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# Microclimatic modeling and simulation tools : an academic benchmark

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## General framework

### DIAMS PROJECT

- Objective:** Evaluate the contribution of thermal infrared satellite measurements in support of numerical modeling for urban climatology for the diagnosis and monitoring of overheating from the urban to the building scale, for use by local authorities.
- First step:** Qualification of various urban microclimate models developed or used by the consortium

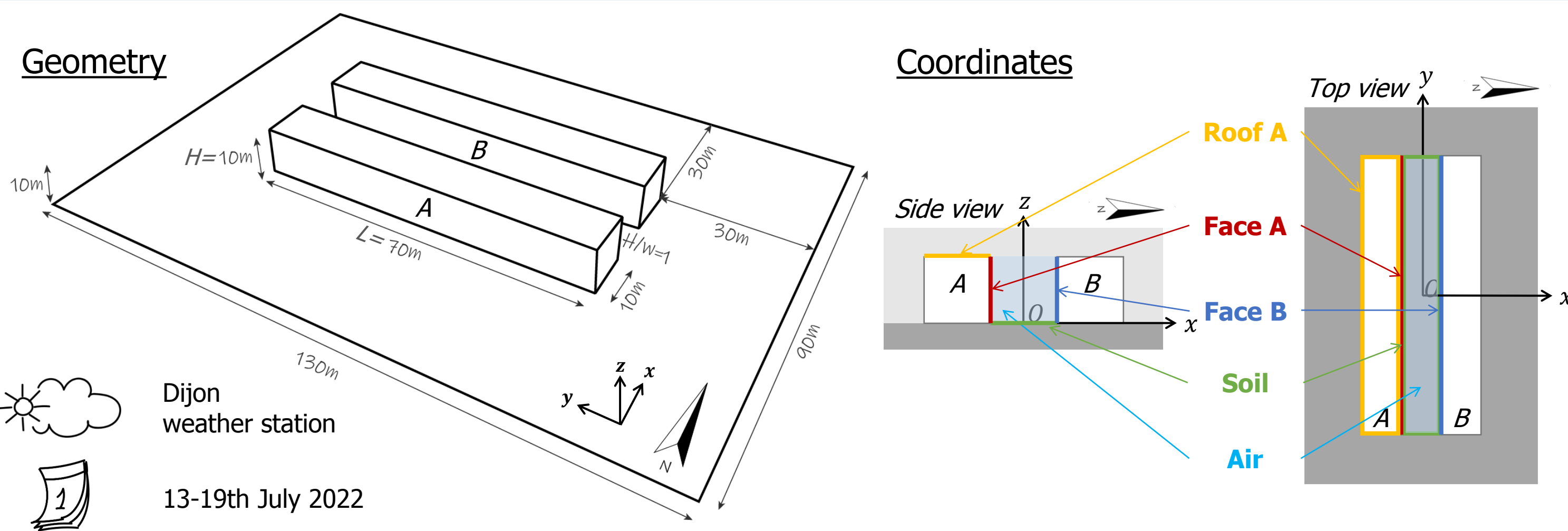
### Challenges for the model qualification:

- heterogeneous, open and large space integrating multiple physical phenomena at different scales
- very large amount of data to have a good knowledge of the area (materials, vegetation, heat sources...)
- very large number of variables (temperatures, air speed and humidity, radiation, surface temperatures...)

