Complexity Insights into Circular Economy

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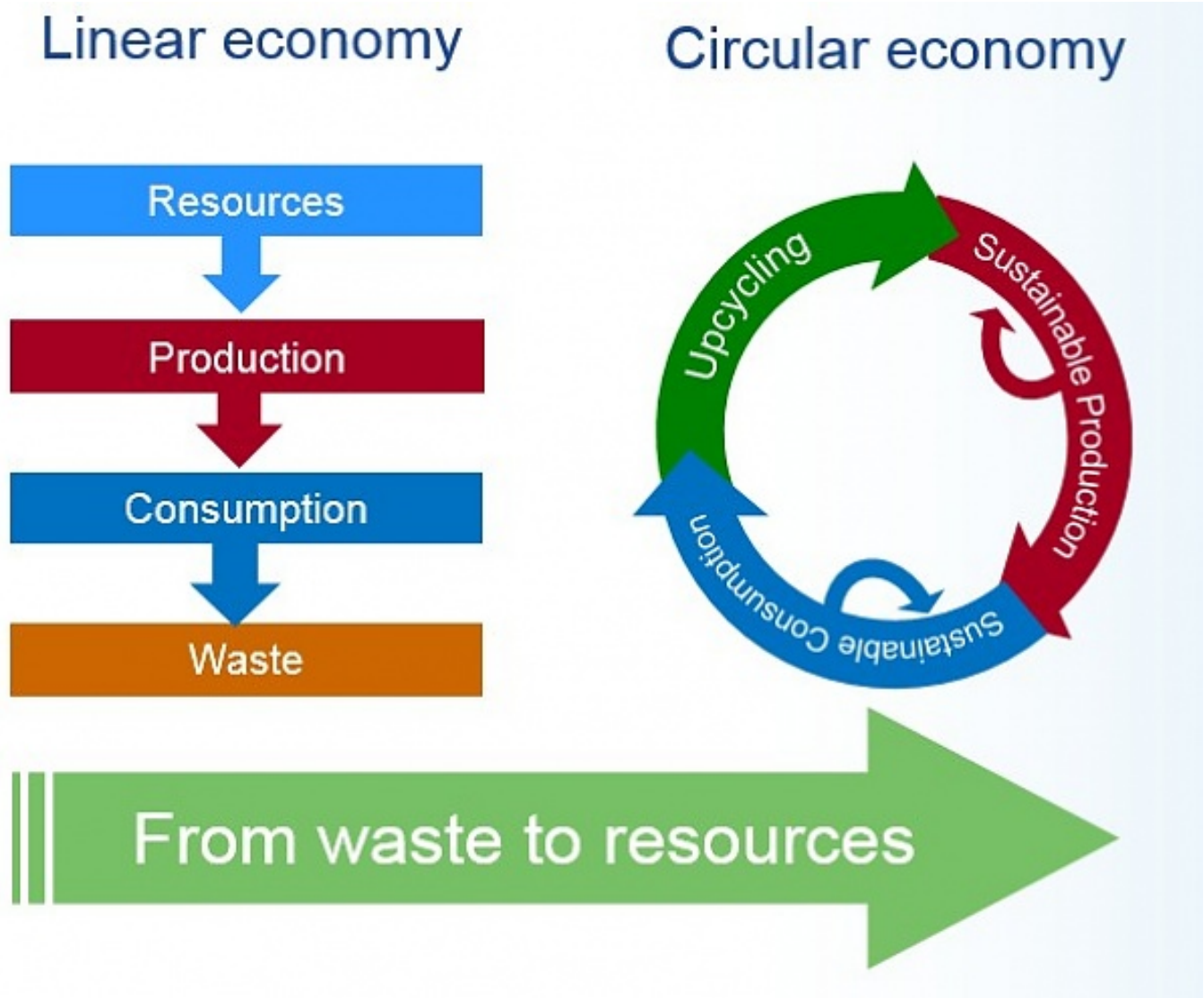
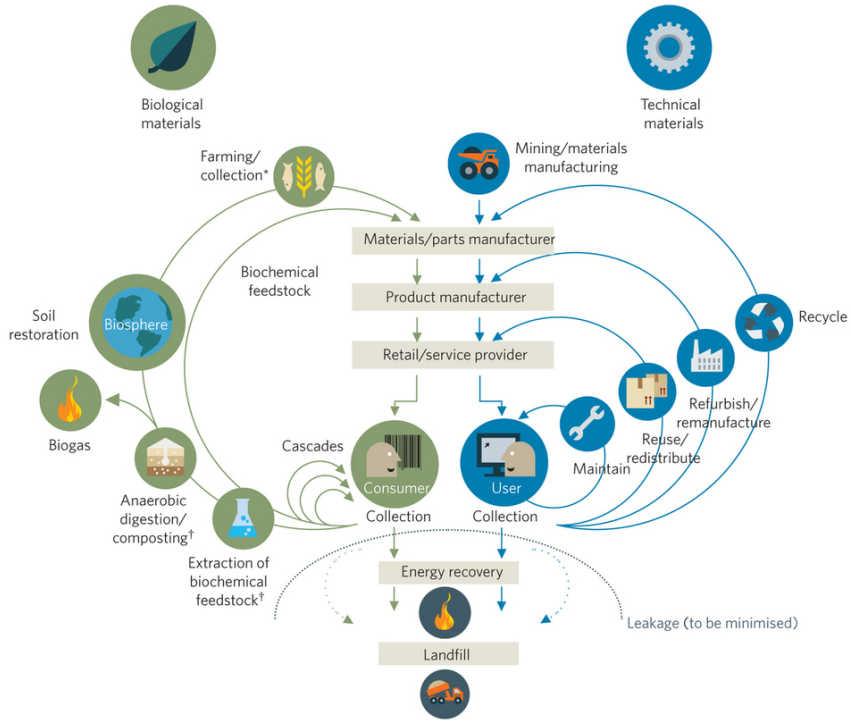
The Circular Economy

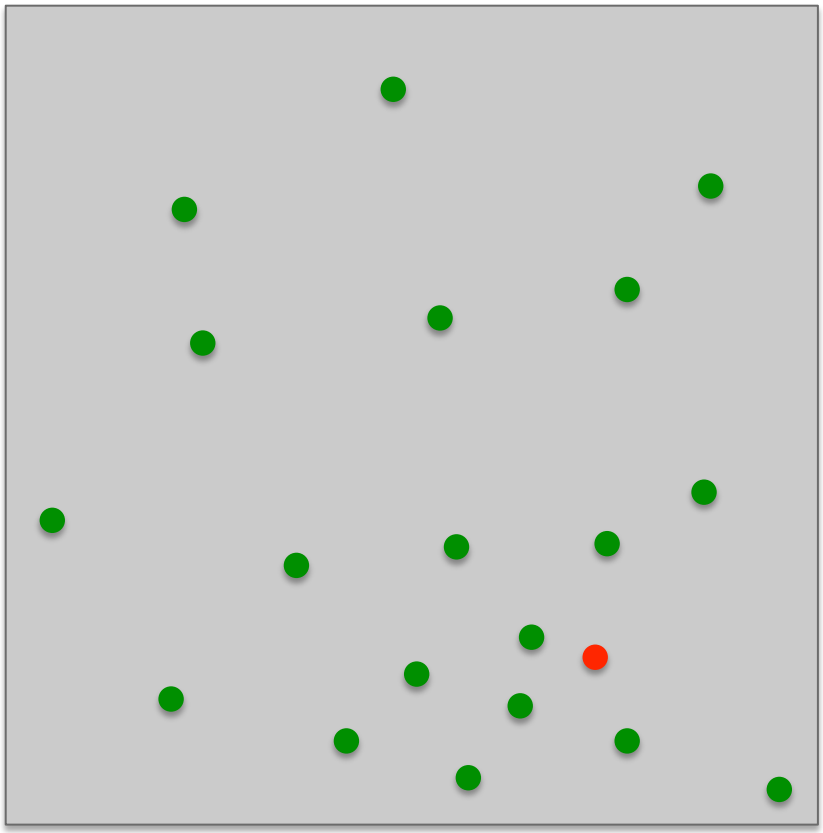


Why use complexity science?

