Response to Reviewers
Manuscript Number: AMT-2015-249
Manuscript Title: Broadband cavity enhanced spectroscopy in the ultraviolet spectral region for measurements of nitrogen dioxide and formaldehyde

The discussion below includes the complete text from the reviewer, along with our responses to the specific comments and the corresponding changes made to the revised manuscript.

All of the line numbers refer to the original manuscript.

Response to Reviewer #3 Comments:

This paper reports the application of a new and particularly intensive light source to BBCEAS which extends towards the short wavelength UV region. As the author argues, this region is of great importance in terms of measuring a few atmospheric trace gases that has strong absorption feature only in the UV. The sensitivity achieved is sufficient and the potential promising, for making it a field instrument which can measure HCHO at its ambient level. I therefore recommend publication of this paper on AMT, subject to a few minor corrections/suggestions as below.

We thank the reviewer for the positive review. Listed below are our responses to the comments and the corresponding changes made to the revised manuscript.

Page 9929, line 8, I see no point of reiterating the value of (1-R) as R is mentioned one word away. Actually this confuses me somewhat because I was trying to understand "loss" as mirror absorption + scattering rather than absorption + scattering + transmission. Similarly in page 9933, line 23.

We have clarified this in the text:

Page 9929, lines 8-10: "The reflectivity of the cavity mirrors is 0.99933 ± 0.00003 (*1 - reflectivity* = 670 ppm loss) at 338 nm, as determined from the known Rayleigh scattering of He and zero air."

Page 9933, lines 22-23: "[…] with manufacturer reported reflectivity of 0.9995 (*1 - reflectivity* = 500 ppm loss) at their nominal center wavelength of 330 nm."

Page 9932, line 3, as far as I know, bandpass filters are not always needed in BBCEAS (depending on the emission profile of the light source). I would suggest the author to add something like that in the parenthesis to reflect this.

In our experience, bandpass filters have been necessary for BBCEAS with LEDs at 365, 405, and 455 nm. However, LEDs with narrow spectral output and carefully chosen cavity mirrors might avoid this. We have modified the text:

Page 9932, lines 3-4: "Second, optical bandpass filters required ~~for~~ *to reject* out-of-band light ~~rejection~~ *from broadband sources* are less efficient in the ultraviolet spectral region."

Page 9933, line 27, can the authors please state how much of intensity gain they managed to achieve with two lens rather than 1.

We do not have specific measurements of the light collection by the fiber collimator, but we have added the part number to the text for interested readers:

Page 9933, 26-27: "The light exiting the cavity is imaged by a 2.54 cm diameter F/3.1 lens onto a 0.5 cm F/2 lens *(74-UV; Ocean Optics, Dunedin, FL, USA)* that couples the light into one lead of a custom fiber bundle."

Page 9939, line 2, the authors rule out the role of "dirty" mirror surfaces (by particles for example) in lowering mirror R. How?

The measured mirror reflectivity is consistently lower than the manufacturer's specifications, even immediately after cleaning the cavity mirrors. As cited in the text, other groups have also reported this, and attributed it to photons propagating off-axis in the cavity or high-order transverse modes with greater losses. We have edited the text to clarify this point:

Page 9939, line 2: "*The repeatability of this result, even after standard procedures for careful mirror cleaning, suggests that it does not arise from surface deposits on the mirrors.* This discrepancy has been reported previously…"

Page 9942, line 1 onwards, I agree that δI_{min} at 330 nm may be ~1E-4, but the light intensity actually changes at all wavelength, which makes its effect in determining the detection limit of trace gases different from that of broadly extinctive species such as aerosol particles (because we use "differential" absorption structures rather than a polynomial fit). If this is factored in, the discussion of "detection limit" based on δdI_{min} at a single wavelength is somewhat irrelevant, and the estimated value may be conservative in fact unless the shape of the emission profile of the light source also distorts significantly with temperature.

We agree with the reviewer that the mirror reflectivity, Rayleigh scattering, and light intensity all vary with wavelength, and that the detection limit for a specific gas will depend on its absorption cross section across the measured wavelength region. Our goal in this section is to present the theoretical shot noise limit and Allan deviation plot at one representative wavelength.

The reviewer raises a question about whether the spectral output of the light source varies with temperature. Please see our response to Reviewer 2, who asked a similar question.