Tuesday, 10 September 2013
Imperial College, London

Cities at Different Scales

Some Current Projects at CASA In and About London

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http://www.spatialcomplexity.info/
http://www.casa.ucl.ac.uk/

http://www.spatialcomplexity.info/

http://www.complexcity.info/

http://blogs.casa.ucl.ac.uk/

Key Themes

- Information is Changing our Perception of How and What We Need to Understand about Cities
- Big Data, Short Times, Fine Spatial Scales: The Next 5 Minutes, 5 Years, or 50 Years?
- The London Oyster Card Data Set
- Simpler Systems: Public Bikes as Exemplar
- Long & Short Term Flooding: Tyndall Cities Project
- Big Disruptions in Infrastructure: Olympics, Cross Rail
- Regional Breakdown: Phase Transitions
- Conclusions: Many More Projects and Perspectives

Information is Changing our Perception of How and What We Need to Understand about Cities

Cities can be explained – I hesitate to use the word explained because our understanding after at least 50 years of sustained research and practice is woefully inadequate – at many different spatial and temporal scales.

Traditionally these have been spatial scale because time has been implicit – cities have been thought of as in equilibrium – until comparatively recently as our senses have told us this is not the case and as new big data has suddenly become available in real time – or rather from real time

Our theories and models and there are many of them are under scrutiny like never before. And our abilities to predict ?

So in this talk I will sketch a few projects that show how we are handling some of these issues in CASA my centre in UCL.

These are projects that are all data and model based – which is our perspective and expertise but I need to remind you and myself continually that most work on cities in somewhere like UCL is not from this perspective but is highly qualitative, a lot is descriptive, and a lot is more physical than spatial, about buildings and transport and so on

Our work is manifestly in the spatial tradition which is founded on subject areas like urban economics, social physics, and transportation interactions.

I am going to concentrate on projects that have a lot of data – some of them big data but date in time as well as space

Big Data, Short Times, Fine Spatial Scales: The Next 5 Minutes, 5 Years, or 50 Years?

Big data is distorting or at least changing our attention span from longer to shorter time periods in which intervention takes place. This is very important as it changes what we are interested in

This is because big data is largely but not exclusively based on massive volumes – terabytes – over very short time spans – seconds – at very precise spatial scales – centimetres or less

The focus thus turns to issues such as disruption of systems for individuals over 5 minutes to 1 hour to 1 day rather than change for aggregate groups of populations from 1 year to 5 years to 50 years.

To an extent there is a general shift from equity to efficiency.

Of course big data is also being streamed incessantly without any potential end limit although systems will inevitably change and there is no guarantee that big data will tell us about change on any and every time scale.

Big data can also be traditionally collected data by manual means and a good working definition is anything that will not fit into an Excel spreadsheet – 4.56 million individual records – the population of Ireland is big data and it might be collected from many sources none of which are streamed in real time.

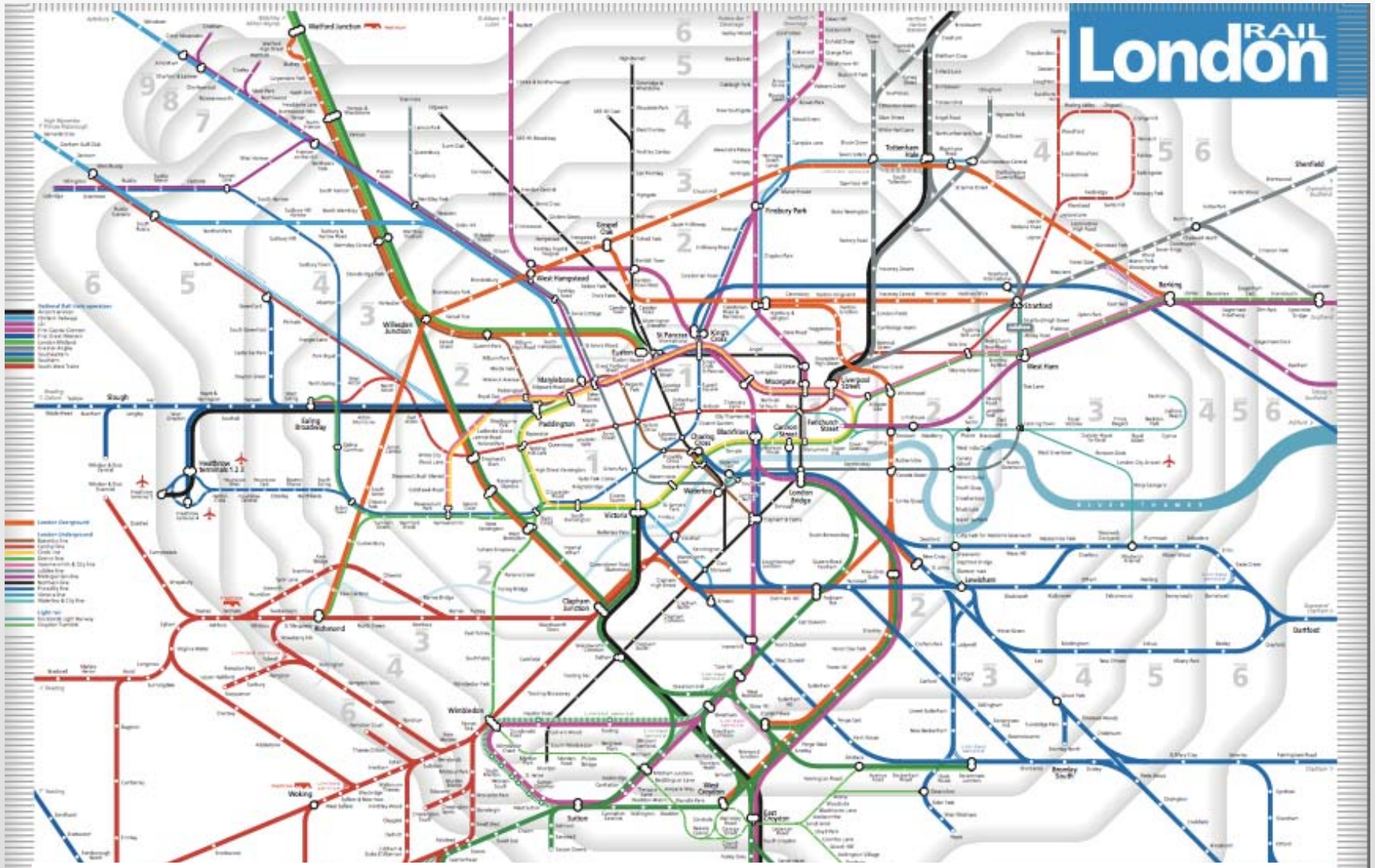
Big data is also as unreliable as small data and perhaps more so and I will tell you of some problems in it as we go along.

The London Oyster Card Data Set

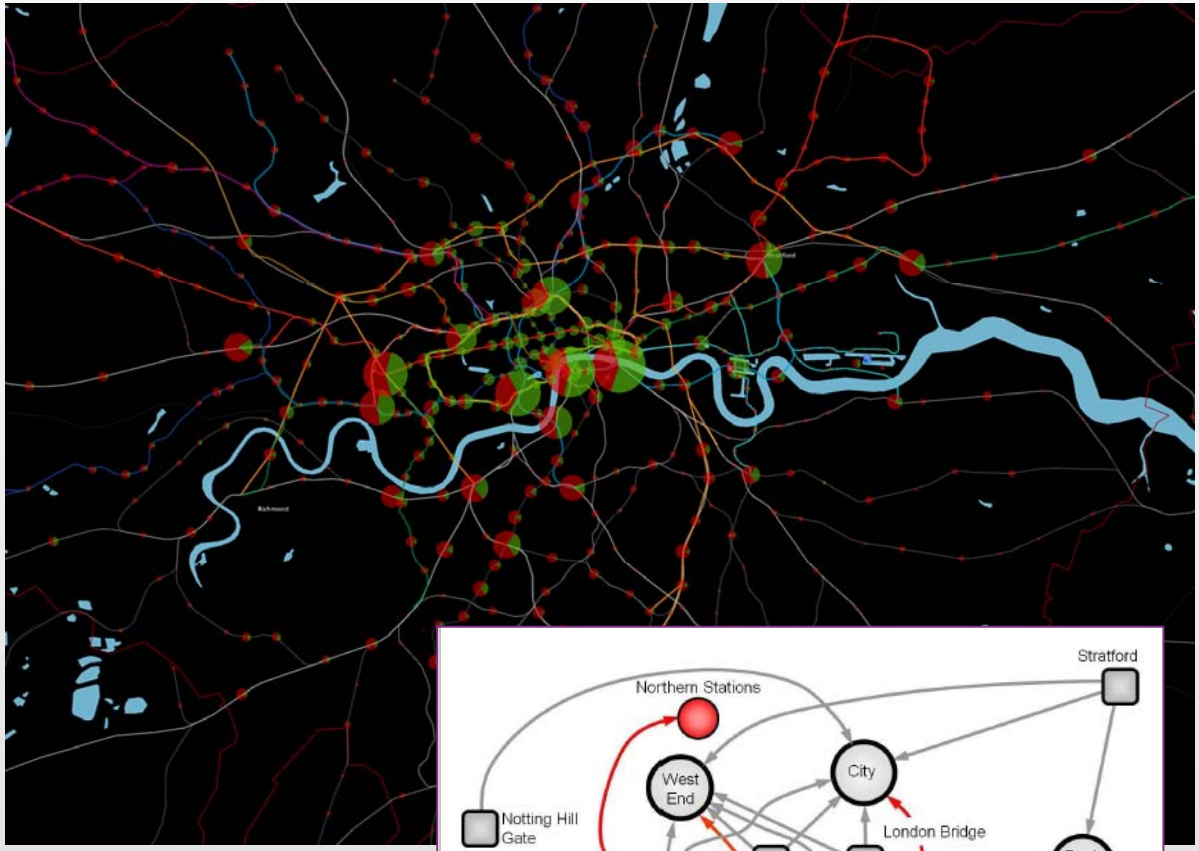
Ok let me begin to illustrate these ideas with some examples. which involve big data and networks. Our Oyster card data set involves all tap in and tap outs by unique ID number with location and time for every person over a 6 month period

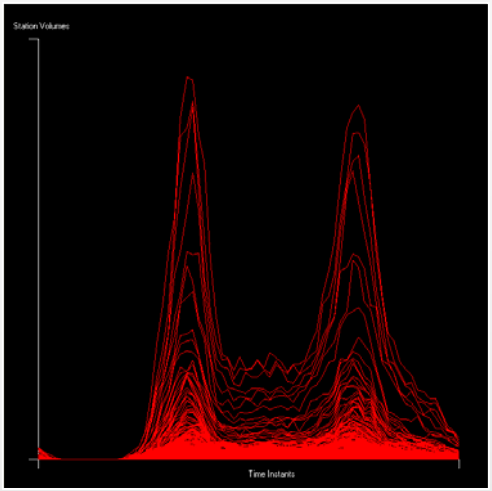
7 million a day, 40 million a week, 160 million a month, nearly 1 billion for every half year. This is very big data – simply to explore it takes a lot of computer time

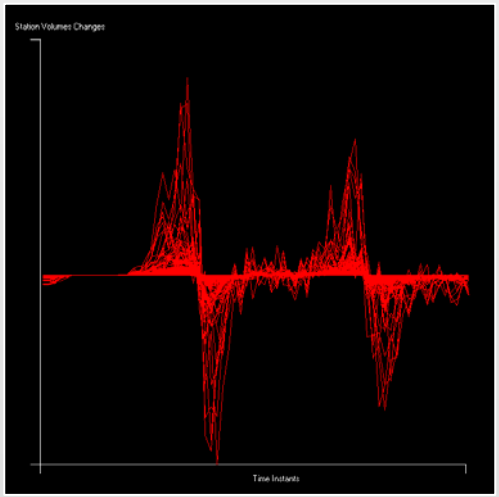
It is very good data in that we can begin to get a very detailed sense of how people travel over time – the routiness of travel but there are a lot of holes in the data too.

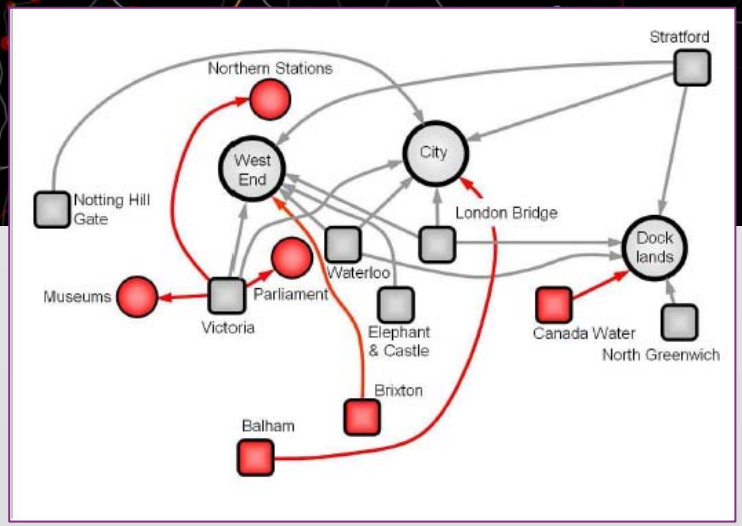


Tube, Overground and National Rail Networks in London where Oyster cards can be used





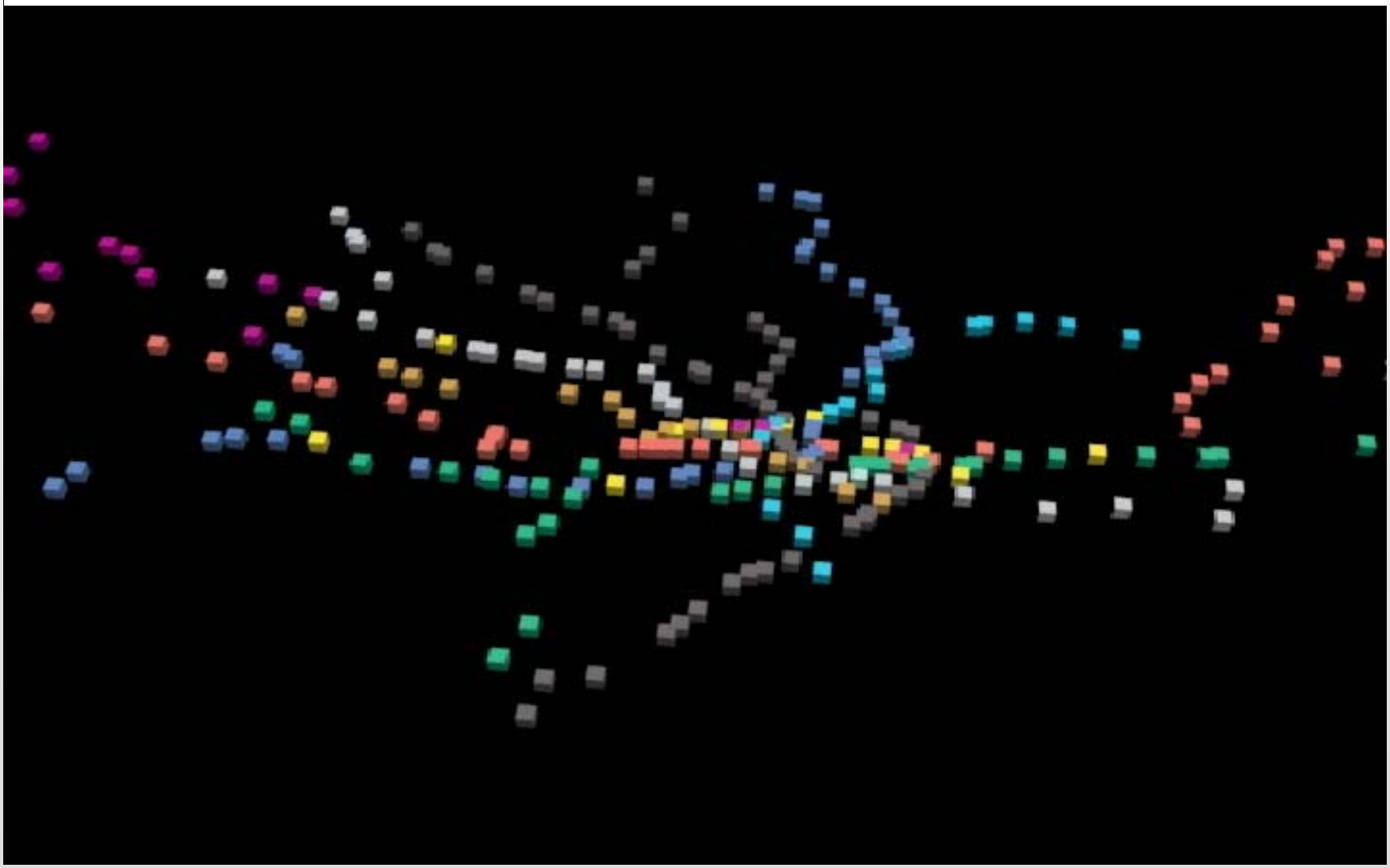


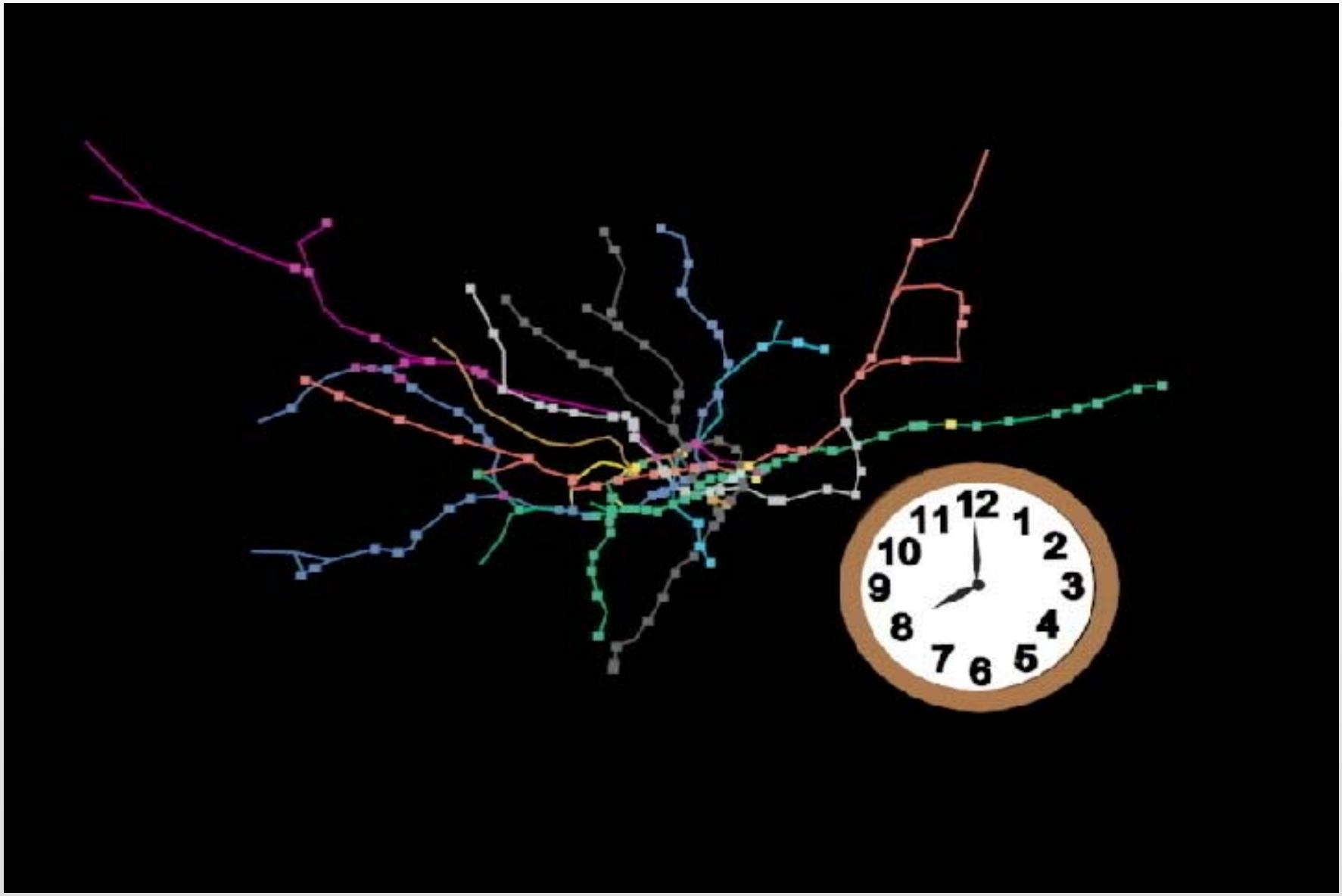


Roth C., Kang S. M., Batty, M., and Barthelemy, M. (2011) Structure of Urban Movements: Polycentric Activity and Entangled Hierarchical Flows. **PLoS ONE 6(1)**: e15923. doi:10.1371/journal.pone.0015923

http://www.simulacra.info/

Animation over 24 hours of speeded up position/time of tubes:
How can we match this supply of vehicles from the API queries to the demand from the Oyster card data?




