



## Climate-Sensitive Vector Dynamics Modelling Workshop



September 19-20, 2024  
Bologna, Italy

# An early warning support system for climate-sensitive vector-borne diseases

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ATMOSPHERE RESEARCH CENTRE

**W**  
wellcome

# Climate-driven vector-borne disease risk assessment



Wellcome Trust Digital Technology Development Awards

Climate-Sensitive Infectious Disease Modelling

## Model and data repository

Open-access repository of vector-pathogen models, climate projections, environmental variables, and surveillance data

## Short/medium/long-term predictions

Risk maps, seasonal activity, temporal projections of vector activity and disease transmission

## Decision support tool

Web-based interactive GIS platform to display risk, run customized scenarios, and inform prevention and control

*Aedes albopictus*

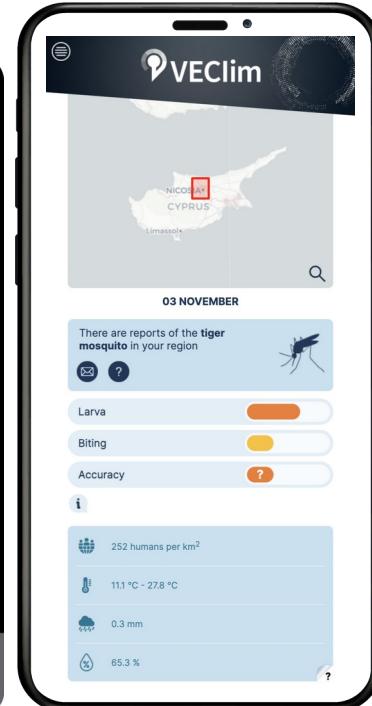
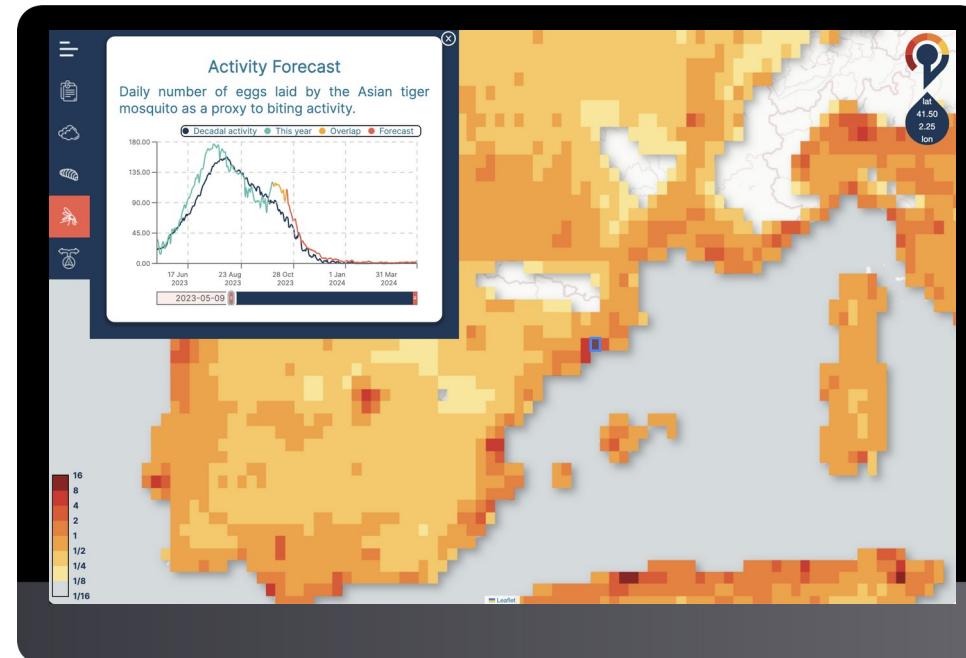


**Invasive  
Aggressive  
Competent**  
chikungunya  
dengue, zika

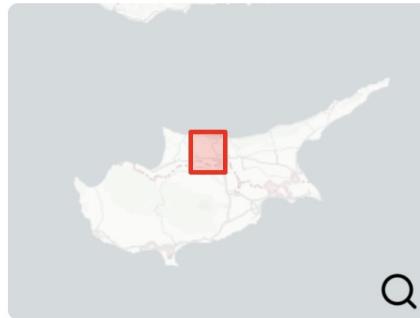
*Phlebotomus papatasi*



**Non-invasive  
Neglected  
Competent**  
leishmaniasis  
sand fly fever



# VEClim's risk indicators



16 SEPTEMBER

There are reports of the **tiger mosquito** in your region

Larva	
Biting	
Outbreak	
Impact	
Accuracy	

- Larva:** Larvae in a typical breeding site
- Biting:** Mosquito activity (bites on people)
- Outbreak:** Outbreak risk due to an imported case
- Impact:** Average impact of an imported case

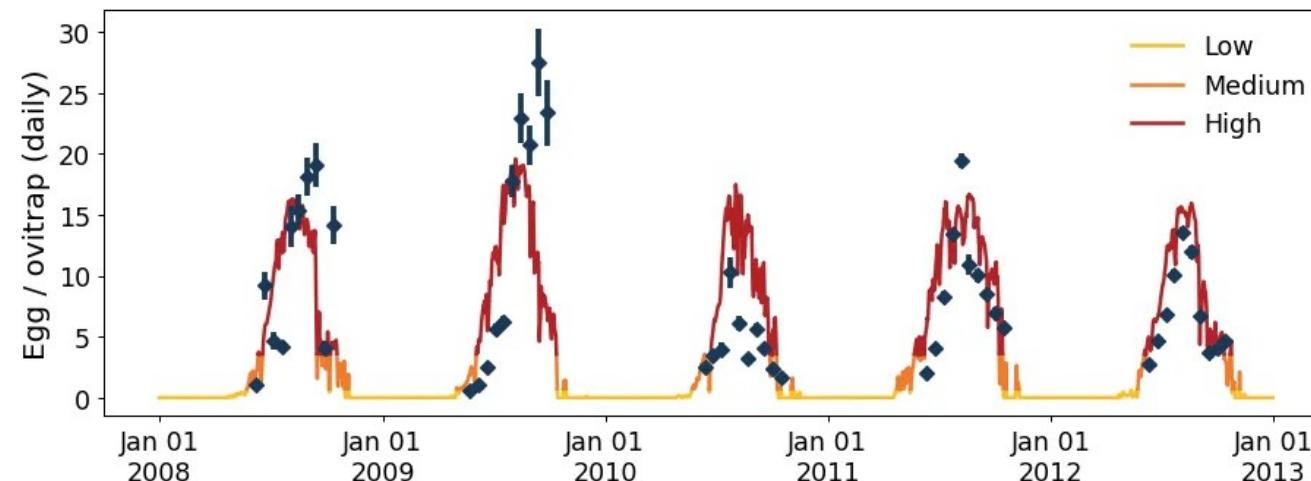
Low



Medium



High



## Current configuration

VEClim presents a set of indicators of daily vector activity and disease risk at  $0.25^\circ$  resolution based on ERA5 decadal averages and an age-structured population dynamics model of *Aedes albopictus* and CHIKV transmission.

