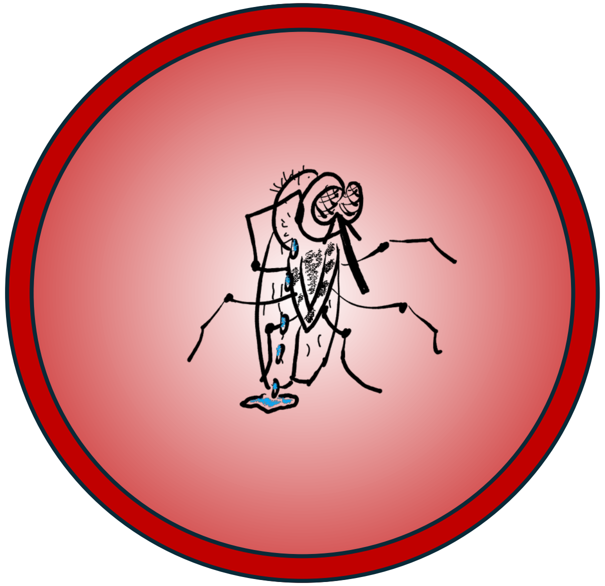
Open Slides

Impact of climate and weather on *Aedes albopictus* in Italy



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Outline

1 Introduction: the VECTRI model

2 Parametrization and calibration of *Aedes albopictus*

3 Objectives

- 3.1 Validate the model against ovitrap data
- 3.2 Asses the geographical distribution and activity in Italy
- 3.3 Study the effect of heatwaves on the population of *Aedes albopictus*

4 Results

5 Conclusion and future perspectives

1 Introduction: the VECTRI model

The **VEC**tor-borne disease community model of ICTP, **TRI**este, is

- A **multi-species** dynamical model, currently describing the life cycle of
  - *Anopheles gambiae s.s.* (original, see *e.g.*, Tompkins *et al.* 2013, Asare *et al.* 2016), malaria is parameterized
  - *Anopheles funestus* (in development, not evaluated)
  - *Anopheles sacharovi* (Karypidou *et al.* 2020)
  - *Aedes aegypti* (in development, not evaluated)
  - *Aedes albopictus* (Garrido Zornoza *et al.* 2024, under review), dengue is **not** parameterized

- **Climate-aware**: air temperature at two-metre height, , and daily rainfall,
- **Open source**: http://users.ictp.it/~tompkins/vectri/
  - Install *Aedes* version:

```
git clone https://gitlab.com/tompkins/vectri.git
git checkout tags/v1.11.3
```

