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Atmospheric Measurement Techniques Discussions

Interactive comment on "Propagation of radiosonde pressure sensor errors to ozonesonde measurements" *by* R. M. Stauffer et al.

Anonymous Referee #1

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General comments

I think this is an important paper, it makes a statistical study of the errors introduced in ozonesonde profiles by non-perfect pressure sensors.

These errors are introduced at two points in the data processing. The calculation of the sonde altitude from integrating the hydrostatic equation can be off by several kilometers. When an ozone mixing ratio is calculated from the ozone partial pressure, a second error is introduced.

The errors caused by the pressure sensor have been under-appreciated for a long time, probably because a lot of the work done on ozonesonde error sources have come from laboratory studies, where no radiosonde was attached to the ozone sensor. Also the

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coincidence that the pressure error does not show up in the integrated amount of ozone from an ozonesonde, will have contributed to the under-appreciation of this problem.

This paper certainly has its limitations.

The paper compares "pressure" altitudes with GPS altitudes. However, no independent evidence is shown that the GPS altitudes are correct. A claim from the manufacturers is the only evidence presented. I wonder if the GPS results have ever been validated at the altitudes where sondes operate.

The authors seem to have decided not to communicate with radiosonde manufacturers about the problems with the pressure sensors. This is a lost opportunity, as these manufacturers will probably know more about the causes of the errors in the pressure sensors. They would know at what times hardware or procedures have changed. They may even have kept the calibration result of each individual radiosonde.

In my opinion there is insufficient discussion on the RS92SGP radiosonde. This radiosonde has a pressure sensor that is actually performing quite well. This opens to opportunity to look at other error sources, for example the errors in GPS at altitude, problems in timing, or sensor hysteresis.

I am very unhappy with the recommendations in section 4.

1) There is the rather awkward subject of the "pump correction factor" (PCF) of the ozonesonde. The PCF currently in use, is not based on actual performance of the pumps in a controlled environment. Rather, the PCF is correcting a number of (known and unknown) errors of the ozonesonde. One cannot recommend a significant change in the way the ozone profile is calculated without reconsidering the PCF. (I can imagine that the current PCF compensates for the systematic pressure errors reported in this paper on page 7781 line 19).

2) Correcting the historical ozonesonde dataset based on the results of this paper alone is dangerous. This would assume that there have not been significant changes in the

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(calibration of) radiosondes over the years. This paper hints at possible differences in properties of radiosondes from different batches (page 7784 line 1). See also my remark on RS92 before and after June 2004.

Specific comments

Abstract: I think there are too many numbers quoted in the abstract. Consider removing the percentiles.

Abstract: Almost all of the numbers in the abstract do not appear in the main text, or the tables. This should be corrected. You could consider to add a line with "all sondes" to table 2 and table 3.

page 7772 line 8: "Three types of .... ozonesonde manufacturers .... are analyzed" The Good the Bad and the Ugly? Please rephrase.

page 7772 line 26: "distinguishable" is too vague a term for an abstract. "superior" is used on page 7785, line 17. I would suggest to repeat this word here.

page 7773 line 11: In the references this is Gaffen et al., 2000?

page 7773 line 18: Smit et al., 2011 does not occur in the references.

page 7773 line 24: It is unclear where "these variables" refer to. Please make this clear.

page 7773, section 1: I think a reference to the following paper is in order. It presents a statistical study of pressure sensor problems, and the effect on ozonesonde profiles. (Note: I am not one of the authors, nor do I work for them.)

D.De Muer H.De Backer: The discrepancy between stratospheric ozone profiles from balloon soundings and from other techniques: A possible explanation. Proceedings of the Quadrennial Ozone Symposium 1992 NASA Conf. Publ. 3266 page 815-818 1992.

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page 7774 line 5: the word "equivalently" cannot be used here. O3mr and ozone mixing ratio are affected by pressure errors in different ways.

page 7775 line 7: A typical response-time of an ECC sensor in an ozonesonde is 20 seconds. A typical ascent-rate of an ozonesonde is 5 m/s. This results in a vertical resolution of about 100 meters, I think the claim of "$\sim$ 10m or less" is simply wrong.

page 7776 line 2: page 7780 line 25: "attached GPS" or "separate GPS" is unclear. I assume what is meant here is: an RS80 with GPS wind-finding. If a separate GPS unit was attached to the flight package, please elaborate on this point.

