EARLY WARNING SYSTEM FOR WEST NILE VIRUS OUTBREAKS BASED ON SATELLITE EARTH OBSERVATION DATA

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MOTIVATION

Mosquito-borne diseases :

- Infect almost 700 million people / year → causing millions of deaths
- The burden of MBDs is estimated to be higher in tropical and subtropical areas, affecting disproportionately the poorest populations.
- Factors that influence the seasonal and geographic distribution of vectors' population and therefore the transmission of the pathogens:

1. Changing climatic and ecological conditions
2. Global travel and trade
3. Human behavior
4. Rapid and unplanned urbanization

➡ Early Warning Systems that can predict the risk of human outbreaks

TIMELINE

EUROGEO INITIATIVE

An initiative of EuroGEOSS Action Group on epidemics (cluster Climate) lead by NOA.

REVIEW PAPER

Scoping paper on the Satellite Earth Observation Data in Epidemiological Modeling of Malaria, Dengue, and West Nile Virus. Review the state-of-the-art and identify research gaps.

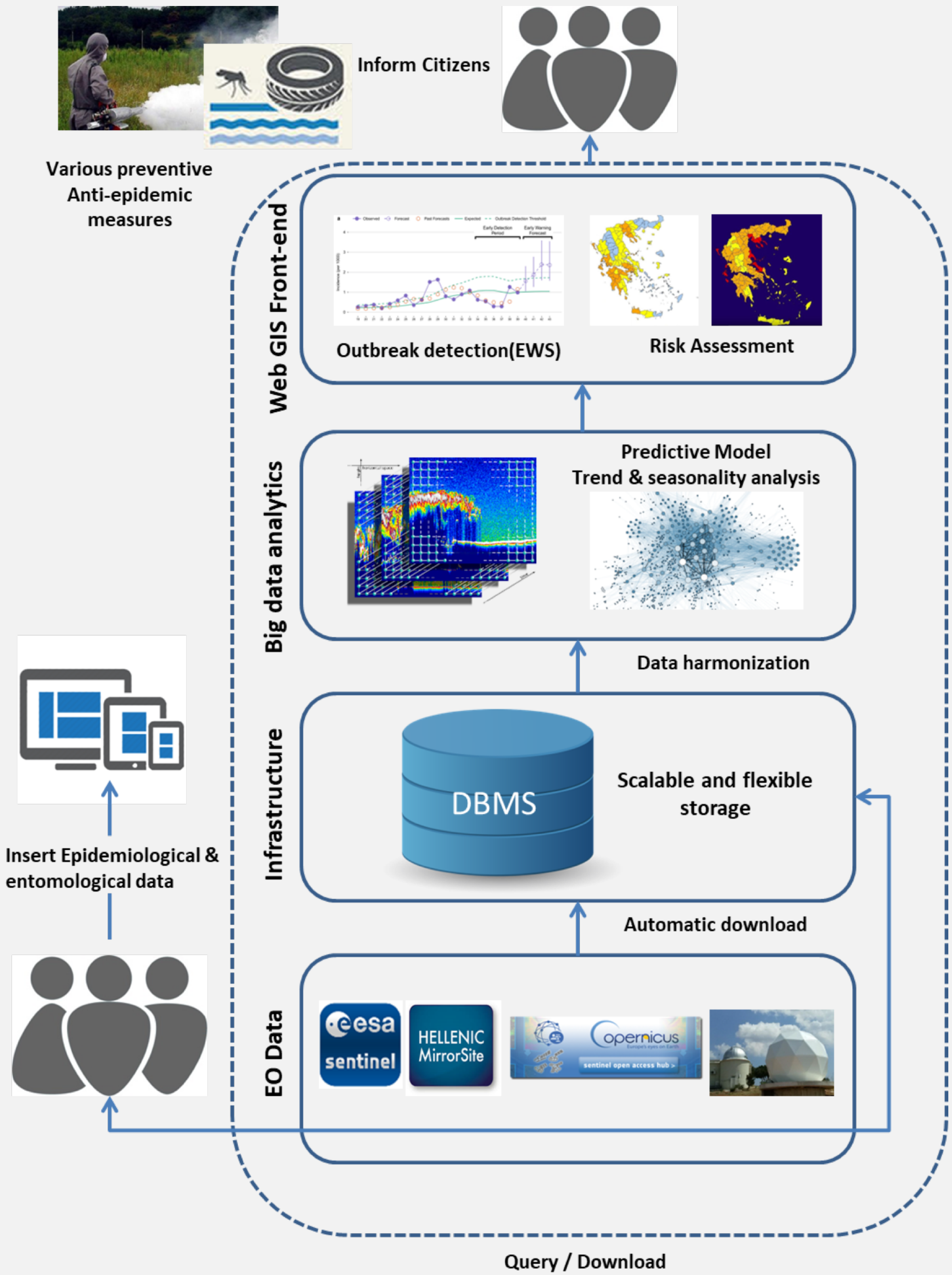
DEVELOPMENT OF EWS

Development of an operational Early Warning System (EWS) that exploits multi-source datasets including satellite EO data, entomological & epidemiological data to predict the human outbreaks of the West Nile virus.

AUTOMATED SYSTEM

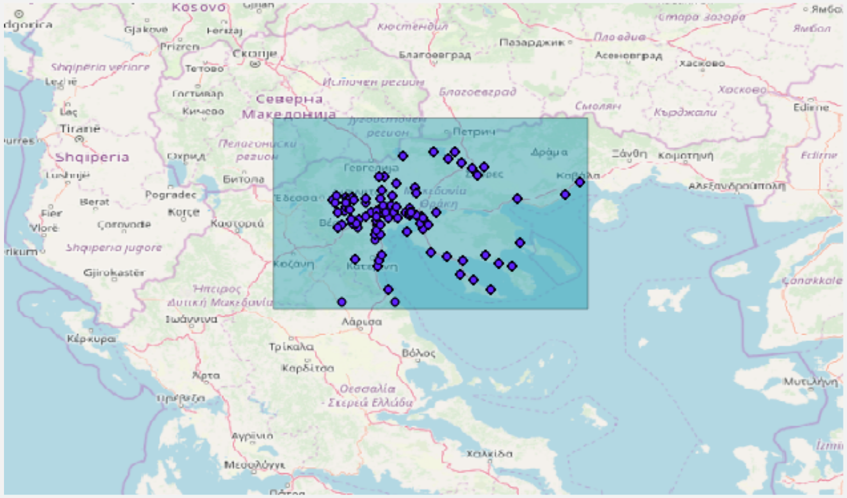
The EWS is a fully automated system based on artificial intelligence, statistical and dynamic models.

OVERVIEW OF THE EWS



TRAIN MODELS

- Open satellite Earth Observation data, meteorological, epidemiological & entomological data were used to train the models for the years between 2010 and 2019.
- The EWS was trained using data from the region of central Macedonia in Greece, the most prone most epidemic-prone region in Greece regarding the WNV.



