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The effect of agricultural structures on the quality of eddy covariance flux data

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The Eddy Covariance (EC) is a common method to directly measure whole canopy turbulent fluxes of scalars like water vapor, air temperature and CO_2. The method was originally developed to measure fluxes from canopies in the open; however, in recent years it was also shown to be valid for flux measurements of agricultural crops cultivated inside structures covered by porous screens, i.e. screenhouses. To reliably measure turbulent fluxes by the EC technique, several air flow conditions should prevail. The purpose of this study was to examine two criteria, commonly used to assess the suitability of turbulent flow conditions for EC measurements in open fields, for flux measurements in different types of agricultural screenhouses and greenhouses. The two tests are the "Integral Turbulence Characteristics" (ITC), which indicates on the development of the turbulent flow, and the "Steady State" (SS), which examines the variation in time of flow statistics during the averaging period. For both tests data was classified according to their suitability for flux measurements.

The research was conducted in 3 types of agricultural structures with 3 different plants: (S1) A banana screenhouse, 5.5 m in height, covered by an 8% shade net; (S2) A pepper screenhouse, 3.7 m in height, covered by an insect-proof, 50 mesh net; (S3) A 12-span naturally ventilated tomato greenhouse with a 6 m height arched gable, equipped with an insect-proof 50 mesh net on the sidewalls, and impermeable plastic cover on the roof. In each structure an EC system was installed between the top of the canopy and the roof, in a position that provided sufficient fetch for the prevailing wind, for a measurement period of at least 20 days. Mean fluxes were calculated over half-hourly time intervals.

In the present study the ITC test was applied in two different approaches: (i) according to the commonly used literature model which prevails for turbulent flow in open fields (ITC1), and (ii) according to a new model that was developed specifically for each structure by regressions of the actually measured data (ITC2).

Results show that according to the ITC1 test, in S1, 80% of all the half-hourly time periods were suitable for EC flux measurements, whereas in S2 and S3 only 63% and 64% were suitable, respectively. On the other hand, using the ITC2 test the percentages of the suitable half-hourly time periods in S1, S2 and S3 increased to 91%, 83%, 82%, respectively. Analysis of the SS test showed that in S1, 88% of all the time periods were suitable for EC flux measurements. On the other hand in S2 and S3 only 77% and 79% were suitable, respectively. We conclude that the quality of flux data measured by the EC technique was high in the banana shading screenhouse, whereas in the pepper insect-proof screenhouse and the tomato greenhouse the quality was lower.