

## Perturbation Methods for Ensemble Data Assimilation

\*Kazuo Saito<sup>1,2</sup>, Masaru Kunii<sup>1</sup>, Duc Le<sup>2,1</sup>, Takuya Kurihana<sup>3</sup>

1. Meteorological Research Institute, 2. Japan Agency for Marine-Earth Science and Technology, 3. University of Tsukuba

Ensemble data assimilation methods are widely noticed as the analysis methods suitable for HPC which have potential to improve the accuracy of numerical weather prediction, substituting for or combining with the variational methods. Ensemble data assimilation methods have an advantage in terms of the development cost over the 4-dimensional variational method in that the adjoint models are not necessary, however, their performances are still arguable and likely have room for further improvement.

In ensemble data assimilation, the forecast error, which is necessary in data assimilation, is estimated by perturbations of the ensemble forecast, while characteristics of the ensemble forecast strongly depend on how the initial ensemble was generated. The ensemble transform (ET), eigenvalue decomposition of the analysis error covariance matrix, is widely used as the initial ensemble perturbation generator for the most ensemble data assimilation including ensemble Kalman filter such as LETKF and the ensemble variational method (EnVAR). The ensemble transform has an advantage in that the magnitude of perturbations (initial ensemble spread) can reflect the magnitude of the analysis error, but on the other hand, it is known that the growth of the errors is slower than other methods such as the singular vector method and the BGM method. In the previous studies for the mesoscale ensemble system (e.g., Saito et al.; 2011; 2012), perturbations from LETKF were not necessarily better than other methods as the initial perturbations, which may affect the accuracy of the analysis field. Non-diagonal components in the transform matrix likely contaminate the synoptic scale structure of the bred vectors in the ensemble forecast in the assimilation window when the localization is applied.

We started to tackle this problem, and in the presentation, some preliminary results using SPEEDY-LETKF will be shown, including spatial structure and power spectrum of ensemble perturbations by diagonal and off-diagonal components of the transform matrix.

Keywords: ensemble data assimilation, ensemble transform, perturbation method