Geophysical Research Abstracts
Vol. 18, EGU2016-16720-3, 2016
EGU General Assembly 2016

Soil Moisture Estimation Across Scales with Mobile Sensors for Cosmic-Ray Neutrons from the Ground and Air

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Soil moisture is a key variable for environmental sciences, but its determination at various scales and depths is still an open challenge.

Cosmic-ray neutron sensing has become a well accepted and unique method to monitor an effective soil water content, covering tens of hectares in area and tens of centimeters in depth. The technology is famous for its low maintanance, non-invasiveness, continous measurement, and most importantly its large footprint and penetration depth. Beeing more representative than point data, and finer resolved plus deeper penetrating than remote-sensing products, cosmic-ray neutron derived soil moisture products provide unrivaled advantage for agriculture, regional hydrologic and land surface models.

The method takes advantage of omnipresent neutrons which are extraordinarily sensitive to hydrogen in soil, plants, snow and air. Unwanted hydrogen sources in the footprint can be excluded by local calibration to extract the pure soil water information. However, this procedure is not feasible for mobile measurements, where neutron detectors are mounted on a car to do catchment-scale surveys.

As a solution to that problem, we suggest strategies to correct spatial neutron data with the help of available spatial data of soil type, landuse and vegetation. We further present results of mobile rover campaigns at various scales and conditions, covering small sites from 0.2 km̂2 to catchments of 100 km̂2 area, and complex terrain from agricultural fields, urban areas, forests, to snowy alpine sites.

As the rover is limited to accessible roads, we further investigated the applicability of airborne measurements. First tests with a gyrocopter at 150 to 200m heights proofed the concept of airborne neutron detection for environmental sciences. Moreover, neutron transport simulations confirm an improved areal coverage during these campaigns.

Mobile neutron measurements at the ground or air are a promising tool for the detection of water sources across many scales. The method has a great potential to improve spatial performance of hydrological models, and help to assess regional soil moisture states for agriculture and flood risk management.