ERATOSTHENES: Excellence Research Centre for Earth Surveillance & Space-Based Monitoring of the Environment

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EYWA

EO based Early Warning System for Mosquito Borne Diseases An operational application in EU

Haris Kontoes

NATIONAL OBSERVATORY OF ATHENS

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This project has received funding from the Government of the Republic of Cyprus through the Directorate General for the European Programmes, Coordination and Development.

CONSORTIUM

Cyprus University of Technology · DLR · TROPOS Leibniz Institute for Tropospheric Research · DEC

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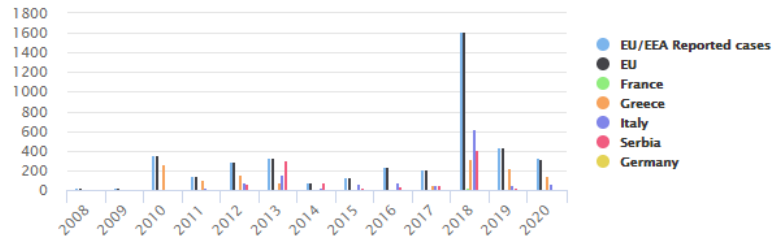
Mosquito-Borne Diseases in Europe

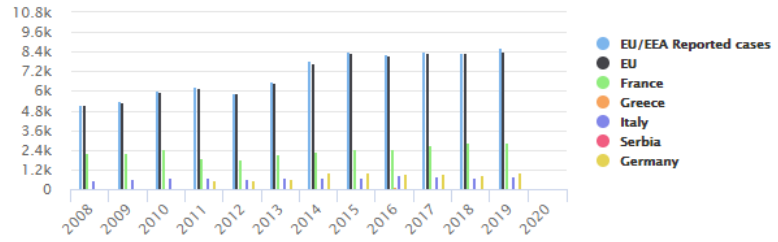
An emerging threat

West Nile Virus:**4226**
Malaria:**85246**
Dengue, Zika and Chikungunya:**30249**
Source: ECDC, EU/EEA Reported cases 2008-2020

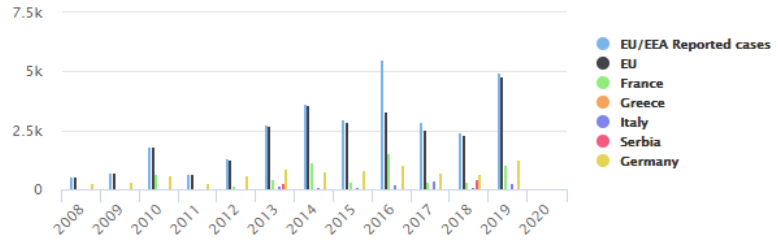
West Nile Virus reported cases (ECDC)



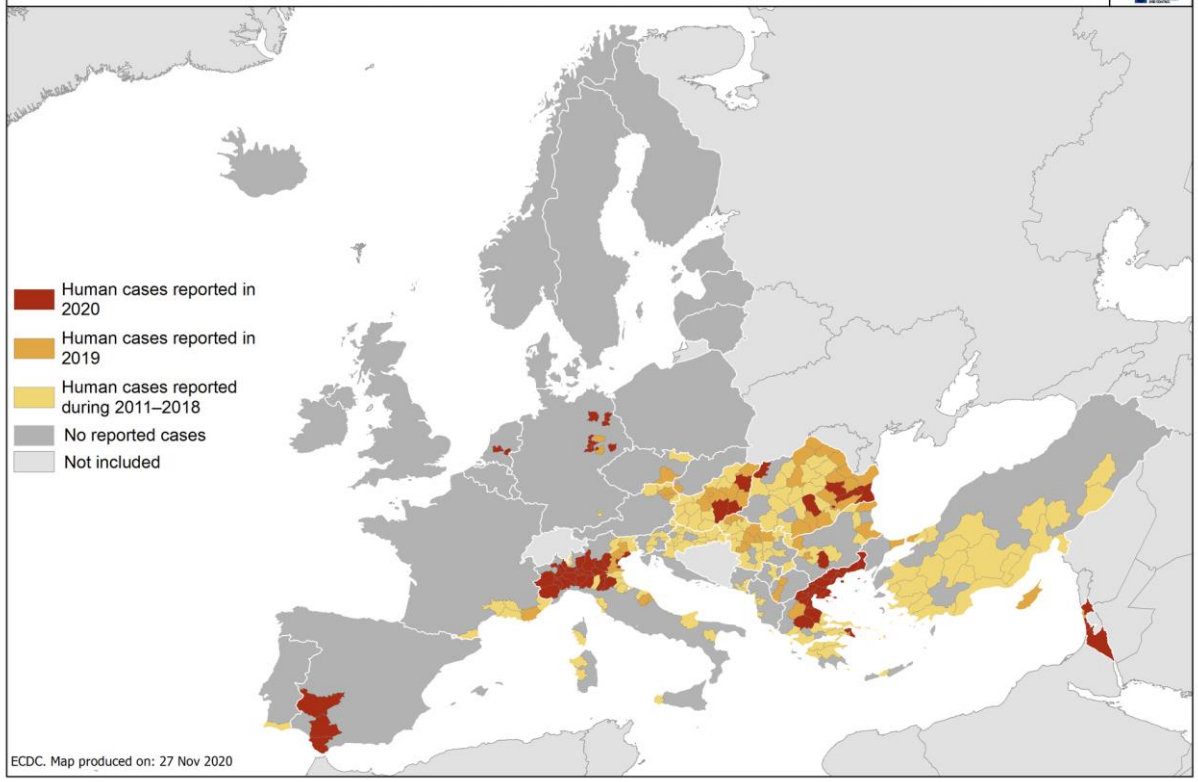
Malaria reported cases (ECDC)



Dengue, Zika and Chikungunya reported cases (ECDC)



Distribution of West Nile virus infections in humans by affected areas in the EU/EEA countries and EU neighbouring countries
Transmission season 2020 and previous transmission seasons; latest data update 26 Nov 2020



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EuroGEO

Action Group EO4EViDence

(Earth Observation for Epidemics of Vector-Borne Diseases)

