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A COsmic-ray Soil Moisture Interaction Code (COSMIC) for Use in Data Assimilation

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If the cosmic ray induced above-ground fast neutron count is to be used to update the soil moisture status in a Soil-Vegetation Atmosphere Transfer Scheme (SVATS) using data assimilation, a model is required to accurately calculate the above-ground neutron count rate from the profiles of soil moisture modeled by the SVATS. An accurate model, the Monte Carlo N-Particle eXtended (MCNPX; http://mcnpx.lanl.gov/) exists to do this but, because this is a time consuming Monte-Carlo model, using it in the context of data assimilation is impractical. Consequently an alternative and efficient model is needed which can be calibrated to accurately reproduce the calculations made by MCNPX and used to substitute for MCNPX during data assimilation. This paper describes the construction and calibration of such a model, COSMIC, which is simple, physically-based and analytic and, because it runs approximately 5000 times faster than MCNPX, is appropriate for in data assimilation applications. The model includes description of (a) degradation of the incoming high energy neutron flux, (b) creation of fast neutrons at each depth in the soil, and (c) degradation of the resulting fast neutrons before they reach the soil surface, all of which processes have parameterized dependency on the chemistry and moisture content of the soil. The comparative performance of SPAM relative to MCNPX when applied to represent cosmic-ray/moist soil interactions at several deployment sites within the COsmic-ray Soil Moisture Observing System (COSMOS) is described.