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Estimating a Lagrangian Length Scale using CO_2 Measurements in Two Plant Canopies

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Studies of trace gas fluxes have advanced the understanding of bulk interactions between the atmosphere and ecosystems. Micrometeorological instrumentation is currently unable to resolve vertical scalar sources and sinks within plant canopies. Analytical Lagrangian equations capable of predicting concentration profiles from known source distributions provide the opportunity to calculate source/sink distributions through inverted forms of these equations. Previous studies have shown that the inverse equations generally produce reasonable source profiles in a variety of canopies. However, the inverse equations can be unstable and give erratic results. Uncertainty concerning estimates of the essentially immeasurable Lagrangian length scale (L_L), a key input to describe the transport of the scalars, compromises the source predictions. Most parameterizations of L_L are based on measurements of the Eulerian length scale. Recent research indicates that a possible cause of error is the inability of the L_L profiles to capture scalar movement in decoupled flow situations.

The present study seeks to investigate L_L in plant canopies by using field measurements to constrain the Warland and Thurtell (2000) analytical Lagrangian equation. Measurements of two sources, the net CO_2 flux and soil CO_2 flux, along with in-canopy profiles of CO_2 concentrations taken in a corn field and mixed forest near Toronto, Ontario, Canada, provided the information required to solve for L_L. The inversion to solve for L_L is also highly unstable. A test of the inversion with wind tunnel data of turbulence statistics, a known heat source, and temperature profiles from Coppin et al. (1986) shows that the parameter estimation routine is capable of closely estimating the measured Eulerian length scale. Inversions using the field data only produces erratic and nonsensical length scale profiles, which suggests that the flow in the canopy may not be captured by the length scale alone. Results contrasting the parameter estimations from both canopies will be presented.