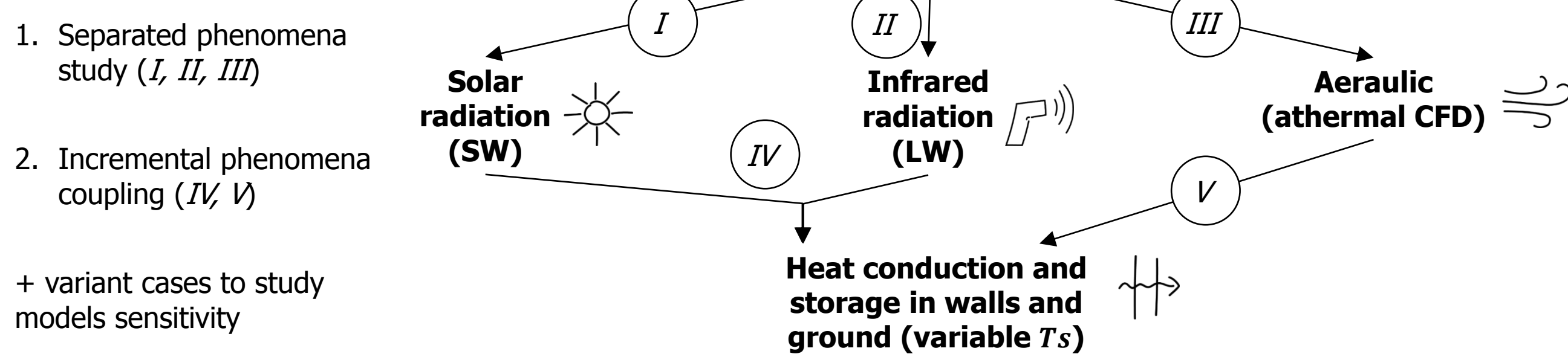
### Definition of an academic benchmark based on a simplified configuration

## Methodology

### CONFIGURATION



### PROCEDURE



### PARAMETRIZATION

Solar radiation	Infrared radiation	Aeraulic	Heat conduction and storage
albedo soil: 0.15 / 0.3	emissivity soil: 0.9	Surface roughness: 0 m	Walls/Int insulation: 5 / 0.03
albedo walls: 0.4 / 0.55	emissivity walls: 0.9 (0 transmittivity)	Wind direction: 0° / 45°	Roof: 30 / 1.7
albedo roof: 0.2	emissivity roof: 0.9 (0 transmittivity)	Velocity profile: $U_{in}(z) = \frac{u_*}{0.43} \ln(\frac{z+10^{-5}}{10^{-5}})$	asphalt: 5 / 0.7
direct horizontal flux: 194.2 - 603.5 - 112.5 W/m <sup>2</sup>	Ts wall: 25 °C / 35 °C (FaceA)	Velocity profile: $U_{in}(10 m) = 3.6 / 5.2 m/s$	soil: 35 / 1.8
diffuse horizontal flux: 128.0 - 263.1 - 115.3 W/m <sup>2</sup>	Ts roof: 25 °C	TKE profile: $k_t(z) = 0.03U_{in}^2(z)$	ground: 160 / 0.5
atmosphere: Transparent air	Ts soil: 17 °C	IC T walls and ground: 20 °C	BC Ts int: 25 °C
	Incident horizontal flux sky model: 394.4 W/m <sup>2</sup>		hc ext: 20 °C
	sky model atmosphere: Isotropic		CFD coupling: 30 W/(m <sup>2</sup> .K)
	Transparent air: Transparent air		

### URBAN MICROCLIMATE MODELS

	MATHIS [2]	SUSHI [3]	SOLENE-MICROCLIMAT [4]	TRABOULE [5]
<b>Radiation</b>	Radiosity	Radiosity	Radiosity	RTE resolution (FV) + absorption
<b>Detail levels</b>	1 node per surface	Unstructured surface mesh ( $\Delta x \sim H/16$ inside canyon)	Structured surface and volume mesh ( $\Delta x = H/20$ )	
<b>Heat conduction and storage</b>	FD method	Transfer functions (FS)	RC / FE methods	FD method
<b>Detail levels</b>	1D multi-layers	1D quadrupoles (1/material)	1D multi-layers	1D multi-layers
<b>Aeraulic</b>	Simplified parametrization	Empirical correlations	CFD (code SATURNE [6]) RANS $k-\epsilon$	CFD (PROLB [7]) LBM-LES
<b>Detail levels</b>	-	-	Unstructured volume mesh ( $\Delta x \sim H/16$ inside canyon)	Structured volume mesh ( $\Delta x = H/48$ inside canyon)

