COMSOL CONFERENCE ROTTERDAM2013

Computational Building Physics

Heat transfer in building constructions with a cavity

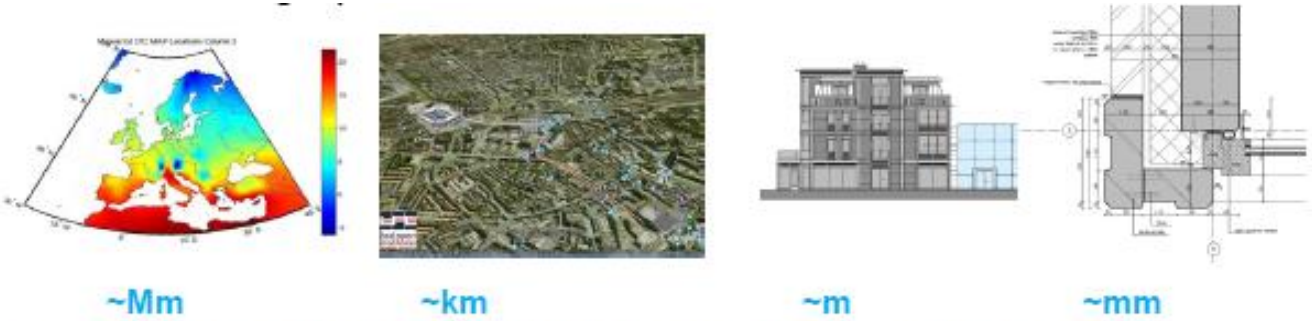
ir. Bram Kersten

dr.ir. Jos van Schijndel (presenter)

