Soil moisture dynamics in a Colorado field: Stability and threshold crossing times under annual crops and perennial vegetation

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Abstract. Soil moisture is a key state variable in many landscapes and varies in space and time. Within an agricultural field, soil moisture dynamics may be similar at many positions but can also vary with landscape topography, soil characteristics and land use/management. Different process models were used previously to simulate space-time soil moisture in a well-monitored agricultural field (106 ha) in northeastern Colorado. The simulated periods comprised primarily a wheat-fallow rotation managed in alternating strips (~120 m wide). In all simulations, the model dynamics of near-surface soil moisture did not fully capture the more stable features of field measurements. That is, simulated responses to infiltration events were more peaked with sharper wetting fronts and often faster drying (recession) than measured moisture contents. While much of the soil-water dynamic behavior is driven by weather patterns from event to inter-annual time scales, land management is an important driving factor. The wheat-fallow field was converted to a Conservation Reserve Program (CRP) in two stages based on alternating crop strips starting in 2013. The current objective is to characterize measured soil moisture dynamics at different landscape positions including changes in these dynamics associated with periods of cropping and the multi-year transition to perennial vegetation. Soil moisture contents were measured hourly with capacitance sensors centered at depths of 30, 60 and 90 cm at 18 landscape positions since 2002, and using two cosmic ray sensors installed in 2015 and 2016 at summit and toe-slope positions, respectively. In addition to conventional temporal statistics for each sensor, we evaluated "crossing times" of when moisture content crossed given thresholds for both wetting and drying. The experimental data were compared with a theoretical model of the distributions of first return times. The data and conceptual model results have implications for potential quantitative assessments of CRP as a program of payments for ecosystem services.