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and Environmental Research

Including the ecology of vector and pathogen in mosquito-borne disease risk assessment in times of climate change:

Dengue transmission by *Aedes albopictus*

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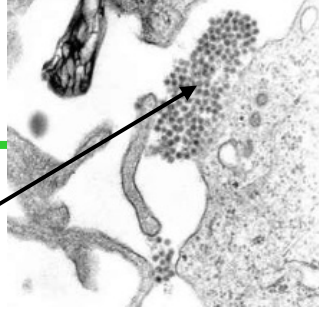
University of Bayreuth

Department of Biogeography and Biogeographical Modelling

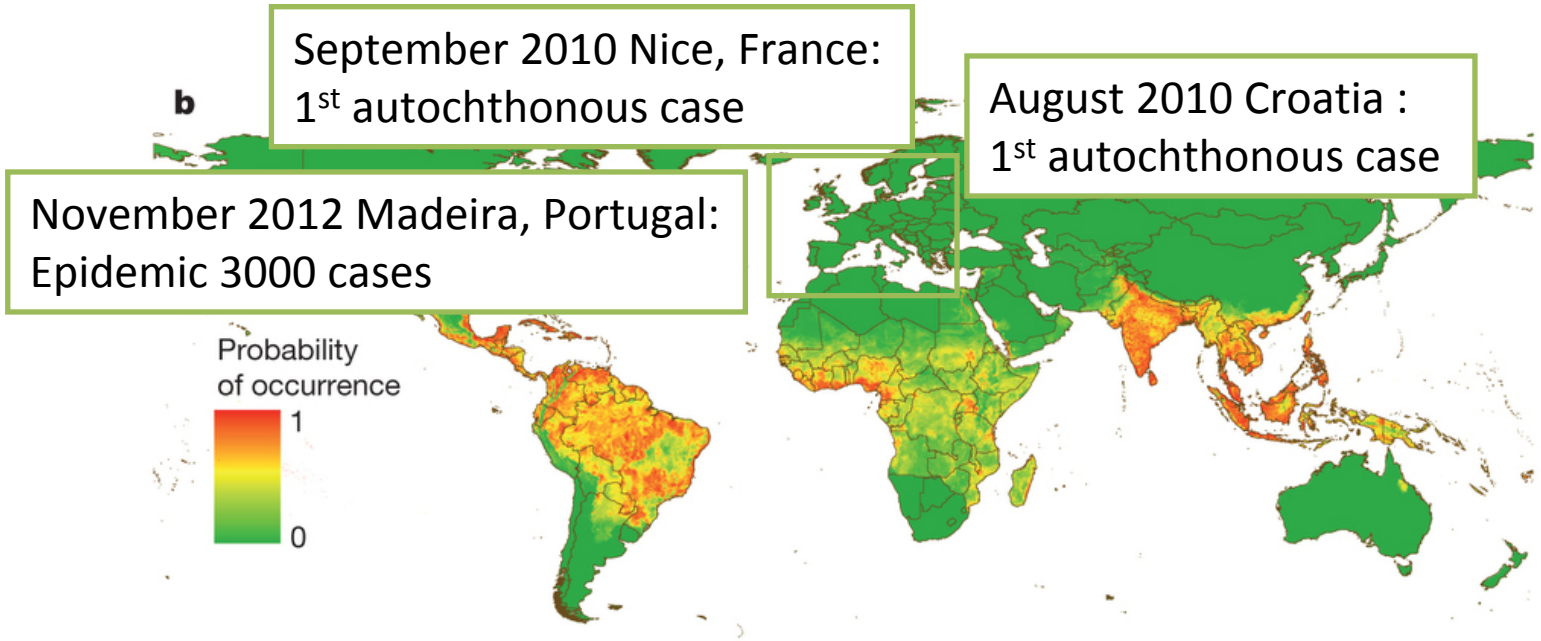
IECID 2015 - Impact of Environmental Changes on Infectious Diseases

Sitges, March 2015

Dengue



- Most rapidly spreading mosquito-borne Flavivirus, (+)ssRNA
- 30-fold increase in global incidence during the past 50 years
- dengue infections per year (modeled by Bhatt et al. 2013):
  apparent: 96 million unapparent: 294 million



Bhatt, S. et al. (2013) Nature

Aedes albopictus

- Native to southeast Asia
- Dispersed on all continents (except Antarctica) mainly due to shipping of used tires and potted plants
- Establishment started where the traded goods were landed
- Aggressive day-biter and tree-hole breeder
- Vector of 24 pathogens such as Dengue and Chikungunya virus

Drivers for Dengue Transmission

Urbanisation	Socioeconomic factors	Climate factors
High population density…	Globalisation of travel…	Temperature dependence of virus transmission & vector lifecycle …

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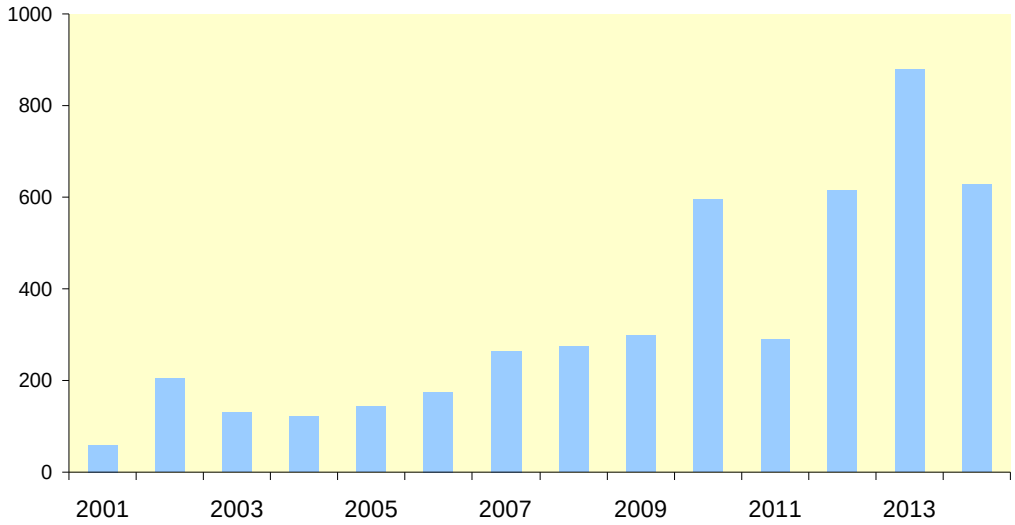
Rising concern in **Europe** due to

→ Widespread establishment of *Ae. albopictus*

→ Increased pathogen introductions by tourism

Travel related Dengue cases in Germany



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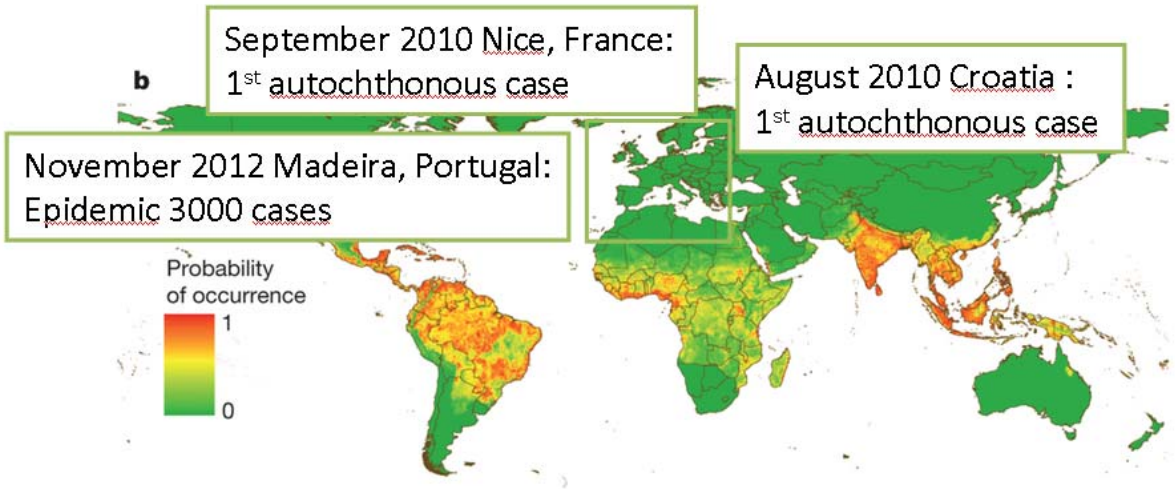
→ Local outbreaks



