

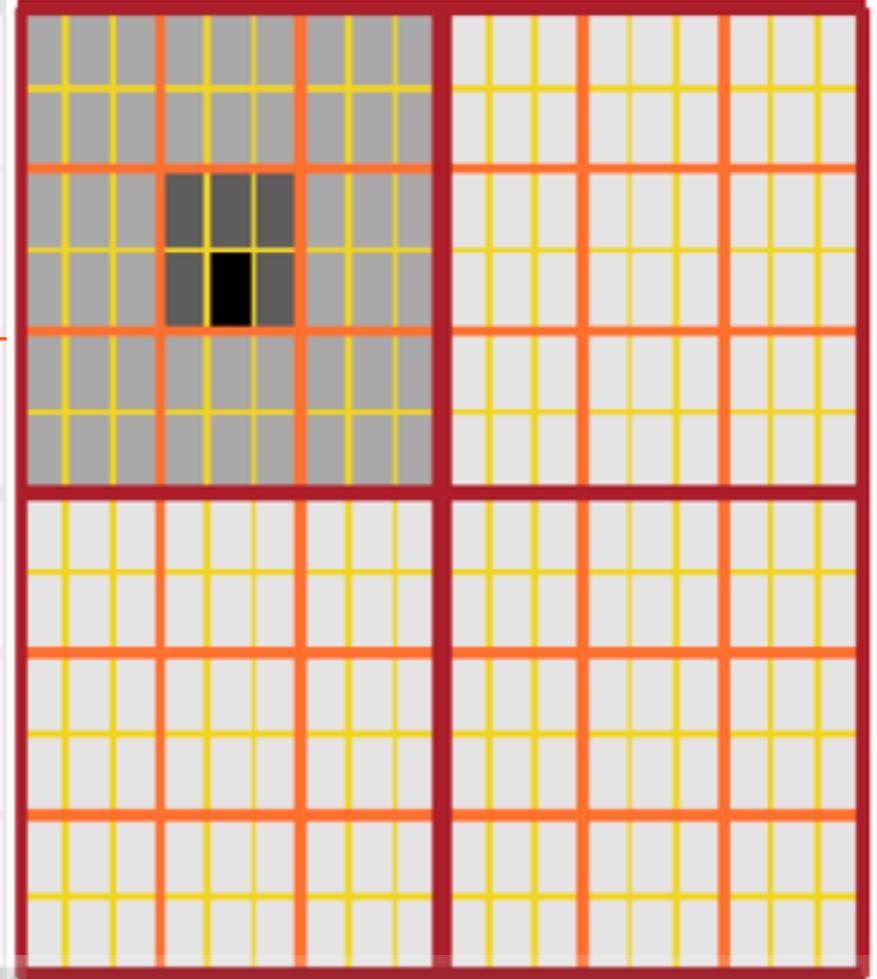
Structural discontinuities of human interactions in space

NetSci 2018

Paris, June 2018

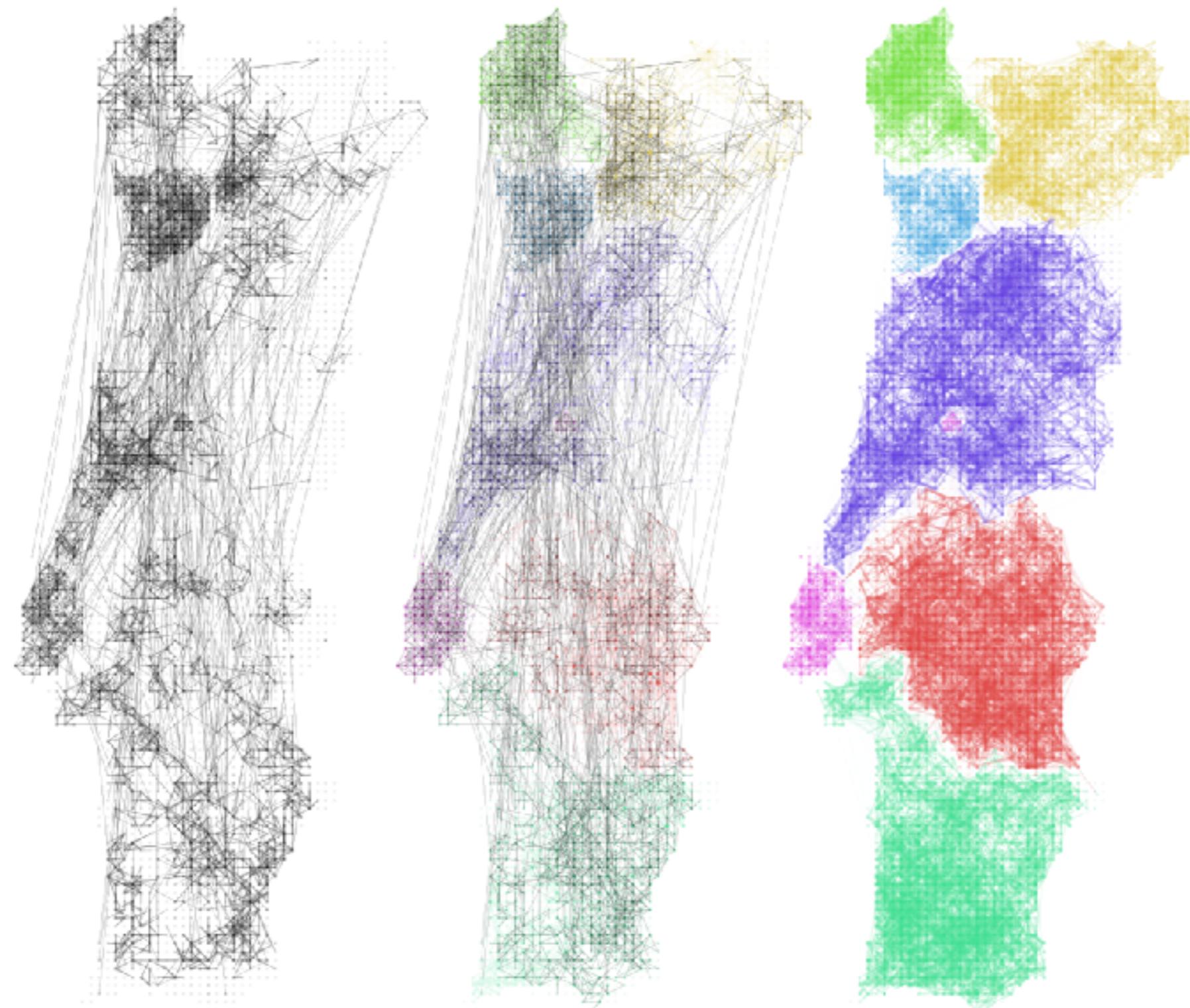
Michael Szell

@mszll



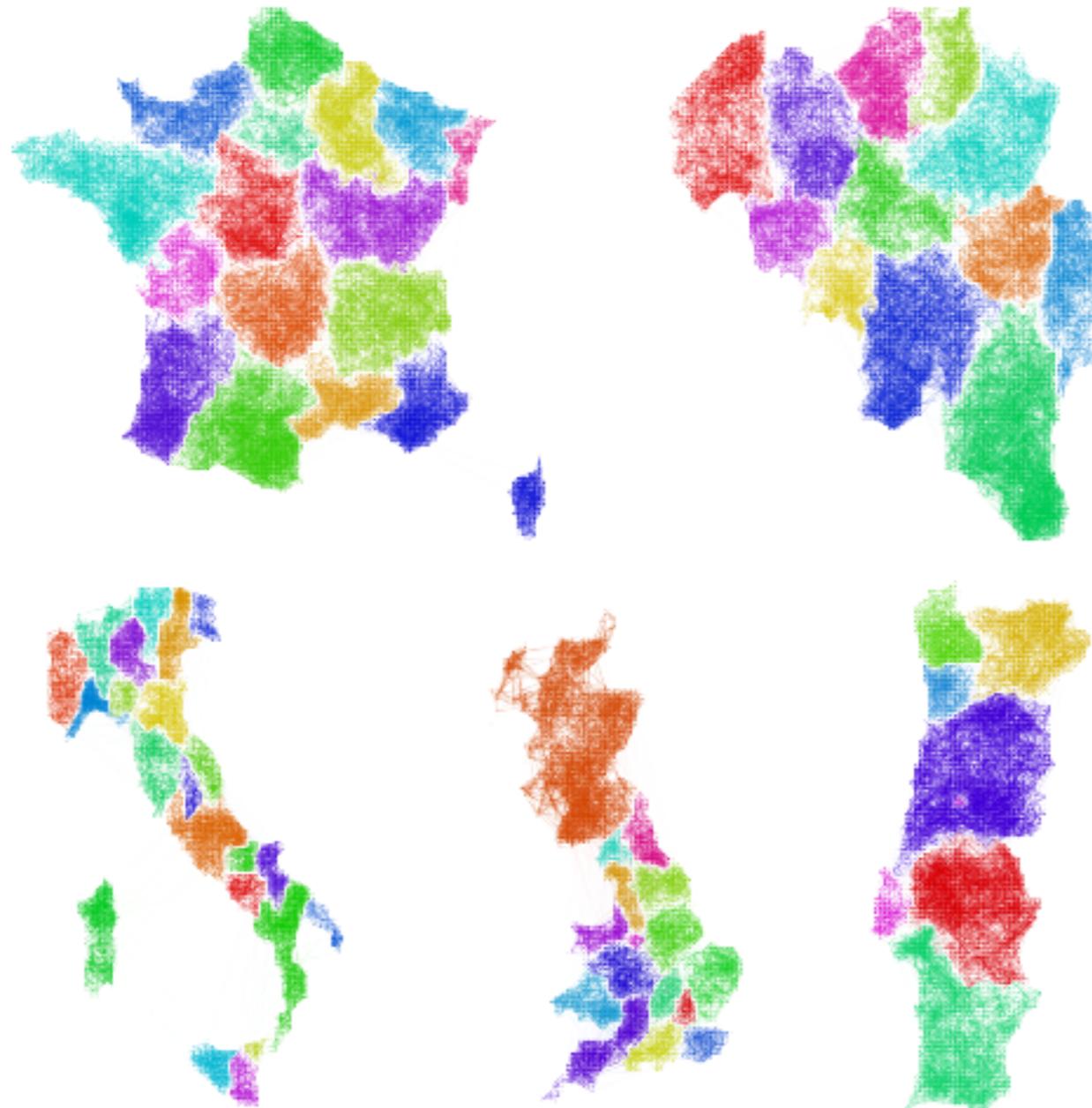
with: Sebastian Grauwin, Stanislav Sobolevsky, Philipp Hövel, Filippo Simini,
Maarten Vanhoof, Zbigniew Smoreda, Albert-László Barabási, Carlo Ratti

