POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH

P I K

City Clustering and Applications

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20. Kolloquium Theorie und Quantitative Methoden in der Geographie
23.2.2012 | 14:30-15:00

the City College of New York
OF THE CITY UNIVERSITY OF NEW YORK

How to define cities?

Cities are complex structures consisting of buildings, infrastructure, interacting agents, as well as energy and material flows

Not clear how to define cities - usually, administrative boundaries are taken into account

What are “the units of observation” (Berry, Cities, 2011)?

Different definitions of cities affect the statistical properties of urban activity

Outline

I. City Clustering Algorithm (CCA)

II. City size and growth (Zipf's Law, Gibrat's Law)

III. Urban Heat Island (UHI)

City growth (Gibrat's Law) & CCA:
Rozenfeld HD, et al. (2008) PNAS 105:18702-18707.

City size (Zipf's Law):
Rozenfeld HD, et al. (2011) AER 101:2205-2225.

Urban Heat Island:
Zhou B, et al. (2012) in preparation

I. City Clustering Algorithm (CCA)

A new definition of cities

We define a new way to construct cities:

- unbiased
- automated
- fast
- based only on location of population
- allows studying cities at different level of observation

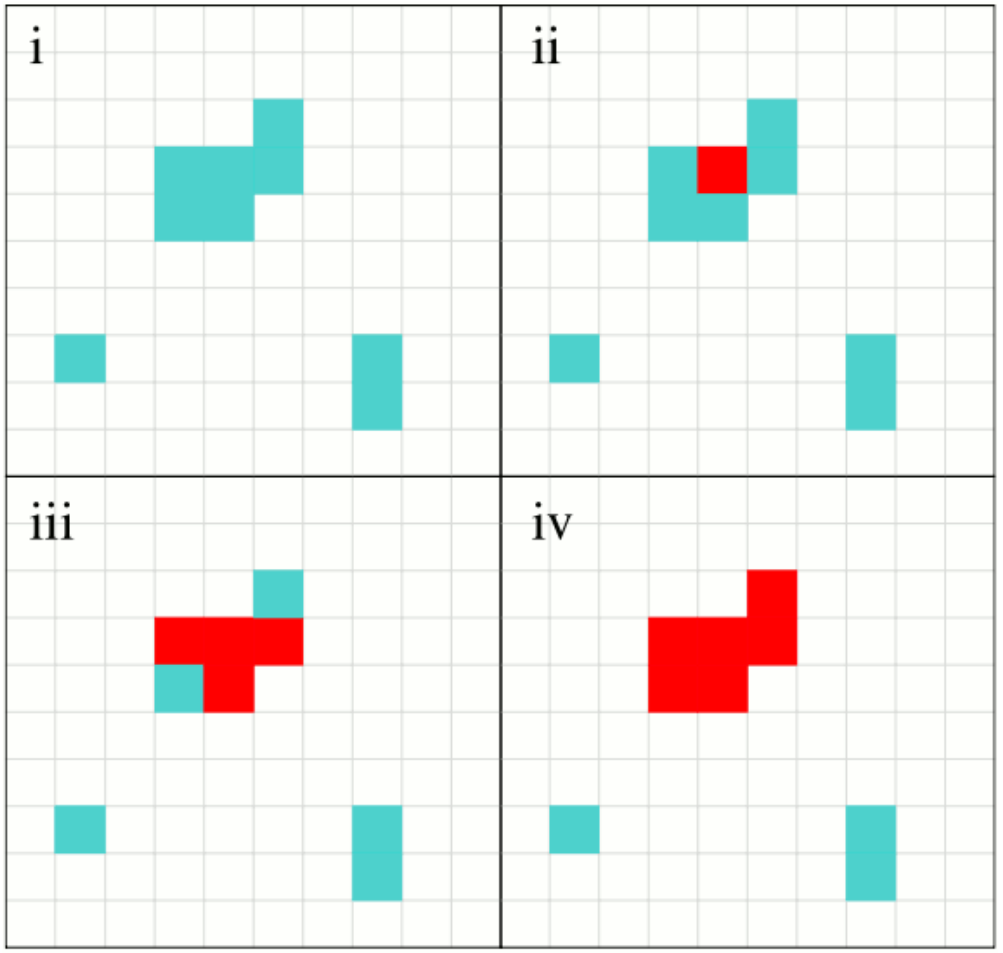
City Clustering Algorithm (CCA)

Population Data

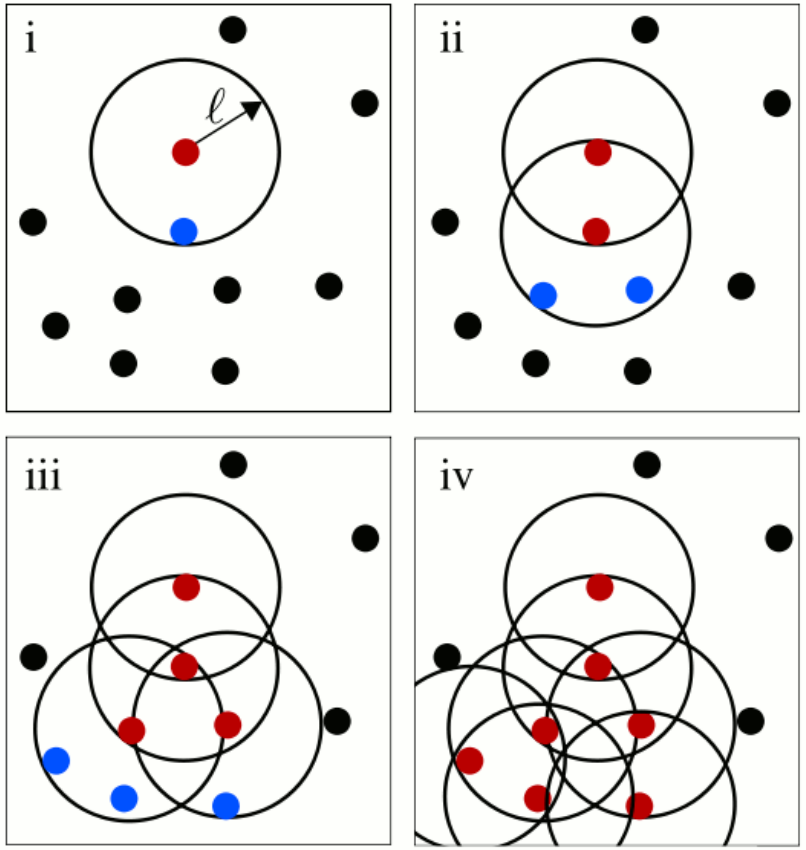
Great Britain (England, Scotland, and Wales):
58.7 millions in 2007
0.23 million km2
grid of 200m x 200m

USA (excluding Alaska):
303 millions in 2007
7.44 million km2
59456 sites (FIPS)

