

Building simulation models coupling territorial and network dynamics at the interface of disciplines and scales

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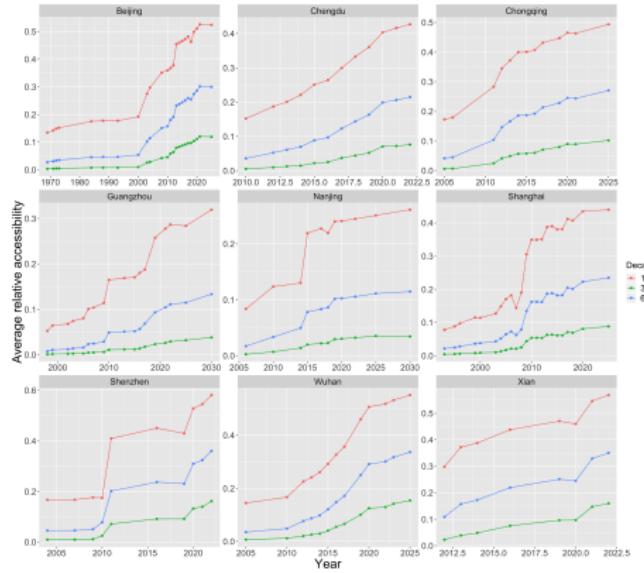
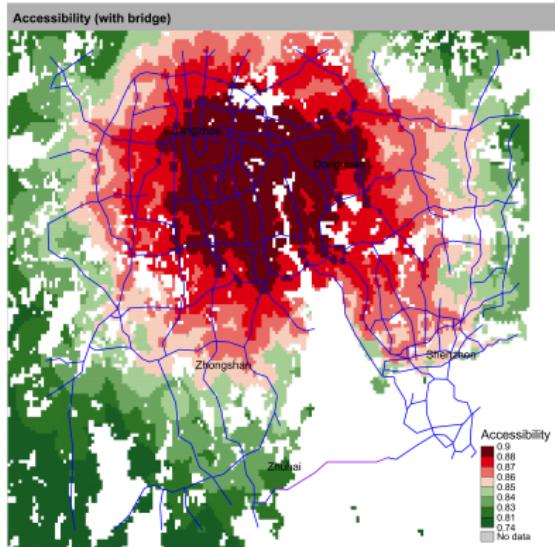
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Interactions between networks and territories

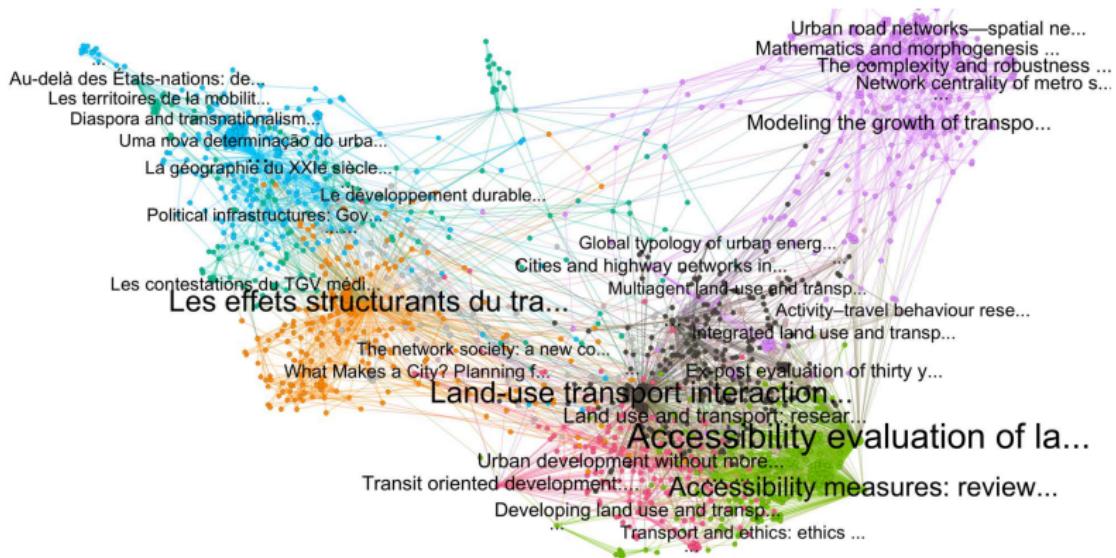


Accessibility as part of complex processes of co-evolution between transportation networks and territories.

