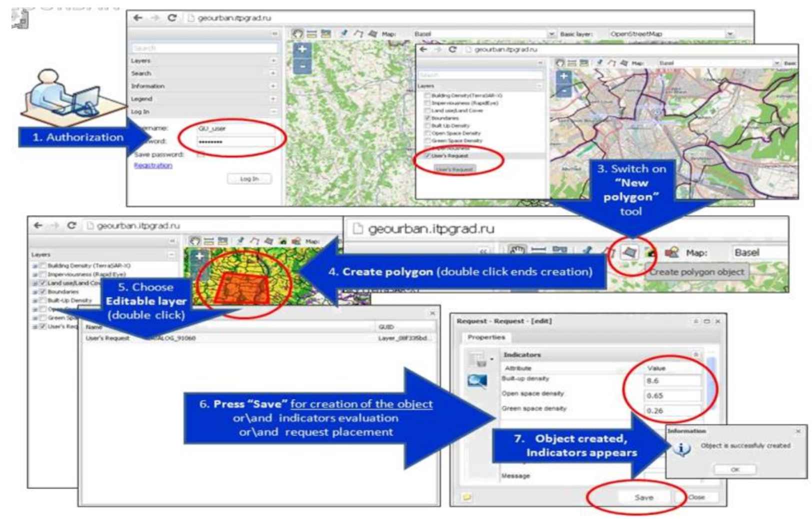
SEN4RUS

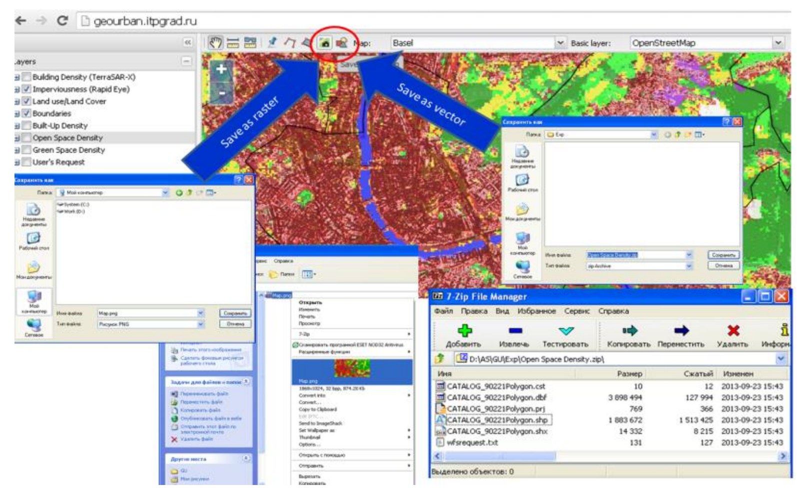
WP5: Progress and Planning

GRADI Ltd.
December 13, 2017
Athens, Greece

WP5 - SEN4RUS WIS development

- **The WIS** will be developed by optimizing and expanding the functionality and performance of the prototype developed in GEOURBAN
- **The WIS** will be web-based, easily transferable to any city, analytical and visualization components are included
- New cloud computing capabilities will be implemented
- **The WIS mobile application** will be developed





According to the national contract :

- **Methodology** for acquiring, processing and visualization satellite data, indicators evaluation, use cases and guides
- EO-based **Indicators** set
- **Software** for satellite data processing, visualisation and evaluation of the indicators

1. November 2016 – June 2017
2. February 2017 – August 2017
3. May 2017 – October 2017
4. November 2017 – April 2018
5. May 2018 – October 2018

R&D project name:
Development of software and methodology for exploiting EO results in the interests of Russian cities and regions development

Funding source: FASIE

Grantee: ГРАД www.itpgrad.ru

Methodology & Indicators:

Inputs specifications:

1. Free of charge satellite data Sentinel-1, 2, Landsat-8 and QuickBird.
2. The spatial resolution of Sentinel 1 images – 10 meters, Sentinel 2 – 20 meters, Landsat-8 – 30 meters and QuickBird – 0,5 meters
3. Optical images visible spectrum (RGB), infrared channel (IR) is required to derived vegetation and buildings, radar (two-dimensional) images is needed to produce DTM/DEM.

EO-based **Indicators** set:

A set of Indicators is selected by GRADI’s specialists (“CoP”) according to their usefulness and six Indicators are derived:

№	Indicator	Users	Objectives
1	Built-up Density	Citizen activists	Monitoring of the urban environment quality and comparing with the standards
2	Green Space Density	Citizen activists, municipalities, urban planners	Monitoring and planning of territory improvement. Calculate the necessary percentage of landscaping
3	Flood	Citizen activists, municipalities, farmers	Detection and estimation of flooding areas. Cartographic material preparation for reporting
4	Road Network Density	Citizen activists, municipalities, ecologists	Monitoring of the urban environment quality and comparing with the standards
5	DEM/DTM dislocation of the land cover	Cartographers, municipalities, urban planners, ecologists, geodesists	Monitoring of the land cover and it’s trans/ dislocation. Preventing landslides, detection of the emergences over the subway, mines/coalpits
6	Building Dynamics	Citizen activists, municipalities, urban planners	Monitoring of the building process in accordance with the standards or master plans and planning of the development perspectives