- ‘Closing the loop’
- Multiple interacting actors
- Multiple organizational levels
- Interdependence
- Optimizing waste flows



Model



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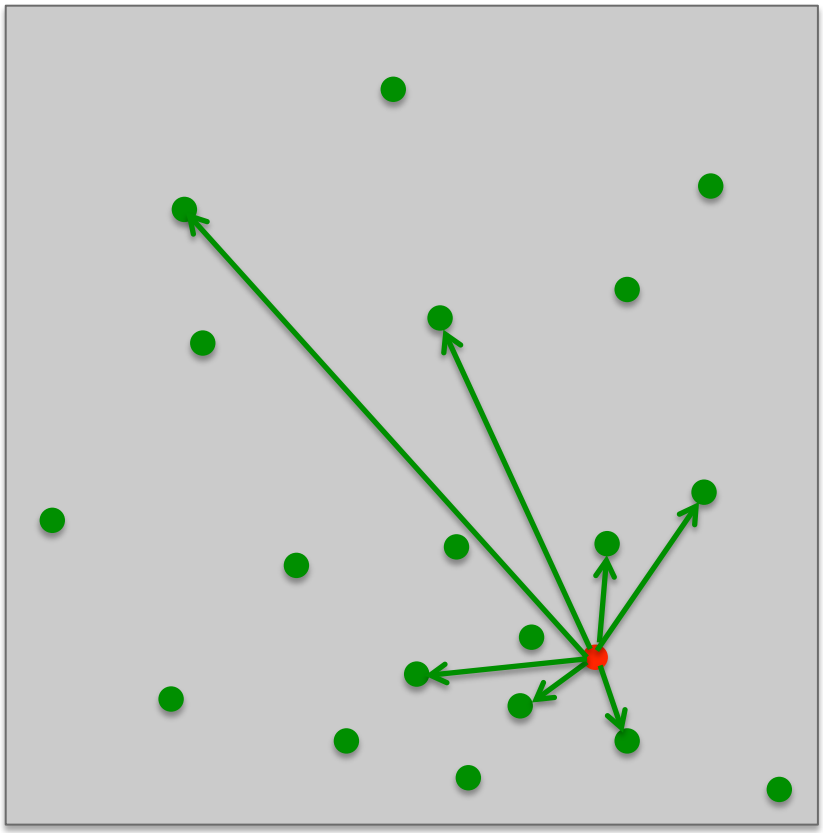

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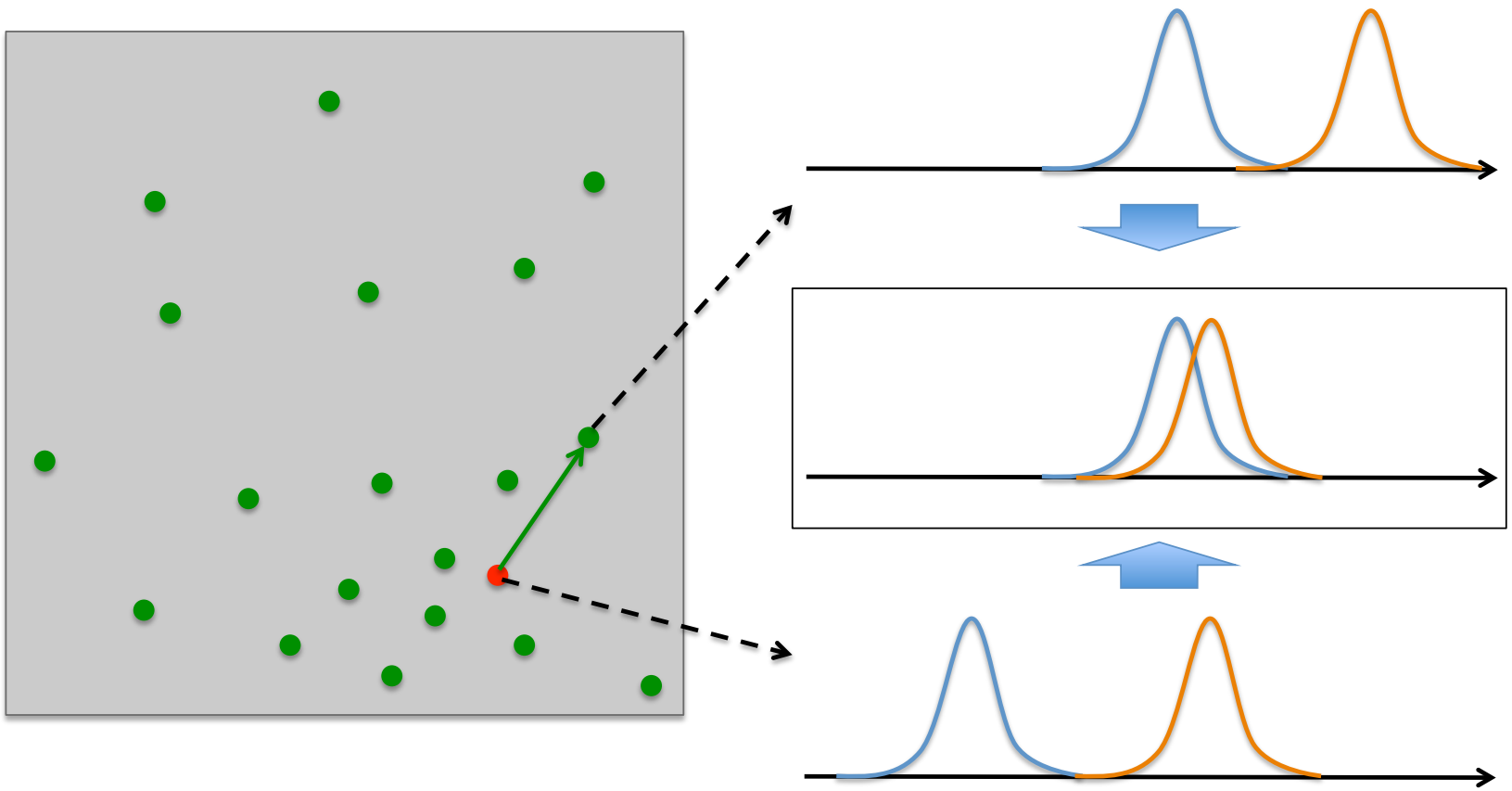

