Comparing Remotely Sensed Land Surface Temperature and Climatic Reanalysis for invasive mosquitoes' mechanistic model

ESA Living Planet Symposium

24/05/2022

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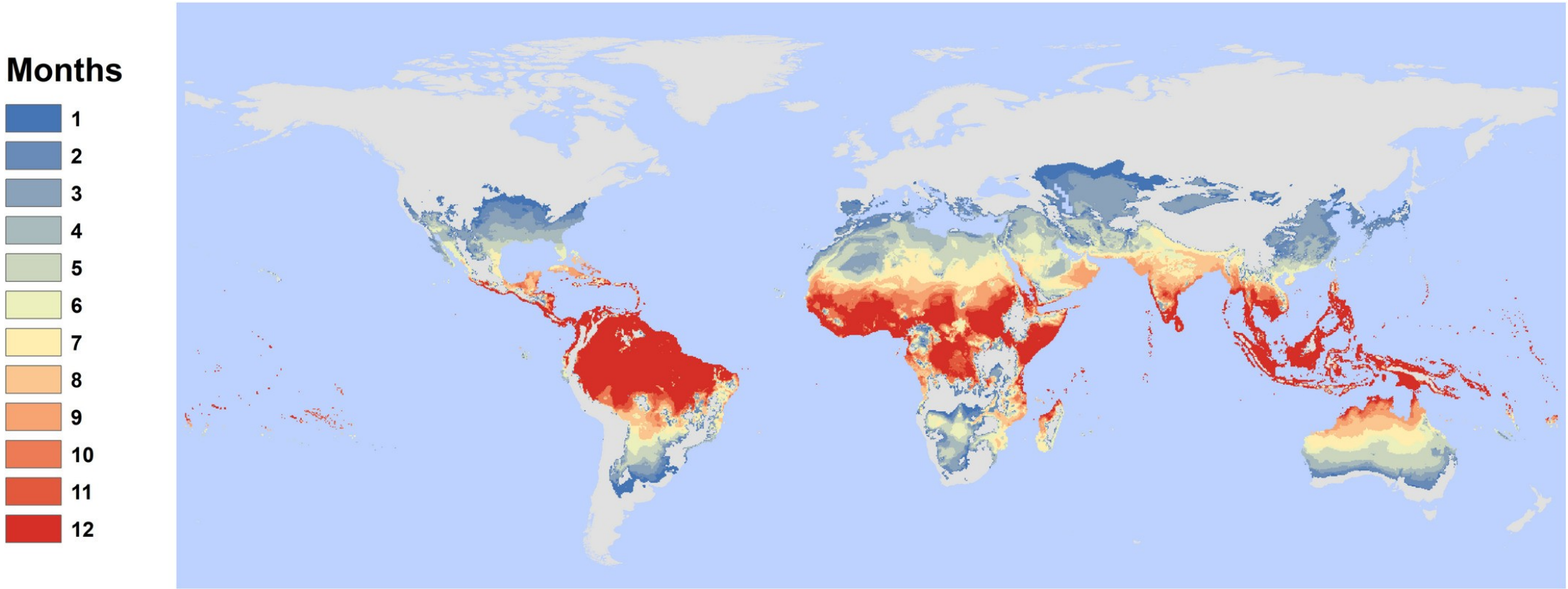
Guillaume Lacour - Altopictus

Sophie O. Vanwambeke – ELIC (UCLouvain)

Number of suitable months with ZIKV R0(T) > 0



Ryan et al. 2020, *Global Change Biology*

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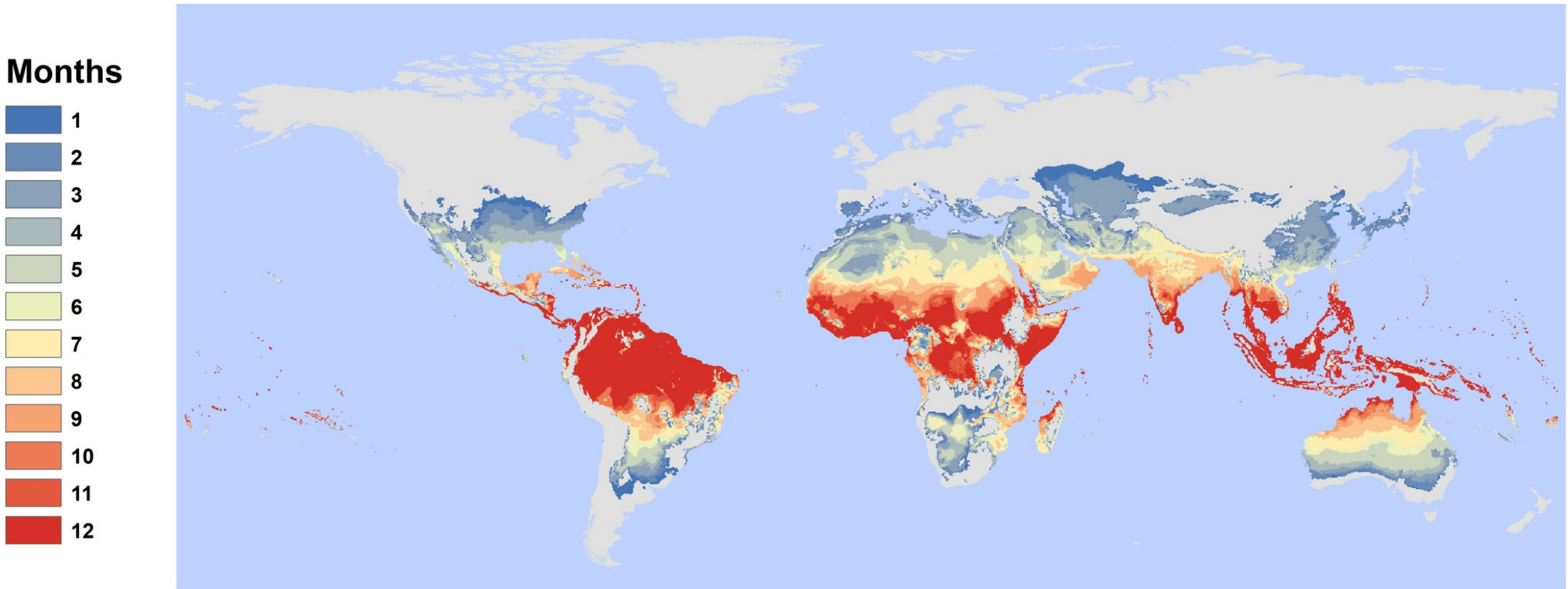

$$R0 = R0_{HV} R0_{VH} = \sqrt{k^2 \frac{\beta_{HM}\beta_{MH}}{\frac{1}{H_{infPer}}\mu_v} \frac{N_V}{N_H} \frac{\frac{1}{EIP}}{\frac{1}{EIP} + \mu_v}}$$

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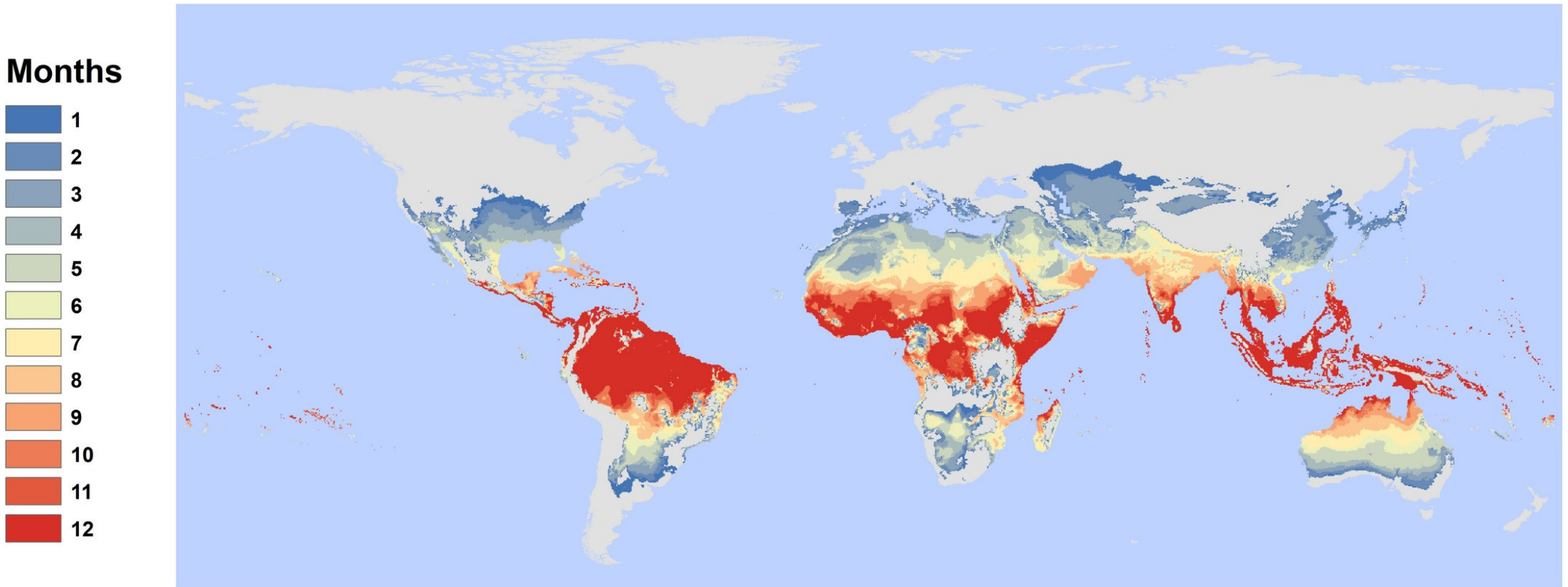

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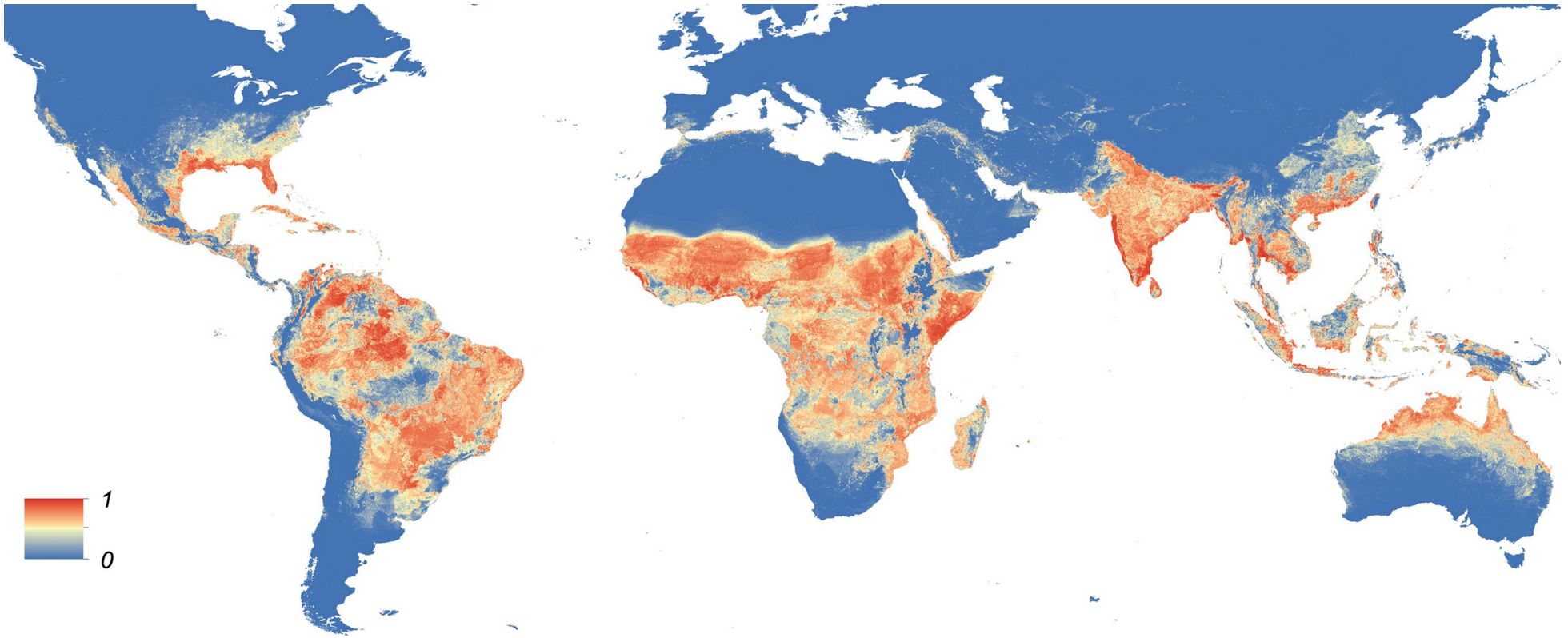
Ryan et al. 2020, *Global Change Biology*

Probability of ***Ae. aegypti*** occurrence



Kramer et al. 2015, *eLife*

dynamAedes

R Programming

A unified population dynamic modelling framework for invasive *Aedes* species

Da Re et al. 2022*, Parasite&Vectors*, in press

Main characteristics of dynamAedes

- Four *Aedes* species*: Ae. aegypti, Ae. albopictus, Ae. japonicus* and *Ae. koreicus*

