EYWA
Early Warning System for Mosquito Borne Diseases

EO creates opportunities for Health & Epidemics

Managing mosquito borne disease through EYWA: a European tool to support public health authorities in preventing epidemics

Presenting: Dimitrios Sainidis on behalf of the EYWA team

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Why bother with mosquitoes and MBDs ?

MBDs (WNV, Malaria, Zika, etc) affect 700 million people in more than 100 countries and result in a million deaths annually.

Climate change and increased mobility affect mosquito population and disease outbreaks.

Mosquitos transmitt diseases to animals (livestock).

Land degradation leads to increased mosquito breeding sites.

Accurate mosquito population and epidemiological risk maps for the upcoming future are essential for maintaining Human and Animal health.

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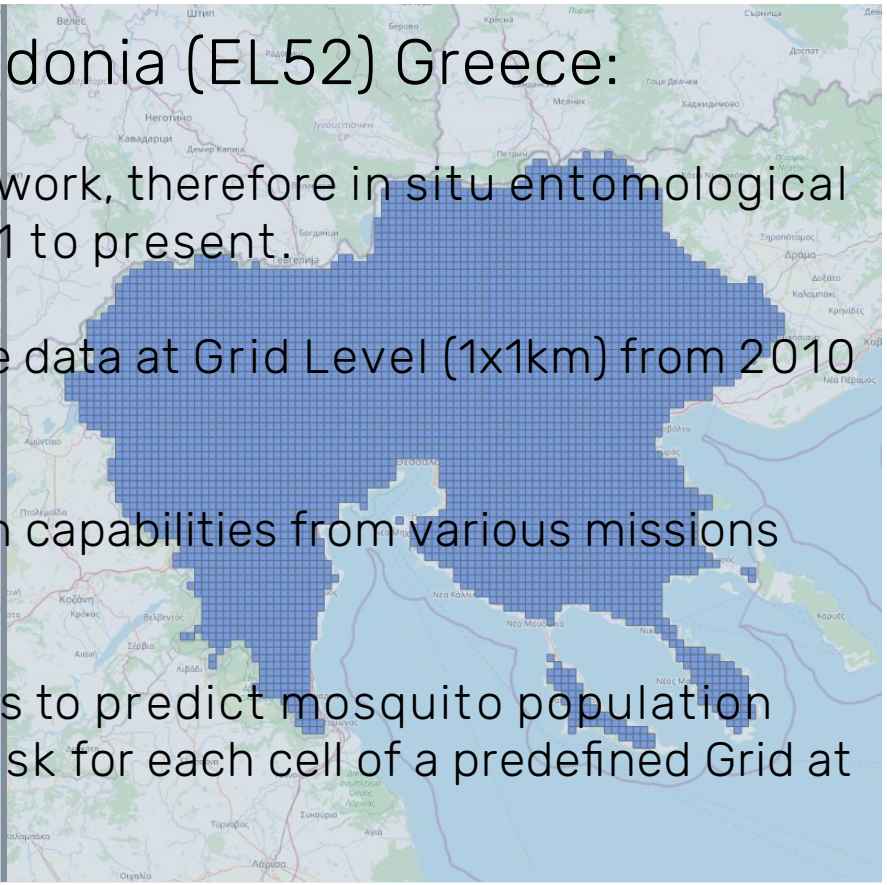
Problem Formulation

Tested region: Central Macedonia (EL52) Greece:

- Access to mosquito trap network, therefore in situ entomological data (culex pipiens) from 2011 to present.
- Access to historical WNV case data at Grid Level (1x1km) from 2010 to 2021.
- Open satellite data collection capabilities from various missions and products.
- Build machine learning models to predict mosquito population and WNV case appearance risk for each cell of a predefined Grid at regular time intervals



