Lecture 8: 2nd November 2011

Extending Complexity:

Coupling Spatial Interaction Models

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Outline

- LUTI Models: A Little Bit of History, Early Graphics Interfaces, and the Tyndall Model
- SIMULACRA: ARCADIA and SCALE Projects
- Requirements: The Model Design: Models Flows: Physical Movements, Money & the Residential Model
- The Visual Template: The Desktop Model: Running It
- Building a Web-Based Model Interface
- Data Bases: Location, Interactions & Networks
- Current Challenges for Immediate Developments

LUTI Models: A Little Bit of History, Early Graphics Interfaces, and the Tyndall Model

The first spatial interaction models were developed in the early 1950s. CATS 1955: They began to be coupled together in the 1960s as **L**and **U**se **T**ransportation **I**nteraction models (LUTI)

Largeness, remoteness from users, crude representation, limits on computation, poor links to policy

Lack of understanding of model outcomes

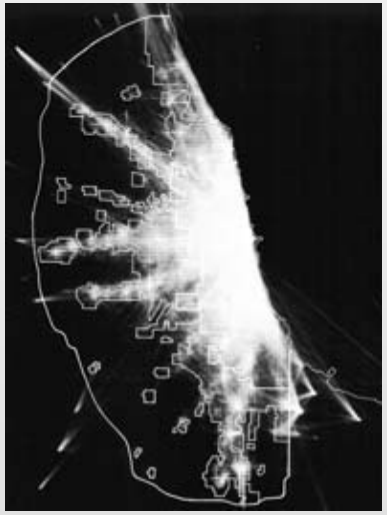
Statics versus dynamics – semi-dynamic models but most operational models predicated in terms of equilibrium and as we have seen, the most developed are structured in terms of a dynamic equilibrium

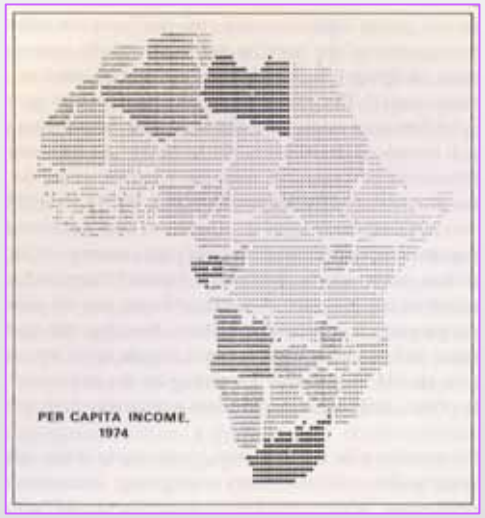
Disaggregation of sectoral activities

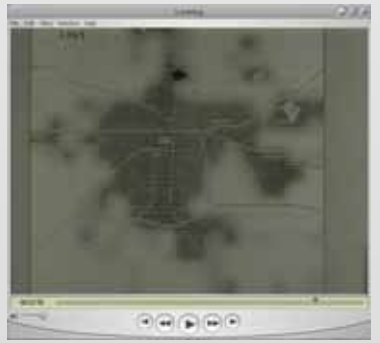
Early attempts at Visualisation: Traffic Flows in CATS, and Schmidt's model of the growth of East Lansing 1967

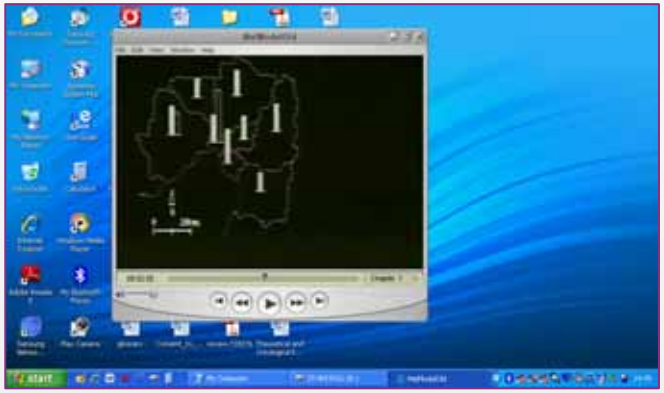
Harvard Lab: SYMAP – Symbol Mapping Systems, 1967-1970

Early cathode ray displays, 1960: By the early 1980s developments in visual display units (VDUs)









Visualisation was & is increasingly a means of making complexity intelligible

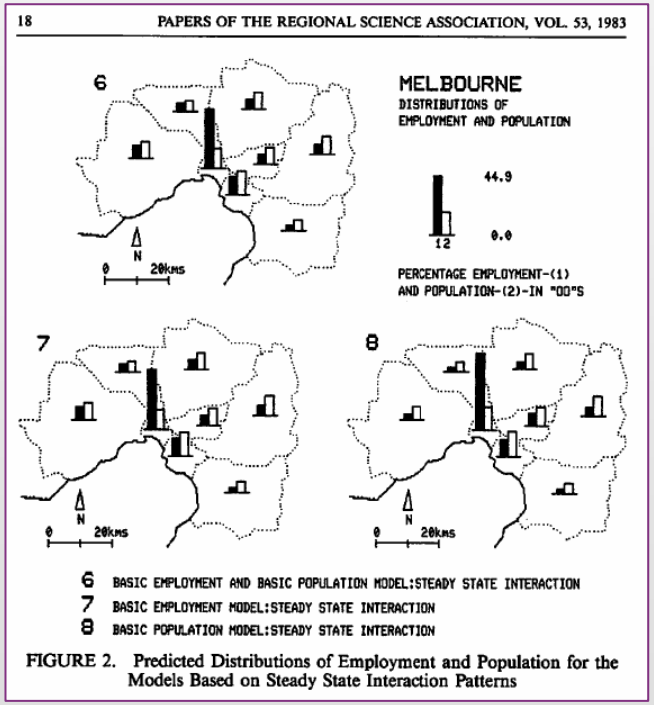


FIGURE 2. Predicted Distributions of Employment and Population for the Models Based on Steady State Interaction Patterns

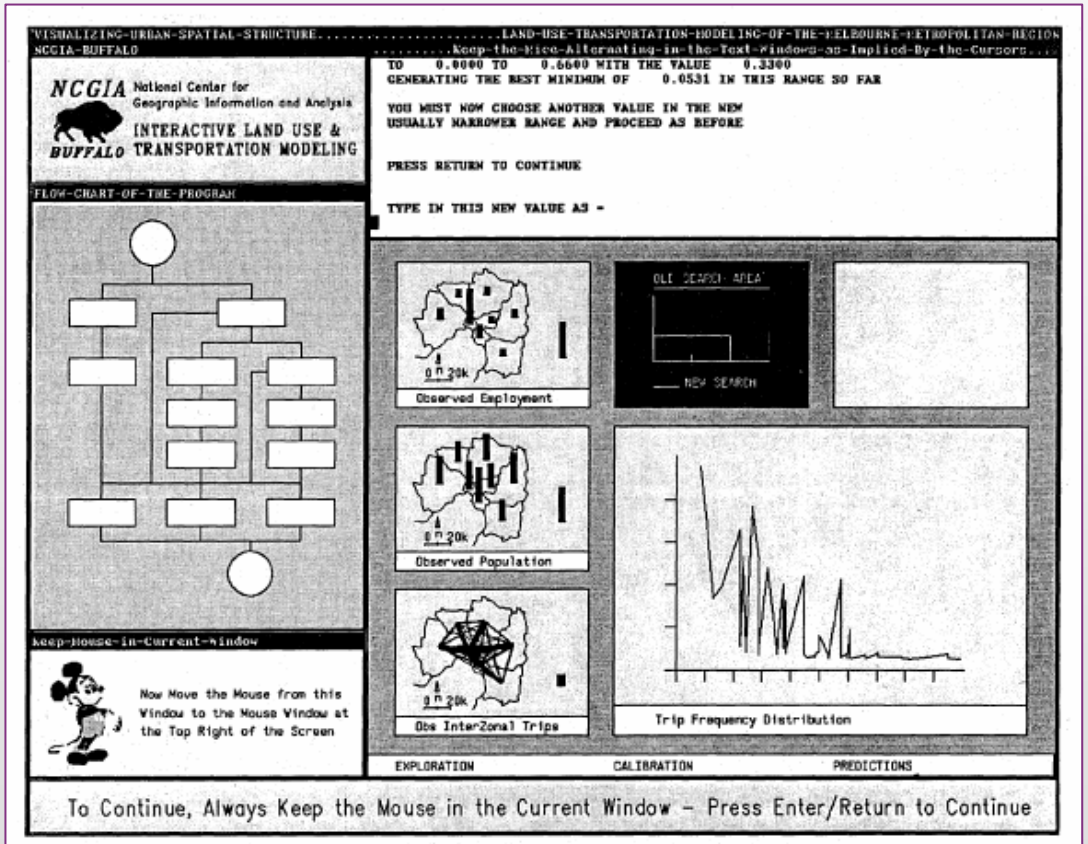


Figure 6. Progress in calibrating the model using dichotomous search.

