



# Assessing the current and future suitability to the Asian Tiger mosquito, a dengue and Zika vector, in major cities in Europe



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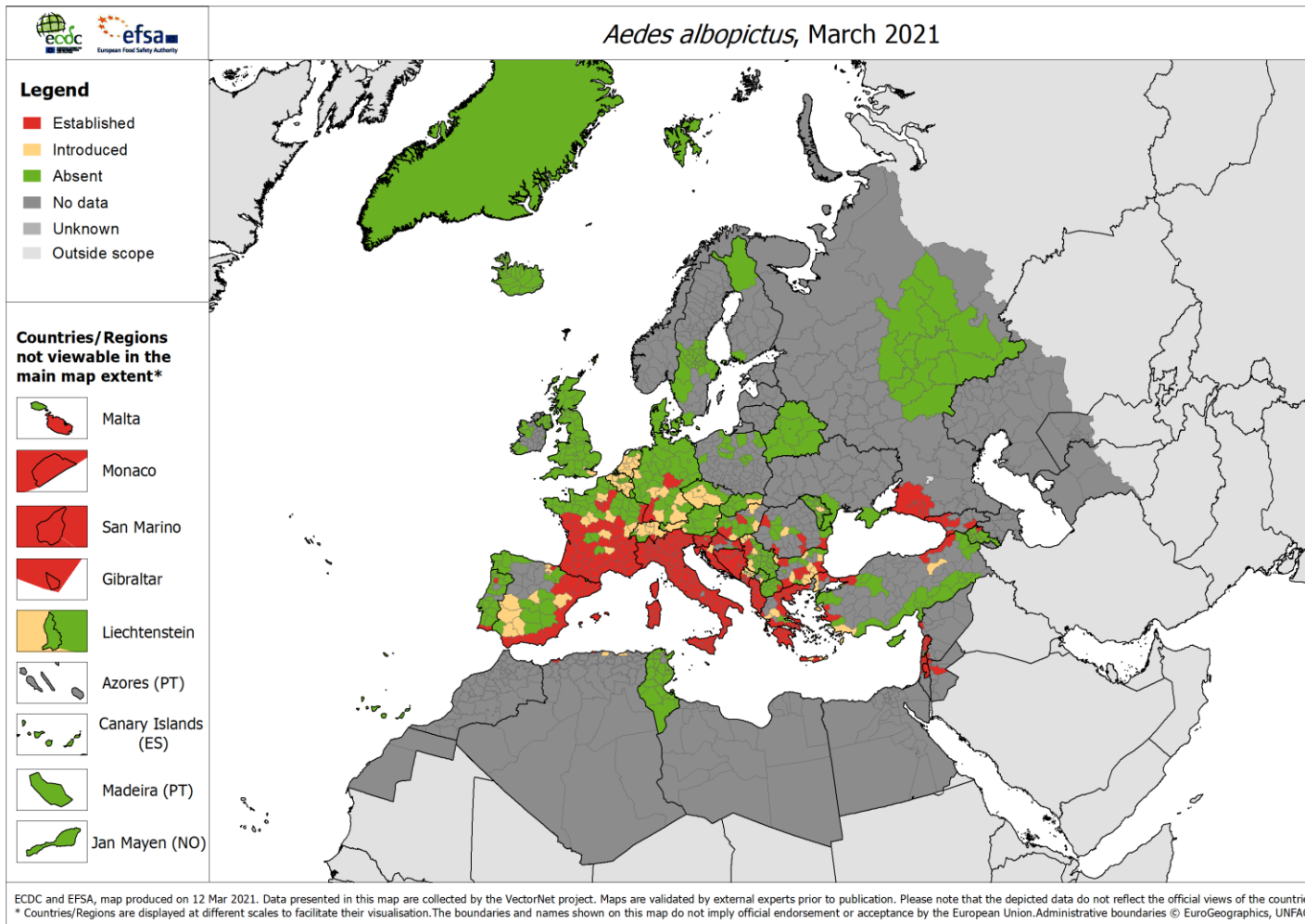
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- Origin in Southeast Asia
- Albania 1979, Italy 1990
- Competent vector for dengue, Zika and Chikungunya
- Outbreaks in Croatia, France, and Italy
- Climate change may increase suitability
- Urban areas particularly vulnerable:
  - heat island effect, higher urban temperature amplifies climate change
  - supply of mosquito breeding sites in man-made water containers and through irrigation
  - availability of potential hosts and dynamics of urban movements - increased risk of disease spread

- Public health concerns fostered research on the suitability to the establishment of the species in Europe
- Different suitability models developed – distinct data sources and methods, equally valid estimates of the potential distribution of the species

- Do they agree?
- Consensus levels differ over Europe?
- Hotspots of (dis)agreement?
- Suitability in urban areas?
- Variations expected in the future?

