EYWA
Early Warning System
for Mosquito Borne Diseases

ΕΜΠΡΟΣ
(EMPROS)

e-shape

EO creates opportunities for Health & Epidemics

Πρόγραμμα Ερευνώ-Καινοτομώ "ΕΜΠΡΟΣ": Ολοκληρωμένο σύστημα πρόβλεψης κρουσμάτων WNV

Ερευνητική Δράση που υποστηρίζει την δημιουργία καινοτομίας του επιχειρησιακού προγράμματος EYWA για την αντιμετώπιση νοσημάτων από κουνούπια

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

EuroGEO

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BEYOND Center of Excellence for Earth Observation Research and Satellite Remote Sensing of the National Observatory of Athens

BIO Presenter

Haris Kontoes holds the position of Research Director in the Institute for Astronomy and Astrophysics Space Applications and Remote Sensing of the National Observatory of Athens (NOA/IAASARS) and leads the Center for Earth Observation Research and Satellite Remote Sensing BEYOND (www.beyond-eocenter.eu). Since 1992 he has been assuming responsibilities in managing Earth Observation operational & research projects, focusing on risk assessment and mitigation, disaster risk reduction, environmental resource management and sustainable development, agriculture and food security, energy and big data analytics for cross sector needs. He leads a multidisciplinary team of researchers with active participation in Space related projects supported by ESA, EC, **COPERNICUS**, **GEO**, **EUROGEO** and International Funding Institutions (WB, EIB, etc). He has been coordinating the operation of Copernicus Data Hubs, as well as the operation of the Hellenic Sentinel Data Mirror Site - http://sentinels.space.noa.gr). He coordinates the **GEO-CRADLE** initiative for the uptake of Earth Observation and Copernicus in the regions of Mediterranean, **North Africa, Middle East, Balkans, and Black Sea**. He is author of more than 200 publications in reviewed journals and scientific conferences. He is member of the editorial board of IJPRS, IJRS, SENSORS, IEEE Geoscience and RS and he is member of the Advisory Boards of EU and ESA programs and initiatives. He speaks English, French and Italian.

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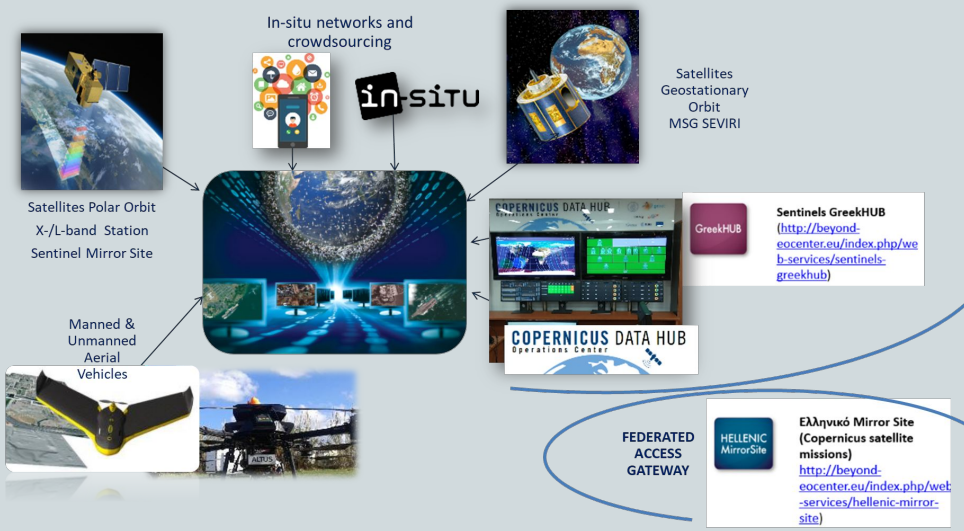
Beyond Centre of EO Research & Satellite Remote Sensing

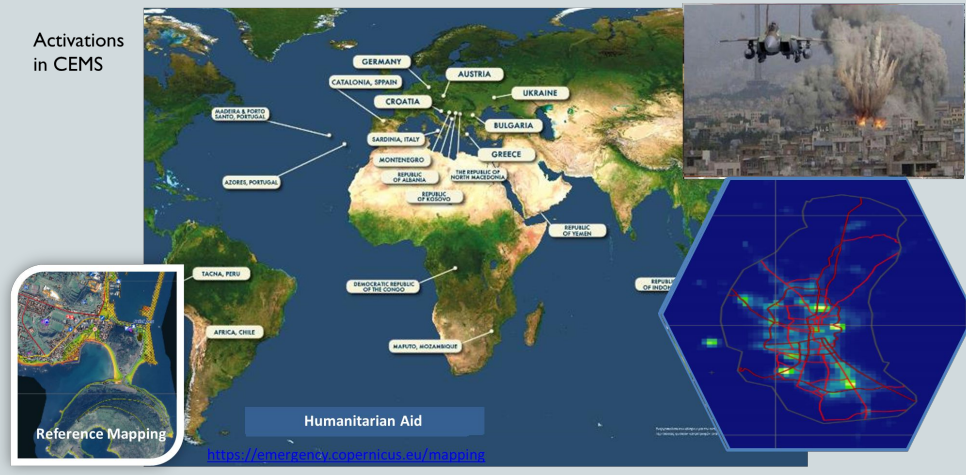
- The BEYOND Center of Excellence develops research and addresses societal and sector priorities in South Eastern Europe, Mediterranean, N. Africa, Middle East and the Balkans.

- The activity of the Center is supported by a multidisciplinary team of experts; annual turnover of 4MEuros from fully competitive R&I contracts

- **Axes of activity:**
- Observing from Space
- Security of Space
- Big Data Analytics
- Data Science and ML/DL/AI
- Modelling (simulation, assimilation) of Physical phenomena and processes
- Transform Data to Knowledge and support decision making processes in Disaster Risk Reduction, Food Security, Sustainable Environment, Climate Change Adaptation, Energy, Humanitarian Crisis, and Health Crisis

- The BEYOND Center has installed and operates large scale infrastructures for the systematic reception, management and redistribution of data acquired by satellites and in-situ monitoring networks. The





BEYOND Κέντρο Αριστείας Επιστημών Παρατήρησης της Γης & Δορυφορικής Τηλεπισκόπισης:

Η διαστημική τεχνολογία και η ανάπτυξη εξειδικευμένων υπηρεσιών για το περιβάλλον και τους πολίτες

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esa
esa
WEB SERVICES

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ΕΜΠΡΟΣ (EMPROS)

Early Detection and Warning on Earth status

Monitoring of the Environment and Climate

Creation of Operational Pictures and Dynamic Changes of Landscape, Ecology, Wildlife Hosting Ecosystems and Meteorological Factors

Gather and Assimilate in Real Time, as well as Weakly, and Seasonal basis Big Data from Entire Planet

