Cool Phase PCM technical component and its applications

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and

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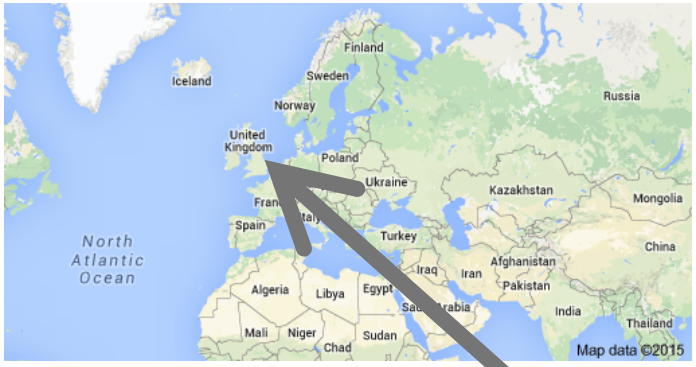
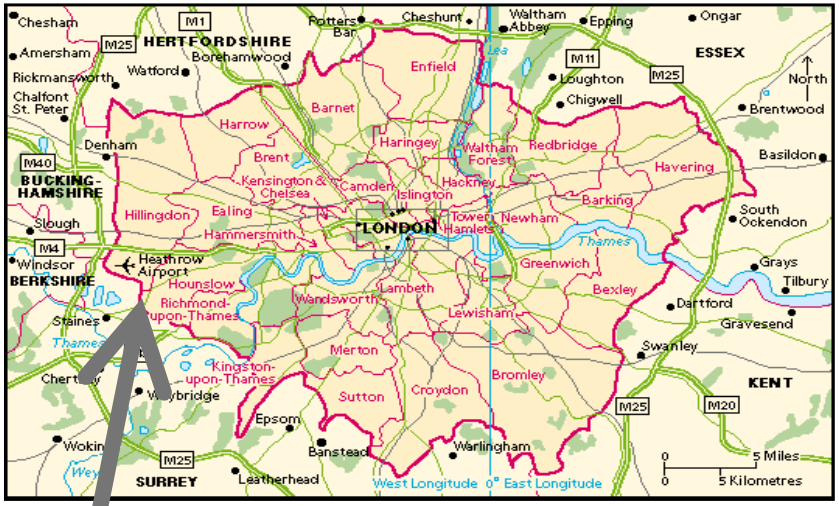
Brunel University London

Where is Brunel University?





Brunel University London

Some background facts

A University since 1966

15,000 students

2,000 international students from over 100 countries

Strong research activities in engineering

Who was Brunel ?

Isambard Kingdom Brunel

Famous Engineer

Born 1806, died 1859

EBC Annex 62 Expert meeting – Sep 2014
In front of Brunel's statue at Brunel University

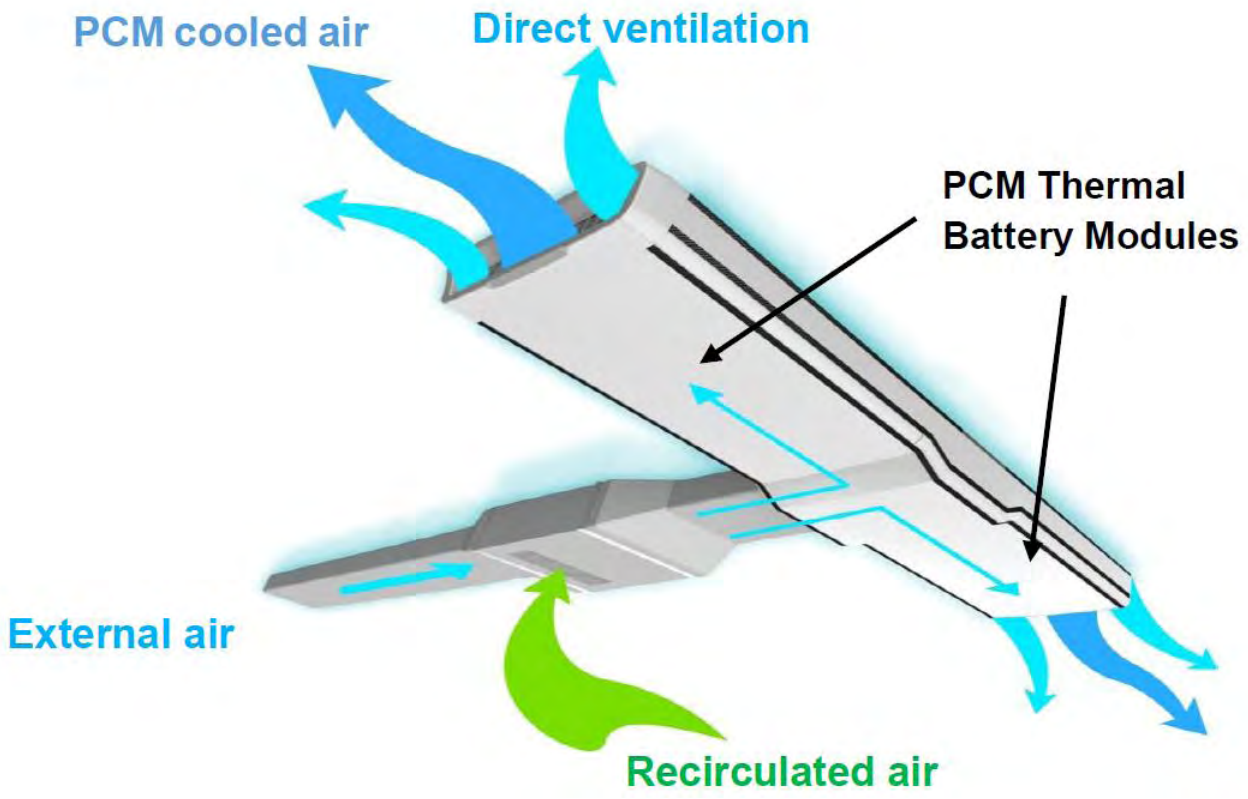
Clifton Suspension Bridge, spanning the River Avon at Bristol

