

EYWA: An established Early Warning System to Address World Wide Epidemics Crisis caused by the Mosquito Borne Diseases in Operational Context



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

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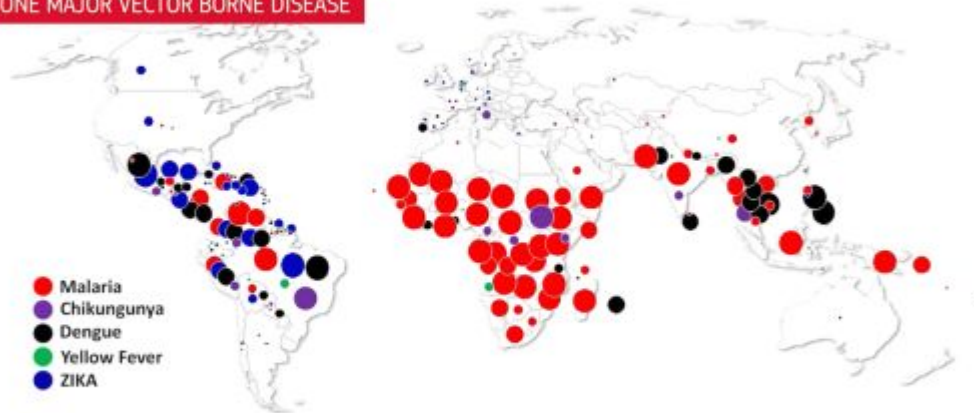
Earth Observation for Epidemics
of Vector-borne Diseases /
EuroGEO Action Group



Introduction | MBDs A global problem to be addressed

80% OF THE GLOBAL POPULATION

LIVES IN THE AREAS OF AT LEAST ONE MAJOR VECTOR BORNE DISEASE



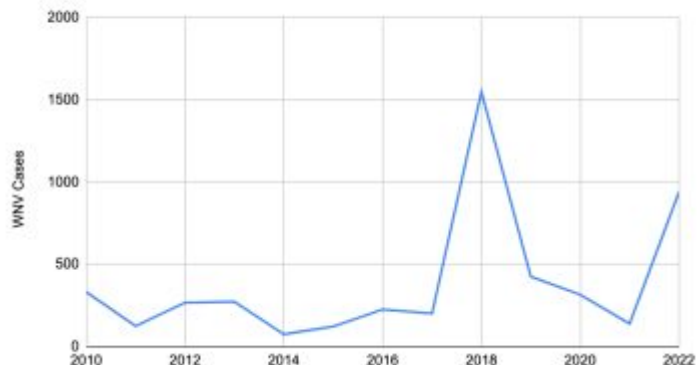
Re-emergence of significant mosquito born disease, including outbreaks, reported native and imported cases (2017-2019)

- ❑ **Climate Change, globalisation** and other drivers are altering ecological conditions for **mosquitoes**.
- ❑ Mosquito-Borne Diseases (MBDs) are present in **over 100 countries**.
- ❑ 700,000 deaths per year.
- ❑ **Malaria**, most lethal for kids aged under five in the sub-Saharan regions.
- ❑ **Europe** a “hot spot” of **West Nile Virus**.
- ❑ **Chikungunya** and **dengue fever** increased 40% over 1950¹.

