Functional Network of the City

Maxime Lenormand

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UIB Universitat de les Illes Balears
CSIC

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Conselleria d'Educació, Cultura i Universitats

European Union
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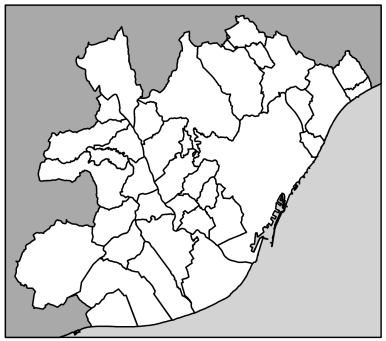
insight
Innovative
Policy Modelling and Governance Tools
for Sustainable Post-Crisis Urban Development

Motivation

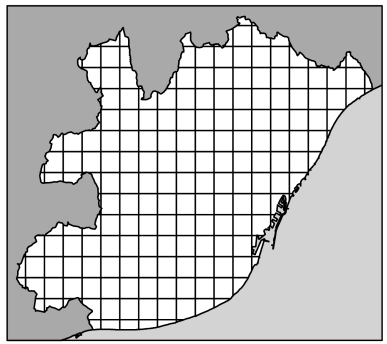
Comparison of land use patterns across cities

- Network approach to detect land use using mobile phone data
- Spatial organization (entropy, Ripley's K...)
- Land use model

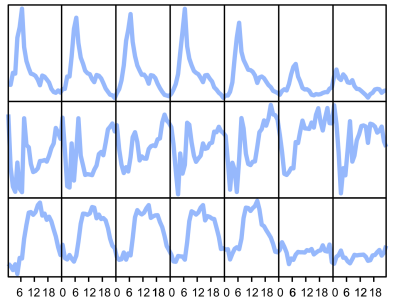
Method used to extract the network



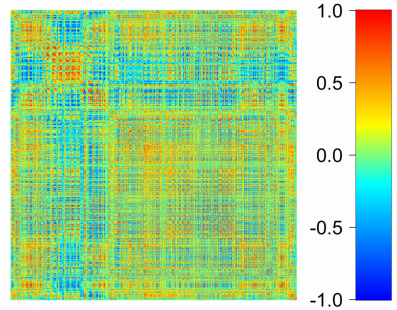
Metropolitan Area



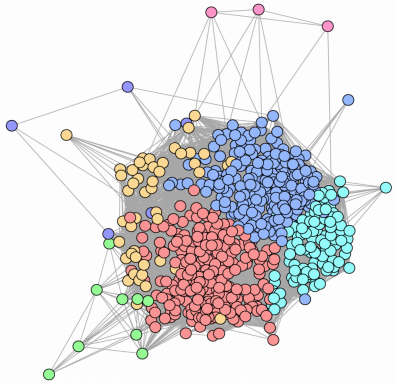
Recordings sites



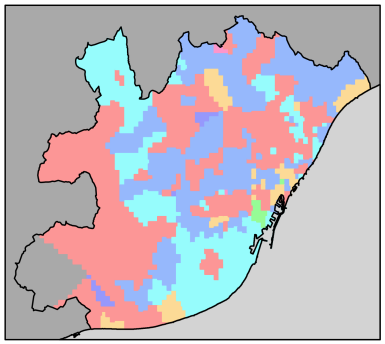
Signals



Correlation Matrix

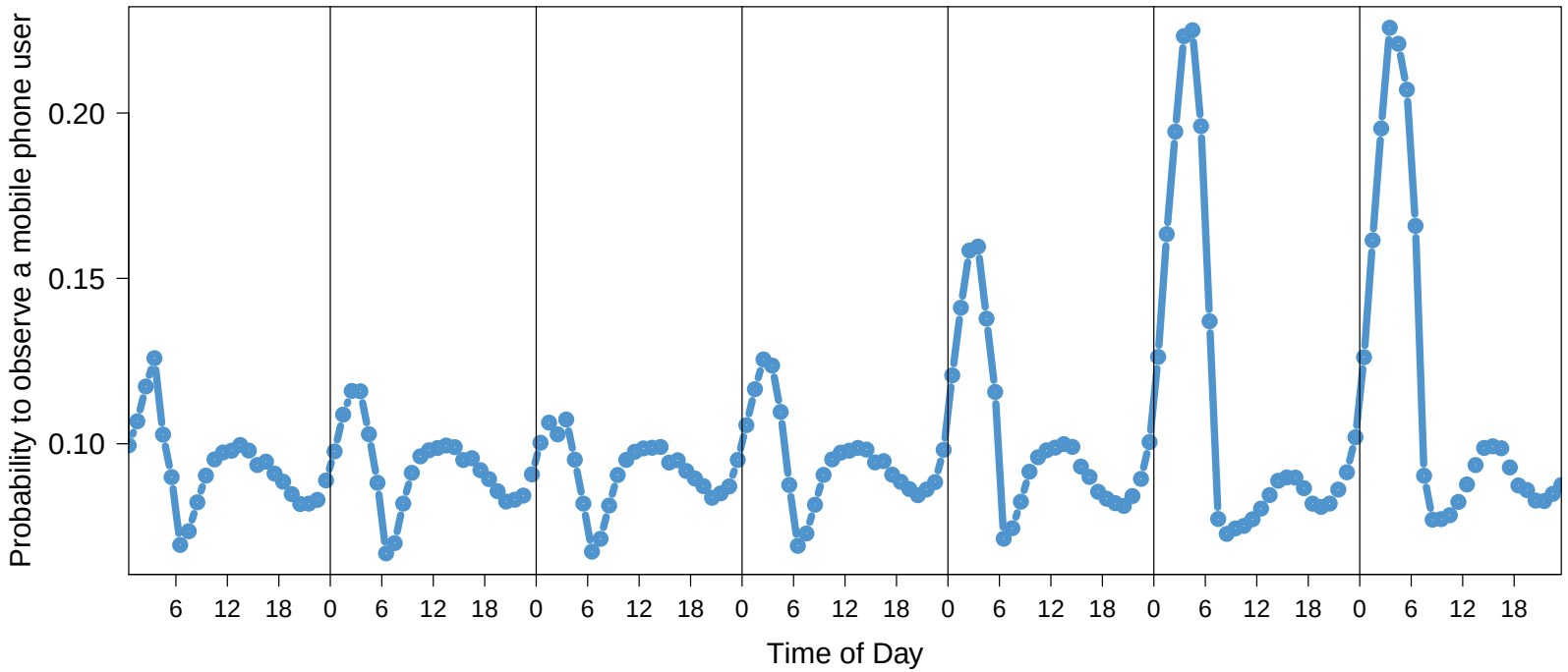


Functional Network



Method used to extract the network

Probability to observe a mobile phone user in a given cell at a given time



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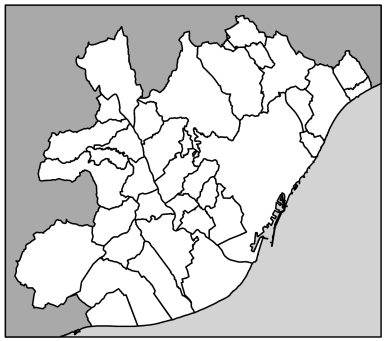
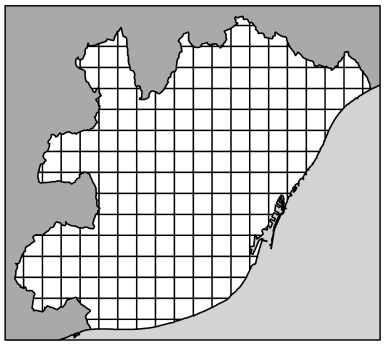


Metropolitan Area



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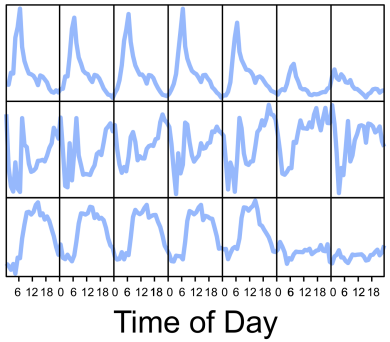
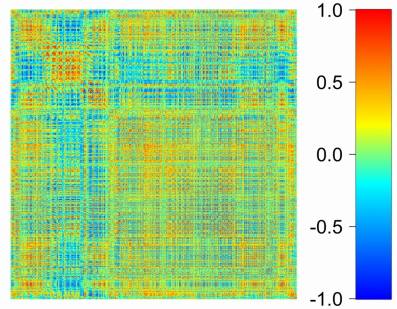


Signals



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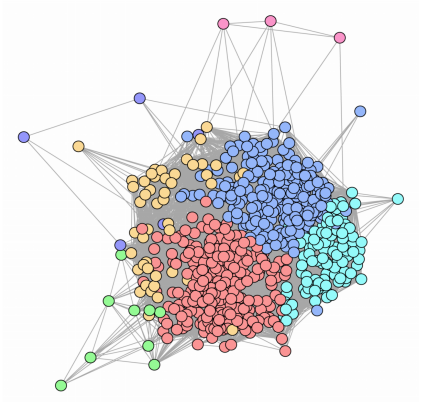
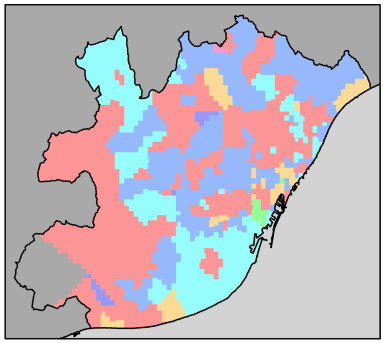
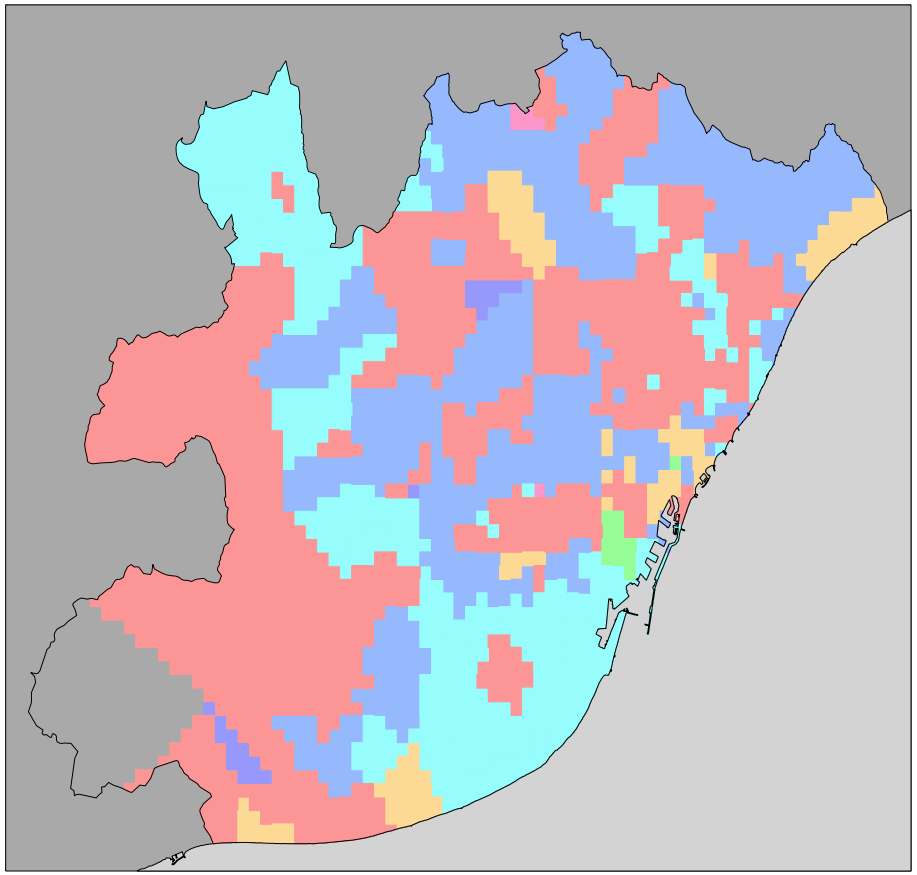