Partitioning of phone networks leads to cohesive regions



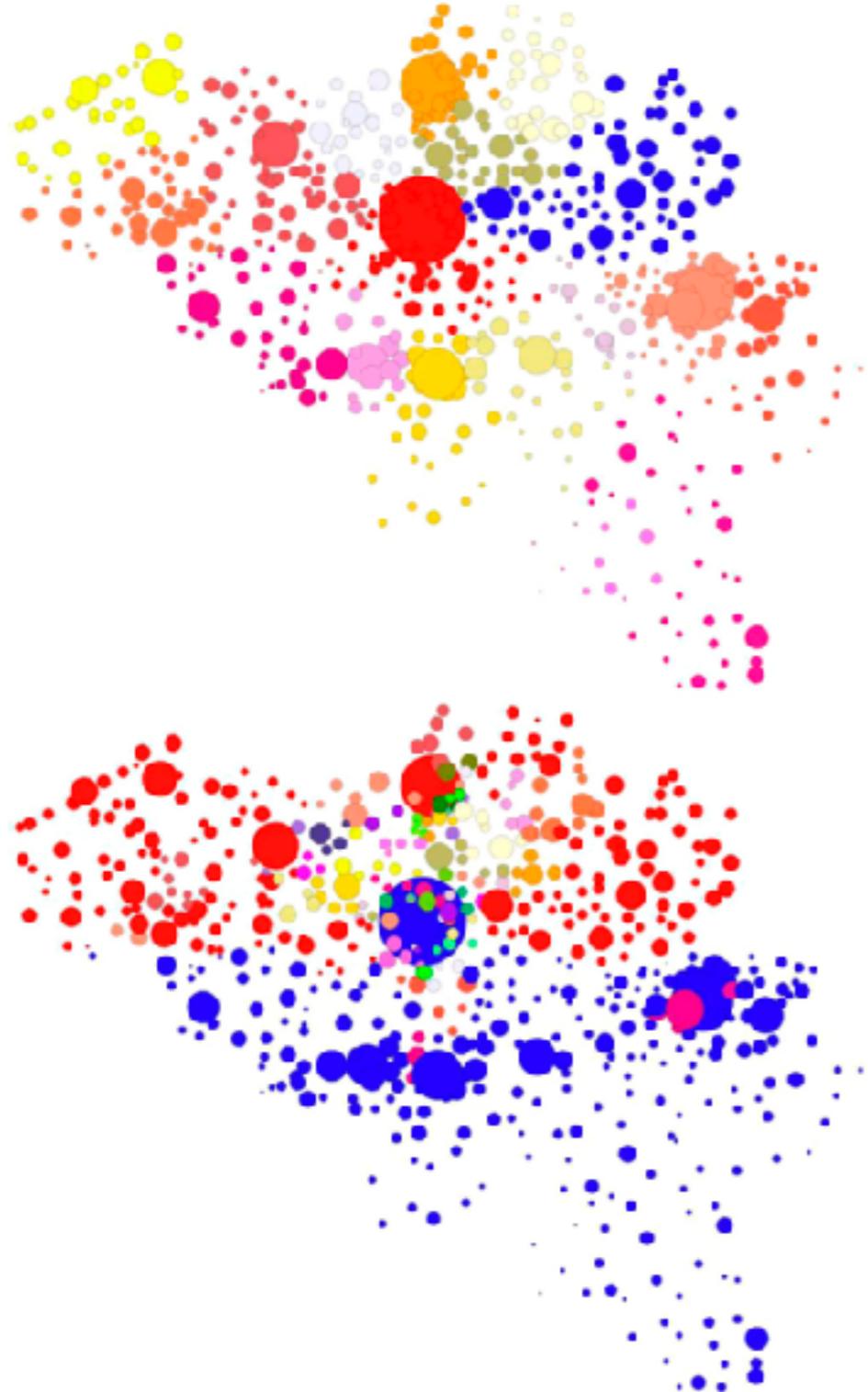
Sobolevsky et al, PLOS ONE 8, e81707 (2013)
Ratti et al, PLOS ONE 5, e14248 (2010)

Partitioning of phone networks leads to cohesive regions



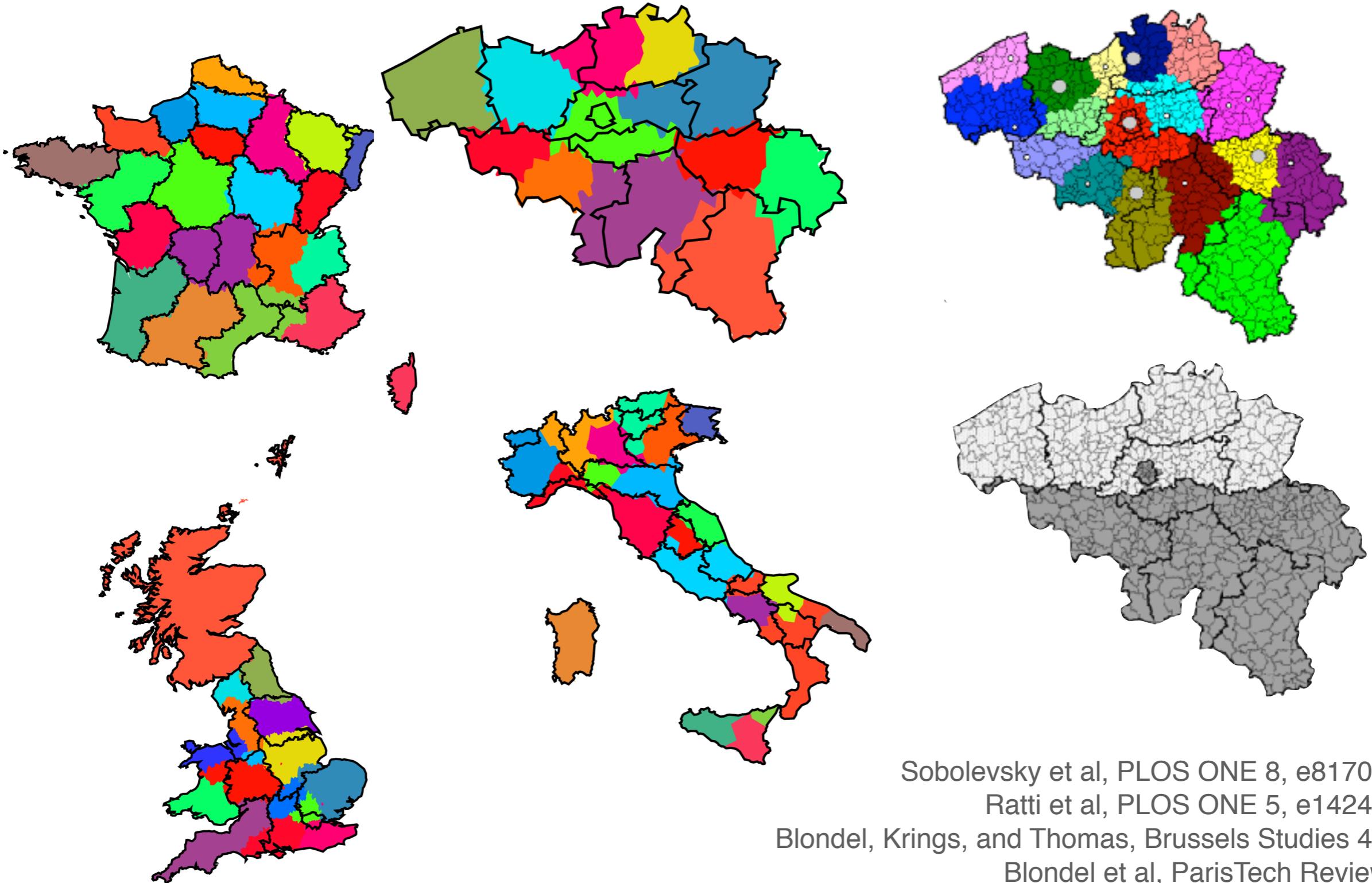
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Blondel, Krings, and Thomas, Brussels Studies 42 (2010)
Blondel et al, ParisTech Review (2011)
Calabrese et al, IEEE SocialCom (2011)

Cohesive regions are not so surprising: Tobler's 1st law



Everything is related to everything else, but near things are more related than distant things.

Surprising: Human interactions follow socio-economic boundaries remarkably well!



Sobolevsky et al, PLOS ONE 8, e81707 (2013)

Ratti et al, PLOS ONE 5, e14248 (2010)

