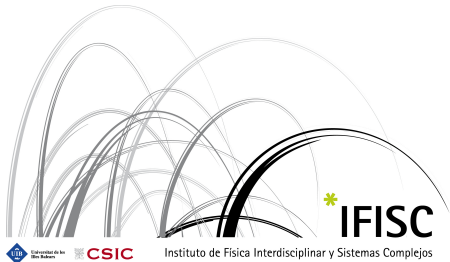


Comparer et modéliser l'utilisation des sols dans les aires métropolitaines espagnoles

Maxime Lenormand

12èmes Rencontres de Théo Quant, Besançon

22 mai 2014



Govern de les Illes Balears
Conselleria d'Educació, Cultura i Universitats



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

Motivation

Comparer l'organisation de l'utilisation des sols dans les villes

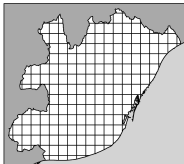
- ▶ Approche réseau pour détecter les différents types d'activités en utilisant des données de téléphones portables
- ▶ Organisation spatiale (entropie, K de Ripley...)
- ▶ Modèle d'utilisation des sols
- ▶ Mélange d'utilisation des sols



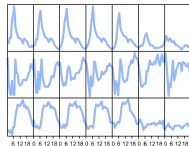
Méthode utilisée pour extraire le réseau



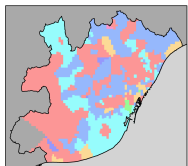
Metropolitan Area



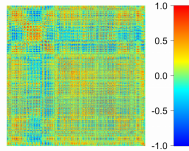
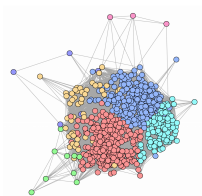
Recordings sites



**Time of Day
Signals**



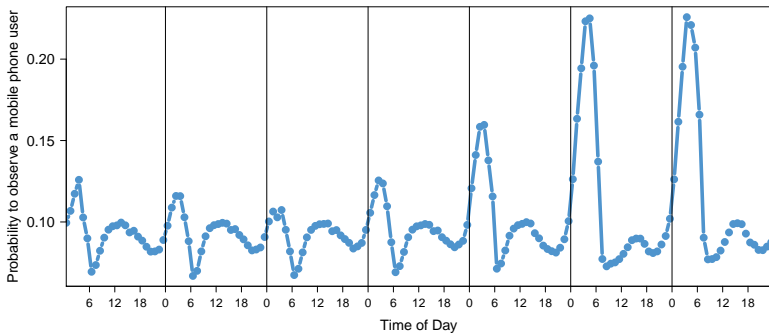
Functional Network



Correlation Matrix

Méthode utilisée pour extraire le réseau

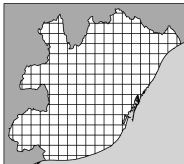
Probabilité d'observer un utilisateur de téléphone portable dans une cellule donnée à un temps donné



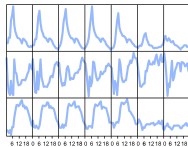
Méthode utilisée pour extraire le réseau



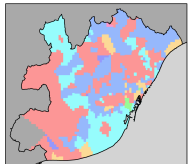
Metropolitan Area



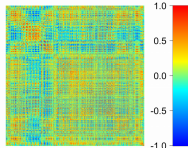
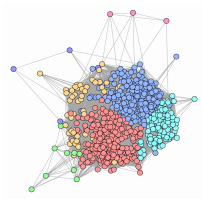
Recordings sites



Signals



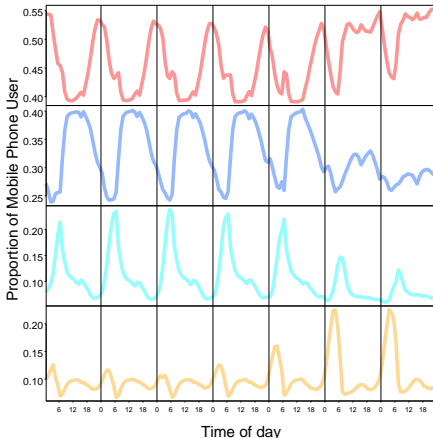
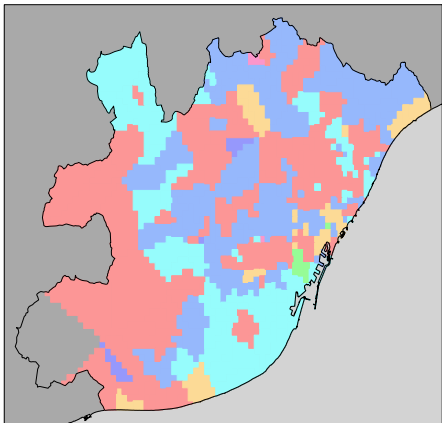
Functional Network