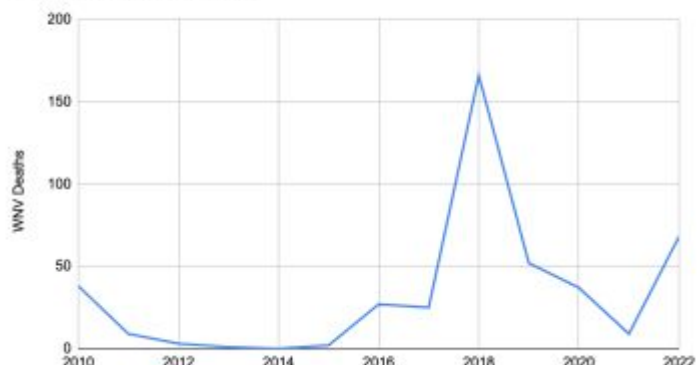
EYWA & West Nile Virus in Europe

- ❑ **West Nile Virus** outbreaks have been registered in all of **southern Europe**.
- ❑ Starting to register cases in 2010, the disease had extreme outbreaks in multiple countries in **2018** with **1549** cases and **166** deaths in a year.
- ❑ In 2022 there is another outbreak ongoing in cases with **939** cases and **68** deaths so far.
- ❑ Overall **4989** cases and **437** deaths in the past **12** years.
- ❑ EYWA supports **11** regions in Europe for a total of **10.909** municipalities and more than **34M** people living in them.

WNV Cases in Europe



WNV Deaths in Europe

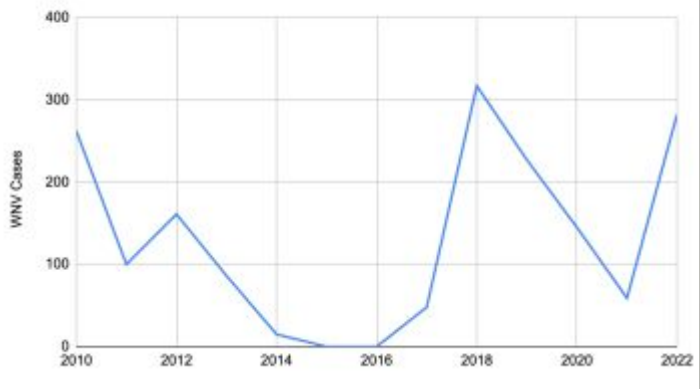


| Country | Region | Municipalities | Population |
|--------------|-------------------|----------------|-------------------|
| Italy | Veneto | 581 | 4,865,380 |
| Italy | Trentino | 176 | 541,098 |
| Serbia | Vojvodina | 37 | 1,931,809 |
| Germany | Baden-Württemberg | 74 | 11,111,496 |
| France | Occitania | 4,454 | 5,933,185 |
| France | Grand-Est | 5,121 | 5,556,219 |
| France | Corsica | 360 | 349,465 |
| Greece | Central Macedonia | 38 | 1,792,069 |
| Greece | Thessaly | 25 | 687,527 |
| Greece | Western Greece | 19 | 679,796 |
| Greece | Crete | 24 | 617,360 |
| Total | | 10,909 | 34,065,404 |

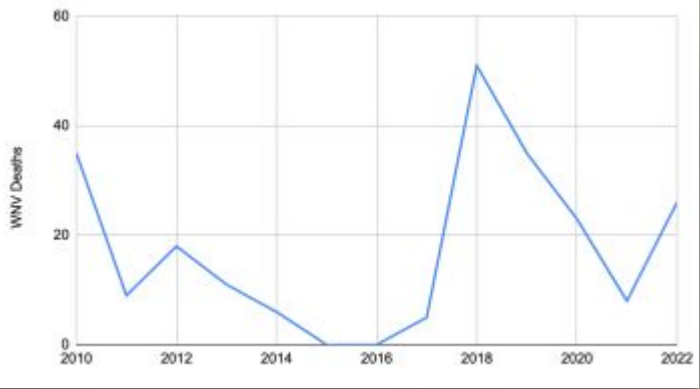
EYWA & West Nile Virus in Greece

EO creates opportunities for Health & Epidemics

WNV Cases in Greece



WNV Deaths in Greece



Aversion of Entomological Risks and Pathogen Transmission by 40-50% based on Health Records



- ❑ **Greece** has been at the epicenter of multiple **WNV** outbreaks.
- ❑ In **2010** Greece registered 262 cases and 35 deaths.
- ❑ The disease shows a cyclical pattern every few years, with a new peak in **2018** with 317 cases and 51 deaths.
- ❑ In **2022** another large increase in cases with 282 cases and 26 deaths so far.
- ❑ Overall Greece has registered **1702 cases** and **227 deaths** in the past 12 years.
- ❑ **EYWA** supports **4 regions** with a total of **2500 settlements** and **3.8M people**.