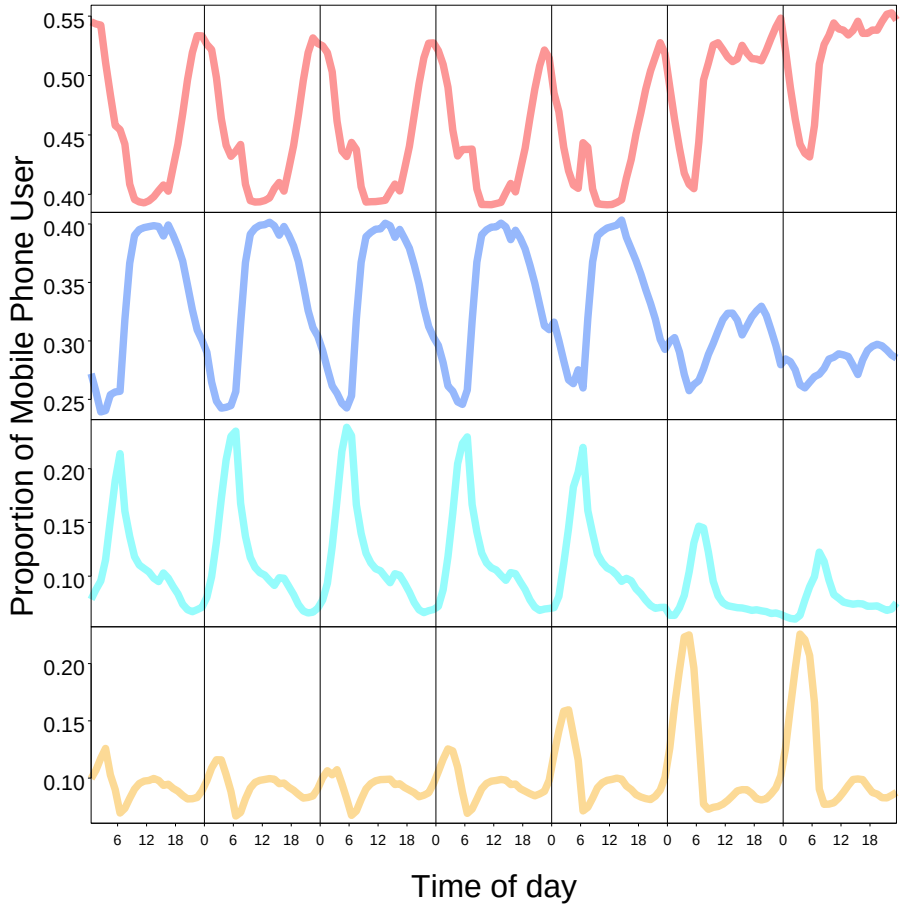
Functional Network



Land use patterns

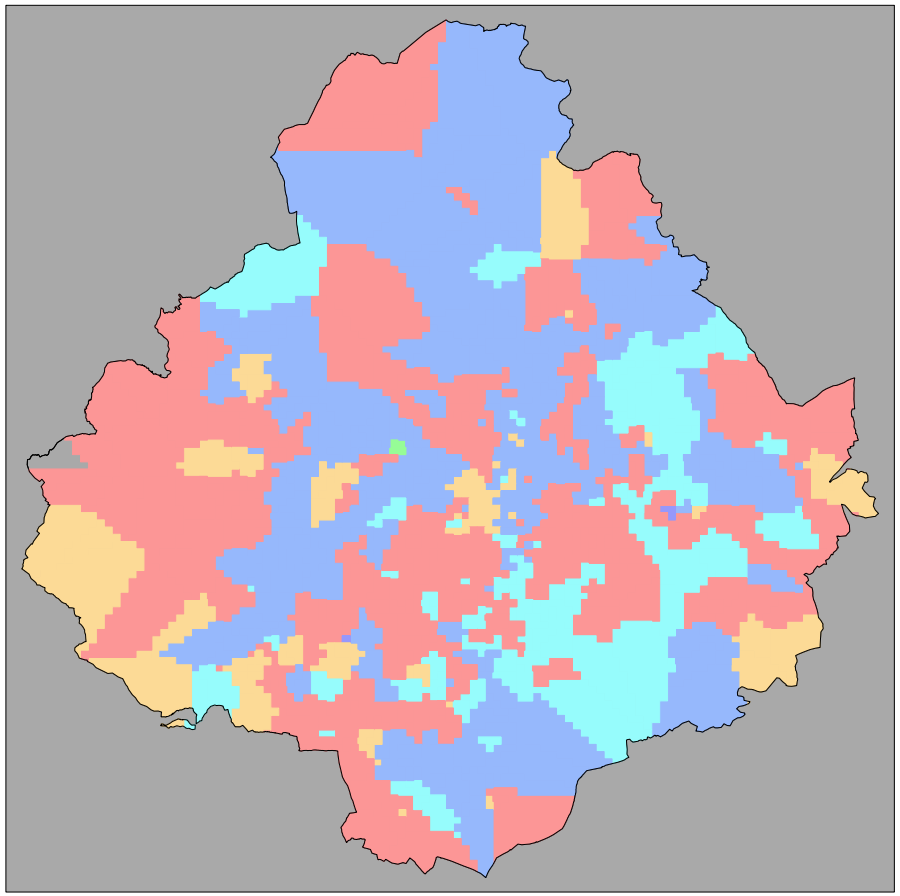
Barcelona (PGP = 60%)

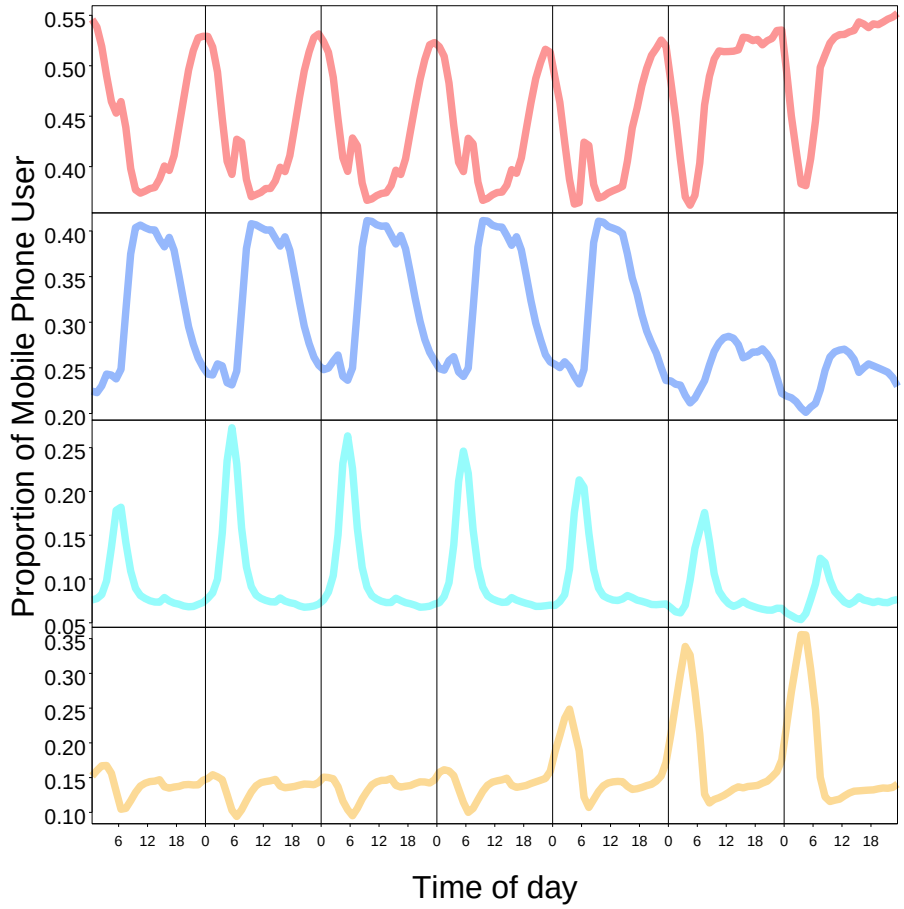




Land use patterns

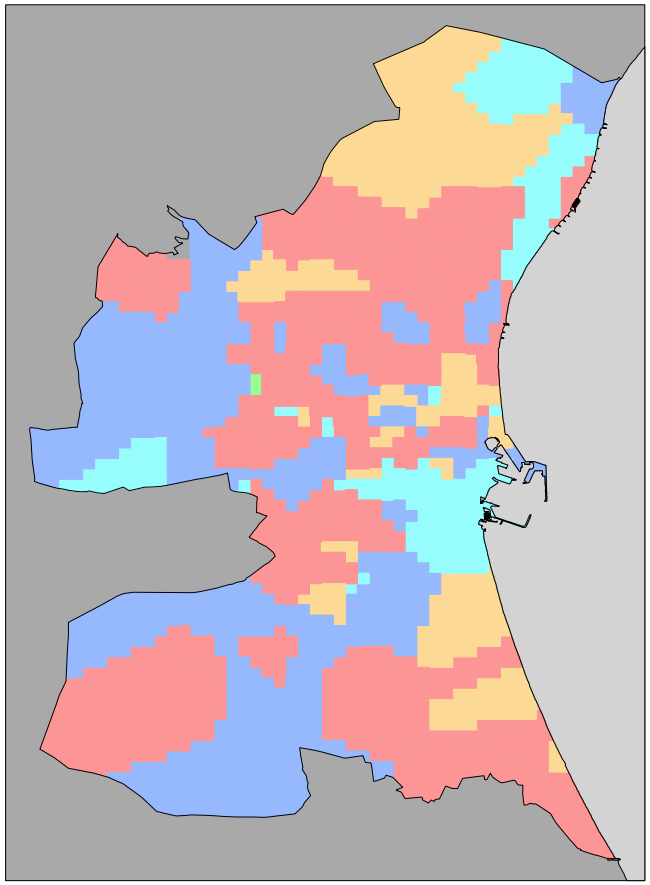
Madrid (PGP = 65%)