Support Disciplines linked with One Health and Eco Health as Climate Change, Ecosystem Service Modeling, Prediction , Prevention and Decision Support in Human. Animal, and Environment Risks

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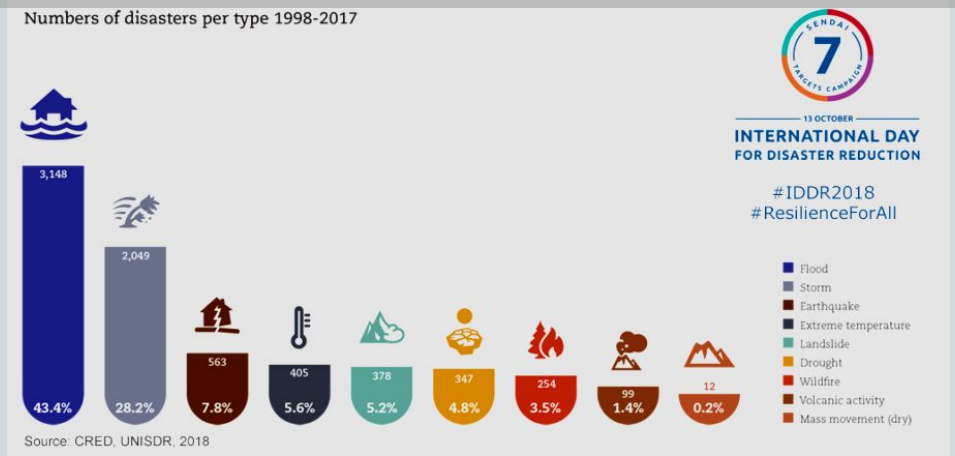
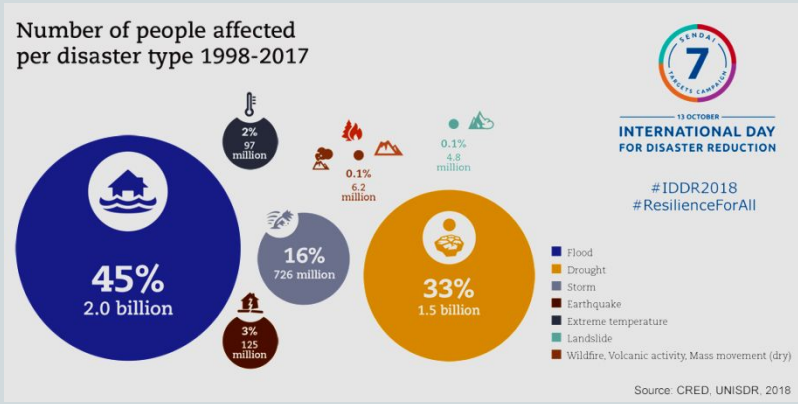
- **1 over 9 people** will be forced to abandon their homes due to climate change and natural disasters
- **1 billion of people** will leave Africa in the next 25 years due to draught and desertification





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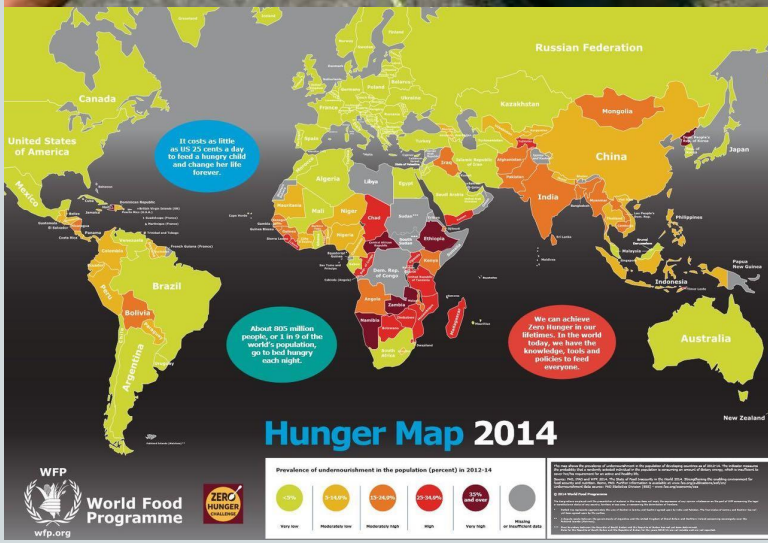
ΕΜΠΡΟΣ (EMPROS)

World hunger in numbers

(Source : United Nations)

- **11.3% of the world's population suffers from hunger**
- **805 millions of people** consume less than **2100 calories per day**
- **25,000 die from hunger every day**
- **9.1 millions of people die worldwide each year because of hunger**
- **4 children die from hunger every minute**

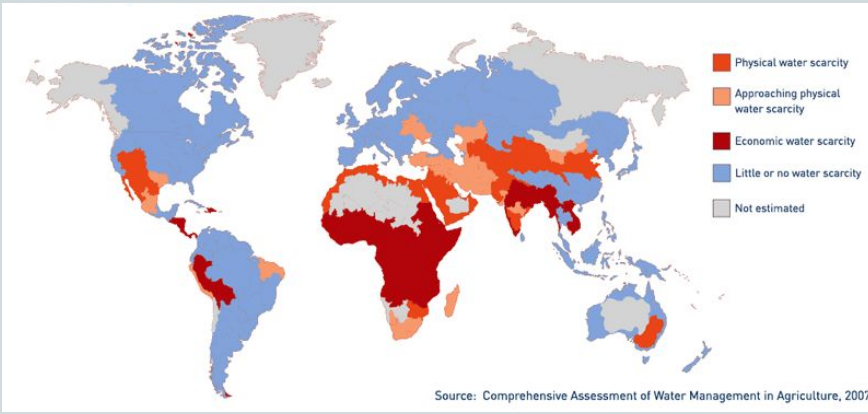
Poverty is the main cause of hunger
Poor land-use, over-exploitation of resources, and **lack of knowledge** in supporting the agricultural policy are factors that opposed to food security, rural economy and environmental/ ecological protection



Water scarci

(Source: United Nations)

- **2.8 billion people around the world** suffer from water scarcity for at least one month every year
- **1.2 billion people** lack access to clean drinking water
- **2.4 billion people** are exposed to diseases such as **cholera, typhoid fever** and others due to water scarcity
- **The absence of clean water and drainage systems contribute to infectious diseases,** with a huge impact on deaths worldwide
- **The irrational use, and the inability to know the water balance,** combined with **climate change** are the main water scarcity factors