Rimbault, J. (2019). Evolving accessibility landscapes: mutations of transportation networks in China. In Aveline-Dubach, N., ed. *Pathways of sustainable urban development across China - the cases of Hangzhou, Datong and Zhuhai*, pp 89-108. Imago. ISBN:978-88-94384-71-0

Literature mapping

Interdisciplinarity and interactions between networks and territories



Rambault, J. (2019). Exploration of an interdisciplinary scientific landscape. *Scientometrics*, 119(2), 617-641.

Rambault, J. (2021). An interdisciplinary bibliometric analysis of models for land-use and transport interactions. arXiv preprint arXiv:2102.13501.

Theoretical context:

- Cities and territories understood from the viewpoint of Pumain's *Evolutionary Urban Theory* [Pumain, 1997]
- Transportation networks materialising “transactional projects”, following the *Territorial Theory of Networks* [Dupuy, 1987]

Processes: A multi-level definition of co-evolution:

- 1 level of agents
- 2 statistical level of agent populations (niches)
- 3 global system level

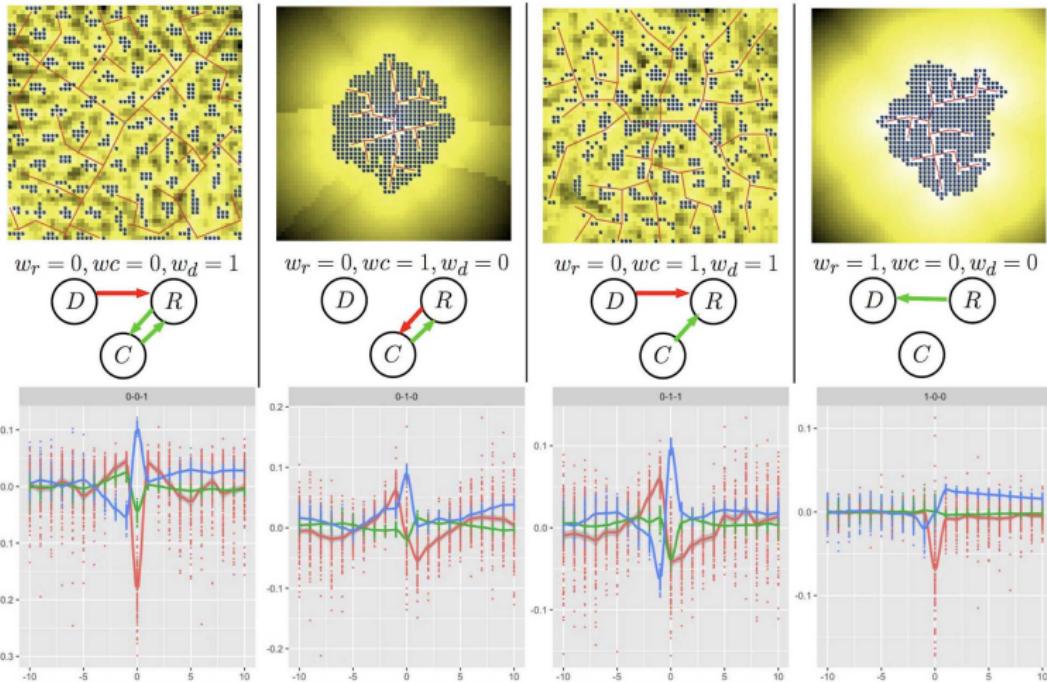
Corresponding approaches:

- 1 Empirical (microscopic level)
- 2 Modeling morphogenesis (niche level)
- 3 Urban dynamics models (macroscopic level)

Raimbault, J. (2018). Caractérisation et modélisation de la co-évolution des réseaux de transport et des territoires (Doctoral dissertation, Université Paris 7 Denis Diderot).