  - Run example in OSF repository https://osf.io/3gcfb/

1 Introduction: the VECTRI model

$$f = f(T¿¿2m)\ or\ f(T_{wat}) \equiv ¿$$

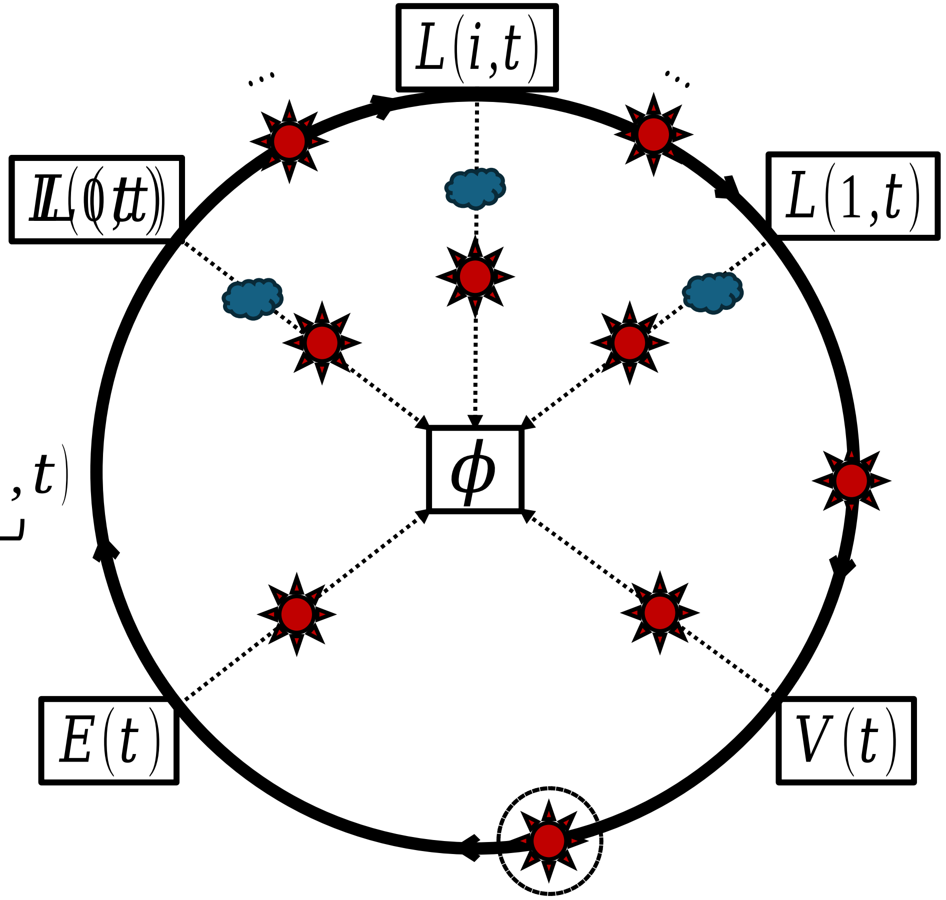
$$f = f(R¿¿d) \equiv ¿$$

$$\frac{dE(t)}{dt} = ¿\ \overbrace{N_{egg} \cdot R_{gono}(T_{2m}) \cdot V(t)}^{\text{oviposition}} - \overbrace{\delta_E(T_{wat}) \cdot E(t)}^{\text{mortality}} - \overbrace{g_E \cdot E(t)}^{\text{hatching}}$$

$$\frac{\partial L(f,t)}{\partial t} = ¿\ \underbrace{\left[f=0\right] g_E \cdot E(t)}_{\text{hatching}} - \underbrace{R_L(T_{wat}) \cdot \frac{\partial L(f,t)}{\partial f}}_{\text{development (advection)}} \underbrace{- \delta_{crowd}(R_d, L) \cdot L(f,t)}_{\text{mortality / predation and overcrowding}}$$

$$\frac{dL(0,t)}{dt}$$

$$\frac{dV(t)}{dt} = ¿\ \underbrace{R_L(T_{wat}) \left.\frac{\partial L(f,t)}{\partial f}\right|_{f=1}}_{\text{emergence}} \underbrace{- \delta_V(T_{2m}) \cdot V(t)}_{\text{mortality}}$$



- Temperature-driven decay rates fitted from lab. and obs. data
- Fixed time step,
- (when no hydro)
- No vector mobility across grid boxes

$$R_{gono}(T_{2m}) = \frac{T_{2m} - T_{gono}}{K_{gono}} \in [0,1]$$

2 Parameterization and calibration of *Aedes albopictus*

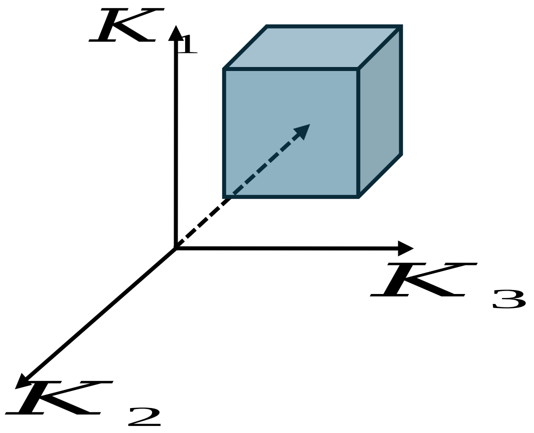
Parameterization

- Temperature mortality scheme for and *i.e.*, Metelmann *et al.* 2019
- Life cycle parameters, *e.g.*, or from literature (referenced in the manuscript)

