Geophysical Research Abstracts,
Vol. 11, EGU2009-11527, 2009
EGU General Assembly 2009

Soil depth constrains whether evapotranspiration contrasts between vegetation types

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Altering vegetation types in semiarid ecosystems has been proposed as a method for managing evapotranspiration (ET). In adjacent sites with contrasting vegetation types, ET is controlled by available energy (net radiation minus storage heat flux), which is largely a function of ecosystem composition and structure, and on how that available energy is partitioned between latent and sensible heat flux. Available energy in woodlands, for example, is typically higher than in grasslands because woodlands absorb more radiant energy. The partitioning of available energy between latent and sensible heat is controlled to a large degree by water availability. In shallow soil systems, however, roots of both grasses and trees are confined and water storage capacity is limited, which may result in lower latent and higher sensible heat than what would occur in deeper soil systems. In a semiarid system underlain by limestone, we compared energy balance partitioning and ET among a continuum of vegetation types: grassland (G), oak savanna (S), and juniper-oak woodland (W). We expect differences among sites to be most pronounced during drought in areas with deep soil because nearly all available energy should transfer to latent heat when adequate moisture is available, regardless of vegetation type. Root depth may differ by species in deep soils, but may only differ in shallow soils if roots penetrate into fractured limestone below the soil horizon. Three adjacent sites (G, S, W) were monitored for ET using the eddy covariance method. Soil depths are approximately 0.5 m at G, 1 m at S, and 0.2 m at W. Trees were equipped with sapflow sensors to monitor species differences in dry down response. Measurements showed that available energy was highest in the woodland, and lowest in the grassland. However, ET was highest in the savanna, the site with the deepest soil. Total ET over a 2-yr period was 1319 mm, 1465 mm, and 1409 mm, respectively at G, S, and W sites. The highest sensitivity of ET to rainfall and water deficits was observed in the woodland, the site with the greatest woody cover, but the thinnest soil. Transpiration in oak in the woodland was more sensitive to precipitation events than juniper. The least sensitivity of ET to rainfall and water deficits was observed in the savanna, the site with the deepest soil. A separate experiment at a new location was conducted to examine root water uptake differences between grass and juniper plots in very deep soils (>1 m) and to calibrate a soil water balance model. The model was then used to simulate changes in uptake with varying soil depth. Deep soils under juniper were depleted of moisture much faster than deep soils under grass, resulting in very large cumulative annual differences (10 times) in water loss between the two vegetation types. However, a model of this system with soil depth constrained to only the top 10 cm (a common occurrence) predicts that differences would be much smaller, only 40% annually. It follows for this semiarid ecosystem underlain by limestone that spatial patterns in ET are dependent upon both vegetation type and soil depth variation.