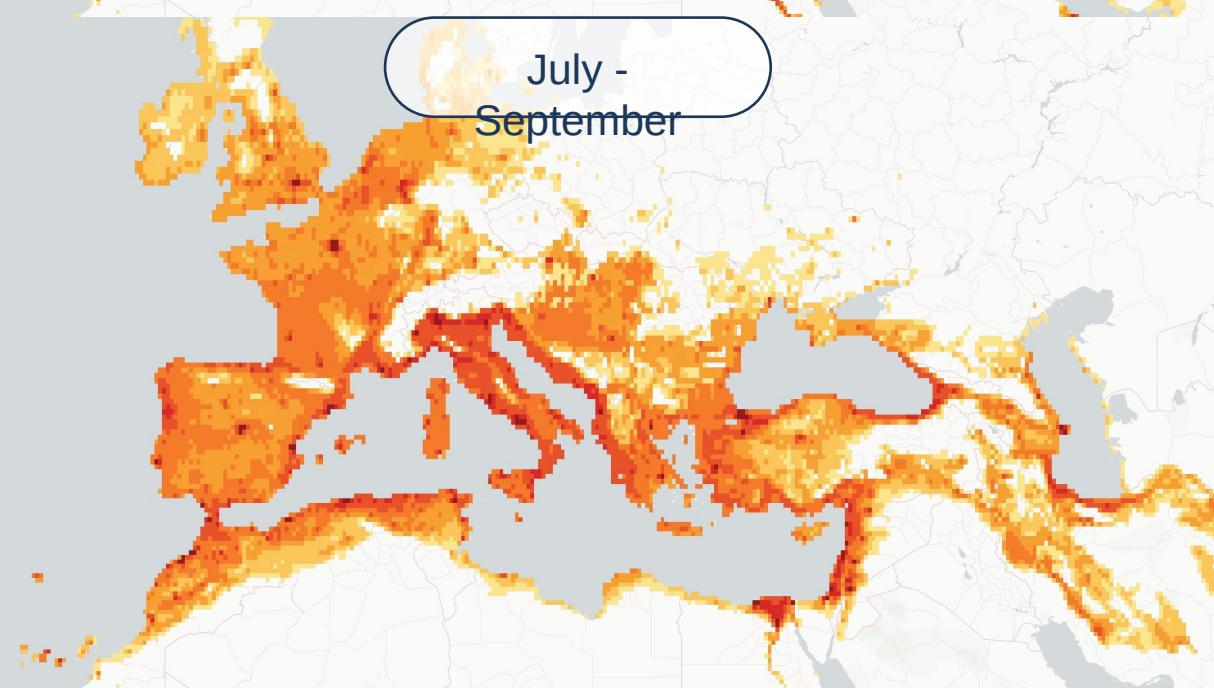
Erguler et al. 2016-2017



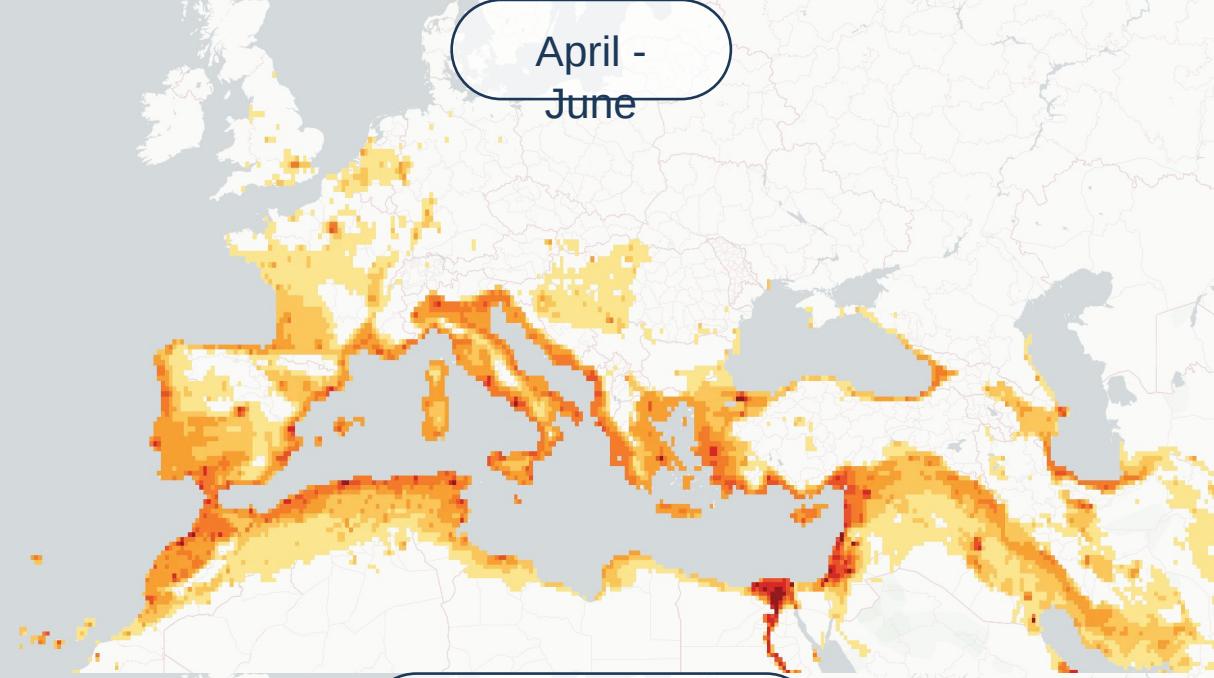
January -  
March



July -  
September



April -  
June

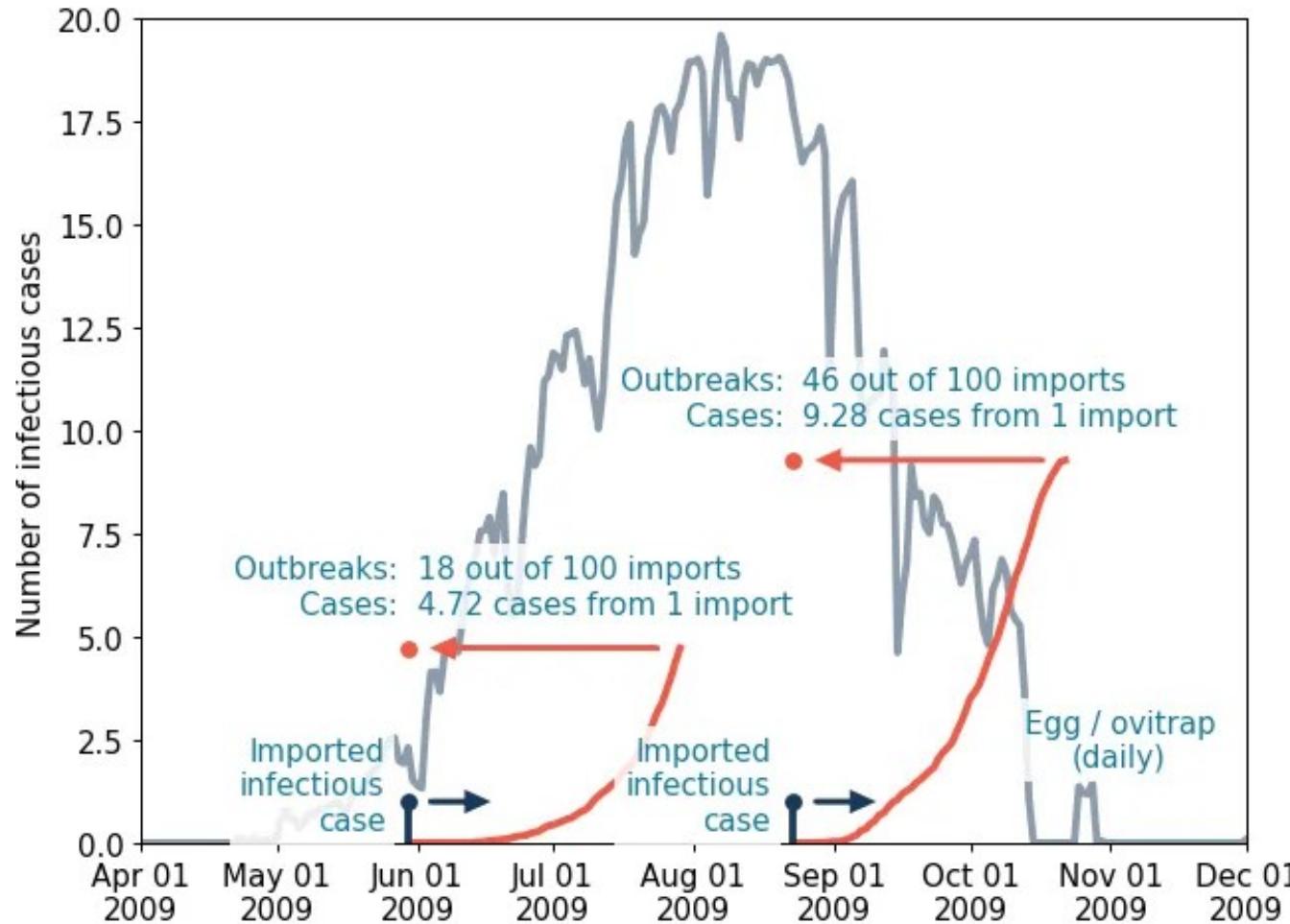


October -  
December

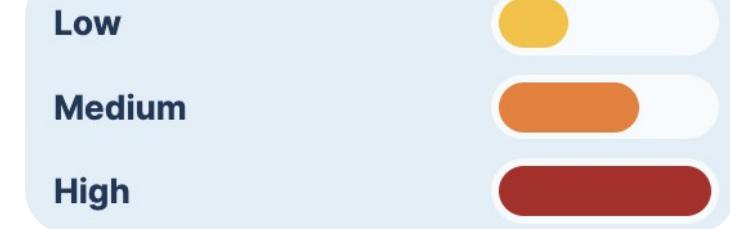


Expected activity from 2010 to 2020

# Relative activity and risk indicators (disease-related)



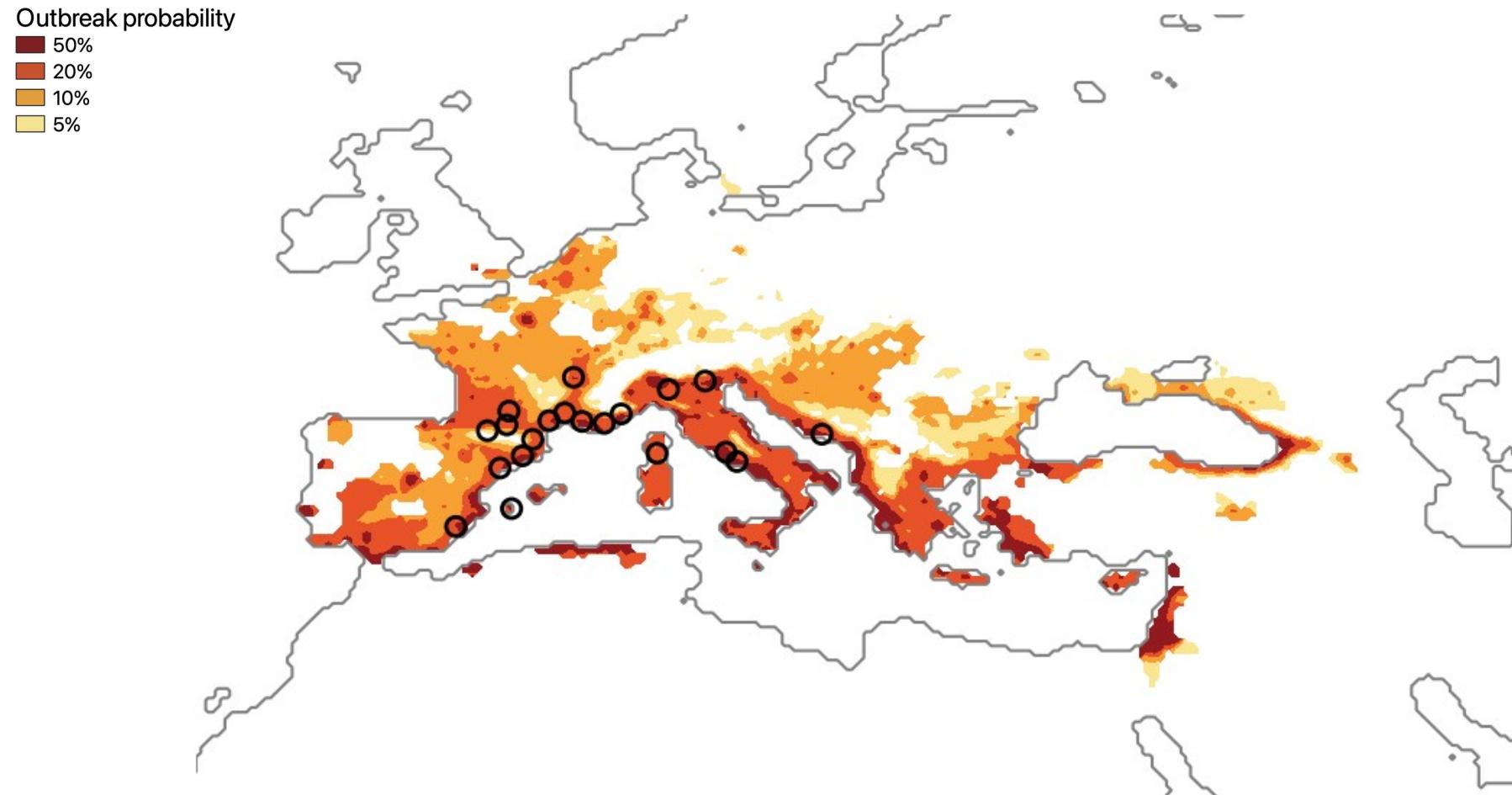
Lower than 1%  
Less than 10 cases



Larger than 50%  
More than 500 cases



# Outbreak probability vs. Dengue outbreaks



The likelihood of an imported case resulting in an outbreak in Europe from 2010 to 2020.

Circles: regions of the observed dengue outbreaks between 2010 and 2023.  
<https://www.ecdc.europa.eu/en/all-topics-z/dengue/surveillance-and-disease-data/autochthonous-transmission-dengue-virus-eueea>

# Decadal averages Medium-range forecasts Long-range projections

## → Decadal averages

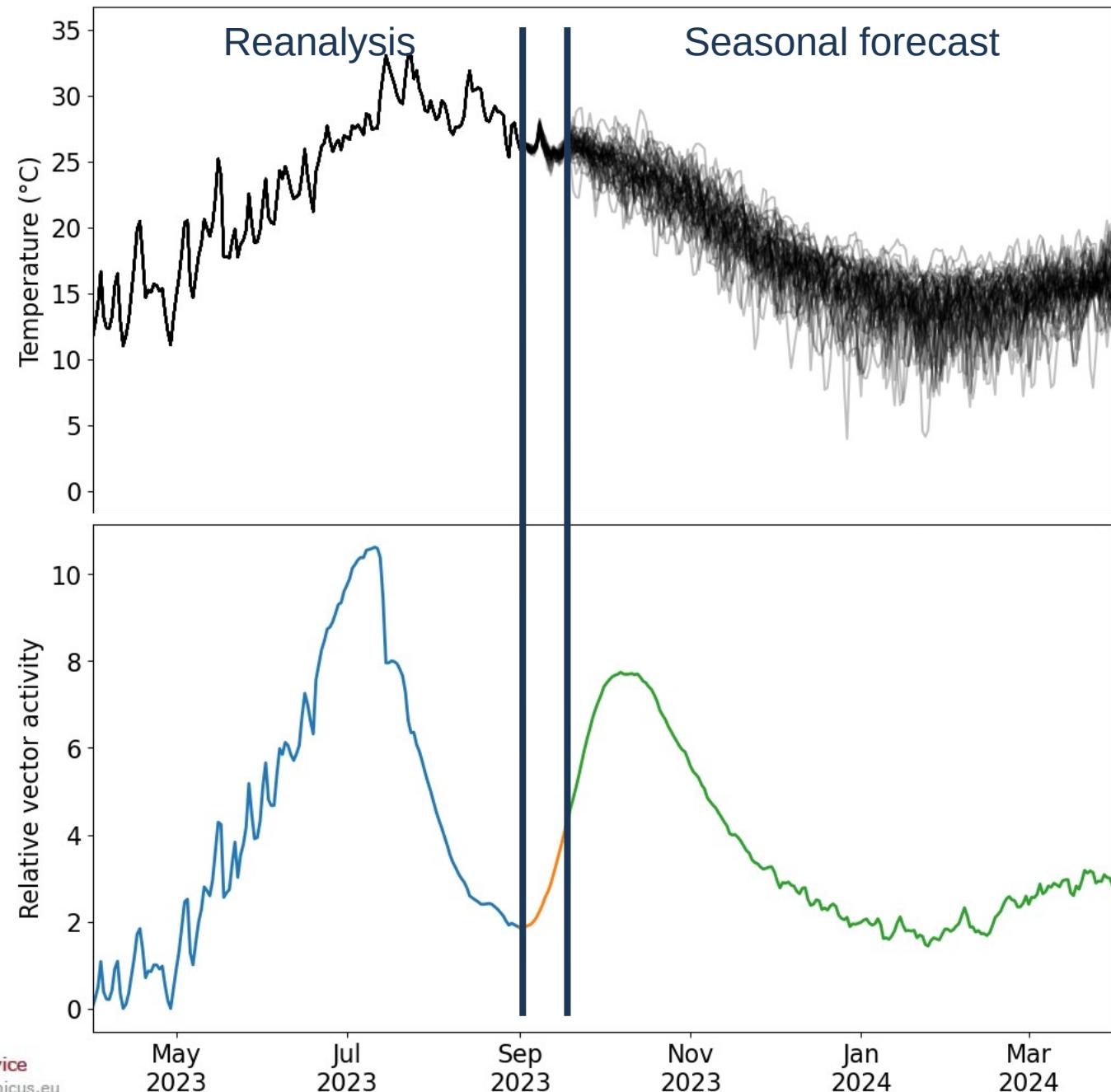
- Reanalysis dataset (2010-2020)
- Daily at 25 km resolution