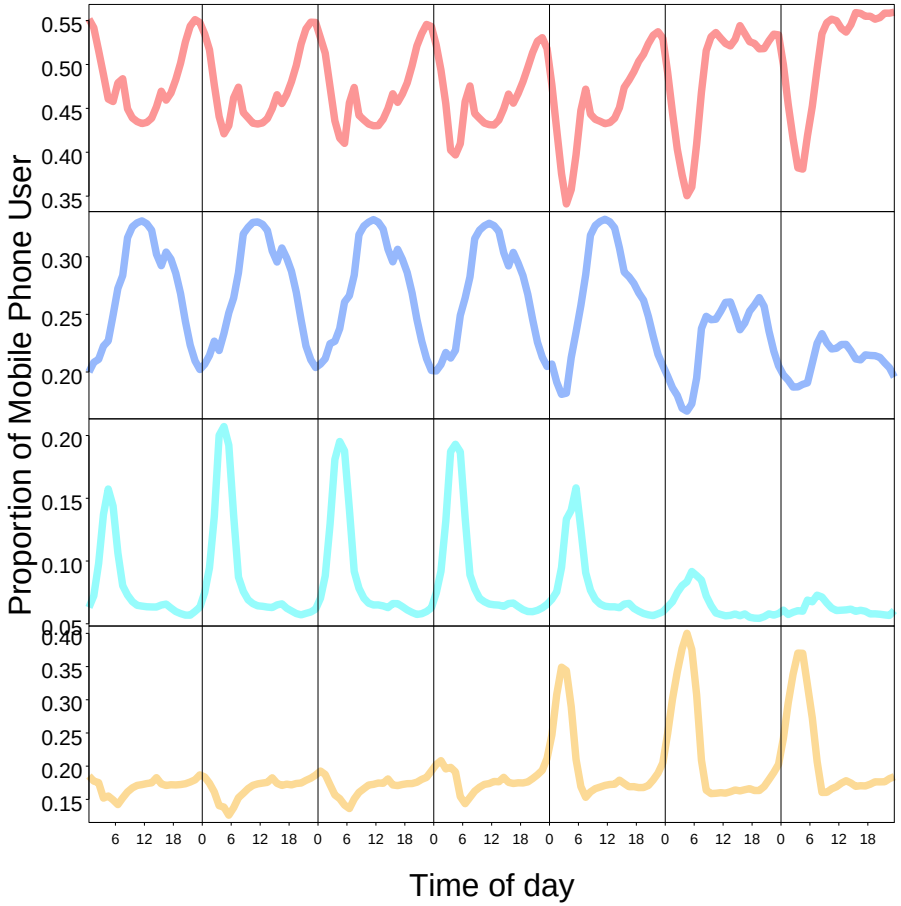




Land use patterns

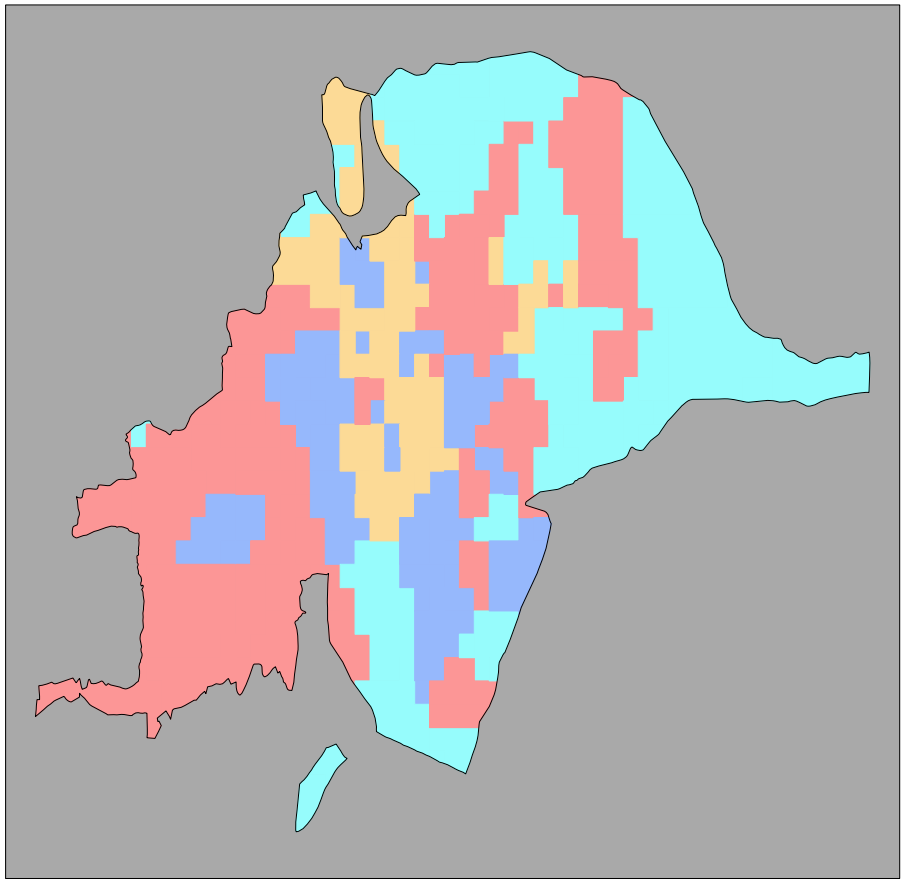
Valencia

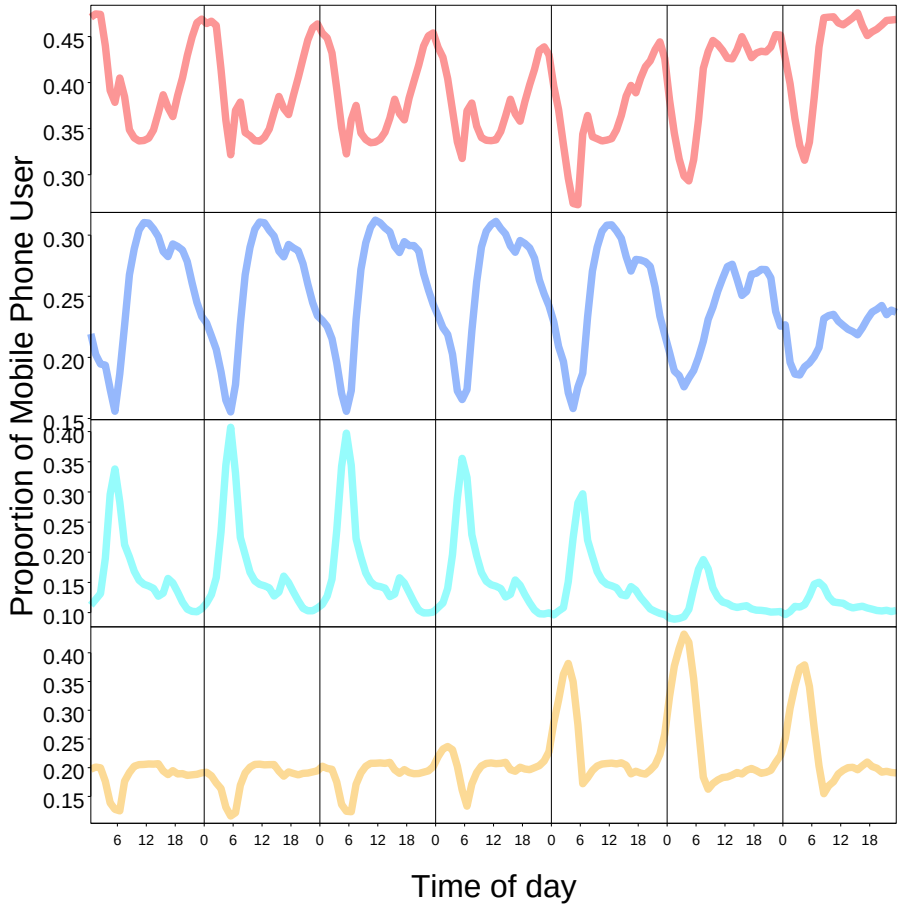




Land use patterns

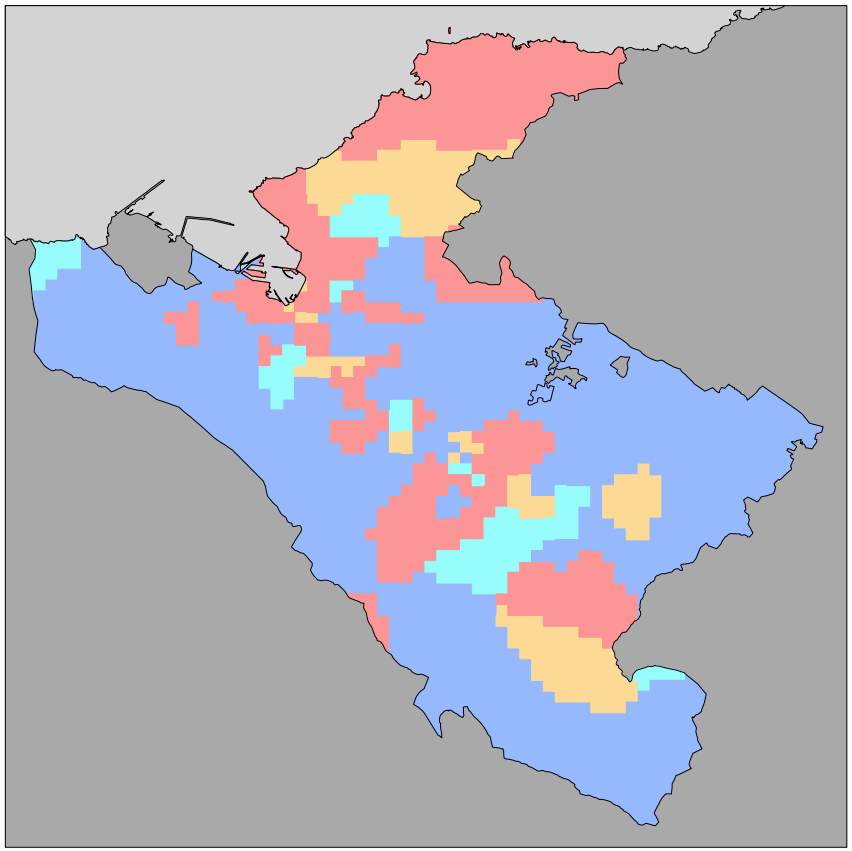
Sevilla

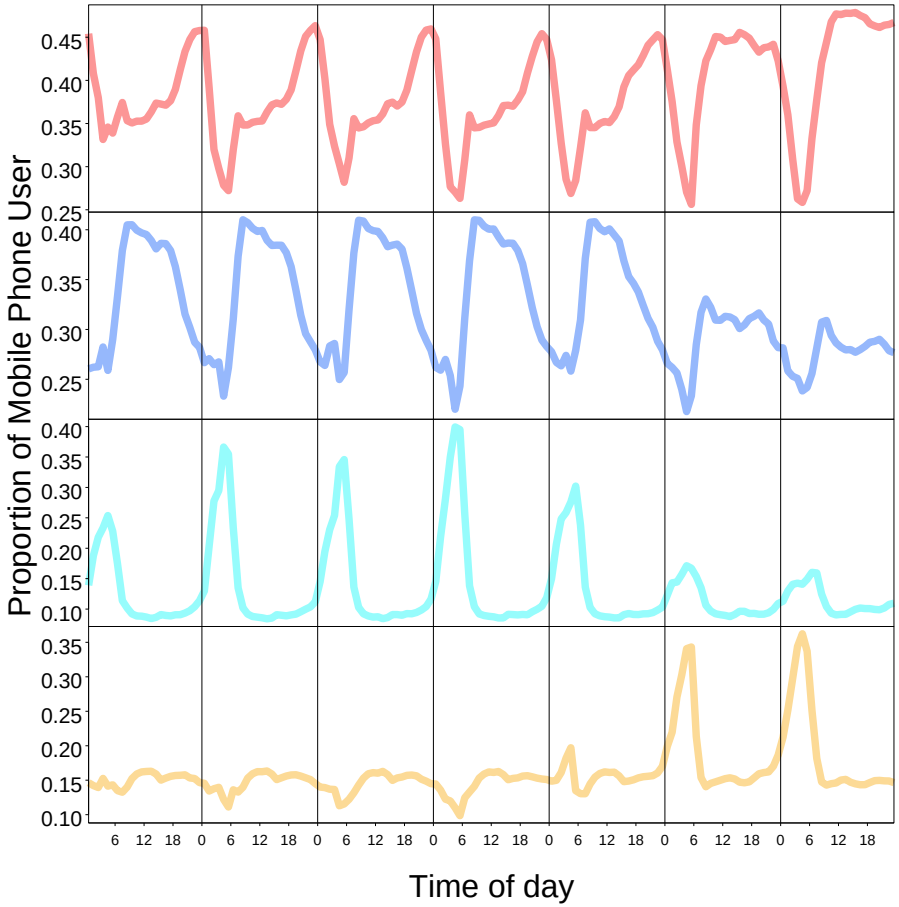




Land use patterns

Bilbao





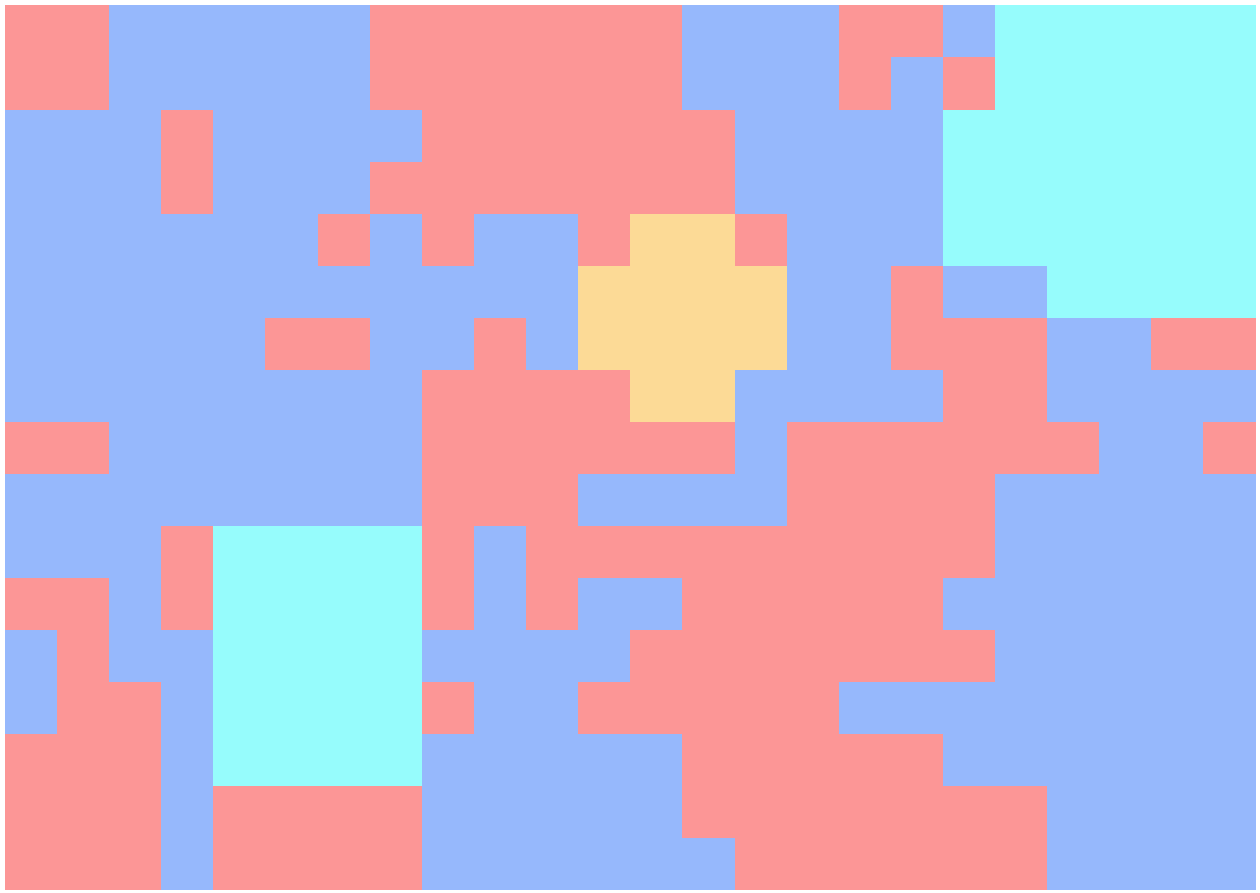
Spatial organization of land use

Three measures of spatial heterogeneity

- Distribution of the distance between the cells and the city center
- Ripley's K
- Entropy index