Correlation Matrix

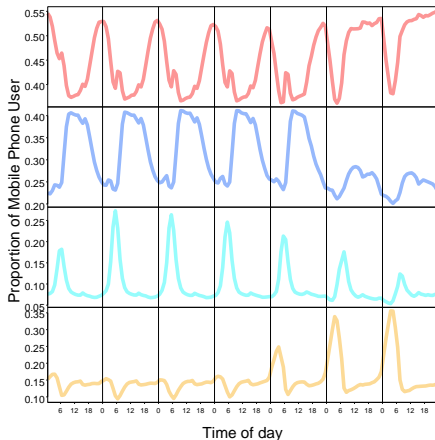
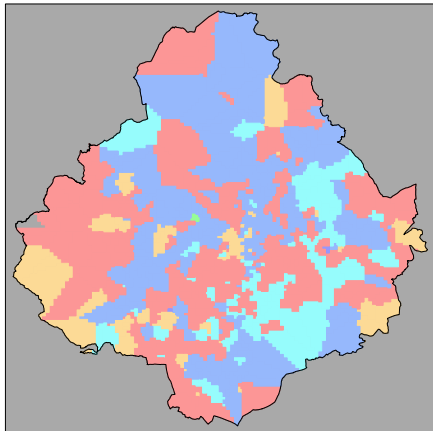
Type d'utilisation des sols

Barcelona (PGP = 60%)



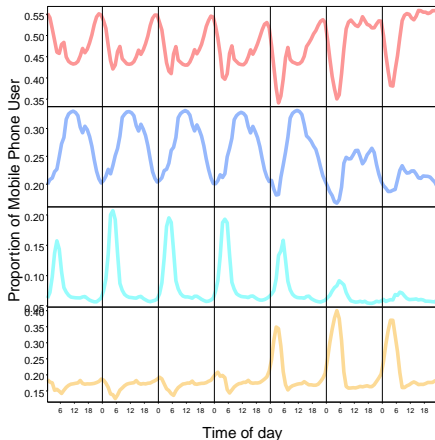
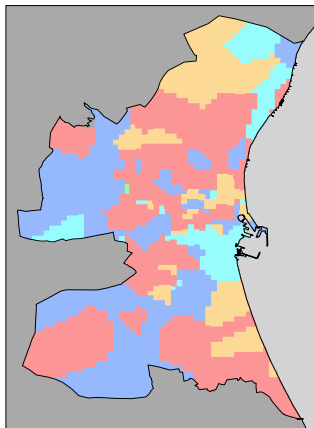
Type d'utilisation des sols

Madrid (PGP = 65%)



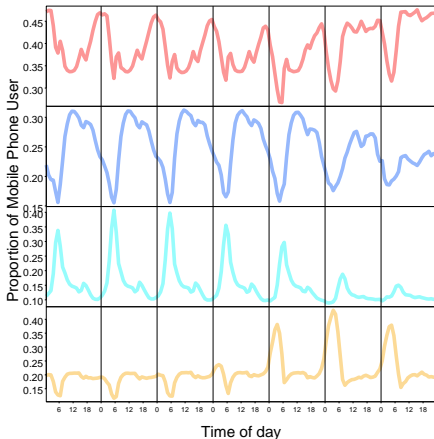
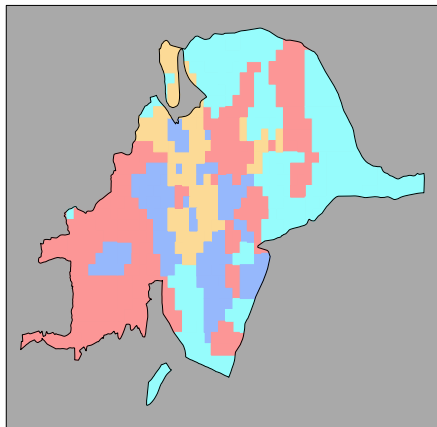
Type d'utilisation des sols

