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Atmospheric Measurement Techniques Discussions

Interactive comment on "A disjunct eddy accumulation system for the measurement of BVOC fluxes: instrument characterizations and field deployment" *by* G. D. Edwards et al.

Anonymous Referee #2

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This paper describes VOC flux measurements using the method of eddy accumulation coupled with disjunct sampling (Disjunct Eddy Accumulation, DEA). This is not a new technique (first implemented and by Rinne et al., 2000), but it has not been the subject of many subsequent studies and many aspects of the technique are yet to be explored. Therefore, it is worthy of publication upon first considering the following remarks:

General Comment: The major point of contention with this manuscript is the use of a sampling threshold or deadband with the DEA technique which excludes sampling of the small eddies (small w'). This is contrary to the basic theory of both eddy accumulation and disjunct sampling and should lead to a systematic overestimation of the flux by artificially increasing the concentration difference, or ΔC, between the up and down reservoirs. The authors do note this and show that by assuming scalar similarity and simulating the DEA sampling with temperature, this overestimation is small ($\sim$8-9% on average) and can be corrected for. Since corrections based on similarity are necessary, this is technically not a "direct flux" measurement per se anymore.

Although the methods used for correction seem appropriate, at some point, one must step back and ask: What is the advantage of using a sampling threshold (or deadband) with the DEA technique? In the analogous Relaxed Eddy Accumulation (REA), the use of the 0.6σw deadband typically increases the concentration differences by $\sim$ 1/3 which is compensated for by re-computing the empirically-derived b-coefficient (see description in manuscript, pg 2718, lines 14-20). This b-coefficient usually decreases from about 0.6 (no threshold) to $\sim$ 0.4 (with 0.6σw threshold). The authors show that the use of a DEA threshold only leads to an 8-9% overestimate in the heat flux. This is tantamount to saying that one has increased ΔC by 8-9%. This is an expected result since the small eddies are sampled proportionately (as opposed to REA where the flow is constant and all eddies are sampled equally) and should only constitute a small amount of the total sample volume within the different reservoirs. So, the question becomes: Does an increase of $\sim$ 8-9% in ΔC result in marked improvement in the precision of the concentration analysis to offset the uncertainty that is added by the need to make similarity corrections?

Other points discussed by the authors as reasons for using a sampling threshold are (1) incorrect volume measurement for very small samples (small w') and (2) errors in measuring small w' values by the anemometer. I would suggest that both of these are very minor issues since the w'-values where these are important are very small and will likely only contribute less than 5% to the total sample volume in either reservoir. For example, erroneous sample volumes that are 30% too low (maximum underestimate at sample time of $\sim$ 1 sec, see Figure 2) will likely only result in a 1 or 2 % error

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(possibly less?) in the total reservoir sample volume since they occur infrequently and contribute such small amounts of volume. In summary, although a sampling threshold can be used with DEA and corrected for accordingly as done in this manuscript, the fact that you are collecting sample volume proportional to the vertical wind velocity makes the use of this threshold relatively unnecessary.

Specific Points:

Equations (7) and (9). Reviewer #2 is correct – the first term on the right hand side should have the average of the absolute values – not the absolute value of the average. It is written correctly in Eqn (2).

Page 2706, lines 17-20. I would also include the flux-gradient methods as an "accumulation" method. Although not included in the name, air samples are often collected over some time period and analyzed later offsite.

Page 2707, line 9. "...and with mechanically undisturbed wind measurements..." Is this not true of any flux methodology?

Page 2709, Eqn. 9. Since the authors are using the planar fit method to rotate the coordinate system, this should minimize the second term of the rhs of Eqn (9). How different are the flux values upon using Eqn (9) relative to the simplified Eqn (2)?

Page 2711, lines 14-24. I am a bit concerned on how well isoprene is trapped on Tenax-TA. Our experience has always been that we need to cool the tubes below about 15oC to get quantitative adsorption of isoprene with Tenax-TA. Please briefly describe the lab tests that were done to look at isoprene breakthrough. One further point – I assume that the 28oC field temperature in line 23 is the ambient temperature. However, what is more important is the temperature within the DEA sampler which could be several degrees warmer than ambient when sitting out on the tower, depending upon the ventilation, pumps and heating devices within the sampler. The authors should comment on if they believe this could be a potential problem.

AMTD

5, C1301–C1305, 2012

Interactive Comment

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Page 2714, line 6-7. In terms of improving the overall technique, what factors could be improved in order to have smaller uncertainty (in other words – where is the largest source of uncertainty in Eqn. (9)).

Page 2714, line 9-13. Was the sonic anemometer and DEA inlet also located at the sampler height (26.6 m). If so, this seems very close to the average canopy height of 24 m (only 2.6 m above canopy). For a reasonably rough canopy typical of a deciduous forest, care must be taken since similarity relationships are not as robust and turbulence is not as homogeneous this close to the canopy. Typically flux measurements are often made ~10 m above the canopy.

Page 2715, first paragraph. I assume that the planar fit rotation angles were applied on-line to the wind velocities during the DEA sampling.

Page 2718, line 18-20. I believe this is incorrect. For DEA with no sampling threshold, no correction factor is necessary. But, since this work uses a sampling threshold, this causes a systematic overestimate of ΔC (and, thus the flux). Even though fairly small, it is true that an empirical correction is necessary for these measurements.

Page 2719, line 2 – should read "Bowling et al., (1999)"

Page 2719, line 16-17. However, the 8.6% difference is a systematic overestimate as opposed to random uncertainty. There is a difference here.

Page 2723, line 14. The authors state that "no calibration standards" were available. However, the FID used responds on a per carbon basis – therefore, calibration with any hydrocarbon can be used to quantitate all other hydrocarbons. It is true that one needs to know what the retention time of the other monoterpenes – this does require some type of sample of the known compound.

Page 2724, first paragraph. In discussing monoterpene concentrations and comparing them with previous studies it is important to relate the average temperatures during those measurement periods. The measurements here showed slightly lower concen-

AMTD
5, C1301–C1305, 2012

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trations, but that could just be due to lower temperatures during this sampling period.

Page 2725, section 9. It is not surprising that fluxes compare better than concentration measurements. The flux comparison only relies on scaling up of the leaf-level measurements whereas determining concentration in the 1-d model also relies on how well the loss processes (chemical losses) are simulated (in addition to the scaling up issues). Overall, it seems that this modeling exercise is a bit overly complicated and uneccessary – why not just plot your flux measurements as a function of temperature and then plot equation (14) with an appropriate β-factor (page 2726, lines 7-9) for this canopy. This should show if the measured fluxes are reasonable or not.

Page 2727, lines 20-22. Given the large modeling uncertainties shown in Figures 9 and 10, it would seem that just about any measurement would lie "within the uncertainty". This is why I would contend that a simpler comparison such as described in my last comment is a more robust metric than the 1-D model.

Page 2729, line 4. The authors suggest that smaller thresholds could be used – as mentioned in my general comments – I would contend that thresholds are not necessary at all in the DEA technique.

Figures 7 and 8. Even though the DEA flux measurements are discontinuous throughout the day, I would assume that the ambient temperature measurements are not. I would recommend plotting the entire day of temperature measurements so readers can see these changes over the entire course of the day.

Interactive comment on Atmos. Meas. Tech. Discuss., 5, 2703, 2012.

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