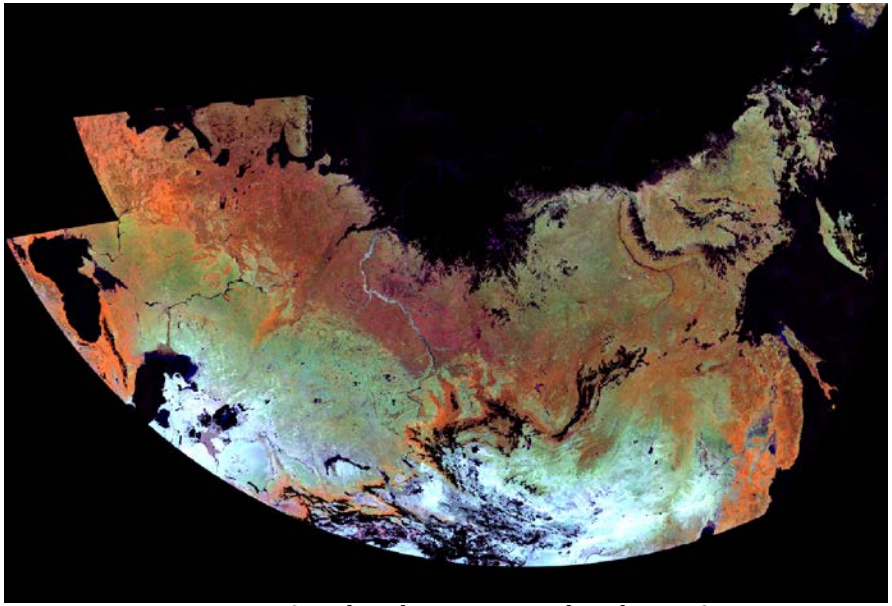


normalized images

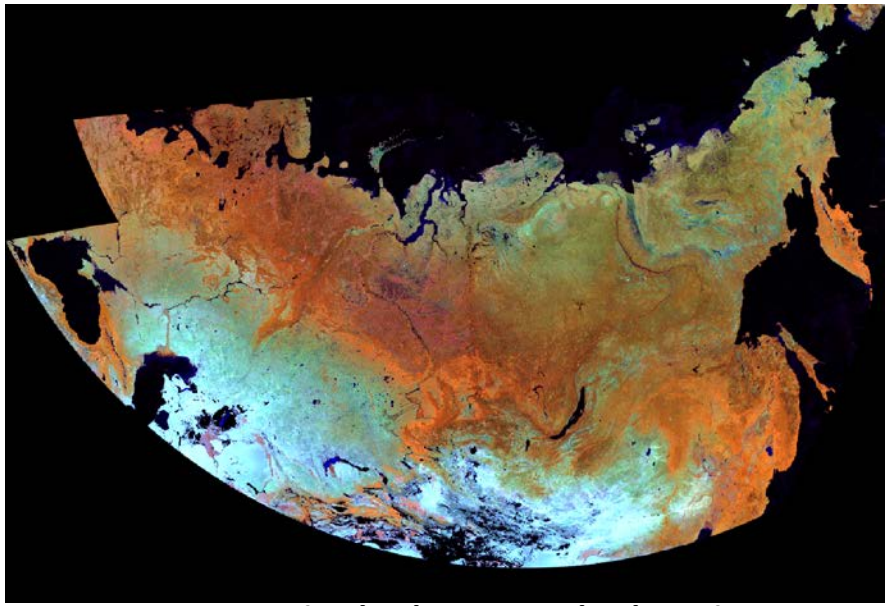




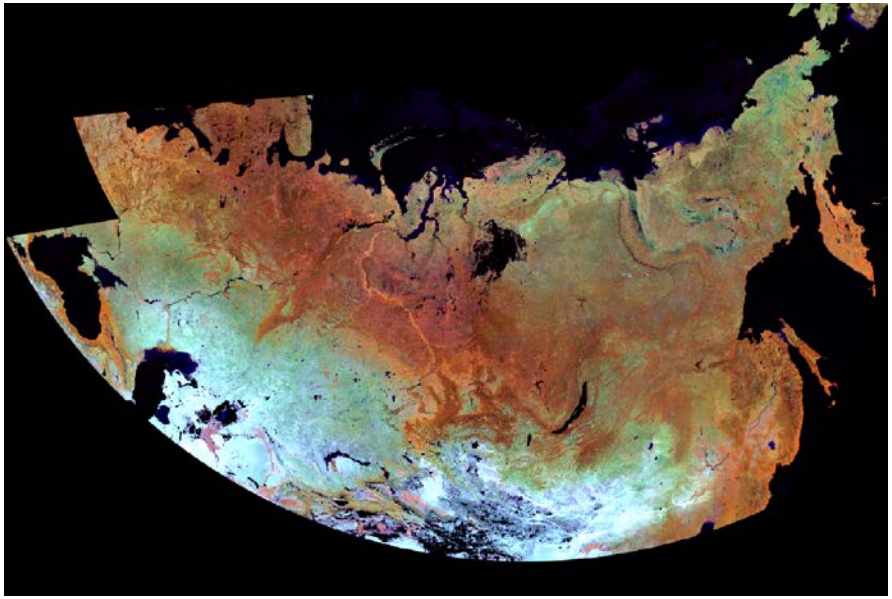
MODIS seasonal composites



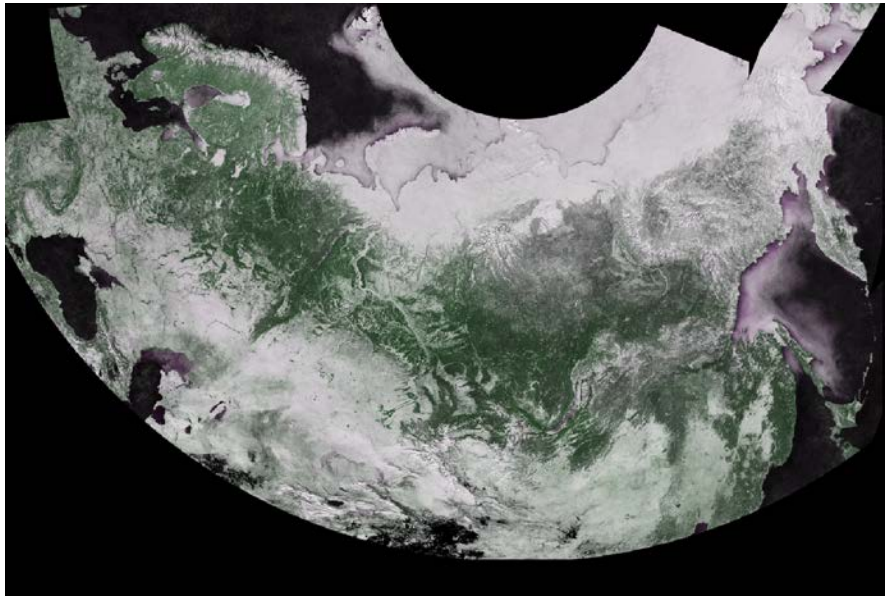
spring (15/04/2010 – 15/06/2010)



summer (15/06/2010 – 15/08/2010)

