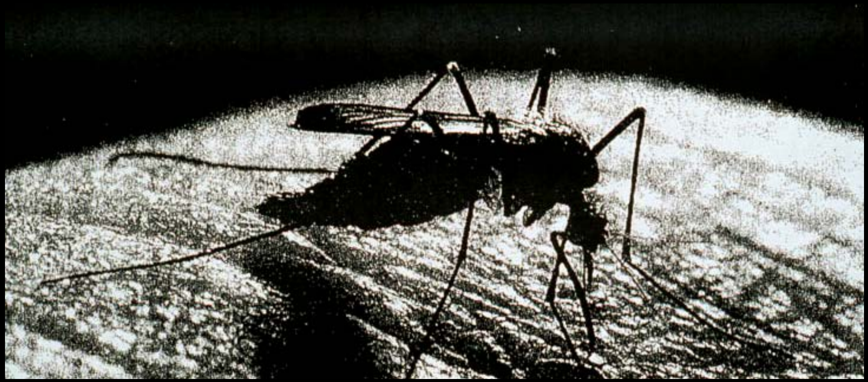
Climate change impact on vector-borne diseases: an update from the trenches



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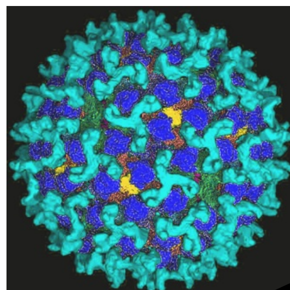
Impacts world 2017, Potsdam, 11-13 Oct 2017

Vector Borne diseases

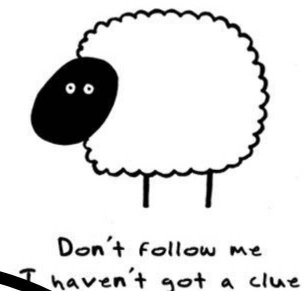
Diseases transmitted by blood sucking arthropods, worms…

- Survival
- Replication rate

Pathogen



Host



- Growth rate
- Survival
- Distribution
- Life habits

Vector

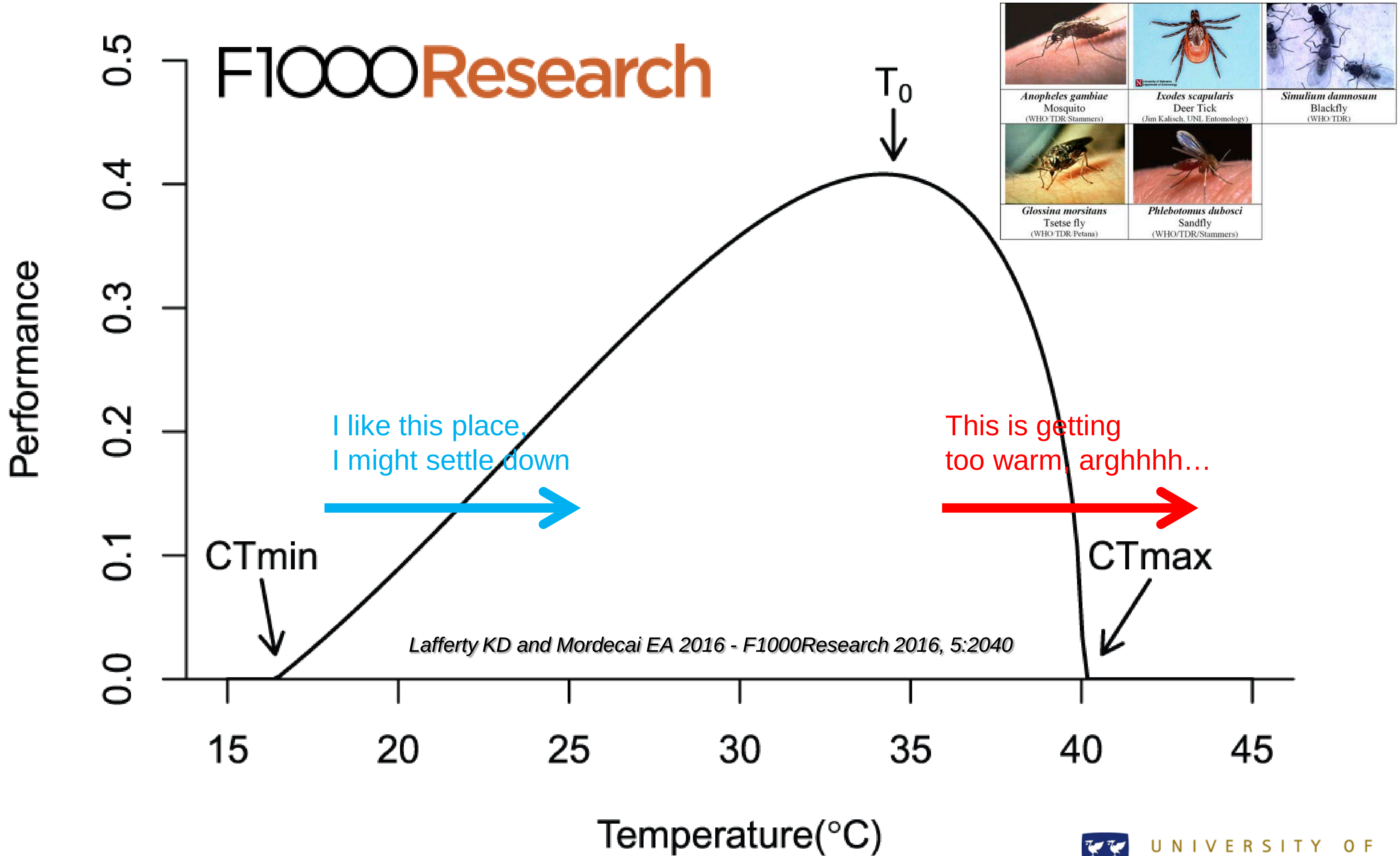
- Breeding sites
- Survival
- Development rate
- Activity
- Length of gonotrophic cycle
- Vector competence
- Biting rate

