PAVEMENT WATERING AS AN URBAN HEAT MITIGATION TECHNIQUE: A CASE STUDY IN MELBOURNE, AUSTRALIA. E. M. Traill[1], K. A. Nice[1,2] and N. J. Tapper[1], [1]School of Earth, Atmosphere and Environment, Monash University, Clayton, Victoria 3800, Australia (etra0002@student.monash.edu, Nigel.Tapper@monash.edu), [2]Transport, Health, and Urban Design Hub, Faculty of Architecture, Building, and Planning, University of Melbourne, Victoria 3010, Australia (kerry.nice@unimelb.edu.au).

Introduction: Rapid urbanisation, climate change, and ageing populations are increasing the exposure and vulnerability of urban residents to heat. Urban heat mitigation techniques are necessary to improve health outcomes and livability. Pavement watering is one such technique, where evaporative cooling is induced through wetting urban surfaces. It is practiced in countries including France [1-2] and Japan [3-4], but not in Australia.

The aim of this research is to assess the potential cooling benefits of pavement watering in Melbourne, Australia.

Methods: A 10 x 10 m section of a car park at Monash University, Clayton Campus was watered, and an experimental and control weather station were assembled to assess impacts of watering (Fig. 1). The weather stations included five air temperature sensors between 0.05 m and 1.5 m. Experiments were conducted on three days (8th, 12th, 13th of February 2022) at midday (M), afternoon (A), and evening (E), thus a total of nine experiments were investigated.

To assess the impact of watering on air temperature, the difference between the stations was calculated (Δ = experimental - control, thus $\Delta < 0$ indicates cooling). Initial analysis showed that differences existed between the experimental and control temperatures before watering took place (Fig. 2). These pre-existing differences were variable between the experiments and the different temperature sensor heights, and both exaggerate and diminish the actual impact of watering. Thus, the cooling benefit was assessed by evaluating the mean difference between the period before watering (both dry) and the period after watering (one wet) (i.e., Mean Δ = Mean $\Delta_{One\ Wet}$ - Mean $\Delta_{Both\ Dry}$). An independent t-test was also conducted between the both dry and one wet periods to verify if the latter was significantly lower than the former. The mean cooling benefits for the different experiments, as well as latent heat flux (Q_E, calculated using the approximate drying time and the amount of water used), were then compared to measured prevailing conditions to assess when pavement watering was most effective.

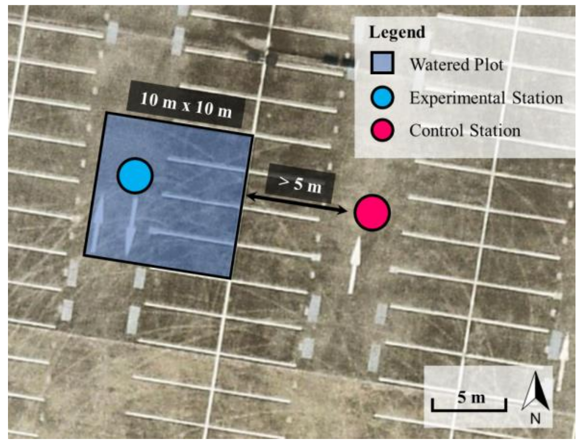

Fig. 1*: Experiment site and set up. Adapted from Nearmap (2022).*

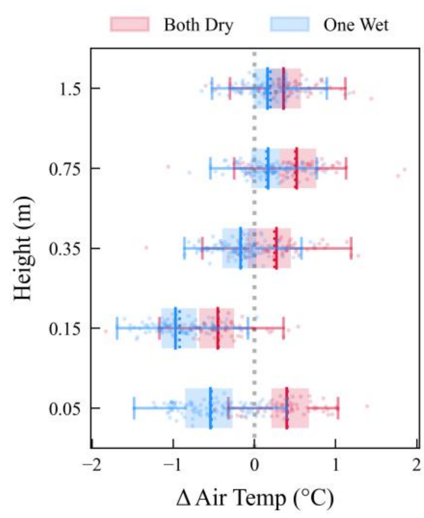

Fig. 2*: Boxplots of the difference between sites at each temperature profile height for experiment 12A.*

Results: Pavement watering had a varied impact of up to 1 °C in air temperature to no observable cooling, with the exception of 2.5 °C at 0.05 m for experiment 8A (experiment on the 8th in the afternoon) (Fig. 3a). In general, cooling decreased with height, and evening experiments had lower benefits (Fig. 3a).

Higher Q_E was found to be correlated to higher wind speeds (p = 0.01), and also related to higher vapour-pressure deficit (VPD) and higher net radiation (Q*) (Fig. 3b). On the other hand, lower wind speeds and higher Q_E were related to more cooling, more so at 1.5 m than 0.05 m (Fig. 3c,d). However, with the exception of Q_E and wind speed, none of the relationships were statistically significant.

