

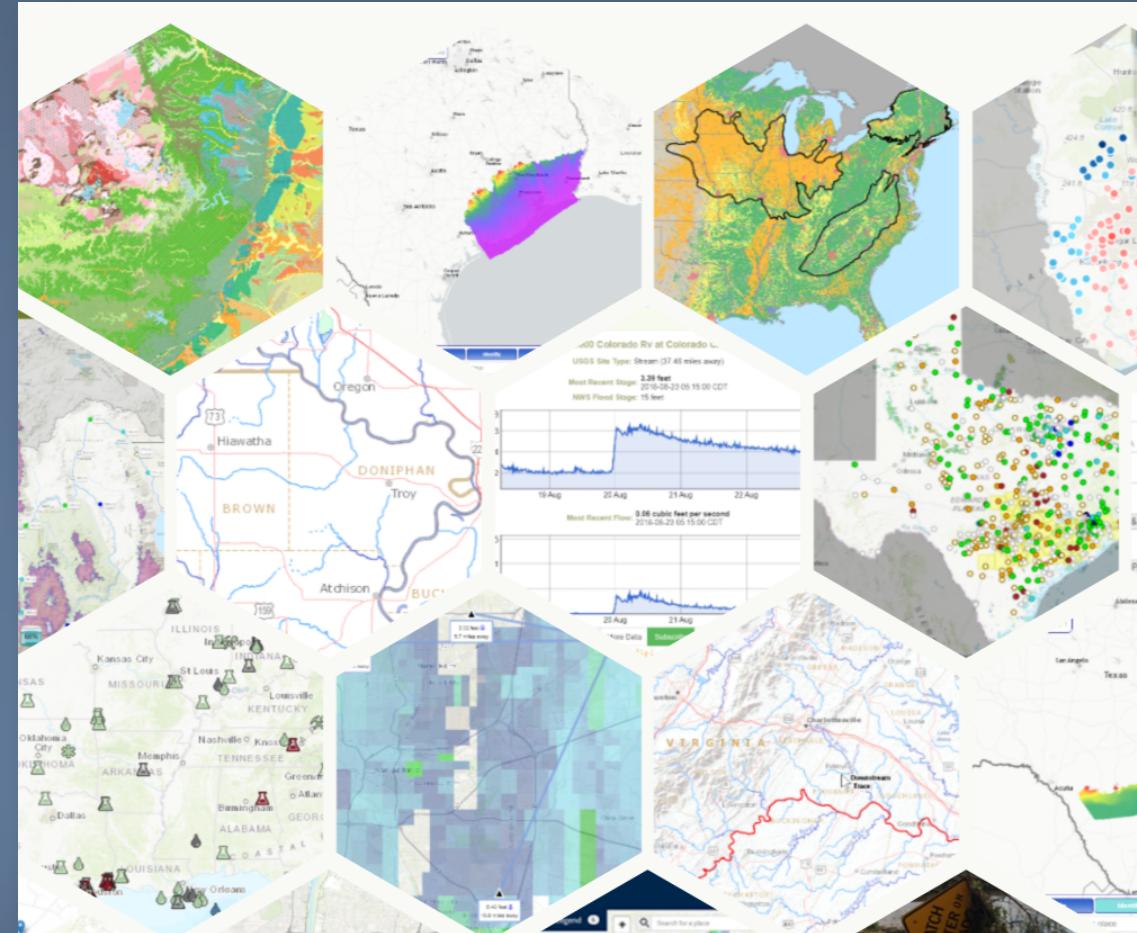
# Geospatial Data Science: Data, Analysis, & Visualization

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# Why geospatial data in the Health Codeathon?

- Movement & mobility of the host or vector
  - Human migration & travel
  - Animal distribution & tracks
- Geography can be an important factor
  - Distance, climate, quality of healthcare, eating habit...
- Geovisualization
  - Map it out to present the spatial patterns directly and interactively



# 1. Human movement—epidemics

**THE LANCET**  
Available online 31 January 2020  
In Press, Corrected Proof 

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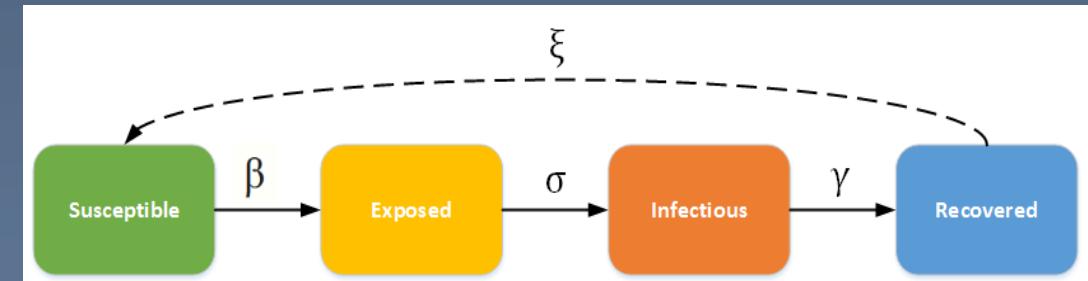
Articles

Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study

Prof Joseph T Wu PhD \*, Kathy Leung PhD \*, Prof Gabriel M Leung MD 

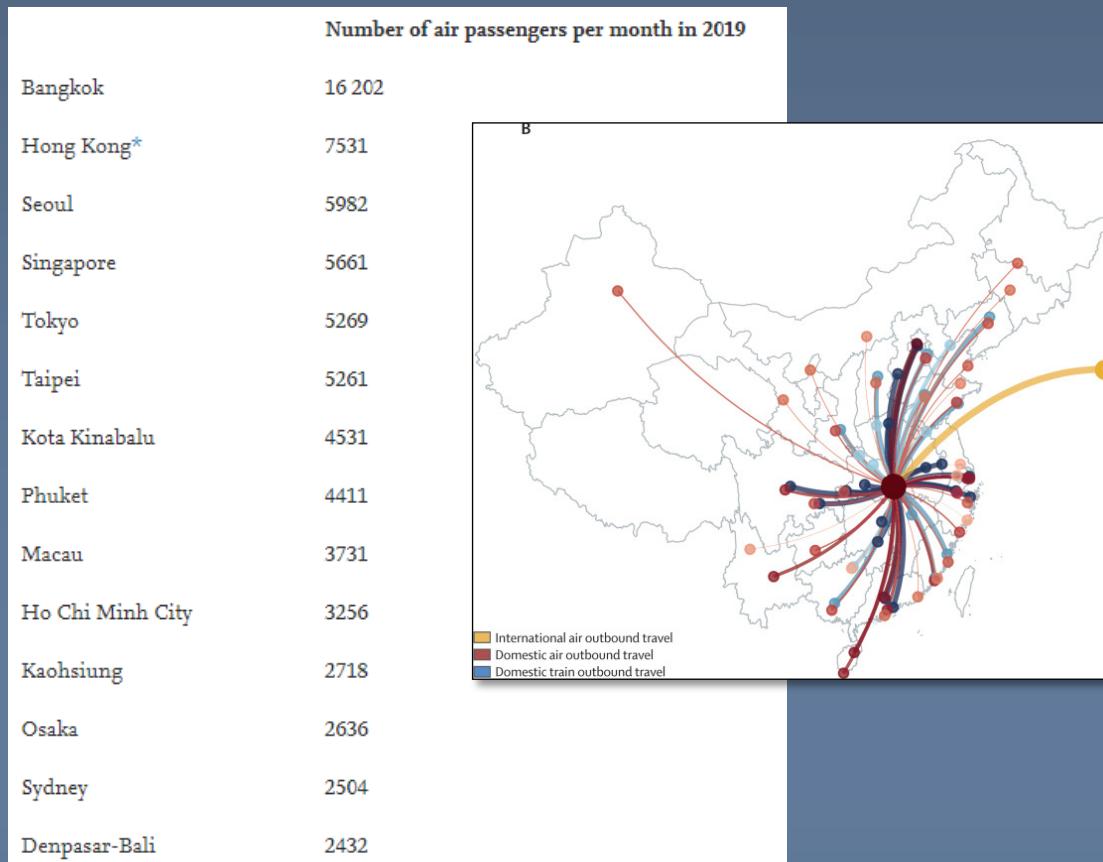


- SEIR model + human travel

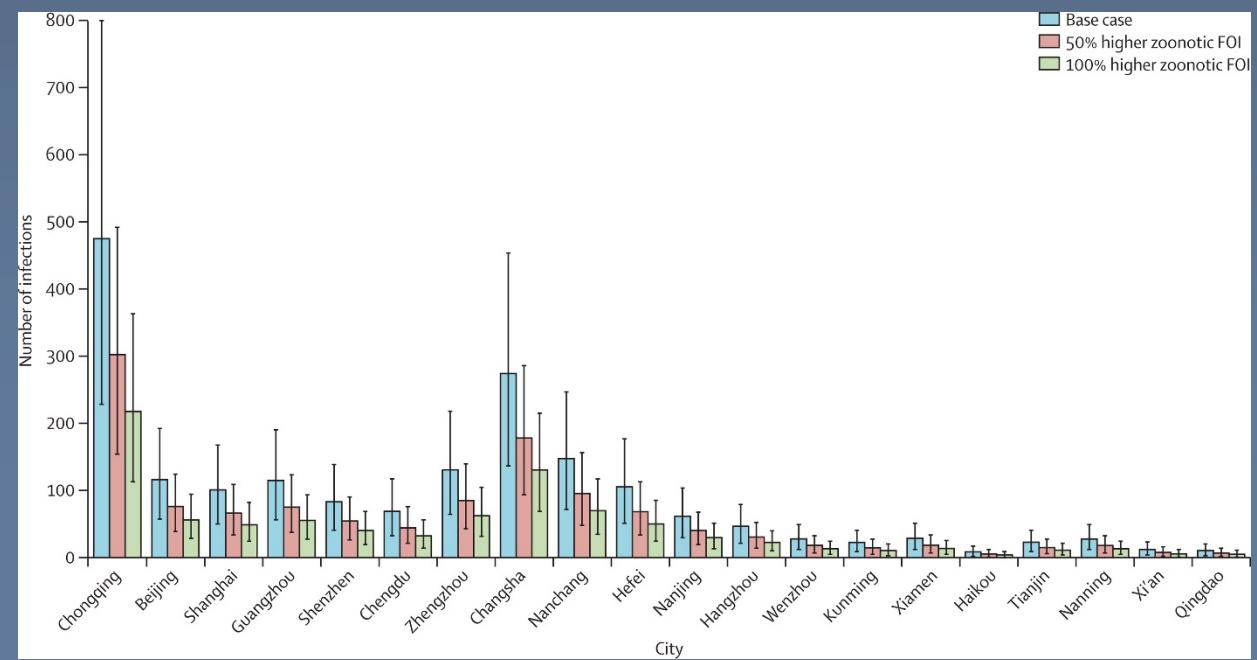


- Disease transmission:
  - SARS-CoV + MERS-CoV
- Human travel
  - Flight + Individual locations

