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2D and 3D simulation on thermal flow around the human body

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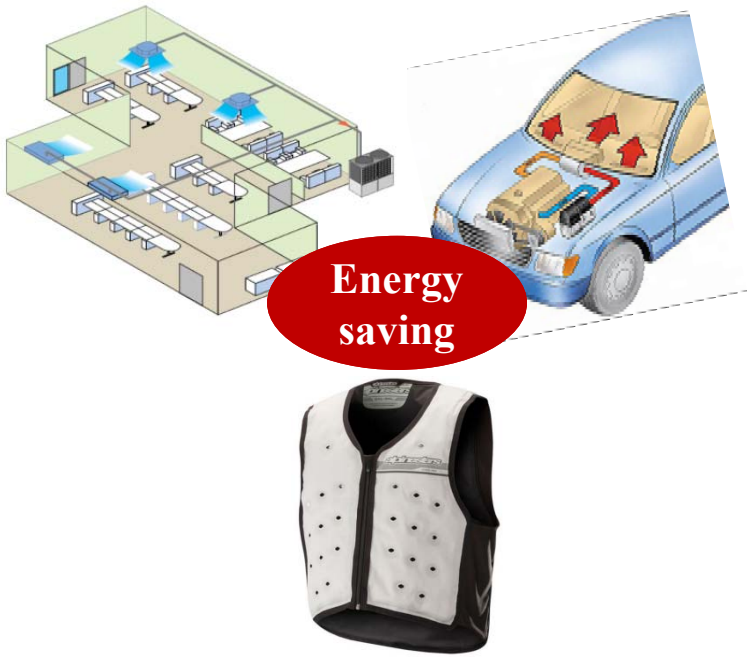
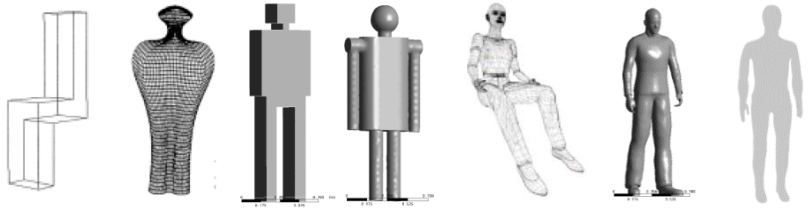
Body Monitoring Group
BIOMIMETIC MEMBRANES AND TEXTILES LAB

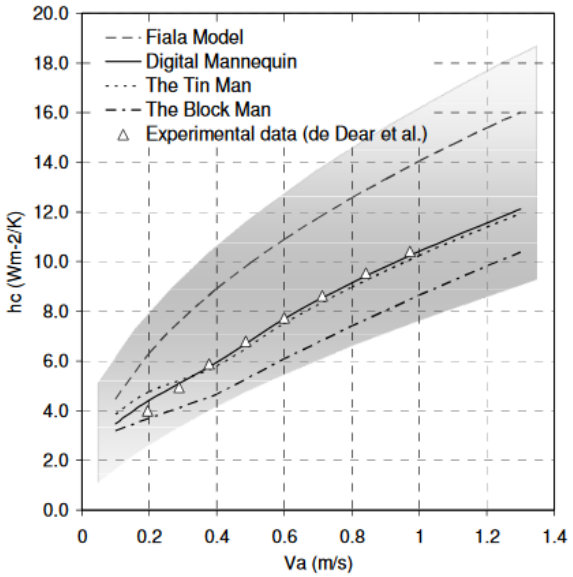
Motivations



- Localized heat transfer from human body

- Human body shape, posture, orientation influence heat transfer coefficient (htc)

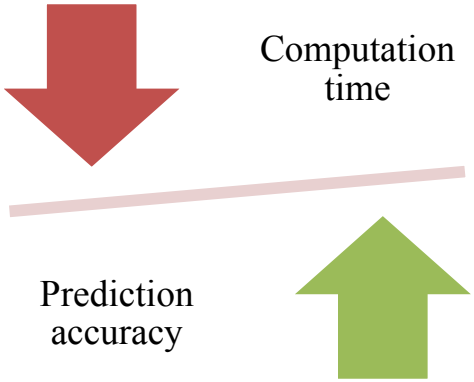




Objectives

- Simulate thermal flow from human body to the environment by using COMSOL Multiphysics 5.3a.

