COMSOL CONFERENCE 2017 ROTTERDAM

TU/e Technische Universiteit Eindhoven University of Technology

Coupled Heat, Moisture and CFD Modeling in the Built Environment

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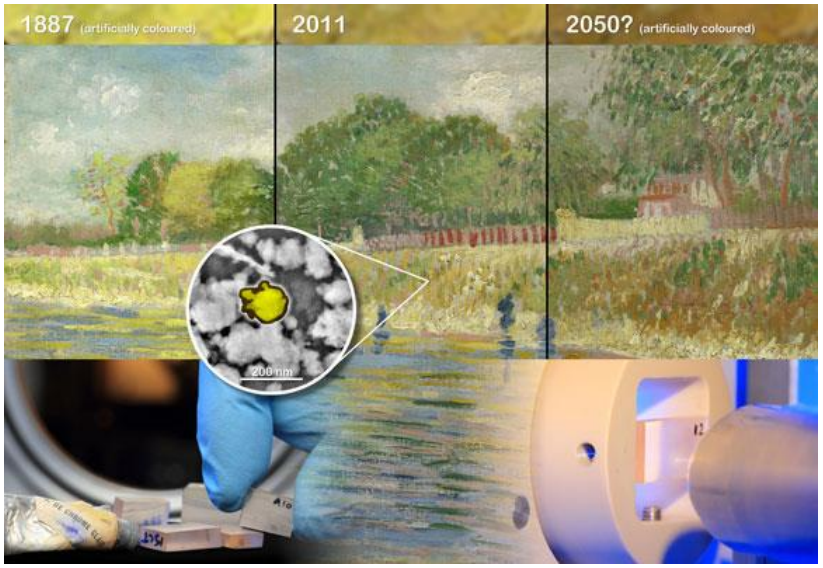
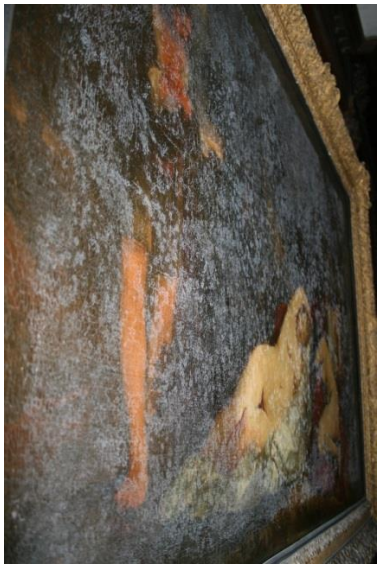
Where innovation starts