References models	Geog. coverage	Spatial resolution	Present-day period	Future period	Scenario	Modelling technique
Caminade et al. (2012) <sup>19</sup>	Europe	0.25° ~ 25 km	1960–2009	2030–2050	SRES A1B	GIS-based (overwintering and seasonal activity); Multi-criteria decision analysis
Campbell et al. (2015) <sup>8</sup>	Global	0.16666° ~ 18 km	1950–2000	2041–2060	SRES B1	MaxEnt
Ding et al. (2018) <sup>11</sup>	Global	0.05° ~ 5 km	1970–2000			Support vector machine (SVM); Gradient boosting machine (GBM); random Forest (RF)
Kraemer et al. (2015 <sup>12</sup> , 2019 <sup>5</sup> )	Global	0.04166° ~ 5 km	1960–2014	2050	RCP 6.0	Boosted regression trees (BRT)
Proestos et al. (2015) <sup>7</sup>	Global	0.46875° ~ 50 km	2000–2009	2045–2054	SRES A2	Fuzzy-logic
Rogers (2015) <sup>52</sup>	Global	0.5° ~ 55 km	1961–1990	2080 (estimated for 2050 by linear interpolation)	SRES B1	K-means clustering; Nonlinear discriminant analysis
Santos and Menezes, (2017) <sup>13</sup>	Global	30 arc-sec ~ 1 km	1950–2000			MaxEnt



RESEARCH ARTICLE

### The global distribution of the arbovirus vectors *Aedes aegypti* and *Ae. albopictus*

Moritz UG Kraemer<sup>1\*</sup>, Marianne E Sinka<sup>1</sup>, Kirsten A Duda<sup>1</sup>, Adrian QN Mylne<sup>2</sup>, Freya M Shearer<sup>3</sup>, Christopher M Barker<sup>1</sup>, Chester G Moore<sup>4</sup>, Roberta G Carvalho<sup>5</sup>, Giovanni E Coelho<sup>6</sup>, Wim Van Bortel<sup>6</sup>, Guy Hendrickx<sup>7</sup>, Francis Schaffner<sup>8</sup>, Iqbal R F Elyazar<sup>9</sup>, Hwa-Jen Teng<sup>10</sup>, Oliver J Brady<sup>1</sup>, Jane P Messina<sup>1</sup>, David M Pigott<sup>1,2</sup>, Thomas W Scott<sup>10,11</sup>, David L Smith<sup>12</sup>, GR William Wint<sup>13</sup>, Nick Golding<sup>1</sup>, Simon I Hay<sup>2,10,14\*</sup>

PHILOSOPHICAL TRANSACTIONS B

### Climate change influences on global distributions of dengue and chikungunya virus vectors

Lindsay P. Campbell<sup>1</sup>, Caylor Luther<sup>1</sup>, David Moo-Llanes<sup>2</sup>, Janine M. Ramsey<sup>2</sup>, Rogelio Danis-Lozano<sup>2</sup> and A. Townsend Peterson<sup>1</sup>

PHILOSOPHICAL TRANSACTIONS B

### Dengue: recent past and future threats

David J. Rogers<sup>1</sup>

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PHILOSOPHICAL TRANSACTIONS B

### Present and future projections of habitat suitability of the Asian tiger mosquito, a vector of viral pathogens, from global climate simulation

Y. Proestos<sup>1</sup>, G. K. Christophides<sup>2</sup>, K. Ergüler<sup>1</sup>, M. Tanarhte<sup>3</sup>, J. Waldock<sup>1,2</sup> and J. Lelieveld<sup>1,3</sup>

Cite this article: Proestos Y, Christophides GK

JOURNAL OF THE ROYAL SOCIETY

### Suitability of European climate for the Asian tiger mosquito *Aedes albopictus*: recent trends and future scenarios

Cyril Caminade<sup>1,\*</sup>, Jolyon M. Medlock<sup>2</sup>, Els Ducheyne<sup>3</sup>, K. Marie McIntyre<sup>4</sup>, Steve Leach<sup>2</sup>, Matthew Baylis<sup>4</sup> and Andrew P. Morse<sup>1</sup>

Global and Planetary Change 78 (2011) 54–64

### Global and Planetary Change

#### Projection of climatic suitability for *Aedes albopictus* Skuse (Culicidae) in Europe under climate change conditions

