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The Effect of Atmospheric Water Vapor on the Cosmic-ray Soil Moisture Signal

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The functionality of cosmic-ray soil moisture sensors deployed in the COsmic-ray Soil Moisture Observing System (COSMOS; http://cosmos.hwr.arizona.edu) relies mainly on the much greater stopping power of high energy neutrons by hydrogen atoms relative to other chemical elements in soil. This study investigates the effect of atmospheric water vapor on the cosmic-ray probe signal and evaluates the fast neutron response in realistic atmospheric conditions using the neutron transport model (Monte Carlo N-Particle eXtended - MCNPX). The vertical footprint of the sensor in the atmosphere (defined as the two e-folding distance) varies by about 10% in dry and wet atmospheres (335 and 300 meters, respectively). The distribution of water vapor within the vertical footprint is estimated from the absolute humidity at surface assuming an exponential decrease in water vapor content with altitude. Modeling results show that atmospheric water vapor near the surface affects the neutron intensity signal and a simple correction is defined to identify the true signal associated with soil moisture. This correction re-scales the measured neutron intensity to the values that would have been observed in the atmospheric conditions prevailing on the day of sensor calibration. This correction approach is evaluated at sample COSMOS sites where surface meteorological measurements are available in the cosmic-ray probe horizontal footprint.