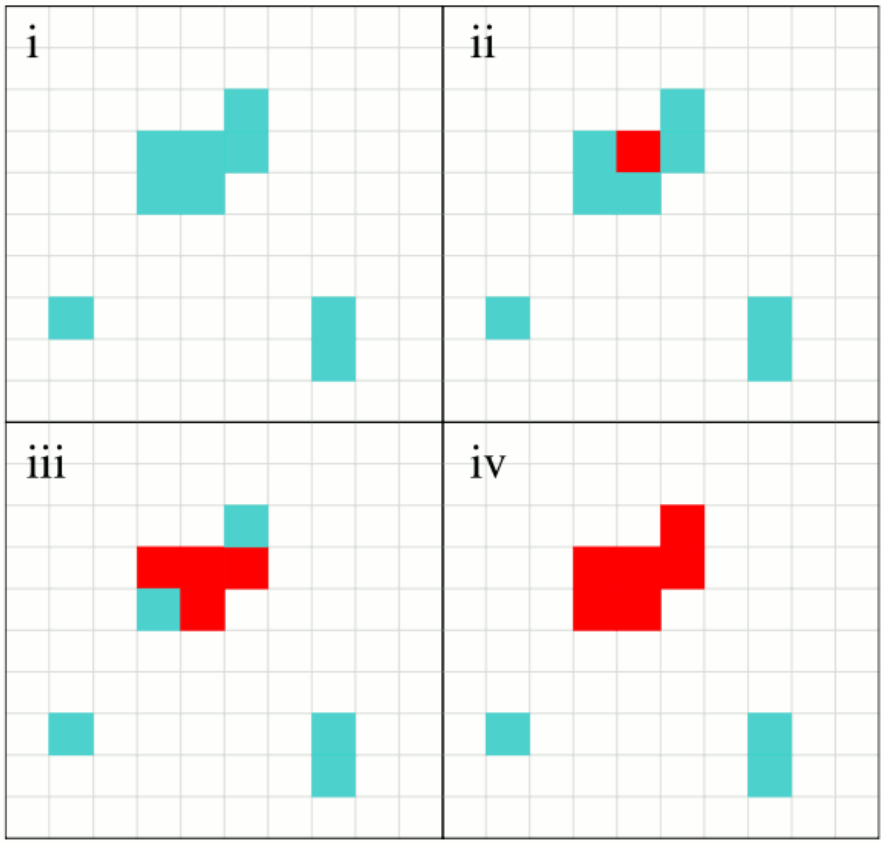
A new definition of cities



A new definition of cities

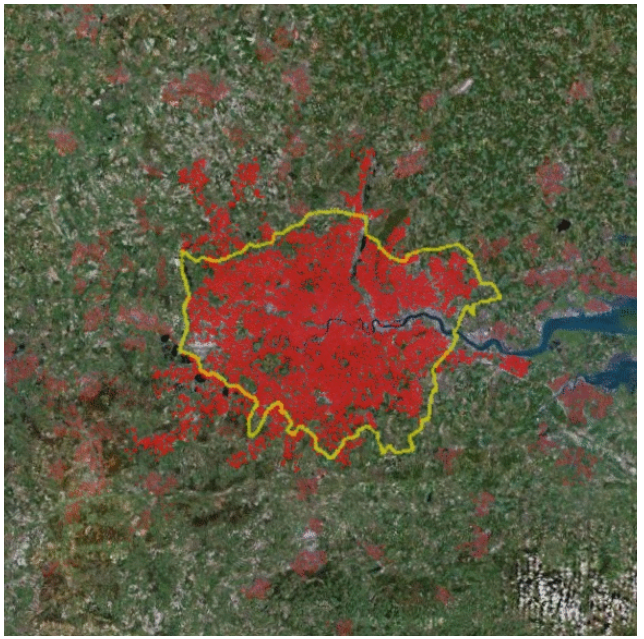


US

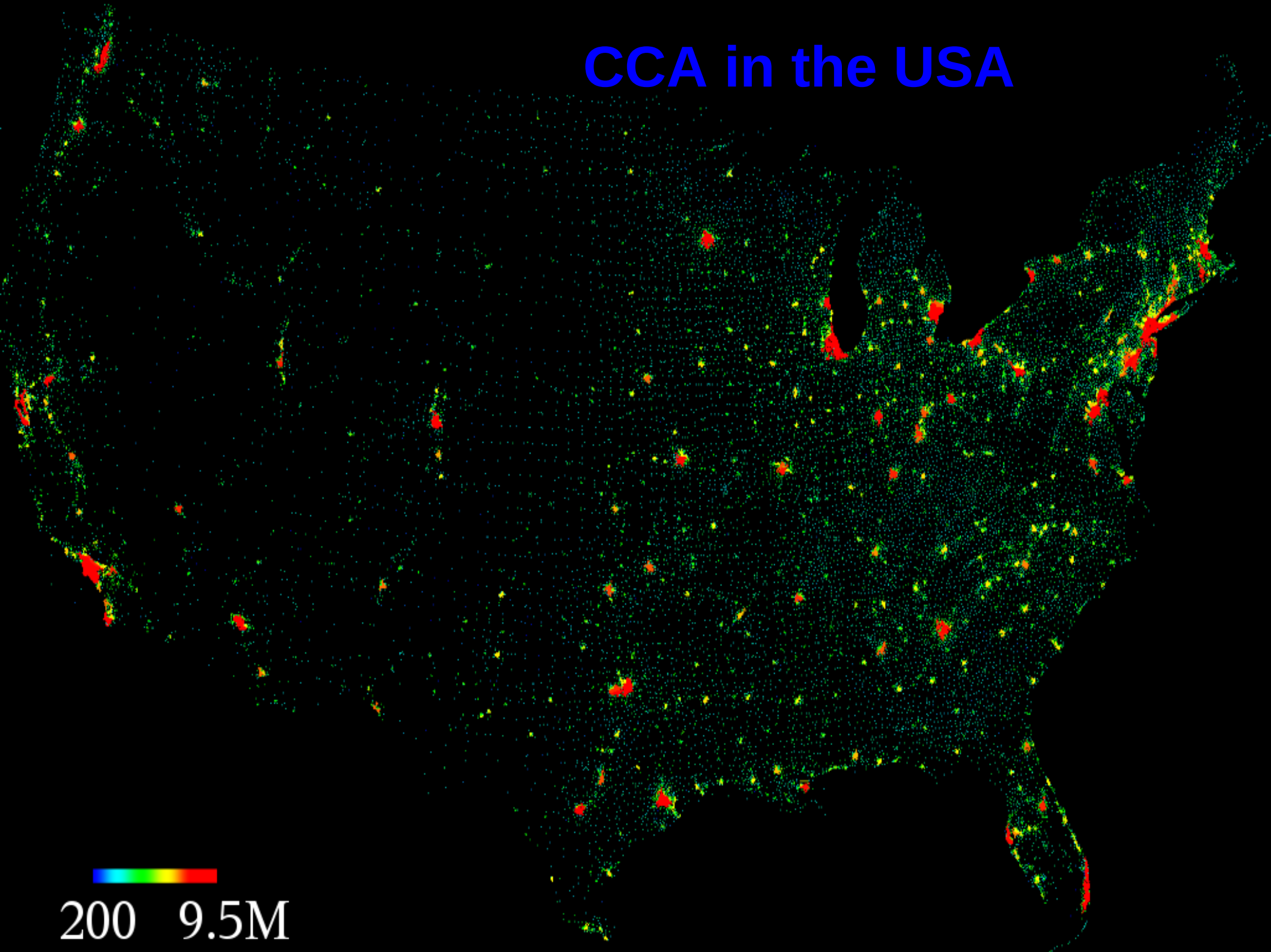


GB

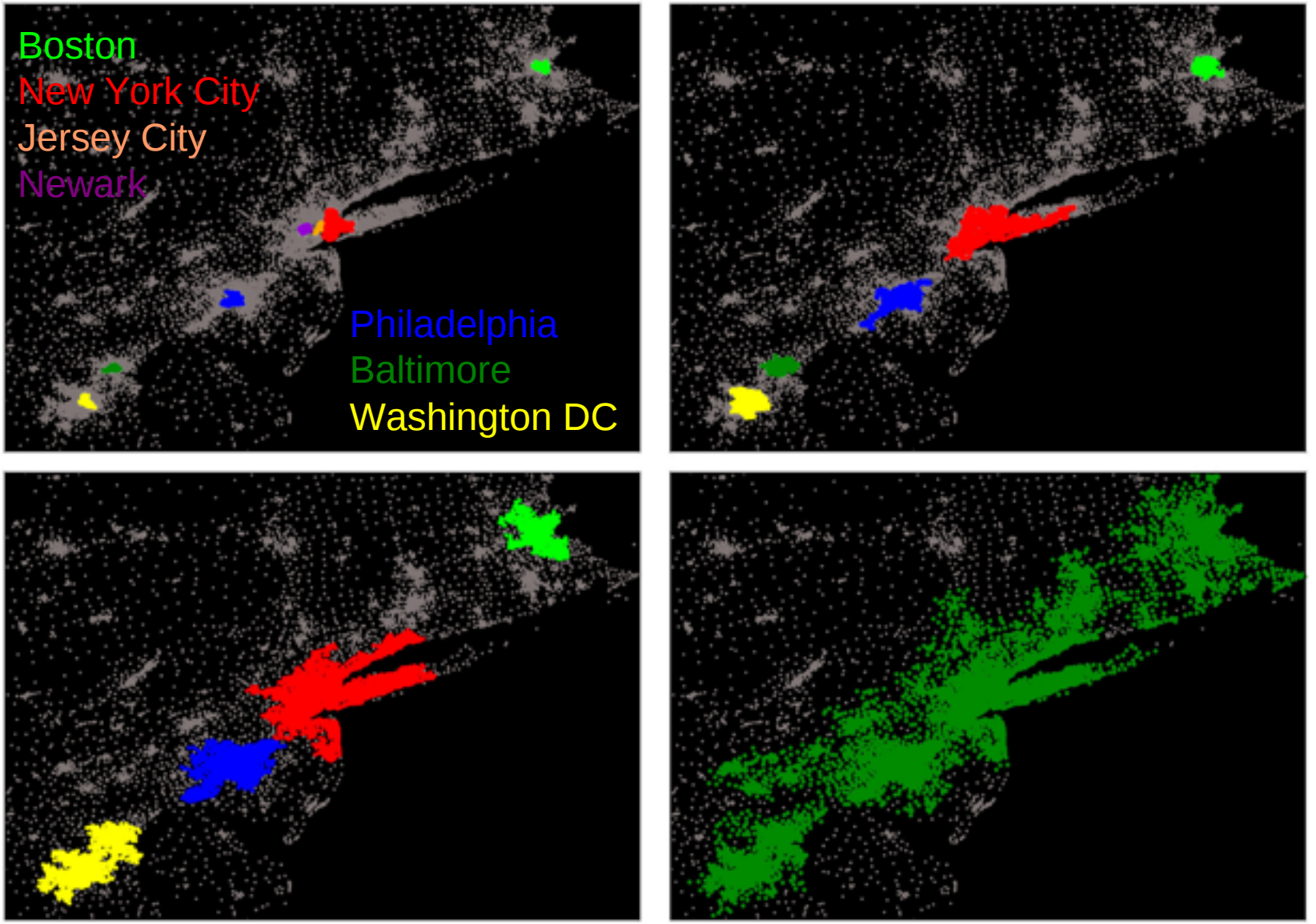
CCA in Great Britain



CCA applied
to Greater London


CCA in the USA
200
9.5M

CCA in the USA



II.a City size (Zipf's Law)

Zipf's Law

$$P(S) \sim S^{-\zeta-1}, \quad \zeta = 1$$

The distribution of sizes follows a power-law with $\zeta = 1$

Zipf's law has been documented for words, firms, size of exports, and many more

Does the city size distribution obey Zipf's Law?

Zipf's Law

Understanding the origin of this regularity is an ongoing task.

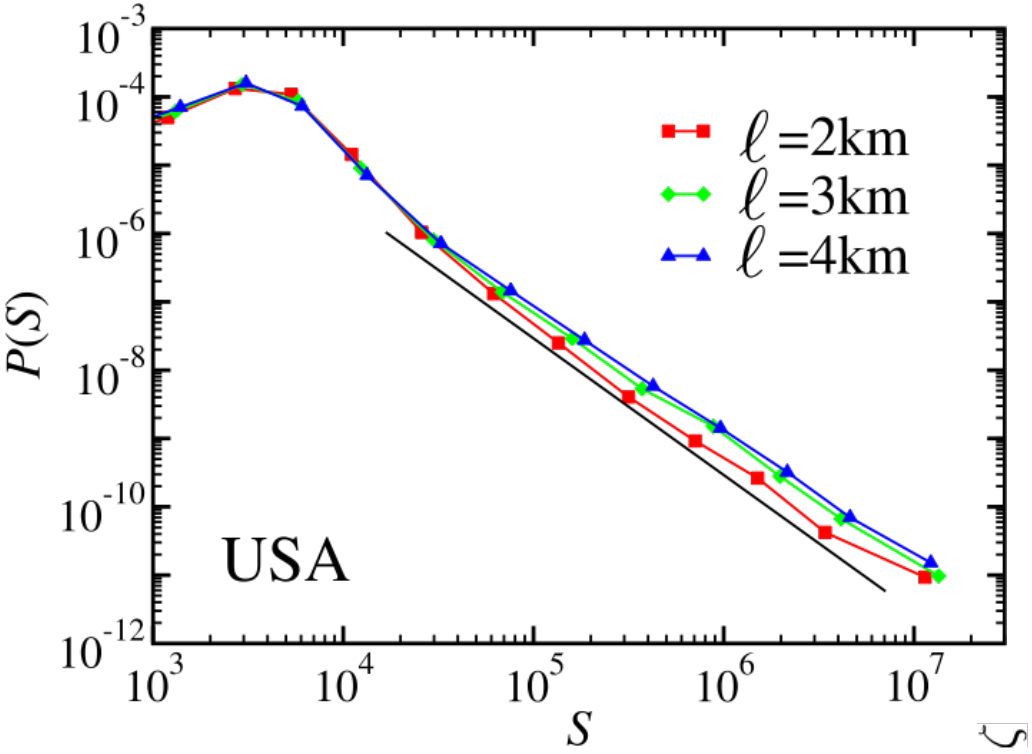
Typically, studies use MSAs for the top 200 cities, i.e. Eeckhout (’07)

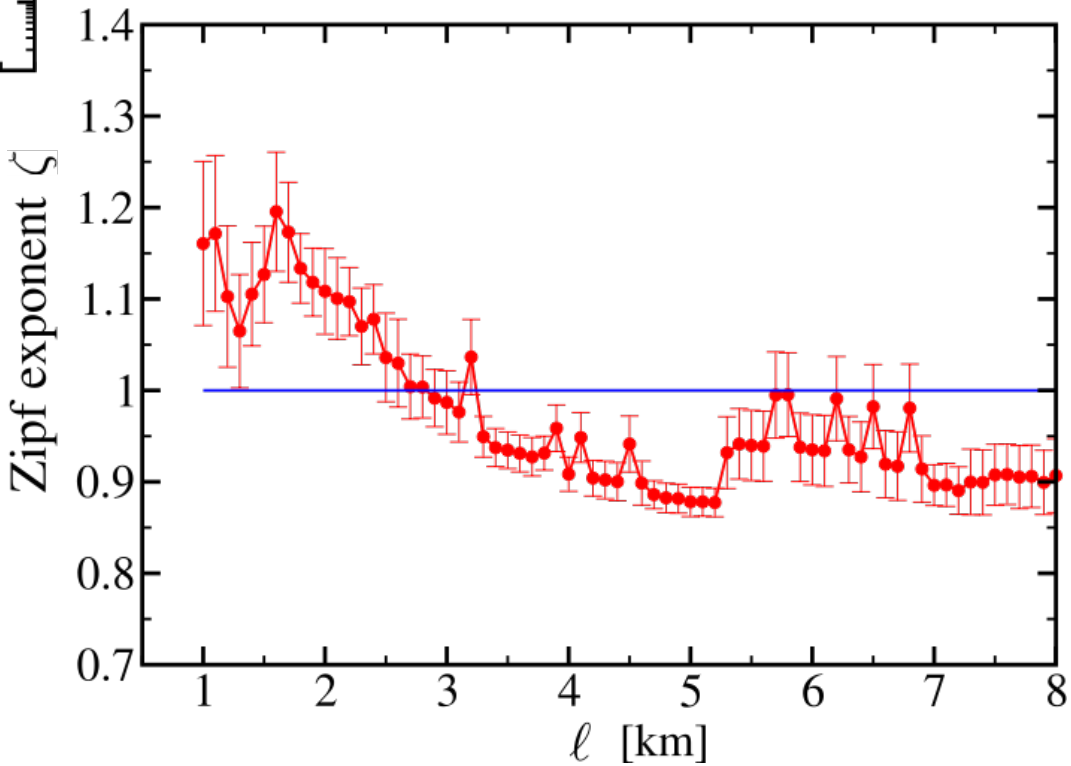
Eeckhout (’07)

- Uses data on all administrative cities
- Finds a very good log-normal fit

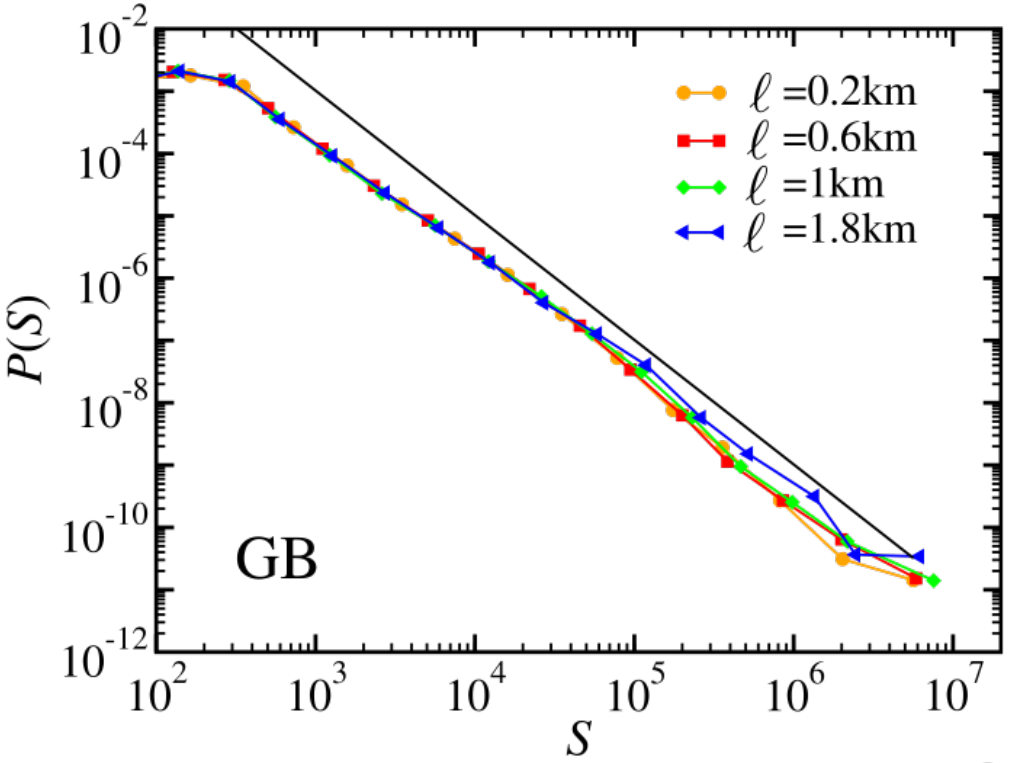
Distribution of city size using the CCA?

