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Social networks and travel behaviour



University College London

Preliminaries: Defining Cities

We Cannot Define Cities Until We Know What a City Is

Breaking Up Britain: Fracturing Britain

Defining Nations, Regions and Cities

City Performance: Wealth and Inequality

Do Bigger Cities Generate More Wealth

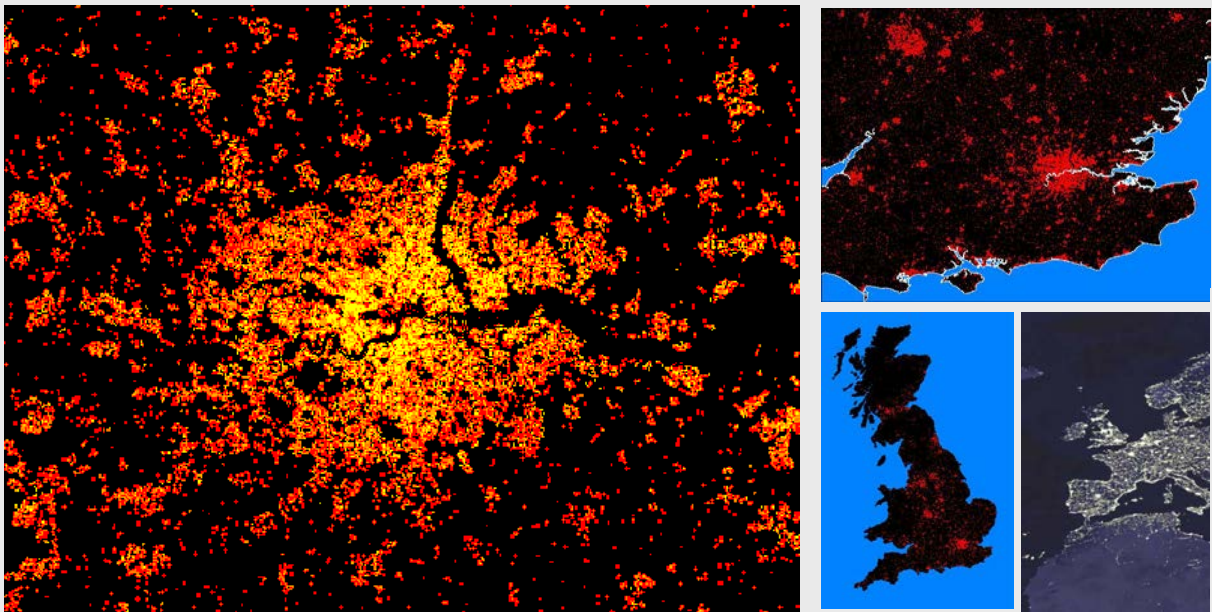
Extensions: Europe, Integration and Fragmentation

Global Small Worlds, Regional Identities

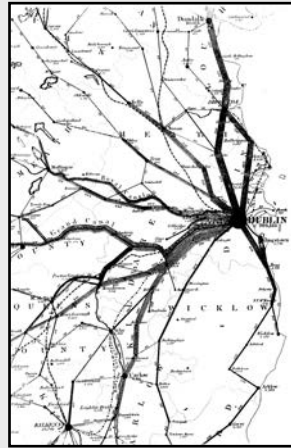
Preliminaries: Defining Cities

We Cannot Define Cities Until We Know What a City Is

- It is spatial extent that is key here – the properties of cities will change as we change extent – this is the ecological fallacy and the modifiable areal unit problem
- It also relates to commuting and interactions, migration, trade flows and now of course the whole issue of electronic interactions
- In short globalisation – where does the city begin and end – how do we define the system in terms of its environment. Here are some pictures



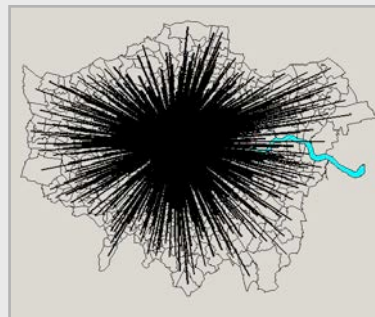
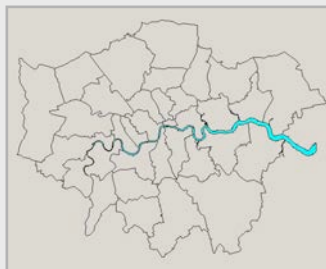
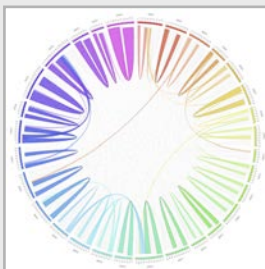
Flows: Dublin 1837, Ireland 1888, London 2001



Harness, 1837



Ravenstein 1888

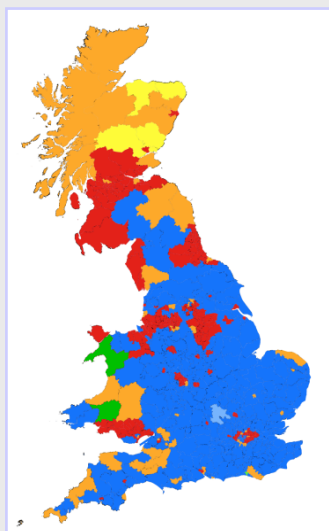


Breaking Up Britain: Fracturing Britain

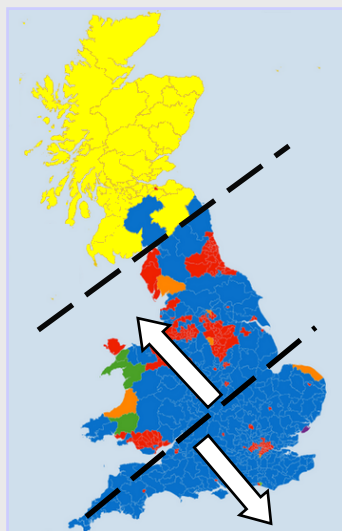
Defining Nations, Regions and Cities

- Ok, let me proceed by seeing how resilient our nations regions and cities are in terms of their connectivity and we will begin by decomposing this connectivity to get some understanding of how we can define spatial units that are robust
- But first I am going to show you something about Britain and Cities from last years regional divisions pertaining to our general election
- We were very struck by these divisions

2010



2015



where



These are very close to our regions when we fracture the entire map network and let me show you what the method is all about

Essentially we are able to perform a regionalisation of Britain using the street pattern and network that contains all the cultural and social history of the last 2000 years as well as more recent urban growth in the last 200.

We knew Britain was fractured – you learn this in high school – the north-south divide – but what we found was more of a surprise, and more of a divide than we expected.

Let me emphasise this point about the street-road network which contains a lot of the economic social and cultural history of Britain, from the Celts, to the Romans, to Anglo-Saxons, to Normans and so on



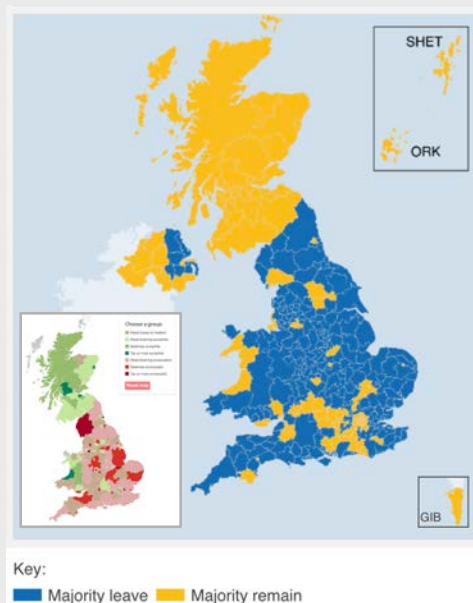


I will tell you the method we used first and only then tell you the detail of why and how we are doing this.

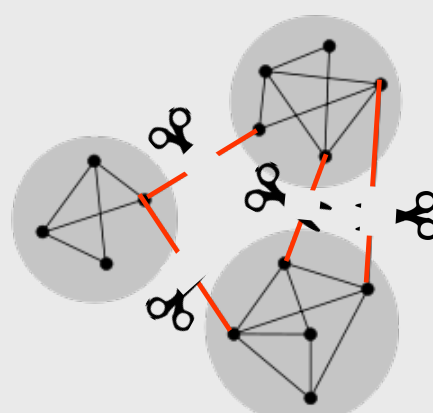
It is part of our project to look at the nature of urban morphology, city size, urban allometry and more particularly the qualitative changes that take place in the economy of cities as they agglomerate

This is a key issue for thinking about a world where every one will be living in cities by the end of this century. But before that, back to Britain.

I need to update you with recent events when we British voted to leave the EU. Let me show you the map of who voted to leave the EU and who voted to stay. I will let you draw your own conclusions but fracturing of the kind I have been showing is key and so is the core-city-suburb-country difference

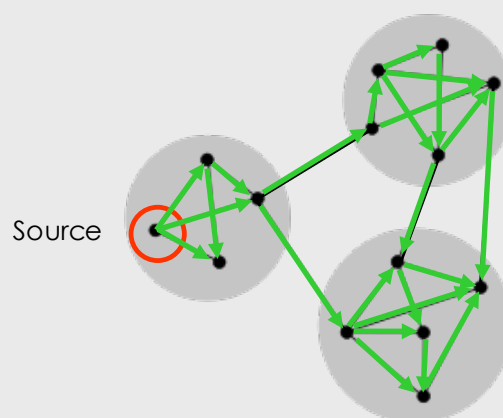


So how do we fracture Britain to predict its nations, regions and cities? Imagine the network of streets and roads which covers these entire islands. Let us cut the longest links – those that are greater than a distance threshold – so that we partition the network into clusters, and we keep on doing this by tightening the threshold, thus building the hierarchy top down



I had given variants of this talk a few times and then someone asked me after the lecture **“Just exactly what is percolation?”**. So I had better tell you a little more explicitly

Imagine a process that diffuses from a source one step at a time. If the diffusion takes place on a network, as the diffusion continues, it takes in more and more of the network. At each stage more and more clusters are embraced and the biggest cluster grows in size – this is the giant cluster. Eventually all the network is covered. Think of a forest fire. Here is the little network example again.