Valencia



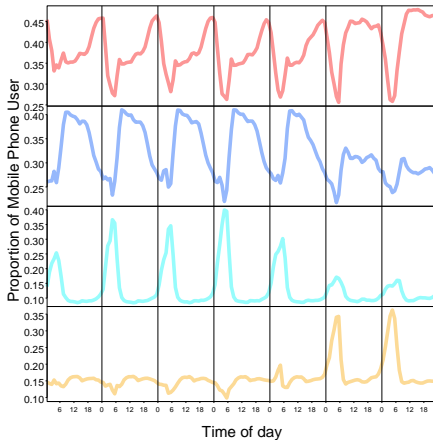
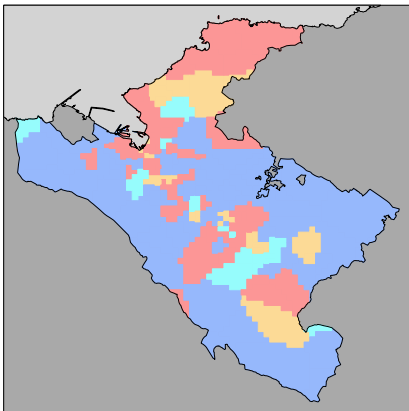
Type d'utilisation des sols

Sevilla



Type d'utilisation des sols

Bilbao



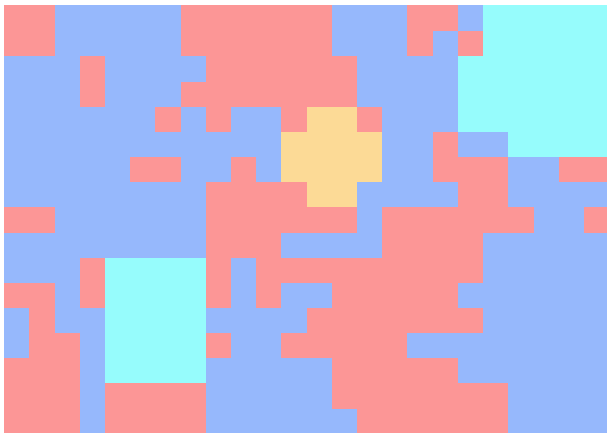
Organisation spatiale

Trois mesures pour mesurer l'hétérogénéité spatiale

- ▶ Distribution de la distance entre les cellules et le centre ville
- ▶ K de Ripley
- ▶ Entropie

