





The EYWA platform: Powering an Early Warning System

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http://beyond-eocenter.eu/

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



EARLY WARNING PREPRODUMICS PRIZE DISCONTINUE European Commission

Winner of the first "EIC Horizon Prize on Early Warning for Epidemics"





Public Health

Authorities

Epidemiological data

WNV

Malaria

Chikungunya, Zika, Dengu

......

Mosquito traps

Network

Entomological data

Culex

Anopheles

Aedes

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DataCube for

Big EO Data

Management

Data Integration

Security & GDPR

compliance

ENSEMBLE

MODELS

Mosquitoes abundance and

human cases risk prediction maps & statistics

Reports for end-users

Storage

AGEMENT

TIER

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BAR site-specific

data-driven model

TIER 6 KNOWLEDGE REPRESENTATION

EXPLANATION

HUMAN CASES RISK PREDICTION MODELS

MIMESIS generic

dynamic mode

2

GitHub

EYWAdcAPI

PostGIS

8

Public Statistical

Authorities

Socioeconomic data

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NDVI NDMI

NDWI NDBI

CORINE Land Use / Land Cover

levation, Aspect

Data Analytics

Discovery & Exploration

Satellites and ground stations

Sentinel-2 MODIS X/L Antenna Landsat 7 & 8

Earth Observation data &

Meteorological dat

CREODIAS

Google Earth Engine

Feature Engineering

& Expansion

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Web Platform UI

GEOSS Portal

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TIER CES &

TIER 2 DATA INGESTION & PRE-PROCESSING

EXPLORATORY DATA

MAMOTH generic

data-driven

auto-calibrated

model

Mosquito Vision application

Open data sharing through the

EYWAopenAPI

NEXTGEOSS

GEOSS Portal

TIER 4

PREDICTIVE

TIER 5



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Making it work The EYWA architecture

- Time-series entomological, epidemiological, socioeconomic, 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)



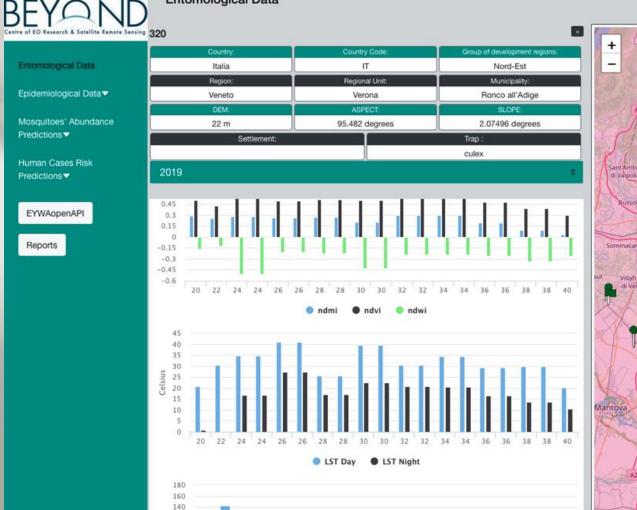


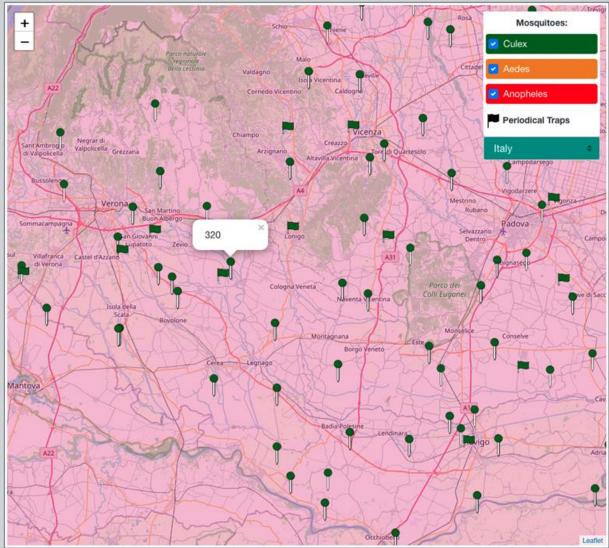
Entomological Data

What does the feature-space look like?





