Geophysical Research Abstracts
Vol. 18, EGU2016-11508, 2016
EGU General Assembly 2016

Influence of total biomass and rainfall interception on soil moisture measurements using cosmic-ray neutron probes

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Cosmic-ray neutron probes are an emerging technology to continuously monitor soil water content at a scale significant to land surface processes. This method relies on the negative correlation between near-surface fast neutron counts and soil moisture content since hydrogen atoms in the soil, which are mainly present as water, moderate the secondary neutrons on the way back to the surface. Any application of this method needs to consider the sensitivity of the neutron counts to additional sources of hydrogen (e.g. above- and below-ground biomass, humidity of the lower atmosphere, lattice water of the soil minerals, organic matter and water in the litter layer, intercepted water in the canopy, and soil organic matter). In this study, we analyzed the effects of changing above- and below-ground biomass and intercepted water in the canopy on the cosmic-ray neutron counts and calibration parameters. For this, the arable field test site Selhausen, which is part of the TERENO and ICOS observation networks, was cropped with winter wheat and additionally instrumented with cosmic-ray neutron probes and a wireless sensor network with 108 soil moisture sensors. In order to increase the sensitivity of the cosmic-ray neutron measurements, we used seven neutron detectors simultaneously. In addition, we measured rainfall interception in the wheat canopy at several locations in the field. In order to track the changes in above and below-ground biomass of the winter wheat, roots and plants were sampled approximately every four weeks and LAI was measured weekly during the growing season. Weekly biomass changes were derived by relating LAI to total biomass. As expected, we found an increasing discrepancy between cosmic-ray-derived and in-situ measured soil moisture during the growing season and a sharp decrease in discrepancy after the harvest. In order to quantify the effect of hydrogen stored in the vegetation on fast neutron intensity, we derived a daily and weekly time series of the calibration parameter N0 using a weekly moving window optimization. We found a linear negative relationship between N0 and total fresh biomass and N0 and intercepted precipitation. Using these relationships for the correction of fast neutron intensity reduced the discrepancy between cosmic-ray-derived and in-situ measured soil moisture.