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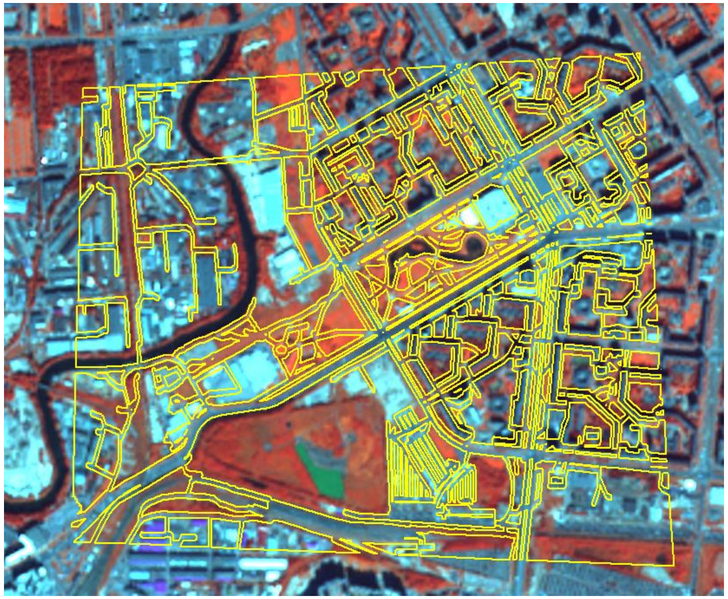
Built-up Density

$$\text{Built-up Density} = \frac{\text{built–up areas (buildings borders)}}{\text{polygon area } (user's/city/community\ borders)}$$

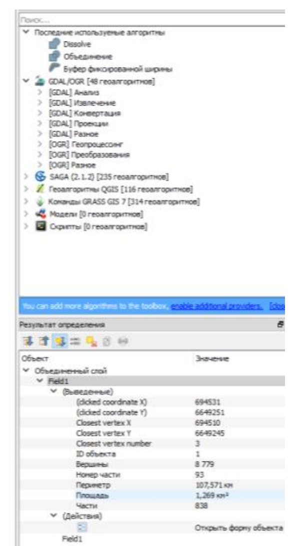


The result of classification is selected building (residential)

For residential zones

BUD = 0.31

BUD (according to the national standards) 0.2 – 0.6



Vector data processing and evaluation of the Built-up Density

Built-up Density

Input Requirements:

- Optical HR image (10 m, Sentinel-2)
- Cloudiness no more than 10%
- The current roads vector to the selected territory

Methodology:

1. Create a polygon area (if needed)
2. Exclude the vector of the road network (recommended)
3. Choose a set of building examples/etalons
4. Binary classification (within the polygon area)
5. Vectorize the result
6. Calculate by formula

$$\text{Built-up Density} = \frac{\text{built–up areas (buildings borders)}}{\text{polygon area } (user's/city/community\ borders)}$$

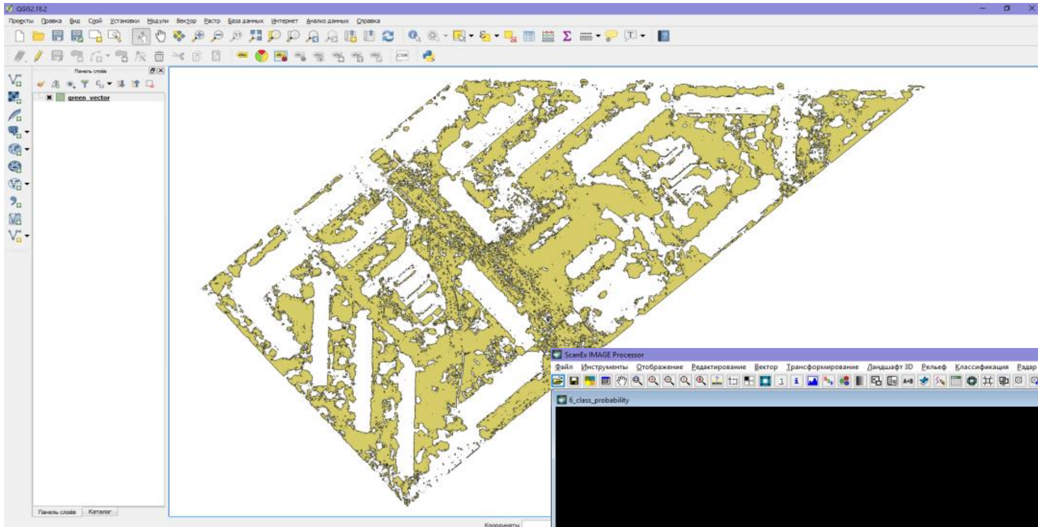
Built-up Density

Problems in evaluation:

