Integrated Modelling of the Spatial Impacts of Climate Change In Greater London

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Outline

The Context: *Climate Change London*

Requirements for Modelling: *Simplicity, Communicating Simulation & Prediction, Robustness*

The Integrated Assessment: *Strings of Models*

The Land Use Transport Model

A Demo of the Model

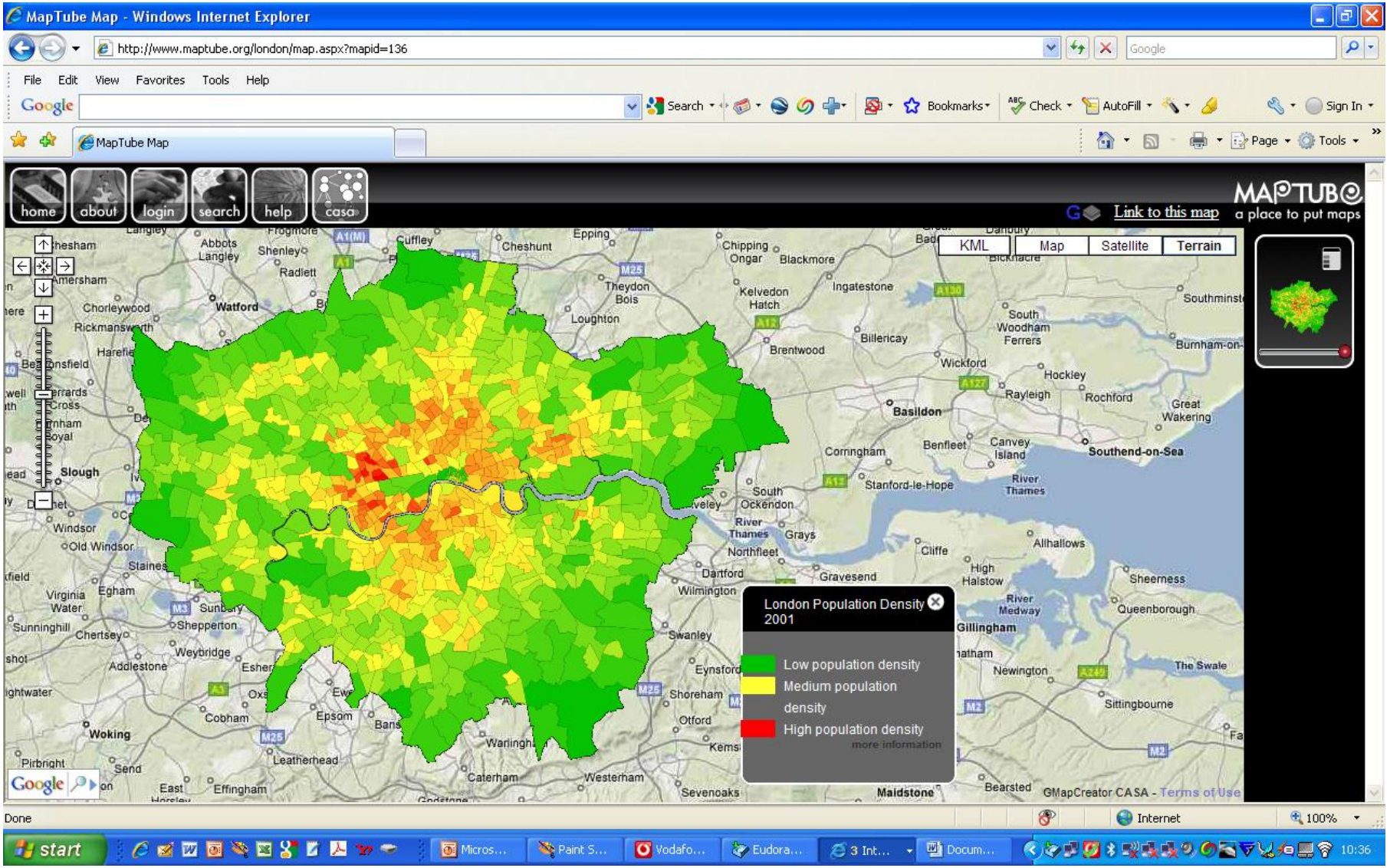
Climate Change in London: *Integrated Assessment*

Next Steps

Location in Europe and the UK:

South East England is the wider megalopolis, Greater London is the 33 boroughs with about 7.7million population

Our study so far focuses on Greater London but will be extended to the wider region in the next phase

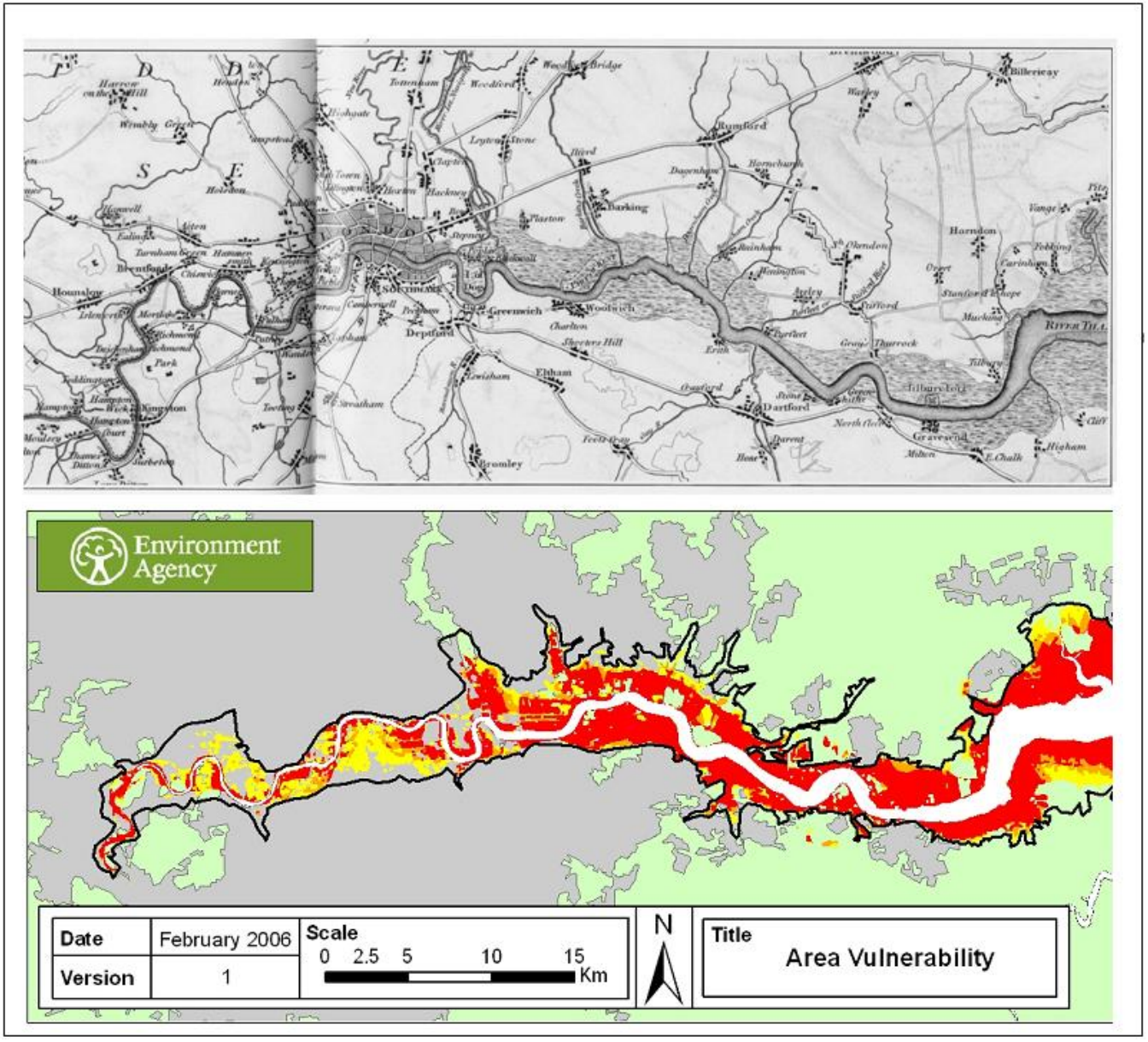


The Greater London Region consisting of 33 boroughs and 7.7million population

The Context: *Climate Change in London: Flooding & Pollution*

Mainly along the River Thames and Its Estuary

The Thames Barrier built from 1978 to 1984 in operation, likely to be ineffective now by 2040? due to new predictions of sea level rise but this is highly debatable …


Environment Agency
Date
February 2006
Version
1
Scale
0 2.5 5 10 15
Km
N
Title
Area Vulnerability

Types of Prediction and Types of Models

The time horizon – short term to long term; obvious uncertainties

In general the longer the time horizon for prediction, the greater the uncertainty that detail in the model is required.

Longer time horizons, simpler models

More robust models – an overused word – hardly every defined – but little point in developing very detailed and intricate models which require huge data resources for very long term forecasting when detailed data inputs are needed to forecast independently

Requirements: Simplicity, Accessibility, Robustness

The model we will demonstrate here is for very long time horizons – for 50 or 100 years when there are quite well established predictions of physical change – climate change, in our case rising sea levels.

Thus the model is comparative static – to forecast small area population change that we assume adjusts over 50 or 100 years. Contestable of course.

The model also needs to be intelligible to a wide variety of professionals and experts as well as informed stakeholders. These stakeholders are uncertain, who are they and how do they interact with the models?

