



Environment
Canada



Fisheries and Oceans
Canada



National
Defence



Mercator
Ocean
Ocean Forecasters



Overview of CONCEPTS Ice-Ocean Prediction Systems

from Research to Operations 2015-2016

Establishing a Core Environmental Prediction Capability in Canada

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The Need for Coupled Atmosphere-Ice-Ocean Prediction

The Government of Canada requires ice-ocean forecasts and information services for:

- Improved weather and wave prediction
 - Timescales from days to seasons
 - Sea ice, tropical cyclones, surface interactions
 - Initialization of seasonal forecasts
- Sea ice prediction
 - Improved automated analyses and forecasts
 - Dangerous high pressure areas
- Emergency response
 - Comprehensive trajectory modelling capacity
 - E.g. dispersion of pollutants
- Maritime operations and safety
 - National defense and Canadian Coast Guard
- Fisheries Management
 - Aquaculture and Stock assessments

CONCEPTS

Environment Canada, Fisheries and Oceans Canada, National Defence

Davidson et al., SCOR, 2013

Ice-ocean modelling with CICE NEMO

Operational Experimental In development

Applications and domains

- Global 1/4° resolution (GIOPS)
 - Medium-monthly forecasting
 - Fully-coupled for NWP
- Global 1° resolution (CanSIPS-GN)
 - Seasonal forecasting
- N. Atlantic and Arctic 1/12° (RIOPS)
 - Short-to-medium range forecasting
 - Coupled HRDPS-Polar for YOPP
- East and West Coastal 1/36° (CIOPS)
- Great Lakes 2km (RMPS-GL)
- Gulf of St. Lawrence 5km (RMPS-GSL)
 - Short-term forecasting

1/4° Global: Surface currents, 1° Global: Resolution, 1/12° N. Atlantic and Arctic: Surface currents, 1/36° Northeast Pac.: Grad SST, 1/36° Grand Banks: Surface currents

Bathymetry, Surface temperature

Global Ice-Ocean Prediction System (GIOPS)

- Produces daily ice-ocean analyses and 10day forecasts
 - NEMO-CICE (1/4°), < 15km in Arctic
- Mercator Ocean Assimilation System (SAM2):
 - Sea surface temperature (from CCMEP)
 - Temperature and salinity profiles
 - Sea level anomaly from satellite altimeters
- 3DVar Ice analysis:
 - SSM/I, SSM/IS, CIS charts, Radarsat image analyses
- Running in real-time since January 2013
- Operational since August 20, 2015
- Update to GIOPSV2.1 on June 25, 2016
 - Addition of IAU and updated MDT
- Dissemination
 - External cluster (pegasus)
 - Available on MSC Datamart (Netcdf4)
 - <http://dd.weather.gc.ca/>
 - WMS using GeoMet or RPNWMS
 - E.g., www.meteocentre.com/plus

Smith et al., QJRM, 2015

Global Coupled Medium-range Deterministic Forecasts

- Coupled NWP system running in operations at CCMEP since July 2016.
 - GDPS coupled to GIOPS
 - Global, fully-coupled A-I-O, 25 km(A)-1/4deg(O), 10 day forecast (2/day)
- Horizontal resolution increase of atmosphere to 15 km in 2017
- Available on RPNWMS:
 - E.g. www.meteocentre.com/plus
- MSC datamart (soon)
 - Atm: GRIB2, Ocean/Ice: Netcdf4

YIN, YANG, GEM, NEMO CICE

Coupled Global Forecast Trials

- Coupled model:
 - Atm: GEM 25km
 - Ocean: NEMO-ORCAO25 (1/4°)
 - Ice: CICE4
- Evaluation of summer trials
 - Daily 10day forecasts
 - 15 Jun – 31 Aug, 2014
 - Verification against ECMWF for geopotential height at 850hPa over Kuroshio region
- Running in operations since July 2016

Kuroshio Region: uncoupled, coupled, Smaller standard deviation, 10% reduction at 120hr, Statistically significant STD reduction

