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Investigation of (de)coupling between surface and subsurface soil moisture using a Distributed Lag Non-linear Model (DNLM)

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Accurate estimates of water content in the soil profile are essential for environmental and climate modeling studies. Current trends for estimating profile soil moisture incorporate remote sensing methods for mapping soil moisture at greater spatial coverage but is limited to the upper soil layers (e.g. 5cm for radar satellites). Data assimilation methods offer promising computational techniques to translate mapped surface soil moisture to estimates of profile soil moisture, in conjunction with physical models. However, a variety of factors, such as differences in the drying rates, can lead to "decoupling" (Capehart and Carlson, 1997) of surface and subsurface soil moisture. In other words, surface soil moisture conditions no longer reflect or represent subsurface conditions. In this study, we investigated the relation and observed decoupling between surface and subsurface soil moisture from 15-minute interval time series datasets in four selected Dutch agricultural fields (SM_05, SM_09, SM_13, SM_20) from the soil moisture network in Twente region. The idea is that surface soil moisture conditions will be reflected in the subsurface after a certain time lag because of its movement or flow from the surface. These lagged associations were analysed using distributed lag non-linear model (DLNM). This statistical technique provides a framework to simultaneously represent non-linear exposure–response dependencies and delayed effects. DNLM was applied to elucidate which surface soil moisture conditions resulted in a high association to subsurface values, indicating good correlation between the two zones. For example, initial results for this ongoing study from SM_13 show an overall low but increasing association from dry to intermediate soil moisture values (0 to ∼25%). At this range of values, we say that the two zones are decoupled. Above these values towards near saturated conditions (∼40%), associations between the two zones remain high. For predictor-specific association showing instantaneous and lagged effects at specific surface soil moisture, values indicate that effects of dry surface soil moisture (<10%) reach its peak within a few hours. However, at near-saturated surface soil moisture conditions, its effect to the subsurface is highest in the beginning and decays with time.