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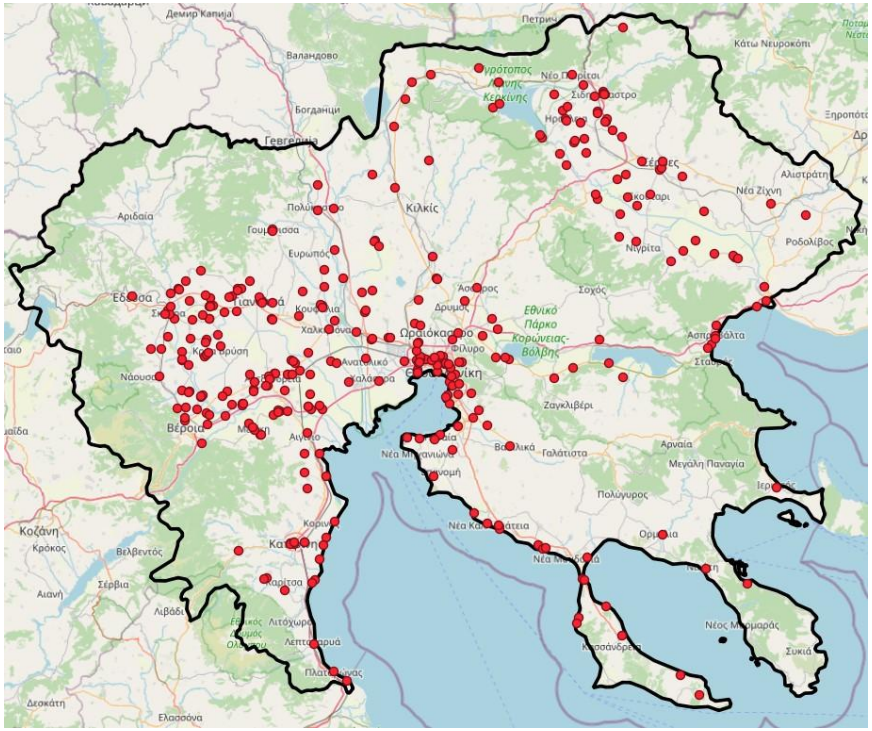
Data Sources - Entomological

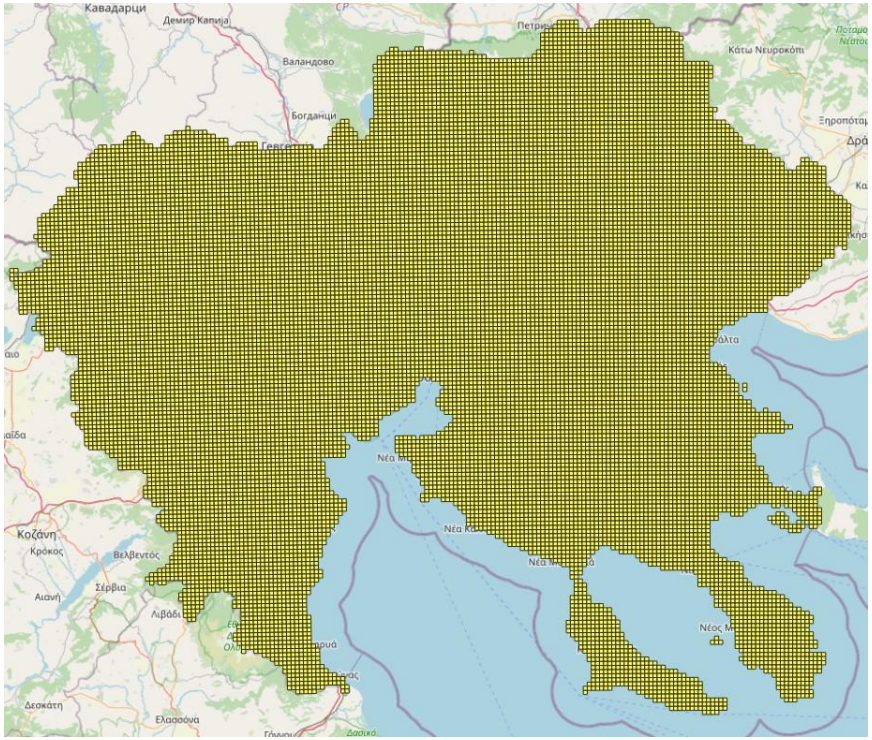


- Each dot represents a mosquito trap (CO2 or gravity trap) forming a mosquito trap network
- Samples are collected from each trap at regular time intervals
- From each sample the mosquito count is generated

trap_id	location	date	culex
ATG521	(22.193, 40.665)	13-05-2015	12
APE451	(22.456, 40.621)	17-05-2015	8
LSM741	(22.245, 41.846)	02-08-2015	153
MBV165	(22.345, 41.156)	07-08-2015	182
NVJ111	(22.095, 41.456)	10-09-2015	43

