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Atmospheric Measurement Techniques Discussions

AMTD

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Interactive Comment

Interactive comment on "Evaluation of the flux gradient technique for measurement of ozone surface fluxes over snowpack at Summit, Greenland" *by* F. Bocquet et al.

Anonymous Referee #1

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The study presented is a very thorough investigation of using the flux gradient method for determination of ozone fluxes over snow. Since the surface fluxes are quite small, a method with high measurement precision is necessary to resolve the very small concentration differences observed. The investigators are very careful in their approach and pay strict attention factors that influence the instrumental precision of their ozone, temperature and wind speed gradients. Overall, this manuscript is quite thorough and the method is explained well. It is of suitable interest and quality that it should suitable for publication by Atmos. Meas. Tech. with a few minor changes.

General Comment: Since instrumental precision is of such paramount importance in determining the small ozone exchange velocities (or concentration differences with height), I am curious as to why the investigators chose to use three separate analyzers to measure ozone at the three heights as opposed to a single analyzer that would switch between levels. I am not suggesting that there is anything wrong with the current work, but if the precision of a single analyzer is 0.02-0.03 ppbv (pg. 1040, for averaging thirty 1-min measurements), then if you only spent 10 minutes on each level with a single analyzer (during a single 30 min. flux period), one would expect the ozone gradients to be good to $\sim$ 0.04-0.05 ppb (dividing by square root of 10 instead of 30, pg. 1040). This is nearly a factor of two better than the reported $\sim$ 0.1 ppbv overall uncertainty reported on pg. 1040 when the differing instrument offsets were factored in. One would have to cycle through the levels relatively quickly (e.g., 1or 2 min./level) to obtain a representative average concentration at each level and would likely still have to bring the inlets to a common height to test for the possibility of differing losses in the individual lines.

Specific Comments: pg 1023, lines 6-12. It may be worth mentioning that although it is much easier to measure the ozone gradients within the snowpack, it is exceedingly difficult to quantitatively ascertain the flux from these types of measurements due to the difficulty in estimating gas diffusion within a constantly changing snowpack, as well as steep gradients in solar irradiance and other chemical constituents within the snowpack that may play a role in the ozone loss. (there are also sampling issues within the interstitial snow)

Pg. 1024, line 24. I am not sure that there is much distinction between the “gradient method” and the “gradient profile method”. Another name is typically the “aerodynamic profile method” (note that Section 3.1 is titled: Aerodynamic gradient method).

Pg 1027, line 20. Is showing the ideal gas law really necessary? Merely stating that you use it along with ambient temperature and pressure measurements to convert mixing ratio to density should be sufficient.

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Pg 1030, line 5. The authors state that ozone losses through all of the system components was less than 2%, but this is nearly 1 ppbv (at 50 ppbv ambient concentration) which is large compared to the gradients you are measuring. The field tests described later where all instruments sample from the same height are more instructive as they not only test for instrument offset, but also for bias (or losses) that differ from inlet to inlet.

Pg. 1031, lines 23-25. The sentence concerning "temperature fluctuations from vertical temperature gradients.... as well as from sensible heat flux..." is a bit redundant. If you have vertical temperature gradients, this implies a sensible heat flux (and vice versa). Since you are looking at mean quantities (and not fluctuations from that mean), I do not think that fast temperature fluctuations are a concern here. On a further note, how do you know that the temperature fluctuations have been equilibrated? For non-conducting sample line material, Leuning and Judd (Glob. Change Biol., 1996, 2, 241) suggest that it can take several hundred meters of tubing to equilibrate temperature fluctuations.

Pg. 1034, line24. Should be the "von Karman constant" (not "van", this occurs several other places in the manuscript).

Pg. 1035, paragraph beginning on line 26. What was the lower wind speed threshold used for filtering the data? It seems that there may be a subset of data where the lowest height would be below this threshold, but a gradient flux could still be obtained from the two highest inlets. Although less reliable (since no corroborating lower gradient), these could still be useful flux data.

Pg 1037, lines 15-18. The corrections applied do assume that you are always operating within the linear range of the instrument. For example, if there are nonlinearities in the wind speed response at low wind speeds, they may not be apparent in a side-by-side intercomparison; however, they may result in a bias when applied to gradients where one is measuring two different wind speeds at two heights.

Pg. 1041, lines 21-27. This behavior is somewhat typical for all gradient flux measurements. As there is more turbulent mixing – the gradients become more difficult to measure. The observation that the highest fluxes also have the largest uncertainty suggests that the flux may be dependent upon turbulent mixing. A plot of the flux vs. friction velocity for periods of similar irradiance might be useful to discern this. This would not be unexpected given the prior evidence for pressure pumping in the upper layers of the snowpack.

Pg 1042, Ozone deposition results. Where there any systematic difference between fluxes determined from the bottom two levels relative to those determined using the top two inlets? The authors should discuss this as this can serve to prove that the measurements were made within the "constant flux layer" or indicate possible biases in the measurements.

Figure 5. Please clarify or describe what the legends represent in this figure. It is not clear what WS-10, WS-2, WS-30, Grad_10_2a, etc. stand for relative to what is described in the text.

Figure 8. Since many of these points overlay one another – it would help clarify if you used a different color for one of the data sets.

Interactive comment on Atmos. Meas. Tech. Discuss., 4, 1021, 2011.