Geophysical Research Abstracts
Vol. 14, EGU2012-9530, 2012
EGU General Assembly 2012

Soil moisture status in a set of rain-fed cereal fields: application of the DR2 model at monthly scale

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One important issue in agricultural management and hydrological research is the assessment of water stored during a rainfall event. In this study, the new Distributed Rainfall-Runoff (DR2) model (López-Vicente and Navas, 2012) is used to estimate the volume of actual available water (Waa) and the soil moisture status (SMS) in a set of rain-fed cereal fields (65 ha) located in the Central Spanish Pre-Pyrenees. This model makes the most of GIS techniques (ArcMapTM 10.0) and distinguishes five configurations of the upslope contributing area, infiltration processes and climatic parameters. Results are presented on a monthly basis. The study site has a relatively long history (since the 10th century) of human occupation, agricultural practices and water management. The landscape is representative of the typical former rain-fed Mediterranean agro-ecosystem where small patches of natural and anthropogenic areas are heterogeneously distributed. Climate is continental Mediterranean with a dry summer with rainfall events of high intensity (I30max, higher than 30 mm / h between May and October). Average annual precipitation was 520 mm for the reference period (1961–1990), whereas the average precipitation during the last ten years (2001–2010) was 16% lower (439 mm). Measured antecedent topsoil moisture presented the highest values in autumn (18.3 vol.%) and the lowest in summer (11.2 vol.%). Values of potential overland flow per raster cell (Q0) during maximum rainfall intensity varied notably in terms of time and space. When rainfall intensity is high (May, August, September and October), potential runoff was predicted along the surface of the crops and variability of Q0 was very low, whereas areas with no runoff production appeared when rainfall intensity was low and variability of Q0 values was high. A variance components analysis shows that values of Q0 are mainly explained by variations in the values of saturated hydraulic conductivity (76% of the variability of Q0) and, to a lesser extent, by the values of the antecedent topsoil moisture (23%) and the volumetric content of water of the soil at saturation (1%). Maps of monthly actual available water after maximum rainfall intensity presented a significant spatial variability, though values varied as a function of total rainfall depth and infiltration, and the five different scenarios of cumulative processes considered on the DR2 model. The minimum value of Waa for each month was well correlated with the average values of precipitation (Pearson's r = 0.86), whereas the mean values of Waa showed a close correlation with the values of maximum rainfall intensity (Pearson's r = 0.92). Maps of SMS and their values were reclassified in seven wetness–dryness categories. Predominant wet conditions occurred in May, September, October, November and December, whereas dry conditions appeared in February, March and July. Drying-up conditions were identified in January and June and wetting-up conditions occurred in April and August. The new DR2 model seems to be of interest to monitor humidity variations and trends in time and space in Mediterranean agricultural systems and can provide valuable information for sustainable soil and water resource management in agro-climatic analysis.