Response to comments from Roeland Van Malderen on manuscript egusphere2022-565: “Development of an automated pump efficiency measuring system for ozonesondes utilizing an airbag type flowmeter”

We appreciate your valuable comments on our paper.

I hereby refer to line numbers of the modified manuscript.

* line 14: replace "body" with "amount" and "measuring data" with "measurements"
* line 26: add "while" before "ambient air is taken in ..."
* line 36: replace "measuring data" with "measurements"
* line 39: remove the sentence "Ozone concentration is calculated from this current."
* line 40: replace with: "and the volumetric flow rate and temperature of the piston pump"
* line 74: replace "body" with "amount"
* line 77: add an s to "observation" (should be "observations")
* line 103: replace "equating to" with "equal to"
* line 108: replace "safe execution these steps" with "safe execution of these steps"
* line 139: replace "via valve inflation/deflation" with "via inflate/deflate valve": better wording and consistent with Fig. 6.
* line 144: add "by the tachometer" after "to indicate a full revolution".
* lines 149-150: Change to "The airbag internal volume V_airbag in its most inflated/deflated states are assumed to be constant, regardless of ambient pressure, as long as the internal/external pressure are equal. The pump flow rate S(p) ..."
* line 194: replace "was examined" with "were examined"
* line 211: add a space between "Fig.9show"
* line 214: replace "chapters" with "sections"
* line 239: drop the comma , in "Differential pressure, thus enables"
* line 269: replace "The airbag" with "the airbag"
* line 272: replace with "The temperature eventually rises by 5-6°C in a measurement sequence" (to be consistent with the numbers quoted in line 231 and shown in Table 1)
* line 276: replace "approximate halving of" with "approximate half of". Replace "Charles' law also held..." with "We could confirm that Charles' law also holds..."
* line 277: replace "This is attributed to" with "We postulate that this apparent inconsistency might be attributed to..."
* lines 278-279: replace with "due to the thermal properties of the polyethylene film, offsetting the effects of volume change due to Charles' law by about half".
* line 289: change "relating" to "related"
* line 315: replace "Stauffer et al. (2020a)" with "Stauffer et al. (2020)": there is no Stauffer et al. (2020b), see later.
* line 316: replace with "... that caused a dropoff in total ozone amounts from ozonesonde measurements at around

a third..."

* line 317: replace with "Stauffer et al. (2022) confirmed the presence of this dropoff in total column ozone in ..."
* line 323: replace "the tendency in relation to ambient air pressure" with "their dependence on ambient air pressure"
* line 325: drop "in" before "the values of Komhyr et al. (1995)"
* line 332: add "University of" before "Wyoming".
* line 344: replace "Figure 13 show flow correction factors..." with "Figure 13 shows that flow correction factors"
* line 345: replace "are seen" with "can be seen"
* line 346: replace "freedom from" with "the absence of"
* line 351: Replace with "the pump correction factors exhibit temporal changes with..."
* line 357: add "the" before "ozonesonde pumps"
* line 360: replace "highlight" with "investigate"
* Fig.15: Add "a)" and "b)" in the top and bottom plot, respectively, since you are referring to Fig. 15a and Fig 15b in the text (line 362). Also in the caption of Fig. 15, replace "Top:" with "a)" and "Bottom:" with "b)".
* lines 368-369: Replace with "Figure 16 compares the mean measured values of the pump flow rate, motor speed, and pump stroke (i.e. obtained by dividing the flow rate by the motor speed) at ground-level pressure and at 10 hPa."
* line 376: replace "resulting in" with "resulted in"
* line 378: replace "sensor side" with "ozonesonde side".
* line 388: add a space after 2008
* line 396: replace with "by Stauffer et al. (2020, 2022)"
* line 446: replace "2020a" with "2020"
* line 450: replace "2020b" with "2022"

We will fix as you stated.

A first main unsolved issue is related to a comment by Reviewer #3 (Line 330: Why use measurements after #24000, rather than before #24000? You've just said that stability was not good after #24000.) and me.

In your updated manuscript (lines 310-312), you wrote that "The pump motor specifications were different from those of post-24000 serial number ozone sensors delivered to JMA in 2013". The results indicate air pressure dependence in terms of motor speed, and suggest that speed was unstable during production lots". From this sentence, it is not obvious if pre-24000 or post-24000 serial numbers are considered as the best. For which production lots was the speed unstable?

