Author Response to Reviewer 1

Antonio R. Segales et al.

We thank Reviewer 1 for the thorough and constructive review of our manuscript. The detailed comments have helped us improve the clarity, precision, and scientific rigor of the paper. Below, we address each comment individually. Reviewer comments are shown in **black**, and our responses in blue. References to line numbers refer to the revised manuscript unless noted otherwise.

General Comment: *"I did find that the language used in some places strayed from the technical into the effusive when describing the Coptersonde, with several instances outlined in the detailed comments below. As also described below, I found that a large portion of Section 2 detailing field experiments made by the Coptersonde 3D seemed out of place in a paper describing a different aircraft."*

We appreciate this observation and have revised the manuscript throughout to adopt more precise language. We have also relocated the detailed CS3D heading-dependent temperature experiment to a new Appendix A, replacing the main text with a concise summary that preserves the key finding (50° yaw tolerance constraint) while directing readers to the appendix for full details.

Comment 1: *"The acronyms LESO and WxUAS are used in the abstract without definition. The acronym PBL is defined, but not used at any other point in the abstract."*

We have corrected all three issues in the abstract: LESO is now expanded as "Linear Extended State Observer (LESO)" on first use; WxUAS is now expanded as "weather-sensing UAS (WxUAS)" on first use; and the unused "(PBL)" has been removed from the abstract (PBL is still properly defined in the Introduction).

Comment 2: *"Lines 108-123 include what appear to be new results from experiments conducted with the Coptersonde 3D [...] Perhaps this section of text is better placed in an appendix."*

We agree. The detailed CS3D heading-dependent temperature experiment has been moved to Appendix A. The main text now contains a brief summary statement referencing the appendix and retaining the key finding (the 50° yaw tolerance constraint that informs the WVFM design).

Comment 3: *"Table 1 provides some specifications for the aircraft which provide both 'maximum limits' and 'theoretical maximums'. The distinction is not really made clear in the text."*

We have revised the Table 1 caption to clearly distinguish between the two categories: values outside parentheses are the maximum values observed during testing (from > 65 flights), while values in parentheses are analytically derived upper bounds based on the propulsion system's rated specifications (e.g., maximum motor RPM, ESC current limits, battery discharge capacity) under idealized conditions (sea-level air density, no wind, nominal motor efficiency). The accompanying text has been updated accordingly.

Comment 4: *"Lines 128-137 Seems to repeat information from the introduction (motivation). Also, there is language that is 'sales pitchy' in the last sentence, for example 'high-power platform' [...] 'UAS-hostile conditions' [...] 'robust safety diagnostics' [...] 'weather-dependent operational modes'."*

We have revised this paragraph to be more specific and less promotional. "High-power platform" has been replaced with "a platform with increased thrust-to-weight ratio"; "UAS-hostile conditions" has been replaced with "high-wind conditions"; "robust safety diagnostics" has been replaced with "environment-aware failsafe logic (e.g., real-time wind-limit monitoring)"; and "weather-dependent operational modes" has been replaced with "battery-selection-dependent operational modes."

Comment 5: *"Line 140 Another sales pitchy statement 'push its performance to the limits' What are the limits?"*

This phrase has been replaced with a specific quantitative statement: "This trade-off enables the platform to operate in atmospheric conditions with sustained winds exceeding 25 m s^{-1}, where lower-thrust UAS platforms are typically grounded."

Comment 6: *"Line 148 Another vague statement that lacks evidence is 'achieve high aerodynamic performance'."*

This phrase has been replaced with "reduce the frontal cross-sectional area exposed to oncoming wind, thereby lowering dynamic pressure drag," which describes the specific aerodynamic mechanism of the elongated and angled airframe design.

Comment 7: *"Line 158 'Driven by a high-performance electronic speed controller' is another example where adjectives are introduced without context."*

The phrase "high-performance" has been removed. The sentence now reads: "driven by an electronic speed controller (ESC) rated for a maximum continuous current of 80 A," allowing the specification to speak for itself.

Comment 8: *"Line 161 'propeller has a size of* $10 \times 4.5 in$*'. The 10 in the prop description describes its diameter and pitch. Not just size. Also, these dimensions should probably be metric."*

The description now reads: "Each propeller has a diameter of 10 in (25.4 cm) and a pitch of 4.5 in (11.4 cm)," providing both the correct terminology and metric equivalents.

