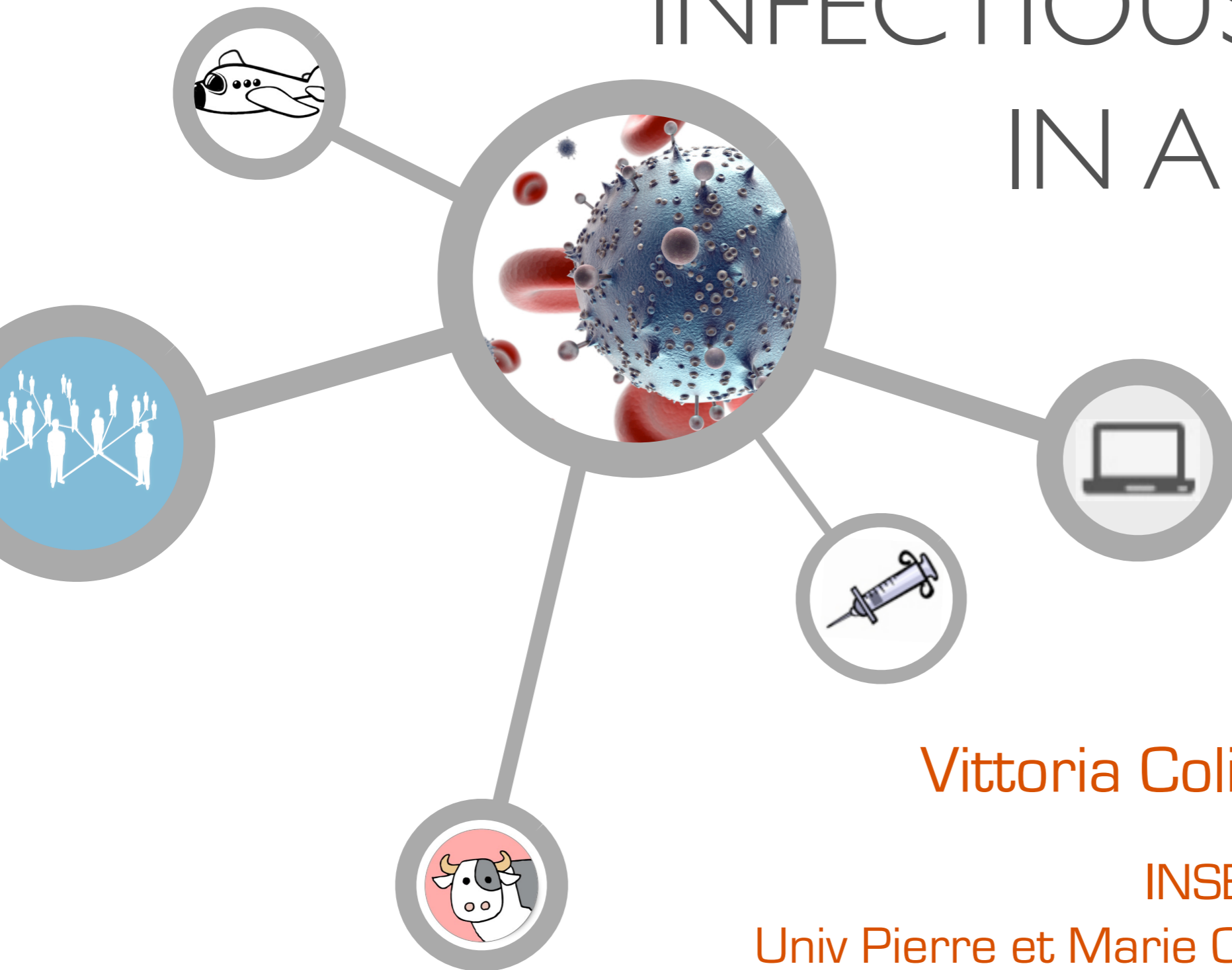


# FIGHTING INFECTIOUS DISEASES IN A COMPLEX WORLD



Vittoria Colizza



**Inserm**

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INSERM

Univ Pierre et Marie Curie  
Paris, France

**UPMC**  
PARIS UNIVERSITAS

Mar 07 2009



[GLEaMviz.org](http://GLEaMviz.org)

Chicago  
New York  
Los Angeles  
Houston  
Toronto  
Vancouver  
Calgary  
Indianapolis

**La Gloria**

Sao Paulo  
Mexico City  
Rio De Janeiro  
San Juan  
Bogota

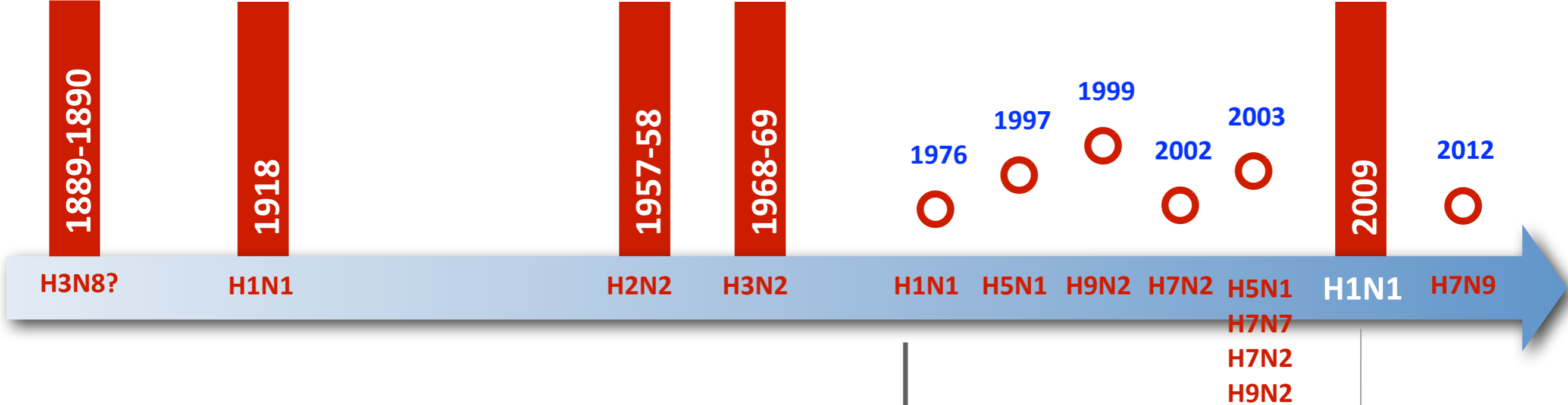
Johannesburg  
Cairo  
Cape Town  
Nairobi

Paris  
Frankfurt  
Amsterdam  
Rome  
Milan  
Moscow  
Dublin

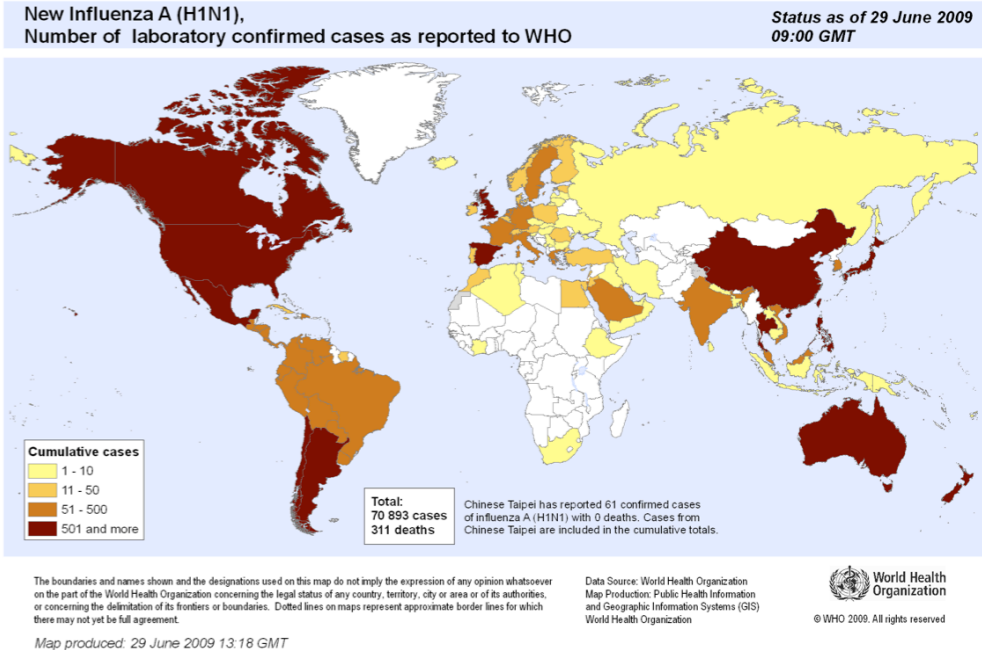
Hong Kong  
Tokyo Narita  
Bangkok  
Singapore  
Beijing  
Manila

Sydney  
Brisbane  
Auckland  
Perth

# BRIEF HISTORY OF FLU



all plagues soon eradicated from Earth  
(US public health officials)



# New 'Sars-like' coronavirus identified by UK officials

By Michelle Roberts  
Health editor, BBC News online

A new respiratory illness similar to the Sars virus that spread globally in 2003 and killed hundreds of people has been identified in a man who is being treated in Britain.

The 49-year-old man, who was transferred to a London hospital by air ambulance from Qatar, is the second person confirmed with the coronavirus.



## Another death to SARS-like virus in Saudi Arabia: DOH

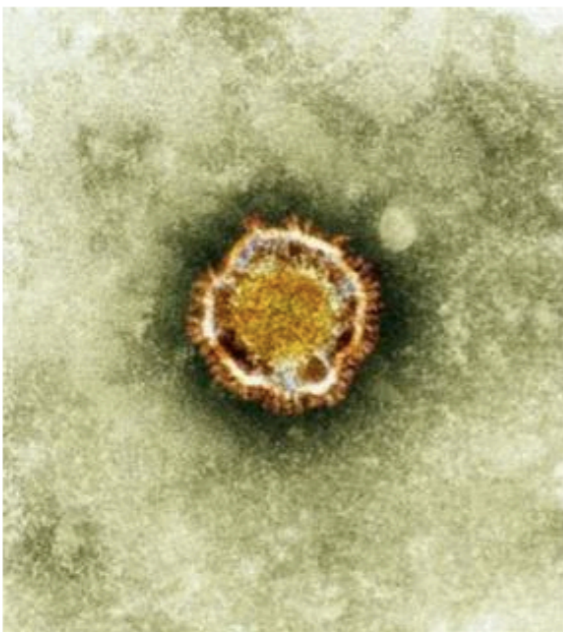
# SARS-Like Virus Spreads From One Person To Another

by MICHAELEEN DOUCLEFF

February 13, 2013 1:52 PM

## Briton dies after contracting new virus

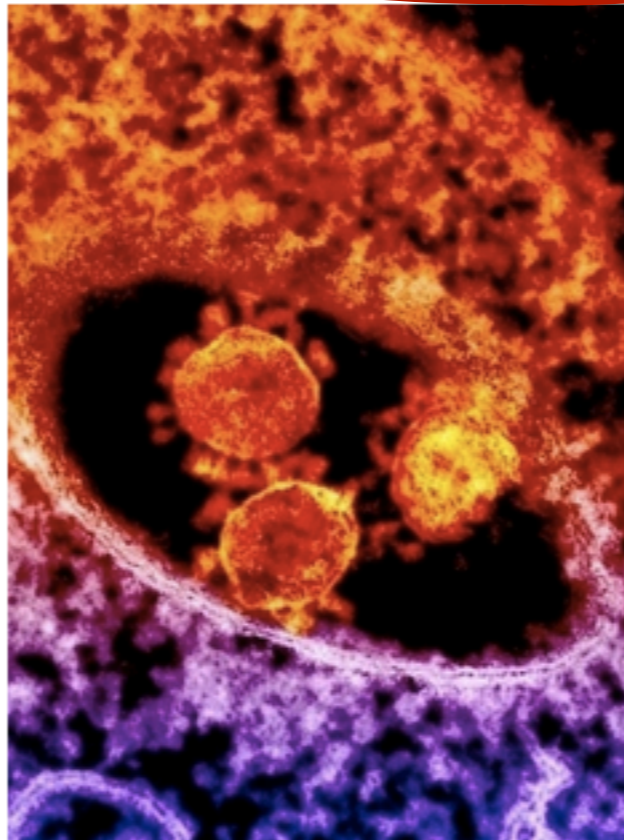
Recommend 317 people recommend this. Sign Up to see what your friends recommend.



By Kate Kelland  
LONDON | Tue Feb 19  
12:09pm EST

(Reuters) - A British man infected with new virus from the same family as SARS has died, health officials said Tuesday, bringing

the worldwide death toll from the previously unknown disease to six.



Virologists discovered the new coronavirus after it killed a Saudi Arabian man last summer.

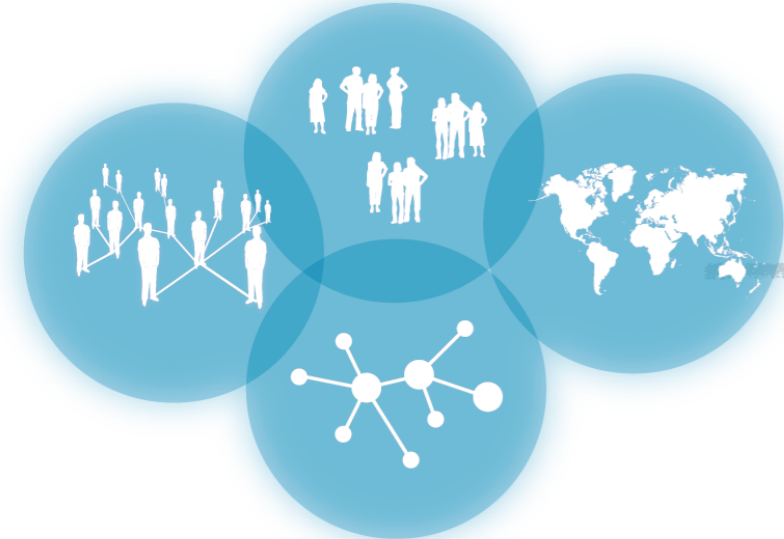
A mysterious illness with a striking resemblance to the one caused by the SARS virus emerged in the Middle East last year.