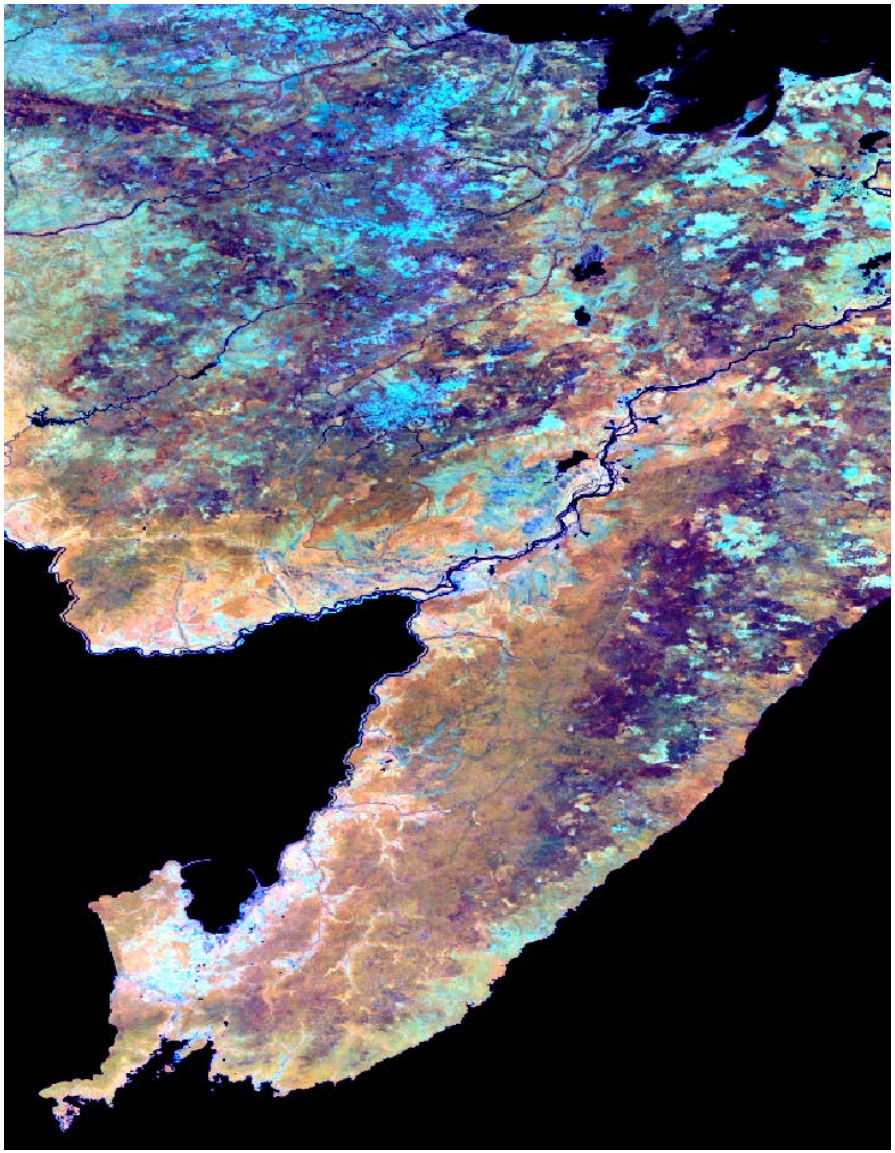


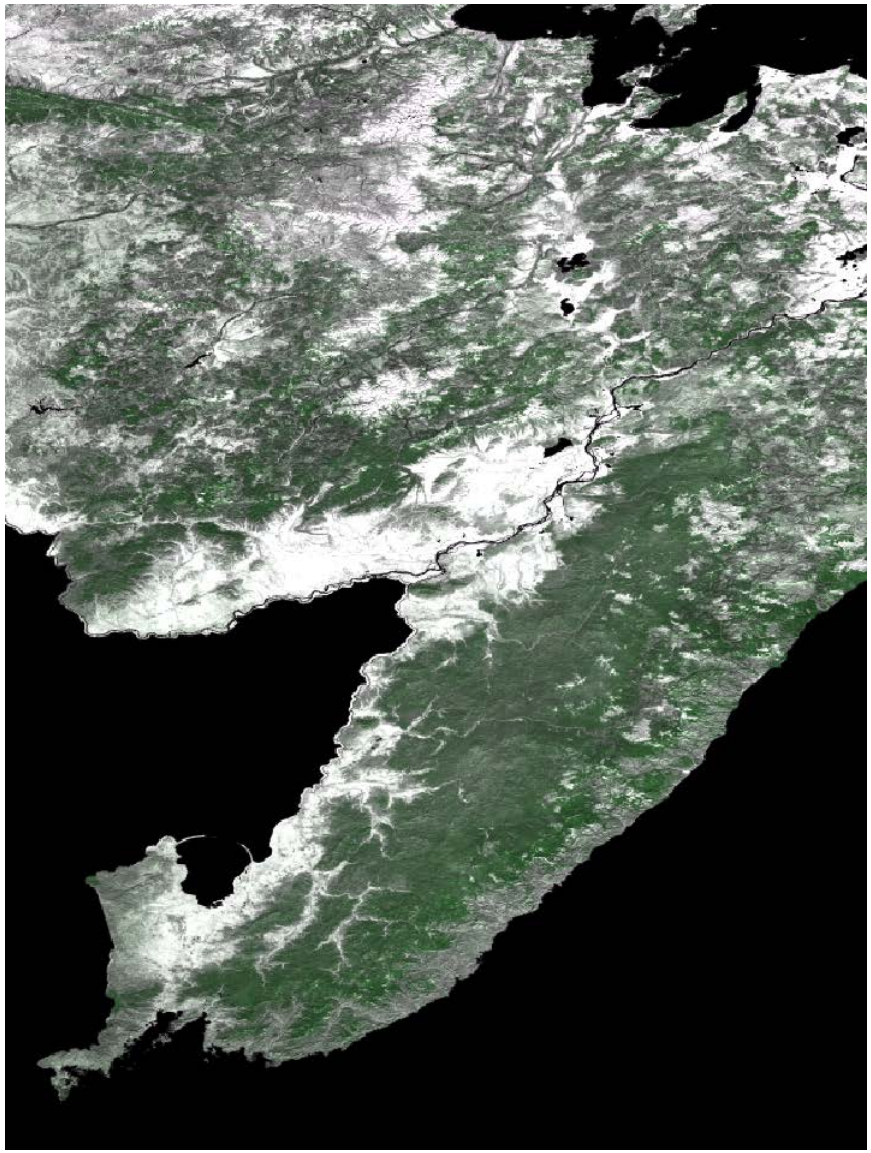
autumn (15/08/2010 – 15/10/2010)



winter (15/11/2009 – 15/03/2010)

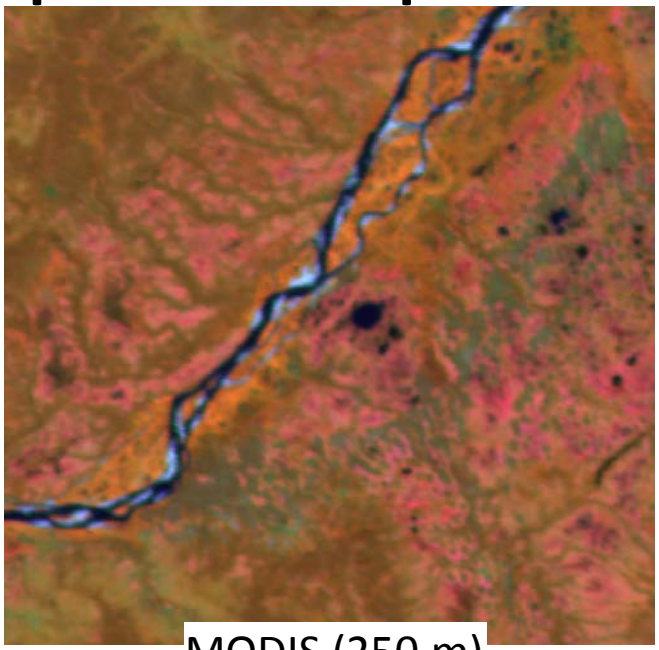
PROBA-V composite images



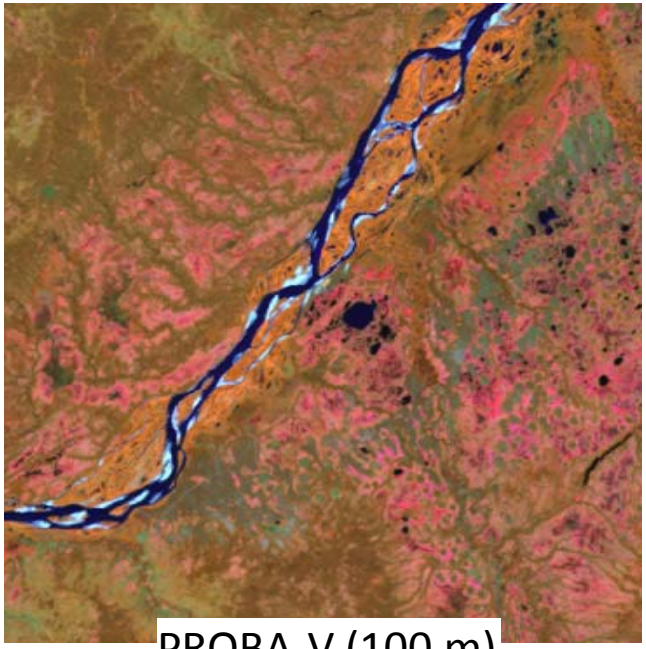


examples of PROBA-V summer (left, **R:** NIR **G:** SWIR **B:** RED)
and winter (right, **R:** RED **G:** NIR **B:** RED) composite images for Russian Far East

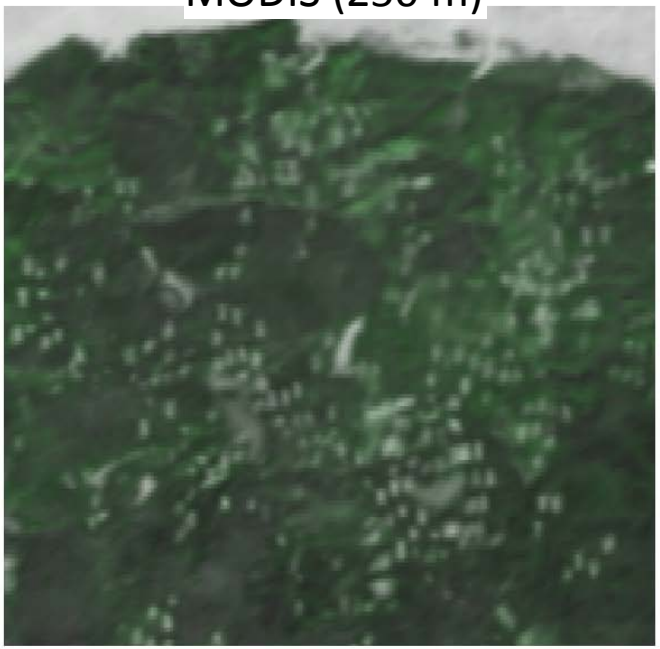
Improved spatial resolution effects

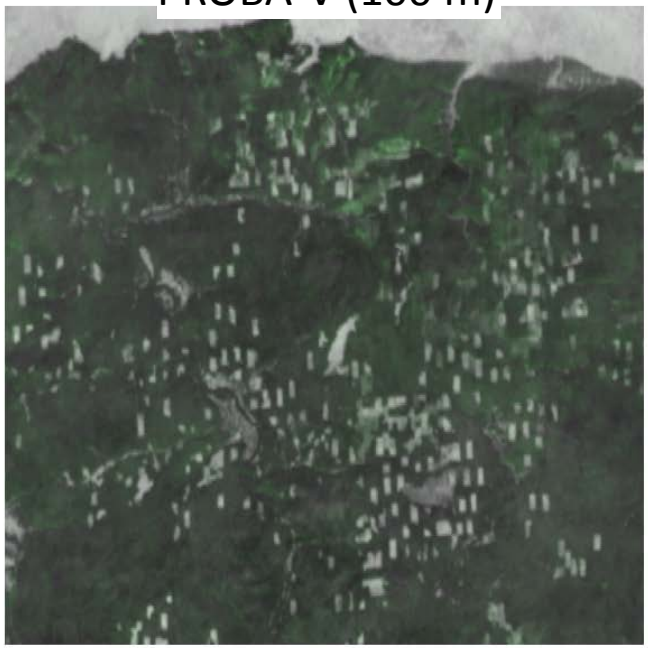


MODIS (250 m)