## → Seasonal forecast

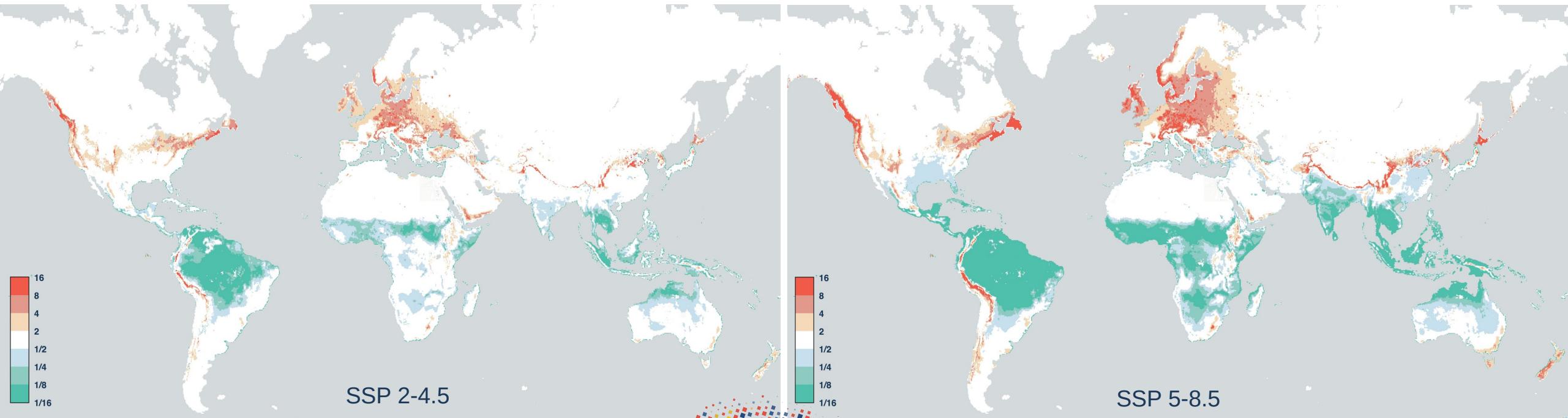
- Present & future (3-6 months)
- Daily at 25-100 km resolution

## → Climate projections

- NEX-GDDP-CMIP6 (2090-2100)
- SSP2-4.5 & SSP5-8.5
- Daily downscaled at 25 km resolution

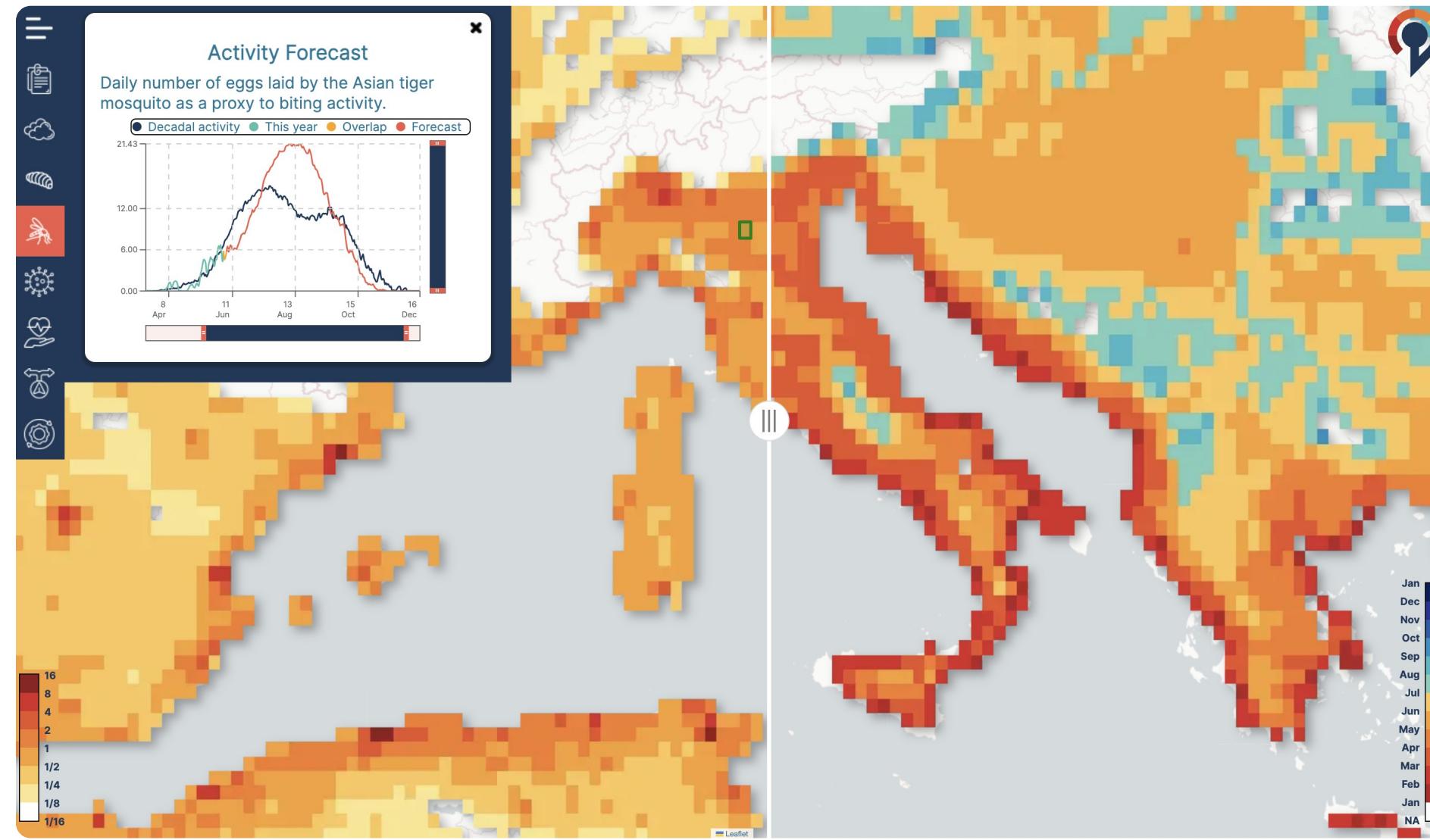


# Expected activity in 2090-2100 compared to 2010-2020



Coming soon!

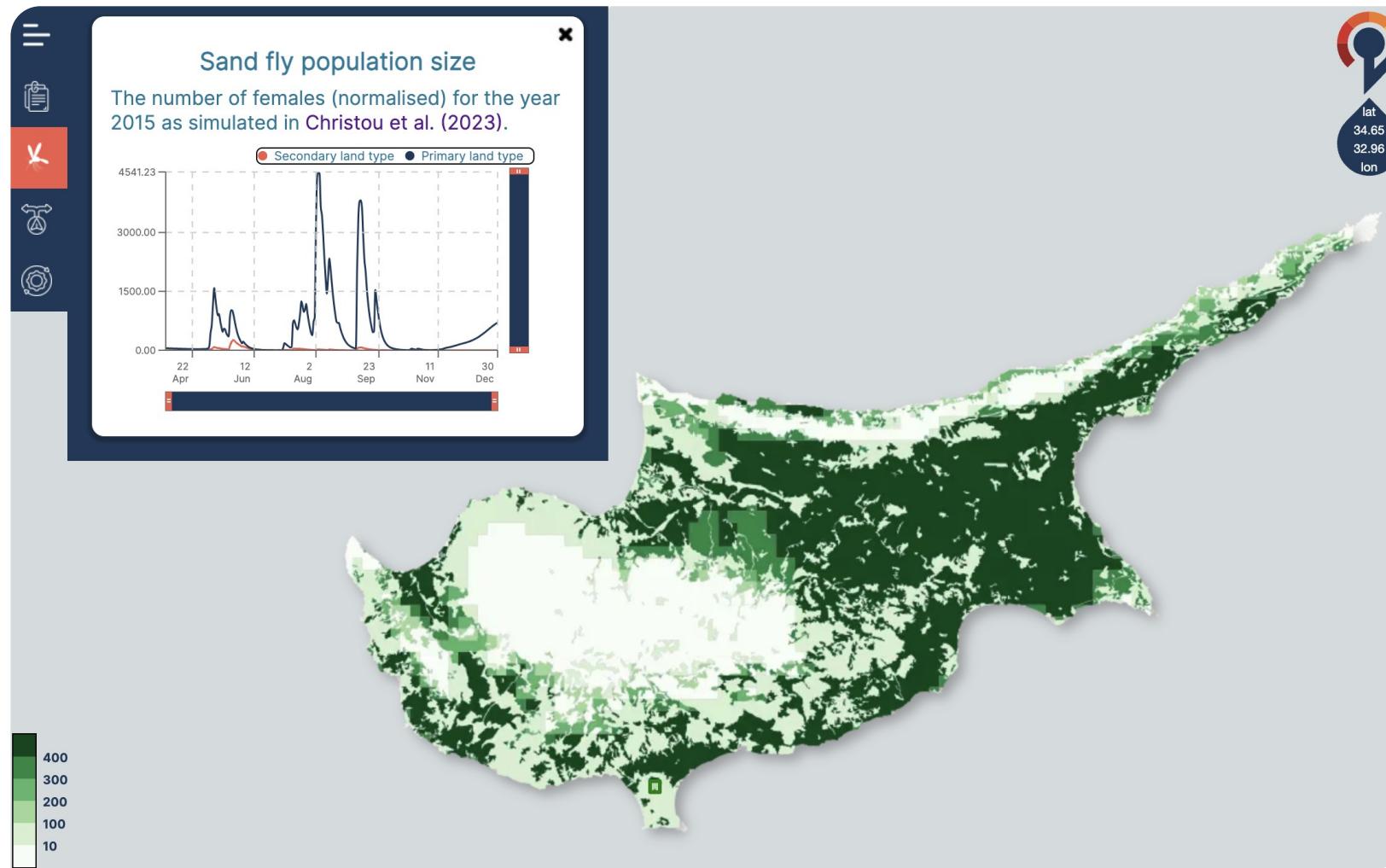
# VEClim's GIS & tile server



## Current configuration

VEClim's versatile GIS tools enable browsing simulation results and risk indicators spatially and temporally, overlaying and analyzing different outputs at the same time.

