THE GENERAL URBAN MODEL: RETROSPECT AND PROSPECT

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PART 1: RETROSPECT

Achievements and insights

INTRODUCTION

- anniversaries:
  - beyond the jubilee: transport models in their 53rd year?
  - comprehensive models in their 44th: Lowry (1964)
  - location models in their 43rd
  - a comprehensive model paper of 41 years ago
  - 40th, British (and Irish) Section
- achievements – huge
- challenges – huge!

- modelling urban development and evolution is one of the grand challenges of 21C science
- we can now see that we have been at the leading edge of complexity science; and the wider developments will now help us
- discuss in turn:
  - retrospect:
    - what has been achieved; what has changed
    - some important insights that are now beginning to be better understood
  - prospect
    - current challenges and prospective breakthroughs

ACHIEVEMENTS

- interaction models
- post-Lowry modellers: Putnam, Wegener, Echenique, Mackett,...
- demographics
- input-output
- the ‘dynamics’ hypothesis
- generalising the classics
- micro-simulation and agent-based modelling
- information systems/GIS/visualisation/geodemographics
- economic foundations: Alonso, Herbert and Stevens, Anas, Krugman,.....
- applications.....

Sector specialists

Financial Services

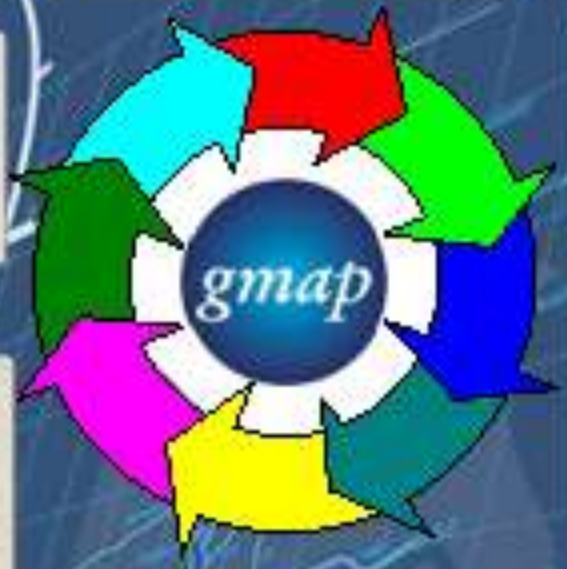
Halifax, Nationwide, Alliance & Leicester, Bank of Scotland, Co-op

Automotive

Ford, Jaguar, Nazda, Volvo, Land Rover, Daimler-Chrysler

Retail Petroleum

Exxon Mobil, BP, Total Fina



Telecoms

Telewest, Marconi, THUS, OnCue, Bulldog

Retail

Asda, Dixons, Sainsbury's, Oxfam IKEA, Our Price

Other

Aventis, Warner-Lambert, DTI, Leeds TEC

INSIGHTS

- representations: exogenous and endogenous variables; requisite levels of disaggregation (10^{13})
- the main submodels:
  - demographics: the challenge of migration
  - input-output: beyond 'final demand' drivers
  - the interaction-based models
  - structural dynamics: development and evolution
- properties of nonlinear models:
  - multiple solutions
  - phase transitions
  - path dependence
  - forecasting capabilities
- the value and limitations of models in planning

PART 2 – PROSPECT

Challenges

The agenda

- the basics: what can be made routine should be – access to data, presentation, analysis, modelling, planning; sub-model development
- the next steps
  - extending the underlying data warehouse
  - layers of disaggregation
  - the evolution of structure
    - phase transitions: the drivers; developing the mathematics
    - urban typologies based on underlying structures: the ‘DNA’ argument
  - linking models to the big picture: neo-geography
- implications for planning

Warehouses and models

- access via warehouses
  - linking data bases
  - missing information via EM, modelling
  - micro-simulation
  - model outputs – e.g. forecasts
- GIS and visualisation
- analysis: e.g. geodemographics, model outputs
- feedback to the warehouse
- *The Wire* argument: do we need models when we have so much data?

Sub-model development

- disciplinary integration: the role of regional science?
- integrating economic with other perspectives
- are we taking full advantage of dual formulations?
- market clearing and suboptimality?
- structural evolutionary models need good demand and production functions: an under-researched area?

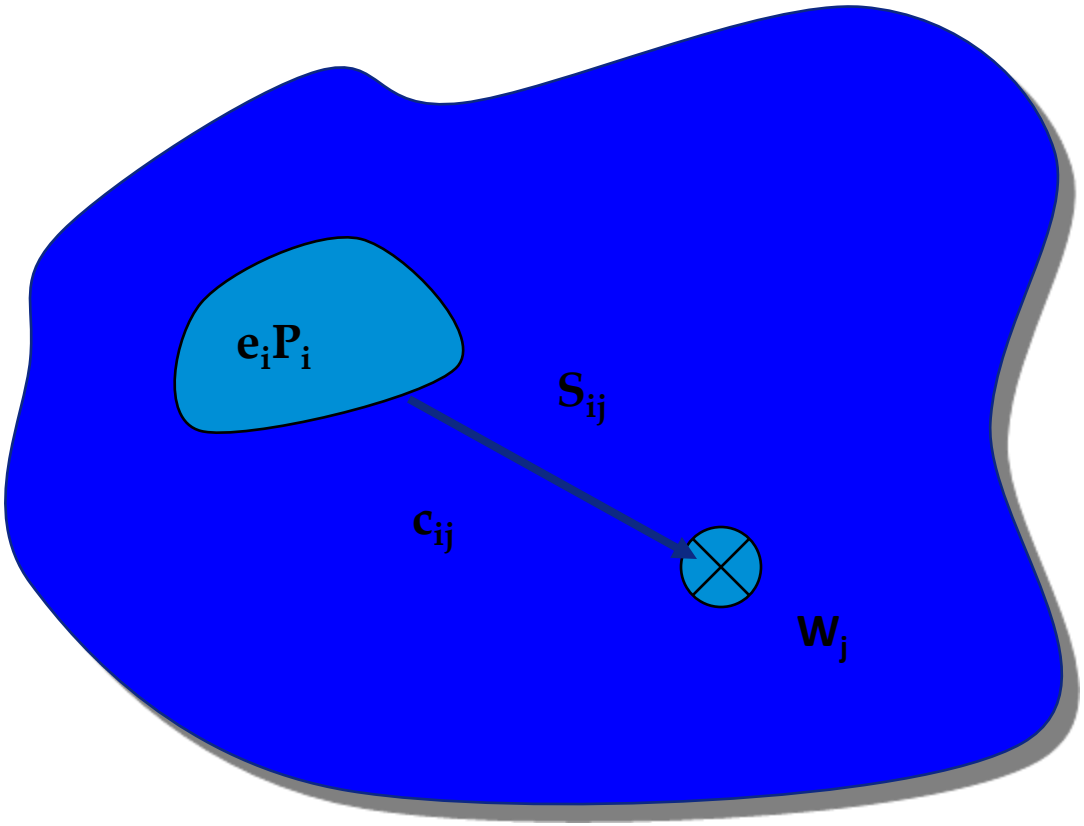
Layers of disaggregation

- upper layer modelling as a framework – particularly in relation to possible rates of development:
  - nations within the international system
  - regions within a nation
  - cities within a region/nation
  - intra-urban
- have we been underestimating upper-layer constraints?
- demography and input-output dominate the upper layers; interaction and spatial structure models, the lowest.

