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Atmospheric Measurement Techniques Discussions

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Interactive comment

Interactive comment on "Homogenizing and Estimating the Uncertainty in NOAA's Long Term Vertical Ozone Profile Records Measured with the Electrochemical Concentration Cell Ozonesonde" *by* Chance W. Sterling et al.

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The authors would like to thank the referees for the constructive criticism of our manuscript. We have outlined our responses to the reviewers' comments as well as the subsequent changes to the manuscript in the following response.

Anonymous Referee #1 Received and published: 22 December 2017 GENERAL COMMENTS: The paper describes the homogenization process (including uncertainty estimation) of the NOAA network of ozonesonde stations. I really enjoyed reading the

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Discussion paper

very well written manuscript (although it is somewhat lengthy at some places). The authors give a nice historical overview of the ozonesonde measurements and describe in a very clear way the different instrumental effects that have to been taken into account in the homogenization process. The uncertainty analysis, developed within the O3SDQA activity, has been applied on the profiles recorded at the NOAA network and has been presented extensively. The impact of the homogenization of the ozonesonde data record has been assessed with Dobson total ozone data and with SBUV profile measurements. So, the research is really well established. One of the major new achievements of the paper is the proposed approach of taking the measured (higher than the historical) pump flowrate corrections and correcting for the ozone sensor efficiency, which is derived from the comparisons of ozonesondes and the reference UV photometer at JOSIE campaigns. This is an alternative approach as the current O3S-DQA guidelines, which have set two standards (SPC 1% KI 1.0B and EN-SCI 0.5%KI 0.5B), which, with two different (historical, low) pump flowrate corrections, are within a few percent from the UV photometer at JOSIE. The authors argue that, a positive bias in the ozone sensor measurements, created by side reactions of the phosphate buffers, has to be compensated by using too low pump flowrate corrections. However, as these guidelines are still in use today, I would propose that the authors apply the O3S-DQA corrections strictly for the Eras in which one of those standards is used at NOAA sites (parts of Eras 1, 2, 3 are using the SPC 1% KI 1.0B) –so using the Komhyr (1986) pump flow correction factors – and compare those corrections with their proposed corrections (applying Eq. (15), which is based on 6 simulated flights during JOSIE 1996). By e.g. showing the average (and standard deviations) of the differences between the vertical profiles corrected by either approach, the authors should be able to demonstrate that their approach is equivalent to the O3S-DQA guidelines.

Authors' Response: The reviewer makes a good point about a difference in the processing methods of NOAA and other ozonesonde sites during Eras 1, 2, and 3. NOAA desires to be consistent with its processing methods throughout the record, so chooses to keep the Johnson 2002 pump efficiencies and ozone sensor efficiency based on the cumulative ozone exposure. To assess the difference in the processing techniques, Era 3 for Boulder, CO and Hilo, HI were processed with each processing technique and compared. Two new figures (Figures S1 and S2) have been included in the supplementary material as well as a new sentence discussing the difference in the 1986 Komhyr processing method and the NOAA Accumulating Buffer Bias Correction. The figure plots the average Boulder and Hilo ozone profiles processed with both methods and a % Difference plot for each. The difference is less than the uncertainty for these data, so we have deemed it neglible. Additionally, the 1986 Komhyr processing method would increase the partial pressure of ozone in comparison to the NOAA approach. This increase would make the comparison with the ozone photometer at JOSIE worse and the comparison with the SBUV measurements worse. What is now Page 15 Line 4 now includes, "NOAA's approach (ozone sensor efficiency) differs from the ASOPOS standard processing for SPC ozonesondes paired with 1.0% KI, 1.0X Buffer Solution (1986 Komhyr corrections) in Eras 1, 2, and 3. To compare the two processing methods, the average profiles for Boulder and Hilo for Era 3 are shown in panel A of Figures S1 and S2, respectively, processed with the NOAA approach and the ASOPOS approach. The percent difference is included on panel B of the plots and the difference is less than the uncertainty of the ozone measurement for these eras."