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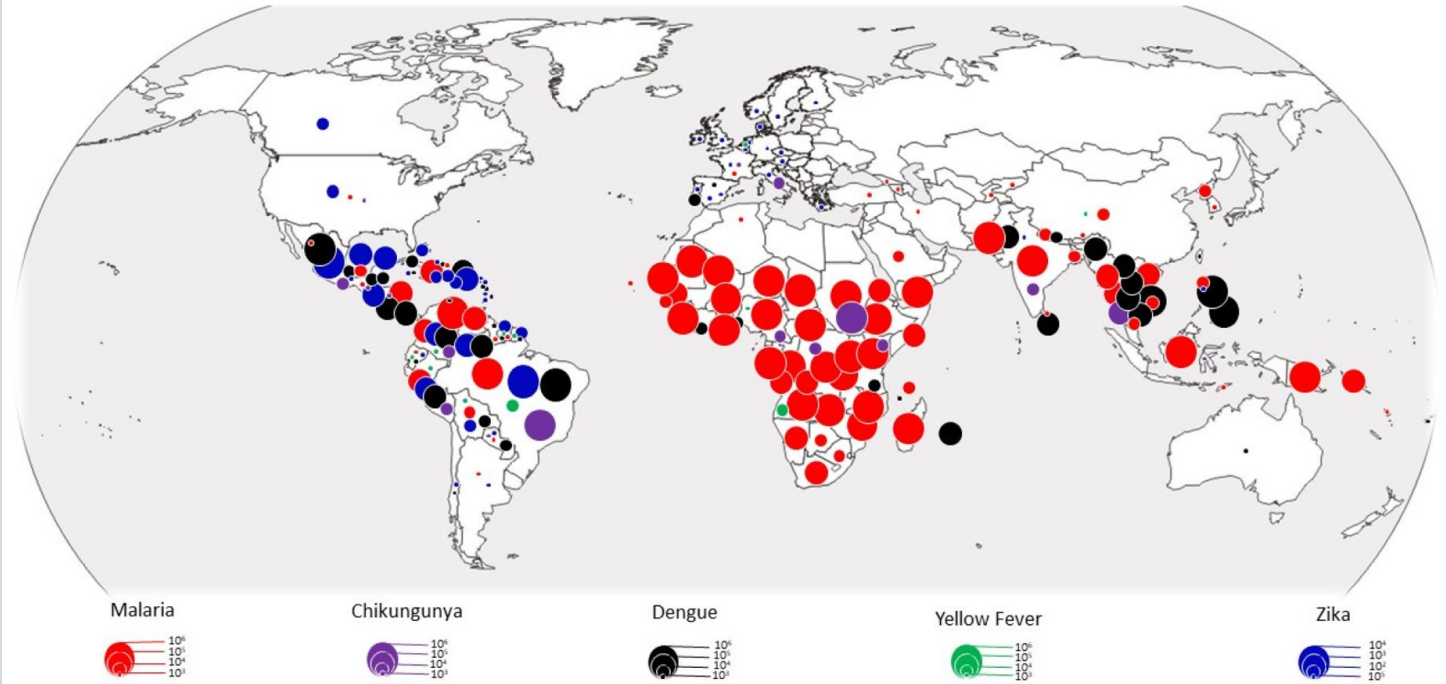
ΕΜΠΡΟΣ (EMPROS)

(Source: WHO)

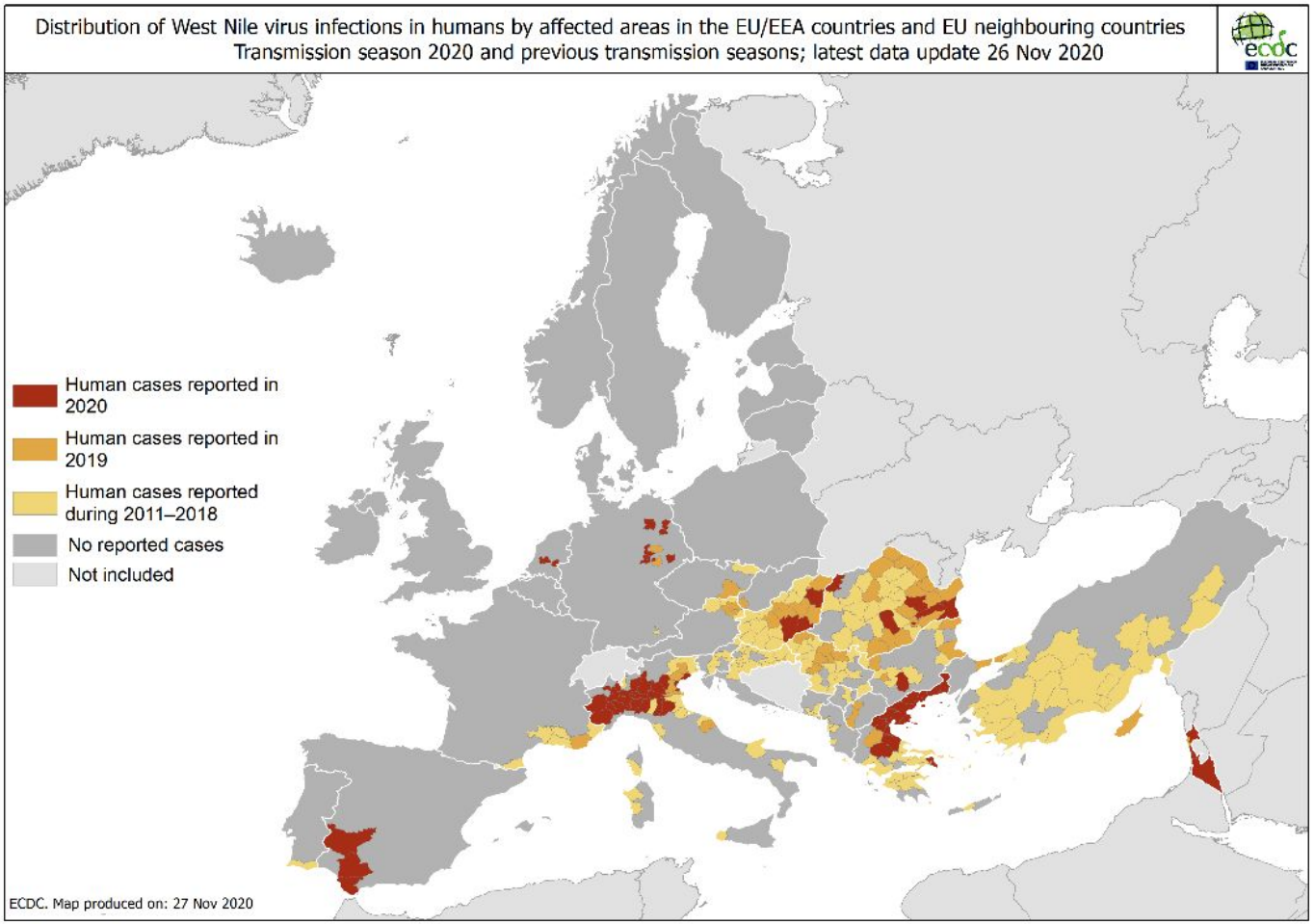
- Y 2020, **241 million cases of malaria** worldwide.
- Y 2020, **Malaria deaths stood at 627000**
- **Dengue cases** increased over 8 fold over the last two decades, from 505430 in 2000, to over 2.4 million in 2010, and **5.2 million in 2019**.



