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Combining eddy-covariance measurements and Penman-Monteith type models to estimate evapotranspiration of flooded and aerobic rice

Arianna Facchi, Daniele Masseroni, Olfa Gharsallah, and Claudio Gandolfi

Dipartimento di Scienze Agrarie e Ambientali - Produzione, Territorio Agroenergia. Università degli Studi di Milano, Via Celoria, 2 - 20133 Milano

Rice is of great importance both from a food supply point of view, since it represents the main food in the diet of over half the world's population, and from a water resources point of view, since it consumes almost 40% of the water amount used for irrigation. About 90% of global production takes place in Asia, while European production is quantitatively modest (about 3 million tons). However, Italy is the Europe's leading producer, with over half of total production, almost totally concentrated in a large traditional paddy rice area between the Lombardy and Piedmont regions, in the north-western part of the country. In this area, irrigation of rice is traditionally carried out by continuous flooding. The high water requirement of this irrigation regime encourages the introduction of water saving irrigation practices, as flood irrigation after sowing in dry soil and intermittent irrigation (aerobic rice). In the agricultural season 2013 an intense monitoring activity was conducted on three experimental fields located in the Padana plain (northern Italy) and characterized by different irrigation regimes (traditional flood irrigation, flood irrigation after sowing in dry soil, intermittent irrigation), with the aim of comparing the water balance terms for the three irrigation treatments. Actual evapotranspiration (ET) is one of the terms, but, unlike others water balance components, its field monitoring requires expensive instrumentation.

This work explores the possibility of using only one eddy covariance system and Penman-Monteith (PM) type models for the determination of ET fluxes for the three irrigation regimes. An eddy covariance station was installed on the levee between the traditional flooded and the aerobic rice fields, to contemporaneously monitor the ET fluxes from this two treatments as a function of the wind direction. A detailed footprint analysis was conducted - through the application of three different analytical models - to determine the position and the size of the footprint area at each monitoring time step (30-min). Two sets of half-hourly ET values, each one concerning one of the two treatments, were therefore obtained, each one comprising about 10-15% of the daytime time steps over the whole agricultural season. To confirm the reliability of the measured ET fluxes, the energy balance closure was computed for the two fields and resulted in an imbalance lower than 10% for both the irrigation treatments.

The two eddy covariance data-sets were then used to calibrate three Penman–Monteith type models: one for the estimation of the rice crop transpiration (T), the second for the soil evaporation (ES), and the third for the evaporation from the water covering the soil in the case of flooded rice fields (EH20). Models were implemented using the available agro-meteorological data detected over the rice canopies and the periodically measured values of crop parameters (leaf area index, crop height). Finally, the calibrated models were used to compute the complete hourly ET data series for the three irrigation regimes.