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Footprint Characteristics of Cosmic-Ray Neutron Sensors for Soil Moisture Monitoring

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Cosmic-ray neutron sensing is a unique and an increasingly accepted method to monitor the effective soil water content at the field scale. The technology is famous for its low maintenance, non-invasiveness, continuous measurement, and most importantly, for its large footprint. Being more representative than point data and finer resolved than remote-sensing products, cosmic-ray neutron derived soil moisture products provide unrivaled advantage for mesoscale hydrologic and land surface models.

The method takes advantage of neutrons induced by cosmic radiation which are extraordinarily sensitive to hydrogen and behave like a hot gas. Information about nearby water sources are quickly mixed in a domain of tens of hectares in air. Since experimental determination of the actual spatial extent is hardly possible, scientists have applied numerical models to address the footprint characteristics.

We have revisited previous neutron transport simulations and present a modified conceptual design and refined physical assumptions. Our revised study reveals new insights into probing distance and water sensitivity of detected neutrons under various environmental conditions. These results sharpen the range of interpretation concerning the spatial extent of integral soil moisture products derived from cosmic-ray neutron counts. Our findings will have important impact on calibration strategies, on scales for data assimilation and on the interpolation of soil moisture data derived from mobile cosmic-ray neutron surveys.