Entomological Data Sample Table

Data Sources - Epidemiological

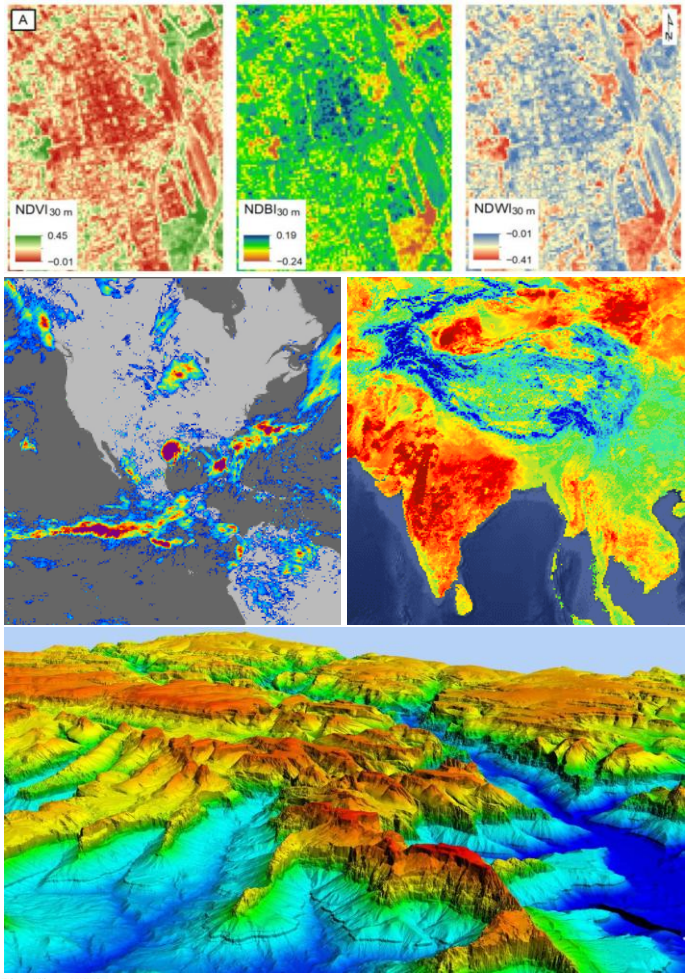


- 1x1 km grid is the spatial resolution of the recorded WNV cases. (NPHO)
- Each recorded case contains the cell code, age, sex and date of onset of symptoms.
- Most cells never see a recorded case -> highly imbalanced dataset.

cell_code	location	age	sex	date
EL520001	(22.468, 40.054)	63	F	10-06-2018
EL521520	(22.961, 40.700)	55	F	12-06-2018
EL522670	(22.650, 40.745)	21	M	15-06-2018
EL520014	(22.934, 40.046)	66	F	21-06-2018
EL525201	(22.557, 40.963)	78	M	30-06-2018

Epidemiological Data Sample Table

Data Sources - Earth Observation



Satellite derived EO data:

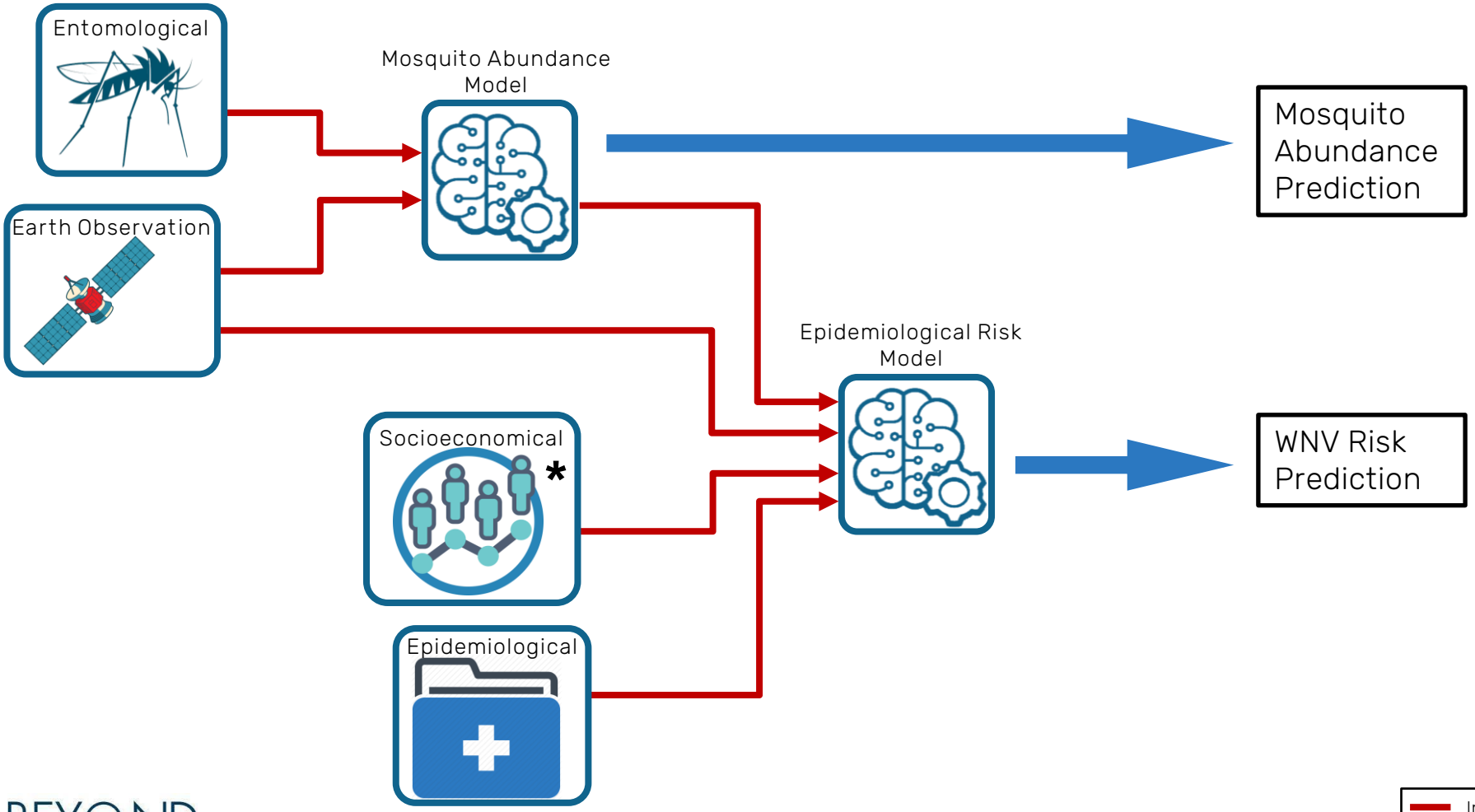
- Environmental indices
  - NDVI - Vegetation proxy
  - NDWI - Water proxy
  - NDMI - Moisture proxy
  - NDBI - Built-up proxy
- Weather data
  - Land surface temperature
  - Daily Precipitation
- Geomorphological (from DEM + shapefiles)
  - Elevation
  - Slope
  - Aspect
  - Distance from coast
  - Distance from river

Data Sources – Socioeconomical

Socioenocomical data are scraped from Eurostat:

- Female & Male Population (Eurostat: demo_r_pjanaggr3)
- Gross Domestic Product (Eurostat: nama_10r_3gdp)
- Inbound Road Freight Transport (Eurostat: road_go_na_rl3g)
- Outbound Road Freight Transport (Eurostat: road_go_na_ru3g)

