Thermal performance simulation technologies contributing to sustainable shelter innovation

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Thermal modeling and shelters ?

- What is thermal modeling?
- Why to use it for shelter improvement?
- How to do?

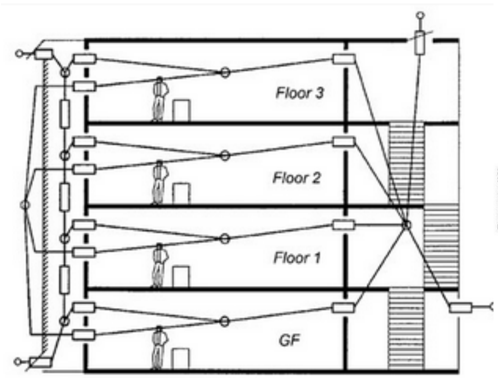
Thermal models?

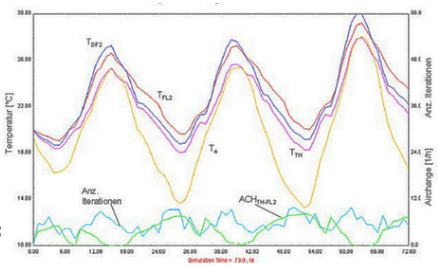
Multizonal dynamic

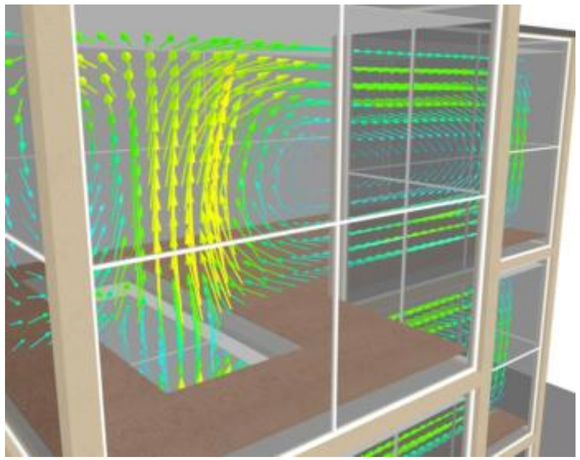
- One room = one point
- Simulate time evolution
- Buidling scale

Computational fluid dynamics

- One room = millions of points
- Simulate spacial distributions
- Room scale







Pictures :
http://www.designbuilder.co.uk
and http://store.aiguasol.coop

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Why a thermal model of shelters ?

- Health problems related to indoor conditions
  - Too cold or too hot
  - Stuffy or too dry
  - Poor air quality in crowded badly ventilated spaces

- Comfort
  - Same parameters as health in a more limited range of values

- Fuel dependance
  - Improving thermal behaviour of the tents may reduce the logistic problem of fuel supply

Case study : IFRC/UNHCR family tent

Picture :
http://www.nrs-international.com/

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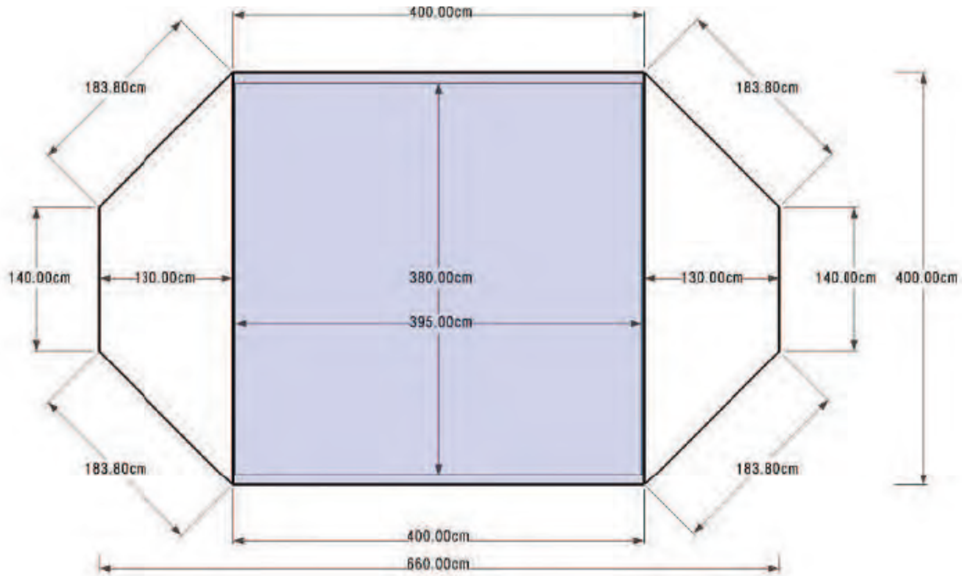
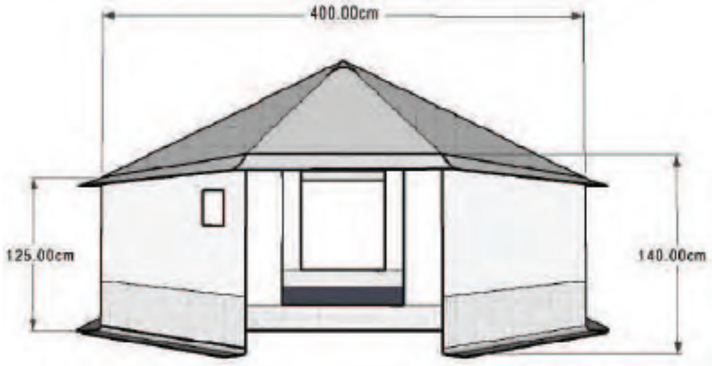
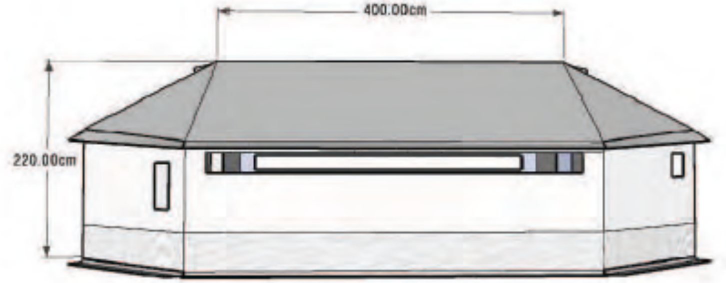


PLANE VIEW



FRONT VIEW



SIDE VIEW

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How to do such a model?

