GEOGRAPHIE-CITES

El Futuro de las Ciudades: introduction and overview

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The complexity paradigm

1 Systems analysis, MIT, Jay Forrester, 1964

General systems theory Bertalanffy 1967

➔System's autonomy / its environment

Models: difference equations

2 Self-organisation theory: Prigogine, Haken (1970-80)

➔Open systems, dissipative structures, impredictible effects of non linear micro-interactions on system's macro structure and dynamics, path dependence (irreversibility)

Models: differential equations

3 Complex systems theory

Santa Fe Institute, ISI, ECSS (1990-2000)

➔Emerging properties

Models: Multi-Agents-Systems

Research Challenges

Which processes explain the resilience of urban systems?

How the systems will manage/adapt climatic or societal crisis?

➔spatial dynamics modelling for addressing urban stakeholders problems

Urban systems are complex systems

- Urban systems are produced by social interactions (conveying information), according to their range in space and duration in time

• Non-linear interaction occur at micro, meso or macro levels, and between levels

• Emergence of collective properties within cities:

➔Urban field (Bleicher, 1892, Clark, 1952)

and within systems of cities:

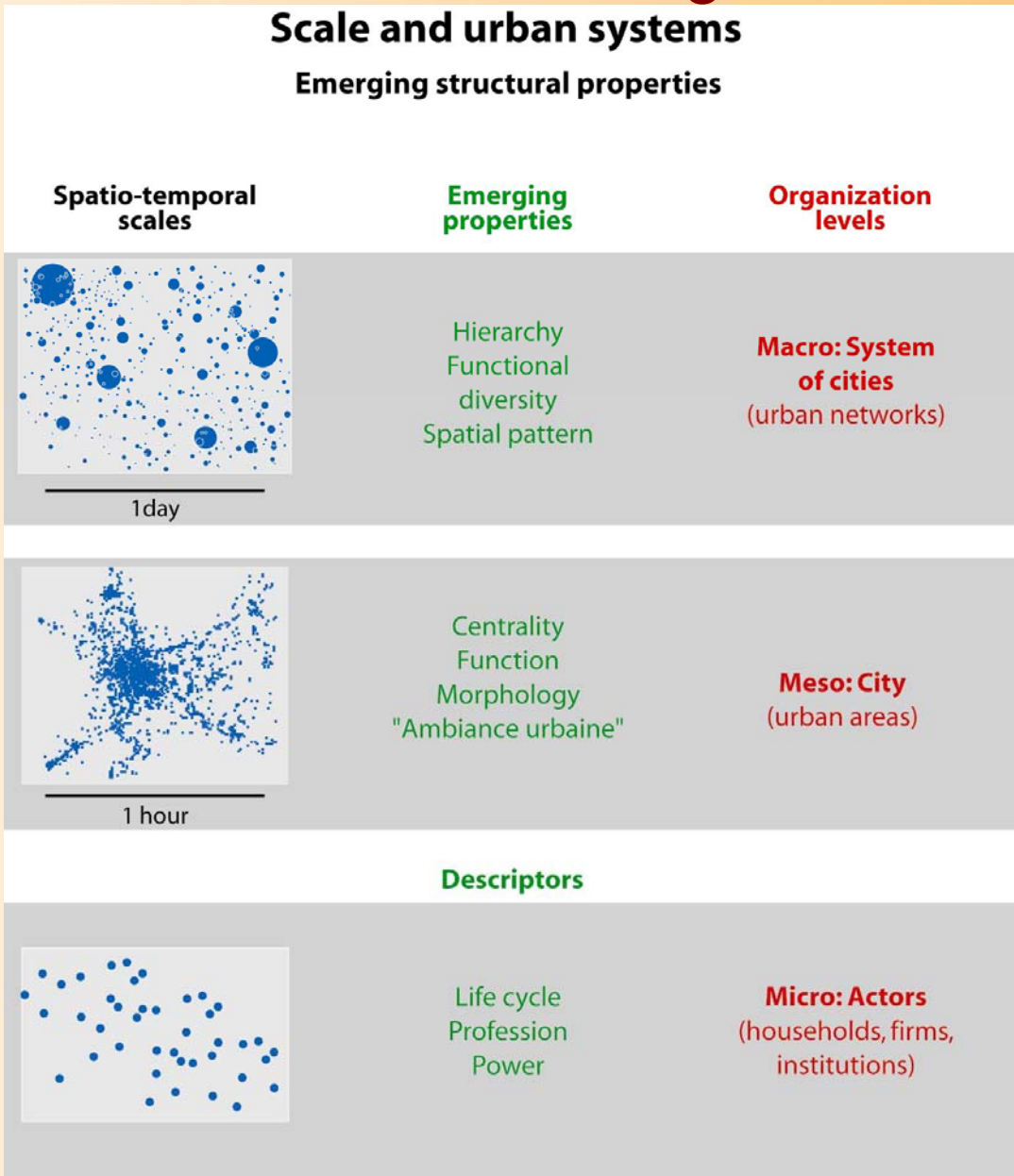
➔Hierarchical organisation (« cities as systems within systems of cities » Reynaud, 1841, Berry, 1964, Pred, 1977)

• Urban « memory » (dynamic path dependence) as a constraint on urban dynamics at both levels

Urban systems hierarchical organisation

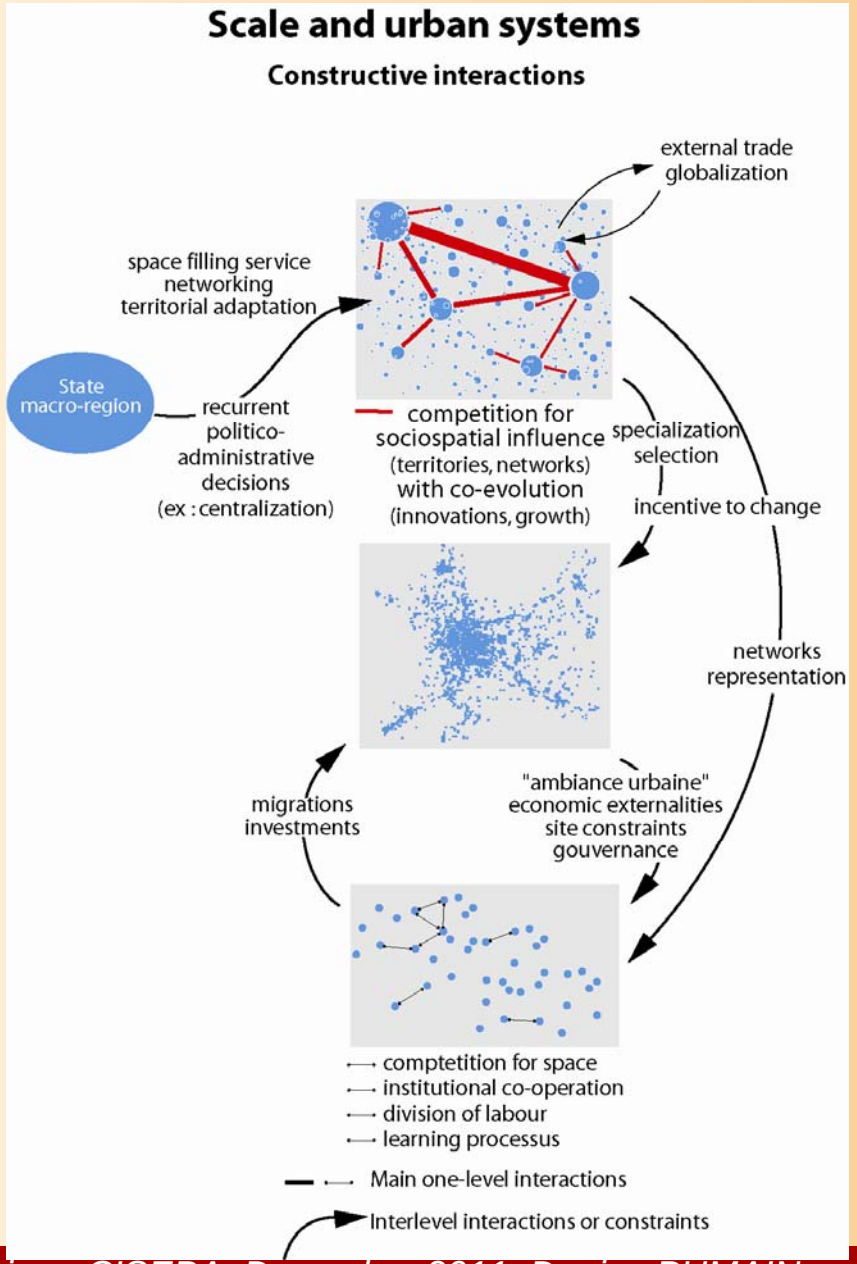
Two levels: Cities and Systems of cities

Pumain D. Hierarchy in natural and social sciences, Springer, 2006



Urban systems emerge from spatial interaction

Multi-levels social interactions



Pumain D. Hierarchy in natural and social sciences, Springer, 2006

Evolutionary theory of urban systems

Hierarchical differentiation of city sizes emerging from interurban interaction (competition >cooperation)

Persistance of urban hierarchies (long term) and specialisation (medium term) despite many local and temporal fluctuations in cities profiles and individual trajectories (firms, households)

Functional geodiversity from innovation cycles generated by interurban competition and emulation

Systemic (proactive) partial diffusion of innovations:

- **Hierarchical selection (top down and bottom up)**
- **Emergence of specialised cities**

  ➔ Growth impulse to large cities and specialised ones

Scale, structure and dynamics in urban systems

- Urban systems are complex systems
- Their geographical structure is dynamically produced through societal spatial interactions
- Irreversible historical processes and path dependence ➔ evolutionary theory of urban systems (Pumain, 1997)
- Scaling laws may help to understand urban dynamics and to predict its future

➔ Examples of scaling processes at two levels of observation/organisation



At local scale: the city

➔Urban sprawl or compactness? Which model is more sustainable?

➔ Urban areas have higher densities (hundred to thousand times those of countryside)

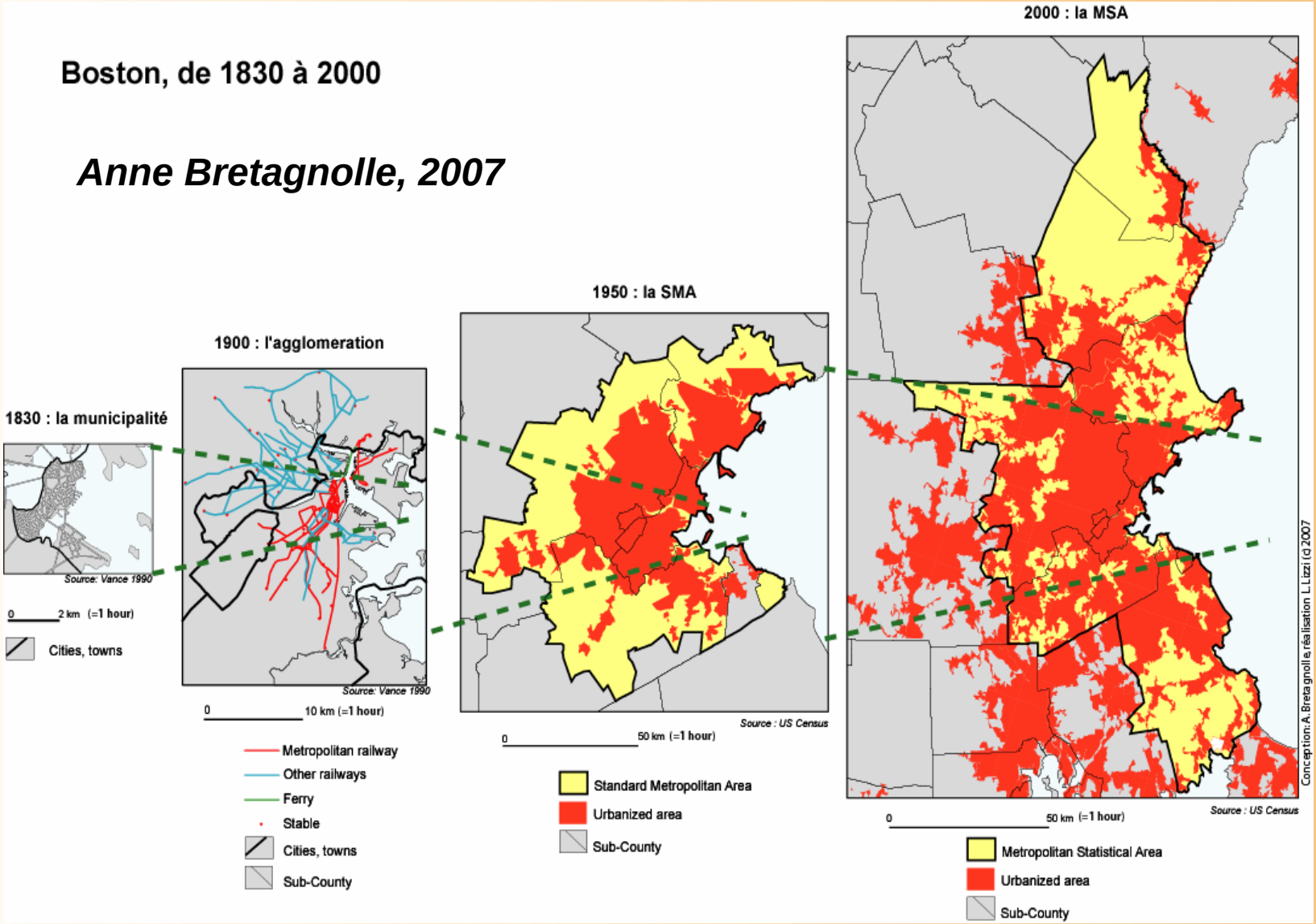
But their ecological footprints are still difficult to measure and probably highly variable

➔ Convergence towards a unique model or path dependency maintaining large variations?

