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A Universal Model of Commuting Networks

Maxime Lenormand

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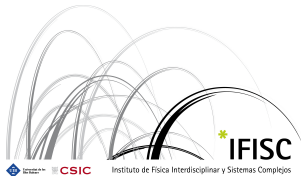
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A Universal Model of Commuting Networks

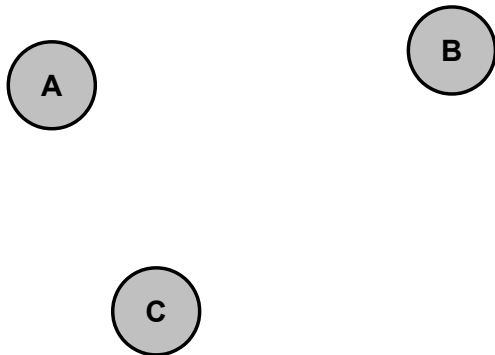
Maxime Lenormand, Sylvie Huet, Floriana Gargiulo and Guillaume Deffuant

Urbannet 2013, Barcelona

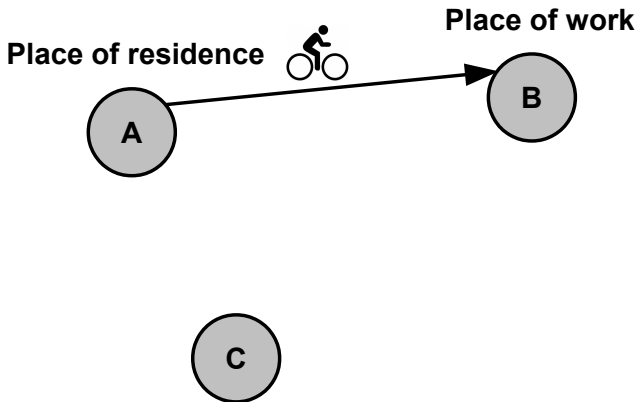
18th of September, 2013



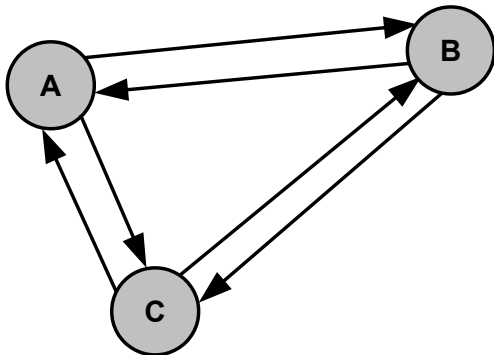
Motivation