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

(ECDC, EU/EEA Reported cases 2008-2020)

- **West Nile Virus:4226**
- **Malaria:85246**
- **Dengue, Zika and Chikungunya: 30249.**



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ΕΜΠΡΟΣ (EMPROS)

EMPROS aims to Advance the Research, Excellence and Innovation Topics of the

EYWA Early Warning Operational System

A game changer in the domain of epidemics

In a nutshell:

- **EYWA** won **EIC Horizon Prize** on **Early Warning for Epidemics.**

- Already **operational** in **9 regions in 5 European countries** at a **TRL 9**, currently expanding to non-European (Côte d'Ivoire, Thailand) TRL from 7 → 9.

- **EMPROS** is a greek research program that develops and provides support to **EYWA.**
- **EarlY WArning System for Mosquito borne diseases EYWA, developed in the context of EuroGEO. A niche state-of-the-art tool** that distills EO data, advanced epidemiological and entomological modeling, and ML big data analytics.
- Provides advanced **predictive modeling** results for both **mosquito populations** and **MBD risk**.
- EYWA **transforms scientific knowledge into decision-making and supports the EU to address a Pandemic State of Emergency at both European and non-European scale.**
- **EYWA was recently onboarded as a pilot to the e-shape H2020 project.**

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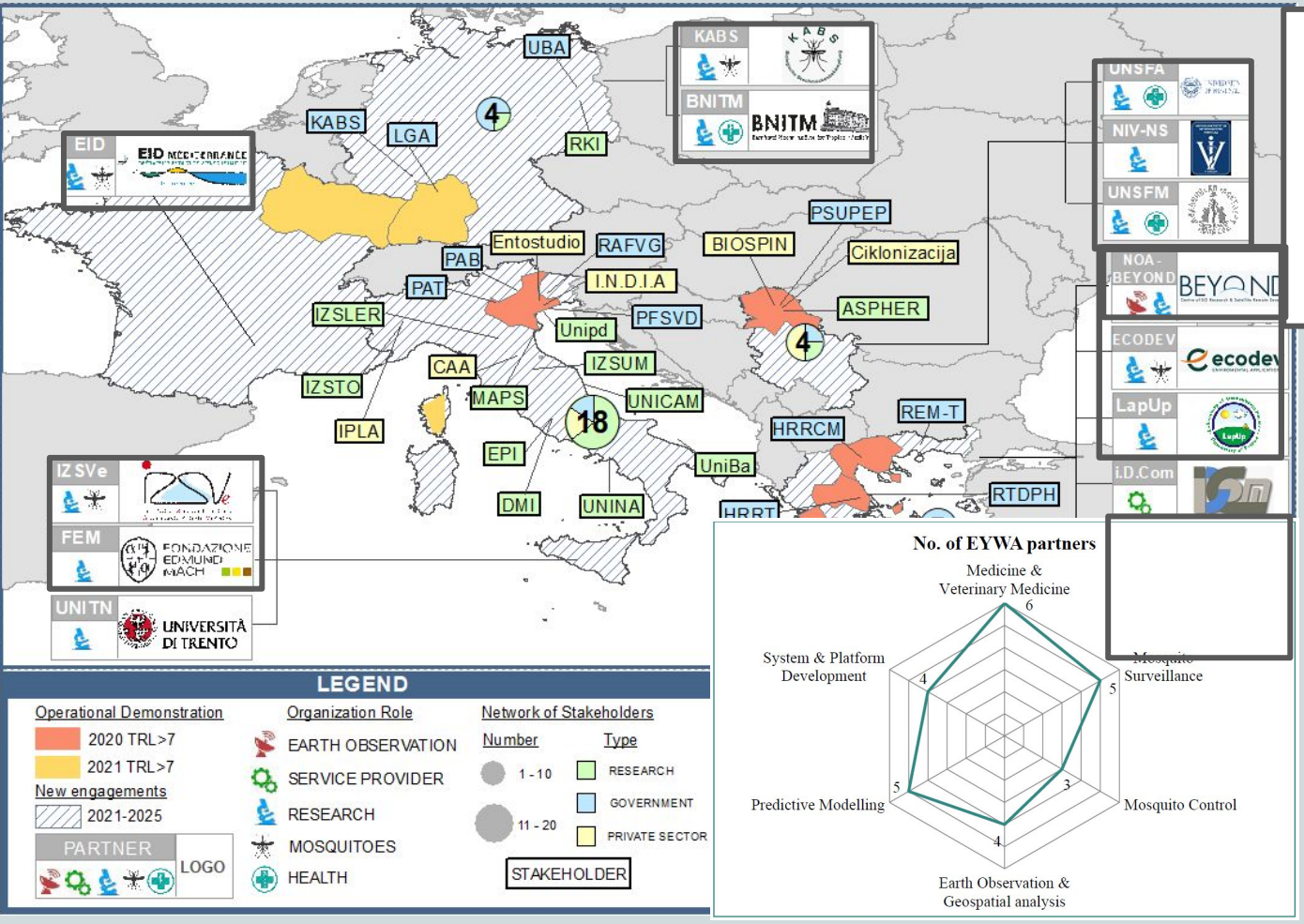
ΕΜΠΡΟΣ (EMPROS)



EYWA team

15 partners
5 countries (~30M citizens)

National/International Roles as Reference Entities

Data Handling, Mosquito Surveillance & Control, Medical & Veterinary Medicine from all 5 countries:
BEYOND/NOA, ECODEV, LapUp, AUTH, UTH (GR)
IZSVe, FEM (IT)
UNSFA, UNSFM, NIV-NS (SRB)
KABS, BNITM (GER)
EID-Mediterranee (FR)

BEYOND/NOA: Crosscutting role for Big Data manipulation, standardisation, harmonization & storage.

