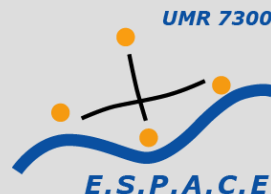


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# Multiple Fabric Assessment: Exploring the Forms of a Metropolitan Area.

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# The “revenge” of urban form

**Functionalist urban planning** overlooked the role of urban form in shaping urban phenomena.

**Spatial analysis** of cities followed the same route, focalizing on function localization.

Last 30 years **new emphasis on urban form** in geoprocessing:

## The form of urban networks

- Configurational approaches (Space Syntax: Hillier, Peponis)
- Multiple centrality assessment (Porta et al., Svetsuk)
- Streets and patterns (Marshall)

## The form of built-up space

- Density (Newman and Kennworthy)
- Space Matrix (Bergauer Pont and Haupt)
- Fractal analysis (Batty and Longley, Frankhauser)

... a more traditional comprehensive approach to urban form: **urban fabrics**

# Urban Fabric

The **finest scale of analysis of urban form** (city block, neighborhood).

**Classical schools of urban morphology** (Italy, France, UK): typical relations between elements of urban form revealing an urban culture

Focus of traditional urban morphology:

1. identification of urban fabric components (streets, buildings, parcels)
2. their geometrical description
3. analysis of their spatial relationships
4. study of the historic process behind the observed forms

A manual, expert-based procedure on a small part of urban space.



Emphasis on urban form analyzed on plan.



What if we want to analyze the vast extent of a metropolitan area as **observed from pedestrians?**

# Goals of Multiple Fabric Assessment

- From manual calculations → to a computational geoprocessing
- From expert-based detection → to a bottom-up procedure
- From planner's point of view → to pedestrian point of view
- From Small scale → to a Large scale

... historical processes lie outside of MFA.



Coastal conurbation of the French Riviera

1510 km<sup>2</sup>

1.1 million inhabitants

101 municipalities



**Questions:** what are the typical fabrics on the French Riviera?  
How are they organized in space?

# MFA Methodology

Spatial Unit Definition

Computation of Morphological Indicators

Identification of Spatial Patterns  
Through Local Indicators of Spatial Association

Bayesian Clustering of Combinations of Spatial Patterns

Identification of Families of Urban Fabrics

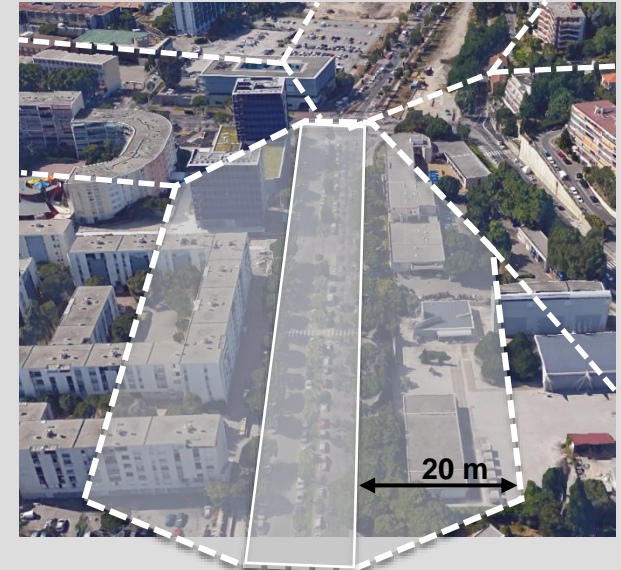
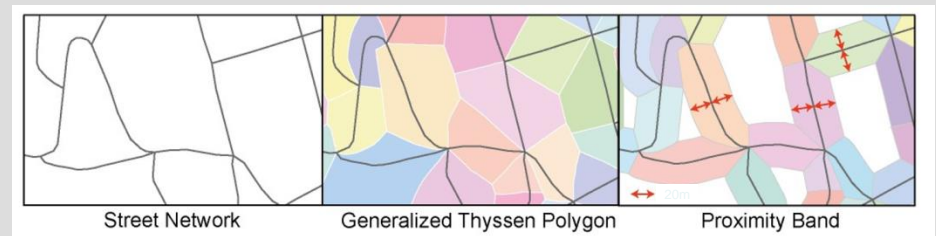
Spatial Organization of the Urban Landscape



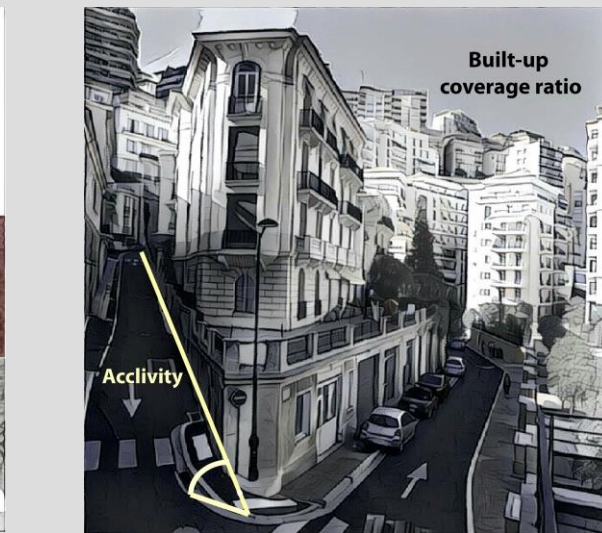
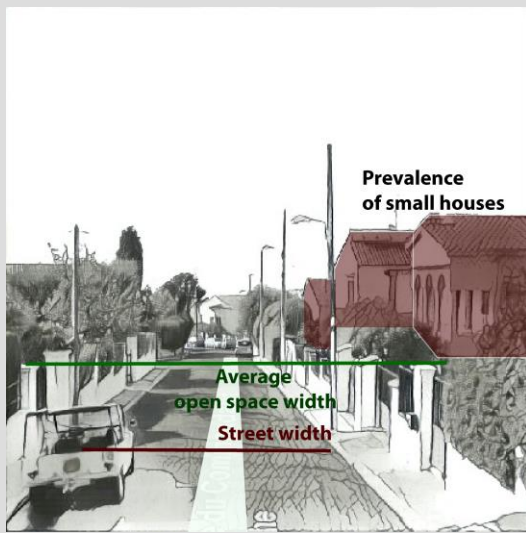
# Spatial Unit Definition

