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Atmospheric Measurement Techniques Discussions

Interactive comment on "Fast response cavity enhanced ozone monitor" *by* A. L. Gomez and E. P. Rosen

Anonymous Referee #2

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The authors describe a surprisingly simple broadband-CEAS device for measuring ozone in ambient air and compare its performance with a single-path photometer. Indeed, its simplicity and high sensitivity can initiate the commercial use of this technique.

The manuscript is well readable and understandable. However, the manuscript is also quite short and the description of the technical details as well as of the results (compared to similar papers) little detailed. Furthermore, I find the manuscript often too laxly written and many references are missing. Besides the demonstration of the high sensitivity, in particular too little details on the accuracy of the technique are given . . . and high accuracy is at least as important as high sensitivity. A rigorous comparison of the advantages and disadvantages of this technique compared to others is also missing.

Thus, I would like to see my concerns considered before I can recommend publica-tion in AMT.

Major concerns

1. More details. The manuscript is short and basically only deals with the demonstration of the high sensitivity compared to a single-path approach. The reader can thus expect much more technical details. The technical description of the new device is only a good page long . . . this is very little for the description of a "new instrument/technique". Examples for more details are: - Well describe (with a picture) the light path, optics, lenses etc. - Assess the performance of your device theoretically. What is the power of the LED and how much of it is guided through the cells and reaches the detec-tors? How far away you are from shot noise?

2. Too laxly written and too little references. The instrument is particularly suitable for the deployment for eddy flux applications, on balloons, or on aircraft. In this respect, the entire introduction up to p.7226 l.9 is not well written, i.e. as it would come from a non-expert in atmospheric sciences. Either let check this passage by an "expert" or concentrate only on the technique. But also here you have to give much more citations; there are many technical papers on UV photometers (e.g. Proffitt and McLaughlin, Rev.Sci.Instr.,1983; Zucco et al., Meas.Sci.Techn. 2003; Hintsa et al., J.Atmos.Ocean.Tech., 2004; Viallon et al., Metrologia, 2006; Kalnais and Avallone, J.Atmos.Ocean.Tech., 2010; Gao et al., AMT, 2012; . . .) in which Kalnais and Avallone even seem to use the same UV LEDs. Also for the rest of the paper you need much more references.

3. Accuracy. The short-term precision of your device is high. But this statement holds for almost all CEAS instruments. Often however, they are not more accu-rate than multi-pass or even single-path approaches, as finally other factors and shortcomings start to play a role. The enhanced accuracy or long-term stability you haven't demonstrated, yet. You write 1 ppbv at 10 Hz. But will this hold for usual field applications?

What is then the accuracy/total uncertainty? The UV-TOP LEDs from SET you use (which exact type, at all) show a typical tempera-ture drift of 1.5-2.0%/K (right?), which is ∼50 ppbv/K for your device (at 1 bar), right? Fig. 5 indicates that the LED was (during this test) well thermalizedt? But what is during field operation with strong temperature variations? Which other drifts you have? Here, the Allan plot (Fig. 5) helps little and it is also somewhat strange. What is the reason for the maximum at ∼0.3s? I would assign this non-white-noise behaviour to 1f-noise of the UV LEDs. We created similar Allan plots based on data from our (home-made) UV photometer, see figure. We have a du-al-beam single-pass system with beam splitter. In the both cells (C1, C2) we see a (compared to Fig.5) very similar Allan plot with similar values (10-5 corre-sponds to 0.5 ppbv). In the ratio C1/C2 (red), where lamp noise vanishes, we get a lower noise of only 0.1 ppbv at 10 Hz which is a factor of 5-10 lower than your numbers. To reach high accuracy, do you also need such a beam-splitter ap-proach or can you also apply the technique of e.g. the Environnement O342M instrument where the (additionally measured) LED light emission is used to get rid of light fluctuations?

4. Comparison of performance with other techniques. You have to compare the performance, advantages and disadvantages of your technique with other instruments (UV photometers, CI techniques). For instance the NOAA single-path instrument (Gao et al., 2012) appears to be more accurate than yours. Due to the strong absorption signal you get in comparison with single-path approaches you should easily reach uncertainties around 0.1 ppbv. The noise of our single-path UV photometer (absorption length 38 cm) is e.g. below 0.06 ppbv at 4s.