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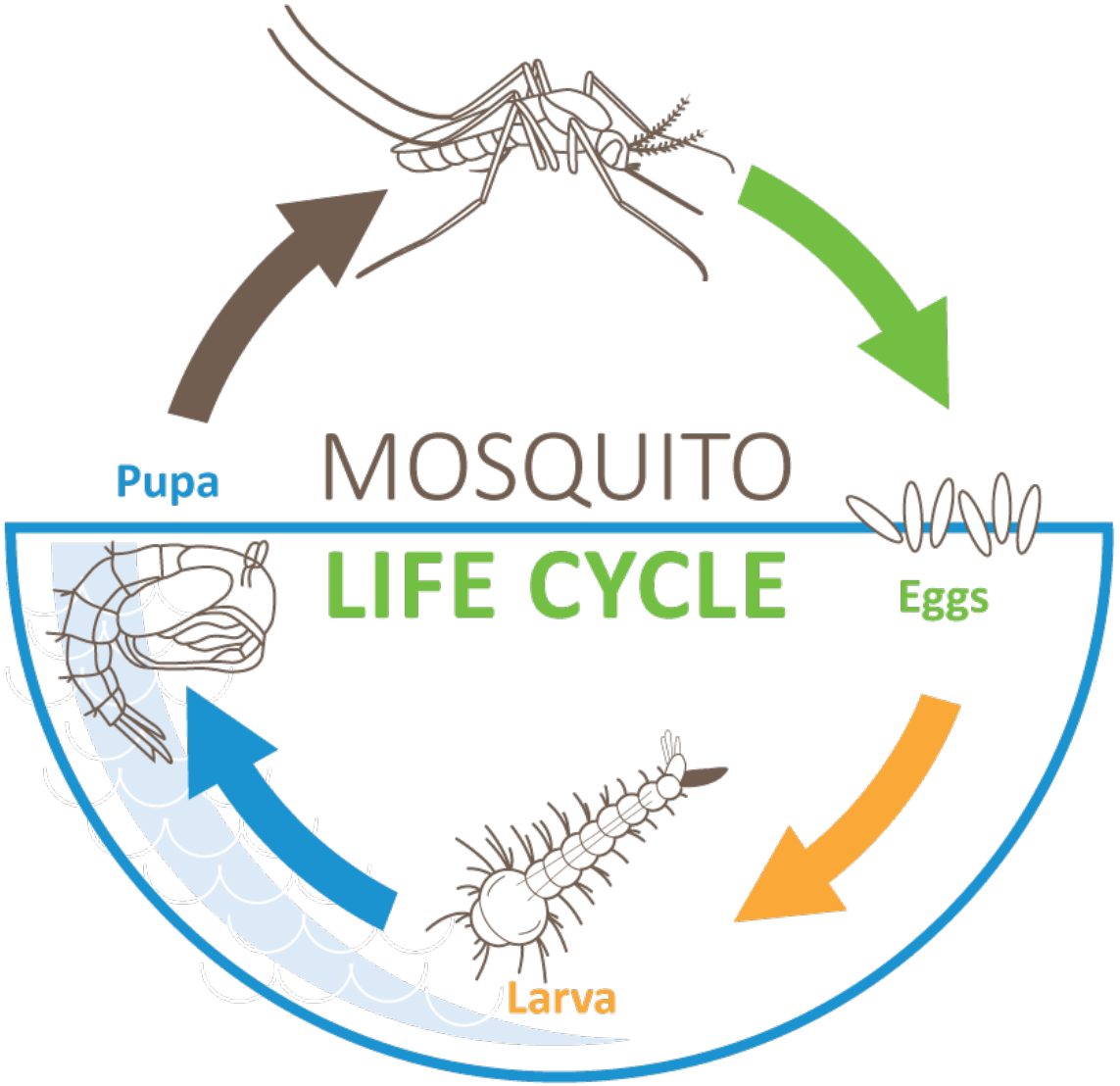
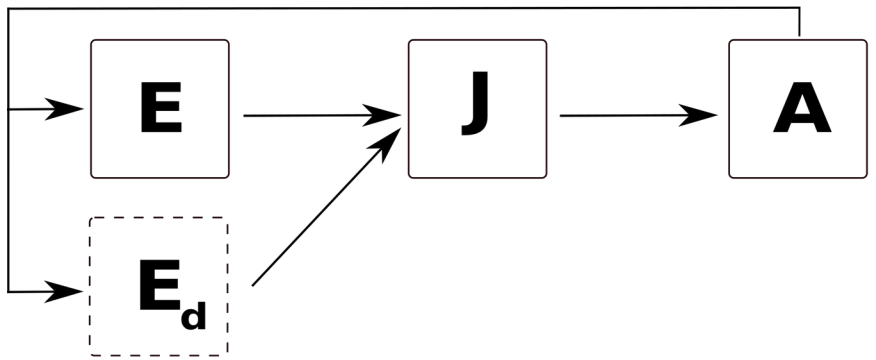
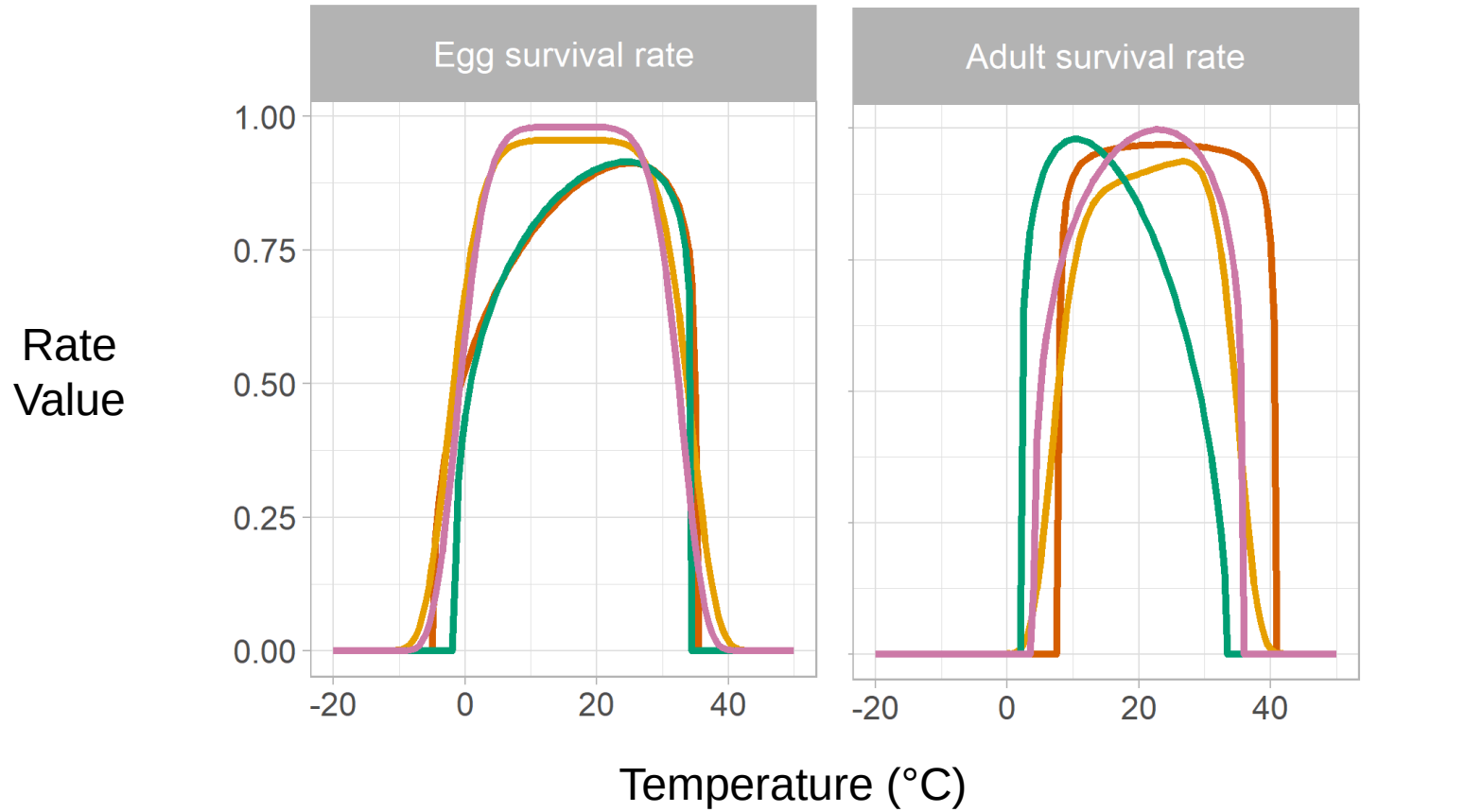
- Three different spatial scales
- Active and Passive dispersal (parametrised from MRR and scientific literature)

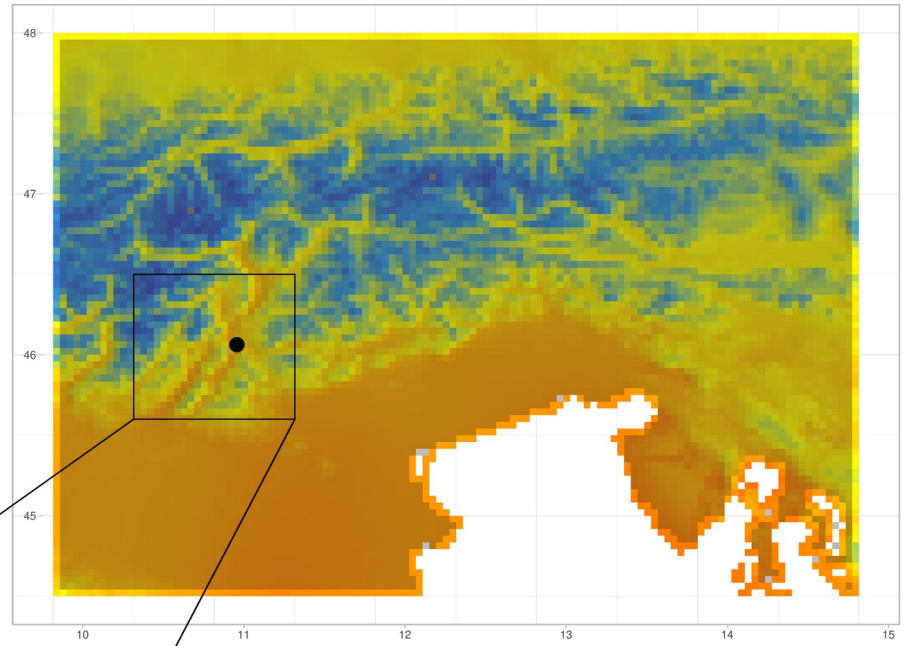




https://prvectorcontrol.org/

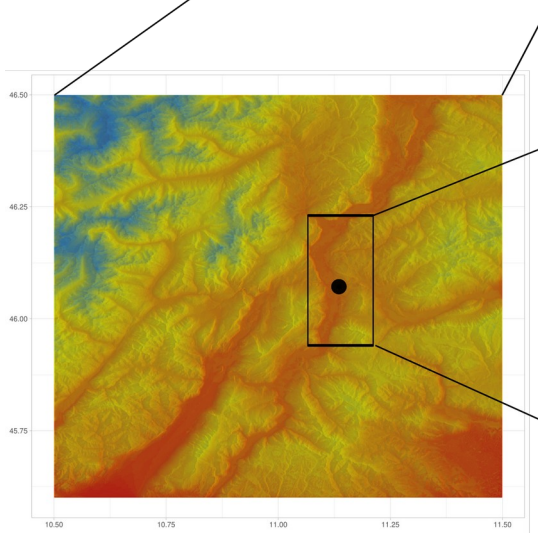

Egg survival rate
Adult survival rate
Rate
Value
1.00
0.75
0.50
0.25
0.00
-20
0
20
40
Temperature (°C)
Species
Ae. aegypti
Ae. albopictus
Ae. japonicus
Ae. koreicus

Spatial scales

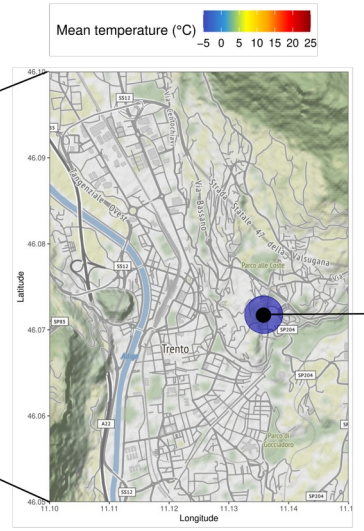


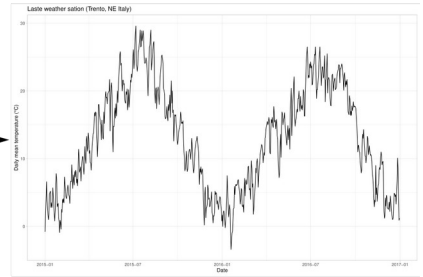
Regional scale
(spatial resolution > 1km)

a)



b)



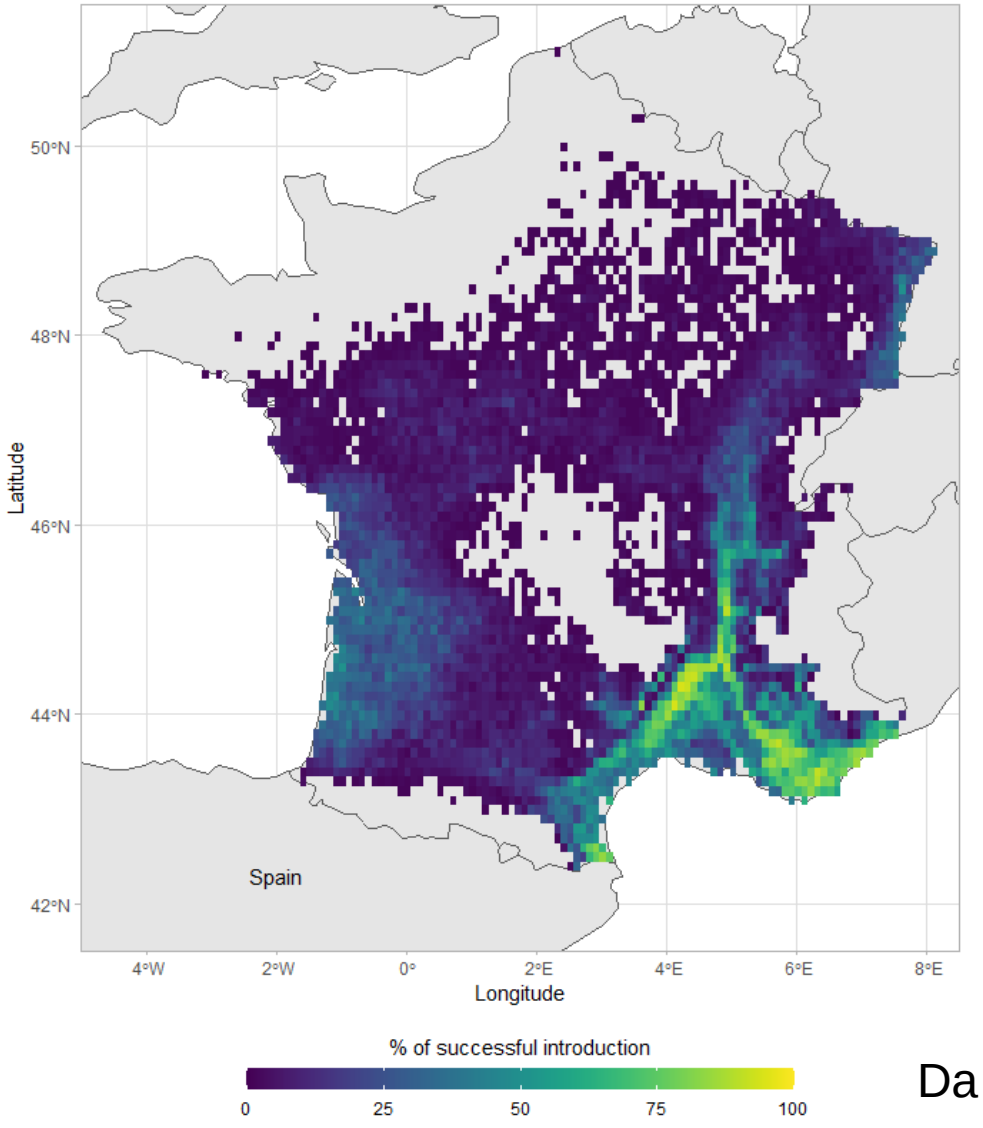


c)

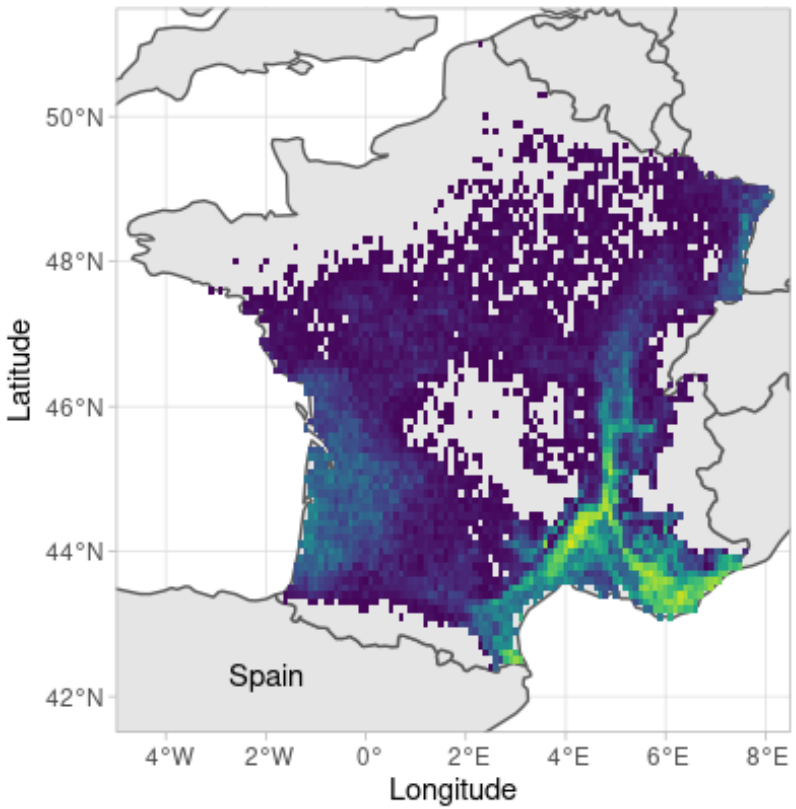
Local scale (spatial resolution < 1km)

Weather station scale

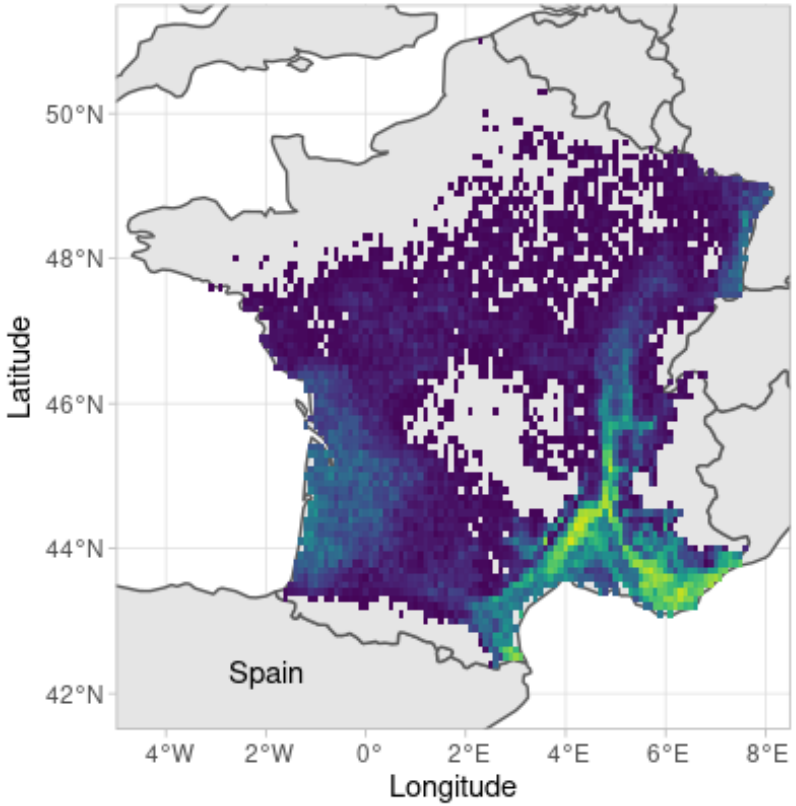
Ae. albopictus regional 2015-2020 model: percentage of successful introductions

