Aalto University
School of Engineering

EXPERIMENTAL STUDY OF VERTICAL AIR TEMPERATURE GRADIENT IN LECTURE ROOMS WITH DIFFERENT VENTILATION SYSTEMS

Natalia Lastovets, Simo Kilpeläinen, Juha Jokisalo , Risto Kosonen

Department of Mechanical Engineering

Department of Mechanical Engineering, Aalto University, Espoo, Finland

Motivation – Context of the study

- Complications in the classroom situation: high and intermittent occupancy
- Dearth of results assessing performance of these systems in actual classroom situation
- Vertical temperature gradient affected by the type of air distribution system
  - Mixed ventilation (MV)
  - Displacement ventilation (DV)
  - Hybrids of the above two
- Data gathered can aid:
  - Numerical evaluation of air distribution systems
  - Study of the thermal mass effect on the vertical temperature gradient
  - Making informed choices regarding retrofits

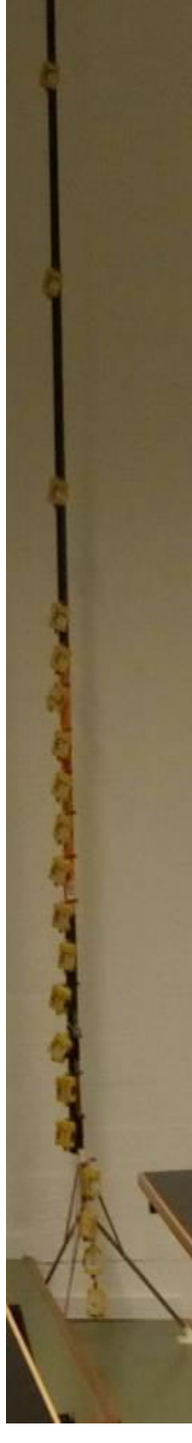
Method – Room description and measurements

Room	Floor Space (m2)	Seating Capacity	Air distribution system	Max. air supply (l/s)	Supply diffusers	Exhaust
U3	94	70	Mixed + Displacement	260 + 500	24 underfloor, 3 in ceiling	4 grilles
U4	156	156	Mixed	1500	3 in ceiling	5 grilles
U135 a	108	65	Displacement	600	50 underfloor	5 grilles

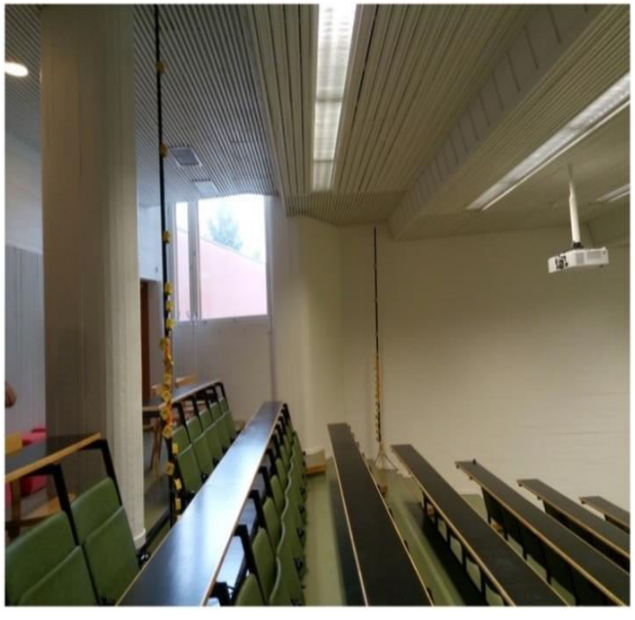
Measurements:

Temperature and humidity at 20 heights:
0.1 – 1.7 every 10 cm and three more at 2, 2.5, and 3 m