**Street proximity bands:** the pedestrian point of view of urban fabric.

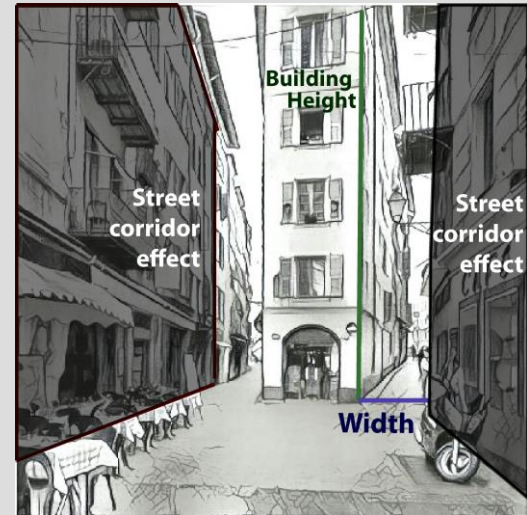
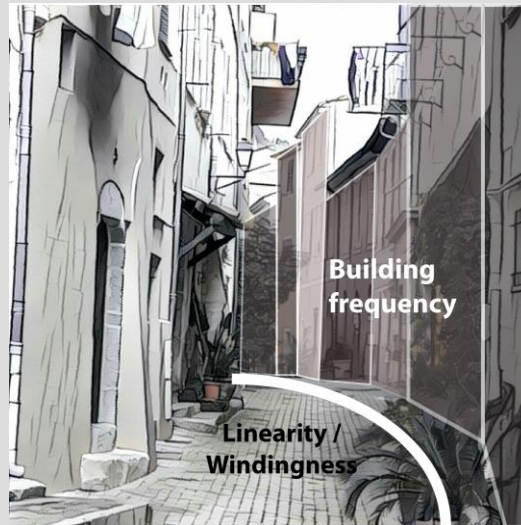
Partition of the planar urban space into regions based on closeness to each network segment within a certain distance from the segment (10 m, 20 m, 50 m)



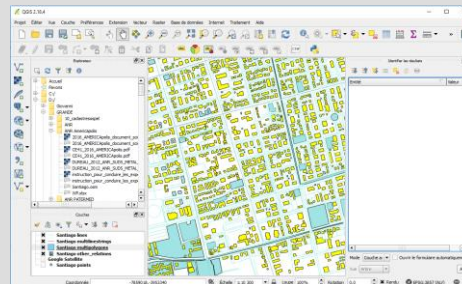
**100 000 street segments**



# Morphological indicators for pedestrians



**Geographical Information System (GIS)**



Computation of morphological indicators through automated geoprocessing

Urban Fabric Component	Indicator	Definition	
<b>Network Morphology</b>	<b>Street Length</b>	Network length of the street segments between two intersections [m]	
	<b>Linearity/ Windingness</b>	Ratio between Euclidean distance and segment length	
	<b>Local connectivity</b>		Average presence nodes of degree 1
			Average presence nodes of degree 4
			Average presence nodes of degree 3, 5 or more
<b>Built-up Morphology</b>	<b>Prevalence of Building type</b>	Ratio between 0-125 m2 building surf. and total built-up surf. in 50 m PB	
		Ratio betw. 125-250 m2 building surf. and total built-up surf. in 50 m PB	
		Ratio betw. 250-1000 m2 building surf. and total built-up surf. in 50 m PB	
		Ratio betw. 1000-4000 m2 building surf. and total built-up surf. in 50 m PB	
		Ratio between >4000 m2 building surf. and total built-up surf. in 50 m PB	
	<b>Proximity band coverage ratio</b>	Building coverage ratio on the 50 m proximity band	
	<b>Building Contiguity</b>	Weighted average of buildings frequency on built-up units	
<b>Specialization of Building Types</b>	Ratio between specialized building footprint and 50m PB surf.		
<b>Network-Building Relationship</b>	<b>Street corridor effect</b>	Ratio between parallel façades and street length in 10 m PB	
	<b>Proximity band building height</b>	Ratio between building vol. and surf. inside 20 m proximity band	
	<b>Open Space Width</b>	Ratio between open space within 20m PB and street length	
	<b>Height/Width Ratio</b>	Ration between average building height and average open space width within the 20m PB	
	<b>Building frequency along street network</b>	Ratio between number of buildings in 20m PB and street length	
<b>Network-Parcels Relationship</b>	<b>Plot fragmentation along street network</b>	Ratio between number of parcels in 20m PB and street length	
<b>Site Morphology</b>	<b>Surface slope</b>	Ratio between high sloped ( $S > 30^\circ$ ) and total space-unit in 50m PB	
<b>Network-Site Relationship</b>	<b>Street acclivity</b>	Computed as segment average of $\arctan(\text{slope})$	



