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Evaluating the urban climate using geo-database: GEOCLIM TOOL

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ICUC9, Toulouse 20th-24th July, Toulouse, France

INTRODUCTION

Need for tools to assess the urban planning impact on UHI that are:

- Simple
- Based on commonly available data

Previous researches show that UHI is strongly linked to urban form and land use

- SVF (Chen et al., 2012; Gál, Lindberg, & Unger, 2009; Lindberg, 2007; Unger, 2004, 2009…)
- Urban vegetation (Takehiko &Yasushi, 2009 ; Cao et al., 2010; Shashua-Bar & Hoffman 2004…)

OVERVIEW

I. Method

II. Urban form characterization

III. Analytical formulation of SW radiation

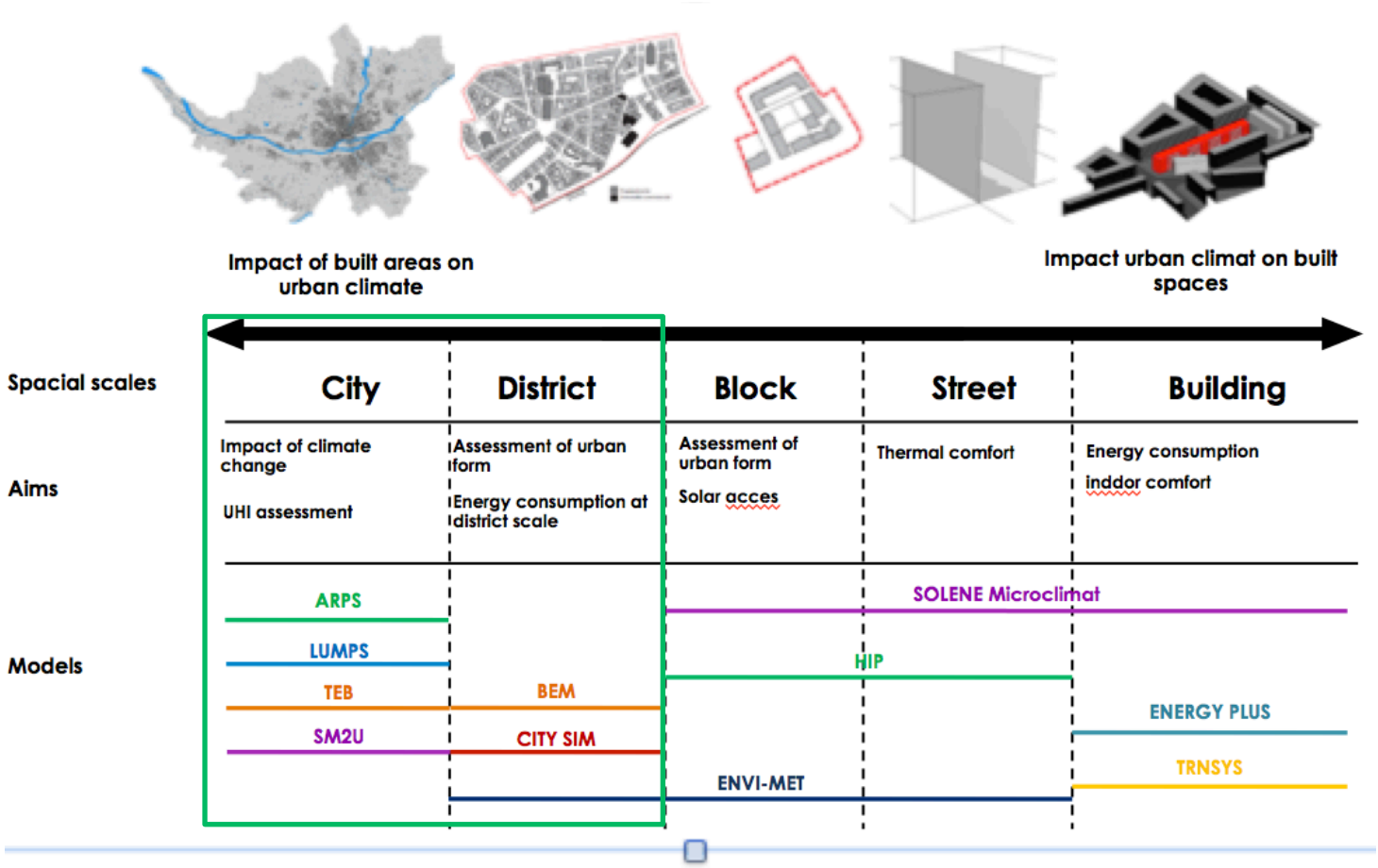
IV. Model construction

V. Conclusions

I. METHOD

I. METHOD

1. Scale



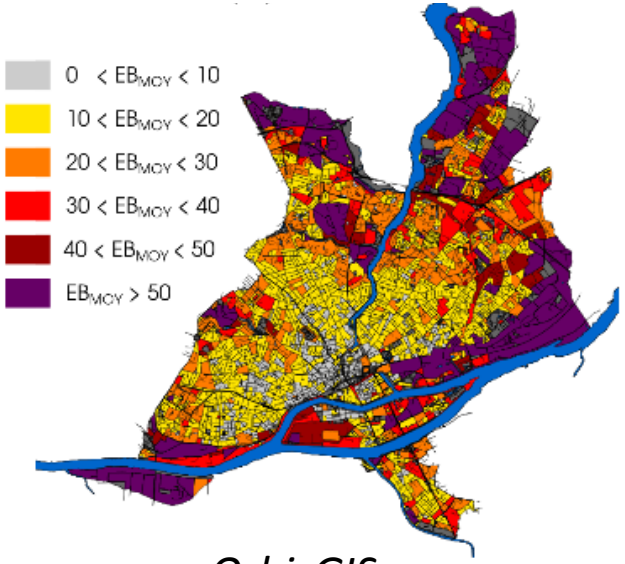
I. METHOD

2. Urban unit: the urban block

I. METHOD

3. Urban typology

Ex: Mean space between buildings



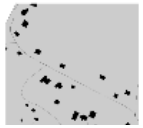
OrbisGIS