But the new virus behind the latest cases didn't seem to be contagious – until now.

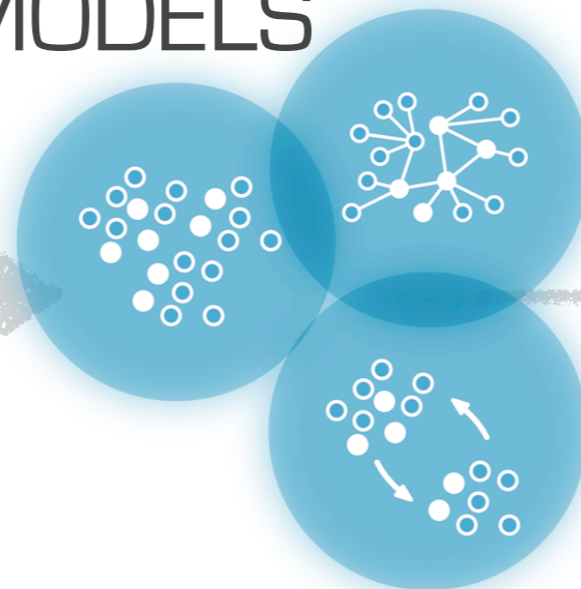
A British resident likely caught the disease from a family member in the U.K., health officials said Wednesday. The patient was in close contact with a sick relative and had never traveled to the Middle East, where all other cases of the new illness originated.

# MODELS

## REALITY

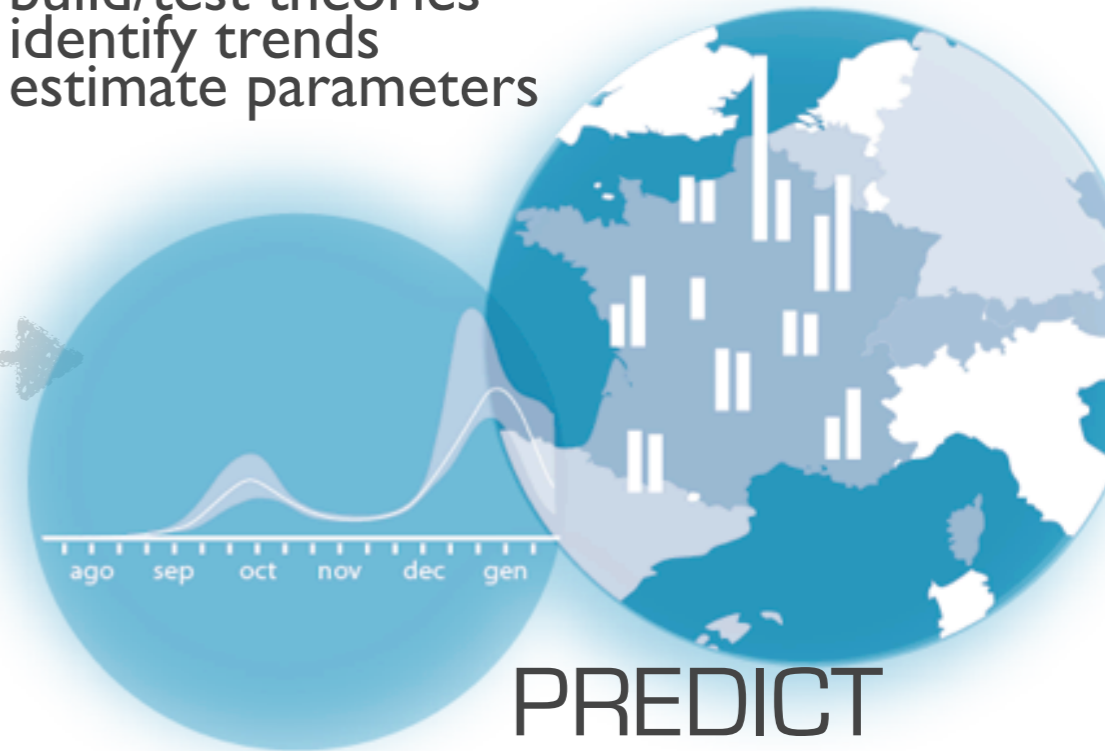


## MODELS



## UNDERSTAND

identify key mechanisms  
obtain basic conceptual results  
build/test theories  
identify trends  
estimate parameters



## PREDICT

test/evaluate/compare interventions  
explore scenarios  
answer specific questions  
provide forecasts (?)

# WHAT DO WE NEED...



people



interactions/mobility



disease

# Black Death, 14th century

Dec 1350

June 1350

Dec 1349

June 1349

Dec 1348

June 1348

Dec 1347

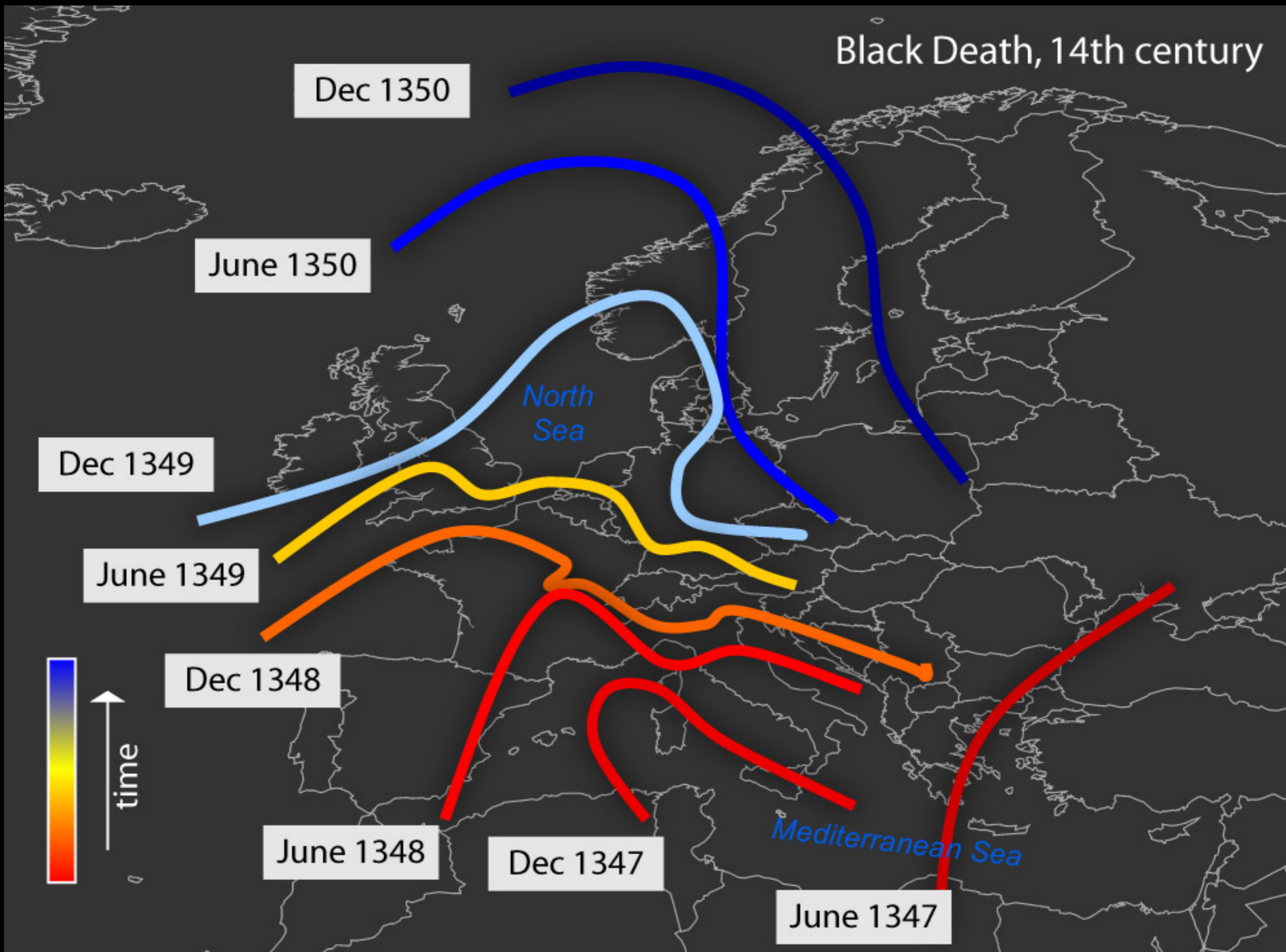
June 1347

North Sea

Mediterranean Sea

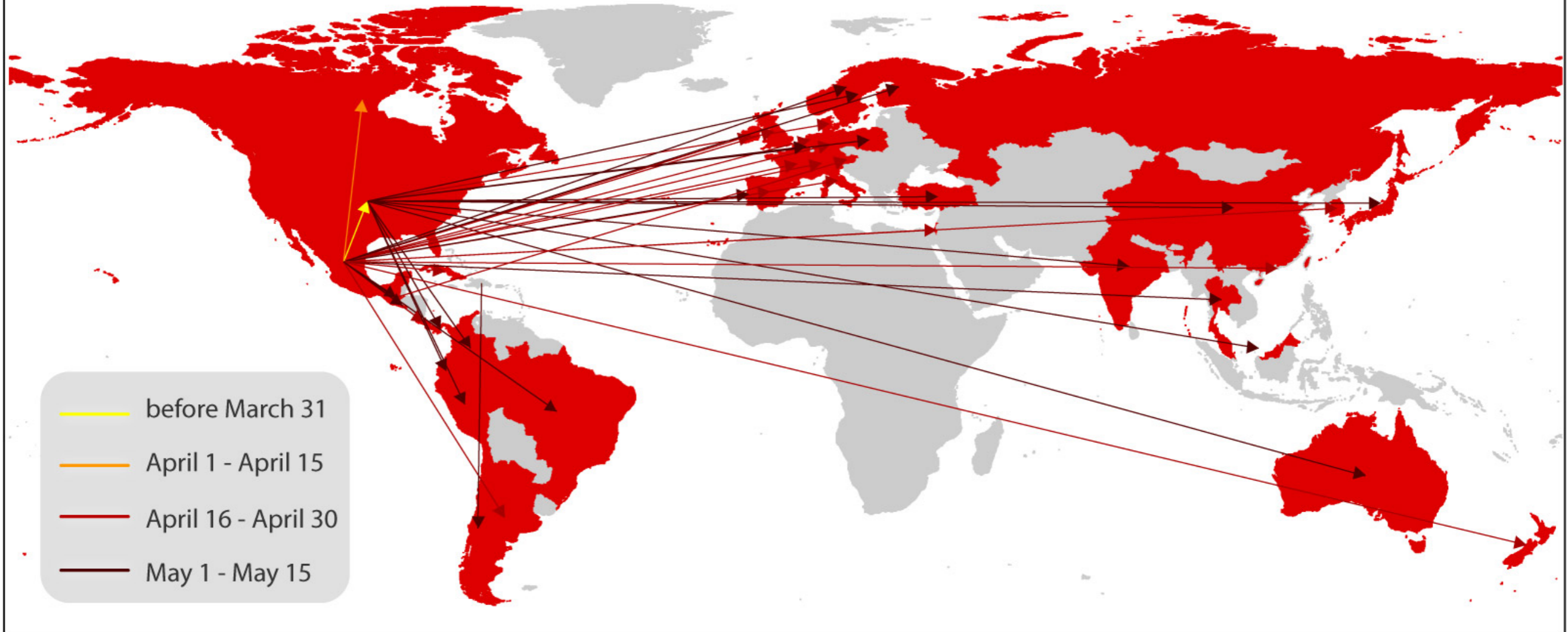


time



# NOWADAYS

H1N1 influenza pandemic, 2009



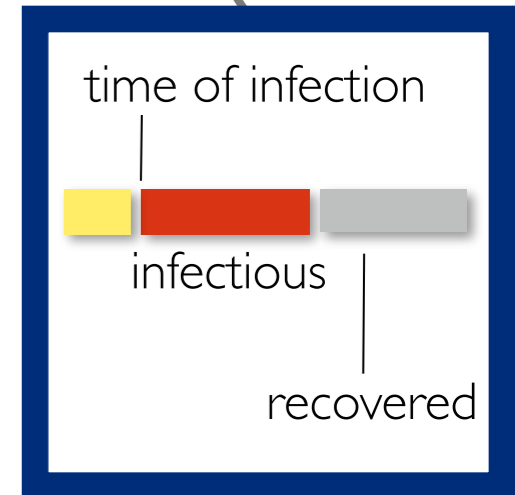
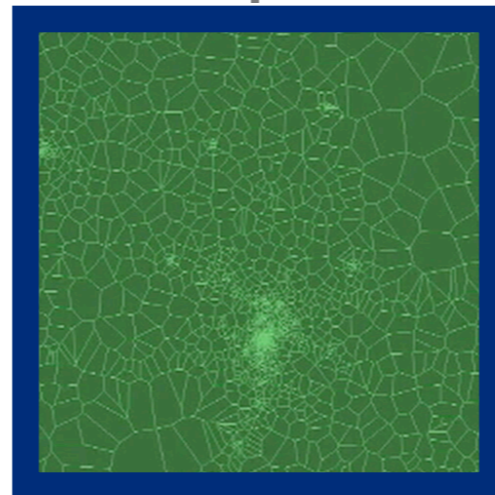
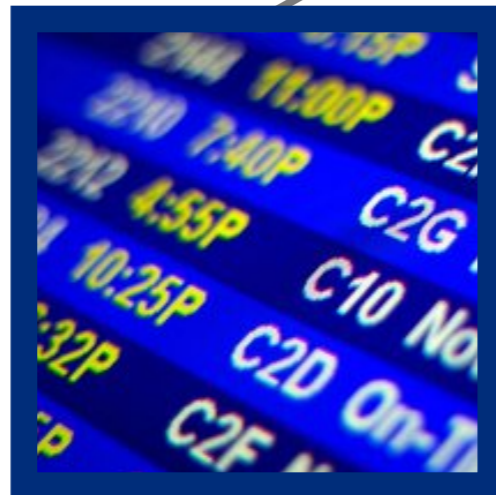