930 ft bridge for

Great Western Railway

Ventilation system: CoolPhase by Monodraught

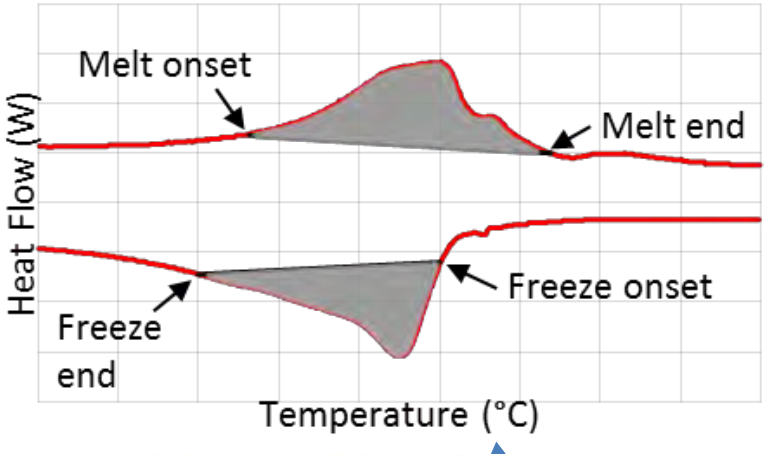
The Cool-Phase® system uses the concept of a thermal battery consisting of Phase Change Material (PCM) plates within the ventilation path to capture and store heat

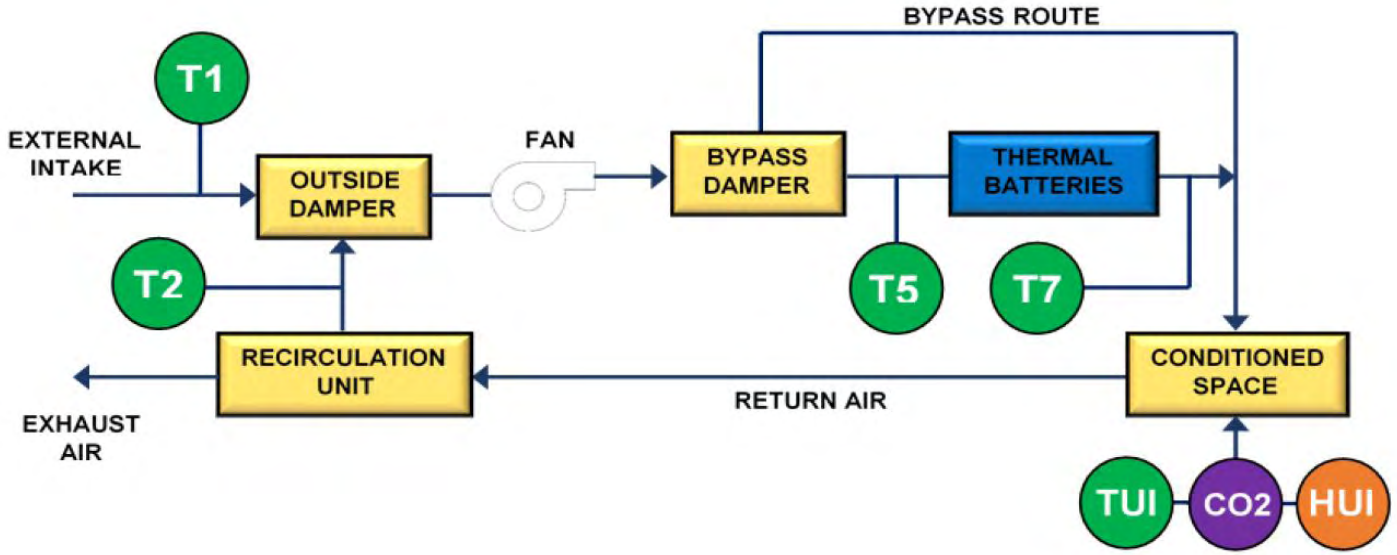


Ventilation system

Sensor points analysed in this work
T1= Outside Air
T2= Recirculation Air
T5= Air before battery
T7= Air after battery

UIH, UICO$_2$, TUI =
air temperature, relative humidity,
CO2 concentration inside the room



