**Response to Reviewers for 'A Fiber Optic Distributed Temperature Sensor for Continuous in situ Profiling up to 2 km Beneath Constant-altitude Scientific Balloons'**

The authors thank the reviewers for the helpful comments on this manuscript. We have responded to all comments within this document below which are provided in **Bold.**

**Reviewer 1 Comments:**

Summary:

This article presents a novel fiber-optic (FO) sensor and application for collecting spatially continuous temperature profiles from an untethered balloon. While the authors designed the system to collect samples at the interfacial layer between the upper troposphere and lower stratosphere (UTLS) across a maximum layer of 2 km, deployments across other atmospheric layers and height ranges are conceivable as long as the prerequisites for pressures and temperature ranges of the contained sensors and the balloon's buoyancy are met. To my knowledge, it's the first system of if its kind with an independent untethered (from a ground station) sampling, processing and storage unit contained in the balloon's gondola unit and in this sense is unique and innovative. Since all electronics including the laser optical bench, loggers, and power supplies need to be carried as payload, some sampling limitations result regarding minimum averaging time (reported as 20 s) and spatial resolution along the fiber (reported as 3 m) in comparison to ground-based fiber-optic distributed sensing (FODS). The latter offer a minimum sampling at 1 Hz and 0.125m. The FLOATS' sampling limitations pose some noteworthy restrictions on the scientific merit of the collected data, particularly when observations from the strongly in stationary ascent and descent phases with great vertical velocities and sharp temperature changes are analyzed. However, given the unique, lightweight, retrievable design of the sensor being able to collect continuous observations over weeks and months, it is a fascinating addition to the family of Raman-scatter based FODS aerial applications. I have very few comments on the technical and data analytical aspects of the study.

However, there is one significant weakness: given the FLOATS' unique sampling capabilities and innovative design, I am somewhat puzzled why the authors present its proof-of-concept study using the Wyoming WY933 test flight, which suffered from three major shortcomings: first and foremost, the temperature reference sensor No. 4 contained in the end of fiber unit (EFU) malfunctioned during the float and descent stages preventing a meaningful post-flight calibration of raw Stokes/AntiStokes ratios into aerial temperatures for length along the fiber (LAF) bins past the rotary connector. While the authors found some work-around and provide some calibrated data, its quality is not representative of the sensor's true capabilities. Second, the fiber-optic cable was only 1200m long. Given the exponential decay of the signal to noise ratio of the Raman photons across the FO cable, assessing measurement uncertainty at the shorter 1200 m LAF distance compared to the full 2000m is different. Third, the deployment at float height (90 min) was too short to resolve the typical period length of gravity waves in the tropopause of several hours, as indicated by the authors. I believe that these shortcomings pose significant limitations on evaluating true system performance regarding accuracy of the retrieved temperature profiles, as well as resolving vertical structure of the UTLS which appears to be of great concern to the authors, as I understand. For me, a proof-of-concept introducing a novel sampling technique shall showcase a system's true capabilities so the reader can decide about its suitability for similar applications. The WY933 flight does not fulfill these requirements. The authors mention that other flights exist (ln 80, Strateole 2 campaign), so why not use those? It is ultimately up to the authors and the editor to decide whether they want to introduce FLOATS with a fizz, r ther than a bang – I believe the latter would be in order.

I have a few minor comments in addition to the main criticism.

In summary, I recommend publication of the study on the novel FODS sampling system using a different, more meaningful dataset, if at all possible. Such an article would demonstrate the system's true capabilities and have significant technical and scientific merit.

**We thank the reviewer for the insightful comments and acknowledgement of the scientific merit of the FLOATS instrument for long duration aerial studies. We understand the reviewers concerns about the limitations of the WY933 flight with respect to showing the full capabilities of the FLOATS instrument due to the broken reference sensor at the end of the fiber and shorter than designed fiber length. However, the results from the WY933 flight are provided in this manuscript instead of the Stratèole 2 flights because WY933 was a successful flight with careful experimental design that highlights the capabilities of the FLOATS instrument under controlled conditions, regardless of the broken sensor. These capabilities would not be as easily resolved in the Centre national d'études spatiales (CNES) managed Stratéole 2 long duration multi-instrumented flights because of the data telemetry and flight control limitation associated with the project. Although not an exhaustive list of the advantages of WY933 the following provides some examples of why the WY933 results are provided in the manuscript:**

