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Urban Climate, Human behavior and Energy consumption : from LCZ mapping to simulation and urban planning (the MapUCE project)

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Context and motivations

- Climate Warming & Green-House Gases
- Urban Heat Island
- City evolution & Urban planning

How to integrate in urban policies and most relevant legal documents quantitative data from urban climate, climate and energy ?

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Objectives

How to integrate in urban policies and most relevant legal documents quantitative data from urban climate, climate and energy ?

1) to get such data

- Buildings (41 % energy consumption in France)
- Highly meteorologically dependent
- Automatically (any city in France)

2) a methodology to integrate climate data in urban policies

- In local or national laws or legal tools

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The MapUCE project (2014-2018)

Urban morphology
Building characteristics

Socio-economical,
Behavioural data

Analysis of legal aspects

GIS-based creation of TEB-BEM input maps

Include behaviour into TEB-BEM

Transfer tools

Simulation of energy demand & urban climate for French cities

Recommendations for urban policies

Objective 1

Objective 2

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Interdisciplinary Team

Meteorologists

Geographers & GIS scientists

Social geographers (in urban planning)

Sociologists (in behaviour)

Architects

Urban planners

Lawyers

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Summary

From Local Climate Zones (LCZ) …

… for modelling of behaviours, energy and micro-climate …

… to Urban Planning & laws

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Interest of LCZ

- Local Climate Zones (LCZ) is a concept understandable by urban planners

LCZ **COMPACT MID-RISE** **2**

DEFINITION

Form: Attached or closely spaced buildings 3–9 stories tall. Buildings separated by narrow streets and inner courtyards. Buildings uniform in height. Sky view from street level significantly construction materials (stone, concrete, brick, tile); thick roofs and walls. Land cover hard-packed. Few or no trees. Moderate space heating/cooling demand. Moderate to he *Function*: Residential (multi-unit housing; multistorey tenements); commercial (office l retail shops); industrial (warehouses, factories). *Location*: Core (old city, old town; ir business district); periphery (high-density sprawl). *Correspondence*: UCZ2 (Oke 2004); (Ellefsen 1990/91).

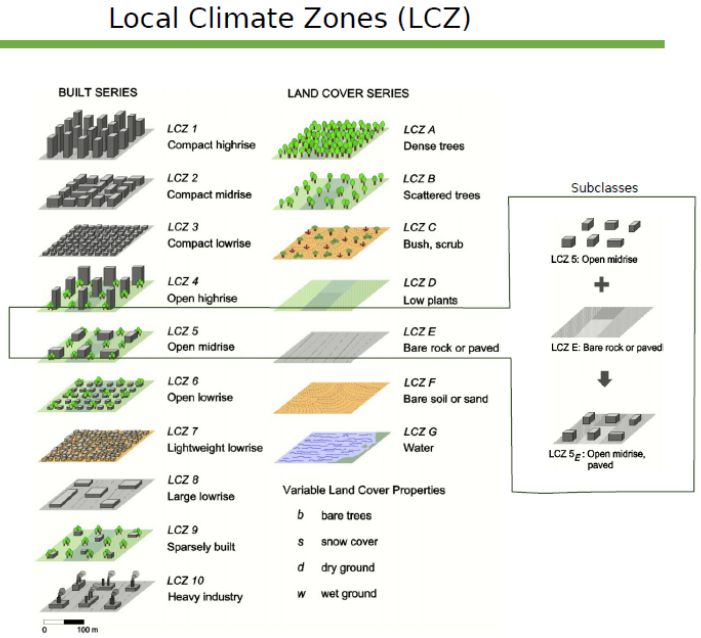
ILLUSTRATION

High angle

Low level

PROPERTIES

Sky view factor 0.3 – 0.6	0 .2 .4 .6
Canyon aspect ratio 0.75 – 2	0 .2 .4 .6 .8 1 2
Mean building height 10 – 25 m	0 10 20 30
Terrain roughness class 6 – 7	1 2 3 4 5 6
Building surface fraction 40 – 70 %	0 20 40 60
Impervious surface fraction 30 – 50 %	0 20 40 60
Pervious surface fraction < 20 %	0 20 40 60
Surface admittance 1,500 – 2,200 J m^{-2} s$^{-1/2}$ K^{-1}	0 500 1,000 1,500
Surface albedo 0.10 – 0.20	0 0.1 0.2 0.3 0.4 0.5
Anthropogenic heat flux < 75 W m^{-2}	0 100 200 300 400