First step: Building harmonised data bases

➔ a **multilevel evolutionary urban ontology**: « cities » are defined as activity-space-time (contiguous urbanised places within one hour travel time) within sytems of cities (= tightly interconnected cities under a common institutional control, not easily bounded)

Harmonised data bases for the observation of cities (urban concept in evolving interaction space)



At city level: a fractal morphology

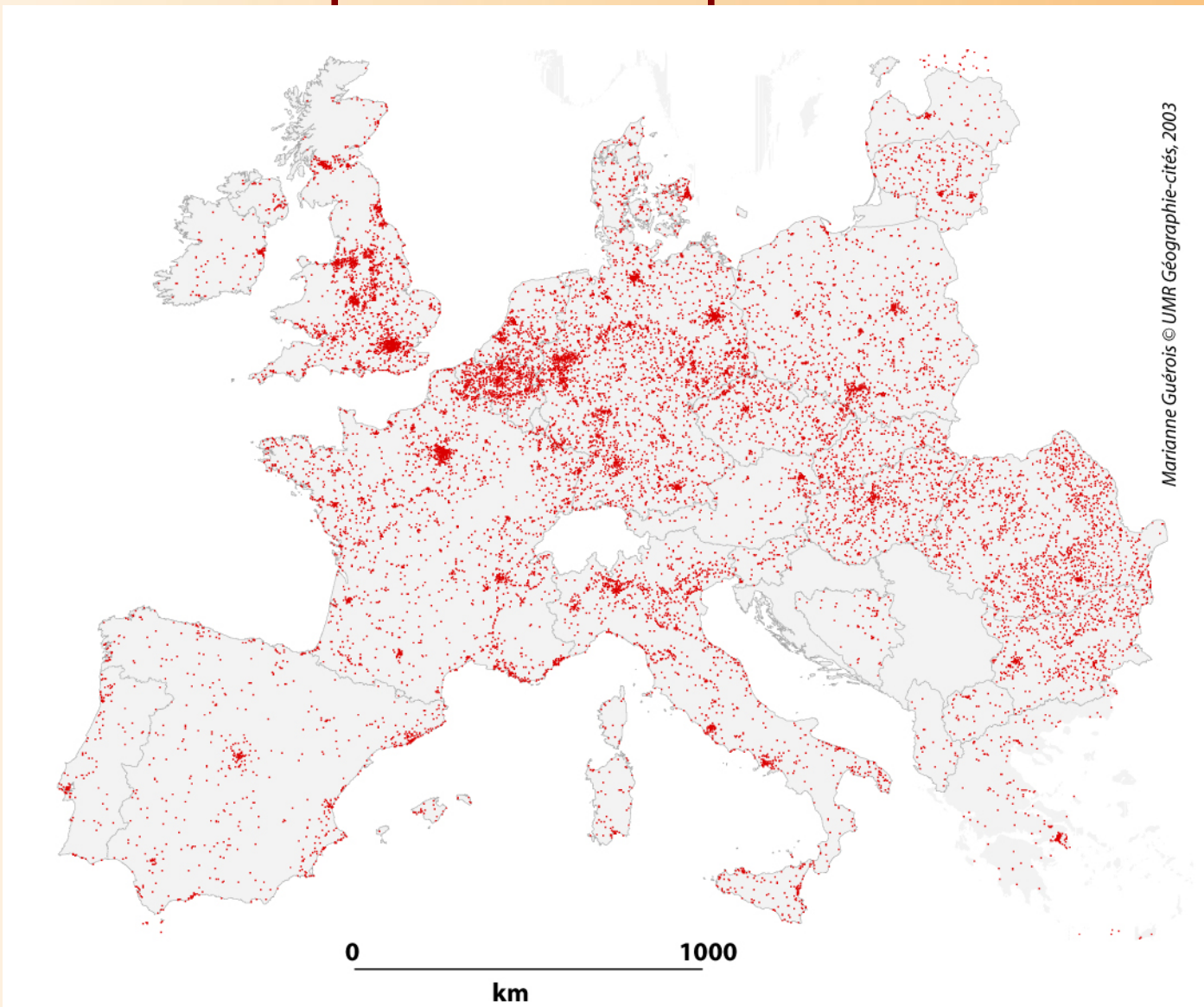
How social interactions shape the major center-periphery structure

➔The urban field

Example in Europe where urban systems have a long history of adapting to different regimes of societal organisation and communication technologies

A view of European urban space

Built-up areas in Europe from the sky (1990)

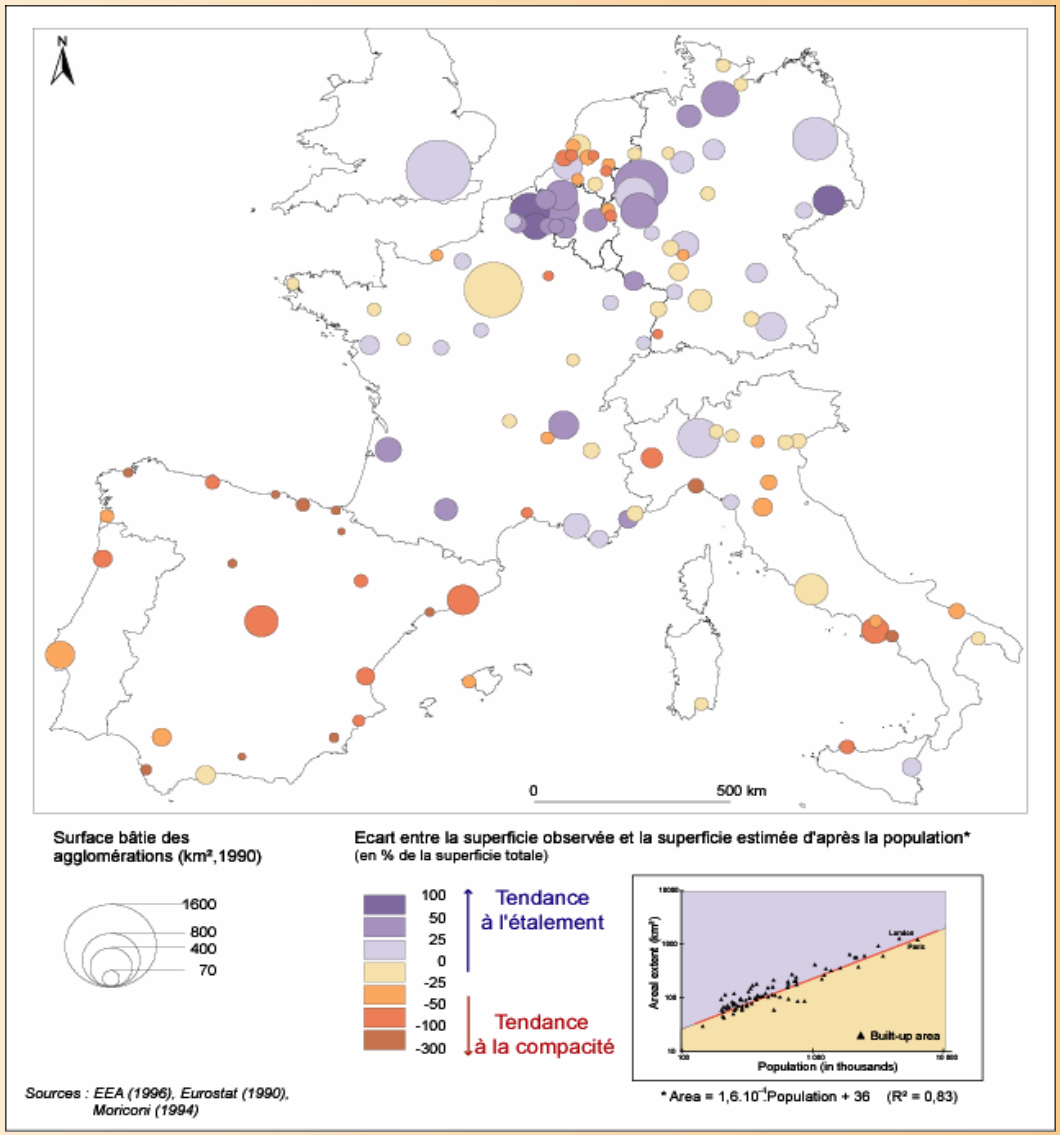


CORINE Land Cover

Source : European Environment Agency (1996)

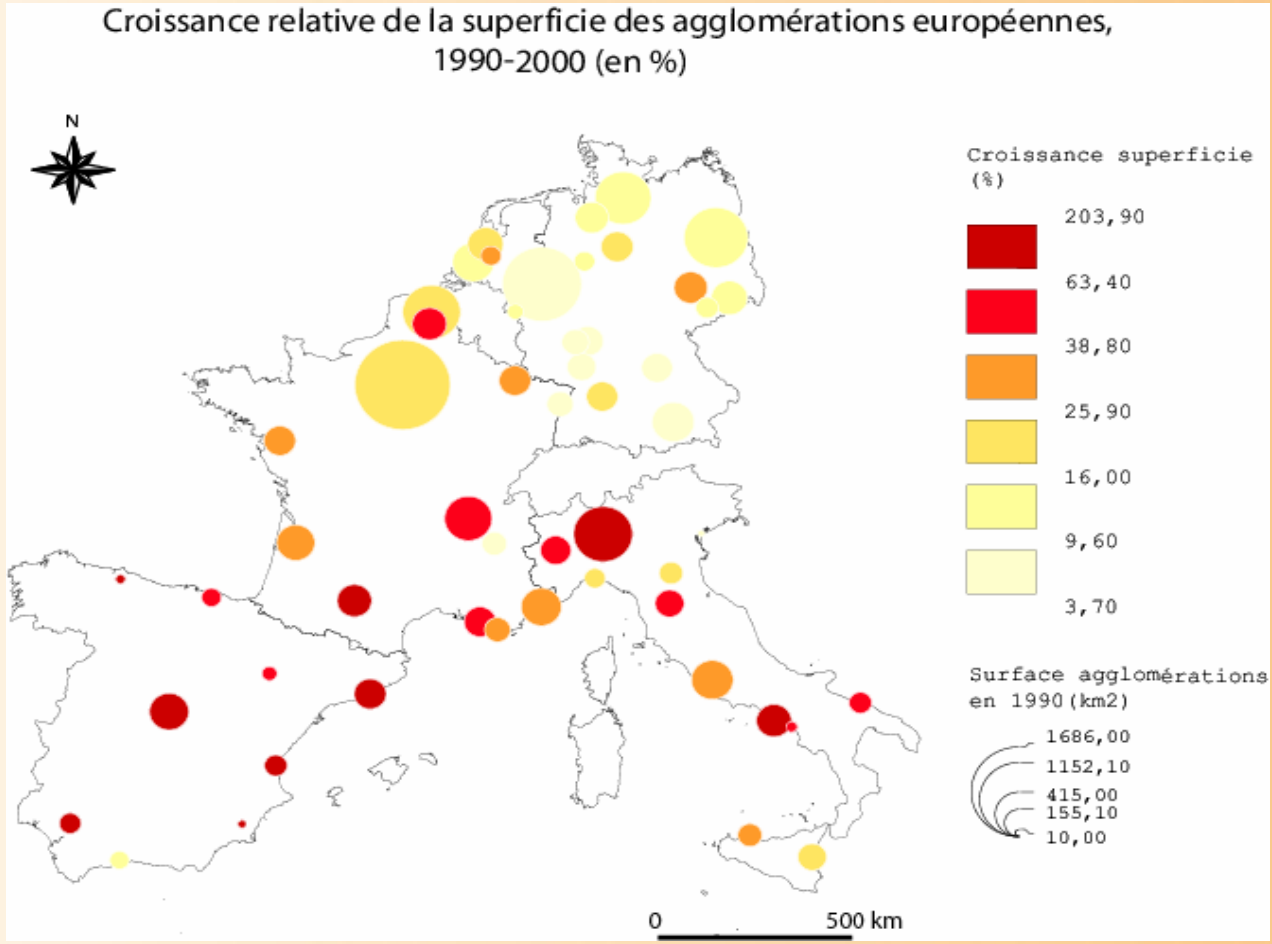
Sprawl in the North, compactness in the South

Marianne Guérois 2008



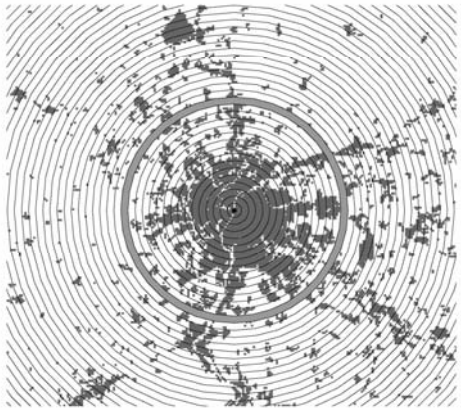
… but converging trends (growth rates of urban surfaces 1990-2000)

Marianne Guérois 2008

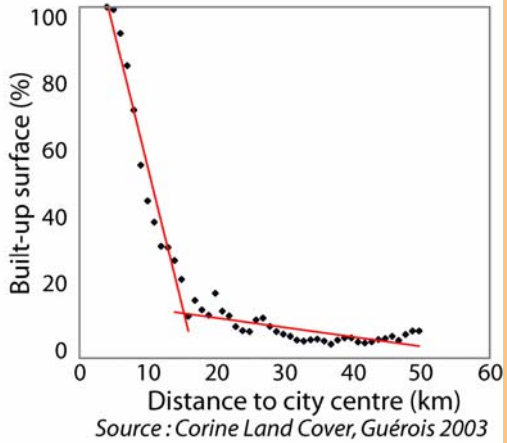


A highly contrasted local urban field

The urban field :
an example around Lyon (France)

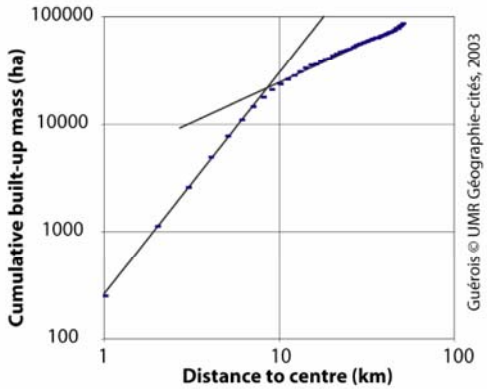


a) grid for analysis



Source : Corine Land Cover, Guérois 2003

b) a double linear gradient

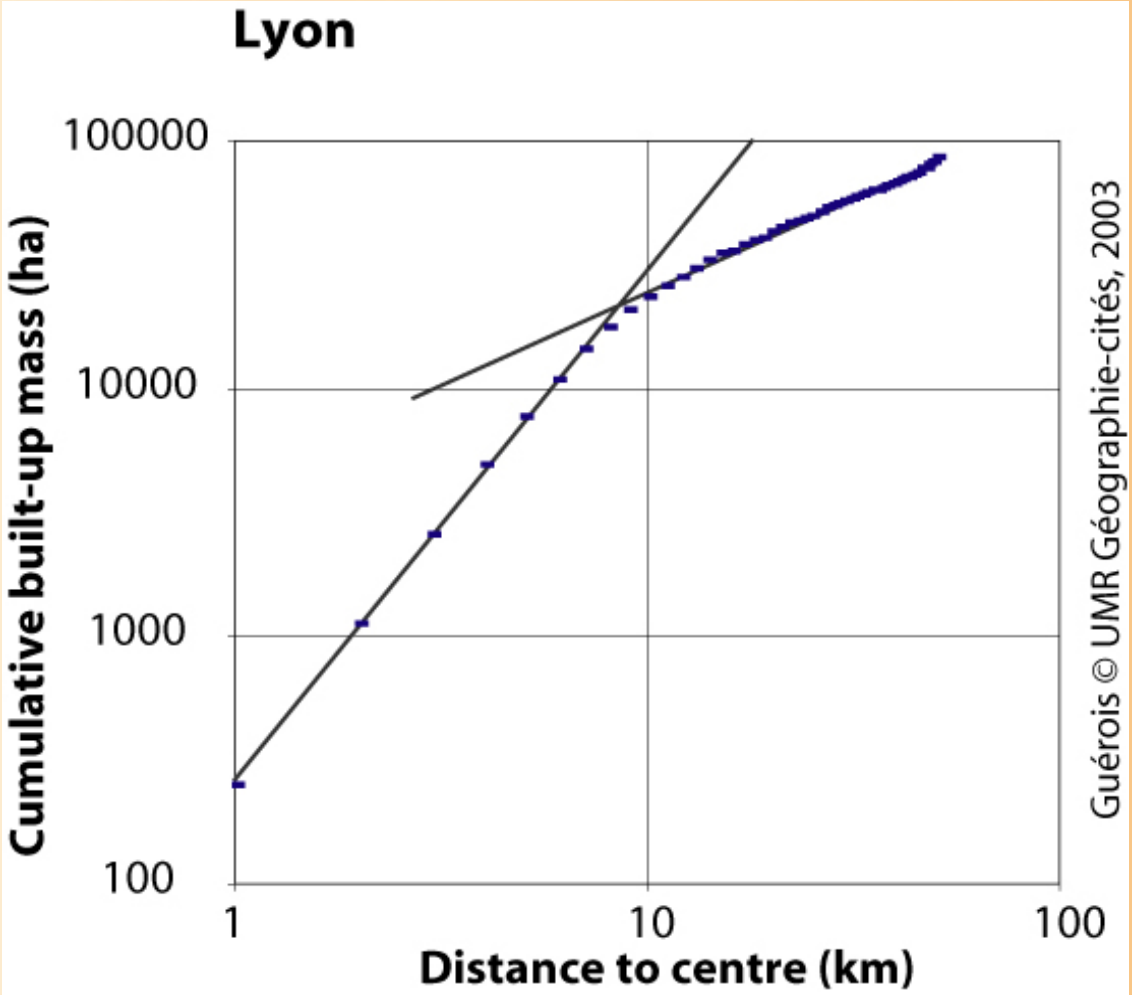


c) two fractal dimensions

Marianne Guérois, 2003

Urban agglomeration and functional area: two fractal dimensions

Two different values of fractal dimension according to the distance from the urban centre