- Step 1 : data acquisition
- Step 2 : model creation
- Step 3 : model validation
- Step 4 : analysis

Step 1 : data acquisition

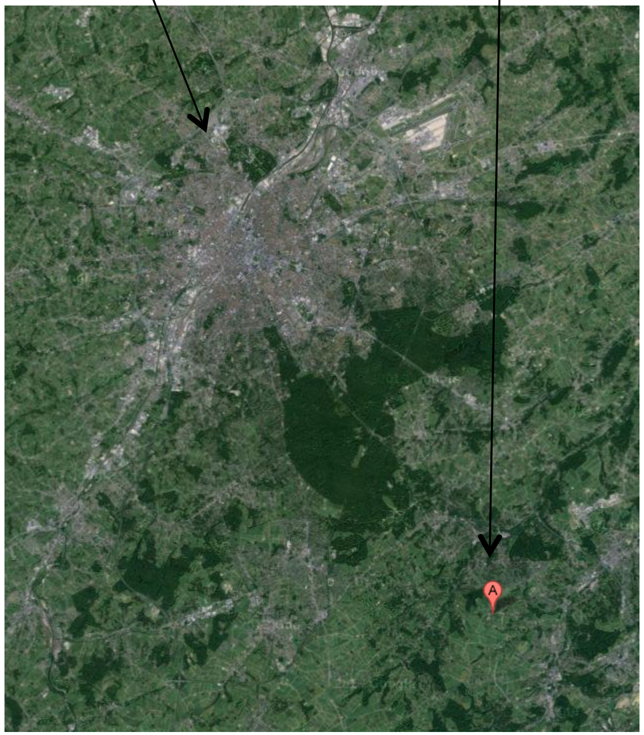
- Thermal behaviour in various climates
  - BBRI experimental facility, Limelette Belgium
  - Burundi

- Thermal behaviour in various operanting conditions
  - Maximal airtightness : all openings closed
  - Free flaot sumer conditions : minimal airtightness
  - Free float winter conditions : closed windows but opened vents
  - Controlled winter conditions : t° evolution when heating

