EYWA
Early Warning System
for Mosquito Borne Diseases

EO creates opportunities for Health & Epidemics

The EYWA platform: Powering an Early Warning System

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(BEYOND Centre | IAASARS | NOA)

BEYOND

http://beyond-eocenter.eu/

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e-shape

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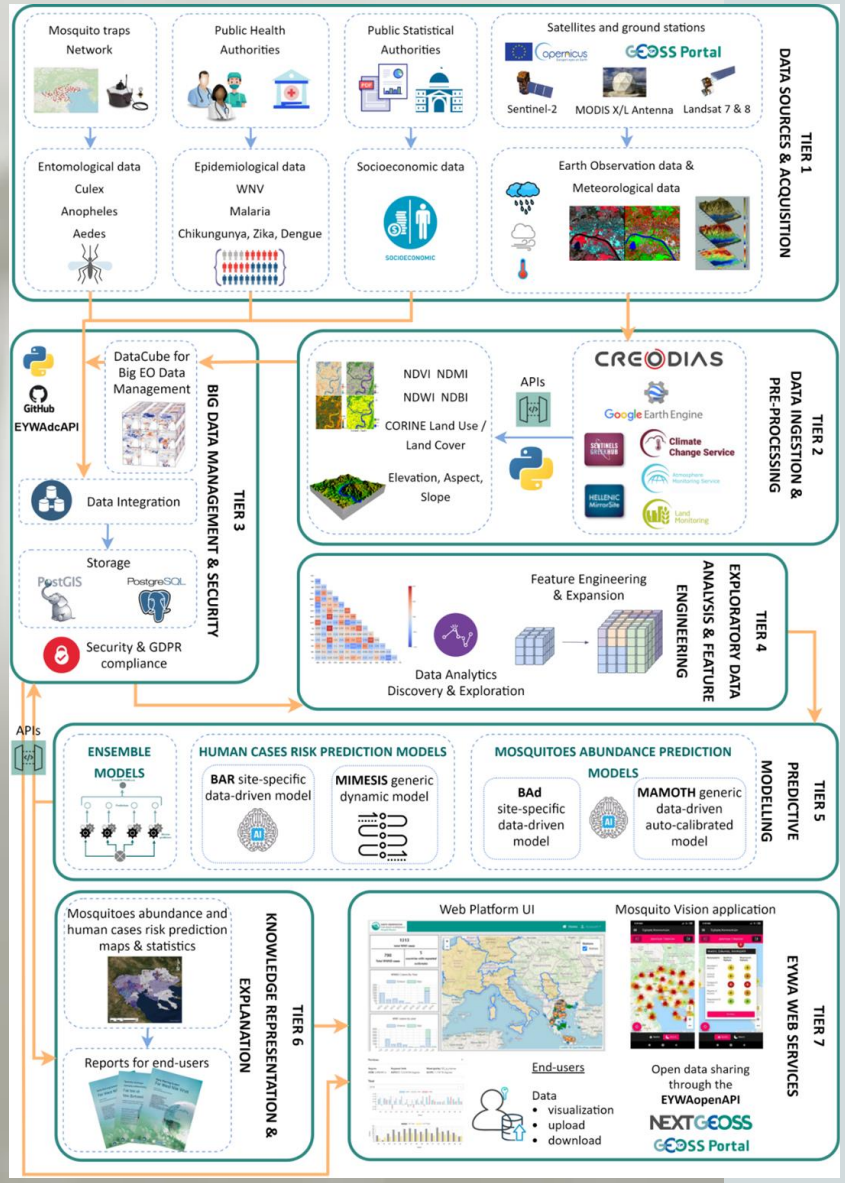

Making it work
The EYWA architecture

- Time-series **entomological, epidemiological, socio-economic, satellite Earth Observation, meteorological and geomorphological** data.
- 36 features for each of the 42.400 mosquito collections in our database.
- A "MAMOTH" feature space **12-years time series of data** for mosquito-traps network in **11 regions** in **Europe** and **2** in **Africa** & **Asia**.
- Processing more than **300 TB** of Earth Observation data to generate them.

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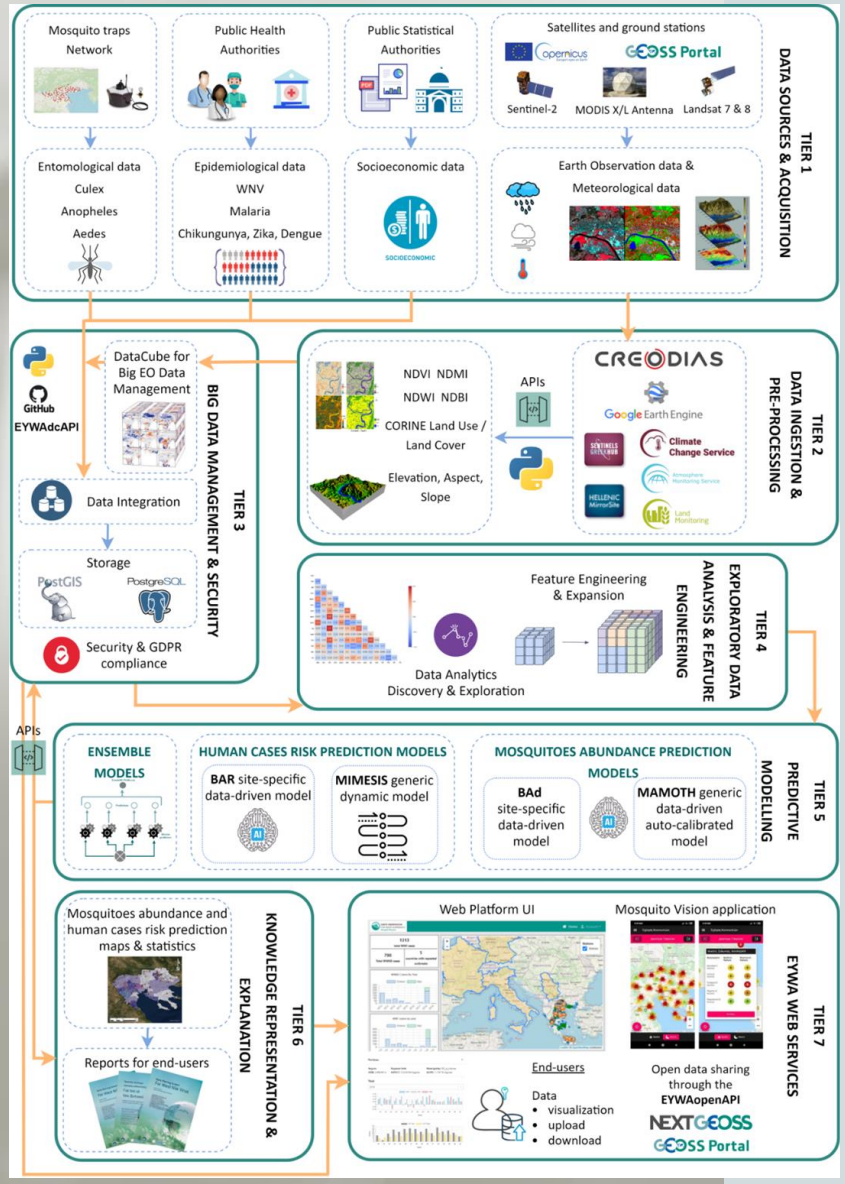

Making it work
The EYWA architecture

- **Environment proxies** (Sentinel 2, Landsat 7/8):
  - Normalized Difference Vegetation Index (**NDVI**)
  - Normalized Difference Moisture Index (**NDMI**)
  - Normalized Difference Water Index (**NDWI**)
  - Normalized Difference Build-Up Index (**NDBI**)
- **Meteorological Data** (MODIS, IMERG, Copernicus ERA-5):
  - Land Surface Temperature (LST), Precipitation, Wind
- **Geomorphological Data** (Alos Palsar, Copernicus Water & Wetness):
  - Elevation, Aspect, Slope
  - Composite features related to water proximity
- **Land Use/Land Cover Data** (Copernicus CORINE)

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What does the feature-space look like?