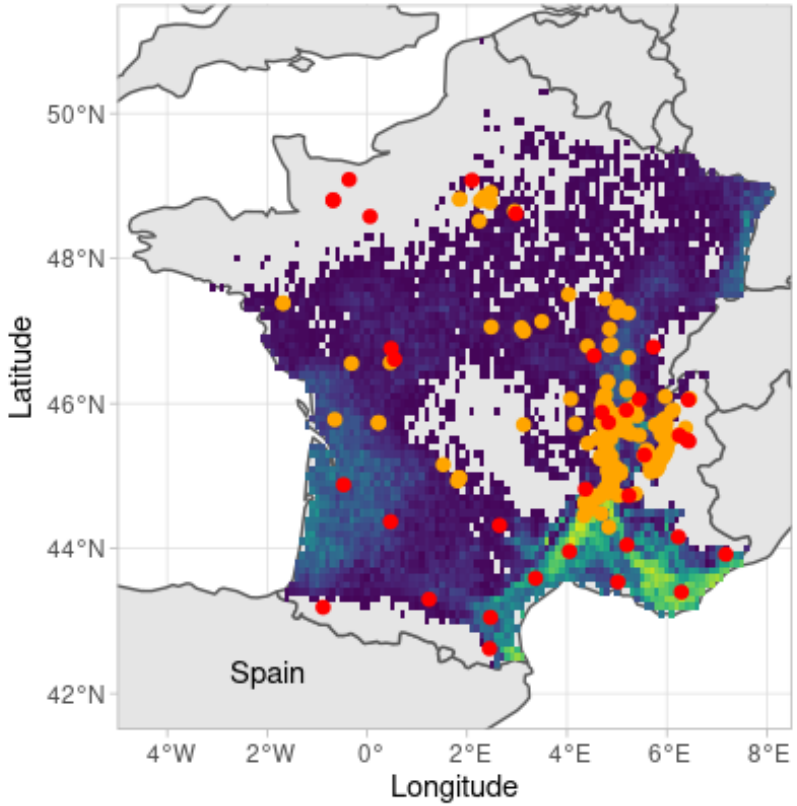


Da Re et al. 2022, *Parasite&Vectors*, in press



AUC: 0.874 (0.867-0.880)





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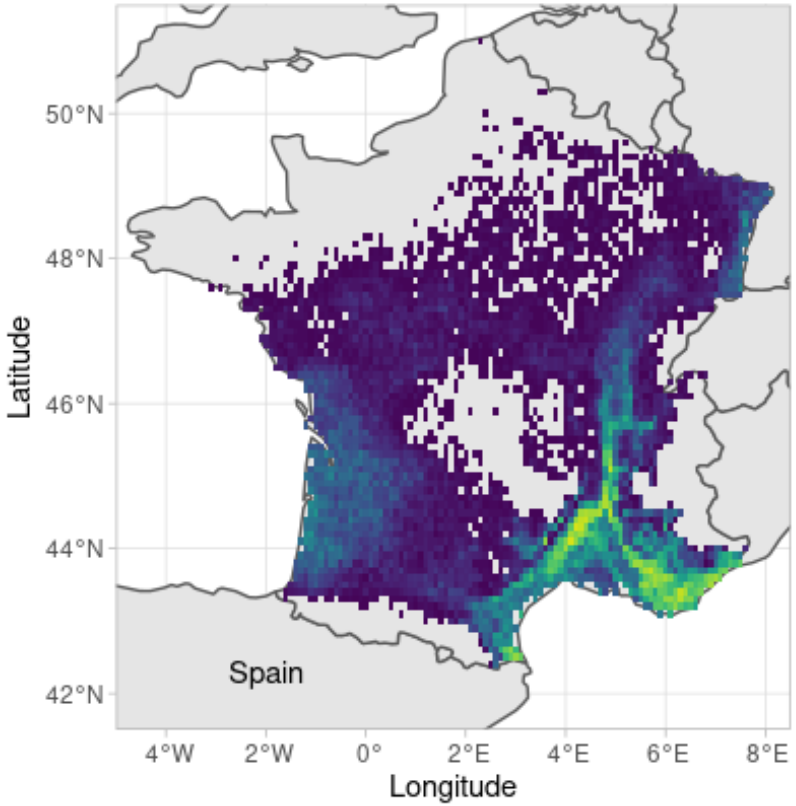
Kramer et al., 2015

Vectornet 2021

88% of the occurrences fall on a pixel having > 1 % successful introduction



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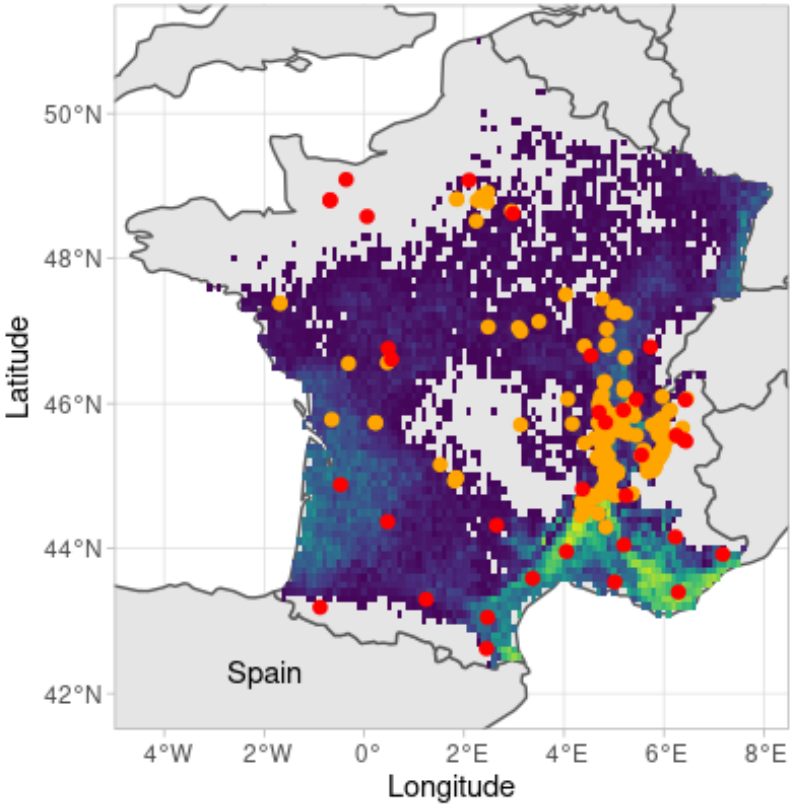

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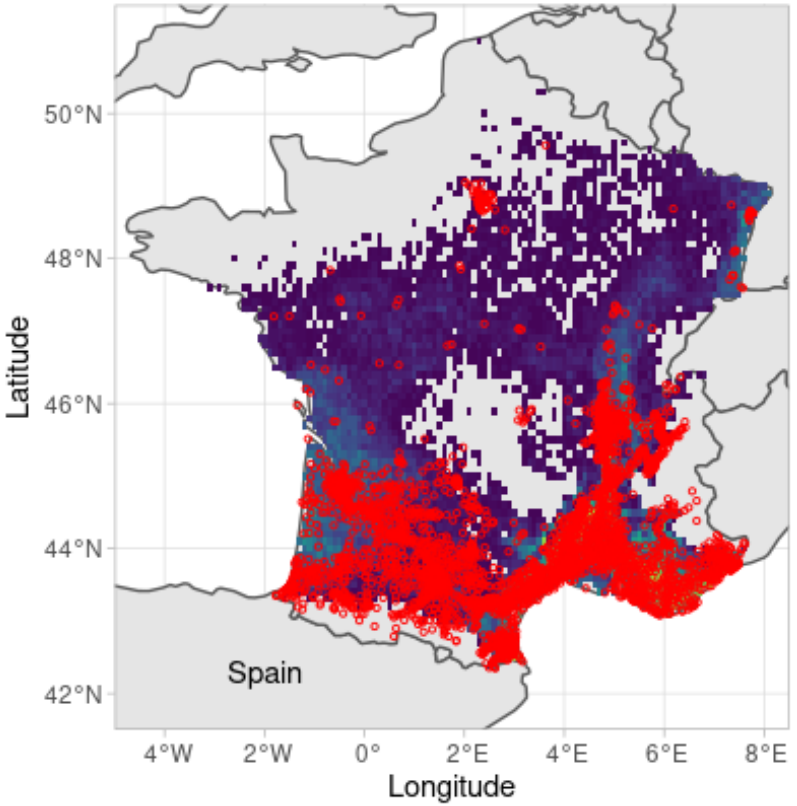

SI LAV 2021

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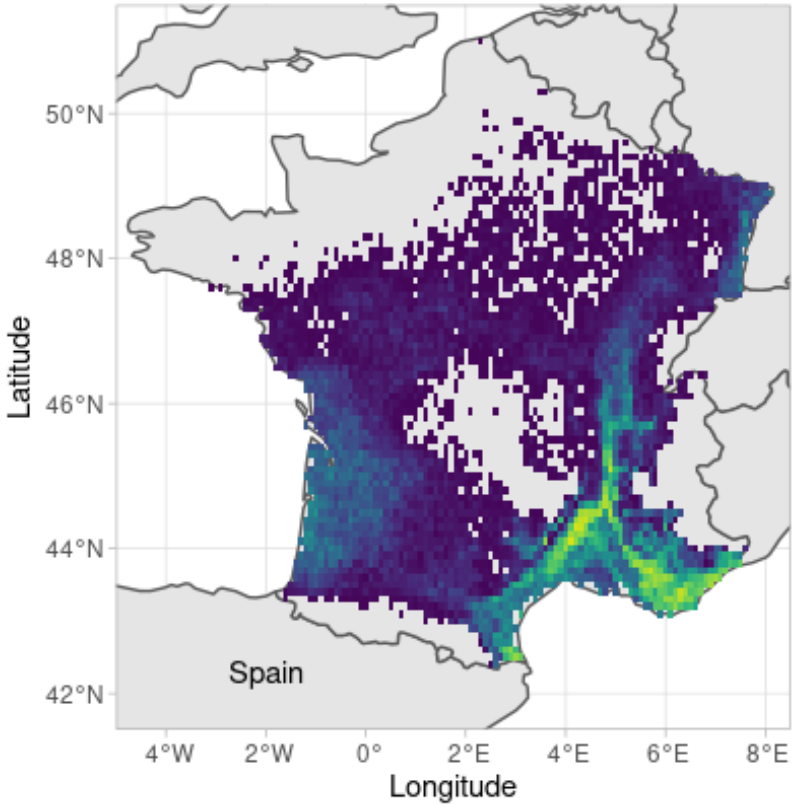

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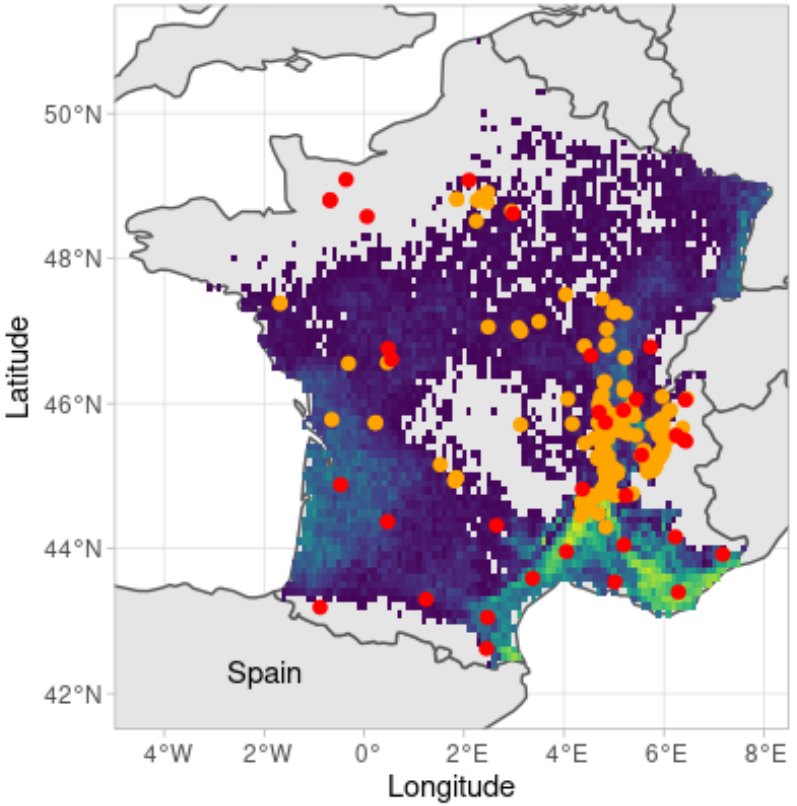

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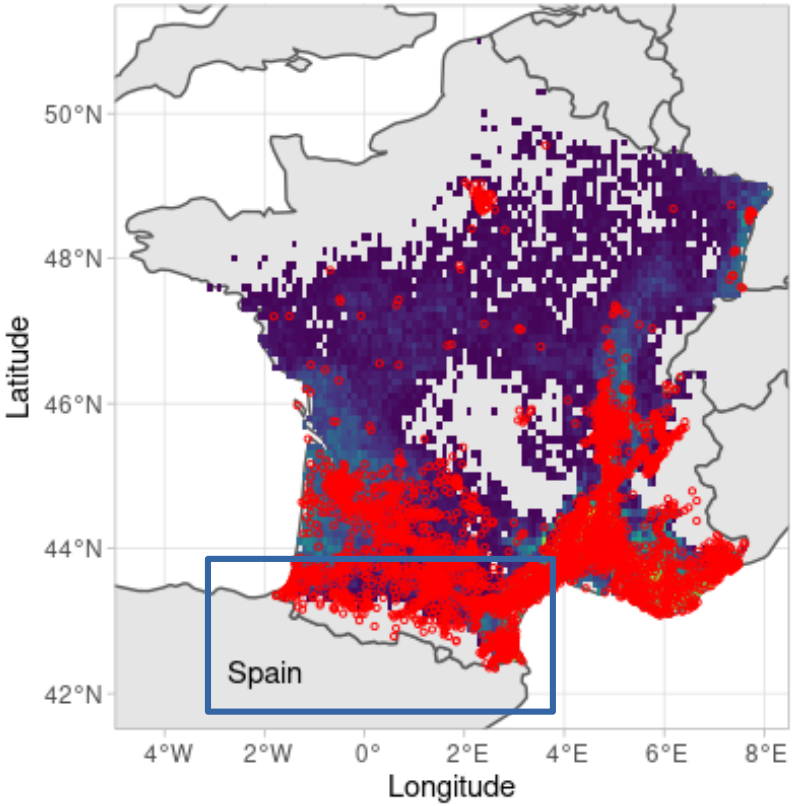

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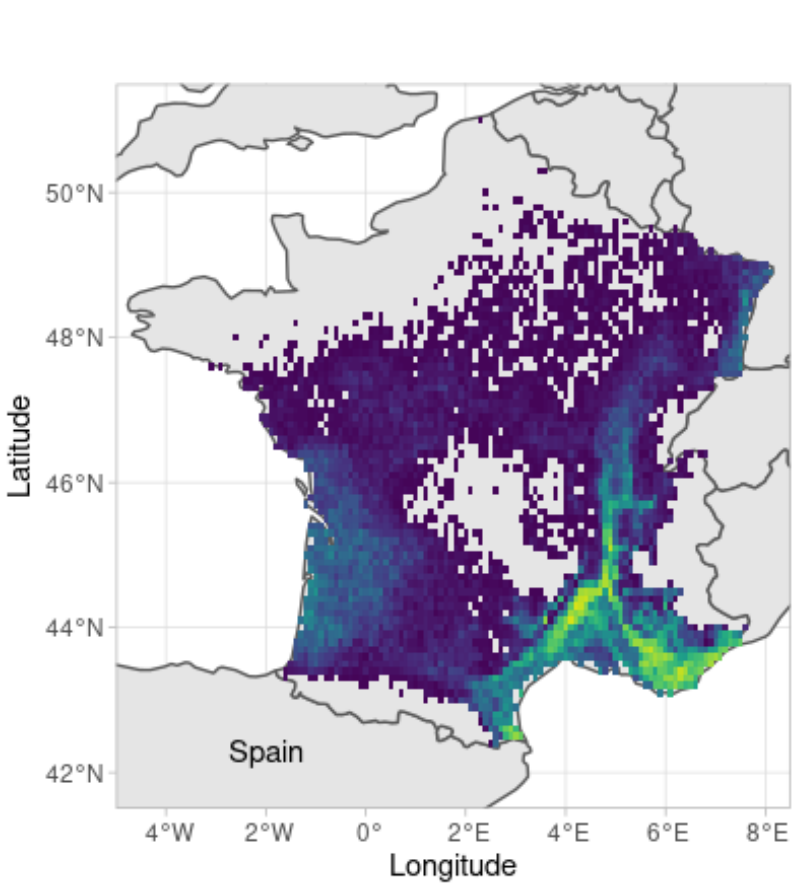

