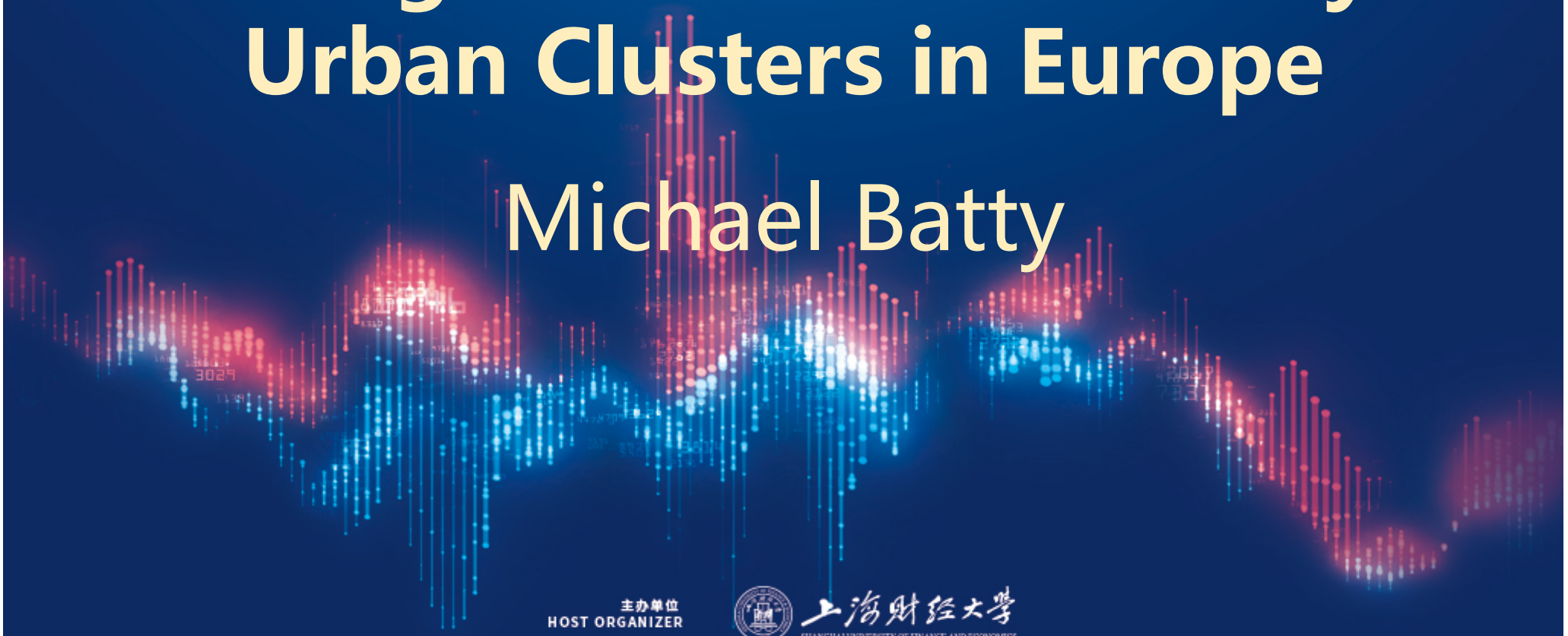
长三角国际论坛
YANGTZE RIVER DELTA INTERNATIONAL FORUM

Defining Cities: The Hierarchy of Urban Clusters in Europe

Michael Batty



主办单位
HOST ORGANIZER

上海财经大学
SHANGHAI UNIVERSITY OF FINANCE AND ECONOMICS

合作伙伴
CO-ORGANIZER

U-SHINE FUND 友山基金

长三角国际论坛
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定义城市：欧洲城市群的层次

Michael Batty
迈克尔·巴蒂

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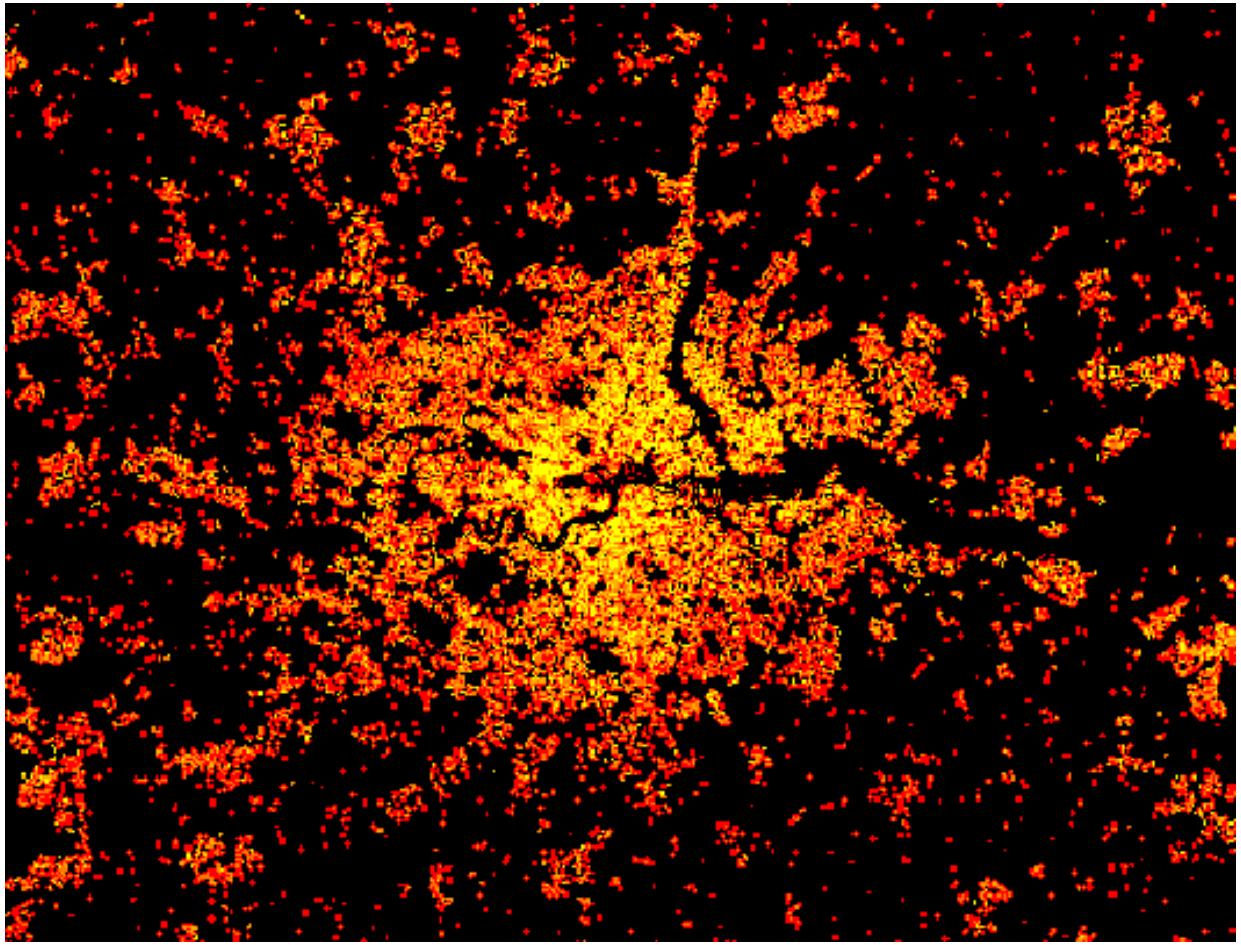
U-SHINE FUND 友山基金

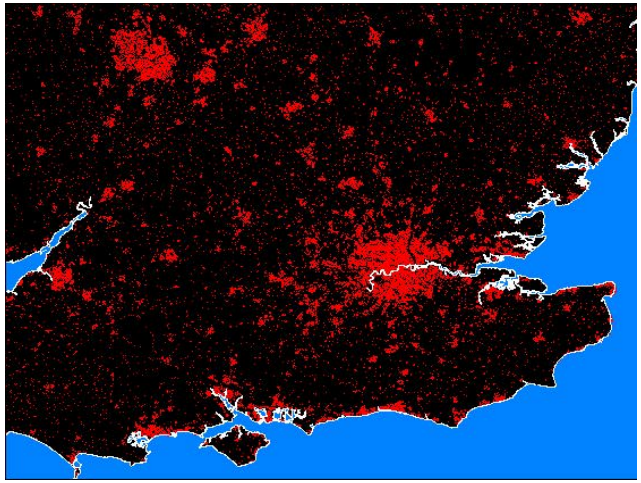
An Outline

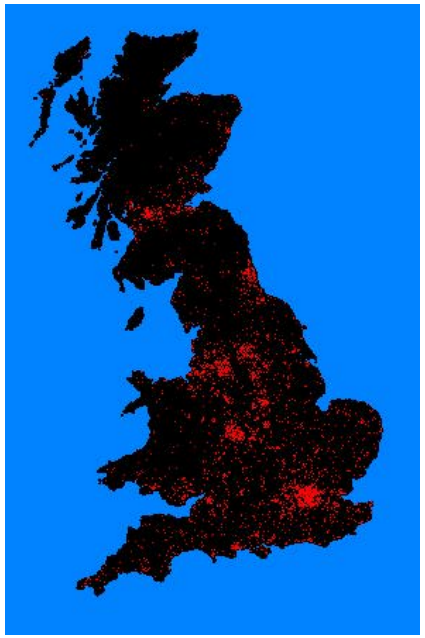
- Preliminaries: Defining Cities
- We Cannot Define Cities Until We Know What a City Is
- Defining Nations, Regions and Cities
- City Performance: Wealth and Inequality
- Do Bigger Cities Generate More Wealth?
- Extensions: Europe, Integration and Fragmentation
- Doing It All at Different Scale: Inside Cities

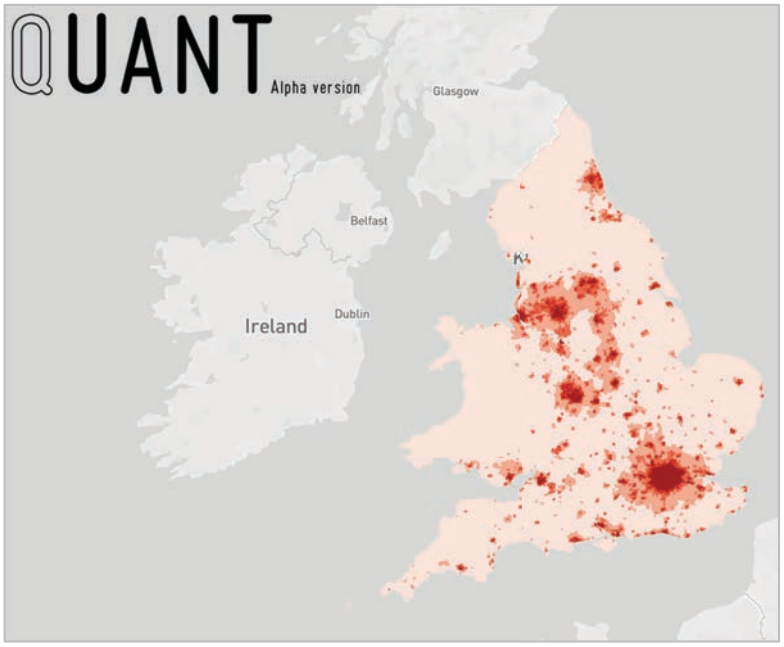
Preliminaries: Defining Cities

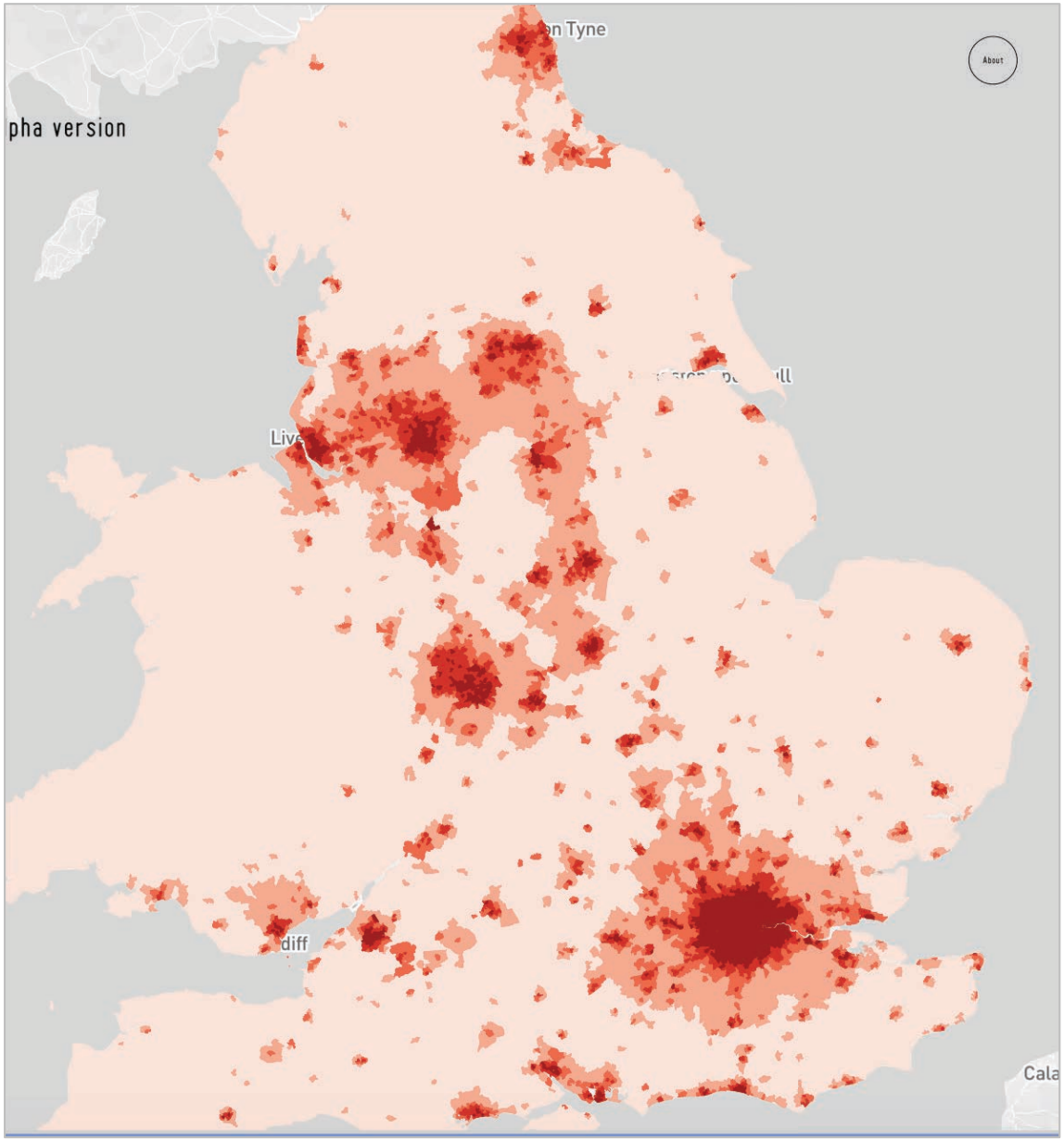
- It is spatial extent that is key here – the properties of cities will change as we change extent – this is the ecological fallacy and the modifiable areal unit problem
- It also relates to commuting and interactions, migration, trade flows and now of course the whole issue of electronic interactions
- 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











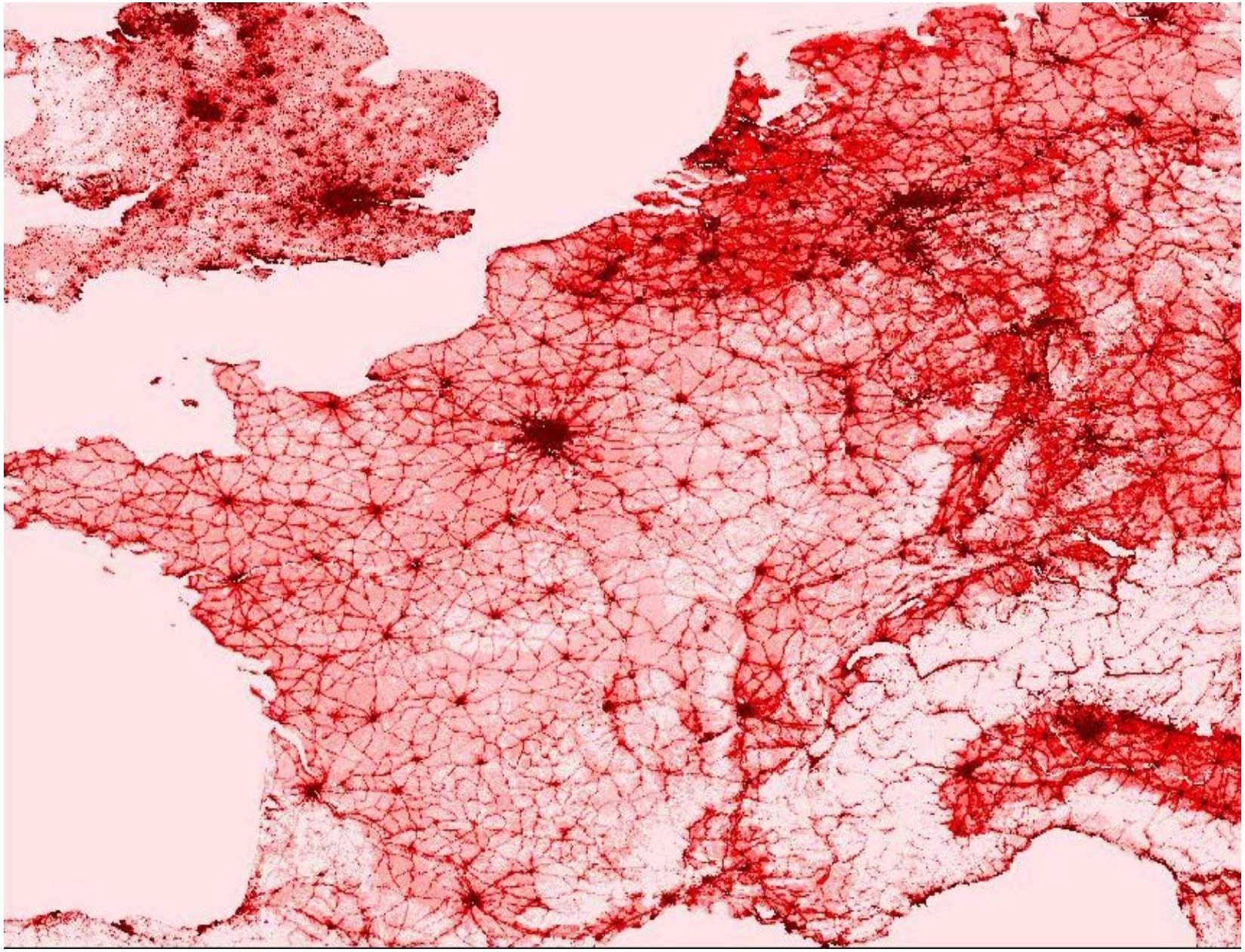
Accessibility – The relative nearness of populations – note how in England and Wales, we have almost one big city – not unlike this Yangtze River Delta



Defining Cities: The Hierarchy of Urban Clusters in Europe



Defining Cities: The Hierarchy of Urban Clusters in Europe

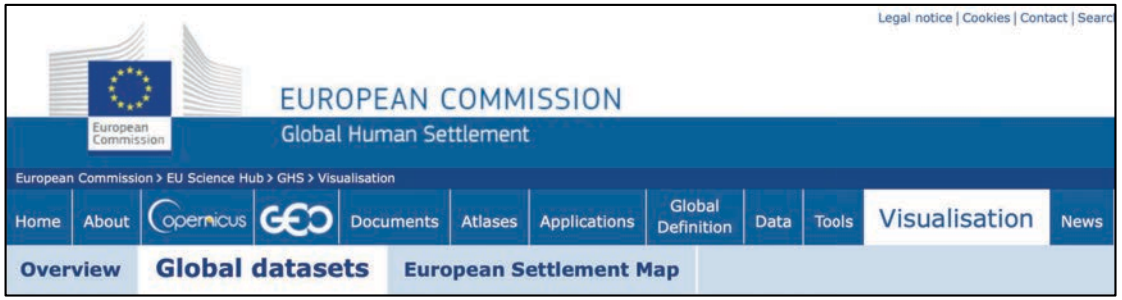


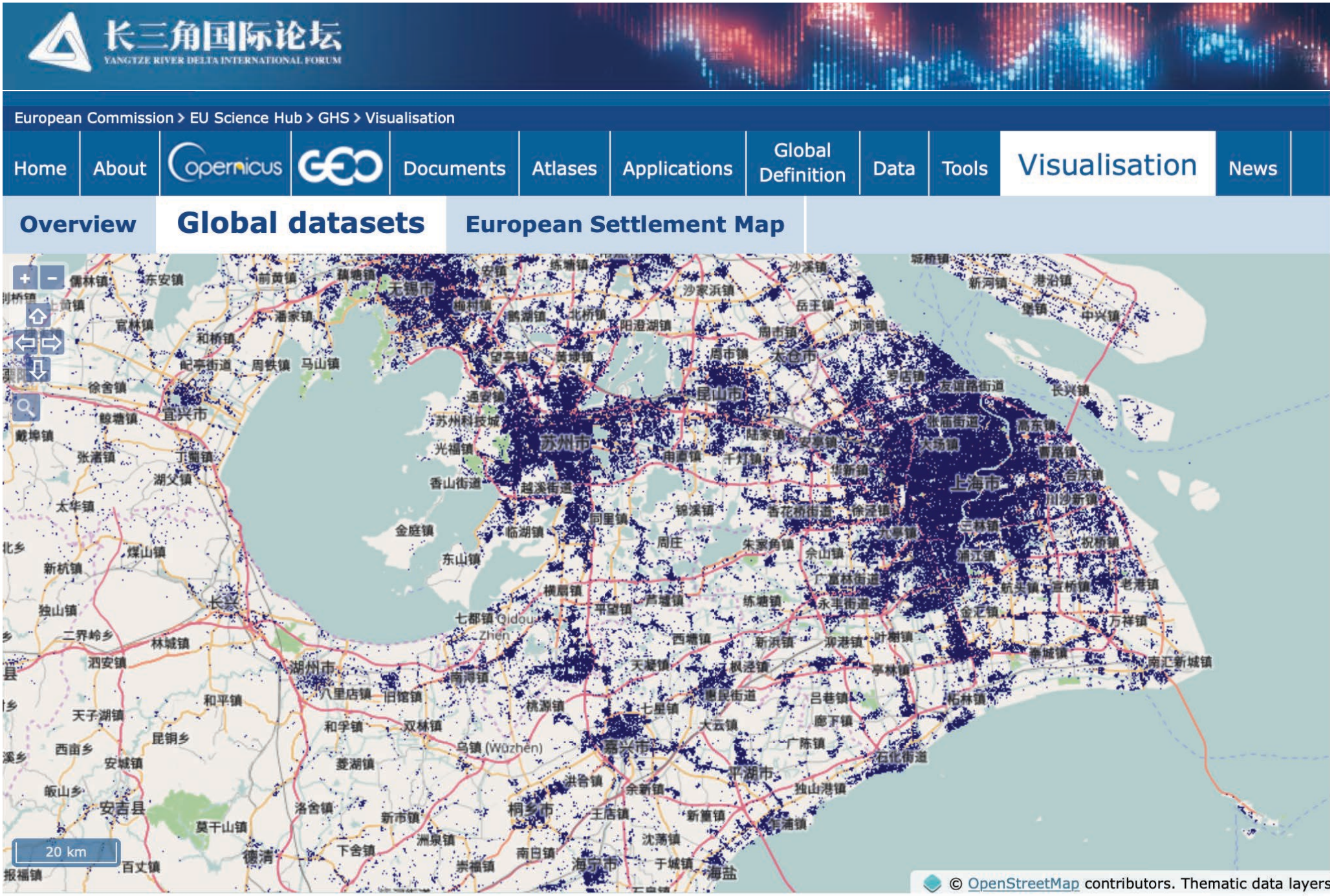
Defining Cities: The Hierarchy of Urban Clusters in Europe