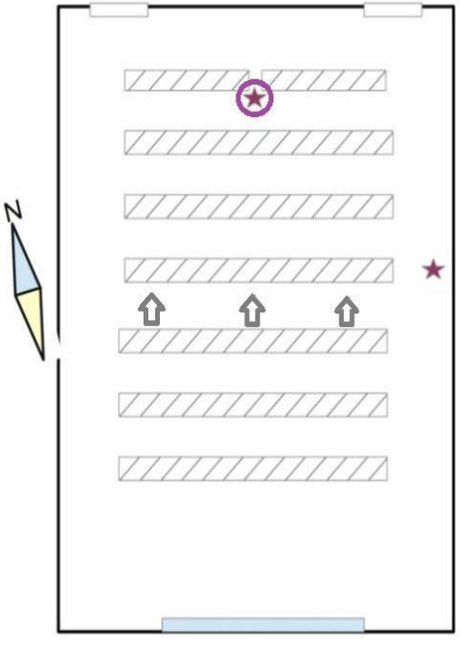
Using two masts with 20 TinyTag Plus 2 Dual Channel loggers

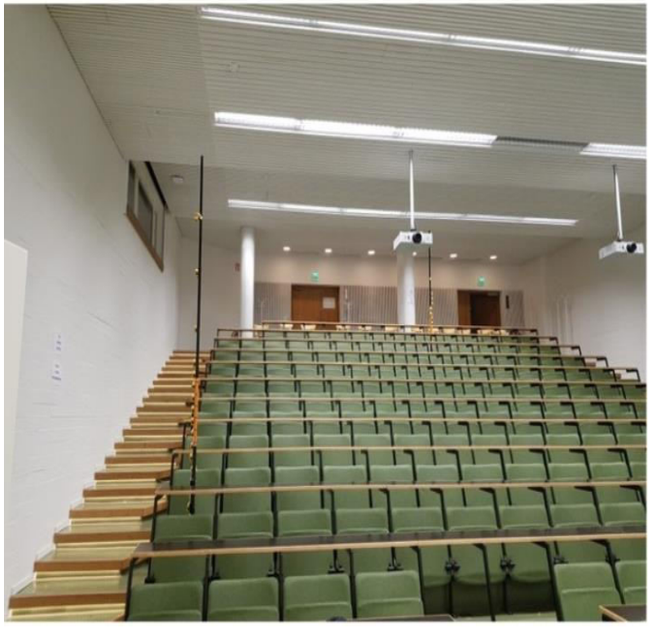


