EMS Annual Meeting Abstracts
Vol. 16, EMS2019-49, 2019

Flow Distortion Effects by Open-path Gas Analyzers for Eddy-covariance Applications

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Accurate measurements of 3D wind and turbulent statistics in the atmosphere are important for measuring energy fluxes by the eddy covariance technique. The sensible and latent heat fluxes provide information about the stability of the atmosphere and serve as a validation for short term weather prediction models. Field experiments often use a flux system consisting of a sonic anemometer for measuring wind and air temperature and an open-path gas analyzer for measuring water vapor and carbon dioxide concentration. However, the close proximity of the open-path gas analyzer can induce flow distortions that cause errors in the turbulence statistics. We present the results from a numerical flow simulation and a field evaluation of the flow distortions for two commonly used open-path gas analyzers. One analyzer has a pedestal-asymmetrical design, where the lower housing is larger than the upper housing. The other analyzer has a C-shaped design with identical small-diameter housings that are symmetrically positioned along the horizontal plane. We propose a method to assess the level of flow distortion from the two analyzers and their effect on the turbulence measurements by the sonic anemometer. The method relies on the comparison of double-coordinate rotation angles that are used to align the wind vector with the streamline coordinates. The stand-alone sonic anemometer is used as a reference. A planar-fit rotation method can be used as an alternative to evaluate wind directions with potential flow-distortion issues. The study concludes that the aerodynamic, C-shaped gas analyzer can be mounted closer to the sonic anemometer without affecting the measurement of turbulence statistics. The close co-location of the two instruments improves the quality of the flux measurements by preserving higher level of co-variance and minimizes the magnitude of the frequency-response corrections associated with sensor separation.