EYWA & MBDs in Ivory Coast

Mosquito Threats in Ivory Coast:

- ❑ Aedes Aegypti spread Dengue Fever, Chikungunya, Yellow fever, Zika fever and more disease agents
- ❑ Anopheles spread Malaria

Challenges:

- ❑ Different climatic conditions
- ❑ Different socioeconomic conditions
- ❑ Non-uniformity in data collection methods
- ❑ In contrast to the European regions mosquitoes in Ivory Coast are active all year round

Health risks:

Malaria in 2020:

- ❑ 26.378.275 population at risk, 7.434.595 suspected cases, 4.587.859 confirmed cases, 2.252.312 in children under 5, 103.947 severe cases, 1.315 deaths.

Dengue fever outbreaks:

- ❑ 2010², 28 suspected cases
- ❑ 2017³: 623 suspected cases, 2 deaths
- ❑ 2022⁴: 11 confirmed cases, 1 death
- ❑ Outbreaks in **Abidjan** with a population of **6.321.017**.

1. <https://www.cdc.gov/globalhealth/countries/cote-d-ivoire/default.htm#malaria>
2. <https://www.sciencedirect.com/science/article/pii/S0399077X14002054>
3. <https://www.who.int/emergencies/disease-outbreak-news/item/04-august-2017-dengue-cote-d-ivoire-en>
4. <https://www.africanews.com/2022/05/04/dengue-fever-outbreak-one-dead-11-cases-recorded-in-ivory-coast/>



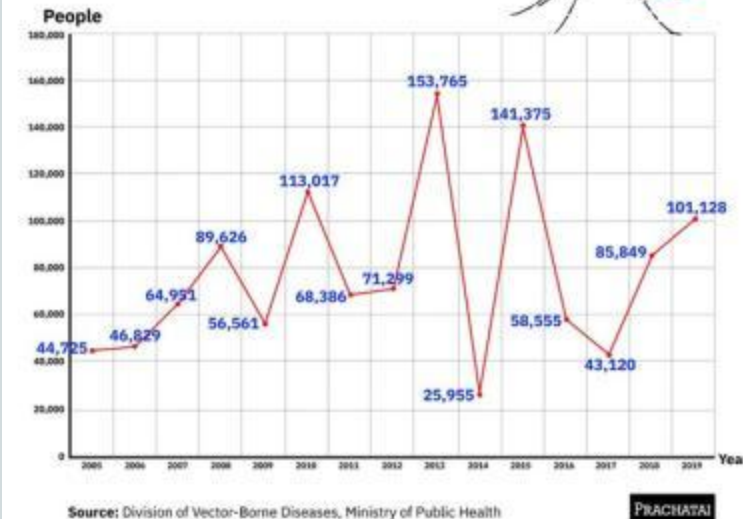
Dengue fever:

- ❑ Dengue is hyper-endemic and all 4 serotypes are in active circulation in Thailand (home to around **69 million individuals**).
- ❑ Two dominant dengue mosquito vectors, **Aedes aegypti** and **Aedes albopictus**
- ❑ Each of the 77 provinces in Thailand have on average, non-zero reported dengue case counts over the past 10 years¹.
- ❑ Large outbreaks in 2013, 2015 and 2019 with 153,765, 141,375 and 128,964 respectively².

Chikungunya:

- ❑ Thailand experienced outbreaks in 2008-2009 (49,069 cases³), and 2018-2019 (approximately 15,000 cases⁴).

DENGUE FEVER PATIENT STATISTICS 2003-2019



1. <https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-020-05666-4>
2. <http://outbreaknewstoday.com/thailand-infectious-diseases-2019-measles-dengue-and-melioidosis-30041/>
3. <https://www.ajtmh.org/view/journals/tjpm/90/3/article-p410.xml>
4. <https://pubmed.ncbi.nlm.nih.gov/33690657/>

EYWA' and its
Transfer Learning
Capability provides a
beneficial and
promising feature to
support mitigation
larvaciding and
adulciding actions
and door-to-door
awareness

MBDs in Ghana

Malaria (2020 data):

- ❑ 31.072.945 population at risk, 5.879.506 suspected & confirmed cases, 12.084 estimated deaths.

