Animal disease and plant pest dynamics and modelling

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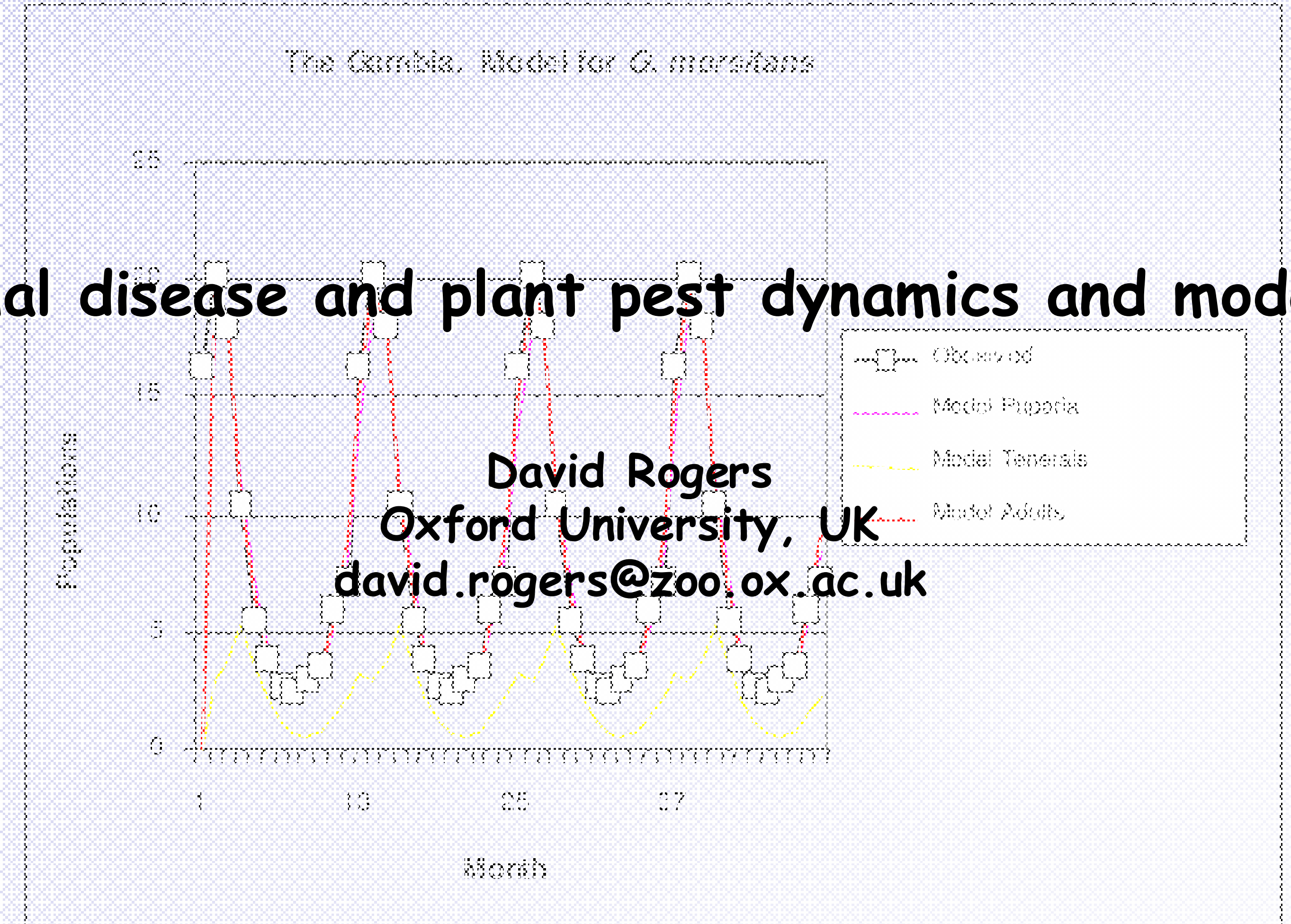


Data courtesy of ITC, The Gambia

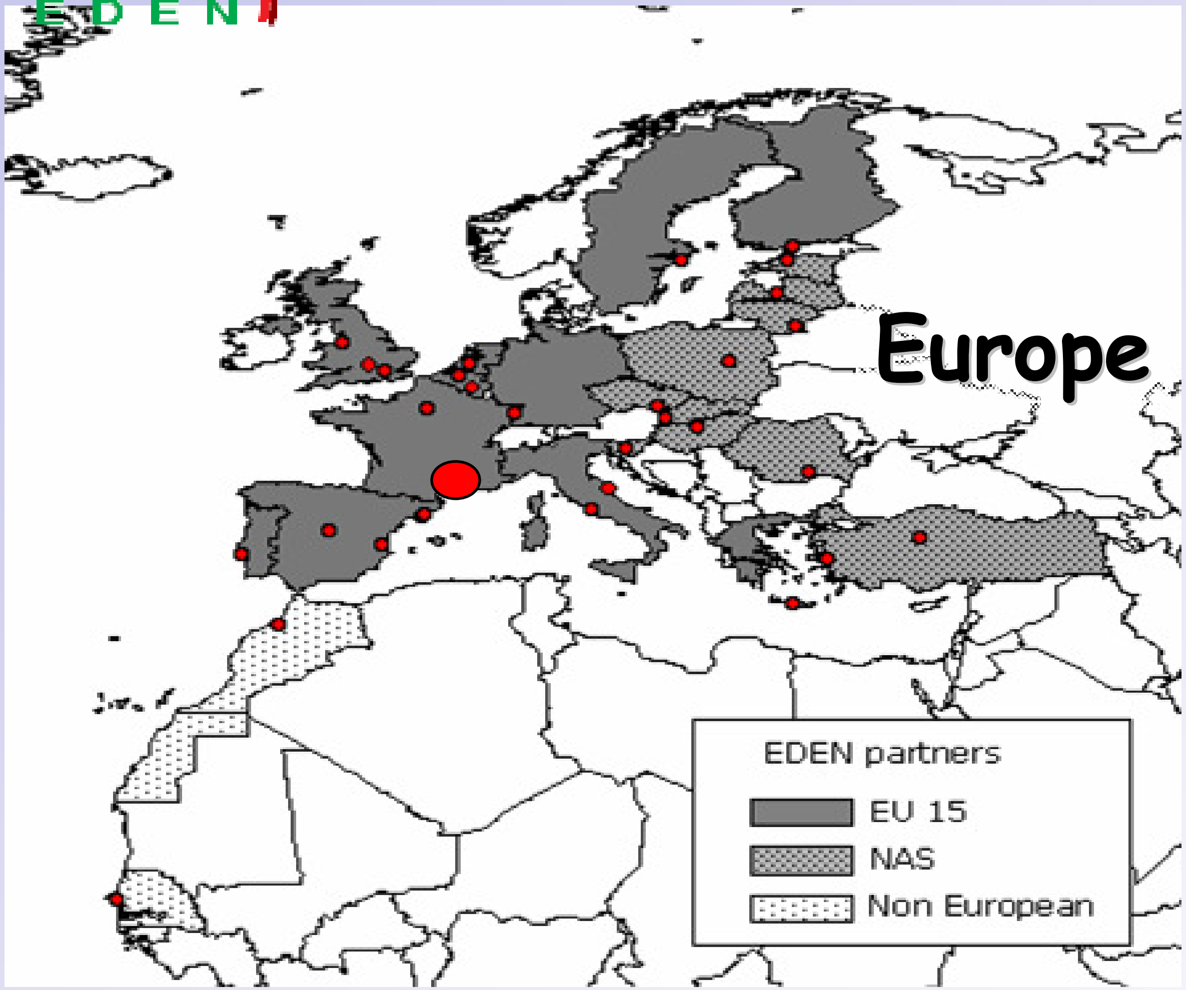
The EDEN project

Emerging Diseases in a changing European eNvironment

"…….preparing for an uncertain future"

European Union Framework 6 project, 2005 - 2009

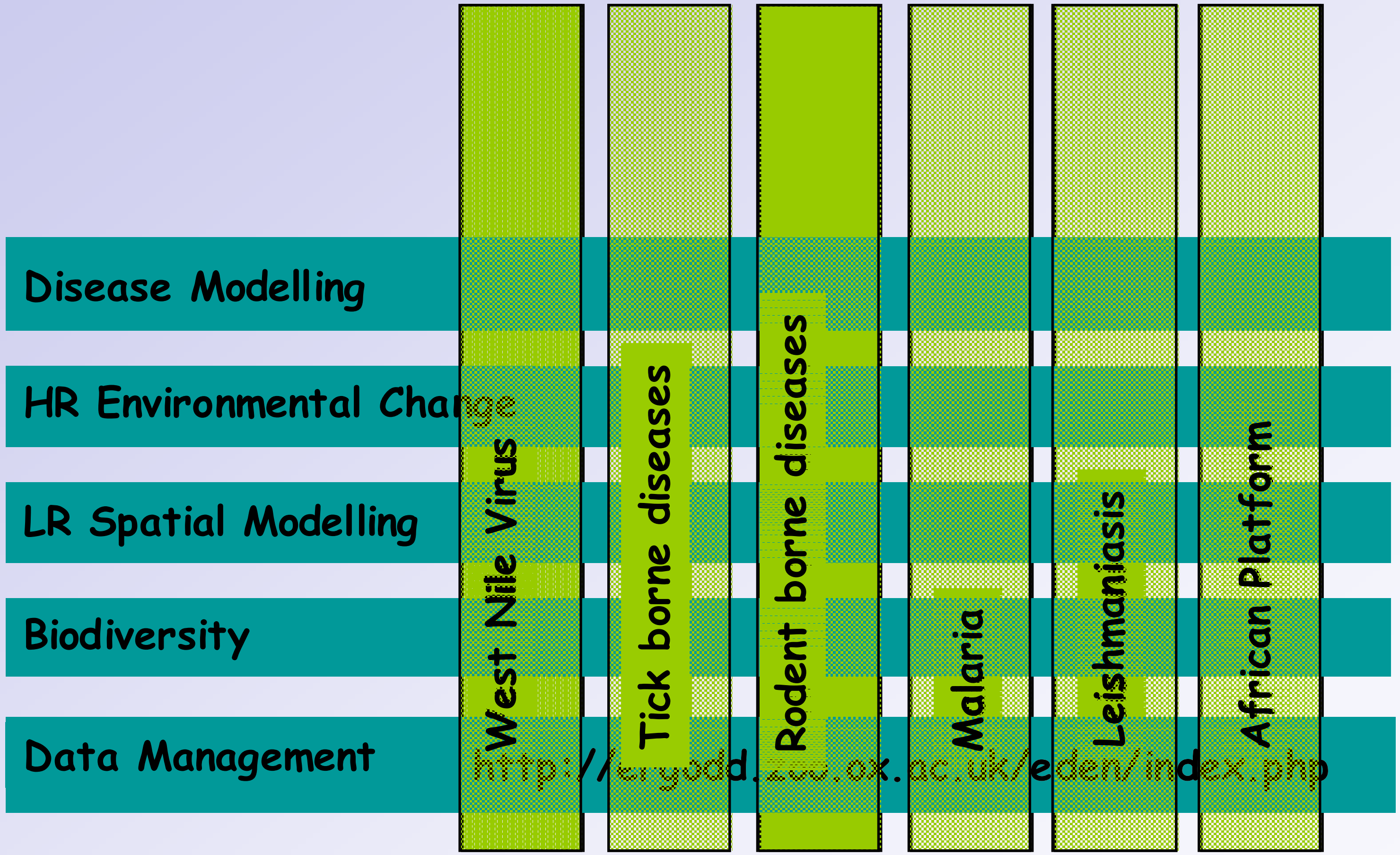
EDEN Network



48 Partners
24 countries

EDEN Structure

Vertical Sub-Projects (SP) and Horizontal Integration Teams (HITs)



EDEN Aims

1) To describe the past

2) To explain the present

3) To predict the future

The Problem

Three stages of invasion:

1. **Arrival** – unpredictable 'chance' event, but loaded by human activities.

2. **Establishment** – depends on local climatic and other conditions.

3. **Spread** – natural diffusion, trade, travel, etc.

