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Multivariate assimilation of coarse scale soil moisture, cosmic-ray soil moisture, land surface temperature and leaf area index in CLM4.5

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The land surface plays a central role in the atmosphere – land surface – subsurface continuum. Surface soil moisture for instance impacts the partitioning of absorbed radiation in heating ground and atmosphere and thus impacts resulting evapotranspiration. The land surface also drives partitioning of rainfall between infiltration which ends up as groundwater recharge and surface runoff contributing to stream discharge. It is therefore expected that the use of observations for characterizing and predicting the land surface state also leads to improved state estimations and predictions in all the other sub-compartments of the system we consider: groundwater, stream discharge and atmosphere. To test this hypothesis requires efficient data assimilation schemes that are capable to take up specific requirements of different compartments, such as different time windows of observations. In this study we will derive such data assimilation methods and quantify the improvement of predictions in the different compartments due to assimilation of multiple observations, and evaluate to what extent assimilation of land surface observations will also improve predictions of land surface states and fluxes for atmosphere and groundwater. We argue that improvements can be achieved by implementing a data assimilation methodology that is capable of simultaneous assimilation of many data sources (remote sensing soil moisture, cosmic-ray measurement for soil moisture, land surface temperature and leaf area index) at different spatial scales ranging from 102 m to 104 m. The multivariate data assimilation system for the land-surface component will be developed and extended to assimilate the coarse scale remote sensing soil moisture, cosmic-ray soil moisture, land surface temperature and leaf area index, and their different combinations using the local ensemble transform Kalman filter. The multivariate data assimilation will be evaluated using a synthetic study which mimics the Neckar catchment (300 rows$\times$260 cols) with 50 ensemble members.