Introduction

Museums

- Strict indoor climate
  - Prevent degradation



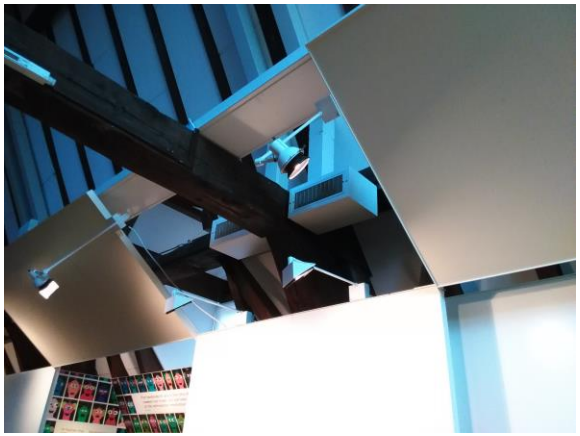


Introduction

Museums

- Strict indoor climate
  - Prevent degradation

- HVAC to stabilize indoor climate



Introduction

Museums

- Strict indoor climate
  - Prevent degradation

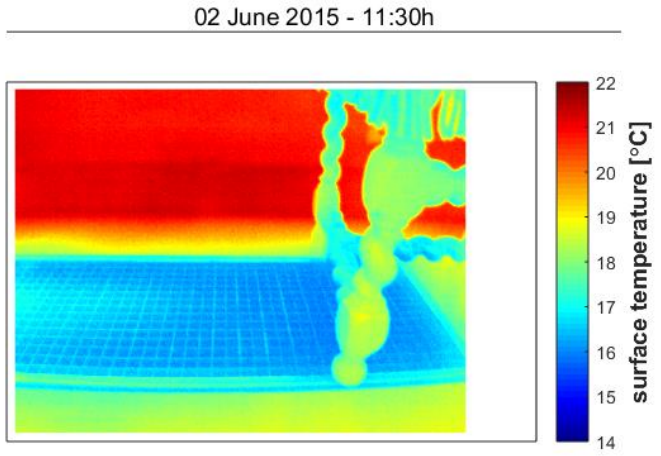
- HVAC to stabilize indoor climate

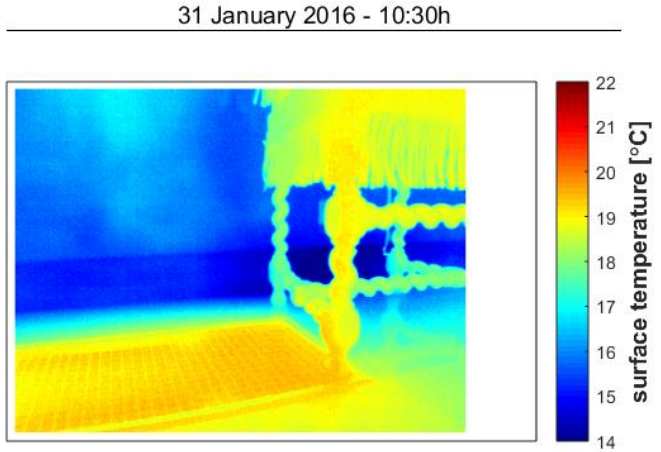
- High energy consumption and irreversible impact to historic buildings

Introduction

Museums

- Strict indoor climate
  - Prevent degradation
- HVAC to stabilize indoor climate
- High energy consumption and irreversible impact to historic buildings
- Local climates caused by HVAC





Objective

Research question

- *Understand the impact of short-term temperature and relative humidity changes in indoor air supply on the indoor climate near objects.*

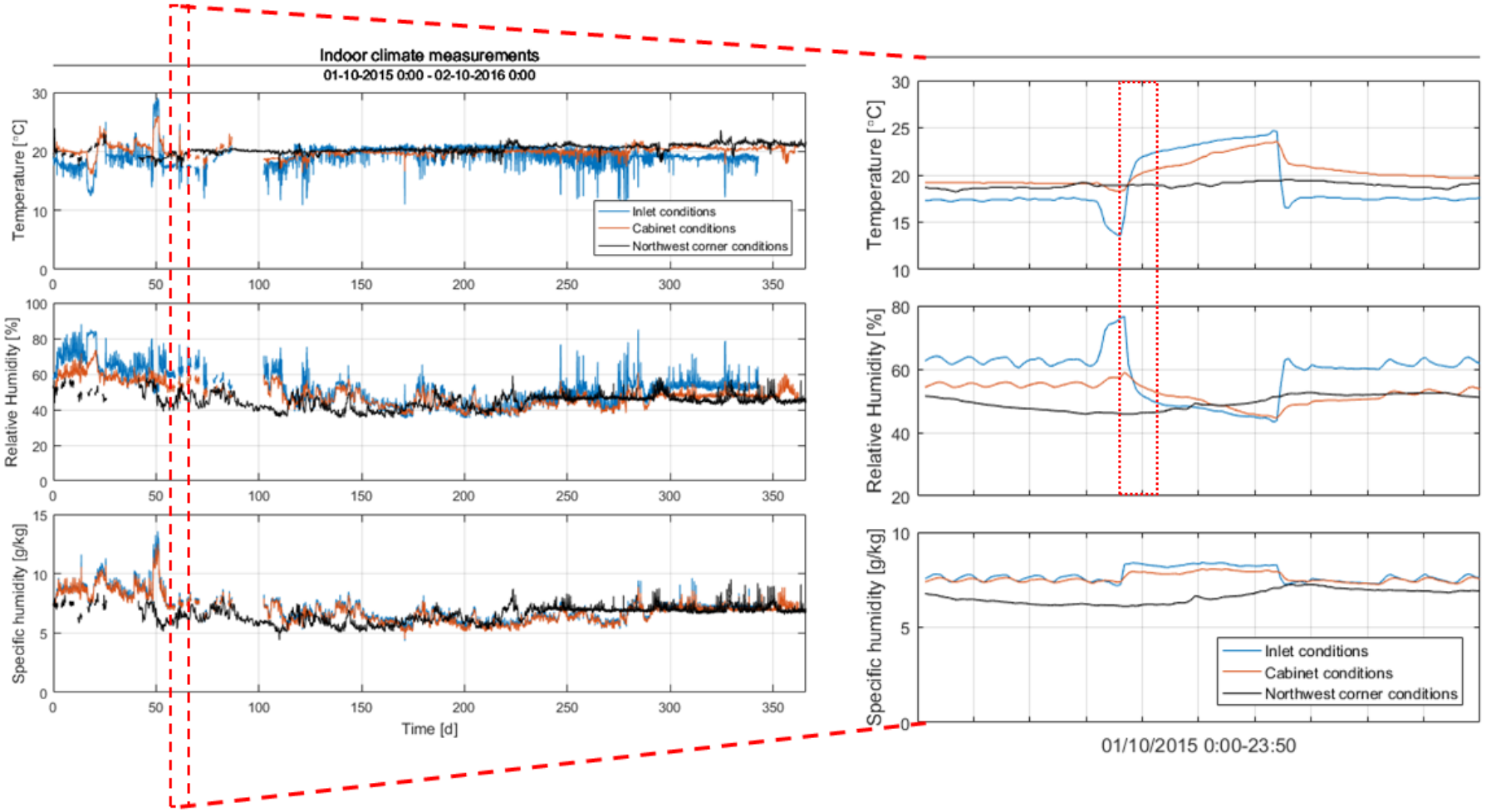
Comsol Multiphysics is used to research the effect of fluctuating conditioned supply air on the indoor climate near objects in an exhibition room.