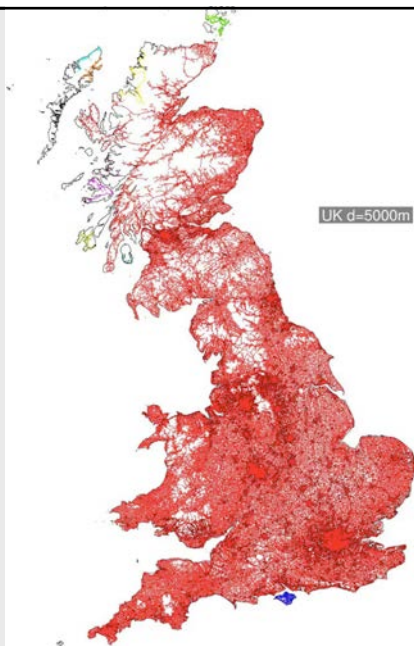
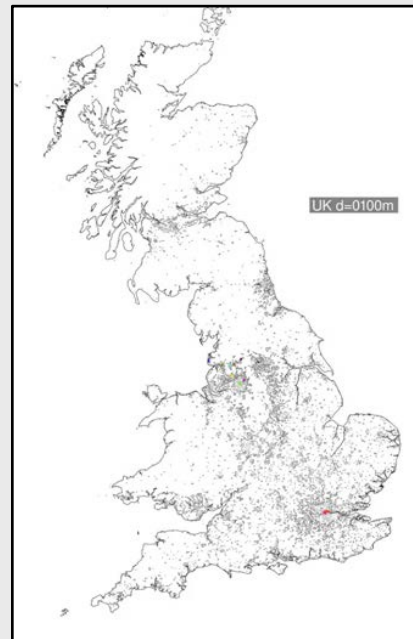
If you play this forwards we build clusters from the bottom up and backwards we build clusters from the top down

We start at 5km and then we progressively build the clusters from the bottom up which assembles the hierarchy from the top down.

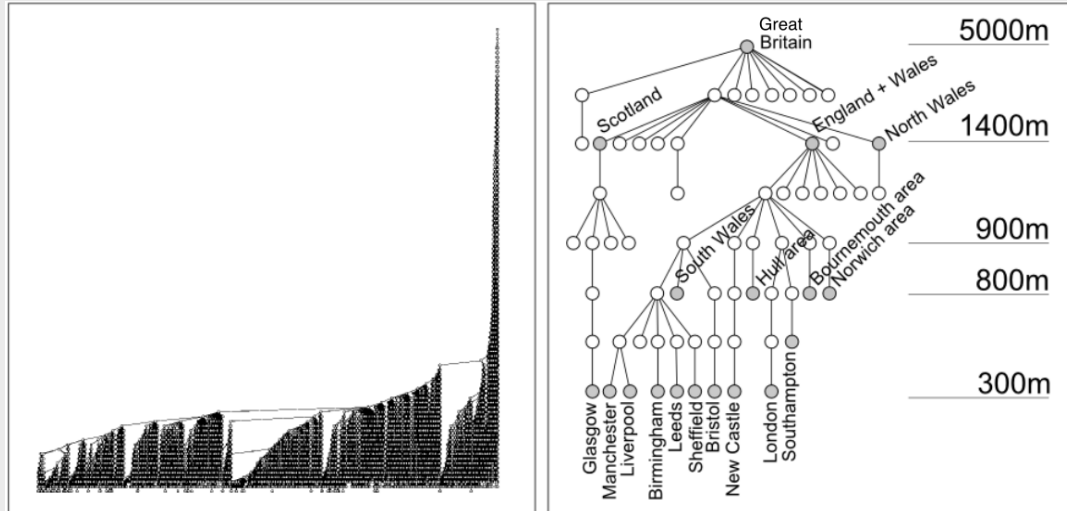
This produces nations, regions and then cities which is our main focus, not the Scottish election which I will return to at the end



I will show the video the other way around from the bottom up because there real power of this is to stop it and look at the regionalisation. And in fact the way we do it is from the bottom up, not the top down; it's easier



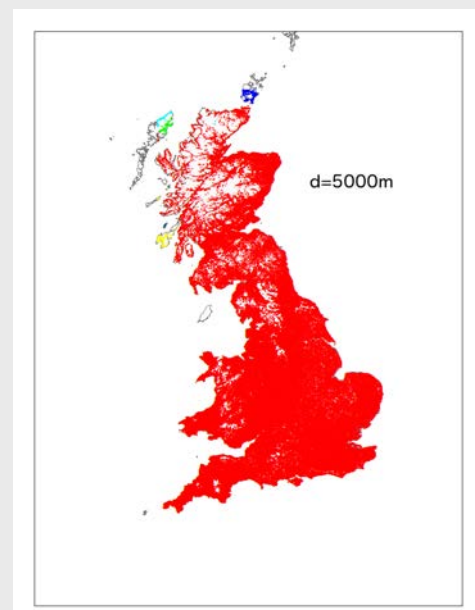
We build or extract a very detailed hierarchy with tens of thousands of clusters

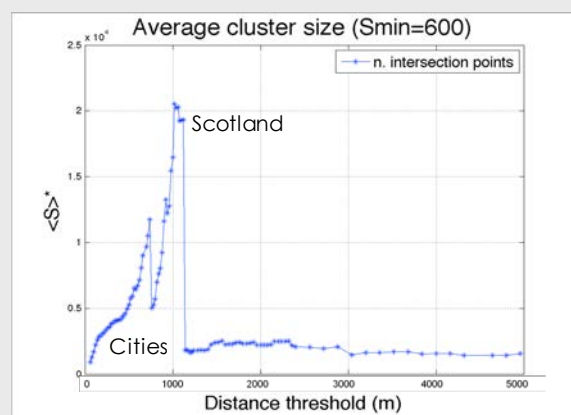
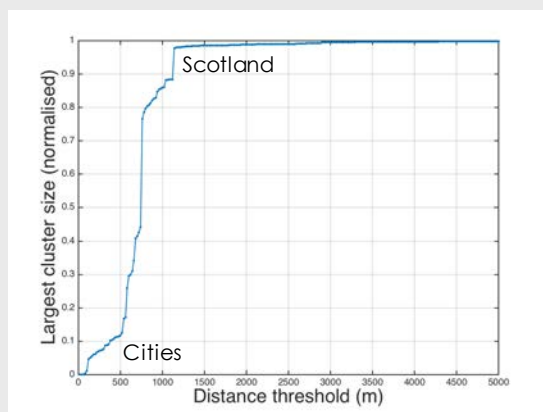
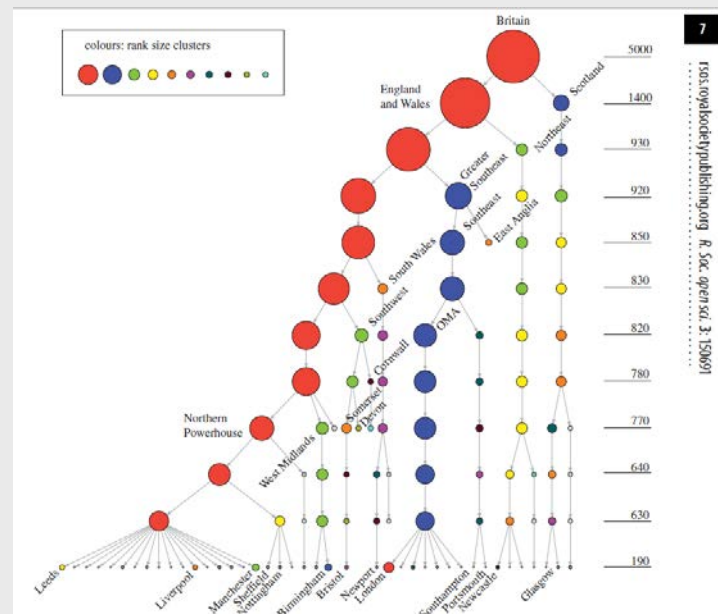


Let us make it a little more relaxed and look at the key stages – the essential issue from the election and what people vote is that *Britain breaks up into its historical cultural pieces*.

Fractured Britain, probably
Fractal Britain

The movie shows it beautifully
but so do these frames





City Performance: Wealth and Inequality

Do Bigger Cities Generate More Wealth

We are testing a theory that is as old as the hills: and that is that as cities get bigger, they get more prosperous, *ceteris paribus*

This is due to Alfred Marshall of course who coined the term urban agglomeration, but it is also key to allometry which is the study of qualitative change in living things as they get bigger.

Arguably Marshall somewhat obliquely was really saying that the bigger the city the richer and perhaps - the more sustainable – debatable in that there is a theory that says rich draw from the poor and as we get richer others get poorer - contestable

The people who are most into this are at Santa Fe. Geoff West and Luis Bettencourt in particular.

They have shown that using MSA data and definitions for 357 cities in the US, the income grows more than proportionately with city size; in short if Y_{city} is income and P_{city} is population, then

$$Y_{city} = kP_{city}^{\beta} \sim kP_{city}^{1.10}$$

This they call superlinear scaling $\beta > 1$

Growth, innovation, scaling, and the pace of life in cities

Luis M. A. Bettencourt^{1,2}, José Lobo³, Dirk Helbing⁴, Christian Kühnert⁵, and Geoffrey B. West^{1,6}

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Edited by Elinor Ostrom, Indiana University, Bloomington, IN, and approved March 6, 2007 (received for review November 19, 2006)

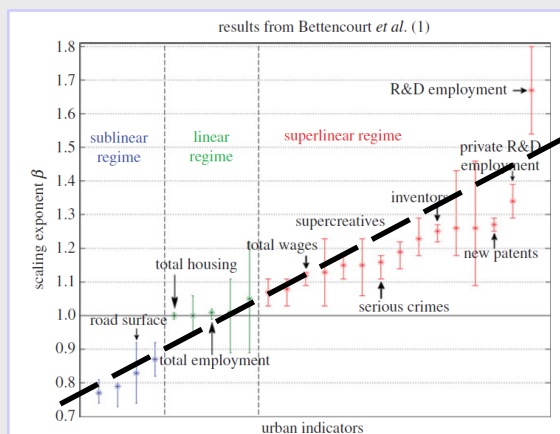
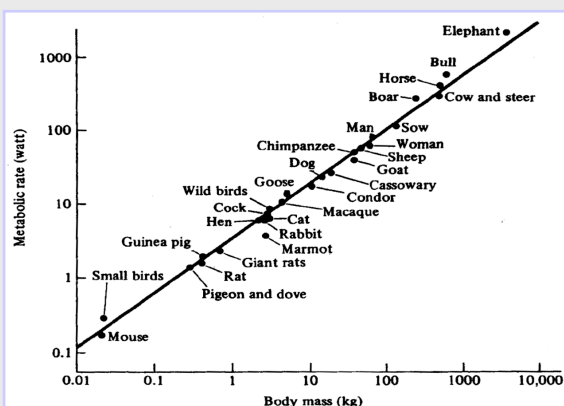
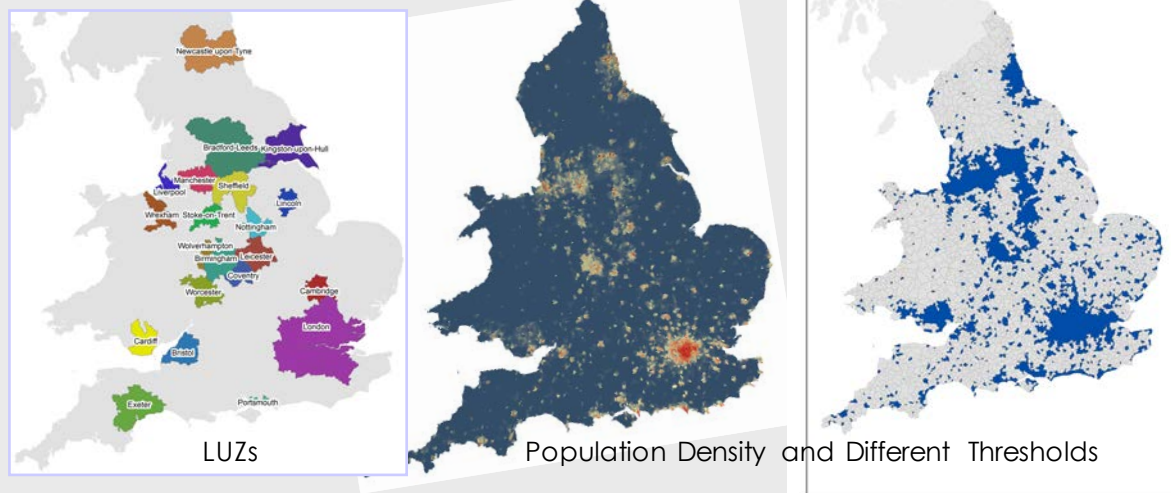