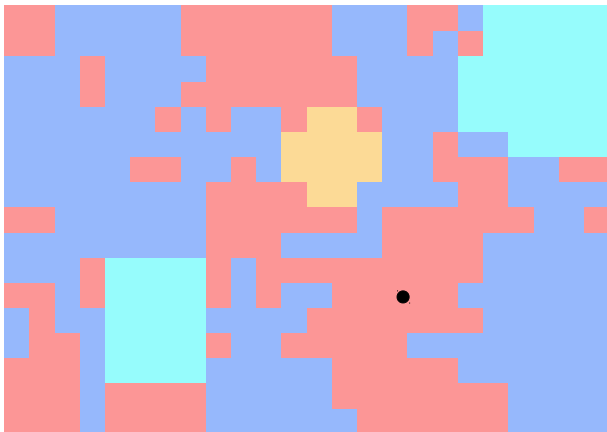
Organisation spatiale

Distance au centre ville



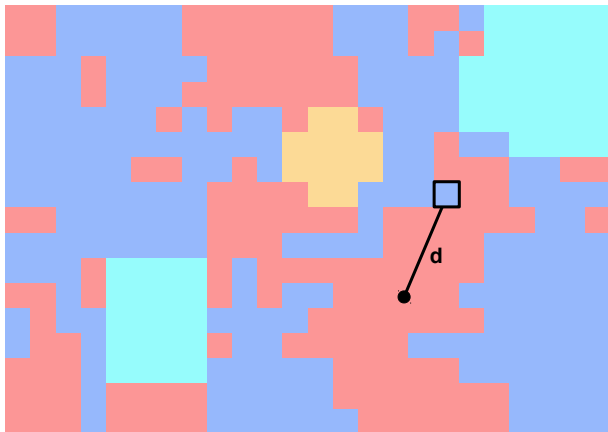
Organisation spatiale

Distance au centre ville



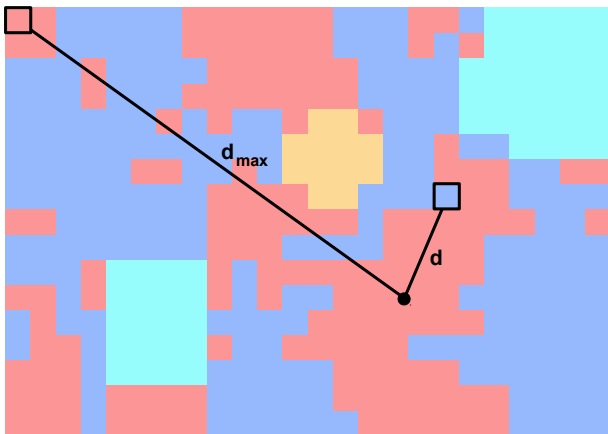
Organisation spatiale

Distance au centre ville



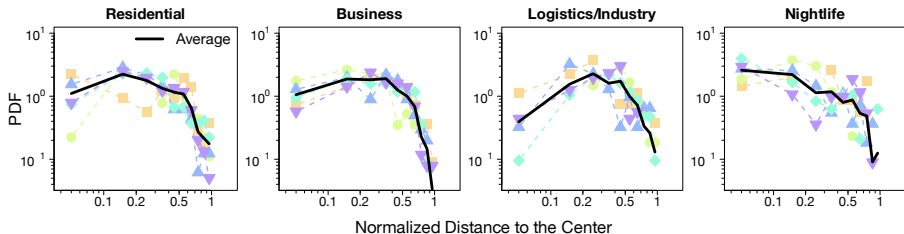
Organisation spatiale

Distance au centre ville



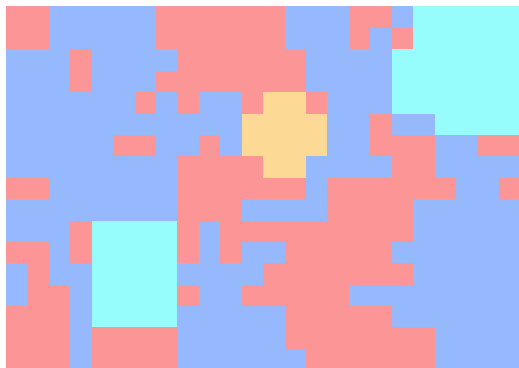
Organisation spatiale

Distance au centre ville



Organisation spatiale

K de Ripley

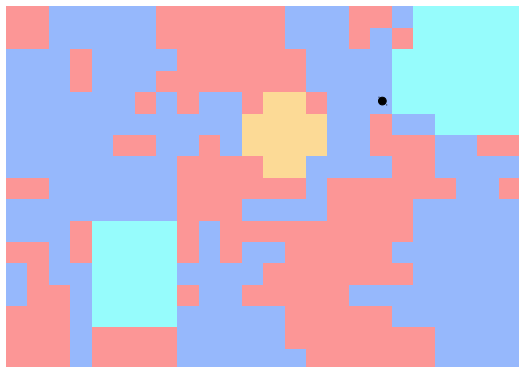


$$K(r) = \frac{A}{n^2} \sum_{i=1}^n N_i(r)$$

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

Organisation spatiale

K de Ripley

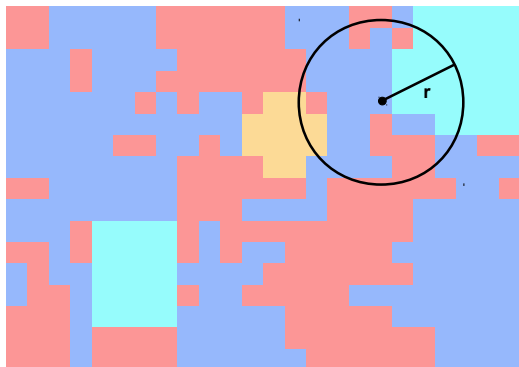


$$K(r) = \frac{A}{n^2} \sum_{i=1}^n N_i(r)$$

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Organisation spatiale