Measurement location in the lecture halls

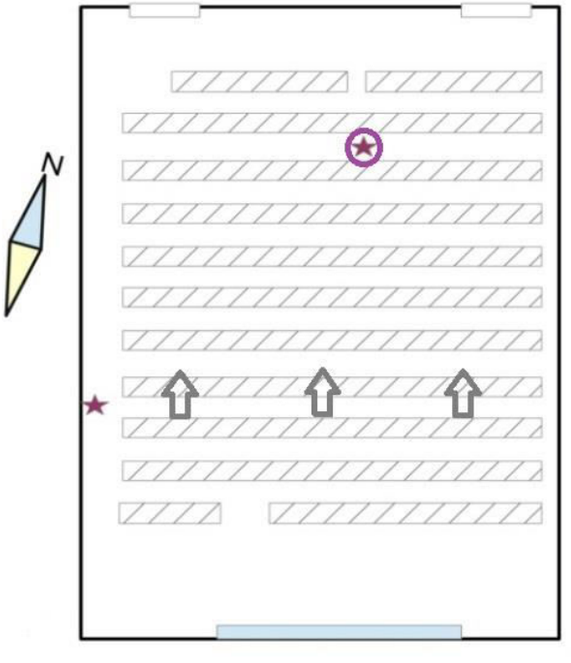


U3



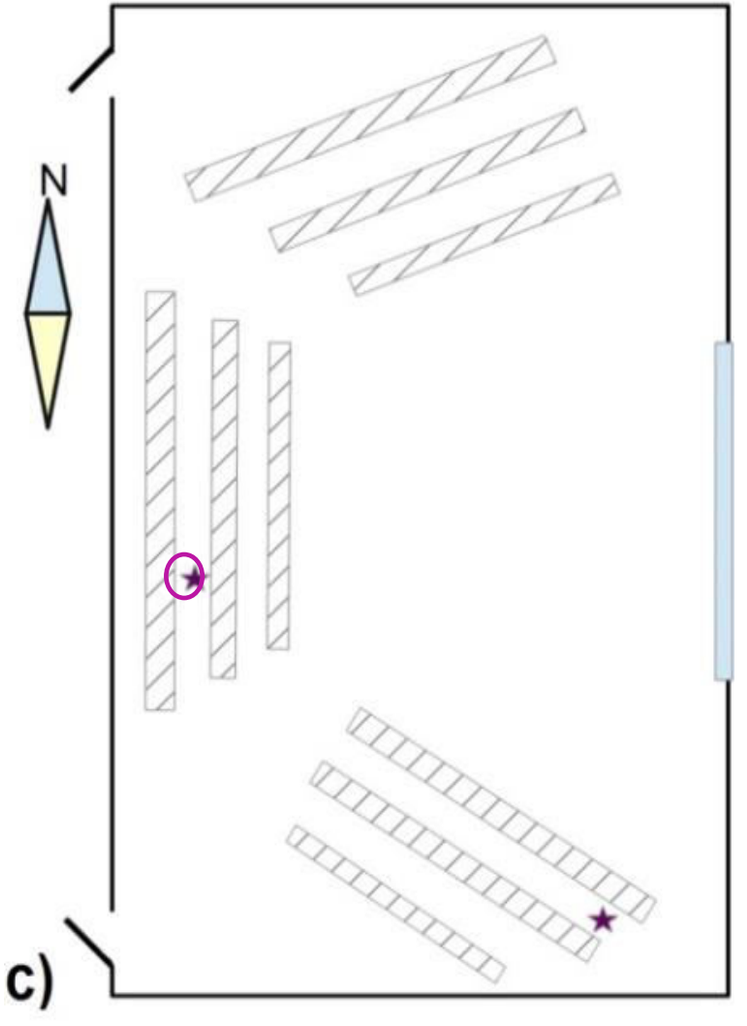