The evolution of structure

- developing explicit models:
  - retail as an archetype
  - in the general model
- phase transitions
  - the impact of improved visualisation
- illustrated for a London example: 600+ residential areas, 220 retail centres

The retail archetype



e_iP_i - demand in zone i

W_j - attractiveness of zone j

S_{ij} - flows between i and j

c_{ij} - cost of travel between i and j

Spatial interaction

$$S_{ij} = A_i e_i P_i W_j^{\alpha} \exp(-\beta c_{ij})$$

where

$$A_i = \Sigma_k W_k^{\alpha} \exp(-\beta c_{ik})$$

and

$$D_j = \Sigma_i S_{ij}$$

which is

$$D_j = \Sigma_i [e_i P_i (W_j)^{\alpha} \exp(-\beta c_{ij}) / \Sigma_k (W_k)^{\alpha} \exp(-\beta c_{ik})]$$

Evolution

Let the cost of running a retail centre be $C_j(W_j)$. Then, the structural dynamics can be presented as

$\Delta W_j(t, t+1) = \varepsilon[D_j(t) - C_j(t)]W_j(t)$

which is, essentially, the Lotka-Volterra equation

Then

$D_j = C_j$

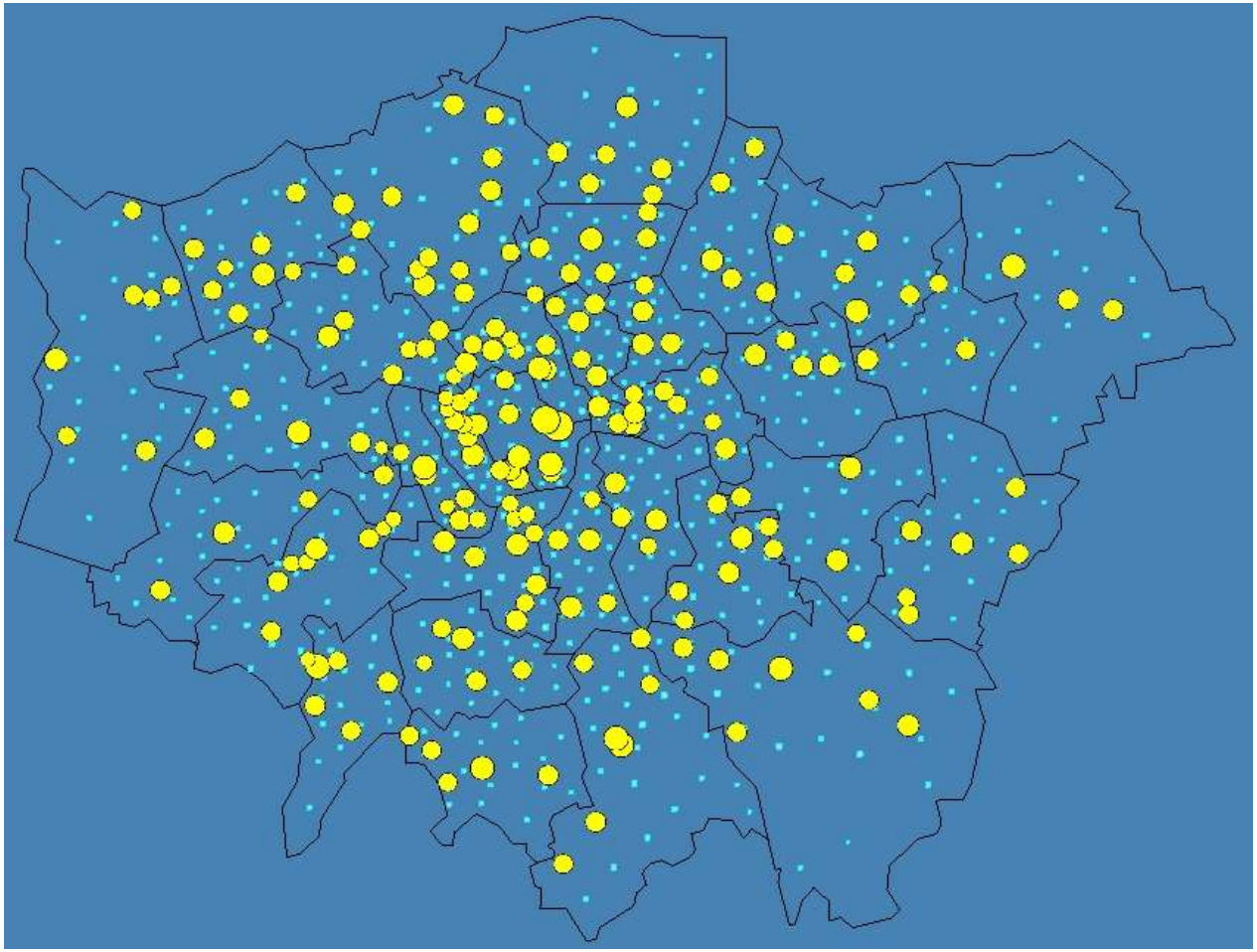
at equilibrium

That is:

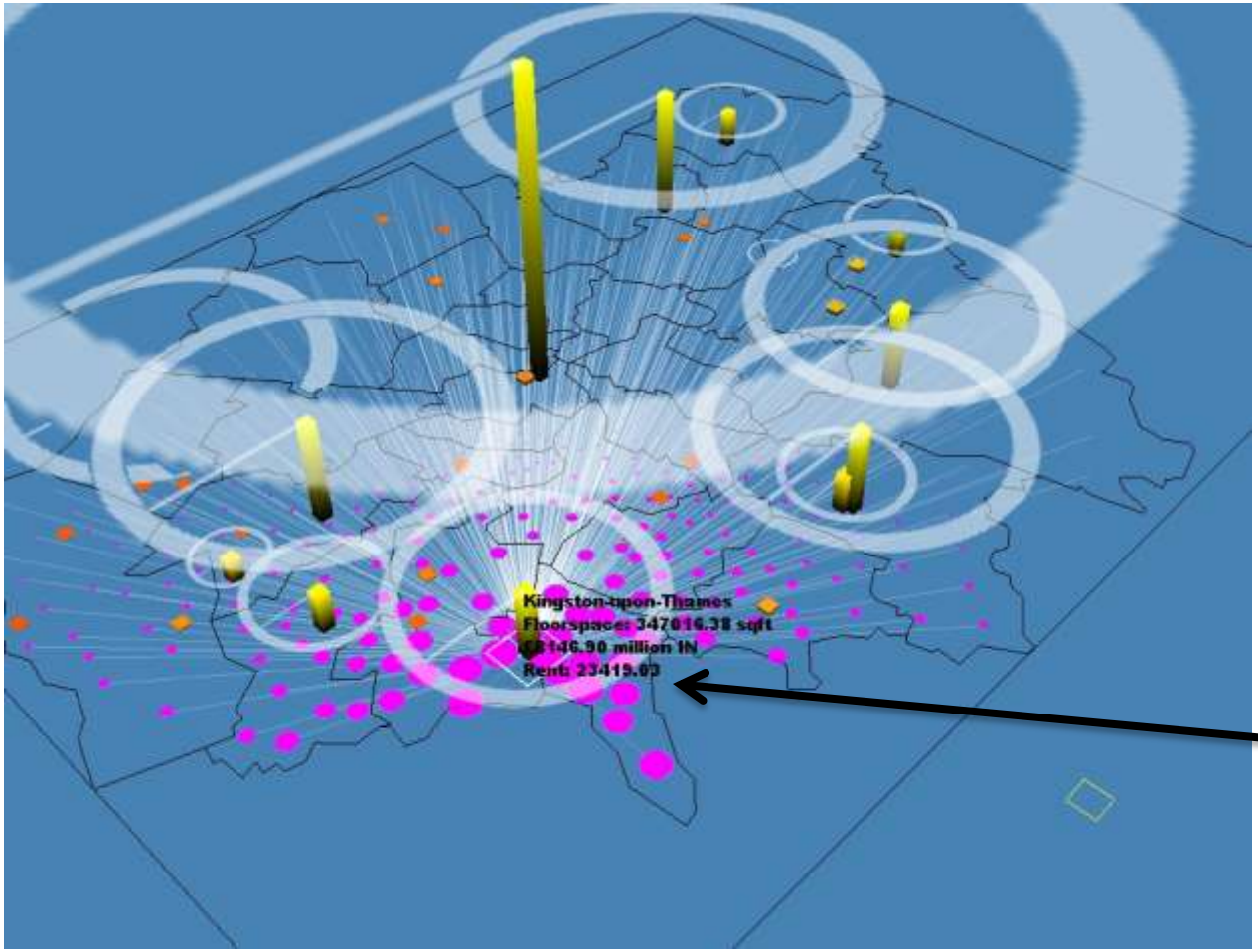
$\Sigma_i\{e_i P_i W_j^{\alpha} \exp(-\beta c_{ij}) / \Sigma_k W_k^{\alpha} \exp(-\beta c_{ik})\} = k_j W_j$