K de Ripley

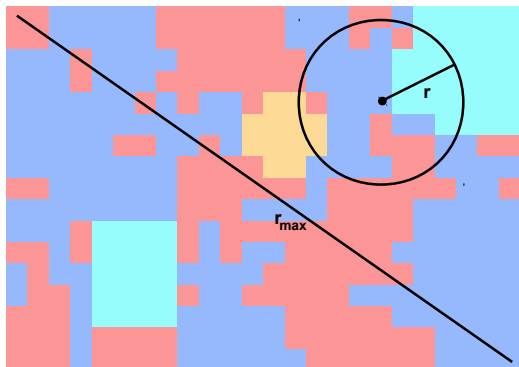


$$K(r) = \frac{A}{n^2} \sum_{i=1}^n N_i(r)$$

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

Organisation spatiale

K de Ripley

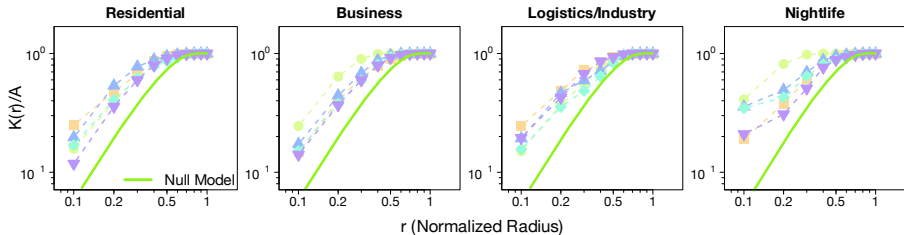


$$K(r) = \frac{A}{n^2} \sum_{i=1}^n N_i(r)$$

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

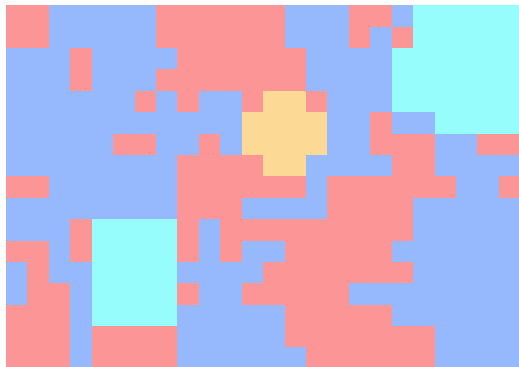
Organisation spatiale

K de Ripley



Organisation spatiale

Entropie

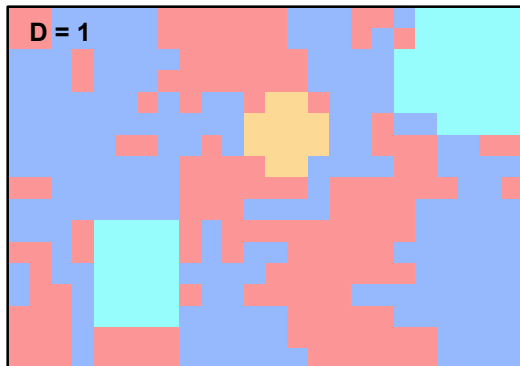


$$E_i = - \sum_{k=1}^4 f_i^k \ln f_i^k$$

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

Organisation spatiale

Entropie

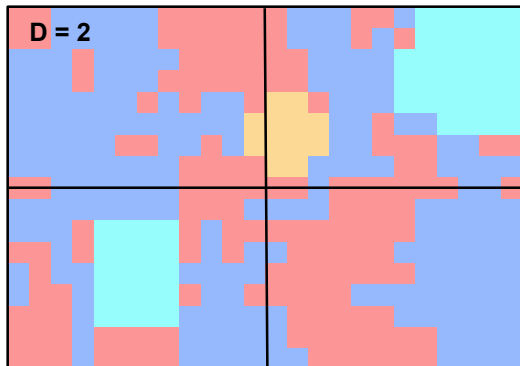


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Organisation spatiale

Entropie

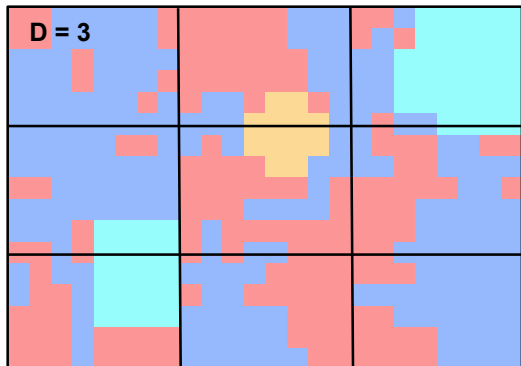