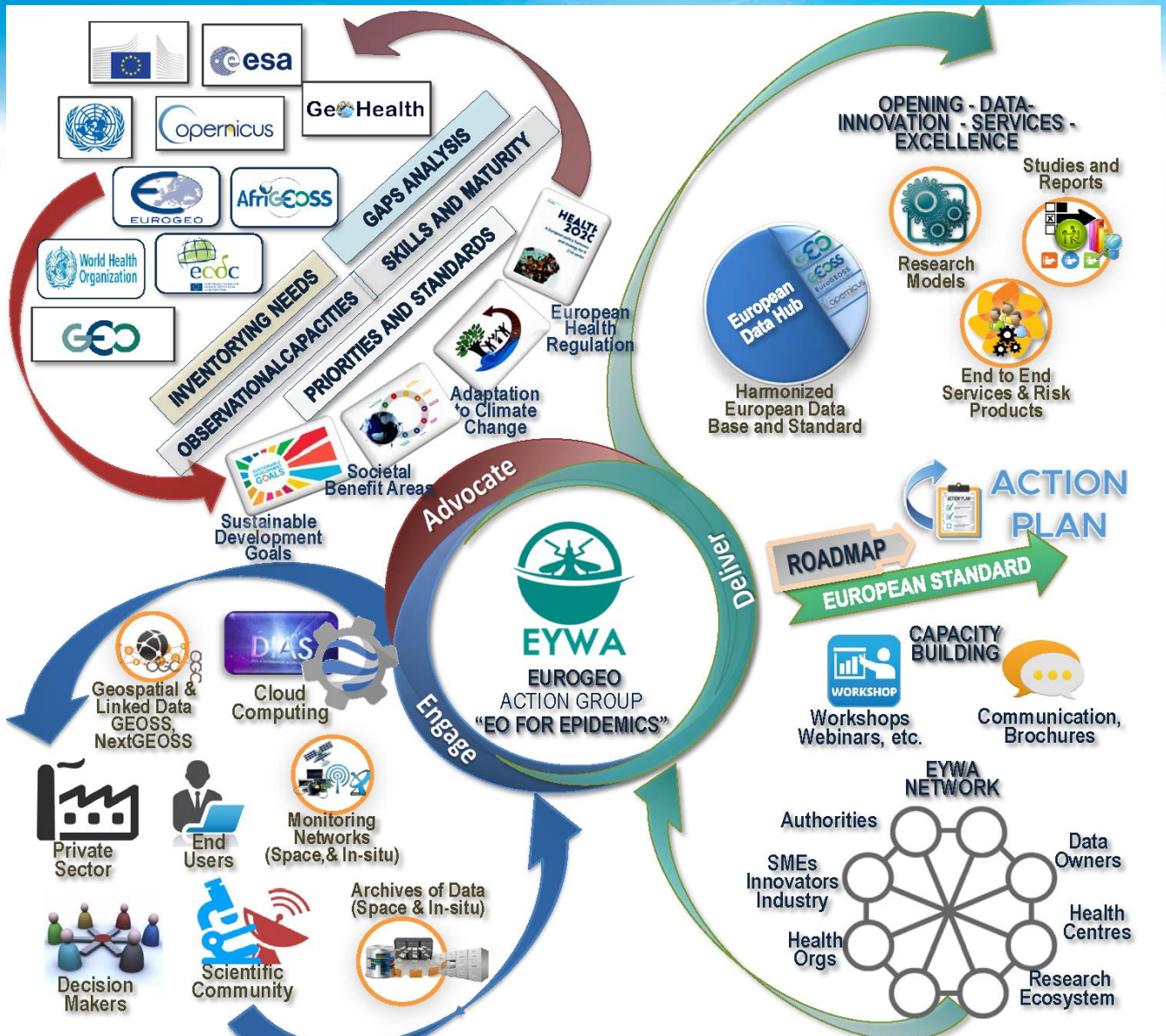
EYWA is a vision, a network, a European and even global standard.

EYWA offers a scalable, reliable and sustainable early warning system, relying on Earth observation big data combined with entomological, epidemiological and socioeconomic data, to forecast and monitor Mosquito-Borne Diseases.

SUSTAINABLE DEVELOPMENT GOALS

EYWA is built on the GEO triptych:

ADVOCATE
ENGAGE
DELIVER



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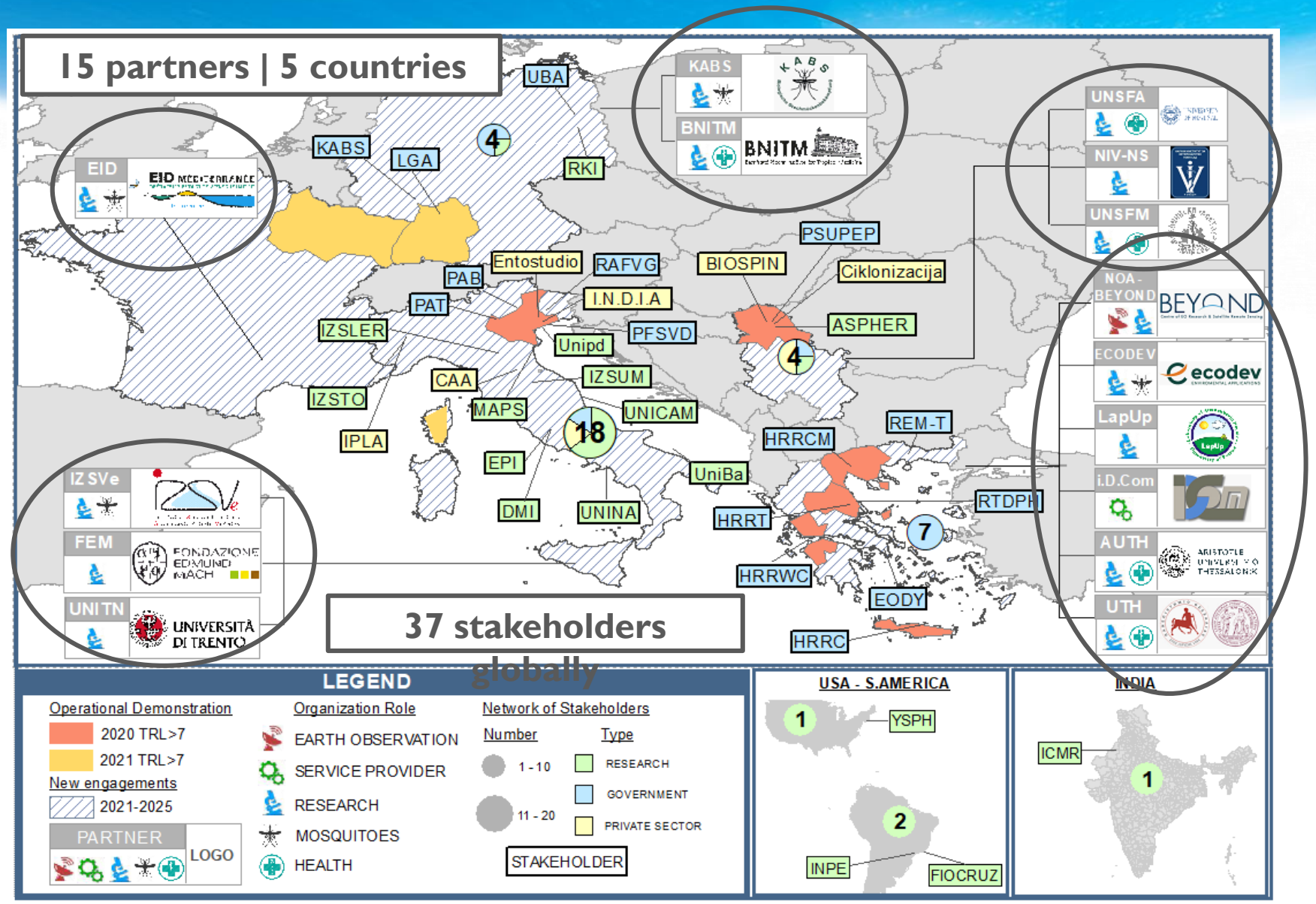
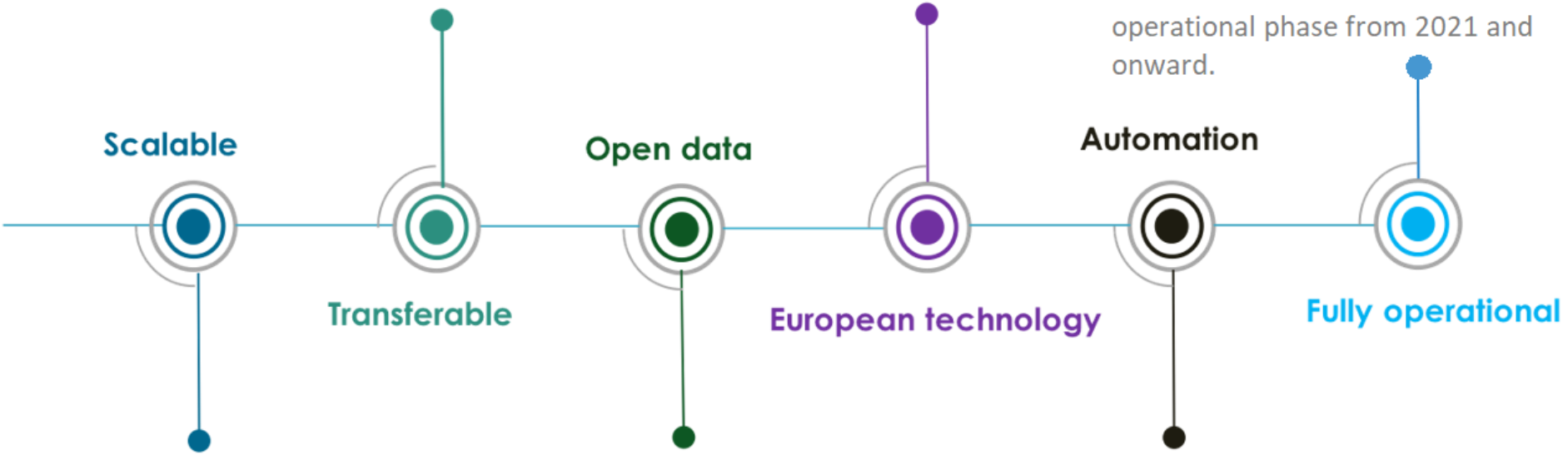
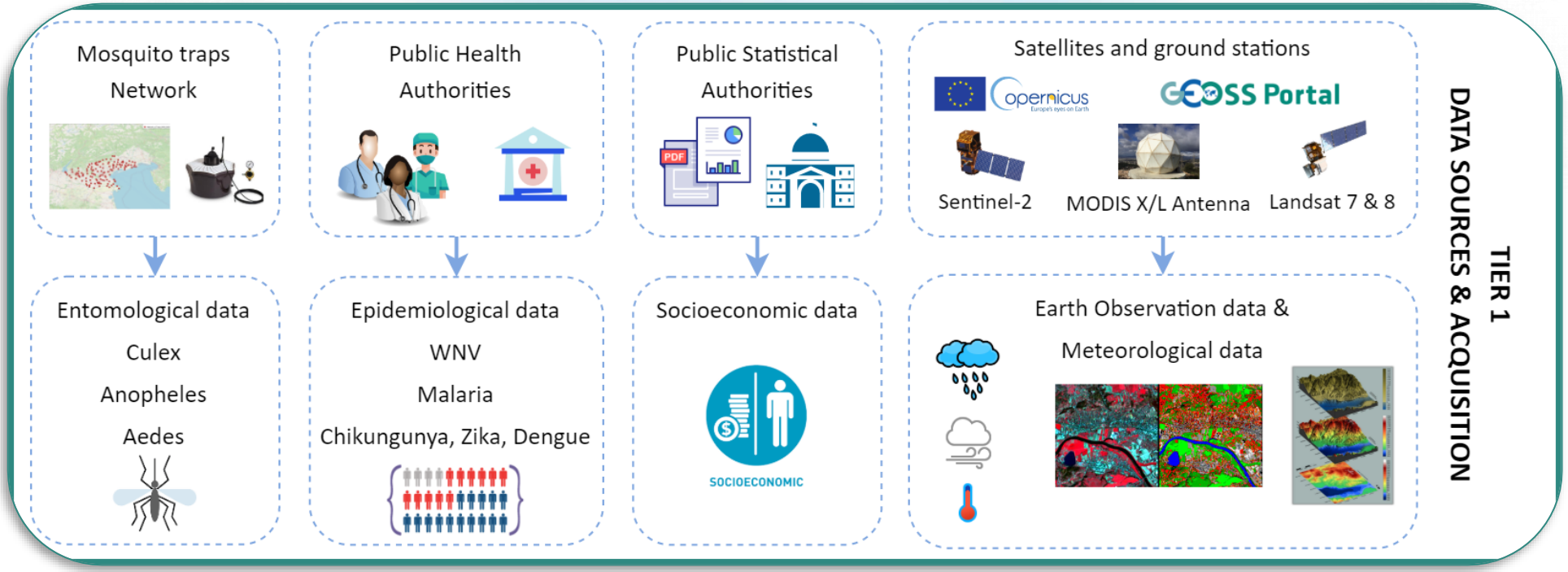