U4

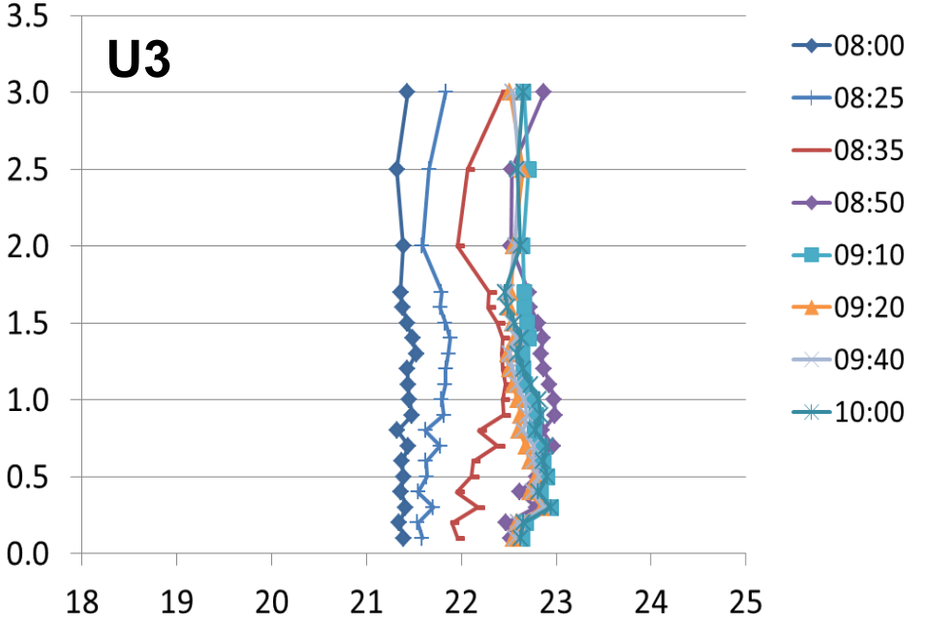


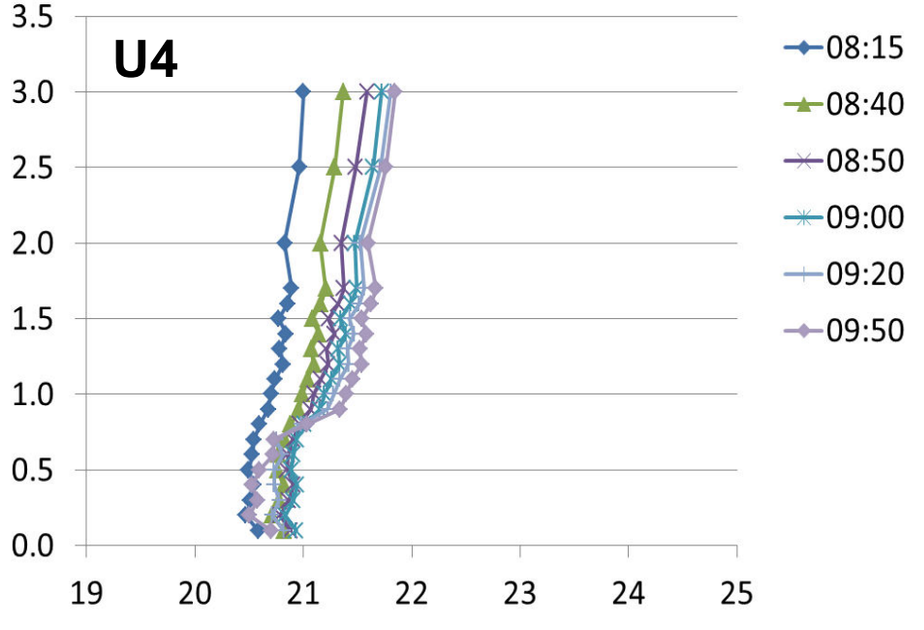
Measurement location in the lecture halls