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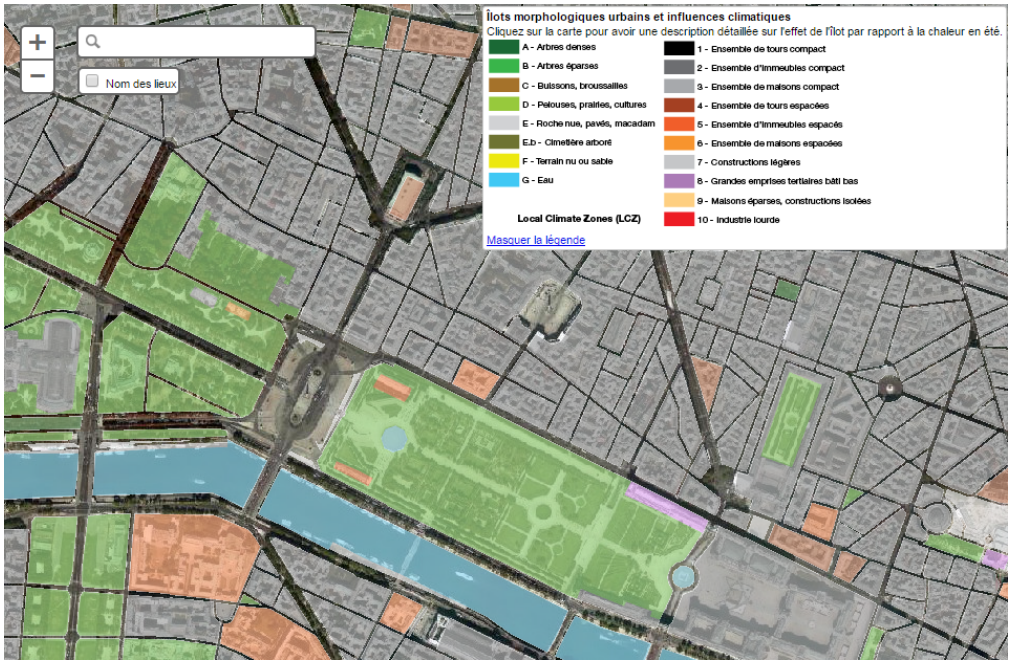
Interest of LCZ

- Local Climate Zones (LCZ) is a concept understandable by urban planners

- Here is the proof :



Done by an urban agency (Paris agglomeration) *alone*

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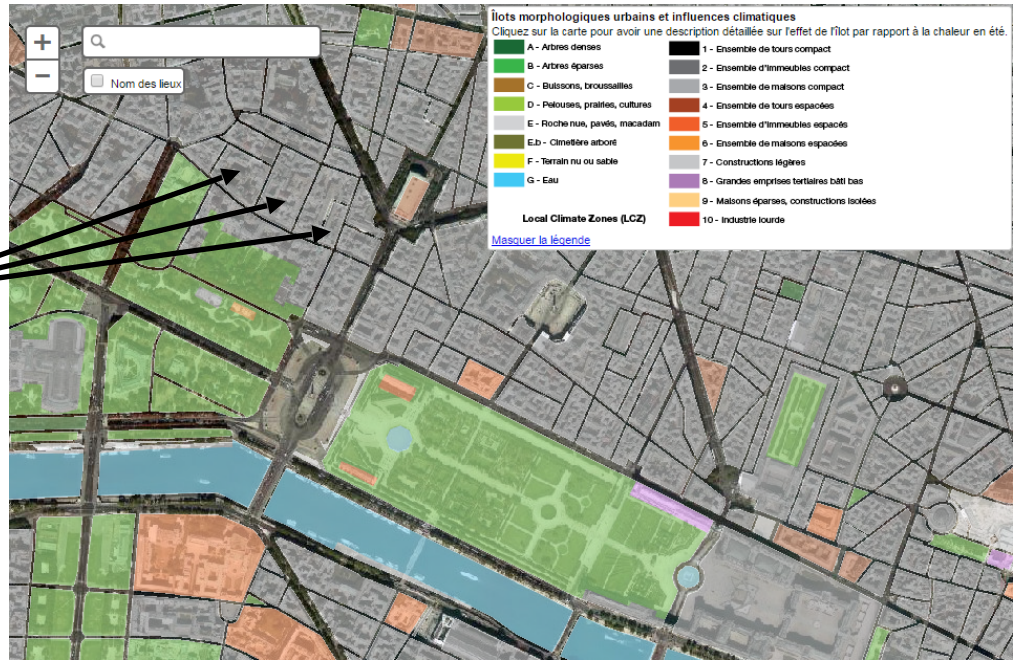
Islets



