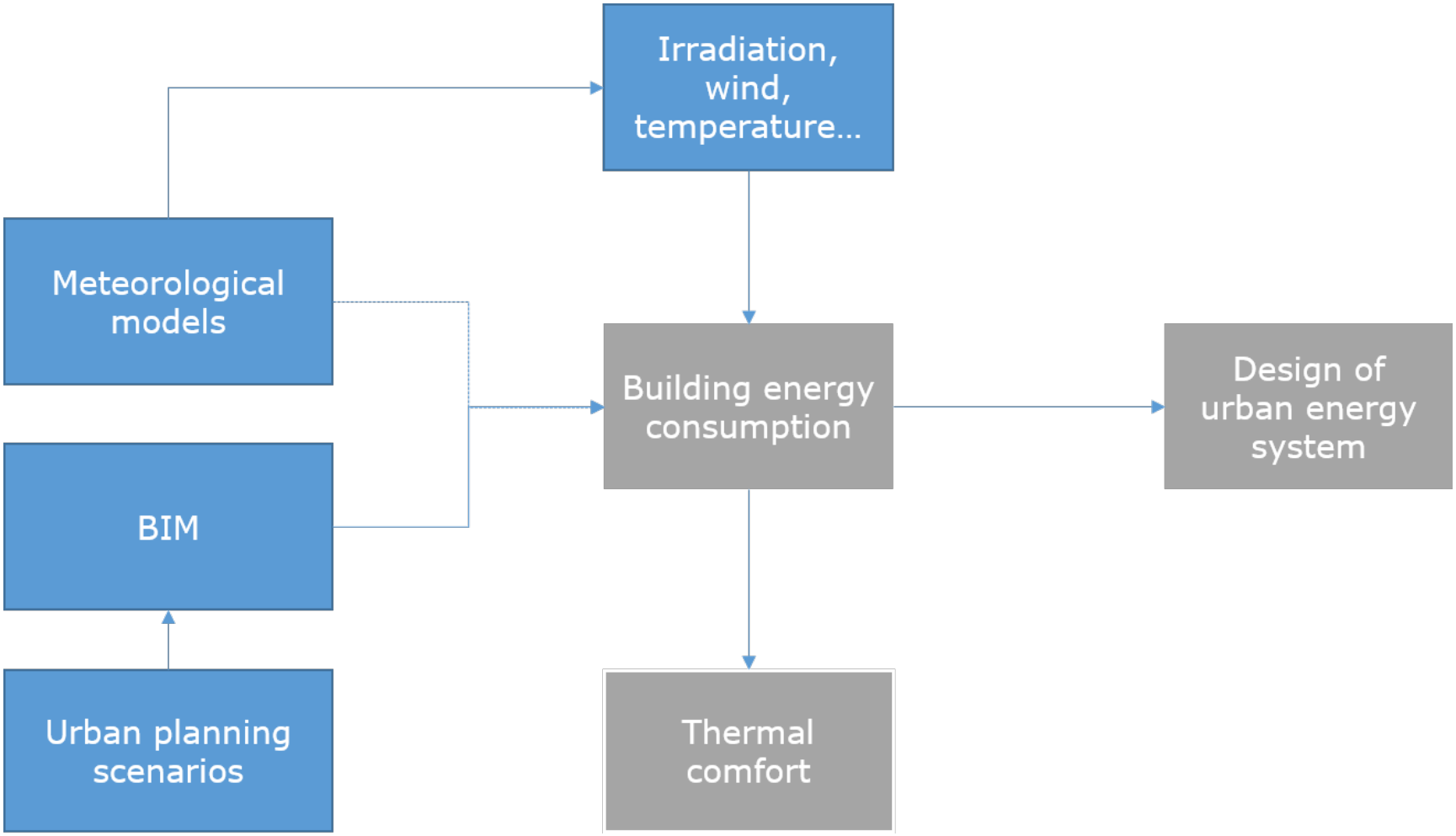
Impact of buildings on the urban climate: modeling and experimental approaches

5 septembre 2017

Urban system simulations group



Study of the impact of buildings on urban climate

1) Introduction
2) Modeling tools
3) Measurement campaign : MoTUS
4) Conclusions & perspectives

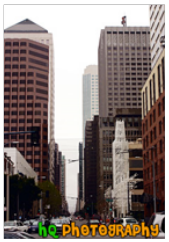
Introduction : Interaction at different scales