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Entomological Data

Epidemiological Data

Mosquitoes' Abundance Predictions

Human Cases Risk Predictions

EYWAopenAPI

Reports

EYWA
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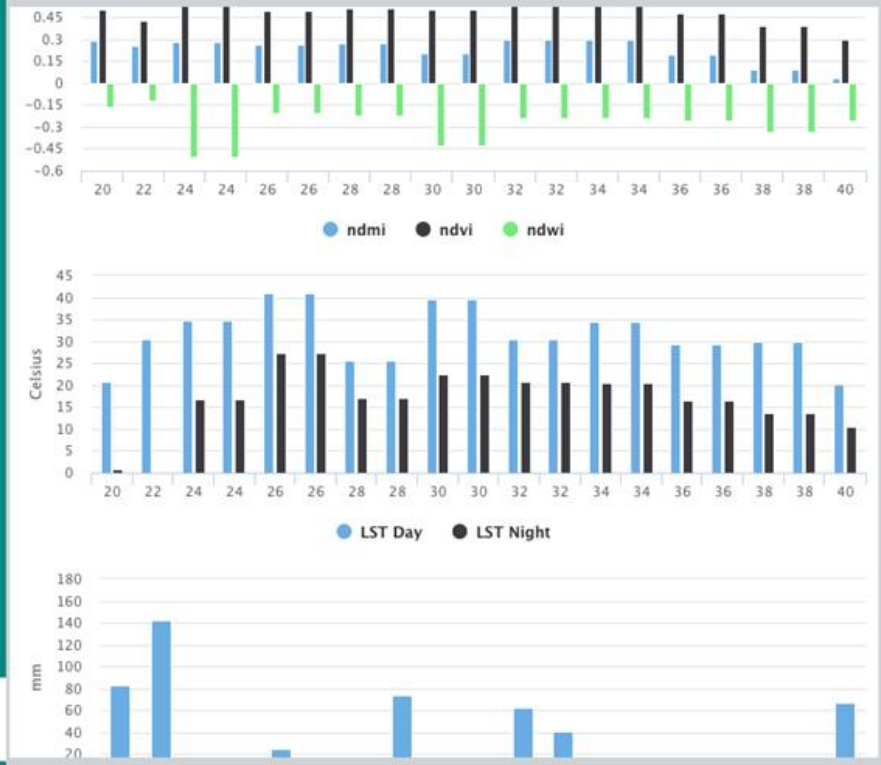
Entomological Data

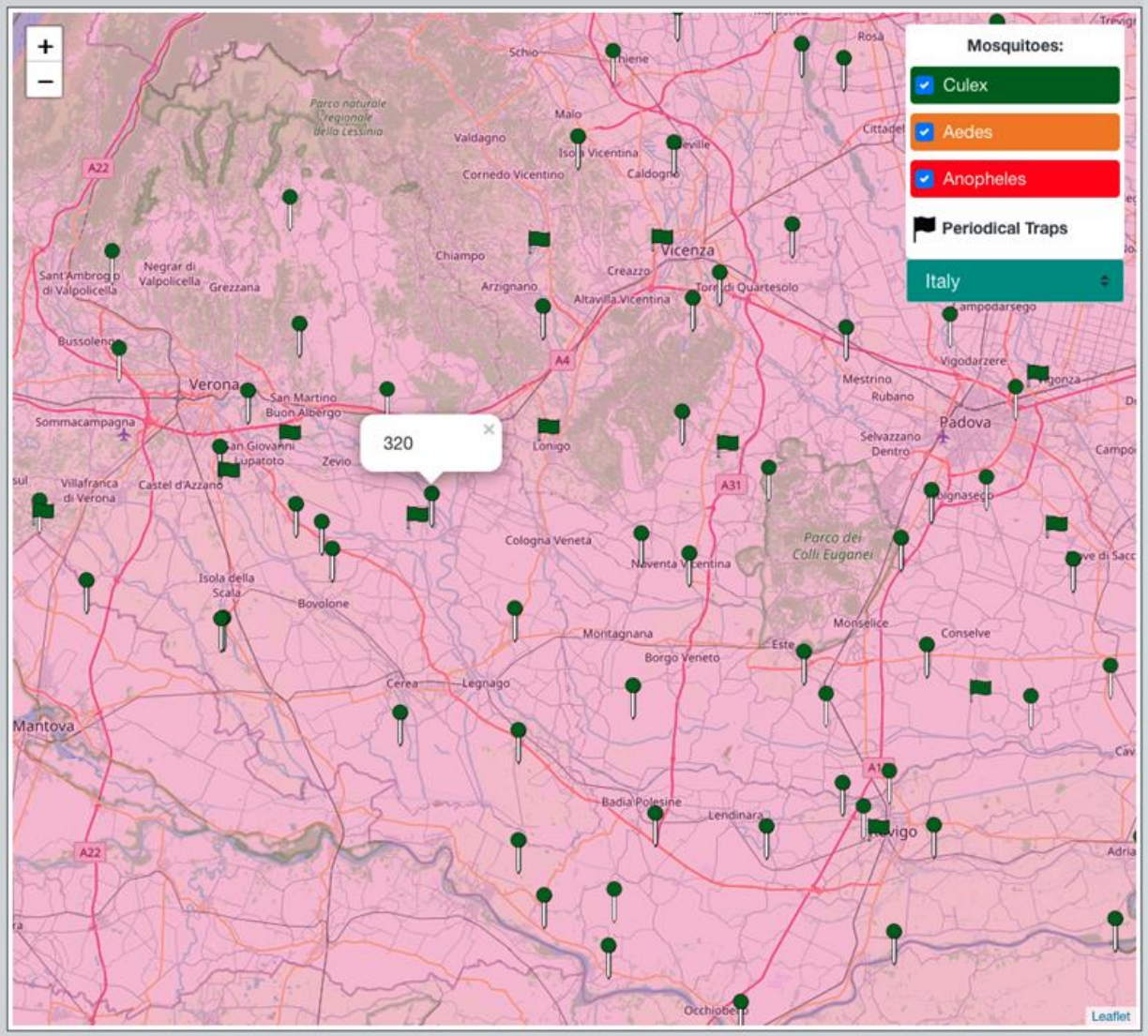
demo

320

Country:	Country Code:	Group of development regions:
Italia	IT	Nord-Est
Region:	**Regional Unit:**	**Municipality:**
Veneto	Verona	Ronco all'Adige
DEM:	**ASPECT:**	**SLOPE:**
22 m	95.482 degrees	2.07496 degrees
Settlement:	**Trap :**	
	culex	

2019





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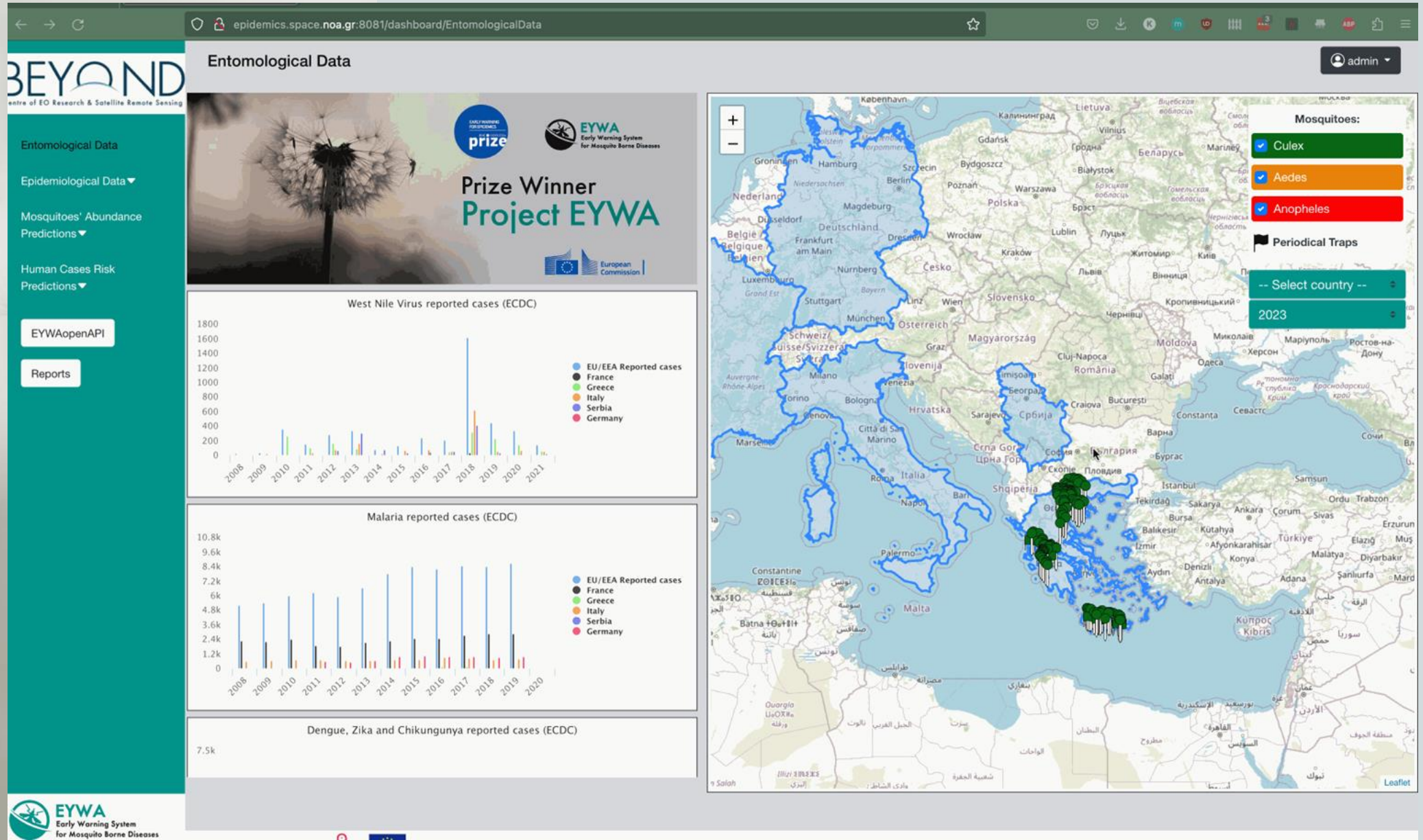

