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Improving soil moisture estimation through a dual-cycle assimilation strategy

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Soil moisture plays a key role in land surface processes. Both remote sensing and model simulation have their respective limitations in the estimation of soil moisture on a large spatial scale. Data assimilation is a promising way to merge remote sensing observation and land surface model (LSM), thus having a potential to acquire more accurate soil moisture. Two mainstream assimilation algorithms (variational-based and sequential-based) both need model and observation uncertainties due to their great impact on assimilation results. Besides, as far as land surface models are concerned, model parameters have a significant implication for simulation. However, how to specify these two uncertainties and parameters has been confusing for a long time. A dual-cycle assimilation algorithm, which consists of two cycles, is proposed for addressing the above issue. In the outer cycle, a cost function is constructed and minimized to estimate model parameters and uncertainties in both model and observation. In the inner cycle, a sequentially based filtering method is implemented to estimate soil moisture with the parameters and uncertainties estimated in the outer cycle. For the illustration of the effectiveness of the proposed algorithm, the Advanced Microwave Scanning Radiometer of earth Observing System (AMSR-E) brightness temperatures are assimilated into land surface model with a radiative transfer model as the observation operator in three experimental fields, including Naqu and Ngari on the Tibetan Plateau, and Coordinate Enhanced Observing (CEOP) reference site on Mongolia. The results indicate that the assimilation algorithm can significantly improve soil moisture estimation.