Машинное обучение в прикладных задачах, решаемых в Лаборатории информационных технологий им. М.Г. Мещерякова

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18.10.2023 ОИЯИ

О машинном обучении и его применении к задачам физики высоких энергий. Ососков Г.А. 15.10

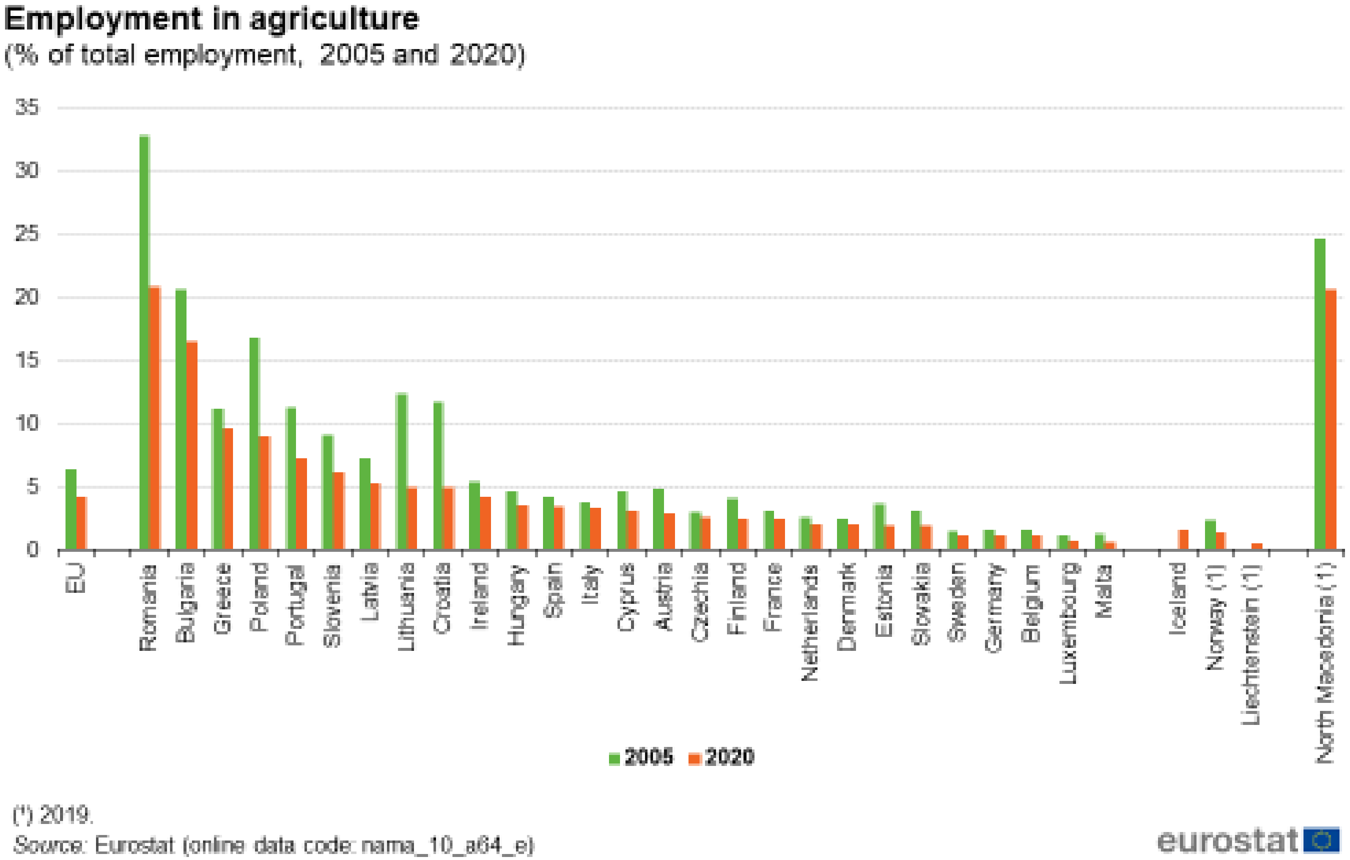
Применение машинного обучения в задаче идентификации частиц. Папоян В.В.

1. Распознавание болезней и проблем в развитии растений

2. Контроль загрязнения тяжелыми металлами

Background

WORLD'S POPULATION
9.1 Billion
by 2050
70%
beyond today's level
FOOD DEMAND SURGING



Employment in agriculture
(% of total employment, 2005 and 2020)
35
30
25
20
15
10
5
0
EU
Romania
Bulgaria
Greece
Poland
Portugal
Slovenia
Latvia
Lithuania
Croatia
Ireland
Hungary
Spain
Italy
Cyprus
Austria
Czechia
Finland
France
Netherlands
Denmark
Estonia
Slovakia
Sweden
Germany
Belgium
Luxembourg
Malta
Iceland
Norway (¹)
Liechtenstein (¹)
North Macedonia (¹)
2005
2020
(¹) 2019.
Source: Eurostat (online data code: nama_10_a64_e)
eurostat

HELP WANTED

Advanced technologies in agriculture

- IoT, sensors,
- remote sensing,
- big-data analysis,
- robots,
- drones,
- digitalization,
- artificial intelligence,
- etc.

There are also many interesting projects in chemistry-, biology-, genetic- and other areas

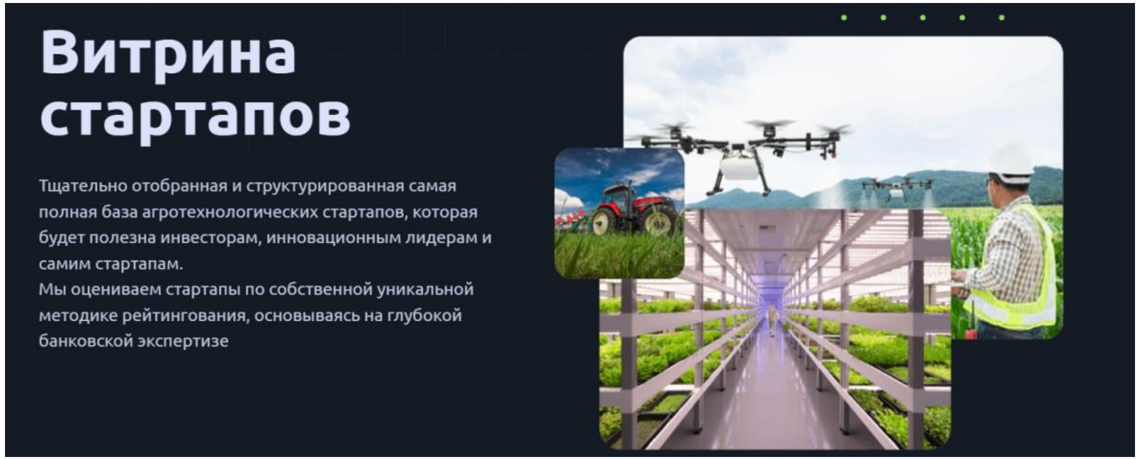
Animal husbandry is very interesting area with great impact of advanced technologies, but it is out of scope of the report!

Artificial intelligence in agriculture

- Soil management,
- problems detection,
- crop health monitoring,
- yield prediction,
- price forecasting,
- yield mapping,
- optimization of pesticides and fertilizers usage,
- etc.

Where to find data?

https://rshbdigital.ru/startups



https://t.me/svoe_fermerstvo

https://t.me/agrotech_startup

https://t.me/fermerznaet

…

https://data-economy.ru/reports

Эффективные отечественные практики на базе технологий искусственного интеллекта в сельском хозяйстве

01.06.2023

From Top to bottom – soil & crop management

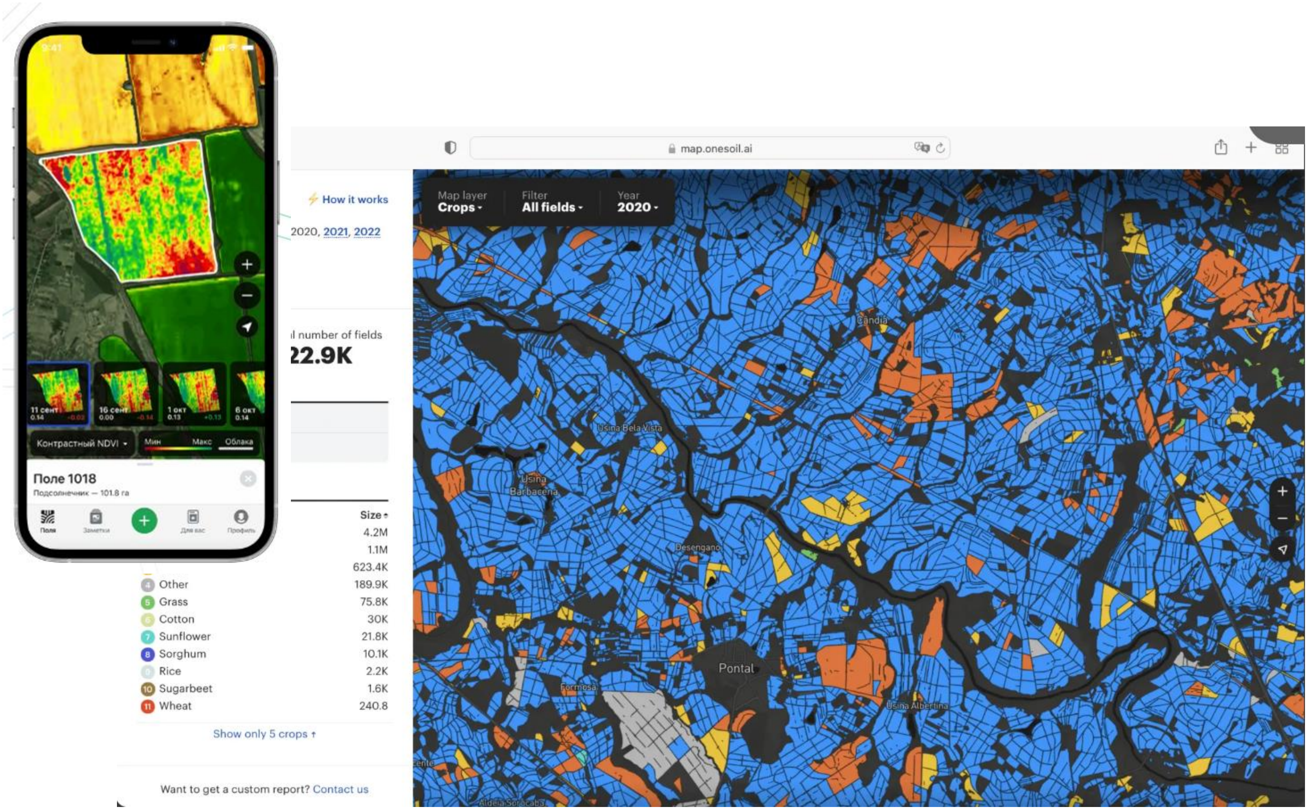
https://www.aerospace-agro.com/

We study territories and cultures using information and aerospace technologies in order to increase the yield and revenue of the enterprise.

Commercial programs

https://onesoil.ai/

Helps to remotely monitor the condition of land, crops, increase yields, reduce the cost of seeds and fertilizers



Open programs. 10 -15 m resolution

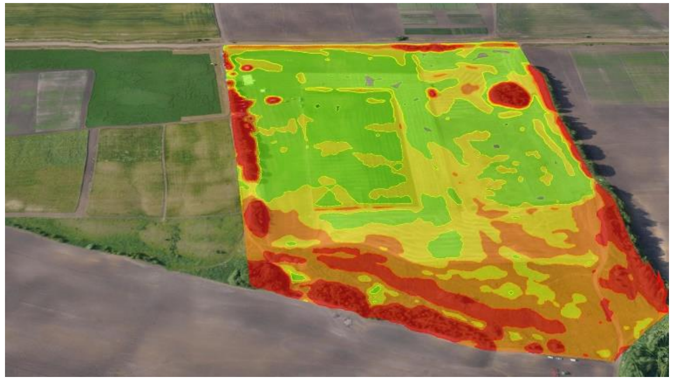
"Teleagronom" - InnoGeoTech, Innopolis University, etc

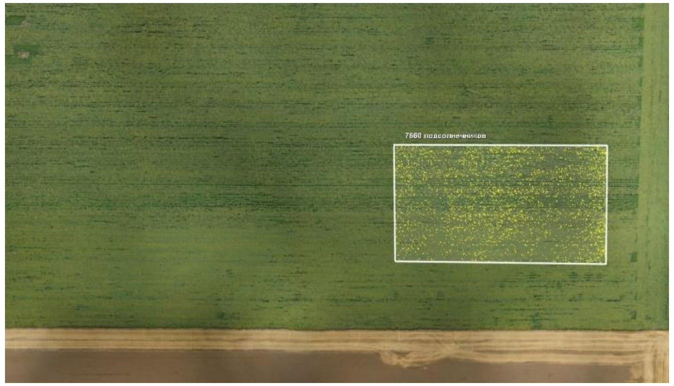
TERRA TECH presented a complex of geoservices "DigitalEarth"

Geoscan

Geoscan is a Russian group of companies engaged in the development and production of unmanned aerial vehicles (UAS), as well as the development of software for photogrammetric data processing and 3D visualization

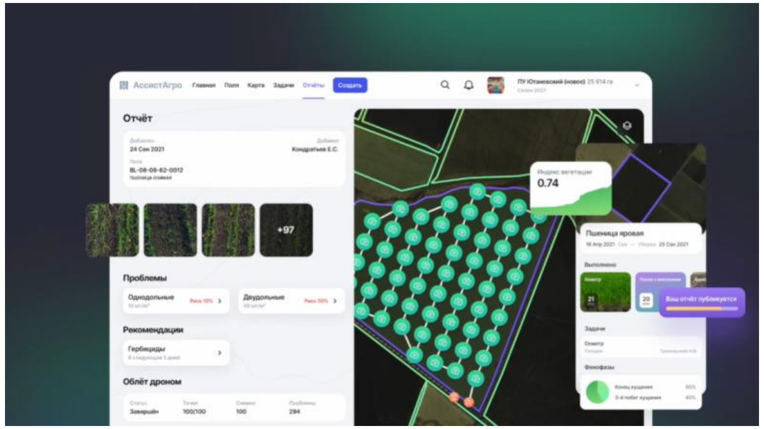
Sputnik AgroGeoinformation system focused on solving the problems of precision farming.





AssistAgro

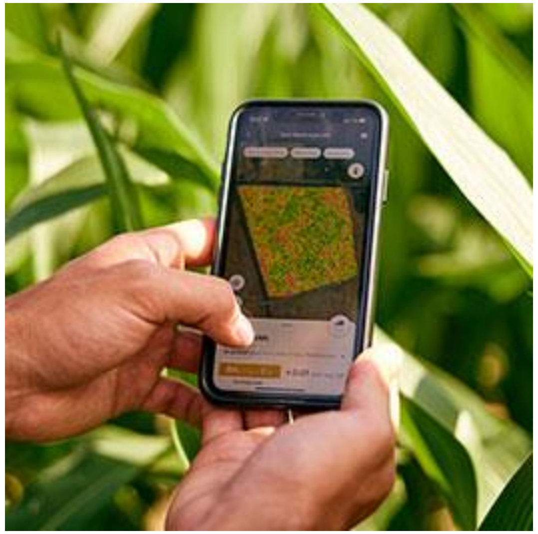
AssistAgro is a digital platform for effective agribusiness management



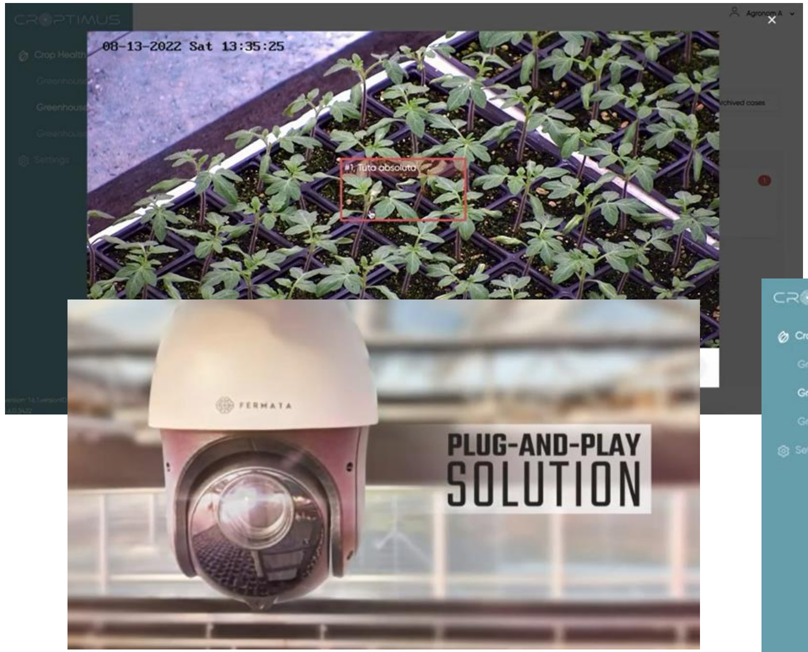
AssistAgro allows one to solve the following tasks:
- forecast of emergence and development of weeds;
- calculation of the density of the condition and the quality of the placement of crop plants;
- forecast of occurrence and development of diseases of agricultural plants;
- forecast of the emergence and development of pests of agricultural plants;
- obtaining recommendations on the optimal dates for agroscouting, pesticide application, tank mix composition and consumption rate;
- yield forecast;
- independent field status control

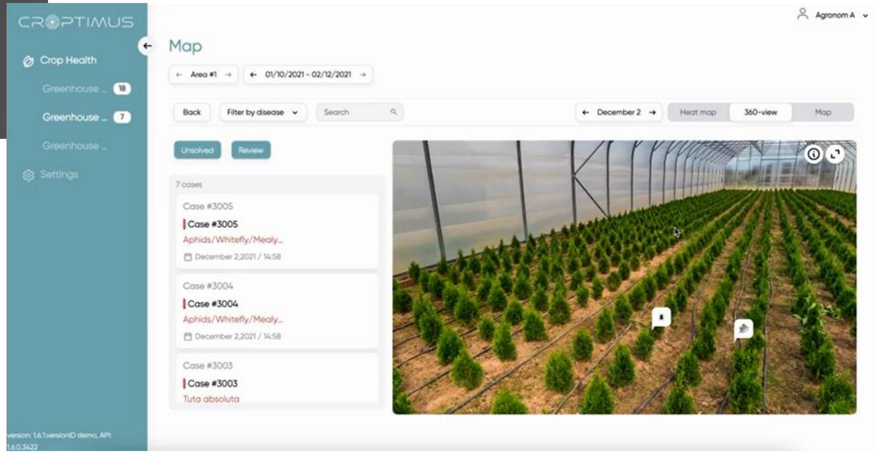
Sure, there are lots of foreign companies with same functional!

https://www.taranis.com/



https://www.fermata.tech/





And many others

SiberianTiger – field robot (project stopped)

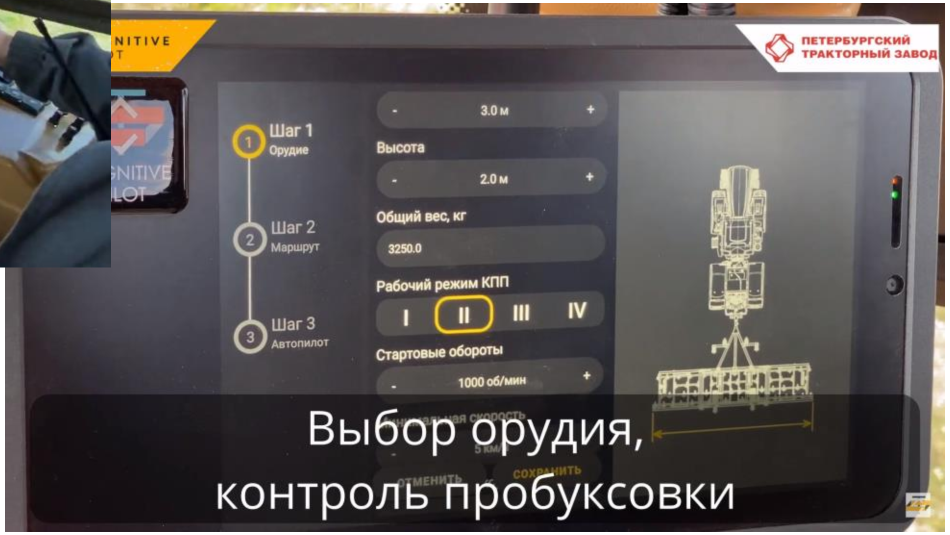
Autonomus agro-robots

https://ravenind.com/ omnipower-3200

Case II Magnum (concept)

Cognitive Technologies (https://cognitive.ru/)

Has installed artificial intelligence (AI)-based autonomous control systems for agricultural transport on more than 1,000 combines in Russia.
Since the spring of 2023, the systems have been installed on more than 100 tractors in Russian agricultural enterprises from Pskov to Blagoveshchensk.
They are serially equipped with tractors "Kirovets" at the St. Petersburg Tractor Plant.
According to experts, the cost of such a complex is no more than 5-10% of the total cost of the machine. Using the system allows you to increase labor productivity up to 25%, save fuel (7%) and other resources.

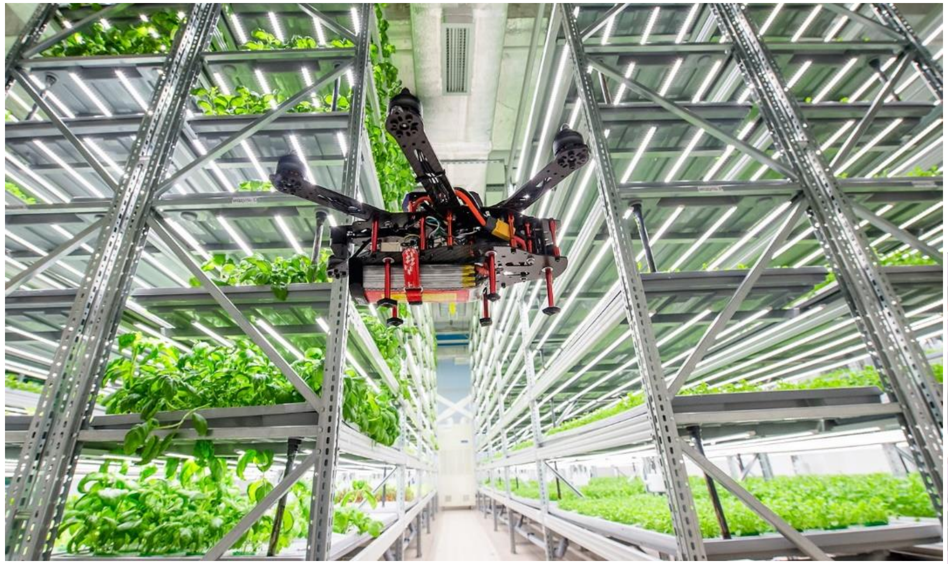


Harvesting robots

Root AI

Controlled environment farming

iFarm (https://ifarm.fi/)



GALAD Green Line (http://npcsvet.ru/)

https://agrotechfarm.com

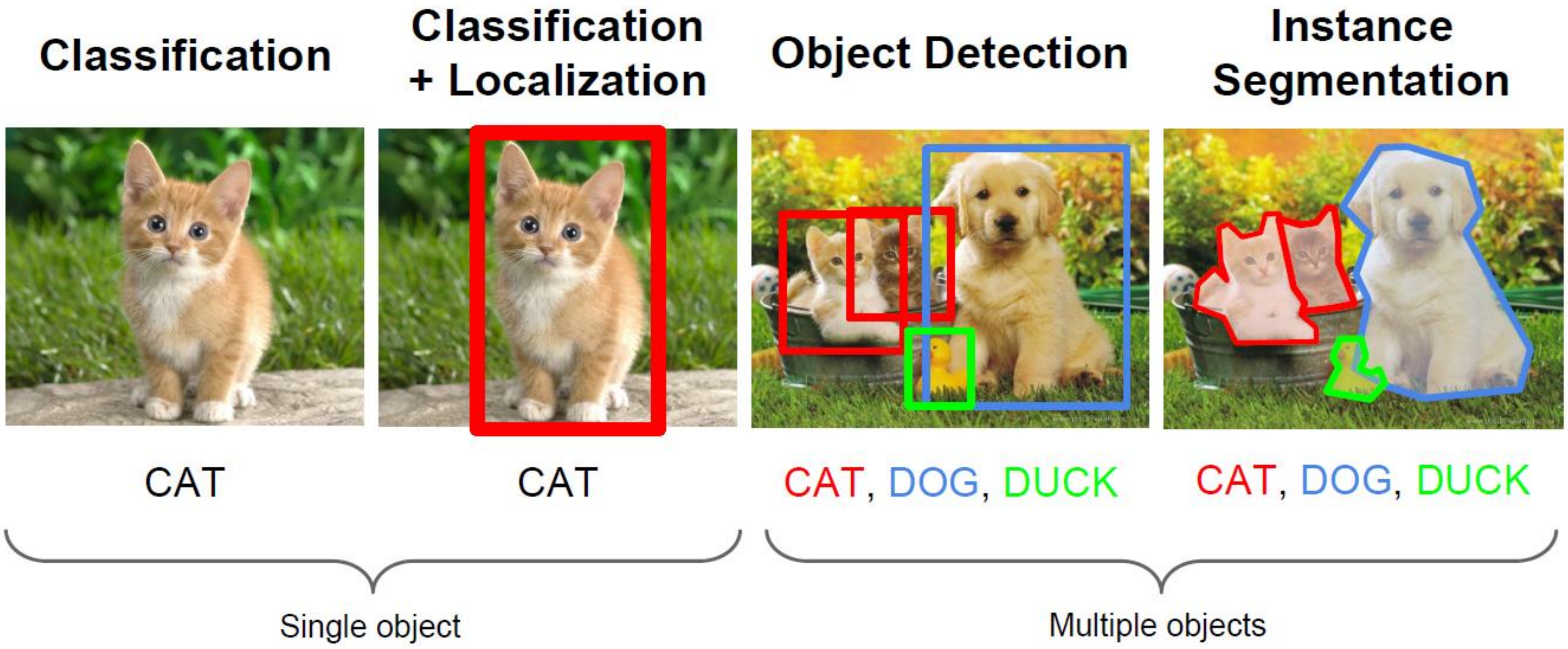
https://city-farmer.ru/),
Healthy garden (https://healthygarden.ru/)

Foreign companies: GreenLabs, Plenty, Pure Harvest Smart Farms iFarm и т.д.

https://farm.bot – plants printer

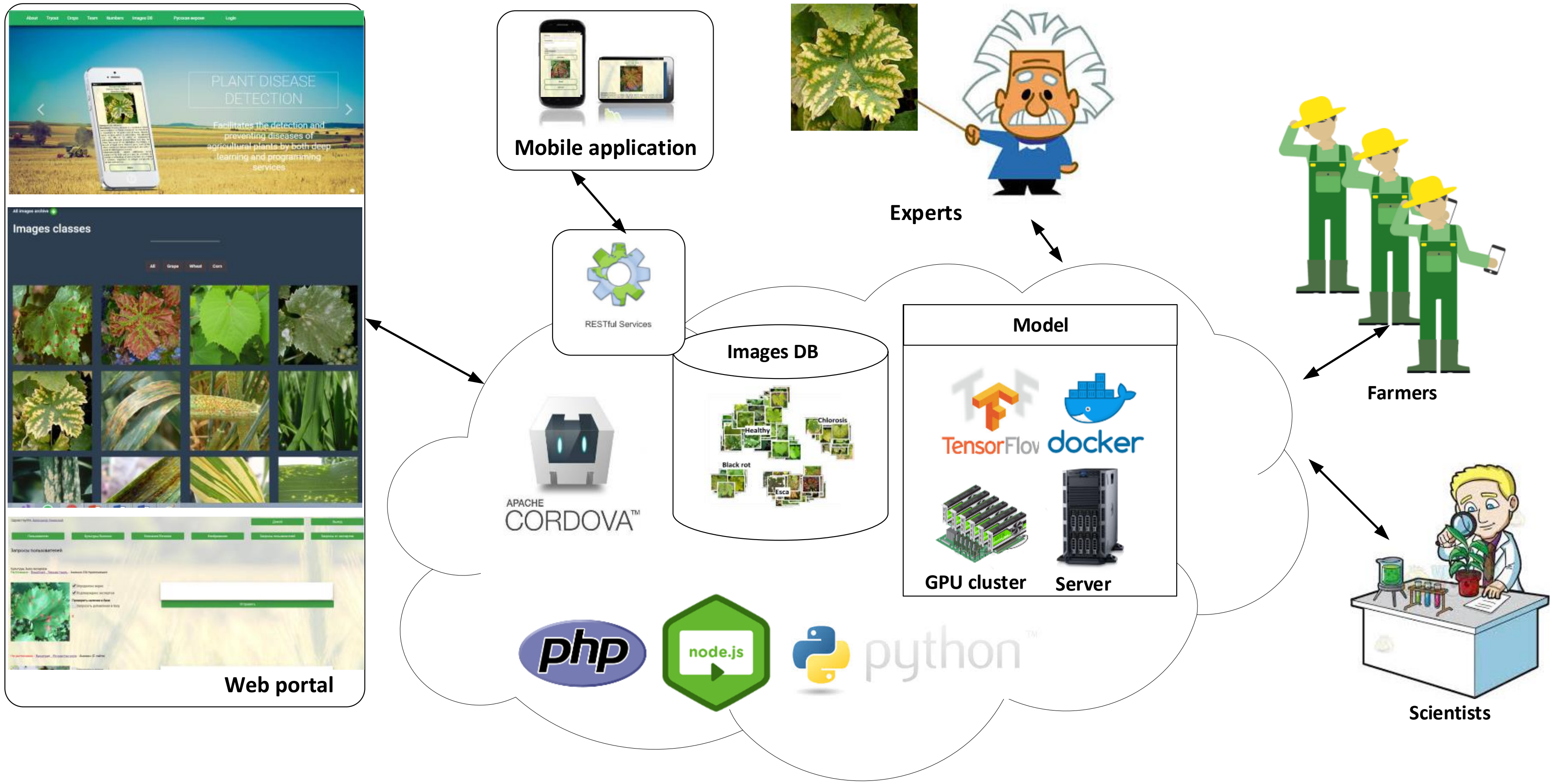
What about LIT activities?