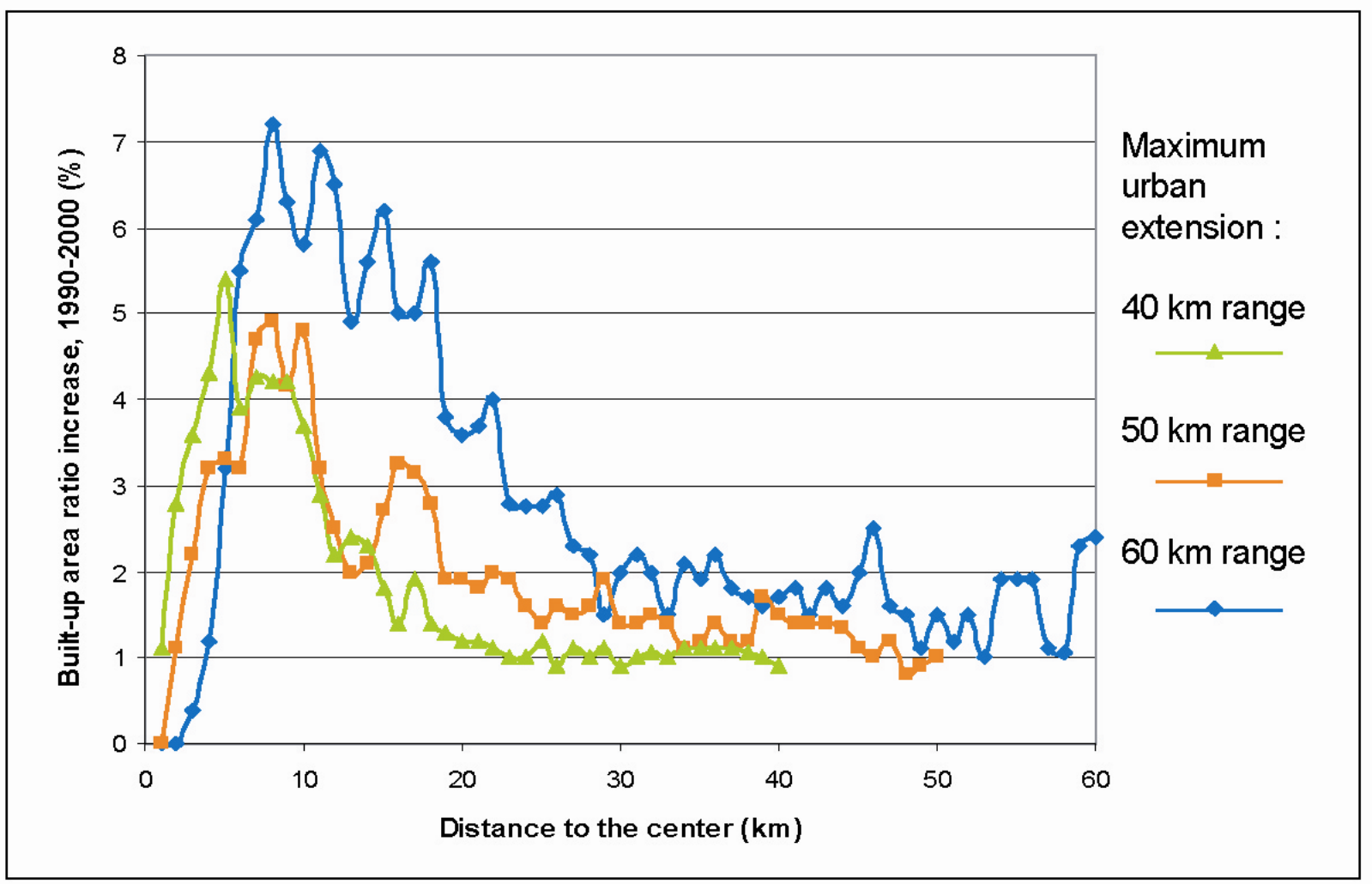


M. Guérois, 2003

A general model for European urban areas

Cities	Spatial range (in km)	Shape	
		Core	Periphery
Amsterdam	50	1,91	1,02
Barcelona	60	1,70	0,88
Frankfurt	50	1,90	1,22
Hamburg	60	1,96	0,65
Hannover	40	1,90	0,87
London	100	2,04	0,76
Lyon	50	2,06	0,76
Madrid	60	1,91	0,72
Milano	60	1,93	1,14
München	50	1,97	0,68
Napoli	60	1,75	0,86
Paris	100	1,97	0,55
Roma	50	1,88	0,60
Rotterdam	50	1,96	1,10
Sevilla	40	1,59	0,61
Stuttgart	50	1,68	1,20
Toulouse	40	1,85	0,38
Torino	50	1,77	0,67
Valencia	50	1,48	0,80

Evolution of built-up areas 1990-2000: densification at the border of continuously built-up areas



Marianne Guérois, 2008

New approaches in urban morphology for explaining emerging properties at city level

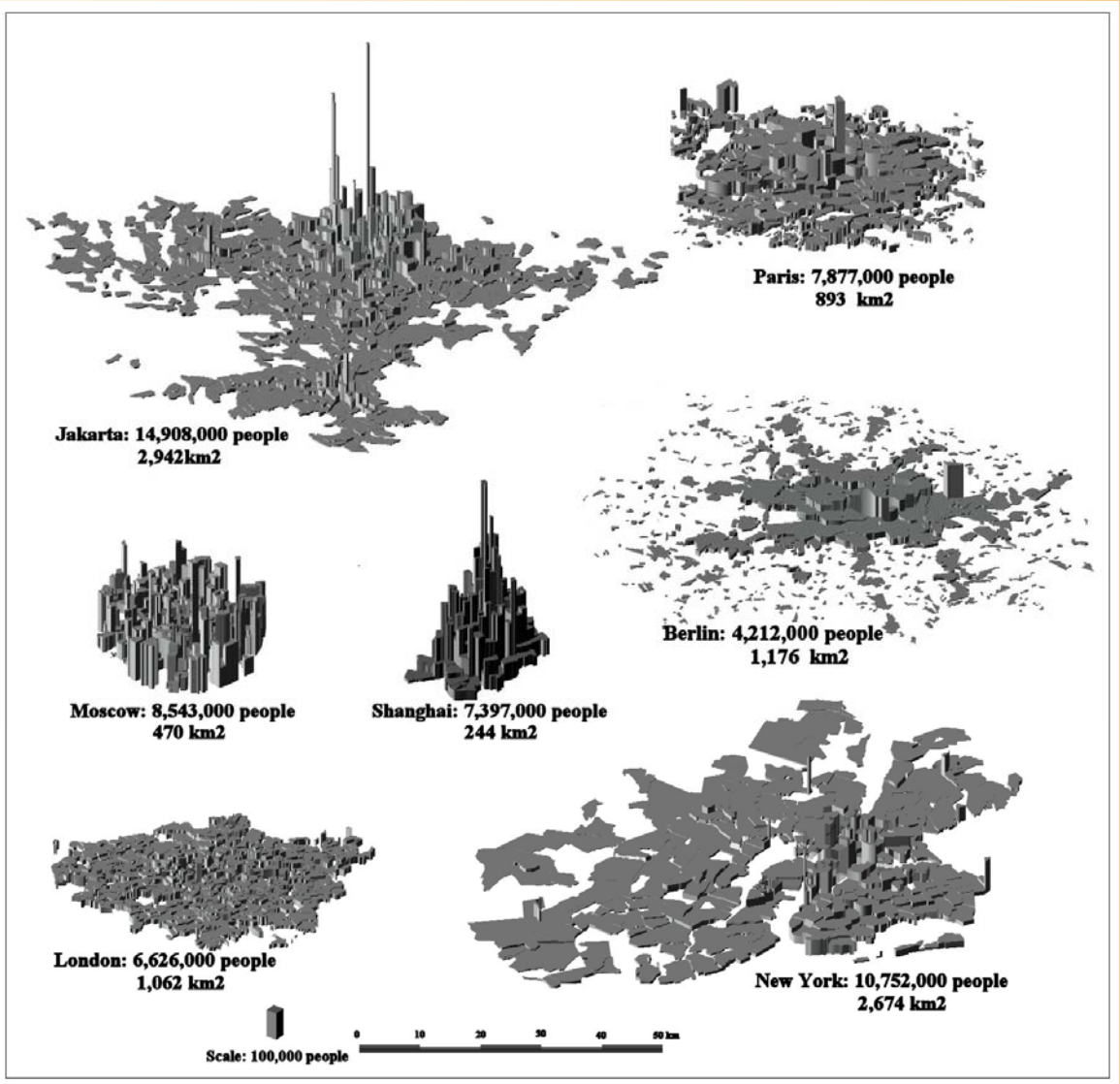
- Fractals: Batty, Longley, Frankhauser
- Complex networks: Barabasi, Anderson, Eubank, Porta, Vespignani, Barthelemy…
- Scaling laws and networks: West, Brown, Bejan…

but: the urban field is not emerging from socio-spatial interaction only, its dynamics is also path dependent

➔ universal structure and regional variations



Universal structure of the urban field



Bertaud 2005

A formal description of the universal structure of urban field

➔ Urban space is an agent-activity space, where activities are increasing over time in number and diversity

➔ agents are connecting their activities through branched communication networks of increasing speed and capacity

➔At two levels of organisation

Level1: the city

critical time (length of travel) 1 hour (Zahavi)

low speed networks (<25 km/h, x by 5 since 1800)

strong interactions (3 to 4 different connected places of activity/person/day)

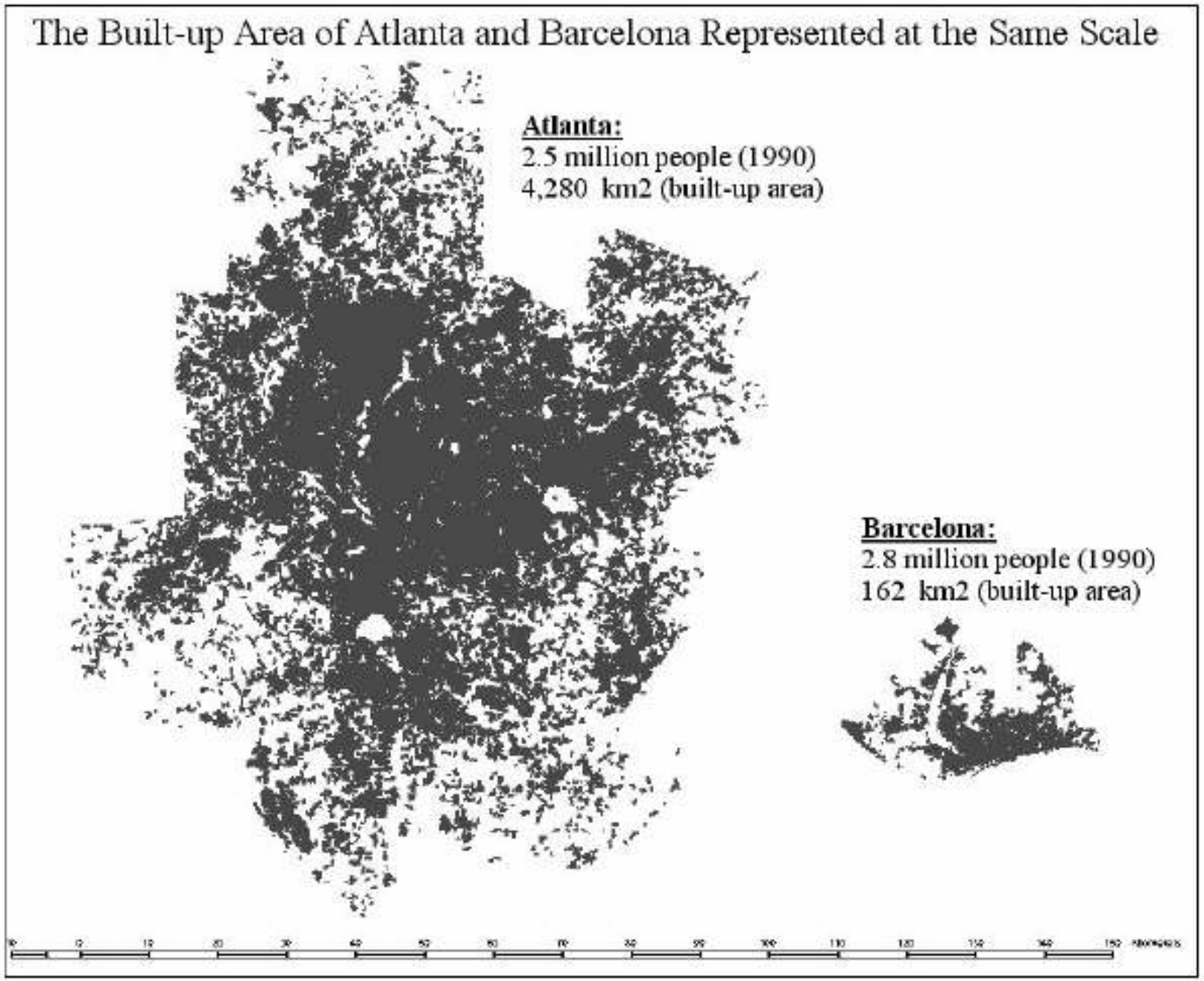
➔ density and price gradients (centre-periphery), fractal spatial organisation, socio-spatial segregation

Path dependence in urban fields

Although universal, the spatial organisation still exhibit patterns expressing not only memory, traces of past (even reinterpreted), but path dependence, i.e. constraints on future dynamics emerging from the succession of historical bifurcations (i.e. choices that are not entirely free, but multi-constrained, especially according to higher level interactions)

A real estate shop window in Guanzhou


上海浦東發展銀行
SHANGHAI PUDONG DEVELOPMENT BANK



The footprint of 2 cities with equivalent population but different densities

Bertaud

Continental inequalities in urban densities

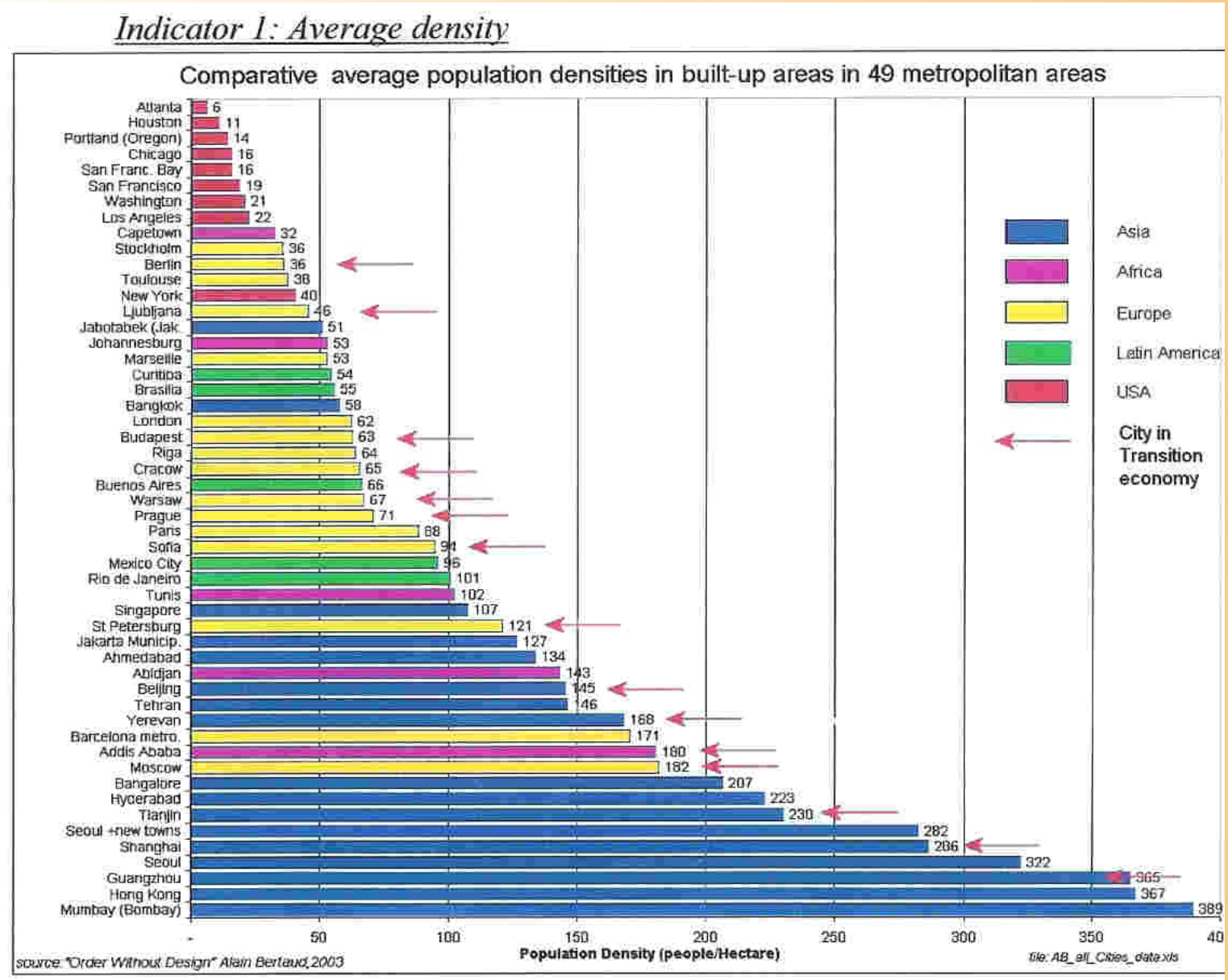


Figure 1: Average population density in the built-up area of 49 cities

Bertaud 2005

Stable (viable?) levels in urban densities…

Average urban densities (population/built-up surface) within >1 million inhab. cities