GLOBAL

Seasonal variations

MESO

Topography, Land uses
Urban-Rural Interaction



NEIGHBORHOOD

Obstacle effects
Urban canopy – atmosphere interaction

BUILDING

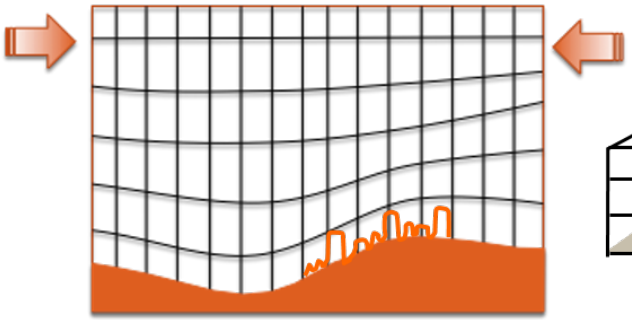
Building energy use

Domain size

+1000KM	+100KM	1KM	10M

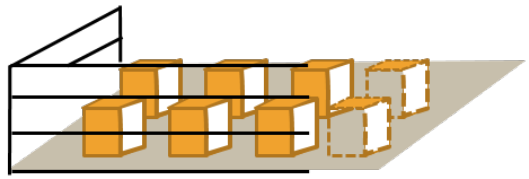
6

Modeling tools : current state



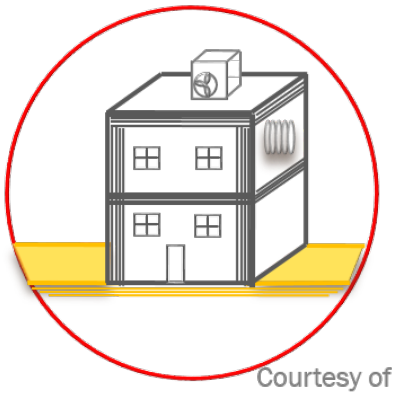
WRF (Skamarock et al., 2008)
Meso-NH (Lafore et al., 1997)
FVM (Clappier et al., 1996)

Rugosity
Influence of obstacles
- Additional term in equations



BEP (Martilli et al., 2002)
TEB (Masson, 2000)

Buildings / Streets
Solar radiation



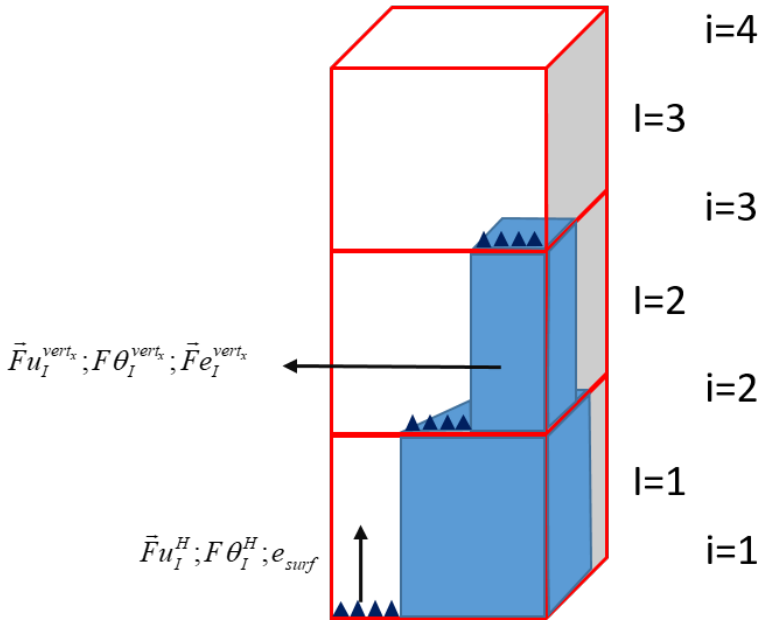
Courtesy of N. Blond

BEM (Krpo et al., 2010)