Specialization



- Choosing the optimal architecture and mechanisms to solve the problem
- Developing a pre-built solution, training models, and implementing a software environment based on proven approaches and methods
- Choosing the equipment and creating devices to support the operation of the models

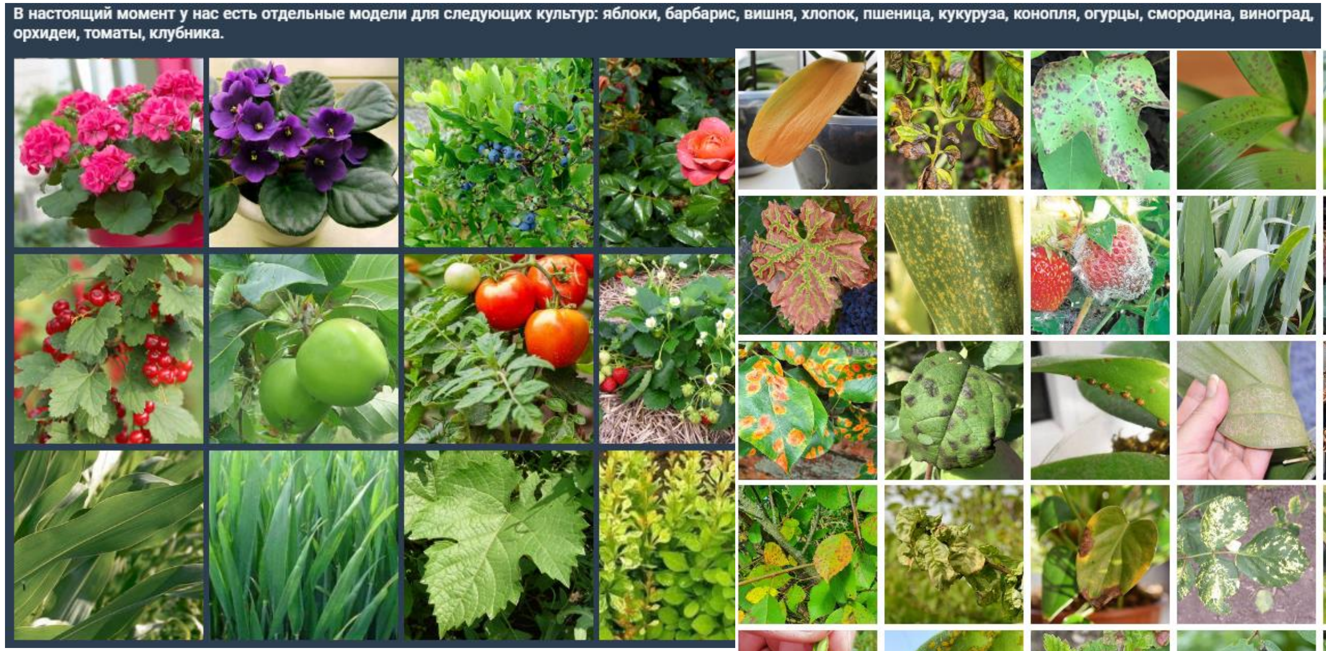
Palnts disease detection platform



PDDP consists of a set of interconnected services and tools developed, deployed and hosted with the help of the JINR cloud infrastructure. Our web-portal (pdd.jinr.ru – old. Doctorp.org - new), was developed with the Node.js and PHP. It provides not only a web-interface but also the API for third-party services. We have the Pytorch model in the Docker realized as a Tensorflow serving. The model can work at the virtual server, or at a GPU cluster.

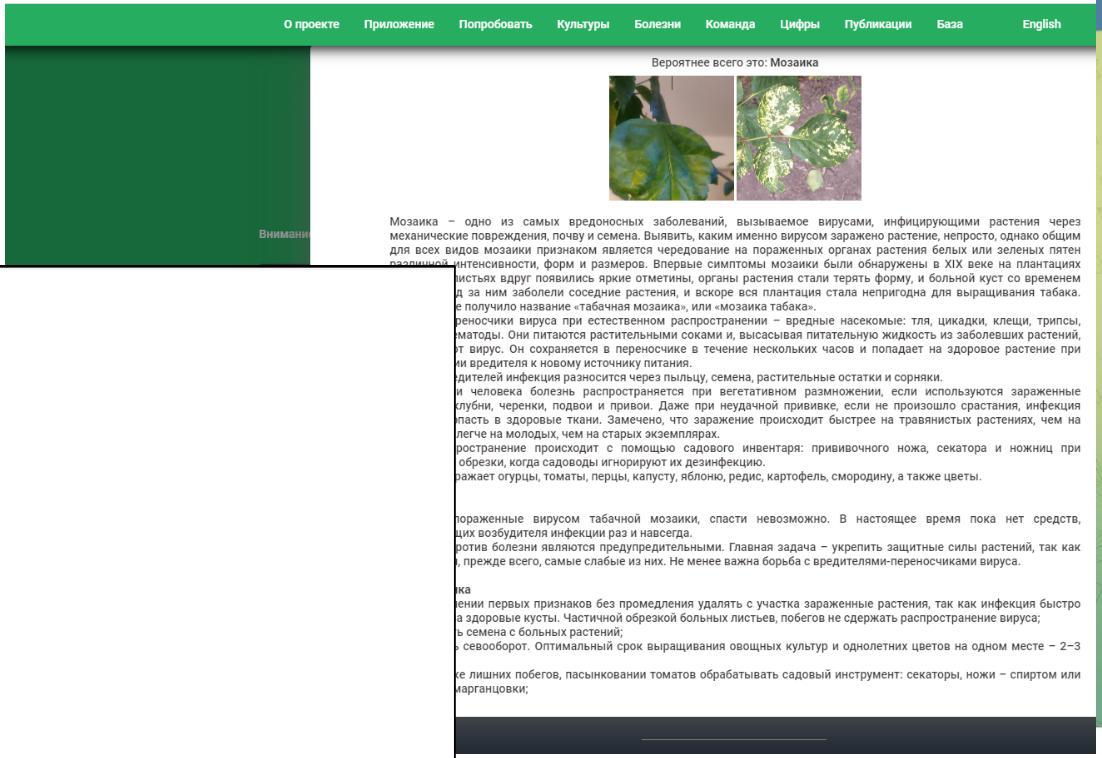
We have a mobile App for Android that was developed using the Flutter, so we could build it for iOS, and Windows.

PDDP database



General model > 65 classes
Corpse model > 70 classes
Specialized models > 25 classes

Web-portal, telegram-bot, API, app




```
{
  "error":0,
  "general_predictions":[
    {…},
    {…},
    {…}
  ],
  "custom_predictions":[
    {…},
    {
      "type":"розы",
      "prediction":[
        {
          "name":"Мозаика",
          "sample":"http://usrbb.ru/botainika/diseases/rmv1.jpg",
          "description":"<p>Это наиболее распространенное заболевание вирусного типа. Узнать его очень просто – листья покрываются хлоротичными пятнами и узорами, которые могут перейти в прожилковый хлороз. Листья деформируются (узколистность, курчавость, морщинистость) и постепенно опадают. Рост побегов замедляется, и они не вызревают. Побеги, которые больны, вырезают. При дальнейшем распространении болезни растение уничтожают
```


- FASCO company with the HoGa application.

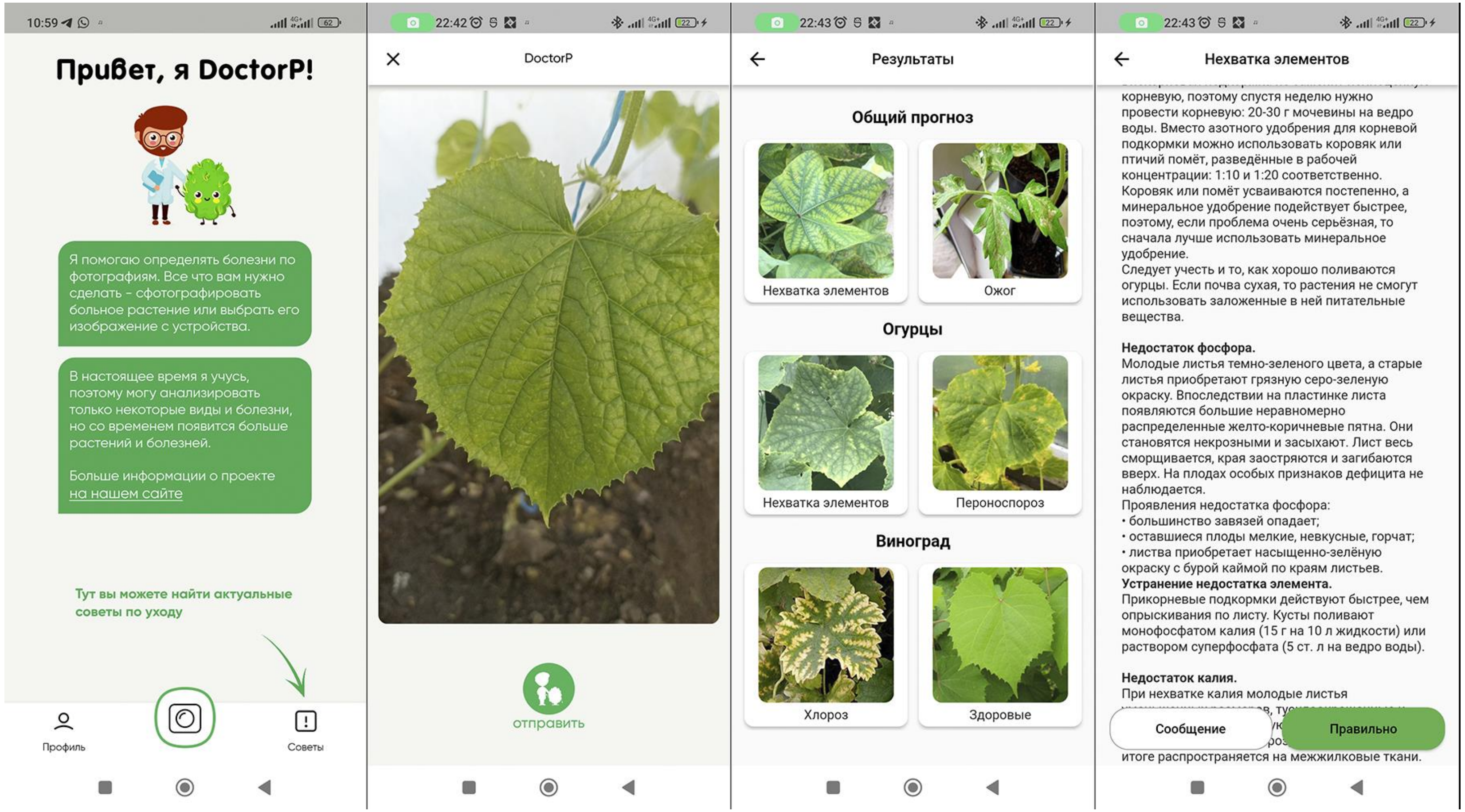
Several organizations have already been granted test access to our API.

- The Plant Care Service from the Russian Agricultural Bank
- Andijan Institute of Agriculture and Agrotechnics of the Republic of Uzbekistan

have utilized our API in their respective applications, which focus on describing plant diseases and pests.

Mobile App

Google play: “**DoctorP**”. * Only android version is available

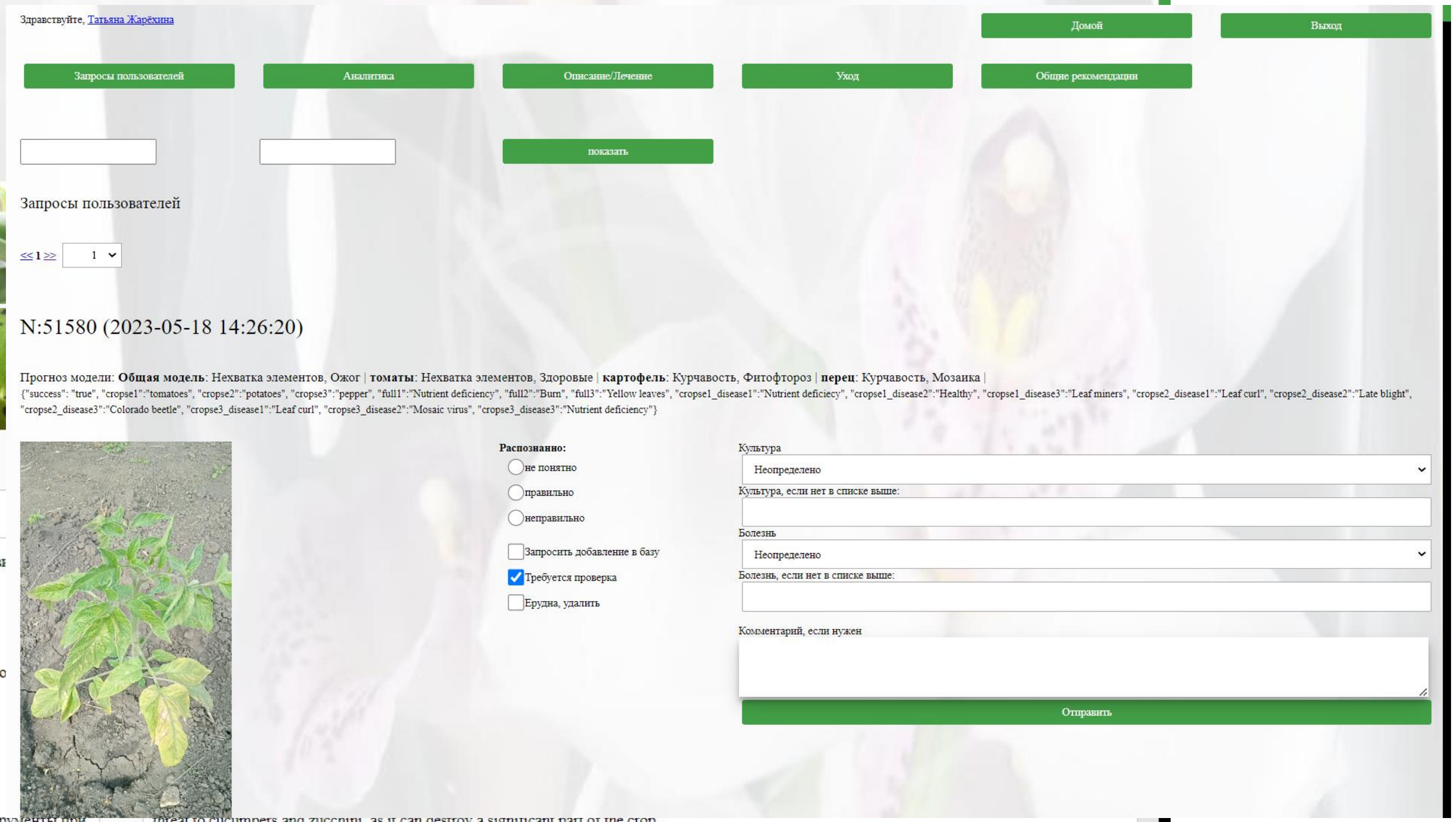


The user has the opportunity to photo a diseased plant and get a prediction for the disease and treatment suggestions.
It is possible to download images from device store.
The application requires access to the Internet to work.

We can run the model on the mobile device directly (we have tried it) but models changing too often.

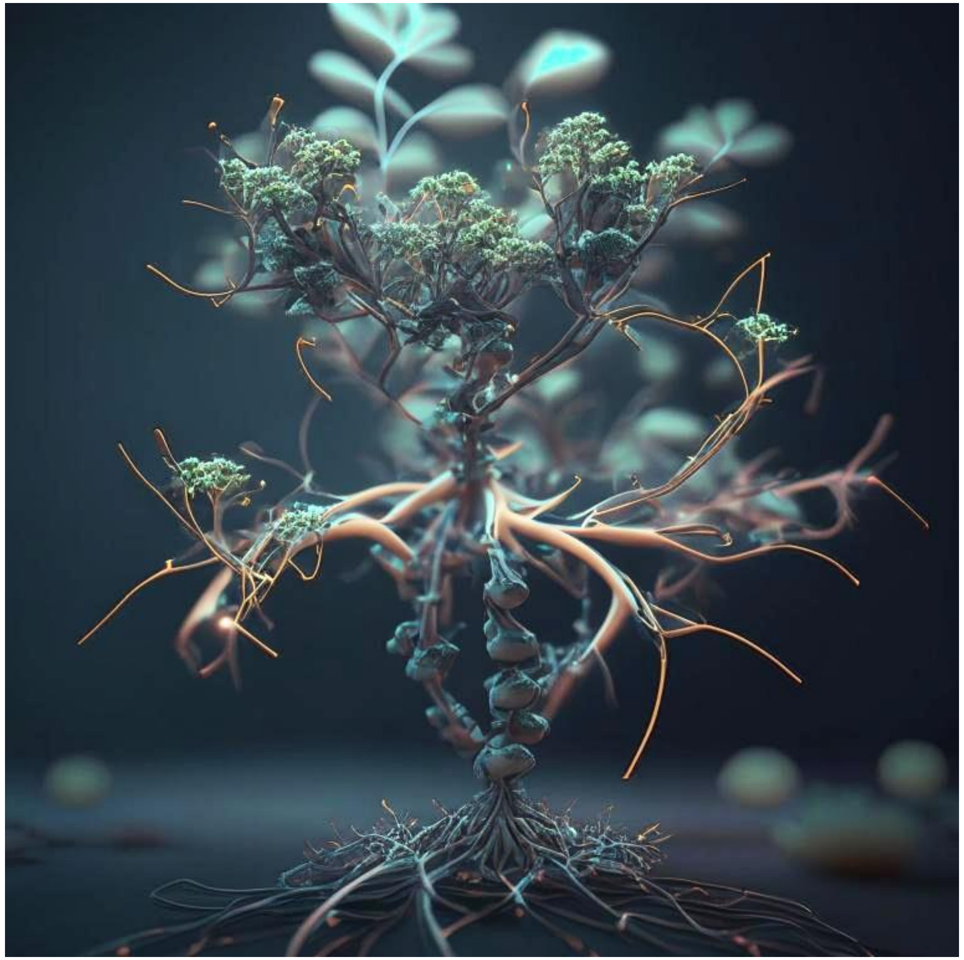
Server side

Здравствуйте, Александр Ужинский
Домой
Выход
Пользователи
Рекомендации
Культуры/Болезни
Описание
Уход
Аналитика
Изображения
Запросы пользователей
Запросы от экспертов
Описание/Лечение:
Добавить
Орхидеи - Антракноз
Описание:
Paragraph
Source
Заболевание антракноз относится к разряду инфекционных. Возбудители – грибы рода Colletotrichum. Встречается несколько подви
• Colletotrichum gloeosporioides поражает преимущественно фаленопсис;
• Colletotrichum orchidearum и Colletotrichum boninense – каттлею;
• Colletotrichum karstii и Colletotrichum crossandrae – ванду ;
• Colletotrichum coccodes и Colletotrichum crassipes – цимбидиум.
На разных сортах цветка болезнь проявляет себя по-разному. Симптомы зависят от структуры и толщины листьев. На антракноз мо
указывать:
• сухие белесые пятна на листьях орхидей;
• коричневые пятна;
• черная пятнистость, постепенно светлеющая;
• круглые подушечки спор (белые, розовые, желтые, бурые) – появляются со временем.
Пятна антракноза постепенно увеличиваются и сливаются.
Антракноз развивается в результате инфицирования. Споры грибов легко переносятся по воздуху, попадают на руки, одежду, инструменты при
работе с зараженными растениями. Нередко источником инфекции становится недавно приобретенный комнатный цветок.
При низкой влажности воздуха в оранжерее (60 % и меньше) антракноз может долгое время не проявлять себя.
В условиях повышенной влажности и жары инкубационный период в среднем занимает от 4 до 10 дней. Чаще всего распространение болезни
происходит при температуре +25 °C и влажности 90 %. Однако антракноз способен развиваться и в гораздо более неблагоприятной среде (при
температуре от +4 °C до +30 °C).
threat to cucumbers and zucchini, as it can destroy a significant part of the crop.
The disease develops as a result of infection. Fungal spores are easily carried through the air and can land on hands, clothes, and tools when working
with infected plants. A recently acquired indoor flower can also become a source of infection.
With low humidity in the greenhouse (60% or less), anthracnose may not manifest itself for a long time. In conditions of high humidity and heat, the
incubation period averages from 4 to 10 days. The spread of the disease is most common at a temperature of +25 °C and a humidity of 90%. However,
anthracnose can also develop in a much more unfavorable environment (at temperatures from +4 °C to +30 °C).



Здравствуйте, Татьяна Жарёхина
Домой
Выход
Запросы пользователей
Аналитика
Описание/Лечение
Уход
Общие рекомендации
показать
Запросы пользователей
<< 1 >>
1
N:51580 (2023-05-18 14:26:20)
Прогноз модели: Общая модель: Нехватка элементов, Ожог | томаты: Нехватка элементов, Здоровые | картофель: Курчавость, Фитофтороз | перец: Курчавость, Мозаика |
{"success": "true", "cropse1":"tomatoes", "cropse2":"potatoes", "cropse3":"pepper", "full1":"Nutrient deficiency", "full2":"Burn", "full3":"Yellow leaves", "cropse1_disease1":"Nutrient deficiecy", "cropse1_disease2":"Healthy", "cropse1_disease3":"Leaf miners", "cropse2_disease1":"Leaf curl", "cropse2_disease2":"Late blight", "cropse2_disease3":"Colorado beetle", "cropse3_disease1":"Leaf curl", "cropse3_disease2":"Mosaic virus", "cropse3_disease3":"Nutrient deficiency"}
Распознанно:
не понятно
правильно
неправильно
Запросить добавление в базу
Требуется проверка
Ерудна, удалить
Культура
Неопределено
Культура, если нет в списке выше:
Болезнь
Неопределено
Болезнь, если нет в списке выше:
Комментарий, если нужен
Отправить

What's under the hood



We conducted research in the field of optimizing neural network architectures for models.

We tested various state-of-the-art neural network architectures, explored methods for automatically selecting optimal data augmentation policies (auto-augmentation), and experimented with different loss minimization functions (including contrastive, triplet, arcface, cosface, and sphereface).