Yellow fever outbreak in 2020I:

- ❑ 3.510.665 population at risk in regions with registered cases
- ❑ 202 suspected cases
- ❑ 70 confirmed cases
- ❑ 35 deaths

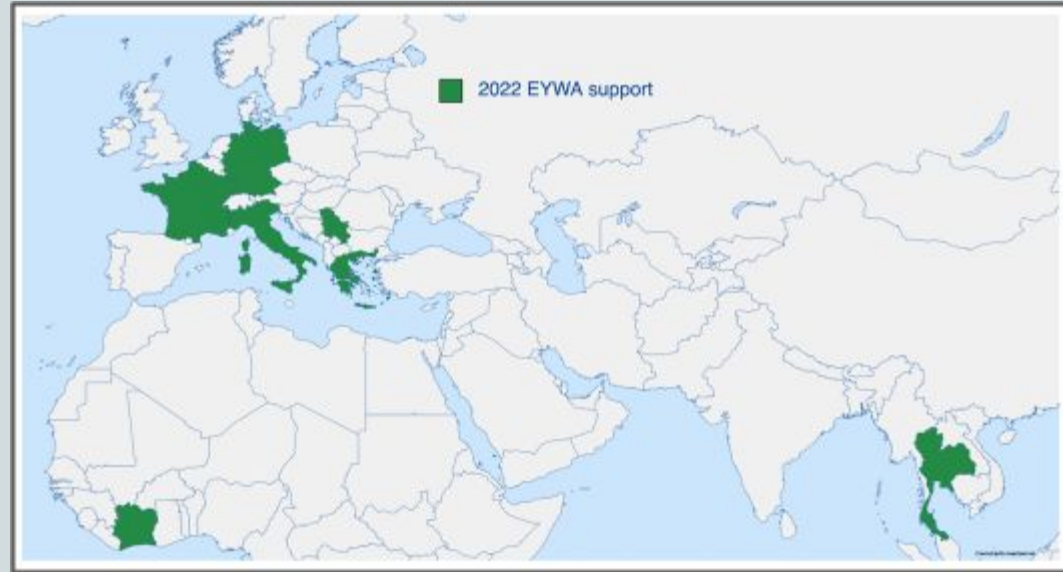
Open/transfer
EYWA and set
collaboration
with Ghana
stakeholders



Areas of yellow fever outbreak in Ghana ([CDC](#))

Working towards a solution

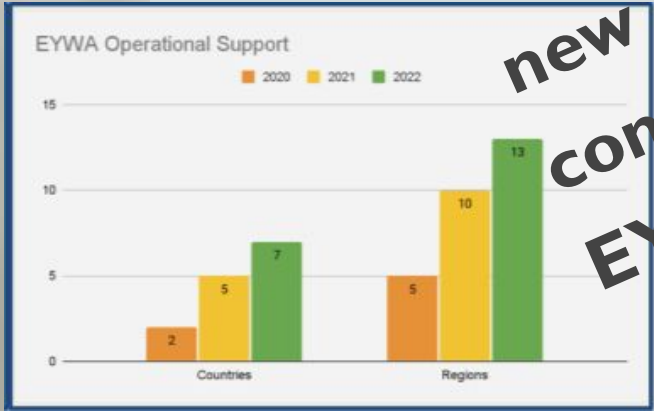
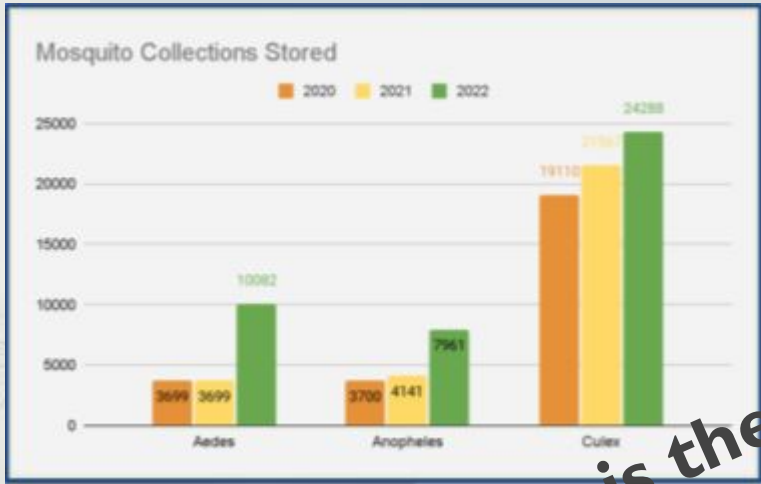
- ❑ After three years of developments the system started its operation in **2020**.
- ❑ Predictions were provided for **4 regions** in **Greece** and **1 region** in **Italy**.
- ❑ In **2021** the system expanded to a total of **10 regions** in **5 European countries** (**France, Germany, Greece, Italy, Serbia**).
- ❑ Joining the e-shape Horizon 2020 project, EYWA expanded to **Cote d'Ivoire** and **Thailand**.
- ❑ Following up on this in **2022** the system expanded to provide predictions in **Ivory Coast** in **Africa** and **Thailand** in **Asia**.
- ❑ Additionally the **Trento** region in **Italy** was integrated bring the total number of regions to 17.