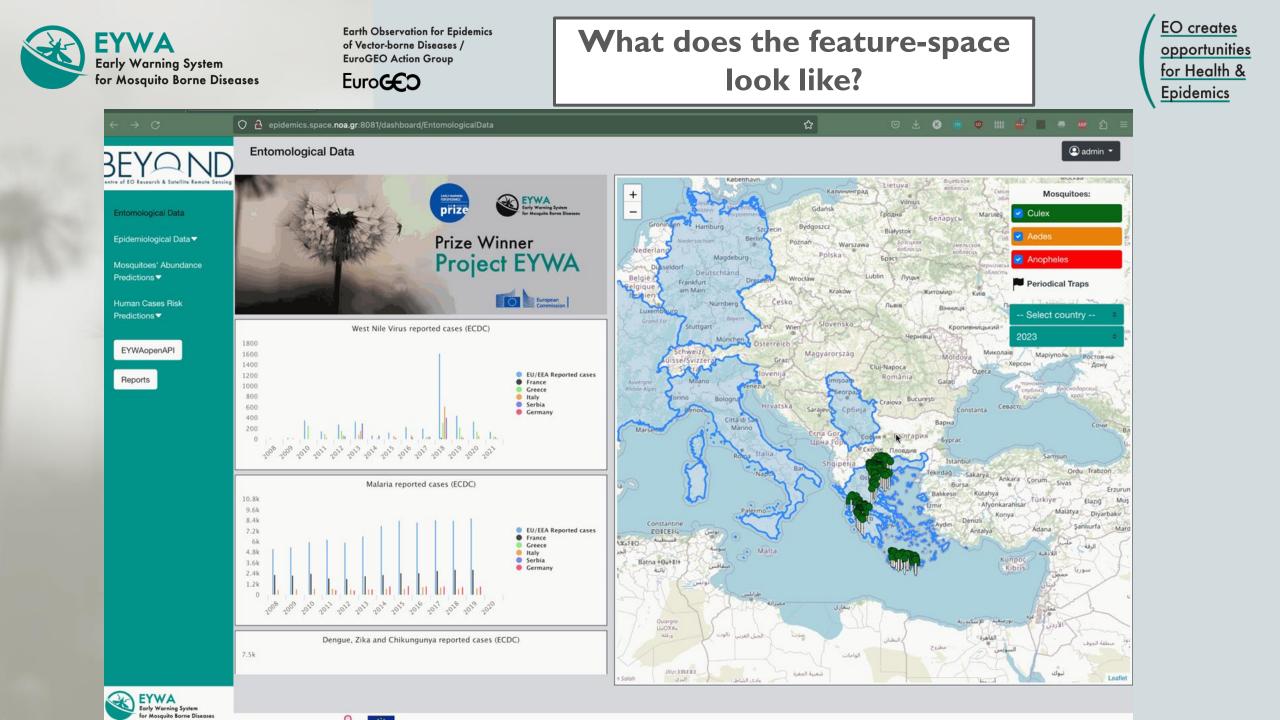






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System Evolution





Satellites and ground stations Mosquito traps Public Statistical Public Health Network Authorities Authorities GEOSS Portal DATA 0 waat ۲ os Sentinel-2 MODIS X/L Antenna Landsat 7 & 8 TIER CES & Entomological data Epidemiological data Socioeconomic data Earth Observation data & Meteorological data Culex WNV 0000 Anopheles Malaria Chikungunya, Zika, Dengue Aedes [sta 2 DataCube for CREODIAS Big EO Data NDVI NDMI TIER 2 DATA INGESTION & PRE-PROCESSING DATA APIs 0 GitHub Management NDWI NDBI the start Google Earth Engine EYWAdcAPI CORINE Land Lise / the -Climate Change Service Land Cover SENTINELS 2 levation, Aspect AGEMENT TIER Data Integration UN Land ω Storage ANALYSIS EXPLORATORY DATA Feature Engineering SECU PostGIS & Expansion B TIER 4 20 Security & GDPR 8 compliance Data Analytics **Discovery & Exploration** ENSEMBLE HUMAN CASES RISK PREDICTION MODELS MOSQUITOES ABUNDANCE PREDICTION PREDICTIVE MODELS MODELS BAR site-specific **MIMESIS** generic TIER 5 data-driven model BAd MAMOTH generic dynamic mode site-specific data-driven data-driven auto-calibrated model model Web Platform UI Mosquito Vision application Mosquitoes abundance and TIER 6 KNOWLEDGE REPRESENTATION & human cases risk prediction maps & statistics EXPLANATION Reports for end-users End-users Open data sharing through the Data **EYWAopenAPI** • visualization R **NEXTGEOSS** upload . dillibility. download GEOSS Porta