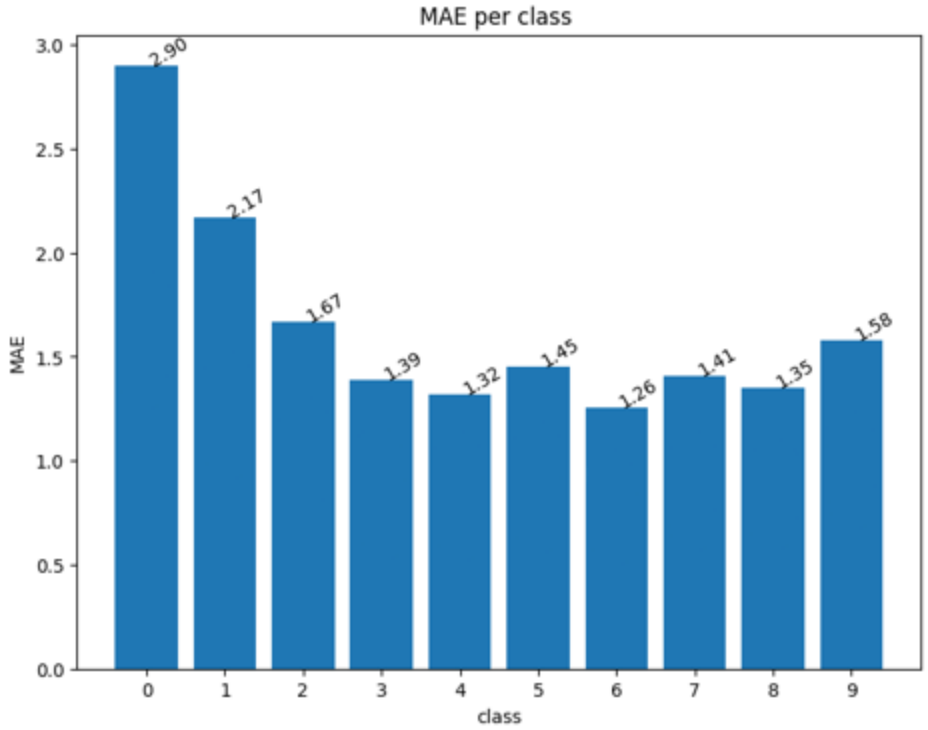
Complete System Architecture



Mosquito Abundance Model – Performance Metrics

- MAE on val set: 1.6095
- Error <= 2: ~80%

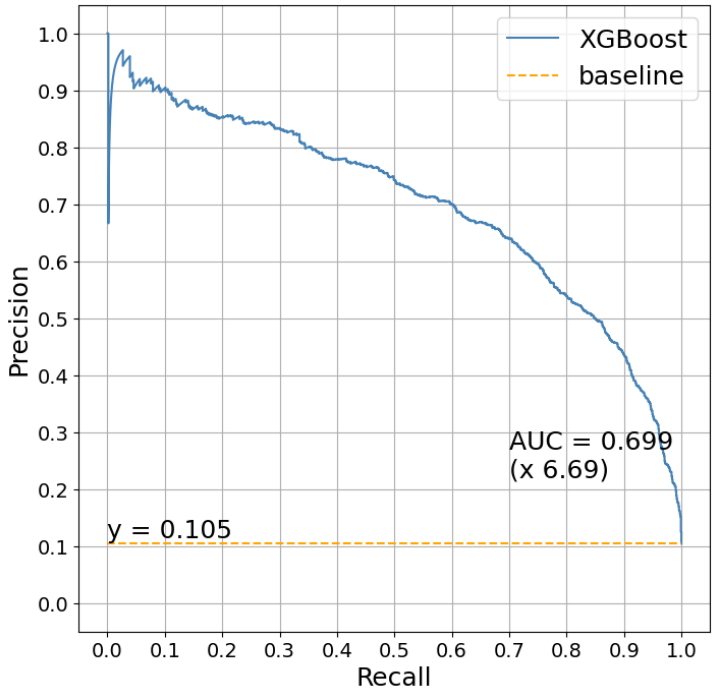
0: [0 – 4]
1: [5 – 13]
2: [14 – 26]
3: [27 – 47]
4: [48 – 79]
5: [80 – 137]
6: [138 – 229]
7: [230 – 387]
8: [388 – 729]
9: [> 729]



Epidemiological Risk Model – Performance Metrics

- Precision = 0.49 ⟶ (class imbalance: 500:1)
- **Recall** = 0.86
- F1 Score = 0.62
- Accuracy = 0.89