My suggestion would be (please check the text) to replace lines 310-315 as: "As will be illustrated in Sect. 5.3, Fig. 16, our measurements pointed to differences in the pump motor specifications of the ozonesondes delivered to JMA before 2013 (serial numbers <= 24000) and after 2013 (serial numbers > 24000). More specifically, the ozonesondes with serial numbers higher than 24000 turned out to have motor speeds that depend on the air pressure and our measurements suggest that their motor speeds were unstable among/depend on production lots. The motor speed and its variability have an affect on the pump efficiency (variability). Therefore, in Table 2, we also make a distinction between post and pre-24000 serial number samples for estimating the average JMA pump correction factors at the different pressure levels. It could thereby be noted that the average pump correction factors and their standard

deviations are larger for post-24000 than pre-24000 serial numbers, at almost all pressure levels. For the comparison with the average pump correction factors measured by other organizations in Fig. 12, we nevertheless plotted the average JMA pump correction factors after serial numbers 24000, as these represent the most recent ozonesondes in use in the global network. Note that the average pump correction factors from the earlier studies in this figure are obtained from measurements with much lower/earlier ozonesonde serial numbers."

We will replace lines 310 – 312 with the sentence as you suggested. This sentence clearly expresses what we want to say.

So, in Fig. 12, you are showing the average JMA pump correction factors for Serial # > 24000 , but then, to calculate the influence on the estimation of the ozone concentrations (section 5.4), the mean pump correction factors for ozone sensor serial numbers before 24000 have been used (lines 385-386). This is so confusing! Please state clearly in lines 385-386 why you used the average pump correction factors pre-24000 here!

We have decided to use the mean pump correction factors for ozone sensor serial numbers after 24000 to calculate the influence on the estimation of the ozone concentrations in section 5.4.

Please also include in the text when discussing Fig. 16, that the variability (standard deviations) of the flow rates, motor speeds, and pump strokes in Fig. 16 (left panel) of the serial numbers post-24000 are larger than those for pre-24000. So, mention it, and give the reason for it once again (motor speed more unstable and dependent on air pressure? --> also refer to Sect. 5.1 for this discussion shortly, i.e. text that I proposed here above), and state clearly which sample of serial numbers (post-24000 or pre-24000) you would consider as most reliable/representative.

We will replace lines 376-378 with “In all parameters, motor characteristics changed discontinuously on the serial number 24000, after then, the standard deviations became lager, and the average values fluctuated with each group of sensor serial numbers. This is presumably because the motor pumps of post-24000 had larger dependency on the air pressure, as mentioned in section 5.1. Therefore, we consider the sample of serial numbers pre-24000 as more reliable.”

A second remark, made by reviewer #3, concerns the x-axis of the top panel of Figure 15 (15a). It is not obvious how the different observations are ranked over the x-axis. This should be clarified. OK, I understand that the ozonesondes are sorted by serial number (y-axis), with x-value 1 being the lowest serial number and the latest serial number having the highest rank number on the x-axis (= the total number of measurements). But, if this is correct, then you should explain why the different stations are grouped together (colour + symbol coding). If, for instance, you ordered 90 ozonesondes, is it so that, to give an example, the 30 lowest serial numbers were sent to Sapporo, the 30 intermediate serial numbers to Tateno, and the 30 highest serial numbers to Naha? Please clarify in the manuscript why the measurement numbers of the different stations are grouped together.

It's exactly as you said. We will replace lines 361 – 362 with “⋯, pump correction factors for the different stations are ordered left to right by serial numbers in Fig. 15a. The measurement numbers of the different stations are grouped together because the ozonesondes delivered to JMA were divided into three by serial number and sent to each station.”

A third issue, raised by reviewer #3 again, is how you calculated the influence on the estimation of ozone concentration. In the modified manuscript, you explained it clearer than it was before. As far as I understand, you use one fixed ozone profile for all calculations (i.e. the JMA mean ozone profile for the period 1994-2008), and the total ozone integration is only done at the ground-level, 500, 200, 100, 50, 30, 20, 10, 7 and 5 hPa pressure levels, by taking into account the differences between the individual pump correction factors and the JMA mean correction pump correction factors (for S/N < 24000). Besides the fact that this is a very rough estimate, I also do not understand why you use a mean ozone profile for the period 1994-2008 (the pump efficiency measurements are taken from 2009 onwards), please specify, and why you are using the pre-24000 mean pump correction factors (while showing the opposite in Fig. 12). But, more importantly, I agree with reviewer #3 that "should you not simply calculate the difference, for each sounding, in the total ozone found using your measured pump corrections to that using the average pump correction curve"? Since JMA is submitting the ozonesonde data to WOUDC, taking the individual pump efficiency correction factors, and presenting the integrated total ozone in the data files, it does not seem to be a large effort to reprocess all individual ozone sounding profiles with the same settings, except using the average JMA pump efficiency factors instead, and comparing the integrated total ozone amounts from the reprocessed ozonesonde time series with the original ones. This is exactly how it should be done operationally and will give the true estimates of the impact on total ozone!