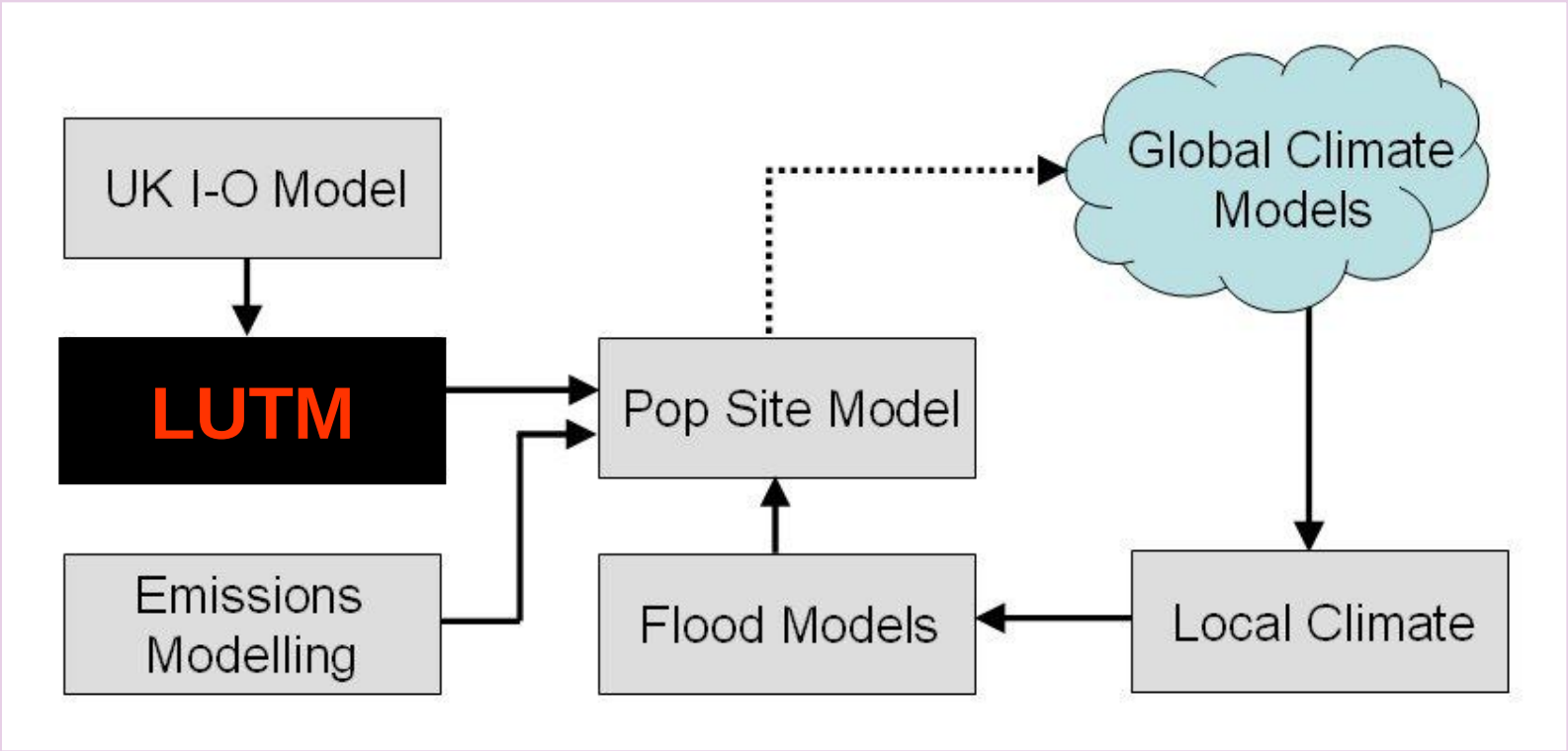
The Integrated Assessment:

Our part in the integrated assessment is a land use transport model to forecast small area population change in Greater London as part of a series or sequence of models designed to explore how more global economic change translates into change in population and how this is affected by rising sea levels.

The land use transport model sits between the aggregate economic modelling and more detailed flood modelling at the local scale.

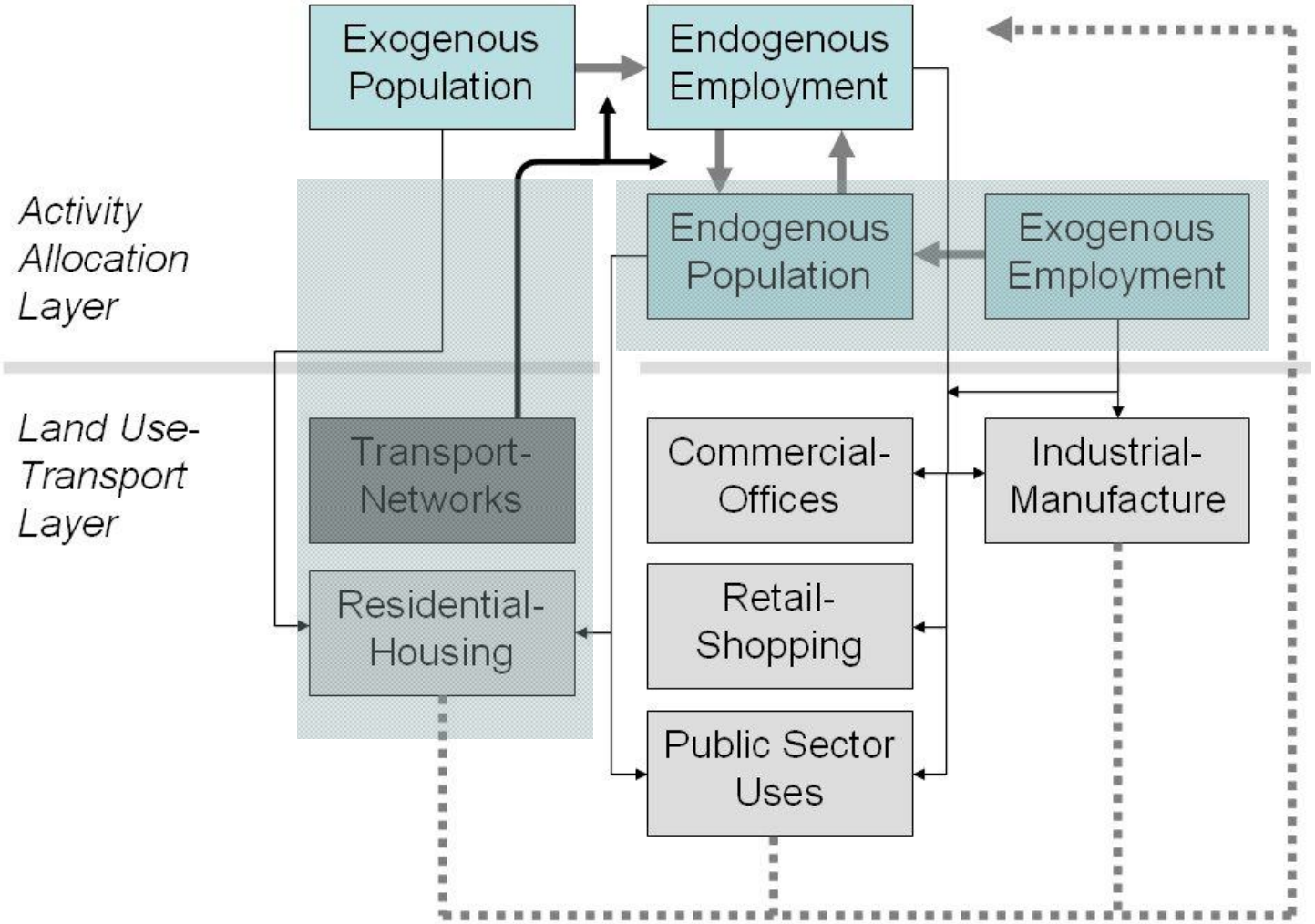
Here is the sequence of models and we will return to this sequence once I have outlined the LUTM & demoed it

The model sits lies at the core of a process of chaining models together built by different groups and coming from different traditions



The LUTM is in two layers – activity allocation and physical location

The Land Use Transport Model



The model is simple, highly visual – so that any informed expert can use it or at least it can be demoed easily.

It is strongly coupled into GIS as mapping is central to the visualisation – in fact all the GIS is purpose built

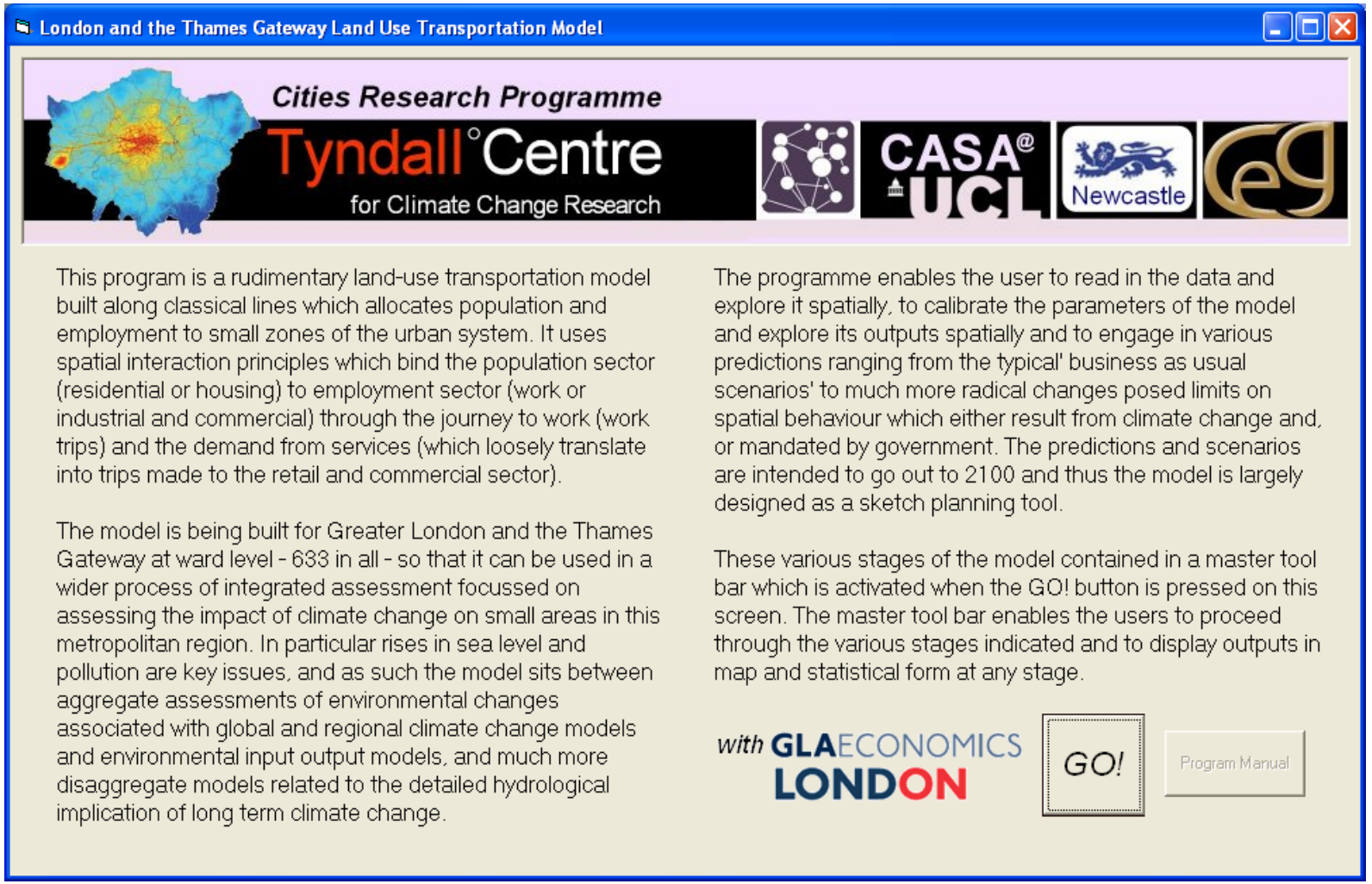
It is accessible, immediate and capable of being demoed quickly