Method

Experimental

Case study Amsterdam Museum

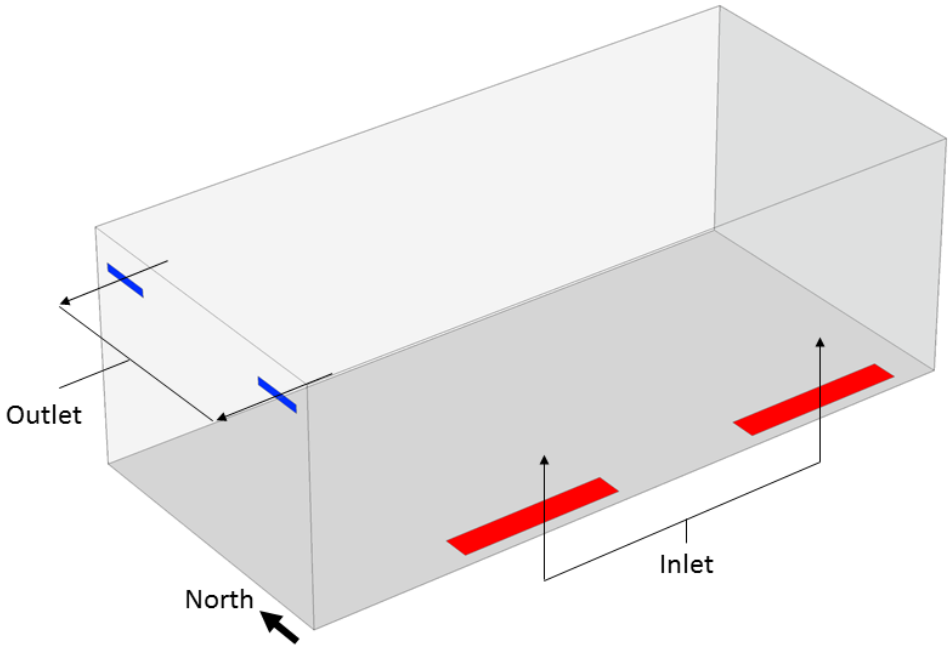
- 15th century building
- Mixed collection
- HVAC since 2007
- Measurements of T_i, T_s, RH_i


