Full-rotation carbon, water and energy fluxes in a tropical eucalypt plantation

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Eucalyptus plantations in Brazil are among the most productive forests of the world, reaching mean annual increments of about 50 m3 ha-1 yr-1 over short (6-7 yrs) rotations. In order to better understand the factors contributing to such high productivities we continuously monitored water vapor, CO2 and energy flux through the eddy-covariance method over a 9 year-period encompassing two successive eucalypt rotations in southeastern Brazil (Sao Paulo State), including the last 2 yrs of the first stand rotation, its harvest, replanting, and a full (7yrs) second rotation. Tree growth, Leaf Area Index (LAI), water table depth, and soil water content (SWC) down to 10 m depth were also monitored. Rooting depth and vertical fine root distribution were assessed at various ages.Mean annual evapotranspiration (AET; 1383 mm yr-1) represented 90% of the annual precipitations (P; 1539 mm yr-1). AET reached maximum values (1598 mm yr-1) about 2-3 years after planting (a.p) when LAI peaked and when deep rooting (about 15 m deep 2.5 yrs a.p) provided access to the large amount of water stored in deep soil layers during the first months after clear-cutting and replanting. Most (88%) of the available energy (3852 MJ yr-1) was partitioned to the evaporation process (latent heat fluxes), with very low sensible heat fluxes over the rotation, except after harvesting and replanting when LAI was low, and later in the rotation during dry events. Deep drainage after harvest of the first stand allowed the water table (WT) to rise from -18 to -12 m over the first 2 years after replanting. Then, WT progressively declined due to groundwater lateral flow and root uptake in the capillary fringe above the WT during seasonal droughts. Both measurements of SWC and model simulations showed that deep water storage and subsequent uptake played a major role in supporting the very high wood production and dampening seasonal droughts.

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