EDEN Modelling

Aims

1) To develop statistical 'Risk Maps' of EDEN's vectors and diseases.

2) To develop process-based biological models of pathogen, vector and host interactions.

What the User Wants – a good model

Biological Models

…… are put together as a series of components

Wrong model assumption, or omission

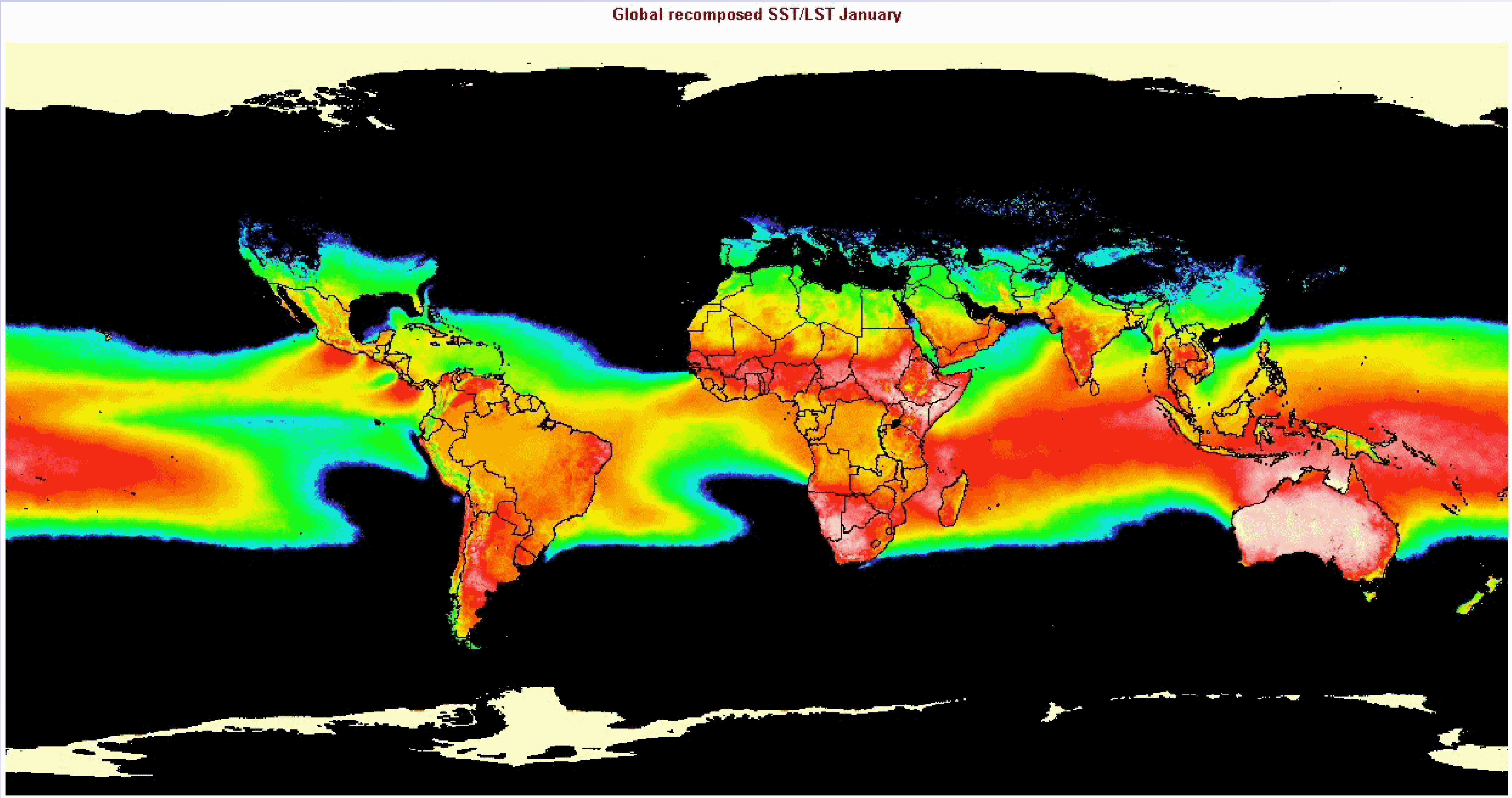
The model can <u>never</u> work the way it was intended

Statistical Models…..

… are put together as a series of (initially crude) correlations

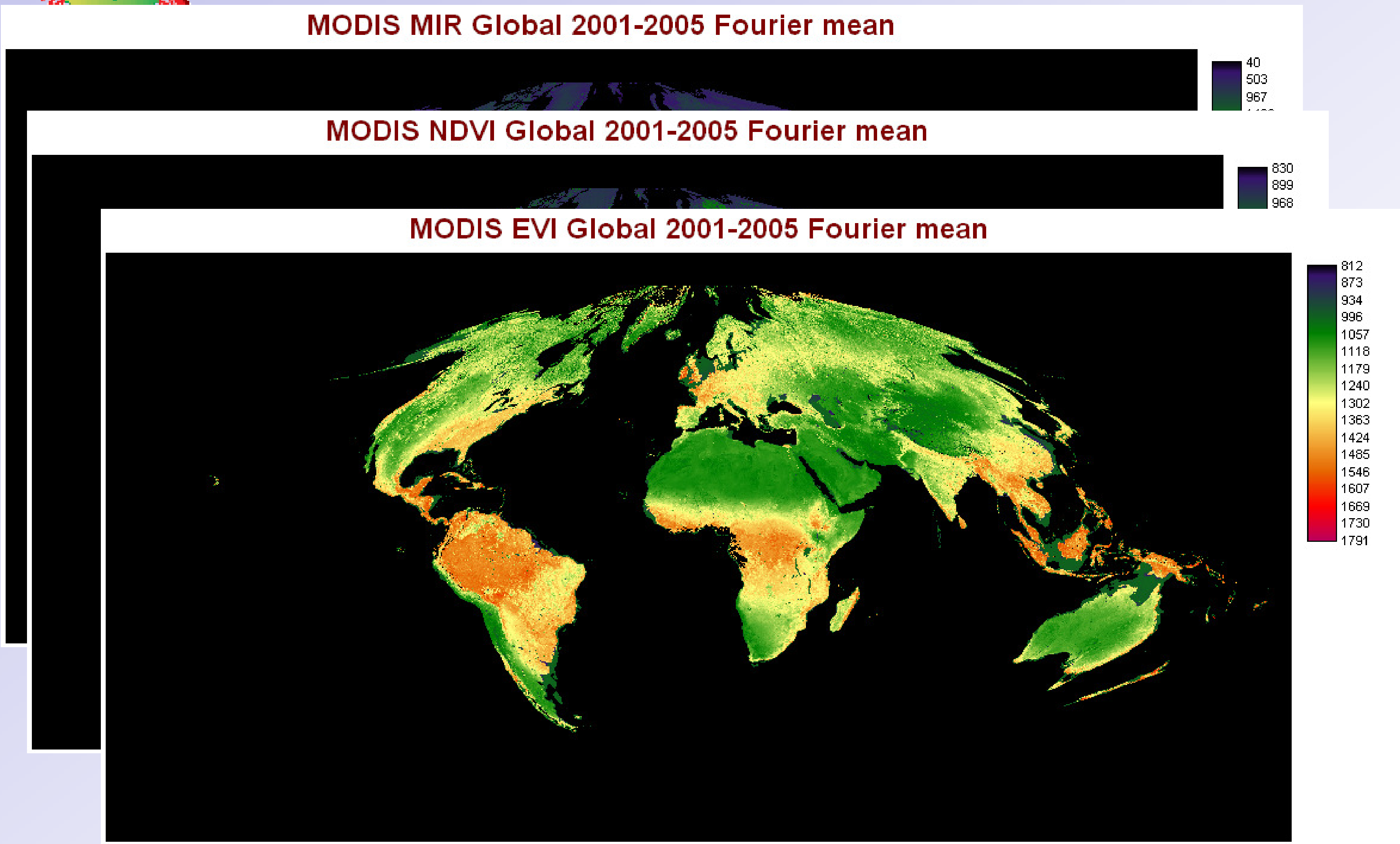
The model always has some descriptive power

Monthly variation in Land Surface Temperature (LST) and Sea Surface Temperature (SST)



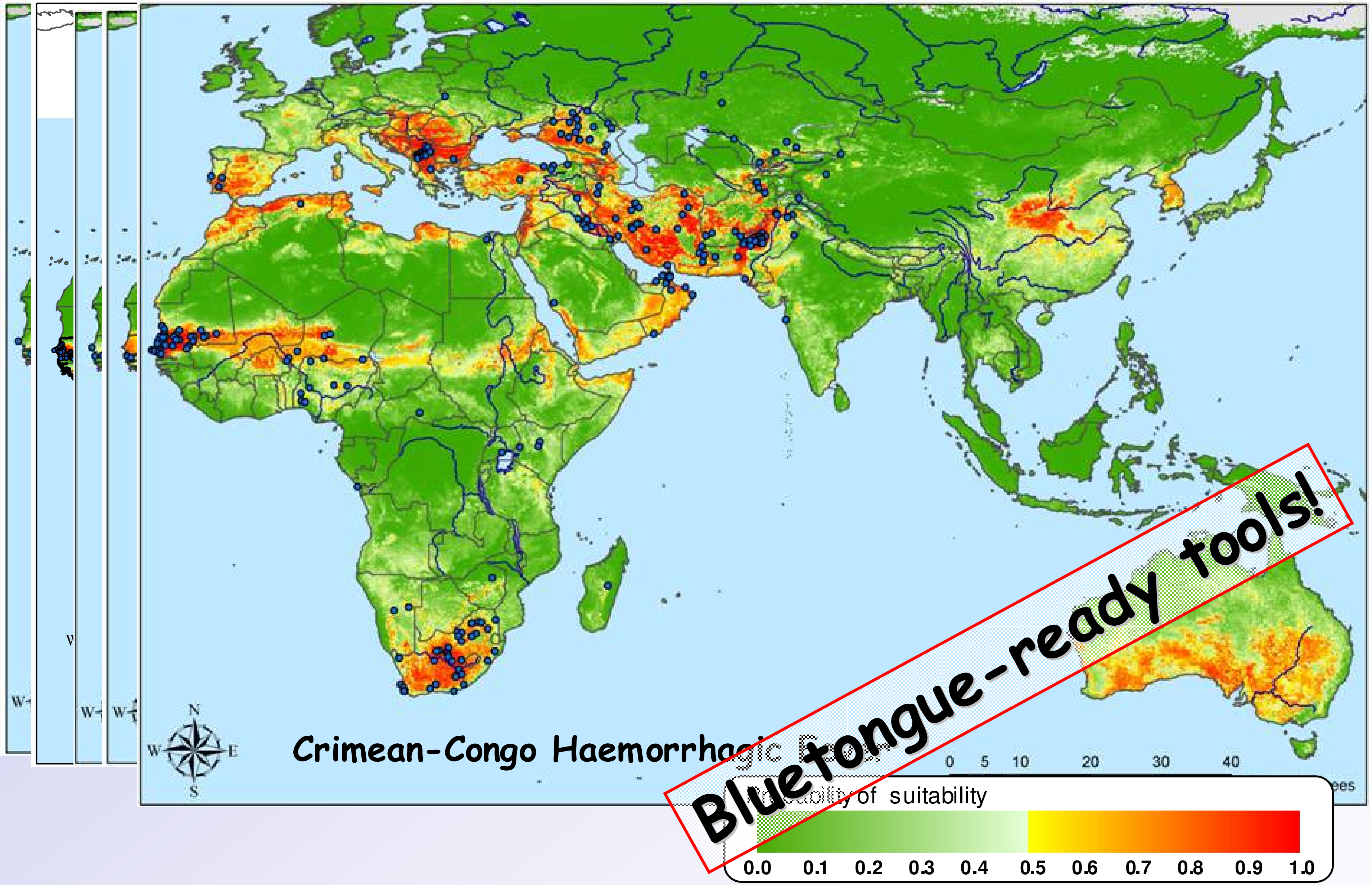
Black, blue, green = lower temperatures. Yellow, red white = higher temperatures

New Satellite imagery – Terra/MODIS



Statistical Modelling

Towards disease burden mapping?



