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

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Cosmic radiation on Earth responds to heliospheric, geomagnetic, atmospheric, and lithospheric changes. In order to use its signal for soil hydrological monitoring, the signal of thermal and epithermal neutron detectors needs to be corrected for external influencing factors. However, theories about the neutron response to soil water, air pressure, air humidity, and incoming cosmic radiation are still under debate. To challenge these theories, we isolated the neutron response from almost any terrestrial changes by operating a bare and a moderated neutron detector in a buoy on a lake in Germany from July 15 to December 02, 2014. We found that the count rate over water has been better predicted by a recent theory compared to a traditional approach. We further found strong linear correlation parameters to air pressure and air humidity for epithermal neutrons, while thermal neutrons responded differently. Two correction approaches for air humidity were similarly able to remove correlations of epithermal neutrons to air humidity. Correction for incoming radiation proved to be necessary for both thermal and epithermal neutrons, for which we tested different neutron monitor stations and correction methods. Here, an established approach worked best with the Jungfraujoch monitor in Switzerland, while more recent approaches were able to adequately rescale data from more remote neutron monitors. However, no approach was able to sufficiently remove the signal from a major Forbush decrease event on September 13th, to which thermal and epithermal neutrons showed a comparatively strong response. The buoy detector experiment provided a unique dataset for empirical testing of traditional and new theories on CRNS. It could serve as a local alternative to reference data from remote neutron monitors.