Initial conditions - London data

Data from the Town Centres Project 2002

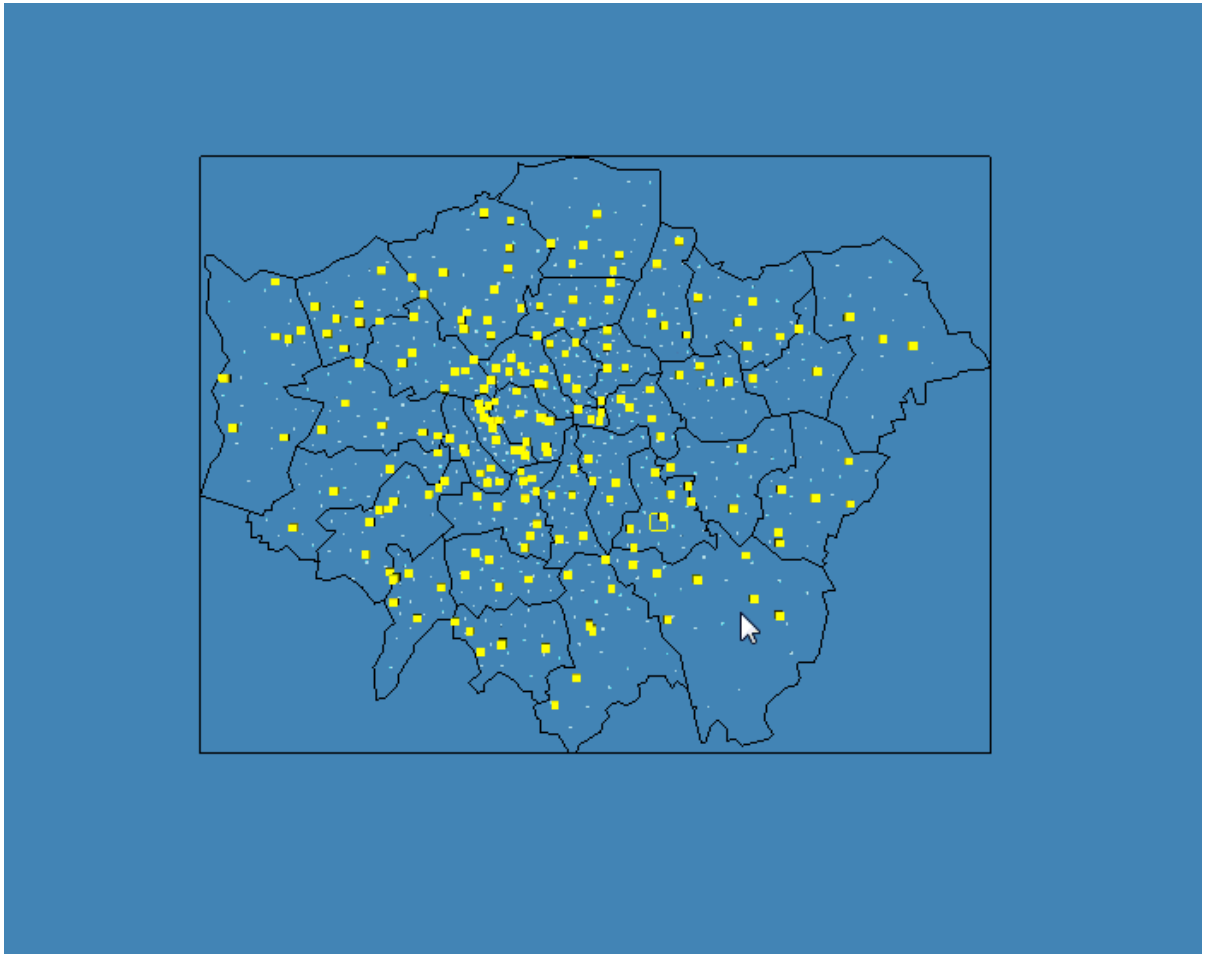


Flows to a centre



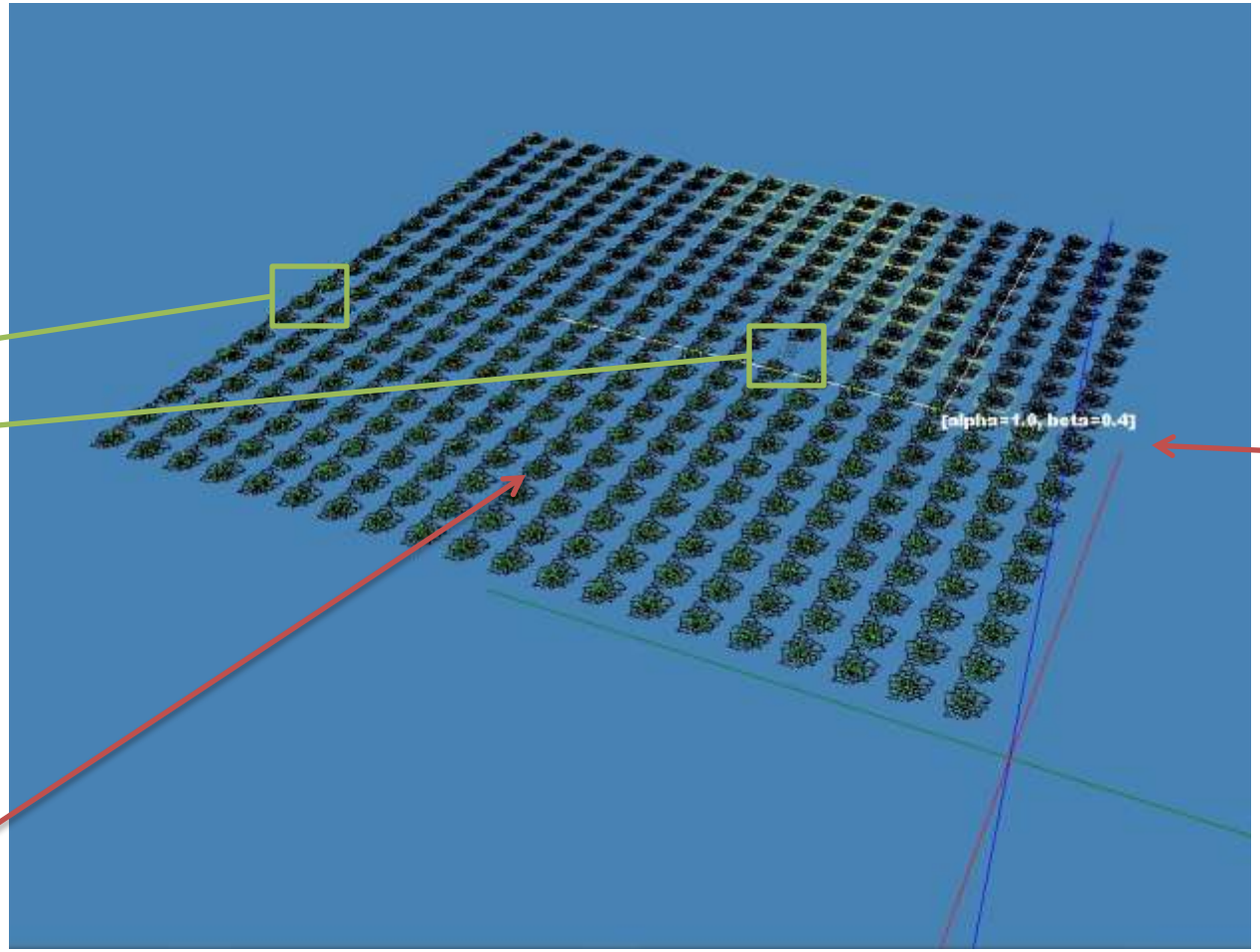
When the user selects a retail centre the population centres are displayed at a size proportional to the amount of money they are sending to the selected retail centre

