Using Cosmic Ray Neutrons to Estimate Snow Water Equivalent in Prairie Environments

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ABSTRACT

Snow influences the water and energy fluxes for surface and groundwater systems in prairie environments. During the winter seasons, prairie soils are often frozen, with shallow, non-permanent snow cover. The expansive areas of low relief topography and little forest cover that are characteristic of prairie and agricultural areas allow wind to continuously redistribute and rework snow. This can lead to highly variable snow cover that ranges from deep snow drifts near barriers (e.g., trees, fences, breaks in topography) to bare, wind-scoured fields. Low vegetation such as crop stubble also has a strong influence on snow accumulation due to capture of wind-driven snow. This makes it challenging to accurately represent snow depth and snow water equivalent measurements. Additionally, snowpack can ablate rapidly in the prairie due to sublimation accelerated by high wind speeds and increased melting from weather fluctuations. For this reason, frequent snow observations are needed to track snowpack evolution and aid in prediction of flood events. We use a cosmic ray neutron sensor (CRNS) installed at Montana State University's Central Agricultural Research Center (CARC) in Moccasin, MT as part of SnowEx 2021 to assess the viability of CRNS for snow water equivalent (SWE) estimation in a prairie environment. CRNS measurements are sensitive to snow mass, which allows for continuous estimation of SWE. The large footprint of CRNS observations (approximately 200 - 300 m radius) allow it to integrate over a significant amount of snow spatial variability, which may enable SWE estimates that are more representative of the surrounding area than other continuous SWE observations (e.g., snow pillows). We compare CRNS-derived SWE estimates to manual snow measurements, continuous soil moisture observations, and drone-based LiDAR snow depth estimates within the sensor's footprint to assess the feasibility of CRNS for SWE monitoring in the prairie.

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