- 1 LCZ = all gray islets ?

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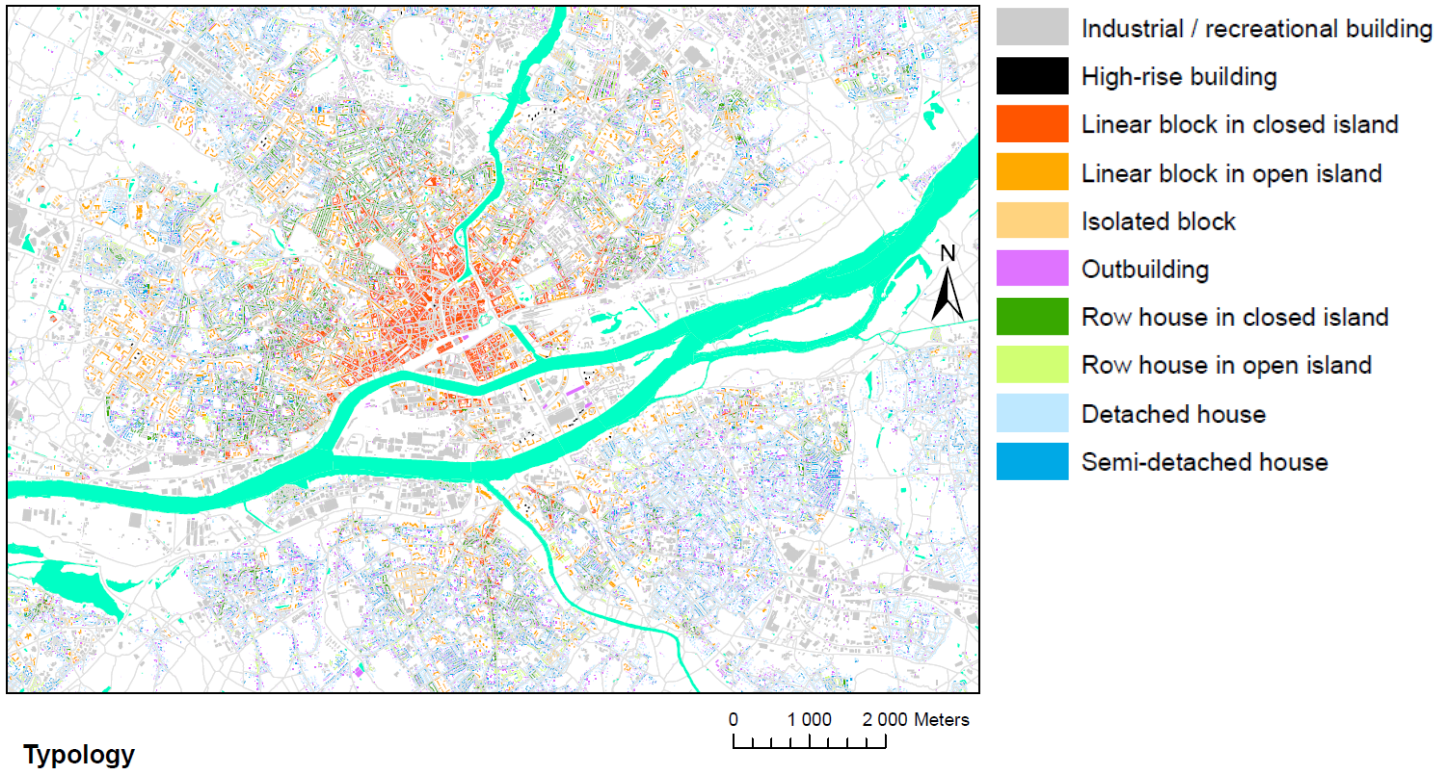
Data production at islet scale