SPECIFIC COMMENTS âŮę Page 3: lines 22-26: Some more recent papers (as the ones mentioned) describe results from homogenized (according to the O3S-DQA guidelines) ozonesonde data: Van Malderen, R., Allaart, M. A. F., De Backer, H., Smit, H. G. J., and De Muer, D.: On instrumental errors and related correction strategies of ozonesondes: possible effect on calculated ozone trends for the nearby sites Uccle and De Bilt, Atmos. Meas. Tech., 9, 3793-3816, https://doi.org/10.5194/amt-9-3793-2016, 2016 (for Uccle and De Bilt) and Christiansen, B., Jepsen, N., Kivi, R., Hansen, G., Larsen, N., and Korsholm, U.S.: Trends and annual cycles in soundings of Arctic tropospheric ozone, Atmos. Chem. Phys., 17, 9347-9364, https://doi.org/10.5194/acp-17-9347-2017, 2017 (for Scoresbysund, Ny Ålesund, Sodankylä, Eureka, and Ørland) Authors' Response: Both citations were added to the text. âŮę Page 6, lines 2 and

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6: please use consistently either hPa or mb through the manuscript. I would propose to use hPa. Authors' Response: Changed all mentions of mb to hPa. âŮę Page 7, line 12: "Figure 1 shows the many changes to the NOAA ozonesonde record." As a matter of fact, Figure 1 does not show all those changes, but just gives an idea of the length of and gaps in the time series of the different NOAA stations. It would be nice to have a graphical or tabular overview of those different changes, see my next point. Authors' Response: Figure 1 has been updated to show the eras and the changes in ozonesonde type, solution type, and radiosonde type. âŮę Page 7, lines 15-25: the definition of the different Eras is described here, but a separate table (or graph) presenting the different characteristics of each Era is really needed, and not hidden as legends in Fig. 2 for example. This separate table (or graph) will make it also easier to follow the discussion of the homogenization, uncertainty analysis and comparison with Dobson and SBUV throughout the paper. Authors' Response: Figure 1 now conveys the Eras and the different characteristics of each. âŮę Page 10, lines 28-31: Before making this statement, please refer to Figure 3 ("Figure 3 shows the different climatological flowrate corrections CPF,SM, expressed in percentages.") . To me, it seems that in Figure 3, only for Boulder, the flowrate corrections w/ Dry Air (please spell out "with") are more stable than those obtained without the Drierite air purifier/desiccant filter. But Figure 3 is very tiny, and it is hard to distinguish between the different symbols (circles and diamonds) and between some colours (Boulder/Samao & South Pole/Huntsville). Authors' Response: The statement "Figure 3 shows the different climatological flowrate corrections CPF,SM, expressed in percentages." has been added to what is now Page 11 Line 8. Figure 3 has been updated to increase the size of the symbols, the size of the graph, and to spell out with. The stability or variation and the uncertainty of the flowrate correction for the surface measurement depend on different factors. The uncertainty of the flowrate correction is based on the uncertainty of the ambient temperature and pressure of the room, the uncertainty of the humidity of the air stream being sampled, and the uncertainty of the pump/ambient temperature difference. The stability of the flowrate

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correction is dependent on the climatological range of these factors. âŮę Page 11, lines 26-27: Please mention in which range the University of Wyoming and the Japanese Meteorological Agency pump efficiency correction factors lie. Authors' Response: On what is now Page 12 line 3, the sentenced has been updated to read, "These PCF's agree nicely with the Johnson et al. (2002), Wyoming (Harder, 1987) and Japan Meterological Agency's PCF's (Private communication, Tatsumi Nakano) of 1.145, 1.120, and 1.122 at 10 hPa and 1.260, 1.224, and 1.213 at 5 hPa respectively." âŮę Page 15, lines 8-10: it should be nice to have an overview here of which ozone sensor efficiencies are used for which combinations of ozonesonde types and sensing solution strengths. I had to read this sentence several times before I understood its meaning, referring to some kind of table would help a lot, I suppose. Authors' Response: A new table has been added, Table 3, which shows the ozonesonde types and sensing solutions with their corresponding ozone sensor efficiency. A new sentence was added on what is now Page 15, Line 28. "Table 3 summarizes the ozone sensor efficiencies used for all ozonesonde type and sensing solution pairings." âŮę Page 17, lines 24-28: where do these uncertainty estimates come from? Is there consistency with the document linked at on the NDACC web page (http://wwwdas.uwyo.edu/âĹijdeshler/NDACC_O3Sondes/NDACC_O3sondes_WebPag.htm)? Authors' Response: The uncertainty estimates does come from Smit, H. G. J. and the O3S-DQA-Panel (Ozone Sonde Data Quality Assessment): Guidelines for homogenization of ozonesonde data, SI2N/O3S-DQA activity as part of "Past changes in the vertical distribution of ozone assessment" document on the NDACC webpage. The citation has now been included for these estimates. âŮę In section 5, and in figures 6, 7, 8. How do the resulting relative uncertainties compare with the relative uncertainties obtained in Van Malderen et al., 2016 & Tarasick et al., 2016, Witte et al., 2017b (???) for sites at similar latitudes? Of course, the approach in Tarasick et al., 2016 is different from the O3S-DQA uncertainty guidelines. Authors' Response: A new sentence has been added on what is now Page 20 Line 18. "The total relative uncertainty of ozone with altitude are similar in shape and comparable in magnitude to other recent ozonesonde uncertainty estimates, Van Malderen et al. 2016, Tarasick et al. 2016, and Witte et al. 2017b." âŮę Page 20, lines 4-5: I guess you mean here "If the balloon burst at a pressure smaller than 7 hPa, the residual column ozone was calculated from 7 hPa". Authors' Response: Yes, that is what was meant and is corrected in manuscript.

