

# 4DEnVar with Iterative Calculation of Nonlinear Nonhydrostatic Model Compared to En4DVar

Sho Yokota (syokota@mri-jma.go.jp)

Meteorological Research Institute, Japan Meteorological Agency,  
Forecast Research Department

En4DVar and 4DEnVar are two popular ensemble-based variational data assimilation methods. Although the ensemble-based forecast error covariance can be reflected in the analyses of both methods, En4DVar calculates the gradient of the cost function with the adjoint of tangent linear forecast model, which requires large development and computational costs. Such costs are generally not required in 4DEnVar because 4DEnVar does not use the tangent linear forecast model. However, 4DEnVar analyses are generally worse than those of adjoint-based En4DVar probably because 4DEnVar does not iteratively calculate the nonlinear forecast model. In this study, therefore, we developed 4DEnVar with iterative calculation of the nonlinear forecast model (hereafter, 4DEnVar-iterF). In 4DEnVar-iterF, the forecasts calculated iteratively are used to gain the cost function and its gradient. We conducted the observation system simulation experiment with the Lorenz-63 model and showed that the 4DEnVar-iterF analysis can be better than those of En4DVar and general 4DEnVar if ensemble perturbations are appropriate. Moreover, we also applied 4DEnVar-iterF to JMA nonhydrostatic model-based 4DVar data assimilation system, and showed that 4DEnVar-iterF analysis is similar to En4DVar analysis. As a next step, we will develop the localization and hybrid of forecast error covariance matrix.