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EO creates opportunities for Health & Epidemics

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

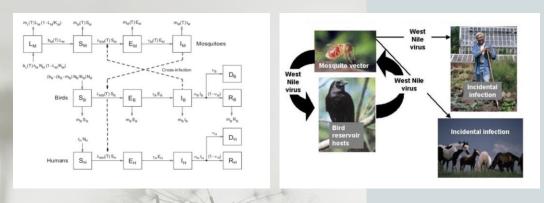
- BAd (ECODEV) abundance
 model
 - Settlement level
 - Weekly predictions

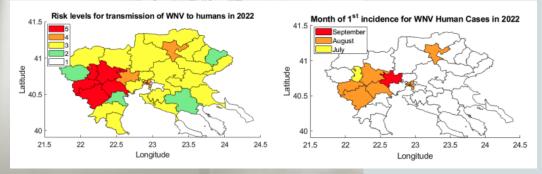
MAMOTH (NOA)

- Point/Trap level.
- Aggregate predictions for any larger area
- Biweekly/Monthly predictions.



Euro GEO





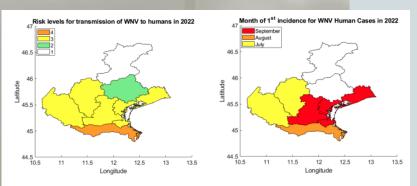


Figure 6. (Left) Map of the risk level of occurrence of WNV human cases in Veneto, (Right) Map with the month of incidence for WNV human cases in Veneto.



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MIMESIS (Univ. of Patras)

MIMESIS (spatial dynaMIcal Model for wESt nlle viruS)

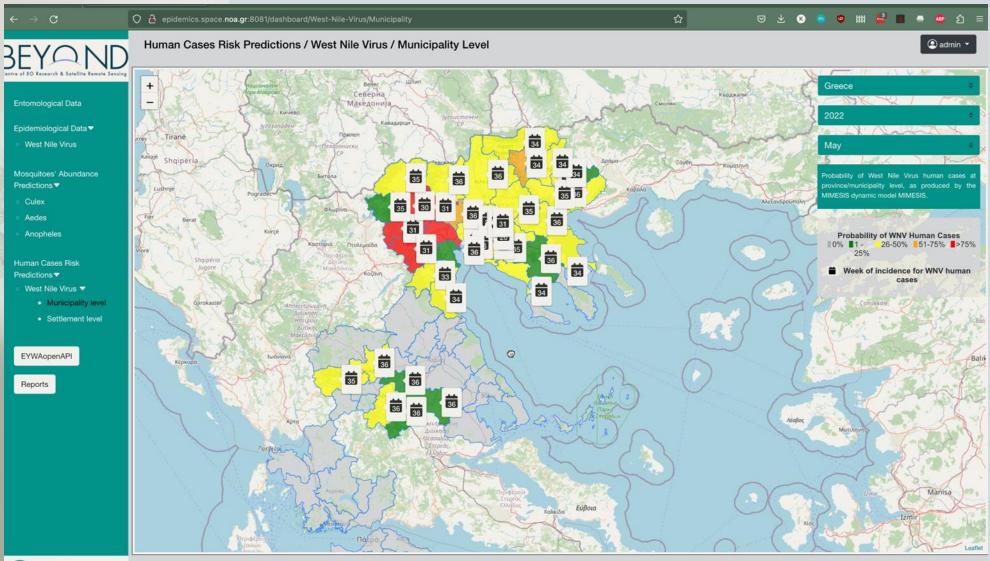
- Developed by the Laboratory of Atmospheric Physics of the University of Patras.
- Climate dependent epidemiological (deterministic) model that works on a ensemble probabilistic frame that provides West Nile Virus risk maps.
- □ The model operates spatially at the meso-scale and temporarily at the monthly 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
 I 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)



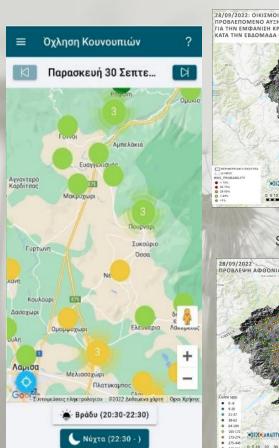




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BAd & BAR (ECODEV)

EO creates opportunities for Health & Epidemics



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 I level on average for cases registered in the August/September period, for an accuracy of 85%.