Dominik Fischer<sup>1,\*</sup>, Stephanie Margarete Thomas<sup>2</sup>, Franziska Niemitz<sup>3</sup>, Björn Reineking<sup>1</sup>, Carl Beierkuhnlein<sup>4</sup>

Acta Tropica 179 (2018) 155–162

### Acta Tropica

Mapping the spatial distribution of *Aedes aegypti* and *Aedes albopictus*

Fangyu Ding<sup>a,b,1</sup>, Jingying Pu<sup>b,1</sup>, Dong Jiang<sup>a,b,1</sup>, Mengmeng Hao<sup>b,1</sup>, Gang Lin<sup>a</sup>

Acta Tropica 168 (2017) 80–90

### Acta Tropica

An integrated approach for the assessment of the *Aedes aegypti* and *Aedes albopictus* global spatial distribution, and determination of the zones susceptible to the development of Zika virus

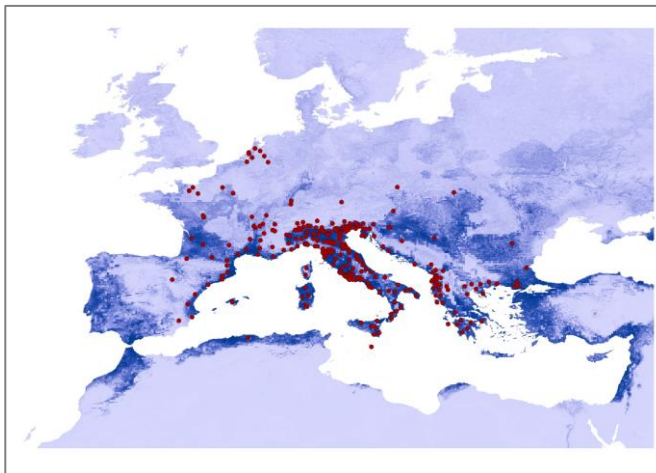
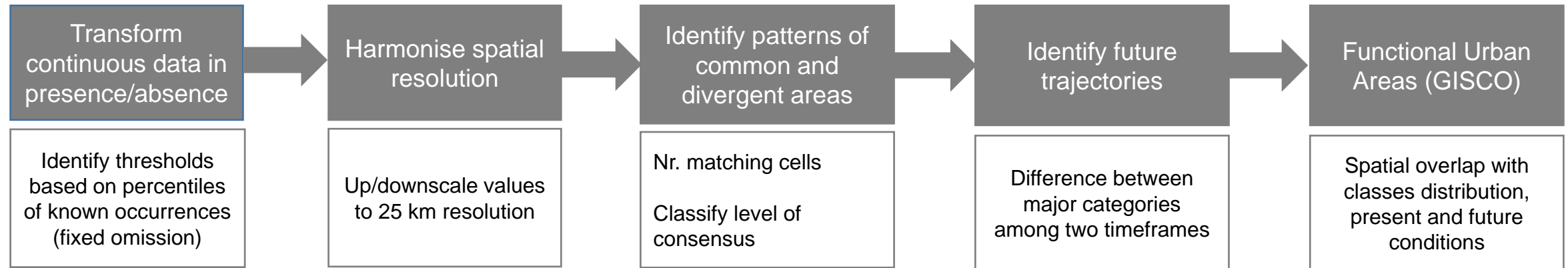
José Santos<sup>a</sup>, Bruno M. Menezes<sup>b,1</sup>