# WHAT DO WE NEED...

people

interactions/mobility

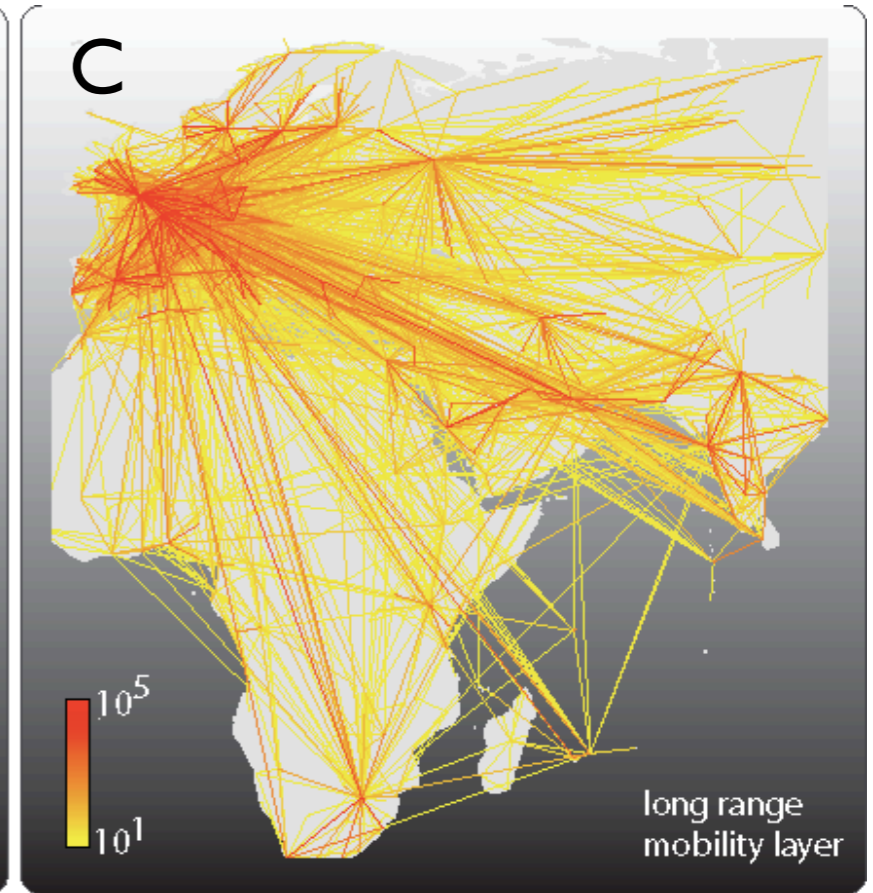
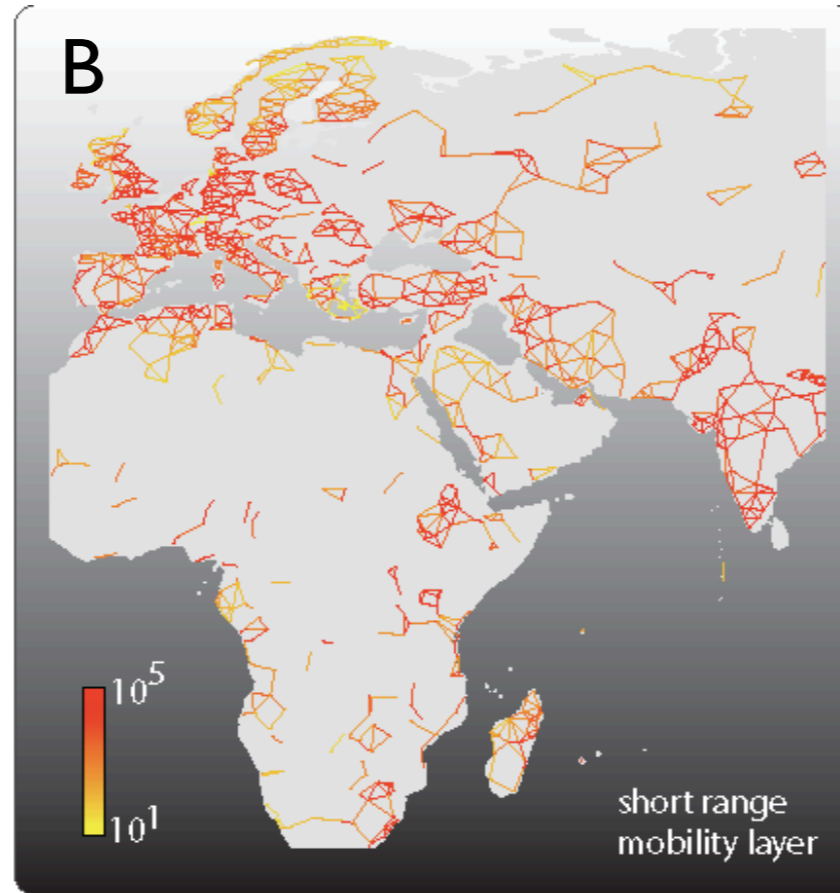
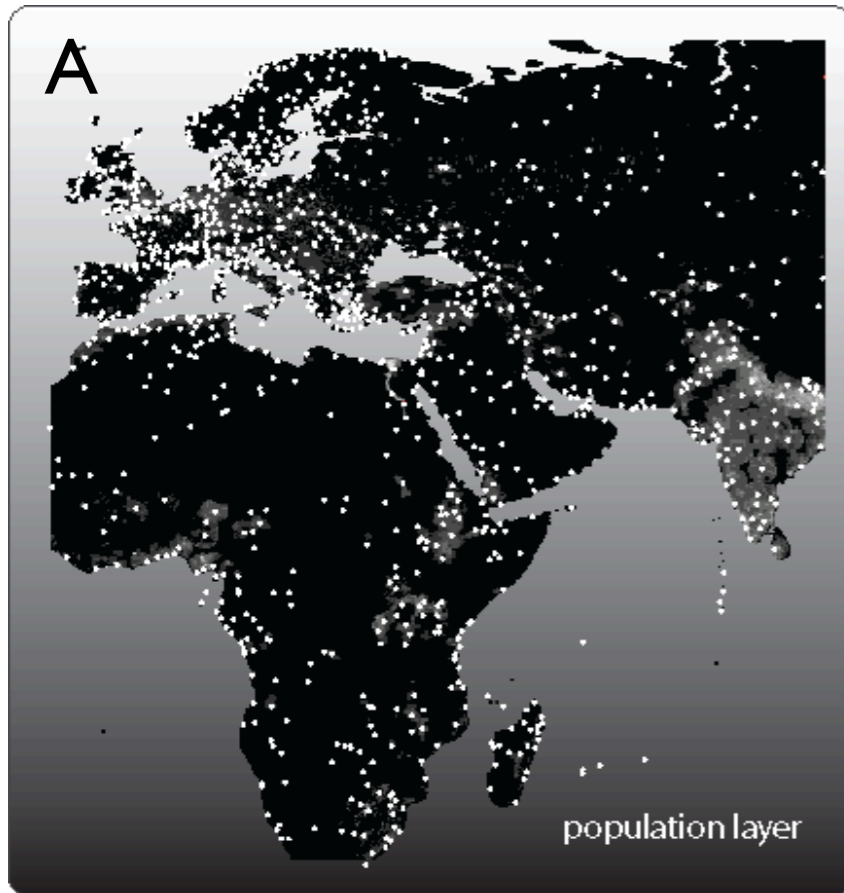
disease



Gonzalez et al (2008)

sociopatterns.org

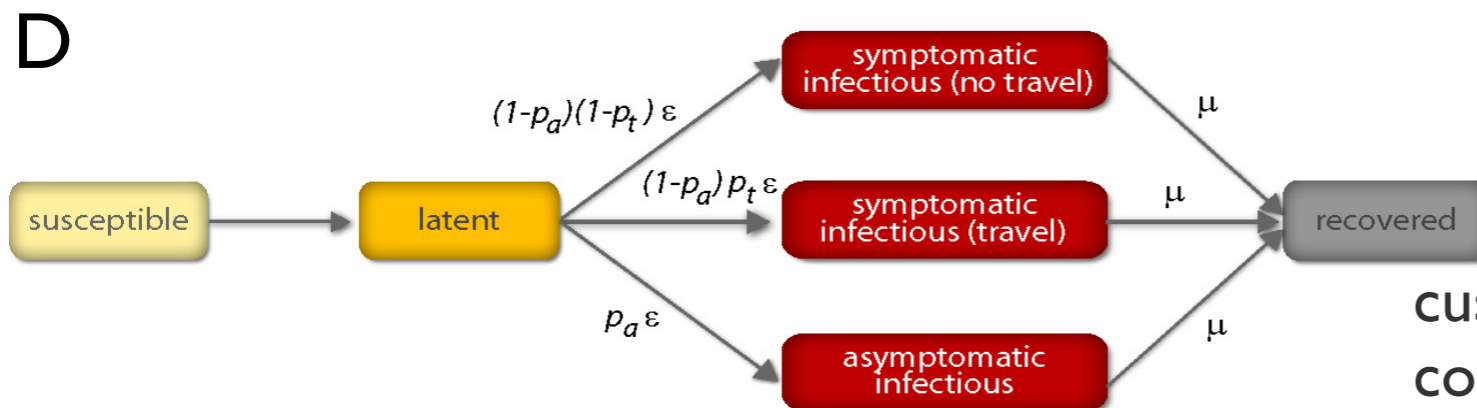
# GLEAM - GLOBAL EPIDEMIC AND MOBILITY MODEL



- population data in cells  $1/4^\circ \times 1/4^\circ$

- daily commuting data

- 3400 airports in 220 countries
- 20,000 connections
- traffic data (IATA, OAG)
- >99% commercial traffic