Climate variability
Rainfall
Temperature
Humidity
Winds...

Future climate change?

Arthropods – climate sensitivity

A thermal performance curve for a hypothetical ectotherm.



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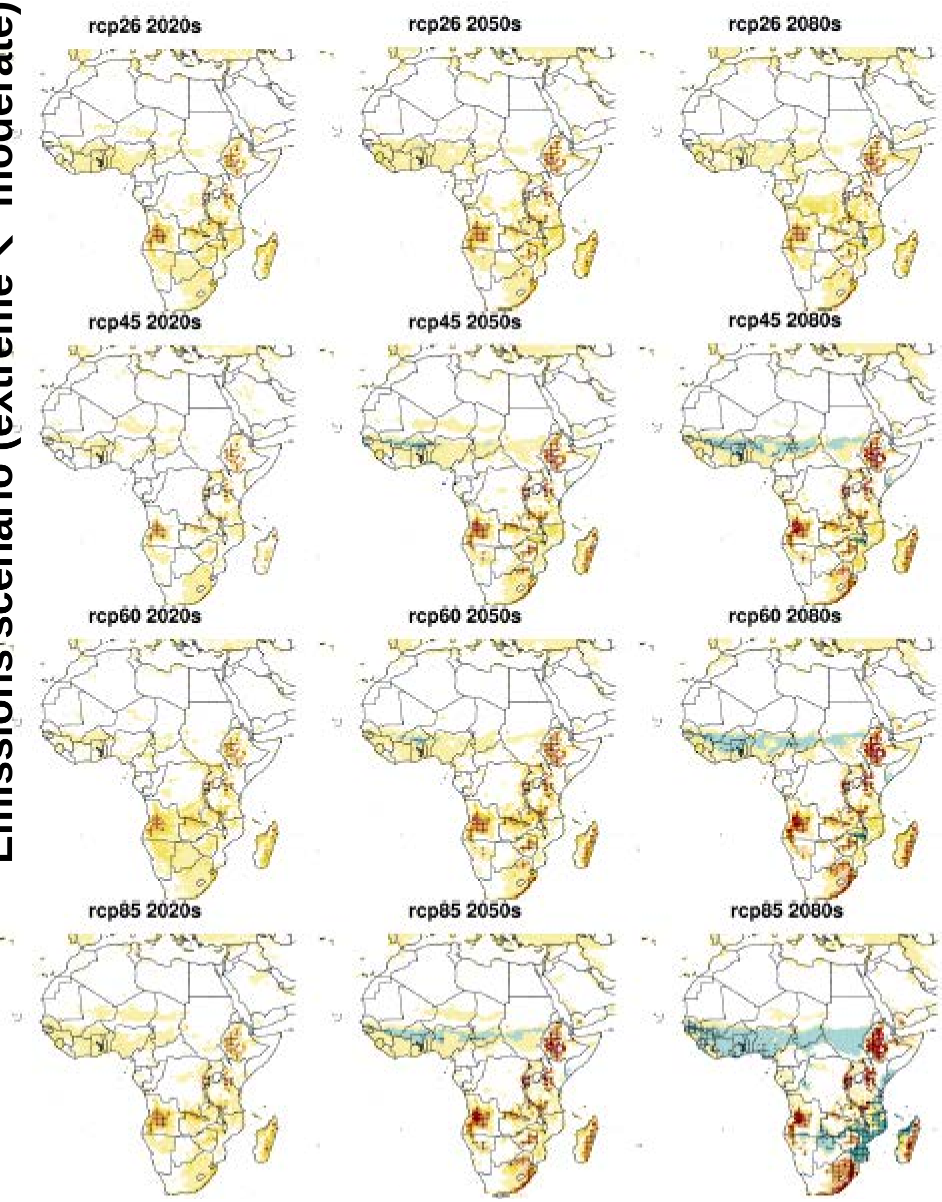
Main drivers associated with emergence or re-emergence of human pathogens

