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Development of a measurement operator for cosmic ray soil moisture observations

R. Baatz, H. Bogena, H.-J. Hendricks-Franssen, J.A. Huisman, C. Montzka, and H. Vereecken

Forschungszentrum Jülich, Institute of Bio- and Geosciences: Agrosphere (IBG 3), Jülich, GERMANY
(r.baatz@fz-juelich.de)

Cosmic ray sensors measure neutron fluxes close to the earth surface. Effective absorption of energetic cosmic rays by hydrogen nuclei in the soil establishes a direct relationship between measured neutron flux and soil moisture content. Using this relationship, cosmic ray sensors are becoming increasingly popular for measuring soil moisture content at the field scale. The interesting aspect of the measurement is that the average soil moisture content (with diameter around 600 m and a vertical depth up to 70 cm) over a larger scale can be obtained (Zreda et al., 2008). However, the relation between the spatial distribution of soil moisture content in the footprint of a cosmic ray probe and the measured number of neutron counts is non-linear and the exact relationship is still subject to uncertainty.

The soil moisture monitoring network SoilNet (Bogena et al. 2010) established in the framework of the TERENO project offers an excellent opportunity to compare soil moisture measurements and neutron counts and improve the calibration of cosmic ray probes. The established relation between the two methods is a non-linear measurement operator in a data assimilation framework. Here soil moisture contents measured in Rollesbroich (Eifel, Germany) at 83 locations and 3 depths (5, 20 and 50 cm) were used to calibrate a cosmic ray probe. First results of the analysis to illustrate the influence of soil moisture heterogeneity in the cosmic ray footprint, the relation between mean soil moisture content and vertical footprint, as well as the causes for deviations between soil moisture content measured by a cosmic ray probe and by SoilNet will be shown. It will be demonstrated that a good correspondence between measured soil moisture contents by TDR or FDR and soil moisture estimated with a cosmic ray probe for a period of a few months does not guarantee a good fit at other times of the year.

References:

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