A good Early Warning System will have to be based on a biological rather than statistical description of diseases.

From Statistics…..

….. to Biology

Vectors are often the most variable element of vector-borne diseases

Biological Modelling

In the beginning……

$$R_0 = \frac{mbca^2 e^{-\mu T}}{\mu r}$$

R_0 = basic reproductive number of the disease

m = vector/host ratio

b,c = transmission coefficients

a = human biting rate

μ = daily mortality rate

T = extrinsic incubation period (days)

r = rate of recovery of from infection

all of these may be affected by climate/weather

Assumption of the 'simple' Ro equation

Things do not

change in space or

through

time

$$R_0 = \frac{mbca^2 e^{-\mu T}}{\mu r}$$

What can we learn from……

The Present

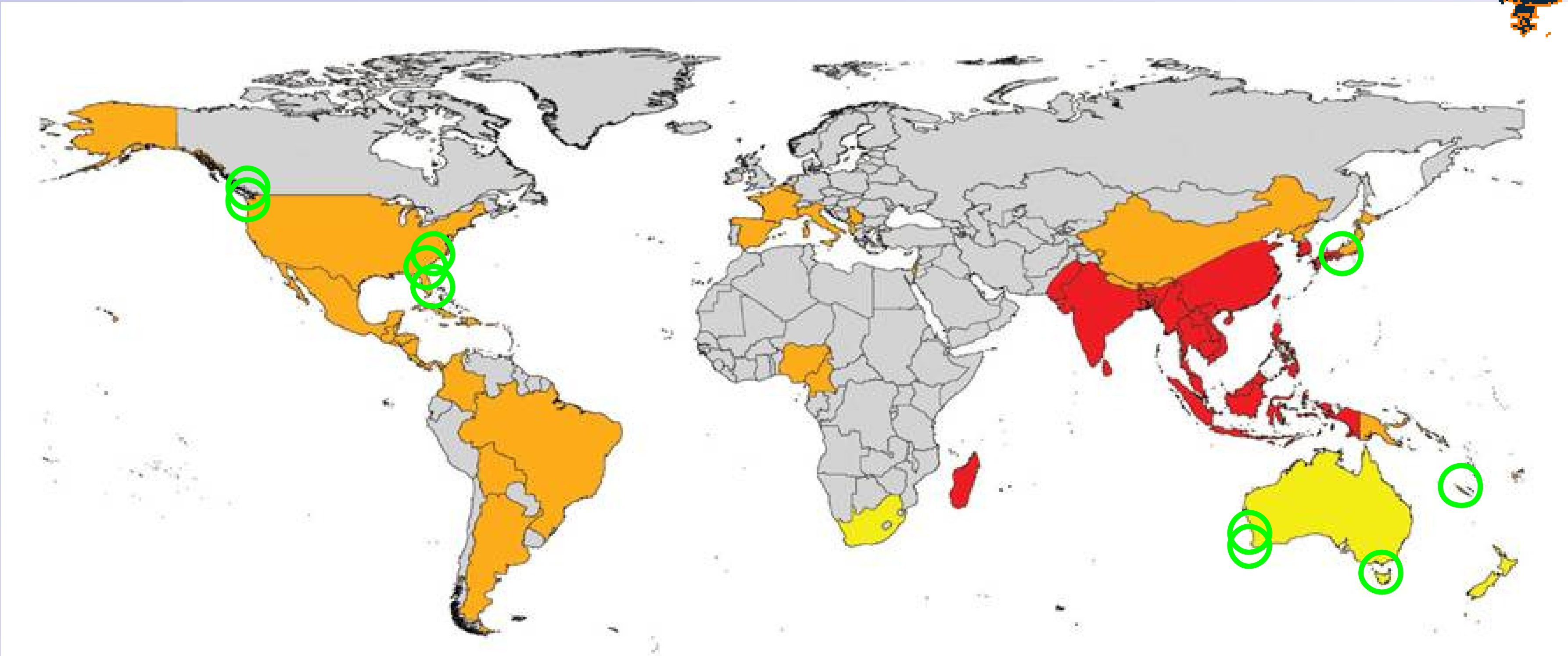
……?

The diseases we already have are changing naturally through space and time

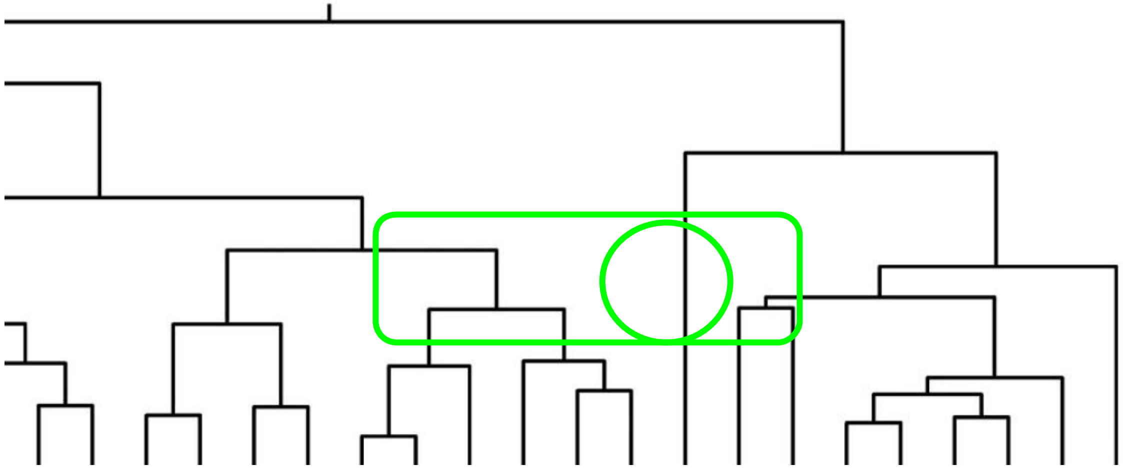
…...usually we do not know the reasons why (trade, travel, global change?)

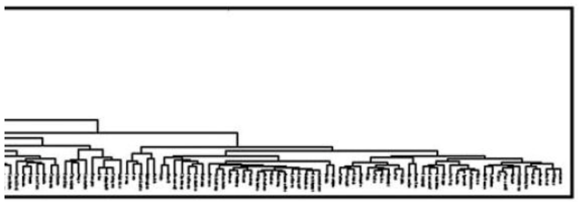
Aedes albopictus – the Asian Tiger Mosquito

Aedes albopictus – original 'home' (red), present distribution (+ orange), and port interceptions (yellow)



lations of *Ae. albopictus* in the last 30 years (orange), and

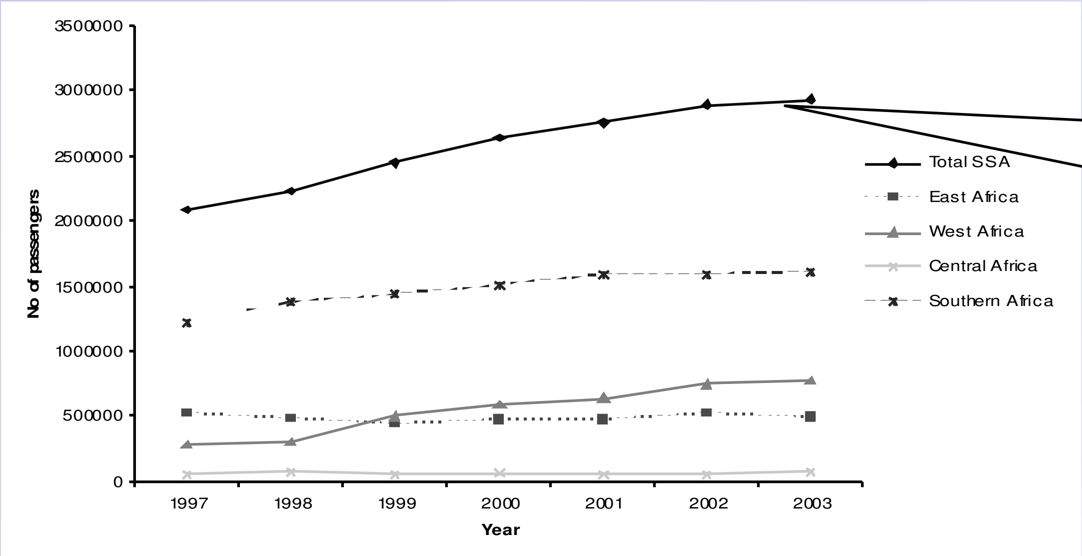




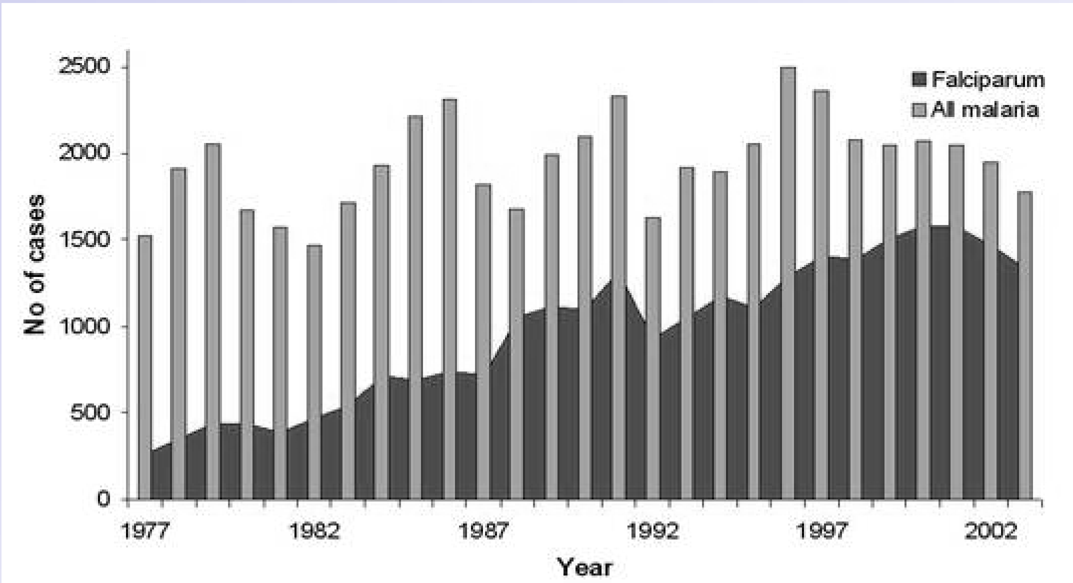
I. & Rogers, D.J. (2006) PNAS **103**, 6242-47

Anopheles gambiae – the malaria mosquito

Number of passengers UK to sub-Saharan Africa (upper) and Imported malaria cases, UK (lower)