12
1
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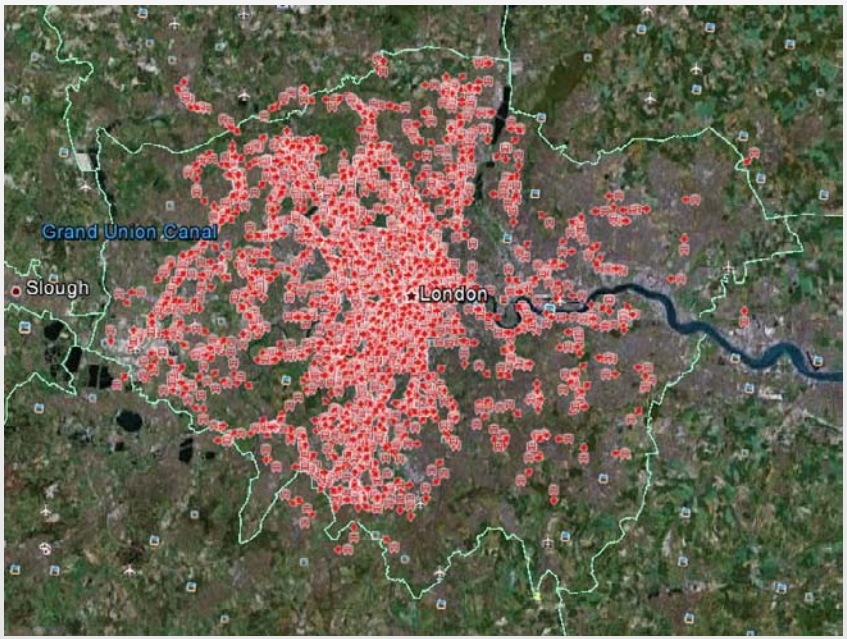
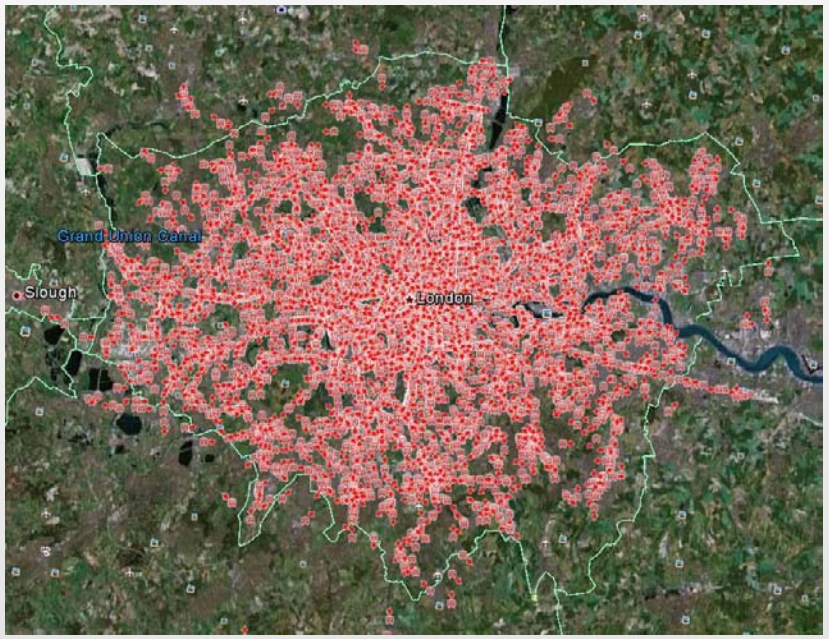
10
11

The effect of a bus strike

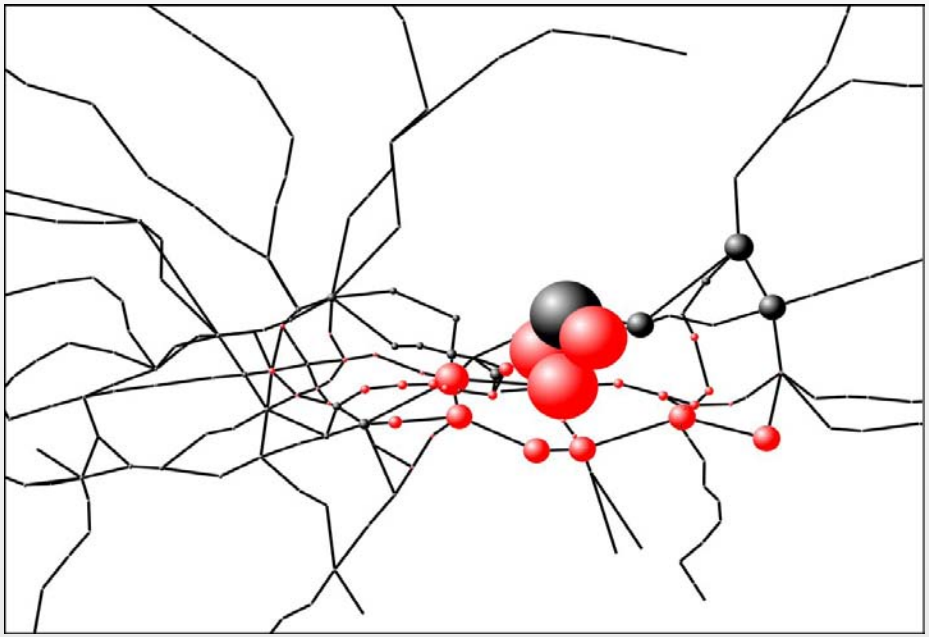


Tuesday 22nd May 2012, 09:00

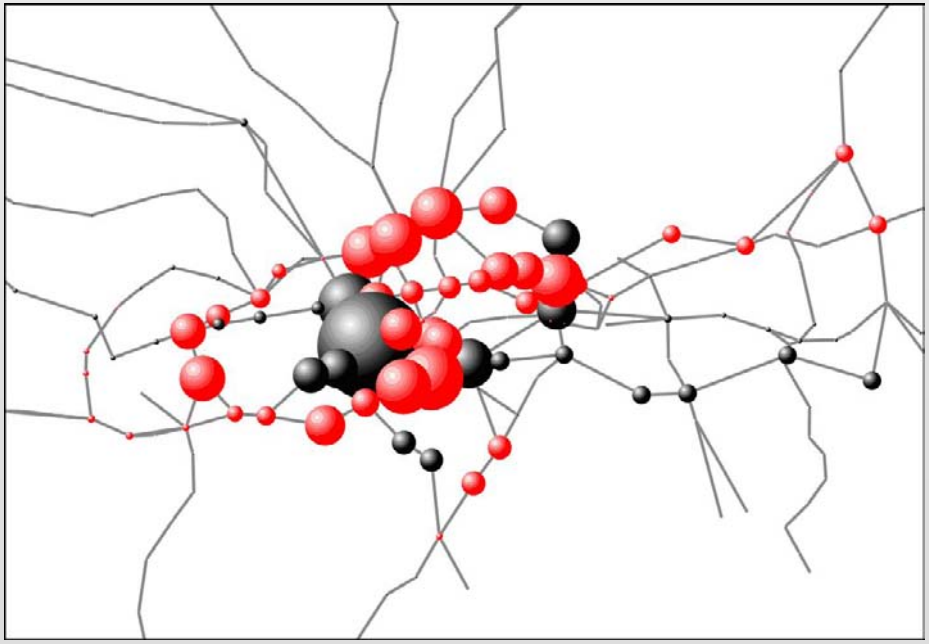


Wednesday 23rd May 2012, 09:00

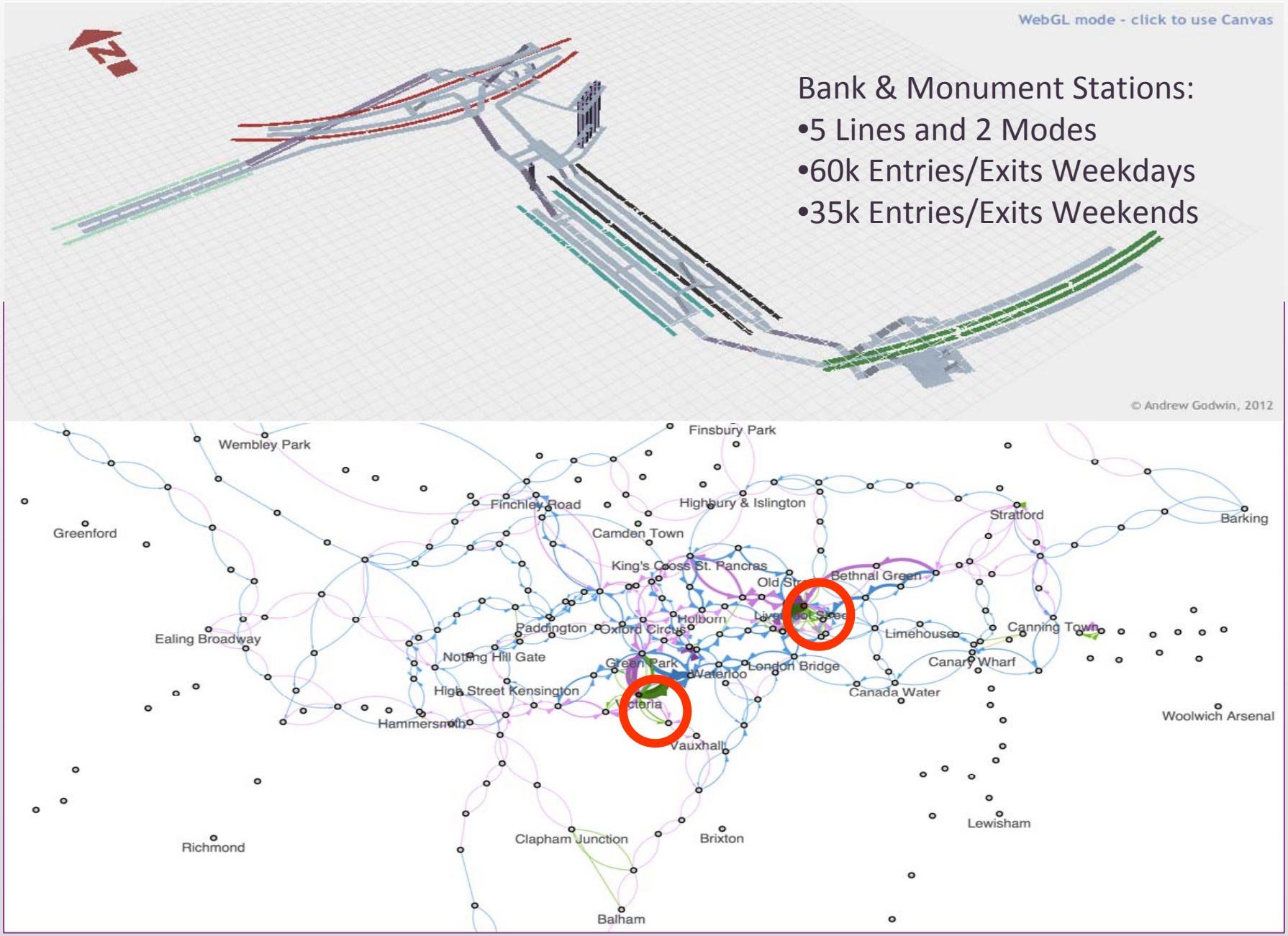
The left image shows the effect of the bus strike on 22nd May 2012, while the image on the right shows a normal day.



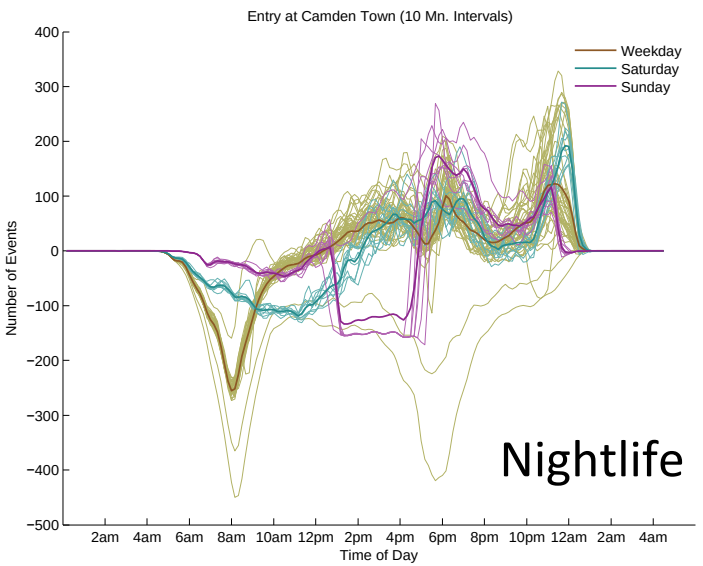
Disruption caused by closing Liverpool Street in terms of the graph of the tube network

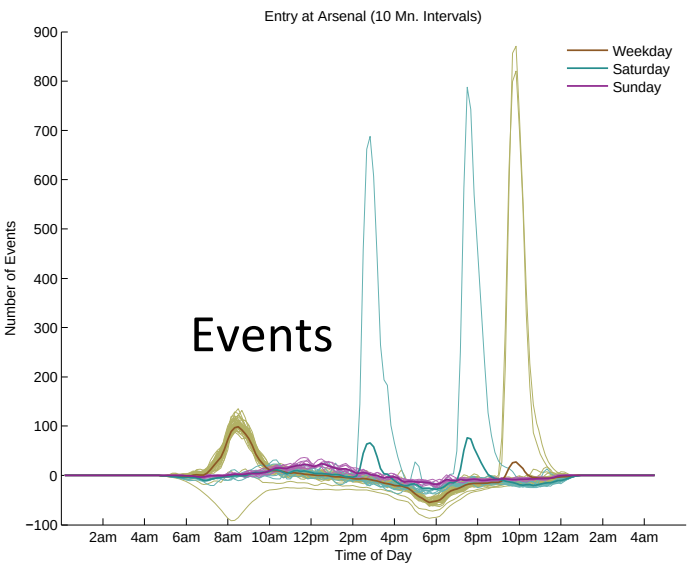


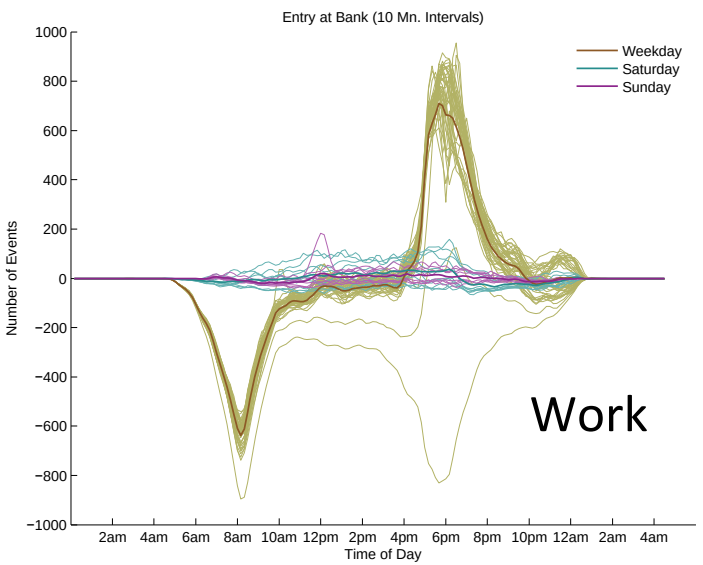
Closing Green Park – shifts in betweenness centrality

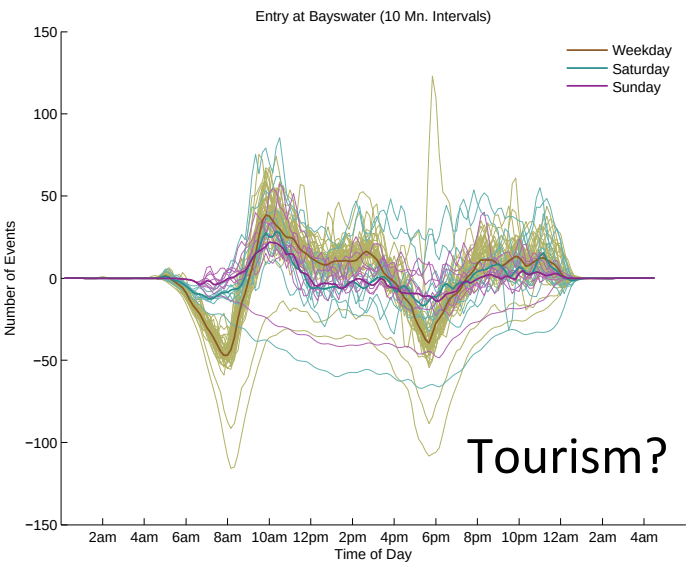

WebGL mode - click to use Canvas
Bank & Monument Stations:
•5 Lines and 2 Modes
•60k Entries/Exits Weekdays
•35k Entries/Exits Weekends
© Andrew Godwin, 2012
Finsbury Park
Wembley Park
Finchley Road
Highbury & Islington
Stratford
Barking
Greenford
Camden Town
King's Cross St. Pancras
Old St
Bethnal Green
Holborn
Paddington
Oxford Circus
Limehouse
Canning Town
Ealing Broadway
Notting Hill Gate
Green Park
Waterloo
London Bridge
Canary Wharf
High Street Kensington
Canada Water
Hammersmith
Victoria
Vauxhall
Woolwich Arsenal
Lewisham
Richmond
Clapham Junction
Brixton
Balham

Particular Events: Weekdays, Saturdays and Sundays









Simpler Systems: Public Bike as Exemplars

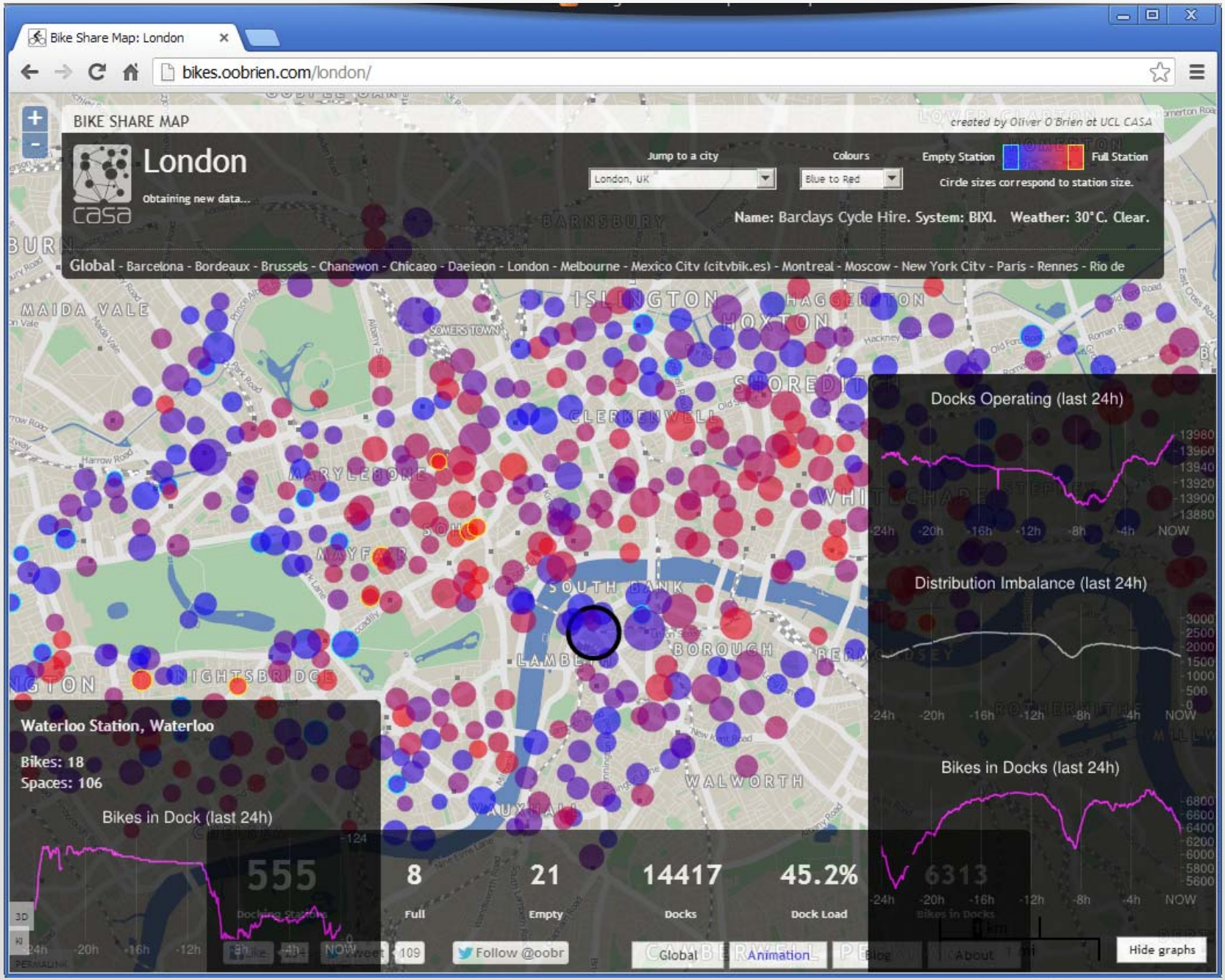
World-wide case study from Ollie O'Brien:

100 cities, 3 years of data
- Docking station status
- Journey records

Looking at cultural behaviour
- Each docking station shown by a circle
  - Blue = empty, Purple = ~50% full, Red = full
- Normally two graphs
  - Weekday (normally Wednesday)
  - Weekend (normally Saturday)

Live versions at http://bikes.oobrien.com/

Let us look at London

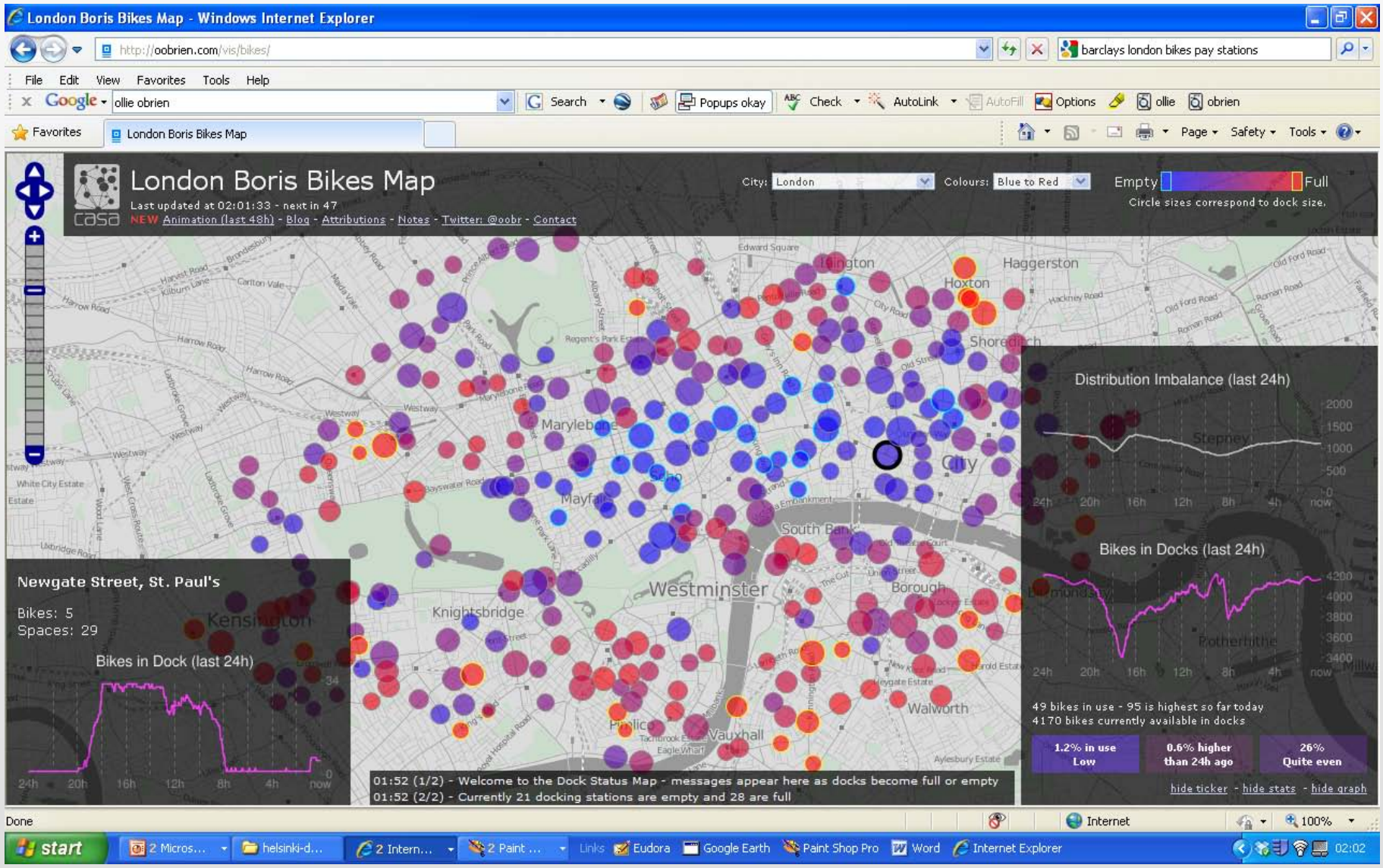

Bike Share Map: London
bikes.oobrien.com/london/
BIKE SHARE MAP
created by Oliver O'Brien at UCL CASA
London
Obtaining new data...
casa
Jump to a city
London, UK
Colours
Blue to Red
Empty Station
Full Station
Circle sizes correspond to station size.
Name: Barclays Cycle Hire. System: BIXI. Weather: 30°C. Clear.
Global - Barcelona - Bordeaux - Brussels - Chanewon - Chicago - Daejeon - London - Melbourne - Mexico City (citybik.es) - Montreal - Moscow - New York City - Paris - Rennes - Rio de
Docks Operating (last 24h)
Distribution Imbalance (last 24h)
Bikes in Docks (last 24h)
Waterloo Station, Waterloo
Bikes: 18
Spaces: 106
Bikes in Dock (last 24h)
555
Docking Stations
8
Full
21
Empty
14417
Docks
45.2%
Dock Load
6313
Bikes in Docks
Follow @oobr
Global
Animation
About
Hide graphs