Walls, roofs & streets
Window
Cooling/ Heating

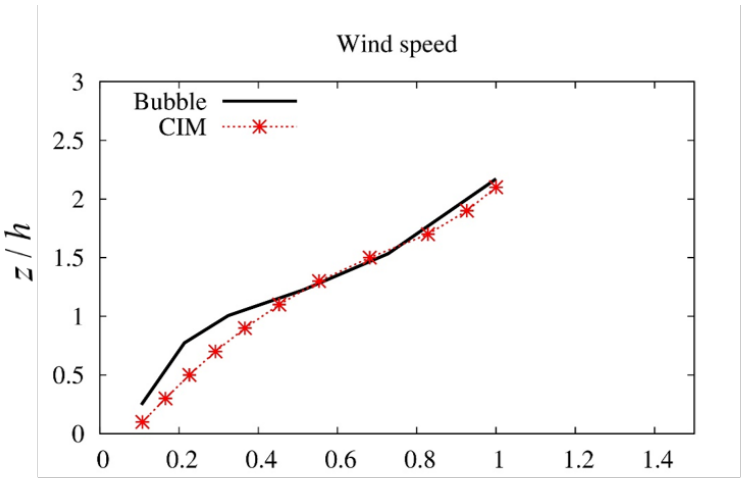
Domain size

Modeling tools :Canopy Interface Model

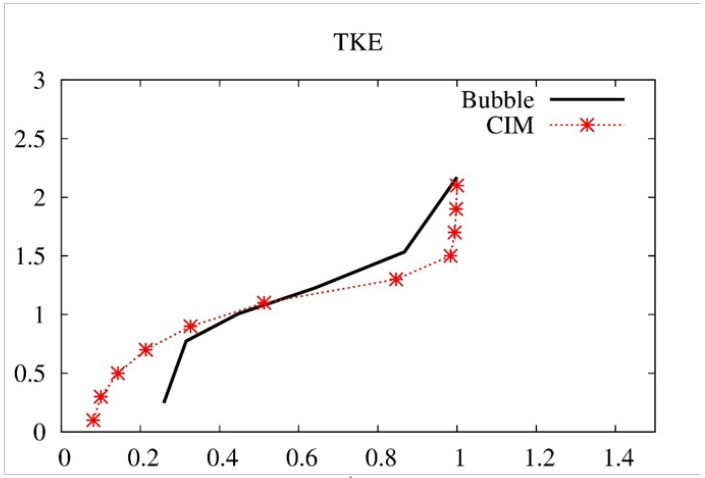


- Simulation of high resolution meteorological profiles
- Use of a diffusion model (computational efficiency)
- Idealized description of buildings / obstacles

