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Asia Oceania Geosciences Society

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Sono Belle Vivaldi Park, Hongcheon

AS74 Mini Tutorial for Ensemble Data Assimilation and the Data Assimilation Research Testbed
Date & Time: Wednesday, 01 July 2020, 08:30 - 10:30

Data assimilation for an earth system model is the process of combining model forecasts with observations to produce improved estimates of the model state. Ensemble filter data assimilation algorithms use a set (ensemble) of model state estimates to enable the assimilation process.

This session is designed to be a short course that provides a practical introduction to ensemble filters through a combination of lecture and interactive tutorials. Basic ensemble filter algorithms will be covered along with an overview of extensions required for successful application in large earth system models. The interactive tutorials use the algorithms that comprise the Data Assimilation Research Testbed (DART), a community software facility for ensemble filter data assimilation. DART can produce high-quality weather predictions but can also be used to build a comprehensive forecast system for any prediction model and observations. DART has been applied to NWP at scales ranging from sub-kilometer to global, but also to space weather, oceans, sea ice, terrestrial systems, hydrologic models, and many other earth system applications. Attendees will leave with a solid foundation that will allow them to explore using DART for existing models and observations. They will also have a basic understanding of what would be required to develop DART assimilation capabilities for new models or observations. Attendees can download the DART tutorials ahead of time onto their own laptops if they want to participate interactively during the session.

Part 1: Introduction to Ensemble Data Assimilation, 50 Minutes
Jeffrey Anderson, *Data Assimilation Research Section, NCAR*

The basic data assimilation problem is introduced. The Kalman filter and the deterministic ensemble Kalman filter will be developed for a one-dimensional system that includes a forecast model for a single variable and periodic observations of that variable. The 1D ensemble filter will be extended to a case with two model variables, one of which is observed. It is shown that understanding the bivariate case is sufficient to understand an ensemble Kalman filter for forecast models of any size and any number of observations. Running ensemble forecasts is expensive, so using small ensembles is always desirable. However, small ensembles often work poorly and may fail completely when used with large geophysical models. This problem is addressed by localization in which observations are only allowed to change model variables that are nearby. Several low-order model examples will be used to demonstrate how localization can improve performance. Ensemble forecasts tend to be too confident (have too little spread) for a variety of reasons. If this problem is not addressed, even ensemble Kalman filters with good localization can still fail. The solution, inflation of ensembles, is introduced and students will explore how it can be combined with localization to produce state-of-the-art assimilation results. Finally, the 1D problem is revisited and some additional ensemble Kalman filter methods are presented. These methods can extend the capabilities of the ensemble Kalman filter to problems that are less Gaussian, including many geophysical models.

Part 2: Introduction to the Data Assimilation Research Testbed (DART), 40 Minutes
Jeff Steward, *Data Assimilation Research Section, NCAR*

The speaker will introduce most algorithms that are commonly used in geophysical ensemble Kalman filter data assimilation. This session will discuss how DART can be used to apply these algorithms for large geophysical models, like those used for numerical weather prediction. A number of examples of ensemble Kalman filter assimilation for geophysical models and observations will be used to highlight the power of these methods. Examples will include atmospheric, oceanic, land surface, and coupled climate system applications. Specific challenges and methods to overcome these challenges will be highlighted for each example. DART already supports many geophysical models and observations. An overview of what is required to develop a DART capability for a new model or observation is presented. Students should leave with an ability to assess whether ensemble data assimilation with DART could be helpful for their unique applications.

Part 3: Application of DART for the Model for Prediction Across Scales (MPAS), 30 Minutes
Soyoung Ha, *MMM, NCAR*

Unlike variational data assimilation techniques which require the development of tangent linear and adjoint codes of all the modules in the prediction system, ensemble data assimilation algorithms do not involve such a heavy code development and are easy to maintain, taking nonlinear full physics in the model into account during the analysis process. The Model for Prediction Across Scales (MPAS) is constructed using the unstructured Voronoi mesh to facilitate multiscale analysis and forecasting without nesting between multiple domains or the need for developing new covariance models at different scales. For both global and regional versions of the weather prediction system, an interface between the MPAS model and the DART analysis systems has been developed using the model's native mesh. This talk will briefly go through the steps for the development of the new model in the DART system, followed by the challenges in the implementation. As the MPAS/DART has been publicly released and supported, the benefit of high-resolution forecasts using the variable-resolution meshes both in the analysis and the forecast systems is presented.

Organized by:
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Dr Jeffrey Anderson, *National Center for Atmospheric Research*
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