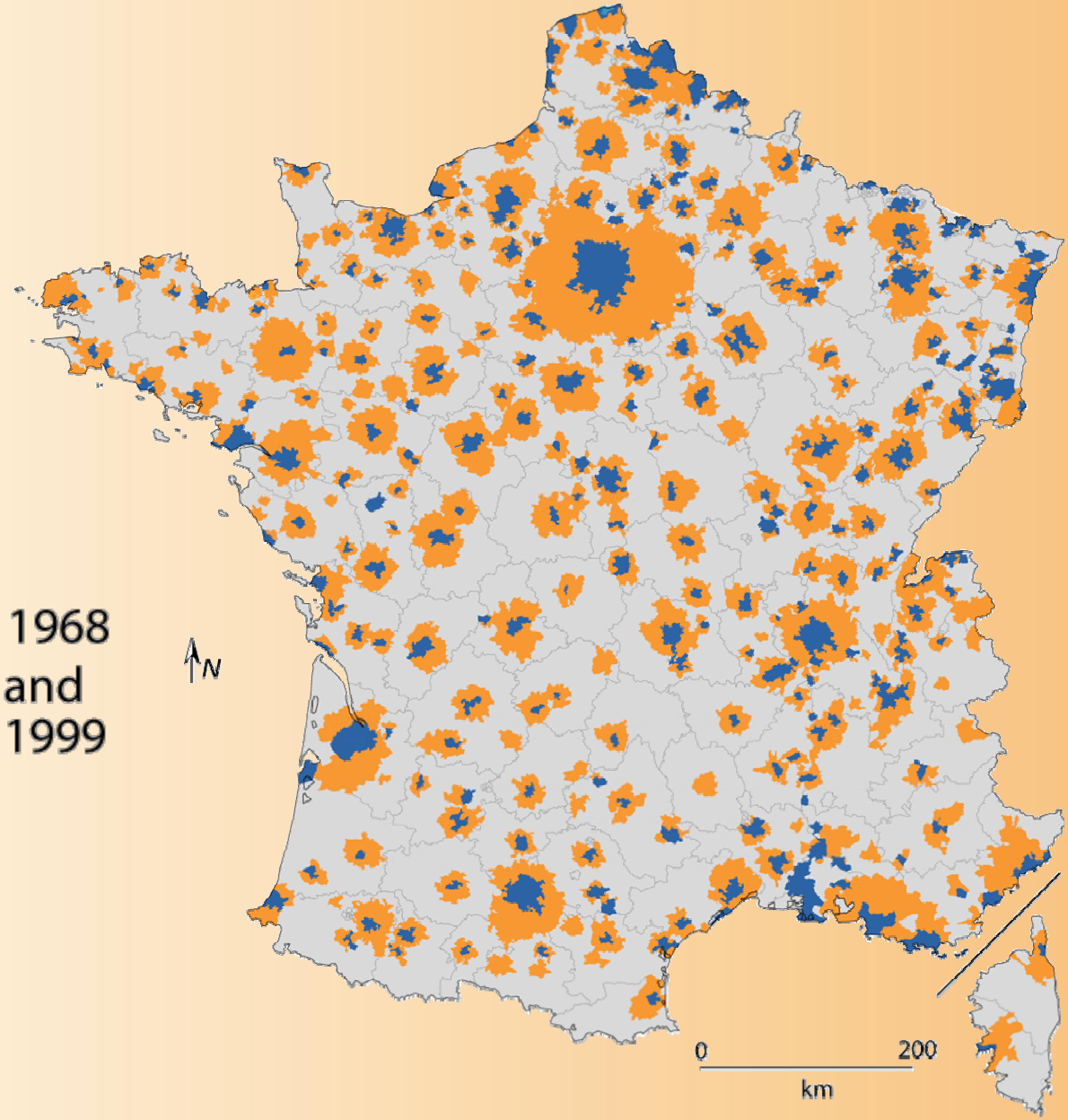
➔three styles of urbanism

- North America: 2 000 inhab/km^2
- Europe: 4 000 to 10 000 inhab/km^2
- Asia: 10 000 to 40 000 inhab/km^2

(Latin America cf Europe but more heterogeneous)

…despite fourty years of urban sprawl everywhere

Example of France
1968-1999



Fabien Paulus, 2004

Urban field variations and sustainable development

Is a convergence in settlement styles possible? desirable?

Facing the same problem of how reducing energy and resource consumption, can we find solutions adapted to each urban context?

➔ Maintaining path dependence as an expression of historical geodiversity?

Questions for research

• How the fractal urban structure could be formalised in an evolutionary spatial framework (space-time contraction)?

Cf. principle of scale relativity (L. Nottale) or network optimisation (A. Bejan)?

• What can be imagined for monitoring spatial and social morphologies in an integrated way?

• Which evolution is expected under policies for sustainable development (compactness, energy and resource sparing) ?

➔ How monitoring fractal structures

At regional or continental scales

Why and how do cities increase more and more their « grandezza e magnificenza »?

(Giovanni Botero, 1588, *Della Ragione di Stato*)

Cities are socio-economic adapters in territorial competition

➔ models of systems of cities and urban hierarchy

At level of systems of cities:what is universal ?

- Hierarchical differentiation (produced by socio-economic incremental innovation):

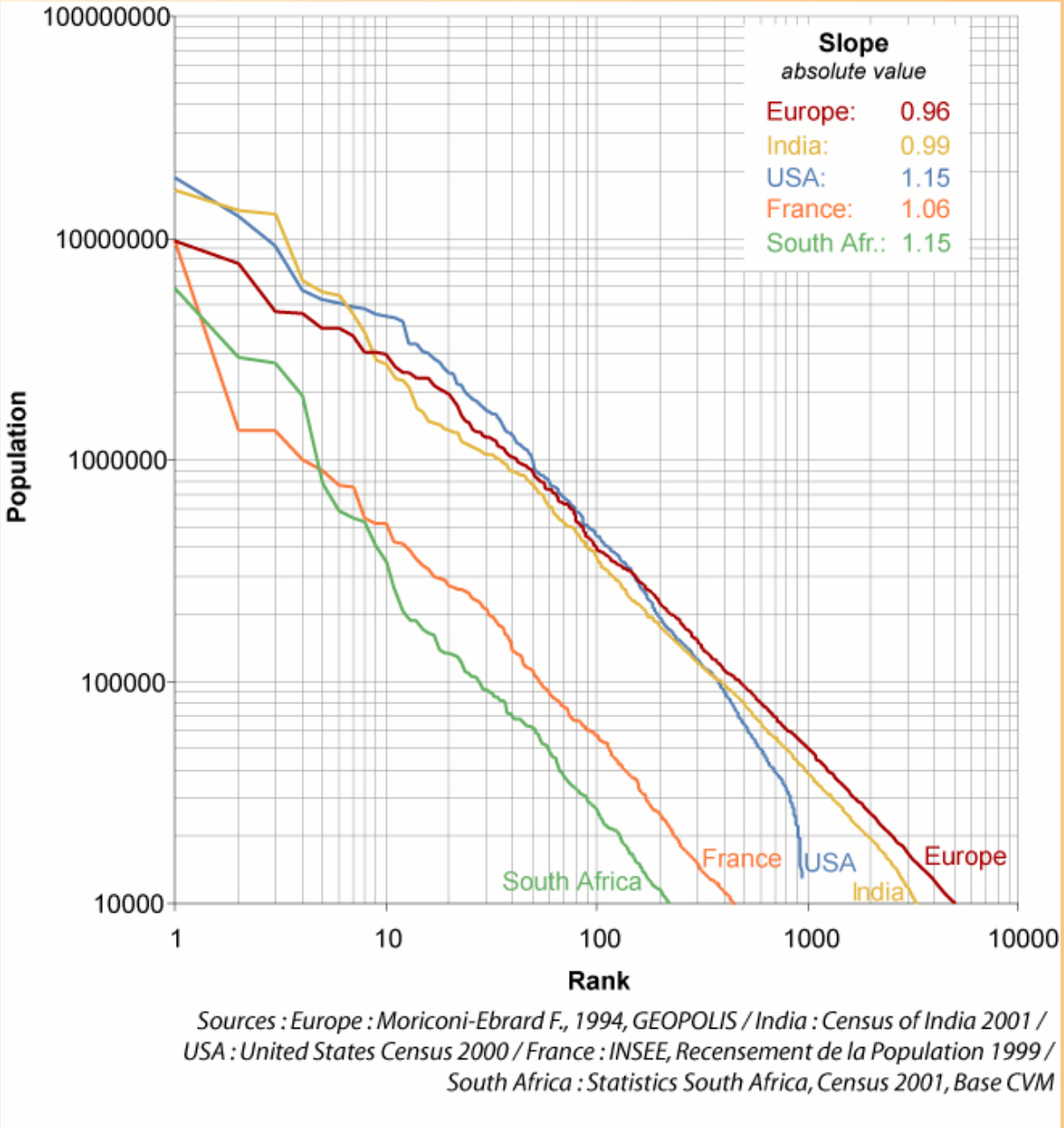
  i.e. inequalities in sizes and influence ➔ consequences for urban policies

- Functional specialisation (socio-economic radical innovation):

  i.e. geodiversity ➔ consequences for urban identity and urban marketing

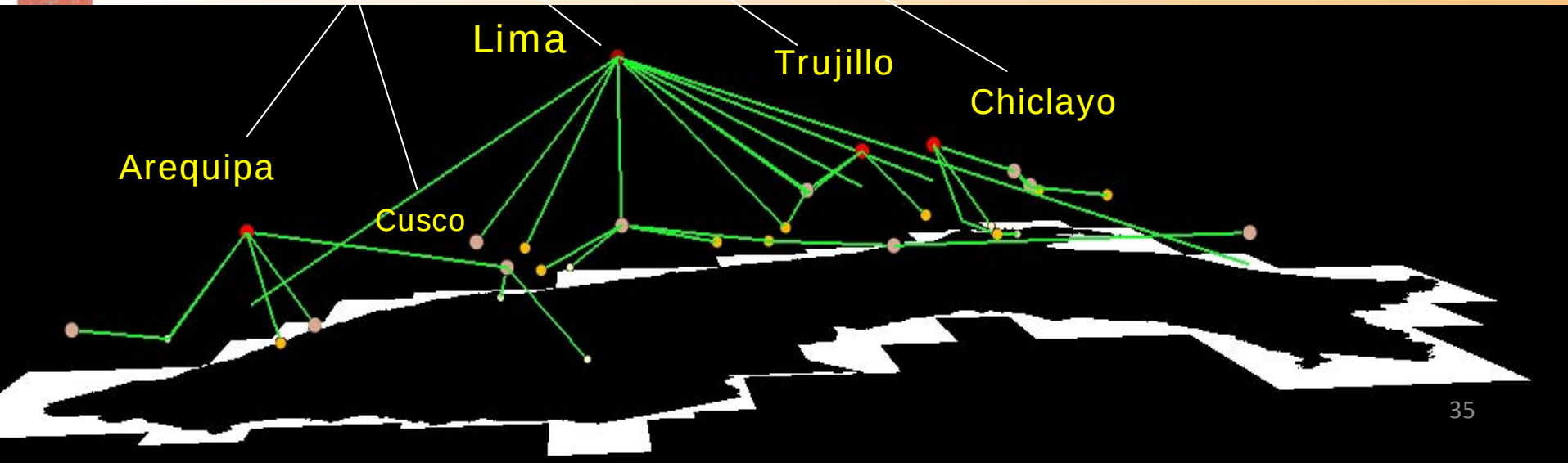
Universal structure: hierarchical differentiation

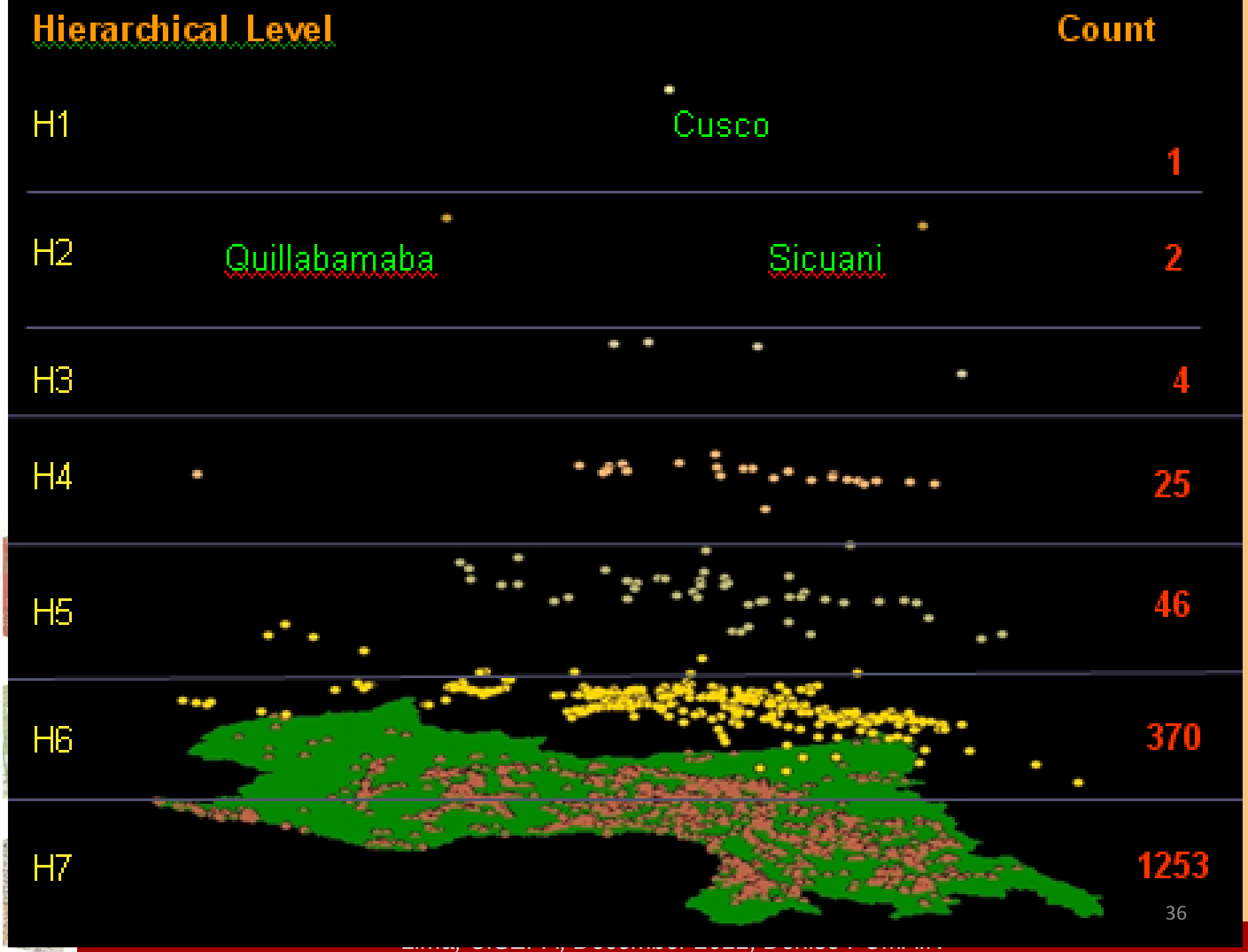
Hierarchical differentiation is an emerging property of integrated urban systems

