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Interactive comment on "Comparison of Vaisala radiosondes RS41 and RS92 in the oceans ranging from the Arctic to tropics" *by* Yoshimi Kawai et al.

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The authors sincerely appreciate your review and valuable comments. We posted a revised manuscript on 25 April, and further revised the manuscript, considering your comments.

1. Lines 101-103: Even though you did not use the GPS-derived pressure and height measurements, I think it would be good in this study to mention what the RS41 GPS-derived pressure and height measurements are. Comparing these measurements to the in-situ measured pressure would strengthen the claim that the pressure bias is real – considering the GPS-derived pressure and in-situ measured pressure are literally on the same instrument. It would also be good to make sure that the GPS-derived pressure and height measurements are the same between the RS41 and RS92.

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–> We checked the GPS-derived pressure of the RS41 radiosondes after Referees #2 and #3 commented. Figure 4 in the revised manuscript shows the difference between the RS92 pressure and the RS41 GPS-derived one. The use of the GPS-derived pressure reduces the bias by approximately 0.2 hPa above an altitude of 15 km, but there is still a bias of 0.4 hPa or more at most of altitudes. The median of the difference in Fig.4 is almost the same as in Fig.3a around an altitude of 5 km. This means that the GPS does not essentially improve the pressure bias, and the reason for the pressure bias is still unknown. We also added a panel to show the difference in height to Fig.3. Figure 3b shows that the height difference increased as the radiosondes rose higher: The median of the RS41 height was greater than that of the RS92 by approximately 35 m at an altitude of 15 km, and 100 m at 22 km. These height differences correspond to the differences of pressure. These descriptions were added to section 3.1 and conclusions (Line 161-171, 333-335).

2. Figure 2, and general comment about the pressure bias: Compared to Jensen et al., 2016, the twin soundings are literally attached together. I think the pressure bias may have inadvertently been caused by drag created by the balloon above it. To explain further, you noted that the pressure bias was larger above 4.5 km and was especially noticeable during the day. During ascent, the balloon itself expands, thus creating a larger object displacing the air above it. Similar to how a falling raindrop has a local high pressure at the base of the drop and a local negative pressure at the "tail" of the drop, perhaps the balloon itself is creating a local minimum pressure tendency below the balloon (i.e. in the same area the twin sondes are located)? I included a sketch on the last page to help explain this. GPS measurements, of course, should be unaffected by this. If the pressure bias is indeed created by drag, then that also adds some credence to using a bar (like in Jensen et al., 2016) to horizontally hang the twin sensors, as opposed to attaching them together by tape – the sondes hung on the edges of the bar would be further away from the area of maximum local negative pressure tendency induced by the drag. It would also be worthwhile to mention in your conclusions that a comparison of the in-situ silicon sensor vs. the GPS-derived pressure on the same

balloon should be done – this could either confirm or eliminate the possibility of air drag affecting the in-situ pressure measurement. With this idea in mind, it is very well possible that the pressure sensor is affected by solar heating as well, especially since pressure is measured by a capacitive element.

–> The difference between the RS41 sensor-measured pressure and GPS-derived one (see Fig.3a and Fig.4 in the revised manuscript) indicates that the stagnation below the balloon might have slightly contributed to lowering the sensor-measured pressure. However, this was not the main reason for the pressure bias between the RS41 and RS92, as we mentioned above. We used a string of 55m originally supplied to the RS41 radiosonde and our twin-radiosonde flight was the same as the standard RS41 flight, except for that an additional radiosonde was attached and the balloon was relatively large (350g). We think that this factor is inessential in the pressure bias.

3. Lines 236-238: The reason the RS92 solar radiative dry bias was absent in the two papers you cited is because they used the relative humidity correction scheme according to Wang et al. (2013; citation provided below). Please include this citation here, and clarify this sentence by mentioning that the absent dry-bias is because this RH correction scheme was implemented. Wang, J., Zhang, L., Dai, A., Immler, F., Sommer, M., and Vömel, H., 2013: Radiation dry bias correction of Vaisala RS92 humidity data and its impacts on historical radiosonde data. Journal of Atmospheric and Oceanic Technology, 30, 197-214.

–> We added your indication to this sentence (Line 256-258).

4. Lines 226 and 242: In addition to the Wang et al. (2013) and Yu et al. (2015) studies already mentioned above or cited already, you may want to consider including these additional citations, as they all expand upon the solar radiative dry bias at high altitudes and discuss various approaches to correcting (and independently validating) the solar radiative induced RH dry bias. The Miloshevich et al. (2009) paper has a very thorough discussion in Section 4.2 on nighttime RH measurements and may be relevant

to your discussion on Figure 7. All of these studies also use precipitable water vapor (PWV) as a reference measurement, and it would be good to include measurements of PWV (perhaps from GPS or microwave radiometer retrievals) to show how much poorer the RS92 RH measurements are compared to the RS41, if its even significant at all. Miloshevich, L. M., H. Vömel, D. N. Whiteman, and T. Leblanc, 2009: Accuracy assessment and correction of Vaisala RS92 radiosonde water vapor measurements, J. Geophys. Res., 114, D11305, doi:10.1029/2008JD011565. Dzambo, A. M., Turner, D. D., and Mlawer, E. J., 2016: Evaluation of two Vaisala RS92 radiosonde solar radiative dry bias correction algorithms, Atmos. Meas. Tech., 9, 1613-1626, doi:10.5194/amt-9-1613-2016, 2016. Moradi, I., B. Soden, R. Ferraro, P. Arkin, and H. Vömel, 2013: Assessing the quality of humidity measurements from global operational radiosonde sensors, J. Geophys. Res. Atmos., 118, 8040–8053 doi:10.1002/jgrd.50589.

–> We showed analyses of CAPE, CIN, and PW in the former revised manuscript, and added a figure of the ratio of RS41 PW to RS92 PW as a function of solar altitude angle in the new revised one (new Fig.9). Similar to Fig.4a of Miloshevich et al. (2009), the ratio was dependent on solar altitude angle. This description was added to section 4.1 (Line 276-281). It seems that the nighttime moist bias of RS92 at the altitude of 15-20 km (Fig.8c) might have been partly ascribed to the time-lag error (Fig.11c in Miloshevich et al. 2009), but I'm not confident of it since the time-lag error must have been corrected in the latest software.

5. Lines 243-246: The reason the values in your Figure 8 agree better than Figure 6 in Vömel et al. (2007) is likely because Figure 6 compares Vaisala RS92 data (before DigiCora v. 3.64 data) to cryogenic frost point hygrometer data, which is widely regarded as one of the best reference instruments in developing RH correction algorithms. In your Figure 8, you compare RS92 DigiCora v. 3.64 data to RS41 data, both of which are much better at measuring relative humidity. You should note, perhaps at the end of this sentence, that the values in Fig. 8 are less than Fig. 6 in Vomel et al. (2007) because the RS92 DigiCora v. 3.64 RH data and RS41 RH data are already

inherently better.

–> We added your indication to this sentence (Line 266-267).

Technical Comments: 1. Line 165: Change ": : : radiosonde tended to record a higher mean relative humidity than the: : :" to ": : : radiosonde recorded a higher mean relative humidity relative to the: : :"

–> We corrected this sentence (Line 181-182).

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