We Cannot Define Cities Until We Know What a City Is

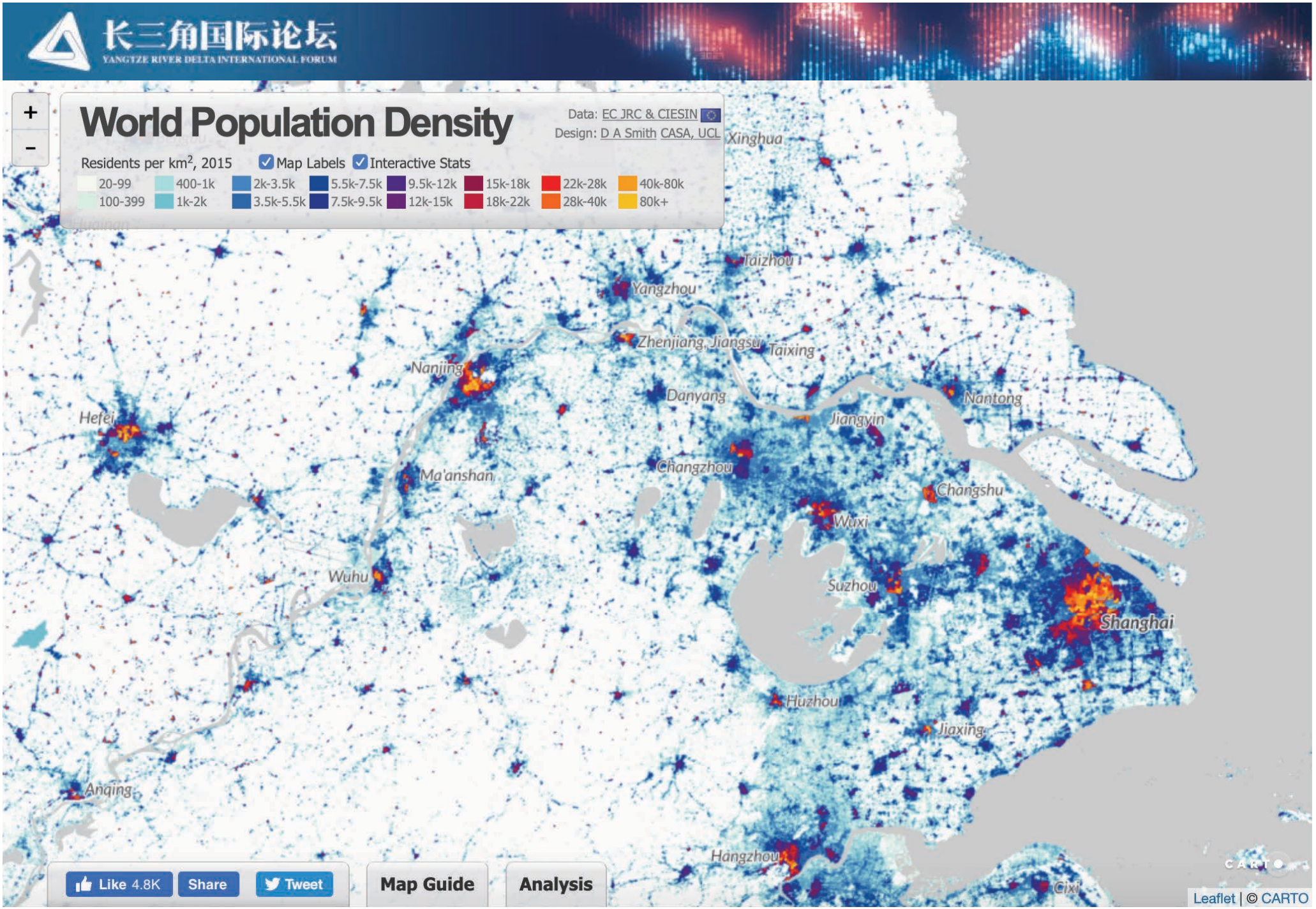
Let us look at the extent of cities in this region – I have taken these slides from various data bases that I will show you later – but here are some data from the various European data bases – the Global Human Settlements Layer – GHSL produced by the JRC at Ispra and Ciesen in Columbia University

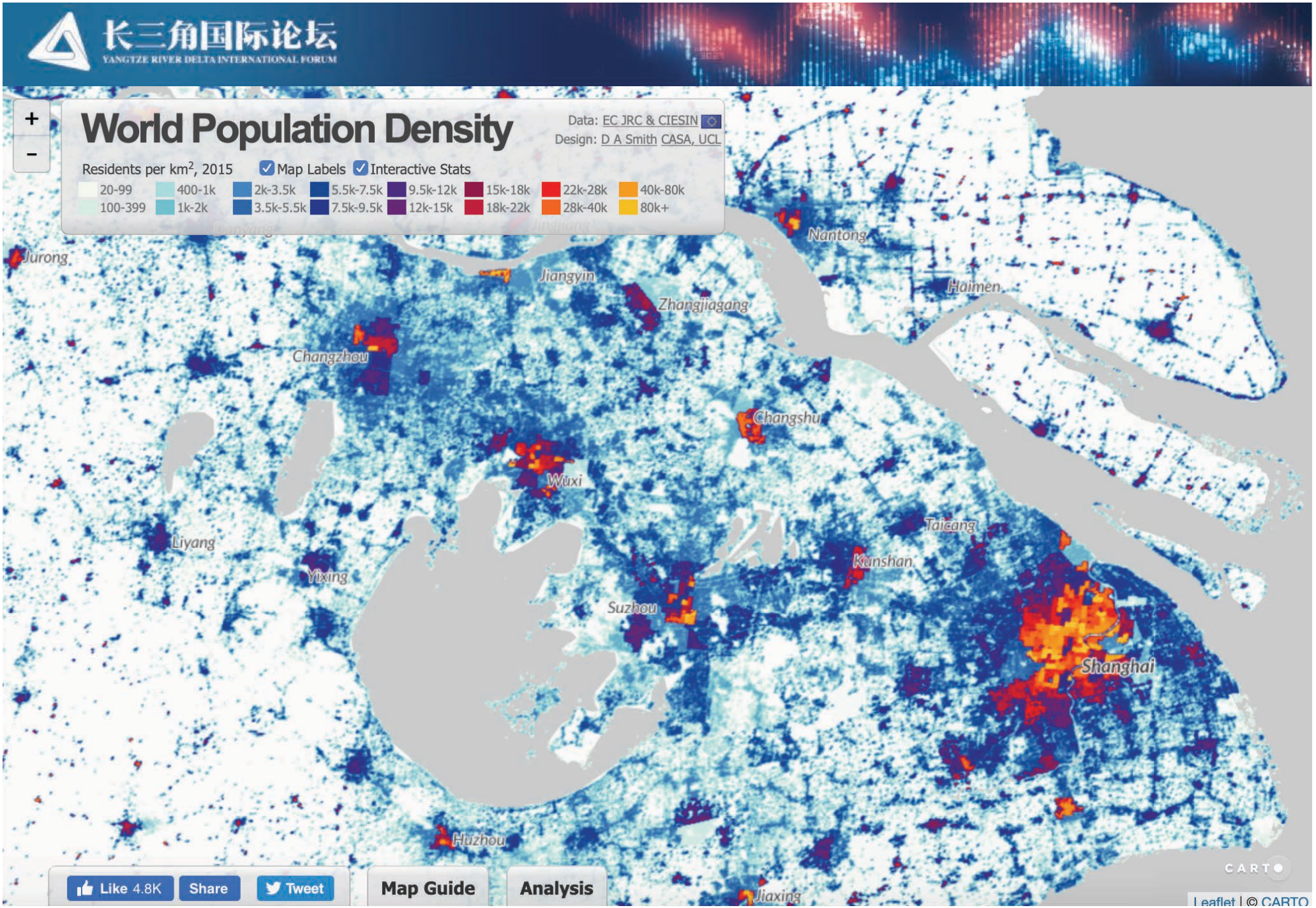
https://ghsl.jrc.ec.europa.eu/visualisation.php

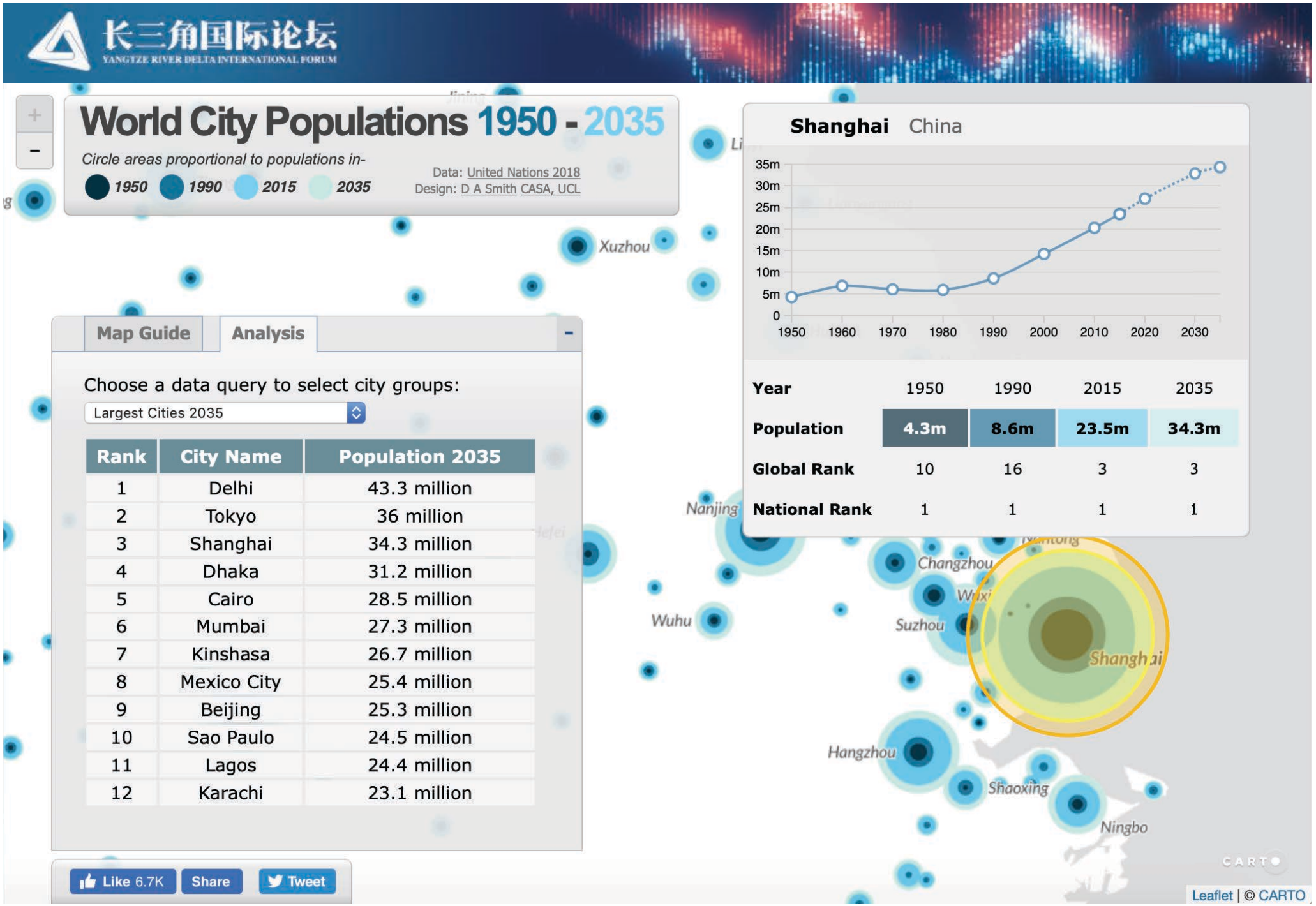




Defining Cities: The Hierarchy of Urban Clusters in Europe


World Population Density
Data: EC JRC & CIESIN
Design: D A Smith CASA, UCL
Residents per km², 2015
Map Labels
Interactive Stats
20-99
100-399
400-1k
1k-2k
2k-3.5k
3.5k-5.5k
5.5k-7.5k
7.5k-9.5k
9.5k-12k
12k-15k
15k-18k
18k-22k
22k-28k
28k-40k
40k-80k
80k+
Xinghua
Taizhou
Yangzhou
Zhenjiang, Jiangsu
Taixing
Nanjing
Danyang
Nantong
Jiangyin
Hefei
Changzhou
Ma'anshan
Changshu
Wuxi
Wuhu
Suzhou
Shanghai
Huzhou
Jiaxing
Anqing
Hangzhou
Cixi
Like 4.8K
Share
Tweet
Map Guide
Analysis
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World Population Density
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12k-15k
15k-18k
18k-22k
22k-28k
28k-40k
40k-80k
80k+
Jurong
Jiangyin
Zhangjiagang
Nantong
Haimen
Changzhou
Changshu
Wuxi
Taicang
Kunshan
Liyang
Yixing
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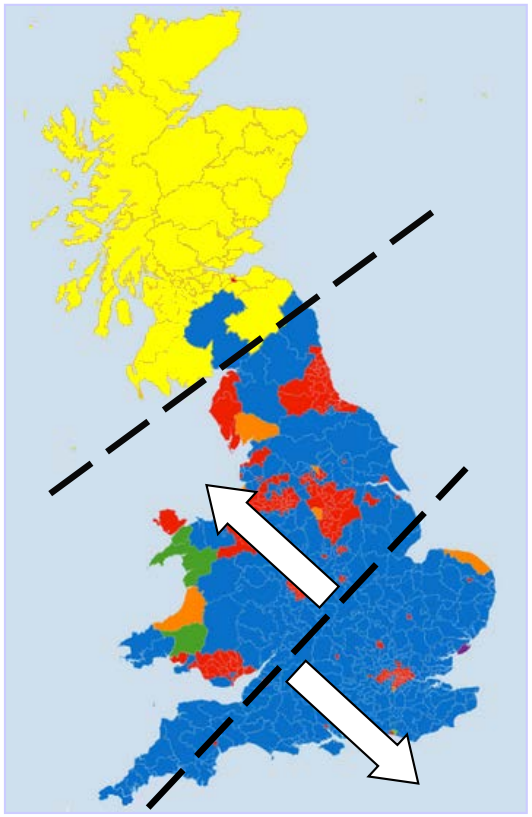
Defining Cities: The Hierarchy of Urban Clusters in Europe

Defining Nations, Regions and Cities

Let me take an example from my own country –

we have a hierarchy of smaller countries in our own federation –

the United Kingdom – Scotland, Wales, England, North Ireland (Ireland)



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

















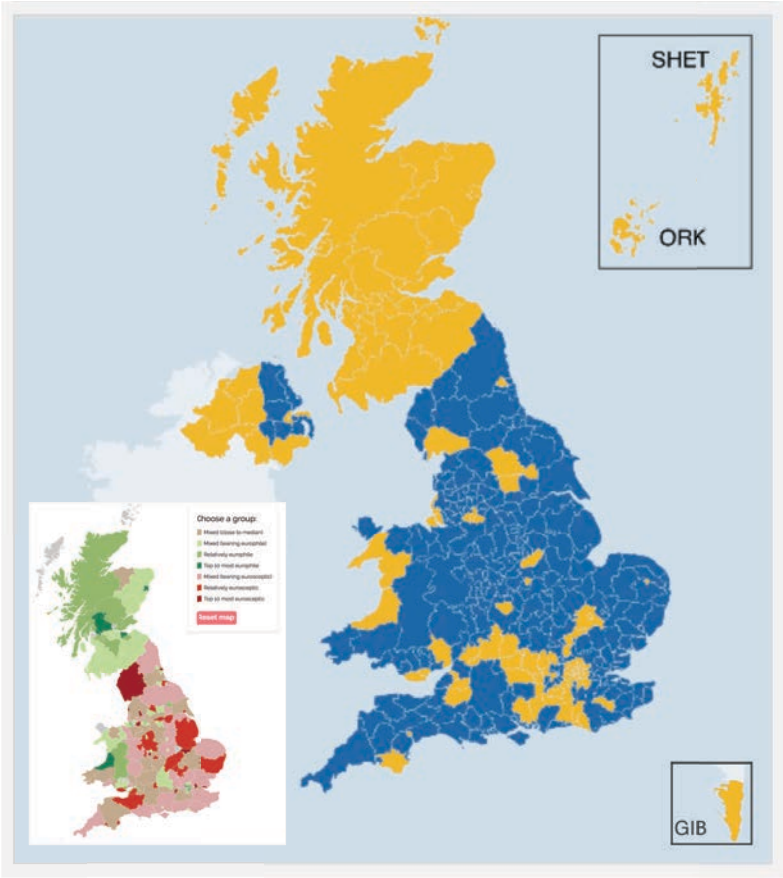
Defining Cities: The Hierarchy of Urban Clusters in Europe

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

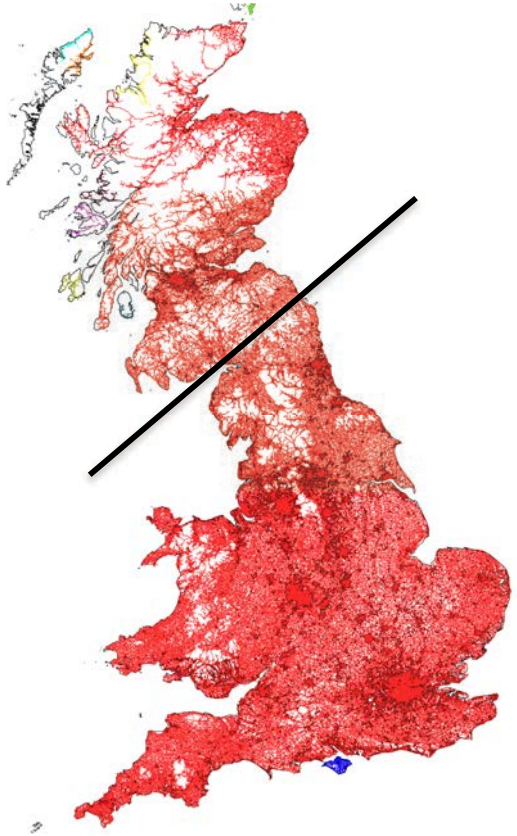
It is part of our project to look at the nature of urban morphology, city size, urban allometry and more particularly the qualitative changes that take place in the economy of cities as they agglomerate

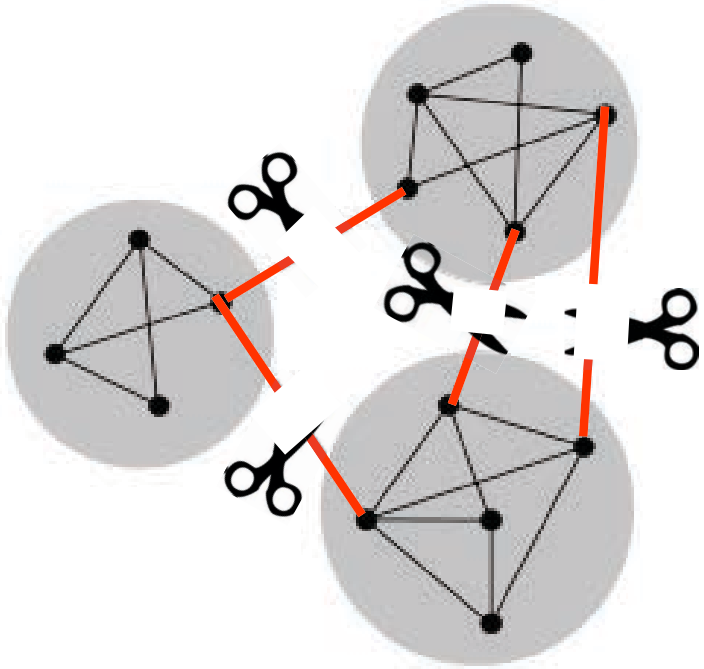
This is a key issue for thinking about a world where every one will be living in cities by the end of this century. But before that, back to Britain.