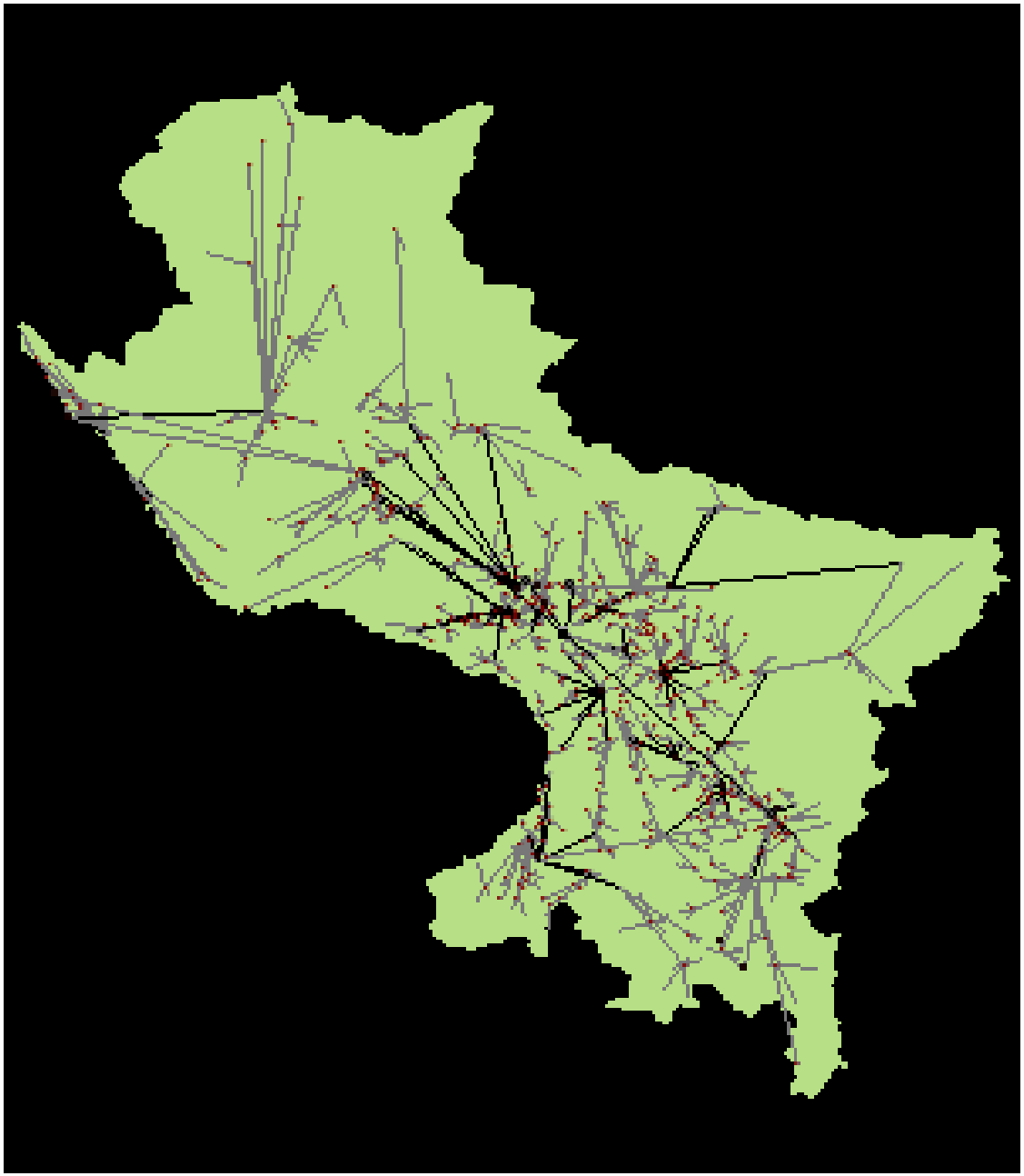


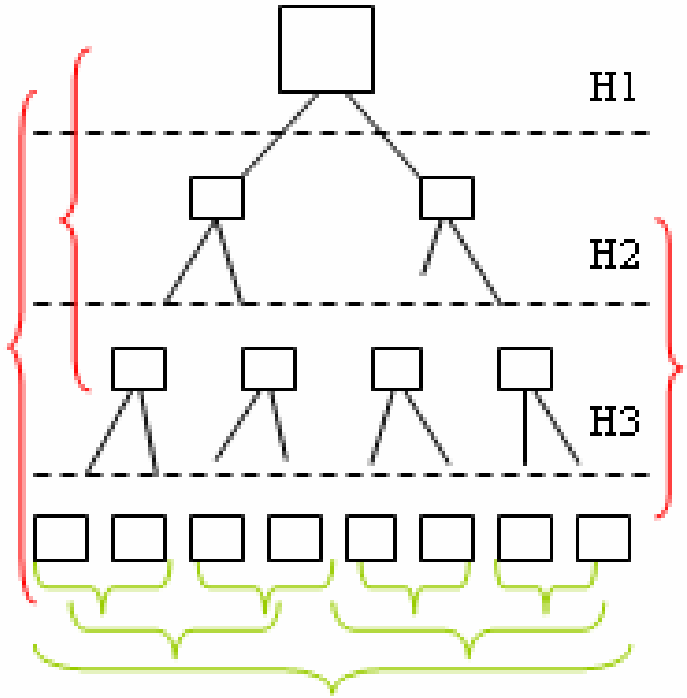
Sources : Europe : Moriconi-Ebrard F., 1994, GEOPOLIS / India : Census of India 2001 / USA : United States Census 2000 / France : INSEE, Recensement de la Population 1999 / South Africa : Statistics South Africa, Census 2001, Base CVM

The Peruvian urban hierarchy




Hierarchical Level
Count
H1
Cusco
1
H2
Quillabamaba
Sicuani
2
H3
4
H4
25
H5
46
H6
370
H7
1253





An urban hierarchy for the Cusco Department, Peru

How spatial interaction produces universal hierarchical differentiation within system of cities

- Cities are never isolated but develop through exchanges (people, goods, information) with other cities
- Exchanges help to reduce the stress of local (ecological) uncertainties
- As cities are in competition for increasing their accessible resources, exchanges also are an incentive to develop innovation

➔ distributed growth (Gibrat's model) through spatial diffusion of innovation leads to lognormal distribution of city sizes

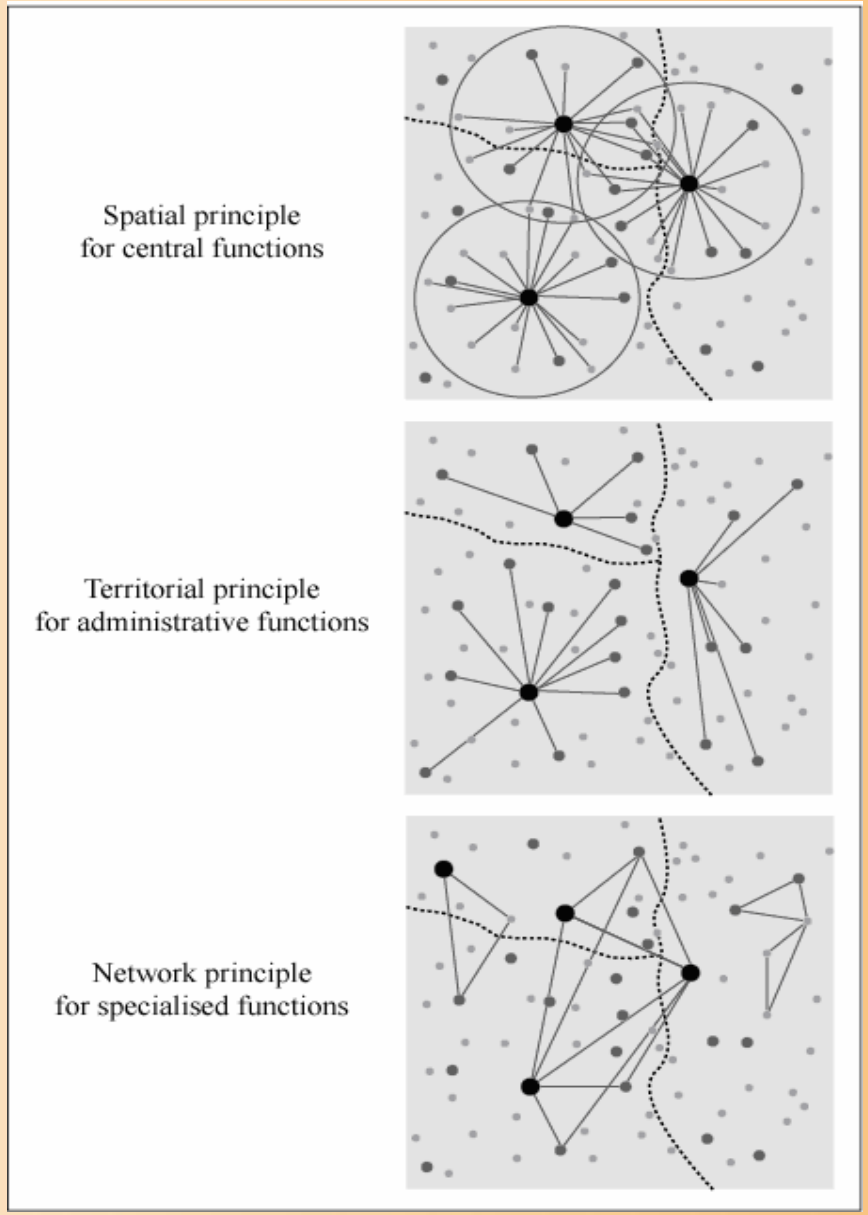
A variety of urban spatial interaction

-According to urban functions:

* **distance constrained** competition (central functions, regional trade and services)

* **proximity and exclusivity** (administrative and political control)

* **network control** (long distance) with or without boundary constraints (manufacturing, finance, tourism)

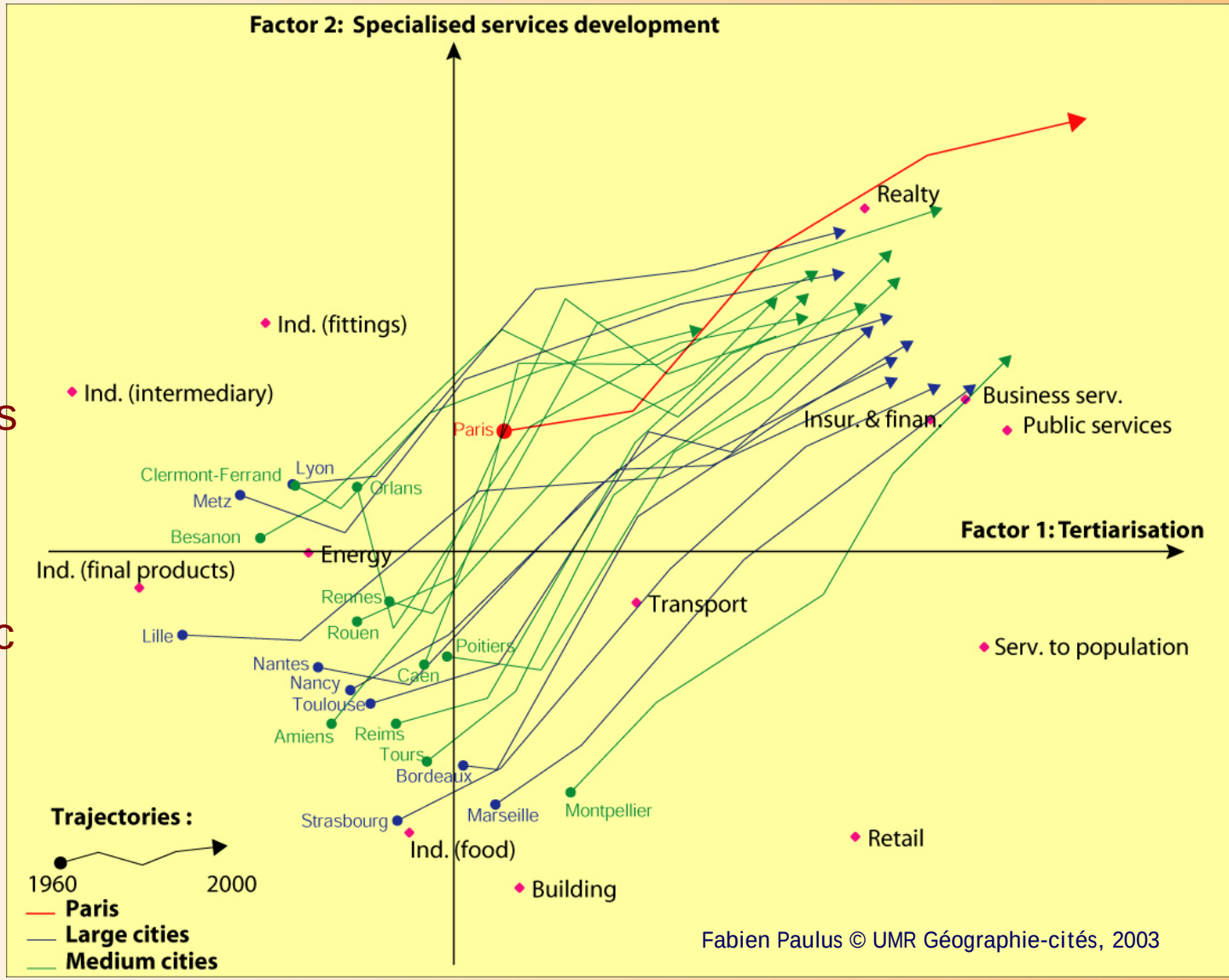


Source: Sanders et al. 2006

Incremental change: Co-evolution of cities' economic profiles

French largest agglomerations evolving in the functional space according to their economic differentiation (1960-2000)

F. Paulus, 2004



Urban patterns and generative processes

➔ Urban space is an agent-activity space, where activities are increasing over time in number and diversity

➔ agents are connecting their activities through branched communication networks of increasing speed and capacity

