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Atmospheric Measurement Techniques Discussions

AMTD

Interactive comment

Interactive comment on "Eddy covariance carbonyl sulphide flux measurements with a quantum cascade laser absorption spectrometer" *by* Katharina Gerdel et al.

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Reply to Anonymous Reviewer #2: We thank reviewer #2 for his/her critical comments to which we reply below in a point-by-point fashion.

Reviewer comment: This manuscript presents a methodological approach to calculate eddy covariance flux of carbonyl sulfide (COS). The topic is very actual and interesting, however I cannot recommend the current version of the manuscript for publication in AMT, because of the following major points: - Performance of QCLAS gas analysers have been already evaluated in the past for other gases (CH4 and N2O). The authors use filtering and analysis approaches to deal with laser drift affecting the low frequency and random noise affecting the high frequency, which are already well know in the flux community.

Author reply: While we agree that similar analyses have been carried out previously for QCLAS instruments measuring other trace gases (which in fact is discussed in the manuscript), we still believe there is the need to assess these corrections for COS and this particular QCLAS. This is particularly so as the few available COS eddy covariance flux publications focused on the "science" and thus necessarily provided little methodological detail. In particular none of the available COS flux papers did explore different processing options and their effects on QA/QC.

Reviewer comment: - The authors did not report a detailed description of EC processing steps and corrections, which I would expected for this kind of technical paper. For instance, it is not clear for me if the COS dry mole fraction (corrected also for spectroscopic effect) was used for calculating fluxes (as it should be). In the data acquisition chapter it was only mentioned that "molar densities were measured : : :".

Author reply: We apologize for this omission – indeed we used dry mole fractions for calculating eddy covariance fluxes (superseding the need for the WPL density correction) – will be corrected in the revised manuscript.

Reviewer comment: One of the main conclusion of the study is that fluxes obtained with several filtering strategies are not differing so much. Moreover, the validation is performed for CO2 and H2O against independent measurements, and not for COS.

Author reply: As the author is likely aware of, the QCLAS used in this study is presently the only instrument providing the time response required for eddy covariance flux measurements – there is thus no possibility to directly validate the COS fluxes with a comparable method.

Reviewer comment: I agree that the use of recursive high-pass filtering is the only approach to deal with laser drift, especially in case of very small fluxes. However, by using this strategy, the true signal may be also filtered out. I believe that optimization of the setup (e.g. QCLAS insulation, minimize variation of ambient temperature, etc..) is the first prerequisite for obtaining defensible measurements.

Author reply: Agreed, will make this point in the revised manuscript.

Reviewer comment: Related to the estimations of flux random uncertainty, I would recommend to look at the comprehensive paper by Rannik et al. (2016).

Author reply: Thanks for pointing us to this paper, which was published in AMT after we had submitted our manuscript. In response to this comment we have adopted the revised Wienhold-approach recommended by Rannik et al. to quantify the flux detection limit in our revised manuscript. In addition, based on a comment by reviewer #1, we have included the flux detection limit by Pihlatie et al. (2005; BG 2, 377-387).

Minor comments: Reviewer comment: pag.4 L16. How much is the sensor separation (in vertical and horizontal directions)?

Author reply: Horizontal sensor separation is 0.1 m perpendicular to the main wind direction, vertical sensor separation 0.1 m – this information will be added to the revised manuscript.

Reviewer comment: pag.4 L22. 3d coordinate rotation is not recommended. Instead, standard methods are the 2d or planar fit.

Author reply: While this is correct in principle, it is also well known that filtering for the third rotation angle (restricting to +/-10°) largely avoids issues with the 3D rotation – CO2 fluxes calculated with the 2D and 3D rotation agree to each other closely at this site, with a slope of 0.995, an offset of 0.128 μmol m-2 s-1 and an R2 of 0.94. In fact, filtering for the third rotation angle removes extreme outliers that would otherwise pass.

Reviewer comment: pag.4 L30-34 How the authors have decided on these threshold values ? How many 30 min runs are included in each of these subsamples?

Author reply: The bin sizes for the determination of the random flux uncertainty following Hollinger and Richardson (2005; TP 25, 873-885) were determined by Wohlfahrt et al. (2008; JGR, 10.1029/2007JD009286) for this site and are similar to those originally proposed by Hollinger and Richardson (2005) – will add this information to revised manuscript; based on these criteria, "similar" environmental conditions are identified during subsequent days and the difference in fluxes used as a measure of random uncertainty – so there are no subsamples created.

