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Temporal Dynamics of Soil Moisture Variance: Closure and Parameter Identification

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The combination of inadequately resolved soil moisture fields and nonlinear relationships between fluxes and soil moisture leads to errors in both diagnostic and predictive estimates of large scale mass and energy fluxes. In this paper we present a conservation equation for the spatial variance of sub-grid root-zone soil moisture. The variance changes in time due to covariances between moisture fields and land surface flux (e.g. infiltration, drainage, evapotranspiration) fields, that either produce or destroy sub-grid moisture variance through time according to their sign. We present a closure of the conservation equations of the first and second moments of the soil moisture field. Closed terms include correlation coefficients between soil moisture and physiographic properties. The approach presented here provides accounting for the effects of dynamic interaction between soil moisture spatial variability and the underlying soil texture and vegetation density fields. Closure is achieved in terms of the spatial-mean soil moisture evolution, with closure coefficients being functions of the correlation coefficient between the underlying soil texture and vegetation density patterns (i.e. the physiographic setting). Making use of these relationships, the proposed approach uses known sub-grid soil texture and vegetation density fields to accurately simulate the temporal trajectory of sub-grid variance of soil moisture, which supports improved estimates of grid-scale land-surface fluxes. The approach is tested synthetically (closure model vs. distributed model) over a wide range of physiographic characteristics and meteorological conditions, with results demonstrating that the closure model based approach reproduces the temporal dynamics of the soil moisture variability and provides improved grid-scale land-surface flux estimates. In fact, the second order closure was shown to reduce the errors in integrated land surface flux estimates, as compared to those derived from zero order approximation estimates, by an order of magnitude

in certain conditions. And, finally, field data are presented and shown to demonstrate a temporal behavior of the spatial variance that is predictable through the proposed approach.