Calibration

- Life cycle **parameters**, , are constrained by field and lab. studies but nevertheless **uncertain**
- **Search** within this uncertainty "window" for the best, yet **realistic**, **solution**
- Constrained optimization using the **Genetic Algorithm** (GA) from Tompkins *et al.* 2018

$$\vec{K}\ s.t.\ \vec{o}(x,t)-\vec{S}(x,t;\vec{K})\rightarrow\vec{0}$$



- **Emilia-Romagna** ovitrap data from Carrieri *et al*. 2011, 2017, 2021

4 Results

4 Results

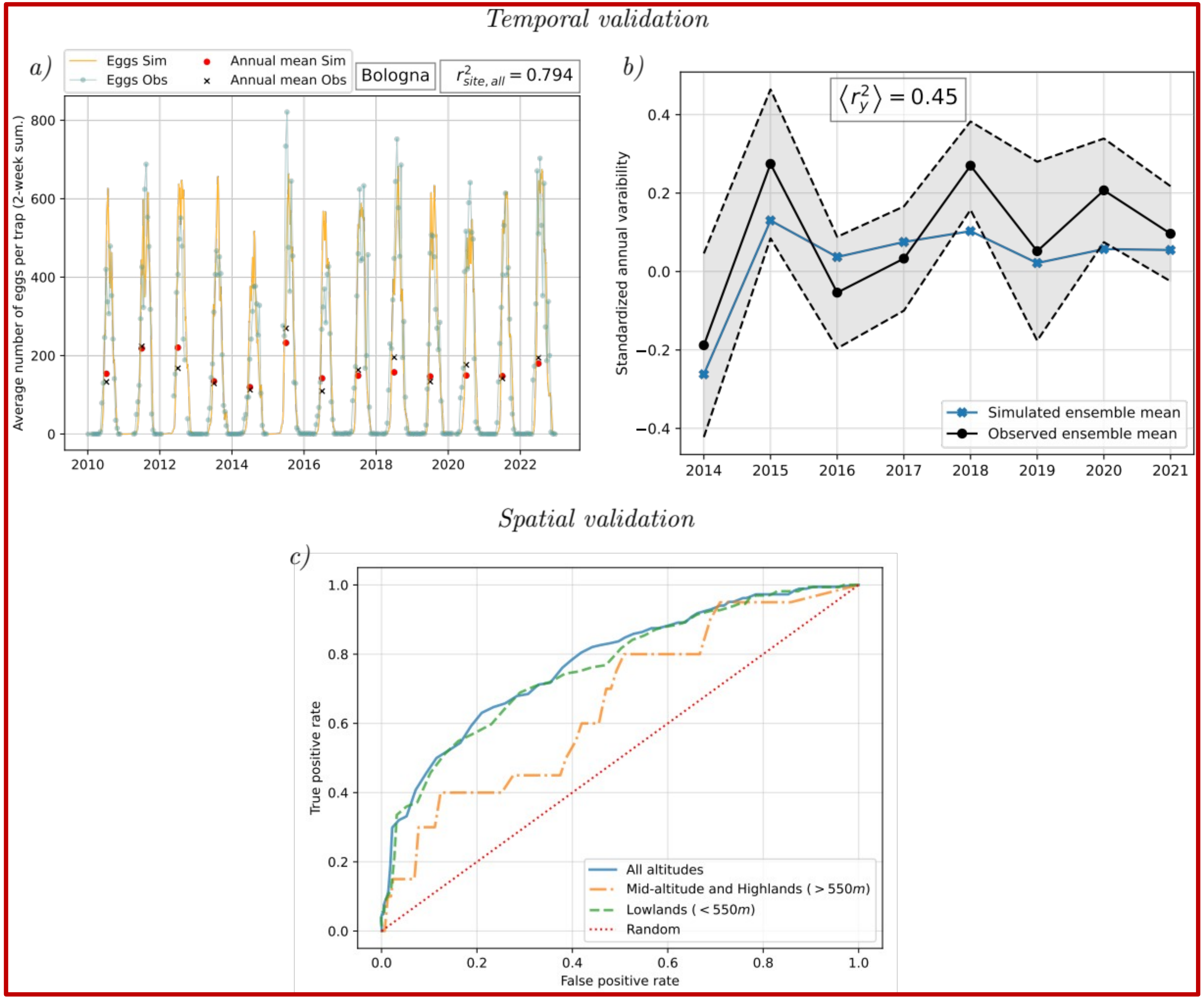
4.1 Model validation

a) Seasonality

b) Inter-annual ensemble

c) ROC curves (AUC)

Garrido Zornoza et al. 2024
(in review for JRSI)



4 Results

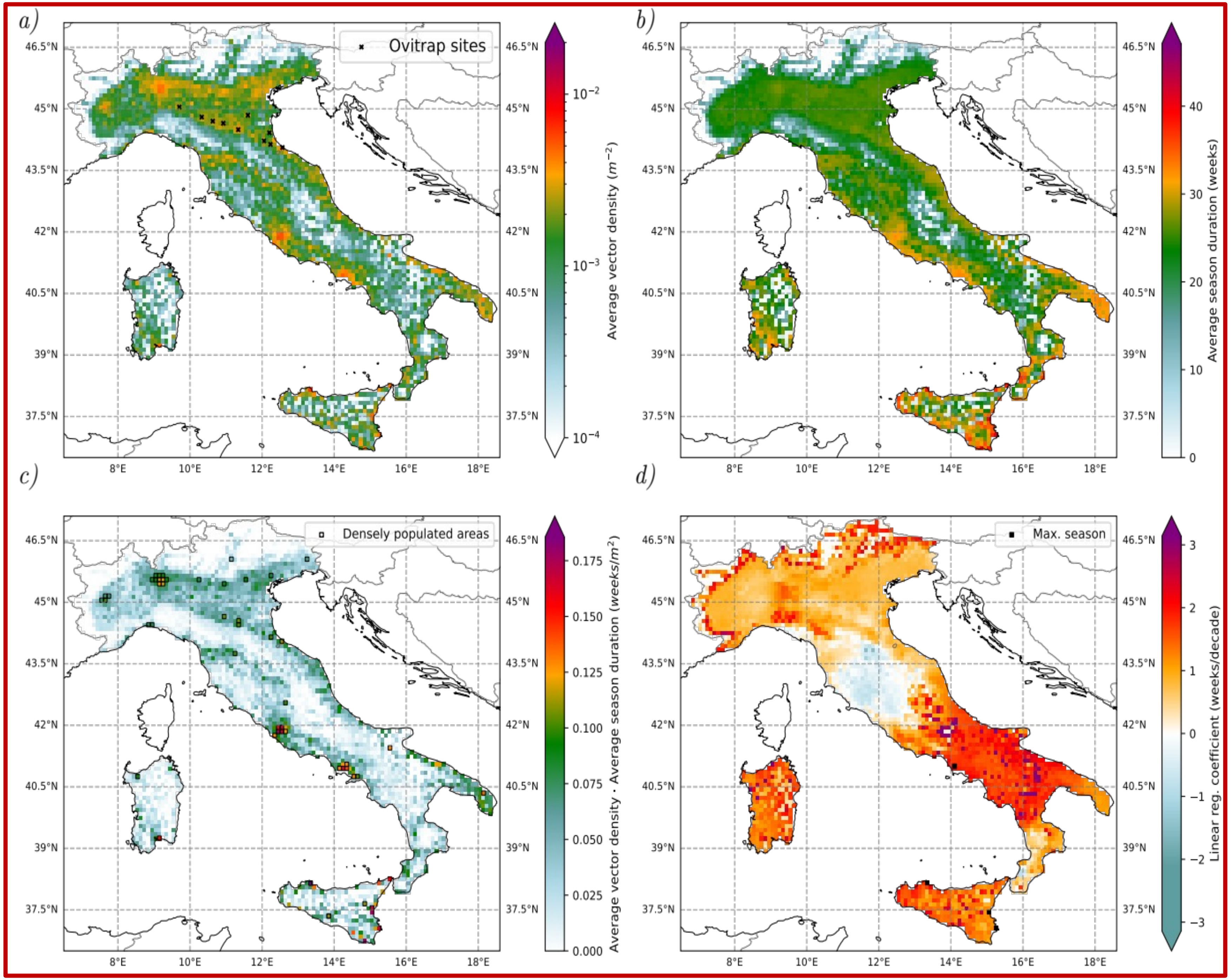
4.2 Geographical distribution and activity in Italy