From a VAX Terminal – A Raster 1982 From a Sun Workstation – Simple Windows - 1991

The model I showed you very briefly in an earlier lecture was a version of these types of simple model – a residential location models broken down by four modes which we can state as follows

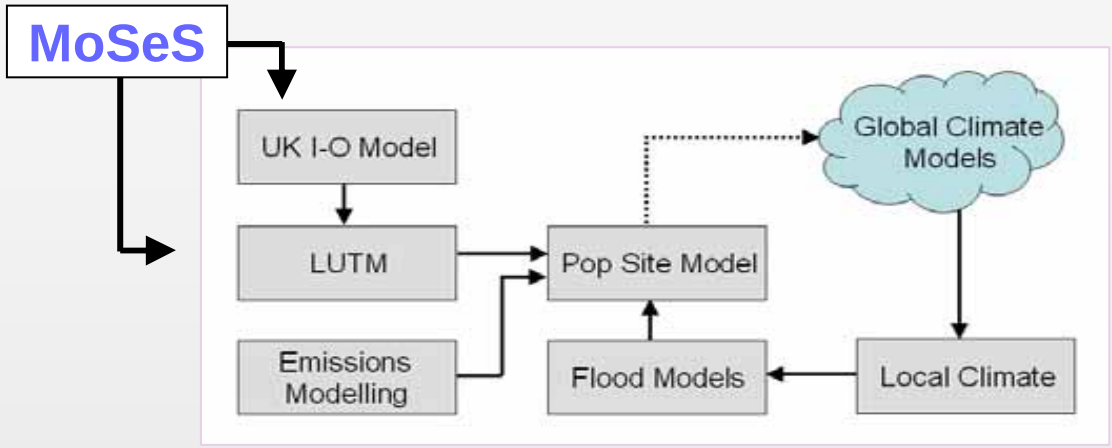
$$T_{ij}^{k} = E_i \frac{\Delta x_j \exp(-\lambda^k c_{ij}^k)}{\sum_{jk} \Delta x_j \exp(-\lambda^k c_{ij}^k)}$$

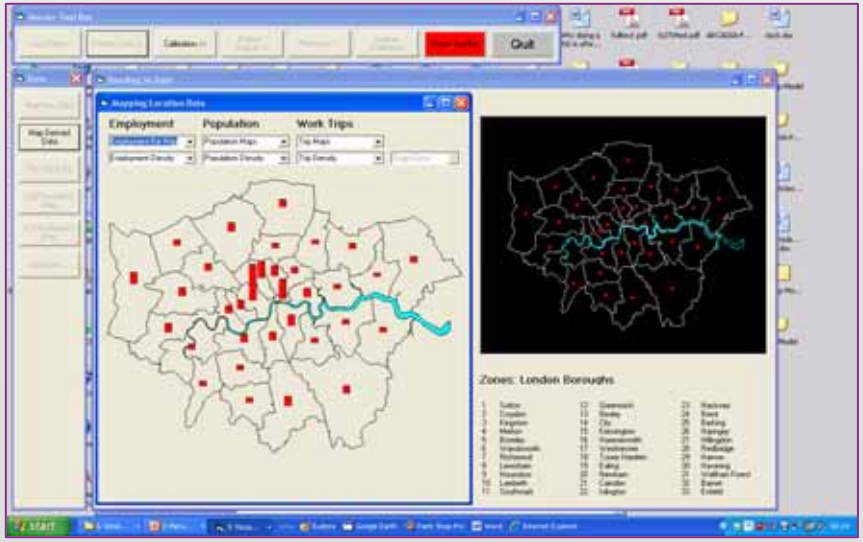
And if we define our spatial entropy which can be used to derive the model, then we can see how the modes k are coupled

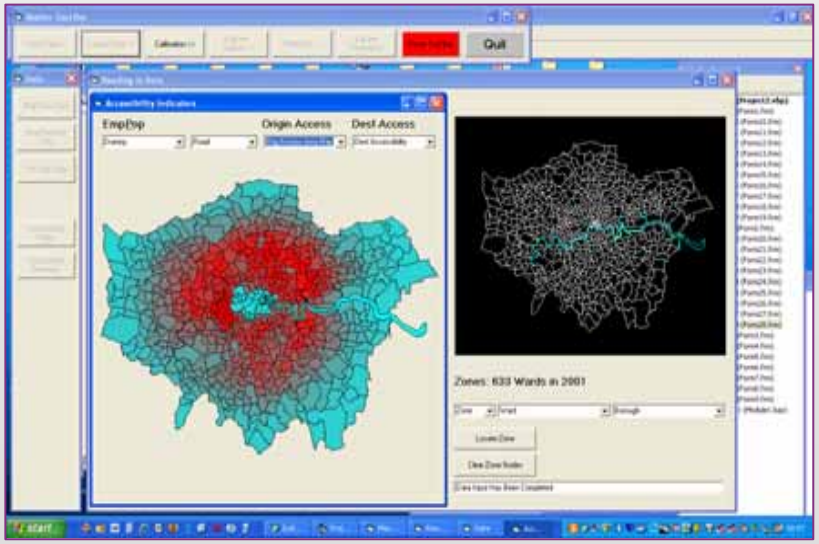
$$p_{ij}^{k} = \frac{T_{ij}^{k}}{\sum_{ijk} T_{ij}^{k}} \quad \text{and} \quad S = -\sum_{ijk} p_{ij}^{k} \log \frac{p_{ij}^{k}}{\Delta x_i \Delta x_j}$$

Note in this model, the area at the origin does not appear in the model as it cancels through the constraint. Should it be in S?

Here is the structure of this residential location model







Essentially we can probably disaggregate the components of complexity in S for mode and we can apply a variety of spatial aggregation rules to partitioning the formula to attribute components to different spaces i.e. i, j, k and aggregations thereof

But in LUTI models, we usually extend the model by adding various sectors – one for residential, one for retailing and commerce, one for industrial location, one for education and so on

In this way, we build up the complexity of the real world through the model

We have not applied these ideas in this way as yet but it would be straightforward to do so

In the rest of this talk, I will simply outline the extended models

SIMULACRA: ARCADIA and SCALE Projects

SIMULACRA[1] is a generic set of models that we are building for a series of projects, first the ARCADIA project that is an extension of Tyndall, and then for another EPSRC Project called SCALE which deals with energy change in large cities

We are on building a model framework in which we can develop many different variants, easily and quickly.

I think we are now in a position in this field where we can and should develop lots of variants, which test the robustness of any approach while at the same time, enabling models to be tuned to the problem in hand.

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[1] *SIMulation of Urban Landuse, And Commercial and Residential Activities*

We want to be able to do the following:

- Alter and aggregate the zoning system quickly and easily, on the fly almost
- Alter by adding and deleting different model sectors, so for example running a model based on simply the retailing and other employment sectors without the residential and so on
- Subjecting the model to various kinds of physical constraints, at will and according to external policies
- Extending all sectors to not only predict endogenous activities but to also be subject to exogenous inputs of the same
- To interface the models easily and quickly with other sectoral models, particularly demographic and possibly more established transport models

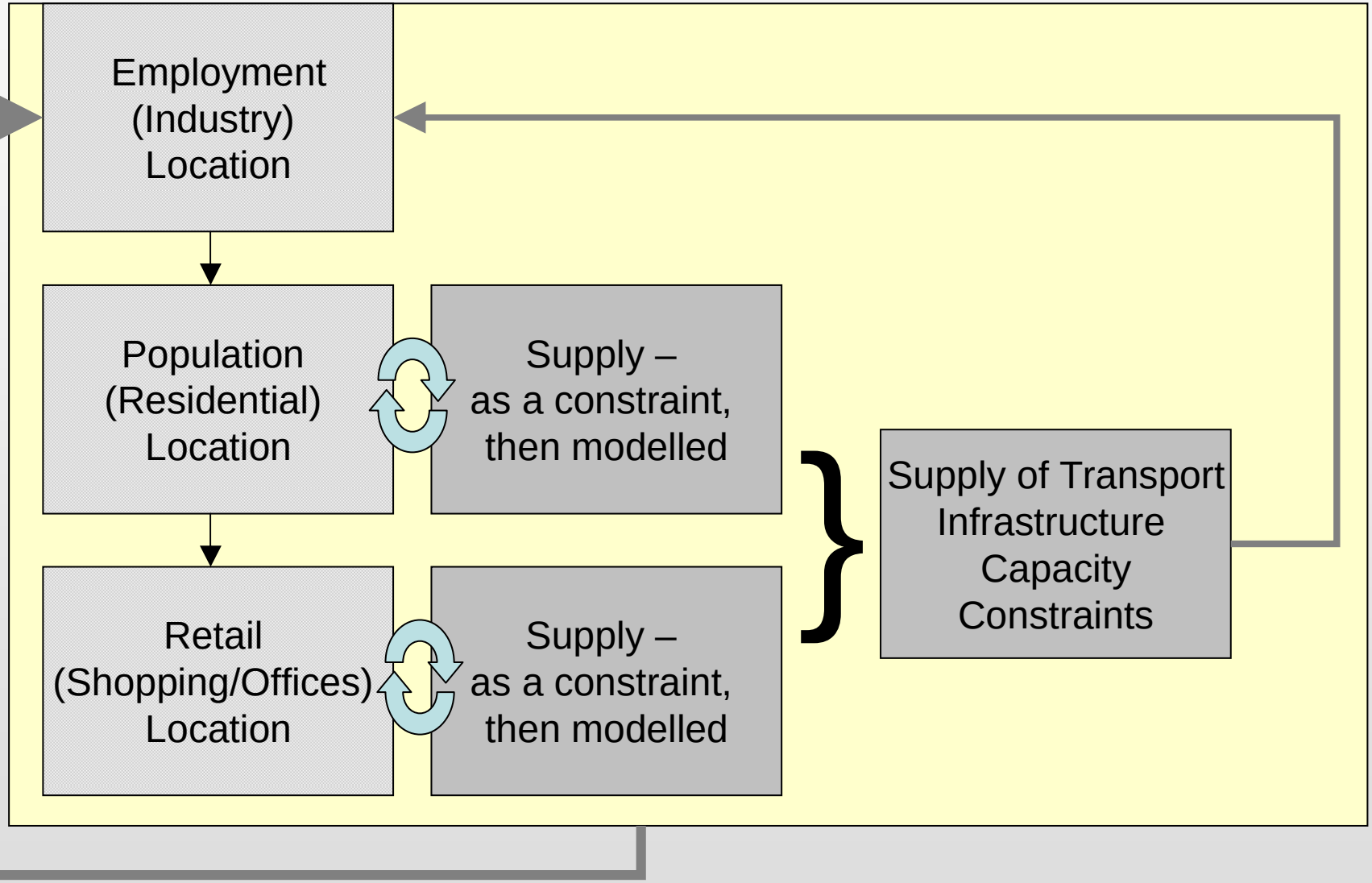
Requirements: The Model Design: Models Flows: Physical Movements, Money & the Residential Model

