Derivation and Testing of Consumptive Water Use Fraction for Specialty Crops

Lee Johnson, Florence Cassel Sharma, Jordan Harding, Jamie Herring, Forrest Melton

The Crop Consumptive Use Fraction (CCUF) expresses beneficial water use in the form of seasonal evapotranspiration of applied water (ETAW), relative to total irrigation volume. The metric is an indicator of the efficiency of agricultural water use and is a recommended component for preparation of agricultural water management plans in California. An FAO-56 based web application has been developed to facilitate retrospective evaluation of ETAW, and hence CCUF, at field level. The current application is optimized for prevailing climate in four of the state's main growing regions: San Joaquin Valley, Sacramento Valley, Central Coast, and North Coast. User inputs include crop type, soil texture, irrigation method, daily irrigation volume, daily rainfall, and seasonal start/stop dates to define the analysis period. Timeseries of fractional green canopy cover (Fc), based on Landsat and Sentinel-2 Earth-resource satellite observations, are imported from NASA's Satellite Irrigation Management Support (SIMS) system. Grass reference evapotranspiration (ETo) timeseries are accessed from Spatial CIMIS (California Irrigation Management Information System). Daily crop height (h) is estimated as a simple function of typical maximum height for the given crop type (from FAO-56) and Fc. A vegetation density coefficient (Kd) is derived from Fc and h. Stomatal control factors during mid- and late-season are applied to tree and vine crops. Typical values for minimum daily relative humidity and mean daily windspeed, derived from historical CIMIS weather data, are used to correct for regional deviations from standard climate (defined as RHmin=45%, windspeed =2m/s). The resulting daily basal crop coefficient (Kcb) represents the ET of a well-watered crop with minimal soil evaporation, relative to ETo. A soil water balance sub-model for the top 0.1 m is used to calculate daily evaporation coefficients (Ke). A second sub-model applies to the root zone to calculate crop water stress coefficients (Ks) and effective precipitation (Pe), which is the fraction of rainfall that is available for crop use. Those coefficients are combined with Kcb and ETo to calculate daily ETc. ETAW is then derived as cumulative ETc less cumulative Pe. For verification purposes, sensor installations were used to measure seasonal ETc in commercial fields for several annual and perennial specialty crops by soil water balance and energy balance methods. Model estimates of seasonal ETc show mean absolute error of <10% compared to the ground measurements.