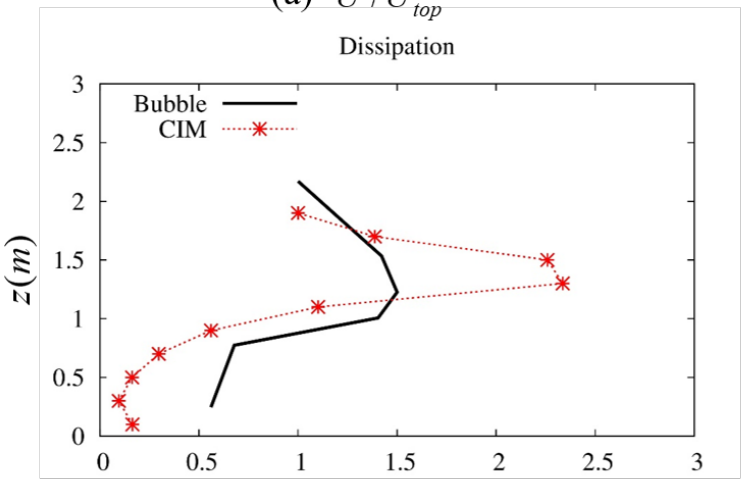
Modeling tools :Canopy Interface Model



(a) U / U_{top}



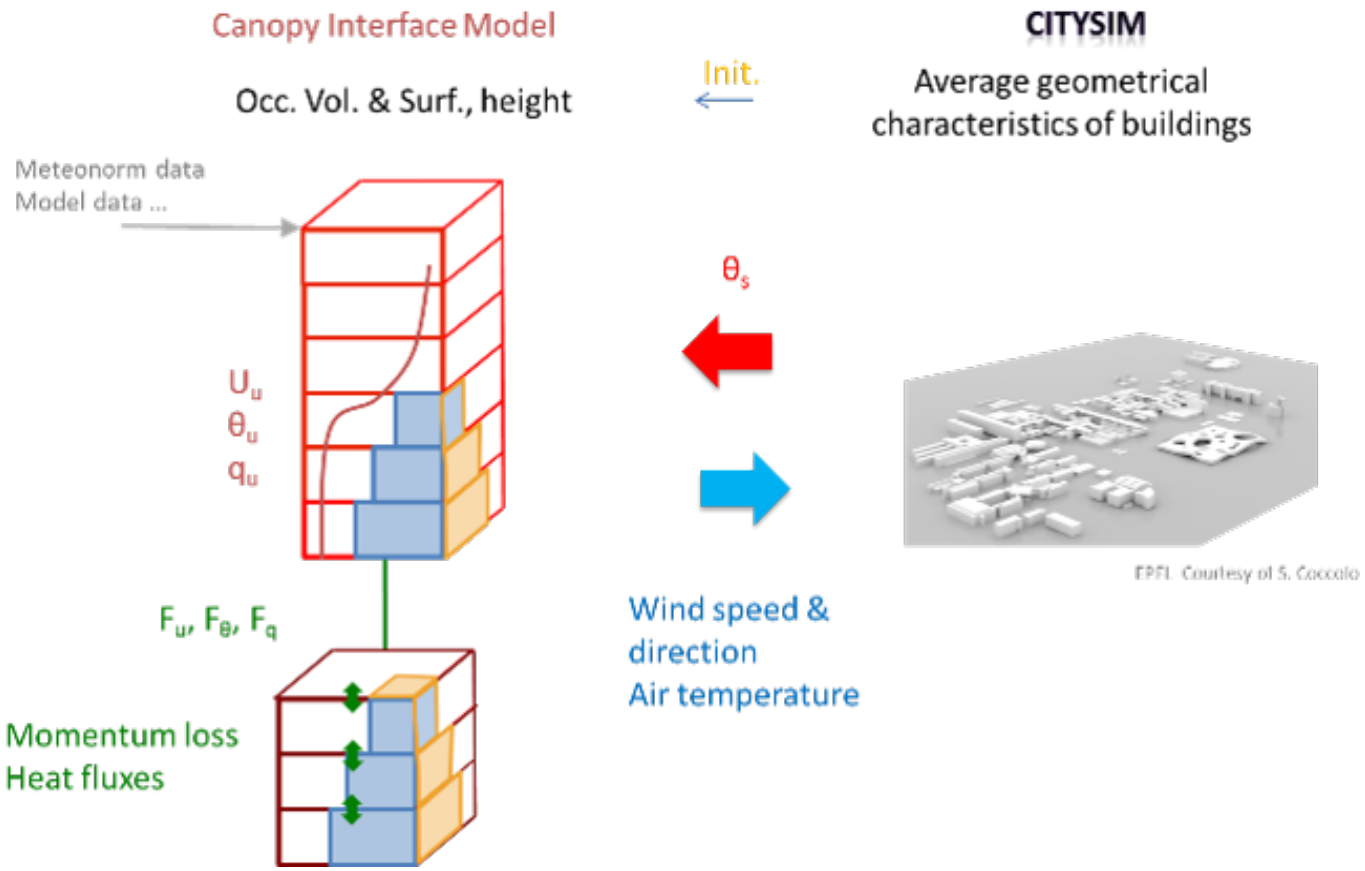
(b) e / e_{top}



(c) $\varepsilon / \varepsilon_{top}$

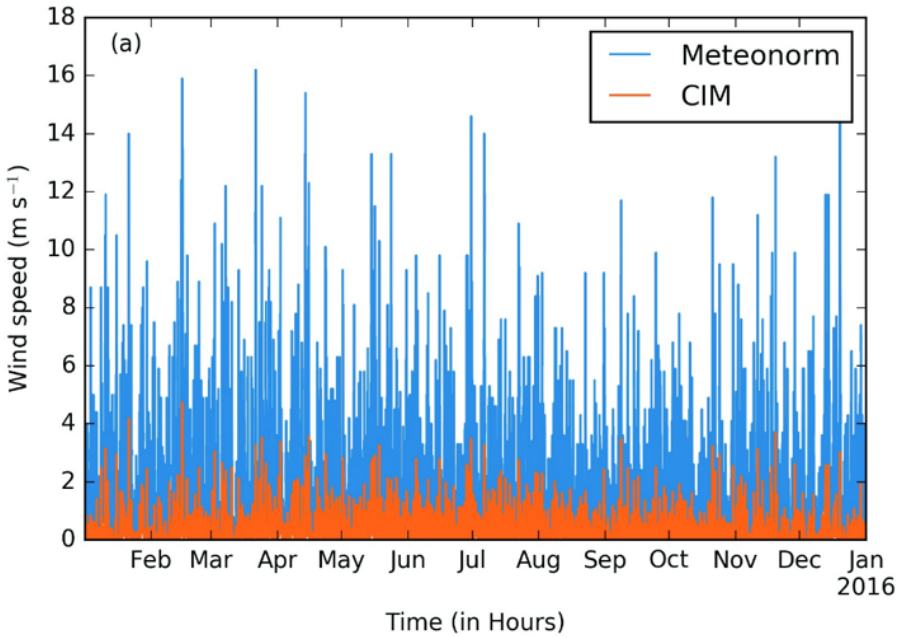
- Validation of CIM (Mauree et al., 2017a)