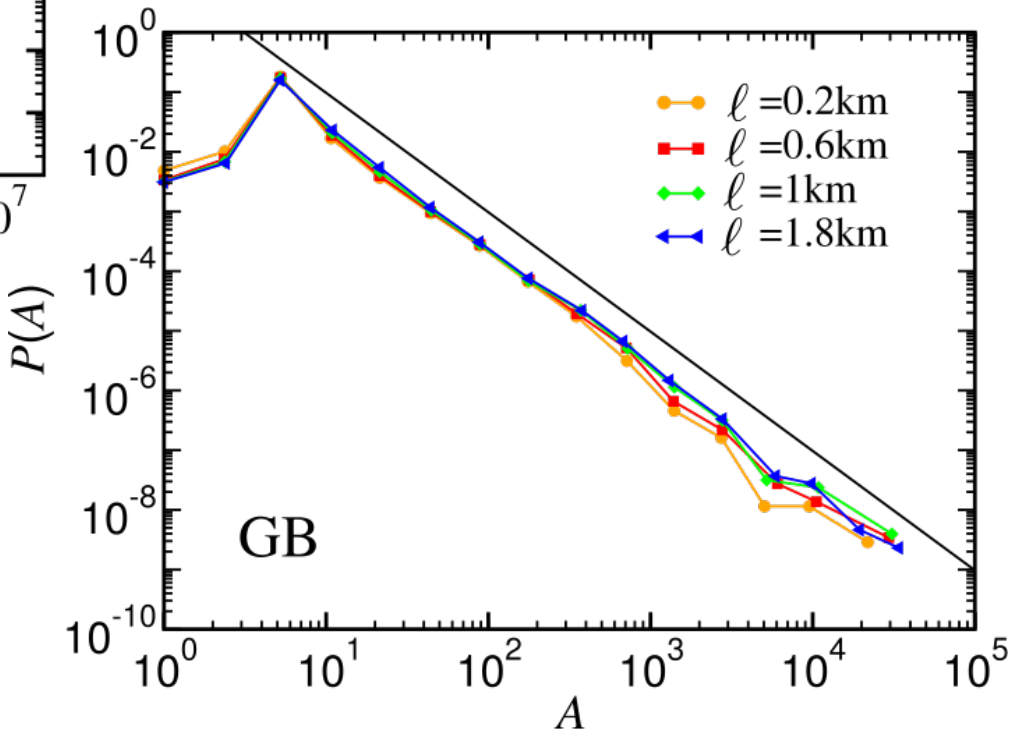
Zipf's Law for the USA



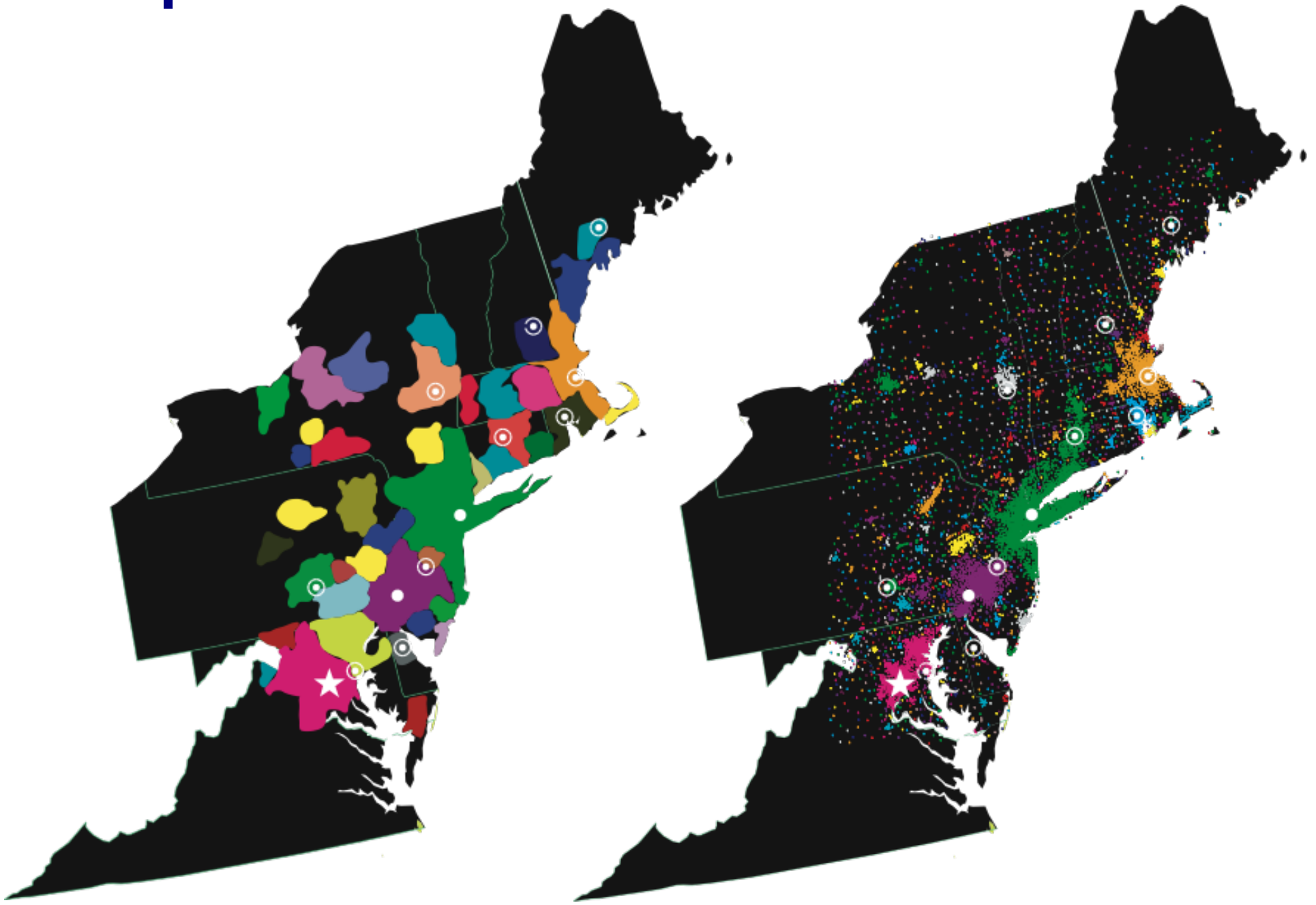


Zipf's Law for the GB

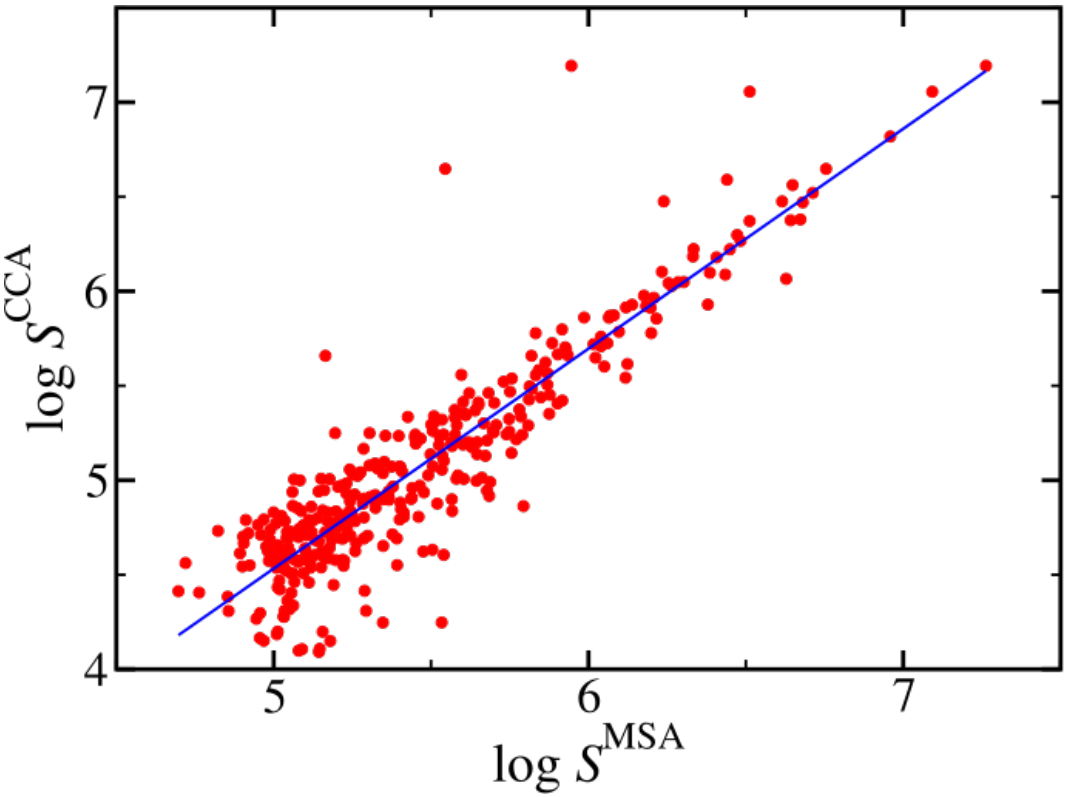


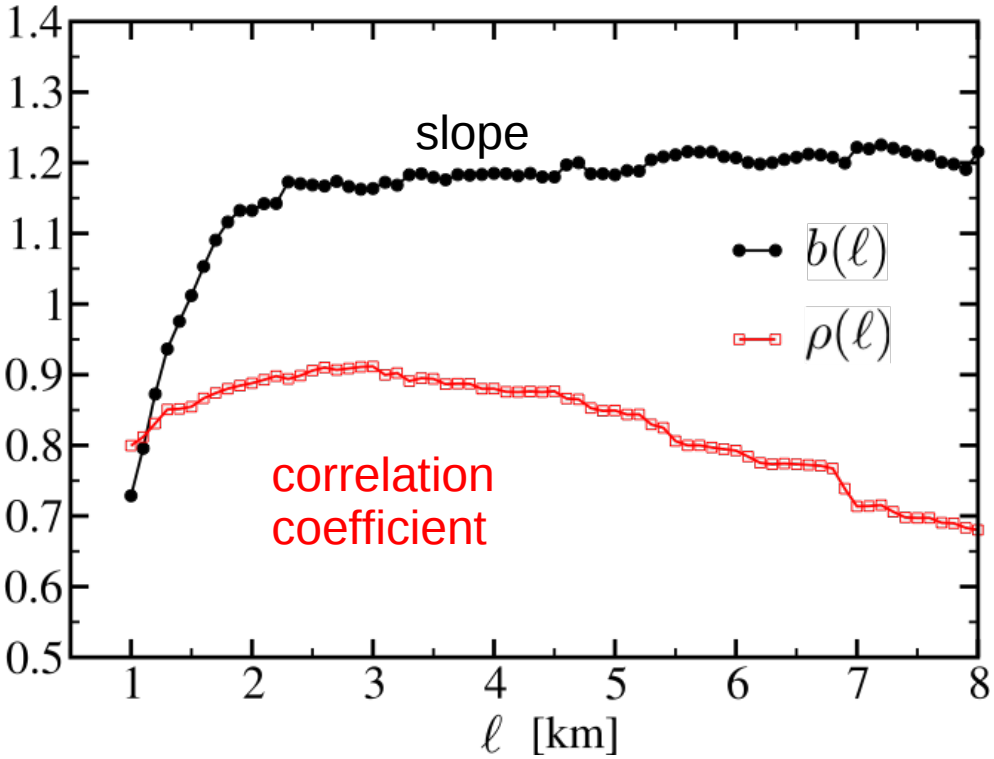


Comparison with MSA: Northeastern USA

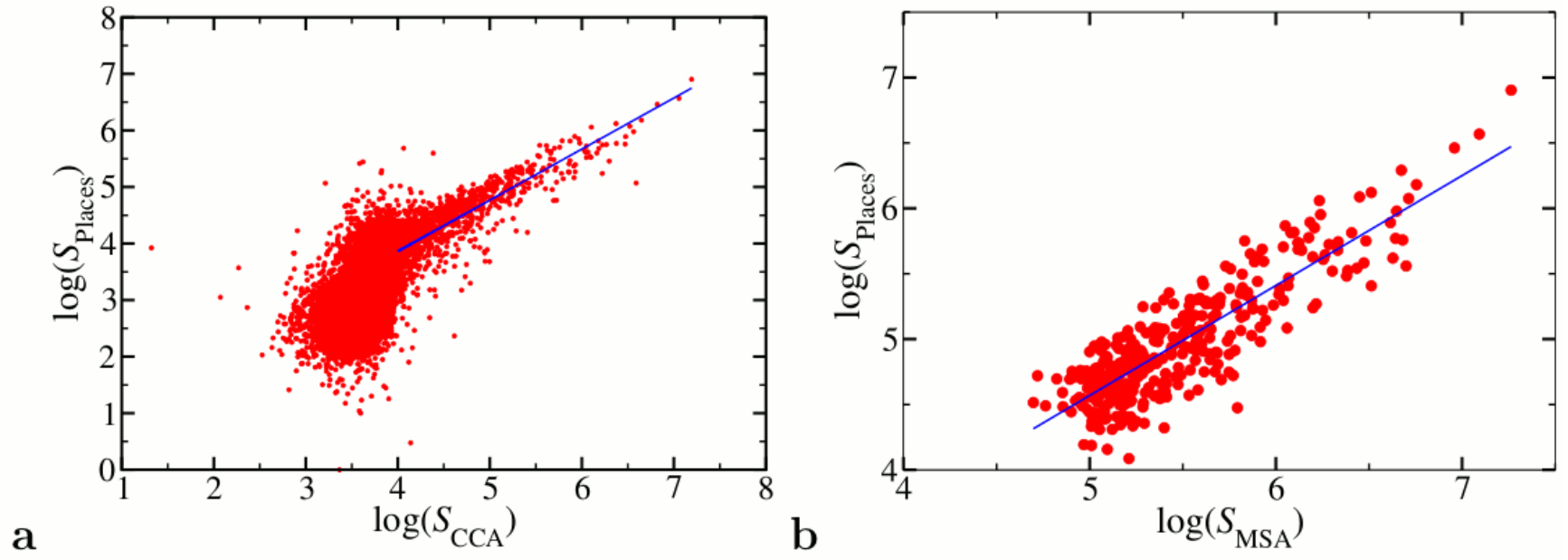


Correlations between MSA and CCA

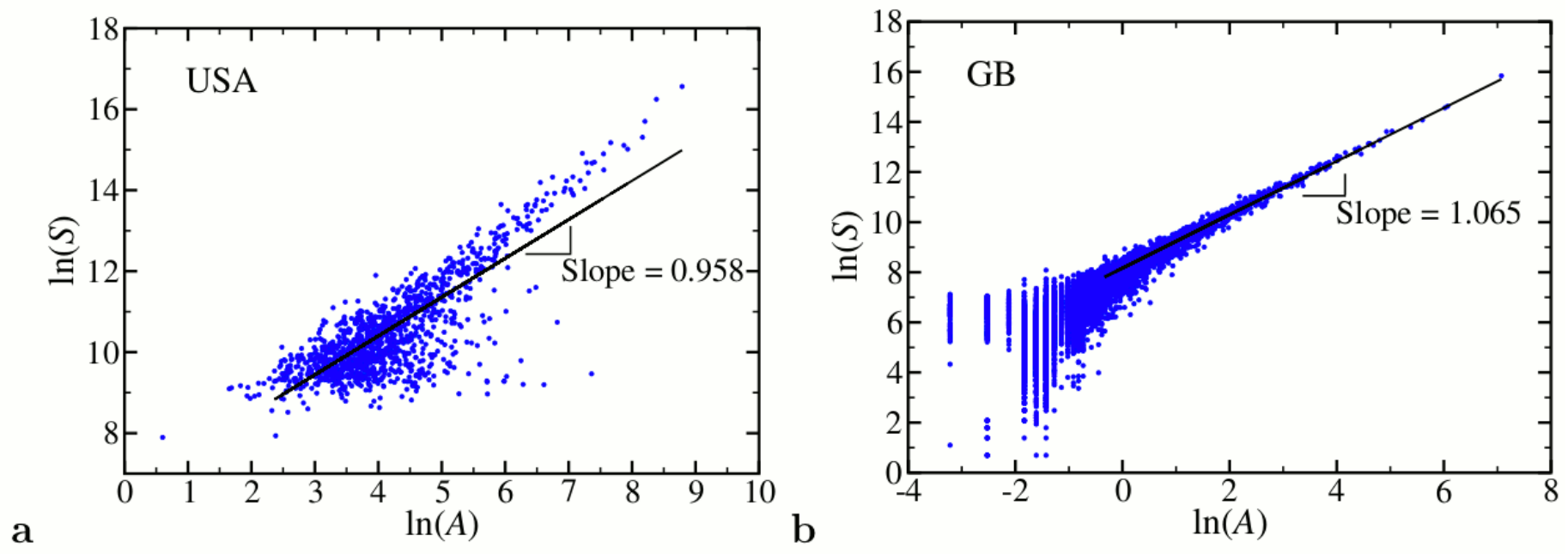




Correlations with Places



Correlations with Area



II.b City growth (Gibrat's Law)

skip this section …

- we find that Gibrat's Law does not hold
- instead, scaling laws being related to spatial correlations

III. Urban Heat Island (UHI)

Approach

apply CCA to land cover (CORINE, EU, 250m)

define boundary with equal area

