Geophysical Research Abstracts
Vol. 21, EGU2019-16726, 2019
EGU General Assembly 2019

Can drip irrigation be scheduled with a Cosmic-ray Neutron Sensor?

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Irrigation is essential for maintaining food production in water-scarce regions. However, unnecessary water usage should be avoided. The irrigation need depends on the water content in the soil, which can be measured by the Cosmic-ray Neutron Sensing (CRNS) technique. It is promising for irrigation management as the measurement footprint is representative for the root-zone at the scale of tens of hectares. The potential of the CRNS technique for drip irrigation scheduling is explored in this work for the drip irrigated Picassent site near Valencia, Spain. To support the experimental evidence, the neutron transport simulation URANOS was used to mimic the Picassent site and to simulate the effect of drip irrigation on the epithermal neutron counts.

The experimental dataset showed methodological limitations to detect drip water input with CRNS, although the overall soil water content in the CRNS footprint has been well characterized within a root mean square error less than 0.03 cm3/cm3. Furthermore, we found that the CRNS performance to sense soil water content in the overall footprint varied significantly along the study period. Both, the experimental data and the simulation results suggest that the large-area neutron response to drip irrigation is dominated by statistical noise in our specific case. The performance is mainly limited by the following conditions:
1. The irrigated area is only 8 % of the total area. Since CRNS has an area-averaging footprint, irrigation of larger areas would be much better visible for CRNS.
2. Changes of water content due to irrigation are small (5 %) under rather wet conditions (35% soil moisture). Neutrons are much more sensitive to changes of water content at the lower end of the soil moisture spectrum.
3. The irrigation period is only a few hours. The employed CRNS detector can resolve small changes of water content only with integration period of 12 hours.

We conclude that CRNS was not able to detect irrigation in our specific case. But the method might be capable of detecting drip irrigation in larger irrigated areas, in drier regions, and for longer and more intense irrigation periods. Since statistical noise is the main limitation of the CRNS measurement, the capability of the instrument could be improved in future studies by larger and more efficient neutron detectors.