# Flights & location tracking



A prediction of COVID-19 spread domestically & internationally



# Human movement data

- ACS migration data from Census Bureau

<https://www.census.gov/topics/population/migration/data/tables/acs.All.html>

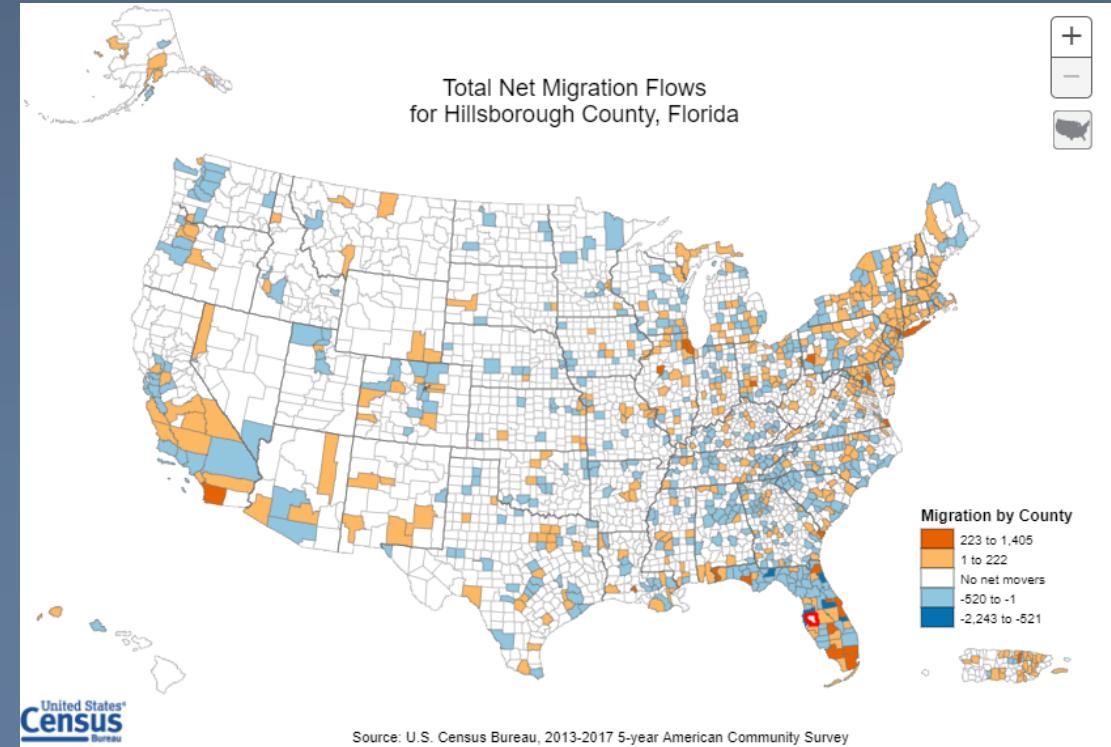
<https://flowsmapper.geo.census.gov/>

- Transport data from DOT : flight, vehicle, etc.