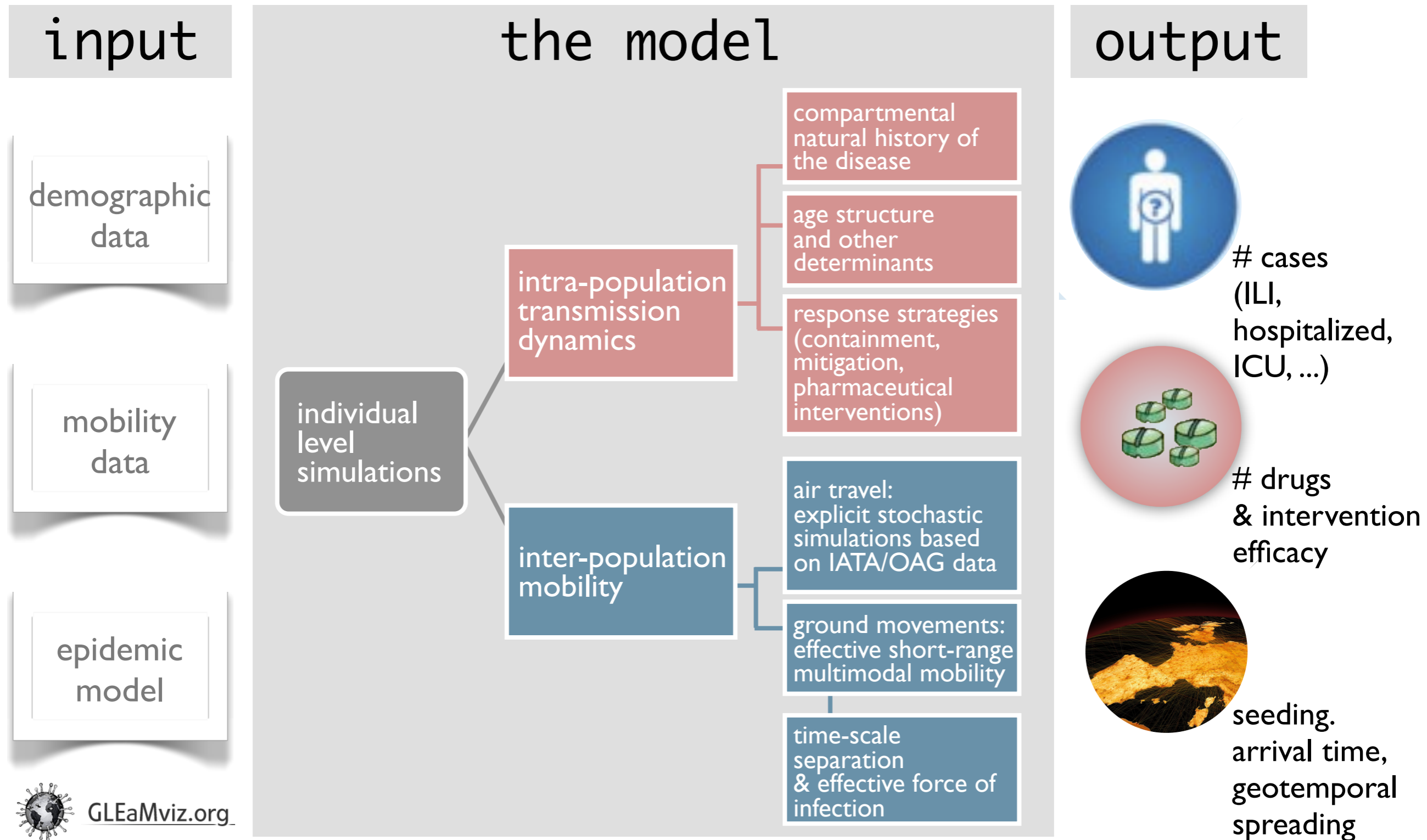


customizable compartmental model

# GLEAM: HOW IT WORKS (I)

GLEaM is based on  
a stochastic metapopulation approach

# GLEAM: HOW IT WORKS (2)

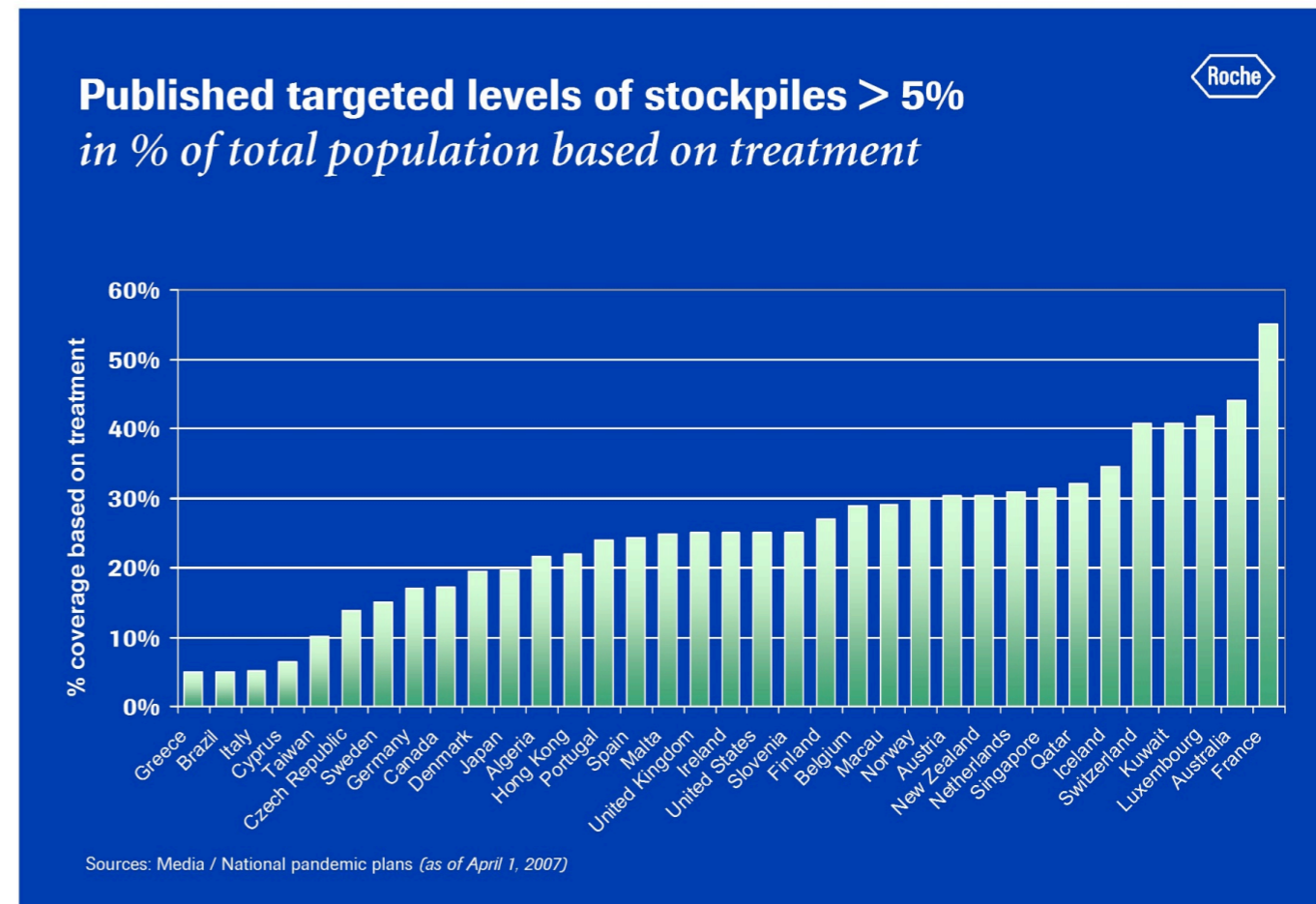
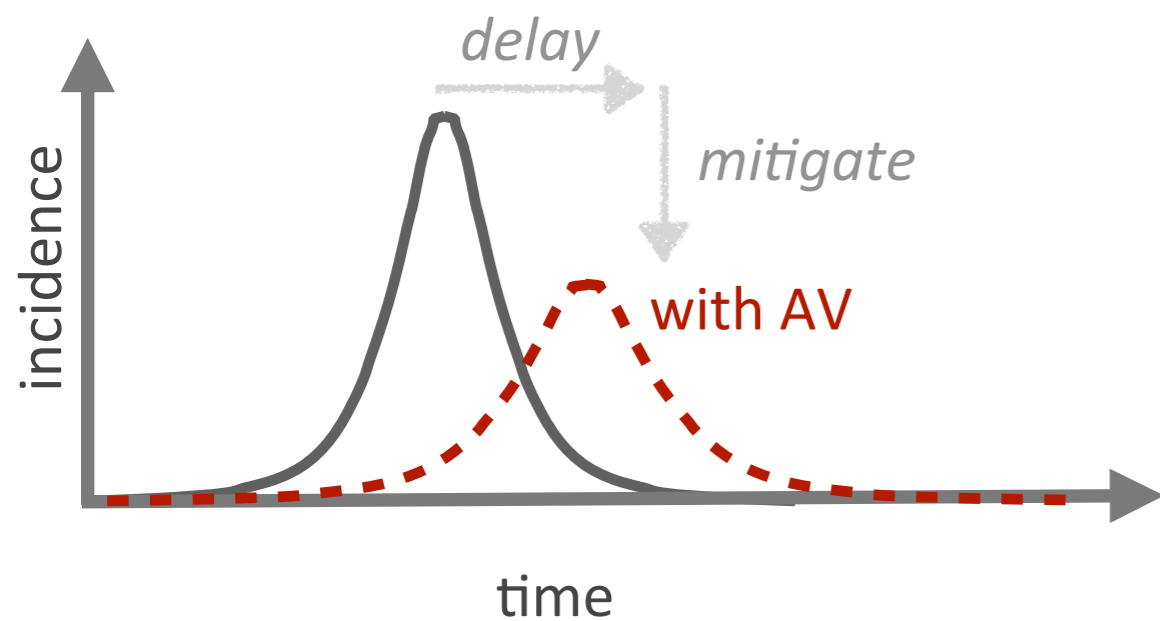


GLEaMviz.org

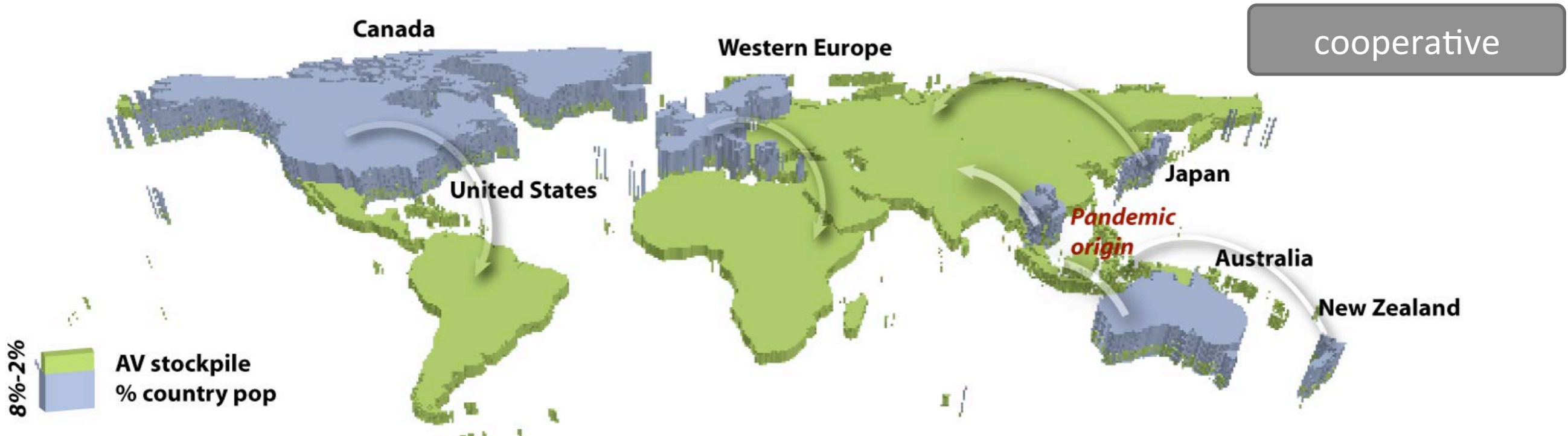
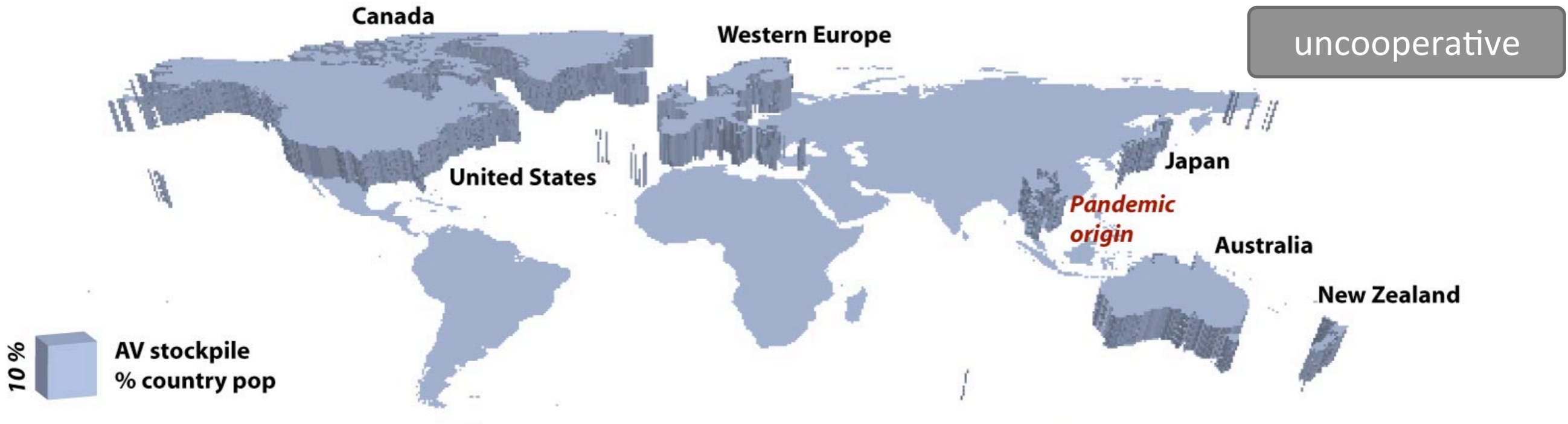
PREPAREDNESS

# WHAT IF... WE USE DRUGS

antiviral (AV) drugs



# GLOBAL STRATEGIES



# WIN-WIN

% cases

no intervention



uncooperative

~50% reduction



cooperative

< 1% reduction!!!