Indoor climate measurements
01-10-2015 0:00 - 02-10-2016 0:00
Temperature [°C]
Relative Humidity [%]
Specific humidity [g/kg]
Time [d]
Inlet conditions
Cabinet conditions
Northwest corner conditions
01/10/2015 0:00-23:50

Method

Numerical

- Heat transfer in fluids
- Moisture transfer in air
- Non-isothermal flow (k-ε turbulence model)

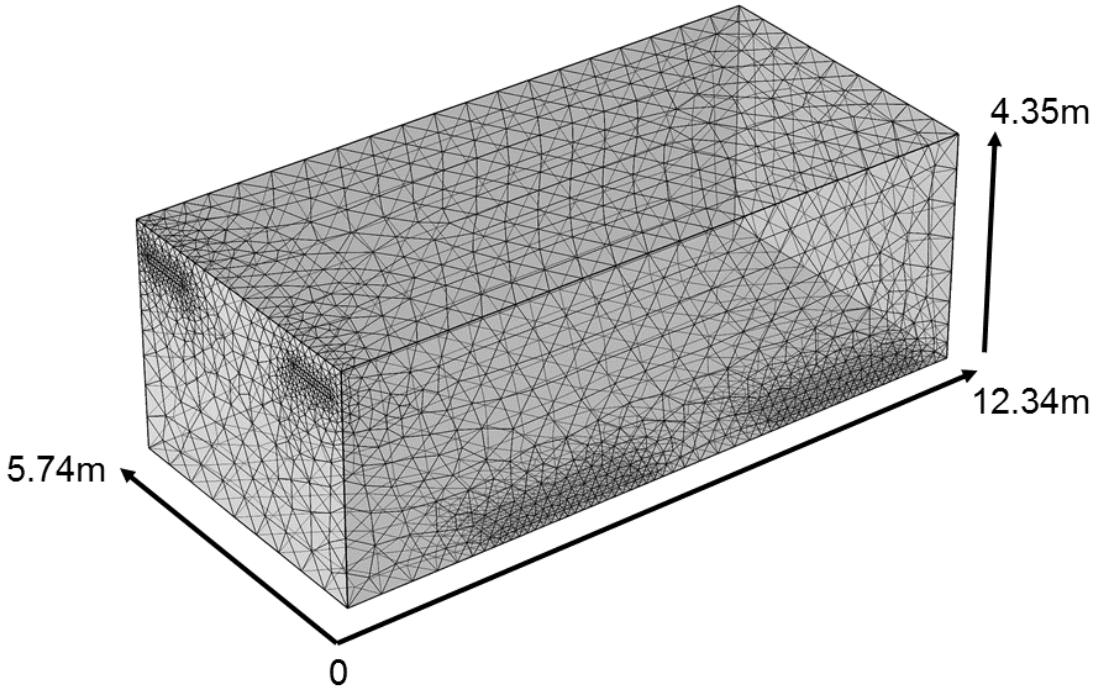


Method

Numerical

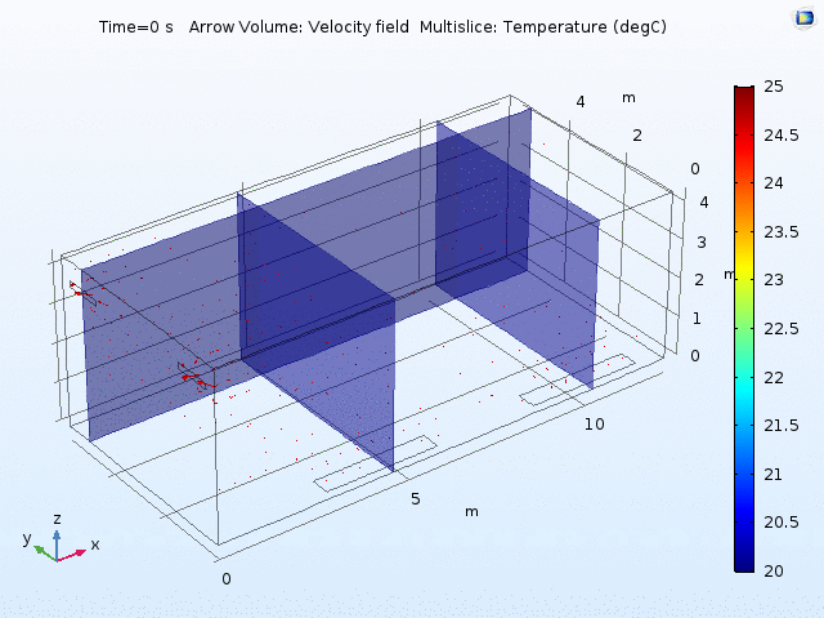
- Grid
  - Fluid dynamics normal element size
  - Inlet/outlet boundaries restricted element size <0.1m

