MTMG34 Experiencing the Weather Field Course
Analysis of Microclimate Observations

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Q.1 Briefly describe your microclimate site, what was measured, where, and with which instrument.

Microclimate F lies south-west of Leeson house (Fig. 1) in a field with $0.3m$ grass, sheltered by $6m$ tall trees $5m$ south and east, with $1m$ tall shrubbery beneath.

Over an hour, 6 instruments were used to record 10 variables within a $2m$ diameter circle: a Kestrel meter (initial altitude, barometric pressure, dry-bulb temperature (T_{db}), and wind speed and gust), a Testo-625 probe (relative humidity (RH), dry-bulb, wet-bulb (T_w), and dew-point temperature), a (whirling) psychrometer (dry-bulb and wet-bulb temperature, and relative humidity using a slide rule), a (cup) anemometer (wind speed and gust), temperature probe (soil temperature), and an infrared thermometer (cloud-base temperature). Cloud amount and type was determined visually with a cloud chart. The coordinates were logged using a mobile application, and the wind direction was sensed physically.

Figure 1: Aerial perspective of the microclimate at coordinates ($\phi = 50.3624, \lambda = 1.5945$), obtained from Google Maps. The red circle indicates the group's location. During the hour period, the sun was positioned to the south east.

Measurements were taken in 5-minute intervals from 09:45-10:45 (UTC) whcih commenced 2 minutes prior to data collection. The mean wind speed and maximum gust were determined visually for the anemometer. Excluding the psychrometer, all other readings reflect mean values observed in the final $30s$ of each period.

A measurement was taken by each instrument at the Leeson House MET Mast at 09:15. Microclimate data was later calibrated by subtracting the difference between the Mast's and the instruments' values. Error propagation was considered with uncertainties for both Mast and instrument taken from Scott and Inness (2023).

Q.2 Analyse and interpret one variable from the microclimate data that your group collected.

RH is measured by the Testo and psychrometer at F. The Testo has a 3% uncertainty, and the psychrometer's estimated uncertainty is $0.5°C$.

Fig. 2 shows a time series of the standardised RHs of both instruments, in which a moderate non-monotonic relation is apparent between the two. From 10:00-10:40, 2 primary maxima emerge, with the magnitude of the psychrometer's being 10% greater and continuing 10 minutes after that of the Testo.

Throughout the hour, a rainbow intensified in distant dark clouds, indicating rain had passed and a high local humidity. The grass was also damp, likely from morning dew caused by the humid conditions. These observations align with the high initial RH values $(70 - 80\%)$.

The turning points of the first maxima coincide with increased sun exposure until 10:15, which raised T_{db} and in turn, lowered RH. The sun was positioned behind the trees to the south-east, and so the psychrometer received more sunlight through the gate region. Thus, a discernible decrease in RH is expected for the psychrometer relative to the Testo. However, the relative difference between the decrease from their relative maxima is only 3%. This is attributed to human error, as the psychrometer's T_{db} was constant despite increased direct sunlight.

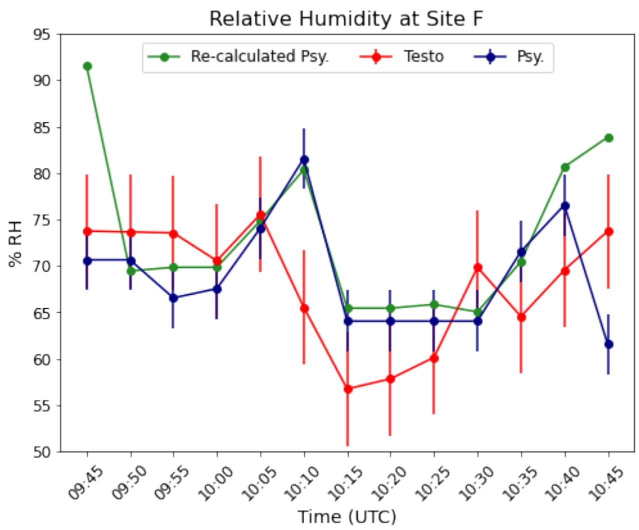

Figure 2: Time series of the (calibrated) relative humidities obtained by the Testo and psychrometer at F.

The increase in RH before the second maximum coincides with increased cloud coverage as well as a light shower from 10:35-10:40, and thus increased moisture evaporation at the ground. The psychrometer's RH drops at 10:45, contrary to the consistent cloud cover and continued evaporation. The non-standardised psychrometer T_w and T_{db} data are re-converted using an RH conversion table, and the re-standardised plot shown in Fig. 2. It is evident that RH consistently rises after the shower, and the slider rule has introduced a significant yet unaccounted uncertainty.

Additionally, the psychrometer's initial data point is an outlier, likely due to human error. The observer may have delayed the wet-bulb reading after slinging, causing a higher T_w and in turn, an erroneously high RH. Similarly, in the second half of the hour, the corrected psychrometer readings are generally higher than the Testo's (both pre and post calibration). This may stem from the psychrometer's wick drying out due to an observed leak.

