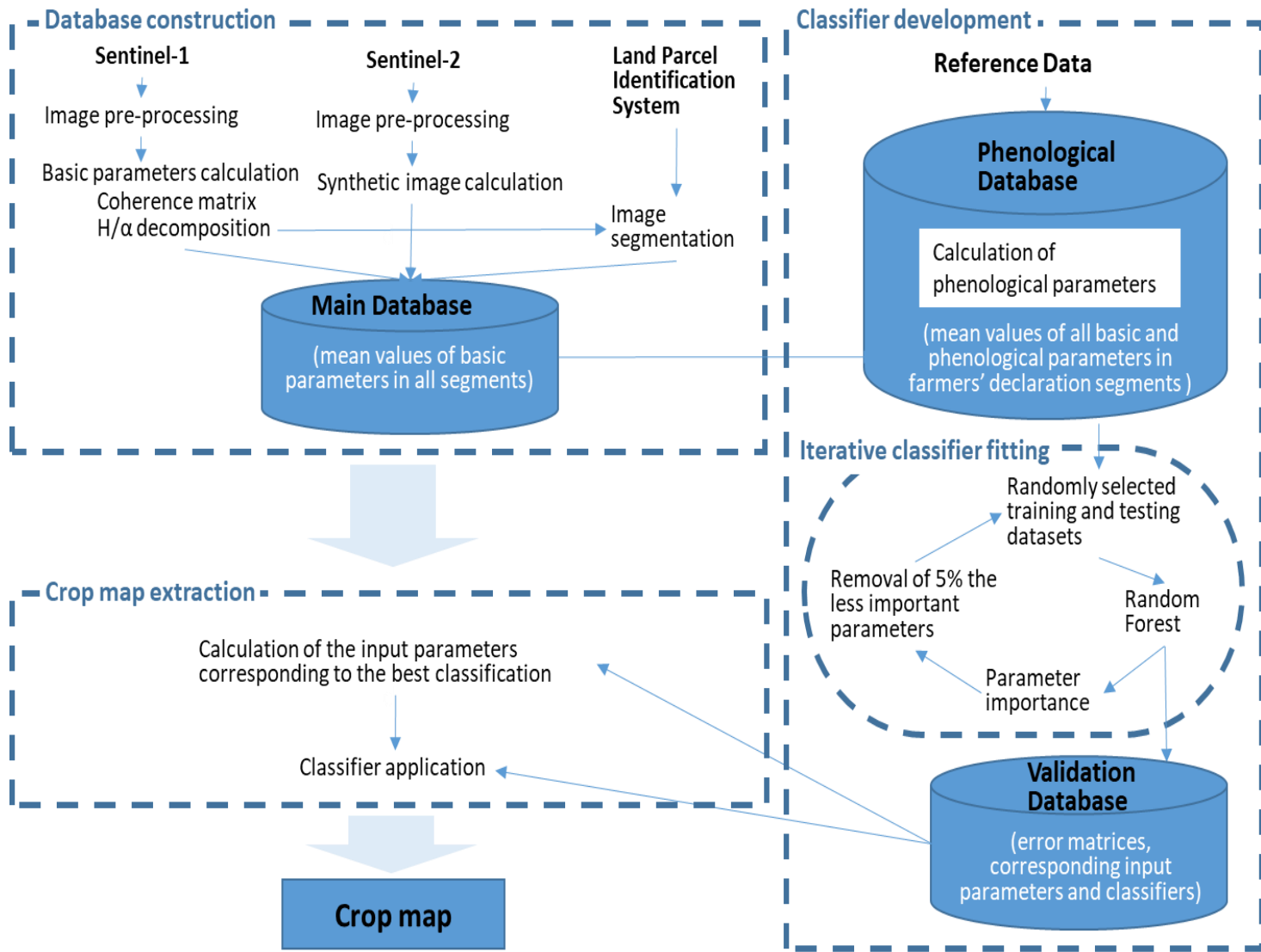


Use of satellite data and remote sensing methods for statistical production.

Przemysław Slesiński
Natalia Kotulak

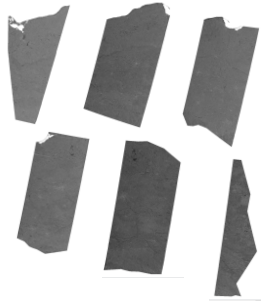
System for estimating the crops area



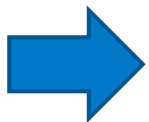
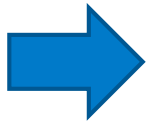
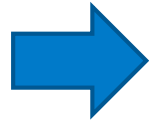
System for estimating the crops area

Classification Module

Processing up to 7 days



Total processing time up to 2 months, approx 30TB of data are being processed



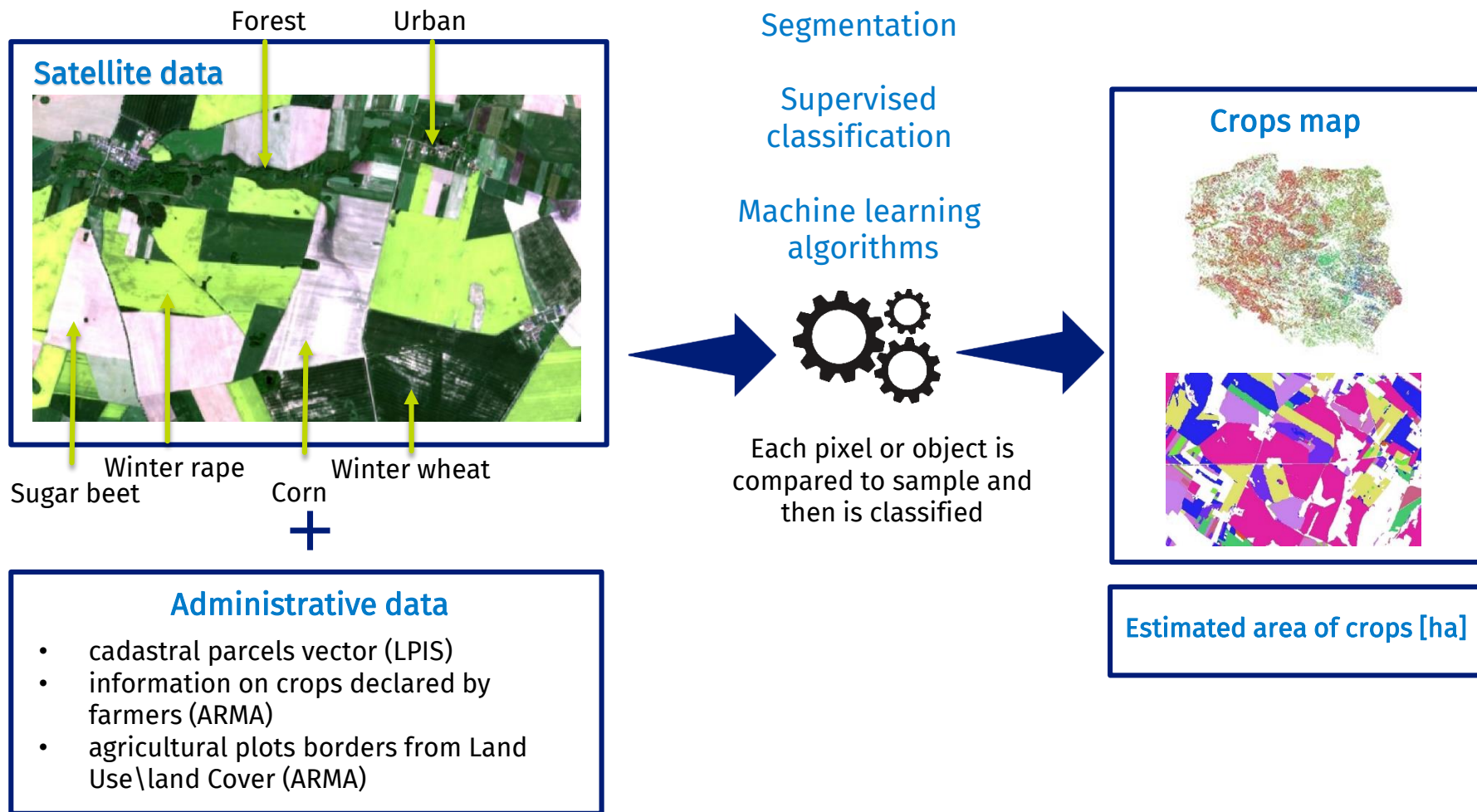
- ClassificationProcess
- Configuration
- configurationEmpty
- configurationFile
- FeaturesMangerS1S2
- FullImageClassification
- gdal204.dll
- InfoPrinter
- IterativeFeatureReduction
- main
- manual
- RasterObject
- Readme.md
- S1prepareForClassificationP
- StatsCreator
- StatsReader