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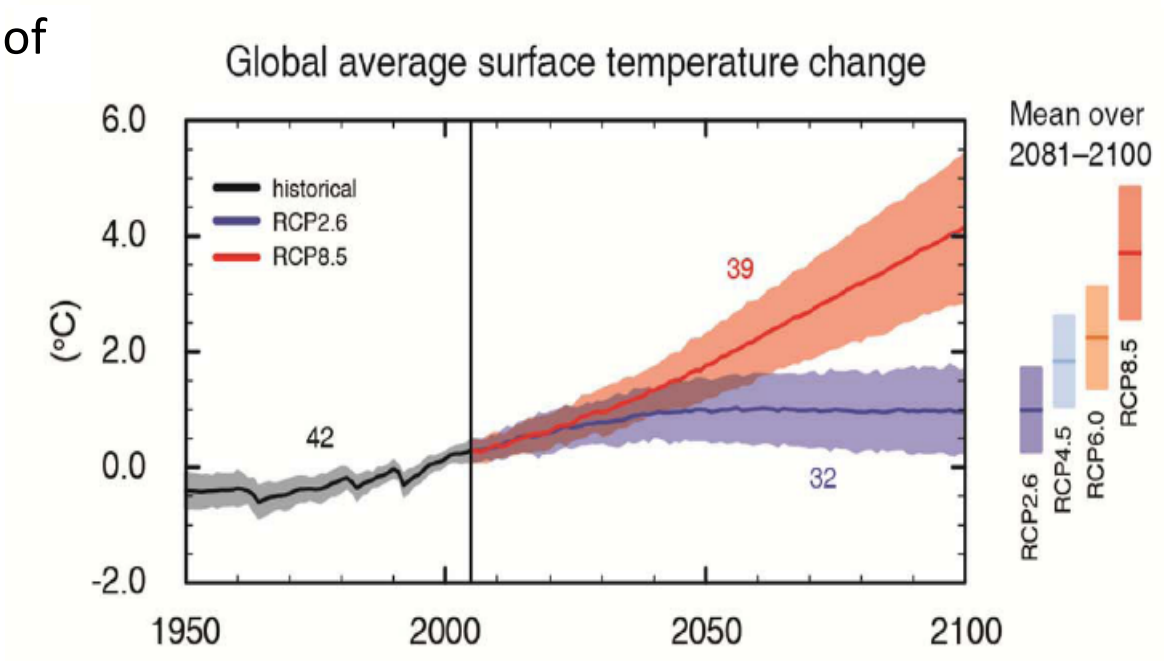
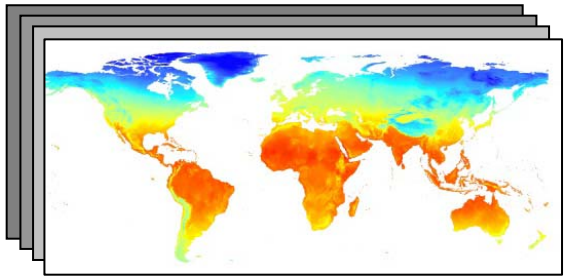
→ Climate Change