Rank*	Driver
1	Changes in land use or agricultural practices
2	Changes in human demographics and society
3	Poor population health (e.g., HIV, malnutrition)
4	Hospitals and medical procedures
5	Pathogen evolution (e.g., antimicrobial drug resistance, increased virulence)
6	Contamination of food sources or water supplies
7	International travel
8	Failure of public health programs
9	International trade
10	**Climate change**

Woolhouse and Gowtage-Sequeria, EID, CDC 2005

Climate change & malaria - ISI-MIP project

Emissions scenario (extreme ← moderate)

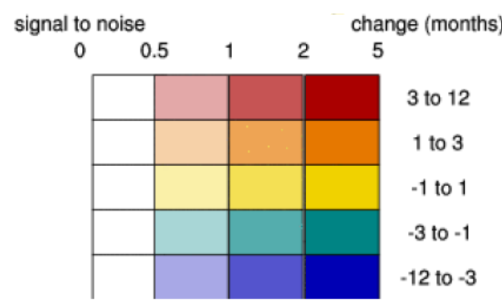


Time (2020s→ 2080s)

The effect of climate scenarios on future malaria distribution: changes in length of the malaria season.

Each map shows the results for a different emissions scenario (RCP). The different hues represent changes in the length of the transmission season for the mean of CMIP5 sub-ensemble (with respect to the 1980-2010 historical mean). The different saturations represent signal-to-noise (μ/Sigma) across the super ensemble (noise is defined as one standard deviation within the multi-GCM and multi-malaria model ensemble). The stippled area shows the multi-malaria multi GCM agreement (60% of the models agree on the sign of changes if the simulated absolute changes are above one month of malaria transmission).

Simulated Increase in transmission over the highlands of Africa (east Africa, Madagascar, Angola, southern Africa) / decrease over the Sahel (extreme scenario / long term)



Caminade et al., PNAS 2014

Other studies & recent news about malaria

From November 2014 to January 2015, ***hundreds of children were treated for malaria at Rutshuru General Hospital in the province of North Kivu in the east of the Democratic Republic of Congo****. Congolese medical staff at the 280 bed facility said it was one of the worst malaria surges they have ever faced, not just in terms of the number of patients admitted with severe malaria but also the duration of the peak. Children are often the first victims, and the situation is worsened when patients are also affected by respiratory infections or severe sepsis. Médecins Sans Frontières has been supporting the hospital since October 2005, providing surgery, intensive and emergency care. Treating burn wounds and survivors of sexual violence are also an important part of the programme (source: MSF).*

Altitudinal Changes in Malaria Incidence in Highlands of Ethiopia and Colombia

A. S. Siraj,[1]* M. Santos-Vega,[2]* M. J. Bouma,[3] D. Yadeta,[4] D. Ruiz Carrascal,[5,6] M. Pascual[2,7]†

The impact of global warming on insect-borne diseases and on highland malaria in particular remains controversial. Temperature is known to influence transmission intensity through its effects on the population growth of the mosquito vector and on pathogen development within the vector. Spatiotemporal data at a regional scale in highlands of Colombia and Ethiopia supplied an opportunity to examine how the spatial distribution of the disease changes with the interannual variability of temperature. We provide evidence for an increase in the altitude of malaria distribution in warmer years, which implies that climate change will, without mitigation, result in an increase of the malaria burden in the densely populated highlands of Africa and South America.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Rare malaria death of girl in northern Italy puzzles doctors