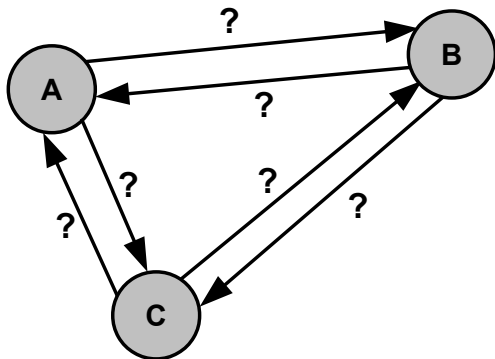
Motivation



Motivation

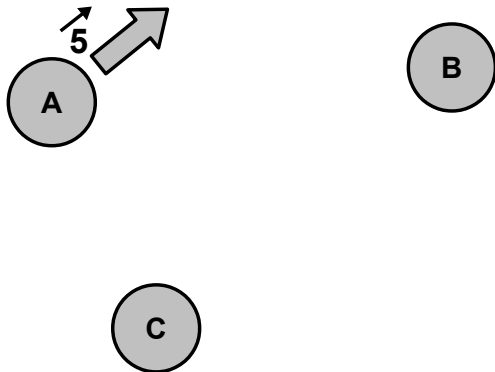


Motivation



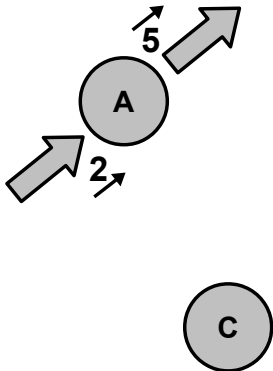
Motivation

Number of out-commuters

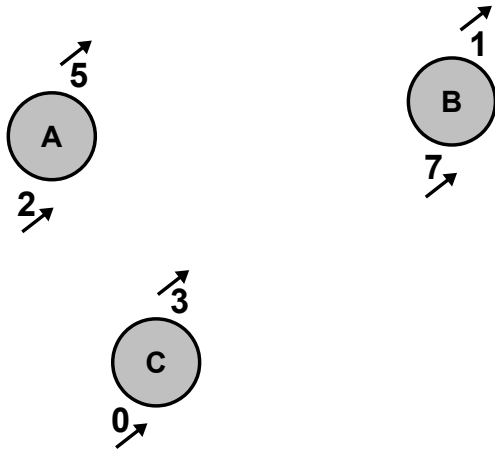


Motivation

Number of in-commuters

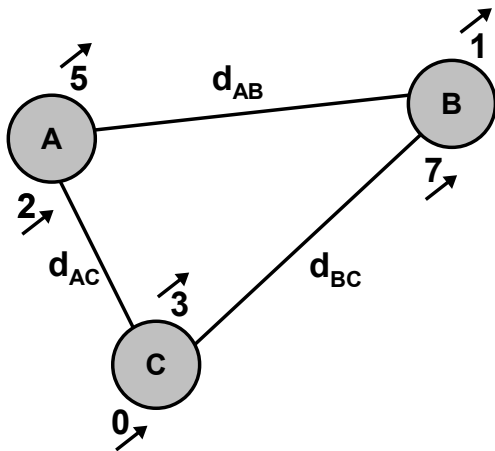


Motivation

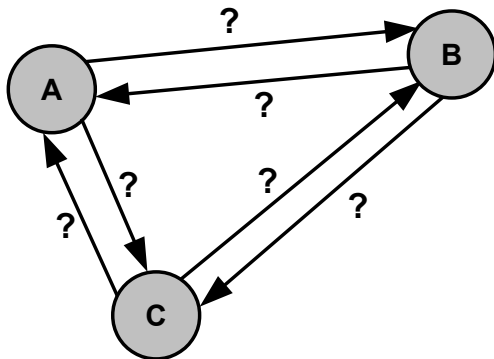


Motivation

Euclidean distances between municipalities



Motivation



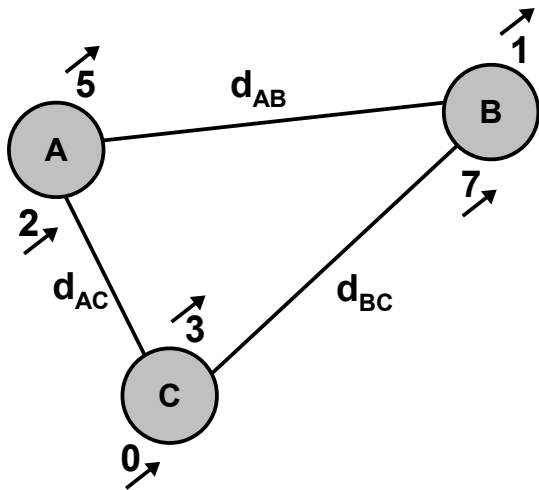
Outline

- ▶ The Model
- ▶ Calibration of β
- ▶ Results
- ▶ Comparison with the "radiation model"