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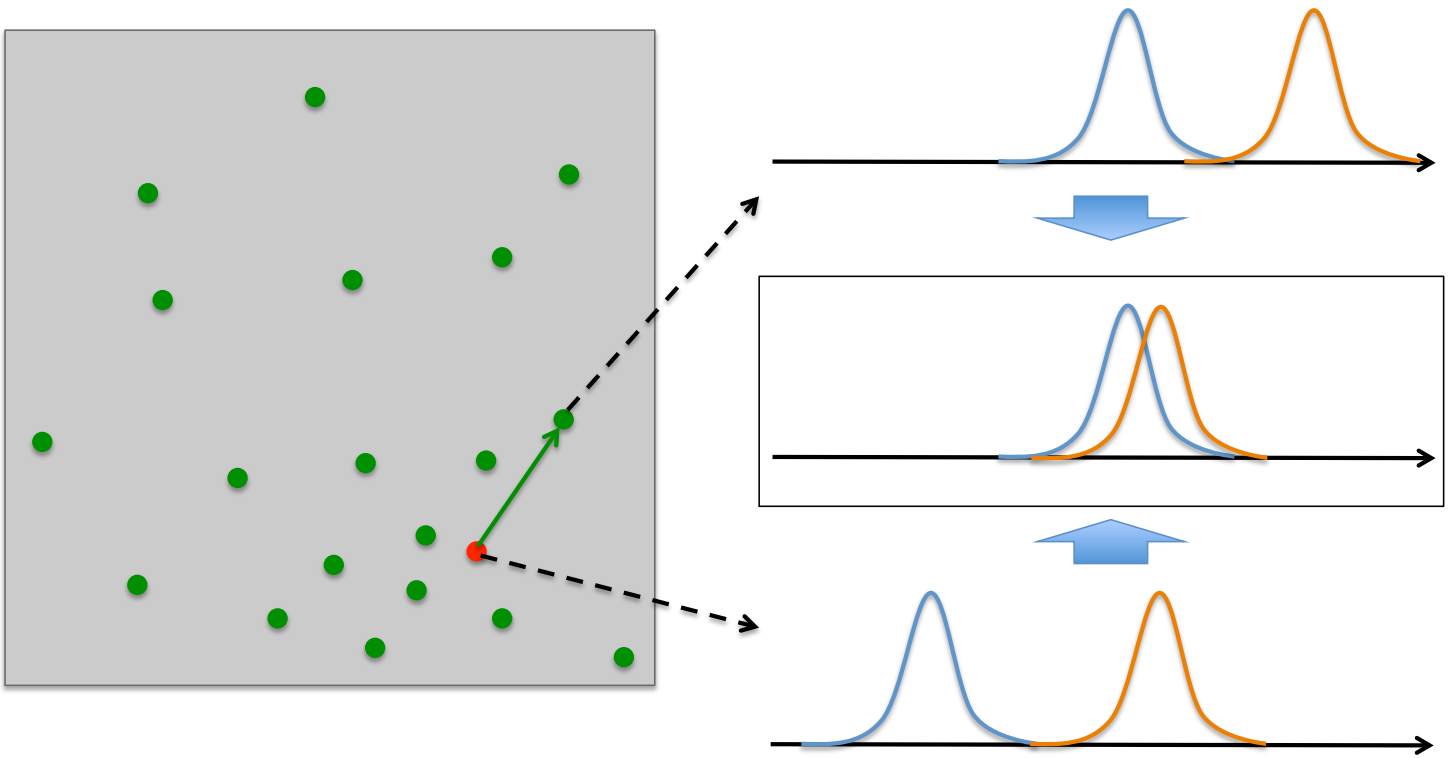
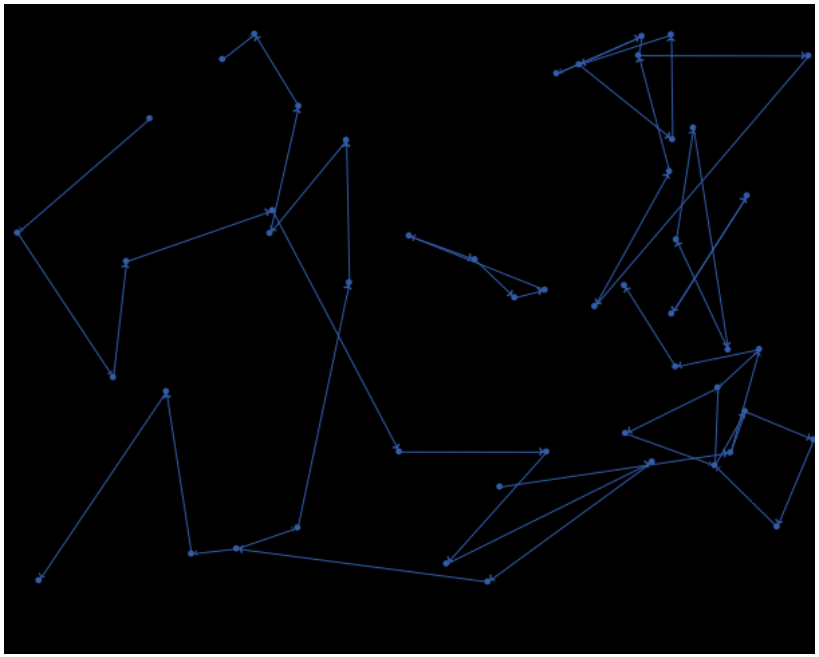
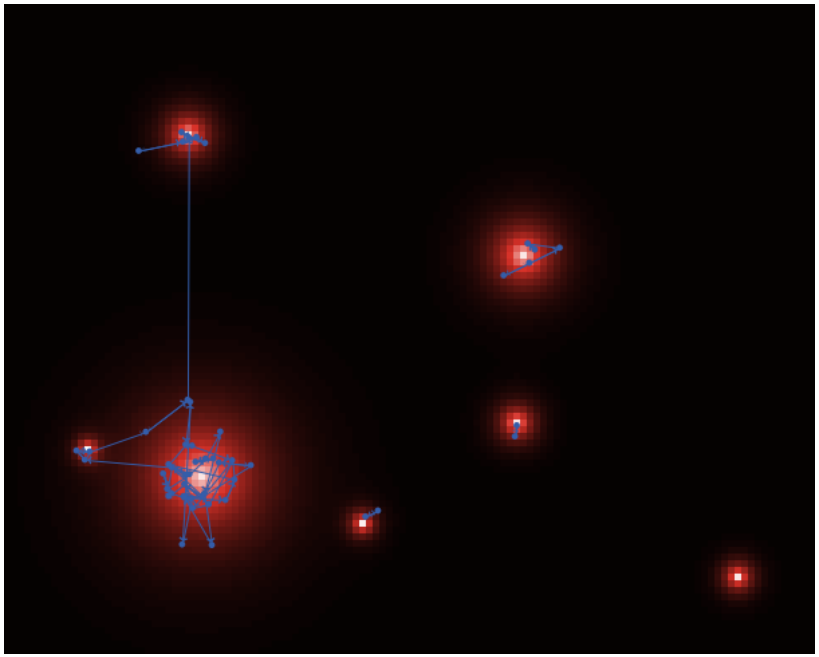


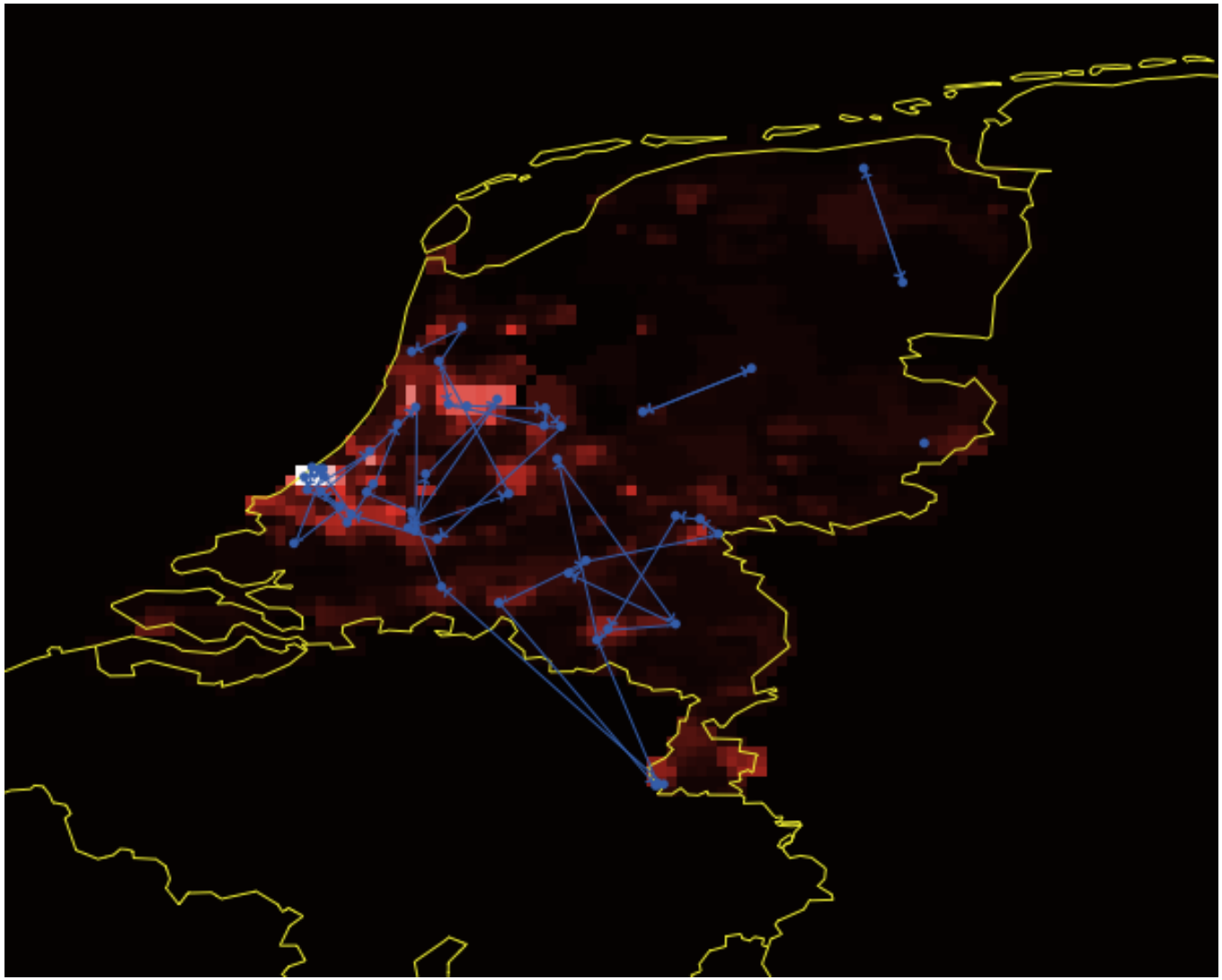
$$u_{ij} = o(i,j) - c \cdot \frac{d_{ij}}{d_{max}}$$