nature microbiology

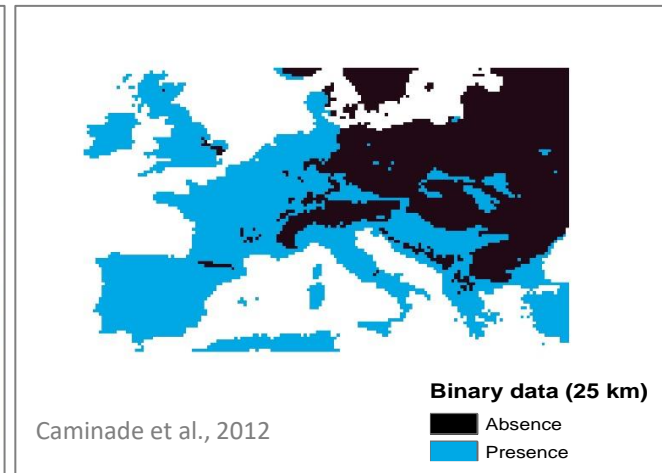
ARTICLES

### Past and future spread of the arbovirus vectors *Aedes aegypti* and *Aedes albopictus*

Moritz U.G. Kraemer<sup>1,2,3,4,5\*</sup>, Robert C. Reiner Jr<sup>4,6</sup>, Oliver J. Brady<sup>6,4,2</sup>, Jane P. Messina<sup>7,8,4,2</sup>, Marius Gilbert<sup>9,10,4,1</sup>, David M. Pigott<sup>1</sup>, Dingdong Yi<sup>11</sup>, Kimberly Johnson<sup>1</sup>, Lucas Earl<sup>1</sup>, Laurie B. Marczak<sup>4</sup>, Shreya Shirude<sup>1</sup>, Nicole Davis Weaver<sup>12</sup>, Donal Bisanzio<sup>13</sup>, T. Alex Perkins<sup>14</sup>, Shengjie Lai<sup>15,16,17</sup>, Xin Lu<sup>18,19,20</sup>

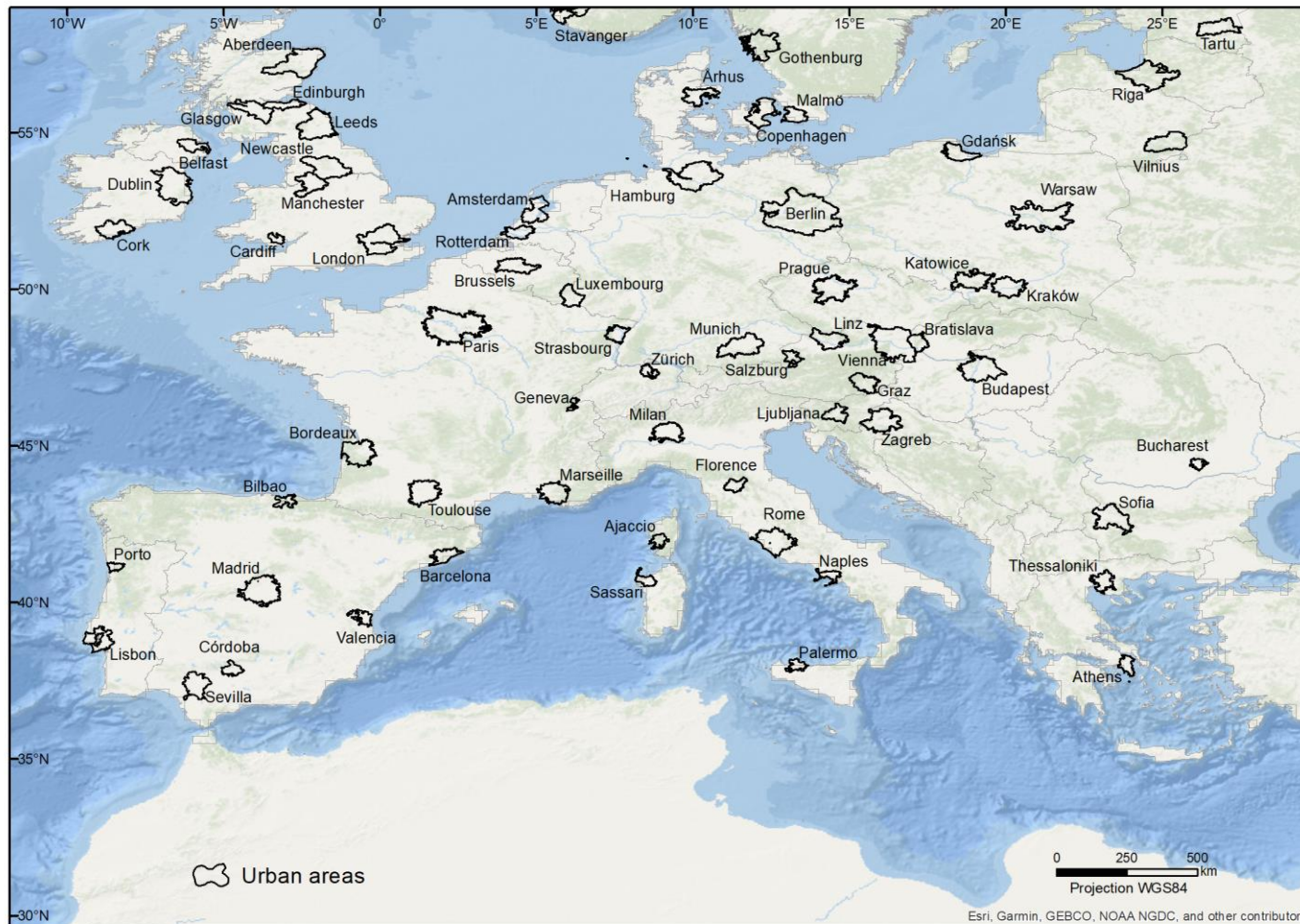


Database of known occurrences (Kraemer et al., 2015).  
n=335



Categories	Present (7 models)	Future (5 models)
Unsuitable, low uncertainty	5 to 7 models agree unsuitable	4 to 5 models agree unsuitable
High uncertainty	Only 3 or 4 models agree	Only 2 or 3 models agree
Suitable, low uncertainty	5 to 7 models agree suitable	4 to 5 models agree suitable

**Functional urban area (FUA)** - a city and its commuting zone. A densely inhabited city and a less densely populated commuting zone whose labor market is highly integrated with the city (*OECD, 2012*).