TU/e Technische Universiteit Eindhoven University of Technology

Where innovation starts

Scale levels Building physics

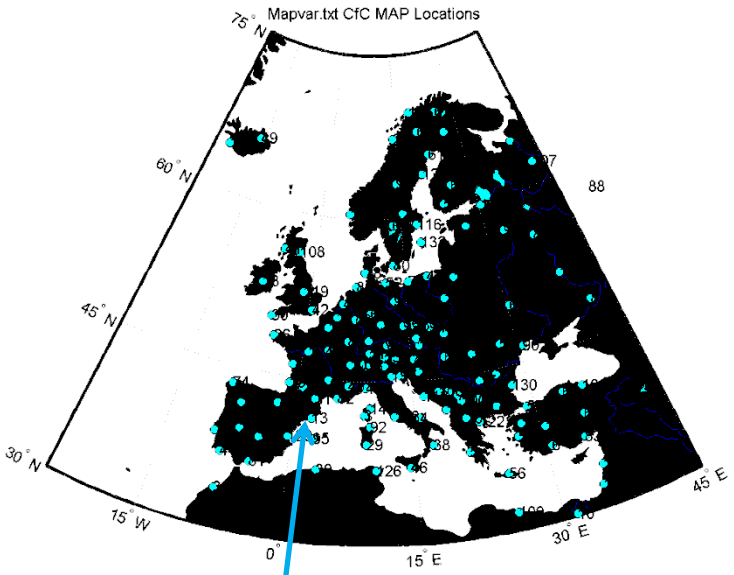


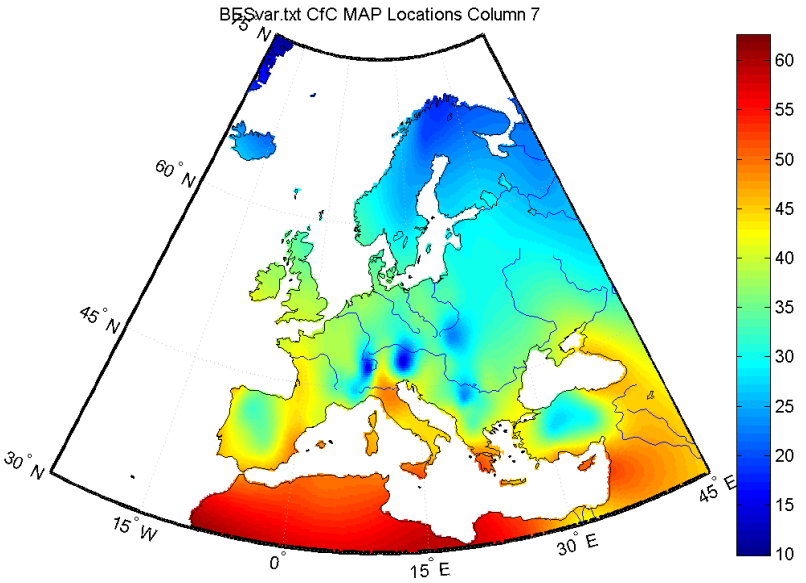
Scale levels, from left to right: EU; Urban area; Building; Material;

- **[mm] Material Physics**
- **[m] Building Physics**
- **[km] Urban Physics**
- **[Mm] … Physics**

Scale level [Mm] EU physics
EU climate scale performance & design

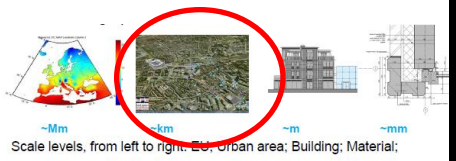
Scale levels, from left to right: EU; Urban area; Building; Material;