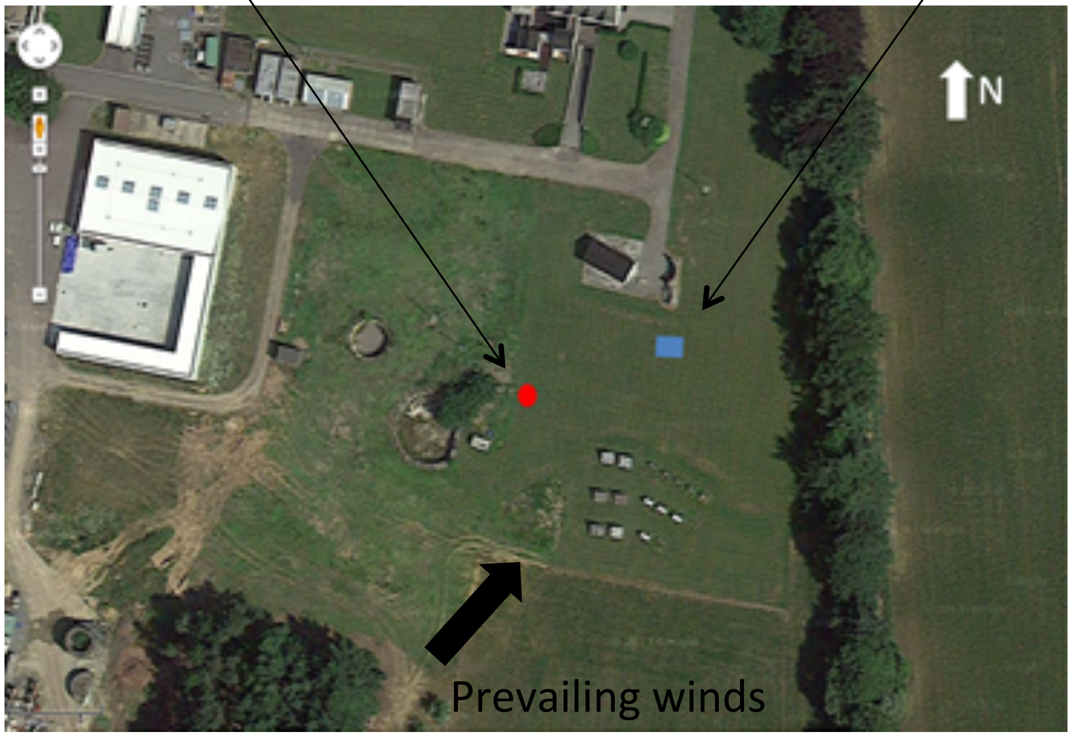
CSTC - WTCB - BBRI

Belgian Building Research Institute

Aidex2013 Limelette

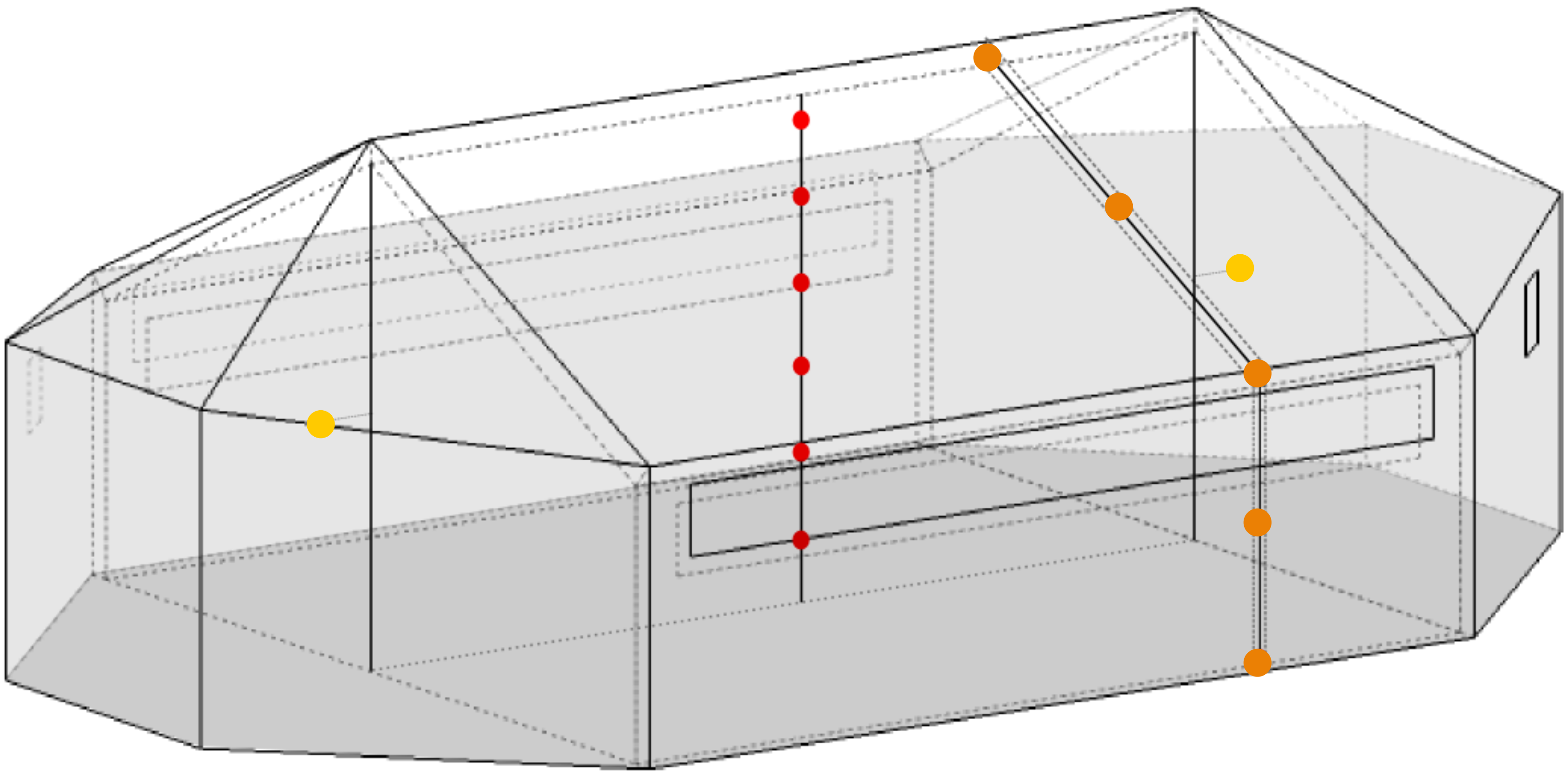


Wind measure station Shelter



13 thermocouples

in the shelter and between the inner and outer tents



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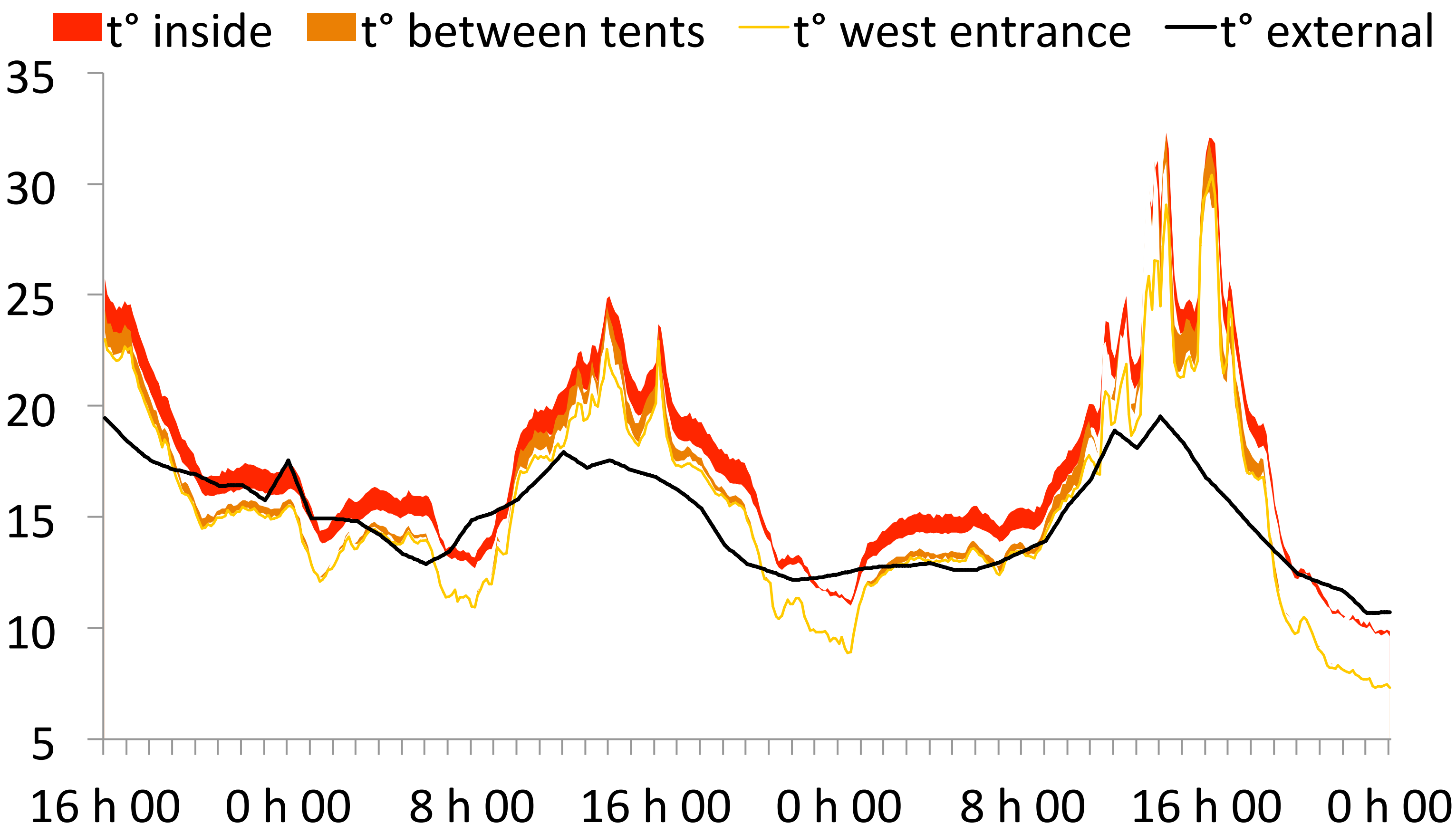
BBRI field experiment



