Referee Comment Responses: The DataHawk2 Uncrewed Aircraft System for Atmospheric Research

Referee Comment #2: Anonymous

The paper deals with describing the uncrewed aircraft system DataHaw2 capabilities for atmospheric studies. The focus is on atmospheric variables such as temperature, pressure and wind profiles, and ultimately provides data related with atmospheric turbulence. The topic is of great interest for atmospheric sciences and therefore suitable for publication in Atmospheric Measurement Techniques. The paper is well written and structured. A lot of details are given about the airplane, including instrument developments and deployments.

However, I have a major concern before recommending its publication in Atmospheric Measurement Techniques and is about the result sections: In its current form, many details are given about the flights performed in different campaigns, but there are no discussions of study cases that show the potential in the airplanes. Only a few graphs are given, but without discussions and even with no appropriate description of the variables represented. Such discussion must include results about atmospheric measurement/topics. Therefore, result section need to be improved

We appreciate the reviewer's comments and thank the reviewer for taking the time to provide detailed feedback. Regarding this first concern, however, we believe that the reviewer has misinterpreted the vision for what is communicated in this article. Given the submittal to AMT, we have chosen to focus the article on the technology itself, and with that provide a brief overview of previous applications of that technology. The section that we believe the reviewer is referring to as the "results" section is intentionally labeled as "Previous Deployments and Scientific Use Cases" to provide a fair and accurate representation of what is in this section. This section was never intended to provide the results of detailed scientific analysis of observations collected during the campaigns that are offered as examples. Each such analysis would result in enough material to develop multiple individual additional publications, some of which have already been published and cited in this text. Therefore, we respectfully disagree with the reviewer's perspective that more "results" are required, as we are including this section to provide examples to the reader on how the technology described has previously been deployed. Additionally, with respect to the reviewer's comment about not having sufficient descriptions of the variables represented, we're not certain we understand this concern. The figure axes and captions clearly state which variables are presented, and the body of the text also specifically calls out which variables are shown and even how these measurements might be interpreted (e.g. discussion about how CT^2 is a proxy for turbulence in the atmosphere, etc.). We believe that we have provided an adequate level of detail for the reader to understand what is being presented, again keeping in mind that we are not attempting to provide a detailed analysis of these observations but are rather sharing these with the reader as an example of the types of measurements that the DataHawk2 can provide. Should the editorial team believe that we are misunderstanding the reviewers concern or that we are not adequately describing the variables shown in the figures, we would be happy to make modifications.

My second point is not a concern. Indeed is a general comment that I would like the authors answer and if possible mention in the manuscript. Uncrewed aircrafts have a tremendous potential for atmospheric studies. However, there are many governmental limitations for flight operations, and that also varies with countries. Could the author provide their feedbacks about that and how to deal with it?

The authors concur with the reviewer's comment that there are many governmental limitations on UAS operation that vary from country to country, vary with location in a country, and vary with time, and add that these limitations can sometimes have a substantial effect on the design of a flight campaign. The University of Colorado (where the DH2 is based) has a Director of Flight Operations (DFO) office that helps obtain flight permissions for the needs of a given campaign wherever CU aircraft are operated. CU has a blanket Certificate of Authorization that enables flight in eligible airspace across the USA up to 400 feet, and also has operators that have FAA Part 107 certification. Either of these avenues can be used for local flight testing and for flight campaign needs that don't require higher altitude flight (or other flight conditions not permissible under the COA/Part 107). When a certain flight campaign requires deviation from the COA/Part 107 rules in the USA, a specific COA is sought to

enable these different flight operations, for example, increasing the maximum flight altitude. In US restricted airspace, rules vary by location and by airspace management practices at that location. When CU operates internationally, the DFO helps UAS operators work with a foreign entity to obtain flight permissions. Many months are sometimes necessary to work out these case-by-case airspace permissions in advance of a campaign.

We have added a sentence to each campaign mentioned in the "Previous Deployments and Scientific Use Cases" section mentioning the flight rules under which each campaign was conducted (ERASMUS: lines 605 – 606, POPEYE/ICARUS: line 620, IDEAL: lines 646 – 647, ShUREX: 666 – 667, LAPSE-RATE: 683 – 684, MOSAiC: 701 – 703). We believe this will give the reader some insight into the complexities of UAS operations from a governmental permissions standpoint and provide potential permissions avenues for a group that may be planning a UAS flight campaign in the future.

I also have some minor concerns that I believe must be addressed:

Introduction: I generally miss references in the Introduction section. For example, there are no references from line 30 to 40.

We agree with the reviewer that this section could use some additional references and have added these into the text.

