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RECENT DEVELOPMENTS FOR AN OPERATIONAL CANADIAN GLOBAL ASSIMILATION AND PREDICTION CAPABILITY FOR THE COUPLED ATMOSPHERE-OCEAN-ICE SYSTEM

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1. INTRODUCTION

*Here we report on recent developments for an operational Canadian global coupled atmosphere-ocean-ice assimilation and modeling system.

Environment Canada (EC), Fisheries and Oceans Canada (DFO), and the Department of National Defence (DND) require environmental information products and capabilities that can be provided by an operational global coupled atmosphere-ocean-ice data assimilation and prediction system. In-situ data from Argo floats together with other observations (e.g., altimeter, remotely sensed sea surface temperature) permit effective ocean data assimilation.

The atmospheric GEM model currently used by EC in operational weather forecasting has state-of-the-art dynamics and assimilative methodologies, but it needs to be coupled to active ocean and ice models to improve forecasting skill in some areas. Ocean analyses will also benefit seasonal to interannual climate forecasts. DFO has been a major contributor to the Argo float program but it has made only a limited investment in the development of the modeling capacity required to make full use of the resulting data. EC has recognized the potential for improved short-, medium- and long-range weather forecasts, and both DFO and DND recognize that they would benefit greatly from the availability of improved oceanic and meteorological information. Although the opportunity and the potential benefits are obvious, the development, maintenance and continued improvement of the required technology are major tasks that are beyond the present capacity of any one department. For cost effectiveness, EC, DFO and DND are collaborating on a major initiative referred to as the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS), and are partnering with Mercator-Océan (France) for the ocean aspects. The success of this initiative will require significant long-term contributions from all three departments as well as input from the academic research community.

The purpose of this presentation is to provide an update on CONCEPTS. Section 2 outlines recent developments, section 3 reports on progress in key activities, and section 4 gives a brief summary.

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2. RECENT DEVELOPMENTS

Recent developments have built on the foundation laid by an Inter-agency Panel that was formed in 2002 to make recommendations regarding the development of an operational coupled atmosphere-ocean-ice data assimilation and modelling capability. The recommendations in the panel's 2004 report were accepted by senior departmental managers, resulting in the development of the CONCEPTS inter-agency initiative. Recently an EC- DFO- DND Memorandum of Understanding has been drafted for Canadian inter-agency collaboration, and a Canada- Mercator agreement has been drafted for an international partnership on ocean aspects. Initial resources have been put in place for the establishment of three major inter-related activities: 1) an operational activity built on existing EC infrastructure by coupling the Canadian atmospheric GEM model with the Mercator NEMO system; 2) a research and development (R&D) activity consisting of long-term government research and complementary academic research networks; and 3) a products activity to identify, develop and disseminate relevant products and outputs. The R&D activity is being enhanced through a research network (Thompson/Ritchie) on "Prediction and Predictability of the Global Atmosphere-Ocean System from Days to Decades" funded by the Canadian Foundation for Climate and Atmospheric Sciences. This academic network, which is referred to as the Global Ocean-Atmosphere Prediction and Predictability (GOAPP) network, includes 17 principal investigators funded for a four year period that started in October 2006.

3. PROGRESS IN KEY ACTIVITIES

CONCEPTS includes projects on: 1) core CMC systems installation, coupling and support; 2) basin-to-global ocean reanalyses for prediction and validation studies; 3) demonstration of regional ocean prediction capability and applications; 4) sea ice modelling and data assimilation; and 5) improved ocean data assimilation capabilities. GOAPP is also involved in several of these projects. In this section we report on progress in some related key activities.

Two configurations of the global NEMO Mercator ocean model have been installed at CMC: the ORCA1 grid at 1 degree resolution nominally with enhanced meridional resolution in the tropics, consistent with versions used in the UK and several other locations; and the ORCA025 ¼ degree grid consistent with Mercator's set-up. The ORCA1 version with its accompanying ice model has been run for multiple years, driven by daily climtological surface forcings, and has produced realistic sea ice thickness evolutions in both hemispheres. Similarly the ORCA025 configuration has been run for multiple years and produced realistic detailed outputs, as illustrated by the ocean currents at 13 m depth on March 1 of model year 2, in figure 1. (Youyu Lu et al.)

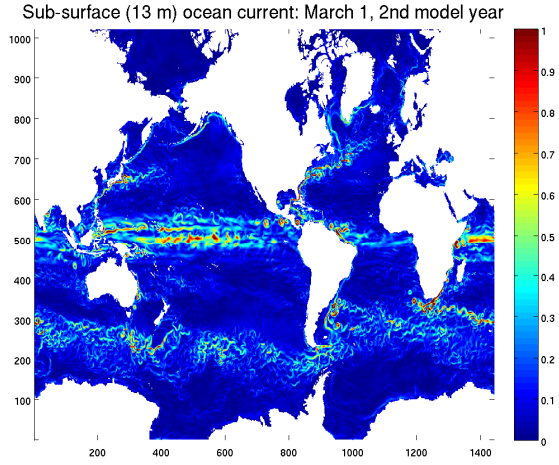

Fig. 1 Ocean currents at 13 m depth on March 1 of ORCA025 model year 2.