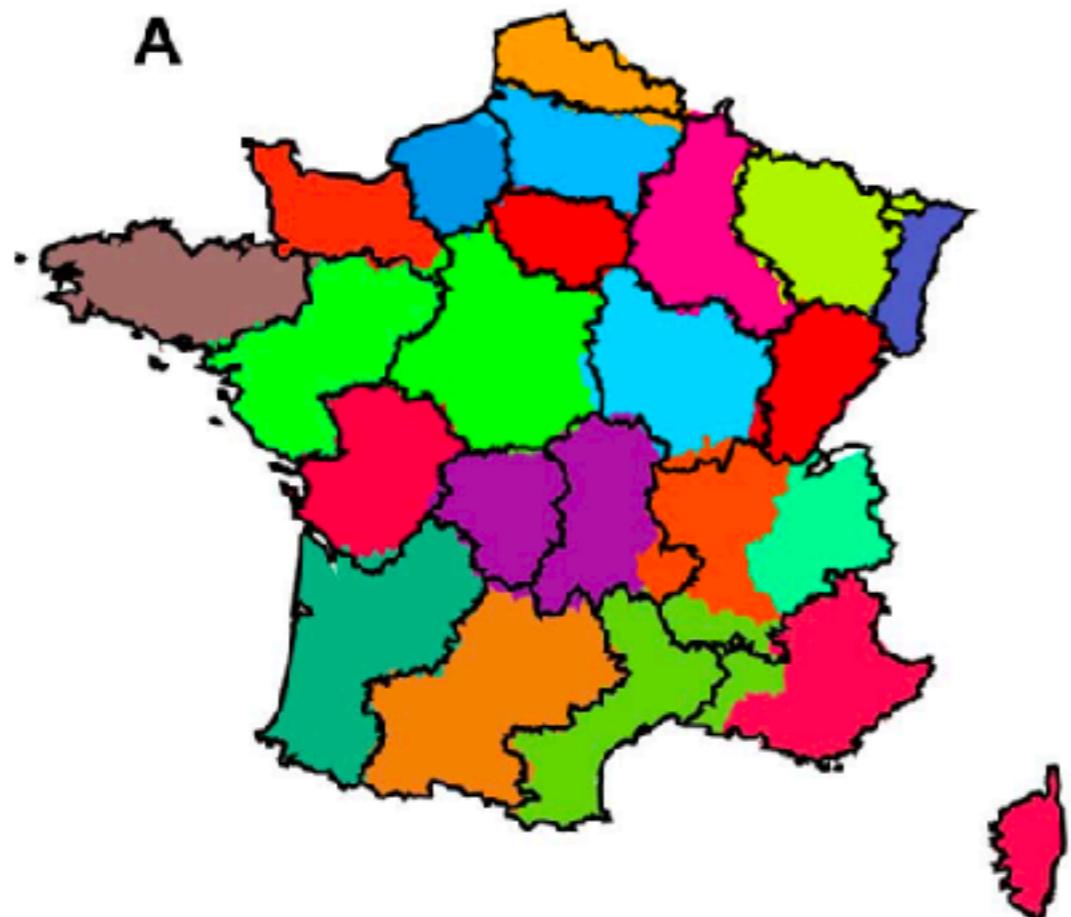
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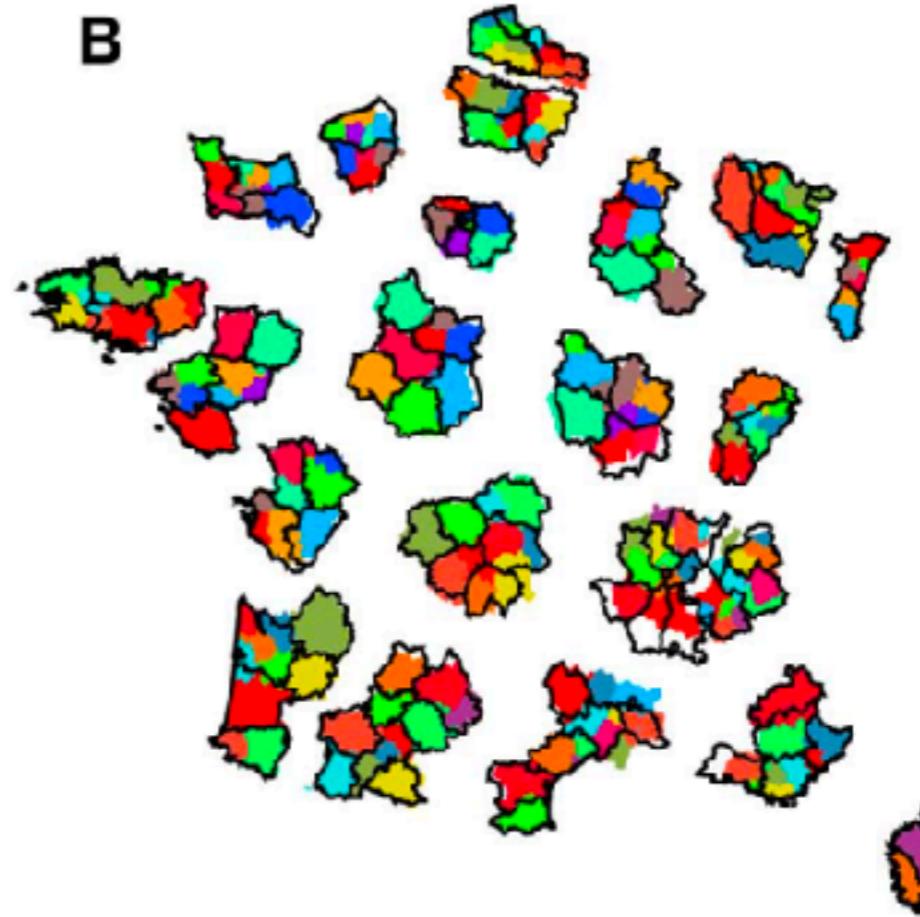
Calabrese et al, IEEE SocialCom (2011)

Surprising: Human interactions follow socio-economic
boundaries remarkably well! On multiple levels!

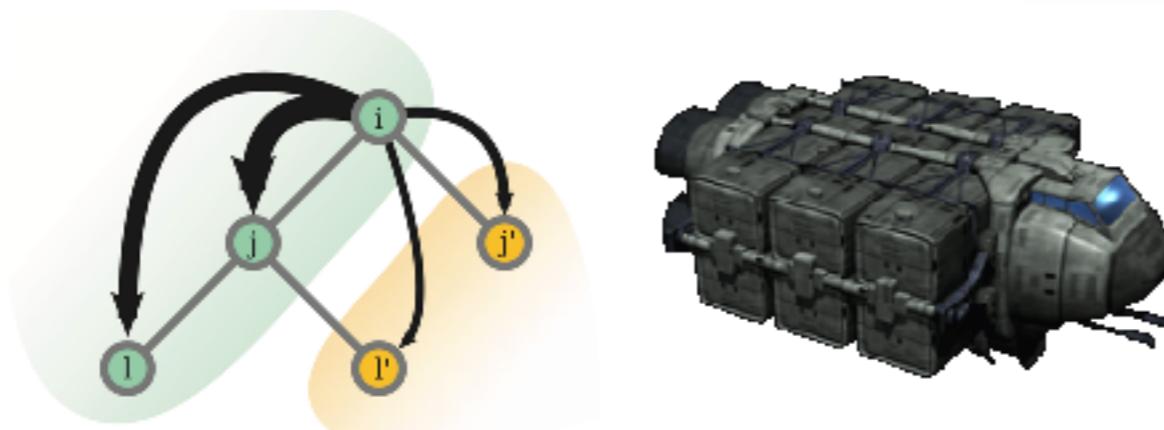
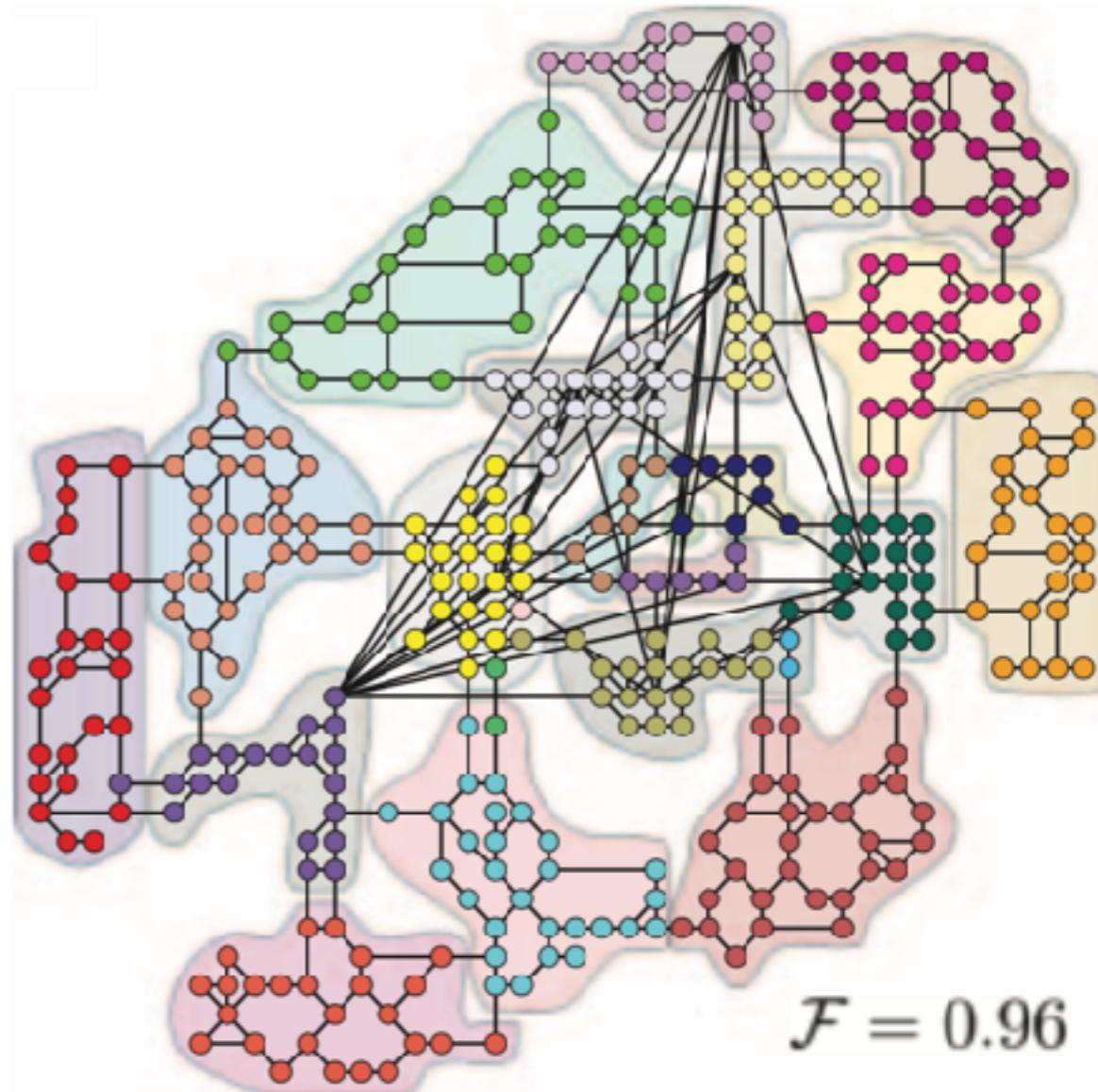
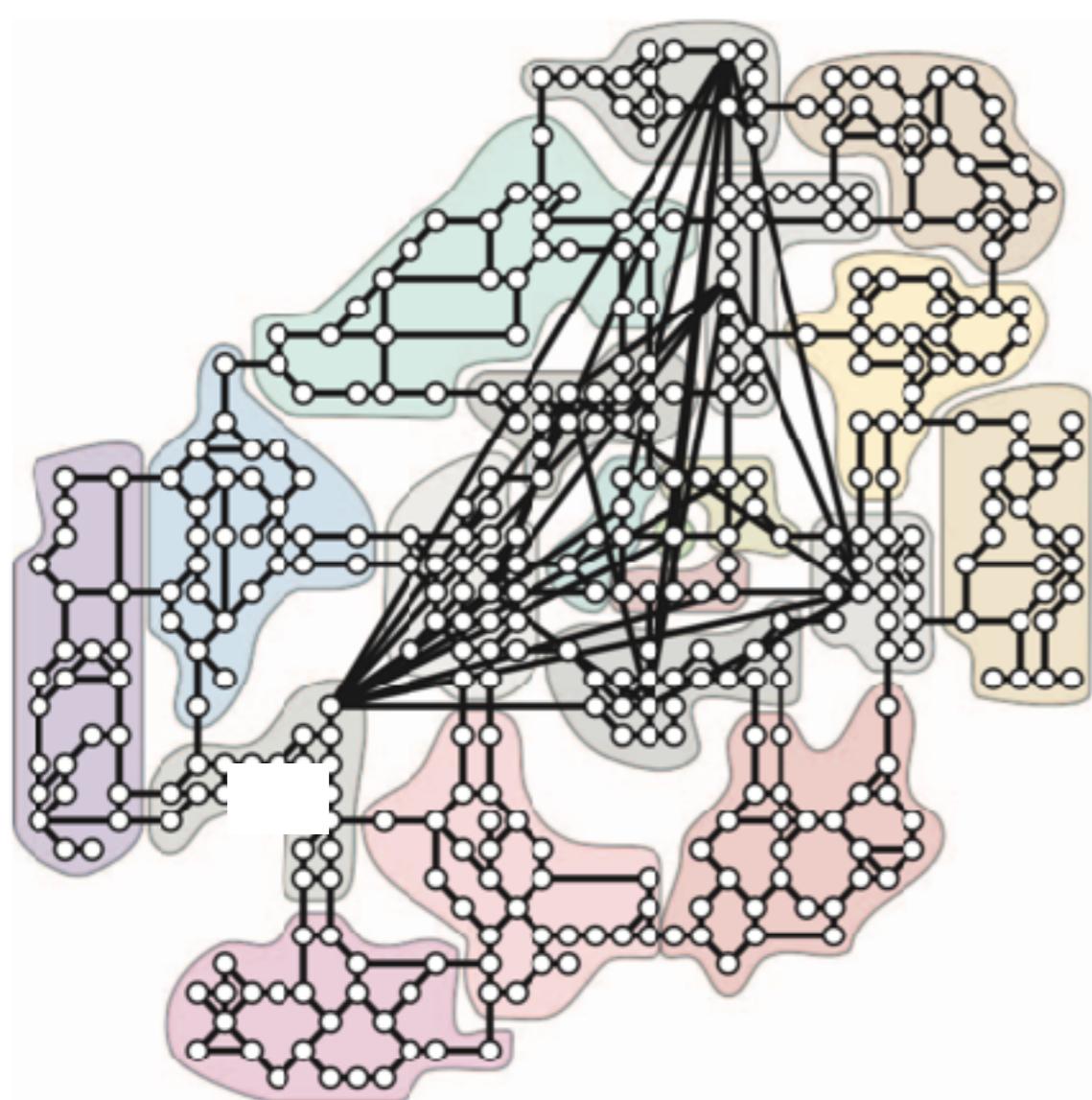
22 NUTS2 regions