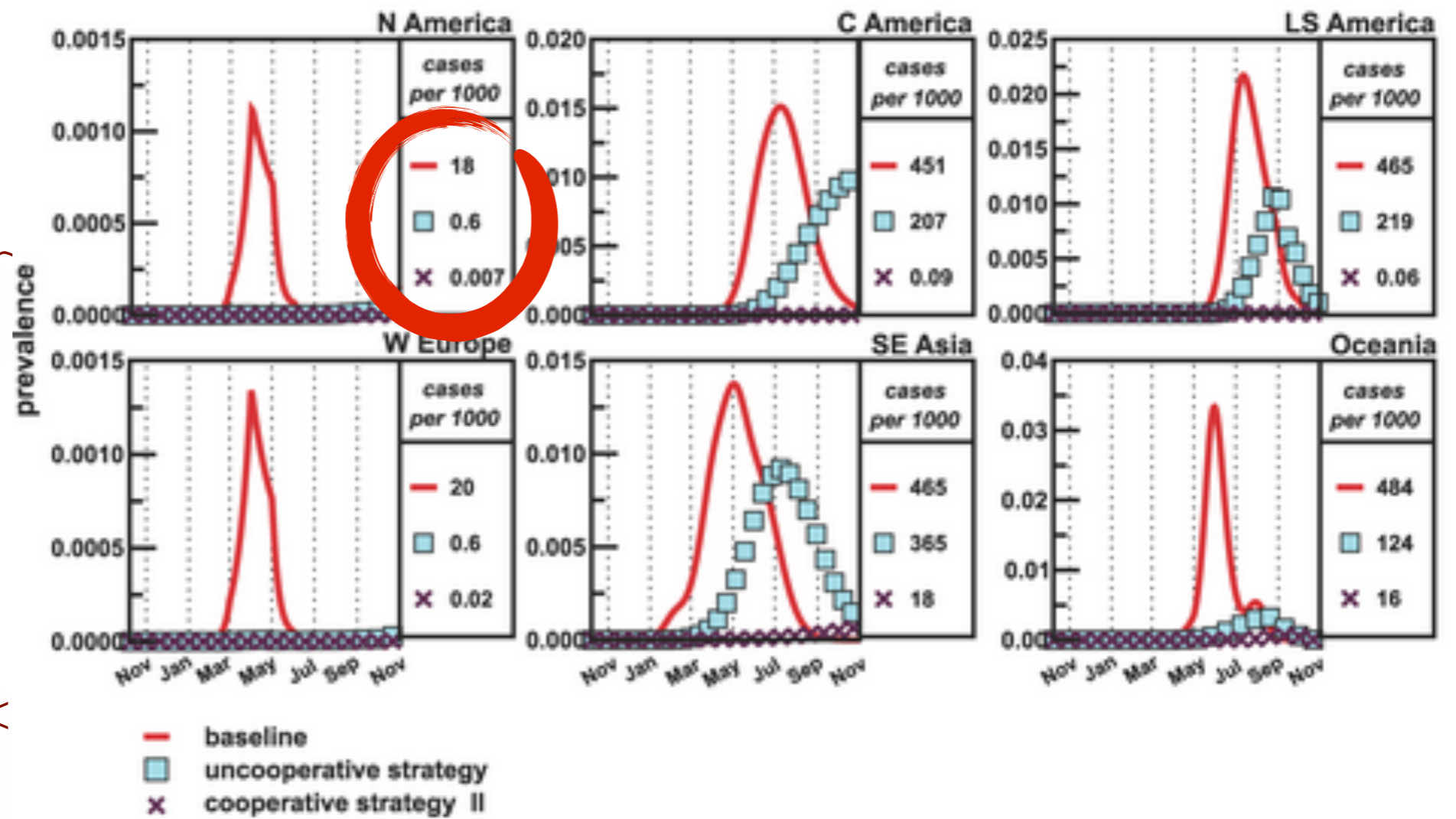
# WIN-WIN

% cases

no intervention

uncooperative

cooperative



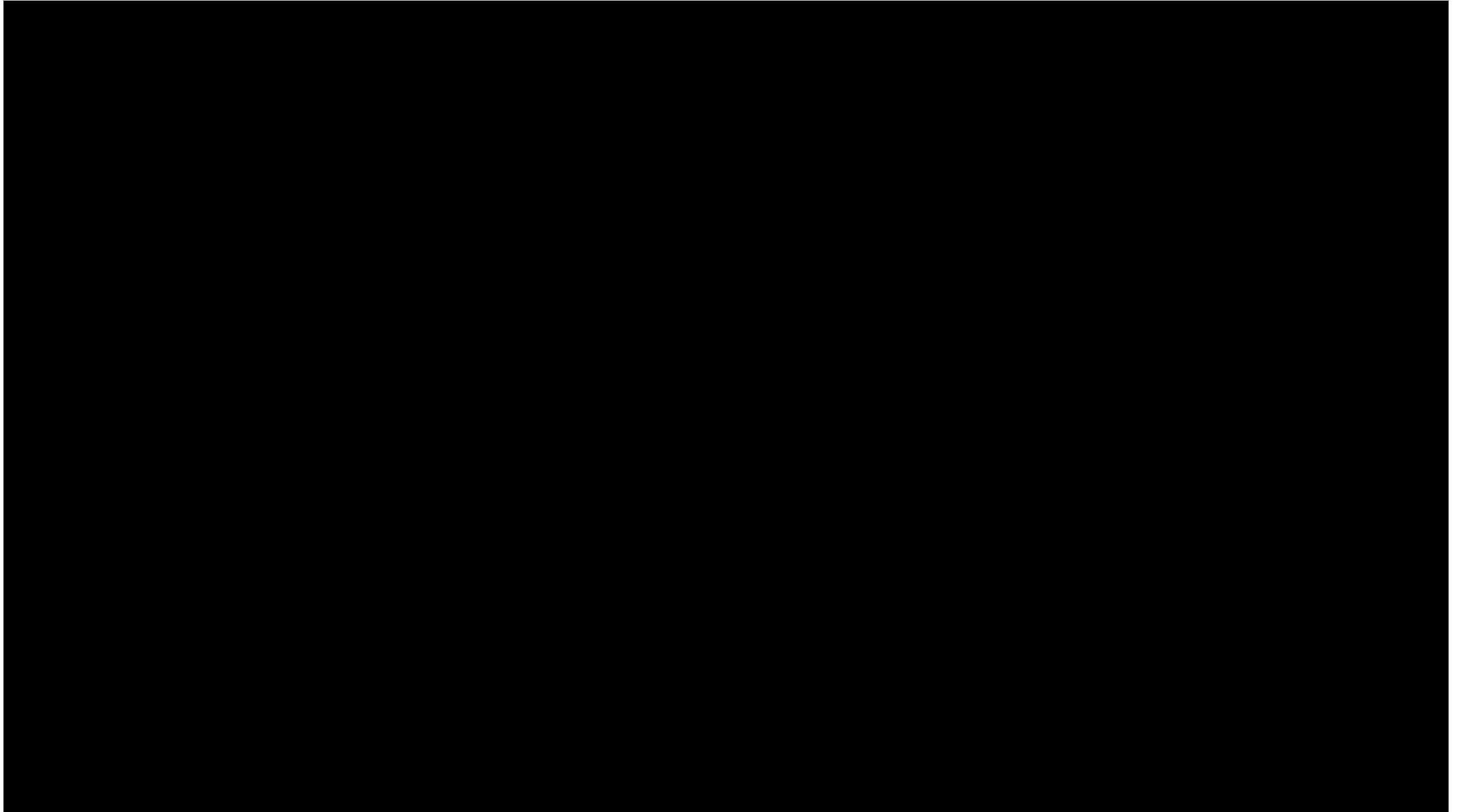
*from*

PREPAREDNESS

*to*

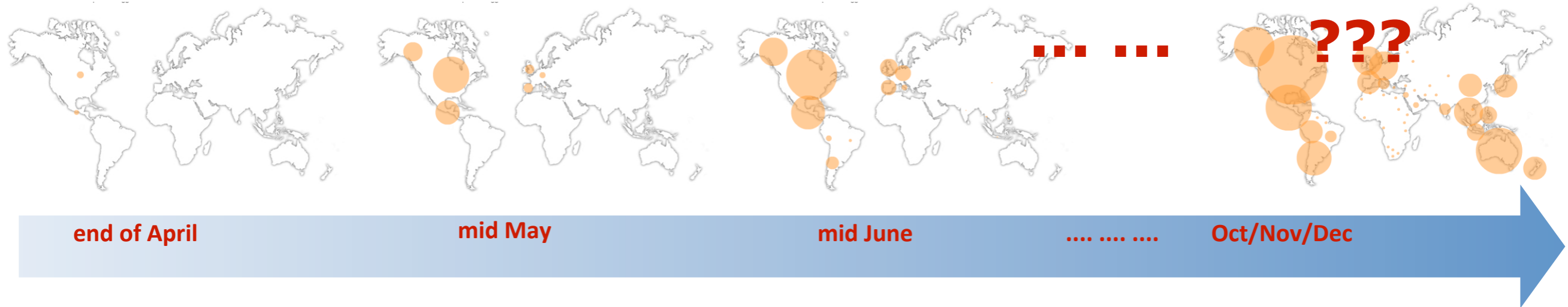
REAL-TIME

# CAN WE ACT *DURING* THE OUTBREAK?



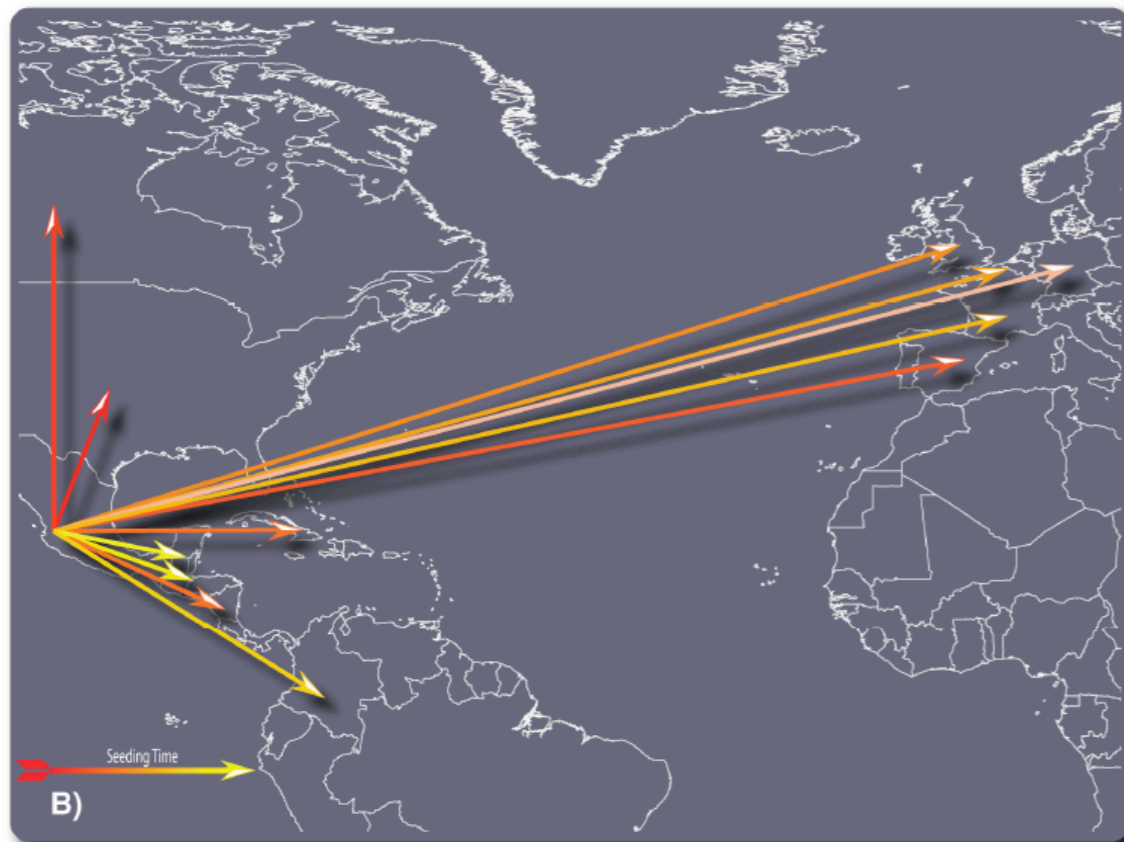
# 2009 H1N1 PANDEMIC

[a true exercise of prediction]