## 62 metropolitan areas

- Large metropolitan (above 1.5 million people)
- Metropolitan (250.000 to 1.5 million people)


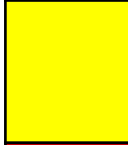

## 3 medium-size urban areas

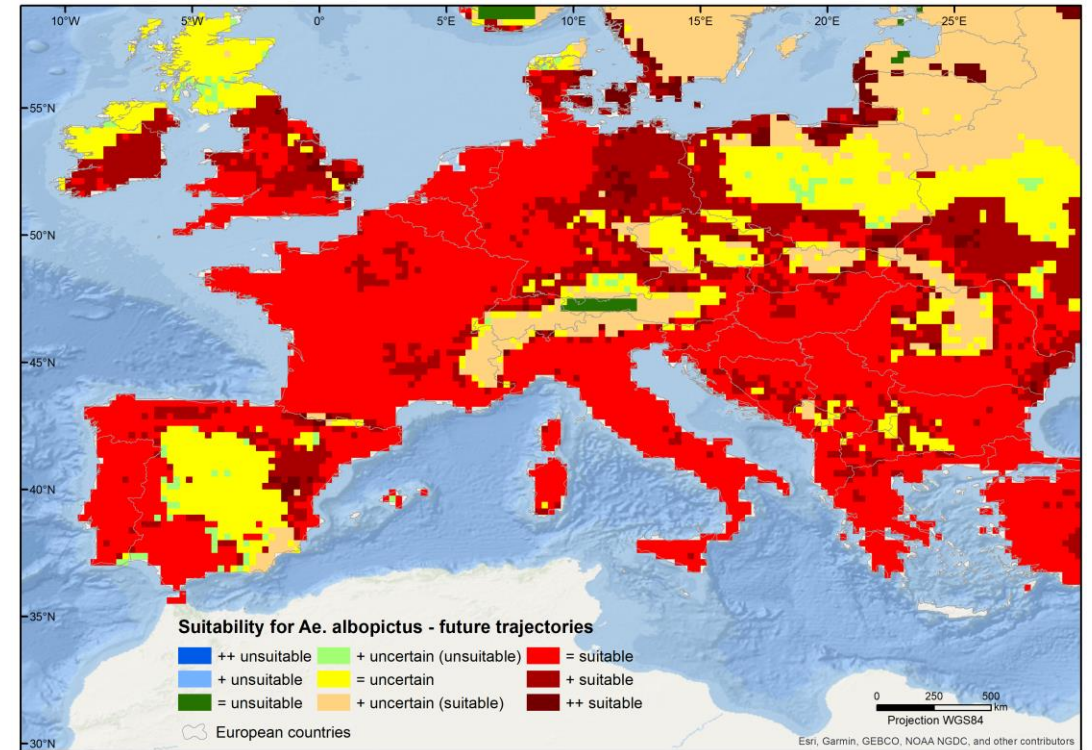
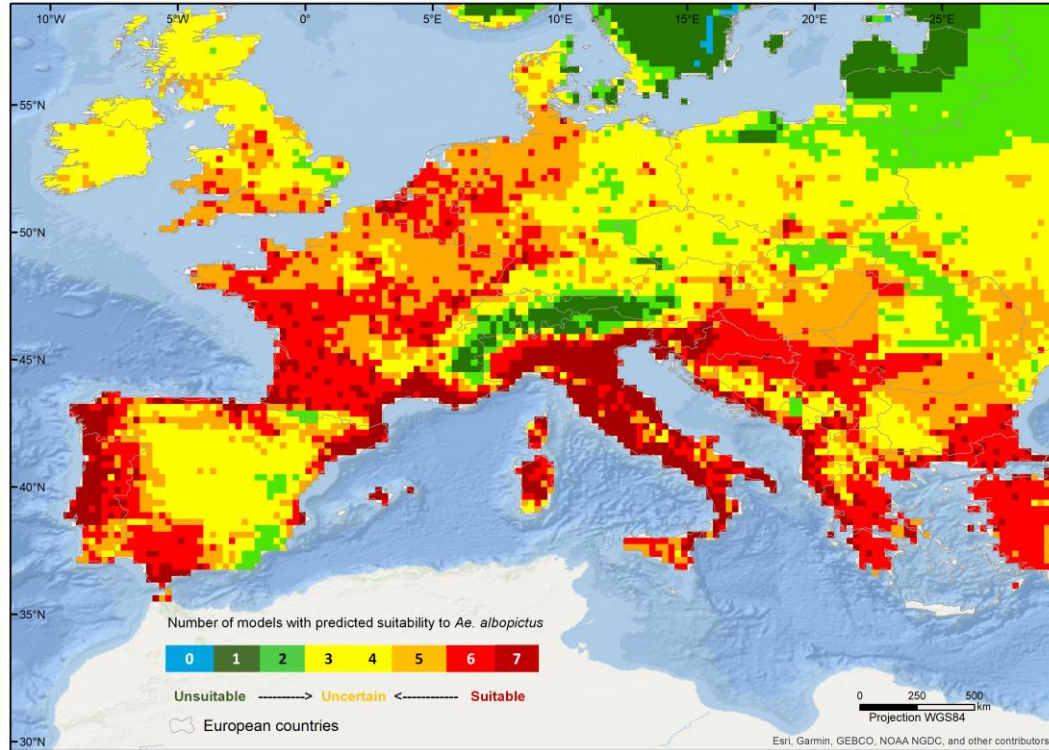
- 3 medium areas (100.000 to 250.000 people),  
in Corsica, Sardinia and Estonia