Single Model Run



Results Explorer Grid

The user can load a pre-generated grid of results from models that have been through a large number of simulation updates. Some models have reached **equilibrium** while others remain in a **chaotic** state

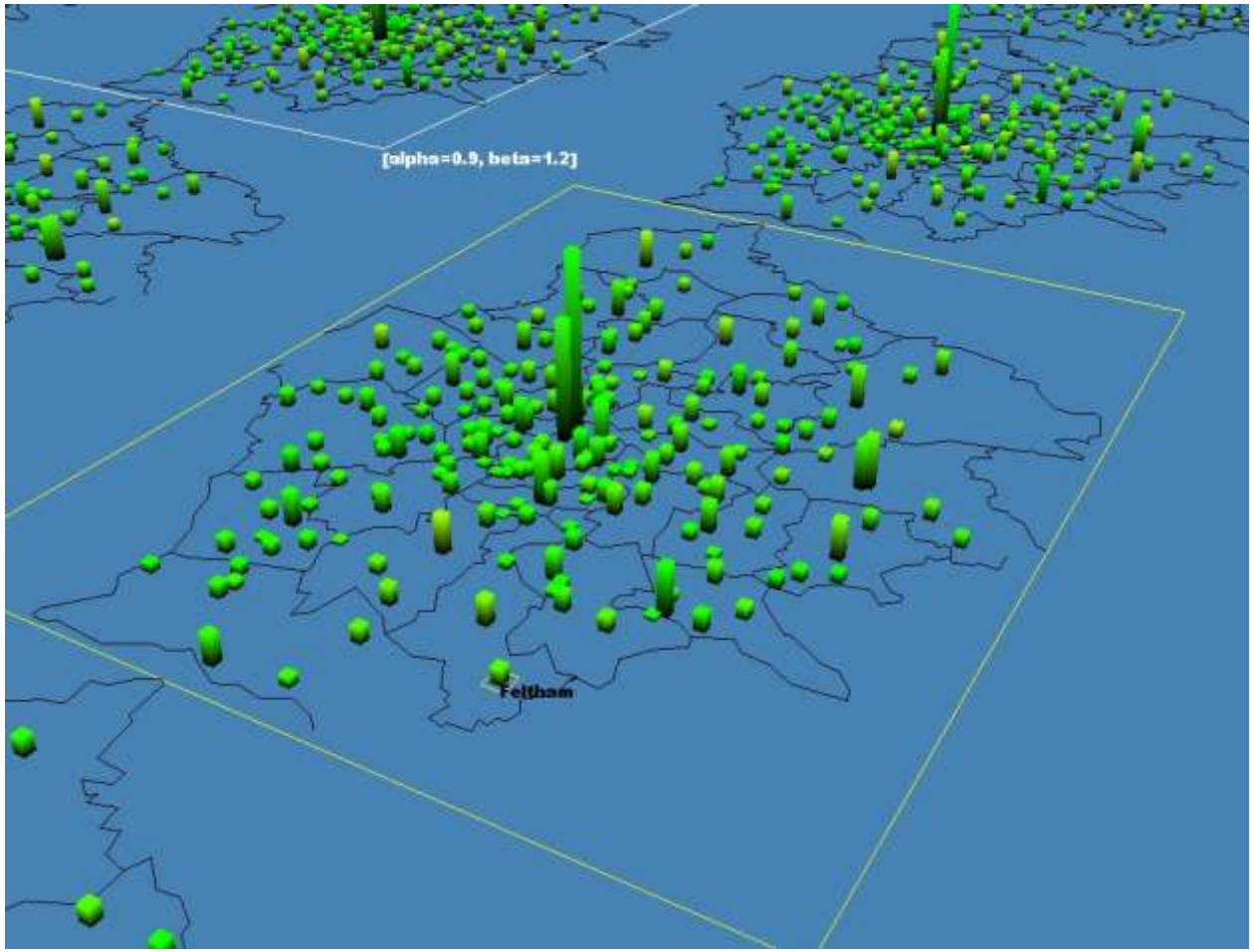


The value of alpha and beta under the cursor are displayed to aid navigation

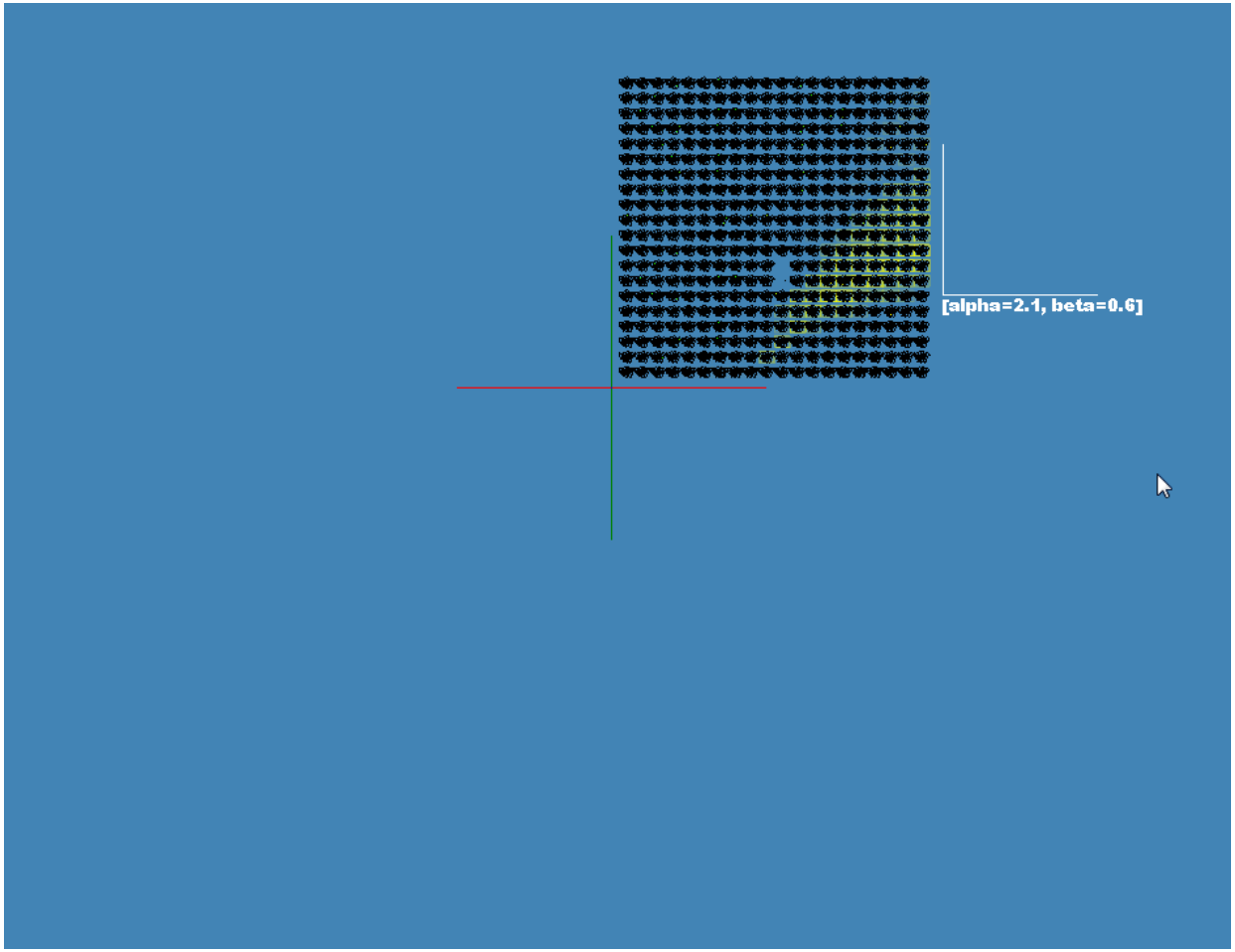
Each model result is displayed in a position on the grid that indicates its alpha and beta parameters