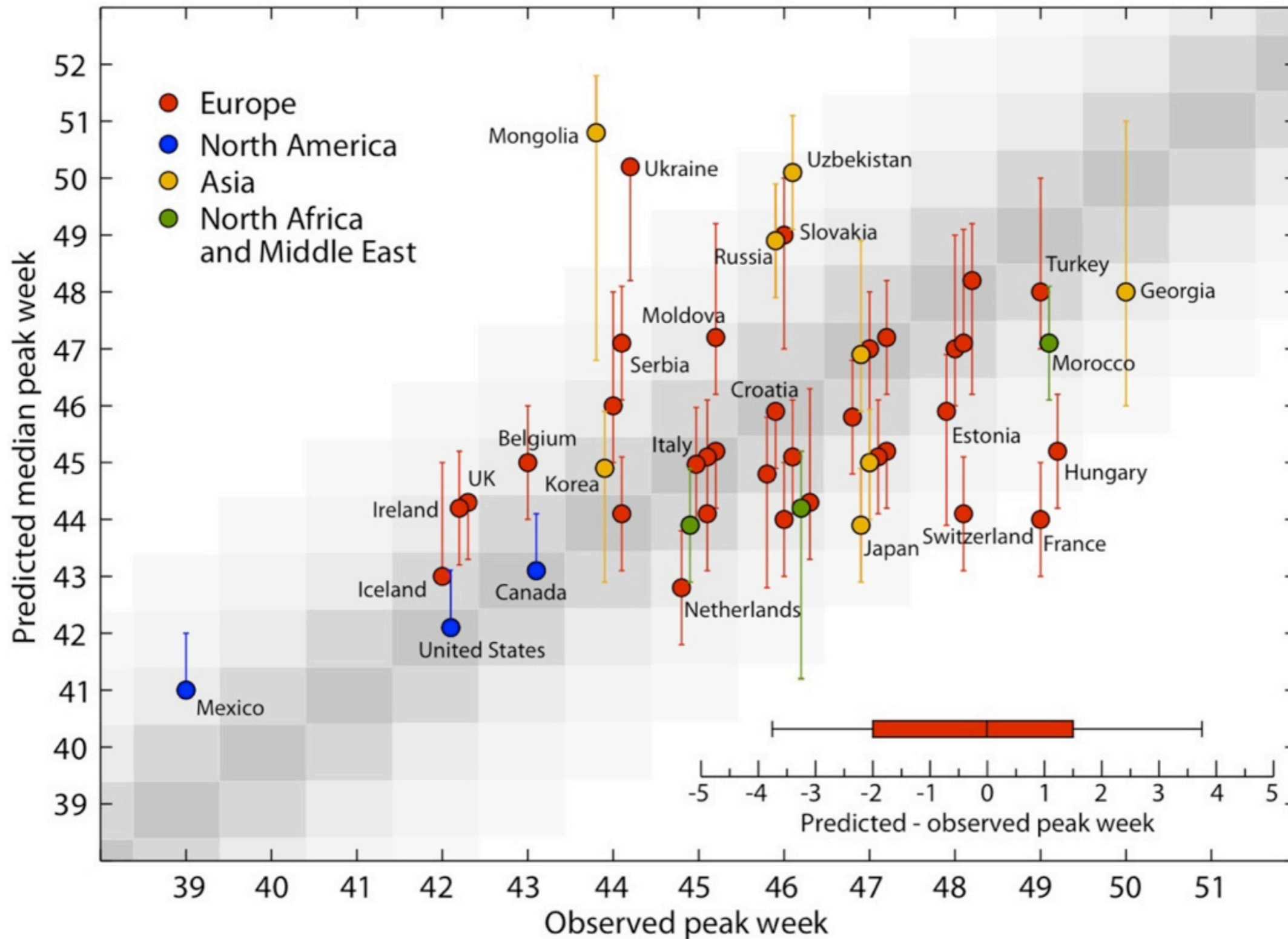


← parameters estimation →

***predictions***



# COMPARISON WITH DATA

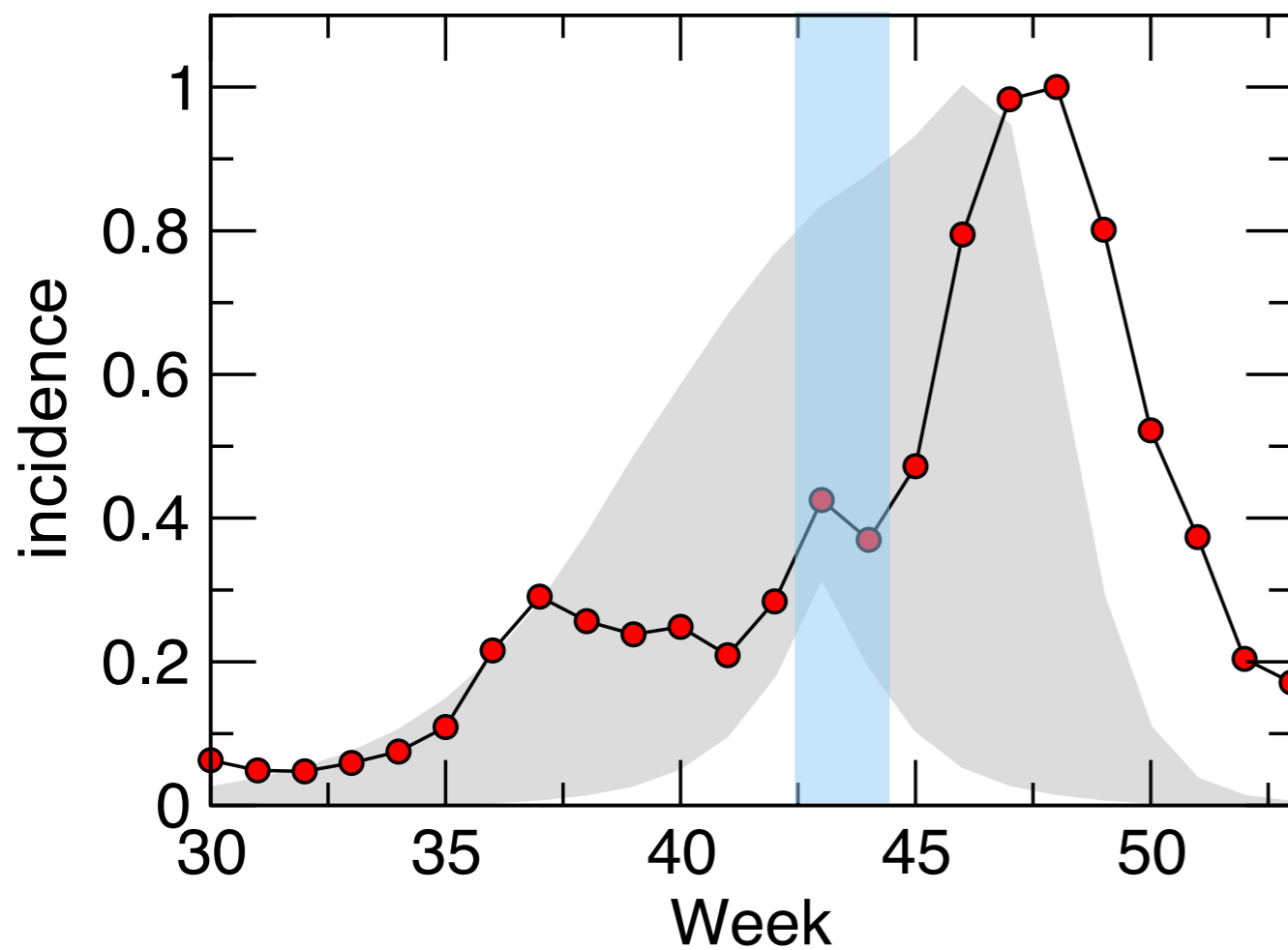


# ZOOM TO FRANCE

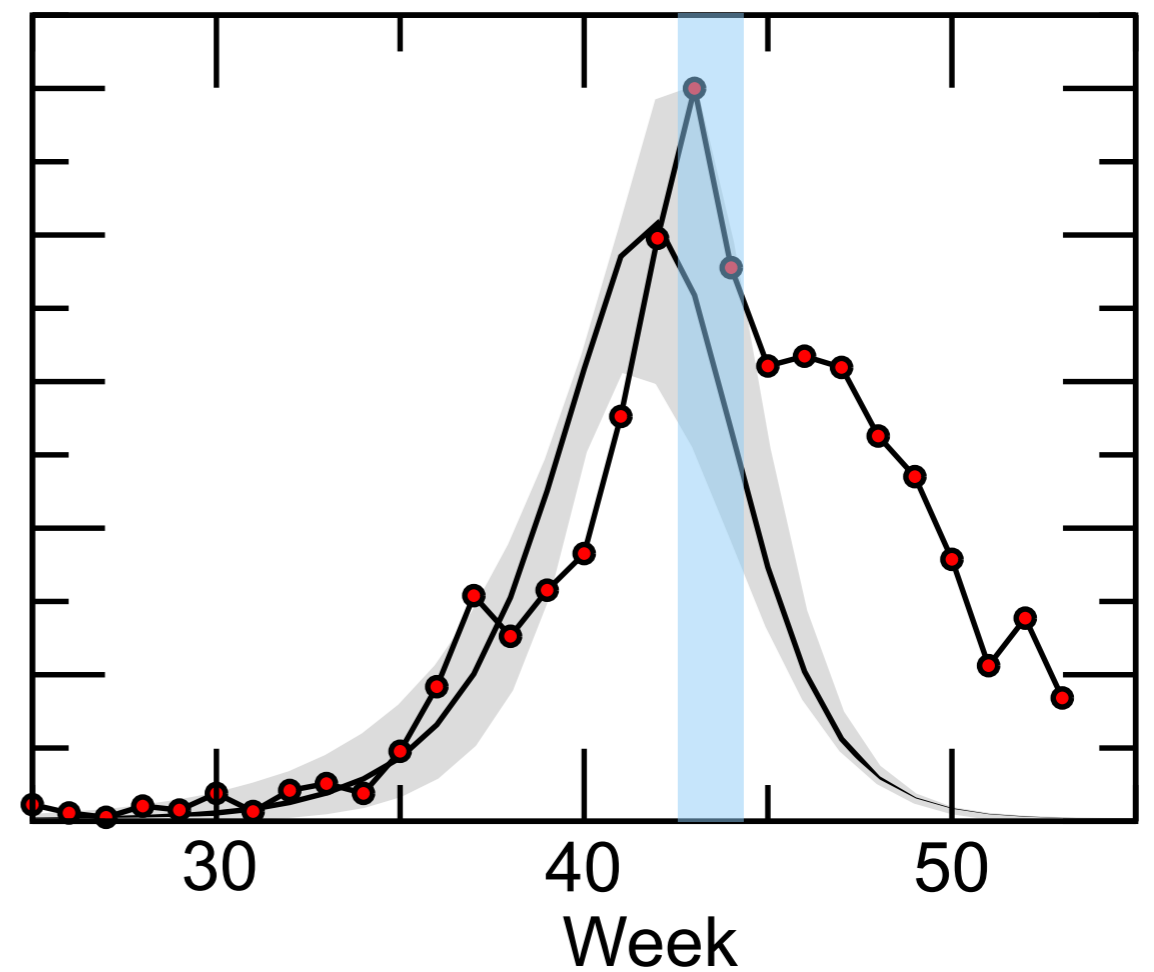
- predictions
- surveillance data

school holiday  
oct 24 - nov 5, 2009

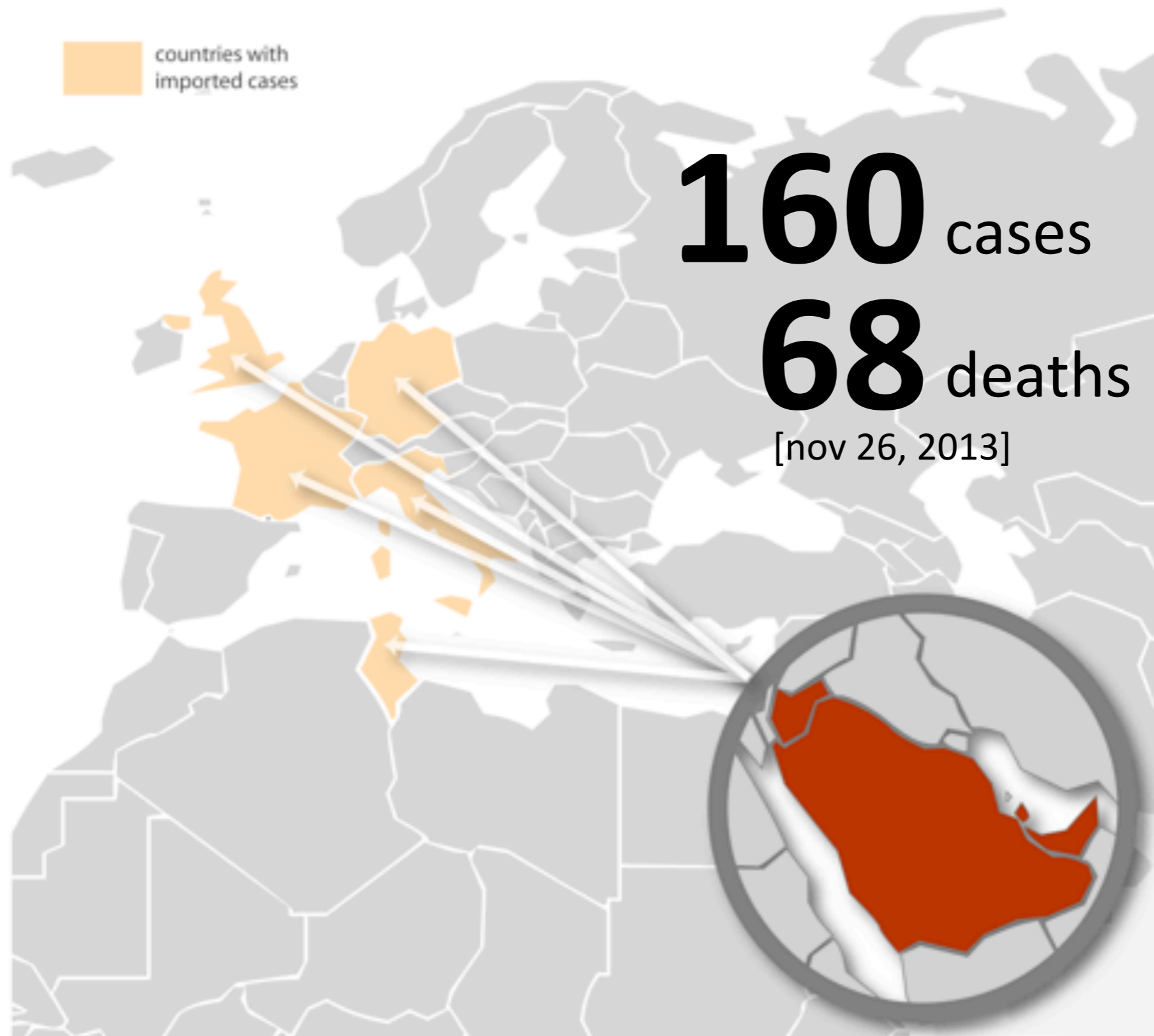
## France



## Ile de France

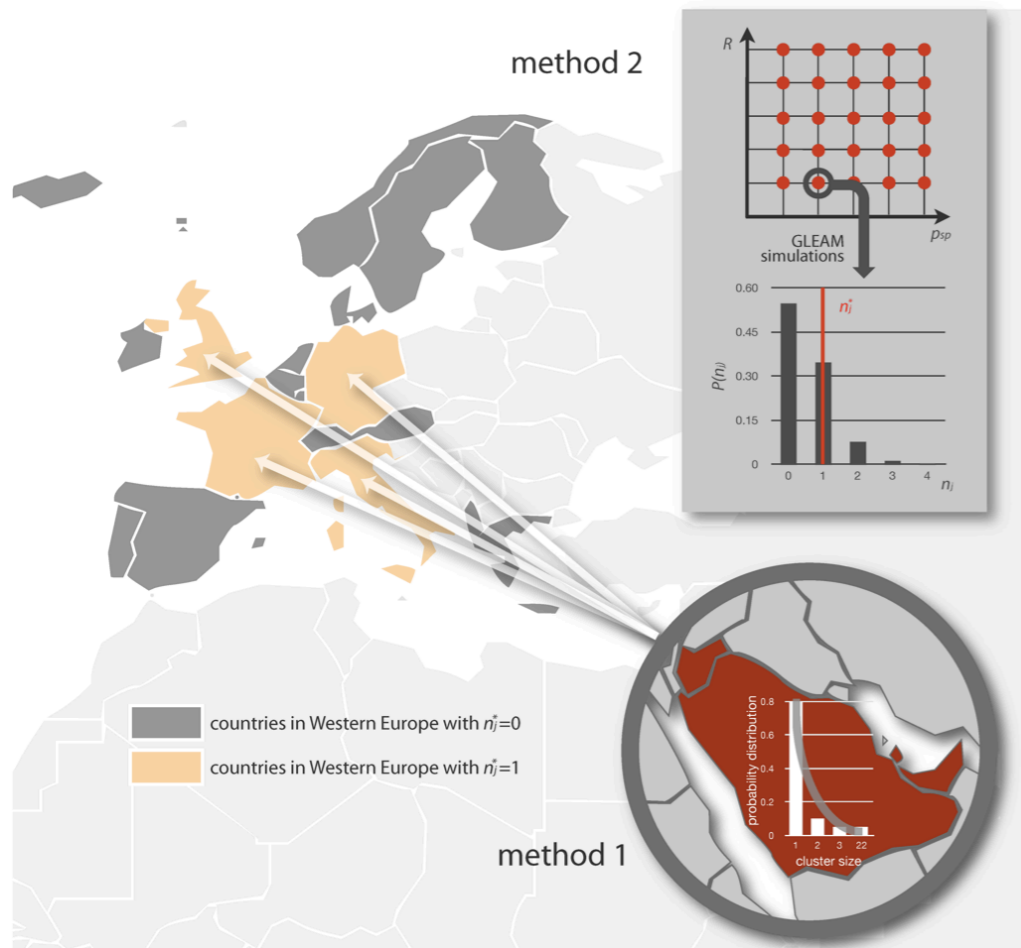


# CURRENT MERS-COV EPIDEMIC



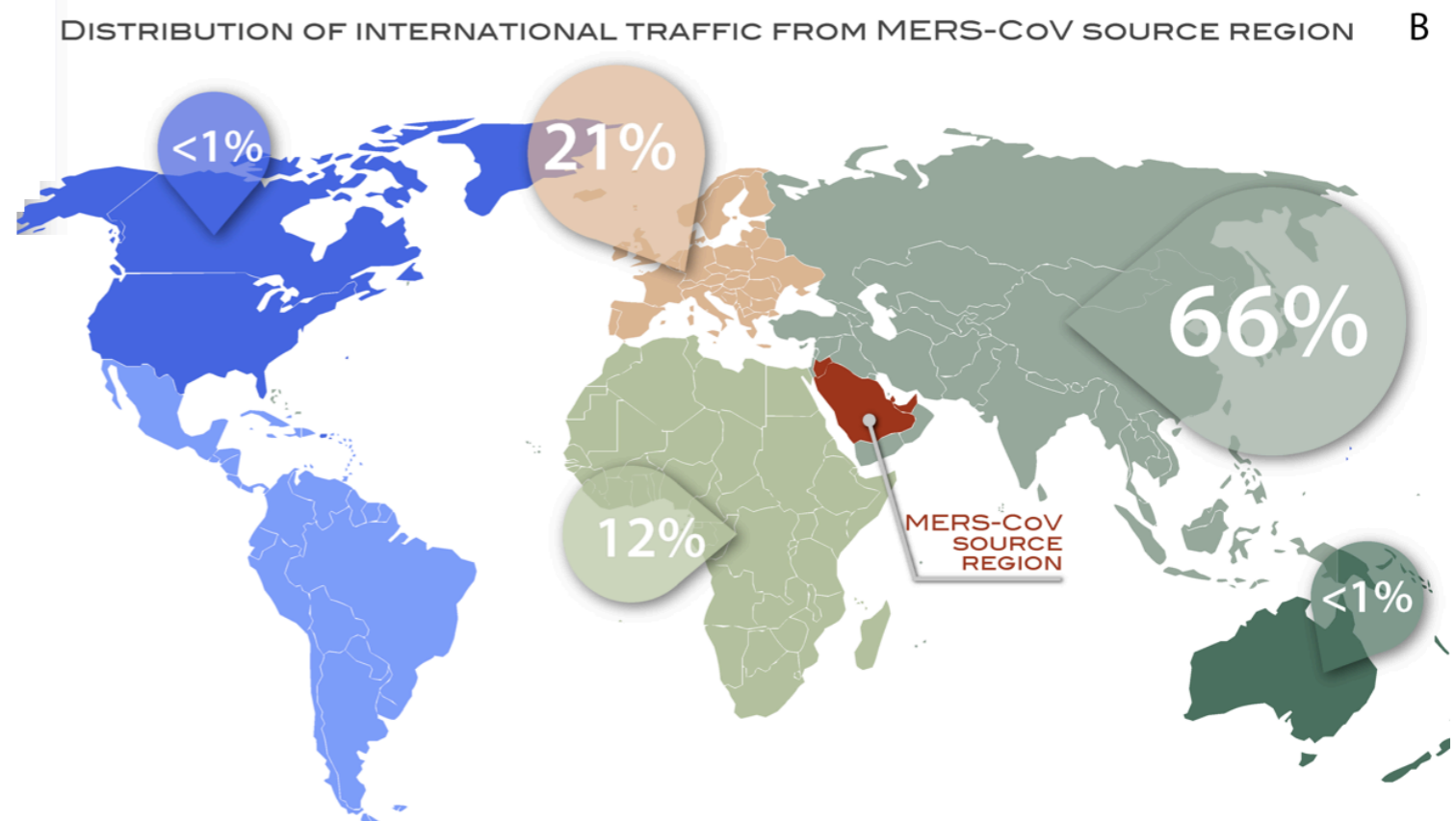
# CURRENT MERS-COV EPIDEMIC

## parameter estimation



## results

- ▶ subcritical epidemic
- ▶ dominance of sporadic cases from zoonotic/environmental transmission
- ▶ actual number of cases 1- to 8-fold the observed number [underascertainment]
- ▶ additional regions at high risk