How EYWA competes



EYWA System Architecture

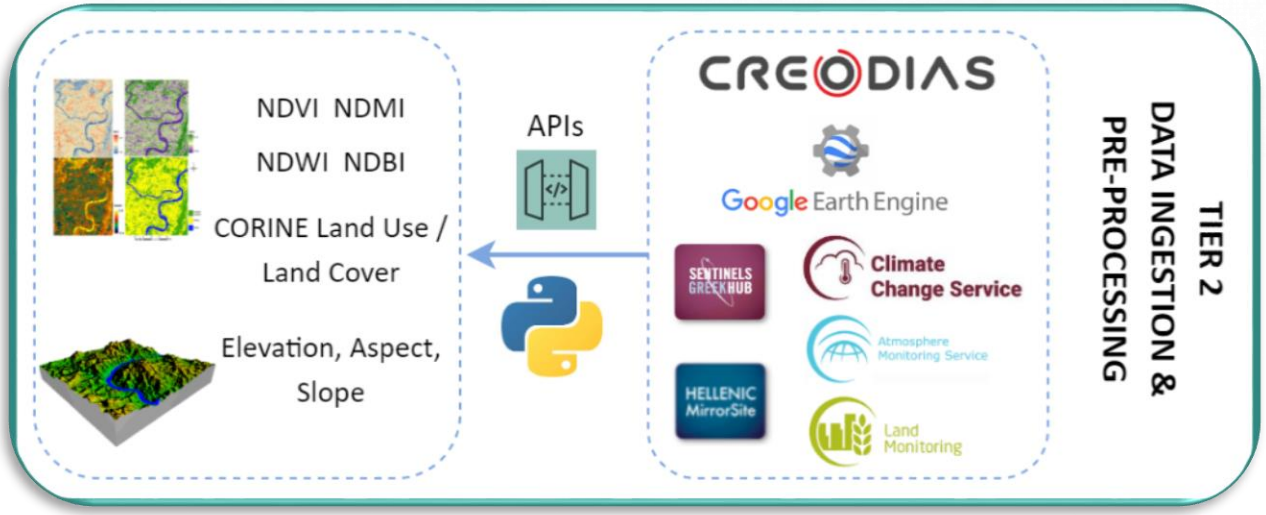


EYWA incorporates 10-years time-series of Copernicus (Sentinel-2) and other space-based data (Landsat-7 & -8, MODIS and ERA-5) in addition to in-situ entomological, epidemiological, socioeconomic and crowdsourcing data.

EYWA System Architecture

A suite of APIs is developed and opened for automatic:

- **Data Harvesting**
- **Data Pre-processing**
- **Index Data Derivation and Conversion for ODC/DB**
- **Raw/Value Added Data Sharing and Opening**

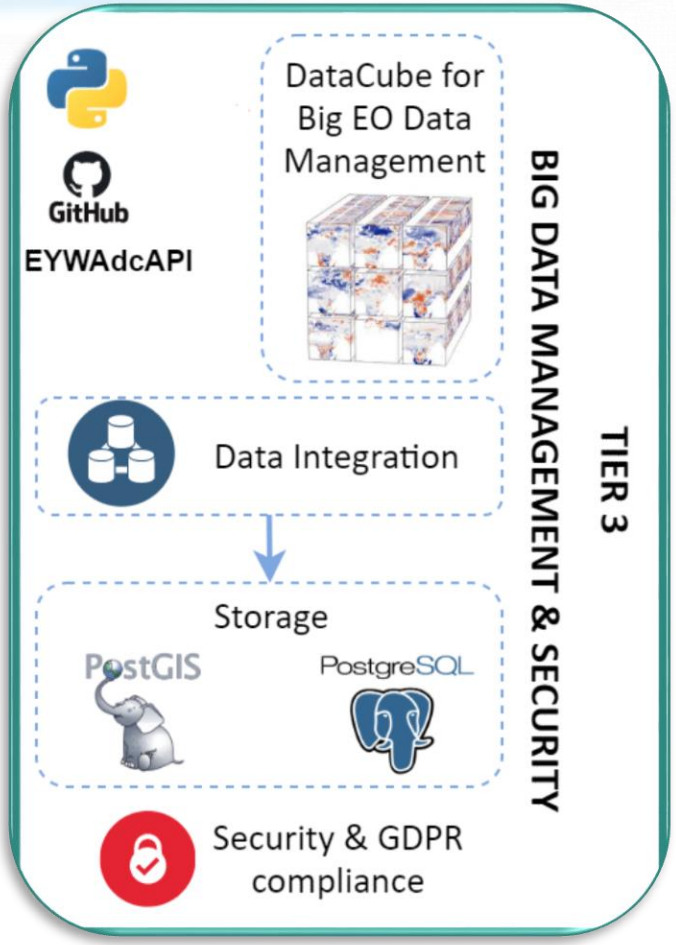


Satellite data harvesting and processing, exploiting European and non-European services:

- Umbrella Sentinel Access Point of the Hellenic Mirror Site (an API that constitutes 100% EU innovation and has been developed by BEYOND-NOA in the framework of the NextGEOSS and EOPEN EU projects)
- CreoDIAS and Google Earth Engine

EYWA System Architecture

- Big Data management (**278 TB and counting**)
- Open Data Cube (ODC) technology, state-of-the-art tool for Earth Observation and other data fusion, feature engineering and data analytics
- All these processing steps are available through the dedicated Python API "**EYWAdcAPI**" at BEYOND-NOA's GitHub profile in the epidemics repository



