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Persistence and memory timescales in root-zone soil moisture dynamics

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The memory timescale that characterizes root-zone soil moisture remains the dominant measure in seasonal forecasts of land-climate interactions. This memory is a quasi-deterministic timescale associated with the losses (e.g. evapotranspiration) from the soil column and is often interpreted as persistence in soil moisture states. Persistence, however, represents a distribution of time periods where soil moisture resides above or below some prescribed threshold, and is therefore inherently probabilistic. Using multiple soil moisture datasets collected at high resolution (sub-hourly) across different biomes and climates, this talk explores the differences, underlying dynamics, and relative importance of memory and persistence timescales in root-zone soil moisture. A first-order Markov process, commonly used to interpret soil moisture fluctuations derived from climate simulations, is also used as a reference model. Persistence duration of soil moisture below the plant water-stress level (chosen as the threshold), and the temporal spectrum of up- and down-crossings of this threshold, are compared to the memory timescale and spectrum of the full time series, respectively. The results indicate that despite the differences between meteorological drivers, the spectrum of threshold-crossings is similar across sites, and follows a unique relation with that of the full soil moisture series. The distribution of persistence times exhibits an approximate stretched exponential type and reflects a likelihood of exceeding the memory at all sites. However, the rainfall counterpart of these distributions shows that persistence of dry atmospheric periods is less likely at sites with long soil moisture memory. The cluster exponent, a measure of the density of threshold crossings in a time frame, reveals that the clustering tendency in rainfall events (on-off switches) does not translate directly to clustering in soil moisture. This is particularly the case in climates where rainfall and evapotranspiration are out of phase, resulting in less ordered (more independent) persistence in soil moisture than in rainfall.