- LogLoss (train) = 0.16
- LogLoss (val) = 0.22



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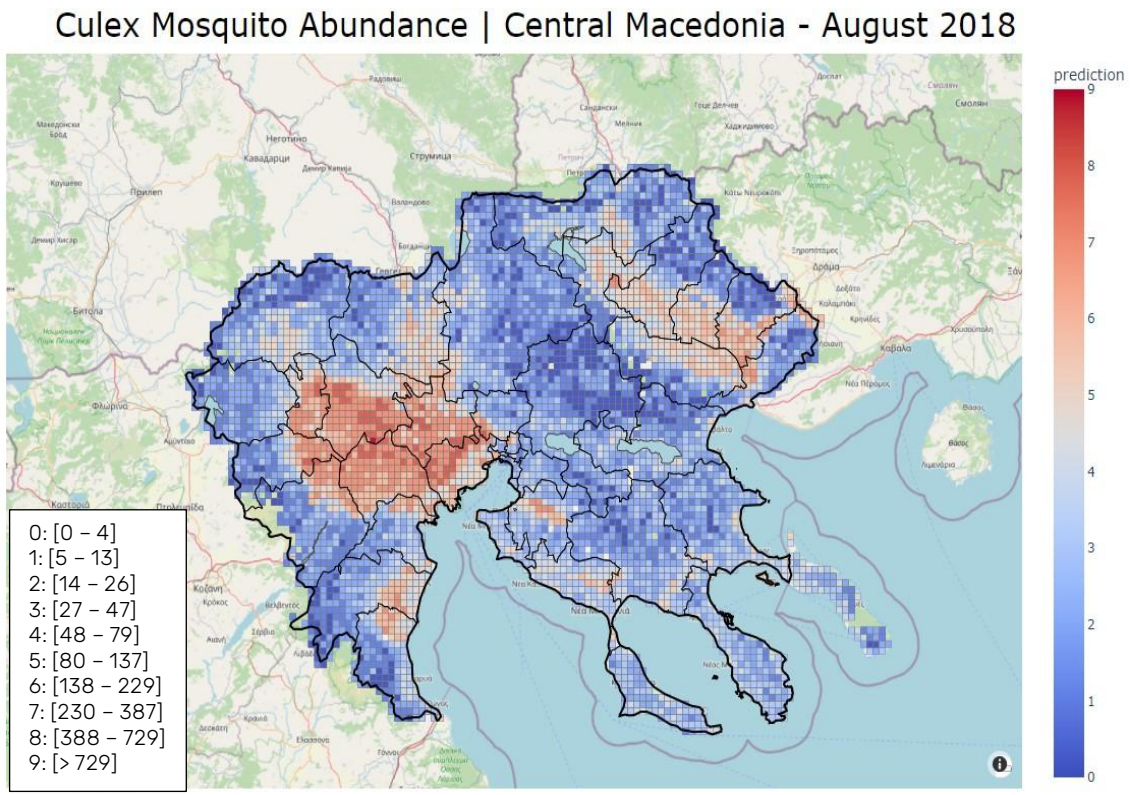
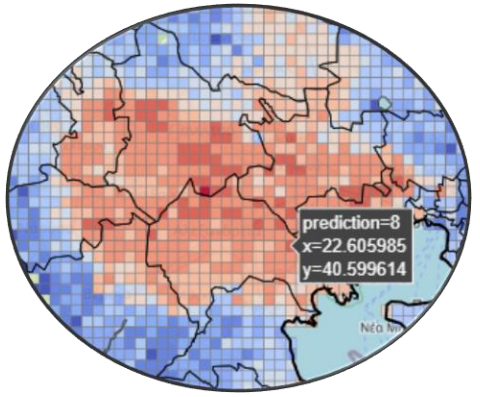
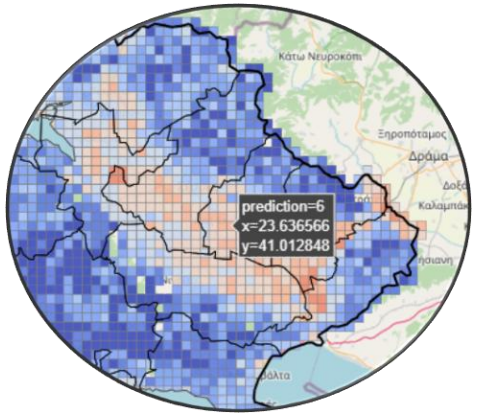
Mosquito Abundance Model – Output





