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Development of an ensemble-based data assimilation system with a coupled atmosphere-ocean GCM

KOMORI, Nobumasa[1*] ; ENOMOTO, Takeshi[2] ; MIYOSHI, Takemasa[3] ; YAMAZAKI, Akira[1] ; TAGUCHI, Bunmei[1]

[1]Earth Simulator Center, JAMSTEC, [2]Disaster Prevention Research Institute, Kyoto University, [3]RIKEN Advanced Institute for Computational Science

To enhance the capability of the local ensemble transform Kalman filter (LETKF) with the Atmospheric general circulation model (GCM) for the Earth Simulator (AFES), 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). 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 for the CLERA-A are taken.

The ensemble spread of SST is larger in CLERA-A than in EnOFES, suggesting positive feedback between the ocean and the atmosphere. Although SST in CLERA-A suffers from the common biases among many coupled GCMs, the ensemble spreads of air temperature and specific humidity in the lower troposphere are 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 single boundary condition for all ensemble members and the lack of atmosphere-ocean interaction.

In addition, the basin-scale structure of surface and subsurface ocean temperature in the tropical Pacific is well reconstructed from the ensemble correlation in CLERA-A but not in EnOFES. This suggests that use of a coupled GCM rather than an oceanic GCM could be important even for oceanic analysis with an ensemble-based data assimilation system.