$$E_i = - \sum_{k=1}^4 f_i^k \ln f_i^k$$

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

Organisation spatiale

Entropie

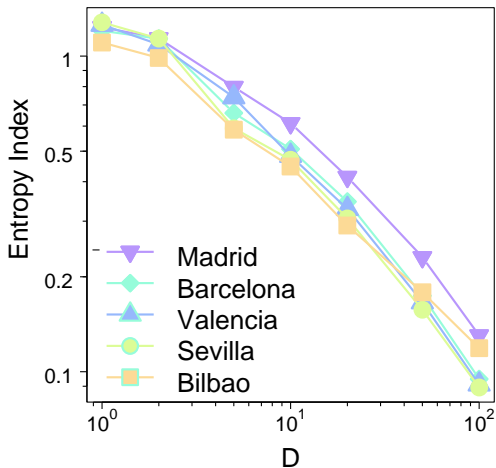


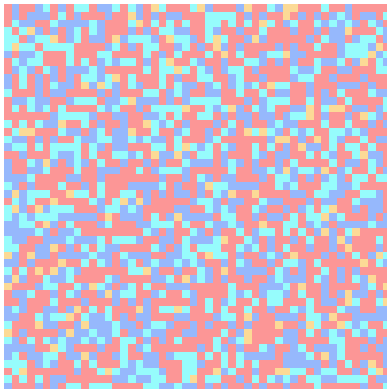
$$E_i = - \sum_{k=1}^4 f_i^k \ln f_i^k$$

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

Organisation spatiale

Entropie



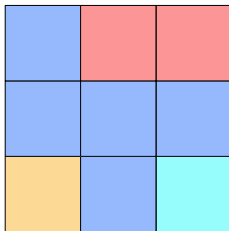


Modèle

Indice de satisfaction

Indice de satisfaction S_{ij} d'une cellule dépend du type d'utilisation des sols des cellules voisines

$$p = (p_1, p_2, p_3, p_4)$$



Modèle

Indice de satisfaction

Logistique/Industrie

$$S_{ij} = p_3$$

| | | |
|--|--|--|
| | | |
| | | |
| | | |

$$S_{ij} = 0$$

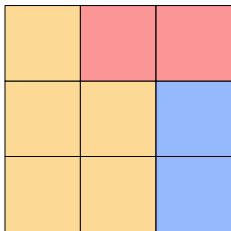
| | | |
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Modèle