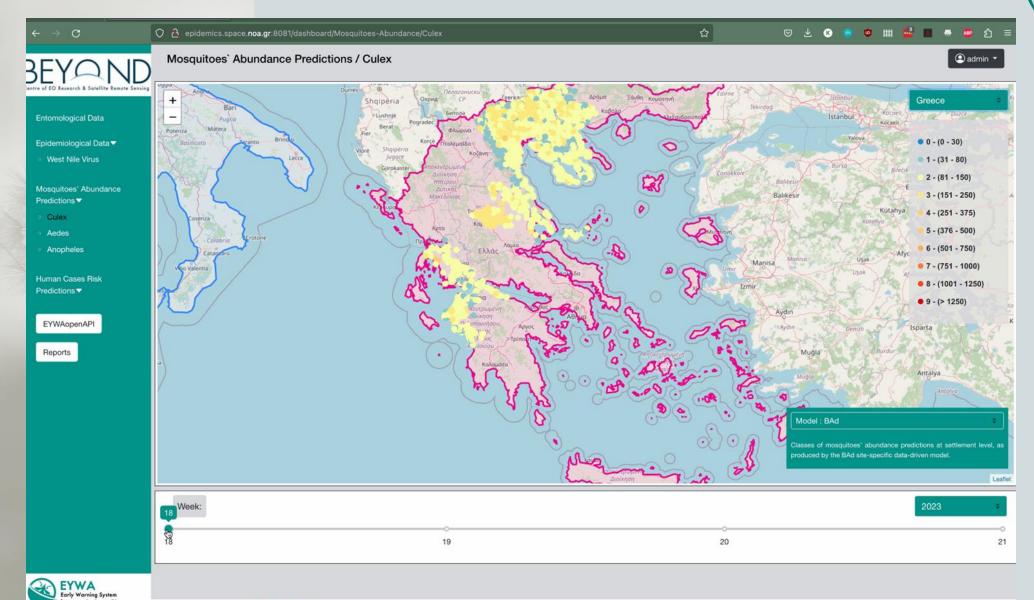


or Mosquito Borne Diseases

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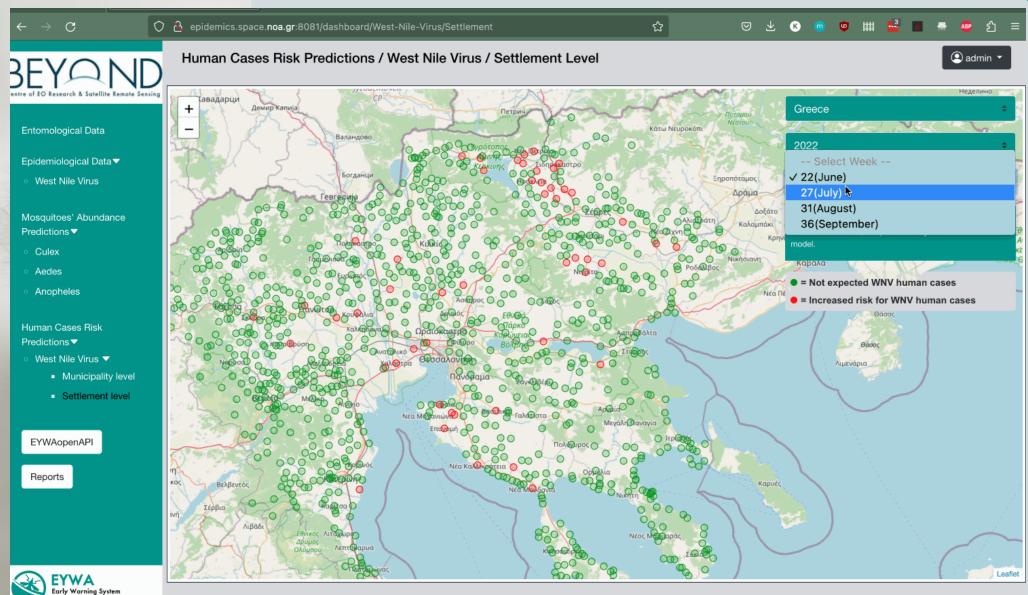