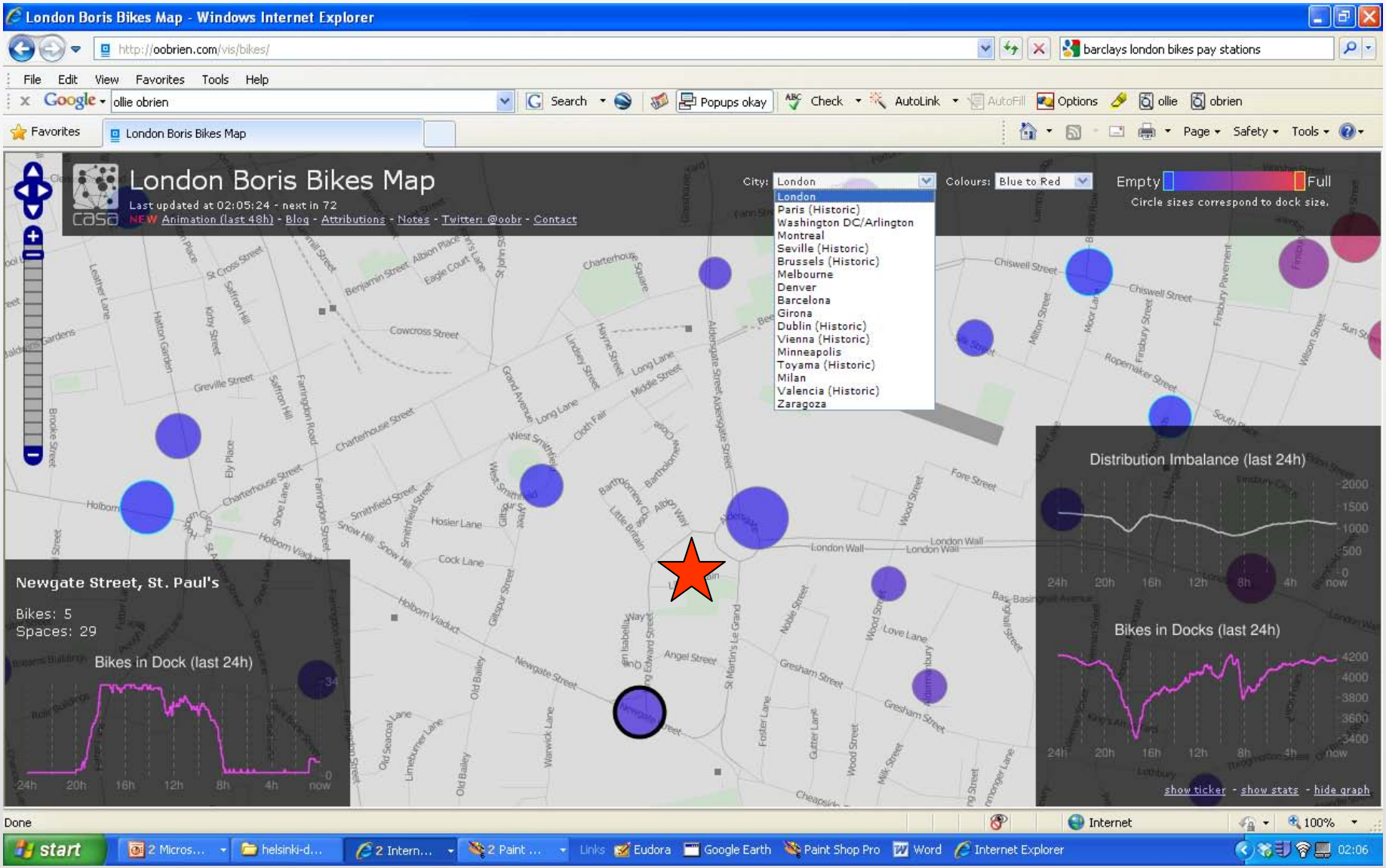
The Barclays Cycle Hire London Project

BCH commenced operations in July 2010 with **5,000 bicycles** and *315 docking stations* distributed across the City of London and parts of eight London boroughs.[10] The coverage zone spans approximately 17 square miles (44 km2), roughly matching the Zone 1 Travelcard area.

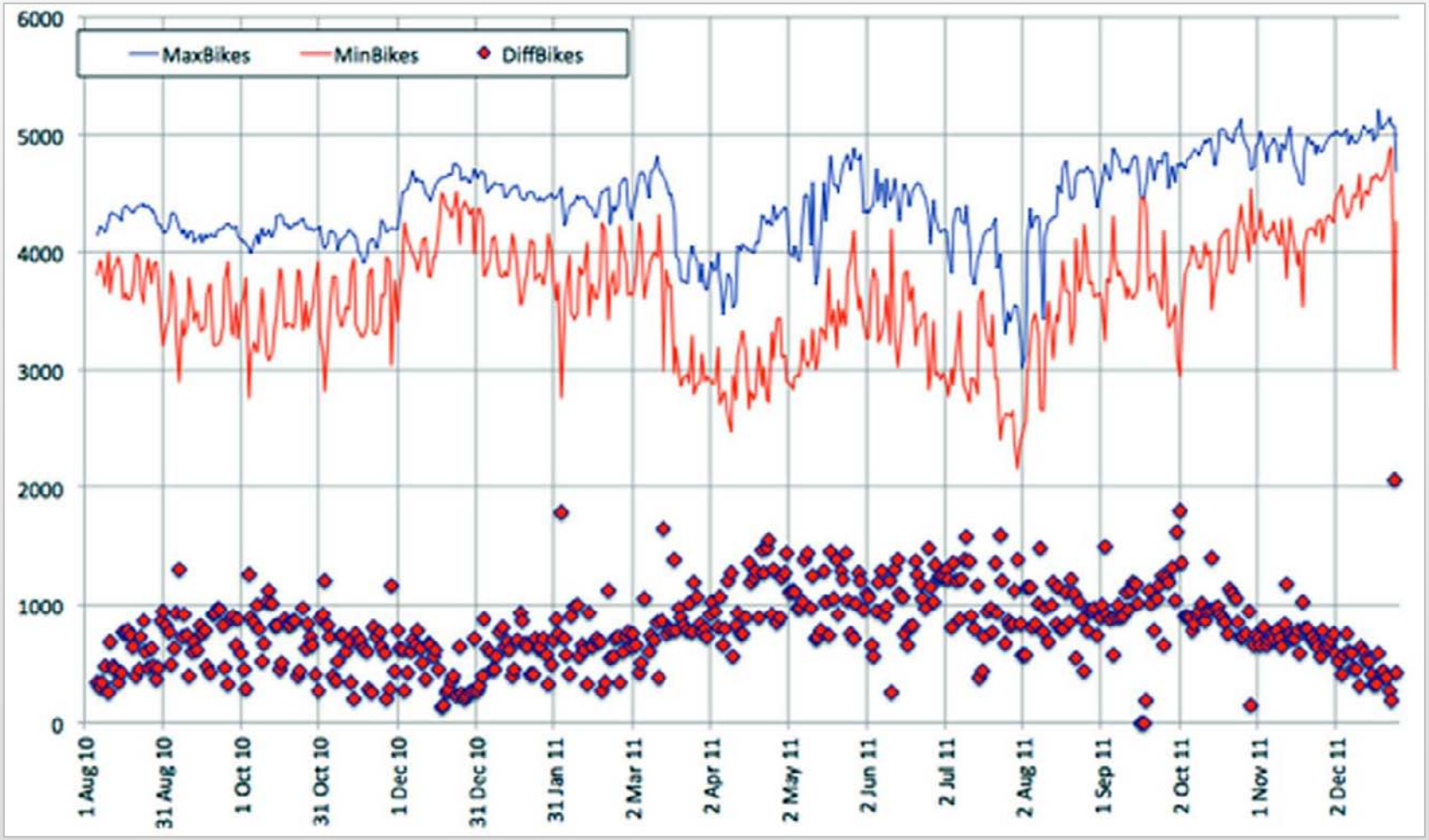
Currently there are some **8,000 'Boris Bikes'** and *570 docking stations* in the BCH scheme, which has been used for over *19 million journeys* to date

City	Official Name	Installed	System	# of Bikes
London	Barclays Cycle Hire	July 2010	Bixi	4,300
Barcelona	Bicing	March 2007	Bikemi	4,200
Milan	Bikemi	December 2008	Bicing	1,100
Saragossa	Bizi	May 2008	Bicing	800
Girona	Girocleta	September 2009	TNT	100
Washington DC and Arlington	Capital Bikeshare	September 2010	Bixi	650
Montreal	Bixi	May 2009	Bixi	4,200
Minneapolis	Nice Ride	June 2010	Bixi	600
Denver	B-cycle	April 2010	B-cycle	350
Melbourne	Bike Share	June 2010	Bixi	400

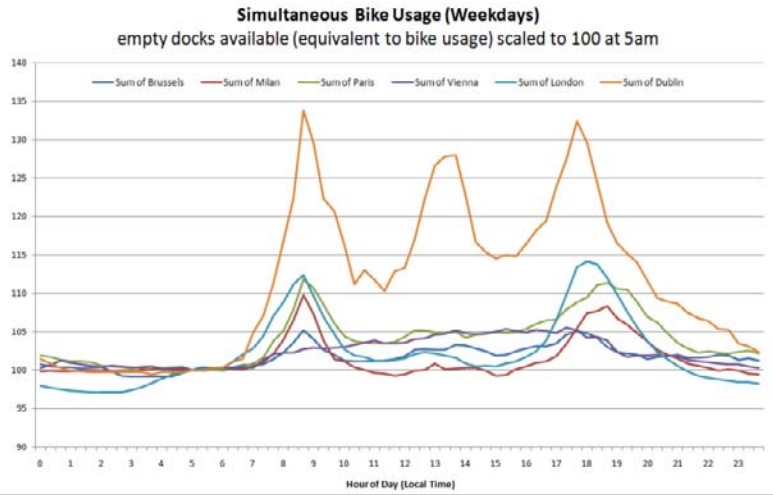

London Boris Bikes Map - Windows Internet Explorer
http://oobrien.com/vis/bikes/
barclays london bikes pay stations
File Edit View Favorites Tools Help
ollie obrien
Popups okay
Check
AutoLink
Options
ollie
obrien
Favorites
London Boris Bikes Map
Page
Safety
Tools
London Boris Bikes Map
Last updated at 02:01:33 - next in 47
NEW Animation (last 48h) - Blog - Attributions - Notes - Twitter: @oobr - Contact
City: London
Colours: Blue to Red
Empty
Full
Circle sizes correspond to dock size.
Distribution Imbalance (last 24h)
Bikes in Docks (last 24h)
Newgate Street, St. Paul's
Bikes: 5
Spaces: 29
Bikes in Dock (last 24h)
49 bikes in use - 95 is highest so far today
4170 bikes currently available in docks
1.2% in use
Low
0.6% higher than 24h ago
26%
Quite even
hide ticker - hide stats - hide graph
01:52 (1/2) - Welcome to the Dock Status Map - messages appear here as docks become full or empty
01:52 (2/2) - Currently 21 docking stations are empty and 28 are full
Done
Internet
100%
start
Eudora
Google Earth
Paint Shop Pro
Word
Internet Explorer
02:02



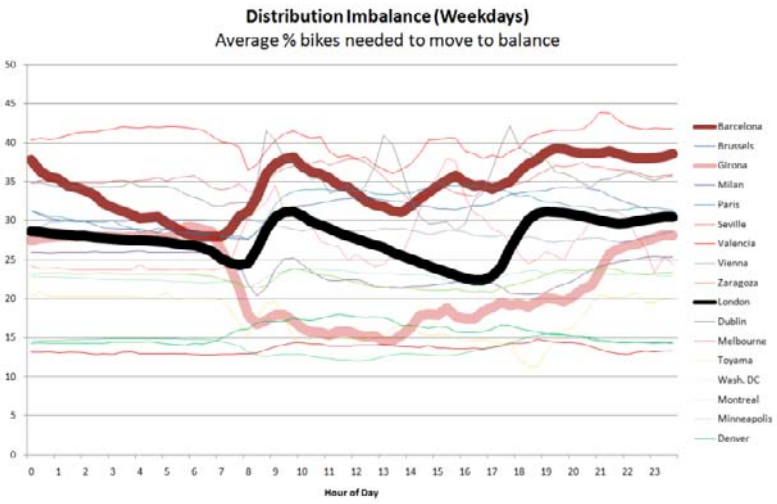
As yet no records of demand from people logging on, so no management capabilities, but could happen probably from an App based software but maybe from the server


MaxBikes
MinBikes
DiffBikes
6000
5000
4000
3000
2000
1000
0
1 Aug 10
31 Aug 10
1 Oct 10
31 Oct 10
1 Dec 10
31 Dec 10
31 Jan 11
2 Mar 11
2 Apr 11
2 May 11
2 Jun 11
2 Jul 11
2 Aug 11
1 Sep 11
2 Oct 11
1 Nov 11
2 Dec 11

Weekday Use – 1. Europe ex-Spain

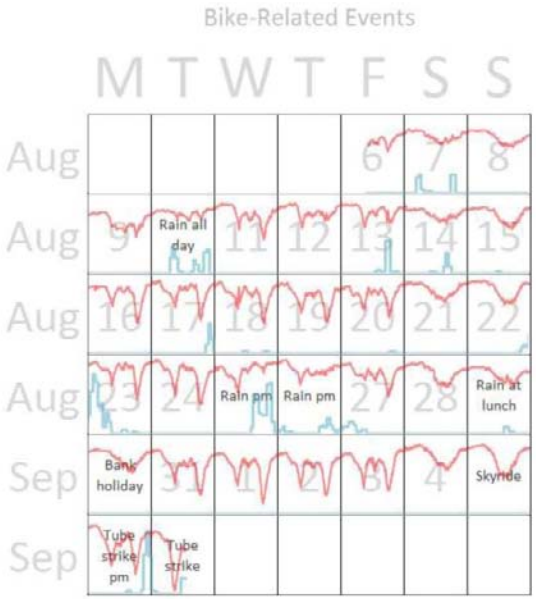


Redistribution Effectiveness



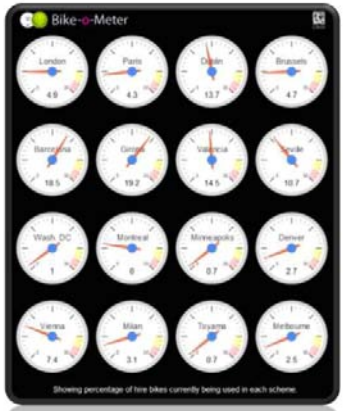
More Analysis

- **London**
- Graph shows number of bikes available to hire
- Effect of rain
  - Using the CASA weather station
- Effect of the tube strikes

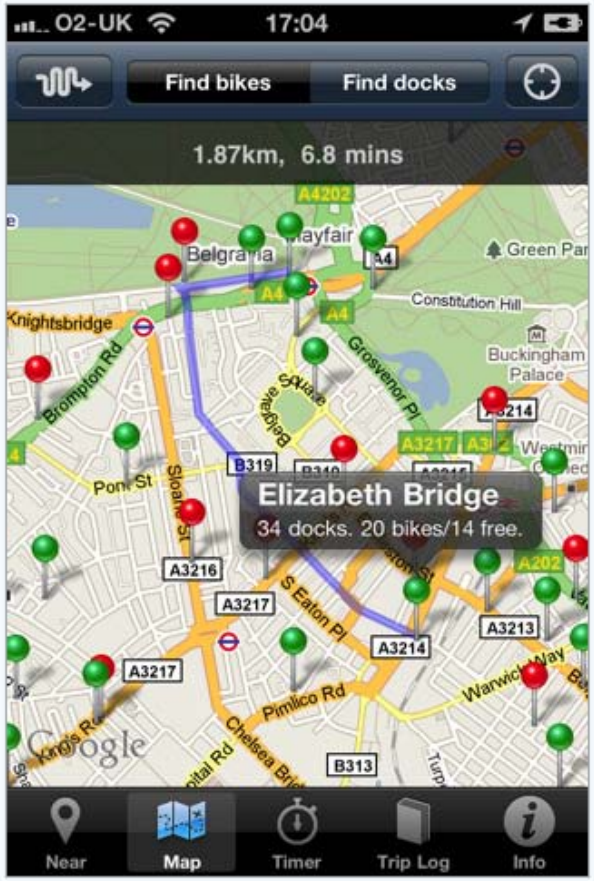


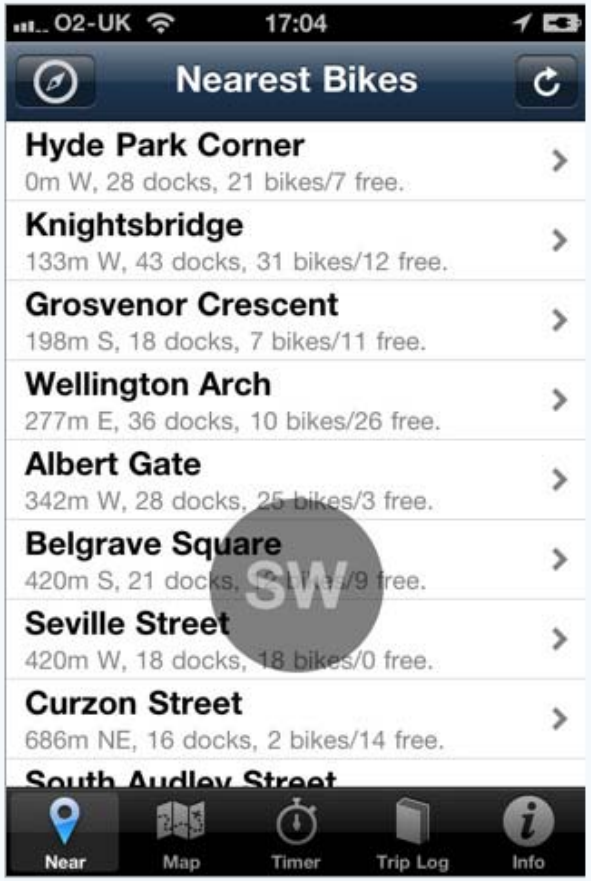
Bike-o-Meter
casa.ucl.ac.uk/bom

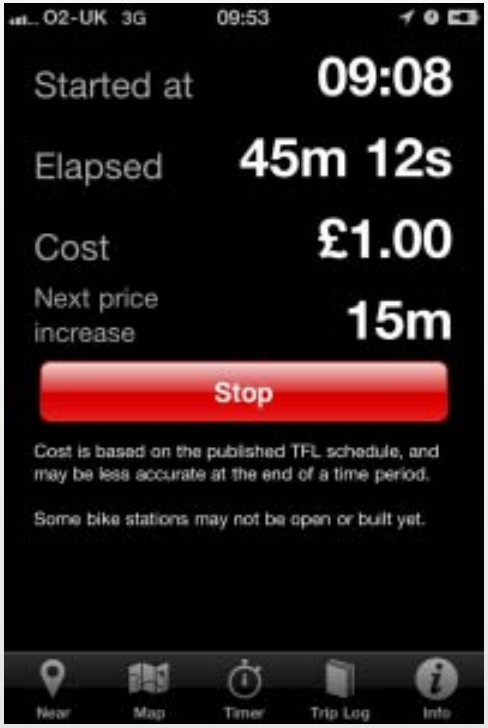
- Tweet-o-Meter for bikes
  - Steven Gray (@frogo)
  - Using Google Gauges
- See the real life Tweet-o-Meters at the new British Library "Growing Knowledge" exhibition
  - Should be easy to hack to show the Bike-o-Meters instead ☺