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Burundi field experiment

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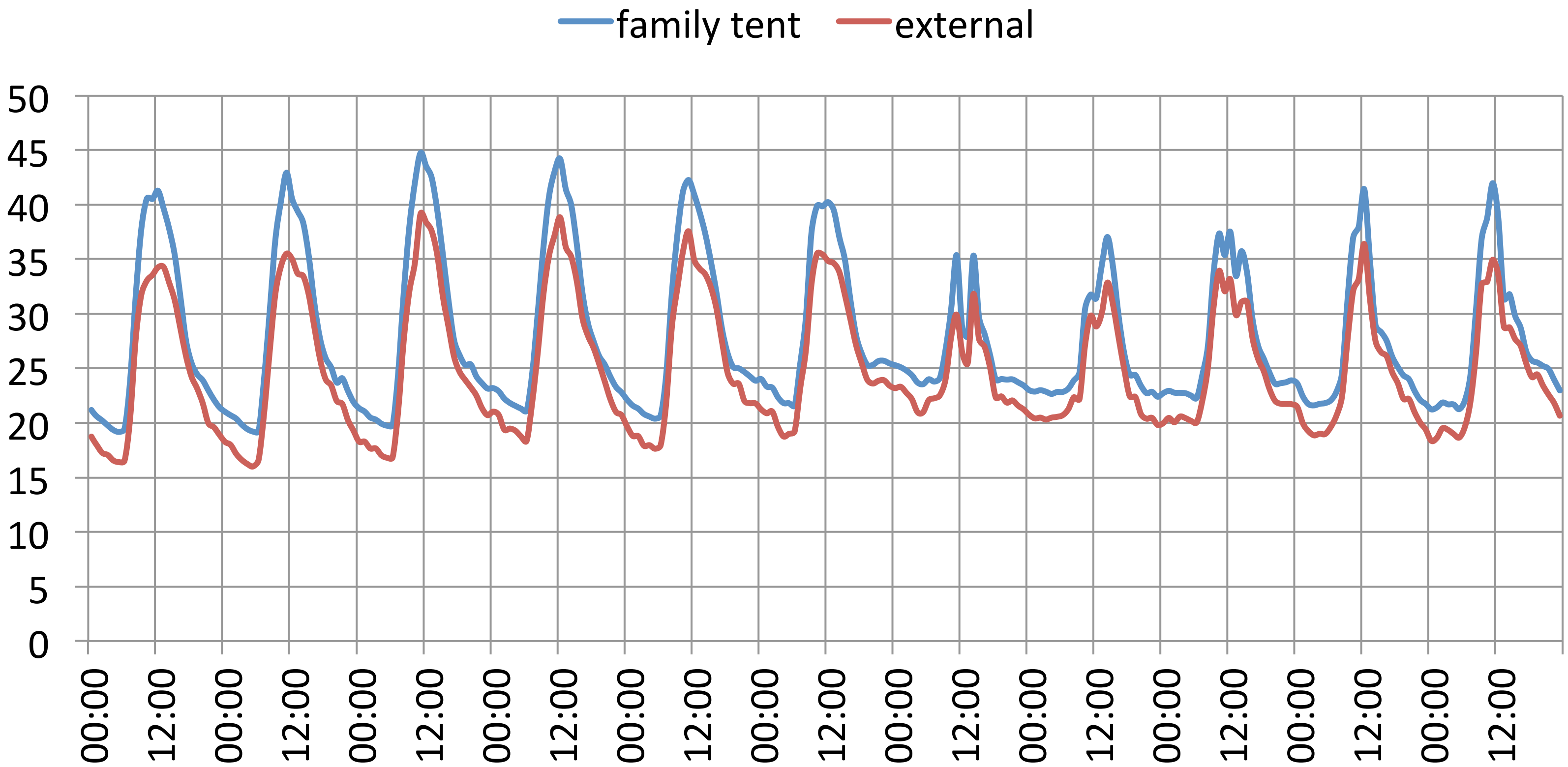
Burundi field experiment



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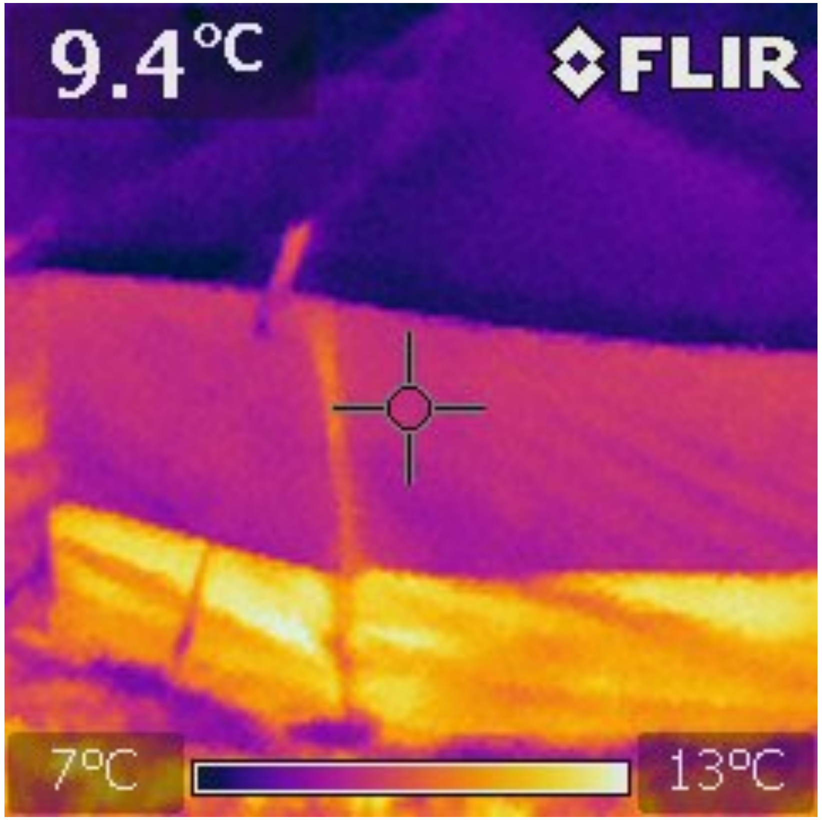
Other datas : fabric properties