Results Explorer Grid Detail

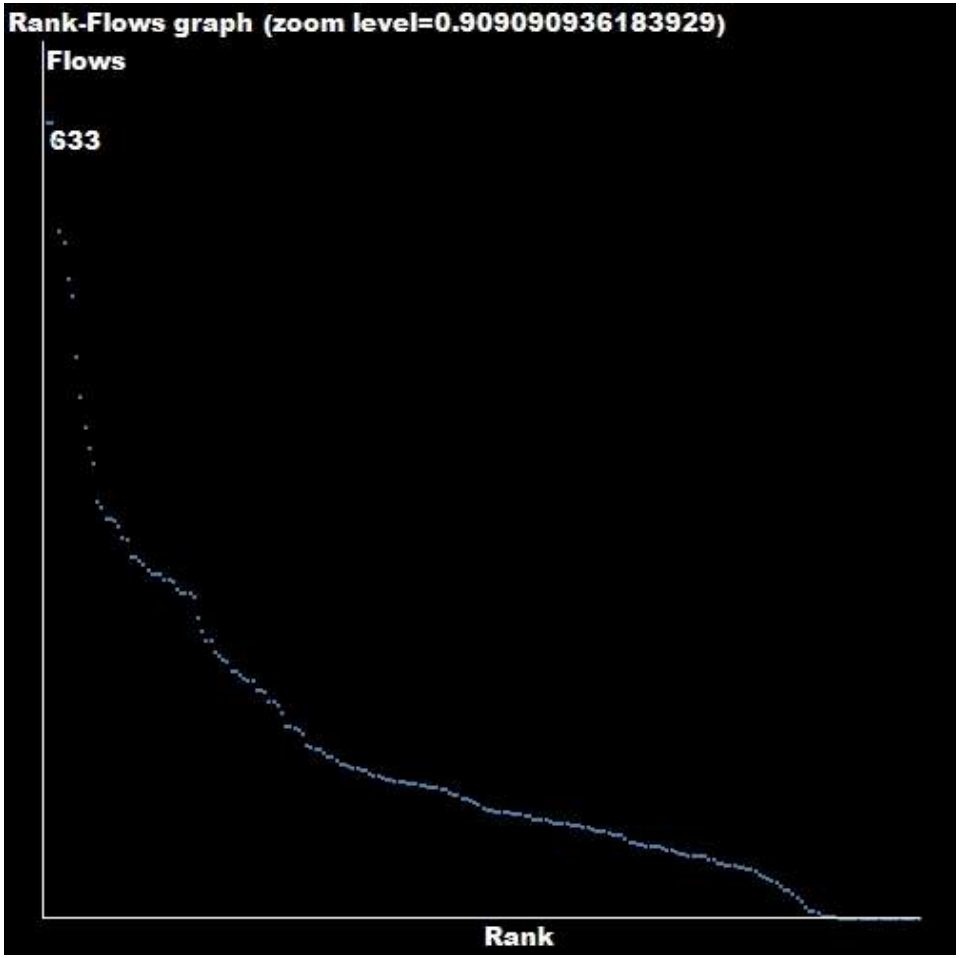
The user can zoom into the grid to look at each result map in detail