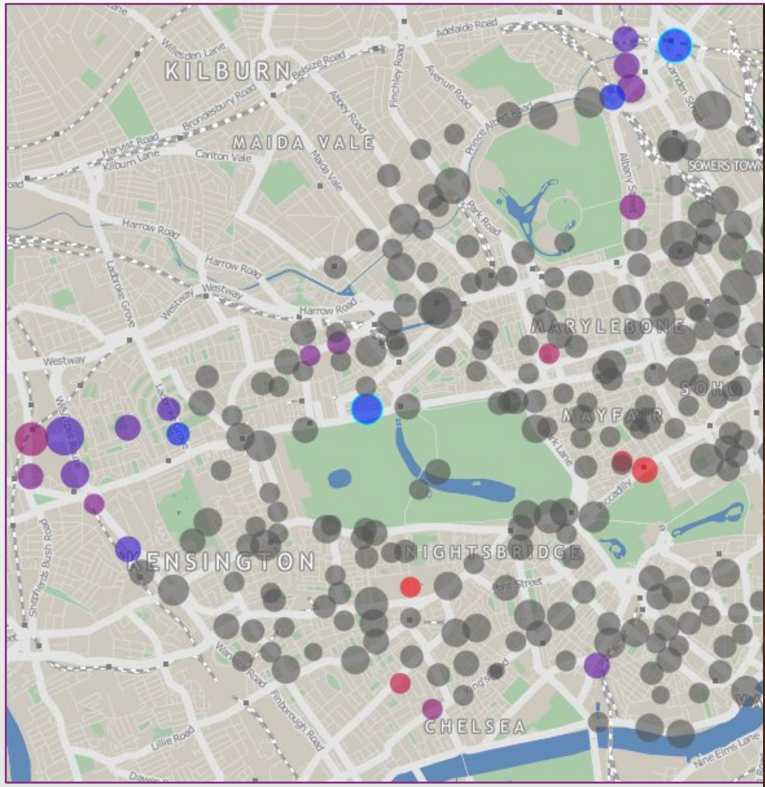
iPhone Screenshots





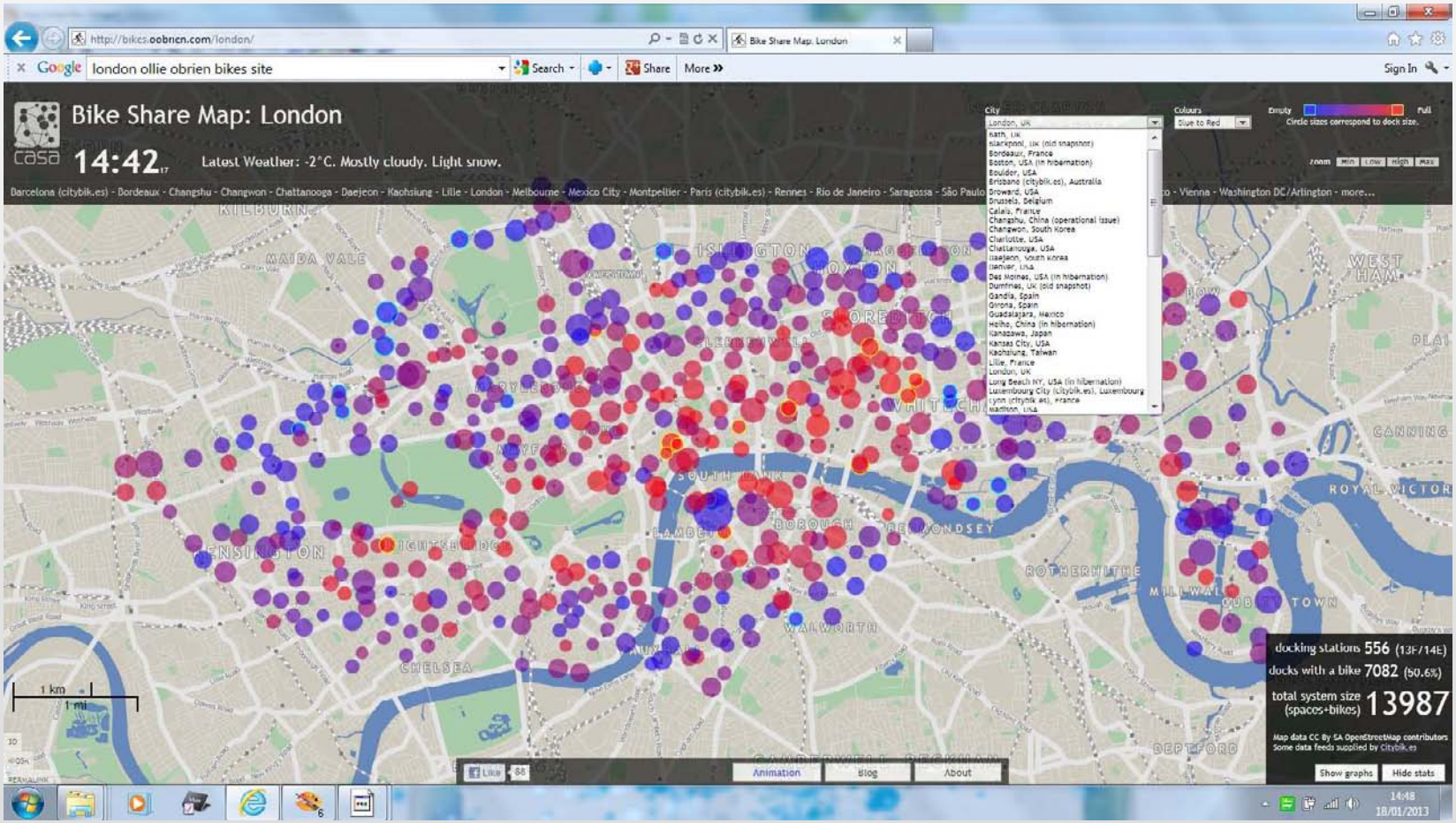


http://oobrien.com/vis/bikes/

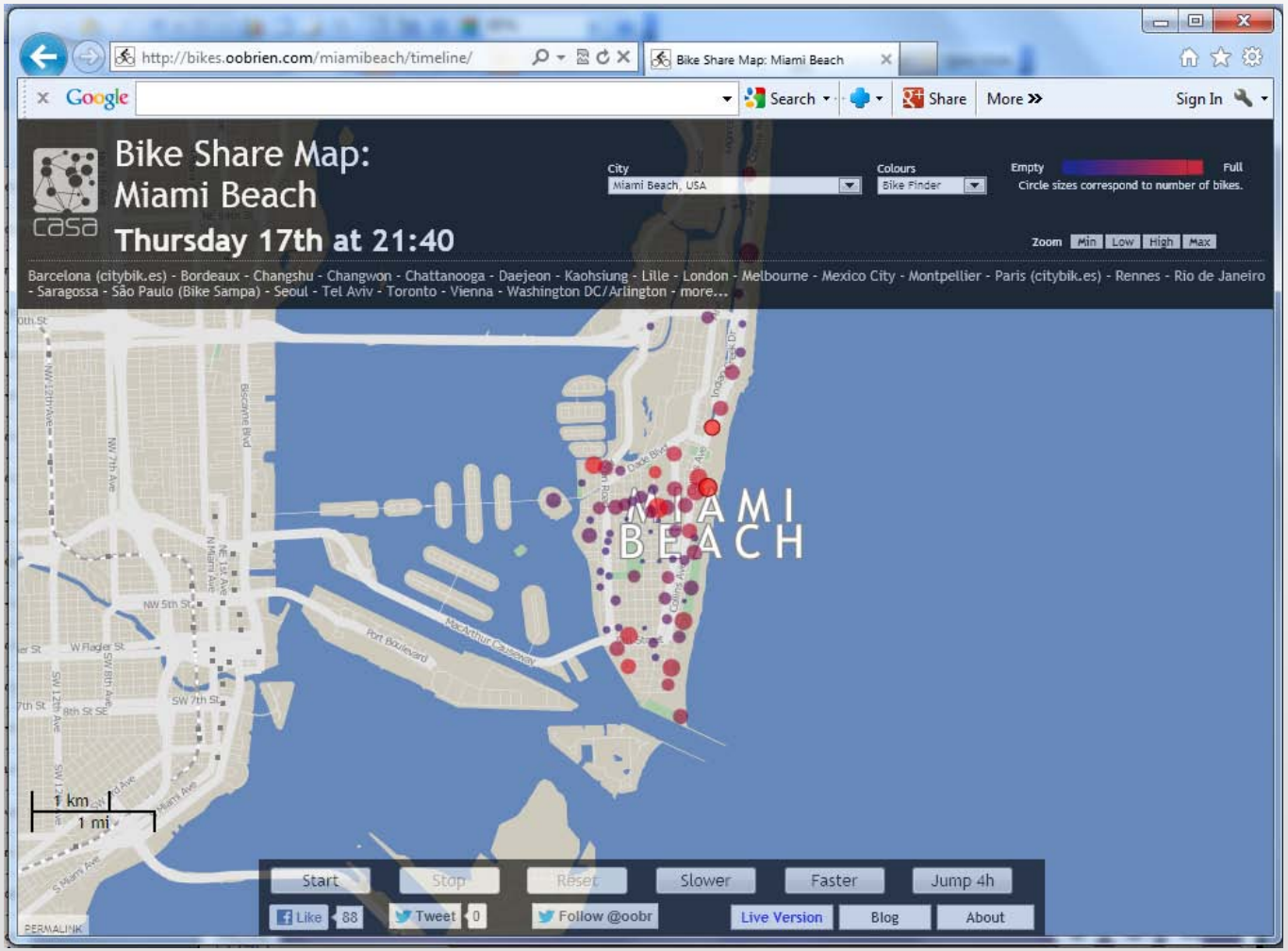

KILBURN
MAIDA VALE
SOMERS TOWN
MARYLEBONE
SOHO
MAYFAIR
KENSINGTON
KNIGHTSBRIDGE
CHELSEA


Transport for London
Barclays Cycle Hire
extends east
from 8 March
tfl.gov.uk/barclayscyclehire
MAYOR OF LONDON
catch up with
BARCLAYS
CYCLE HIRE

The Website: Real Time Visualisation of Origins and Destinations Activity http://bikes.oobrien.com/london/

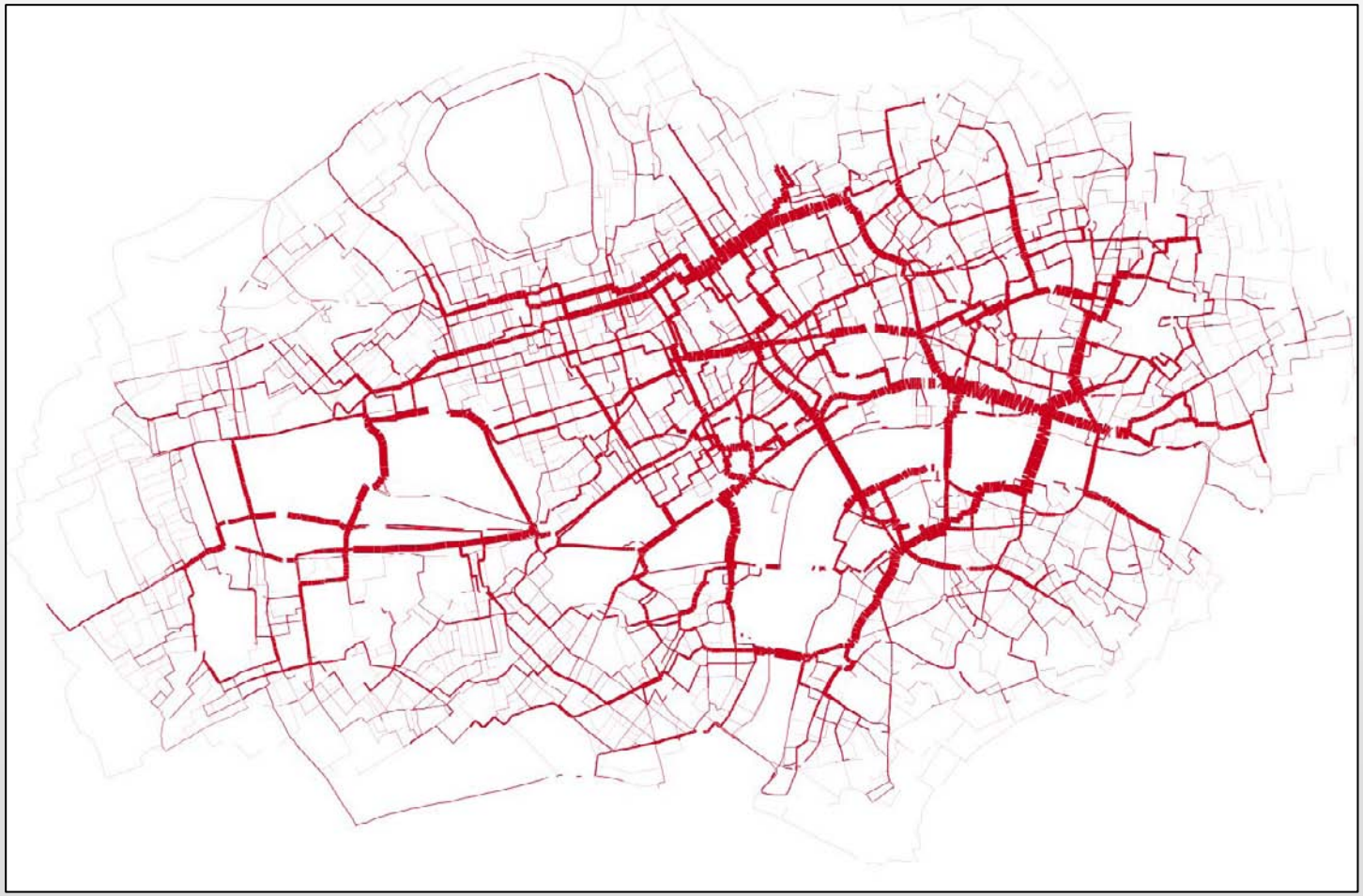


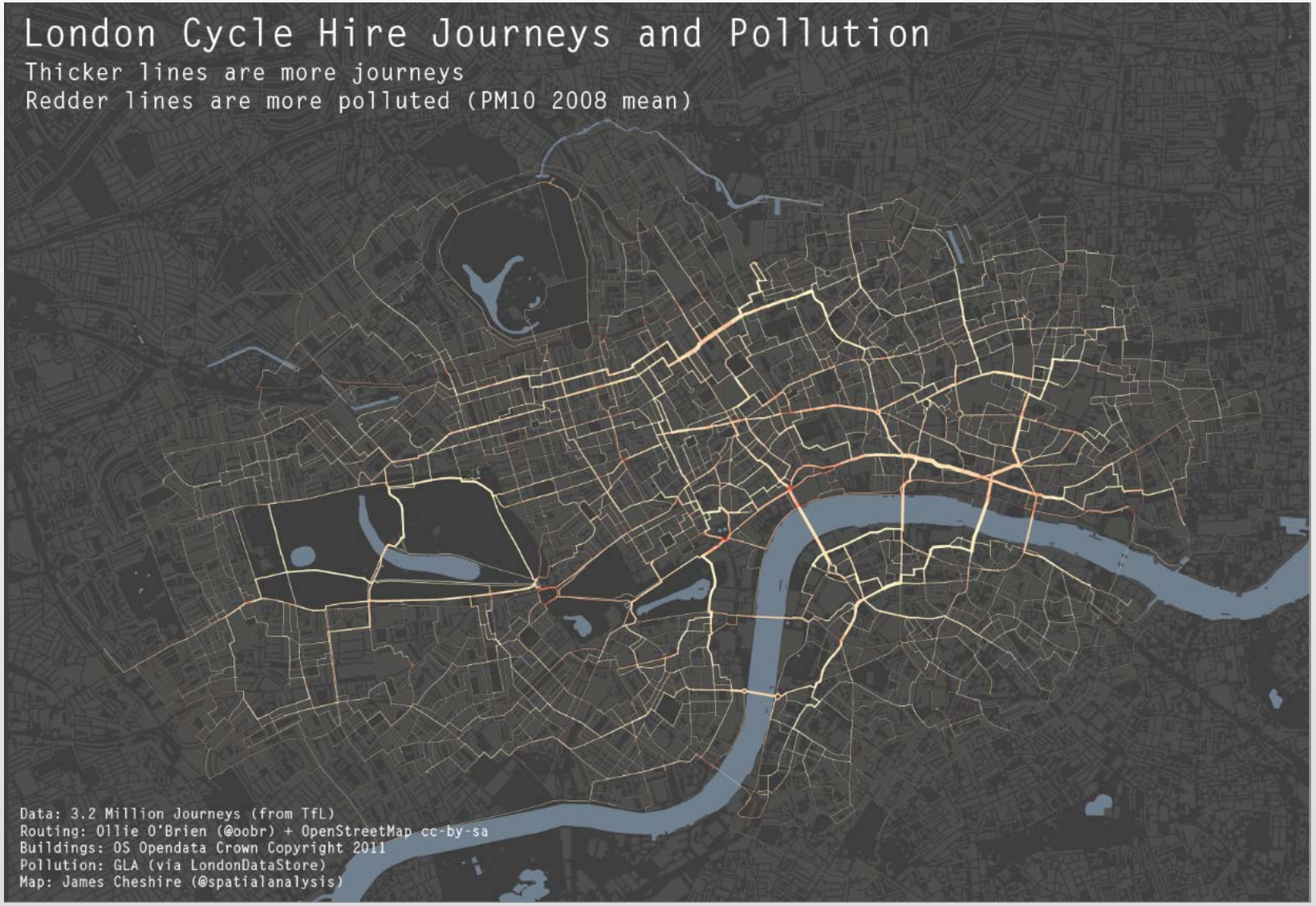
Your can play back the last couple of days from the animator for many of the cities where the data is captured online



Initial Analyses

Flows – Origins and Destinations



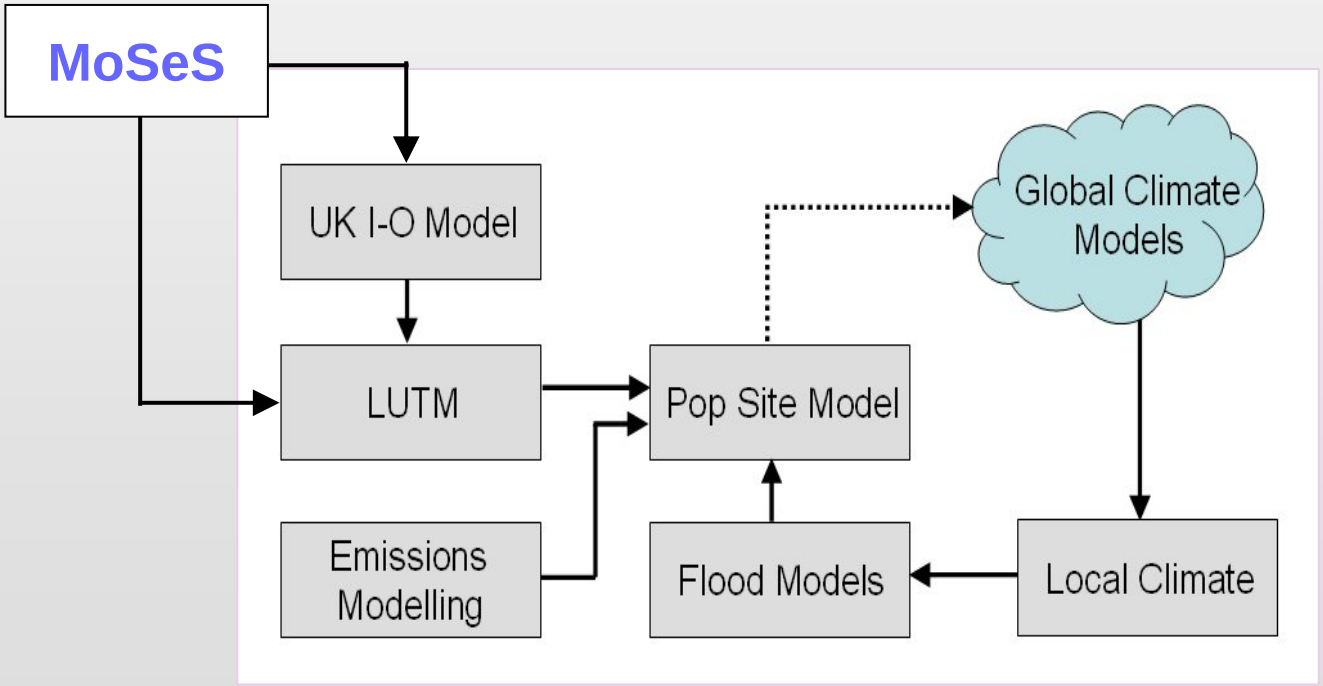

London Cycle Hire Journeys and Pollution
Thicker lines are more journeys
Redder lines are more polluted (PM10 2008 mean)
Data: 3.2 Million Journeys (from TfL)
Routing: Ollie O'Brien (@oobr) + OpenStreetMap cc-by-sa
Buildings: OS Opendata Crown Copyright 2011
Pollution: GLA (via LondonDataStore)
Map: James Cheshire (@spatialanalysis)

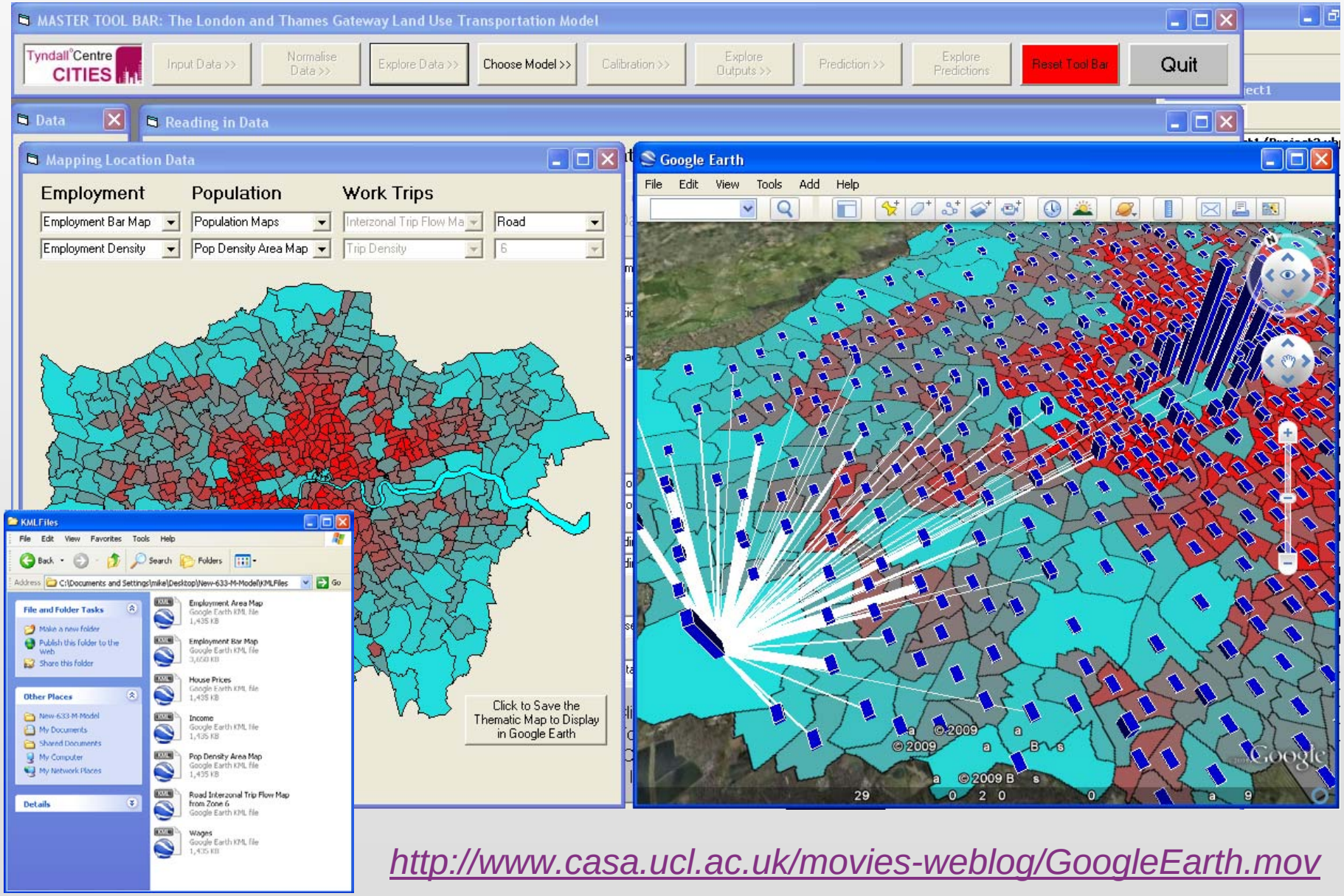
Thre are quite a few visualisations on Vimeo which have been developed by James Cheshire and Martin Austwick where they have used shortest routes methods to figure out bike paths

http://vimeo.com/19982736 **And one from Jo Wood at City University** http://vimeo.com/33712288

Long & Short Term Flooding: The Tyndall Cities Project

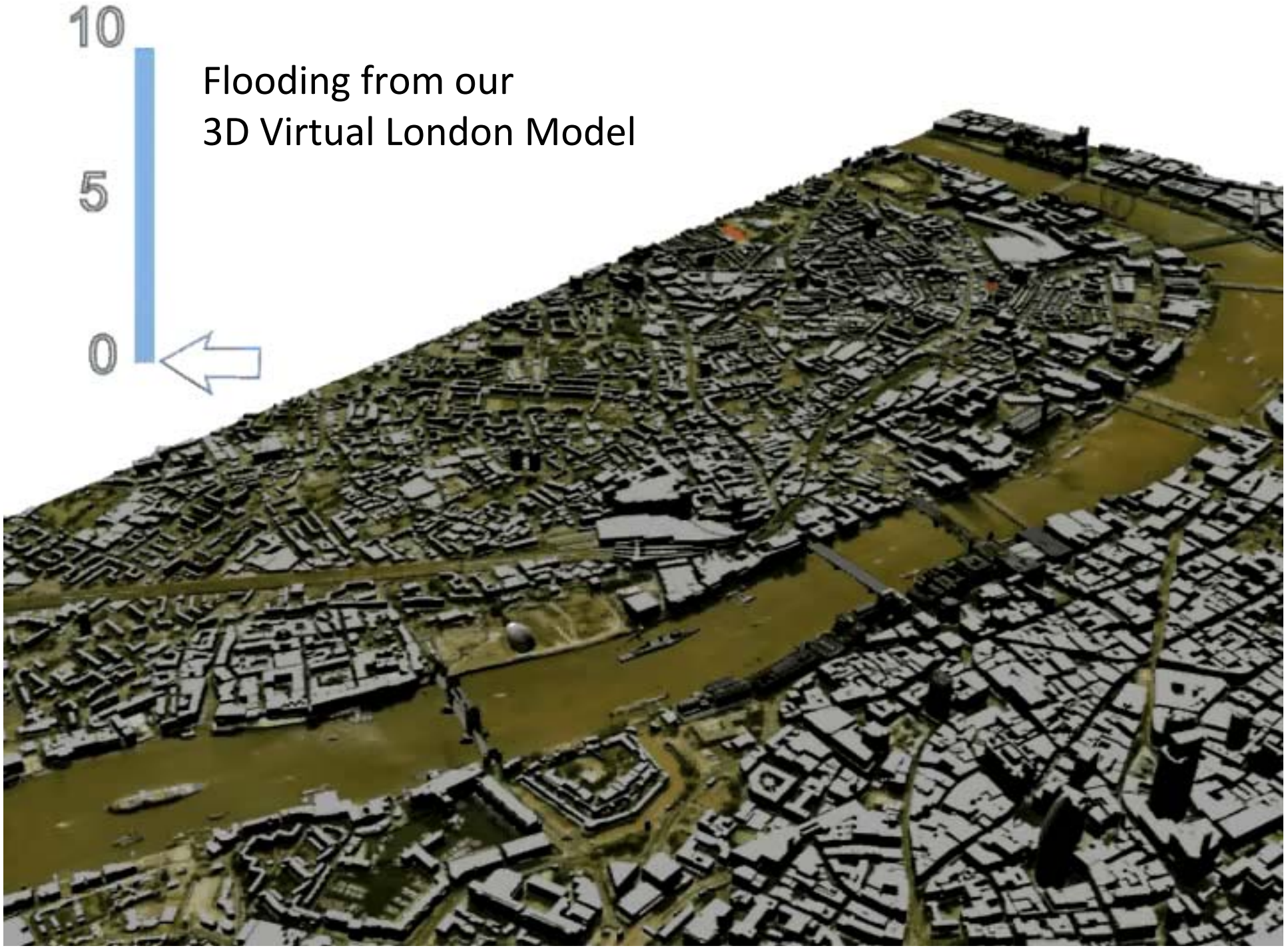
We have been involved in a large consortium project led by Newcastle Civ Eng to look at an integrated assessment of climate change in Greater London