Area with high mosquito population



Area with medium mosquito population

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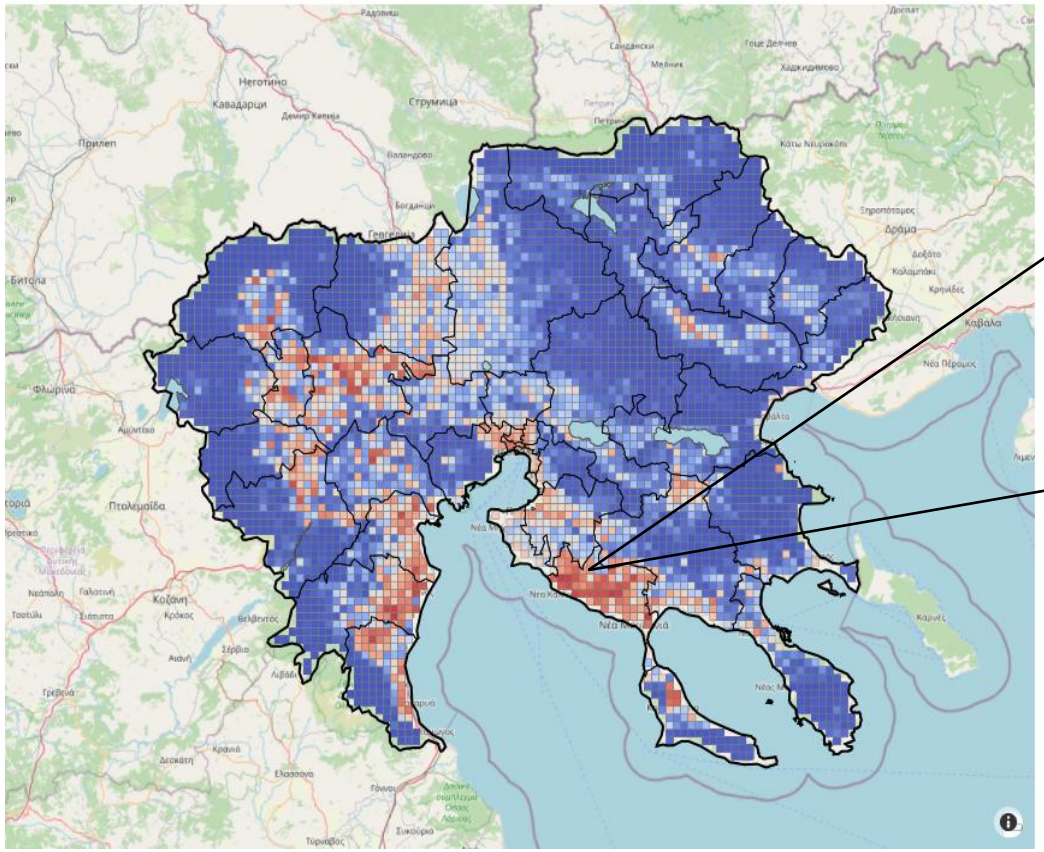
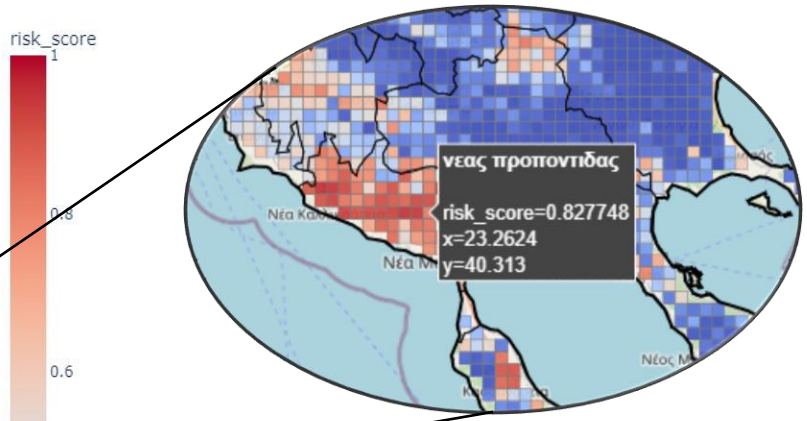
Epidemiological Risk Model - Output