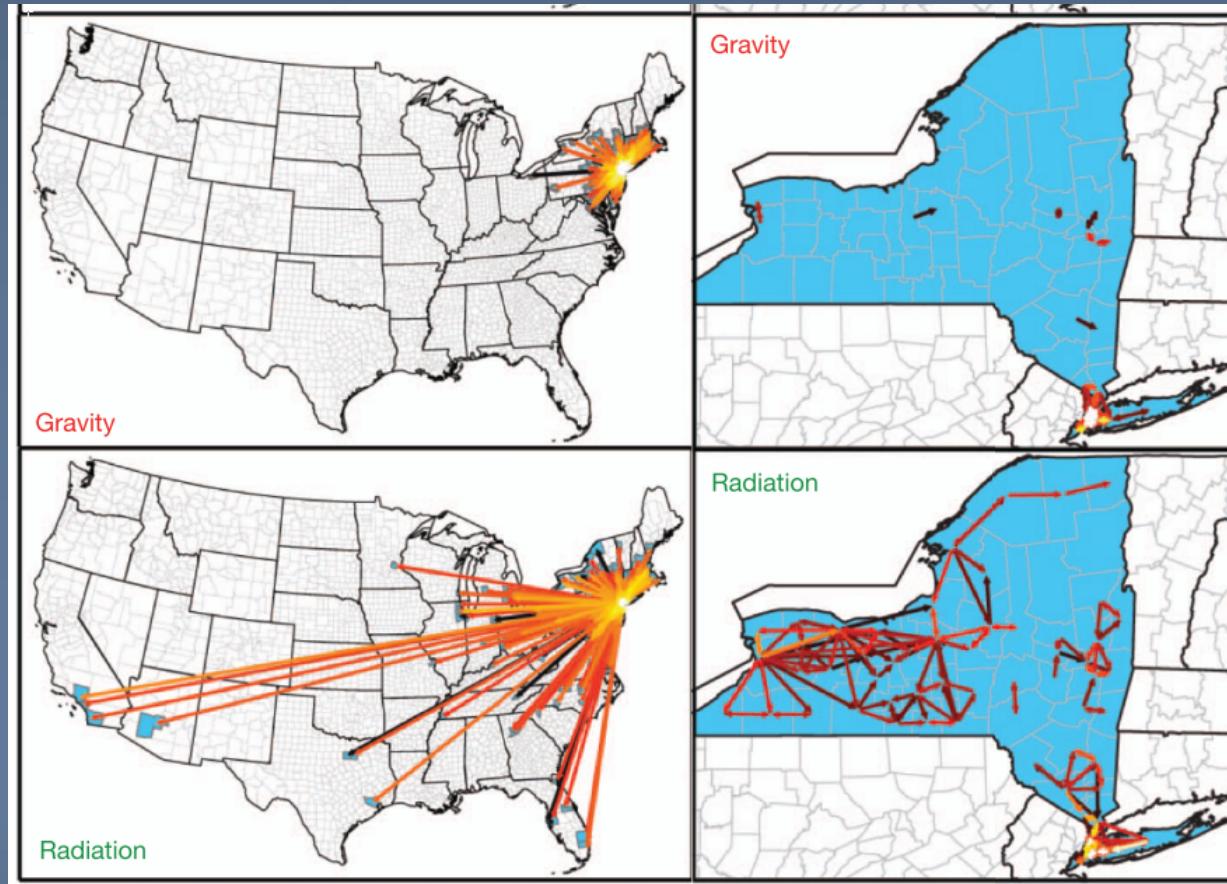
<https://www.bts.gov/browse-statistical-products-and-data>

- Uber Movement

<https://movement.uber.com/?lang=en-US>



# Simple model of movement flows



- Gravity model

$$T_{ij} = \frac{m_i^\alpha n_j^\beta}{f(r_{ij})}$$

- Radiation model

$$\langle T_{ij} \rangle = T_i \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}$$