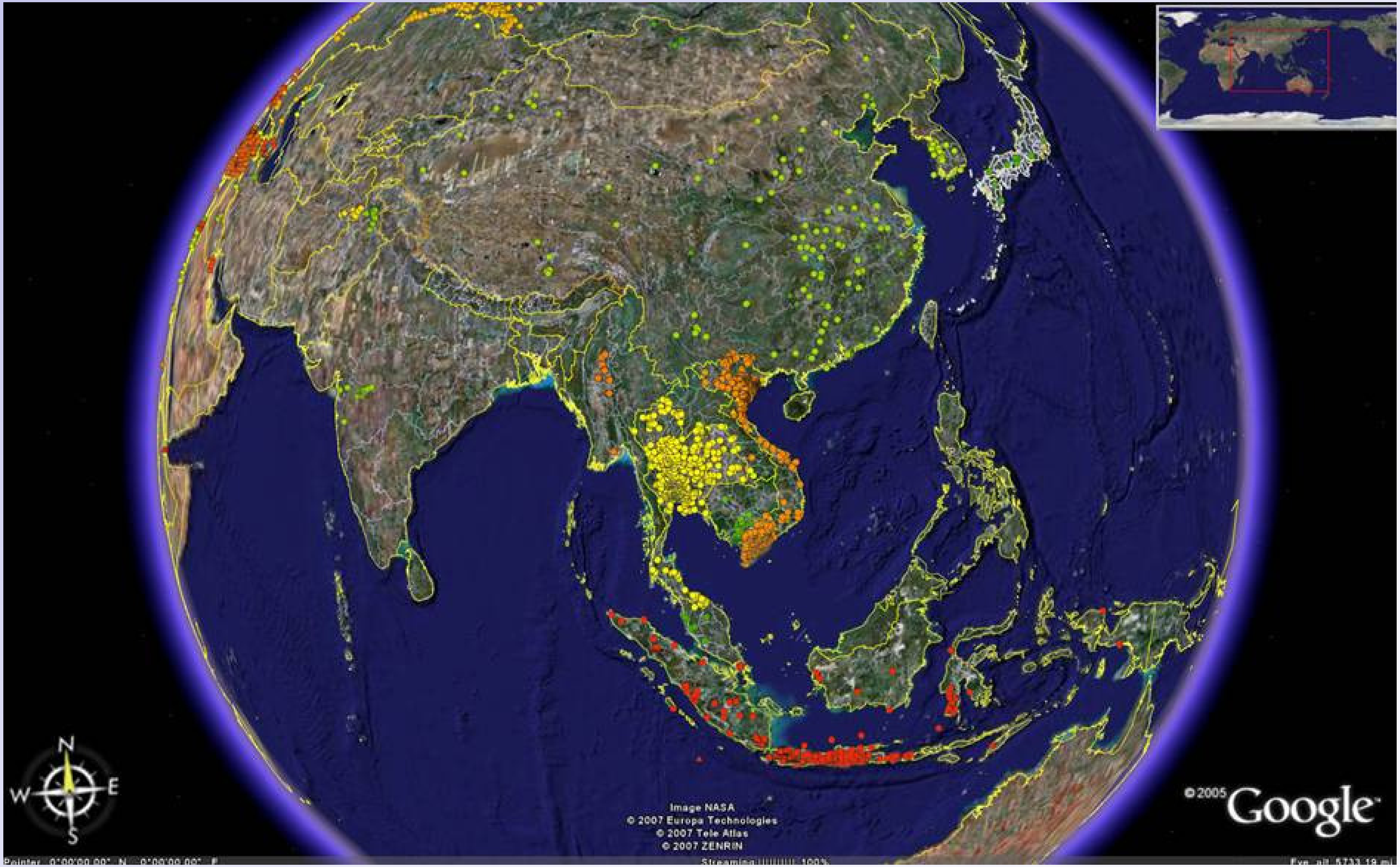
Number of UK travellers to SSA, 1997 - 2003



i.e. approx 1 in 2,000 UK travellers to SSA return with *P. falciparum* malaria

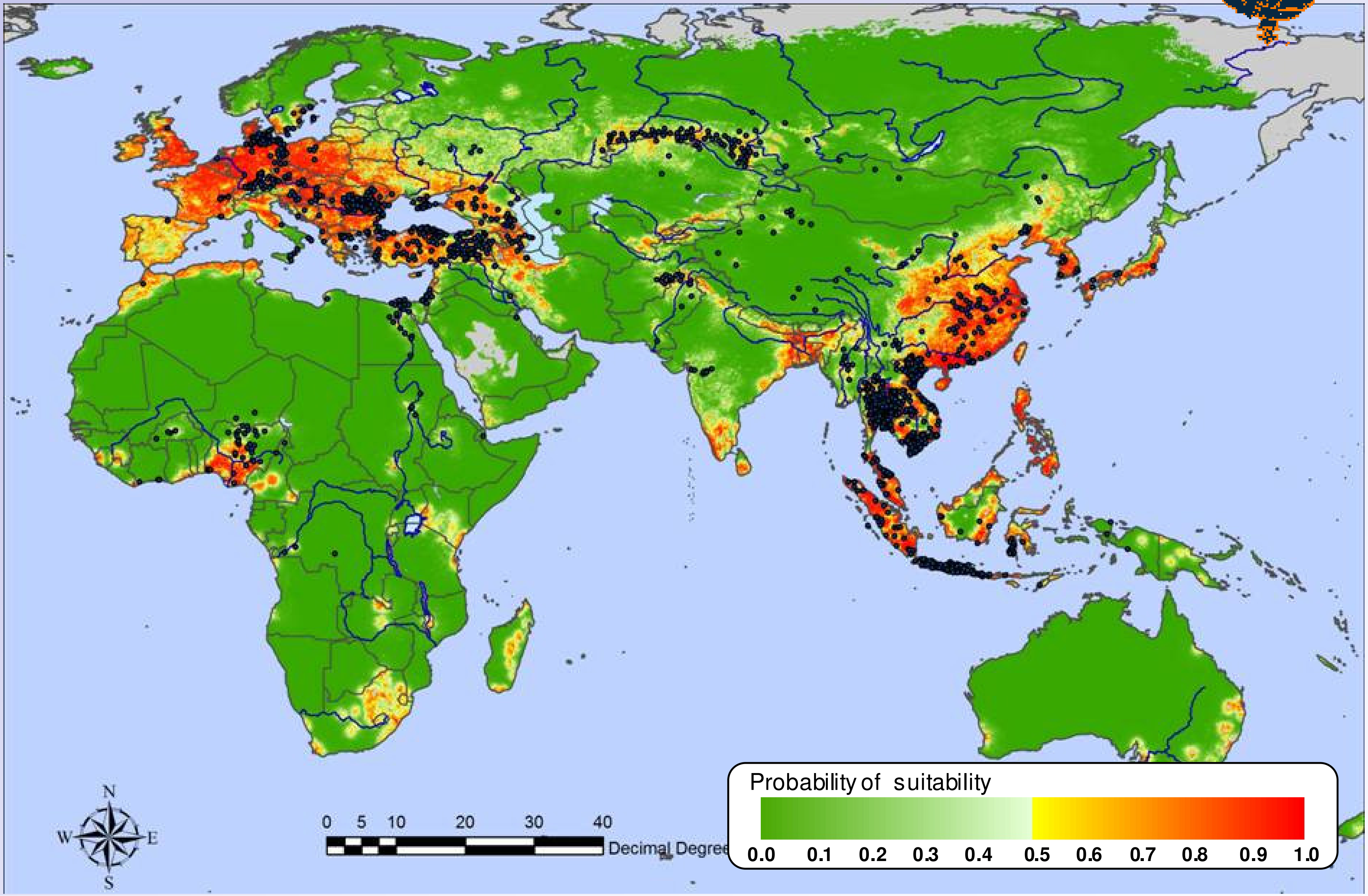
Travels of the domestic chicken

Google Earth, showing the locations of H5N1 records in Asia



H5N1 Risk maps

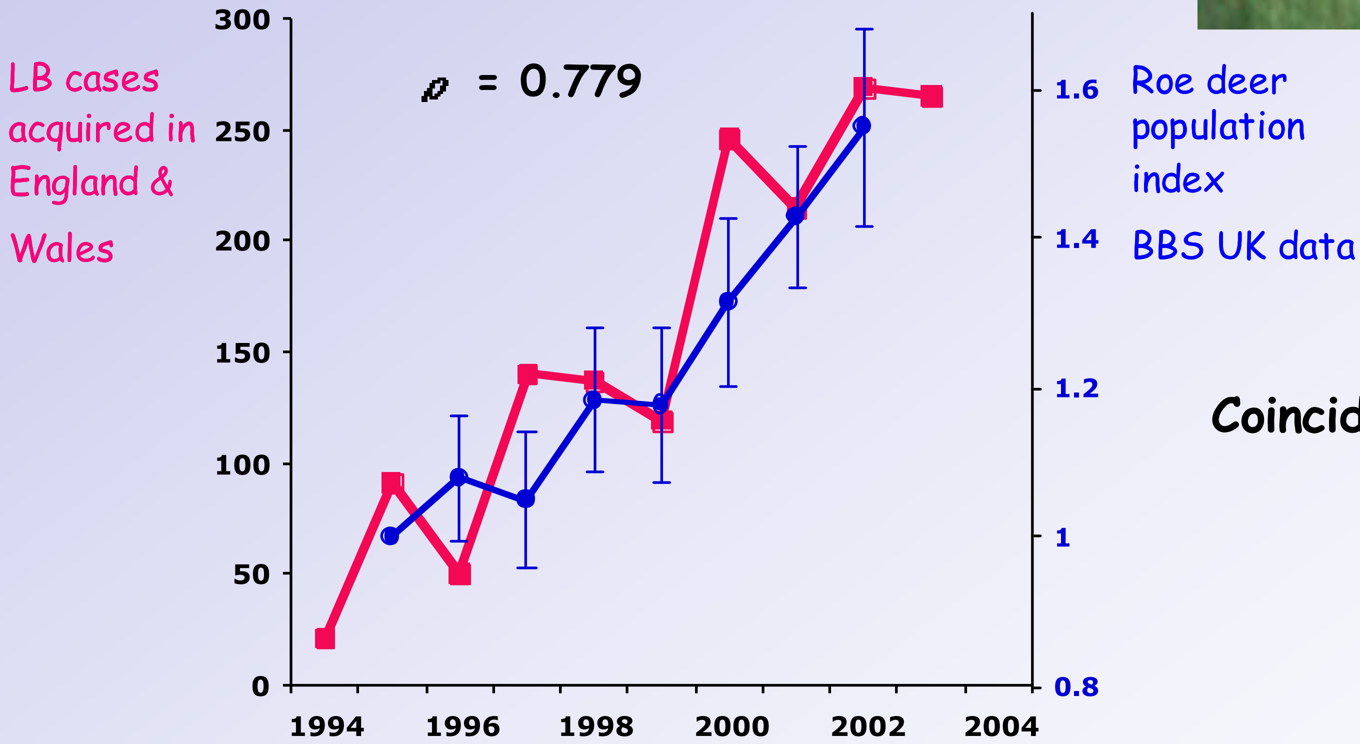
With only environmental data …. or also with poultry density



Ixodes ricinus – vector of Lyme disease and TBE

Lyme borreliosis and deer abundance in the UK

Roe deer



Coincidence
or
causal?

Analysis by Dr Jörn Scharlemann, Oxford

New or newly emerging diseases do not necessarily behave in the same way in new hosts, new vectors or new continents