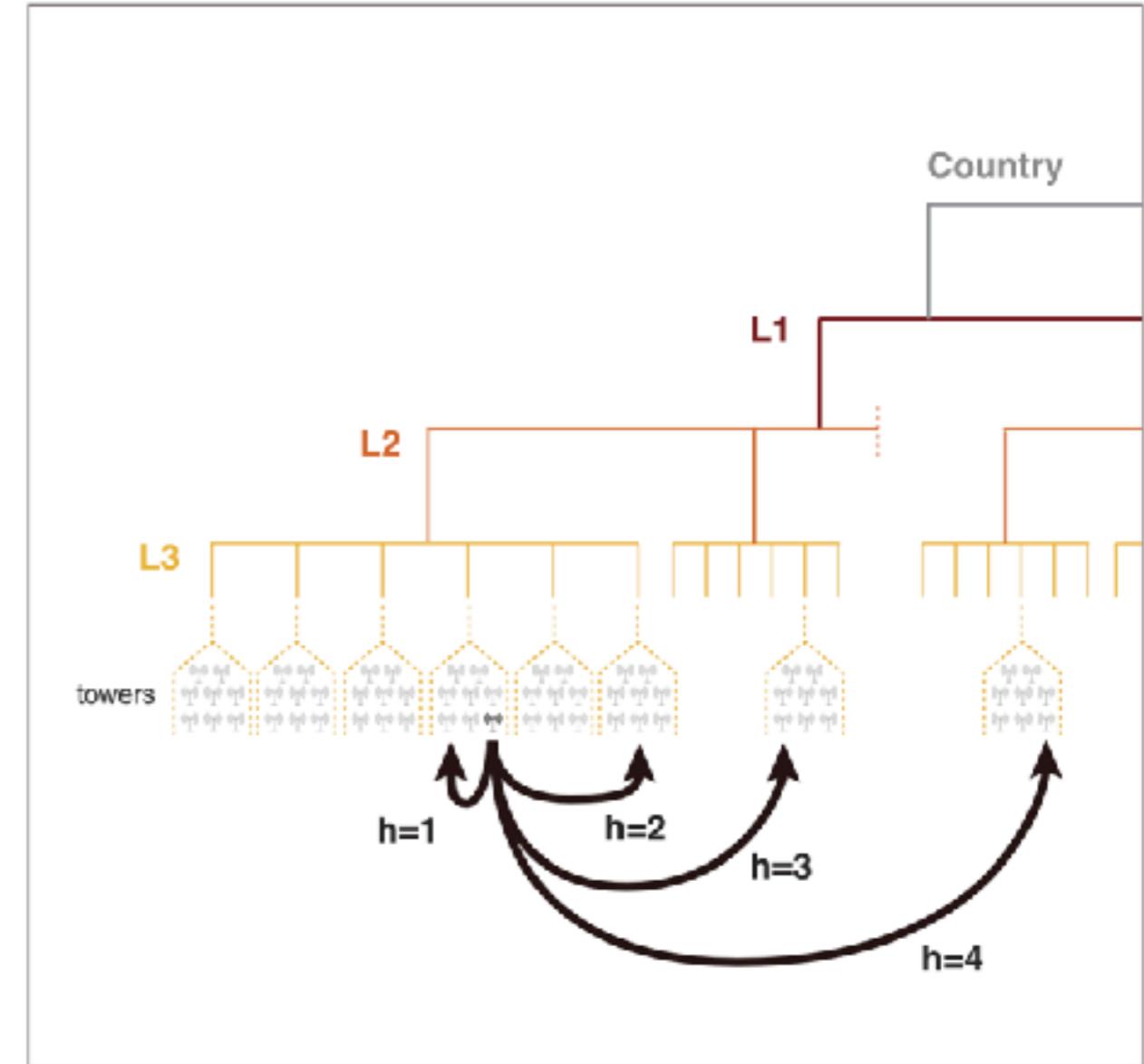
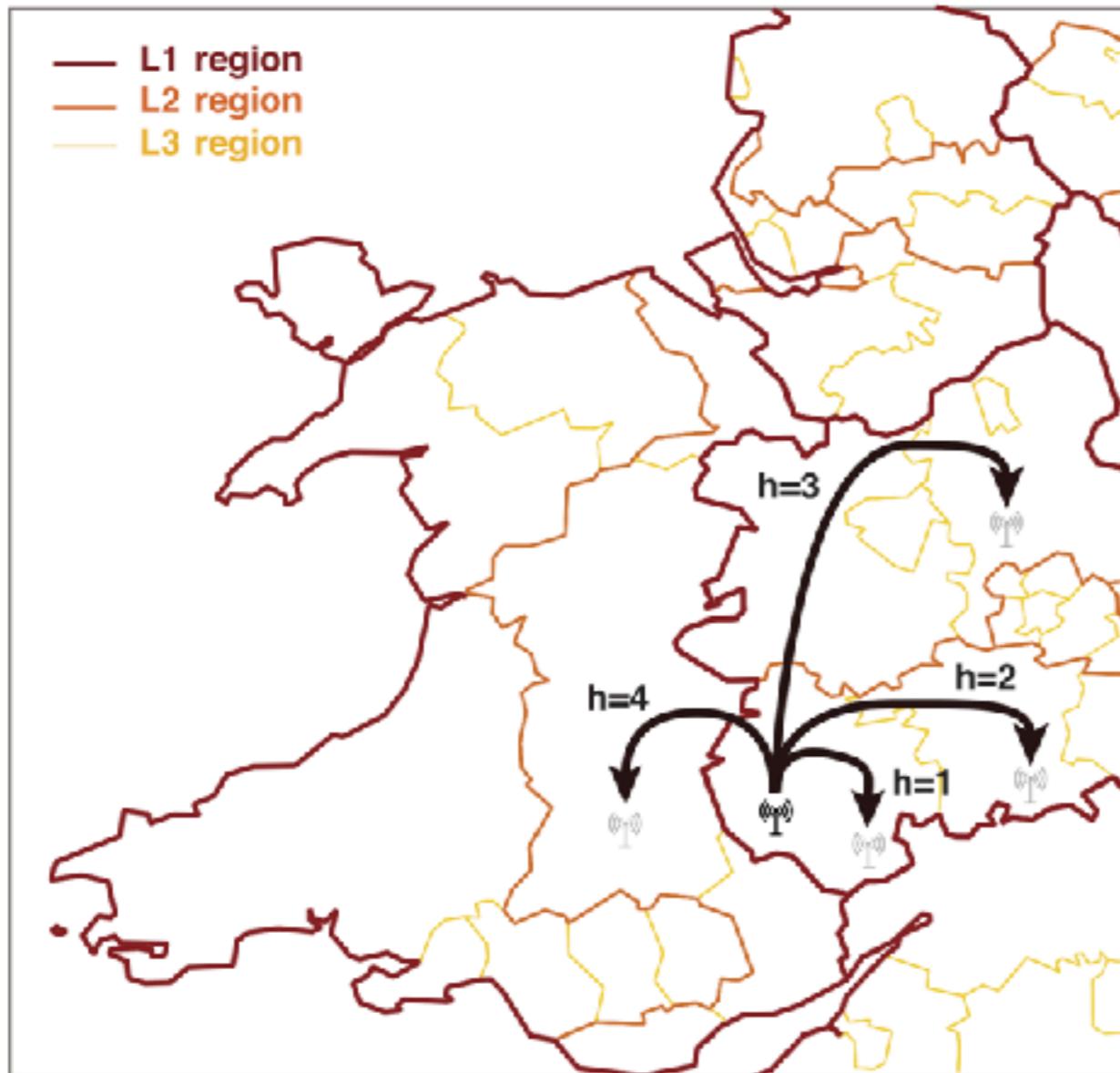
101 NUTS3 regions



We also found evidence for the strength of socio-economic boundaries in an online world



Is society organized hierarchically in space?

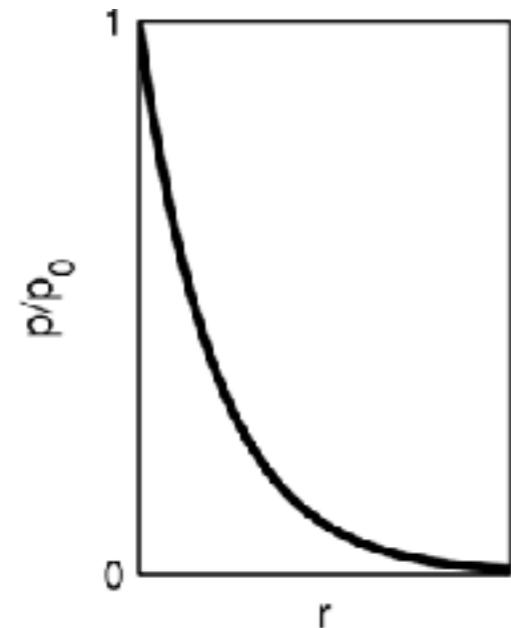
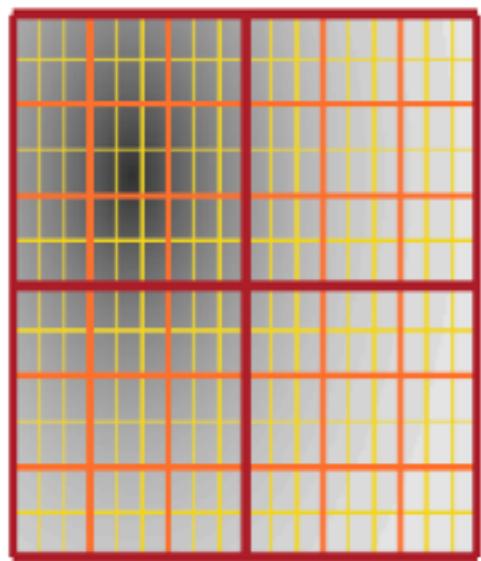