Figure 1. Exponents with 95% CI for different urban indicators found for the USA, Germany and China in reference [14]. These are colour-coded according

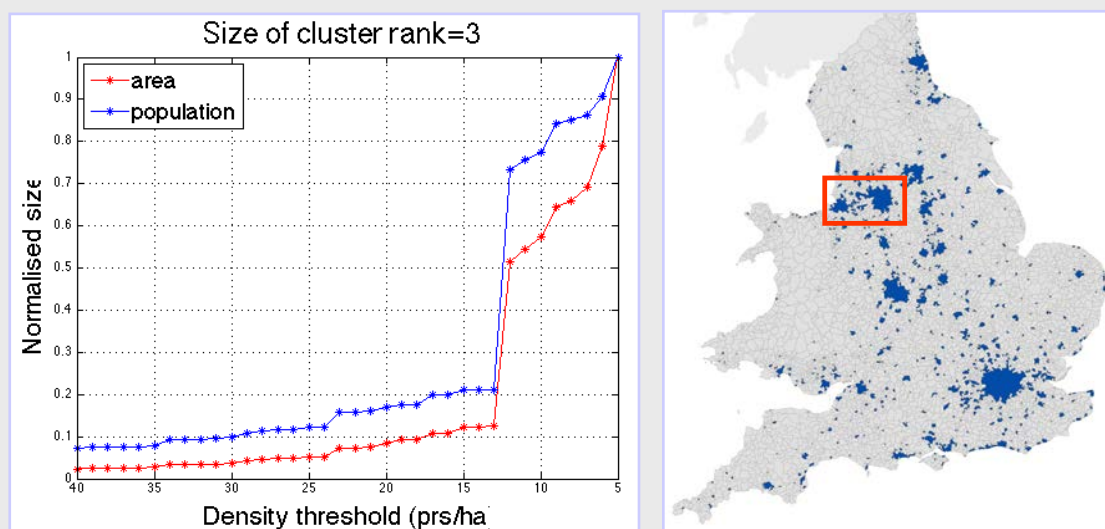
Our group considers the West-Bettencourt results to be problematic for the UK. We do not think that income scales superlinearly with population. We cannot reproduce this result from standard definitions of UK cities and we believe that the *globalisation of cities* destroys this kind of simplicity.

In short, everything turns on what we define as a city. In terms of MSAs, many are simply not good definitions of where people **locate** & particularly **interact** to do city things. So what we are doing is **defining cities** and to do this, we consider percolation theory a good potential approach. Let us begin however with some standard tests of this hypothesis for the UK or rather E & W

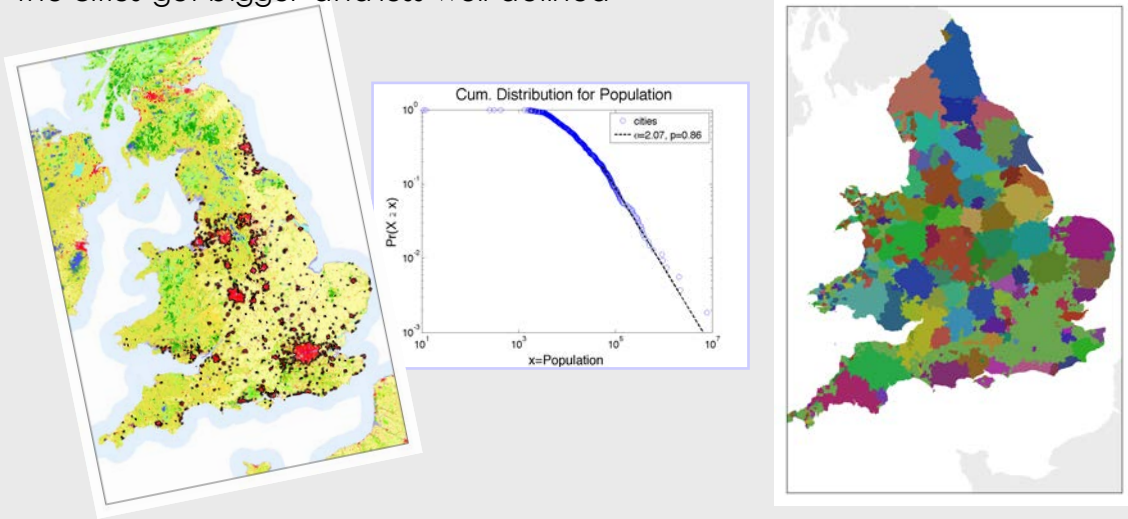
There are some poor definitions of cities in the EU such as LUZ – large urban zones and we should not use these but we will use density then commuting thresholds



We consider 14 persons per hectare to be the right density cut-off ; here Liverpool and Manchester separate



The correlation with the EU Corine RS data is good and Zipf's Law looks stable but we need to look at commuting fields – as they get larger around any place then the cities get bigger and less well-defined

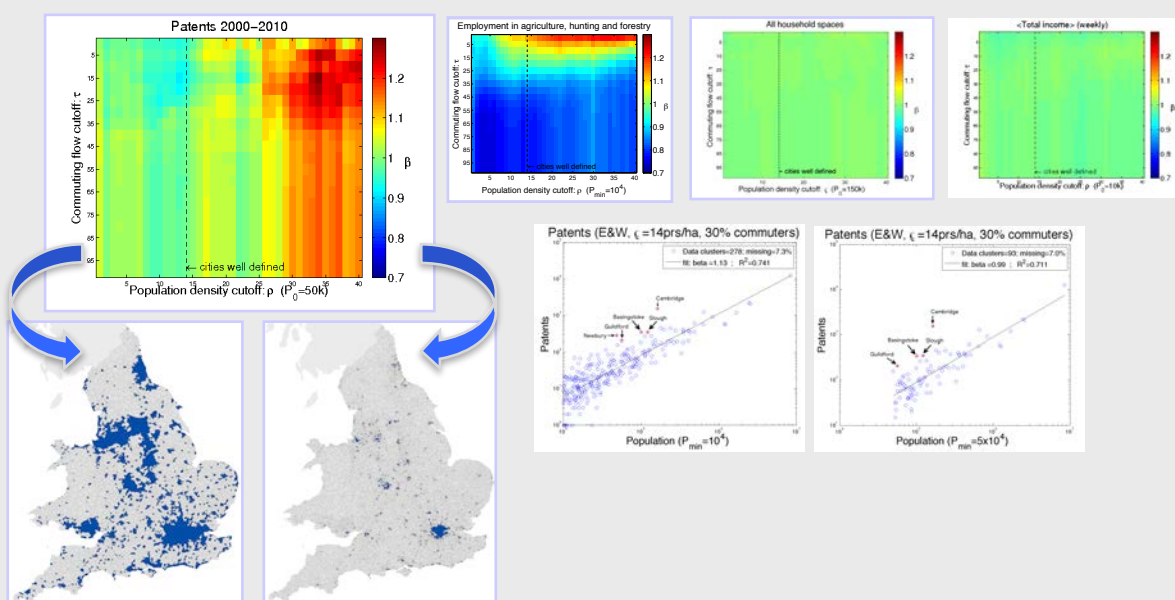
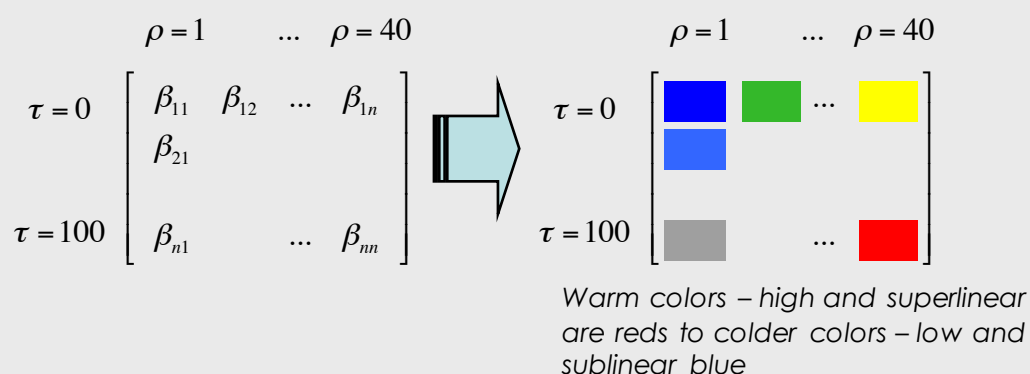


When we put all these definitions together defining cities at **14pph and with the 30% commuting** thresholds, and we examine a range of indicators wrt to city size, **we do not get superlinear scaling** for income against the population cities.

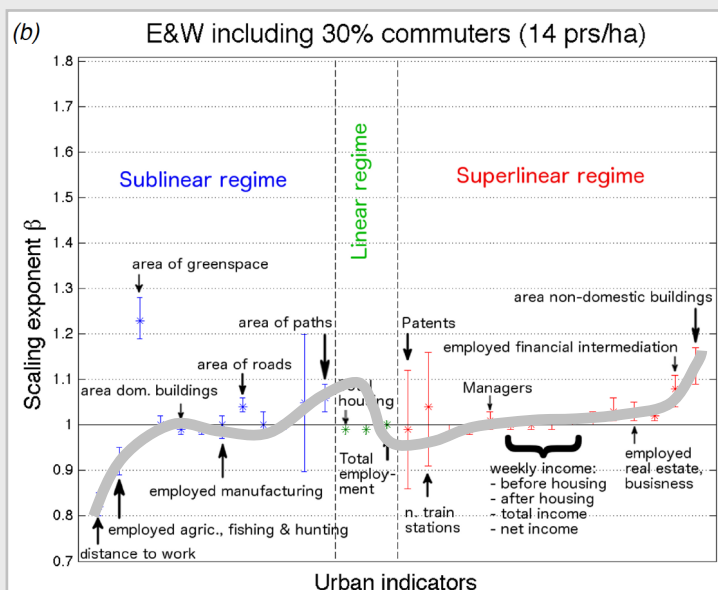
The bigger the city does not mean the richer in E&W and London is an enormous outlier.