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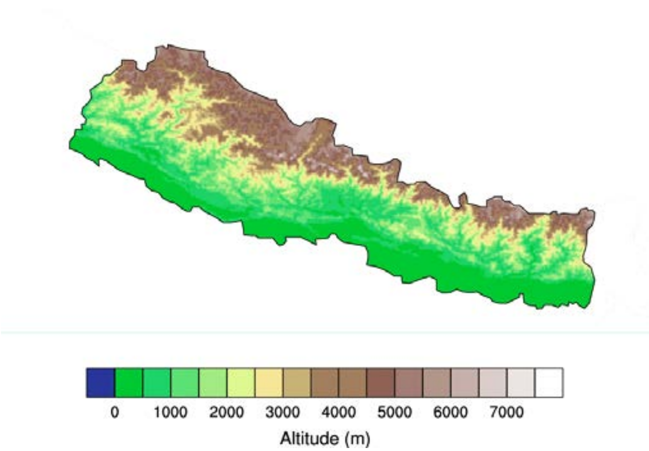
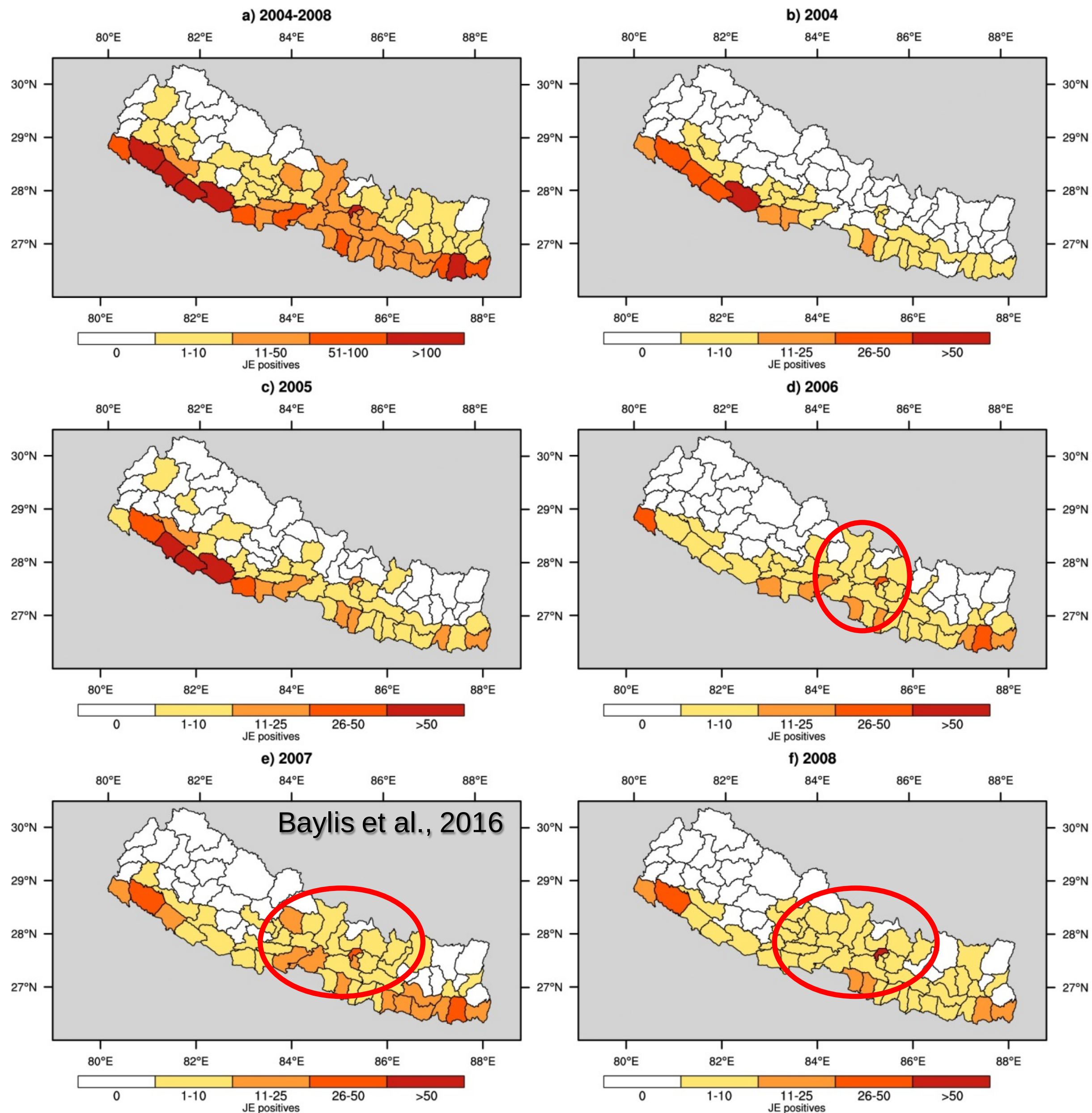
Features

Japanese encephalitis moving to higher grounds Nepal 2004-2008



Increase of autochthonous disease transmission to non endemic regions (>2000m) in Nepal:

Japanese encephalitis
Malaria
Dengue fever
Lymphatic filiarisis
Visceral leishmaniasis
(Dhimal et al., 2015, PlosOne)



The Asian tiger mosquito - *Aedes albopictus*

Rapid spread worldwide

Wikimedia commons

blue: original distribution, cyan: areas where introduced in the last 30 years.

Main introduction routes

Figure 2. Main Aedes albopictus inroduction routes: (A) Used tyres. (B),(C) Lucky Bamboo (Dracaena spp.).

