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The Met Office Coupled Atmosphere/Land/Ocean/Sea-Ice Data Assimilation System

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The Met Office has developed a weakly-coupled data assimilation (DA) system using the global coupled model HadGEM3 (Hadley Centre Global Environment Model, version 3). At present the analysis from separate ocean and atmosphere DA systems are combined to produced coupled forecasts. The aim of coupled DA is to produce a more consistent analysis for coupled forecasts which may lead to less initialisation shock and improved forecast performance.

The HadGEM3 coupled model combines the atmospheric model UM (Unified Model) at 60 km horizontal resolution on 85 vertical levels, the ocean model NEMO (Nucleus for European Modelling of the Ocean) at 25 km (at the equator) horizontal resolution on 75 vertical levels, and the sea-ice model CICE at the same resolution as NEMO. The atmosphere and the ocean/sea-ice fields are coupled every 1-hour using the OASIS coupler. The coupled model is corrected using two separate 6-hour window data assimilation systems: a 4D-Var for the atmosphere with associated soil moisture content nudging and snow analysis schemes on the one hand, and a 3D-Var FGAT for the ocean and sea-ice on the other hand. The background information in the DA systems comes from a previous 6-hour forecast of the coupled model.

To isolate the impact of the coupled DA, 13-month experiments have been carried out, including 1) a full atmosphere/land/ocean/sea-ice coupled DA run, 2) an atmosphere-only run forced by OSTIA SSTs and sea-ice with atmosphere and land DA, and 3) an ocean-only run forced by atmospheric fields from run 2 with ocean and sea-ice DA. In addition, 5-day and 10-day forecast runs, have been produced from initial conditions generated by either run 1 or a combination of runs 2 and 3. The different results have been compared to each other and, whenever possible, to other references such as the Met Office atmosphere and ocean operational analyses or the OSTIA SST data.

The performance of the coupled DA is similar to the existing separate ocean and atmosphere DA systems. This is despite the fact that the assimilation error covariances have not yet been tuned for coupled DA. In addition, the coupled model also exhibits some biases which do not affect the uncoupled models. An example is precipitation and run off errors affecting the ocean salinity. This of course impacts the performance of the ocean data assimilation. This does, however, highlight a particular benefit of data assimilation in that it can help to identify short term model biases by using, for example, the differences between the observations and model background (innovations) and the mean increments. Coupled DA has the distinct advantage that this gives direct information about the coupled model short term biases. By identifying the biases and developing solutions this will improve the short range coupled forecasts, and may also improve the coupled model on climate timescales.