Comment 9: *"Line 180 '-which requires beyond visual line of sight (BVLOS) authorization'. This statement should probably also require the qualifying statement that this will be jurisdiction dependent."*

We have added the following wording: "which may require beyond visual line of sight (BVLOS) authorization, depending on the applicable airspace regulations and jurisdiction."

Comment 10: *"Lines 197 and 202 The term 'streamline' and 'streamlined' lack technical definition and is somewhat vague in this context."*

Both instances have been revised. "Streamline its longitudinal aerodynamic profile" is now "reduce its longitudinal frontal area, thereby lowering pressure drag." "Streamlined aerodynamic enclosure" is now "a smooth and continuous-surface aerodynamic enclosure that minimizes step changes and flow separation."

Comment 11a: *"This section does not include any description of the fan and flow rate used to aspirate the sensors."*

We have added a description of the aspiration system: "A small brushless ducted fan, mounted at the rear of the sensor chamber, draws ambient air through the scoop at a calibrated constant aspiration speed of approximately 12 m s^{-1}. This fan-driven flow is supplemented by the forced-air effect of the CSWX flying into the wind via the WVFM."

Comment 11b: *"There's also more sales pitchy statements such as 'patented sensor placement'."*

Revised to: "Following the sensor placement methodology described by Chilson et al. (2021)."

Comment 11c: *"There is also a lot of detail missing from the simulation setup. For example, what flow rates were used? What were the wind speeds?"*

We have added detailed simulation parameters: fan aspiration speed (12 m s^{-1}), ambient wind speeds matching each flight day (2–12 m s^{-1}), solar irradiance values (0–800 W m^{-2}), and an acknowledgment that the steady-state approach does not capture transient effects such as turbulent gusts and rapid sun-angle changes, which likely account for the remaining discrepancies.

Comment 11d: *"Figure 7: I would argue that the air temperature within the duct would be much more useful information than the wall temperature. Also, the font in this figure legend is really small."*

We have regenerated Figure 7 (now Figure 6) with larger legend font. We agree with the reviewer that the air-temperature distribution is relevant for a better understanding the temperature disturbances observed among the sensors. However, visualizing this effect in a 2D image is challenging. For this reason, the authors chose to show only the heat sources, which are the focus of mitigation approach shown in this work, while the resulting air-temperature distribution is assumed uneven due to the contamination source.

Comment 11e: *"Line 223: 'heated walls disrupt local airflow and introduce convective heating'. This statement is only true if the magnitude of the Richardson number is greater than order 1."*

We have added a clarification: "particularly when the Richardson number exceeds order unity (i.e., when buoyancy-driven effects dominate over forced convection). At the aspiration speeds maintained by the ducted fan ($\sim$12 m s^{-1}), forced convection is expected to dominate within the sensor chamber, limiting but not entirely eliminating this effect. Re-radiation from heated interior walls may also contribute a small bias, though this is mitigated by the white, high-reflectivity surfaces used inside the scoop."

Comment 11f: *"Line 235: 'with the CS3D showing the largest absolute deviations'. What physical changes were made to the duct which would impact these deviations?"*

We have added an explanation of the physical differences: "The larger CS3D spreads are attributed to differences in scoop geometry: the CSWX features a deeper sensor chamber with a more curved inlet path that increases the separation between the heated outer walls and the sensing elements, as well as hiding the sensors from direct sun radiation exporsure regardless of the incidence angle, thereby reducing both direct and re-radiated solar heating of the sensors compared to the CS3D's shallower duct design."

Comment 11g: *"Line 235: 'These observations confirm that solar loading is the dominant driver...' Perhaps weaken this statement to 'suggest' instead of 'confirm'?"*

We have replaced "confirm" with "suggest" as recommended.

Comment 12: *"Line 263: Does not thrust, which is largely unknown, also need to be determined?"*

We have clarified that thrust is computed from measured rotor RPM using the propeller model of Rajan et al. (2019) and iteratively refined with the current airspeed estimate within the LESO loop. This is now explicitly stated in the revised text.

