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Multi-scale Data Assimilation for Large Scale Hydrologic Modeling Applications

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Recent developments in hydrologic modeling have resulted in continental-to-global modeling domains at high temporal and spatial resolutions. For example, global hydrologic simulations have been performed at 0.5 degree level or finer, and regionally (over United States) simulations have been performed at 1 km resolutions. As the number of modeling pixels increase rapidly (and expected to reach at least 10^5 to 10^6 grids), so increases the dimension and complexity of the data assimilation problem associated with such applications. Traditional data assimilation computational approaches normally cubically with problem size, making large problems practically impossible to solve. So it is critical to develop efficient assimilation techniques to meet this challenge.

In this presentation a computationally efficient assimilation system for large scale hydrologic modeling applications is presented based on a multi-scale autoregressive (MAR) framework. The MAR framework was developed for high dimensional signals with multi-scale features and provides an efficient filtering procedure for the optimal estimation (data assimilation) of high dimensional dynamic systems. An ensemble version of the multi-scale filtering algorithm, the ensemble multi-scale filter (EnMSF), is utilized. The EnMSF relies on Monte Carlo samples, making this technique suitable for a range of geosciences data assimilation problems. The EnMSF is implemented within a hydrologic data assimilation system that runs a land surface model and assimilates remotely sensed soil moisture. Assimilation experiments are carried out over the Arkansas-Red river basin in central U.S. (645,000 sq km), using the Variable Infiltration Capacity (VIC) model with a computing grid of 1062 pixels. Two assimilation experiments are presented: one is driven by meteorological forcing fields downscaled from NOAA/NCEP's Climate Forecast System (CFS) ensemble seasonal climate forecasts; and the second experiment is driven by ensembles generated from remotely sensed rainfall data (the TRMM 3B42-RT product.) The results not only confirms both the efficiency and accuracy of the multi-scale assimilation method, but also shows the great potential of the multi-scale assimilation system for large-scale applications driven by either coarse-scale atmospheric model forecasts or remote sensing observations.