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Application of an ensemble smoother to precipitation assimilation

Sara Zhang (1), Dusanka Zupanski (2), Arthur Hou (1), Milija Zupanski (2)

(1) GMAO, NASA Goddard Space Flight Center, USA, (2) CIRA, Colorado State University, USA

Assimilation of precipitation in a global modeling system poses a special challenge in that the observation operators for precipitation processes are highly nonlinear. In the variational approach, substantial development work and model simplifications are required to include precipitation-related physical processes in the tangent linear model and its adjoint. An ensemble based data assimilation algorithm "Maximum Likelihood Ensemble Smoother (MLES)" has been developed to explore the ensemble representation of the precipitation observation operator with nonlinear convection and large-scale moist physics. An ensemble assimilation system based on the NASA GEOS-5 GCM has been constructed to assimilate satellite precipitation data within the MLES framework. The configuration of the smoother takes the time dimension into account for the relationship between state variables and observable rainfall. The full nonlinear forward model ensembles are used to represent components involving the observation operator and its transpose. Several assimilation experiments using satellite precipitation observations have been carried out to investigate the effectiveness of the ensemble representation of the nonlinear observation operator and the data impact of assimilating rain retrievals from the TMI and SSM/I sensors. Preliminary results show that this ensemble assimilation approach is capable of extracting information from nonlinear observations to improve the analysis and forecast if ensemble size is adequate, and a suitable localization scheme is applied. In addition to a dynamically consistent precipitation analysis, the assimilation system produces a statistical estimate of the analysis uncertainty.