# Architectural Archetypes Database
## – Propositions for WUDAPT

**Valéry Masson[1], Marion Bonhomme[2], Julia Hidalgo[3], Nathalie Tornay[2], Serge Faraut[2], Robert Schoetter[1]**
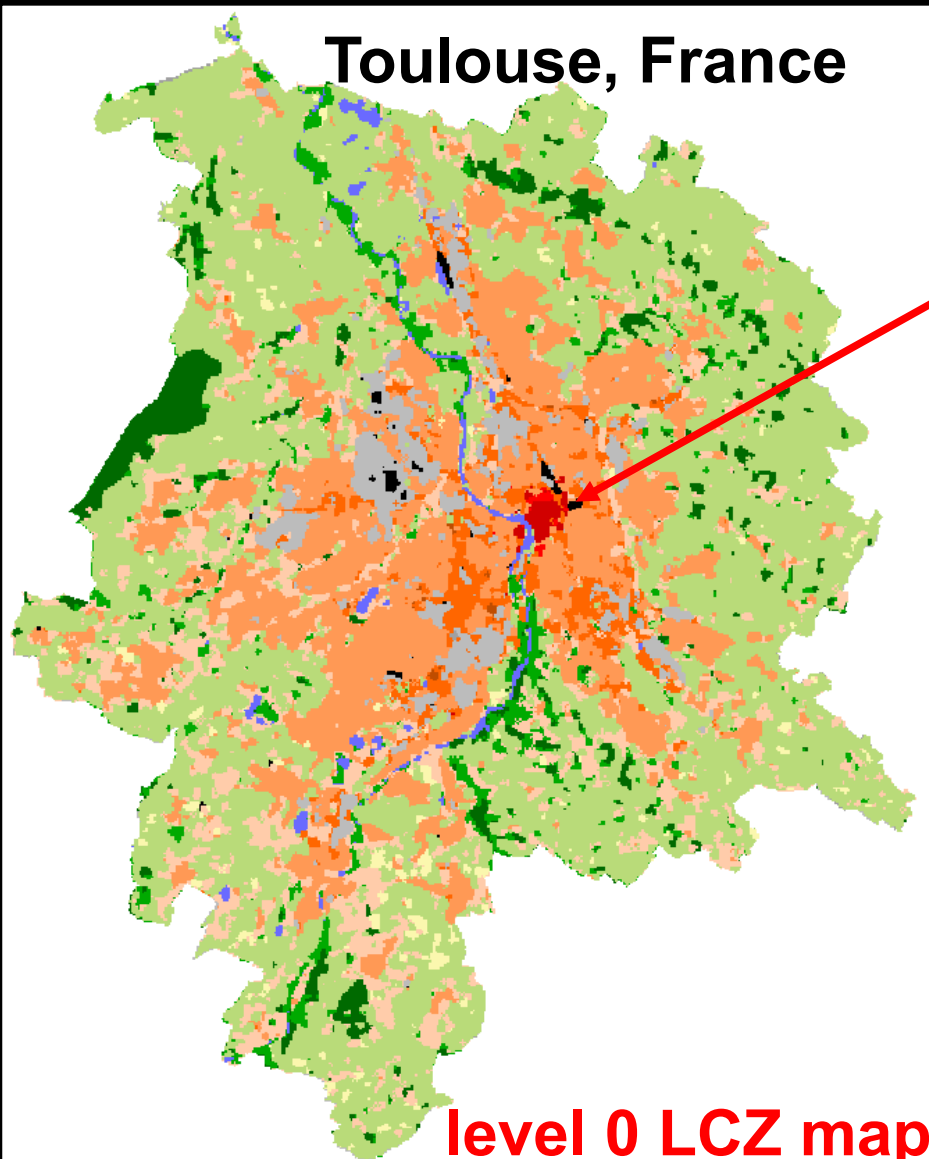
1) CNRM, Météo-France/CNRS, Toulouse, France
2) Laboratory of Research in Architecture, Toulouse, France
3) University of Toulouse - Jean Jaurès, Toulouse, France

