Biases of CO_2 storage in eddy flux measurements in a forest pertinent to vertical configurations of a profile system and CO_2 density averaging

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- Analyses of CO_2 data at the Missouri Ozark flux site revealed the importance of CO_2 storage in the vertical air column beneath the measurement height in eddy covariance measurements to estimates of CO_2 exchange between a forest ecosystem and atmosphere.
- The study stressed the effects of sampling resolution and configuration in a CO_2 profiling system on the accuracy of CO_2 storage estimation. Without the correct configuration and calculation of storage contributions, estimates of net ecosystem exchange (NEE) of CO_2 can be substantially in error at calm nights and in the early mornings, which leads to an incorrect interpretation on whether an ecosystem is a CO_2 source or sink at those times.
- Vertical configurations of a CO_2 profiling system are much more important than the number of sampling levels in determining the effectiveness of this profile in estimating CO_2 storage.
- Relative to their volumes, lower canopy layers represent a disproportionately large contributor to the total CO_2 storage. A profile with an unsampled thin layer in the lower canopy produces larger biases than another one with an unsampled thick layer in the upper canopy (see table below). An optimized profile will contain higher vertical resolution in the lower canopy.

Sampling level in a profile (m)	Unsampled layer and its thickness (m)	Root mean square error for CO_2 storage (μmol m^{-2} s^{-1})
30.48, 22.86, 16.76, 12.19, 9.14, 6.10	6.10 m between ground and 6.10m	1.117
30.48, 22.86, 16.76, 12.19, 6.10, 3.05	6.09 m between 6.10 and 12.19 m	0.722
30.48, 22.86, 16.76, 9.14, 6.10, 3.05	7.62 m between 9.14 and 16.76 m	0.888
30.48, 22.86, 12.19, 9.14, 6.10, 3.05	10.67m between 12.19 and 22.86 m	0.981
30.48, 16.76, 12.19, 9.14, 6.10, 3.05	13.72 m between 16.76 and 30.48 m	1.034

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CO_2 storage in a 30-minute period in a tall forest canopy often makes significant contributions to net ecosystem exchange (NEE) in the early morning and at night. When CO_2 storage is properly measured and taken into account, underestimations of NEE on calm nights can be greatly reduced. Using CO_2 data from a 12-level profile at the Missouri Ozark flux site, we demonstrate that the lower canopy layer (below the thermal inversion) is a disproportionately large contributor to the total CO_2 storage. Effects of resolution and configuration in a profiling system on the accuracy of CO_2 storage estimation are evaluated by comparing subset profiles to the 12-level benchmark profile. It is demonstrated that the effectiveness of a profiling system in estimating CO_2 storage is not only determined by its number of sampling levels but, more importantly, by its vertical configuration. In an optimized profile, the lower canopy should contain a higher resolution than the layers above. If a higher resolution in the lower canopy is constructed at the expense of upper canopy (an oversparsely sampled upper canopy relative to an overdense coverage in the lower canopy), however, the performance of a profile system might be degraded. If CO_2 density from a single profile is averaged in time and then used in assessing CO_2 storage to reduce random errors, biases associated with this averaging procedure become inevitable. Generally, larger window sizes used in averaging CO_2 density generate poorer estimates of CO_2 storage. If absolute errors are concerned, it appears that the more significant the CO_2 storage is during a period, the larger effects the averaging procedure has.

Yang, B., P. J. Hanson, J. S. Riggs, S. G. Pallardy, M. Heuer, K. P. Hosman, T. P. Meyers, S. D. Wullschleger, and L.-H. Gu (2007), Biases of CO_2 storage in eddy flux measurements in a forest pertinent to vertical configurations of a profile system and CO_2 density averaging, *J. Geophys. Res.*, *112*, D20123, doi:10.1029/2006JD008243.