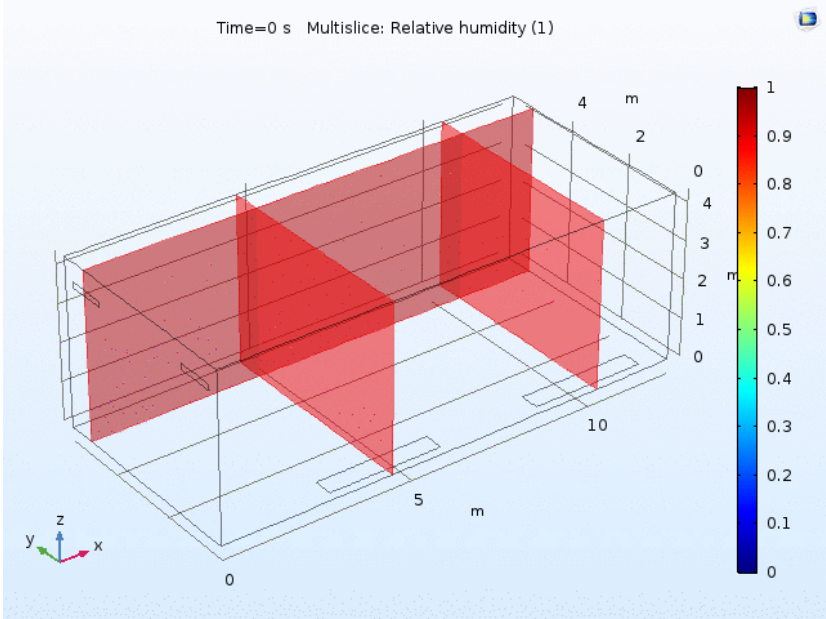
- Boundary Conditions
  - Inlet: step function
  - Walls: constant T



