Initial Results of MetSprite Verification at the KNMI Cabauw 200m Meteorological Mast

Ben Pickering [1], William Smith [1], Nick Castledine [1], Tiemo Mathijssen [2], Paul de Jong [2], Cisco de Bruijn [2], Arnoud Apituley [2], Peter Mooney [1], John Mooney [1]

1: Menapia Ltd., Leeds, Yorkshire, United Kingdom
2: KNMI, De Bilt, Utrecht, Netherlands

Introduction

Introducing MetSprite, a fully automated, high-altitude, harsh-weather resistant multirotor UAS with integrated meteorological sensors, designed for routine observations.

The core measurements built into MetSprite with industry-leading traceable calibration are temperature, humidity, pressure and 3D winds. Surplus energy and mounting options allow for an array of supplementary instruments.

Table 1: *Technical specification of MetSprite UAS.*

Endurance	> 40 mins flights time (hover w/o wind)
Flyability	2 km profiling, 97% of the year (UK) [1]
Velocity	16 m s^{-1} ascent, > 28 m s^{-1} max. speed
Ceiling	10 km AGL max. profile (no wind)
Payload	Capacity to integrate most 3rd party sensors

Figure 1: *The MetSprite UAS, without sensor attachments.*

The Metsensor (T/P/RH) is located under the UAS arms for aspiration of the sensors, reducing response time. A novel connector and 3D-printed components allow for rapid design iterations, so new sensors can be easily integrated.

This poster describes a validation campaign for the MetSprite, which took place at the KNMI 200-metre tall meteorological mast in Cabauw, NL for five days between 27th March and 31st March 2023. 53 flights were conducted and the 200-m sensors were passed 159 times.

Figure 2: *The MetSprite UAS hovering at the 200-m altitude of the KNMI Cabauw meteorological mast, tilting into wind.*

Methodology

The data were first blind-filtered for anomalous values. Flight controller telemetry were filtered for timestamps within 200 metres with a tolerance of ± 10 metres. Both mast and MetSprite observations were extracted for these timestamps, and all the altitude-valid MetSprite meteorological data (measured at 10 Hz) were aggregated onto the time signature of the Cabauw mast (12-second average).

Note that some aggregated MetSprite data will contain < 12 seconds of observations, such as when MetSprite profiles past 200 m altitude at the nominal ascent speed of 8 m s^{-1}.

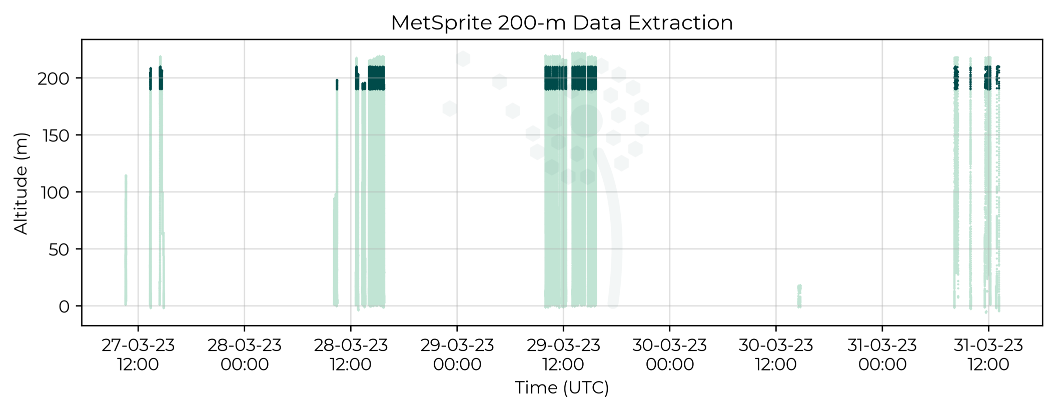


Figure 3: *Extracted 200-m MetSprite data (dark green) against the whole dataset from the campaign (light green).*

Results

In total, over 300 data pairs were compared over four days. The temperature range experienced was 4–13 °C and the relative humidity range experienced was 50–100%.

