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Predicting the Likely Value of Cosmic-Ray Neutron Measurements for Soil Hydrauilc Property and ET Estimation

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The cosmic-ray neutron method, developed measures water content at a scale not attainable by other instrumentsand is therefore a promising way to investigate (and in some cases eliminate) the problem of upscaling soil water content measurements. The method is in part based on the same principles as the conventional nuclear neutron probe commonly used in hydrologic and soil science investigations. A neutron probe consists of a fast neutron emitting source and a thermal neutron detector. Both our method and the neutron probe utilize the exceptionally high slowing down power of hydrogen to detect water. However, unlike conventional neutron probes, our method is non-invasive and utilizes fast neutrons produced naturally in soil by cosmic rays. These neutrons are generated with energies similar to those from the Ra-Be and Am-Be neutron probe source, but at much lower intensity. Previously, we have demonstrated that measurements of ambient soil neutron fluxes are feasible and practical, that soil neutron fluxes are clearly related to soil moisture conditions, and that in most cases the behavior of cosmic ray neutrons in soil can be described accurately using advanced neutron transport codes. In this investigation, we couple a simplified one dimensional neutron transport code and a one dimensional water flow model to predict the response of the cosmic ray neutron probe to infiltration and subsequent drainage. The objective of the modeling is to determine: 1) whether the probe is likely to respond to the expected water content changes; and 2) whether the expected response is likely to constrain interpretations of hydrologic fluxes and parameters given the measurement error characteristics of the cosmic-ray neutron probe. We show that this pre-modeling exercise is a valuable, even necessary, step in planning hydrologic field

experiments using geophysical methods.