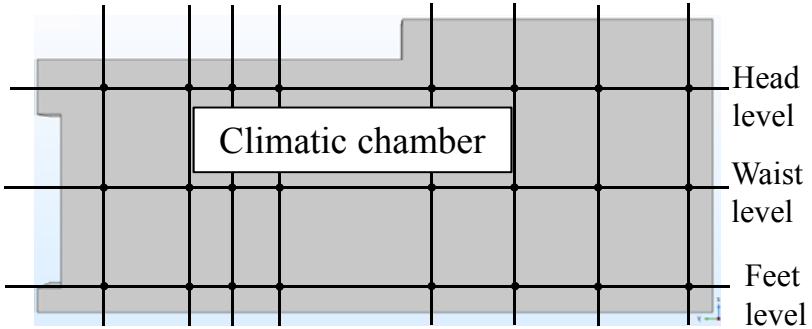
- The effect of 2D simplified model on air flow.
- The effect of body geometry simplification on heat transfer from body surface.

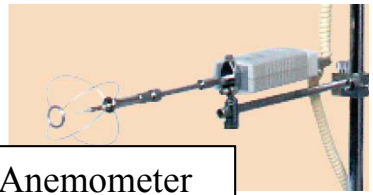


Methods

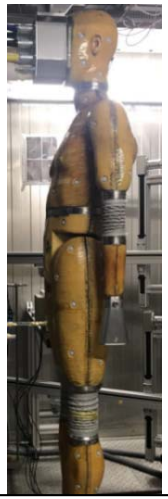
Experiment

- Air velocity measurements
- Heat flux measurements





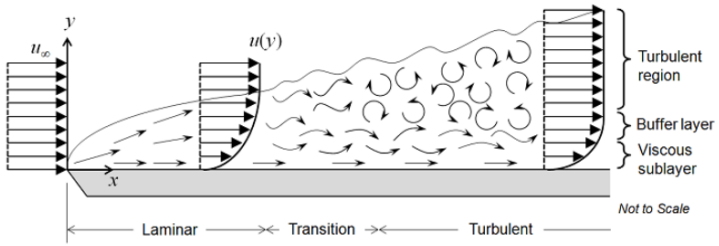
Anemometer



SAM manikin

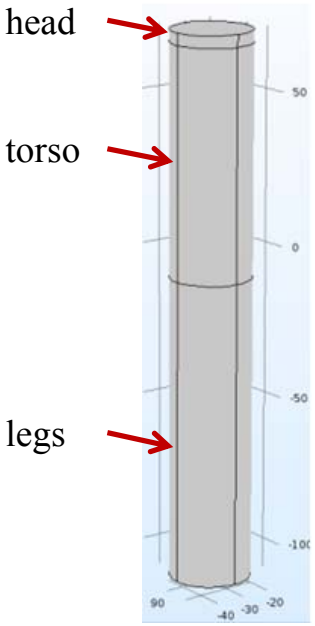
Simulation

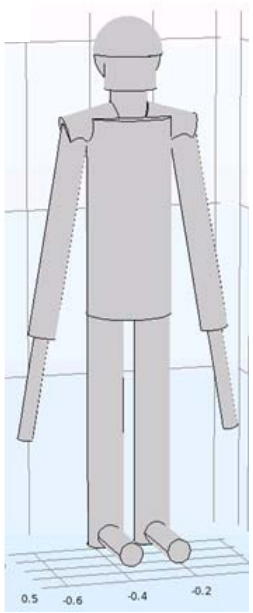
- Air flow