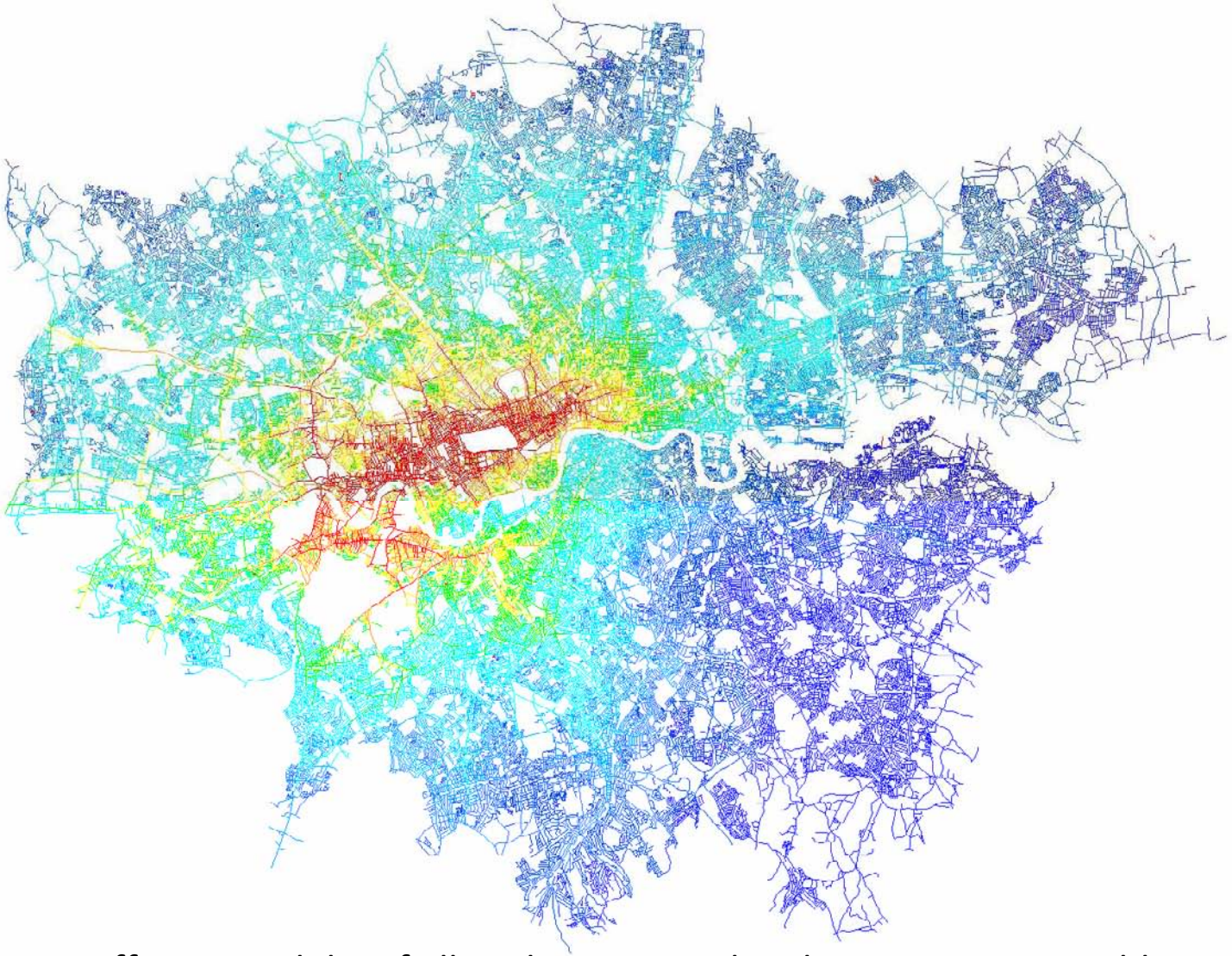




http://www.casa.ucl.ac.uk/movies-weblog/GoogleEarth.mov

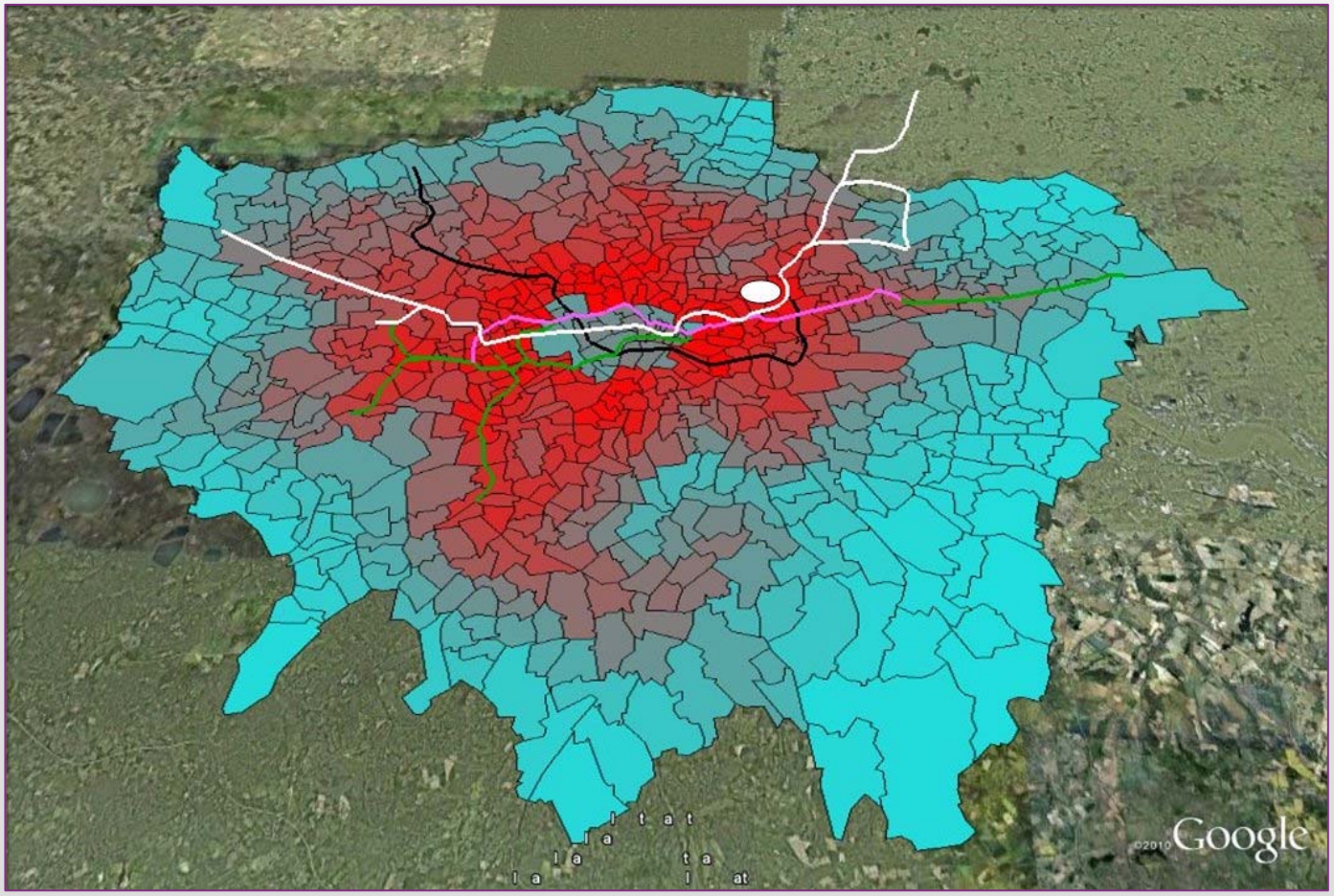
Flooding from our
3D Virtual London Model



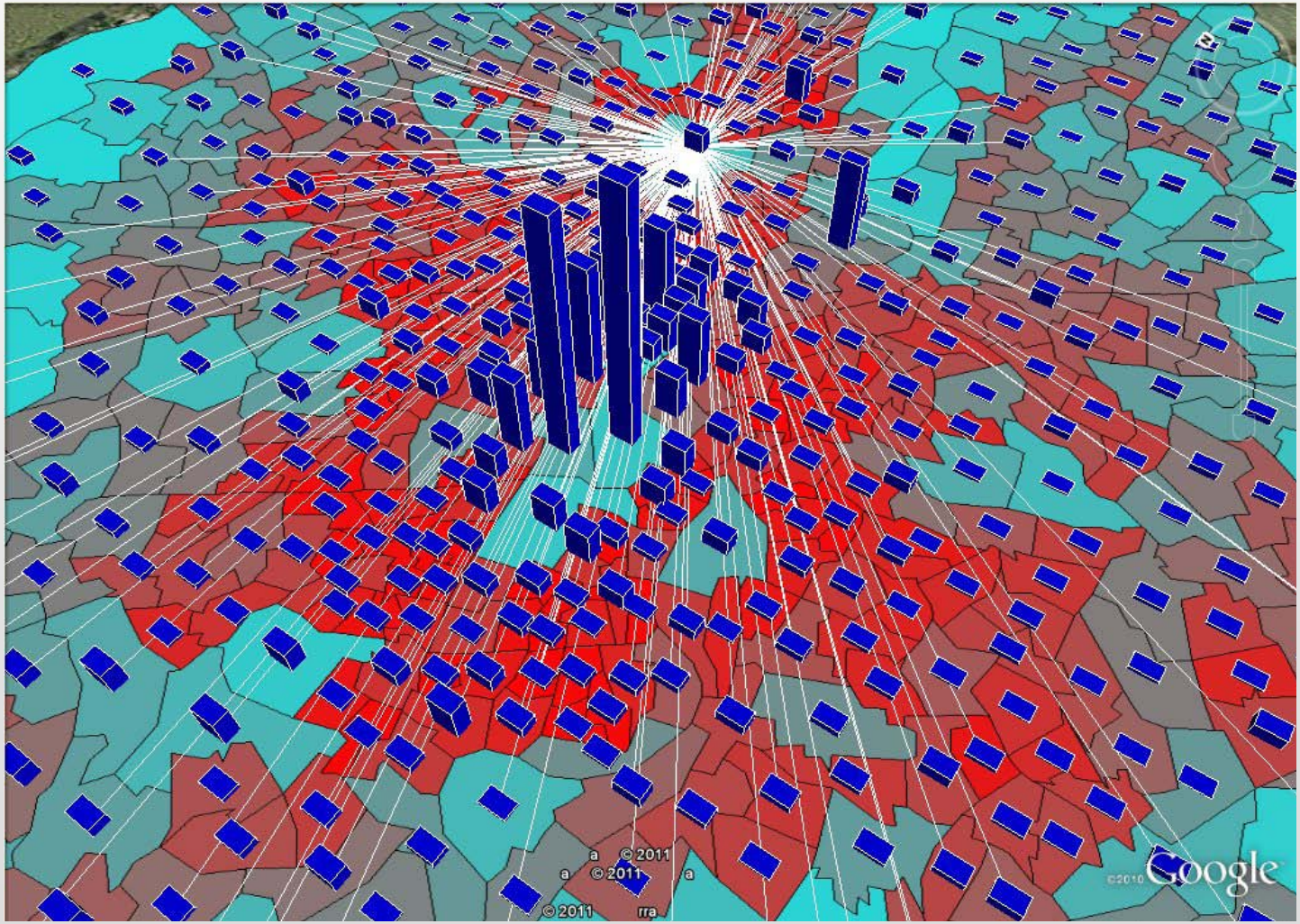


Shifts in Traffic Accessibility if all Bridges across the Thames are Inoperable as far West as Hammersmith

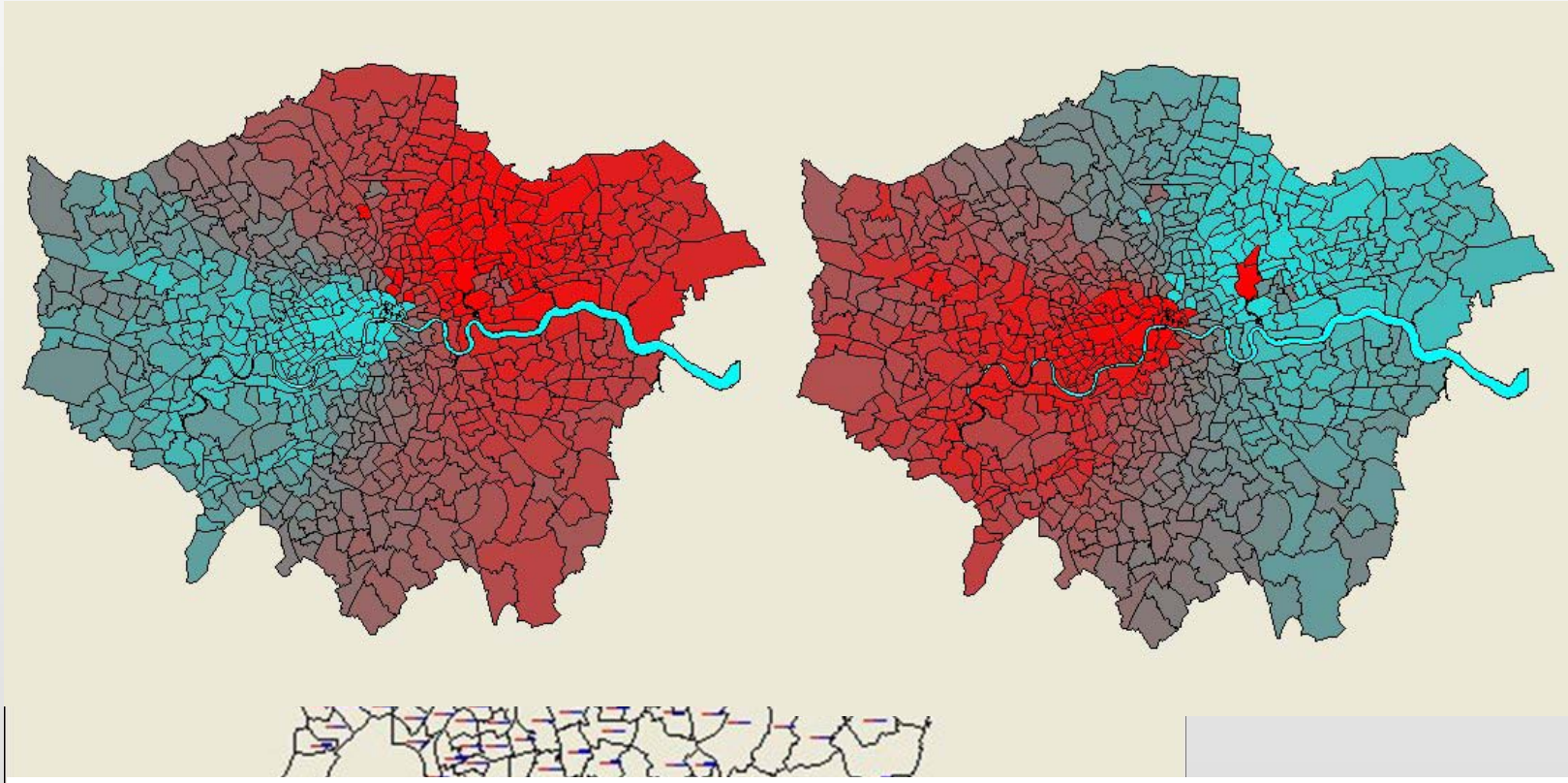
Big Disruptions/Additions in Infrastructure: The Olympics games Regeneration of East London and Cross Rail



The Impact of Additional Employment and Population at the Olympic Games Site in East London

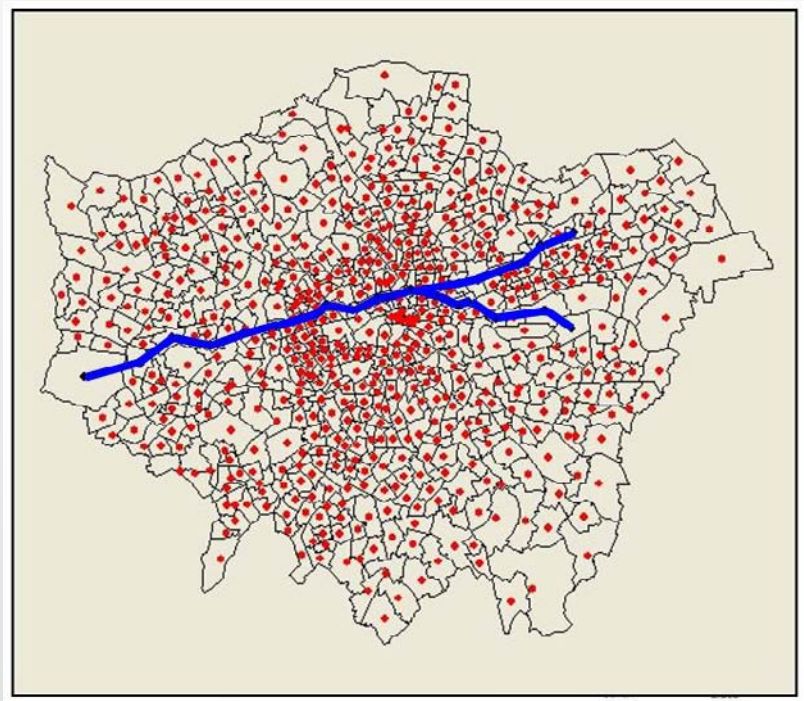


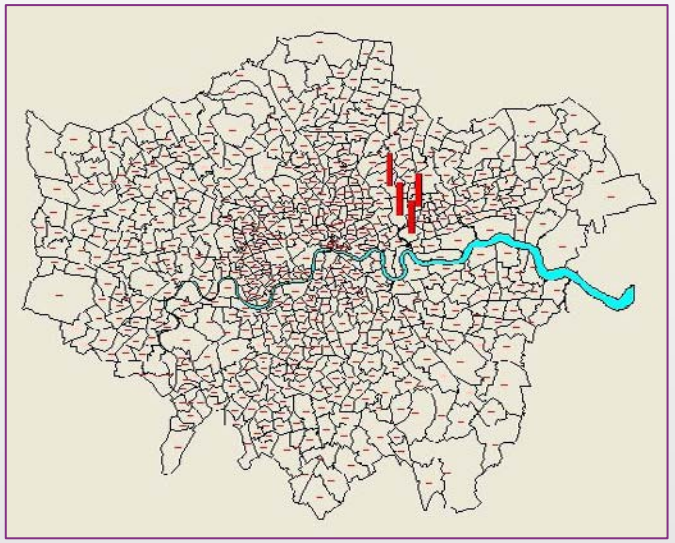
Absolute Gains in Population (left) in East London but Relative% Gains in Population in West London (right)

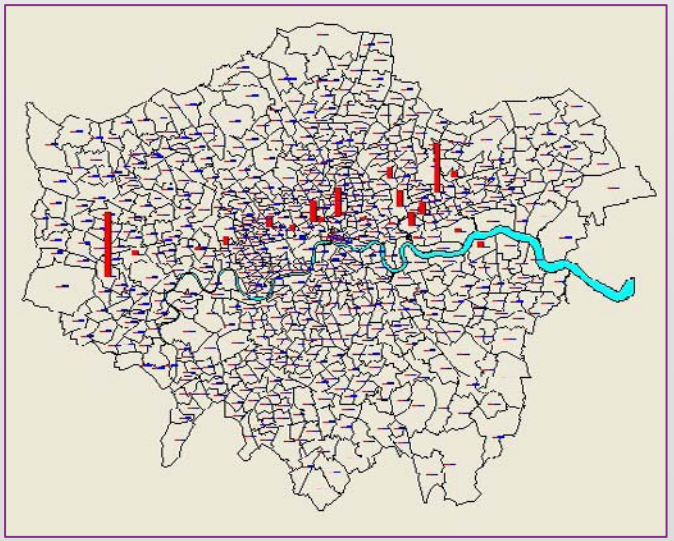


M. Batty (2012) Urban Regeneration as Self-Organisation, **Architectural Design**, **215**, 54-59

Cross Rail: The High Speed Rail Line from Maidenhead to Stratford – 30 trains an hour each way







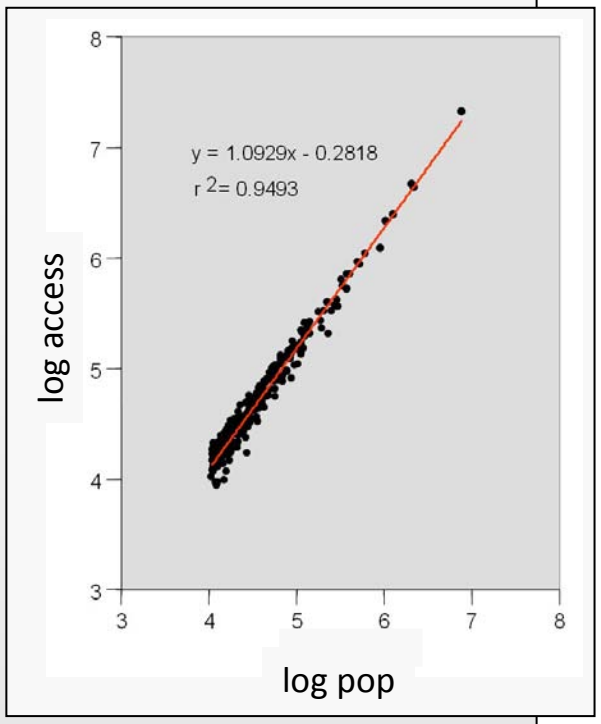
Regional Breakdown: Phase Transitions

My last example shifts scale massively to the entire country. We are working on a problem essentially in the regional economic geography of the UK – or at least England, Wales and Scotland examining how prosperous cities are with scale.