City center

Suburban

Discontinued housing

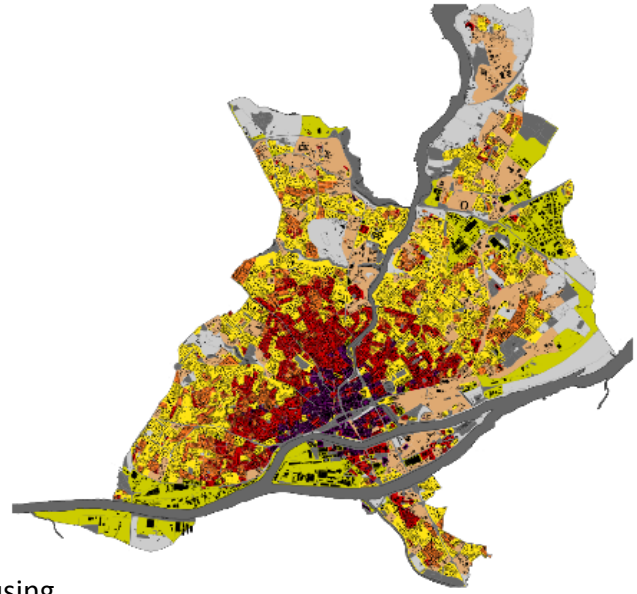
Continued housing



Scattered housing

Collective buildings

Industrial areas

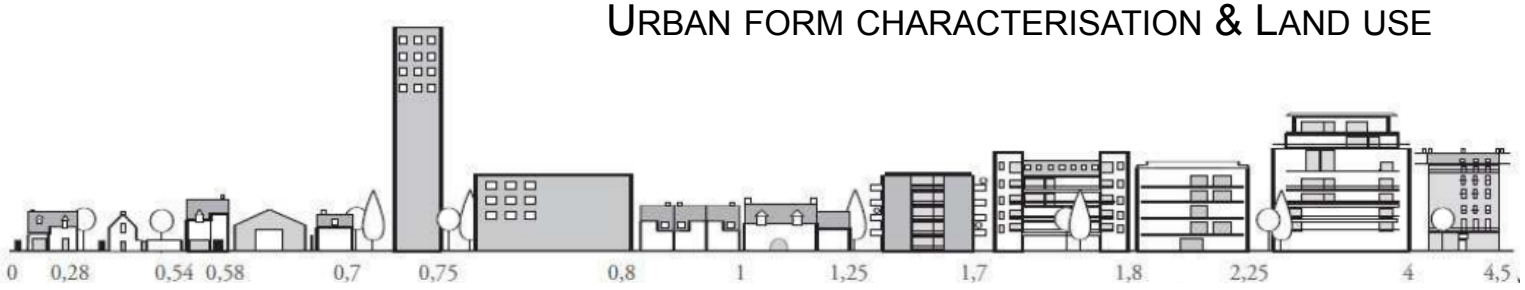


I. METHOD

4. Model

1

URBAN FORM CHARACTERISATION & LAND USE



2 SW RADIATIVE MODEL

3 LW RADIATIVE MODEL

4 TRANSFER IN BUILDINGS AND SOIL

5 ASSEMBLING : AIRFLOW - ADVECTIVE MODEL

II. URBAN FORM CHARACTERIZATION

II. URBAN FORM CHARACTERIZATION

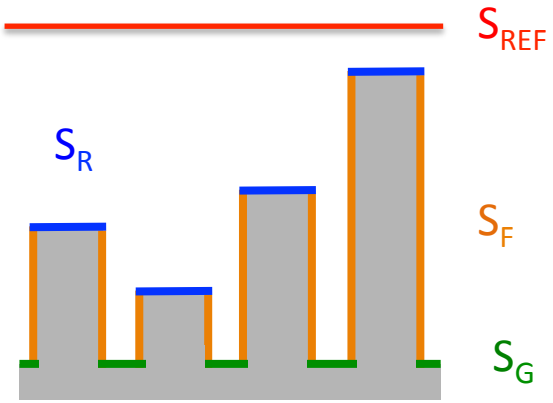