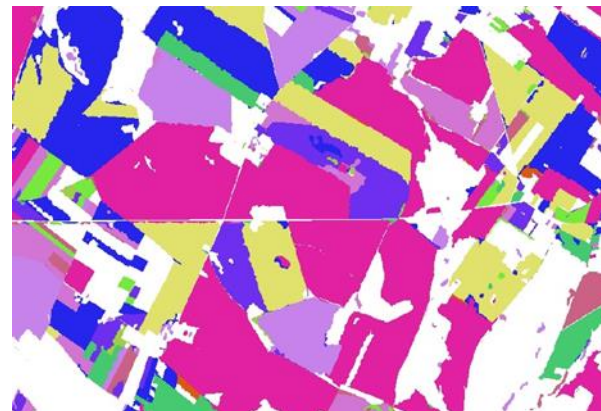
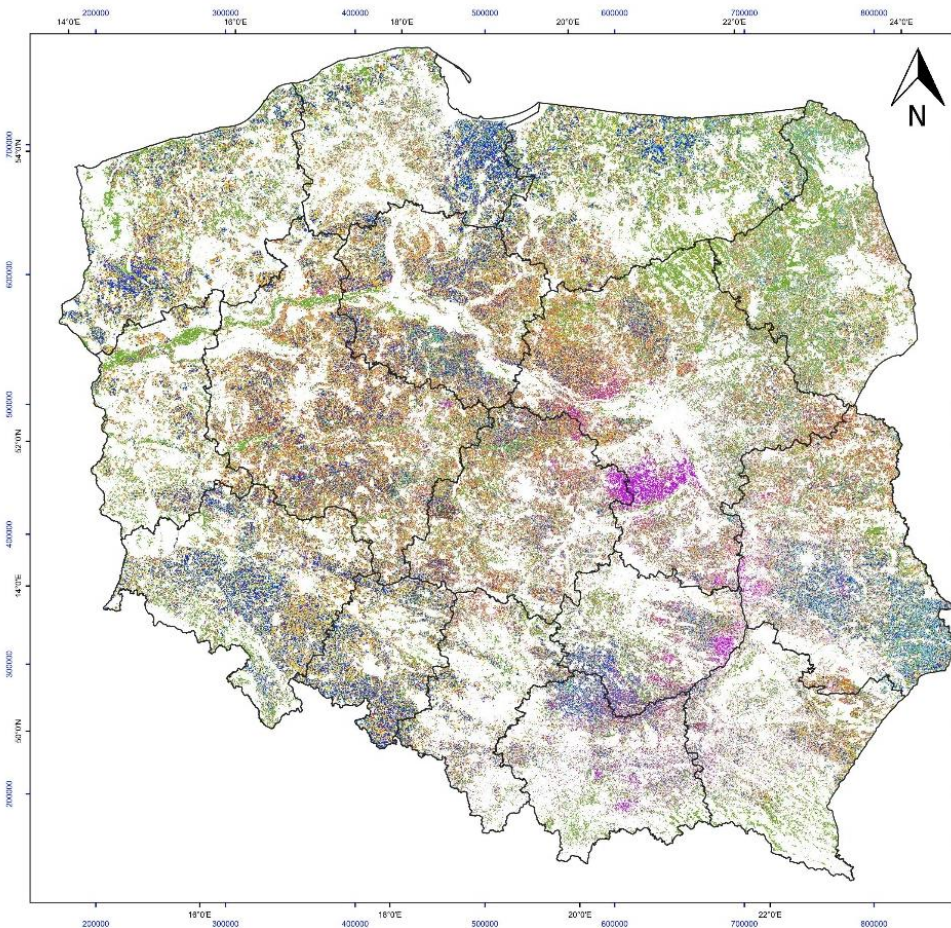
```
Anaconda Prompt (Anaconda3) - python main.py
rasterize:"crop_name"="gorczyca"
rasterize:"crop_name"="gryka
rasterize:"crop_name"="jeczmen jary'
rasterize:"crop_name"="jeczmen ozimy'
rasterize:"crop_name"="kukurydza"
rasterize:"crop_name"="mieszanki zbozowe'
rasterize:"crop_name"="owies'
rasterize:"crop_name"="plantacje drzew owocowych'
rasterize:"crop_name"="plantacje krzewow owocowych'
rasterize:"crop_name"="proso'
rasterize:"crop_name"="pszenica jara'
rasterize:"crop_name"="pszenica ozima'
rasterize:"crop_name"="pszenzyto jare'
rasterize:"crop_name"="pszenzyto ozime'
rasterize:"crop_name"="rzepak jary'
rasterize:"crop_name"="rzepak ozimy'
rasterize:"crop_name"="straczkowe'
rasterize:"crop_name"="TIUZ_MD'
rasterize:"crop_name"="truskawka'
rasterize:"crop_name"="tyton'
rasterize:"crop_name"="warzywa'
rasterize:"crop_name"="ziemniaki'
rasterize:"crop_name"="ziola i przyprawy'
rasterize:"crop_name"="zyto'
D:\@_Classification_software\3_Classification_Stats_Toolbox\PI\S1prepareForClassificationP.exe coordRef D:\1_Classificati
on_working_directory\2_2021_eCognition_segmentation\PI\results\ExportImage\PI_resi_ext_uint_resampled_arcgis.tif D:\1_Cl
assification_working_directory\workingDir1\PI\stats\segmentsPointsSelected.tif D:\1_Classification_working_directory\wor
kingDir1\PI\stats\RefCoordsSelected.bin
```

Object based image classification

- How does the whole process look like?



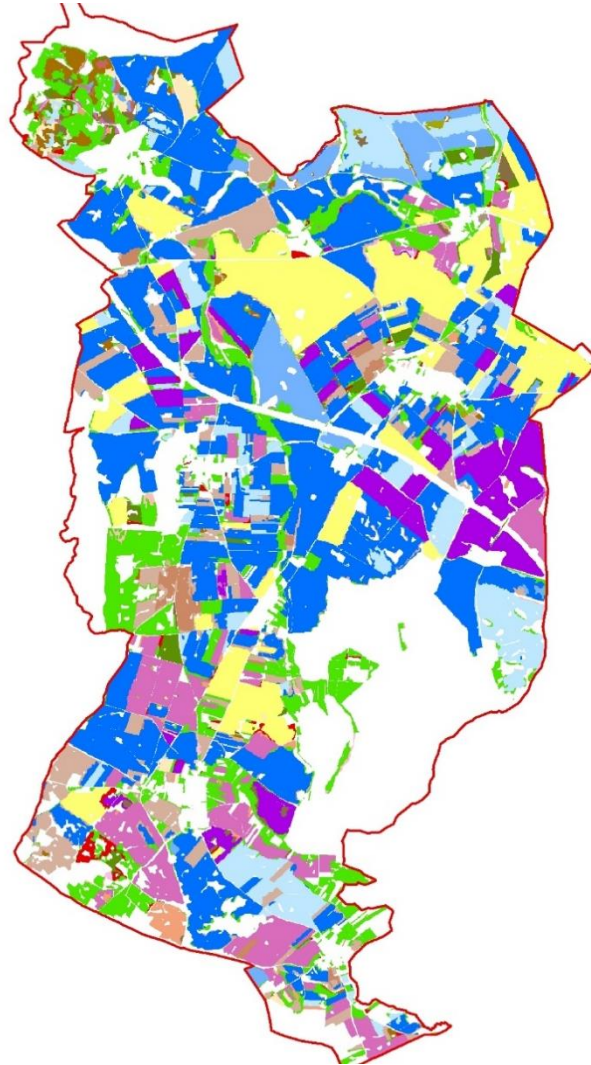
System for estimating the crops area



37 crops
OA = 78%

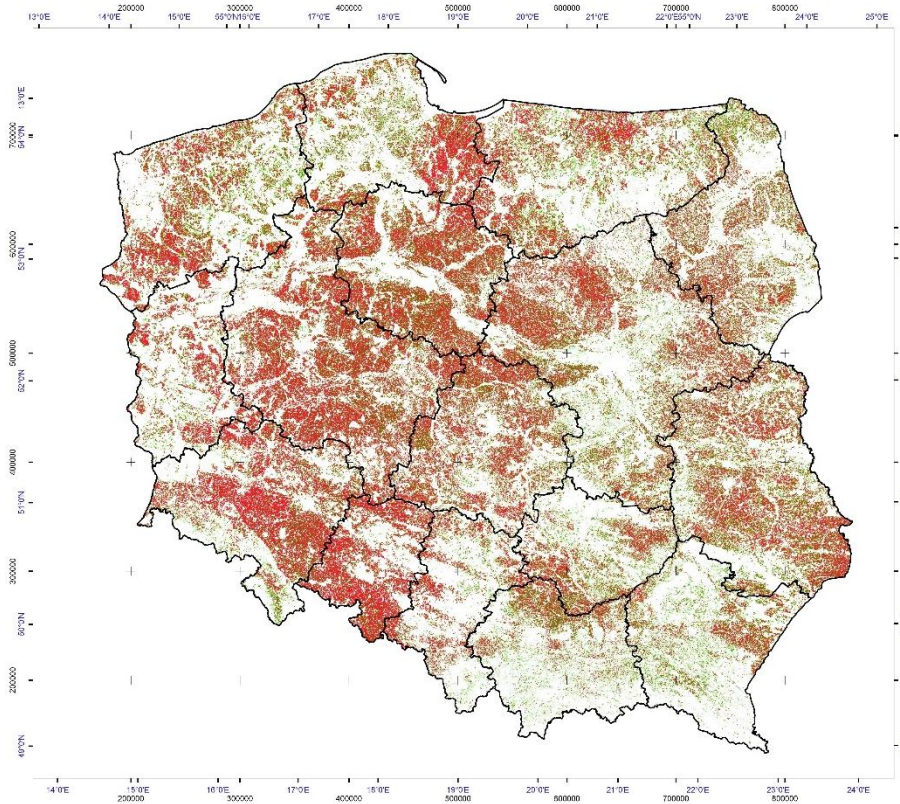
kod_pow	pow_nazwa	kod_gm	gm_nazwa	buraki cukrowe	gorczyca
0201	Powiat bolesławiecki	0201011	Bolesławiec (1)	0,00	0,01
		0201022	Bolesławiec (2)	27,74	16,41
		0201032	Gromadka (2)	5,33	4,61
		0201043	Nowogrodziec (3)	4,02	20,71
		0201052	Osiecznica (2)	0,00	0,01
		0201062	Warta Bolesławiecka (2)	118,82	3,21
	Powiat bolesławiecki Suma		155,92	45,11	
0202	Powiat dzierzoniowski	0202011	Bielawa (1)	21,21	1,81
		0202021	Dzierżonów (1)	35,67	0,11
		0202033	Pieszycze (3)	38,55	3,41
		0202041	Piława Góra (1)	8,50	0,81
		0202052	Dzierżonów (2)	332,82	18,81
		0202062	Łagiewniki (2)	471,32	7,91
		0202073	Niemcza (3)	240,91	0,61
	Powiat dzierzoniowski Suma		1 148,98	33,61	

System for estimating the crops area



Crop classification map at LAU level

Winter crop area estimation (early spring)



- Time series march – april every year
- Sentinel-1/2
- Based on NDVI and sigma nought
- Object based image classification
- Random Forest ML algorithm
- Google Earth Engine, eCognition

Google Earth Engine

```
28 // Filter input collections by desired data range and region.
29 var criteria = ee.Filter.and(
30   ee.Filter.bounds(region), ee.Filter.date(START_DATE, END_DATE));
31 s2Sr = s2Sr.filter(criteria).map(maskEdges);
32 s2Clouds = s2Clouds.filter(criteria);
33
34 print('s2Sr', s2Sr);
35
36 // Join S2 SR with cloud probability dataset to add cloud mask.
37 var s2SrWithCloudMask = ee.Join.saveFirst('cloud_mask').apply({
38   primary: s2Sr,
39   secondary: s2Clouds,
40   condition:
41     ee.Filter.equals({leftField: 'system:index', rightField: 'system:index'})
42 });
43
44 var s2CloudMasked =
45   ee.ImageCollection(s2SrWithCloudMask).map(maskClouds).median();
46
```

GEE code sample

System for estimating the crops area – cloud computing

For research purposes we use Google Earth Engine cloud computing

- no need to download 30TB of data,
- no need to use workstations (saving energy and money),
- shortening the processing time from 2 months to about less than 1 week

