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Improving Soil Moisture Monitoring from Cosmic Ray Neutron Sensors under Various Climate Conditions

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Soil moisture is a critical hydrological variable affecting rainfall-runoff processes, regulating net ecosystem exchange, and an essential agricultural variable that constrains food production. Soil water deficiency results in water stress to plants, causing a reduction in biomass and yield production. Thus, assessing soil moisture conditions and estimating the effects of drought or water excess are relevant and important information associated with a decline in agricultural yield. This study analyses time series data of the Cosmic Ray Neutron Sensor (CRNS) to estimate soil moisture in three different climatic zones with distinct seasonal dynamics. The CRNS allows non-invasive and continuous monitoring of soil moisture by detecting the neutrons generated by cosmic rays that mainly interact with the hydrogen atoms in soil water. This study demonstrates an improved CRNS signal processing to enhance the temporal accuracy and overall signal-to-noise ratio by observing sub-daily soil moisture changes. In particular, this study investigates the effectiveness of the Moving Average (MA), Median filter (MF), Savitzky-Golay (SG) filter, and Kalman filter (KF) to minimize errors in soil moisture estimates at distinct points in time. We anticipate the improved signal-to-noise ratio to benefit CRNS applications such as the detection of rain events at the sub-daily resolution, provision of SM at the exact time of a satellite overpass, and irrigation applications.