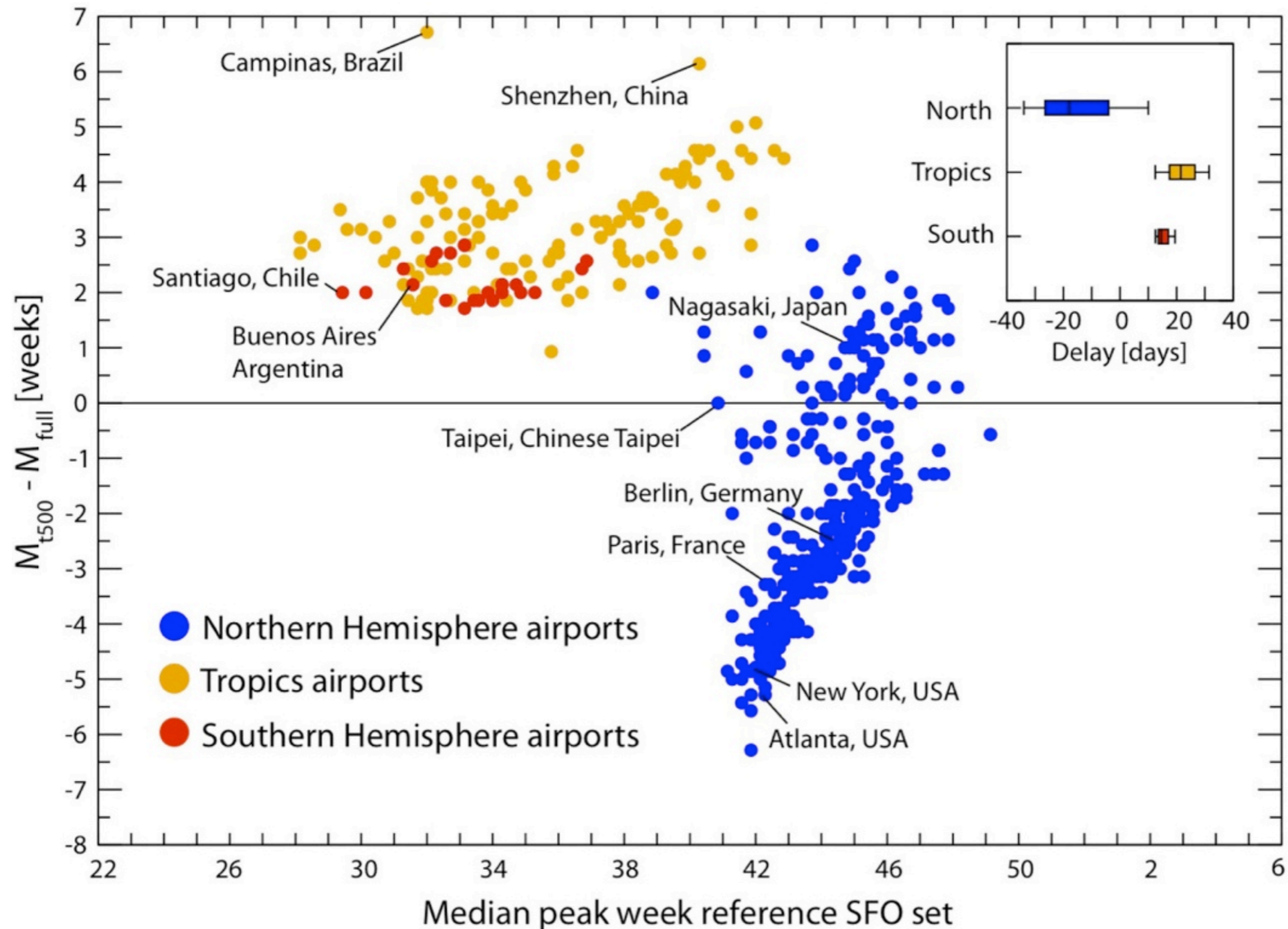


HOW MUCH *BIG DATA*?

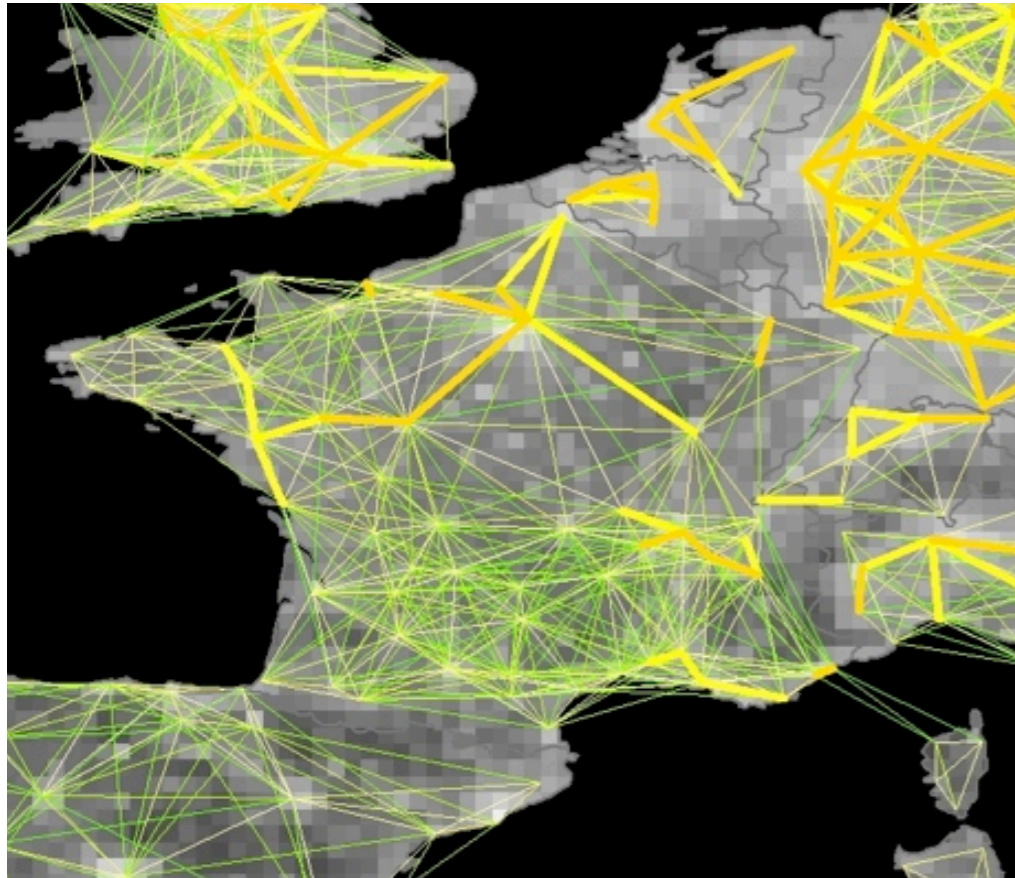
# AIRPORT NETWORK

reference	# airports	# countries
Rvachev & Longini, 1985	52	35
Grais et al, 2003; Flahault et al, 2006	52	35
Cooper et al, 2006; Wu et al, 2009	105	
Epstein et al, 2007	155	
Kenah et al, 2011	321	
Hufnagel et al, 2004	500	>100
Colizza et al, 2006-2007	3,100	220
Balcan et al, 2009; Bajardi et al, 2011; Tizzoni et al, 2012	3,362	220

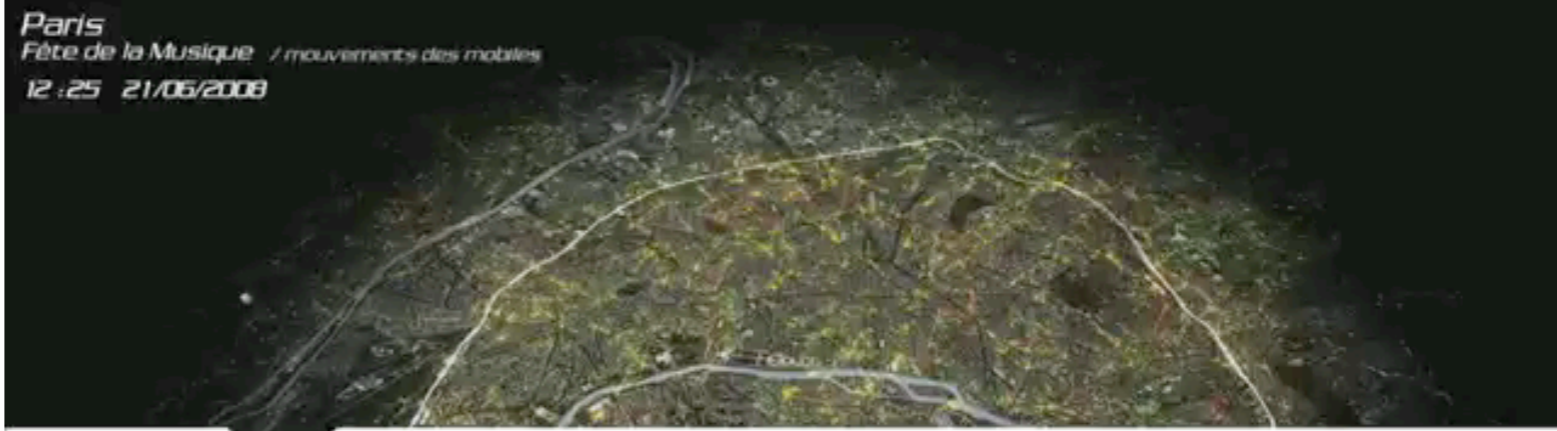
# ERROR ON PREDICTIONS



# INDIVIDUAL MOBILITY



Paris  
Fête de la Musique / mouvements des mobiles  
12:25 21/06/2008



**UrbanMobs**  
●●●

Client: Orange Labs  
December 2007  
*Designing dynamic data visualization tool displaying urban populations activity.*