h = hierarchical distance

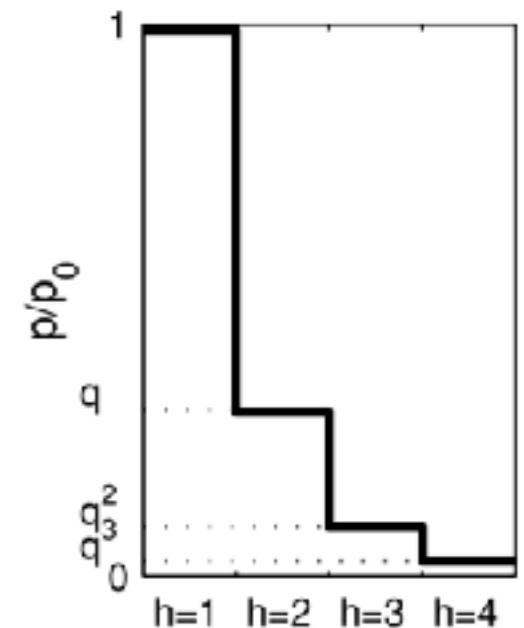
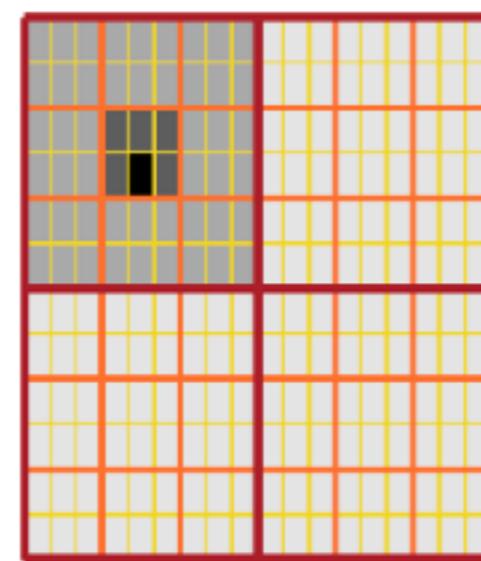
This is not just a discretization of euclidian distance!

Idea: Can we formulate an improved mobility model
that uses the hierarchical information?

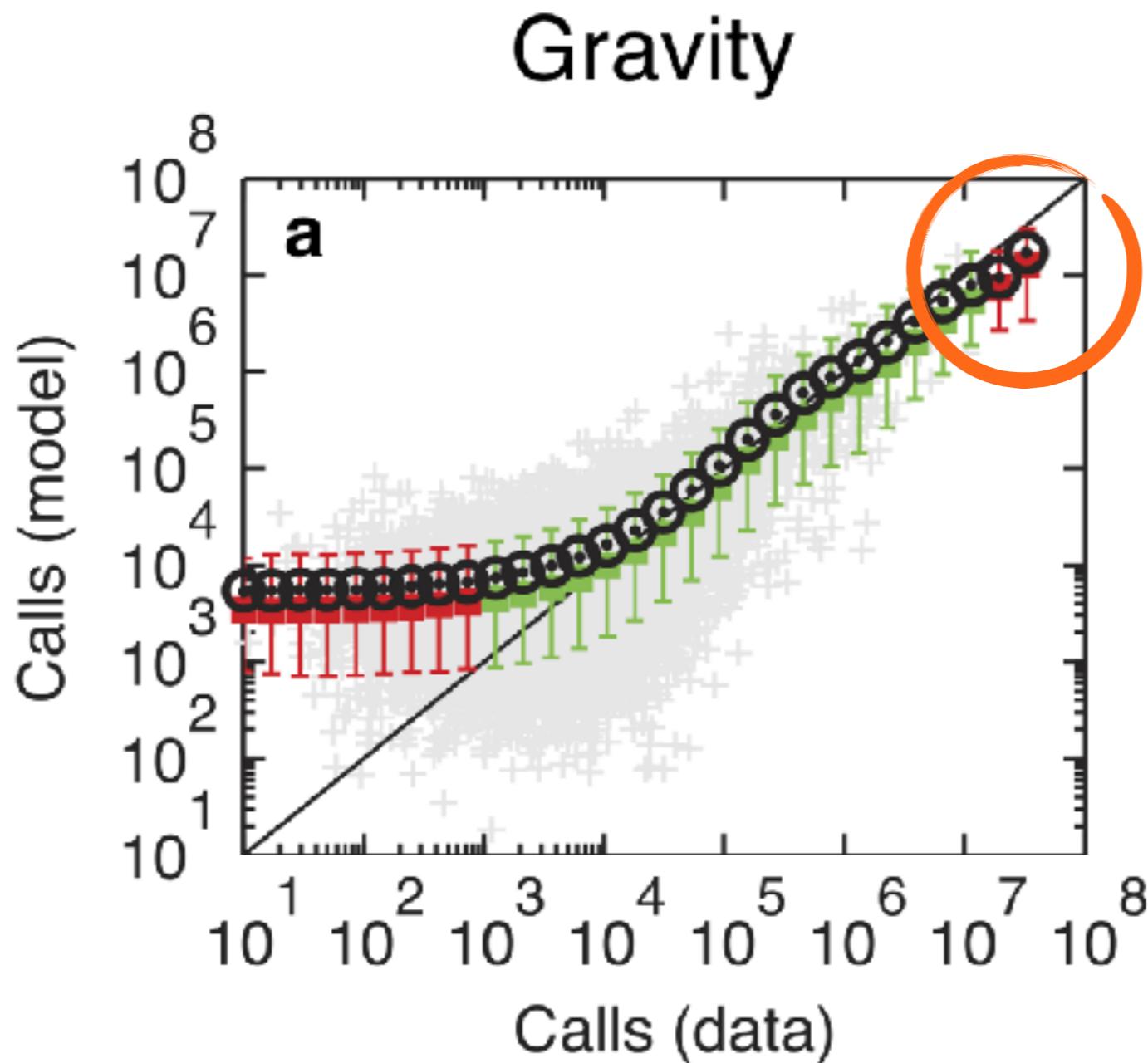
Old models



New model?



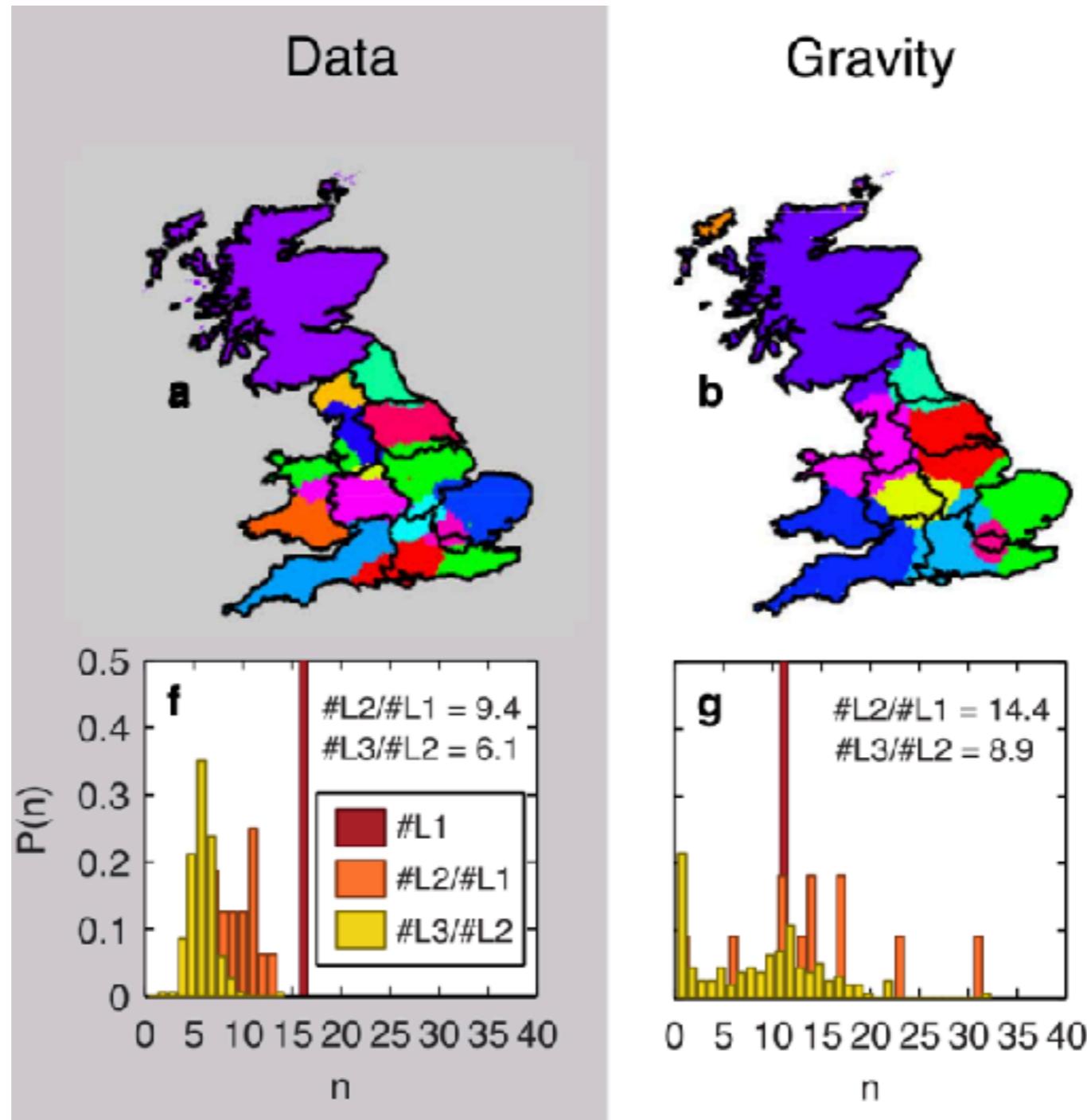
Problems with old mobility models: 1) gravity