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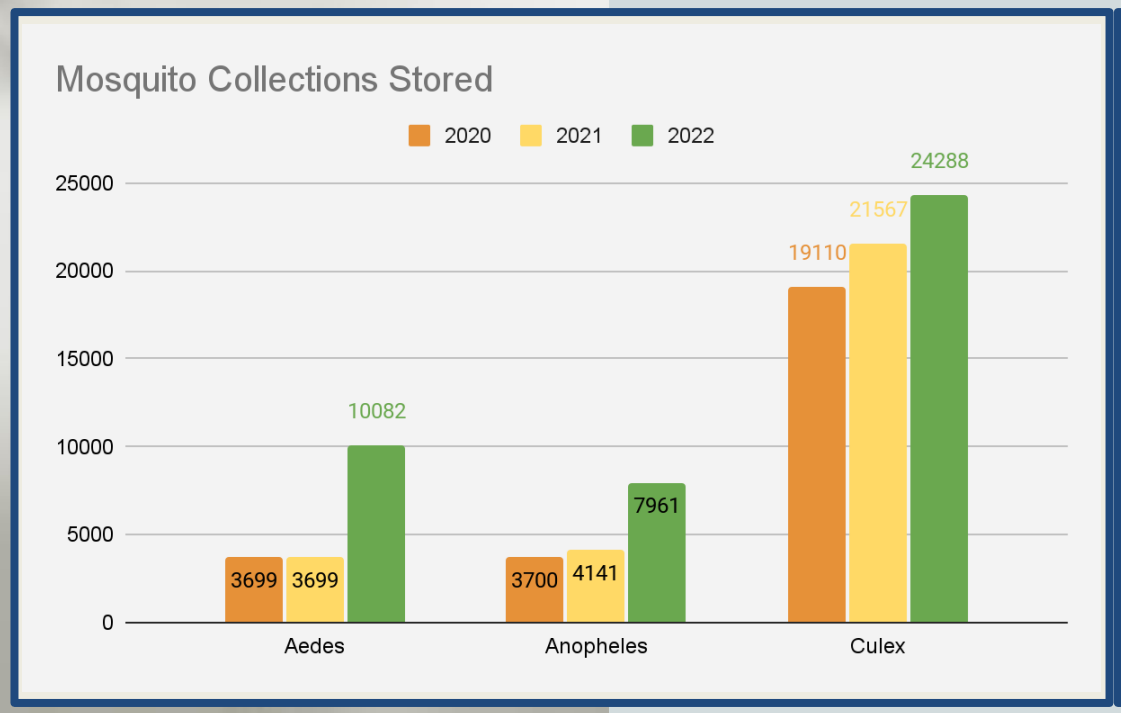
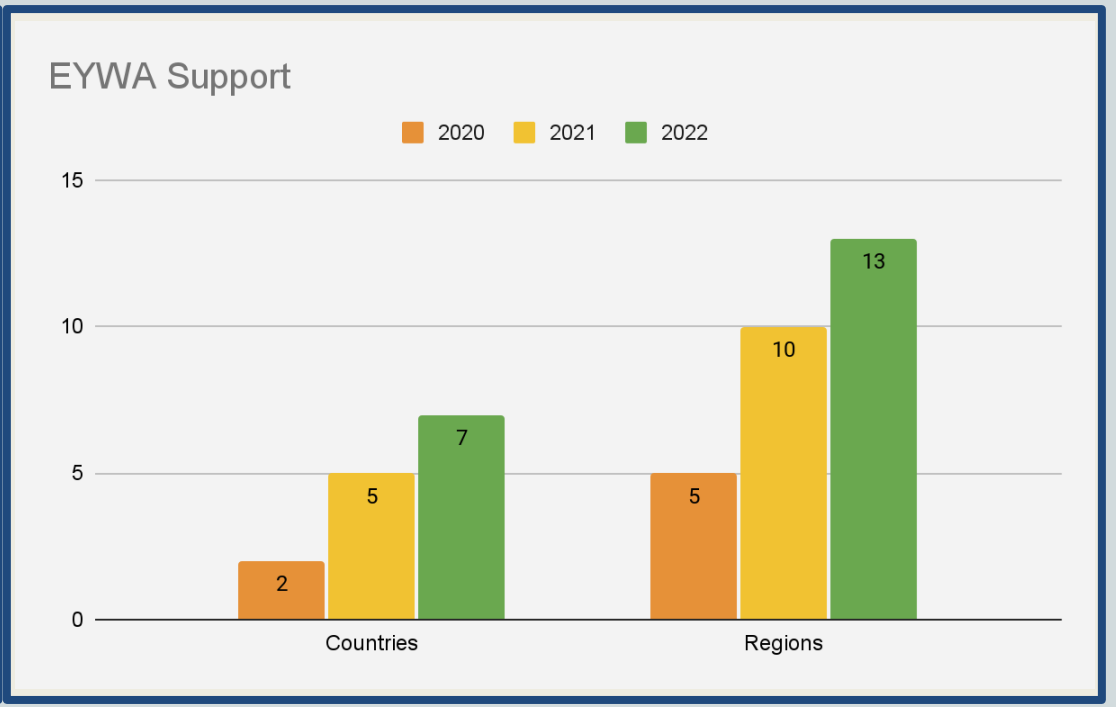
System Evolution





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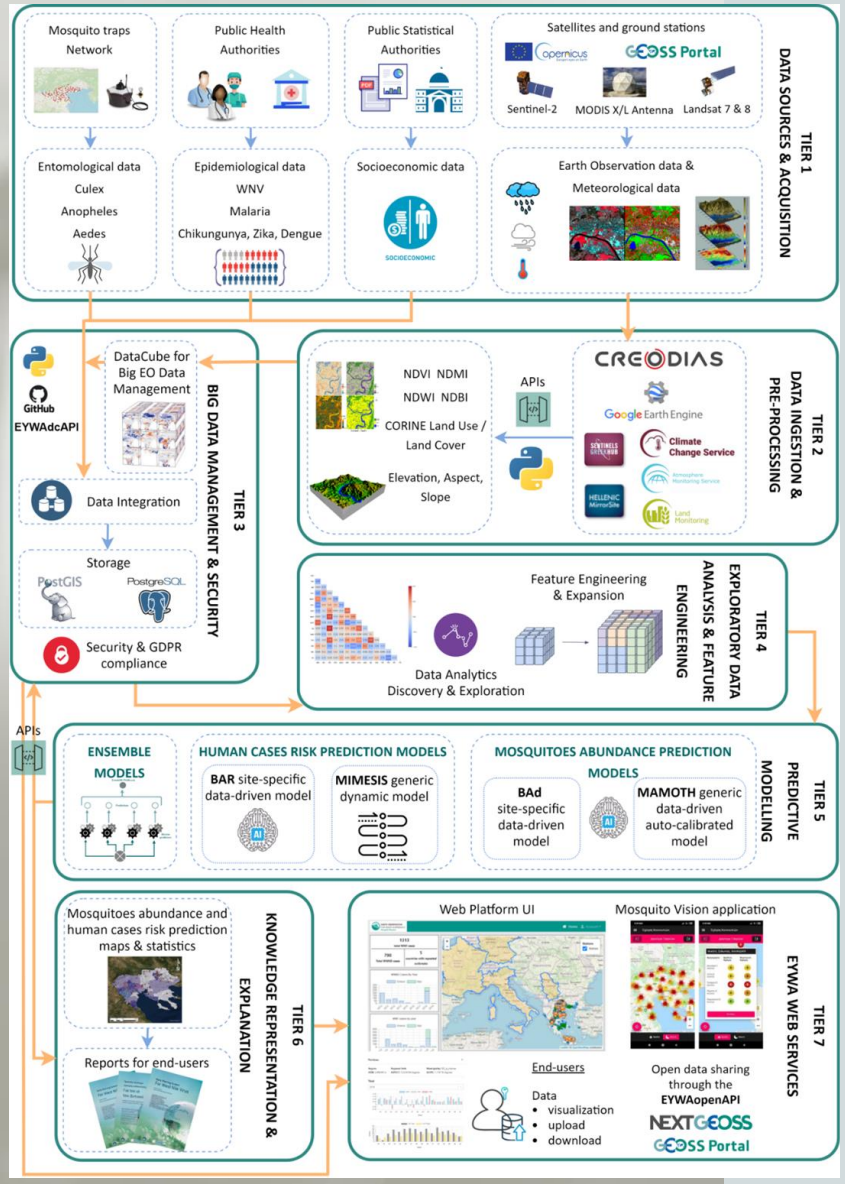

What/Where does EYWA provide as models for Early Warning?