page 7776 from line 25 to page 7777 line 6: In my opinion the list of campaigns is unnecessary here, and quite unreadable. In breaks the flow of the paper. Please consider removing this list.

page 7777 line 8: The Vaisala radiosondes are not properly introduced. There have been many types of RS80, and there are many types of RS92. This could be relevant in understanding the differences between the results from various stations. Outside the USA the RS80-15GE and the RS92-SGP may have been used. In the USA different models have probably been used. Please report the correct model in table 1.

page 7777 line 8: The International Met Systems radiosondes have not been properly introduced. Three models are mentioned. What are the differences?

page 7777 line 11: page 7795 table 2: The quoted accuracies for Vaisala sondes, are only valid if the sonde has been calibrated with a "ground check" before flight. This should be stated here. Did the various stations perform this "ground check"?

page 7777 line 16: There appears to be a big improvement in the RS92 in sondes manufactured after June 2004 (Steinbrecht 2008, Nash 2006). The manufacturing date can be deduced from the sonde's serial number.

page 7777 line 25: the word "proportional" here is vague. The ozonesonde measures ozone molecules per second, and with a known pump flow (m3/s) this is converted in

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molecules per cubic meter. Knowing "the temperature" this can be converted into a partial pressure. The word "proportional" suggests "the temperature" is constant. It is not.

page 7778 line 10: The gravity is not only latitude dependent, but it also depends on altitude. This should be mentioned here. If this dependence has been omitted in the calculations, I am afraid the calculations will have to be done again.

page 7779 line 7: "is .... considered" Is this a claim by the authors? If not, please give a reference. If not, please elaborate. It is very difficult to measure stratospheric temperatures properly. In my opinion it is quite thinkable that (part of) the problems with PTU altitude are actually caused by bad temperature measurements.

page 7779 line 9: "only in the vertical" I think it would be better to say explicitly that the pressure should NOT depend on the (horizontal) position and NOT on time.

page 7779 line 11: "hypsometric equation" I think this refers to equation (2). Please indicate that. Strangely, this is called "a form of the hydrostatic equation" on page 7778, line 18

page 7779 line 20: "stabilizes in the stratosphere" I wonder what the P-Pgps actually does during the descending phase of the flight. Was any of the descending data kept? If so, please present an example in the paper.

page 7780 line 1: I fail to see how the water vapor mixing ratio depends on the pressure. Please explain.

page 7772 line 19: page 7780 line 7: page 7782 line 21: "a region critical for O3 trend analyses" I tend to disagree. Please add a reference.

page 7782 section 3.2: No stations close to the polar jet were analyzed. Because the ozone profile shows much more (fine-) structure there, pressure errors could results in huge errors in ozone mixing ratio.

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page 7782 line 3: "well into the balloon flight" This paper considers altitude/pressure errors as a function of altitude/pressure. Considering these errors as a function of time is confusing and unnecessary. Please rephrase.

page 7782 line 16: manufacturer -> radiosonde type

page 7782 line 23: A possible cause of the different behavior in Beltville and RHB sondes is that an incorrect value for the local gravity has been used. Simply using a "latitude model" for the Earth's gravity is probably not good enough. Please check.

page 7783 line 21: McPeters et al., 2011 does not occur in the references.

page 7784 section 3.3: This paper goes as far as to compute the total ozone column from the sondes, but it does not compare this value to "total ozone" from other instruments (groundbased or satellite). This check is an important step for ozonesonde operators to validate their results. Please show how good the sonde's ozone column compares to (for example) OMI OMTO3 data, before and after the recalculation of the sonde height.

page 7786 recommendation #2: This may be a good advice for Imet en RS80 sondes, but this cannot be generalized to all types of radiosondes. In fact, if this is done for the RS92 sonde, information on boundary layer ozone is lost. For this type of radiosonde it is probably best to construct a mixed-mode pressure/height profile, making use of both the GPS and the pressure data.

page 7787 Appendix A: I think this paper does not require an appendix. The note on smoothing the data could be transferred to the main text. Figure A2 can be deleted. Figure A3 can replace figure 4, and figure A4 can replace figure 7. Add type of radiosonde in the legend.

page 7790 line 32: McPeters et al, 2007 is not cited

page 7791 line 31: Smit and Berg, 2011 is not cited

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And finally a note about language: "altitude" versus "height" http://en.wikipedia.org/wiki/Altitude This paper uses "height" where "altitude" would be better.

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