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

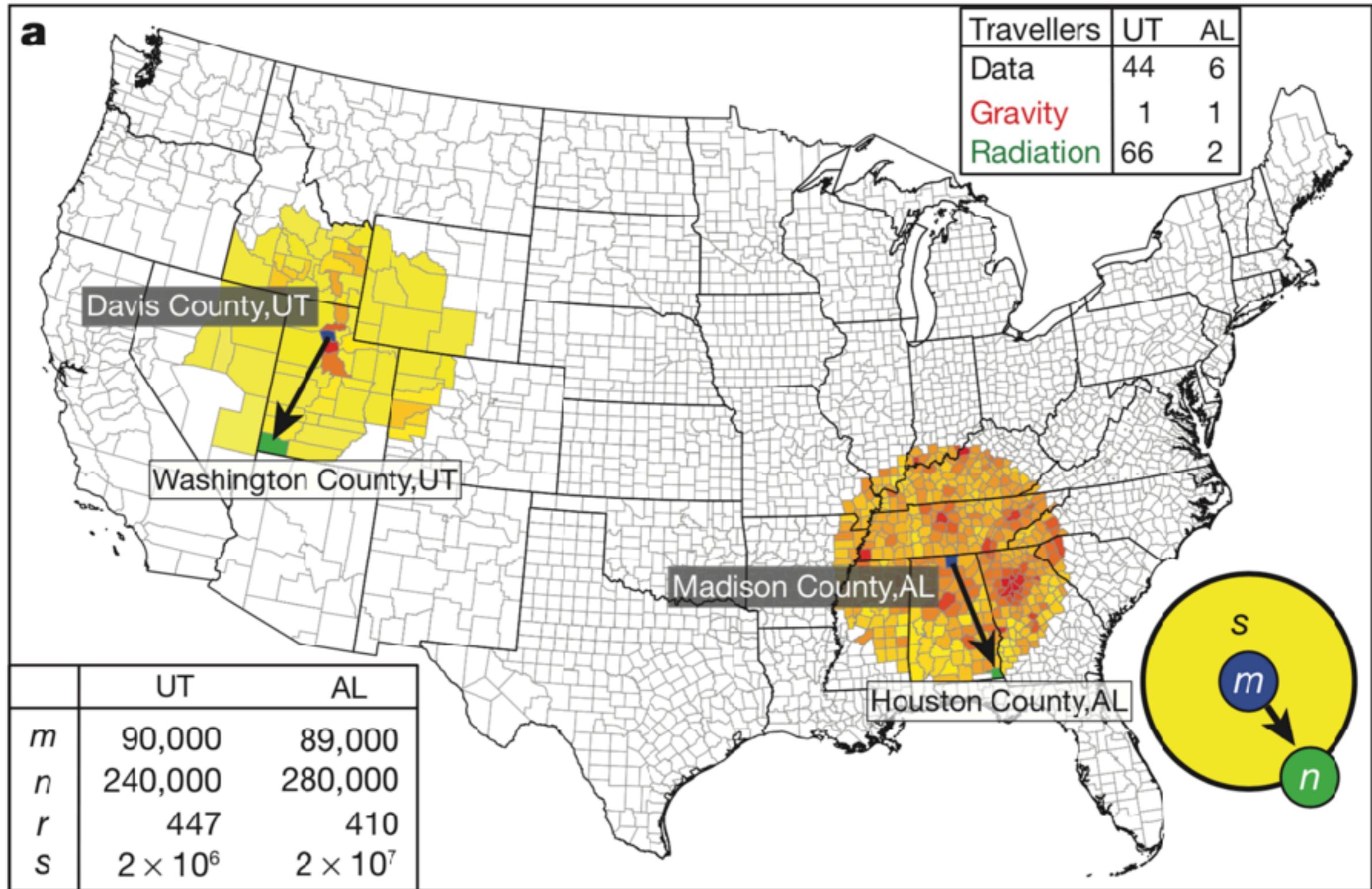
Underestimates high-range flows...

Problems with old mobility models: 1) gravity

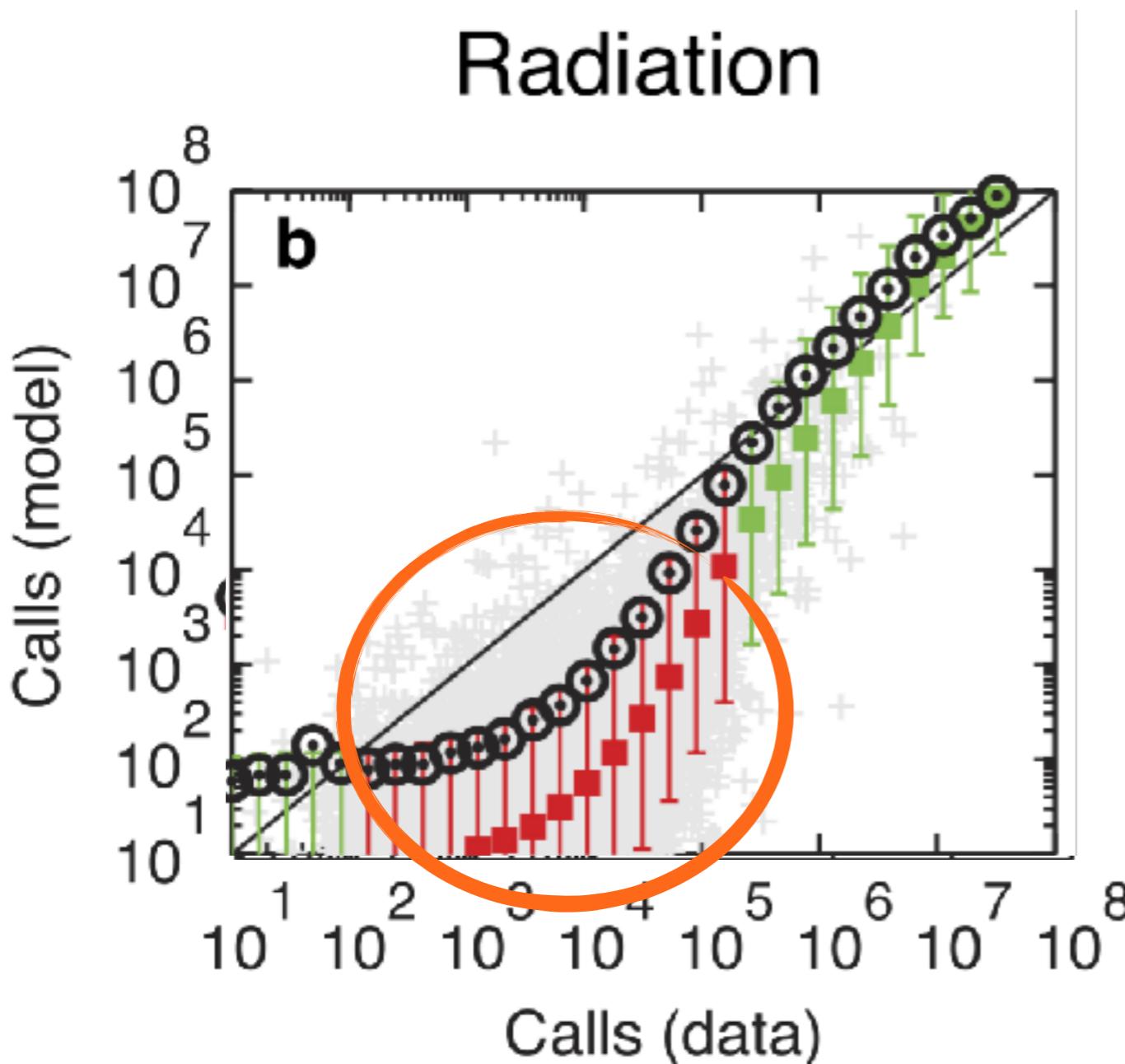


Underestimates high-range flows...
...leading to too few and large communities

Problems with old mobility models: 1) gravity



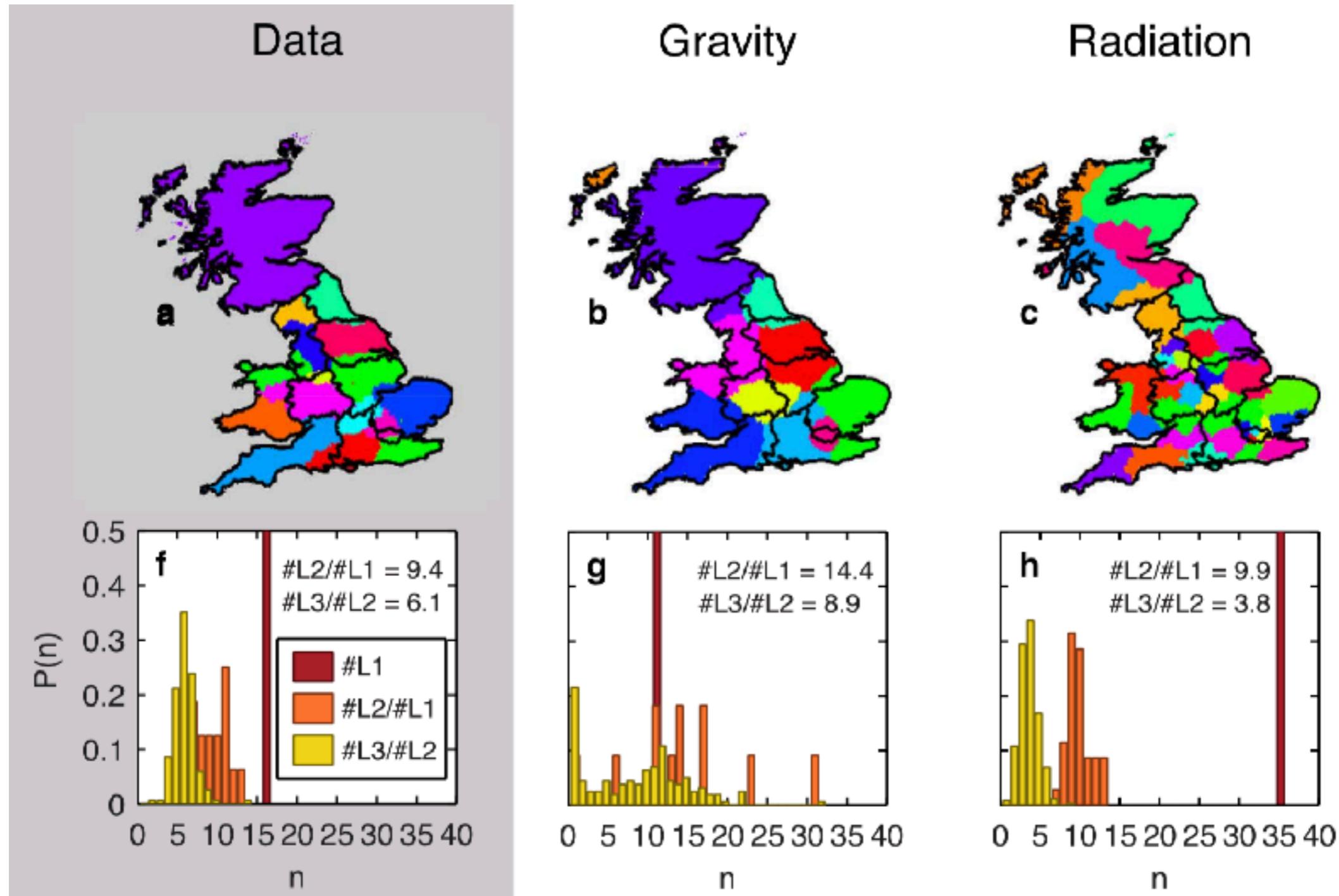
Problems with old mobility models: 2) radiation



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

Underestimates low-range flows...