WNV risk

- ❑ **MIMESIS (Univ. of Patras)**
  - **Municipality** level.
  - **Monthly** predictions.
  - Predicted probability/number of WNV cases & expected first week of registered case.
- ❑ **BAr (ECODEV)**
  - **Settlement** level
  - **Weekly** predictions
  - Predicted **probability WNV case**.

Mosquito Abundance

- ❑ **BAd (ECODEV) abundance** model
  - **Settlement** level
  - **Weekly** predictions
- ❑ **MAMOTH (NOA)**
  - **Point/Trap** level.
  - **Aggregate** predictions for any **larger** area
  - **Biweekly/Monthly** predictions.

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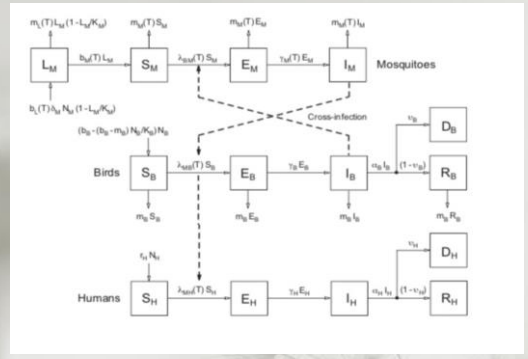

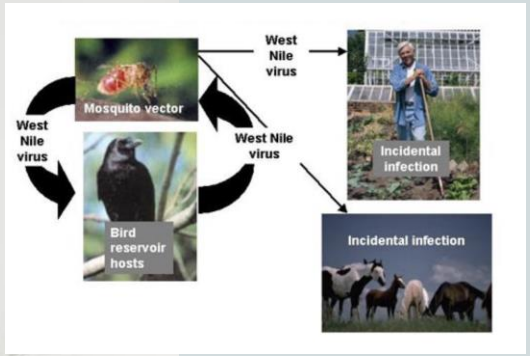

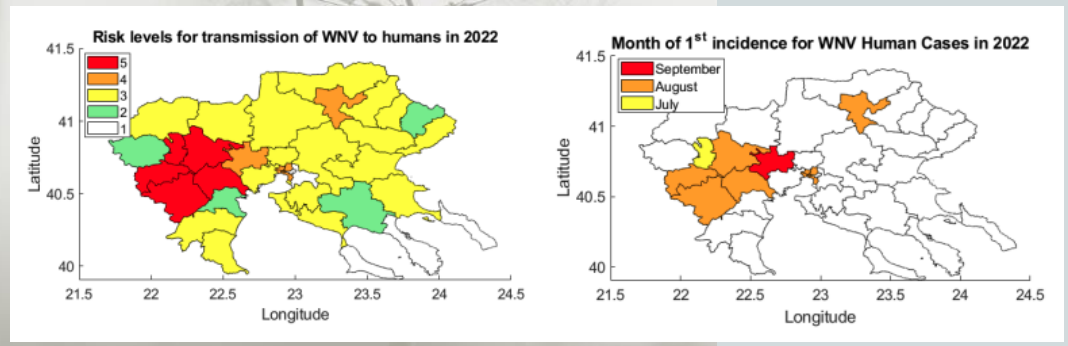

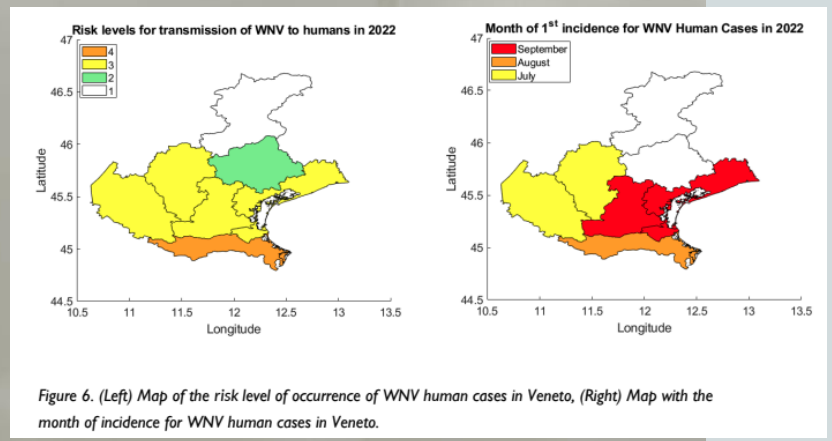

Figure 6. (Left) Map of the risk level of occurrence of WNV human cases in Veneto, (Right) Map with the month of incidence for WNV human cases in Veneto.

MIMESIS (Univ. of Patras)

MIMESIS (spatial dynaMIcal Model for wESt nIle viruS)

- Developed by the Laboratory of Atmospheric Physics of the University of Patras.
- Climate dependent epidemiological (deterministic) model that works on a ensemble probabilistic frame that provides West Nile Virus risk maps.
- The model operates spatially at the meso-scale and temporarily at the monthly to seasonal scale.
- Supports 4 regions in Greece and 1 region in Italy.
- Average detection probability exceeds 74% (reforcasts).
- During the 2022 operational season:
  - In April, in the region of Central Macedonia the model predicted 11 municipalities as high risk areas of registering WNV cases.
  - In 10 of those cases were later indeed registered (91% accuracy).

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MIMESIS (Univ. of Patras)

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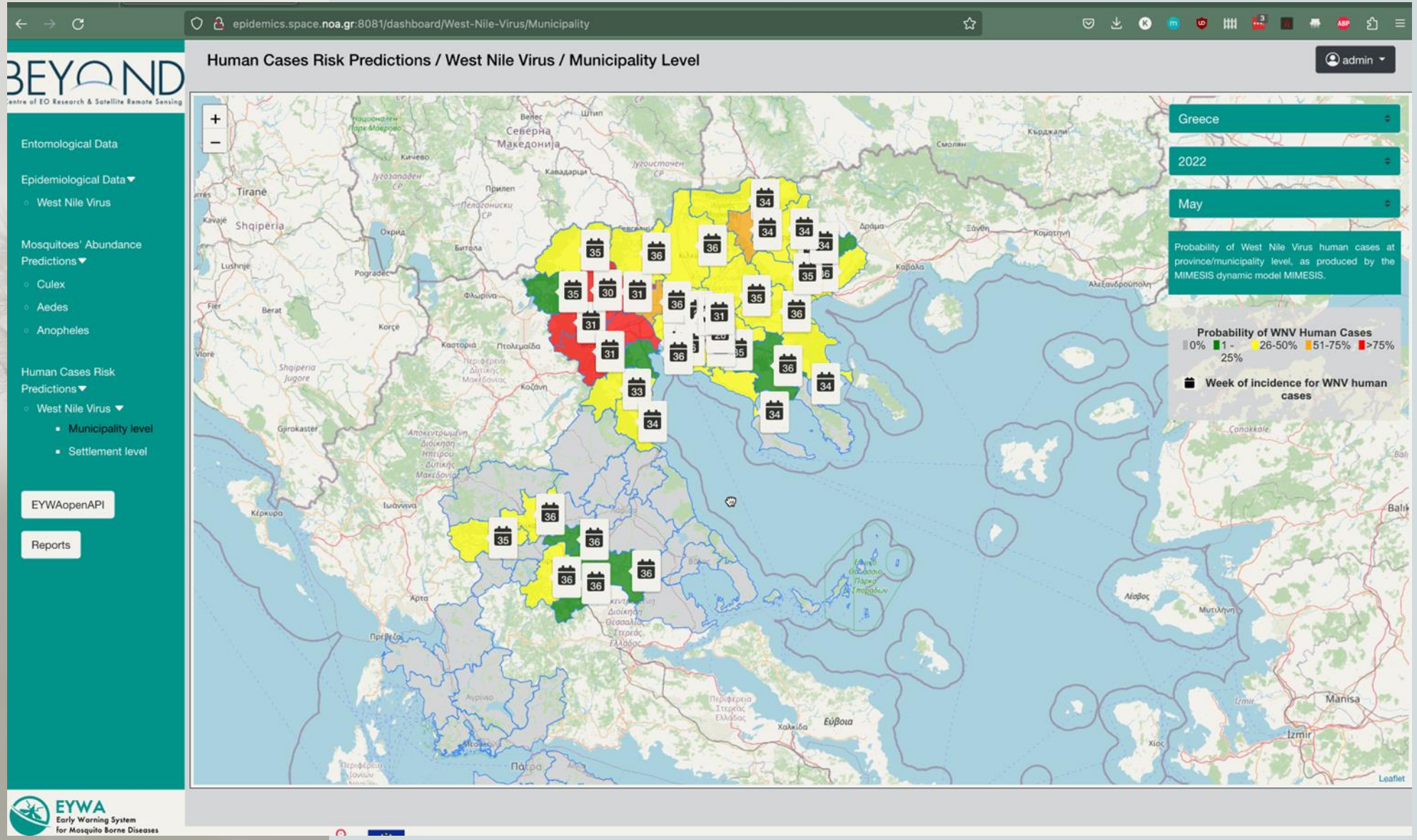