We identified the optimal approaches for training the models

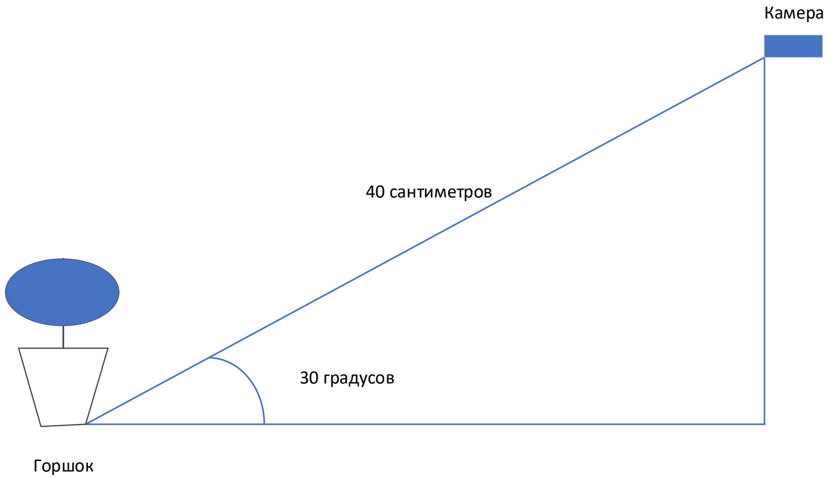
MobileNet/ ConvNeXt + No augmentation + No quantization + Triplet loss

General model -> corpse model -> custom models

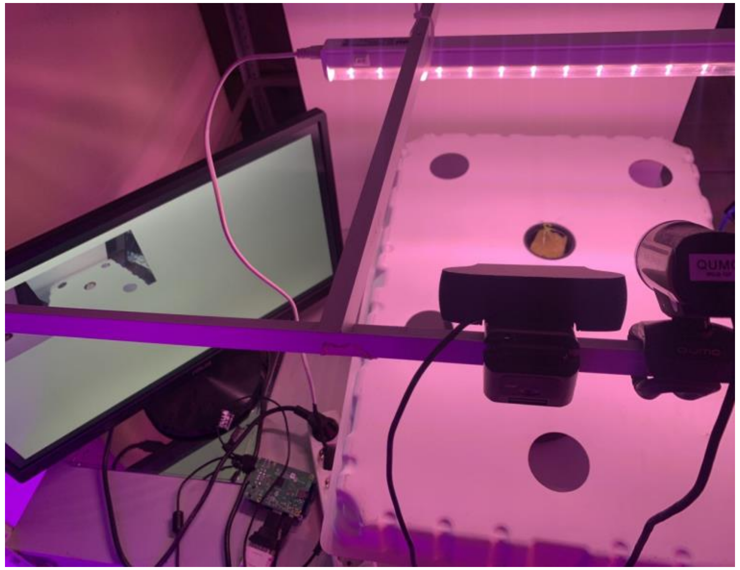
Validation accuracy > 97%

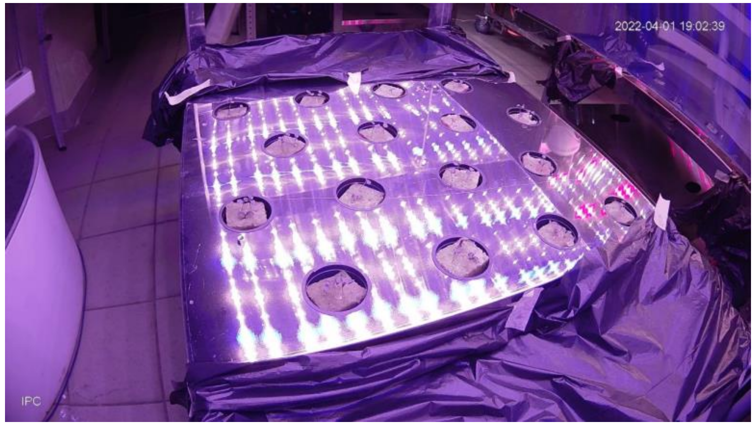
Plant state tracking

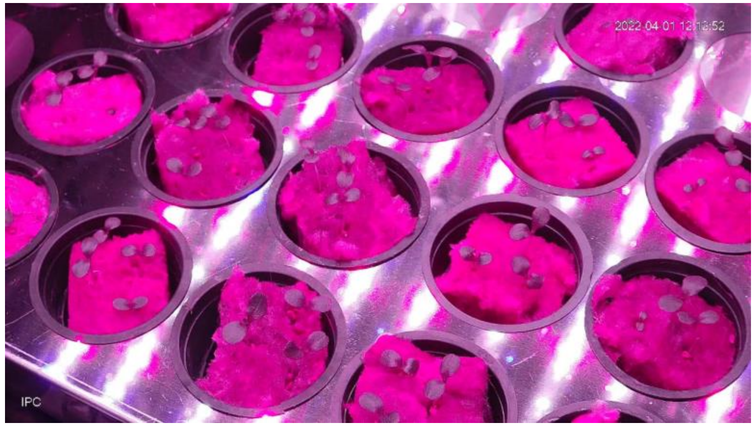
Joint project with the Temiryazev Academy within the framework of the project World-class Scientific Center “Agrotechnologies of the Future”



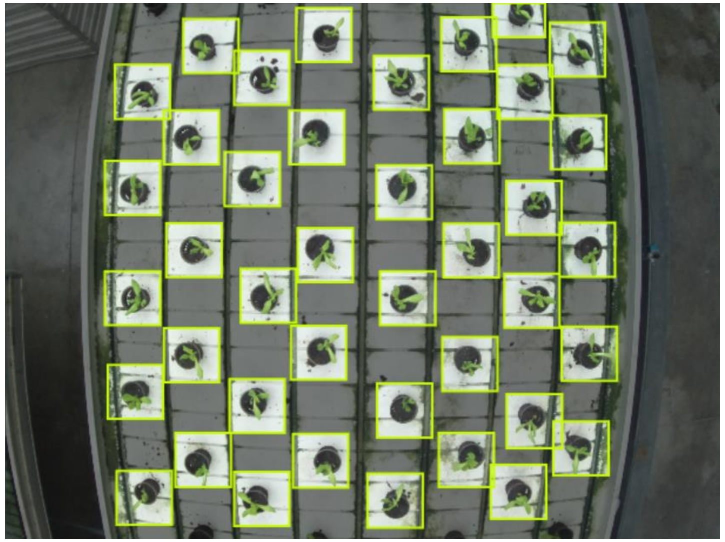
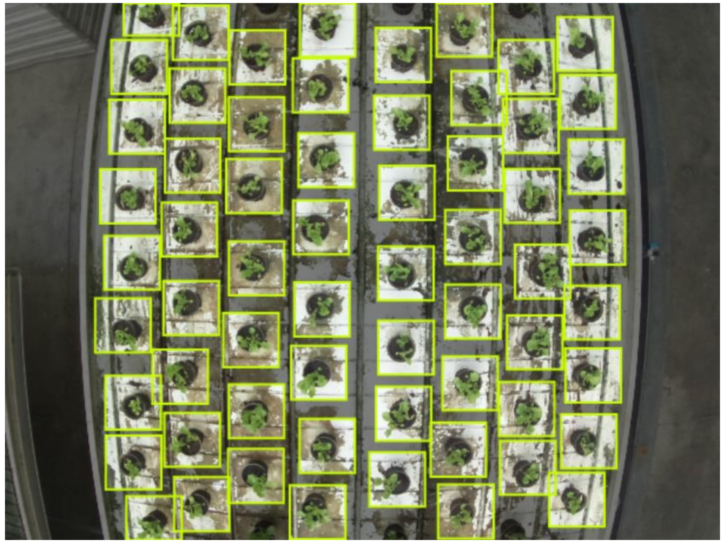
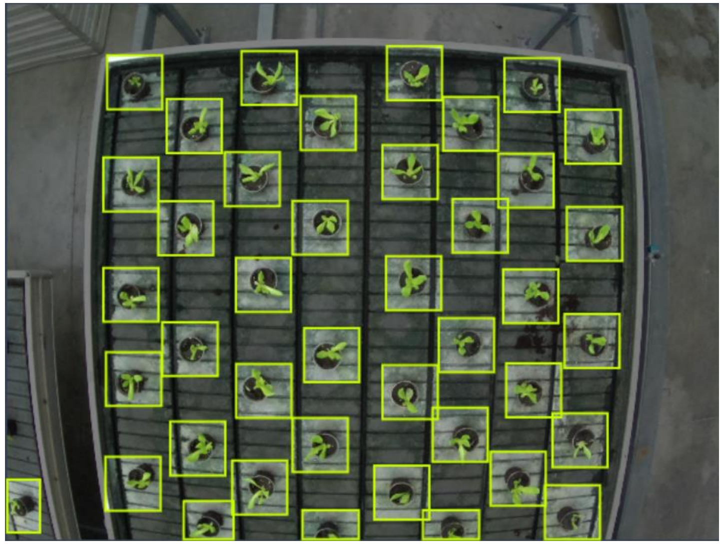
- **Classification of the degree of development of the plant.**
- **Determination of the weight group of the plant.**







Salads classification

Object detection – 1 class
Classification – 6 classes

Accuracy > 99%

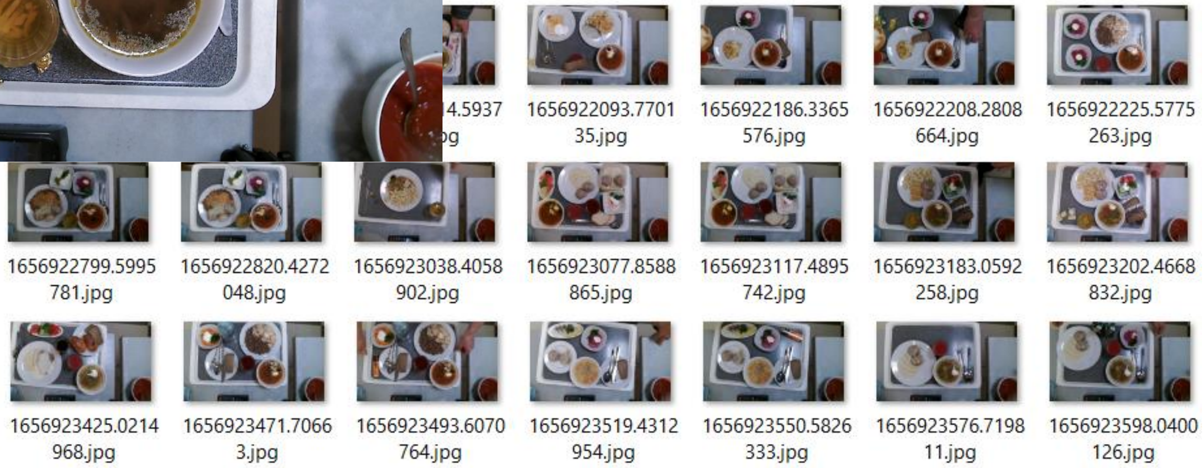
Set of images

Data collection was carried out in automatic mode using raspberry pi 4, a digital camera with manual focus, and sonar.

Dining room LIT JINR

A set of images in 5 days:

- 446 images
- More than 150 different classes of objects



Final results

Yolo v5s

Metrics results

Recall	0.856
Precision	0.723
mAP	0.906

Yolo v6s

Metrics results

Recall	0.805
Precision	0.687
mAP	0.854

Yolo v7

Metrics results

Recall	0.901
Precision	0.845
mAP	0.925

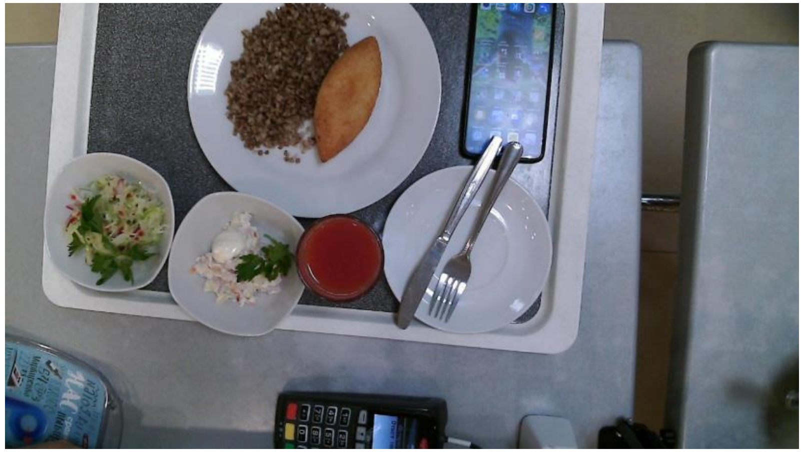
Yolo + Triplet

Metrics results

Recall	0.995
Precision	0.994

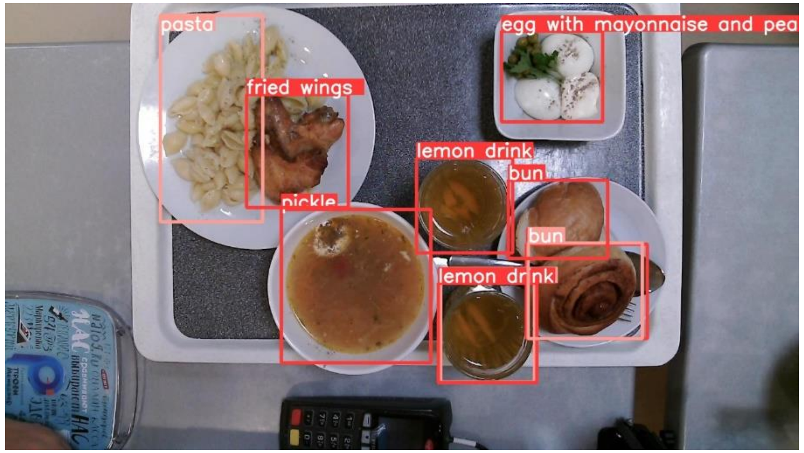
Examples

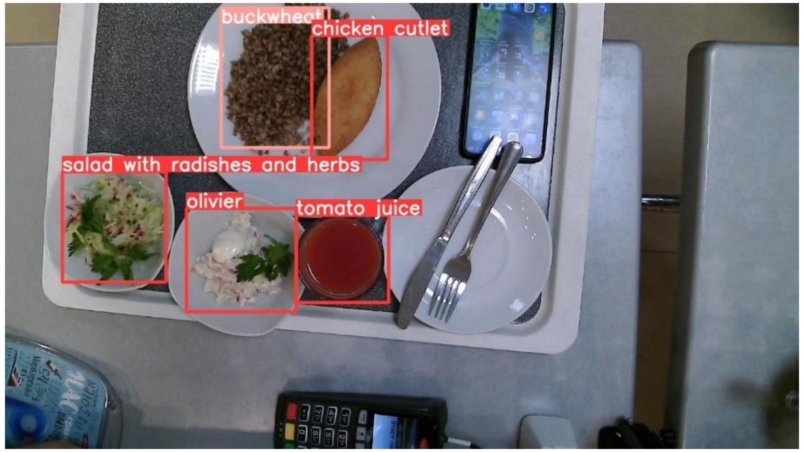
Input images



Processing

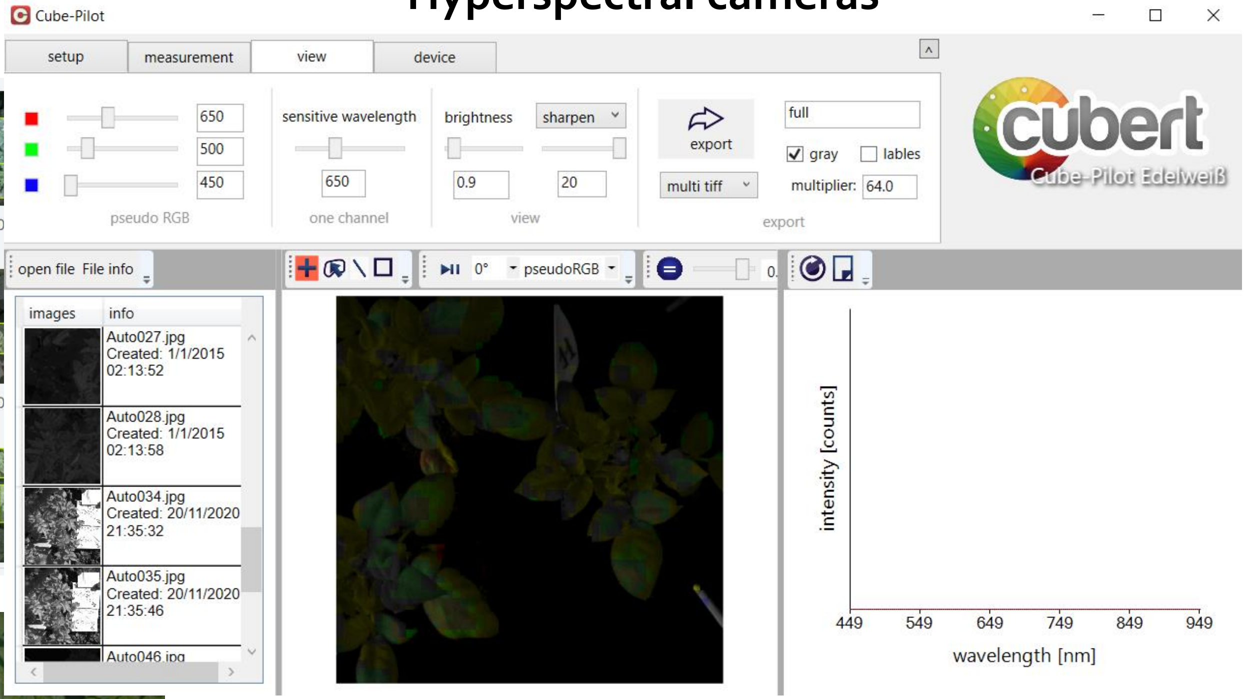
Output images

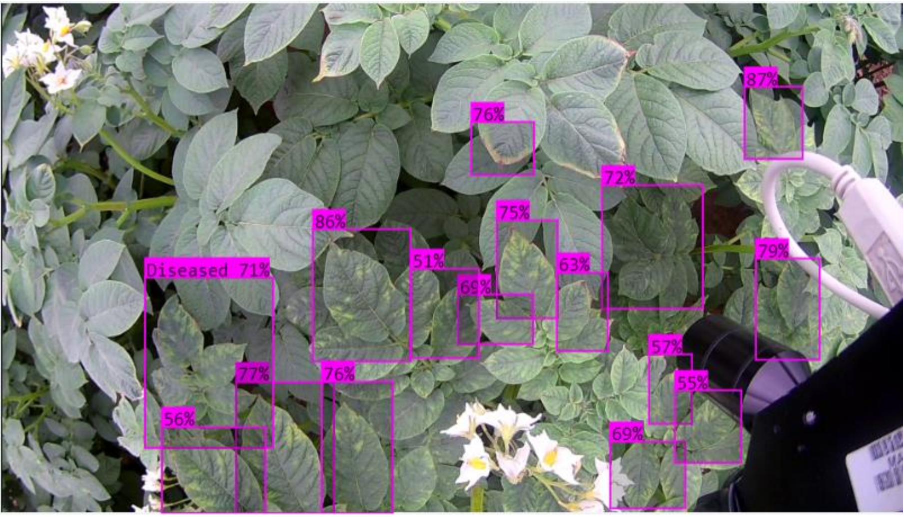




Potatoes disease (Doka-Gennyye Tekhnologii)

Hyperspectral cameras





YOLOv7

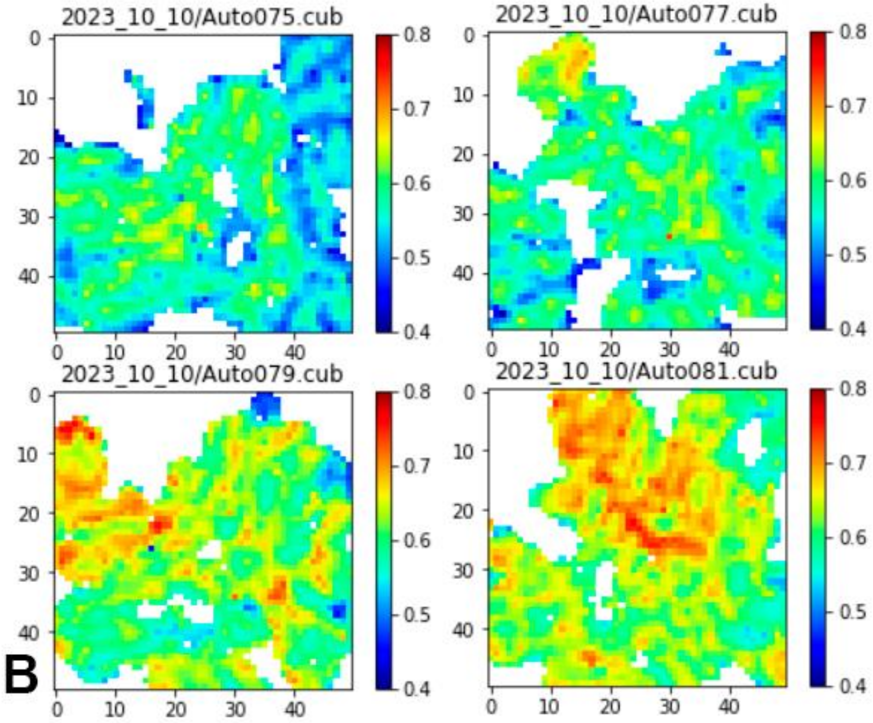
YOLO-NAS

ultralytics YOLOv8

Potatoes disease (Doka-Gennyye Tekhnologii)

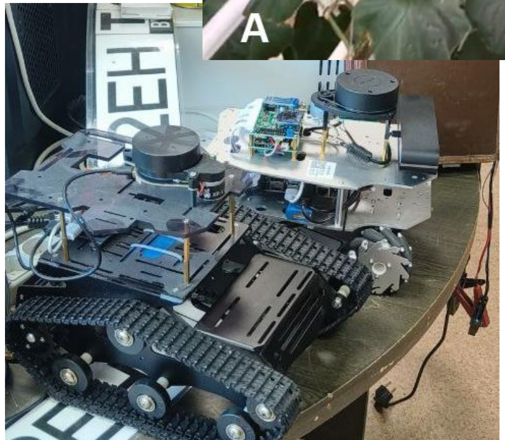
RGB

Hyperspectral cameras



Automated analysis of the state of plants in the greenhouse complex

https://skoltech.space/greenhouse-robot-the-first-test-run-turned-successful



Контроль загрязнения тяжелыми металлами

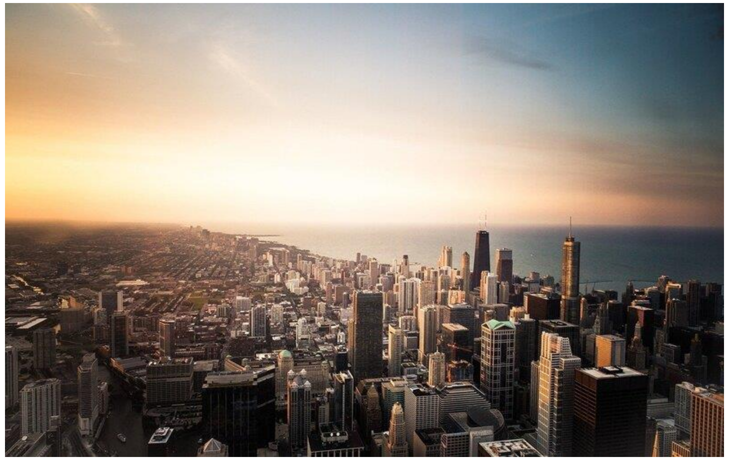
Environmental Concerns

The environmental problems like global warming, acid rain, air pollution, urban sprawl, waste disposal, ozone layer depletion, water pollution, climate change and many more affect every human, animal, and nation on this planet.

Over the last few decades, the exploitation of our planet and the degradation of our environment has gone up at an alarming rate. As our actions have been not in favor of protecting this planet, we have seen natural disasters striking us more often in the form of flash floods, earthquakes, blizzards, tsunamis, and cyclones.





Air pollution

Air pollution has a significant **negative impact** on the various components of ecosystems, **human health**, and ultimately, causes significant **economic damage**.

More than nine out of 10 of the world's population – 92% – lives in places where **air pollution exceeds safe limits**, according to research from the World Health Organization (WHO).

There are regional and international **environment control programs**. They use different techniques and tools but as a result, they all want to understand **what is the current situation** and how it will evolve.

Approaches

Generally, studies are based on the data obtained at the sampling sites in manual or automatic mode. The collected material is analyzed using various techniques in the field or in special laboratories. Air quality (AQ) monitoring stations provide information about regulatory air pollutants such as gaseous pollutants, PMs, and rarely about heavy metals. To get detailed information samples should be processed in laboratories.

After collection, the data are aggregated and interpreted, and quite often the results are ambiguous and require the involvement of experts.

In most cases such kind of researches are limited, both spatially and temporally

Modeling - Motivation & Benefits

Modelling of air pollution can be a good option for overcoming gaps in the data gathering.

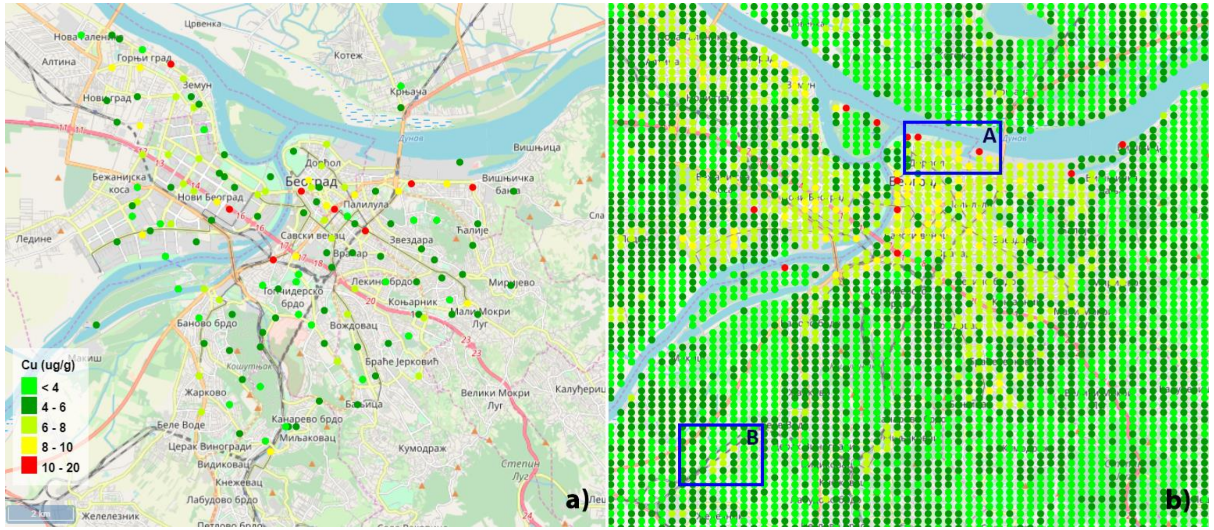


Figure 1. Concentration of Cu in the summer of 2013 (Belgrade): a) real measurements, and b) prediction values; area A represents central part of Old Belgrade with permanently high traffic flow; area B represents a large railway terminal

Modelling allows us to:

- monitor the evaluation of situation when it needed,
- get detailed information about areas of interests,
- check the situation at the cross border areas,
- partly automate the environment control process.

