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Atmospheric Measurement Techniques Discussions

Interactive comment on "Development and characterization of the CU ground MAX-DOAS instrument: lowering RMS noise and first measurements of BrO, IO, and CHOCHO near Pensacola, FL" *by* S. Coburn et al.

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Dear referee # 3, thank you for taking the time to review our paper and for your helpful comments. Detailed below are our answers.

The study by Coburn et al. reports on the "Development and characterization of the CU ground MAX-DOAS instrument: lowering RMS noise and first measurements of BrO, IO, and CHOCHO near Pensacola, FL". The paper comprises three major sections: 1) a very detailed description of the instrument, 2) the characterisation of the instrument in the laboratory, and 3) the application in the field. In general, the topic of the paper fits into the scope of AMT. However, I doubt some of the author statements and conclusions given in their study. Therefore major corrections are needed before publication.

Since I agree with several comments from reviewer #2 and in particular reviewer #1, I'm focussing mainly on those items not addressed in detail so far. One thing I have to repeat: The authors claim several times that they have developed an instrument which is only photon shot noise limited. However, they are not able to proof that under realistic conditions. Most (if not all) of their suggestions to improve the RMS have been addressed by other groups working in this field in a similar way: e.g. improving the temperature stabilisation and using the system in a specified saturation level. Table 1 shows quite clear that these groups end up with a very similar detection limit, which means that in practice other effects might limit the RMS level. But one should mention, and that is the positive thing about this study, to my knowledge the level of investigation for these parameters is really outstanding here and might help novel workers in this field to better understand the limitations of the different instruments. The authors should focus on these (really good) results without arguing that they have solved general experimental problems about MAX-DOAS leading to an instrument which is about 10 times better than others which is obviously not the case.

- As an addition to this manuscript we have expanded the signal to noise tests using a non structured light source (a tungsten lamp) to provide other examples of the capabilities of this instrument. In regards to the suggestions to improve RMS found in this manuscript, we feel that our suggestions are fundamentally different than those found in the literature relating other MAX-DOAS hardware. Namely, here further temperature stabilization is realized through the use of a two-stage temperature controlling system, whereas all other hardware only utilize a single stage temperature control. Also, we control the saturation level of the detector to very narrow range in order to avoid the effects of the non-linearity of the detector, while most other groups do this to account for the changes in light intensity for different atmospheric conditions.

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In section 3 a discussion on the change in FWHM with wavelength is completely missing. When looking to Figure 2 it is quite obvious that the spectral resolution of the instrument is decreasing with wavelength with about 0.74 nm in the Visible and 0.99 nm FWHM in the UV with the latter one being on the upper end of what is needed for a proper DOAS retrieval in that wavelength region. Furthermore it is also visible that the slit function is becoming more and more (non-linear?) asymmetric towards the UV. How this is addressed in the DOAS retrieval and what is the impact on the results? Is the measured slit function used for convolution of the cross sections or a fitted Gauss function?

- Text has been added to Section 4 in order to address the change in FWHM across the CCD and how this is dealt with in our DOAS retrieval. To go ahead and answer that question, though, we do use the slit function of the instrument to convolve all the cross sections used in the analysis, and we do use a slit function taken from the appropriate wavelength region for the UV and Visible range analyses.

For section 4 I would like to see some statistics (plot) between derived dSCD, RMS and elevation angle and/or solar zenith angle for all measurements both in the UV and the visible. This should give an impression on the real performance of the instrument. Similar to reviewer #1: What is this scaling factor about? I can imagine what the authors mean, but how it is derived? The whole chemistry discussion in this section is useless when not supported by any serious radiative transfer calculation and statistics on the measured columns.

- The updated version of Fig. 5 now shows both a low and a high elevation angle for the field measurements, and all of the presented measurements are of a solar zenith angle below 80°. Therefore, we feel that this figure is a good representation of the actual performance of the instrument. The scaling factor is merely a means to assess which dSCD values we can consider sufficiently above the detection limit to be “significant”. It is derived by looking at fits from a variety of conditions in the analysis and assessing how statistical the residual looks. The use of two is rather conservative

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as that it tends to lead to a detection limit that is roughly six times greater than the fit error from the DOAS retrieval. Text has been added to the discussion of the use of the geometrical AMF approach to clarify that radiative transfer calculations were made, but the uncertainty in the vertical profile these trace gases in the free troposphere led to errors that were on the same order of assuming a geometrical AMF.

