Sonic Anemometer Angle of Attack Errors

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Angle of attack or (co)sine errors are caused by the wakes formed downwind of sonic anemometer transducers. These errors occur when the vertical component of the wind velocity is non-zero, and they cause underestimation of the measured vertical wind speed. The importance of (co)sine errors in eddy covariance based mass and energy budgets have been established by past wind tunnel studies. In more recent field studies, these errors have been quantified in turbulent surface-layer flows. In the present study, (co)sine errors were estimated for over 100 combinations of angle of attack and wind direction using an RM-Young (8100VRE) sonic anemometer and a novel technique to measure the true angle of attack and the wind velocity within the turbulent surface layer. Corrections to the vertical wind speed varied from -5% to 37% for all angles of attack and wind directions examined. When applied to eddy covariance data from two Ameriflux sites, the (co)sine error corrections increased the magnitude of CO_2 fluxes, sensible heat fluxes, and latent heat fluxes by ca. 10%. A sonic anemometer designed with one pair of transducers aligned with the vertical axis (Applied Technologies, Inc., "VX" style) was also tested at four angles of attack (Fig. 2). Corrections to the vertical wind speed measured using this anemometer were within ± 1% of zero. Sensible heat fluxes measured using the Applied Technologies anemometer were ca. 9% greater than fluxes of sensible heat fluxes measured using the RM-Young. These results indicate that sensors with an off-axis transducer orientation, such as the RM-Young (Fig. 1), Gill, and CSAT anemometers, should be redesigned to allow for measurement of the vertical velocity using one pair of vertically aligned transducers, like the “Vx” style Applied Technologies anemometer (Fig. 2).

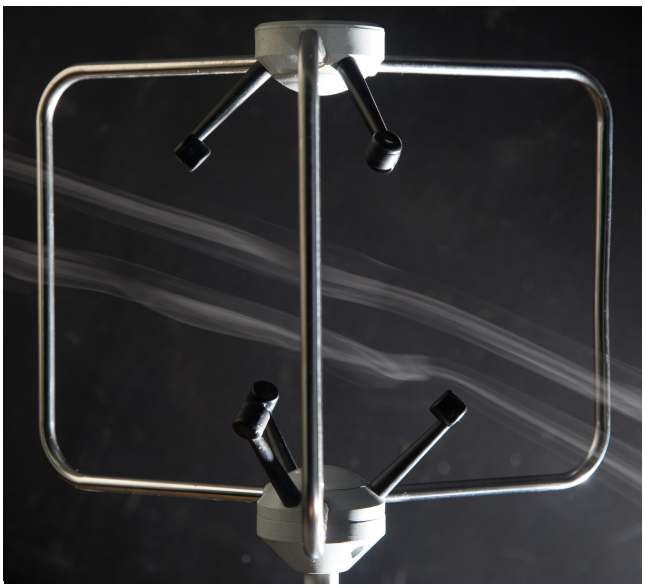

Figure 1. Photograph of a transducer wake in laminar wind tunnel flow.

Figure 2. Photograph of the Applied Technologies sensor (center) tilted 30° during the experiment.