# VEClim's GIS & tile server

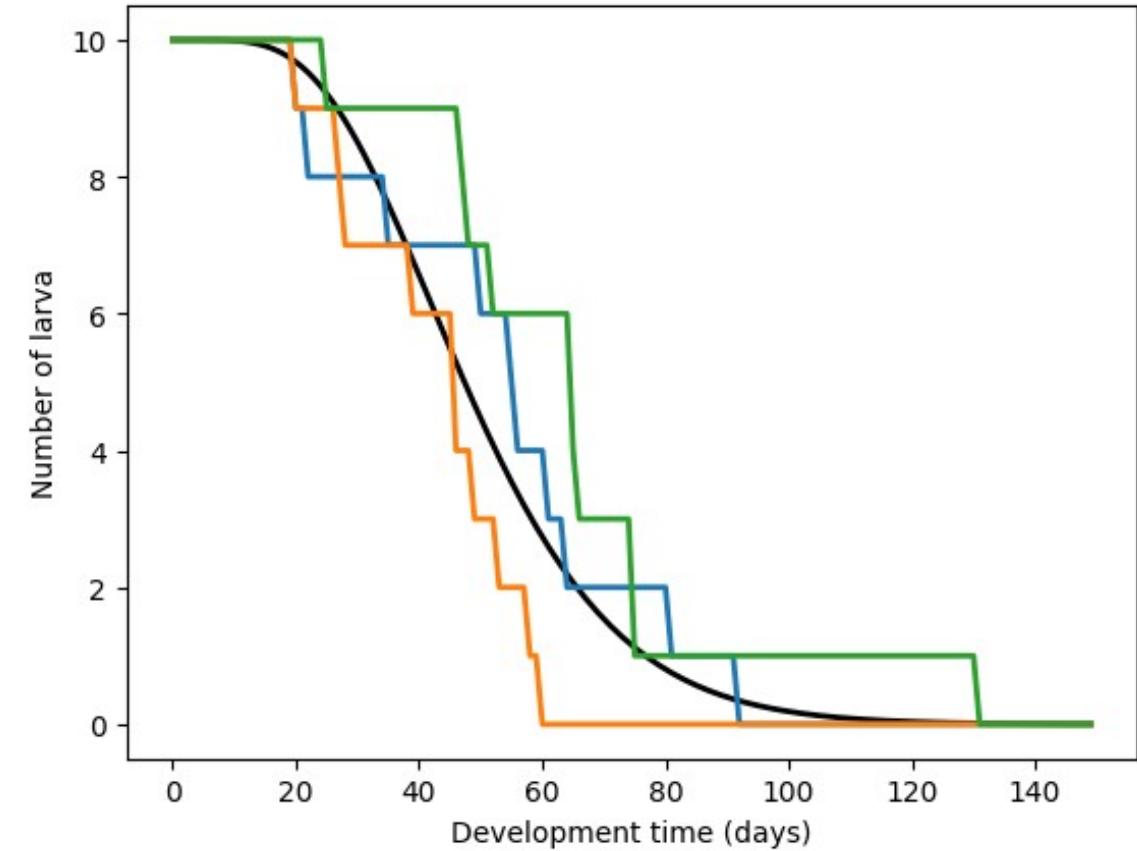


## Current configuration

The platform enables studying different models and predictions, operating at any spatial and temporal resolution and over custom geospatial ranges.

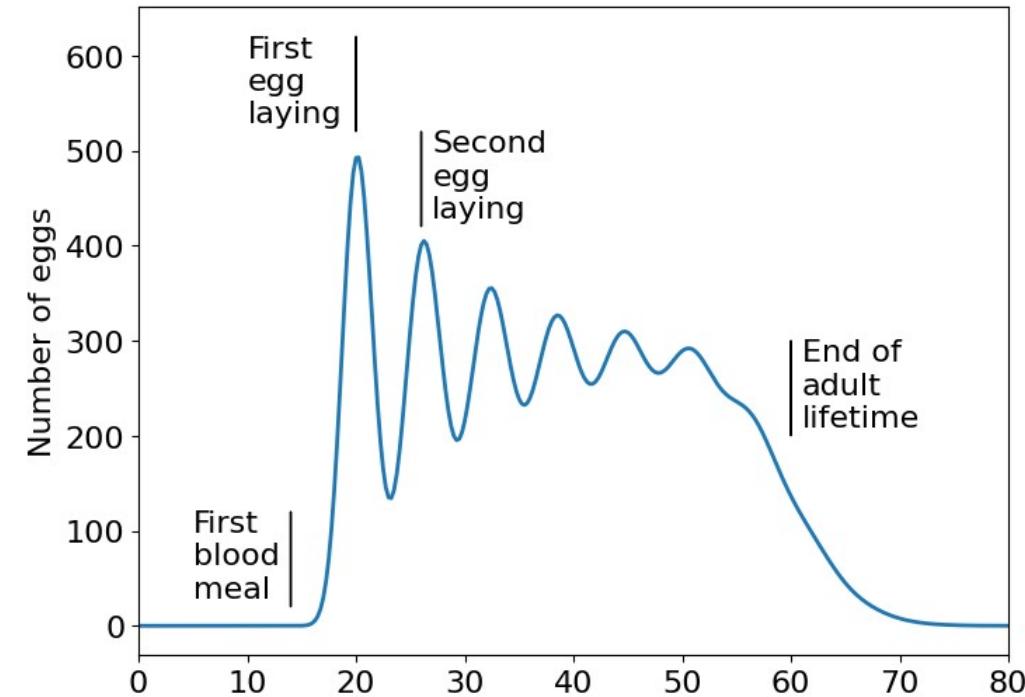
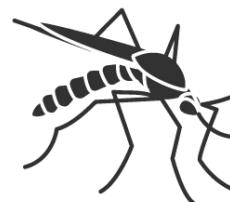
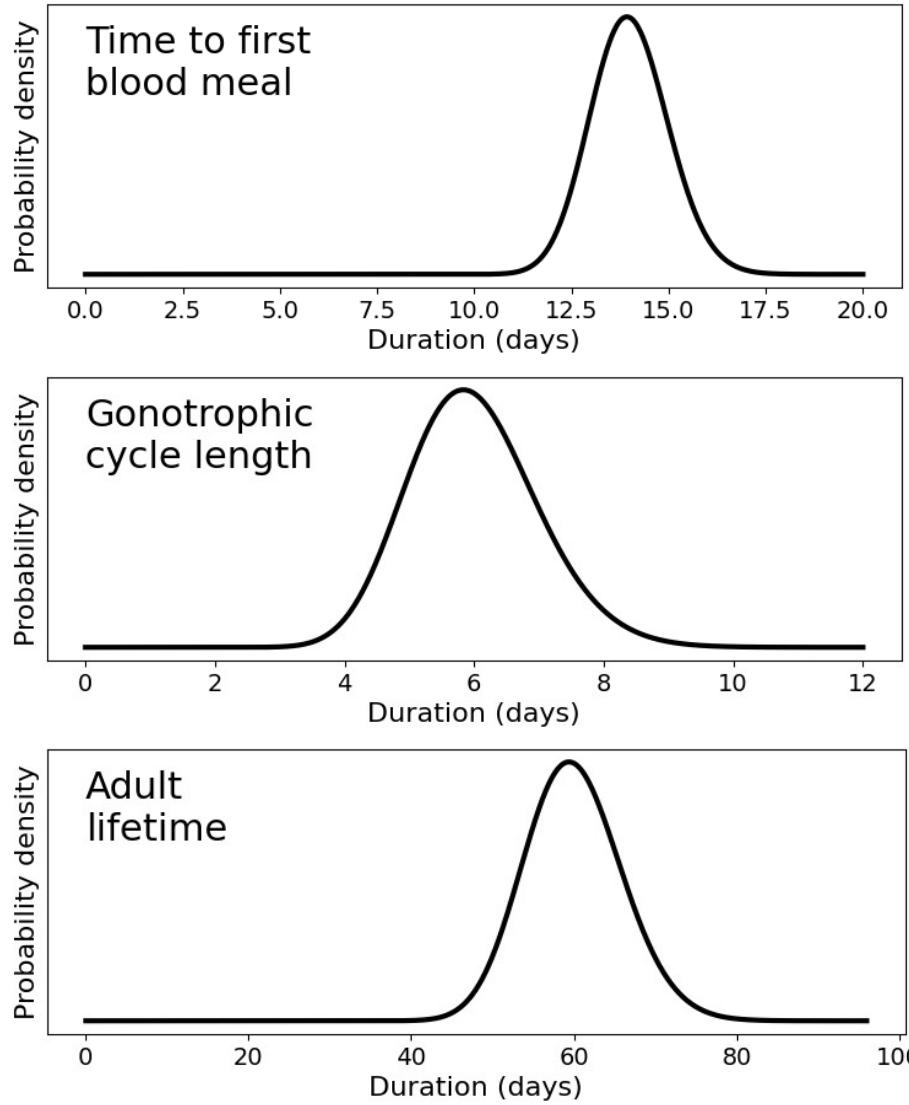
# PopJSON: a JavaScript Object Notation representation

```
{  
  "model": {  
    "title": "Climate-sensitive population dynamics",  
    "type": "Population",  
    "url": "https://github.com/kerguler/Population",  
    "deterministic": true,  
    "parameters": {  
      "algorithm": "Population",  
      "istep": 0.001  
    }  
  },  
  "populations": [  
    {  
      "id": "larva",  
      "name": "The larva stage",  
      "processes": [  
        {  
          "id": "larva_dev",  
          "name": "Larva development time (days)",  
          "arbiter": "AGE_GAMMA",  
          "value": [10, 4]  
        }  
      ]  
    }  
  ]  
}
```



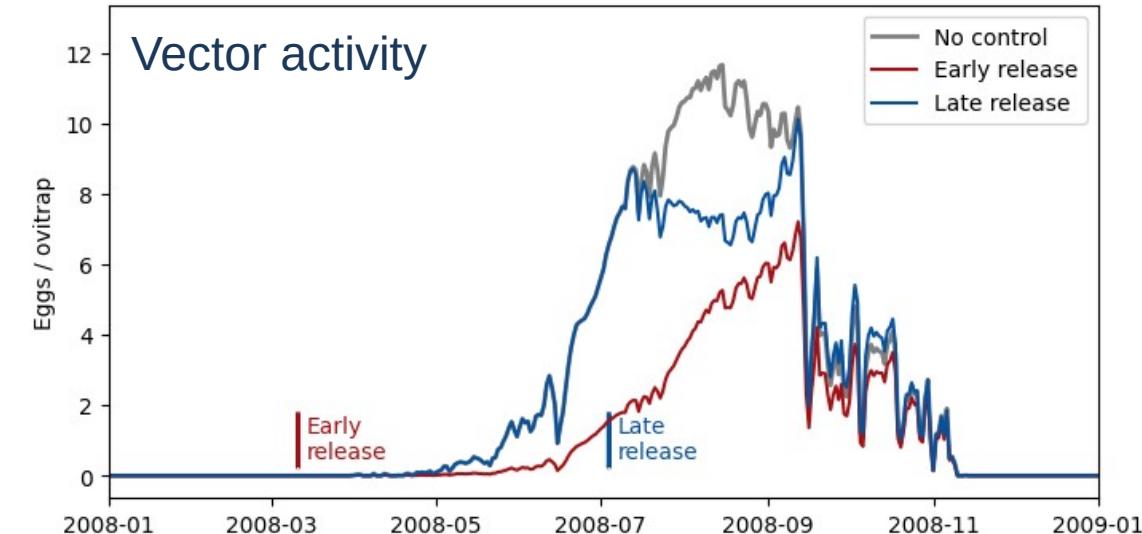
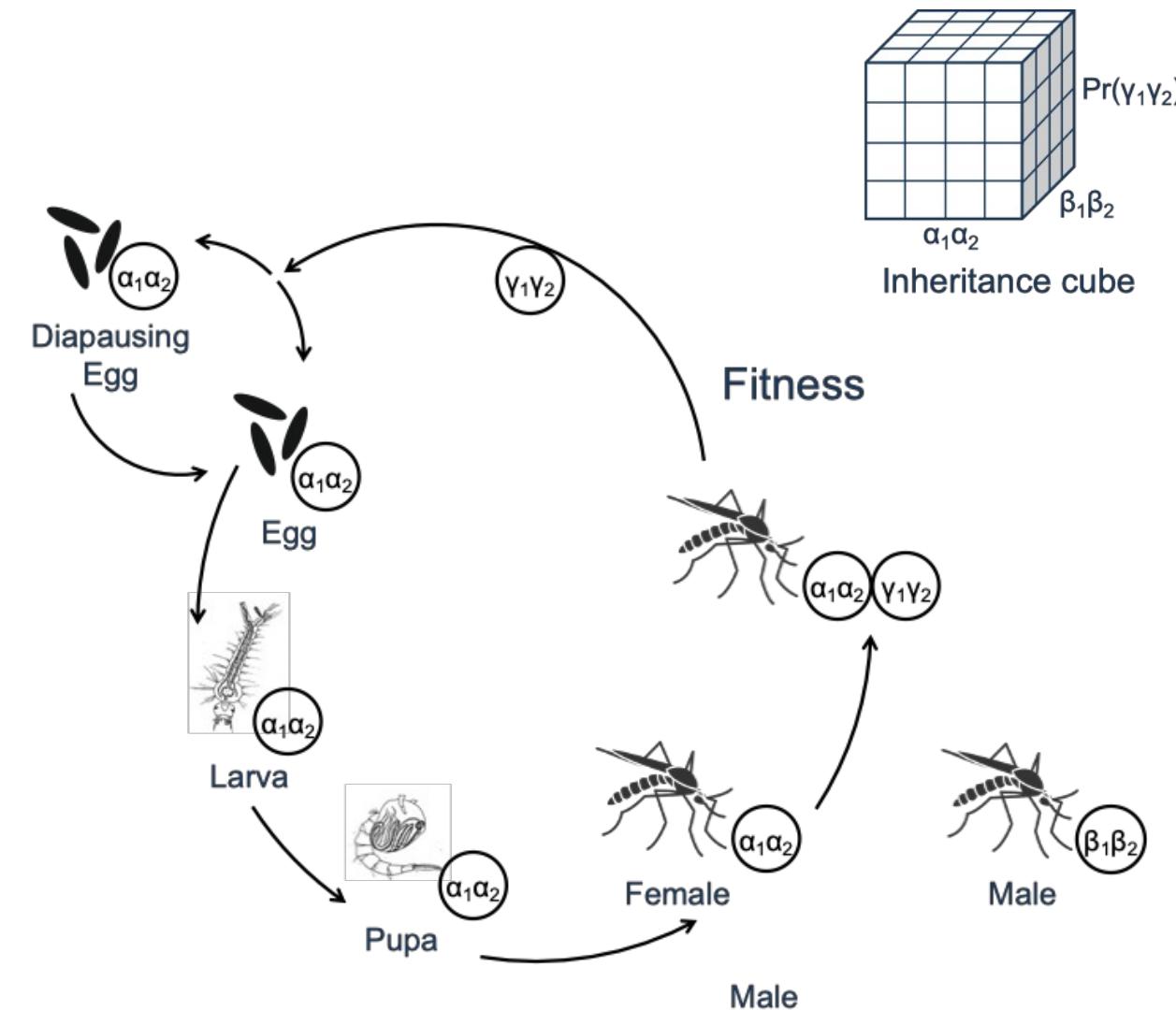
clarity - reproducibility - transferability