# Looking for Spatial Patterns: LISA vs. LINCS

From surface-based to network-based geostatistical analysis

**LISA - Local Indicators of Spatial Association** :  $I_i = z_i \sum_j w_{ij} z_j$   
Local Moran's I (*Anselin 1995*)  
 $z_i = \frac{x_i - \bar{x}}{SD_x}$

Patterns of urban form features **from a pedestrian point of view**



Morphological Indicators within the street proximity band :  
bidimensional space with a network configuration

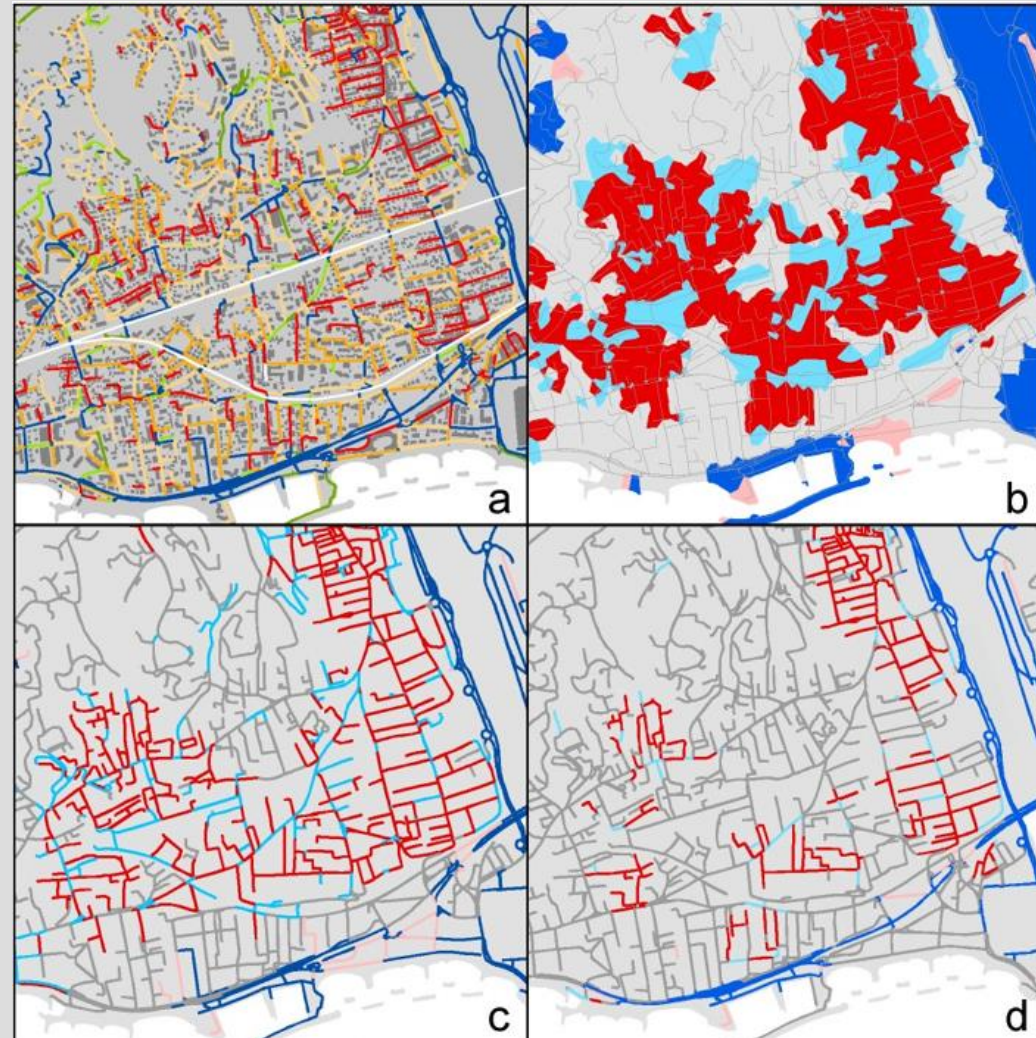
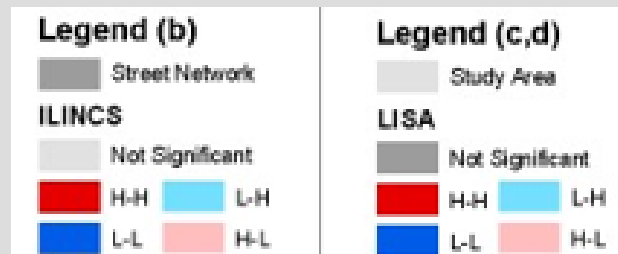
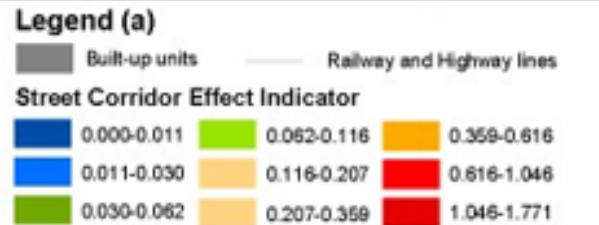
From LISA to **LINCS - Local Indicators of Network-Constrained Clustering**  
(*Yamada and Thill 2007, 2010*)