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 it key and so it the city-country difference



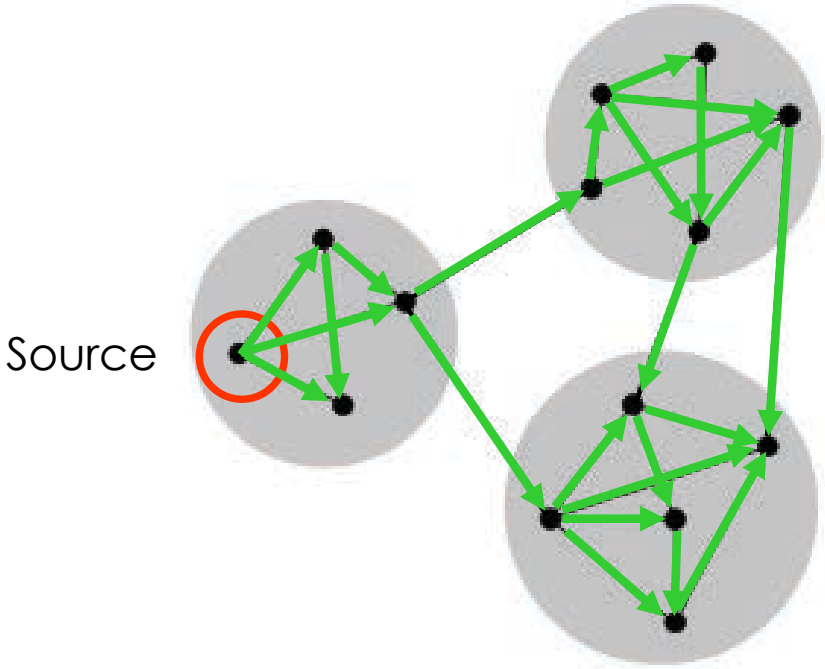
So how do we fracture Britain to predict its nations, regions and cities? Imagine the network of streets and roads which covers these entire islands. Let us cut the longest links – those that are greater than a distance threshold – so that we partition the network into clusters, and we keep on doing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

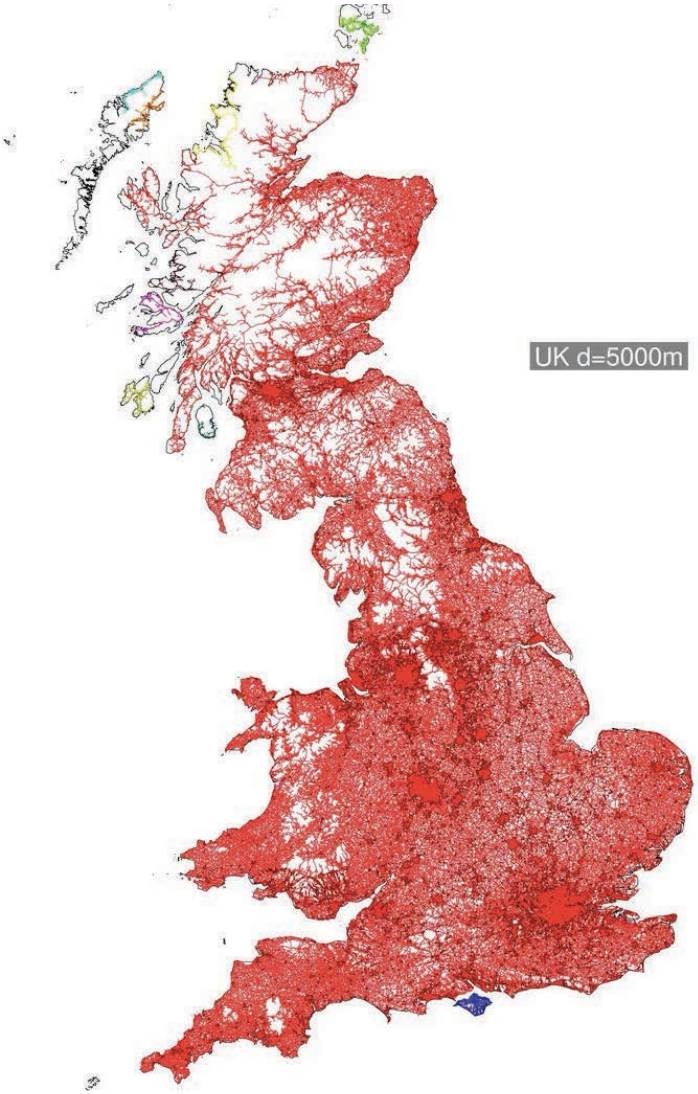
Imagine a process that diffuses from a source one step at a time. If the diffusion takes place on a network, as the diffusion continues, it takes in more and more of the network. At each stage more and more clusters are embraced and the biggest cluster grows in size – this is the giant cluster. Eventually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

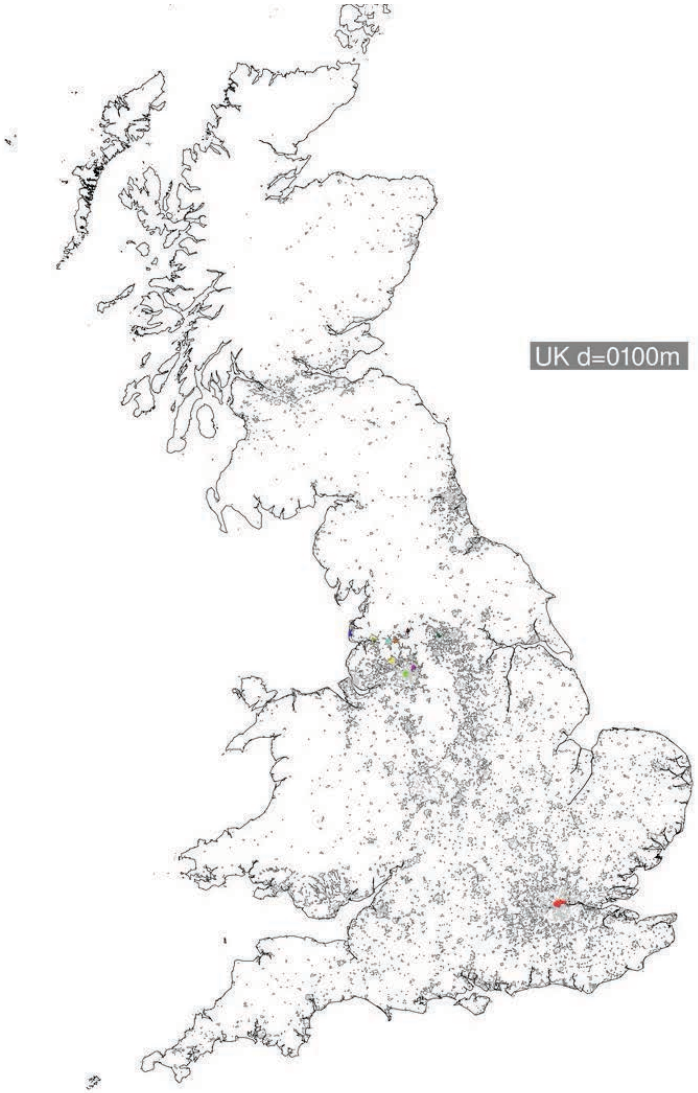


If you play this forwards we build clusters from the bottom up and backwards we build clusters from the top down

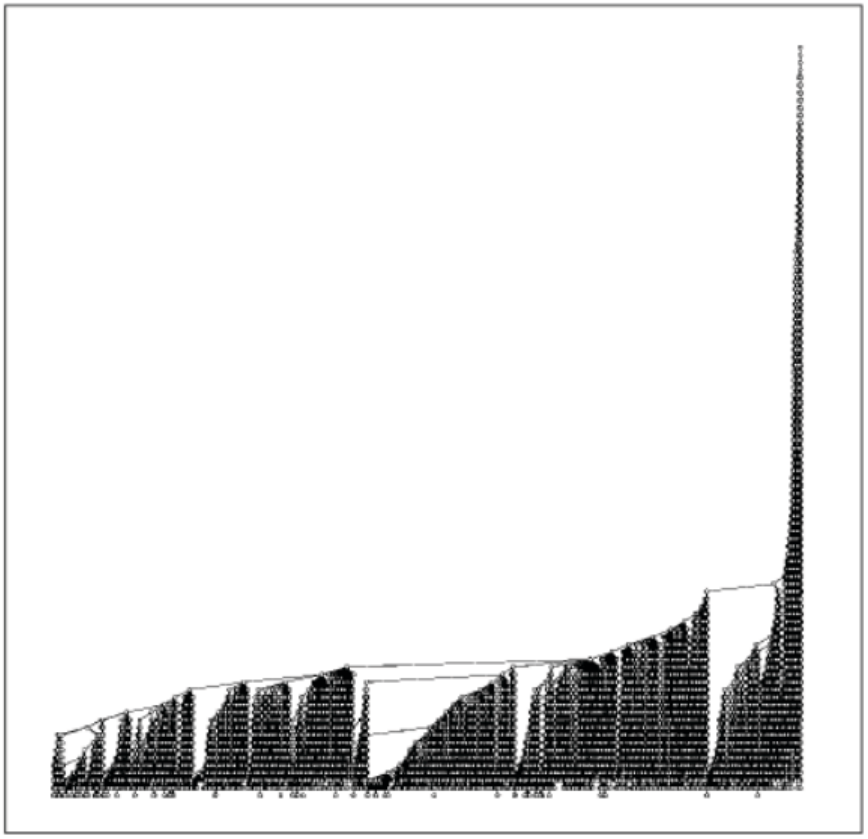
We start at 5km and then we progressively build the clusters from the bottom up which assembles the hierarchy from the top down.

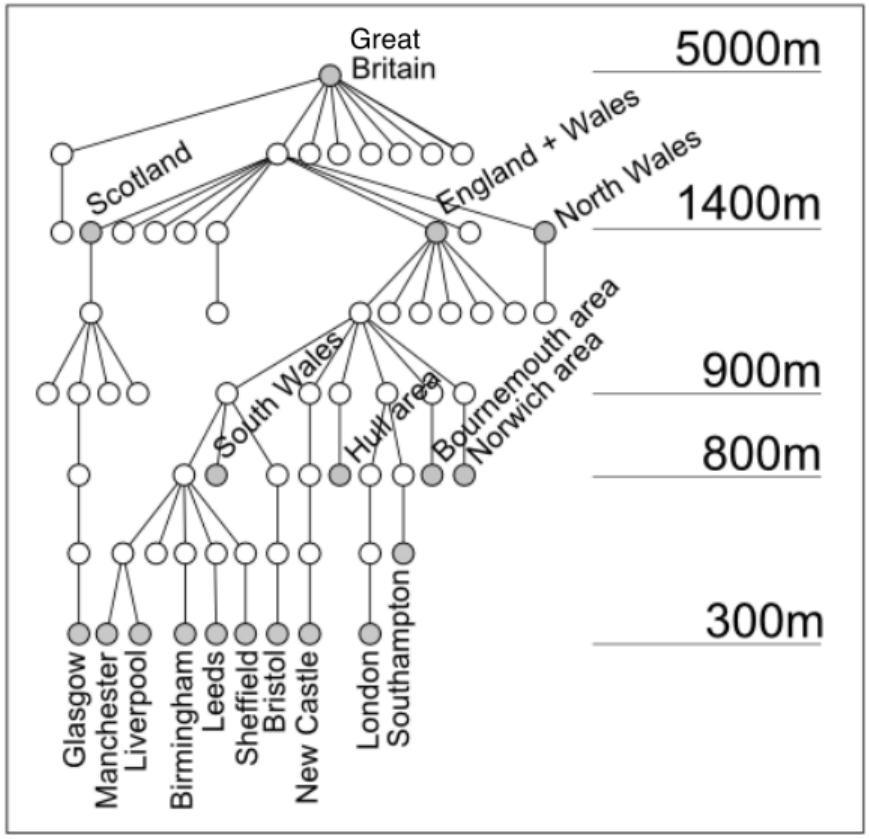
This produces nations, regions and then cities which is our main focus, not the Scottish election which I will return to at the end





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

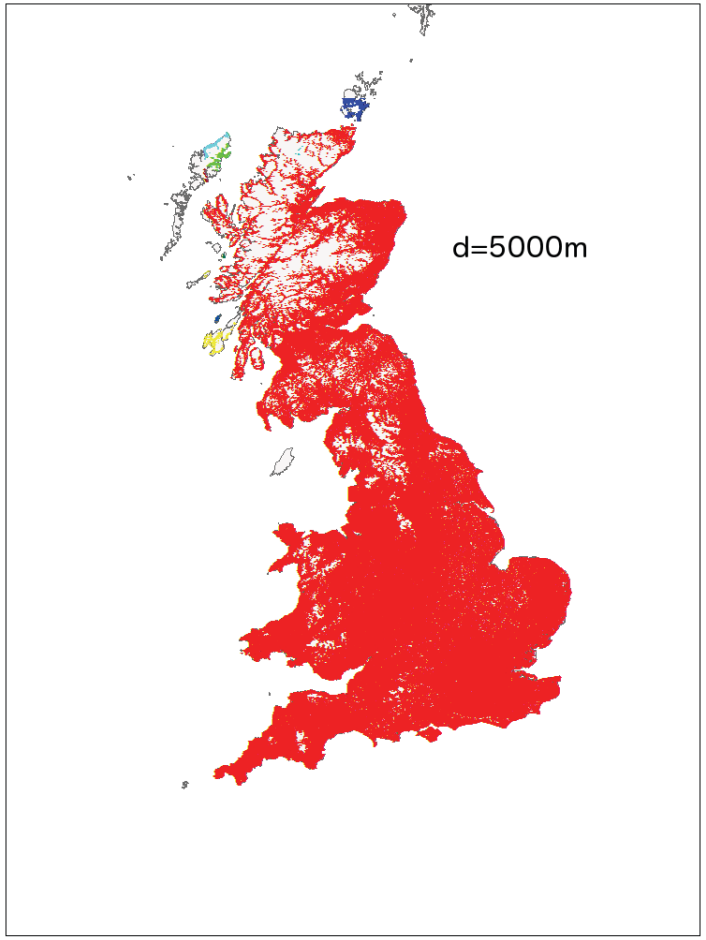




Let us make it a little more relaxed and look at the key stages – the essential issue from the election and what people vote is that *Britain breaks up into its historical cultural pieces*.

Fractured Britain, probably
Fractal Britain

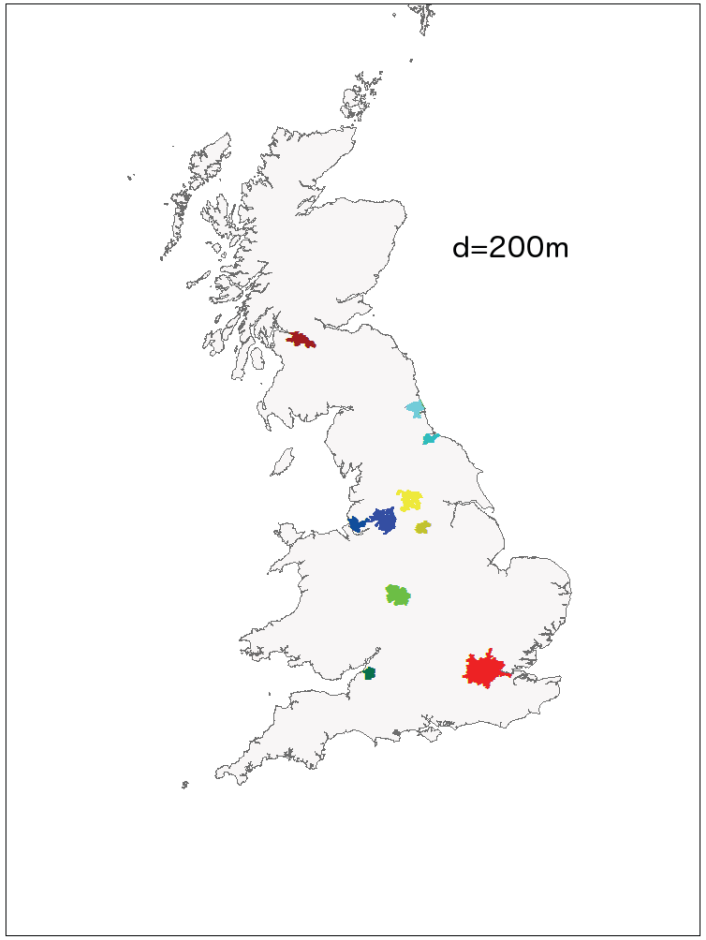
The movie shows it beautifully but so do these frames …..

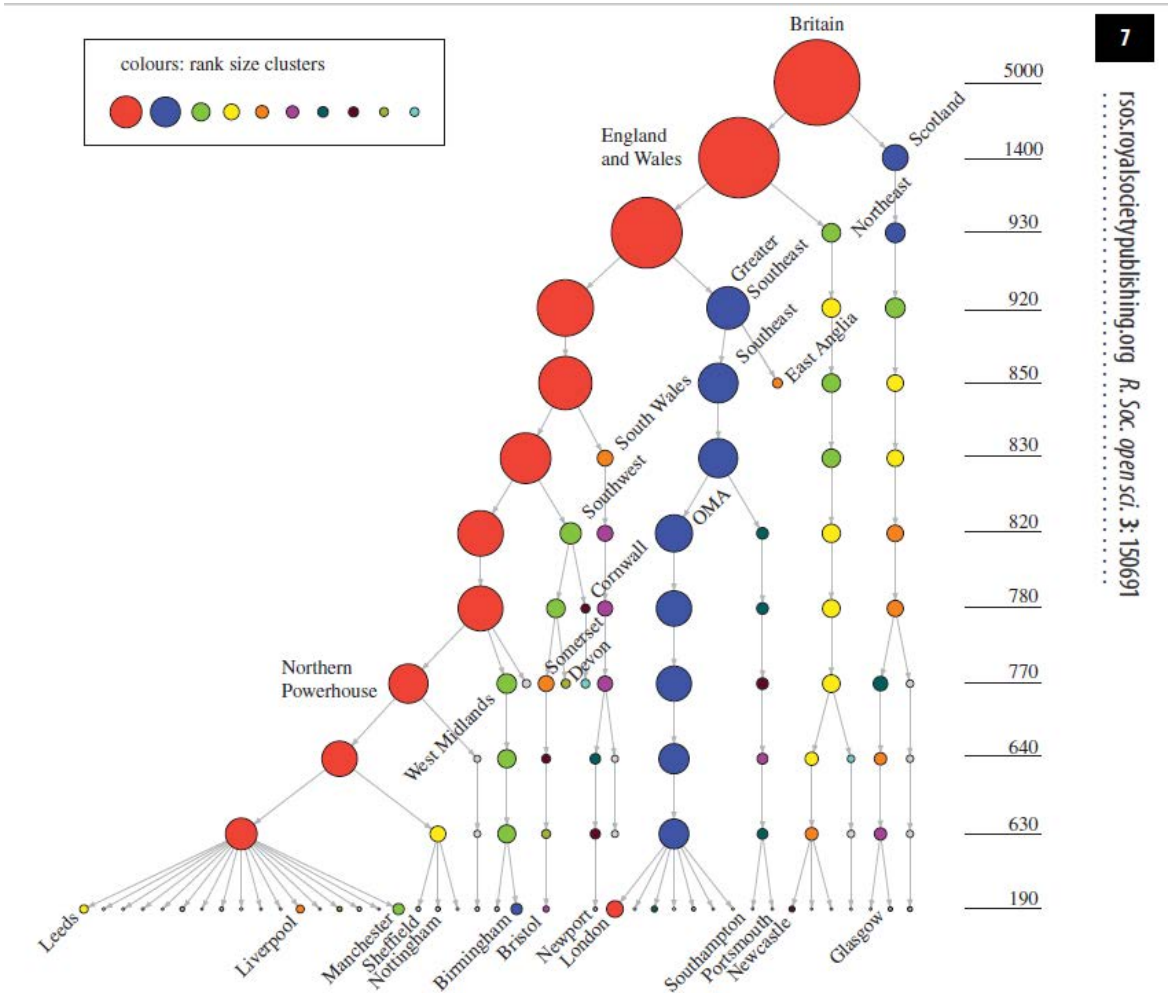


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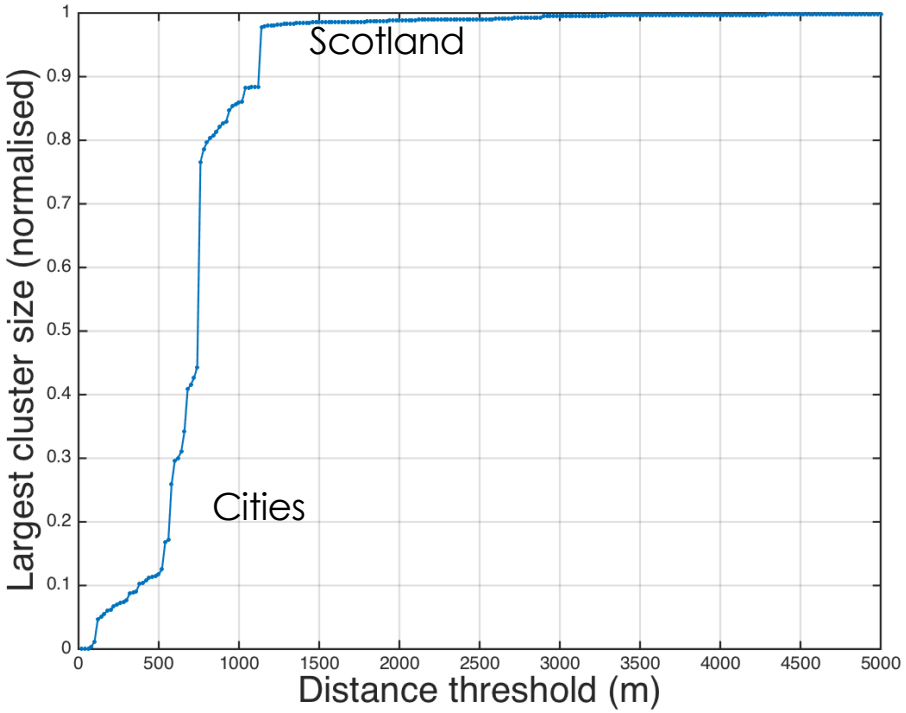
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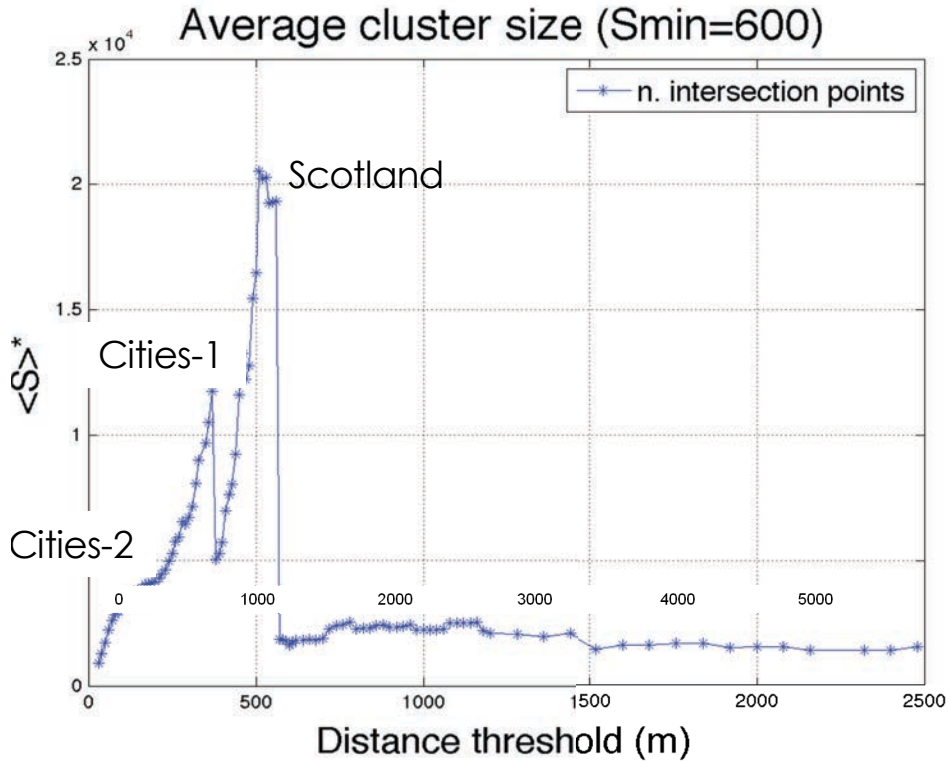
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Largest cluster size (normalised)
Distance threshold (m)
Scotland
Cities
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000