# Dynamic multi-process modelling with PopJSON and the Population package

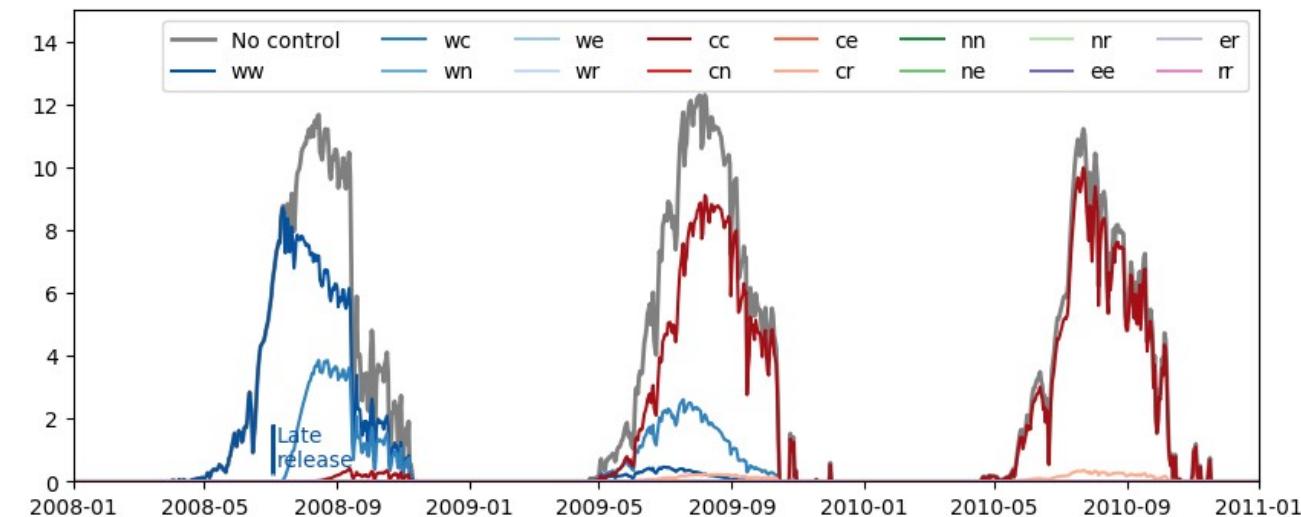


# Dynamics of genetic control

Sterile insect technique

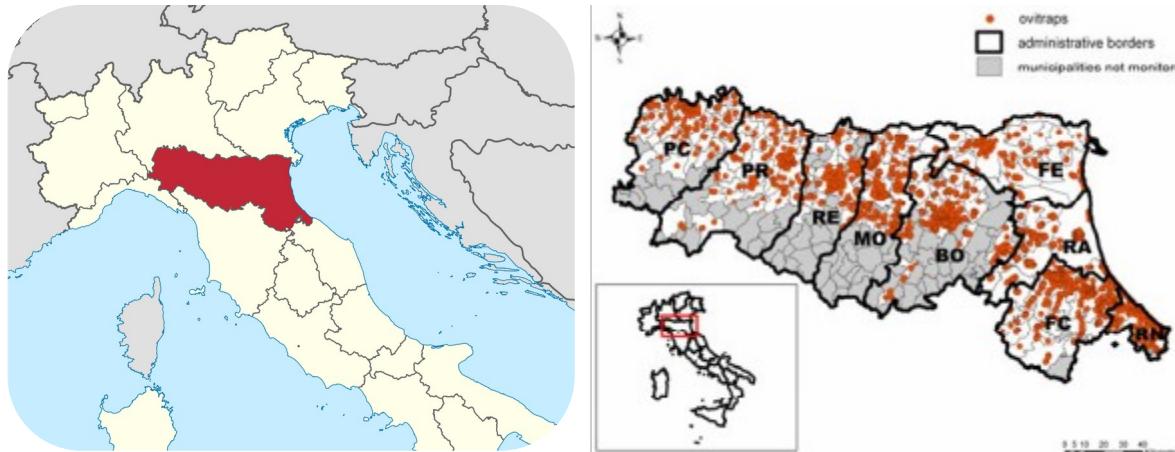


Classical replacement gene drive

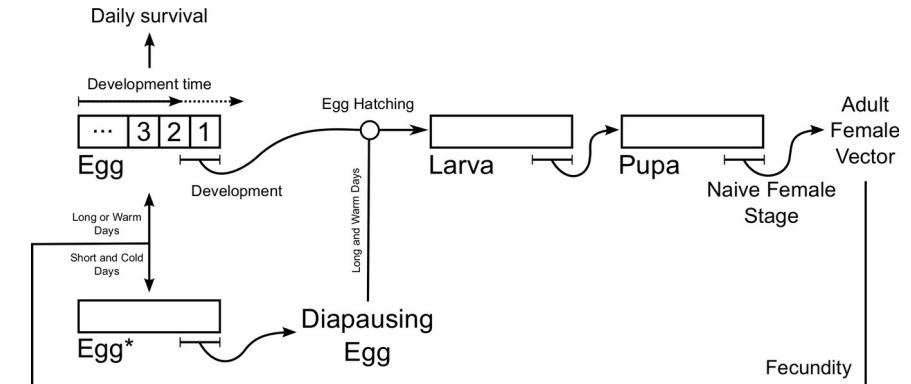
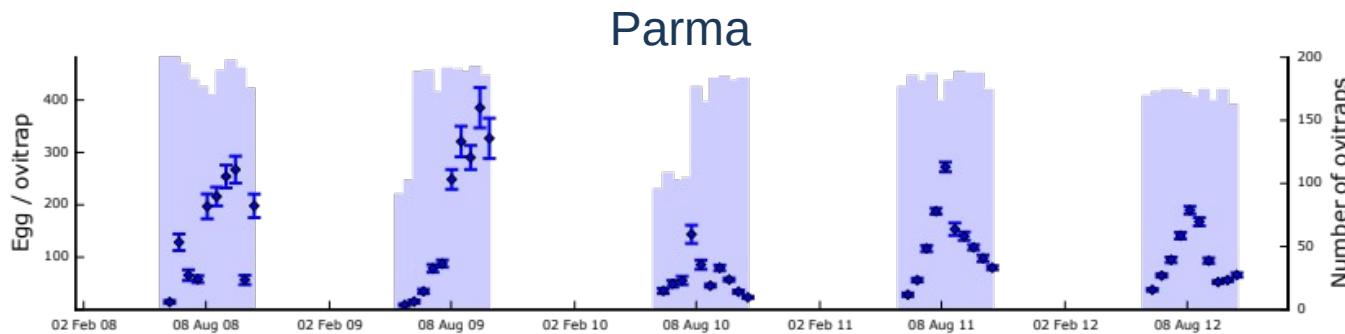




# Predicting tiger mosquito abundance

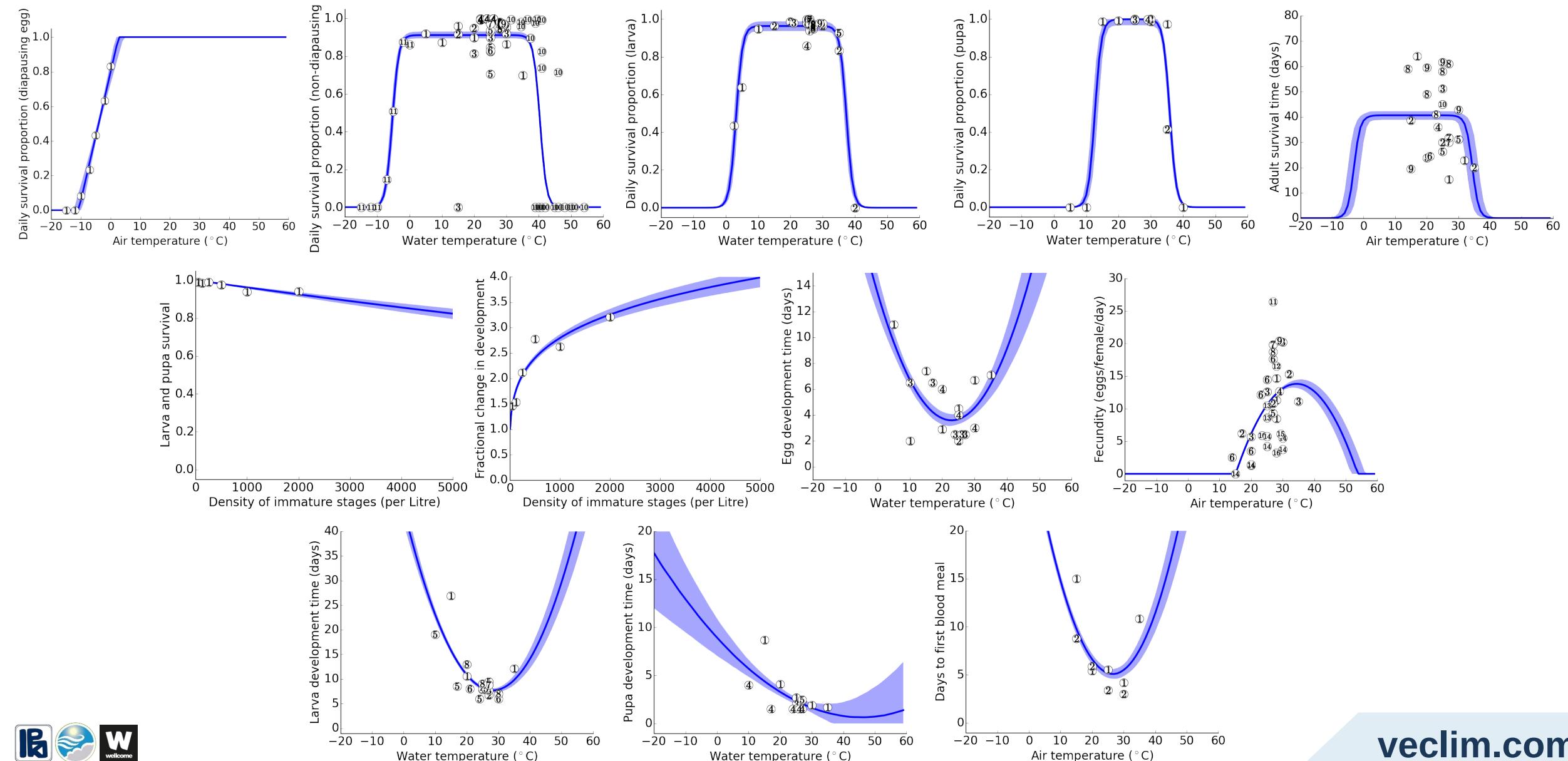


Albieri et al. Bull. Insectology 63(2) (2010)