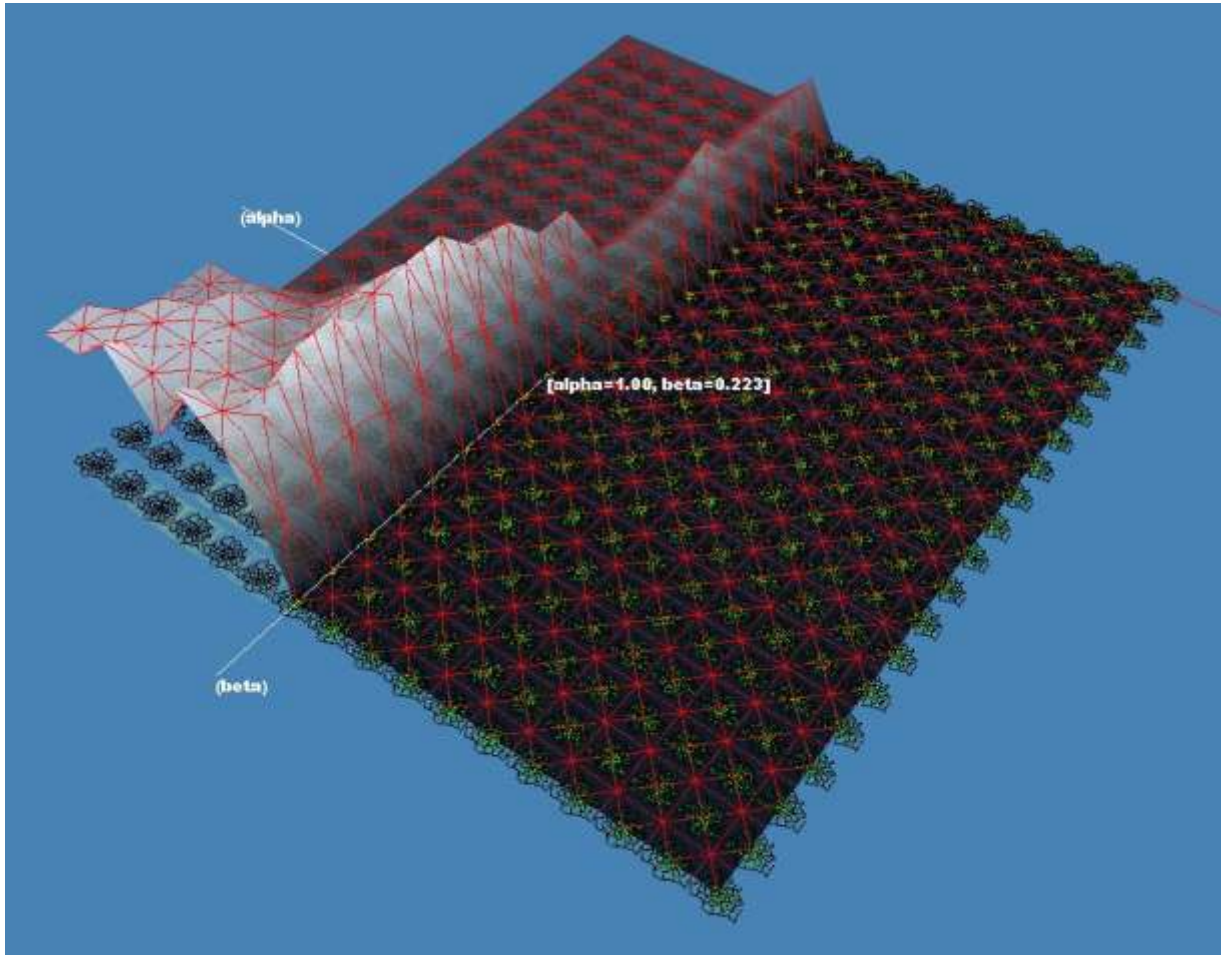
Results Explorer Animation



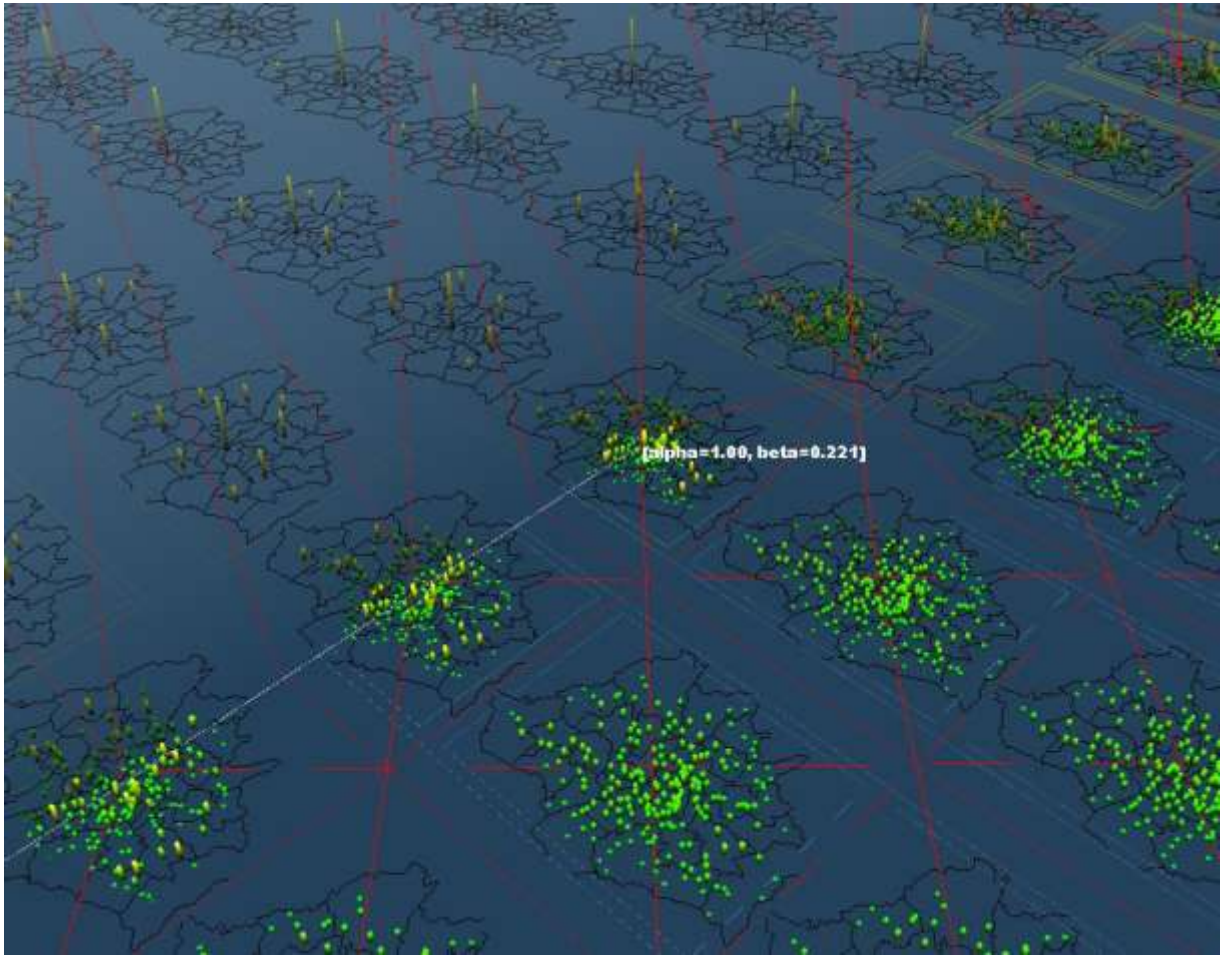
Rank Flows: an aside on network analysis



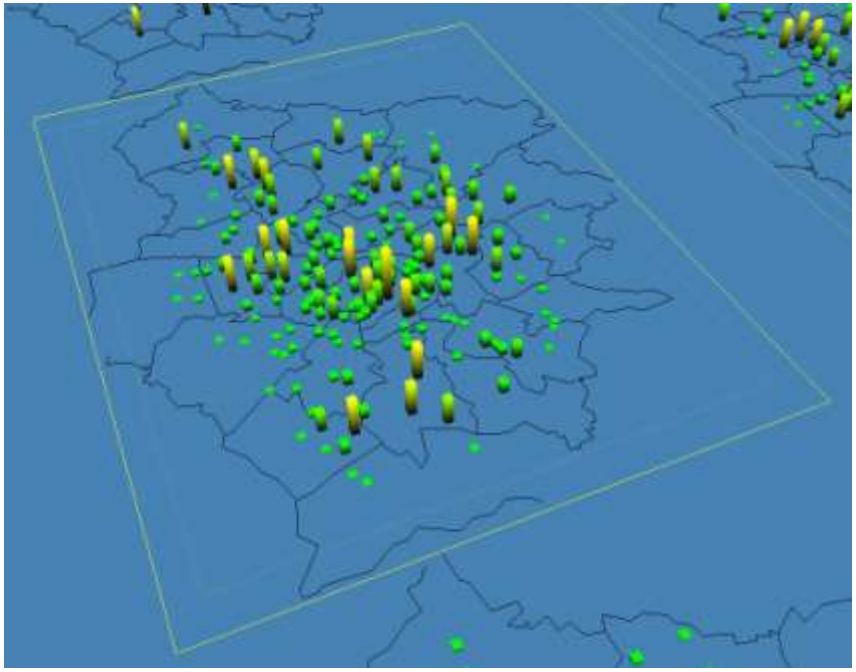
Searching for phase changes: the order parameter surface