Reviewer comment: pag.5L10 and Fig.1 Why the cross-covariance functions look so smooth? Is this because of low-pass filtering? Please explain.

Author reply: This, admittedly very neat, example was calculated by block-averaging, so no additional filtering was applied.

Reviewer comment: chapter 3.3 and fig.3. The noise at high frequency range of the COS cospectrum is something normal, considering the probably low signal-to-noise ratio of this dataset, and the fact that a single run cospectrum is shown. Instead, I would recommend doing this kind of analysis using ensemble average cospectra. I am sure that visually the noise will be much less. How the cospectra of CO_2 and H_2O look like?

Author reply: Based on this reviewer comment we have conducted a comprehensive (co-)spectral analysis averaging data by bins of stability and wind speed; the analysis indeed shows that the erratic behavior at higher frequencies (noise) vanishes when averaged over a large enough sample; we will show the results for COS, CO_2 and H_2O in a new figure (Figure R2_1 shown below) replacing former Figure 3; as a by-product of the cospectral analysis we have adopted the low-pass filtering correction procedure by Aubinet et al. (2001; AFM 108, 293-315) – the corresponding results will be presented in an additional figure

Reviewer comment: pag.7 L.15. Were the ustar thresholds visually estimated? Or how was it done?

Author reply: Ustar thresholds were determined visually – in the revised paper we will report ustar thresholds based on the change point detection algorithm by Barr et al. (2013; AFM 171-172, 31-45); as shown below (Fig. R2_2), the new objective procedure has changed the ustar thresholds somewhat.

Reviewer comment: pag8 L.9-10 Sorry to say, but this is a very dangerous statement, which gives a wrong message to the reader. The random uncertainty is intrinsically part of EC flux measurements, and the low frequency fluctuations are not necessarily due only to instrumental noise (laser drift), but can be also real.

Author reply: This is just a factual statement reporting that high-pass filtering reduces the random uncertainty – but we understand the reviewer's concern and will modify the sentence correspondingly.

Interactive comment on Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-313, 2016.

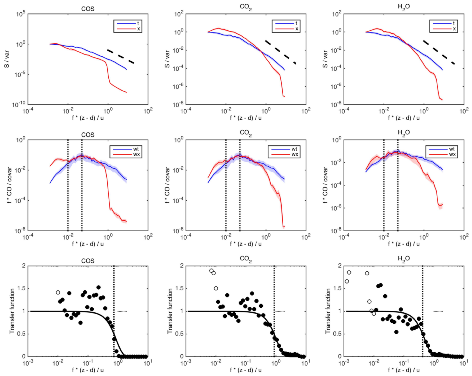

Figure R2_1 Spectra (upper panels), cospectra (middle panels) and experimental transfer function (lower panels) for COS, CO_2 and H_2O. Solid lines and shaded areas refer to the average and one standard error. Data have been filtered for unstable conditions and wind speeds between 1.00 and 1.25 m s^{-1}. The dashed line in the upper panel indicates the expected -5/3 decay in the inertial subrange; vertical dotted lines in the middle panel encompass the frequencies between which cospectra were normalized to each other; vertical dotted lines in the lower panels indicate the half-point frequency. Only data indicated by closed symbols in the lower panels were used to estimate the half-point frequency.

Fig. 1.

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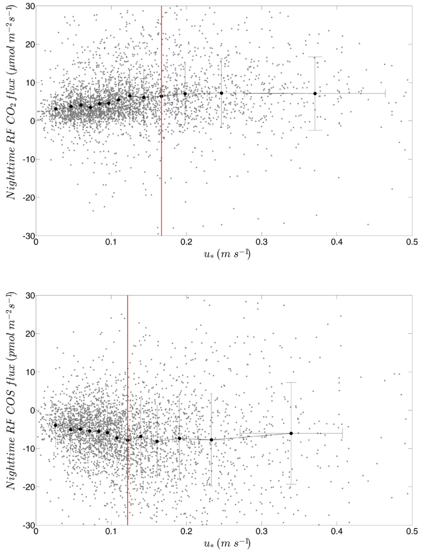

Figure R2_2 U* thresholds (red vertical lines) determined with the change-point-detection after Barr et al. (2013).

Fig. 2.

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