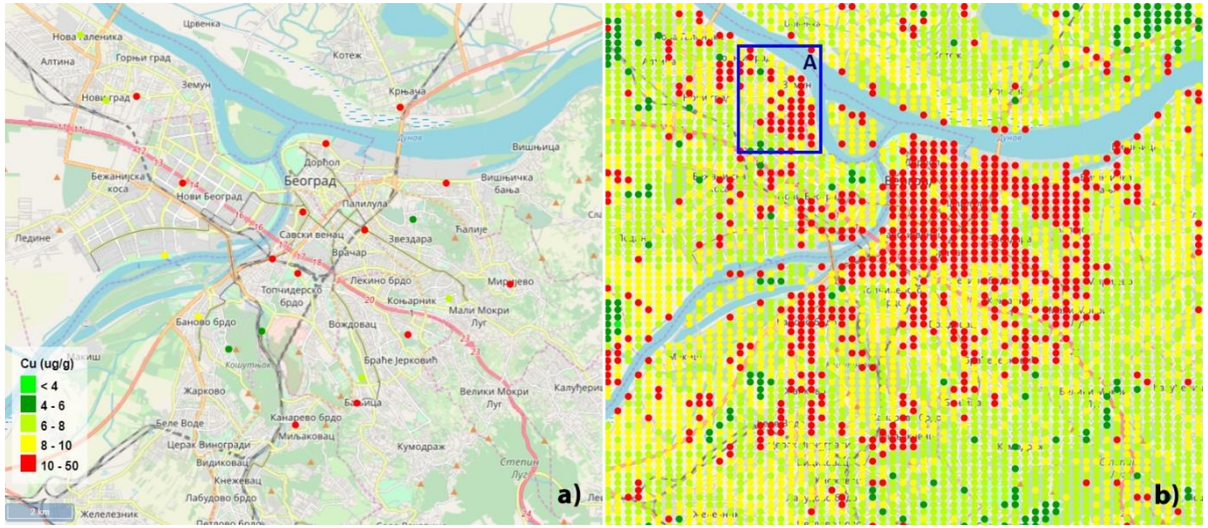
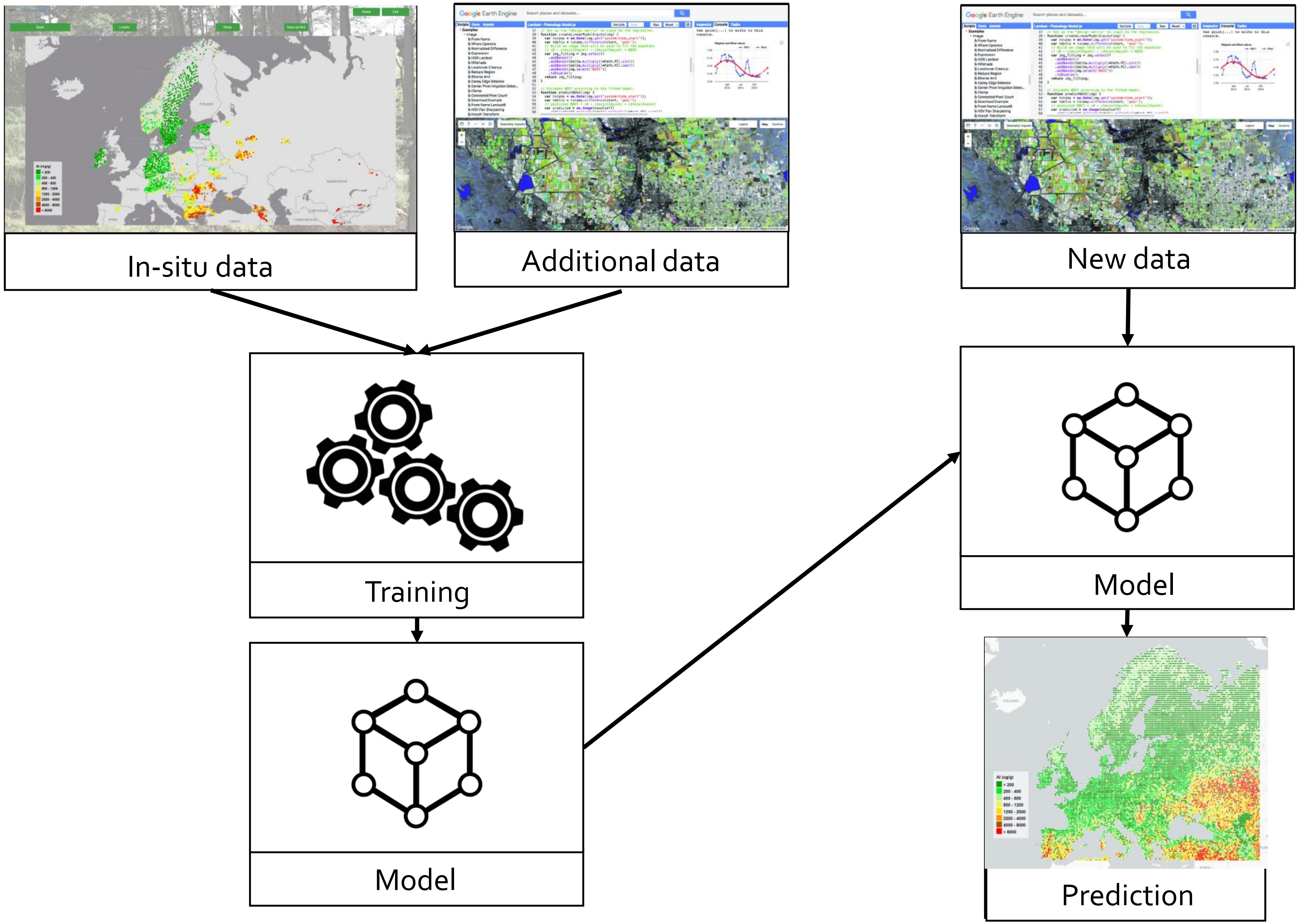


Figure 2. Concentration of Cu in the winter season 2013/2014 (Belgrade): a) real measurements, and b) prediction values; area A represents an old city core highly polluted in winter season

Machine learning (Supervised learning)

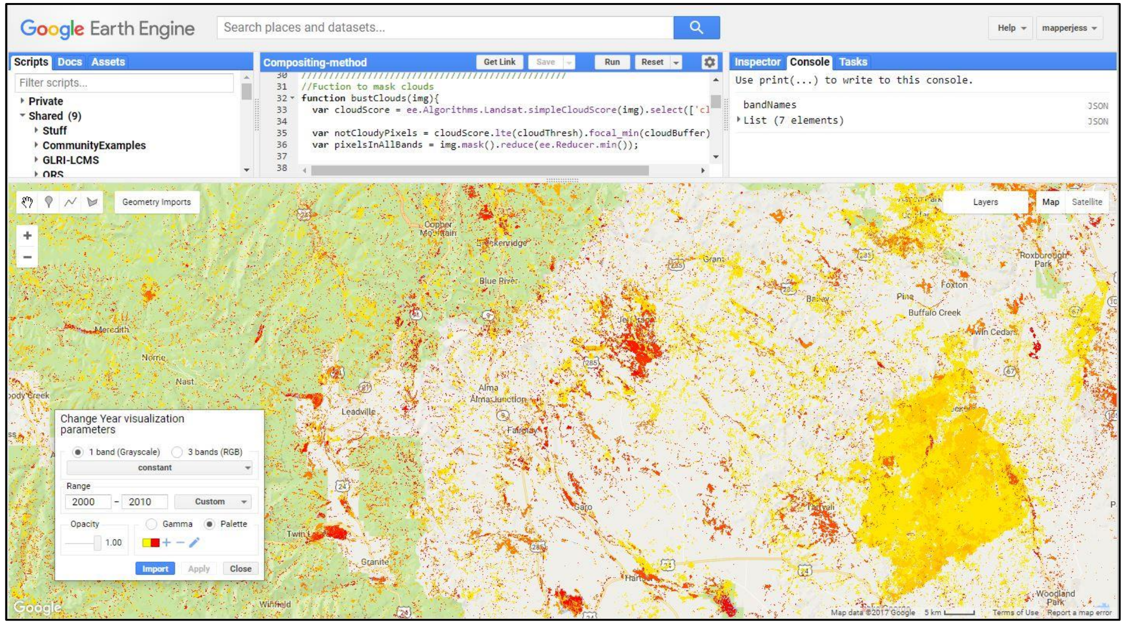


Satellite programs

Source: NASA

Differences

Task: Map all change between 2000 – 2010 over a specific forest



Old solution:

- Select Area of Interest
- Find WRS path/row(s) – assume an area of 4 scenes

Data Prep:

- Download and store all Landsat during growing season (1 GB / zipped scene)
- Extract and layer stack all Landsat (1.75 GB / scene)
- ~48 scenes per year * 11 years = ~528 scenes, or 924 GB
- Apply atmospheric correction (924 more GB)
- Normalize scenes
- Apply FMASK or similar to remove clouds and shadows
- Create composite and mosaic by year
- Generate vegetation index per year (NDVI and/or NBR)

Analysis:

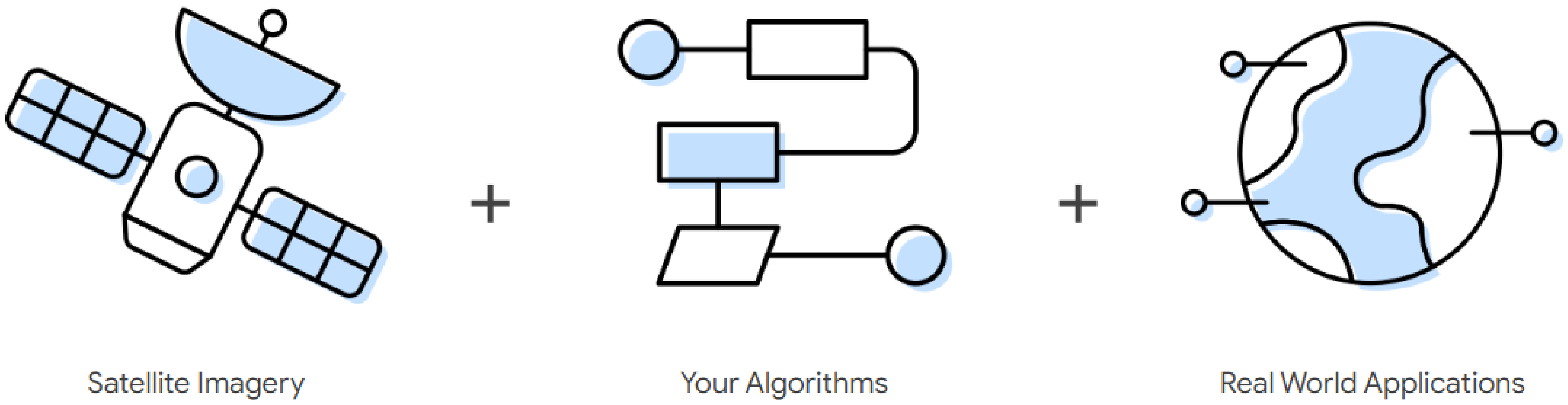
- Build spatial model in ERDAS to compare year pairs
- Generate change layer
- Classify pixels > certain value as "change"
- Build spatial model to apply year attribute to each pixel
- Repeat for each year pair
- Build spatial model to stack all attributed change layers into a single raster image, with the most recently changed pixel on top
- Apply color ramp visually demonstrating change

The new method took an experienced geospatial programmer about an hour and ~100 lines of code to generate a raster layer showing the extent of landscape change thematically colored by year of change (in this case, yellow changed closer to the year 2000 and red colors changed closer to 2010.

Users can change the AOI very simply and run this same process anywhere in the world, then export the results to a raster TIFF image.
This represents an extremely dramatic improvement in efficiency. In fact, it allows us to ask new questions.

Google Earth Engine

Google Earth Engine combines a multi-petabyte catalog of satellite imagery and geospatial datasets with planetary-scale analysis capabilities. Scientists, researchers, and developers use Earth Engine to detect changes, map trends, and quantify differences on the Earth's surface. Earth Engine is now available for commercial use, and remains free for academic and research use.



Earth Engine provides easy, web-based access to an extensive catalog of satellite imagery and other geospatial data in an analysis-ready format. The data catalog is paired with scalable compute power backed by Google data centers and flexible APIs that let you seamlessly implement your existing geospatial workflows. This enables cutting-edge, global scale analysis and visualization.

The Earth Engine Data Catalog

Landsat & Sentinel 1, 2
10-30m, weekly

MODIS
250m daily

Vector Data
WDPA, Tiger

Terrain & Land Cover

Weather & Climate
NOAA NCEP, OMI, ...

... and upload your own vectors and rasters

> 200 public datasets

> 5 million images

> 4000 new images every day

> 80 petabytes of data

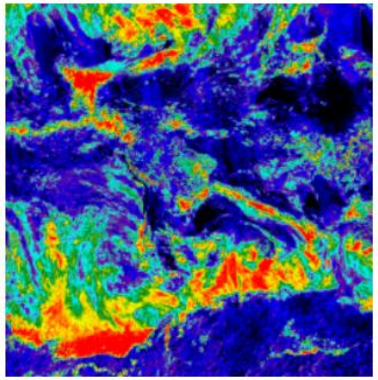
The Earth Engine Data Catalog

Earth Engine Data Catalog | Search | Русский | Войти

Datasets tagged climate in Earth Engine

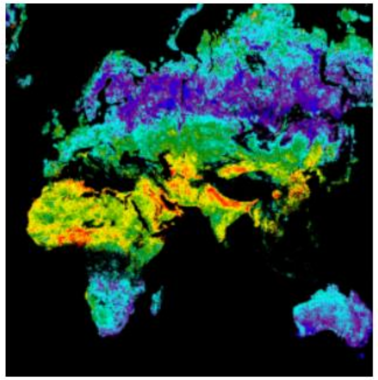
Filter list of datasets

Sentinel-5P NRTI CLOUD: Near Real-Time Cloud



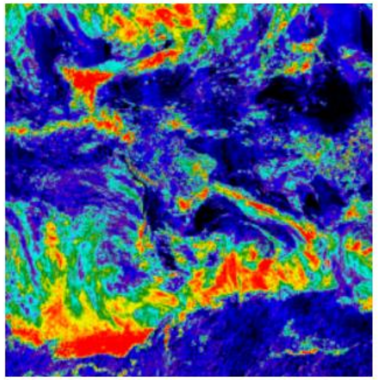
NRTI/L3_CLOUD This dataset provides near real-time high-resolution imagery of cloud parameters. The TROPOMI/S5P cloud properties retrieval is based on the OCRA and ROCINN algorithms currently being used in the operational GOME and GOME-2 products. OCRA retrieves the cloud fraction using measurements in the UV/VIS spectral ...

Sentinel-5P OFFL CH4: Offline Methane



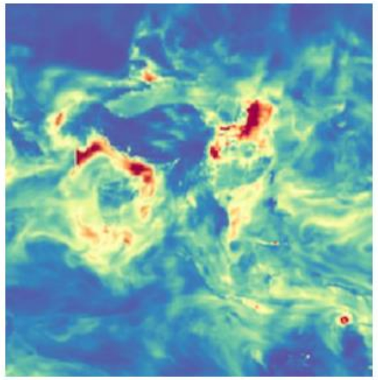
OFFL/L3_CH4 This dataset provides offline high-resolution imagery of methane concentrations. Methane (CH4) is, after carbon dioxide (CO2), the most important contributor to the anthropogenically enhanced greenhouse effect. Roughly three-quarters of methane emissions are anthropogenic and as such it is important to continue

Sentinel-5P OFFL CLOUD: Near Real-Time Cloud



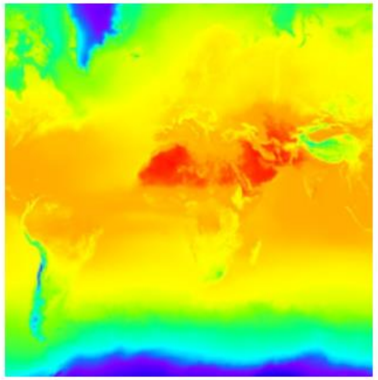
OFFL/L3_CLOUD This dataset provides offline high-resolution imagery of cloud parameters. The TROPOMI/S5P cloud properties retrieval is based on the OCRA and ROCINN algorithms currently being used in the operational GOME and GOME-2 products. OCRA retrieves the cloud fraction using measurements in the UV/VIS spectral regions ...

Copernicus Atmosphere Monitoring Service (CAMS) Global Near-Real-Time



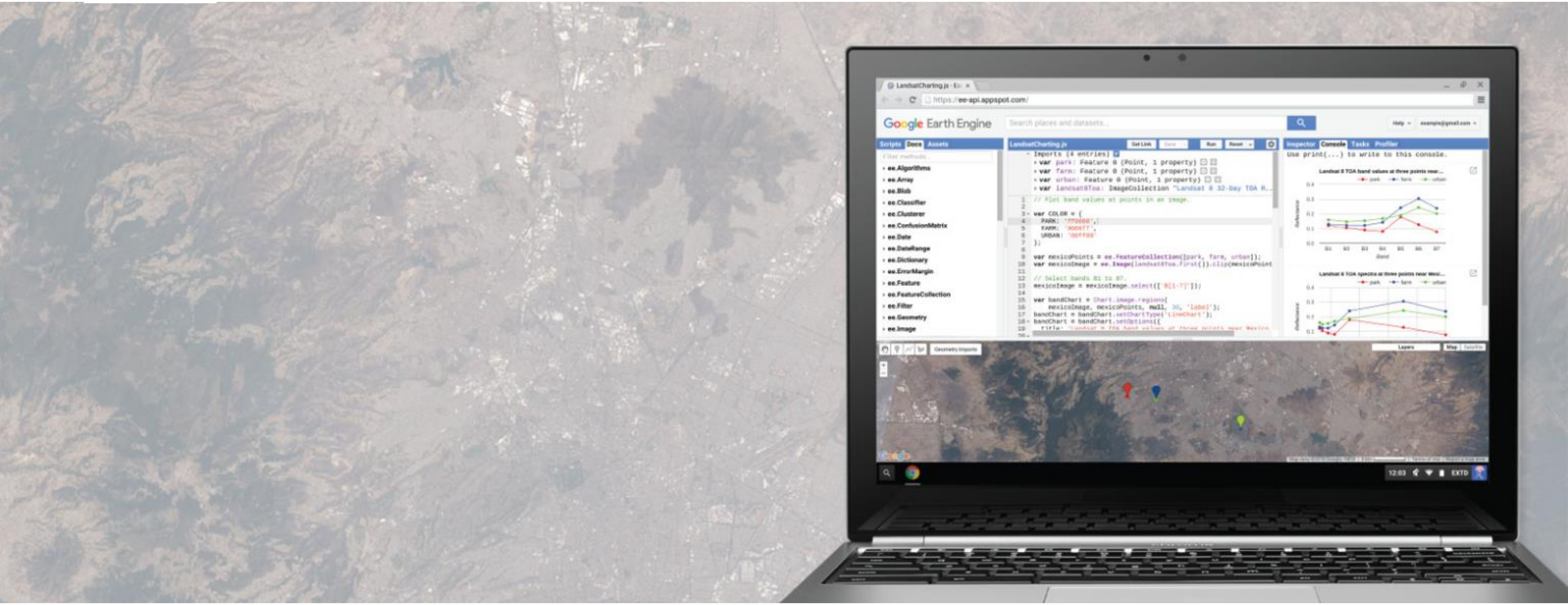
The Copernicus Atmosphere Monitoring Service provides the capacity to continuously monitor the composition of the Earth's atmosphere at global and regional scales. The main global near-real-time production system is a data assimilation and forecasting suite providing two 5-day forecasts per day for aerosols and chemical ...

ERA5 Daily Aggregates - Latest Climate Reanalysis Produced by ECMWF / Copernicus Climate



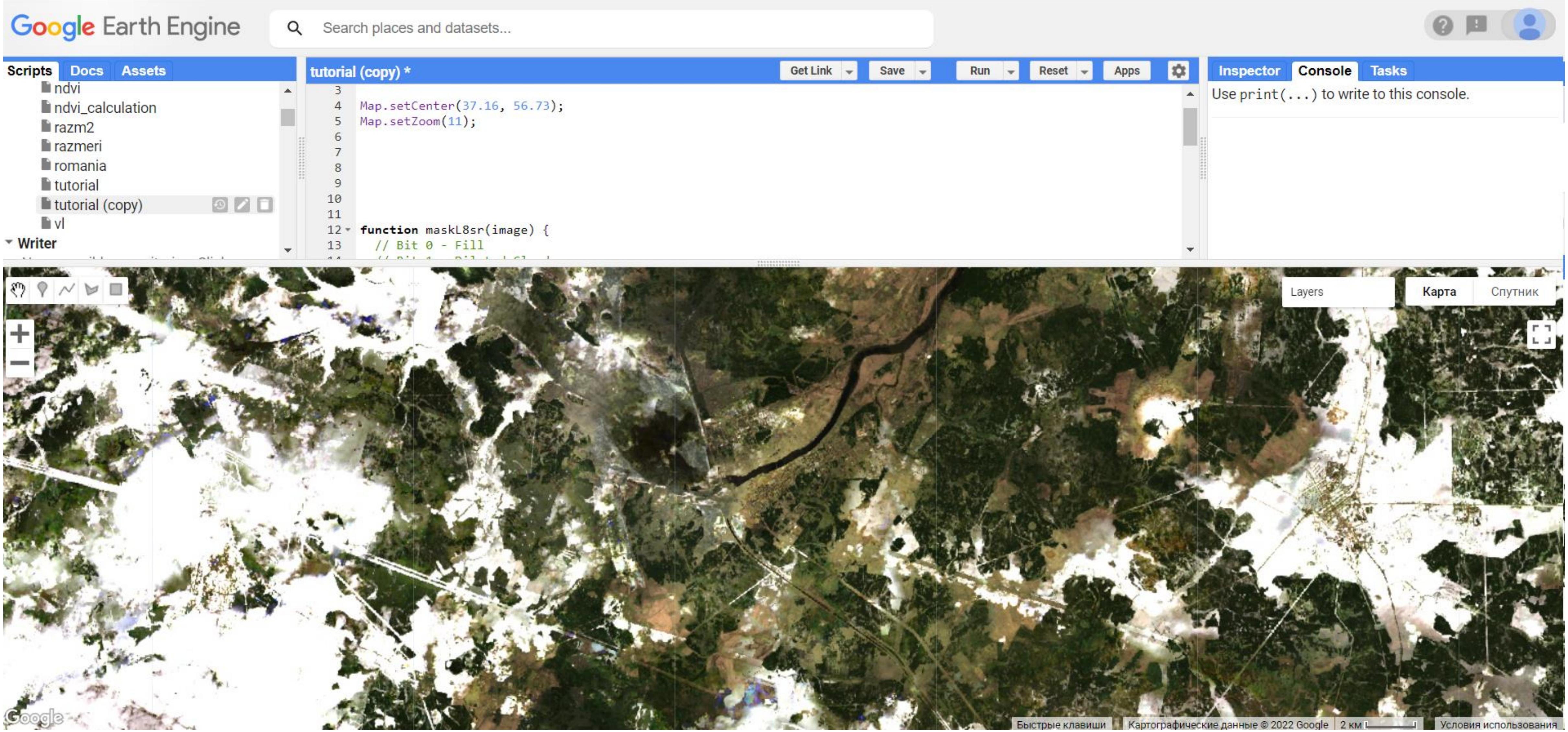
ERA5 is the fifth generation ECMWF atmospheric reanalysis of the global climate. Reanalysis combines model data with observations from across the world into a globally complete and consistent dataset. ERA5 replaces its predecessor, the ERA-Interim reanalysis. ERA5 DAILY provides aggregated values for each day for ...

JavaScript code editor https://code.earthengine.google.com/

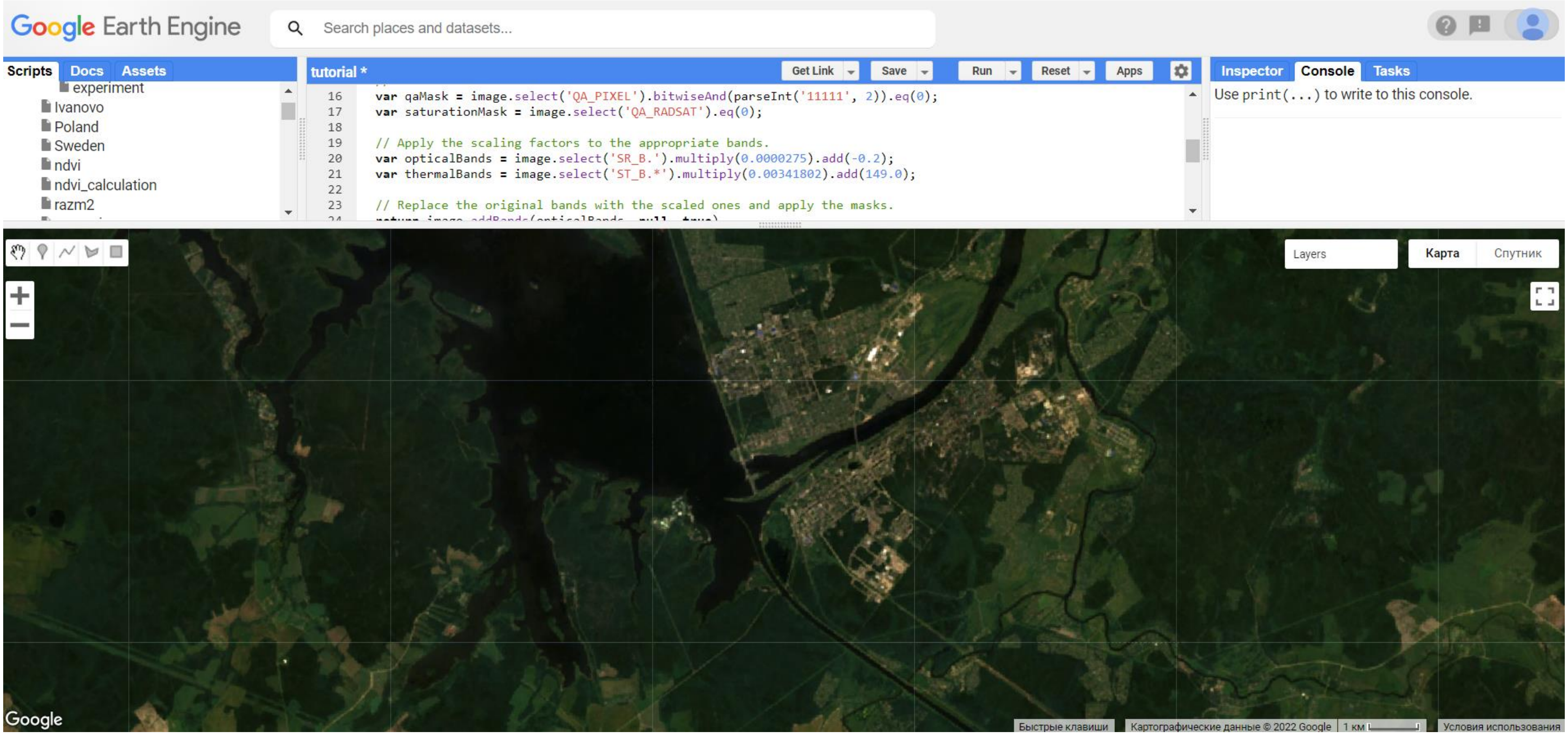


* Python API too and also Google colab!

Example of map



Cloud free map



Data Types and Geospatial Processing Functions

- **Image** - band math, clip, convolution, neighborhood, selection ...
- **Image Collection** - map, aggregate, filter, mosaic, sort ...
- **Feature** - buffer, centroid, intersection, union, transform ...
- **Feature Collection** - aggregate, filter, flatten, merge, sort ...
- **Filter** - by bounds, within distance, date, day-of-year, metadata ...
- **Reducer** - mean, linearRegression, percentile, histogram ....
- **Join** - simple, inner, outer, inverted ...
- **Kernel** - square, circle, gaussian, sobel, kirsch ...
- **Machine Learning -** CART, random forests, bayes, SVM, kmeans, cobweb ...
- **Projection** - transform, translate, scale ...

over 1000 data types and operators, and growing!