TECHNICAL CORRECTIONS âŮę Page 3, line 20: "based on the JOSIE and BESOS intercomparisons" instead of "based on the WMO and JOSIE intercomparisons" Authors' Response: Corrected in manuscript. âŮę Page 6, line 25: "cannot be measured directly" instead of "cannot me measured directly" Authors' Response: Corrected in manuscript. âŮę Page 18, line 9: "of the data quality assessment project" instead of "of the homogenization project"? Authors' Response: Corrected in manuscript. âŮę Page 20, line 6: "Evans et al., 2017" instead of "Evans et al., 1017". I don't think Bob is that old. Authors' Response: Corrected in manuscript. âŮę Page 21, line 4: "Figures 11 and S7" instead of "Figures 9 and S2" Authors' Response: Corrected in manuscript. âŮę Page 21, line 5: "(Layer 10 – Figure 14)" instead of "(Layer 10 – Figure S1)" Authors' Response: Corrected in manuscript. âŮę Page 21, line 7: "(Figure 13)" instead of "(Figures 8 & 9)" Authors' Response: Corrected in manuscript. âŮę Page 28, line 28: the Thompson et al. JGR 2017 paper is now published Authors' Response: Corrected in manuscript. âŮę Page 31, caption Figure 2: please add that those histograms are taken for the measurements at the sites Boulder, South Pole & Hilo Authors' Response: Corrected in manuscript. Now reads, "Histogram of all cell current backgrounds from Boulder, South Pole and Hilo broken into four time periods. A) Eras 1 and 2 B) Era 3 C) Era 4 D) Era 5"

The authors would like to again thank the reviewers for doing a thorough job of reviewing the manuscript. It improved the paper a great deal. A few other grammatical and formatting errors that did not change the meaning or intention of the text were found and corrected during the process of responding to the reviews.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2017-397, 2017.

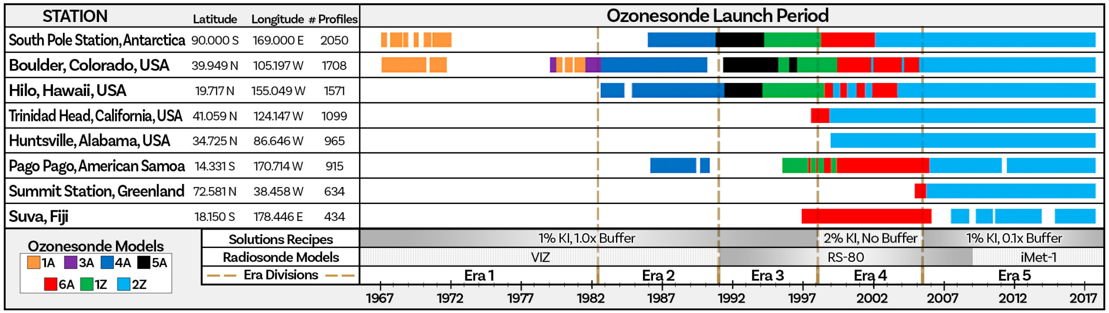

Fig. 1. Figure 1: The eight long-term NOAA ozonesonde stations with Latitude, Longitude, # of Profiles, and launch period.