a) Average density 1980-2022

b) Average sesion duration

c) Risk estimate

d) Increase in season length of weeks per decade

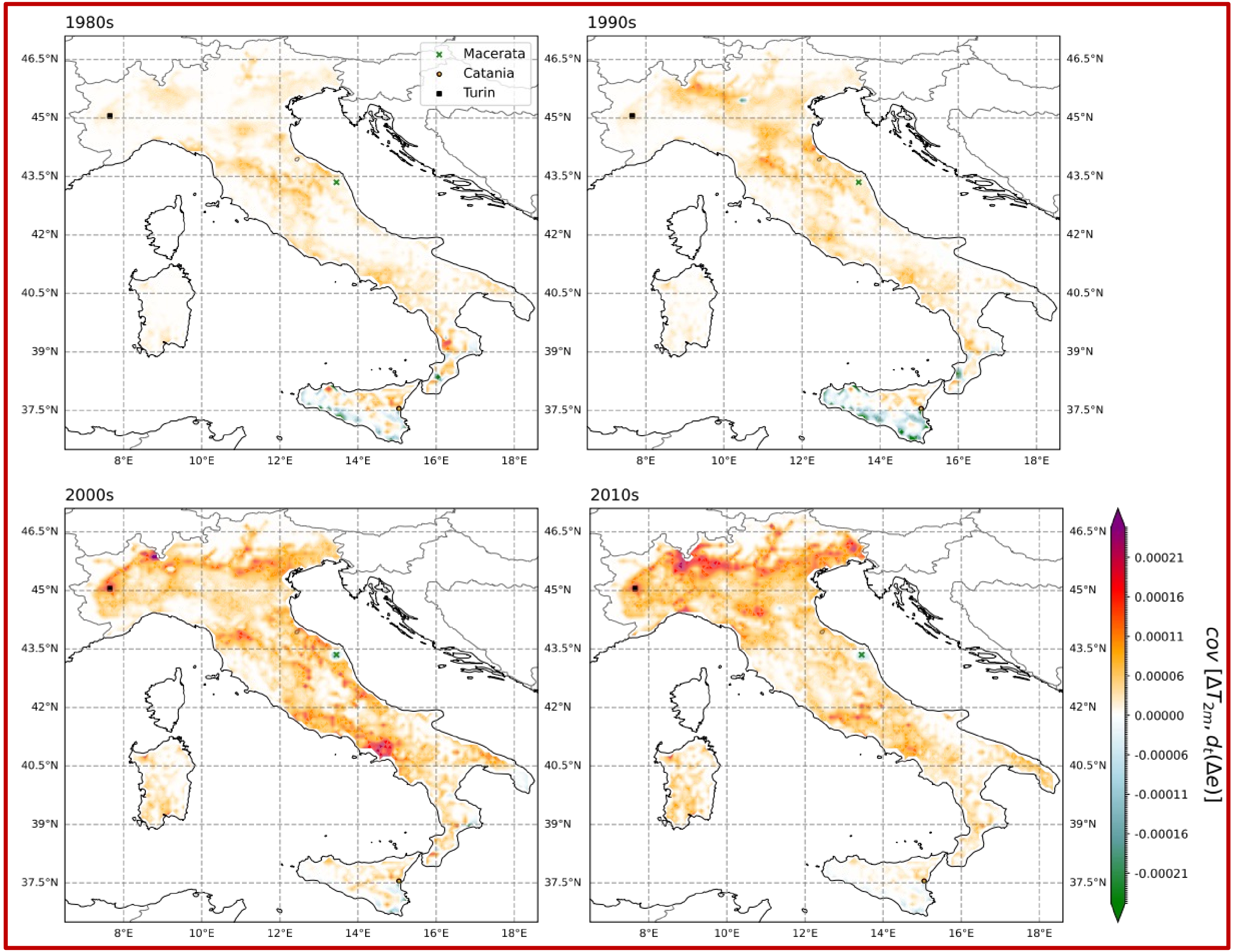


Garrido Zornoza et al. 2024 (in review for JRSI)

4 Results

4.3 Heatwaves

- Decadal increase
  - Mostly positive
  - Can be negative in southern areas



Garrido Zornoza et al. 2024
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4 Results