RGB Sentinel-2 mosaic



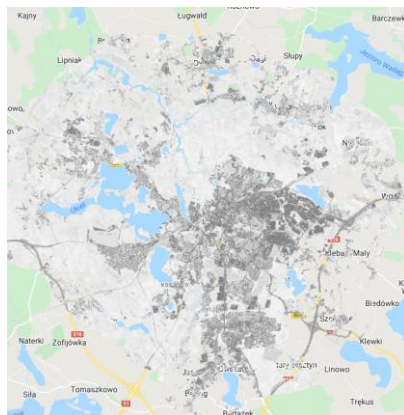
Sentinel-1 mosaic



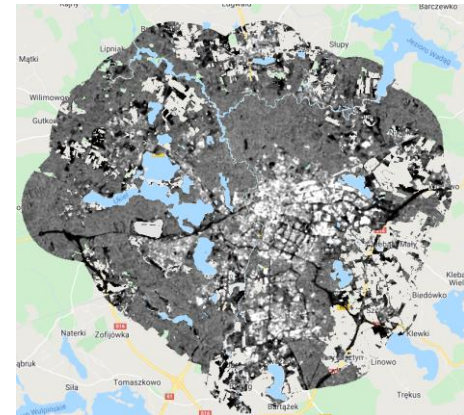
RGB Sentinel-2 mosaic masked



NDVI



Sigma_0 S1



System for estimating the crops area – demo

The screenshot displays the Google Earth Engine interface. At the top, the search bar contains "Search places and datasets...". The left sidebar shows a list of scripts under the "Scripts" tab, with "0_OBIA_classification_SAR_asc_desc_example" selected. The main panel shows the script code, which includes variables for learning and control samples, and functions for filtering and calculating composite images. The right sidebar shows the "Inspector" tab with accuracy metrics: Overall accuracy: 0.8514851485148515, Kappa: 0.8183453237410072, User accuracy (rows): List (1 element), and Producer accuracy (columns): List (11 elements). Below the script, a map shows the classified crop areas, with a legend on the left indicating 10 different crop types represented by various colors. The map includes labels for locations like Nowy Dwór Elbląski, Gronowo Elbląskie, and Jasień.

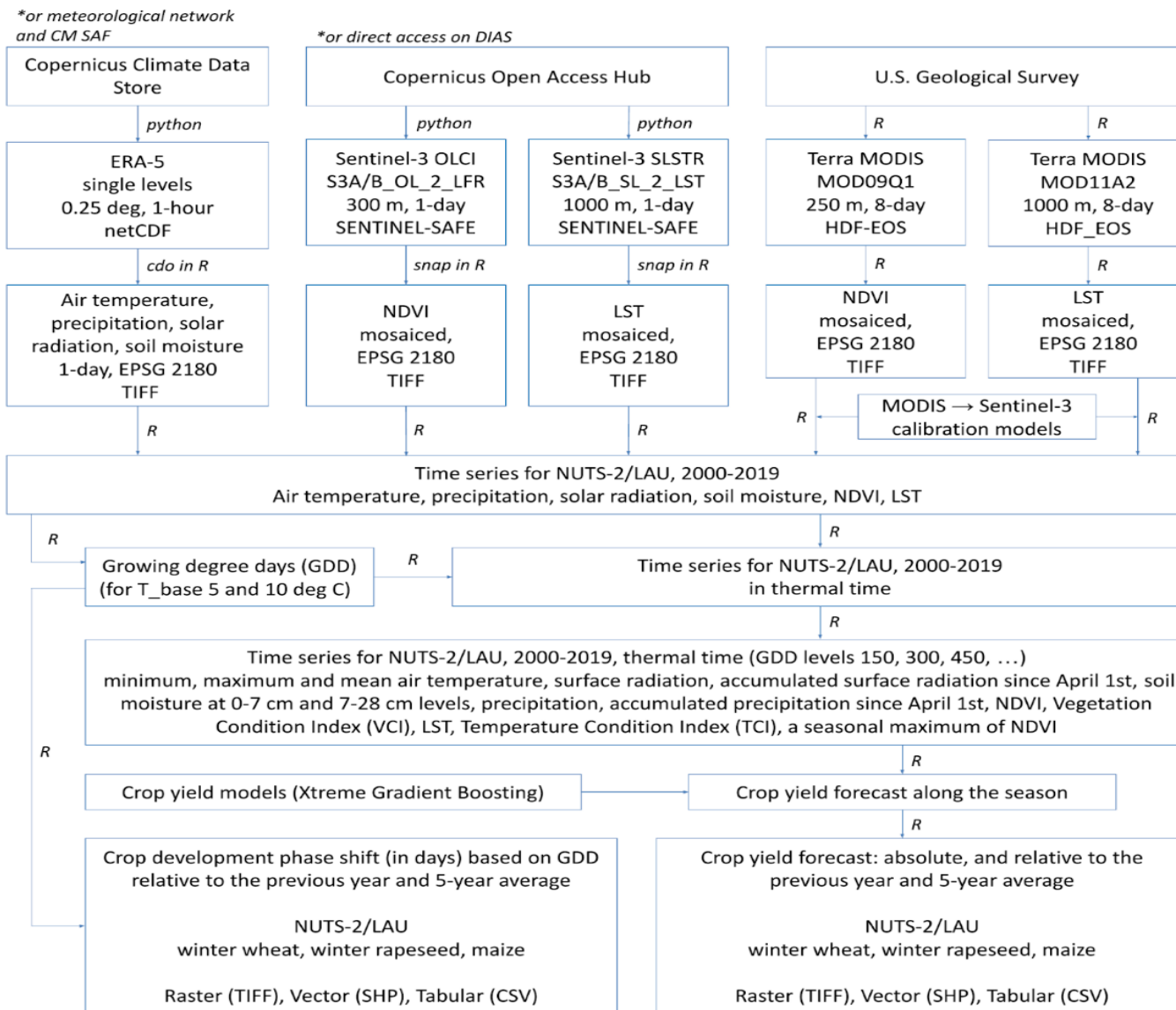
```
0_OBIA_classification_SAR_asc_desc_example
var learn_samples: Table users/pslesinski/01_learn_samples
var control_samples: Table users/pslesinski/02_control_samples

1
2 Map.centerObject(AOI, 13);
3
4 // Image 1
5 //DESCENDING
6 var vvS1_1 = sentinel1.filterDate('2021-04-16', '2021-04-26')
7   .filter(ee.Filter.eq('orbitProperties_pass', 'DESCENDING'))
8   .filter(ee.Filter.listContains('transmitterReceiverPolarisation', 'VW'))
9   .filter(ee.Filter.eq('instrumentMode', 'IW'));
10
11 var vhS1_1 = sentinel1.filterDate('2021-04-16', '2021-04-26')
12   .filter(ee.Filter.eq('orbitProperties_pass', 'DESCENDING'))
13   .filter(ee.Filter.listContains('transmitterReceiverPolarisation', 'VH'))
14   .filter(ee.Filter.eq('instrumentMode', 'IW'));
15
16 var compositeS1VW_1 = ee.Image.cat([
17   vvS1_1.select('VW').median(),
18   ]).focalMedian().clip(AOI);
19
20 var compositeS1VH_1 = ee.Image.cat([
21   vhS1_1.select('VH').median(),
22   ]).focalMedian().clip(AOI);
23
```

Legend

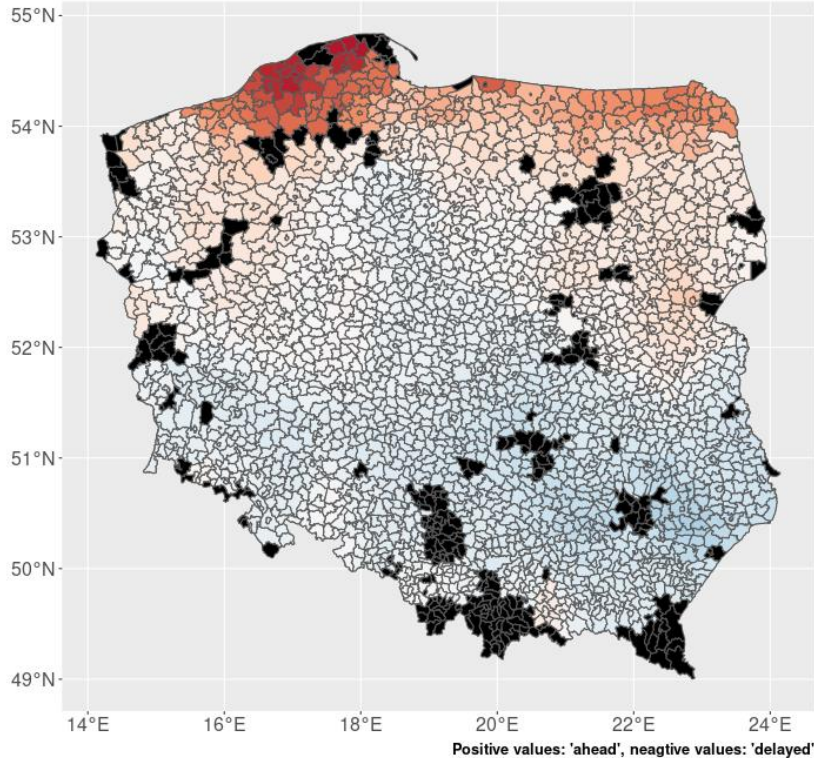
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

System for assessing the condition of crops and predicting yields



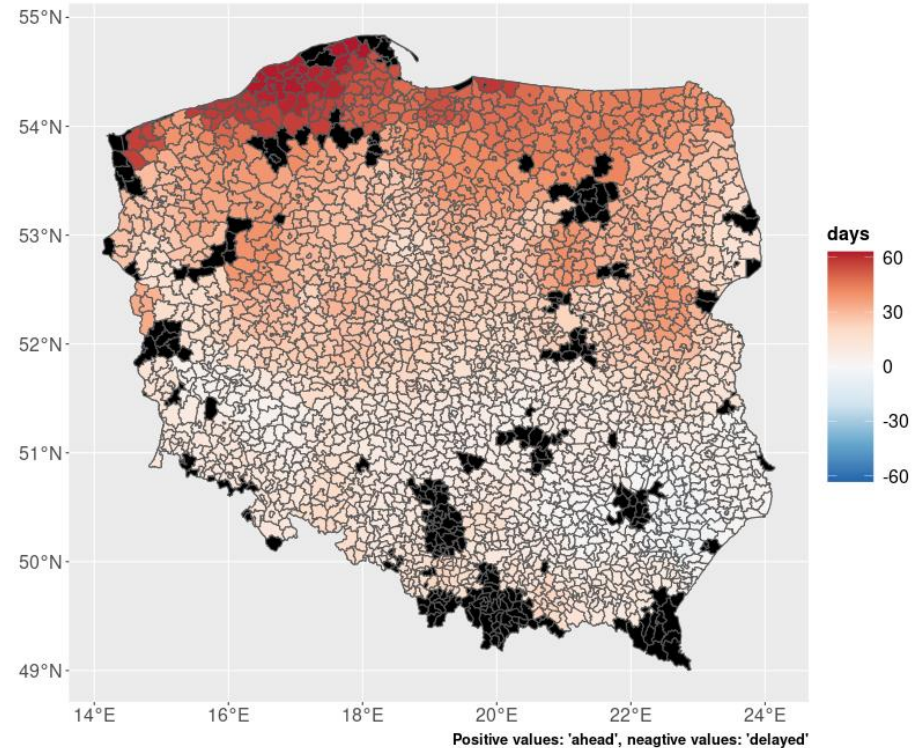
Crops condition module – final products at LAU units

