EFFECTS OF VEGETATION ON SOIL WATER BALANCE IN UNSATURATED PYROCLASTIC SLOPE

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In unsaturated soils, rainfall is the most usual triggering cause, due to rainwater infiltrating into the superficial soil, which causes a decrease in matric suction and consequently in shear strength. In this regard, the vegetation is the one of the factors affecting the infiltration. Here the influence of the vegetation on the hydraulic slope behavior will be discussed. Apart from the mechanical contribute[1], the effects of vegetation consist of: (i) changes of the soil porosity, thus, of the hydraulic soil properties; (ii) the water uptake resultant from the transpiration of the plants; (iii) interception of rainfall. The last two features, the evapotranspiration and the interception, were investigated by processing data from the test site at Monteforte Irpino[2] where meteorological data, matric suction and volumetric soil water content measurements were collected for about four years. In order to comprehend the effects of vegetation on the infiltration, the Soil Water Balance (SWB) can be applied to the soil surface of the instrumented pyroclastic cover:

$$P\text{-}(I+R_{off})\text{-}ET_c = Q_{top} \quad (1)$$

Rainfall, P, was measured directly by the weather station while crop evapotranspiration, ETc, was estimated by the meteorological data collected in situ and according to the vegetation existing at site. Interception, I, was estimated by using an empirical equation proposed for area covered by the same vegetation present at site[3]. The term Q_{top} is the water flowing normal to the slope surface across the top boundary of the superficial ash layer. It was calculated as function of the field saturated conductivity. The runoff, Roff, was unknown, thus, estimated by Eq. (1). In Fig. 1a–d about three years of data are reported, from July 2009 to September 2012. The maximum daily rainfall occurs in autumn, from October to December. The evapotranspiration term, et_c, was calculated by the FAO-Penman–Monteit method. The dual crop coefficient approach was used. The basal crop coefficient, kcb, was chosen in light of the vegetation present, namely bushes. The instantaneous values of the reference and crop evapotranspiration fluxes et_0 and et_c (Fig.1b) are very similar and smaller than 1 mm/day in winter from October to April when such fluxes depend on meteorological conditions alone. The instantaneous values of crop evapotranspiration become slightly higher than those of reference evapotranspiration in spring due to the peak in vegetation growth, and reach values of 3–4 mm/day. In summer, from July to September, et_c is between two and three times lower than et_0 due to water deficiency at the ground surface, ranging from 1.5 to 2 mm/day. However, both the fluxes show a seasonal trend. In Fig. 1c transpiration and evaporation components are reported; the former is predominant in spring and in summer, the latter in the rest of the year. Fig. 1d reports the interception by vegetation that amounts at maximum to 12 mm when 80 mm of rainfall occurs. However, according to the empirical equation adopted, the interception is always equal to 0.7 mm during leafless period (December-April). The mean values of the normal components of the instantaneous and cumulative groundwater flux are reported for the superficial ash layers in Fig.1g. A positive value indicates a flux directed downwards. The mean instantaneous normal flux is positive from October to May, ranging from 2 mm/day to 6 mm/day; it takes negative values in the dry period due to evapotranspiration. By observing Fig. 1e-f it is possible to appreciate the effects of vegetation on the yearly soil water balance. The cumulative crop evapotranspiration ETc ranges between 350 and 400 mm, thus, 15-20% of the yearly rainfall. The total interception is equal to 10-15% of the yearly rainfall. In particular it amounts to 5% from December to April and to 20% during the leafed period, from May to November. Therefore, both transpiration and interception keep the highest values during the late spring and summer when the flowslides usually do not occur. Nevertheless, as the evapotranspiration establishes over all the year by keeping a constant value around 0.5-1 mm/day during the winter, it is able to decrease the soil humidity into the top layer by improving the safety factor of the slope between two intense rainfall events spaced by dry days.

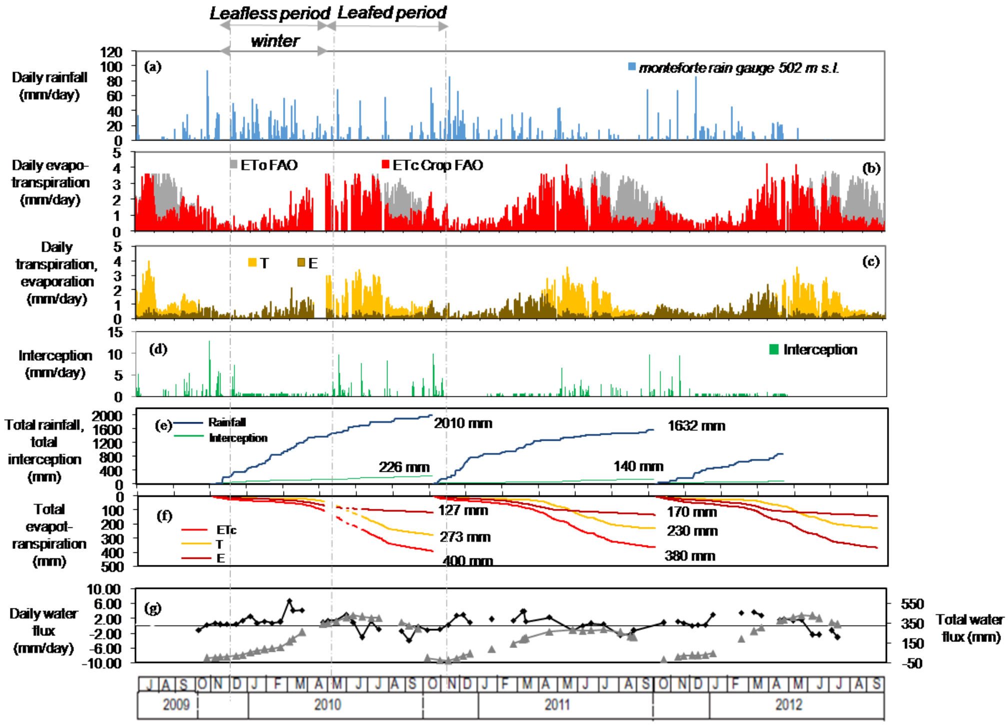

Figure 1. Meteorological data registered/estimated at site from June 2009 to September 2012: a) daily rainfall; b) reference and crop evapotranspiration; c) transpiration and evaporation; d)interception; e)total rainfall and total interception; f) total crop evapotranspiration; g) daily and total water flux into top layer.

Keywords: Soil water balance, evapotranspiration, in situ monitoring, partial saturation, pyroclastic soils

References

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