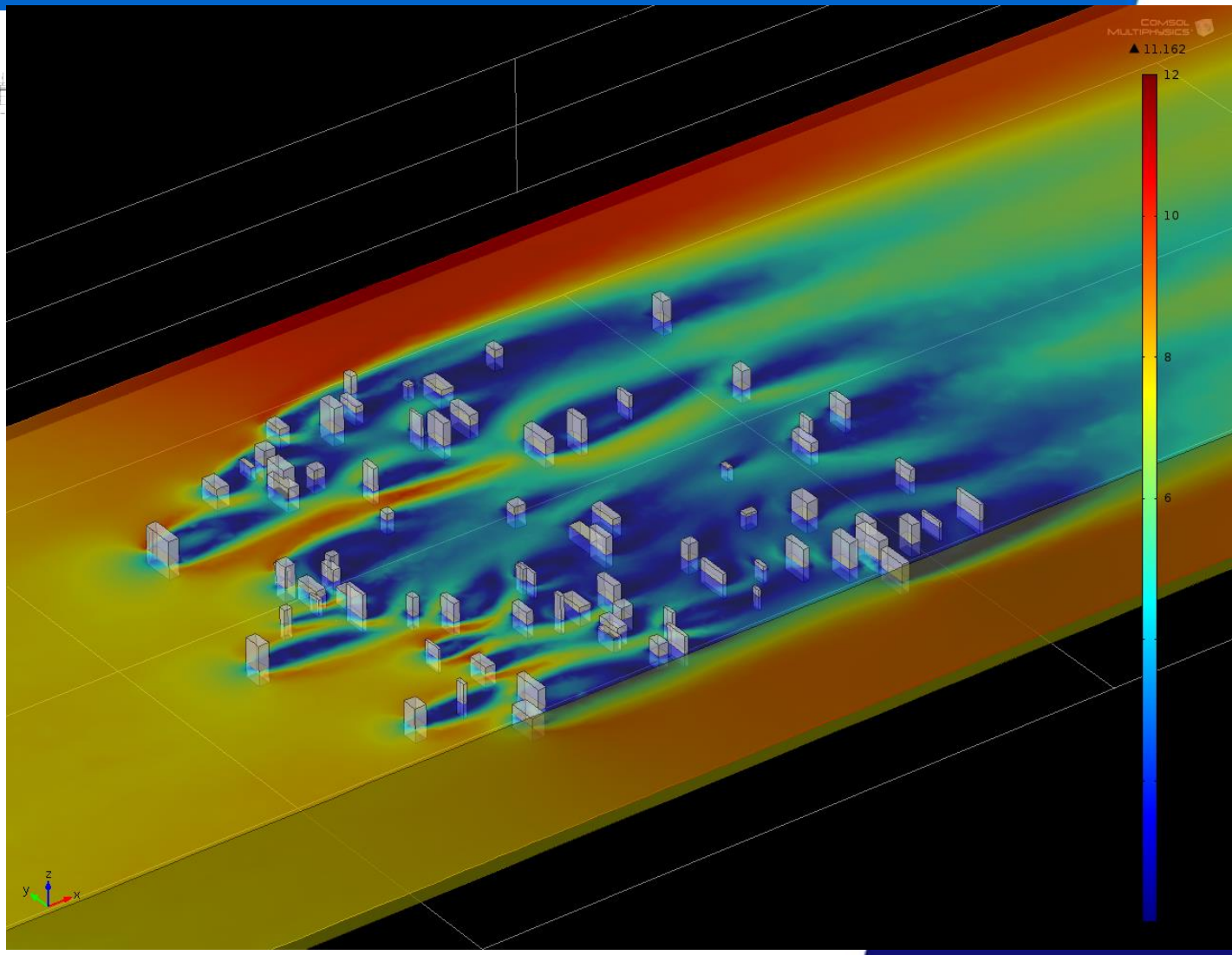


Virtual building placement

Scale level [km] Urban physics
Urban climate performance

