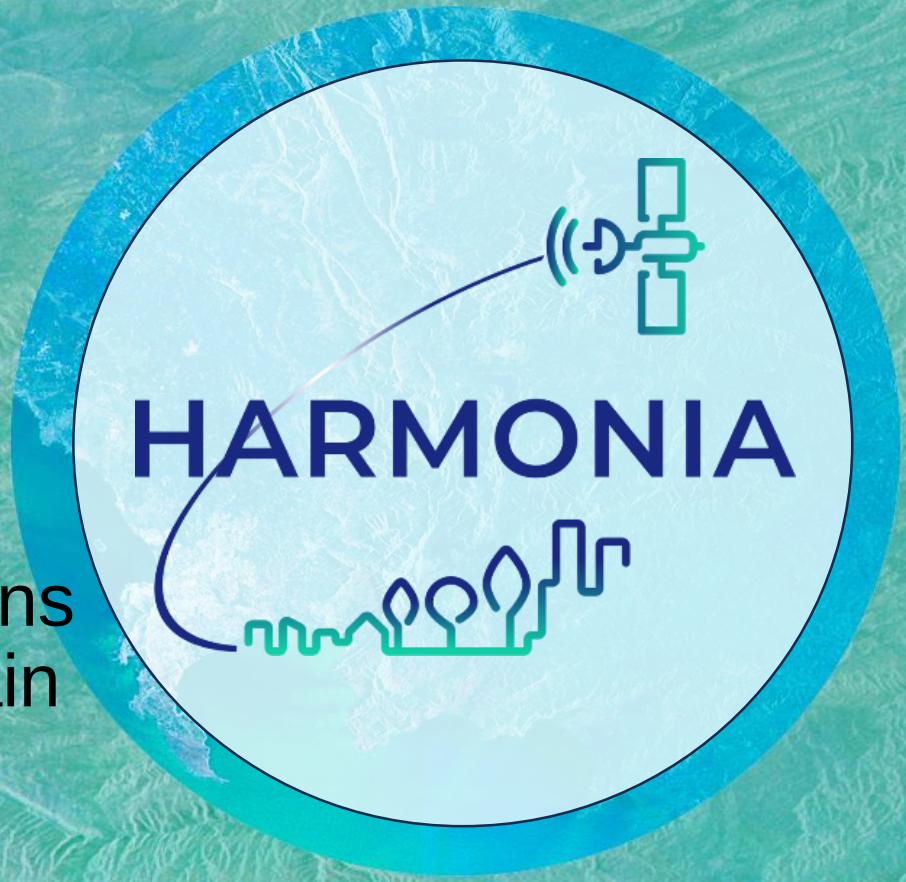
GEO WEEK & MINISTERIAL SUMMIT 2023

The City Talks – HARMONIA solutions & potential synergies in urban domain among GEO Community

#TheEarthTalks



science & innovation
Department:
Science and Innovation
REPUBLIC OF SOUTH AFRICA

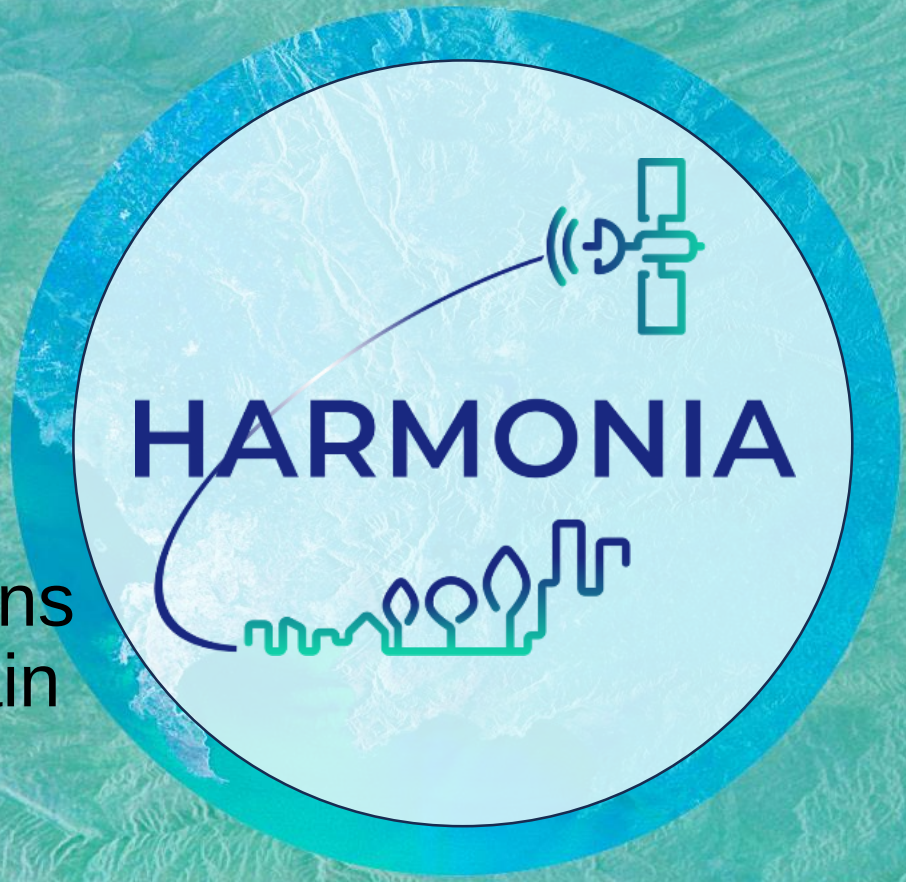
GEO WEEK 2023 MINISTERIAL SUMMIT

GEO GROUP ON EARTH OBSERVATIONS

The Harmonia project has received funding from the EU Horizon 2020 research and innovation programme under agreement No. 101003517

GEO WEEK & MINISTERIAL SUMMIT 2023

The City Talks – HARMONIA solutions & potential synergies in urban domain among GEO Community



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#TheEarthTalks

GEO WEEK & Ministerial Summit 2023

HARMONIA

Development of a Support System for Improved Resilience and Sustainable Urban areas to cope with Climate Change and Extreme Events based on GEOSS and Advanced Modelling Tools

LC-CLA-19-2020: Integrated GEOSS climate applications to support adaptation and mitigation measures of the Paris Agreement

22 PARTNERS

4 Academias
9 Companies
4 Research institutes
1 NGO
4 Municipalities

4 PILOT CITIES

Milan (Italy)
Sofia (Bulgaria)
Piraeus (Grece)
Ixelles (Belgium)

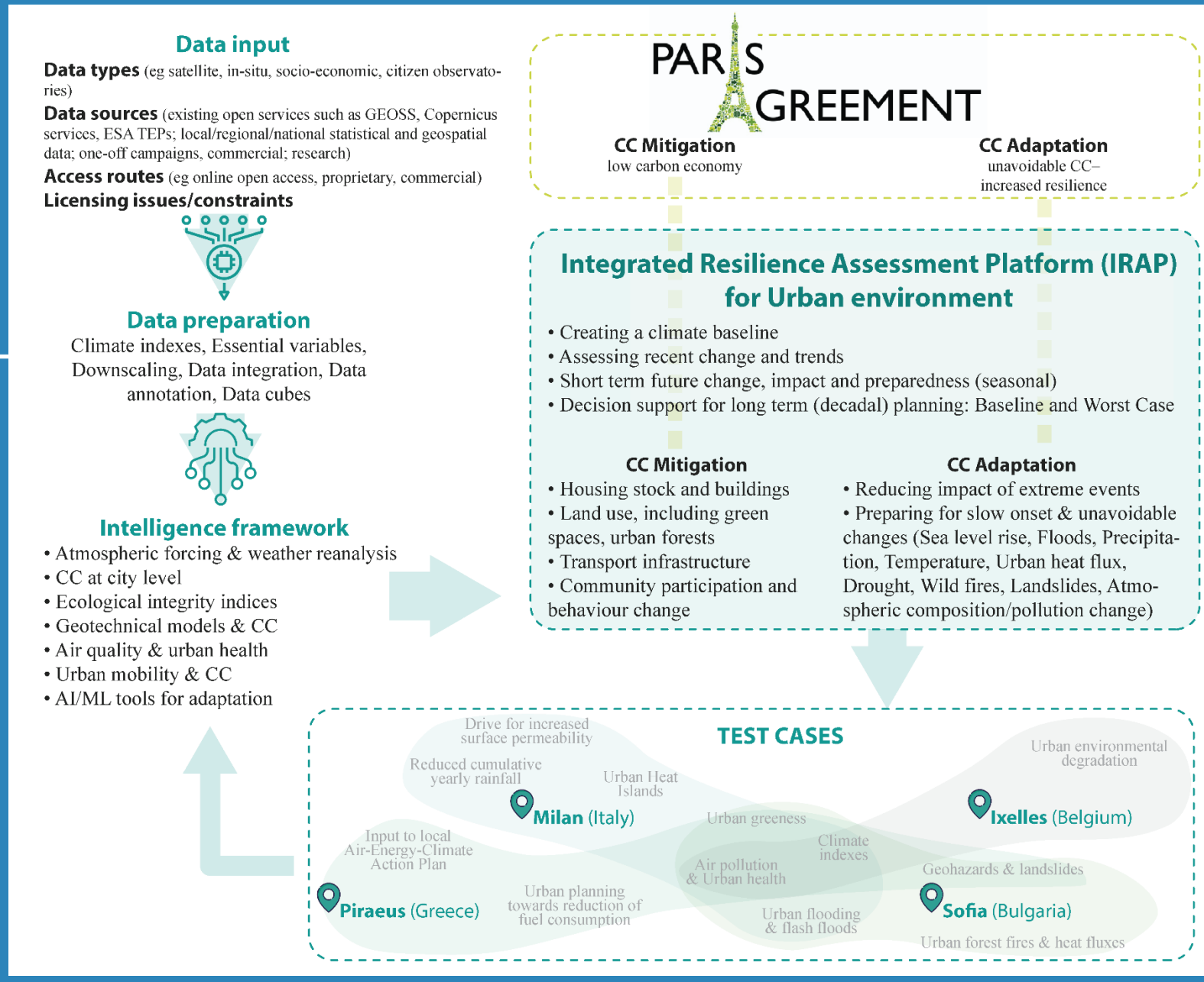
Politecnico di Milano, Italy

GEO WEEK 2023 MINISTERIAL SUMMIT

HARMONIA

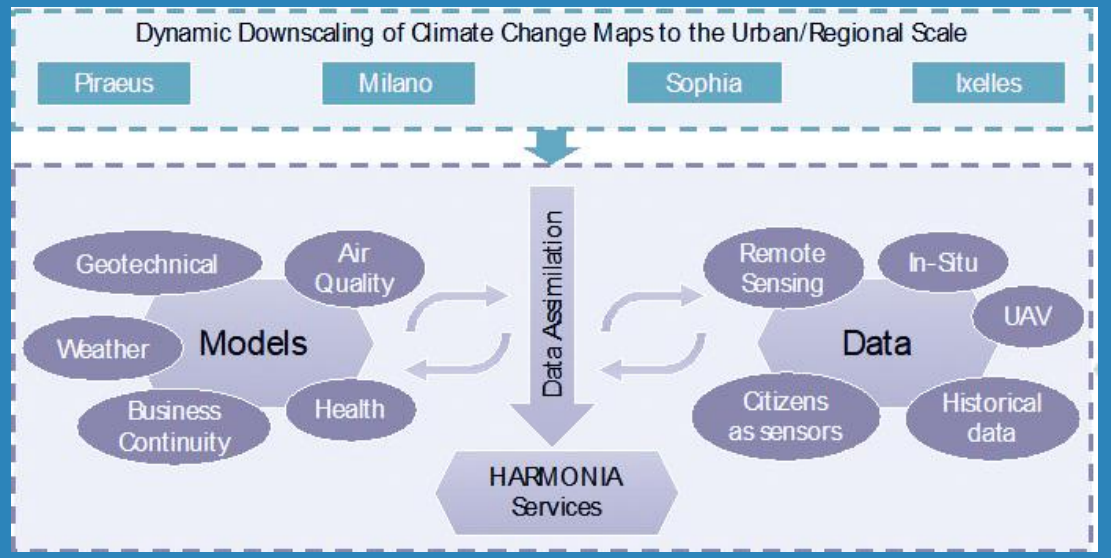
HARMONIA APPROACH

HARMONIA's main objective is to reorganise and integrate the huge amount of data already available and to make the best use of existing monitoring technologies and geospatial services for urban hazard assessment and disaster risk management.



HARMONIA PURPOSE

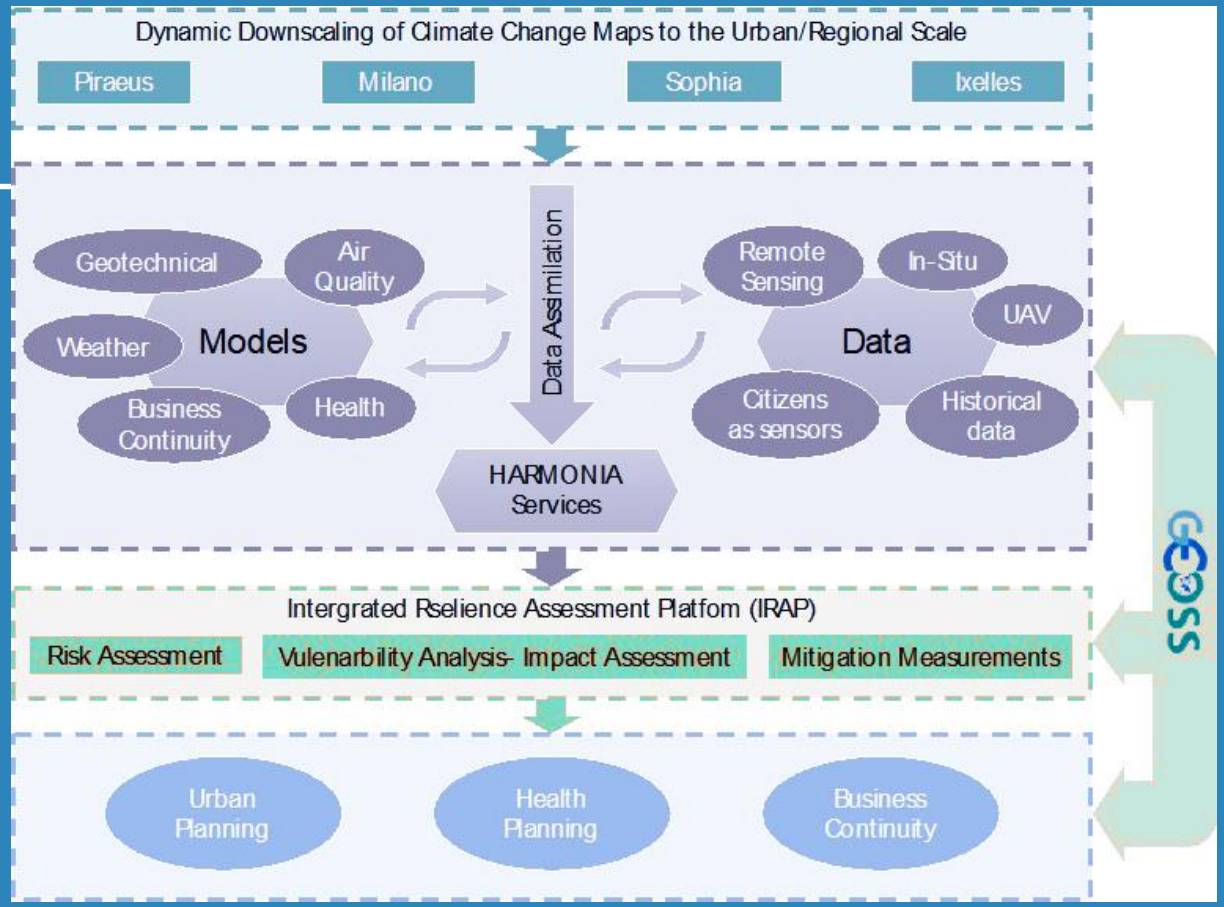
HARMONIA capitalises on a wealth of existing Earth Observation (EO) datasets and services –including GEOSS, Copernicus, ESA TEPs services and other ESA data and services, as well as National Data Cubes – with ensemble modelling, socio-economic and in-situ data at the spatial and temporal scales **relevant for the urban environment…**



HARMONIA PURPOSE

……to deliver an Integrated Resilience Assessment Platform (IRAP)

a system that allows stakeholders to model a range of planning options against a number of CC scenarios towards targeted applications in order to mitigate CC effect in urban areas, helping deliver resilient cities for current and future generations



HARMONIA

IRAP

The IRAP (Integrated Risk Assessment Platform) is a constellation of cloud-based datasets and services made accessible through a REST API and a suitable backend framework. It encompasses several main functionalities:

Data Integration

AI-Driven Models

Risk Assessment and Mapping

Decision Support Systems

Urban Planning and Optimization

Health and Well-being Assessment

IRAP Platform Integration

IRAP platform is a sophisticated system consisting of multiple software components designed to work together in a harmonized way

The purpose of the integration is to facilitate efficient HARMONIA data exchange and communication among the various parts of the platform

