7LY3M0 – online workbook – answer sheet

4.1 Thermal comfort

1a. What range of values for relative air velocity _var yield a comfortable PMV? Note: with “comfortable”, we mean PMV values between -0.5 and 0.5.

for ta = 25 degrees C:
_var = 0.1463 m/s yields _pmv = 0.5000.
The PMV does not go below -0.45 for any value of _var. Therefore
-0.5 < PMV < 0.5 for _var>0.1463m/s

1b. What range of values for relative air velocity _var yield a comfortable PMV?

for ta = 30 degrees:
The PMV does not go below 1.12 for any value of _var. This is the least uncomfortable PMV achievable at this temperature.

1c. For ta = 30 degC, name two strategies that could be used to improve thermal comfort. Support your arguments with literature and refer back to the PMV calculation.

The first step for improving thermal comfort when occupants are too hot should be adjustment of their clothing. The file initially uses 1 clo as a starting point, while normal summer clothing are around 0.6 clo and should improve the thermal comfort of occupants quite drastically.(Howell&Kennedy, 1979) Implementing this change causes the PMV to converge to 0.54 for very high _var. At a _var of 3 m/s, a pretty strong breeze for indoors, PMV = 0.65. This is already a massive improvement compared to PMV = 1.29 at the same _var but with clo=1.0.

Another effective measure would be increasing thermal reflectivity of the windows. (Goia et al., 2013) Changing this from the given 23 degrees to 20.7 gives PMV = 0.5 at clo = 0.6.

Combining the proposed measures gives the desired result.

2a. How does your data compare to the example? Include screenshots in your answer.