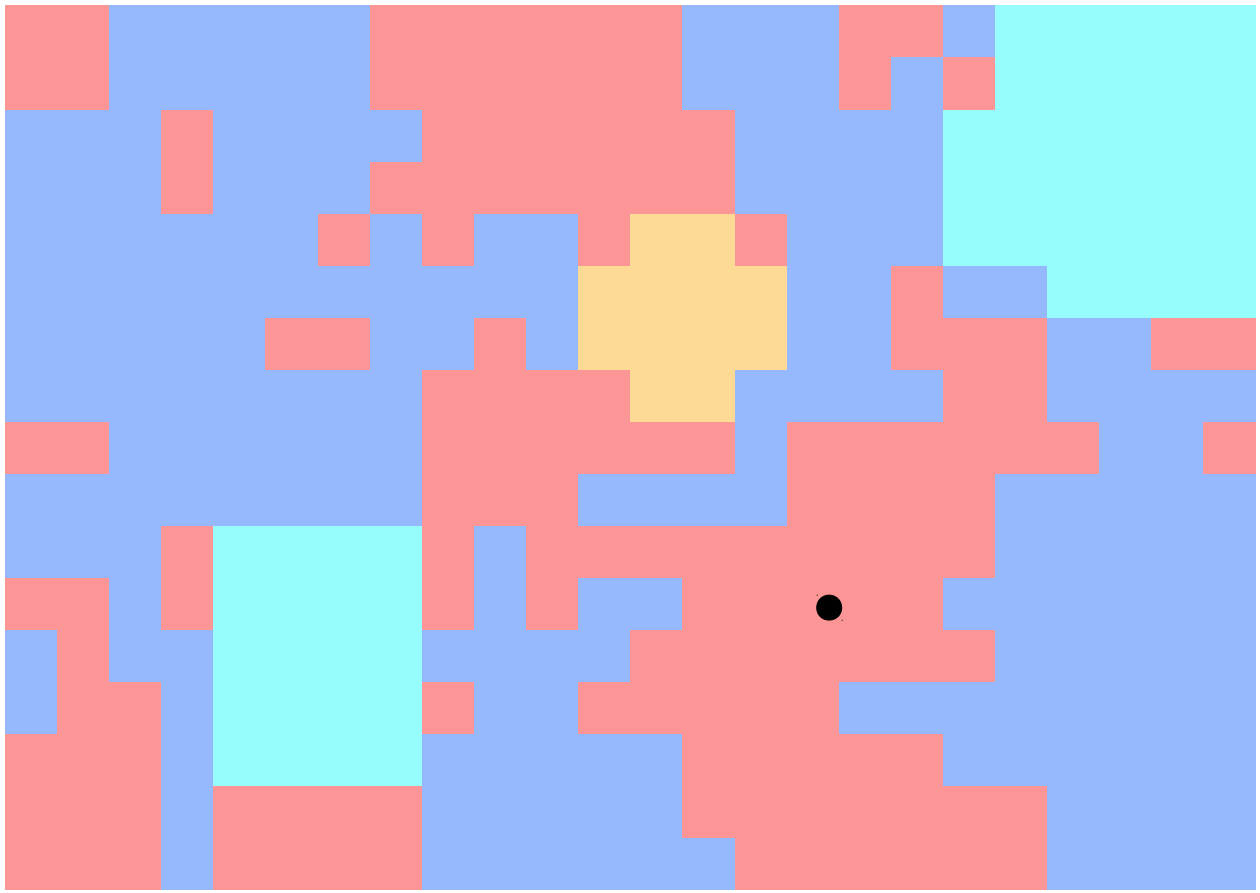
Spatial organization of land use

Distance to the city center



Spatial organization of land use

Distance to the city center



Spatial organization of land use

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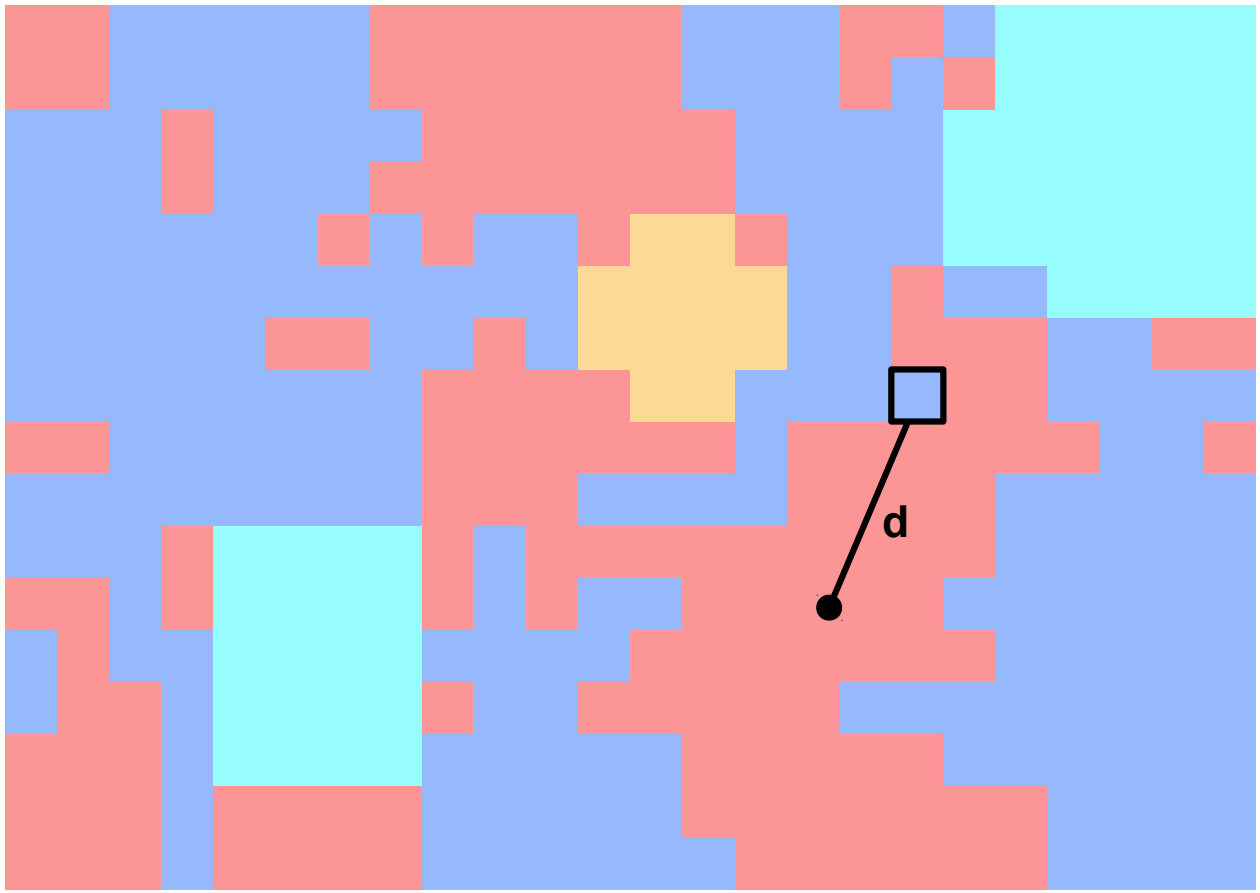

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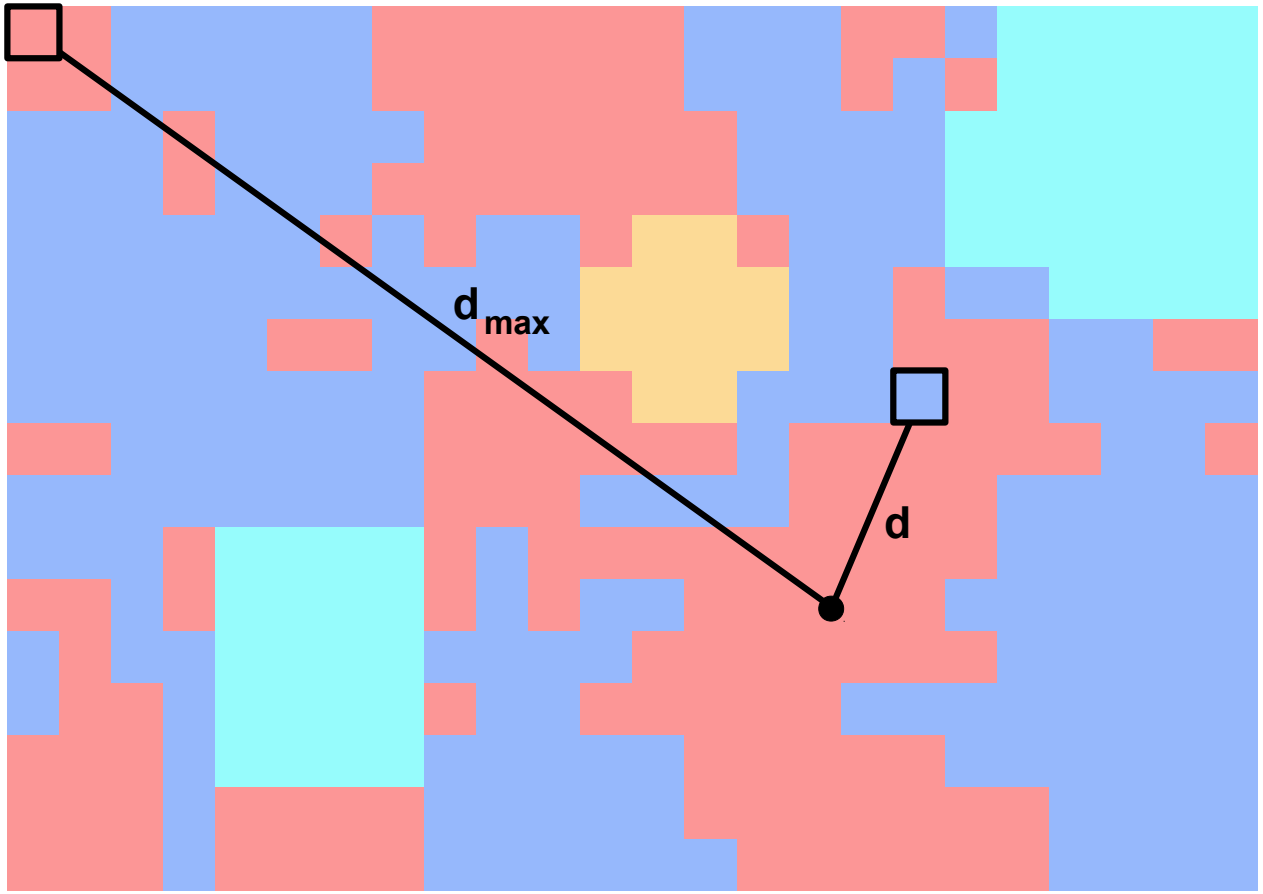