# Outline

- **Required data for WUDAPT**

- **Methodology of Architectural types (from MAPUCE to WUDAPT)**

- **Example for Toulouse**
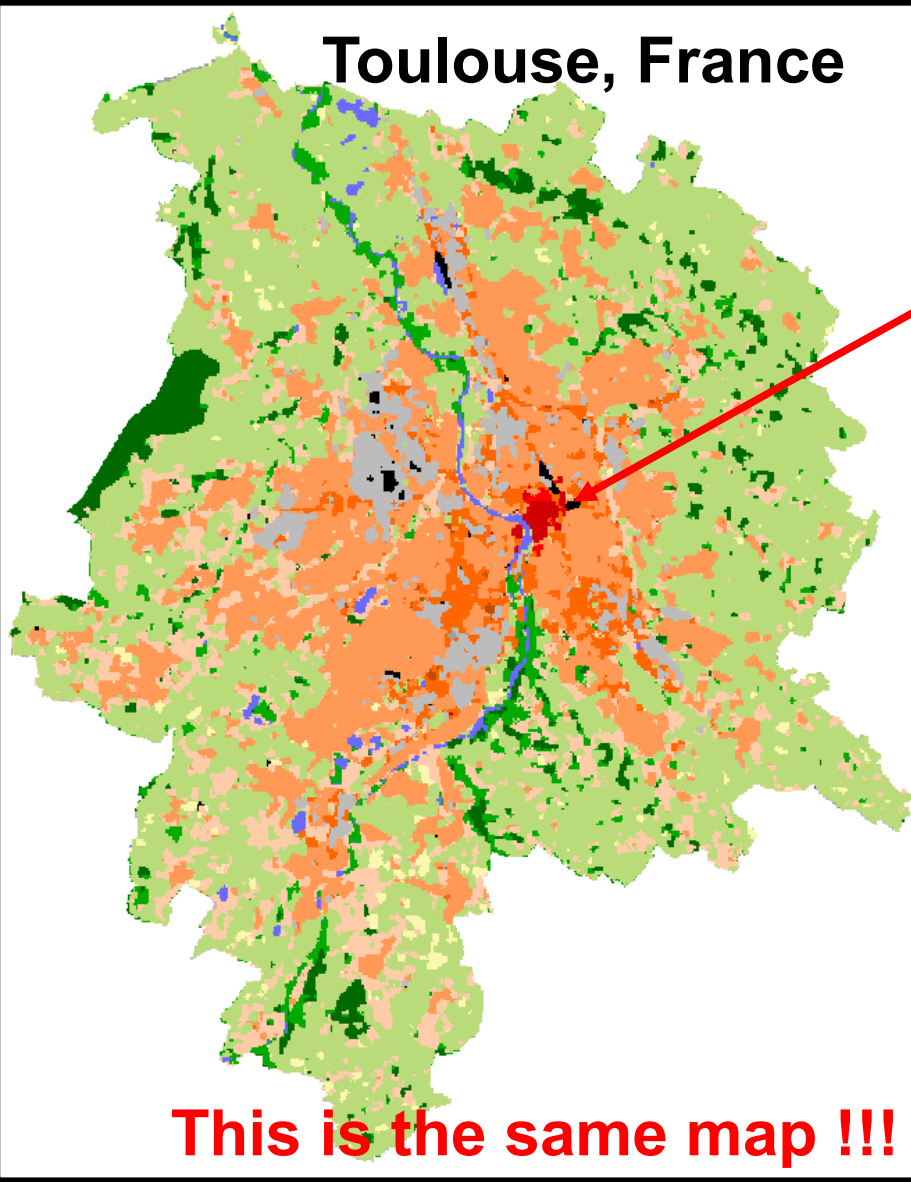
- **Propositions for WUDAPT**

**Toulouse, France**

**Level 0**

**level 0 LCZ map**

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 reduced. Heavy construction materials (stone, concrete, brick, tile); thick roofs and walls. Land cover mostly paved or hard-packed. Few or no trees. Moderate space heating/cooling demand. Moderate to heavy traffic flow. *Function*: Residential (multi-unit housing; multistorey tenements); commercial (office buildings, hotels, retail shops); industrial (warehouses, factories). *Location*: Core (old city, old town; inner city, central business district); periphery (high-density sprawl). *Correspondence*: UCZ2 (Oke 2004); A1, A2, A4, Dc2 (Ellefsen 1990/91).

**ILLUSTRATION**

*High angle*

*Low level*

**PROPERTIES**

| Property | | | | | |
|---|---|---|---|---|---|
| *Sky view factor* $0.3 - 0.6$ | | | | | |
| *Canyon aspect ratio* $0.75 - 2$ | | | | | |
| *Mean building height* $10 - 25$ m | | | | | |
| *Terrain roughness class* $6 - 7$ | | | | | |
| *Building surface fraction* $40 - 70\ \%$ | | | | | |
| *Impervious surface fraction* $30 - 50\ \%$ | | | | | |
| *Pervious surface fraction* $< 20\ \%$ | | | | | |
| *Surface admittance* $1{,}500 - 2{,}200$ J m$^{-2}$ s$^{-1/2}$ K$^{-1}$ | | | | | |
| *Surface albedo* $0.10 - 0.20$ | | | | | |
| *Anthropogenic heat flux* $< 75$ W m$^{-2}$ | | | | | |

**Toulouse, France**

**This is the same map !!!**

# Level 1

## Specific for Toulouse region

| 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 reduced. Heavy construction materials (stone, concrete, brick, tile); thick roofs and walls. Land cover mostly paved or hard-packed. Few or no trees. Moderate space heating/cooling demand. Moderate to heavy traffic flow. *Function*: Residential (multi-unit housing; multistorey tenements); commercial (office buildings, hotels, retail shops); industrial (warehouses, factories). *Location*: Core (old city, old town; inner city, central business district); periphery (high-density sprawl). *Correspondence*: UCZ2 (Oke 2004); A1, A2, A4, Dc2 (Ellefsen 1990/91).

