Soil water decomposition for downscaling soil water and understanding its controls

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Soil water content (SWC) is crucial to a range of land surface processes at the watershed scale. Time stability of SWC has been used for SWC downscaling, but this method may be limited when temporal anomaly of SWC explains fair amounts of spatial variances. The SWC controls are usually determined by correlating environmental factors to the original (un-decomposed) SWC values, but SWC controls may be misunderstood because of the correlations among environmental factors.

A model was used to decompose the spatiotemporal SWC into a time-stable pattern (TS), a space-invariant temporal anomaly (TAsi), and a space-variant temporal anomaly (TAsv), with the TAsv being responsible for the spatial variability of soil water dynamics. The TAsv was further decomposed with empirical orthogonal function (EOF). We have two hypotheses: (1) underlying (i.e., time-invariant) spatial patterns exist in the TAsv, and inclusion of these underlying patterns can be beneficial to SWC downscaling; (2) understanding of soil water dynamics controls can be improved by correlating environmental factors to the TAsv.

Soil water dataset from a small watershed scale in the Canadian Prairies (CP) and Chinese Loess Plateau (CLP) indicated that underlying spatial patterns exist in the TAsv. Data from the CP showed that the new method improved the estimation of spatially distributed SWC over time-stability based models, especially for dry conditions. Data from the CLP showed that topography (i.e., elevation and aspect) contributed to soil water dynamics. The role of topography was time-dependent and usually but not always less important than that of soil and vegetation. This study corrected the misleading results from the traditional correlation analysis that SWC was positively correlated to elevation and negatively correlated to Cos(aspect). Therefore, both soil water downscaling and soil water processes understanding at a watershed scale benefit from the decomposition of TAsv with the EOF method.