Raimbault, J. (2019). Modeling interactions between transportation networks and territories: a co-evolution approach. arXiv preprint arXiv:1902.04802.

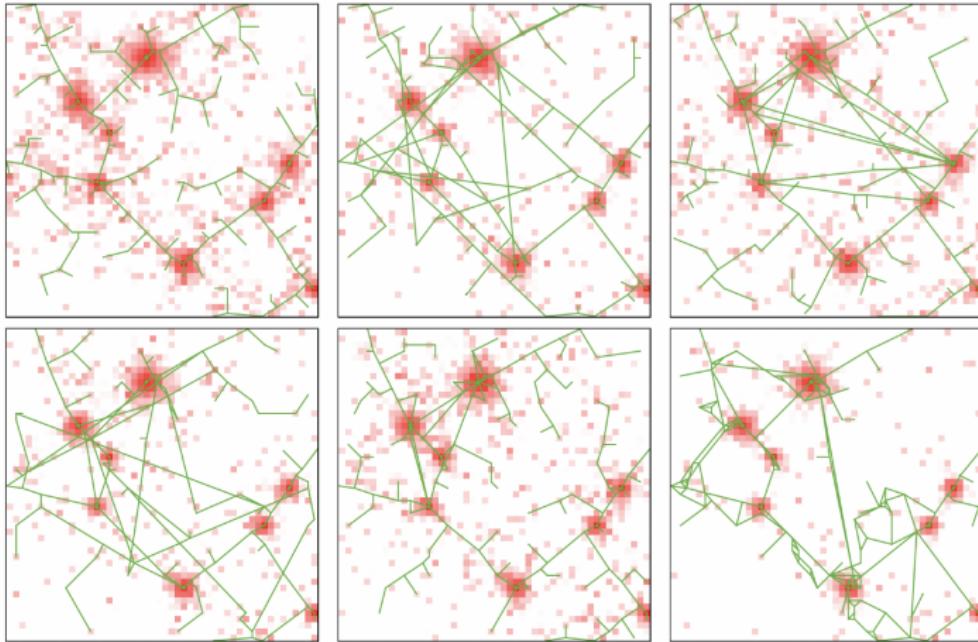
Characterising co-evolution



Raimbault, J., Banos, A., & Doursat, R. (2014). A Hybrid Network/Grid Model of Urban Morphogenesis and Optimization. In 4th International Conference on Complex Systems and Applications (pp. 51-60).

Raimbault, J. (2017). Identification de causalités dans des données spatio-temporelles. In Spatial Analysis and GEOMatics 2017.

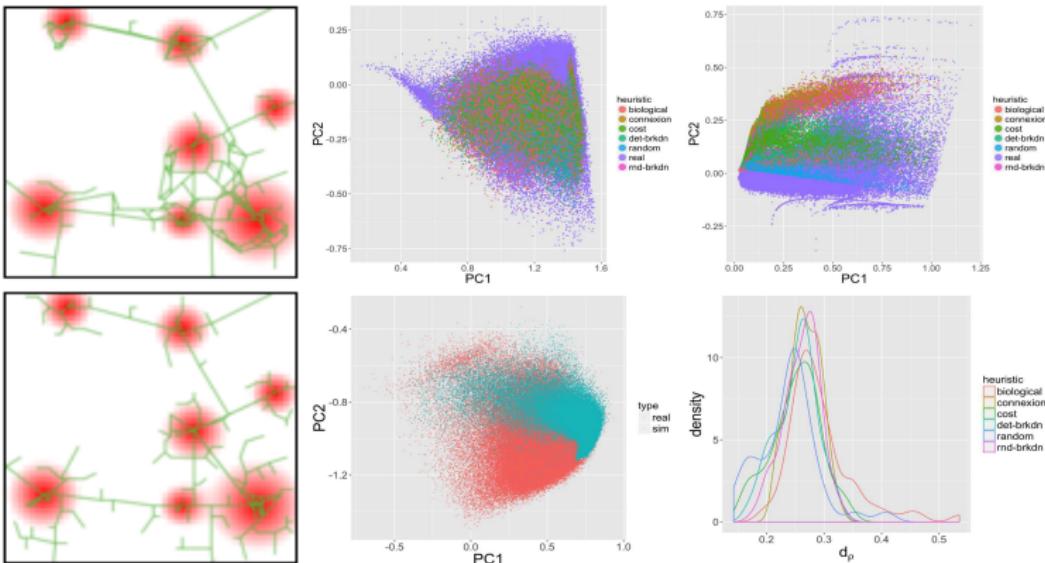
Mesoscopic scale: morphogenesis models



Raimbault, J. (2018). Multi-modeling the morphogenesis of transportation networks. In Artificial Life Conference Proceedings (pp. 382-383). MIT Press, Cambridge.