Geographical setup



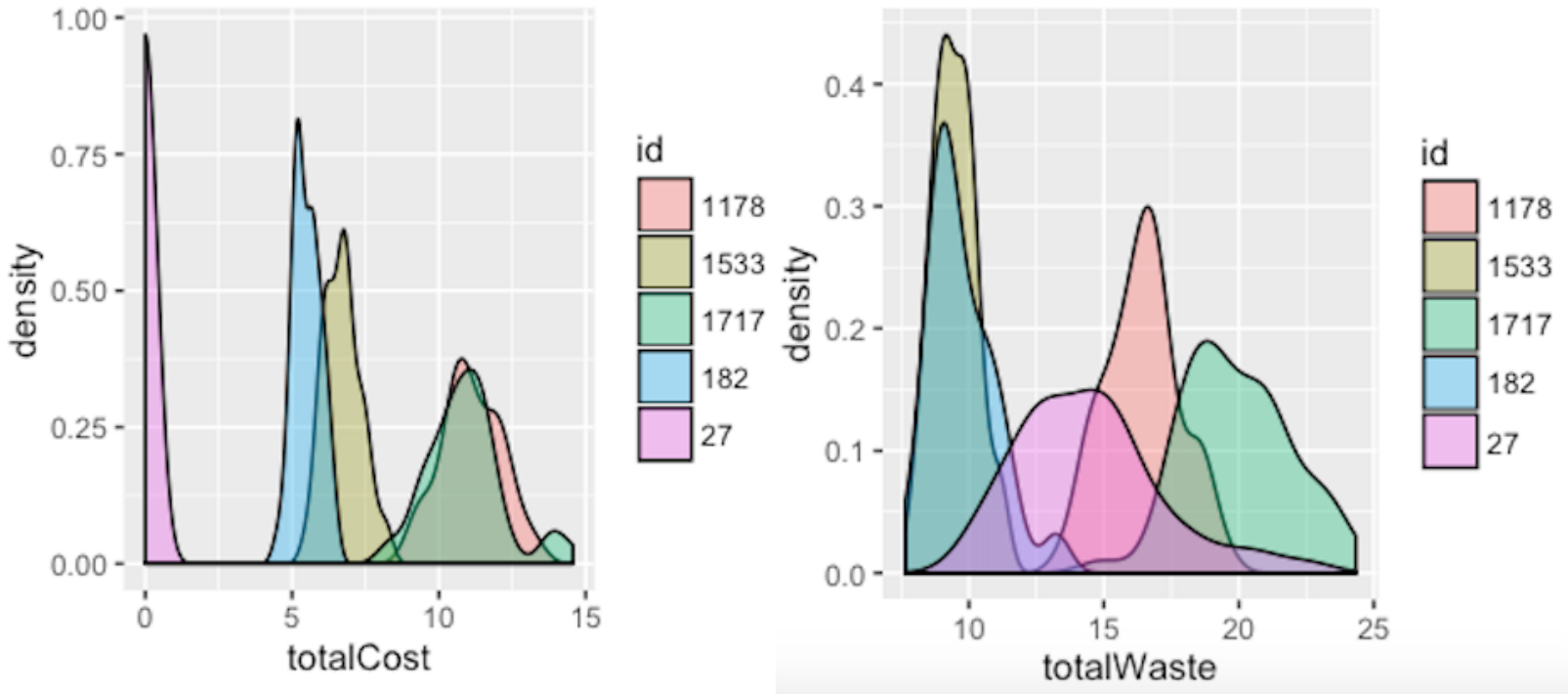


Application on a real city system



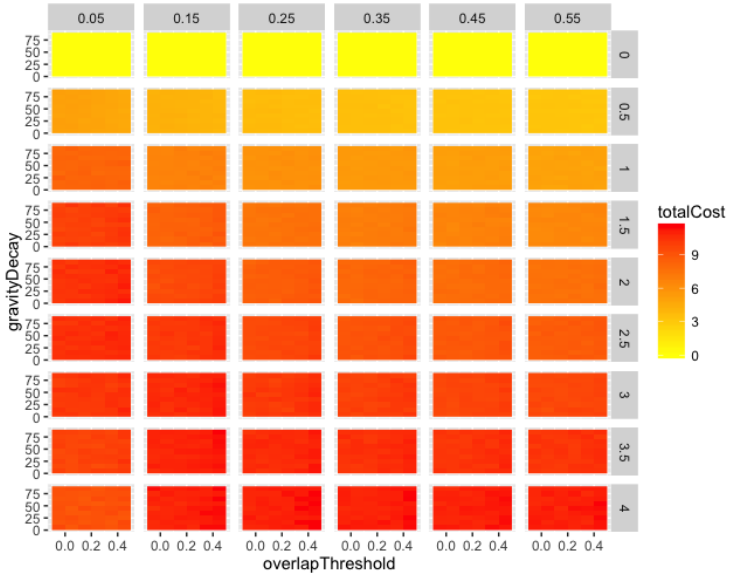
Model Exploration : Intensive parallel computation ($\simeq 5 \cdot 10^5$ runs) using `OpenMole` [Reuillon et al., 2013]

