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Atmospheric Measurement Techniques Discussions

Interactive comment on "Comparison of two closed-path cavity based spectrometers for measuring air-water CO_2 and CH_4 fluxes by eddy covariance" *by* Mingxi Yang et al.

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Corrigendum

I wrote my review based on the manuscript uploaded to AMT 27 Jun 2016, which has continuous line numbering and was provided to the reviewers. The publicly available discussion version amt-2016-215.pdf is identical to this original manuscript, however the line numbering is reset for every page. Below is the same review but with adapted line numbering to match the discussion version.

General comments

In this submission the authors present direct Eddy Covariance measurements of CO_2 and CH_4 air-sea fluxes made with two commercially available cavity based spectrometers (a Picarro G2311-f and a Los Gatos Research (LGR) FGGA) on a coastal site. The two analysers are deployed side by side and the flux measurements are compared directly. The Picarro was most of the time deployed downstream of a Nafion dryer, while the LGR was sampling the air directly.

The authors address measurement issues like the under sampling of high frequency fluctuations by the closed path Eddy Covariance systems and the cross-sensitivity of the optical measurements of CO_2 and CH_4 to H_2O.

Different methods are used to calculate flux detection limits for CO_2 and CH_4 and these are put in context with global climatologies, providing useful guidance for the planing of future measurements of these gas fluxes over the open ocean.

The authors find that the CH_4 and CO_2 fluxes measured by the two analysers agree within the given uncertainties, but that the LGR showed much higher noise in the two flux signals than the Picarro. A discussion of the potential reasons for the inferior performance of the LGR, like suboptimal cavity ringdown time, less rigorous maintenance of a stable measurement cell pressure and temperature, as well as a less sophisticated H_2O cross sensitivity correction performed by the LGR is provided. In my opinion the addressing of the sample air density and H_2O cross sensitivity related corrections made in the LGR would benefit from some minor revisions.

Specific comments

Page 5, lines 8–10 "*As a result, we expect biases in CO_2 and CH_4 fluxes computed from Equations 1 and 2 only when the fluctuations in H_2O are large and are correlated with fluctuations in dry CO_2 and CH_4 mixing ratios (i.e. due to any residual cross-sensitivity with H_2O).*":

I find this sentence rather confusing: In general the fluctuations of the concentrations of all three gases should be highly correlated as they are transported by the same eddies. Biases in the CO_2 and CH_4 fluxes computed from Equations 1 and 2 would suggest that the cross-sensitivity model is insufficient or that the coefficients are inaccurate, e.g., when $b = d = 0$ is assumed for the LGR FGGA.

The relative magnitudes of the corrections made in the Equations 1 and 2 scale with the magnitude of the H_2O fluctuations (in the measurement volume) and with the ratio of the CO_2/CH_4 background concentrations to the ambient fluxes, which is typically the case for CO_2.

Page 6, lines 3–6: Based on the slow response to the flushing with pure nitrogen, I would speculated that the offset could be caused by H_2O sticking to the mirrors of the LGR cavity (or rather to the salt and dust particles mentioned in lines 214–215). How did the Picarro react to the flushing with pure nitrogen?

Page 7, lines 15–17 *"Since the gas fluxes were computed using the same wind data and the two analyzers were sampling the same gas stream, differences between them are primarily caused by noise in the instruments, rather than by the presence of water vapor."*:

Based on the evidence provided I cannot follow this conclusion. It might well be that the relatively small H_2O cross sensitivity corrections, which are applied by the LGR, are insufficient. See also the next comment on Figure 5.

Page 7, lines 18–23 and Figure 5.: If the differences in the CH_4 and CO_2 measurements from the LGR (wet) and Picarro (dry) are caused by cross sensitivity of the LGR signals to H_2O one would expect a correlation with the latent heat flux measured by the LGR, but not necessarily with the predicted latent heat flux (the authors stated large

and variable losses in the H_2O flux signal measured by the LGR). I would therefore suggest to use the Latent heat flux measured by the LGR, instead of the predicted flux, as independent variable in Figure 5. The difference in the CO_2 fluxes measured by the two instruments should also be plotted as function of the latent heat flux measured by the LGR.

Page 7, lines 25–26: How where the coefficients for the here mentioned spectral line broadening correction for the LGR determined?

By using the Picarro (dry) CH_4 and CO_2 measurements as reference signal, you could calculate spectral line broadening coefficients for this specific LGR instrument in real time. Are these estimated coefficients constant or do they change in time? The latter might indicate a similar cross sensitivity effect as for the non-dispersive infra red gas analysers (Prytherch et al. 2010, Blomquist et al. (2014), and Landwehr et al. (2014)).

Page 8, lines 3–4: Did you get a chance to verify this by opening the cavity? The presence of salt and dust particles in the cavity might also explain the slow response to the flushing with N2, mentioned in the lines 155–159.

Page 8, lines 12–16: Were the temperature and pressure in the cavities measured and used to account for dilution effects on CH_4 and CO_2 (Webb correction)?

Page 11, lines 1–5: For the estimation of the high frequency loss in the gas fluxes, it might be more adequate to use the sensible/virtual heat flux cospectra measured by the (open-path) sonic anemometer, instead of the momentum flux cospectra.

Figure 3: Do the authors have any suggestions, what may cause the large scatter

apparent in the difference between the LGR fluxes from numerically dry and ambient mixing ratios of CO_2 and CH_4, while the same difference appears to be a solemn function of the humidity flux for the Picarro?

Page 12, lines 24–27 and Figure A2: I would suggest to add a trend line to the data shown in Figurer A2. To me the difference in the drag coefficients looks more like 30% of the CORARE 3.5 drag coefficient.

From comparing the Picarro (wet) and Picarro (dry) measurements can you find any effect of the Nafion dryer on the CO_2 and CH_4 flux detection limits?

Technical corrections

Page 5, lines 11-12:: I would suggest to add the uncertainties of the slopes and intercepts.

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