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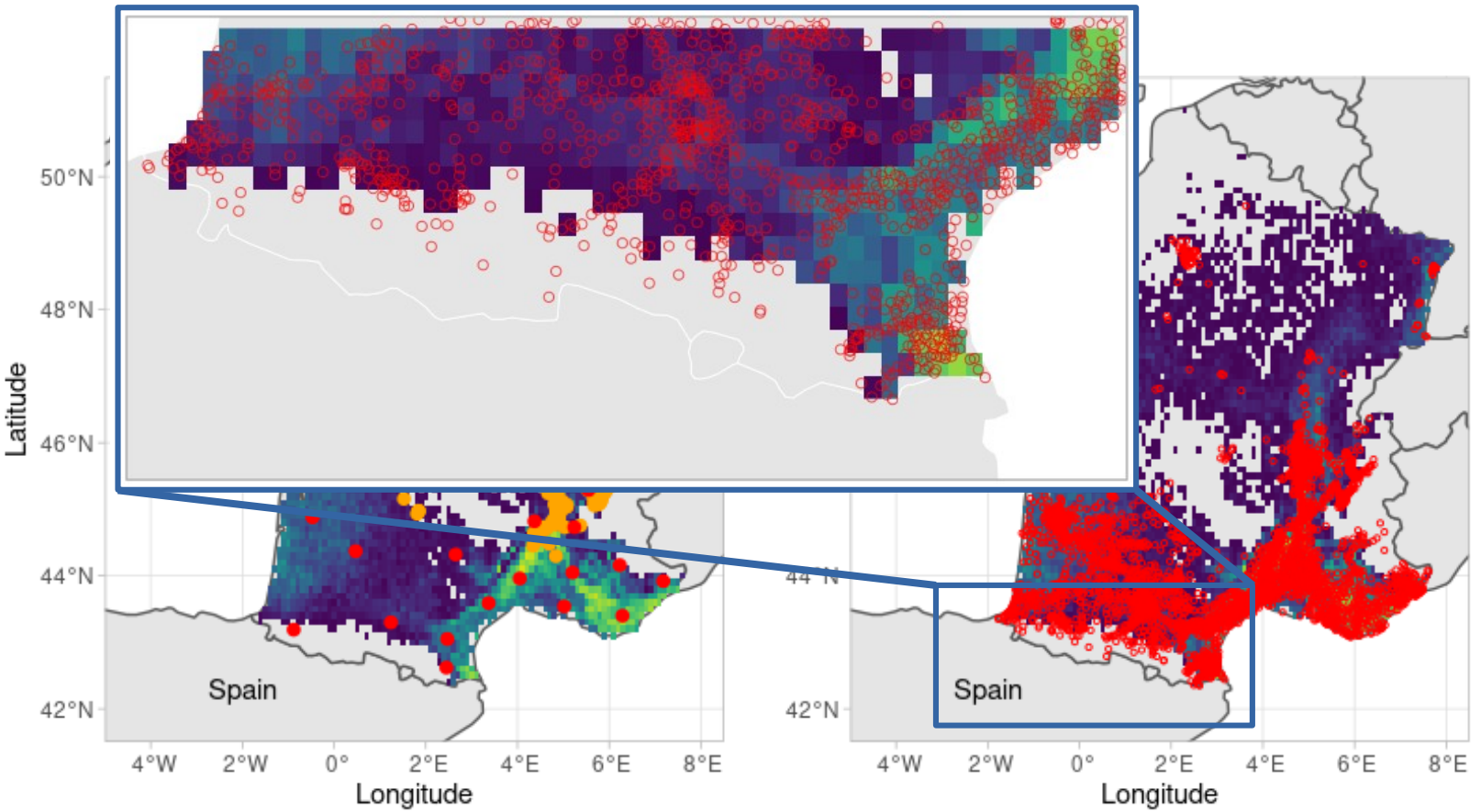

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- Vectornet 2021

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Limitations of the dynamAedes predictions with ERA5

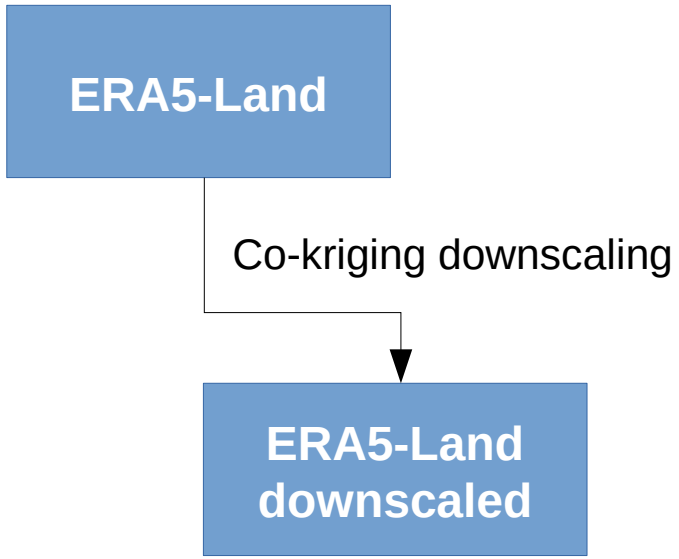
Inaccurate predictions in topographically complex landscapes

Test temperature dataset with higher spatial resolution

Different temperature dataset are available

Dataset	Temporal resolution	Spatial resolution	Source
ERA5-Land	hourly	~9 km	Muñoz-Sabater et al., (2021). *Earth System Science Data*

Different temperature dataset are available



Dataset	Temporal resolution	Spatial resolution	Source
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ERA5-Land downscaled	hourly	User choice	Kusch & Davy (2022). *Environmental Research Letters*

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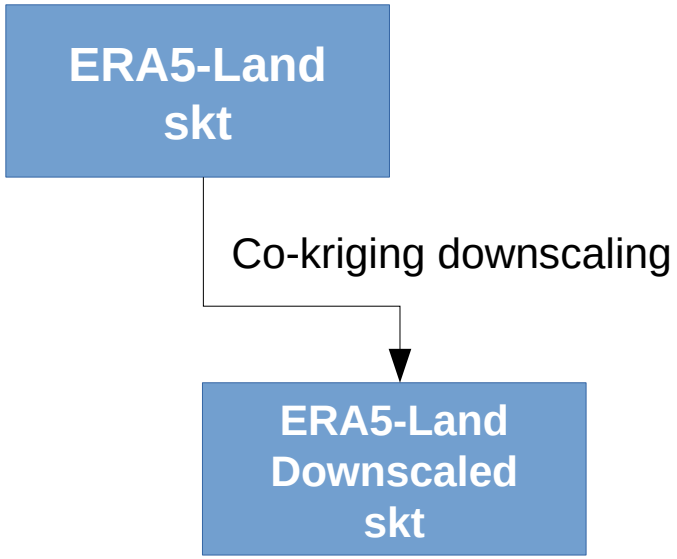
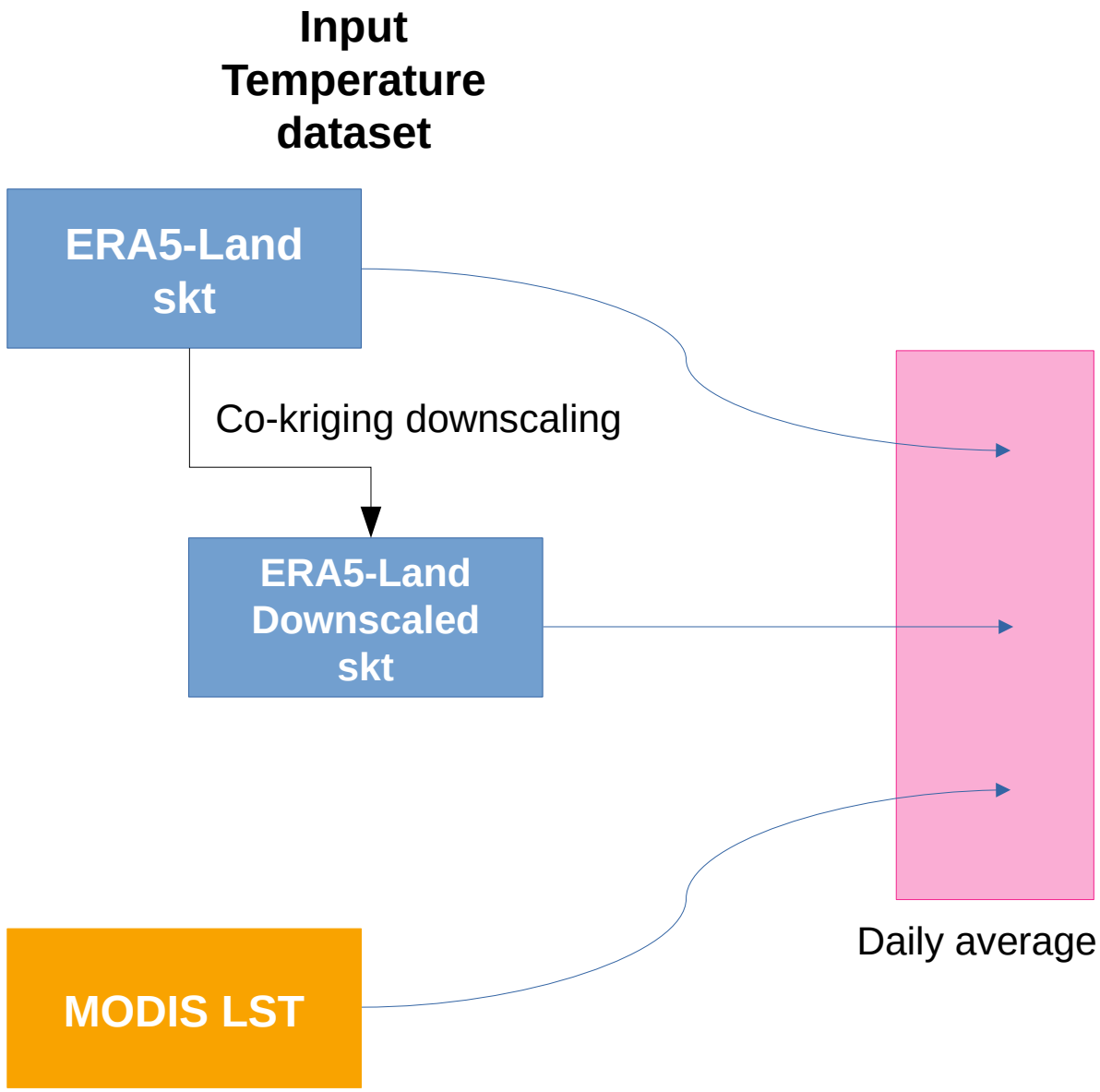
Co-kriging downscaling			
ERA5-Land downscaled	hourly	User choice	Kusch & Davy (2022). *Environmental Research Letters*
MODIS LST	Daily: 2 day + 2 night	~1 km	Zhang et al (2022). *Earth System Science Data*

Input Temperature dataset



MODIS LST


Input
Temperature
dataset
ERA5-Land
skt
Co-kriging downscaling
ERA5-Land
Downscaled
skt
MODIS LST
Daily average

Input Temperature dataset

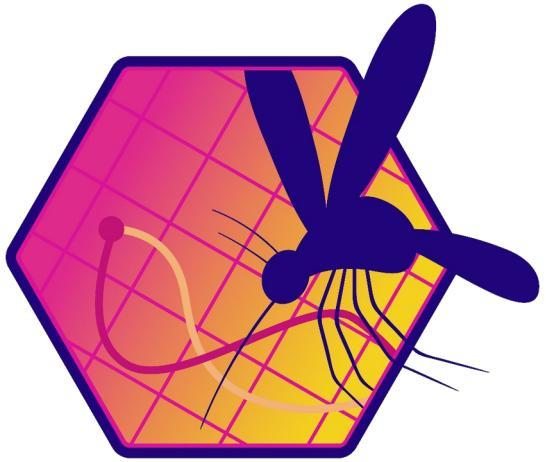
ERA5-Land skt

Co-kriging downscaling

ERA5-Land Downscaled skt

MODIS LST

Daily average



Start: 2018-02-15

End: 2019-05-15

Intro: 1000 diap. eggs

Input Temperature dataset

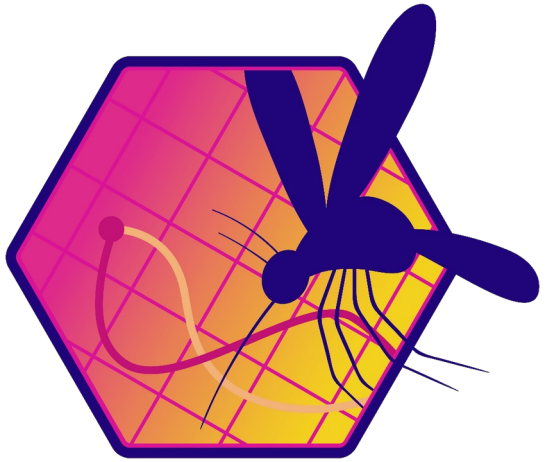
ERA5-Land skt

Co-kriging downscaling

ERA5-Land Downscaled skt

MODIS LST

Daily average



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Intro: 1000 diap. eggs

***Ae. albopictus* Successful Introduction Outputs**

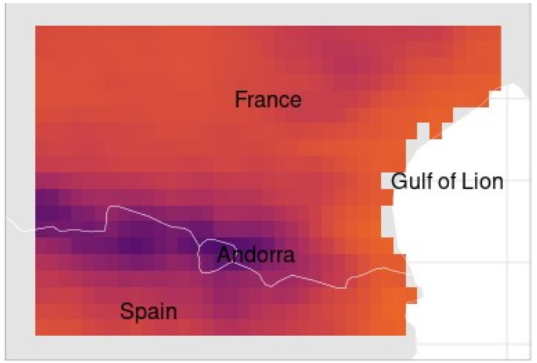
~9 km spatial resolution (ERA5-Land skt)

~1 km spatial resolution (ERA5-Land skt downscaled)

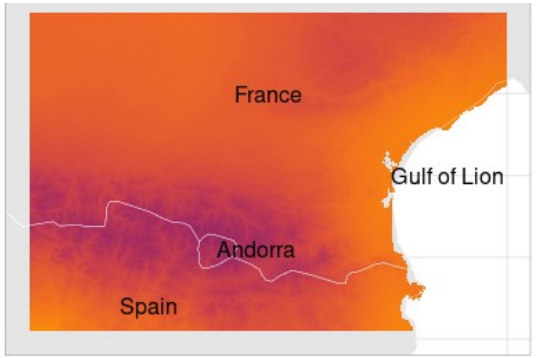
~1 km spatial resolution (MODIS LST)

