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Advances in Fast Response Acoustically Derived Air Temperature Measurements

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Fast-response accurate air-temperature measurements are required when estimating turbulent fluxes of heat, water and carbon dioxide by open-path eddy-covariance technique. In comparison with contact thermometers like thermocouples, ultra-sonic thermometers do not suffer from solar radiation loading, water vapor condensation and evaporative cooling effects. Consequently they have the potential to provide more accurate true air temperature measurements. The absolute accuracy of the ultrasonic thermometer is limited by the following parameters: the distance between the transducer pairs, transducer delays associated with the electrical-acoustic signal conversion that vary with temperature, components of the wind vector that are normal to the ultrasonic paths, and humidity. The distance between the transducer pairs is commonly obtained by coordinate measuring machine. Improved accuracy demonstrated in this study results from increased stiffness in the anemometer head to better maintain the ultrasonic path-length distances. To further improve accuracy and account for changes in transducer delays and distance as a function of temperature, these parameters are characterized in a zero-wind chamber over the entire operating temperature range. When the sonic anemometer is combined with a co-located fast-response water vapor analyzer, like in the IRGASON instrument, speed of sound can be compensated for humidity effects on a point-by-point basis resulting in a true fast-response air temperature measurement. Laboratory test results show that when the above steps are implemented in the calibration of the ultrasonic thermometer air-temperature accuracy better than ± 0.5 degrees Celsius can be achieved over the entire operating range. The approach is also validated in a field inter-comparison with an aspirated thermistor probe mounted in a radiation shield.