➔At two levels of organisation

Level2: system of cities

critical time (length of travel) 1 day (E. Reclus)

high speed networks (x by 40 since 1800)

weak interaction (less frequent:<1/person/week or /month)

hierarchy of sizes, scaling laws between size and number of activities

Space-time contraction for societal interaction

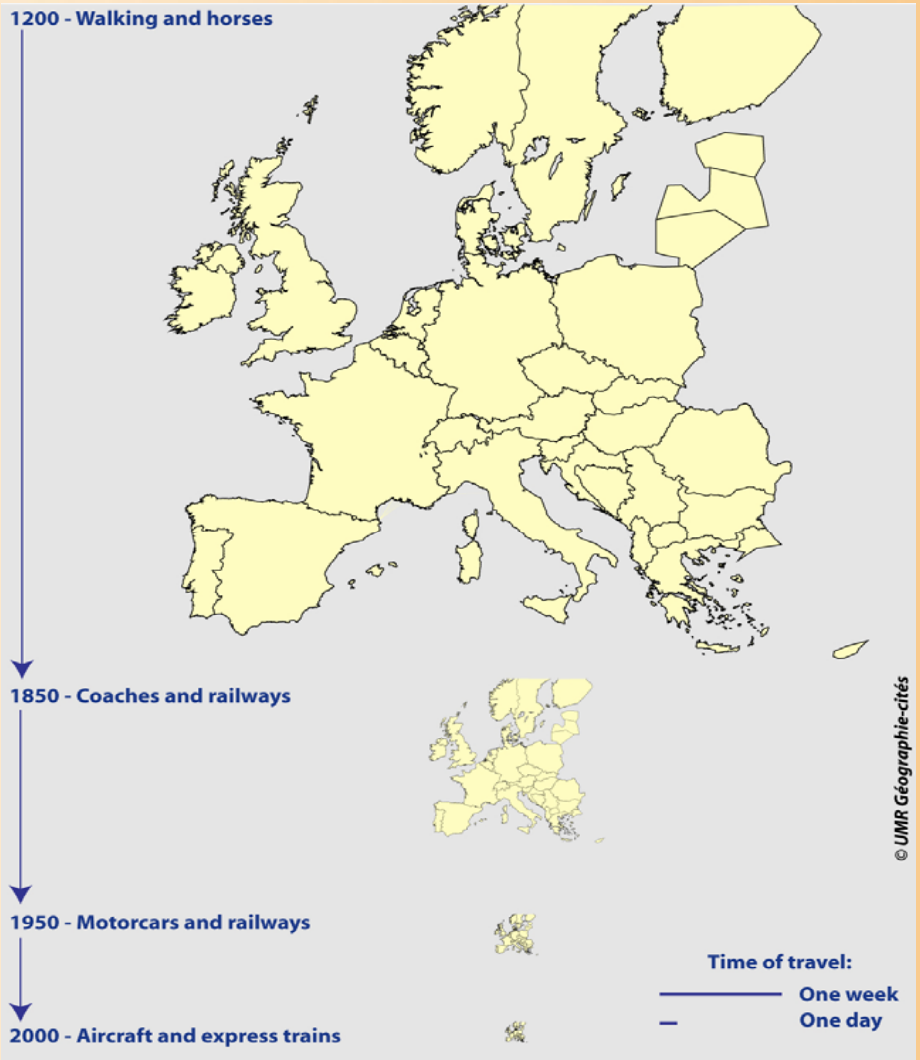
walking
riding

surface of Europe

proportional to travel time

train

airplane



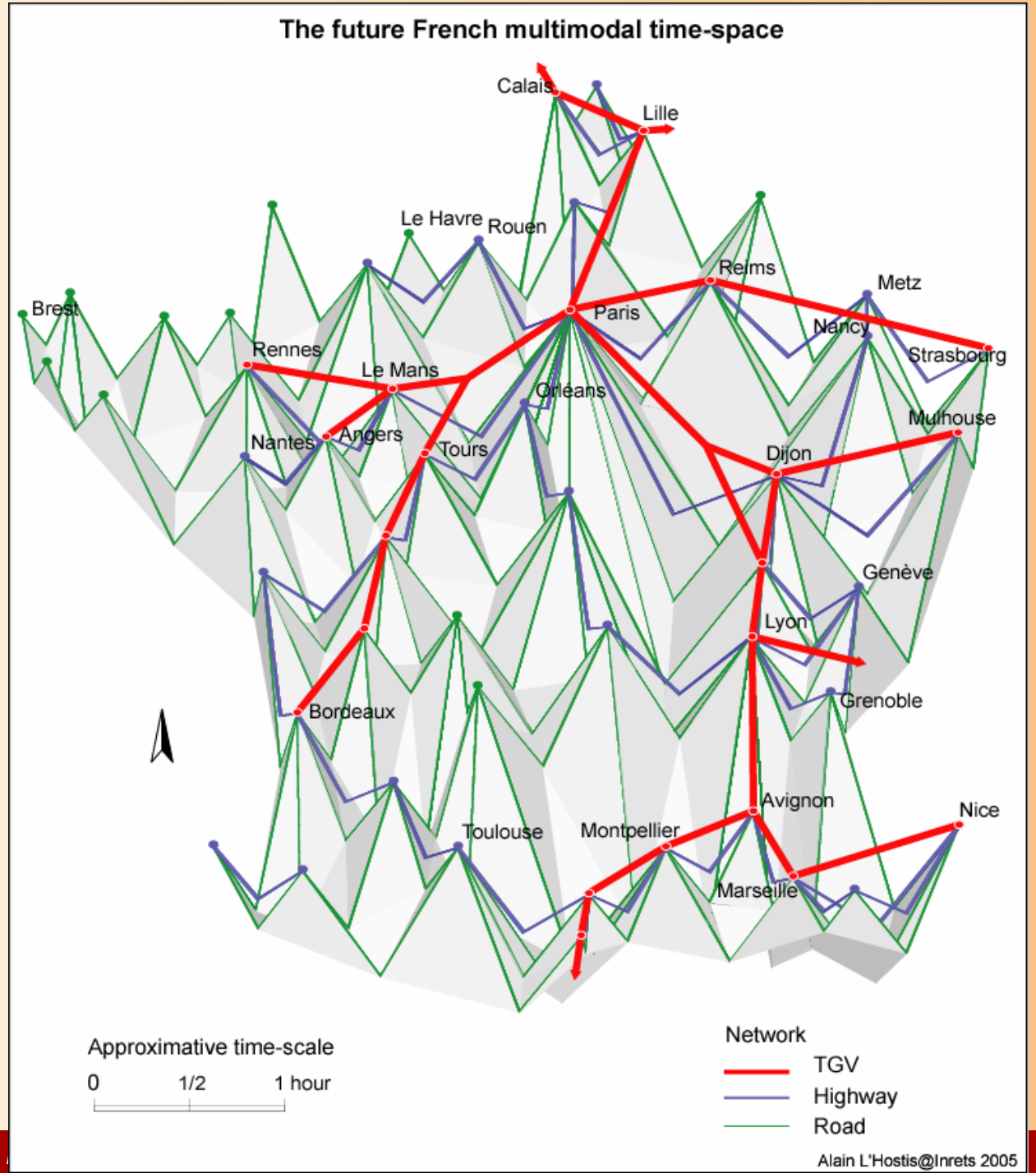
A. Bretagnolle, 1999

Multiscalar accessibility in time space

(A. L'Hostis)

➔ A shrinking world is folding

(Tobler, 2001)



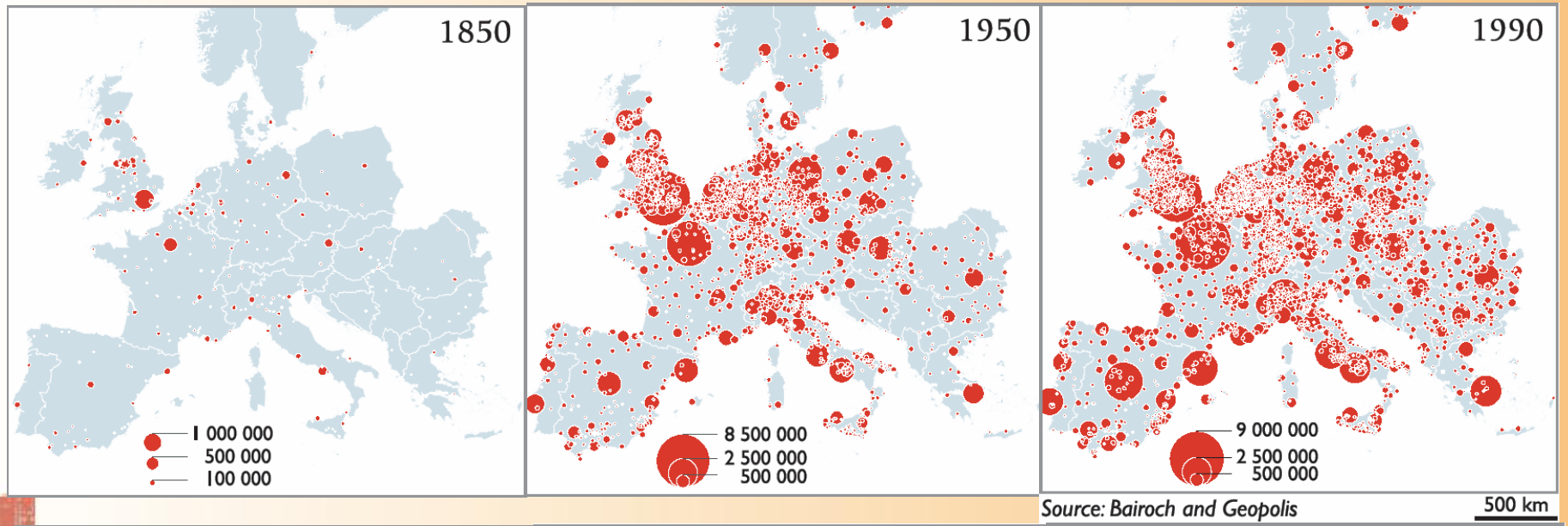
Effect of path dependence on systems of cities: different styles of settlement systems

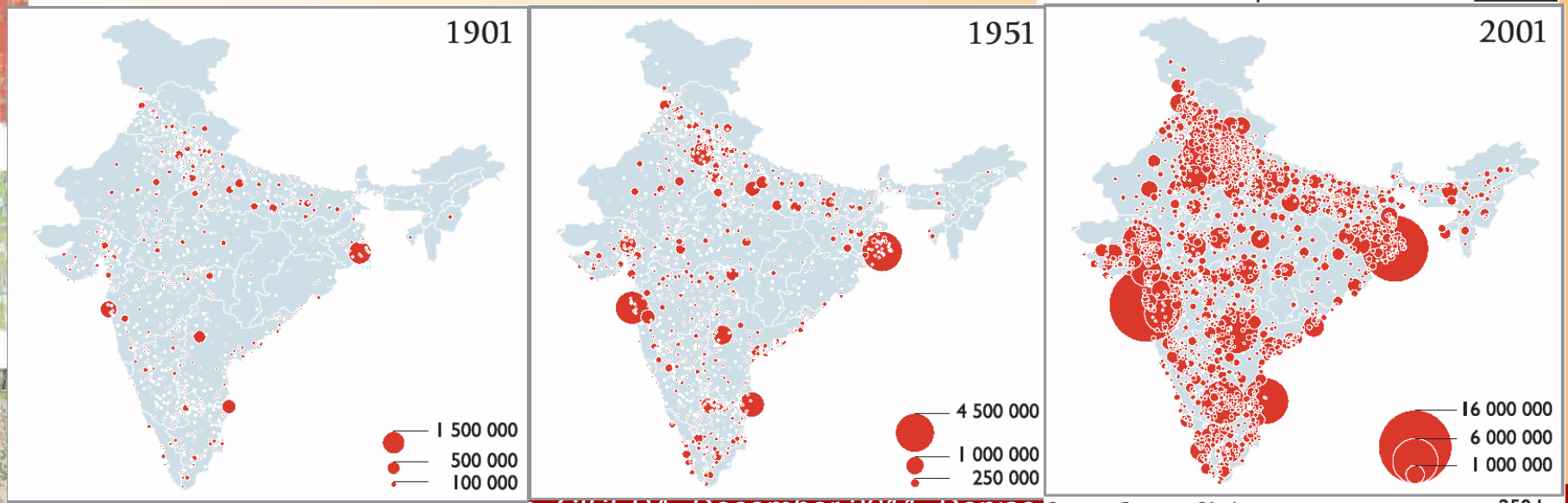
Three major types of systems of cities in the world:

- Old settlement systems: short spacing, weak hierarchisation (Europe, Asia)
- New settlement systems: wide spacing, strong hierarchisation (US, Australia)
- Two stages urbanisation (autonomous then under colonial systems): strong primacy or macrocephaly and dual urban systems (India, Africa…)

