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Buoy-based detection of low-energy cosmic-ray neutrons to monitor the influence of atmospheric effects

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Neutron monitors on the Earth's surface are usually used to observe the dynamics of highly energetic cosmic-ray particles, assuming that local environmental conditions do not influence the measurement. In another young research field, low-energy cosmic-ray neutrons are used to monitor local dynamics of environmental water content. Water in soil, air, snow and vegetation determines the amount of ground albedo neutrons in the sensitive energy range from 1 eV to 100 keV. Plenty of small neutron detectors are operated on natural or agricultural sites all around the world.

A major issue is the modulation of the neutron flux by the dynamics of incoming high-energy cosmogenic particles. Conventionally, independent data from neutron monitors are consulted to serve as a reference for the correction of the local detectors. However, the performance of this comparative correction approach is unreliable, because it does not account for geographical displacement, different energy windows of the detectors, or potential influence of atmospheric conditions on the referenced neutron monitor.

To test the traditional correction approaches for incoming cosmic radiation, air pressure, and air humidity, an experimental setup should avoid any influence of changes due to soil moisture. Therefore, a set of neutron detectors have been deployed in a buoy at the center of a lake for six months. The measurement period also included a Forbush Decrease in September, 2014.

We found that the neutron signals correlated with air pressure, air humidity, and secondary cosmic radiation. The thermal neutron response to air humidity has been revealed to be different from the epithermal neutron response, while air pressure and incoming radiation similarly influenced the thermal and epithermal signals. The results have been used to evaluate different existing strategies for air humidity correction of low-energy neutron data. Additionally, the potential effect of lake temperature on the thermal neutron count rate has been investigated. We have also analyzed the performance of the buoy signal together with different neutron monitors in their capability to correct for the changes of incoming radiation and for the Forbush Decrease

during the measurement period.

Overall, the study demonstrates how low-energy neutron detectors on a buoy could be used to assess the influence of atmospheric and cosmogenic factors on the signal without the influence of soils. Despite the low count rate over water, the general principle could also serve as an alternative to remote neutron monitors as a more local reference signal at more comparable energies.