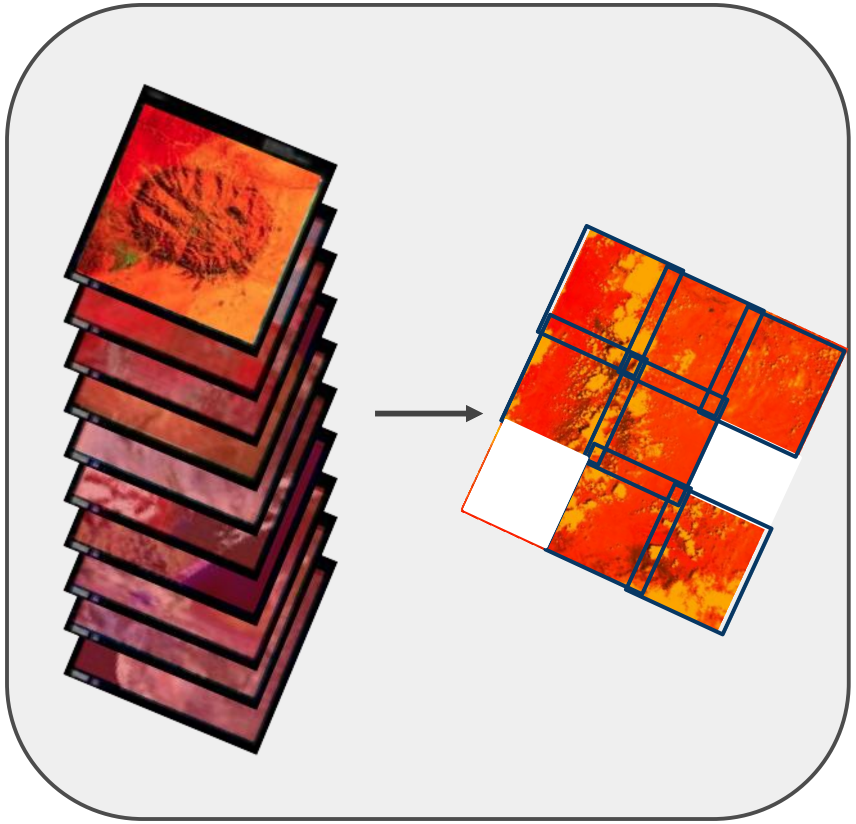
Reduce

Aggregate everything in a collection

"Reduction"

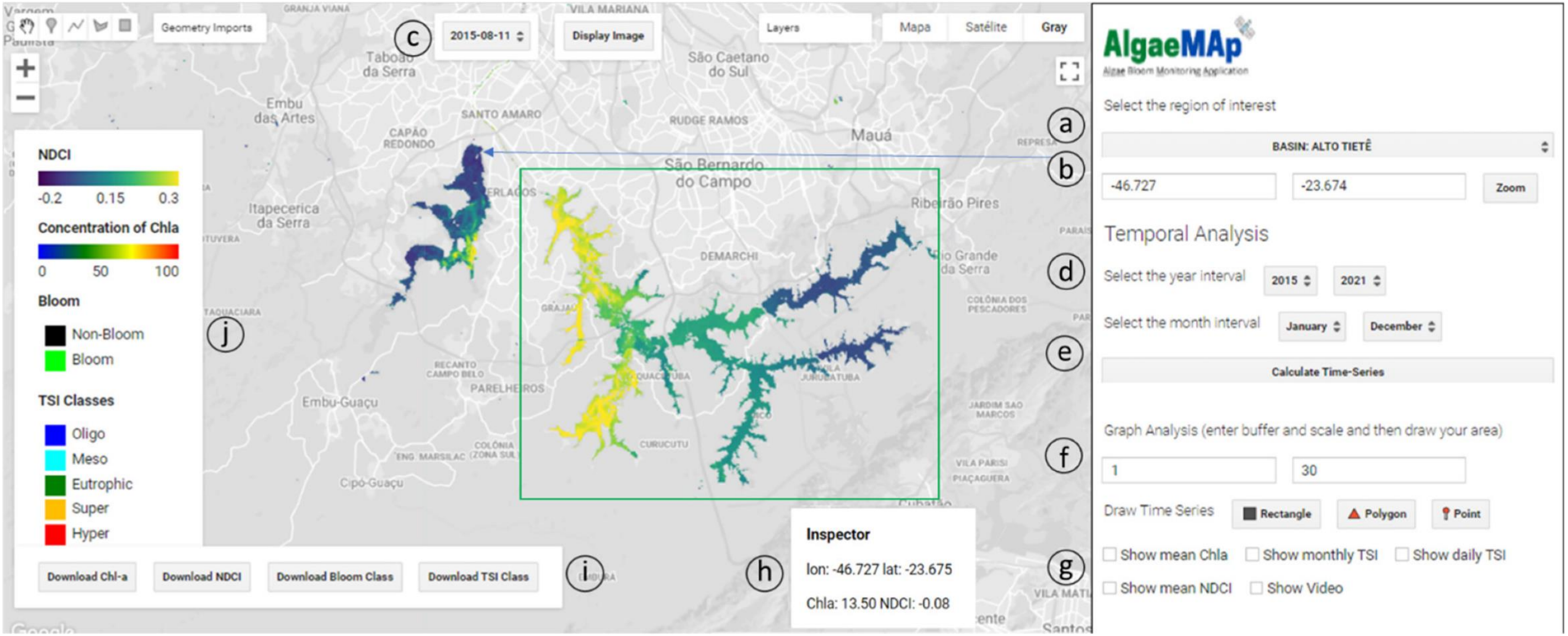
Examples

- Summed area over all features
- Median-pixel composite
- Train a classifier



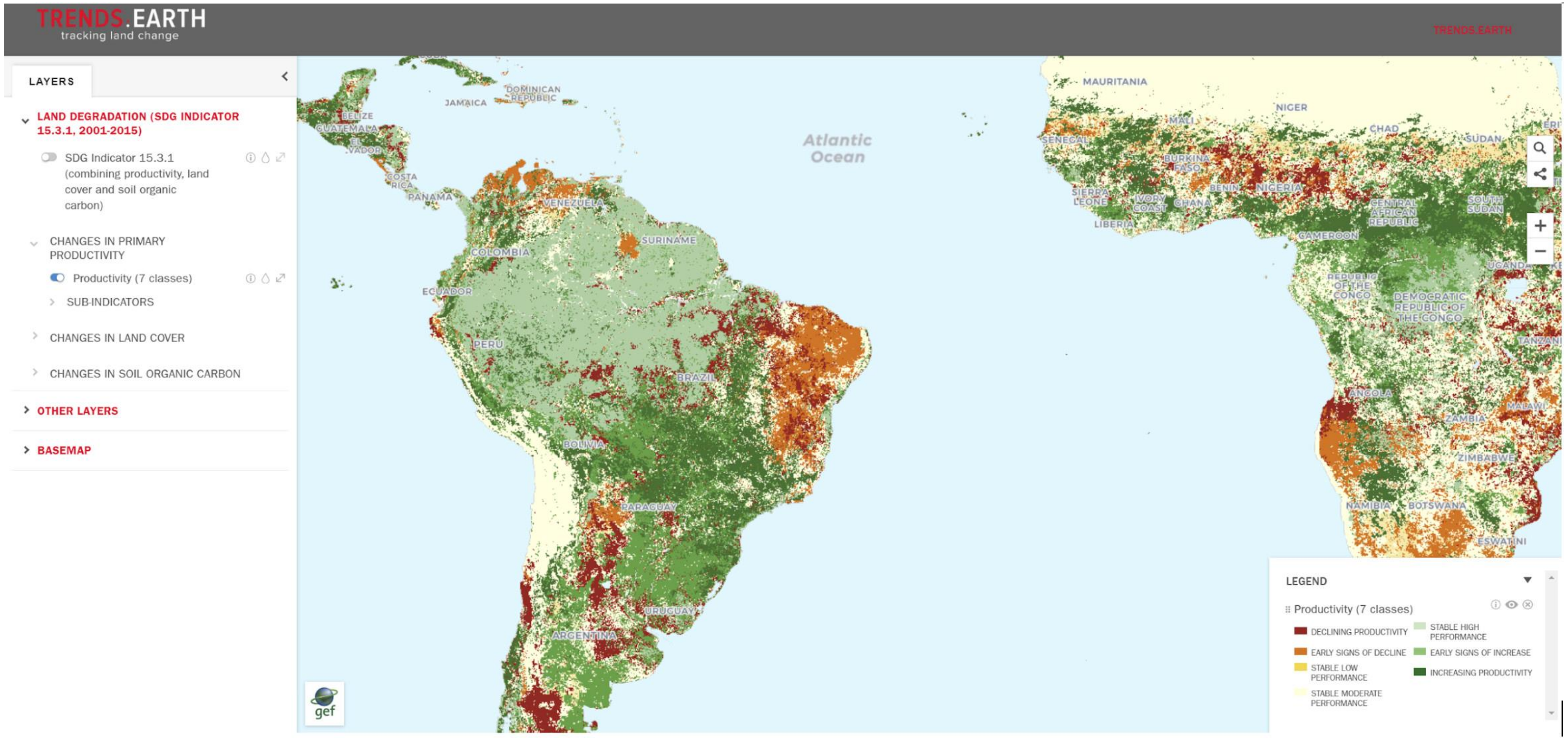
Alert System for Algal Bloom

Algae blooms occur when certain kinds of algae grow very quickly, forming patches, or "blooms," in the water. These blooms can be indicators of water degradation and emit powerful toxins that can endanger human and animal health.



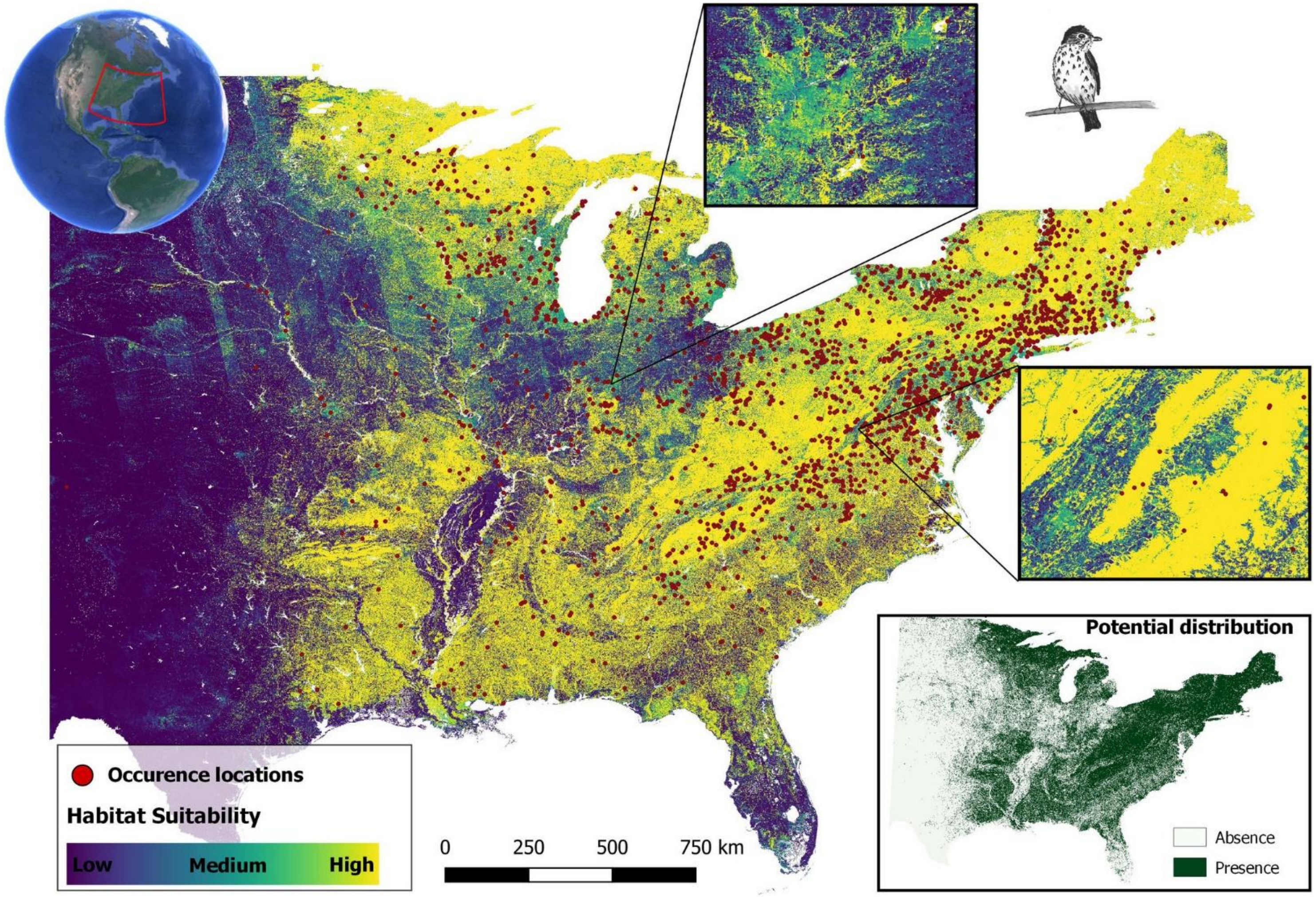
Trends.Earth

Through this project, we will develop a cloud-based platform dedicated to mapping land degradation which identifies potential land restoration opportunities at national to regional scale, allowing communities to prioritize areas to protect, manage, and restore in order to achieve land degradation neutrality.

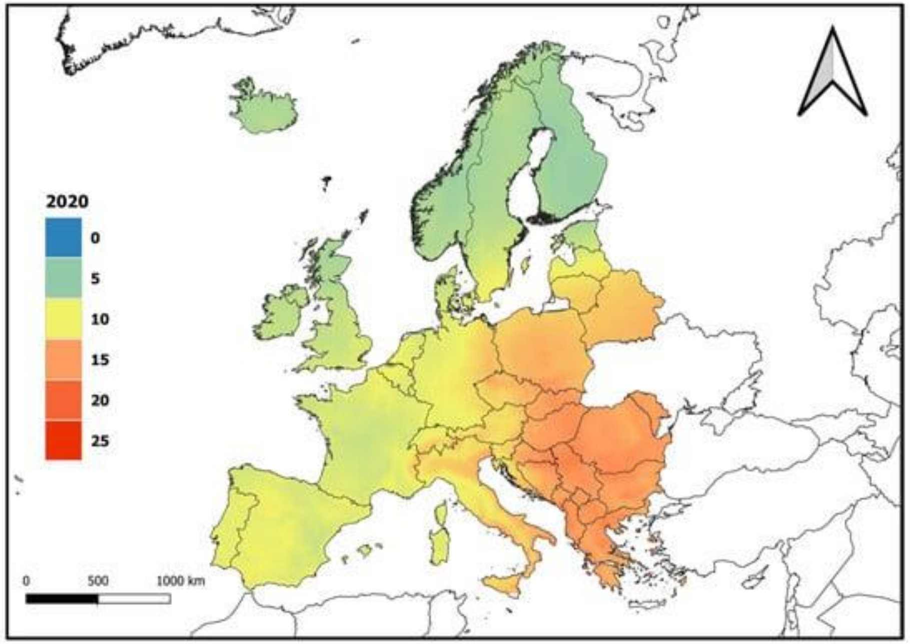


Essential Biodiversity Variables - ScaleUp

We implemented a workflow for species distribution modelling in GEE that includes importing species occurrence data into the GEE platform, selecting and preparing predictor variables, and performing model fitting with spatial or temporal split-block cross-validation techniques.



The determination of different gaseous and PMs based on satellite imagery

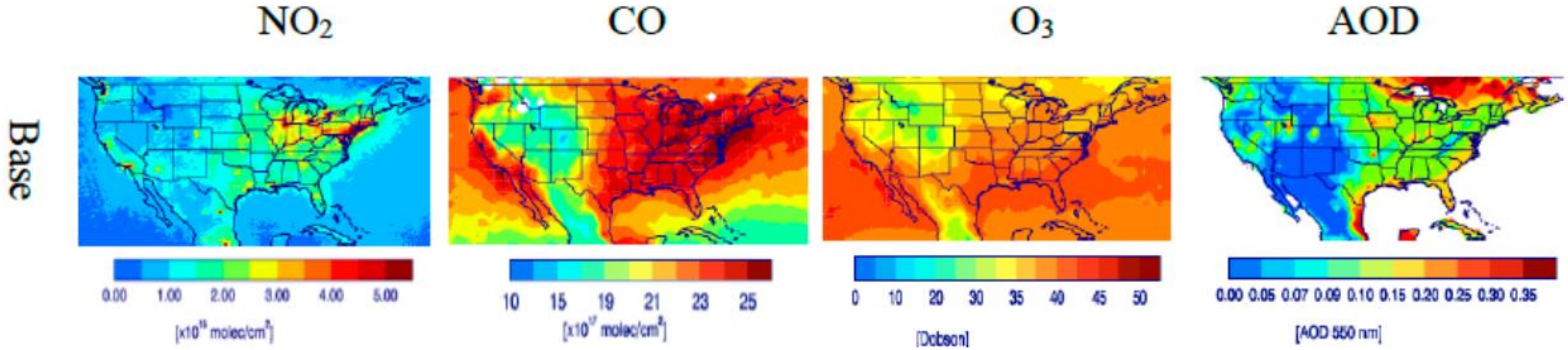


Tongshu Zheng, Michael H. Bergin, Shijia Hu, Joshua Miller, David E. Carlson. (2020). Estimating ground-level PM2.5 using micro-satellite images by a convolutional neural network and random forest approach. Atmospheric Environment, Volume 230, 117451, ISSN 1352-2310, https://doi.org/10.1016/j.atmosenv.2020.117451.

Ibrahim, S.; Landa, M.; Pešek, O.; Brodský, L.; Halounová, L. Machine Learning-Based Approach Using Open Data to Estimate PM2.5 over Europe. Remote Sens. 2022, 14, 3392. https://doi.org/10.3390/rs14143392

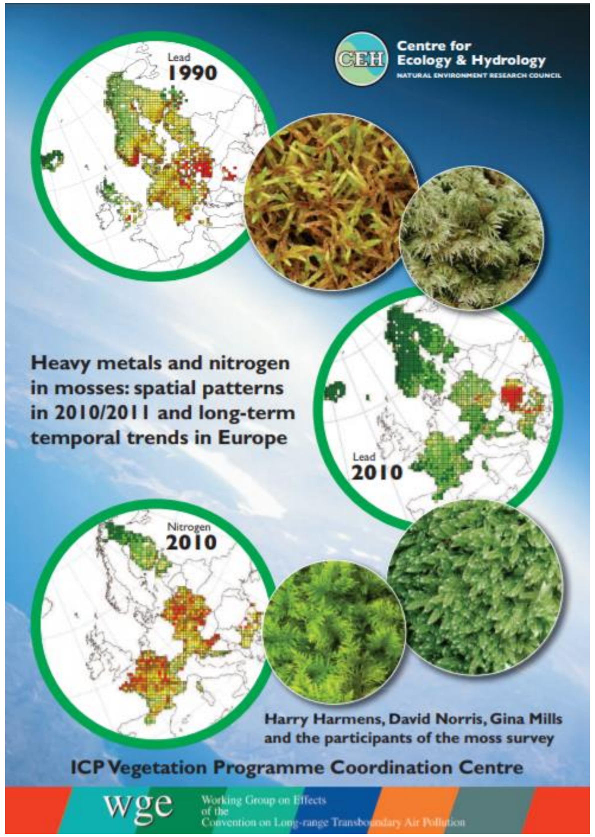
Elshorbany, Y.F.; Kapper, H.C.; Ziemke, J.R.; Parr, S.A. The Status of Air Quality in the United States During the COVID-19 Pandemic: A Remote Sensing Perspective. Remote Sens. 2021, 13, 369. https://doi.org/10.3390/rs13030369

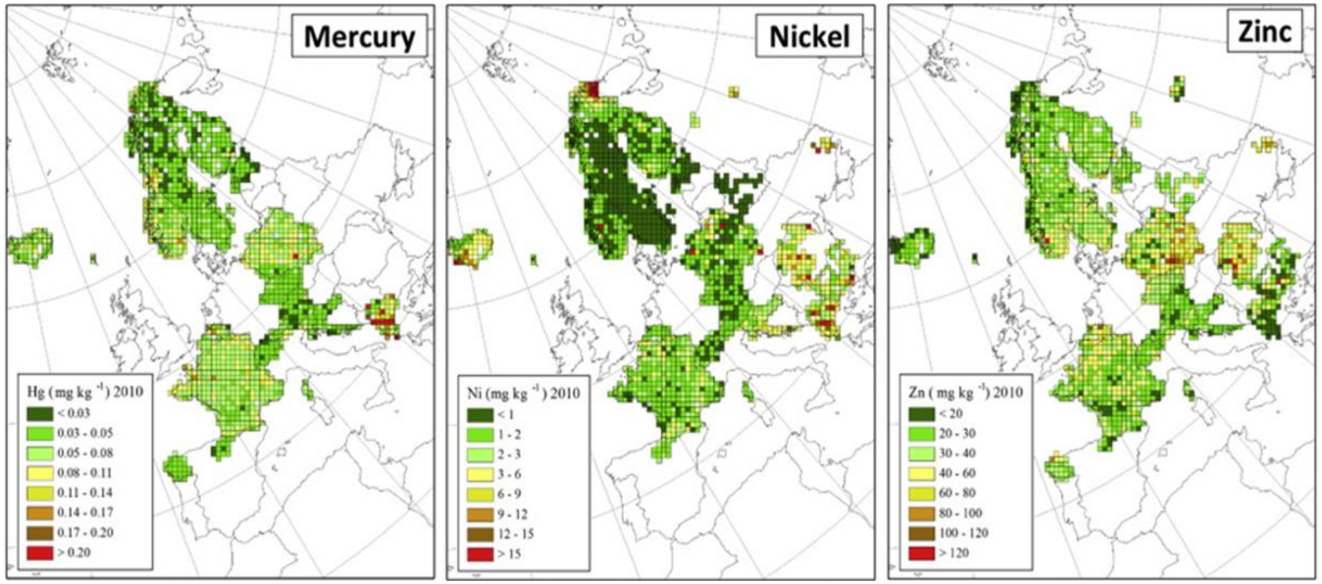
Seham S. Al-Alola, Ibtesam I. Alkadi, Haya M. Alogayell, Soha A. Mohamed, Ismail Y. Ismail, Air quality estimation using remote sensing and GIS-spatial technologies along Al-Shamal train pathway, Al-Qurayyat City in Saudi Arabia, Environmental and Sustainability Indicators, Volume 15, 2022, 100184, ISSN 2665-9727, https://doi.org/10.1016/j.indic.2022.100184.



ICP Vegetation

The aim of the **UNECE International Cooperative Program (ICP)** Vegetation in the framework of the United Nations Convention on Long-Range Transboundary Air Pollution is to **identify the main polluted areas of Europe**, produce regional maps and further develop the understanding of the long-range transboundary pollution. Atmospheric deposition study of heavy metals, nitrogen, persistent organic compounds (POPs) and radionuclides is based on the analysis of naturally growing mosses through moss surveys carried out **every 5 years**. The program is realized in **39 countries of Europe and Asia**. Mosses are collected at thousands of sites

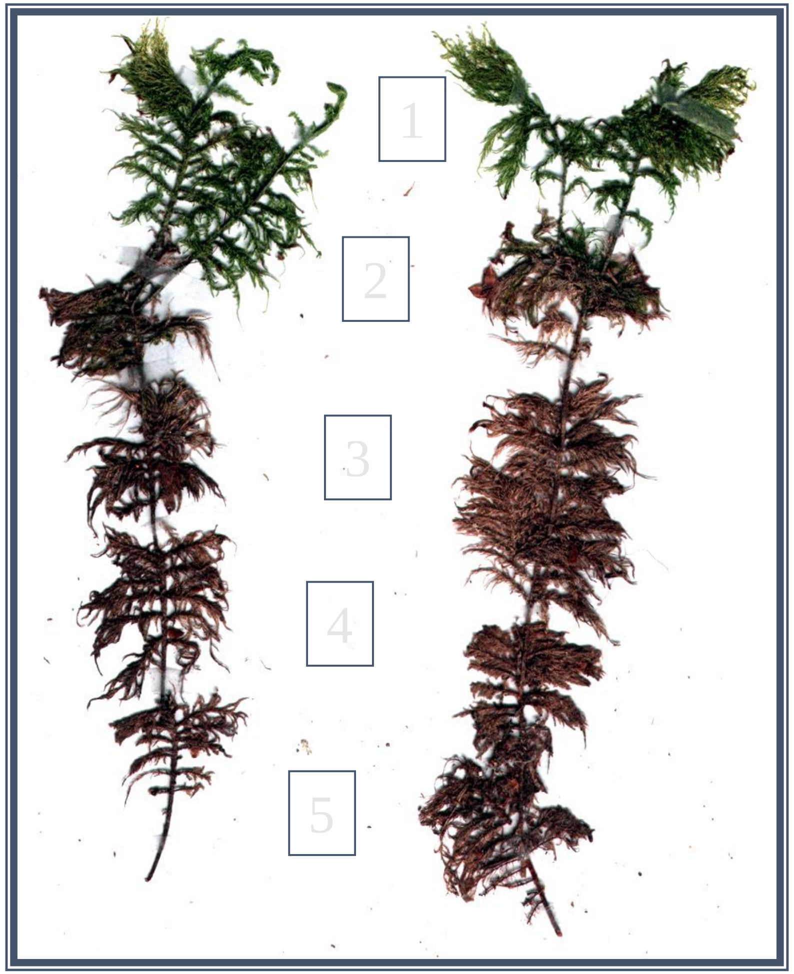




Examples of distribution maps in old Atlas

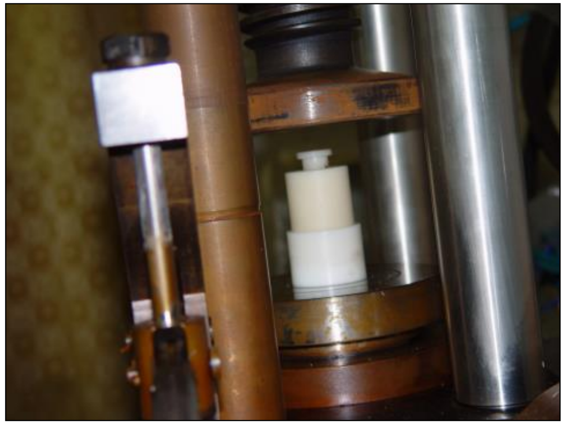
Since 2014 the JINR Frank Laboratory of Neutron Physics sector of neutron activation analysis is the **coordinator of the ICP** Vegetation program

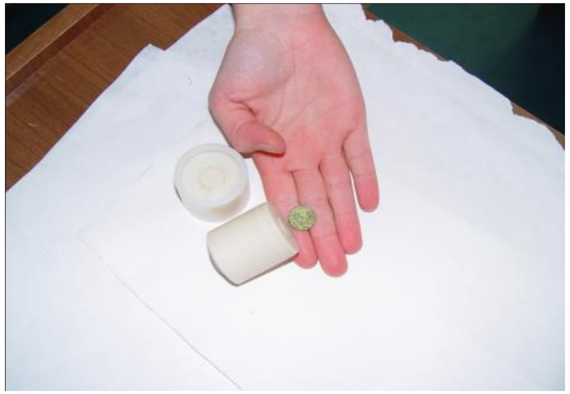
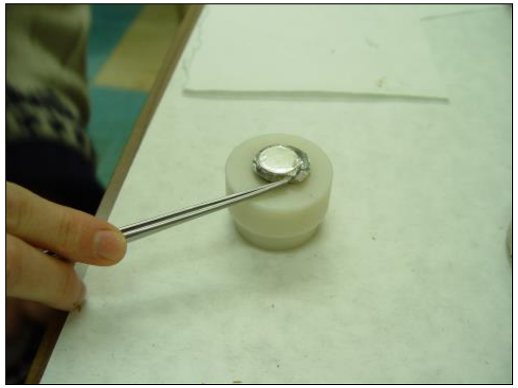
Moss biomonitor



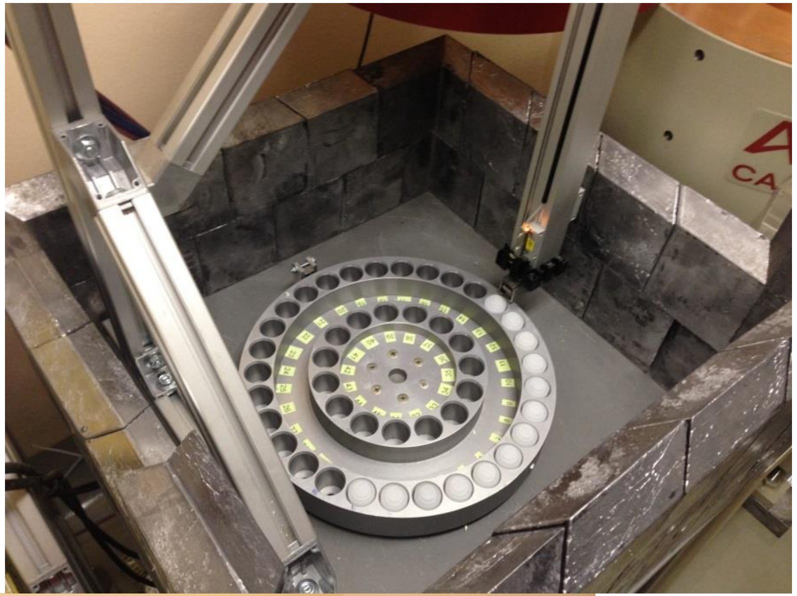
Annual segments

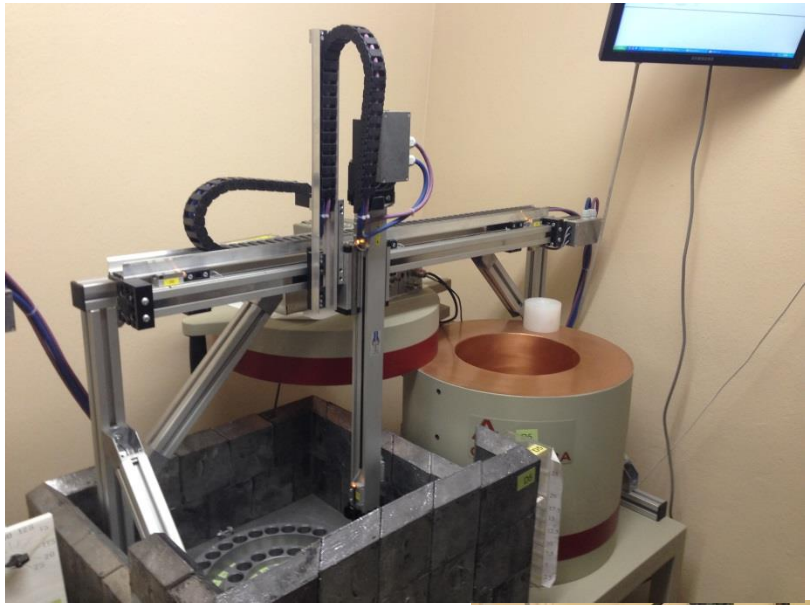
Sampling

1.
2.
3.