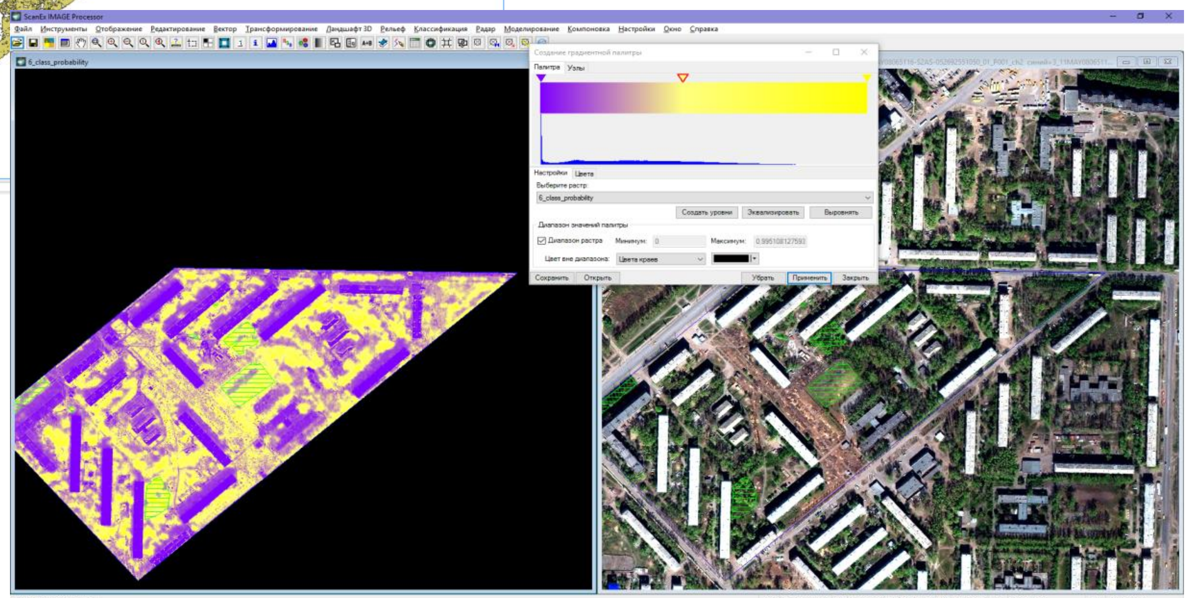
1. Alternative EO-data and different methods are needed for result verification
2. Built-up Density is not as useful as Built-up Density Ratio which is calculated as the ratio between the sum of all building floors area and built-up area, because it is impossible to atomize the calculation of the amount of all floors from a satellite image
3. The result of binary classification strongly depends on the quality of the satellite image. The result should be controlled by the operator
4. Roads networks and railways are determined as the same spectral class in the classification from the Sentinel-2 satellite optical images. It is necessary to use a vector layer with roads and railways in order to exclude them from calculations.

Green Space Density $= \frac{\text{green space}}{\text{polygon area } (user's/city/community\ borders)}$

The grass, bushes, hedges, football or other playing fields etc.



GSD = 0,46



Green Space Density

Input requirements:

- Optical HR image (10 m, Sentinel-2)
- Cloudiness less than 10%

Methodology:

1. Create a polygon area (if needed)
2. Exclude the vector of the road network (recommended)
3. Choose a set of greens examples/etalons
4. Binary classification (within the polygon area)
5. Vectorize the result
6. Calculate by formula

$$\text{Green Space Density} = \frac{\text{green space}}{\text{polygon area}\ (user's/city/community\ borders)}$$

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Green Space Density

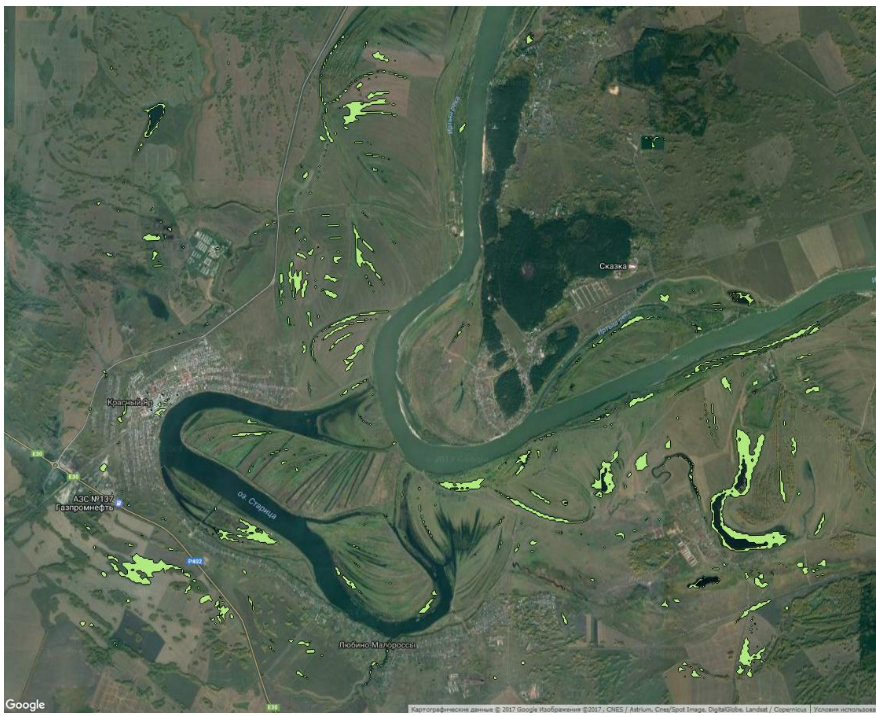
Problems in evaluation:

1. Alternative EO-data and different methods are needed for result verification
2. There are no national standards to compare with results that is why the indicator is not useful and “just for information”
3. It is impossible to get a different types of green spaces/vegetation from the Sentinel-2 images

Flood

is the difference between two vector layers of water objects, acquired in different time

The result of binary classification and vectorization



Flooding zones

Flood

Input requirements:

- Two optical images, e.g. Landsat-8 (1^{st} image – any time, 2^{nd} – during flooding period).

Methodology:

1. Create a polygon area (if needed)
2. Choose a set of water examples/etalons on 1^{st} image
3. Binary classification (within the polygon area) on 1^{st} image
4. Vectorize the result on 1^{st} image
5. Repeat steps for the 2^{nd} image
6. Calculate the difference between two vector layers

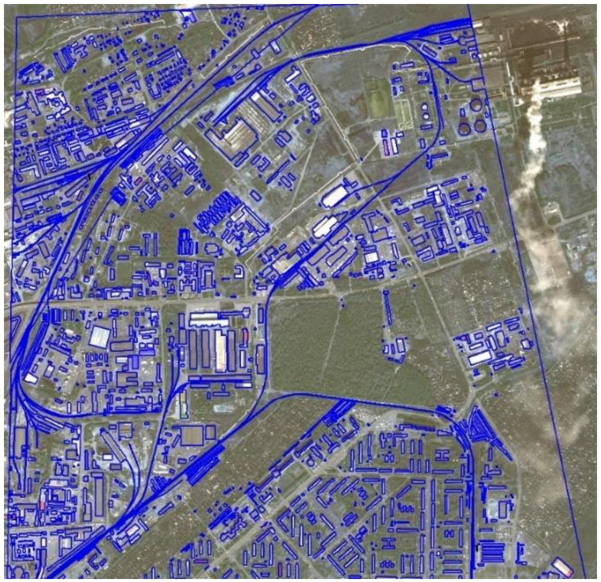
Flood

Problems in evaluation:

1. In order the indicator will be used by municipalities It should be legalized and officially confirmed by authorities that is why the indicator is not useful and “just for information”

$$\textbf{Road Network Density} = \frac{\text{total length of roads}}{\text{polygon area } (\textit{user's/city/community borders})}$$

Roads centerlines



Overlaying the vectors of railways and buildings (Omsk)

The result of roads vectorization after the classification and filtration

RND = 1,9 km/km2

RND (according to the national standards) 1.5 – 4.5 km/km2

Road Network Density

Requirement for source data:

- Optical image with HR (5 meters, QuickBird)
- Vector of the roads and railways

Methodology:

1. Create a polygon area (if needed)
2. Exclude the vector of the buildings and railway (recommended)
3. Choose a set of road examples/etalons
4. Binary classification (within the polygon area)
5. Filter the image (Gaussian smoothing filter)
6. Vectorize the result
7. Determine the roads centerlines
8. Calculate the total length of the roads centerlines
9. Calculate by formula

$$\text{Road Network Density} = \frac{\text{total length of roads}}{\text{polygon area}\ (user's/city/community\ borders)}$$

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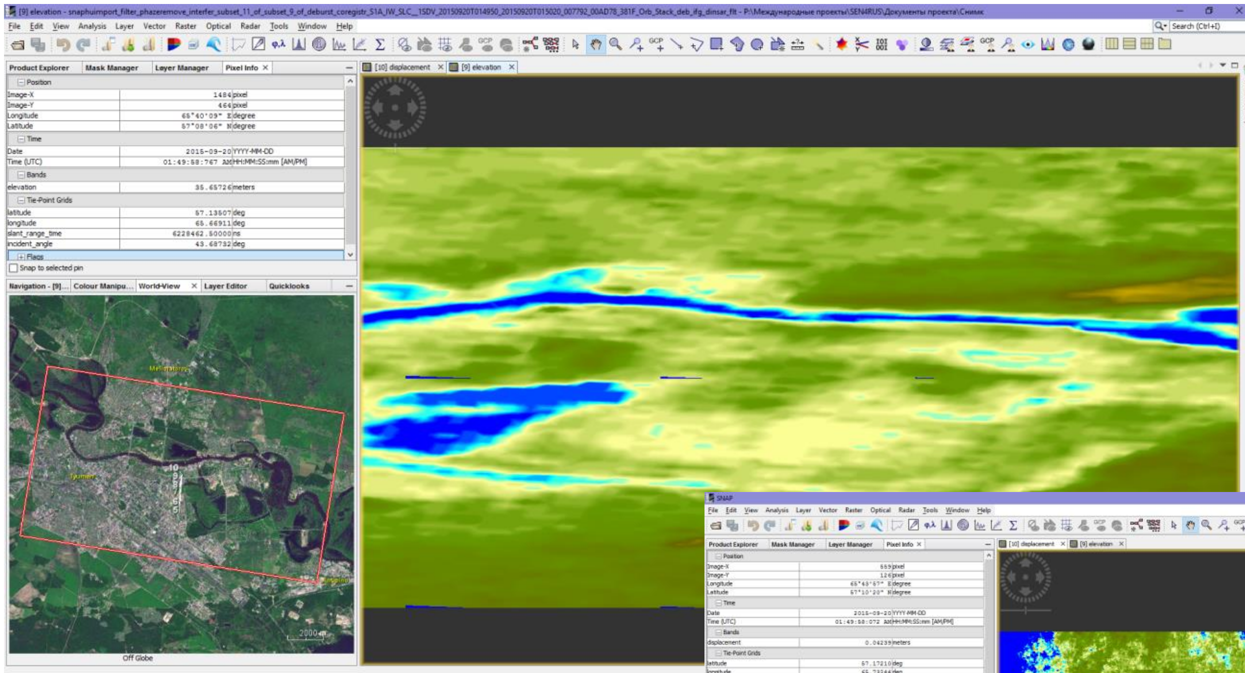
Road Network Density