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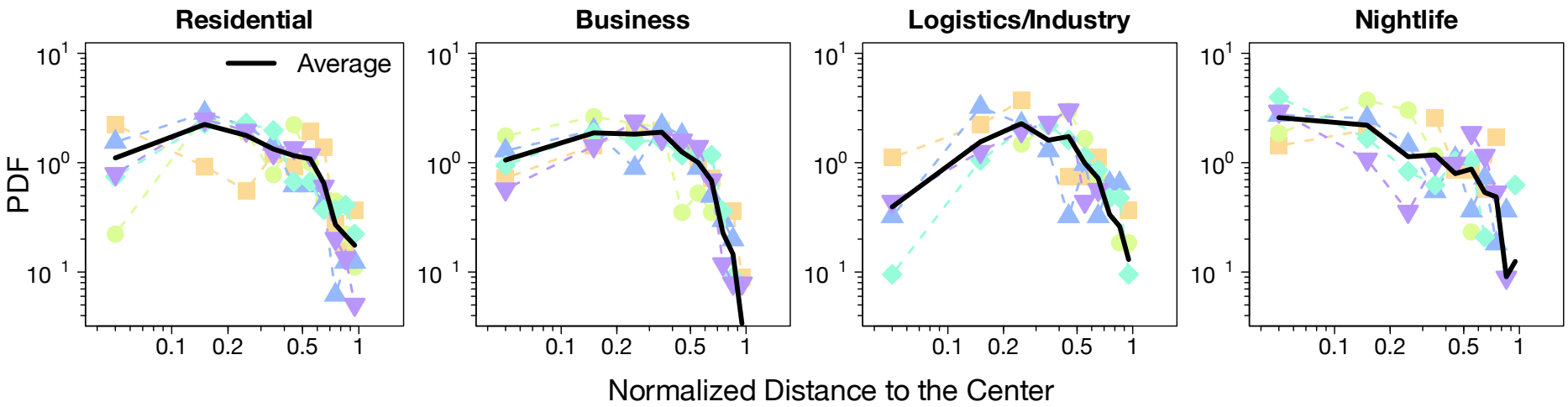
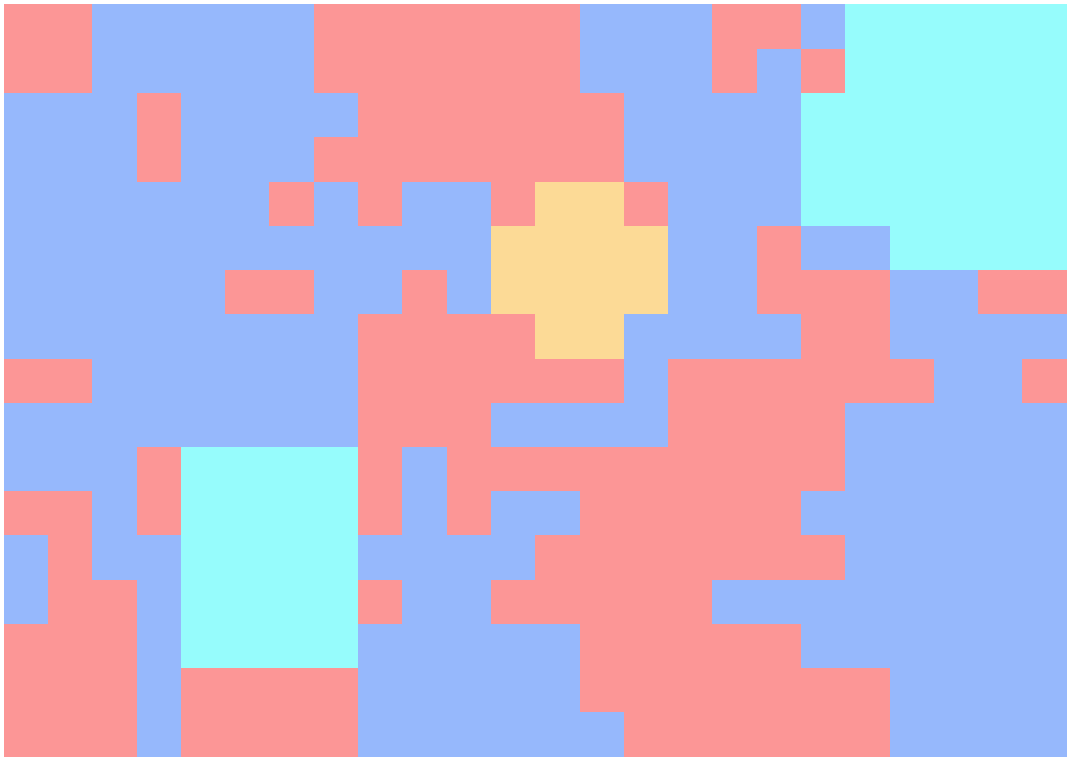


Spatial organization of land use

Ripley's K

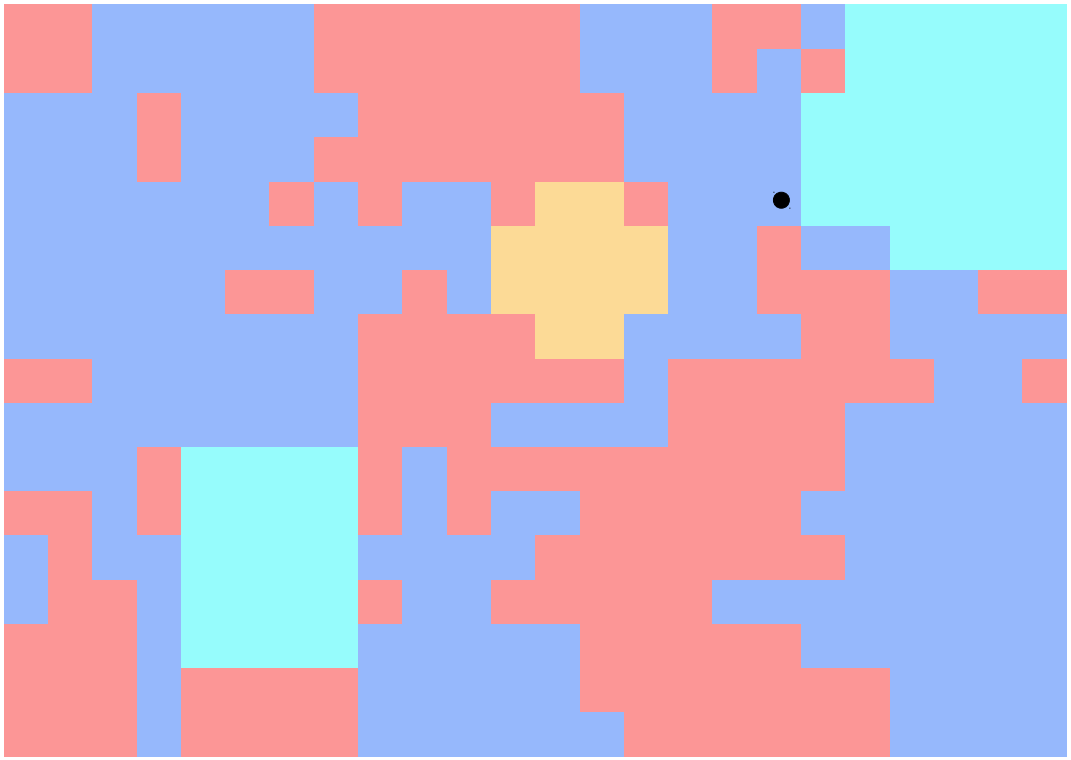


$$K(r) = \frac{A}{n^2} \sum_{i=1}^{n} N_i(r)$$

$$\hat{K}(r) = K(r)/K(1)$$

Spatial organization of land use

Ripley's K



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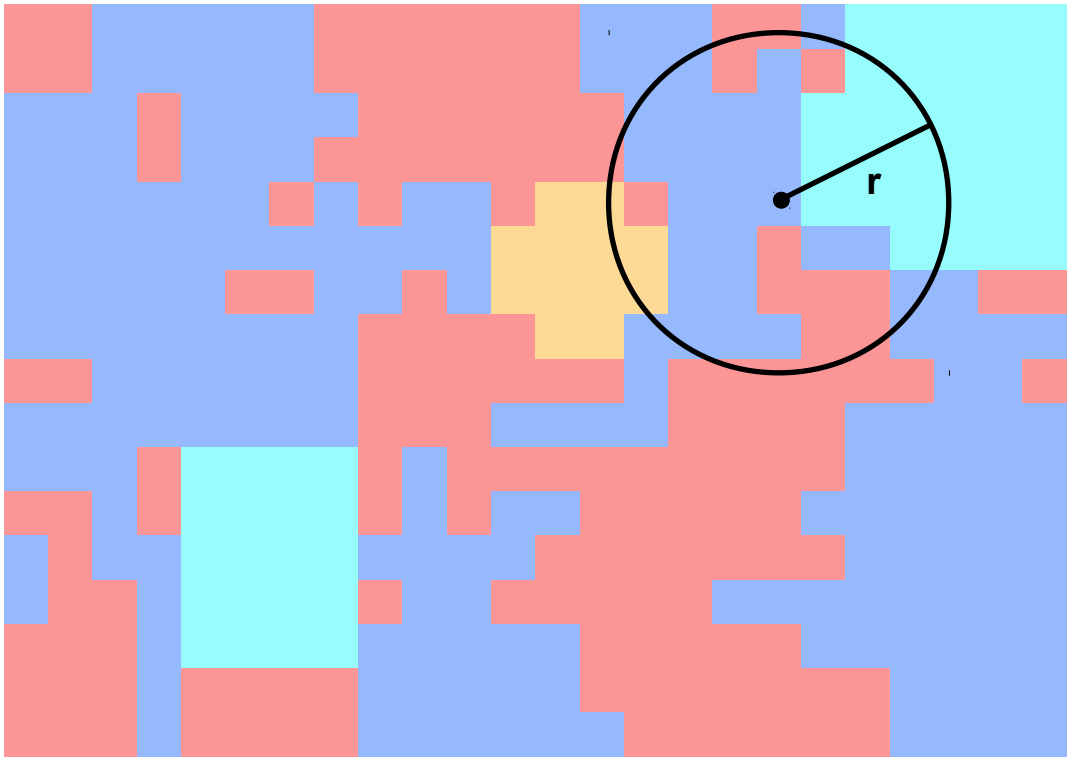

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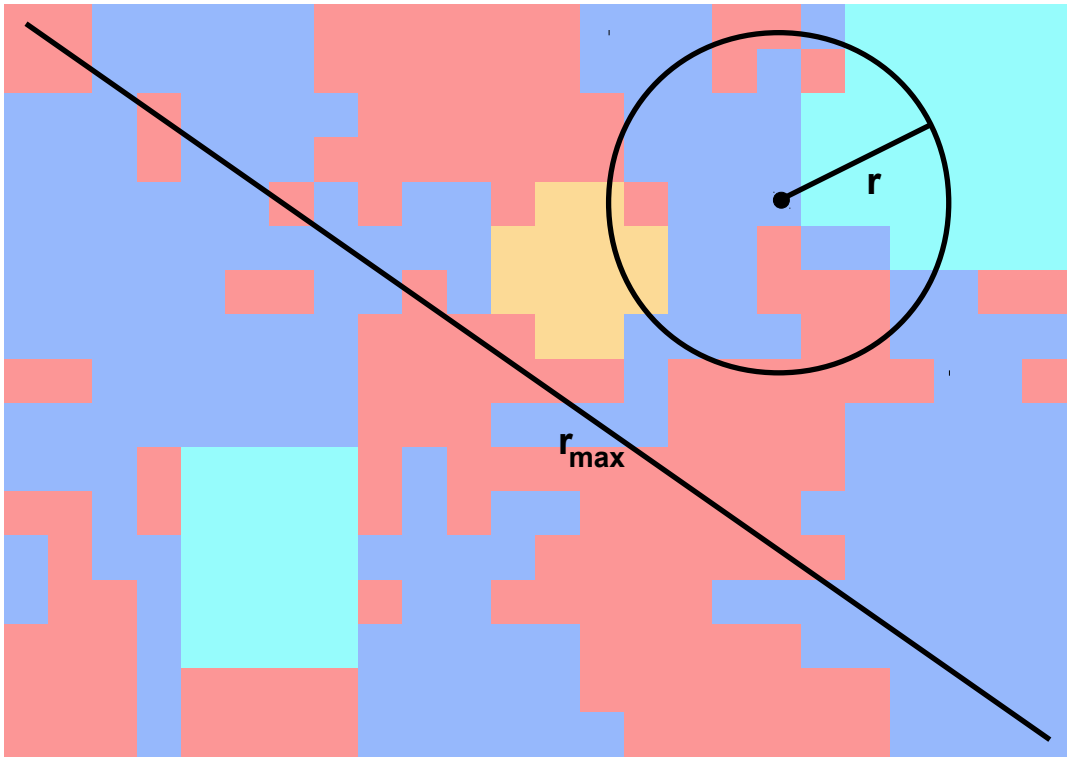