DATA AND TECHNOLOGIES

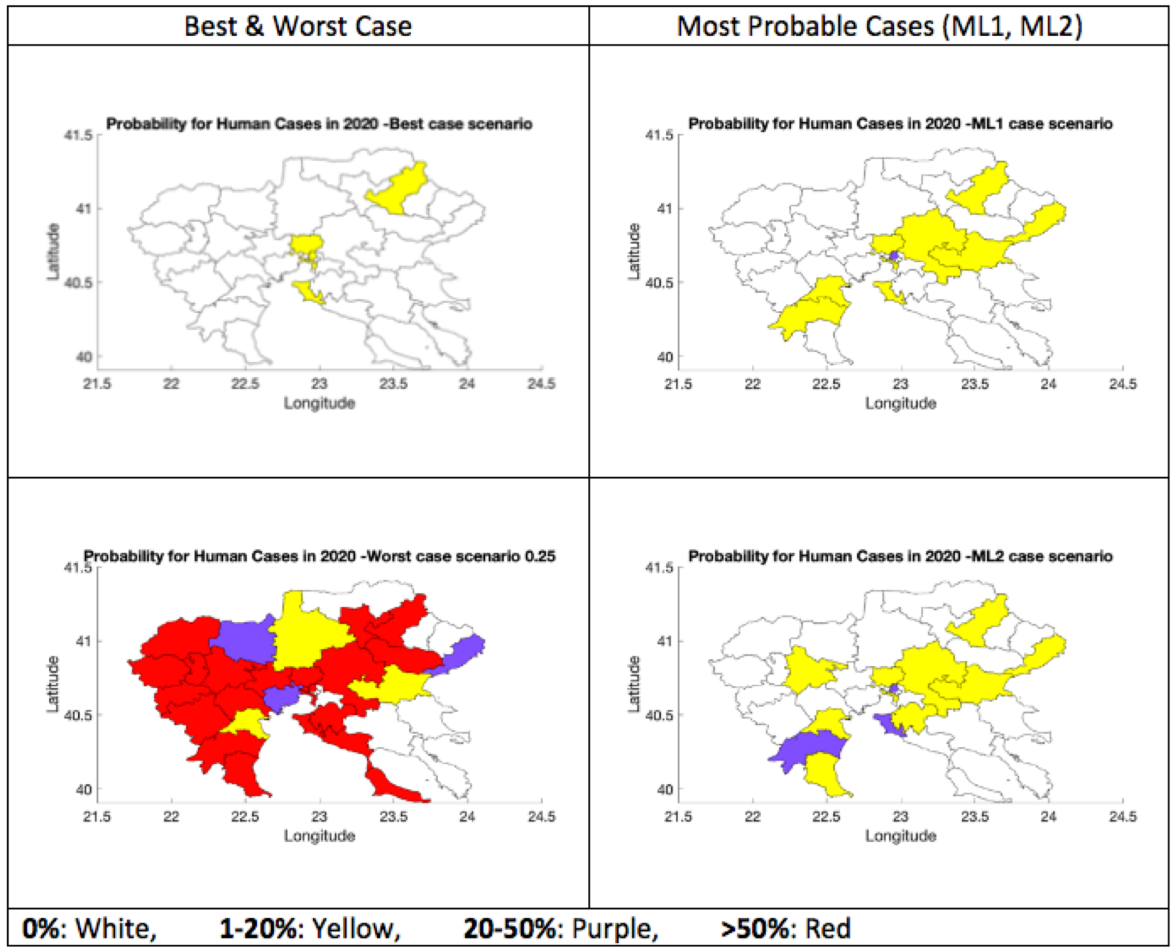
Data	Satellite data: NDVI/ NDWI/NDMI, LST, Precipitation, WIND: LANDSAT-7, 8 Sentinel MODIS, IMERG,ERA5-LAND	Epidemiological & Entomological data Of WNV	Socioeconomic data
Datacubes /Data Processing & Management	PostgreSQL	Spatial extension PostGIS	Open Data Cube/ Google Earth Engine
Python framework for building web apps	Geoserver API	GeoDjango GIS Web applications	GDAL / rasterio / OpenCV /

HYBRID DYNAMIC-ML EPIDEMIC MODEL

DEVELOPED BY IOANNIS KIOUTSIOUKIS

- The model dynamically simulates the life cycle of mosquitoes, birds and humans and the West Nile virus infection cycle between mosquitoes, birds and humans.
- In total, it includes 14 health conditions in which the populations are divided according to their current epidemiological situation. The main health conditions are the vulnerable, the exposed, the infected, the immune and the dead.
- The interconnection between the 14 states is done through dozens of parameters that have climatic, demographic, geographical or seasonal dependence. In addition, there are parameters that can be thought-provoking, statistical distribution, or consistent.
- Mathematically, the model is described by 14 differential equations that are solved numerically. The model has been calibrated in historical WNV simulations for the period 2010-2019. For the production of forecasts, some parameters of the model are estimated by artificial intelligence methods.

OUTPUT OF MODEL - RISK MAPS



ML ALGORITHMS TO PREDICT POPULATION OF CULEX PIPIENS

Machine learning algorithms were used to predict the population of Culex pipiens.