2019-05-15

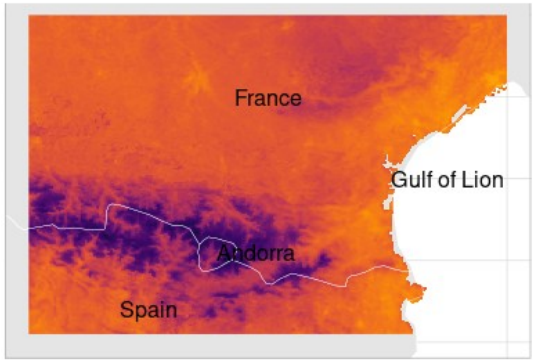
ERA5Land skt ~9 km

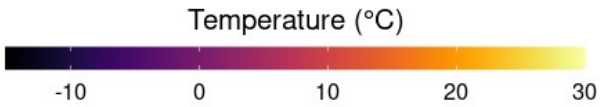


ERA5Land skt
downscaled 1km

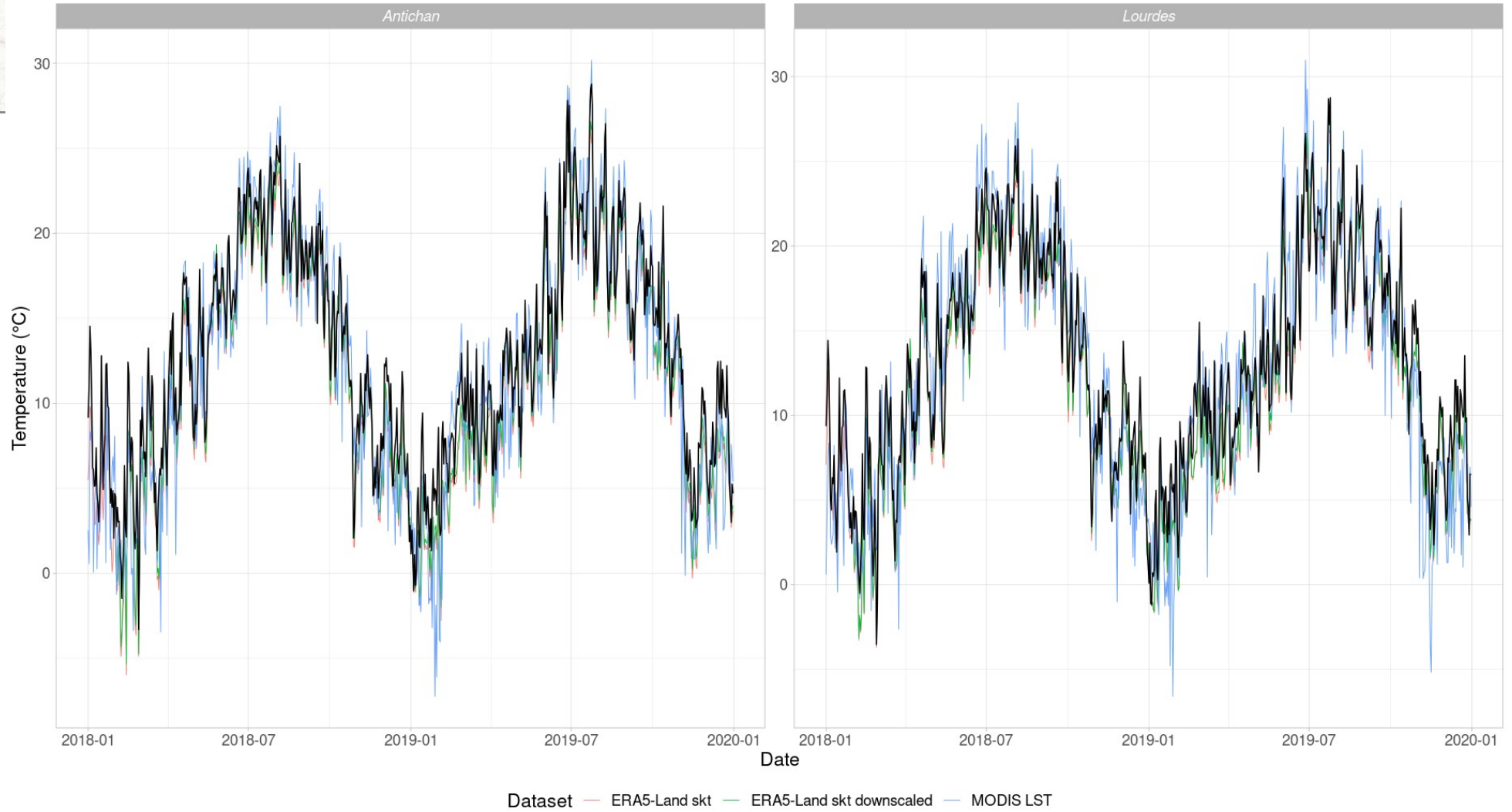


MODIS LST 1km

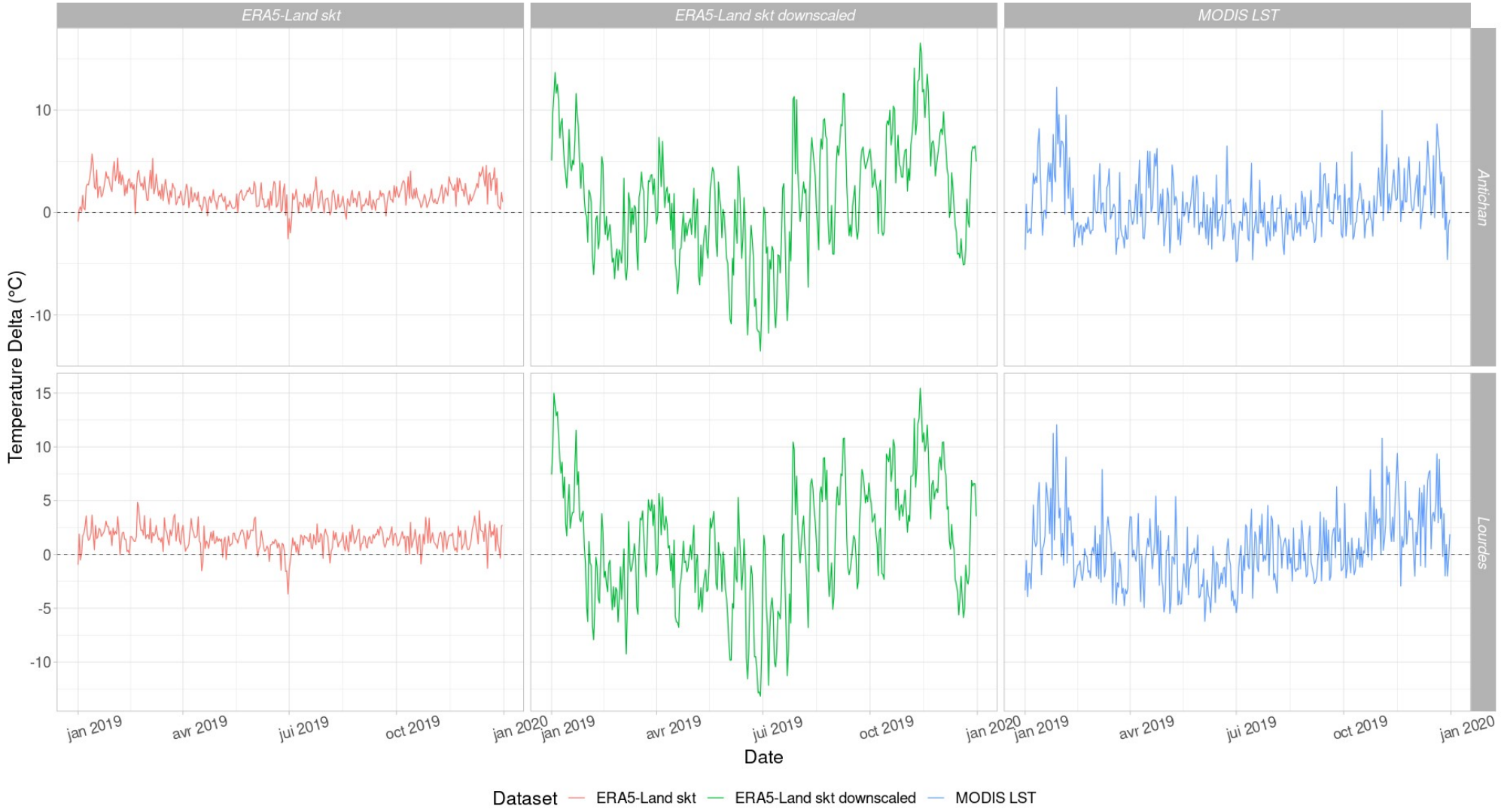




Weather station-pixel comparison

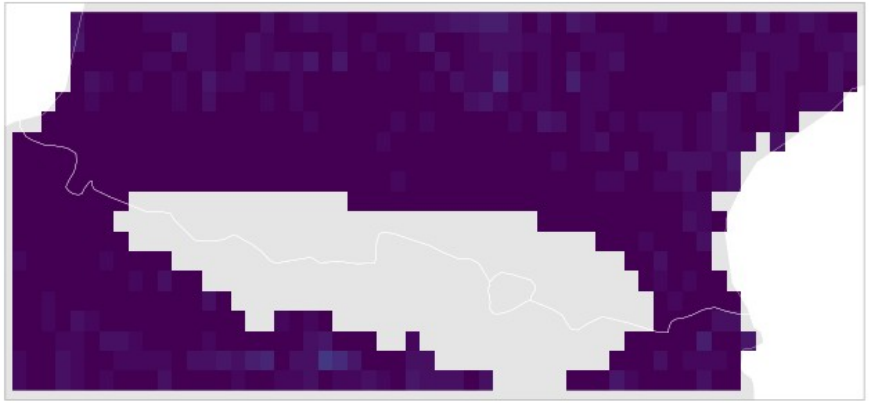


The downscaling approach introduce some variability with respect to the weather stations observations



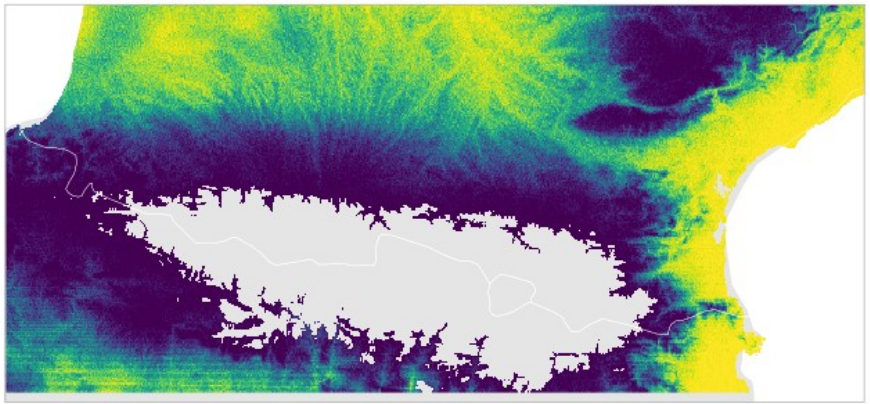
But we are comparing skin temperatures with 2m air temperatures

ERA5Land skt ~9 km



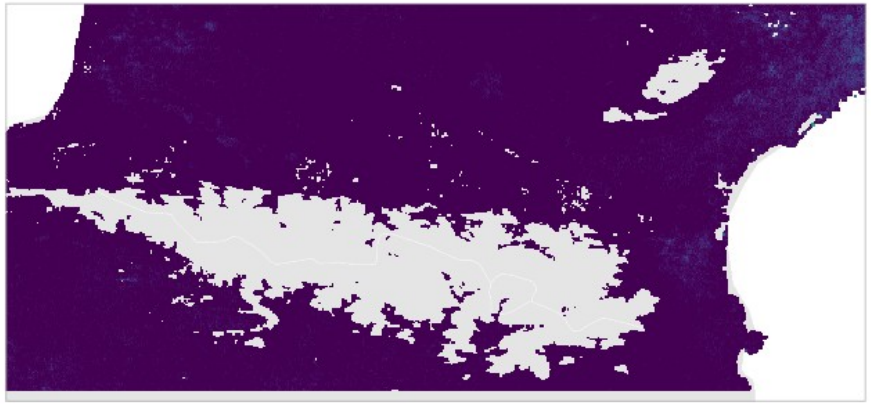
[0, 0.16]

ERA5Land skt
downscaled 1km



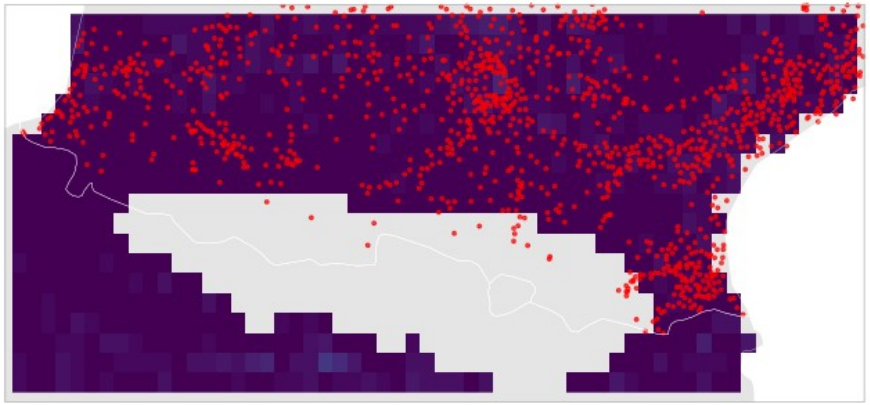
[0, 1]

MODIS LST 1km

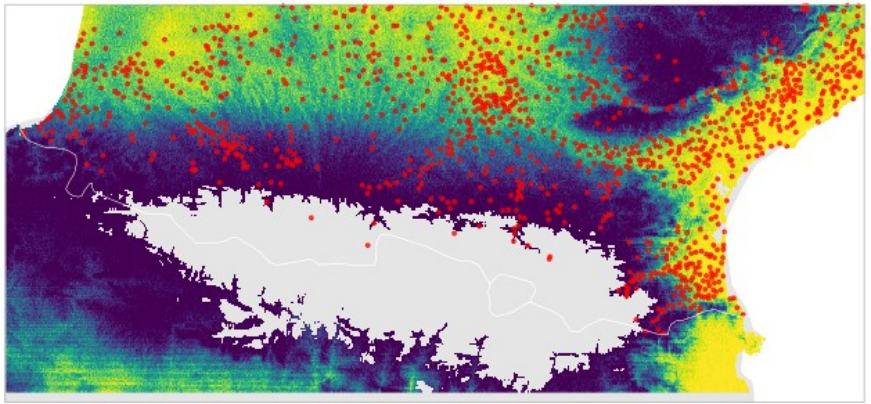


[0, 0.66]

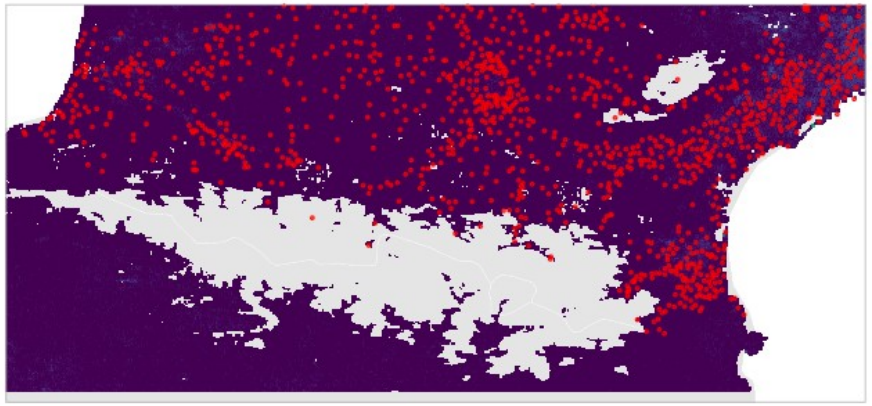
ERA5Land skt ~9 km



ERA5Land skt
downscaled 1km

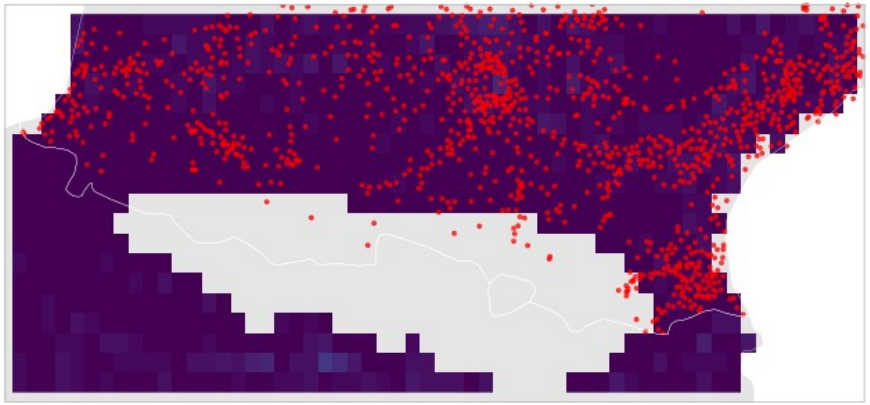


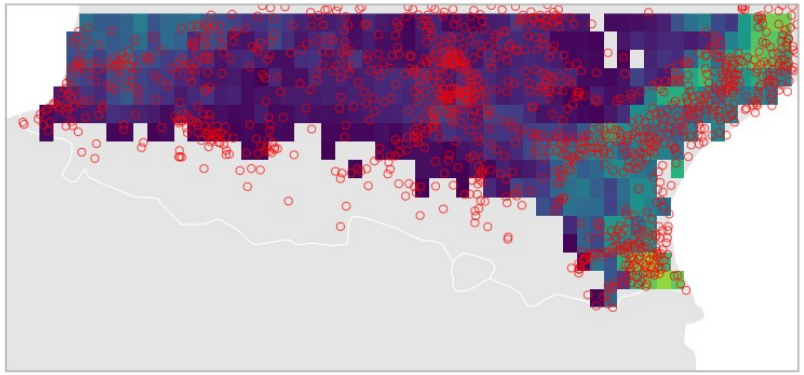
MODIS LST 1km



● SI LAV 2021

ERA5Land skt ~9 km





ERA5Land skt
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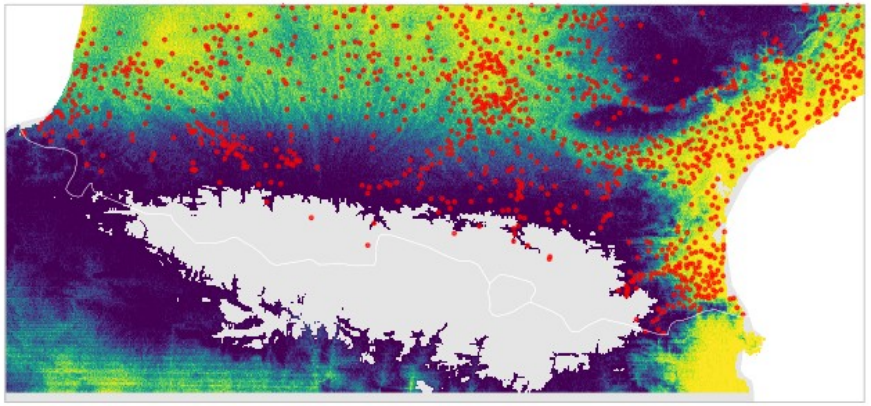
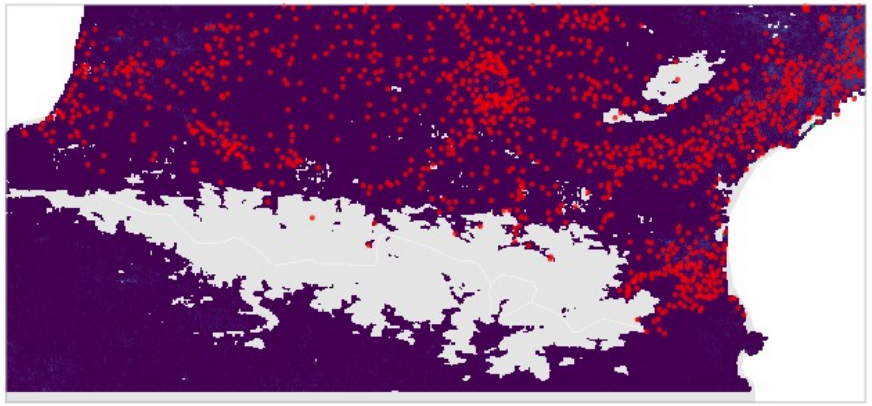