- Both from litteracy and lab measurments

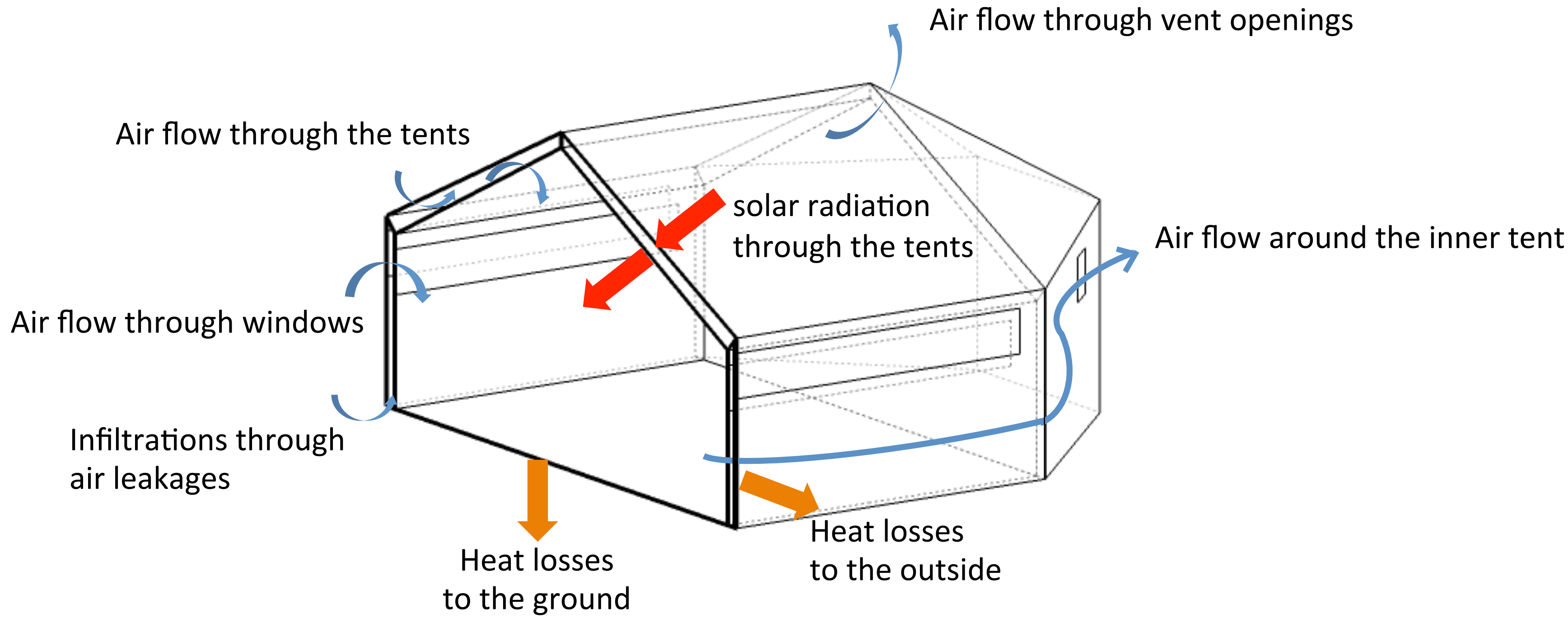
	Outer tent	Outer roof	Ground sheet
Composition	Cotton: 40%, polyester: 60%	Cotton: 40%, polyester: 60%	Coated polyethylene
Weight (g/m^2)	239	373	165
Solar trans. (%)	13.38	8.52	0.46
Solar reflex (%)	62.15	64.48	34.64
Air permeability @100Pa ($l/(m^2s)$)	30.1	3.88	<0.1

Other datas : IR pictures



Step 2 : model creation

- Calculate the interaction between many physical phenomenons



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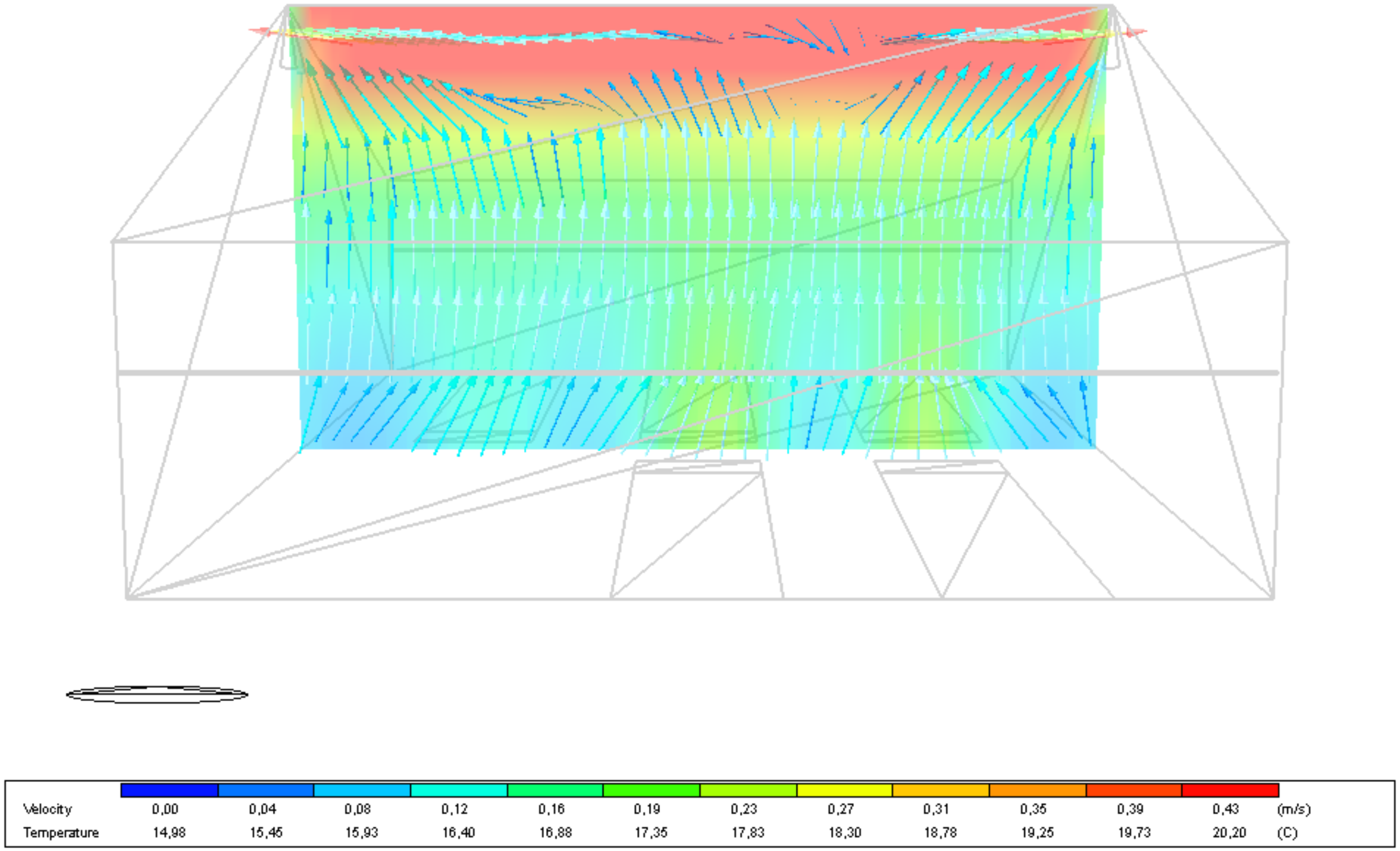
Thermal model

