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Nonlinear ensemble data assimilation employing Maximum Likelihood Ensemble Filter (MLEF) and WRF model

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Many observations of geophysical processes have nonlinear and often discontinuous relationship with the model state variables. This has been long recognized as a serious challenge in data assimilation. In variational data assimilation methods, for example, a special care is being taken to reduce negative impact of nonlinear and discontinuous operators on the data assimilation and forecast results, (e.g., via the use of iterative minimizations and regularized tangent linear and adjont models). The ensemble-based data assimilation methods, even though not relaying on the use of linearized models, also need to address this problem, since linearity assumption is often implicitly present in the ensemble-based methods.

At Colorado State University, we have designed an ensemble-based data assimilation method, called Maximum Likelihood Ensemble Filter (MLEF), with the primary goal for applications to nonlinear and discontinuous forecast models and observation operators. The MLEF employs an iterative minimization of a cost function and the so-called "generalized gradient" and "generalized Hessian" that are defined without requirements for differentiability of the forecast models and observation operators.

In this presentation we will focus on the MLEF data assimilation results with nonlinear and discontinuous operators, using a complex atmospheric model, the Weather Research and Forecasting (WRF) model, and observations (conventional and satellite) related to cloud microphysical processes, which are known to be nonlinear and discontinuous. Severe weather cases from Europe and North America will be examined in more detail.