AMTD Author’s response to Anonymous Referee #2
Referee’s comments are bold and italicized, and the author's are plain text.

General Comments: In the manuscript “The CopterSonde: An Insight into the Development of a Smart UAS for Atmospheric Boundary Layer Research” by A. R. Segales et al., the authors introduce the CopterSonde which has the ability to enhance scientific understanding of boundary layer processes by providing routine measurements of temperature, humidity, and wind. The authors describe the CopterSonde’s autopilot system and how winds are derived from the platform, provide details on the calibration procedures, and present examples of its measurements from recent case studies. Overall, I find the manuscript to be well-written, and I am happy to see that the CopterSonde is capable of providing robust thermodynamic information. However, I have a few concerns, including about the CopterSonde’s winds, which I discuss in more detail below. These concerns and others need to be addressed before I can recommend publication in Atmospheric Measurement Techniques.

1. I would like to see a graph or two showing the calibration procedure used to determine the coefficients C0 and C1 when operating the CopterSonde next to a tower. What do you mean by a “representative range of conditions”? Does this include very low / nearly calm winds as well?

We added figure 9, which is a comparison of CopterSonde calibrated estimated wind speeds versus the reference Oklahoma Mesonet tower. It is then referenced in the text in lines 289--290. We tested wind speeds from 2--11 m/s, which are fairly calm conditions at the low end. See Bell et al. (2020, in review; cited in text) for further discussion on how the wind speed estimations perform.

2. A couple of the figures need to be regenerated. Can you find a better picture to use for the inset images shown in Figure 2? In Figure 8, the CopterSonde’s measurements of temperature and dew point temperature were virtually indistinguishable from the rest of the figure. The hodograph also needs to be made larger in order to better distinguish the different features.

Figure 2 was replaced with a side view picture of the CopterSonde. The number of inset pictures was reduced to one. The new figure shows the locations of the Lidar and IrLock camera on the CopterSonde more clearly.

Updated figure 8 (now figure 10) to one from the LAPSE-RATE campaign. Line widths were increased for the plotted data and the size of the hodograph was increased.

3. It is encouraging that the CopterSonde was operated at temperatures down to -20 ◦C during the ISOBAR field campaign without any significant negative impacts on performance. However, it is unclear what the purpose of Figure 9 is. What do we learn from a simple time-height plot of temperature? Were humidity and winds unavailable from the CopterSonde during ISOBAR? Can you comment on the interpolation procedure used for the temperatures shown here?

Figure 9 (now Figure 11) was generated with data collected during the LAPSE-RATE field campaign. We added context to the caption of figure 9 (now figure 11). It now reads: “Plot of the temperature evolution over time with contour lines up to a height of 914 m. Each CopterSonde profile is separated by about 15 min, and is denoted by vertical dashed lines. The contours and color fill are produced by interpolating each observation level in time, resulting in a rectangular time-height cross-section.”

Figure 10 and 11 are just examples of CopterSonde profiles visualisations. These two perspectives enable atmospheric scientists to understand small-scale ABL processes in frameworks they are already familiar with from radiosondes and ground-based remote sensors. Lines 344--345 were added.

4. The CopterSonde shows a significant wind direction bias, particularly for low wind speeds. The CopterSonde’s wind directions are more than 100 degrees different from the rawinsonde’s observations in the lowest ~150 m (c.f., Figure 10b). This needs to be addressed. Even around 750- 950 m AGL there is also a non-trivial offset, on the order of 45 degrees, between the CopterSonde and rawinsonde’s wind directions.

We agree with the reviewer. Below 200 m, the wind speeds presented in panels a) an b) are very light, which makes it difficult to reliably estimate the wind direction. In the case of the radiosonde, these data have been averaged in height by the software provided by the manufacturer. Moreover, radiosonde data can be unreliable below 100-200 m because of the 'pendulum effect' created by the swinging movements of the instrument package after release. The agreement between the CopterSonde and VAD wind direction is better (Figure 12 was improved and VAD data is more visible); although, there is still significant scatter, likely because of the low wind. For the data between 750-950 m AGL, we again see an offset in wind direction between the radiosonde and the UAS (and VAD). Here again, the agreement is better between the UAS and VAD. Both the UAS and VAD are true vertical profiles, while the radiosonde will have drifted horizontally with the mean wind. The measurements were collected in a complex terrain and there is likely considerable spatial (horizontal) variability in the wind direction above the region of directional wind shear. Based on the reviewer's comments, we have modified the text to reflect some of these thoughts in the manuscript.

Third paragraph of section 4.2 now reads:

Sample data from the Moffat site is shown in Fig.12a-c compared to both co-located radiosondes and remote sensors from CLAMPS. During this time period, winds were less than 5 m s-1 throughout the CopterSonde profile (Fig.12a). The CopterSonde generally estimated the wind speed to be approximately 2 m s-1 less than both the radiosonde and the Velocity Azimuth Display (VAD) from the CLAMPS Doppler lidar. The CopterSonde did successfully capture a directional shear layer around 750 m (Fig.12b). It should be noted that the wind direction data presented in Fig.12b reveal better agreement between the CopterSonde and VAD than the CopterSonde and radiosonde. Since the radiosonde drifts with the wind, only the measurements from the CopterSonde and VAD represent true vertical profiles. Moreover, at lower altitudes, below 200 m AGL, there is considerable scatter in the wind direction measurements from the CopterSonde and VAD, likely because of the low speeds. The radiosonde data have been smoothed over height. Here again there is better agreement between the CopterSonde and VAD. The swinging motion of the instrument package on a radiosonde can produce erroneous result at low altitudes after release. Though the wind speed bias falls outside the stated accuracy above (+-0.6m s-1), it is a consistent bias and can be corrected. Work is ongoing to determine the a calibration procedure for calculating the coefficients in Eq.5 for an ascending rotary-wing UAS, as opposed to a hovering rotary-wing UAS (see Sect. 2.6.2). For this case study, the temperature measured by the CopterSonde is nearly identical to the radiosonde temperature (Fig.12c).

5. Given the rich dataset available from the LAPSE-RATE field campaign, it would be helpful to show additional comparisons between the CopterSonde and other platforms to provide more fidelity in the wind speed and direction measurements obtained from the CopterSonde. How representative were the results from the one case shown in Figure 10a-10c? I suggest showing mean difference plots, with estimates of error, across a range of conditions from the LAPSE-RATE field campaign.

The paper's scope is mainly about the description of the CopterSonde platform and it's capabilities. Although some examples of case studies were presented, more detailed comparisons with rich dataset can be found in Bell et al. (2019, in review) cited in the lines 407-408.

Minor comments: 1. Line 128: "achieved" misspelled 2. Line 349: "descent" misspelled
Both fixed.