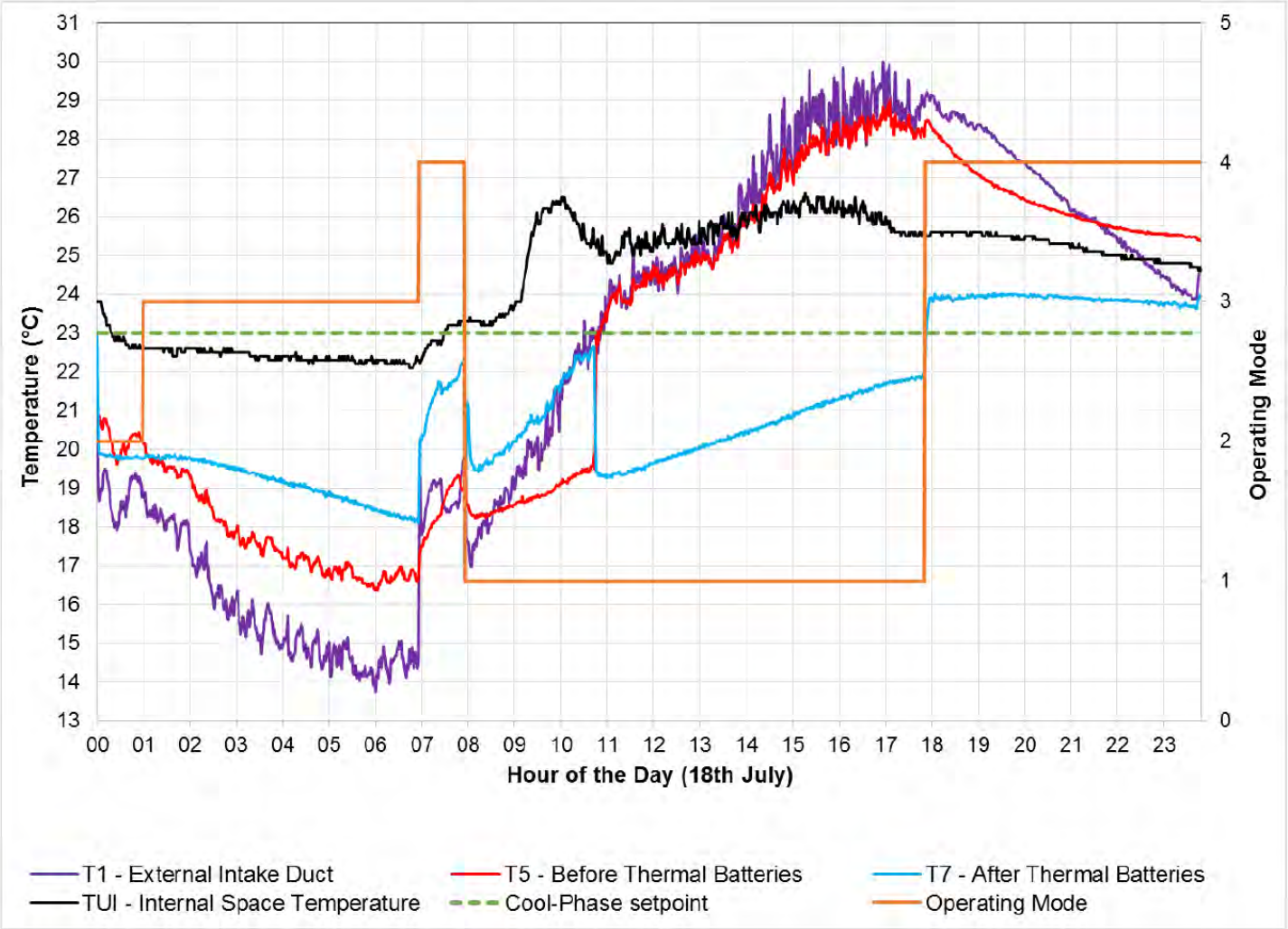


Monitoring in two operational buildings in south England

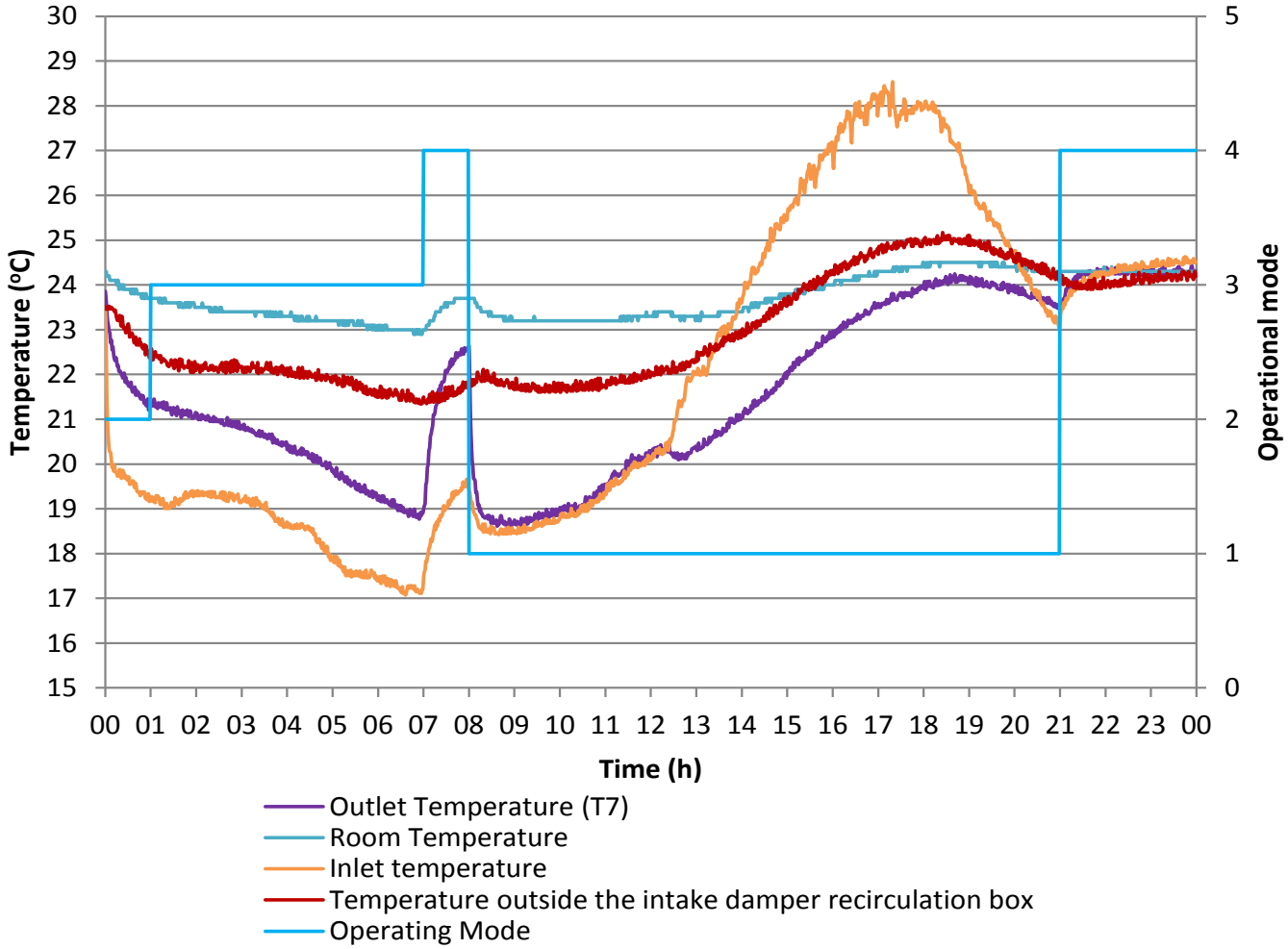
Open Plan Office Building

Educational Building Computer Seminar Room

Open Plan office system operation on a summer day 2016 based on system data



Seminar room system operation on a summer day 2013 based on system data



Requirements: UK school buildings

Overheating:

Until recently overheating criteria for schools were based on fixed air temperature (28°C which can be exceeded for 120hrs and 32°C not to be exceeded) outside the heating season and during the occupied period from 1st May to 30th September.