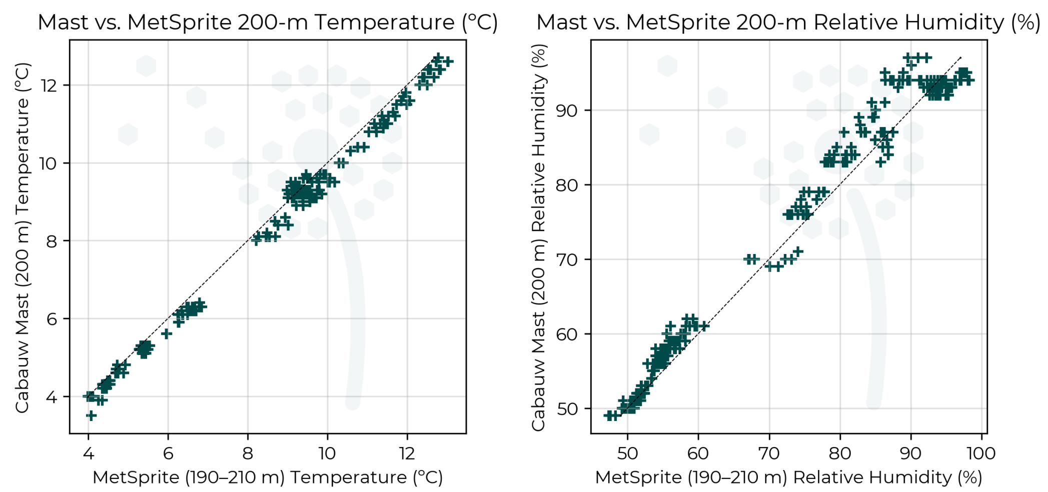


Figure 4: *Scatterplots of KNMI Cabauw mast vs. MetSprite for 200-m temperature (left) and relative humidity (right).*

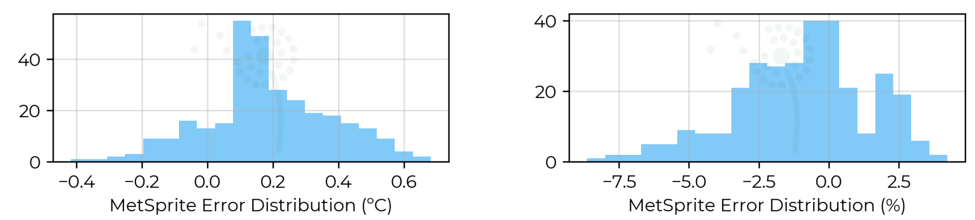


Figure 5: *Histograms of MetSprite errors for 200-m temperature (left) and relative humidity (right).*

A useful benchmark is the WMO OSCAR [2] requirements for convective-scale forecasting. These dictate that values of temperature and relative humidity have RMSE values less than a specified amount. The categories are "Threshold" (3 °C, 10%), "Breakthrough" (1 °C, 5%), and Goal (0.5 °C, 2%).

Temperature observations had a bias of +0.18 °C and an RMSE of 0.27 °C (OSCAR "Goal").

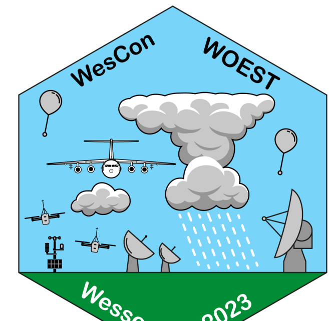
Relative humidity observations had a bias of –1.0% and an RMSE of 2.6% (OSCAR "Breakthrough").

These results show that the MetSprite is already a world-class measurement tool for atmospheric profiling. This first verification campaign has already motivated MetSprite design changes which are being implemented before the first long-term campaign of MetSprite in mid-2023.

Upcoming Campaigns

WOEST-WesCon (UK) [3]
June — August 2023

Four MetSprite will fly every weekday hour for 10 weeks, reaching up to 2 km AGL. The purpose of the campaign is to study the processes of atmospheric turbulence and their representations in km and sub-km scale weather and climate models.



A suite of atmospheric observations will be deployed alongside the four MetSprite wxUAS: multiple dual-pol radars, ground weather stations, cloud cameras, radiosondes, and more.

The results of the campaign will have an impact on extreme weather event forecasting in the UK and beyond.

WMO UAS Demonstration Campaign (Global) [4]
March — August 2024

This campaign, being led by the World Meteorological Organisation, aims to encourage the use of wxUAS (like the MetSprite) in as many locations around the globe as possible. The intention is that wxUAS observations will be collected on a routine basis. These observations can then be used operationally to assess their benefits to forecasting.

As well as real-time interpretation, these observations will be assimilated into NWP models to examine their benefits, in an observation system experiment (OSE).

Menapia Ltd. are seeking partners to collaborate on the WMO UAS-DC. If you are interested in applying for funding or using your existing funds for MetSprite observations, get in touch.

Scan the QR code to learn more:

References

[1]: Pickering, B. S., & Mooney, J. (2023, January). The Flyability of Vertically-profiling WxUAS in a 3D Mesonet Configuration. In *103rd AMS Annual Meeting*. AMS.

[2]: https://space.oscar.wmo.int/observingrequirements, accessed 23rd March 2023.

[3]: Barrett, P., Abel, S., Lean, H., Price, J., Stein, T., Stirling, A., and Darlington, T.: WesCon 2023: Wessex UK Summertime Convection Field Campaign, EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-2357, https://doi.org/10.5194/egusphere-egu21-2357, 2021.

[4]: O'Sullivan, D., Pinto, J. O., Pickering, B. S., and Lockett, D.: A Global Demonstration Campaign for Evaluating the Use of Uncrewed Aircraft Systems in Operational Meteorology. WMO, 7 Mar 2023.

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