Morphogenesis models

A morphogenesis model with reaction-diffusion and multi-modeling of network growth: complementarity of heuristics, calibration for Europe on forms and their correlations

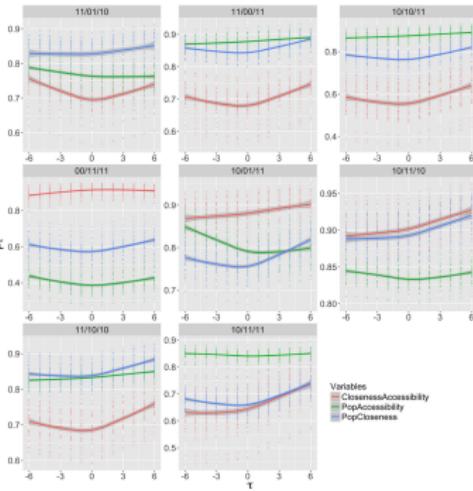
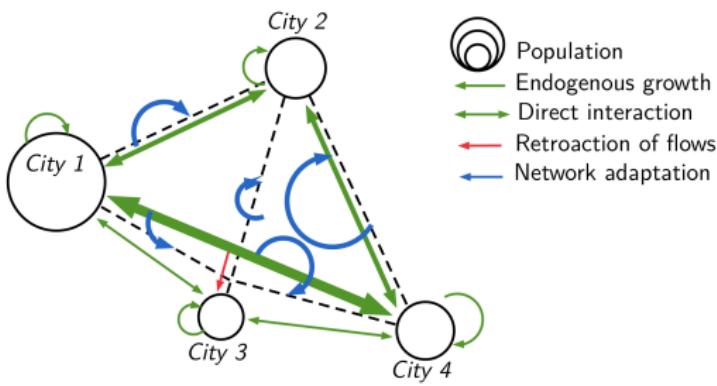


Raimbault, J. (2018). Calibration of a density-based model of urban morphogenesis. PloS one, 13(9), e0203516.

Raimbault, J. (2019). An urban morphogenesis model capturing interactions between networks and territories. In The Mathematics of Urban Morphology (pp. 383-409). Birkhäuser, Cham.

Macroscopic interaction models

System of cities interaction model including network evolution; production of multiple co-evolution regimes and calibration for France.