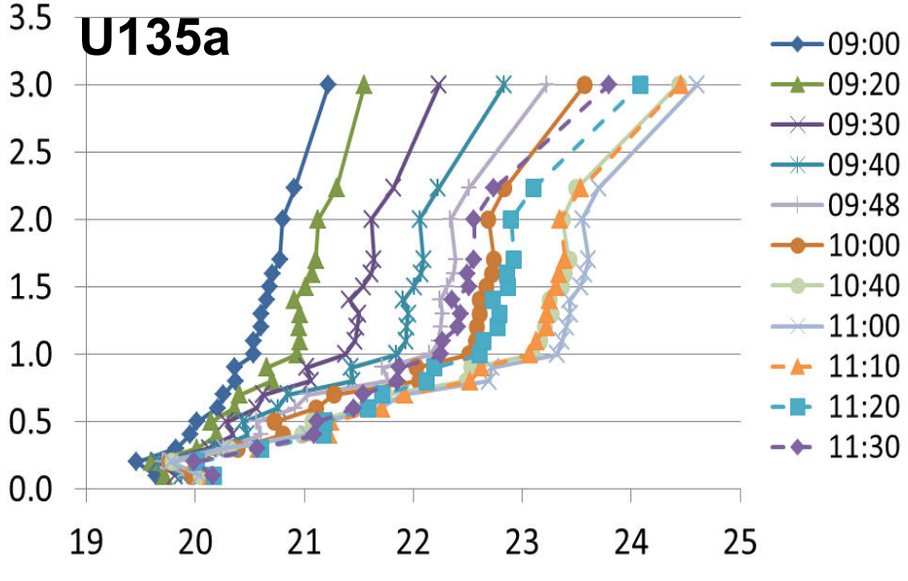
U135a



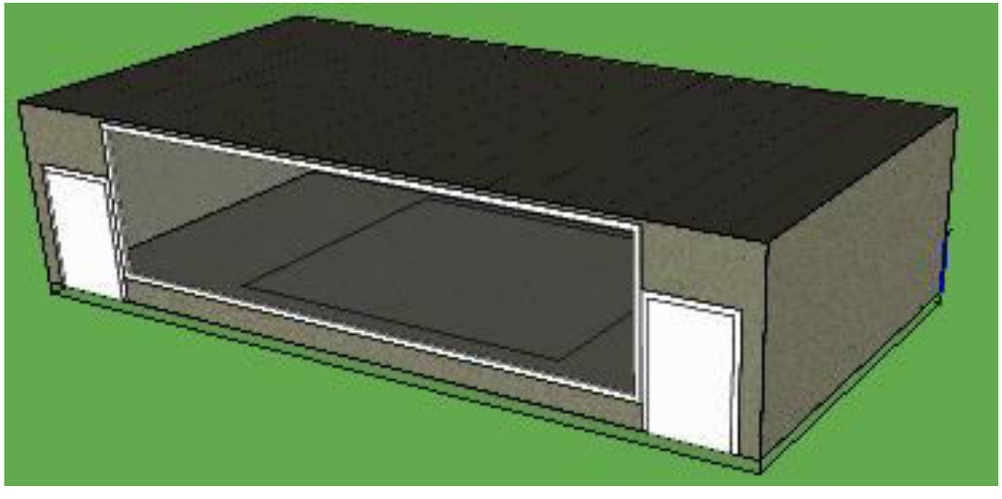
Results – Temperature profiles





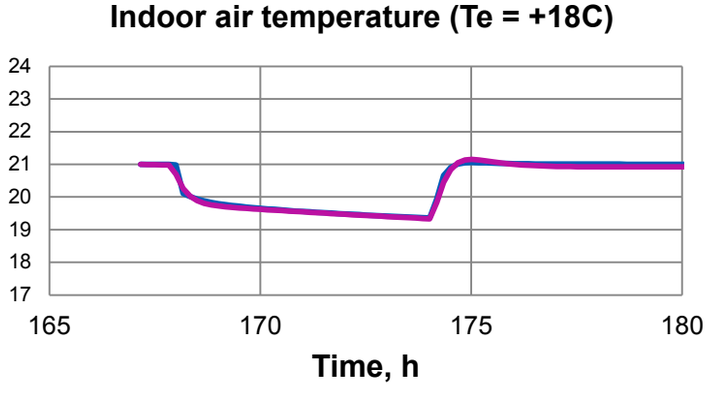


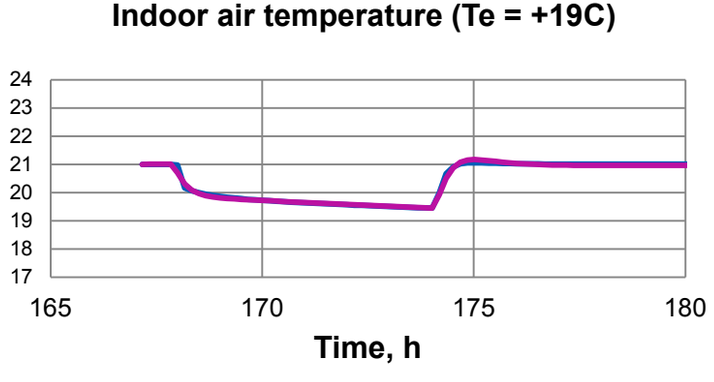
IDA-ICE model of the lecture room with displacement ventilation

