Regional Weather Forecasting Using the Local Particle Filter

Jonathan Poterjoy[1,2]
1. University of Maryland, United States
2. National Oceanographic and Atmospheric Administration (NOAA) Atlantic Oceanographic and Meteorological Laboratory, United States
Email: poterjoy@umd.edu

Abstract

Particle filters (PFs) are sequential Monte Carlo methods that can solve data assimilation problems characterized by non-Gaussian error distributions for prior model variables or measurements. From the perspective of a geoscientist, PFs contain several theoretical properties that make them attractive for research and environmental prediction. Namely, they preserve dynamical balances during data assimilation update steps; they require no special treatment for nonlinear measurement operators or non-Gaussian errors; and they provide an elegant solution to the underlying Bayesian filtering problem. Recent efforts applying PFs for geophysical models have resulted in "localized" PFs, which approximate a given data assimilation application as a large set of loosely coupled problems that can be solved independently using relatively small ensembles – an approach long used for ensemble Kalman filters (EnKFs). While localization delivers a potentially transformative strategy for implementing PFs for high-dimensional systems, its use for real geophysical applications has been limited to small-scale, easily localized fluid motions such as moist convection in atmospheric models.

This seminar reveals findings from synoptic-scale weather forecasting experiments performed with a localized PF. The experiments use a modified version of the Poterjoy (2016) local PF (see Poterjoy et al. 2018), which is implemented in a community data assimilation package used operationally in the United States. Experiments are carried out using the Hurricane Weather Research and Forecasting (HWRF) model with an extensive domain that covers most of the Atlantic hurricane basin. To measure potential benefits of the new system, medium-range HWRF ensemble forecasts generated from

local PF members are scrutinized alongside forecasts generated using EnKF members. These forecasts occur over a four-week period that features the formation and evolution of several major tropical cyclones from the 2017 season. The experiment poses a challenging geophysical data assimilation problem, owing to strong nonlinearity in the system dynamics and the extensive use of indirect remotely-sensed measurements from satellites. This research identifies several advantages of the local PF for an application known to pose challenges for Gaussian filters and smoothers, and describes broader implications of PFs for environmental prediction.

References:

Poterjoy, J., 2016: A localized particle filter for high-dimensional nonlinear systems. Mon. Wea. Rev., 144, 59 – 76.

Poterjoy, J., L. Wicker, and M. Buehner, 2018: Progress toward the application of a localized particle filter for numerical weather prediction. Mon. Wea. Rev., in press