Simple calculation: performed in a GIS

Built density

$D_B = S_{ROOF}/S_{REF}$

Facade density

$D_F = S_F/S_T$

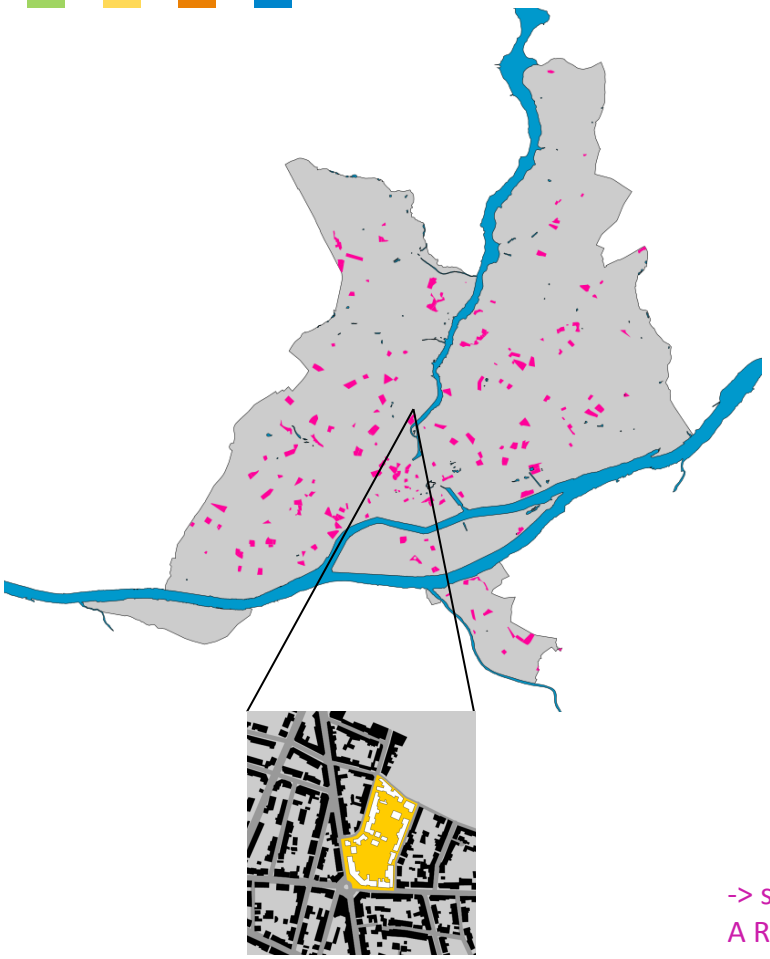


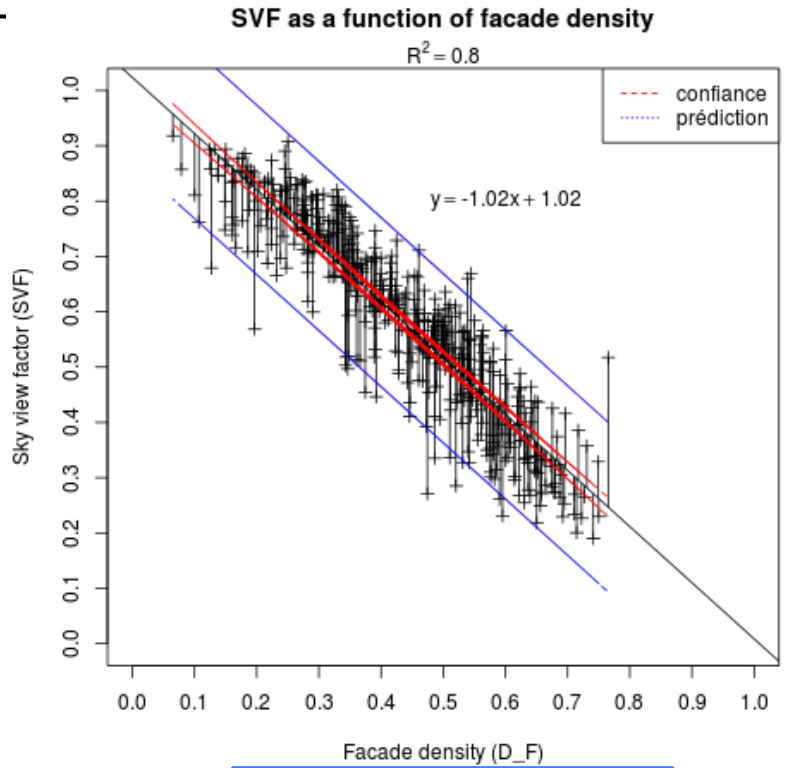
$S_T = S_G + S_F + S_R$
$= S_{REF} + S_F$

Calculation for wich a 3D model is needed

Sky-view factor

II. URBAN FORM CHARACTERIZATION





$SVF_{BLOCK}=1-D_F$

-> see: Groleau, D., Mestayer, P., 2013. Urban Morphology Influence on Urban Albedo: A Revisit with the Solene Model. Boundary-Layer Meteorology 147, 301–327.