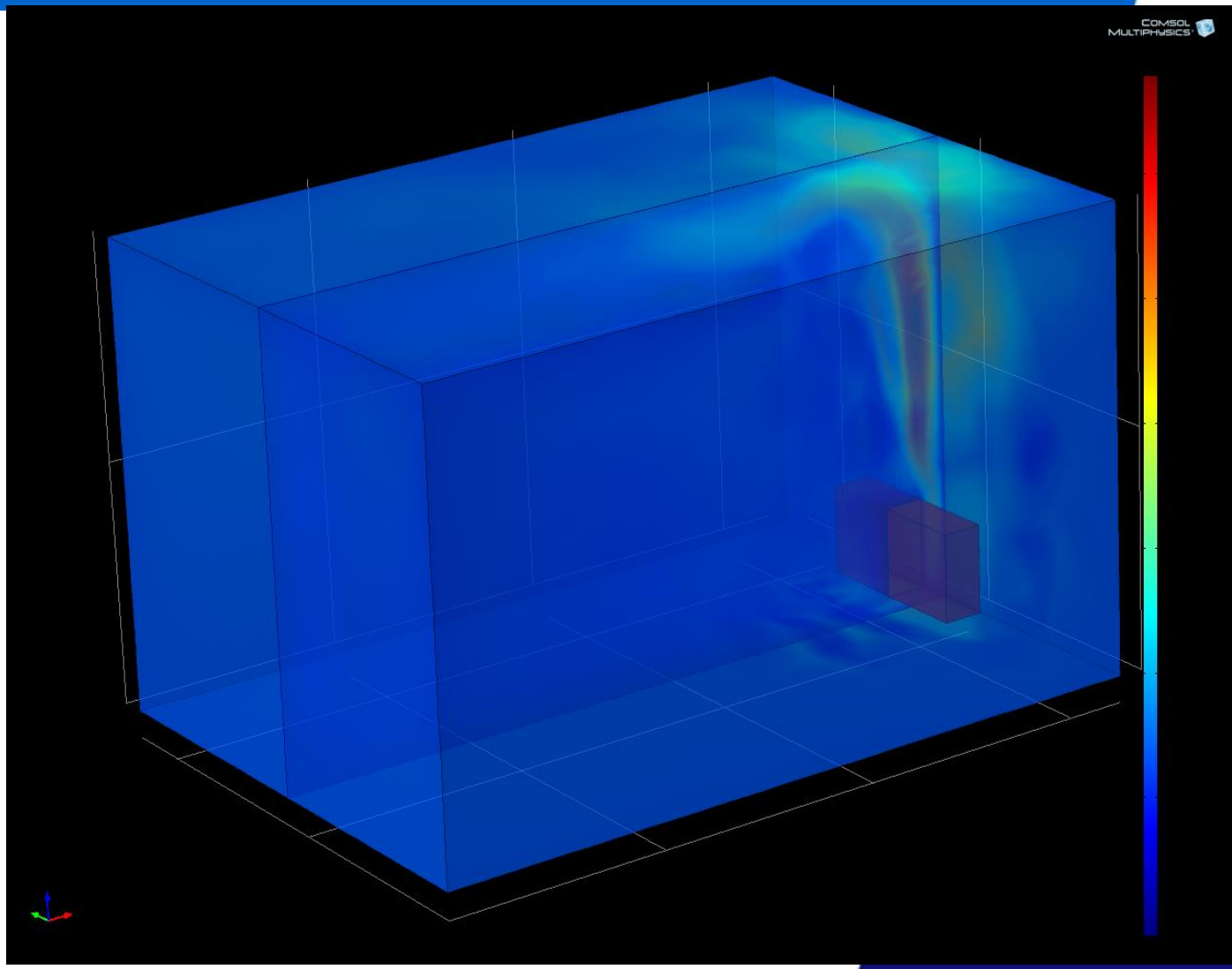


Scale levels, from left to right: EU; Urban area; Building; Material;