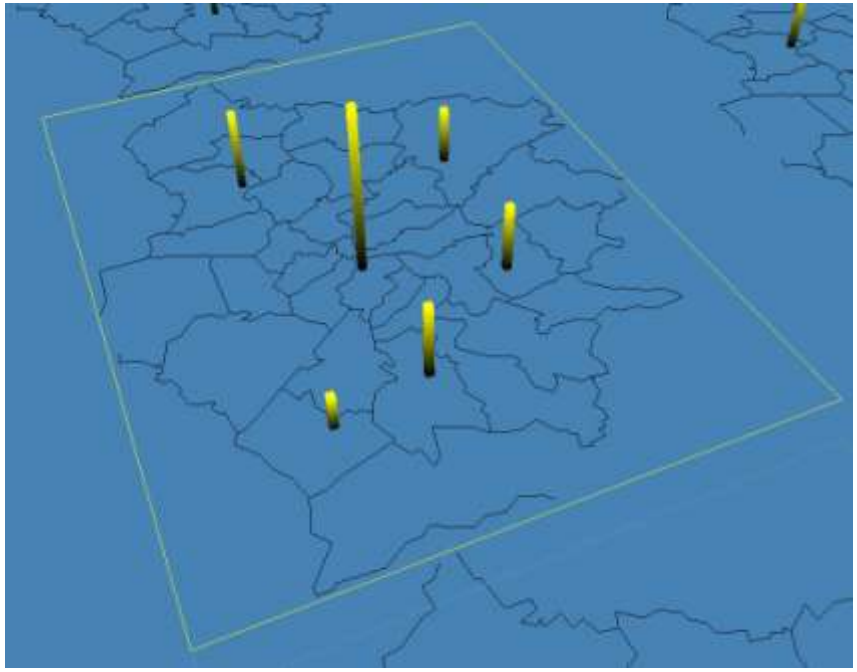


A possible phase change

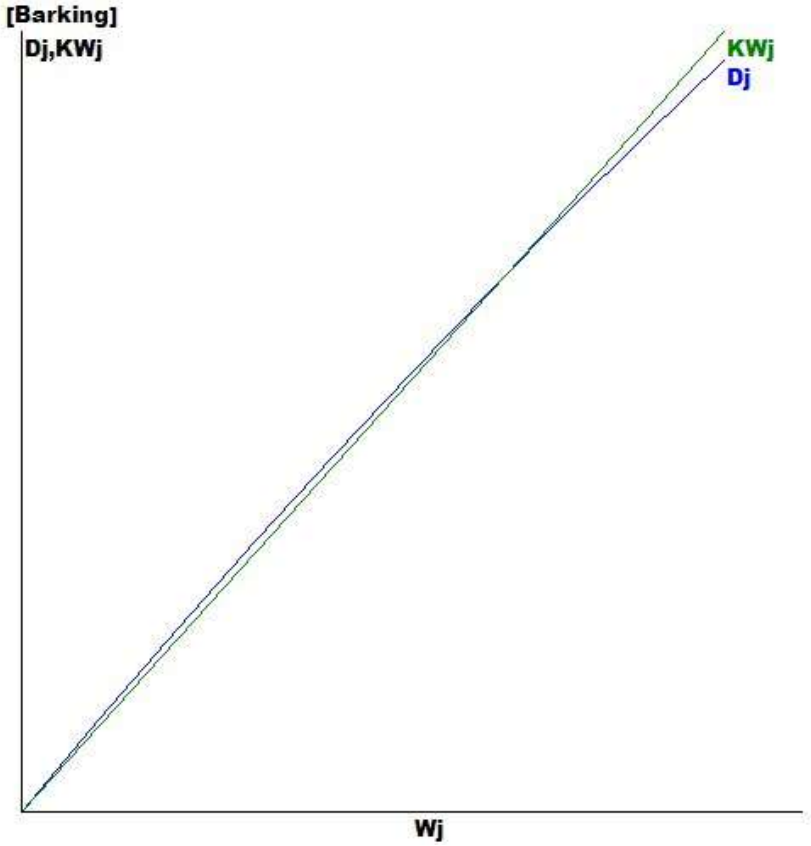


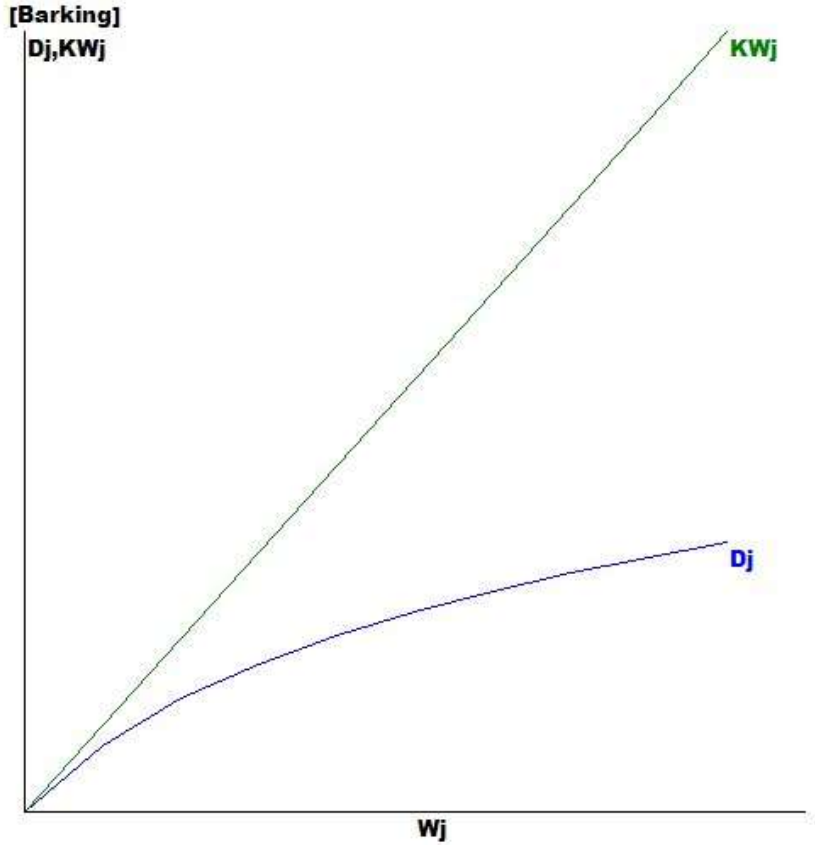
Possible phase change maps at equilibrium