Scholte & Schaffner, 2007

Rapid spread in Europe

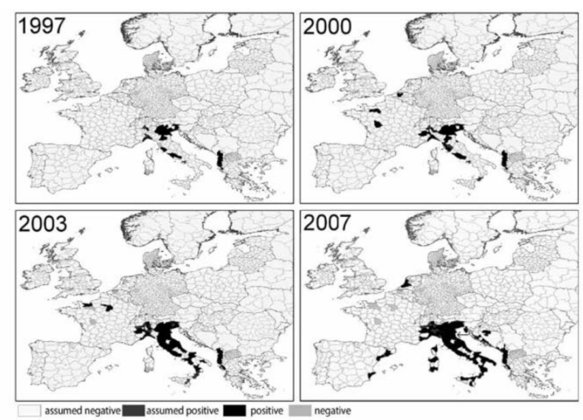
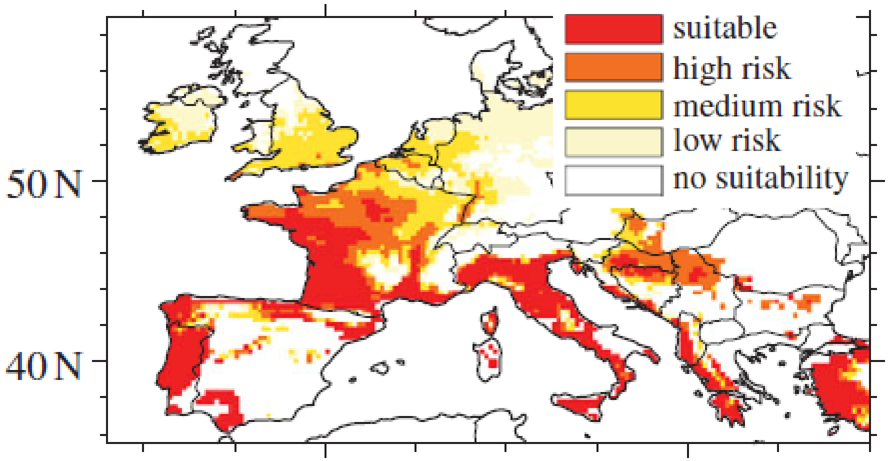


Figure 3. Presence of Aedes albopictus in Europe per province for the years 1997-2007. Data to complete this figure were kindly made available by Roberto Romi (Italy), Roger Eritja and David Roiz (Spain), Eleonora Flacio (Switzerland), Charles Jeannin (France), Anna Klobučar (Croatia), Zoran Lukac (Bosnia and Herzegovina), Igor Pajovic and Dusan Petrić (Serbia and Montenegro), Bjoern Pluskota (Germany), Anna Samanidou-Voyadjoglou (Greece). The map was made by Patrizia Scarpulla. The 2007 outbreak of Chikungunya virus in Italy is indicated with an arrow in the 2007 box.

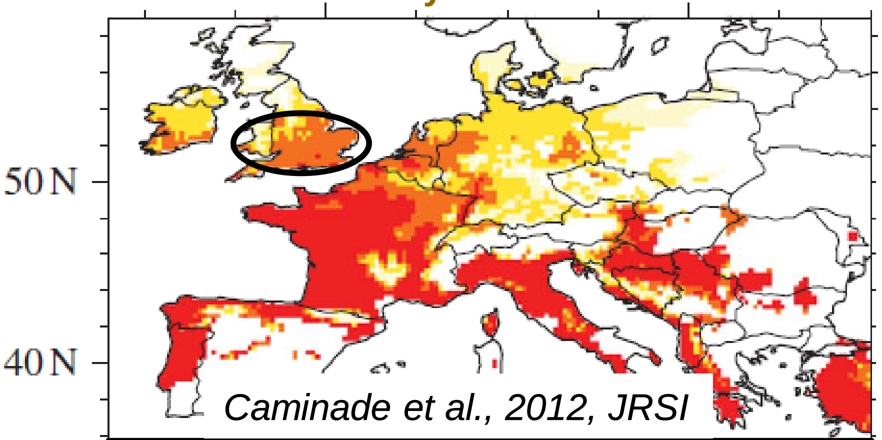
Scholte & Schaffner, 2007

Regions climatically suitable for *Ae. albopictus*

Model driven by climate obs (EOBS) 1990-2009



Model driven by 11 RCMS 2030-2050



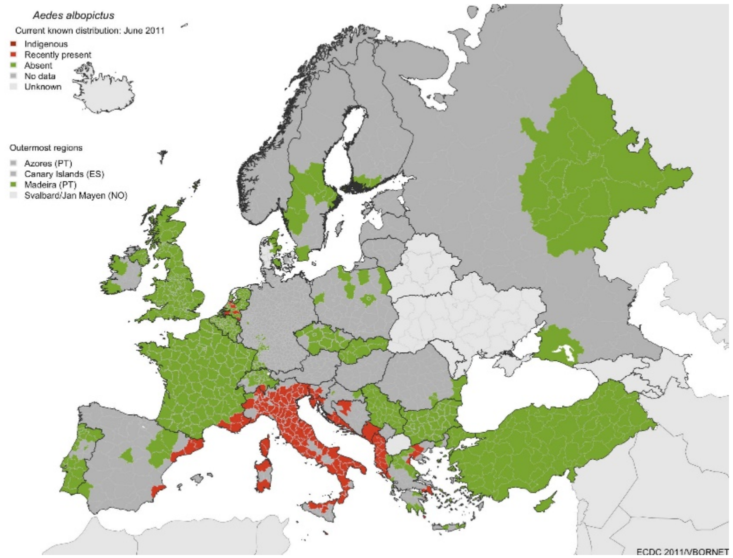
Model based on an overwintering criterion (Tjanuary >0C, Rain_annual>500mm) and different thresholds in annual Temperature:

suitable	12C< T_annual
high risk	11C< T_annual < 12C
medium risk:	10C< T_annual < 11C
low risk:	9C< T_annual < 10C
no suitability:	T_annual < 9C

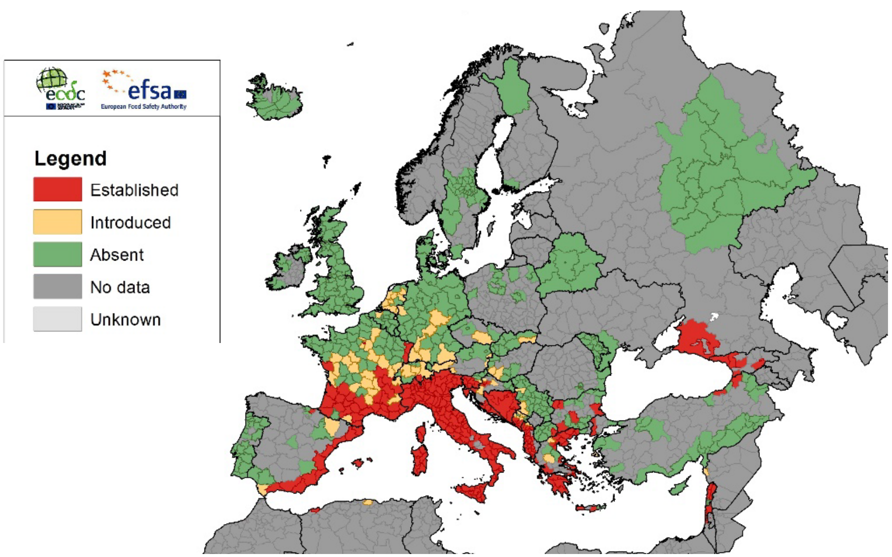
Future risk increase: Benelux, Balkans, western Germany, the southern UK