## Suitability of urban areas to the presence of *Aedes albopictus*

- Suitability class per 25 km cell, using the 3 major categories (traffic light scheme)
- Spatial overlap between cells and urban areas boundaries
- *Baseline scenario* - assigning to each urban area the category with wider spatial coverage (majority, >50%)
- *Worst-case scenario* – 1/3 urban area covered by a more unfavorable variation than given by the baseline

### Traffic-light scheme

	Most favorable situation from the human viewpoint (unsuitable with low uncertainty)
	High uncertainty, regarding either suitability and unsuitability
	Most negative situation, with suitability for the mosquito being consensual across models



**Table S2.** Classification and color scheme defined to represent the major categories and future trajectories of suitability for *Ae. albopictus*

Major categories	Timeframe		Trajectory	
	Present	Future	Code	Description
Unsuitable, low uncertainty	1	1	=	Equally unsuitable
		2	+	Higher uncertainty (towards suitable)
		3	++	Much more suitable
High uncertainty	2	1	+	More unsuitable
		2	=	Equal uncertainty
		3	+	More suitable
Suitable, low uncertainty	3	1	++	Much more unsuitable
		2	+	Higher uncertainty (towards unsuitable)
		3	=	Equally suitable

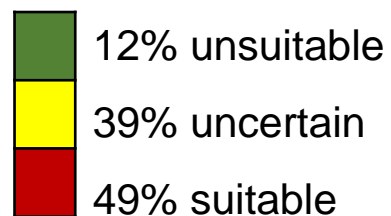
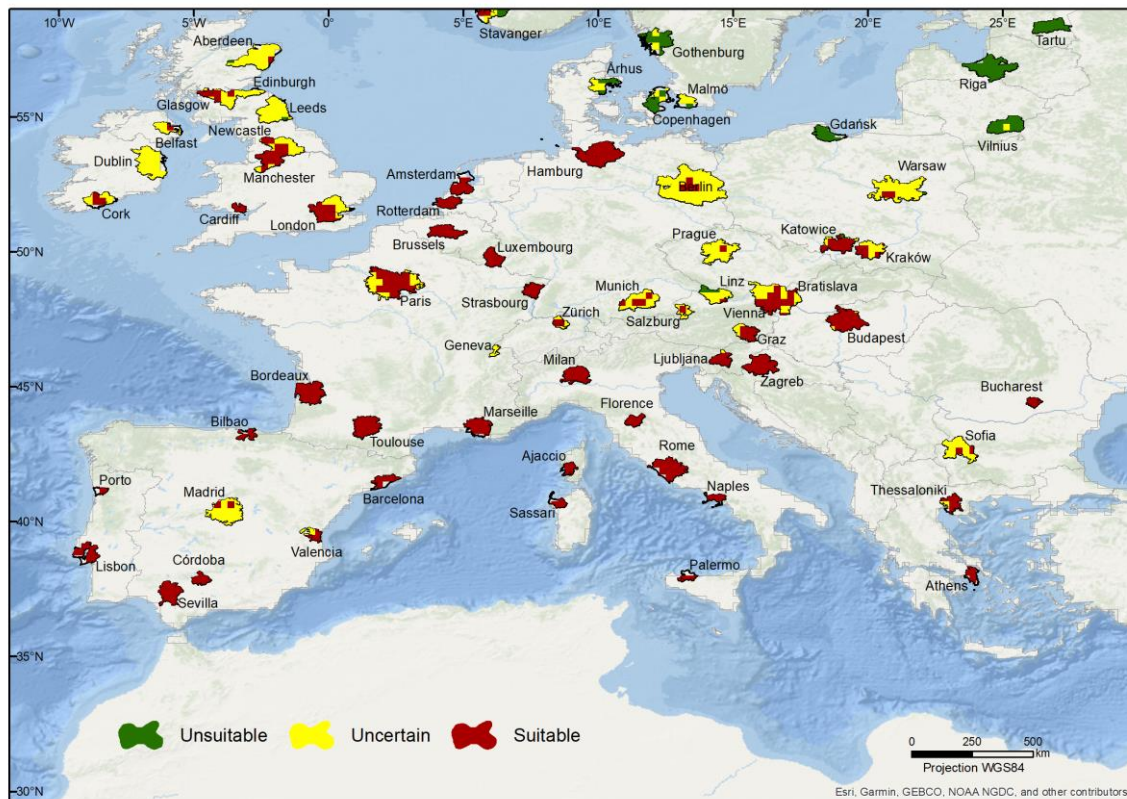
## Present conditions