The crop development difference with respect to the long-term average
Status on 2021-10-03



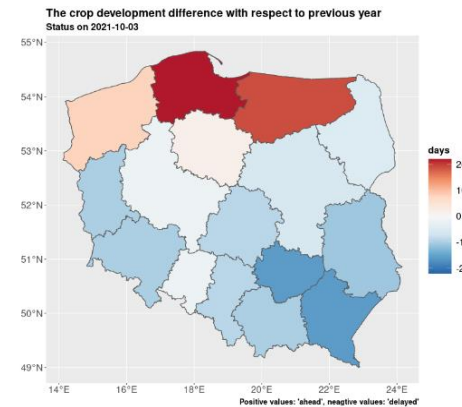
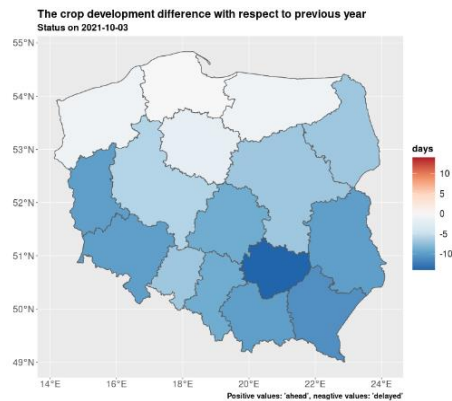
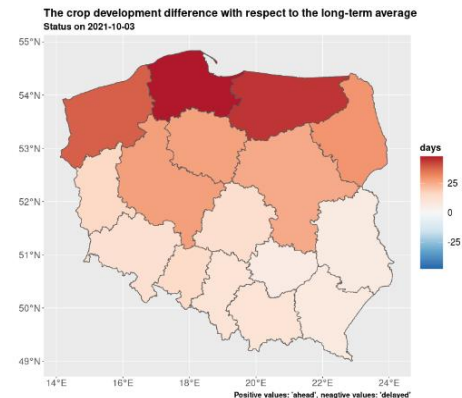
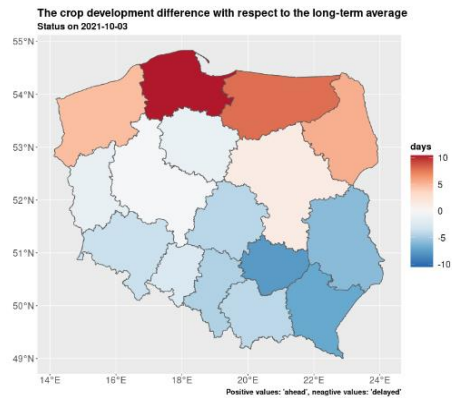
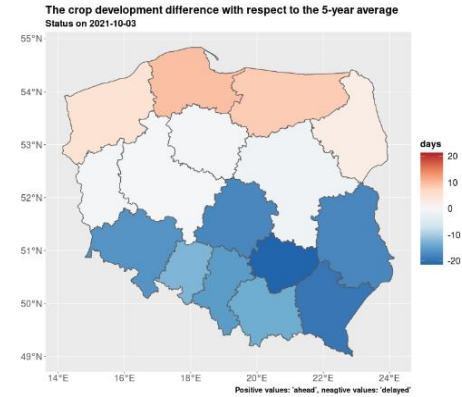
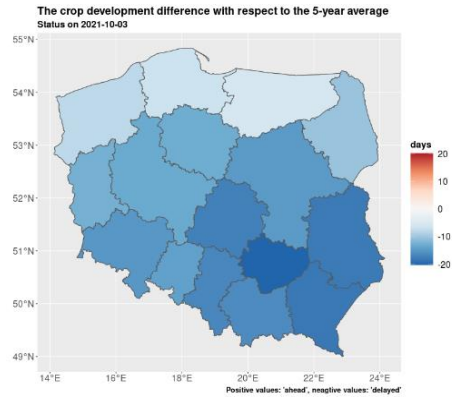
winter rapeseed, winter wheat

The crop development difference with respect to the long-term average
Status on 2021-10-03



