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Atmospheric Measurement Techniques Discussions

Interactive comment on "Dried, closed-path eddy covariance method for measuring carbon dioxide flux over sea ice" *by* Brian J. Butterworth and Brent G. T. Else

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Review

This paper describes a system for measurement of air-sea and air-ice CO2 flux using the eddy covariance method and dried, closed-path infrared gas analyser instrumentation. The novel aspects are the successful deployment of such instrumentation in a particularly challenging environment (The Canadian Arctic) and the technical challenges overcome in doing so. The authors also present convincing evidence that the flux measurements from their system are plausible, and that the closed-path system performs much better than the different instruments (open-path infrared gas analysers)

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Discussion paper

previously used in such environments.

The paper is well written, well structured and thorough. I have a few questions and comments for the authors and some minor corrections. With these addressed, I am very happy to recommend this manuscript for publication in Atmospheric Measurement Techniques.

Comments

Section 2.1. and later. I felt like a little more discussion of the flux footprint might be useful. The far reaches of the footprint certainly seem likely to be over water (e..g the Kljun et al., 2015 model suggests for a 10 m tower the footprint doesn't extend further than 1km). However there can be significant influence from land close to the measurement site (20-100m). On page 8, line 11, you state that winds were selected within 150 deg of the front to reduce flow distortion from the mast and instruments but also because they included land in their footprint. From the photos and video provided, it appears that a far greater wind sector is potentially affected by the island. As the discussion on page 9 and fig 7. makes clear, most of the winds come from the southeast or southwest. It is also stated that the front of the tower facing the water is North. This at least suggests many of the measurement periods had winds blowing over a substantial part of the island. From the information given it is hard to determine how significant this might be. Further discussion, and a more detailed map showing the island itself, and the position and facing of the mast, would be useful additions. If it is the case that for many of the measurements, significant land (ie greater than say 20m) is within the footprint, then an estimate of this influence on the measurements should be made, using for example the footprint model above.

Section 2.2.1. Did the authors have any issues with ice formation, either on the sonic or the open path gas analysers? The model of sonic used does not appear to have any heating element. My experience is that for sonics, affected periods are straightforward to identify but this is not always the case for (open path) IRGAs. Did the authors use

any particular method to identify icing periods?

Section 2.2.2. Newer versions of the Li-7500 have a 'cold weather' mode, designed to reduce some of the biases apparent in these conditions. Did the model used in this study have such a mode and was it used or tested?

Section 3.1 and Figure 6. Humidity units are given in ppt. Presumably this is parts per thousand. My preference would be not to use this to avoid confusion with parts per trillion.

Section 4.4. The authors note that high spatial and temporal variability in the pCO2w measurements. Is this a potential explanation for the low frequency flux signal observed (ie 2.3.1), either from the temporally varying pCO2w itself, or from varying wind directions and the spatial variation in pCO2w?

Section 4.4, page 13, line 13. I think the statement that open-path IRGAs are not capable of providing accurate FCO2 measurements in the marine environment is somewhat overstated. As shown in Blomquist et al., 2014, the open path 7500 instrument has a lower sensitivity/signal to noise than the closed path 7200, and particularly the dried closed path instrument. If the flux is large enough (ie a large delta pCO2) then an open path instrument can work well. When the flux is small, they perform badly. I think this is not necessarily a marine issue (e.g. Landwehr et al., 2014 showed that error in open path measurements did not seem to depend on the presence of hygroscopic particles (salt) as previously thought), though of course marine, and especially sea ice environments typically have much lower CO2 fluxes than found on land. The sentence here should be slightly changed, perhaps to 'measurements in the relatively low delta PCO2 conditions typically found in the marine environment'.

Section 4.6. The limit of 40 uatm for deltapCO2 has been widely used historically, but I think it can be misleading. It was commonly used as a limit on ship-based studies with additional motion-based sources of noise. It may also be more appropriate for different instrumentation than that used in this study. The author's themselves use a limit of 20

uatm elsewhere (Figure 12) so maybe just omit the value here.

Corrections

Page 9 line 8. typo, change to ‘snow-covered sea ice’.

Page 9 line 16. Not clear which period you are referring to. I think to the whole period presented in the paper, so perhaps change to ‘through the study period’.

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