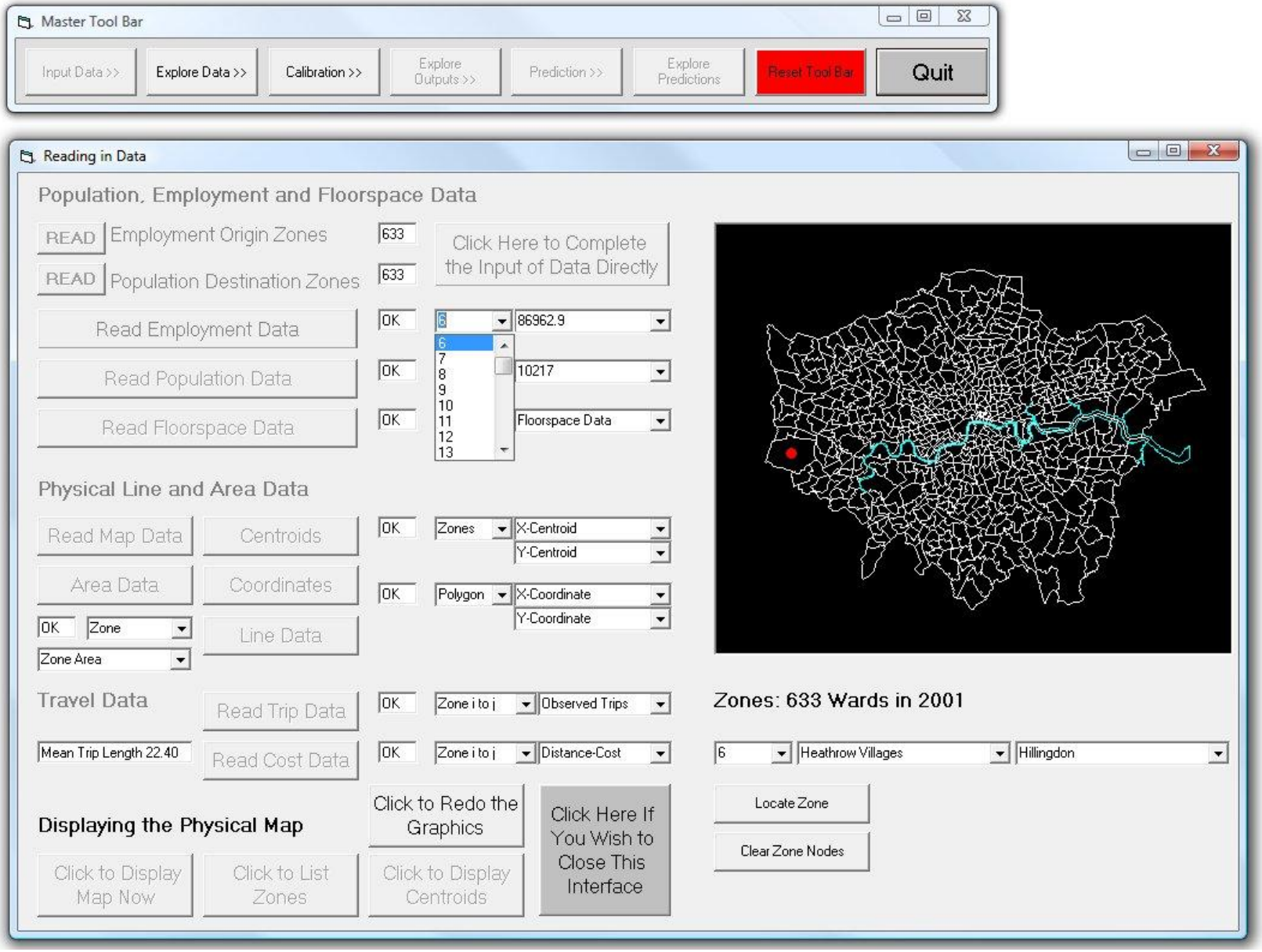
It is quite different from many of the current large scale LUTM models like UrbanSim, more aggregate

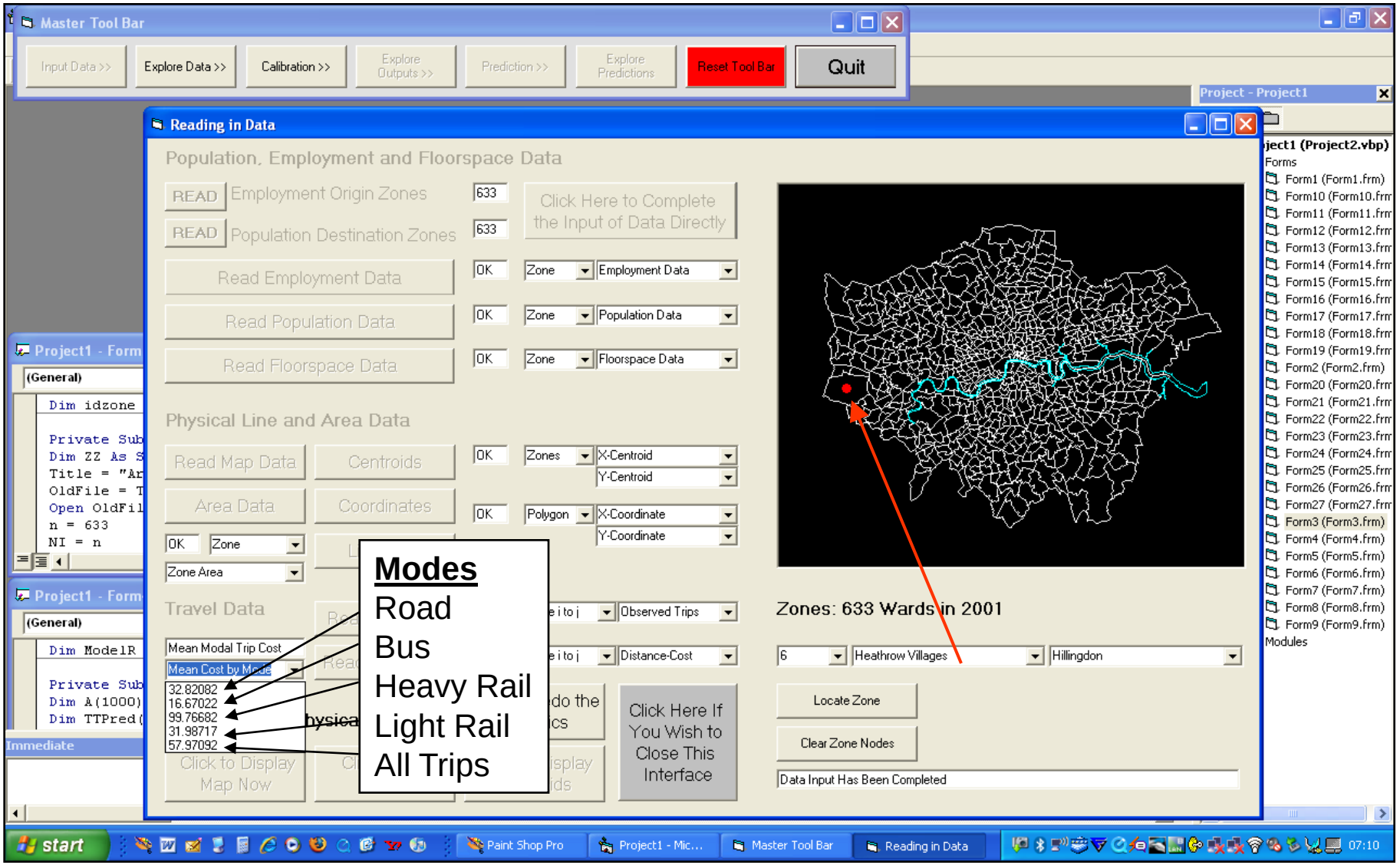
This doesn't mean it is better, far from it. It is different and designed for a very different purpose. It is designed to give structure to the process of **very** long term forecasting and scenario setting

The easiest way is to demo it ….

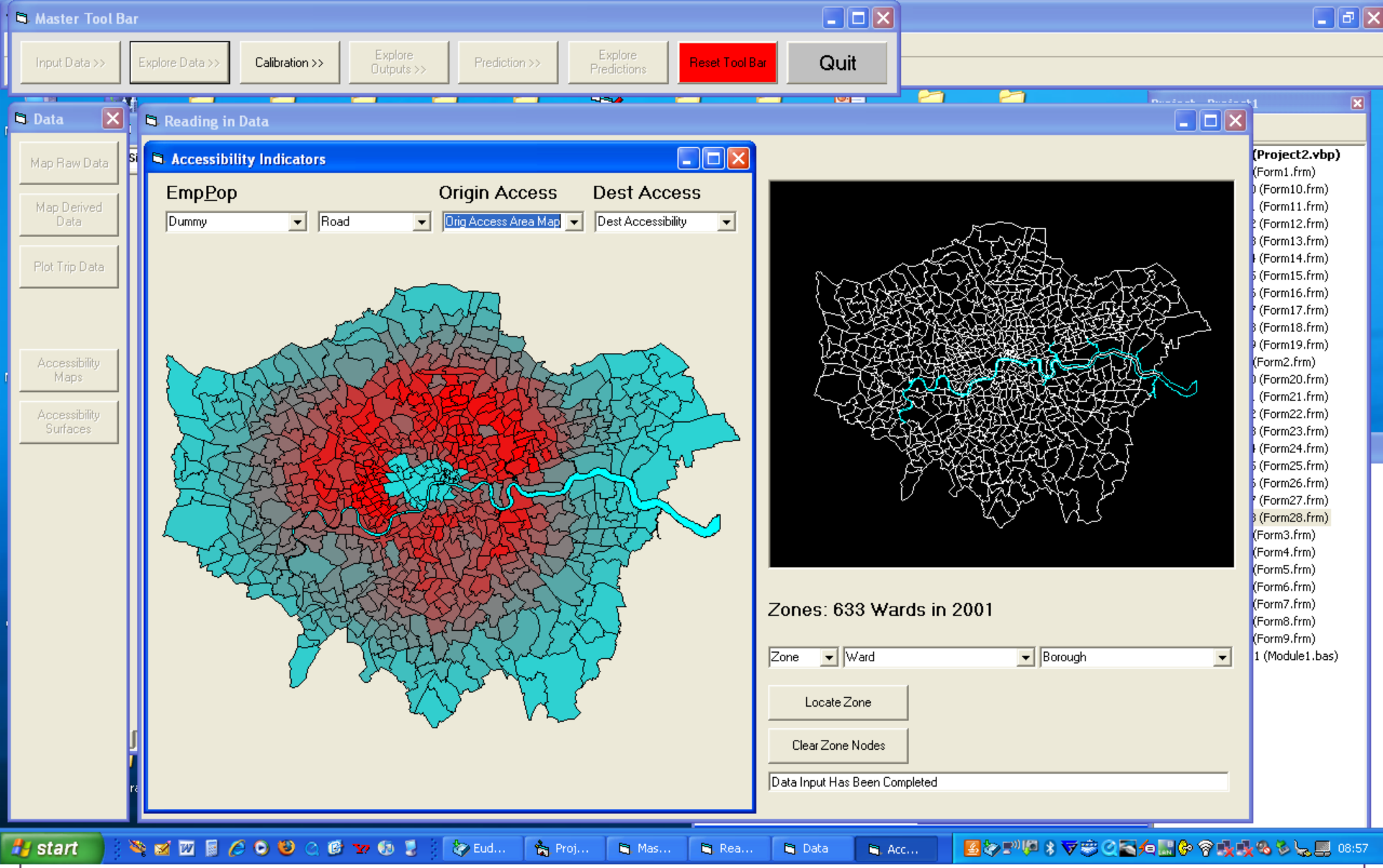
To give a flavour of the model, I will show some screen shots first