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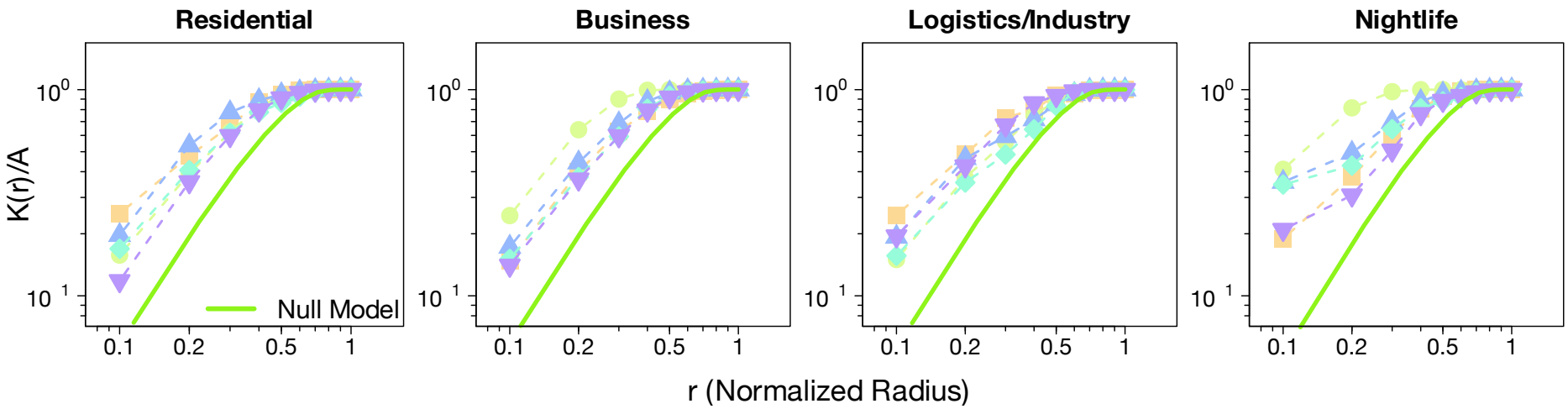
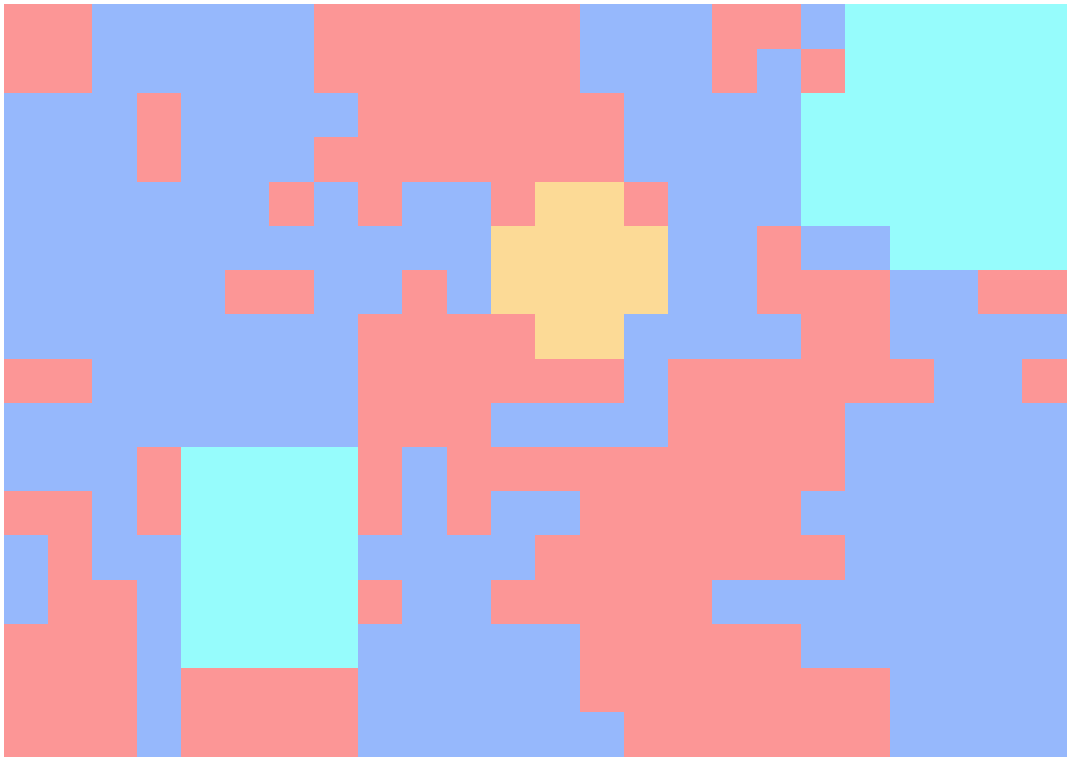


Spatial organization of land use

Entropy index

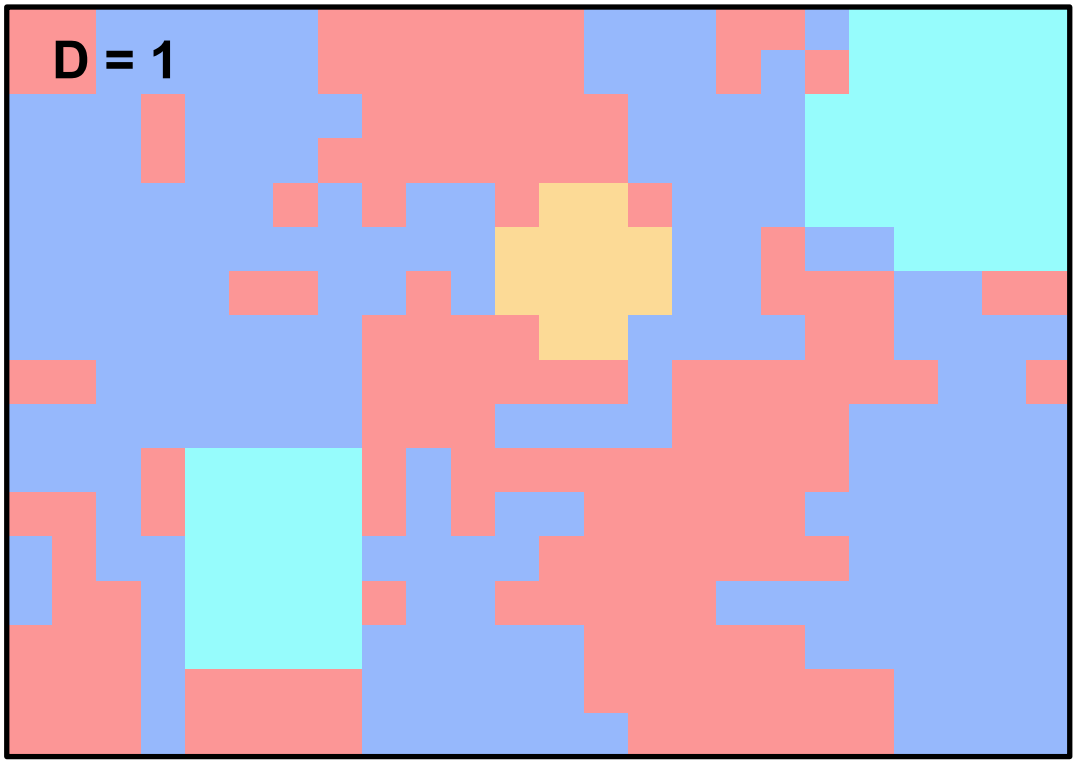


$$E_i = -\sum_{k=1}^{4} f_i^k \ln f_i^k$$

$$E(D) = \frac{1}{D^2} \sum_{i=1}^{D^2} E_i$$

Spatial organization of land use

Entropy index



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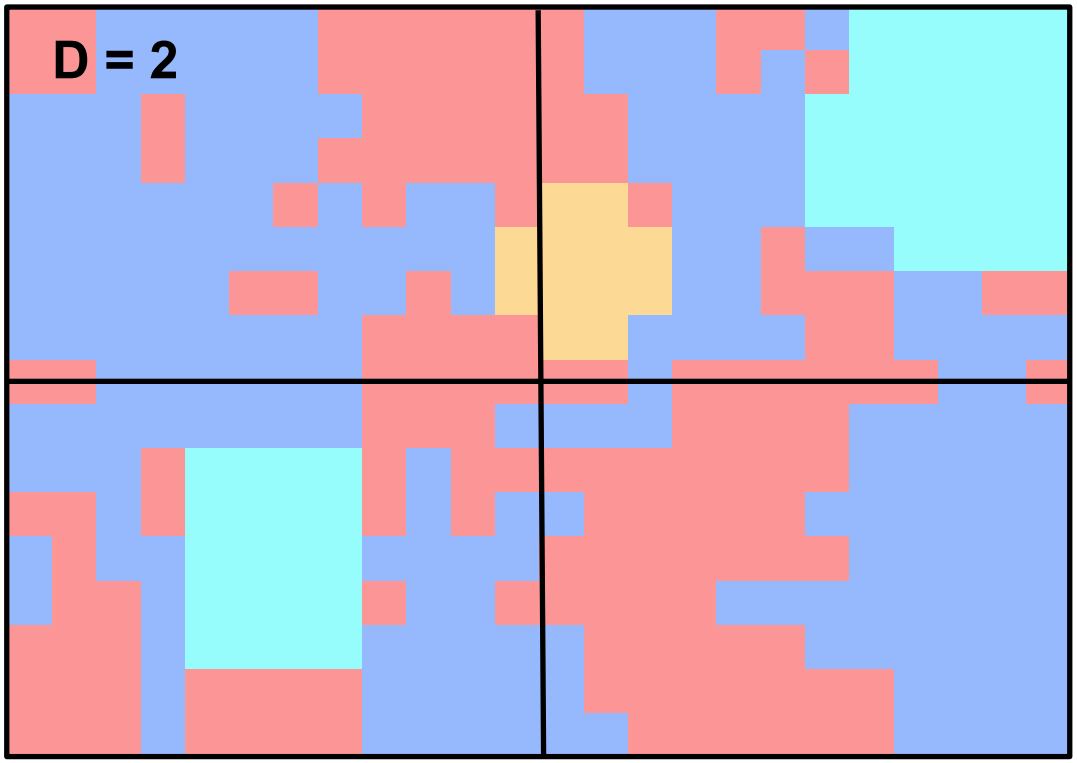

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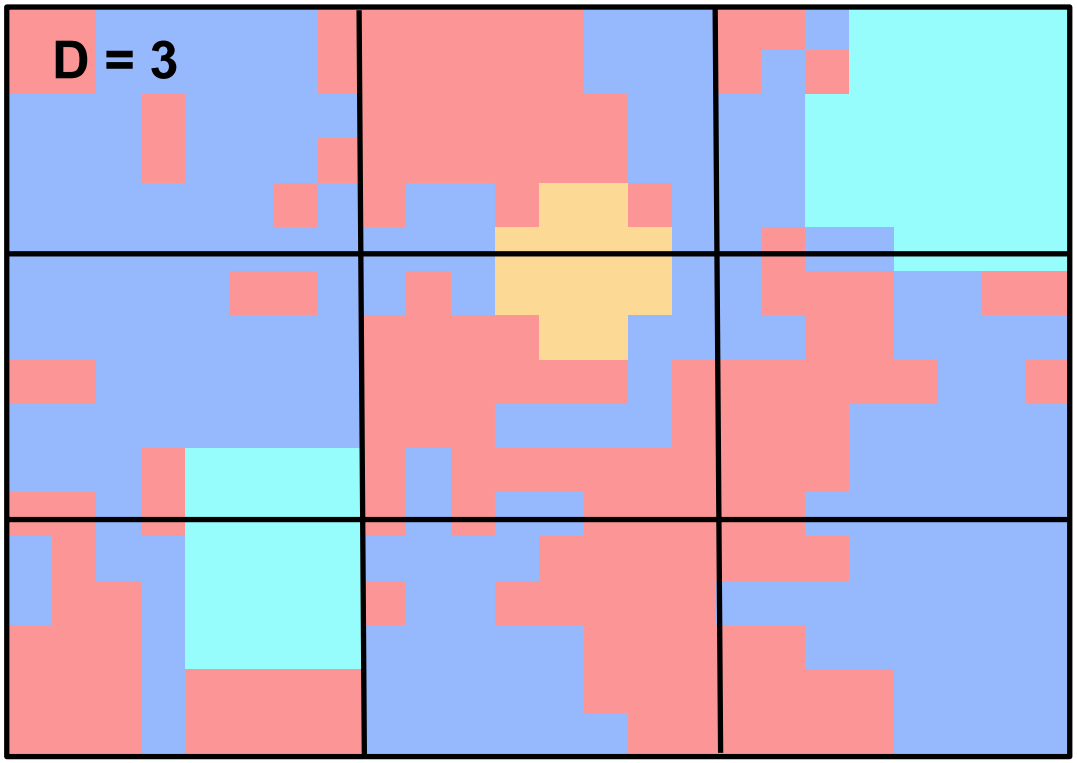