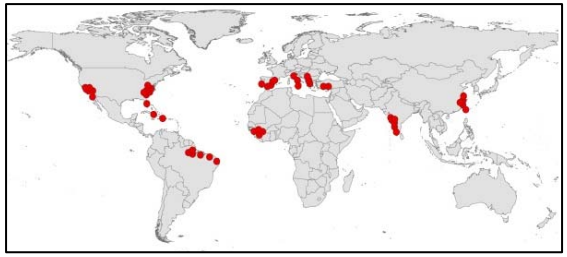


Correlative Modelling

1.) Current

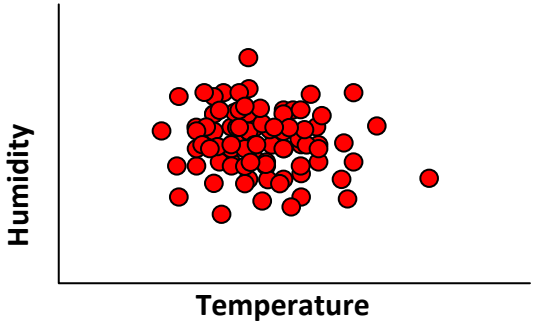
Climatic variables + Occurrence records

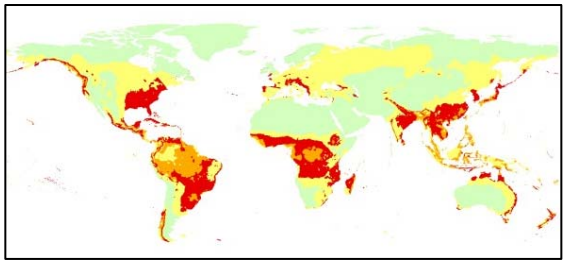




2.) Current

Identify environmental envelope

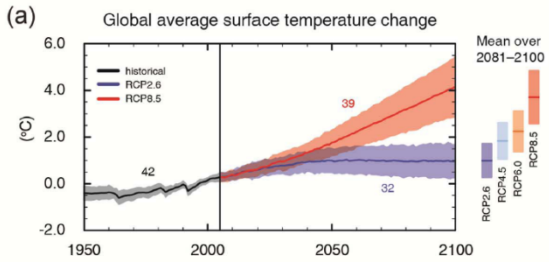




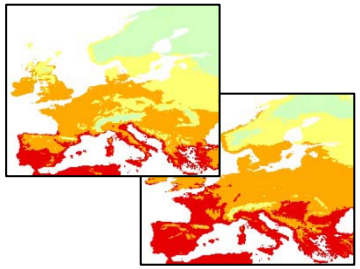
3.) Future

Relate to climate change models

IPCC scenarios, AR5, 2013



MPI-ESM / COSMO



Fischer, Thomas, Beierkuhnlein (2010) Nova Acta Leopoldina

Correlative Modelling

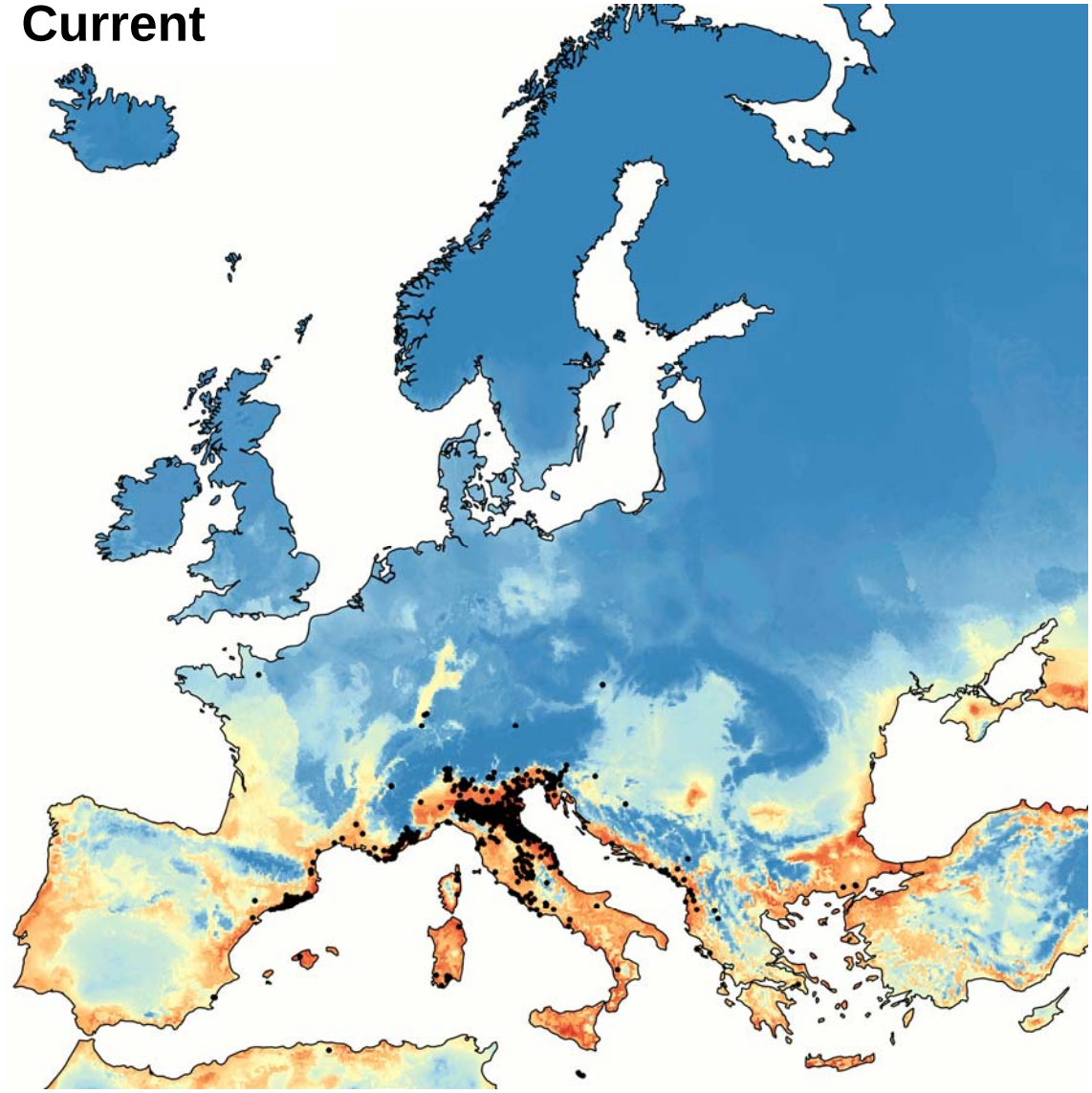
- Correlative species distribution model using
- Ensemble approach (biomod2) combining GLM, GBM, RF and Maxent
- 6913 observed presences
- Climatic variables derived from worldclim (5 arc min):

  Mean temperature of driest quarter
  Mean temperature of warmest quarter
  Mean temperature of coldest quarter
  Max temperature of warmest month
  Min temperature of coldest month
  Annual mean temperature

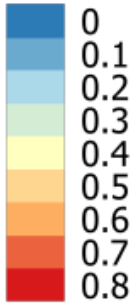
- Five global climate models
- Two IPCC 5 scenarios: rcp 4.5 (+1.8°C) and rcp 8.5 (+3.7°C)