1. **In WY933, the payload was recovered which allowed for analysis of the full resolution data. This was not possible with the Stratéole 2 flights because the payloads were not recovered (as designed) and because of data limits due to satellite-based telemetry and power conservation.**
2. **The ascent portion of flight provided a full vertical temperature profile comparison in WY933, which was not possible in the Stratéole 2 flights because fiber optic deployment was delayed for flight safety reasons until the balloon was at a constant flight level.**
3. **Close comparisons to meteorological soundings are used for temperature profile validation and wave analysis of the WY933 results. Comparisons to meteorological sondes are challenging with the Stratéole 2 flights compared to WY933 because the Stratéole 2 flight took place in the tropics, primarily over oceans, where sounding stations are sparse.**

**We expect to present the results from the Stratéole 2 long duration flights in future science focused publications. The goal of the present work is to provide a technical overview of the instrument and its general capabilities, and to provide the background for the analysis required to retrieve the temperature profiles. As described in lines 80-85 of the revisions.**

**To address the reviewers concerns about the ~1200m length of fiber optic used in WY933 compared to the 2000 m designed capabilities of FLOATS, the WY933 length was chosen deliberately as part of the experimental design. The length was chosen to allow for multiple fully deployed FLOATS temperature profile retrievals during ascent and maximize data collection at float altitude. The deployment speed of the fiber is limited by the mechanical system, deploying a full 2000m would take longer than the ascent time and limit the time available for fully deployed measurements at float level before the fiber needed to commence retraction. We understand the WY933 flight does not address uncertainty at length along fiber distances between 1200 to 2000 m and therefore have made two changes to the manuscript. First, the title has been changed to "*in situ Profiling up to 2 km Beneath Constant-altitude Scientific Balloons*" from *"Profiling 2 km Beneath….".* This change will remove ambiguity about the capabilities of the WY933 flight. Additionally, we have added a statement to the end of Section 2.6 that addresses the point made above: "*The length of cable was chosen to allow for full deployment of the fiber optic cable within the ascent portion of flight to retrieve fully deployed FLOATS temperature profiles during ascent…*"**

**To comment on the reviewers concerns about the WY933 flight duration being too short to resolve gravity waves, we address this exact concern in the submitted manuscript (Line 646 of revisions): "*As the float time during the test flight was limited to about 2 h the inertia gravity wave with a period of 8 h could not be fully sampled by FLOATS. However, in future long duration flights up to several months (Haase et al. 2018), the ability of FLOATS to sample small vertical and temporal scale structures will become valuable to observe both small- and large-scale waves, extending to global horizontal scales,…*". In our wave discussion (Section 3.6) we provide two analysis techniques that resolve two different types of waves in the WY933 flight. First, the end of fiber position as FLOATS rises vertically 4.5 km between 14.5 and 19 km combined hodograph analysis is used to resolve an inertial gravity wave with an estimated vertical wavelength of 3 km (period of 11-12 hours). This is backed up with temperature perturbation profiles from FLOATS and a nearby meteorological sounding. The second wave identification technique uses an established spectral analysis method to resolve gravity waves with periods of less than 1 hour. In both techniques the hypothesized wave observations were within the spatial and temporal limits of the FLOATS and the WY933 flight.**

**As described in our initial statements above, the WY933 flight is a proof-of-concept flight that demonstrates the capabilities of FLOATS, with some experimental controls that are not possible with constant altitude long duration flights. Although the WY933 does not provide the same level of science data as a longer flight, we consider the flight a technical and scientific achievement and will not use another dataset in this FLOATS introduction as suggested by the reviewer.**

Minor comments:

1. Ln 51: The authors may not be aware of the tethered balloon deployment using FODS by Fritz et al. (2021) to sample the near-surface boundary layer thermal structure at high

spatiotemporal during the morning transition. There are many parallels regarding technical (resolution, assumption of negligible curvature resulting in linear conversion of LAF into height above ground, etc) and scientific (changes in static stability, gravity waves, automated indemnification of layers of similar stability, etc ) aspects, so I would like to bring it to their attention for completeness and comparison of uncertainties including those to ground-based remote sensing systems. Citation: Fritz, A.M., Lapo, K., Freundorfer, A., Linhardt, T., Thomas, C.K., 2021. Revealing the Morning Transition in the Mountain Boundary Layer Using Fiber-Optic Distributed Temperature Sensing. Res. Lett. 48, e2020GL092238. https://doi.org/https://doi.org/10.1029/2020GL092238