**ILLUSTRATION**

High angle

Low level

**PROPERTIES**

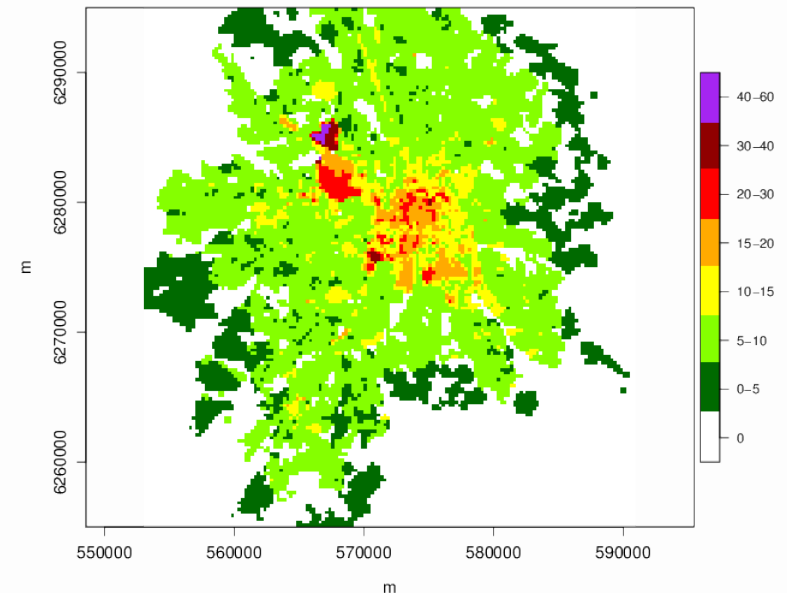| | |
|---|---|
| *Sky view factor* 0.3 – 0.6 | |
| *Canyon aspect ratio* 0.75 – 2 | |
| *Mean building height* 10 – 25 m | |
| *Terrain roughness class* 6 – 7 | |
| *Building surface fraction* 40 – 70 % | |
| *Impervious surface fraction* 30 – 50 % | |
| *Pervious surface fraction* < 20 % | |
| *Surface admittance* 1,500 – 2,200 J m$^{-2}$ s$^{-1/2}$ K$^{-1}$ | |
| *Surface albedo* 0.10 – 0.20 | |
| *Anthropogenic heat flux* < 75 W m$^{-2}$ | |

**Toulouse, France**

**This is the same map !!!**

# Level 2

**+ fine scale data**

e.g. building height map
*(source : MAPUCE project)*

**One can mix levels 1 & 2**

# How can we obtain the lvl 1 & 2 parameters ?

- **Building height (& other morphological parameters) maps**   **OK**
  - **From GIS building data**
  - **From satellite data**

- **Land use (vegetation, impervious surfaces)**   **OK**
  - **From satellite images**

- **Anthropogenic heat fluxes**
  - **From vehicle counting**   **OK**
  - **From buildings energy models**   **NO**

- **Architecture (albedo, emissivity, thermal characteristics)**   **NO**
  - **???**
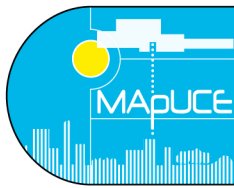
# Architectural types : MapUCE project

**Transdisciplinary project**

**Goal n°1: develop modelling strategy <u>to provide data on urban climate and building energy demand</u>**

**Urban data (morphology, architecture, socio-economical)**

**Adaptation of TEB**

**Simulations and evaluation**

| | |
|---|---|
| ⬜ | Industrial / recreational building |
| ⬛ | High-rise building |
| 🟧 | Linear block in closed island |
| 🟧 | Linear block in open island |
| 🟨 | Isolated block |
| 🟪 | Outbuilding |
| 🟩 | Row house in closed island |
| 🟩 | Row house in open island |
| 🟦 | Detached house |
| 🟦 | Semi-detached house |
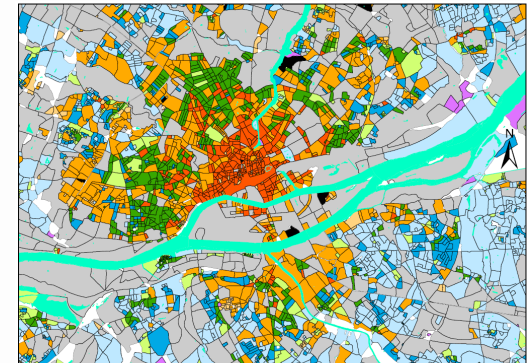
Typology

*Example: building type in Nantes*

**Goal n°2 : develop methods to take into account the produced data <u>for urban planning</u>**

# The MapUCE database - Overview
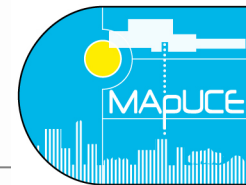
**Administrative datasets**
- Digital basic map
- Census data
- ...