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BAd & BAR (ECODEV)

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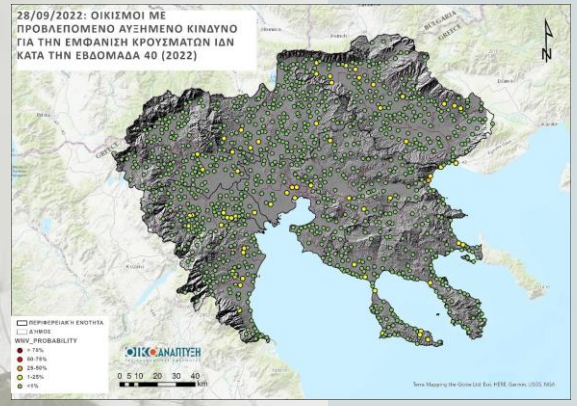
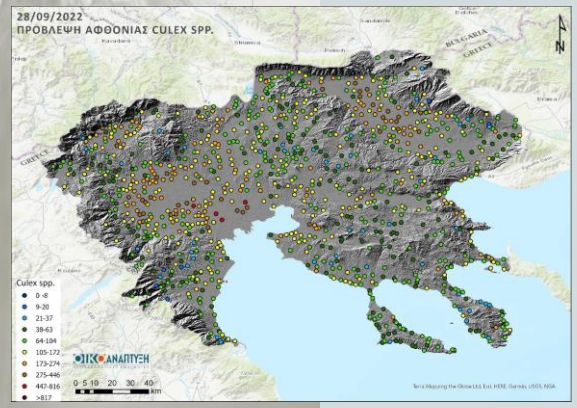
Mosquito Vision app
BAd predictions / nuisance levels



BAR22 predictions
Settlement level WNV risk



BAd predictions
Culex Mosquito Abundance

BAd (Big data technologies' model for Adult mosquitoes)

- ❑ Developed by Ecodevelopment S.A.
- ❑ Daily forecasts of mosquito abundance on a settlement level.
- ❑ Available in 4 regions in Greece.
- ❑ Outputs 10 equiprobable classes of populations
- ❑ A data driven regression machine learning model, using the XGBoost implementation of the boosted trees algorithm.
- ❑ Trained using data from 11.138 mosquito collections.
- ❑ It is fed with another model that provides predictions on mosquito larvae.
- ❑ The model accuracy is calculated with the Mean Absolute Error, and the validation error has been calculated to 1.27 classes.
- ❑ Powers the Mosquito Vision app that provides the model output as nuisance level available in more than 2400 settlements.

BAR22 (Big Data Technologies model for the Assessment of Risk)

- ❑ Developed by Ecodevelopment S.A.
- ❑ Weekly forecasts of West Nile Virus risk on a settlement level.
- ❑ A data driven neural network model.
- ❑ Outputs risk on 5 levels (0-4, very low to very high)
- ❑ Available in the Central Macedonia region.
- ❑ Supports larviciding actions.
- ❑ Updated version of the older BAR model works on providing predictions on zones of settlements.
- ❑ Operational since 1st August 2022.
- ❑ For 46 out of 54 zones (covering 888 settlements) the risk level was off by 1 level on average for cases registered in the August/September period, for an accuracy of 85%.

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BAd (ECODEV)

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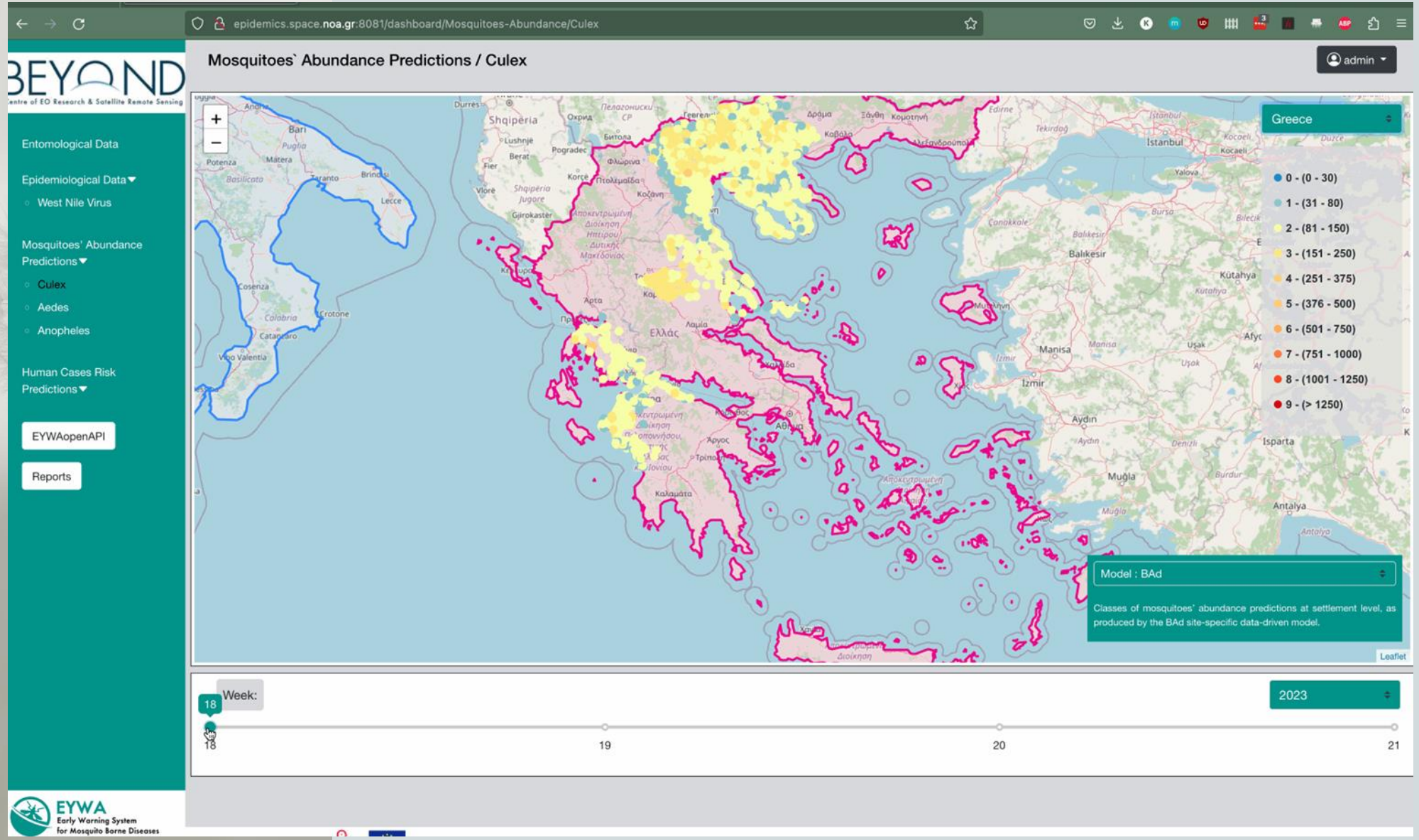