1. **Clustering K-means to define classes of the mosquito population.**
2. **Classification problem**

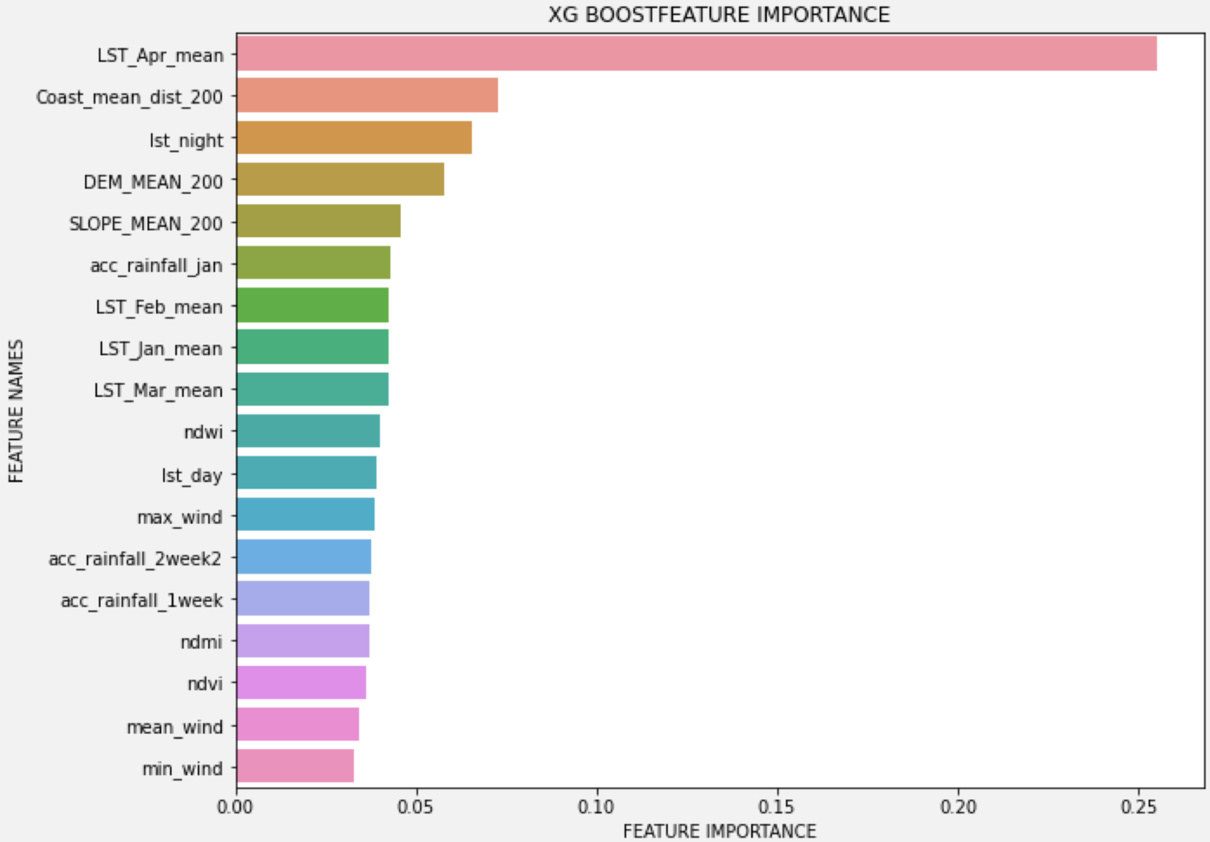
Accuracy of different algorithms:

SVM: 62%

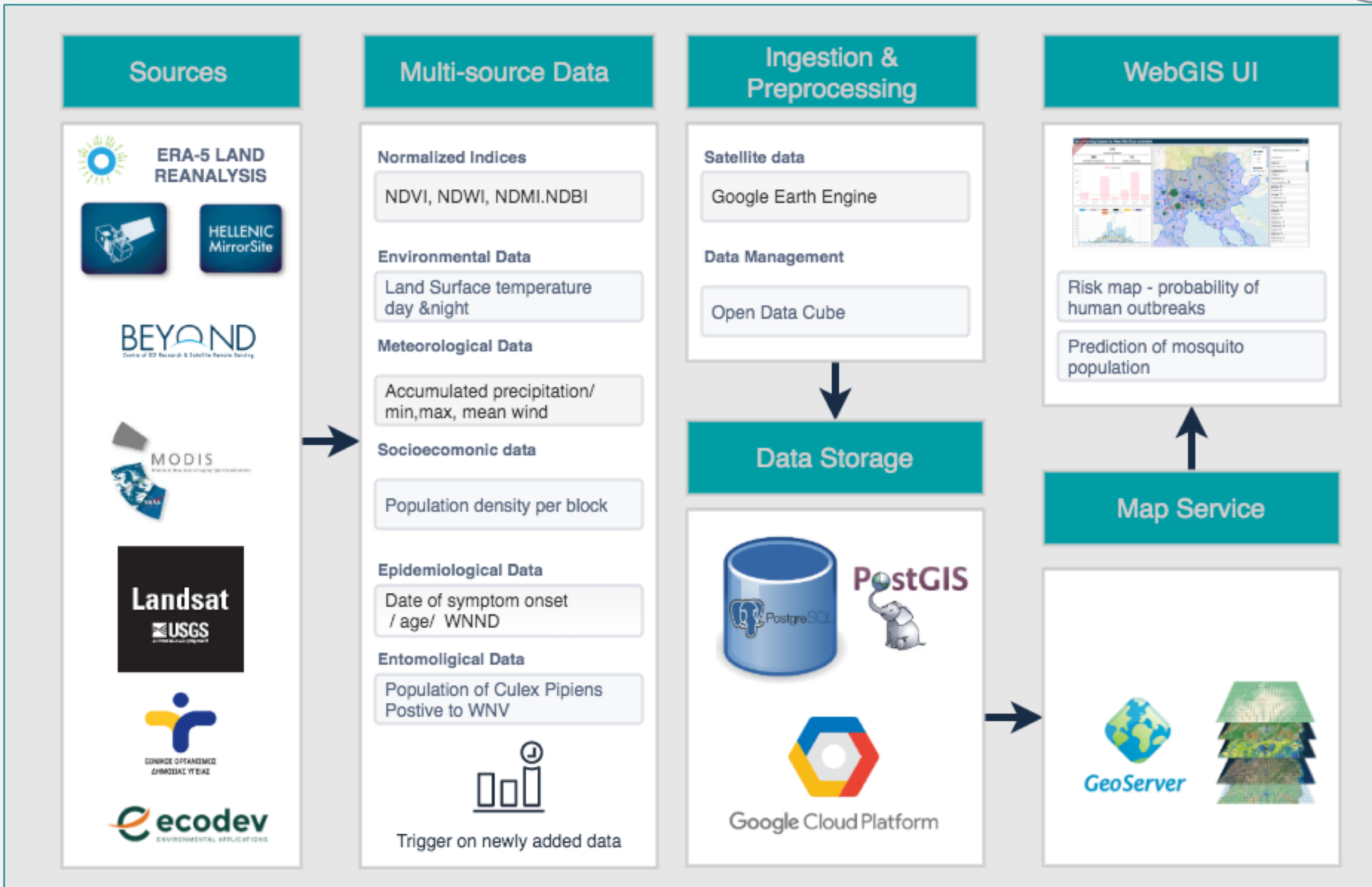
Random Forest: 68%

Extreme Gradient Boosting: 69.42%

FEATURE RANKING XBOOST



EWS ARCHITECTURE



USER ENGAGEMENT

- The results of the EWS have been disseminated to the end users – different municipalities in Greece in form of weekly reports.
- The weekly reports provide information on the prediction of the upcoming weeks.
- The feedback of the end-users has been used to validate the results and improve the EWS.
- Iterative process with the purpose of optimizing the EWS. Goal of the EWS is to provide preparedness to the decision makers.

NEXT STEPS

- Prove the systems transferability and scalability by applying the same algorithms to other European Countries e.g. Italy Veneto.
- Apply ML algorithms to predict human outbreaks using the EO dataset.
- Optimize the algorithms and data pipeline.
- Publication of the results.
- Provide results for other Areas of Interest in Greece and in Europe and deliver weekly reports to various municipalities.

THANK YOU

National Observatory of Athens - Institute for Astronomy, Astrophysics, Space Applications and Remote Sensing (IAASARS)