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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.

R. M. Stauffer et al.

rms5539@psu.edu

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-*This is a preliminary response prior to final edits on this manuscript. Iterative comments are welcome*

-The authors sincerely appreciate the insightful comments provided by the reviewer and we look forward to incorporating them into our paper.

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 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.

-The error does appear in the integrated ozone column since the vertical coordinate is changed. The coincidence in the total column being only slightly affected comes from the use of the McPeters and Labow climatology added on after 10 hPa, which reduces the ozone error caused by the pressure offset above that level.

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.

-Thank you for this suggestion. We will pursue more information on this.

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.

-We are currently in an ongoing dialogue with radiosonde manufacturers for additional background material and characterization of the radiosondes studied here.

I am very unhappy with the recommendations in section 4.

-We will be making some changes to our recommendations based on these, and other reviewer comments.

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).

-The pressure offset error can be considered separately from other issues such as the PCF, thus we are focused on addressing this one problem.

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 (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.

-We understand this anxiety about the historical records. Our goal is to identify and bring attention to the pressure offset with statistics from various radiosonde types in different locations.

Specific comments

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

the percentiles.

-The percentiles will be removed from the abstract since they appear in the text and tables as well.

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.

-The cited numbers in the abstract, text and tables will be adjusted accordingly so the three are in lockstep.

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

-This will be rephrased.

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.

-“superior” will be used in the abstract as well.

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

-This should be Gaffen et al., 1999. It is correct in text and will be changed in the references.

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

-This citation should read Smit and Berg, 2011. This is a presentation that is listed in the references between pgs 7791-7792: http://igaco-o3.fmi.fi/VDO/presentations_2011/ground-based/ WS_2011_Smit.pdf

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

-This will be made clearer that we are discussing the laboratory-tested characteristics of the ozonesonde.

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.

-We will consider this reference and thank you for the recommendation.

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

-We suspect you are referring to ozone mixing ratio and ozone partial pressure. This will be fixed since ozone mixing ratio has both a magnitude and altitude change, while the ozone partial pressure has only an altitude change.

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 "_ 10m or less" is simply wrong.

-This will be changed to include the effect of the ozonesonde response time.

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.

-A Garmin GPS unit was added to the inside of the ozonesonde Styrofoam box that gives altitude and wind information. This will be added to the text.

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.

-The data in this paper were taken and characterized by the coauthors, and we encourage others to view the data. We feel this list belongs in the paper, but it may be moved to a table in the interest of cleaning up that paragraph.

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.

-The RS80s used in this study were all RS80-15N models. This will be updated in the text. An ongoing dialogue with sonde manufacturers is taking place to characterize the radiosondes.

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

-See comment above.

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"?

-Information on the surface pressure entered as metadata is available from most stations, though this disclaimer about the validity of the Vaisala pressure accuracy being dependent on ground calibration will be added to the table footnote.

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.

-We suspect that since the first RS92 launch is in late July of 2006, that this won't be an issue, but we will attempt to verify with the manufacturer.

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 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.

-We will elaborate and discuss the variables required to calculate ozone partial pressure from the cell current using the ozone partial pressure equation and appropriate reference.

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.

-All calculations have been updated and gravity's decay with altitude is now included. The equation for gravity with latitude and altitude will also be included in the paper, although we note that this is a small correction.

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.

-This is a claim by the authors, and we will present a figure to the reviewer in the final response showing the differences in pGPS based on different radiosonde temperature biases.

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.

-This text will be updated.

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

-The text will be updated and hypsometric equation will be used throughout.

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.

-The bias is reproduced during descent as well, and we will provide an example for the reviewer in the final response.

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

-The radiosonde measures RH from capacitance, so H2Ov mixing ratio must be calculated from that using the air pressure.

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.

-This statement will be reevaluated.

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.

-This is true. The coauthors are most familiar with this data having collected and characterized it. It is our experiences with the data that prompted this paper.

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.

-This statement will be rewritten.

page 7782 line 16: manufacturer -> radiosonde type

-This will be changed.

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.

-These two different behaviors are still evident even after updating the formula by including gravity's decay with altitude.

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

-This should be McPeters et al. 2007. This will be fixed.

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.

-A figure showing improvement in ozone column agreement with OMI OMTO3 v8.5 will be provided for the reviewer in the final response.

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.

-As seen in Fig7, in the boundary layer, and even up to 10km or more for nearly every radiosonde launch, the percent ozone mixing ratio difference is within +1%. In Fig4, the pressure differences can often be +2 hPa, but ambient pressures of 800 or 900 hPa will result in a tiny correction to the ozone mixing ratio.

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.

-We will consider this comment and revise accordingly.

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

-See comment above regarding “McPeters et al. 2011.” This will be cited in the text.

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

-See comment above regarding “Smit et al. 2011” mistake.

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

-The language will be changed to make this clearer.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 7771, 2013.