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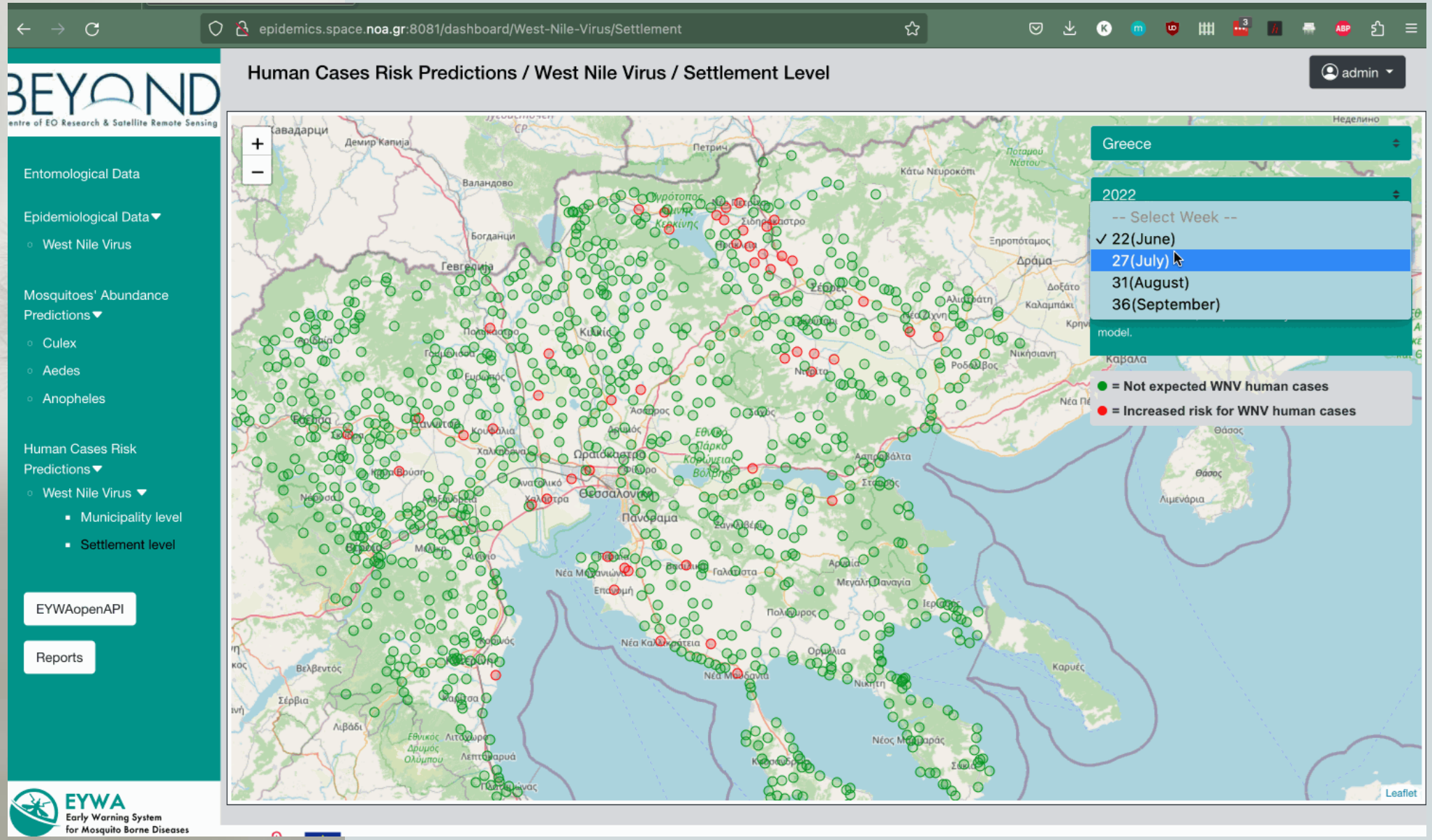

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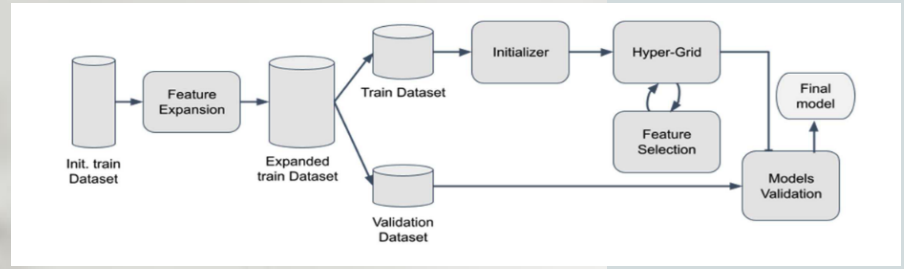
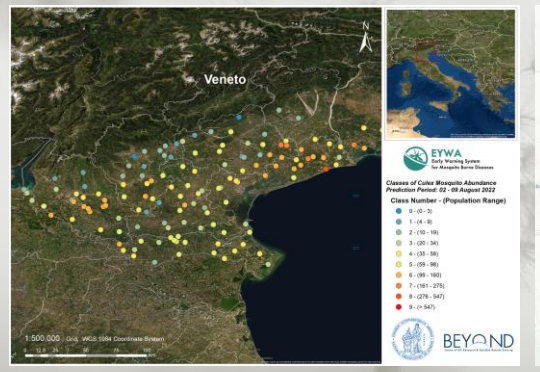
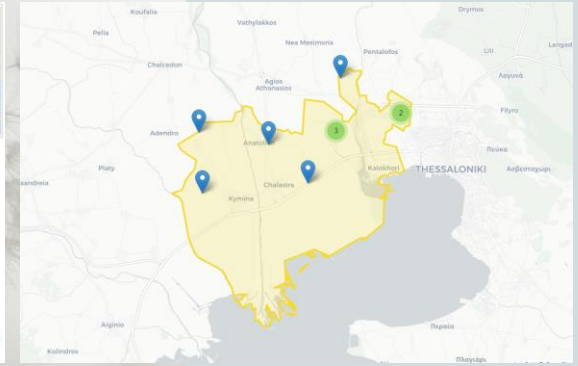


Model Training Pipeline



Operational predictions
(Veneto region)



Mosquito abundance aggregate statistics
(color represents mean value)
Delta municipality, Central Macedonia

MAMOTH (**M**osquitoes **A**bundance prediction **M**odel aut**O**-calibrated from features ple**TH**ora)

- Data driven model, developed by the Beyond Operational Unit of the IAASARS/National Observatory of Athens using the 12-year series of tabular entomological data (42.400 collections) from multiple countries, based on the neural networks.
- The model takes as input all available entomological data and the EO generated features in each region & species, and using a train/validation pipeline selects the best features, then predicts the expected mosquito population on any point for the next 15-30 days (customizable).
- Works with the Aedes, Anopheles & Culex mosquitoes in all EYWA supported countries, supporting all mosquito-borne diseases.
- Accuracy of > 93% in predicting high/medium/low risk of mosquitoes.
- Implementation available to provide complete entomological risk map of a whole region in a 2x2km grid.
- Has been extended to provide area level (province / municipality / settlement) aggregate statistics of mosquito populations, by sampling the area of interest to generate random points then predicting for each point and aggregating.
- Work is being undertaken for the MAMOTH model to feed predictions on a municipality level (aggregate statistics) into the MIMESIS model beginning in the coming 2023 operational season.

Robustness, Scalability, Transferability, Site and Mosquito type agnostic, Transfer Learning capability

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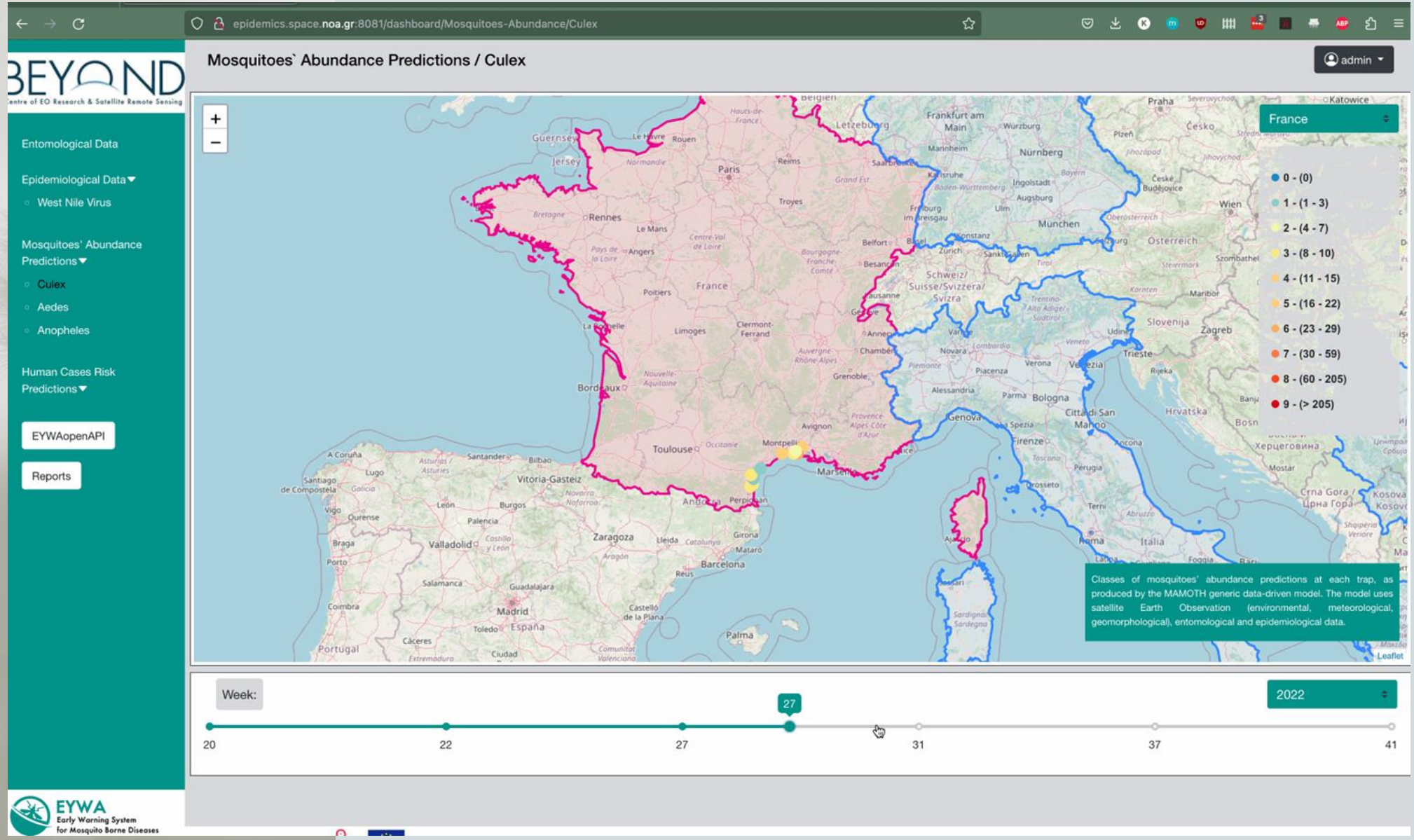

