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"Reconcile land system changes
with planetary health"

Investigating water fluxes and hydraulic lift in agroforestry: Innovative monitoring techniques and machine learning

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Abstract

Agroforestry is one of the oldest systems of sustainable agriculture that conserves natural resources and meets human needs for food, timber, and fiber. To evaluate the benefits of agroforestry, ensure effective management, and maintain it properly, further research is required to understand the intricate relationships between the components and processes in such a complex system. Water fluxes are critical in influencing plant growth, the movement and transformation of soil nutrients, and the balance of energy within the soil-plant system. Therefore, understanding the spatial and temporal distribution of soil moisture is crucial for gaining insight into hydrological, soil, and environmental processes. This study discusses the innovative methods and instruments currently applied in the Silvoarable Agroforestry System at Gladbacherhof, Hesse, Germany. Soil moisture sensors were installed on three transects perpendicular to the rows of apple trees in the field at distances of 1.5, 2.5, 6, and 10.5 m from the trees to measure soil moisture at soil depths of 10, 40, and 60 cm. In addition, Cosmic Ray Neutron Sensors (CRNS) were installed to study soil moisture dynamics on a field scale. To provide a comprehensive overview of soil moisture on a medium scale, we will use machine learning methods such as random forest models, multilayer perceptron neural networks, and deep learning methods. In addition, high-temporal-resolution soil moisture measurements will be used to study the presence of hydraulic lift, with the increase in soil moisture at night during dry periods being particularly evident. This observation will be followed by the second phase of the experiment, which takes advantage of water stable isotope techniques to track the spatio-temporal pattern of water taken up from the soil by trees, grassland, and arable plants. Because this is an ongoing experiment, we expect to gain a better understanding of the key factors and spatial features responsible for the observed patterns.

Keywords: Agroforestry, cosmic ray neutron sensor, hydraulic lift, machine learning, random forest, soil moisture, sustainable agriculture, water isotope techniques

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