GC53A-1018 - GENIUS, A tool for multi-disciplinary and multi-scalar databases

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CONTEXT

Cities and energy, disease or cure ?
Cities are the biggest consumers of energy due to the concentration of human activities on their territory. But life in cities seems to be the best way to preserve the environment and save natural resources.

A multidisciplinary question
To assess the question of energy consumed and produced at the city scale, a multidisciplinary approach is required. In particular, energy balance models must be coupled with microclimate simulations.

A multi-scale question
Coupling models goes with multiple spatial scales.
The evolution of the city and of the climate also involves multiple temporal scales (from yearly analysis to simulations of towns' evolutions over a century).

Conclusion : A lack of multi-scaled urban databases for multidisciplinary research

DATABASES FOR CITIES, ENERGY & MICROCLIMATE

Objectives of GENIUS : to provide databases

At building scale for energy balance models:
- Building height, footprint, roof slope,
- Building materials and thermal properties,
- Inhabitants' behaviors,
- Building equipment (H&V systems)…

At neighborhood scale for microclimate models:
- Surfaces of roads, roofs, walls,
- Surfaces of vegetation and water,
- Height of urban canopy layer…

Evolutionary databases for prospective studies

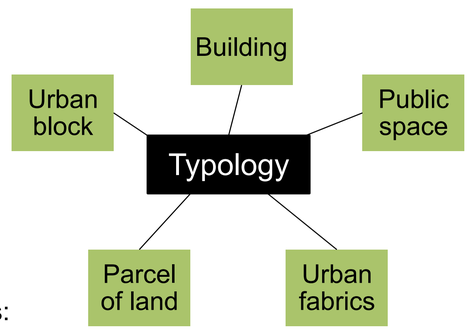
OBJECTIVES

METHODOLOGY

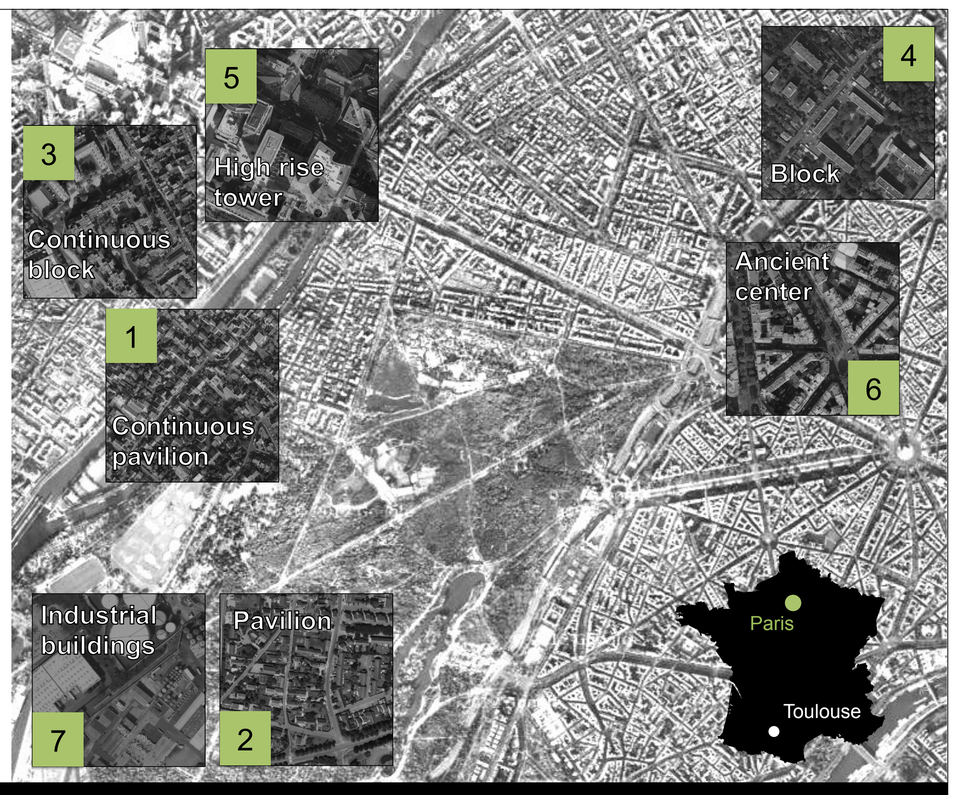
STEP 1 : Transform existing maps of Paris and Toulouse into archetypical maps
Archetypical maps are grids of 250 m x 250 m in which the urban form is composed of "typical blocks" i.e. archetypes of urban blocks that can be found in most European cities.

About 50 morphological indicators calculated on Paris and Toulouse…
… in order to identify those "typical blocks" :
- Height
- Standard deviation of height
- Built-up density
- Population density
- Compactness
- Contiguity,
- Road surface,
- …

Tree of indicators:



A statistical analysis of those indicators allowed us to identify 7 typical blocks
We ran a principal components analysis to select relevant indicators.
Then, the clustering method K-mean is used to identify 7 types of blocks in the city.