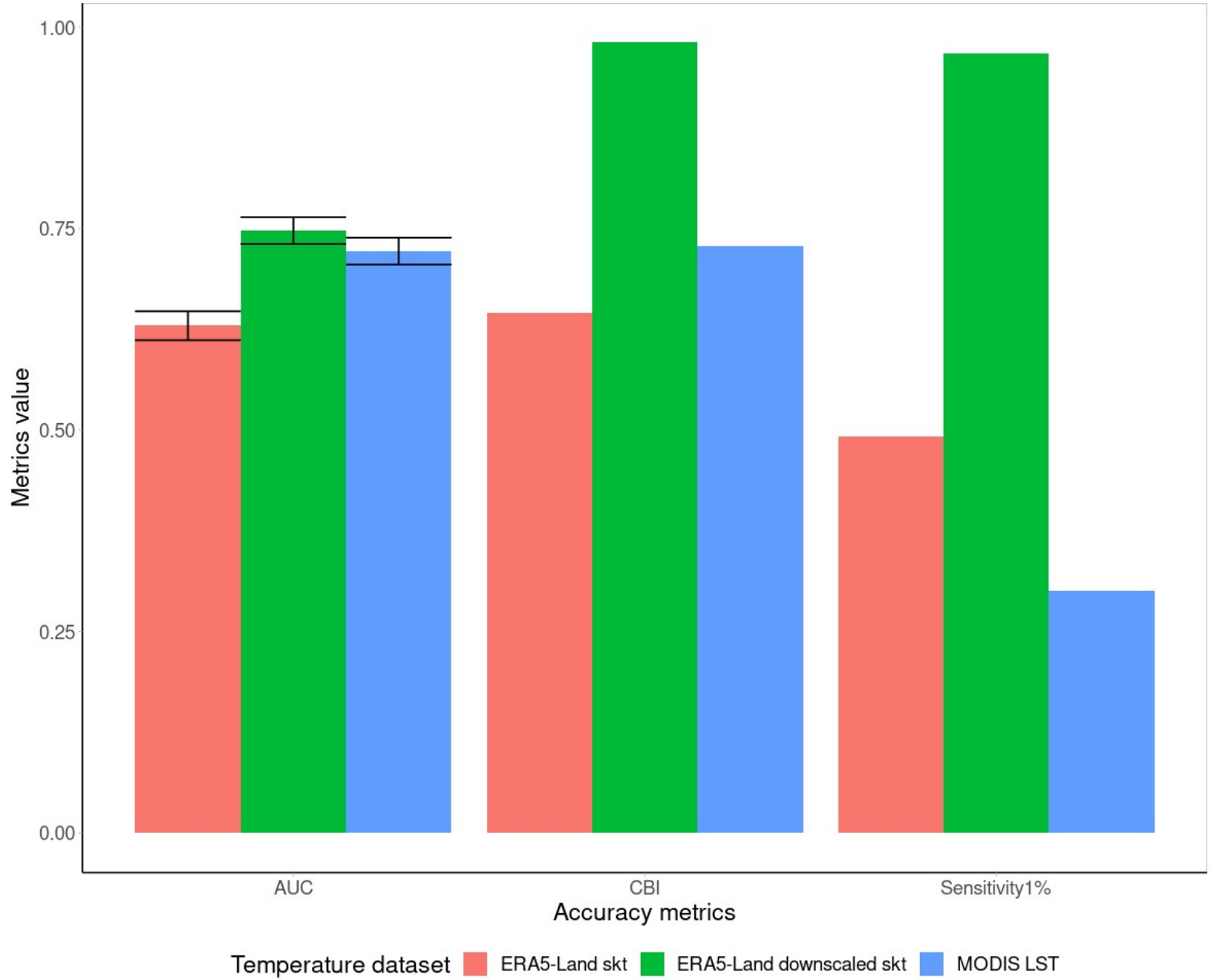
MODIS LST 1km

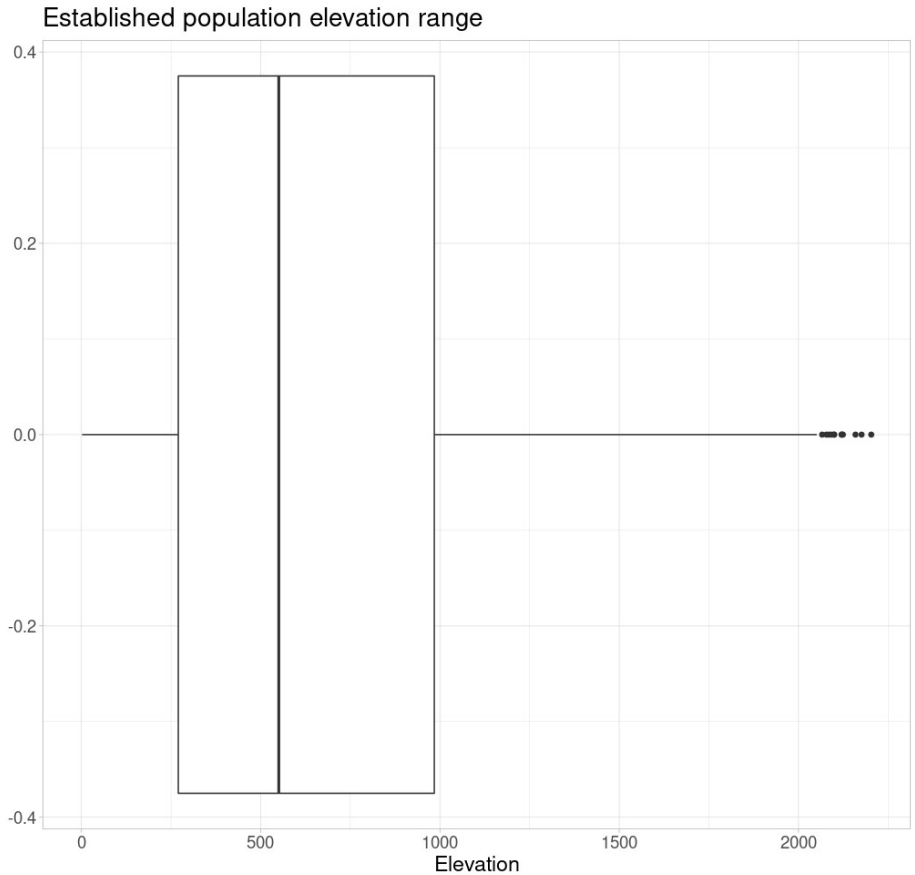


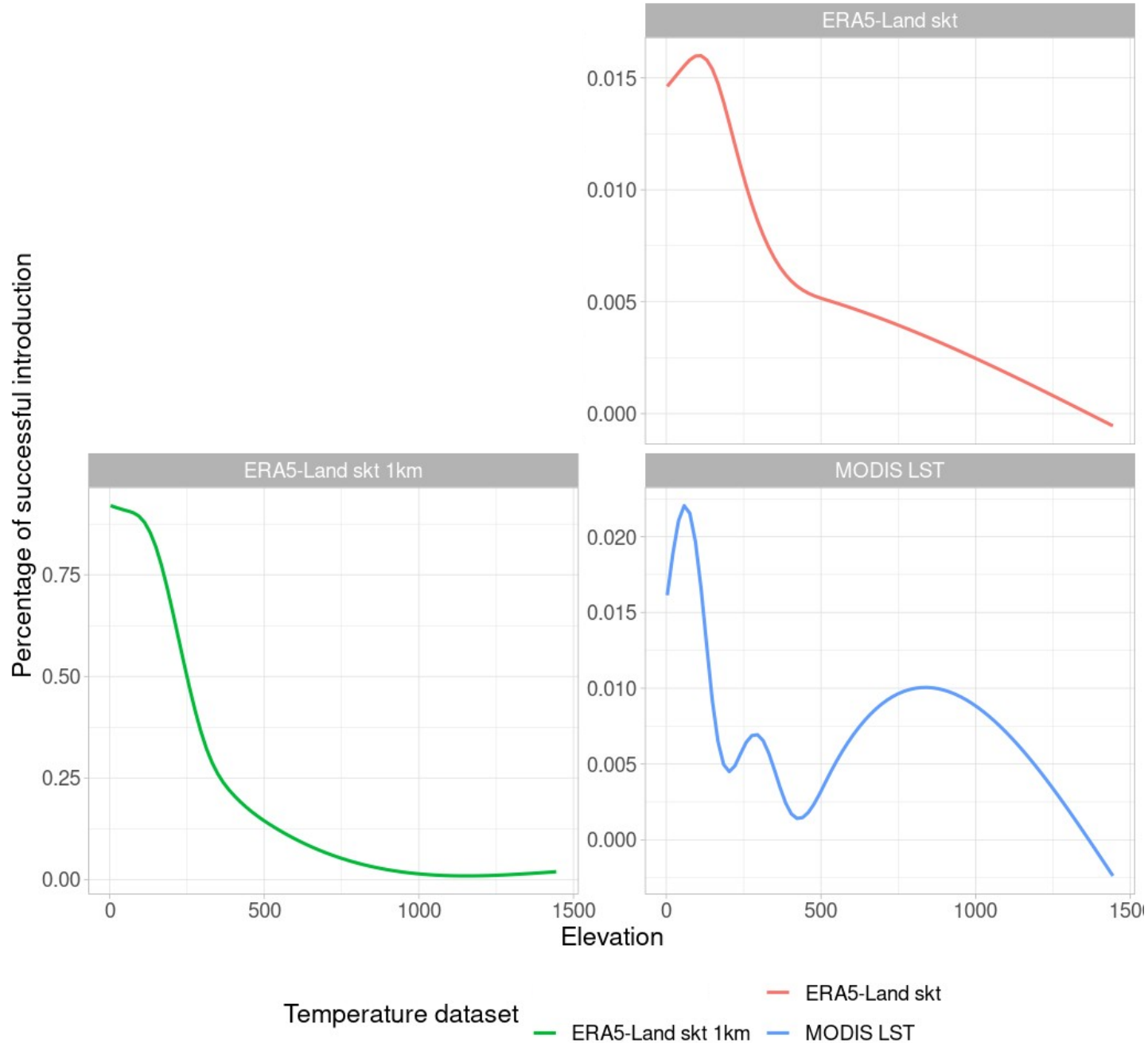
Percentage of successfull introduction

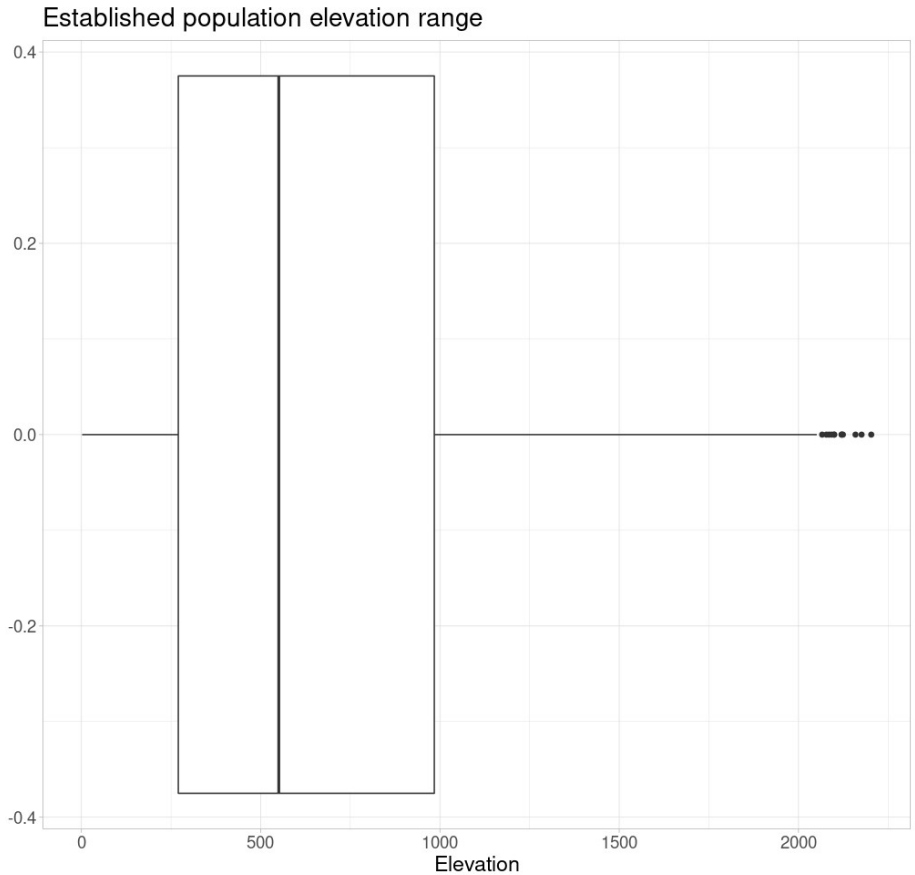
0.00 0.25 0.50 0.75 1.00

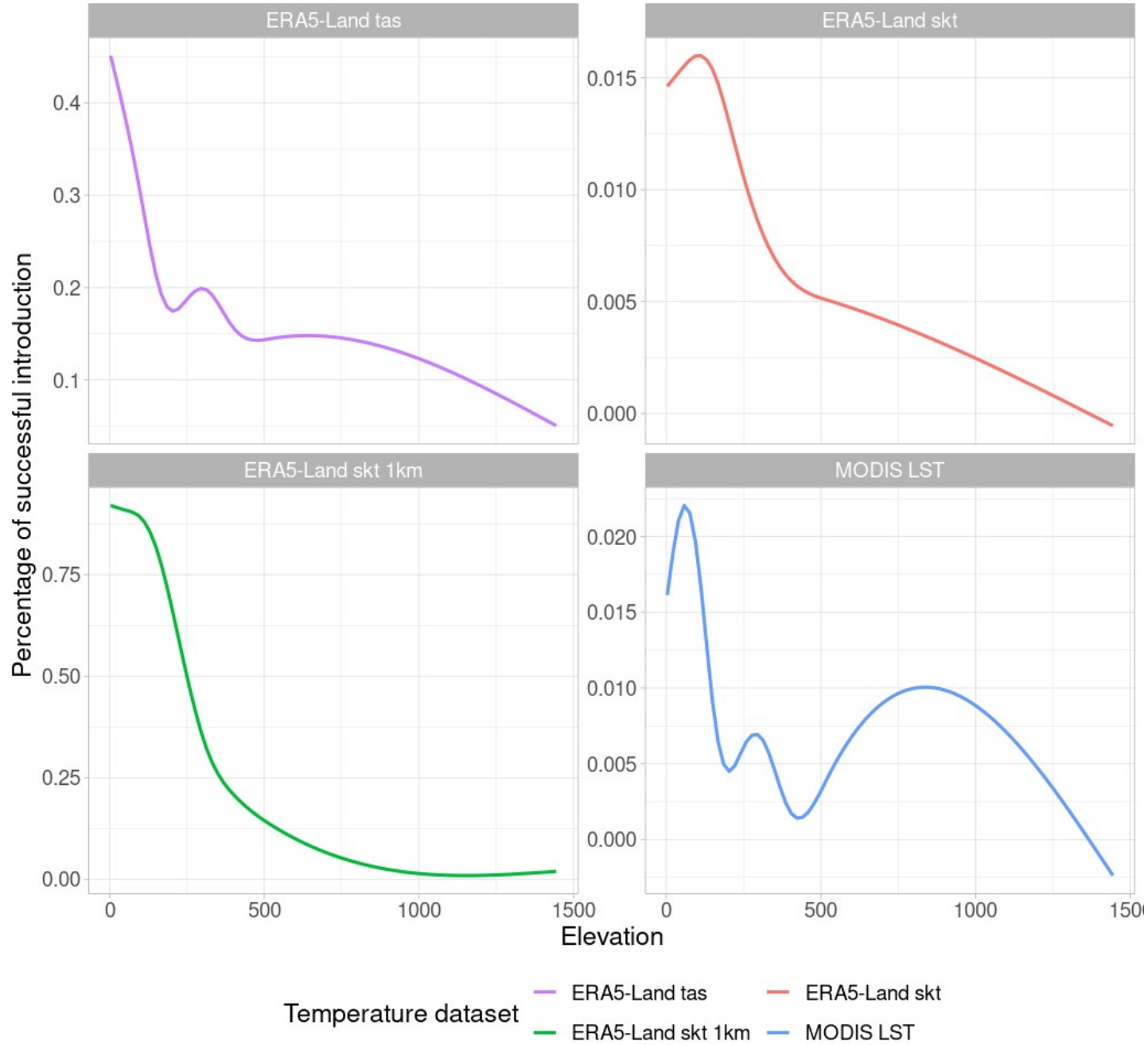
SI LAV 2021


1.00
0.75
0.50
0.25
0.00
Metrics value
AUC
CBI
Sensitivity1%
Accuracy metrics
Temperature dataset
ERA5-Land skt
ERA5-Land downscaled skt
MODIS LST