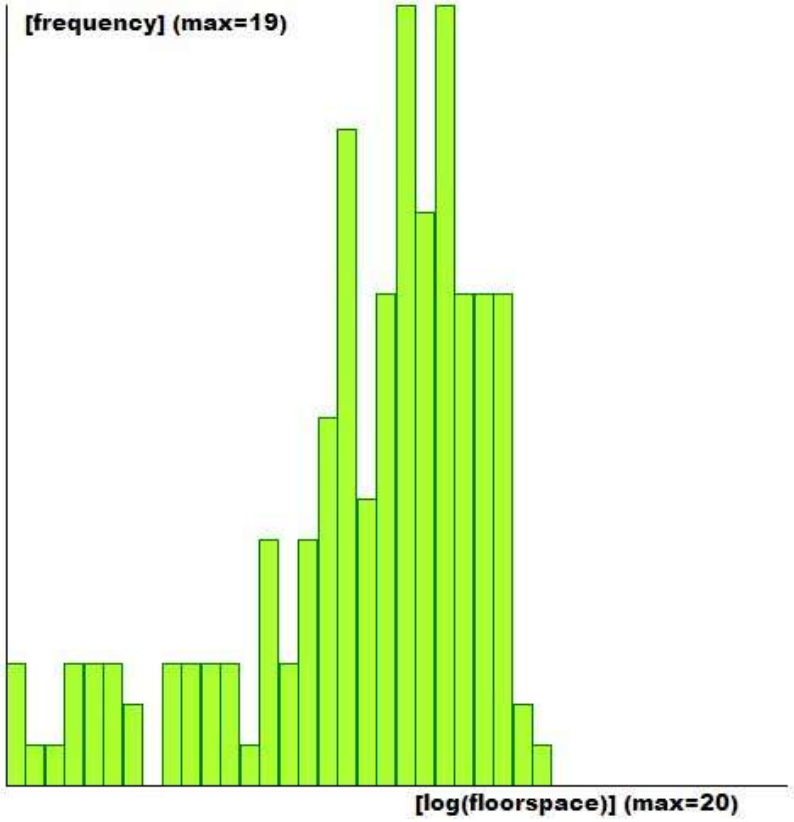


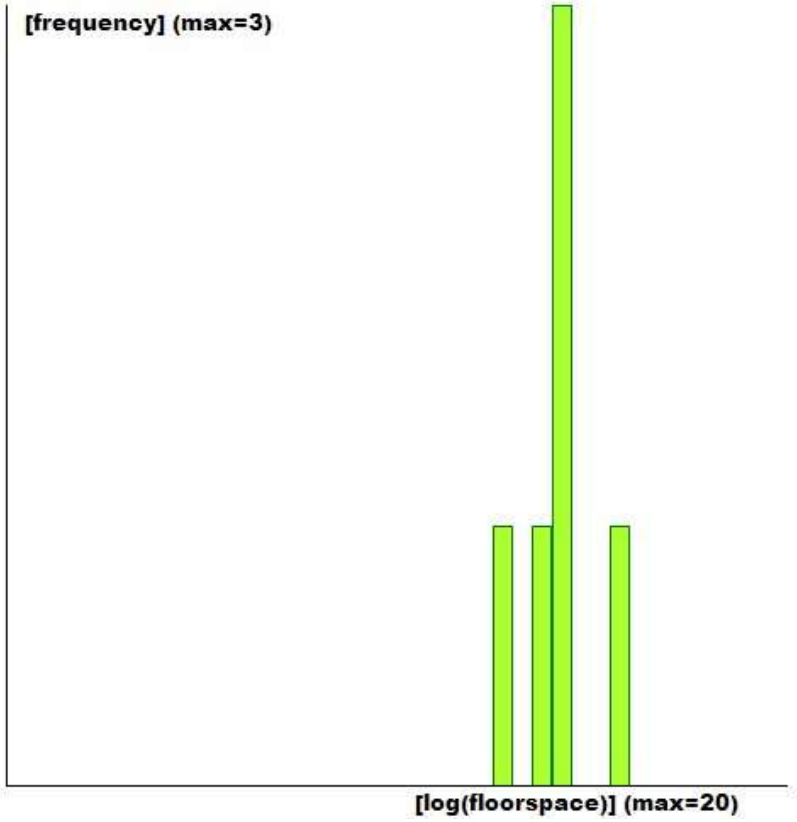
Zonal plots for Barking





Floor space histograms

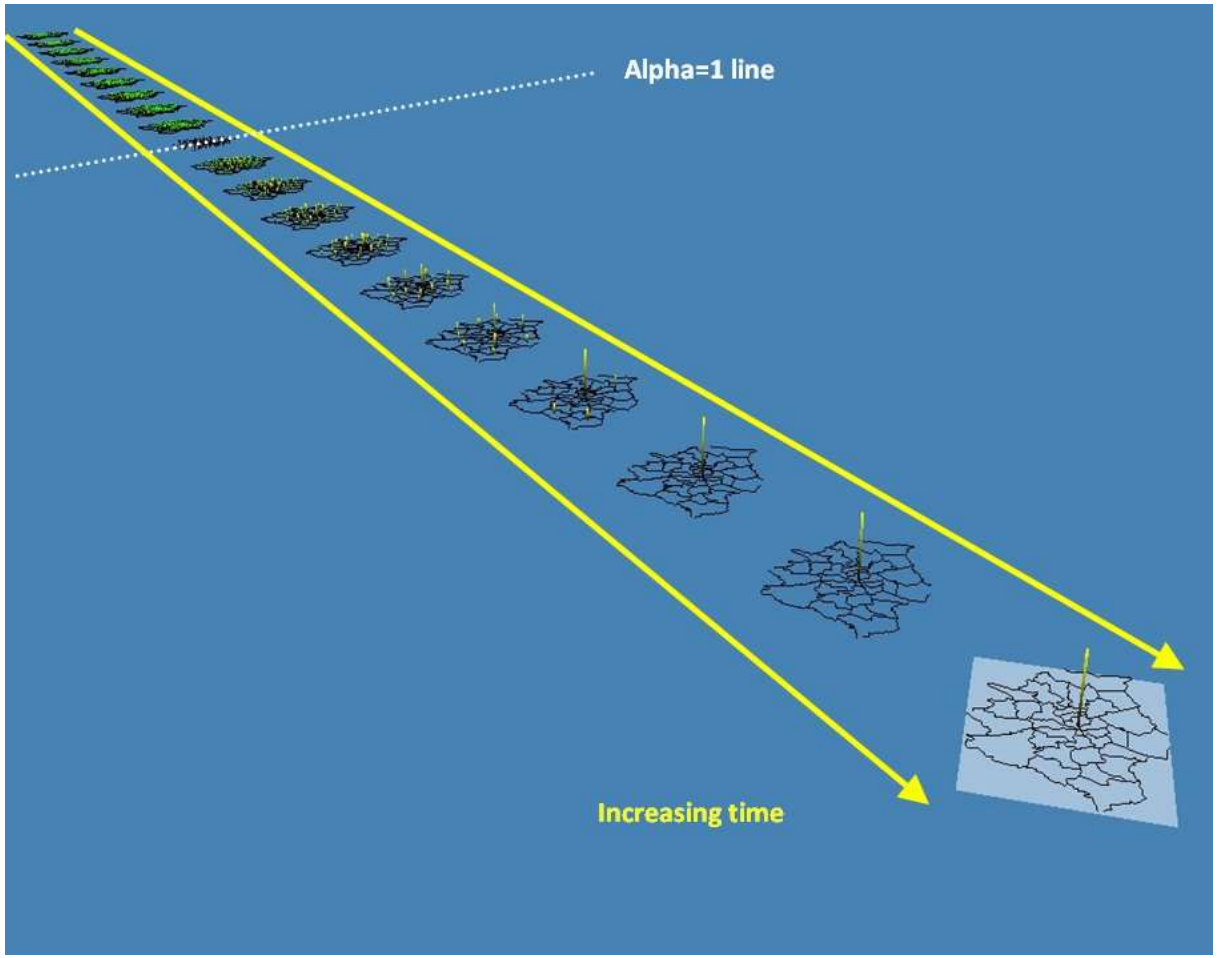




Urban typologies: the ‘DNA’

- a state vector: {P, H, V, W, X, L, p, c, G}
- recall ‘path dependence’:
  - development can be seen as constrained by the initial conditions
  - then see the structural variables – the initial conditions - as the ‘DNA’
- what are the development ‘possibilities’ for current DNA?
- can we see how to ‘adjust’ the DNA
  - either to avoid an end state
  - or to move towards one?

A timeline: charting urban evolution



The ‘big picture’; neo-geography

- creating the big picture through model based warehouses?
- that is: a data/information/intelligence (model-based) warehouse

Next steps: understanding urban evolution

- fully exploit the retail system as a model archetype to understand system evolution
- explore other submodels
- explore the general model
- explore the argument at different scales
- understand the ‘DNA’ analogy
- exploit the ideas in planning

Models in planning

- building on the past but with enhanced technology and understanding – cf. insights
- endogenous/exogenous again
- scenarios
- handling phase changes: Friston et al

Concluding comments

- what is being sketched out is a ‘big science’ challenge