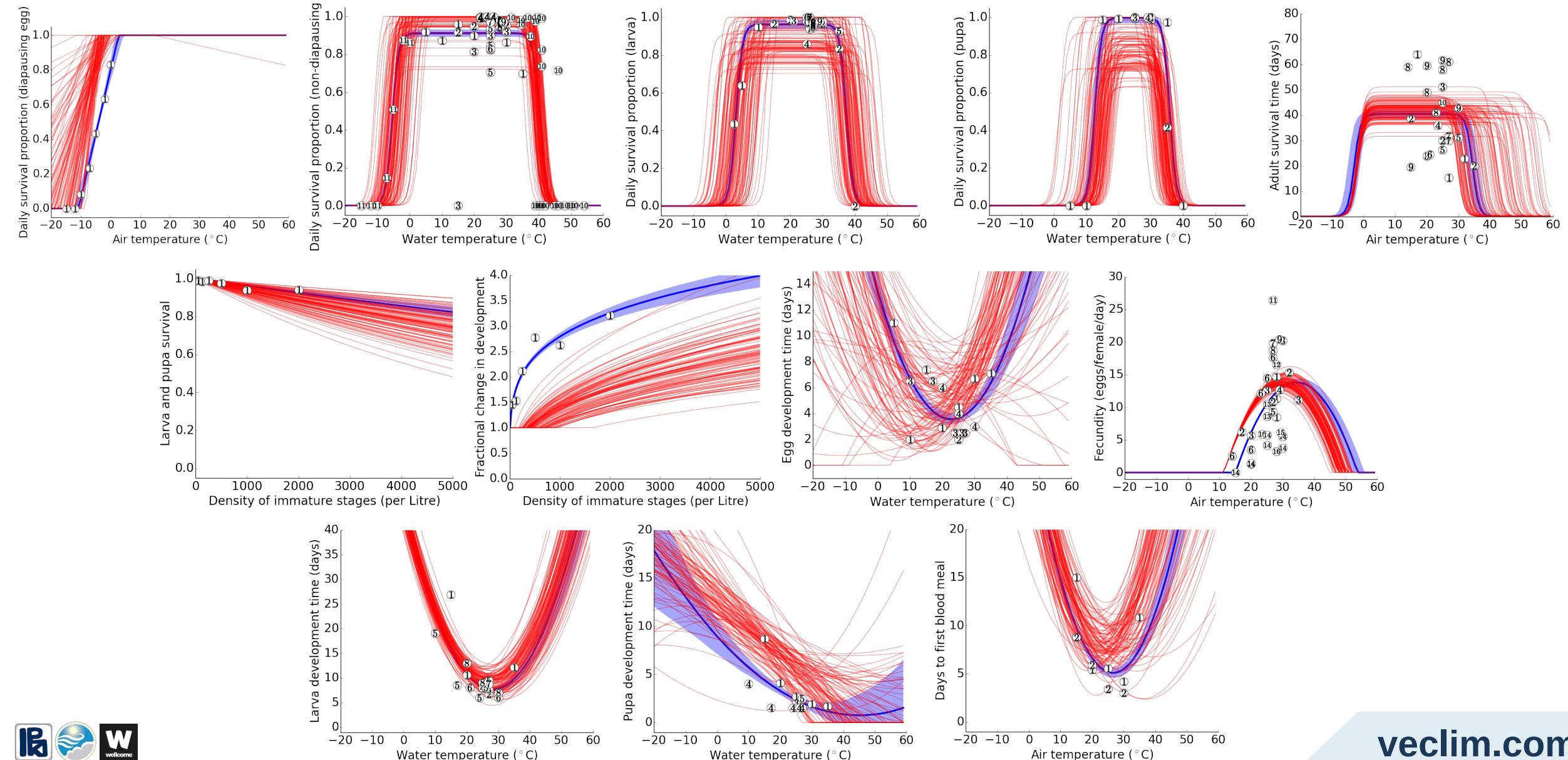


- Temperature and precipitation (E-OBS)
- Human population density (SEDAC)
- Photoperiod

# Environmental dependency of life processes

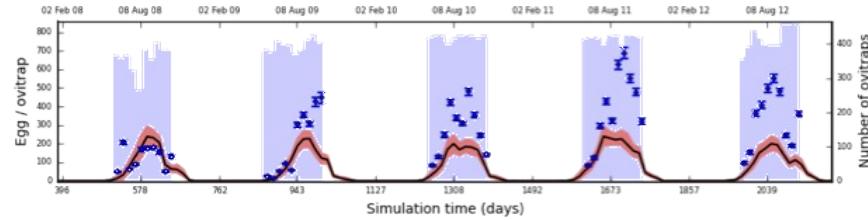


# Environmental dependency of life processes

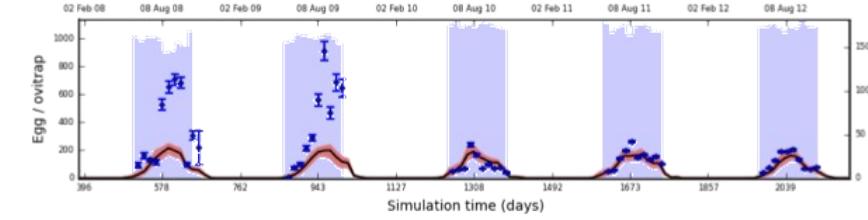


# Goodness-of-fit over Emilia-Romagna

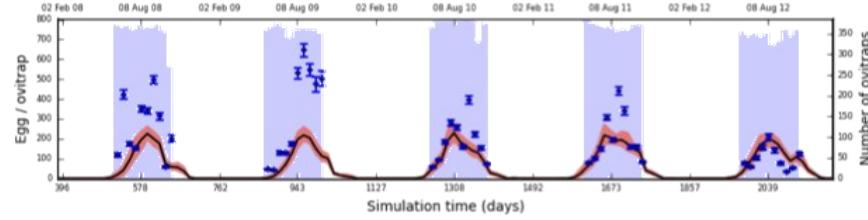
**Bologna**



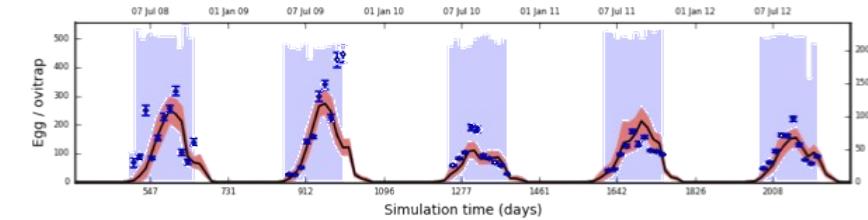
**Piacenza**



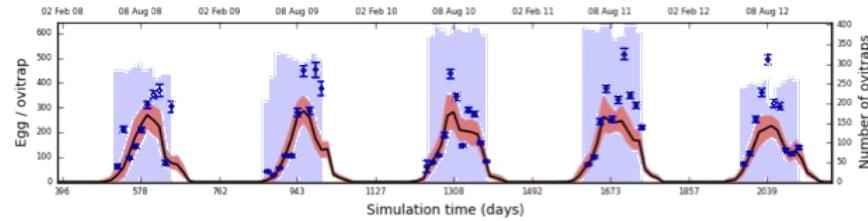
**Ravenna**



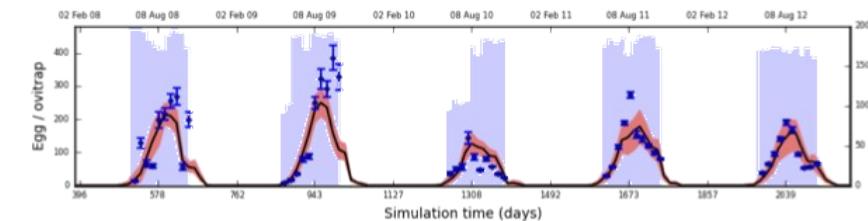
**Reggio Emilia**



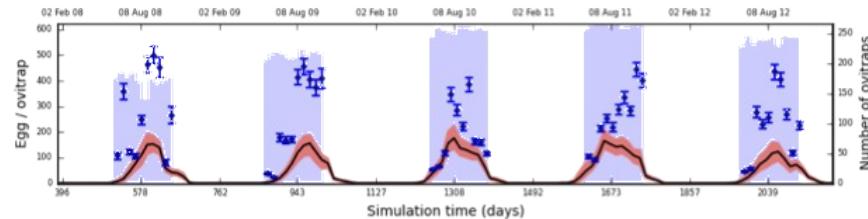
**Modena**



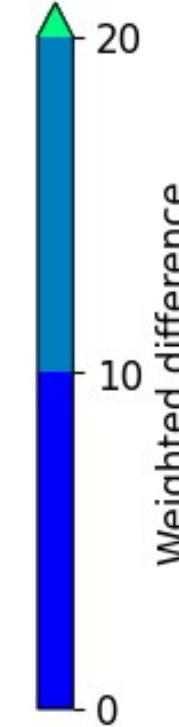
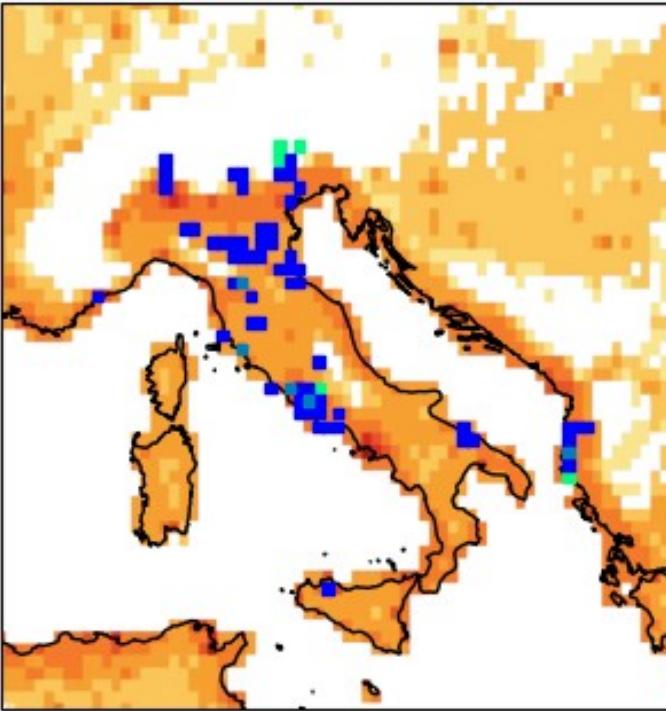
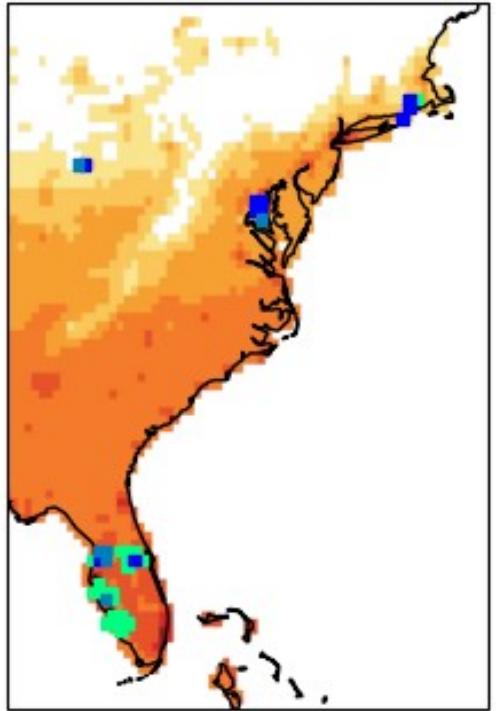
**Parma**