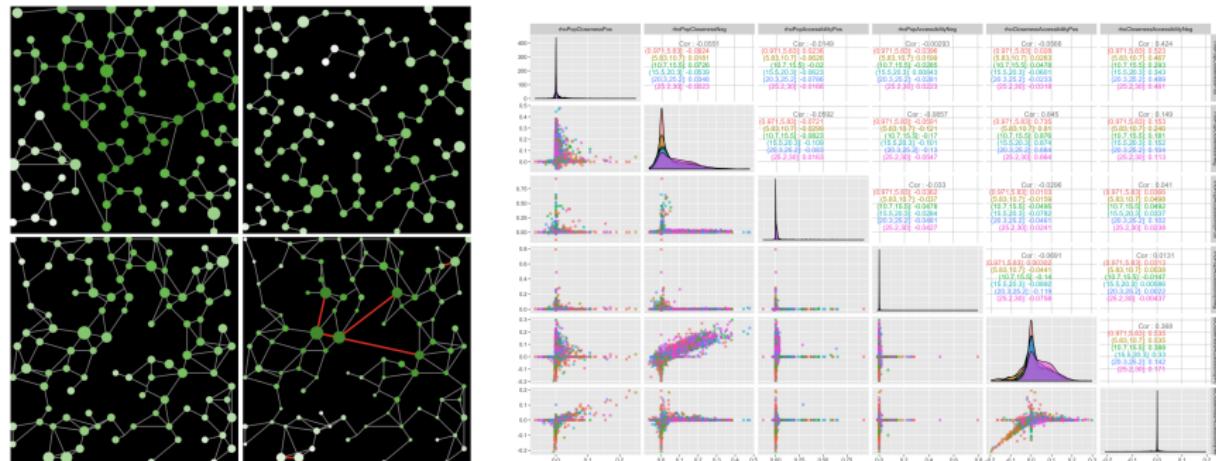


Raimbault, J. (2020). Indirect evidence of network effects in a system of cities. Environment and Planning B: Urban Analytics and City Science, 47(1), 138-155.

Raimbault, J. (2021). Modeling the co-evolution of cities and networks. In Niel, Z., Rozenblat, C., eds. *Handbook of Cities and Networks*, Edwar Elgar Publishing, *in press*.

Capturing co-evolution at the macro scale

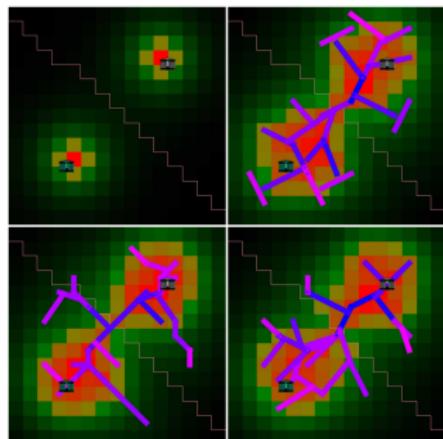
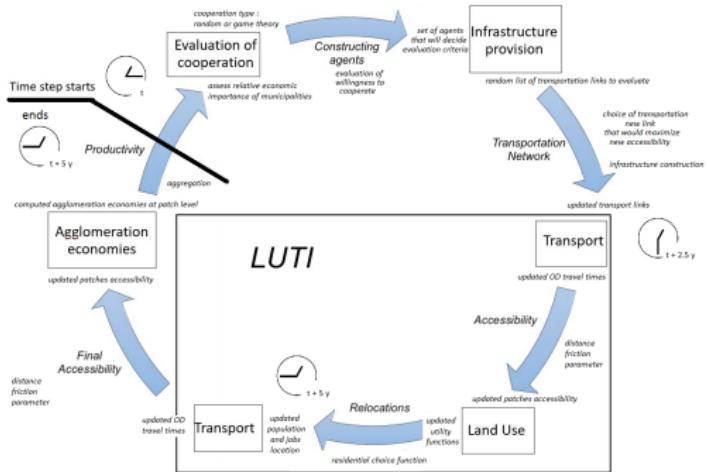
Similar models for co-evolution capturing it only partly.



Raimbault, J. (2020). Unveiling co-evolutionary patterns in systems of cities: a systematic exploration of the simpopnet model. In Theories and Models of Urbanization (pp. 261–278). Springer, Cham.

Extending LUTI models: transport governance

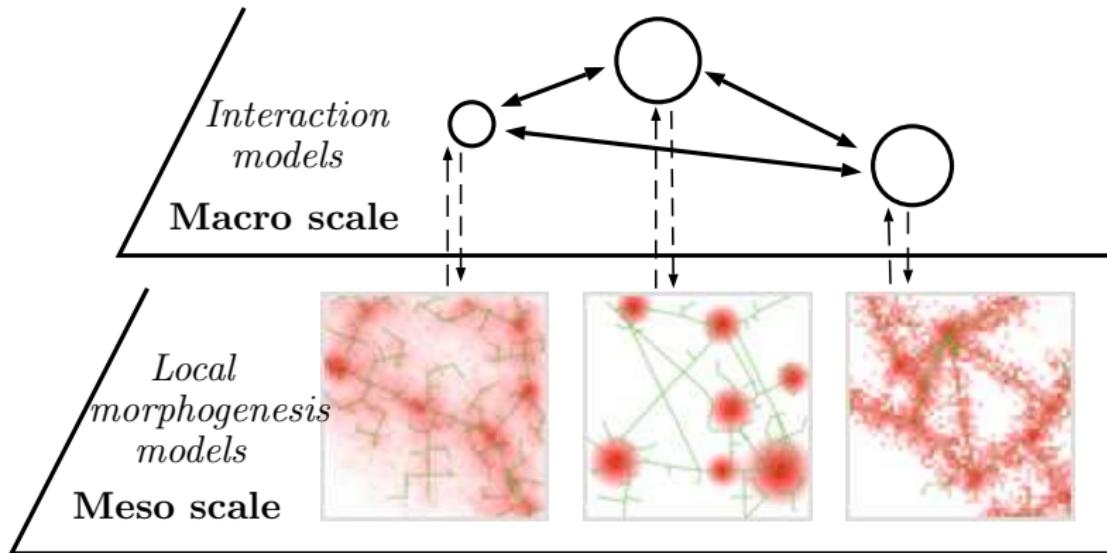
A co-evolution model integrating transport governance dynamics through game theory