**Urban tissue**
- Building type, use, LCZ
- Construction period
- Geographical location

**Surveys on human behaviour**

LIENSs — Lab-STICC — LRA — LATTS

**Urban morphology**
- Building height
- Building fraction
- ….

**Building architecture**
- Roof and wall materials
- Insulation
- ….

**Behavioural indicators**
- Heating design temperature
- Internal heat release
- ….

**The MaPUCE data will be available for the 80 largest cities in France**

**TEB-BEM & other models**

CNRS — METEO FRANCE
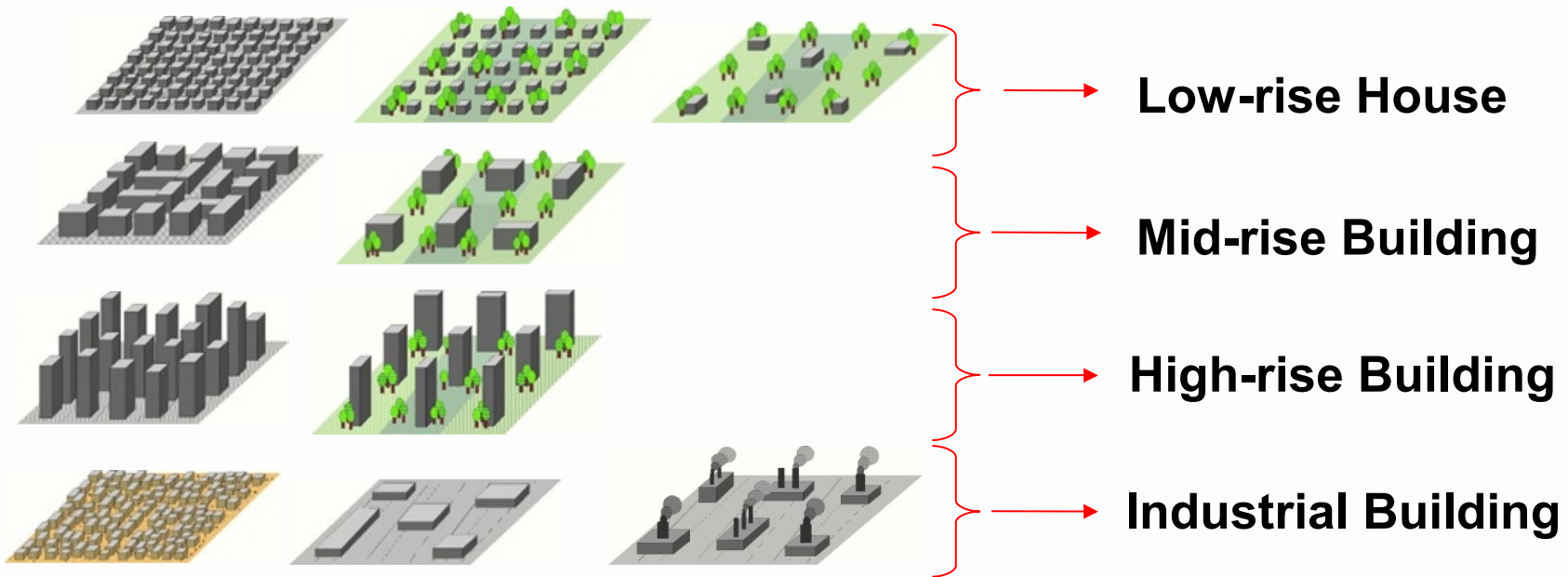
# Architectural typologies