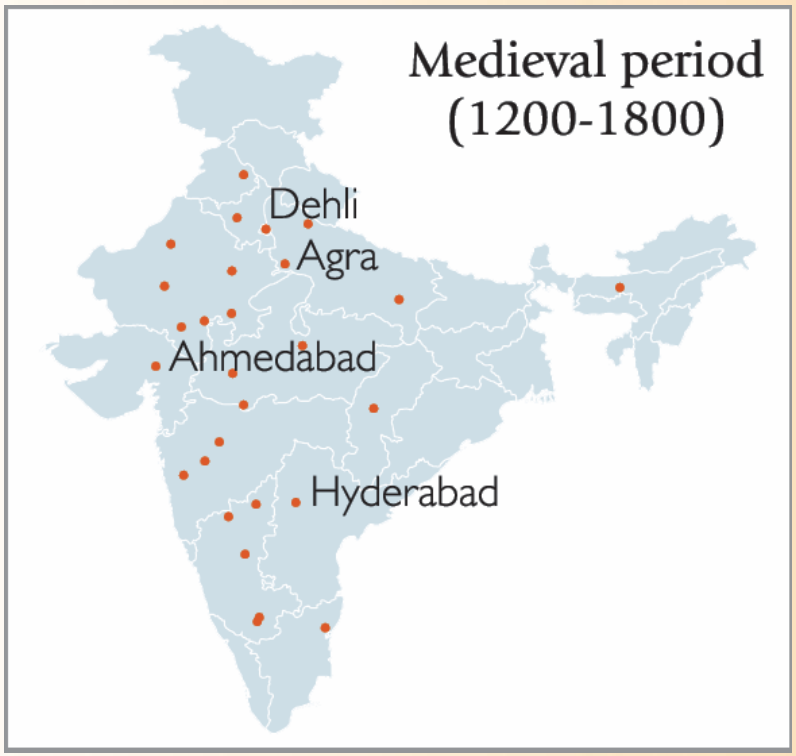


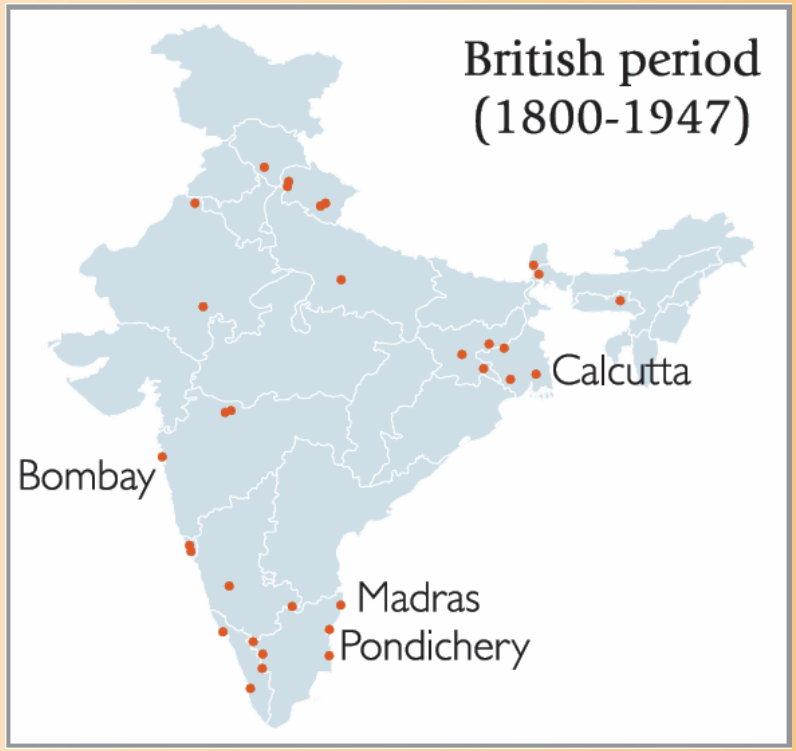
Distributed growth in old urban systems





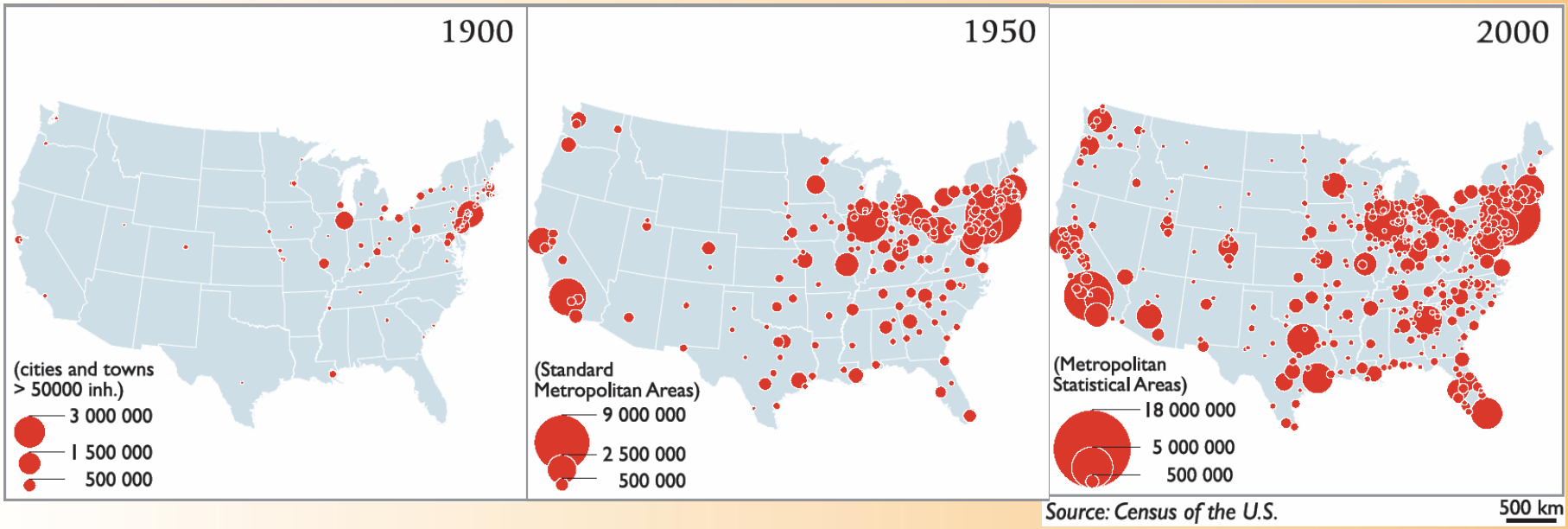
Spatial shift of primate cities at colonial time

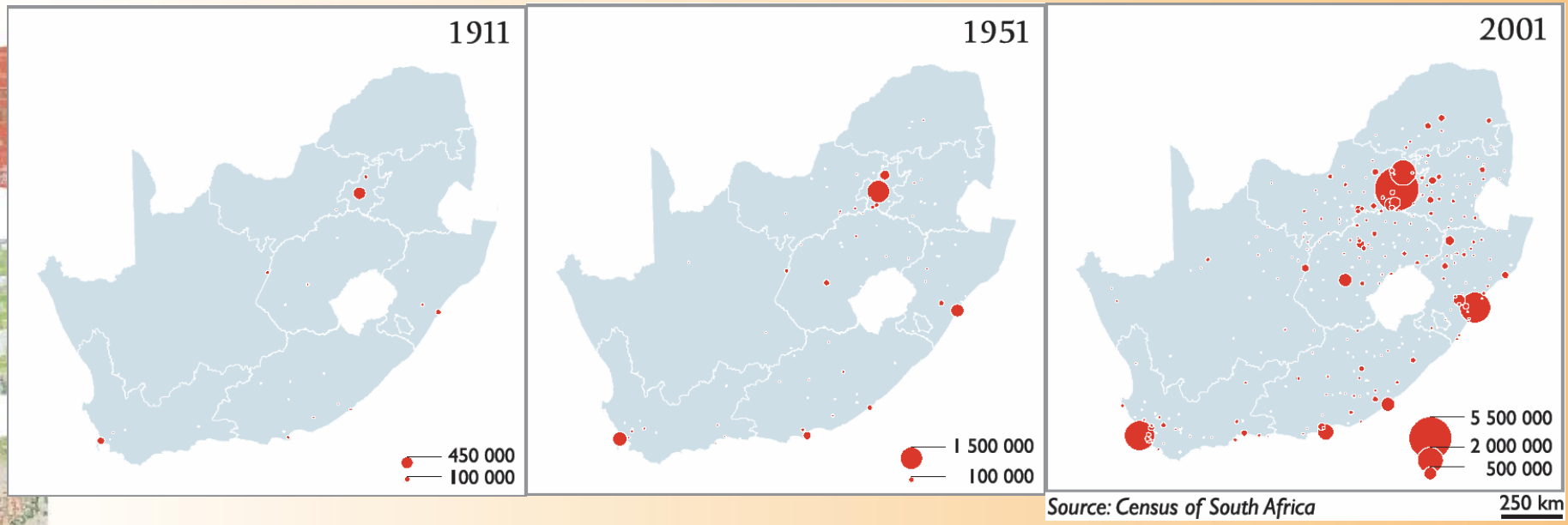




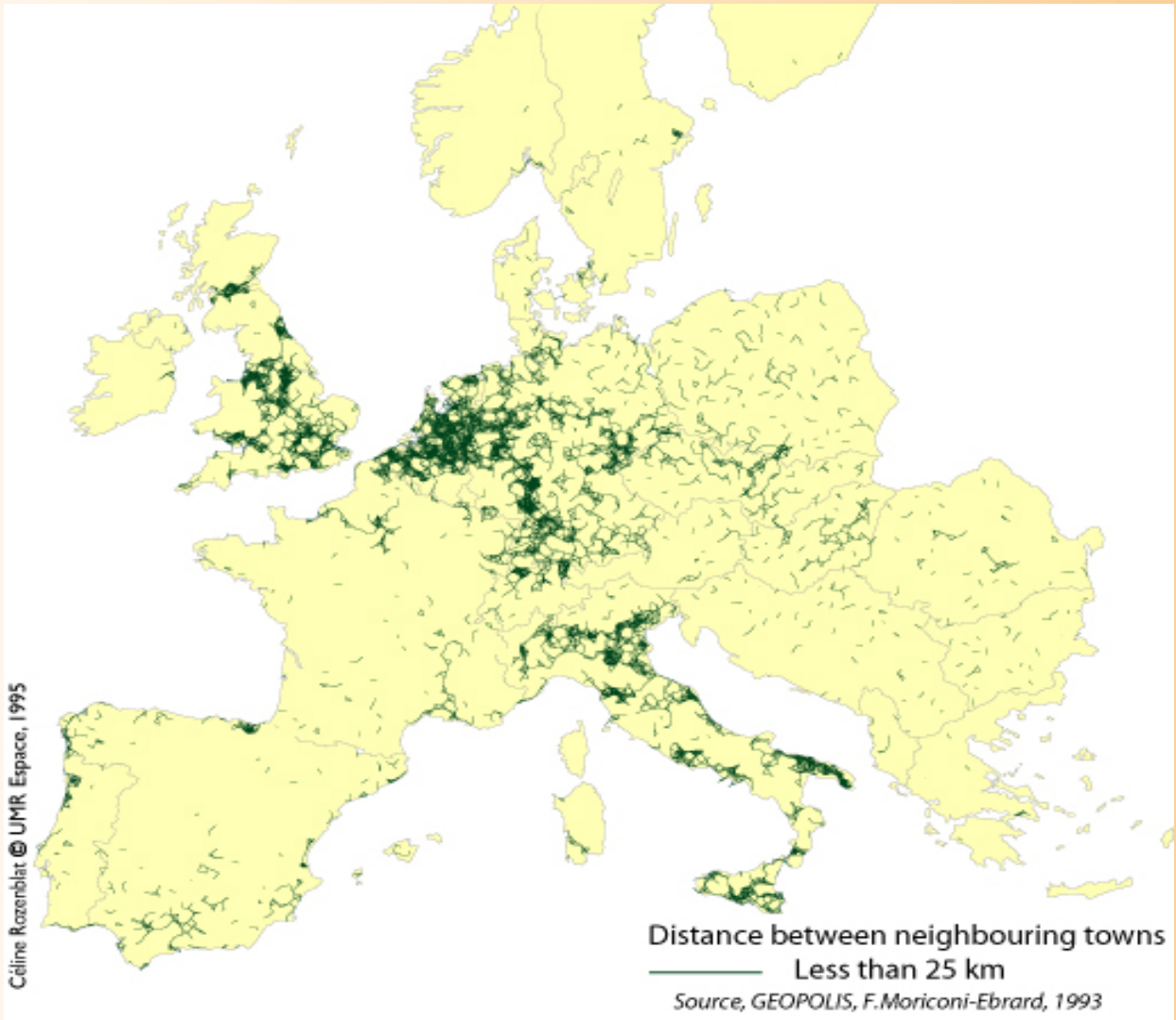
➔Path dependence of the colonial bifurcation in the Indian urban system until today

Frontier urbanisation then distributed growth in new urban systems



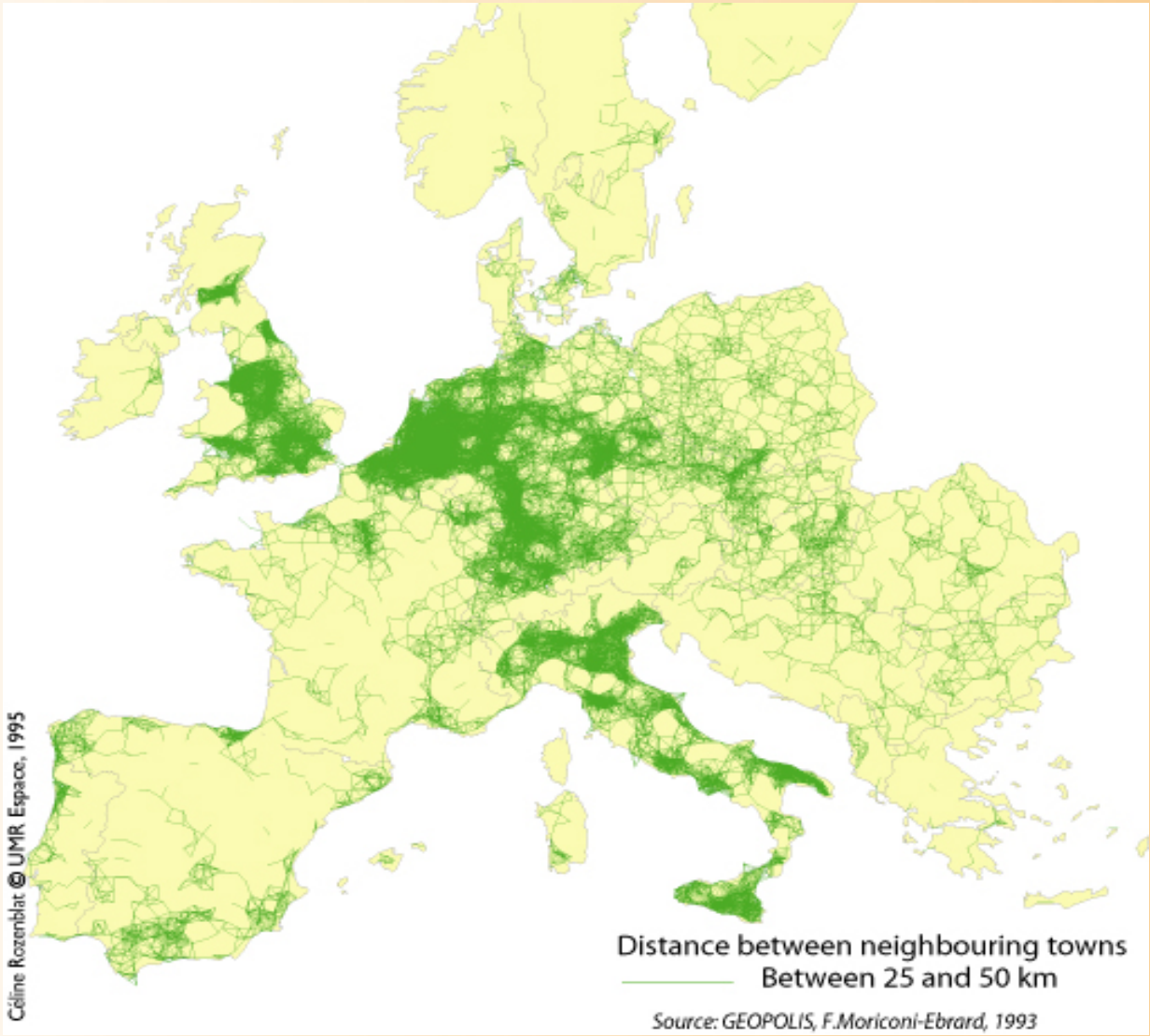


Path dependence in European urban patterns



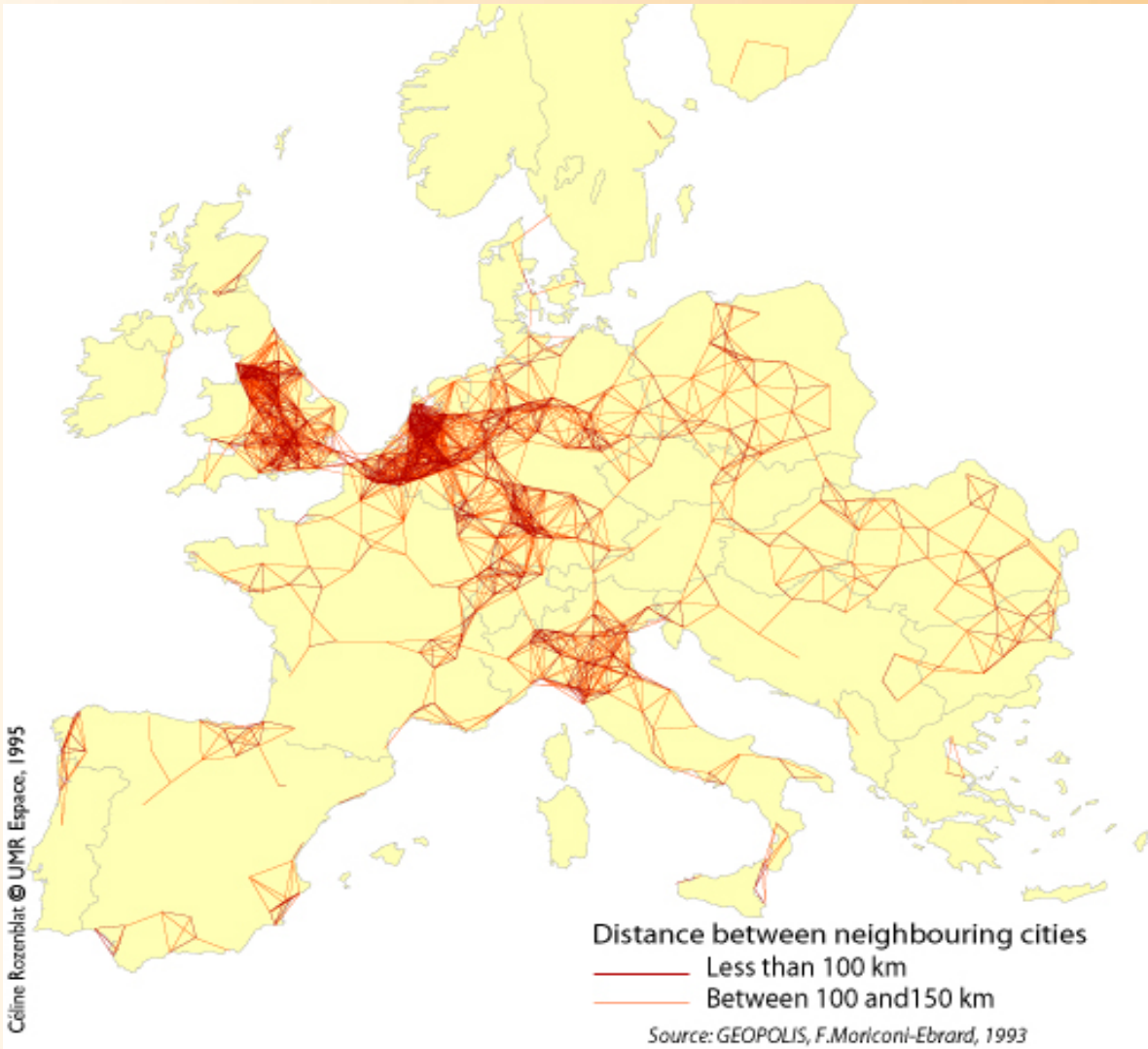
Céline Rozenblat, 1996

Path dependence in urban patterns



Céline Rozenblat, 1996

Path dependence in urban patterns



Céline Rozenblat, 1996

An evolutionary theory of urban systems

- Competing cities through exchanges of information ➔ urban hierarchy (size and social functional complexity)
- Hierarchical diffusion process➔ historical trend to metropolisation
- Selection and substitution processes

➔ functional specialisation associated to innovation cycles



Questions for research

Growing from creating and capturing innovation is the favorite urban sport, therefore:

- Will large cities become still larger?
- Which future for medium size cities and small towns? Will they become as specialised and tiny as villages were?
- Which effect can have new technologies and policies for sustainable development?