Problems with old mobility models: 2) radiation



Underestimates low-range flows...
...leading to too many and small communities

Hierarchical distance defines damping parameters q

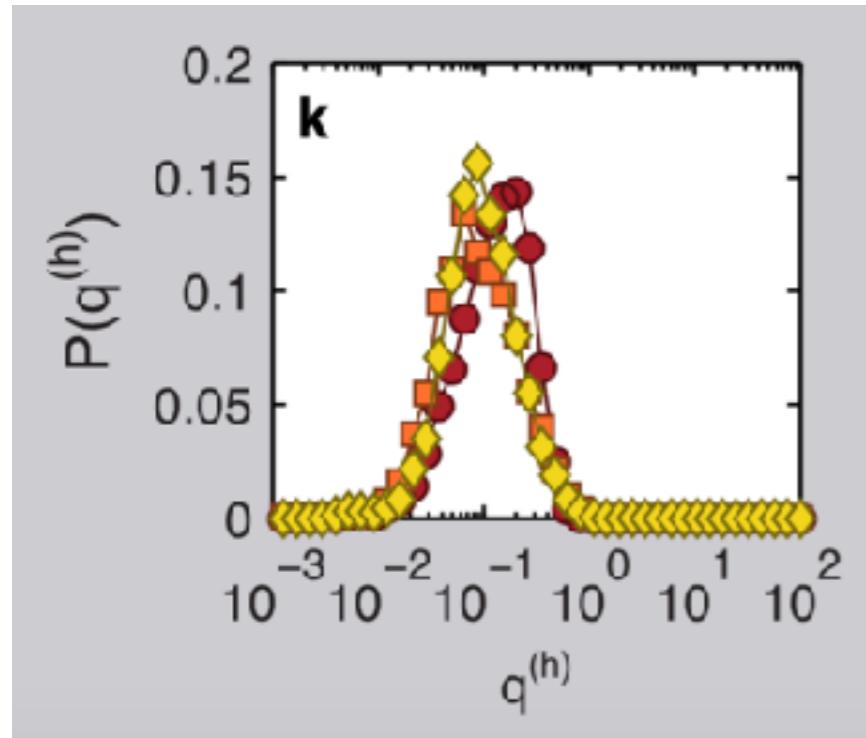
All calls from locations at distance h from i

$$q_i^{(h)} = \frac{T_i^{(h+1)}}{W_i^{(h+1)}} \frac{W_i^{(h)}}{T_i^{(h)}}, \quad h = 1, 2, 3$$

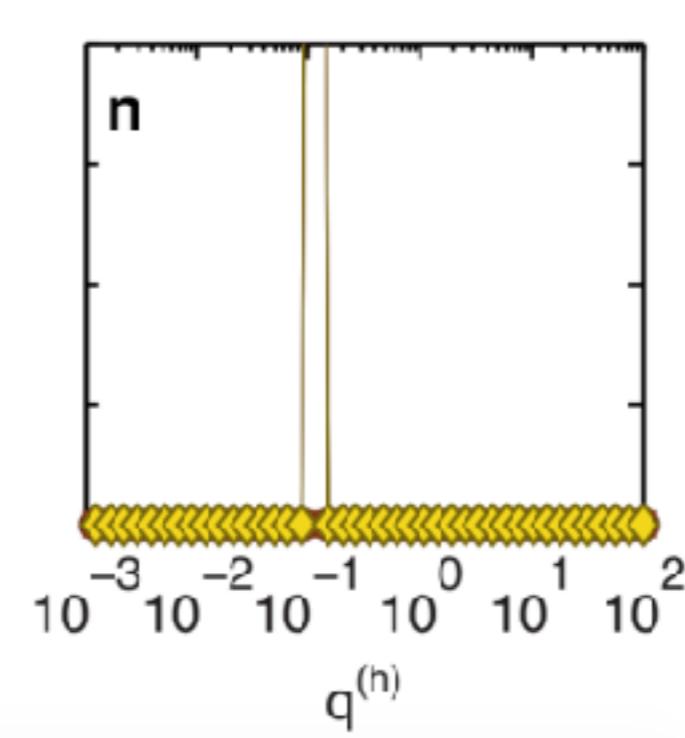
Relative importance of locations at distance h+1 compared to those at h, from i

All calls from i to all locations at distance h

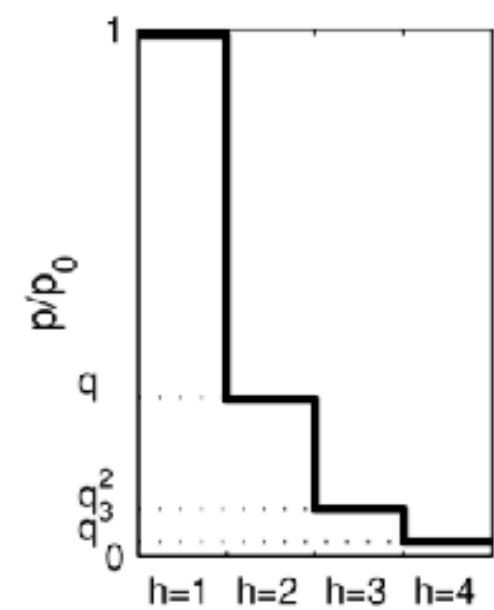
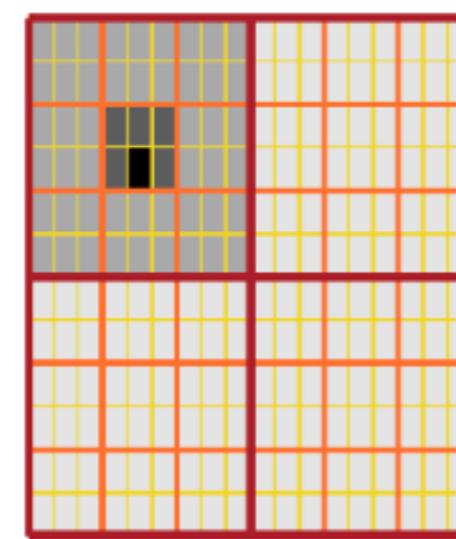
Empirical damping parameters q are independent of h and i



$$q_i^{(h)} \simeq q$$



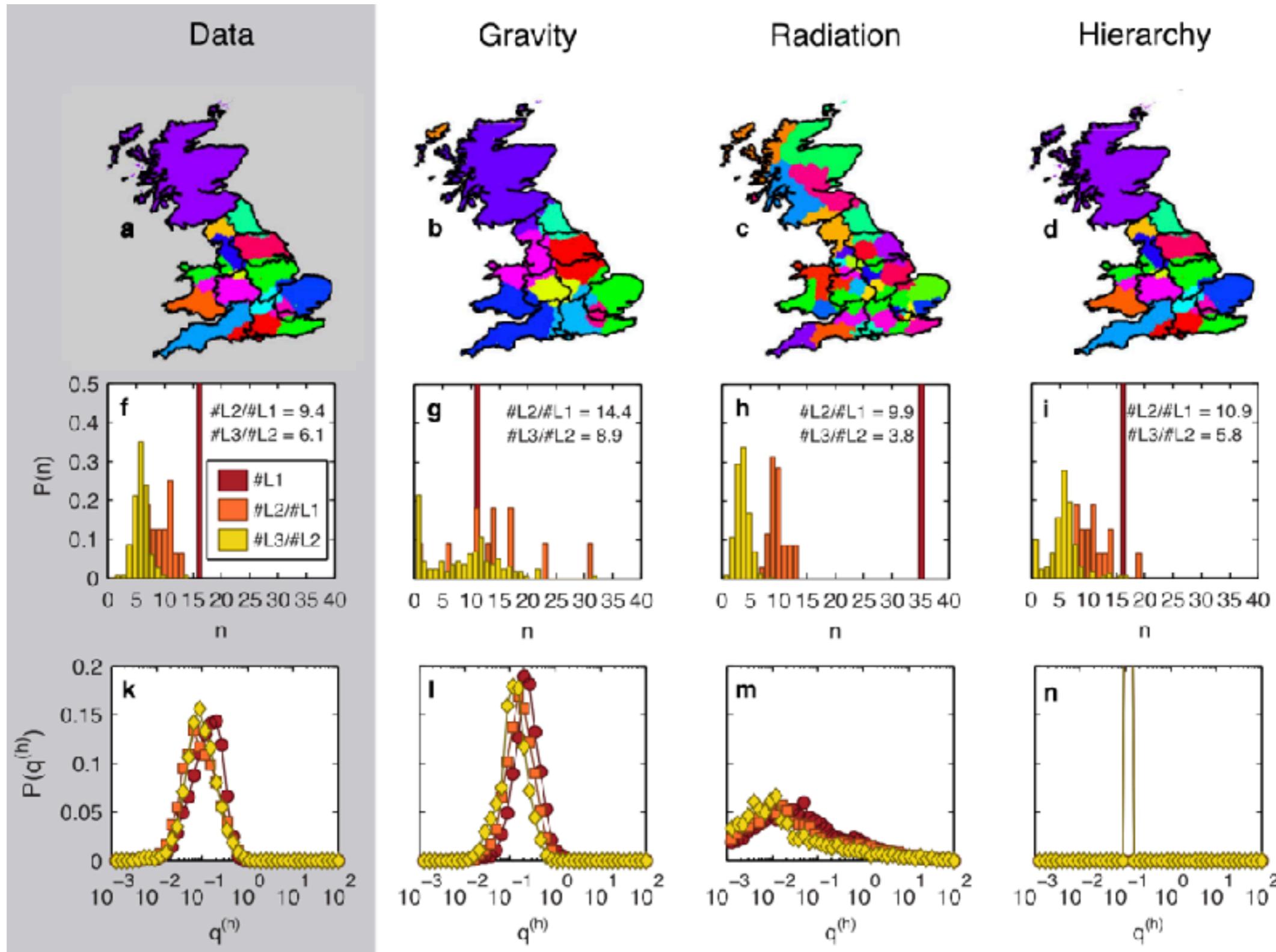
$$T_{ij}^{\text{Hier}} = C_i w_i w_j q^{h_{ij}}$$