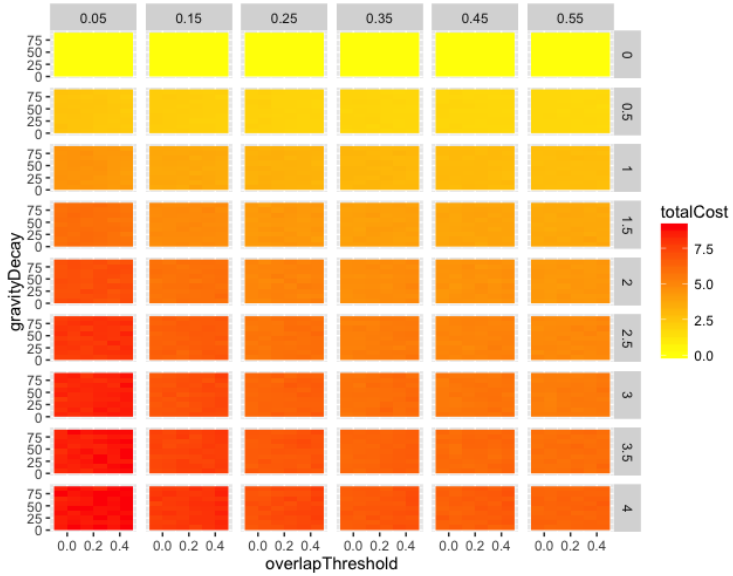
Statistical distributions of indicators

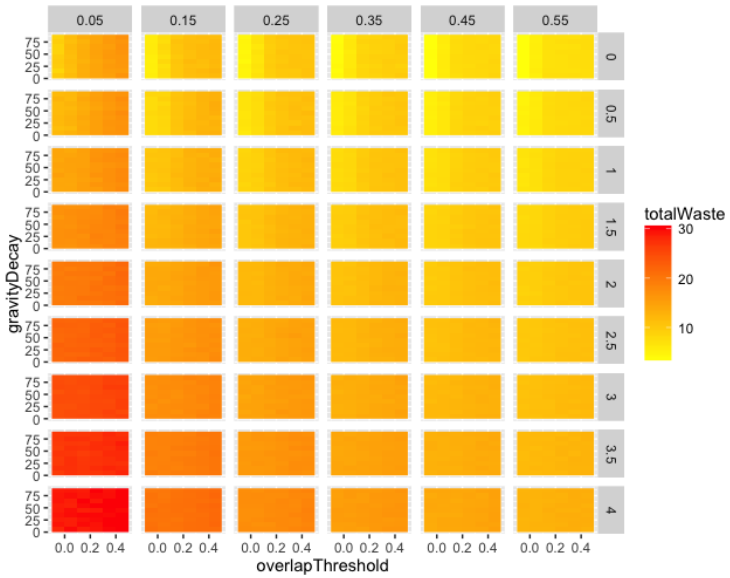


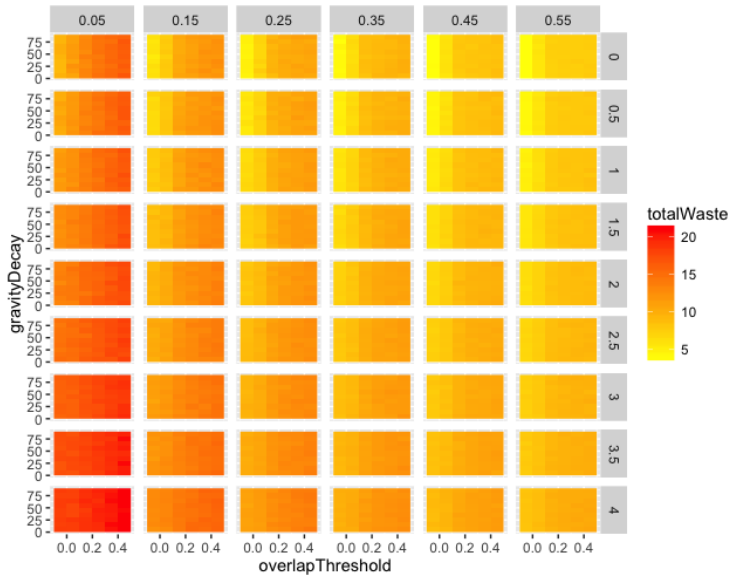
Results : Model Exploration

Left : uniform ; Right : real case. Qualitative change in behavior.



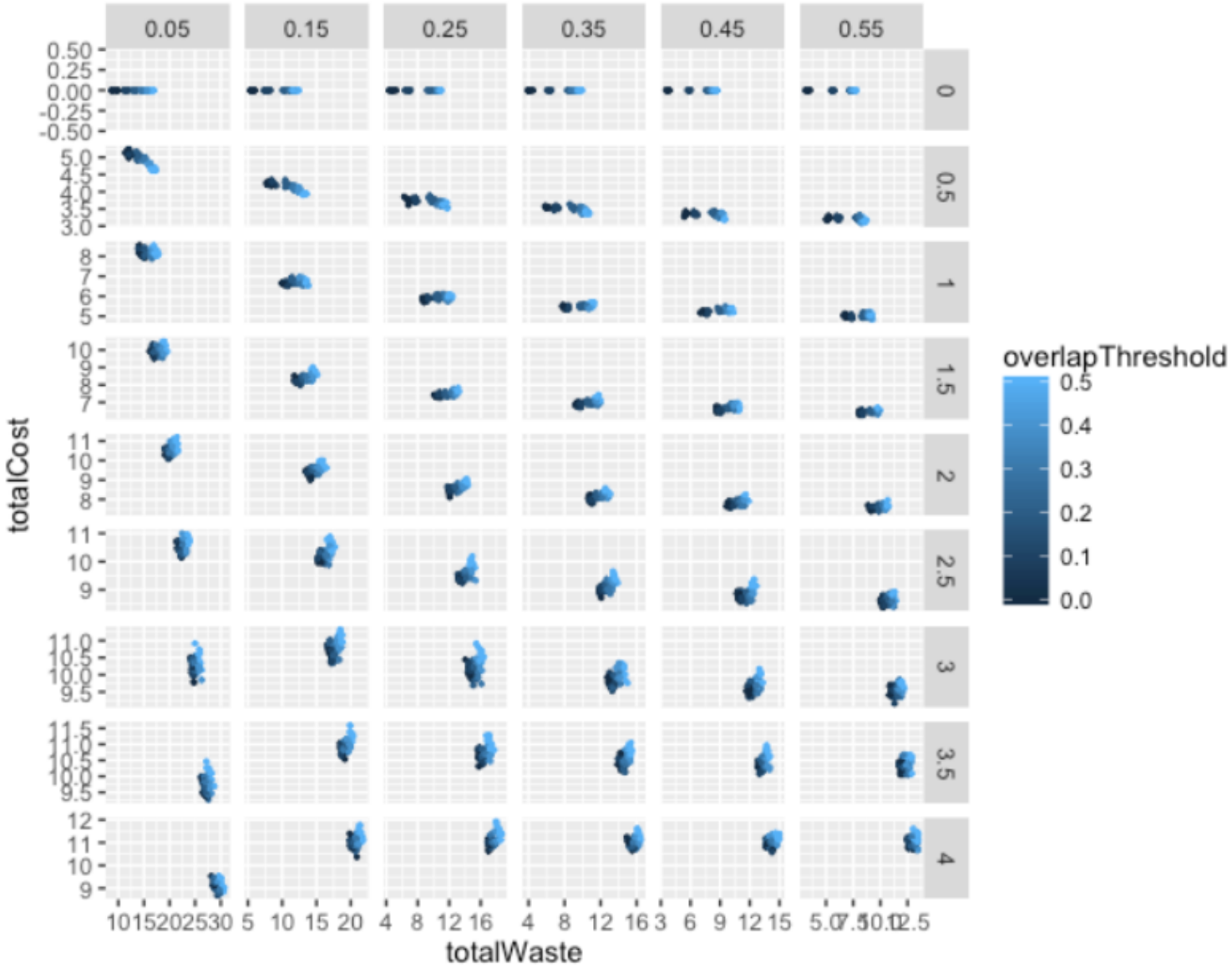






Results : Optimization

Pareto fronts for contradictory objectives



Perspectives

- Test on:
  - Existing maps and infrastructures
  - Biobjective Calibration of the toy-model on waste and cost
  - Use data to calibrate the model
- Open source monitoring
- Insights into the ‘waste market’

Reserve slides

Model setup

Demand and Offer functions : $\vec{D}_i(\vec{y}) = D_i^{(0)} \cdot \vec{d}_i(\vec{y})$ and $\vec{O}_i(\vec{y}) = O_i^{(0)} \cdot \vec{o}_i(\vec{y})$, where $\vec{d}_i$ and $\vec{o}_i$ are multivariate probability densities