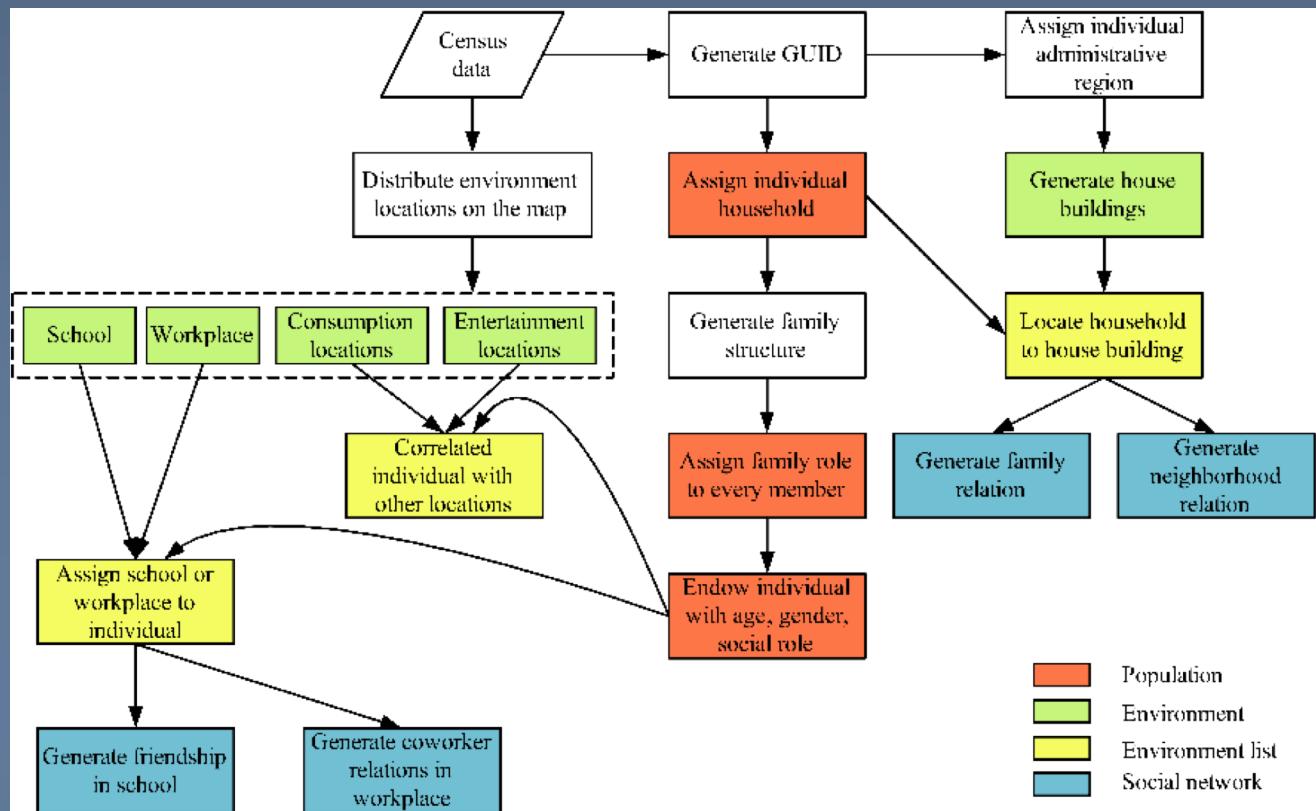
Data needed: population, distance

Tool: <https://github.com/scikit-mobility/scikit-mobility>

Simini, F., González, M. C., Maritan, A., & Barabási, A. L. (2012). A universal model for mobility and migration patterns. *Nature*, 484(7392), 96–100.

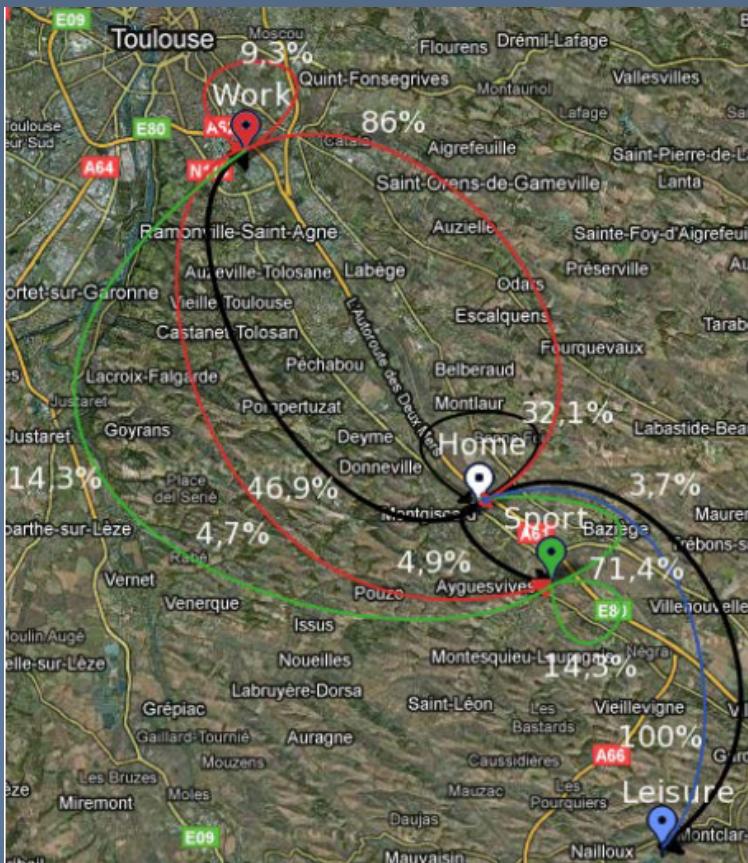
# Fine-resolution human mobility model

Environment + Social network



# Individual mobility models

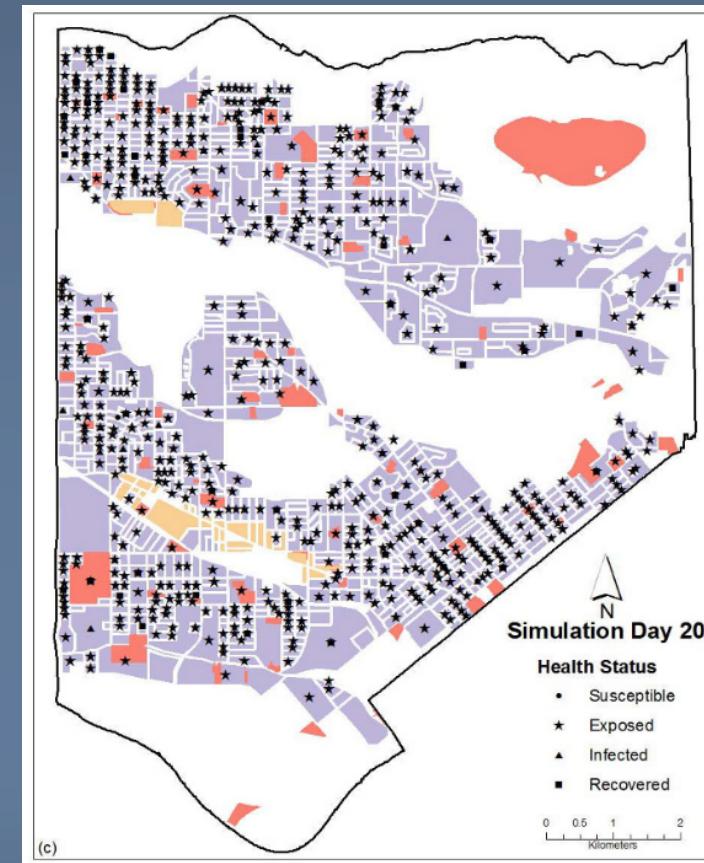
Next place prediction with Markov chains



Gambs, S., Killijian, M. O., & Del Prado Cortez, M. N. (2012). Next place prediction using mobility Markov chains. *Proceedings of the 1st Workshop on Measurement, Privacy, and Mobility, MPM'12*, 0–5.