Currently, the adaptive thermal comfort approach is used which follows the methodology and recommendations of European Standard EN 15251. Two of the three criteria must be met:

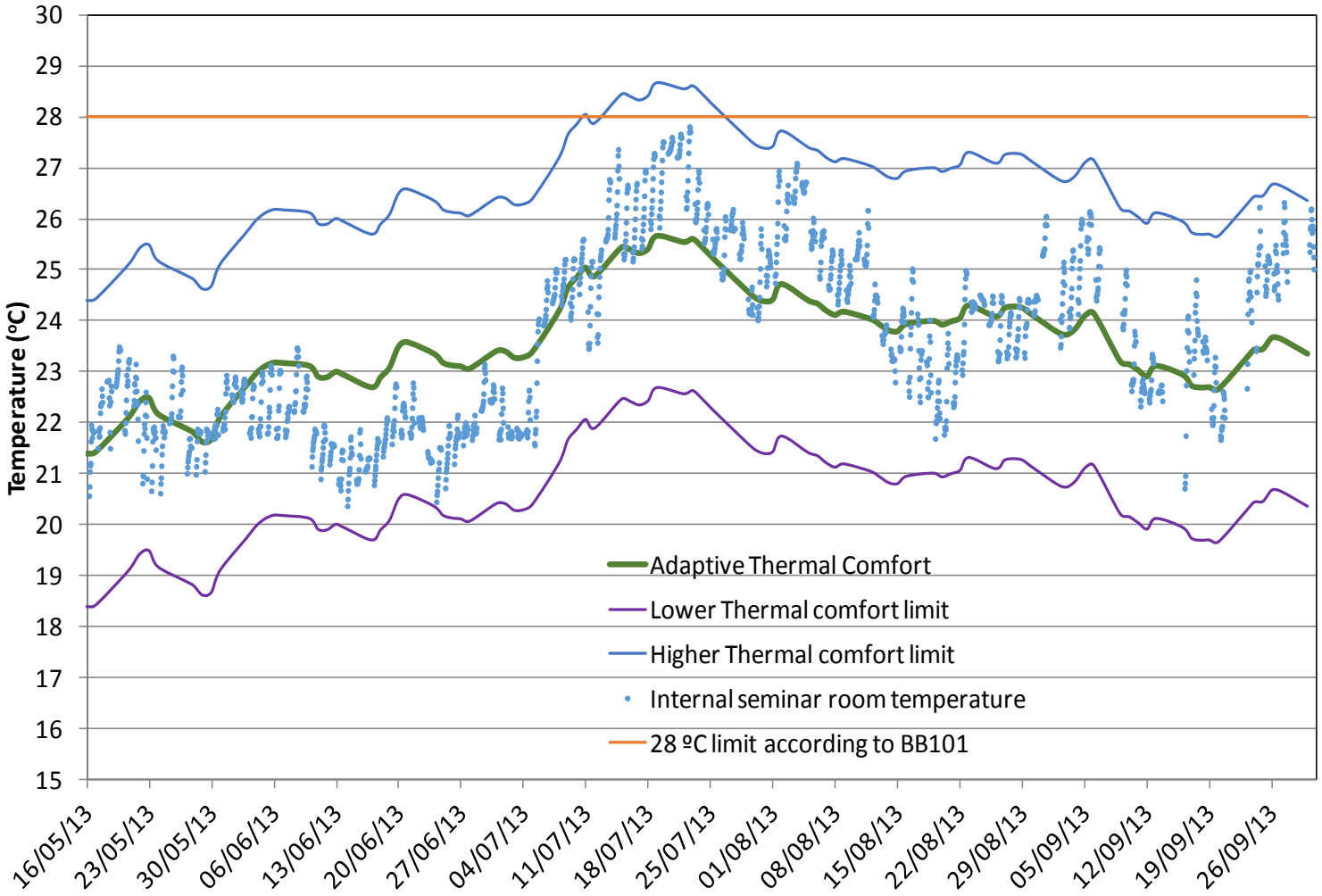
- Hours of Exceedance: The number of hours operative temperature exceeds the maximum acceptable operative temperature (θmax) by 1K, must not exceed 3% of the total occupied hours or 40 hours, during the five summer months.
- Weighted Exceedance: The sum of the weighted exceedance for each degree K above θmax (1K, 2K and 3K) is ≤ 10.0.
- Threshold/Upper Limit Temperature (θupp): The measured/predicted operative temperature should not exceed the θmax by 4K or more at any time.