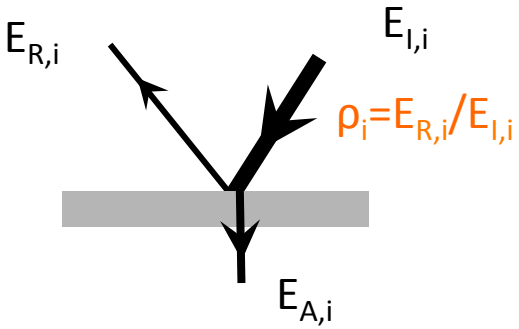
Bernabé, A. et al.. Radiative and heat storage properties of the urban fabric derived from analysis of surface forms. Urban Climate.

III. ANALYTICAL FORMULATION OF SW RADIATION

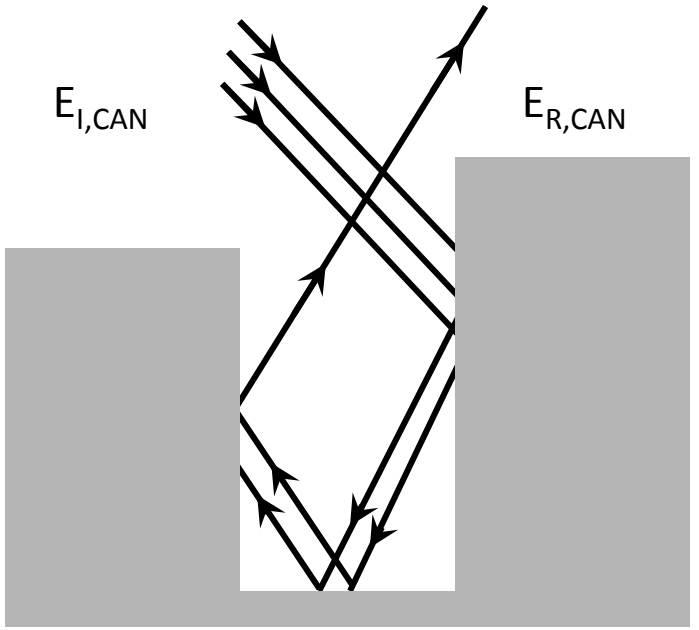
III. ANALYTICAL FORMULATION OF SW RADIATION

1. Radiative trapping formulation

Surface albedo



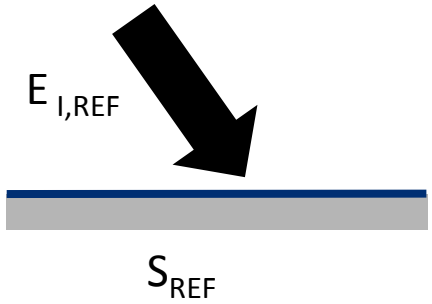
Multiple reflections in the urban form



Equivalent albedo

$\rho_{CAN}=E_{R,CAN}/E_{I,CAN}$

III. ANALYTICAL FORMULATION OF SW RADIATION



Using energy conservation law, and SVF=1-D_F we obtain :