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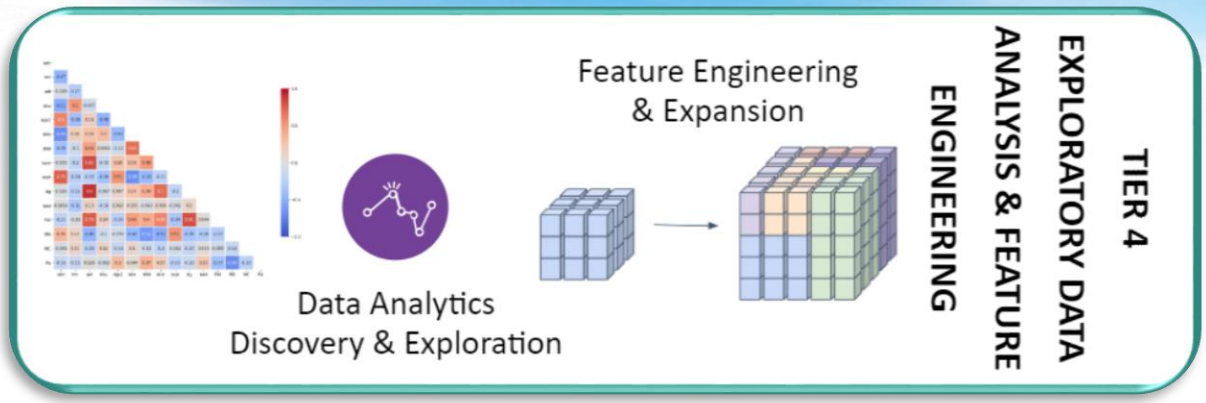
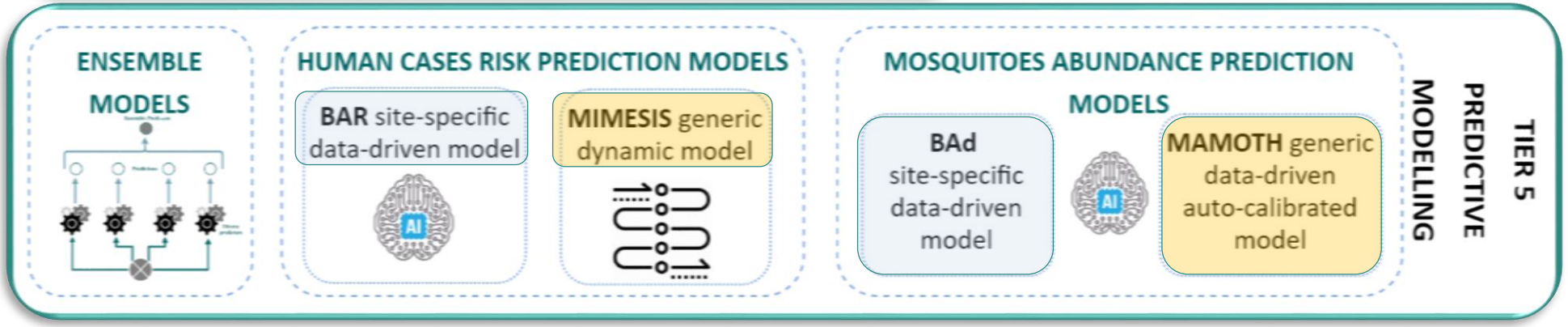
EYWA System Architecture



A "mammoth" feature space of at least 10-years time-series of data for every mosquito-traps network in nine regions in Europe.



How is this plethora of independent data transformed into meaningful scientific knowledge?

EYWA has a factory of dynamic and data-driven models, learning about the dynamics of mosquitoes' abundance and mosquito-borne diseases transmission, and providing monthly, weekly, daily predictions.

