The purpose of the present study is to develop a sampling error damping method for the Cloud-Resolving Model (CRM) Ensemble-based Variational Assimilation (EnVA). This is because, in ensemble-based assimilation schemes for CRMs, sampling error is serious, in particular, for precipitation-related variables (precipitation rate, vertical wind speed) because they are confined in rainy areas [1].

Based on the CRM ensemble forecast error analyses for various precipitation cases, we adopted a Neighboring Ensemble (NE) method and a dual scale separation of NE as the sampling error damping method. The NE method approximated the forecast error correlation using NE members within a reduced-grid box (5 x 5 grids in the present study) based on the spectral localization assumption [2]. In the dual scale separation, we divided the NE forecast error into large-scale portions (13 x 13 grid averages in the present study) and small-scale deviations so as to reflect the horizontal scale differences in forecast error between precipitation-related variables and others.

In order to introduce the sampling error damping method to the CRM EnVA, we assumed that the EnVA analysis increments were subject to the dual scale NE forecast error subspace. In addition, we reduced the vertical dimension of the subspace by approximating the subspace with the primary Singular Value Decomposition (SVD) modes of the vertical cross correlation of the dual scale NE forecast error.

The EnVA scheme of the present study derived the optimal analysis increments by minimizing the three-dimensional cost function in the subspace spanned by the vertical SVD primary modes. Since the SVD modes were mutually independent, the cost function resulted in that for the horizontal component of the analysis increment of the each SVD mode. Then, we horizontally diagonalized the background term of the cost function using the horizontal correlation of the NE forecast error. We used the conjugate gradient scheme to solve the nonlinear minimization of the cost function, and obtained the optimal analysis increment of the ensemble mean [1]. Then we calculated the analysis of the each ensemble member using Zupanski’s method [3].

References