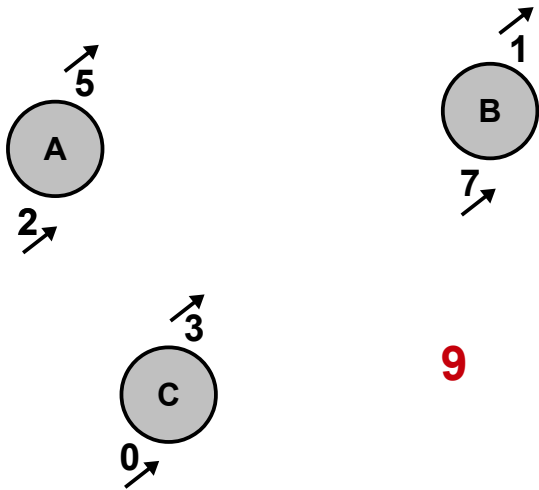
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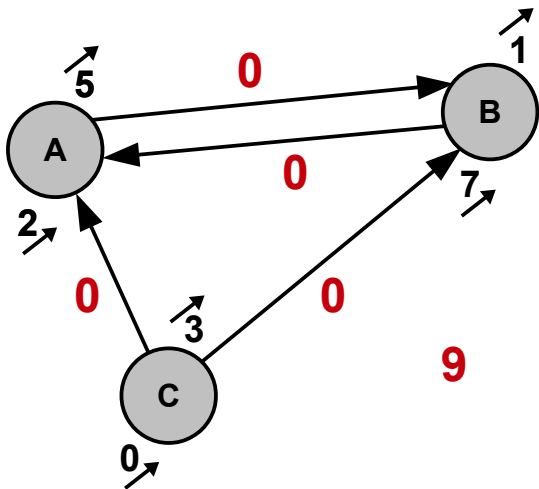
The Model



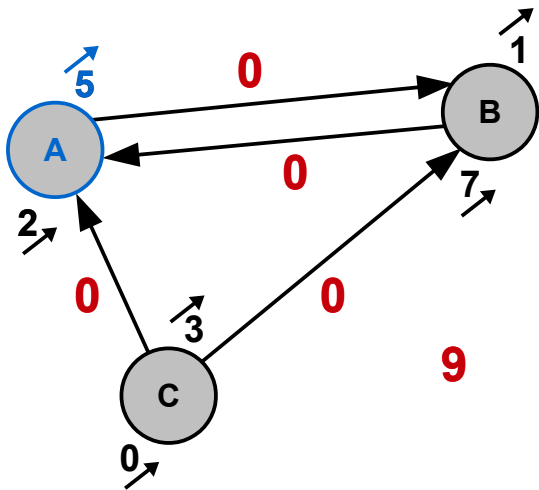
The Model



The Model



The Model



The Model

$$P_{A \rightarrow B} \sim 7 \cdot e^{-\beta d_{AB}}$$

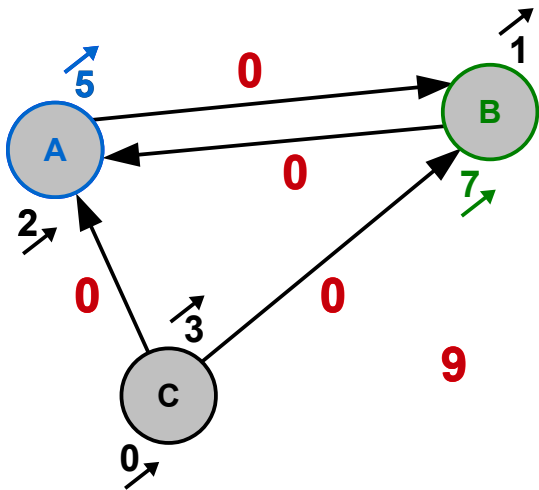
$$P_{A \rightarrow C} \sim 0 \cdot e^{-\beta d_{AC}}$$

The Model

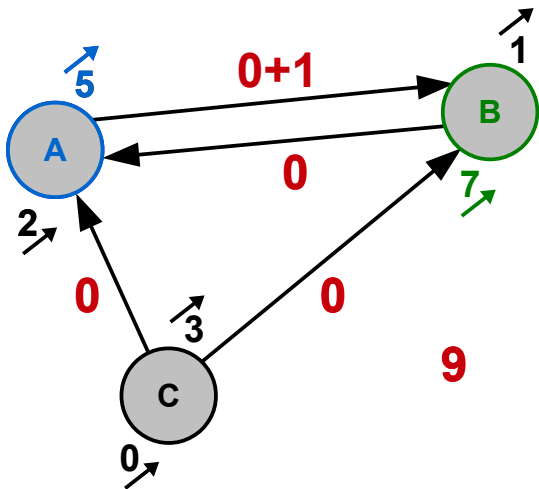
$$P_{A \rightarrow B} \sim 7 \cdot e^{-\beta d_{AB}}$$