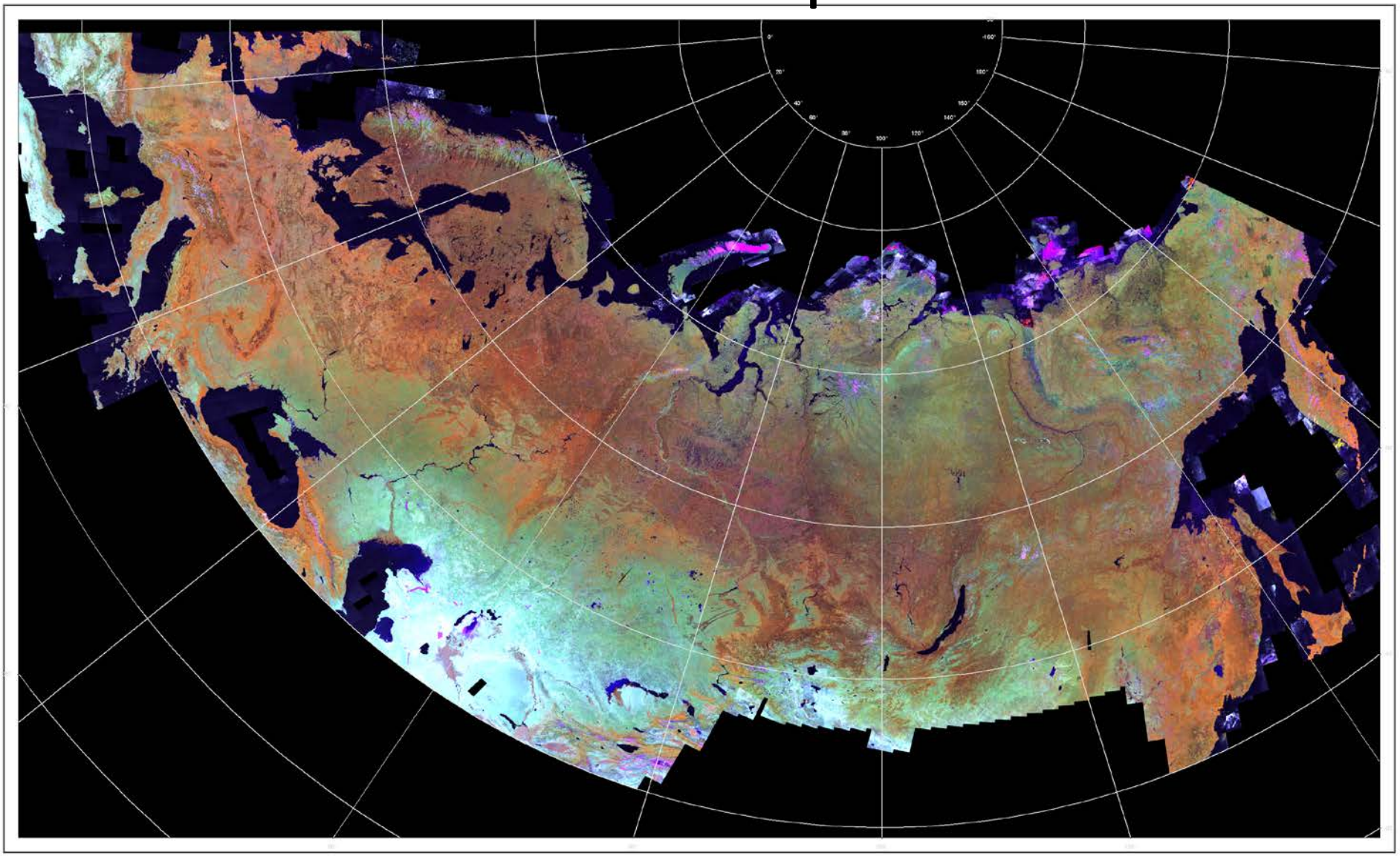


PROBA-V (100 m)



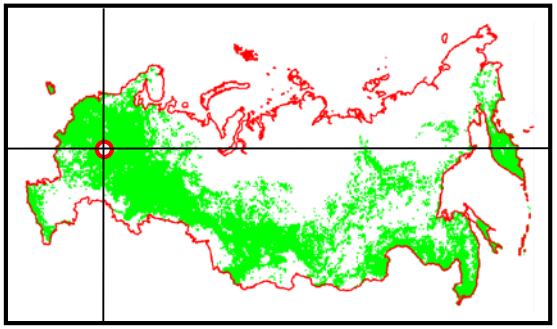


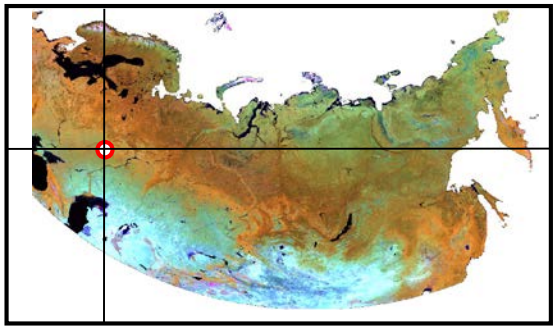
Landsat composite



The data processing chain allows yearly production of the Landsat-TM/ETM/OLI cloud-free composites over Northern Eurasia