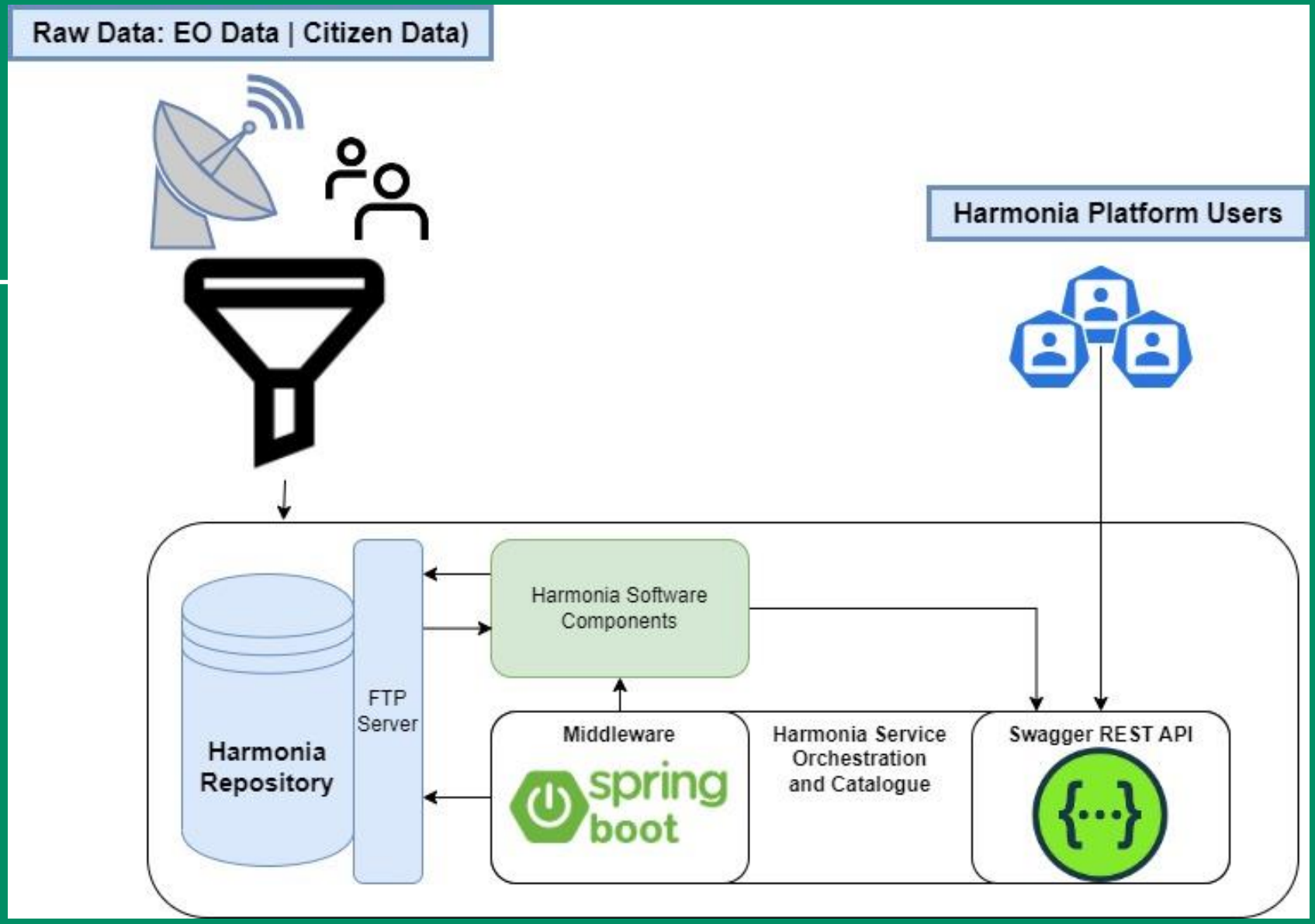
This Data regard the output datasets and analysis of the various HARMONIA software Components

Development:

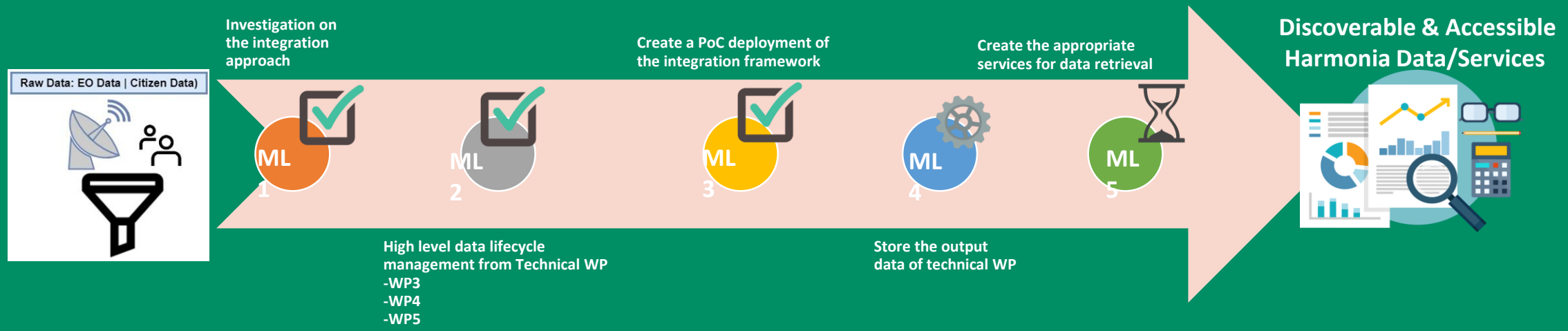
I. To enable this communication, a central repository is used to store all the data needed by the different parts of HARMONIA. This repository is called an FTP server, which is essentially a computer designed to store and manage large amounts of files.

II: On top of the FTP Server a middleware software was implemented (Spring framework) in order to facilitate the Services needed for transferring the correct data.

IRAP Platform Integration



Technical Integration Process & Roadmap



Conclusions

- EO data represent a great opportunity to **understand and improve**
- **the resilience of urban systems**

- their actual **accessibility and usability** by local administrations is however **limited** by technical difficulties and the immense amount and variety of data available

- there is therefore a **need for integrated platforms** such as HARMONIA IRAP to facilitate access to these data sources and make the results accessible

- the integration of the use of EO data into the processes of municipalities must necessarily start from mapping the **needs and requirements of local end users**

- in order to support an effective translation of new knowledge into active policies, risk assessment cannot disregard the **citizens active engagement**

HARMONIA

Get in touch!

contact@harmonia-project.eu

http://harmonia-project.eu/

https://twitter.com/ProjectHarmonia

https://www.linkedin.com/in/harmonia-project/

https://www.instagram.com/harmonia.h2020/

https://www.facebook.com/HarmoniaProject2021

#TheEarthTalks

GEO WEEK 2023 MINISTERIAL SUMMIT

6-10 NOVEMBER

CAPE TOWN, SOUTH AFRICA

science & innovation
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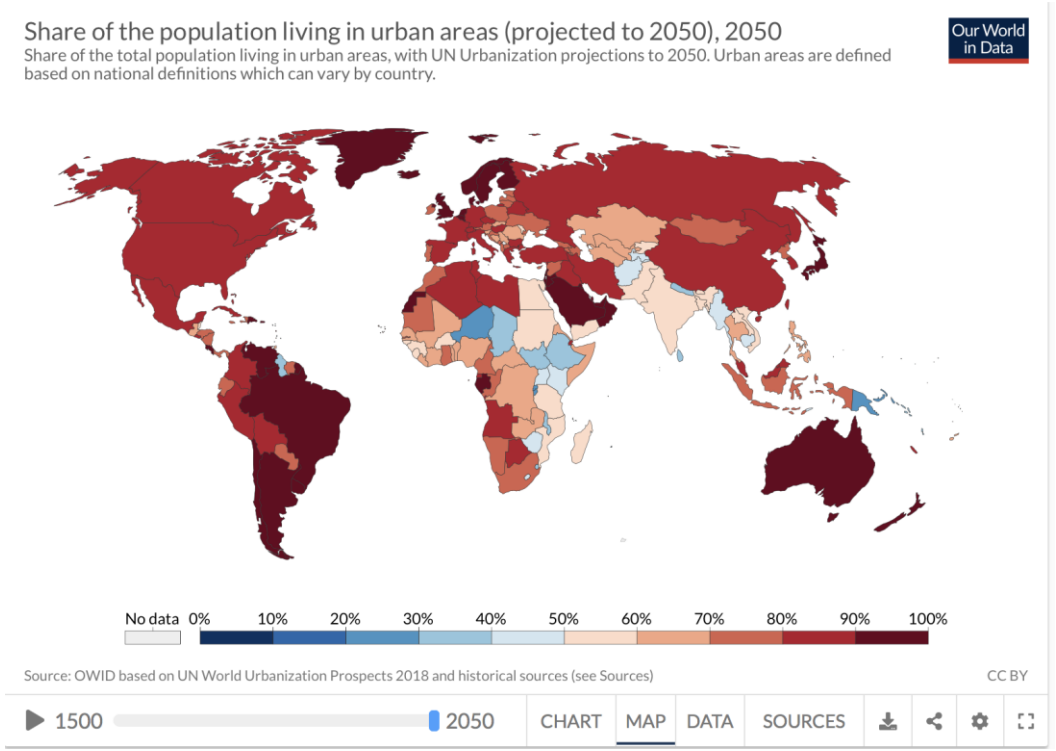
REPUBLIC OF SOUTH AFRICA

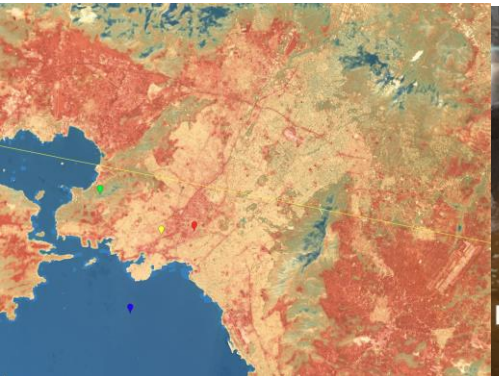
GEO GROUP ON EARTH OBSERVATIONS

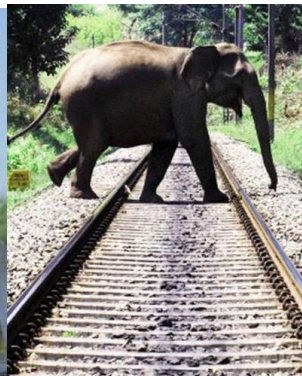
Enhancing Urban Resilience with AI and Earth Observation Big Data

Yifang Ban
Professor & Director, Division of Geoinformatics (yifang@kth.se)
Department of Urban Planning & Environment
KTH Royal Institute of Technology
&
Associate Director, Digital Futures
Stockholm, Sweden

Urbanization and Environmental Impact

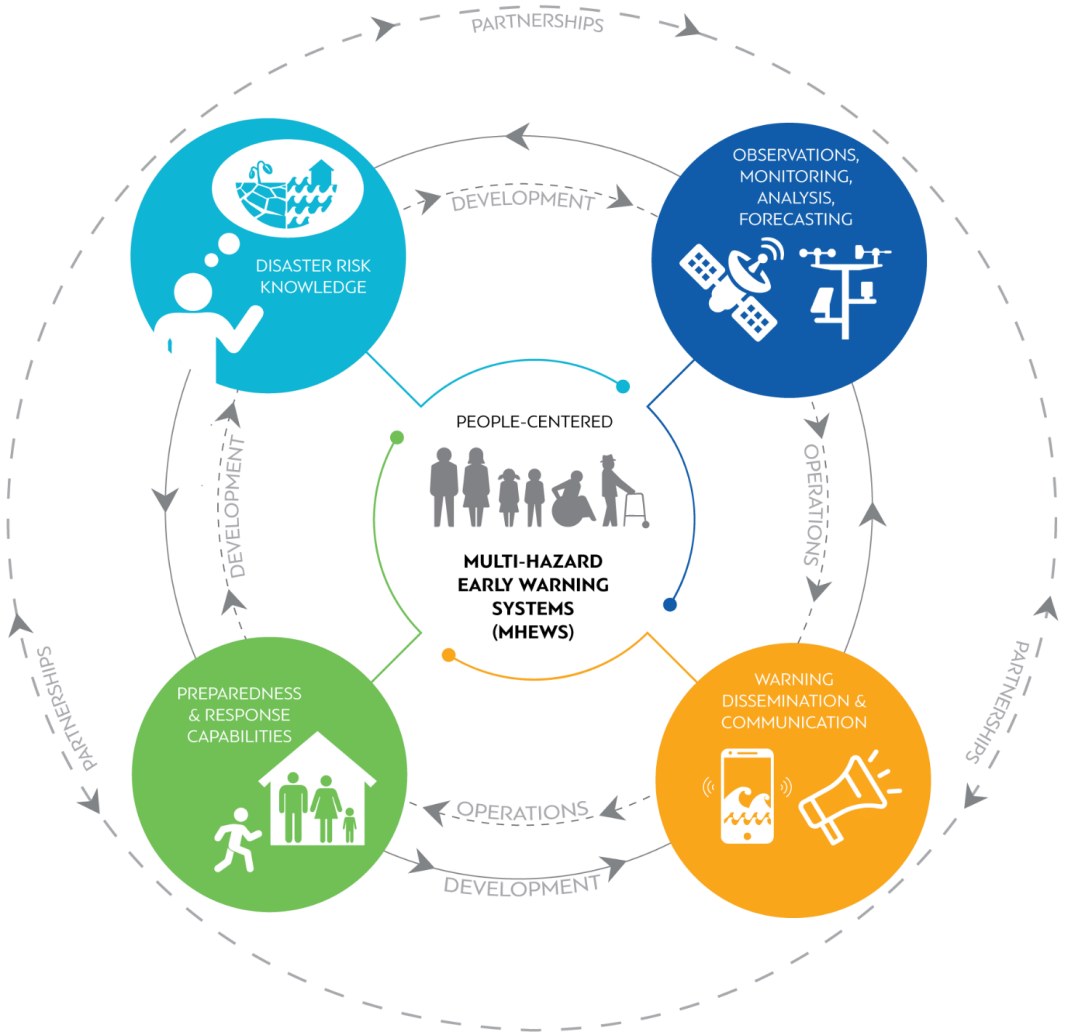






Early Warnings for All

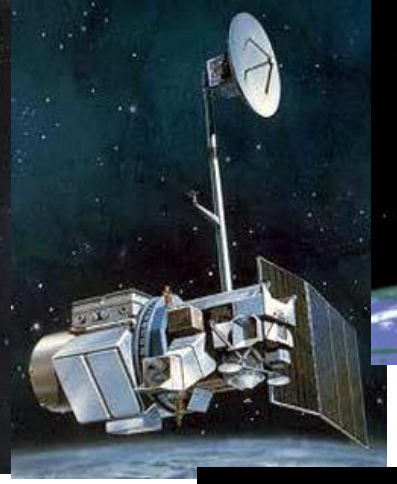
The UN Global Early Warning Initiative for the Implementation of Climate Adaptation

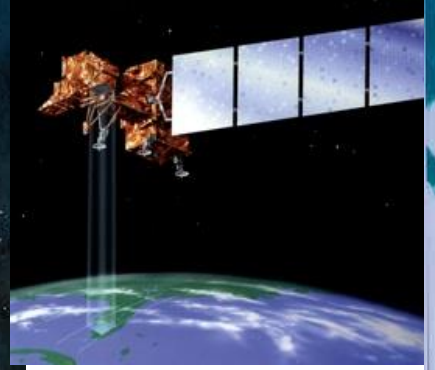


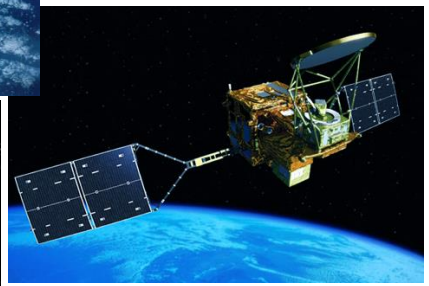
> Today I announce the United Nations will spearhead new action to ensure every person on Earth is protected by early warning systems within five years. I have asked the World Meteorological Organization to lead this effort and to present an action plan at the next UN climate conference, later this year in Egypt.
>
> UN Secretary-General Antonio Guterres on World Meteorological Day 23 March 2022

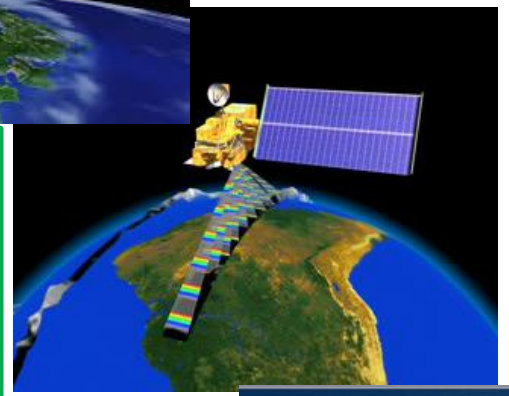
WORLD METEOROLOGICAL ORGANIZATION

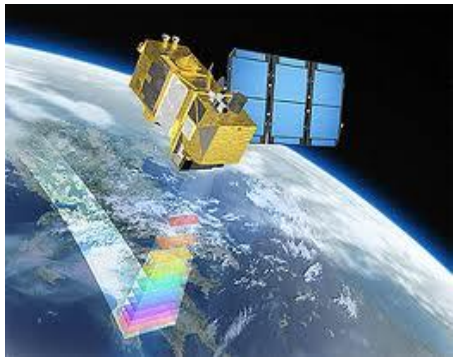
COP27 SHARM EL-SHEIKH EGYPT 2022

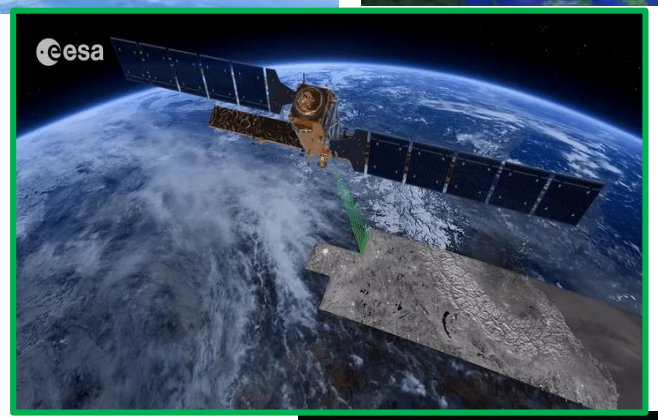








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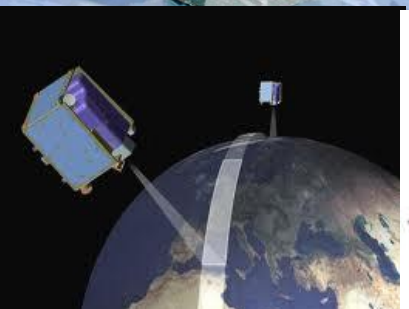

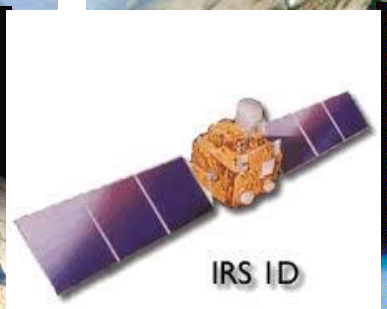
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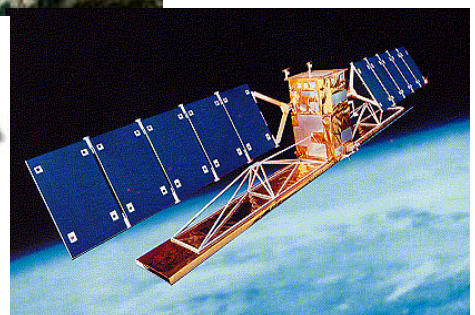
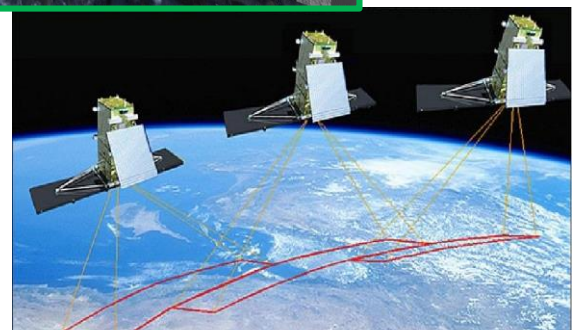
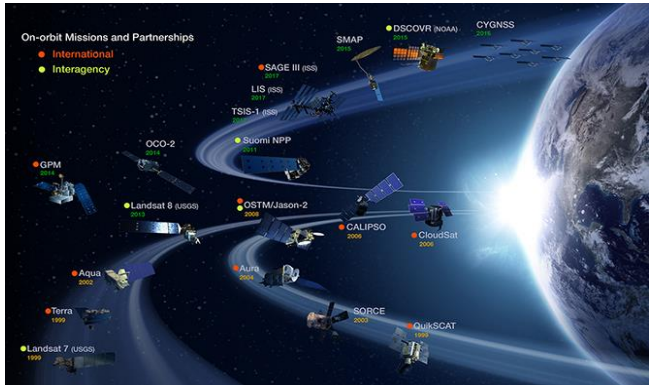


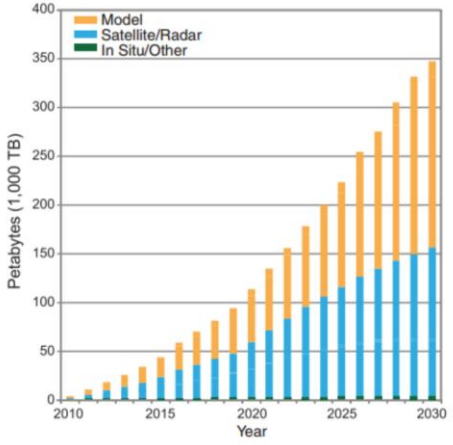


1980
1990
2000
2010
Meteorological Missions
Copernicus: "Sentinel" Missions
"Earth Explorer" Missions

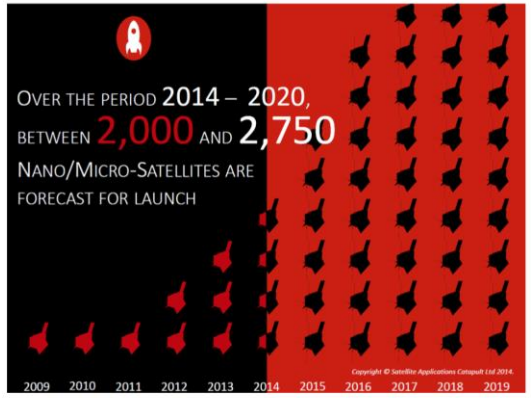
Earth Observation Big Data

- Thanks to the fast growth of satellite technology, we are moving forward into a new era of Earth Observation Big Data.
- National/International space agencies and innovative companies are supporting various EO programs acquiring huge volumn of data every day





Jonathan T. Overpeck et al, Science 2011



Capella Space

planet.