Spatial associations identified among connected elements (at a given depth)

# Spatial Patterns of Street Corridor Effect

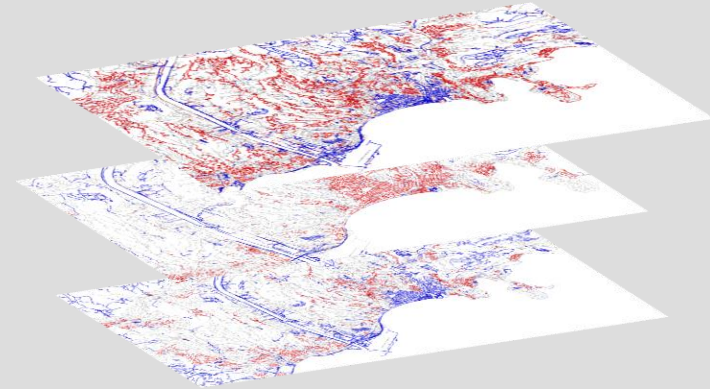
(Araldi and Fusco 2016)

From indicators calculated for every street segment to spatial patterns of statistically significant ( $p=0.05$ ) higher or lower values.



# Bayesian Clustering

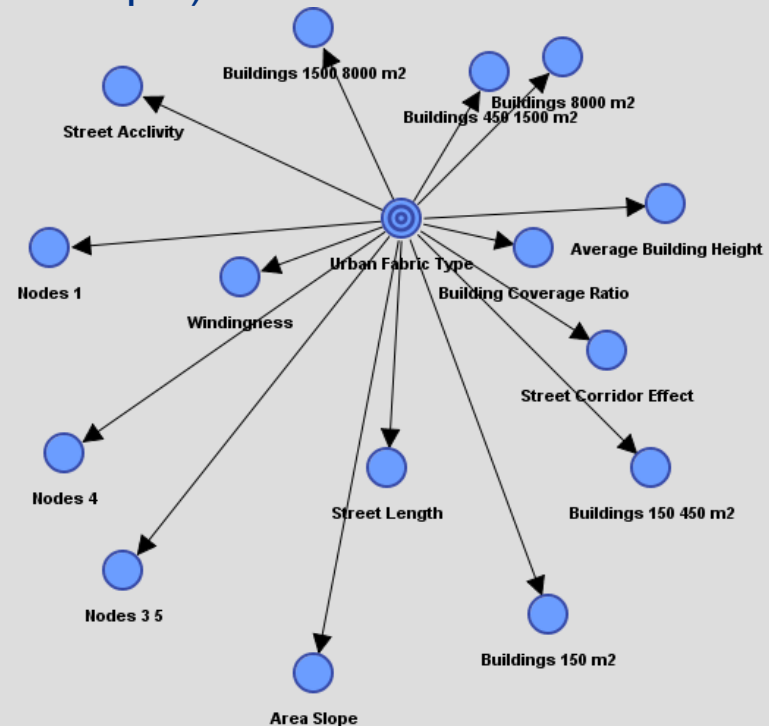
21 different **spatial patterns** for the 21 indicators, differently structuring the 100k spatial units: **how to summarize this information?**



**Bayesian Clustering** Solution (powerful AI technique).

Advantages:

- Use the **categorical values** of geostatistical analysis (HH, LL, HL, LH, NS)
- Clusters defined through the identification of **common values on a subset of indicators** (K-means or NN clustering would look for homogeneity).
- **Probability** that a given spatial unit belongs to a given cluster.





# Bayesian Clustering

**Score optimization** (log-likelihood + penalization for number of clusters... in order to avoid overfitting).

**Random walk** in solution space under constraints :

- Min % of street segments in each cluster (1%)
- Max number of clusters (20)
- Minimum average cluster purity (90%)
- ...
- Pseudo-random initialization with given seed