Future risk decrease: Spain and Mediterranean islands

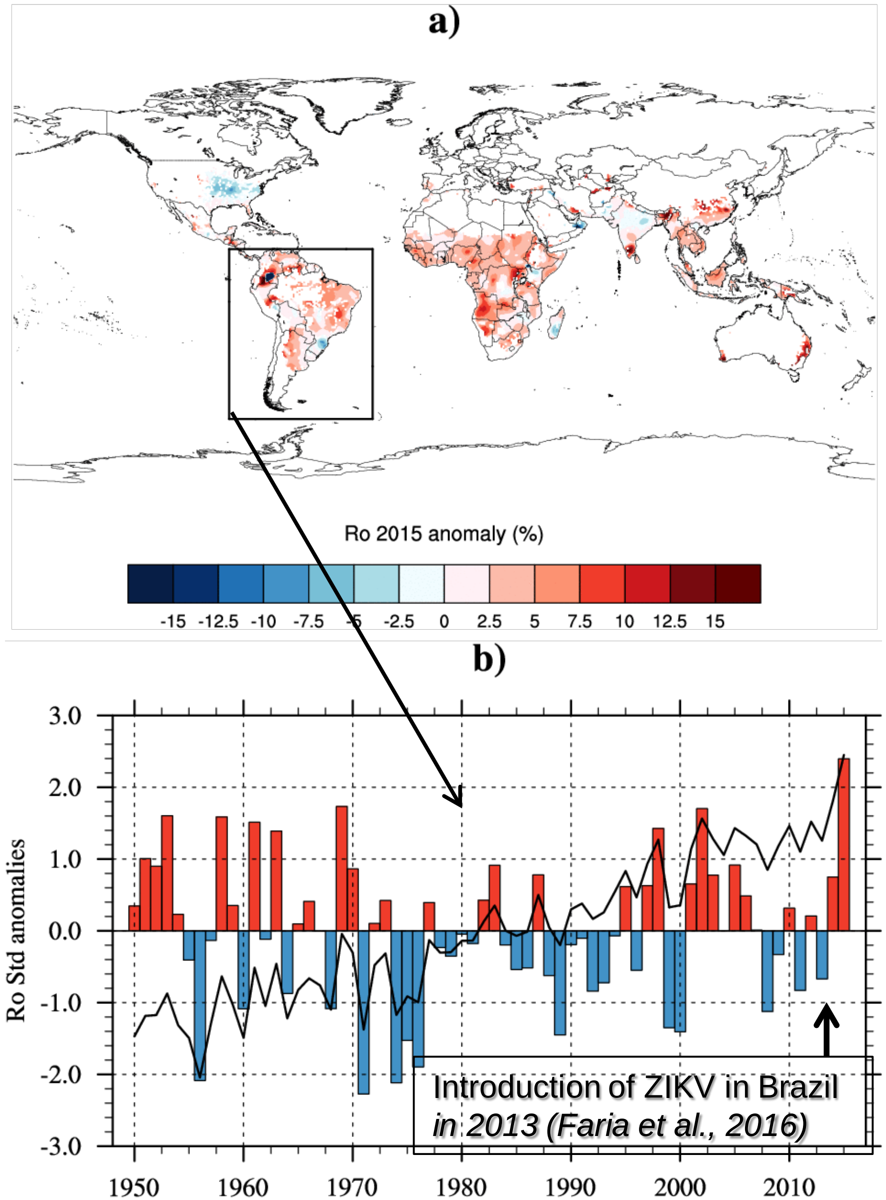
ECDC Obs – June 2011



ECDC Obs – April 2017



R_0 anomaly for Zika virus transmission in 2015



1. 2015 appears to be the most suitable year for ZIKV transmission in South America over the past 67 years!

2. The conducive temperature conditions over South America are related to the 2015-2016 El Niño event.

3. The large positive R_0 anomaly shown over Angola and DRC in 2015 also matched an outbreak of yellow fever (transmitted by *Ae. aegypti*).

El Niño 2015-2016 fuelled the Zika epidemic

Caminade et al., PNAS 2017

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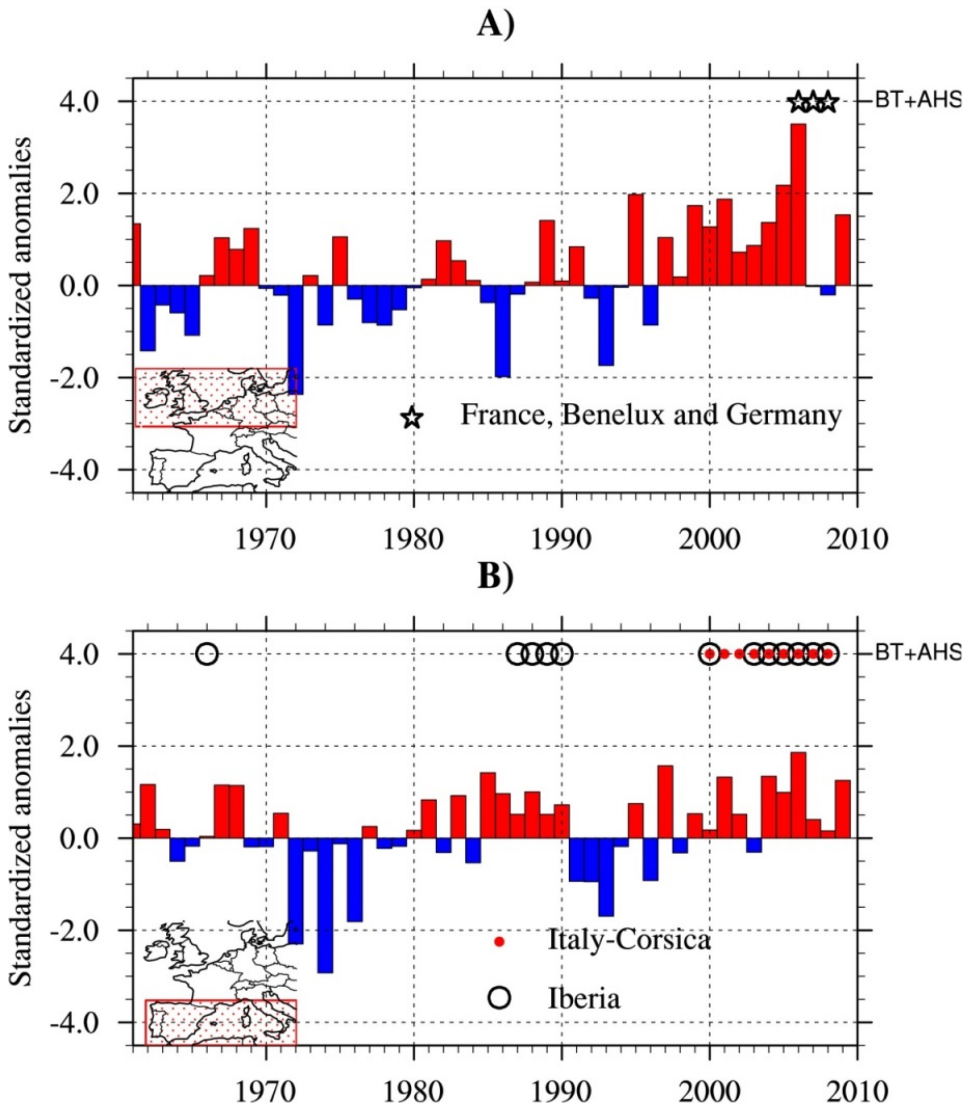
Un air de déjà-vu - BT outbreak Northern Europe 2006