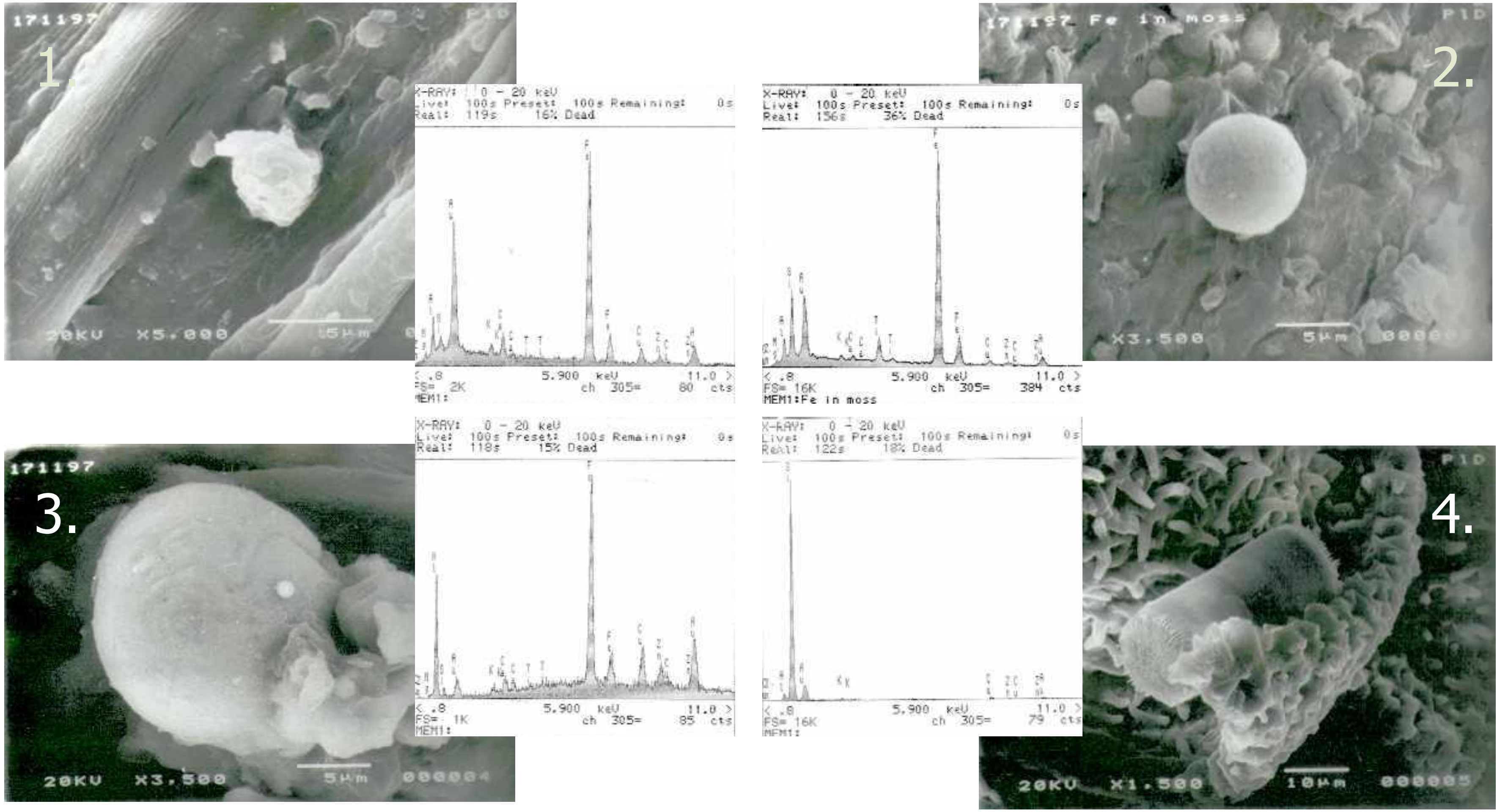


Three sample changers were installed

Each sample changer consists of:

- ❖ two axes liner movement device M202A (DriveSet, Germany)
- ❖ Rotated disk with 40 cells for samples (JINR)
- ❖ Three axes Xemo Motion controller with software and cables (Systec GmbH, Germany)

Scanning electron microscope images of captured particles on the moss surface and corresponding spectrograms



1 - Fe particle with Mg impurity; **2** - Spherule of pure iron;
3 - Al-Fe cluster particle with impurities of Zn, Cu, and Ti; **4** - Diatomic alga

ICP Vegetation (Past)

The UNECE ICP Vegetation program had a serious drawback related to its **weak adoption of modern informational technologies**. Information on collecting and processing of samples was carried out **manually** or with minimum automation.

Until 2016, data mostly was stored in Excel files. It was aggregated and processed in different packages (ArcGIS, MATLAB, etc.) **manually by the coordinator**.

Files from respondents were usually passed to the coordinator **by email**. There were **no common standards** in data transfer, storing and processing software.

Such a situation does not meeat the modern standards for quality, effectiveness, and speed of research and demands developing a **single platform** to provides a comprehensive solution for biological monitoring and forecasting tasks

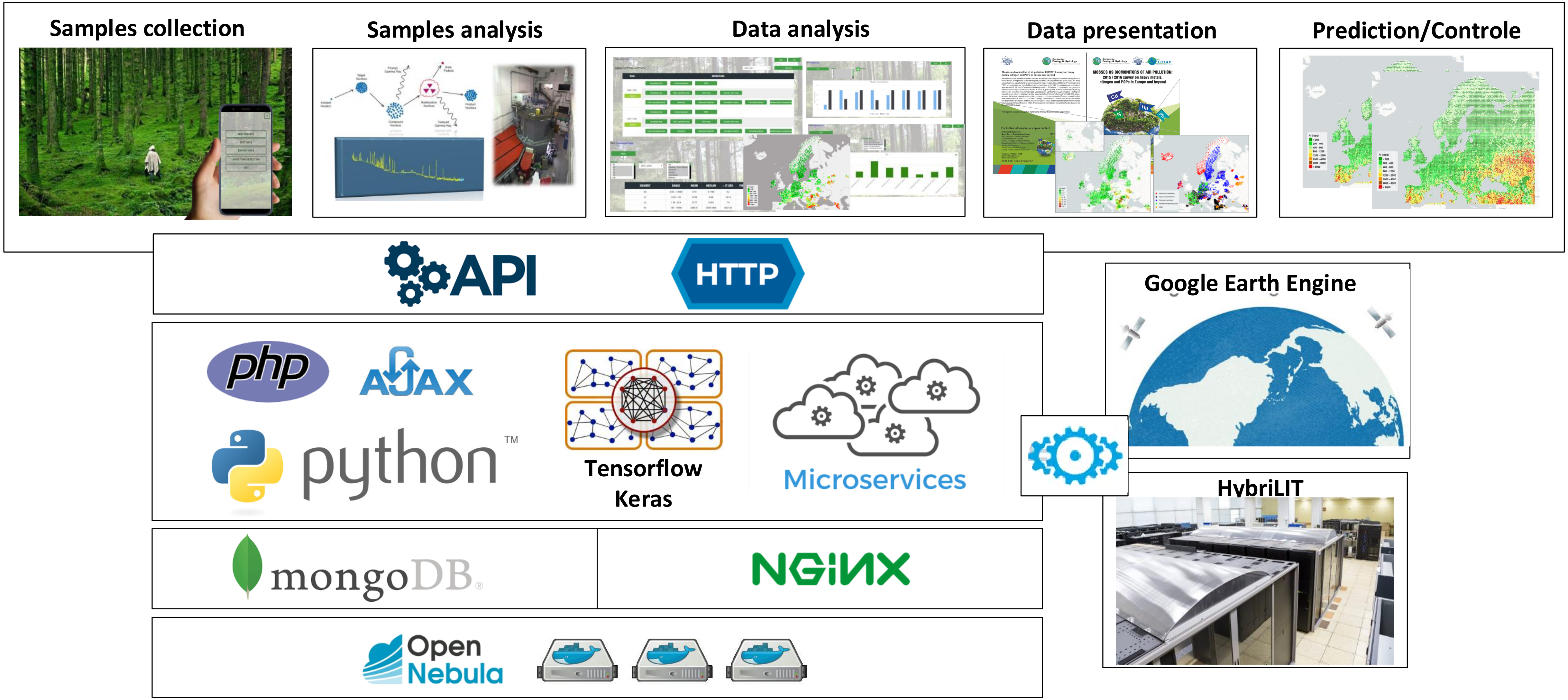
ICP Vegetation (First steps)

The idea was to create a cloud platform for data management to facilitate IT aspects of all biological monitoring stages starting from a choice of collection places and finishing with generation of pollution maps of a particular area or state-of-environment forecast in the long term

to more complicated one:
- optimization of the sample collection spatial distribution
- advanced mathematical methods for multi-level intelligent statistical analysis,
- geostatistical analyses,
- atlases and reports creation
- and others.

We was going to move from simple tasks:
- storing and manipulating with data,
- processing of data,
- calculation of basic statistics,
- creation of simple maps
- etc.

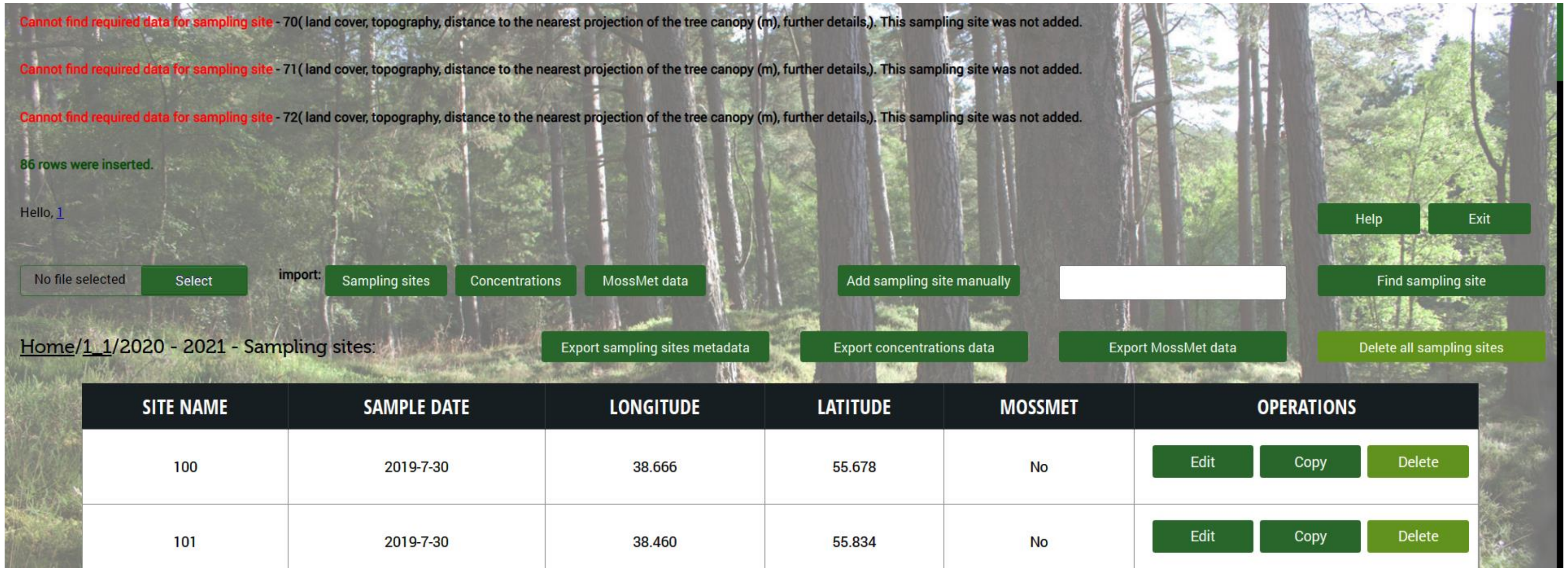
The platform now



Since the launch of the first version of the platform, a mobile application has been developed to simplify the process of collecting and verifying data, deep learning models for image classification and pollution prediction based on remote sensing data, various functional blocks implemented in a microservice architecture to automate a number of operational tasks, and the analytical capabilities of the system are also expanded.

WHY IT’S USEFULL

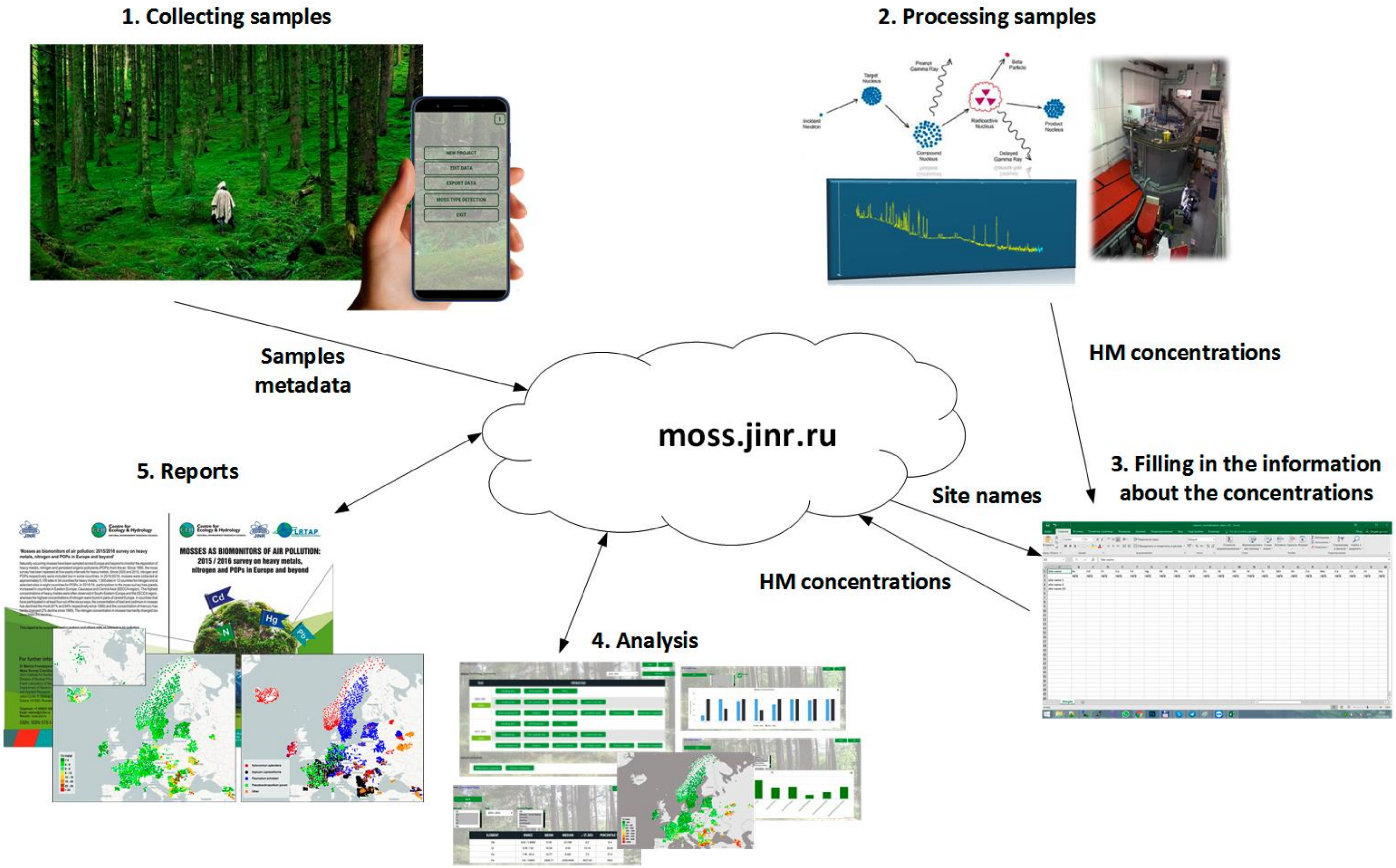
Fast verification of data structure and it completeness



Easy way to find human made mistakes

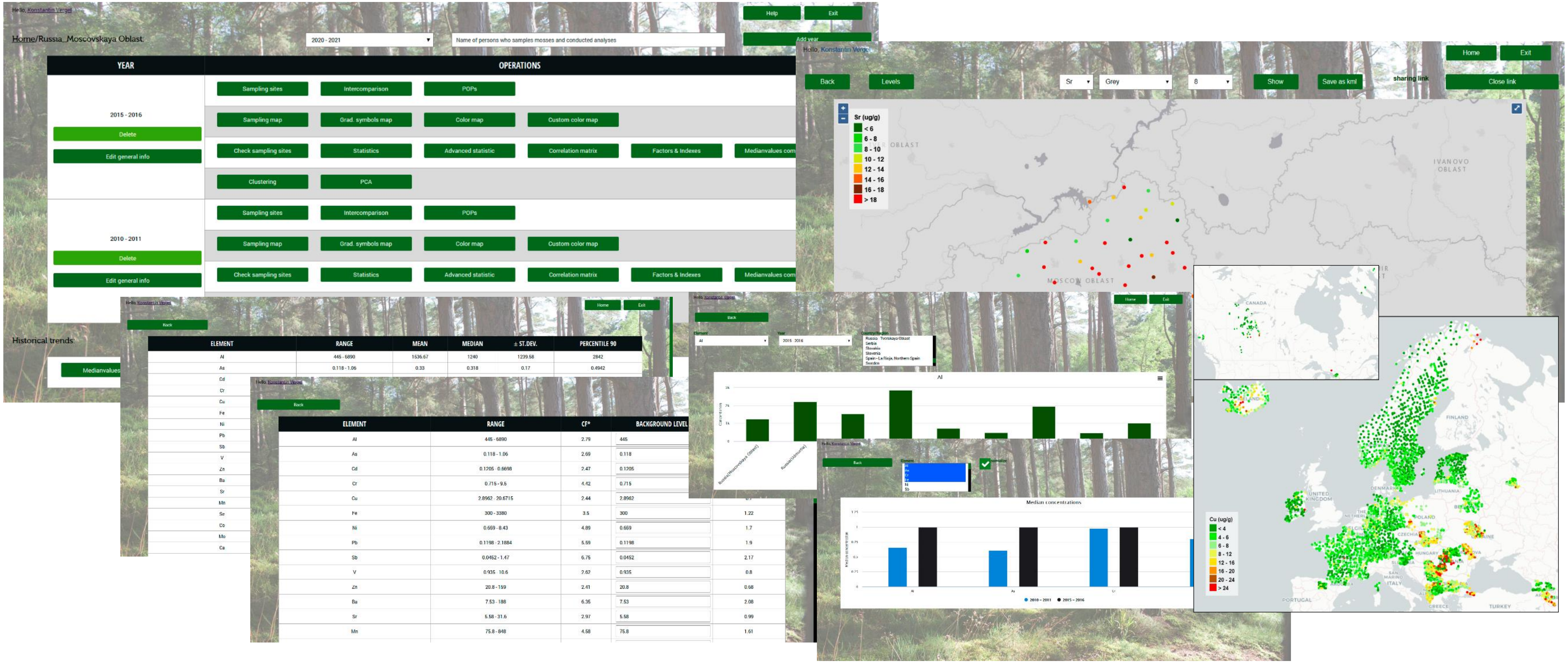
- Nice tool to analyze data. • Access to yours data from anywhere. • Online processing and results.
- Ability to store historical data and analyze trends

Workflow


1. Collecting samples
2. Processing samples
Samples metadata
HM concentrations
moss.jinr.ru
5. Reports
3. Filling in the information about the concentrations
Site names
HM concentrations
4. Analysis
MOSSES AS BIOMONITORS OF AIR POLLUTION: 2015 / 2016 survey on heavy metals, nitrogen and POPs in Europe and beyond

DMS

The Data Management System (DMS) of the UNECE ICP Vegetation was developed at the Laboratory of Information Technologies and consists of a set of interconnected services and tools deployed and hosted at the Joint Institute for Nuclear Research (JINR) cloud infrastructure. DMS is intended to provide its participants with a **modern unified system of collecting, analyzing and processing of biological monitoring data.**



DMS. Atlas 2015-2016

JINR

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

'Mosses as biomonitors of air pollution: 2015/2016 survey on heavy metals, nitrogen and POPs in Europe and beyond'

Naturally-occurring mosses have been sampled across Europe and beyond to monitor the deposition of heavy metals, nitrogen and persistent organic pollutants (POPs) from the air. Since 1990, the moss survey has been repeated at five-yearly intervals for heavy metals. Since 2005 and 2010, nitrogen and POPs respectively were included too in some countries. In 2015/2016, mosses were collected at approximately 5,100 sites in 34 countries for heavy metals, 1,500 sites in 12 countries for nitrogen and at selected sites in eight countries for POPs. In 2015/16, participation in the moss survey has greatly increased in countries in Eastern Europe, Caucasus and Central Asia (EECCA region). The highest concentrations of heavy metals were often observed in South-Eastern Europe and the EECCA region, whereas the highest concentrations of nitrogen were found in parts of central Europe. In countries that have participated in at least four out of the six surveys, the concentration of lead and cadmium in mosses has declined the most (81% and 64% respectively since 1990) and the concentration of mercury has hardly changed (2% decline since 1995). The nitrogen concentration in mosses has hardly changed too since 2005 (5% decline).

This report is for scientists, policy makers and others with an interest in air pollution.

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ISBN: ISBN 978-5-9530-0508-1

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JINR

LRTAP
Long-range Transboundary Air Pollution

MOSSES AS BIOMONITORS OF AIR POLLUTION:
2015 / 2016 survey on heavy metals, nitrogen and POPs in Europe and beyond

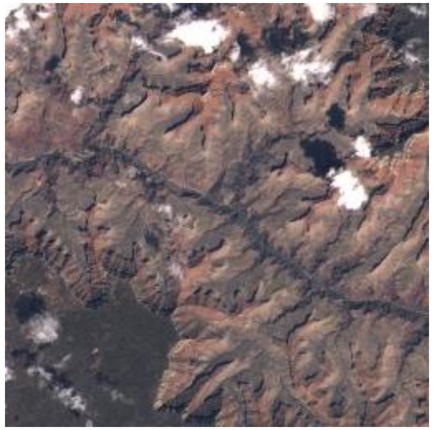
Marina Frontasyeva, Harry Harmens, Alexander Uzhinskiy
and the participants of the moss survey

ICP VEGETATION

wge Working Group on Effects of the Convention on Long-range Transboundary Air Pollution

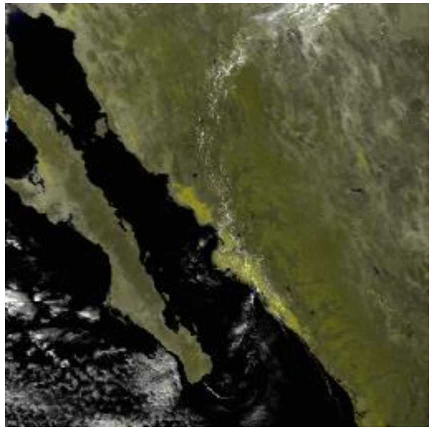
Google Earth Engine

There are more than **100 satellite programs** and modeled datasets. Google Earth Engine has **JavaScript online editor** to create and verify code and **python API** to communicate with user's applications.

