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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.

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(This is prepared under discussion with Y. Inai, M. Fujiwara, and F. Hasebe.)

- Thank you again for your comments and responses.

We found that the first part of this paper about pressure offsets statically calculated for various types of radiosondes shows very interesting results and conveys an important message to radiosonde user community particularly for the stratosphere. However, we suspect that the latter part about estimation affecting on ozonesonde measurements is somewhat misleading in view of the altitude coordinate when they make a comparison.

- We have made it clear that the comparisons in the submitted paper are comparisons

based on coincident measurements with the altitude scale being the GPS altitude. You appear to be interested in comparing both ozone and geopotential altitude from the GPS and the radiosonde geopotential altitude to derive your percent offsets. That is a different goal.

We are interested in a vertical profile of ozone mixing ratios along a specific vertical coordinate such as in geopotential height or geometric height. In the following we consider the three cases for ozone profiles to make our discussion clear.

If we use a radiosonde with a pressure sensor, but without a GPS sensor, we will get an ozone profile in ozone mixing ratio using the pressure sensor data and geopotential height using the pressure sensor data. This is what we usually get from a conventional ozonesonde system with a pressure-sensor-type radiosonde. Hereafter we call this Profile A.

-Yes, Profile A is equivalent to the original profile in our paper; the output derived from the radiosonde pressure. However, the GPS altitude with the original O3MR is what our recalculated GPS pressure and O3MR are compared to when analyzing pressure offsets and percent O3MR offsets.

If we use a radiosonde with a GPS sensor, but without a pressure sensor, we will get an ozone profile in ozone mixing ratio using the GPS geometric height data which is converted to pressure, and geopotential height using the GPS data. This may be thought as the "true" profile, since GPS measurements are known to have much smaller uncertainty particularly in the stratosphere (Nash et al., 2011). Hereafter we call this Profile B.

-Your Profile B is indeed is not identical to what is described in our paper, but it is close to our "correct" profile. The GPS altitudes remain as the geometric height. The conversion from GPS altitude to geopotential GPS altitude, however, is a straightforward calculation.

-We prefer to show coincident measurements using GPS altitude and understand your comparison of the GPS geopotential altitude to the radiosonde geopotential altitude along with ozone. Our point is to show the difference between the original O3MR and the recalculated O3MR at a particular GPS altitude/coincident measurement. As mentioned, this can be converted the geopotential GPS altitude quite easily, which is what you've done before comparing the measurements. You are comparing two altitude scales and two ozone measurements, whereas we are comparing the two different O3MR measurements on a single GPS altitude.

If we can conduct a dual-launch of the above two types of radiosondes each of which has a pressure sensor and a GPS sensor, respectively, we can get various ozone profiles. One example is that in ozone mixing ratio using the pressure sensor data, and geopotential height using the GPS data. Hereafter we call this Profile C. What we really need to know as ozonesonde users is the differences between the "true" profile with a GPS sensor and the observed profile with a conventional pressure sensor. This should be based on a comparison between Profile A and Profile B. However, results shown in this paper seem to be based on the comparison between Profile B and Profile C.

-Profile C is similar to the comparison profile for the original radiosonde profile in our paper. However, we do not convert to geopotential GPS altitude. Profile C in our paper would be called the geometric GPS altitude with the original O3MR measurements. Nothing other than comparing the O3MR from the GPS pressures and O3MR from the radiosonde pressure was done to obtain percent offsets with GPS altitude.

-The profile with GPS altitude and GPS O3MR can be converted to geopotential altitudes as would be put out like a radiosonde, but as stated above that is not the quantity desired.

In the following we would like to make these points clear using examples of ozone profiles calculated for Profiles A, B, and C. The data we used here is based on those used

for Fig. 2 in Stauffer et al. (kindly provided by Ryan Stauffer), and figures presented in Fig. 1 are focused in the stratosphere with a coordinate system in geometric height.