1) to use building & social national databases



Typology

Note that buildings typology is not included in the initial databases.

It is deduced from other indicators by the way of architectural expertise

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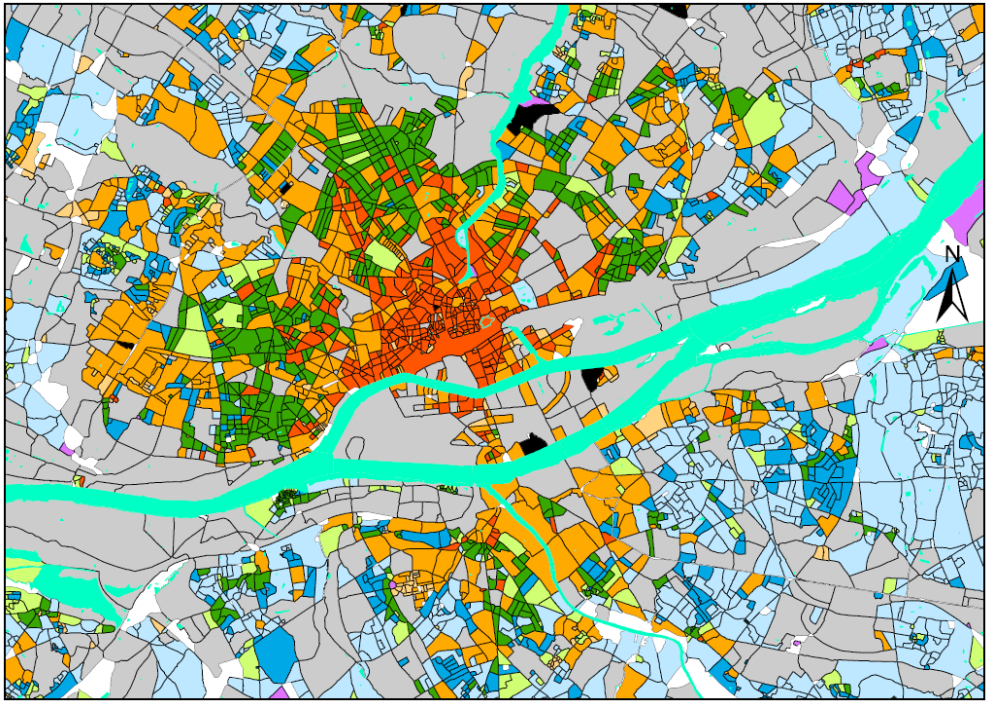
Data production at islet scale