Results: Correlative model

Current



Climatic suitability

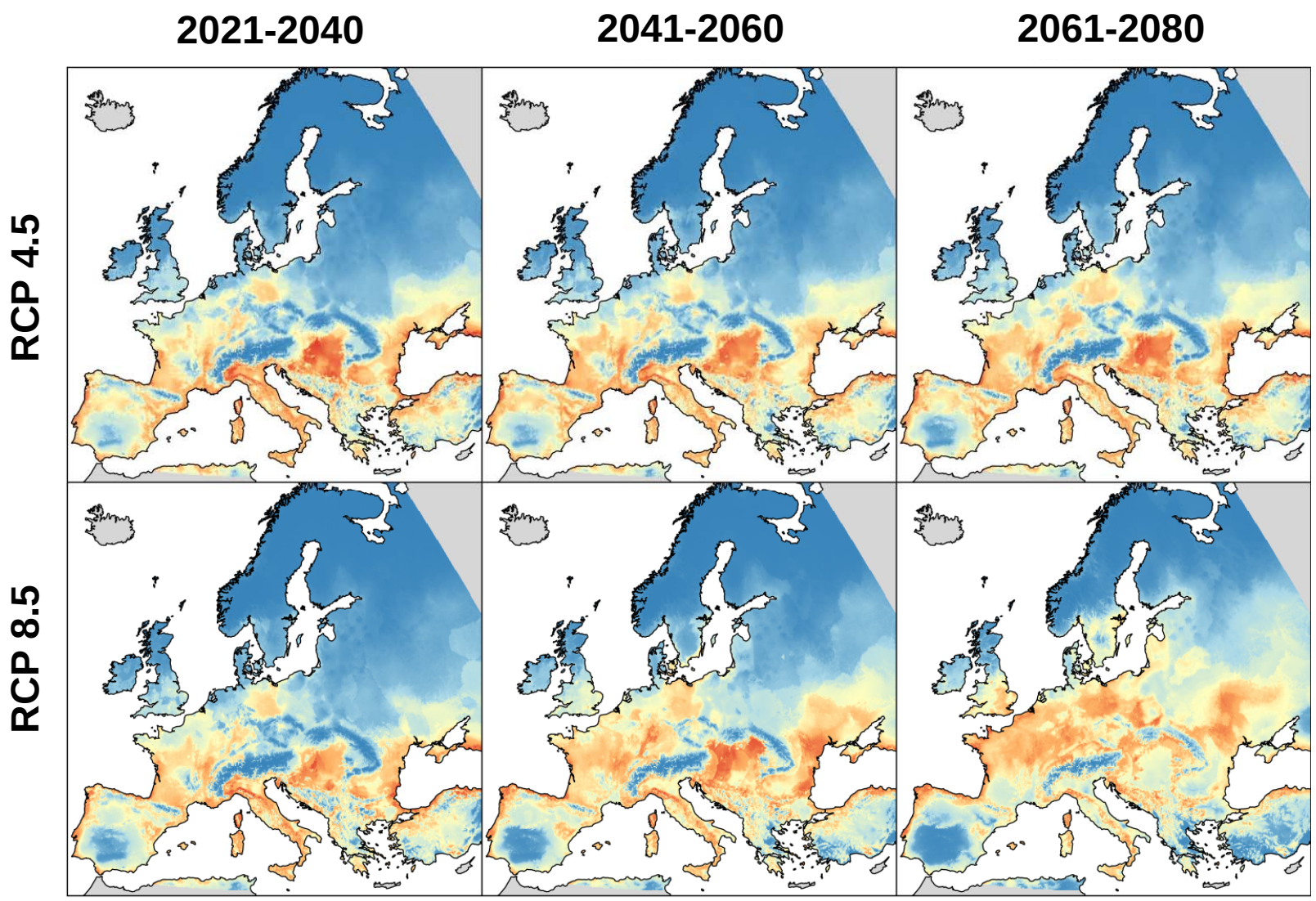


no data

Observed occurrence *Ae. albopictus*

Ensemble of GLM, GBM, RF and MAXENT

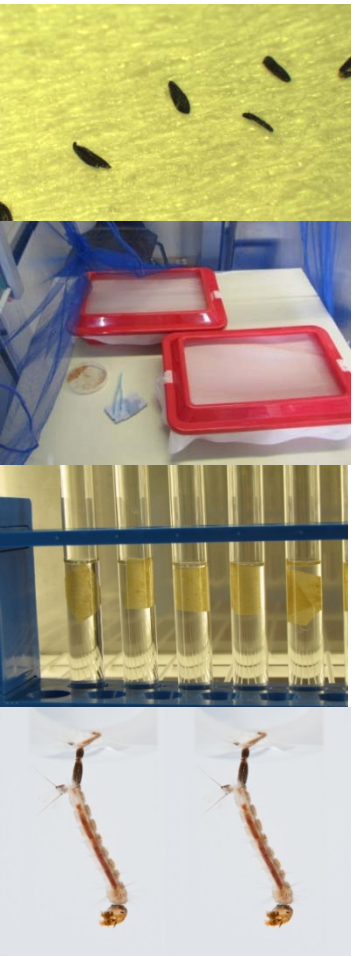
Results: Correlative model

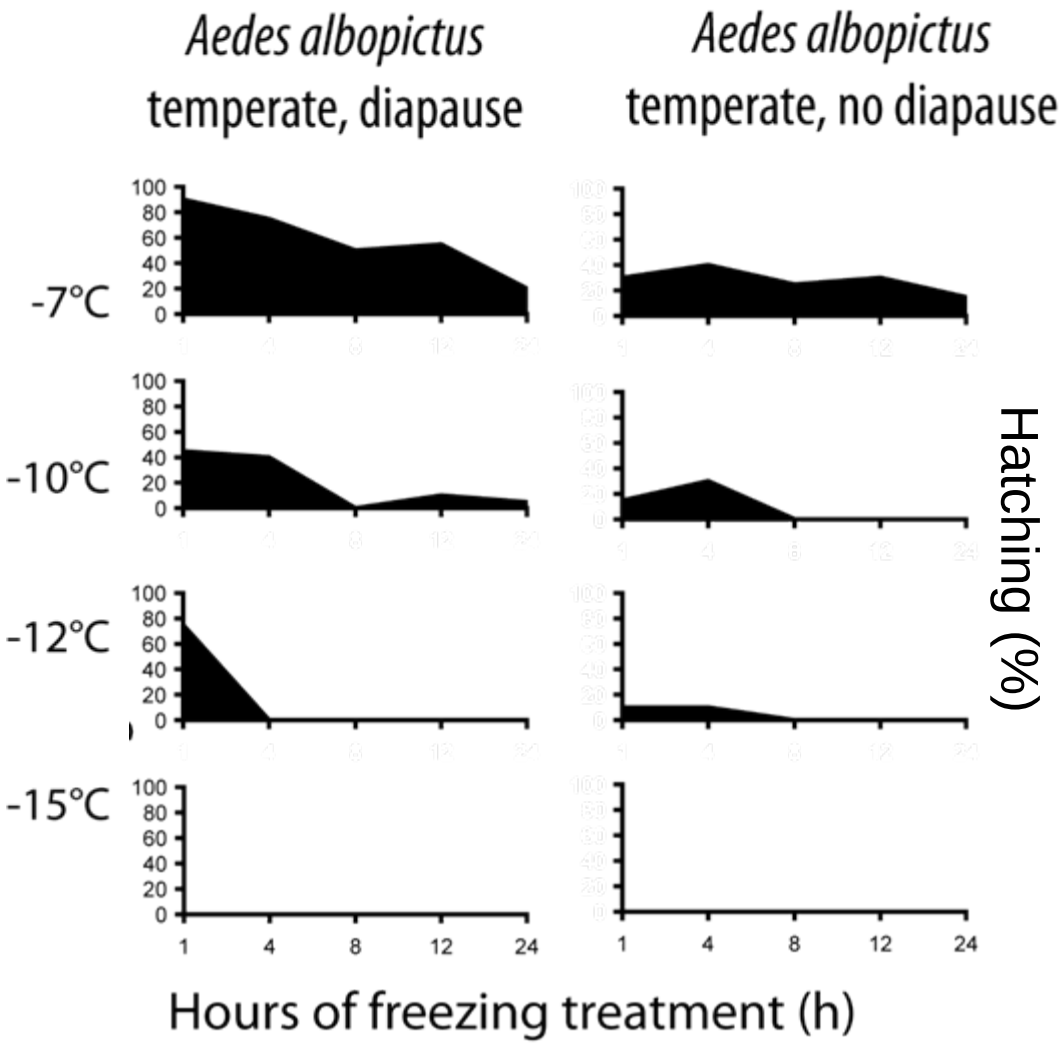


Climate model: MPI-ESM-LR; Ensemble of GLM, GBM, RF and MAXENT

Methods: Ecological Constraints

Climate chamber experiments to detect
low temperature thresholds for mosquito egg survival





Thomas, S.M. et al. (2012) Parasites & Vectors

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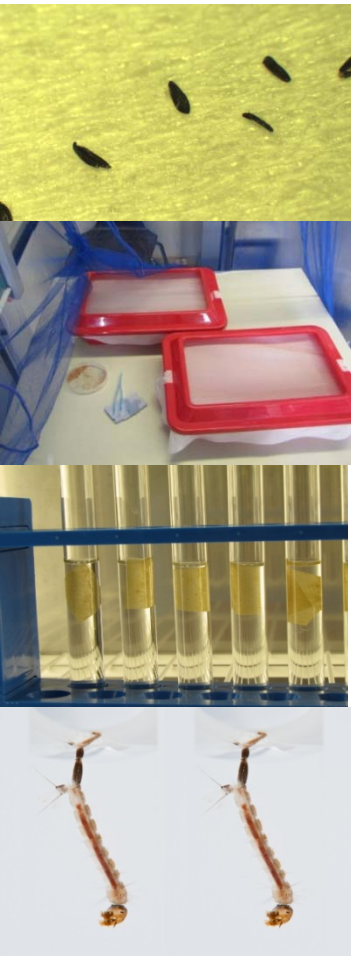
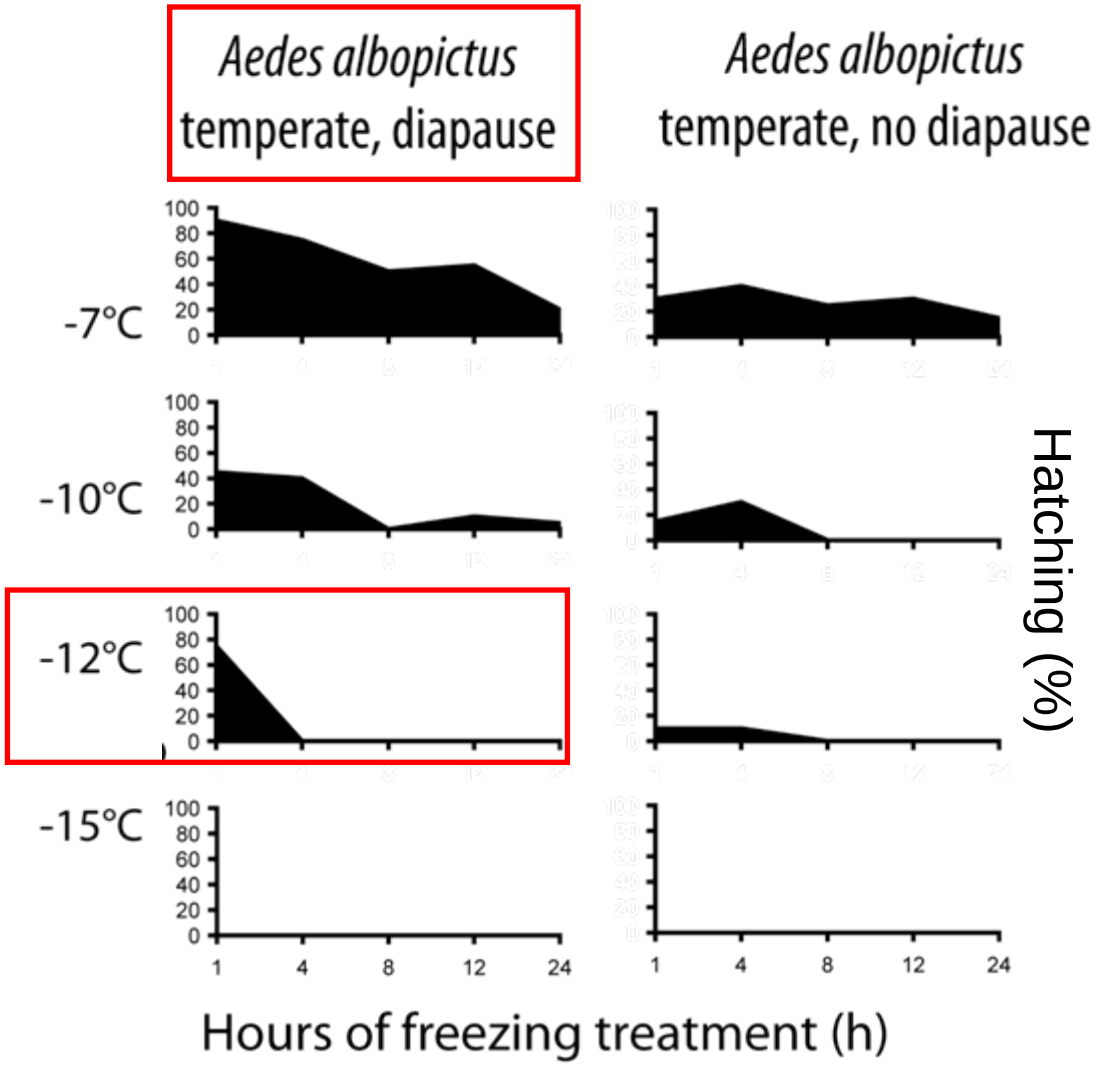
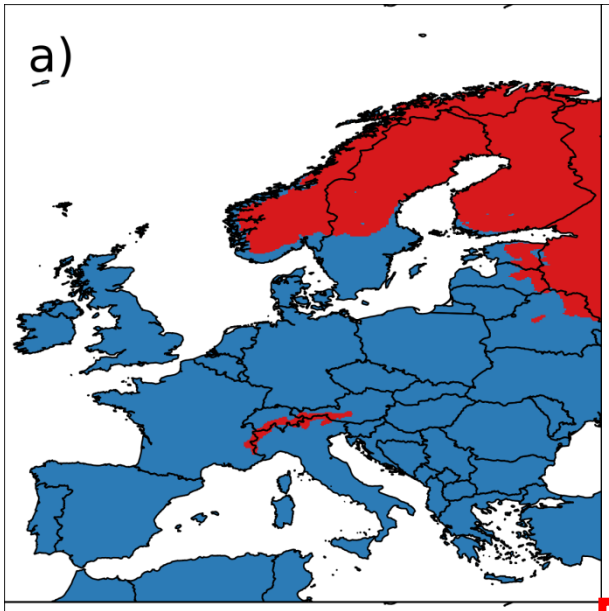