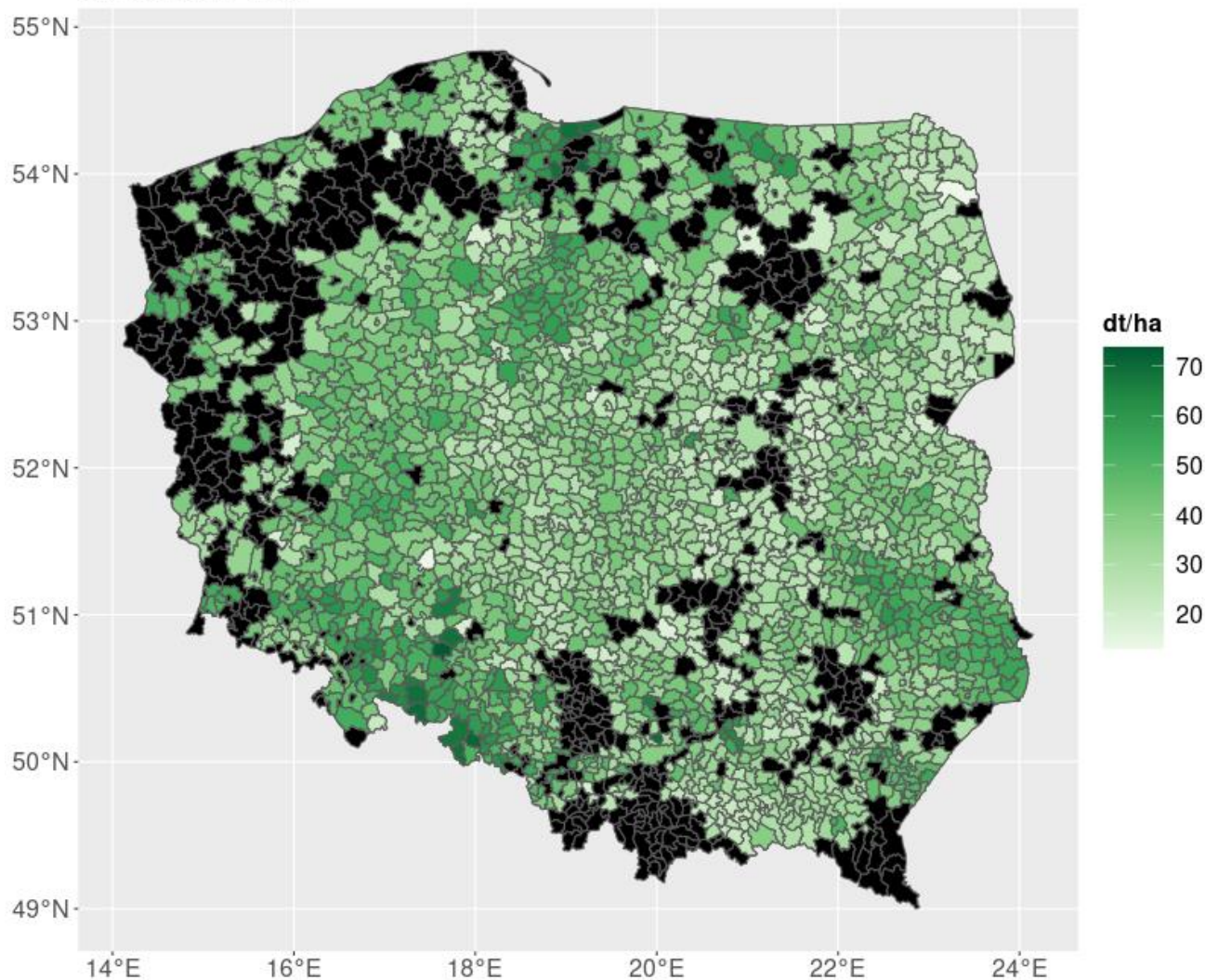
maize

Crops condition module – final products at NUTS units

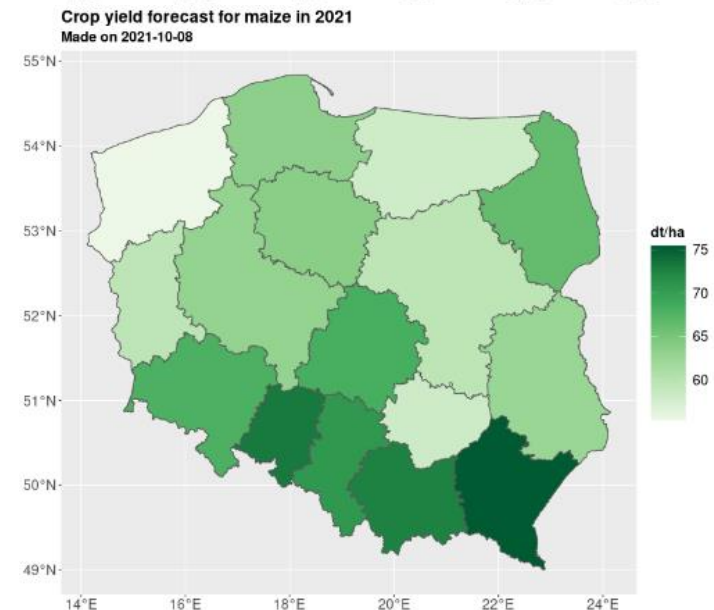
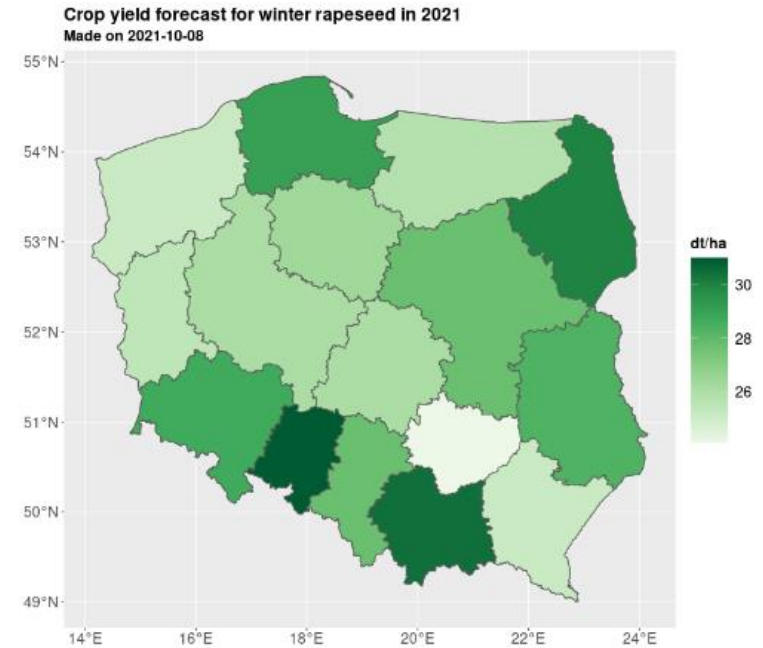
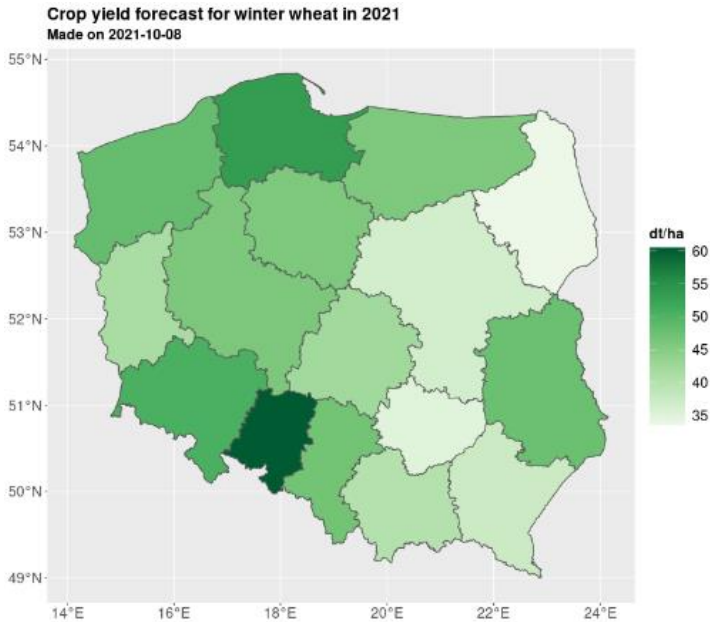


Yield prediction module – final products LAU units

Crop yield forecast for winter wheat in 2021
Made on 2021-10-08

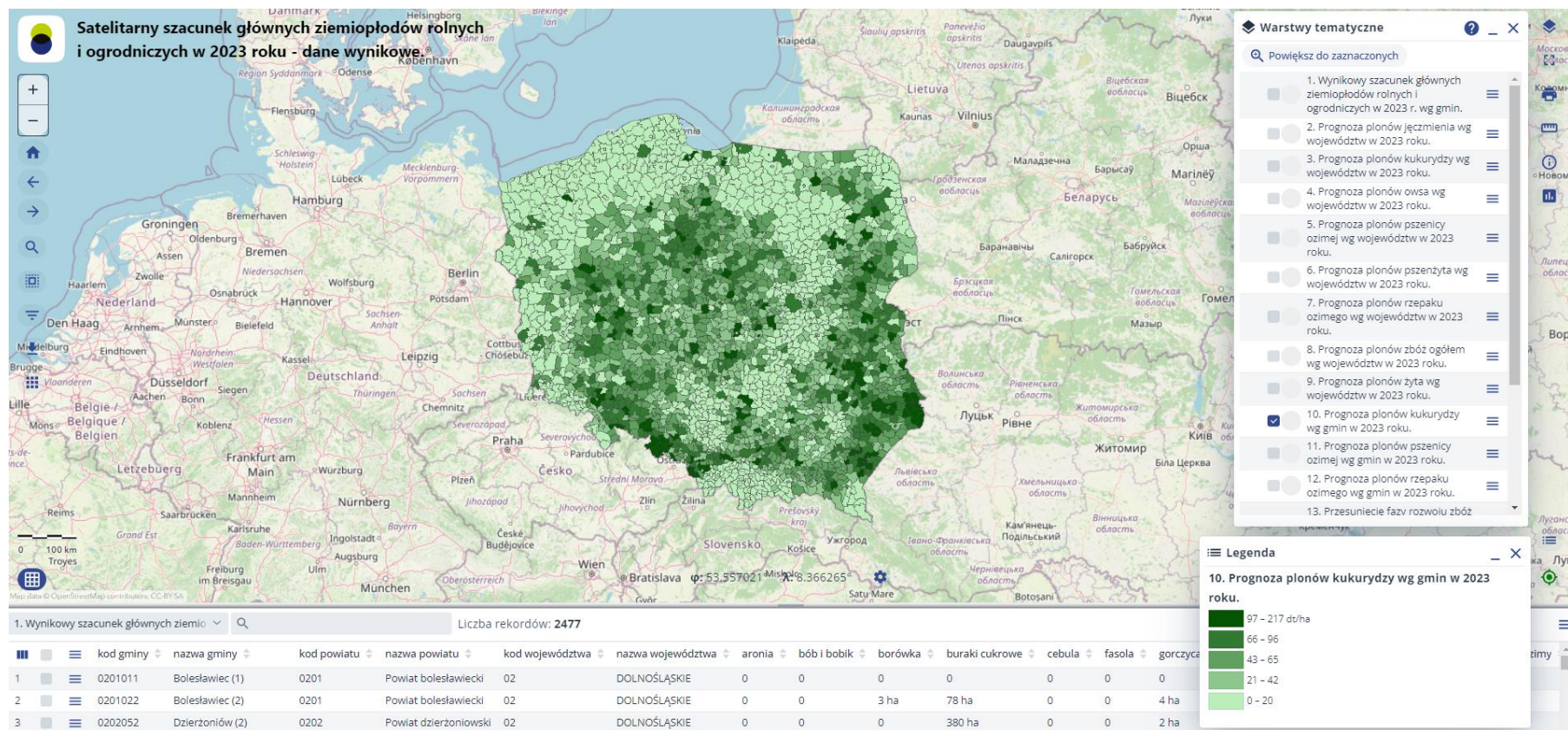


Yield prediction module – final products NUTS units



13 crop species – barley, maize, oat, rye, total cereals, winter triticale, winter rapeseed, winter wheat, mix spring cereals, pastures, permanent grassland, potatoes, sugar beets

Final products SATMIROL



All aggregated data for crops area and yield forecasting are available via Geostatistical Portal <https://geo.stat.gov.pl/>

SDG Goals – based on GIS and remote sensing methods

Indicator 9.1.1 Proportion of the rural population who live within 2 km of an all-season road

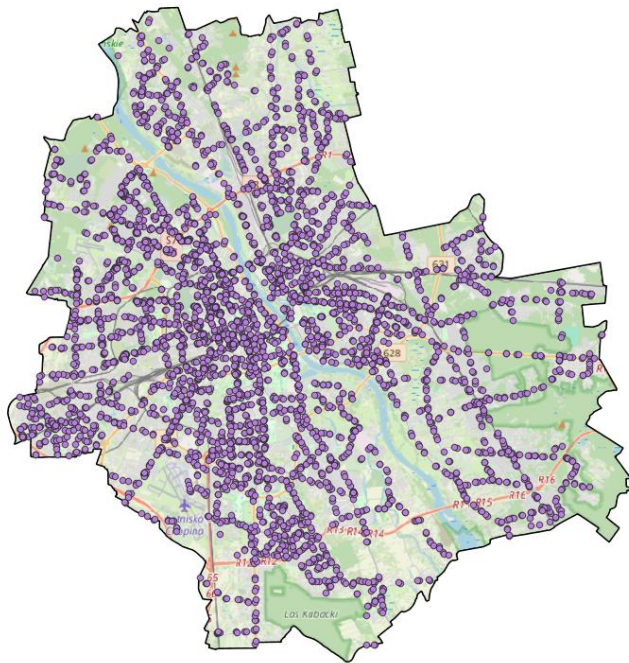
Indicator 11.3.1 - Ratio of land consumption rate to population growth rate

Indicator 11.2.1 - Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities

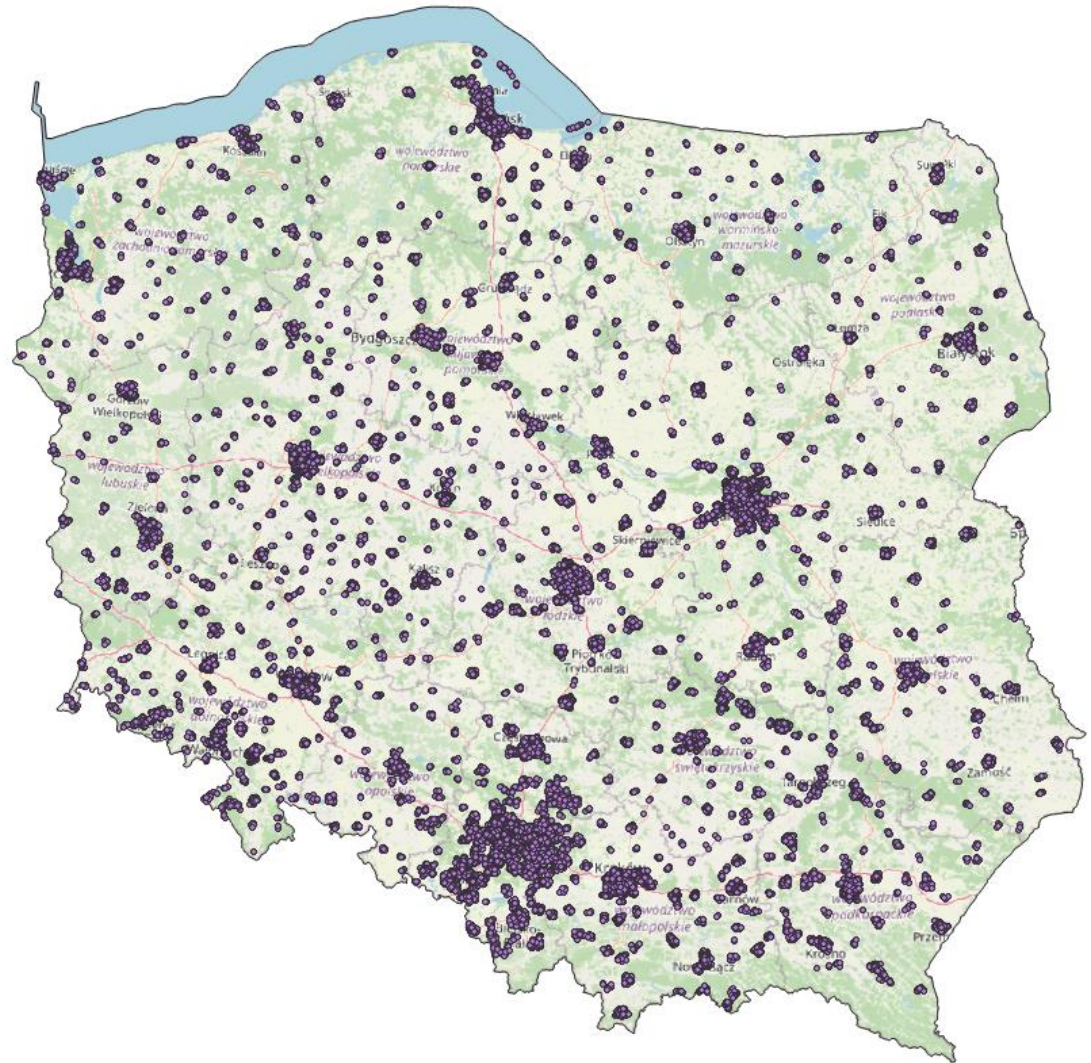
Indicator 11.7.1 - Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities

Indicator 11.2.1 - Methods

Public transport stops located in cities from the BDOT10k database.