LAGMA : Locally Adaptive Global Mapping Algorithm





Local spectral-temporal signatures of classes

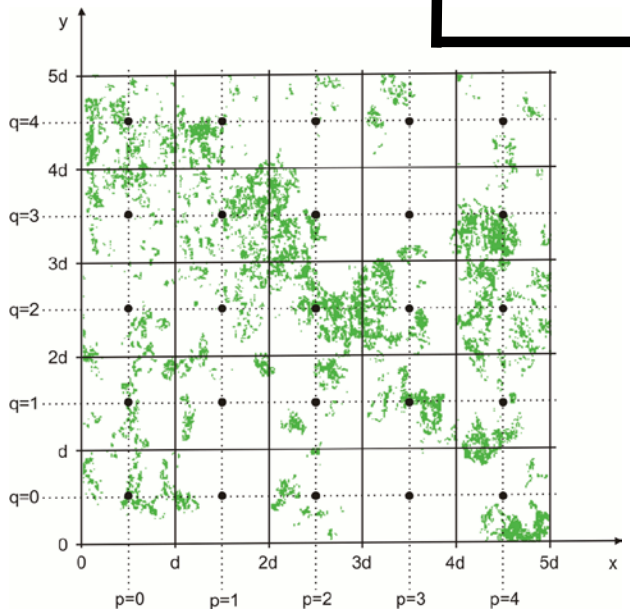
Σ_i — Covariation of metrics

$\bar{a}_i$ — Average of metrics

n_i — Number of samples

Spectral-temporal MODIS data

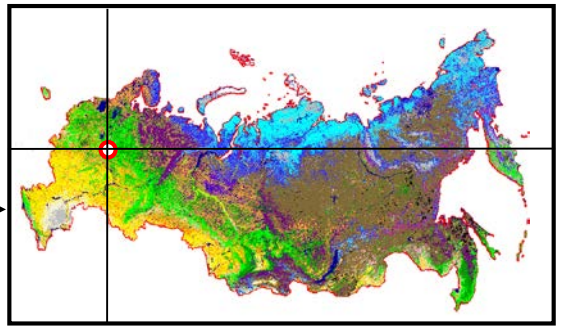
$\bar{x}$ — Metrics for the pixel



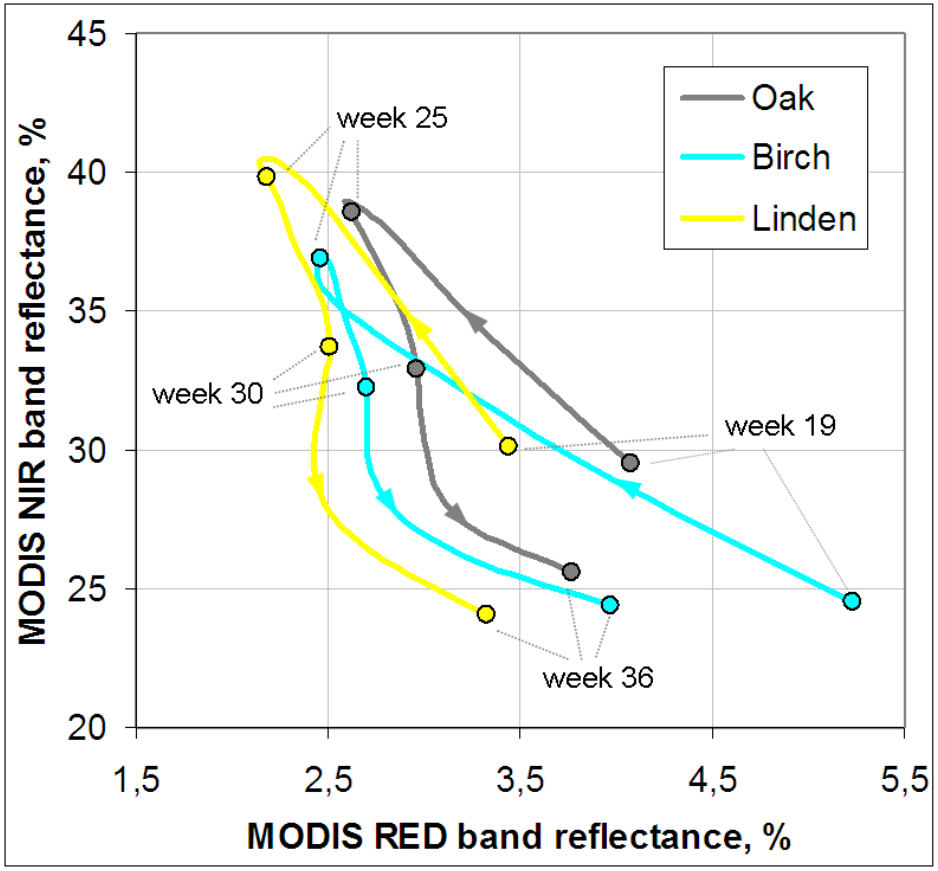
Maximum likelihood classifier

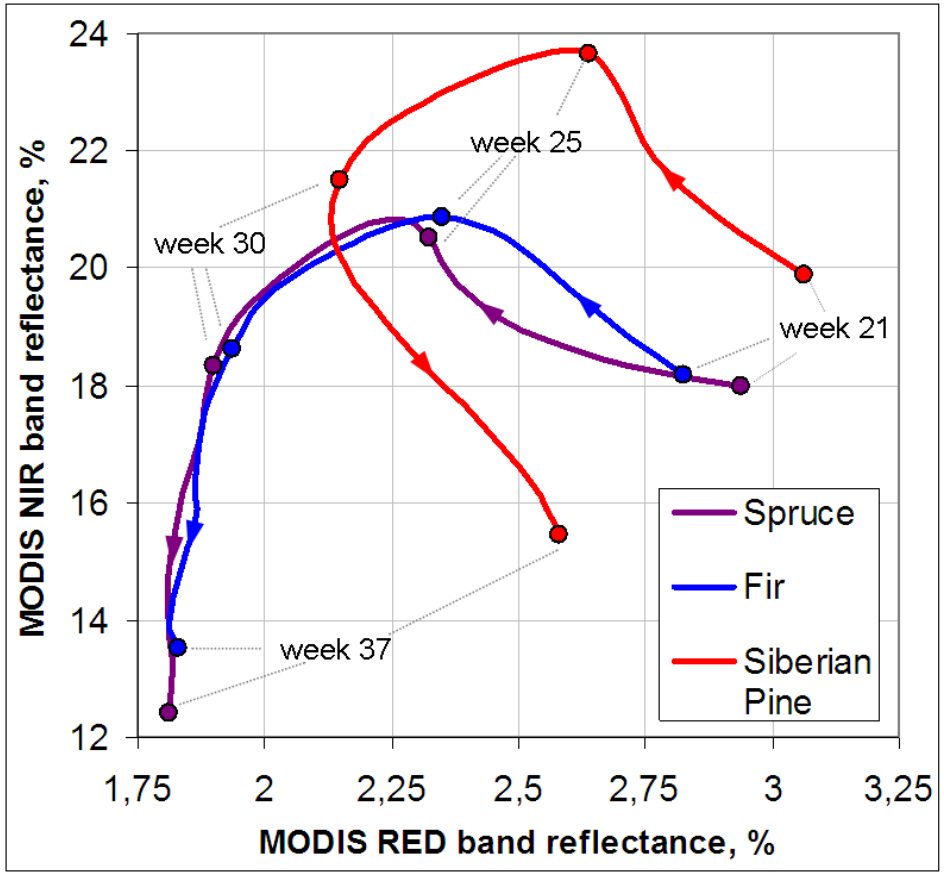
$f_i(\bar{x})$

Probabilities for classes

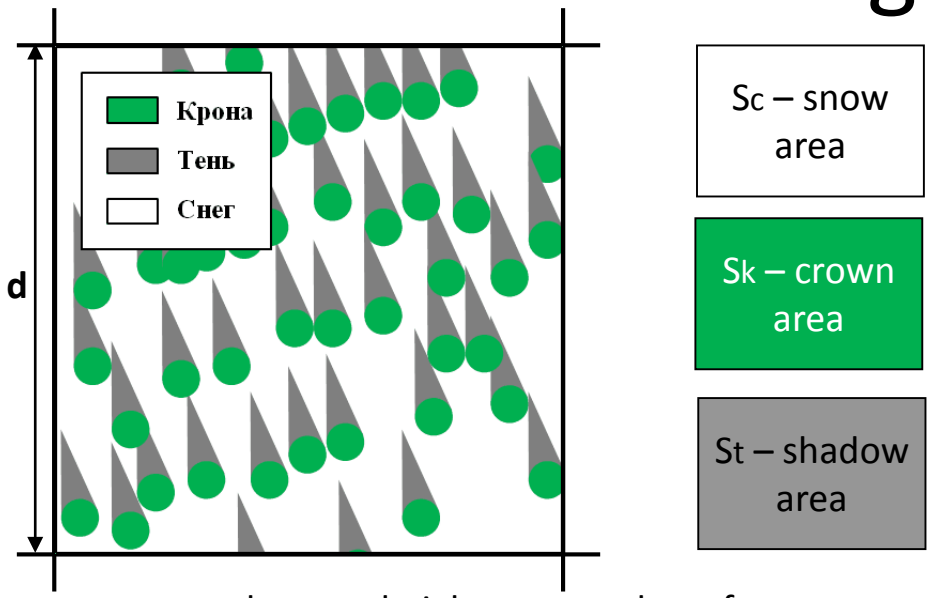


Tree species trajectories in RED-NIR space during a growing season

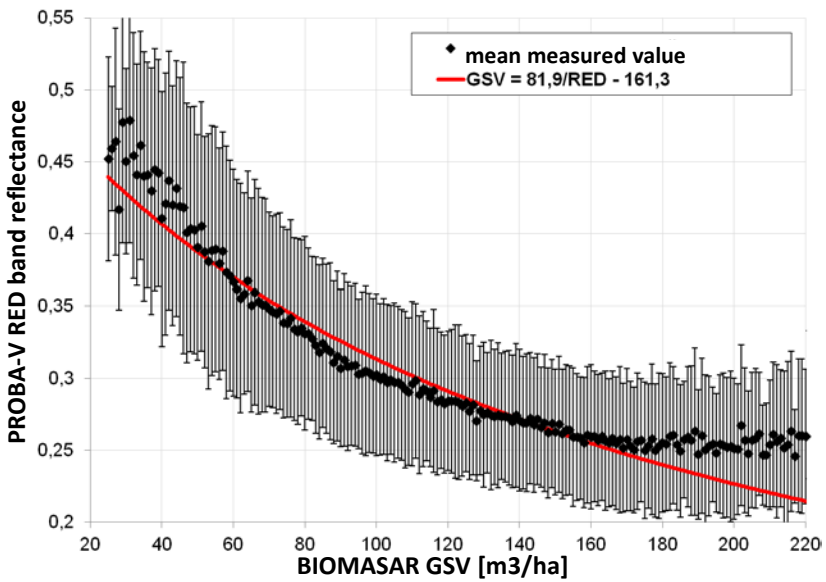




GSV estimation using “winter” EO data



h – tree height; n – number of trees



winter composite image reflectance-GSV relationship for pine forests in Russia

Pixel RED band reflectance:

$$R = f\left(S_c, S_k, S_t\right);$$

$$S_c = d^2 - S_k - S_t,$$

$$S_k = f_1(n), S_t = f_2(n,h),$$

$$R = f_3(n,h);$$

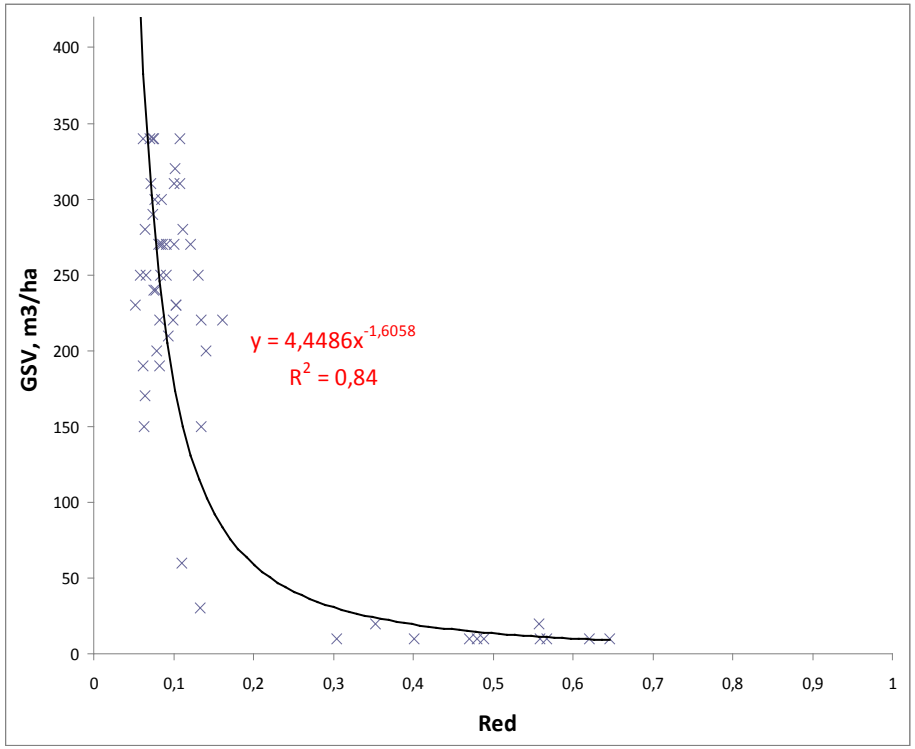
Pixel GSV:

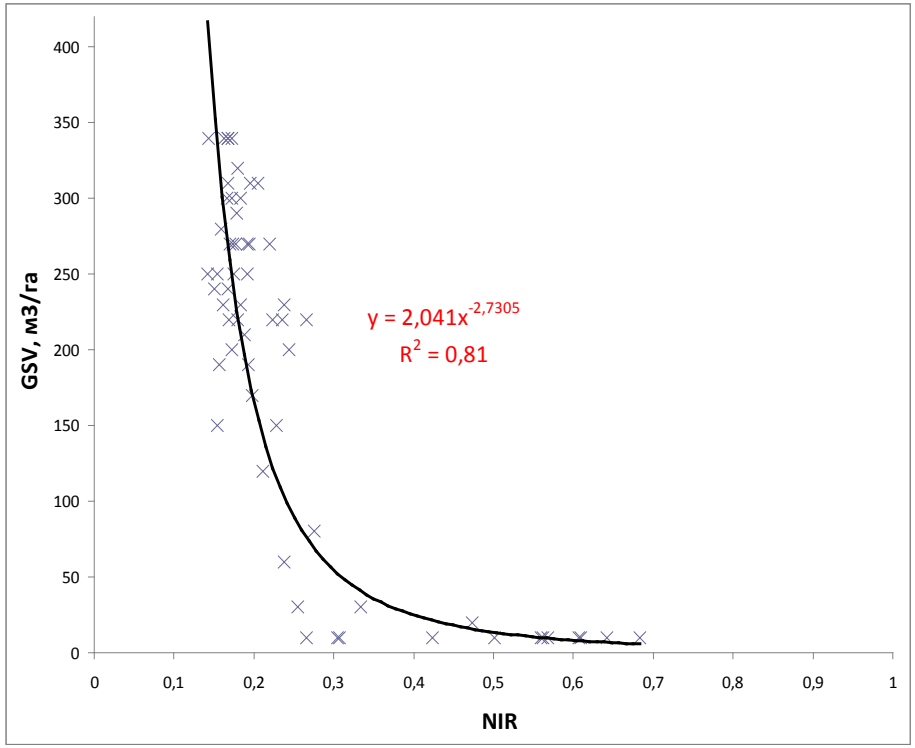
$$GSV\left[m^3/ha\right] = f_4(n,h)$$

<u>Model:</u>

$$GSV\left[m^3/ha\right] \sim 1/R$$

Relationships between GSV of spruce forests and surface reflectances in Red and NIR bands of Sentinel-2 “winter” image



