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Estimating soil moisture using portable Cosmic-Ray neutron sensor, field data and remote sensing methodologies: Spatial and temporal comparison

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Accurate information of spatial and temporal variation of soil moisture is crucial for understanding the land surface processes and their management. Antecedent soil moisture can be one of the most important factors controlling hydrological and erosive processes, affecting the runoff and soil loss in agroforestry systems. In situ field measurements of soil moisture are restricted to discrete data at specific locations. However, to avoid spatial and temporal variations and obtain a valid estimate of soil moisture one needs to collect data from numerous locations within a given area, becoming time-consuming and expensive. In the last years, development in remote sensing satellite technology has offered a number of techniques for estimating soil moisture across a wide area continuously over time offering an edge over the conventional data collection methods. However, the measurement depth of many of these methods is still limited to the upper soil and the spatial and temporal resolution is rather coarse. Recently, a technique that intends to bridge the scale gap between point measurements of soil moisture and remote sensing is the use of Cosmic-Ray neutron sensors (CRNS) as indicators of soil moisture.

This research details the preliminary results and efforts to apply for the first time in Spain the use of portable CRNS. Field surveys were conducted during the spring and summer of 2018 in a representative Mediterranean upland agroforestry system located in northern Spain. The selection of sampling points along a heterogeneous transect aimed to obtain information including different land uses vegetation cover and slope positions. This contribution shows how soil moisture varies temporally and spatially along different seasonality conditions (late wet spring, dry and wet summer), in locations with certain land use (crops, pastures or Mediterranean forest) topography or soil properties. A total of seven CRNS surveys, nearly one thousands in-situ field measurements, and a series of ten Sentinel-2 images were used. Soil moisture data obtained with i) portable CRNS backpack, ii) HS200 sensor Delta-T Devices, and ii) satellite-based information was compared. Results showed that the CRNS backpack captures soil moisture dynamics well, but also emphasize the need for further research in order to compare CRNS data with both, in-situ soil moisture measurements and the moisture index obtained with remote sensing.

Measuring soil moisture content non-invasively with Cosmic-Ray neutrons is a promising technique for intermediate spatial scales, and also for calibration of satellite sensors and validation satellite-based products. This study demonstrate the efficacy of portable CRNS in Spain for obtaining field scale soil moisture data which will enable to a better understanding of how the water content affects the process of soil degradation and soil loss due to water erosion. *This study was conducted within the IAEA Cooperation Research Project CRP-D1.50.17 "Nuclear techniques for a better understanding of the impact of climate change on soil erosion in upland agro-ecosystems".*