Master Tool Bar
Input Data >>
Explore Data >>
Calibration >>
Explore Outputs >>
Prediction >>
Explore Predictions
Reset Tool Bar
Quit
Reading in Data
Population, Employment and Floorspace Data
READ
Employment Origin Zones
633
READ
Population Destination Zones
633
Click Here to Complete the Input of Data Directly
Read Employment Data
OK
6
86962.9
6
7
8
9
10
11
12
13
Read Population Data
OK
10217
Read Floorspace Data
OK
Floorspace Data
Physical Line and Area Data
Read Map Data
Centroids
OK
Zones
X-Centroid
Y-Centroid
Area Data
Coordinates
OK
Polygon
X-Coordinate
Y-Coordinate
OK
Zone
Line Data
Zone Area
Travel Data
Read Trip Data
OK
Zone i to j
Observed Trips
Mean Trip Length 22.40
Read Cost Data
OK
Zone i to j
Distance-Cost
Displaying the Physical Map
Click to Redo the Graphics
Click Here If You Wish to Close This Interface
Click to Display Map Now
Click to List Zones
Click to Display Centroids
Zones: 633 Wards in 2001
6
Heathrow Villages
Hillingdon
Locate Zone
Clear Zone Nodes



Road: 38%; Bus: 12%: Heavy Rail: 12%: Light Rail 19%; Other (Walk, Bike, Fly): 19%


Master Tool Bar
Input Data >>
Explore Data >>
Calibration >>
Explore Outputs >>
Prediction >>
Explore Predictions
Reset Tool Bar
Quit
Data
Map Raw Data
Map Derived Data
Plot Trip Data
Accessibility Maps
Accessibility Surfaces
Reading in Data
Accessibility Indicators
EmpPop
Origin Access
Dest Access
Dummy
Road
Orig Access Area Map
Dest Accessibility
Zones: 633 Wards in 2001
Zone
Ward
Borough
Locate Zone
Clear Zone Nodes
Data Input Has Been Completed
(Project2.vbp)
(Form1.frm)
(Form28.frm)
(Module1.bas)
start
08:57

Master Tool Bar

Input Data >> | Explore Data >> | Calibration >> | Explore Outputs >> | Prediction >> | Explore Predictions | Reset Tool Bar | Quit

Predict

Input Scenario Data

Scenario from File

Employment Changes

Floorspace Changes

Distance Changes

Run Scenario Model

Run Model

More Scenario Runs ...

Expansion .....

Expansion .....

Expansion .....

Reading in Data

Prediction Routines

Long Term Scenarios Based on the Impact of Changes in Employment, Residential Floorspace, and Transport Costs

Predictions with the model involve forecasting the location of small area populations and the trip patterns associated with the four modes used to distribute employment as population to these small (residential) areas. This involves changing the input variables - employment and residential floorspace by small area, and the travel costs associated with each mode of transport, which in turn imply changes to the transport infrastructure. The user also has control over the parameter values on the friction of Travel Cost or travel cost associated with each mode. This can be changed in value to reflect changes in the average Travel Cost or cost travelled on each mode.

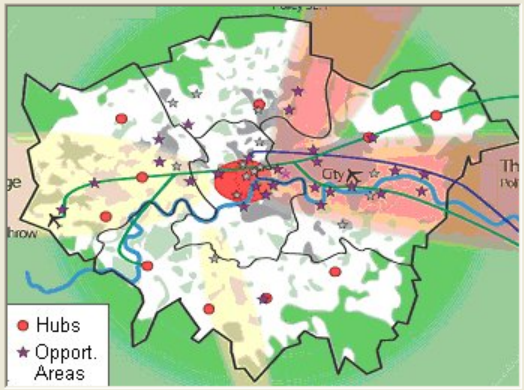
Users have a choice of inputting a preset scenario in which all these variables are changed exogenously or a process of changing these variables interactively, on screen. The interactive process can involve many thousands of changes and is probably best used to input data which reflects 'what-if' scenarios which require a small number of rather simple changes in the inputs reflecting substantial or radical change.

By clicking the 'Scenario from File' button in the toolbar to the left, a preset scenario is loaded and the user is then taken to the point where the model must be run. Alternatively if the user clicks the Employment Changes button, the user activates a screen where each employment zone can be identified by pointing the mouse at it and clicking. Then the user can use a slider bar to increase the value of employment in that zone by up to 100 percent or decrease it by up to 100 percent. As many zones as required can be changed using this method. When the user is satisfied with the employment scenario which has been developed, a button accepting these changes can be clicked. The same can then be done for floorspace activated by clicking the relevant button from the toolbar to the left.

Finally the travel cost on any link by any mode from one zone to another can be changed using the same method. An origin and then a destination zone need to be clicked and then reduced or increased travel cost (by up to 100 percent) made using the slider bar. The user must choose the mode each time and the program then recomputes all the shortest routes implied by these changes once the changes are accepted.

The user then proceeds to run the model as for the 'Scenario from File' option and once this is done, the outputs can be visualised using the same system for exploring the data and calibration results.

Key Elements of the London Plan to 2025 Shown Below.



(Project2.vbp)
(Form1.frm)
(Form10.frm)
(Form11.frm)
(Form12.frm)
(Form13.frm)
(Form14.frm)
(Form15.frm)
(Form16.frm)
(Form17.frm)
(Form18.frm)
(Form19.frm)
(Form2.frm)
(Form20.frm)
(Form21.frm)
(Form22.frm)
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(Form24.frm)
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(Form27.frm)
(Form28.frm)
(Form3.frm)
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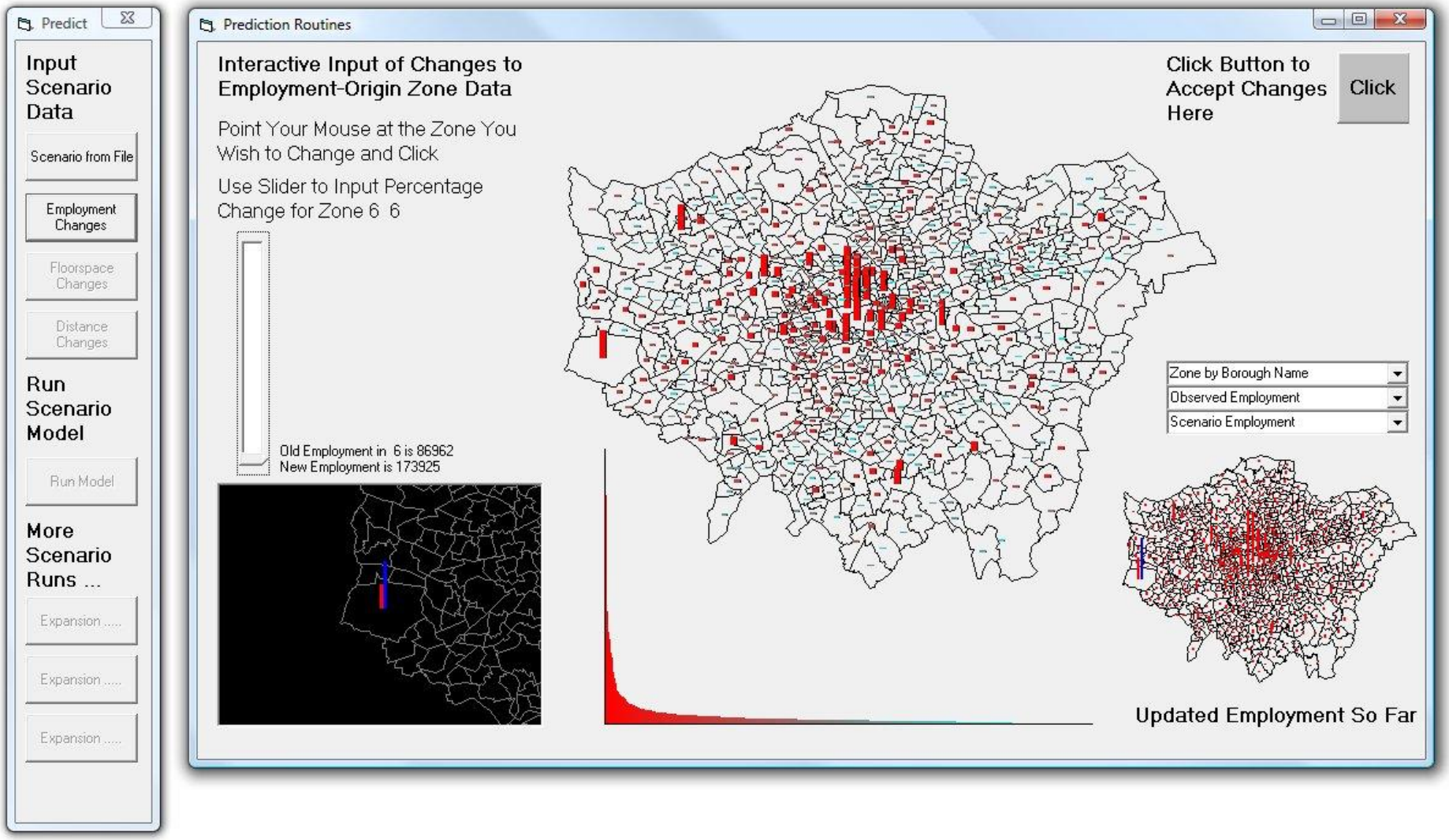
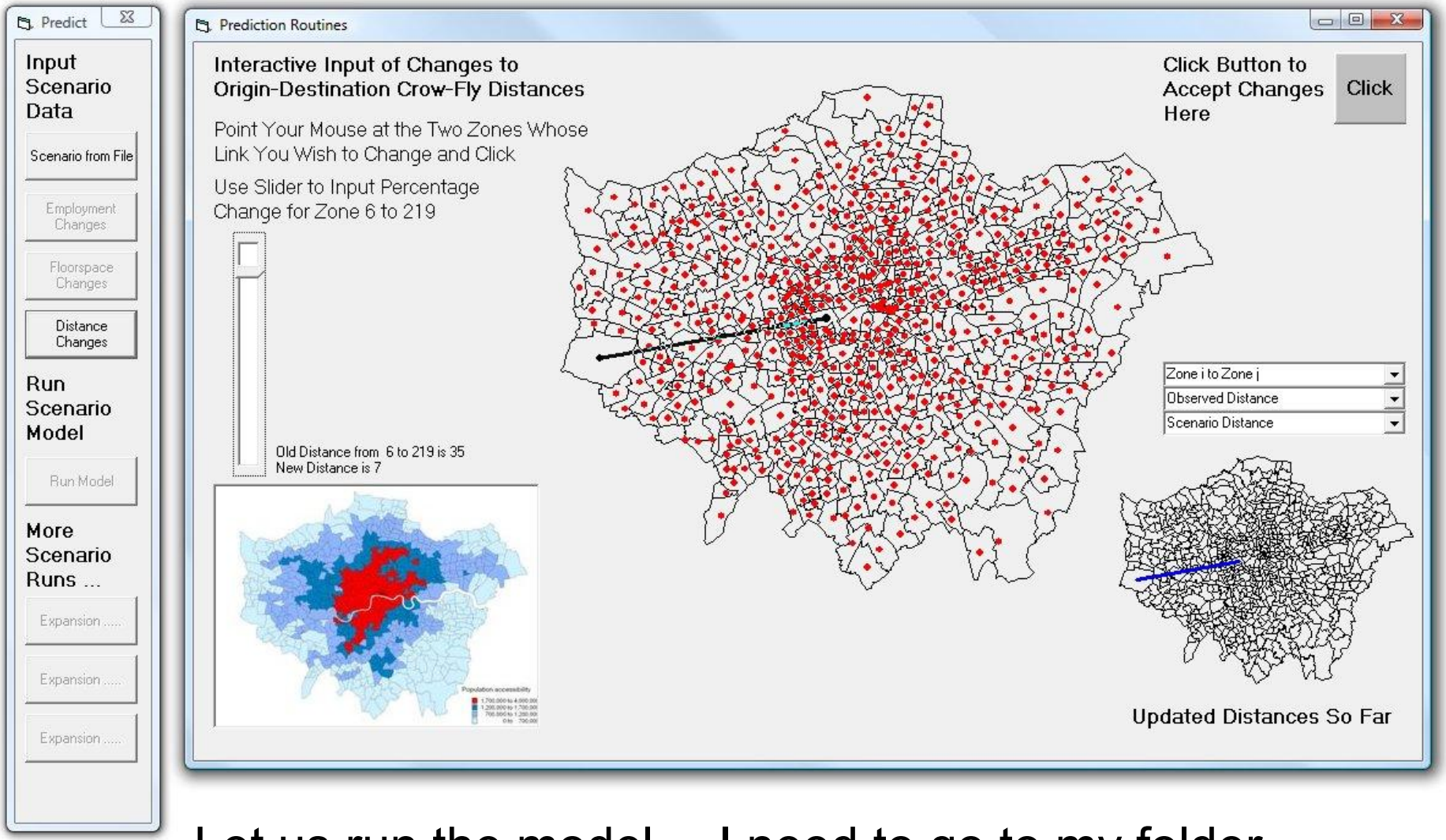
(Form6.frm)
(Form7.frm)
(Form8.frm)
(Form9.frm)
(Module1.bas)