…...we rarely know the reasons why

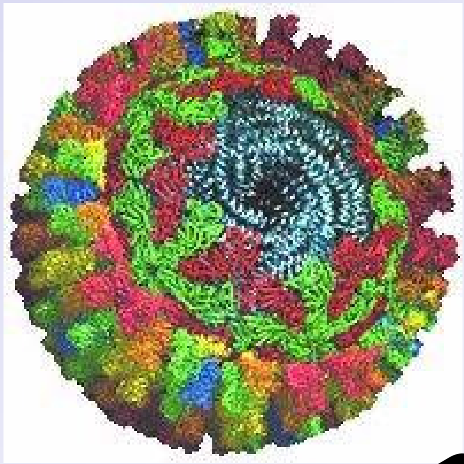
Passing the baton

– there are also epidemiological Relay Races

Bluetongue Transmission Cycle

Domestic sheep

BT virus

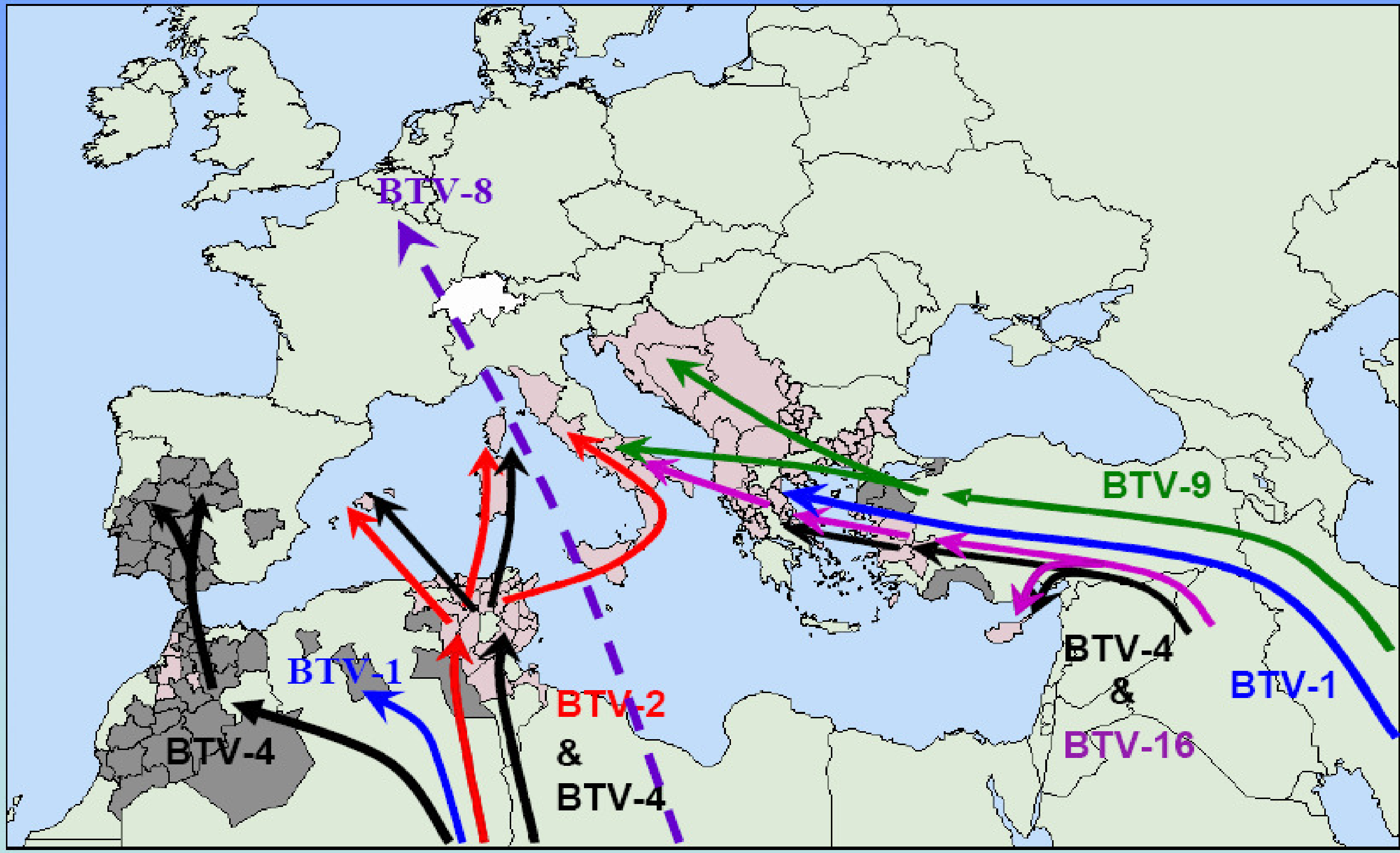


Culicoides spp.

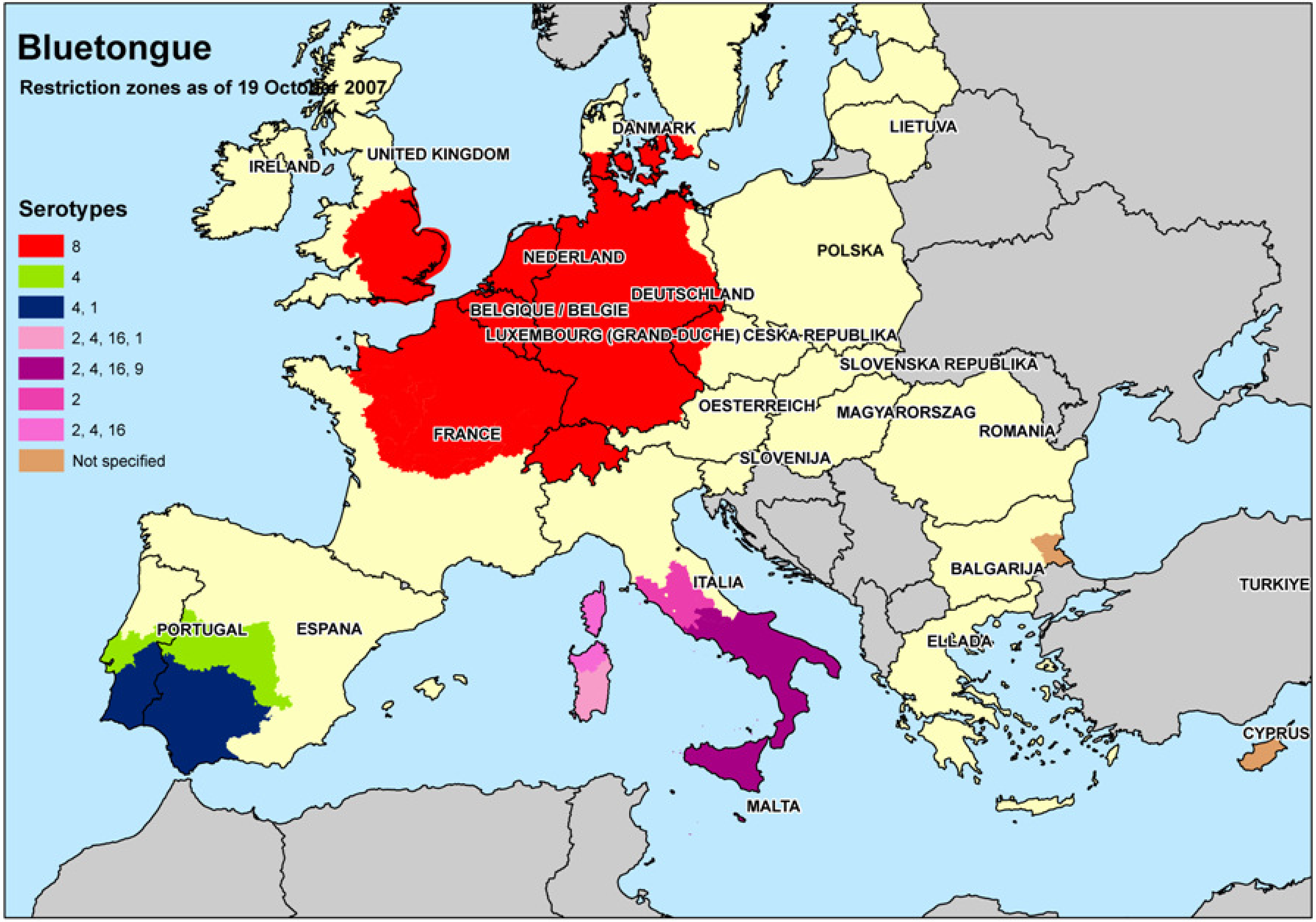
NEW EPIDEMIOLOGIES

Bluetongue. The Problem

Nine introductions of different BTv strains into N. Africa and Europe since 1998



Bluetongue restriction zones October 2007



Bluetongue. The Problem

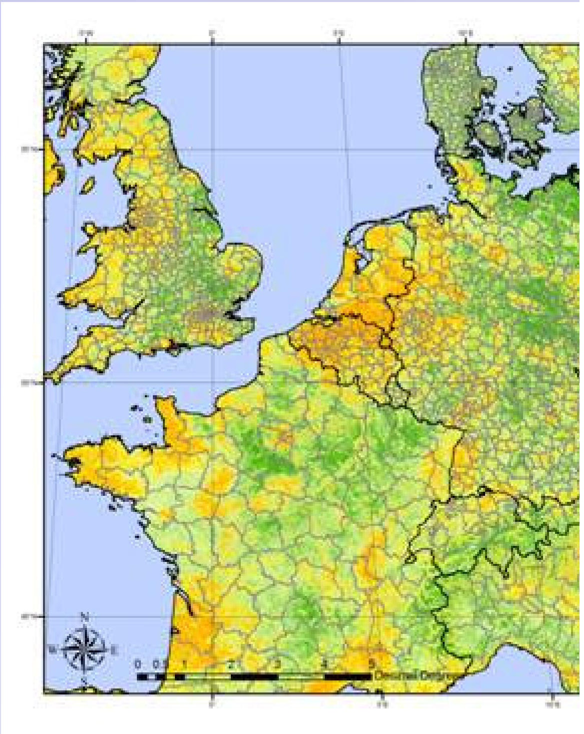
Three stages of invasion:

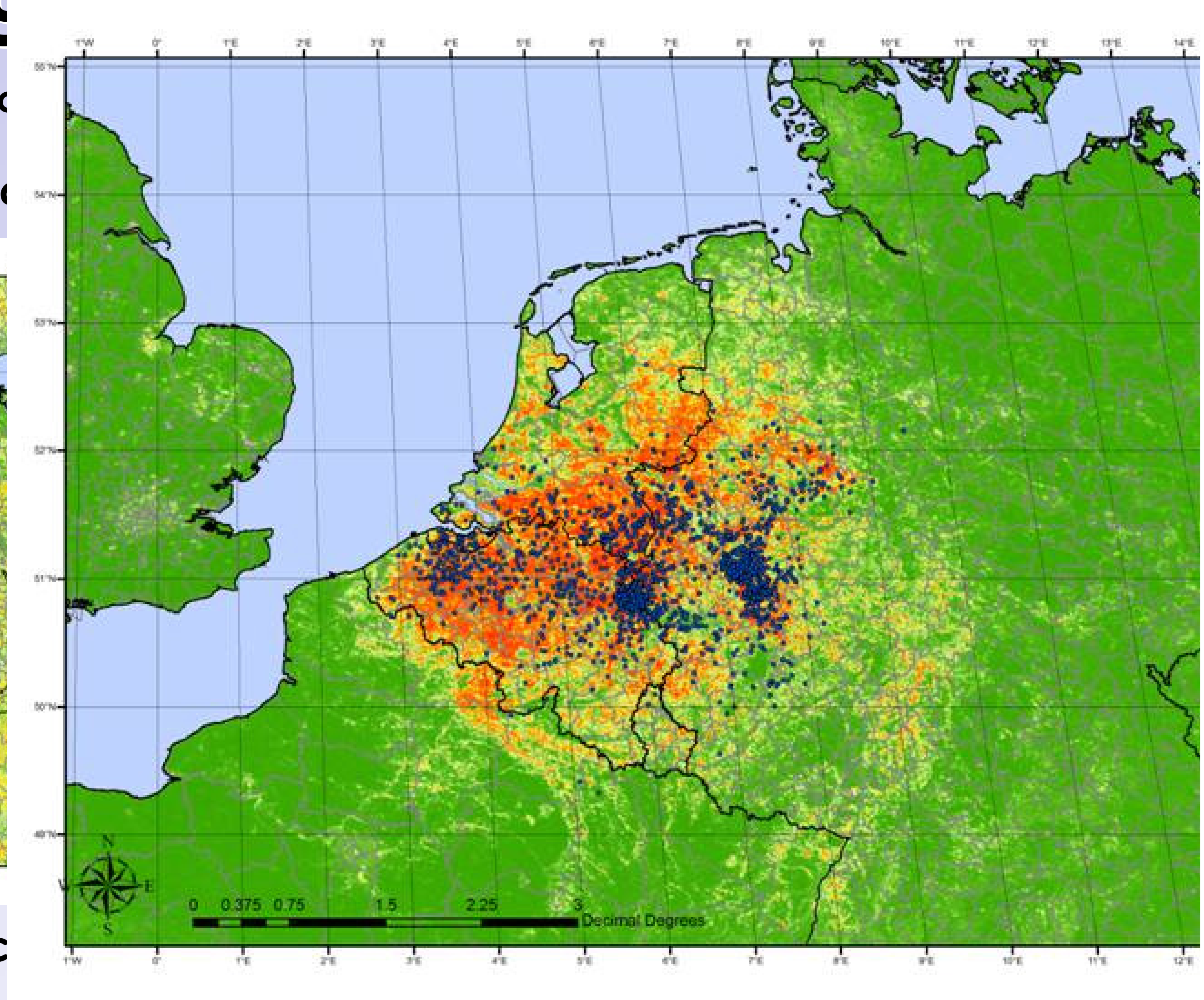
1. **Arrival** – wind field studies
2. **Establishment** – environmental studies/ modelling
3. **Spread** – wind field/environmental/modelling