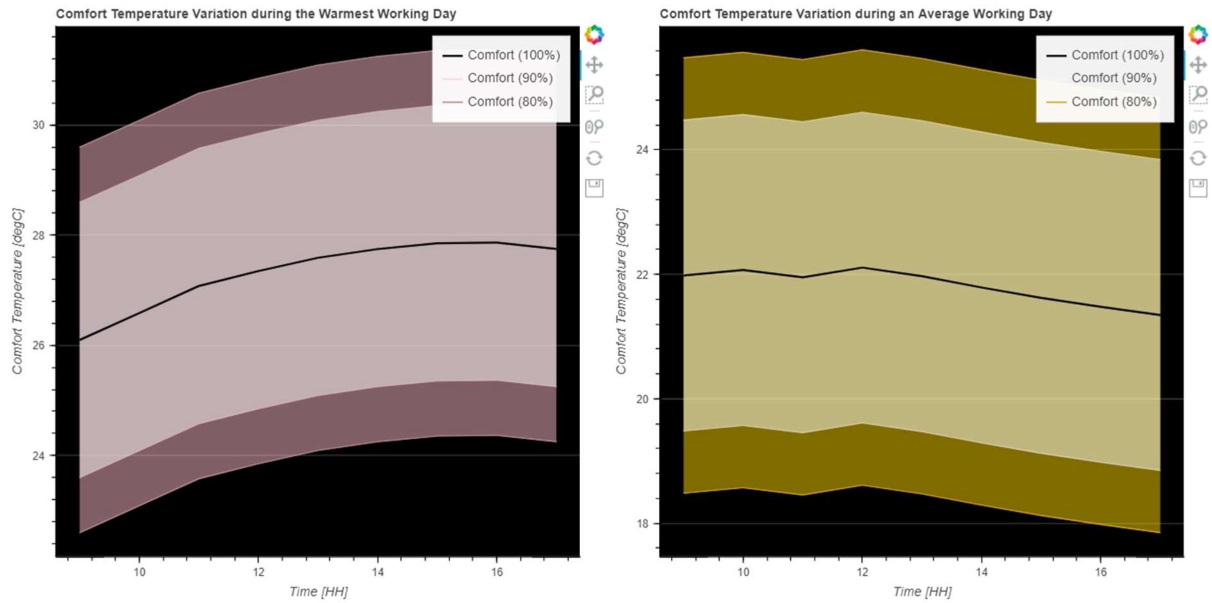

Figure 1 Example, Weather Station 210

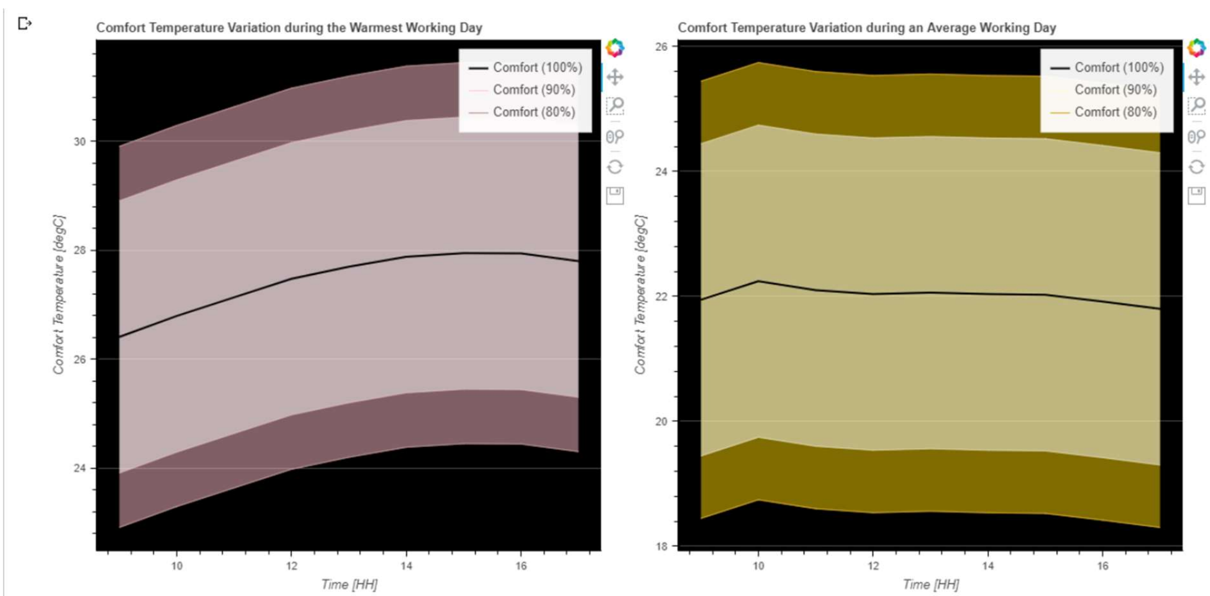

Figure 2 My result, Weather Station 260

for the warmest day my data starts of and peaks with a slightly higher temperature, but the shapes of the graphs are extremely similar.
For the average day the example graph drops a bit more at the end of the day, there the temperature clearly declines towards the end of the day. The data from weather station 260 doesn’t show this kind of behaviour, perhaps there is some UHI effect involved there.

2b. What do you notice when you compare the warmest day and the average day? Explain why this happens.
The warmest day has a rise in temperature towards the late afternoon, whereas in the average day it is more steady. This makes a lot of sense when you think about it, on hot days the sun is often baking all day, warming up the environment, and the air temperature steadily rises towards the latter stages of the afternoon. Average days usually have a more constant temperature throughout the day.

3a. Discuss the difference between the heat balance method and the adaptive method. Mention a hypothetical scenario where the heat balance approach would be more suitable or vice versa.
heat balance method: input 7 parameters, from which 4 more are calculated. End result is a PMV on a scale from +3 to -3 which is a measure of thermal comfort, with [-0.5, 0.5] the range of acceptable values. adaptive method: takes the outdoor conditions into account, since those have an impact on occupant satisfaction as well. Results in a range of temperatures in which a certain percentage of occupants will be satisfied. If indoor conditions are far more humid than outdoors the adaptive method won't be satisfactory, but the heat balance method takes this into account.

3b. List two variables that influence thermal comfort but aren't included in the two models. Make sure to support your statements via literature.
People of different ethnicities have different temperature experiences.(Zhou et. Al., 2014) This is hard to take into account in a model like this, but nevertheless it is a factor that is missing. Posture also influence thermal comfort levels. Someone sitting up straight might have a different comfort level compared to someone standing or sitting slouched in their chair.

Sources:

Howell, W. C., & Kennedy, P. A. (1979). Field Validation of the Fanger Thermal Comfort Model. Human Factors: The Journal of the Human Factors and Ergonomics Society, 21(2), 229–239. https://doi.org/10.1177/001872087902100211

Goia, F., Perino, M., & Serra, V. (2013). Improving thermal comfort conditions by means of PCM glazing systems. Energy and Buildings, 60, 442–452. https://doi.org/10.1016/j.enbuild.2013.01.029

Zhou, X., Zhang, H., Lian, Z., & Zhang, Y. (2014). A model for predicting thermal sensation of Chinese people. Building and Environment, 82, 237–246. https://doi.org/10.1016/j.buildenv.2014.08.006

Kaynakli, O., Unver, U., & Kilic, M. (2003). Evaluating thermal environments for sitting and standing posture. International Communications in Heat and Mass Transfer, 30(8), 1179–1188. https://doi.org/10.1016/s0735-1933(03)00183-0