Predictive modelling:
BEYOND/NOA, ECODEV, LapUp

System, Web Platform and mobile applications development:
BEYOND/NOA, i.D.Com, ECODEV, LapUp

EYWA engages 37 stakeholders globally up to now & has received **Letters of Support** from: Germany, Italy, Serbia, Greece, USA, Brazil & India

211 publications & more than 44,450 citations

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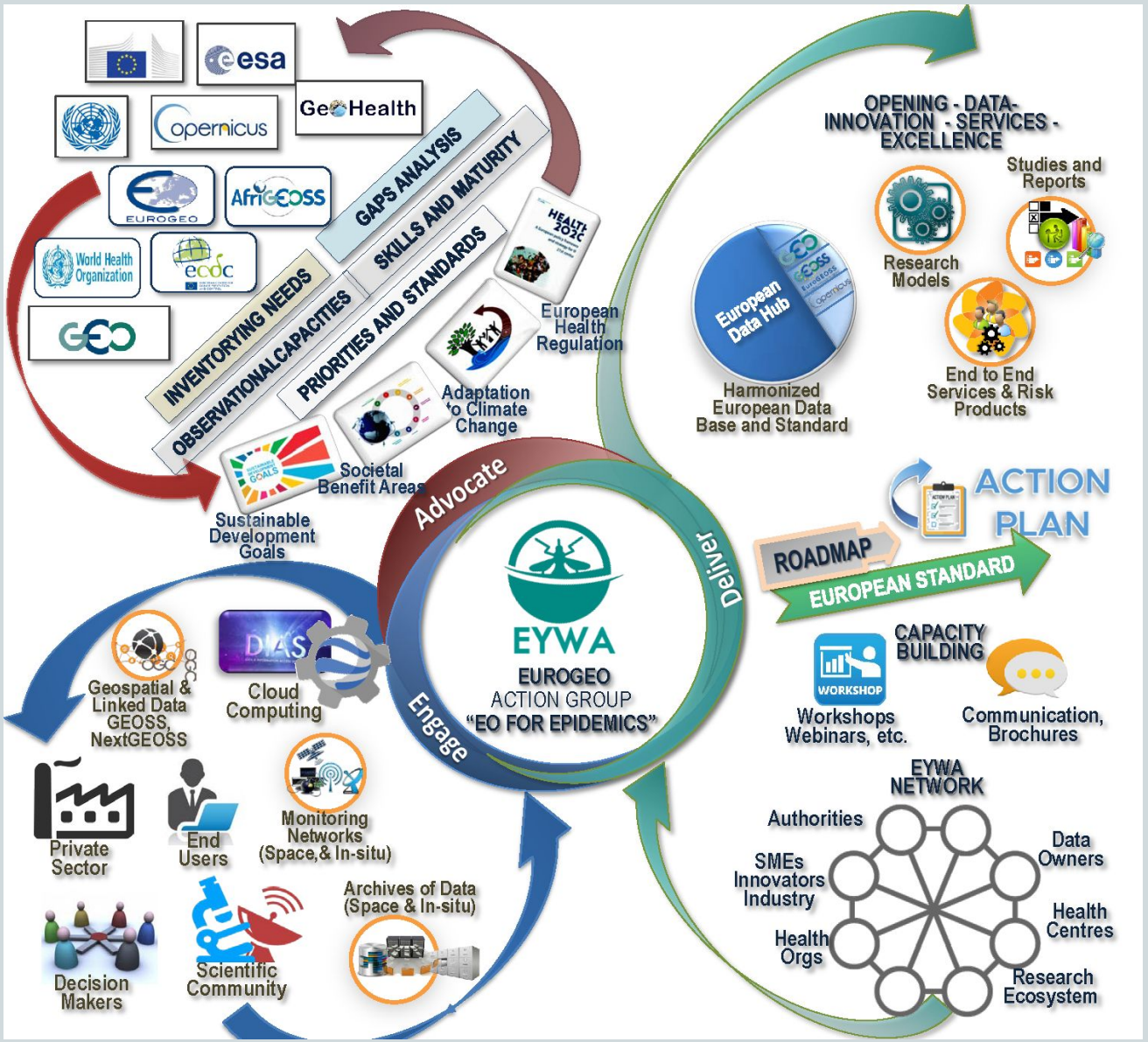
ΕΜΠΡΟΣ (EMPROS)

EYWA is built on the GEO triptych:

ADVOCATE
ENGAGE
DELIVER

DELIVERS

1. Digital Services
   a) Mosquito abundance
   b) Disease outbreak
2. Network of Stakeholders
3. Action Plan
   a) Service and Quality Standards
   b) Assist Policy and Regulations



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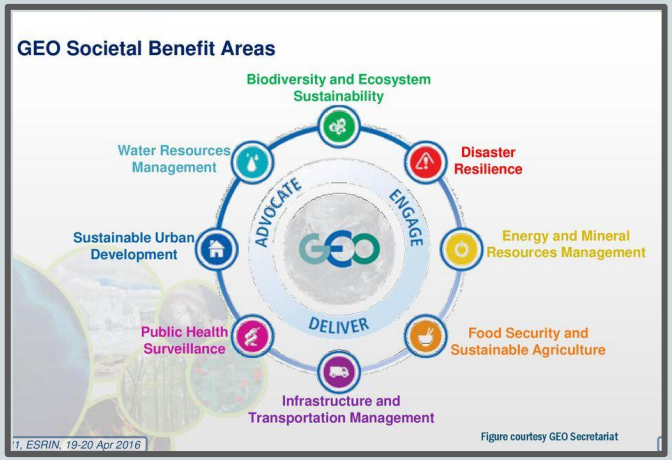
EuroGEO

Action Group "EO4EVIDence"

(Earth Observation for Epidemics of Vector-Borne Diseases)

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



EU HEALTH EMERGENCY PREPAREDNESS AND RESPONSE AUTHORITY

DG SANTE
Directorate-General for Health & Food Safety

HEALTH

SUSTAINABLE DEVELOPMENT GOALS

3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

13 CLIMATE ACTION

European Climate and Health Observatory

DG ECHO
EU Civil Protection & Humanitarian Aid Operations

Humanitarian Aid Civil Protection

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ΕΜΠΡΟΣ (EMPROS)

How EYWA competes

Free and open satellite Earth Observation and meteorological data

Open data

European technology

Copernicus Sentinels, CAMS, CLMS, CCS, CreoDIAS, GEOSS, Sentinels Greek Hub, Hellenic Mirror site

Streamlined and automated pipeline for EO, entomological, epidemiological and auxiliary data ingestion

Automation

Scalable

EYWA's generic models are designed to scale-up easily and were in pre-operational phase in 5 European regions

EYWA's generic and site-specific models can be transferred in multiple geographic regions

Transferable

Fully operational

EYWA is in successful operational use since April 2020 in Greece & Italy. From 2021 and onward, is aditionally operational in Serbia, Germany and France.

