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A Particle Batch Smoother for soil moisture determination by assimilating soil temperatures

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Soil moisture plays a pivotal role in hydrological modeling. Information on soil moisture spatial variability is difficult to obtain using either traditional point scale, or footprint scale remote sensing measurements. This challenge limits both hydrological model performance and the utility of soil moisture products. Distributed temperature sensing (DTS) is an innovative tool for making high resolution temperature measurements (spatial < 1m, and temporal < 1min), along cables which can be up to several kilometers in length. Previous studies demonstrated the feasibility of estimating soil moisture by assimilating temperature observations at shallow layers in a sequential data assimilation system. In this study, we propose a smoothing approach developed from the particle filter, in which series of temperature observations rather than instantaneous observations are assimilated. The evolution of soil temperature in time contains more information of soil moisture than instantaneous observation points. Compared with the standard particle filter, our particle smoothing approach provides improved estimates using same amount of temperature information. It is particularly beneficial for inferring root zone soil moisture. The smoothing approach here may provide a viable tool for determining distributed soil moisture information from DTS observations.