**We thank the reviewer for the citation recommendation. We have included it into the revised version of the manuscript in reference to studies that have focused on boundary layer dynamics used DTS (line 51 in revision) and in reference to successful tethered balloon studies with DTS (line 53 in revision)**

2. Ln 80: As mentioned before, I believe the long-duration deployment during Strateole 2 would be much better suited to showcase FLOATS' capabilities.

**We have addressed this comment in the response to the reviewer's initial comments.**

3. Ln 130: Can you give an uncertainty range for the constant temperature environment of the gondola? This may have important implications during long-duration flights characterized by changing thermal and light environments, and resulting changes in post-flight FODS calibration. Was the sensitivity of the calibration parameters to the temperature of the electronics evaluated in the laboratory?

**We have provided some information on the internal temperature of the WY933 gondola within the Revisions in Section 3.1 lines 281-283: "*During the flight the internal temperature of the gondola ranged from -17° C to 14° C with an average (+- standard deviation) of -15.1(+-2.0)° C at float altitude*."**

4. Ln 144f: Is there any reinforcement fiber (Kevlar,…) contained in the FO cable? What is the color and albedo of its outermost jacket?

**There is no reinforcement braid like what would be used with off the shelf jacketed fiber optic. The fiber optic contains a single ~250 $\mu$m single layer of liquid crystal polymer (LCP) for reinforcement and UV shielding of the fiber optic cable. The LCP is an off-white color, but the albedo of the material is unknown. We have made updates to Section 2.2 and the statement of Line 145 of the revisions to provide more details on the LCP: "*The fiber optic cable used for ambient temperature sensing outside of the balloon gondola is size 50/125 µm multimode fiber optic with a single off-white coating of a proprietary liquid crystal polymer (LCP) manufactured by Linden Photonics,…*"**

5. Ln 200ff: I noticed that the authors do not necessarily use the terminology commonly used in the aerial FODS literature (e.g. differential attenuation, single-ended, non-duplexed, etc). For ease of reading and comparison with existing studies, I recommend using this nomenclature (see e.g. Thomas, C.K., Selker, J.S., 2021. Optical fiber-based distributed sensing methods, in: Foken, T. (Ed.), Springer Handbook of Atmospheric Measurements. Springer Handbooks, Springer Nature Switzerland AG 2021, pp. 609–631. https://doi.org/10.1007/978-3-030-52171-4_20).

**As described in Section 2.5 we use the terminology and nomenclature provided in Hausner et al. 2011 and Suárez et al. 2011 who give calibration methodology for single-ended DTS. Terms like 'single-ended' and 'differential attenuation' are described within Section 2.5. We have included '*non-duplexed*' in line 203 of the revisions to emphasize that FLOATS is a non-duplexed system.**

6. Ln 245f: Step losses from FO cable breaks or optical connectors need to be treated entirely different from estimating the continuous differential attenuation during post-field FODS calibration.

   Since the optical junction at the rotary connector between the gondola FO cable (between Reference 1 and 2), and the actual ambient sampling FO cable is not held at a uniform temperature, I do not see the utility of the fitted three unknowns for the gondola cable for application to the ambient cable to assess the different (and cumulatively changing) effective differential attenuation of the optical path from the bench to the end of the FI cable at the EFU.

   The design must call for at least two separate known reference sections (Ref3 and Ref4) to assess the change in the differential attenuation. This is the main reason why WY933 is ill-posed.

   How does your calibration routine compare to established methods such as des Tombe, B., Schilperoort, B., Bakker, M., 2020. Estimation of Temperature and Associated Uncertainty from Fiber-Optic Raman-Spectrum Distributed Temperature Sensing. Sensors 20. https://doi.org/10.3390/s20082235?