Reached the **Technology Readiness Level 9** in Greece, Italy, Serbia, Germany and France

"EYWA is a robust and scalable Early Warning & Decision Support System that welcomes new partners from around the world to share data and transform scientific knowledge into decision-making & mosquito control actions"

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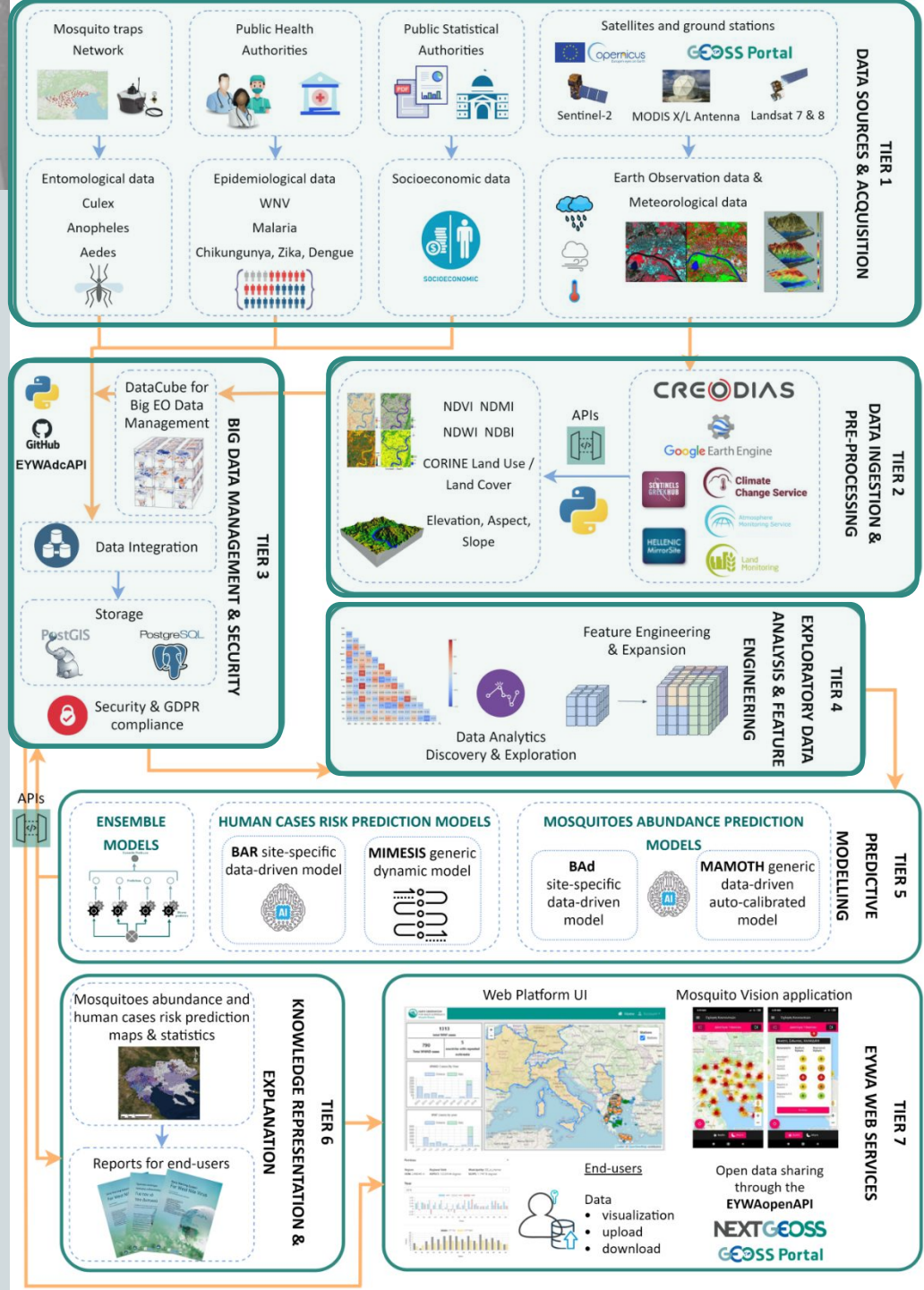
EYWA System Architecture

- Time-series of **entomological, epidemiological, socio-economic, satellite Earth Observation, meteorological and geomorphological** data
- A suite of APIs is developed and opened for automatic data harvesting, pre-processing and indices derivation.
- Big Data management (~300 TB and counting) > **2 εκατομμύρια εγγραφές ανεξάρτητων μεταβλητών**
- Open Data Cube (ODC) technology
- 36 features for each of the **39.000 mosquito collections in our database**.
- A "MAMOTH" feature space of at least **10-years time-series of data** for every mosquito-traps network in ten regions in Europe.

Data Opened through NextGEOSS



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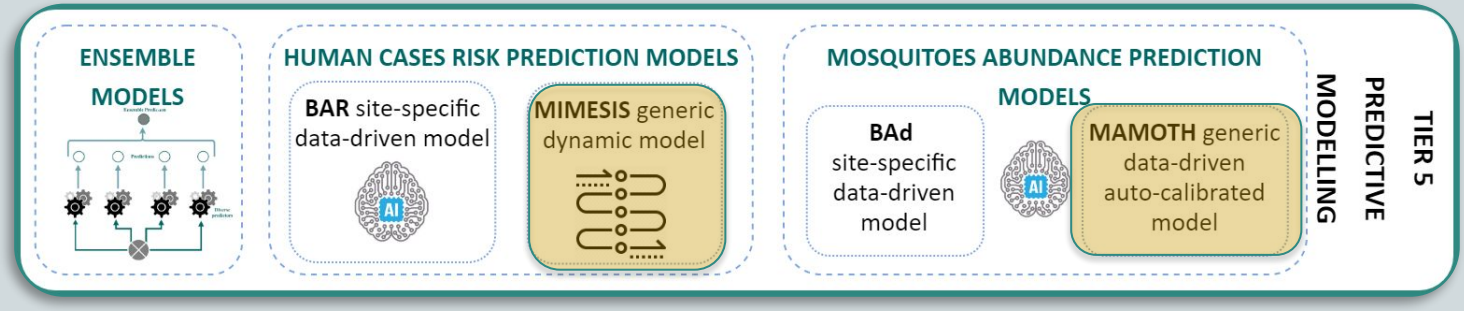
ΕΜΠΡΟΣ (EMPROS)

EYWA state-of-the-art Models

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.



MAMOTH(NOA)

- **Data-driven ML** (Gradient Boosting) model
- **Auto-calibrated**, generic, **applicable/transferable** to all landscapes
- **Trap and off-trap level**

MIMESIS(Uni of Patras)

- **Climate-dependent epidemiological model(deterministic)** operating in an ensemble (probabilistic) framework.
- **Spatial-temporal scale:** municipality, monthly, seasonal
- **Climate forcing**: **ECMWF seasonal forecasts issued every month**, hence MIMESIS forecasts are updated on a monthly basis.
- Model Outputs include **infected mosquitoes, mosquito abundance, infected humans, risk, week of infection**.