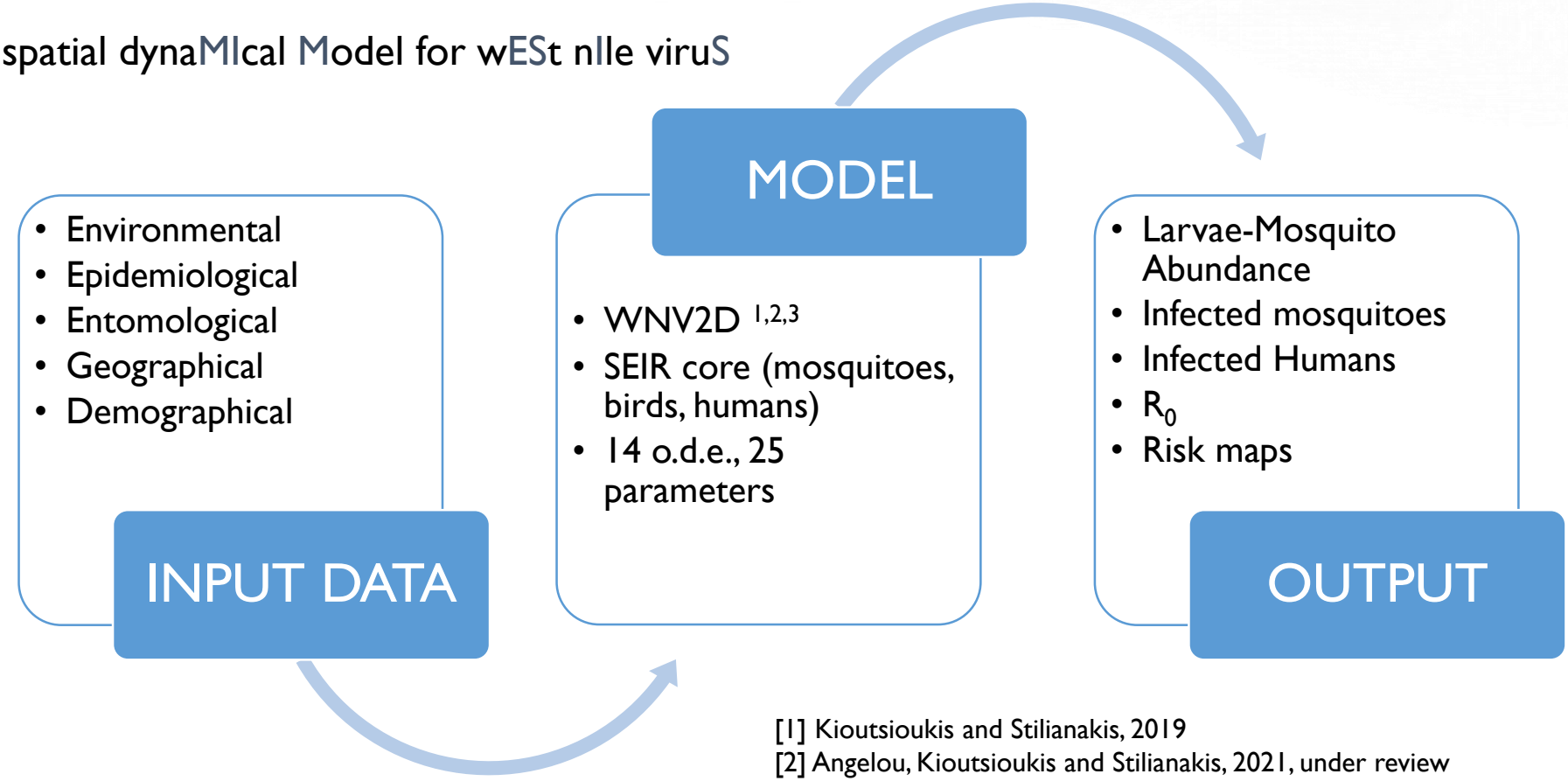
EYWA System Architecture

The MAMOTH model

EYWA System Architecture

The MIMESIS model

MIMESIS: spatial dynaMIcal Model for wESt nIle viruS

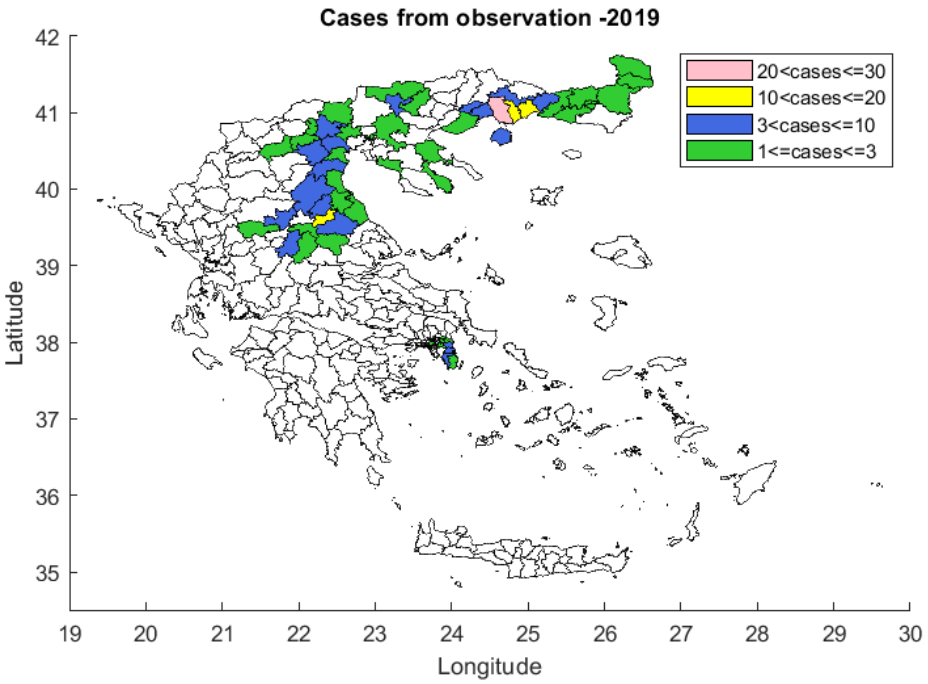


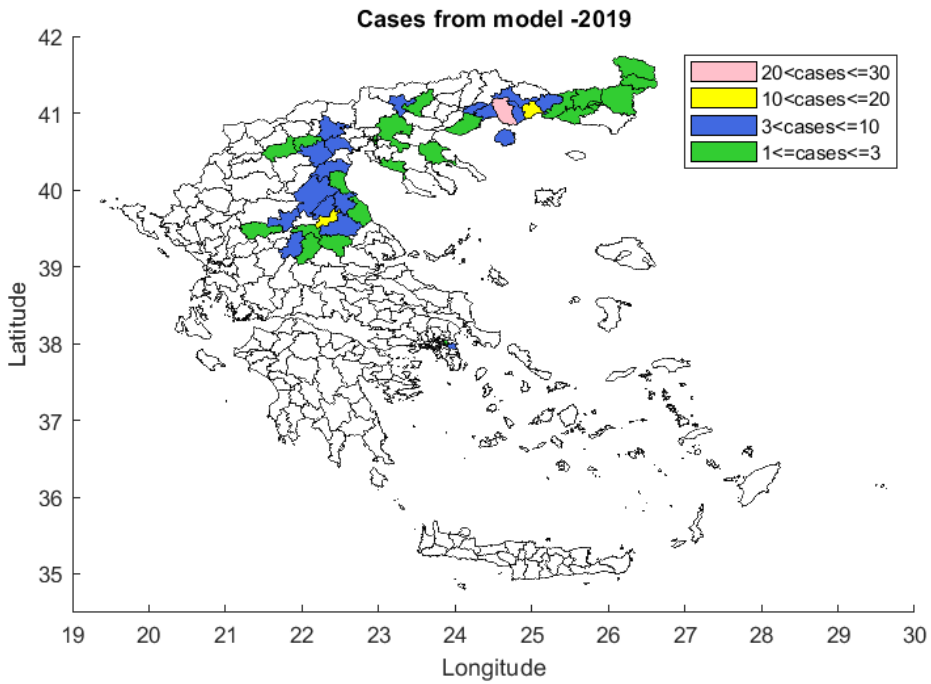
[1] Kioutsioukis and Stilianakis, 2019
[2] Angelou, Kioutsioukis and Stilianakis, 2021, under review
[3] Kioutsioukis et al., 2021, submitted

EYWA System Architecture

The MIMESIS model

Validation Statistics

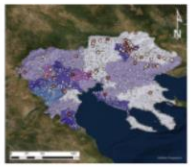




EYWA System Architecture

TIER 6 – KNOWLEDGE REPRESENTATION & EXPLANATION

Mosquitoes abundance and human cases risk prediction maps & statistics

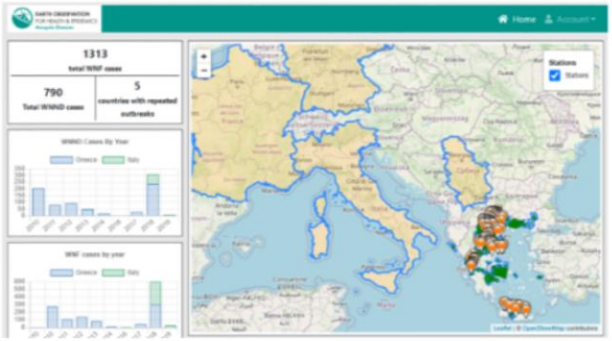


Reports for end-users

Predictions results dissemination to the relevant Public Health Authorities through monthly reports and the EYWA Web Platform

