MOBO - An experimental network for urban heat island analysis in a green district of the Middle-East

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MOBO experimental network

The MOBO experimental campaign began in April 16^{th} 2011 with the installation 72 temperature and relative humidity loggers (HOBO Onset U12) over the campus, 18 at each of four heights: 3, 7, 11, and 15 meters above street level. HOBO loggers were programmed to measure urban temperature and humidity with a sampling rate of 15 min. A first level of loggers was installed at the angle of each concrete column of the ground level. The other loggers were fixed behind the facade covering each balconies.

Among the set of 72 HOBO loggers we run in Masdar Institute between 2011 and 2013, we decided to focus our analysis on the 8 loggers installed inside the campus at ground level (i.e. 3 m.). Due to their location, these loggers provide us a better evaluation of the thermal outdoor comfort felt by pedestrians in Masdar Institute. During the MOBO campaign, we unfortunately lost measurements of temperature recorded by ground loggers from 2012. To estimate summer UHI effect in Masdar Institute, ground loggers continuously measured urban temperature from August 13^{th} to September 31^{st} 2011. Figure 1 illustrates the locations and IDs of the 8 ground HOBO loggers we used for analyzing the UHI effect in Masdar Institute.

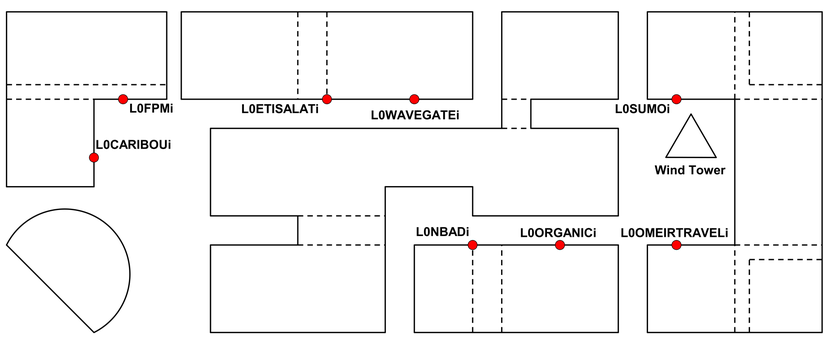

Figure 1: Location of ground level HOBO loggers used for UHI effect analysis in Masdar Institute

Masdar wind tower

To reduce the outdoor temperature inside the campus, Masdar Institute has a unique a facility providing fresh and humid air: the wind tower. Louvers were installed at the top of this facility to capture upper-level winds and conduct air downward to its base. Louvers are operated by sensors detecting wind direction to automatically open exposed louvers (and close the others). Inside the polytetrafluoroethylene membrane tube, the captured wind may be adiabatically cooled to saturation by mist generators injecting water droplets. A technical schema of the Masdar wind tower is shown in Figure 2.

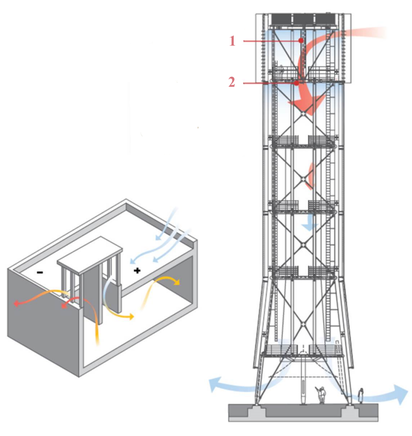

Figure 2: Masdar wind tower

Urban heat island effect in Masdar Institute

Figure 3 illustrates measured urban temperature and UHI intensity at Masdar Institute from August 13^{th} to September 31^{st} 2011. By UHI intensity, we mean the temperature difference between HOBO logger and Masdar Field Station measurements. During the period under analysis, a clear heating effect (i.e. positive UHI intensity) appears at nighttime while a significant cooling effect (i.e. negative UHI intensity) can be seen at daytime.

Table 1 shows the average and average maximum UHI intensity computed from the 8 ground level HOBO loggers between August 13^{th} and September 31^{st} 2011. During this period, we can observe that the average UHI intensity did not go over 1 K. Some measurement points like L0NBADi and L0ORGANICi recorded temperatures below open desert ones on average over August and September 2011. It is not surprising to observe that the two hottest points (i.e. L0CARIBOUi and L0FPMi) compared to open desert temperature are the one which are located the furthest from the wind tower. The average maximum UHI intensity varies from 1.4 and 2.9 K. The proximity to the wind tower does not seem to have an influence on this value.