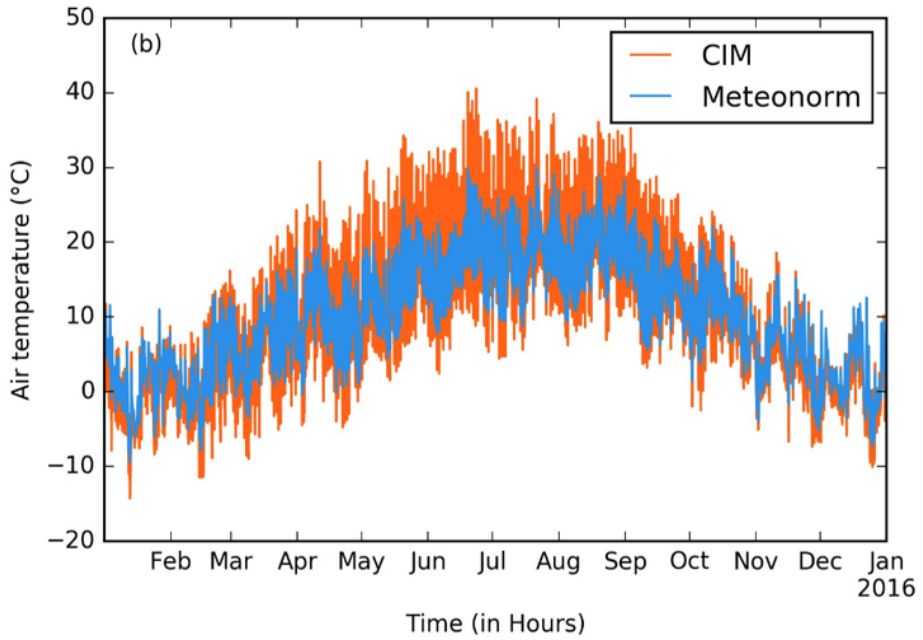
Modeling tools : CIM-CitySim



- Application of CIM results - Coupling with CitySim

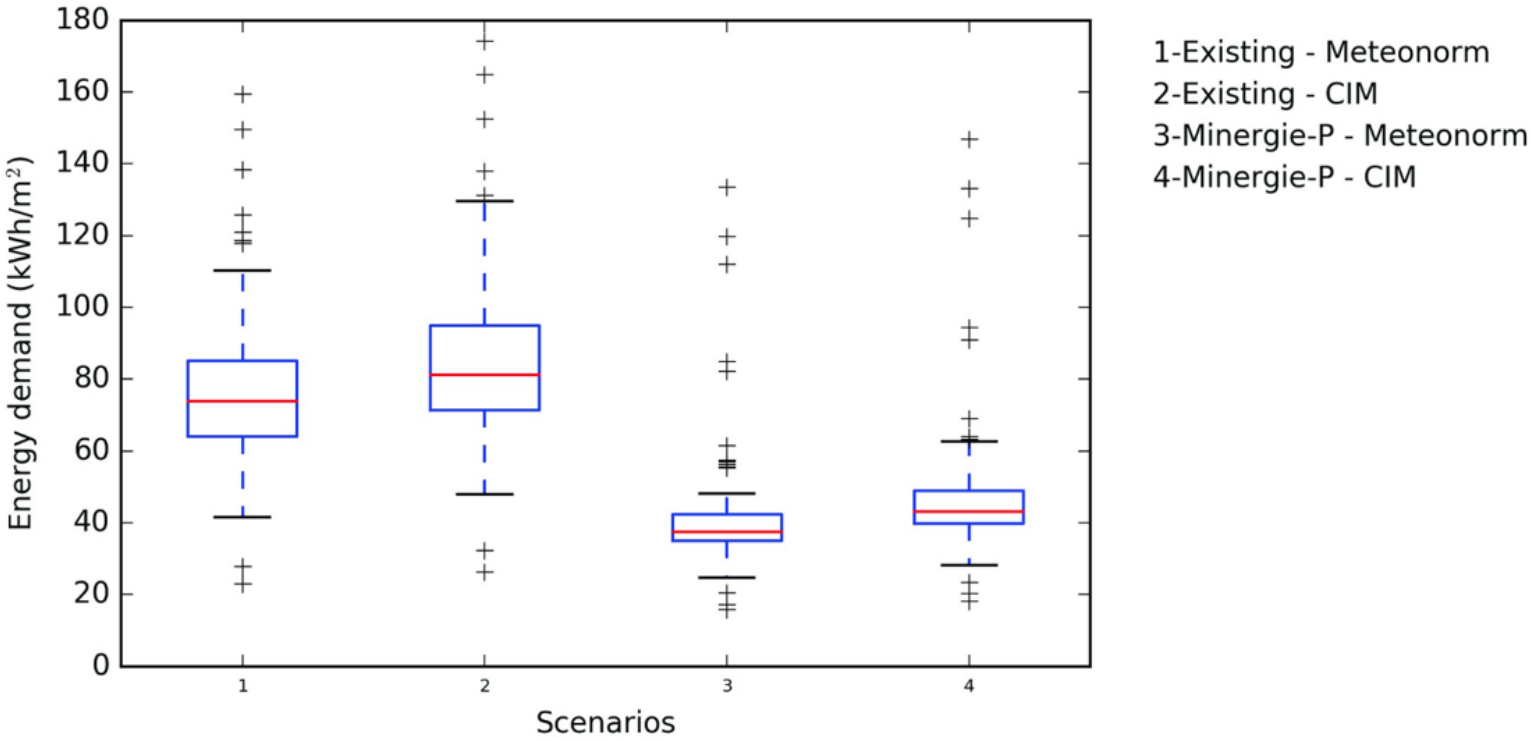
Modeling tools : CIM-CitySim





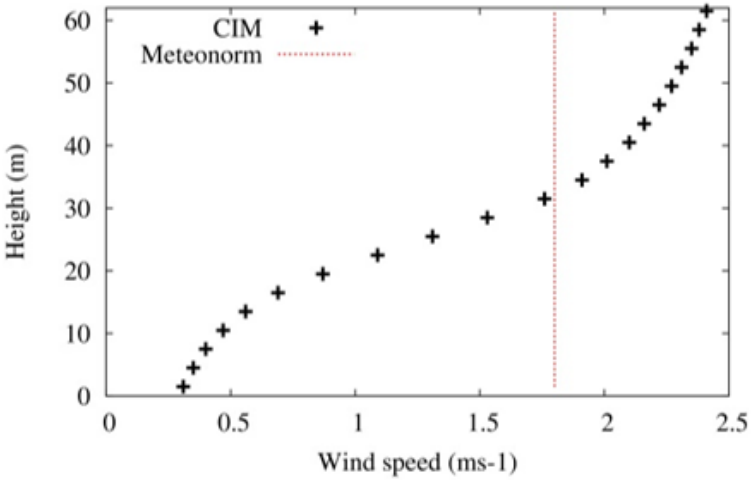