We show these scaling relations and they are quite different from the Bettencourt-West results

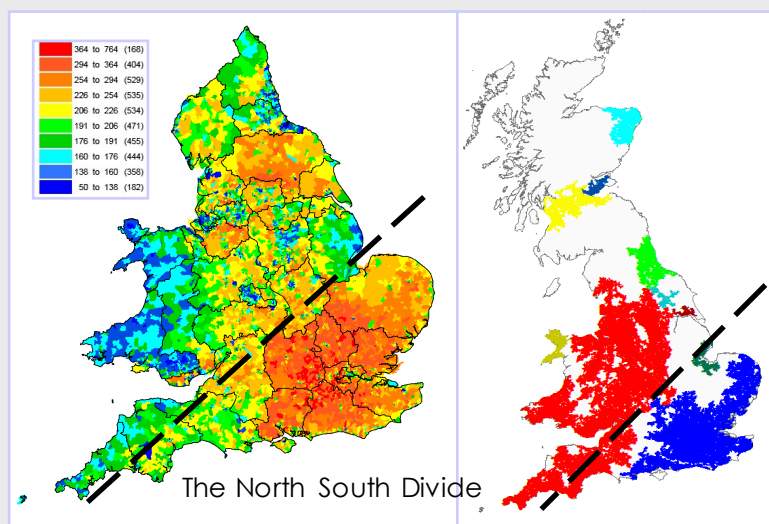
We now need to do sensitivity analysis on these definitions varying the density ρ and commuting cut-offs τ and seeing what happens to β



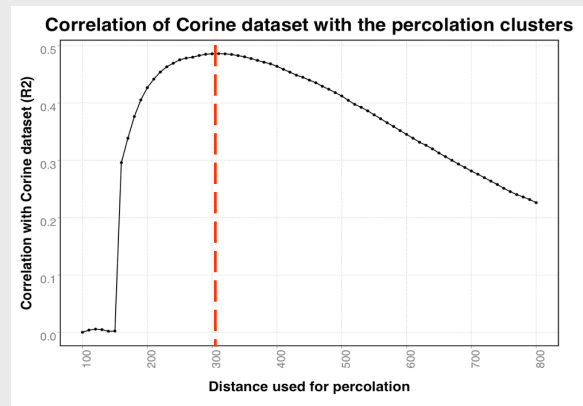
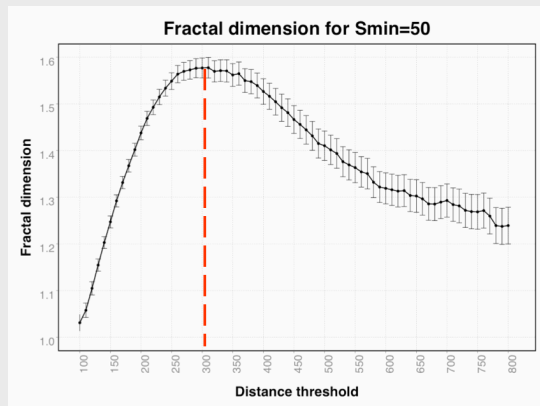
Here is the regime equivalent to the West-Bettencourt analysis and as you see the linearity of the indicators is not what the W-B results for the USA imply



A little more on percolation From the earlier work

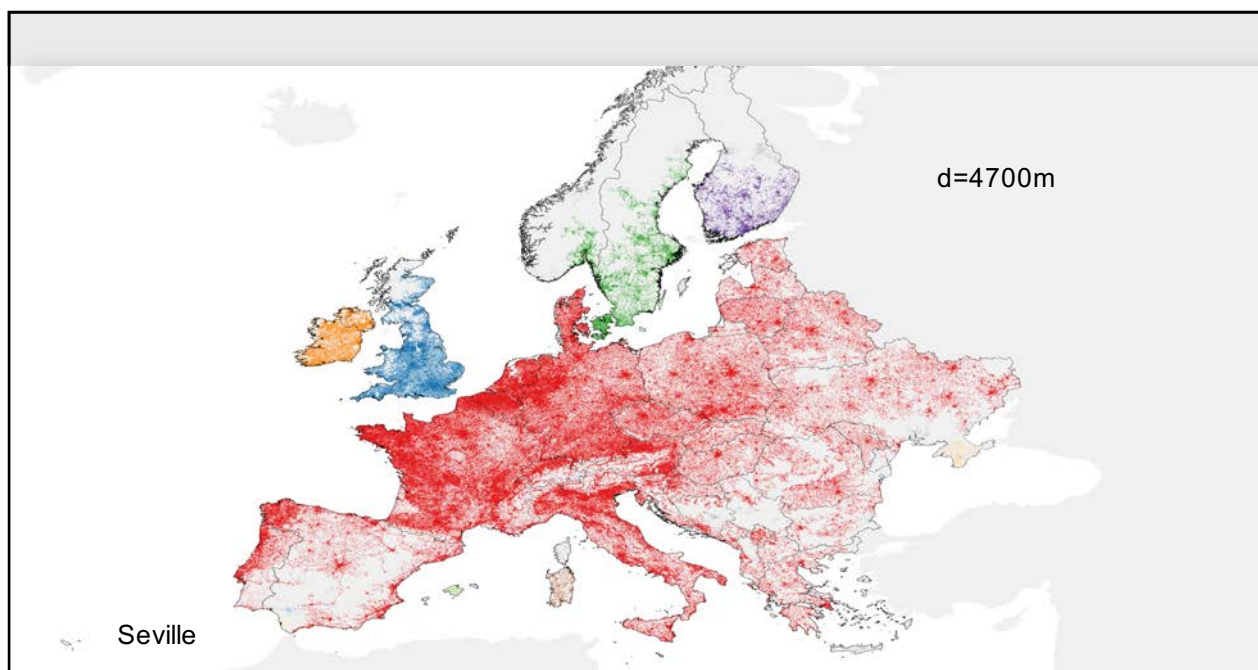
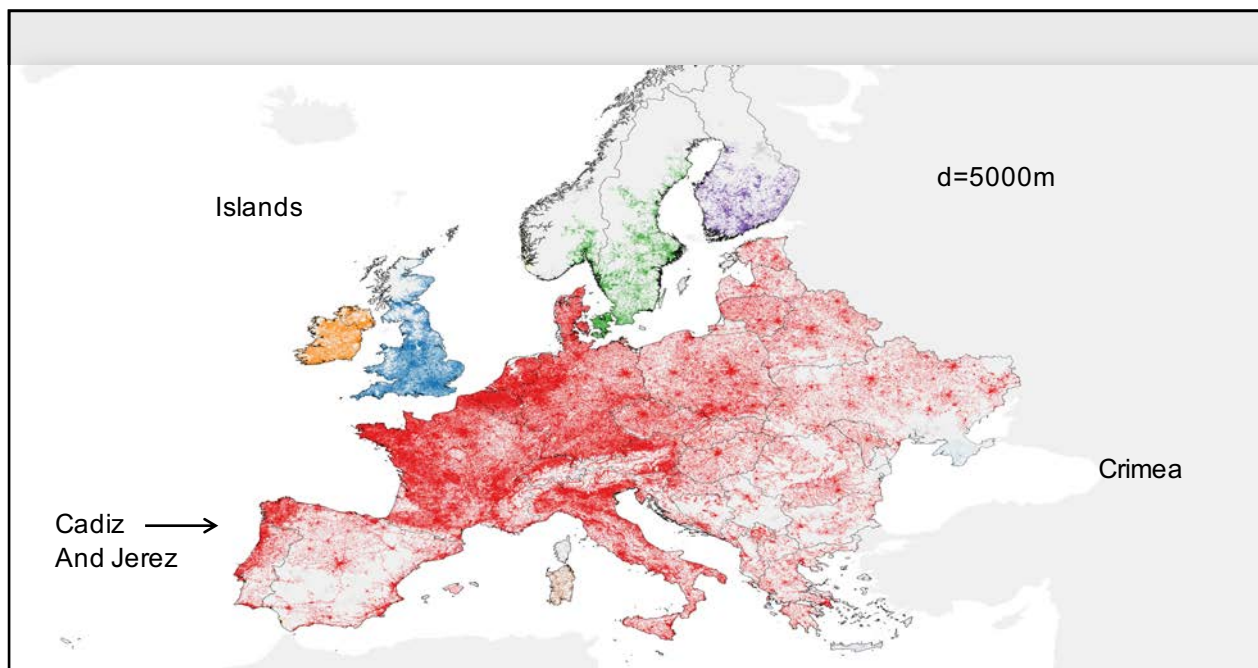


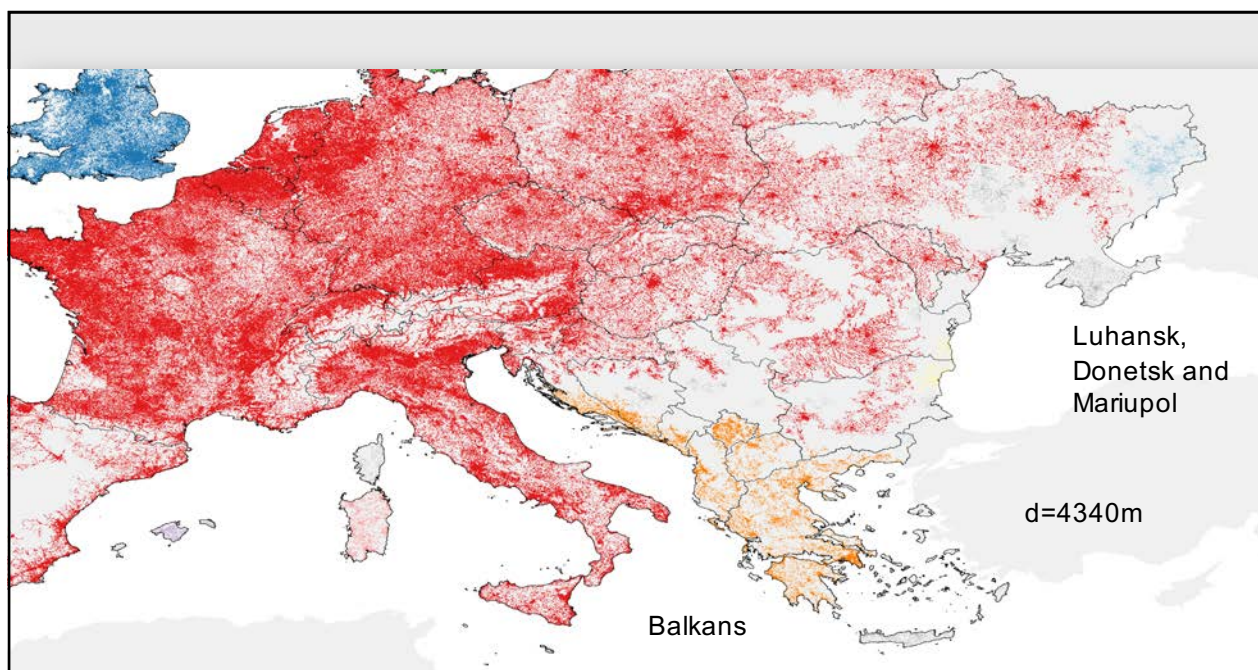
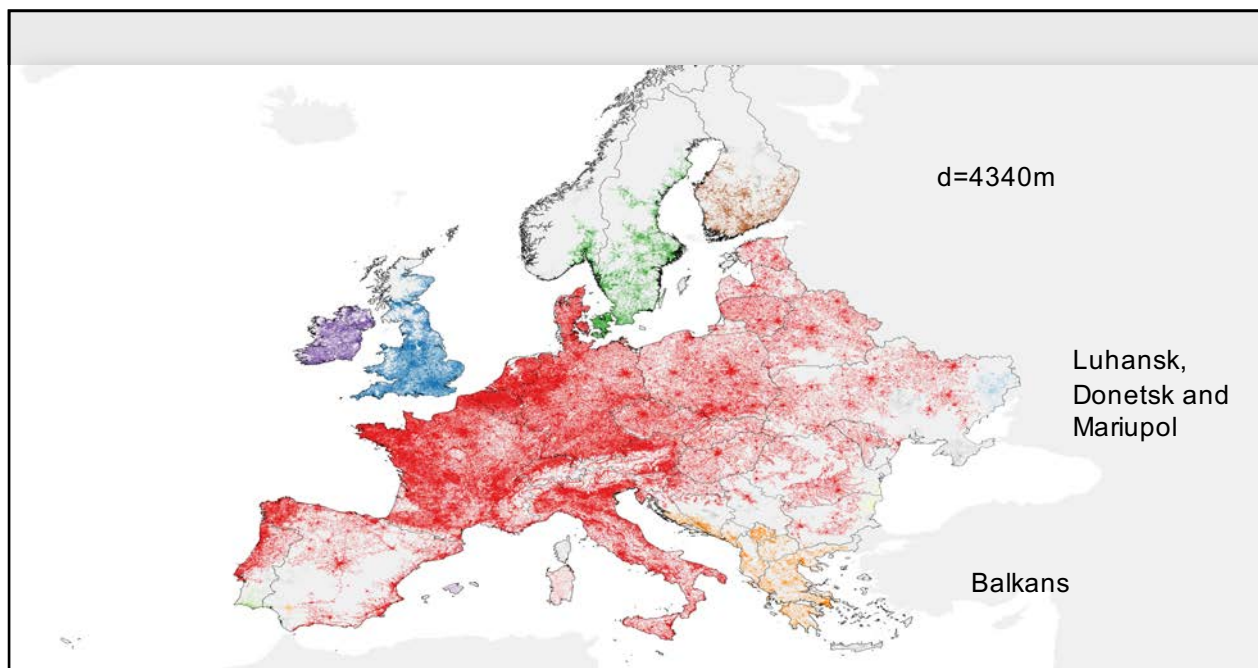
Defining cities: fractal dimension – maximum space filling; and correlation with RS imagery interpretations

