Reply on reviewer report #2 regarding the manuscript egusphere-2023-510 from 21 June 2023

We are grateful to the reviewer for the time they have spent on our manuscript again. Our answers to the individual points raised by the reviewer are given below with citations from the original report marked by blue text colour.

The resonses were generally helpful. I would like to see some points from them incorporated into the main manuscript.

> We are glad that you consider our approach on the revision as helpful. Below we describe how we incorporated more of our answers from the previous revision into the manuscript.

'Two other flights with a similar setup (Dusch et al) show essentially the same results.'

> From line 69, we added "Two other soundings of the advanced setup show essentially the same results. Their results are presented in Dusch et al. (2023, under revision) but will be omitted here for clarity."

'In our manuscript we describe general properties of the balloon flight that originate from very fundamental concepts in fluid dynamics and the pendulum motions of the sonde. Accordingly, we are confident that the results are more widely representative, because the effects shown in this study are properties of the flow around the balloon and not of the geophysical conditions.'

> This information is now added to the discussion in the paragraph starting at line 228: "In our study, we describe general properties of balloon soundings that originate from fundamental concepts in fluid dynamics and the pendulum motions of the sonde. Accordingly, we are confident that the results are more widely representative, because the effects shown in this study are mainly properties of the flow around the balloon and not of the geophysical conditions. In Appendix B we show the dependence of the height of the flow regime change on sounding setup parameters like balloon size and ascent rate. Furthermore, we briefly discuss the remaining geophysical influences on this."

Detailed comments

8. 'use data from a descending balloon in order to avoid disturbances from the wake of the balloon on temperature and humidity measurements due to the decreased string length.'

Wake effects are more of a problem in the mid-stratosphere - which isn't reached in your descending balloon setup!
My statement is partly based on WMO/Elms et al (1994), they looked at mean temperatures rather than indivudual spikes and recommended "Suspension lengths of less than lOm should be avoided if best quality radiosonde temperature observations are required at pressures lower than 50 hPa. A suspension length·of 40m is probably longer than necessary for most routine operational radiosonde observations." (Of course the balloon diameter is greater at upper levels giving a wider wake. Temperature spikes are usually removed by the ground rocessing.)

> We fully agree with the reviewer that wake effects on radiosonde measurements are stronger in the stratosphere due to larger balloon and wake diameters. However, as we

state in the introduction and several other parts of the manuscript, our aim is to increase the altitude resolution of radiosonde data beyond what is achieved on standard soundings. Soeder et al. (2019) estimate that the mean probability for wake encounter on a standard radiosonde ascent is 30 percent (55 m string). Tiefenau and Gebbeken (1989) estimate that the temperature drop in the wake during nighttime at 300 hPa is 0.69 K, which should not be neglected for high-resolution campaigns from our point of view. We added the following sentence at line 235: “These temperature biases in the wake are below one Kelvin around tropopause level and reach above two Kelvin in the stratosphere (Tiefenau and Gebbeken, 1989).”

Specifically for wind research a wind-only GNSS sonde could be used (Graw make one, I think Meteomodem do too). If using a wind-only sonde would you choose to measure on ascent or descent? If high-resolution wind data were required up to say 30 km presumably you would measure on ascent. (Obviously the abstract is not the correct place to discuss all these issues, but I would like to see them discussed somewhere within the manuscript.)

We added the following paragraph to the discussion starting at line 242: “If only high-resolution wind measurements are required for a certain research question, we would suggest using ascending sondes in the sub-critical Reynolds number range with a short string and additional wind vanes. Compared to a descending setup this simplifies the operation without degrading wind data quality.”

World Meteorological Organization, 1994: The difference in observed temperatures from radiosondes suspended 10 m and 40 m beneath a 1400 g balloon (J.B. Elms, J. Nash and G. Williams).
Papers Presented at the WMO Technical Conference on Instruments and Methods of Observation (TECO-94), Instruments and Observing Methods Report No. 57, WMO/TD-No. 588, Geneva, pp. 121-126.
https://library.wmo.int/doc_num.php?explnum_id=9607

126. 'sharp reduction in ascent rate from 10 km to 15 km altitude'
Please include the following from your response:
"The tropopause height for this launch was 11.1 km. For radiosonde type balloon launches at 5 m/s ascent rate, the flow condition change usually happens slightly above the tropopause. This is, because the density declines quicker with height above the troposphere, leading to a sharper decline in the Reynolds number (c.f. Figure 3)."

Thanks for your suggestion. The requested addition has been made.

258. 'all modern radiosondes measure horizontal winds from the drift of the balloon by GPS'
'all' - 'most' See section 5.1 of ECMWF Tech memo 807
https://www.ecmwf.int/en/elibrary/80268-assessment-different-radiosonde-types-20152016
Radar is still extensively used by China and Russia (I would describe the Chinese radar sondes as 'modern', but not the Russian ones). Indonesia and some adjascent countries still make extensive use of PILOT ascents, probably radar.

Thanks for pointing this out. The requested change has been made.

289. 'Dusch et al., 2023, under rev.' - 'under revision'

The correction has been made.