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Influence of strip-irrigation on CRNS soil moisture measurements under heterogeneous soil properties

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In recent years, the use of Cosmic Ray Neutron Sensing (CRNS) for climate-compatible agriculture has attracted increasing attention, as it allows the soil moisture in the root zone to be determined continuously and non-invasively at field scale. However, the intrinsic integration of the neutron signal across the entire monitored field, and possibly beyond, can mask the distinct contributions from above-average dry or wet areas. This can potentially lead to biased soil moisture observations. In strip-irrigated fields, varying amounts of water are applied to different areas over the course of an irrigation cycle that, depending on field dimension and availability of machinery and water wells, can last multiple days. Hence, the neutron signal is not only affected by heterogeneities in soil properties but also by the irrigation pattern itself.

To better understand the contribution of heterogeneous soils and irrigation patterns on the neutron signal, we ask the following research questions: 1) Can different irrigation events be sensed by the neutron detectors and by point-scale measurements alike? 2) How much do strip irrigation events that only affect a portion of the field contribute to the neutron signal? 3) What is the effect of soil heterogeneity on the signal contribution? 4) How sensitive does the CRNS need to be in a given environment? To answer these questions, three CRNS detectors with different sensitivities were installed across a 14 ha potato field with marked soil heterogeneity and compared to soil moisture measurements at point-scale using two different profile probes. Prior to the measurement campaign, the spatial distribution of soil characteristics was assessed using Electro-Magnetic Induction (EMI) and the measurement sites were chosen to cover the main soil types present in the field. To gain a better understanding of the effects of localized irrigation events on the neutron signal, we used the URANOS neutron transport model to simulate the movement of neutrons in the studied environment and under the observed soil moisture conditions, taking into account the soil and sensor characteristics.

We found that the CRNS clearly outperformed the point-scale profile soil moisture probes, as these tend to lose contact with the soil due to erosion of the potato dams, thus leading to erroneous soil moisture measurements at all measurement sites. Despite the higher measurement accuracy of the CRNS, their sensitivity to irrigation decreased with the distance from the irrigated areas and not all irrigation events were sensed by all stations. Comparing CRNS with different measurement sensitivity, we found that using CRNS with only one proportional counting

tube placed far from the center of the field was less suitable for detecting the irrigation events. On the contrary, the use of a CRNS with two proportional counter tubes placed in the center of the field provided sufficient sensitivity to adequately detect irrigation events.