Environment Canada | Fisheries and Oceans Canada | National Defence | Mercator Ocean Ocean Forecasters

The CONCEPTS Global Ice-Ocean Prediction System

Establishing a Core Environmental Prediction Capability in Canada

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Abstract

Here we describe a new system implemented recently at the Canadian Meteorological Centre (CMC) entitled the Global Ice Ocean Prediction System (GIOPS). GIOPS provides ice and ocean analyses and 10 day forecasts daily at 00GMT on a global 1/4° resolution grid. GIOPS includes a full multivariate ocean data assimilation system that combines satellite observations of sea level anomaly and sea surface temperature (SST) together with in situ observations of temperature and salinity. In situ observations are obtained from a variety of sources including: the Argo network of autonomous profiling floats, moorings, ships of opportunity, marine mammals and research cruises. Ocean analyses are blended with sea ice analyses produced by the experimental Global Ice Analysis System. Atmospheric fluxes for 10 day forecasts are calculated using fields from CMC's Global Deterministic Prediction System.

GIOPS has been developed as part of the Canadian Operational Network of Coupled Environmental PredicTion Systems (CONCEPTS) tri-departmental initiative between Environment Canada, Fisheries and Oceans Canada and National Defense. The development of GIOPS was made through a partnership with Mercator-Océan, a French operational oceanography group. Mercator-Océan provided the ocean data assimilation code and assistance with the system implementation. GIOPS has undergone a rigorous evaluation of the analysis, trial and forecast fields demonstrating its capacity to provide high-quality products in a robust and reliable framework. In particular, SST and ice concentration forecasts demonstrate a clear benefit with respect to persistence. These results support the use of GIOPS products within other CMC operational systems, and more generally, as part of a Government of Canada marine core service.

Model and Analysis System Description

- Ice-Ocean Model Configuration
  - Global 1/4° resolution grid (ORCA025)
  - NEMOv3.1++, CICEv4.1
- Mercator Ocean Assimilation System (SAM2)
  - Reduced-order extended Kalman Filter
  - Multivariate error modes
- Ocean Observations Assimilated
  - Sea surface temperature (CMC analysis)
  - Temperature and salinity profiles
  - Sea level anomaly from satellite altimeters
- 3DVar Sea Ice Analysis
  - 10km global analyses, 4/day
  - SSM/I, SSM/IS, ASCAT, CIS charts, Radarsat image analyses
- System Output
  - Daily blended ice-ocean analysis and 10day forecasts

Verification of Sea Surface Temperature Forecasts

- RMS differences after 7 days for boreal summer
- Other seasons show smaller differences
- Overall, trial better than persistence everywhere except:
  - Eastern equatorial Pacific and Atlantic Oceans
  - Areas of marine stratocumulus cloud cover
  - Small areas in southern ocean

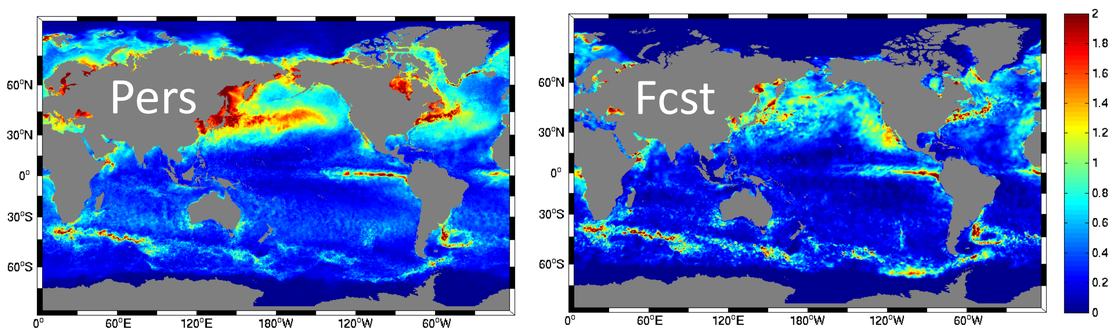

Fig. 1: *Verification of 7day SST forecasts. RMS differences from GIOPS analyses over the period 2011-06-01 to 2011-08-31 are shown for persistence (left) and GIOPS forecasts (right).*

Sea Ice Forecast Verification

Method 1: Analysis tendency

- Only evaluate points where the 3DVAR analysis changes by more than 10% over forecast lead time (7 days; Van Woert et al., 2004)
- Pro: Only includes points where we have confidence in 3DVAR ice analysis
  - Focus on ice edge in particular
- Con: Excludes areas of incorrect model changes
  - E.g: coastal polynyas, false alarms along the ice edge

Results:

- **GIOPS shows signficant forecast skill over most regions and seasons**
- **Largest errors found east of Greenland**