- Difference between Meteonorm and CIM data (Mauree et al., 2017b)

Modeling tools : CIM-CitySim

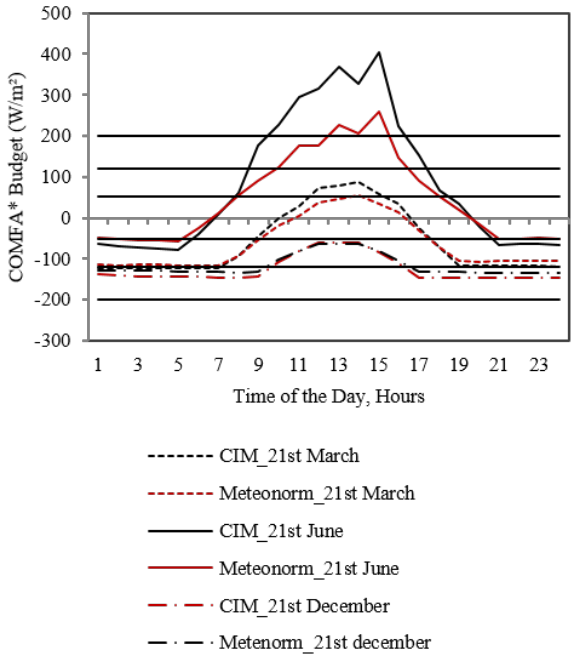


- Estimation of energy demand for EPFL campus (Mauree et al., 2017b)