**As described in our methodology and in appendix A, step losses due to optical connections and differential attenuation are treated differently and optimized by minimizing the absolute mean bias following the methodology of Hausner et al. 2011. The treatment of differential attenuation and step losses are also consistent to the methodology proposed in Tombe et al. 2020 for single ended measurements. We recognize the unknowns associated with the optical connections and spooled fiber optic between Ref2 (i.e. gondola temperature controlled reference sensor) and Ref3 (length of fiber optic directly below the gondola and referenced to the iMet1 radiosonde attached to the gondola) and that is why we used the optimization techniques described within Appendix A. We would also like to note that the listed connections are a technical necessity of FLOATS due to the limitations imposed by the mechanical reeling system. Although the reviewer has taken issue with WY933 we show**

**throughout the submitted manuscript that the FLOATS retrieved temperature profiles are consistent with internal and external temperature references demonstrating that our methodology is sound, but like with any atmospheric temperature sensor it has its limitations.**

7. Ln 286: The shortwave radiation error for aerial FO deployments was discussed in detail by Sigmund, A., Pfister, L., Sayde, C., Thomas, C.K., 2017. Quantitative analysis of the radiation error for aerial coiled-fiber-optic distributed temperature sensing deployments using reinforcing fabric as support structure. Atmos. Meas. Tech. 10, 2149–2162. https://doi.org/10.5194/amt-10-2149-2017. I believe the models and equations contained in this manuscript could strengthen the discussion in this paper. I am particularly concerned about non-uniform shortwave exposure across the ambient FO cable. For future applications: could the simultaneous use of a twisted (or parallel) black and white FO cable offer insight and utility?

**We thank the reviewer for the reference on radiation error associated with atmospheric DTS and suggestion of future application. We agree that solar heating of the fiber optic under unventilated conditions could generate biases within the FLOATS temperature retrievals. We note that energy balance model examples for atmospheric DTS are available in Sayde et al. 2015, GRL and in Sigmund et al. 2017. We however do not consider the experimental design of WY933 sufficient to develop a quality energy flux model because of the unknowns associated with solar irradiance at float level and unknowns about the optical properties of the FLOATS fiber optic cable. We plan to investigate these topics further in future works. For now, we have addressed solar heating bias while at float altitude by investigating wind shear profiles (See Appendix B). We show in the Appendix and in Section 3.4 that the majority of the fiber optic cable was likely well ventilated and therefore solar heating was likely not biasing the temperature retrievals.**

8. Ln 313: I believe this is the most significant shortcoming for the presented dataset.

**We have addressed this comment and concerns about the broken Ref4 sensor in the response to the reviewer's initial comments.**

9. Ln 380: I think to recall conflicting information about when Ref4 ceased to work properly: was it still operational during ascent (cp. Ln 396), or did it fail during the float?

**Yes, this is stated in Section 3.1 of the submitted manuscript (Line 320-328 of the revisions):** ***"Unfortunately, the EFU TSEN thermistor was damaged during the WY933 launch and was unable to report end of fiber temperature, although the position of the EFU was recorded. Because of the damaged sensor, modifications to the temperature calibration method discussed in Section 2.2 and Appendix A were made to retrieve temperature from the WY933 Raman backscattering profiles. These modifications are unique for the ascent/descent profiles and the float altitude profiles. For the ascent/descent profiles, RS4 temperature was derived from the***

***iMet-1-RSB temperature profile by matching GPS altitudes from radiosonde and the EFU. For the float altitude profiles, a static ΔT was estimated from the ascent profiles closest to the float level. The float level temperature profiles were then retrieved from a 3-Reference Section calibration where only the rotary joint step loss value was optimized as discussed in Appendix A."***

10. Ln 406: It's a tightly buffered FO cable, so mechanical strain inflicted during retraction and because of temperature changes is most likely. Was it reversable when FLOATS was on the ground?

**The WY933 spool of cable was unfortunately not able to be analyzed on the ground post flight to assess whether the cable was damaged from retraction or if there were temperature dependent effects on the differential attenuation. The true properties of the cable can only be determined when the cable is unspooled, and it was not feasible to unspool and characterize the fiber after flight.**

11. Ln 416ff, 434f: This section can be improved: the resulting effective vertical resolution of the FODS observations are a function of vertical velocity of the sampling unit, the FO cable's and optical bench response time, and the minimum averaging interval. Combining those will yield an effective resolution and uncertainty.