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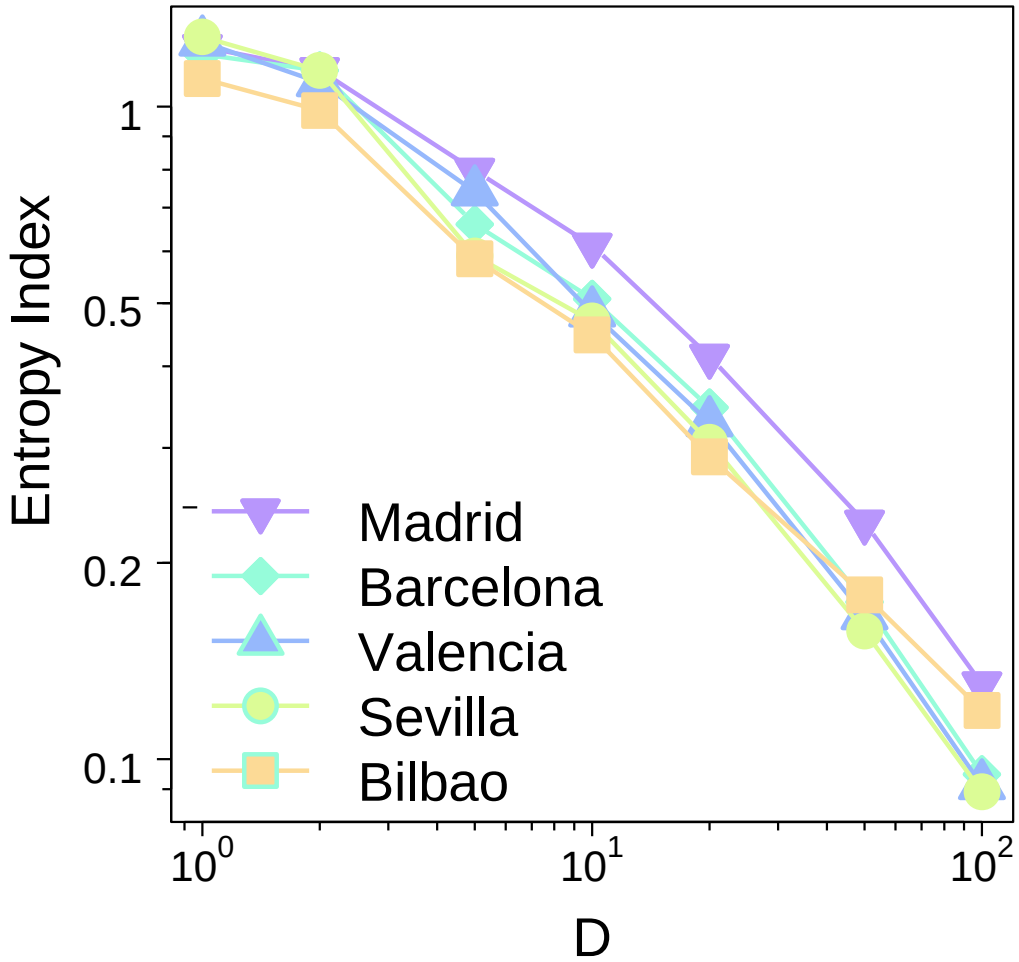
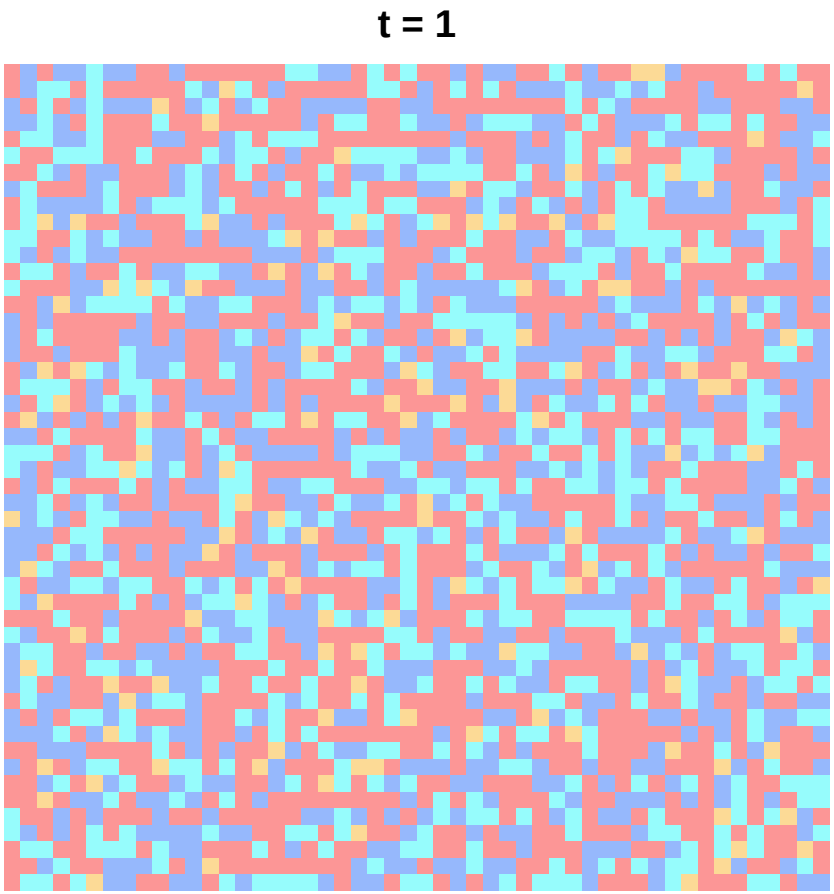


Land use model

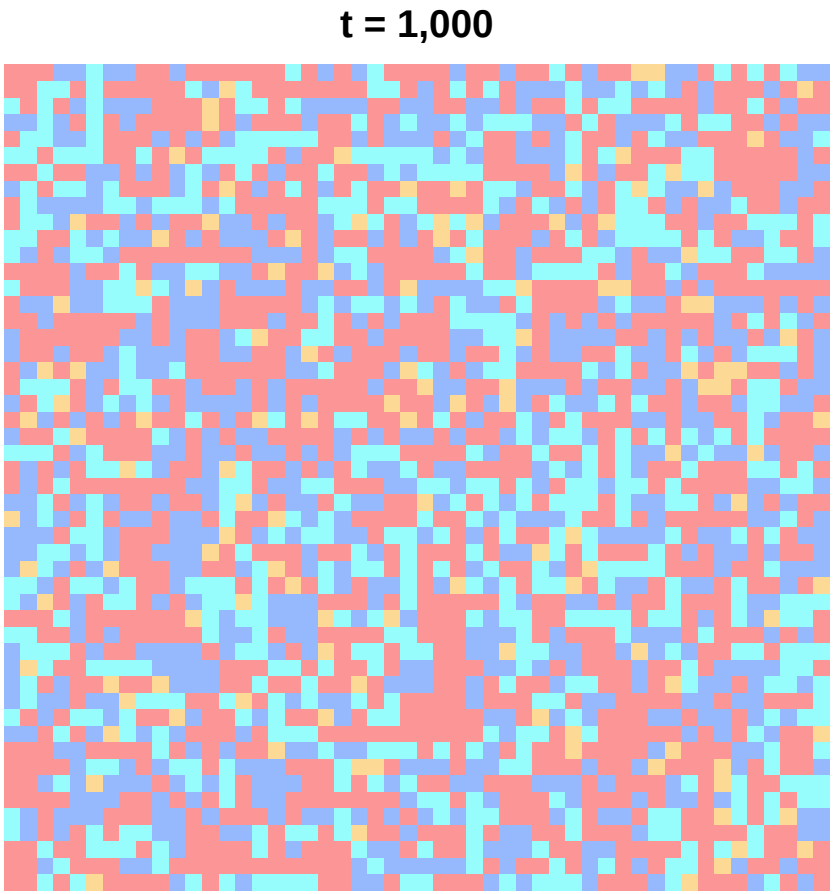
Simple model inspired by Schelling's segregation model

- Land use type randomly assigned to each cell
- Satisfaction index defined for each cell considering cell type and neighbour cell types
  - **Repulsion** between Logistics and the other types
  - **Attraction** between Residential and Business (parameter γ)
- Model updated by choosing random pairs of cells and interchanging their land use

Land use model



Land use model



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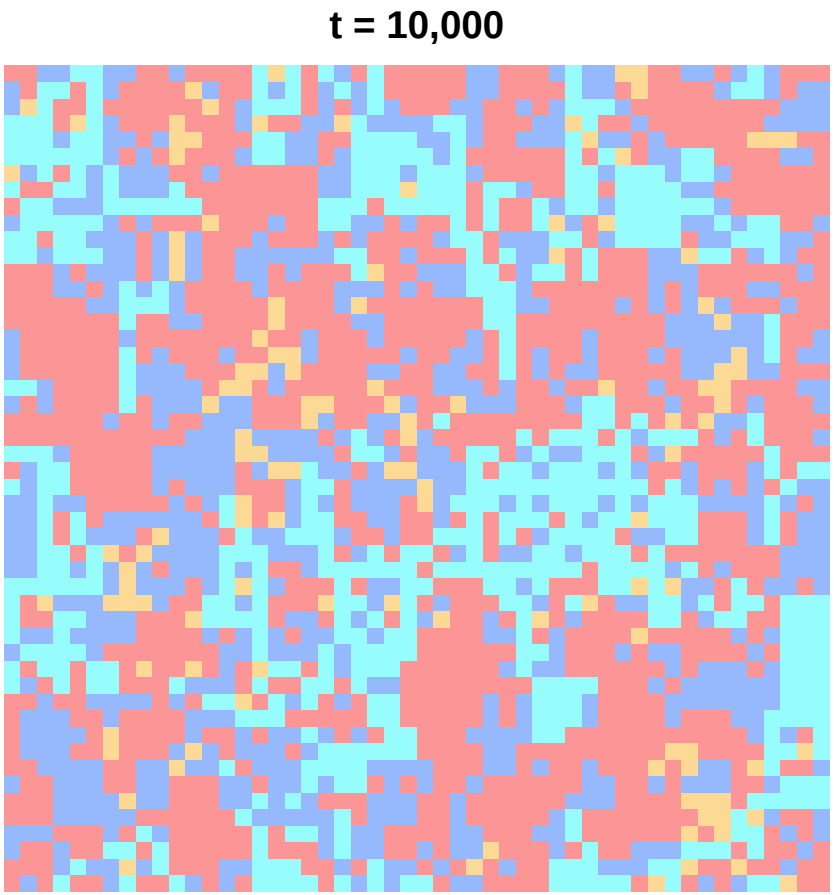

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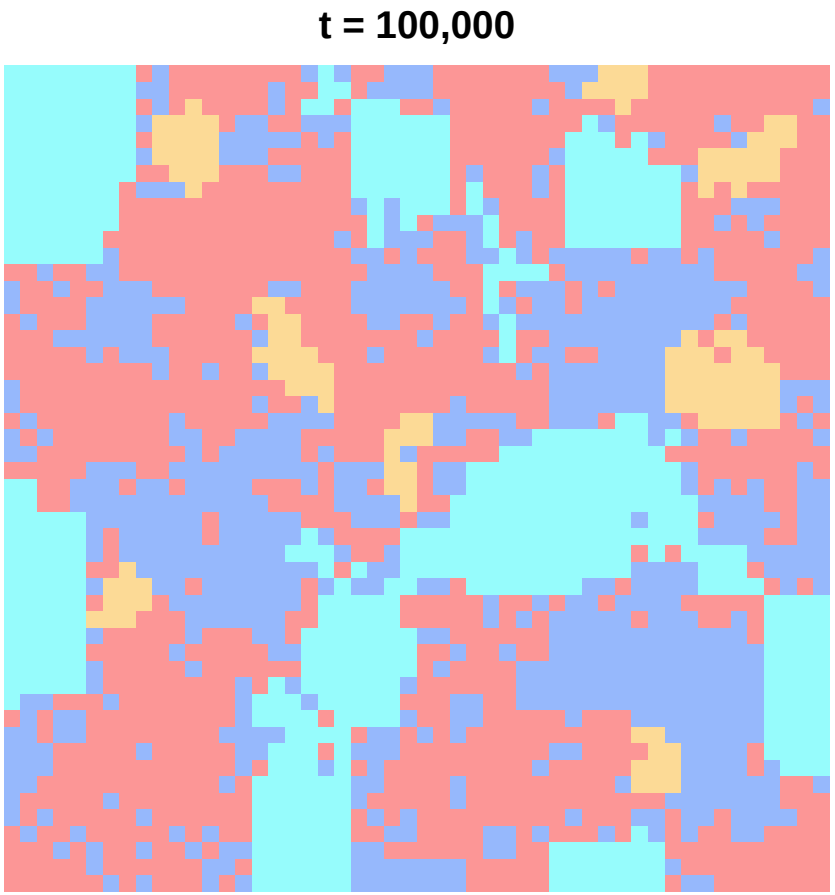