start

08:59

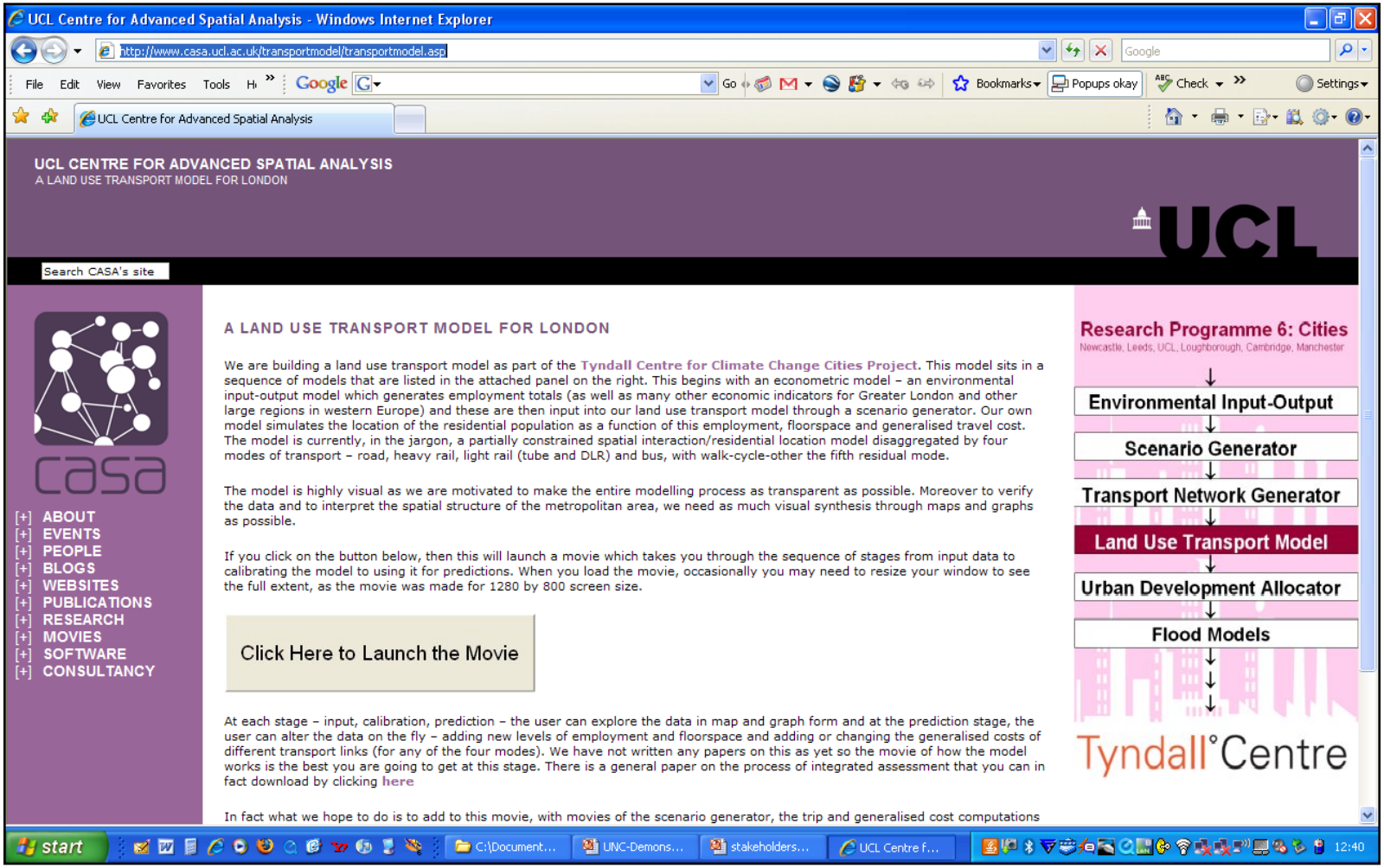

Predict
Input Scenario Data
Scenario from File
Employment Changes
Floorspace Changes
Distance Changes
Run Scenario Model
Run Model
More Scenario Runs ...
Expansion .....
Expansion .....
Expansion .....
Prediction Routines
Interactive Input of Changes to Employment-Origin Zone Data
Point Your Mouse at the Zone You Wish to Change and Click
Use Slider to Input Percentage Change for Zone 6 6
Old Employment in 6 is 86962
New Employment is 173925
Click Button to Accept Changes Here
Click
Zone by Borough Name
Observed Employment
Scenario Employment
Updated Employment So Far



Let us run the model… I need to go to my folder…

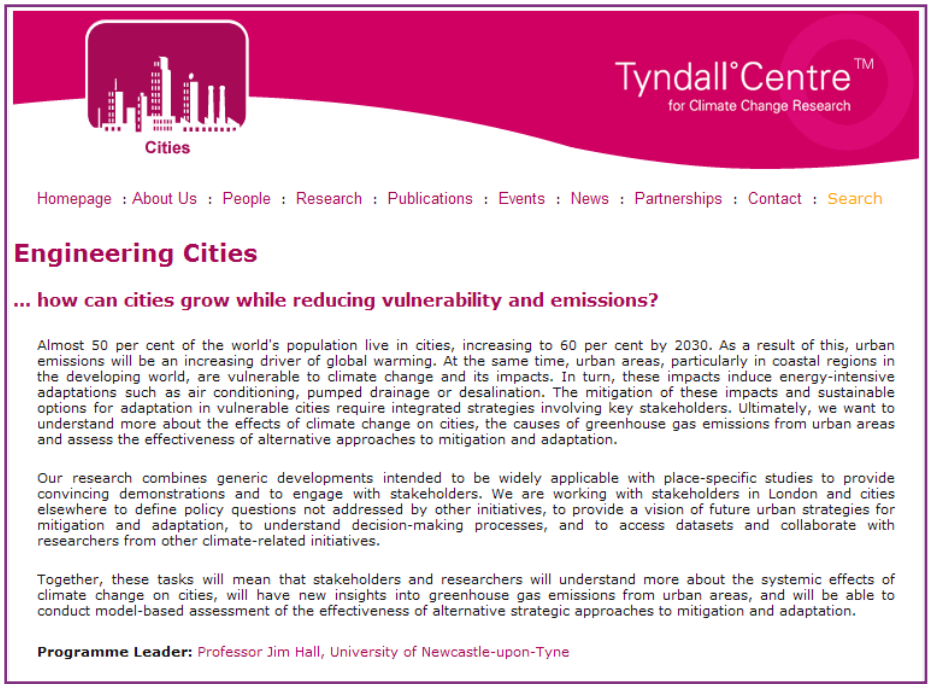
For a movie of all this go to our web site

http://www.casa.ucl.ac.uk/transportmodel/transportmodel.asp



You can find more about the Tyndall Cities Project on the Tyndall Web site

http://www.tyndall.ac.uk/research/programme6/



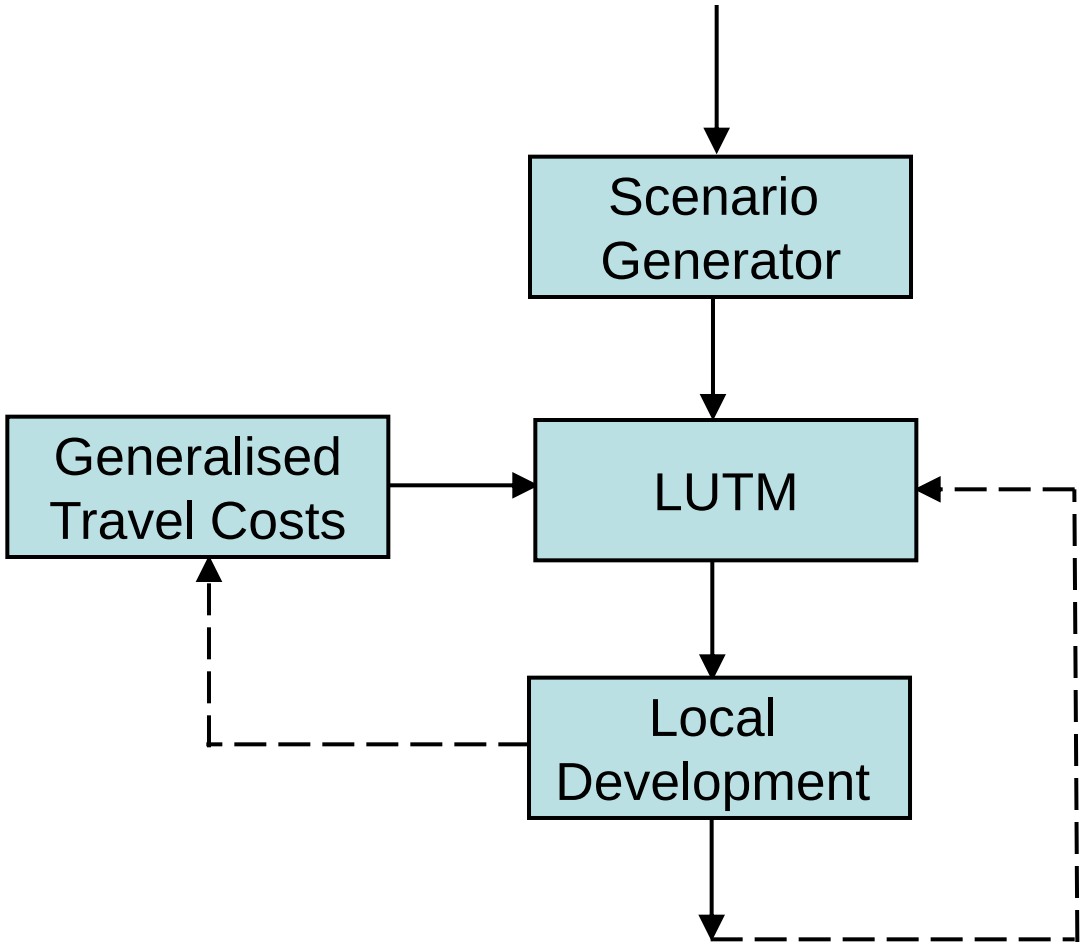
But there is a launch event in London October 16th 2009 at the GLA …..

