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Biogeosciences Discussions

Interactive comment on "A case study of eddy covariance flux of N_2O measured within forest ecosystems: quality control and flux error analysis" *by* I. Mammarella et al.

Anonymous Referee #3

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General comments:

This article aimed to address the required quality control aspects when measuring N2O EC fluxes by tunable diode spectrometry. In addition, the possible errors are discussed in these EC flux measurements. This topic is important since only a few papers have been published in which the quality control is partly addressed of EC flux measurements of N2O (e.g., Eugster et al., 2007; Kroon et al., 2007). These published articles noted that laser drift could possible cause an over- or underestimation of

the fluxes. However, no thoroughly investigation has been done on the effect of drift on flux values. This manuscript addressed the possibility of filtering laser drift by a running mean filter. In addition, the drift is evaluated using several techniques, e.g. Allan variance and fast Fourier transforms. It is relevant to discuss the required filtering technique in the community before a standard methodology could be developed for EC flux measurements of N2O.
I recommend that this paper will be published after revisions. The manuscript should be written more clearly. In addition, some additional information should be included. Major/minor comments and technical comments will be listed below.

Major/minor comments:
1. Introduction
Page 6950, line 23: The greatest warming potential. The GWP of N2O is indeed larger than the GWP of CH4 and CO2. However, there are some species with a larger GWP (see Table 2.14 of 2007 IPCC Fourth Assessment Report (AR4)).The sentence should be rewritten.
Page 6951 (line 28) – Page 6952 (line 18): This part should be rewritten. The following aspects should be written more clearly. The gap of knowledge, the objectives, the way in which the research is performed. For example: there have been published already some other papers in which the performance/suitability of spectroscopic techniques is evaluated (e.g., Eugster et al., 2007, Kroon et al., 2007). Euster et al., 2007 and Kroon et al., 2007 focus both on quantum cascade laser spectrometer N2O EC flux measurements. The author should indicate this in the introduction. In addition, the author should check if there are some articles available about the performance of TDL EC flux measurements of N2O. Then, the author should describe better the gap of knowledge and the related objectives of this paper (For example: 1. Detailed evaluation of the main error sources and uncertainties 2. Derive recommendations how to treat data for post-processing) Next, the author could tell how they will reach this goals. For example: Using the datasets ... over a period ...

Some more small points which could be improved: For example: some parts are now written twice; that EC fluxes are compared with chamber measurements (at line 4-6 and 16-17).
After the second objective, recommendation how to treat data for post-processing, the post processing elements which are discussed in this paper could be listed.
Which parts are new in comparison with CO2 EC flux measurements?

2. Site description and measurements
Page 6952 – 6952. The same characteristics of both measurements campaigns should be given. Some examples: Coordinates, precipitation rates and mean temperature are not given for the first campaign and are given for the second campaign. LAI is given for the first campaign and is not given for the second campaign.
Page 6954, line 12: Both TDL's were calibrated once during the measurement period? Did the author check if the calibration factors were constant in time?

3. Methods
3.1 EC measurements: data processing and corrections
General: In the introduction, the author noted that a detailed description will be given of the main error sources and uncertainties. That's why; it is recommended pointing out the possible errors and uncertainties more clearly. For example: the author could start this section with how the fluxes are calculated (using LD and RM), then how the lag time is calculated and then they could list very shortly all possible errors, e.g. calibration error, low and high frequency response losses error, density fluctuations error. Then the author could describe the errors involved in this study and how they quantify theses errors/correct for these systematic errors.
Page 6954, line 23: Include the time period over which the linear detrending is performed.

3.2 Random error of flux estimates

Maybe, the author could couple section 3.1 and 3.2 better with adding one sentence at the beginning of section 3.2. For example: after applying corrections for all systematic errors, there are still some random errors/uncertainties left.
It will be interesting to include also the absolute uncertainty in 30 min EC flux values. This uncertainty can be derived using Businger et al., 1986.

$$u_{\mathsf{ran}} = \sqrt{(20Z/TU)}\sigma_{w'c'} \quad (1)$$

Businger, J.A., 1986. Evaluation of the accuracy with which dry deposition can be measured with current micrometeorological techniques. Journal of climate and applied meteorology, 25, 1100-1124.
In the present manuscript, only the uncertainties of sensible heat and N2O EC fluxes can be compared. The absolute magnitude as function of EC flux magnitude will be very interesting to add to this manuscript.

4. Results
General comments:
In my opinion, the structure should be changed to improve the manuscript. Section 4.3 should be included in section 4.1. Both sections are devoted to how researchers should deal with instrumental drift. Section 4.2 should be included in section 4.6. Below, I will describe in more detail which parts could/should be improved for publication.

4.1 TDL system stability and performance
The author noted very well which requirements are needed before drift could be contaminate to the flux. Then it should be noted more clearly that first point 1 is addressed and than point 2. Point 1 is addressed partly by the Allan variance versus FFT comparisons. Point 2 is addressed using co-spectral analysis (section 4.3 which could be better included in section 4.1).
As noted at line 7 of page 6962, at the Soro site there is a smaller laser drift effect.