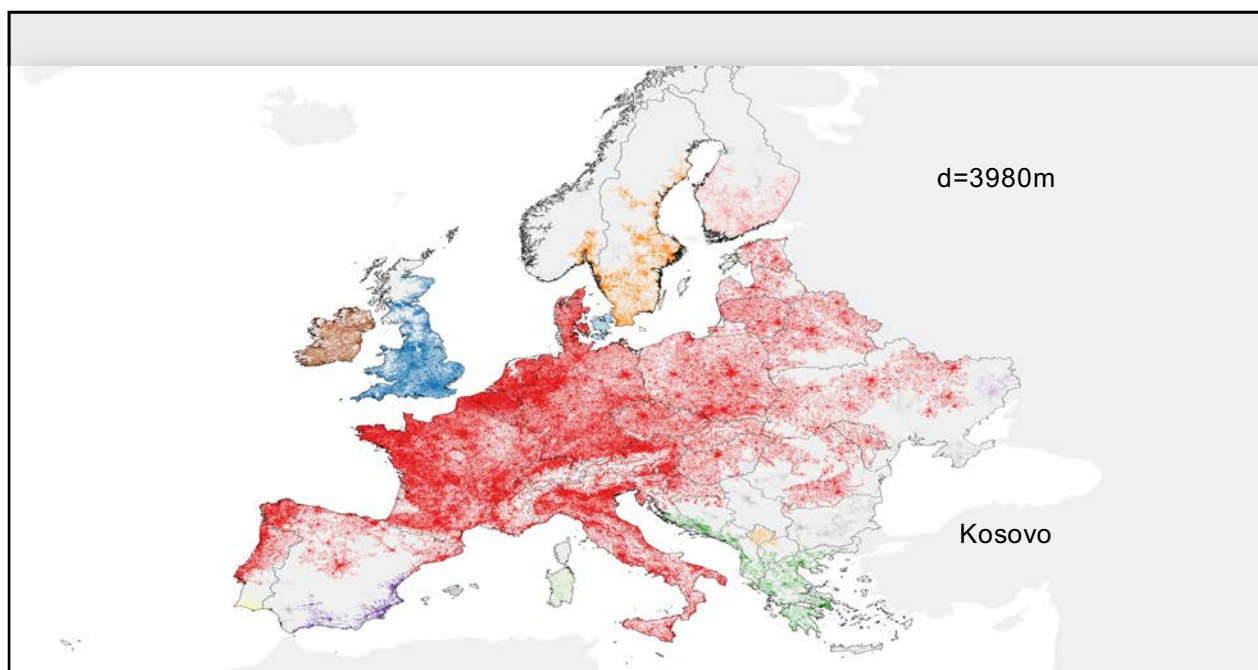
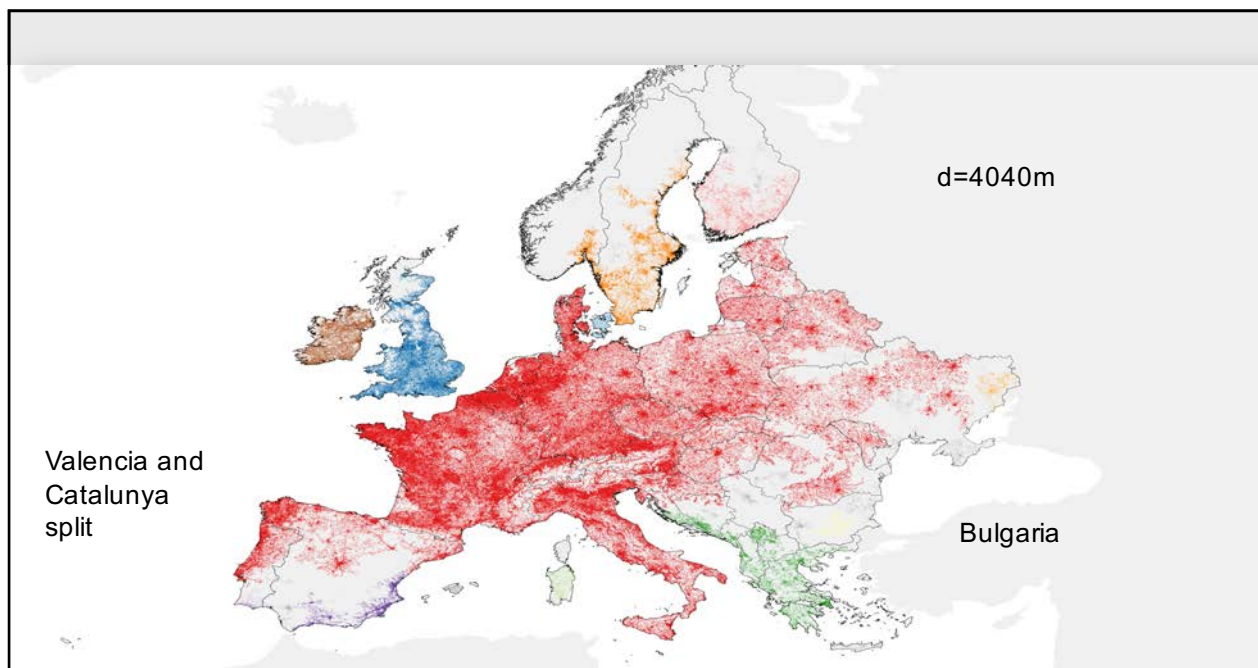


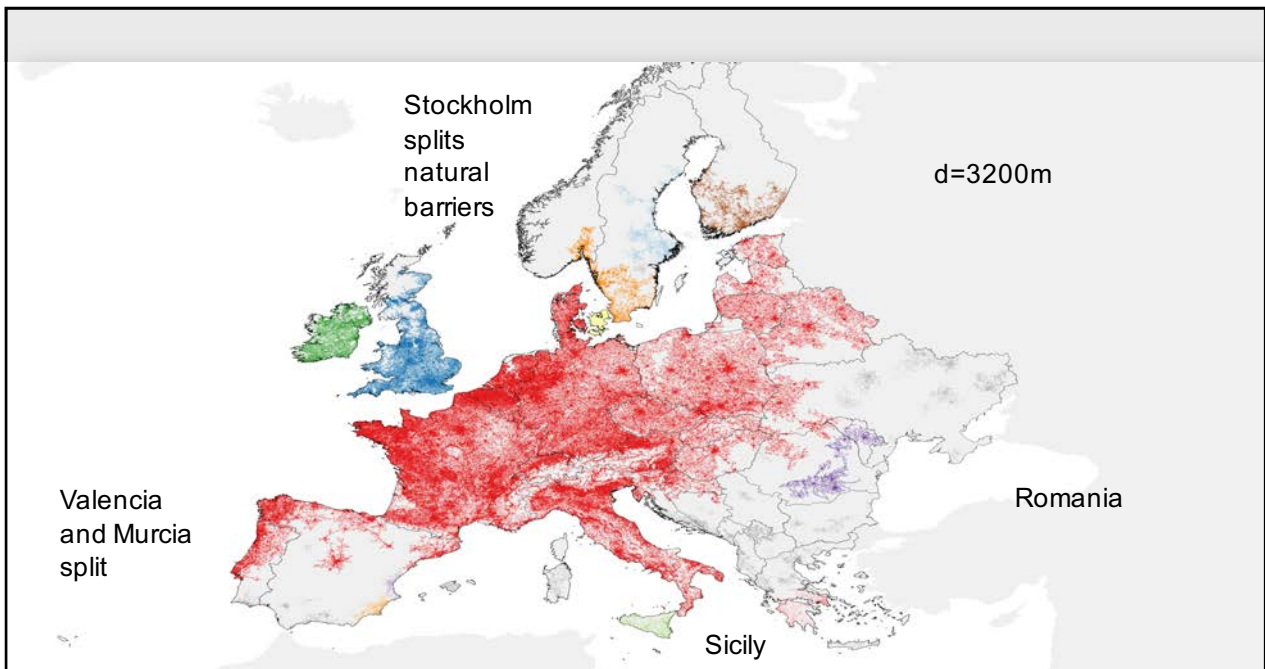
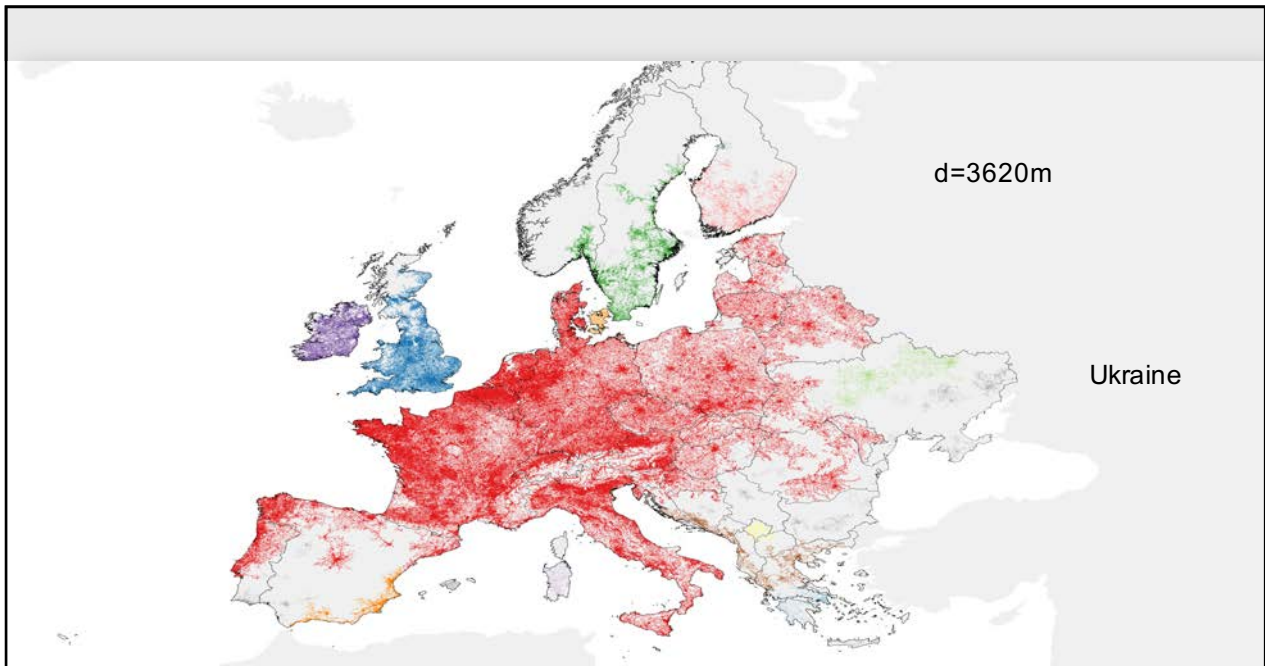
Extensions: Europe, A New View of BREXIT