We will now show the current model to present the logic of our framework. Our model has now been scaled up massively to include the outer met area – 1767 zones (33 – 633 – 1767)

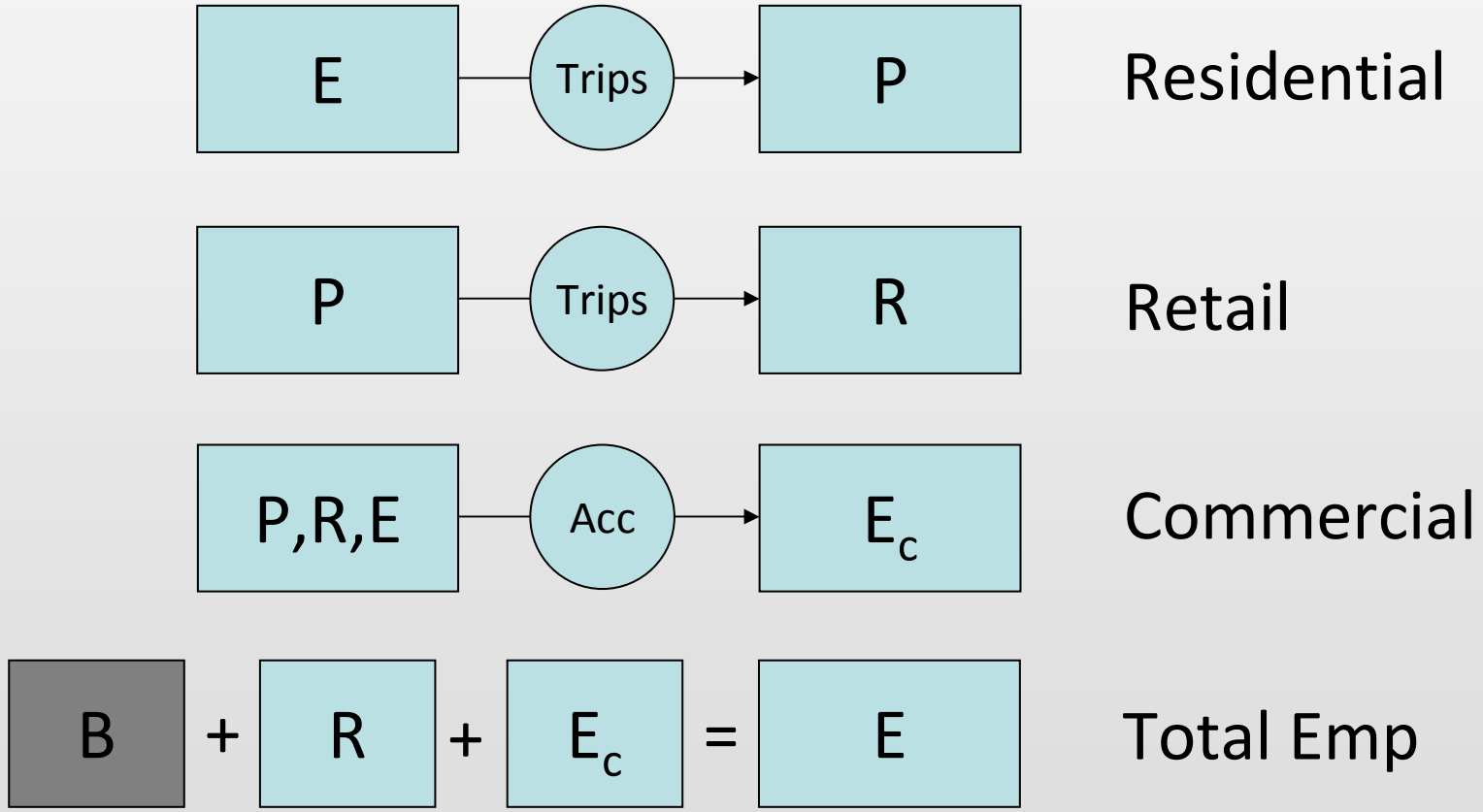
It is now a three sector model, not simply a residential location model as it includes internal employment location, retail location and residential location

So far, we do not have modal split or any disaggregation of the sectors but we will have five modes and then probably 5 population categories and maybe 5 employment types in terms of occupations – in short the model will ultimately scale up to some 100 times the size of the current model

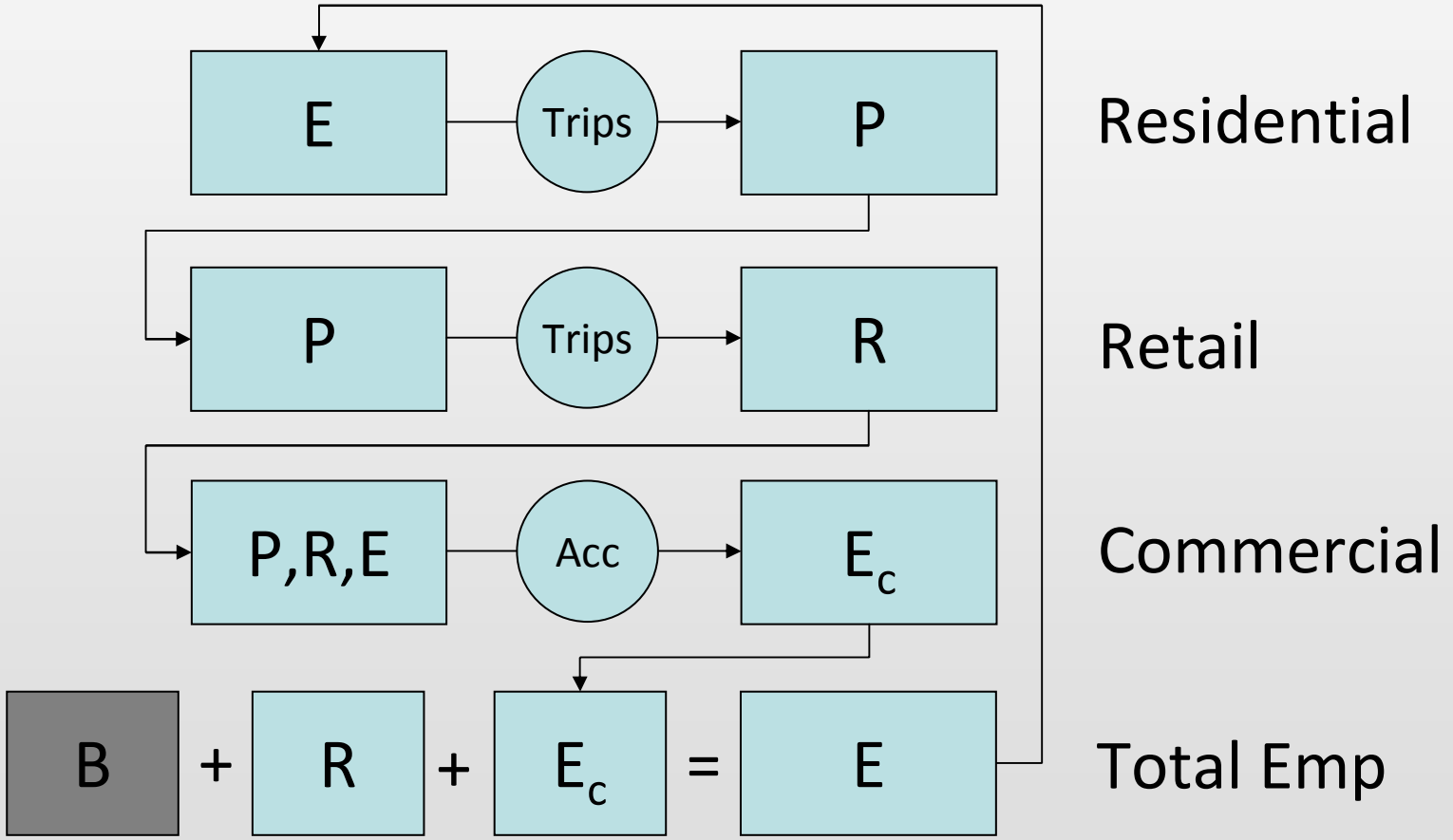
Essentially the model can be pictured as follows:



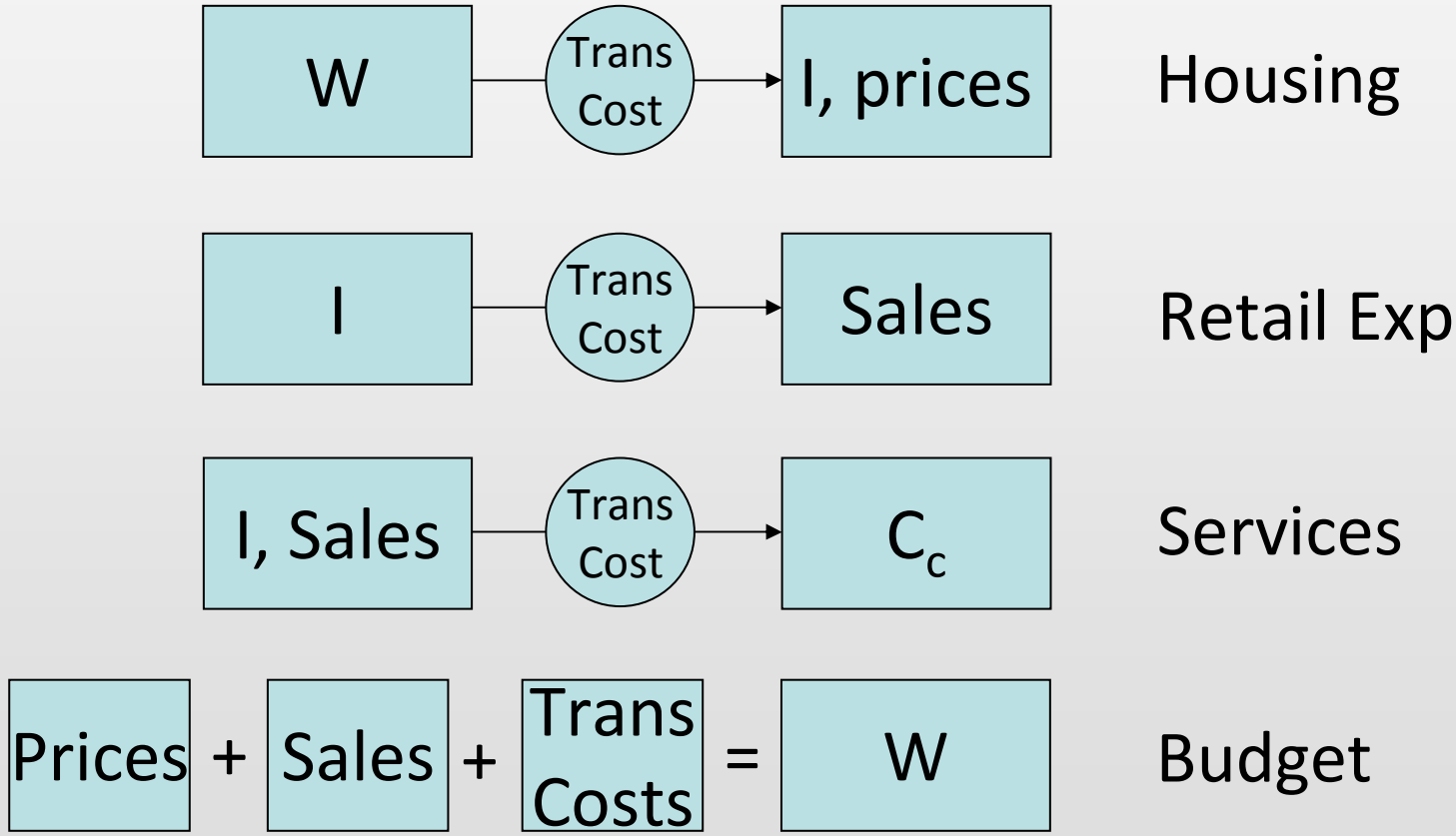
In fact it is easier to show the model structure as follows where we can see how we can elaborate it as a static or dynamic equilibrium model in terms of physical flows



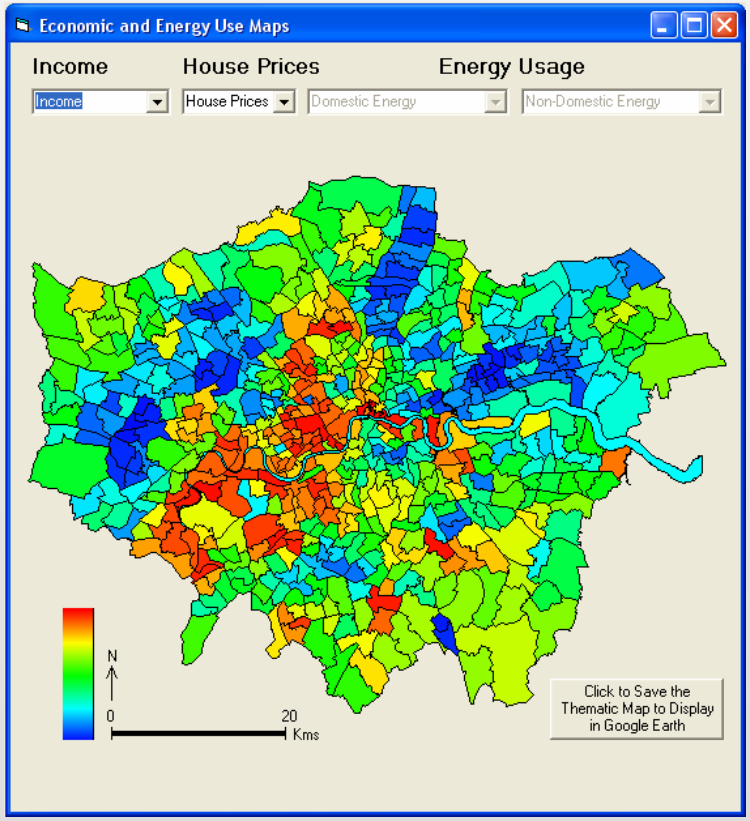
We can now show many ways in which these modules might be connected into an equilibrium framework: this is just one.

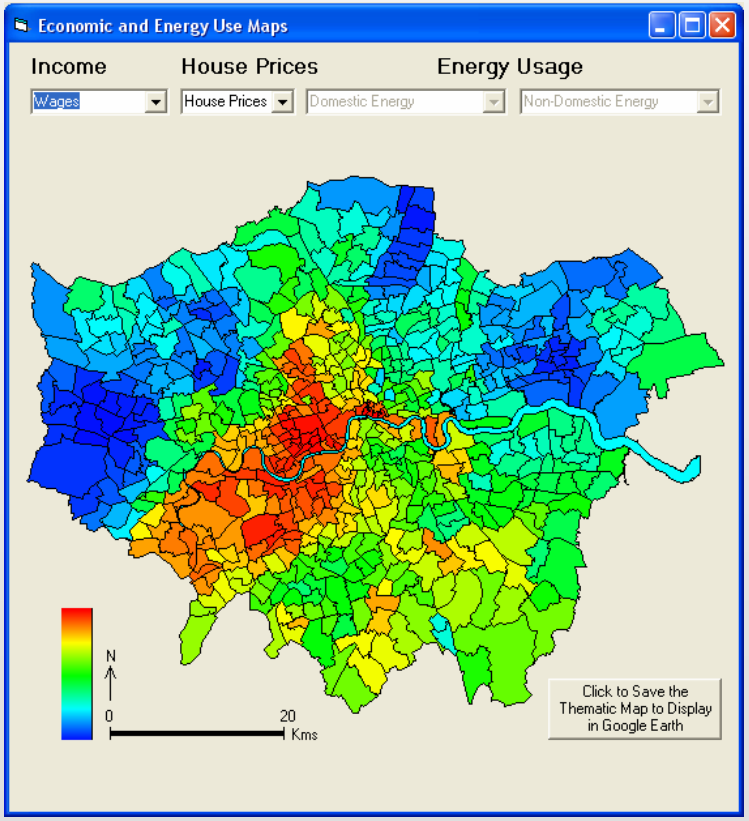


We can have also developed this model in money flows rather than physical flows with wages driving the process



I want to just show very briefly the sort of data that we have in the money sector that is driving this variant of the model and also state the residential location equation so you have some sense of what is going on





And the model is formalised as

with travel as a difference or variance σ^2 between these two sets of costs. Then, the system must satisfy the constraint

$$\sum_i \sum_j T_{ij}[(h_i + t_i) - (c_{ij} + \rho_j)]^2 = \sigma^2 \quad . \qquad (11)$$

The model that is generated from this constraint and which is the alternative residential location model in the current model variant is

$$T_{ij} = E_i \frac{A_j \exp(-\lambda[(h_i + t_i) - (c_{ij} + \rho_j)]^2}{\sum_j A_j \exp(-\lambda[(h_i + t_i) - (c_{ij} + \rho_j)]^2} \quad , \qquad (12)$$

which is subject to the usual origin constraint, generating population from equation (2) with (12) replacing equation (1).