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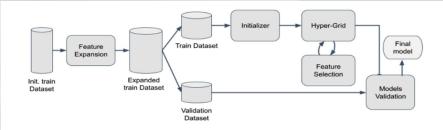
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BAd (ECODEV)

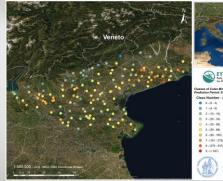




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Model Training Pipeline





Operational predictions (Veneto region) Mosquito abundance aggregate statistics (color represents mean value) Delta municipality, Central Macedonia

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

MAMOTH (NOA)

EO creates opportunities for Health & Epidemics

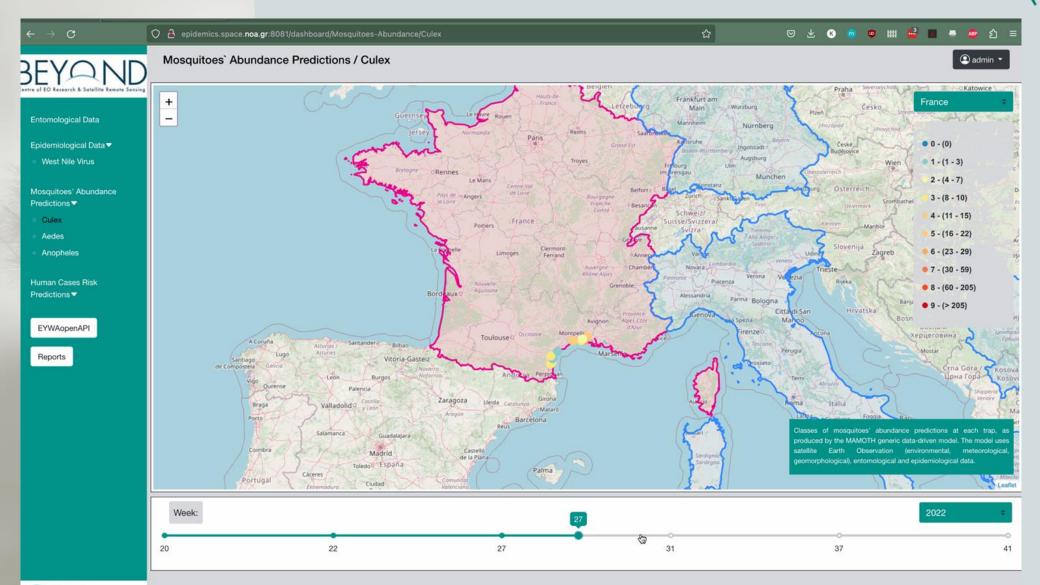
MAMOTH (Mosquitoes Abundance prediction Model autO-calibrated from features pleTHora)

- □ Data driven model, developed by the Beyond Operational Unit of the IAASARS/National Observatory of Athens using the I2-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.



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EYWA Early Warning System for Mosquito Borne Diseases

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Early Warning System for Mosquito Borne Diseases