The Testo's higher variance $(39\% > 32\%)$ may arise from its high sensitivity and sampling rate $(2s^{-1})$. Thus, the observer may have had difficulty determining the true mean in the final $30s$ of each observation period.

Q.3 Relate observations of one variable at your location to those gathered simultaneously in all microclimates.

Wind gust is measured by the Kestrel and anemometer in microclimates A-F. The Kestrel's threshold is $0.4m.s^{-1}$, and a similar anemometer model's is $1.0m.s^{-1}$ (Murno Instruments (2022)). During calibration, the Mast recorded a $0.2m.s^{-1}$ gust, while most instruments recorded $0m.s^{-1}$. Therefore, the calibration was not performed so as to preserve the instrument's thresholds, with 98% of observations remaining above their threshold.

Wind roses for Kestrel gusts are shown in Fig. 3. The highest gust was recorded at A, with slightly lesser gusts at E, B, and F, and the smallest at C and D. A, the most exposed site with the highest sky view factor, reported the highest gusts. D, sheltered by trees from the south and Leeson house to the north, reported the lowest gusts. B, beneath tree cover, and C, in a small exposed field, surprisingly experienced comparable westerly gusts. D and E registered a $135°C$ wind-direction difference, despite proximity and clear line of site. Both were, however, in agreement with C, which registered both easterly and westerly gusts.

Variance in wind direction across sites may be due to low-wind magnitudes ($< 1.5m.s^{-1}$), making direction determination more challenging. While A reports one-directional gusts, moderately exposed regions (B, C, F) report bi-directional gusts due to the influence of trees and shrubbery, causing greater wind re-direction. Regardless, the wind roses suggest a prevailing westerly/south-westerly wind, consistent with Atlantic ocean influence.

Fig. 4 shows time series data for both instruments. The Kestrel's uncertainty is 3% and the anemometer's estimated uncertainty is $0.5m.s^{-1}$. The Kestrel almost consistently recorded higher gusts than the anemometer. The majority of the Kestrel readings $< 1.2m.s^{-1}$ are not observed by the anemometer, suggesting that its tolerance lies close to this value.

Maximum gusts were not highly coordinated across microclimates, but strong peaks from 10:40-10:45 ($1.5 - 4m.s^{-1}$) were recorded in all microclimates for the Kestrel, and half for the anemometer.

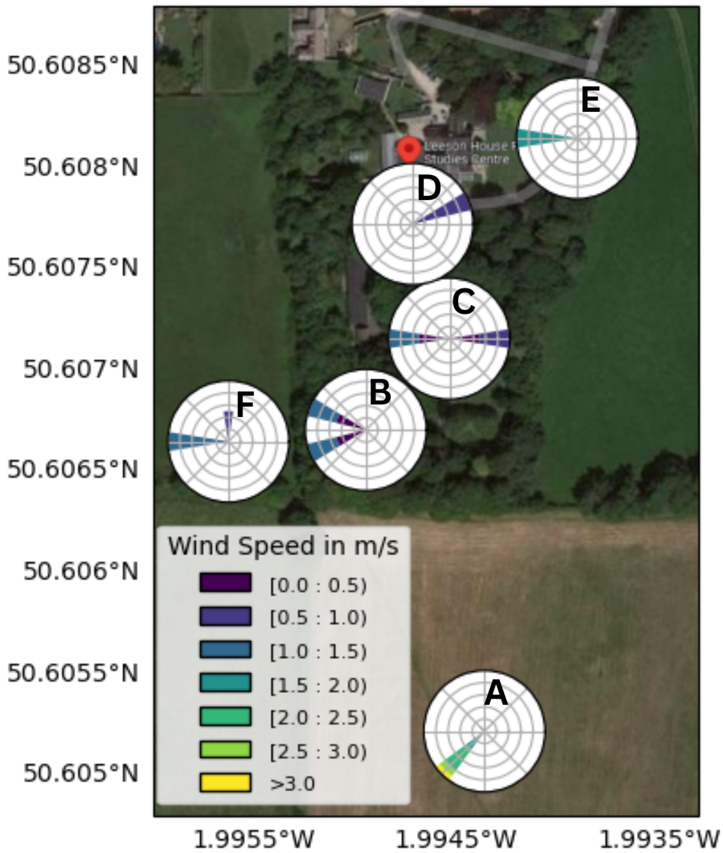

Figure 3: Wind roses corresponding to each microclimate. The purple-yellow colour spectrum indicates increasing wind speeds.