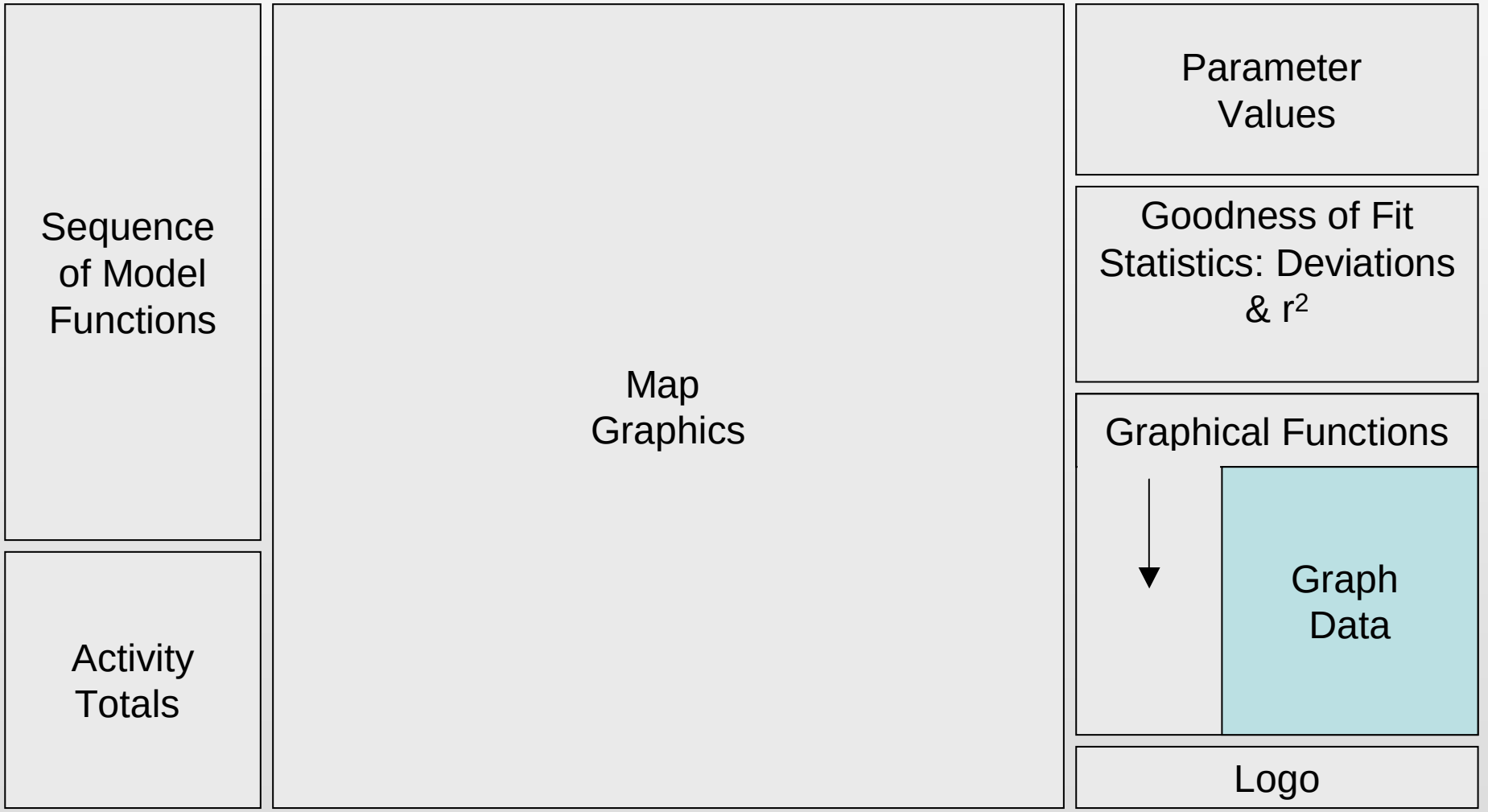
The Visual Template: The Desktop Model

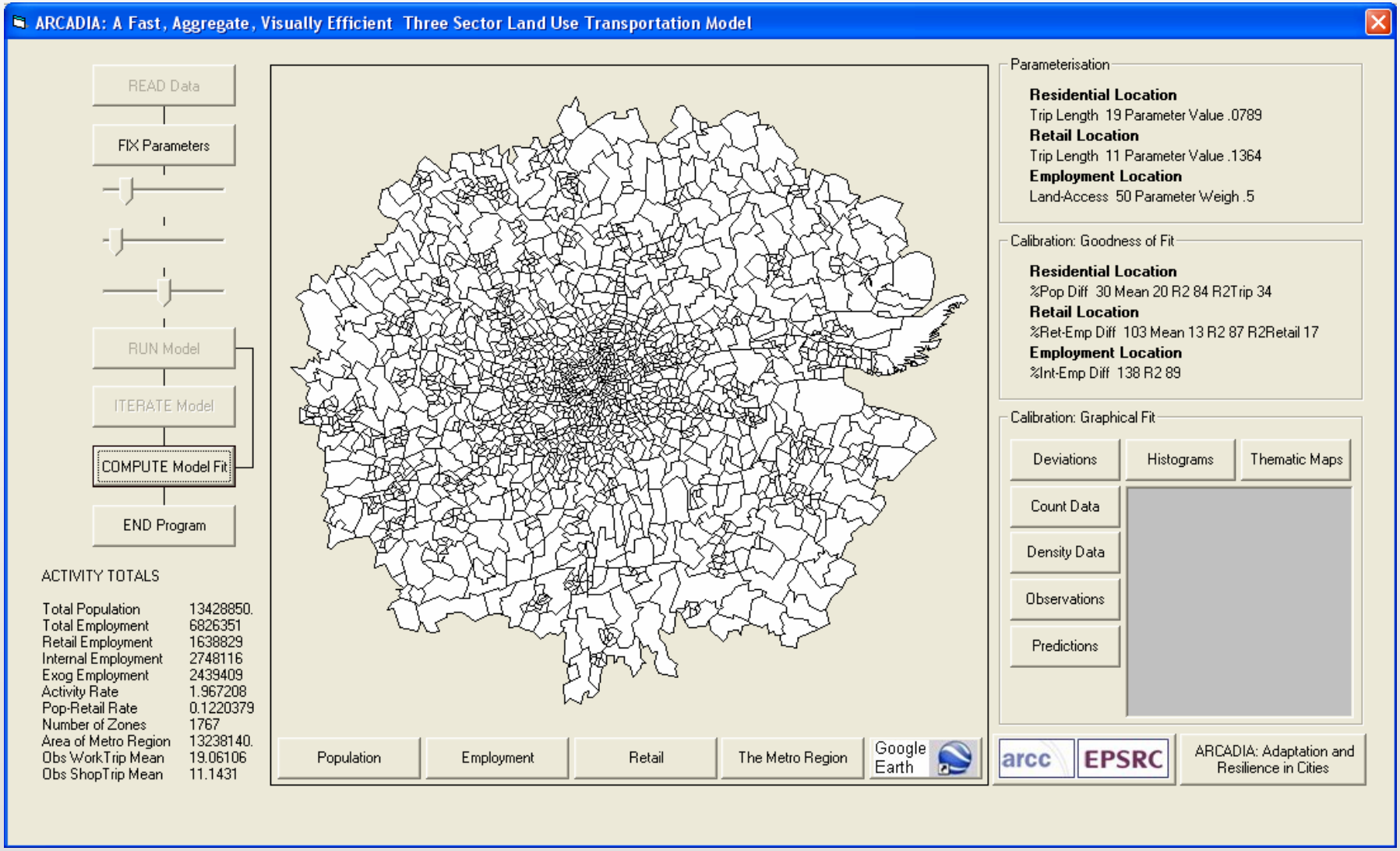
Ok – let me quickly tell you our strategy – we are building a fully fledged model using state of the art software and various web–based interfaces which is highly visual and will be as fast as possible

We are also building a mirror model on the desktop which is my contribution to the project and this is a one window minimal model which is for comparative purposes and to enable the bigger model to be tested

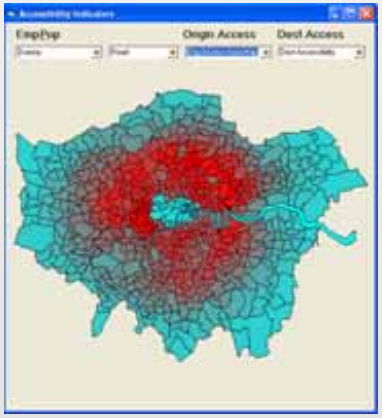
This is the model I will now show and then I will sketch the bigger application very briefly which Camilo in our group is developing