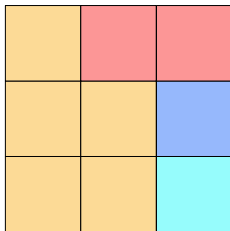
Indice de satisfaction

Vie nocturne

$$S_{ij} = p_4$$



$$S_{ij} = 0$$



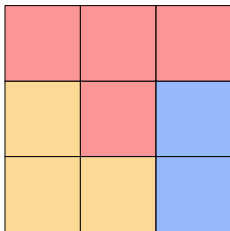
Modèle

Indice de satisfaction

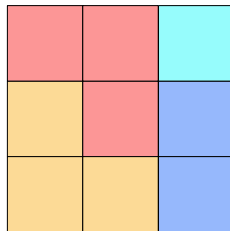
Résidentiel

$$rand() \geq \gamma$$

$$S_{ij} = p_1$$



$$S_{ij} = 0$$



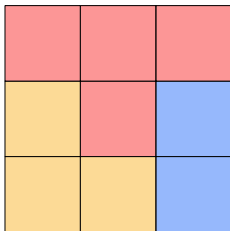
Modèle

Indice de satisfaction

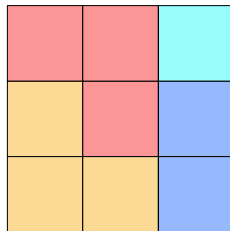
Résidentiel

$$rand() < \gamma$$

$$S_{ij} = 1$$



$$S_{ij} = 0$$



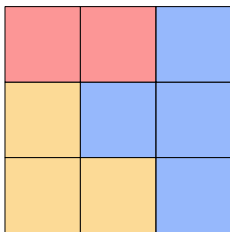
Modèle

Indice de satisfaction

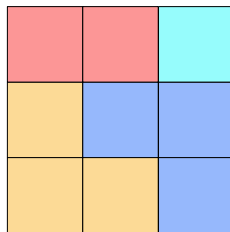
Commercial

$$rand() \geq \gamma$$

$$S_{ij} = p_2$$



$$S_{ij} = 0$$



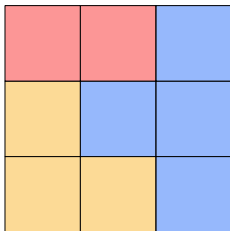
Modèle

Indice de satisfaction

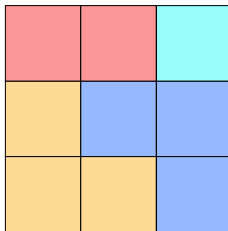
Commercial

$$\text{rand}() < \gamma$$

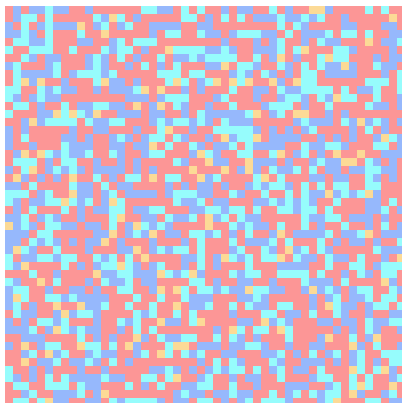
$$S_{ij} = 1$$



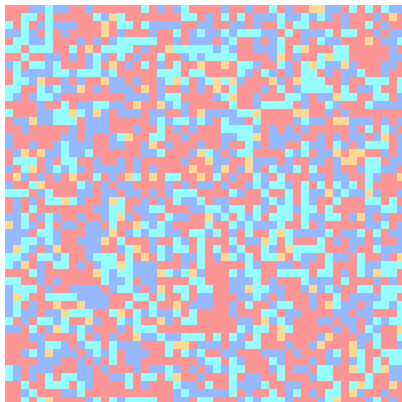
$$S_{ij} = 0$$



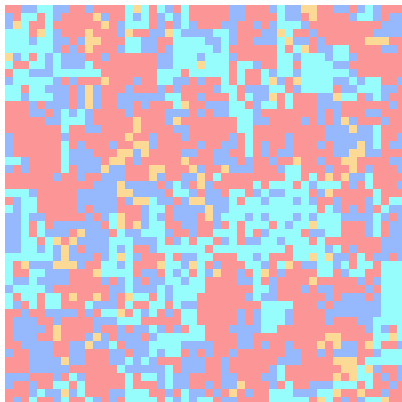
$t = 1$



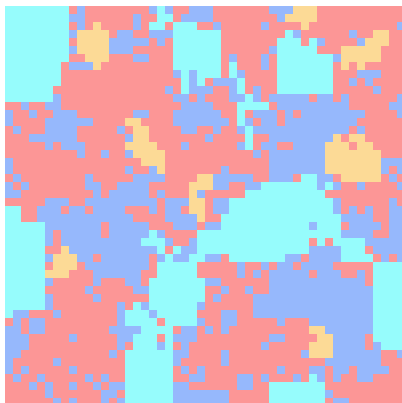