Indoor Air Quality based on CO_2 concentration

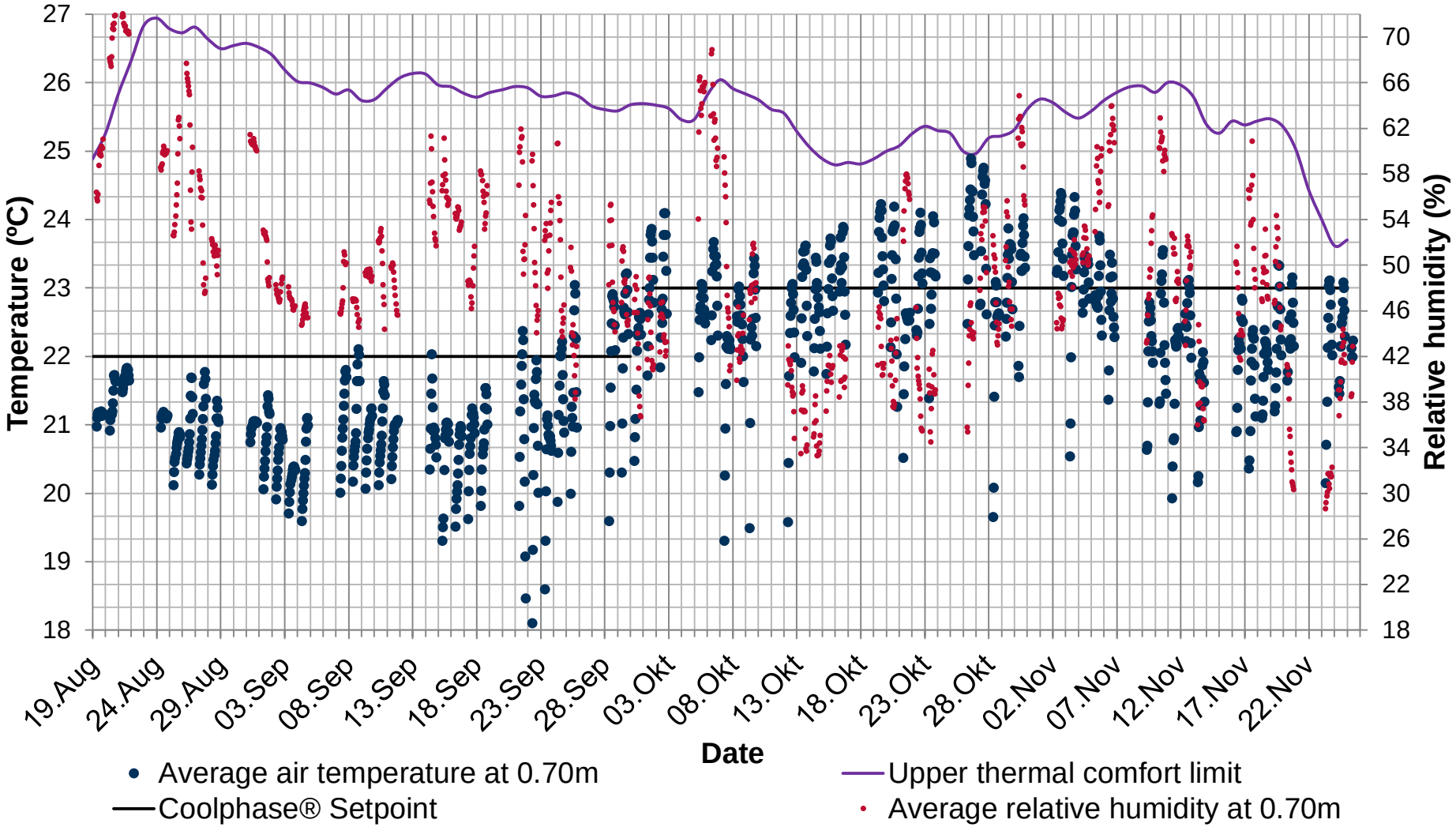
Until recently the guidance was that when measured at seated head height, during the continuous period between the start and finish of teaching on any day, the average concentration of carbon dioxide should not exceed 1500 parts per million (ppm). This criterion is changed to the following criteria:

- Ventilation should be provided to limit the concentration of carbon dioxide measured at seated head height in all teaching and learning spaces.
- Where mechanical ventilation is used or when hybrid systems are operating in mechanical mode, ie the driving force is provided by a fan, sufficient fresh air should be provided to achieve a daily average concentration of carbon dioxide during the occupied period of less than 1000ppm and so that the maximum concentration does not exceed 1,500ppm for more than 20 consecutive minutes each day.

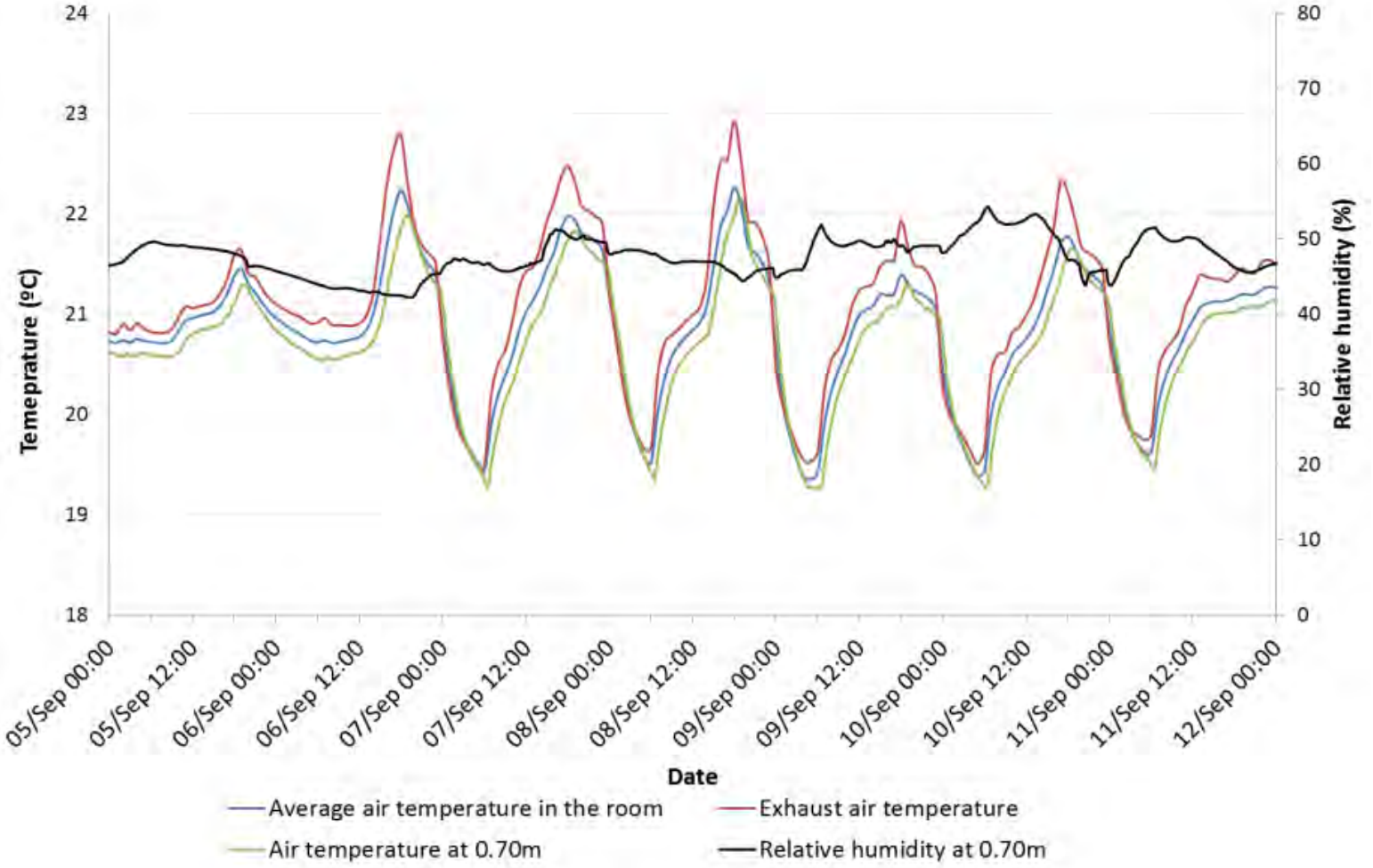
Computer seminar room: Thermal assessment based on system data (more data are currently analysed)