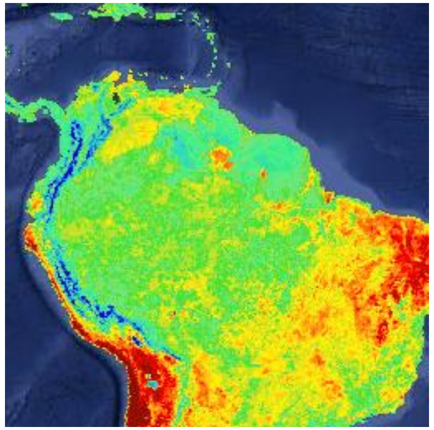


Landsat (15-30m Resolution)

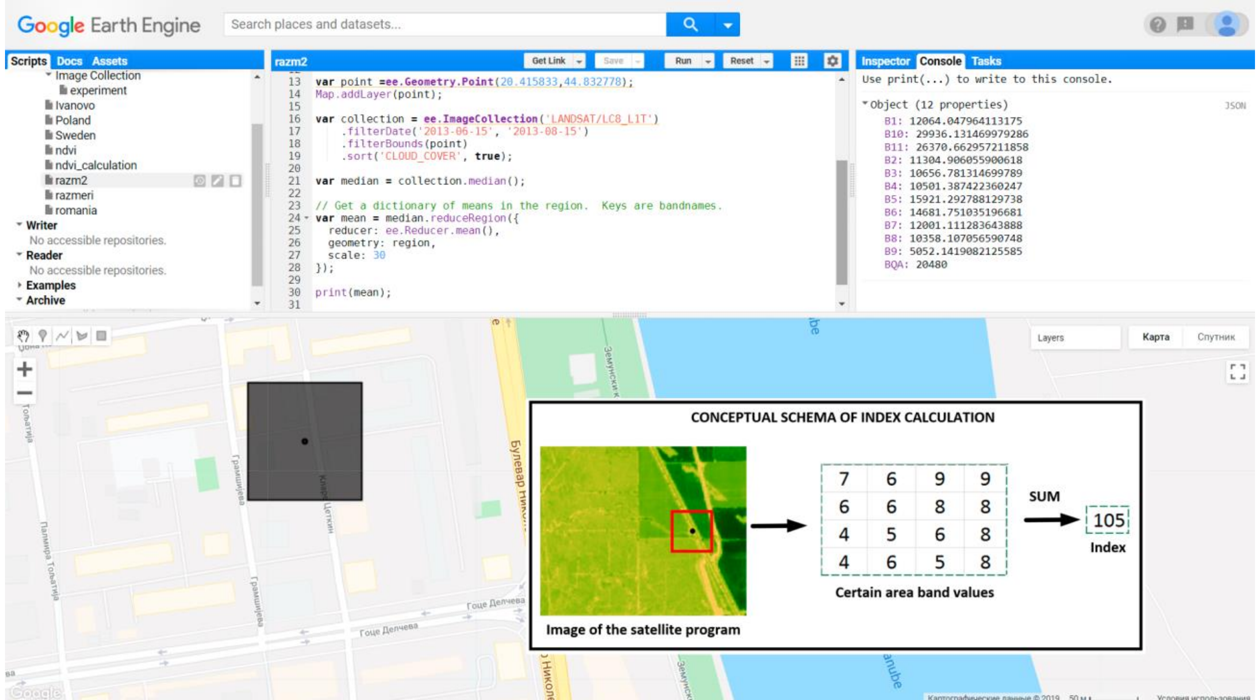
Modis (250-500m Resolution)



Sentinel (250-500m Resolution)



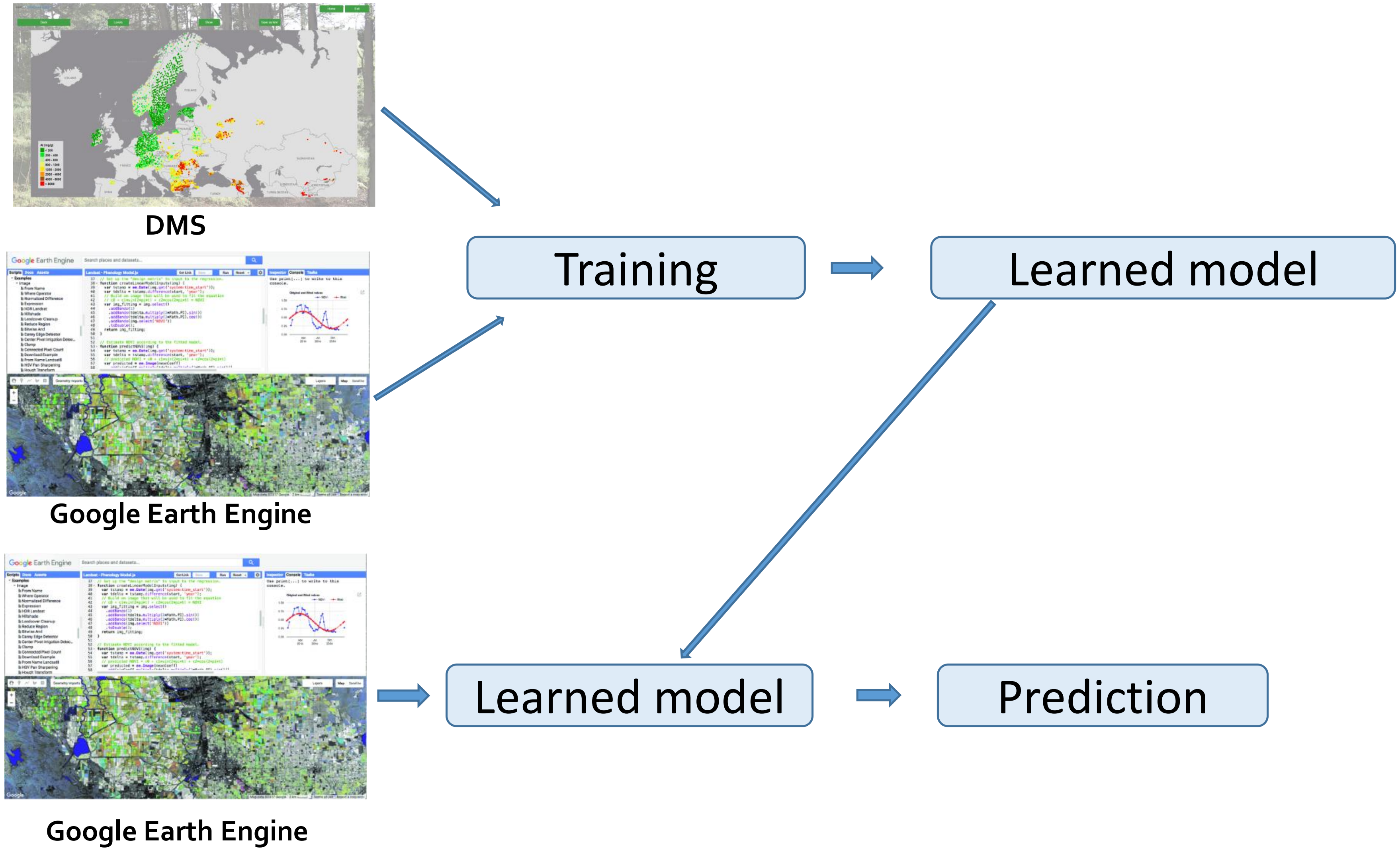
The MOD11A2 V6 average 8-day land surface temperature (LST) in a 1200 x 1200 kilometer grid.



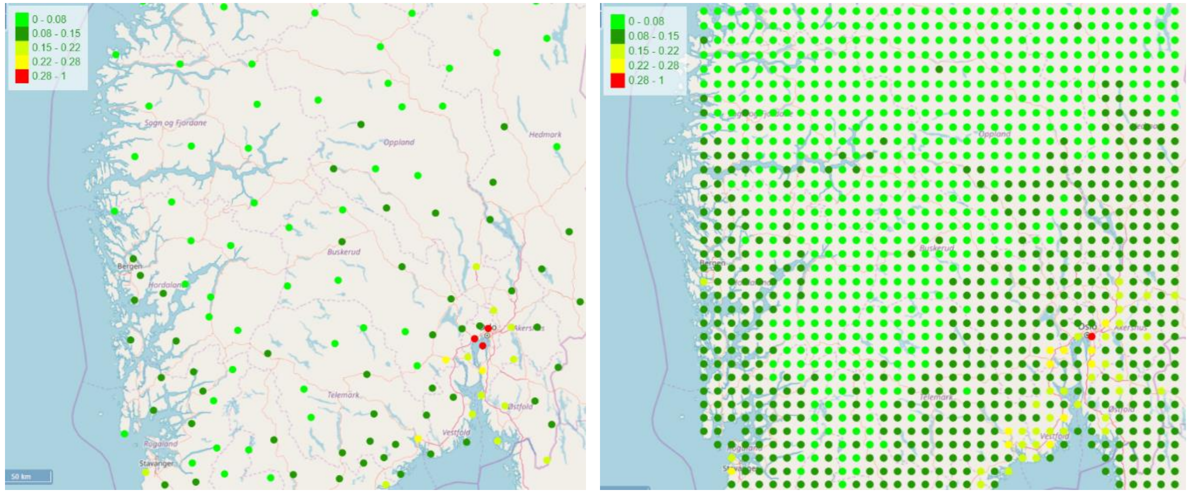
Specify program and time-period to get a collection of images, for example, program – "MODIS/006/MOD09A1" from 2013-06-15 to 2013-08-15 (the period relevant for in situ biomonitoring). Then, define the analyzed area, for example, a square kilometer, with center at the coordinates where sampling was performed. During the satellite data collection, under the bands (channels) of the median image, we execute some mathematical functions (max, min, median, etc.) and get the numerical values.

Schema

We use **satellite imagery data** and the **artificial neural network** to **predict concentration**. The general idea is to use data that we can get from satellite images together with sampling data from DMS to learn NN and then use only data from satellite images to predict concentration.

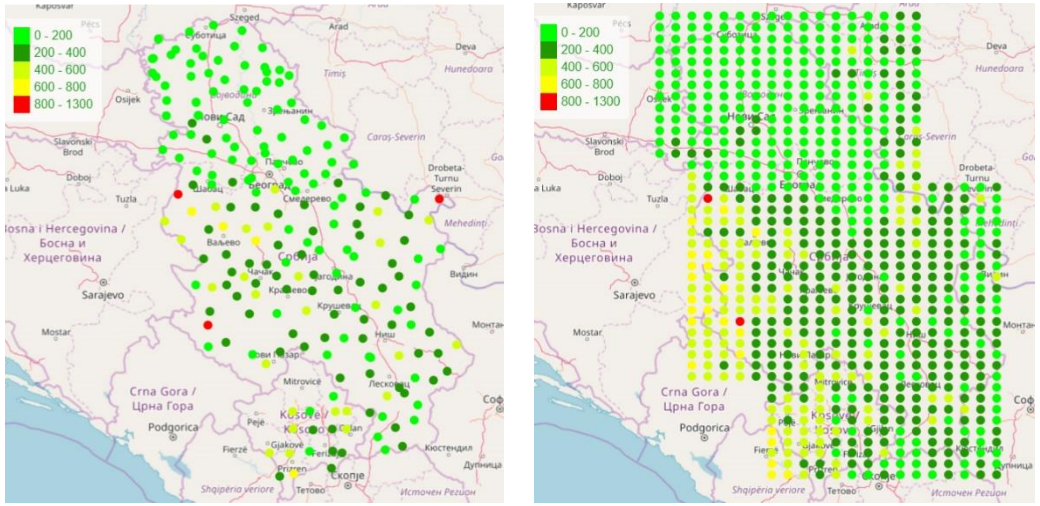


Results on the regional level

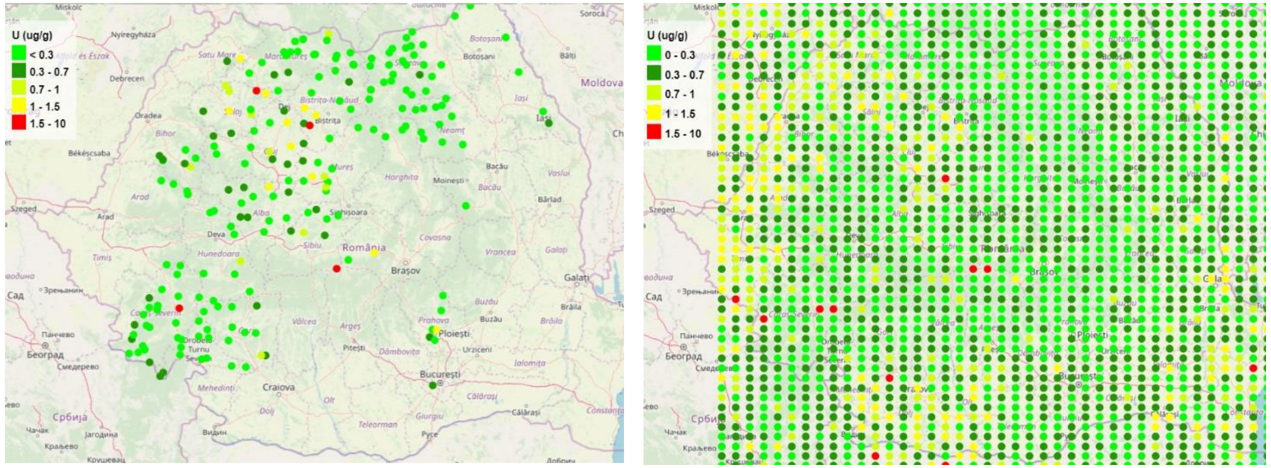


Sb at Norway. Left – real life, right - prediction

Candidates for modeling:
Al, As, Cr, Cu Fe, Mn, Ni, Pb, V, Sb, U ...



Mn at Serbia. Left – real life, right - prediction



U at Romania. Left – real life, right - prediction

Urban Level (Belgrade)

The goal of this study was to facilitate the highly resolved mapping of the presence of potentially toxic elements in the air of an urban area, which is typically characterised by high and variable pollution. + to check whether model can keep appropriate accuracy during long time period.

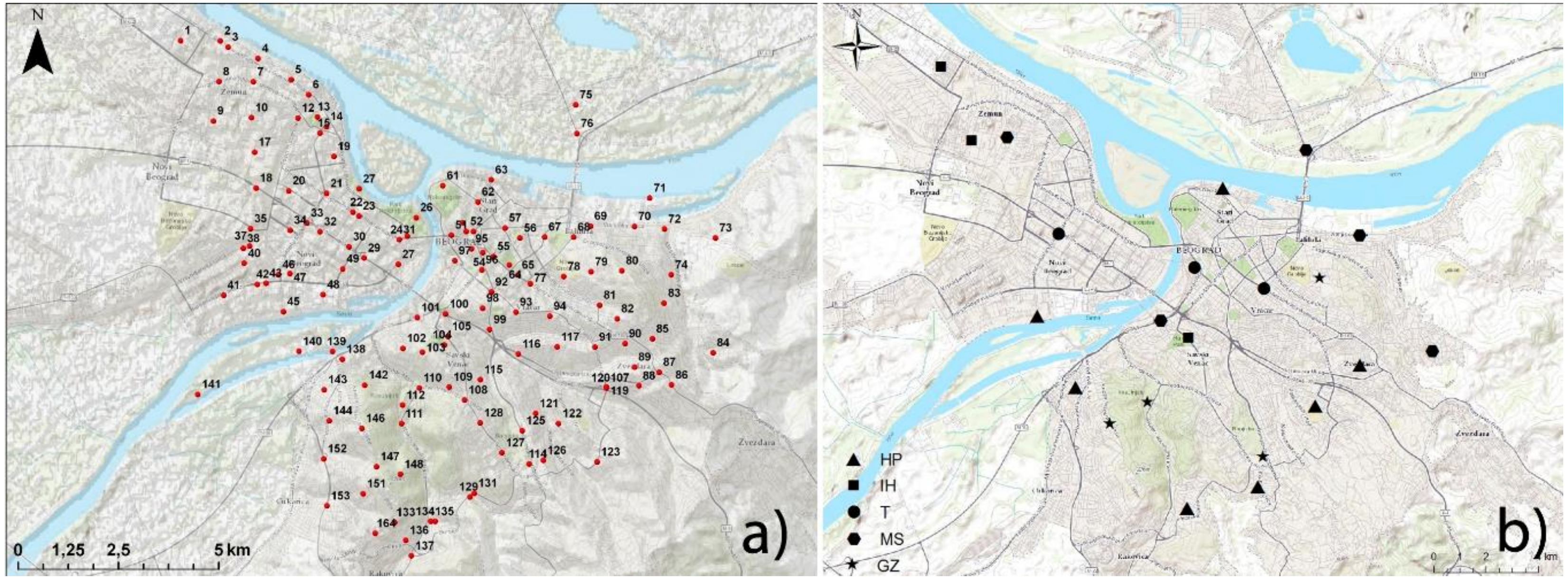


Figure 1. Moss bag biomonitoring across the Belgrade urban area; maps of the sampling sites during two seasons: (a) summer (urban, suburban and green zones) and (b) winter (U–urban sites, GZ–green zones)

Urban Level (Belgrade)

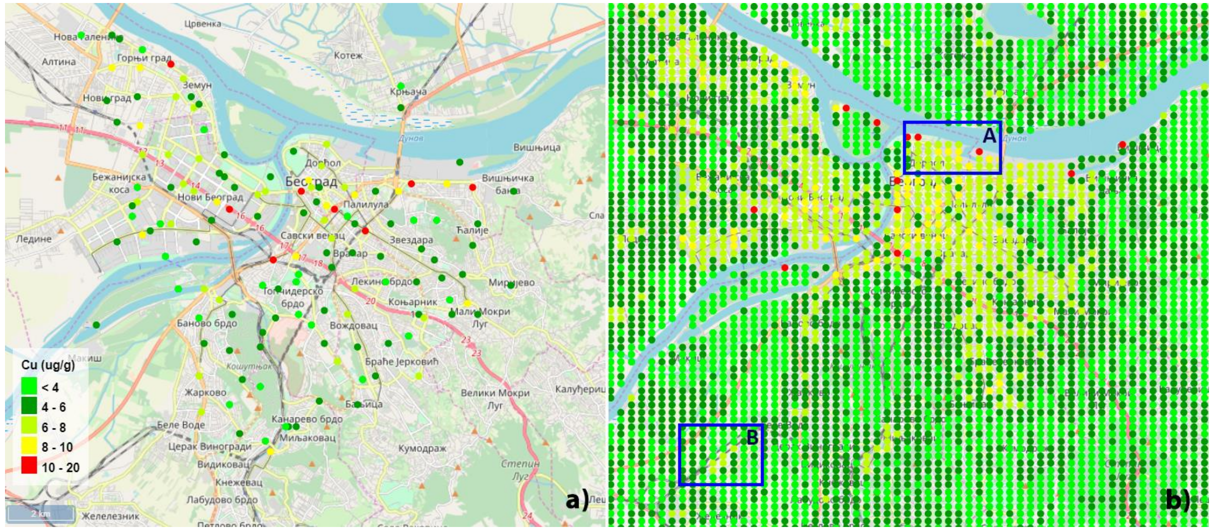


Figure 3. Concentration of Cu in the summer of 2013 (Belgrade): a) real measurements, and b) prediction values; area A represents central part of Old Belgrade with permanently high traffic flow; area B represents a large railway terminal

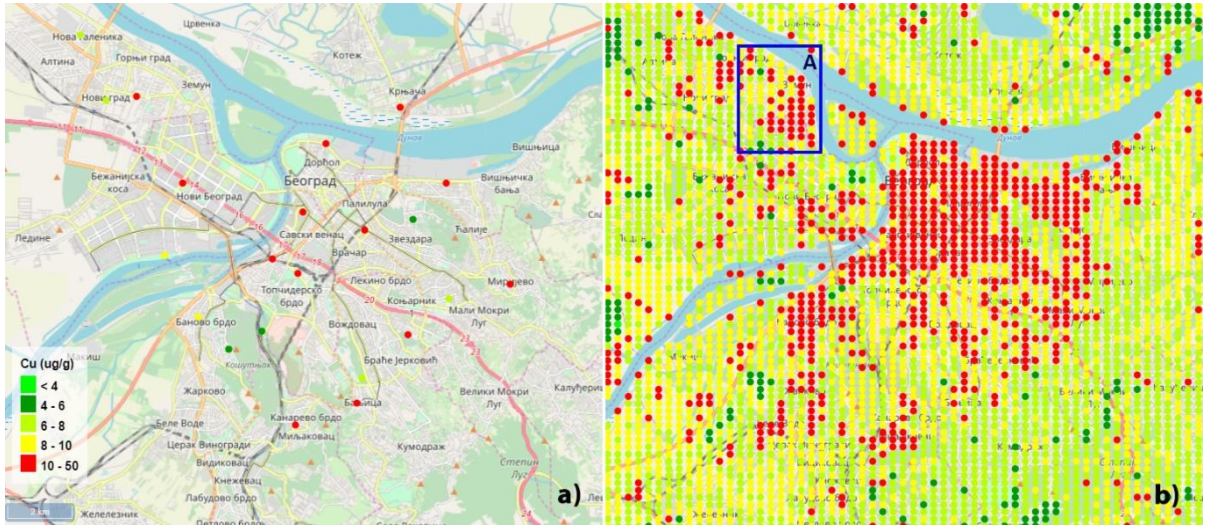


Figure 4. Concentration of Cu in the winter season 2013/2014 (Belgrade): a) real measurements, and b) prediction values; area A represents an old city core highly polluted in winter season

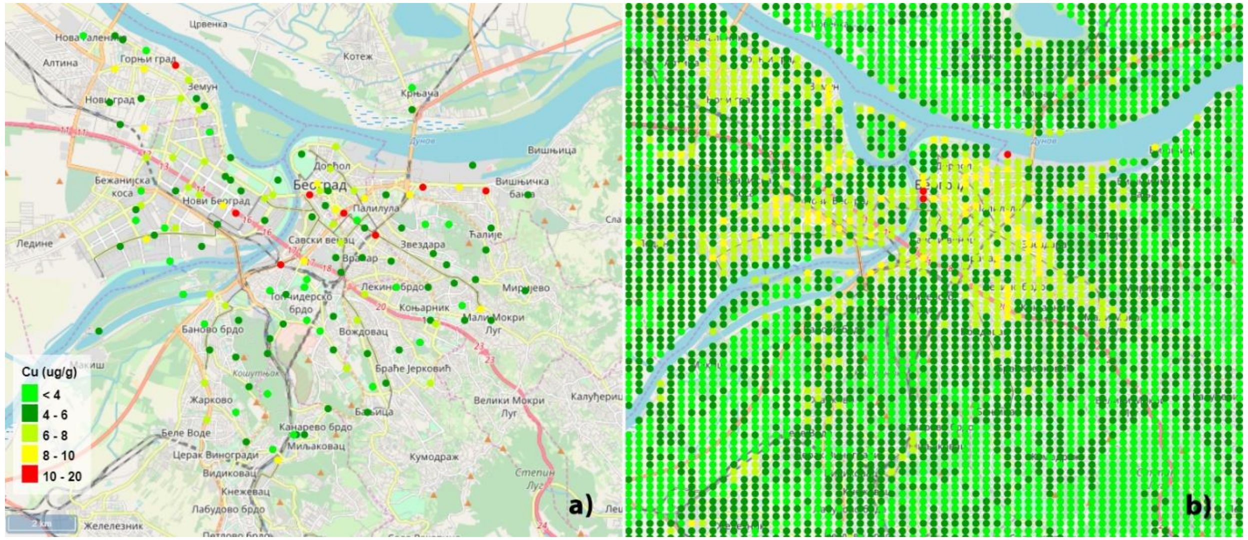
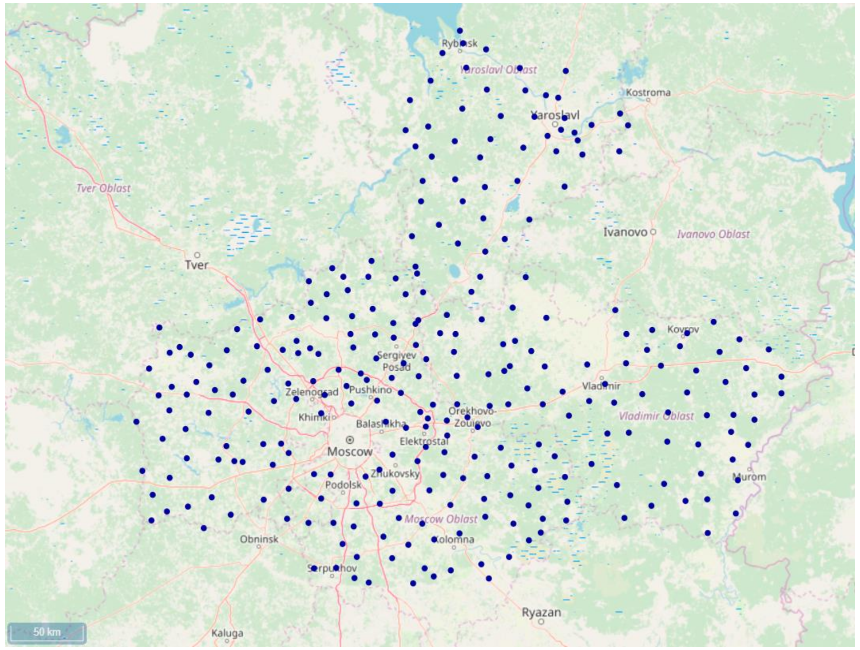


Figure 5. Concentration of Cu in Belgrade: a) biomonitoring measurements in the summer of 2013, and b) prediction for 2018

Machine learning and neural networks



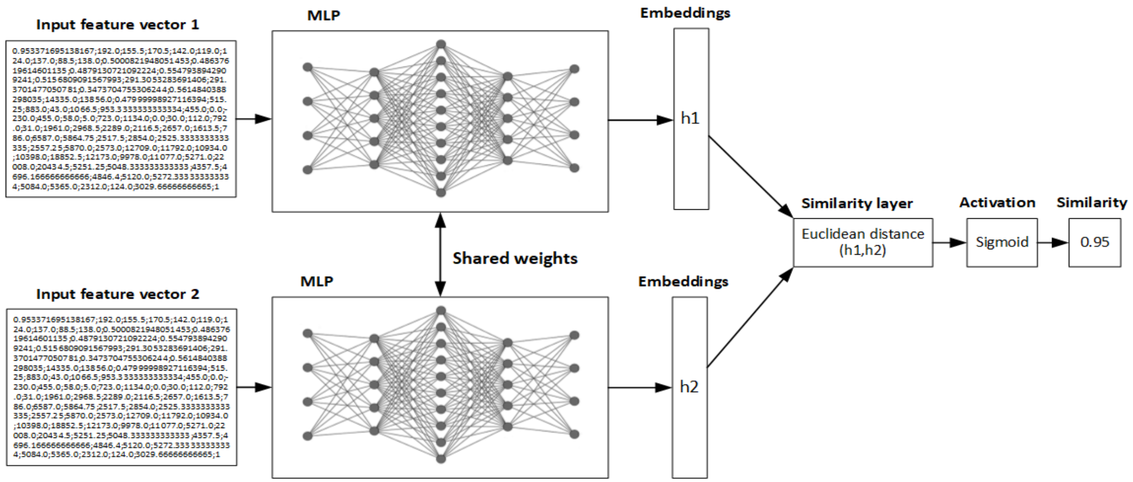
We use the information on 73, 53, and 156 samples from the Vladimir, Yaroslavl, and Moscow regions gathered in 2018 - 2019.

The indices are gathered based on data from 13 programs for 281 sampling sites, and their linkage with the concentration of 18 heavy metals is verified. Altogether 9 HMs, i.e., Al, Fe, Sb, Na, Sc, Sm, Tb, Th, and U, look very prospective for modeling.

We examine three approaches: Gradient Boosting, Multilayer perceptron, and Siamese network.