Thomas, S.M. et al. (2012) Parasites & Vectors

Results: Egg survival model

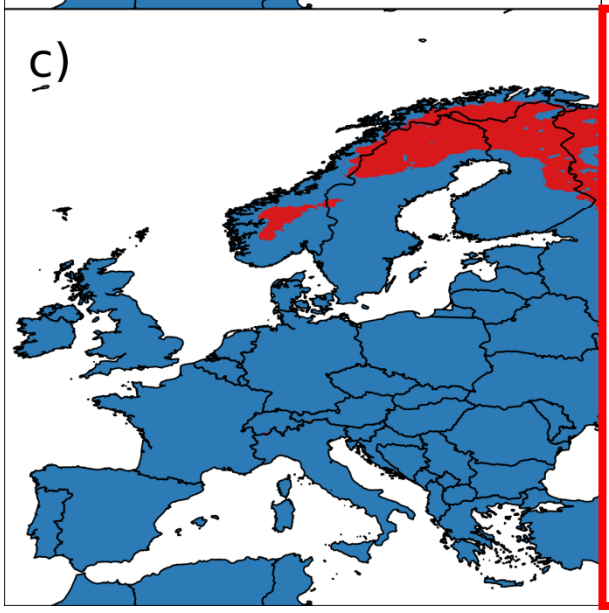


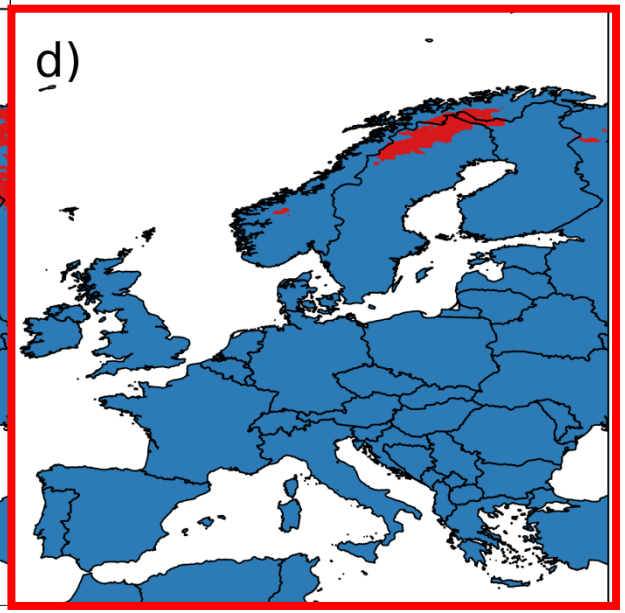
a) *Ae. albopictus*, tropical, non-diapause (-5°C)

c) *Ae. albopictus*, temperate, non-diapause (-10°C)

d) *Ae. albopictus*, temperate, diapause (-12°C)

