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Dynamic citrus orchards irrigation performance assessment by a surface energy balance method using Landsat imagery

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Vegetation evapotranspiration (ET) is a key component of the hydrological balance. Several tools and models for estimating evapotranspiration in tree orchards have been proposed. Among them, the most widely used approach is that proposed by the Food and Agriculture Organization (FAO) which takes into account climatic variables included in the reference evapotranspiration (ETo) and the crop type and its characteristics included in a single crop coefficient (Kc). However, there is evidence that in tall and discontinuous canopies, such as citrus orchards, with a high degree of coupling to the environment, Kc may change depending on local environmental conditions and the vegetation amount.
Other methods such as stem water potential measures, sap flow sensors and moisture probes allow to determine crop water status but only for a limited number of trees and exists uncertainties when values are extrapolated. Remote sensing covers this gap provided that the spatial and temporal resolutions are adequate for the monitored crop. One approach successfully applied in water management is using models that calculate the latent heat as a residual of the surface energy balance (SEB).
In this work, the Surface Energy Balanced Algorithm (SEBAL) has been applied to an irrigation district. The study site is located in Valencia region (Spain; 39º22'43" N, 0º28'20" W) with drip irrigated citrus. Nearly 100 free cloud images from Landsat 7 and 8 for period 2013-2106 were used to estimate instantaneous ET upscaled to daily values of actual ET (ETSEBAL) using climatic data. ETSEBAL was compared with crop water requirements estimated by FAO methodology (ETFAO) assuming no soil-water limitations and the ratio was calculated. ETFAO/ETSEBAL ratio values higher than 1 implies the crop was under water stress, while ETFAO/ETSEBAL ratio lower than 1 implies that actual evapotranspiration is higher than potential. This can occur if water soil content is higher than when Kc was estimated. At the same time, ETFAO was compared with the water supplied (Vol) by means of the ratio ETFAO/Vol. In this case, values higher than 1 suggests that crop is irrigated at lower rate than what required to fulfill the potential ET. On the other hand, values lower than 1 implies that the crop is overirrigated.
On a monthly basis, linear and potential trends of ETFAO/ETSEBAL compared to ETFAO/Vol were determined. Every studied month there was a positive correlation for the two trends, indicating that ETSEBAL in stressed crops is lower than ETFAO. These values were validated with stem water potential measures in nine orchards. The potential trend has shown best determination coefficients (0.65 on average). This is probably because in overirrigated crops water percolates and is not accounted in the surface SEB model.
In the rainy months like October, when precipitation was lower than usual (years 2013, 2014, 2016), ETSEBAL performed better than ETFAO in predicting irrigation performance, showing lower Kc values in non-stressed orchards than those estimated from data from standard years.
The obtained results suggest that Landsat images can be successfully used to monitor irrigation performance in large irrigation districts.