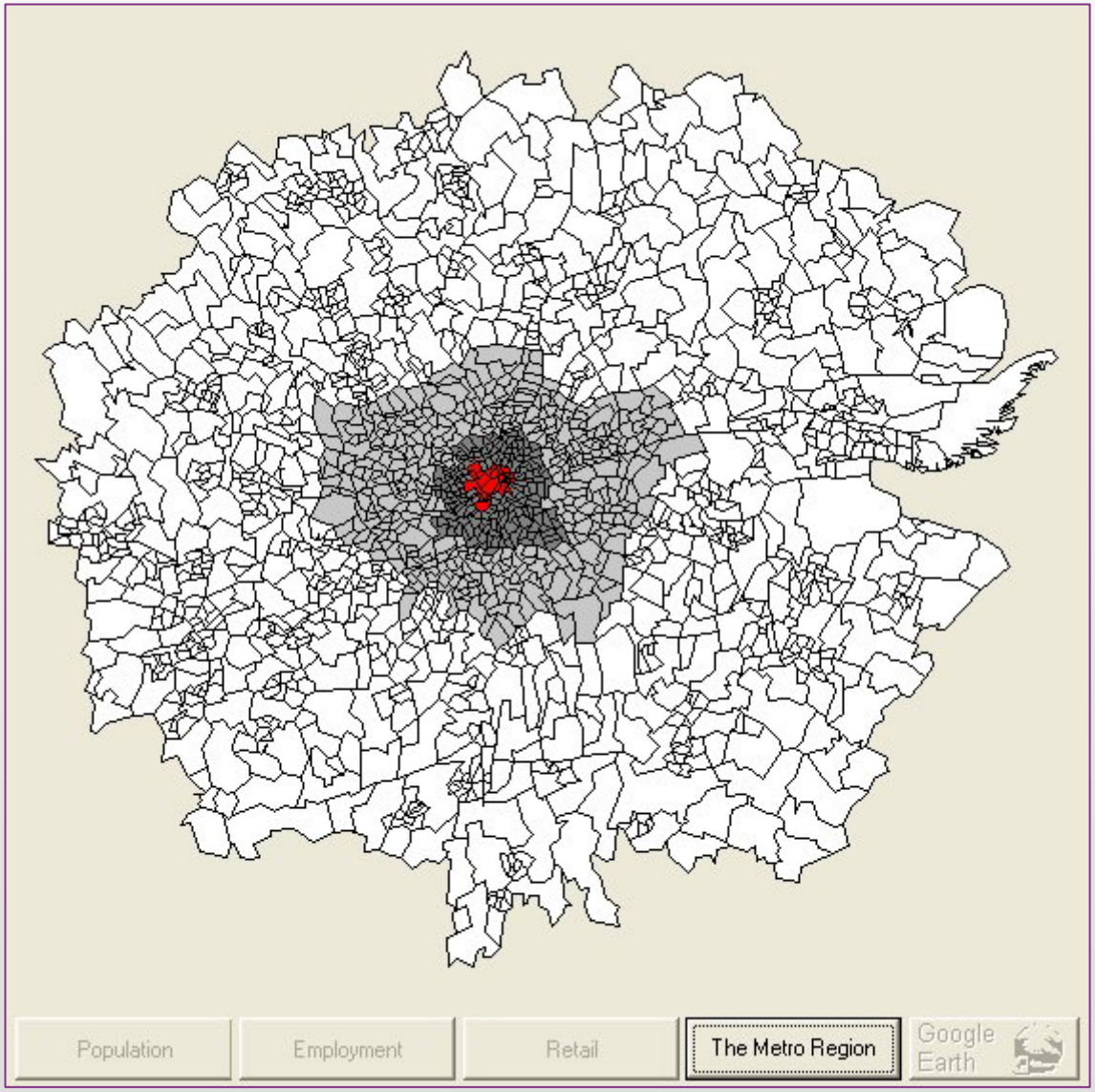
This is the order in which the operations take place



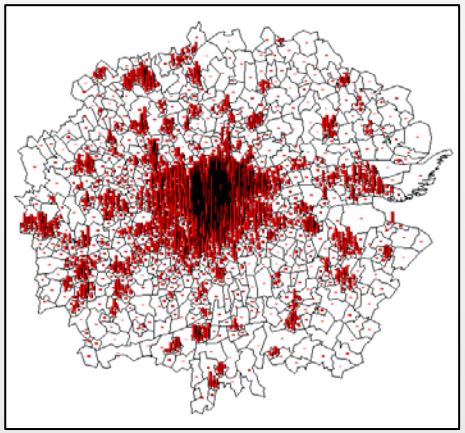

ARCADIA: A Fast, Aggregate, Visually Efficient Three Sector Land Use Transportation Model
READ Data
FIX Parameters
RUN Model
ITERATE Model
COMPUTE Model Fit
END Program
ACTIVITY TOTALS
Total Population 13428850.
Total Employment 6826351
Retail Employment 1638829
Internal Employment 2748116
Exog Employment 2439409
Activity Rate 1.967208
Pop-Retail Rate 0.1220379
Number of Zones 1767
Area of Metro Region 13238140.
Obs WorkTrip Mean 19.06106
Obs ShopTrip Mean 11.1431
Population
Employment
Retail
The Metro Region
Google Earth
Parameterisation
Residential Location
Trip Length 19 Parameter Value .0789
Retail Location
Trip Length 11 Parameter Value .1364
Employment Location
Land-Access 50 Parameter Weigh .5
Calibration: Goodness of Fit
Residential Location
%Pop Diff 30 Mean 20 R2 84 R2Trip 34
Retail Location
%Ret-Emp Diff 103 Mean 13 R2 87 R2Retail 17
Employment Location
%Int-Emp Diff 138 R2 89
Calibration: Graphical Fit
Deviations
Histograms
Thematic Maps
Count Data
Density Data
Observations
Predictions
arcc
EPSRC
ARCADIA: Adaptation and Resilience in Cities

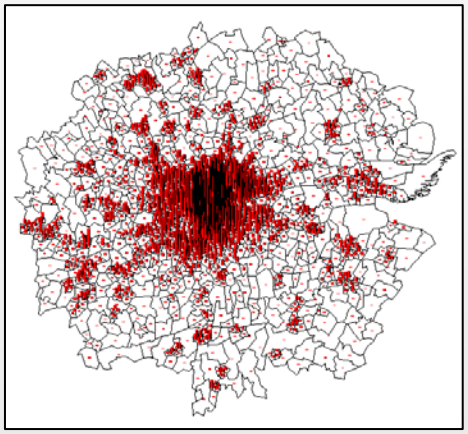

Employment
Population
Work Trips

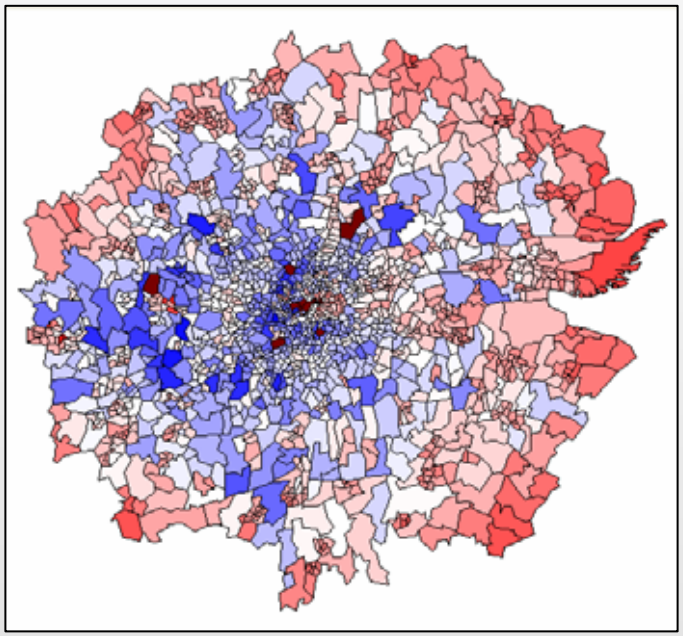

EmpPop
Origin Access
Dest Access

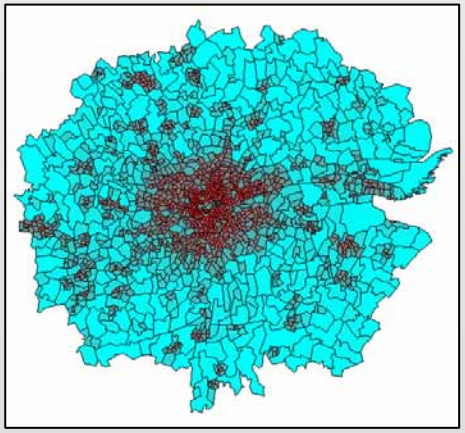

Population
Employment
Retail
The Metro Region
Google Earth

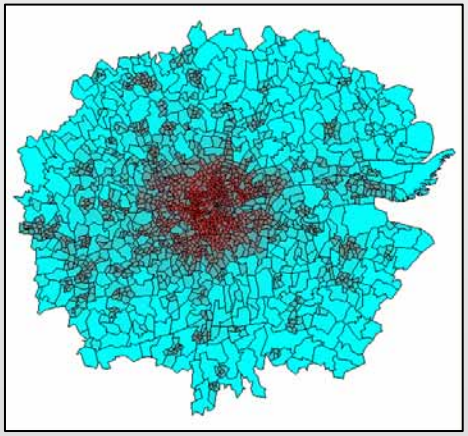
Here are some sample outputs – I will run the model as speed is important – here goes





