Towards an integrated marine Arctic prediction system for METAREAs

*Hal Ritchie, Meteorological Research Division, EC, Dartmouth NS,
Gregory Smith, Meteorological Research Division, EC, Dorval QC
Christiane Beaudoin, Meteorological Research Division, EC, Dorval QC
Mark Buehner, Meteorological Research Division, EC, Dorval QC
Serge Desjardins, Meteorological Service of Canada – Atlantic, EC, Dartmouth NS
Pierre Pellerin, Meteorological Research Division, EC, Dorval QC
Charles-Emmanuel Testut, Mercator-Océan, Toulouse, France
Gilles Garric, Mercator-Océan, Toulouse, France

With the ever-increasing interest in resource exploitation and marine transport in the Arctic there is a mounting need for improved knowledge about the current and future environmental conditions in the Arctic. This need can be met by a new tri-ministerial initiative called the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS) among Environment Canada (EC), Fisheries and Oceans Canada (DFO), and the Department of National Defence (DND). CONCEPTS, in close collaboration with the French operational oceanographic centre Mercator-Océan, is providing a framework for research and operations on coupled atmosphere-ice-ocean prediction in Canada. Operational activity in CONCEPTS is based on coupling the Canadian atmospheric GEM (Global Environmental Multi-scale) model with the Mercator ice-ocean forecasting system based on the Nucleus for European Modelling of the Ocean (NEMO) ice-ocean model. The Mercator data assimilation system is based on a multi-variate SEEK data assimilation method that assimilates sea level anomaly, sea surface temperature (SST) and in situ temperature and salinity data. Using the Mercator forecasting system, weekly 1/4° resolution global 10-day ice-ocean forecasts are now being produced as well as daily 10-day forecasts at 1/12° resolution for the Northwest Atlantic. Ice fields are initialized using a 3DVAR ice analysis system that assimilates the manual ice analyses from the Canadian Ice Service, RadarSAT manual analyses as well as AMSR-E data. In addition, a high-resolution regional forecasting system for the Arctic is also under development. This system is initialized using 3DVAR ice analyses on a 5km North American grid (including the western Arctic) and produces daily 48hr ice forecasts.

In December 2007 Canada accepted official designation as the Issuing Service for meteorological Marine Safety Information (MSI) in the form of forecasts / warnings and ice bulletins for METAREAs XVII and XVIII (covering roughly the Beaufort Sea and the Canadian Arctic Archipelago up to the north pole; http://weather.gmdss. org/ metareas.html) as part of the Global Maritime Distress and Safety System (GMDSS). An important part of Environment Canada's involvement is the development of an integrated marine Arctic prediction system and satellite products in support of monitoring and

* *Corresponding author address*: Harold Ritchie, Environment Canada, 45 Alderney Drive, Dartmouth NS, Canada B2Y 2N6; E-mail: Harold.Ritchie@ ec.gc.ca

warnings. The integrated marine Arctic prediction system will feed into a highly automated information dissemination system. In particular, the METAREAs project objectives include the development, validation and implementation of marine forecasts with lead times of 1 to 3 days using a regional high resolution coupled multi-component (atmosphere, land, snow, ice, ocean and wave) modelling and data assimilation system to predict near surface atmospheric conditions, sea ice (concentration, pressure, drift, ice edge), freezing spray, waves and ocean conditions (temperature and currents). The core of the system will be an Arctic extension of the highly successful Gulf of St. Lawrence (GSL) coupled modelling system, with the GEM model as the atmospheric component coupled to the ice-ocean model. An ice-ocean data assimilation system is being developed in collaboration with Mercator-Océan using their SAM2 system for ocean data assimilation together with the 3DVAR ice analysis system developed at EC. The METAREAs research and development is a cornerstone activity within CONCEPTS.

An initial step toward the full coupled prediction system is the development of a stand-alone sea ice forecasting system. To investigate the potential skill of such a system, a simple forecasting system has been constructed based on the sea ice model from the coupled GSL forecasting system on the 5km North American grid used by the 3DVAR ice analysis system. To aid in the identification of sources of forecasting skill, two sets of forecasts have been produced: one with the thermodynamics activated in the model and a second without thermodynamics. As such, in the latter there is no formation or melt of sea ice; only the effects of ice advection and deformation due to wind forcing are included. This Sea Ice Forecasting System is running daily at the Canadian Meteorological Centre forced by forecasts from the Regional Deterministic Prediction System (RDPS). Ice forecasts are initialized using the 3DVAR North American sea ice analyses. Verification against Canadian Ice Service daily ice charts for the Eastern Arctic demonstrates that, by allowing the ice field to evolve based on model dynamics forced only by the winds, a modest gain can be obtained on a 24hr timescale as compared to persistence of analyses. When the Arctic is undergoing a period of ice formation, a significant further gain in ice forecasting skill is also obtained by activating thermodynamic processes in the ice model.

Development work is underway within the METAREAs project to couple the ice-ocean model to the GEM atmospheric model. Inclusion of an active ocean component will benefit the sea ice forecasts through a better representation of the role of tides in the development and maintenance of both sensible and latent heat polynyas as well as on ice drift and deformation. Following the benefits seen in the GSL (Faucher et al., 2010), a full atmosphere-ice-ocean coupling is expected to lead to further improvement in ice forecasting skill through the inclusion of a range of coupled processes. In particular, the large heat fluxes that occur across rapidly changing leads and polynyas have a large impact on the atmosphere and can lead to strong feedbacks through the winds and sea ice.

Reference

Faucher, M., F. Roy, H. Ritchie, S. Desjardins, C. Fogarty, G. Smith and P. Pellerin, 2010: "Coupled Atmosphere-Ocean-Ice Forecast System for the Gulf of St-Lawrence, Canada", Mercator Ocean Quarterly Newsletter, #38, July 2010, Laurent Crosnier editor, http://www.mercator-ocean.fr/documents/lettre/lettre_38_en.pdf, pages 23-37.