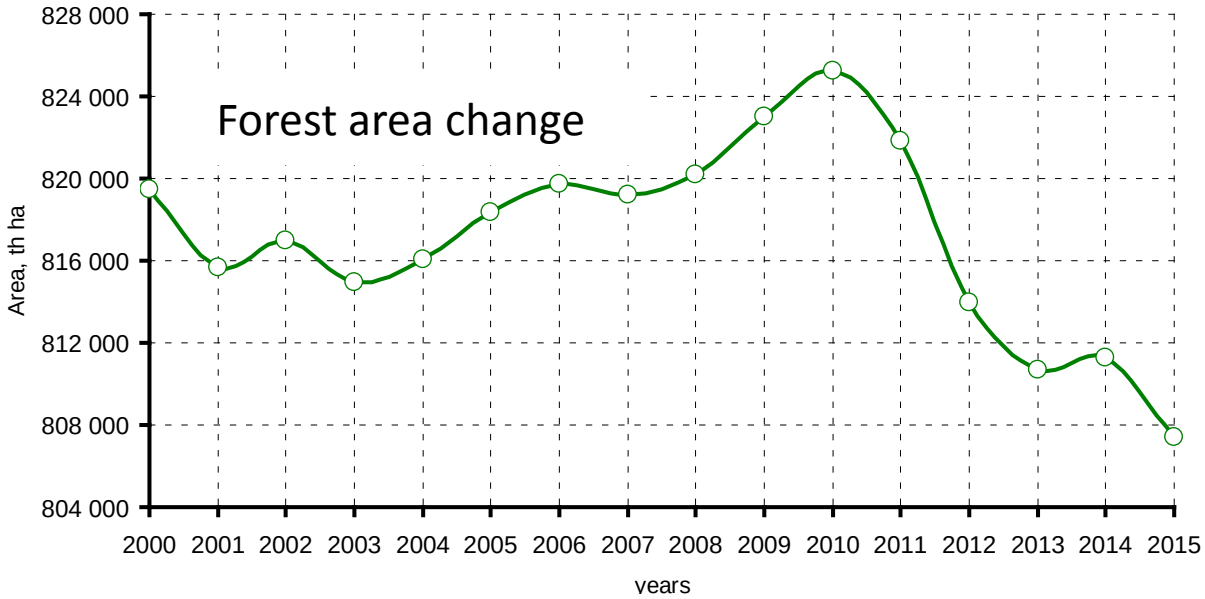


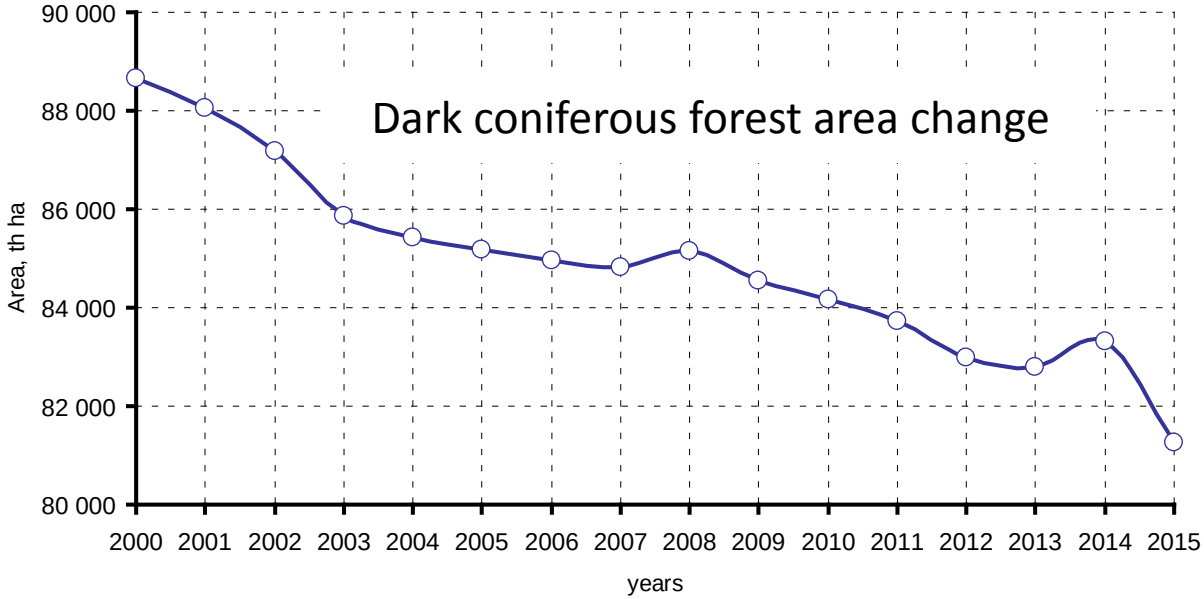
The land cover map of Russia based on MODIS 250 m

The forest cover is classified considering dominant tree species using seasonal time-series of MODIS data

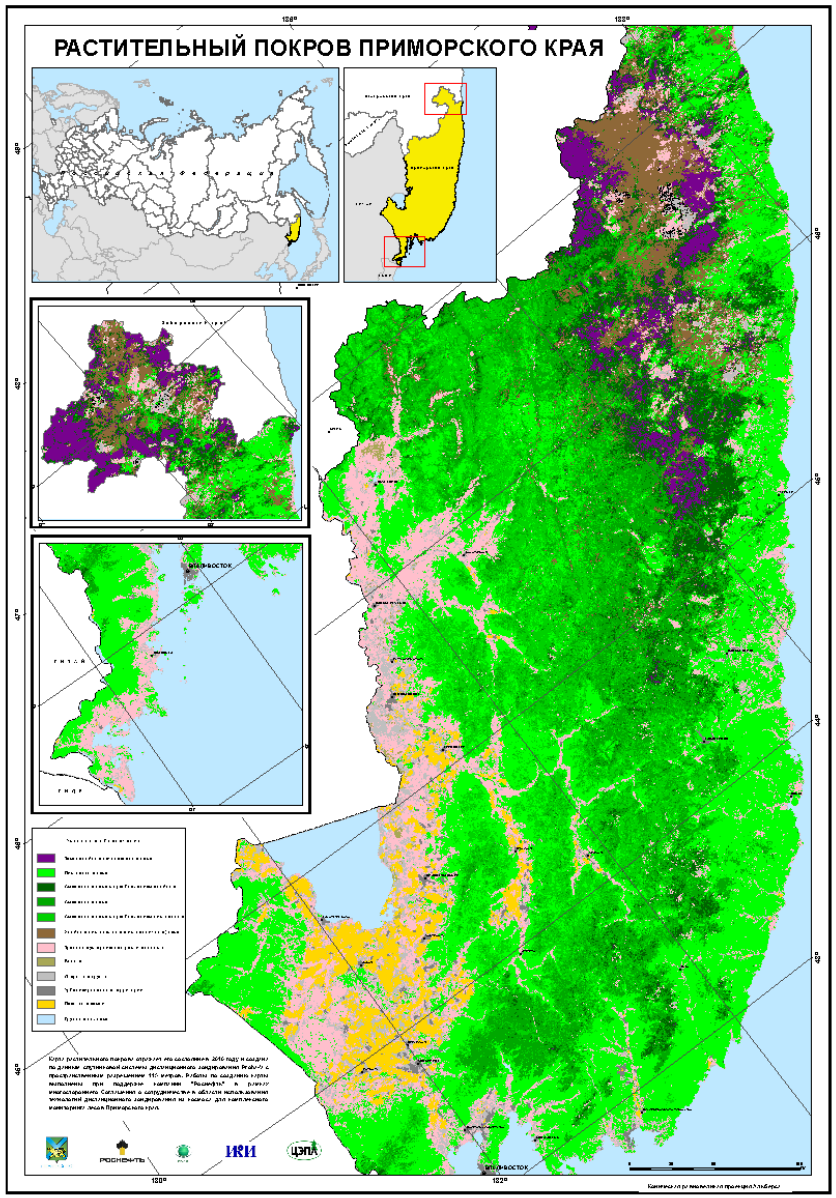
Enhanced forest GSV retrieval is based on Envisat-ASAR derived BIOMASSAR product and MODIS data snow composite synergy (250 m, year 2010).

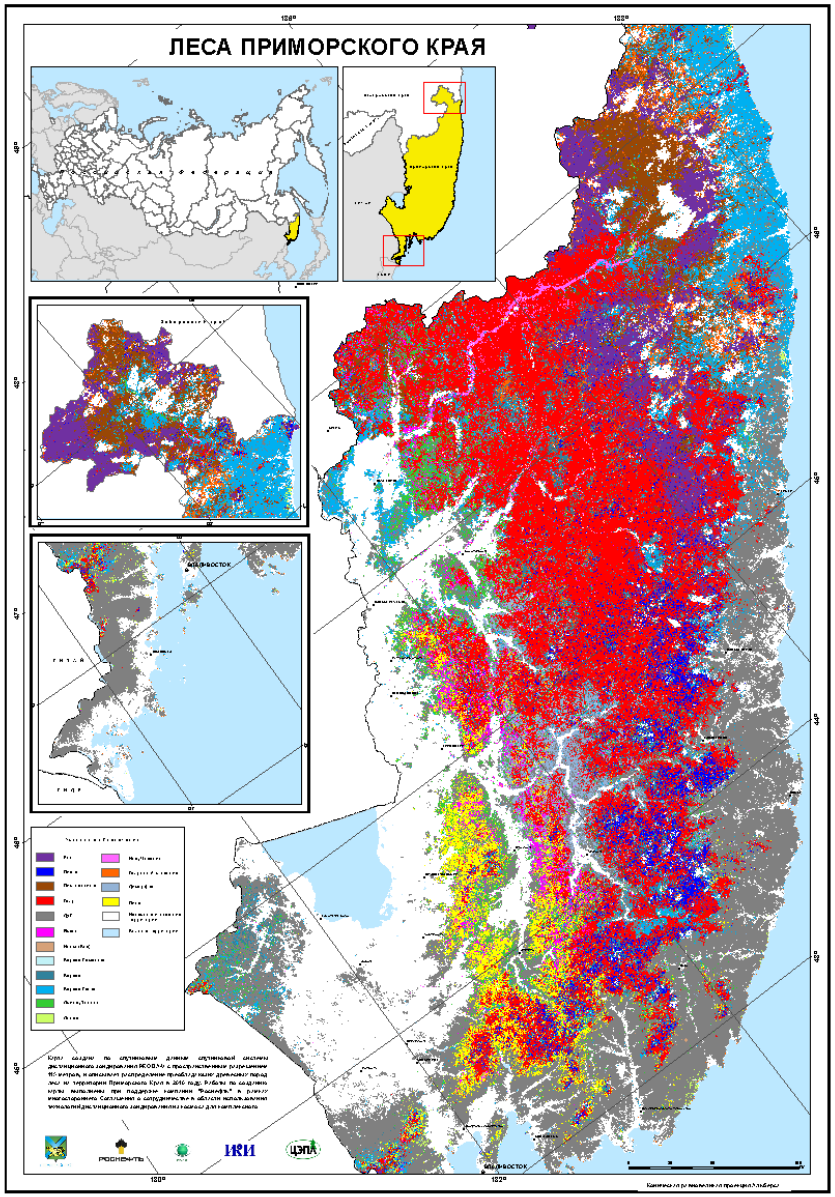
Forest area change in Russia based on MODIS





