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Field Intercomparison of Gas Analysers and Ultrasonic Anemometers for Eddy Covariance Measurements

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Eddy covariance is a well established and widely used methodology for the measurement of turbulent fluxes of mass and energy in the atmospheric boundary layer, in particular to estimate CO2/H2O and heat exchange above ecologically relevant surfaces. Despite its long term application and theoretical studies, many issues are still open about the effect of different experimental set-up on final flux estimates. Moreover recent instrumental and theoretical developments posed new questions to the micrometeorological community. In particular the sampling and sensing principles of gas analysers introduce several sources of uncertainty in the concentration measurement and in the consequent flux estimates. The open or closed-path design can be influenced by distinct physical variables, leading to different effects: the so-called WPL term affects mainly open path analysers, while high relative humidity has been recently recognized to introduce significant distortion in closed-path estimates of water vapour concentrations. These issues have been experimentally evaluated in a field test in which three kinds of analysers have been deployed above an agricultural site for a long enough period to span a wide range of micrometeorological and climatic conditions. Two closed-path, a LI-7000 and a prototypal LI-7200, and an open-path LI-7500 (all by LI-COR Biosciences Inc.) have been deployed for more than one year in the site of Roccarespampani (Italy, Lat. 42° 23' 25" N, Long. 11° 55' 15" E) in the framework of ICOS and IMECC research projects. Using a second LI-7000 we also estimated the impact of proper heating and thermal isolation and the quantitative relevance of water vapour attenuation in sampling tubes of closed-path analysers at different values of ambient relative humidity (RH). Results showed that high RH values cause significant high frequency attenuation of water vapour and consequent underestimation of latent heat fluxes even for the 4m intake tubes of LI-7000 and the 1m intake tube of the LI-7200, hence for set-up previously considered not influenced by such RH dependency. We show also that heating the tubes substantially improves the measurements by doubling the system's cut-off frequencies. A second LI-7500 has been used to evaluate the effect of horizontal displacement and the accuracy and repeatability of the instruments. In the same field test several models of sonic anemometer-thermometers (SATs), selected among the most used in the community, have been used to perform a field intercomparison of turbulence measurements. For this exercise we used two horizontal mounting anemometers, an HS (Gill Instruments Ltd.) and a CSAT3D (Campbell Scientific Inc.), and three vertical mounting anemometer, an R3 and a WindMaster by Gill and, in the last months, an USA-1 (Metek GmbH), to compare turbulence statistics estimated with each device.