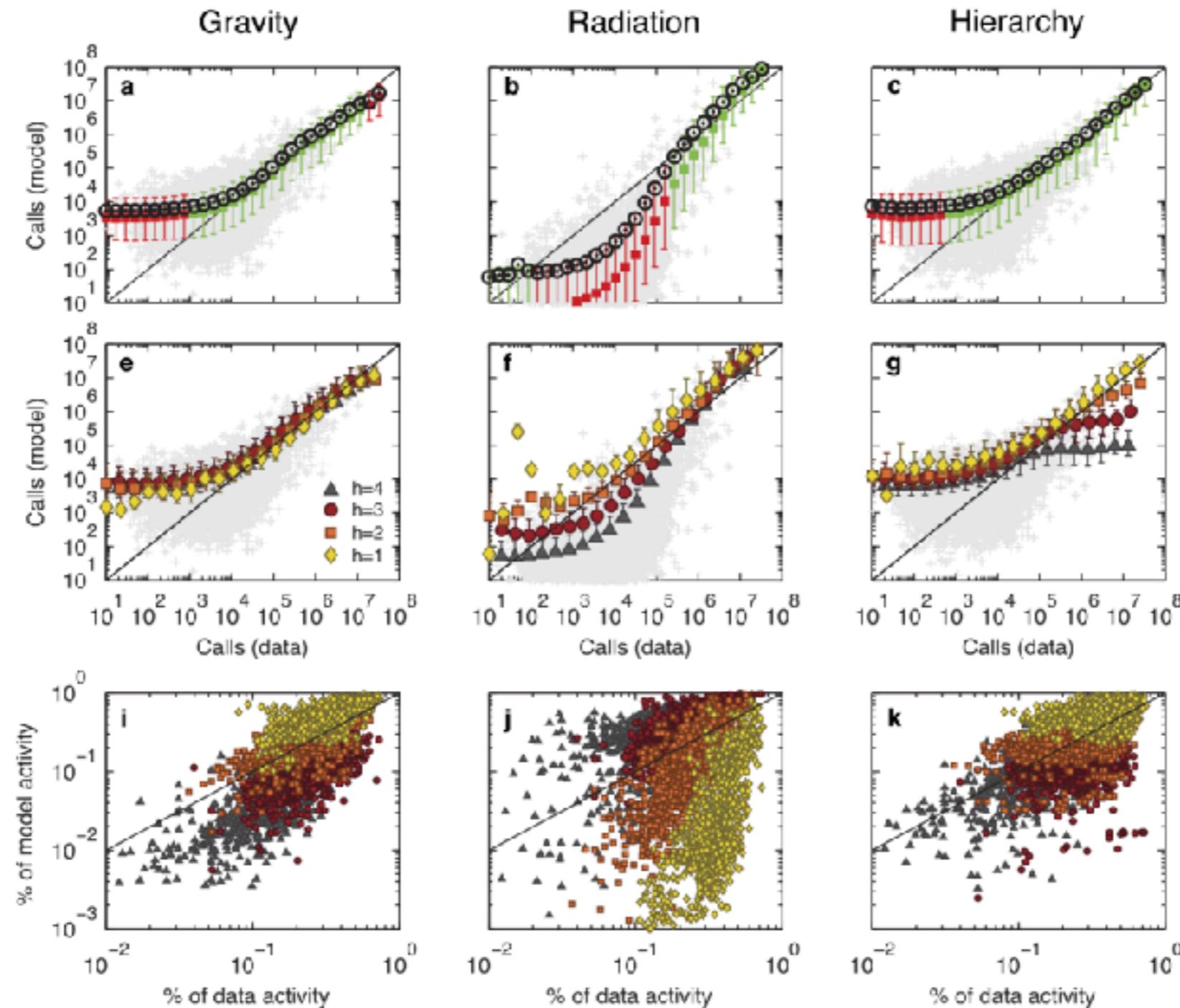
In practice, setting $q=0.2$ works fine.

Grauwin et al, Sci Rep 7:46677 (2017)

Full picture: the hierarchy model outperforms the others!



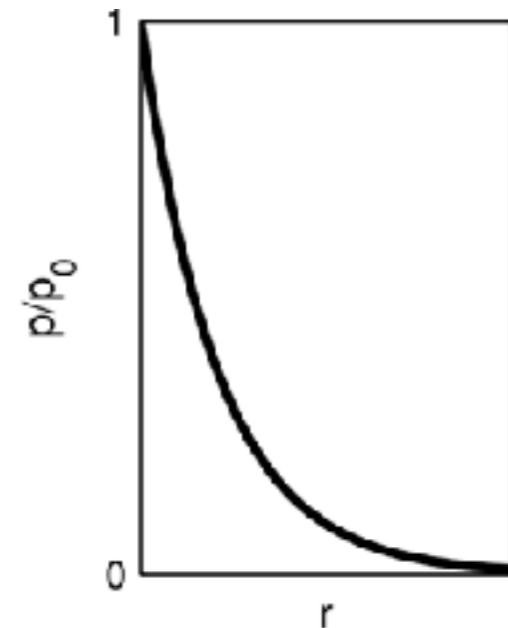
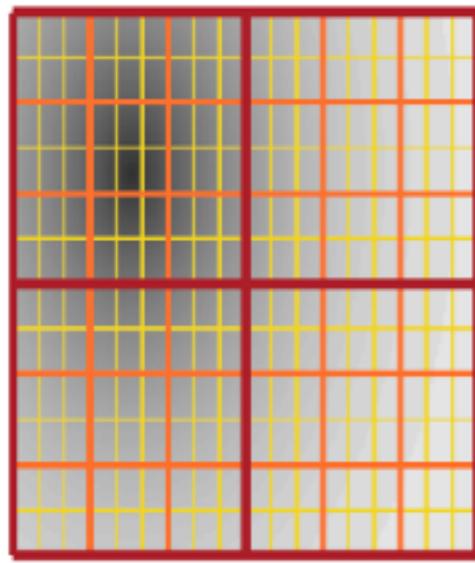
Full picture: the hierarchy model outperforms the others!



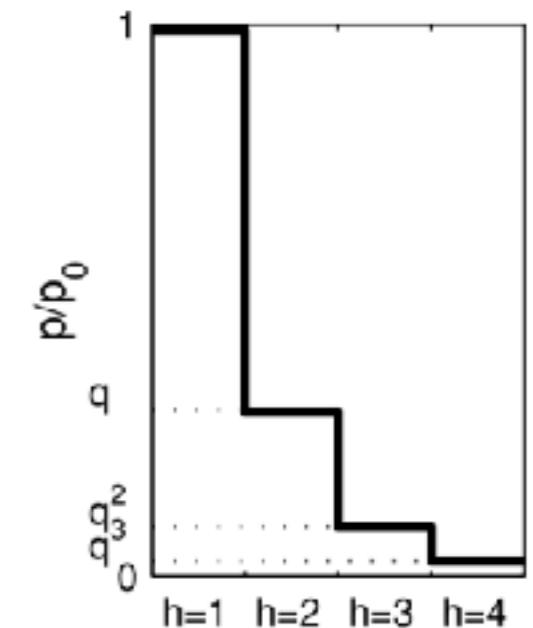
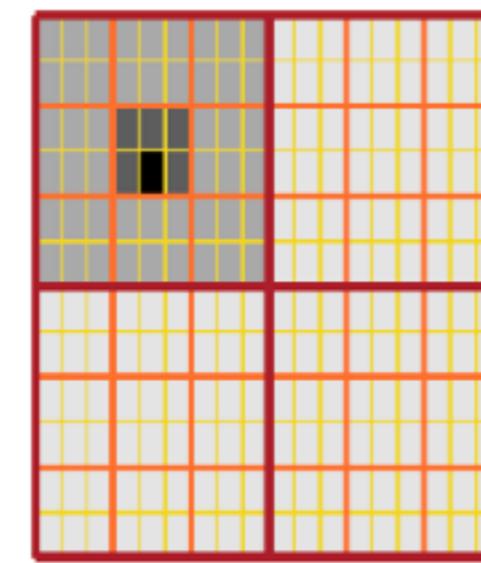
Further robustness tests
confirm this result.

Full picture: the hierarchy model outperforms the others!

Old models

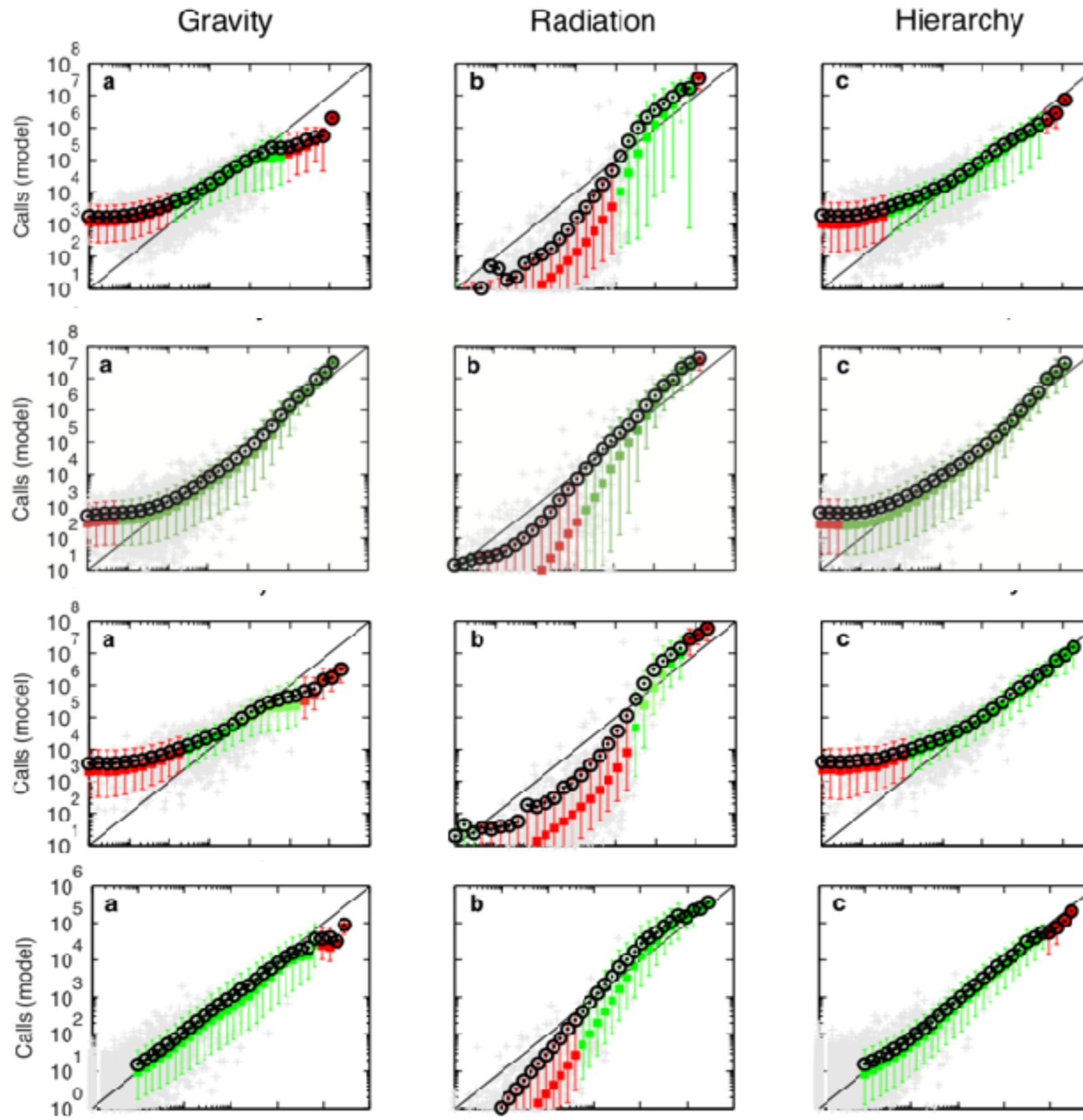


Hierarchy model



The improvement is remarkable because continuous euclidian distance is replaced by one damping parameter!

Similar result for other countries



Portugal

France

Ivory Coast

Country X



OPEN

Identifying and modeling the structural discontinuities of human interactions

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Grauwin et al, Sci Rep 7:46677 (2017)

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