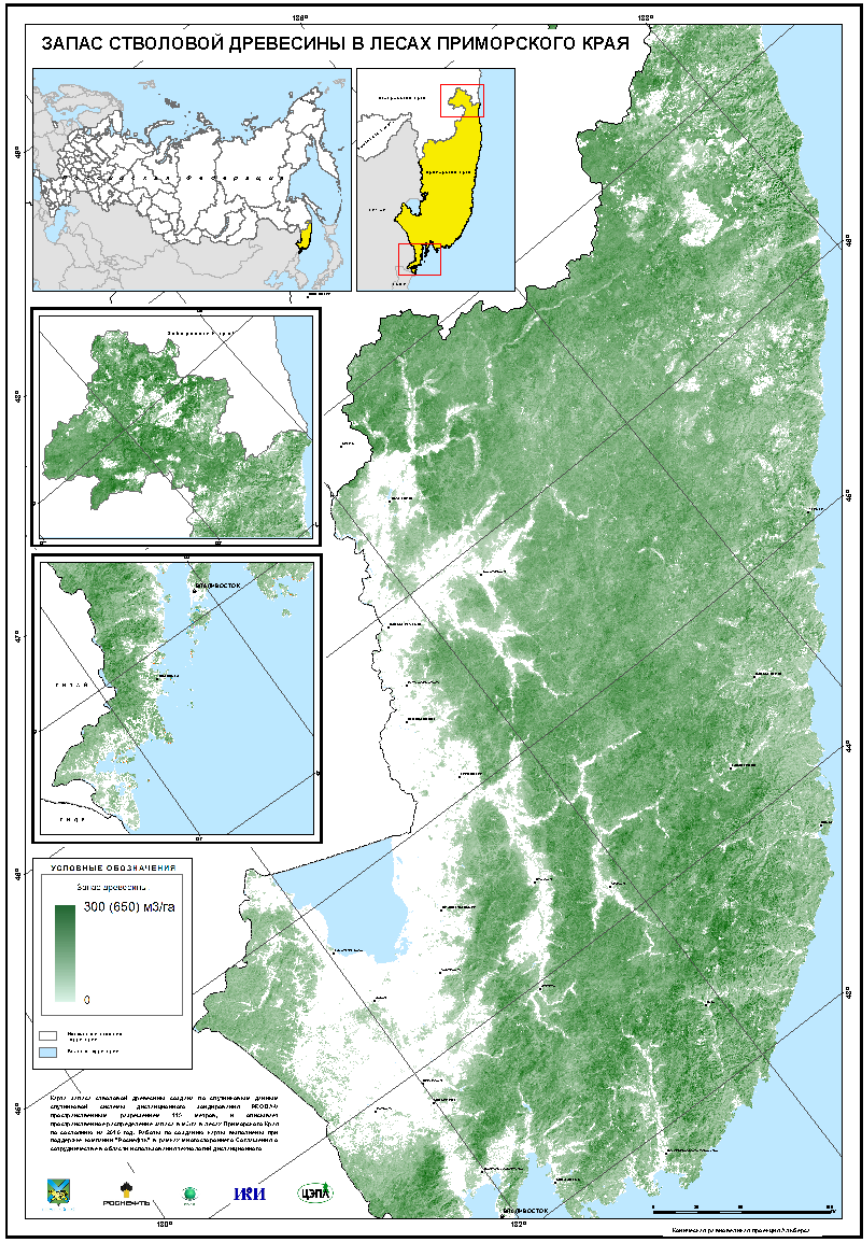
PROBA-V land cover and forest maps



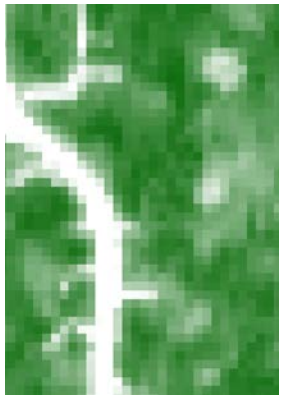


examples of Land Cover (left) and dominant forest tree species (right) maps based on 100 m resolution PROBA-V data for Primorsky Kray region

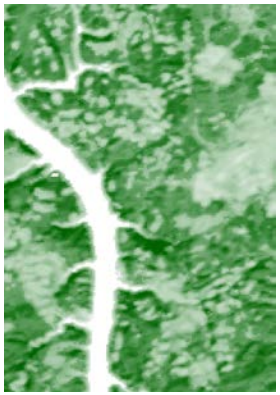
PROBA-V GSV map



100 m GSV map for Russian Primorskiy Krai region

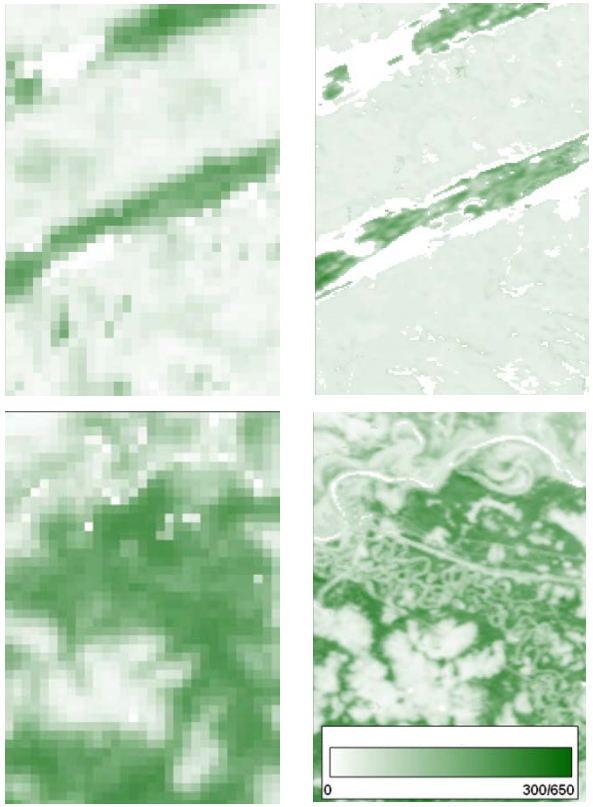


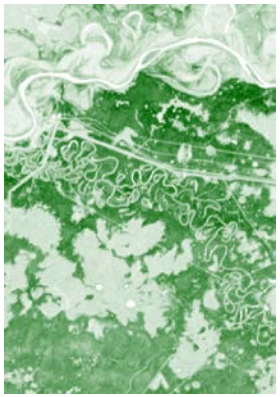
1 km BIOMASAR GSV



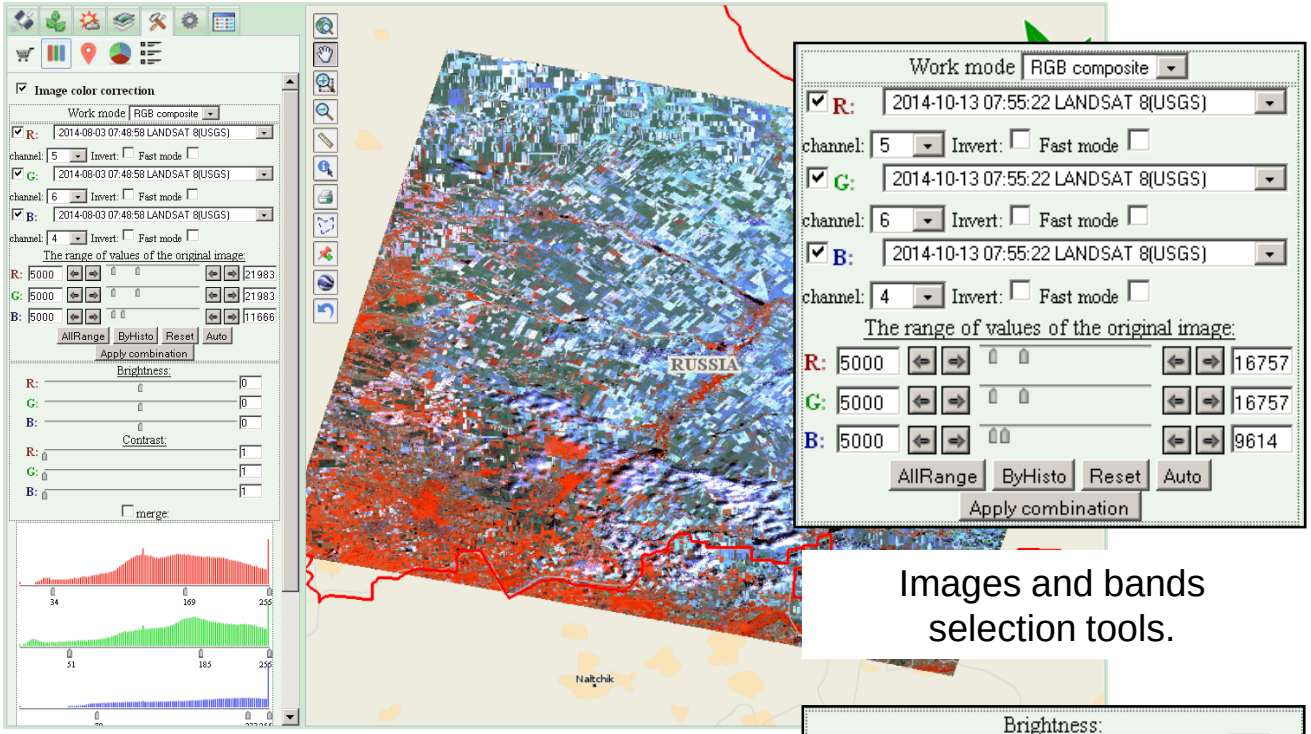
250 m MODIS GSV

100 m PROBA-V GSV

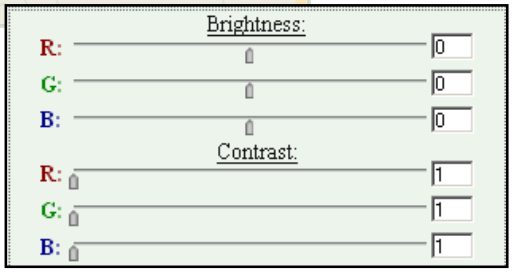




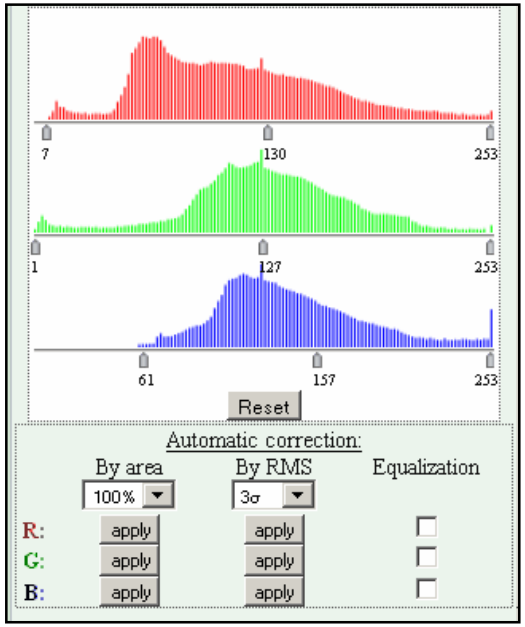
The VEGA EO data analysis tools: image enhancement and colour compositing



Images and bands selection tools.