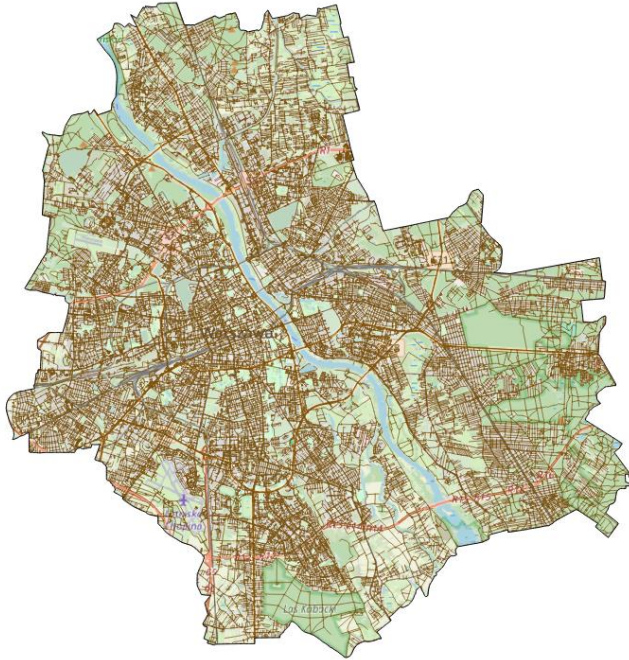


Warszawa

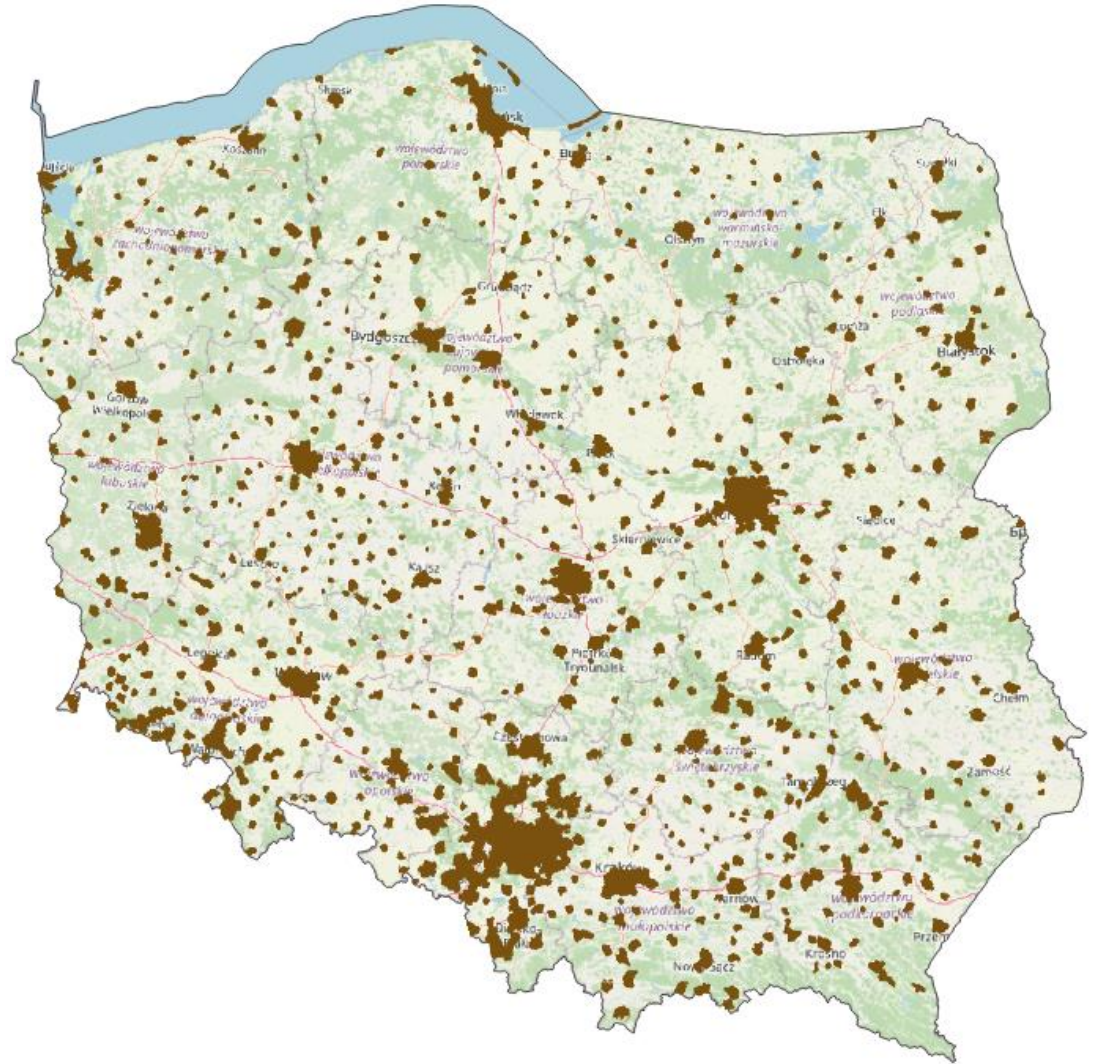


Indicator 11.2.1 - Methods

Network of roads in cities.

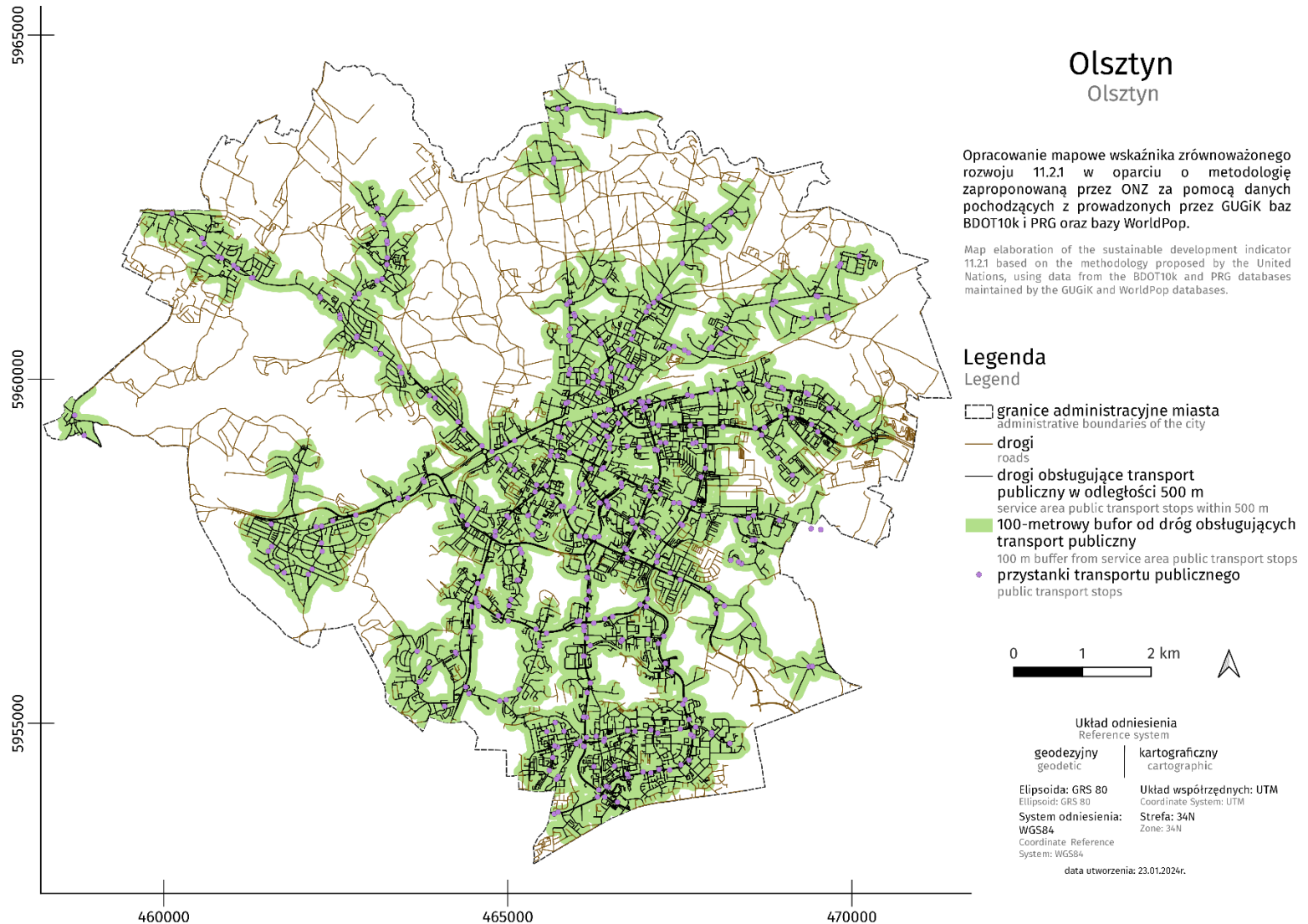


Warszawa



Indicator 11.2.1 - Methods

Spatial analysis of convenient access of the urban population to public transport by age and gender groups.



Indicator 11.3.1 - Methods

Implementation of object classification and development of maps built-up areas and calculation of their area for 2015 and 2020.