Synspective

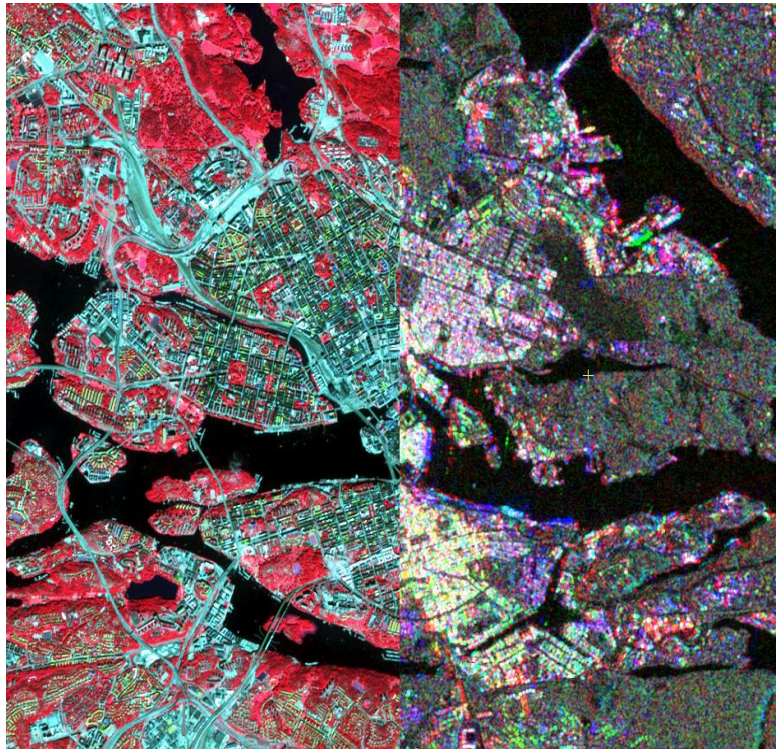
ICEYE

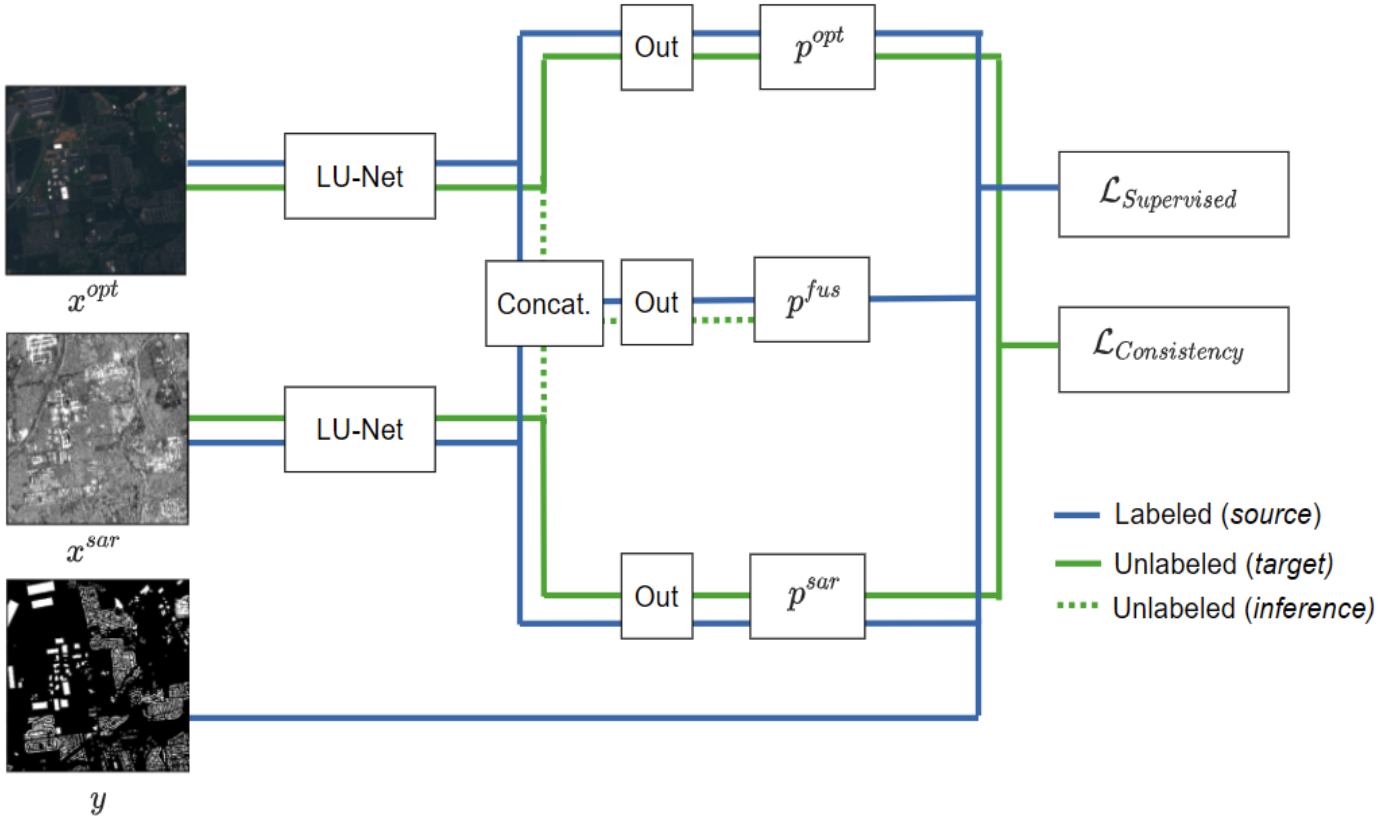
EO Big Data:
Opportunities & Challenges

- **Opportunities**
  - Near-real time monitoring of phenomena affecting built and natural environment
  - Dense time series for analysis of global environmental changes
  - New possibility to deploy operational and reliable services
- **Challenges**
  - Computing infrastructure to handle, store and process the data
  - New methods and algorithms to extract valuable information
  - New approaches to Integrate EO Data with other geospatial big data (i.e. social media, ground sensors, crowdsourced data)

EO Time Series for Urbanization Monitoring

EO& AI for Urban Mapping





Hafner, S., Y. Ban, and A. Nascetti. 2022. Unsupervised Domain Adaptation for Global Urban Extraction using Sentinel-1 and Sentinel-2 Data. *Remote Sensing of Environment*, Volume 280, 113192, https://doi.org/10.1016/j.rse.2022.113192.

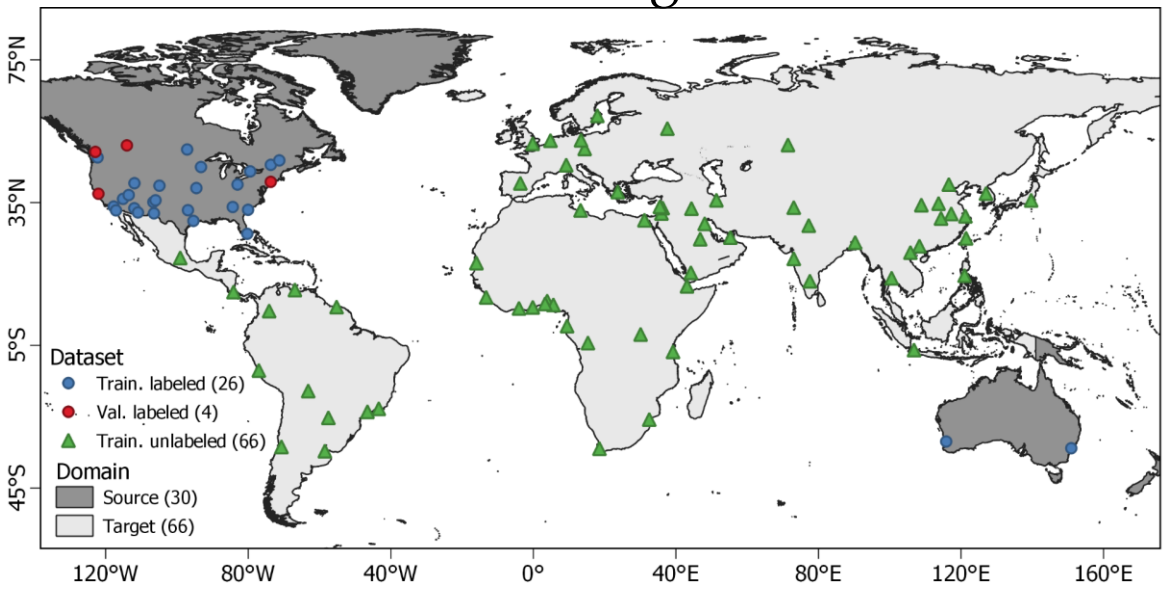
Hafner, S. and Y. Ban. 2023 Multi-Modal Deep Learning for Multi-Temporal Urban Mapping with a Partly Missing Optical Modality. *IGARSS 2023*

Urban Mapping

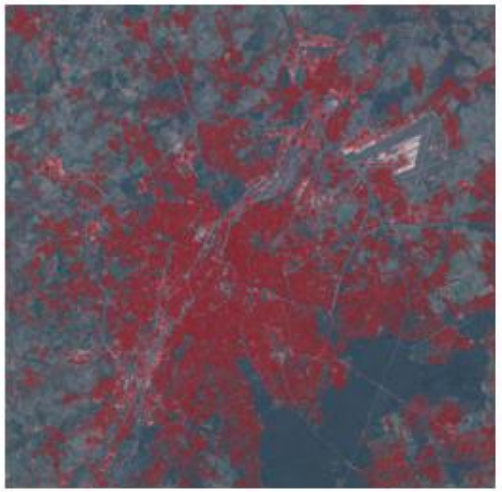
- Microsoft Building Footprints as labels

- Introduce a domain gap
- Produced Sentinel-1/2 data and corresponding labels

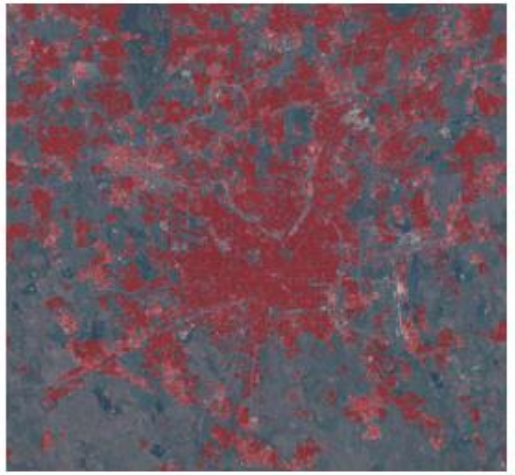
Locations of the training and validation sites



(a) Athens

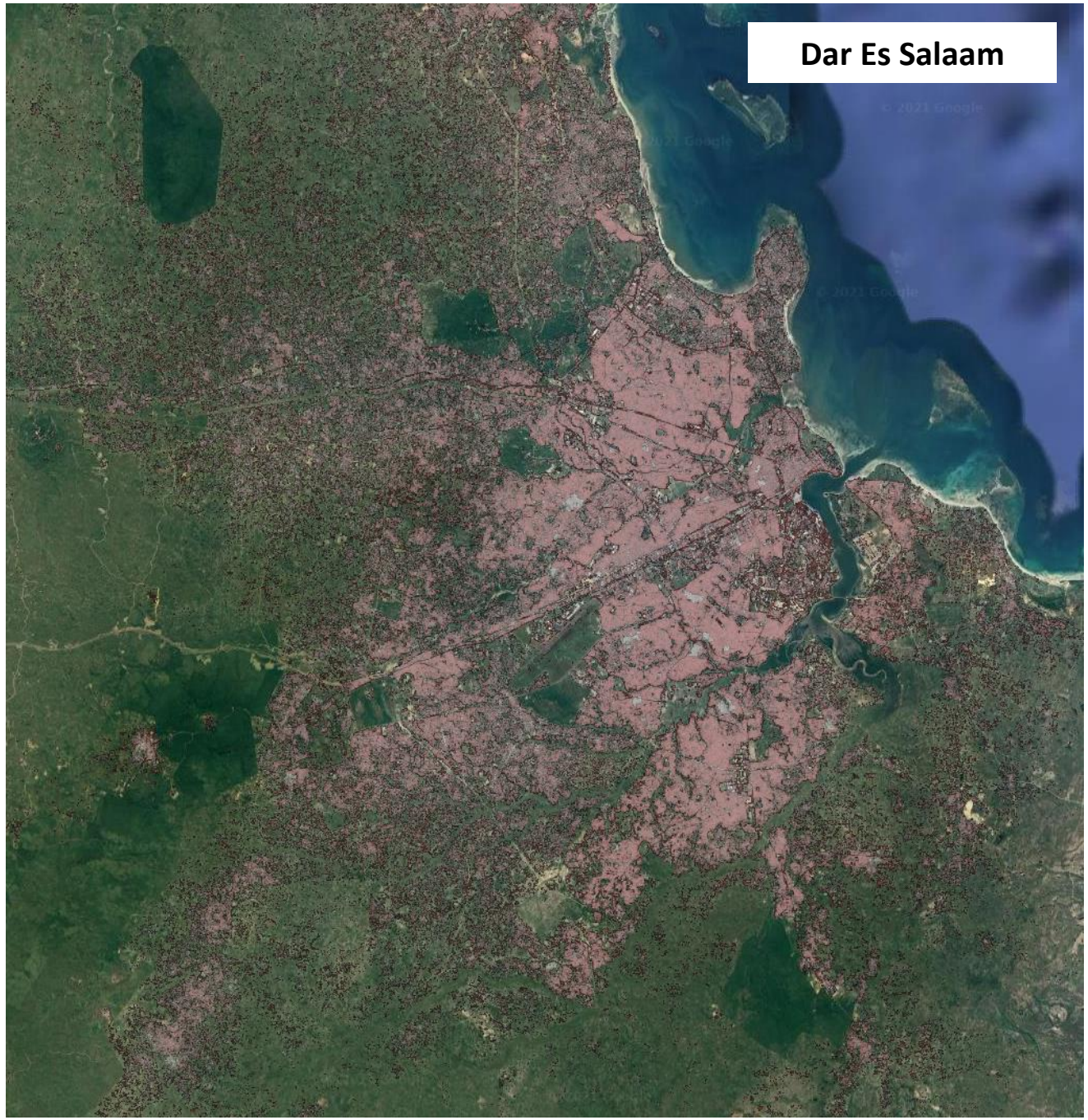


(b) Brussels



(c) Milan

(d) Sofia


Dar Es Salaam

KTH

GHS-S2

EO&AI-Powered Tool for Urban Mapping

Drive Folder

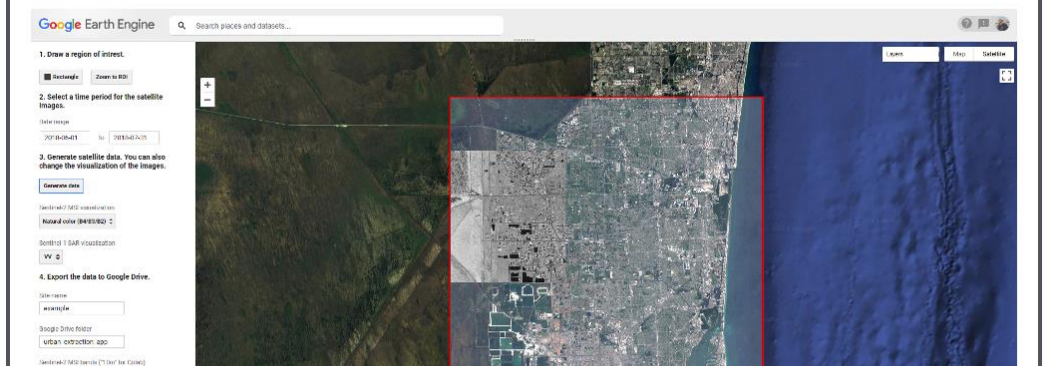
My Drive > urban_extraction_app

Type | People | Modified

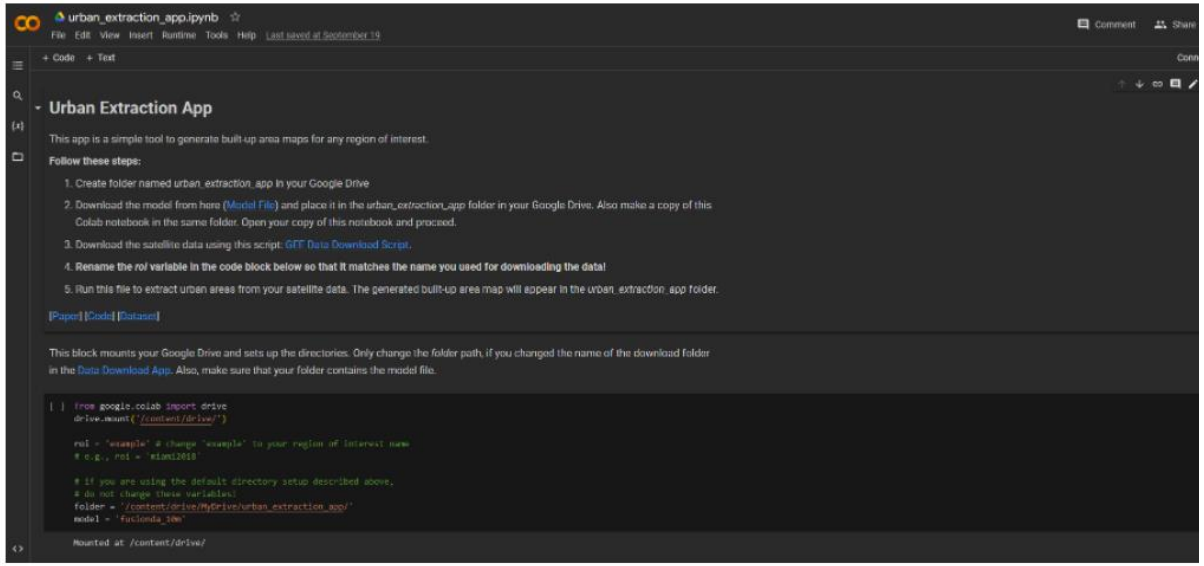
Name	Last m...
urban_extraction_app.ipynb	10:36
fusionda_10m.pt	8 Sept 2023