Raimbault, J. & Le Néchet F. (2021, forthcoming). Introducing endogenous transport provision in a LUTI model to explore polycentric governance systems. Journal of Transport Geography.

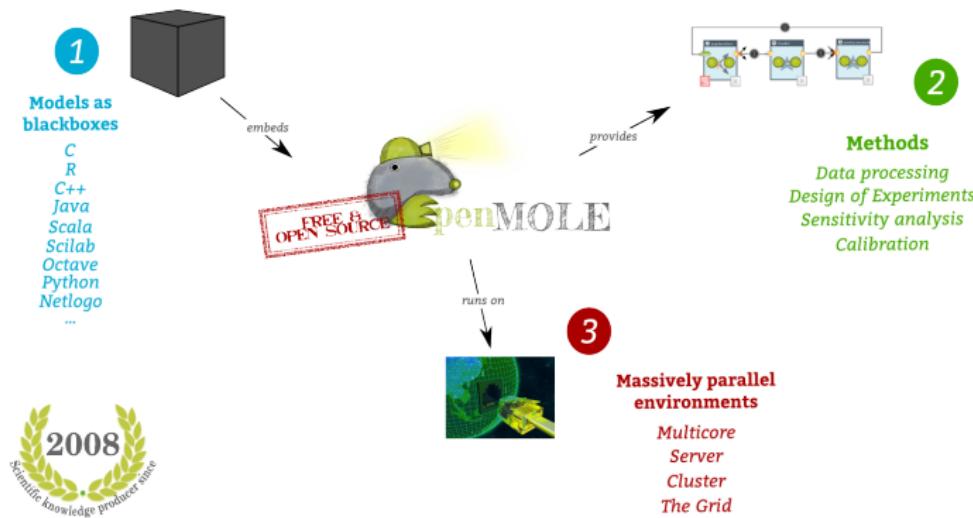
Towards multi-scale models

Processes specific to scales, models across scales require dedicated ontologies

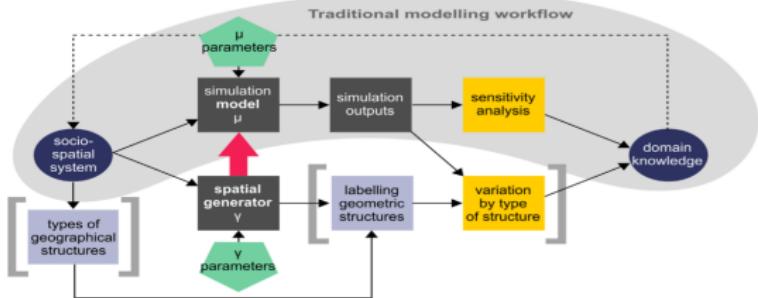


Raimbault, J. (2021). Strong coupling between scales in a multi-scalar model of urban dynamics. arXiv preprint arXiv:2101.12725.

OpenMOLE software [Reuillon et al., 2013]: (i) *Innovative exploration methods*; (ii) *Scaling of methods on high performance computing environments*; (iii) *Scripts to embed and couple models*.