2015

Indicator 11.3.1 - Methods

Implementation of object classification and development of maps built-up areas and calculation of their area for 2015 and 2020.



2020

SDG platform

All results for SDGs estimation data are available via experimental statistics portal

https://sdg.gov.pl/statistics_exp/

National Reporting Platform - SDG

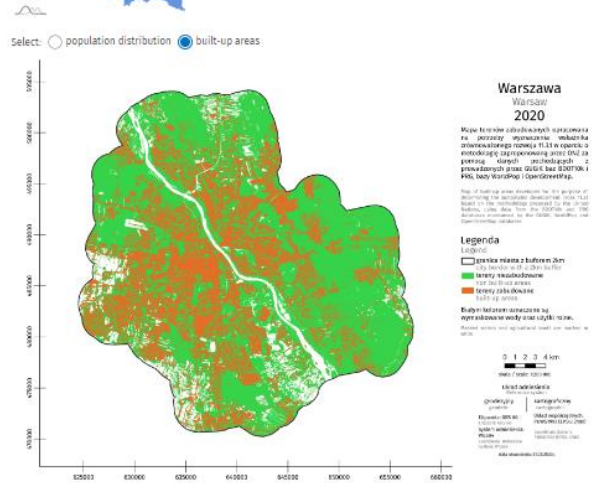
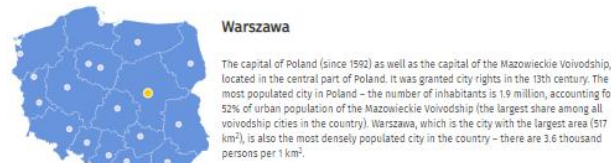
Statistics Poland | SDG | Introduction | Select indicator | FAQs | SDG Platform

Experimental statistics
Goal 11 - Sustainable cities & communities

Home / Goal 11 / Indicator 11.3.1

11.3.1 Ratio of land consumption rate to population growth rate

Map | Context indicators | Calculations | Data sources | Value for sustainable development



City	11.3.1 Ratio of land consumption rate to population growth rate	Land consumption rate [%]	Population growth rate [%]	Land consumption per capita 2015 [m ² /person]	Land consumption per capita 2020 [m ² /person]	Change in land consumption per capita [%]
Warszawa	-0.1	0.0	0.2	128.6	127.1	-1.2

National Reporting Platform - SDG

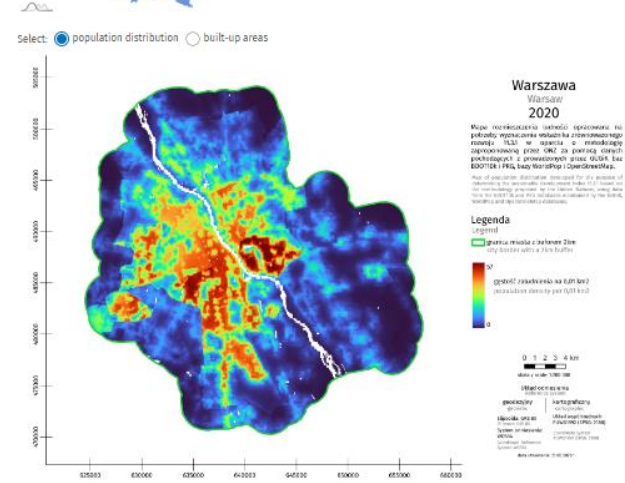
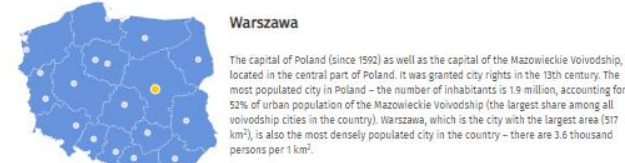
Statistics Poland | SDG | Introduction | Select indicator | FAQs | SDG Platform

Experimental statistics
Goal 11 - Sustainable cities & communities

Home / Goal 11 / Indicator 11.3.1

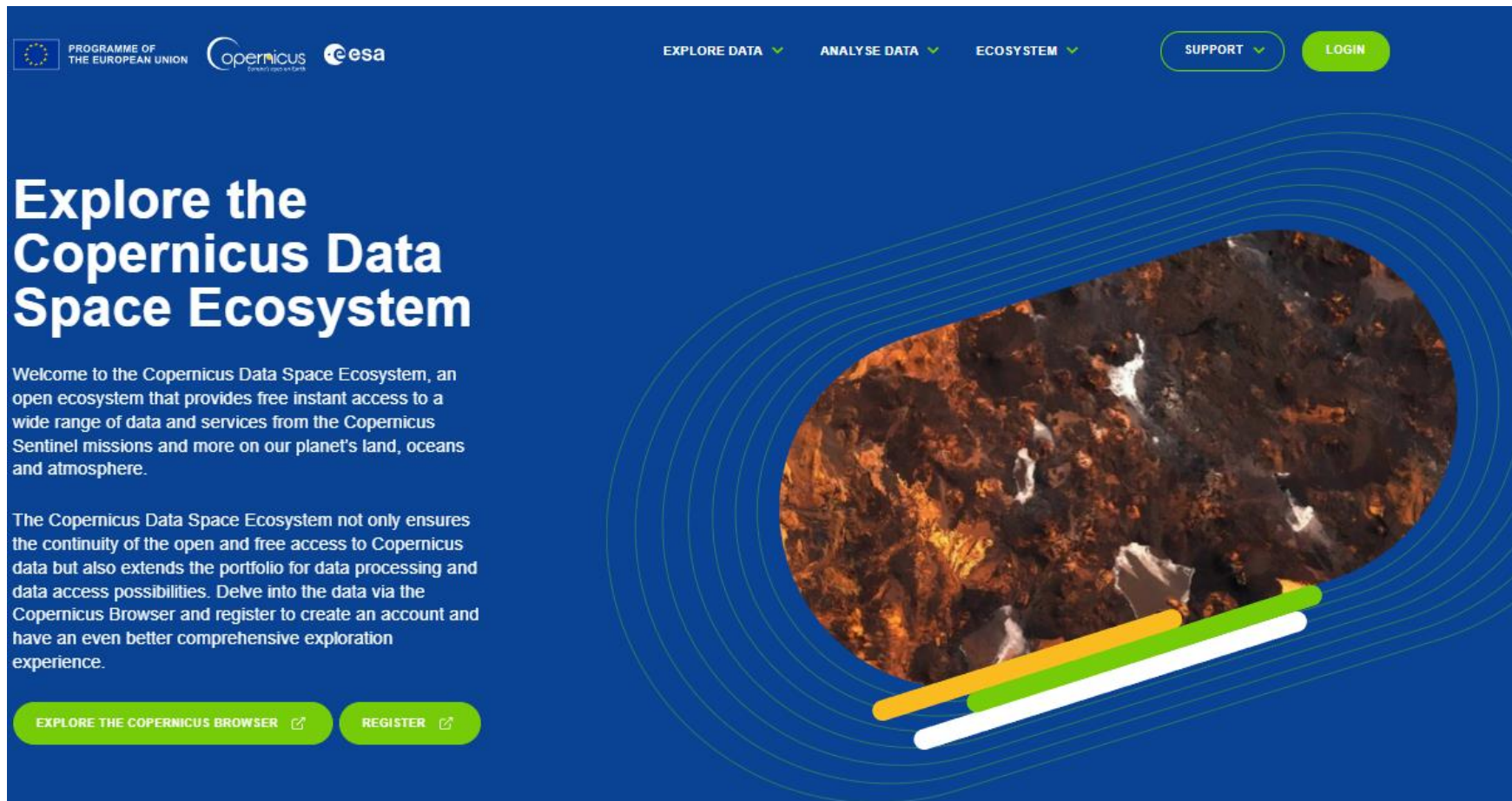
11.3.1 Ratio of land consumption rate to population growth rate

Map | Context indicators | Calculations | Data sources | Value for sustainable development



City	11.3.1 Ratio of land consumption rate to population growth rate	Land consumption rate [%]	Population growth rate [%]	Land consumption per capita 2015 [m ² /person]	Land consumption per capita 2020 [m ² /person]	Change in land consumption per capita [%]
Warszawa	-0.1	0.0	0.2	128.6	127.1	-1.2

Air pollution statistics based on satellite data



The image shows the homepage of the Copernicus Data Space Ecosystem. The header features the logos of the European Union, Copernicus, and ESA. Navigation links include 'EXPLORE DATA', 'ANALYSE DATA', 'ECOSYSTEM', 'SUPPORT', and 'LOGIN'. The main heading is 'Explore the Copernicus Data Space Ecosystem'. Below this, there is a welcome message and a paragraph describing the ecosystem's purpose. At the bottom, there are two buttons: 'EXPLORE THE COPERNICUS BROWSER' and 'REGISTER'. A large satellite image of Earth is featured on the right side, with a stylized graphic of three overlapping lines (yellow, green, white) at the bottom right.