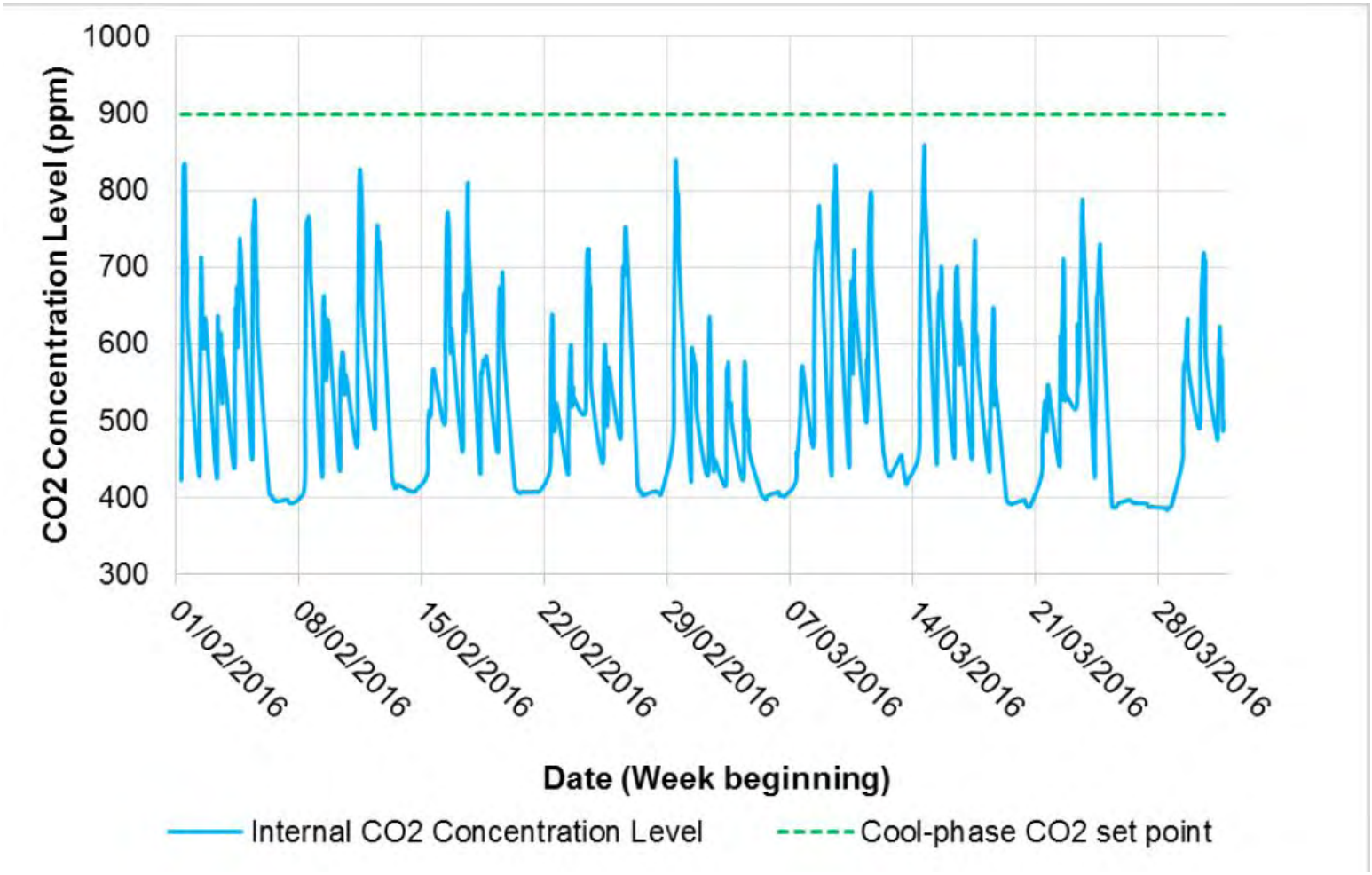
Thermal assessment based on purpose monitor data (more data are been monitored and will be analysed)