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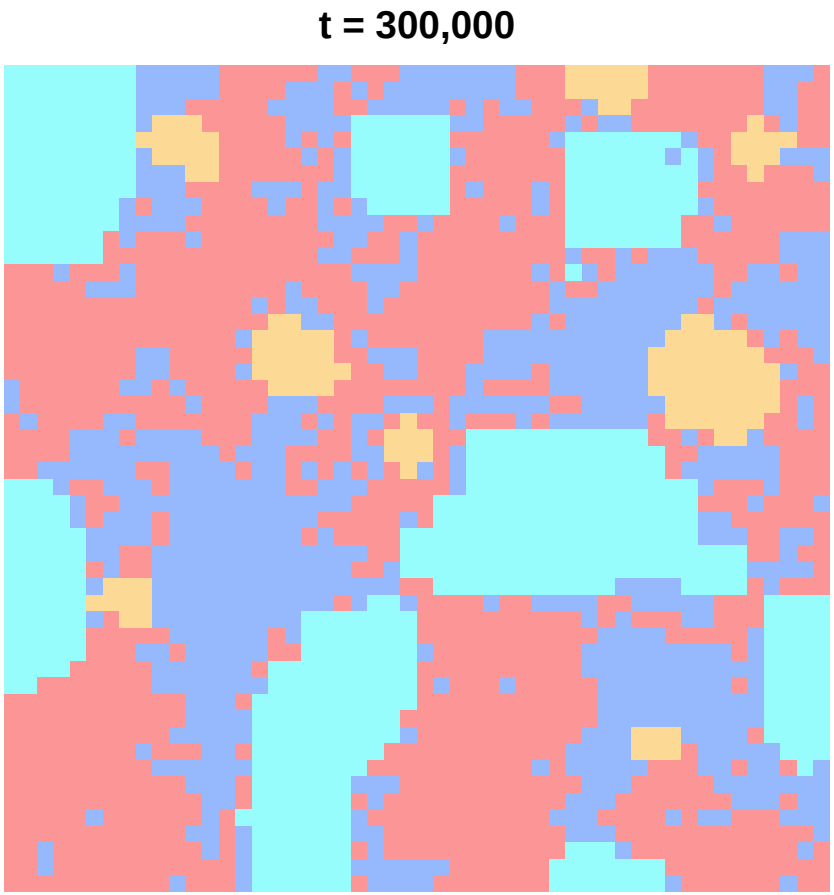
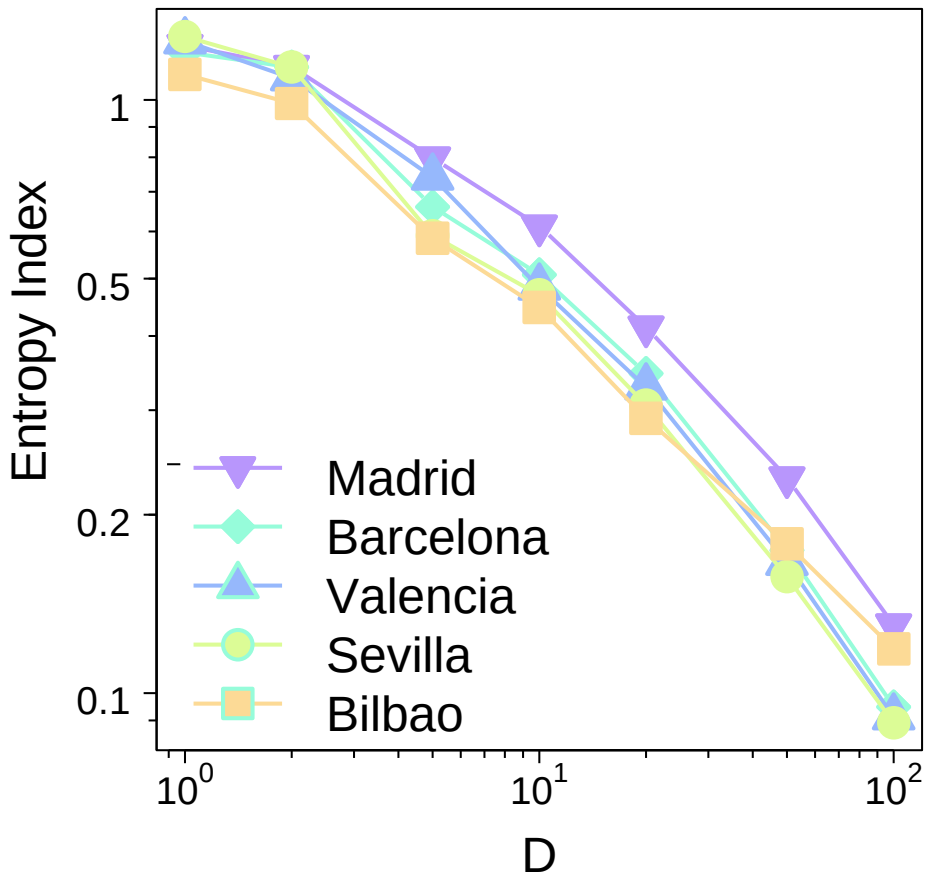
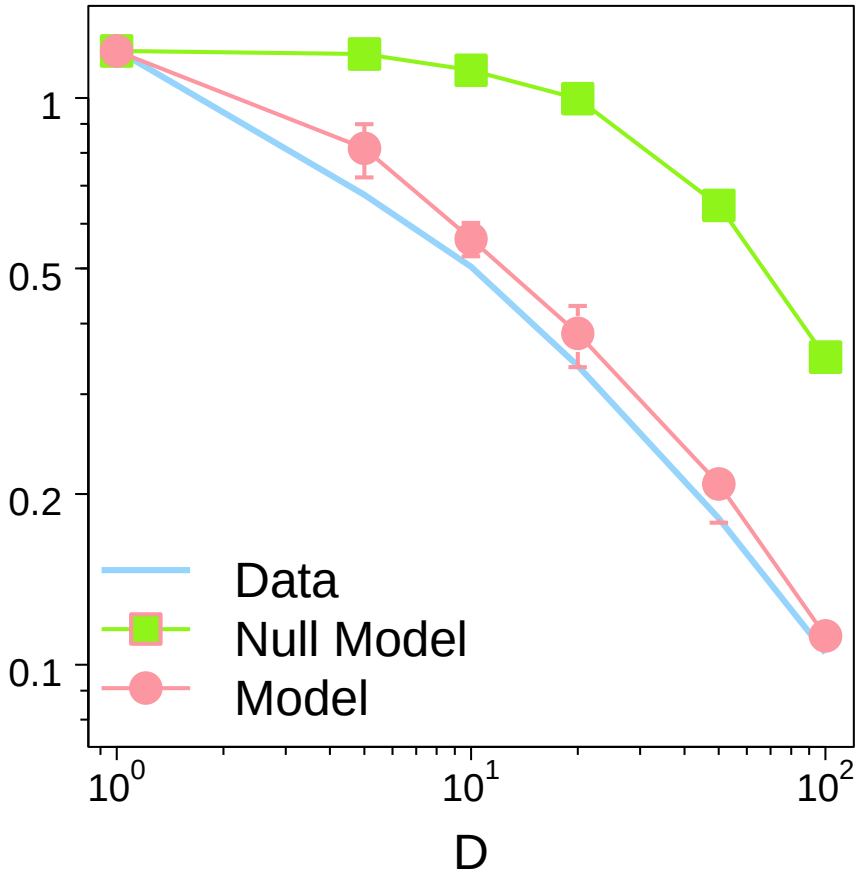


Land use model

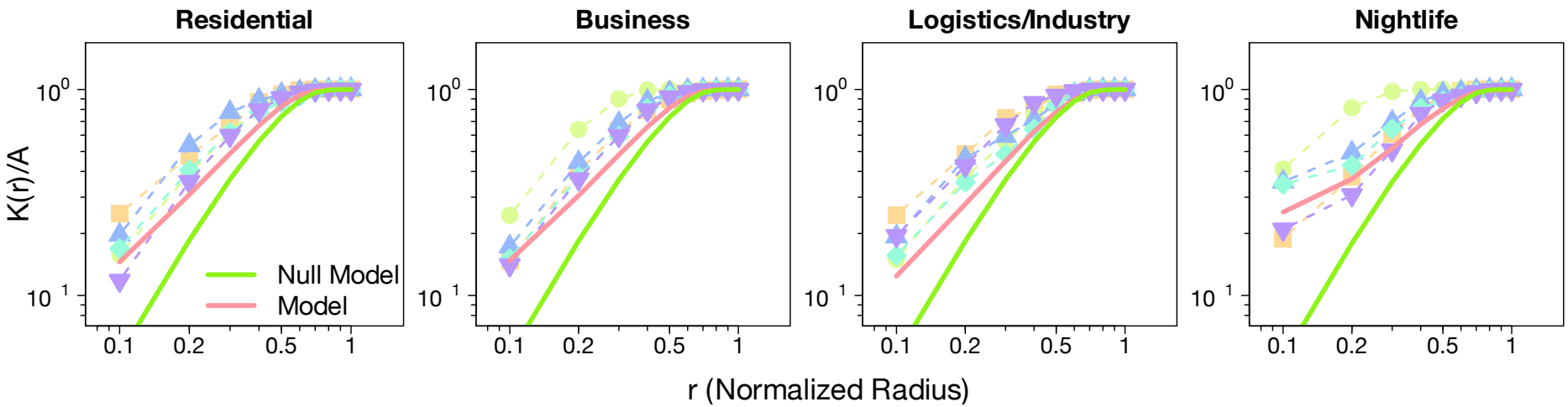
Calibration of γ





Land use model

Ripley's K



Take home messages

- Network approach to detect land use using mobile phone data;
- Four land use types (Residential, Business, Logistics, Nightlife);
- Similarities in the spatial organization of land use across cities;
- Land use model based on attraction-repulsion between land use.

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Ricardo Herranz

Marc Barthelemy

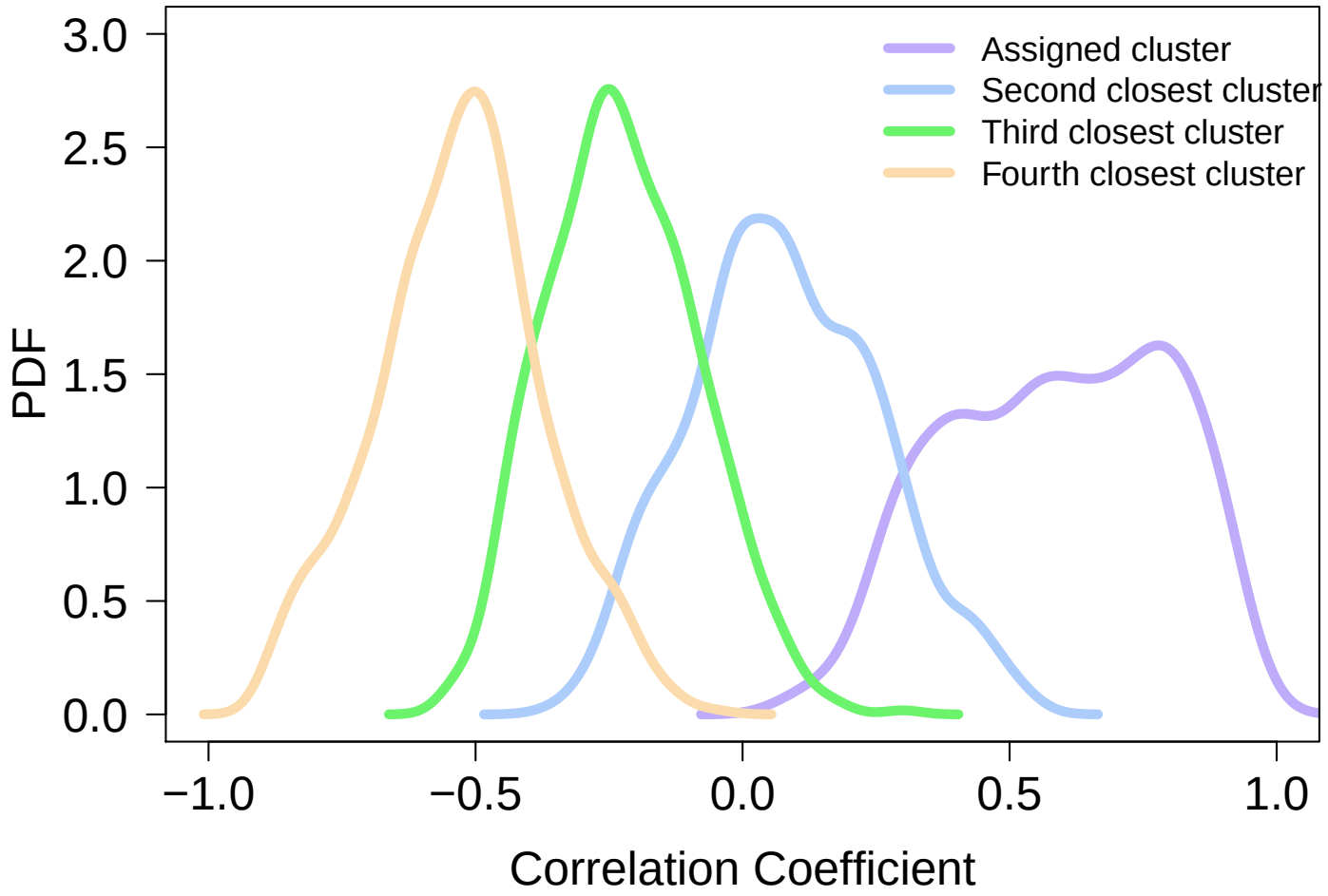
Enrique Frías-Martínez

Maxi San Miguel

José Javier Ramasco

Lenormand *et al.* Comparing and modeling land use organization in cities. Arxiv e-print, arXiv:1503.06152

Mixing of land use



Mixing of land use