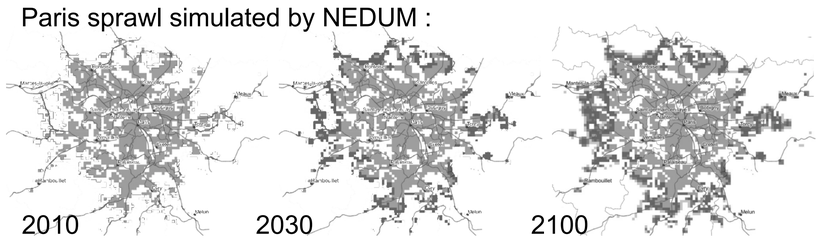


A GIS BASED METHOD

STEP 2 : Set rules to predict urban evolutions

SLEDUM, simulates the city sprawl year after year until 2100 as well as the evolutions in built-up density. GENIUS predicts the evolution of morphologies based on SLEDUM outputs and on previous maps.

Paris sprawl simulated by NEDUM :



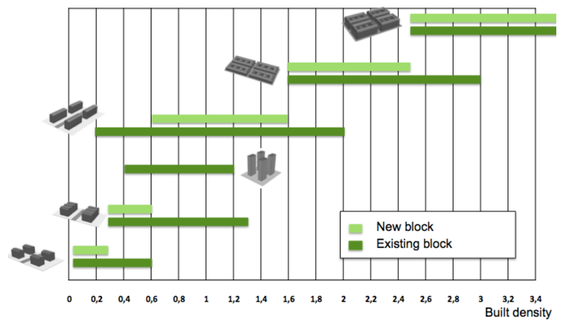
COUPLING

STEP 3 : Set rules to predict the architectural evolutions

First set of rules : Typology
For different prospective scenarios, we make a correspondence between built-up density and typologies.

Second set of rules : Morphology
For a given scenario, we make a correspondence between built-up density and morphological indicators : height, area of road, area of vegetation, compactness, …

Technical parameterization
According to its age and type, we attribute technical properties to the buildings (thermal insulation, H&V systems, …)



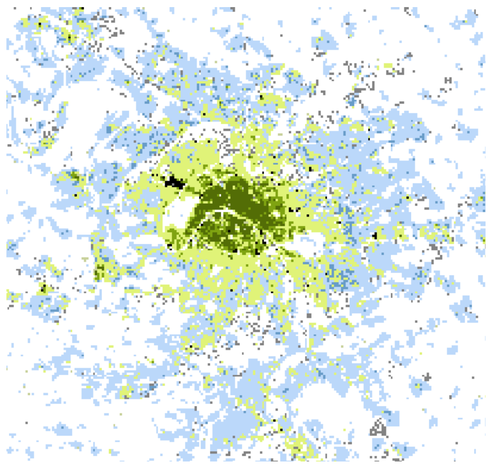
Correspondence between density and typologies
« Compact morphology » scenario

EVOLUTION

RESULTS

Archetypical map of Paris in 2010 :

N°	Ilot type	
1	Continuous pavilion	
2	Discontinuous pavilion	
3	Continuous block	
4	Discontinuous block	
5	High-rise tower	
6	Ancient center	
7	Industrial building	

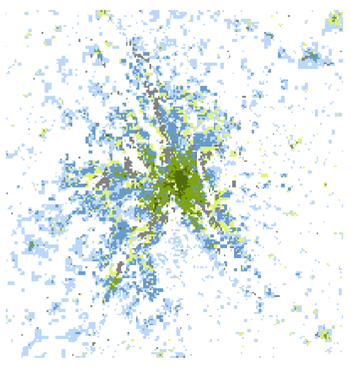


The map is validated with 91% of correlation

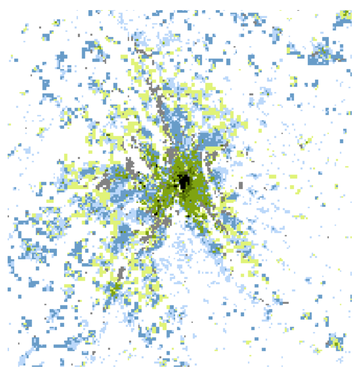
A VALIDATED URBAN DATABASE

A multi-scaled urban database for multidisciplinary research
The maps are used for microclimate simulations as well as building energy balance simulations.

A tool to compare different scenarios
GENIUS allows to compare different scenarios of socioeconomic development and town planning governance. For instance, we compared the evolution of Toulouse for different scenarios : business as usual, compact morphology, vertical morphology, …
We can now assess which city has the best compactness, the smallest sprawl, the largest space for green areas …



Toulouse in 2100
« Business as usual »



Toulouse in 2100
« Vertical morphology »

AN EVOLUTIONARY URBAN DATABASE

GENerator of Interactive Urban blockS - GENérateur d'Ilots UrbainS