EGU2020-11180
https://doi.org/10.5194/egusphere-egu2020-11180
EGU General Assembly 2020

Local high-energy particles measurements for detecting primary cosmic-ray variations: application for soil moisture estimation

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In the last decade the measurement of secondary cosmic ray neutrons has been established as a unique approach for intermediate scale observation of land surface hydrogen pools. Originally developed for soil moisture measurements, it has shown also promising applications for snow, biomass and canopy interception. The approach relies on the correlation between natural neutron background as created by cosmic-ray fluxes and local hydrogen pools. Due to the specific capabilities of the neutrons to move in air, the signal detected by the sensor installed above-ground is sensitive to an area of hundreds of meters providing a new perspective for proximal land-surface observations. The measurements are generally performed based on moderated proportional counters filled with Helium-3 or Boron and the moderation is created by adding shielding material (mostly polyethylene) around the counter.

The signal is affected by the temporal variability of the incoming neutron fluxes. At first, the variability of neutron fluxes is due to solar activities. The neutrons are further attenuated by the mass of the air and air humidity.

Specific corrections have been proposed to account for these effects. Air pressure and humidity corrections rely on local measurements that could be easily collected. Incoming correction due to solar cosmic-ray fluctuation is based on a worldwide network monitoring station (NMDB). This network provides online access to their data in real-time. However, this approach showed some limitations in region where incoming fluxes could be not representative of local conditions introducing errors that could be relevant for the estimation of the targeted variable. In addition, it requires the need of post-processing of the data resulting in some difficulties to provide, e.g., soil moisture observations in real-time.

In the present contribution, we show the results of tests conducted on an alternative commercial sensor based on scintillators. The new probe has the capability to identify different neutron energies ranges and gamma-rays providing new opportunities for hydrological observations at different spatial scales. In addition, the probe is sensitive to high energy particles that can be used for correcting the neutron signal by the variations of primary cosmic-ray flux. We present results from the comparison of the new probe with standard proportional counters and neutron monitor

database in a long-term outdoor case study. We show how the use of local high energy particles is a practical alternative to account atmospheric corrections and overcome the limitation of using data from NMDB.