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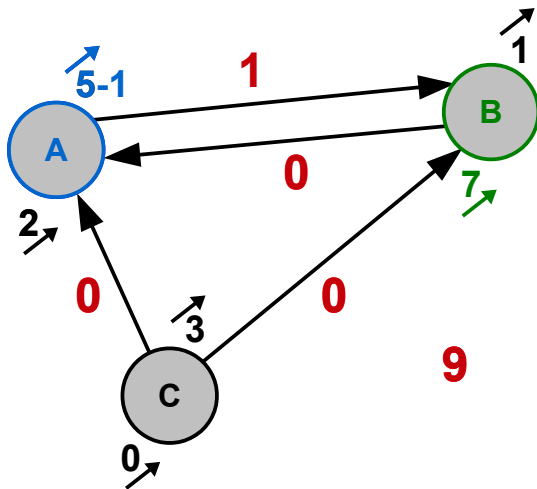
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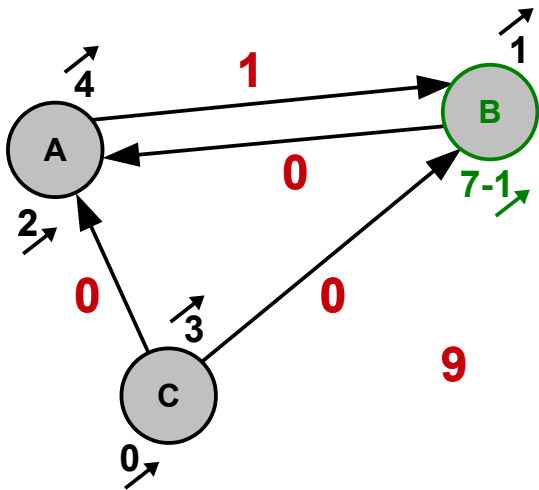
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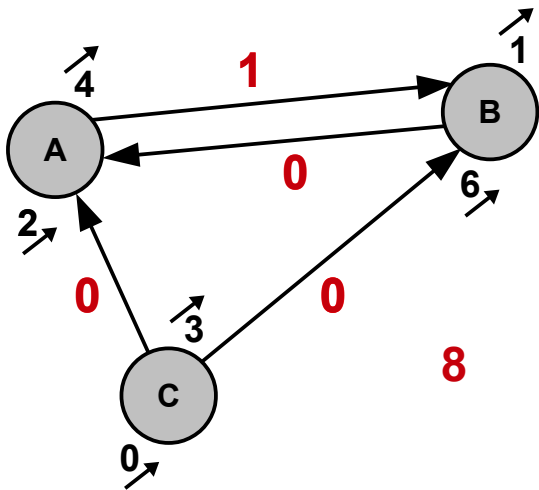
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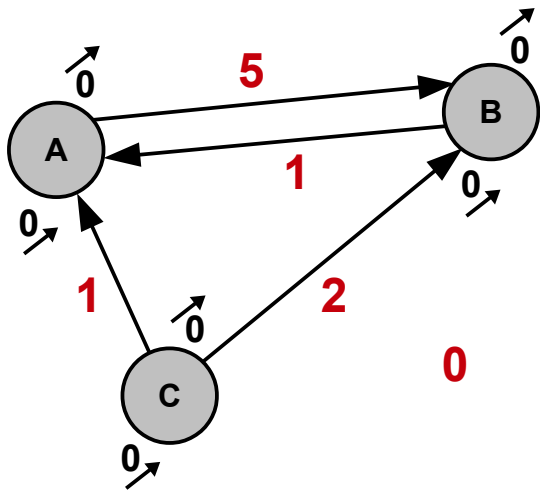
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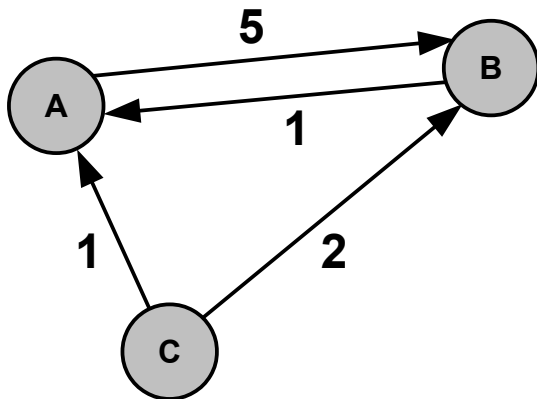
The Model