no survival
survival



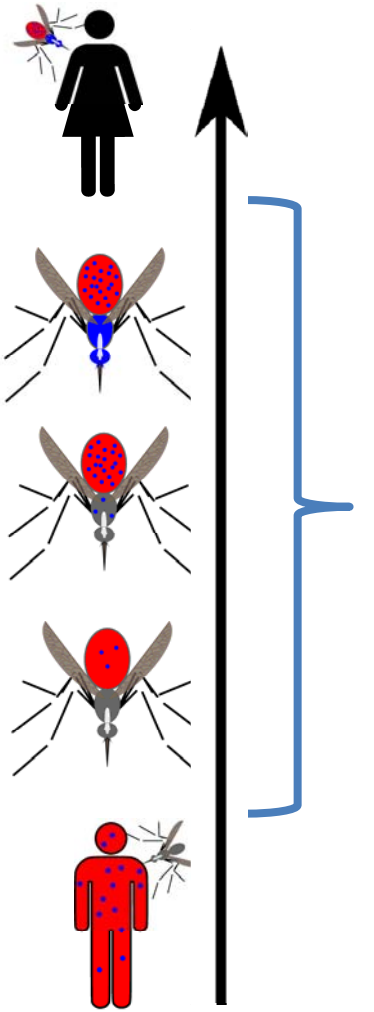


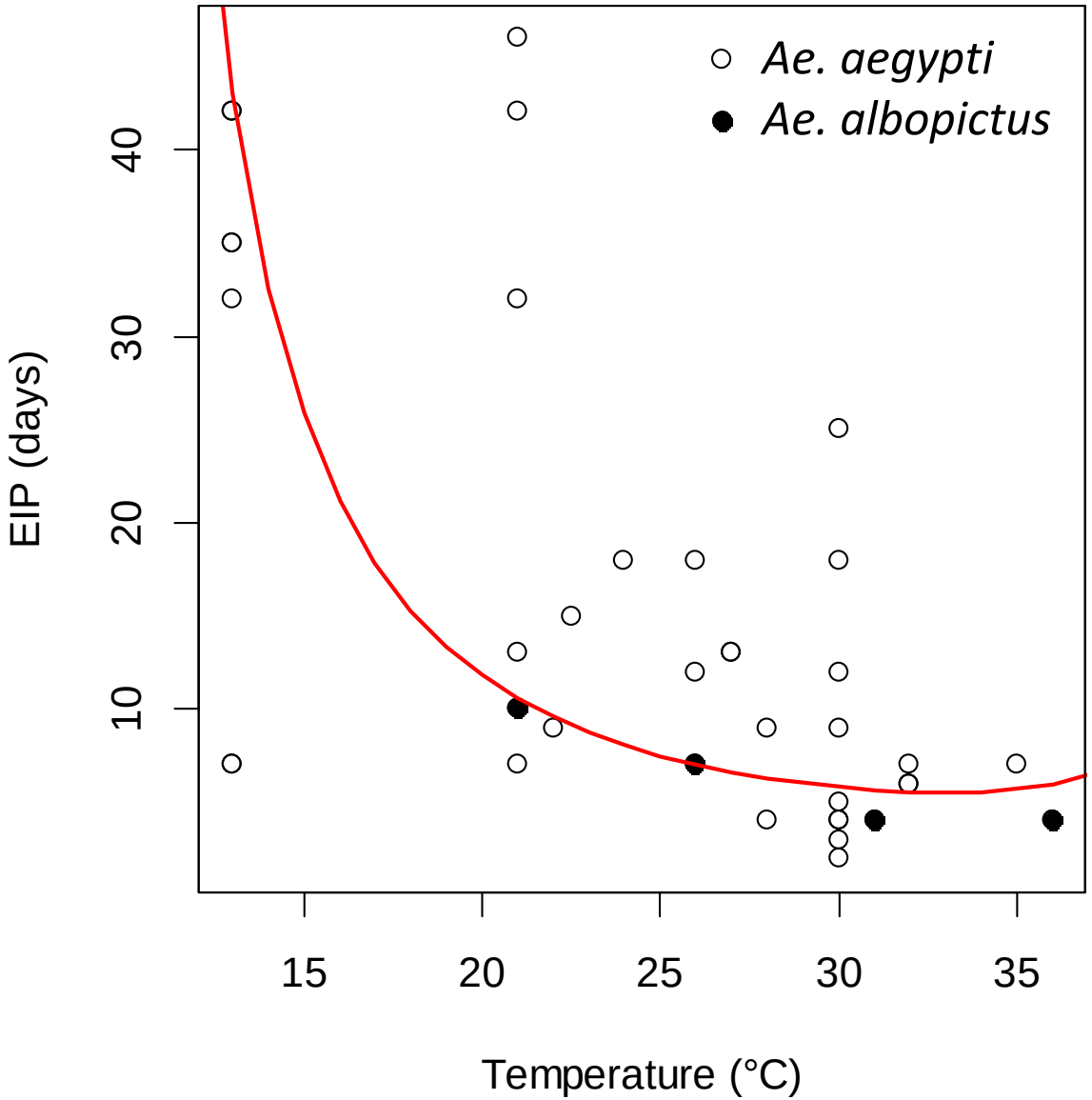
Scenario: RCP 4.5

Timestep: 2021-2040

Climate model:
MPI-ESM / COSMO

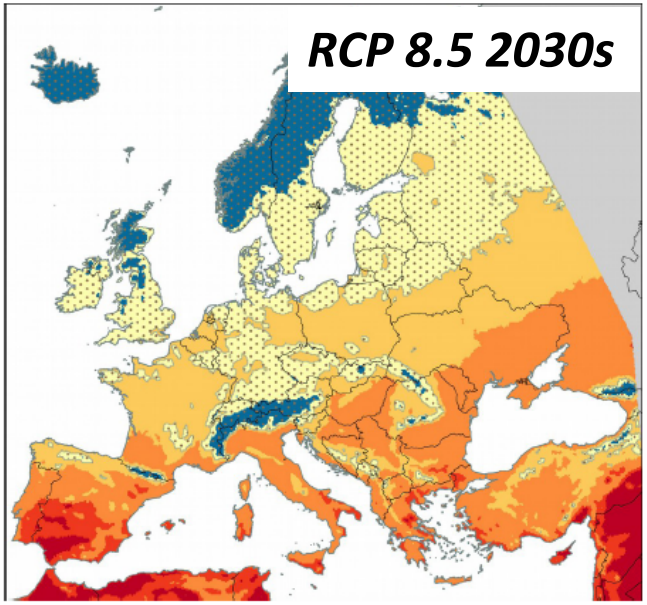
Methods: Extrinsic Incubation Period

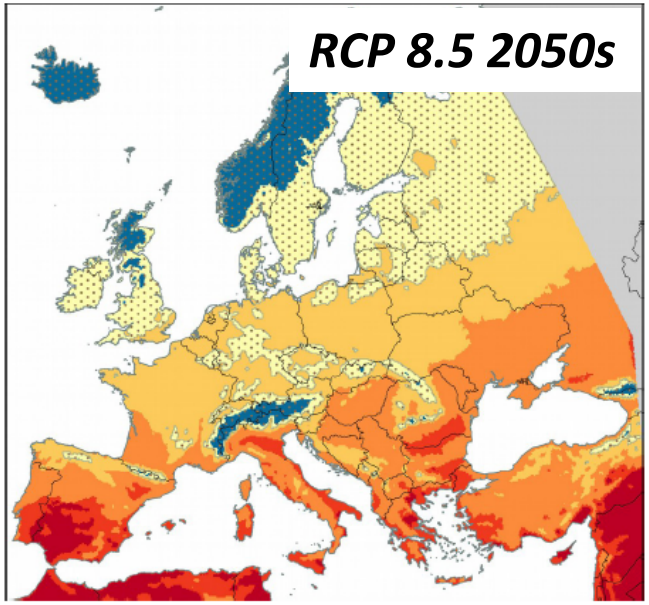


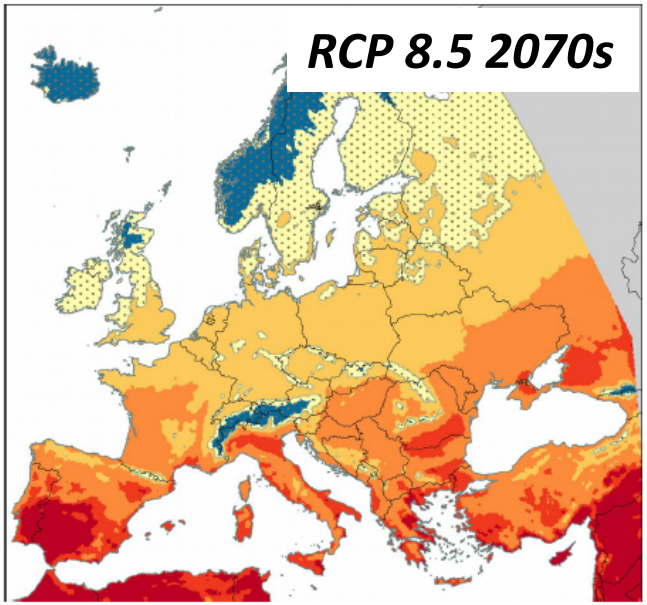


Tjaden, N.et al. (2013) PLoS Neglected Tropical Diseases; Vega Rua et al. (2013) PLoS One; Xiao et al. (2014) Arch Virol

Results: Extrinsic Incubation Period







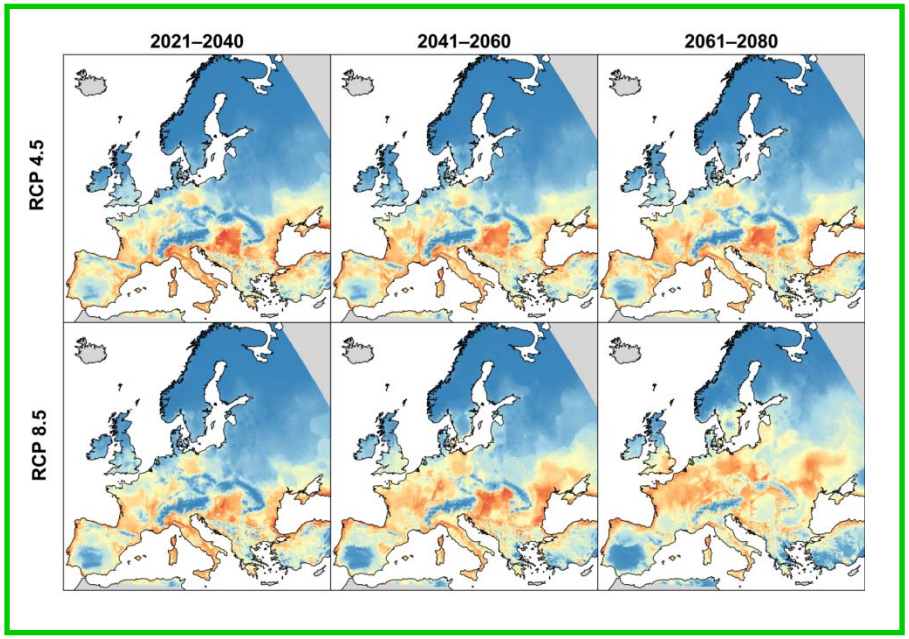
EIP (d)

- 5.0 - < 6.0
- 6.0 - < 7.0
- 7.0 - < 11.0
- 11.0 - < 21.0
- 21.0 - < 60.0
- ≥ 60.0
- no data