TIER 7 – EYWA WEB SERVICES

Web Platform UI



End-users

Data
- visualization
- upload
- download

Mosquito Vision application

Open data sharing through the **EYWAopenAPI**

NEXTGEOSS

GEOSS Portal

EYWA in Action

EYWA's **operational implementation in 2020** (TRL>7) with a demonstrated impact in:

- Greece (Regions of Central Macedonia, Thessaly, Western Greece and Crete)
- Italy (Veneto region)

forecasting *Culex* mosquito populations and West Nile Virus outbreaks in 2020.

EYWA's **pre-operational test in 2020** for:

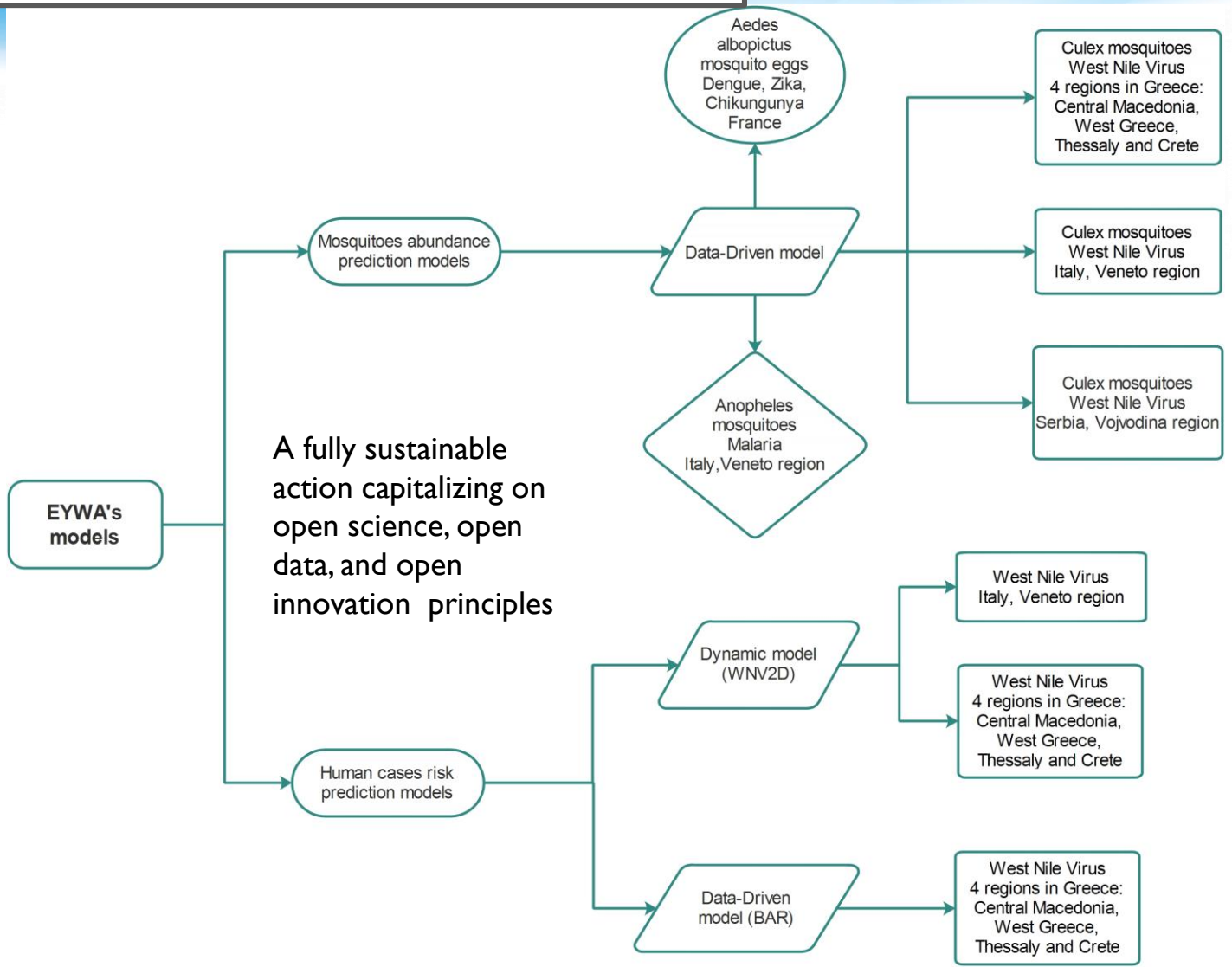
- *Culex* (WNV) abundance prediction in Serbia (Vojvodina region) and Germany (Baden-Württemberg region)
- *Anopheles* (Malaria) in Italy (Veneto region)
- *Aedes* (Chikungunya, Dengue, Zika) in France (Grand Est and Corsica regions)

EYWA in Action

EYWA is a suit of validated epidemiological and entomological models either dynamic or data driven.

During the development phase, the models were adapted to site specificities, for as far as the types of mosquitoes and disease outbreaks are concerned.

In the years to come, more countries and diseases will be included in the integrated EYWA system to develop a European/Global Early Warning System.



A fully sustainable action capitalizing on open science, open data, and open innovation principles

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EYWA in Action

Reports with operational results

EYWA produces knowledge in the form of reports, statistics, validated assessments and web GIS information layers, all available to the end-users through the EYWA Web Platform.

The EYWA Reports are delivered operationally from April to October every year to the relevant Public Health Authorities and decision makers.