The Model



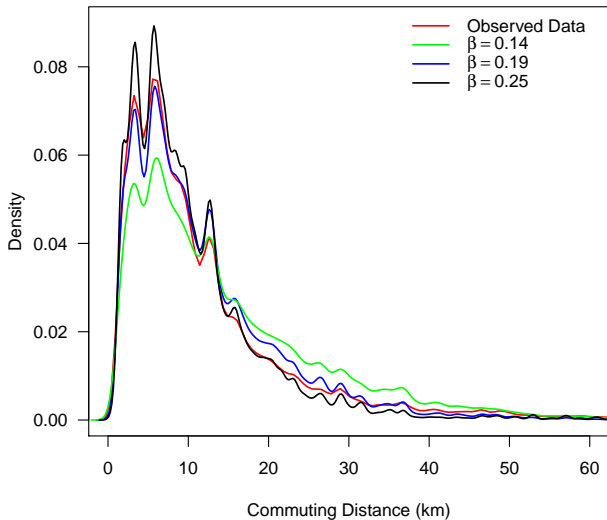
The Model



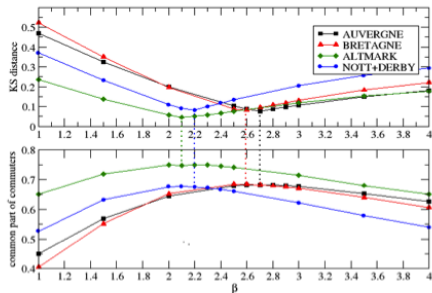
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Calibration of β



Calibration of β



$$D_{KS} = \sup_d |F_O(d) - F_S(d)|$$

$$CPC = \frac{2 \sum_i \sum_j \min(S_{ij}, O_{ij})}{\sum_i \sum_j O_{ij} + \sum_i \sum_j S_{ij}}$$

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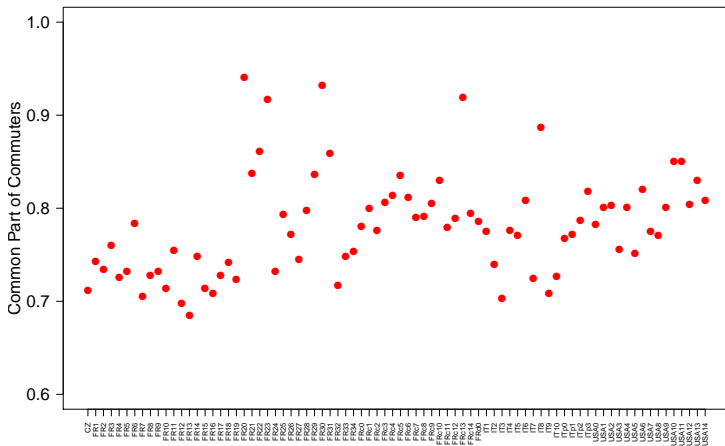
Results

Datasets

- 1 Czech Republic - 1 region - municipality - 2001
- 2 France - 34 regions - municipality - 1999
- 3 France - 15 regions - canton - 1999
- 4 France - 1 region - département - 1999
- 5 Italy - 10 regions - municipality - 2001
- 6 Italy - 5 regions - provincia - 2001
- 7 USA - 15 regions - county - 2000