1) to use building & social national databases

2) to derive the limits of islets

3) to compute (~80) indicators



Typology ≈ LCZ

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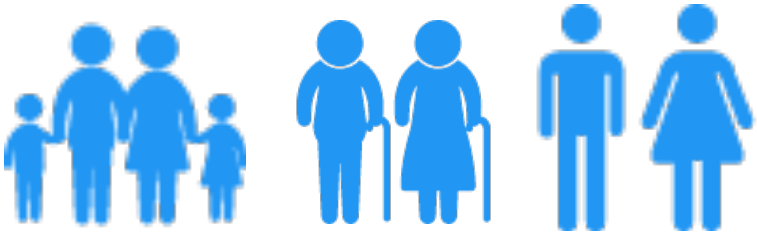
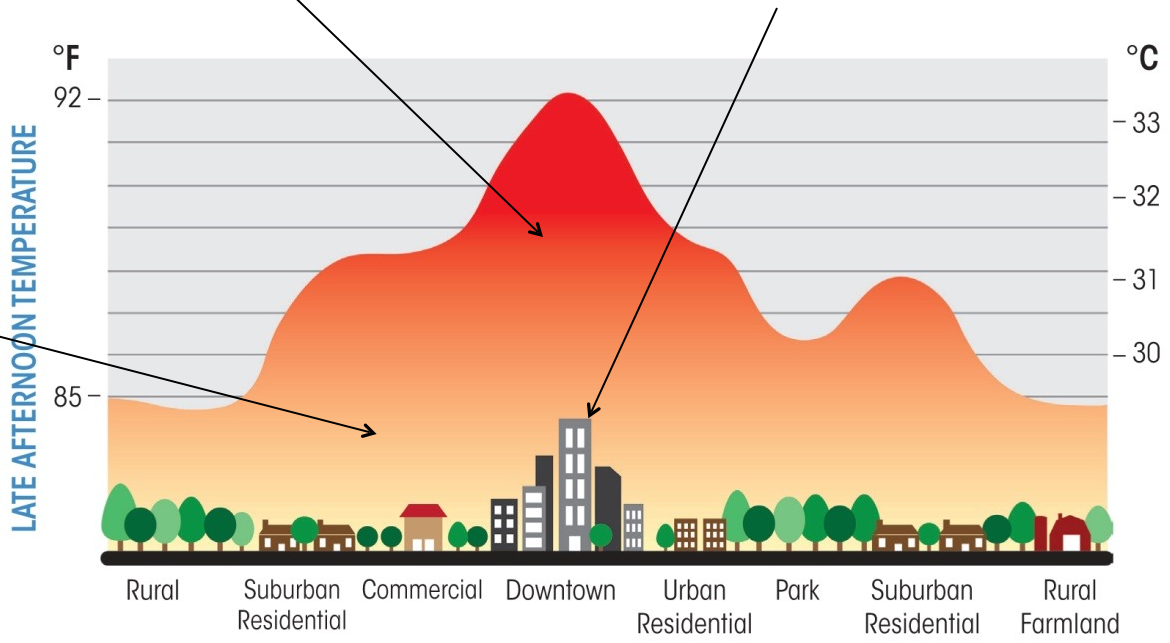
Urban Heat Island & behaviours

Housing characteristics

Land use



Households behavior



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Urban Heat Island & behaviours

Available datasets :

- Behaviour (2k households; Paris region) (Energihab project)
- Energy consumption (5k households; France)
- Housing and households (50k; France)
- Housing and households (20M, France), at urban district scale

Scientific questions :

Which information is important ?

→ analysis of the databases + sensitivity studies with TEB

How to derive the information at islet scale ?

→ crossing of information at different spatial scales

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Urban Heat Island & behaviours

Sensitivity analysis with TEB-BEM model

- on Toulouse city center
- validation data on energy consumption and heat fluxes

Internal heat release (due to Household electrical appliances, cooking,…)

Strong influence on heating/air-conditioning

Medium importance on micro-climate in **winter**, **Strong in summer**

Design temperatures

Important in summer, Very important in winter

Occupancy is also important

Ventilation and shading

Medium importance if no air-conditioning

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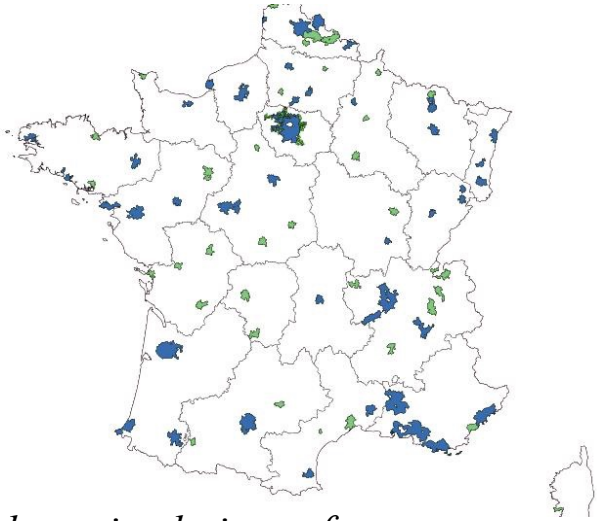
Modelling of behaviours in TEB