Established population elevation range
0.4
0.2
0.0
-0.2
-0.4
0
500
1000
1500
2000
Elevation


ERA5-Land skt
ERA5-Land skt 1km
MODIS LST
Percentage of successful introduction
0.015
0.010
0.005
0.000
0.75
0.50
0.25
0.00
0.020
0.015
0.010
0.005
0.000
0
500
1000
1500
Elevation
Temperature dataset
ERA5-Land skt
ERA5-Land skt 1km
MODIS LST


Established population elevation range
0.4
0.2
0.0
-0.2
-0.4
0
500
1000
1500
2000
Elevation


ERA5-Land tas
ERA5-Land skt
ERA5-Land skt 1km
MODIS LST
Percentage of successful introduction
Elevation
Temperature dataset
ERA5-Land tas
ERA5-Land skt
ERA5-Land skt 1km
MODIS LST

Final thoughts

Spatial scale and the choice of the temperature dataset matters!

Final thoughts

Spatial scale and the choice of the temperature dataset matters!

Usage and Popularity: MODIS LST **>** ERA5Land

Spatial resolution: MODIS LST **>** ERA5Land (native)

Temporal resolution: MODIS LST **<** ERA5Land

Take home message

Using a downscaling approach

dynamAedes informed with
ERA5-Land performed better!

Received: 5 July 2018 | Accepted: 4 September 2018
DOI: 10.1111/2041-210X.13093

RESEARCH ARTICLE

Methods in Ecology and Evolution BRITISH ECOLOGICAL SOCIETY

Microclima: An R package for modelling meso- and microclimate

Ilya M. D. Maclean[1] | Jonathan R. Mosedale[1] | Jonathan J. Bennie[2]

Methods in Ecology and Evolution BRITISH ECOLOGICAL SOCIETY

APPLICATION

MCERA5: Driving microclimate models with ERA5 global gridded climate data

David H. Klinges, James P. Duffy, Michael R. Kearney, Ilya M. D. Maclean

LST product types

Hourly LST | 10-day LST Daily Cycle | 10-day LST TCI

Access | Algorithm | Quality | Application | Technical | Documents

Copernicus Global Land Service

Providing bio-geophysical products of global land surface

Product version	Access	Sensor	Temporal coverage	Spatial information	Timeliness
2	Product portal	Imagers on-board geostationary satellites	Jan 2021 - present, hourly	Global, 5km resolution	Within 4 hours
1	Product portal	Imagers on-board geostationary satellites	Oct 2010 - Jan 2021, hourly	Global, 5km	Within 4 hours

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Thank you

@DaReDaniele1

daniele.dare@uclouvain.be

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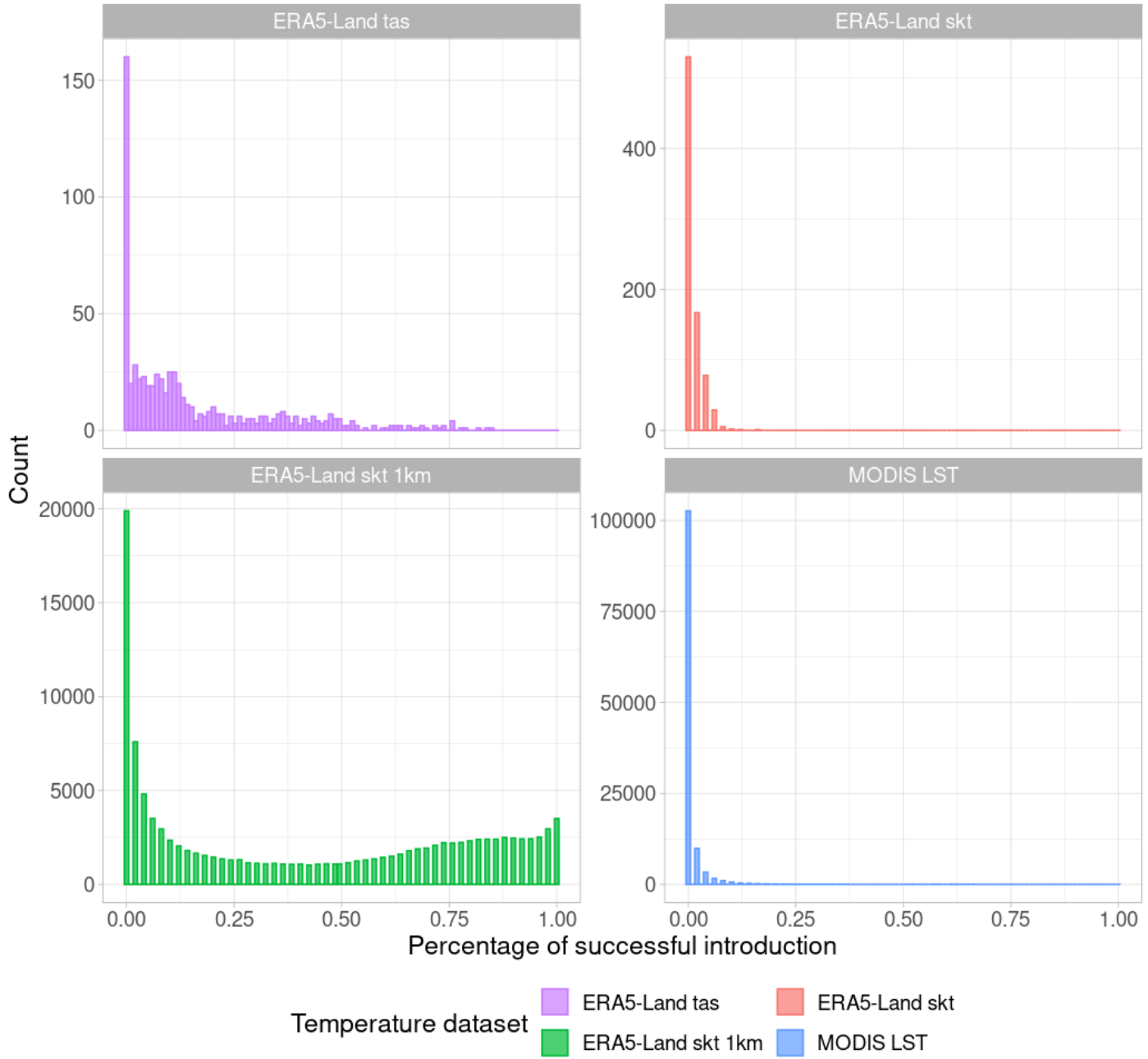
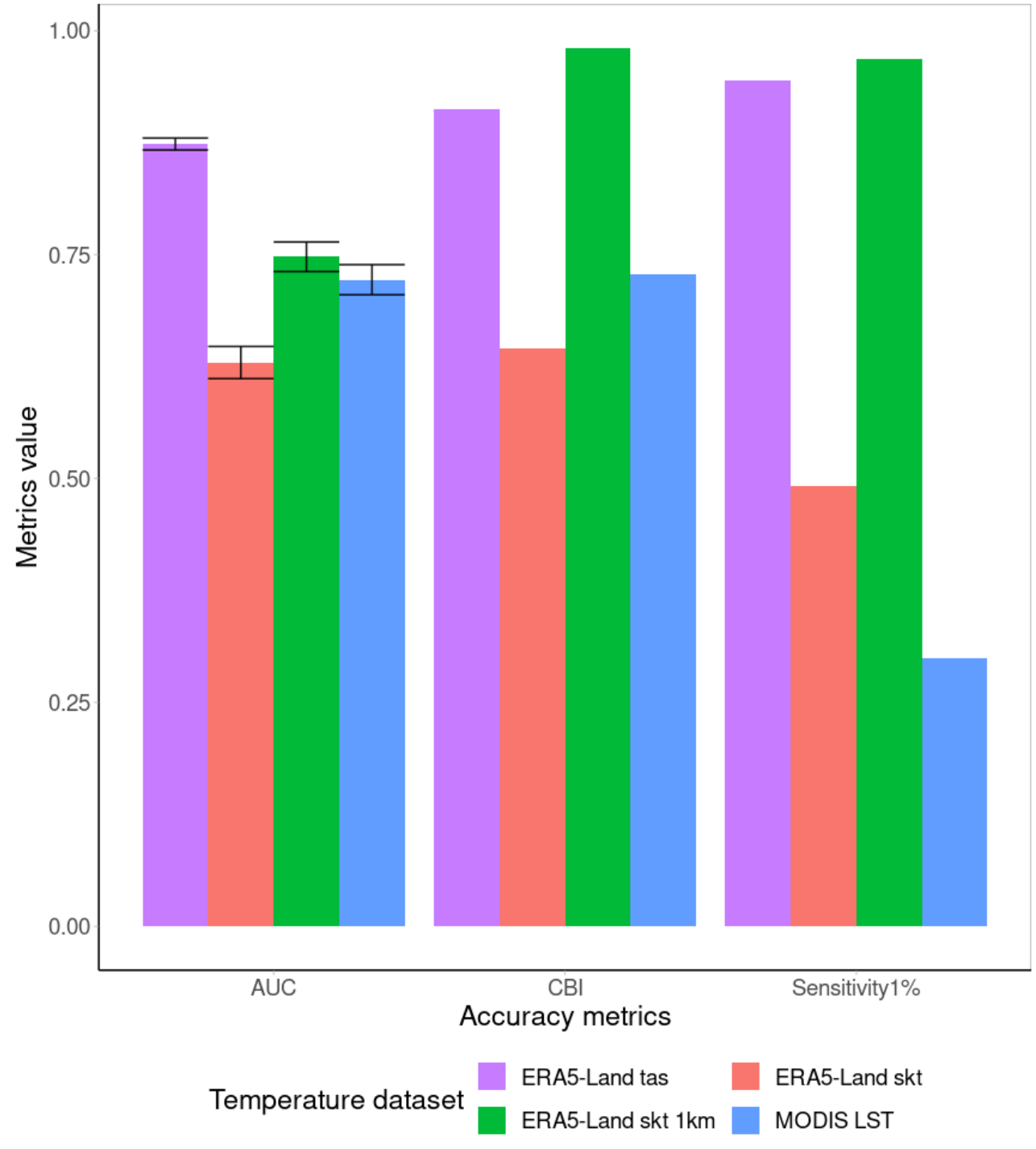
MINISTÈRE DES SOLIDARITÉS ET DE LA SANTÉ
Liberté
Égalité
Fraternité

Predicted values distribution




1.00
0.75
0.50
0.25
0.00
Metrics value
AUC
CBI
Sensitivity1%
Accuracy metrics
Temperature dataset
ERA5-Land tas
ERA5-Land skt
ERA5-Land skt 1km
MODIS LST

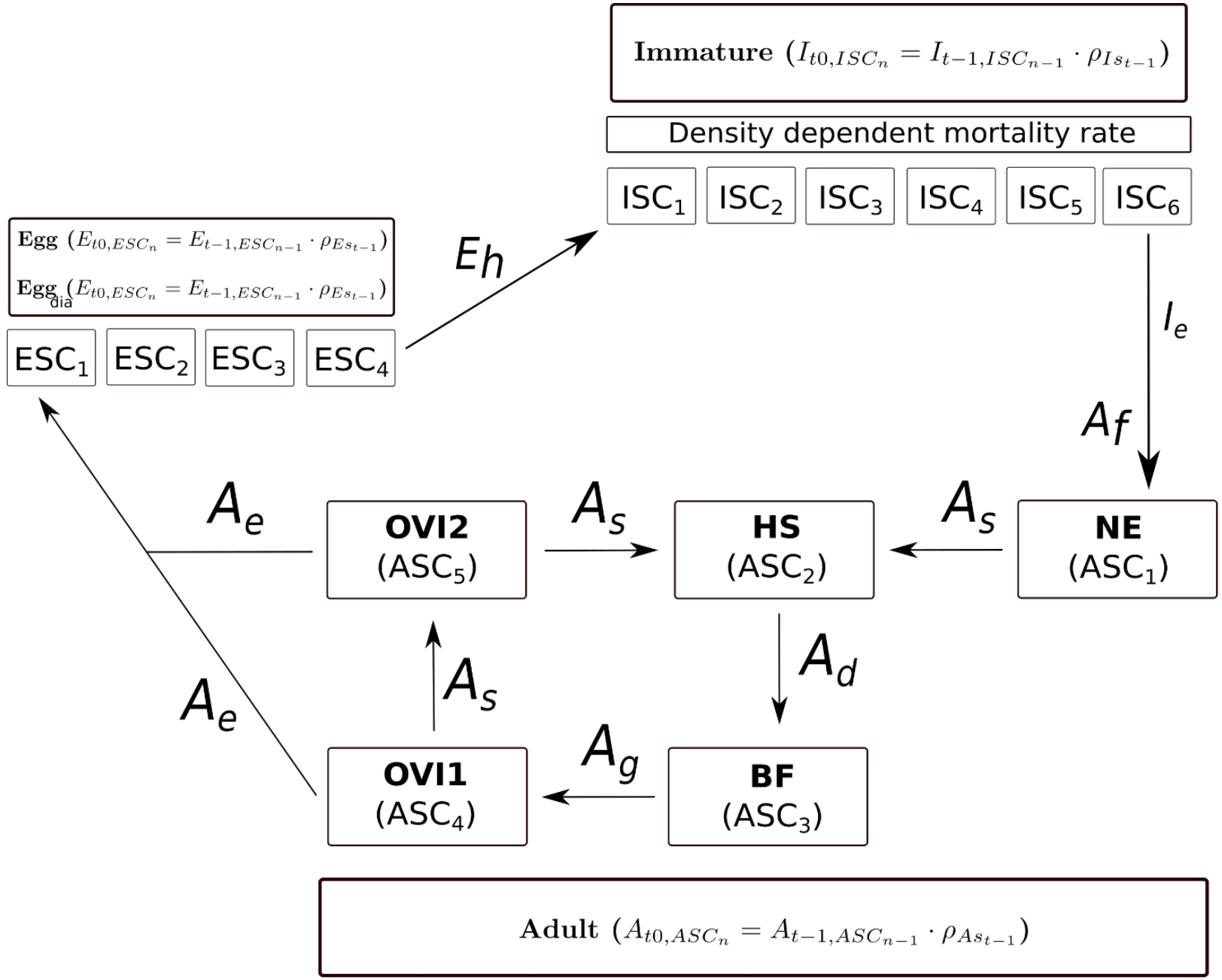
ELSEVIER

Ecological Informatics

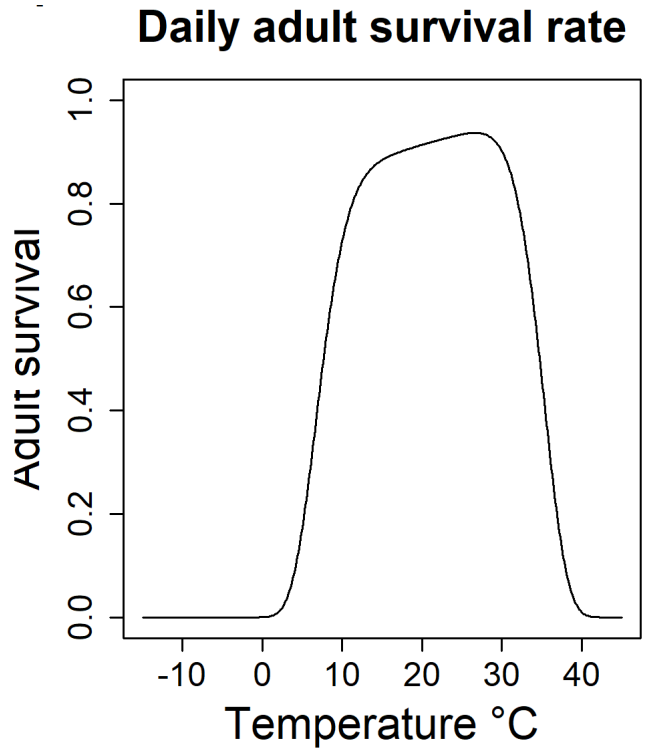
Volume 61, March 2021, 101180

Will the yellow fever mosquito colonise Europe? Assessing the re-introduction of *Aedes aegypti* using a process-based population dynamical model