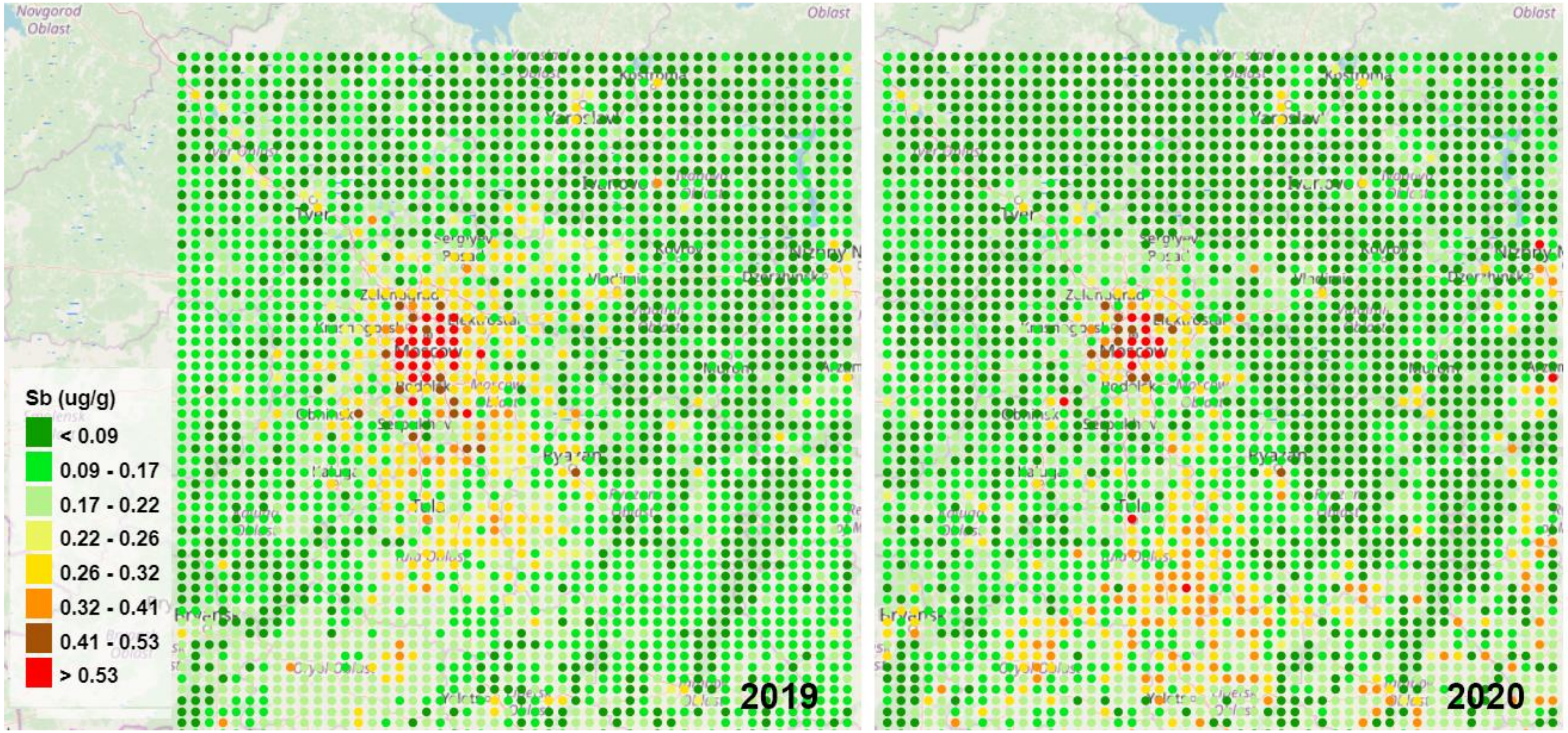
	Al		Fe		Sb	
	Acc si	Acc ai	Acc si	Acc ai	Acc si	Acc ai
GB	0.91	0.92	0.92	0.93	0.94	0.94
MLP	0.89	0.91	0.92	0.92	0.89	0.92
SNN	0.92	0.93	0.93	0.93	0.93	0.94

Table 2. Mean accuracy of the models. GB is gradient boosting. MLP is the multilayer perceptron. SNN is the Siamese neural network. Acc Si is the accuracy on the selected indices. Acc Al is the accuracy on all indices.



Siamese network architecture

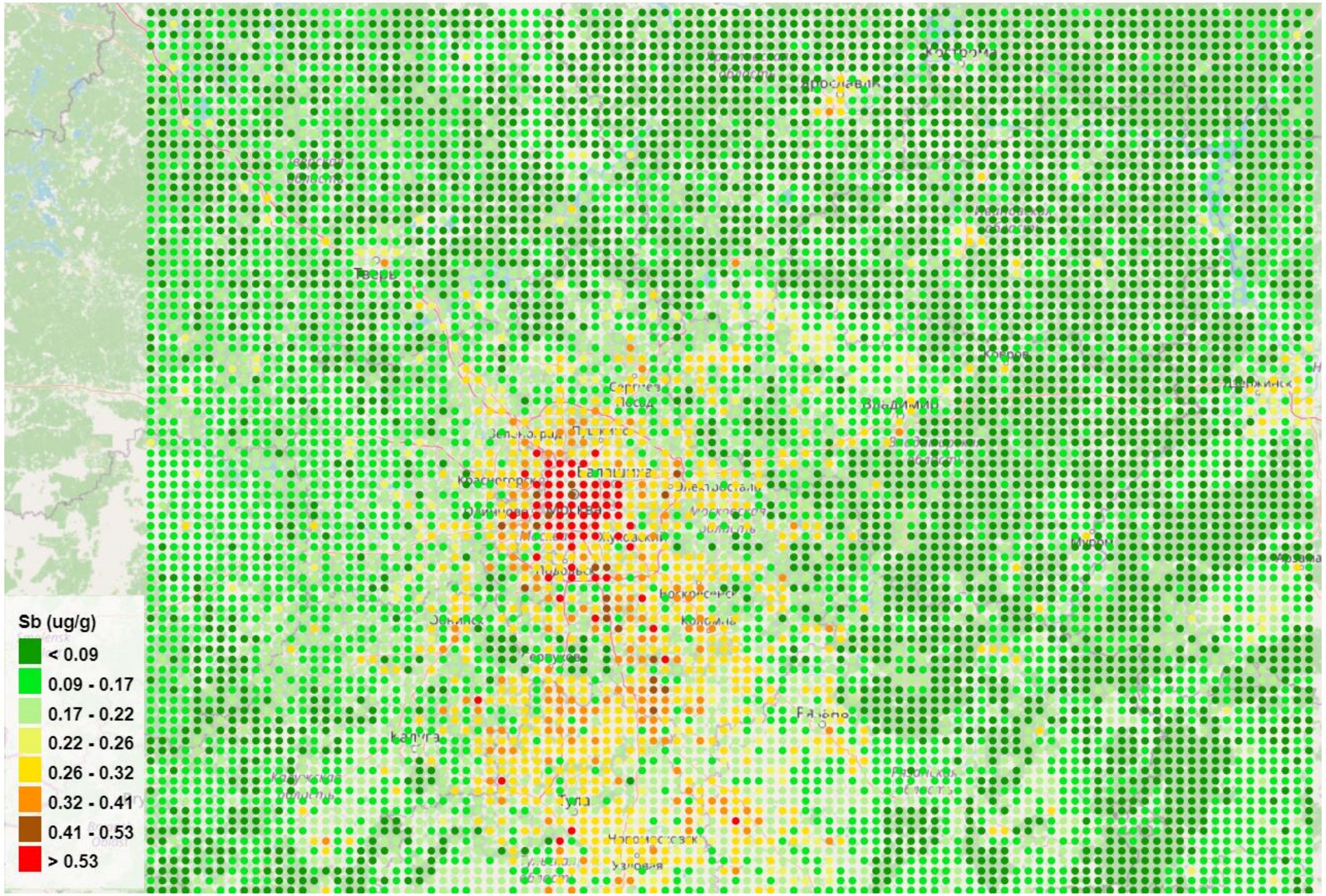
Results (2019 – 2020)



Sb contamination prediction for 2019 (left) and 2020 (right)

The lockdown in Russia that lasted for approximately 1.5 months imposed different limitations. Most of the limitations restricted the movement activities of the population. According to the official statistics, industrial production in Russia decreased by 2.9% from the past, by the end of 2020.

Results (High spatial resolution)



High spatial resolution of the SNN model prediction of Sb contamination

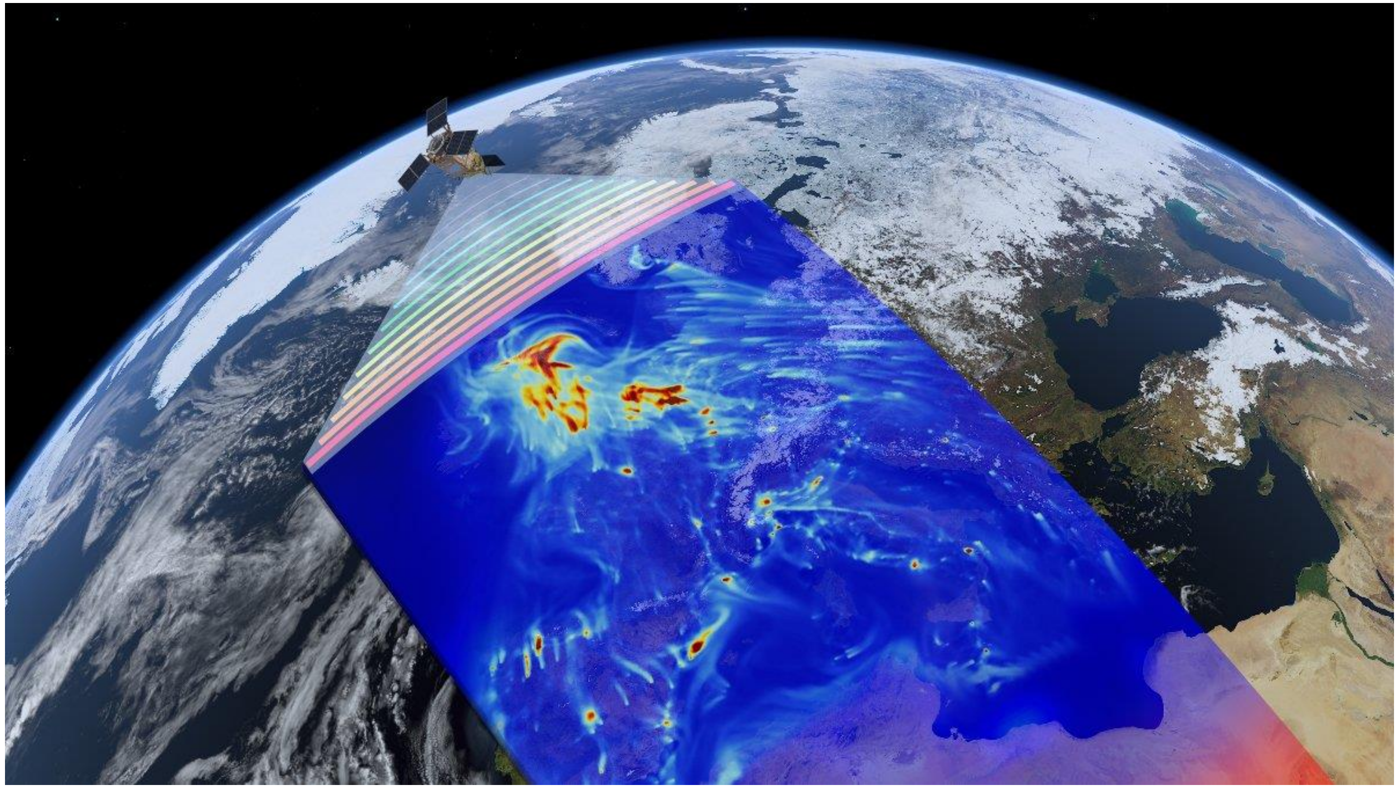
Moscow is a thickly populated city, and the population is increasing at a fast pace. Published information reveals, there are about 12.5 million habitants in Moscow. Therefore the Sb contamination level there is bound to be very high.

The map also reveals clusters of hot spots in large cities, such as Tula, Kaluga, Vladimir, Tver, Nizhny Novgorod, Yaroslavl, etc. It is also seen that from Sergiyev Posad to the north direction, the contamination level is rather low, except Yaroslavl, where the working oil refinery is located.

The Tula region stands out on the map. There is a multitude of industrial enterprises located in the region, i.e., chemical, metallurgical, and machine-building, besides several large thermal power plants. Huge transport nodes and federal freeways are seen, rather clearly, on the map.

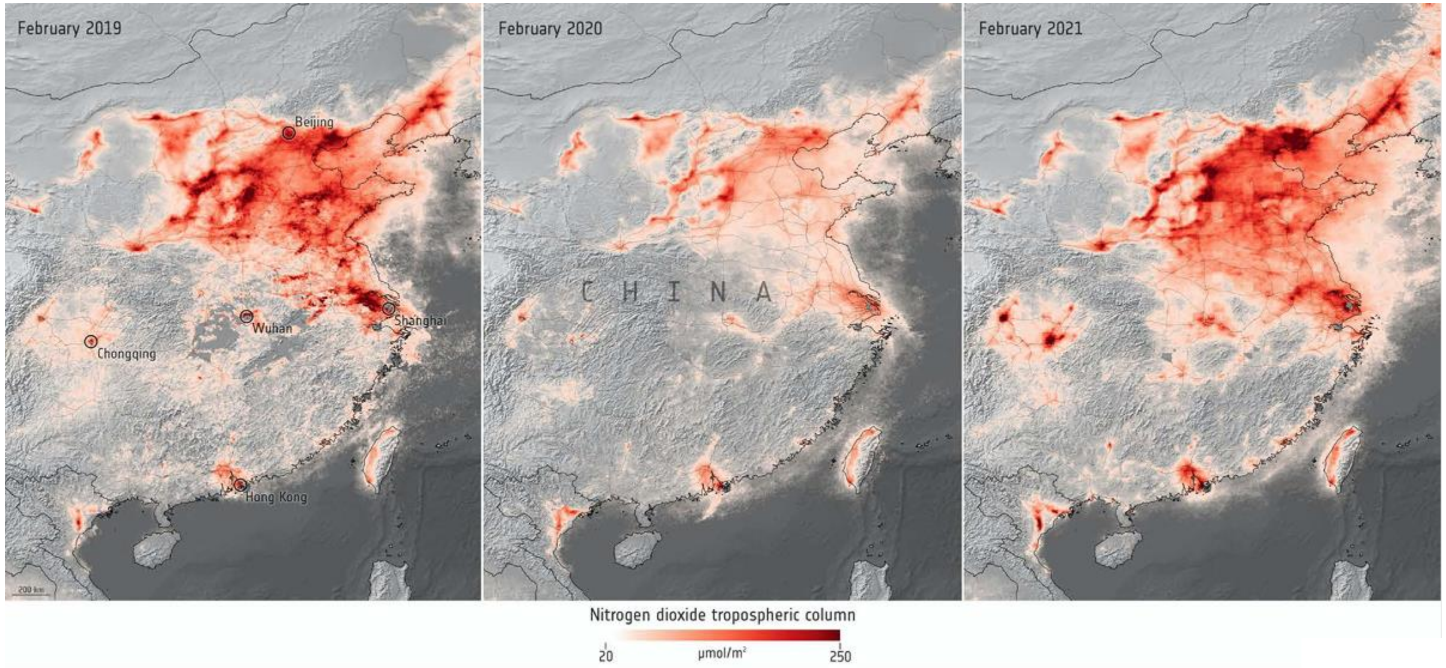
Sentinel-5

The Sentinel-5 mission is part of the European Earth Observation Programme "Copernicus" which is a coordinated and managed by the European Commission (EC). The space component of the Copernicus observation infrastructure is developed under the aegis of the European Space Agency (ESA).



Sentinel-5 is focused on air quality and composition-climate interaction with the main data products being O_3, NO_2, SO_2, HCHO, CHOCHO and aerosols. Additionally Sentinel-5 will also deliver quality parameters for CO, CH_4, and stratospheric O_3 with daily global coverage for climate, air quality, and ozone/surface UV applications.

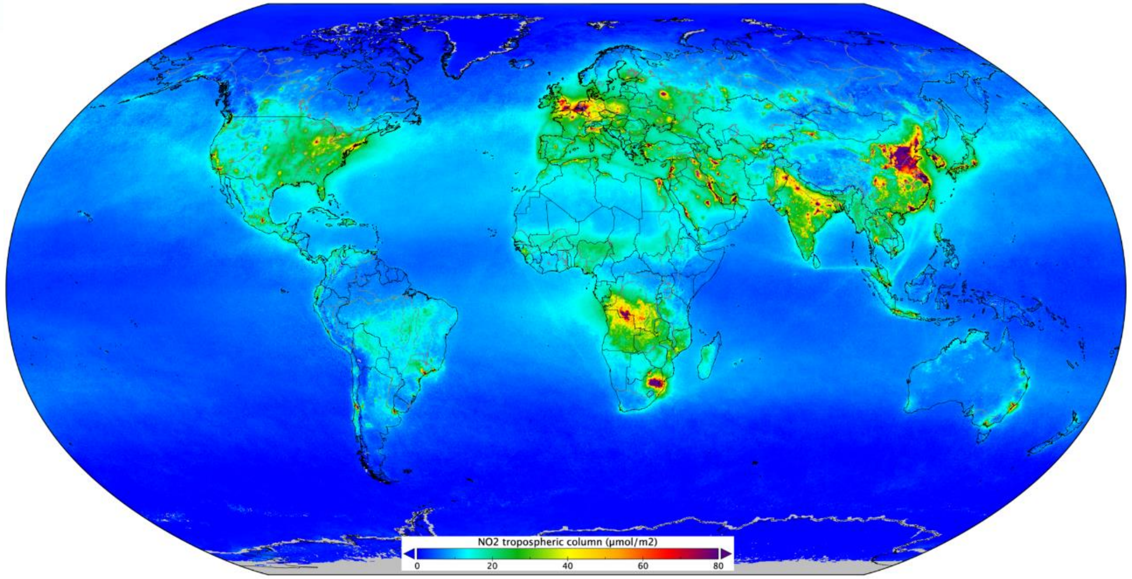
Sentinel-5



contains modified Copernicus Sentinel data (2019-21), processed by ESA

The Sentinel-5 mission consists of high resolution spectrometer system operating in the ultraviolet to shortwave infrared range with 7 different spectral bands: UV-1 (270-300nm), UV-2 (300-370nm), VIS (370-500nm), NIR-1 (685-710nm), NIR-2 (745-773nm), SWIR-1 (1590-1675nm) and SWIR-3 (2305-2385nm).

Resolution ~ 1114 m,
Orbital cycle 16 days.



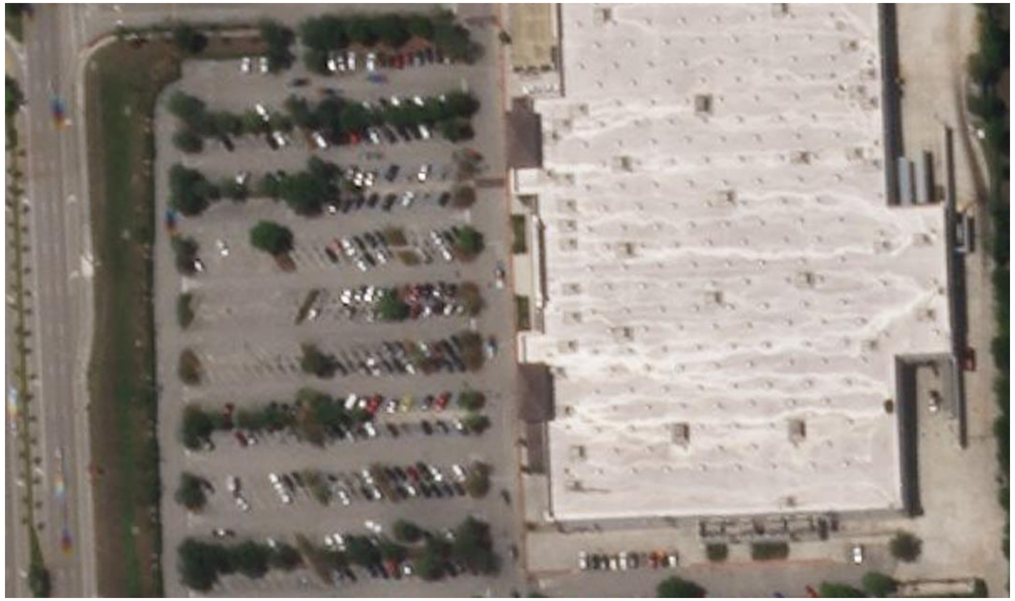
Nitrogen dioxide worldwide 12/03/2019

Sentinel 7 (CO2M - Copernicus Anthropogenic Carbon Dioxide Monitoring) 2025 - 2026

Formula 1 Miami Grand Prix

2019

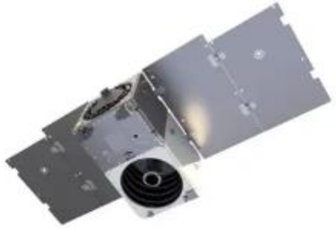
Daily, less than 3m resolution, 4 spectral channels



Commercial programs - www.planet.com

Now



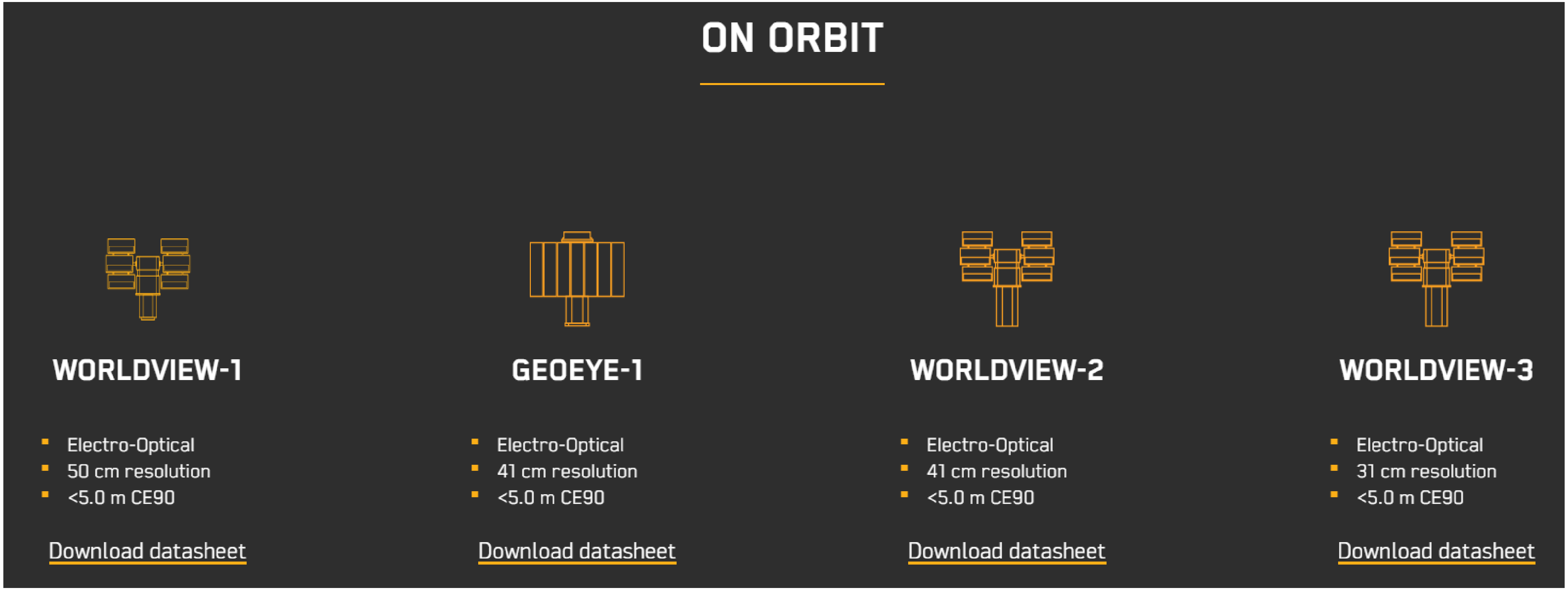



PlanetScope Always-on Monitoring	SkySat High-Resolution Tasking	Pelican Very High Resolution	Hyperspectral Broad Spectral Range
~200 Satellites	**21** Satellites	**~32** Satellites	**2** Satellites
3.7 m (3.0 NIIRS) GSD	**0.5 m (4.0-5.0 NIIRS)** GSD	**0.3 m (>5.5 NIIRs at-nadir)** GSD	**30 m** GSD
8 Spectral Bands	**RGB, Pan and NIR** Spectral Bands	**7** Spectral Bands	**400-2500nm (5nm spacing)** Spectral Bands
Not required Tasking	**Sub-daily** Tasking	**Up to 12 revisits/day** Tasking	**Tasking Required** Tasking

Commercial programs - maxar.com

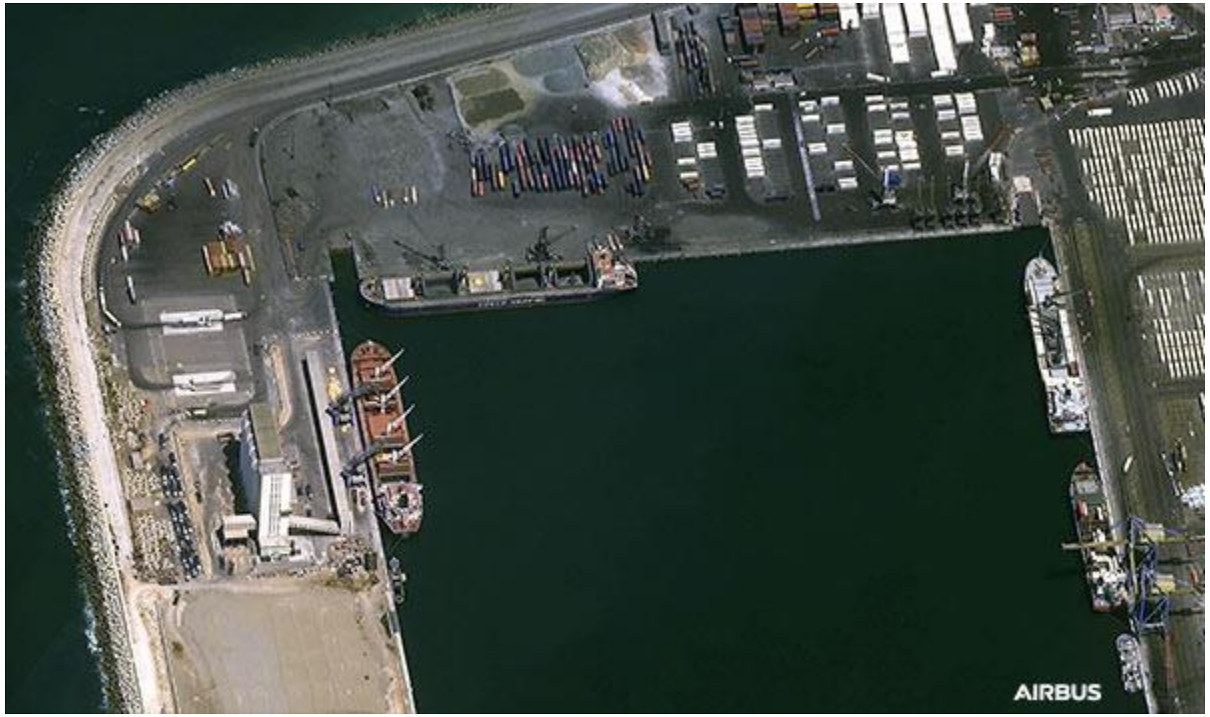
1999
~ 3 days, 3m resolution, 3 spectral channels

Commercial programs - maxar.com



From 2007	From 2008	From 2009	From 2014
~ 2 days	< 2 day	~ 1.2 day	< 1 day
1 spectral channel	5 spectral channels	9 spectral channels	29 spectral channels

Commercial programs - Airbus



Commercial programs - Airbus

Google Earth Engine

More than
80 Pb of data

The total number of AI publications doubled, growing from 162,444 in 2010 to 334,497 in 2021.

According to UCS, there are 4,852 active artificial satellites orbiting the Earth as of January 1, 2022,
2,944 belong to the United States.

Monitoring is the first step to control, so I look in the future with optimism and believe that Earth will become clearer and safer.

Если хотите попробовать порешать интересные задачи и поучаствовать в проектах:
email: auzhiskiy@jinr.ru
https://t.me/bigzmey

Спасибо за внимание!

Если осталось время – то будет небольшой туториал!