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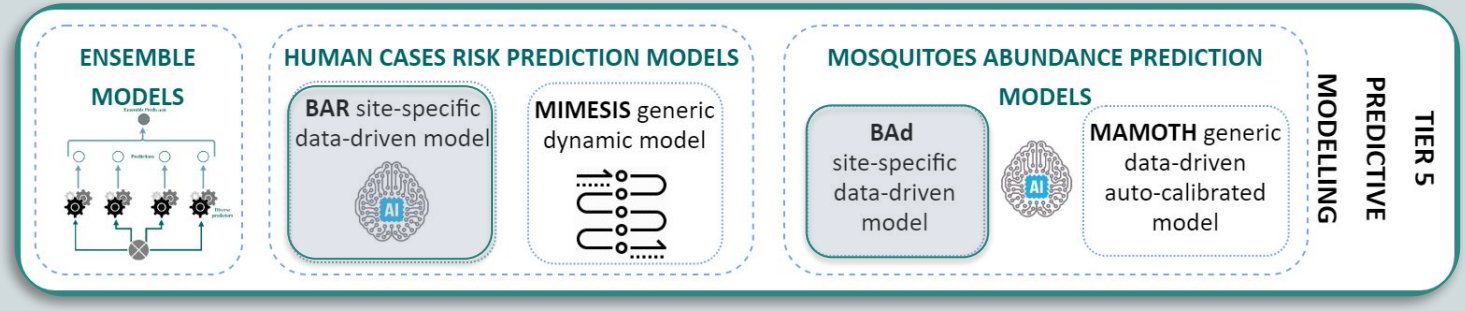

BAd(ECODEV)

- Data-driven ML (Neural Network) model
- **High resolution**, Site-specific
- **Settlement level**

BAR(ECODEV)

- Data-driven (Neural Network) model
- **High resolution**, Site-specific
- **Settlement level**

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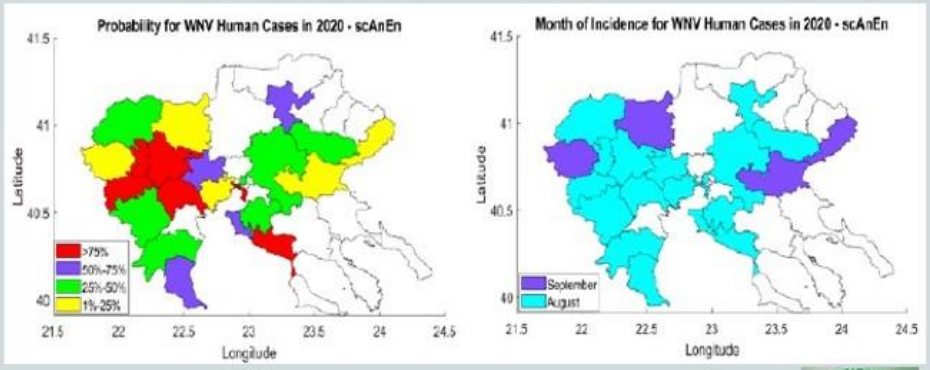
ΕΜΠΡΟΣ (EMPROS)

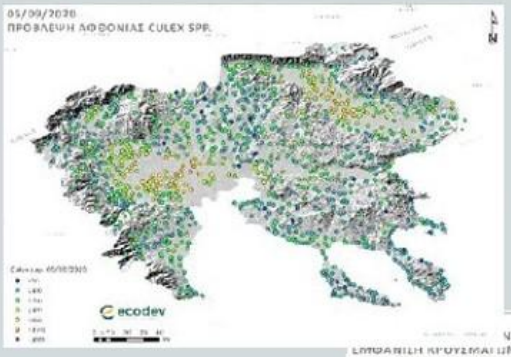
Indicative EYWA operational results during the period | April – October 2020

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



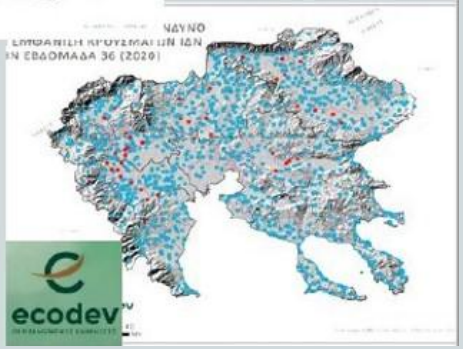
Human case probability map (left) and probable month of human cases incidence (right)

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



Mosquito abundance 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

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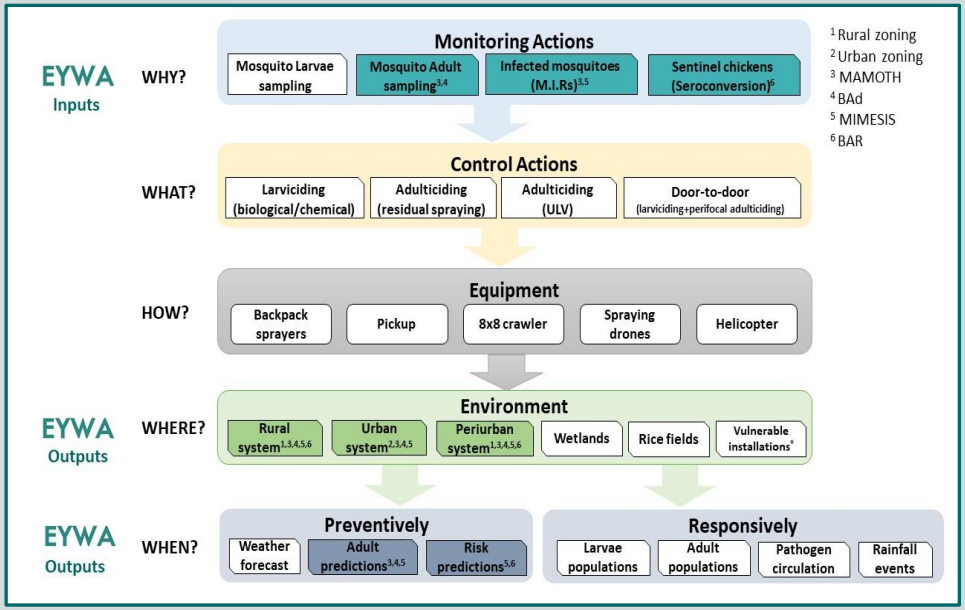
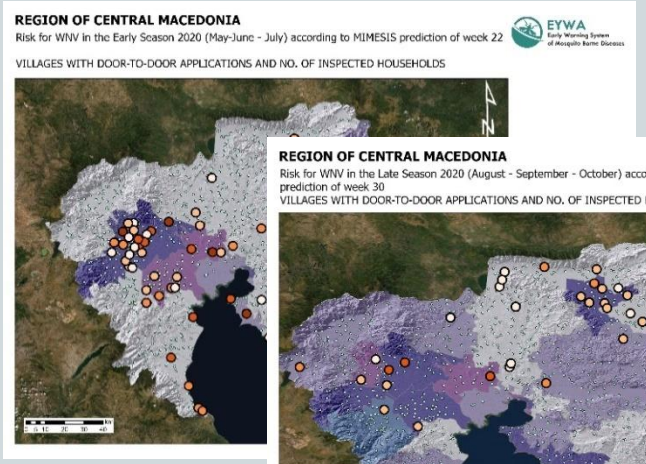
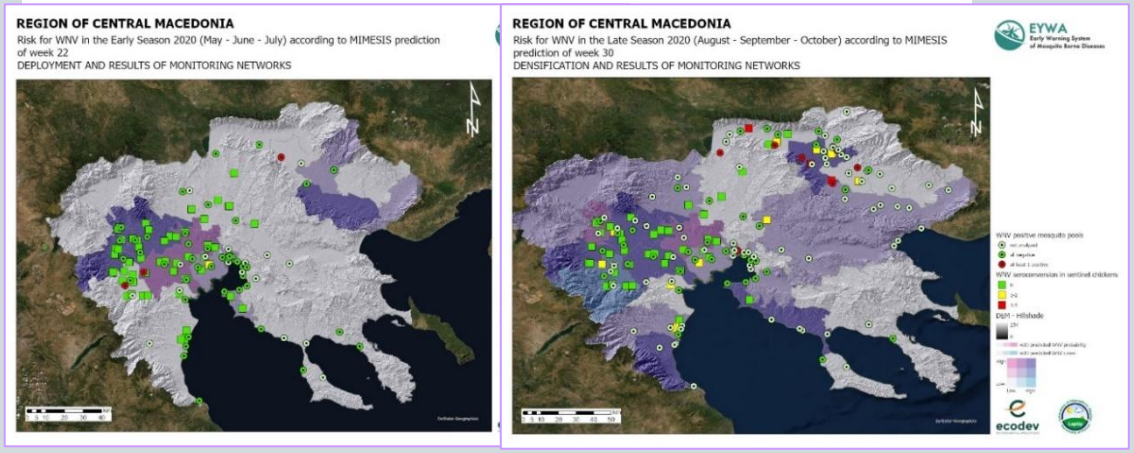