**Administrative datasets**
- Digital basic map
- Census data
- ...

**Urban tissue**
- Building type, use, LCZ
- Construction period
- Geographical location

**Surveys on human behaviour**

**Urban morphology**
- Building height
- Building fraction
- ….

**Building architecture**
- Roof and wall materials
- Insulation
- ….

**Behavioural indicators**
- Heating design temperature
- Internal heat release
- ….

**TEB-BEM & other models**

**The MaPUCE data will be available for the 80 largest cities in France**

# Architectural typologies
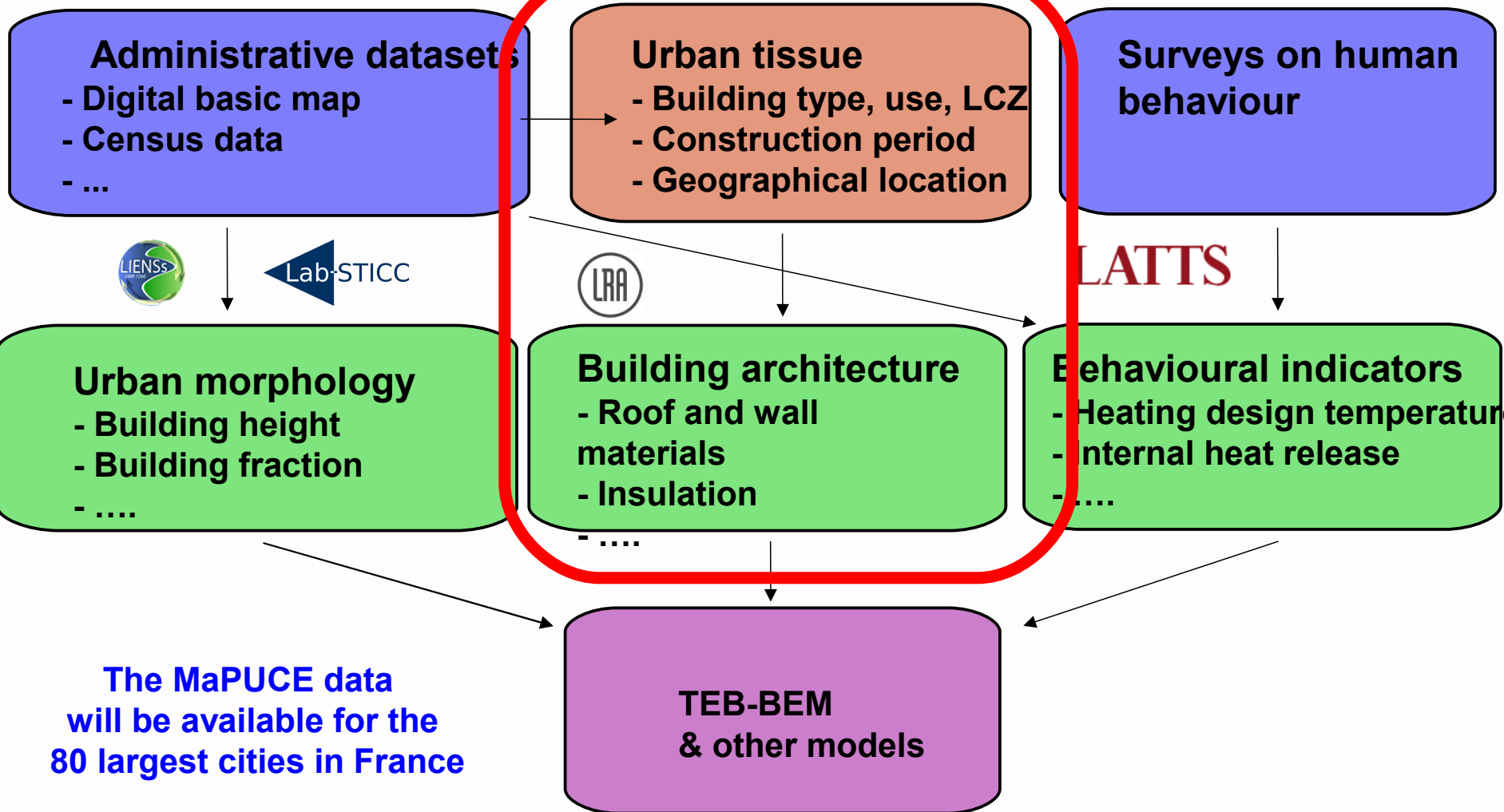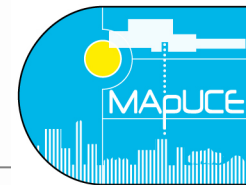
**From 10 LCZ** ⟶ **4 archetypes of buildings (architecturally speaking)**

**→ this reduces the number of needed architectural information**



**Low-rise House**

**Mid-rise Building**

**High-rise Building**

**Industrial Building**

# Conclusions of WUDAPT December workshop

## For each of the 4 Architectural typologies :

- **Required architectural description :**
  - Wall materials (material, presence of insulation) & covering / colour
  - Roof materials
  - Window/wall ratio
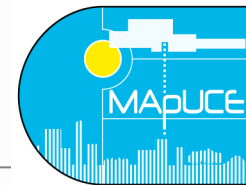  - Use of Heating or Air Conditioning systems
  - Number of floors

- **That may depend on :**
  - Building's use
  - Building's age
  - Location : country, …