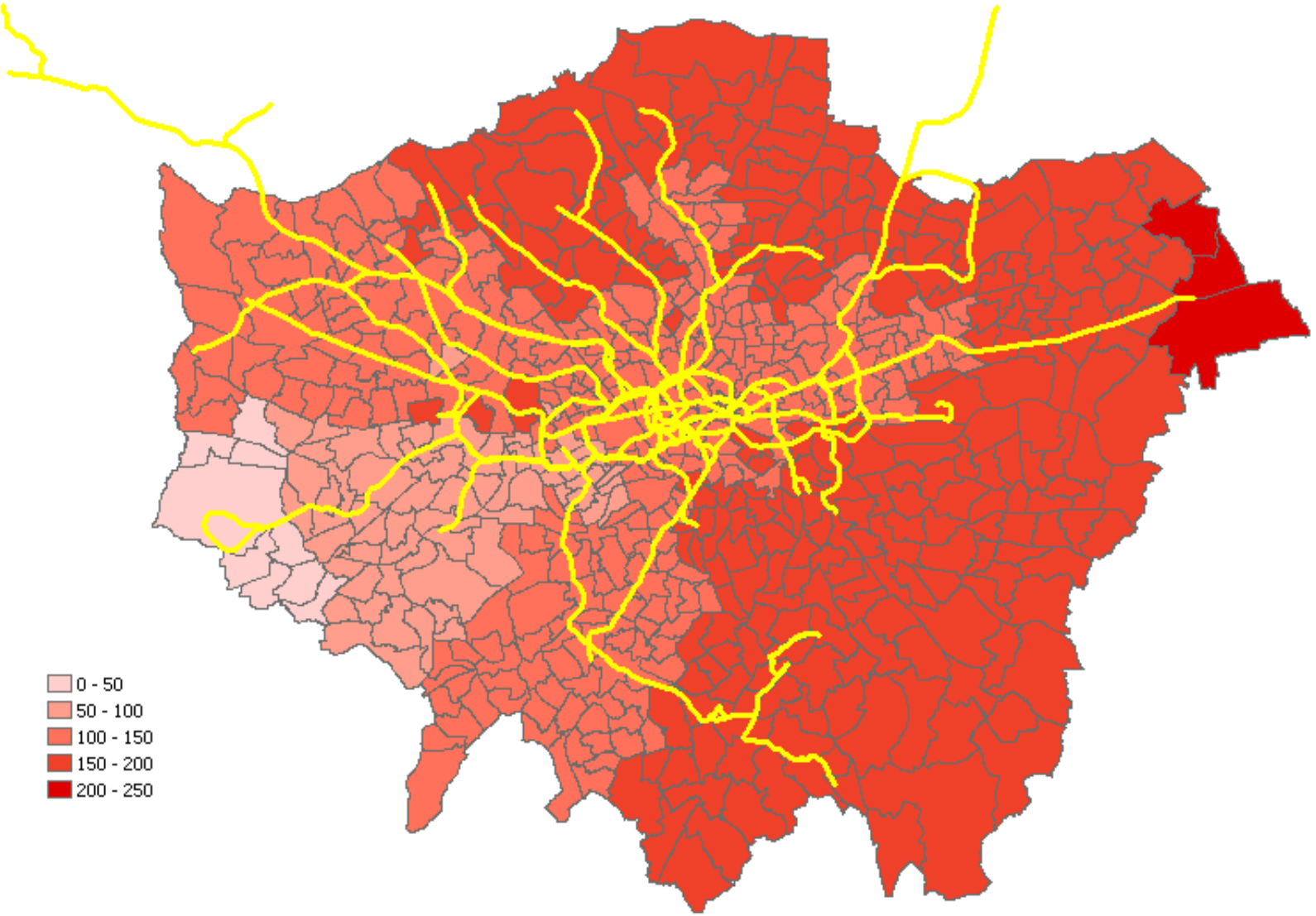
Ok let me step back and tell you more about the integrated assessment:

- The Aggregate Economic Forecasting
- The Scenario Generator
- The Transport Network Analysis Module
- The LUTM
- The Local Development Model
- The Flooding Models
- The Aggregate Emissions Models

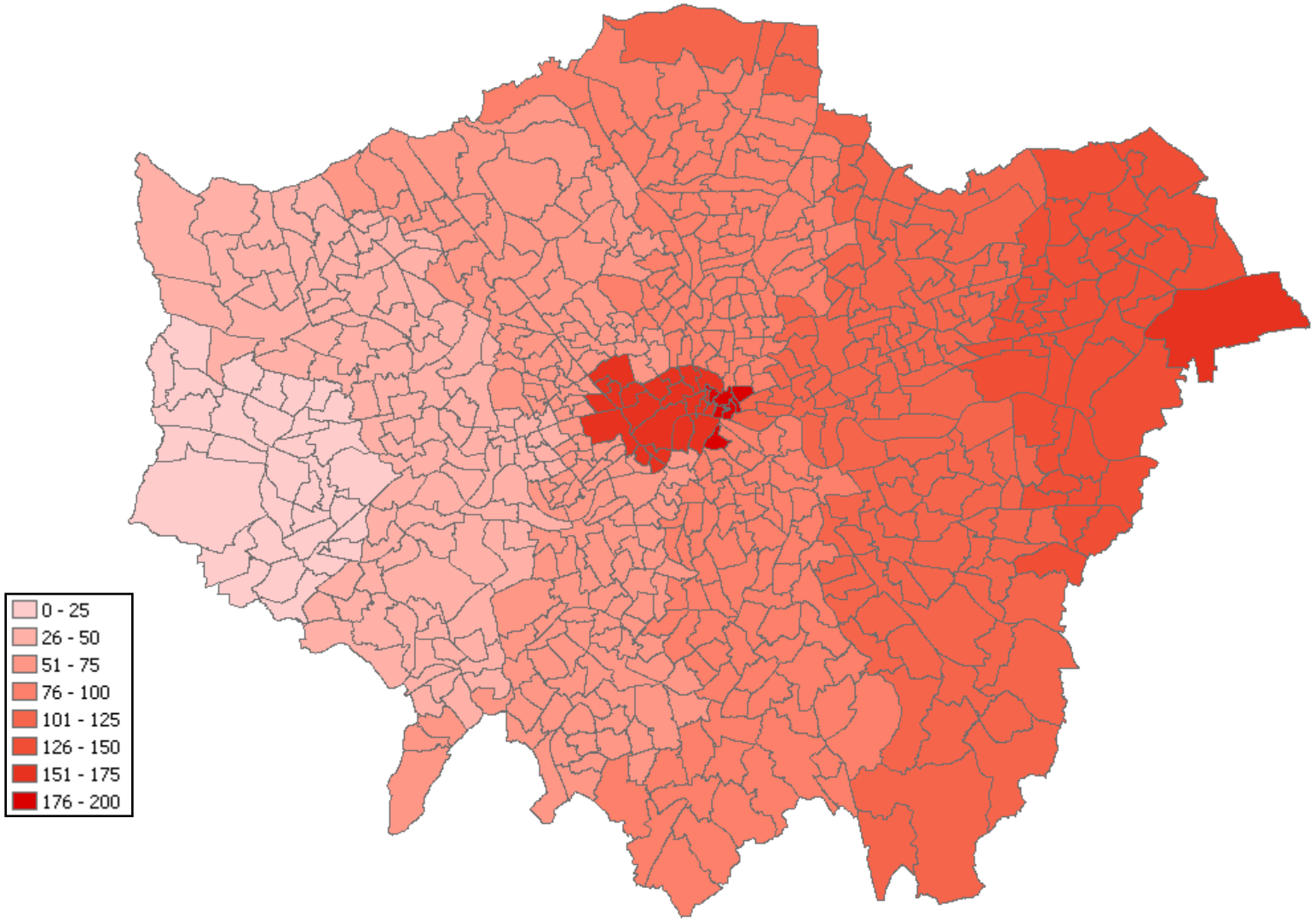
I am going to sketch just two of these models to give a sense of how they are integrated

Let us unpack the LUTM process as there are really four types of models/analytical tools here





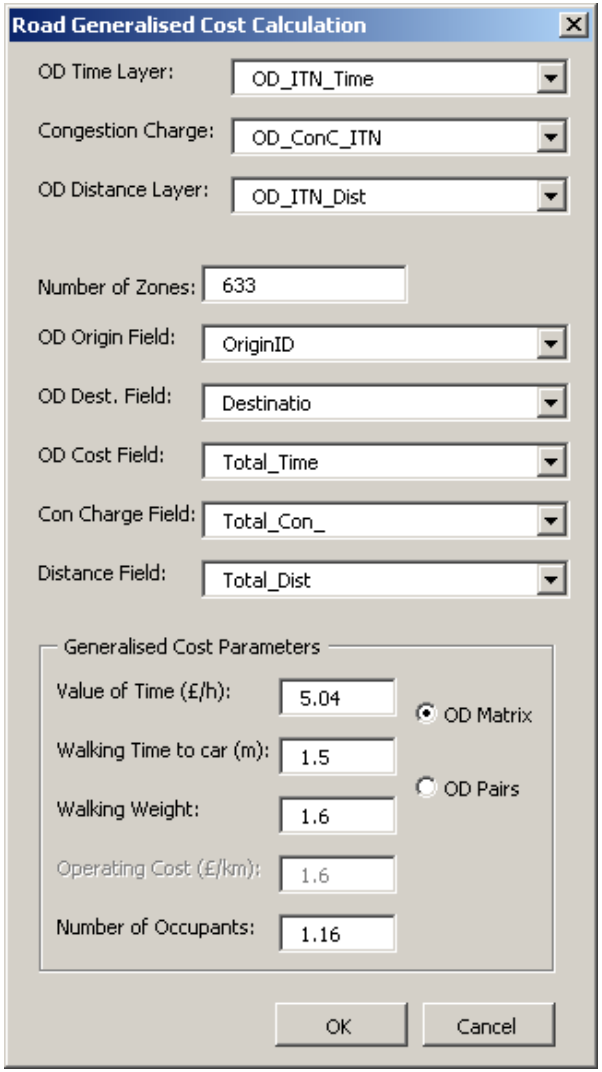
Light Rail Generalised Costs from Heathrow Ward (minutes)