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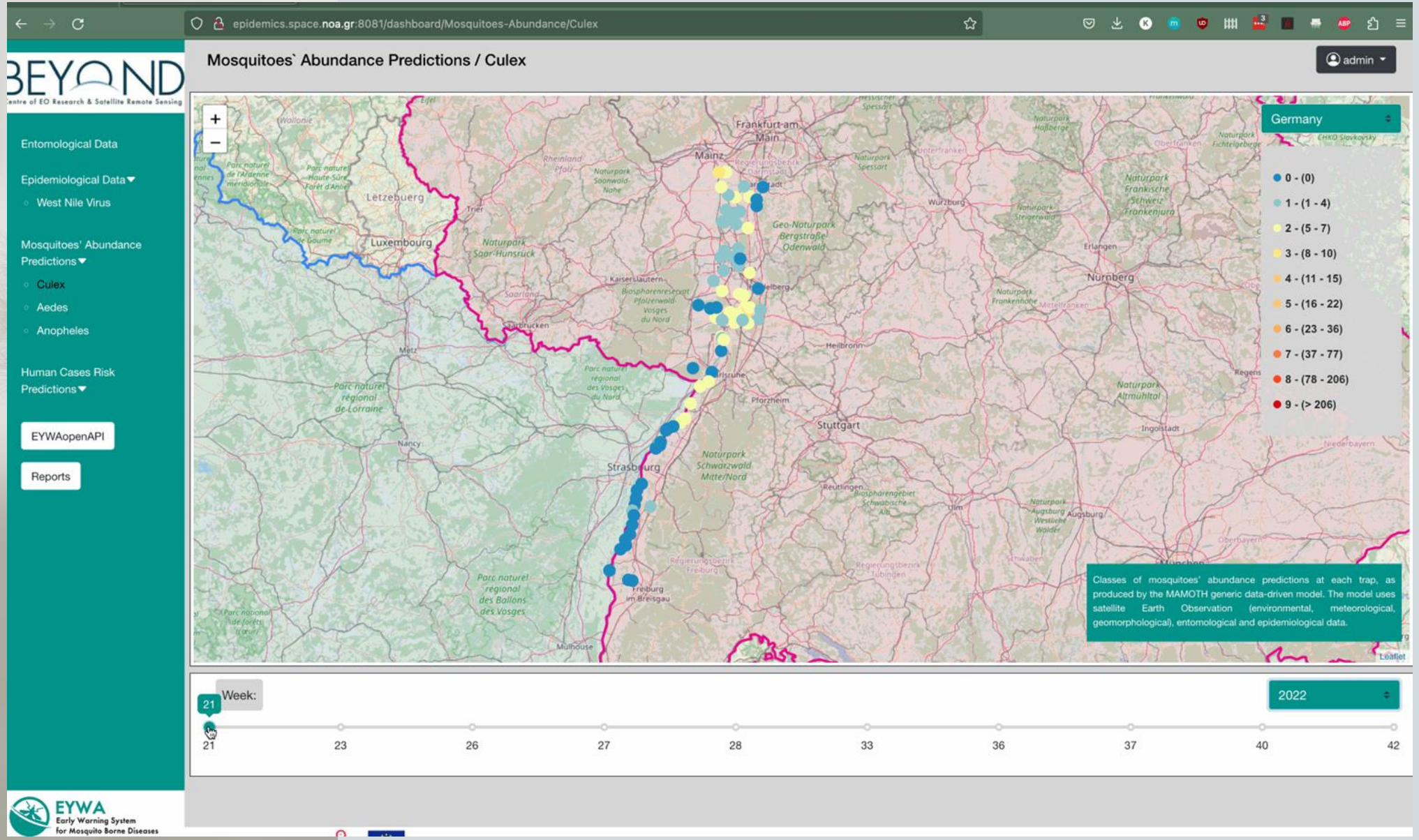

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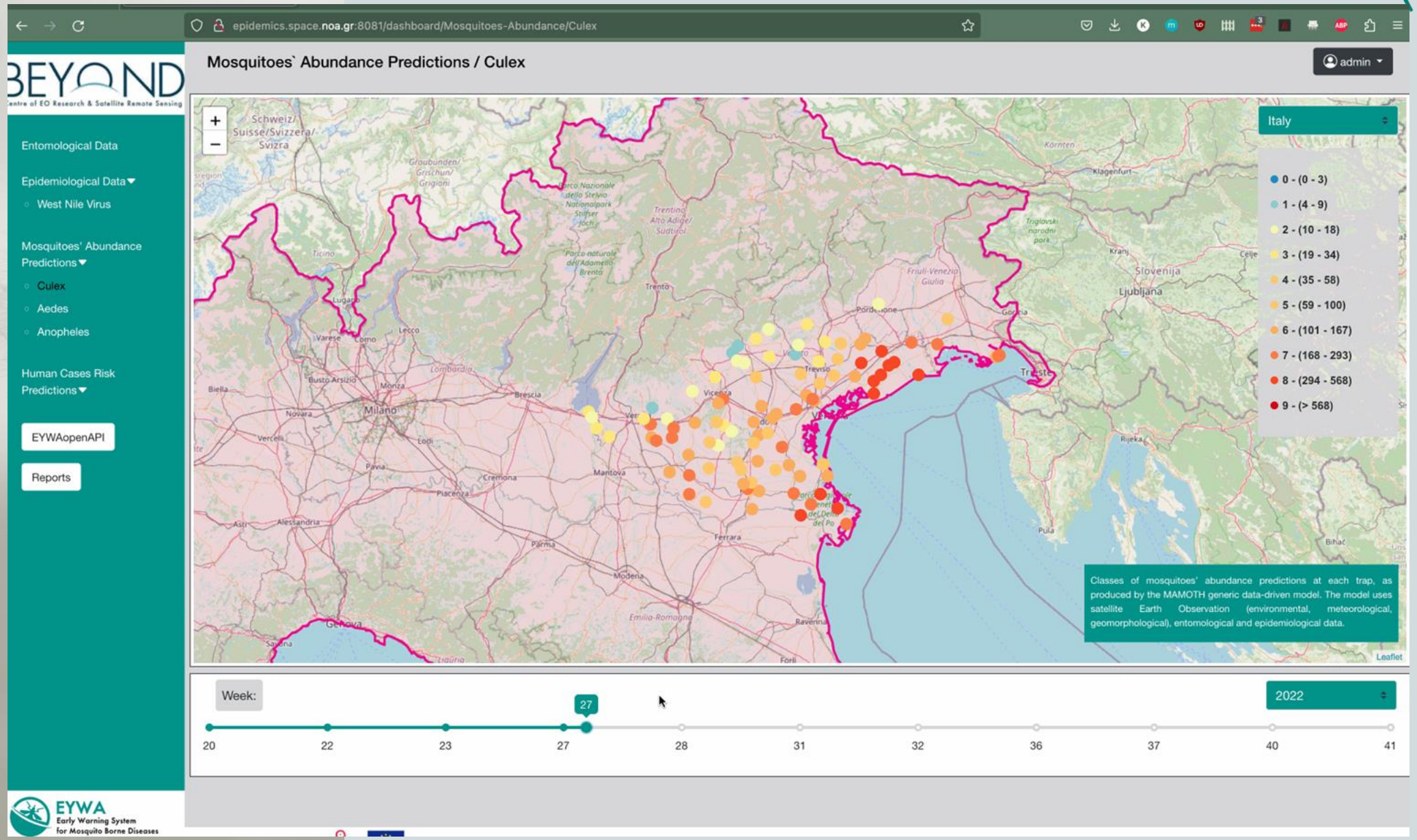

