Atmospheric Measurement Techniques Discussions

Atmos. Meas. Tech. Discuss., referee comment RC2
https://doi.org/10.5194/amt-2022-93-RC2, 2022

Comment on amt-2022-93

Anonymous Referee #2

Referee comment on "A fiber-optic distributed temperature sensor for continuous in situ profiling up to 2 km beneath constant-altitude scientific balloons" by J. Douglas Goetz et al., Atmos. Meas. Tech. Discuss., https://doi.org/10.5194/amt-2022-93-RC2, 2022

Review report

A Fiber Optic Distributed Temperature Sensor for Continuous in situ Profiling 2 km Beneath Constant-altitude Scientific Balloons

By Goetz et al.

This paper presents a newly developed atmospheric temperature sensor system using a fiber optic distributed temperature sensing (DTS) instrument, named FLOATS, for the use with constant-altitude scientific balloons flying slightly above the tropopause. According to the authors, this DTS method has been largely applied to hydrologic and geologic research, and to some atmospheric research, but this is the first case to apply DTS to upper troposphere and lower stratosphere temperature (UTLS) measurements. The section on Design and Methods is very well written, showing clearly very careful designing and development by the authors.

Radiosondes are most widely used balloon borne instruments with a long history of development and improvements. But, even the recent radiosonde temperature sensors and their data processing have issues that need further improvements (see e.g., Dirksen et al., 2014; Kizu et al., 2018). The largest uncertainty comes from the correction of solar heating on the sensor during the daytime flights in the stratosphere, which is greater at higher altitudes (i.e. lower pressures). This means that even the modern radiosondes use active *corrections* for solar heating based on laboratory and flight experiments. The application of FLOATS is for the UTLS region, where the solar heating effects may not be so strong (at least for radiosonde instruments), but long optical fiber is obviously very different from radiosonde temperature sensors, and thus its thermal characteristics (e.g., heat capacity, emissivity, surface reflection of visible and infrared lights) would be needed to be investigated. It is also noted that infrared cooling to space may also be non-negligible for FLOATS (although it is considered to be negligible for modern radiosonde sensors). One more complication is the use of FLOATS with constant-altitude balloons which drifts with winds, in other words, basically without air flow around the sensor. This gives more significant radiative heating/cooling effects, which need to be evaluated and corrected/subtracted to obtain true air temperatures with uncertainty estimation. I had some difficulties in interpreting the float level temperature data in Section 3.4. Some more explanation/clarification would be necessary. But, overall, the paper is well written and the new instrument is very promising.

Specific comments:

- Lines 281, 284-286: I think that some laboratory measurements can be made to characterize the heat capacity, emissivity, and reflectivity of the fiber.

- Figure 2 (and other places in section 3.1): Does this mean (or do the authors consider) that the effects of solar heating on FLOATS would maximize at sunrise and at sunset when solar radiation direction is perpendicular to the fiber? In other words, during the mid-day, solar effects may not be so strong compared to the sunrise and sunset? (Of course, there is also the factor of air mass (i.e. optical depth) – i.e., solar radiation is much stronger during the mid-day than at sunrise and sunset.)

- Line 414: Again, heat capacity of the fiber can be evaluated from e.g. laboratory experiments.

- Line 417: Response time may be evaluated as relative to that of iMet-1 radiosonde temperature sensor, by using data shown in Figure 4 (i.e., by smoothing iMet-1 data to find the best fit with FLOATS data). (The iMet-1 radiosonde sensor may not be well characterized, but if we assume that its response time is similar to other modern radiosonde sensors, it is around 1 sec (see Kizu et al., 2018, page 39). Note that this value is obtained under the condition of air flow with 5 m/s.)

- Section 3.4 and Figure 5. Solar heating effects need to be evaluated (and maybe subtracted if necessary). Otherwise, it is not clear to me whether the "warm layer" (line 480) was real or artificial. Please add to Panel (c) average profiles for 07:05-07:40 and 07:45-8:10; and these profiles may be compared to other radiosonde data shown in Figure 6. (I also understand that "optical distortion" (line 492) is another, unique factor when interpreting FLOATS data. Is it possible to have some in-flight house-keeping data to evaluate the degree of distortion in future developments?)

- Figure 6: Please also prepare a separate panel enlarging 17-19.5 km region.

- Pages 21-22, lines 604-619, and Figure 8.

It is probably useful to explicitly write that the wave parameters obtained here are the “intrinsic” ones, relative to the background flow, as the FLOATS is drifting with the mean flow.

Please clarify the situation, either the wave field is almost fixed and the FLOATS scanned the field, or the waves were passing through the rather fixed FLOATS.

Could you explicitly write the strength of the FLOATS measurements for gravity wave research, i.e., temperature *curtain* measurements rather than point measurements by previous constant-altitude balloon measurements?

References:

Dirksen, R. J., Sommer, M., Immler, F. J., Hurst, D. F., Kivi, R., and Vömel, H. (2014): Reference quality upper-air measurements: GRUAN data processing for the Vaisala RS92 radiosonde, Atmos. Meas. Tech., 7, 4463-4490, https://doi.or/10.5194/amt-7-4463-2014

Kizu, N., T. Sugidachi, E. Kobayashi, S. Hoshino, K. Shimizu, R. Maeda, and M. Fujiwara (2018), Technical characteristics and GRUAN data processing for the Meisei RS-11G and iMS-100 radiosondes, GRUAN-TD-5, 152 pp. Available at https://www.gruan.org/documentation/gruan/td/gruan-td-5/