2001 Road Generalised Cost from Heathrow Ward (minutes)

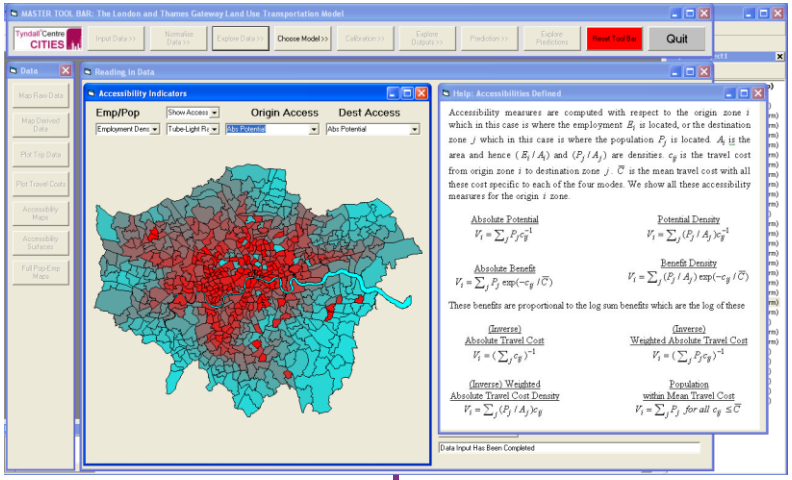
The ArcGIS Interface

- Reflect the cost of travel including:
  - Monetary costs
  - Time
- Differing calculations for public and private transport
- Includes policy drivers:
  - Cost of fuel
  - Road user/congestion charging
  - Ticket costs
  - Service frequencies
- Allows modelling of both geographical and economic costs



Accessibility from the LUTM model

Many different accessibility measures, 8 in all



Help: Accessibilities Defined

Accessibility measures are computed with respect to the origin zone i which in this case is where the employment E_i is located, or the destination zone j which in this case is where the population P_j is located. A_i is the area and hence (E_i / A_i) and (P_j / A_j) are densities. c_{ij} is the travel cost from origin zone i to destination zone j. $\overline{C}$ is the mean travel cost with all these cost specific to each of the four modes. We show all these accessibility measures for the origin i zone.

Absolute Potential
$$V_i = \sum_j P_j c_{ij}^{-1}$$

Potential Density
$$V_i = \sum_j (P_j / A_j) c_{ij}^{-1}$$

Absolute Benefit
$$V_i = \sum_j P_j \exp(-c_{ij} / \overline{C})$$

Benefit Density
$$V_i = \sum_j (P_j / A_j) \exp(-c_{ij} / \overline{C})$$

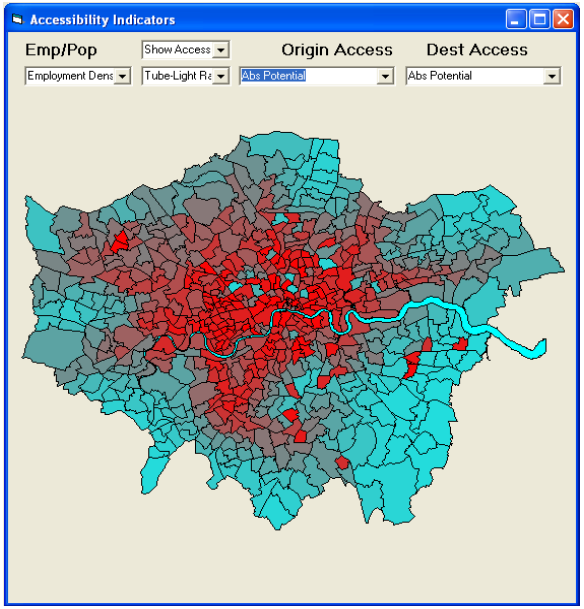
These benefits are proportional to the log sum benefits which are the log of these

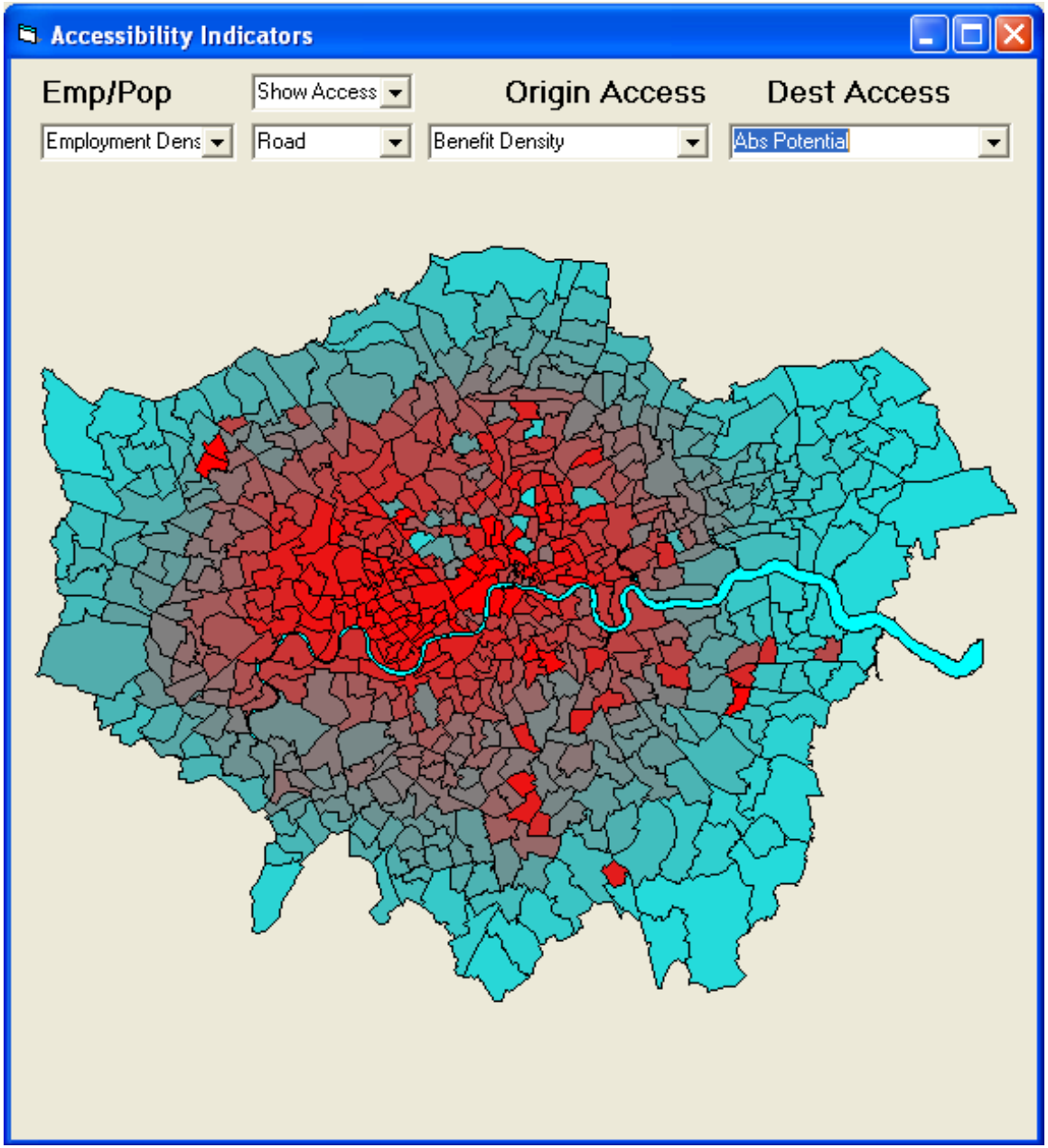
(Inverse) Absolute Travel Cost
$$V_i = (\sum_j c_{ij})^{-1}$$

(Inverse) Weighted Absolute Travel Cost
$$V_i = (\sum_j P_j c_{ij})^{-1}$$

(Inverse) Weighted Absolute Travel Cost Density
$$V_i = \sum_j (P_j / A_j) c_{ij}$$

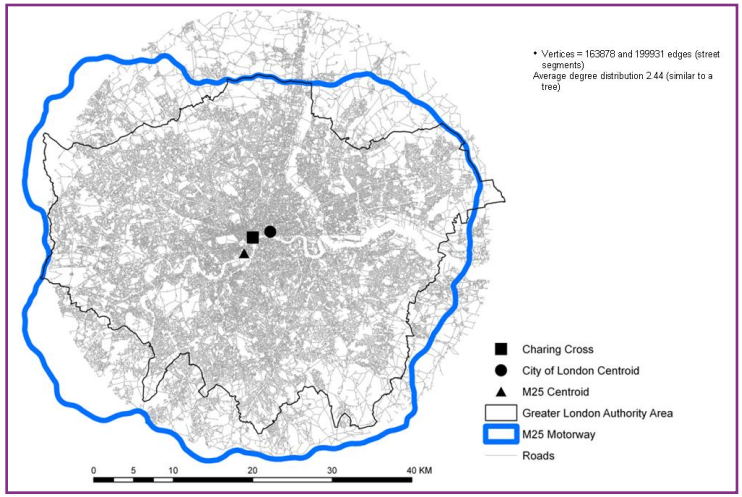
Population within Mean Travel Cost
$$V_i = \sum_j P_j \text{ for all } c_{ij} \le \overline{C}$$

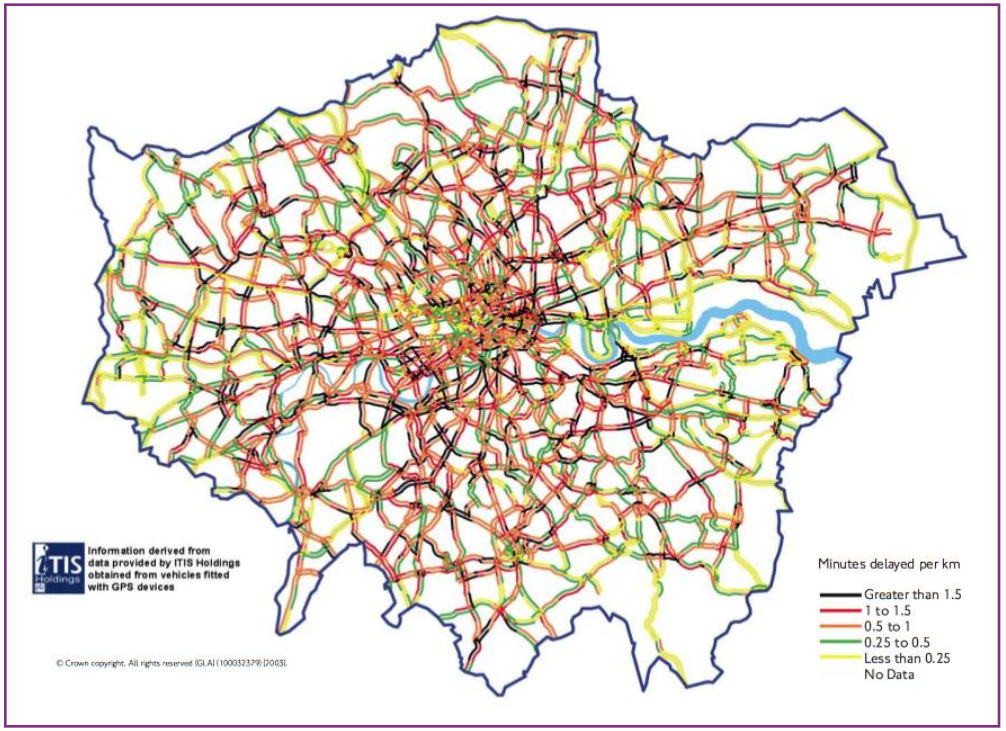

Accessibility Indicators
Emp/Pop
Show Access
Origin Access
Dest Access
Employment Dens
Tube-Light Ra
Abs Potential
Abs Potential