Some more general comments: The authors should avoid strong language (e.g. “first measurements of” in the title and several times in the body text, which is completely waste, since than almost every field measurement is somehow the first one; “one of the most light-efficient instruments” in section 2, which is just speculation, since much more parameters have to be considered to evaluate the light throughput; “approach was first presented . . . in the first field deployment”(p260, l28-29) this approach is used by other groups since several years).

- The text in the title has been modified so that it reads that these are the first measurements in this particular region – and this is being pointed out do to the relevance on the discussion pertaining to mercury oxidation. As for p260 lines 28-29, the approach being referred to here is the controlling of the saturation level in order to remove the non-linear effects of the detector for which this was first addressed in Volkamer et al (2009), and the “first field deployment” is referring to this particular instrument.

Like reviewer #1: Please state only numbers in the text which can be derived from the results!! E.g. in the conclusions: “The instrument is able to measure [sic!] RMS<1.0e-5 . . . under laboratory conditions using solar stray-light.” A lot of acronyms are redundant (CU GMAX-DOAS, MDN, OLF, EPA, FL, IAM, FT) and make the text as a whole difficult to read. Other acronyms are not introduced like proportional–integral–derivative controller (PID).

- The RMS value of 6x10ˆ-6 can be found in Fig. 5 panel (b) lower right corner blue triangles. We have gone through the manuscript and remove unneeded acronyms and update text to be sure and correctly introduce the ones that we do use.

The level of details given in the different sections is sometimes much too high, and sometimes not sufficient. Examples (too detailed) Section 2.1.: “is driven by an Intelligent Motion Systems Inc. MDrive34 Plus motor (48V, 4A maximum)” Sections 2.2 and 3: No need to mention several times, that custom Labview code is used. Section 4.2, p.264, l5-11: 54862 individual spectra recorded . . .. (not enough information)

- The text has been updated to remove unnecessary detail and attempt to expand where it is deemed appropriate.

Section 4.1: What is the method behind the calculation of the Ring spectrum? There is no information given in Krauss, 2006.

- The DOASIS software can calculate an effective cross section for the Ring effect based on Raman scattering and a given solar spectrum file.

References: Some references are missing (in particular Roscoe et al., AMT, 2010, or Vlemmix et al., AMT, 2010)

-A reference to Roscoe et al 2010 has been added to the introduction around the text presenting Table 1. As that Vlemmix et al 2010 describes the use of the Mini MAX-DOAS instrument, which is already found in Table 1, adding this reference to the table would not add any information content, and since the table is meant to be an overview of current MAX-DOAS capabilities rather than a comprehensive list of instrumentation we would prefer not to include this reference .

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 247, 2011.

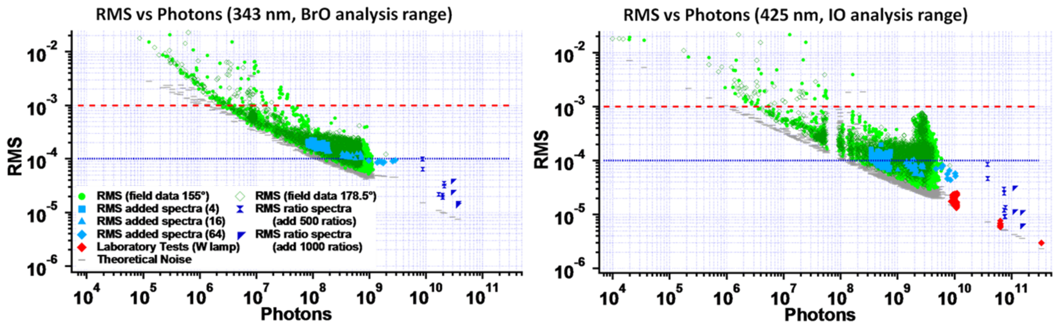

Fig. 1. Figure 5: Here an additional elevation angle for the field data has been added as well as the results of the signal to noise tests using a tungsten lamp

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