Therefore, it is recommend including also a Figure of the Soro site in Figure 1 and in Figure 2.
Allan variance stability time is 50 s, however, it will be good to note some examples given in other studies (For example given in Nelson et al., 2004 and Kroon et al., 2007)
Nelson et al., 2004. High precision measurements of atmospheric nitrous oxide and methane using thermoelectrically cooled midinfrared quantum cascade lasers and detectors, Spectrochimica Acta Part A, 60, 3325-3335.

4.2 Co-spectra
Page 6960, line 23-25. At the low frequencies there are negative and positive contributions? So what's the net effect of the laser drift? Does it give a flux under- or overestimation?
It will be important to note the effect on the flux values when using a 50 s RM, 100 s RM etc? If we use a 50 s RM do we miss real contributions which should be added to the flux? How could we correct for these missing contributions? What will be the correct data processing method? (Just a guess: Should we first check the Allan variance stability time, then performing a RM filter with that time and next correcting the missing contributions using sensible heat or other spectra??)

4.3 Flux systematic error
State here that only the high frequency losses systematic error is discussed in this section. It will be of added value when the low frequency losses systematic error is also included to this section.
It should be stated if the separation distances are horizontal and/or vertical.

4.4 Flux random uncertainty
It will be a great added value when the absolute uncertainty of 30 min EC fluxes is also evaluated in this section. (See comment above with reference of Businger et al., 1986)

4.5 Comparison with chamber fluxes
In my opinion, the footprint Figure could be skipped and a short summary of the footprints of both EC flux towers could be included in this section.
Before comparing EC fluxes with chamber data, it will be important to note which corrections are made on the EC flux values. (For example: the high frequency response corrections as discussed in section 4.5 are these corrections performed on the used data in the comparison?)
Is it fair to remove the fluxes with a relatively large uncertainty?
Could you explain why the EC fluxes and chamber measurements are much more comparable at the Kalevansuo site than at the Soro site? Is this possible due to missing contributions of eddies with time scales larger than 50 s?
The EC values are smaller than the chamber flux values. Could this be explained by the missing eddies with time scales larger than 50 s?

Conclusions
Page 6966, line 6-9. They are not really in good agreement. It will be better to give a percentage of the difference between both emission estimates.

Table 1
Could the author indicate if the spatial separation was vertical/horizontal or both?

Figure 1
Both Figures should be made in the same lay-out. In addition, the unity of T should be included.

Figure 2
Include unities (For example Allan Variance [ppb2]). Include a -5/3 line in the middle range of Figure 2c. in addition, the measurement site could be noted in the caption.

Figure 3
The average used z/L value could be indicated in the caption.

Figure 8
AC should be explained in the caption.

Technical comments:
Abstract
Page 6950, line 1: Include (N2O) after nitrous oxide
Page 6950, line 8: Abbreviation EC is already introduced at line 1 after this introduction EC can be used instead of eddy covariance
Page 6950, line 19: Include , after however.

Introduction
Page 6951, line 6: Include (EC) after eddy covariance and use the abbreviation EC in the whole text after this point.
Page 6951, line 10: Include e.g. before Aubinet et al., 2000. There are more papers written about the methodology of EC flux measurements.
Page 6951, line 26 is related should be changed into are related

Site description and measurements
Be consistent. For example: Page 6952, line 21, east-west and Page 6953, line 20 southwest.

Methods
EC measurements: data processing and corrections
Page 6954, line 24: Include , after however
Page 6955, line 14: Include bracklets Werle et al. (1993)
Page 6955, line 22: Change de-trended into detrended

Results
4.1 TDL system stability and performance
Page 6957, line 16 space between 10 and Hz.
Page 6958, line 1-6, sentence should be written more clearly.
Page 6958, line 7, is displayed should changed into are displayed.

4.6 Flux random uncertainty
Page 6962, line 24: include , after however.

References
The references are a mess. Some references are included which are not given in the text. There are also some references given in the text and not in the referee list. A list of mistakes is given below. However, the author should also check this very carefully by himself.

Given in text and not in referee list:
Ambus and Christensen, 2005
Amiro et al., 1990
Brodeur et al., 2008
Cava et al., 2005
Hernandez, 1986
Horst, 1997
IPCC, 2001
Kaimal and Finnigan, 1994
Laville et al., 1999
Lee et al., 2004
Lenschow, 1994
Lumley and Panofsky, 1964

Moore et al., 1996
Nelsen et al., 2002
Scanlon and Kiely, 2003
Silver et al, 2005
TDL manual
Vickers and Mahrt, 1997
Webb et al., 1980

Given in referee list and not in text:
Conen and Smith, 2000
Fowler et al., 1995
Hutchinson and livingston, 2001
Kroon et al., 2008
Pihlatie et al., 2007
Rochette, 2008

In text Laville et al., 1999 and in reference list Laville et al., 1996. This should be checked.
Werle et al., 2008 should probably be removed as reference since this reference is probably not easy to find.

Interactive comment on Biogeosciences Discuss., 6, 6949, 2009.