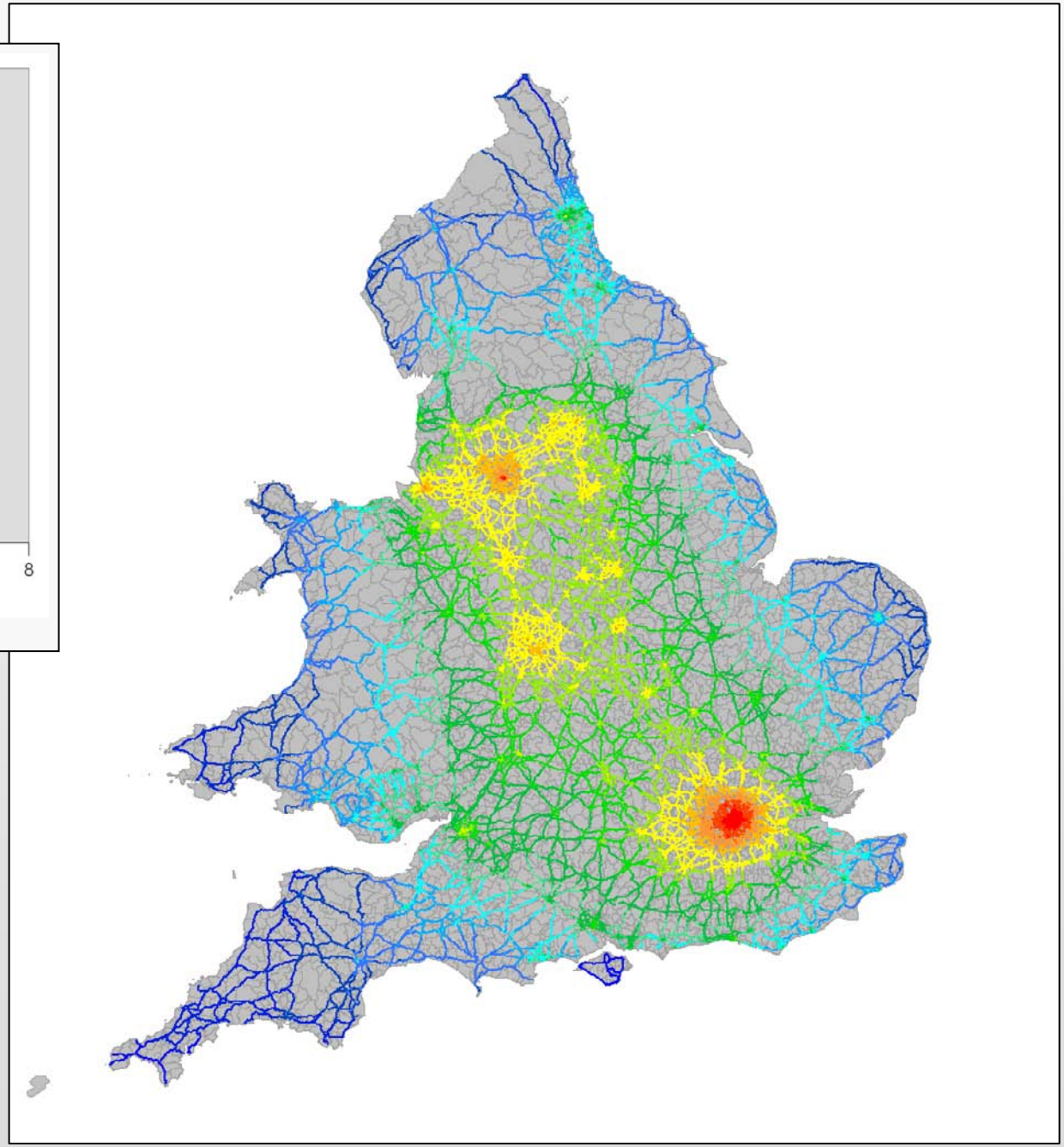
This is called allometry of city sizes – the idea is that as cities grow they generate economies of scale and to cut a long story short, their per capita income grows with size. This is called superlinearity – in short their metabolism get faster with size – the pace of life gets faster, congestion gets greater and crime gets greater per capita as does income, inventiveness and so on

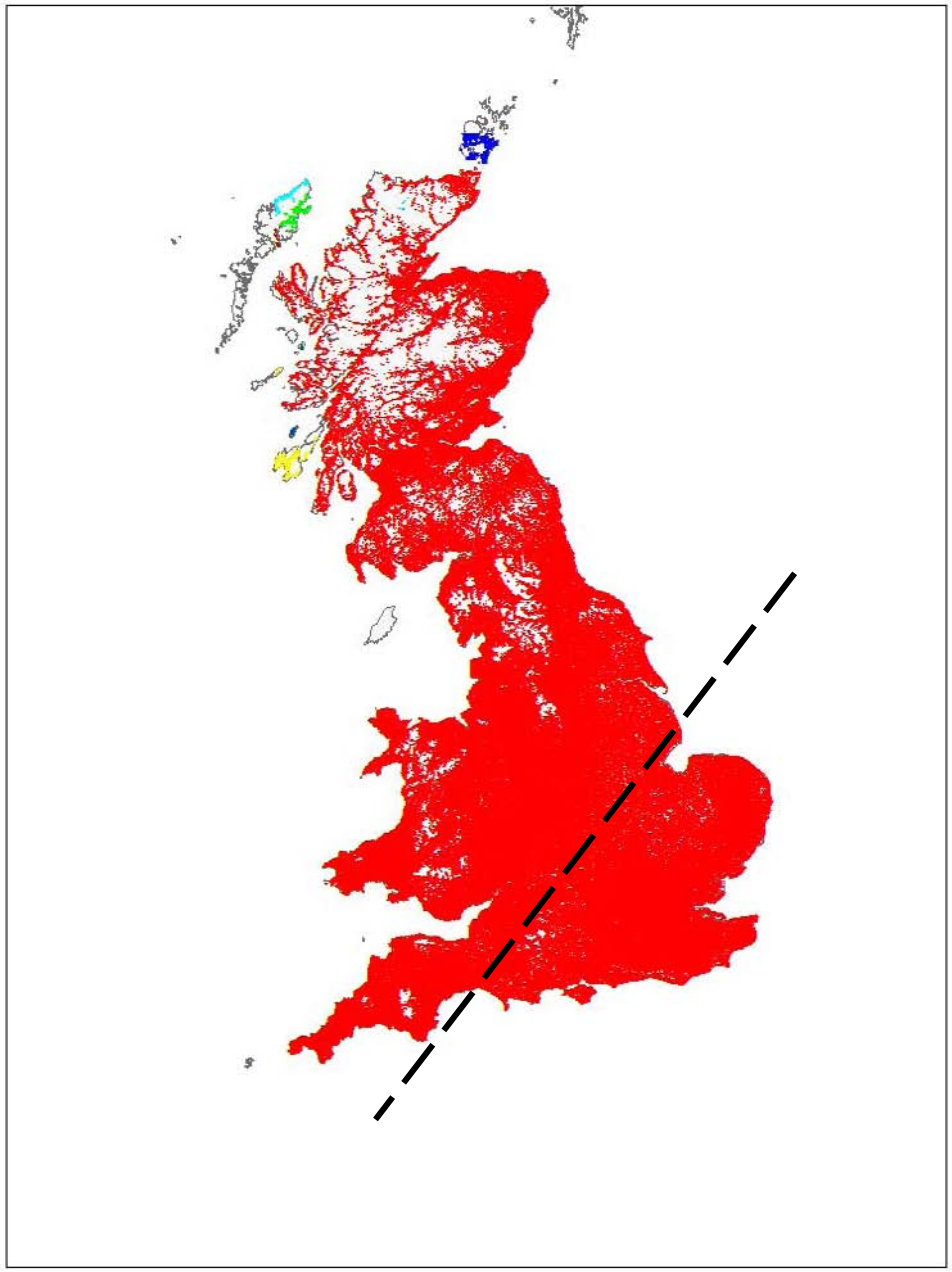
I cant go into this in any detailed but to do this we need to construct cities from the ground up – to define them – the work done in the US for MSAs indicates that for every doubling of city size, income more than doubles going up by 215% or so.

In the UK we have not found this – incomes do not go up superlinearly but linearly and this we believe is due to many factors – it may well be that the UK urban system is much more integrated than the US – more global and it may be that policy, historical path dependence of how the country has developed and so on is key – we don't know but we need to define proper defintions of cities and this we are using percolation theory to do this – let me give you a sense of how we can break up the regional system from the UK network



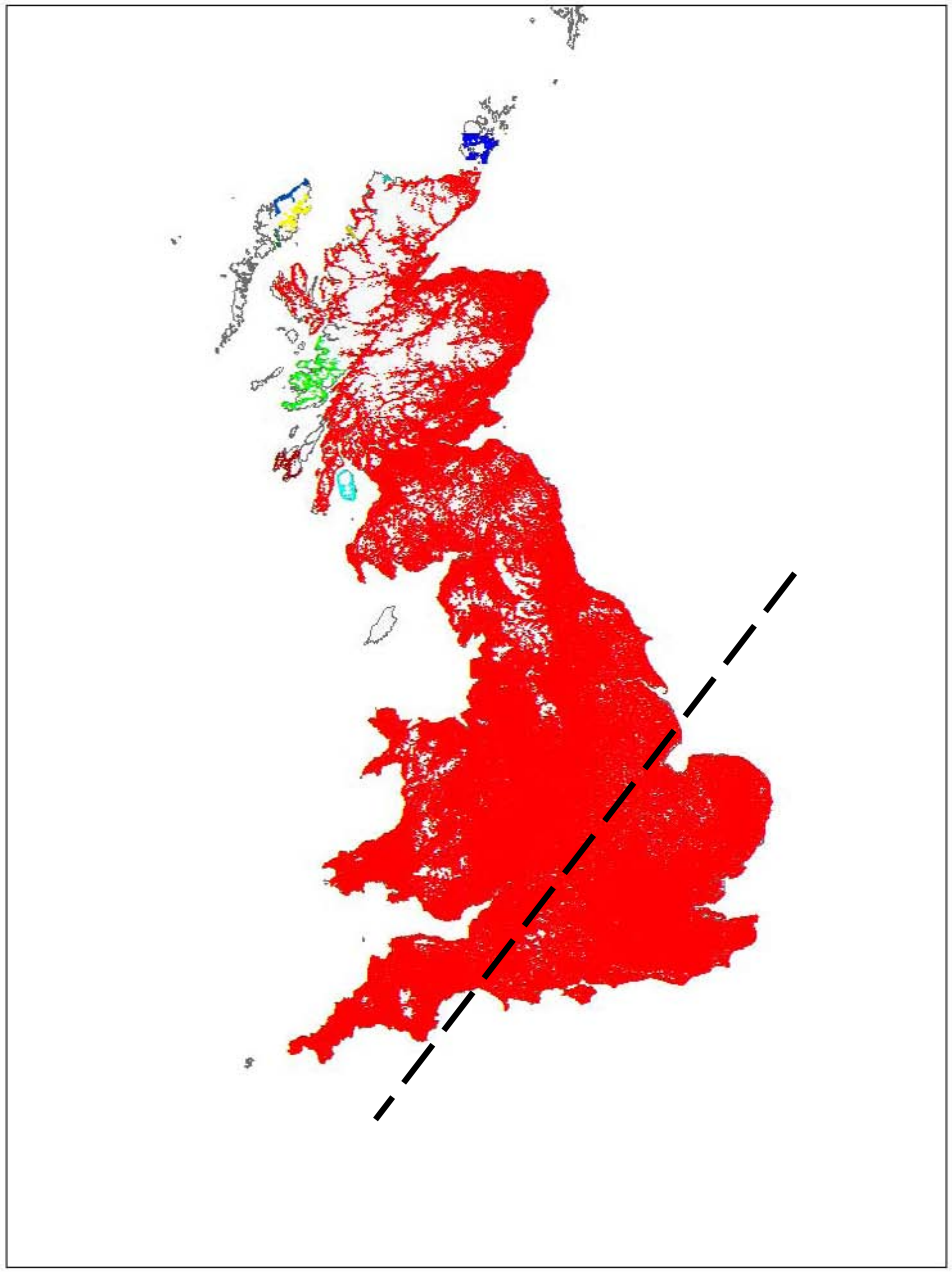
A Theory of City Size, **Science**, 21 June 2013: Vol. 340, 1418-1419





What we do is we decrease the distance threshold for places to connect with one another systematically, starting from any integrated system – where we show the top ten clusters in terms of size

This reveals the splits in the system eventually giving us cities



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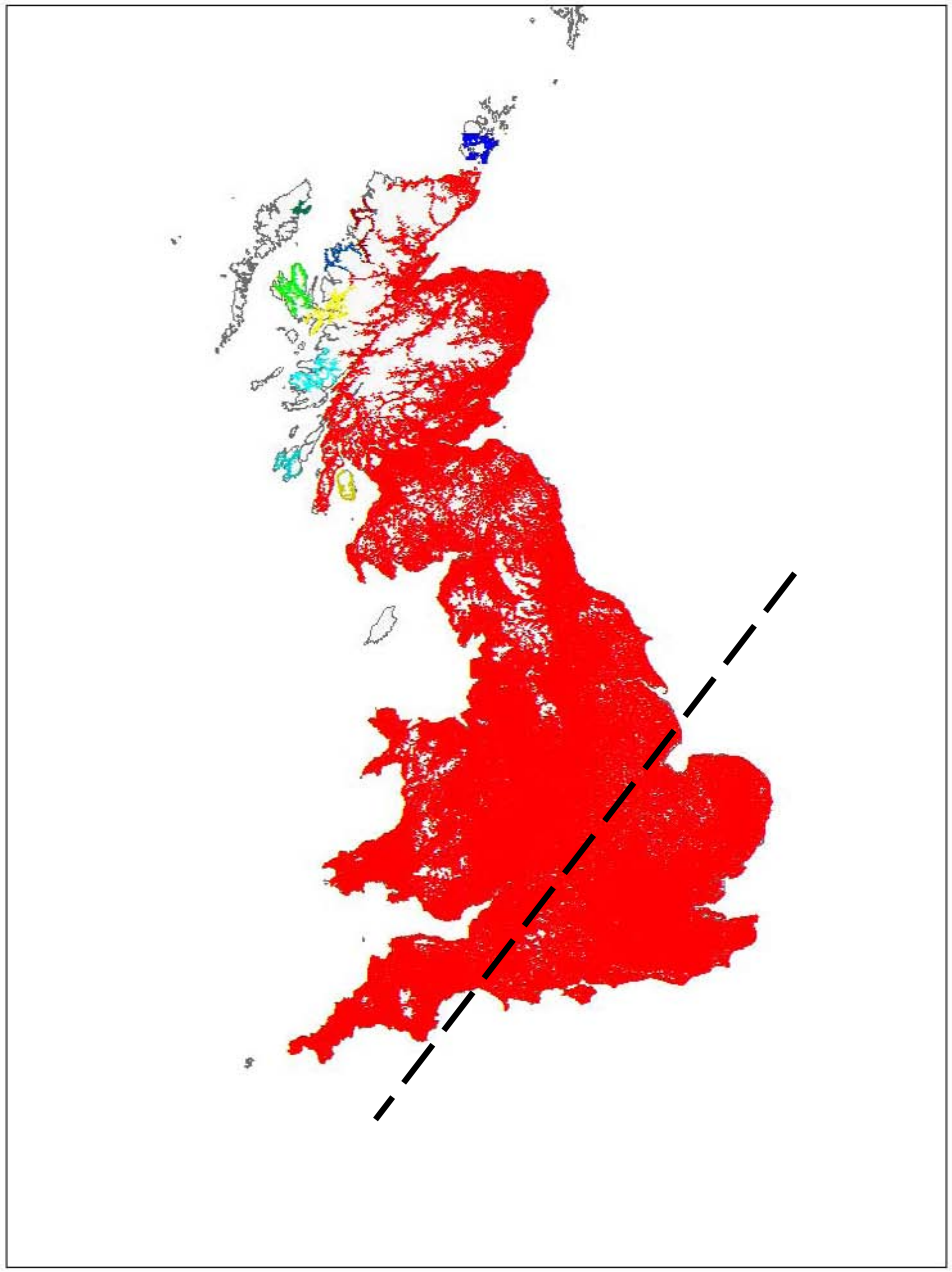

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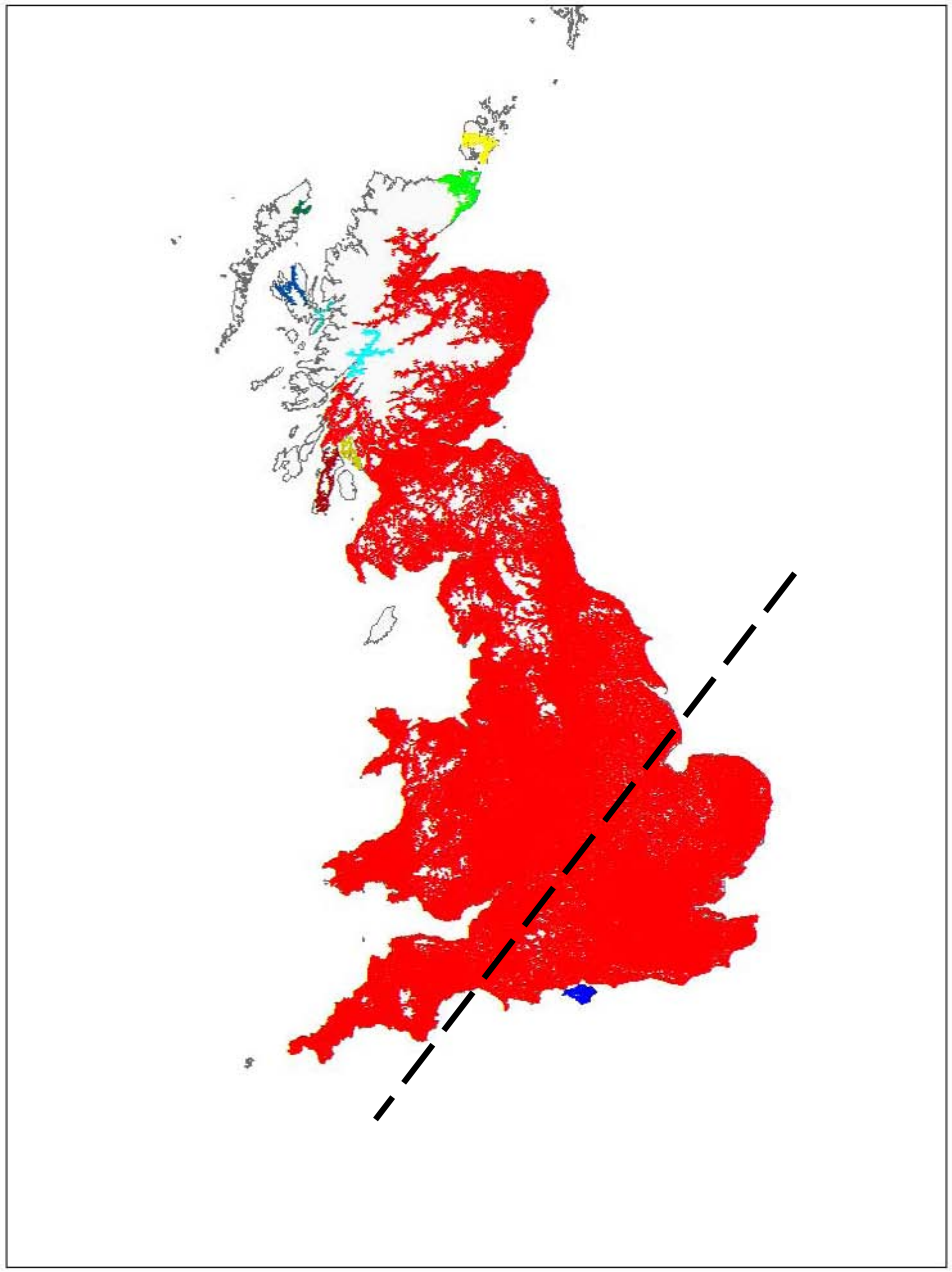

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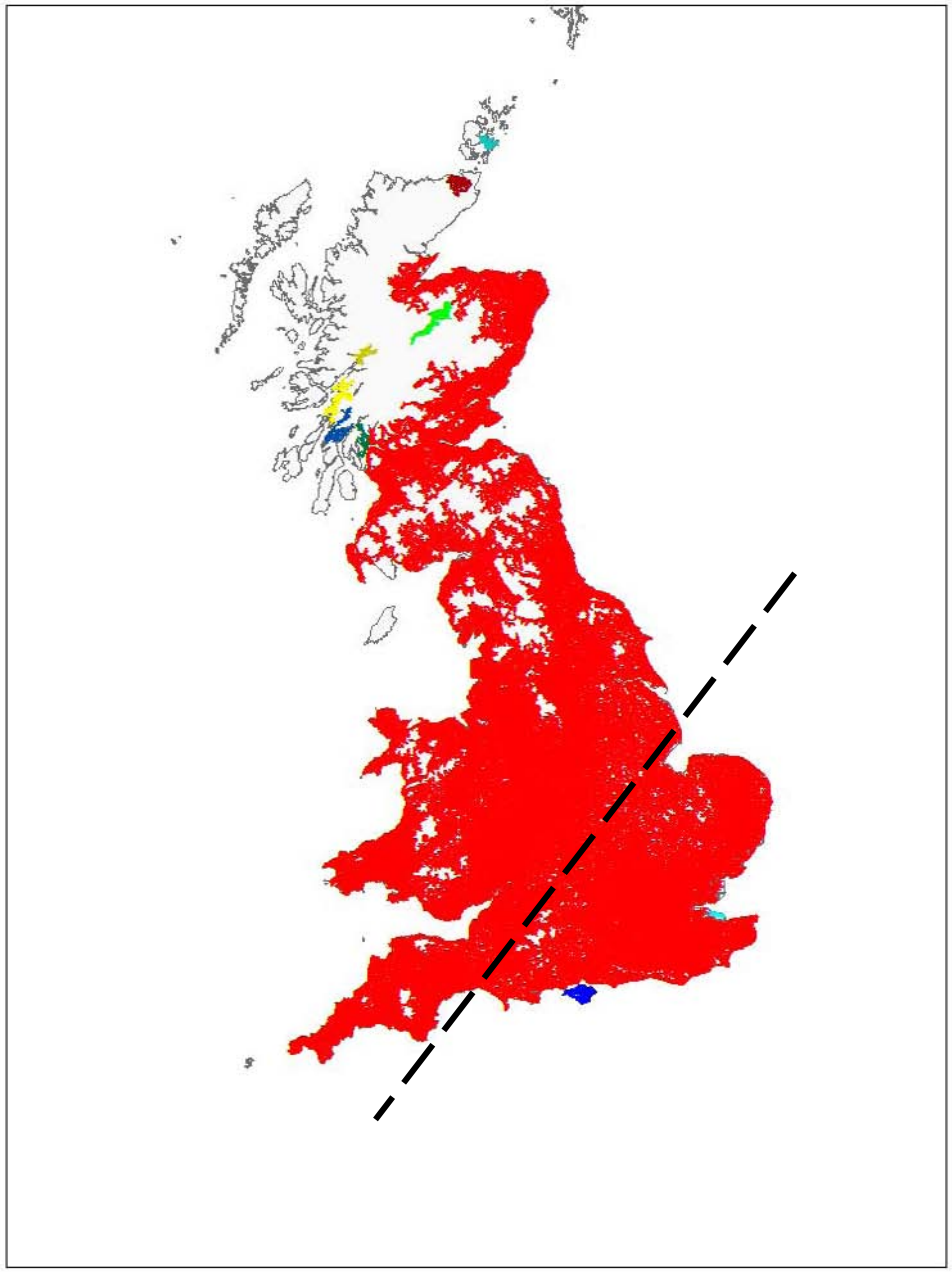