Unfulfilled flying condition

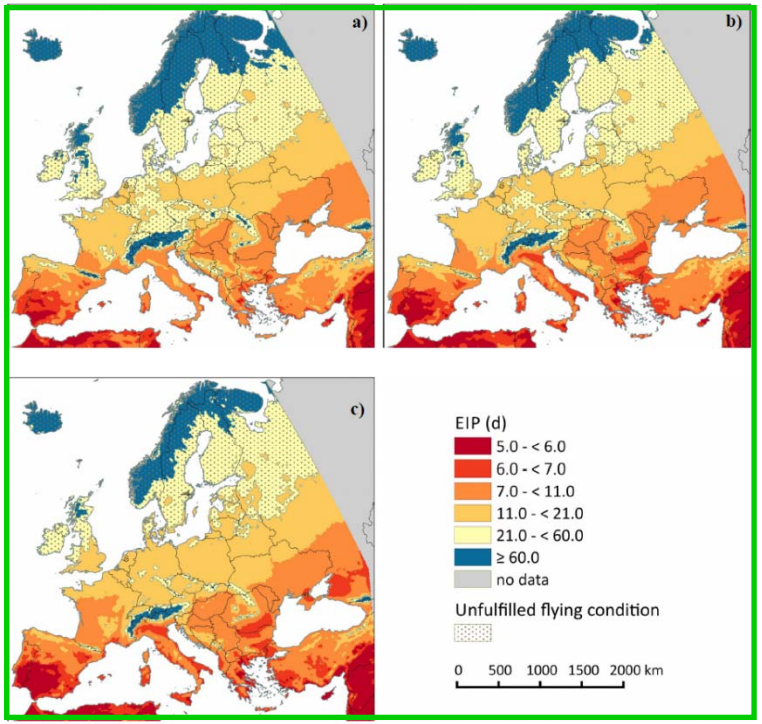
Methods: Dengue Transmission

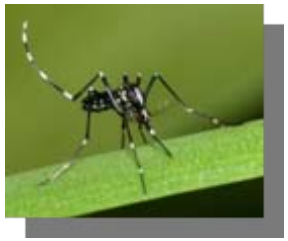
Aedes albopictus
climatic suitable regions

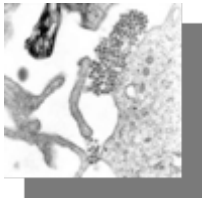


+

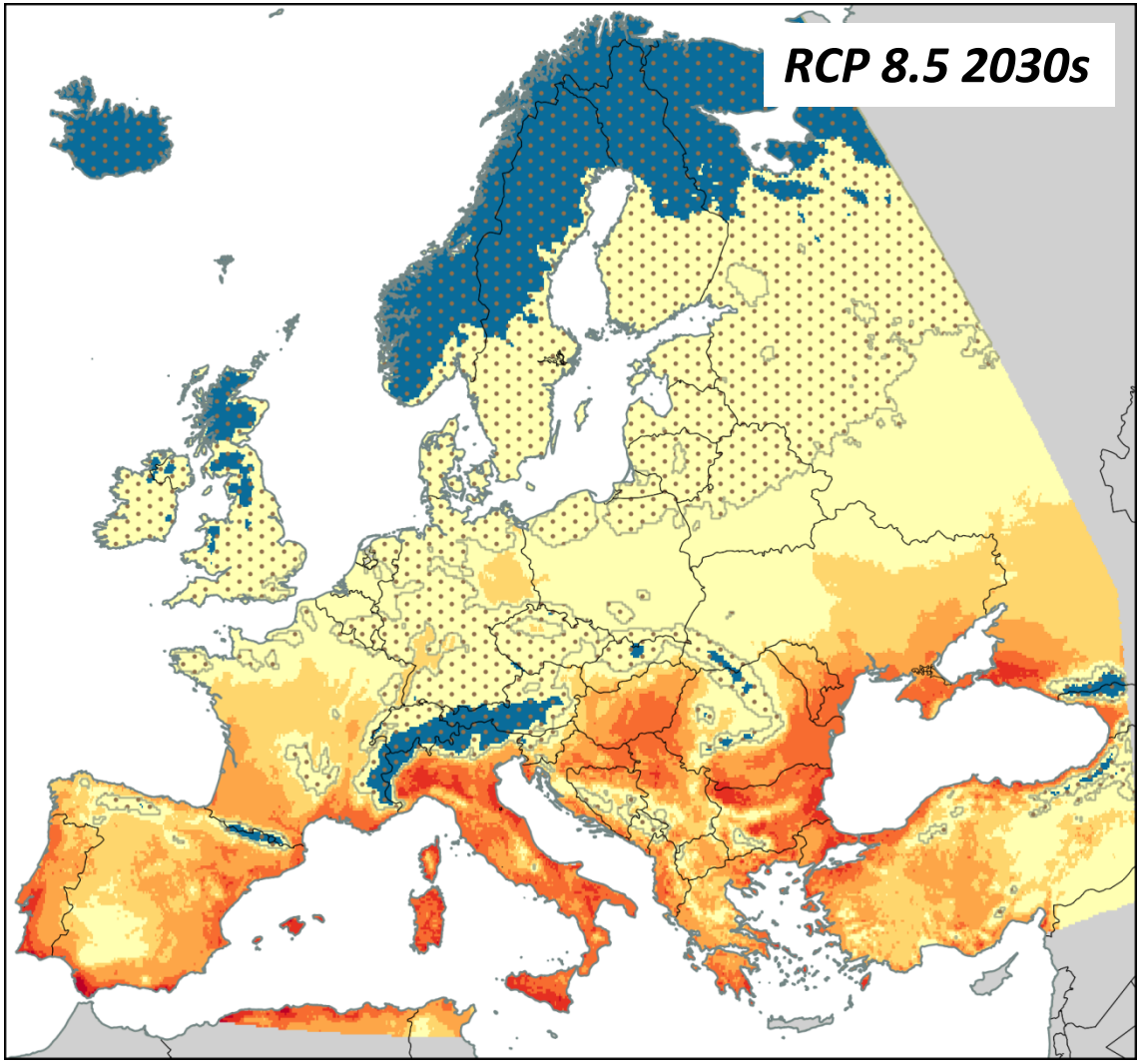
Dengue
Extrinsic Incubation Period







Results: Dengue Transmission



Climatic suitability

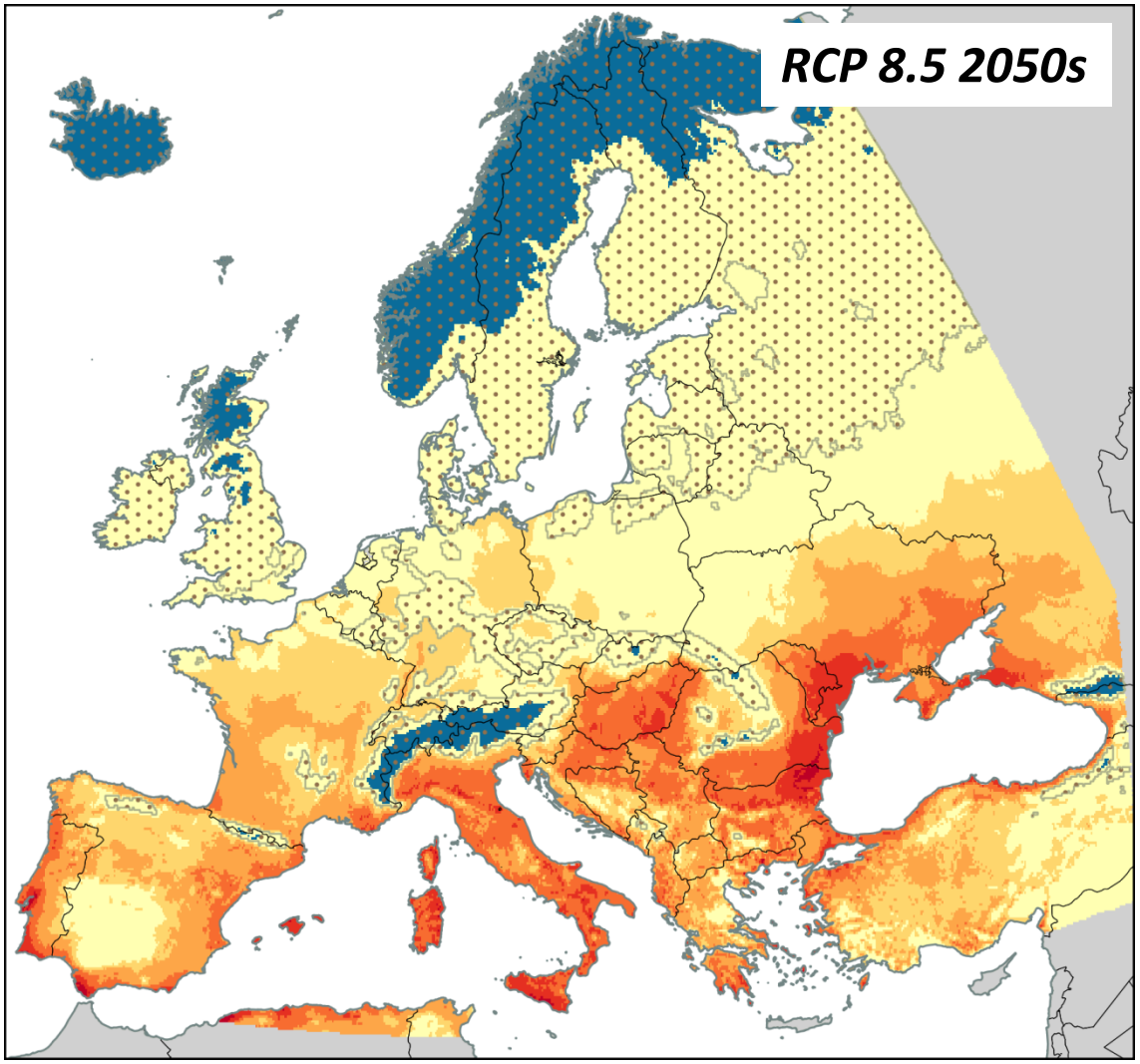
- 0.0 - < 0.1
- 0.1 - < 0.2
- 0.2 - < 0.3
- 0.3 - < 0.4
- 0.4 - < 0.5
- ≥ 0.5
- no data