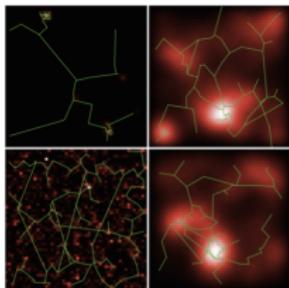


Validation: spatial sensitivity analysis

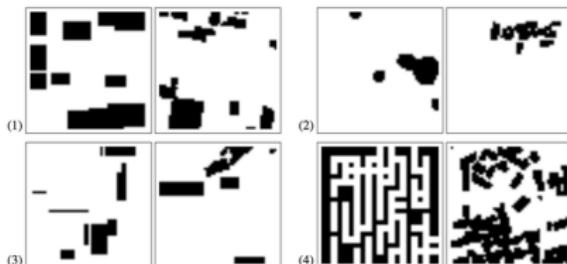


Raimbault, J., Cottineau, C., Le Texier, M., Le Nechet, F., Reuillon, R. (2019). Space Matters: Extending Sensitivity Analysis to Initial Spatial Conditions in Geosimulation Models. *Journal of Artificial Societies and Social Simulation*, 22(4).

Raimbault, J., Perret, J., & Reuillon, R. (2020). A scala library for spatial sensitivity analysis. *GISRUK 2020 Proceedings*, 32.



Raimbault, J. (2019). Second-order control of complex systems with correlated synthetic data. *Complex Adaptive Systems Modeling*, 7(1), 1-19.



Raimbault, J., Perret, J. (2019). Generating urban morphologies at large scales. In *Artificial Life Conference Proceedings* (pp. 179-186).

- Multiple dimensions of urban systems: **models at the interface of disciplines.**
- Multiple scales: **at the interface of scales.**
- Multiple types of knowledge: **simulation models and their exploration and validation as an integrating approach.**

To use OpenMOLE (free and open software) and contribute:

<https://openmole.org>

All models open source at

<https://github.com/JusteRaimbault/CityNetwork>

-  Dupuy, G. (1987).
Vers une théorie territoriale des réseaux: une application au transport urbain.
In *Annales de géographie*, pages 658–679. JSTOR.
-  Pumain, D. (1997).
Pour une théorie évolutive des villes.
L'Espace géographique, pages 119–134.
-  Raimbault, J. (2017).
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-  Raimbault, J. (2018b).
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Exploration of an interdisciplinary scientific landscape.
Scientometrics, pages 1–25.
-  Rimbault, J. (2019c).
Modeling interactions between transportation networks and territories: a co-evolution approach.
arXiv preprint arXiv:1902.04802.
-  Rimbault, J. (2019d).
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Complex Adaptive Systems Modeling, 7(1):1–19.

-  Rimbault, J. (2019e).
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In *The mathematics of urban morphology*, pages 383–409. Springer.
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Indirect evidence of network effects in a system of cities.
Environment and Planning B: Urban Analytics and City Science,
47(1):138–155.
-  Rimbault, J. (2020b).
Unveiling co-evolutionary patterns in systems of cities: a systematic exploration of the simpopnet model.
In *Theories and Models of Urbanization*, pages 261–278. Springer.

-  Rimbault, J. (2021a).
An interdisciplinary bibliometric analysis of models for land-use and transport interactions.
arXiv preprint arXiv:2102.13501.
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In Niel, Z., Rozenblat, C., eds. Handbook of Cities and Networks, Edwar Elgar Publishing, in press.
-  Rimbault, J. (2021c).
Strong coupling between scales in a multi-scalar model of urban dynamics.
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In *4th International Conference on Complex Systems and Applications*, pages 51–60.
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Space matters: Extending sensitivity analysis to initial spatial conditions in geosimulation models.
Journal of Artificial Societies and Social Simulation, 22(4).
-  Rimbault, J. and F., L. N. (2021, forthcoming).
Introducing endogenous transport provision in a luti model to explore polycentric governance systems.
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Proceedings of GISRUK 2020.
-  Reuillon, R., Leclaire, M., and Rey-Coyrehourcq, S. (2013).
Openmole, a workflow engine specifically tailored for the distributed exploration of simulation models.
Future Generation Computer Systems, 29(8):1981–1990.