What EYWA offers?

A couple of weeks/one month earlier it informs on mosquito abundance and pathogen transmission and suggests preventive and awareness door-to-door actions in the villages at risk

A fragmented landscape



What is the new in the concept of EYWA?

After EYWA

EYWA set the stage for:

- ❑ Data centralization in a common database
- ❑ Big features spaces of environmental, entomological, health, socio-economic, climatic data
- ❑ Validated Transfer Learning models

Before EYWA:

- ❑ Siloed collections Entomological & epidemiological records
- ❑ Lack of data providing dynamics:
 - Environment, weather, landscapes hosting areas mosquitoes
- ❑ No Standardization in feature engineering to feed AI/Dynamic forecasting models
- ❑ No robust/transferable solutions

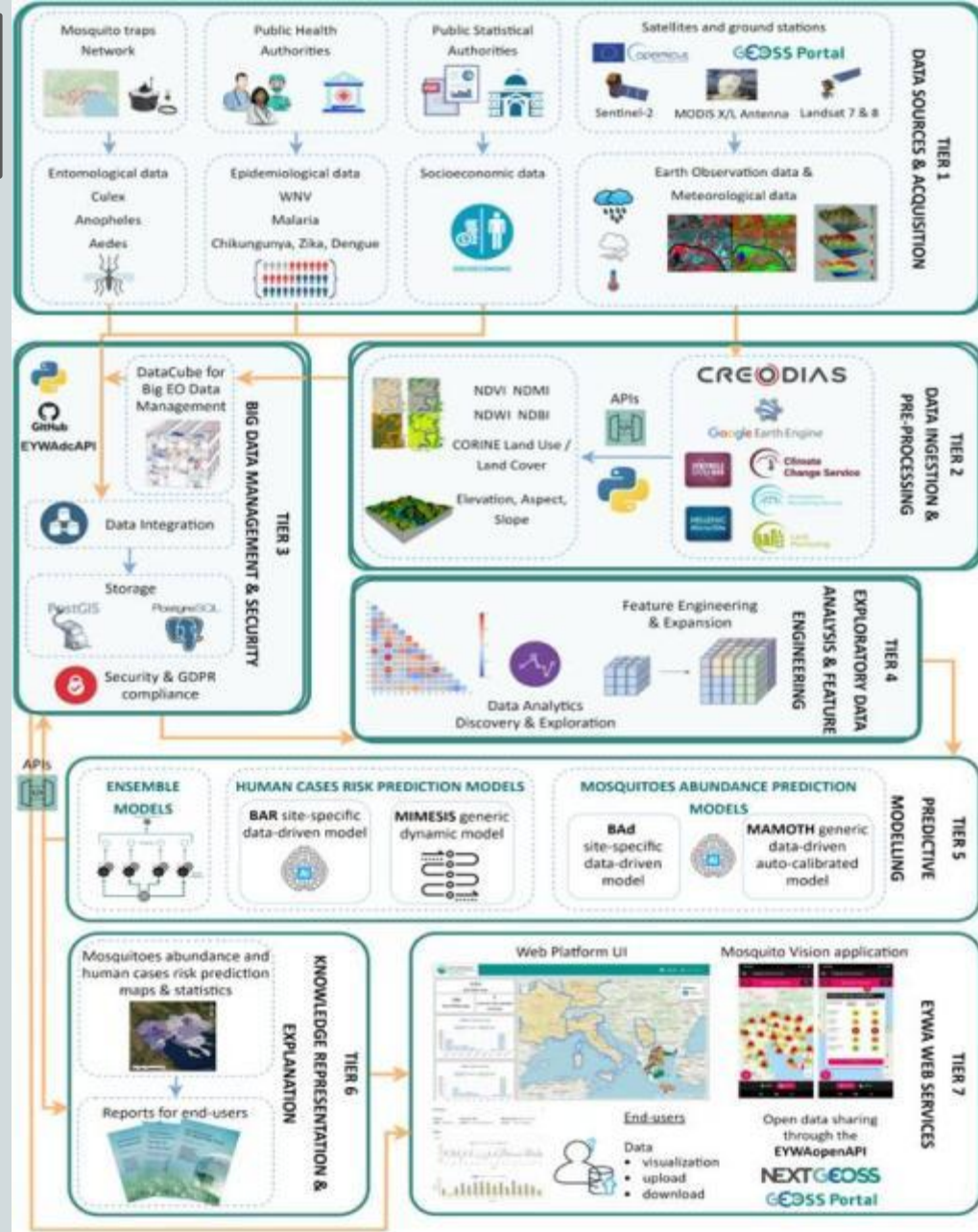
