Response to Referee #3 for AMT-2020-515.

Dear Referee #3, thank you for your interest in our work and detailed review of our 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.

The authors present field deployments testing two types of quad-copters in the harsh conditions of the high-Arctic in winter. The technical description and challenges are relevant and clearly articulated. In general, the work presented here seems very useful for the establishment of high Arctic measurements by drones. Nevertheless, some of the technical issues discovered were only stated but no possible amendments were suggested/applied. Also, the presentation of the results needs some augmentation, especially when comparing to local measurements. More statistical analysis and discussion might be warranted, especially since the current study findings show much deeper inversions than previously suggested for the Arctic (versus the Antarctic).

Minor comments:

Line 17 in the abstract: agrees well with the one (one comparison seems odd)

Lines {19-20}

Done. "The inversion lapse rate agrees well with the results obtained from the radiosonde temperature measurements."

Line 56, positively correlated with what?

Lines {83-84}

Corrected as follows: "They found the strength, occurrence frequency and depth of the SBI are larger in winter and fall than in summer and spring and are positively correlated between each other, both spatially and temporally."

Line 99-100, sentence too long; consider parsing

Lines {164-167}

Done. Parsed as suggested.

Line 123, on SBI shaping

Done.

Line 144, specification of 0.1 m

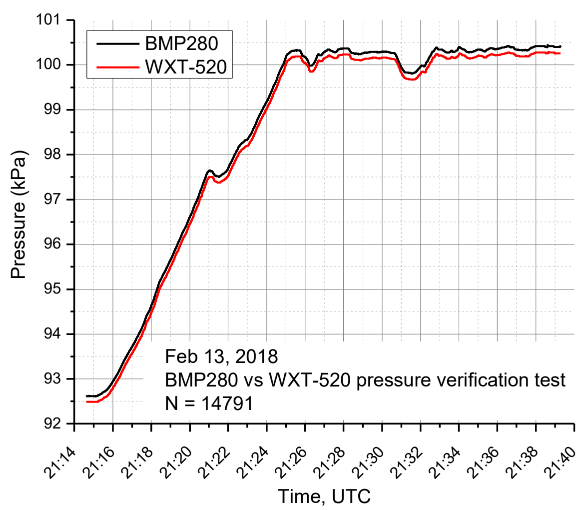
Lines {216-218}

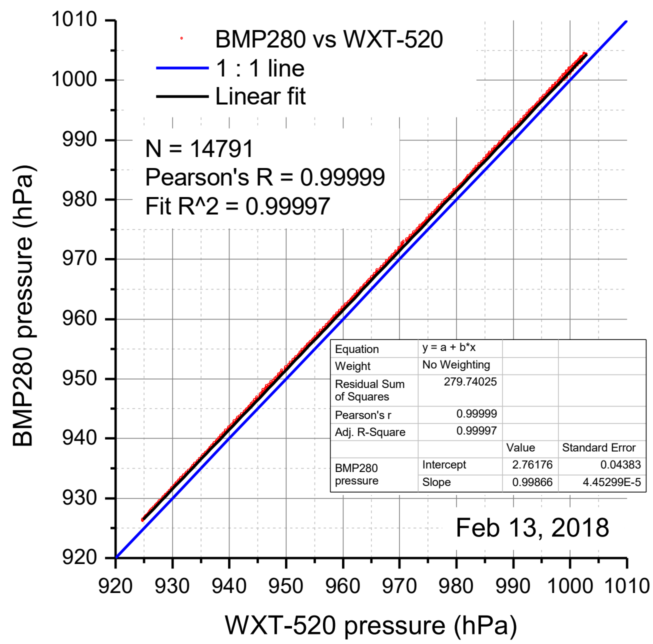
Done. Corrected as follows: “According to specification a hovering accuracy of 0.1 m in both vertical and horizontal directions can be reached by utilizing the drone together with DJI D-RTK ground system kit (RTK mode).”