Accessibility Indicators
Emp/Pop
Show Access
Origin Access
Dest Access
Employment Dens
Road
Benefit Density
Abs Potential

Further work on networks

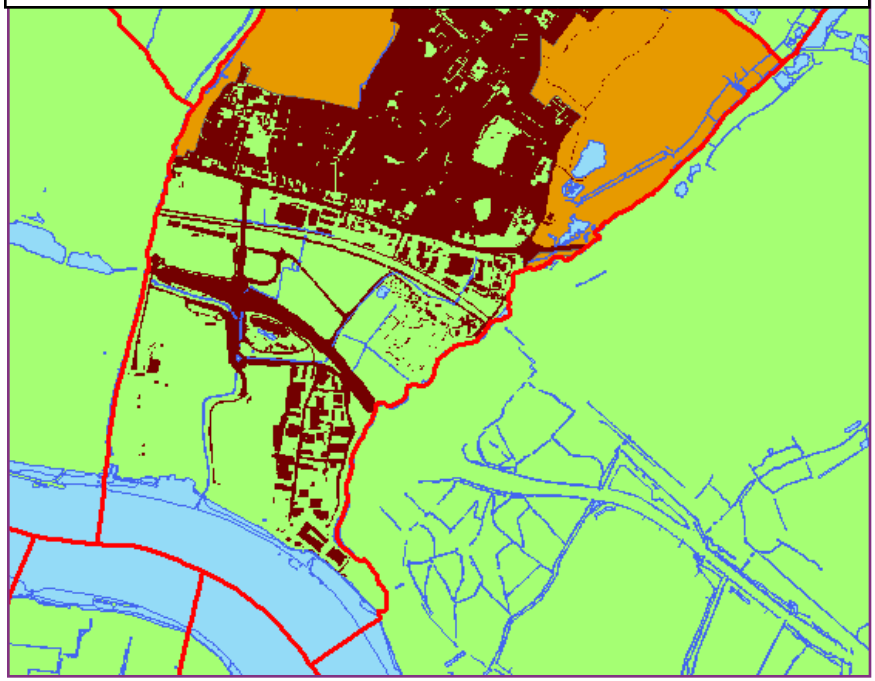
From our London database project which Andrew Crooks and Duncan Smith talked about this morning

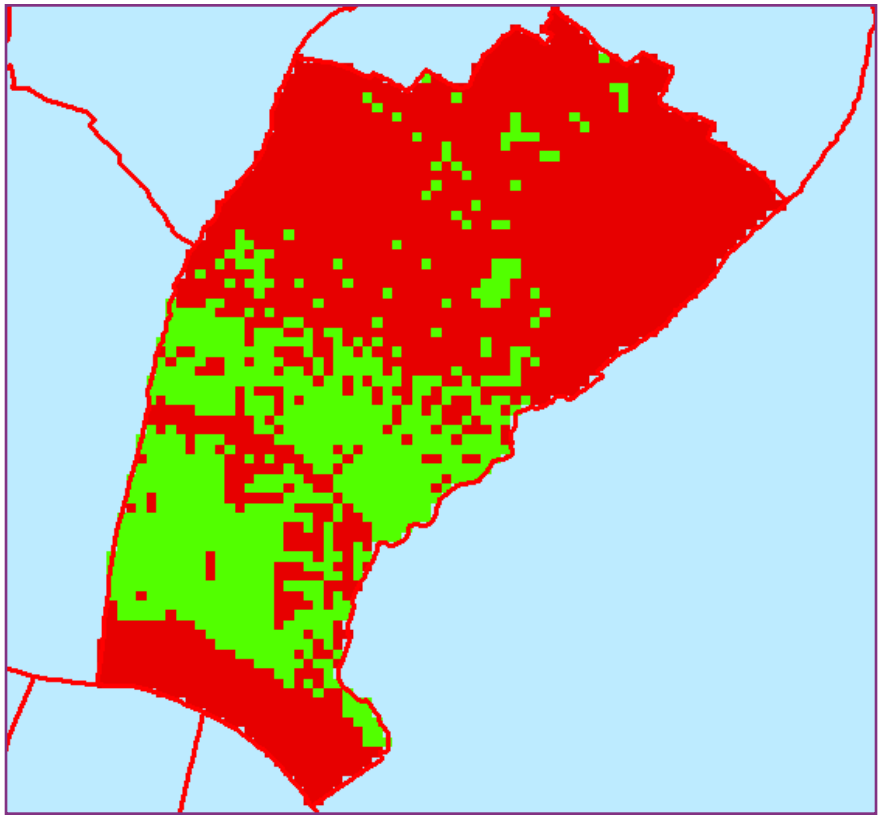




Bring the data in-house
Currently we have the
Road system in good
Detail with speeds etc
From TfL

The local development model
GIS layers at 50 metre resolution

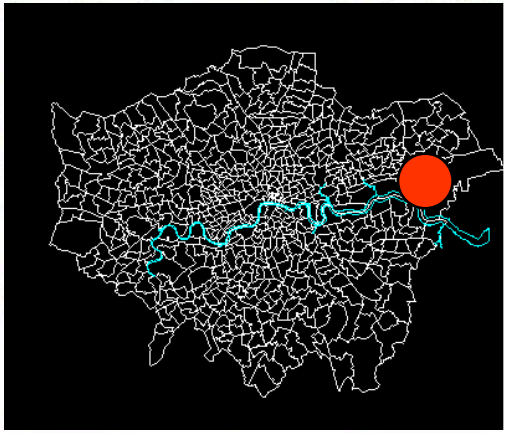


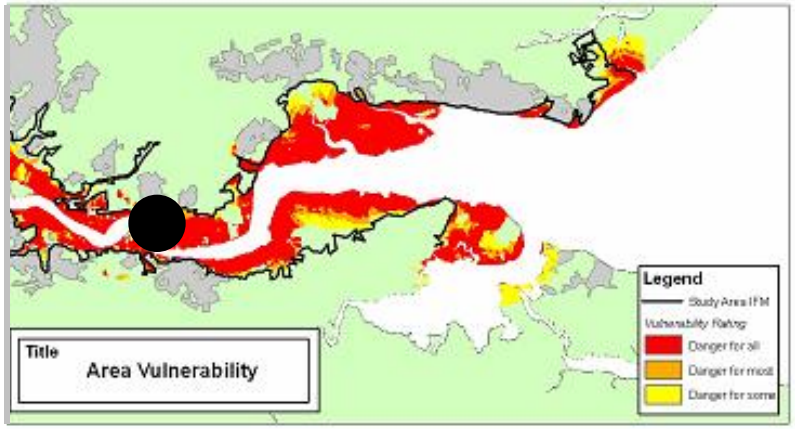


Current Water

Currently Developed

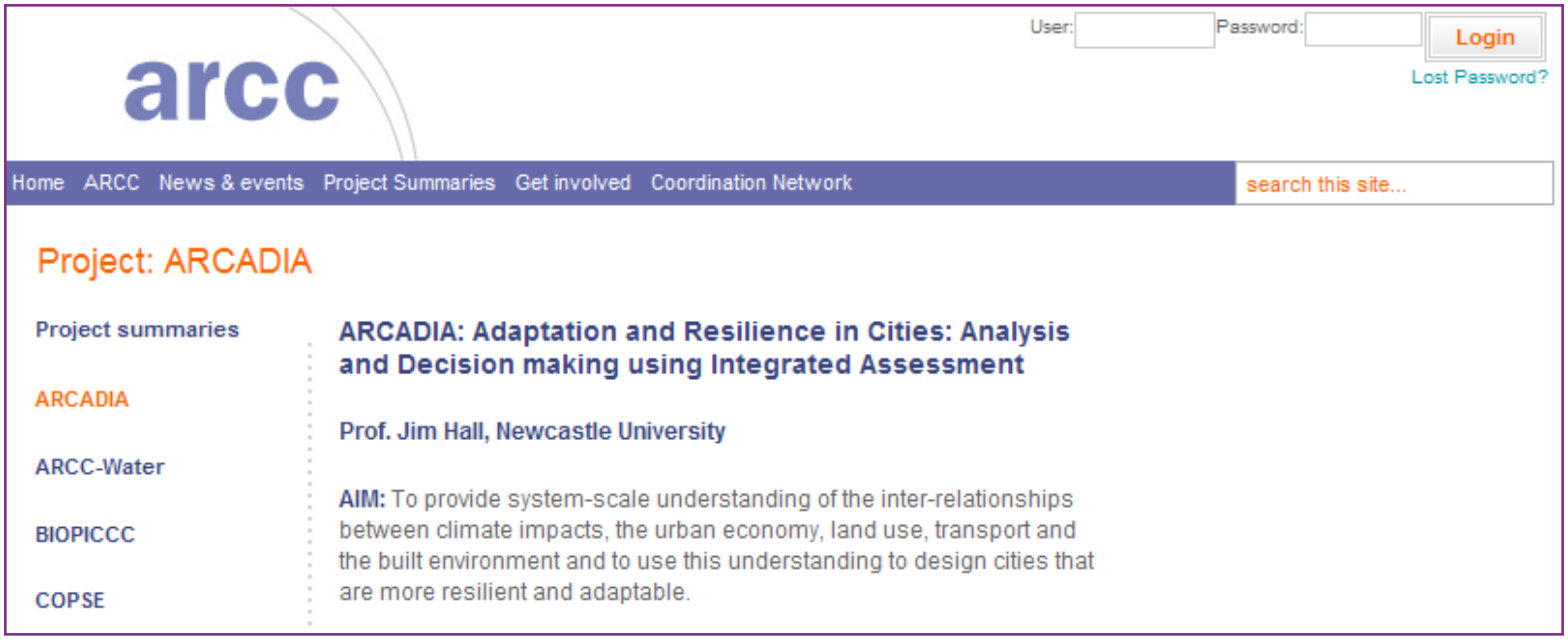
Planning Constrained Land





Extending the formal project

The roll out of all these models will be accomplished in a second phase of Tyndall which in fact is financed not by NERC but by EPSRC under the ARCADIA project http://www.ukcip-arcc.org.uk/



Next Steps

Extensions to the Gateway

Extending the model to generate employment

Disaggregating the Model to five population and five employment groups

Developing the Land Use Constraints

Developing feedbacks from transport to land use

Extending the transport costs and travel time to incorporate explicit energy use

Extending the location models to incorporate energy use in work and home …….

Thanks, Any Questions?

Look at

http://www.casa.ucl.ac.uk/transportmodel/transportmodelmovie.html