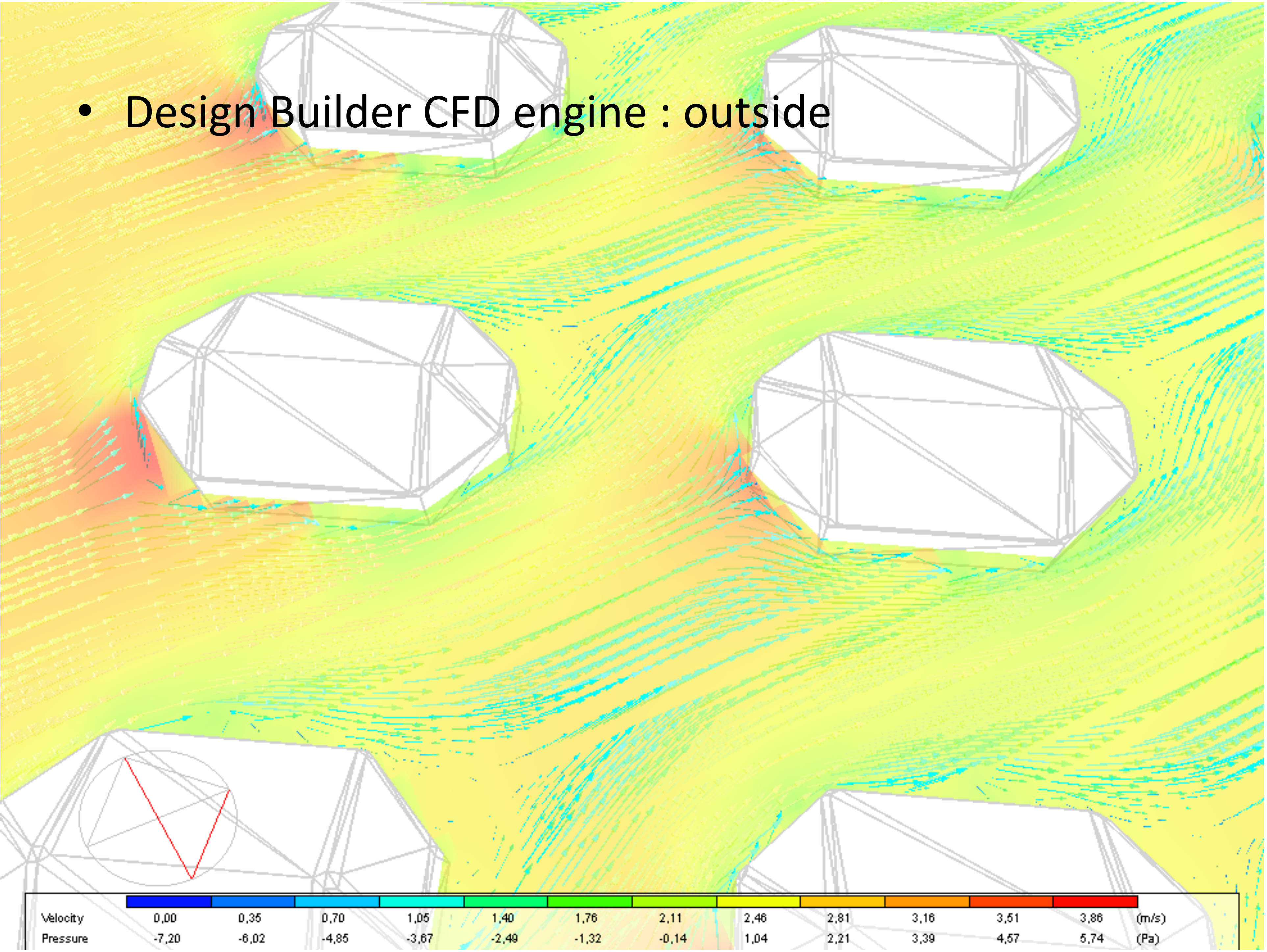
- Building models tools:
  - Energy+ simulation software
  - combined with Sketchup 3D plugin

- To be adapted
  - Extremely lightweight structure
  - Solar transmission through walls
  - No airtight walls
  - Box in a box shape