Discussion: The differences between the experimental and control stations when both sites were dry may be due to errors associated with sensors and setup. Indeed, sensors were not calibrated before nor after the experiment due to time constraints and frequent sensor malfunctions.

As pavement watering utilises Q_E to cool surroundings, it was interesting to observe Q_E has little impact on cooling. This is likely due to the competing effect of wind speed. While lower wind speeds limit evaporation and thus Q_E, it simultaneously allows cooling to accumulate and propagate upwards. For example, 8A has the highest observed cooling, with relatively low wind speeds and medium Q_E (Fig. 3). On the other hand, 12M has insignificant cooling at 1.5 m with low wind speeds and low Q_E (Fig. 3c). This indicates the pavement watering is effective when Q_E is high at low wind speeds, for example when Q* and VPD is high.

It is also likely that the small scale of the experiment limited the observed cooling benefits and may have enhanced the impact of wind. Overall, pavement watering was shown to reduce air temperature in the right conditions, and thus may potentially be used in emergencies to provide some cooling in Melbourne. Larger scale studies are necessary to fully understand the benefits of pavement watering.

Acknowledgments: Many thanks to Andrew Gunn for running the course 'Data Analysis in Earth Science' and imparting knowledge that contributed to the making of this abstract.

References: [1] Hendel M. et al. (2015) *JSDEWES*, *3*, 1-11. [2] Parison S. et al. (2020) *Urban Clim.*, *33*, 100651. [3] Hideki T. (2021) *Energy Build.*, *250*, 111299. [4] Solcerova A. (2018) *Water*, *10*, 741.

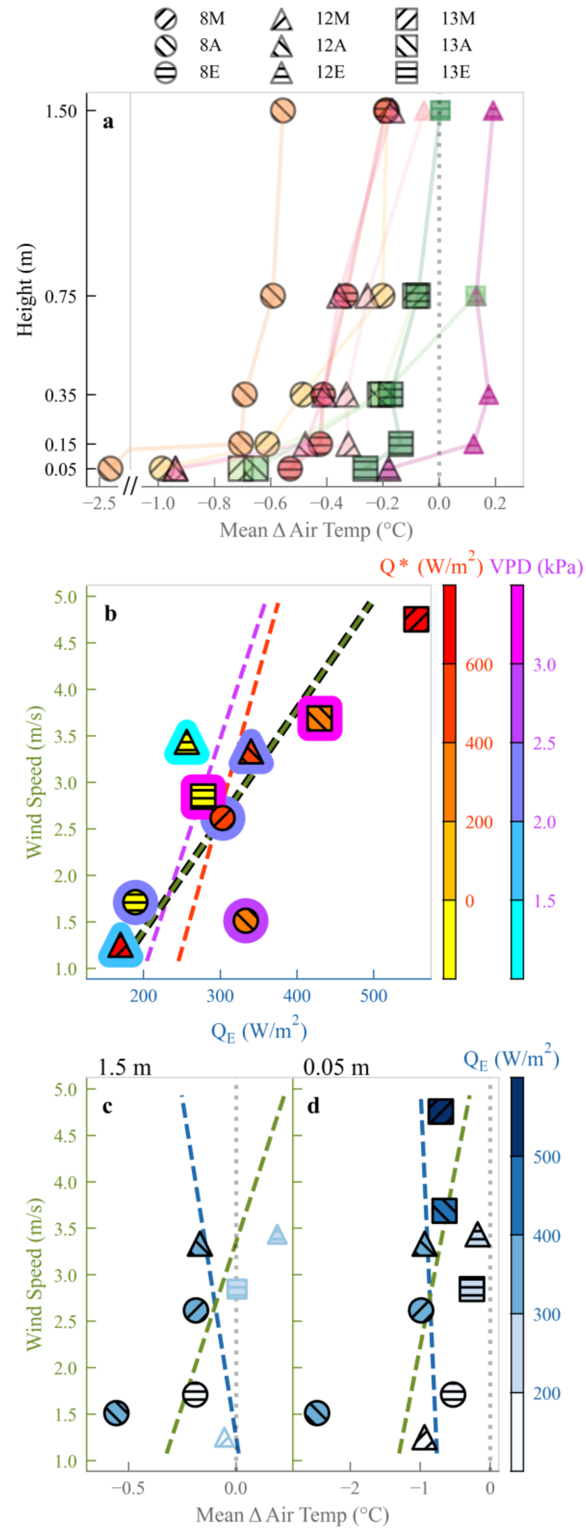

Fig. 3: *(a) Mean change in the temperature profile; (b) the relationship between Q_E and wind, Q*, VPD; and the relationship between (c) 1.5 m and (d) 0.05 m mean temperature change and wind, Q_E. The black outline indicates a significant (p < 0.05) change in temperature (a, c, d) and linear relationship (b).*