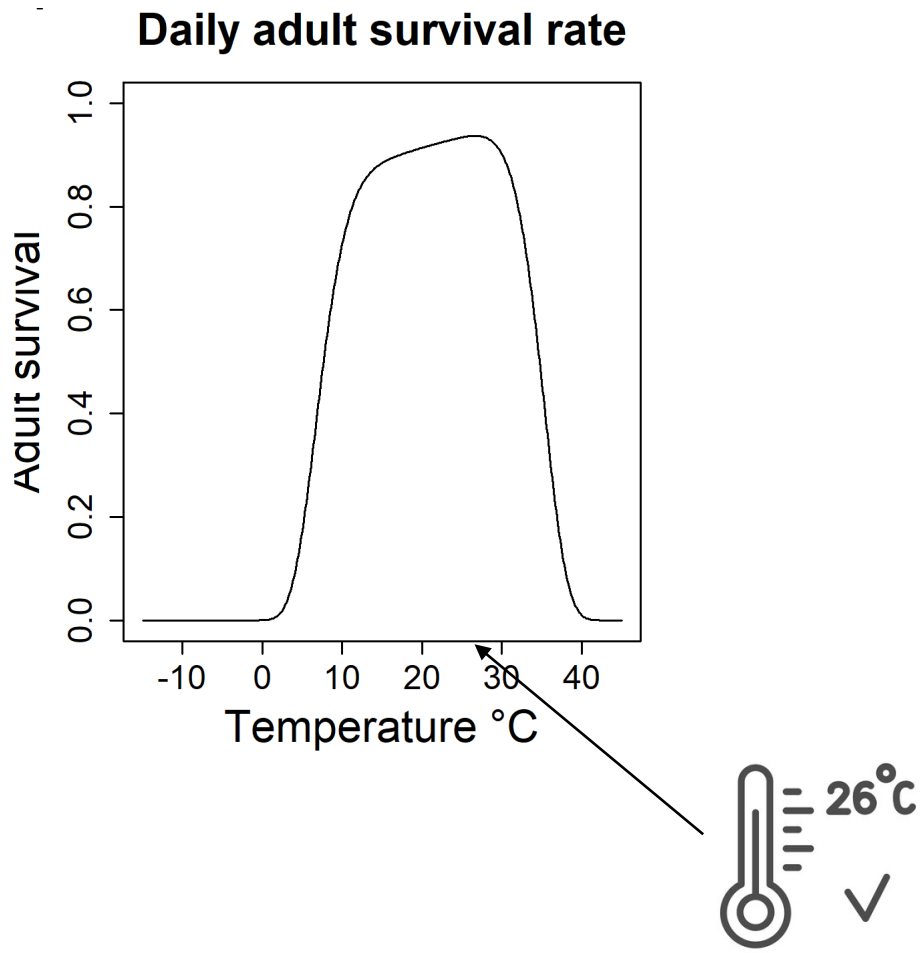
Daniele Da Re [a], Diego Montecino-Latorre [b], Sophie O. Vanwambeke [a], Matteo Marcantonio [c]


Immature ($I_{t0,ISC_n} = I_{t-1,ISC_{n-1}} \cdot \rho_{Is_{t-1}}$)
Density dependent mortality rate
ISC1
ISC2
ISC3
ISC4
ISC5
ISC6
Egg ($E_{t0,ESC_n} = E_{t-1,ESC_{n-1}} \cdot \rho_{Es_{t-1}}$)
Egg dia ($E_{t0,ESC_n} = E_{t-1,ESC_{n-1}} \cdot \rho_{Es_{t-1}}$)
ESC1
ESC2
ESC3
ESC4
Eh
Ie
Af
Ae
OVI2 (ASC5)
As
HS (ASC2)
As
NE (ASC1)
Ad
Ae
As
OVI1 (ASC4)
Ag
BF (ASC3)
Adult ($A_{t0,ASC_n} = A_{t-1,ASC_{n-1}} \cdot \rho_{As_{t-1}}$)

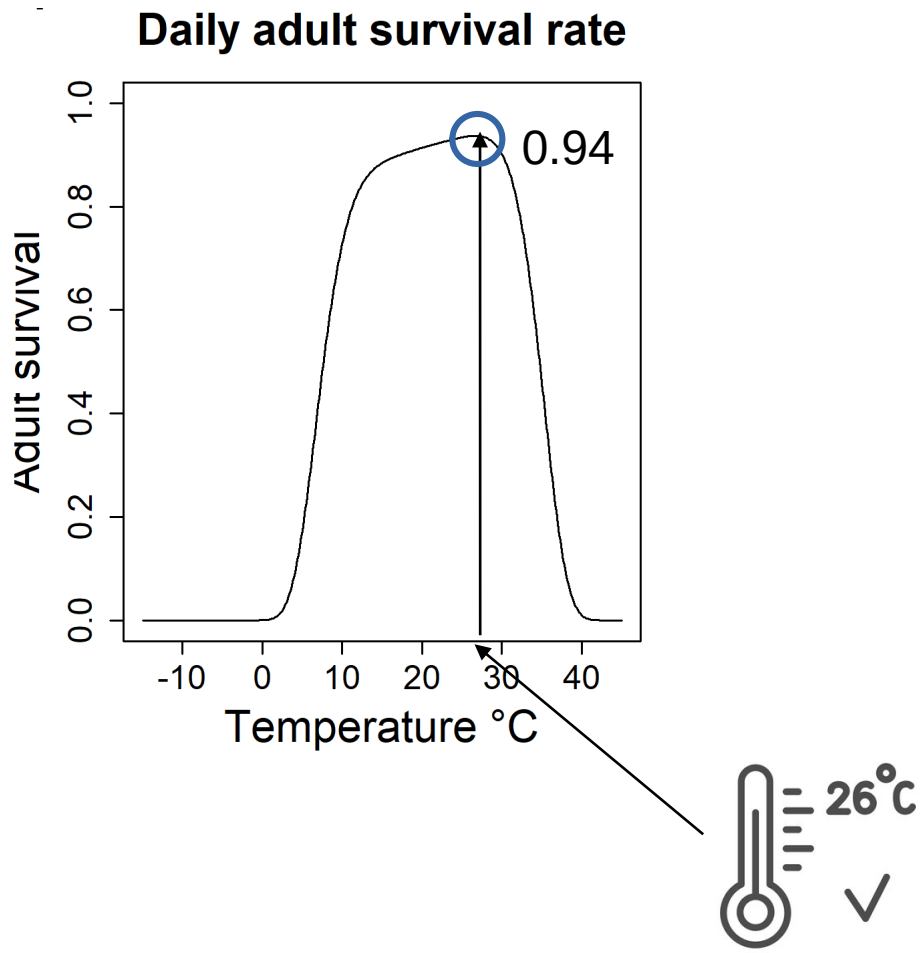
Binomial draws informed by temperature-dependent functions



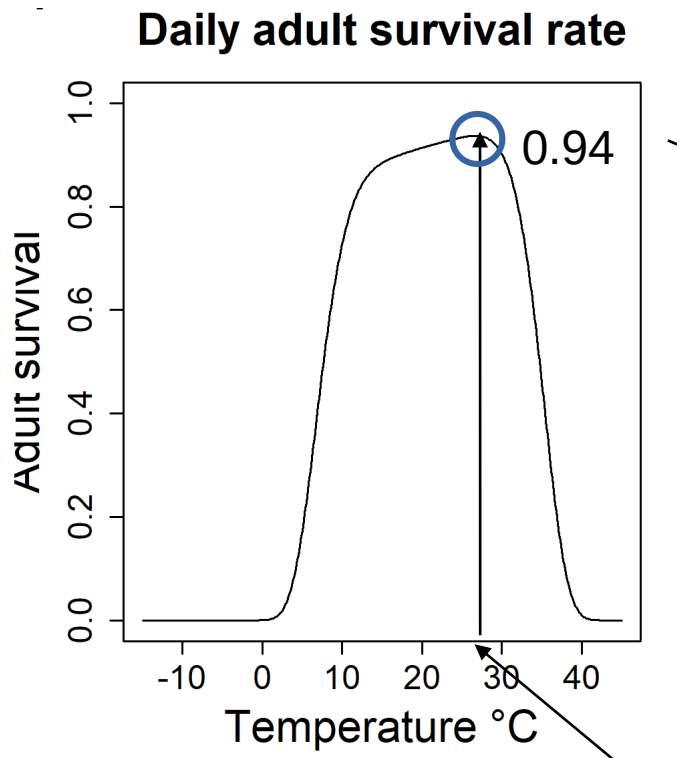
Binomial draws informed by temperature-dependent functions



Binomial draws informed by temperature-dependent functions

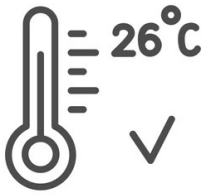


Binomial draws informed by temperature-dependent functions

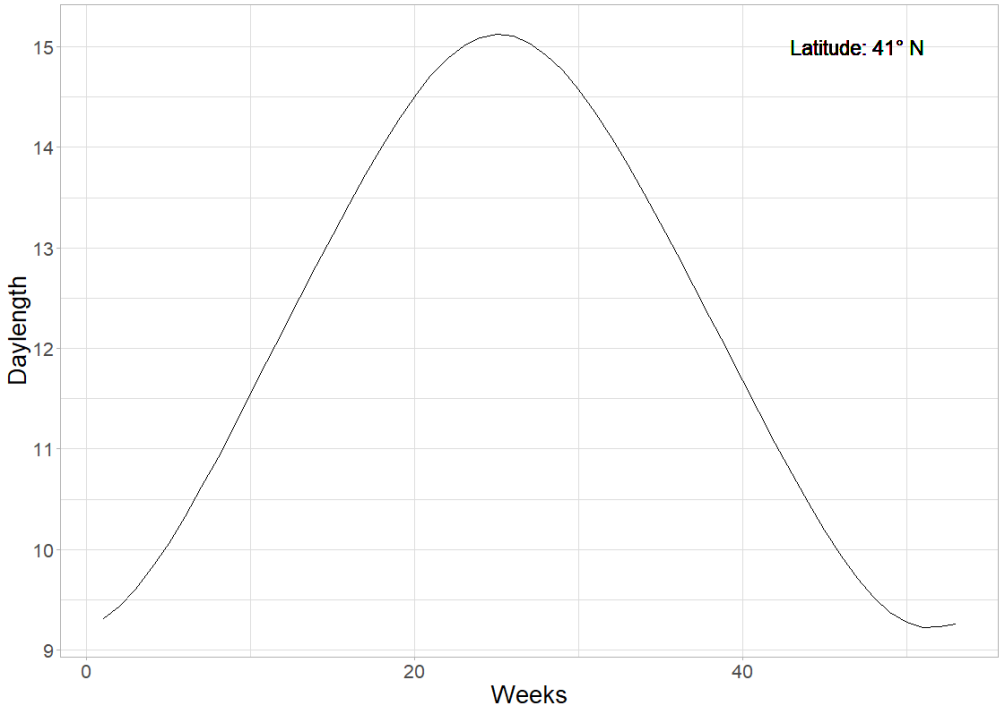



```
rbinom(PopulationSize=500, prob=0.94)

466
```



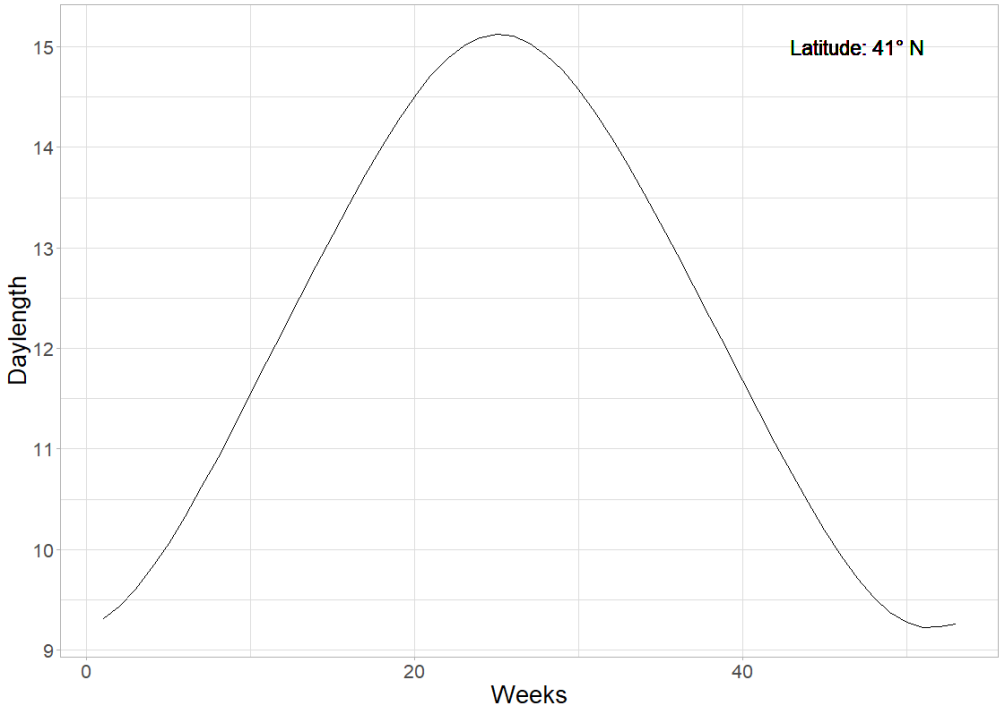
Diapausing eggs and photoperiod

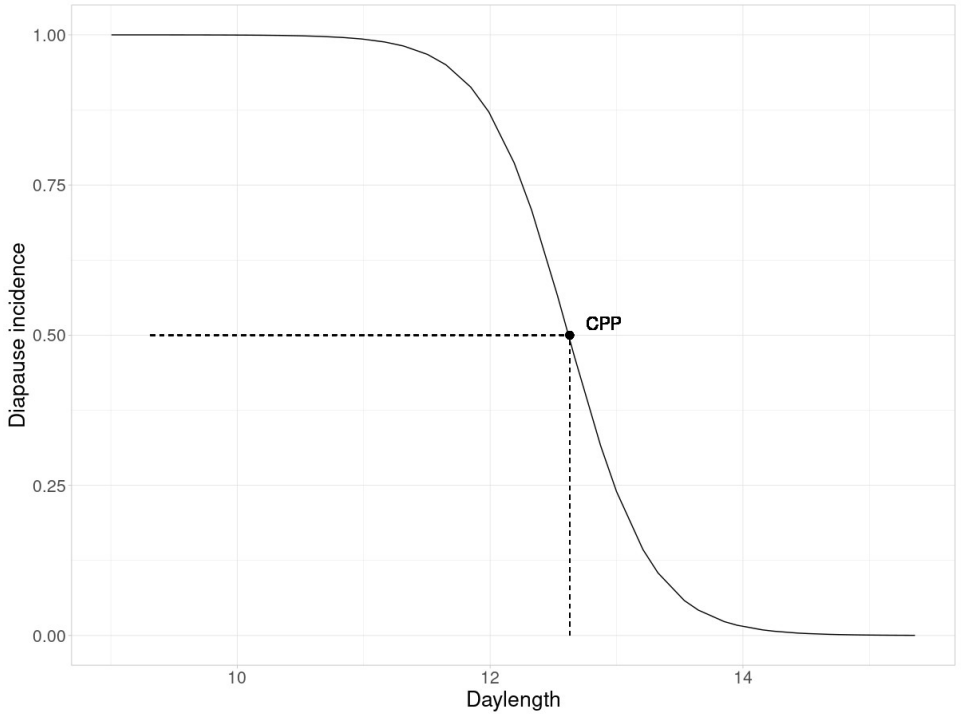


Lacour et al., 2015, *PlosOne*

Krupa, Henon & Mathieu et al., 2021, *Parasite*

Diapausing eggs and photoperiod





Lacour et al., 2015, *PlosOne*

Krupa, Henon & Mathieu et al., 2021, *Parasite*