Introduction

We have developed a weakly-coupled data assimilation (DA) system using the global coupled model HADGEM3 (Hadley Centre Global Environment Model, version 3). This model combines the atmospheric model UM (unified Model) at 60 km horizontal resolution on a 27x25 grid, the ocean model NEMO (Nucleus for European Modelling of the Ocean) at 24 km (at the equator) horizontal resolution on 75 vertical levels, and the sea-ice model CICE at the same resolution as NEMO. The atmospheric and the ocean/sea-ice fields are coupled every 1-hour using the OASIS coupler. The coupled model is corrected using two separate 8-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.

The aim of the work is to see whether the weakly-coupled DA system offers improvements over starting from separate atmosphere/ocean/sea iced initial conditions. To assess the benefit of the weakly-coupled DA, one-month experiments have been carried out, including (1) a full atmosphere/ocean/sea-ice coupled DA run, (2) an atmosphere-only run forced by OMAI SSTs and NEMO sea-ice with atmospheric 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 coupled forecast runs, started twice a day, have been produced from initial conditions generated by either run 1 or a combination of runs 2 and 3.

Method

Positive impact has been shown of coupled models compared with uncoupled ocean or atmosphere models on medium range forecasts (e.g. John et al., 2012). Accurate coupled forecasts require accurate and consistent initial conditions. However, existing ocean and sea-ice DA. In addition, 5-day coupled forecast runs, started twice a day, have been produced from initial conditions generated by either run 1 or a combination of runs 2 and 3.

In the weakly-coupled framework the background trajectory is produced by running the coupled model. Separate inner loops are run in ocean and atmosphere. System nudging is used to directly initialise atmosphere component of the coupled model. Incremental Analysis Updates (IAU) is used to initialise the ocean component of the coupled model.

Experimental set-up

We focus on the impact of the coupled initialisation strategy on the performance of short-range coupled forecasts. Benefits of coupled-modeling strategy are demonstrated.

We do a comparison to the control uncoupled run and operational FOAM and NWP. One month trials for 2 periods: Dec 2011 and June 2012. Both the control and coupled DA runs are used to initialise sets of coupled forecasts. Forecast results for June 2012 are not yet available. We focused on following on Dec 2011.

The control results are somewhat preliminary as it is not possible to be confident of a weak uncoupled analogue to the coupled atmosphere.

Conclusions

We have compared coupled and uncoupled DA in one-month trials using 5-day forecasts initialised by coupled or uncoupled DA. Run for two periods Dec 2011 (finished) and June 2012 (not finished).

The initial assessment for coupled shows good results in global and regional statistics against observations. Examined were monthly mean and standard deviation of surface fields and their differences, termed innovations for the ocean fields. Also we looked at forecast differences (e.g. precipitation). The median distribution of the innovation cycle of all showed the coupled DA system performing well.

Overall the impact of coupled DA is rather small, but generally beneficial. More impact on the atmosphere than on the ocean. Longer lead times show more impact. Differences in the potential impact with the surface wind speed in the coupled model. Some interesting features: the impact of the ocean is visible in the atmosphere. Societally interesting differences south of Sahel. Dipoles in atmosphere forecasts suggest different patterns of events. Innovation SST slightly smaller but moves smaller. Improvement in Sea ice concentration.

Encouraging results particularly as the system has not been tuned for coupled DA.

Future work

Our short term: Finish the June 2012 period. Study more closely the interesting features. Run case studies for particular phenomena (Forcumus, monsoon). Plan: Implement a demonstration operational system for coupled DA. Run OSEI and OSEI for ocean (SST and Argo data). Evaluate inter-annual evolution of coupled DA. Implement on initialisation shock and assimilation with University of Reading. General SST assimilation improvement, implement higher resolution (< 25 km) for the atmosphere.

References

Johns et al., 2012. Accurate coupled forecasts require accurate and consistent initial conditions. However, existing ocean and sea-ice DA. In addition, 5-day coupled forecast runs, started twice a day, have been produced from initial conditions generated by either run 1 or a combination of runs 2 and 3.

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

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