Model Parameters

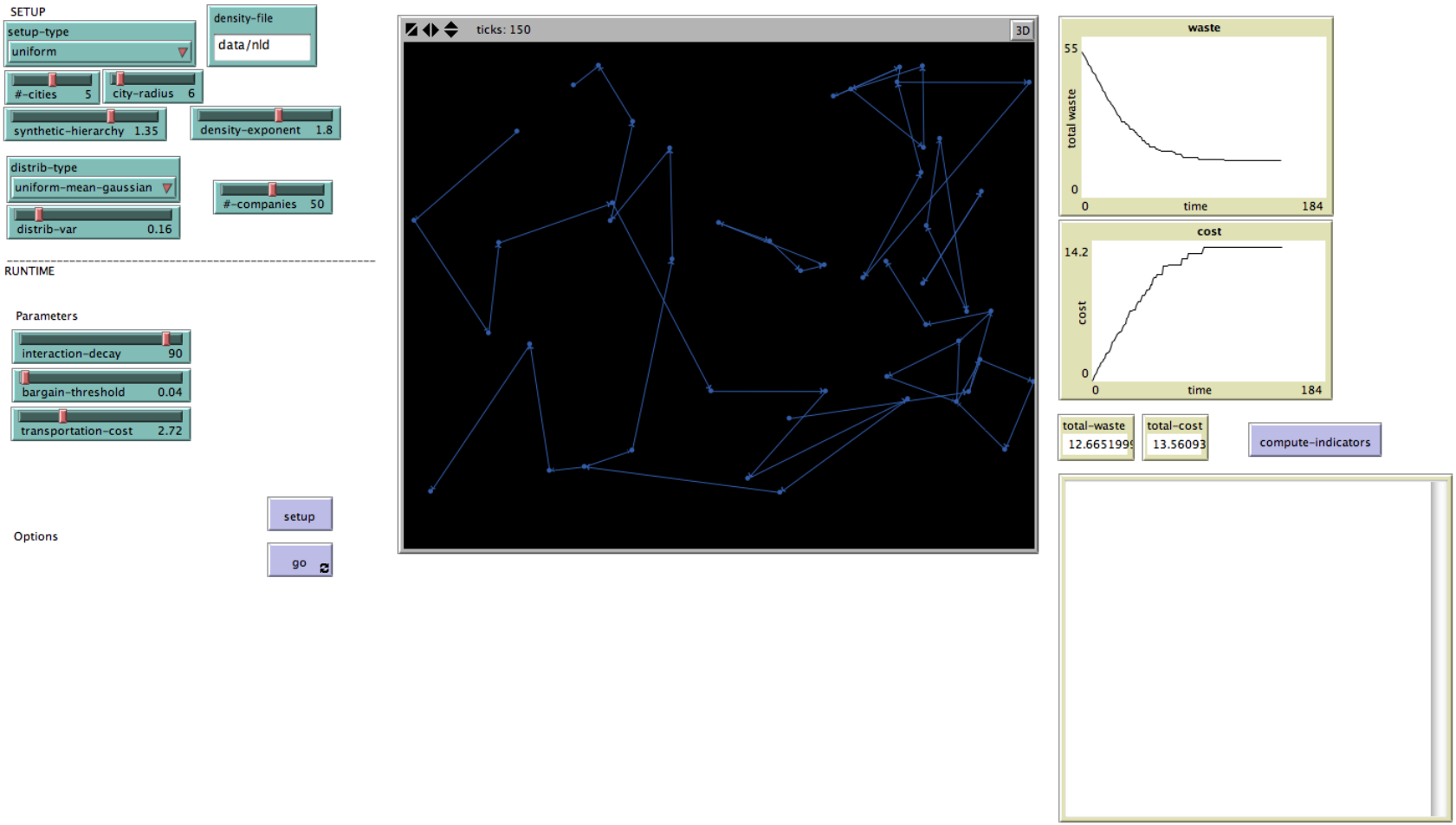
Parameters

- σ_0 standard deviation of input/output distributions
- d_0 characteristic decay distance for spatial interaction potential
- c transportation cost
- θ_O overlap threshold over which transactions are feasible

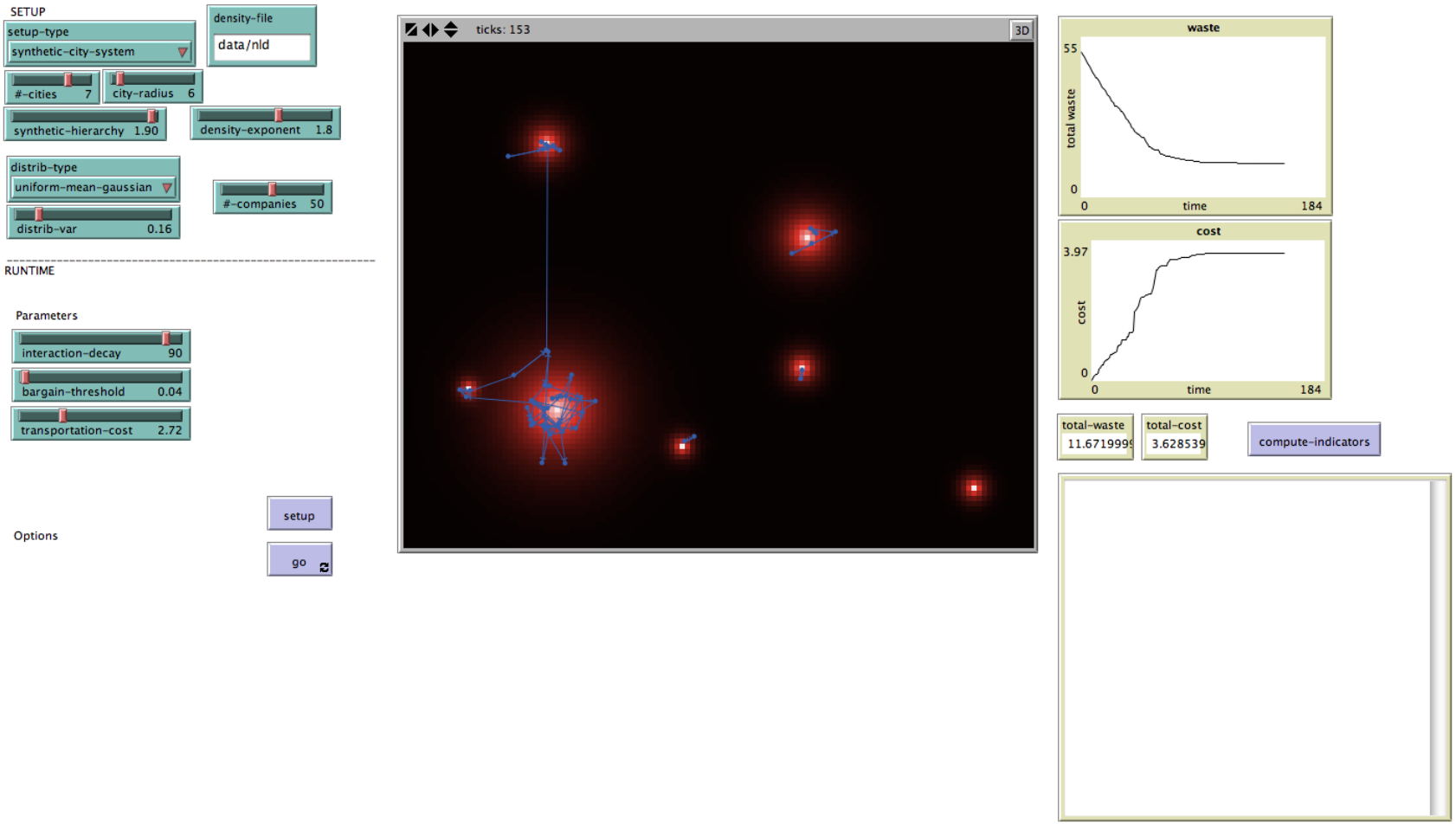
Model Indicators

- Total waste : sum of remaining output distributions
- Total cost : weighted network length
- Network topology indicators : clustering coefficient, in/out mean degree, component number