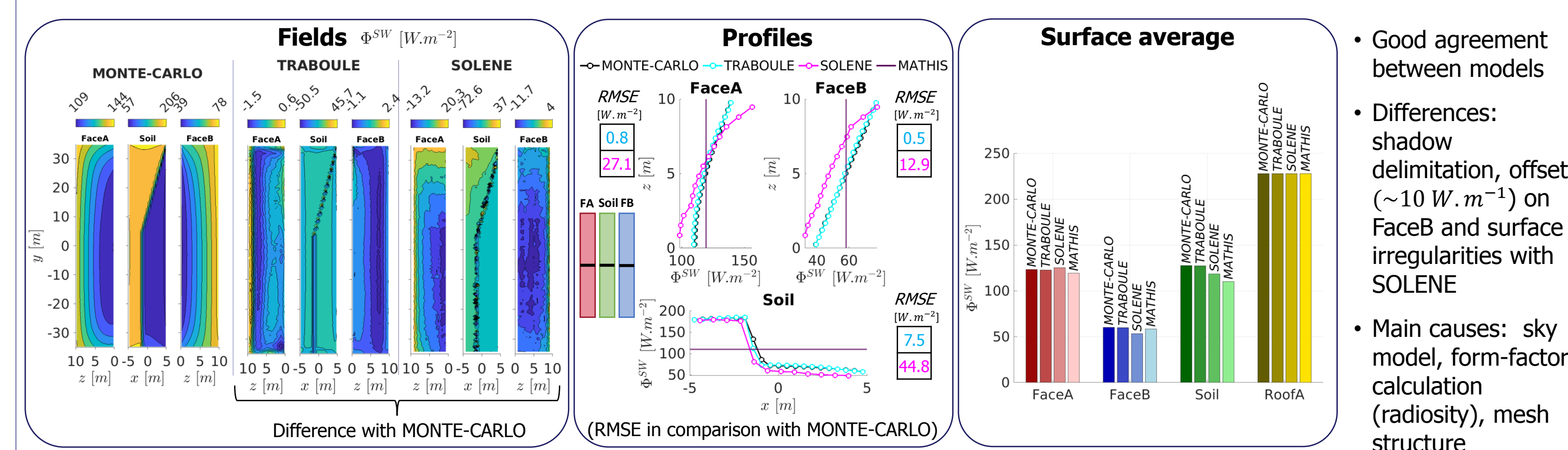
FD: finite differences / FE: finite elements / FS: Fourier space / FV: finite volumes / RC: electrical analogy / RTE: radiative transfer equation

