Recent Developments in MRD coupled Atmosphere-Ocean-Ice Modelling

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Coupled numerical environmental prediction research is pivotal to meeting Environment Canada's key priority for integrated environmental monitoring and prediction. Our focus is on developing coupled atmosphere-ocean-ice modelling systems in order to improve the accuracy of environmental forecasts on time scales from minutes to seasons and space scales from kilometres to global. Progress in both deterministic and ensemble environmental forecast systems is crucial for applications such as managing hydrological, energy, land and marine resources, and preparedness for environmental emergencies. This is being accomplished by contributing to and leveraging research, information and data through national and international partnerships. One notable example is the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS) in which Environment Canada (EC), Fisheries and Oceans Canada (DFO) and the Department of National Defence (DND) are developing atmosphere-ocean-ice systems in partnership with Mercator-Océan (France) for ocean aspects based on their Nucleus for European Modelling of the Ocean (NEMO) system, and with the university Global Ocean-Atmosphere Prediction and Predictability (GOAPP) research network funded by the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS). CONCEPTS is providing a framework for research and operations that will provide environmental information products and capabilities required by EC, DFO and DND.

EC's Meteorological Research Division (MRD) has made considerable progress on the installation of the existing 1/4-degree Mercator ocean data assimilation and prediction system at the Canadian Meteorological Centre (CMC). The NEMO model configuration has been installed and validated by comparing with Mercator forecasts using initial conditions and forcings provided by Mercator for a 2-week period. Subsequently the NEMO model, initiated by Mercator analyses, is being driven by the operational CMC GEM atmospheric model forcings to potentially produce a 2-member ensemble together with Mercator forecasts. Installation of the Mercator SAM2 Ocean

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Data Assimilation system has been validated by reproducing Mercator analyses using the same input data, initial conditions, and forcings. Initial coupling of 1 degree global NEMO and GEM forecast models has also been completed, and coupling of ¼ degree NEMO and meso-global GEM forecast models is in progress.

Our most advanced project is the fully interactive coupled atmosphere-ocean-ice forecasting system for the Gulf of St. Lawrence (GSL) that has been installed in experimental mode at CMC. This project follows a study by Pellerin et al. (2004) showing more accurate weather forecasts over the GSL and adjacent coastal areas resulting from the coupled system in a case study involving rapid ice motion. This has been confirmed in more extensive testing and preparations for operational use that were carried out in a collaboration amongst several groups in EC and DFO. Results during the past year have demonstrated that the coupled system produces improved forecasts in and around the GSL during all seasons, proving that atmosphere-ocean-ice interactions are indeed important even for short-term Canadian weather forecasts. This has important implications for CONCEPTS and other coupled modeling and data assimilation partnerships that are in progress. It is anticipated that this GSL system will soon become the first fully interactive coupled system to be implemented at CMC.

Within our coupled modelling activity there is also a particular focus on sea ice in order to improve its representation in models used for forecasting of weather, climate and sea-ice features. An offline atmosphere-ice modelling system has been developed and is being used to produce ice forecasts over various Canadian regions and is being incorporated in sea ice data assimilation cycles.

Another activity focuses on wave modeling and ensembles. A project entitled "An ensemble modeling system for winds and waves" has been highly successful in keeping Canada's wave model competitive with wave models in other countries, and has allowed the Canadian model to take advantage of improvements in data assimilation and in atmospheric modeling, thus providing optimal environmental information, predictions and services to ensure safety and support economic activity for which waves are an important consideration. Another project on "Development of Probabilistic Forecast Tools for Search and Rescue" is carrying out research and development aimed at enhancing the marine weather and wave forecast information that is made available to Search and Rescue for predicting target location, and to improve the forecast information available to all marine interests for high impact weather events. The goal is to quantify the uncertainty in forecasts of important marine elements such as winds and waves, so that forecast products can be presented in terms of probabilities of occurrence of important weather events, in addition to the current practice of specifying the expected location and time of the occurrence of a significant event. Such probability estimates of wind, for example, can then be used as input to models such as CANSARP (CANadian Search And Rescue Planning) and the wave model (WAM), to give probabilities of target location in the former case and probabilities of high wave heights in the latter case.

Reference

Pellerin, P., H. Ritchie, F.J. Saucier, F. Roy, S. Desjardins, M. Valin and V. Lee, 2004 : Impact of a two-way coupling between an Atmospheric and an ocean-ice model over the Gulf of St. Lawrence. *Mon. Wea. Rev.*, 132, 1379-1398.