In preparation for reanalyses in the North Atlantic basin, the "spectral nudging" method has been installed and tested in the ¼ degree North Atlantic NEMO model (a sub-grid of ORCA025) where it has proved to be highly effective in controlling drift of the Gulf Stream, while leaving the eddies free to evolve realistically. Encouraging results have also been obtained with spectral nudging in the ORCA1 global model. (Dan Wright et al.) ORCA1 and ORCA025 configurations (with spectral nudging) are also set up for the North Pacific basin, and simulations are in progress (Mike Stacey et al.)

Within the Canada – Newfoundland Operational Forecasting System (C-NOOFS), observations from long term ocean climate monitoring sections are being used, together with a variety of other data sets, to validate Mercator analyses and assess their improvements in more recent versions (Fraser Davidson et al.)

An innovative automated sea-ice analysis system has been developed using a variational approach (incremental 3D first guess at appropriate time, Mark Buehner, Alain Caya and Tom Carrieres). It has been applied over the Canadian east-coast region and is giving encouraging resuls. Figure 2 shows the change in ice concentration over a 48-hour period during a case of strong advection due to northeasterly winds in April 2007. This case, in which numerous fishing vessels were trapped, will be studied further. This analysis system will be ported to other regions, such as the Canadian Arctic archipelago and the Gulf of St. Lawrence, where Canada's first fully coupled atmosphere-ocean-ice system is now running experimentally in real-time, resulting in improved atmospheric forecasts.

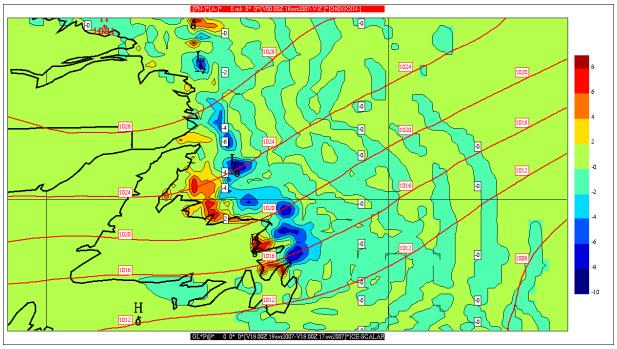

Fig. 2 Change in ice concentration field over a 48-hour period in April 2007 as discussed in text.

Improved ocean data assimilation capabilities are being developed within the GAOPP network. In particular, a new hybrid method for assimilating altimeter and Argo data is showing promise. It is computationally efficient, multivatiate, simplifies matrix specification, and allows for complex temperature-salinity relationships. It has been used in a study of short term predictability in the North Atlantic, where areas of high and low predictability are identified. Results are presented in figure 3 which shows predictability as a function of lead time for three areas. The three areas are shown in the lower right panel, while the root-mean-square differences between the predicted and observed sea levels as a function of lead time are shown in the other three panels as labeled. The dashed curves are for free running predictions ("control"), the grey curves are for predictions started from climatological initial conditions ("climatological"), the thin black curves present the differences between the observations and the analyses from the ocean data assimilation system ("ODA"), and the thick black lines are for predictions started from the ODA analyses ("forecasts from ODA"). Taking the climatological predictions as the "no-skill" method, we see that in area II (which includes the highly active Gulf Stream region) the forecasts from ODA show predictability until about eight days after which the skill decays to that of the control predictions. In area III towards Europe, the skill persists until about twenty days, whereas in the relatively quiet southern area I, there is skill until about twenty-five days. (Keith Thompson and Yimin Liu)

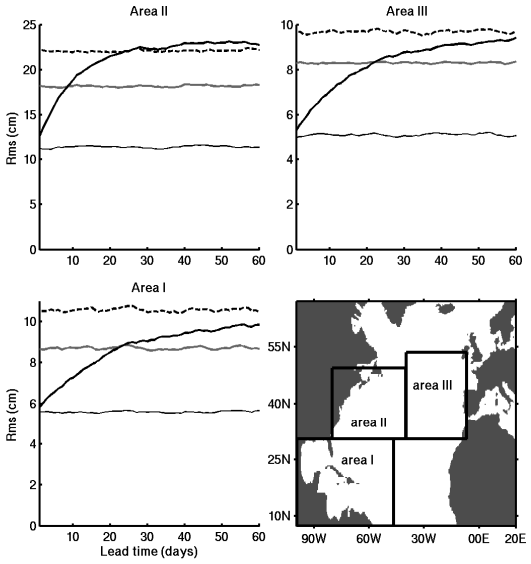

Fig. 3 Predictability as a function of lead time.

4. SUMMARY

The development of an operational Canadian global assimilation and prediction capability for the coupled atmosphere-ocean-ice system has begun. There are strong interactions between CONCEPTS and the complementary GOAPP network. National and international collaborative research projects are in progress. Required long-term resources are being sought.