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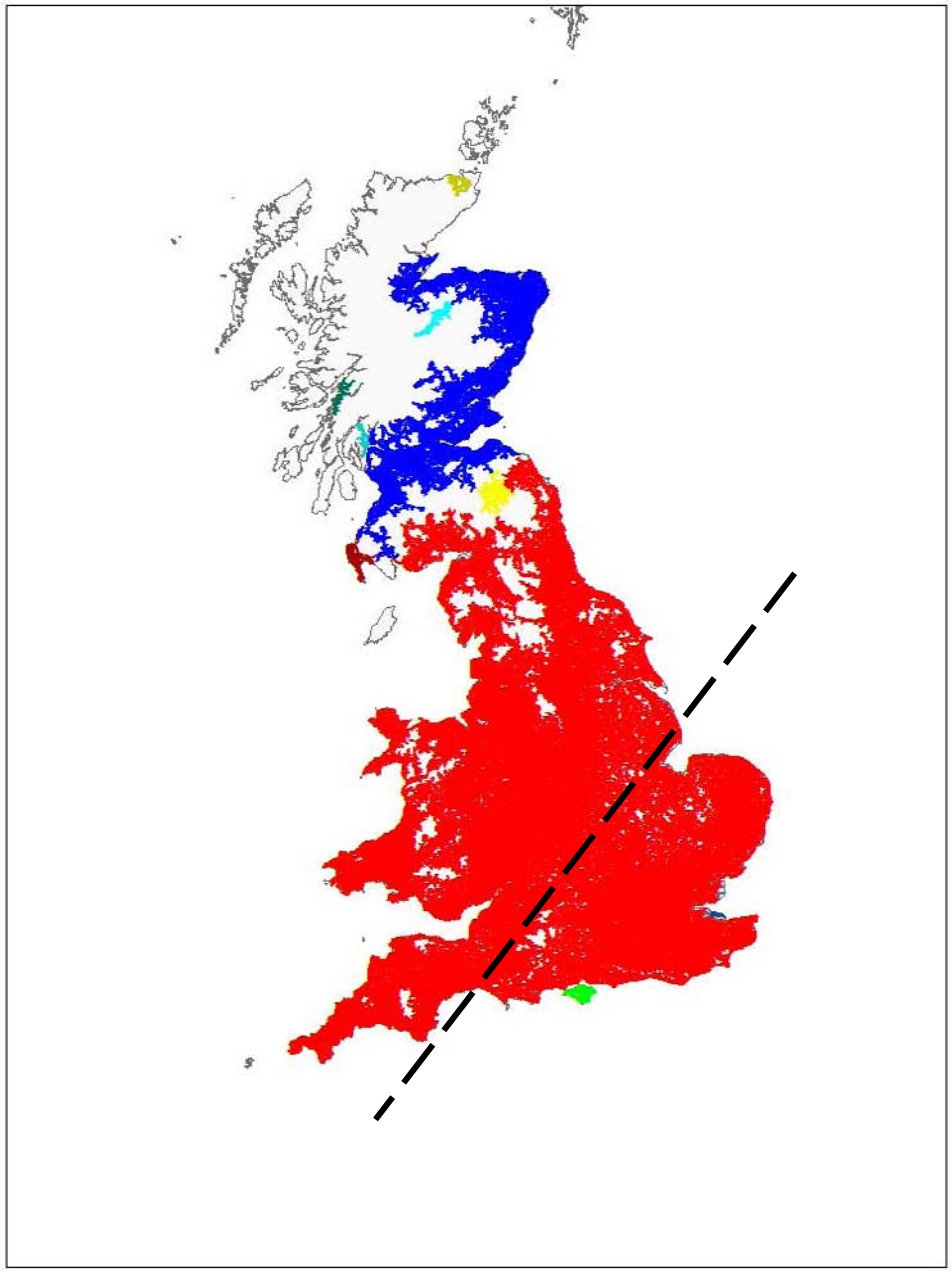

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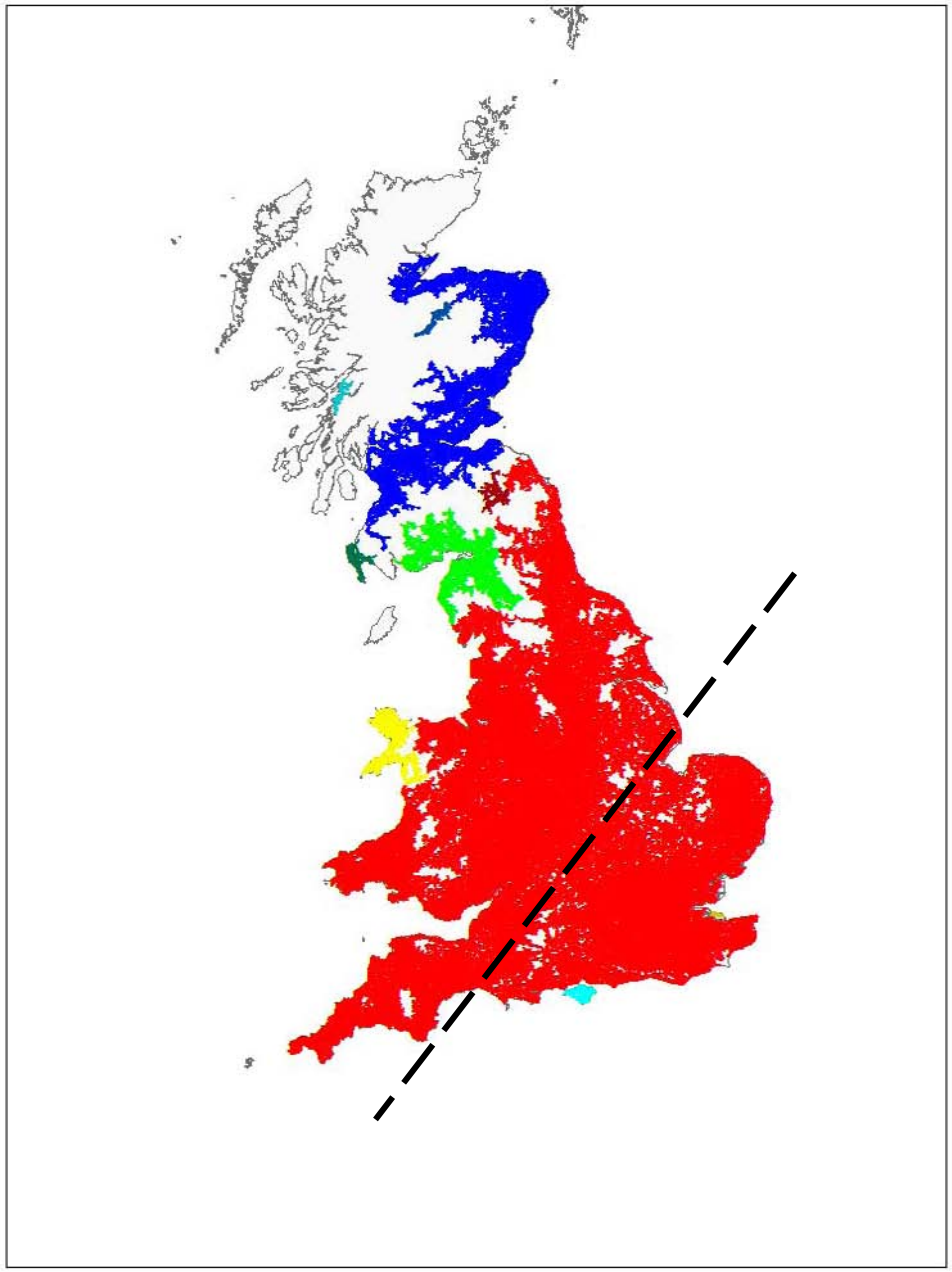

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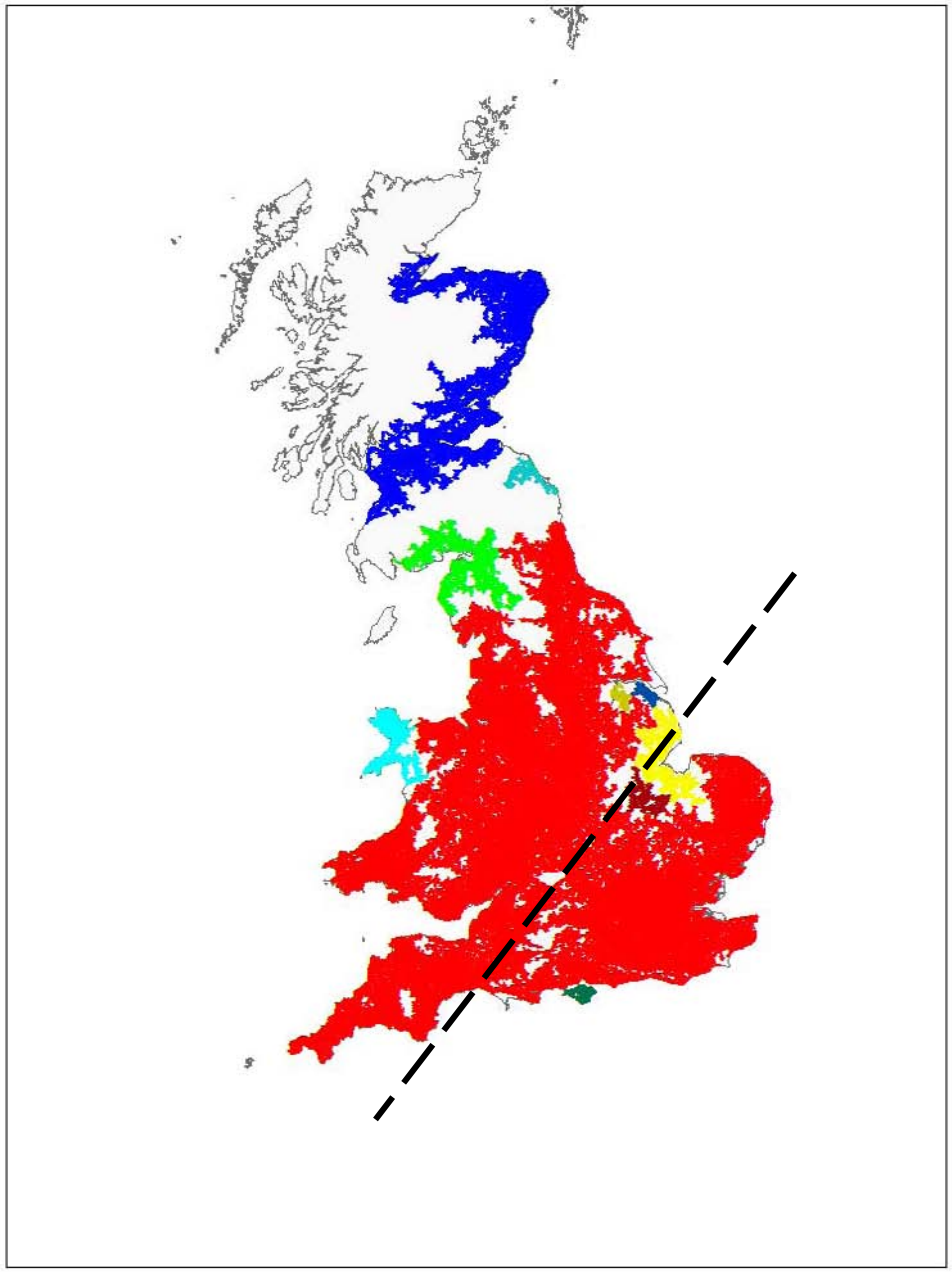

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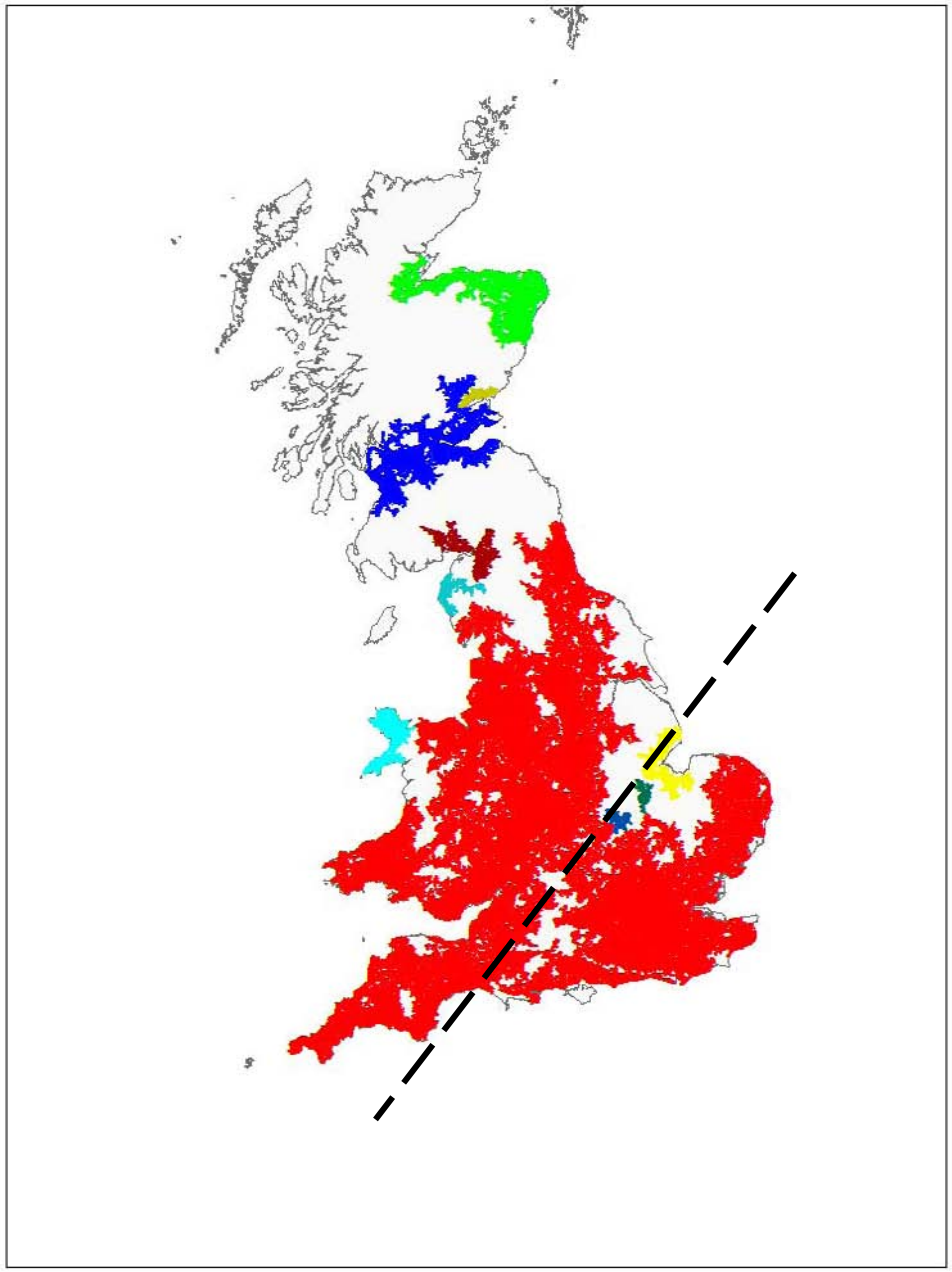

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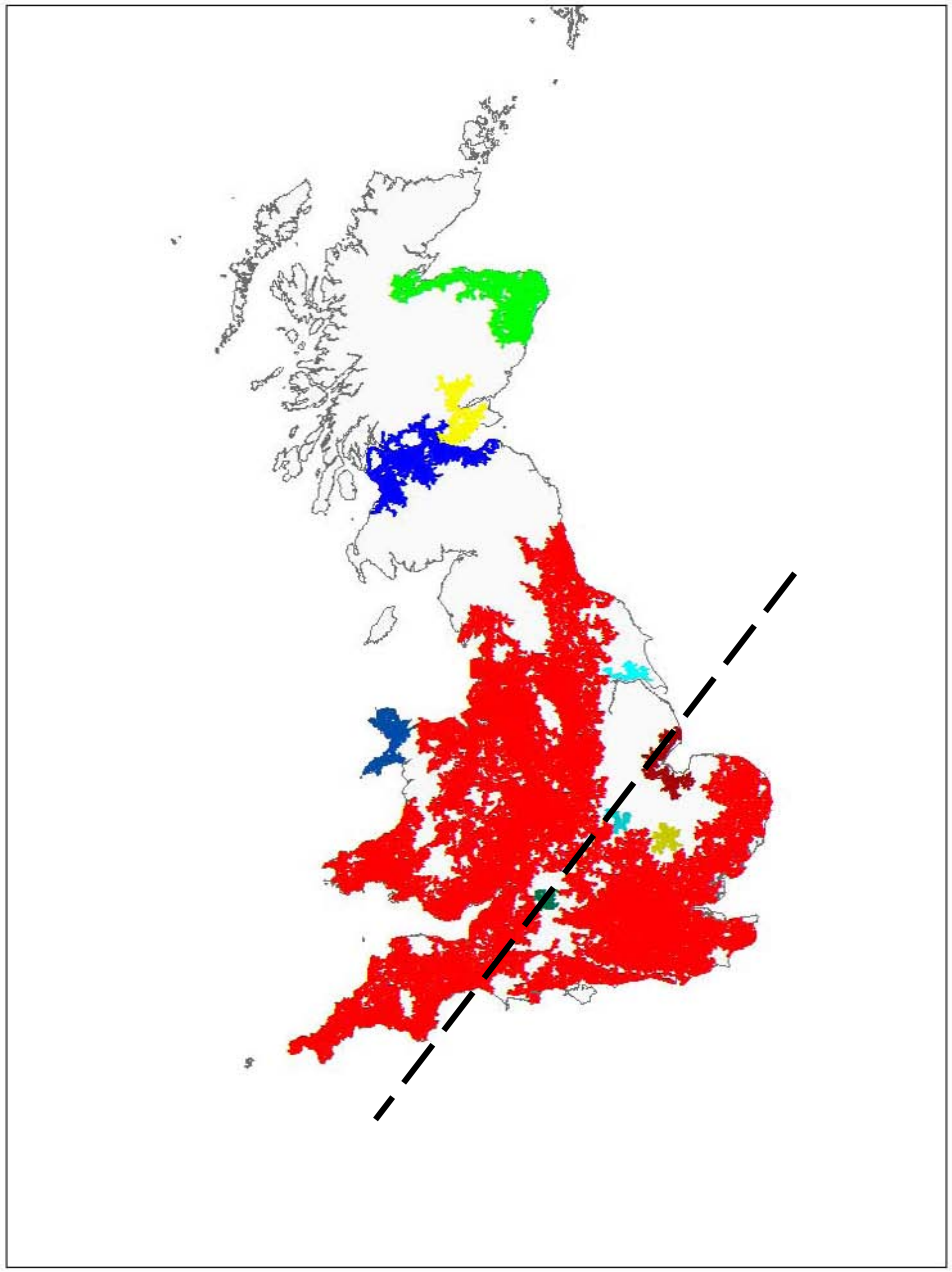

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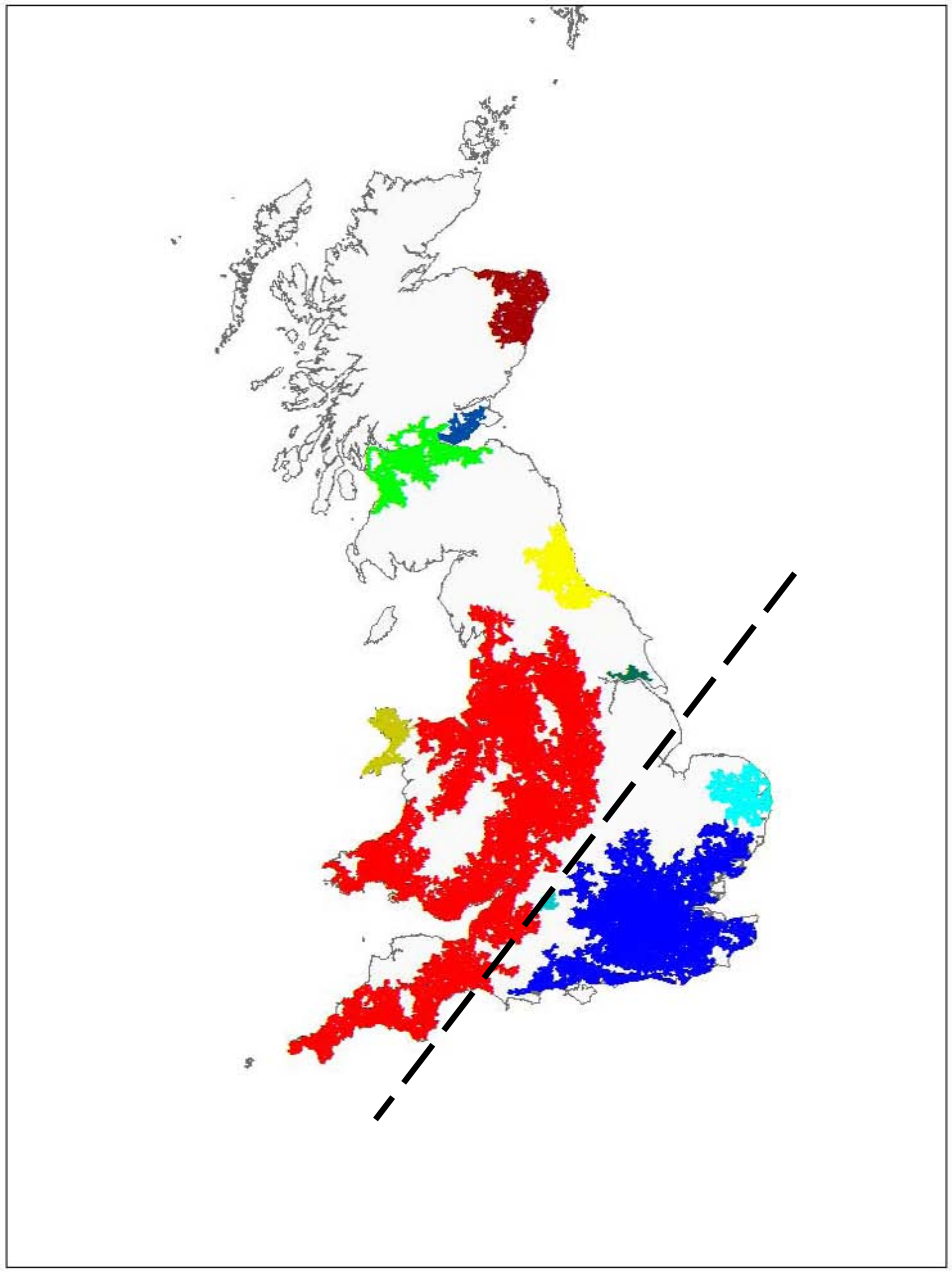

