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Estimating surface turbulent heat fluxes from land surface temperature and soil moisture using the particle batch smoother

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This study is focused on estimating surface sensible and latent heat fluxes from land surface temperature (LST) time series and soil moisture observations. Surface turbulent heat fluxes interact with the overlying atmosphere and play a crucial role in meteorology, hydrology and other climate-related fields, but in-situ measurements are costly and difficult.

It has been demonstrated that the time series of LST contains information of energy partitioning and that surface turbulent heat fluxes can be determined from assimilation of LST. These studies are mainly based on two assumptions: (1) a monthly value of bulk heat transfer coefficient under neutral conditions (CHN) which scales the sum of the fluxes, and (2) an evaporation fraction (EF) which stays constant during the near-peak hours of the day. Previous studies have applied variational and ensemble approaches to this problem. Here the newly developed particle batch smoother (PBS) algorithm is adopted to test its capability in this application. The PBS can be seen as an extension of the standard particle filter (PF) in which the states and parameters within a fix window are updated in a batch using all observations in the window.

The aim of this study is two-fold. First, the PBS is used to assimilate only LST time series into the force-restore model to estimate fluxes. Second, a simple soil water transfer scheme is introduced to evaluate the benefit of assimilating soil moisture observations simultaneously. The experiments are implemented using the First ISLSCP (International Satellite Land Surface Climatology Project) (FIFE) data. It is shown that the restored LST time series using PBS agrees very well with observations, and that assimilating LST significantly improved the flux estimation at both daily and half-hourly time scales. When soil moisture is introduced to further constrain EF, the accuracy of estimated EF is greatly improved. Furthermore, the RMSEs of retrieved fluxes are effectively reduced at both daily and half-hourly scales, and the temporal flux variations become more reasonable. We also tested the performance of this method when the number of available LST observations is limited. Generally, the RMSEs decrease with increasing LST observations when only LST is assimilated. However, when soil moisture is assimilated, the number of LST observations has very limited influence on RMSEs. This may prove particularly useful for the application with remote sensing data, in which the availability of observations is often hampered by cloud contamination.