

# ***Interactive comment on “An Approach to Minimize Aircraft Motion Bias in Multi-Hole Probe Wind Measurements made by Small Unmanned Aerial Systems” by Loiy Al-Ghussain and Sean C. C. Bailey***

**Anonymous Referee #2**

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general comments:

Reliable wind and turbulence measurements are highly required for a wide range of topics in basic atmospheric boundary layer research and its application, e.g. for air quality estimates or the wind field characterization for wind energy purposes. UAS provide a flexible and rapidly increasing resource for performing those measurements in unprecedented spatio-temporal resolution. The presented manuscript provides a step forward in the understanding of inherent errors in the wind estimates from multi-hole probes mounted on small aircraft, and also suggests and validates a method to mini-

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## Interactive comment

imize those uncertainties. By that the manuscript is timely and thematically well-suited for being considered for publication in AMT. There are, however, a few shortcomings that have to be addressed before I can recommend publication. The manuscript is in general well written and clearly structured. One exception is the introduction that in my opinion misses a clear line of argumentation towards the main goals of the presented work. The figures are in general of rather good quality, except for 7 and 8 that are nearly impossible to read and interpret and need a thorough overhaul (see also my specific comments below). Based on that I recommend major revisions to the manuscript in its present form.

specific comments:

I2: "aircraft spatial orientation, translation and velocity"; I feel there is some inconsistency/inaccuracy that should be clarified: a) Aircraft spatial orientation: do you mean attitude with respect to the Eulerian angles for Pitch, roll and yaw or something else? b) translation is already a velocity, do you want to distinguish between translational and angular velocities? be more Clear and concise here!

I12: insert "a" before "wide"

I13: insert "," before "such as"

I15: you are citing a lot here, which is in general not bad, but if you decide to go so broad out, then I feel that in particular for turbulence there are some central references missing, e.g.:

Mansour, M., Kocer, G., Lenherr, C., Chokani, N., & Abhari, R. S. (2011). Seven-Sensor Fast-Response Probe for Full-Scale Wind Turbine Flowfield Measurements. *Journal of Engineering for Gas Turbines and Power*, 133(8), 081601. <https://doi.org/10.1115/1.4002781>

Calmer, R., Roberts, G. C., Preissler, J., Sanchez, K. J., Derrien, S., & Dowd, C. (2018). Vertical wind velocity measurements using a five-hole

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probe with remotely piloted aircraft to study aerosol–cloud interactions. *Atmospheric Measurement Techniques*, 11(5), 2583–2599. <https://doi.org/10.5194/amt-11-2583-2018>

Båserud, L., Reuder, J., Jonassen, M. O., Kral, S. T., Paskyabi, M. B., & Lothon, M. (2016). Proof of concept for turbulence measurements with the RPAS SUMO during the BLLAST campaign. *Atmospheric Measurement Techniques*, 9(10), 4901–4913. <https://doi.org/10.5194/amt-9-4901-2016> those references should also be used again when introducing multihole probes on suAS, i.e. p2, l40/41

I22: what is the flexibility in a profile? do you mean the flexibility in choosing ascent/descent rates, or just the flexibility in location that is already stated before?

I26: I think you forgot temperature as the most commonly sampled parameter!

I37/38: "Usually, wind velocity measurements by fixed-wing suAS require velocity probes with slightly better temporal response than Sonic anemometers (Witte et al., 2017; Mayer et al., 2012)."; My first response here was "Why?"; what exactly do you want to express here; there are sonics around with 100 Hz measurement capability matching the typical sampling frequency of multihole probes

I42: "large wind velocities"; that should here better read "large flow velocities", as we are talking about the relative flow between the probe and the air

I49: "fly at velocities an order of magnitude greater than the wind velocity"; that can of course be the case, but in reality you easily can fly a fixed-wing in wind speeds up to 80% of the cruise speed of the Aircraft, so you should not generalize this statement

I60: replace "multi-hole probe" by "multi-hole probes"

I61: remove "with" before "a central hole"

I61: I suggest to replace "parallel to" by "in line with"

I85: Equation 6 and corresponding text: that reminds me very strongly to Don



Lenshows basic work; maybe a good idea to refer to!

I116: insert "the" before "determination"

I123: remove "due" before "to allow"

I126: "... and should include multiple changes of direction of the aircraft."; How relates this statement to the calibration maneuvers suggested/required by Lenschow?

I175 (and other occasions): "horizontal wind velocity magnitude"; I strongly suggest to use "horizontal wind speed" instead, this is the meteorologically correct term here

figure1: has apparently the wrong y-axis label (should be wind direction in degrees); I also highly recommend not to use line plots for wind direction!; how is the downsampling done, just picking an individual value or applying some form of averaging? in addition I would just use horizontal wind speed, maybe abbreviated as vh as y-label for a)

figure2: same comments as for figure 1:

figure 3: again the velocity labels could be much easier and intuitive vh\_MURC and vh\_sUAS; in addition there is something mixed up in the figure caption: Wind speed is a) and c), not a) and b) as stated in the caption

I219: "there is little-to-no evidence of this periodicity! is a rather brave statement; I still see some clear indications of such a periodicity and a formulation in the direction "shows a distinctly reduced periodicity" sound to me much more appropriate!

figure6 and discussion I221-227; what exactly do you want to achieve with this potential temperature profiles? If it is just to give an overview on the state of the atmosphere, then you should distinctly simplify your presentation by e.g. only showing the 4 average profiles (e.g. by bin averaging over 25 m vertical intervals; if you are also interested to present an inter-flight variability you can achieve that by using whiskers around your bin mean); as it is it is a rather hard to read/interpret figure

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figures 7 and 8: those are just messy in the present form; if you want to keep the shown information you could have this as a background with grey and reddish color, but on top you should again show some bin averaged values that would then give a clear picture how mean value and variability/standard deviation react on the proposed correction.

I235: insert "," before "even"

I237: "suggesting a potential time response lag between the five-hole probe and inertial measurement unit" a) insert "the" before "inertial measurement unit" b) this has been reported before: Båserud, L., Reuder, J., Jonassen, M. O., Kral, S. T., Paskyabi, M. B., & Lothon, M. (2016). Proof of concept for turbulence measurements with the RPAS SUMO during the BLLAST campaign. *Atmospheric Measurement Techniques*, 9(10), 4901–4913. <https://doi.org/10.5194/amt-9-4901-2016>

I244: insert "," after "For Z>200 m"

I256: remove "measured" before "profiles"

I264/265: how will a systematic time shift, e.g. introduced by a time delay of the data output of the IMU (as hypothesized in line 237), affect the correction procedure and your results? It might be worth to test (e.g. by a correlation analysis) if there is such a systematic time delay in your data set.

I267: insert "been" after "increasingly"

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