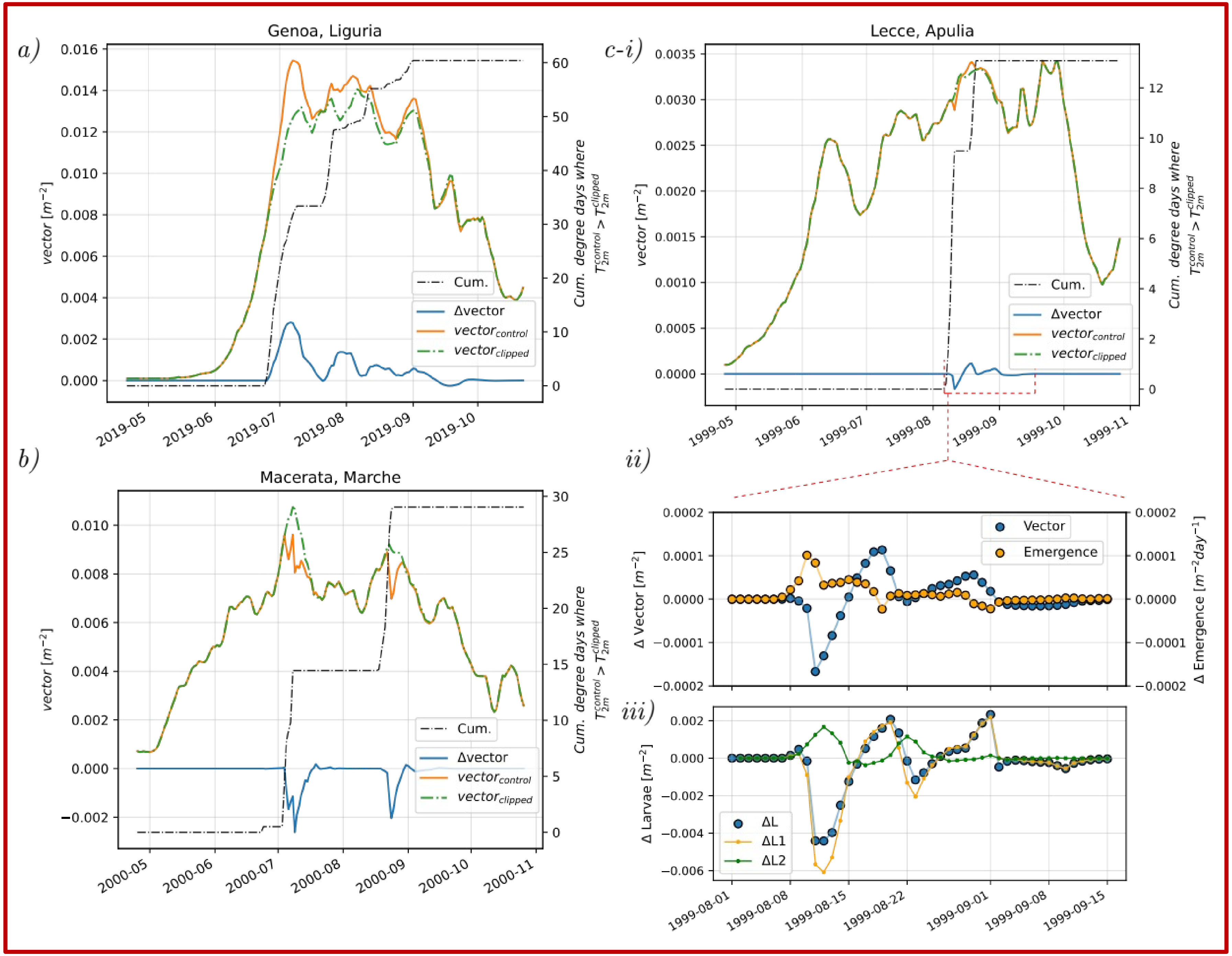
4.3 Heatwaves

a) Beneficial

b) Detrimental

c-i) Temporarily detrimental

c-ii,iii) Differential impact on larval age structure



Garrido Zornoza et al. 2024
(in review for JRSI)

5 Conclusion and future perspectives

Summary

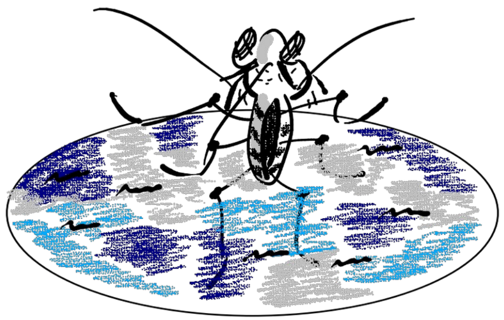
- VECTRI as a multi-species **climate-aware** mechanistic model
- Adapted VECTRI to *Aedes albopictus* parameterization + calibration
- **Validated** the model for Italy (Emilia-Romagna ovitrap data)
- Model reproduces **seasonality** and **inter-annual** variability of observed ovitrap data
- Densely populated areas are hotspots
  - ➢ Rome, Milan, Naples, Foggia, Catania, Palermo, Lecce, …
- Modelled **increase** of vector **activity** of weeks per decade between 1980-2022
- Heatwave impact on simulated *Ae. albopictus* population can be **detrimental** in warmest regions but is **beneficial** over most areas during summer

Future perspectives

- Include **diapause** parameterization, larval **cannibalism** and **dengue** transmission dynamics

Thank you for the attention

S.1 Introduction: the VECTRI model



<u>Breeding model for larval development</u>

$$\frac{\partial L(f,t)}{\partial t} = \text{¿} \boxed{\text{hatching}} + \text{¿} \boxed{\text{mortality}} + \text{¿} \boxed{\text{predation and overcrowding}} + \text{¿} \boxed{\text{emergence}}$$

$$-\delta_{crowd}(R_d, L) \cdot L(f,t)$$

$$\text{¿}\, 1 - P_{L,surv}(R_d, L)$$

$$\text{¿}\, P_{L,surv0} \cdot P_{flush}(R_d) \cdot P_{crowd}(R_d, L)$$

stationary | stationary | dynamic

- Logistic

- Fractional water coverage of potential breeding sites

- are vector-specific **usage coefficients**