



## **Initial Trials of 4D-Ensemble-Var for Data Assimilation and Ensemble Initialization**

N. E. Bowler (1), J. Flowerdew (1), S. Pring (1), P. Jermey (1), A. Lorenc (1), E. Lee (2,1)

(1) Met Office, Exeter, United Kingdom (Neill.Bowler@metoffice.gov.uk), (2) Korea Meteorological Administration, Seoul, Republic of Korea

Hybrid data assimilation schemes augment flow-dependent ensemble covariances with a climatological covariance. Variational hybrids combine ensemble information with existing methods such as 4-dimensional variational assimilation (4DVar). However, the perturbation-forecast and adjoint models which 4DVar uses to evolve covariances over time impose significant computational and maintenance costs, and may not scale well on future massively parallel computer systems. 4D-Ensemble-Var (4DEnVar) offers an alternative approach, in which the temporal correlations are taken from the ensemble.

We will show results from early trials of 4DEnVar in the Met Office Numerical Weather Prediction (NWP) system. For initializing a deterministic forecast, we find that 4DEnVar is superior to 3DVar and hybrid-3DVar, has similar average performance to 4DVar, but is inferior to hybrid-4DVar (the current operational system), when all are run at the same resolution. 4DEnVar performs relatively worse in the Southern Hemisphere, where reduced observation density places greater reliance on the accuracy of the ensemble covariances. However, the 4DEnVar system is a factor 3-6 cheaper than hybrid-4DVar, even though the latter has been optimized much more than the former. These cost savings could be recycled into extra resolution, extra ensemble members, and/or use of an outer loop.

The reduced cost of 4DEnVar makes it an attractive method for ensemble initialization. It has theoretical advantages over the Ensemble Transform Kalman Filter (ETKF) currently used by the Met Office, in areas such as localization, re-linearization, the use of balanced variables, and greater consistency with the way the central analysis is produced. A single system serving both purposes should also reduce maintenance costs. Better ensemble perturbations may in turn benefit the hybrid data assimilation, further improving both deterministic and ensemble forecasts. Initial trial results comparing a 4DEnVar ensemble with the current ETKF will be presented, including consideration of alternative inflation methods such as relaxation-to-prior-spread and additive inflation.