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"Cosmic Sense" – a newly established German initiative to join cosmic-ray neutron sensing efforts in soil hydrology

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The exchange of water between atmosphere, biosphere, and hydrosphere can be viewed as a result of complex interactions of dynamic feedback mechanisms, where soil moisture content acts as the key state variable. Approaches are required to handle land surface complexity and scale dependency of water fluxes. State-of-the-art observations of soil moisture content are ranging from continuous point-scale measurements via field-scale snapshots to remote sensing products on the basin scale and beyond. They have to deal with a space-time trade-off since the measurement frequency typically decreases with the covered spatial scale.
Cosmic-ray neutron sensing is one of the growing techniques to move soil hydrological observations forward. We have established a research unit (DFG FOR 2694) named "Cosmic Sense" to jointly improve such measurements with or in combination with cosmic-ray neutron sensing, especially in annual joint field campaigns at small catchment scale. Key aims are to
- bridge existing gaps between scales through additional techniques and sources of information about the soil water storage. Cosmic-ray neutron sensing measures the presence of water by sensing changes in neutron density above the ground. We want to develop a quantitative, adaptable, and transferable approach for observing representative soil moisture content values on the field scale while accounting for other dynamic water pools on the land surface, such as biomass, interception, and snow. Furthermore, by sensor clusters and mobile neutron detectors the mapping of soil moisture can be transferred to larger scales.
- bridge gaps between disciplines. Cosmic-ray neutron sensing shall function as a unique combination of invasive and non-invasive observations in joint field campaigns. The measurement and interpretation of soil moisture by Cosmic-ray neutron sensing requires advanced knowledge of soil hydrology as well as particle physics including neutron transport modeling. Efforts will be made for detector development that aims to substantially improve the temporal resolution and spatial coverage.
- foster an approach that is especially tailored to resolve the discrepancy in support volume and timing between hydrological models and field observations. Comprehensive observations by cosmic-ray neutron sensing, remote sensing and complementary methods will be used concertedly with hydrological and land-surface models at the regional scale to infer also groundwater recharge and atmospheric fluxes. Thereby, models and observations together will allow for identifying patterns and processes at the scale of small catchments with improved spatio-temporal resolution.