Comment 13: *"Line 268: The assumption that the mean wind changes slowly over time may be correct, but the drag will respond to rapid changes in the wind direction [...] so the assumption that $h = 0$ may be significant."*

We have added a discussion of this assumption: "This quasi-steady assumption is appropriate for the profiling ascent rates used (3.5 m s^{-1}) and WVFM function enabled. As a result, the platform traverses slowly enough that the mean wind speed profile evolves on longer timescales than the LESO's 10 Hz update rate. Additionally, it is assumed that the WVFM's time response is fast enough to catch up with the mean angular wind shear and keep the CSWX pointing into the wind, making h stay close to zero relative to the CSWX's reference frame."

Comment 14: *"Lines 269-271 The connection between drag and wind is never expressed explicitly in this section."*

We have added an explicit statement that "aerodynamic drag $\vec{D}$ is a function of the wind-induced airspeed and acts as the coupling between the wind vector and the platform's translational dynamics through the Rayleigh drag equation." The LESO estimates this drag as an extended state variable, from which the wind vector is then inferred.

Comment 15: *"Line 304 'maintaining the best accuracy at the upper end of the wind speeds.' This doesn't indicate accuracy."*

Revised to: "maintaining the best agreement with the reference instruments at the upper end of wind speeds."

Comment 16: *"Figure 11 What were the conditions under which these measurements were taken? [...] was any averaging applied to the lidar?"*

We have updated the Figure 11 caption (now Figure 10) to state that measurements were "collected during a developing convective boundary layer approximately one hour after sunrise under clear skies." We also now acknowledge that the CS3D's greater scatter "may reflect both higher noise in the CS3D's wind-estimation algorithm due to a bulkier airframe, less responsive propulsion system, and less accurate GPS unit." Regarding the DWL, the caption now specifies that "The raw DWL profiles were collected using 5 s temporal averages, which were then linearly interpolated to match the 0.1 s sampling period of the CopterSondes."

Comment 17: *"Line 335: What is meant by the phrase 'notably tighter alignment'?"*

This vague phrase has been replaced with a precise description: "smaller deviations from the radiosonde reference (i.e., lower point-to-point differences)." We also added an important caveat that smoother profiles do not inherently guarantee higher accuracy, but the simultaneous reduction in RMSE relative to the radiosonde supports the interpretation that the improvements are genuine.

Comment 18: *"Line 346 What is an 'acceptable' error envelope? What defines this envelope?"*

The vague phrase "within an acceptable error envelope" has been replaced with a direct reference to the quantitative RMSE values: "within the RMSE values reported in Table 3." We also now report the specific mean RMSE values: 0.63 m s^{-1} (horizontal) and 0.25 m s^{-1} (vertical).

Comment 19: *"Figure 14: The font is really small on these figures."*

We have regenerated Figure 14 (now Figure 13) with a slightly larger font, maximizing the available space. We prefer to keep these plots together so the reader can view them in a compact layout that better supports understanding of the calculations, while also avoiding unnecessary extension of the paper onto an additional page.

Comment 20: *"Figure 16 and associated text. The fact that the Coptersonde SWX produced readings in moderate rain/highly humid conditions does not imply that the readings were correct. Were there any reference measurements made?"*

We agree that operational resilience does not imply measurement accuracy. The text supporting Figure 16 (now Figure 15) has been revised to state: "These profiles show that the CSWX operated in highly humid and rainy conditions and produced smooth and physically plausible temperature and relative humidity curves without exhibiting obvious rain-induced artifacts. However, no independent reference instrument was available during these flights to quantitatively validate the absolute accuracy of the measurements. Therefore, these results demonstrate the platform's operational resilience in wet conditions but should not be interpreted as a full accuracy assessment under precipitation." The conclusions have been similarly updated.

Comment 21: *"Conclusions: There is more sales-pitchy language [...] 'setting it apart from conventional platforms' [...] 'penetrating and characterizing extreme PBL conditions' [...] does a low level jet and moderate rain count as severe weather flights?"*

We have revised the conclusions: "setting it apart from conventional platforms" has been replaced with "a capable weather-sensing UAS with demonstrated improvements over its predecessor designs"; "penetrating and characterizing extreme PBL conditions" has been replaced with specific quantitative language: “operating in high-wind (up to $\sim$24 m s^{-1} sustained) and wet conditions that exceed the operational limits of its predecessor and many comparable small UAS platforms”; “Severe-weather flights” has been replaced with “High-wind and rain flights.” We have adopted more reserved language throughout to accurately characterize the tested conditions without overstatement.