## Conclusions

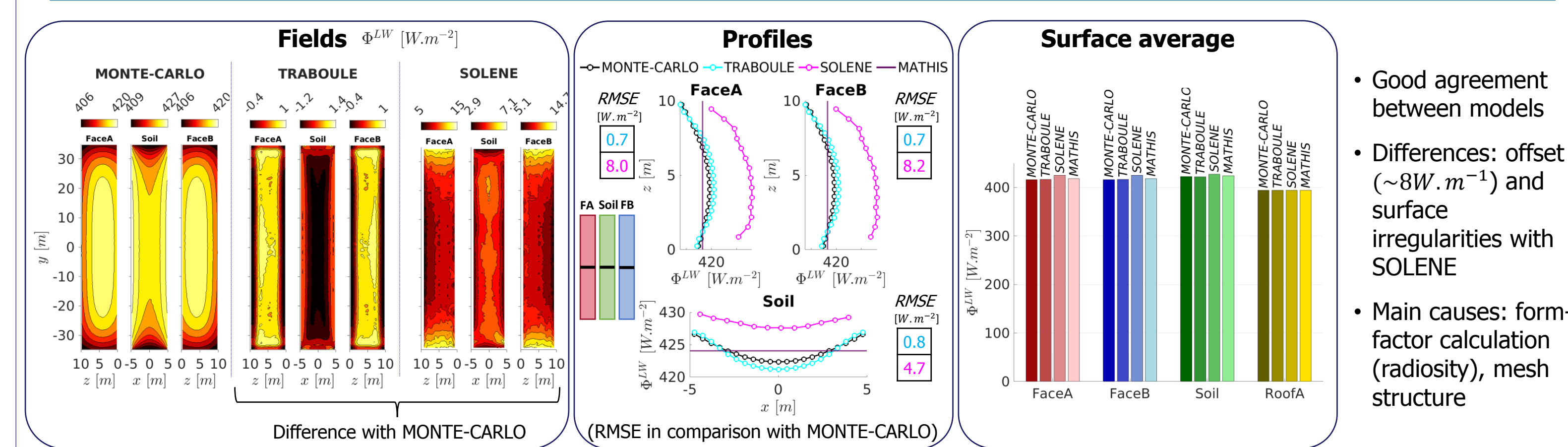
- Definition of a robust strategy to discuss and evaluate the urban microclimate models capabilities
  - Selection of a simplified geometry and common input parameters
  - Gathering of different data types from simulations
  - Results analysis on three levels: surface average, profiles and fields
- Comparable results but with different resolution and objectives for the models

## Results

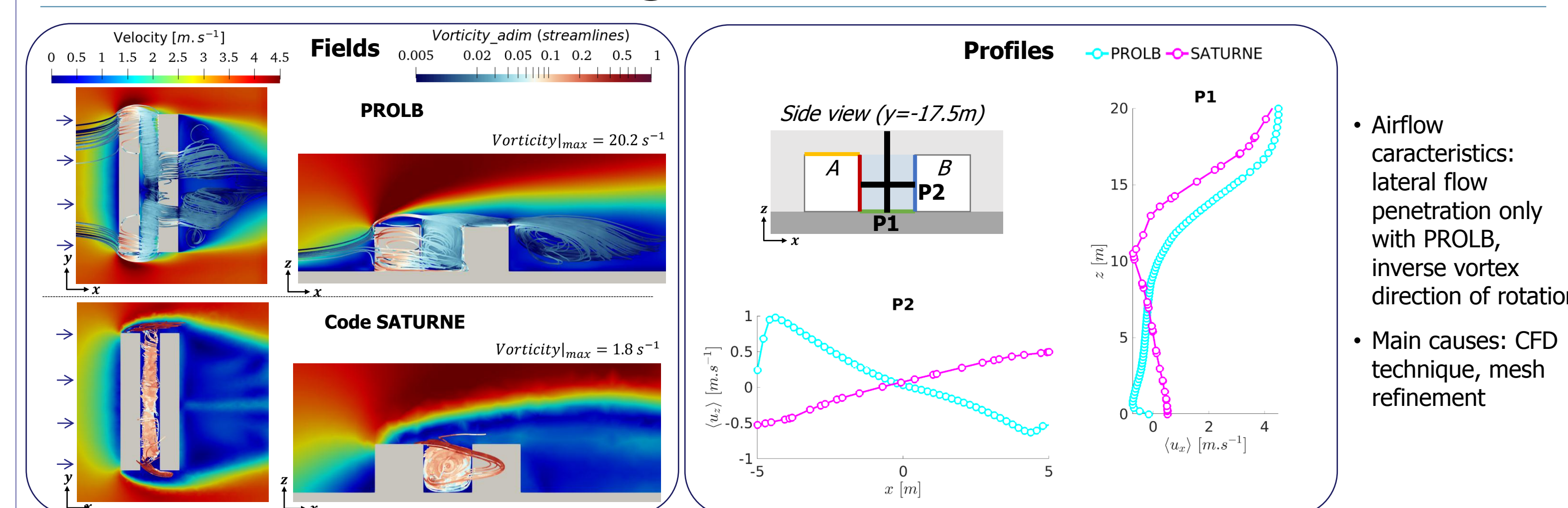
### I SOLAR RADIATION (base case, 17:30 pm)