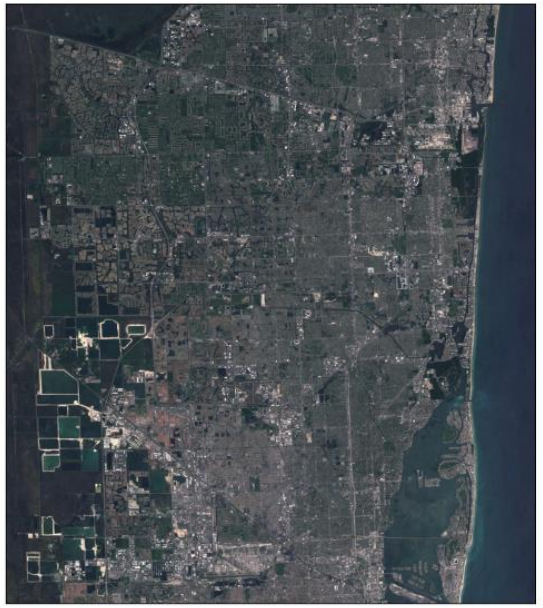
1 Setup up Drive Folder

2 Data Download in GEE

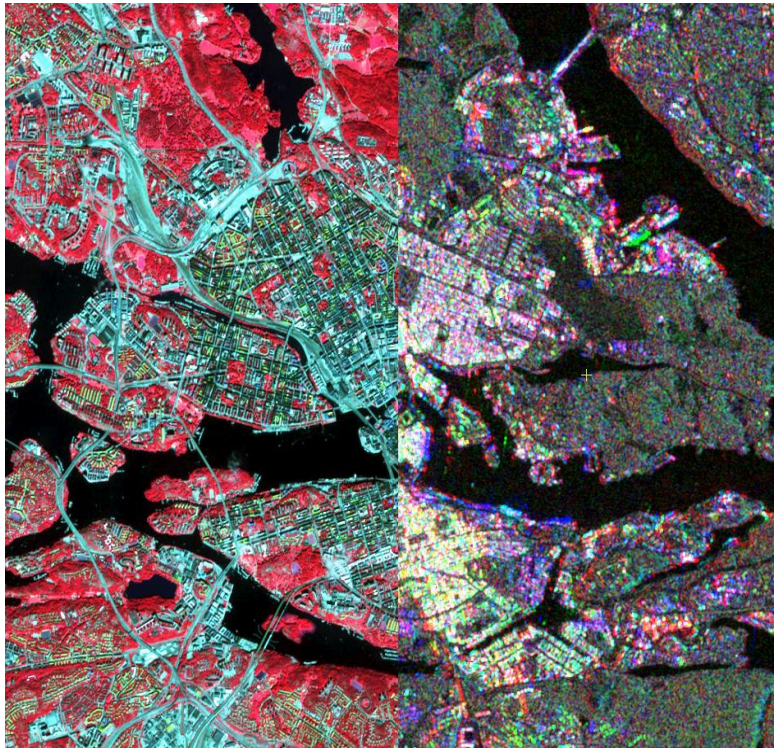


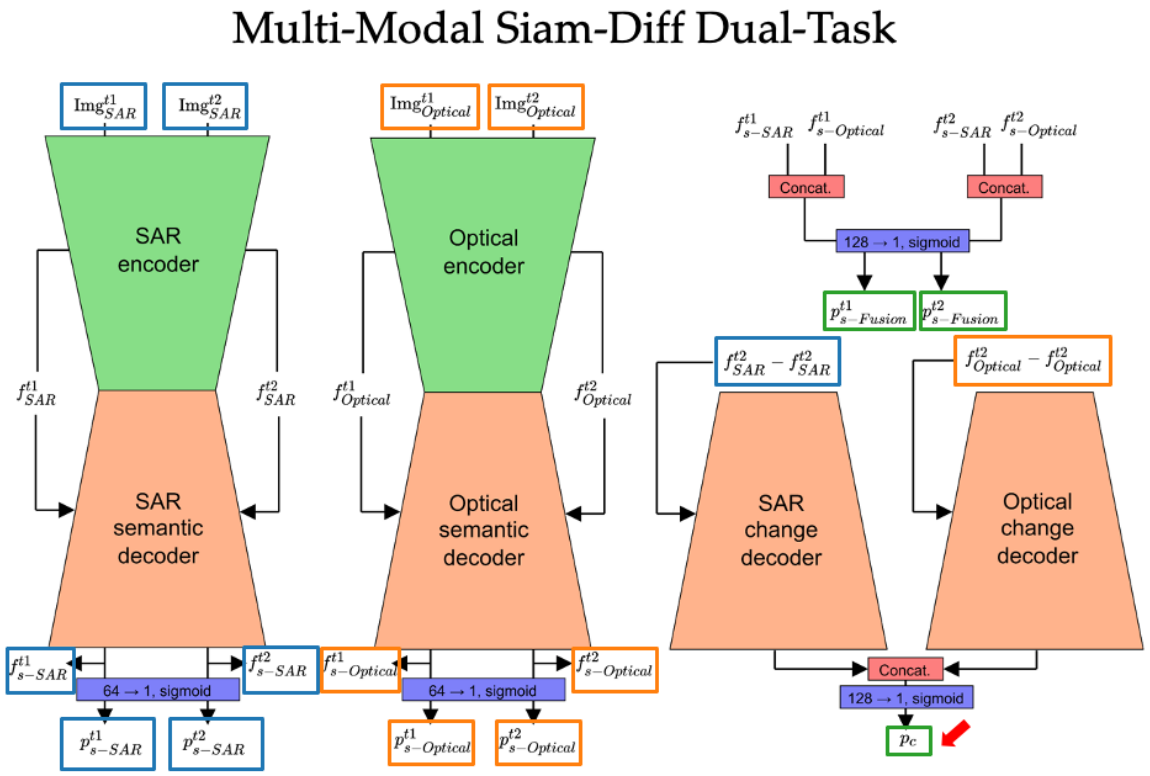
3 Inference using Colab





EO & AI for Urban Change Detection





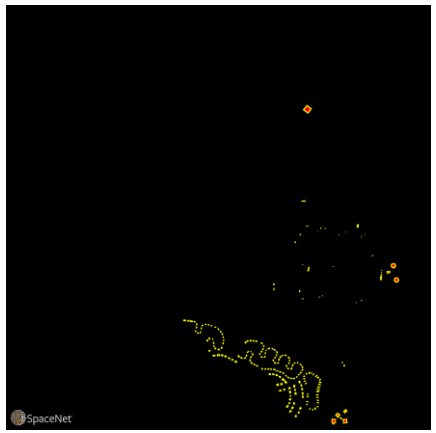
Hafner, S., A. Nascetti, H. Azizpour and Y. Ban. 2021. Sentinel-1 and Sentinel-2 Data Fusion for Urban Change Detection using a Dual Stream U-Net. *IEEE Geoscience and Remote Sensing Letters*, Vol. 19, 4019805.

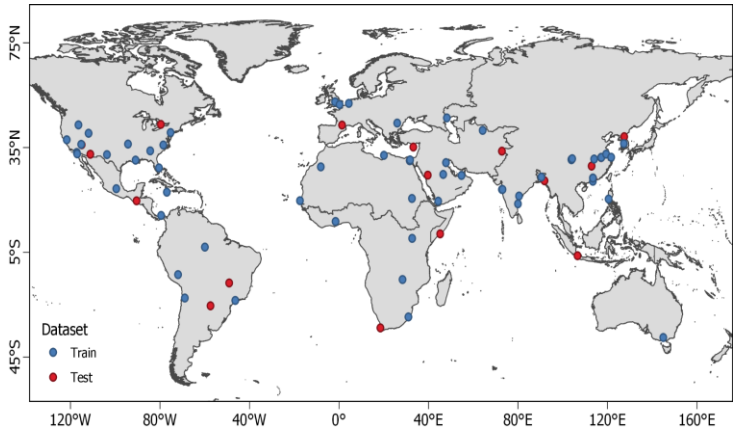
Hafner, S., Y. Ban and A. Nascetti. 2022. Urban Change Detection Using a Dual-task Siamese Network and Semi-supervised Learning. *IGARSS 2022*.

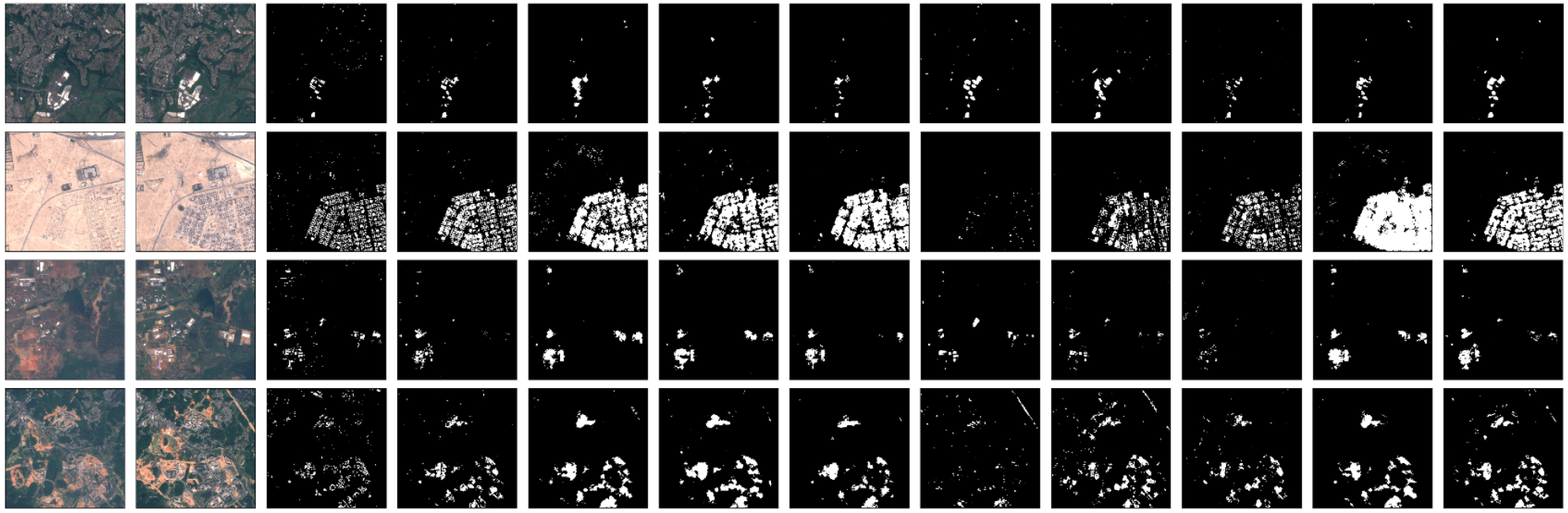
Hafner, S., Y. Ban and A. Nascetti, 2023. Multi-Modal Consistency Regularization Using Sentinel-1/2 Data for Urban Change Detection. *Remote Sensing*.

Urban Change Detection

- Time series of monthly Planet images
- Covering ~ 100 unique sites
- Approximately 24 images per site
- Over 10 million individual annotated building footprints

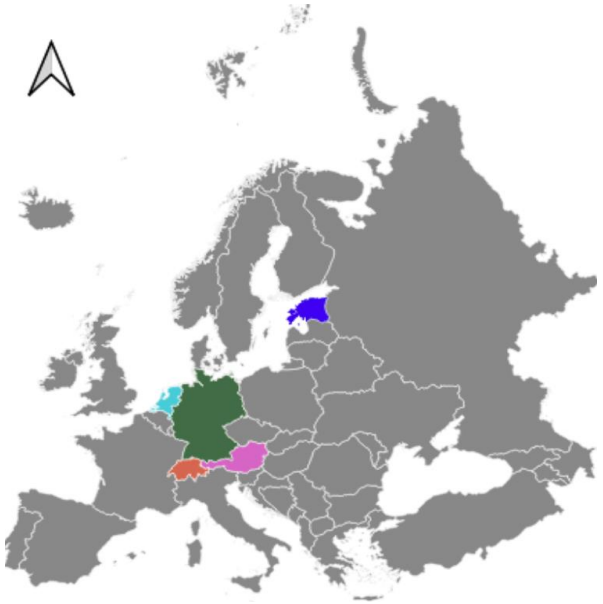




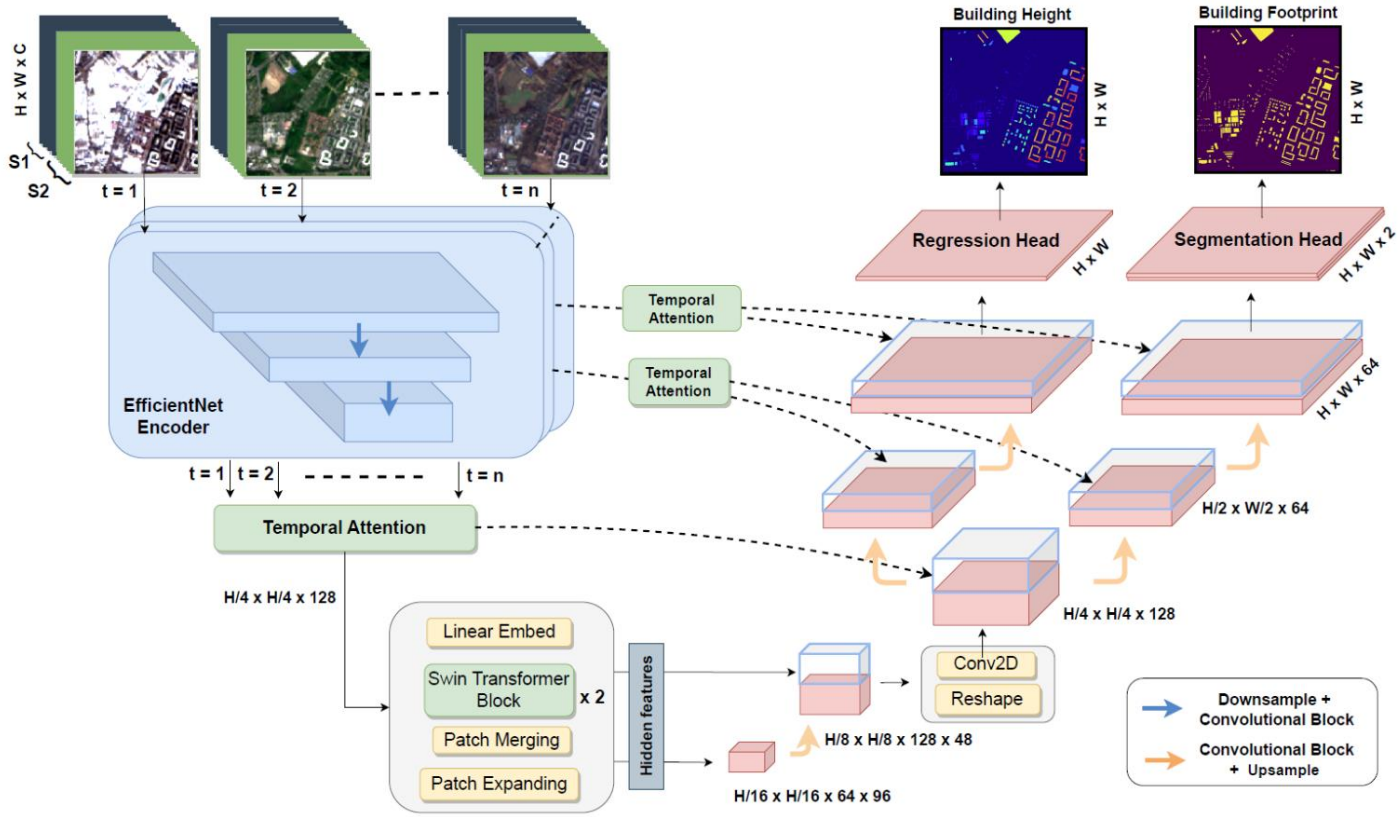


3D Urban Mapping with AI & Sentinel-1 SAR & Sentinel-2 MSI Time Series

Methodology



Input



Outputs

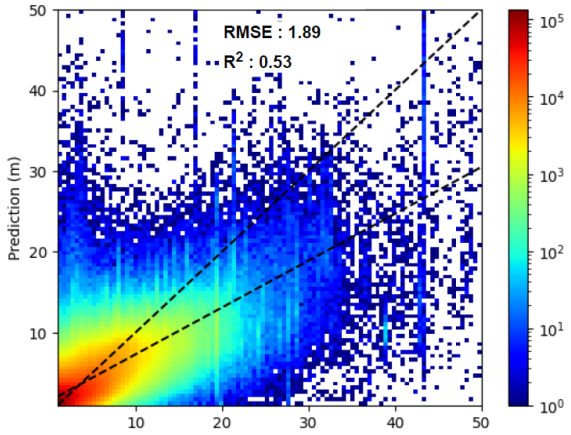
- 4 Country Data
- 12 month Sentinel-1 SAR & Sentinel-2 MSI Time Series

