



Airborne Detection of Cosmic-Ray Albedo Neutrons for Regional-Scale Surveys of Root-Zone Soil Water

Martin Schrön (1), Lutz Bannehr (2), Markus Köhli (3), Marek Zreda (4), Jannis Weimar (3), Steffen Zacharias (1), Sascha E. Oswald (5), Jan Bumberger (1), Petra Zieger (6), Ulrich Schmidt (3), and Peter Dietrich (1)

(1) UFZ - Helmholtz Centre for Environmental Research, Monitoring and Exploration Technologies, Leipzig, Germany (martin.schroen@ufz.de), (2) Institut für Geoinformation und Vermessung, Hochschule Anhalt, (3) Physikalisches Institut, Heidelberg University, (4) Dep. Hydrology and Atmospheric Sciences, University of Arizona, (5) Institute of Earth and Environmental Science, University of Potsdam, (6) Fraunhofer-Institut für Kommunikation, Information und Ergonomie FKIE

While the detection of albedo neutrons from cosmic rays became a standard method in planetary space science, airborne neutron sensing has never been conceived for hydrological research on Earth. We assessed the applicability of atmospheric neutrons to sense root-zone soil moisture averaged over tens of hectares using neutron detectors on an airborne vehicle.

Large-scale quantification of near-surface water content is an urgent challenge in hydrology. Information about soil and plant water is crucial to accurately assess the risks for floods and droughts, to adjust regional weather forecasts, and to calibrate and validate the corresponding models. However, there is a lack of data at scales relevant for these applications. Most conventional ground-based geophysical instruments provide root-zone soil moisture only within a few tens of m², while electromagnetic signals from conventional remote-sensing instruments can only penetrate the first few centimeters below surface, though at larger spatial areas.

In the last couple of years, stationary and roving neutron detectors have been used to sense the albedo component of cosmic-ray neutrons, which represents the average water content within 10–15 hectares and 10–50 cm depth. However, the application of these instruments is limited by inaccessible terrain and interfering local effects from roads.

To overcome these limitations, we have pioneered first simulations and experiments of such sensors in the field of airborne geophysics. Theoretical investigations have shown that the footprint increases substantially with height above ground, while local effects smooth out throughout the whole area. Campaigns with neutron detectors mounted on a lightweight gyrocopter have been conducted over areas of various landuse types including agricultural fields, urban areas, forests, flood plains, and lakes. The neutron signal showed influence of soil moisture patterns in heights of up to 180 m above ground. We found correlation with ground-truthing data, using mobile cosmic-ray neutron sensors, local soil samples, TDR, and buried wireless soil moisture monitoring networks.

The work opens the path towards further systematic assessment of airborne neutron sensing, which could become a valuable addition – or even an alternative – to conventional remote-sensing methods.