02/26/2020

Agent-based modeling (ABM)

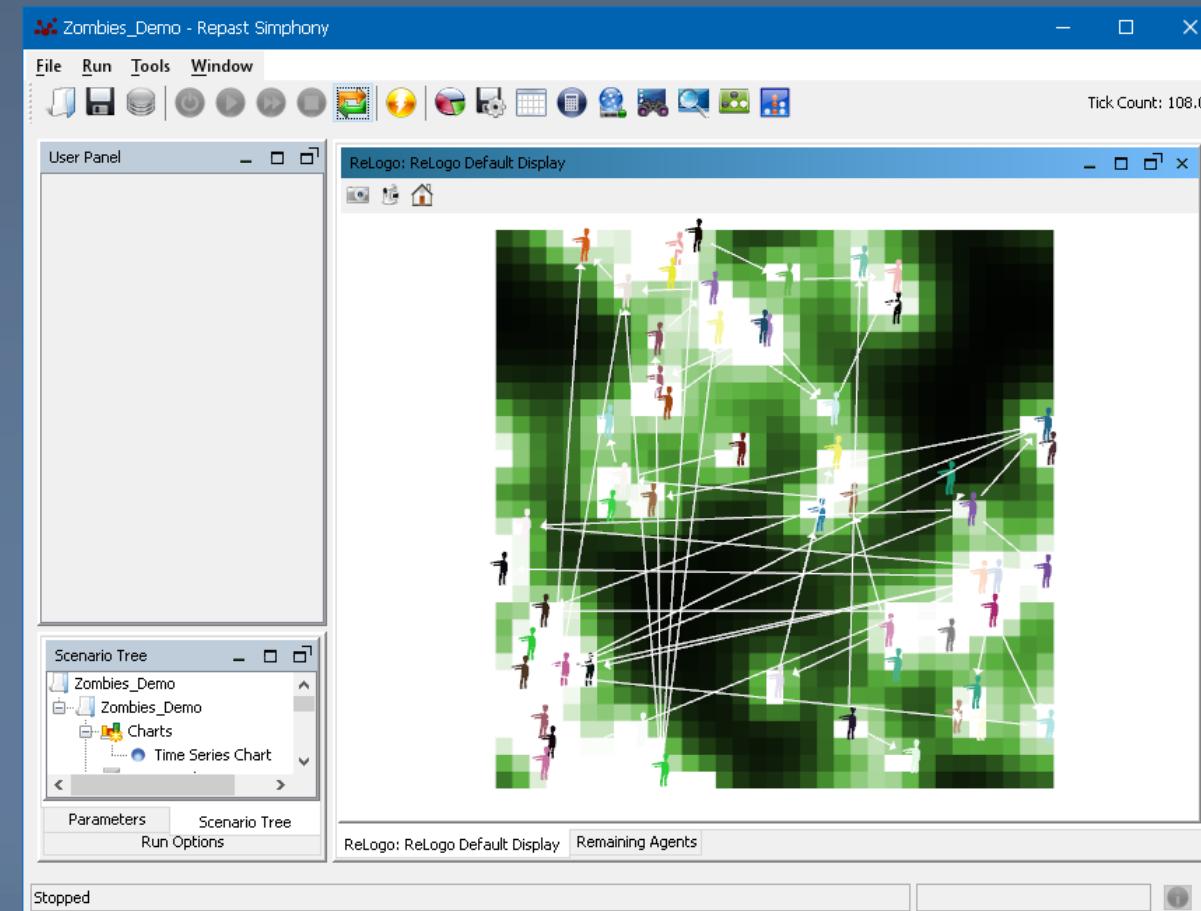


Perez, L., & Dragicevic, S. (2009). An agent-based approach for modeling dynamics of contagious disease spread. *International Journal of Health Geographics*, 8(1), 1–17.