Areas of high uncertainty (high disagreement between models) mainly in eastern Europe, northern Britain, Ireland and central Spain

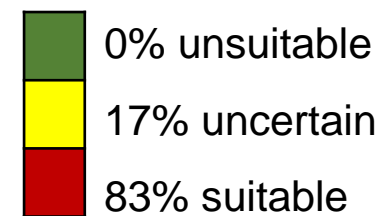
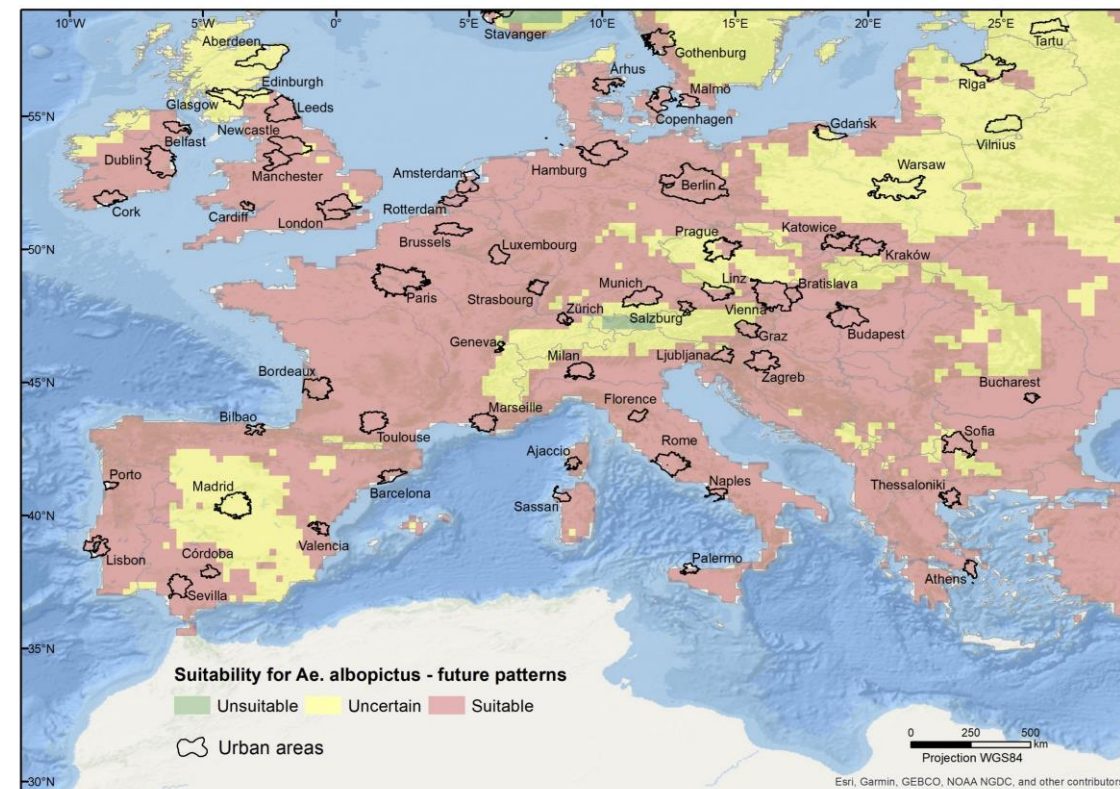
## Future trajectories

