Response to Prof. John Cassano (Referee #1) for AMT-2020-515.

Dear Prof. Cassano, thank you for your interest in our work and valuable comments on the paper. On behalf of the co-authors, I am providing responses to your comments below. The line, page and figure numbers in {…} brackets correspond to the "latexdiff" version of the manuscript.

This paper describes the use of two different commercially available quadcopter drones for observing temperature inversions during the Arctic winter. Very strong temperature inversions, with temperature gradients of 100-300 K / km were observed immediately above the surface and matched in-situ observations from a 10 m tower and from radiosonde observations. This manuscript provides an excellent description of the technical challenges (related to quadcopter navigation and autopilot use) at high latitudes. The scientific results are limited to flights from a 7 day period in March 2020 although the data collected during these flights illustrate the very strong inversion conditions present at Eureka at the end of the winter. The main issue with the data shown in this manuscript are related to sensor lag, the impact of propellor downwash and sensor location on the quadcopter which result in non-negligible errors in the observed temperature. Despite this the results presented will be of interest to those hoping to use small drones to make meteorological measurements and I recommend that this manuscript be accepted for publication. Below I offer a few minor comments.

Specific comments

In the paragraph starting on line 65 it would be good to discuss some of the smaller fixed wing RPAS used for polar research as these are similar in terms of ease of deployment and payload capacity as multi rotor drones. Small Unmanned Meteorological Observer (SUMO)

Reuder et al. (2009)

Reuder et al. (2012)

Cassano (2014)

Jonassen et al. (2015)

DataHawk2

Lawrence and Balsley (2013)

de Boer et al. (2018)

Lines {139 -151}.

Done. The manuscript has been updated with a discussion of the smaller fixed-wing RPAS and references to corresponding papers.

Note that Cassano (2014) also note issues with sensor lag for ascent vs descent temperature profiles similar to what you have found.

Lines {139 -151}.

Done. The manuscript has been updated with a short summary of the results and a reference to the paper.

Line 226: Did you measure the battery temperature during the flight? If not, how do you know the battery temperature during the flights?

Lines {200-201, 209-211}.

Done. The stock batteries of both DJI M100 and DJI M210 RTK drones are equipped with internal temperature sensors, which continuously monitor battery core temperatures during the flight. The temperature readings are displayed on the screen of the drone's remote controller and stored in the log files onboard the drone together with other telemetry data.

The paragraphs describing drone's specification and battery enclosure have been populated with information about the internal battery temperature sensors.

A discussion of the temperature measurement issues (sensor lag, downwash impacting observed temperature and temperature differences for the RTD located at different positions on the quadcopter) should be discussed in the conclusions. These are the scientific issues that will limit the usefulness of quadcopters for making scientifically useful measurements of the near surface temperature profile.

Lines {656-668, 693-697}.

Done. A discussion has been added to section 3.2.5. and to the conclusion.

While not necessary to cite you may be interested in mid-latitude observations of cold pools using a bicycle based temperature sensor described in Cassano (2014b)

Thank you for useful reference and idea. We will consider the "Weather Bike" approach for our future studies in Eureka. We find this approach valuable and relatively easy to implement. The bike can be replaced by a RC controlled vehicle, and it could be a good addition to our drone measurements to study micro meteorological conditions and their links with local topographic features.

Technical corrections

Line 13: Replace of with above in "60 m of the ground"

Done.

Line 49: Replace one with was in "than one measured in Antarctica"

Done.

Line 131: Please include link to the relevant DJI web pages here.

Done.

Line 316: Replace one with that in "similar to one observed"

Done.

References

Cassano, J.J.: Observations of atmospheric boundary layer temperature profiles with a small unmanned aerial vehicle. Antarctic Science, 26, 205-213, doi:10/1017/S0954102013000539, 2014

Cassano, J.J., 2014b: Weather bike: A bicycle-based weather station for observing local temperature variations. Bulletin of the American Meteorological Society. doi:10.1175/BAMS-D-13-00044.1.

de Boer, G. et al. 2018, A bird's-eye view: Development of an operational ARM unmanned aerial capability for atmospheric research in Arctic Alaska. Bulletin of the American Meteorological Society, doi:10.1175/BAMS-D-17-0156.1.

Jonassen, M.O., Tisler, P., Altstädter, B., Scholtz, A., Vihma, T., Lampert, A., König-Langlo, G., and Lüpkes, C.: Application of remotely piloted aircraft systems in observing the atmospheric boundary layer over Antarctic sea ice in winter, Polar Research, 34, 25651, DOI:10.3402/polar.v34.25651, 2015.

Lawrence, D.A. and Balsley, B.B.: High-resolution atmospheric sensing of multiple atmospheric variables using the DataHawk small airborne measurement system. Journal of Atmospheric and Oceanic Technology, 30, 2352-2366, doi:10.1175/JTECHD-12-00089.1, 2013.

Reuder, J., Brisset, P., Jonassen, M., Müller, M. and Mayer, S., The Small Unmanned Meteorological Observer SUMO: A new tool for atmospheric boundary layer research. Meteorologische Zeitschrift, 18, 2, 141-147, 2009

Reuder, J., Jonassen, M.O., and Olafsson, H.: The Small Unmanned Meteorological Observer SUMO: Recent developments and applications of a micro-UAS for atmospheric boundary layer research. Acta Geophysica, 60, 1454-1473, doi:10.2478/s11600-012-0042-8, 2012.

Done. The manuscript has been updated with suggested references.