determine temperature from land surface temperature (MODIS, 1km)

(surface) UHI intensity as difference between cluster and boundary temperature

systematically study all clusters

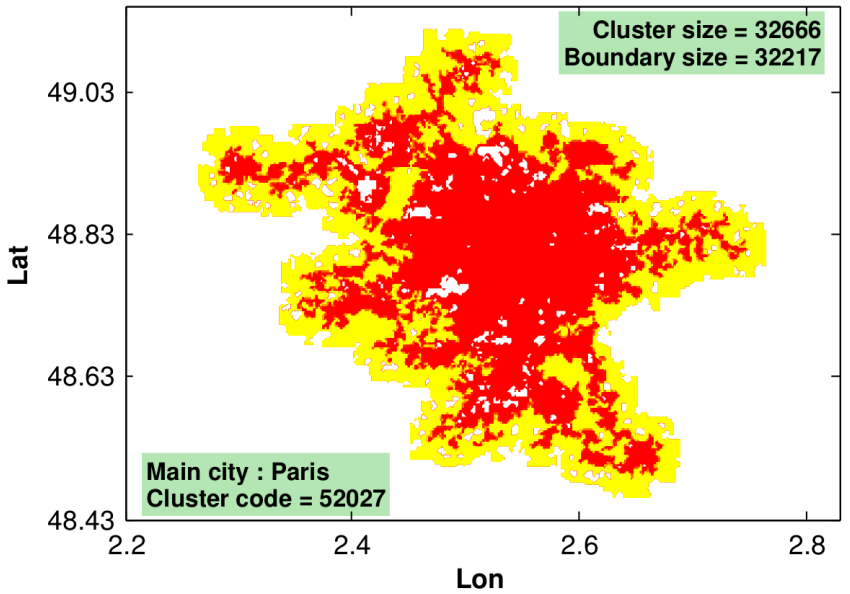
Clusters

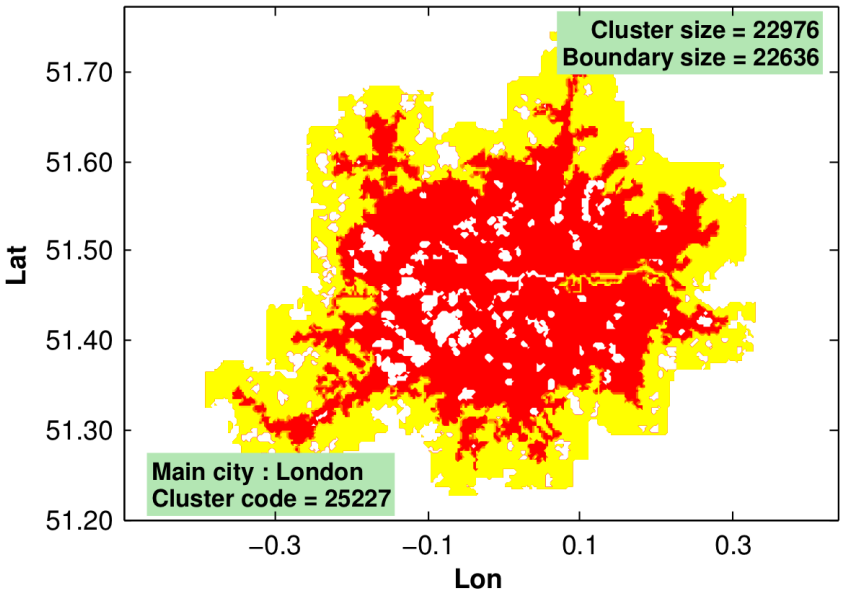
approx. 130 000 clusters (l=2)

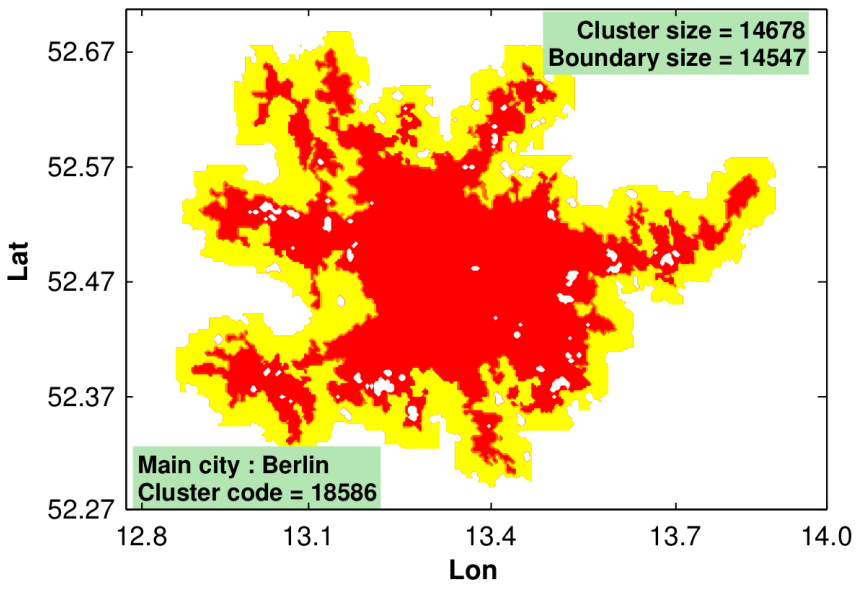
- 4917 clusters with min. 100 cells
- 2042 clusters with min. 200 cells

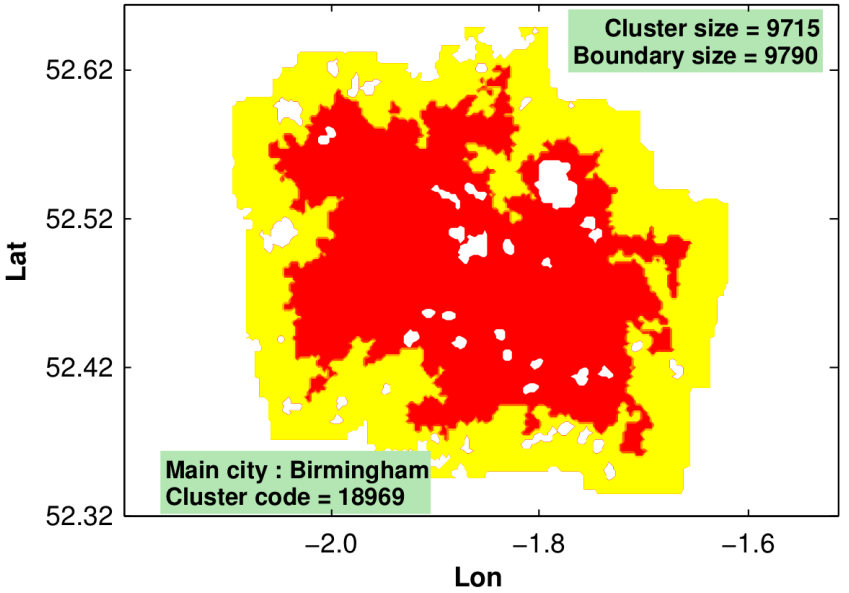
largest clusters	*cells*	*km²*
Flemish Diamond	77298	4831.13
Paris	32666	2041.63
London	22976	1436.00
Milan	21327	1332.94
Ruhr	20150	1259.38
Cologne-Bonn	20148	1259.25
Berlin	14678	917.38
Birmingham	9715	606.69
Hamburg	9707	606.69

