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Atmospheric Measurement Techniques Discussions

Interactive comment on "The NASA Carbon Airborne Flux Experiment (CARAFE): Instrumentation and Methodology" *by* Glenn M. Wolfe et al.

Anonymous Referee #1

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General Comment: The paper by Wolfe et al. describes airborne eddy covariance measurements on a C-23B Sherpa aircraft. It summarizes results from flights in the eastern US. The general topic is suitable for AMT, but there are a couple of issues that need to be addressed before publication. In particular, the discussion on errors needs revision.

Specific Comments:

It is not clear whether a Webb correction was necessary for CO2 and H2O fluxes, and how this was incorporated in the flux analysis code. The 10Hz humidity correction for the LGR instrument mentioned on page 5 (line 31) seems tricky – since there was a

redundancy of humidity measurements, a better experimental setup would have been to use a Nafion dryer for the EC system and just focus on CO2 and CH4 to avoid this problem all together. As the data are treated it is not clear to what extent the water vapor flux influences CH4 and CO2 fluxes, or how the correction procedure would degrade the precision of the flux calculation, given the large random errors of 10 Hz concentration datasets.

According to eq. 12 the turbulent random error should always be smaller than the combined error which includes instrument noise. Inspecting figure 7 actually shows the opposite for most tracers; the relative turbulent error is larger than REFS01 for T, H2O and CO2; this contradicts the theory. An explanation is needed – could there be a calculation error in the analysis code?

Eq. 12 is cast in the time domain. For aircraft measurements the time domain is not really meaningful. The discussion of errors should be handled in the spatial domain. For example, a cut off frequency of 0.02 Hz corresponds to a distance of 3.75 km at the aircraft speed of the C-23B Sherpa. The same criterion would correspond to a 12 km distance on a G5-aircraft.

The issue of spatial vs. temporal scale should be treated consistently throughout the manuscript. While the error discussion is treated in the time domain, some figures show a spatial, others a temporal scale. Figures 5 and 9 should be modified to show a spatial scale as well.

Total error: Systematic errors inherent to unresolved scales always lead to an underestimation of fluxes and should be used to correct the data rather than adding these to a total error. Adding systematic errors to the total error is generally only admissible, if they are not separable from other errors or if their sign cannot be defined. Neither is true for SErt and SEturb. Additional systematic errors for surface fluxes arising from flux divergence are discussed separately but should probably be part of section 3.4.

Repeatability: it is mathematically not sound to simply average second moments as

presented in Figure 11 (see for example: https://www.eol.ucar.edu/content/combining-short-term-moments-longer-time-periods). Within the uncertainty of the presented data it might not make a large difference for Figure 11, but it would be worth double checking using the correct averaging formula.

Figure 6: the plotted differences are likely caused by a dramatic increase of systematic errors (eq. 7) towards the edges of the CWT – could the calculated flux ratios improve when accounting for these SE ? (e.g. by introducing a weighted SE along the CWT). To be more specific, the COI cuts off a substantial part of the frequency domain towards the edge of the CWT which should result in a systematic flux underestimation according to eq 7.

Minor Comments: Figure 8: How high was zi? Figure 9a: A label for the CO2 and CH4 instrument should be added (e.g. LGR)

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