- Air flow + heat transfer

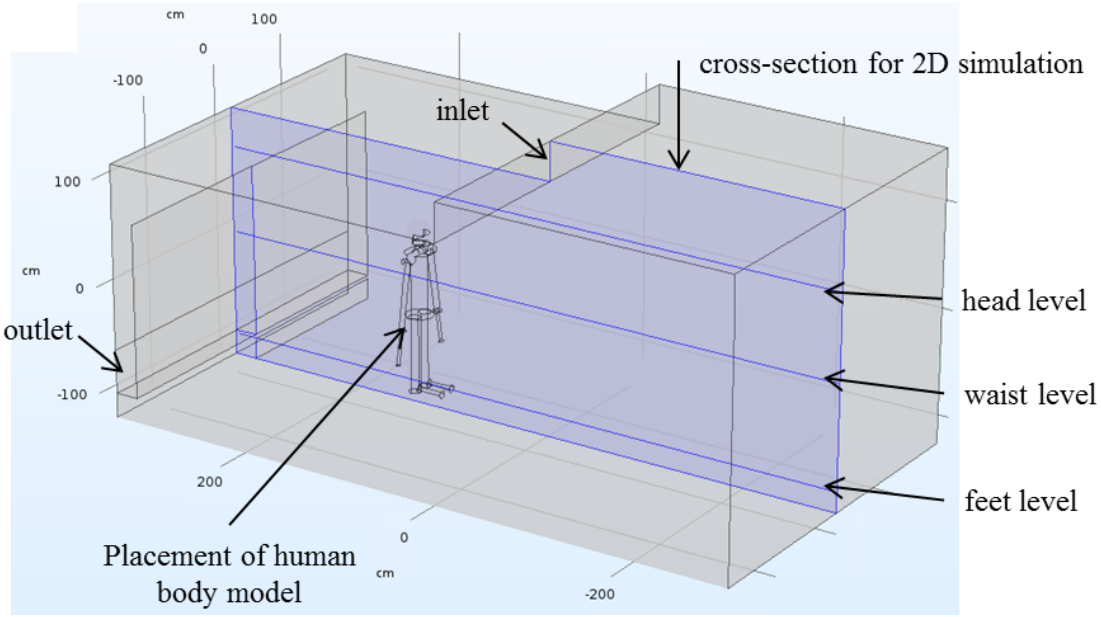


Methods

❑ Geometric models







Cylinder man

Tin man

Convective heat

Radiative heat

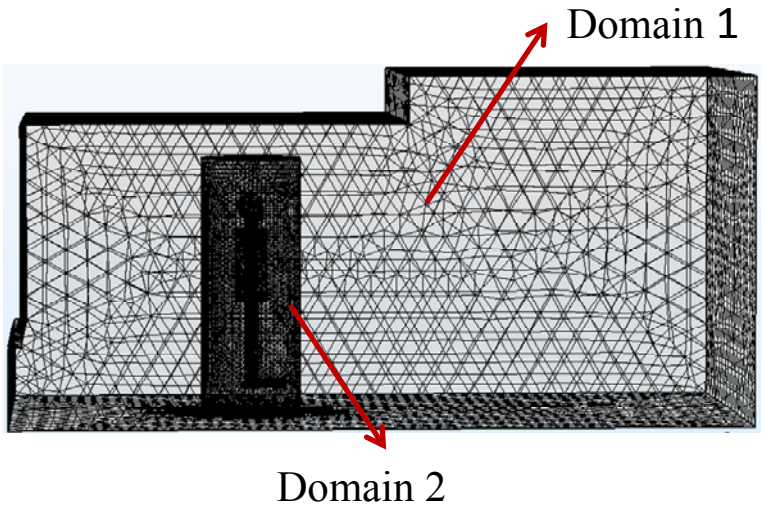
Climatic chamber model

Methods

❑ Boundary conditions for stationary study

BCs	Inlet air velocity	Inlet air temperature	Skin temperature	Turbulence model	Heat transfer	Radiation model	Wall function
2D model	0.62 m/s	23.5 ℃	-	Low Re k-ε	Heat transfer in fluids	S2S	No
3D model	0.89 m/s		34 ℃				