Line 168, the results showed good agreement (can you please specify the correlation coefficient? Number of data points?)

Lines {240-243}

Done. The BMP280 altimeter was verified by comparing its pressure readings to simultaneous measurements taken with a Vaisala WXT-520 weather transmitter within the pressure range between 92.5 and 100.2 kPa. Both sensors were placed in a truck and collected data at 10 Hz sampling rate while the truck was driven from the PEARL Ridge Laboratory (610 m.a.s.l.) down to the Eureka Weather Station (10 m.a.s.l.). Total number of data points is equal to 14791. Pearson’s correlation coefficient is equal to 0.99999. Linear fit R-Square coefficient is equal to 0.99997. Plots representing the results of validation of BMP280 pressure sensor against Vaisala WXT-520 weather transmitter are shown below.





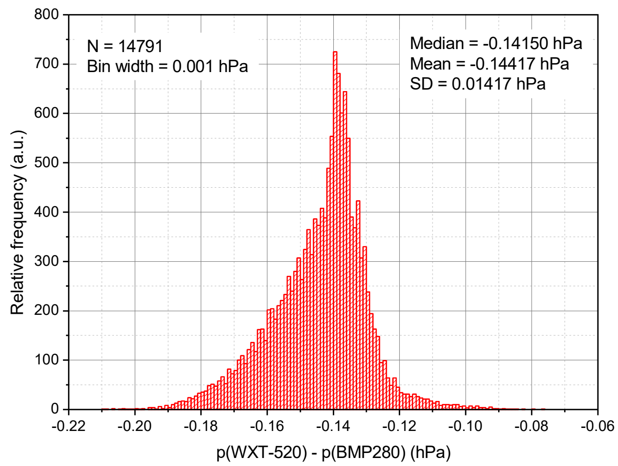


Figure 5 and its discussion: the results shown are for one short profile. I would expect seeing some additional statistics and comparisons with the FT and radiosonde data during the campaign duration, to support or decline the proposed biases and/or agreements.

We are not able to provide additional statistics and comparisons of drone data with the FT data for 2020 for now. The reasons for this are as follows. Unfortunately, 2020 FT data are still not available. This is due to a failure in the FT data transfer system which is not possible to fix till somebody of our staff travels to Eureka. Since the staff is still under travel restrictions due to COVID-19 pandemic and we are still waiting for an approval from Canadian government to travel to the site, there is no timeline for the trip yet.

Some statistics could be retrieved from the measurements made in 2017-2019. However, during that period we were developing the drone temperature measurement technique. The flights were sporadic in time with a large variation of flight parameters and several drone failures.

In regards to the drone vs radiosonde comparisons, it is not possible to provide valid drone vs radiosonde comparisons for the layer <10 m above the ground, since radiosondes can not resolve this layer well. Within 10-60 m above the ground our drone lapse rates agree well with the lapse rates obtained from the Eureka RSs, launched within 4 hours after the drone flights and are close to the results of multi-year studies conducted by Bradley et al. (1993) and by Walden et al. (1996) based on Eureka RS data covering 1967-1990.

While the drone and the RS lapse rates agree, spatial separation between ECCC WS and RTS, temporal separation between the drone flights and radiosonde launches and up to several degrees natural temperature variations on a time scale ranging from 1 minute to several hours make the results of the comparisons of drone vs RS absolute temperatures for 10-100 m altitudes challenging. To address this, we plan to conduct drone temperature measurements simultaneously with the radiosonde launches in the future as soon as we can travel to Eureka. Other option is to install RS onboard the drone and conduct simultaneous temperature measurements using drone and RS temperature sensors.

Also, the temperature measurements show lapse rates much higher than previously observed in the Arctic region and this also calls for some additional discussion.

Lines {682-686, 701-707}

Done. The conclusion has been updated with additional discussion and comparisons.

Lines 355-357, the temperature profile differences between the passes in Figure 7 are not always "slight"; there are some variations of 1 degree (subplot c), which warrants more attention. Is there a reference instrument that can attest to the change in ambient conditions over this time?