First we discuss profiles in ozone partial pressure (the upper left (UL) figure). We suppose this is basically similar to Fig. 10 B in Stauffer et al. The radiosonde type for this measurement is Vaisala RS80, and Inai et al. (2009) found that it has a pressure bias âĹij -0.5% and a resulting altitude bias âĹij +300 m. The altitude shift seen in this figure is rather larger than that estimated by Inai et al (2009), but we clearly see the difference between Profile A and Profile B; Profile C is the same as Profile B, so the two profiles are overlapped.

-Yes, we are comparing Profile B (GPS altitude and GPS calculated O3MR) and Profile C (GPS altitude and original O3MR) because these represent coincident measurements. What you describe is a goal of comparing the radiosonde geopotential height and ozone profile to a geopotential GPS height with recalculated O3MR, which is a slightly different way of looking at the data.

-As stated up front, this paper aims to contribute to the ongoing ozonesonde data homogenization process. This radiosonde pressure bias is a large error that needs to be fixed. We provide a method for correcting these errors.

If we calculate ozone mixing ratios for Profiles A, B, and C, we get the upper right (UR) figure. For this calculation we need to consider two factors: one is a shift of the altitude coordinate for Profile A (blue) and a pressure bias for calculating ozone mixing ratios. For Profile C (black) a pressure bias is only taken into account, but for Profile A we need to calculate ozone mixing ratios using an ozone partial pressure profile as shifted in Fig. UL.

- The UL figure is similar to that shown in Fig.10B. For this flight, the pressure difference at burst is radiosonde: 10.45 hPa and GPS: 12.36 hPa, with an altitude difference of radiosonde: 31284 m and GPS: 30287 m. What is meant then by saying -0.5% pressure bias and +300 m altitude bias. If we were to convert that 30287 m GPS altitude to geopotential and compare to the radiosonde burst geopotential height, the difference would be even greater at 1.2 – 1.3 km. Because gravity decreases with height, geometric altitude will always be higher than geopotential altitude near balloon burst.

The difference between Profile A – Profile B (blue) and Profile C – Profile B (black) are shown in the lower left (LL) figure. As we easily expect from Fig. UL, the differences between Profile A and Profile B change sign around the maximum of ozone partial pressure. Also ozone profiles usually include small scale variations owing to small scale atmospheric waves such as gravity waves, so we see vertical variations in the difference between Profile A – Profile B (blue). On the other hand, the difference between Profile C – Profile B (black) only shows one side and smooth bias with increasing height. For this specific model (Vaisala RS80), an effect from the pressure bias seems to cancel out that from the altitude shift in some sense.

-Profile B – Profile C is basically what appears in our paper that states that at a particular GPS altitude, this is the difference between the original O3MR and the GPS calculated O3MR. We show the increasing difference in O3MR with altitude due to the pressure sensor bias.

-The profile shift is what prompts the discussion on column ozone in Fig 10B. The GPS ozone column is greater than the original radiosonde column up to the ozone maximum. This was simple to show because ozone partial pressure is unaffected by the pressure bias, and we are only dealing with a difference in one variable, the vertical coordinate. We chose to only compare one variable at a time in this paper, in this case, O3MR or pressure against GPS altitude.

From these results we suppose that the comparison shown in this paper is a case for the difference between Profile B and profile C, which is not what we want to know as ozonesonde users who really want to know the difference between profile A and Profile B. Using an ozonesonde system with a conventional radiosonde and a GPS sensor,

such as used in this study, we can use coincident ozone data with pressure information calculated from GPS height information to calculate ozone mixing ratios correctly. However, people are still using an ozonesonde system with a conventional radiosonde without GPS, and the situation is similar to those ozonesonde measurements that were done in the past. In these cases, we need to know the difference between profile A without GPS and Profile B with GPS. These are points of our comments.

- Your comments are a reminder for clarity and rationale in describing methods. This will be done in the revision. You point out that there are other ways to handle profiles. We are responding to a stated need in the ozonesonde community. Namely, there is a requirement to compare a single variable at a time: the original O3MR and the recalculated O3MR, which are measured at the same time, on a single altitude. Nonetheless, it is good that you point out that there is more than one way to go about handling the comparison of profiles. We feel it is simplest this way.

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