WNV Risk | Central Macedonia - August 2018





- Risk estimation in clusters, not individual squares

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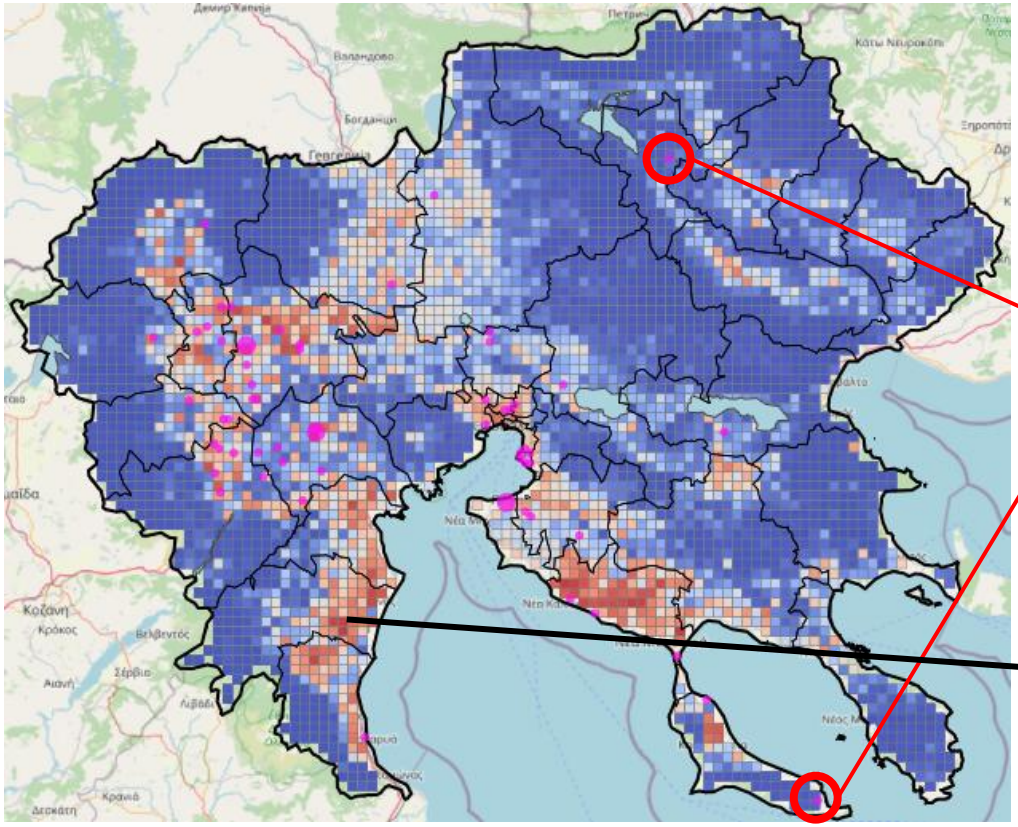
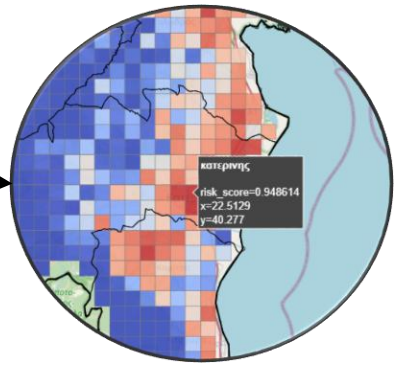
Epidemiological Risk Model – Validation



- Actual WNV Cases in Purple
- Most Cases are within High and Medium risk zones
- 2 Recorded Cases in Low Risk areas



Conclusions

- This is the first work to estimate mosquito population and MBD risk in fine spatial resolution – 2km x 2km square grid.
- The fine spatial resolution compensates the prediction error in both models.
- The dependence on Earth Observation data and open data makes the solution easily transferable to any place on earth.
- The high population and high risk areas revealed by our models could help health authorities direct their action where it is mostly needed. (e.g. mosquito control programs, MBD awareness campaigns, etc.)

Thank you for your attention!

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