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Partitioning evapotranspiration: variations in the relative contribution of soil evaporation in a semi-arid Aleppo pine forest

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Water availability, especially in semi-arid and arid regions, has both direct and indirect affects on biomass production, decomposition, and long-term carbon sequestration. Evapotranspiration (ET) is the main route in which soil moisture is lost to the atmosphere and is comprised of transpiration (T) from leaves and evaporation (E) from soil and other surfaces. Temporal and spatial variations in E, and independently in T, can have implications on local soil water availability for plants and microbial activities. However, only total ET flux is often considered due to difficulties in partitioning this flux to its components. In this study, we investigated separately the variations in E and T at the Yatir semi-arid Allepo pine forest (long term mean annual precipitation 280 mm, LAI 1.1-1.5). A new method was adapted to measure E from the soil surface, utilizing a modified soil respiration chamber. Tree transpiration was measured continuously with the 'heat pulse' technique and based on field campaigns to measure leaf-scale transpiration. ET was measured by a 19 m eddy-covariance tower. Measurements of E showed large spatial variability: fluxes in inter-tree gaps were twice as large as those below the tree canopies (0.031 mm hr^{-1} compared with 0.015 mm hr^{-1}, on average). A clear diurnal cycle in E was observed; with peak spring rates (0.1 mm hr^{-1}; 12:00) preceding peak rates of T (0.25 mm hr^{-1}; 13:00). Water uptake by the soil was detected in early mornings and late afternoons during the summer, with consequent very low E during warmer hours even at this dry period (E $\sim$0.04 mm day^{-1}; volumetric water content for depth 0-30 cm $\sim$8%). The annual cycle of ET was characterized with low fluxes in summer ($\sim$0.2 mm day^{-1}), followed by a gradual increase after first rains, until peak flux at late spring ($\sim$1.6 mm day^{-1}). The annual cycle of E was different, characterized by high E during autumn, after first rains when tempera-

tures were still high, and at early spring, after rise in temperatures ($\sim$0.35 mm day^{-1}). E was low during the high activity winter and during the stressful summer (0.04 mm day^{-1}). This behavior was consistent with changes in soil water content (measured with TDRs to a depth of 1.3 m), which showed that soil drying ceased at early spring, while ET had not yet reached its peak flux. Interestingly, only the layer around 15 cm, which is the depth of maximum fine root density in Yatir, furthered dried up until June, indicating extensive root uptake throughout this period. Accordingly, E/ET markedly varied over the seasonal cycle. While the maximum daily ratio was 25% in early spring, the ratio was only $\sim$14% during the dry season. This study showed that the relative contribution of each flux to total ET varies through space and time. We can deduce that lower E rates below trees, in addition to lower direct radiation loads, resulted with improved soil water conditions for localized biomass production (annuals and shrubs). During summer, both E and T are low, but while T gradually rises till a peak at late spring, E is high at autumn and early spring, when soil is wet and temperatures is high, and low during the wintertime. High T rates during late spring, when superficial soil is dry, is reinforced by the drying up of the maximum root density layer, probably constraining decomposition of soil organic matter at this depth.