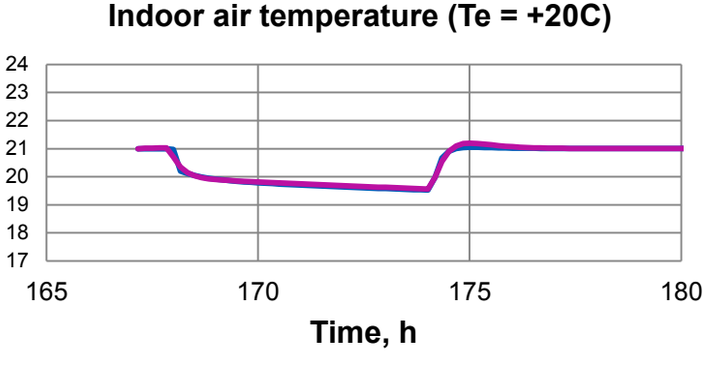


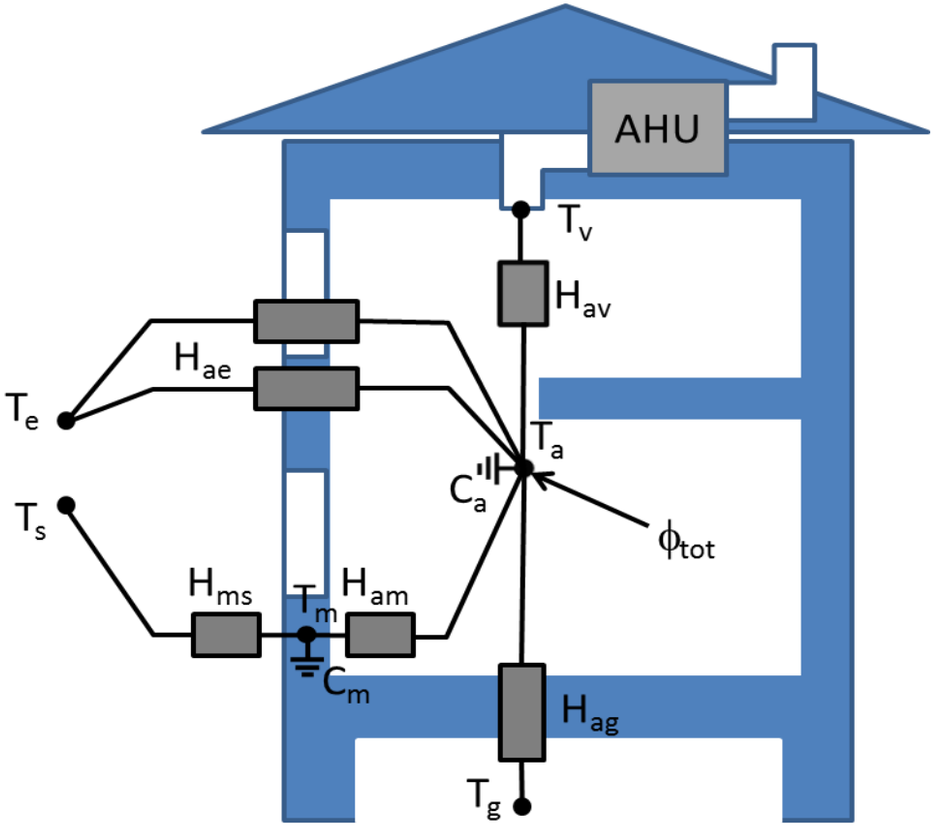
Room height – 3 m
Floor area – 86.4 m^2
Airflow rate – 0.6 m^3/s
Heat loads are adjusted from the measurements