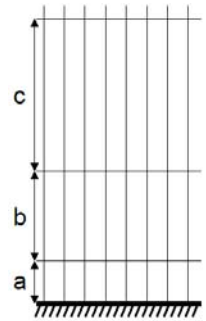
❑ Grids



- Surface mesh: triangular
- Domain mesh: tetrahedral
- Body surface, inlet, outlet: < 4 cm
- Boundary layer: 5 layers

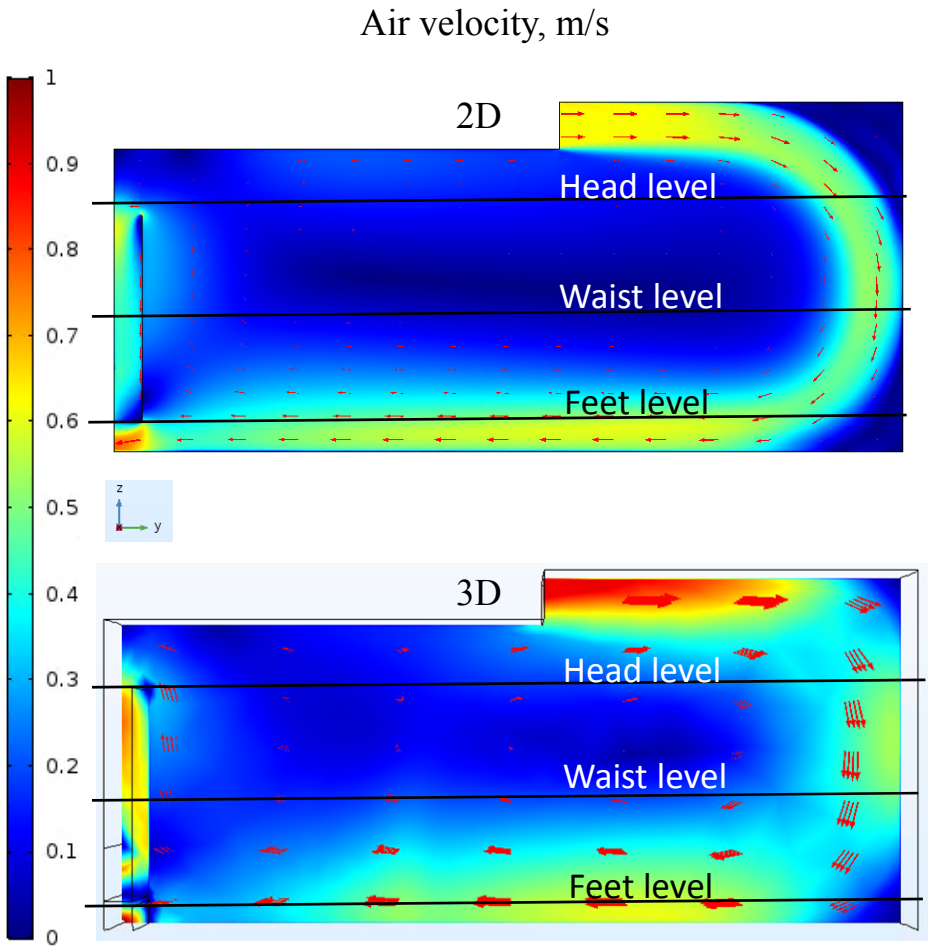
  1.2 stretching factor

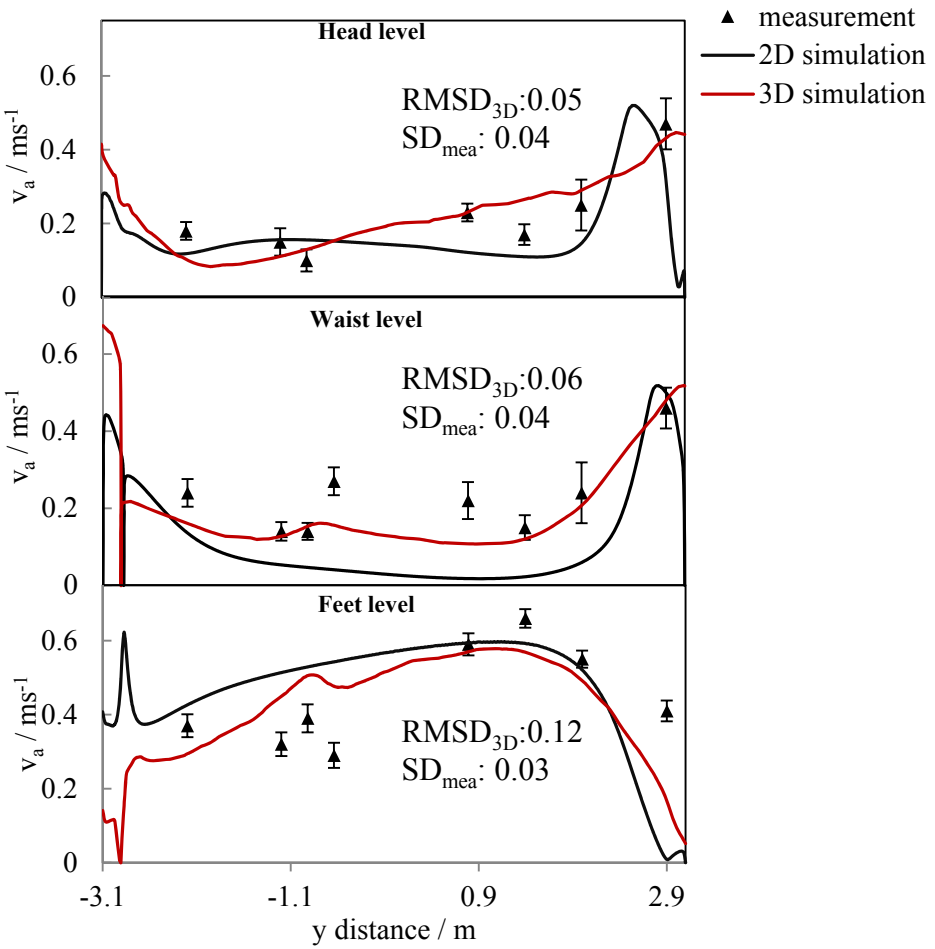
  L_a: 0.033cm
- y^+ value: <1



Results

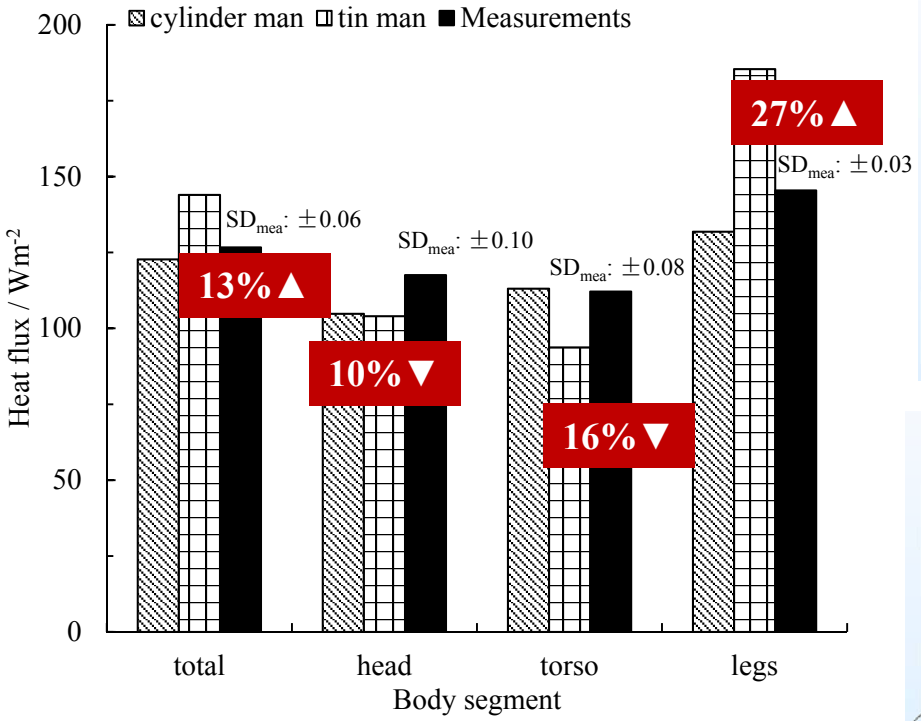
Air flow in the chamber

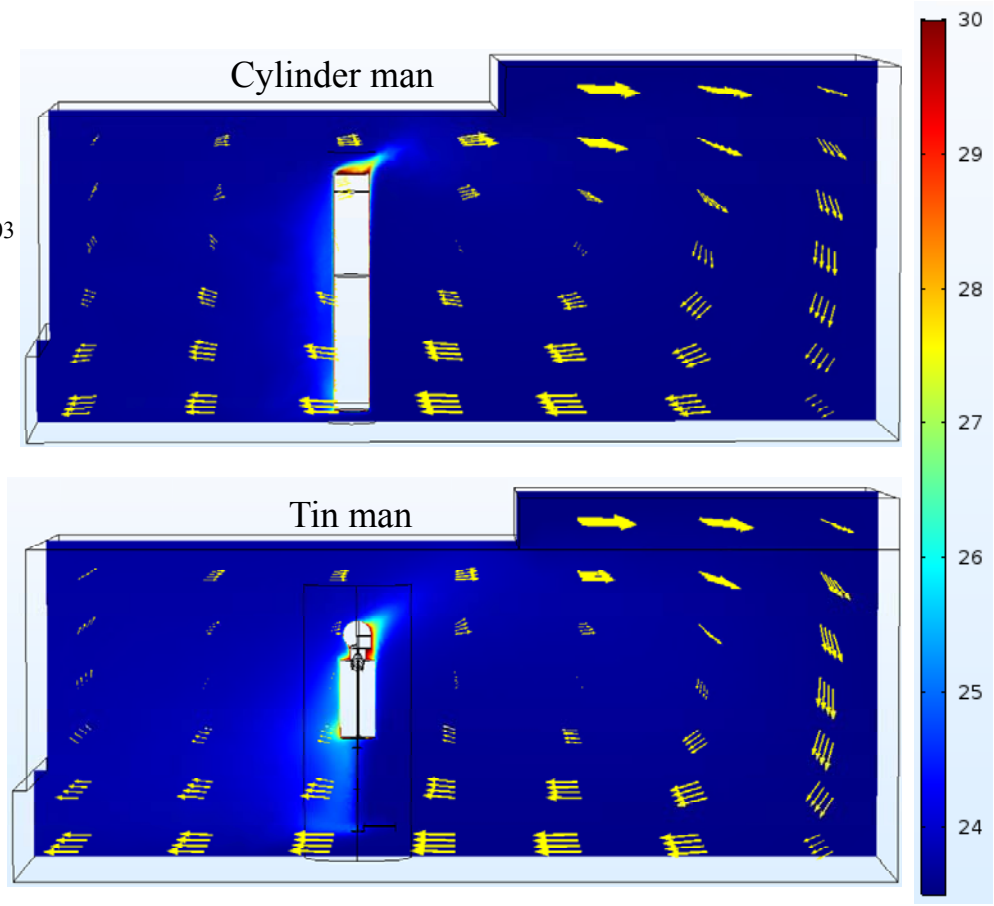




Results

Heat flux at body surface





Conclusions

❑ 2D vs 3D

- 2D model is able to predict the approximate air flow distribution in an indoor environment.
- 2D simulation definitely can be used for determination on BCs and grid size for 3D simulation.

❑ Cylinder man vs tin man

- Body simplification influences both overall and local heat transfer from body surface.
- More complex body structure requires denser mesh for more accurate heat transfer prediction.

Reference:
Jingxian Xu, Agnes Psikuta, Jun Li, Simon Annaheim, René M. Rossi. Influence of human body geometry and surrounding environment on local heat transfer between unclothed human body and the environment.

Danke für Ihre Aufmerksamkeit.
Thank you for your kind Attention.

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Empa
Materials Science and Technology