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Observations of soil water dynamics around a tree on a hillslope

Author : Mr. Wei-Li Liang
Lab. of Erosion Control Division of Forest Science Graduate School of Agriculture IAHS

Co-Author: Kenichirou Kosugi, Takahisa Mizuyama

Precipitation in a forest is intercepted by the canopy and partitioned into throughfall and stemflow, leading to heterogeneous water inputs that affect soil water dynamics. To clarify the effects of a tree stand on rainfall infiltration processes on a steep forested hillslope, we conducted detailed and long-term observations of throughfall, stemflow, soil water content, and pore water pressure at high spatial resolution. Observations began in August 2005 on a hillslope at the Kamigamo experimental station of Kyoto University, located in southern Kyoto Prefecture, central Japan. The hillslope has a mean gradient of 28 degrees, with brown forest soil underlain by sandstone and slate. It is predominantly covered with tall stewartia (Stewartia monadelpha), planted in 1956. To monitor the soil water dynamics around a tree, we selected a tall stewartia and delineated a longitudinal observation line from upslope to downslope of this tree. We installed a capacitance meter (Sentek, EasyAG-5p) at each of 10 points upslope and downslope from the tree stem. Each capacitance meter consisted of five sensors to measure soil water content at depths of 10, 20, 30, 40, and 50 cm. Additionally, we installed tensiometers at the soilbedrock interface at the same 10 points to measure pore water pressure. For throughfall and stemflow measurements, we selected another tall stewartia, located at a similar point on the slope. To measure throughfall distribution, we installed a tipping bucket rain gauge at each of 6 points upslope from and downslope from the tree stem. We used two tubes cut longitudinally and wrapped spirally around the upslope and downslope sides of the trunk to collect separately the stemflow along the upslope and downslope sides of the trunk of the tree. The results showed that the soil water content increased rapidly and greatly in the region downslope from the tree stem, especially at points close to the tree stem. At these points, maximal soil water storage was more than 100 to 200% of the cumulative open-area rainfall, and occurrences of bypass flow were recognized. Moreover, the pore water pressure at the soilbedrock interface increased more rapidly and to a greater degree in the region downslope from the tree stem than in the upslope region. For a heavy storm event, the cumulative infiltration height of the stemflow along the downslope sides of the tree trunk was 18.9 times the cumulative height of the open-area rainfall. Locally concentrated rainwater input attributable to the stemflow on the downslope side of the tree trunk probably caused the large and rapid increases of water content and pore water pressure in the downslope region, resulting in the development of an asymmetric saturated zone around the tree.