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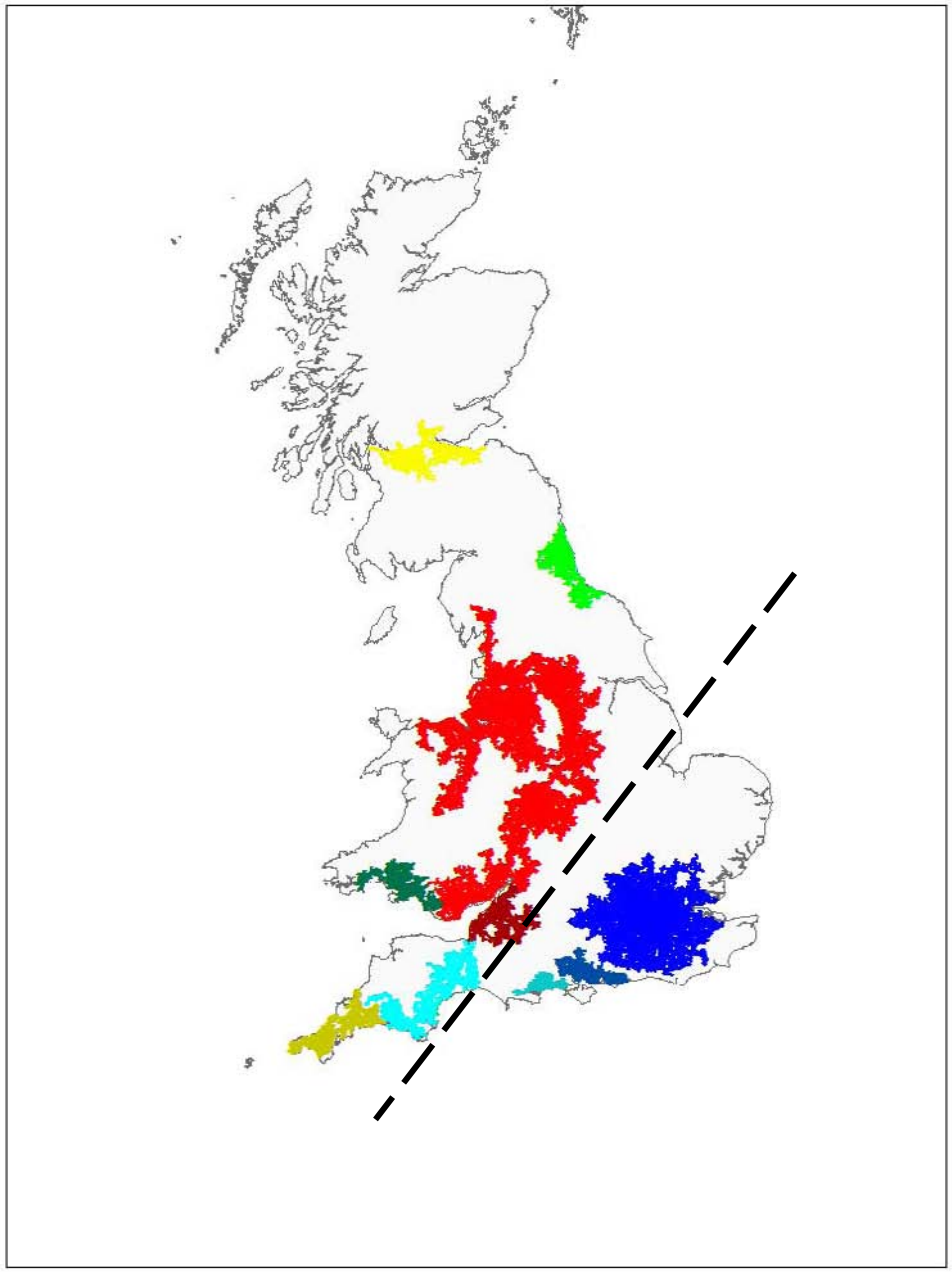

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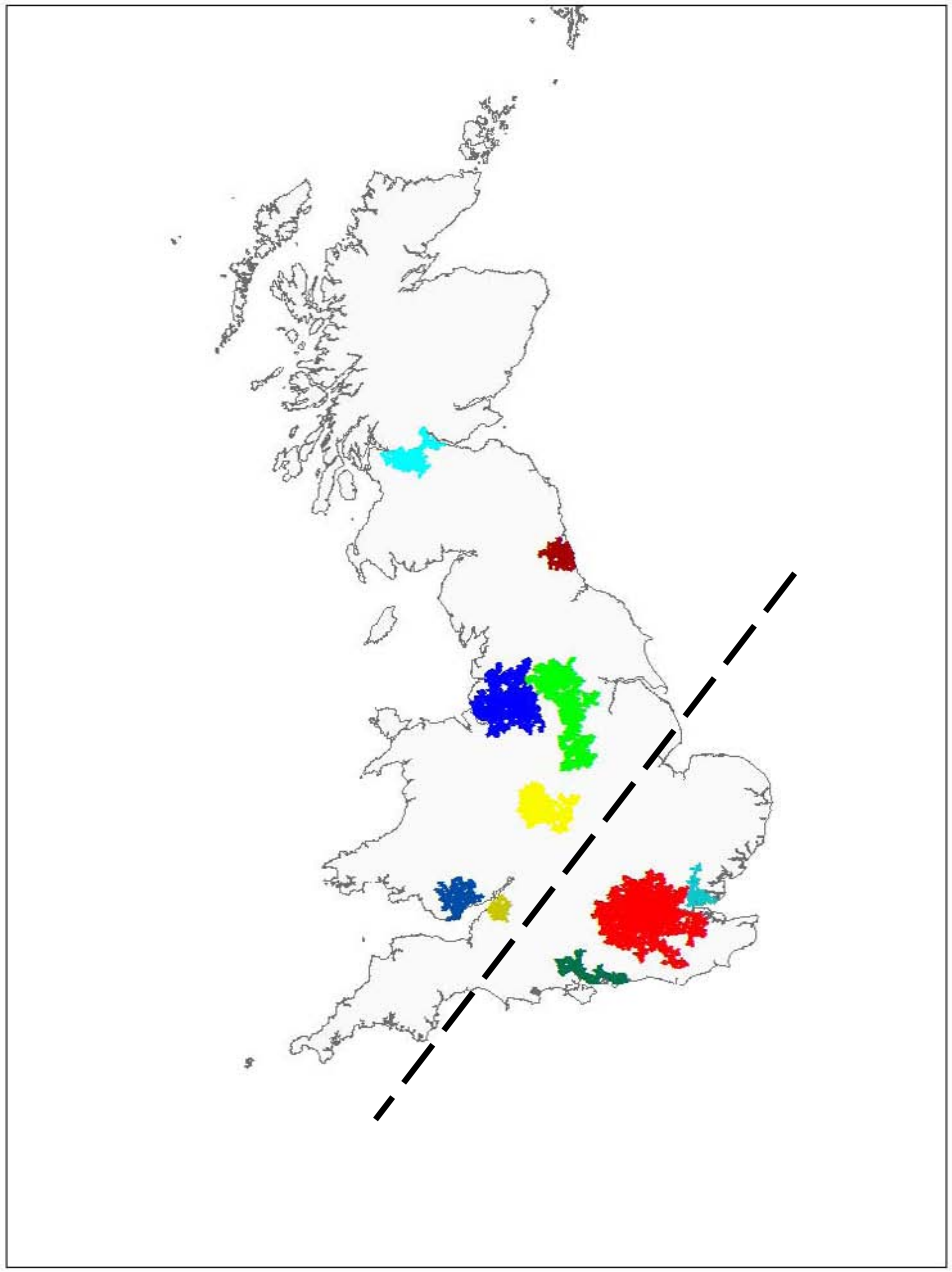

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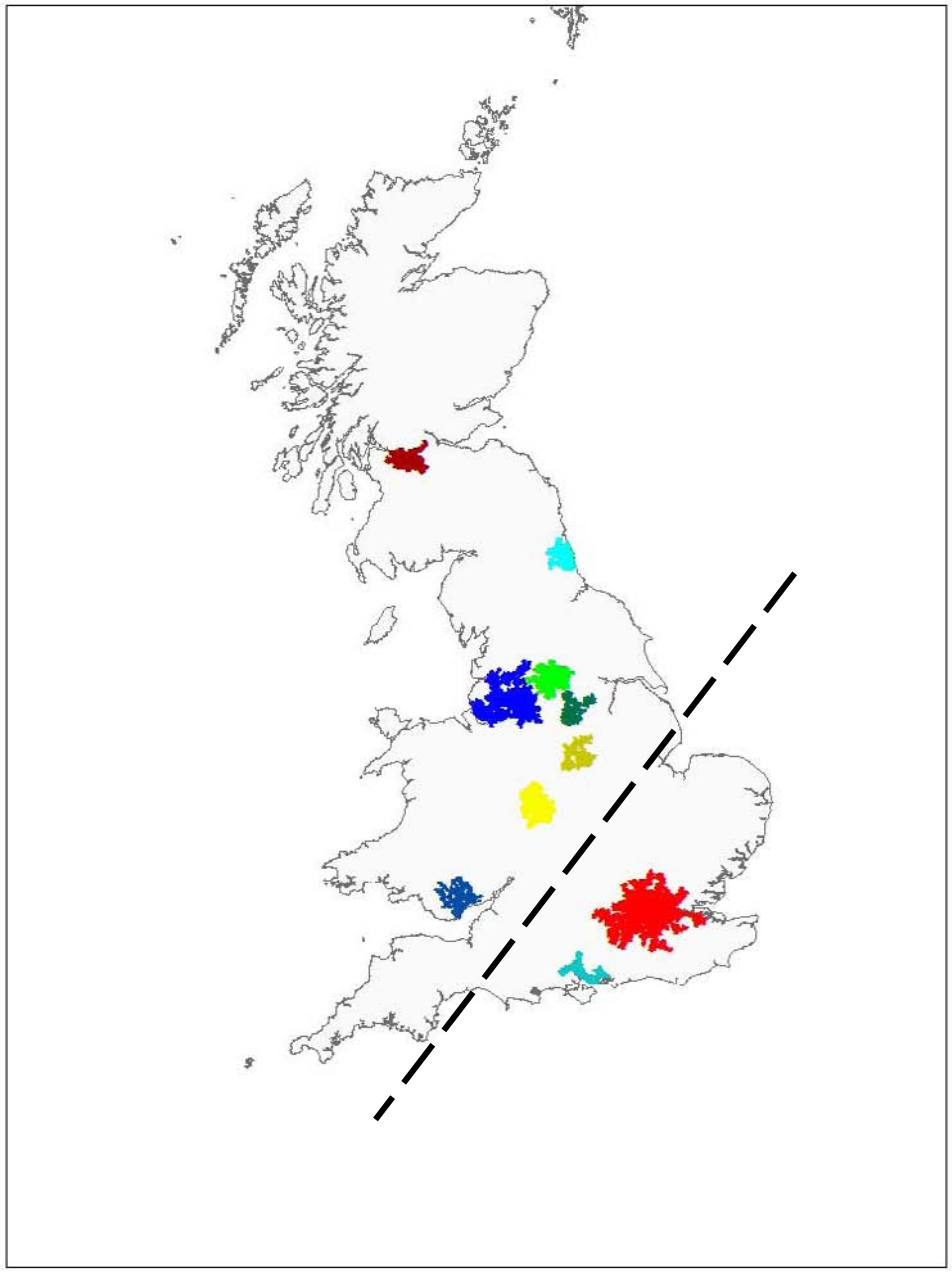

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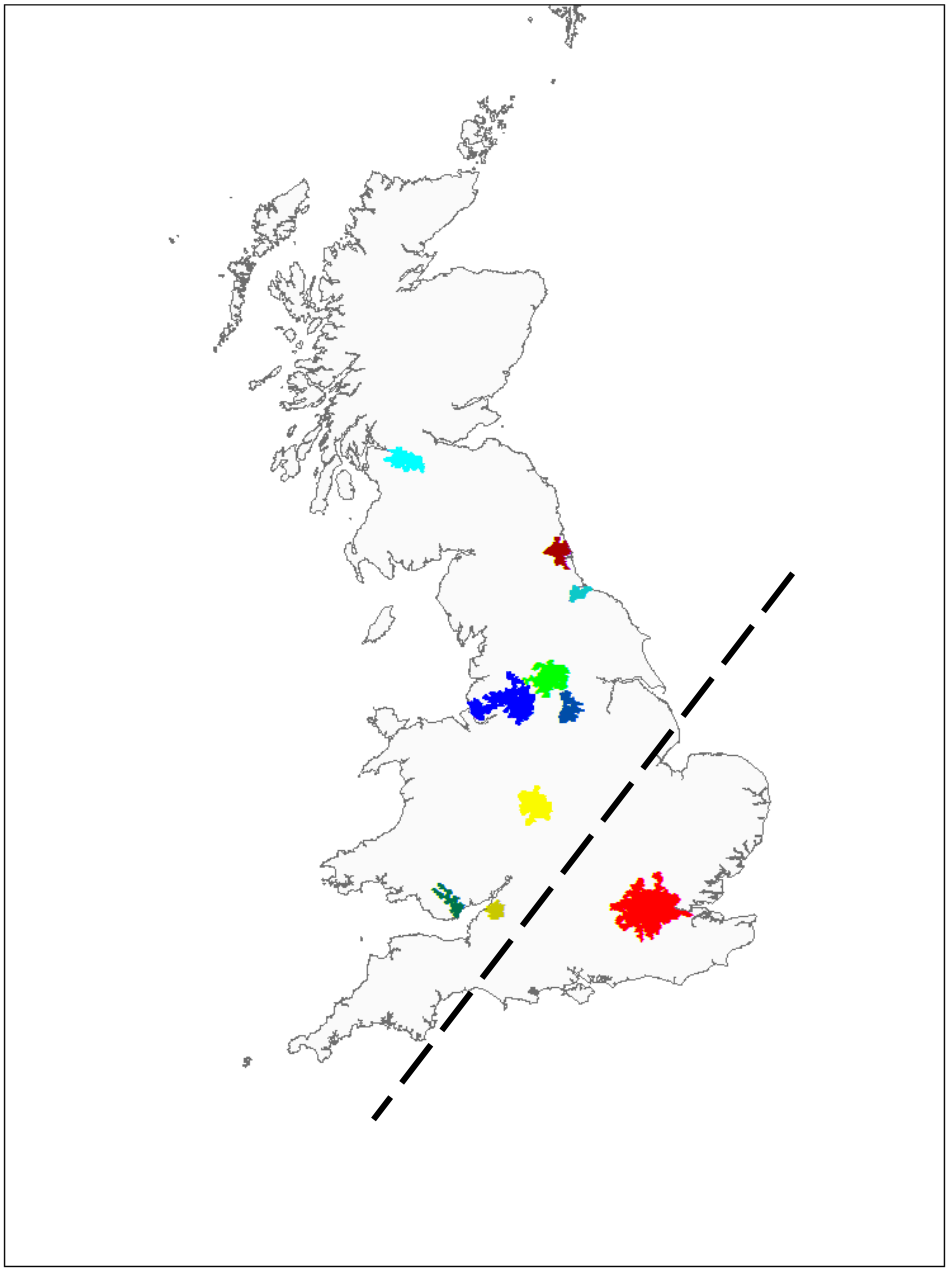

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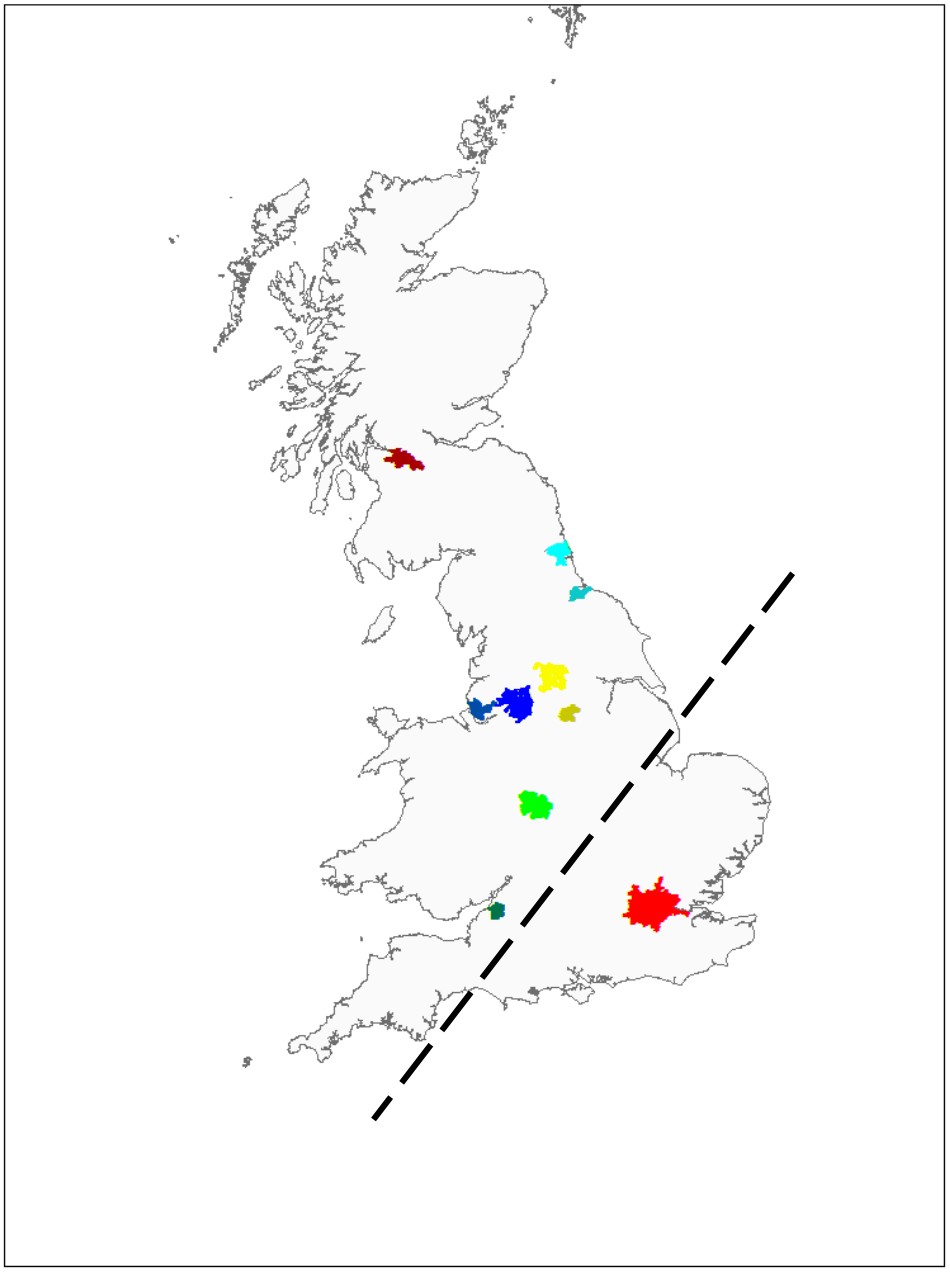

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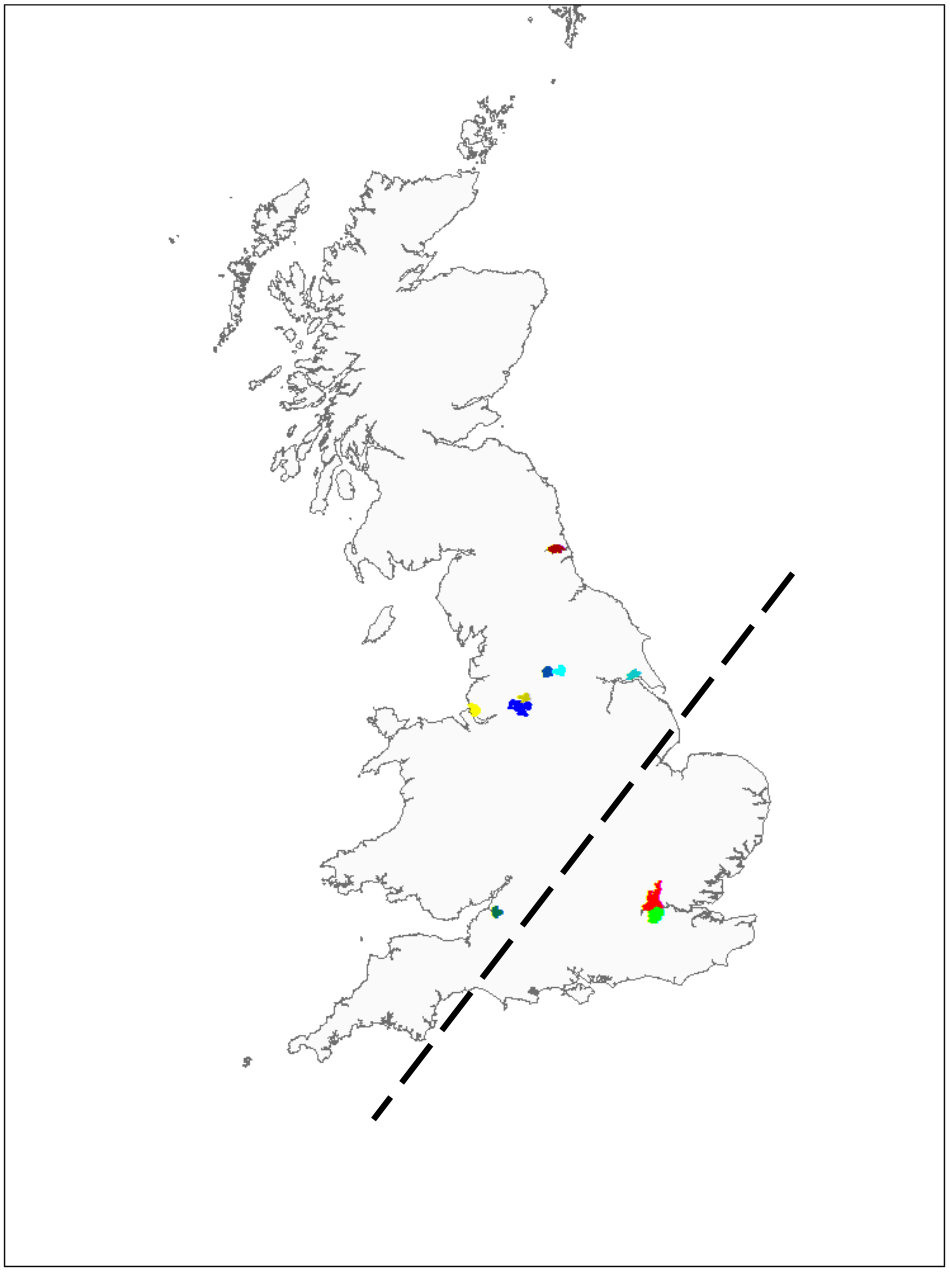

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Conclusions: Many More Projects and Perspectives

I have tried to give you a sense of where we are going across different spatial and temporal scales which throw up different kinds of problems

We haven't looked at the finest scales but we are doing work on local movement in this sense.

Prediction is a major issue and in general as the fact that are cities are complex tends to mean that they are unpredictable in the large even if they 'seem' to be predictable in the small.

The challenges of course are to embed this knowledge into the wider context – nit just in planning but in ways in which everyone who might benefit from these perspectives might be able to use them

And this means dissemination and translation …..

Some Papers

On Bikes (in London)

O. O'Brien, J. Cheshire, M. Batty (2013) Mining bicycle sharing data for generating insights into sustainable transport systems, **Journal of Transport Geography**, in press & online

Zaltz Austwick M, O'Brien O, Strano E, Viana M (2013) The Structure of Spatial Networks and Communities in Bicycle Sharing Systems. **PLoS ONE 8(9)**: e74685. doi:10.1371/journal.pone.0074685

On Climate Change and London

Walsh, C. L., Dawson, R. J., Hall, J. W.,Barr, S. L., Batty, M., et al….(2011) Assessment of Climate Change Mitigation and Adaptation in Cities, **Urban Design and Planning** (Proceedings ICE), 164, 2, 75–84.

Batty, M. (2012) Urban Regeneration as Self-Organisation, **Architectural Design, 215**, 54-59

Batty, M. (2010) Integrated Models and Grand Challenges, **ArcNews**, Winter 2010/2011, **32**, no 4, available at http://www.esri.com/esri-news/arcnews

On Defining Cities and Prosperity

E. Arcaute, E. Hatna, P. Ferguson, H. Youn, A. Johansson and M. Batty (2012) City boundaries and the universality of scaling laws. **arXiv:1301.1674** [physics.soc-ph]

M. Batty (2013) A Theory of City Size (Perspectives), **Science**, **340** no. 6139, 1418-1419