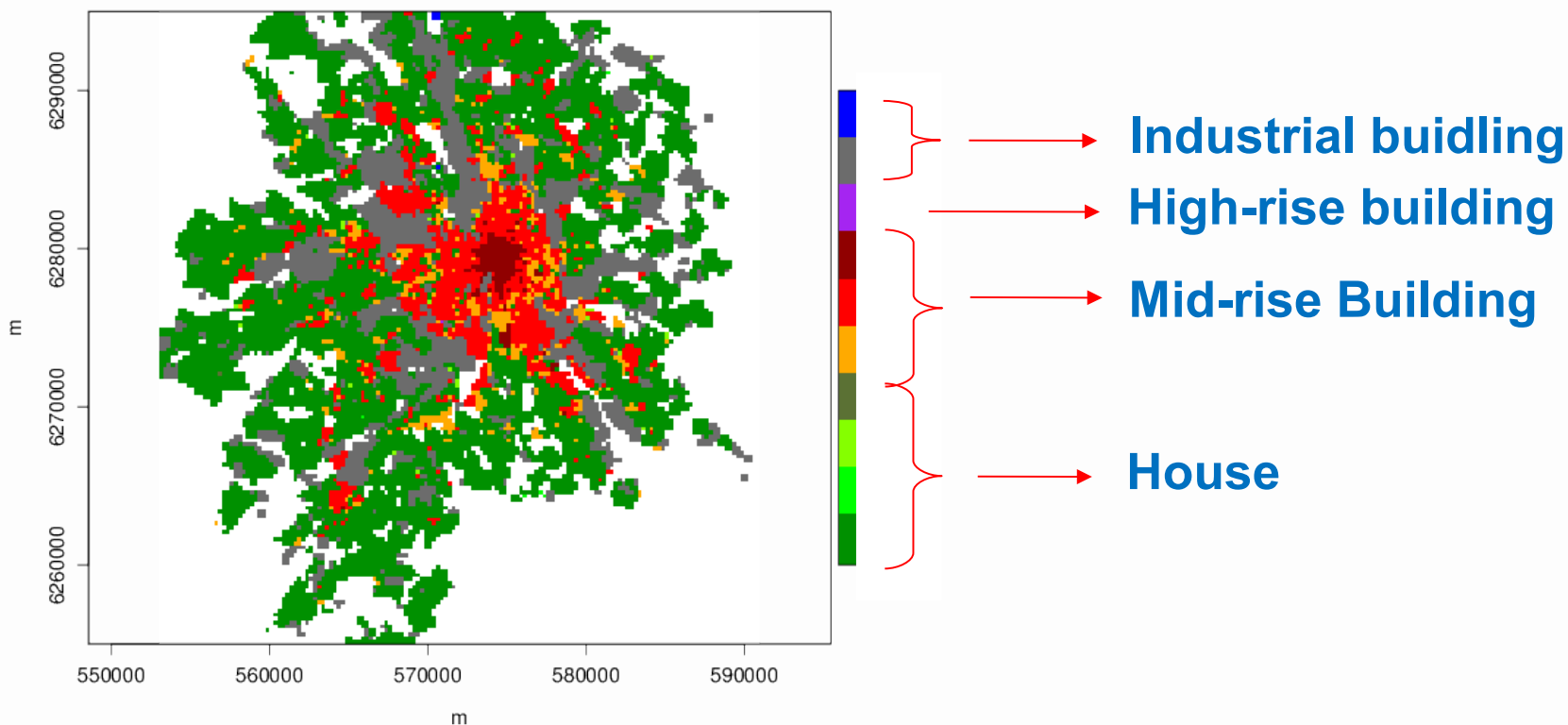**architectural information**

→ **Need of a architectural information**
→ **Need to link with the physical variables of models**

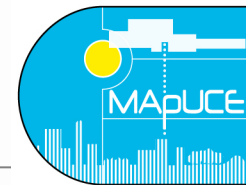# Example for Toulouse : Building's types

