

Atmos. Meas. Tech. Discuss., author comment AC3  
<https://doi.org/10.5194/amt-2021-172-AC3>, 2021  
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## Reply on RC3

Ryan Thalman et al.

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Author comment on "Detection of Sulfur Dioxide by Broadband Cavity Enhanced Absorption Spectroscopy (BBCEAS)" by Ryan Thalman et al., Atmos. Meas. Tech. Discuss., <https://doi.org/10.5194/amt-2021-172-AC3>, 2021

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### Response to Reviewer #3

Thalman and Hansen describe a promising new broadband cavity-enhanced absorption spectrometer for quantification of SO<sub>2</sub> in air in the 305-312 nm region. Overall, I think this paper was perhaps submitted prematurely as some needed experimental work and a (critical) discussion of the results were absent. In my opinion, this paper should be rejected at this time, but I would like to see the authors submit a revised version once more data have been collected and the manuscript has been revised.

### Major/general comments:

The authors present what looks like a promising instrument, but the manuscript is lacking a few key elements:

(1) Since the scope of this journal is on atmospheric measurement techniques, I would have expected to see some sample ambient air measurements with this new instrument, in parallel to a trusted reference method. Are there interferences in ambient air, for example? The authors state that other species were not included in the fit, which may be OK for a laboratory comparison, but does this approach hold up for ambient air measurements?

Ambient measurements have been added to the manuscript along with data evaluating interfering species. Additional species are fit for ambient measurements (NO<sub>2</sub>).

(2) What can the authors say about the stability of this instrument? The LED manufacturer shows a stability data over a 2,000-hour life span on their web site - does this imply that the LED will have to be replaced after 3 months of use?

This is a good point brought up by the reviewer. For the time period of this work (off and on for 6+ months), no appreciable decay in the LED intensity was observed.

(3) A critical discussion of the results needs to be added. How does the performance of this instrument compare to other instruments, including commercially available ones? Is it better, worse, and why?

Commercial viability for regulatory purposes is driven by standards for SO<sub>2</sub> of 75 ppbv (EPA, 1-hour average) and 63 ppbv (WHO, 24 hour average). The reality is that current sensitive techniques and BBCEAS are much more than capable of measuring at these standard levels. Possible advantages in future developments for a BBCEAS include weight and power as well as cost, operation free of calibration standards, and lack of interfering species. These points have been added to the conclusions.

What was the dynamic range, response time, power requirements, size compared to (many) other instruments out there? What has this paper contributed to the problem of SO<sub>2</sub> measurements? Does this new instrument provide a faster, more sensitive, or more accurate data? What needs to be done to improve matters further? Are any parts of the design advantageous or trouble (such as the 3Dprinted cages, or the materials used for printing)? Since two spectrometers were evaluated, what are the advantages of the Avantes over the Andor (and vice versa), and are the observations consistent with what might have expected from the manufacturer specs?

Instrument specifications including power consumption and interferences has been added to the paper, all relative to the Thermo UV flash fluorescence instrument. While the current iteration of the instrument is a longer cavity attached to a 19" instrument rack mount box (9"x 19"x 24"), there is still plenty of room for further optimization in size, power consumption, streamlined electronics, etc.

Specific comments: line 3 LOD is stated as 3.6 ppbv on line 122, but 0.6 ppbv on line 3.

lines 20 Consider consolidating all this information in a Table.

The information presented here covers only a few techniques and focuses on the fluorescence instruments produced by Thermo, so the text provides the smallest footprint in the paper.

line 53 3D-printed cages are not very common. Please discuss (in the discussion section) pros and cons and the performance (do they last?) of the printed cages.

This is a good point and some discussion has been added about cavity construction and stability has been added to the conclusions.

line 57 "The LED was temperature controlled with a Peltier cooler". More detail is needed here. How was the LED mounted/secured? How/where was the Peltier element attached? What model Peltier element was used? How/where was the temperature measured?

The instrument description has been updated for more detail and a figure (picture) has been added to the Supplementary Information.

line 64 "260 - 820 nm" This huge range seems to be mismatch for this application - consider exchanging the grating in future.

The Avantes spectrometer was one that was available for initial use and was not ideal, thus the paper will now only include results and discussion about the data taken with the Andor spectrometer.

line 67-69 "The Avantes spectrometer was not ideal" - consider moving this sentence to the discussion section.

Per comments from the other reviewers and further experiments, the data and discussion

relative to the Avantes spectrometer has been removed from the paper as it is unnecessary for the results.

pg 3 / Figure 2 - Panel A is of insufficient resolution.

An updated figure has been provided and will be proofed to ensure proper resolution before final publication.

line 72 "The material of choice was changed for various structural elements depending on the structural and design requirement." Please provide more details here. What are the structural and design requirements? Changed how?

This section has been updated to have more detail relative to choices made in 3D printing material.

line 94-95 This is not a grammatically correct sentence.

The sentence has been updated.

line 102 how were temperature and pressure measured?

Details of the pressure and temperature measurement have been added to the instrument description.

line 104 What was the manufacturer-specified uncertainty of this standard?

The manufacturer specified uncertainty was 1.4% and has been added to the description of the standard.

line 120 Strike duplicate author names (twice); replace "rather that" with "rather than"

The duplicate reference has been fixed and the sentence updated to remove the "rather that".

line 134 "Known interferences ... are avoided using the BBCEAS method". Please provide data to show that this is indeed the case.

NO was provided to the instruments as a comparison and the results of the interference have been added to the results and discussion.

line 136 "Improvements" - is this future work?

This section has been updated to reflect "Future Work" which is pertinent to the description of the instrument and obvious improvements that were not able to be tested.

line 150 "Data for the experiments and figures are available in the Supplementary Material". There was no supplementary material uploaded.

The text has been updated to reflect the data will be available through the Scholars archive.