$$E_{I,BLOCK}=(1-D_F)\ E_{I,REF}$$

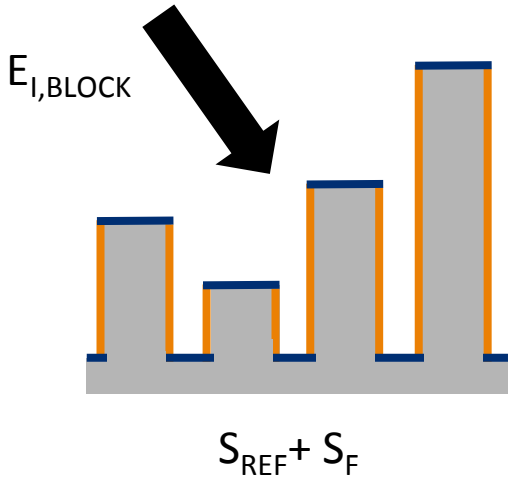
Initial irradiance

$$E_{A,BLOCK}=(1-\rho)\ (1-D_F)\ (1+\gamma)\ E_{I,REF}$$

Absorbed SW radiative flux

$$\gamma=D_F*\rho*(1-D_B)/((1-D_B)*(1-D_F)+D_F*(1-\rho))$$

Contribution of multiple reflections

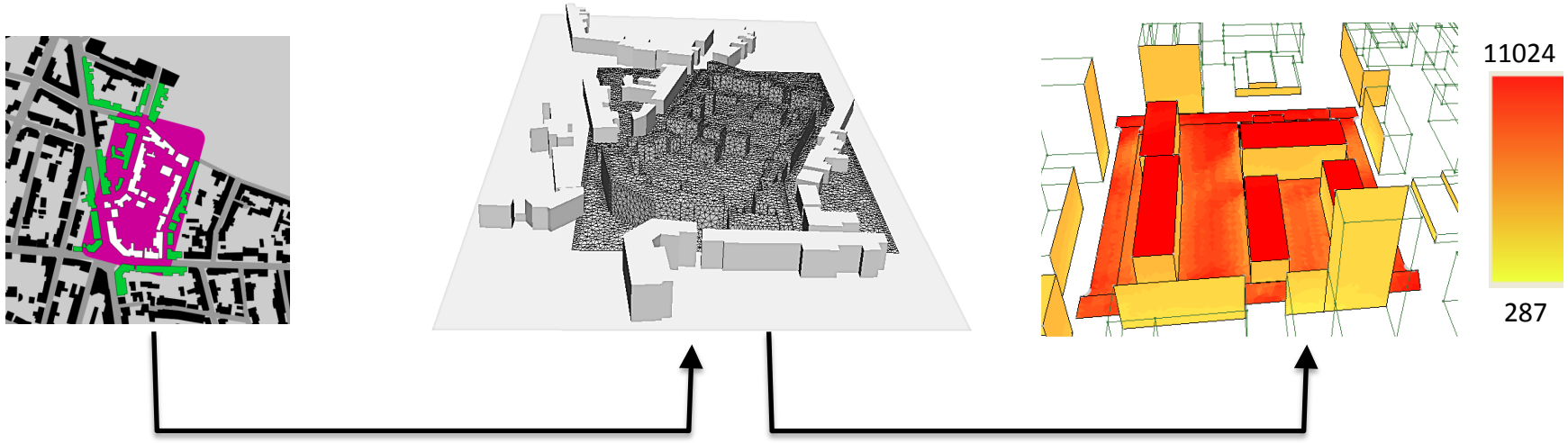


Equivalent albedo

$$\rho_{BLOCK} = \rho - \gamma + \rho * \gamma$$

III. ANALYTICAL FORMULATION OF SW RADIATION

2. Validation

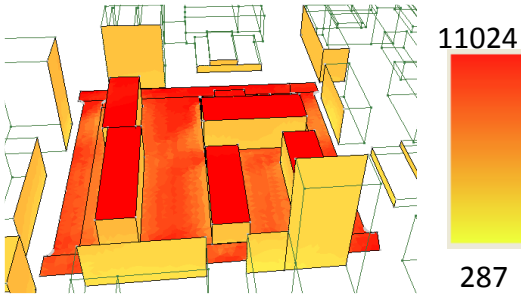


Use of SOLENE for irradiance and multiple reflection calculation

III. ANALYTICAL FORMULATION OF SW RADIATION

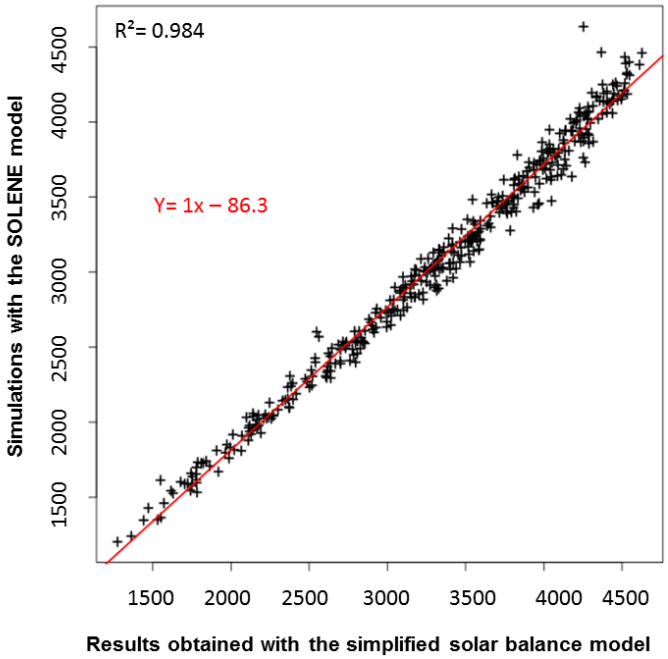