Suitable regions will encompass 21% more area, adding to the 47% of the continent that is suitable nowadays

## Present conditions



## Future conditions



Main city (country)	P	F	Main city (country)	P	F	Main city (country)	P	F
Aberdeen (UK)	●	●	Glasgow (UK)	●	●	Prague (CZ)	●	●
Ajaccio (FR)	●	●	Gothenburg (SE)	●	●	Riga (LV)	●	●
Amsterdam (NL)	●	●	Graz (AT)	●	●	Rome (IT)	●	●
Århus (DK)	●	●	Hamburg (DE)	●	●	Rotterdam (NL)	●	●
Athens (EL)	●	●	Katowice (PL)	●	●	Salzburg (AT)	●	●
Barcelona (ES)	●	●	Kraków (PL)	●	●	Sassari (IT)	●	●
Belfast (UK)	●	●	Leeds (UK)	●	●	Sevilla (ES)	●	●
Berlin (DE)	●	●	Linz (AT)	●	●	Sofia (BG)	●	●
Bilbao (ES)	●	●	Lisbon (PT)	●	●	Stavanger (NO)	●	●
Bordeaux (FR)	●	●	Ljubljana (SI)	●	●	Strasbourg (FR)	●	●
Bratislava (SK)	●	●	London (UK)	●	●	Tartu (EE)	●	●
Brussels (BE)	●	●	Luxembourg (LU)	●	●	Thessaloniki (EL)	●	●
Bucharest (RO)	●	●	Madrid (ES)	●	●	Toulouse (FR)	●	●
Budapest (HU)	●	●	Malmö (SE)	●	●	Valencia (ES)	●	●
Cardiff (UK)	●	●	Manchester (UK)	●	●	Vienna (AT)	●	●
Copenhagen	●	●	Marseille (FR)	●	●	Vilnius (LT)	●	●
Cordoba (ES)	●	●	Milan (IT)	●	●	Warsaw (PL)	●	●
Cork (IE)	●	●	Munich (DE)	●	●	Zagreb (HR)	●	●
Dublin (IE)	●	●	Naples (IT)	●	●	Zürich (CH)	●	●
Edinburgh (UK)	●	●	Newcastle	●	●			
Florence (IT)	●	●	Oporto (PT)	●	●			
Gdansk (PL)	●	●	Palermo (IT)	●	●			
Geneva (CH)	●	●	Paris (FR)	●	●			

Unsuitable ●  
 Uncertain ●  
 Suitable ●

- Cities located in northern Europe expected to undergo the most severe changes (from unsuitable to suitable)

*Arhus, Copenhagen, Gothenburg, Stavanger*

- Cities of central Europe, Great Britain and Ireland are expected to become suitable (from uncertain today)

*Berlin, Dublin, Geneva, London, Prague, Vienna*

- Uncertainty remains in the future for cities such as:

*Edinburgh, Madrid, Munich, Warsaw*

## ***Patterns and trends of suitability to *Aedes albopictus*:***

- ✓ Nowadays, West and South Europe suitable. Climate change will aggravate conditions (increase suitability)
- ✓ In about 30 years, *Ae. albopictus* will find suitable areas in 68% of the European continent
- ✓ 83% of large urban areas (out of 65 analyzed) predicted as suitable in the future (2050). None unsuitable
- ✓ Suitability to *Aedes albopictus* in Europe raises public health concerns. Need to integrate monitoring and control measures of vectors

## ***Consensus analysis of existing models:***

- ✓ Transformation of the original data. Details specific to each model were lost
- ✓ Able to identify hotspots of high and low suitability for *Ae. albopictus*, and areas with high inter-model mismatch (uncertainty)
- ✓ Contribute to transfer scientific outputs (numerous and divergent) into tangible and consensual policies



# Thank you!

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### Wide and increasing suitability for *Aedes albopictus* in Europe is congruent across distribution models

Sandra Oliveira, Jorge Rocha, Carla A. Sousa & César Capinha

Scientific Reports 11, Article number: 9916 (2021) | Cite this article

560 Accesses | 2 Altmetric | Metrics

#### Abstract

The Asian tiger mosquito (*Aedes albopictus*), a vector of dengue, Zika and other diseases, was introduced in Europe in the 1970s, where it is still widening its range. Spurred by public health concerns, several studies have delivered predictions of the current and future distribution of the species for this region, often with differing results. We provide the first joint analysis of



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