Bluetongue Establishment

Pred

Single predictor v

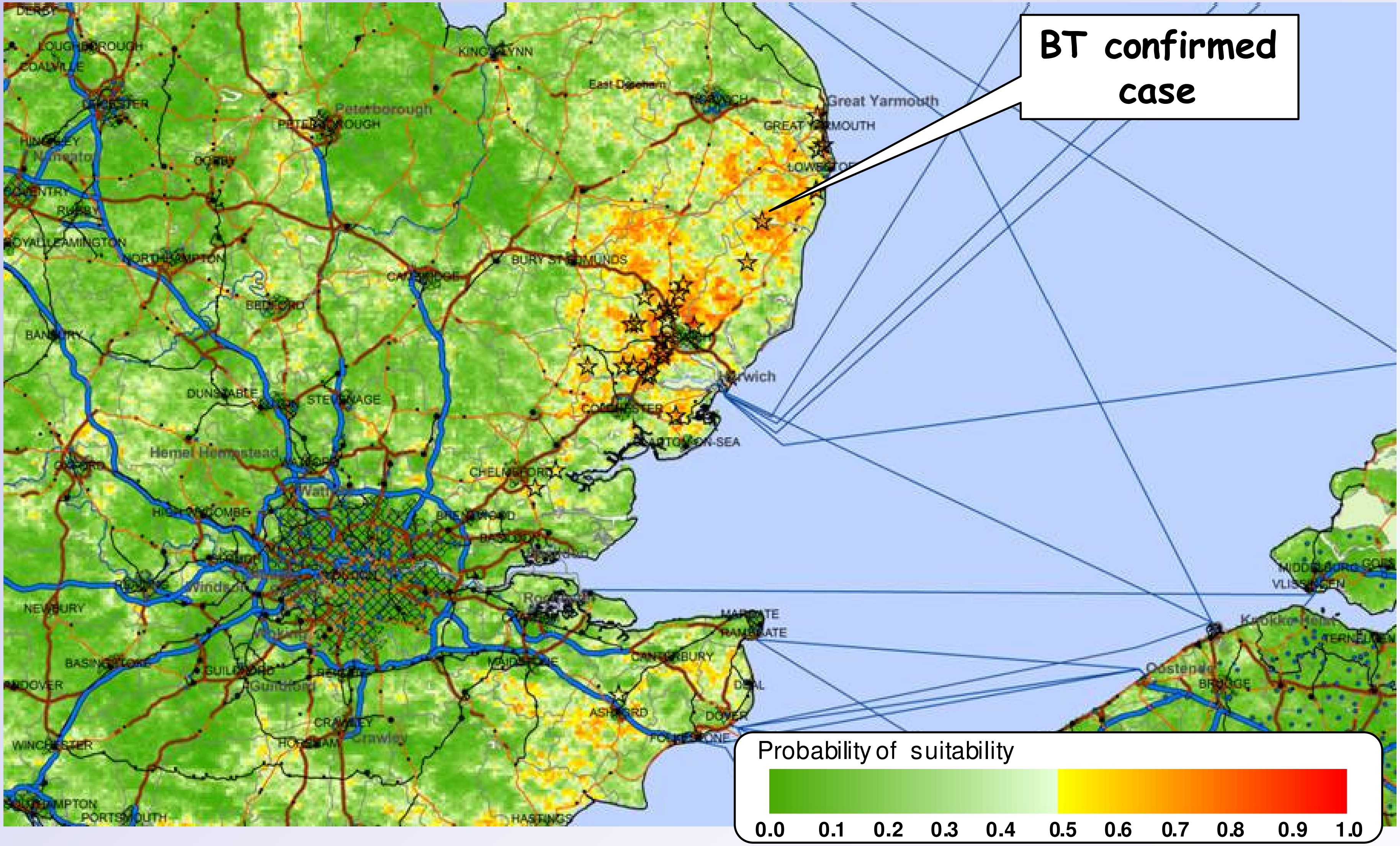




BT over-predic

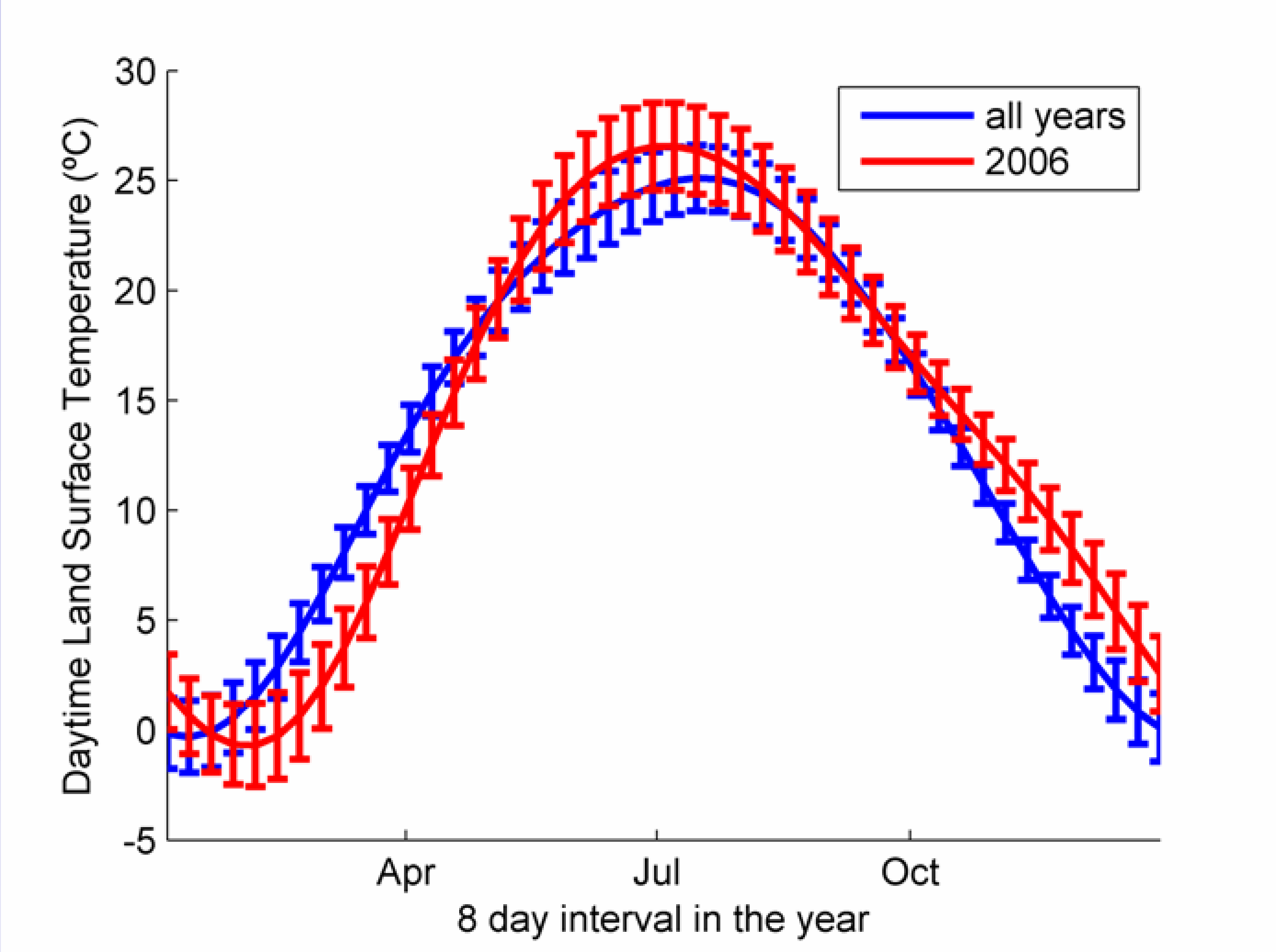
Bluetongue. Establishment

The UK situation 10.10.07



Bluetongue. Why 2006?

MODIS day-time temperature profiles in Europe 2001-2006

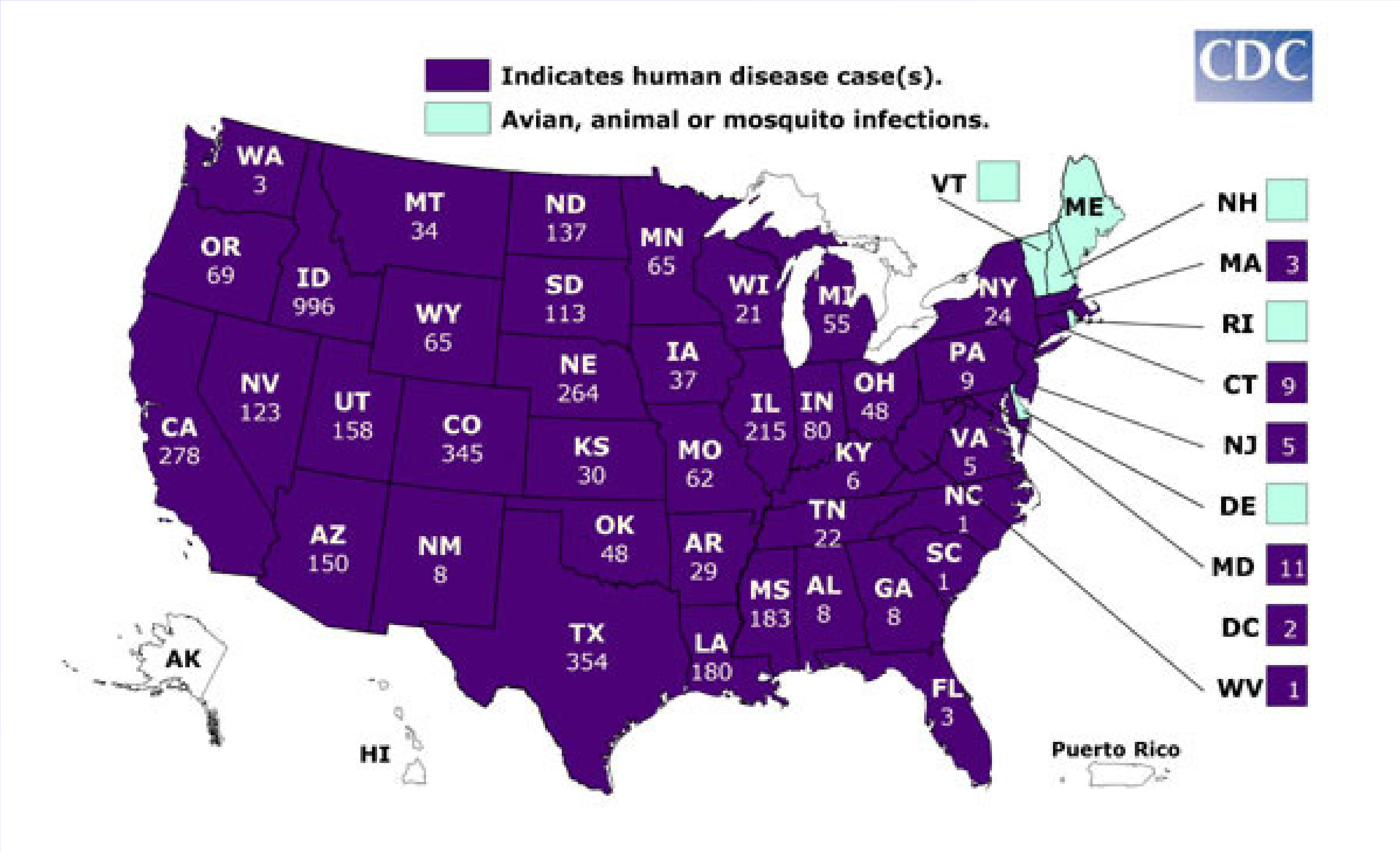


Culex pipiens – vector of West Nile Virus (WNV)