**Level 2 building's type :**

*Where are the 4 buildings architectural types?*



Industrial buidling

High-rise building

Mid-rise Building

House

*Map of building's typologies*

**Level 2 building's type**

   **+**

**Level 2 building's use (not shown)**

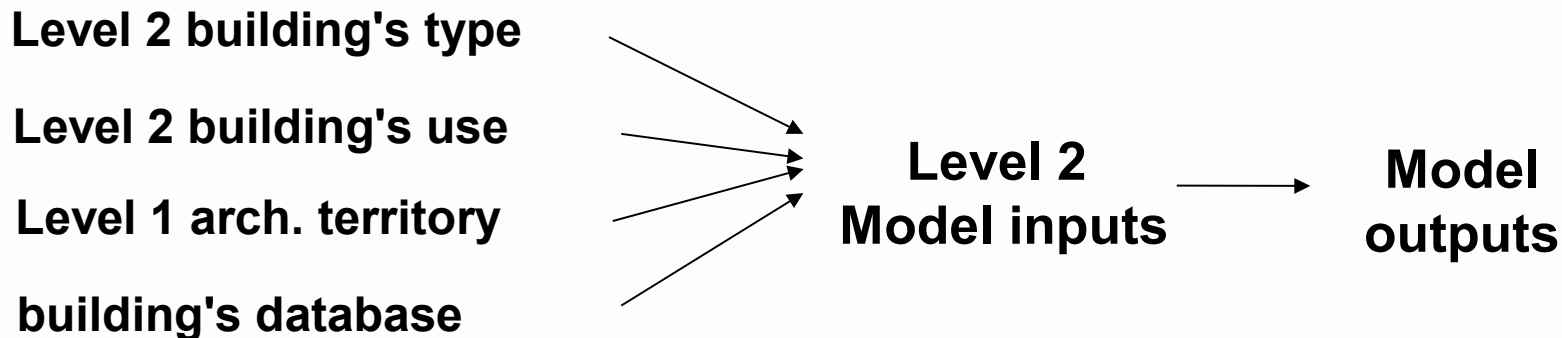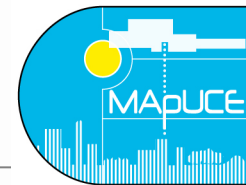   **+**

**Level 2 building's age (not shown)**

   **+**

**Location : Toulouse region**

We use architectural characteristics
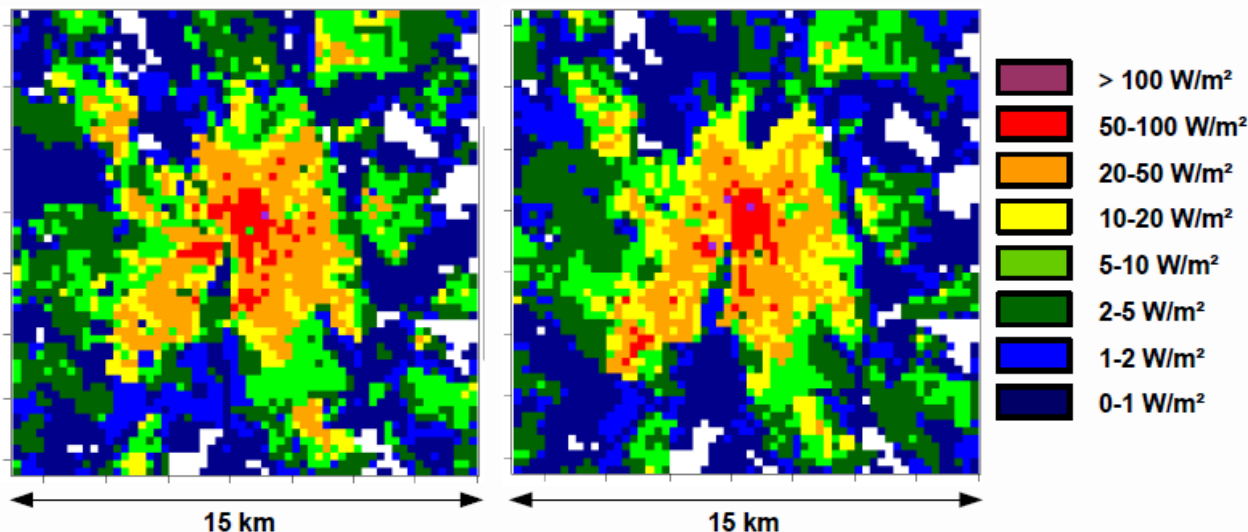Typical from Toulouse agglomeration
(red bricks for old buildings, ...)

# Example for Toulouse :
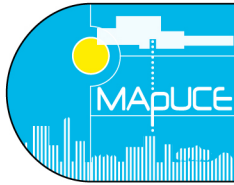# Modelling of Energy Consumption

**Level 2 building's type**

**Level 2 building's use**

**Level 1 arch. territory**

**building's database**

→ **Level 2 Model inputs** → **Model outputs**

**Simulated (TEB) building's anthropogenic flux**

**Inventory (top-down method)**



| | |
|---|---|
| | > 100 W/m² |
| | 50-100 W/m² |
| | 20-50 W/m² |
| | 10-20 W/m² |
| | 5-10 W/m² |
| | 2-5 W/m² |
| | 1-2 W/m² |
| | 0-1 W/m² |

15 km          15 km

# Architecture varies from one location to another

## At country scale (here France)



*Architectural territories
Before 1948 (a lot of variety)*

Legend:
- GREA
- VOLA
- SCHT
- MEUT
- GRET
- GRAT
- GRAA
- GNET
- GALT
- TERT
- CALT
- CALA
- CALZ
- BRIT
- BOIA
- BOIT

# Architecture varies from one location to another

At world scale ( →  WUDAPT )