Lines {548-565}

There is no closely located reference instrument that can attest to the change in ambient conditions over the time of our flights, except the temperature sensors installed at the NOAA Flux Tower (FT).

Unfortunately, 2020 FT temperature data are still not available.

According to the FT data from 2017 and early years, temperature variations on a scale of ~1C per minute occur nearly continuously during periods of extremely stable boundary conditions in Eureka (see Figure {6} in the updated version of the manuscript). Such fluctuations are natural. They could be the reason of the differences in the drone temperature profiles. A discussion describing the temperature variations based on 2017 FT data has been included in the manuscript (see section 3.1.2 and Figures {5} and {6}).

Eureka A (the closest alternative weather station to the RTS) and Eureka Climate (the closest weather station to the FTS) temperature data are available, but only at 1 hour resolution.

Figure 9 caption: probably course and not coarse

Done.

Line 370, not able to maintain

Lines {584-585}

Done. Rephrased as follows: "During this flight the RTK system experienced a number of intermittent failures and the drone was not able to maintain its altitude properly."

Figure 10, it is interesting to see the better agreement for the FT flights; is this a coincidence or the result of the location/specific conditions? Were additional comparisons were made with the FT?

Page {35}.

Figure {11} shows temperature profiles measured during M210 RTK flux tower flight along WP1-WP7 way-points on 9 March 2020. Temperature profiles from the RS launched from the ECCC WS at 23:15 UTC and corrected for the altitude difference between the ECCC WS and the RTS elevations are depicted in the figure together with 18:00, 19:00 and 20:00 UTC Eureka A temperatures.

A comparison of the FT temperature data for 28 February 2017 with simultaneously measured drone temperature profiles and 11:15 and 23:15 UTC RS profiles (see Figure {5}) suggests that a good agreement between the drone and RS temperature profiles in Figure {11} could be coincident. Most of the drone temperature profiles measured at the RTS in 2020 show positive bias in comparison with the RS profiles (see Figures {8-11}). Horizontal and vertical separation between the RS launch site and the RTS, time difference between the measurements and natural temperature variations makes the results of the comparisons of drone vs RS absolute temperatures challenging. RS measurements conducted simultaneously with the drone and FT measurements would clarify whether this a coincidence or the result of the location/specific conditions.

Please, all see the answers to the comments above and below, since they are related to each other.

Fig.11-12, I think there is room for further discussion of the results, especially on the different profile shapes on the different days and their similarity (dissimilarity) on the different days in the gully vs. the runway. For example, profile shapes in Fig. 12 seem similar but shifted between the gully and runway, while Fig. 11 shows more similar trends. More discussion on the conditions and why we see these results.

As it was mentioned above, 2020 temperature data from our reference instrument – the FT, are still not available. We would like to avoid further discussion of the conditions that could cause the similarity (dissimilarity) in the gully vs the runway temperature profiles without these data. Therefore, we would like to present the gully vs the runway results as is for now and get back to detailed analysis as soon as the FT data become available. Although, two potential reasons that could cause the similarity (dissimilarity) in the profiles have been briefly highlighted at the end of section 3.2.3.

Line 413: Field instead of Filed

Done.

Lines 413-415, while IR sensor and a Lidar can be a valuable addition, these are much heavier instruments and more complicated installations, so mentioning their addition as a side-note might not be appropriate without further scrutinization. Maybe state the expected challenges from such add-ons.

Lines {649-654}.

An IR sensor is a small instrument. There are many lightweight “turn-key” solutions and development boards (<50 g) with a variety of communication interfaces (USB, I2C, SPI) available commercially.

By the Lidar we meant Laser Altimeter/Rangefinder. The manuscript has been corrected accordingly. Lightweight (~100-200 g) altimeters with an operation range of 100-200 m are also commercially available.

We do not expect many challenges in implementing such add-ons.