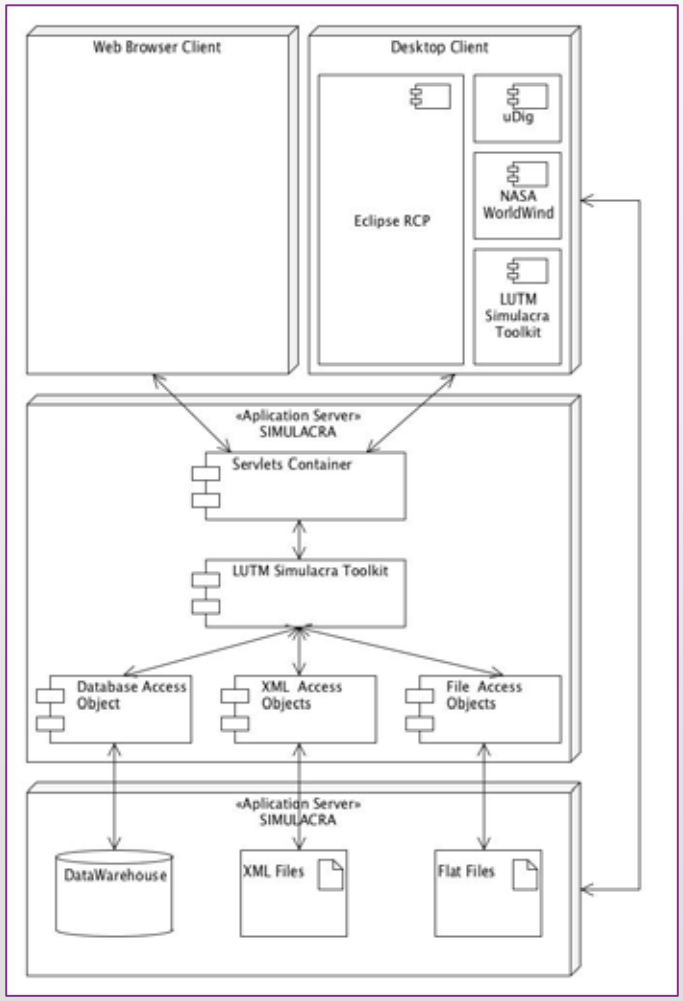




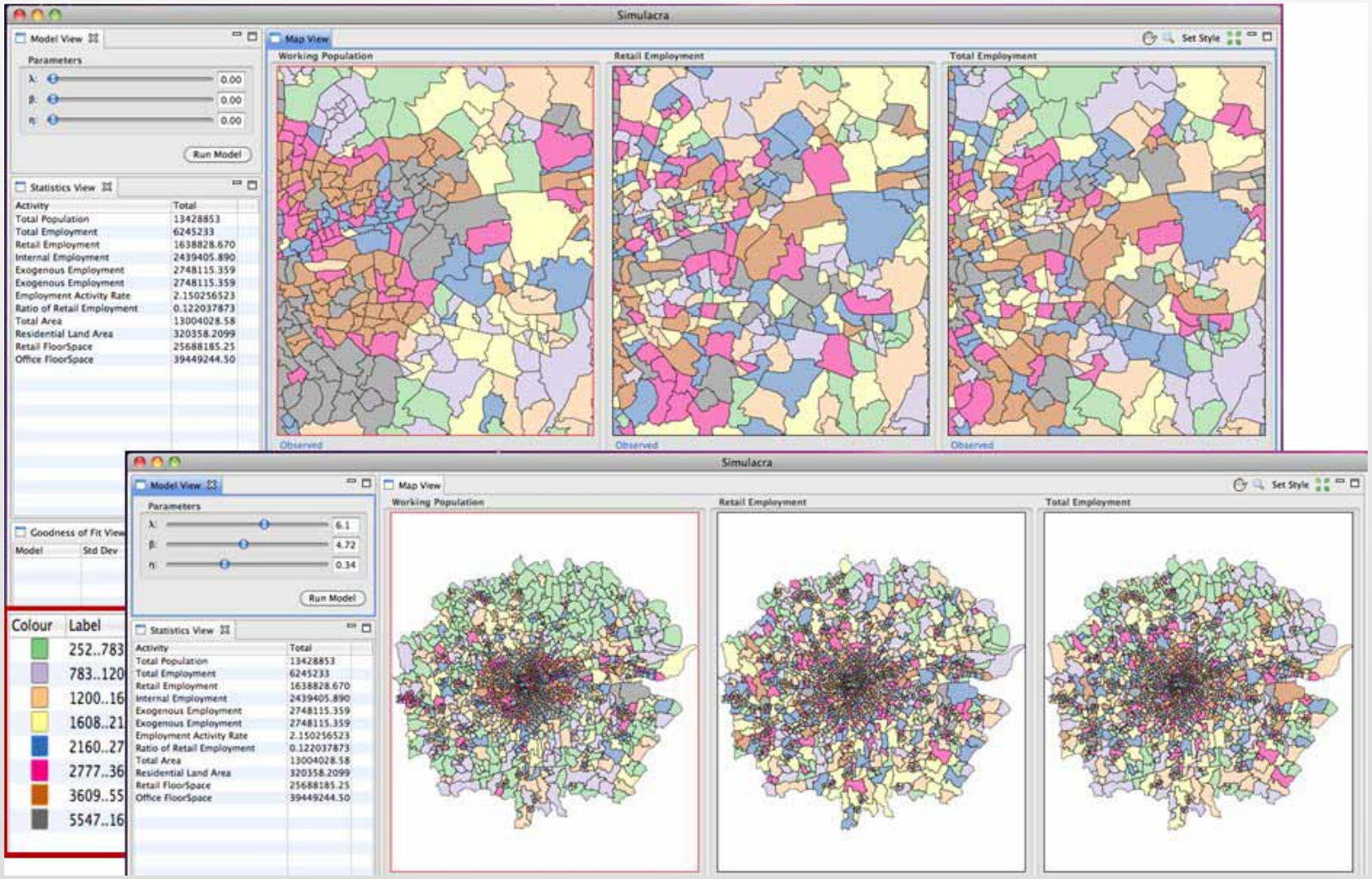


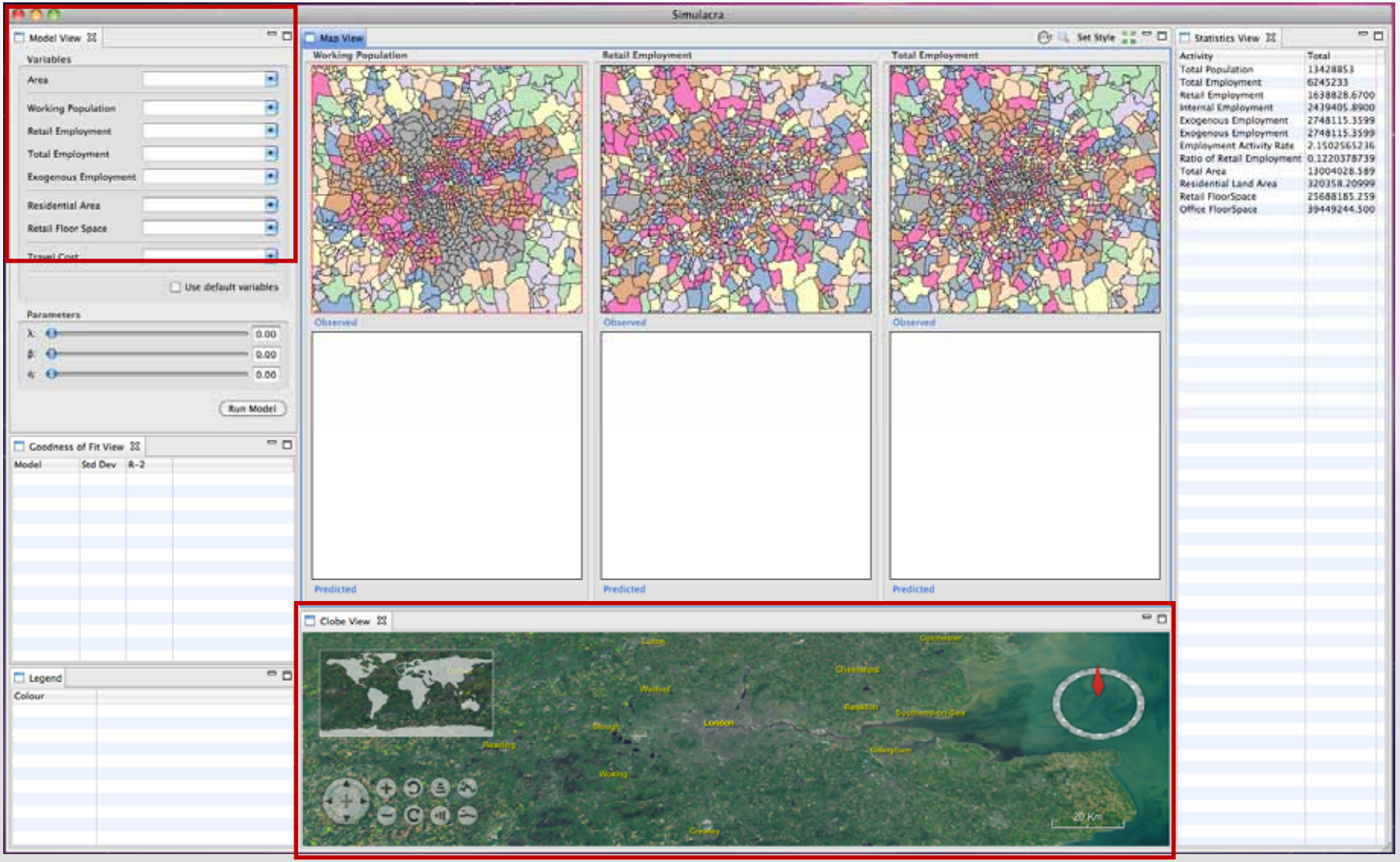
Ok I will run the model from here – in fact I need to go to the file