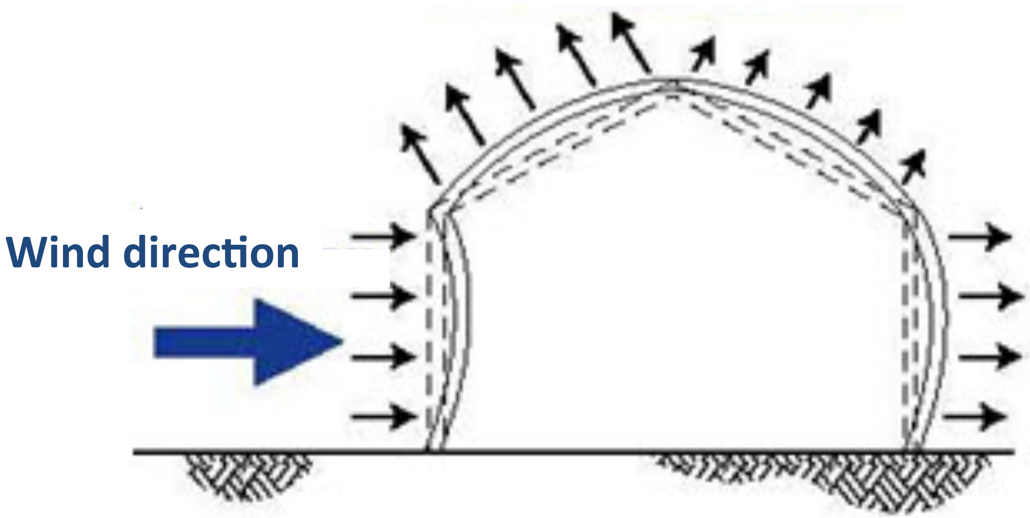
- Design Builder CFD engine: inside



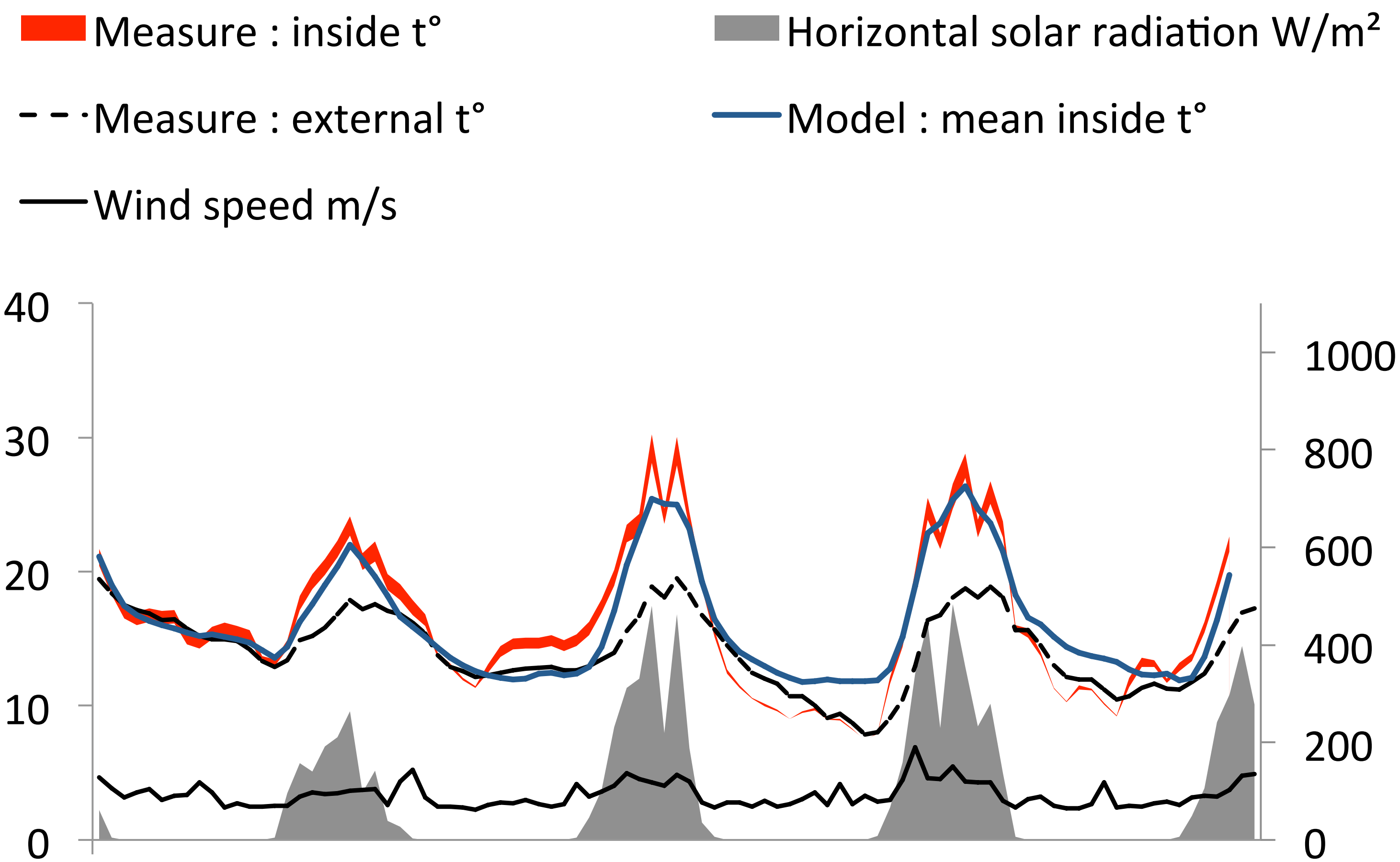
- Design Builder CFD engine : outside



- TNO Cp generator
  - Wind pressure coefficients values according to wind direction and building shape
  - Simplified method based on wind tunnel experiments databases