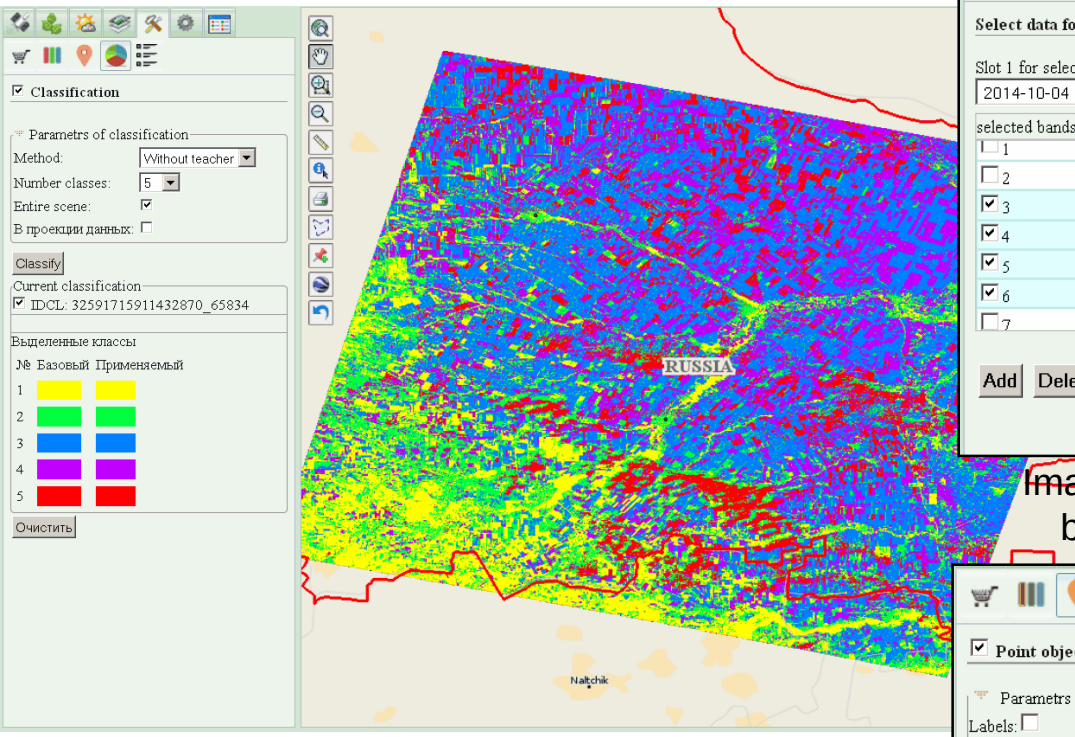
Brightness and contrast correction tools

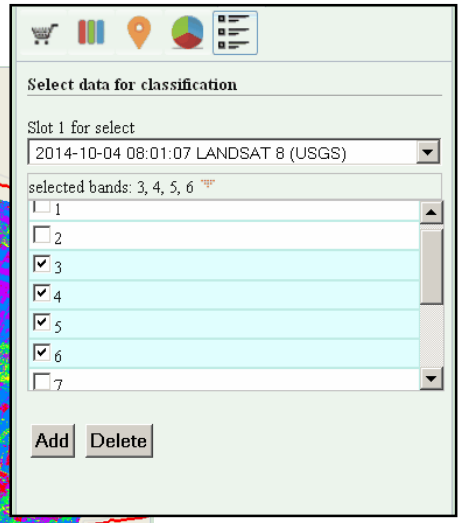


Tools for image histogram stretching

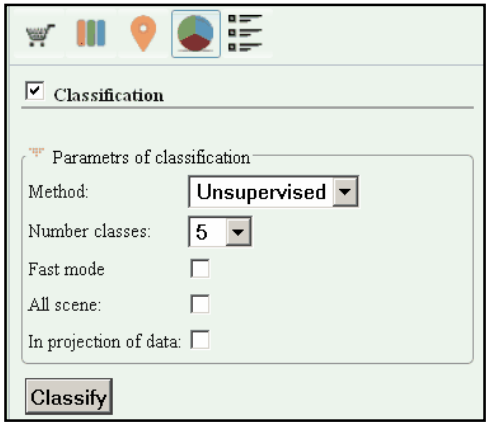
The tools for image enhancement as well as multi-spectral and multi-temporal color compositing.

The VEGA EO data analysis tools: image classification



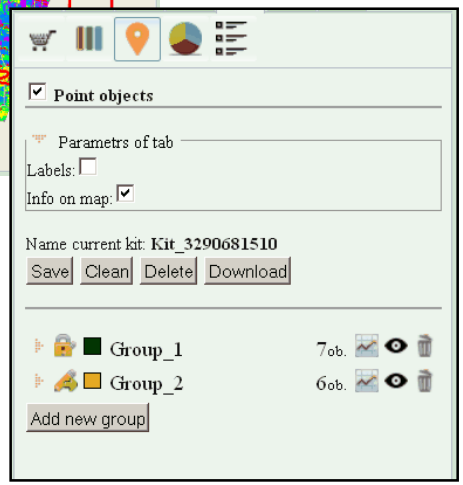


Images and spectral bands selection

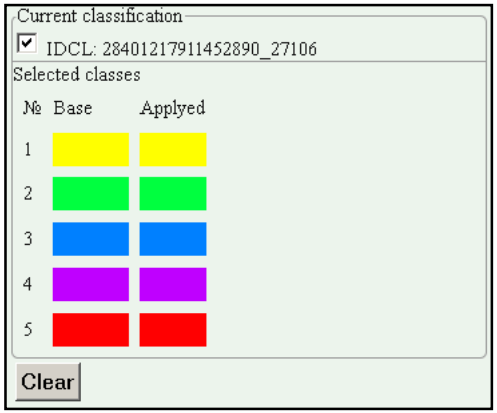


A classification method and parameters set

Map interface contains the supervised and unsupervised image classification tools.