Lines 60 – 61: I do not understand how the compositions of the atmosphere affect the uncertainties in remote sensing measurements

We apologize for the misunderstanding – in this case "composition" was meant to encompass the presence of clouds and precipitation, which can attenuate the signal of many remote sensors. We have updated the text to use the phrase "properties", rather than "composition".

Lines 62 – 63: Dial and Raman lidar for water vapor do not need particle backscattering. Please correct.

The reviewer is correct in their statement that not all lidar systems require particles to provide a measurement. Our comment here was specific to lidar systems used for wind measurement and aerosol backscatter lidars that are used to derive information on the presence of particulates and hydrometeors. We have updated the text to reflect this.

Lines 80 – 85: I would highlight the potential for studying spatial variability of atmospheric variables.

We agree with the reviewer that highlighting the potential for studying spatial variability would be a good addition to this section. We have modified the last sentence in this paragraph (lines 86 – 88) to highlight the potential for studying spatial variability

Changed from: "Additionally, they provide greater horizontal resolution than tethered balloons, along with the ability to operate in higher wind conditions."

To: "Additionally, they provide enhanced perspectives on spatial variability compared to tethered balloons, along with the ability to operate in higher wind conditions."

Line 93: After reading the manuscript, I did not find any instrument deployed in DataHaw2 for aerosol-cloud interactions. Is there a plan to install miniaturized instruments for that?

We do not have plans to install a miniaturized aerosol instrument on the DH2 at this time, but this may be something we'd like to pursue in the future. The authors find aerosol-cloud interactions to be an interesting and valuable area of study that could make this endeavor worthwhile.

Lines 160 – 170: I am confused. Is there a final version of DataHaw2 commercially available? What would be the final cost?

The authors apologize for any confusion here; there is not a final version of the DH2 commercially available, and it would be very difficult to estimate the cost of the aircraft in a commercial setting, as this is highly dependent on labor cost and other factors. The authors would also like to note that there will likely never be a final version of the DH2, as the aircraft is designed to be adaptable to various research goals and will therefore be modified for each use case to some degree. The following sentence has been added to lines 173 – 175 for clarification: "The DH2 is not commercially available at this time, though the authors are open to future collaboration that would use the DH2 in its current configuration or a configuration evolved to meet the needs of a specific research project."

Scientific Payload: I think that summarizing everything in a Table could make the paper easier to read.

The authors agree that summarizing the scientific payload in a table makes the paper easier to read and have added a table at the start of the Scientific Payload section.

Instrument Performance can be divided in several sub-sections to make the manuscript easier to read.

The authors agree that adding sub-sections to the Sensor Performance and Evaluation section will make the manuscript easier to read. The following headings have been added.

- 3.1 Thermodynamic Properties
- 3.2 Turbulence Properties
- 3.3 Wind Estimation
- 3.4 Radiosonde Comparison: Example Flight from MOSAiC

To make the sections more logical in layout, the radiosonde comparison paragraphs/figures were moved to the end of the Sensor Performance and Evaluation section, and the IR temperature sensor paragraph was moved up to the new "Thermodynamic Properties" section.

Figura 4 needs further explanation. I do not understand 'frequency' in Figure 4b

The authors would like further clarification of this comment by the reviewer, if the editorial team feels it is appropriate. The plot in question (now labeled Figure 3 due to re-organization; was previously Figure 4) is a commonly used plot in spectral analysis and is described in the caption and discussed in lines 426 – 432.

Section 4 ' Previous deployments and Scientific study cases': I think that a table summarizing all the campaigns and with the main flights characteristics and objectives could serve as a good illustration. Are data of the different campaigns free available? See also my main concern about the results section

Respectfully, the authors believe they have provided sufficient detail for the overviewed campaigns and disagree that a table would add significant value to the paper. Further information on each campaign and the data available can be found in the paragraphs describing each campaign or the referenced works for each deployment (see lines 590 – 620 for ERASMUS, 622 – 647 for IDEAL, 653 – 667 for ShUREX, 673 – 684 for LAPSE-RATE, and 686 – 704 for MOSAiC). Additionally, the data used in the MOSAiC radiosonde comparison section is referenced in the "Data Availability" section of the paper. If the editorial team feels that the information provided is insufficient, the authors would be happy to make modifications to the current sections.

Conclusions: I think this section need to be re-written. Authors focus more on negative points than in main achievements.

The authors agree that more detail should be added on the achievements of the DH2, especially in the first paragraph (lines 706 – 716) of the "Summary and Outlook" section. Campaign locations have been added to the paragraph, along with a concluding sentence highlighting the total number of flight hours the DH2 has conducted, and mention of an upcoming Antarctic deployment.