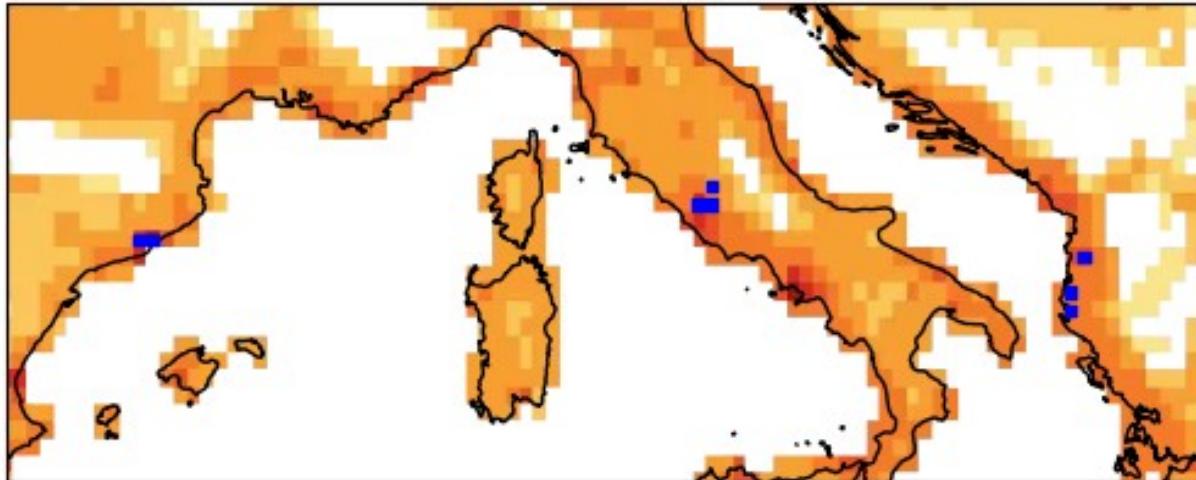
**Ferrara**



Surveillance period:  
2008 - 2012



AIMSurv



# Global applicability assessment

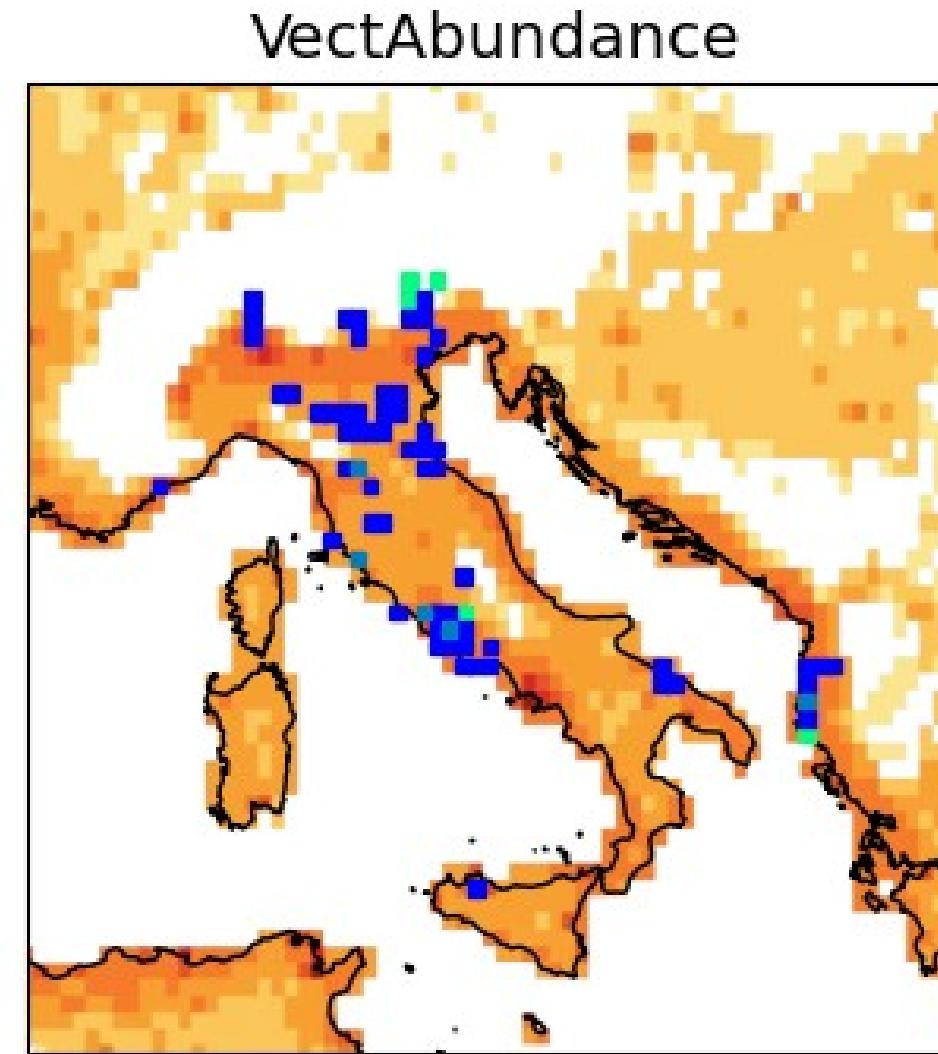
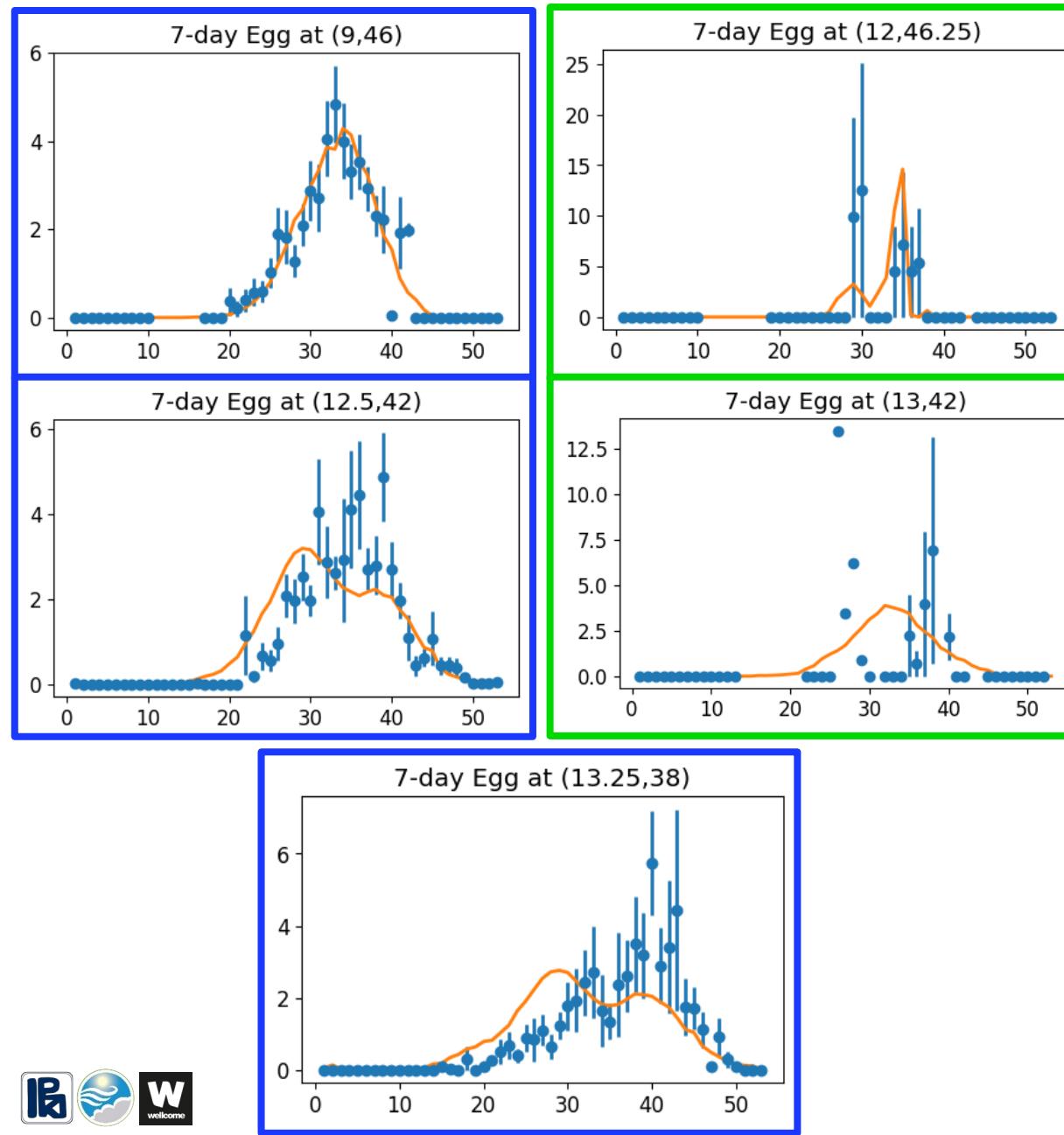
## Methods

- Gridded
  - 25 km
- Filtered
  - At least 50 data points
  - Sampling: 1-day adult, 7-day egg

## Results

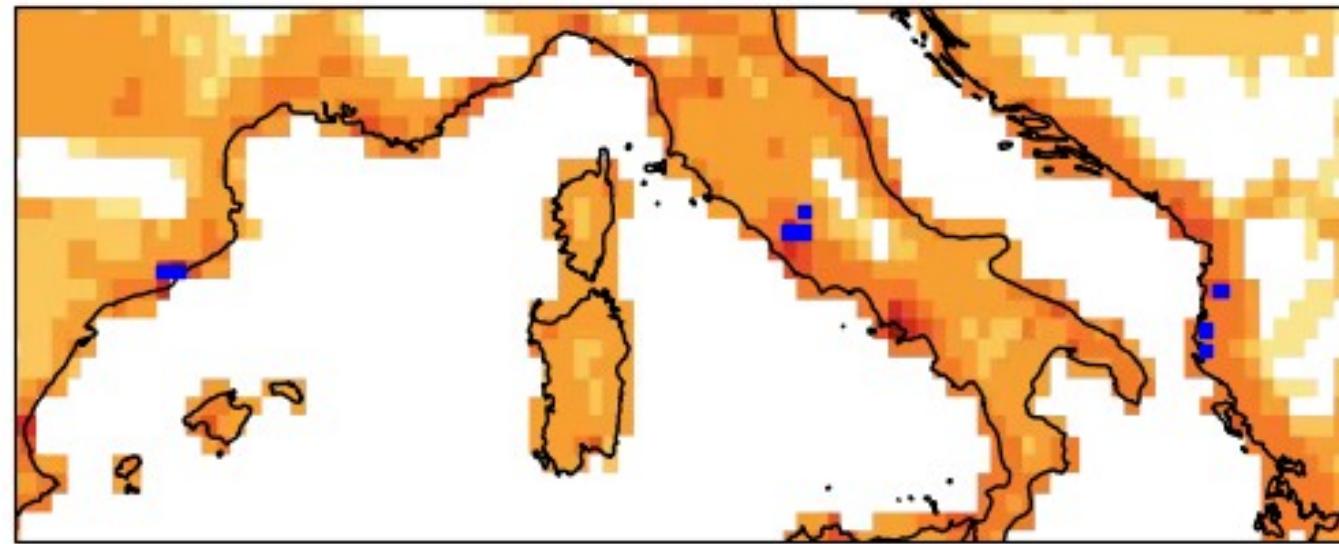
- Predictive in
  - Italy
  - Temperate and similar climates
- Needs improvement in
  - High altitudes
  - Tropical regions

