Identifying the importance of regional characteristics on soil moisture patterns across a range of scales

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Abstract. Soil moisture is an important variable in hydrology, agriculture, and many other disciplines. Spatial patterns and temporal dynamics of soil moisture are complex because they depend on the interaction of many variables. While remote sensing techniques can measure near surface soil moisture, such measurements are available at spatial resolutions that are too coarse for most applications. Thus, downscaling methods are needed. If regional characteristics that are easily observed at a finer resolution are closely related to soil moisture patterns, then those characteristics could be used to downscale observations of soil moisture from remote sensing. We hypothesize that the variability in soil moisture patterns can be described by a relatively small number of spatial structures that are related to soil texture, topography, and vegetation. To test this hypothesis, an empirical orthogonal function and principal component (EOF/PC) analysis has been conducted on an available soil moisture dataset. The soil moisture data are from the Southern Great Plains field campaign of 1997 and were collected using an airborne sensor. The data are available on a 0.64 km^2 grid for 16 days during June and July. During the observation period, three precipitation events were observed, and these events were separated by periods of drying. From the EOF/PC analysis, we find that only 3 orthogonal spatial structures (EOFs) are required to explain 87% of the variation in the soil moisture and 5 such structures can explain 93% of the variation. To identify the regional characteristics that are most influential in determining soil moisture patterns, each of these EOFs has been compared to regional characteristics using a correlation analysis. The primary EOF is most highly correlated with the percent sand in the soil, whereas the second EOF is most highly correlated with topographic elevation. These EOFs are also dependent on other regional characteristics to a lesser degree. By aggregating the soil moisture data to spatial resolutions up to 1025 km^2 and repeating the analyses above, it is observed that the surface roughness and other regional properties play an increasingly important role at larger scales. The EOF/PC analysis also produces a principal component time series for each EOF that describes the contribution of the EOF to the soil moisture on each day. The precipitation events and drying periods are clearly exhibited in the most important PCs, which suggests that the associated EOFs characterize the soil moisture accumulation and drainage tendencies throughout the region.