Modeling tools : Outdoor Human Comfort

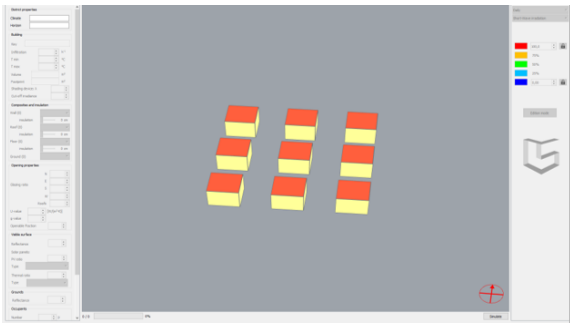


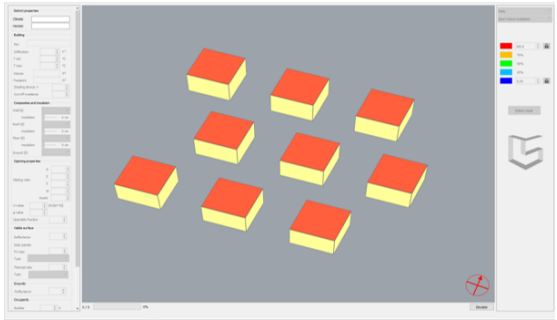
Bocce court

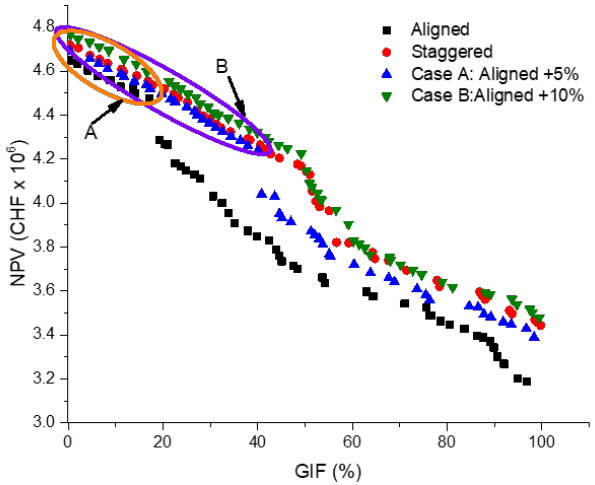


- Difference in vertical wind speed profile (m s $^{-1}$) for the 21st of June & evaluation of the COMFA* for 3 selected days (Mauree et al., 2016)

Modeling tools : Energy System Design Comfort

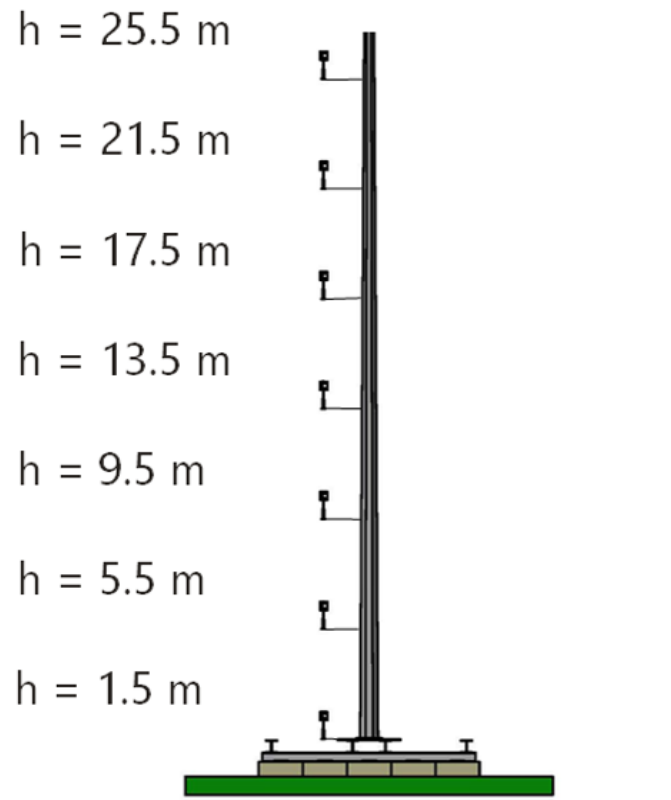






- Energy system design for aligned and staggered building configuration (Mauree et al., 2017c)