Building a Web-Based Model Interface



And here are some screen shots from the desktop version of this ultimately to be a web based application – on Mac and PC




Simulacra
Model View
Variables
Area
Working Population
Retail Employment
Total Employment
Exogenous Employment
Residential Area
Retail Floor Space
Travel Cost
Use default variables
Parameters
Run Model
Goodness of Fit View
Model
Std Dev
R-2
Legend
Colour
Map View
Set Style
Working Population
Retail Employment
Total Employment
Observed
Predicted
Statistics View
Activity
Total
Total Population 13428853
Total Employment 6245233
Retail Employment 1638828.6700
Internal Employment 2439405.8900
Exogenous Employment 2748115.3599
Exogenous Employment 2748115.3599
Employment Activity Rate 2.1502565236
Ratio of Retail Employment 0.1220378739
Total Area 13004028.589
Residential Land Area 320358.20999
Retail FloorSpace 25688185.259
Office FloorSpace 39449244.500
Globe View
London
Reading
Slough
Luton
Chelmsford
Basildon
Southend-on-Sea
Colchester
Woking
Crawley
20 Km

Data Bases: Location, Interactions & Networks

We have a big problem in getting the networks sorted out for the aggregate model as these networks are at a very fine scale

We need them to be at a coarser scale for the model as we need to do all the assignment and capacity checking at the level of the model

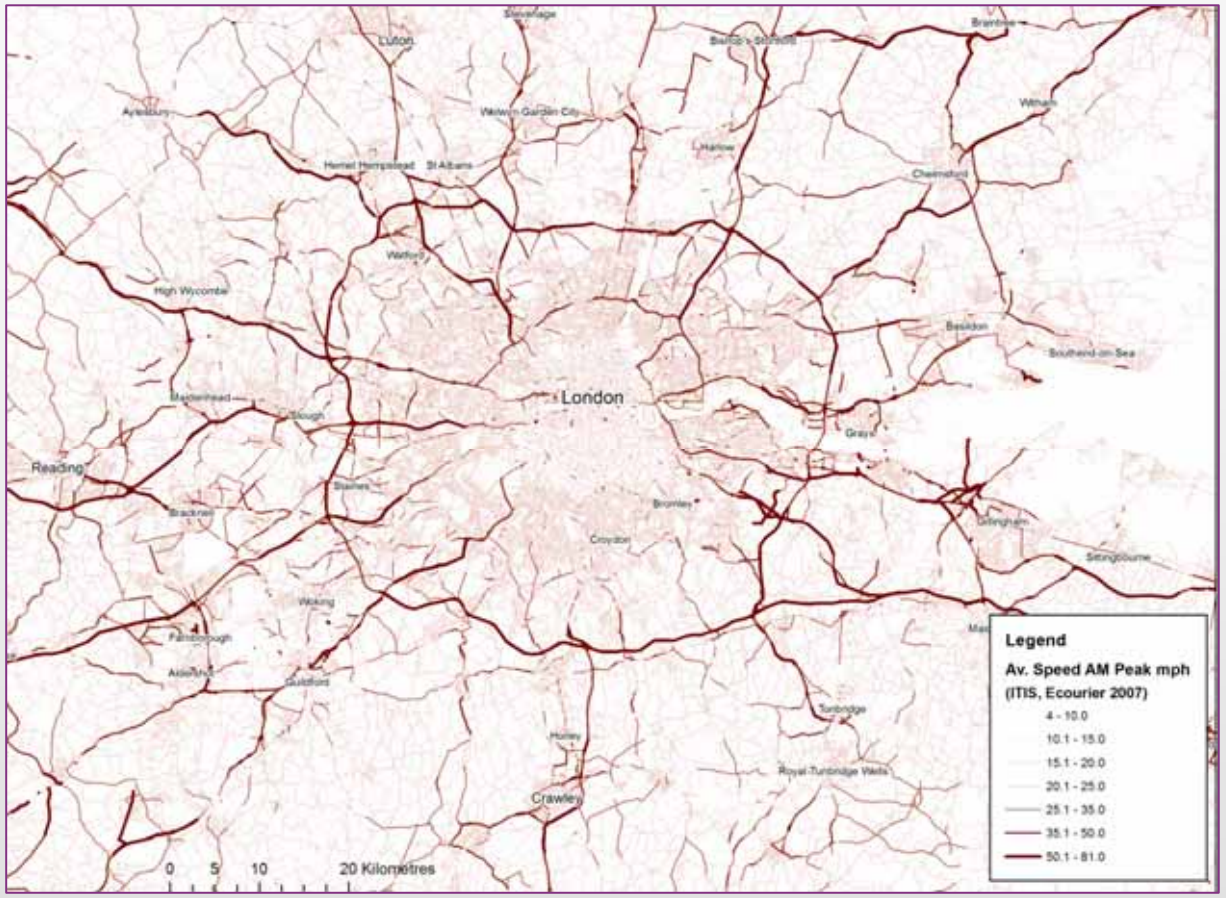
This is a long standing issue, we know, but we cannot afford to move down the local fine scale level to do the assignment of trips to the network because this would simply destroy our basic principle of accessibility of the model to users and also the speed requirements we need

We will show some of the detail we have by way of illustrating our work in progress.

Road Costs

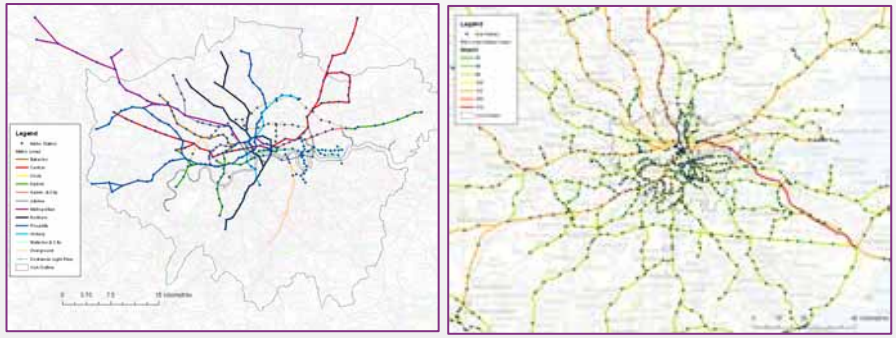
Used GPS data for realistic road speeds across the South East. Sourced from ITIS and Ecourier.

Future improvements with dynamic consideration of congestion.



Public Transport Costs

Based on network geometry and timetabled services. Initially using model presented. Allows multi-modal PT trips.



TransXchange

Full UK PT timetable available in XML format. Could be used to automate process of generating PT networks.

Key Challenges for Immediate Developments

- Speed of Models
- Quick and Effective Visualisation
- Running the Model with Users/Stakeholders
- Building a Residential Model Based on the Housing Market Cost, prices, travel and energy costs etc - The Wegener Principle
- Moving to a Semi-Dynamic Model with Inertia and Internal Migration
- A Local UK Dimension: Thinking of the Modelling Strategy as being Informed by National Data Bases such as Neighbourhood Statistics

To conclude, I would like to refer you to our Blogs and Web Site

http://simulacra.blogs.casa.ucl.ac.uk/
http://www.complexcity.info/
www.casa.ucl.ac.uk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Help
simulacra blog casa
Search
Popups okay
Check
AutoLink
AutoFill
Options
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Simulacra » Showcasing land use transport modelling, ...
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Themes
Resources
Visualising Public Transport Networks
With the increasingly widespread availability of transport data, we can now visualise and explore new dynamic geographies of urban transport flows and networks. In this post, I show detailed animations of UK multi-modal public transport networks using
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