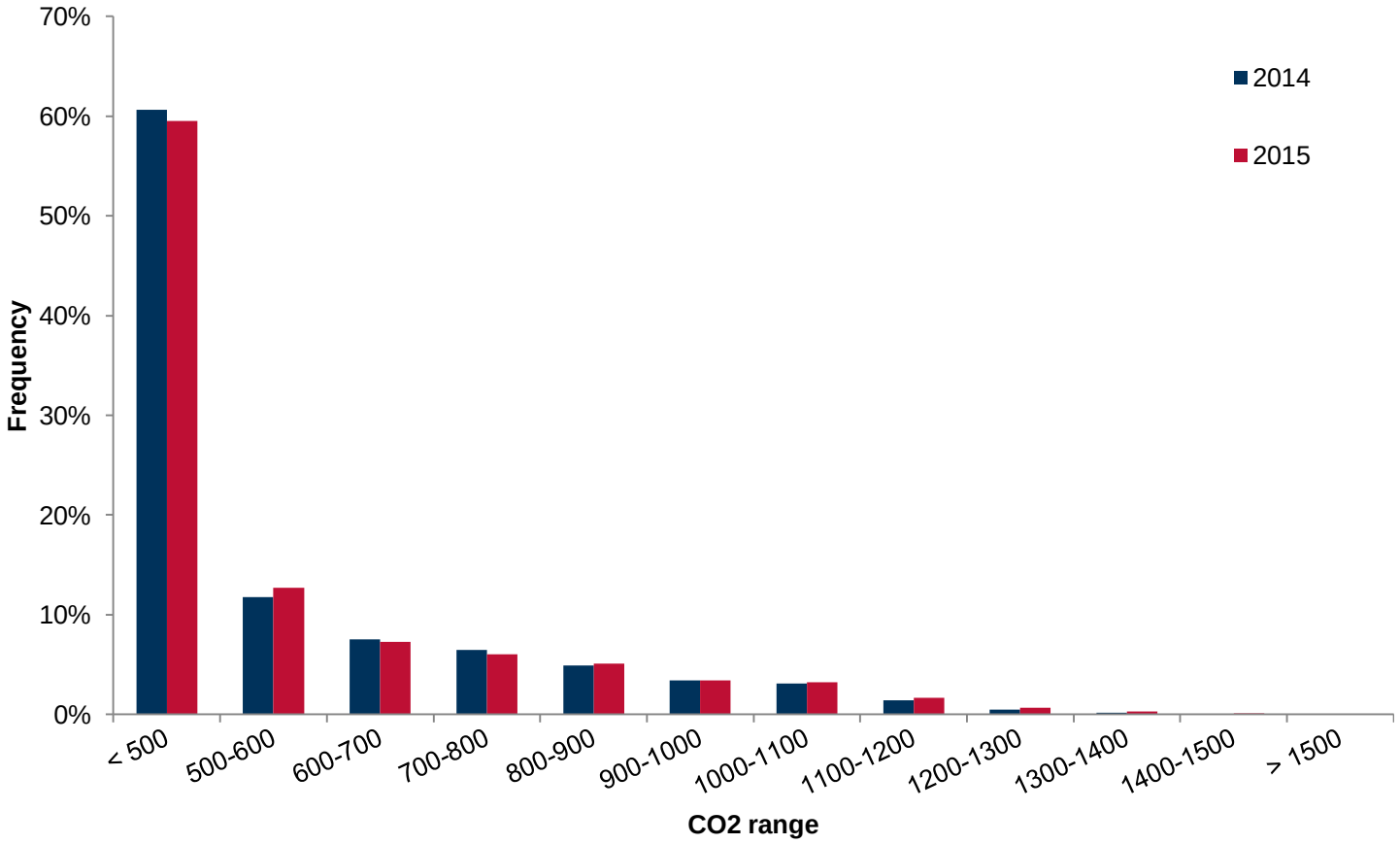
Air temperature and relative humidity at different points in the seminar room.