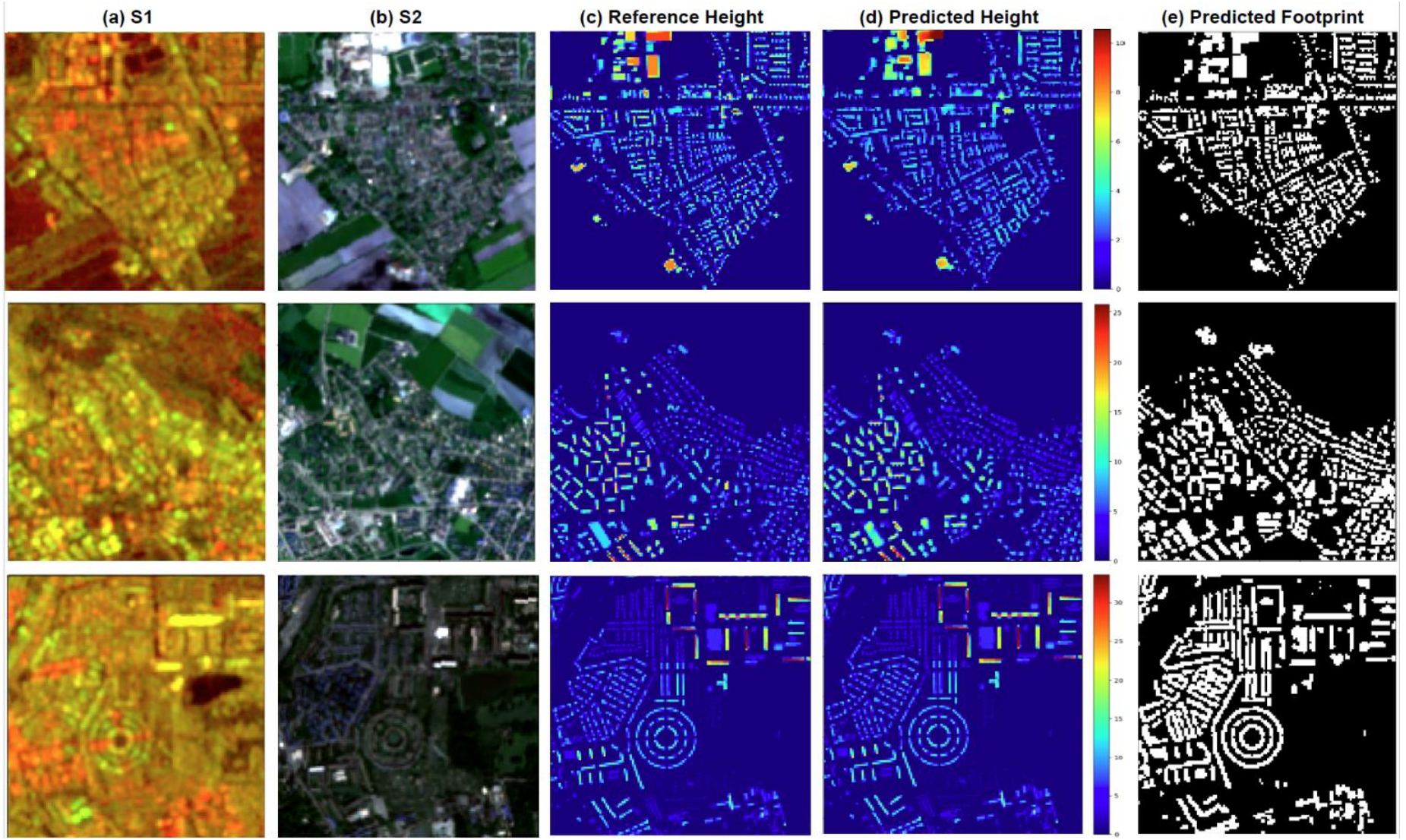
TA-SwinUNETR Network Architecture

Building Height Estimation at 10m Resolution

	RMSE (m)↓	R^2 ↑	IoU ↑
UNet	3.02	0.369	0.481
TransUnet	2.49	0.422	0.501
SwinUNETR	2.05	0.456	0.512
UTAE	2.04	0.489	0.510
T-SwinUNETR	**1.89**	**0.533**	**0.58**

	RMSE (m)↓	R^2 ↑	IoU ↑
w/o MTL	1.91	0.50	0.56
With MTL	**1.89**	**0.53**	**0.58**
S1	2.25	0.37	0.47
S2	1.94	0.47	0.56
S1+S2	**1.89**	**0.53**	**0.58**

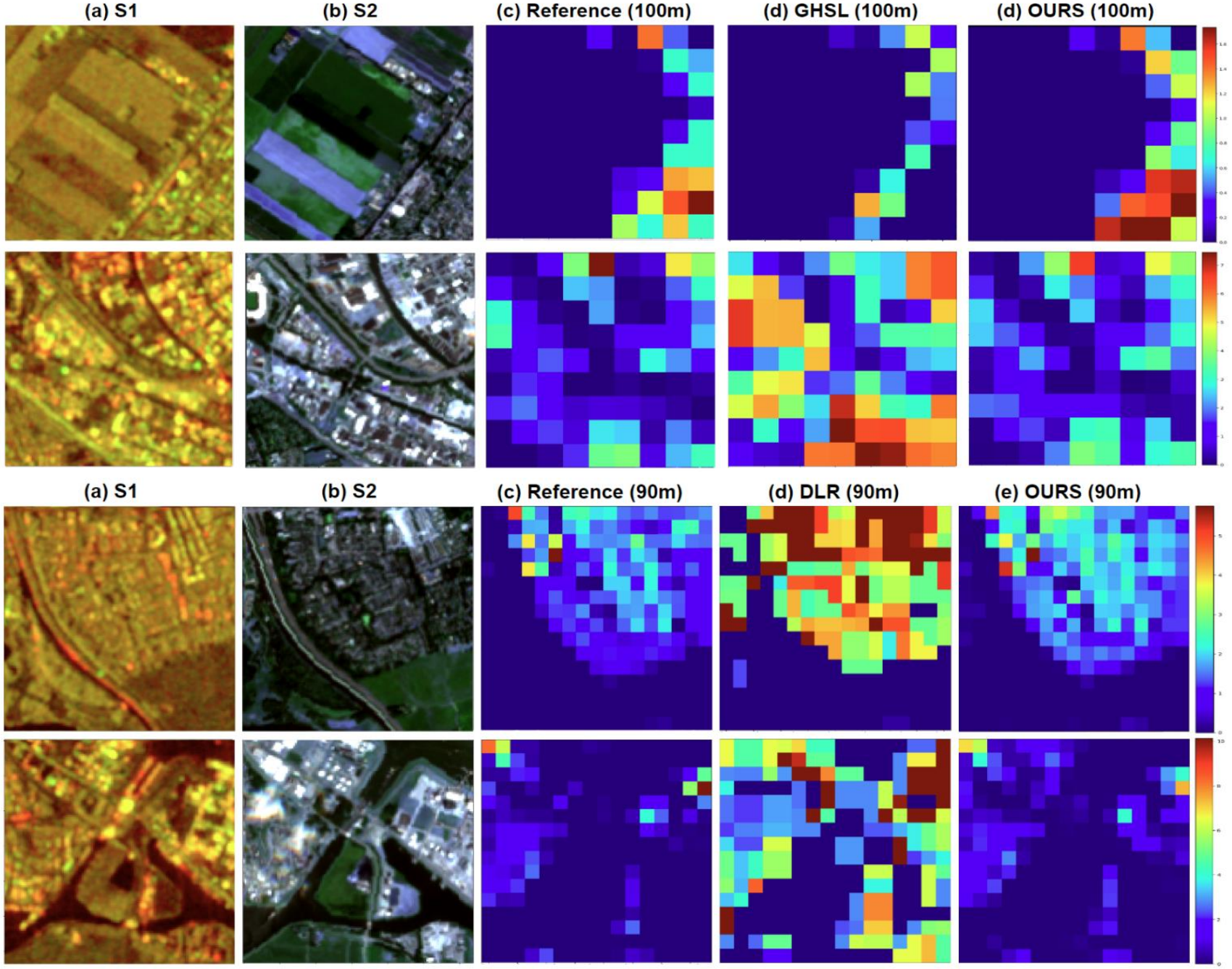




Comparison with GHSL-Built-H product at 100 m

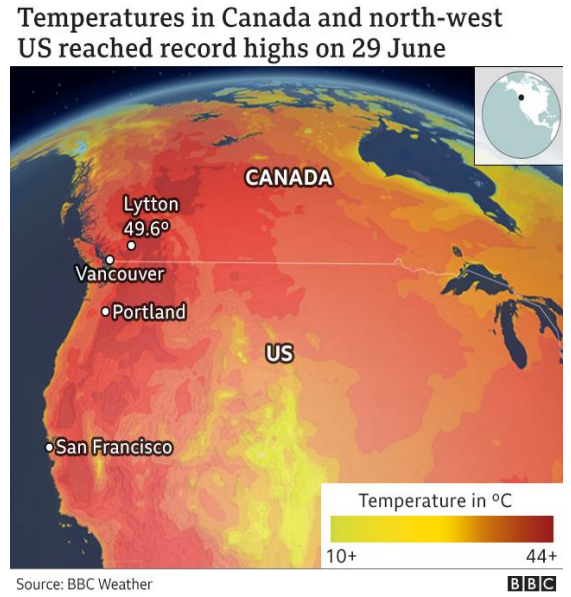
	RMSE (m)↓	R^2 ↑	IoU ↑
T-SwinUNETR (100m)	0.26	0.810	0.691
GHS-Built-H (100m)	0.47	0.269	0.483
T-SwinUNETR (90m)	0.37	0.789	0.681
DLR-WSF3D (90m)	3.03	-11.265	0.345

Comparison with DLR-WSF3D product at 90 m

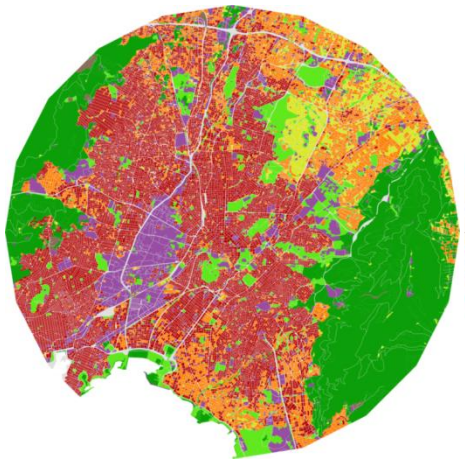


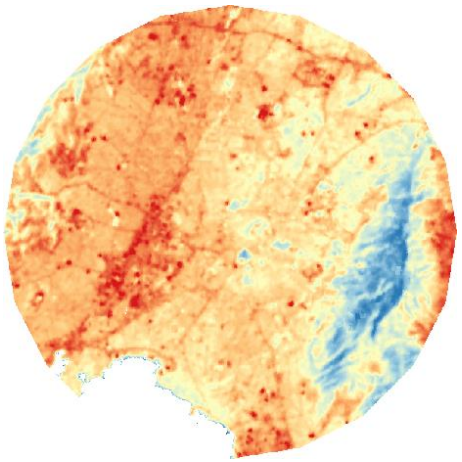
EO for Mapping Urban Heat Island

- Heatwave in recent years almost impossible without human-induced climate change.
- EO-based analysis can support improved urban thermal environment with nature-based solutions.