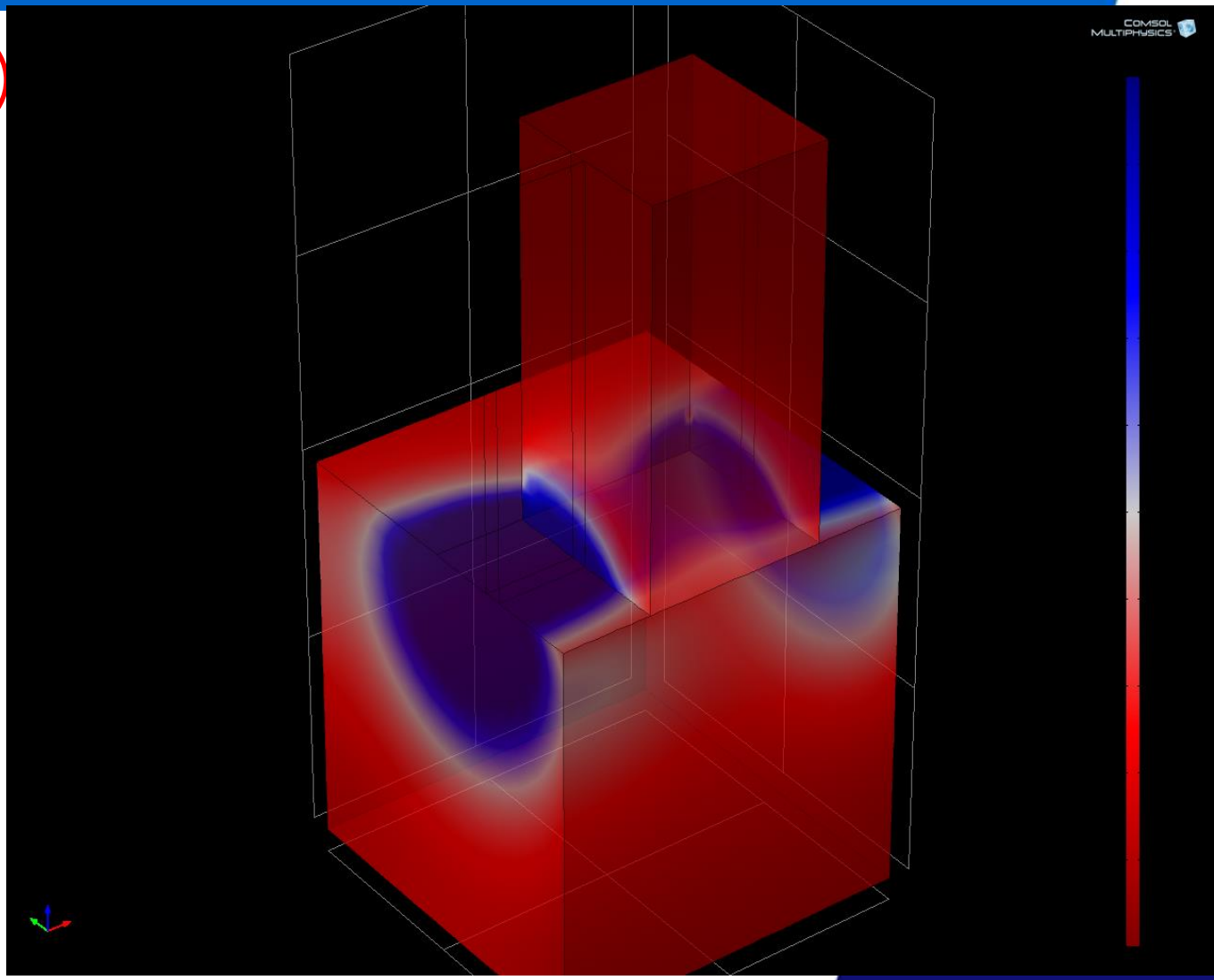
Scale level [m] Building Physics
Indoor climate performance & design