Making it work

The EYWA architecture

Benefits

- ❑ Tools for Federated and Free Access to big/extreme Data
- ❑ Advanced DataCube/DB engines to store/open data
- ❑ Ready-to-use trained/validated AI/ML/DL models
- ❑ User friendly web/mobile frontend for early awareness
- ❑ Mapping/visualization/reporting tools

- ❑ 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 33 TB of Earth Observation data to generate them.
- ❑ **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** (Copernicus ERA-5, MODIS, IMERG):
 - Wind, Land Surface Temperature (**LST**), Rainfall
- ❑ **Geomorphological Data** (Alos Palsar, Copernicus Water & Wetness):
 - Elevation, Aspect, Slope
 - Composite features



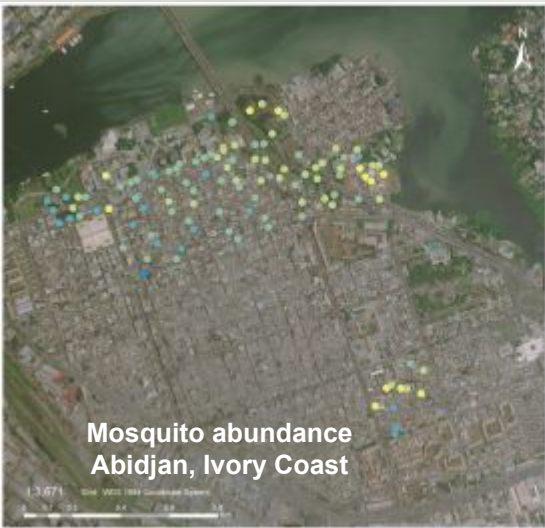
What/where does EYWA provide as models for Early Warning?