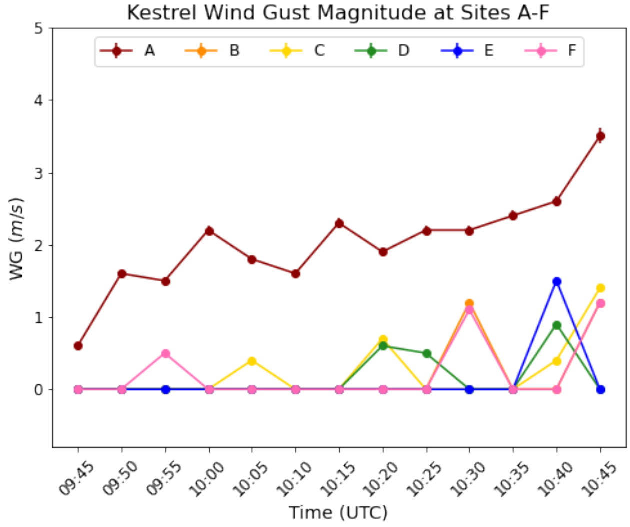

Figure 4: Kestrel data.

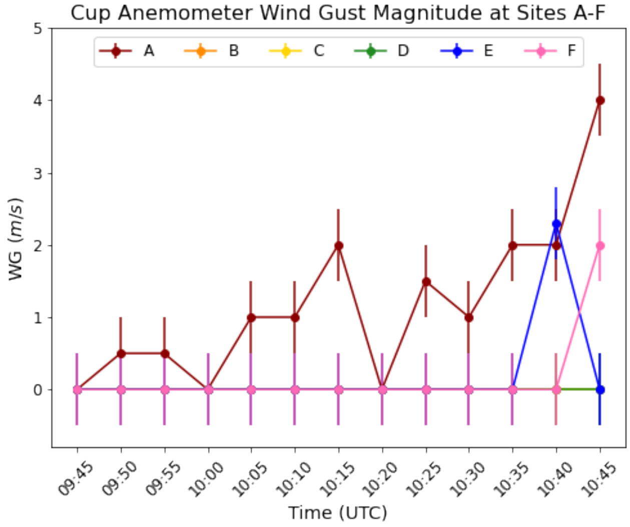

Figure 5: Anemometer data.

Figure 6: Time series of the wind gust magnitudes obtained by the Kestrel and anemometer at each microclimate.

Q.4 Relate observations of one variable at your location to ONE other data source,

In microclimate F, T_{db} is measured by the Kestrel, Testo, and psychrometer. The Kestrel and Testo have a $0.5°C$ uncertainty, which is also assumed for the psychrometer. The Mast's measurements, obtained via capacitors, have a lower $0.3°C$ uncertainty. Calibration parameters for the Kestrel, Testo, and psychrometer are $(-4.2 \pm 0.8)°C$, $(-3.9 \pm 0.8)°C$, and $(0.0 \pm 0.8)°C$, respectively. Environmental acclimation delay may contribute to the Kestrel and Testo's discrepancy.

Fig. 7 displays time series data for calibrated T_{db} values from the 4 sources. The Mast's T_{db} increases monotonically by $3°C$ over the hour. The psychrometer exhibits the highest significant Spearmann coefficient $(\rho = .71, p < .01)$ with the Mast data, suggesting a moderate monotonic relation.

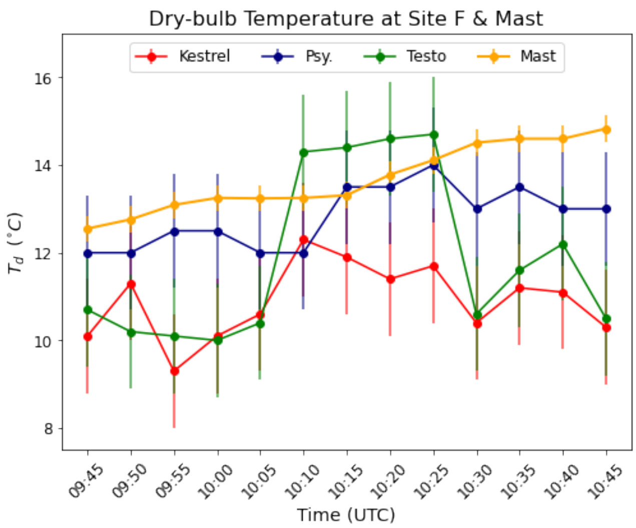

Figure 7: Time series of (calibrated) dry-bulb temperatures obtained by the Kestrel, Testo, and psychrometer at F, and the MET Mast at C.

The Mast at site C, is at a higher altitude and more exposed than the instruments at F, resulting in higher sunlight exposure. This is reflected in higher T_{db} values in Fig. 7, compared to those at F.

As discussed in Q.2 the rise in T_{db} from 10:10-10:30 at F coincides with increased sun exposure, followed by a 5 minute decrease as rain clouds passed. The latter is not registered by the Mast, indicating this variation in cloud coverage was unique to site F.

The Testo's magnitude of temperature change during this time is twice as the other instruments. It exhibits significantly greater variance $(3.4°C)$ compared to the other 3 instruments $(0.4 - 0.7°C)$. As with RH in Q.2, this can be attributed to instrument sensitivity.

Word count: 998

References

Murno Instruments, 2022: *IM159 Handheld Anemometer*. https://hansbuch.dk/wp-content/uploads/2022/06/im159-datasheet-1.pdf.

Scott, C., and P. Inness, 2023: Experiencing the weather. 1-30 pp.