1. Similar R_0 model developed for bluetongue disease, which affects ruminants in Europe (two vectors – two hosts)

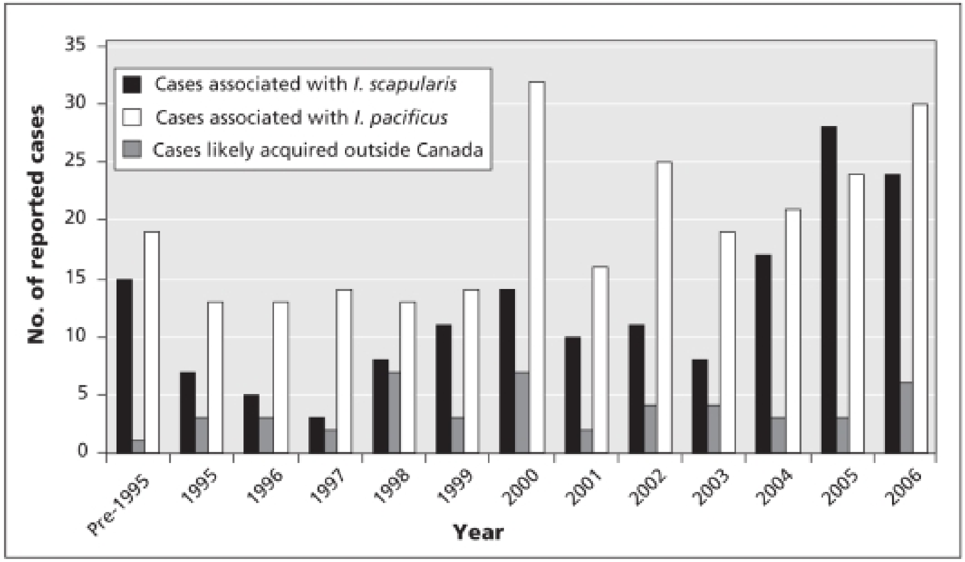
2. 2006 appears to be the most suitable year for BT transmission in Northern Europe over the past 50 years! Suitable conditions for 4-5 months in a row…

3. The mechanistic model reveals that the increased BT risk in Northern Europe can be related to a shortening of the extrinsic incubation period while changes in the South are related to the spread of the vector *Culicoides Imicola*.

Guis et al., 2012, JRSI & Baylis et al., OIE reviews 2017

Lyme disease in cold climes - Canada & Russia

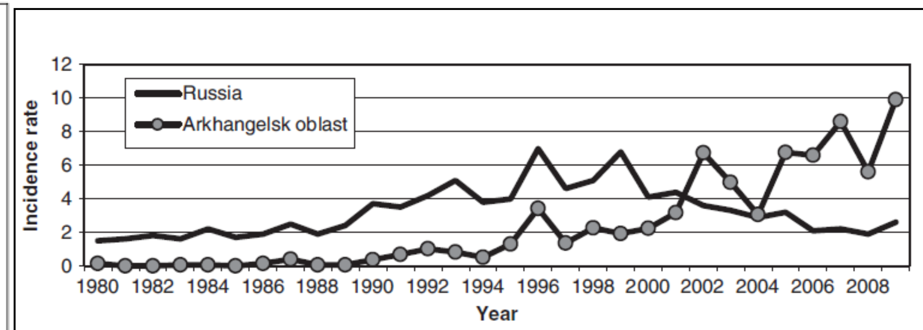
Canada



Annual number of cases of Lyme disease reported voluntarily by the provinces and territories since the late 1980s.

Ogden et al., 2008

Russia



Tick-borne encephalitis in Russia and AO from 1980 to 2009.

Tokarevich et al., 2011

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Conclusions and perspectives

- Disease and vector models were useful in anticipating problems?
- More recent evidences that climate change favoured the rise of vector-borne diseases to higher latitudes and altitudes **BUT** other factors to consider: **increased travel and trade, land use, vulnerability of populations, drug resistance, economic development**…
- Current dynamical disease models can be improved – work in progress. Statistical model very useful when surveillance systems improve
- **Multi data source simulations and ensembles useful and needed** (using ensembles of disease models, climate models, population and climate change scenarios, economic projections…) – "ISI-MIP like"
- **Multi-disciplinary projects required** (entomologists, epidemiologists, human and animal health specialists, climatologists-meteorologists, human scientists, interface scientists) e.g. **One Health approach**
- **Development of operational risk models** (using seasonal forecasts or based on satellite data…) for climate sensitive diseases and link with climate services.

Thanks for your attention

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