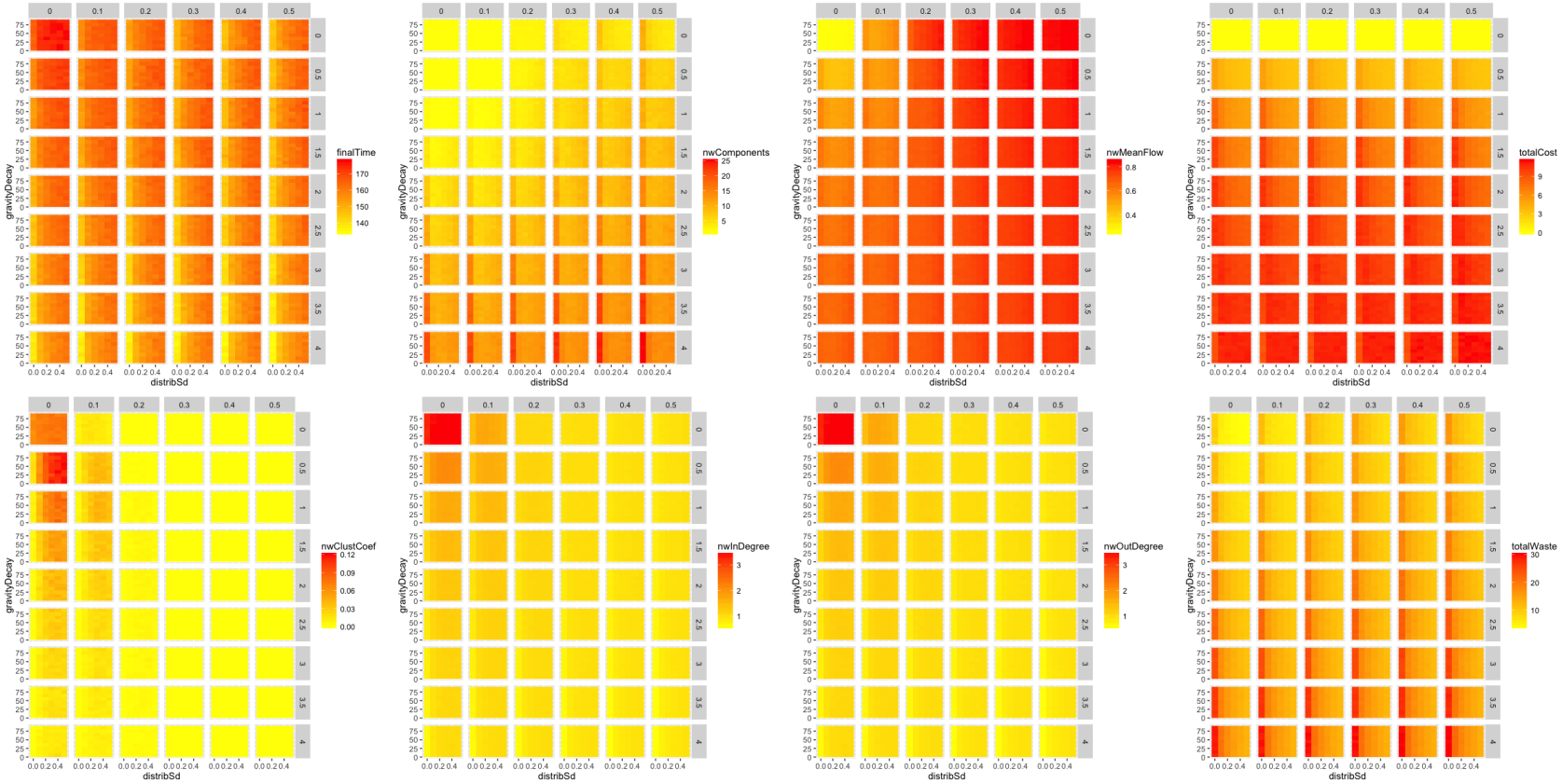
Model Interface (uniform)



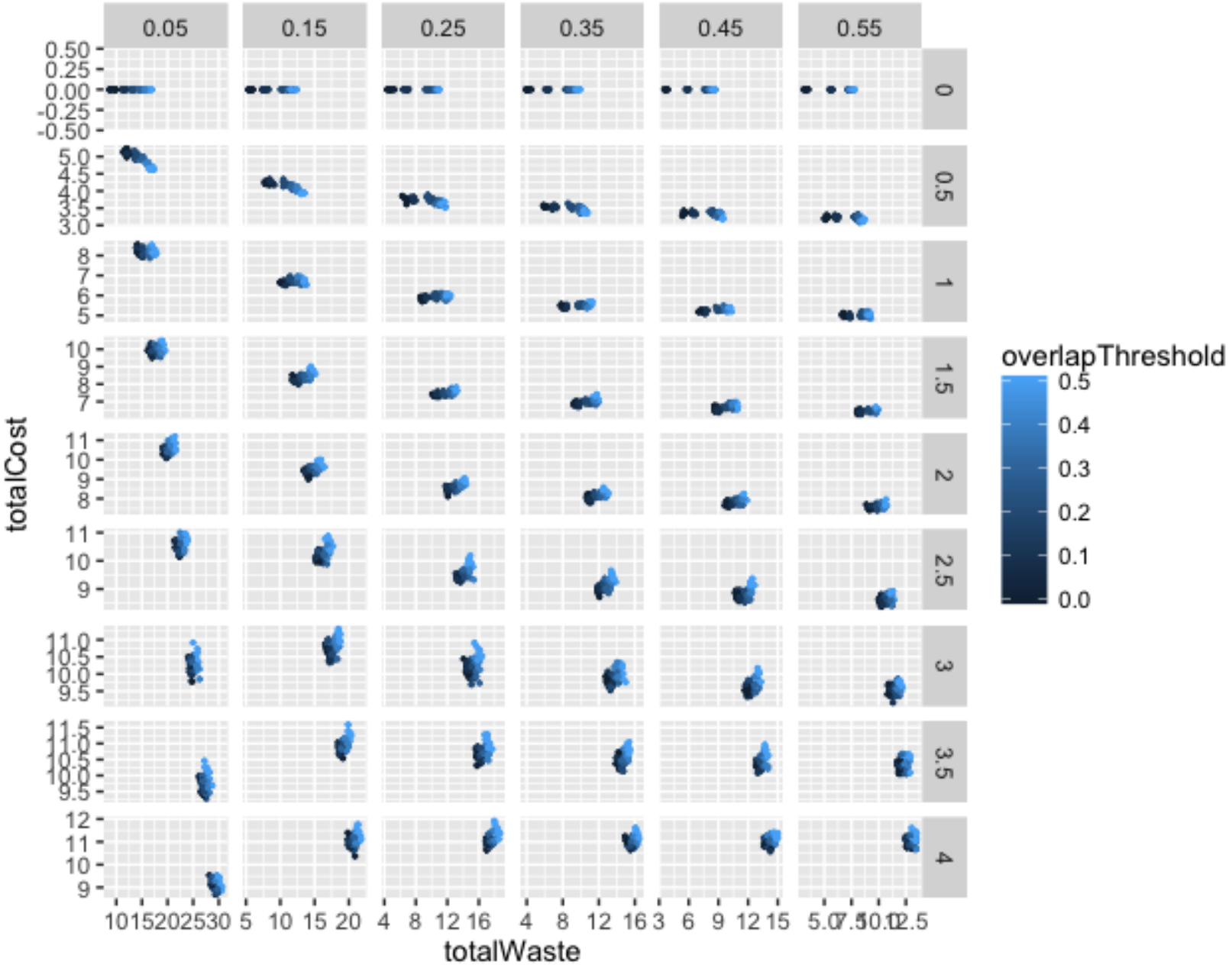
Model Interface (synthetic)



