RC2: 'Comment on egusphere-2024-3566', Anonymous Referee #2, 03 Jan 2025 reply

Overview:

The manuscript outlines the development and testing of a Flying Laboratory Flab using an uncrewed aerial system equipped with various instruments to measure meteorological parameters and in situ trace gases and aerosol particles. The Flab is equipped with an anemometer for measuring wind speed and direction along with temperature, humidity and pressure, CO2 and O3 analyzers, instruments for measuring aerosol particles. The manuscript outlines various tests to determine data uncertainties and optimal flight parameters for data accuracy and precision. The treatment is thorough and the manuscript is well written. I recommend this manuscript for publication.

- ➔ Thank you for this positive judgement of the manuscript and the constructive comments. Individual comments are answered below.

Minor Comments:

Lines 37-44: In addition to the limitations outlined by the authors, lidar instruments specifically have near-field dead zones and when used from the ground, cause there to be a lack of continuity between ground observations and remote observations. UAS are ideal for bridging this gap.

- ➔ Thank you for pointing this application case out. We included a brief mentioning of this limitation of lidar applications to the introduction, implicating the additional advantage of using UAS to measure the near-field zones in lines 40-41:

  "However, these methods are limited by near-field dead zones close to the instrument, leaving the lowermost part of the atmosphere uncovered."

Line 125 and line 132-134. There are some statements here which are confusing. I believe that all of the language here is used to describe the aerosol instruments but when it states 'an Arduino Uno is used to store the processed instrument data on a common SD card for all instruments' it could be interpreted that all instruments on board are backed up to the SD card. Perhaps it would make more sense to describe that the ozone monitor and the aethalometer only use internal storage (is that the correct interpretation?). Start with the data storage that is independent and then qualify the integrated data storage (and transmittance) for the aerosol instruments as only for those aerosol instruments.

- ➔ Thank you for the suggestions. Actually, the Arduino indeed was used to store data from all instruments, not only from those which did not store data internally. We revised the text to make this clearer. We also adopted the reviewer's suggestion and now first mention the instruments which store data independently and then describe how all instruments send their data to the Arduino microcontroller in real time (even the ones that store data individually anyway) in lines 126-129:

  "The ozone monitor and the aethalometer store their data in independent internal memories. In addition, both instruments as well as all the other instruments transmit measurement data in real-time to Arduino Mega microcontrollers (ATmega 2560)."

  The description of the independent internal memories from lines 133-134 was removed.

- ➔ Additionally, we clarified how the data is transformed (from raw to transmittable data) on the Arduino in lines 129-131:

  "Due to the low processing power of the Arduino Mega, three microcontrollers are required in the FLab to receive raw data and to process the partially large output strings to compact data packages."

Line 151: Which instruments had RS232 interfaces which required modification. Just list parenthetically.

- ➔ Reply: We included this information in lines 156-158, according to the reviewer's suggestion.

Line 371: requires a space between parentheses and 'which'

- ➔ Reply: Done, thank you.

Lines 410-415: The statement 'the wind speed determined by the UAS is almost constant within 0.1 ms-1 with respect to the reference wind speed at all altitudes and vertical velocities' implies that there should be some indication of the reference wind speed in Figures 5 and 6 but there is none. What do you mean by reference wind speed? Also the statement 'the UAS-derived wind speed is unreliable with the payload attached' is confusing. Are there observations of UAS-derived winds which are accurate but not so once the payload is attached? Reference performance of only UAS-derived winds with no payload or something to clarify. Or this paragraph needs some statement to agreement with reference wind speeds – the figures that are referenced are only comparing the anemometer and UAS but I don't believe either of them to be considered reference.

- ➔ Thank you for pointing this out. The sentence was indeed poorly worded and therefore misleading. What was meant was that the DJI wind speed was constant within +/- 0.1m/s, whereas the anemometer onboard Flab (misleadingly termed "reference") did not show this behavior. We rephrased the sentence in lines 456-457 to:

  "The wind speed determined by the UAS is almost constant within ± 0.1 m s^{-1} for all altitude levels within each flight (Figs. 5a and 6e)."

  As described in Sect. 2.2.1, the attached payload may lead to miscalculation of wind speed as calculated by the UAS since this is derived from the thrust force on the propellers and the GPS data. When a payload is attached to the UAS, the propellers experience an increased thrust force, which results in a biased wind speed calculation. A detailed explanation can be found in Wildmann and Wetz (2022).

  To clarify how the UAS wind speed is derived this information was now also added to lines 421-425:

  "The ambient wind speed derived from the ANE does not appear to be significantly affected by relative winds up to 15 m s^{-1}. In contrast, the wind speed received from the M600 UAS, which is based on the GPS position and the rotors' thrust force, overestimates the wind speed and appears less reliable (Fig. 4e). The attached payload could cause a miscalculation of the wind speed by the M600 on-board computer, which bases its calculations on the nominal flight behavior of the (payload-free) M600."

References:

Wildmann, N. and Wetz, T.: Towards vertical wind and turbulent flux estimation with multicopter uncrewed aircraft systems, Atmospheric Measurement Techniques, 15, 5465-5477, https://doi.org/10.5194/amt-15-5465-2022, 2022.