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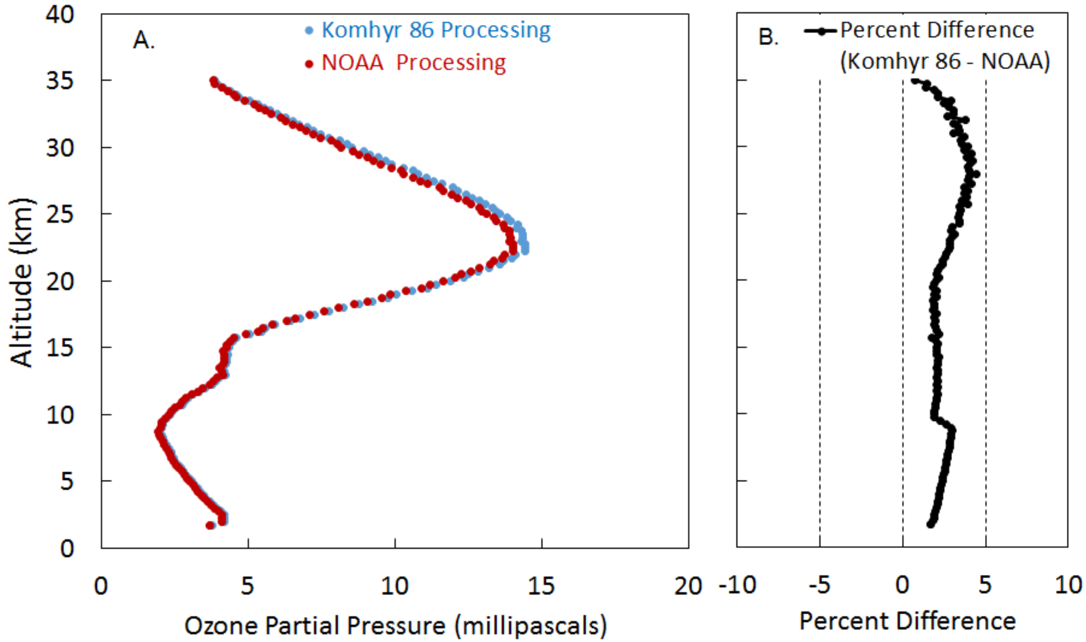

Fig. 2. Figure S1: Average Boulder profile for Era 3 processed with the 1986 Komhyr processing and the NOAA ozone sensor efficiency processing techniques, Panel A. The percent difference in the two processing

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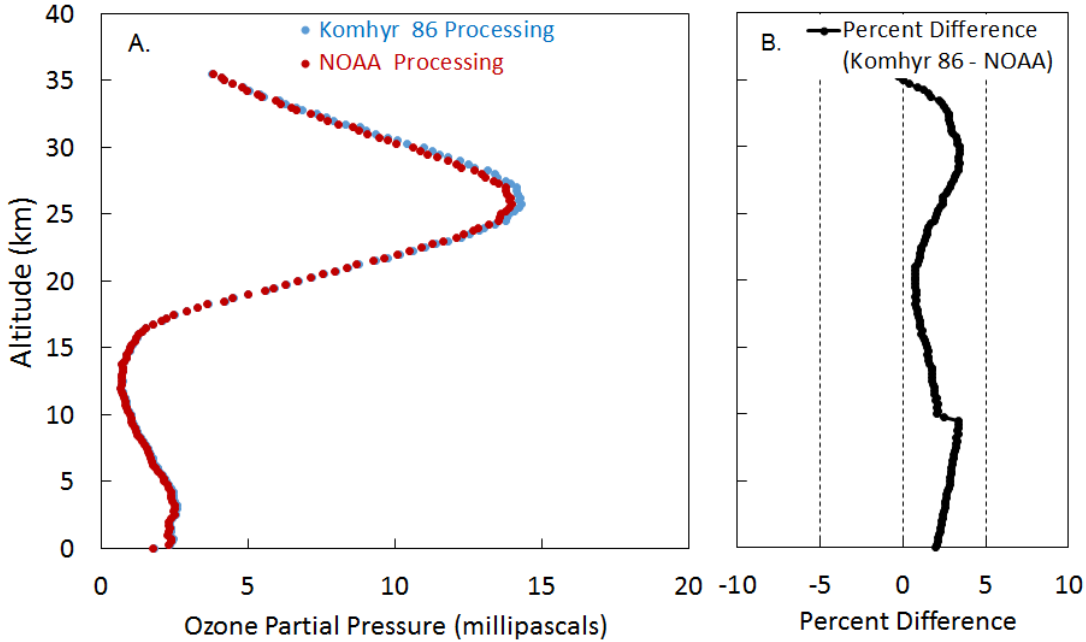

Fig. 3. Figure S2: Average Hilo profile for Era 3 processed with the 1986 Komhyr correction and the NOAA ozone sensor efficiency correction, Panel A. The percent difference in the two processing is shown in P