EIP (d) ≥ 60.0

Unfulfilled flying condition

0 500 1000 1500 2000 km

Results: Dengue Transmission



Climatic suitability

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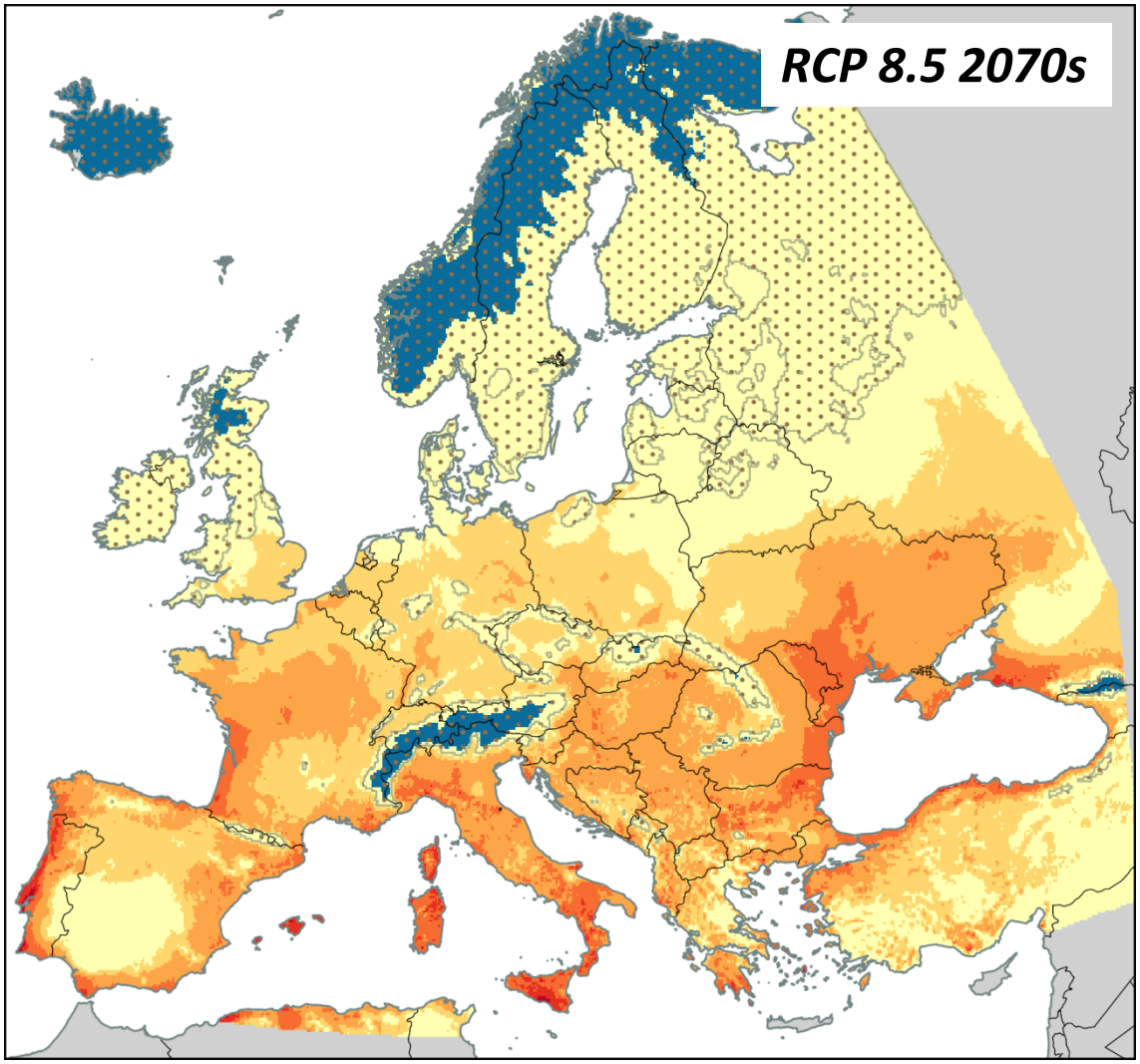
- 0.1 - < 0.2
- 0.2 - < 0.3
- 0.3 - < 0.4
- 0.4 - < 0.5
- ≥ 0.5
- no data

EIP (d) ≥ 60.0

Unfulfilled flying condition

0 500 1000 1500 2000 km

Results: Dengue Transmission



Climatic suitability

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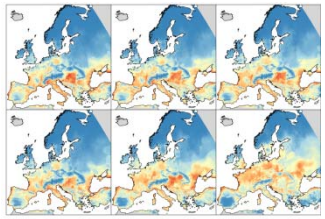
- 0.2 - < 0.3
- 0.3 - < 0.4
- 0.4 - < 0.5
- ≥ 0.5
- no data

EIP (d) ≥ 60.0

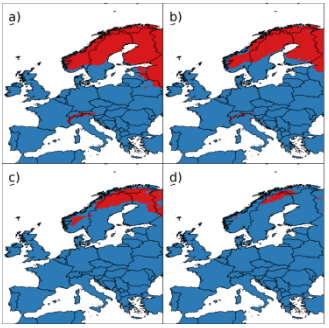
Unfulfilled flying condition

0 500 1000 1500 2000 km

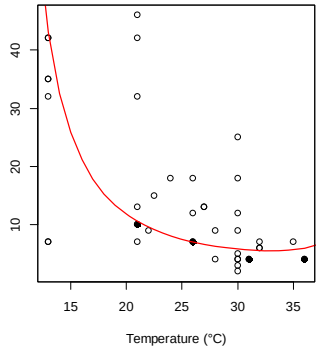
Summary and Outlook



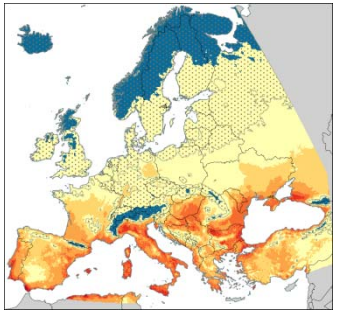
- Increasing climatic suitability for *Ae. albopictus* in Europe up to the end of the century



- Cold tolerance of eggs limits establishment of *Ae. albopictus*, but cannot usefully be replicated with climate models
  - weather data



- Implementing non linear regression of EIP highly supports Dengue risk assessment
  - EIP Experiments are needed with *Ae. albopictus* especially between 15-20°C - temperate climate



- Areas at Risk for Dengue by combing projections for vector & pathogen:
  Islands of the Mediterranean Sea
  coastal areas Mediterranean Sea
  large areas in southeastern Europe

} Tourism

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Thank you for your attention!

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Lena Muffler

Nils Tjaden

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Nationale
Forschungsplattform
für Zoonosen