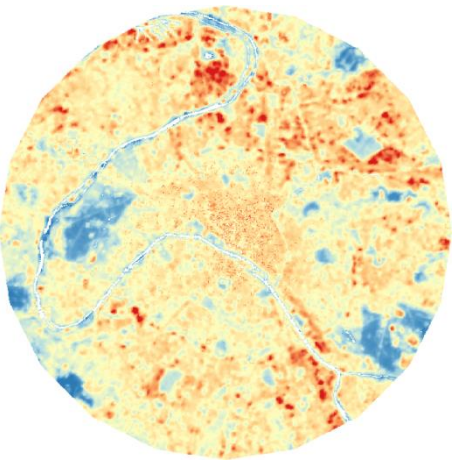


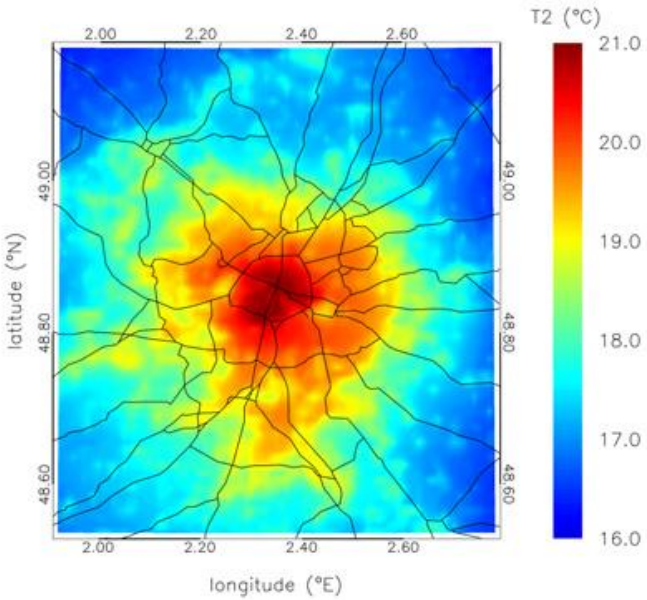
Athens





Paris



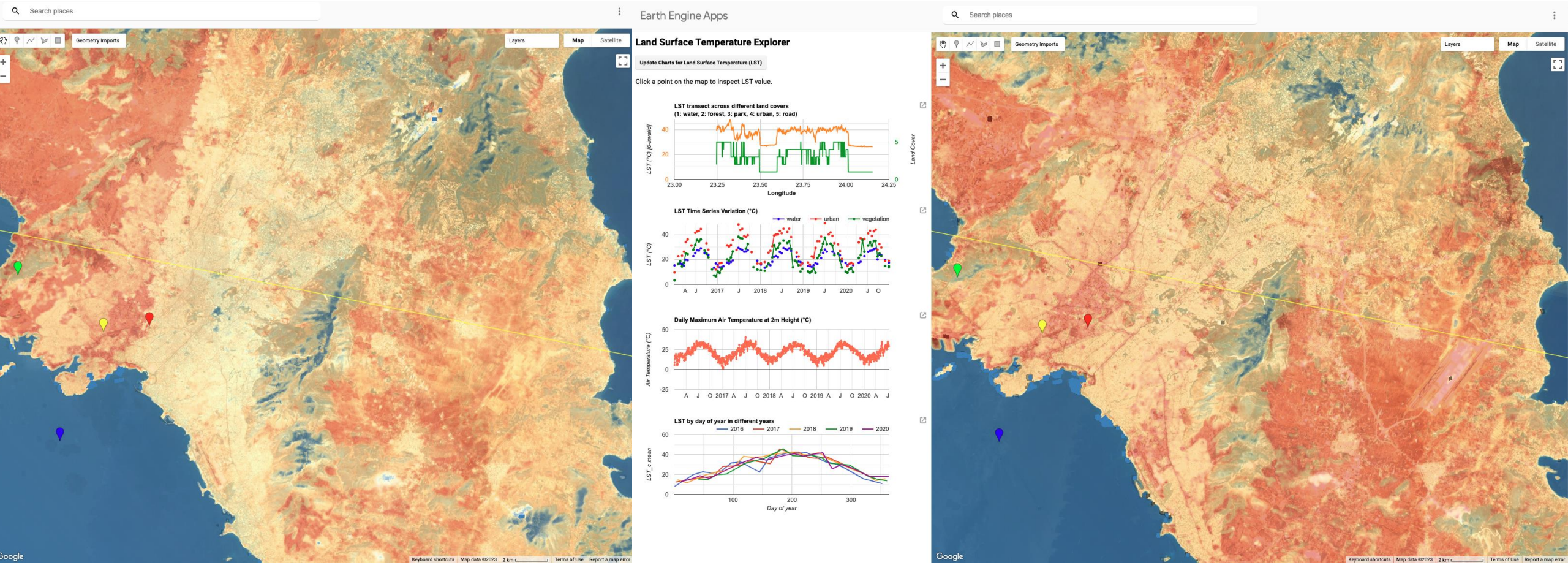


Source: EO4SmartCities

Urban Risk Analysis

Athens Land Surface Temperature: 1990

Athens Land Surface Temperature: 2020

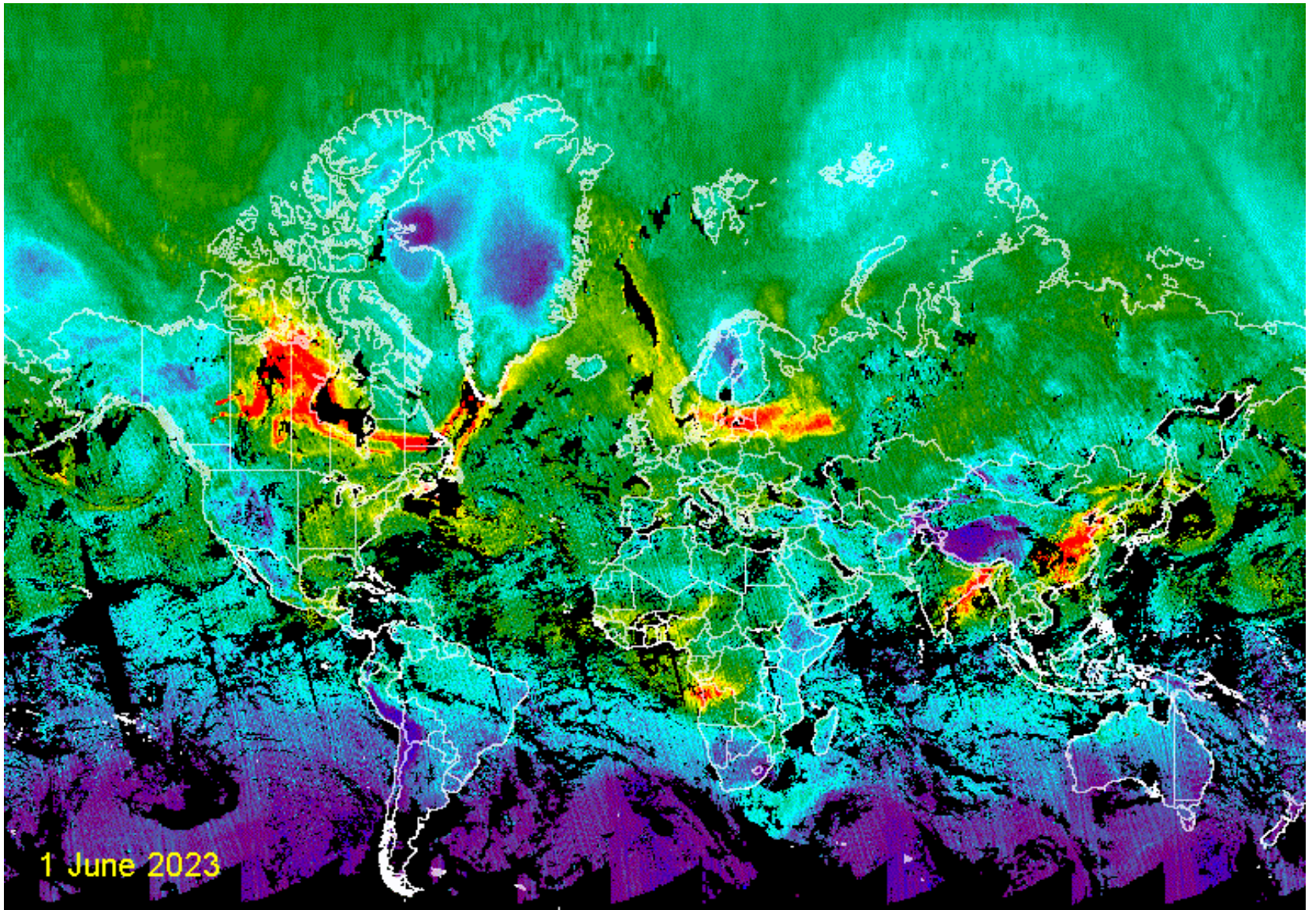


https://omegazhangpzh.users.earthengine.app/view/uhi-athens

Urban Risk Analysis

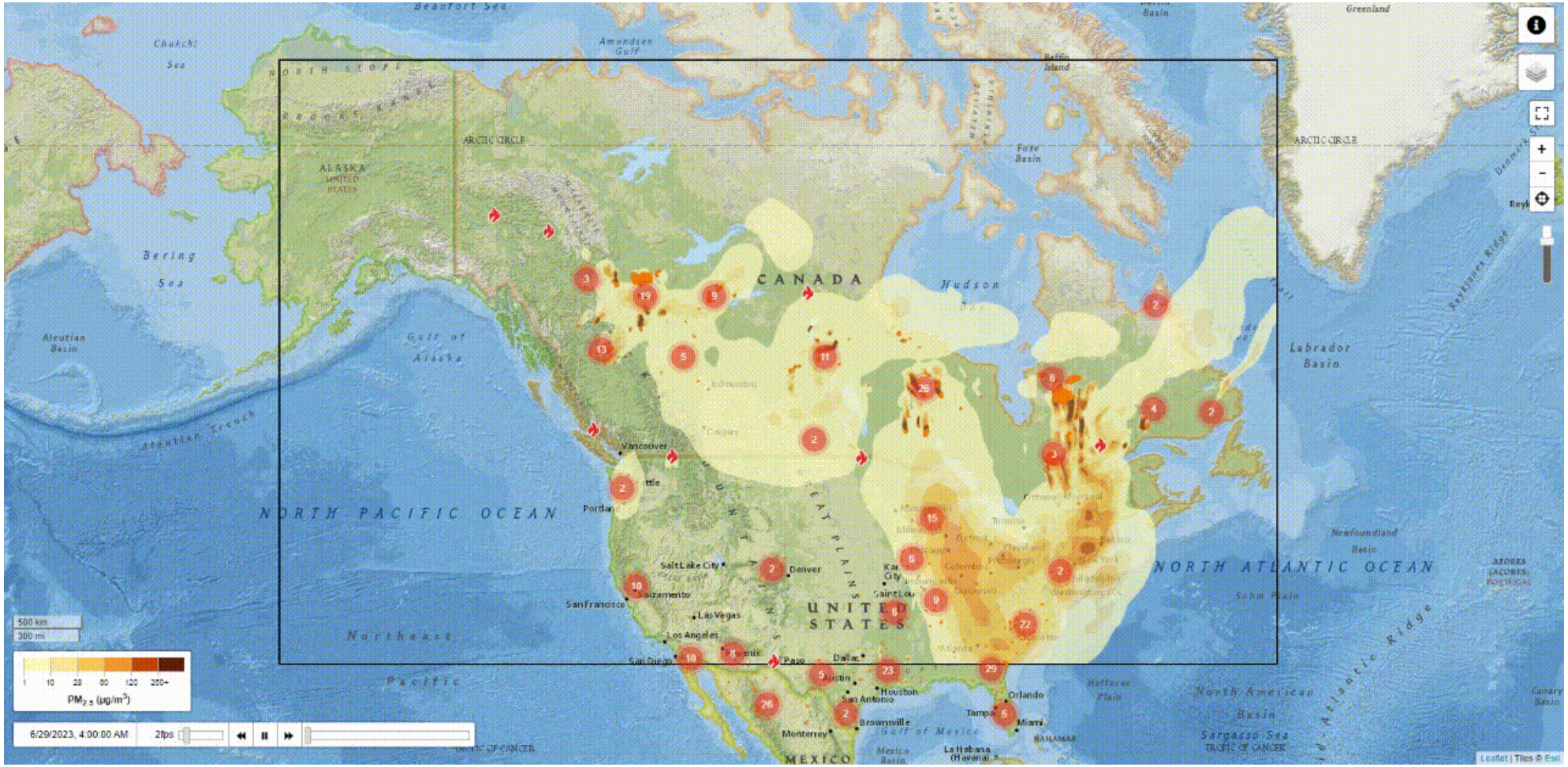
Nearly One-Third of U.S. Population Under Heavy Smoke Conditions Due to Wildfires

Direct Relief is preparing N95 masks for shipment to communities impacted by thick smoke and particulates in the air from wildfires in Canada.



Urban Risk Analysis

Wildfire Smoke Forecast

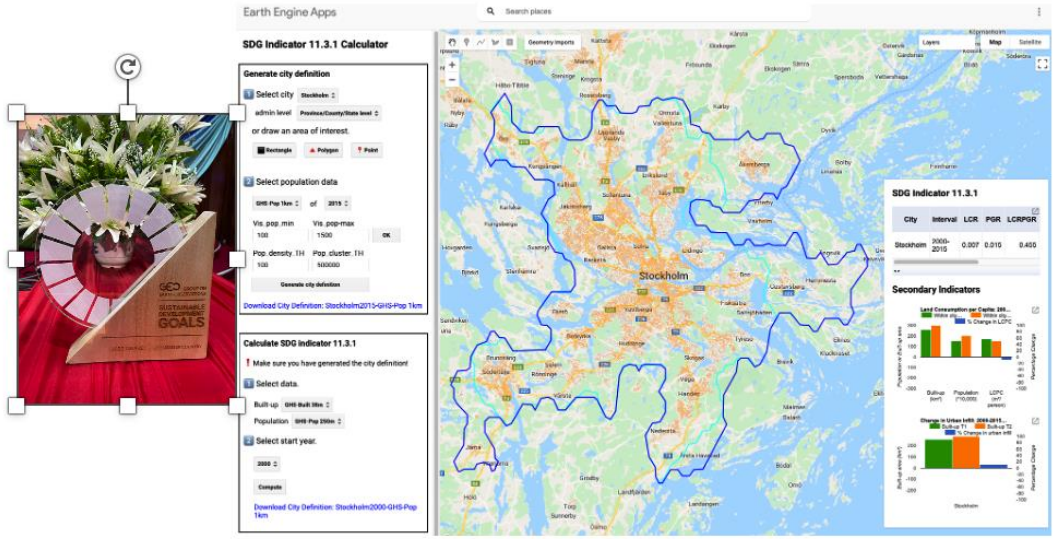


Project funded in the Horizon 2020 Programme under Grant Agreement 101003517

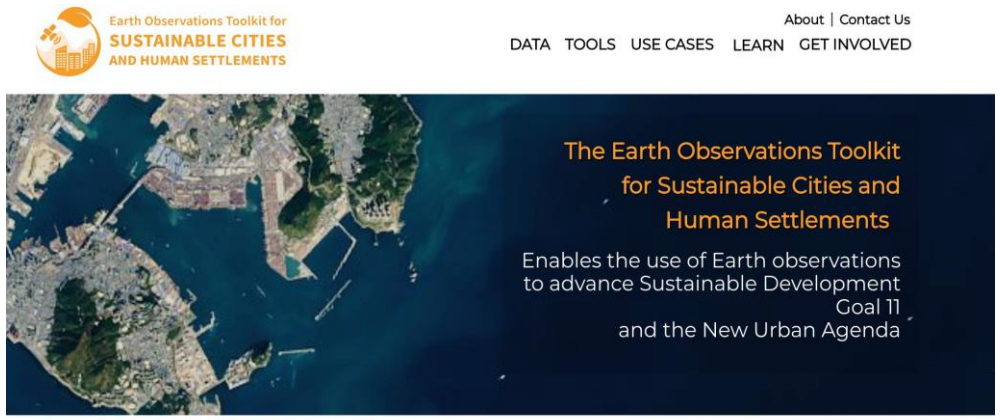
GEO-UN Habitat EO4SDG11 Toolkit

EO-based Monitoring:

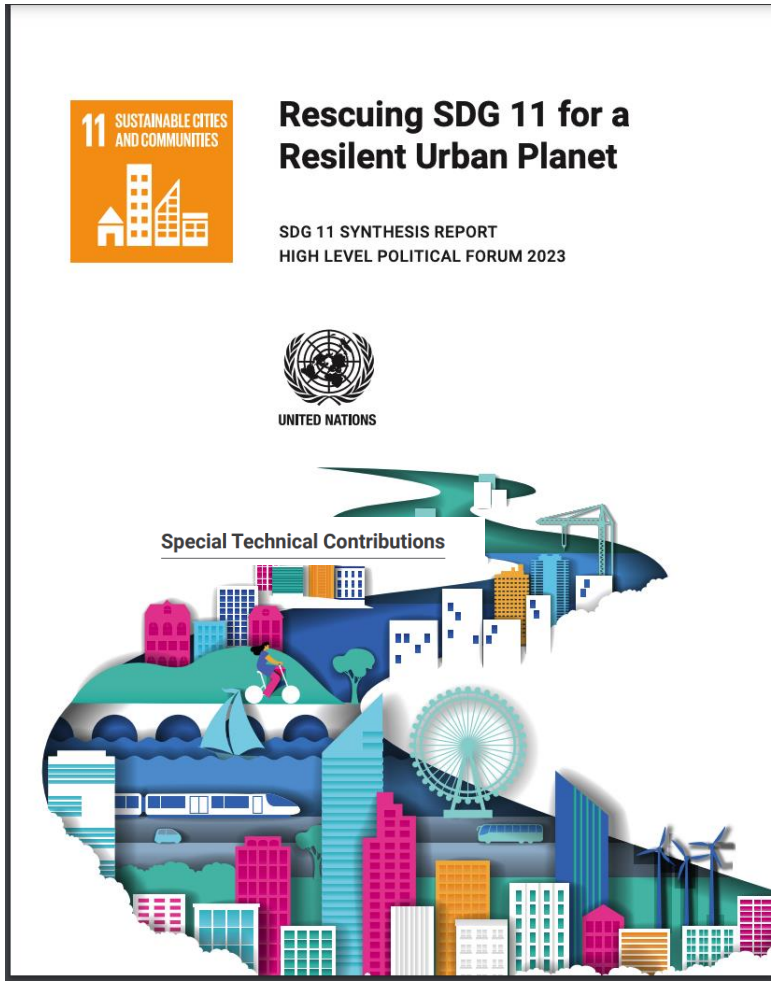
SDG Indicator 11.3.1 Land Use Efficiency



https://eo4sdg11.users.earthengine.app/view/sdg-1131-indicator



Visit: eotoolkit.unhabitat.org



Special Technical Contributions

KTH Royal Institute of Technology and Digital Futures: Yifang Ban

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The City Talks – HARMONIA solutions & potential synergies in urban domain among GEO Community

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#TheEarthTalks

GEO WEEK & Ministerial Summit 2023

The City Talks – HARMONIA solutions & potential synergies in urban domain among GEO Community

HARMONIA IRAP

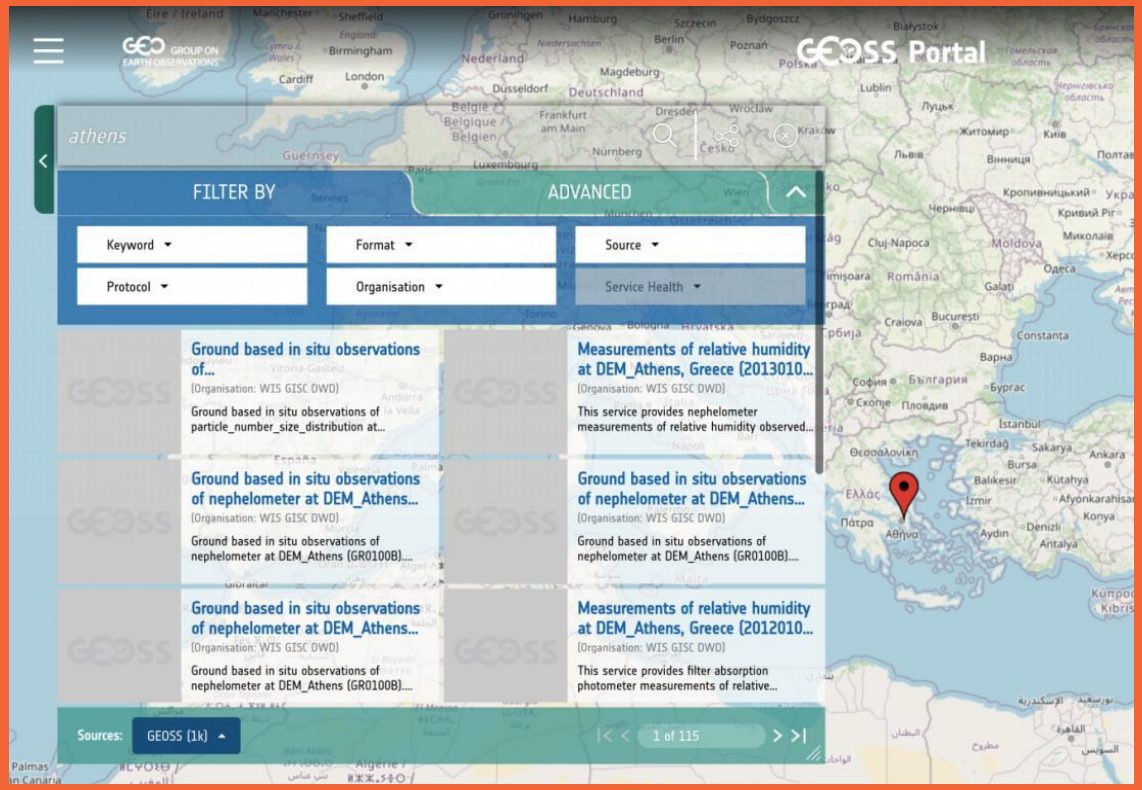
Ioannis Kavouras

06/11/2023 17:05-17:15

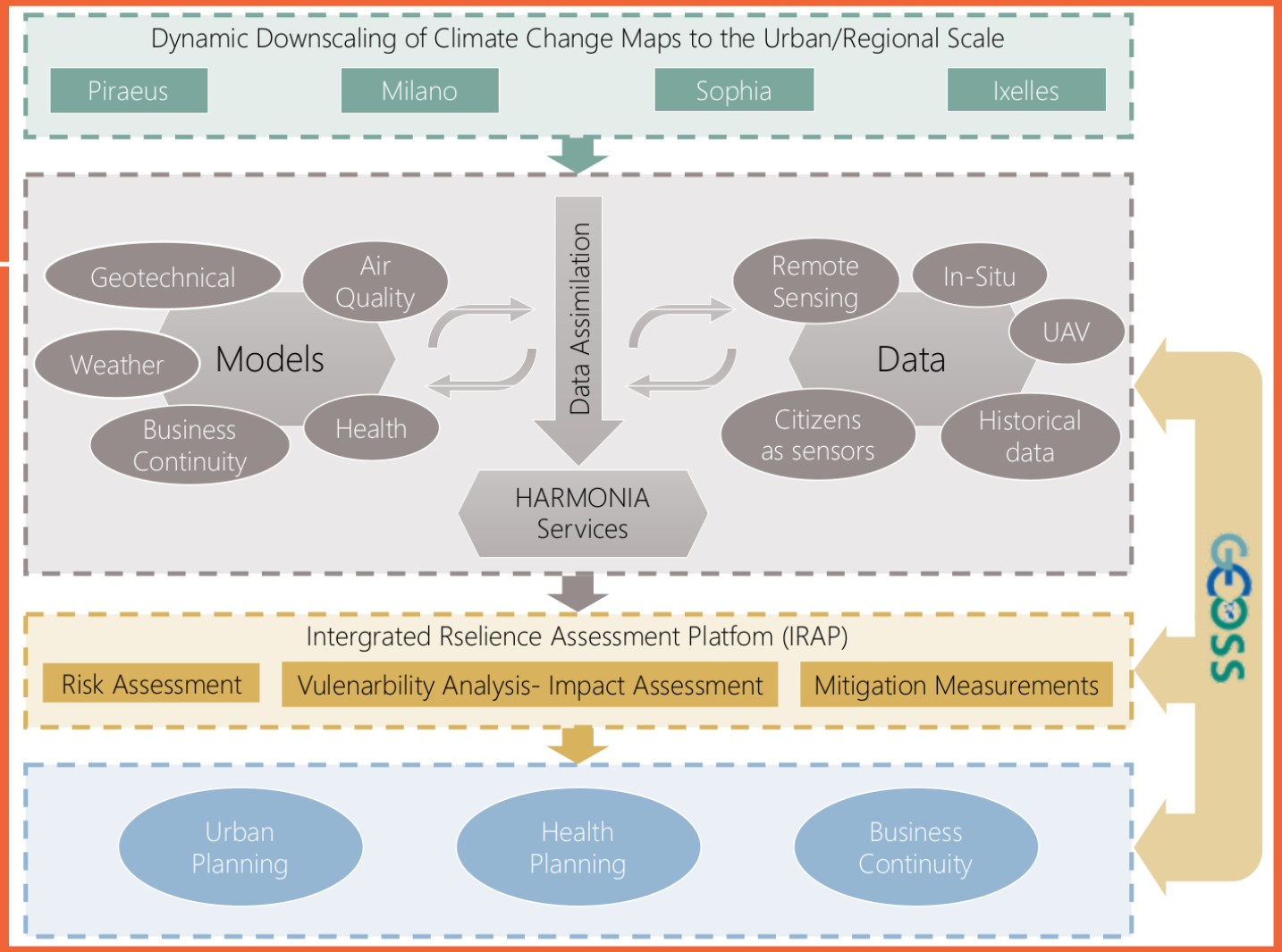
The HARMONIA Integration

HARMONIA integrates GEOSS climate applications (i.e., APIs, datasets) to support the adaptation and mitigation measures of the Paris Agreement for urban environment. Moreover, HARMONIA exploits AI tools on top of GEOSS and offers innovative solutions for:

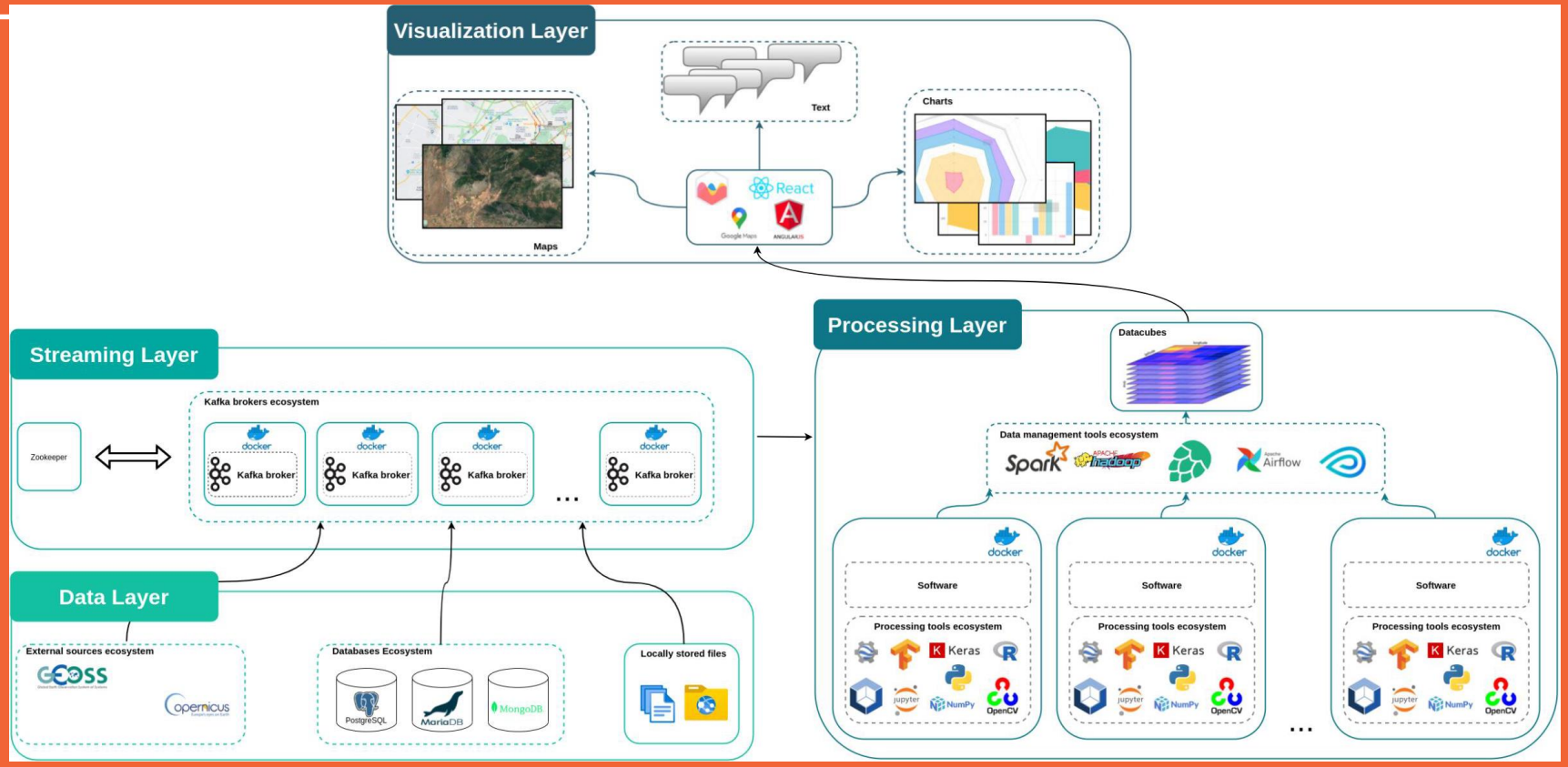
- **risk management,**
- **damage prevention,**
- **protection from eco-hazards**
- **preparedness for potential future calamities.**



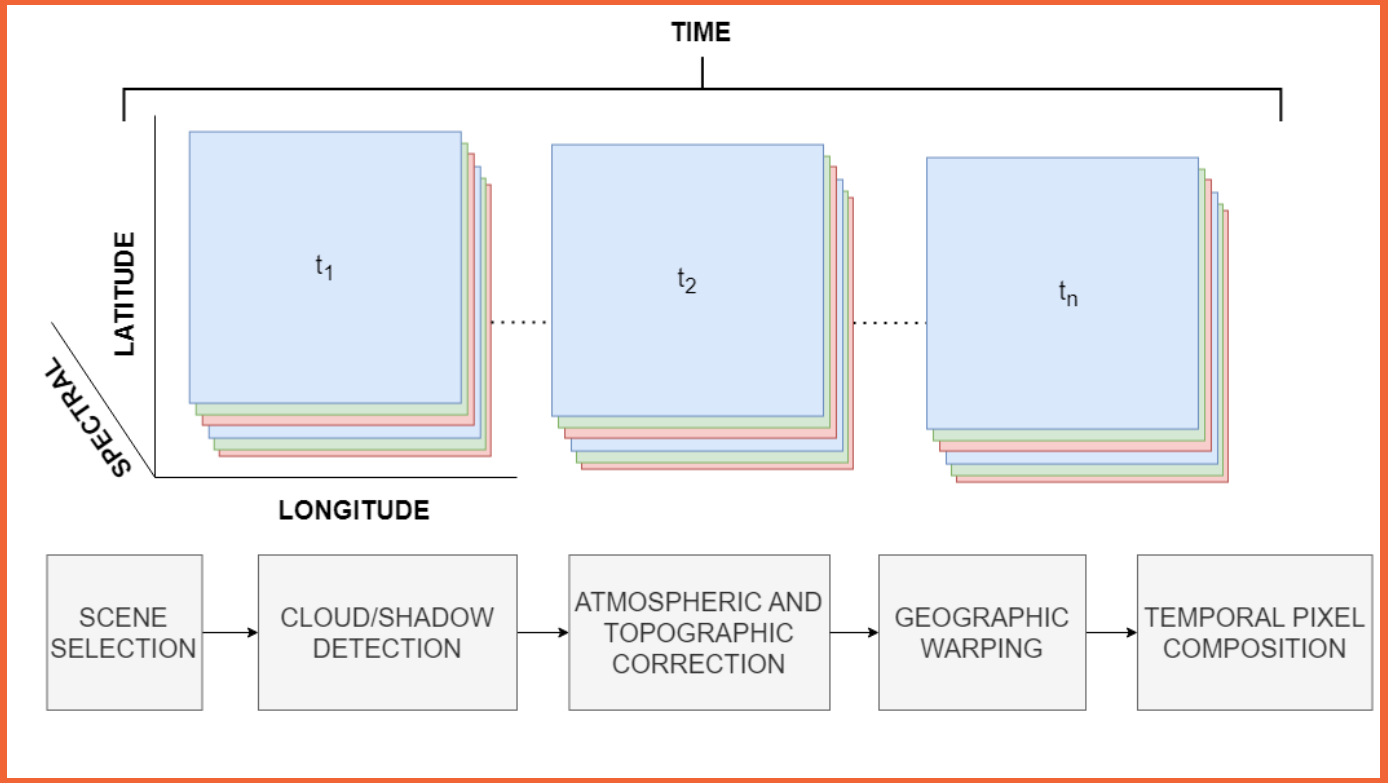
The HARMONIA concept

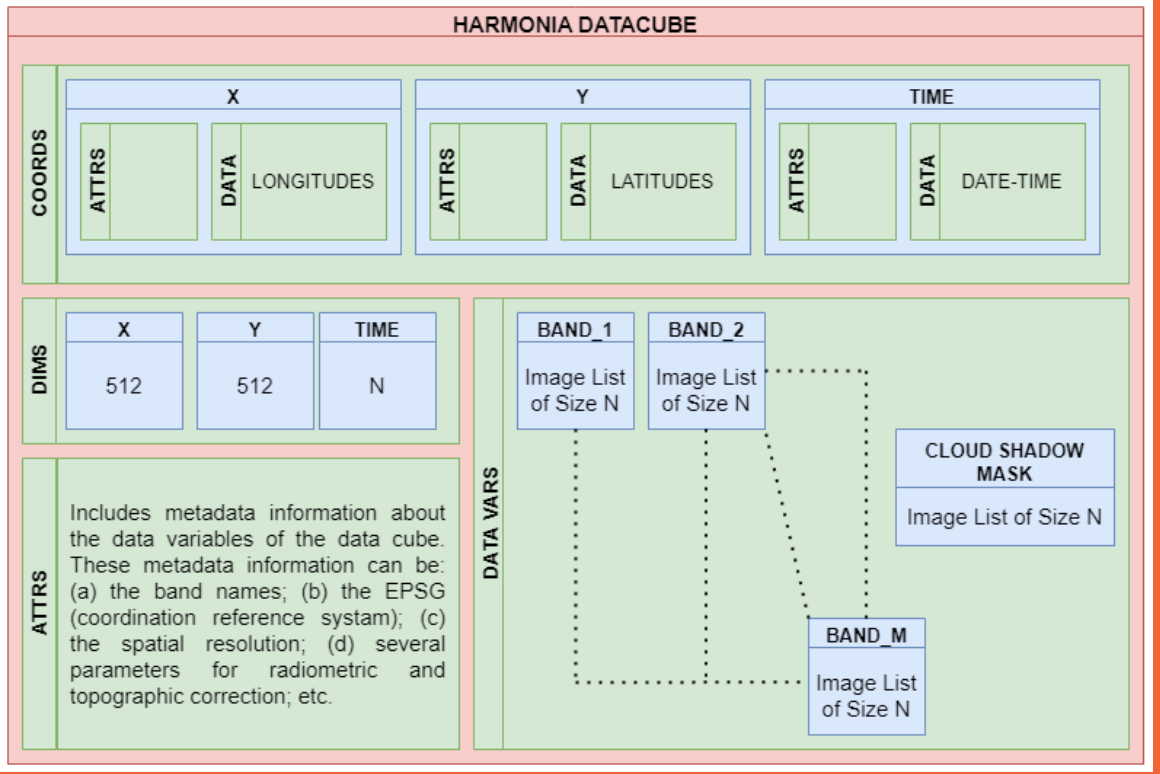


The IRAP Platform

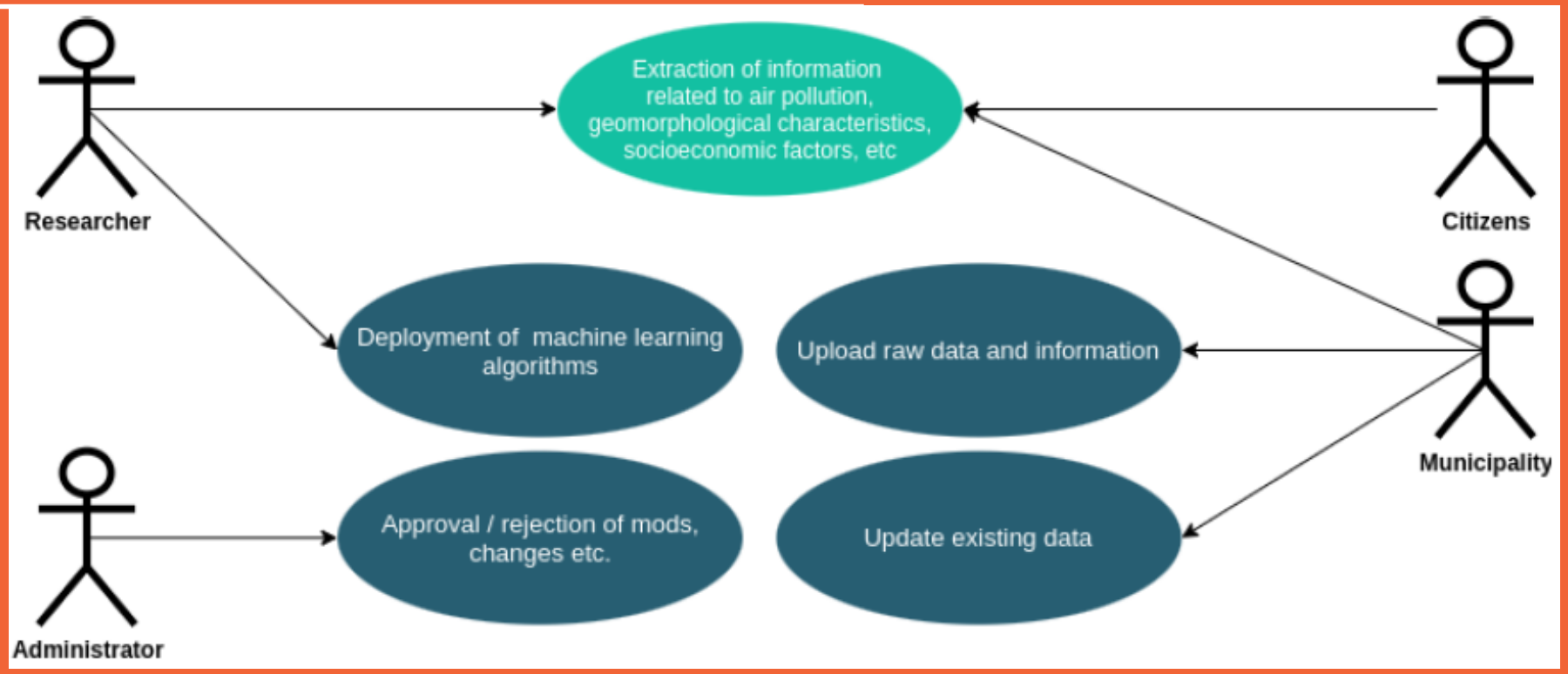


The IRAP Platform – Data Cube Implementation

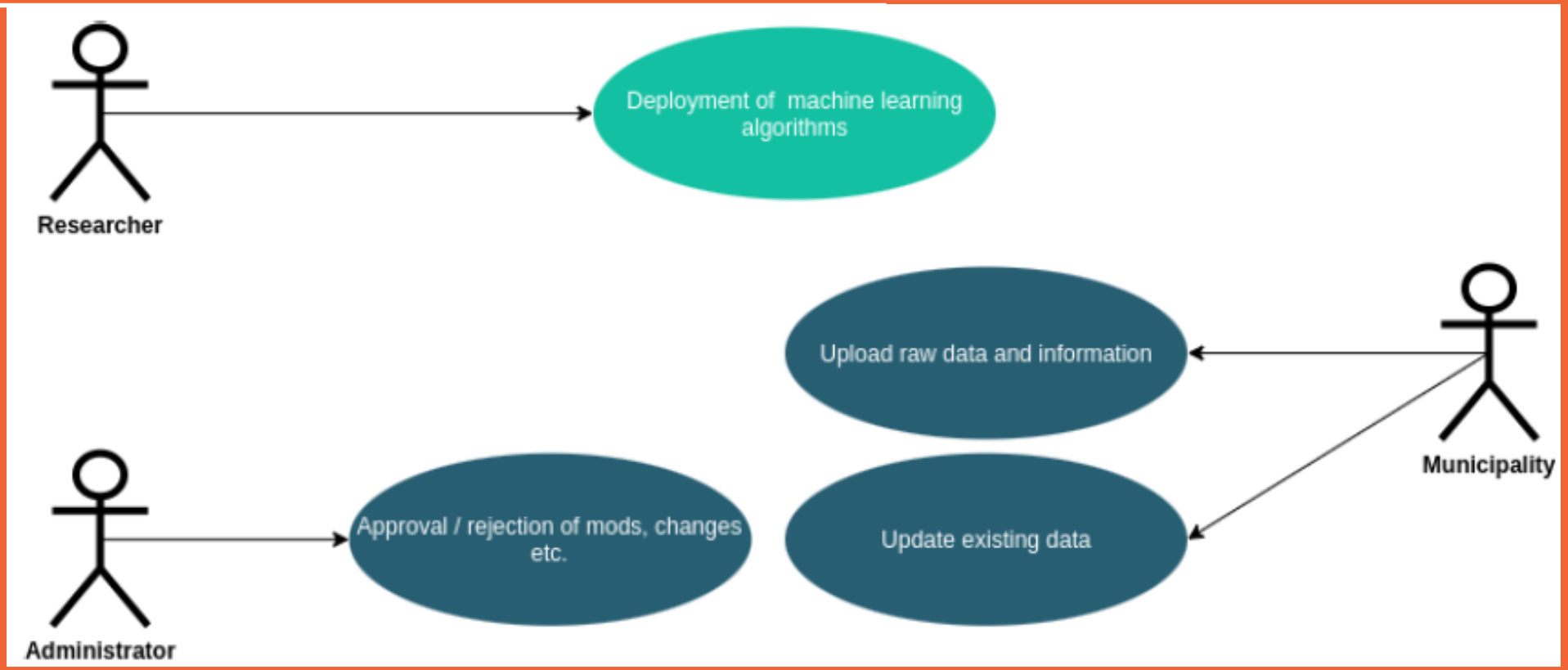




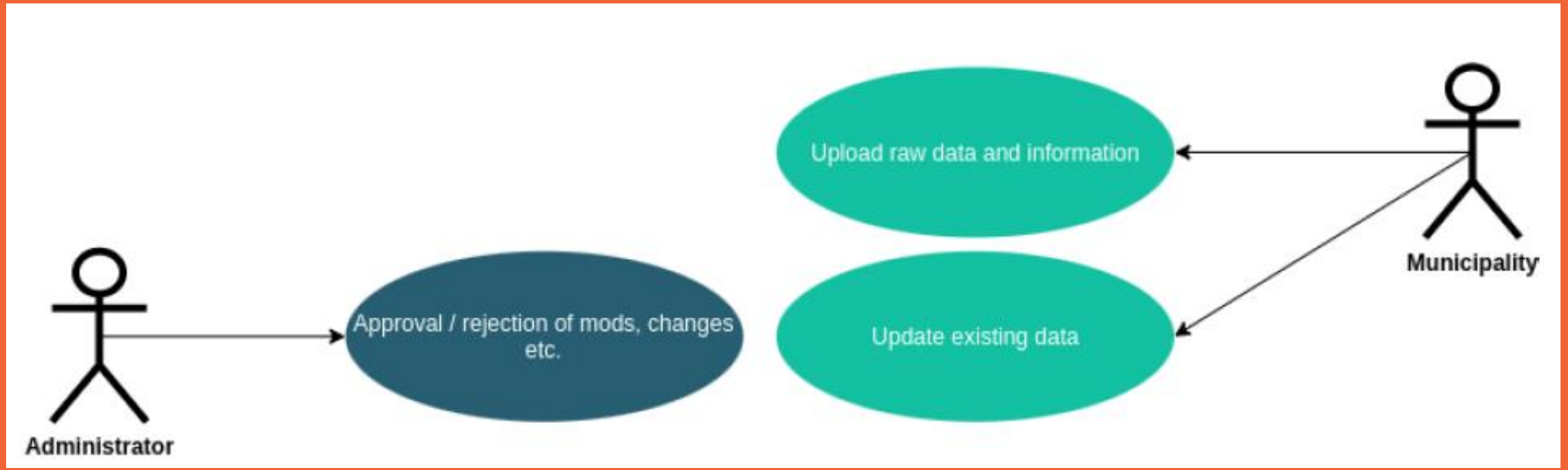
Use Case 1: Extraction of information



Use Case 2: Deployment of Machine Learning Algorithms



Use Case 3: Uploading/Updating data and information



IRAP demo

HARMONIA

Development of a Support System for Improved Resilience and Sustainable Urban areas to cope with Climate Change and Extreme Events based on GEOSS and Advanced Modelling Tools

LC-CLA-19-2020: Integrated GEOSS climate applications to support adaptation and mitigation measures of the Paris Agreement

The IRAP platform

Project funded in the Horizon 2020 Programme under Grant Agreement 101003517

Partners and Affiliations

The HARMONIA project has received funding from the EU Horizon 2020 research and innovation programme under agreement No. 101003517.