Average cluster size (Smin=600)
x 10^4
n. intersection points
Scotland
Cities-1
Cities-2
<S*>
Distance threshold (m)
0
0.5
1
1.5
2
2.5
0
500
1000
1500
2000
2500
0
1000
2000
3000
4000
5000

City Performance: Wealth and Inequality

- 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 $\beta > 1$

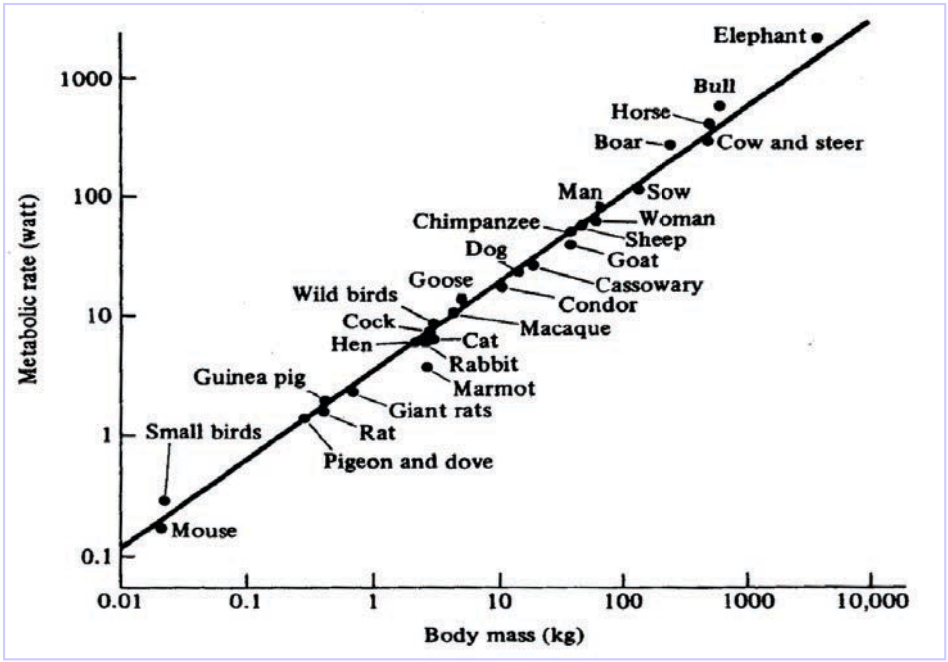
PNAS

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

Luís M. A. Bettencourt*†, José Lobo‡, Dirk Helbing§, Christian Kühnert§, and Geoffrey B. West*¶

*Theoretical Division, MS B284, Los Alamos National Laboratory, Los Alamos, NM 87545; ‡Global Institute of Sustainability, Arizona State University, P.O. Box 873211, Tempe, AZ 85287-3211; §Institute for Transport and Economics, Dresden University of Technology, Andreas-Schubert-Strasse 23, D-01062 Dresden, Germany; and ¶Santa Fe Institute, 1399 Hyde Park Road, Santa Fe, NM 87501

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



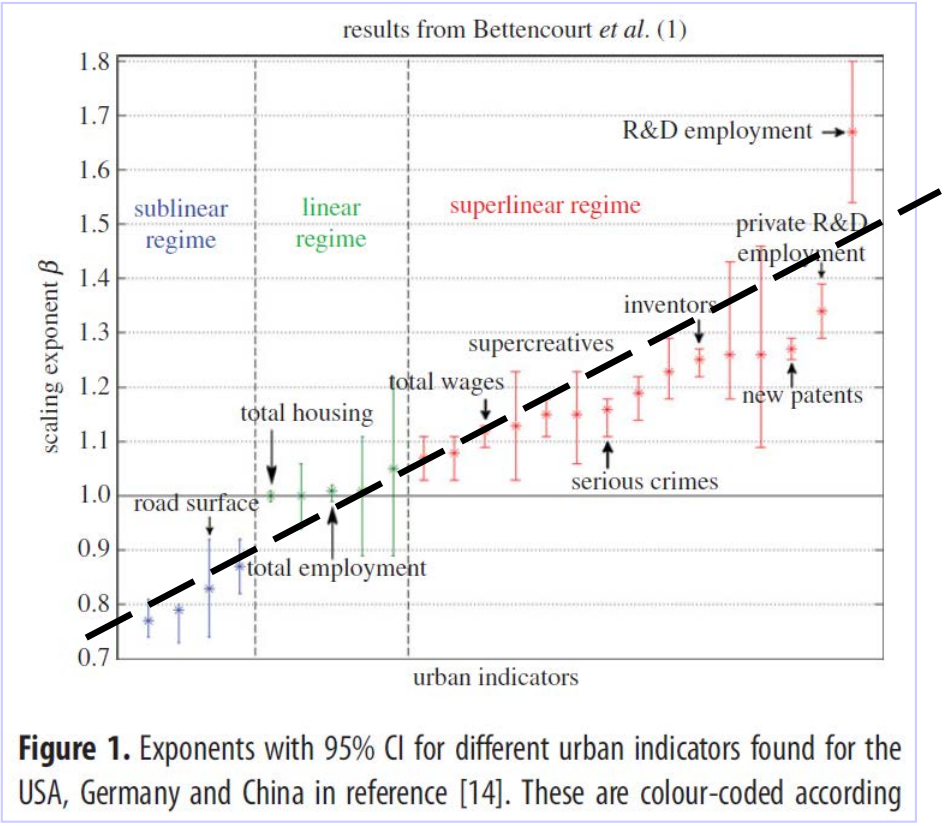


Figure 1. Exponents with 95% CI for different urban indicators found for the USA, Germany and China in reference [14]. These are colour-coded according

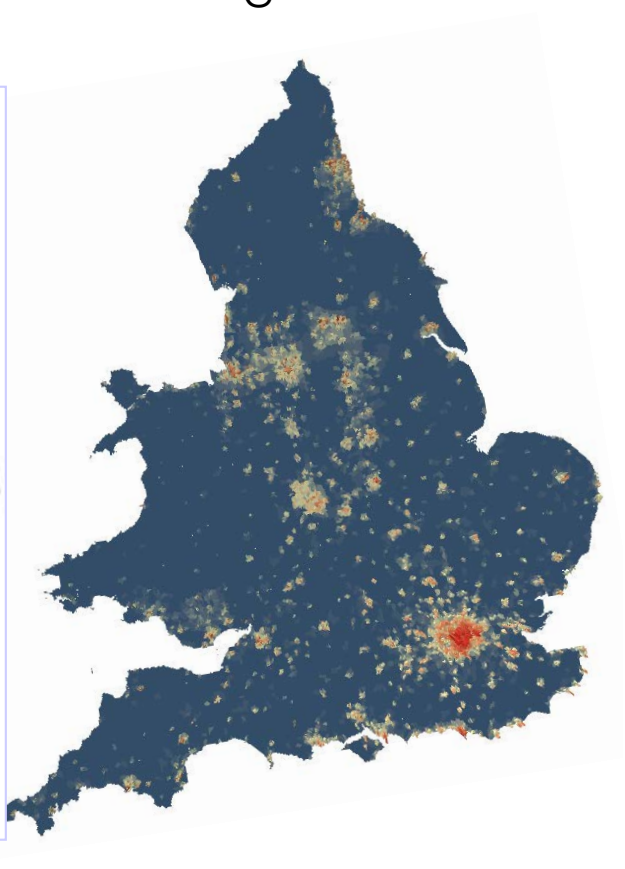
- Our group considers the West-Bettencourt results to be problematic for the UK. We do not think that income scales superlinearly with population. We cannot reproduce this result from standard definitions of UK cities and we believe that the *globalisation of cities* destroys this kind of simplicity.

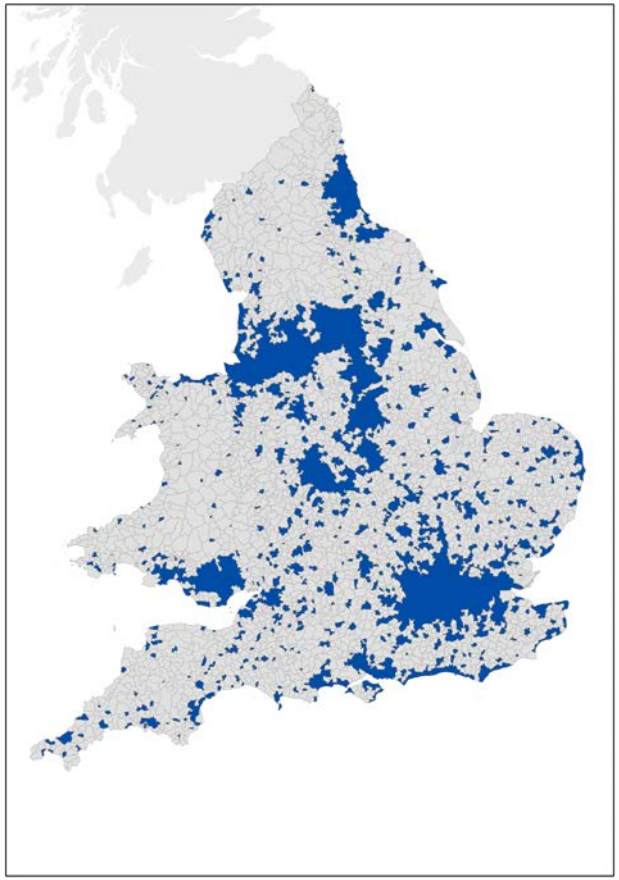
- In short, everything turns on what we define as a city. In terms of MSAs, many are simply not good definitions of where people ***locate*** & particularly ***interact*** to do city things. So what we are doing is ***defining cities*** and to do this, we consider percolation theory a good potential 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



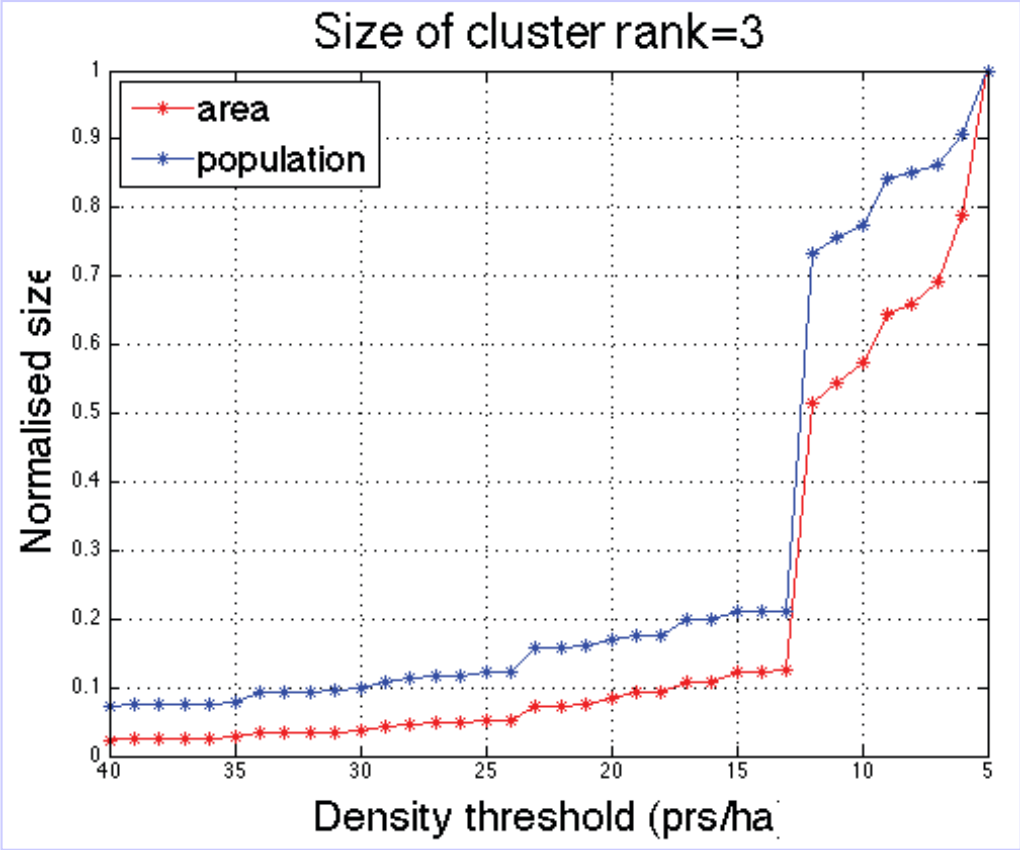
LUZs

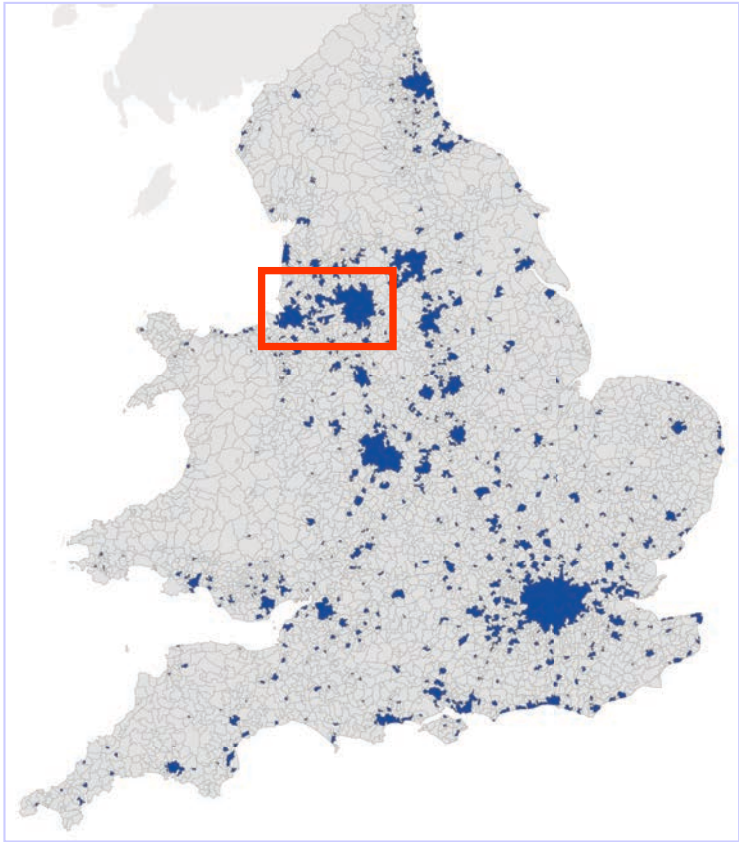




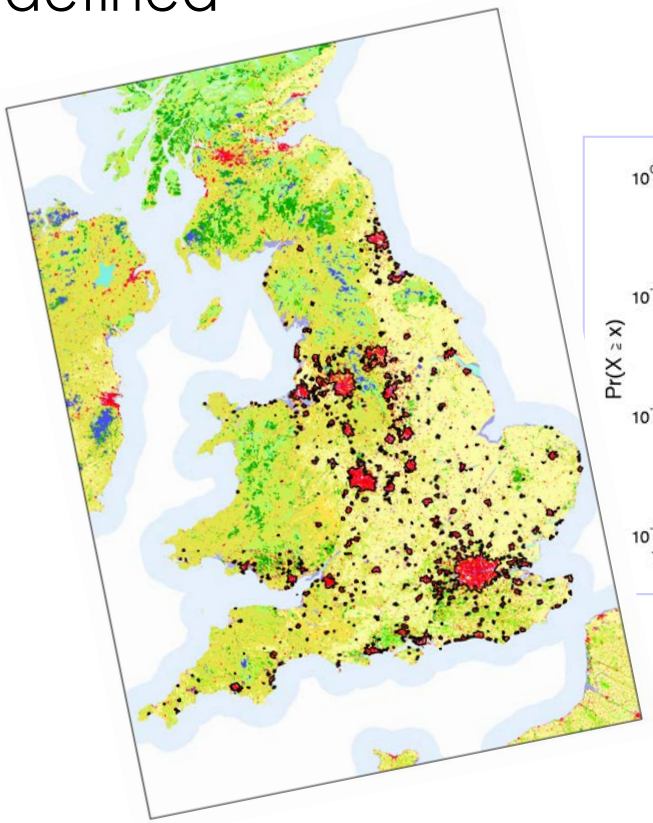
Population Density and Different Thresholds

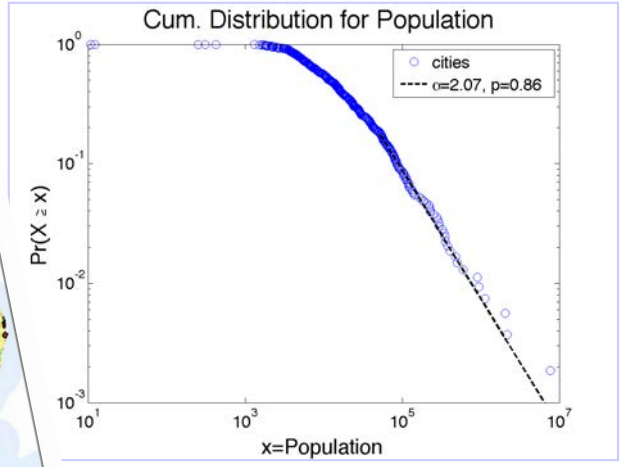
We consider 14 persons per hectare to be the right density cut-off; here Liverpool and Manchester separate

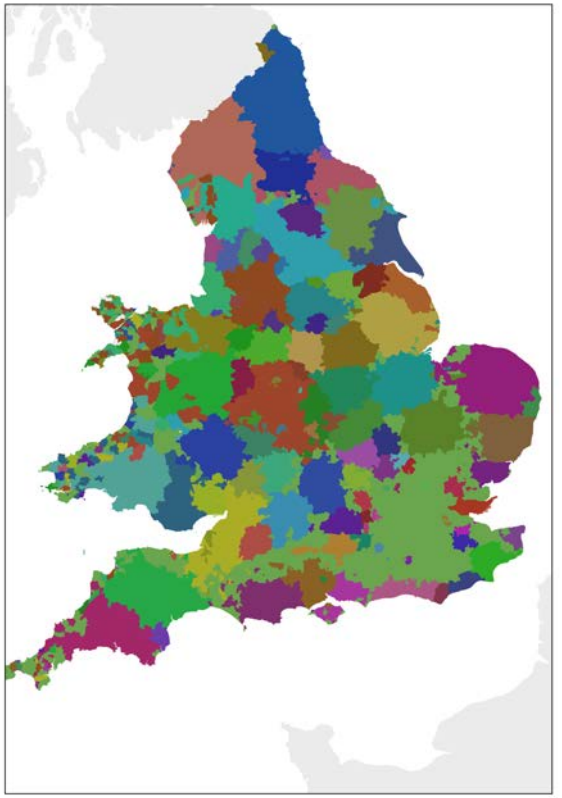




The correlation with the EU Corine RS data is good and Zipf's Law looks stable but we need to look at commuting fields – as they get larger around any place then the cities get bigger and less well-defined







- 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.

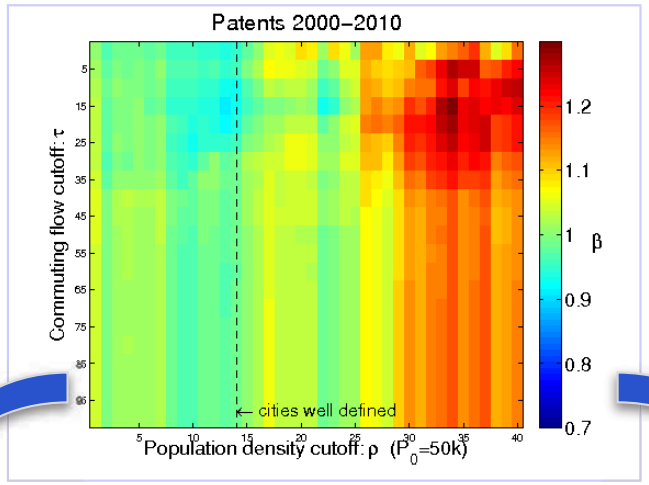
- The bigger the city does not mean the richer in E&W and London is an enormous outlier.