We simply calculated the difference, for each sounding, in the total ozone found using our measured pump corrections to that using the table values of pump correction factors measured for ozone sensor serial numbers post-24000.

We will replace lines 386 – 395 with

“Fig. 17 shows impacts on total ozone values if the table values of pump correction factors measured by JMA for ozone sensor serial numbers post-24000 were used rather than measured individual pump correction factors. For each sounding, the relative differences between the total ozone calculated using the measured pump correction factors and that using the table values were determined during the period from 2009 - 2022. For calculation of the residual ozone column above balloon burst altitude, the mixing ratio was assumed as equal to the measured value at the top of the sonde profile. The standard deviation in the relative differences of total ozone values by lot was around 1%, and that between production lots was around 0.6%. As per Section 5.3, the pump correction factors tended to increase, but a decreasing tendency was seen with conversion to total ozone values.”

We will remove “, as compared to reference ozone profiles,” in line 17.

We will replace Figure 16 with follows.

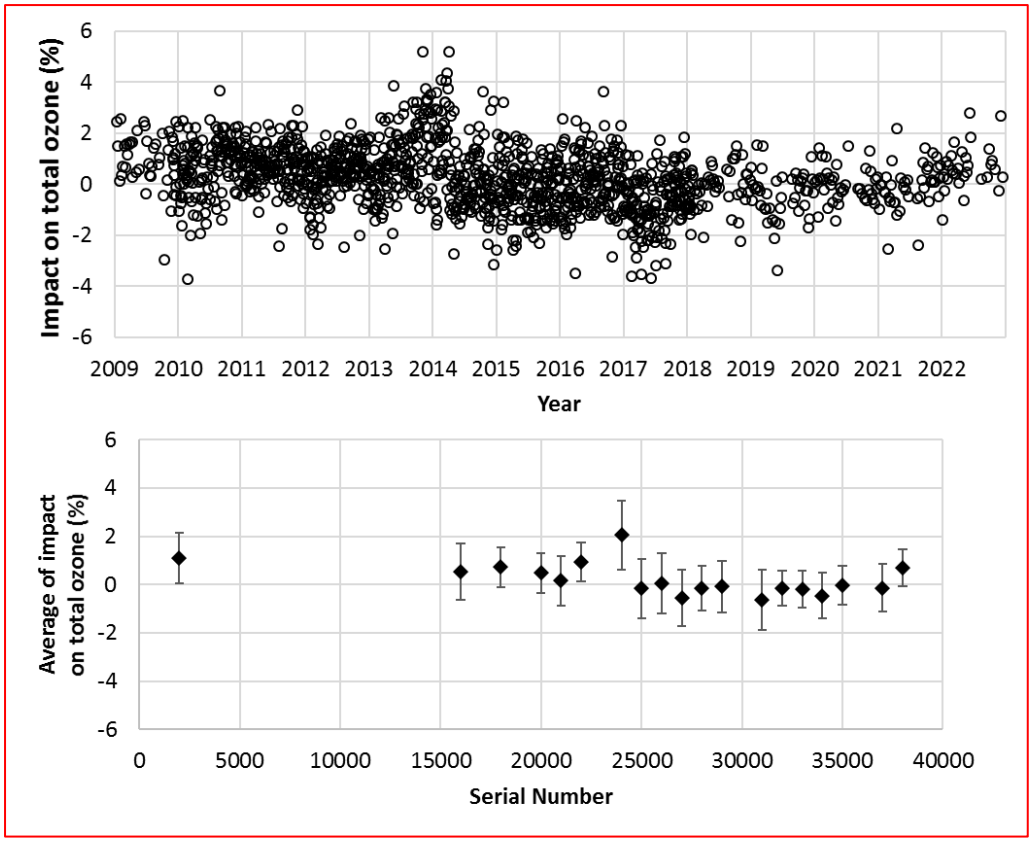

Figure 17: Top: Estimated impacts on total ozone values with use of the average pump correction factor table. Bottom: Impacts on total ozone values for each serial number lot, with error bars indicating standard deviation.