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Spatiotemporal characterization of soil moisture fields in agricultural areas using cosmic-ray neutron probes and data fusion

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Approximately 40% of global food production comes from irrigated agriculture. With the increasing demand for food even greater pressures will be placed on water resources within these systems. In this work we aimed to characterize the spatial and temporal patterns of soil moisture at the field-scale (∼500 m) using the newly developed cosmic-ray neutron rover near Waco, NE USA. Here we mapped soil moisture of 144 quarter section fields (a mix of maize, soybean, and natural areas) each week during the 2014 growing season (May to September). The 12 by 12 km study domain also contained three stationary cosmic-ray neutron probes for independent validation of the rover surveys. Basic statistical analysis of the domain indicated a strong relationship between the mean and variance of soil moisture at several averaging scales. The relationships between the mean and higher order moments were not significant. Scaling analysis indicated strong power law behavior between the variance of soil moisture and averaging area with minimal dependence of mean soil moisture on the slope of the power law function. In addition, we combined the data from the three stationary cosmic-ray neutron probes and mobile surveys using linear regression to derive a daily soil moisture product at 1, 3, and 12 km spatial resolutions for the entire growing season. The statistical relationships derived from the rover dataset offer a novel set of observations that will be useful in: 1) calibrating and validating land surface models, 2) calibrating and validating crop models, 3) soil moisture covariance estimates for statistical downscaling of remote sensing products such as SMOS and SMAP, and 4) provide daily center-pivot scale mean soil moisture data for optimal irrigation timing and volume amounts.