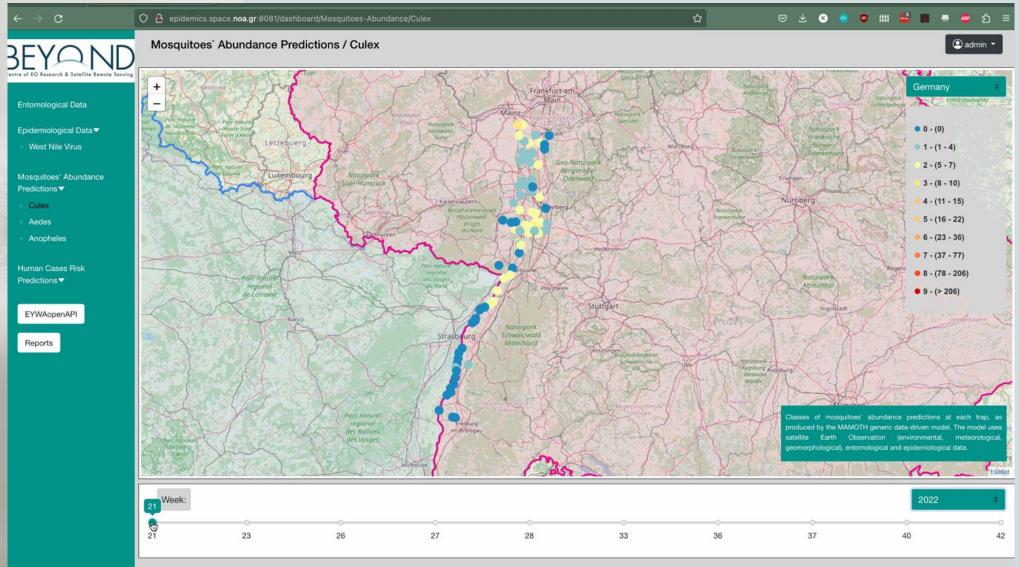
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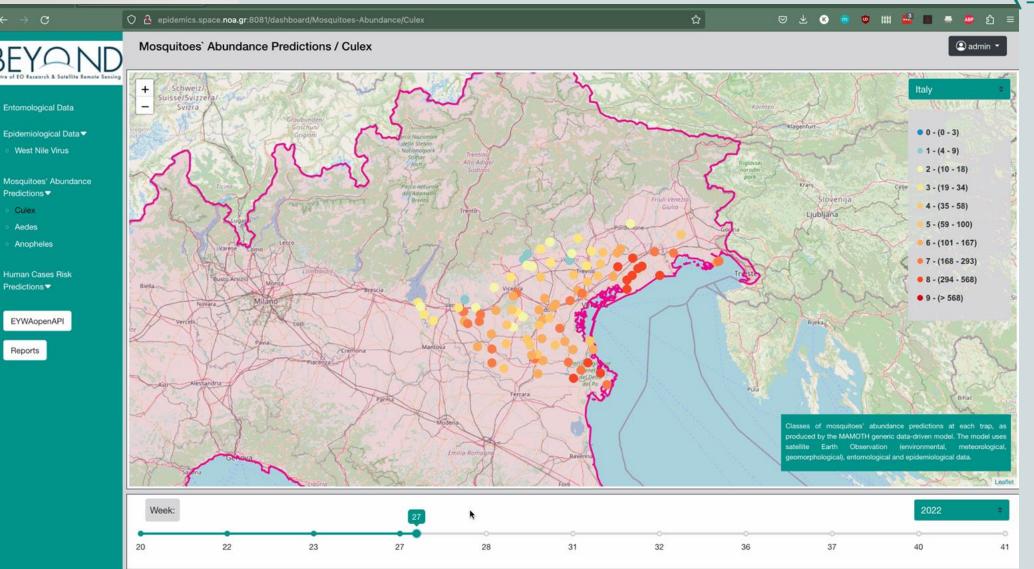
MAMOTH (NOA)