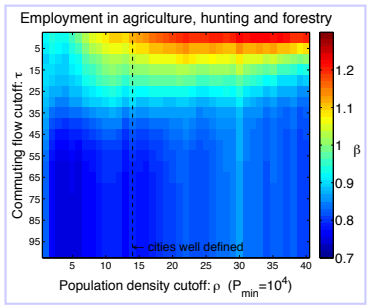
- We show these scaling relations and they are quite different from the Bettencourt-West results

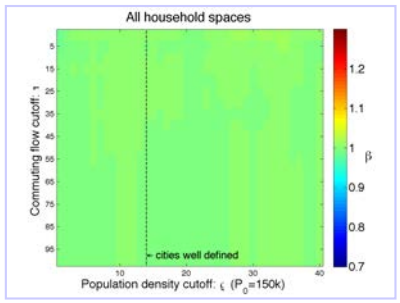
We now need to do sensitivity analysis on these definitions varying the density ρ and commuting cut-offs τ and seeing what happens to β

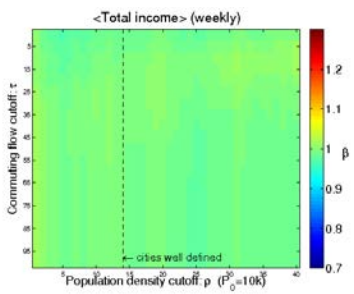
$$\begin{array}{c} \\ \tau = 0 \\ \\ \\ \tau = 100 \end{array} \begin{array}{c} \begin{array}{cccc} \rho = 1 & & \ldots & \rho = 40 \end{array} \\ \begin{bmatrix} \beta_{11} & \beta_{12} & \ldots & \beta_{1n} \\ \beta_{21} & & & \\ & & & \\ \beta_{n1} & & \ldots & \beta_{nn} \end{bmatrix} \end{array} \Rightarrow \begin{array}{c} \\ \tau = 0 \\ \\ \\ \tau = 100 \end{array} \begin{array}{c} \begin{array}{cccc} \rho = 1 & & \ldots & \rho = 40 \end{array} \\ \begin{bmatrix} & & \ldots & \\ & & & \\ & & & \\ & & \ldots & \end{bmatrix} \end{array}$$

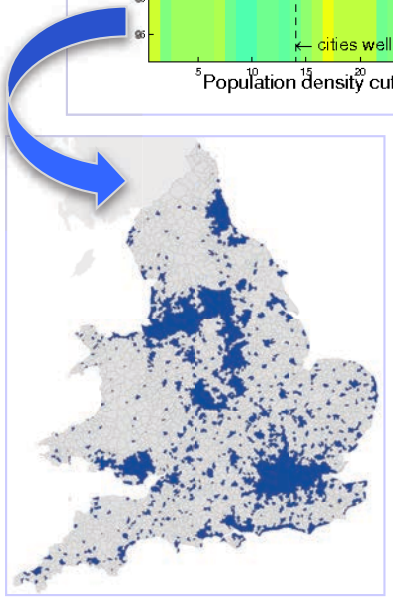
Warm colors – high and superlinear are reds to colder colors – low and sublinear blue

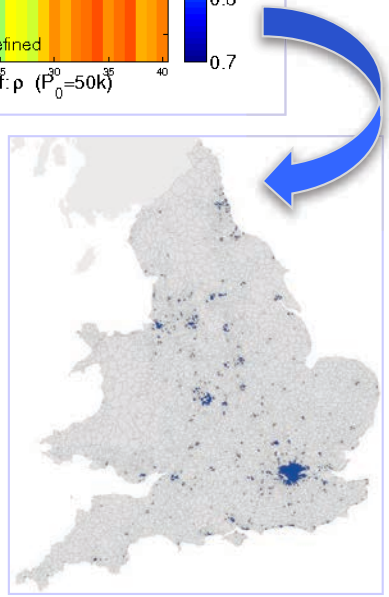

Patents 2000–2010
Commuting flow cutoff: τ
Population density cutoff: ρ (P0=50k)
← cities well defined
β

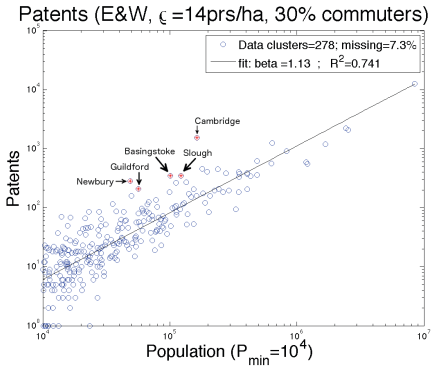

Employment in agriculture, hunting and forestry
Commuting flow cutoff: τ
Population density cutoff: ρ (Pmin=10^4)
← cities well defined
β

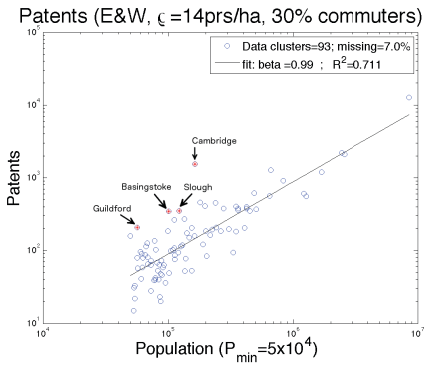

All household spaces
Commuting flow cutoff: τ
Population density cutoff: ρ (P0=150k)
← cities well defined
β


<Total income> (weekly)
Commuting flow cutoff: τ
Population density cutoff: ρ (P0=10k)
← cities well defined
β

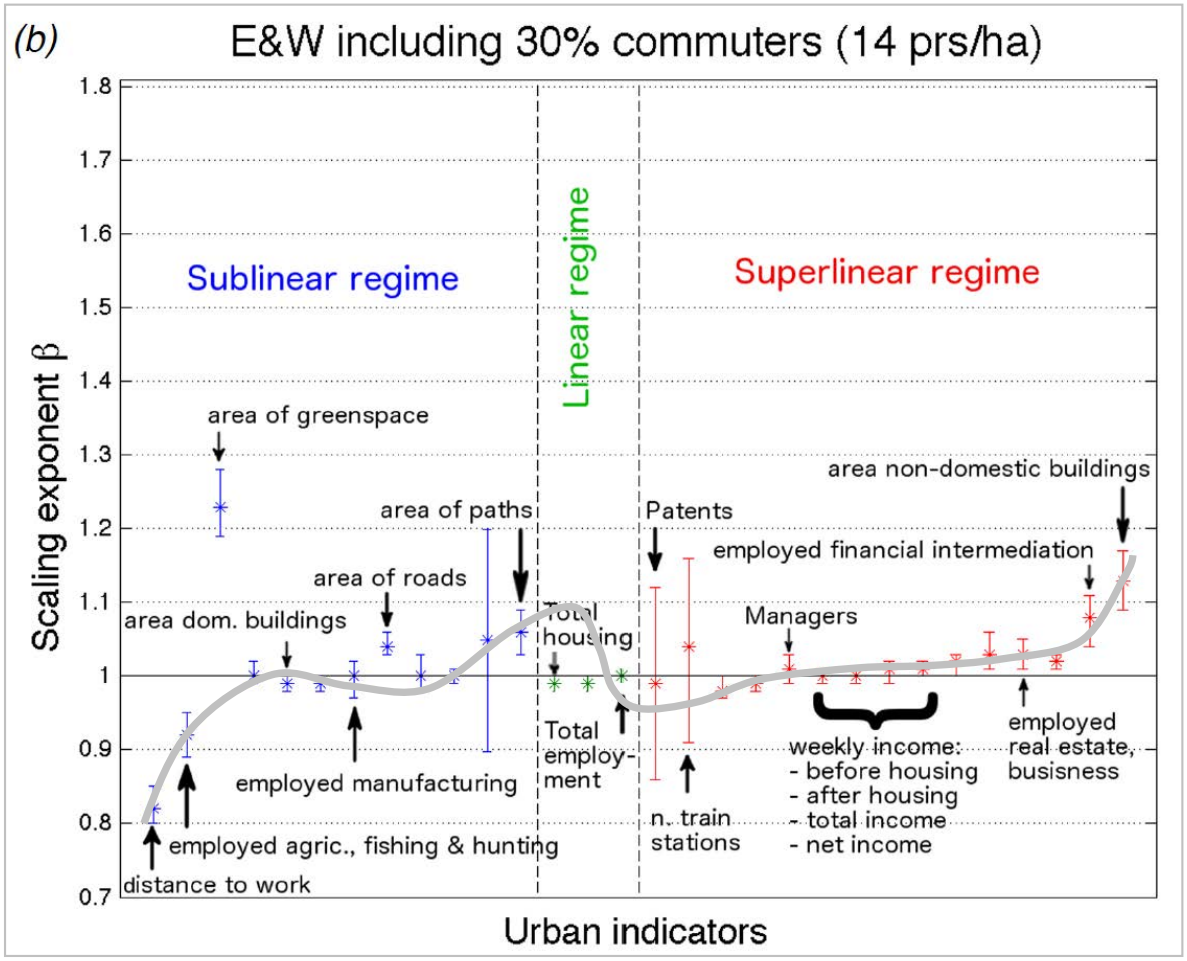




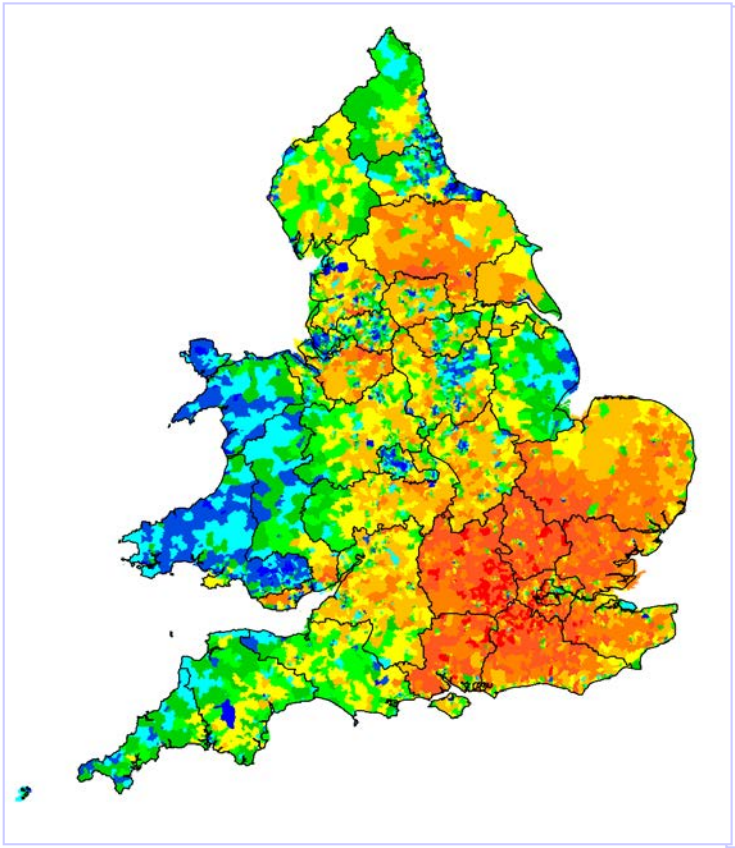

Patents (E&W, ϱ =14prs/ha, 30% commuters)
Data clusters=278; missing=7.3%
fit: beta =1.13 ; R2=0.741
Cambridge
Basingstoke
Slough
Guildford
Newbury
Patents
Population (Pmin=10^4)


Patents (E&W, ϱ =14prs/ha, 30% commuters)
Data clusters=93; missing=7.0%
fit: beta =0.99 ; R2=0.711
Cambridge
Basingstoke
Slough
Guildford
Patents
Population (Pmin=5x10^4)

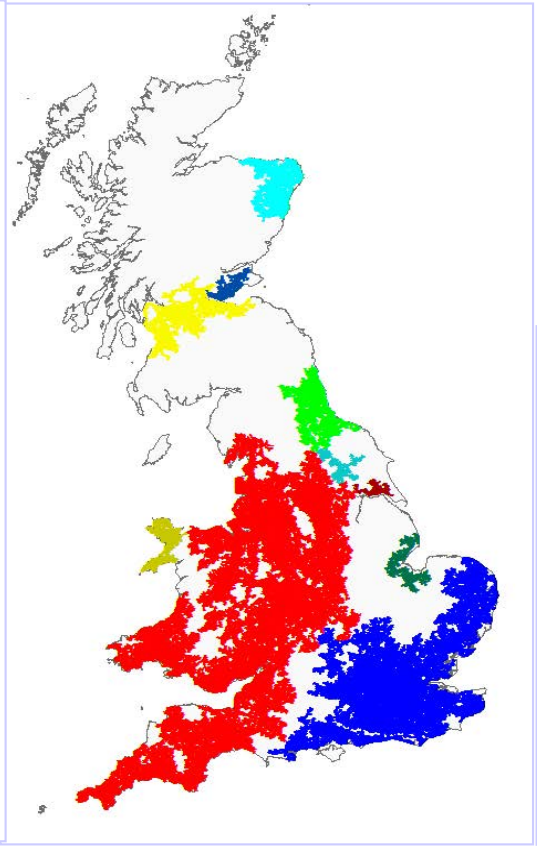
Here is the regime equivalent to the West-Bettencourt analysis and as you the linearity of the indicators is not what the W-B results for the USA imply



Do Bigger Cities Generate More Wealth?

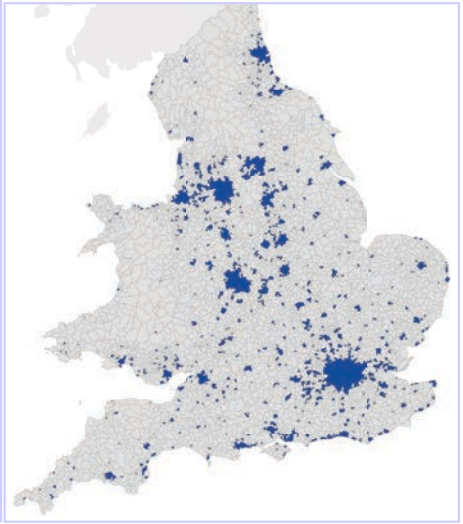


Income



Percolation

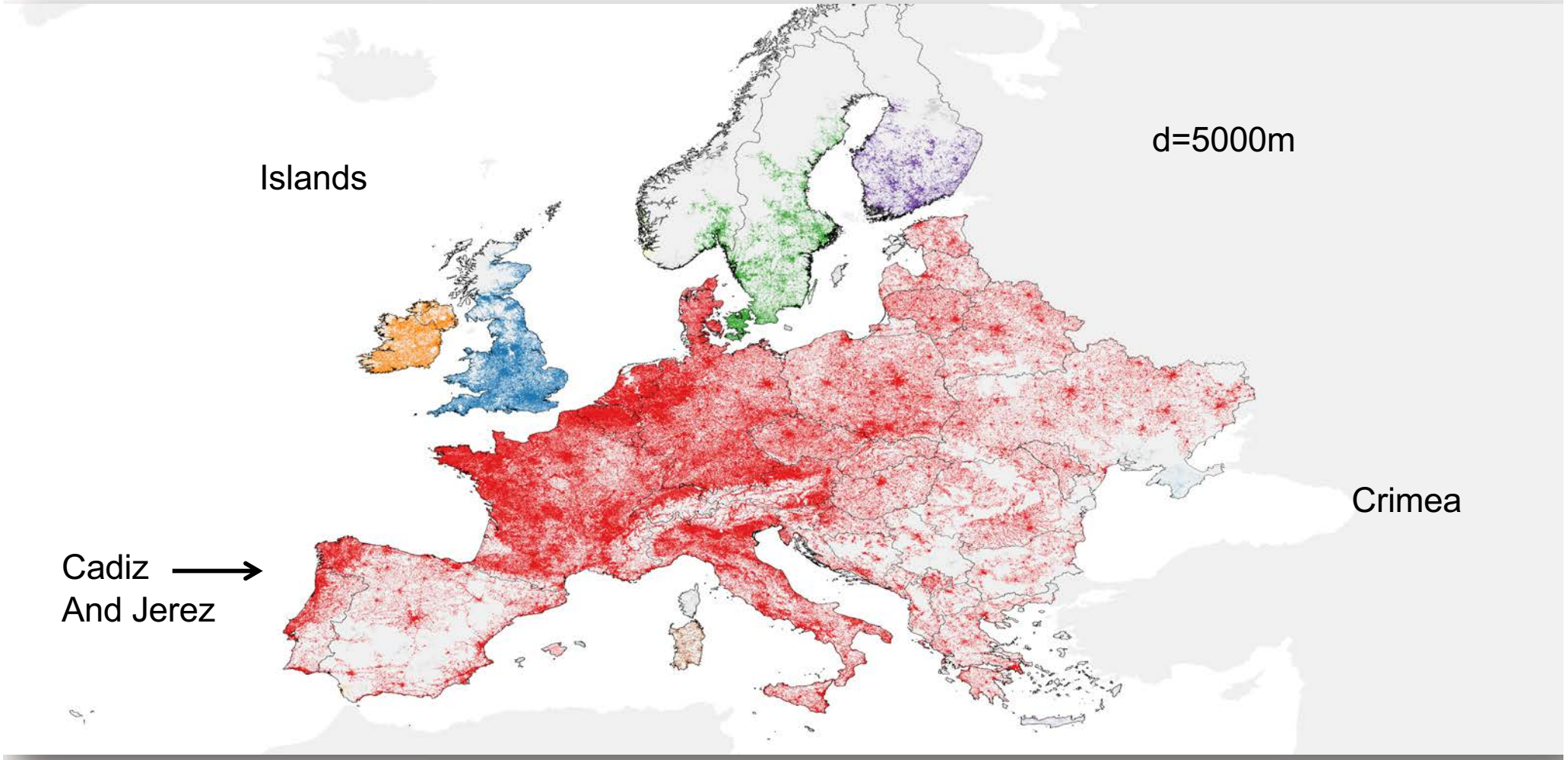
From 14 pph and 20% commuting field



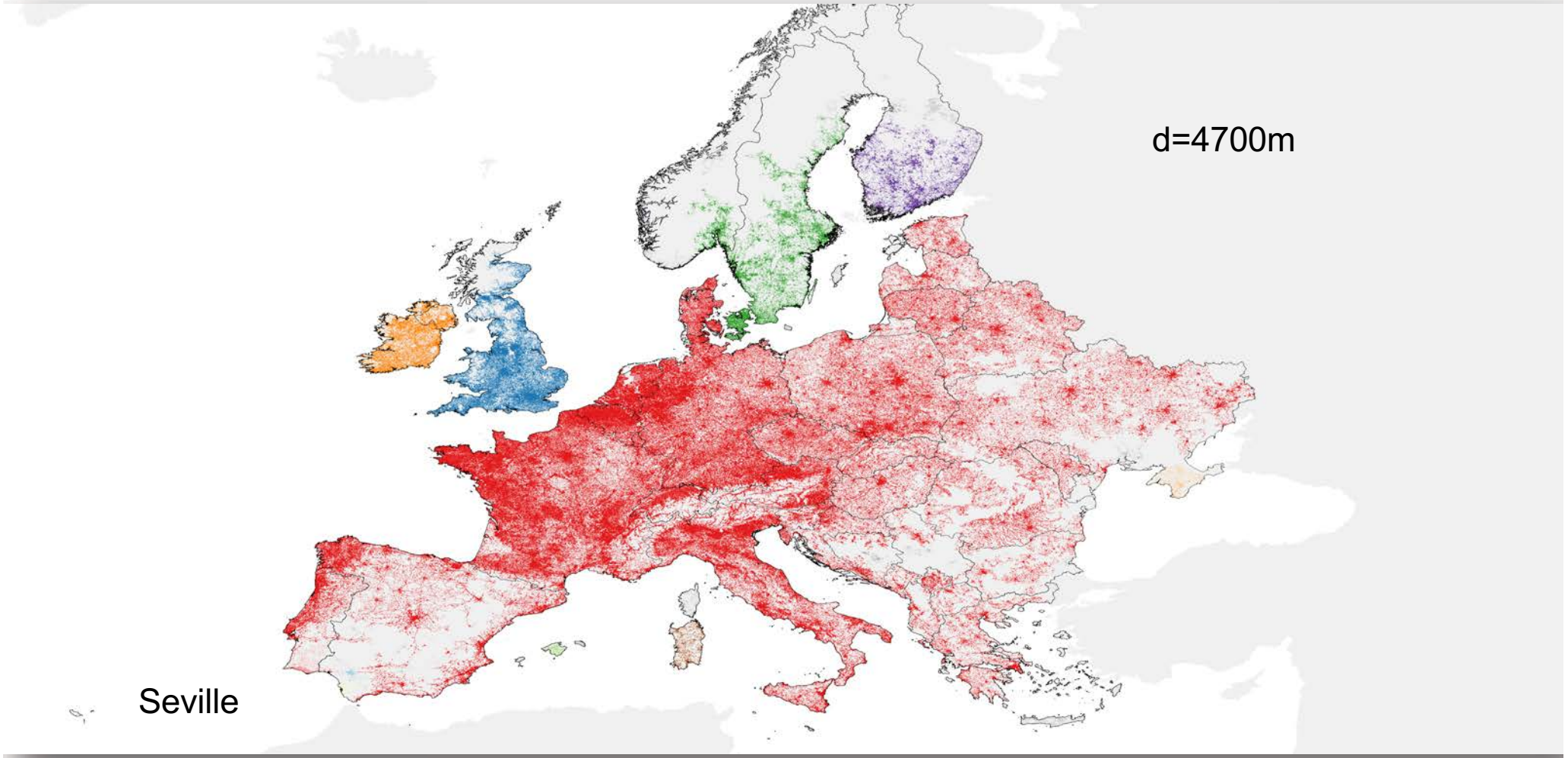
Best Cities

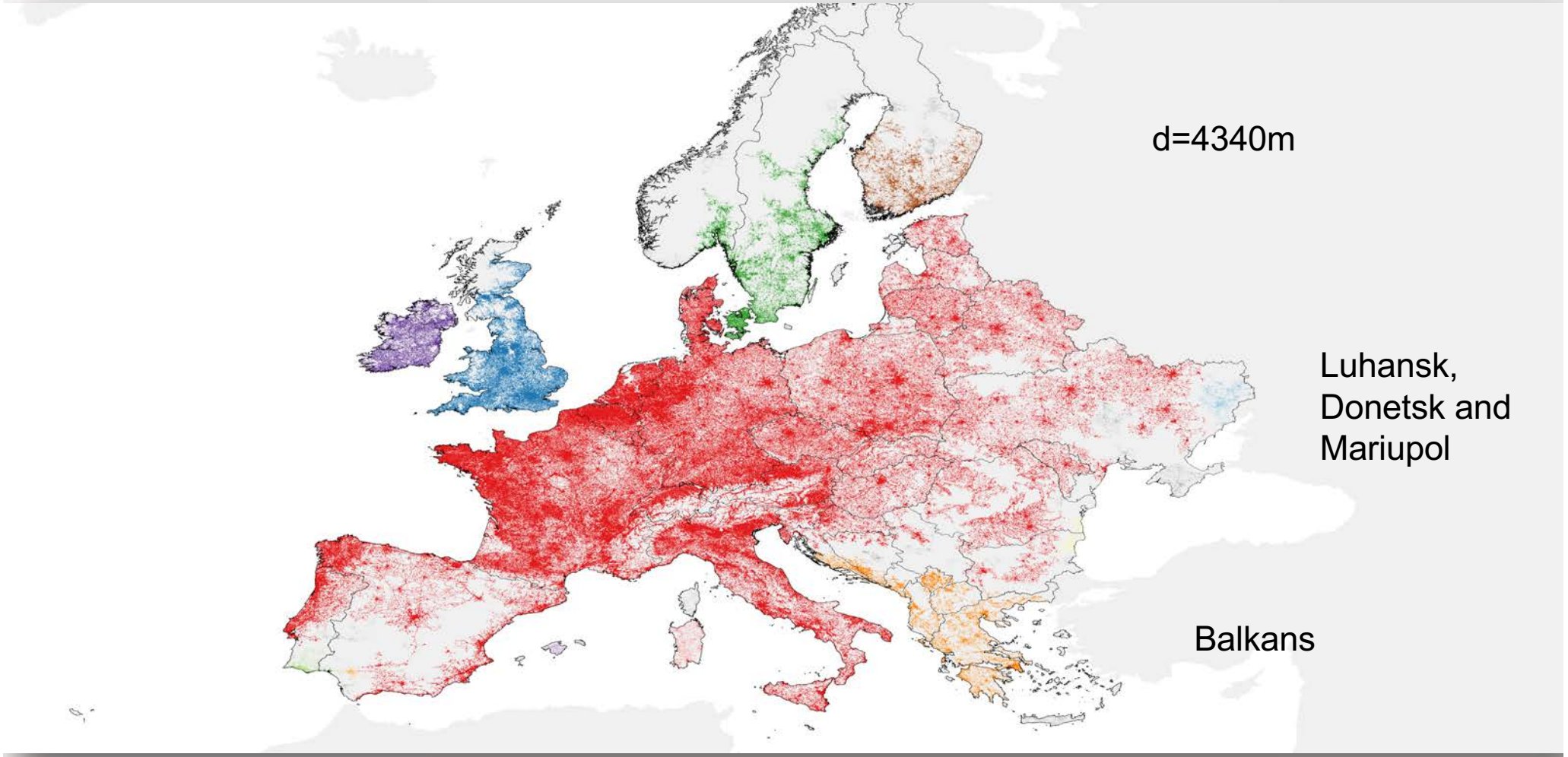
Extensions: Europe, Integration and Fragmentation