t = 1,000



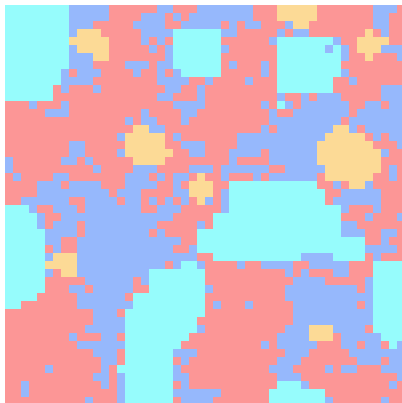
t = 10,000



t = 100,000

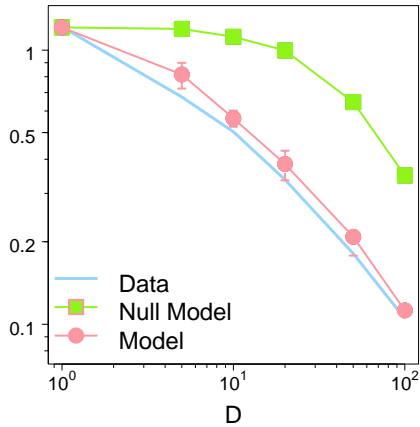
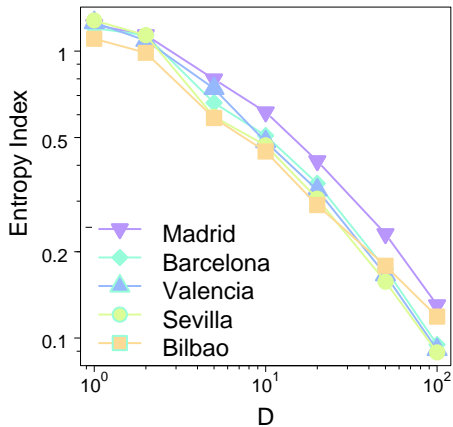


t = 300,000

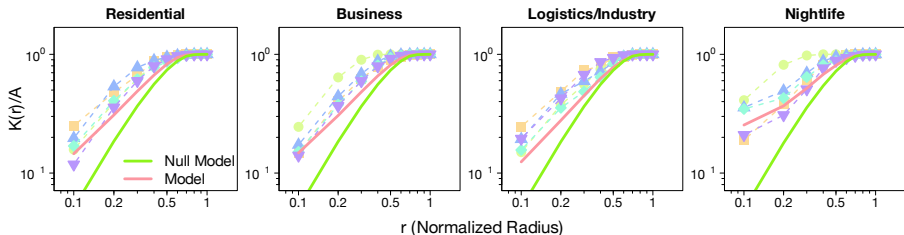


Modèle

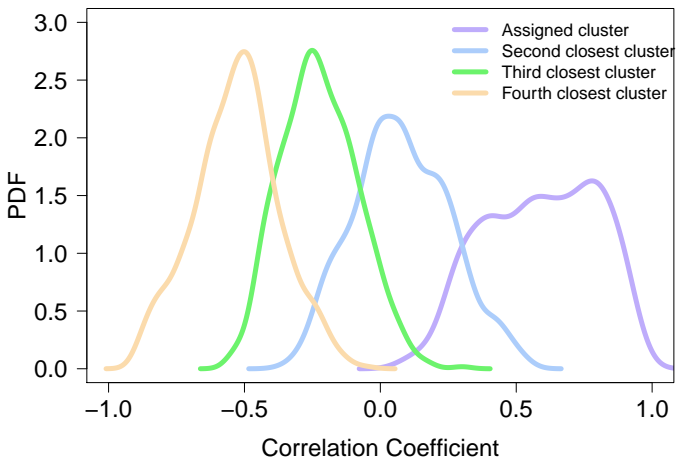
Calibration de γ



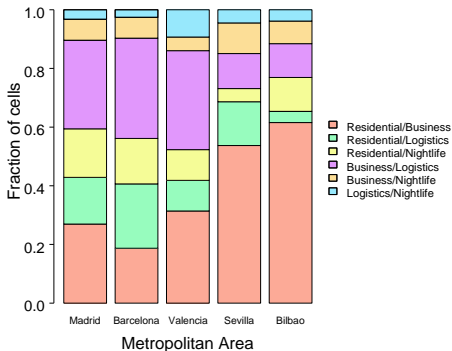
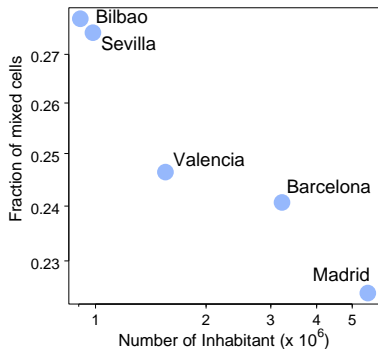
Modèle K de Ripley



Mélange d'utilisation des sols



Mélange d'utilisation des sols



Conclusions

- ▶ Approche réseaux pour détecter les différents types d'activités en utilisant des données de téléphones portables;
- ▶ Quatre types d'utilisation des sols (Résidentiel, Commercial, Logistique, Vie nocturne);
- ▶ Similarité dans l'organisation spatiale de l'utilisation des sols au sein des villes;
- ▶ Modèle se basant sur des règles d'attraction et de répulsion entre les types d'utilisation des sols;
- ▶ Mélange d'utilisation des sols.



Miguel
Picornell



Oliva
Garcia Cantu



Thomas
Louail



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.