Decision making process of the mosquito control



Door-to-door applications during late season were intensified up to 5-8 times more in villages at risk compared to villages without risk

The average spraying applications, and the average sprayed surfaces per at-risk village, were ranging from 2 up to 6 times more in risk compared to no risk areas, guided by the prediction for week 32, was 8,5 times higher in at-risk than in no-risk villages



Intensification of sampling activities in at-risk areas vs no-risk areas

EARTH OBSERVATION
FOR HEALTH & EPIDEMICS
Mosquito Diseases

EO creates opportunities **for Health & Epidemics**

EYWA IMPLEMENTATION

ΕΜΠΡΟΣ (EMPROS)

2020-2021 Response actions

- **Wetlands**
- **Rural areas**
- **Periurban**

Aerial larviciding

Ground larviciding
(*8,5 sprayed surfaces 2020)

Drones

- **Built environment**

Cities - catch basins
(+ 2-5 extra rounds 2020)

Villages – cesspools
(+ 60 villages extra 2020)

ULV

12/07/21 Spiros Mourelatos

EYWA Success Metrics

2 years of successful operation

The EYWA system has displayed

- Can predict mosquito abundance populations with more than 90% accuracy
- Can highlight the settlements and municipalities with high WNV risk. Through real world operational validation about half WNV cases have been registered in the settlements and municipalities that have been predicted by the system, thus allowing taking targeted measures to combat mosquitoes and larvae in those high risk areas. (e.g. in the Central Macedonia region in 2020 33 out of 65 settlements where WNV cases were eventually registered have been highlighted out of a total 1050 available settlements in the whole region).
- Based on the above data we can say that the mosquito populations have been significantly reduced (up to 50%) compared to the historical averages, thus reducing the risk of WNV.

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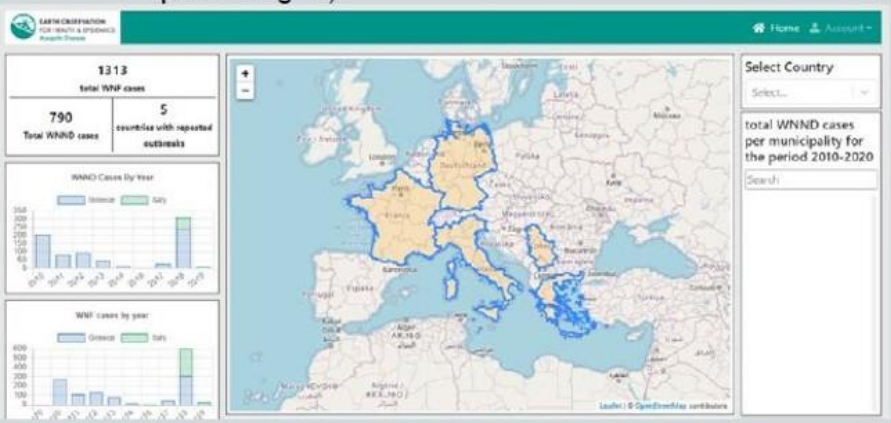
EYWA Web GIS Platform – Indicative Functionalities

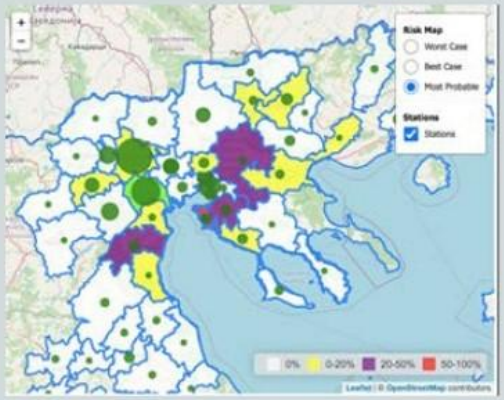
Authenticated end users are able to upload data and get the results (entomological/ epidemiological)



Visualise the areas of application and the number of MBDs historical human cases published by ECDC and National Health Organisations

Select any country and visualise the mosquito traps networks

For any selected trap visualise time-series, statistics, and data analysis and trends of calculated and recorded meteo, societal, and environmental parameters (NDVI, NDMI, NDWI, temperature, rainfall, population)



Visualise and report on the human cases risk forecasts produced from the various predictive models (dynamic – data driven)

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opportunities
for Health &
Epidemics

ΕΜΠΡΟΣ (EMPROS)

EYWA Web Platform

Thank you!

EYWA
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for Mosquito Borne Diseases

ΕΜΠΡΟΣ
(EMPROS)

Contact us

kontoes@noa.gr
(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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University of Patras – Physics Department - Laboratory of Atmospheric Physics (LapUP)

Dimitrios Vallianatos (IDCOM)

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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