Scale levels, from left to right: EU; Urban area; Building; Material;

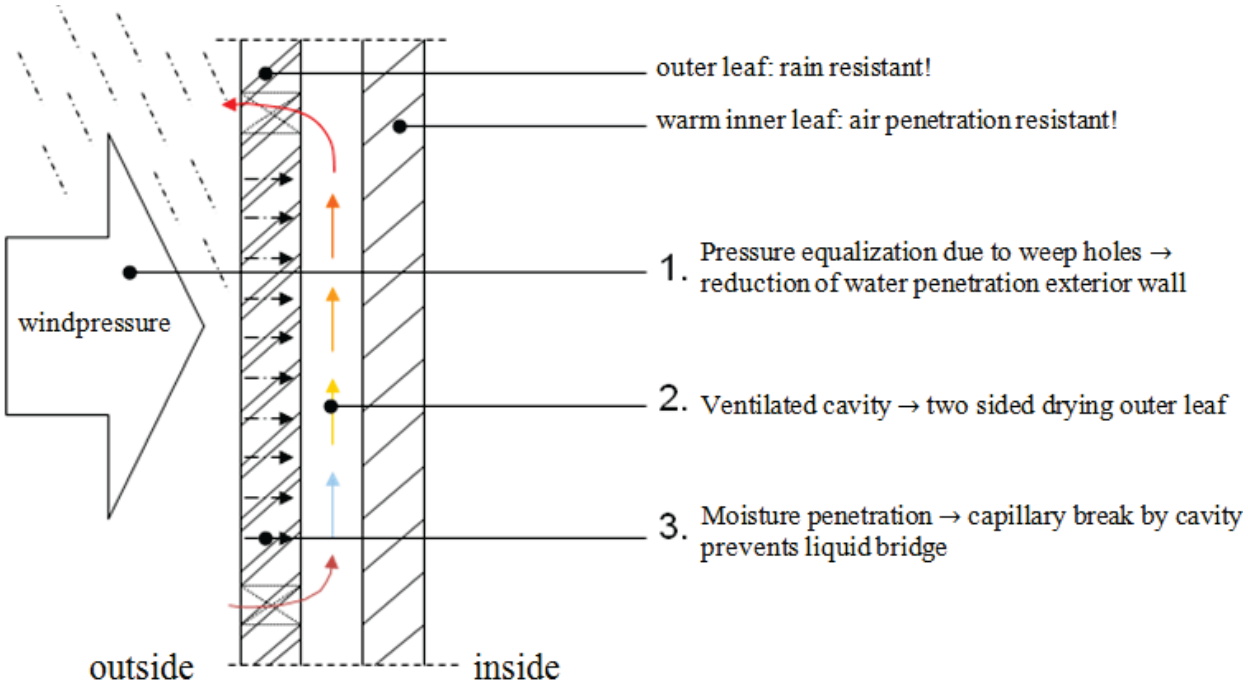


Scale level [mm] Material Physics
Moisture induced damages

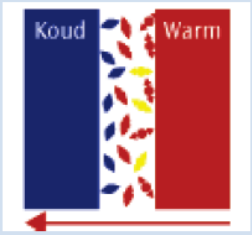
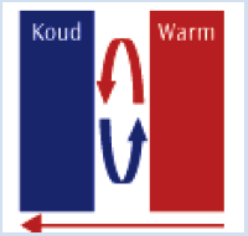
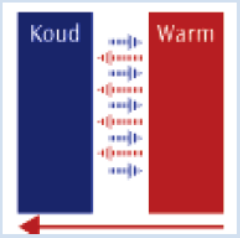
Scale levels, from left to right: EU; Urban area; Building; Material;