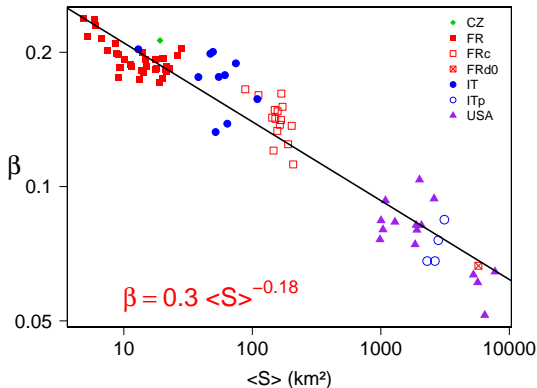
Results

Model evaluation



Results

Estimation of β

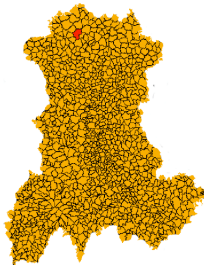


Lenormand, M., Huet, S., Gargiulo, F., and Deffuant, G. A Universal Model of Commuting Networks. *Plos One*, 2012, .

Results

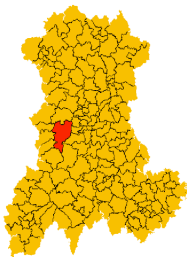
Estimation of β

MUNICIPALITY



$\langle S \rangle \sim 15\text{Km}^2$

CANTON



$\langle S \rangle \sim 150\text{Km}^2$

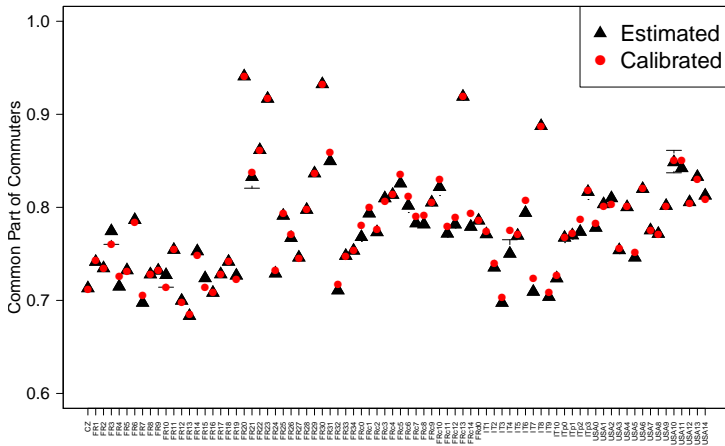
DEPARTMENT



$\langle S \rangle \sim 5000\text{Km}^2$

Results

Estimation of β



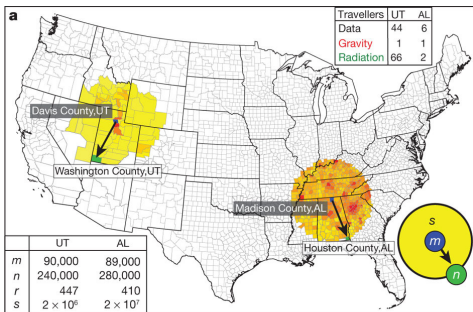
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Comparison with the "radiation model"

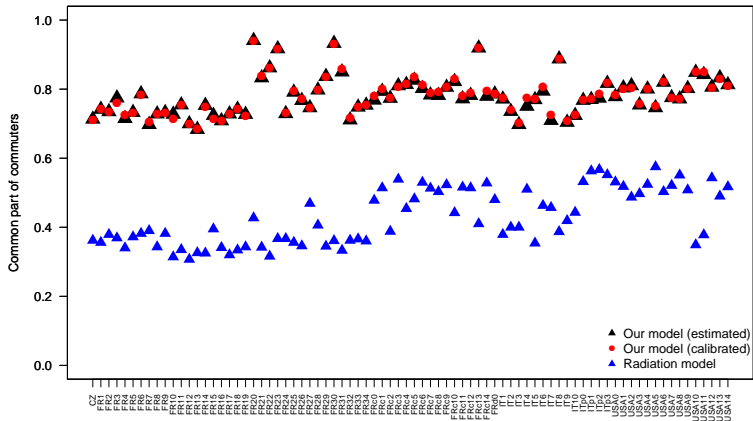
Radiation Model

$$\langle T_{ij} \rangle = \left(m_i \frac{P_c}{P} \right) \frac{m_i n_j}{(m_i + s_{ij})(m_i + n_j + s_{ij})}$$