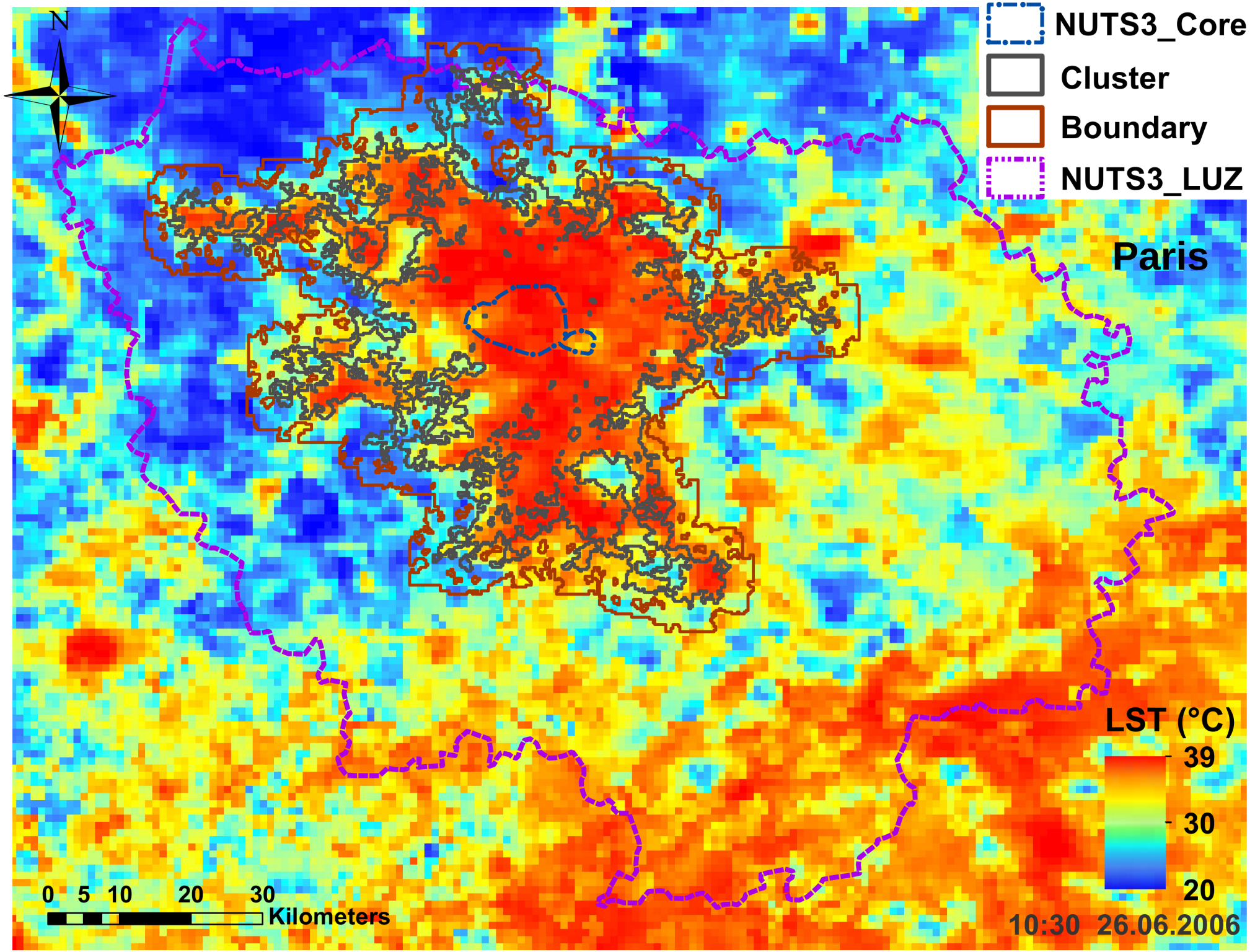
Cluster & boundary







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NUTS3_Core
Cluster
Boundary
NUTS3_LUZ
Paris
LST (°C)
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30
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0 5 10 20 30
Kilometers
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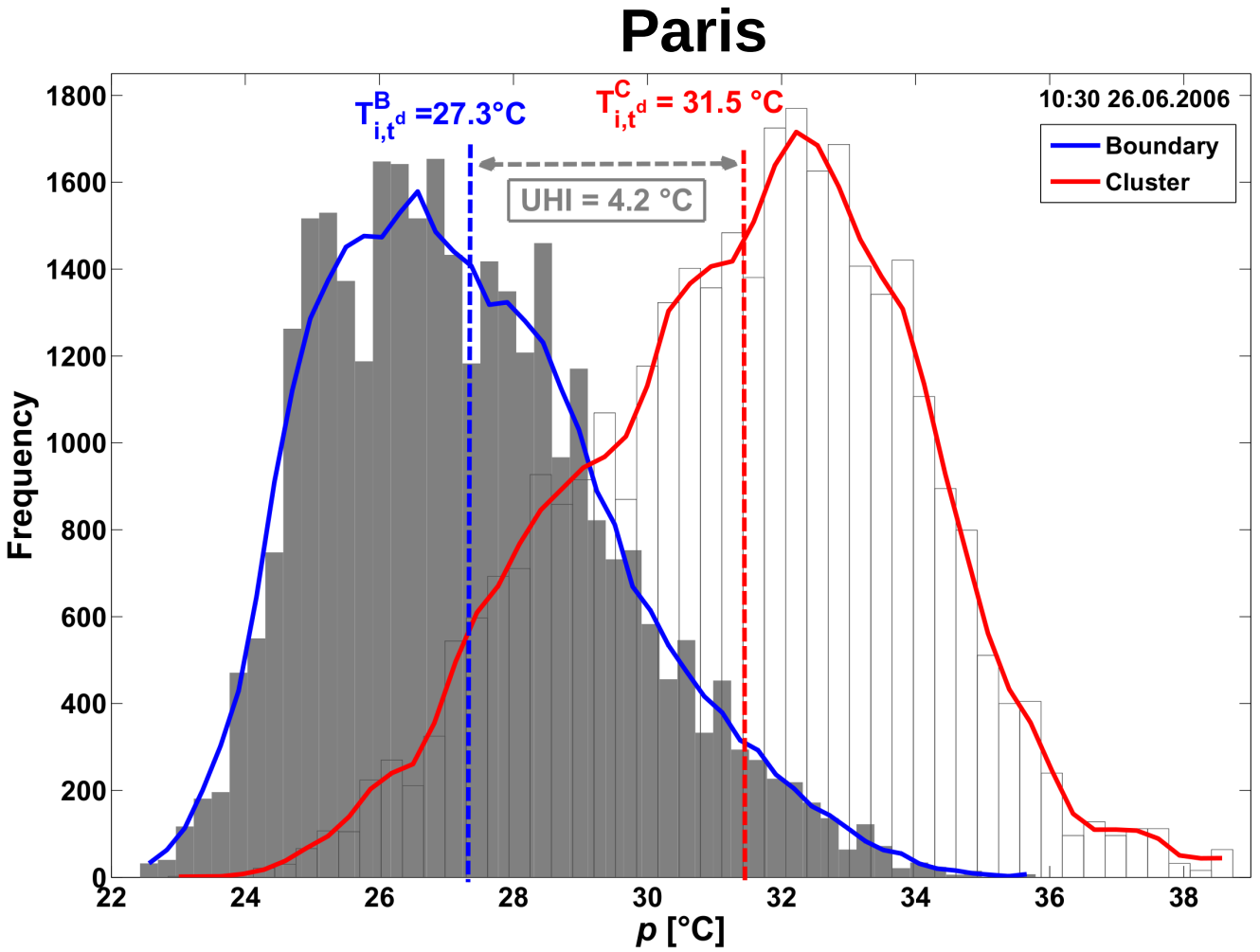
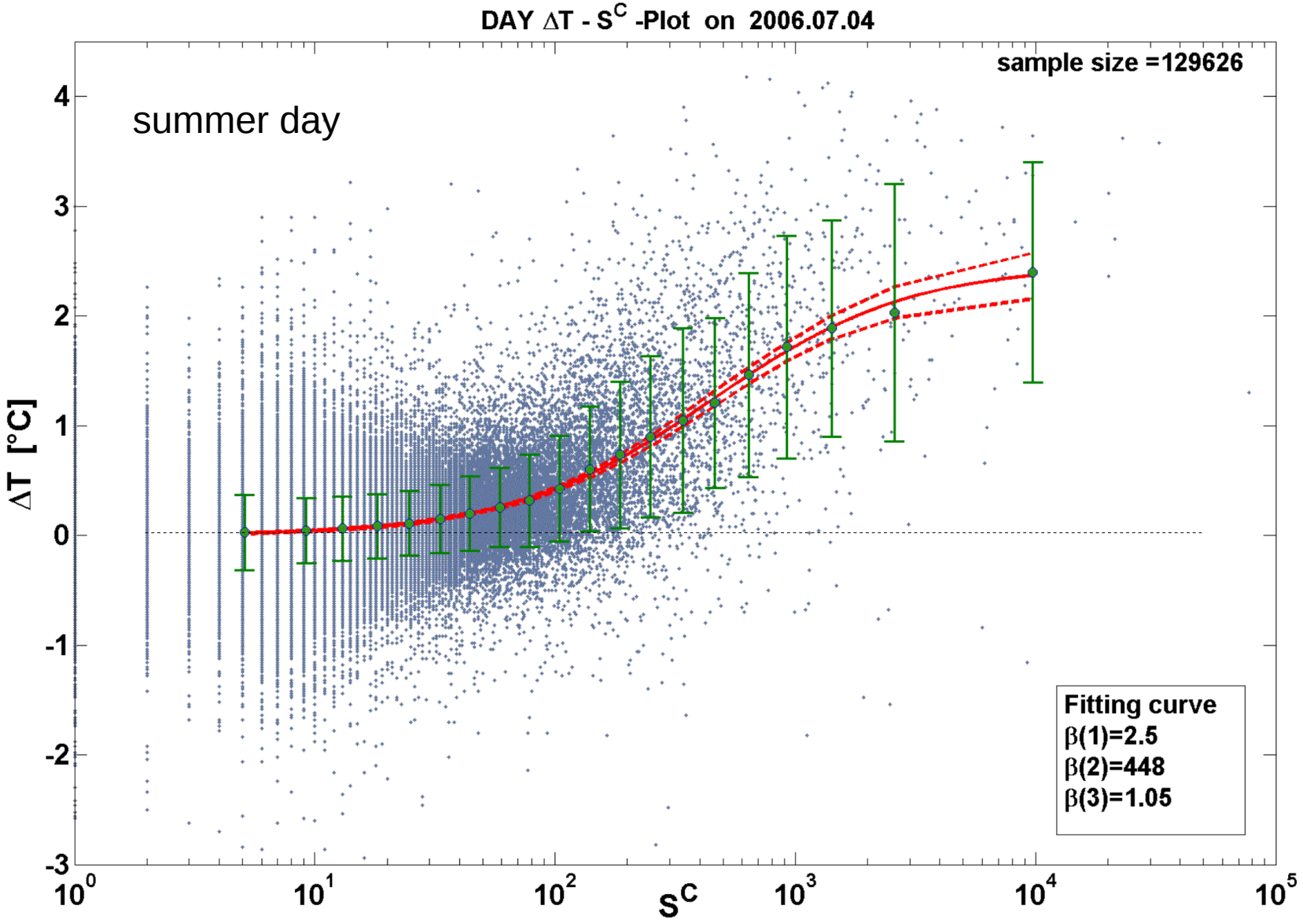
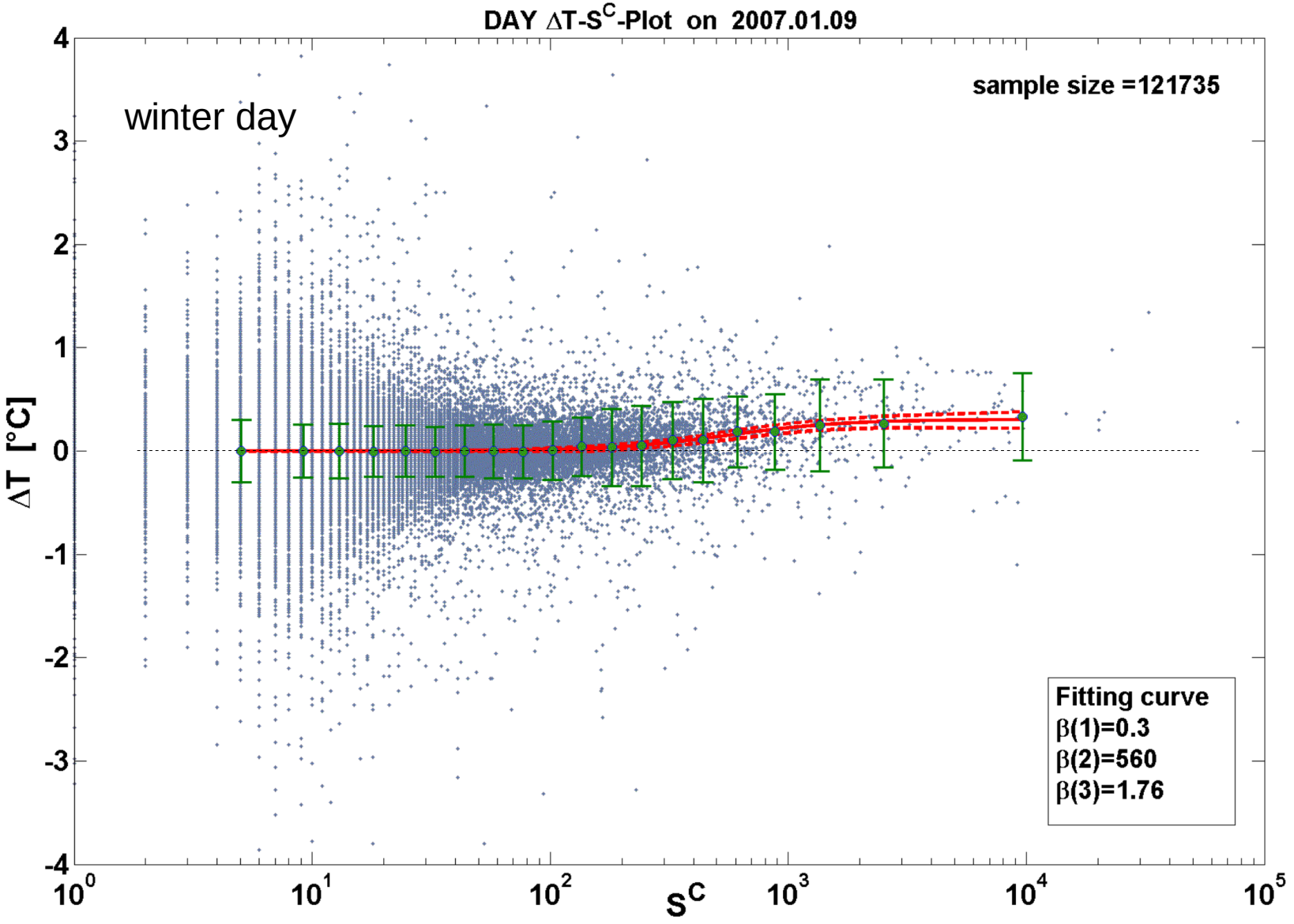
Paris: cluster & boundary temperatures