NEW EPIDEMIOLOGIES

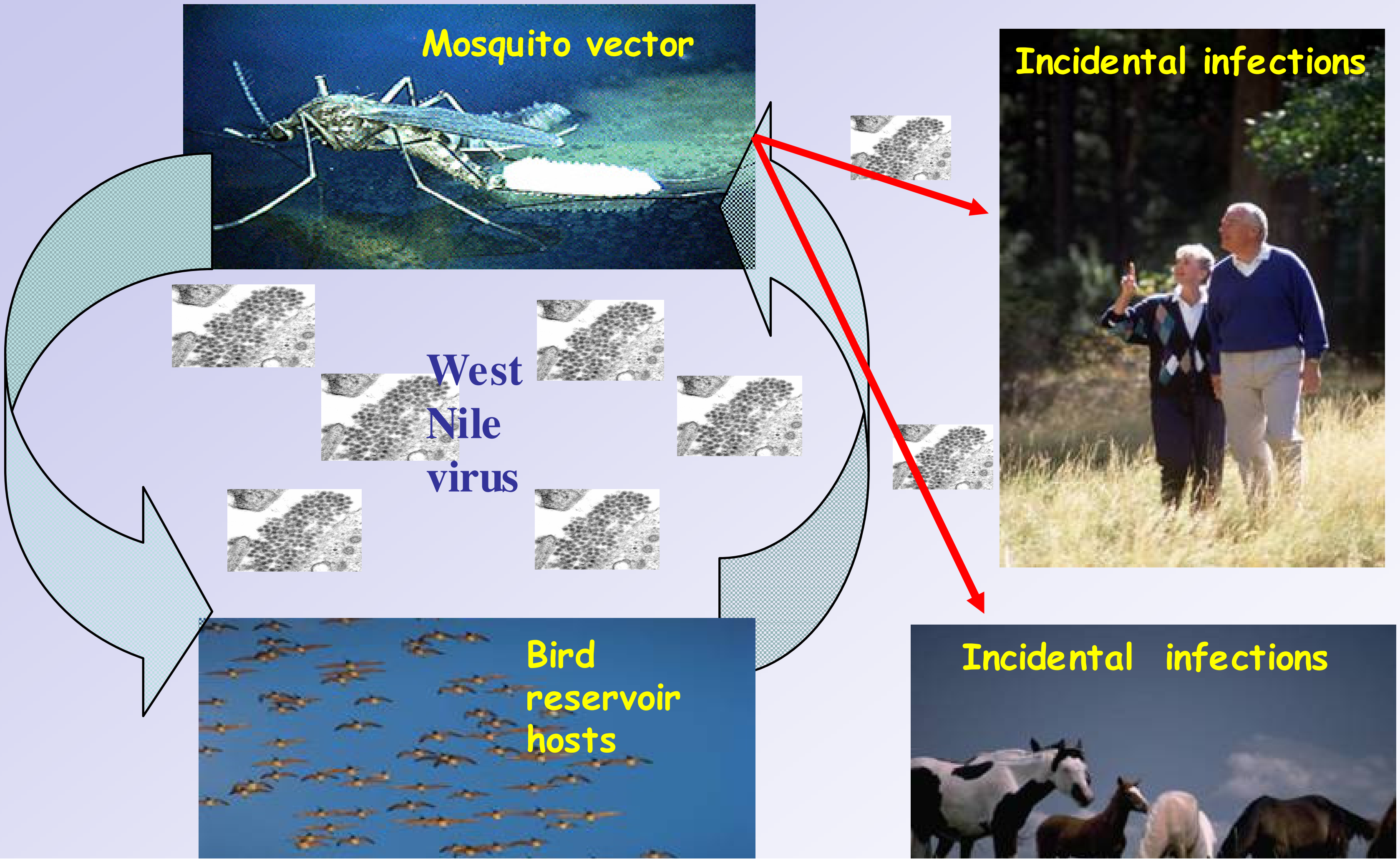
The Spread (and numbers) of Human West Nile Virus cases in the USA 1999 to 2006

1999 2000 2001 2002 2003 2004 2005 2006



Human cases are the <u>darker</u> colors

West Nile Virus Transmission Cycle



At least 70 N. American mosquito species have been implicated in WNV transmission

How can we prepare for……

The Future

……?

The diseases we already have are changing naturally through space and time

…...usually we do not know the reasons why (trade, travel, global change?)

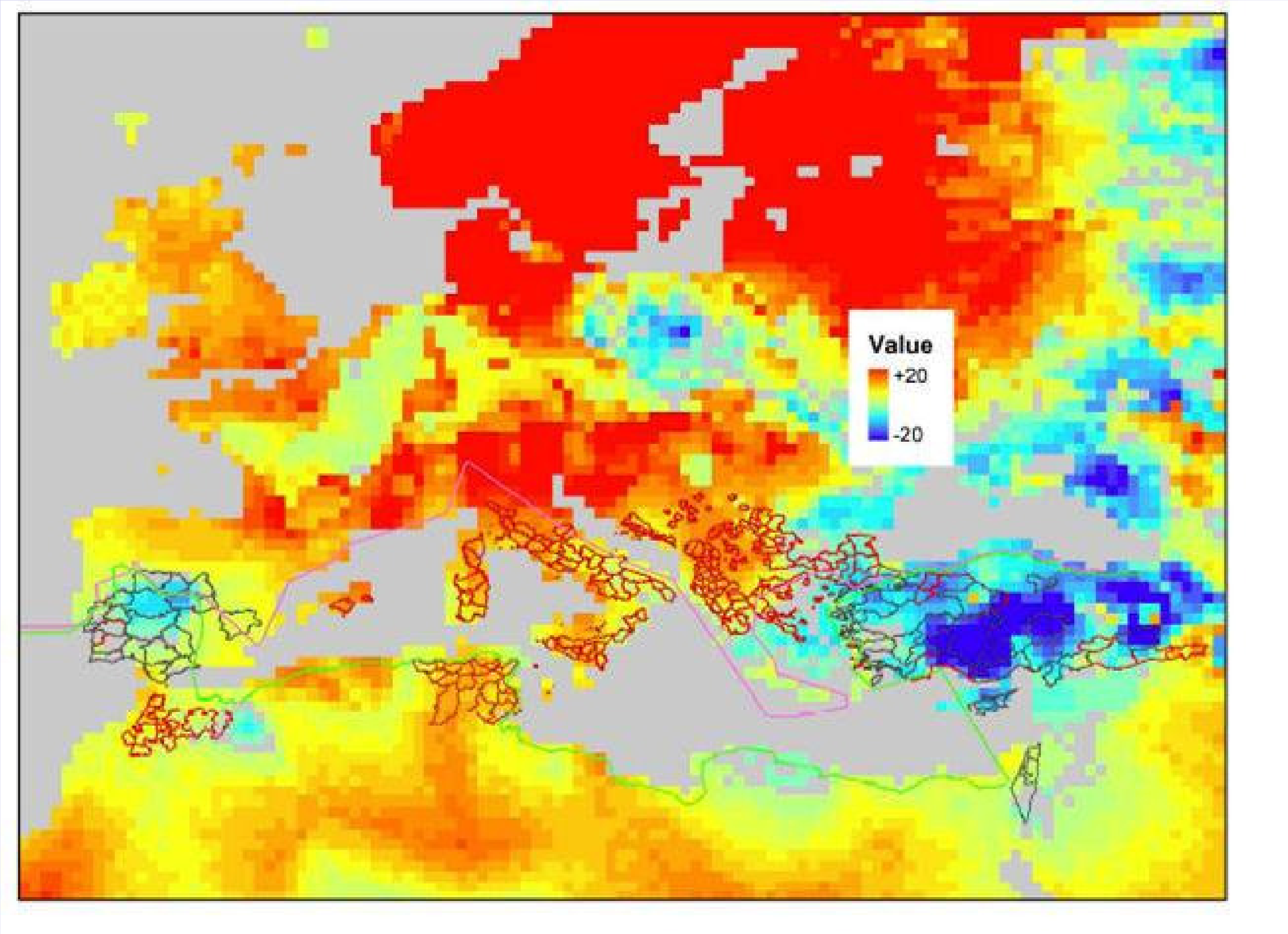
…...but some may be due to global warming

It is uncertain that global warming will cause an increase in <u>all</u> vector-borne diseases

For example tick-borne encephalitis and rodent-borne hantaviruses appear to do better at lower temperatures … and for different reasons…….

Changes in recorded Minimum Temperatures across Europe between the 1980's and 1990's.

Units are 0.1 degrees Celsius; increases in yellow/red, decreases in blue

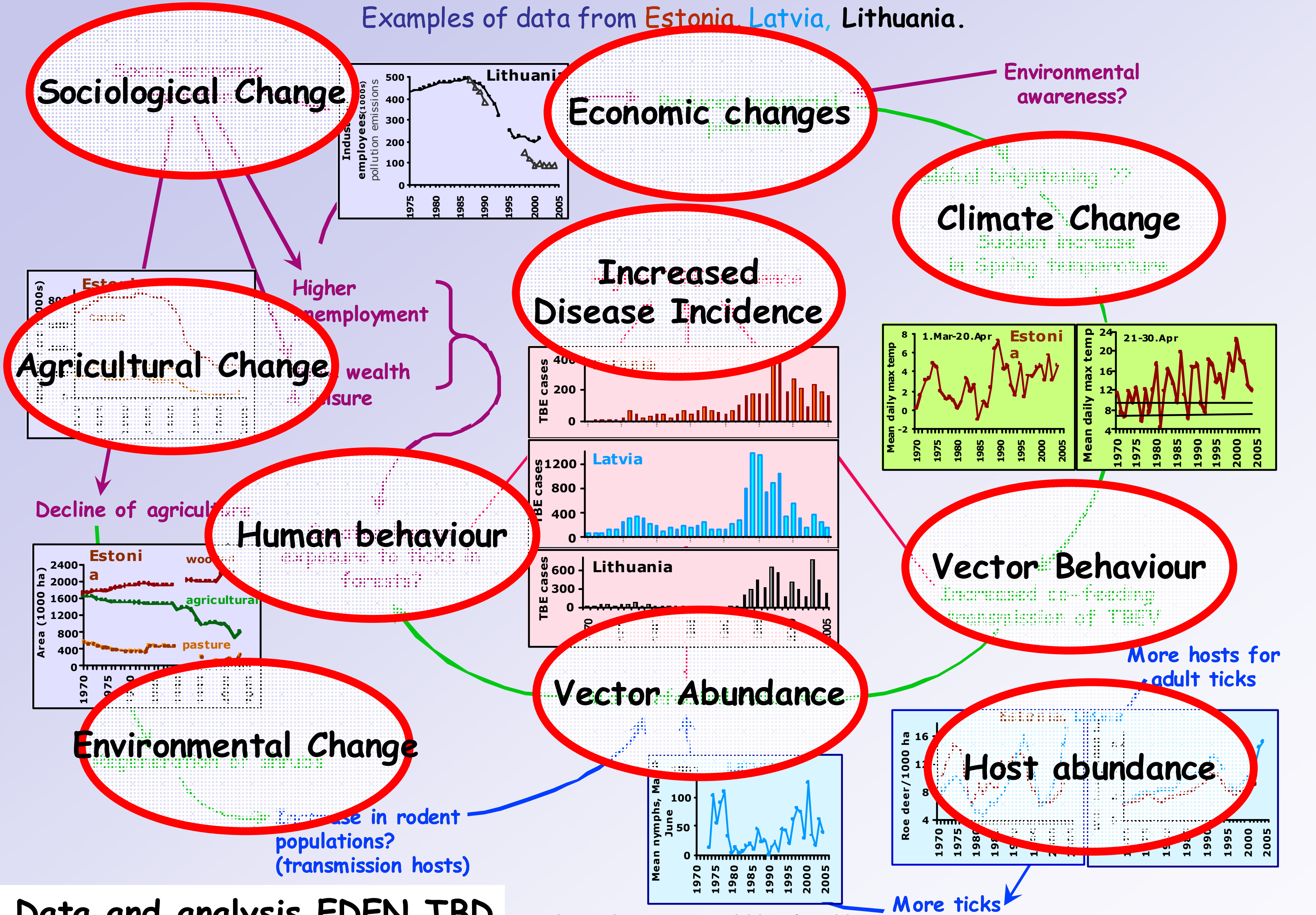


**“We do these things not because they are easy,
but because they are hard.”**

President J.F. Kennedy, on committing the USA to landing a man on the moon before the end of the 1960s.