PROGRAMME OF THE EUROPEAN UNION Copernicus ESA

EXPLORE DATA ANALYSE DATA ECOSYSTEM SUPPORT LOGIN

Explore the Copernicus Data Space Ecosystem

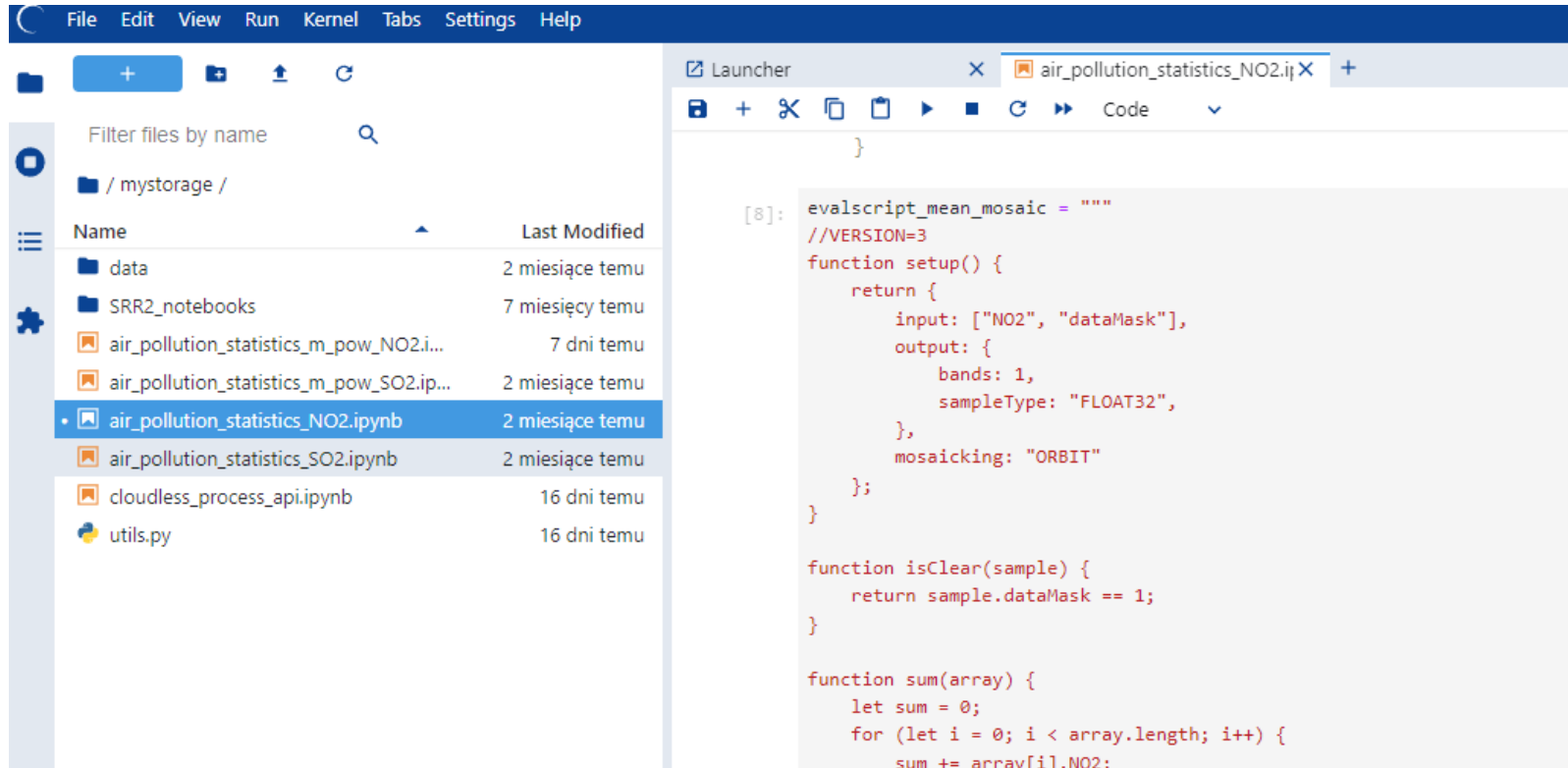
Welcome to the Copernicus Data Space Ecosystem, an open ecosystem that provides free instant access to a wide range of data and services from the Copernicus Sentinel missions and more on our planet's land, oceans and atmosphere.

The Copernicus Data Space Ecosystem not only ensures the continuity of the open and free access to Copernicus data but also extends the portfolio for data processing and data access possibilities. Delve into the data via the Copernicus Browser and register to create an account and have an even better comprehensive exploration experience.

EXPLORE THE COPERNICUS BROWSER REGISTER

Copernicus Data Space Ecosystem - <https://dataspace.copernicus.eu/>

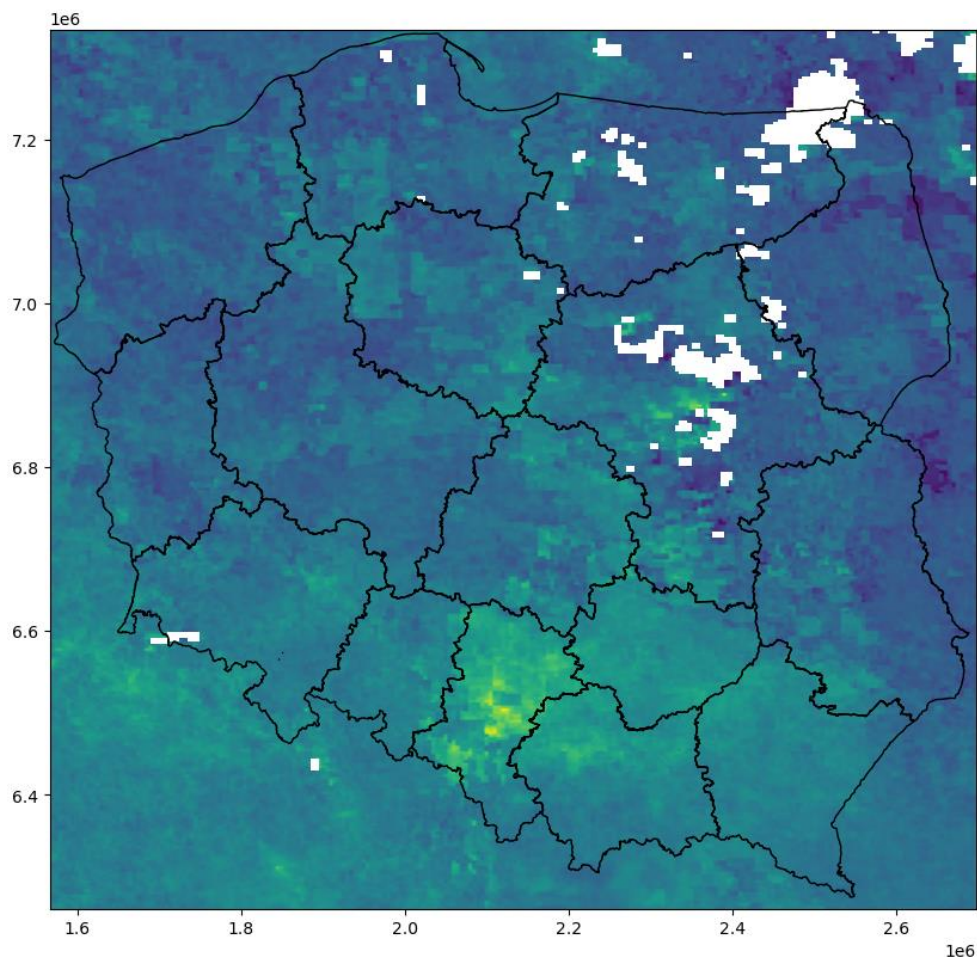
Air pollution statistics based on satellite data



```
[8]: evalscript_mean_mosaic = ""  
//VERSION=3  
function setup() {  
  return {  
    input: ["NO2", "dataMask"],  
    output: {  
      bands: 1,  
      sampleType: "FLOAT32",  
    },  
    mosaicking: "ORBIT"  
  };  
}  
  
function isClear(sample) {  
  return sample.dataMask == 1;  
}  
  
function sum(array) {  
  let sum = 0;  
  for (let i = 0; i < array.length; i++) {  
    sum += array[i].NO2;  
  }  
}
```

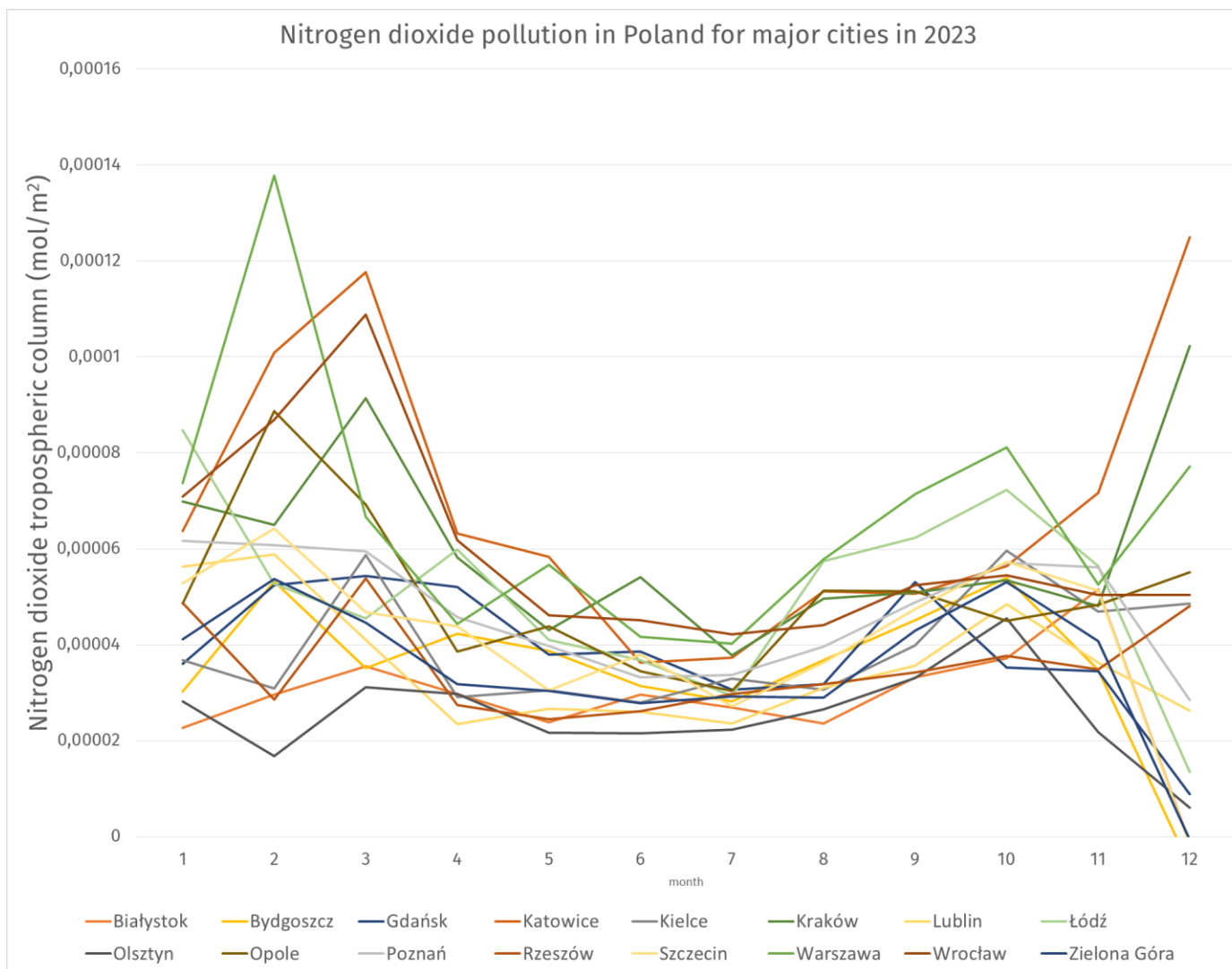
JupyterLab and cloud computing within Copernicus Data Space Ecosystem

Air pollution statistics based on satellite data (experimental)



Mean values of nitrogen dioxide for Poland in december 2023.
SENTINEL-5P

Air pollution statistics based on satellite data (experimental)



Mean monthly values of nitrogen dioxide for major cities in Poland in 2023.

Thank you for your attention