CO_2 concentration in the open plan office

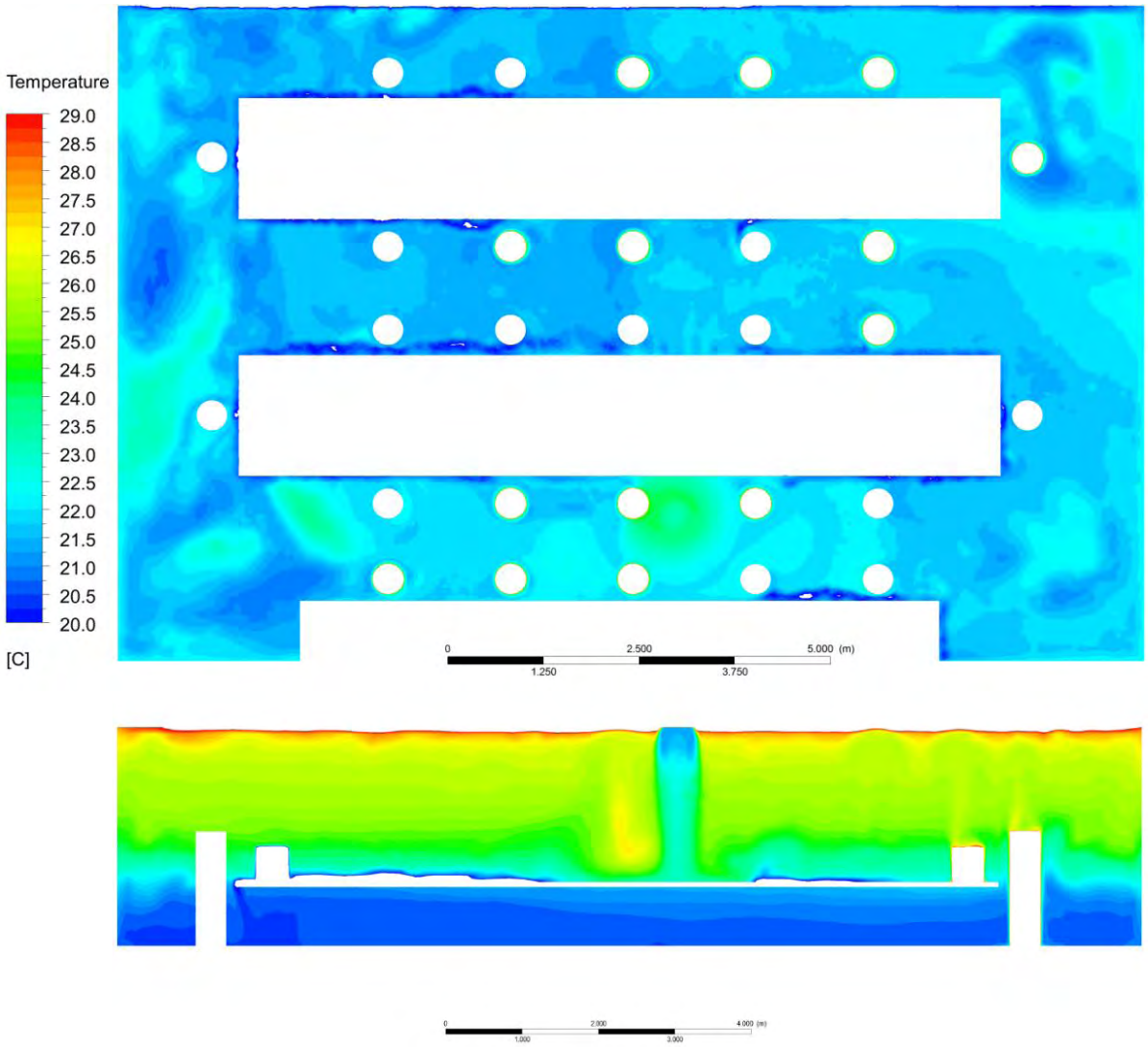


CO_2 concentration in the computer seminar room

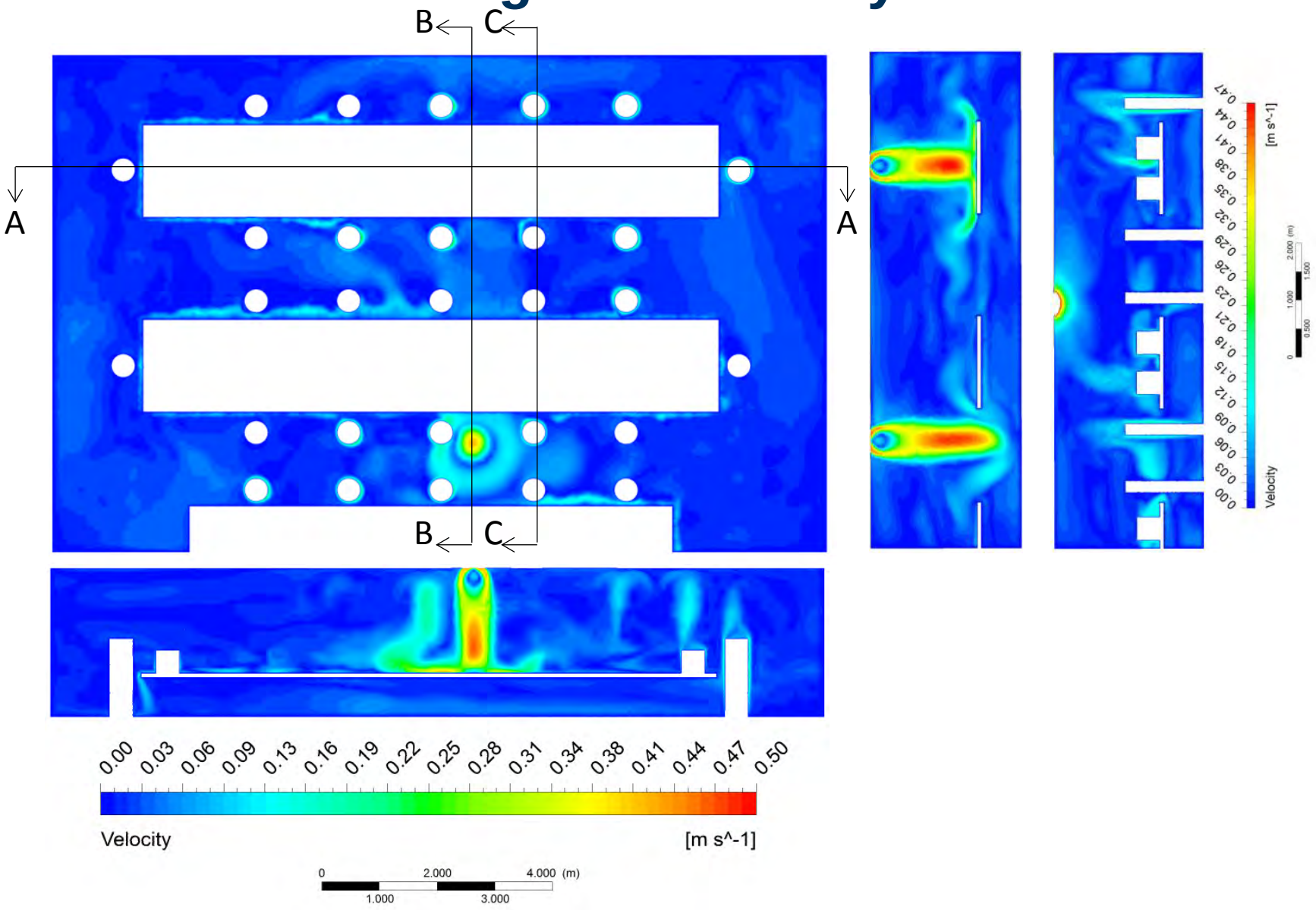


CFD Modelling – Temperature distribution

- Average difference between simulation and monitored measurement is 0.3K (or 1.42%) which shows that the simulation is well calibrated.
- Uniform temperature distribution is achieved at seating level



CFD Modelling – Air velocity distribution



Energy Used

Computer Seminar Room:

The fan energy used by the system for the year was calculated to be 90kWh in 2014 and 79 KWh in 2015. This equates to less than 0.8 kWh/m^2/annum. Annual electricity energy use intensity for secondary schools has a median of 51 kWh/m^2. This increases by 5kWh/m^2 when moving from 'heating and natural ventilation' to 'heating and mechanical ventilation' buildings. CIBSE TM57 [8] presents good case-studies with cooling energy intensity of 12.5kWh and 3.5 kWh/m^2.

Open Plan Office:

The fan energy used by the system was calculated to be 125 kWh/annum, equating to 0.23 kWh/m^2/annum. ECON 19 gives cooling and fan energy consumption for open plan offices as 4 kWh/m^2/annum for naturally ventilated and 44 kWh/m^2/annum for air-conditioned best practice open plan offices.

Future work

- Continue analysis of system data (3 years data) and internal space detailed monitoring data (2 year data)
- Thermal analysis using IESVE to study the system in more detail and propose possible improvements mainly optimisation of control algorithms.
- Study alternative PCM materials and thermal battery design (contribution to Subtask B); CFD modelling, prototype and testing experimentally.
- Investigate application to other building types/climates with more extreme conditions (contribution to Subtask B).