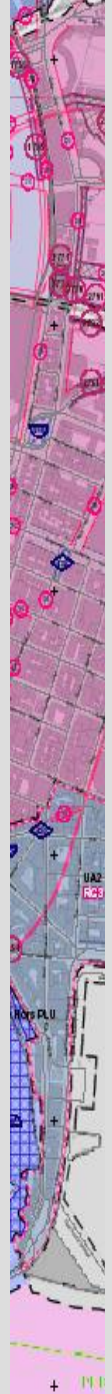
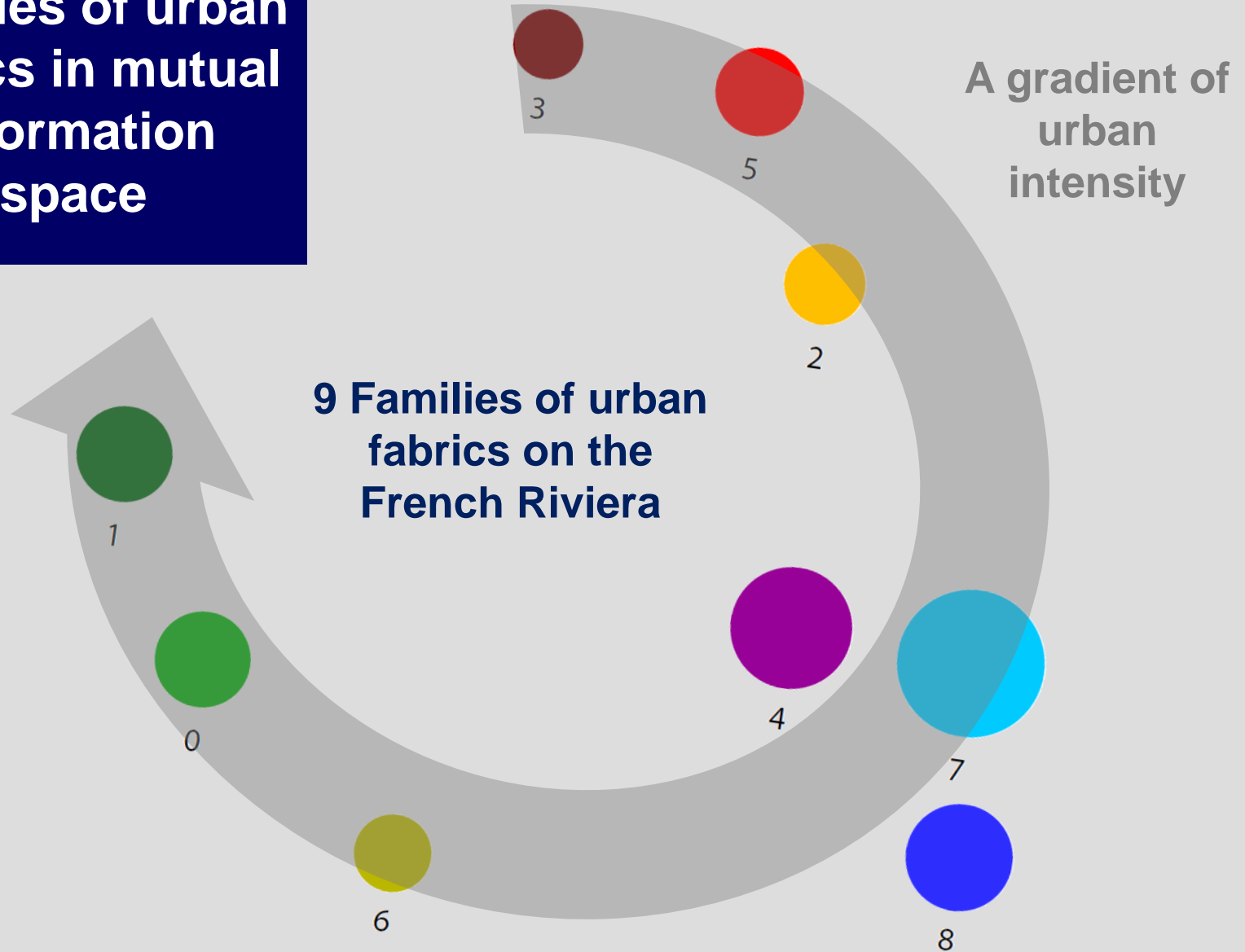
**Different search parametrizations → different clustering results**

**Sensitivity analysis** to parametrization: always the same 9 cluster solution

**Final result: 9 clusters**

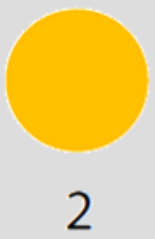
(contingency table fit score of 59,4%)

# Families of urban fabrics in mutual information space



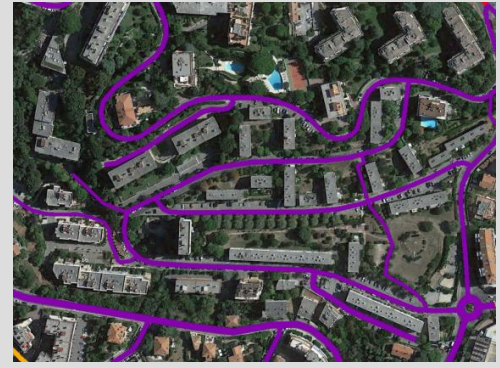
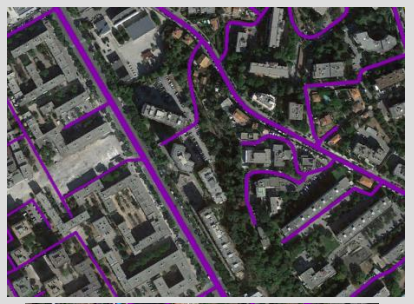
# Old constrained urban fabrics of town-houses

# Traditional urban fabrics of the plain with adjoining buildings



**Discontinuous and irregular urban fabrics with houses and buildings**

**Modern discontinuous urban fabrics with big and medium-sized buildings**



4



7



8

**Suburban residential fabrics in hills or plain**



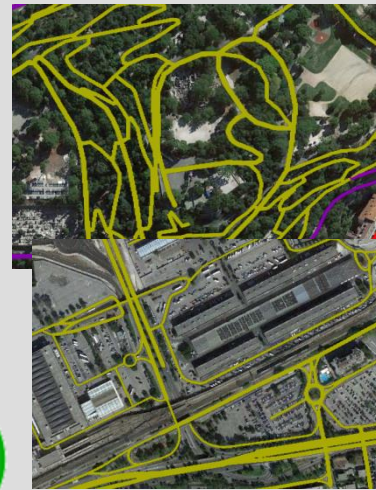
**Small house constrained suburban fabrics**