- 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

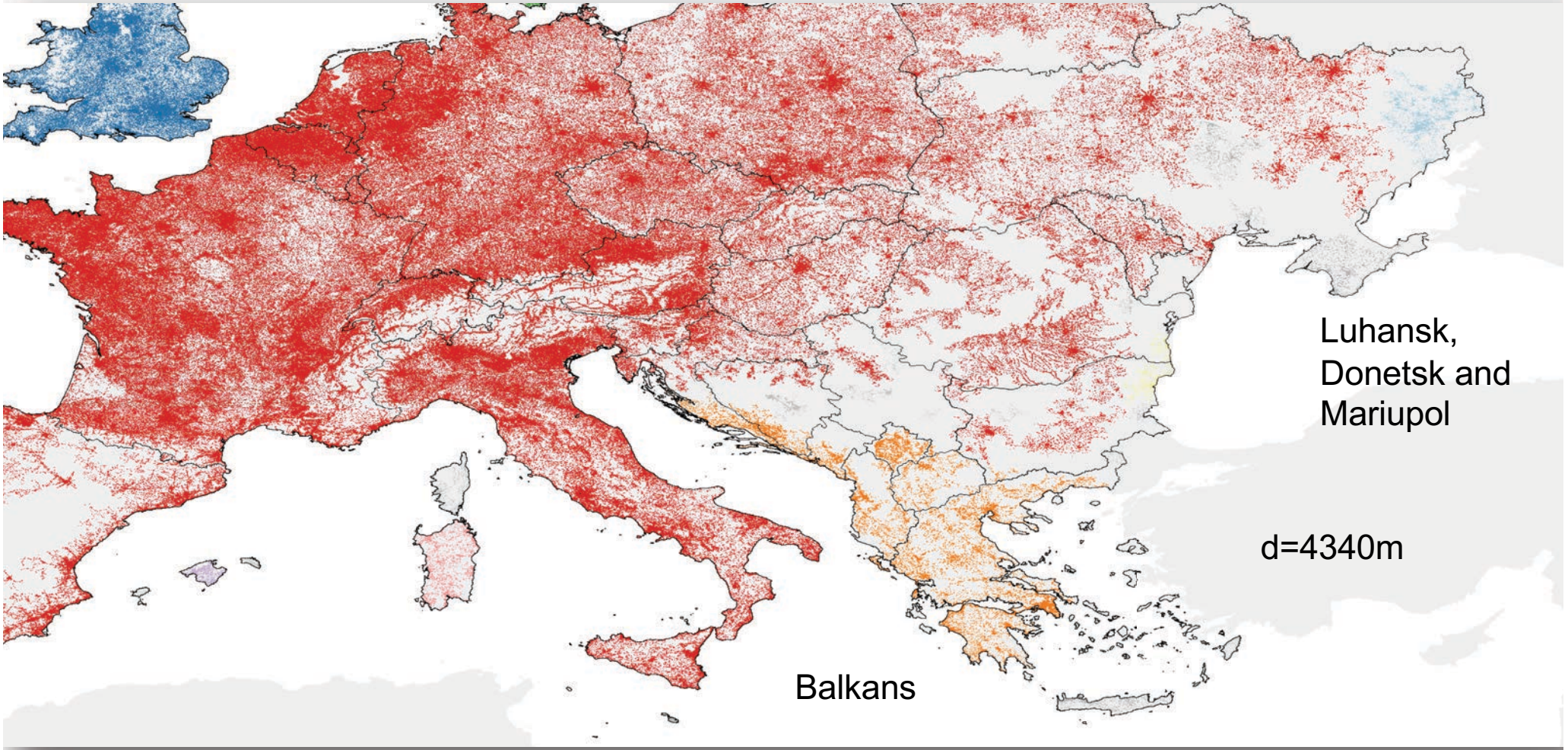


Defining Cities: The Hierarchy of Urban Clusters in Europe

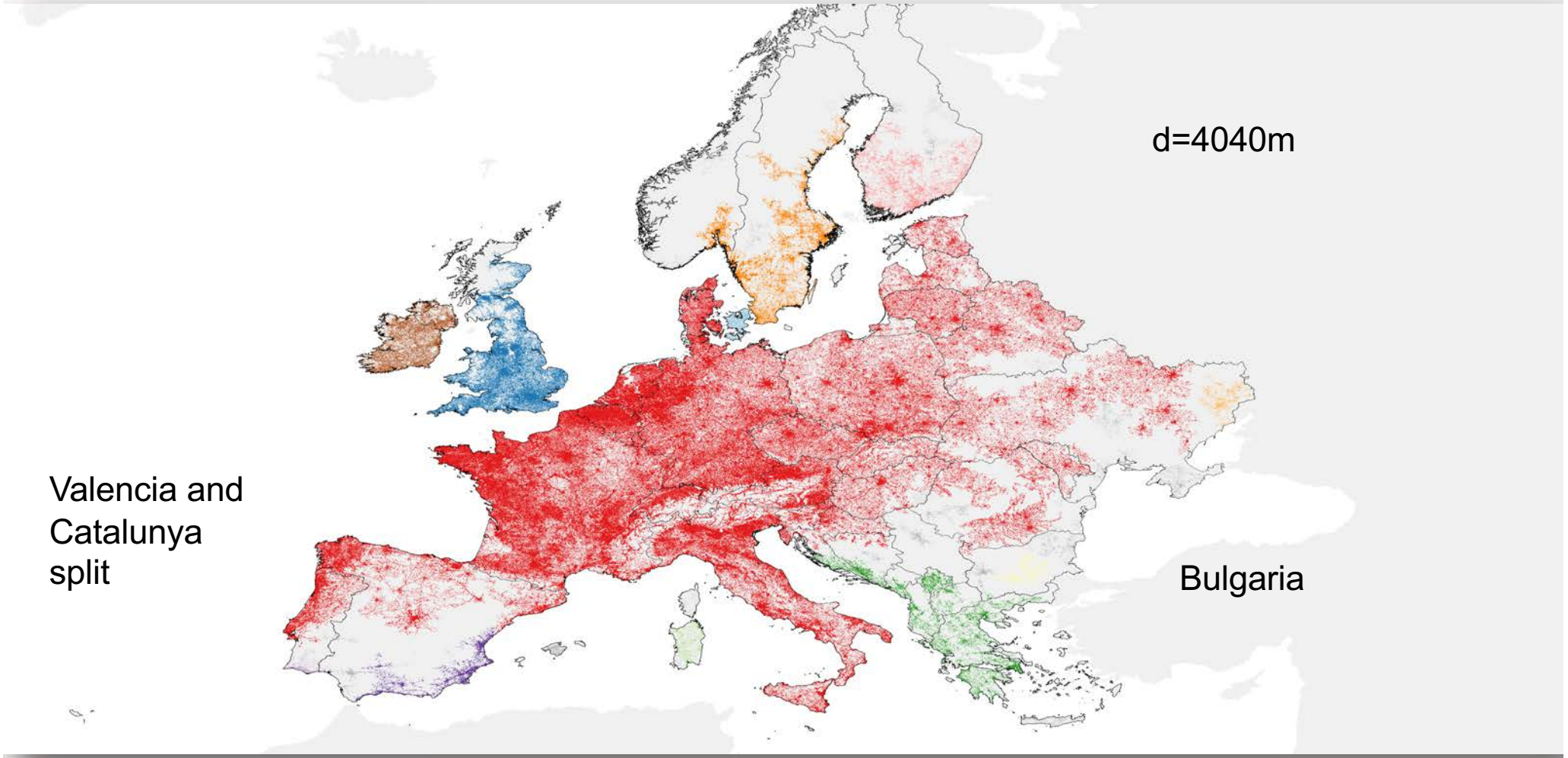

d=4700m
Seville

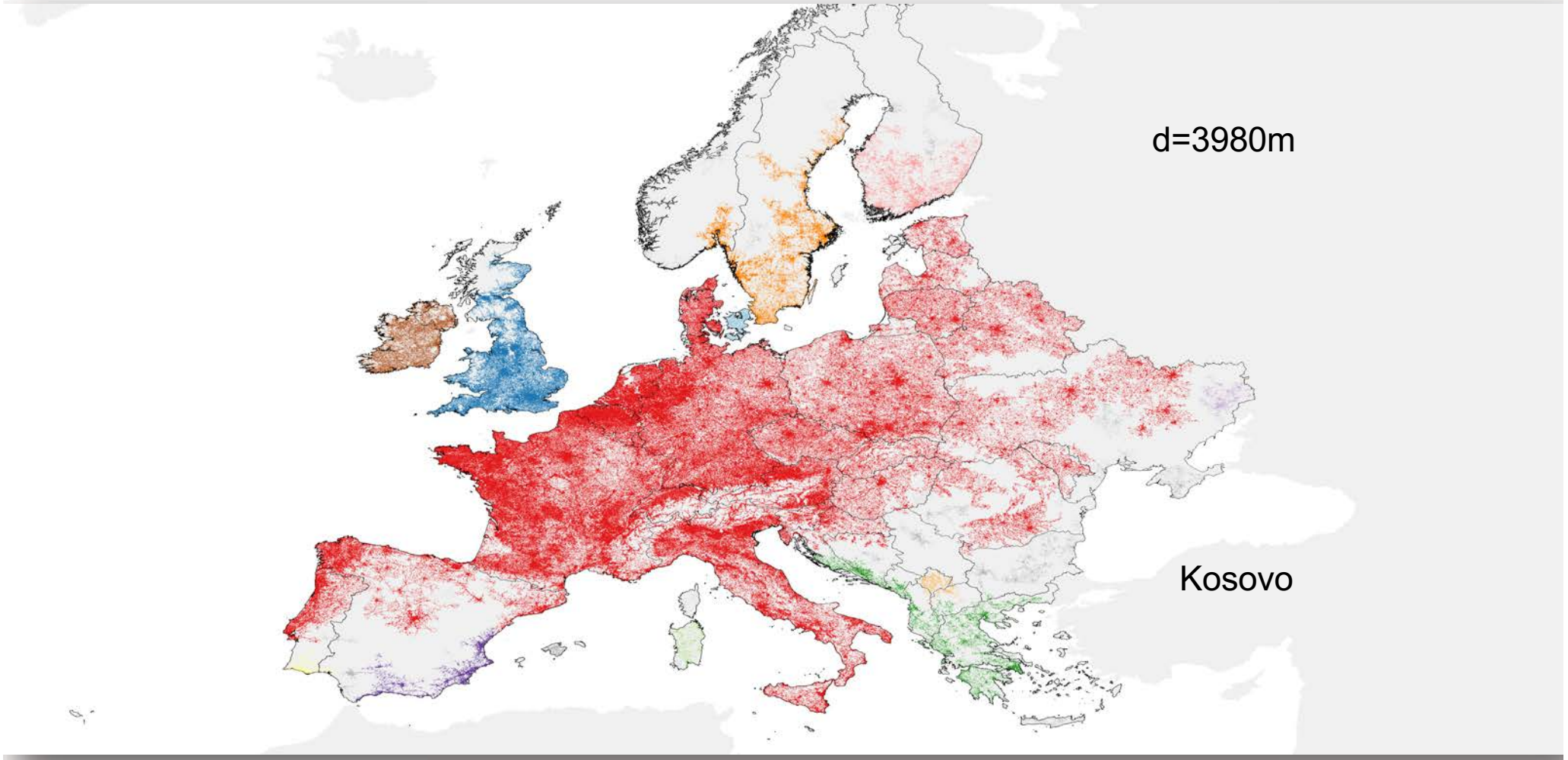


Defining Cities: The Hierarchy of Urban Clusters in Europe

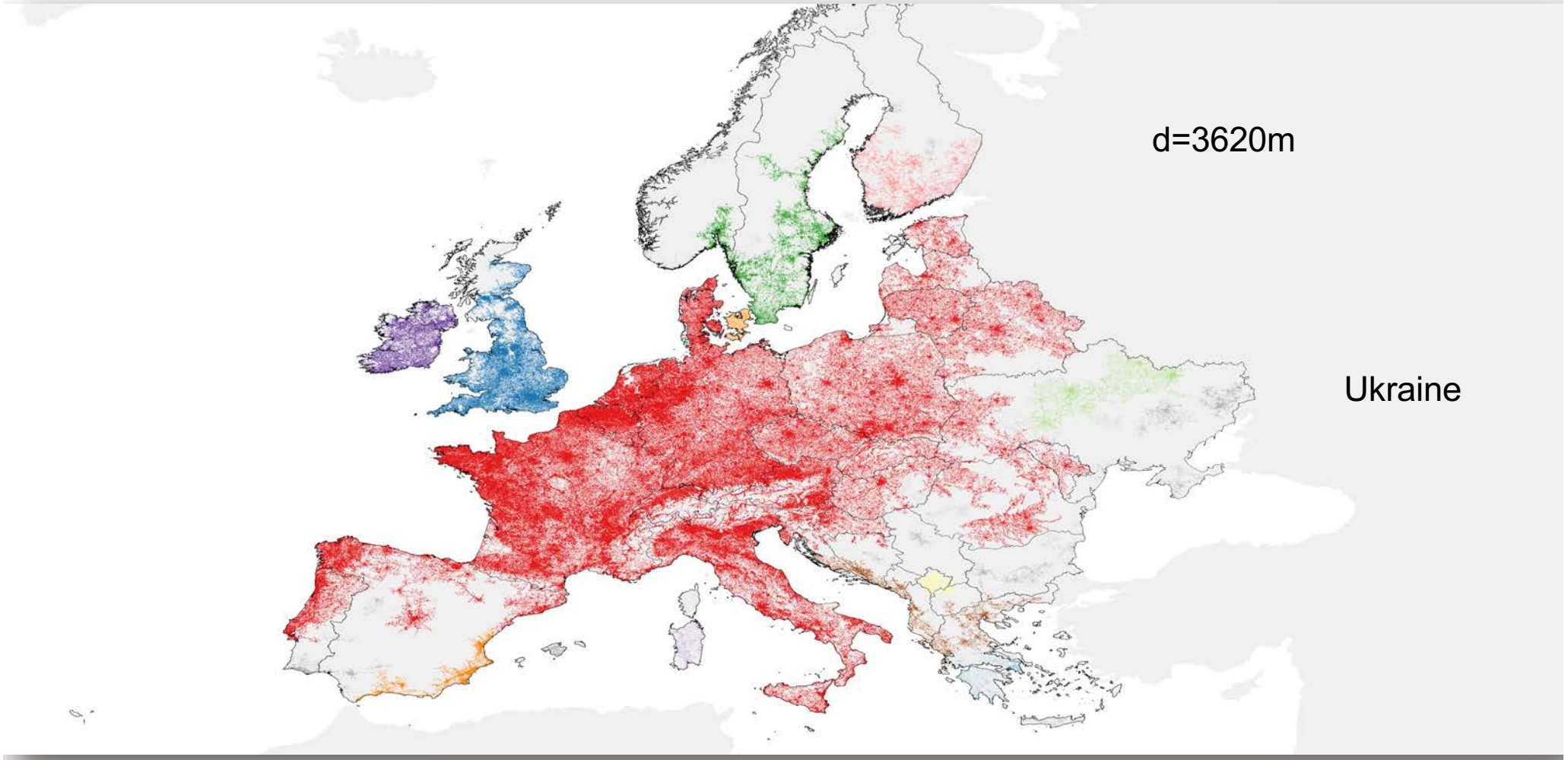


Defining Cities: The Hierarchy of Urban Clusters in Europe