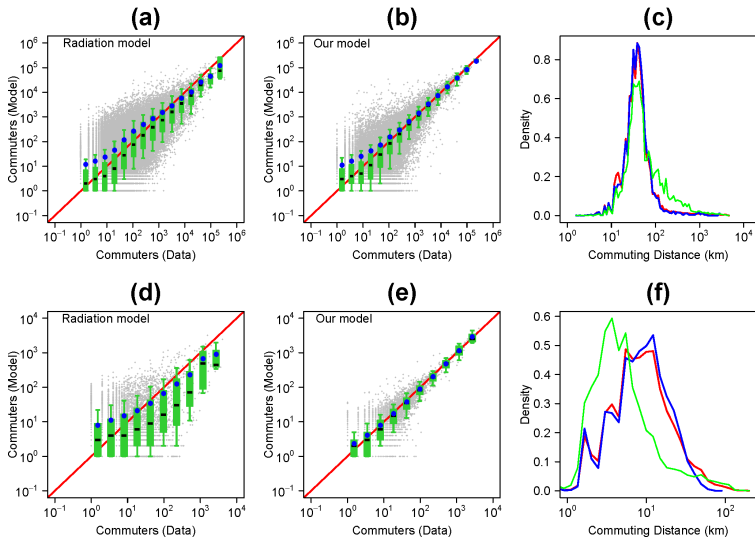


Simini, F., Gonzalez, M. C., Maritan, A., and Barabasi, A.-L. A universal model for mobility and migration patterns. *Nature*, 2012, 484(7392):96-100.

Comparison with the "radiation model"



Comparison with the "radiation model"



Summary

- Model tested on 80 different regions (size and scale).

Summary

- Model tested on 80 different regions (size and scale).
- Estimation of β tested on 80 regions.

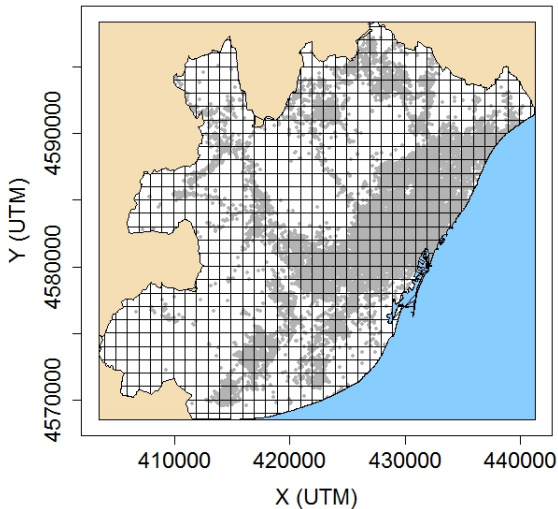
Summary

- Model tested on 80 different regions (size and scale).
- Estimation of β tested on 80 regions.
- Comparison with the "radiation model".

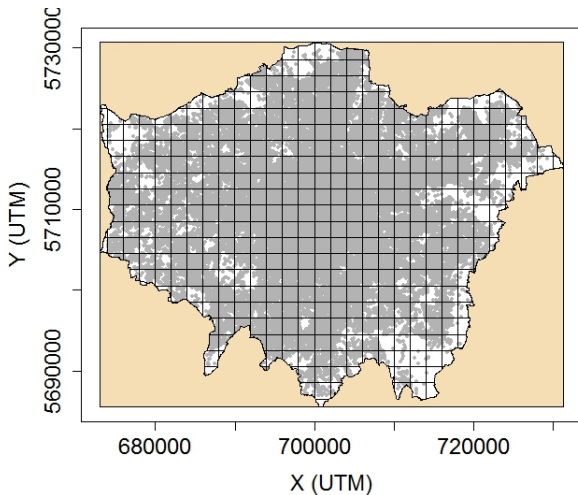
Summary

- Model tested on 80 different regions (size and scale).
- Estimation of β tested on 80 regions.
- Comparison with the "radiation model".
- **Does it works at urban scale?**

Barcelona



London



Results