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GEO WEEK & Ministerial Summit 2023

HARMONIA DSS presentation

The added value of HARMONIA DSSs to efficient urban policies towards urban sustainability and resilience

Monday, November 6 at 17:15-17:30

Betty Charalampopoulou

CEO/President at Geosystems Hellas SA

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HARMONIA

GROUP ON EARTH OBSERVATIONS

HARMONIA Resilience DSSs

HARMONIA develops three advanced Decision Support Systems tailored to the needs of today's cities for urban resilience and sustainability.

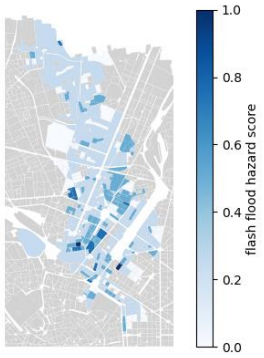
1 Multi-hazard mitigation & adaptation measures DSS

2 Urban Planning DSS

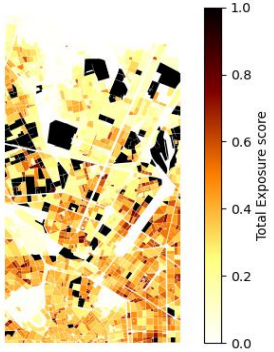
3 Urban health & well-being DSS

HARMONIA DSSs

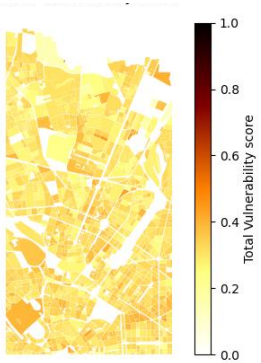
Hazard Score



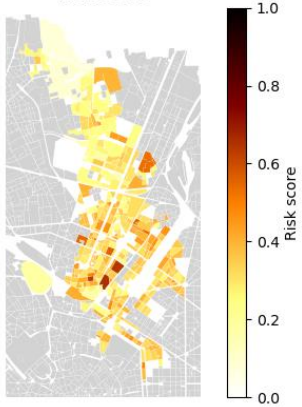
Total Exposure Score



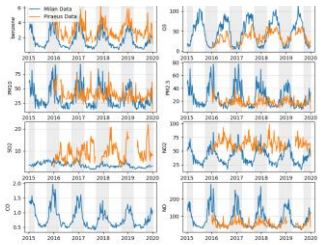
Total Vulnerability Score



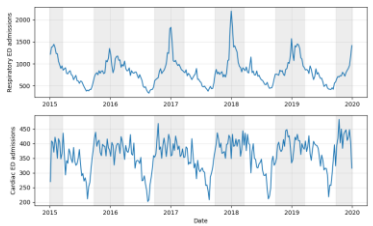
Risk Score



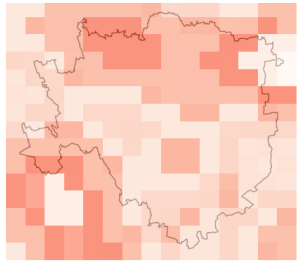
Air Quality Data



Health Data



Health Hazard Map



Multi-hazard mitigation & adaptation measures DSS

ResilienceGuard
Business Continuity | Crisis Management

Urban health & well-being DSS

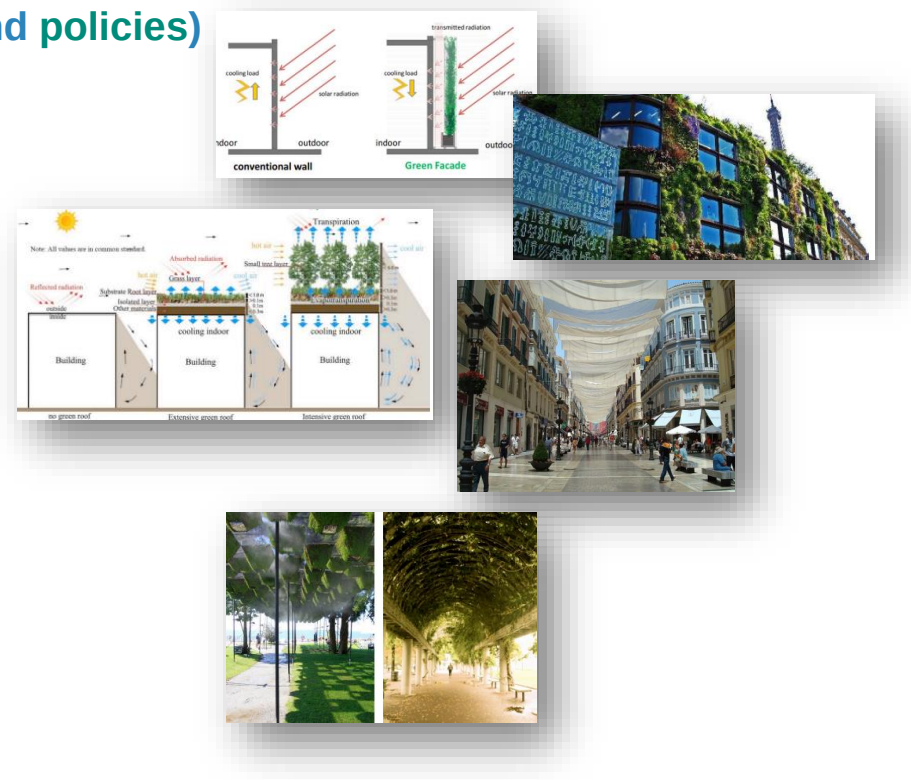
HUMANITAS
RESEARCH HOSPITAL

The Urban Planning DSS

A wide variety of tangible urban planning recommendations (interventions and policies) has been collected and categorised into different urban planning solution

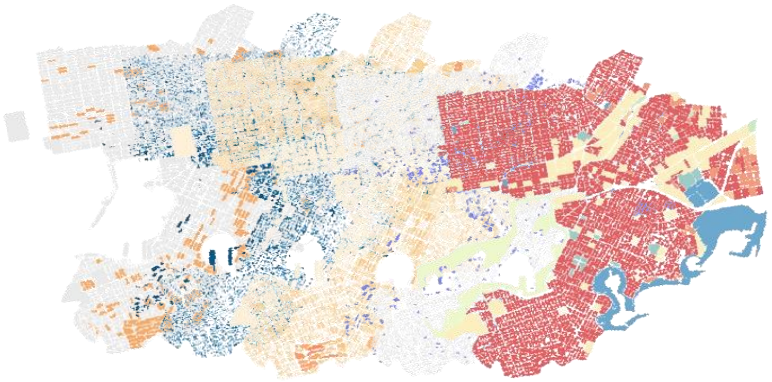
Each recommendation is analysed based on 6 indicators as well as the requirements of its implementation:

1. Peril (UHI, air quality, etc.)
2. Pilot Cities (Piraeus, Milan, etc.)
3. Scale (BB, neighbourhood, global)
4. Cost (score 1-5)
5. Performance (score 1-5)
6. Co-Benefits (biodiversity, well-being, etc.)

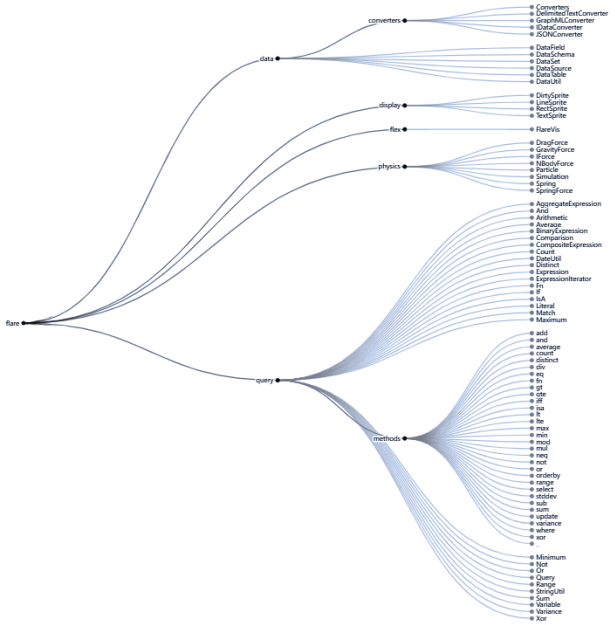


The Urban Planning DSS

A rich dataset of urban context data has been acquired and harmonized for each Pilot City providing the current state of the urban environment

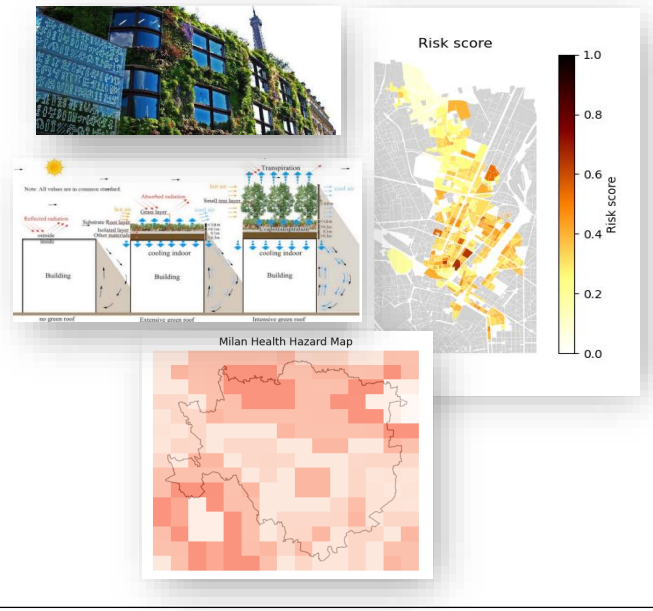


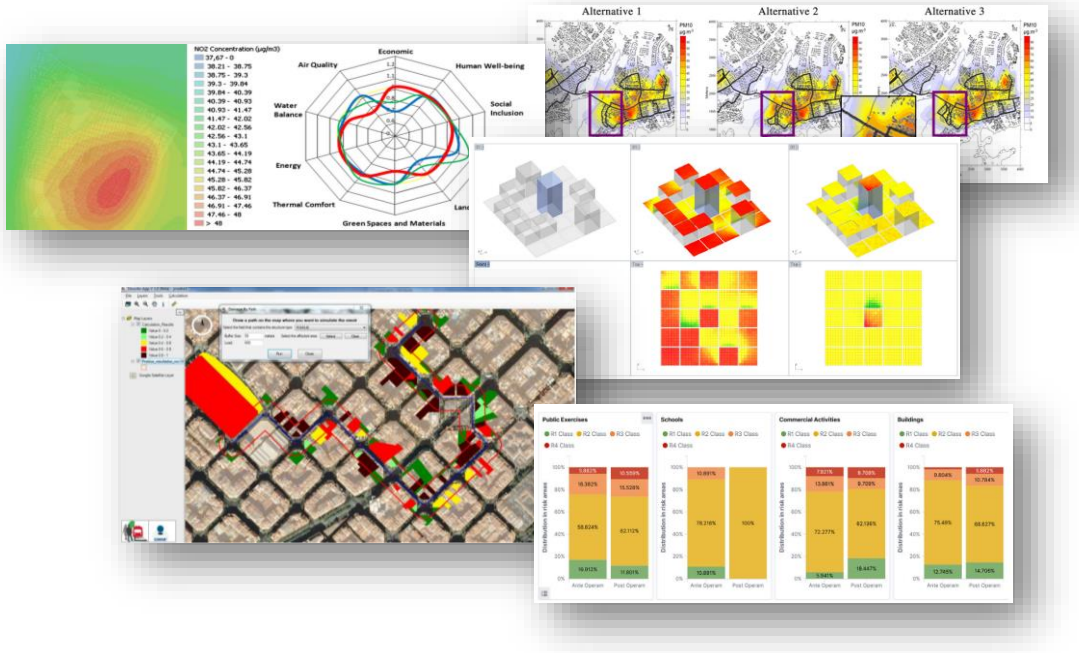
A Rule-based Algorithm is developed to point out the urban planning solutions that befit each study area, based on the analysed indicators.



All-in-one DSS solution

The Urban Planning DSS utilizes the hazard and risk outcomes of the other 2 collaborative DSSs as well as the acquired geo-information to focus on the urban critical areas and provide efficient urban planning recommendations and reports.



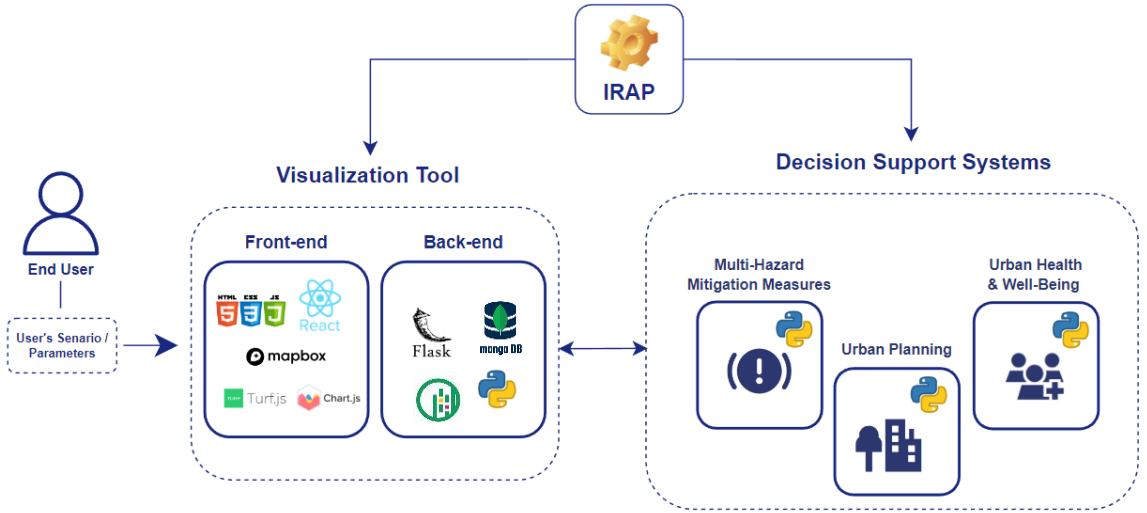


A wide variety of advanced visualization methods and tools has been explored to find the most efficient and user-friendly approach to visualise the final outputs aiming for a better understanding and an enhanced user experience.

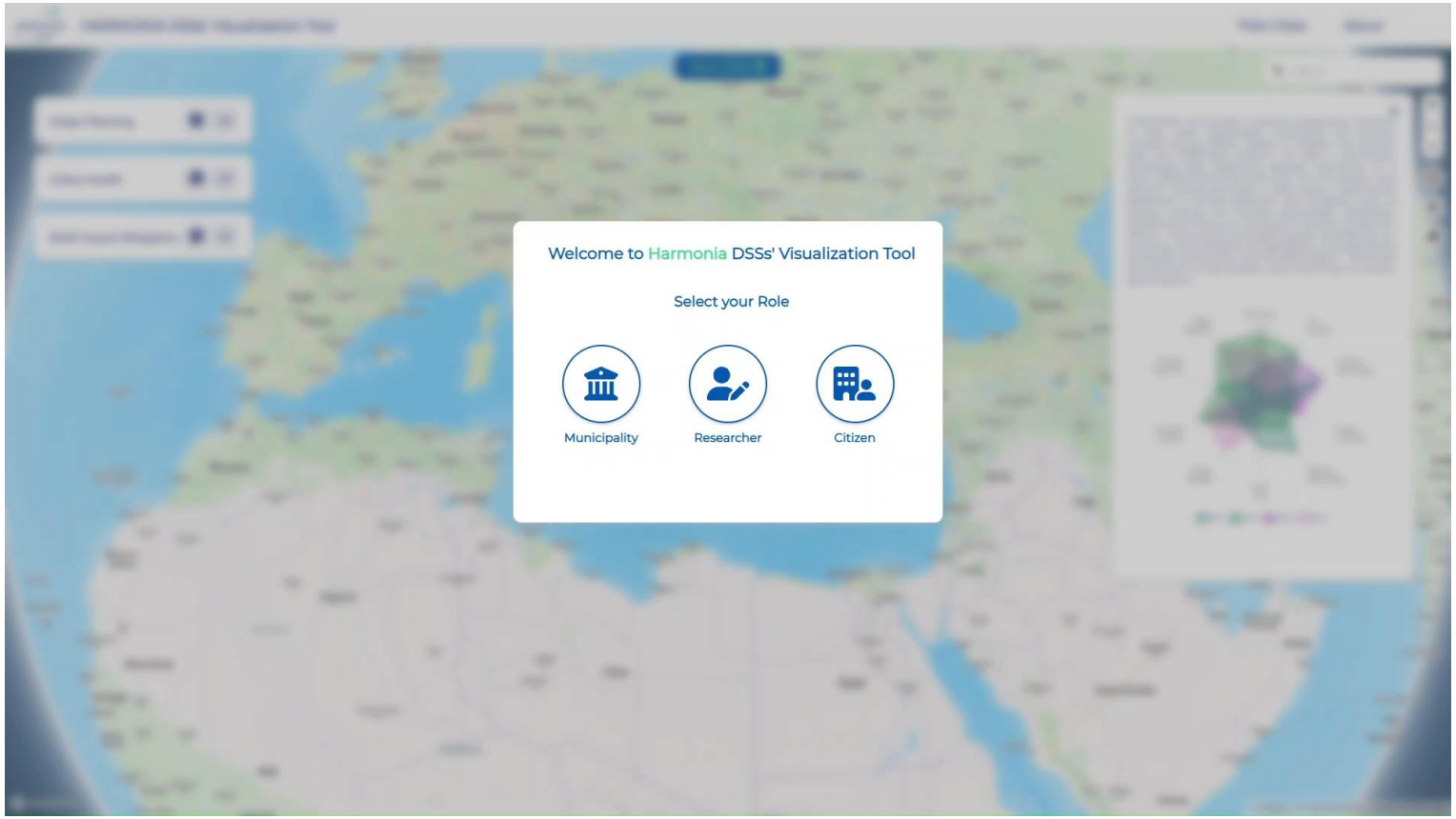
DSSs' Online Visualization Tool

The DSSs visualization tool is a web-based user interface with an end-to-end connection to the IRAP and capable of:

1. User-friendly dynamic content interface
2. DSSs - end-user interaction and parameterization
3. Scenarios builder, spatial and graphical comparison tools
4. Geospatial data handling
5. 3D spatial layers' symbology & visualization



DSSs' Online Visualization Tool



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