# Global applicability assessment

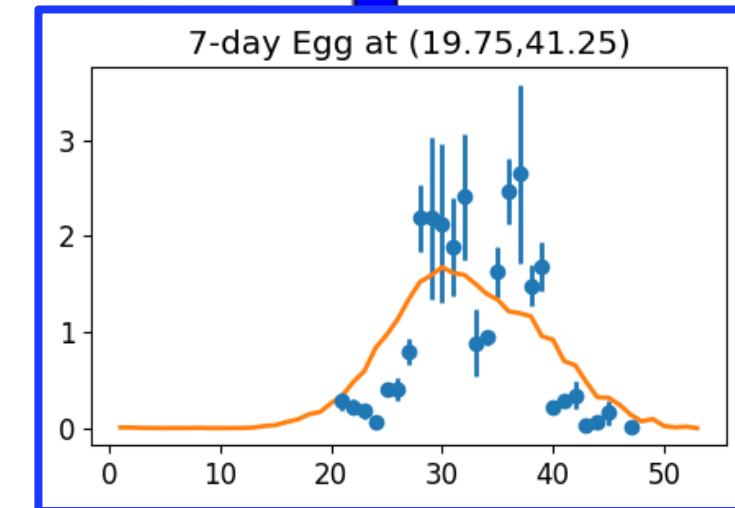
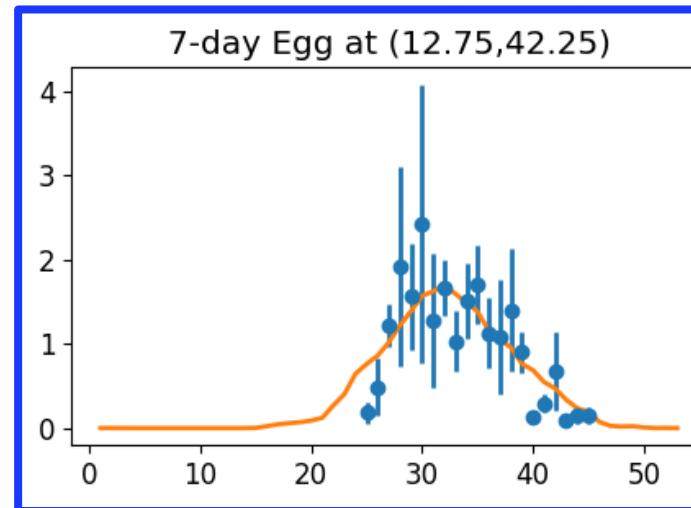
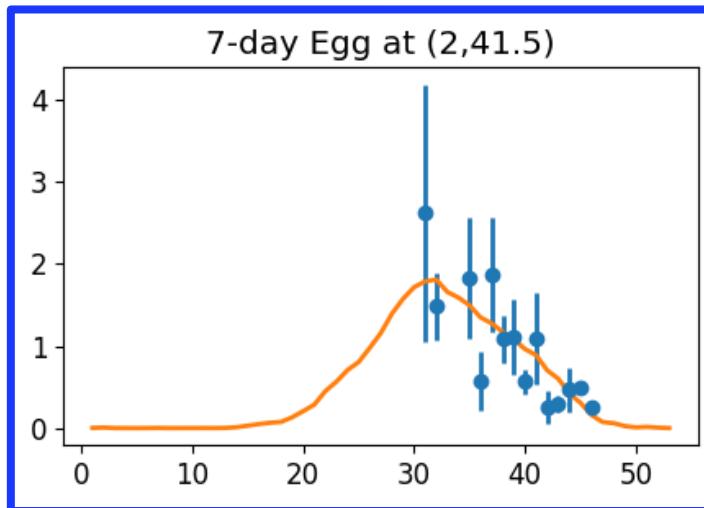


# Global applicability assessment

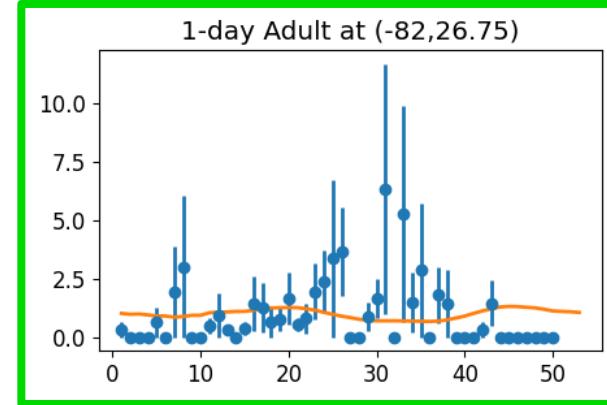
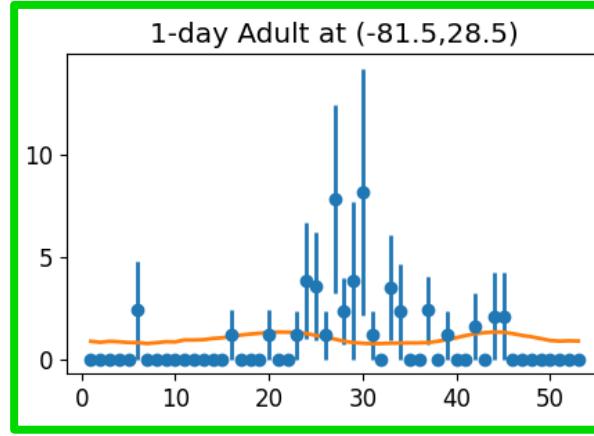
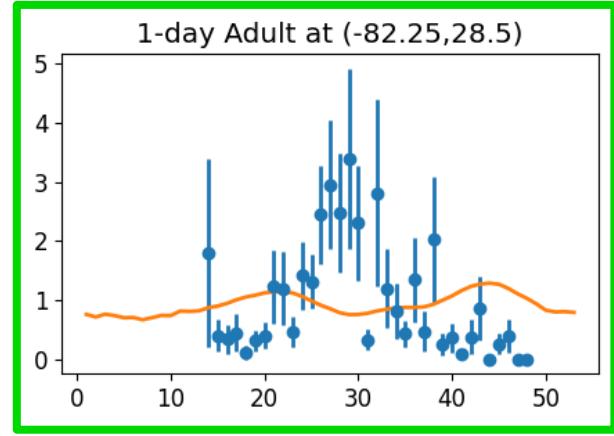
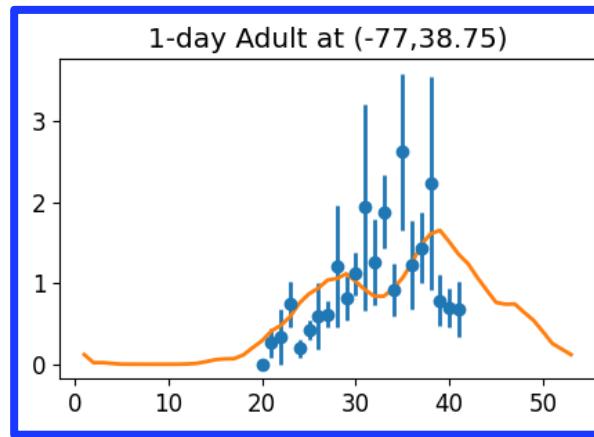
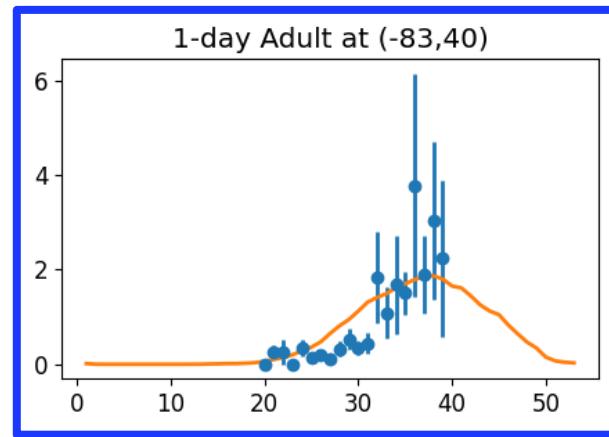
AIMSurv



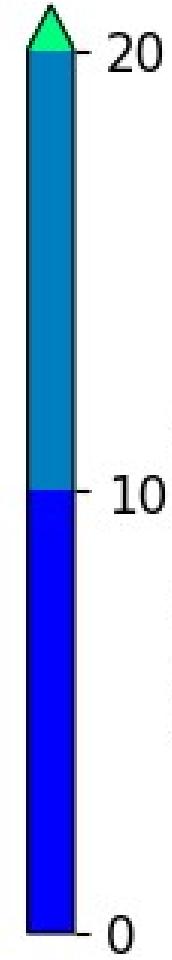
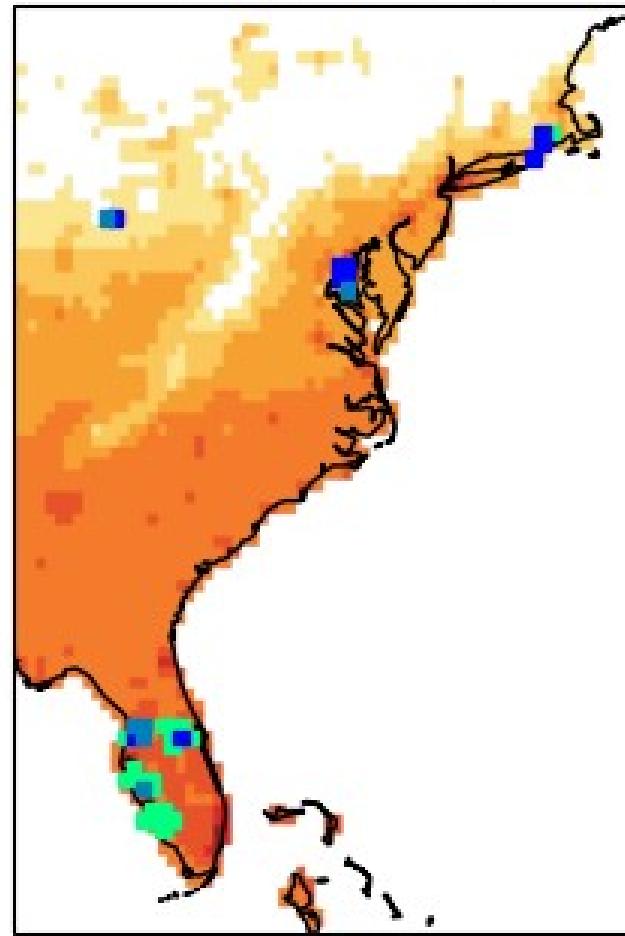
Weighted difference



# Global applicability assessment

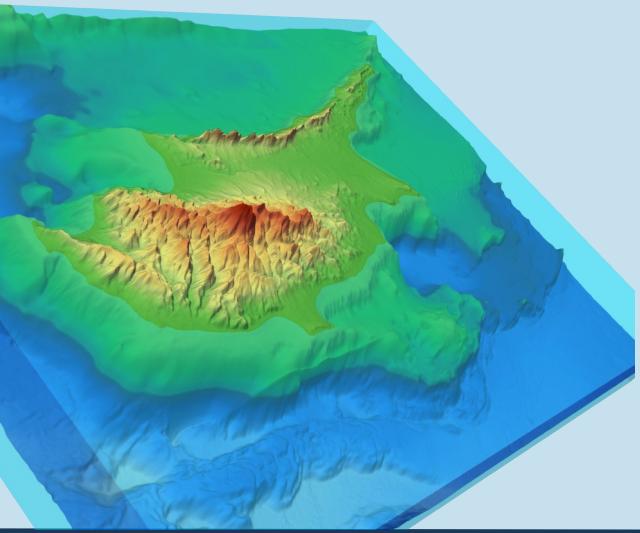


VectorBase





# THANK YOU



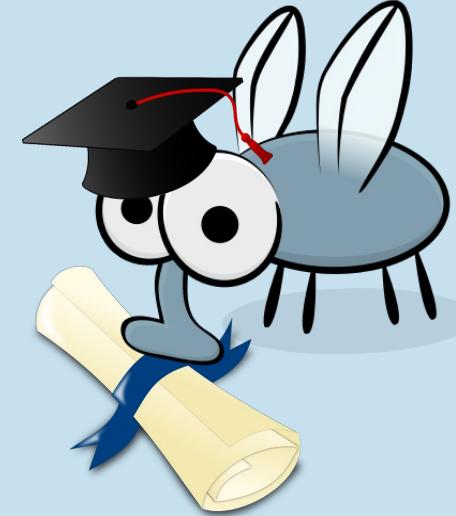
Ahmet



Hande



George



LOOKING  
FOR  
TEAMMATES!

Funded by