**We thank the reviewer for this suggestion and have made several edits to Section 3.3 based on this comment. The effective resolution of FLOATS on ascent was calculated to be approximately 75m based on ascent rate, deployment speed, and the sampling interval of FLOATS. This new resolution has been used as an averaging interval to make ascent phase comparison between the iMet-1-RSB and the FLOATS temperature. These changes have been reflected in Figure 4, in a new discussion about variability with increasing altitude, and in the updated mean absolute error value between the two sensors. The 75m averaging resolution increased the ascent MAE slightly, but still shows that the FLOATS vertical profile compared well with the reference sensor.**

12. Table 1: Given the uncertainty of the optical bench, the 2$^{nd}$ decimal place for FODS temperatures may not be significant? Please check and adjust if necessary.

**Again, we thank the reviewer for the suggestion and have updated Table 1 and the discussion of results shown in Table 1 to show less significant figures. This is in line with the precision of the DTS listed by the manufacturer.**

13. Figure 4: A profile of the temperature differences between the two sensors in relation to the height-dependent temperature gradient may make a meaningful addition to evaluate performance. Can you explain why your analysis focuses on ascent profiles, while the

true strength of FLOATS lies with the float stage as spatially continuous, simultaneous profiles are collected? Is this for comparison reasons only?

**The reviewer's suggestion was taken into consideration and the vertical ascent profile of the absolute difference between the radiosonde sensor and FLOATS has been included in Figure 4. We have also included some description of the additions to the figure in Section 3.3 of the revised manuscript (Lines 449-455). We focus on the ascent profile in the DTS performance section because it is as close to a direct comparison of the vertical profile as possible with FLOATS. Even with an operational reference sensor at the end of the fiber optic cable the float level measurements only give comparison points at the top and bottom end of the profile.**

14. Ln 522: What metrics are the basis for this statement? Overall shape, or height of strong temperature changes, or…? As a boundary-layer meteorologist I may not be aware of what is most important for UTLS dynamics.

**The statement in question: *"Generally, the FLOATS average ascent profile compared well with the sounding and best match COSMIC-2 profile."* Is described in the succeeding statements. The two profiles show similar structure with respect to the tropopause, are within a similar temperature range, and produce and MAE of 1.3°C.**

15. Ln 613ff: See comment above, I recommend using a different dataset for this proof-of-concept study.

**We have addressed this comment and concerns about the resolvability of gravity waves in the response to the reviewer's initial comments.**

16. Ln 663: Analyses of temperature spectra (from FFT, wavelet, MRD etc) between FLOATS and reference sensors in controlled conditions may make a nice addition to evaluating system performance, particularly when having ABL turbulence applications in mind.

**Without more description we are uncertain about the context of the temperature spectra analysis suggested by the reviewer or the utility of such analysis. We can however comment that testing a fully deployed FLOATS in controlled conditions like a laboratory thermo-vacuum or thermal chamber is challenging and nearly impossible to simulate flight conditions. This is primarily due to the differences in differential attenuation observed between spooled fiber optic cable, unspooled cable without load, and unspooled cable under flight loads. In laboratory testing it is impossible to simulate flight loads and the resources required to test unspooled and unloaded cable in the laboratory is outside the scope of this project. For these reasons the manuscript focuses on a proof-of-concept field experiment and does not include extensive laboratory results.**

**Reviewer 2 Comments:**

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.

**We thank the reviewer for the thoughtful and encouraging comments about FLOATS and this manuscript. We understand the issue of the radiative effects on atmospheric temperature sensors and agree FLOATS may see some biasing either from solar heating in poorly ventilated sections of the fiber optic cable (e.g. where there is no wind shear compared to the gondola level) or from radiative cooling at night. We acknowledge in the manuscript that this is a likely limitation to the measurements close to the gondola. Furthermore, we have attempted to address this in the best way we can with the flight results to identify any effects of solar heating on the measurements and rely on comparisons to other sensors, e.g. on-board radiosonde, nearby sondes, and satellite measurements to infer that the solar heating effects are negligible or at least similar to the reference sensors.**