Step 3 : model validation



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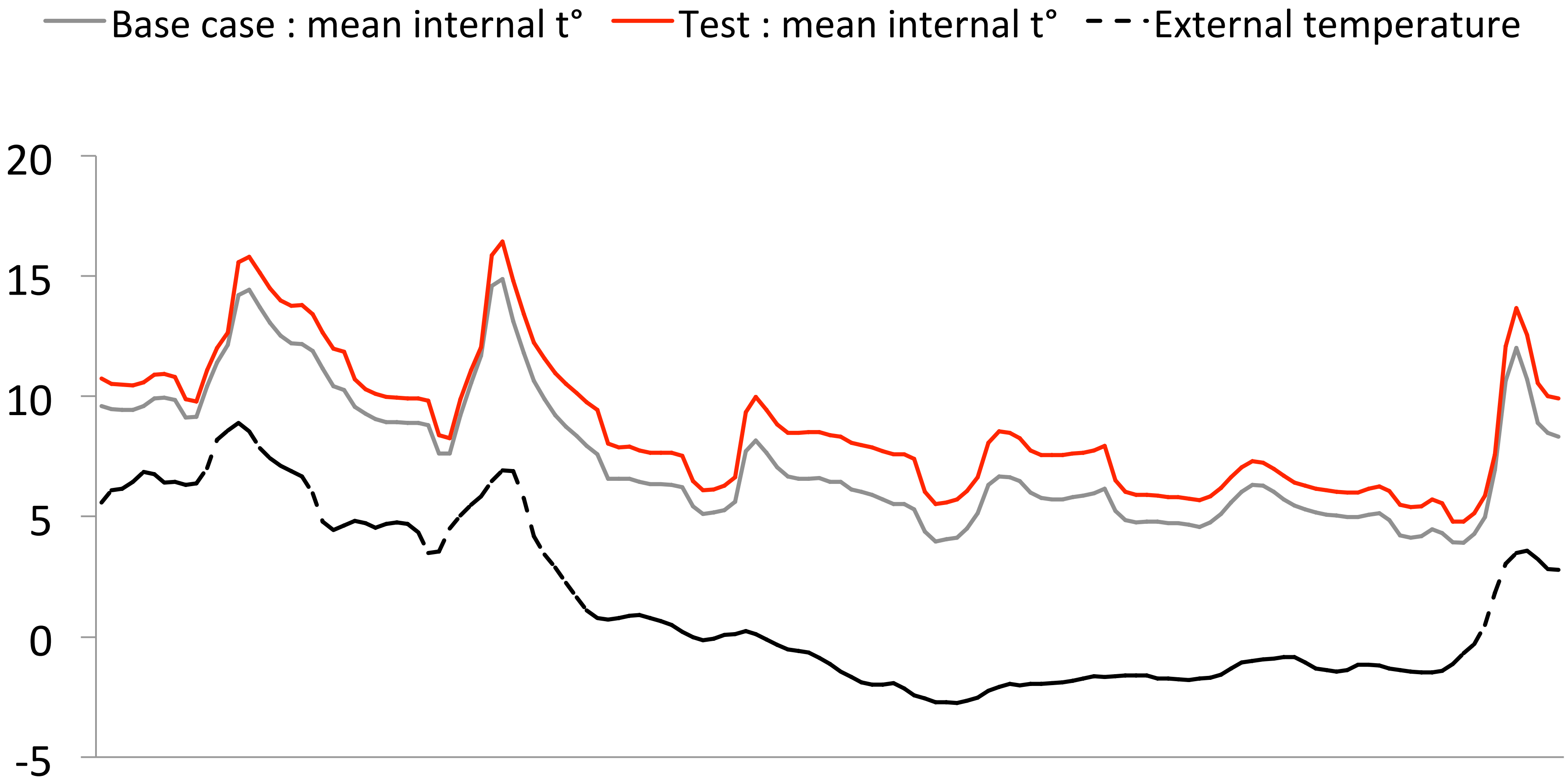
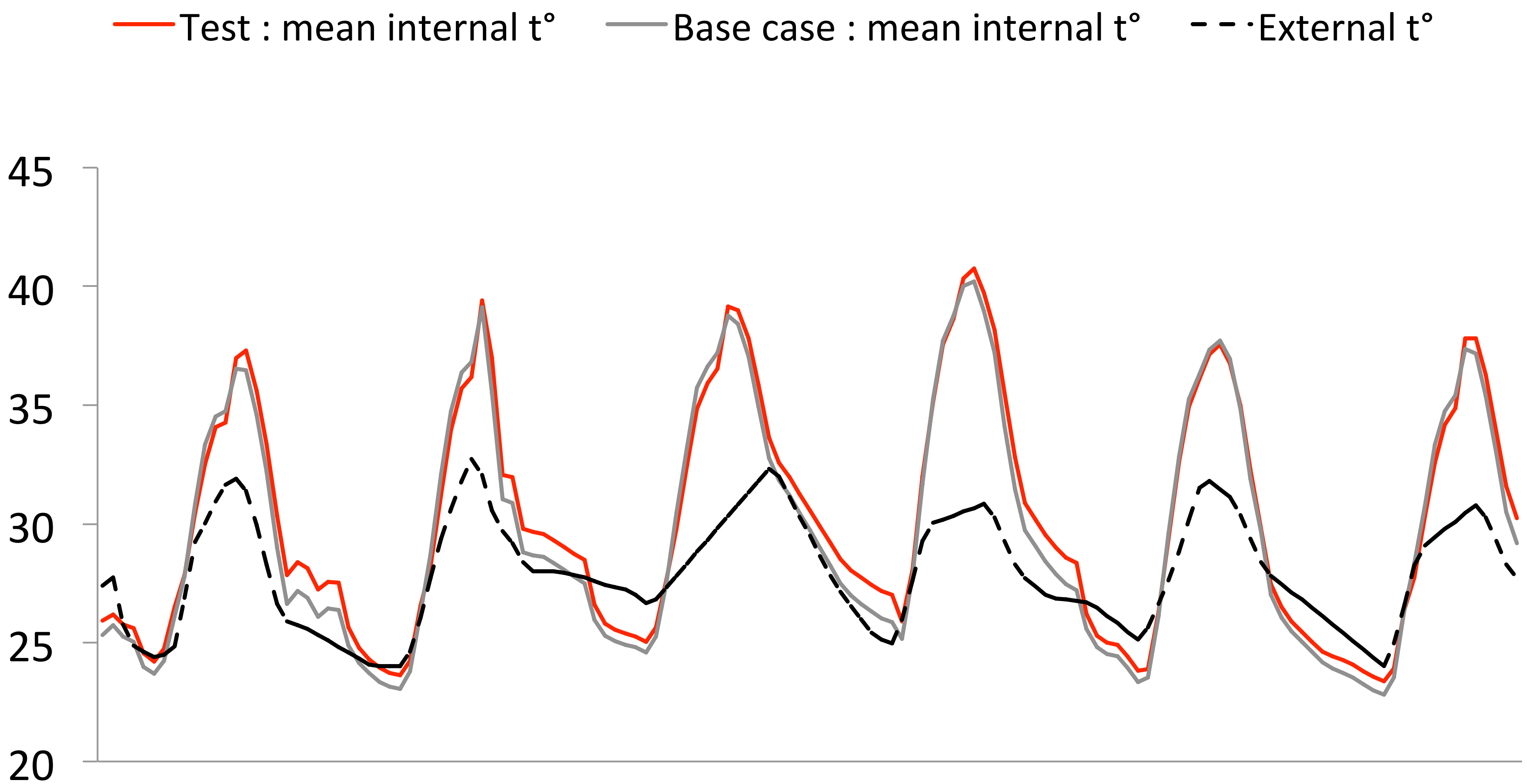
Step 4 : analysis

- Example : what if the inner tent was made of a stronger fabric ?
  - ➢ Less airtight
  - ➢ Less solar transmission
  - ➢ More thermal resistance

Winter in Belgium



Summer in Burundi



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Further works

- Looking for development ressources in order to
  - Make additional measurements and improve calibration
  - Develop a user-friendly interface
  - Develop a conection to world scale wheater files databases
  - Run parametric studies to help IFRC express technical requirements for new tents