Monitoring soil water content and water potential dynamics in irrigated apple orchards using cosmic-ray neutron probes.

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In the Mediterranean area, the agricultural sector often relies on irrigation. Additional pressure on these environments will come from the increasing occurrence of dry years and of heat waves that are connected to climate change. Thus, more efficient water management strategies and, when possible, precision irrigation practices should be implemented. So far, a wide range of soil moisture sensor-based systems have been successfully used to monitor soil water content (SWC) dynamics in agricultural contexts. The relatively new, and non-invasive, technique cosmic-ray neutron sensing (CRNS) relies on the negative correlation between fast neutrons originating from cosmic radiation and soil moisture content. It has the advantage of a large footprint, covering the field-scale. Despite this, only few studies explored the use of CRNS for irrigation management. In this study, we examine how CRNS can provide insights in the monitoring of irrigation and the associated fluctuations in SWC dynamics and water potential. In September 2020, two apple orchards of 1.2 and 1.3 ha in size and located in the Pinios Hydrological Observatory (Greece) were provided with an extensive instrumentation in the context of the Agricultural Interoperability and Analysis Systems (ATLAS) project. At each field, 12 SoilNet nodes measure volumetric soil moisture at three depths (5, 20, and 50 cm) and water potential at one depth (20 cm). Additionally, one Atmos41 compact climate station and a CRNS probe were placed in each of the two orchards. All these instruments are equipped with NB-IoT connections and transmit data in near-real time. The irrigation of both fields is monitored using water meter pumps equipped with a LoRaWan connection. Instrument installation was preceded by geophysical surveys and by extensive soil sampling and analysis. Moreover, soil samples from 18 locations were collected per CRNS probe on the day of installation to provide instrument calibration information. However, additional calibration was required due to temporary sensor failure and was performed using the surrounding SoilNet nodes. During the subsequent months, the CRNS probes generally showed good agreement with the SWC measured by the SoilNet stations as well as a strong response to precipitation events. Once the irrigation of the apple orchards started in April 2021, it was found that small and localized irrigation events were not featured in the CRNS signal. However, when prominent irrigation events started in May 2021, the CRNS probes showed good agreement with the changes in SWC and in water potential measured with the SoilNet nodes. Such agreement depended largely on the timing of the irrigation event as well as on the CRNP calibration strategy. These findings indicate the possibility for using the CRNS technique as a tool for precision irrigation.