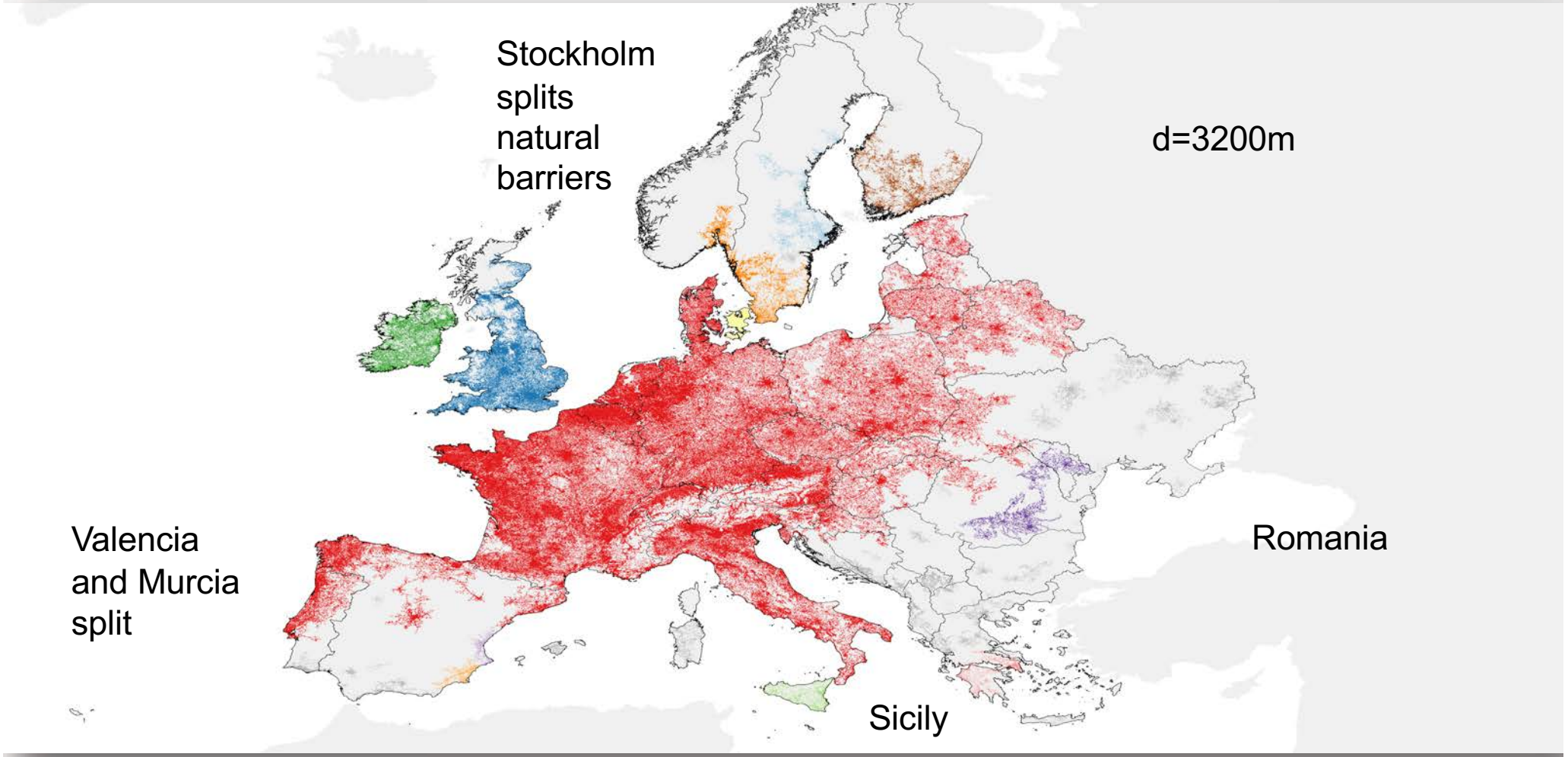

d=4040m
Valencia and Catalunya split
Bulgaria

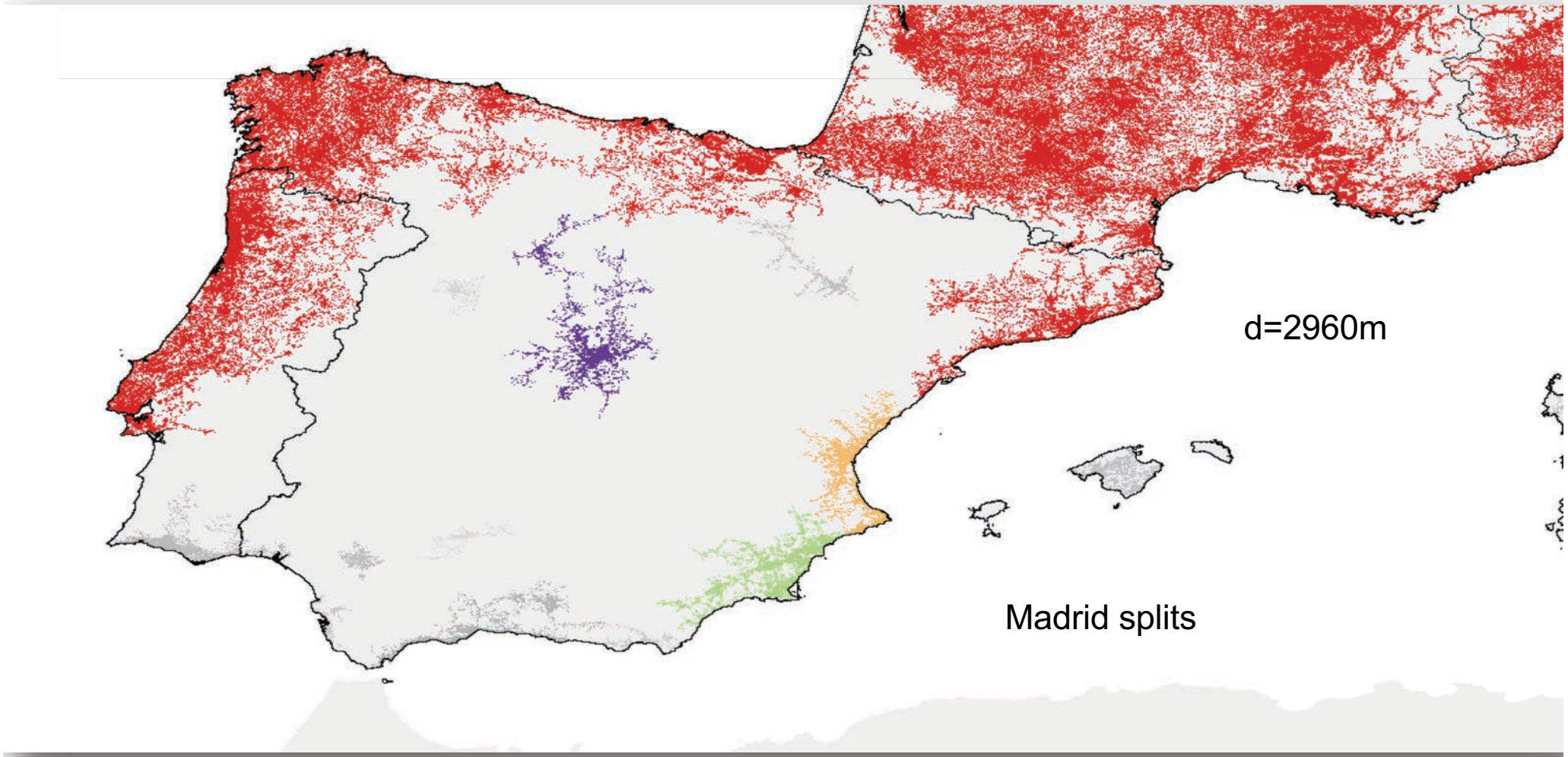


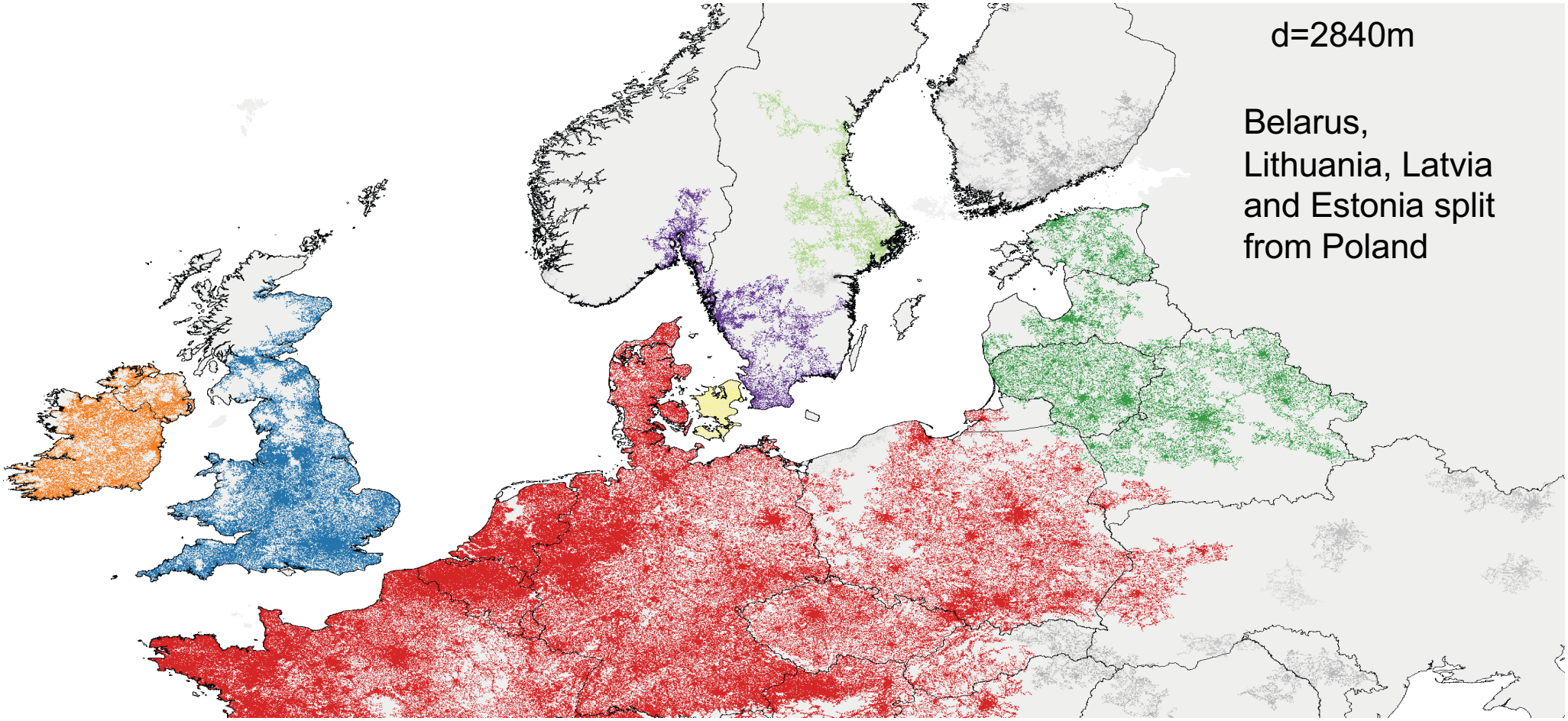
Defining Cities: The Hierarchy of Urban Clusters in Europe



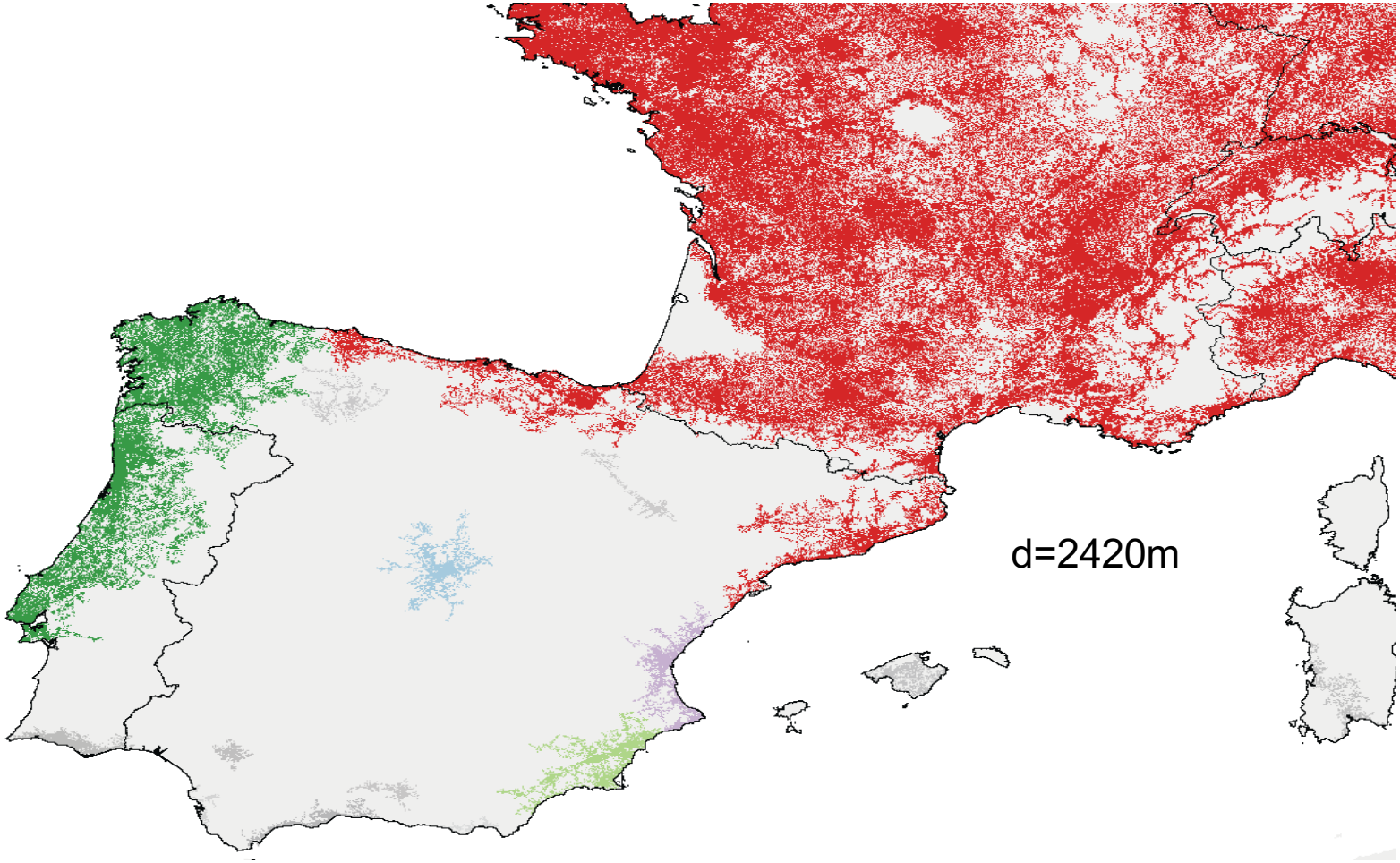
Defining Cities: The Hierarchy of Urban Clusters in Europe

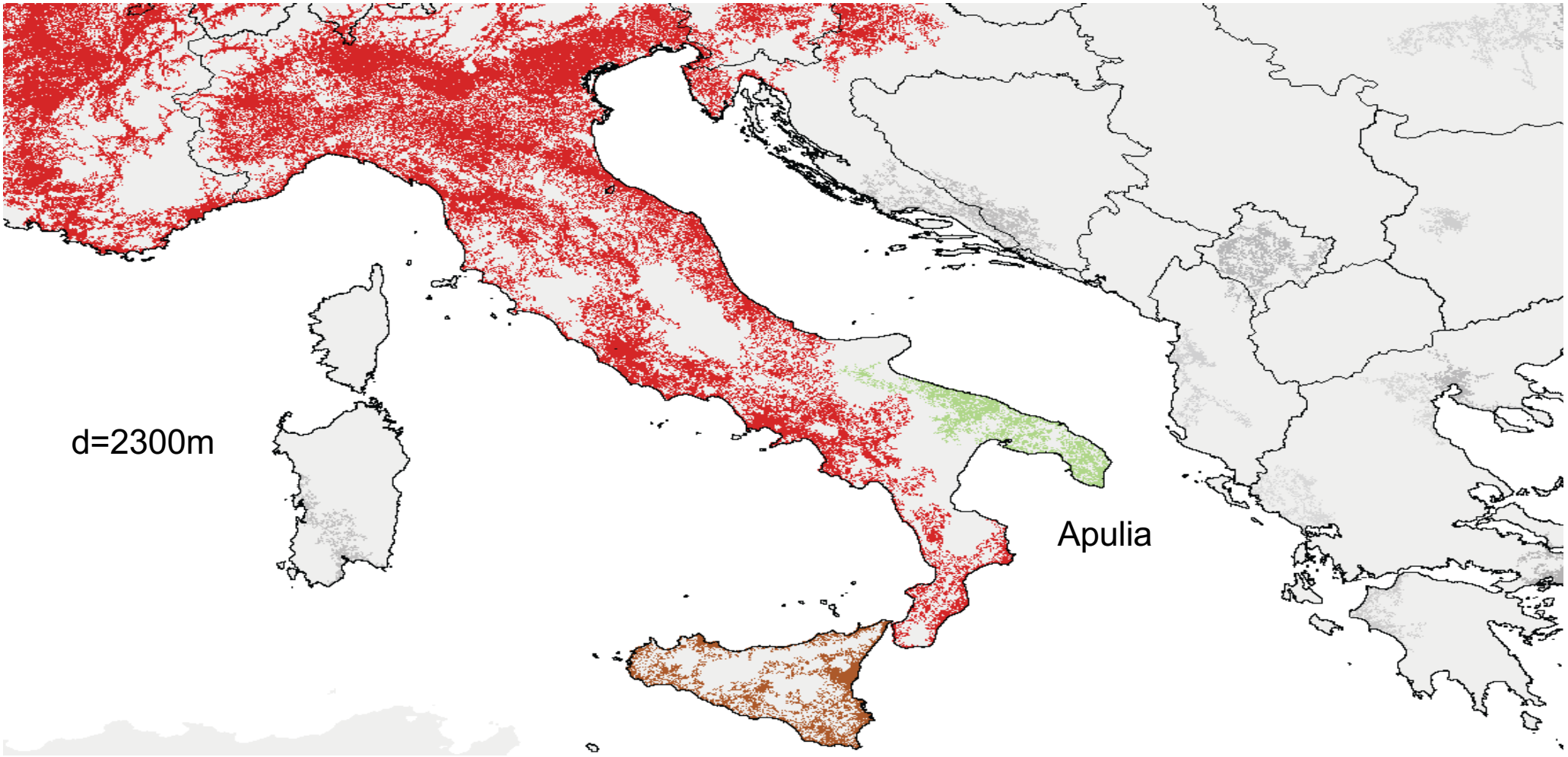

Stockholm splits natural barriers
d=3200m
Valencia and Murcia split
Romania
Sicily