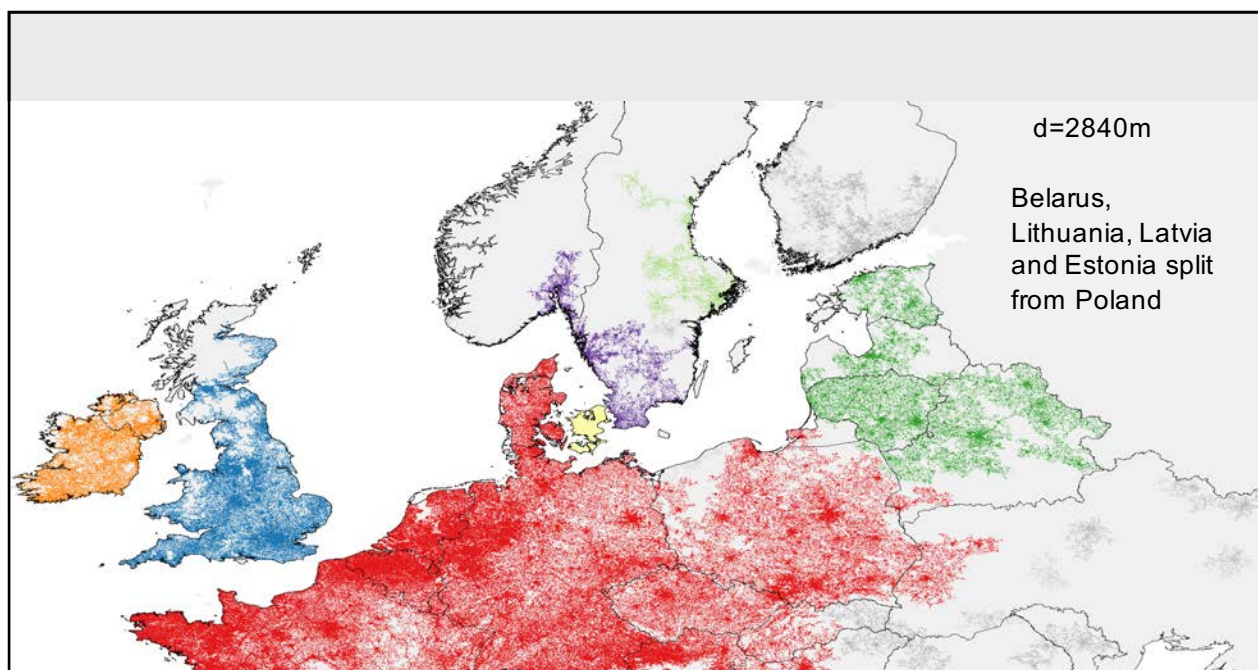
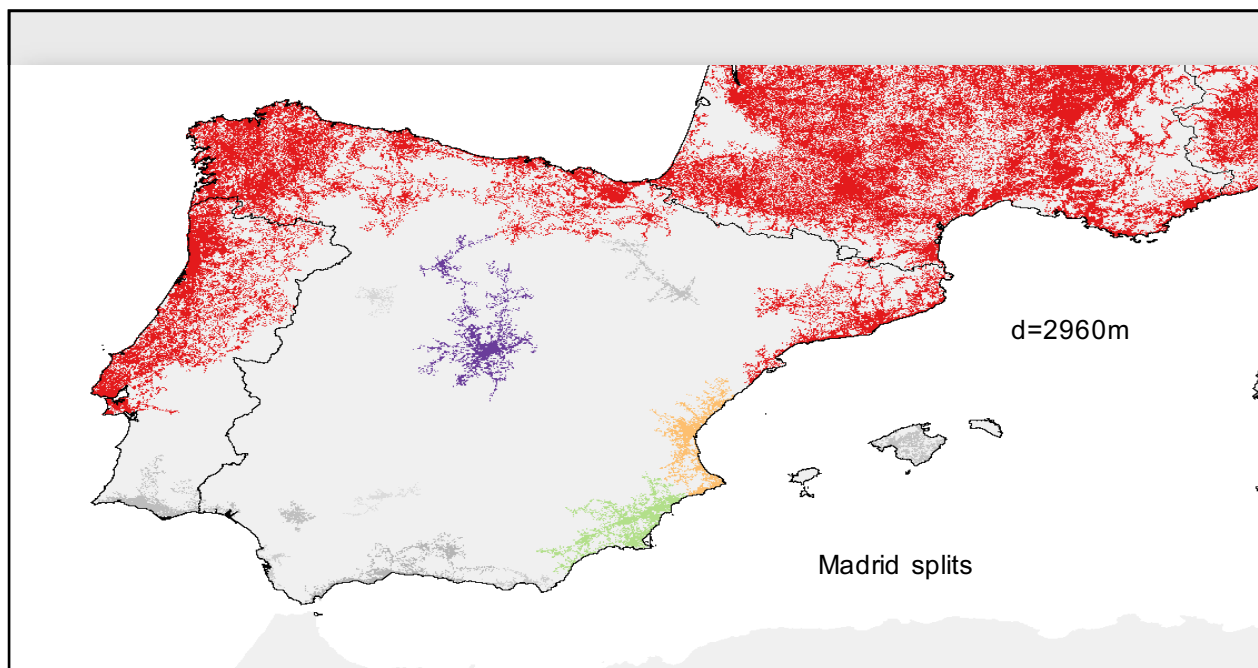
- Develop percolation theory for defining cities and although we have not yet reproduced the E&W results for a definition of cities based on percolation – we know that the clusters at a certain level are similar to density/commuting thresholds
- Do the same for Europe and America – I will show Europe
- Work out new measures of performance and extend the percolation to weighted measures
- Begin to do this at the intra-urban level – to define how cities are formed and evolve from the bottom up – I will show preliminary results for London

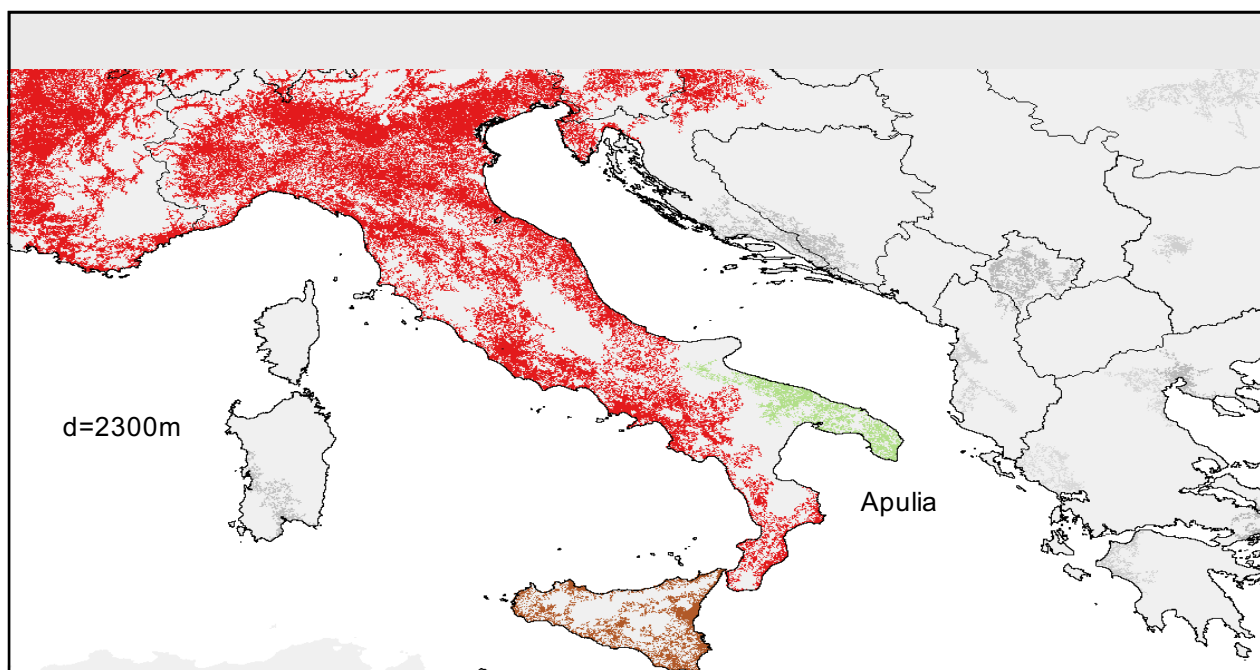
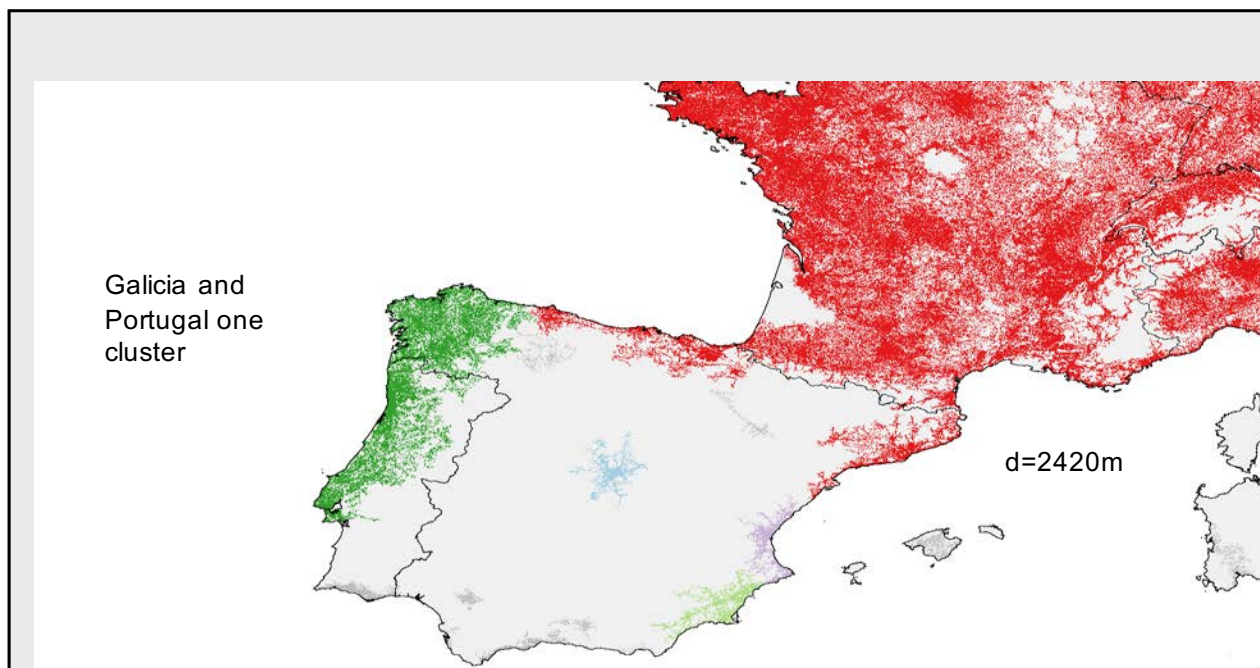