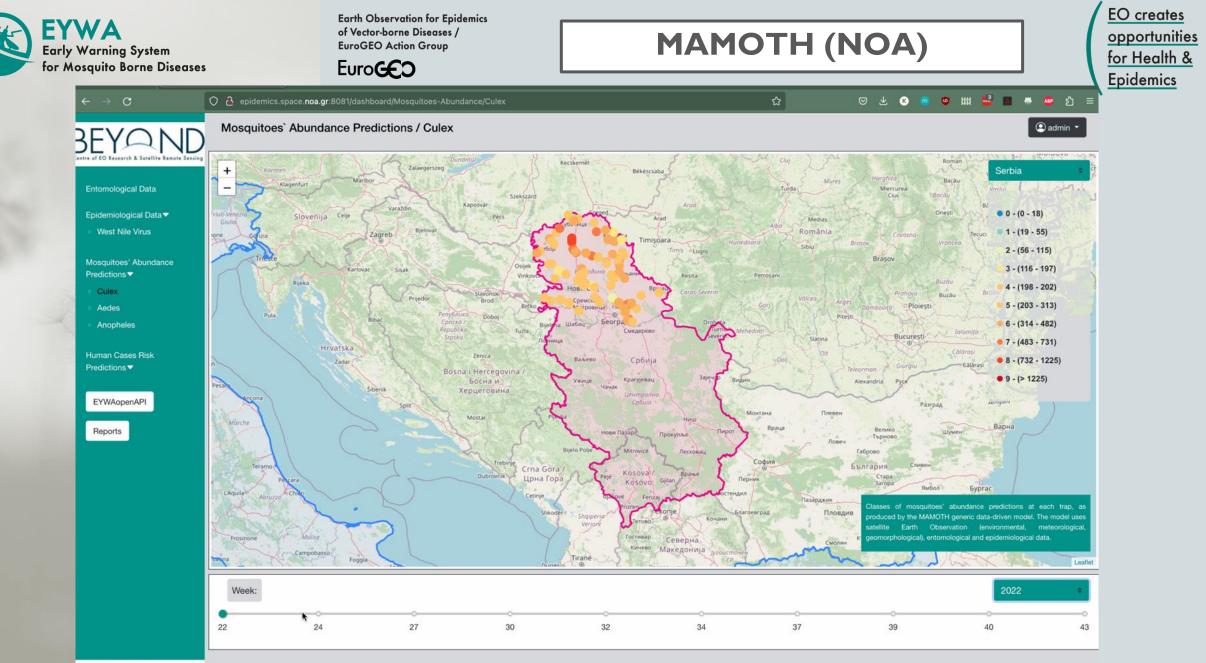


MAMOTH (NOA)

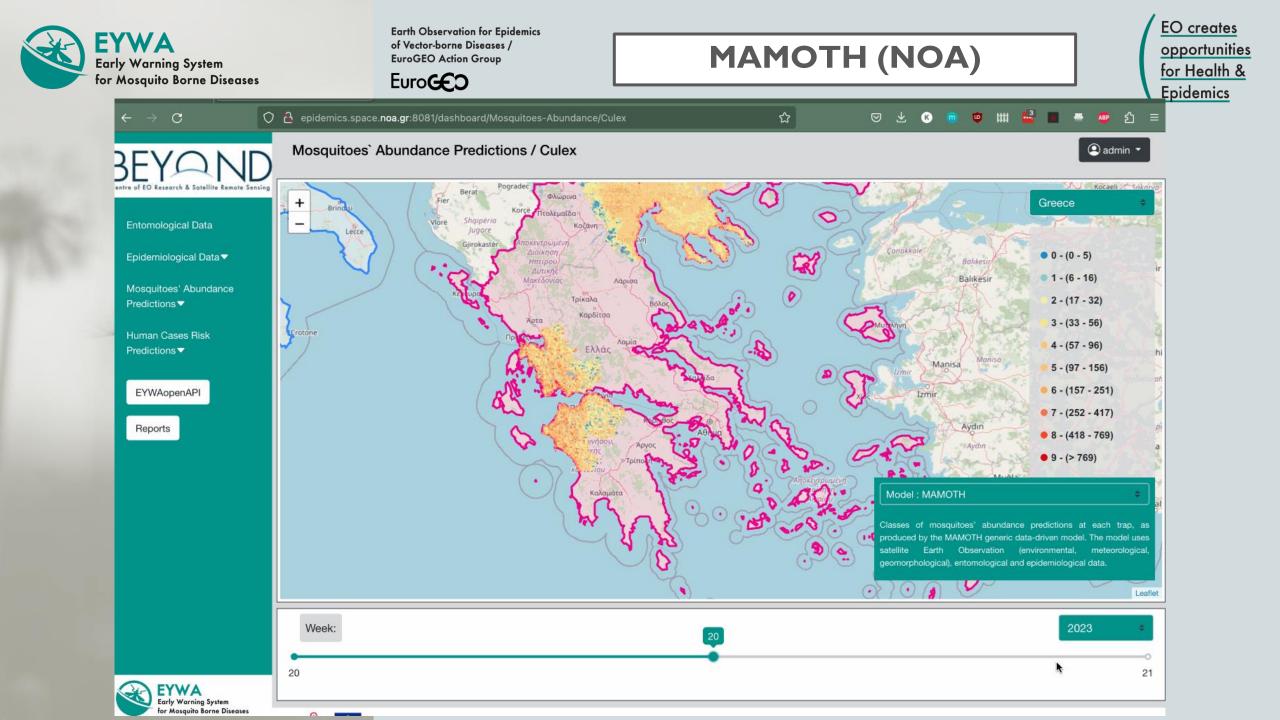








EYWA Early Warning System for Mosquito Borne Diseases





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!

EO creates opportunities for Health & Epidemics



Contact us

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(Coordinator of EuroGEO Action Group for Epidemics) (Lead Partner of EYWA)

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Euro GEO

19 Partners | 8 Countries 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

Ivory Coast

Centre Suisse de Recherches Scientifiques en Côte d'ivoire

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