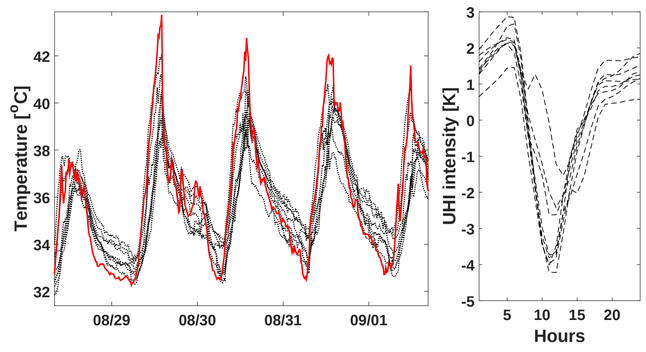

Figure 3: Urban (black) and open desert (red) temperature (left), and average diurnal cycle of UHI intensity (right) measured at Masdar Institute from August 13^{th} to September 31^{st} 2011

HOBO ID	Average UHI intensity [K]	Average Max. UHI intensity [K]
L0CARIBOUi	0.55	2.28
L0FPMi	1.04	2.24
L0NBADi	-0.54	1.45
L0OMEIRTRAVELi	0.15	2.13
L0ORGANICi	-0.11	2.17
L0ETISALATi	0.32	2.86
L0WAVEGATEi	0.22	2.66
L0SUMOi	0.30	2.10

Table 1: Average and average maximum UHI intensity reported from the 8 ground level HOBO logger measurements from August 13^{th} to September 31^{st} 2011

Figure 4 illustrates the summer UHI intensity we assessed from the MOBO experiment compared to the average annual UHI intensity recorded in other Asian and Australian cities [1]. With a summer average UHI intensity of 0.24 K., Masdar Institute reaches the 6^{th} of 34 cities in terms of annual average UHI intensity. In other words, the measured average UHI intensity between August 13^{th} and September 31^{st} 2011 is four and eleven times lower than the mean and the maximum, respectively, average annual UHI intensity of Asian and Australian cities under study (including Masdar Institute).

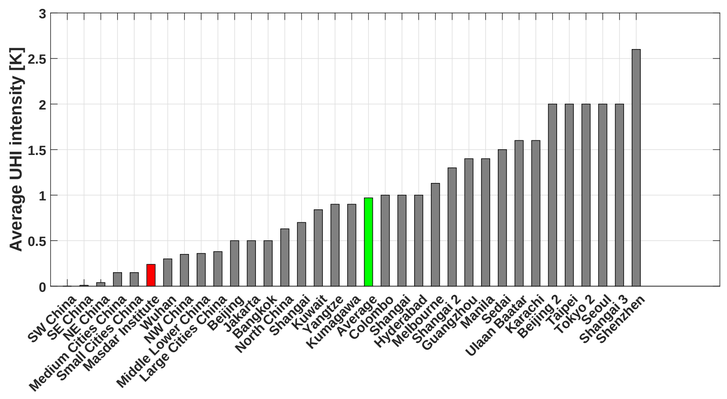

Figure 4: Summer average UHI intensity at Masdar Institute (red) compared to the average annual UHI intensity of other Asian and Australian cities (gray)

Conclusion

In this study, we introduced the facilities installed during the MOBO experimental campaign to analyze the urban heat island effect in Masdar Institute. As a result of this experiment, we observed that the summer urban heat island effect in Masdar Institute is less significant than that taking place in most of Asian and Australian cities. A number of factors may contribute to this small number. First, Masdar Institute has very little anthropogenic heat (as cars). Then, the built up area has small scale of 80x160 m. or 160x220 m. After that, the waste heat caused by air conditioning consumption is rejected 400 m. away from the campus. Finally, an optimal orientation from North (about 37^{o}) was chosen to build the campus. In the future, it would be interesting to proceed to a similar experiment in Abu Dhabi downtown, and compare the results to what we obtained in Masdar Institute.

Acknowledgements

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References

[1] M. Santamouris. Analyzing the heat island magnitude and characteristics in one hundred asian and australian cities and regions. *Science of the Total Environment*, 512:582–598, 2015.