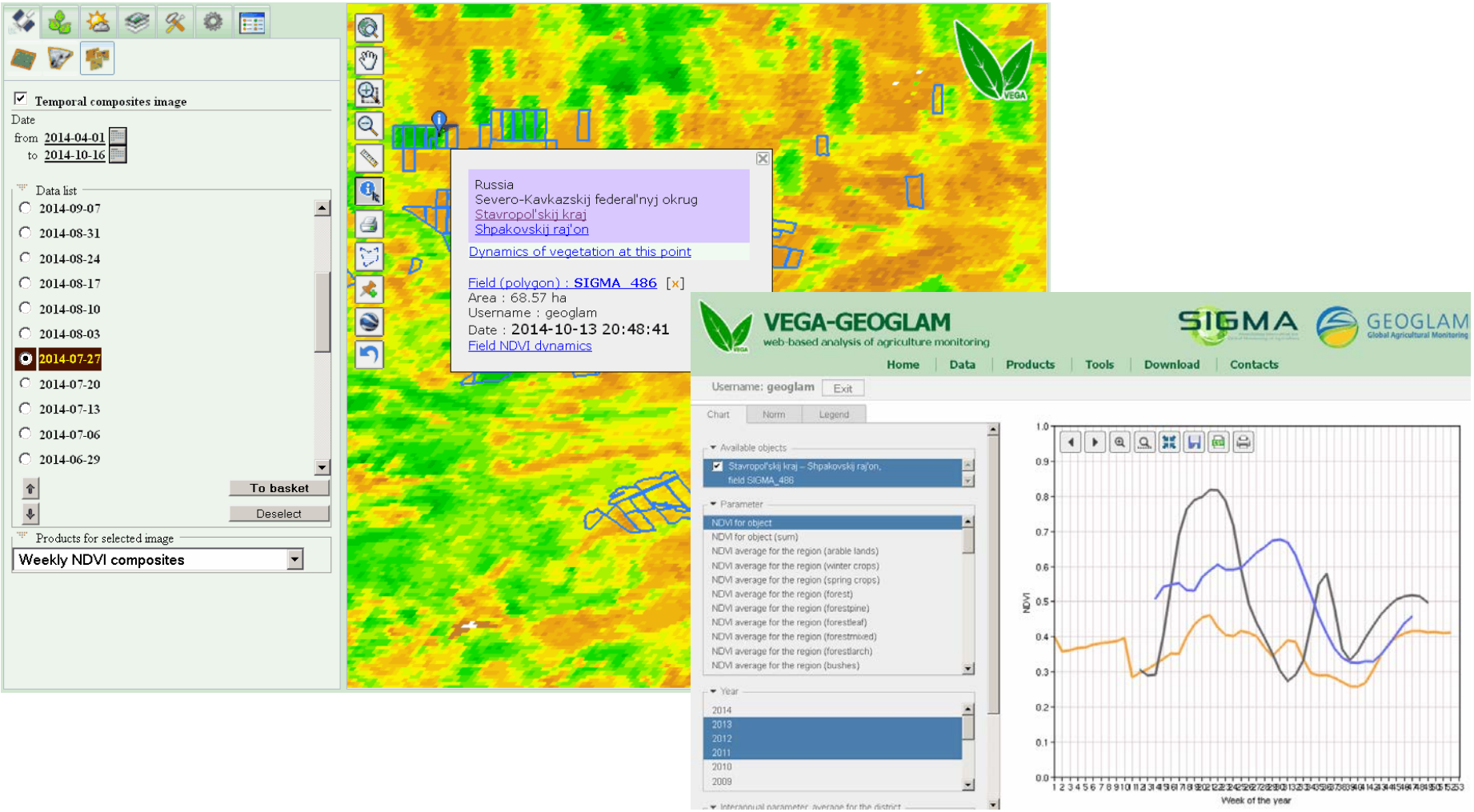


Training sites creation



Classification results

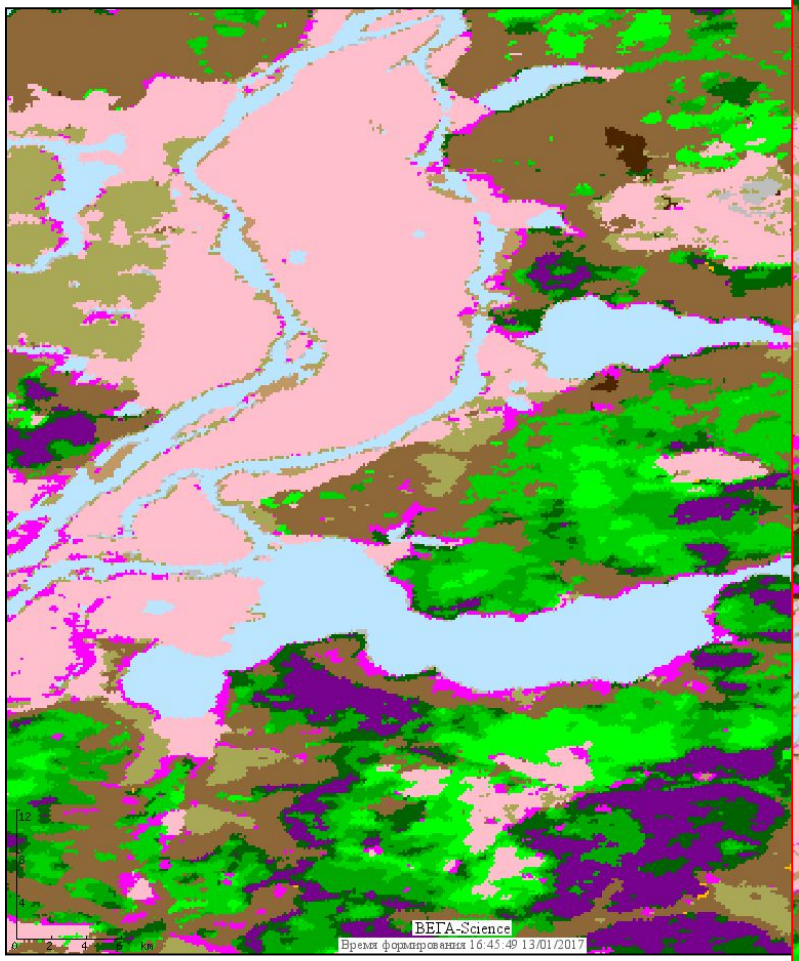
EO data time-series analysis using VEGA

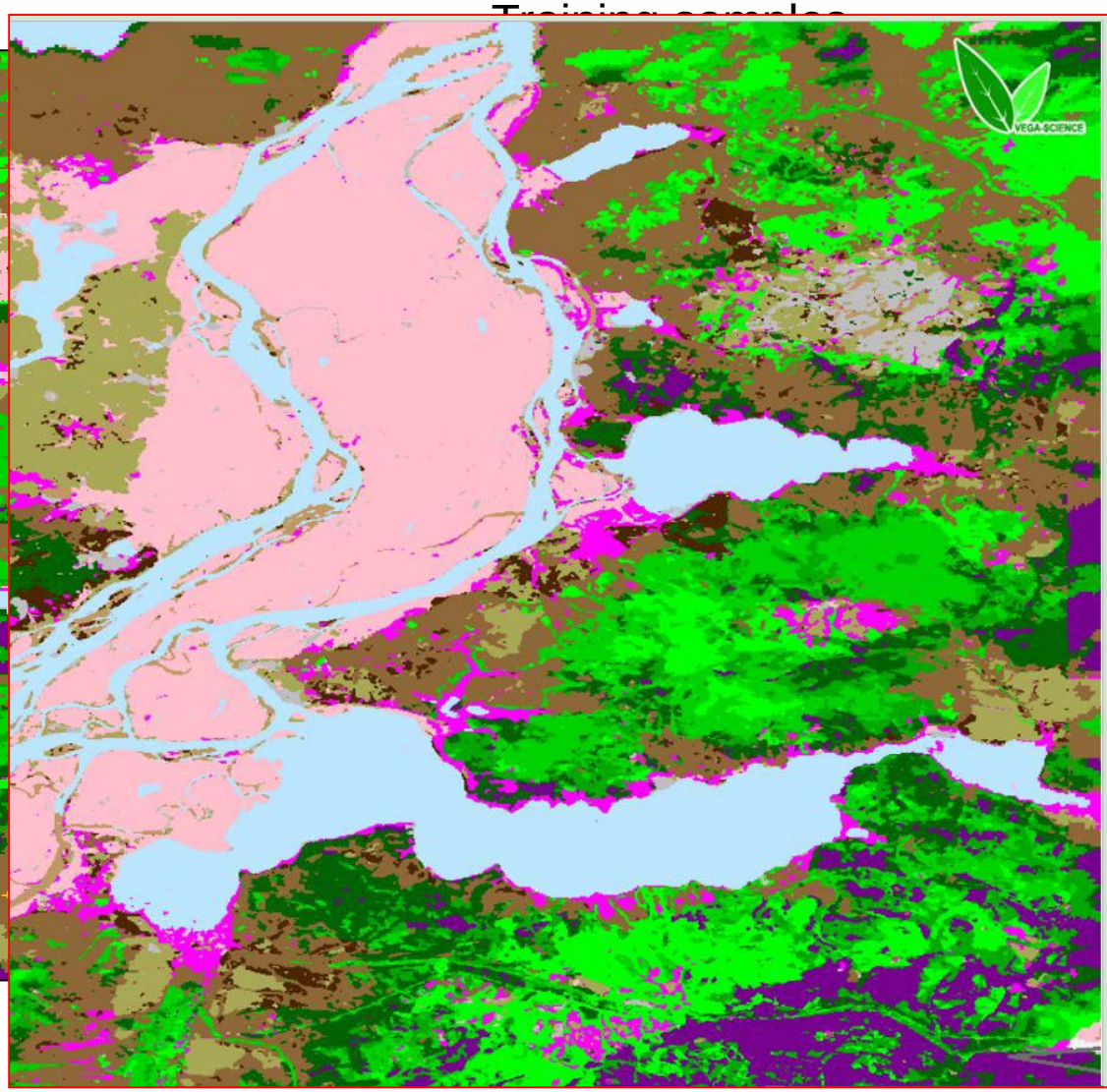


The VEGA provide access to NDVI multi-annual time-series data aggregated at users defined polygons (fields' limits).

Supervised classification of land cover types using EO data and VEGA tools

MODIS land cover map

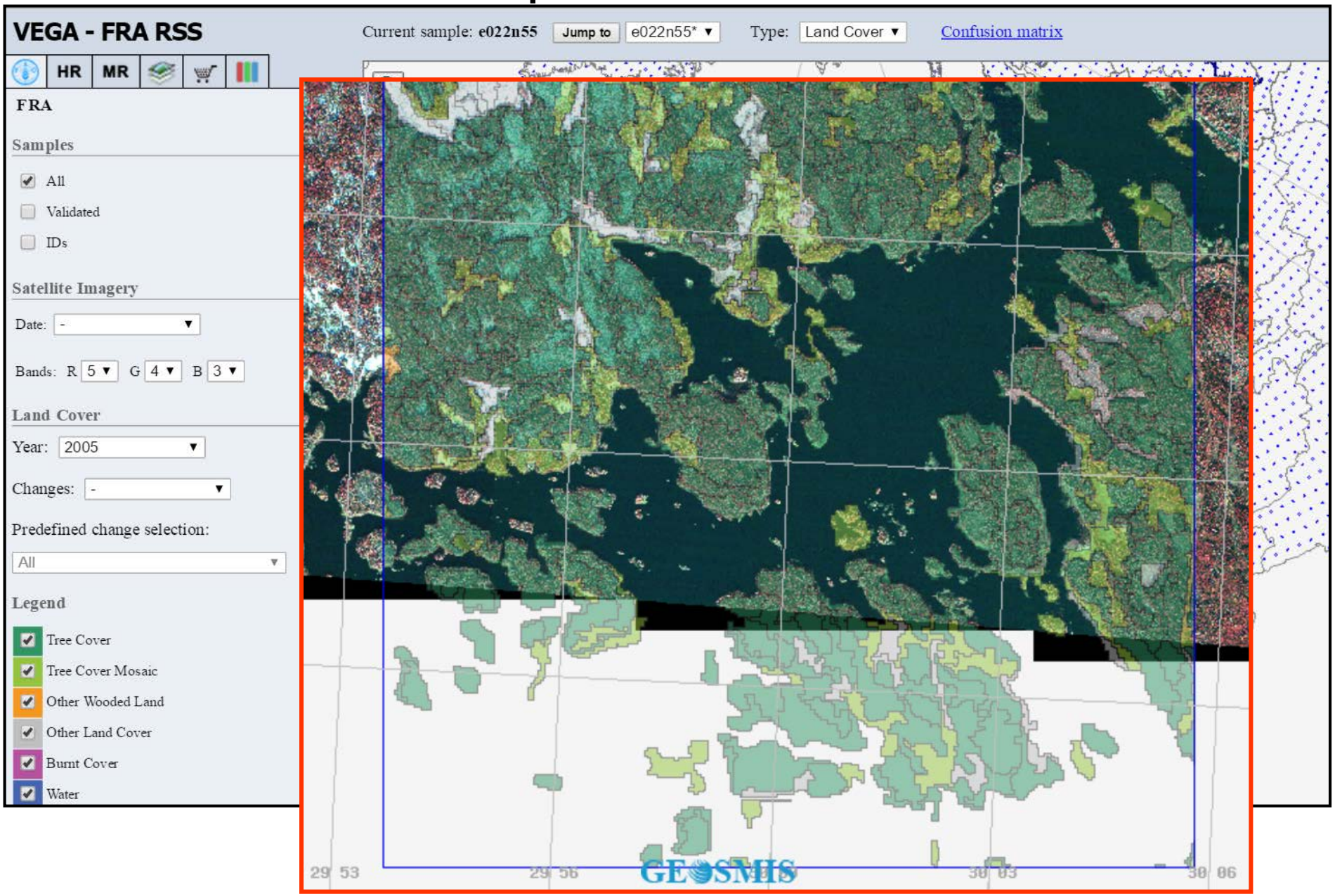




Landsat land cover map

VEGA-FRA RSS Service Prototype

http://fra.smislab.ru/



Thank you !