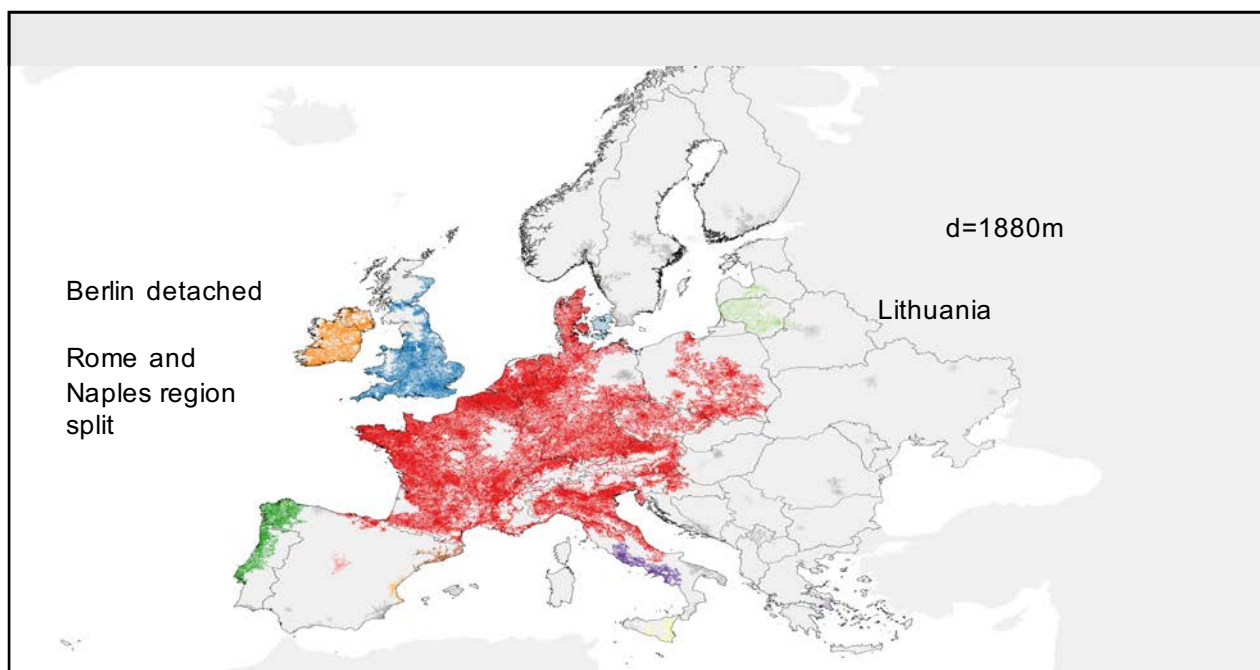
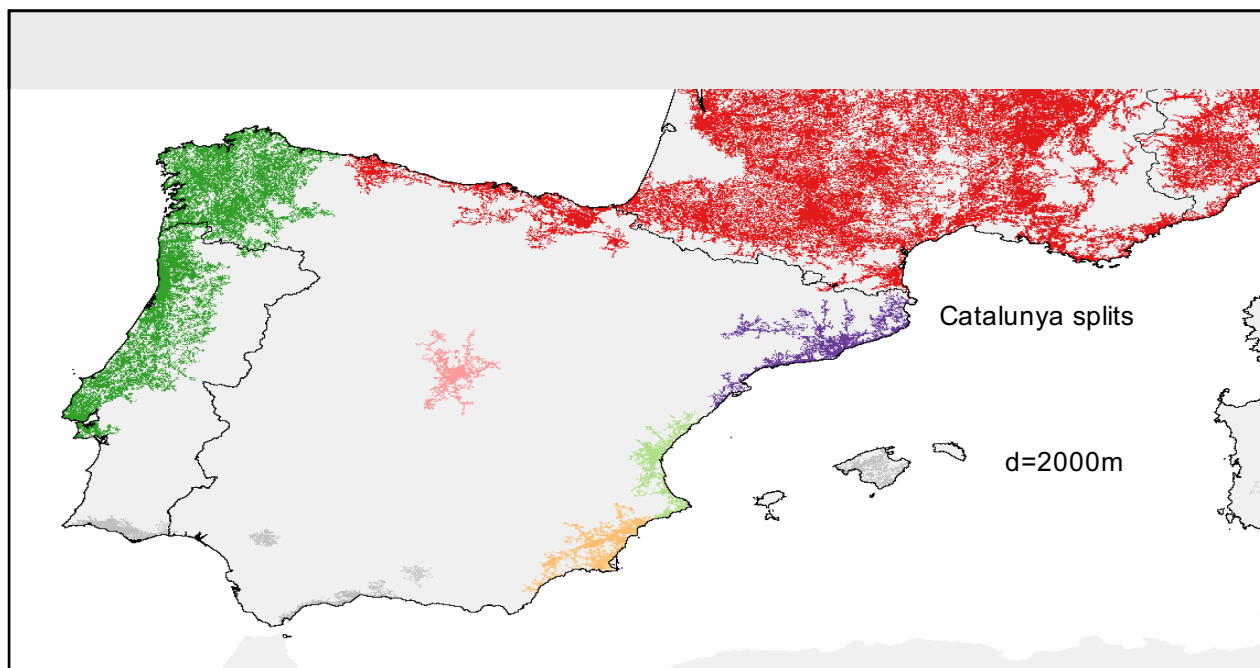


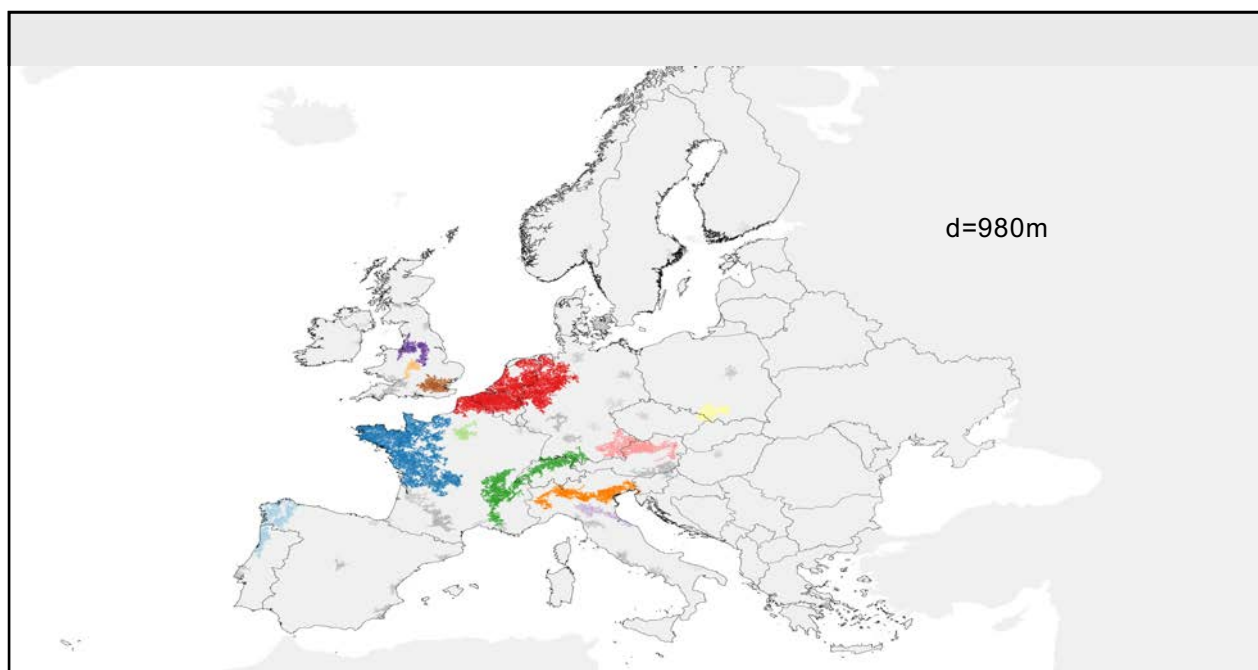
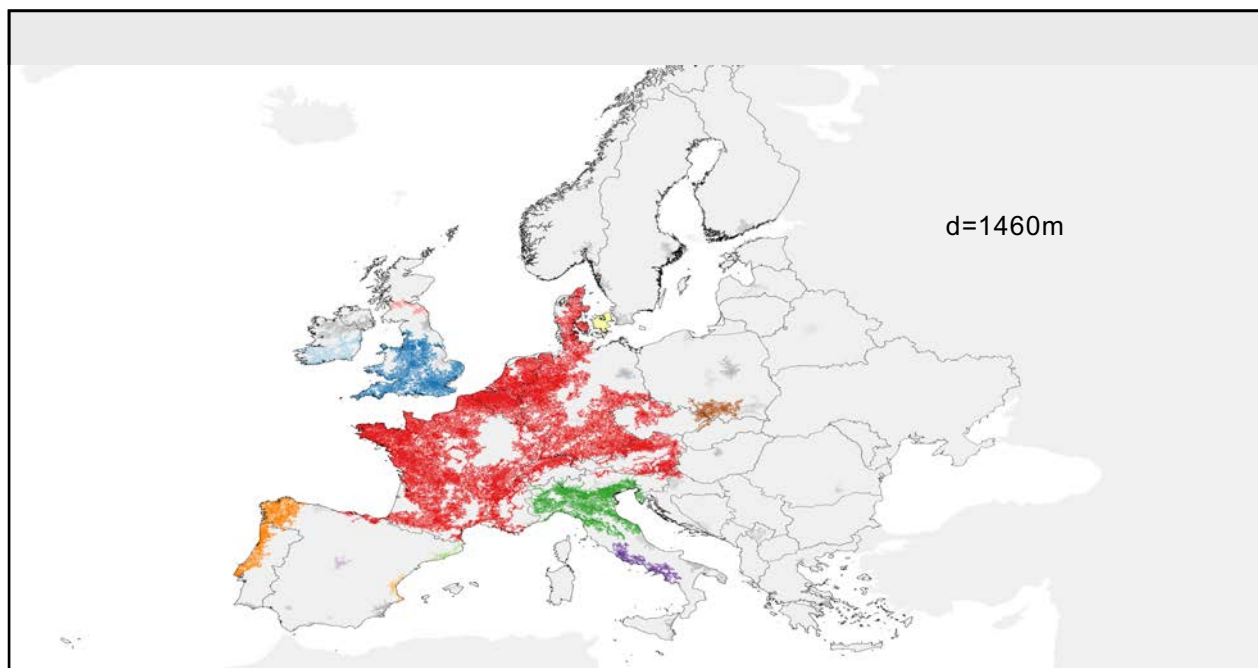


