Drone measurements of surface-based winter temperature inversions in the high Arctic at Eureka

by Tikhomirov et al.

The authors present measurements of temperature profiles obtained with quadrocopters in the high Arctic in winter under challenging environmental conditions. The description of the methodology is sound and of interest to a broad range of scientists. In particular the technical challenges that were encountered can be very valuable for other drone operators.

There are a few minor comments. My only major point is the suggestion to correct the measured profiles for time lag and take this into account for the analysis of lapse rate, which might be strongly influenced by the correction.

The article is clearly structured and well written.

Detailed comments:

Major points:

- The authors derive the lapse rate/strength of near-surface temperature inversions. However, as they point out, they do not correct the time lag of sensors. This can be seen by the disagreement of temperature profiles around the top of the profiles. As the quadrocopter goes up to the maximum flight altitude and subsequently down again, there is only a short time between the two measurements, and the temperature should be comparable. This obvious artefact induced by the measurement method/sensor characteristics should be corrected before deriving parameters like lapse rate and inversion strength. It would be nice to have two sub-plots of Fig. 5, one with the raw data like shown already, one with the corrected data. The large differences of temperature profiles for ascent and descent are clearly artefacts and not features. This is further underlines by the dependence of the differences on sensor position.
- You mention the influence on response time in l. 352. Please apply a correction, and compare also the correction to the literature.
- Further, it would be nice to embed the lapse rate observations more in the literature which describes such values.

Minor comments:

- The lapse rate is provided in °C/m and °C per km. This seems an unusual parameter to me. Mostly known in atmospheric science is the temperature change within 100 m (usually roughly within the range of plusminus 1°C). Another method would be to describe the temperature change within the 10 m altitude interval. Values like 300°C/km are difficult to understand at a first glance, and appear throughout the text.

- l. 18: is the heat flux through sea ice really called sensible heat flux? I would suggest to remove the "sensible". The term sensible heat flux usually refers to turbulent transport of heat from the ground into the atmosphere
- l. 25: if you mention the remote sensing techniques for satellite-based temperature measurements, please explain in more detail. In particular satellite based surface temperature measurements are strongly hampered by clouds. In any case I'm not aware of a satellite based method for deriving surface temperature inversions.
- l. 70/l. 76: I do not agree that fixed-wing aircraft are able to transport more payload than multirotor aircraft. If they have the same mass, let's say 25 kg, usually fixed-wing systems have a payload in the range of 5 kg plus batteries for an endurance of around 45 min flight time. Multirotor systems can handle easily up to 10 kg of payload, but with a typical endurance of 20 min. Please specify what exactly you mean here.
- l. 85: please be more specific about the advantages of unmanned systems compared to manned aircraft. In remote regions it may be easier to do measurements with a manned aircraft with longer endurance and without the need of access to the site. Further, manned aircraft usually allow to include more payload, which is clearly an advantage.
- please be specific about the usage of the terms "autonomous" and "automatic". Usually for drone operation, automatic refers to using an autopilot to fly along a given trajectory or way points. Autonomous means that you have a decision making instance on board, which can do tasks like detect and avoid. Not sure if you have this. In l. 309 it is mentioned that the "obstacle avoidance system" was disabled. This means that you were doing the flights in automatic mode.
- l. 233: Why did you choose the maximum flight altitude of 90 m? Was this an arbitrary decision? Why not 100 m? Were there restrictions of air space?
- l. 235, 240: repetition of favourable flight conditions
- l. 240: contradiction: you say that the relative humidity was 70%, and the air was very dry. Maybe you refer to absolute humidity of water vapour mixing ratio? Please specify.
- l. 248: add coordinates of measurement location
- l. 252: explain acronym GNSS when using it for the first time
- l. 268: refer to Fig. 4 for TS1
- l. 269/l. 324: explain FT earlier in the text
- l. 329: please explain more in detail how you investigate the influence of local topography
- l. 341: is the bias reproducible and can therefore be corrected?
- Fig.6/Fig 7: please use the same denominations for all flight legs and way points. What is "2-pass" (in the figure caption)? What is "–profile 2/3 passes" in the caption of Fig. 7? Does this correspond to waypoint p 3/5 in Fig. 6?
- Fig. 13: why is the style so different to the other figures? There are many more pixels / different line style.
- l. 414: maybe use the term "laser altimeter", if you only want to detect the ground return? Lidar may also refer to backscatter or wind lidar, which is not what you plan to use.

Suggestions for grammar/spelling:

- l. 17: above ~~the~~ sea ice
- l. 29: The WMO assess<u>es</u> global temperature
- l. 107: spent on ~~a~~ <u>the</u> development
- l. 132/137: same spelling: wheelbase or wheel base?
- l. 155: housed ~~a~~ in 25 mm….. tubes
- same style of date throughout the text, including year: 11 June 2019, also in tables, provide full date with year
- l. 232: <u>The</u> initial flight strategy
- l. 259: <u>the</u> drone performance
- l. 275: above ~~the~~ ground
- l. 334: wind speed~~s~~
- l. 370: maintain <u>the</u> drone's altitude
- l. 391: this suggests <u>that</u> the local …
- l. 394: "created" instead of "creating"?
- l. 404: unclear: "and with 19:00 UTC Eureka C temperature". Please rephrase.
- l. 413: field operations (not filed)?
- l. 424: conducted with <u>the</u> M100 drone
- l. 437: "suggested" instead of "suggesting"