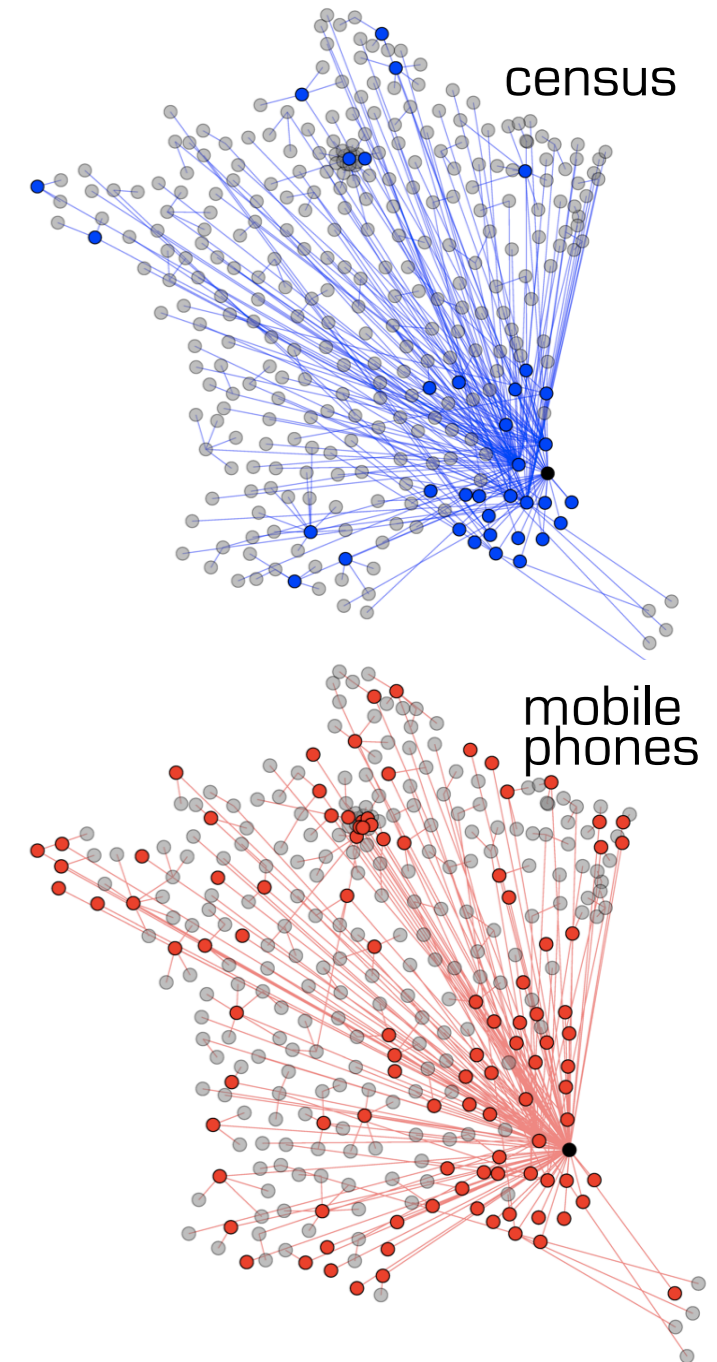
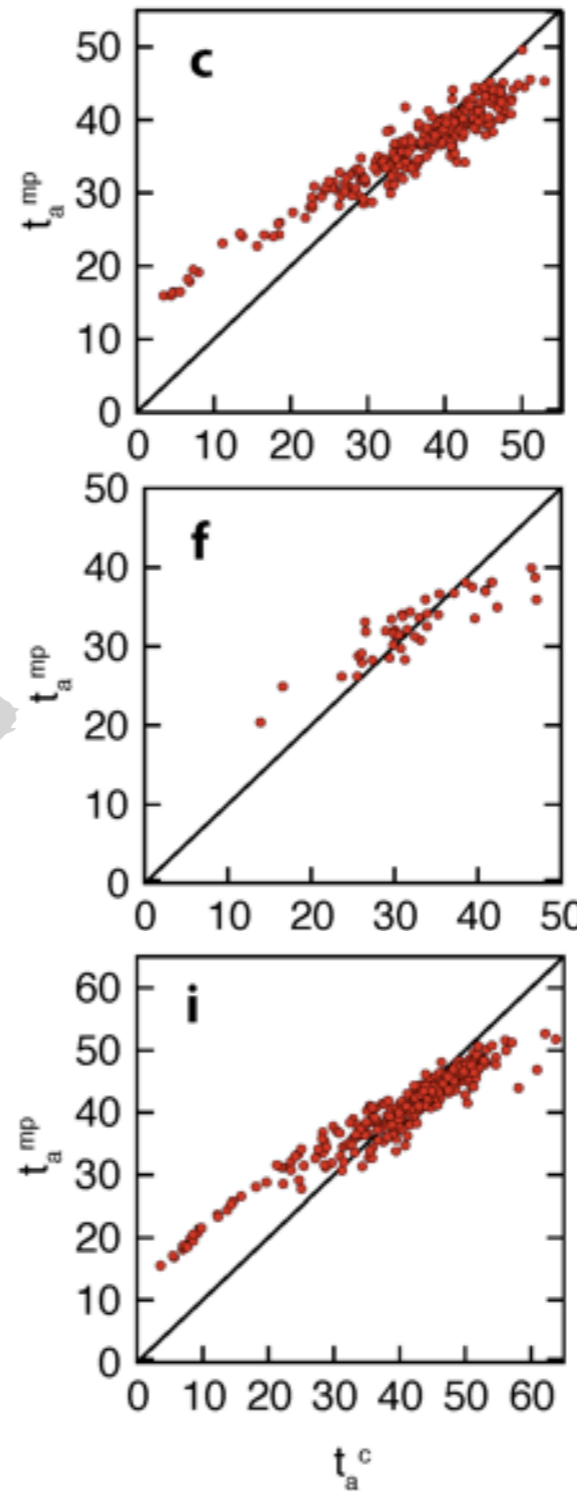
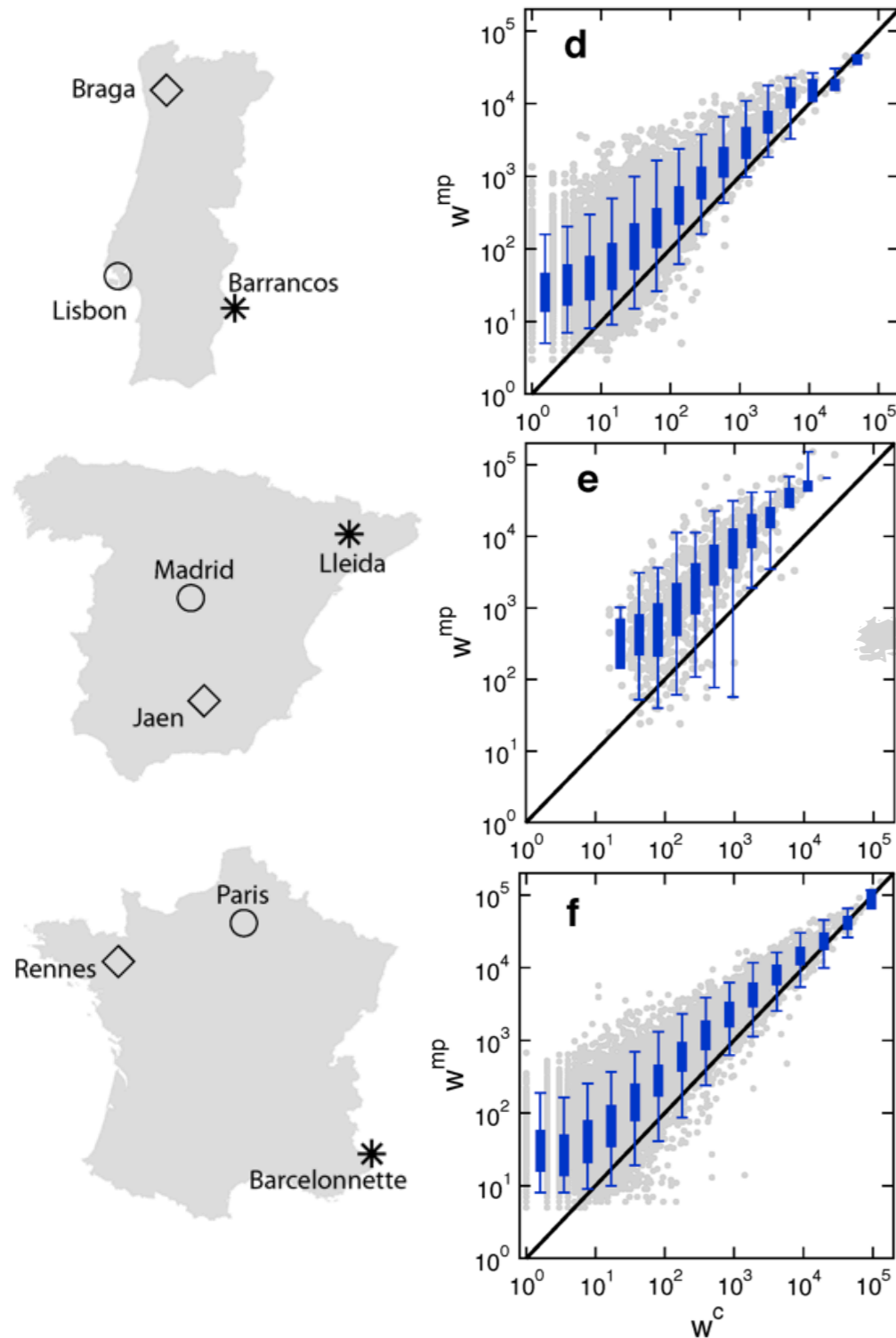
The complex block contains a screenshot of the UrbanMobs application. At the top, it shows a dark aerial view of a city at night, with a network of white lines overlaid, representing individual mobility patterns. The text 'Paris Fête de la Musique / mouvements des mobiles' and '12:25 21/06/2008' is displayed in the top left corner. Below the screenshot, the title 'UrbanMobs' is prominently displayed in a bold, sans-serif font, followed by three small colored dots (red, green, blue). Underneath, the client information 'Client: Orange Labs' and the date 'December 2007' are listed. At the bottom, a descriptive sentence reads: 'Designing dynamic data visualization tool displaying urban populations activity.'

# MOBILE PHONES VS. CENSUS

overestimation of mobility

epidemic acceleration but same rank of infection time

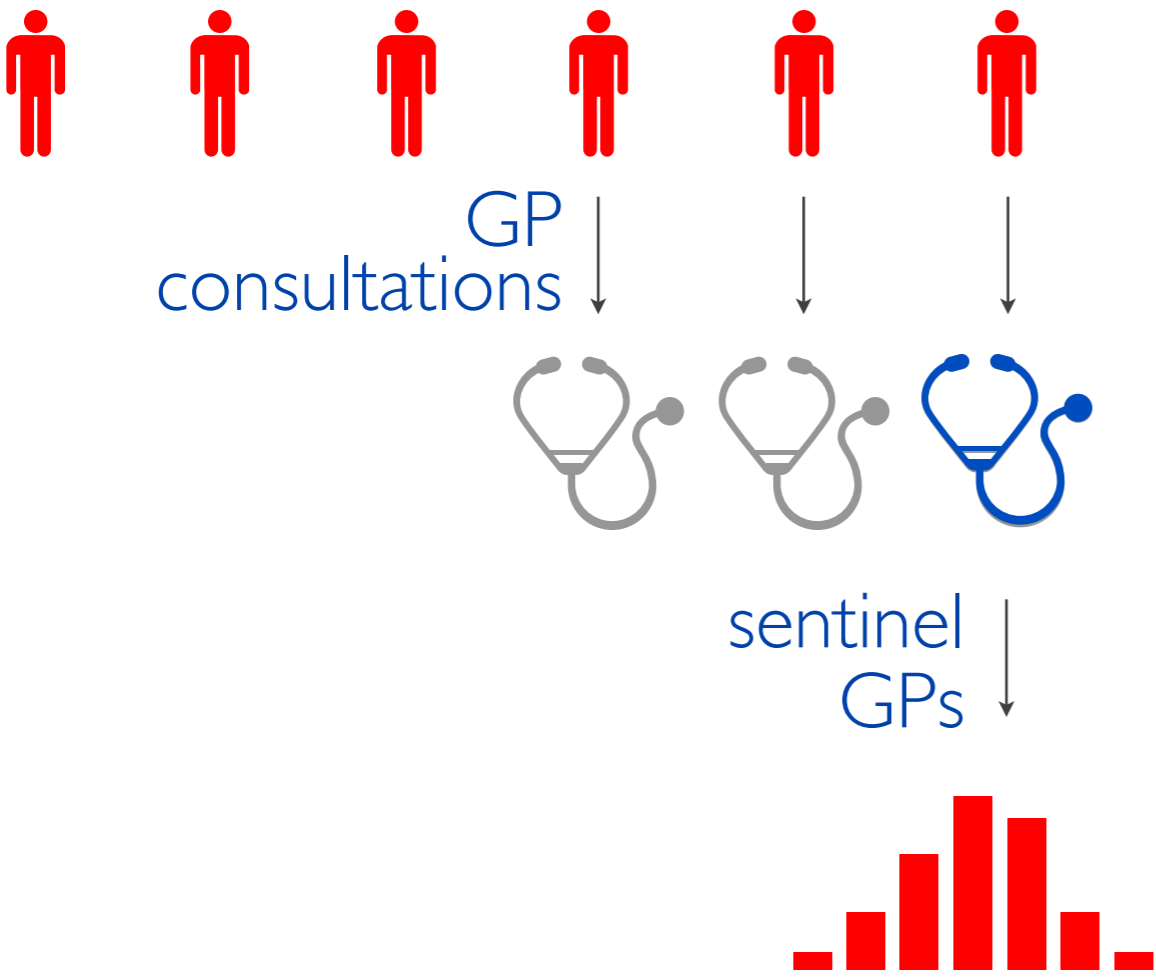
similar epidemic pathways



# COUNTING FLU CASES



digital  
participatory  
surveillance



# ACKNOWLEDGMENTS

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Heike Schmitt



Zbigniew Smoreda



Paolo Bajardi  
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