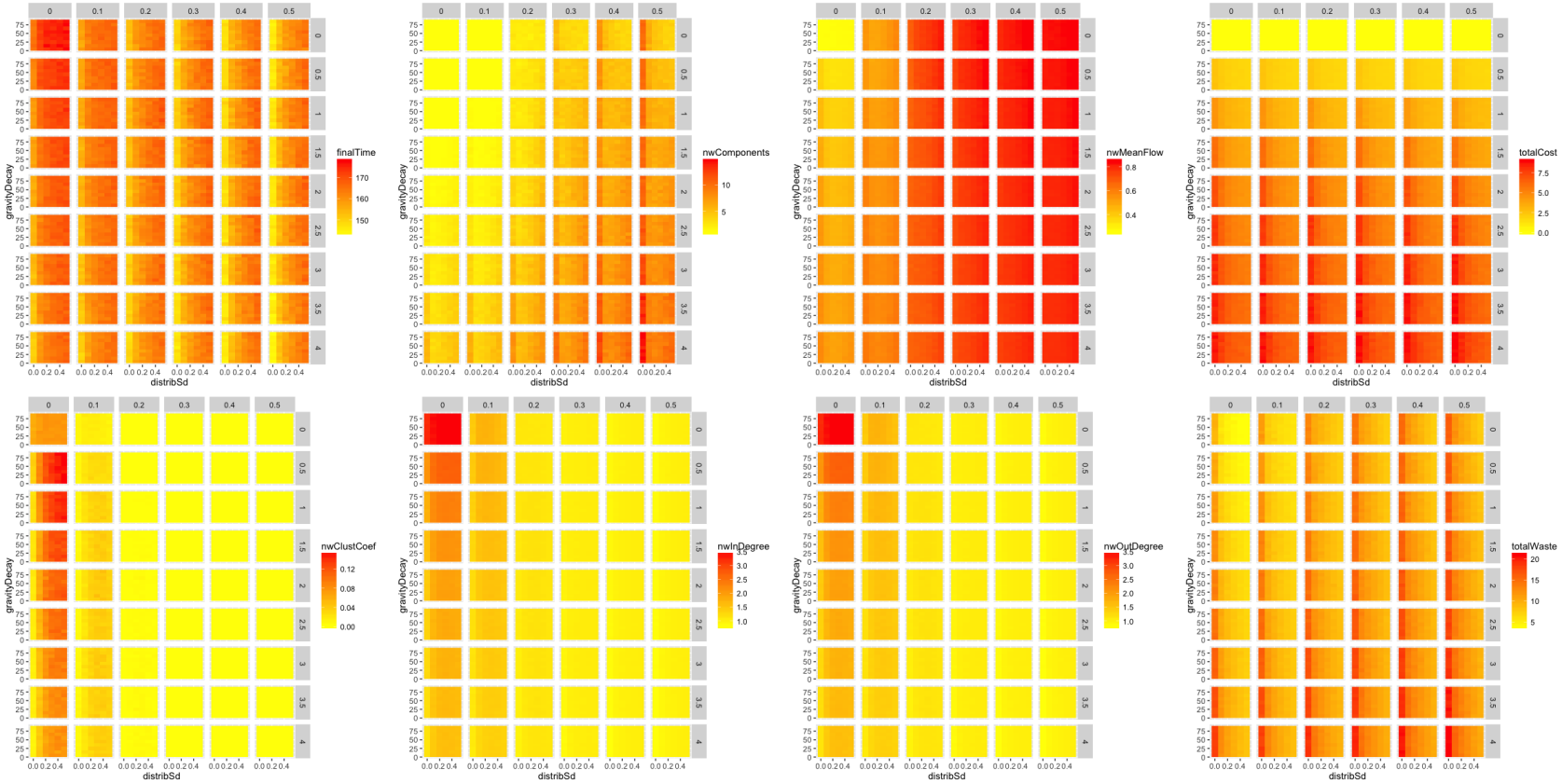
Indicators (uniform spatial distribution)



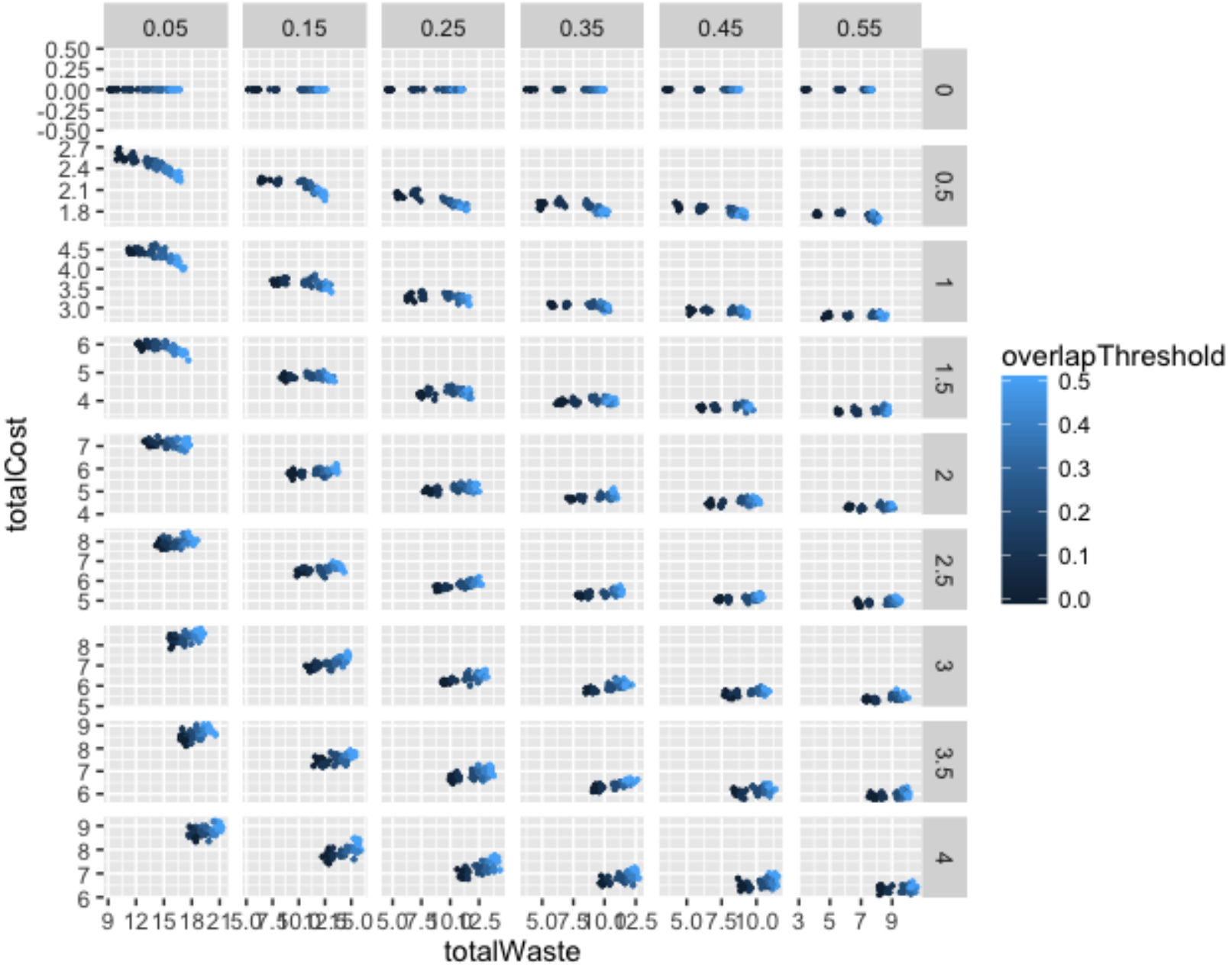
Pareto front (uniform spatial distribution)



Indicators (real case)



Pareto front (real case)



References I


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.