# Handy tools to simulate agent movements

Repast by Argonne National  
Laboratory  
<https://repast.github.io/>

<https://www.youtube.com/watch?v=N-B0J4z7yhc&feature=youtu.be>



# Animal movement data

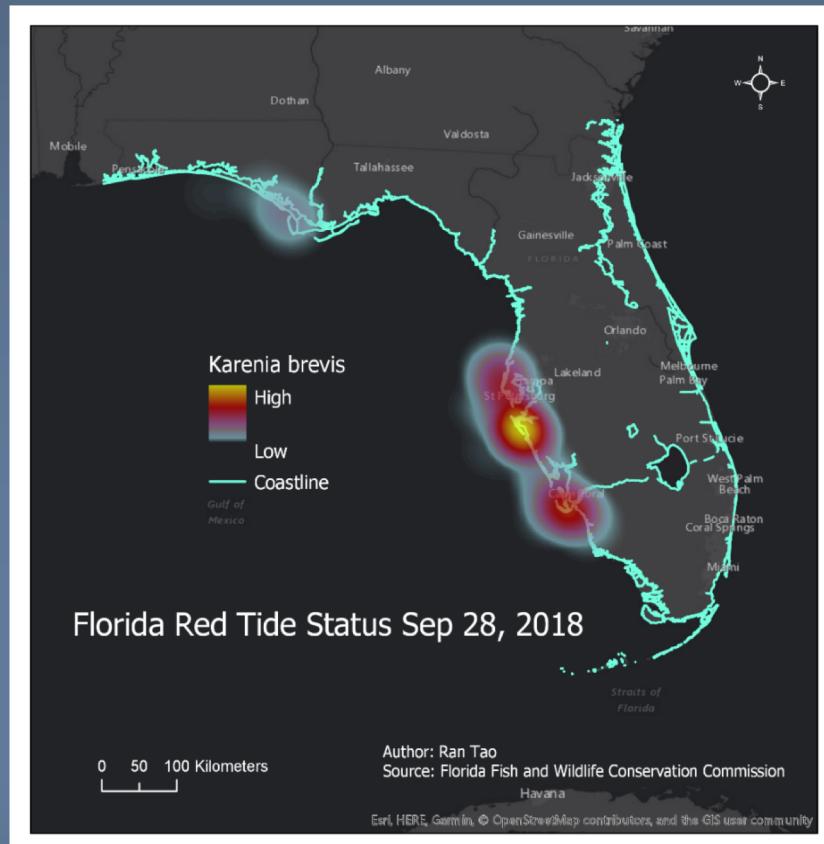
- <https://www.movebank.org/>



- Manually record the locations

# Distribution of Karenia brevis (red tide)

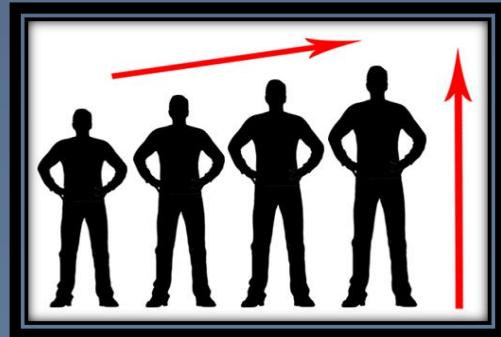
- <https://myfwc.com/research/redtide/statewide/>



## 2. Geography as a factor

Temporal

Compare with your past



One-dimension & direction

$$y_t = \rho y_{t-1} + x\beta + \varepsilon$$

Spatial

Compare with your neighbors



Multi-dimensions & directions

$$y = \rho W y + x\beta + \varepsilon$$

where  $W$  is the spatial weight matrix

# Spatial Regression

Tools: PySAL or R

Quantify the spatial effects

- Spatial Lag Model
  - Incorporates spatial effects by including a spatially lagged dependent variable as an additional predictor

$$y = \rho W y + x\beta + \varepsilon$$

- Spatial Error Model
  - Incorporates spatial effects through error term

$$\begin{aligned} y &= x\beta + \varepsilon \\ \varepsilon &= \lambda W \varepsilon + \xi \end{aligned}$$