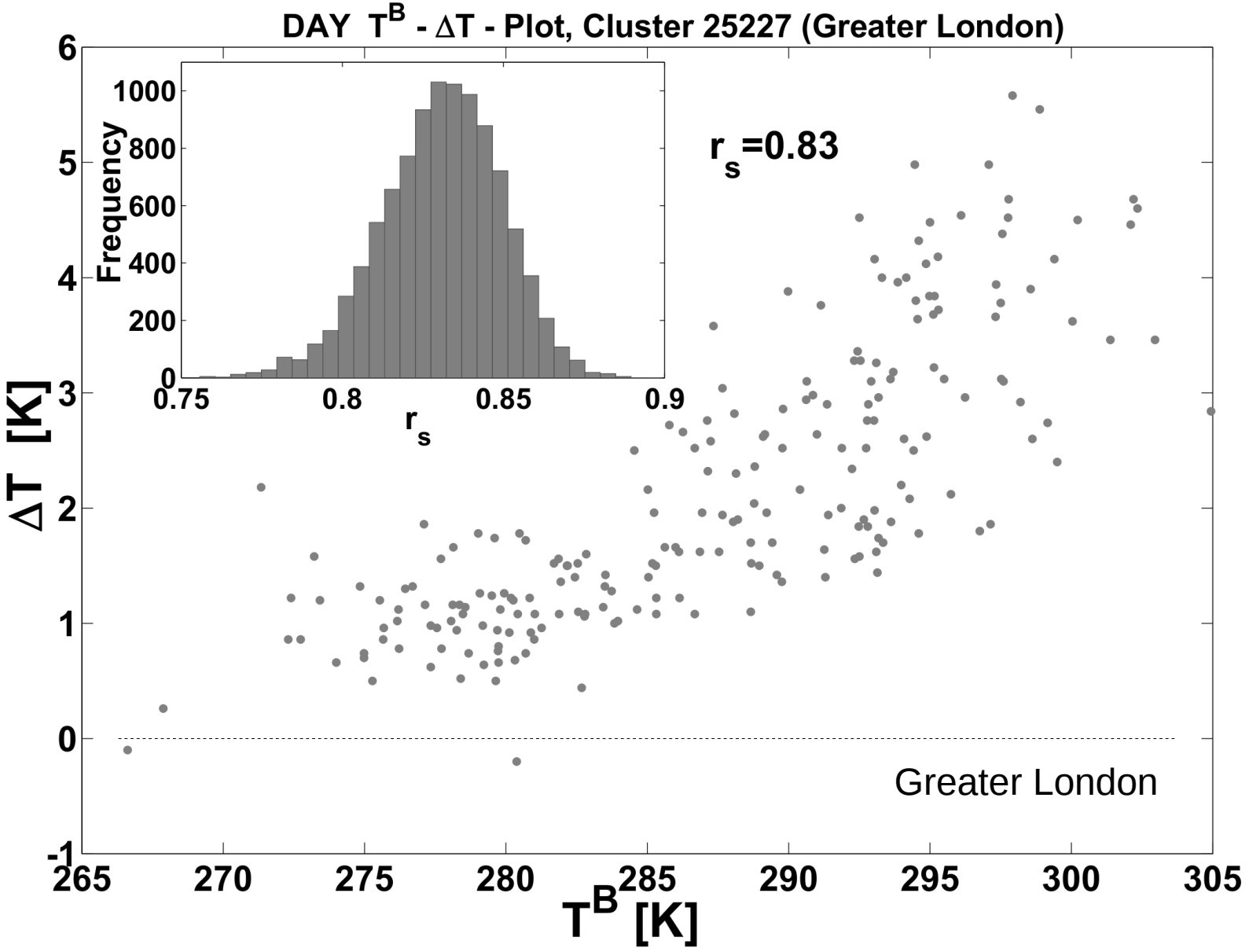
UHI intensity and cluster size



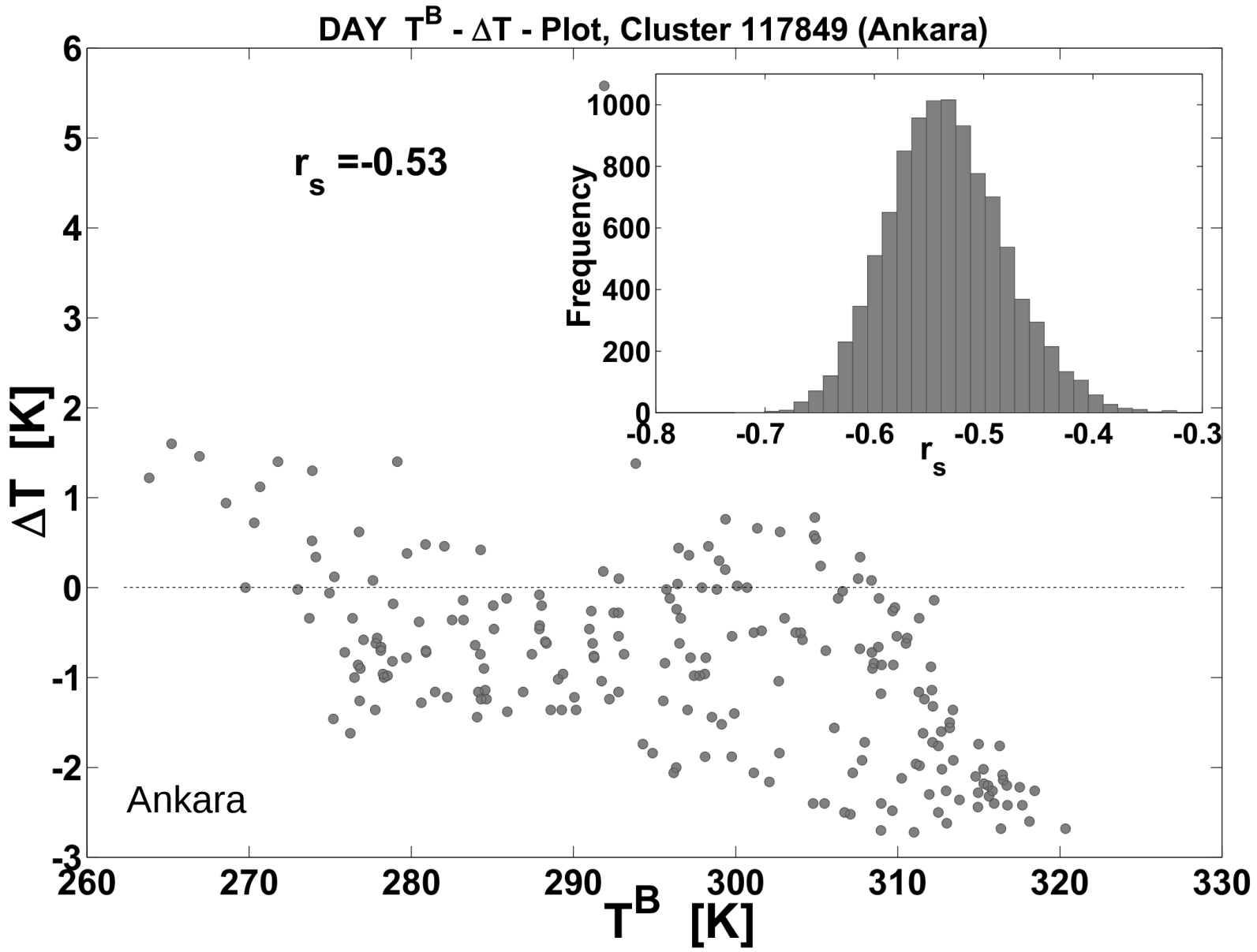
UHI intensity and cluster size



UHI intensity and boundary temperature



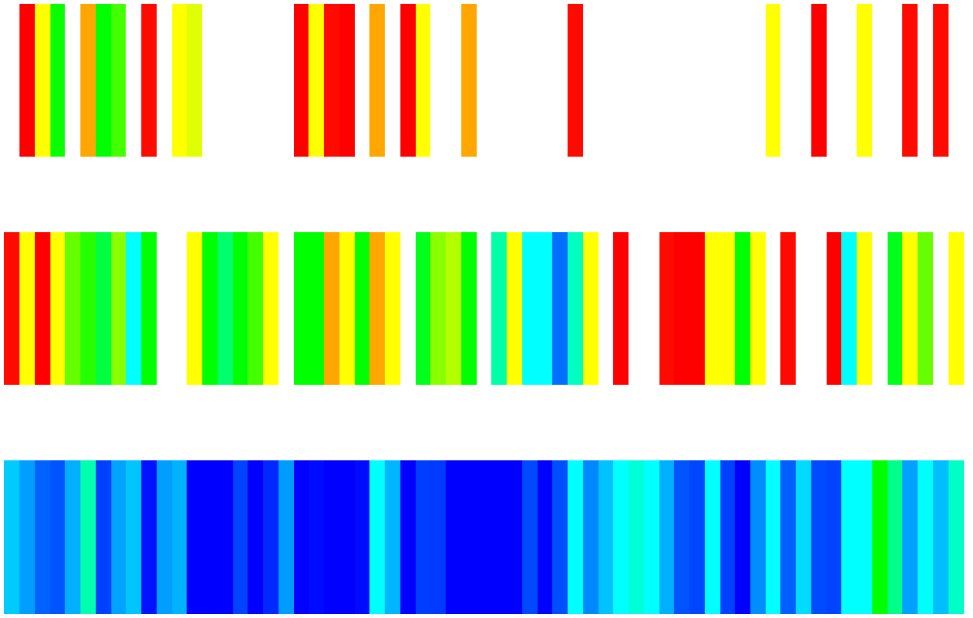
UHI intensity and boundary temperature



Summary

- CCA constructs cities based only on geographical features
- Zipf's Law holds over a wide range, even for smaller cities
- Scale-invariant growth, violation of Gibrat's Law (not shown)
- Systematic study of Urban Heat Island (UHI)
- Cluster size and individual clusters
- Work in progress

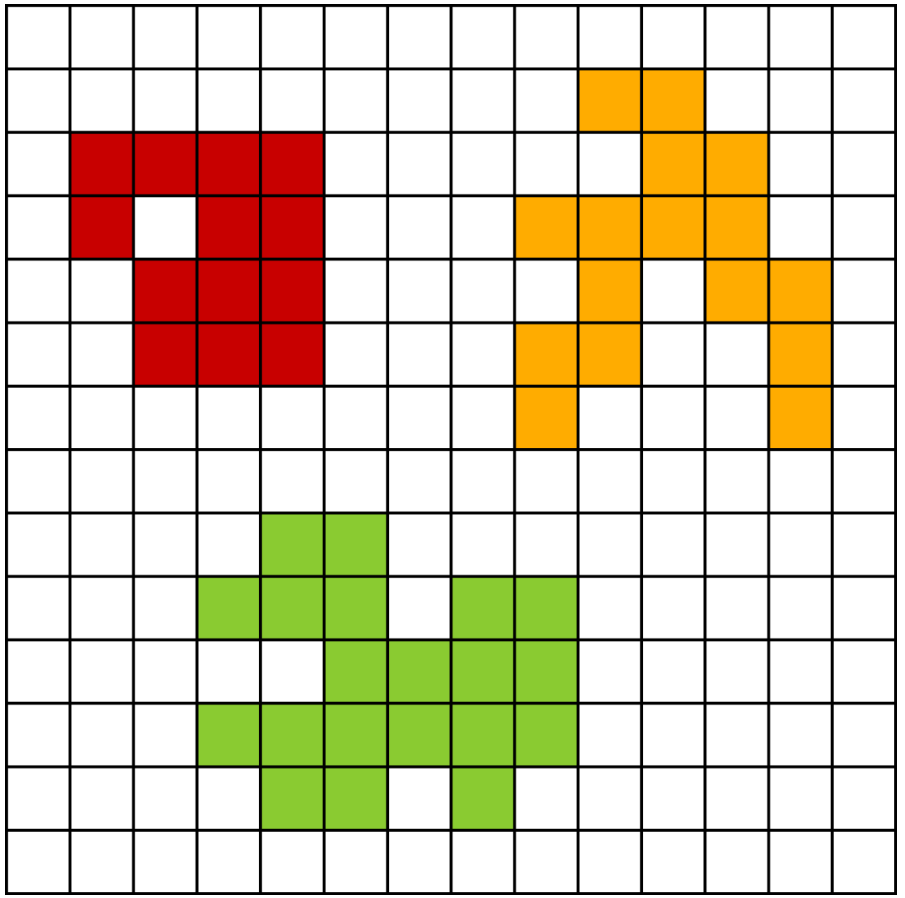
Thank you for your attention.



http://www.rybski.de/diego/

http://www.pik-potsdam.de/members/rybski/

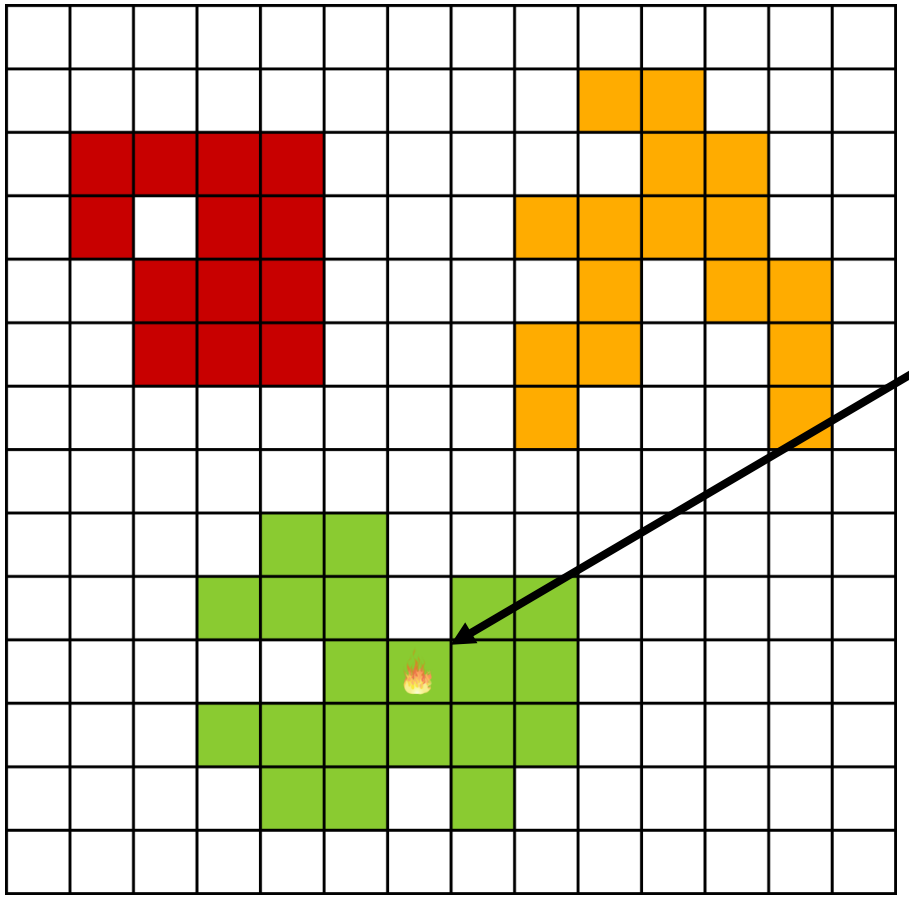
A new definition of cities



The map is gridded.
The populated cells are identified.