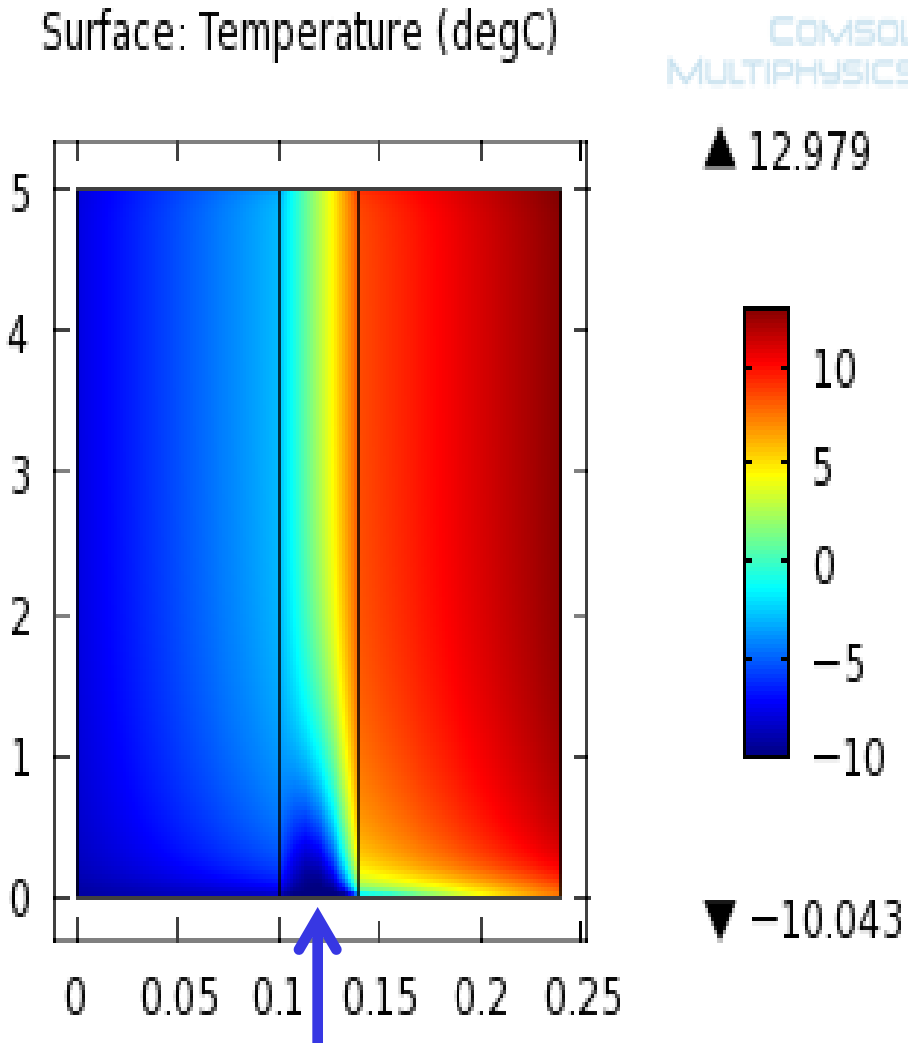
Building constructions with a cavity



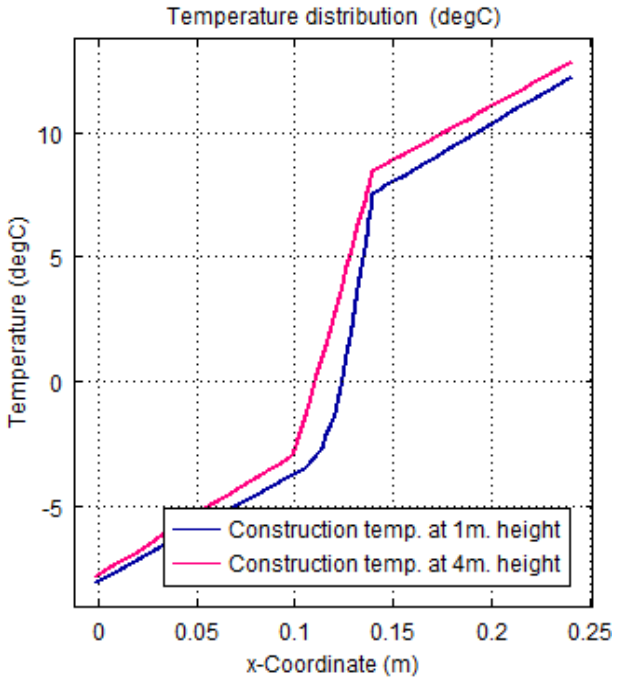
Heat transfer in cavities

	Visualization	Influence parameters
Conduction	Heat flow through a material due to temperature differences	
		• Thickness • Thermal conductivity material, λ • Temperature difference
Convection	Heat exchange due to a flowing fluid	
		• Gas properties (ρ,v,Cp) • Cavity volume (with and high) • Surface coefficient of heat transfer • Air velocity • Temperature difference
Radiation	Heat exchange by electromagnetic waves from a warm to cold surface	
		• Gas properties (ρ,v,Cp, κ_r) • Surface emissivity • Surface area • Temperature • Temperature differences

Exemplaric result



Airflow,-10 ^{o}C , 0.05 m/s



Overall results

Nr	Cavity thickness	Insulation	Air velocity	Cavity heat exchange		Cavity thermal resistance	Overall thermal resistance
1	14 cm	No	Without air	Radiation:	1,73 W/m^2.K	0,24 m^2.K/W	0,58 m^2.K/W
2	14 cm	No	Stagnant, 0 m/s	Conduction: Radiation:	0,07 W/m^2.K 1,70 W/m^2.K	0,23 m^2.K/W	0,57 m^2.K/W
3	4 cm	No	Stagnant, 0 m/s	Conduction: Radiation:	0,22 W/m^2.K 1,60 W/m^2.K	0,21 m^2.K/W	0,55 m^2.K/W
4	4 cm	No	0,2 m/s	Conv.+cond.: Radiation:	0,67 W/m^2.K 1,51 W/m^2.K	0,12 m^2.K/W	0,46 m^2.K/W
5	4 cm	No	0,05 m/s	Conv.+cond.: Radiation:	0,41 W/m^2.K 1,56 W/m^2.K	0,17 m^2.K/W	0,51 m^2.K/W
6	4 cm	Yes	No air in cavity	Radiation:	0,32 W/m^2.K	0,30 m^2.K/W	3,14 m^2.K/W
7	4 cm	Yes	Stagnant, 0 m/s	Conduction: Radiation:	0,04 W/m^2.K 0,28 W/m^2.K	0,26 m^2.K/W	3,09 m^2.K/W

Conclusions

- **Comsol can be used for thermal design and optimization of building constructions.**
-
- **Future work will include 3D applications**