- **Type of Model:** Mathematic, XGboost, Neural Network
- **Spatial Resolution:** City Block
 - Village-Municipality-Region-Country
- **Temporal Resolution:** Weekly-Monthly-Seasonally
- **Type of Mosquito:** All
- **Door-to-Door:** Established in thousands of houses during the mosquito period
- **Risk Forecast Accuracy:** >90%
- **MIMESIS (Univ. of Patras), and BAR (ECODEV) WNV risk models**
 - Municipality/Settlement level
 - 4 regions in Greece and 1 in Italy
 - Support preventive actions
 - Door to door awareness
- **BAd (ECODEV) abundance model**
 - Settlement level
 - 4 regions in Greece
 - Mosquito Vision: notifications through app >2400 villages in Greece
- **MAMOTH (NOA) abundance model**
 - Available for 3 mosquito species (**Aedes, Anopheles, Culex**)
 - 5 European countries 2 non-EU

Operational Products

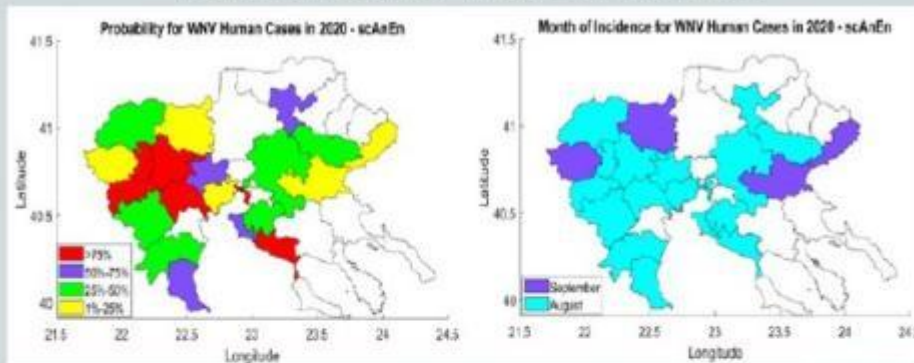
EO creates opportunities for Health & Epidemics



Mosquito abundance Abidjan, Ivory Coast



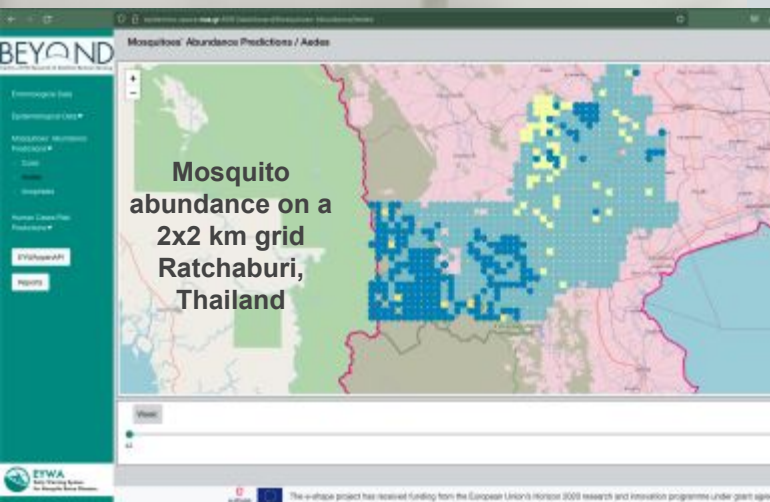
Human case risk forecast – Region of Central Macedonia - Dynamic modelling – Issued on 25/07/2020



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 on a 2x2 km grid Ratchaburi, Thailand



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



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

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



In Summary

- ❑ **EYWA** is an established truly **impactful & transferable** Early Warning System.
- ❑ The system is **expanding** each year **to new regions** with different climatic & socioeconomic conditions.
- ❑ Models provide true **early warning services** and guide **targeted** peri-urban larviciding actions and **door to door** awareness campaigns.
- ❑ Established **expansion to a large number of regions worldwide**, providing support of entomological risk
- ❑ Highlights the power of **Earth Observation** in supporting the **communities** and **Health Systems** around the world.

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

15 Partners | 5 Countries

Greece

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

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Dimitrios Vallianatos (IDCOM)

Aristotle University of Thessaloniki

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

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Scientific Veterinary Institute “Novi Sad”

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German Mosquito Control Association (KABS)

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