We define:
"a city" = "a cluster of connected populated cells, with maximal size"

A new definition of cities

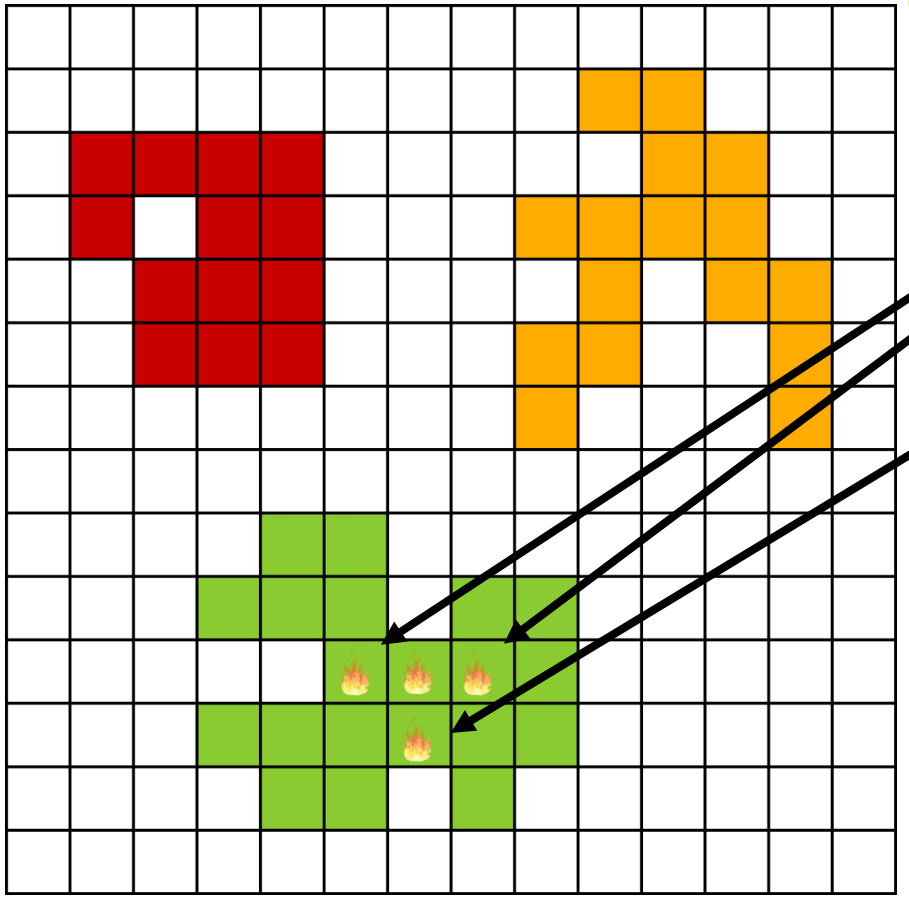


The burning algorithm.

Pick a populated cell and burn it.

Stauffer *Introduction to percolation theory* (‘84).

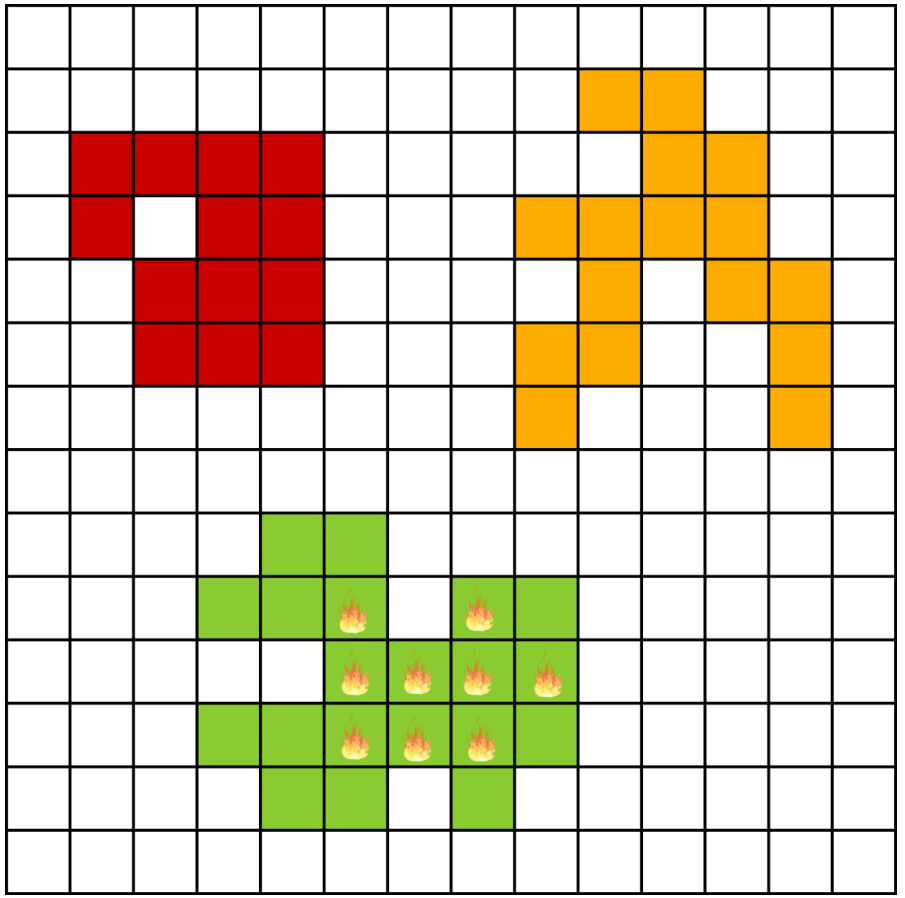
A new definition of cities



The burning algorithm.

Find the populated neighbors of the burnt cell and burn them.

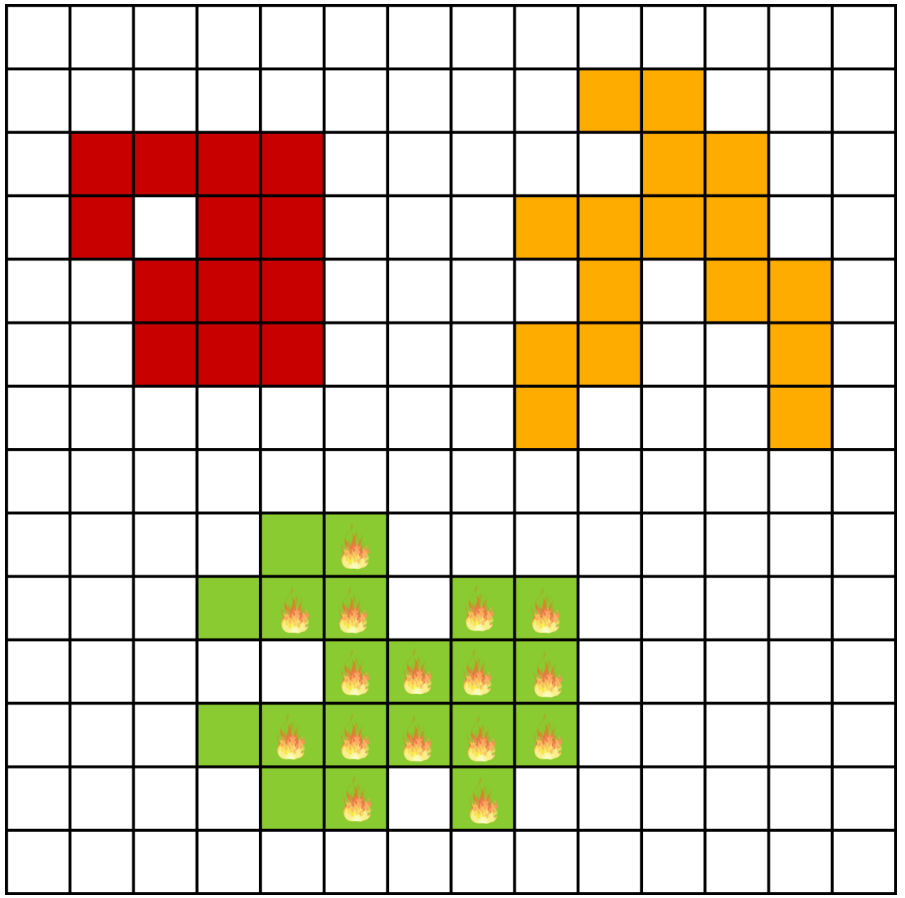
A new definition of cities



The burning algorithm.

Find the populated neighbors of the burnt cells and burn them.

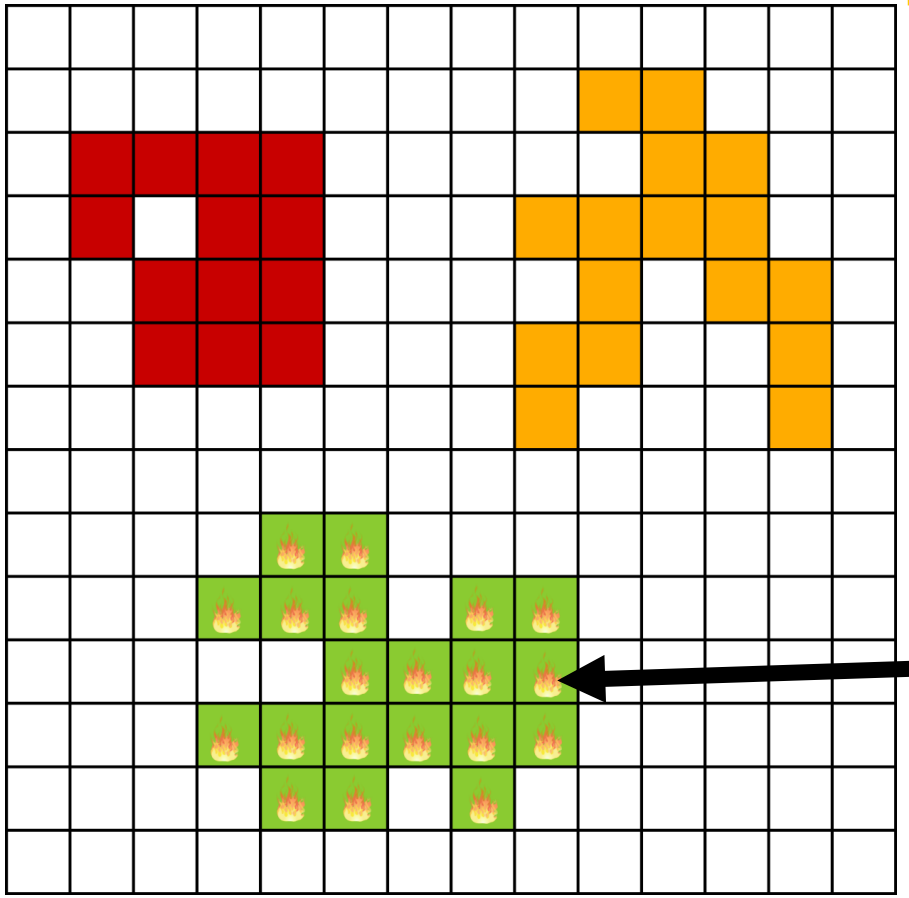
A new definition of cities



The burning algorithm.

Recursively,
continue identifying
the populated
neighbors
of the burnt cells
and burning them.