Use of the behaviour/energy/social databases

Behaviour = function (household, housing)

Household and housing are estimated at islet scale anywhere in France

These relations are implemented in TEB for pertinent behaviours



Cities where simulations of energy consumption & urban climate will be done first

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Analysis of legal tools & practices

Several scales of decision / regulation

Nation, Region, Agglomeration, City

Several ‘strengths’

Informative, Incentive, Compulsory

Analysis done in France, but probably the same in any country

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Analysis of legal tools & practices

20 legal planning tools were analyzed :

- Urban planning and land management laws;
- Energy and climate planning documents;
- Documents from the sustainable development field

Opportunities arise in these documents and in their articulations.

Not only one but with several complementary legal documents.

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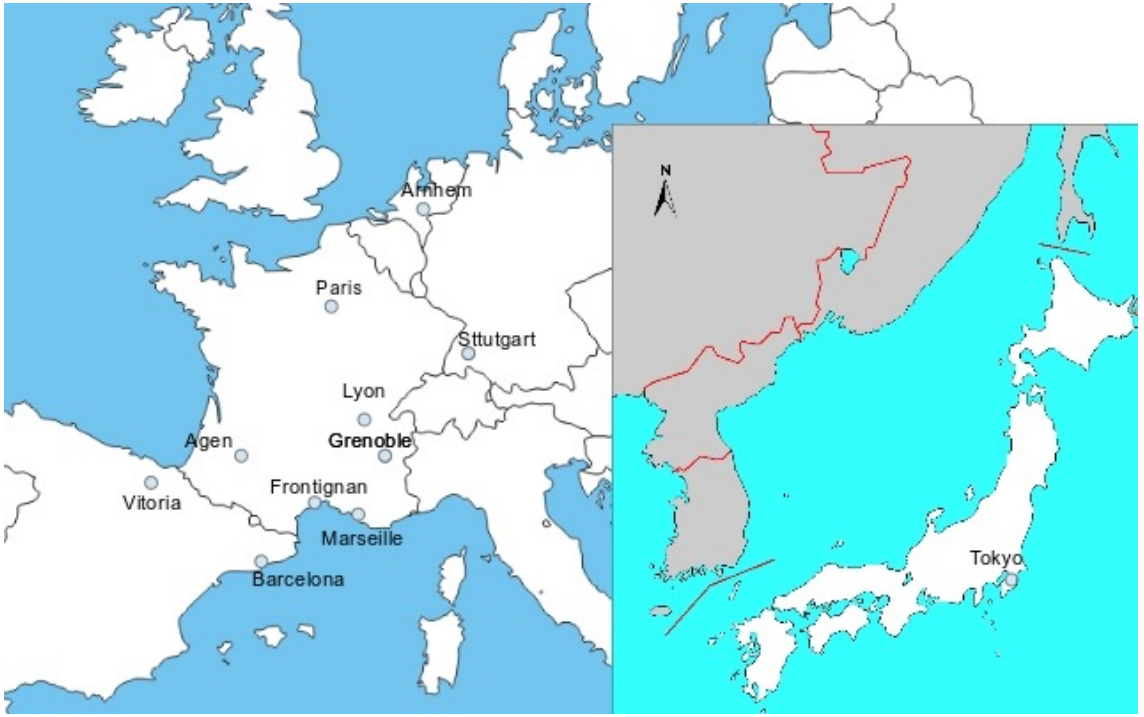
Exemplary cases

The analysis of exemplary cases showed us that :



Money is not the main factor inhibiting the consideration of energy and climate in planning

Good practices are favored by key persons making the link between several city services & some other institutions (e.g. labs).

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In urban planning agencies ?