Results

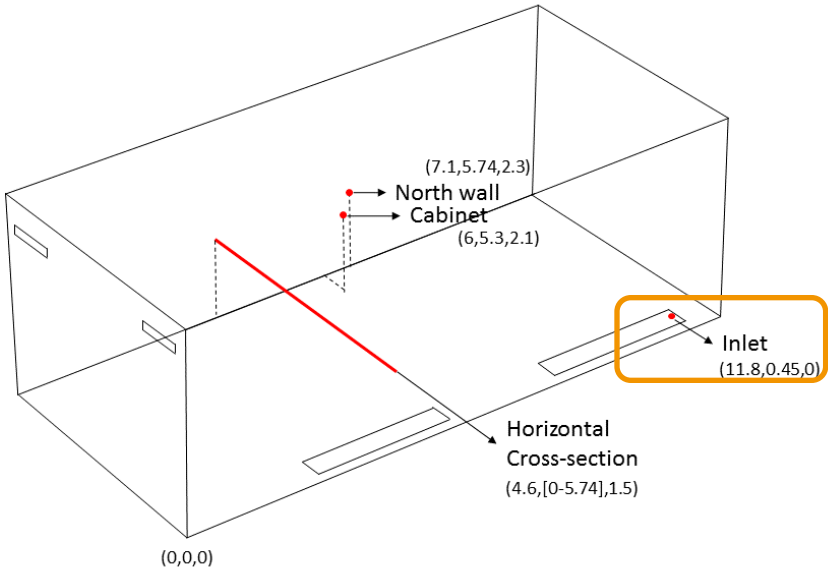
Transient simulation

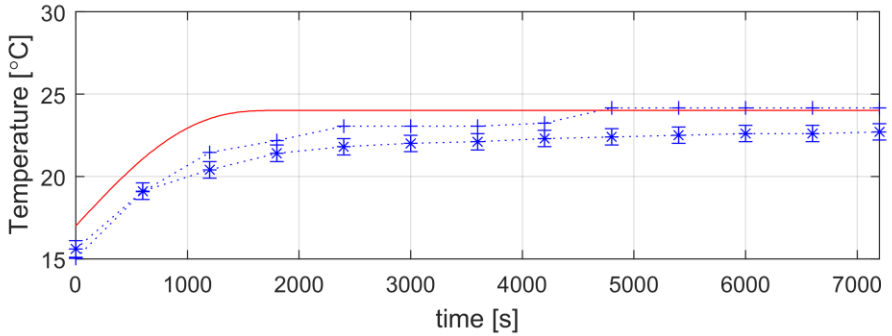


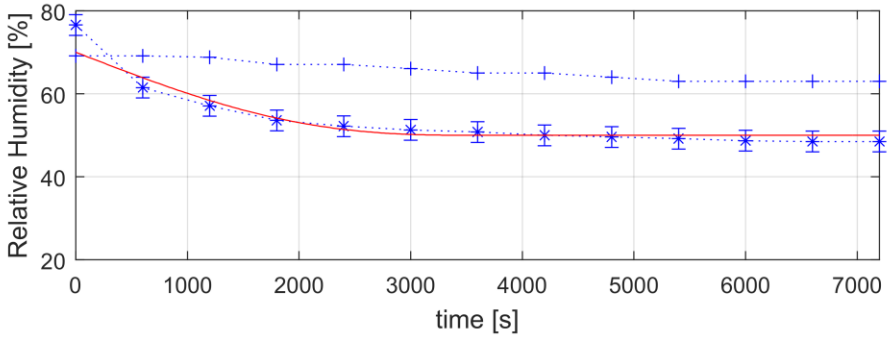


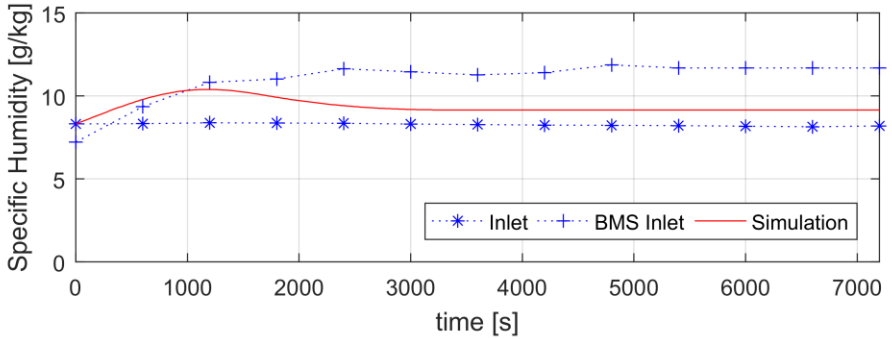
Results

Validation









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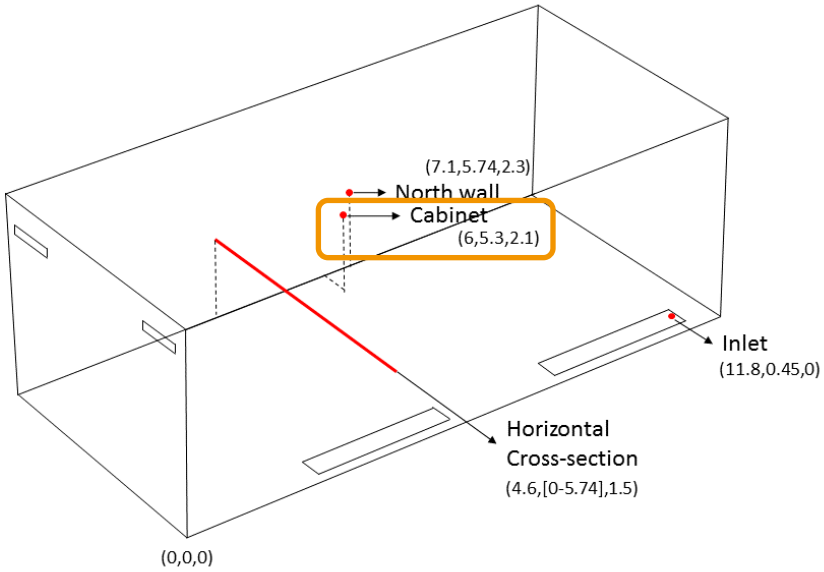

