Development of an Ensemble-based Data Assimilation System with a Coupled Atmosphere–Ocean GCM

Nobumasa Komori a,b, Takeshi Enomoto a,b, Takemasa Miyoshi a,c, Akira Yamazaki a, and Bunmei Taguchi a

a Earth Simulator Center, Japan Agency for Marine-Earth Science and Technology, Japan, komori@jamstec.go.jp,
b Disaster Prevention Research Institute, Kyoto University, Japan,
c RIKEN Advanced Institute for Computational Science, Japan.

To enhance the capability of the local ensemble transform Kalman filter (LETKF) with the Atmospheric general circulation model (GCM) for the Earth Simulator (AFES) [1], a new system has been developed by replacing AFES with the Coupled atmosphere–ocean GCM for the Earth Simulator (CFES). An initial test of the prototype of the CFES–LETKF system has been completed successfully, assimilating atmospheric observational data (NCEP PREPBUFR archived at UCAR) every 6 hours to update the atmospheric variables, whereas the oceanic variables are kept unchanged throughout the assimilation procedure.

An experimental retrospective analysis–forecast cycle with the coupled system (CLERA-A) starts on August 1, 2008, and the atmospheric initial conditions (63 members) are taken from the second generation of AFES–LETKF experimental ensemble reanalysis (ALERA2) [2, 3]. The ALERA2 analyses are also used as forcing of stand-alone 63-member ensemble simulations with the Ocean GCM for the Earth Simulator (EnOFES), from which the oceanic initial conditions are taken.

In both CLERA-A and EnOFES, the ensemble spread of sea surface temperature (SST) is much larger in the summer hemisphere than in the winter hemisphere in spite that atmospheric disturbances and their spread are much larger in the winter hemisphere. This is likely caused by the difference in the oceanic mixed-layer depth between the summer and winter hemispheres: the mixed layer thins in summer, and SST becomes sensitive to the atmospheric disturbances. The ensemble spread of SST induced by atmospheric disturbances is larger in CLERA-A than in EnOFES, suggesting positive feedback from the ocean to the atmosphere. On the other hand, the spread caused by ocean dynamics such as tropical instability waves is slightly smaller in CLERA-A than in EnOFES. This could be a result of the damping process through the momentum flux [4].

Although the ensemble spread of SST does not grow sufficiently to affect the ensemble spread of air temperature, the ensemble spread of specific humidity in the lower troposphere is larger in CLERA-A than in ALERA2. Thus replacement of AFES with CFES successfully contributes to mitigate an underestimation of the ensemble spread near the surface resulting from the common boundary conditions among all ensemble members and the lack of atmosphere–ocean interaction.

References