Survey to all 51 French urban planning agencies

- Energy consumption issues are currently addressed
- Micro-climate is (far) less taken into account
- A very large heterogeneity (depending on city size, historical relations)

It has also been pointed out:

- The difficulty to get access to data
- The weak use of GIS to cope with these issues

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Conclusions

After 1 year of project

- A database is produced automatically at the islet scale
- Complex indicators (including LCZ type) are calculated
- Behaviour are still under study
- Analysis of practices and laws showed us ways of improvement

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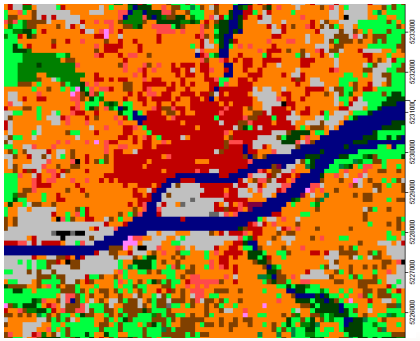
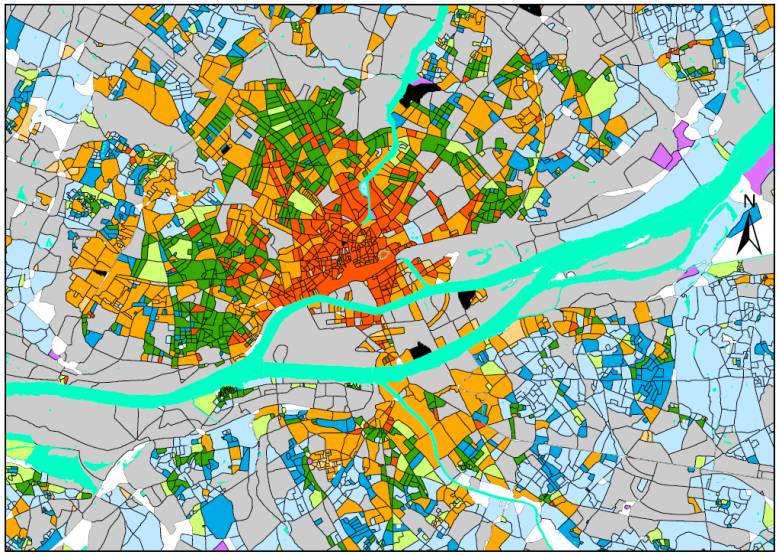
What next ?

- Simulations with TEB-BEM (& behaviours) of French cities
- Possibility to build scenarios including social evolutions
- Climate maps
- Likely link with the WUDAPT initiative
  - data production for WUDAPT,
  - use of our database for validation

WUDAPT :
see session GD2





Typology

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Other presentations on MAPUCE

Bocher E., G. Petit, N. Fortin, 2015: H2GIS a spatial database to feed urban climate issues, *9th International Conference on Urban Climate*, **GD5**, 20th-24th July 2015, Toulouse, France.

Hidalgo J., S. Haoues-Jouve, C. Ximena Lopez, 2015: Integration of urban climate issues in urban planning : reflections on which are the keys of success, *9th International Conference on Urban Climate*, **TUKUP1**, 20th-24th July 2015, Toulouse, France.

Plumejeaud-Perreau C., C. Poitevin, C. Pignon-Mussaud; N. Long 2015: Building Local Climate Zones basing on socio-economical and topographic vectorial databases, *9th International Conference on Urban Climate*, **GD3**, 20th-24th July 2015, Toulouse, France.

Tomasset G., S. Haoues-Jouve, J. Hidalgo, 2015: Urban climate and materials properties: What do we know about this field? How can we use this knowledge for urban planning? How can we adapt and better build our cities for tomorrow?, *9th International Conference on Urban Climate*, **POSTER26-TUKUP**, 20th-24th July 2015, Toulouse,

Tornay N., M.Bonhomme, S. Faraut, 2015: GENIUS, a methodology to integer building scale data into urban microclimate and energy consumption modelling, *9th International Conference on Urban Climate*, **GD5**, 20th-24th July 2015, Toulouse, France.

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