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ATS 101 and Microsoft Teams

The Data Assimilation Research Testbed:
An Introduction to Powerful Nonlinear and
Non-Gaussian Data Assimilation Tools

The development of numerical weather prediction was one of the great scientific and computational achievements of the last century. Computer models that approximate solutions of the partial differential equations that govern fluid flow and a comprehensive global observing network are two components of this prediction enterprise. An essential third component is data assimilation (DA), the computational method that combines observations with predictions from previous times to produce initial conditions for subsequent predictions. In this century, DA is now routinely applied to applications across the Earth system.

This talk describes some of the capabilities of a community software facility for ensemble filter data assimilation, the Data Assimilation Research Testbed (DART). DART can produce high-quality weather predictions but can also be used to build a comprehensive forecast system for any prediction model and observations. As an introduction, the standard ensemble Kalman filter algorithms implemented in DART are described.

These standard algorithms are handicapped by a number of assumptions related to Gaussianity, linearity, and statistical sampling error. Novel extensions of the basic ensemble DA algorithms in DART are described. These extensions are especially important for DA applied to bounded quantities in Earth system models. Atmospheric water vapor, chemical tracers in the atmosphere or ocean, sea ice concentration, and snow cover are just a few examples. The extensions are also relevant for distinctly non-Gaussian situations, for instance the initiation of convection in a fluid. The extensions make use of simple but powerful generalizations of standard ensemble Kalman filter algorithms using quantiles to represent the ensemble samples. A high-level description of this quantile framework will be presented. Examples are shown for a variety of bivariate prior ensembles including bounded quantities and multimodal distributions. Results from cycling assimilation tests in idealized models are also presented. The method has potential to significantly improve data assimilation for distinctly non-Gaussian quantities in Earth system models.