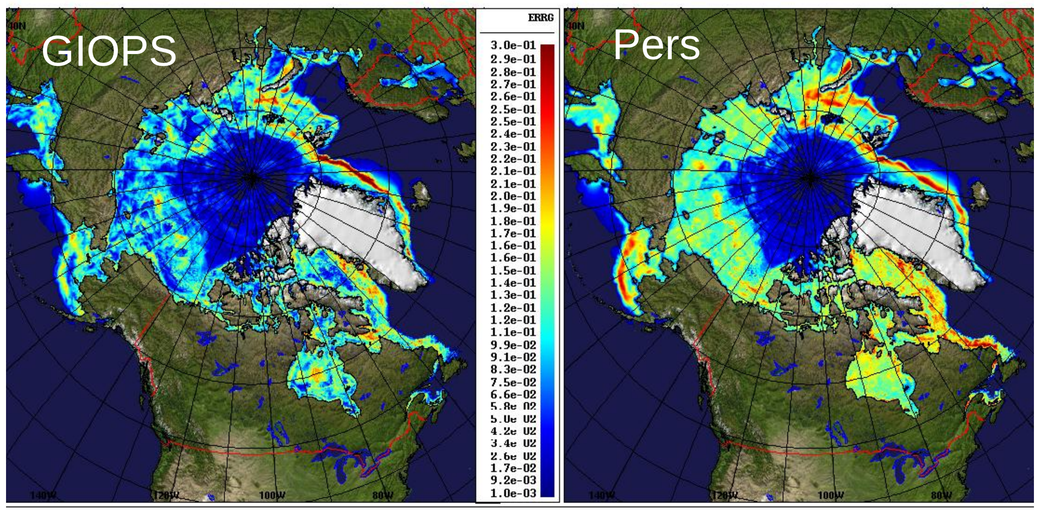

Fig. 2: *Verification of 7day sea ice forecasts. RMS differences of 7 day GIOPS forecasts (left) and persistence (right) evaluated against 3DVar analyses restricted to points where the analysis has changed by more than 10%.*

Method 2: Contingency Table Analysis

- Comparison with IMS Analyses:
  - Interactive Multisensor Snow and Ice Mapping System (NOAA-NIC)
  - Daily Northern Hemisphere ice analyses on 4km grid (ice/water)
  - Assimilates : AVHRR, GOES, SSM/I
- Evaluation Methodology:
  - Interpolate model forecasts to IMS grid
  - Calculate contingency table values using 0.4 ice conc. cutoff
  - Bin results on 1° lat-lon grid

	IMS Ice	IMS No ice
Forecast Ice	Hit ice	False Alarm
Forecast No ice	Miss	Hit water

- Proportion Correction Ice: PCI = Hit ice / (Hit ice + Miss) [0,1]
- Proportion Correction Water: PCW = Hit water / (Hit water + False Alarm) [0,1]

Results:

- **Significant forecast skill in MIZ (PCI), due to formation and advection**
- **Tendency to overestimate ice extent (PCW), esp. in summer**

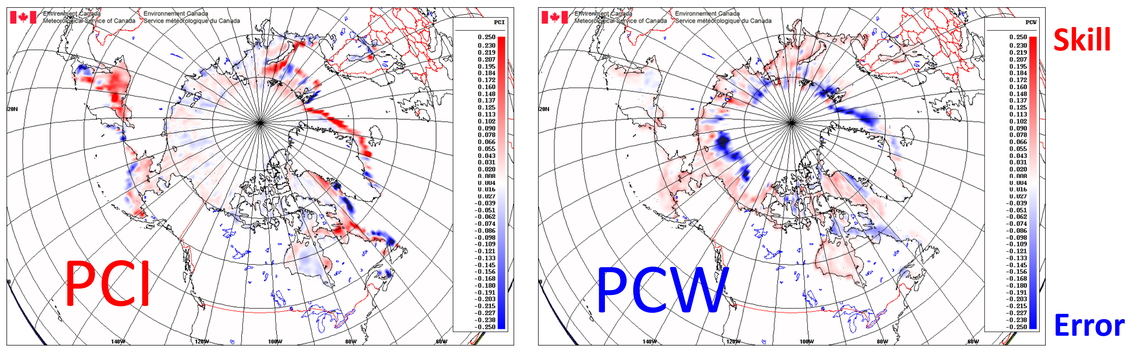

Fig. 3: *Verification of 7 day sea ice forecasts. Differences in PCI (left) and PCW (right) between GIOPS and persistence evaluated against IMS analyses. Warm (cool) colours represent skill (error).*

Future Work

Development of a coupled ensemble medium-range environmental prediction system is underway at CMC using GIOPS. Initial trials with the atmosphere-ocean model show significant improvements in the tropics and at mid-latitudes. In polar regions, details of the ice cover are extremely important and point to the need for improved ice deformations, as well as the inclusion of landfast ice and ice-wave coupling.

References

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