Evaluation of an EOF-Based Method to Estimate Soil Moisture Patterns at Catchments without Local Soil Moisture Observations

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Abstract. Soil moisture is a critical variable for numerous hydrologic and ecological processes, but direct measurement of catchment-scale soil moisture patterns is time consuming and expensive. Many efforts have been made to estimate soil moisture patterns based on readily available information such as topography, which is known to affect soil moisture patterns within catchments. However, reliable estimation of soil moisture patterns for catchments without any available soil moisture observations remains difficult. The purpose of this study is to evaluate the efficiency of an EOF-based method, originally developed at the 11 ha Tarrawarra catchment, to estimate soil moisture patterns at other catchments. In this method, the space-time soil moisture dataset at Tarrawarra was decomposed into time-invariant patterns of covariation called empirical orthogonal functions (EOFs) and associated time series known as expansion coefficients (ECs), which indicate the importance of the EOFs on each date. The statistically significant EOFs and ECs were retained. The retained EOFs were found to depend strongly on various topographic attributes, and the ECs were closely related to the spatial-average soil moisture. The soil moisture pattern can be estimated for any date by calculating the EOFs from the topography and the ECs from the spatial-average soil moisture and then combining the spatial average with the EOF/EC combinations. If the relationships determined from the Tarrawarra catchment are relatively robust, the method could be used to estimate the soil moisture at any catchment with known topography and spatial-average soil moisture (perhaps from remote sensing). In this study, the method is applied first to 13 dates at the Tarrawarra catchment where it was originally developed. Then, it is applied to 8 dates in the Tarrawarra 2 dataset, which encompasses a roughly 115 ha area surrounding the original Tarrawarra catchment. Both catchments are located in a humid region and have relatively uniform vegetation, which is grass. Finally, the method is applied to 9 dates for an 8 ha catchment in the Cache la Poudre basin west of Fort Collins. This catchment is located in a semiarid climate and has heterogeneous vegetation cover (forest and shrublands). When applied to the Tarrawarra catchment, the estimated soil moisture patterns are relatively similar to the observations. When applied to the other catchments, the performance deteriorates somewhat as expected.