➔ Urgent need for integrative models of urban growth!



More urban growth

Number of urban agglomerations in the world

	1950	2010
> 10^7 inhabitants	2	31
> 10^6 inhabitants	83	482
> 10^5 inhabitants	1150	5100
> 10^4 inhabitants	10 800	59 000

Source : F. Moriconi-Ebrard, Geopolis, 1993 and 2010

➔ two thirds of urban population live in developing countries

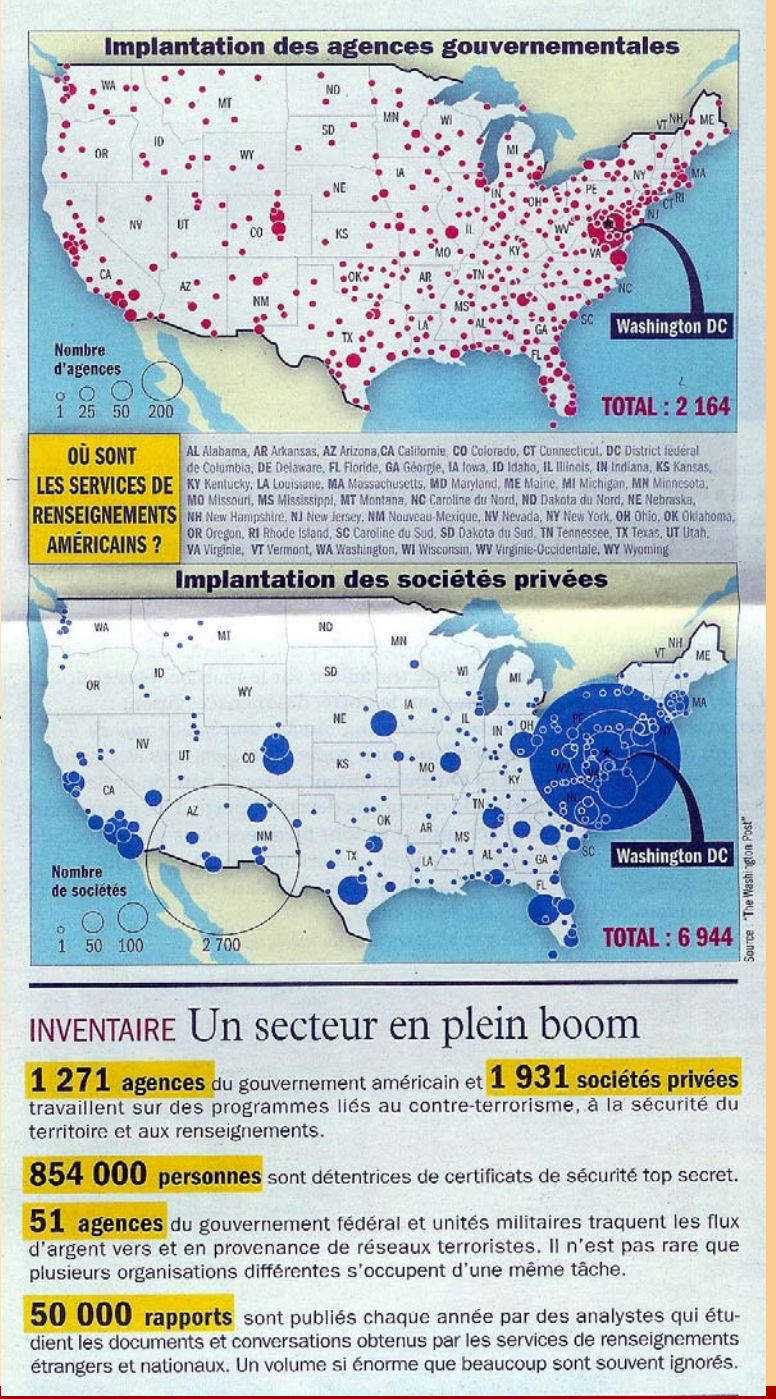
More urban concentration?

Public agencies

Private firms

Location of secret services agencies in United States in 2010

Source:
Courrier International
1030, Juillet-Août 2010



A need for global scenarios

Climate change: completing grids of variables with urban network patterns

Completing and harmonizing urban data bases

EEA, ESPON, Eurostat, Urban Audit, e-Geopolis (Africa, India, China…)

Mixing urban knowledge from decision makers, stakeholders, scientists and modellers in « user friendly » interactive simulation models

Global view: share of population in cities (%)

Size of agglos.	<500 000	500 000 to 5 millions	>5 millions
Latin America	36	22	15
North America	30	35	12
Europe	47	22	4
Asia	19	13	6
Africa	23	11	3

Source: UN



World megapoles (population 2010)

City	millions	City	millions
Tokyo	37	Calcutta	15
New York	26	Moscou	15
Mexico	23	Buenos A	14
Séoul	23	Dacca	13
Mumbai	21	Téhéran	13
Sao Paulo	20	Lagos	13
Manille	20	Karachi	12
Delhi	19	London	12
Los Angls	18	Beijing	12
Shanghai	18	Joburg	12
Osak K K	17	Rio de J	12
Le Caire	16	Paris	12

In red: deve-loping countries

Source: Population Data.net

World megapoles: population and GDP

Rank population	Rank GDP
Tokyo	New York
New York	Tokyo
Mexico	Los Angeles
Séoul	Osaka
Mumbai	Paris
Sao Paulo	Londres
Manille	Chicago
Delhi	San Francisco
Los Angeles	Dusseldorf
Shanghai	Boston
Osaka K K	Washington
Le Caire	Séoul

In red: deve-loping countries

Le numérique peut-il casser des briques?

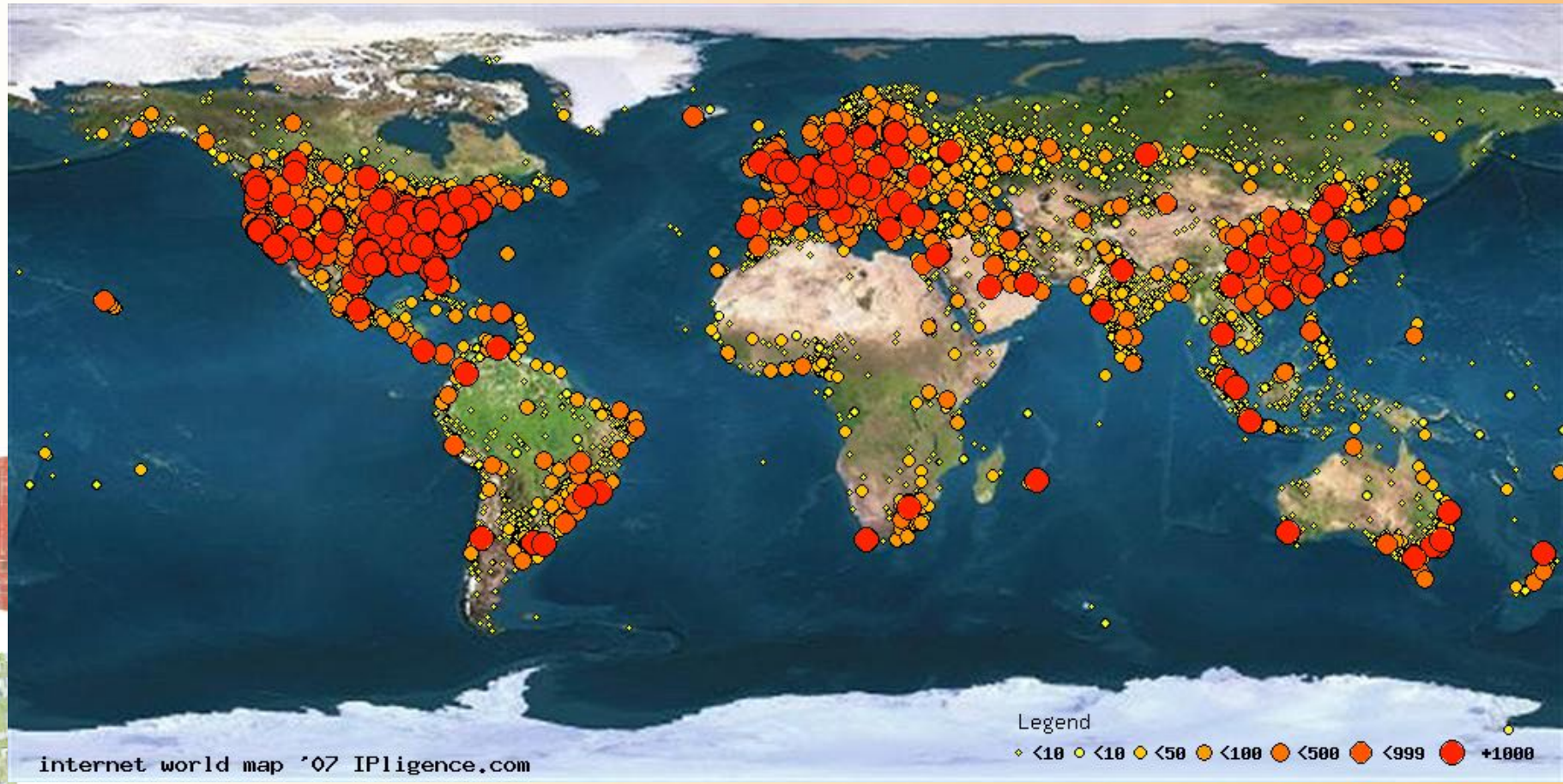
Which influence IT on urban evolution?
Accessibility, ubiquity of information➔ toward settlement dispersal, « shrinking cities »?

But autonomy and path dependency in urban systems dynamics…

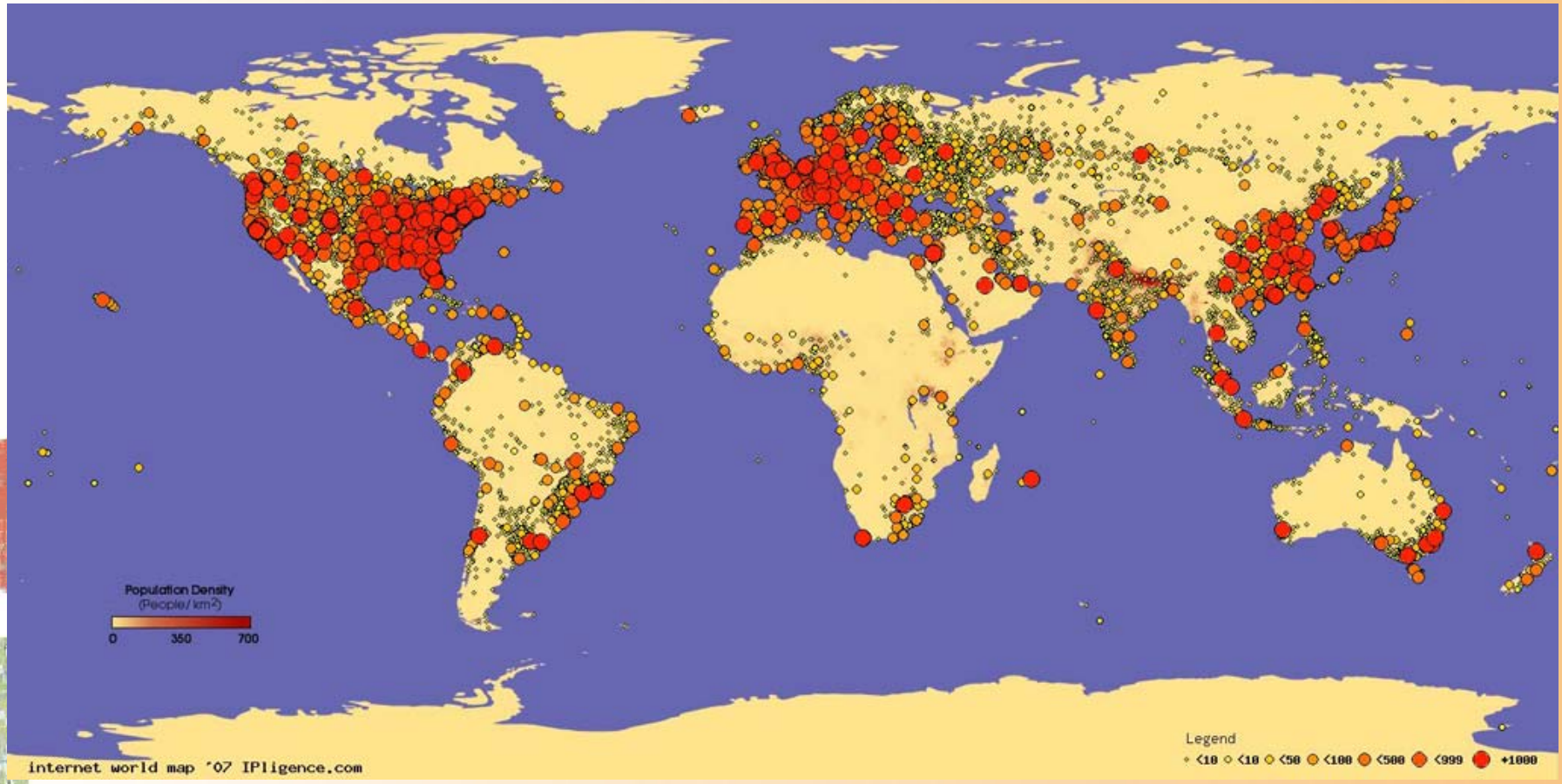
➔Internet will change the urban order, no more no less than railways and phone have done…

➔More urgent need for modelling tools!

Number of IP adresses in 2007: the cities



But density of Internet= country GDP…



Which consequences for urban planning?

➔ Adaptation is a creative action, as well as innovation (learning process)

➔ Urban actors have to develop their information networks

Various strategies are available:

- Imitation: safe solution but right timing is required
- Exploration of unexplored niches (but risk of lock-in)
- data bases and simulation models elaborated between stakeholders, decision makers and researchers are always needed!

Urban modelling tools and resources

Thank you for your attention!

S4 http://s4.parisgeo.cnrs.fr

S4 Spatial Modelling Platform

http://www.spatial-modelling.info/

Cybergeo http://www.cybergeo.eu

CASA www.casa.ucl.ac.uk

CSISS www.csiss.org

CSIS www.csis.u-tokyo.ac.jp