Formulation based on urban form

SOLENE Calculation



D_F D_B SVF → **SOLENE** → Radiative fluxes and albedo

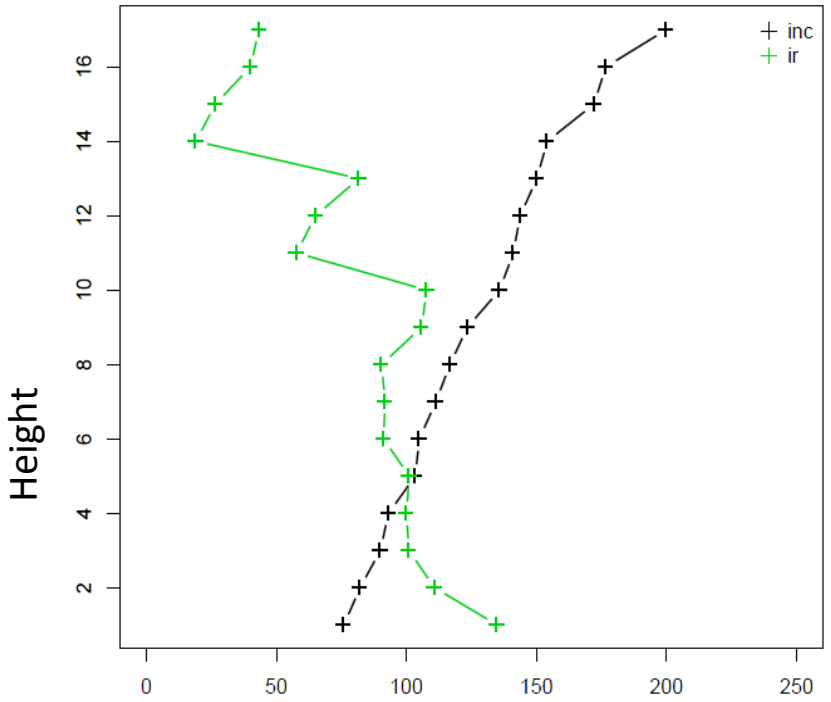
Comparison



Example: daily absorbed solar flux with ρ=0.45 – June 21th

III. ANALYTICAL FORMULATION OF SW RADIATION

3. Vertical variation of fluxes



Initial irradiance (black) and multi reflections (green)

VI. MODEL CONSTRUCTION

VI. MODEL CONSTRUCTION

- LW radiative flux also expressed asa function of SVF then D_F
- Exchanges with building expressed from, built density and building types

  See paper presented by J. Bernard « Urban heat island and inertial effects : analyse from field data to spatial analysis »

