Development of a Coupled Atmosphere-Ocean Model in JMA/MRI

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A coupled atmosphere-ocean data assimilation (DA) system is a system in which atmospheric and oceanic observation data are assimilated into a coupled atmosphere-ocean model. Many researchers consider a coupled DA system as an indispensable tool for seamless forecasting of daily weather to interannual climate variations. Using a coupled DA system is also considered to be effective to improve the skill of ENSO forecasting. For example, JAMSTEC developed a coupled DA system based on a four-dimensional variational (4DVAR) method, and confirmed its potential for improving ENSO forecasts (e.g. Sugiura et al. 2008; Masuda et al. 2015). JMA/MRI has also been developing a quasi-coupled DA system in which only ocean data are assimilated into a coupled model (atmospheric data is not assimilated) since 2006, and confirmed that the system improved key atmospheric climate features such as the Walker Circulation, the Monsoon Trough, and the Typhoon activities in the Philippine Sea over simulation of an uncoupled atmospheric model forced by observed SST data, that is, AMIP-Run (Fujii et al. 2009, 2011).
Recently, operational agencies such as NCEP, ECMWF, and UKMO, have started to develop or to use coupled DA systems in order to realize the seamless forecasting and to improve climate predictions (Saha et al. 2010, Laloyaux et al. 2015, Lea et al. 2015). Those systems are, however, so-called weakly-coupled data assimilation systems; atmospheric and ocean analyses are generated independently by separated atmosphere and ocean data assimilation systems. First-Guess fields for next analysis time-windows are given by the simulation of a coupled model from the ocean and atmospheric analysis fields. Although a weakly-coupled data assimilation system is not sufficient for generating balanced analyses fields of atmosphere and ocean due to the lack of explicit evaluation of the balance, development of the system is relatively easy because existing atmosphere and ocean data assimilation systems can be exploited.
JMA/MRI have also started to develop a weakly-coupled DA system by coupling the 4DVAR global atmosphere DA system, MRI-NAPEX, the global ocean data assimilation system, MOVE-G2, and the coupled atmosphere-ocean model for seasonal forecasting, JMA/MRI-CGCM2. In the plan, the system will use assimilation time-windows of 6 hours for the atmosphere and 10 days for the ocean. The system simulates time-evolution of the atmosphere and ocean from the atmospheric analyses fields generated by MRI-NAPEX and ocean fields at the end of the previous simulation using JMA/MRI-CGCM2. In the simulation, the ocean fields are continuously modified by adding oceanic analysis increments estimated by MOVE-G2. Atmospheric first-guess fields for the next assimilation time-window are prepared by the simulation. Thus, the system uses the uncoupled atmospheric model for the inner loop and the coupled model (JMA/MRI-CGCM2) for the outer loop in the 4DVAR DA system. Here, it should be noted that MOVE-G2 and JMA/MRI-CGCM2 have been used in the operational seasonal forecast in JMA since June 2015.
We have also developed a new quasi-coupled DA system using MOVE-G2 and JMA/MRI-CGCM2, and performed a reanalysis experiment for the period after 2000. In the presentation, we will introduce results of the reanalysis experiment as well as the features of the weakly-coupled DA system which we are developing now.

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