**Other DTS studies have identified solar heating as an artifact with ground-based sensing and have modeled energy fluxes of the fiber optic cable based on incoming shortwave and longwave parameters, outgoing longwave radiation, and convective heat flux due to wind (e.g. Sayde et al 2015, GRL, https://doi.org/10.1002/2015GL066729) However,**

**parameterizing radiative impacts with the WY933 flight is not possible because it was not part of the experimental design and modeling of energy fluxes would include numerous assumptions about the optical properties of the fiber optic cable coating and irradiance at float altitude. We plan to address the issue further in future studies using the FLOATS instrument.**

**To further address the above comment, we have conducted a short analysis of the wind profiles compared to the float level altitude observed during the WY933 ascent and descent to make inferences about degrees of ventilation observed by the fiber optic cable while at float altitude. We have included a wind shear figure in Appendix B and included some discussion in Section 3.4 The wind profiles suggest some degree of ventilation for almost the entire length of fiber optic during the constant level float period and varying ventilation along the length of the profile. The wind profiles also show that the wind field was likely not static from the beginning of the float period to the end. Therefore, the consistent temperature structure observed in the FLOATS temperature retrievals was likely not due to the effects of incoming solar radiation. Finally, we have shortened Section 3.4 to better focus on comparisons to the ascent/descent profiles and focus on statements about solar radiative biasing.**

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.

**We agree that the optical and physical properties of the LCP coated fiber optic cable could be characterized within the laboratory and that it would a valuable addition to the manuscript. Nevertheless, this type of laboratory testing is outside the scope of this work due to the funding timeline of the project and the resources required to accomplish this type of testing. We do consider it an important aspect of future work with the FLOATS instrument since there are no literature resources related to the optical properties on LCP coating and manufacturer datasheets focus on physical/chemical characterization related to the electrical and mechanical properties of the material. This work presents an early description and summary of results from a novel application of DTS in the stratosphere, and we acknowledge that there is more work to be done to fully characterize this sensor system.**

- 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.)

**We hypothesize that the effects of shortwave solar irradiance will be strongest at low solar zenith angles (i.e. when the sun is closest to its zenith position) and weakest when the sun is close to the horizon. In WY933 we attempted to retrieve temperature profiles prior to twilight and after sunrise to evaluate the impact of solar heating and this is why section 3.1 has a brief discussion on SZA. The attempt to capture pre-twilight scans was not successful because of delays in the balloon launch schedule.**

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

**As stated in the above responses the authors agree that the heat capacity of the fiber optic can be characterized in laboratory experiments, however without further investigation into the radiative properties of the fiber, a measurement of heat capacity alone will not constrain these biases. A full characterization of the fiber under stratospheric conditions through laboratory experiments are outside the scope of this work.**

- 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.)

**We thank the reviewer for the suggestion and have modified Figure 4 and section 3.3 based on this comment and comments from Reviewer 1. We have changed the averaging distance from 5 m to 75 m to reflect the vertical resolution of the FLOATS ascent profiles based on vertical ascent rate, the DTS sampling period, and the fiber optic deployment speed. The revision has changed some discussion on the comparison between the FLOATS and iMet1 radiosonde ascent profiles in section 3.3 and has changed the MAE from 0.71°C to 0.85°C.**

- 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?)

**As discussed in the response to the reviewer's initial comment we address solar heating effects during the WY933 to the best of our abilities based in the experimental design and limitations of constant level balloon-based sampling. In Section 3.4 we infer that solar heating**

**did not impact the float level measurements because the profiles from the start and end of the float level period are consistent with the ascent and descent temperature profiles shown in panel C Figure 5. The FLOATS average profiles have been included in Figure 5c. Finally, we have included some statements on ventilation, which was discussed in response to the reviewer's initial comment.**

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

**Thank you for the suggestion. We have added zoomed in panel in Figure 6.**

- 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.

**"Intrinsic frequency" has been defined and clarified, now at line 639. We also clarify that the Fig. 8b spectrum is for T' measurements at flight level. (Whether the wave appears almost fixed or varying will depend of course on the wave period relative to the total 2-hr flight time.)**

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?

**We have added several changes to the concluding paragraph of section 3.5 to address this comment. We explicitly state that the FLOATS temperature retrievals provide spectra with increased sample sinze, vertical displacement, and resolution compared to point-wise sensors.**