Network of independent but synergistic biological and non-biological factors

Examples of data from Estonia, Latvia, Lithuania.



Data and analysis EDEN TBD

Sumilo et al, PLoS ONE 2007, 6, e500

“What we don’t know is really what we need,
And what we know is of no use whatever!”

Faust, by Rembrandt

Faust laments being unable to halt the plague

Conclusions

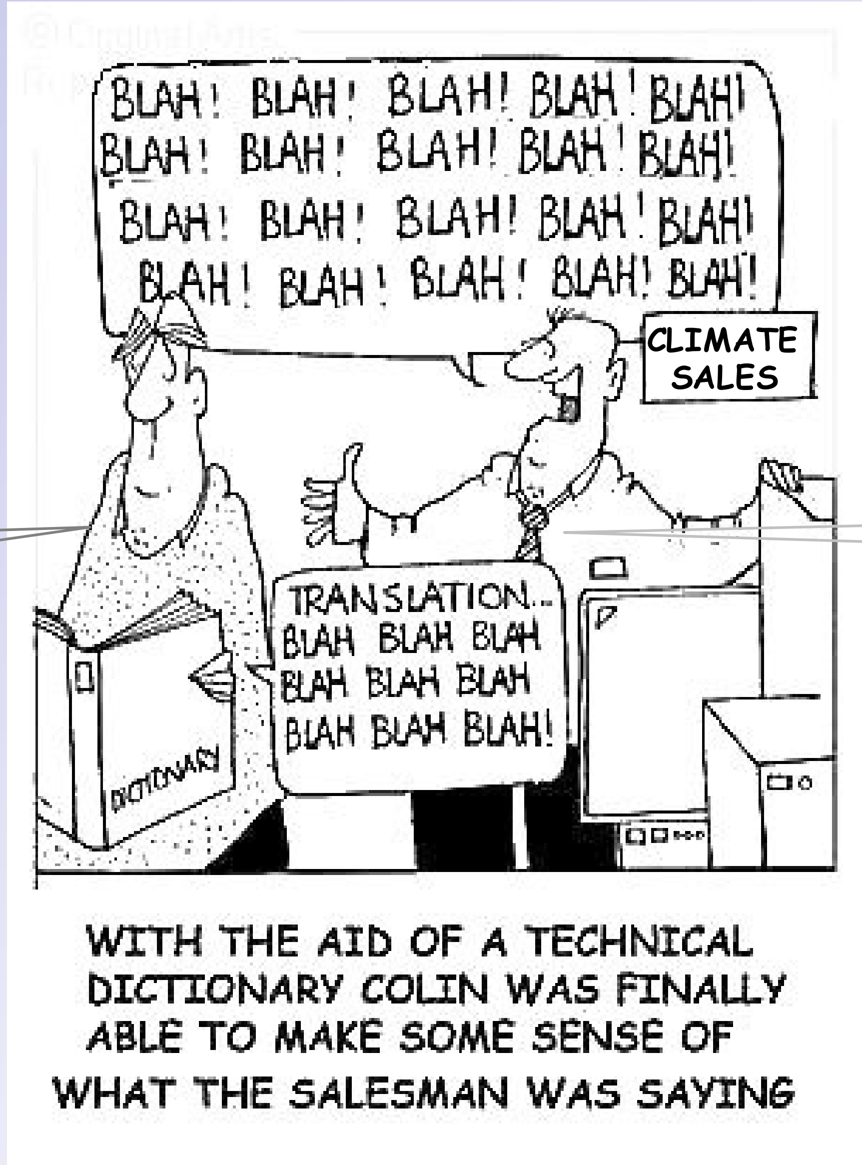
Global Warming and Animal Diseases.

1. Learn from the past.
2. Understand the present. Background knowledge, e.g. of pathogen, vector and host distributions, and how these are changing through space and time (environmental monitoring/satellite data/sentinel animals)
3. Explore understanding in a modelling framework
4. Develop forecasting tools - Disease Monitoring and Early Warning Systems (DMEWS)
5. Do not forget the public! Public/Veterinary Health and Information systems (to recruit, advise, forewarn and protect)
6. Predict the future, but expect the unexpected!

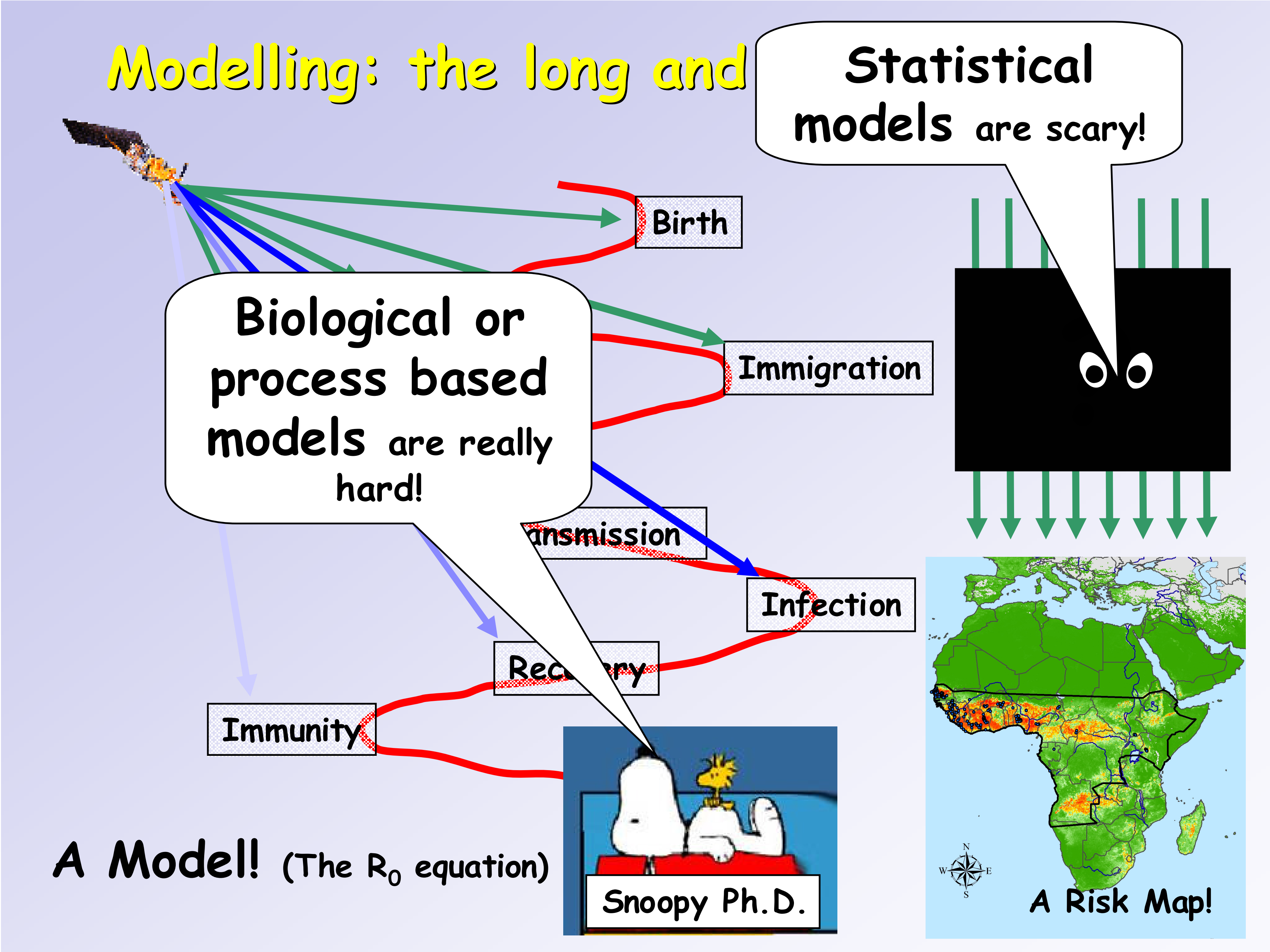

Thank you

Problems with Inter-Disciplinary studies

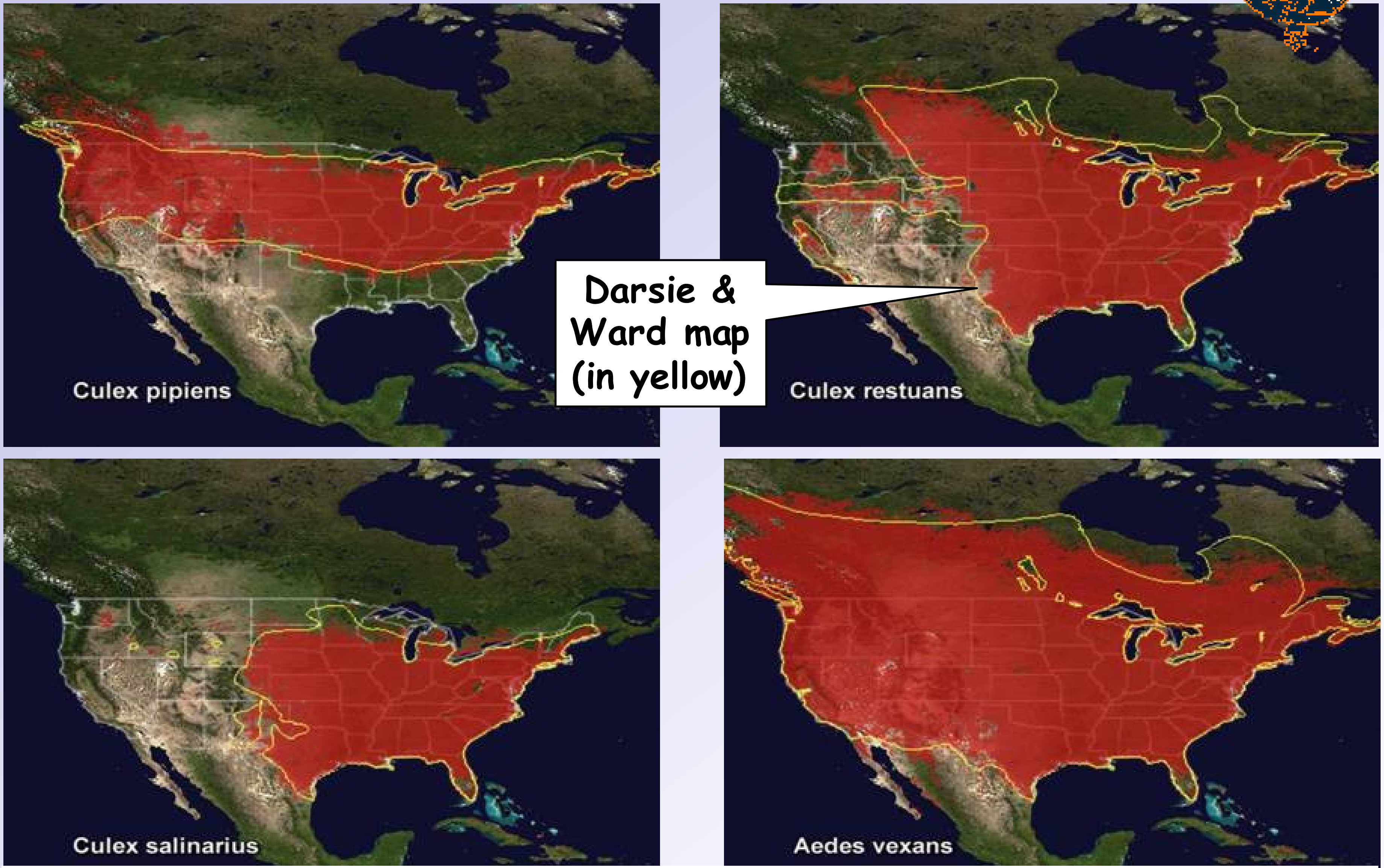
Epidemiologist



Climatologist


Modelling: the long and
Statistical models are scary!
Birth
Biological or process based models are really hard!
Immigration
ansmission
Infection
Rec ry
Immunity
A Model! (The R_0 equation)
Snoopy Ph.D.
A Risk Map!
N
W
E
S

Satellite predicted presence/absence maps for 4 WNV mosquito vectors.



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