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A reevaluation of the atmospheric pressure dependence of secondary cosmic-ray neutrons in the context of Cosmic-Ray Neutron Sensing

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Secondary cosmic-ray neutrons may be effectively used as a proxy for environmental hydrogen content at the hectare scale. These neutrons are generated mostly in the upper layers of the atmosphere within particle showers induced by galactic cosmic rays and other secondary particles. Below 15 km altitude their intensity declines as primary cosmic rays become less abundant and the generated neutrons are attenuated by the atmospheric air. At the earth surface, the intensity of secondary cosmic-ray neutrons heavily depends on their attenuation within the atmosphere, i.e. the amount of air the neutrons and their precursors pass through. Local atmospheric pressure measurements present an effective means to account for the varying neutron attenuation potential of the atmospheric air column above the neutron sensor. Pressure variations possess the second largest impact on the above-ground epithermal neutron intensity. Thus, using epithermal neutrons to infer environmental hydrogen content requires precise knowledge on how to correct for atmospheric pressure changes.

We conducted several short-term field experiments in saturated environments and at different altitudes, i.e. different pressure states to observe the neutron intensity pressure relation over a wide range of pressure values. Moreover, we used long-term measurements above glaciers in order to monitor the local dependence of neutron intensities and pressure in a pressure range typically found in Cosmic-Ray Neutron Sensing. The results are presented along with a broad Monte Carlo simulation campaign using MCNP 6. In these simulations, primary cosmic rays are released above the earth atmosphere at different cut-off rigidities capturing the whole evolution of cosmic-ray neutrons from generation to attenuation and annihilation. The simulated and experimentally derived pressure relation of cosmic-ray neutrons is compared to those of similar studies and assessed in the light of an appropriate atmospheric pressure correction for Cosmic-Ray Neutron Sensing.