**Mountain natural space with sparse houses**



1



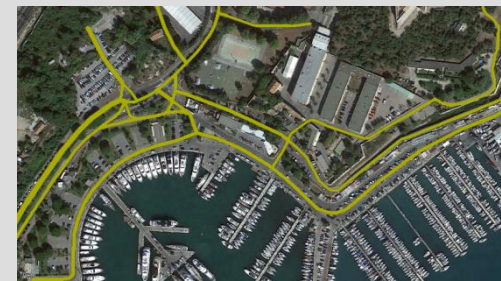
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**Non urbanized space in hills or plain with sparse homes and buildings**



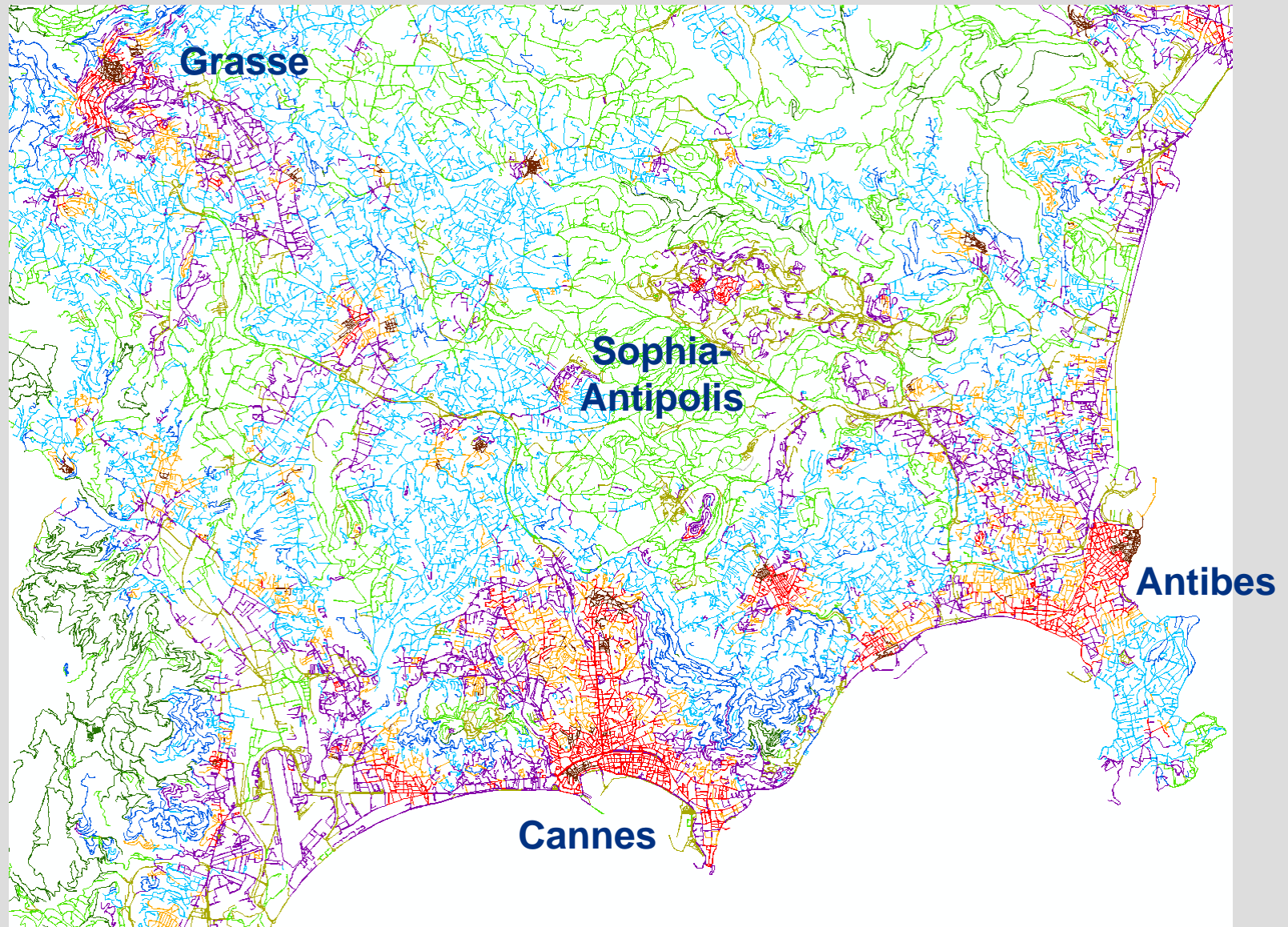
6