Seattle


Copenhagen
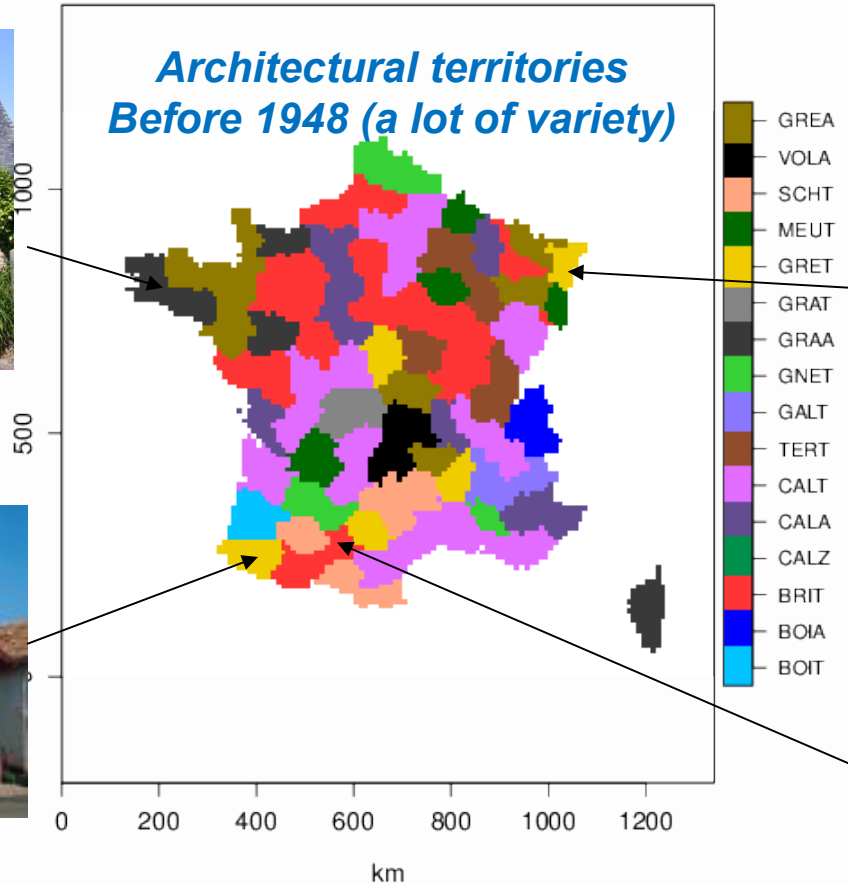
**Architecture for mid-rise buildings**


Shanghai


Quito, Equador


Andalousia


Tombouctou, Mali
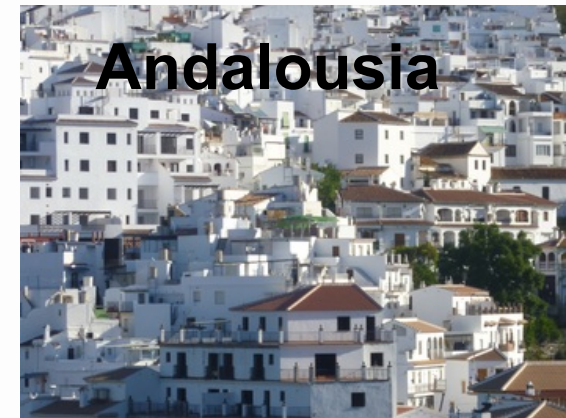
# Architecture varies from one location to another

At world scale ( → WUDAPT )

**Architecture for houses**


Seattle


Copenhagen


Shanghai


Quito, Equador


Andalousia


Tombouctou, Mali
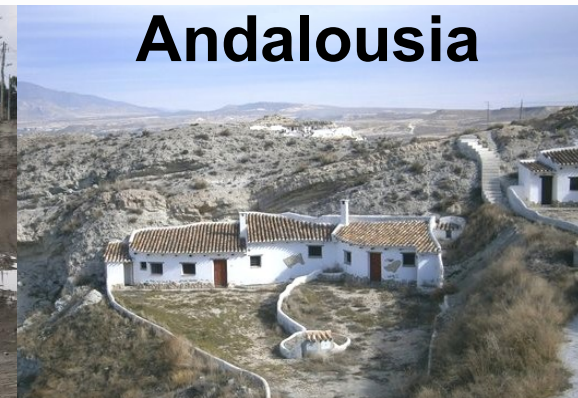
- **To think in terms of 4 buildings archetypes**
  - Houses, Buildings, High-rise buildings, Industrial buildings

- **To define building's architectural properties**
  - For each territory (Country ? Continent ? Region? City ? LCZ ?)
  - Potentially as a function of : building's use & age, local population income

- **The information could be gathered through**
  - Architects' expertise
  - Crowdsourcing
  - Other sources ?