Minor concerns

Reviewer 1 has already listed many points. Amongst them, I have only some further ones:

p.7224, l.19 . . . strong impact on health, atmospheric chemistry, and . . .

p.7724, l.20 . . . stratosphere (0.1 to . . .

p.7225, l.22ff SOAs can only serve as cloud condensation nuclei in the tropo-sphere. The stratosphere is completely free of clouds (besides very rare occurrences of polar stratospheric clouds, PSCs, in the wintertime polar vortices).

p.7226, l.1ff “To improve radiative . . .”. The entire paragraph is wrong. ALL in-situ O3 instruments available are sufficiently fast for all these studies and comparisons. However, required are fast, accurate, and light-weight instruments, e.g. for eddy-covariance measurements or the deploy-ment on moving platforms.

p.7226, l.13 Most in-situ ozone instruments use MgO2 scrubber.

p.7228, eq.4 I have never seen this equation and do not believe it. At very low ozone concentrations, E would tend to infinity. Correct is E=I/Io/(1-R).

p.7229 You use moderately reflective mirrors. Explain why. Are you already limited by dark noise?

Section 3 You have neither explained the measurement procedure nor the pro-cedure how you calculate ozone. What are the measurement times and flushing times? What you use as Io? Give an equation. Do you measure a certain time (e.g. 1 min) with high frequency (e.g. 10 Hz) and only then flushes the cell with O3-free air?

p.7232, l.16ff Allan plot. As written by reviewer 1, you should create such test with real ozone data. Which drifts you have, see also my comment above with the T drift of the LED? Try to find explanations for the strange Al-lan plot, see e.g. Werle et al., Spectrochim. Acta, 60, 1685–1705, 2004. A dark noise measurement and measurement of a noise-free stable voltage (e.g. from a battery) fed in the detection system allows to characterize most noise sources. The rest is due to LED noise.

p.7233, l.27 The typical uncertainty of commercial UV photometers is 0.5-1.0 ppbv at 6-20 s. The very compact device by 2B-Technologies should not be a benchmark for your device.

p.7234, l.8 That your device “allows for one to two orders of magnitude improve-ment

. . .” is not shown. The NOAA device (Gao et al., 2012) is similarly accurate and fast (if the detection speed is set to 10 Hz). Moreover, what sample flow you need to guarantee real 10 Hz measurements? How often you have to measure Io to guarantee also high accuracy? To my understanding you have reached the short-term precision of the best photometers existing worldwide, but you didn’t get ahead yet.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 7223, 2012.

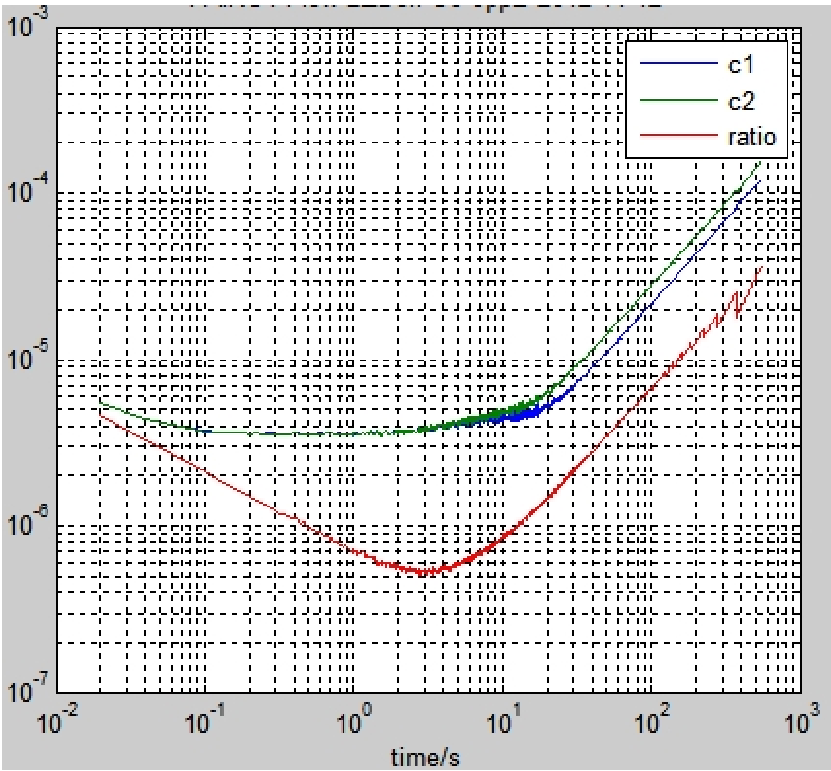

Fig. 1.