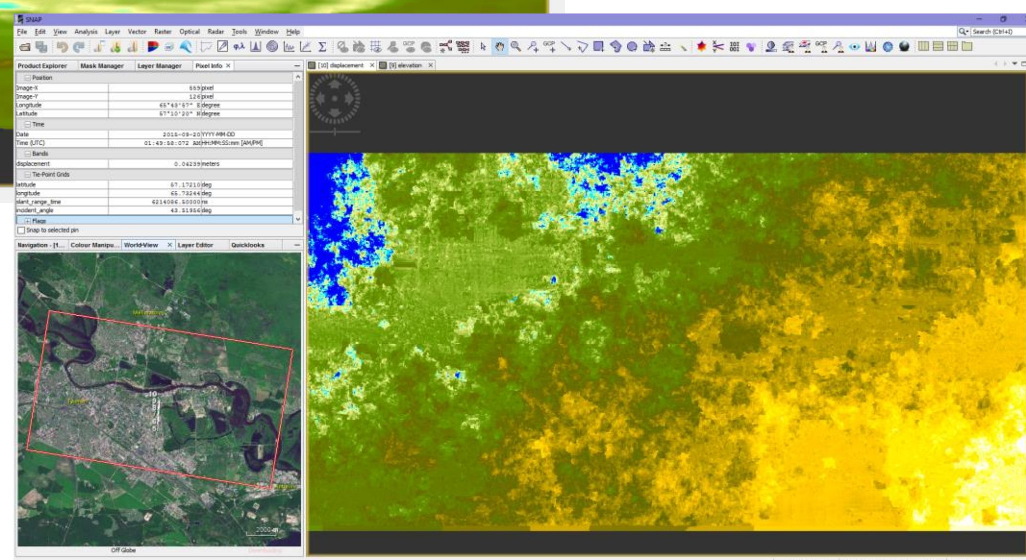
Problems in evaluation:

1. The calculated Road Network Density is approximate but in accordance to the standards of urban planning
2. The input data is a classified raster has a complex shape, because of it the process calculation and filtering takes a long time

Digital Elevation Model (DEM)