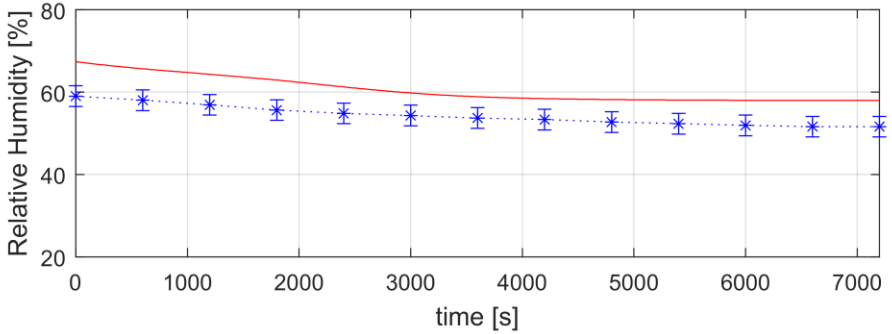

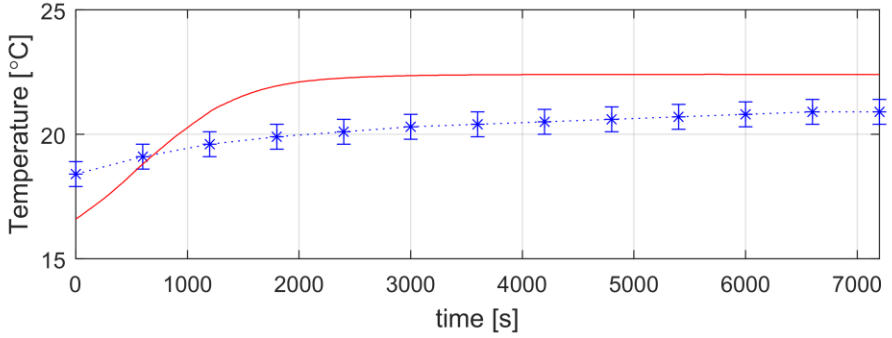

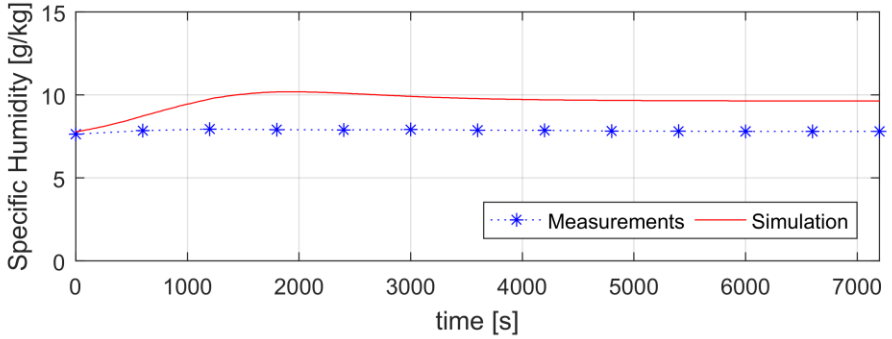

Conclusions

Findings

- It is possible to use COMSOL Multiphysics as computational tool for indoor environment modelling influenced by HVAC climate control.

- The outcome is valuable for locating critical areas in an exhibition rooms and could be of help while staging a museum exhibition, or evaluating novel climate control strategies.

Model limitations

- The model is not yet adequately validated for this case study.

- It takes quite some computational effort to perform simulations based on coupled Heat, Air and Moisture transport, even in a simplified situation.

- The simulation results are sensitive to the imposed boundary conditions and solver settings.

Conclusions

Future work

- Future steps in this study will include performing a grid-sensitivity analysis and re-evaluate the validation of the model based on extensive experimental data.

- Influence of solar radiation as short-term fluctuation on indoor climate conditions.

- Couple indoor climate as boundary condition to a stress-strain model of typical heritage objects.

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Thank you for your attention

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