Measurement campaign : MoTUS



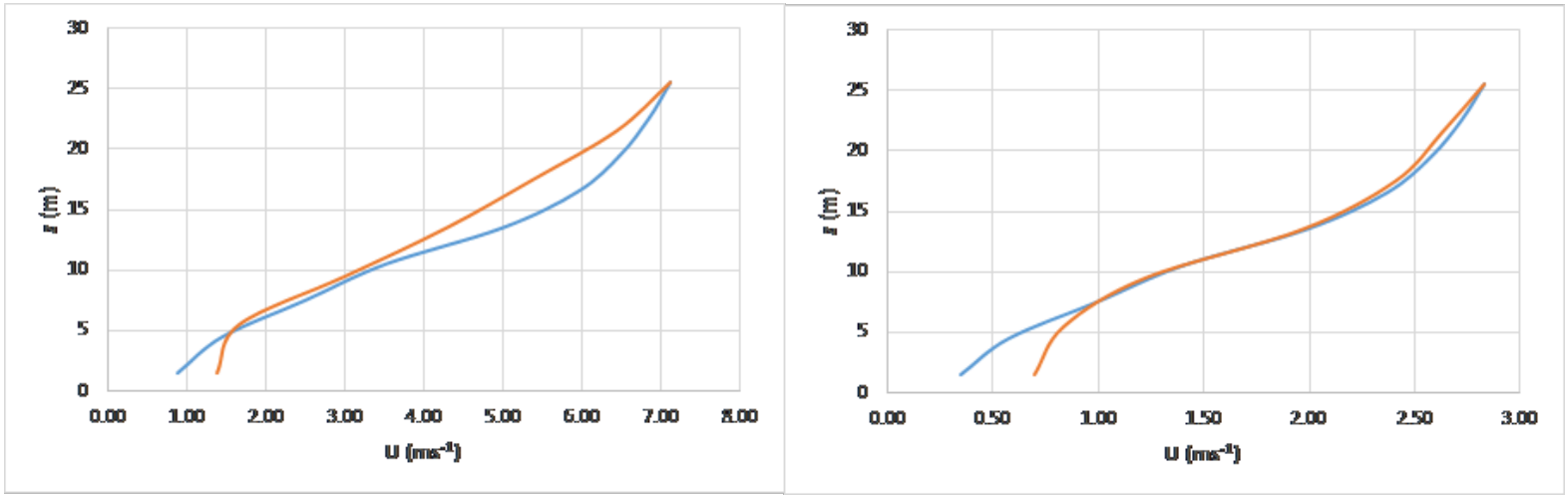
- 3 years of continuous monitoring of high frequency measurement of meteorological variables

Measurement campaign : MoTUS

Instrument	Brand	Type
3D sonic anemometers	Gill	Windsonic
Meterological station	Gill	GMX 300
Surface temperature sensor	Optris	OPTCSLT15K
Net radiometer	Kipp & Zonen	CNR4

Table – List of instruments installed

Measurement campaign : MoTUS



- Comparison of measured and simulated profiles (Blue - CIM & Orange - MoTUS
- Underestimation of the wind speed close to the ground - better parameterization needed

Conclusions

- Simplified model developed to calculate high resolution vertical profiles of meteorological variables
- Improved computational time to enable coupling with energy demand model
- Validated model and coupling with CitySim
- Multiple application to improve the design of sustainable urban areas (outdoor comfort, urban energy systems, blind monitoring...)

Perspectives

- Need for further improvement in the parameterization of physical processes
- Use and compare coupled model in other cases
- Evaluate the impact of more building configuration on the climate and on the energy system

Thank you.

Dr. Dasaraden Mauree

dasaraden.mauree@epfl.ch
@D_Mauree

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

LESO-PB LABORATOIRE D'ENERGIE SOLAIRE PHYSIQUE DU BÂTIMENT

MoUS

In cooperation with the CTI
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sccer future energy efficient buildings & districts