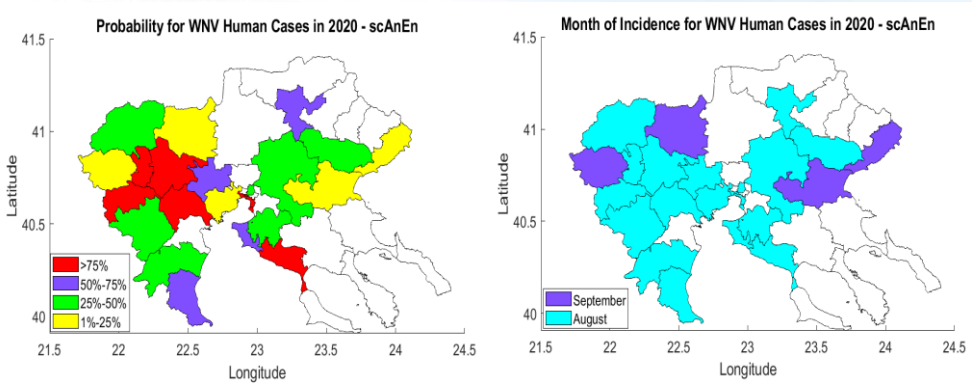
The weekly/monthly reports help the authorities to anticipate preventive measures and organize mosquito combating operations. Measurable performance indicators are used to evaluate the level of EYWA's effectiveness towards the protection of the engaged communities against the disease outbreak.

The reports indicate:

- Up-to-date epidemiological status of the Region
- The state-of-the-art models used
- The estimated human risk
- The mosquito abundance predictions for the month

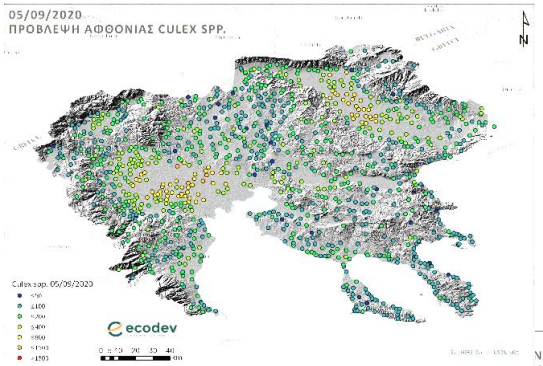
Indicative EYWA operational results during the period | April – October 2020

Human case risk forecast – Region of Central Macedonia - Dynamic modelling – Period 25/08/2020-25/09/2020

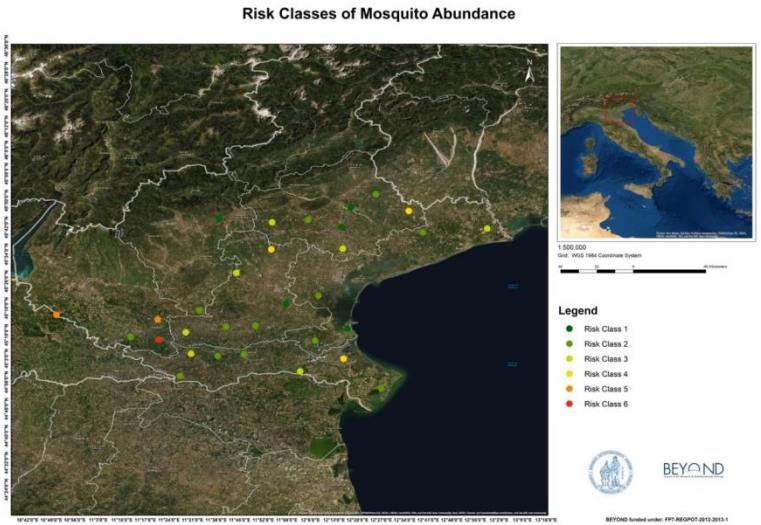


Human case probability map (left) and probable month of human cases incidence (right)

Mosquito Vision: Smartphone application for 5-day predictions of evening and night nuisance from mosquitoes

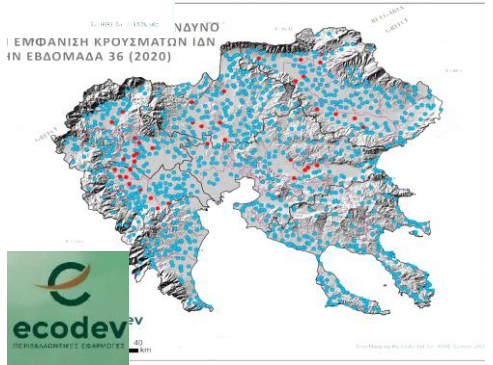


Mosquito abundance forecasts in the 1040 municipalities of Central Macedonia for the week 02/09 έως 06/09/2020



Mosquitoes population risk map - Data Driven Model - Region of Veneto (Italy) Period 25/08/2020-25/09/2020

Human case risk forecasts for WNV incidence calculated over the 1040 municipalities in Central Macedonia for the week 31/08-06/09/2020



EYWA SUMMARY

- A **sustainable and cost-effective** Early Warning System (EWS) that is seamlessly integrating detailed data from different countries leveraging on the use of open and multi-source data encompassing long time series of collected, cleaned, harmonised and standardised at local/regional/country level of exhaustive entomological, epidemiological, meteorological, Earth Observation data and value added products

- Relies on the advancements of **big EO and ICT and AI sciences** and leverages on the use of the **EU investments** in the domains of Copernicus, GEO/EuroGEO, Space based / in-situ / citizen observatories, and relevant infrastructures such as satellite data hubs and repositories, DIAS platforms, Cloud HPC, Open DataCubes, etc)

- Lies with the open science and open innovation principles and contributes to EuroGEO and Copernicus by providing an **innovative scalable, reliable, transferable, and integrated solution** at various spatio-temporal scales (municipality → regional → country→ continent level), while delivering open data sets and open information and forecasts on risks for different disease outbreaks

- EYWA comprises of fully operational modules and radically new technique for modelling and predicting mosquito–borne outbreaks across different temporal and spatial scales in Europe with the Technology Readiness Level ranging from 7 – 9 (system prototype demonstration in operational environment).

- EYWA intends to become a **state-of-the-art tool**, in the hands of National Health Organizations and Public Authorities developed through a continuous co-design and co-creation approach. When fully developed and operational, EYWA, attempts to become **a European standard**.

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Thank you!

Contact us

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(Coordinator of EuroGEO Action Group for Epidemics)

(Lead Partner of EYWA)

Earth Observation for Epidemics of Vector-borne Diseases / EuroGEO Action Group

EuroGEO

Partners

Greece

National Observatory of Athens (NOA) – BEYOND Centre of EO Research & Satellite Remote Sensing

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University of Thessaly, Medical School. Laboratory of Hygiene and Epidemiology

Italy

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Serbia

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France

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Project acronym:	**EXCELSIOR**

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