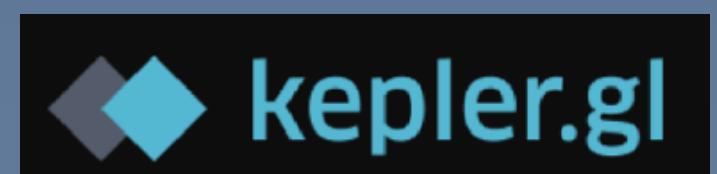
PySAL: <https://pysal.org/>

R: <https://rspatial.org/raster/analysis/7-spregression.html>

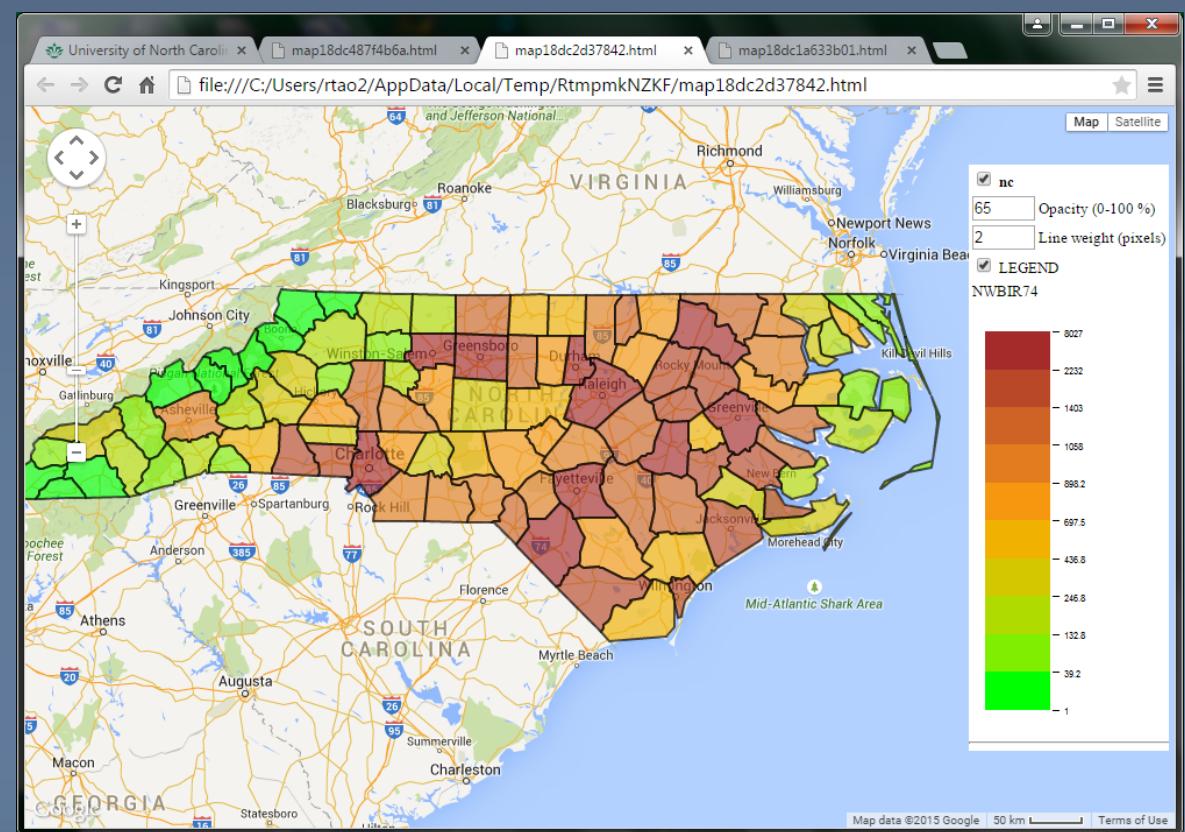
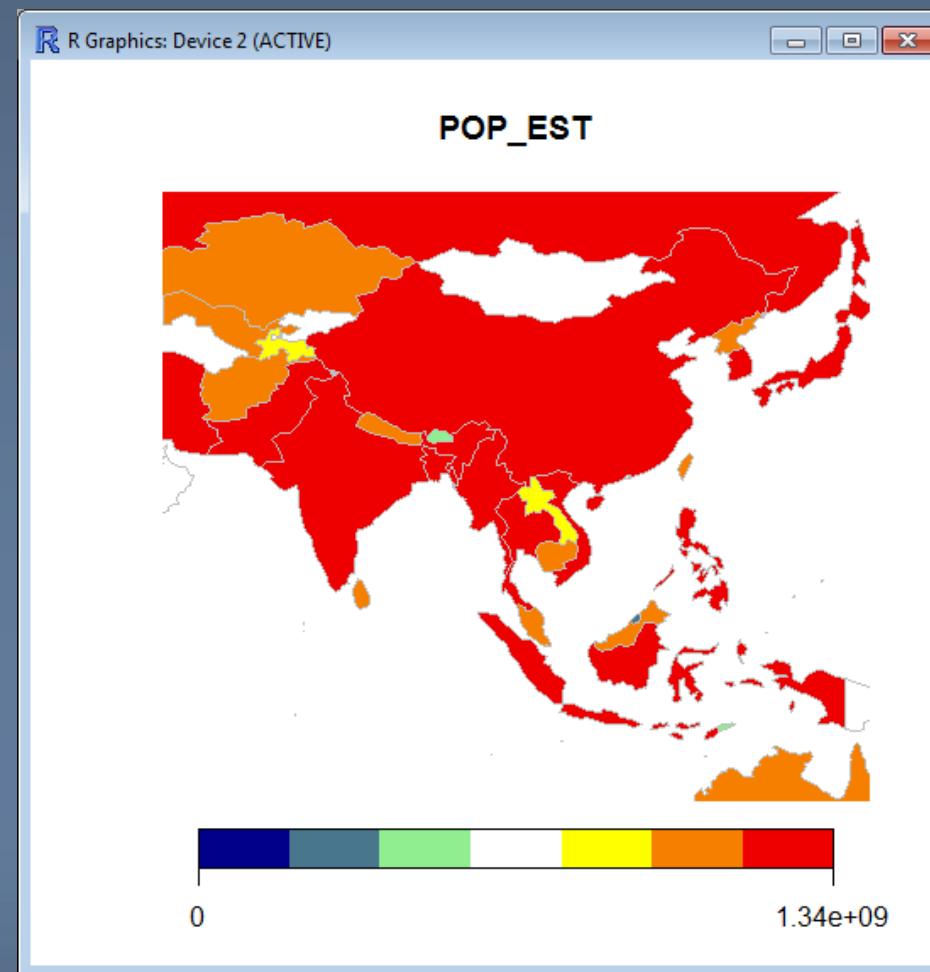
### 3. Mapping tools



ArcGIS Online



# R: Map Interactively In Browser



plotGoogleMaps