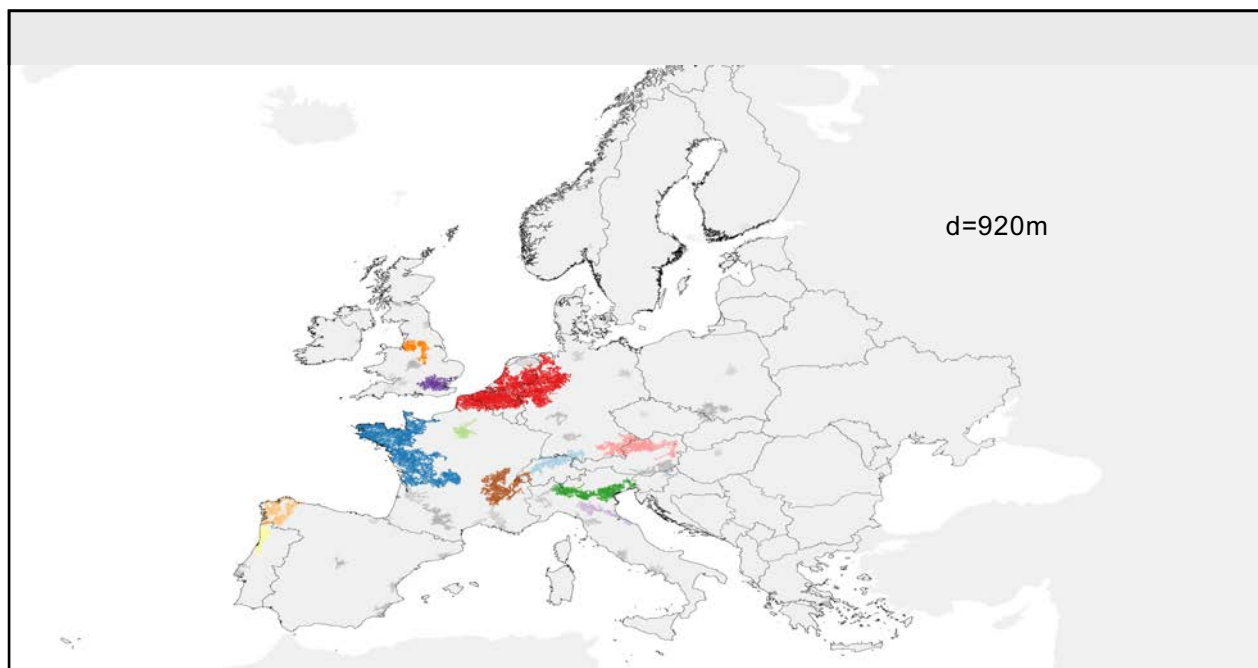












Inside Cities: London: Unpicking Its Structure

Let us generate clusters this time from the bottom up, from a very local threshold up to the radius of the entire city. We are looking here at London within the M25 – the GLA area for purely data availability reasons – we should go wider – include Oxford?



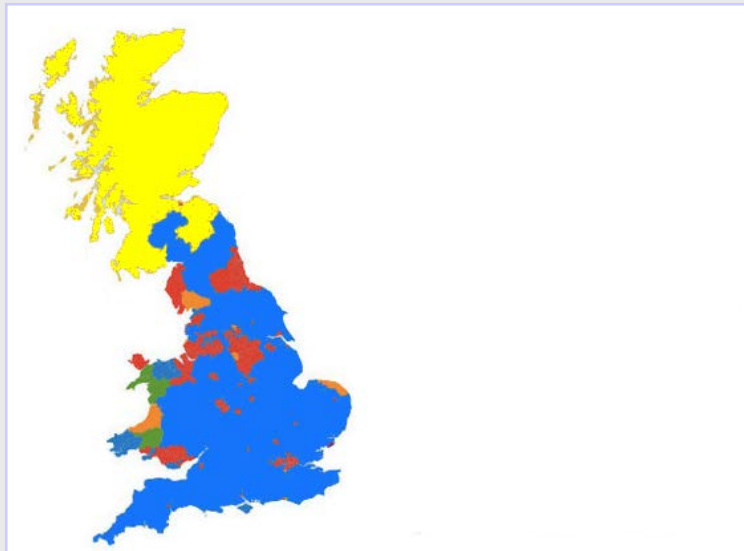
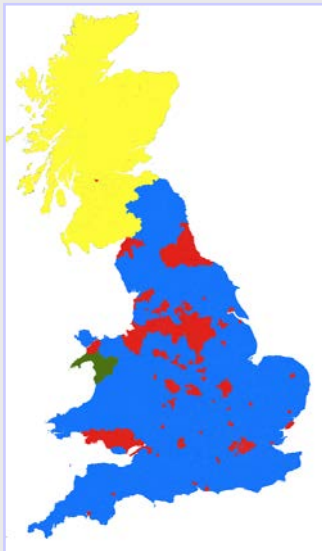
Before I conclude, let me qualify heavily the subtext

- To an extent, all this is hardly new but it focuses on something we have been very bad at doing - looking at the properties of cities. What we don't know about cities and their science, one could write a book about
- We now have a lot of work going on about these properties – partly it is addressed by looking at elements and how they vary with size and shape – how they scale – scaling – rank size, power laws and so on
- But it is also about how cities vary in their patterns of interaction. How we travel differently as cities get bigger etc

- What we need is a well worked out theory – a wider framework – and there are elements of this in the making – in this talk allometry of course and also in hierarchy and central place theory and so on
- It would be very nice to connect all this up and for someone, not me, to try and pull many things together
- I think much of this is consistent with quantitative and theoretical human geography of the last 50 years, and of urban economic theory too
- But it has to be cast in terms that we know which is size and shape of cities, and it has to be cast in how cities change through time and how technology changes

Let me finish by returning to the General Election

- We did make some predictions. What we did was to cluster the nodes in the street network as you have seen.
- Then we produced a hierarchy of clusters and from the overlaps with constituencies we allocated the 2010 votes.
- As a constituency overlapped a cluster we then produced new voting patterns from the averages of how much of the clusters overlapped the constituencies.
- This gave us a new voting profile. Then we made some assumptions about what else from socio-economic data affected voting and this gave us a predictive model



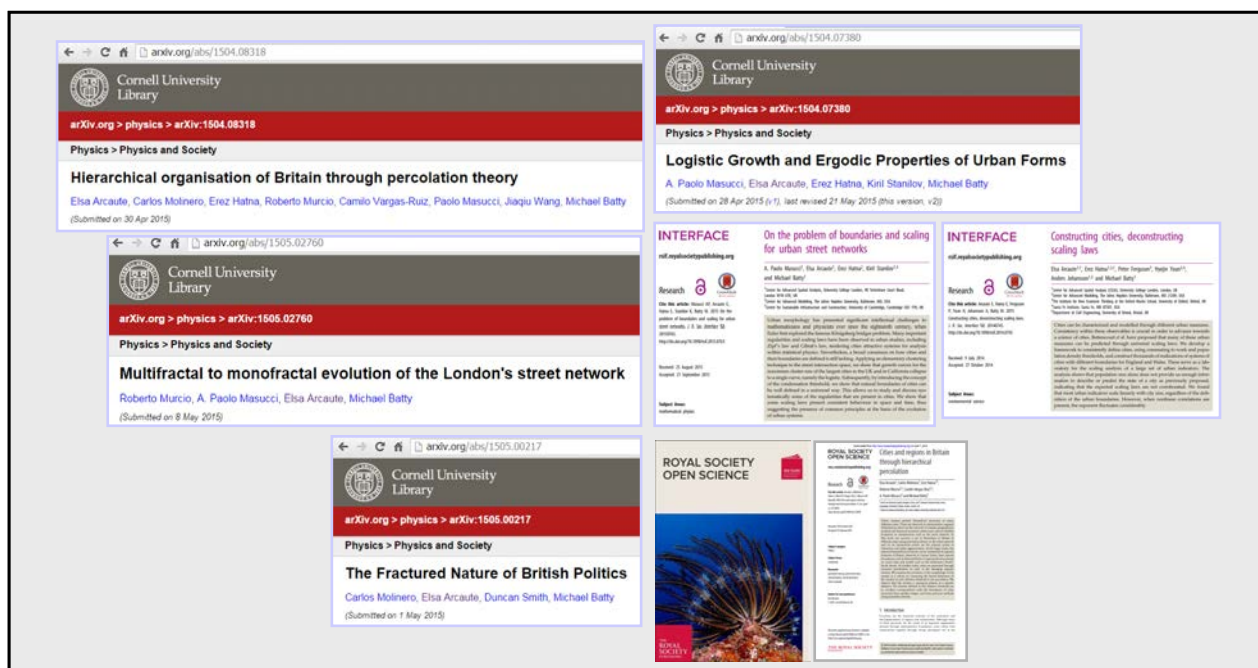
supply your own caption

I have to thank a lot of my colleagues for this work. I also need to thank the ERC and EPSRC



Drs. Elsa Arcaute, Carlos Molinero, Erez Hatna (Johns Hopkins), Anders Johansson (U Bristol/Crowd Vision), Pete Ferguson & Camilo Vargas-Ruiz (Prospective Labs), Roberto Murcio, Jaiqiu Wang, Paolo Masucci & Clementine Cottineau.

We have a bunch of unpublished papers in the Arxiv, & three published ones



Thanks

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www.complexcity.info