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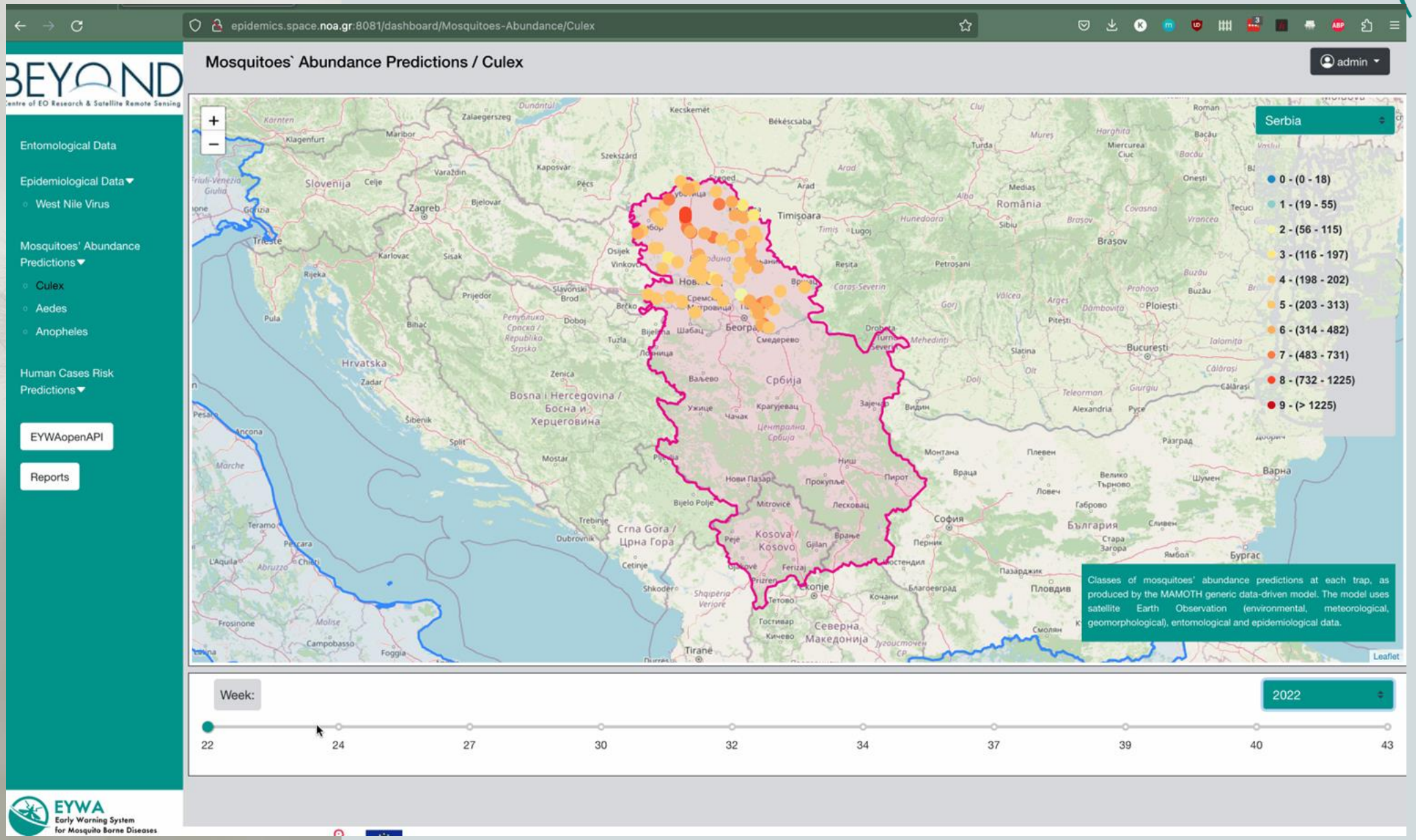

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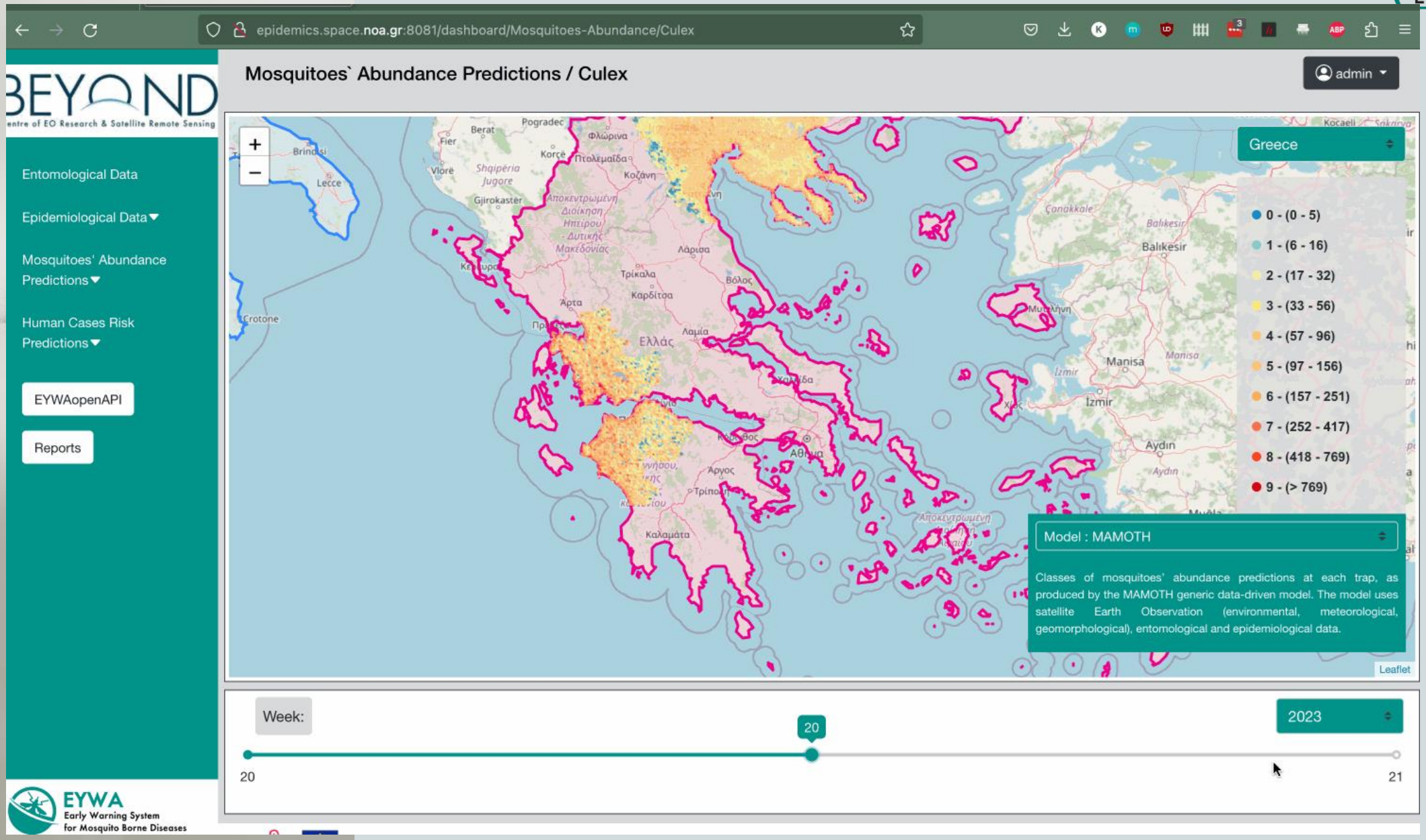

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In Summary

EO creates opportunities for Health & Epidemics

- **EYWA** set the stage for the creation of **a truly big unique databases** of **entomological & epidemiological data augmented with EO derived data.**
- Enabled the creation of **advanced data-driven & deterministic models** for mosquito abundance & risk mapping.
- The platform supports the visualization of the **global entomological & epidemiological** datasets.
- Also provides visualization for the **model predictions** for stakeholders.
- It's a complete state-of-the-art Early Warning System.

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Thank you!

Contact us
kontoes@noa.gr
(Coordinator of EuroGEO Action Group for Epidemics)
(Lead Partner of EYWA)

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Greece

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

Ecodevelopment S.A

University of Patras – Physics Department - Laboratory of Atmospheric Physics (LapUP)

Dimitrios Vallianatos (IDCOM)

Aristotle University of Thessaloniki

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

Italy

Istituto Zooprofilattico Sperimentale delle Venezie (IZSVe)

Edmund Mach Foundation

University of Trento

Serbia

University of "Novi Sad", Faculty of Agriculture, Laboratory for Medical and Veterinary Entomology

Scientific Veterinary Institute "Novi Sad"

University of Novi Sad, Faculty of Medicine

Germany

German Mosquito Control Association (KABS)

Bernhard Nocht Institute for Tropical Medicine

France

EID Méditerranée

European Commission

Joint Research Center

Ivory Coast

Centre Suisse de Recherches Scientifiques en Côte d'ivoire

Thailand

Vector Biology and Vector Borne Disease Research Unit, Department of Parasitology, Faculty of Medicine, Chulalongkorn University

Ghana

Department of Geomatic Engineering, College of Engineering, Kwame Nkrumah University of Science and Technology