A new definition of cities

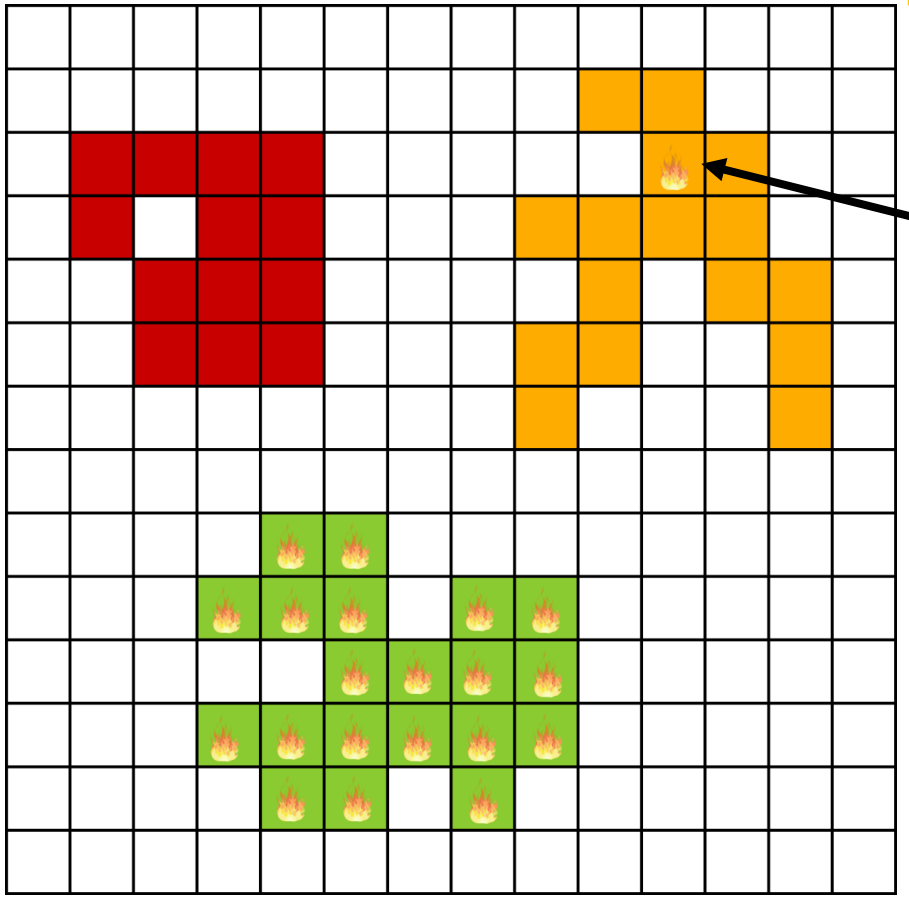


The burning algorithm.

When all burnt cells have no populated neighboring cells, the cluster is completed.

Our first cluster!

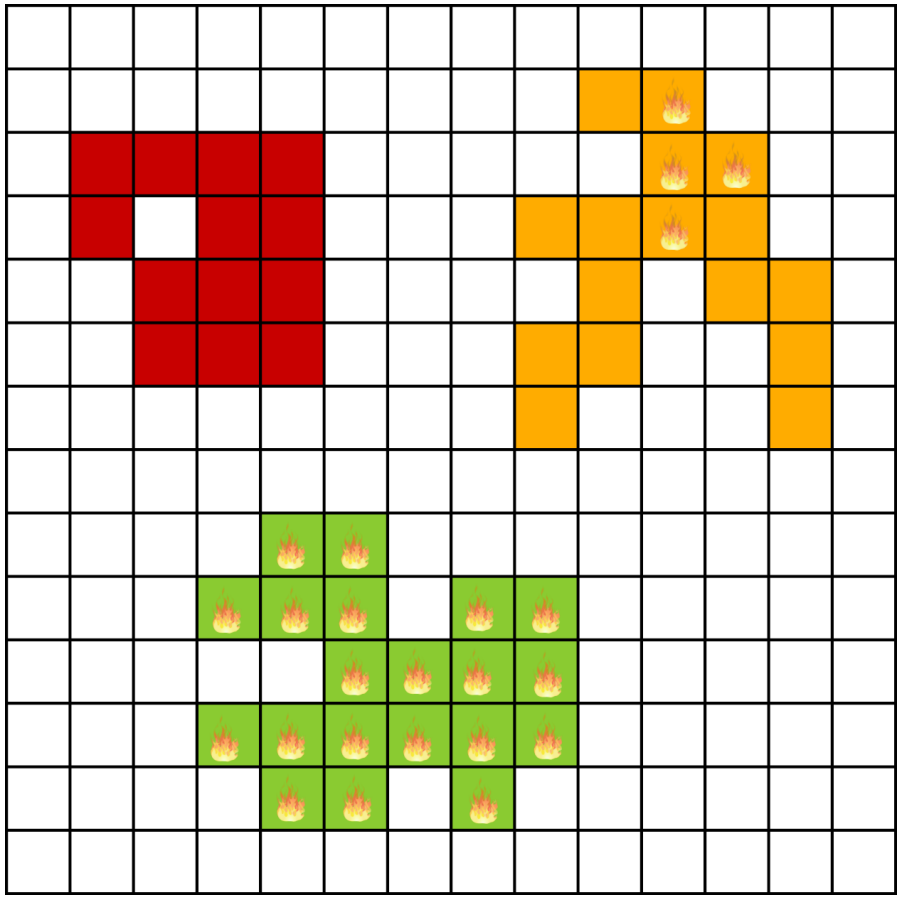
A new definition of cities



The burning algorithm.

Pick a new (not burnt) populated cell.

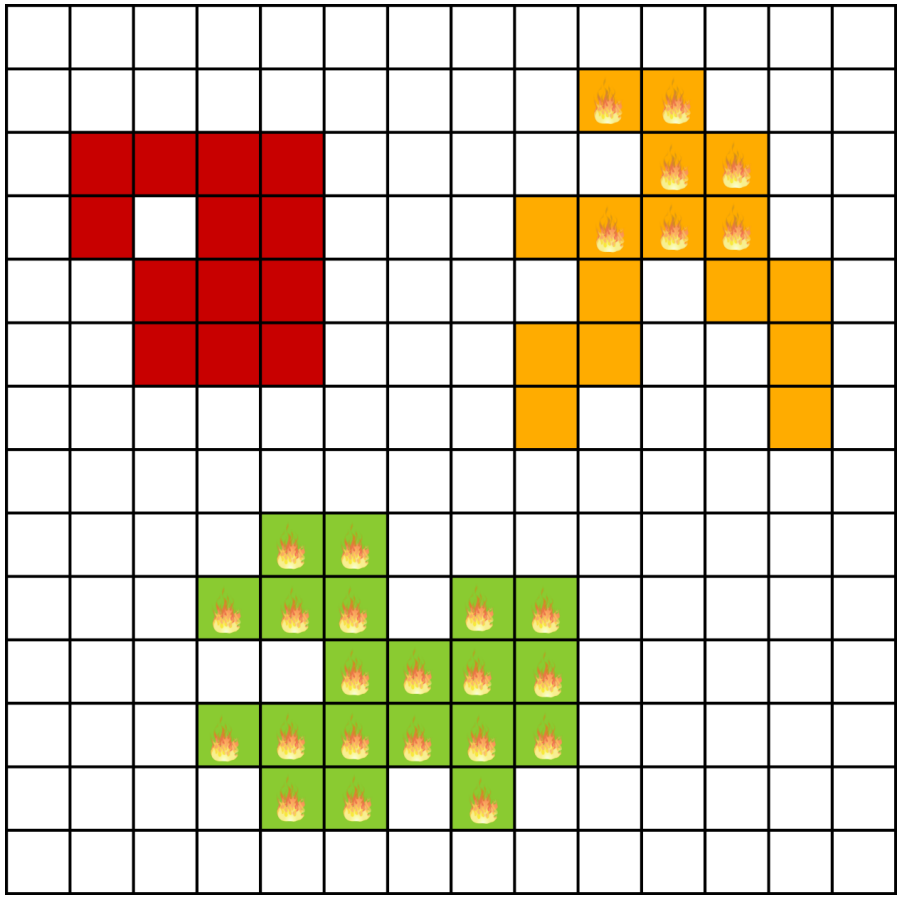
A new definition of cities



The burning algorithm.

Continue burning…

A new definition of cities

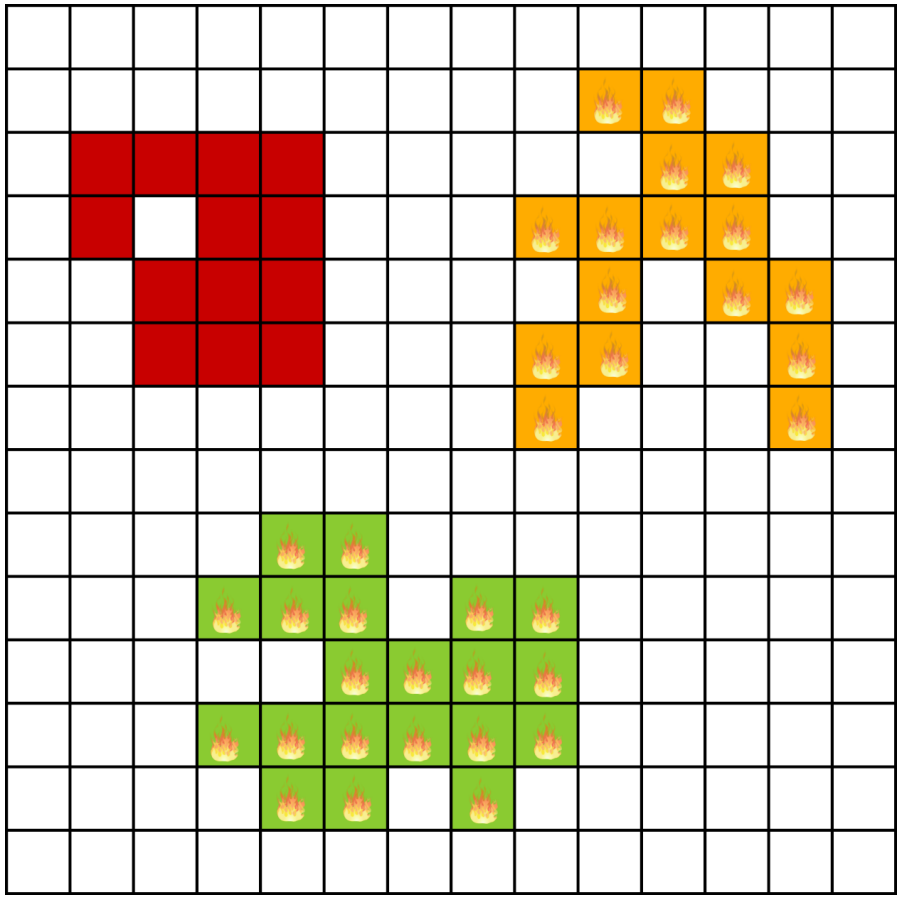


The burning algorithm.

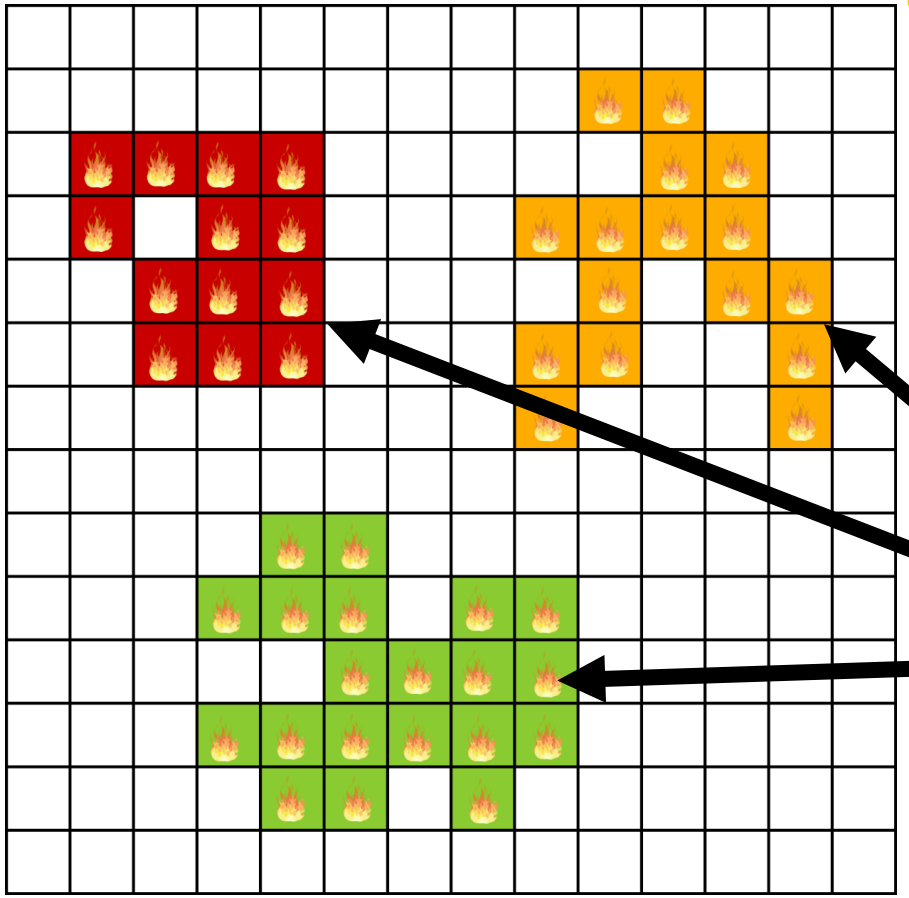
Continue burning…

A new definition of cities

The burning algorithm.



A new definition of cities



The burning algorithm.

Repeat the procedure
Until all populated cells
are burnt.

Our three clusters!