Calibration of 2-capacity model

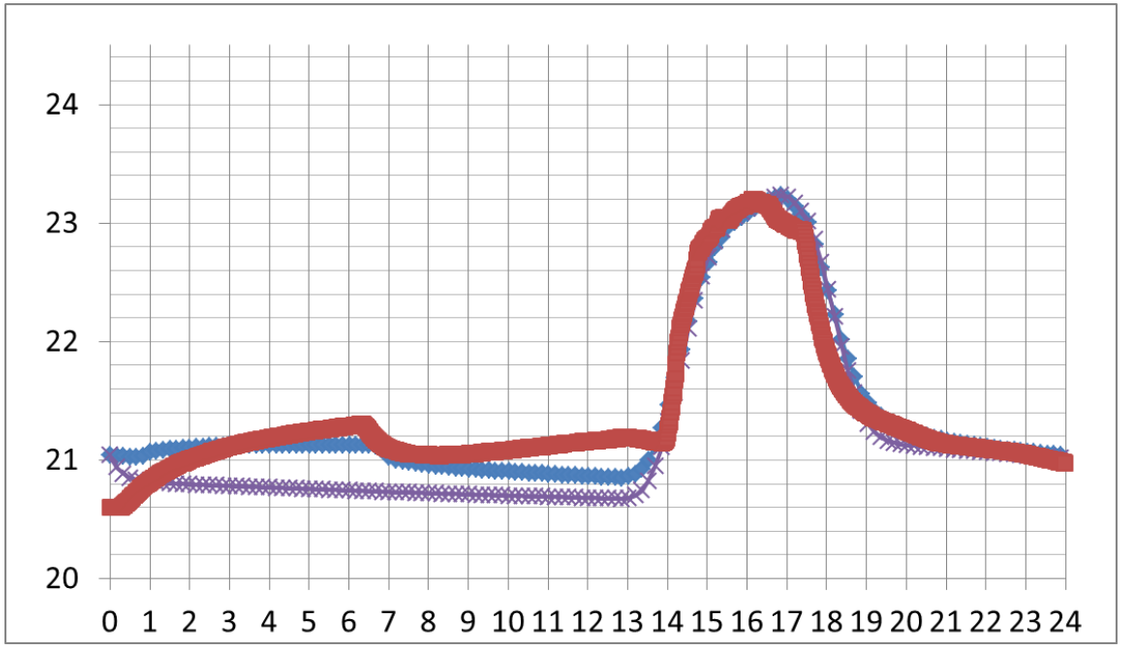


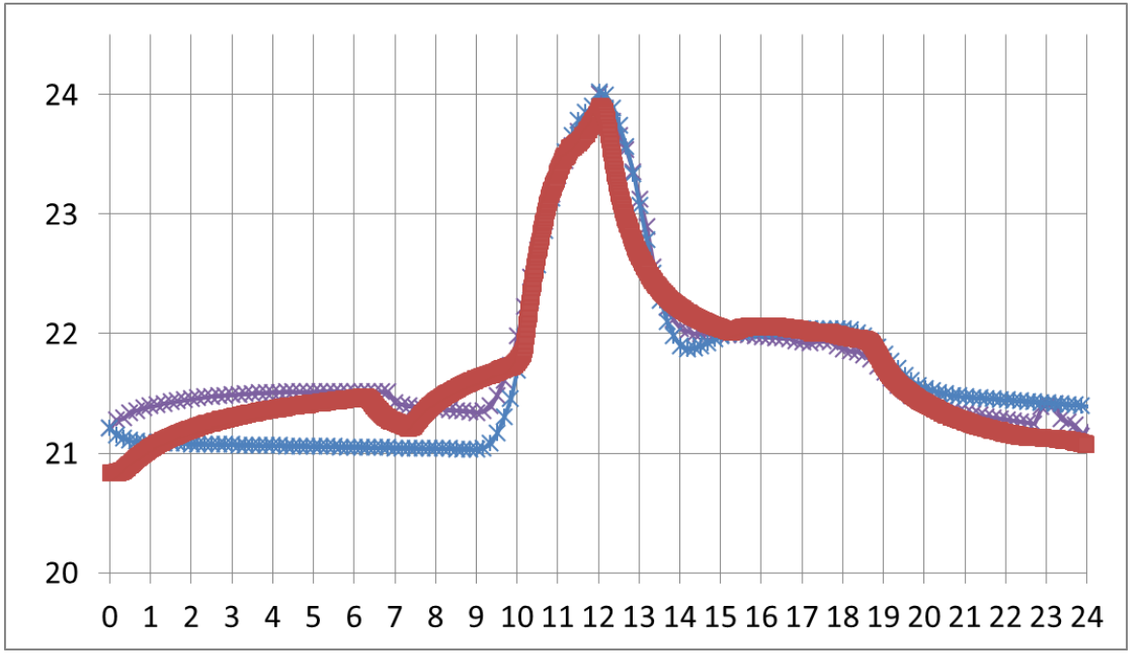






Modelled and measured exhaust air temperatures during 1 day





IDA-ICE model

2-capacity model

Measured

Conclusions

- Vertical temperature profiles depended on air distribution system, as did the temporal variations
- Temporal variations of temperature tracked the students coming in and leaving in the beginning and at the end of lectures
- The influence of student presence on the temperature profiles highly depends on indoor air mixing
- MV+DV showed very little stratification of air temperature
- The effect of thermal mass is the highest in the DV cases
- The measurement results can be used to validate the simplified dynamic models of indoor temperature gradient