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Atmospheric Measurement Techniques
Discussions

Interactive comment on "Evaluation of a lower-powered analyser and sampling system for eddy-covariance measurements of nitrous oxide fluxes" *by* Shannon E. Brown et al.

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1. Being a method paper, it'd be useful to see some cospectra (in order to be convinced that all of the fluxes are captured). I recognize that small fluxes lead to noisy cospectra, but the authors could look at the brief period(s) when the N_2O fluxes were very large. Do all the sensors show agreement? This would also enable a direct comparison of high frequency flux loss between the frequency response method (which the authors have focused on so far) and the cospectral/ogive method.

A supplement (S2) was added to the manuscript to provide spectral figures for the time period when there was an N_2O flux event. This showed that both TDLAS analyzers had similar spectral characteristics, and that both analyzers when using a non-optimized intake system capture the majority of the flux information. The cutoff frequencies calculated from the cospectral analysis were greater than 2 Hz.

It is difficult to directly compare the cospectral and frequency-response methods of calculating the absolute values of f_c. The cospectral method is highly dependent on the adherence of the spectra to similarity scaling. It is also affected by sensor separation and by imperfect synchronization of the scalar with vertical wind. For these reasons we believe the impulse response test provides a more accurate estimate of f_c, and we have included cospectral analysis in a supplement rather than the main body of the paper.

Included in Results (line 11 page 17):

Response times calculated using measured cospectra are included in the Supplementary Materials.

2. The authors have reported frequency response times, but what kind of flux loss do they amount to under typical atmospheric conditions? The authors have presented the equations to estimate this but haven't provided any numbers (that I could see). This information would be informative for readers.

Included at line 3 of page 17 :

Spectral losses (equation 7) calculated with the f_c were on average 5% of the measured flux for the TLDAS-TE and 7% for the TDLAS-LN.

3. It would be useful to know what the flux detection limits are. There is a lot of interest now in knowing the emission of N_2O from the ocean (especially low-oxygen regions). However per m^2 the N_2O flux over the ocean is typically orders of magnitude lower than fluxes over land. Would this sensor be able to detect oceanic N_2O flux? There are multiple ways of estimating the flux detection limits. See this paper as an example: https://www.atmos-meas-tech.net/9/5509/2016/

Included in Methods (line 11 page 14):

Flux detection limits (δF) were calculated using the method described in Blomquist et al. (2010) and Yang et al. (2016) where the detection limit is calculated using the instrument noise and the variability of the concentration signal:

$$\delta F = \frac{2\sigma_w}{\sqrt{T_f}} \left[\sigma^2_{C_a}\tau_{wc} + \frac{\varphi_{Cn}}{4}\right]^{1/2} [8]$$

such that σ_w is the standard deviation of w, T_f is the flux-averaging period, $\sigma^2_{C_a}$ is the ambient variance of the concentration signal, τ_{wc} is the integral timescale for the ambient concentration variance, and φ_{C_n} is the band-limited analyzer noise. The φ_{C_n} was calculated as the mean of the variance spectra from 1 to 5 Hz. Values of $\sigma^2_{C_a}$ were calculated as the second point of the autocovariance of the concentration signal (Yang et al. 2016). Blomquist et al. (2010) estimated τ_{wc} using the peak frequency of the variance cospectrum. Peak frequencies here were modelled via the equation given in Horst (1997).

Included in Results section (line 8 page 18):

Figure 7 shows the mean variance spectra of the N_2O signal from each TDLAS analyzer for a period of 10 days where no N_2O fluxes were observed (29 June 2016 to 9 July 2016). The variance spectra of both analyzers were dominated by instrument noise as N_2O emissions were at background levels. Values of φ_{C_n} were 0.28 ppb^2 Hz^{-1} for the TDLAS-TE and 0.22 ppb^2 Hz^{-1} for the TDLAS-LN. When considering only instrument noise, detection limits with mean conditions of U = 3.5 m s^{-1}, z = 4 m, and σ_w = 0.5 m s^{-1} were 6.6 ng N_2O-N m^{-2}s^{-1} for the TDLAS-TE and 5.2 ng N_2O-N m^{-2}s^{-1} for the TDLAS-LN. Incorporating signal noise increased δF_{N2O} to 9.9 ng N_2O-N m^{-2}s^{-1} for the TDLAS-TE and 19.6 ng N_2O-N m^{-2}s^{-1} for the TDLAS-N. Despite the lower instrument noise, concentration signals of the TLDAS-LN were less steady than the TLDAS-TE during the period evaluated ($\sigma^2_{C_a}$ of 0.27 ppb^2 and 0.042 ppb^2, respectively).

Figure 7: Mean N_2O variance spectra of each TDLAS analyzer from 29 June 2016 to 9 July 2016.

4. That the sensor is sensitive to motion (generated by wind) is a bit concerning. Any idea why and any effort in trying to reduce this sensitivity (rather than just securing the sensor better/in a more sheltered location)?

This motion sensitivity is caused by Fabry-Perot interference, a consequence of unwanted reflections within the optical path. This optical interference modulates the background of the spectral scan, causing an offset error in the concentration measurement. The optical system is not perfectly rigid, which allows wind-driven vibrations to introduce very small changes in optical alignment. These changes in alignment shift the position and shape of the optical interference pattern, thereby changing the offset error over time. However, a simple baffle along the side of the analyzer facing the mean wind direction, such in the way that the TDLAS-LN sheltered the TDLAS-TE, is sufficient shelter from strong winds. Compared to other EC-capable N_2O analyzers that require larger weather-proofed, temperature controlled enclosures, a baffle is a minor addition to an EC tower.

Included in Discussion (line 8 page 19):

A simple baffle the height of the analyzer (0.55 m) along the side of the analyzer facing the mean wind direction would provide sufficient shelter from strong winds (U > 5 m s^{-1}).

Please also note the supplement to this comment:
https://www.atmos-meas-tech-discuss.net/amt-2017-169/amt-2017-169-AC2-supplement.pdf

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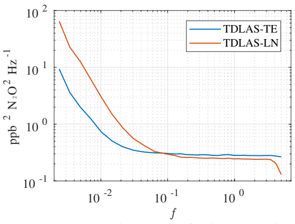

Figure 7: Mean N_2O variance spectra of each TDLAS analyzer from 29 June 2016 to 9 July 2016.

Fig. 1.