**Connective artificial fabrics with sparse specialized big buildings**

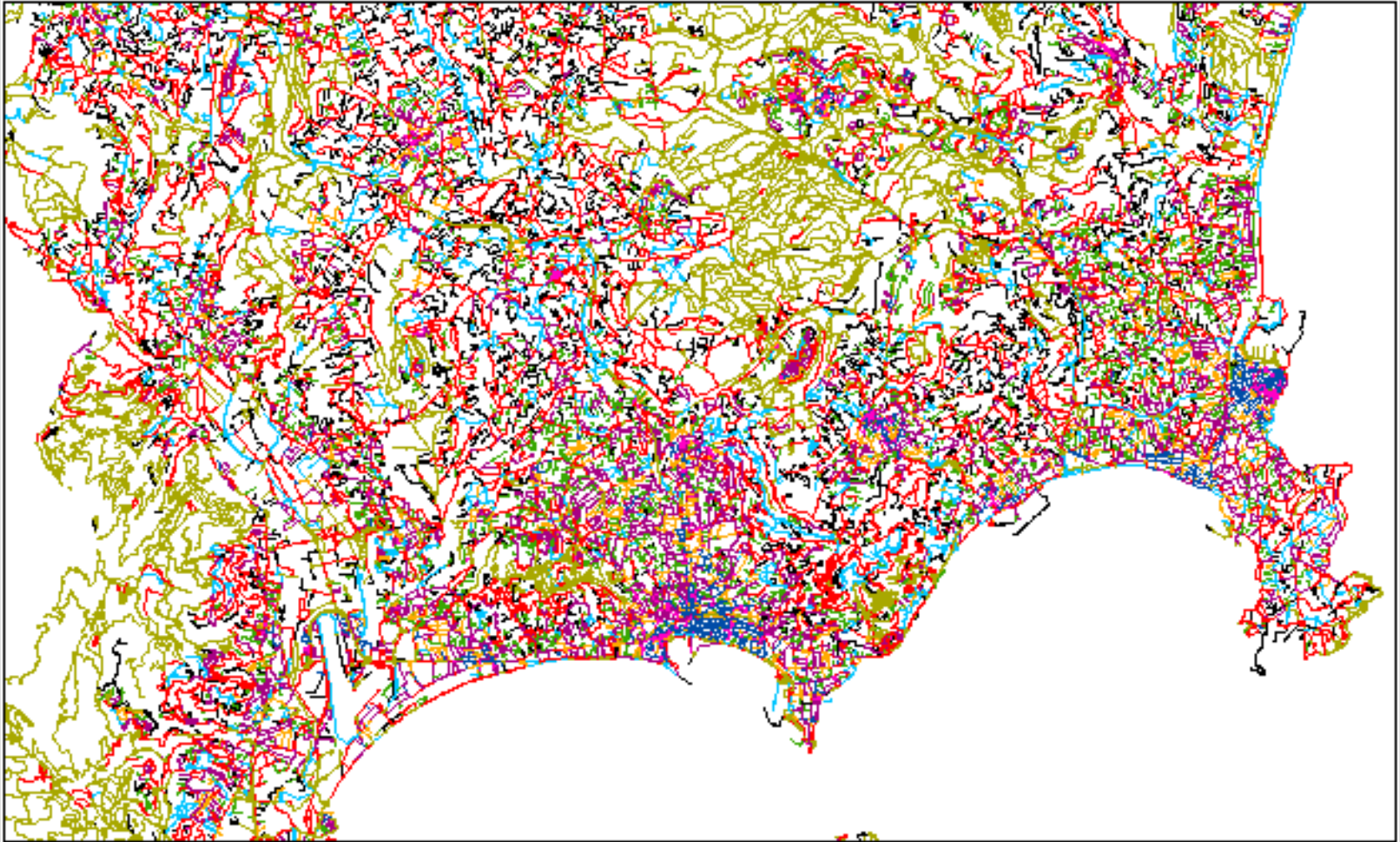




# Projection in Geographic Space (West)



# An Impossible Result without our Methodology



Bayesian clustering of the 100k spatial units using indicator values instead of LINC5 values: 9 clusters and still a much messier picture.

