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ORIGINAL PAPER

Evaluation of METRIC-derived ET fluxes over irrigated alfalfa crop in desert conditions using scintillometer measurements

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Abstract A field study on a 50-ha alfalfa (*Medicago sativa* L.) irrigated field was conducted to investigate the performance of the remote sensing (RS) based Mapping EvapoTranspiration at high Resolution with Internalized Calibration (METRIC) model in the estimation of evapotranspiration (ET) under the arid conditions of Saudi Arabia. The METRIC model performance was investigated by comparing the energy fluxes estimated by the model to the output of a surface layer scintillometer (SLS) system installed in the field, given the fact that the SLS is efficient in measuring sensible heat fluxes (H) over vegetative areas. Landsat-8 reflectance data were used as inputs for the METRIC model. Results of the study revealed that the H_{METRIC} data was strongly correlated with the H_{SLS} data with an R^2 value of 0.74 ($P > F = 0.0064$) and a mean bias error (MBE) of 6.05 W m^{-2} (6 %). The METRIC model showed a good performance in estimating the hourly latent heat (LE) fluxes compared with SLS data with an R^2 value of 0.81 ($P > F = 0.0023$), an MBE of 24.46 W m^{-2} (8 %) and a Nash–Sutcliffe efficiency (NSE) of 0.91. Furthermore, the hourly ET was estimated with an MBE and an NSE of 0.036 mm h^{-1} (8 %) and 1.00, respectively. Compared to the SLS data, the METRIC model was found to generally provide an efficient and an accurate means of energy fluxes estimation; therefore, ET estimation over the studied irrigated alfalfa crop.

Keywords Centre pivot system · Evapotranspiration · Landsat-8 data · Alfalfa field · Surface layer scintillometer

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Introduction

In agriculture, evapotranspiration (ET) plays a major role in the quantification of consumptive use of irrigation water and precipitation. Therefore, an accurate estimation of ET is essential for the determination of crop water needs and crop water use efficiency (Gowda et al. 2007). Accurate ET measurements can be achieved through weighing lysimetry, soil-water monitoring, and micrometeorological methods (eddy covariance, scintillometry, Bowen Ratio, etc.). Of which, the micrometeorological methods were found to be more accurate, as they worked under critical environmental conditions without disturbing the microenvironment of the area under investigation (Mengistu and Savage 2010).

Scintillometry is one of the popular micrometeorological methods used by agro-meteorologists, hydrologists, and micrometeorologists for various applications (Thiermann and Grassl 1992; Savage et al. 2005; Odhiambo and Savage 2009). A surface layer scintillometer (SLS) is a scientific device that works on scintillometry techniques and is used to measure small fluctuations of the refractive index of the air caused by variations in temperature, humidity, and pressure (Beyrich et al. 2012). It consists of an optical or a radio wave transmitter and a receiver at opposite ends of an atmospheric propagation path. The receiver detects and evaluates the fluctuations in the intensity of the transmitted signal, which is termed as scintillation (Solignac et al. 2009). The variance of the logarithm of the intensity fluctuations can be related to the structure parameter