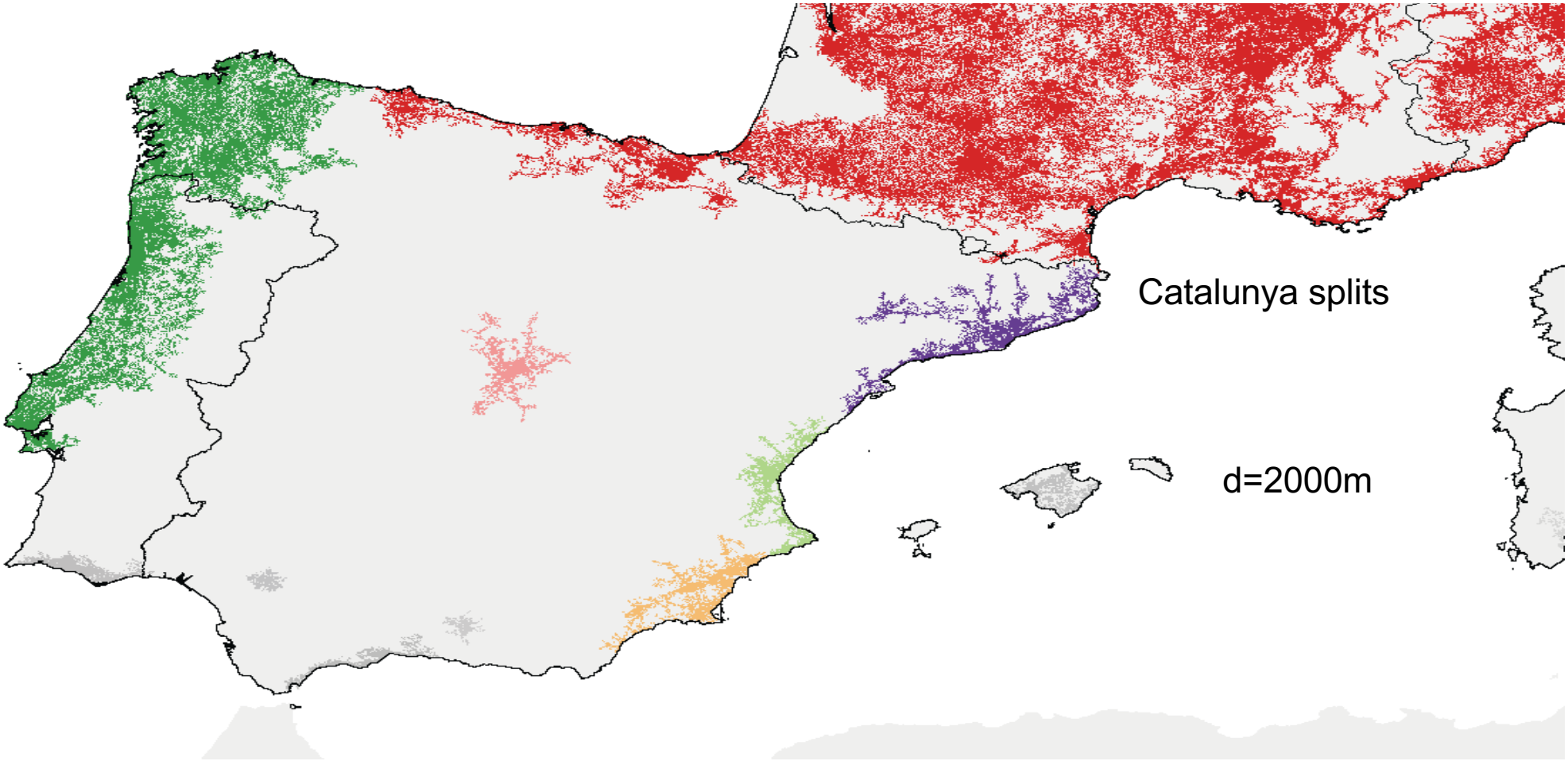

d=2960m
Madrid splits

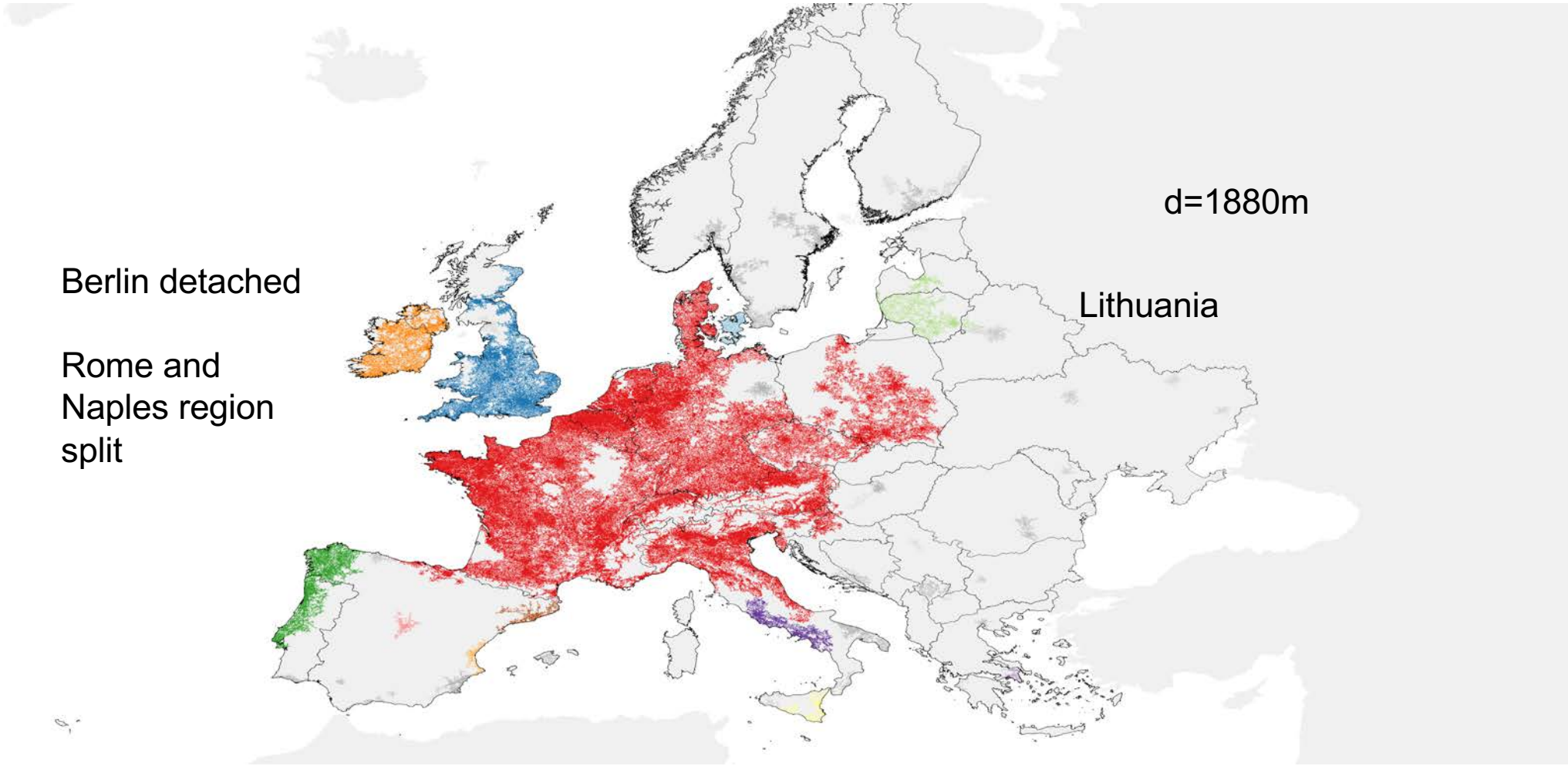

d=2840m
Belarus,
Lithuania, Latvia
and Estonia split
from Poland

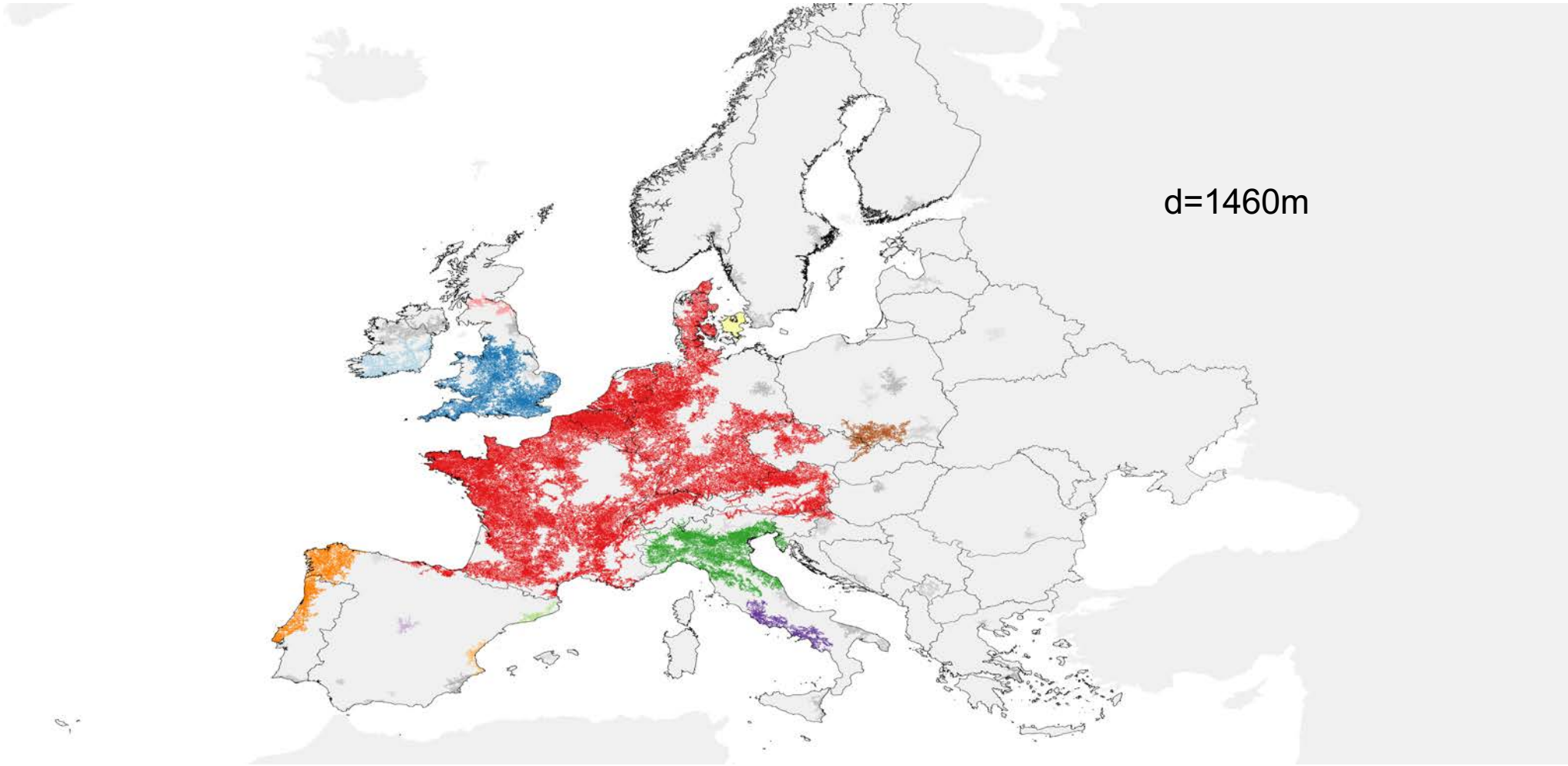
Galicia and Portugal one cluster



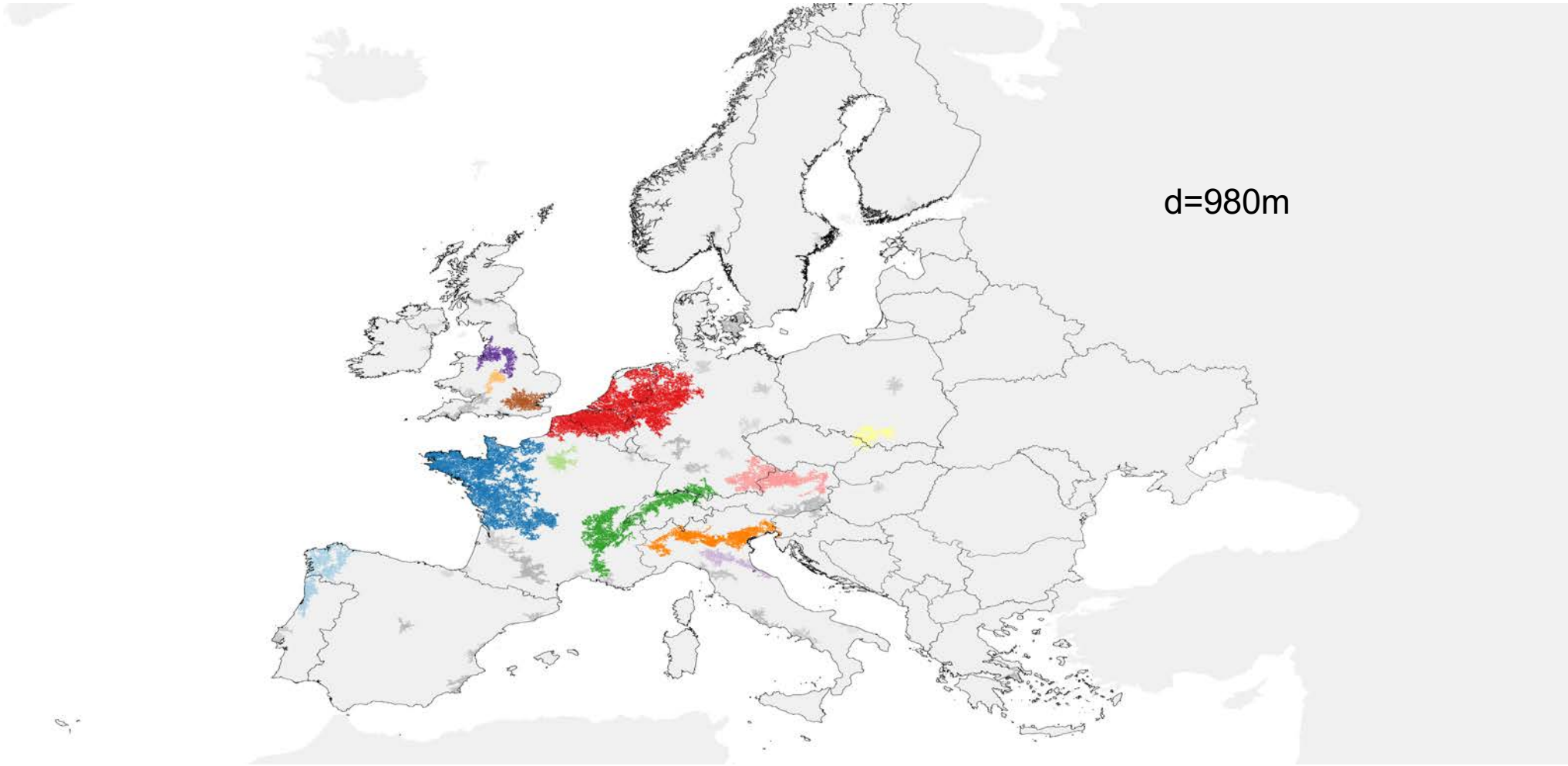

d=2300m
Apulia


Catalunya splits
d=2000m

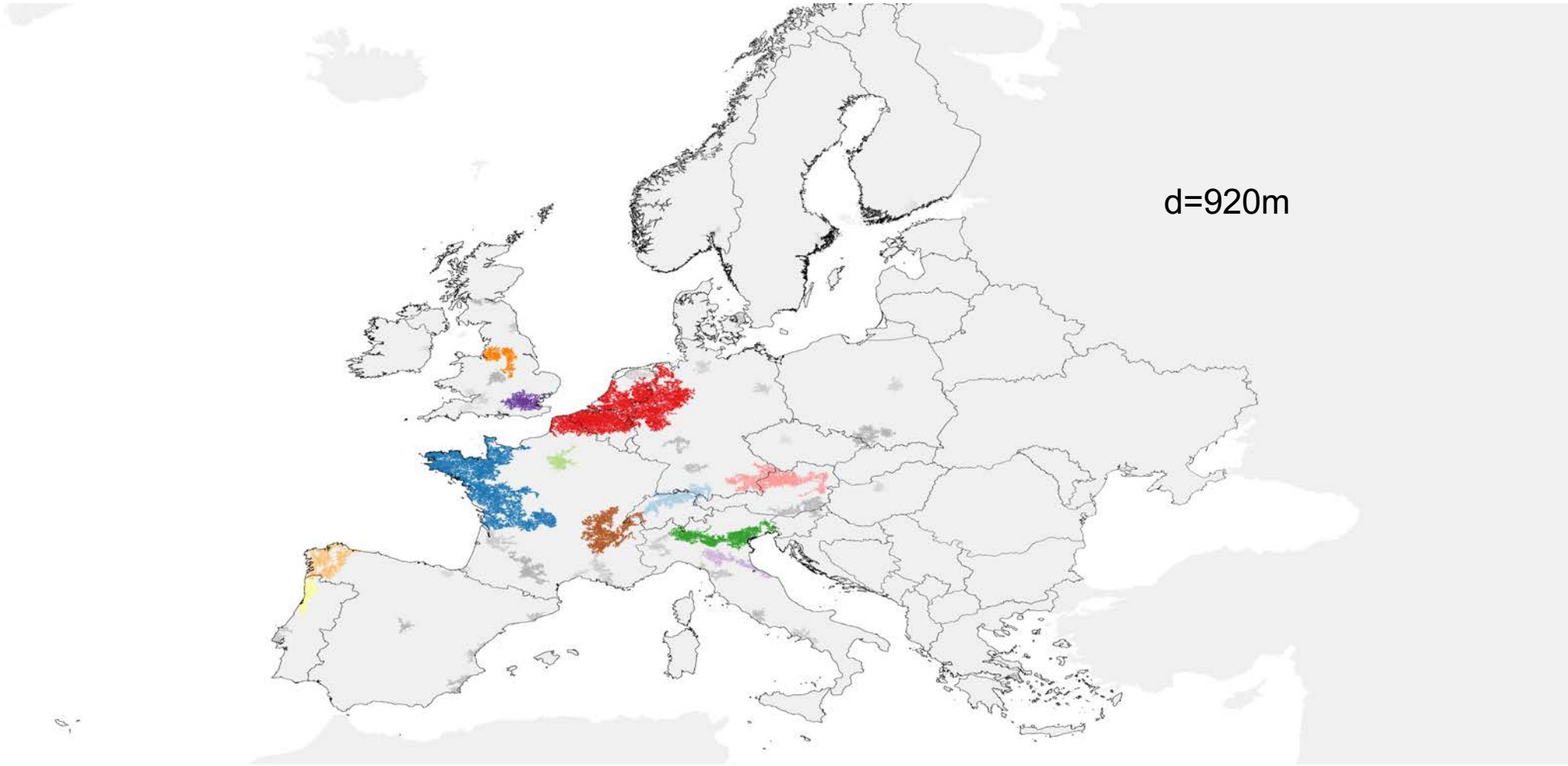

d=1880m
Berlin detached
Lithuania
Rome and
Naples region
split



Defining Cities: The Hierarchy of Urban Clusters in Europe



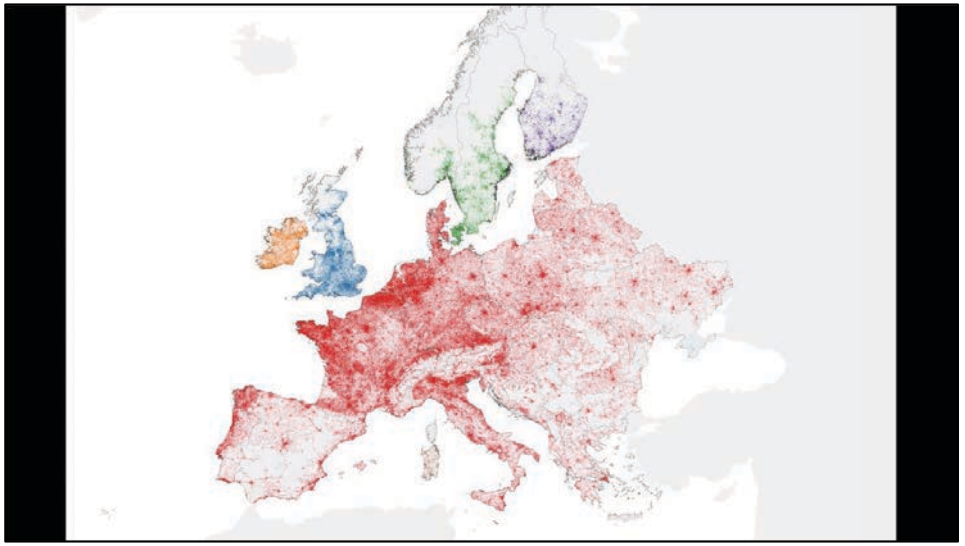
Defining Cities: The Hierarchy of Urban Clusters in Europe



Defining Cities: The Hierarchy of Urban Clusters in Europe


London
Birmingham
Manchester
Leeds
Glasgow
At d=200m
1
2
3
4
5
6
7
8
9
10
11
12
13
50
Paris
Milan
Rome
Madrid
Athens



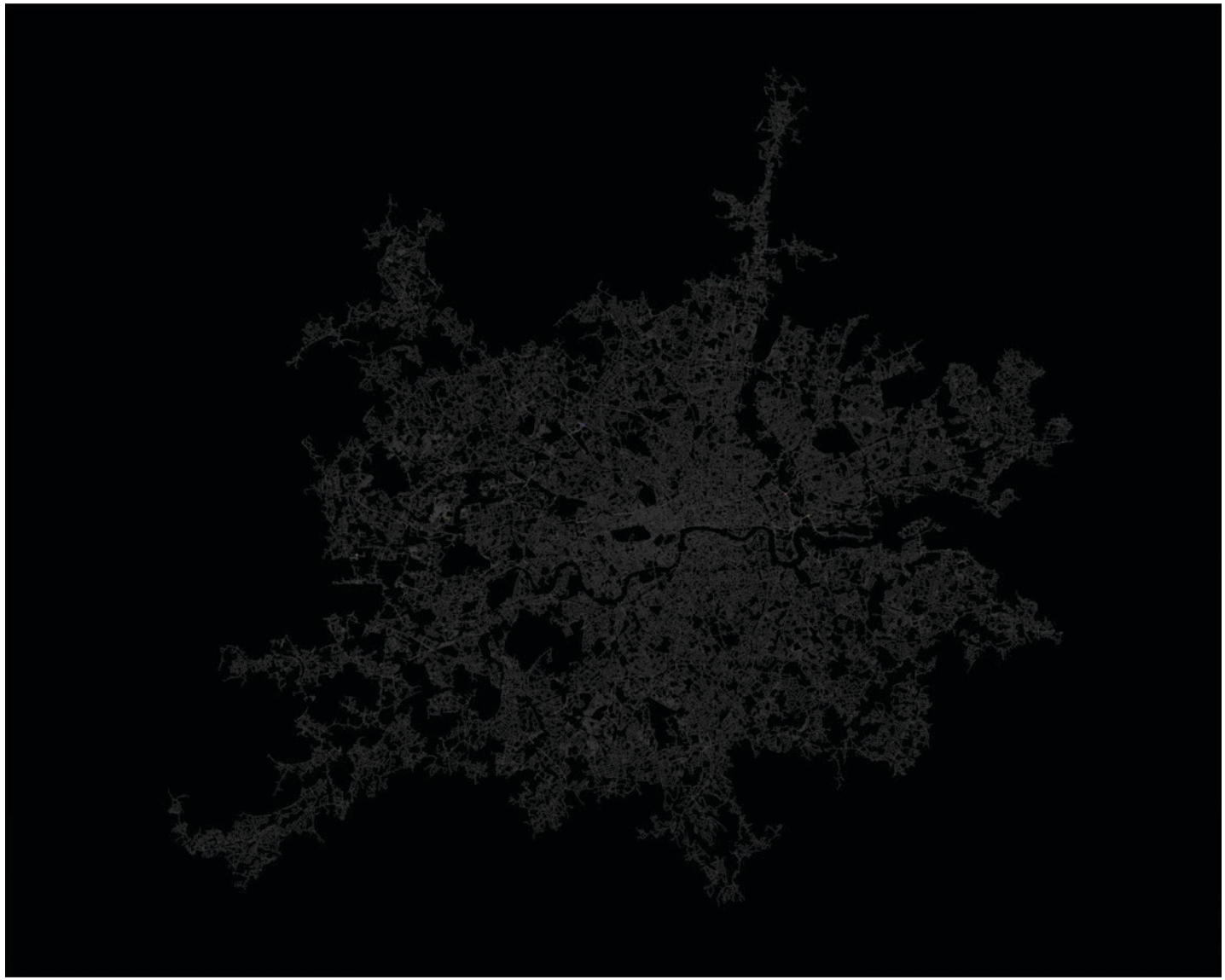


Defining Cities: The Hierarchy of Urban Clusters in Europe

Doing It All at Different Scale: 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?

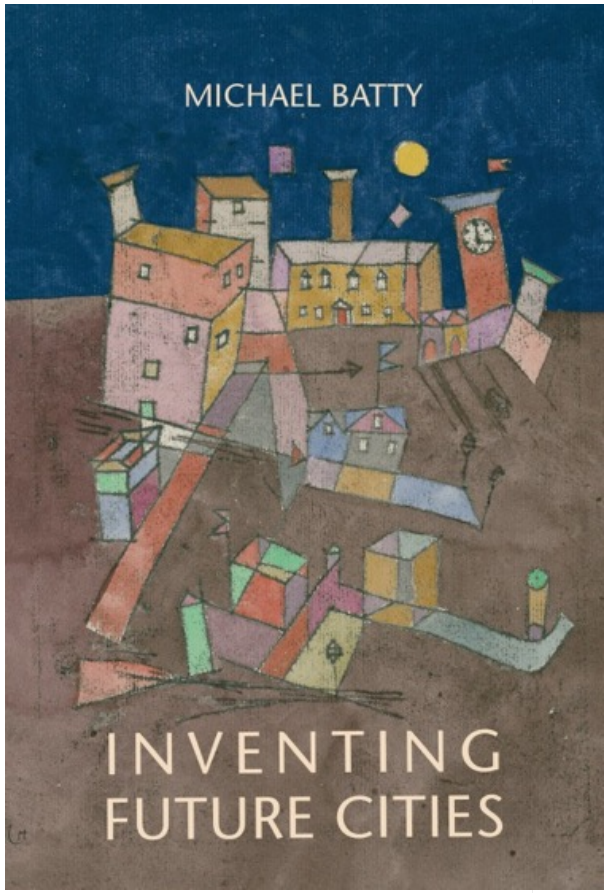




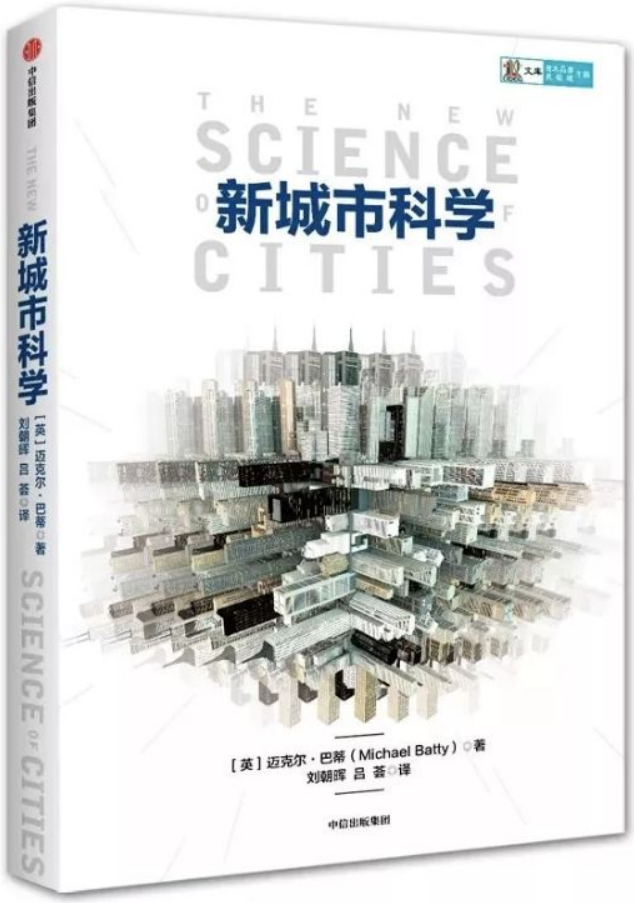
Some Brief Conclusions

- 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 of hierarchy and central place theory and so on


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MIT Press, 2018

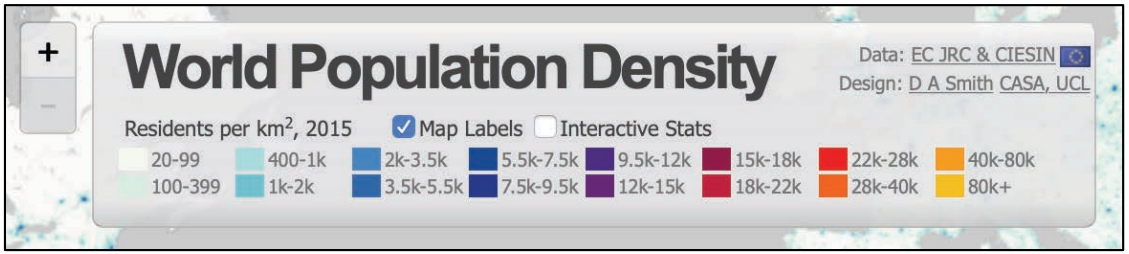


MIT Press, 2013,
translated 2019



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CityGeographics: urban form, dynamics and sustainability

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