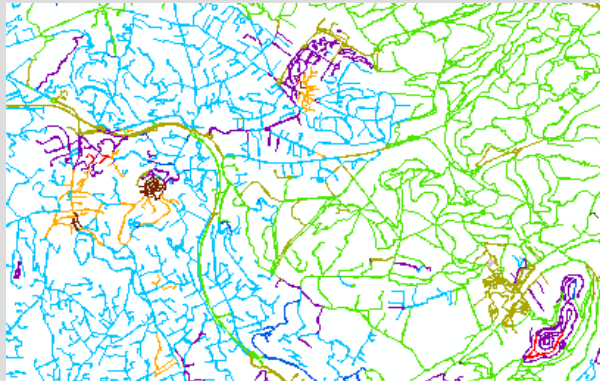
## Homogeneous morphological regions



**Cannes**

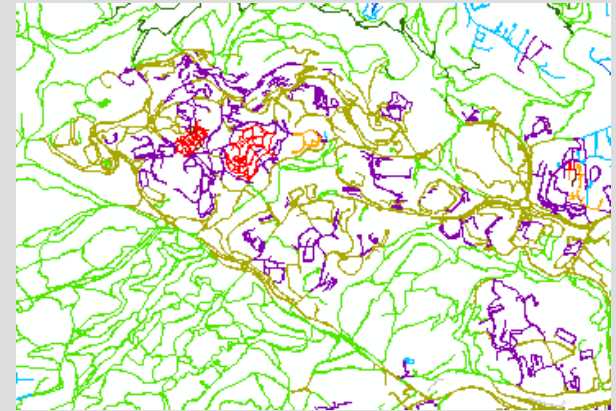


**Nice**



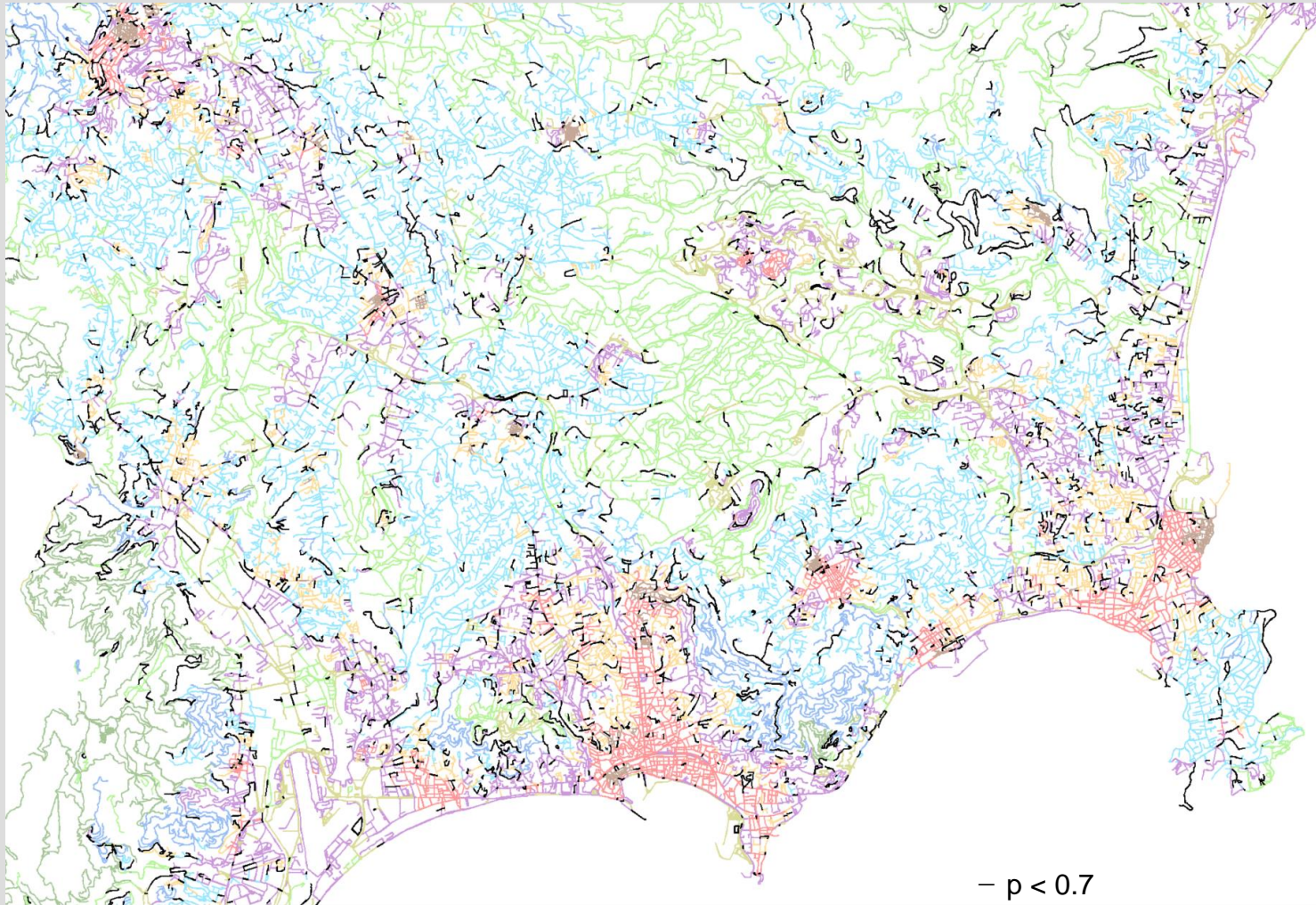
**Mougins**

## Morphological regions defined by mixtures of urban fabrics



**Sophia-  
Antipolis**

# Projecting Uncertainties



Probabilistic uncertainties reveal border zones of overlapping characteristics opposed to archetypical cores.

# Archetypical structure of the urban landscape in the cities of the French Riviera



- Consistent spatial logics
- Trans-scalar self-similarity in the spatial arrangements of morphological regions.

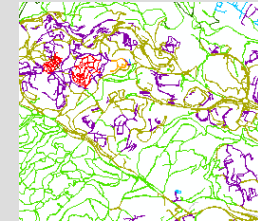
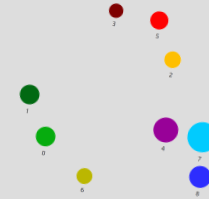
# MFA - Conclusions

- An multi-step geoprocessing approach to identify urban fabrics:
  - Morphological Indicators
  - Network-Constrained Geostatistics
  - Bayesian Clustering
- LINCS produce a necessary filter of individual characteristics of spatial unit to focus on meso-scale patterns
- Bayesian Clustering can identify clusters based on a few shared characteristics (instead of forcing homogeneity)
- Method proved successful in identifying urban fabrics in a real-world metropolitan area...



# MFA reveals complexity of metropolitan area

- 9 families of urban fabrics
- Homogeneous vs. Mixed morphological regions
- Cores of morphological regions vs. borders of overlapping characteristics
- Self-similarity and modularity of metropolitan area





# Future Developments

- Integrate more specific indicators of **visibility analysis**
- Link identification of urban fabrics with **knowledge of historical processes** behind observed morphologies.
- Interest of **comparative analysis with other metropolitan contexts** (urban fabrics are linked to urban cultures)
- Study the **relation between forms and urban functioning / human behaviors** (linked to perception of urban form like retail activity, neighborhood satisfaction, crime, health, etc.)





# Thanks for your attention

## Credits :

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