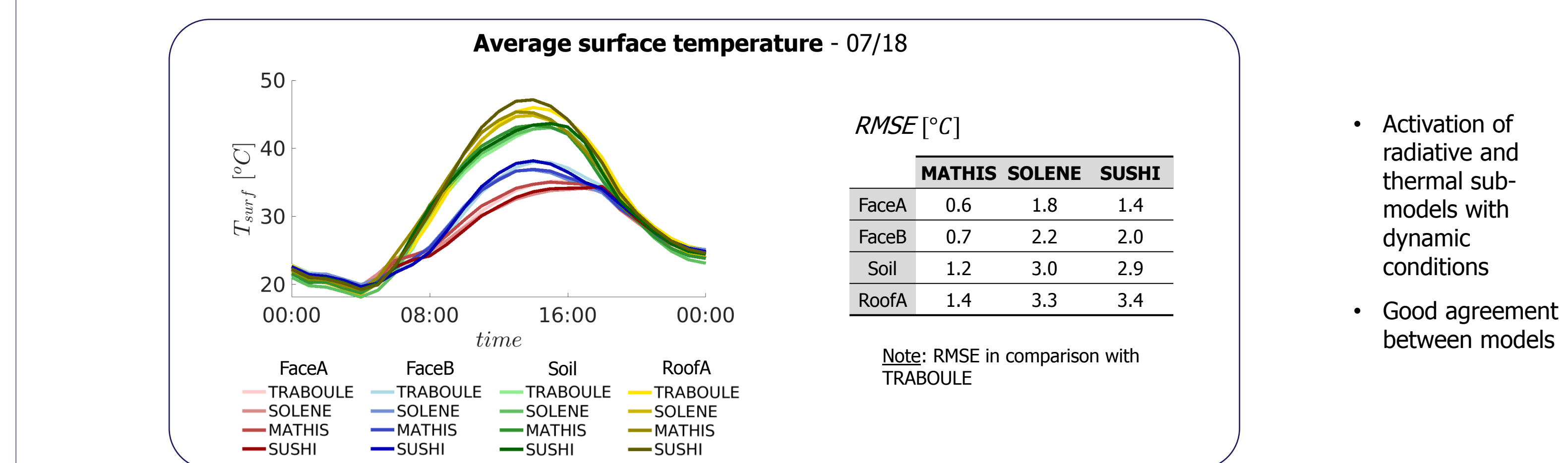
### II INFRARED RADIATION (base case)



### III AERAULIC (base case)



### IV HEAT CONDUCTION AND STORAGE (base case)



## Perspectives

- Ready-to-use datasets allowing modelers to validate and compare urban microclimatology tools
- Application to a real-life configuration: the experimental campaign CAMCATT (oral presentation n°75)
- Implementation of a complete approach for the validation of urban microclimate models (oral presentation n°191)

## References and acknowledgments

[1] M. Galtier et al. (2022) <https://doi.org/10.1016/j.applthermaleng.2022.119020>  
 [2] J. Soriano et al. (2021) <https://doi.org/10.26868/25222708.2021.30279>  
 [3] N. Lalanne, et al. (2015) <https://doi.org/10.1080/17686733.2015.1066134>  
 [4] M. Musy, et al. (2021) [10.1007/978-3-030-65421-4\\_13](https://doi.org/10.1007/978-3-030-65421-4_13)  
 [5] F. Schmitt et al. (2022) <https://doi.org/10.1615/TFEC2022.emt.041362>

[6] L. Malys et al. (2015) <https://doi.org/10.1080/17512549.2015.1043643>  
 [7] L. Merlier, et al. (2019) <https://doi.org/10.1016/j.buildenv.2018.11.009>

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