- Airflow expressed in function on frontal density

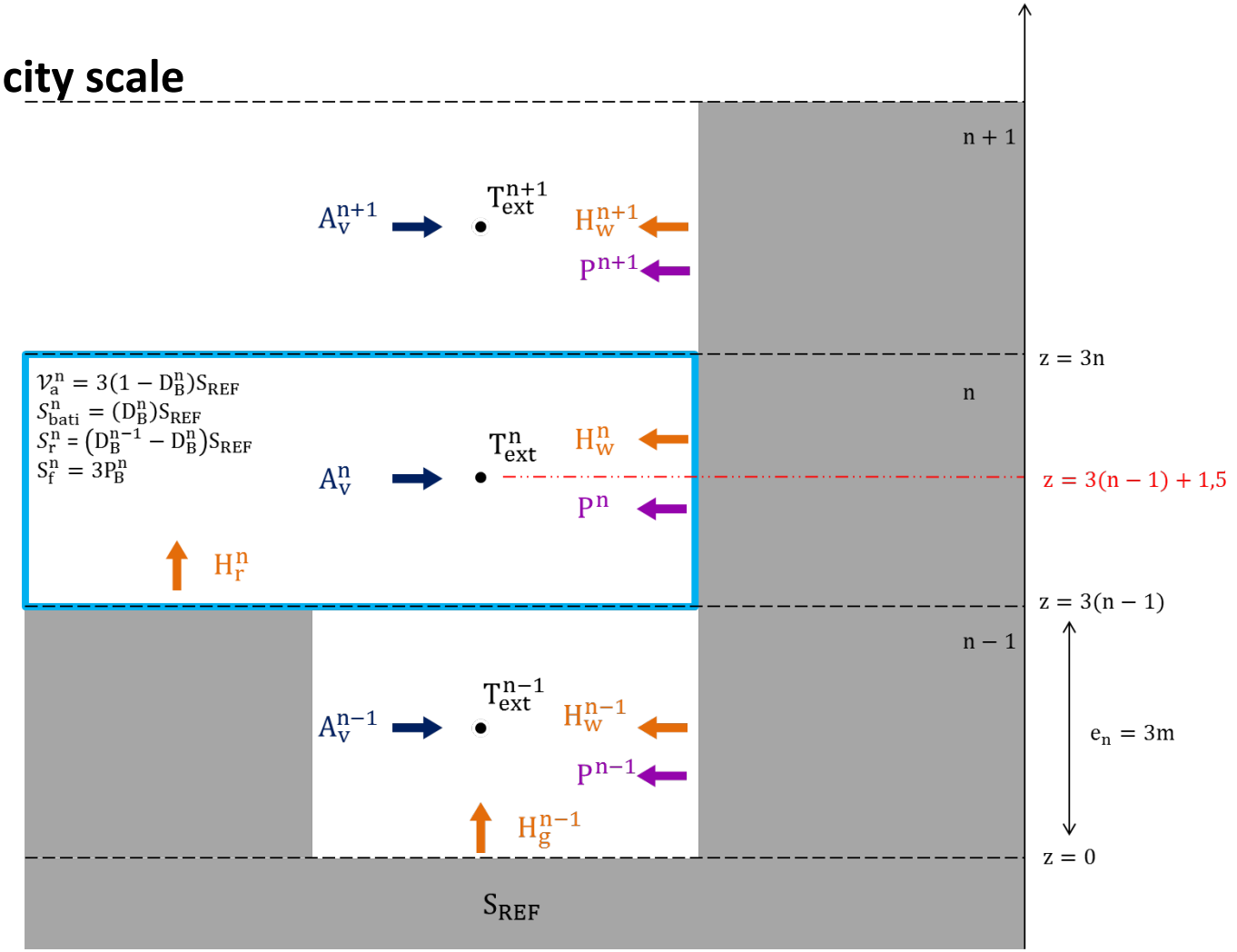
VI. MODEL CONSTRUCTION

A zonal model at the city scale

Blocks are splitted into layers: creating cells

Airflows, and advective fluxes are calculated between cells

Energy balance is written for each cell to calculate air temperature



V. CONCLUSIONS

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- A radiative model at the block scale based on morphology that can be used in mesoscale climate models (-> ARPS-VUC)
  - Validated for homogeneous reflectivities
  - Must be studied for heteogeneous reflectivities

- A urban climate model based on zonal models methods and GIS
  - In progress

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