Impact of Coupling on Forecasts for TC Neoguri

96h forecasts, valid 00Z, July 10, 2014

- Coupling results in ~4°C cooling of sea surface temperature for tropical cyclone
- with associated >500 W/m² reduction in latent heat flux
- Leads to reduced intensification at all lead times (24-120h)

Sea Surface Temperature difference, Latent heat flux difference, Coupled-Uncoupled, GDPS analysis, July 8, 2014

The Regional Ice-Ocean Prediction System (RIOPS)

Purpose:

- METAREAs 17&18
- CIS support
- Iceberg drift
- Fisheries and aquaculture management

- 4x48hr ice-ocean forecasts
- 3-5km resolution in the Arctic
- 3DVar RIPS ice analysis
- RIOPS adds ocean component and improved ice model physics to RIPS
- Spectral nudging to GIOPS ocean analyses
- Real-time production since April 2016

2003010300, Dec 2015

Ice-Ocean Coupling

Roy, F. et al. (2015): Arctic sea ice and freshwater sensitivity to the treatment of the atmosphere-ice-ocean surface layer. J. Geophys. Res., 120(6), 4392-4417.

- Entire Arctic freshwater balance shown to be sensitive to surface flux parameterizations
- Improving consistency in atmosphere and ice-ocean models leads to more accurate simulations of ice conditions
- In particular ice roughness has a large effect and impacts net liquid and solid freshwater exports

Ice thickness (m), L30 - ICESAT, L30zo - ICESAT, L30zoza - ICESAT, C5 - ICESAT, C5zo - ICESAT, C5zoza - ICESAT

Parameterization of Landfast Ice

Lemieux, J. et al. (2015): A basal stress parameterization for modeling landfast ice. J. Geophys. Res. Oceans, doi: 10.1002/2014JC010678

- Landfast ice is parameterized by estimating the drag of ice keels on the ocean bottom
- Currently evaluating impact in operational systems

Landfast ice area in Laptev Sea, NIC data, Parameterization represents well the amplitude of landfast ice area, Shows some interannual variability, Addition of tensile strength (Lemieux et al., 2016)

Contribution for the Year of Polar Prediction

High-resolution coupled atmosphere-ice-ocean prediction system

- In support of:
 - Weather prediction for northern Canada
 - EC METAREAs Services
 - Marine emergency response
- Coupled atmosphere-ice-ocean model
 - GEM (2.5 km)
 - Improved microphysics
 - NEMO-CICE (3-8 km)/WW3
 - Tides, landfast ice
 - Form drag, melt ponds
 - wave-ice coupling
 - Improved ice-ocean assim
 - Arctic Rivers
 - 72 h forecasts (4/day)

RIOPS, GEM 2.5km

CONCEPTS Ocean Navigator

Dataset: GIOPS Monthly, Plot Type: Map, Location: Northwest Atlantic, Time: February 2015, Variable: Water Temperature, Variable Range: Anomaly, Depth: 0 m, Colourmap: Default for Variable, Overlay: None, Arrows: None, Additional Contours: None

Water Temperature Anomaly at 0 m, February 2015

CONCEPTS Systems Status and plans

- Five systems running in operations
 - Global Ice Ocean Prediction System (1/4 deg, daily 10d fcast)
 - Global Coupled Medium-range NWP System (25km, 10d fcast, 2/day)
 - Regional Ice Ocean Prediction System (2-6km, 48h fcast, every 6hrs)
 - Great Lakes Coupled Forecasting System (2km; 48h fcast, daily)
 - Coupled A-I-O Gulf of St. Lawrence (5km; 48h fcast, every 6hrs)
- Several systems in various stages of development
 - Full Canadian regional ice-ocean system (2-8km)
 - Coastal (2km) system for east and west coast
 - Coupling with regional and ensemble NWP systems
 - Local-scale modelling (1m-2km)
 - West coast Fjords (FVCOM), St. Lawrence River (H2D2)