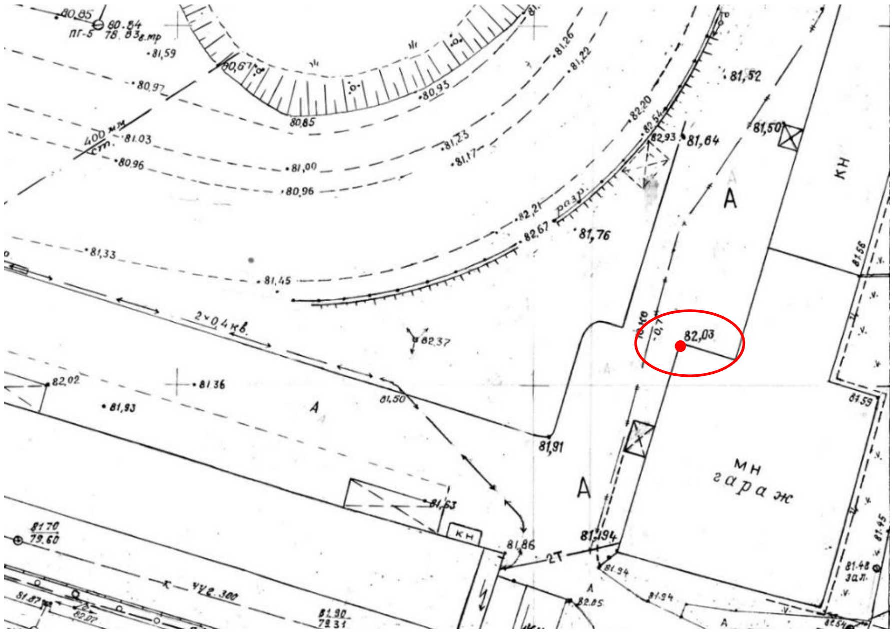


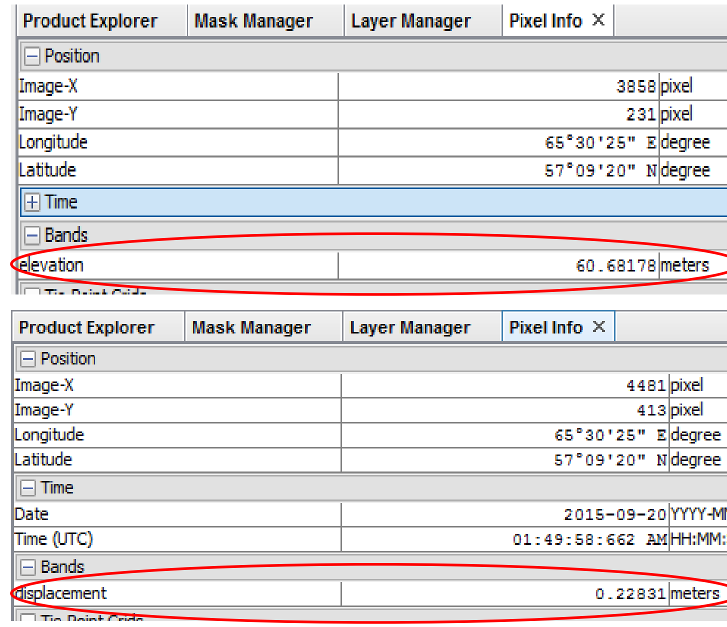
Translocation/ dislocation of the land cover



DEM and trans/dislocation is the result of interferometric processing of two radar images

DEM accuracy estimation (Sentinel-1)





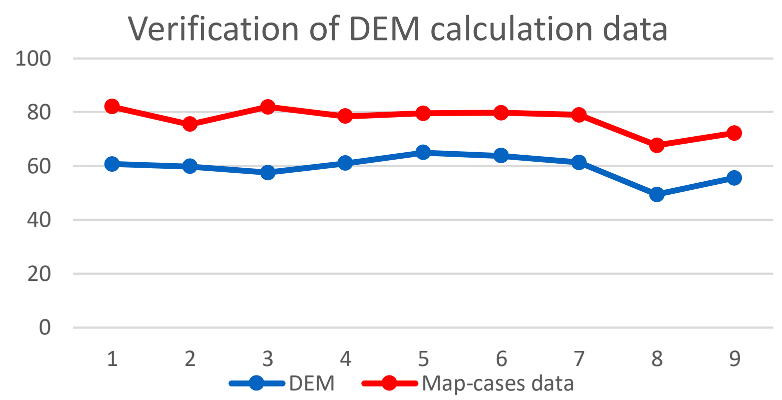
9 points per map-case and DEM

Calculation of the root-mean-square deviations (RMS) in two groups:

- $RMS_{map\text{-}cases} = 13,44$ m
- $RMS_{DEM} = 13,24$ m

DEM accuracy estimation (Sentinel-1) и SRTM

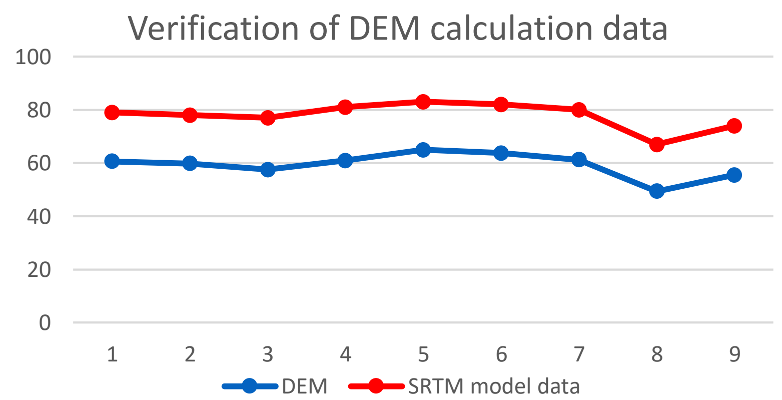
№ point	Point coordinates	Height at point according to DEM, m	Height at point according to SRTM, m
0448	Lat 57°09'20" N Lon 65°30'25" E	60.68	79
0465	Lat 57°09'51" N Lon 65°30'35" E	59.83	78
0467	Lat 57°09'10" N Lon 65°30'38" E	57.49	77
0571	Lat 57°09'37" N Lon 65°31'48" E	60.97	81
0572	Lat 57°09'27" N Lon 65°31'51" E	64.93	83
0573	Lat 57°09'21" N Lon 65°31'51" E	63.73	82
0729	Lat 57°08'45" N Lon 65°33'22" E	61.27	80
0922	Lat 57°09'13" N Lon 65°35' E	49.41	67
2408	Lat 57°07'49" N Lon 65°35'21" E	55.56	74



9 points per SRTM and DEM;

Calculation of the root-mean-square deviations (RMS) in two groups:

- RMS_{SRTM} = 13,89 m
- RMS_{DEM} = 13,24 m



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DEM

Input requirements:

- Two radar images (Sentinel-1)
- IW shooting mode
- Radar images should be selected according to rules, which are developed into the project

Methodology:

http://sentinel1.s3.amazonaws.com/docs/S1TBX%20TOPSAR%20Interferometry%20with%20Sentinel-1%20Tutorial.pdf

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DEM

Problems in evaluation:

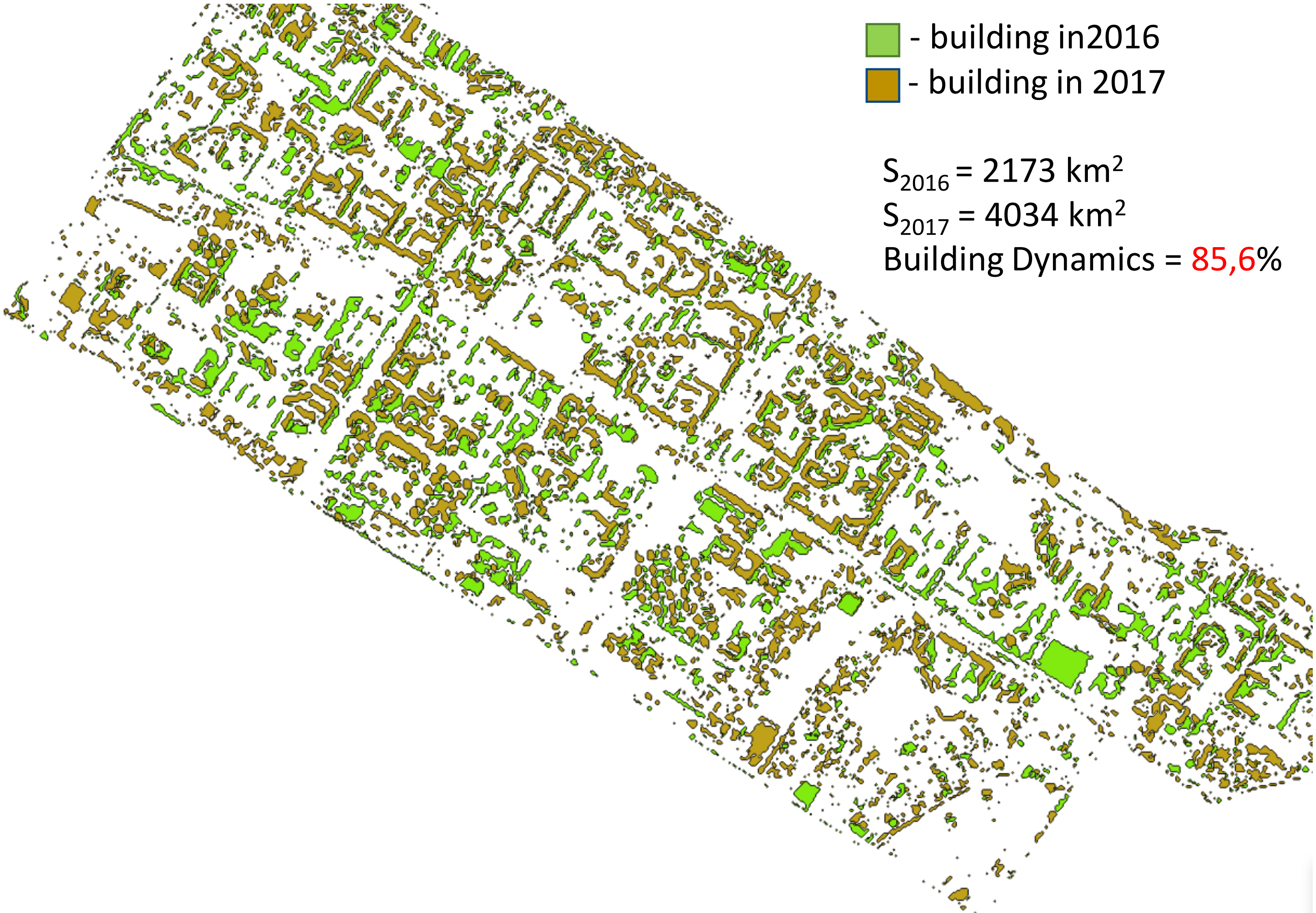
1. It is required a high qualification of the users to select a pair of radar images
2. It is hard to select two coherent images
3. It is hard to automate the evaluation of this
4. Spatial resolution of the Sentinel-1 radar images is not enough to satisfy an objectives

DEM accuracy estimation

Problems in evaluation:

1. It is necessary to know the map-cases or other input data export date (for relevance)
2. It was estimated by comparing the RMSD of the evaluated DEM and the map-case and SRTM

Building Dynamics



- building in2016
- building in 2017

S_{2016} = 2173 km^2
S_{2017} = 4034 km^2
Building Dynamics = 85,6%

Building Dynamics

Input requirements:

- Two optical Sentinel-2 images (summertime)
- The same weather conditions for a good shoot (well brightness, etc.)
- The vector of the roads (recommended)

Methodology:

1. Create a polygon area (if needed)
2. Exclude the vector of the buildings, roads and railway (recommended)
3. Choose a set of buildings examples/etalons
4. Binary classification (or ISODATA method)
5. Visual check of the result
6. Combine classes that contain buildings
7. Vectorize the result
8. Calculate the ratio between two vector layers

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Building Dynamics

Problems in evaluation:

1. It is hard to find two images with high and similar (the same) quality and free of charge
2. There is no alternative data to check the result

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The **WIS's** Functionality

1. Create the project for the satellite images processing and indicators evaluation
2. Select, download free EO-data into the storage and project
3. Manage the storage: add, edit and delete the vector
4. Manage a map: display the satellite images, set the channels, switch on/off layers, change the projection
5. Automatic indicators evaluation
6. Display indicator's attributes and legend (short and detailed format)
7. Personal settings of the project, indicator displaying and legend etc.
8. Export the indicator
9. Print a map
10. Copy a link to a map's extent
11. Make an order of EO-data from other satellites with payment
12. Display user's guide and methodology description

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Problems during our experience

- Free satellite images is not suitable for making decision in urban planning sphere. The required spatial resolution should be High or Very High
- VHR space images with 4 channels (RGB, NIR) is not available
- Other EO-data, for examples orthophotos, do not have any channels and can not be used
- Now the indicators are evaluated using Sentinel-1, 2, Landsat-8. Methods of VHR images processing differ from the developed
- The selection and downloading (only one or two together) of free space imagery (without clouds, needed borders and dates etc.) takes a long time
- Choosing a set of needed examples/etalons takes a long time
- Image processing and indicators evaluation needs a user's visual control or verification
- There are no available open source software with needed algorithms for indicators evaluation
- The WIS GEOURBAN is not available for use and improvement as it used to be because of technologies

Technologies

2012 → 2013 → 2014 → 2015 → 2016 → 2017 → 2018

- Data Base

ORACLE → PostgreSQL

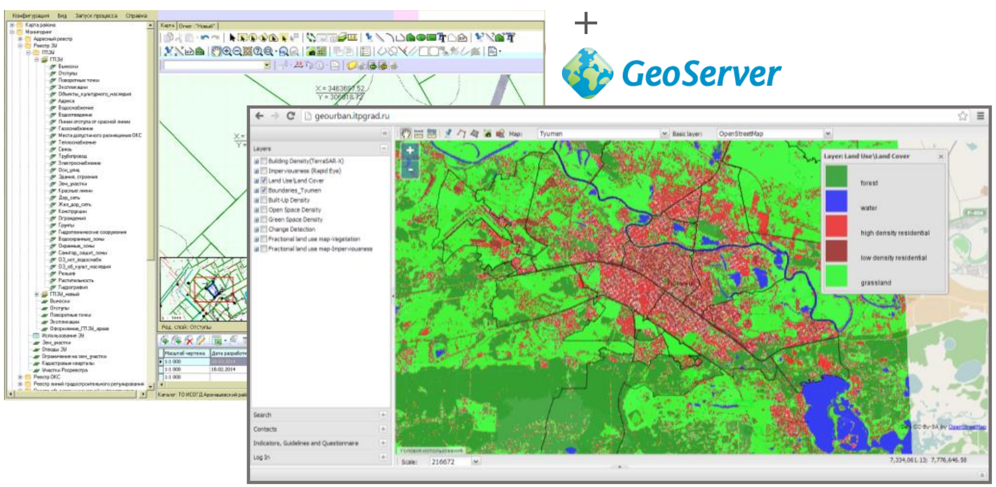
- GIS component

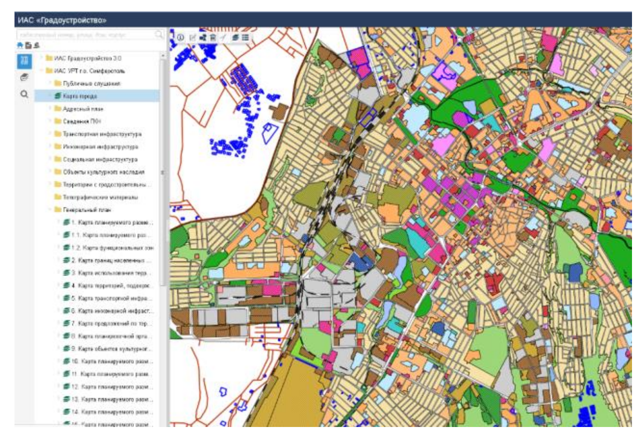
MapXtreme. C# WinForms

MapXtreme SDK
+
Oracle Locator (Spatial)
+
GeoServer

→

GeoServer
+
Leaflet
+





The organization problems of GRADI

2012 → 2013 → 2014 → 2015 → 2016 → 2017 → 2018

- Rebrand

GRADI ГРАД www.itpgrad.ru → ГРАД ИНСТИТУТ ТЕРРИТОРИАЛЬНОГО ПЛАНИРОВАНИЯ

- Reorganization

IT Department
Employees migration
(40 analytics and programmers) → **Different IT company**

- Finish of Collaboration with Funding source FASIE

Thank you very time!