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Overview of an integrated marine Arctic prediction system for METAREAs

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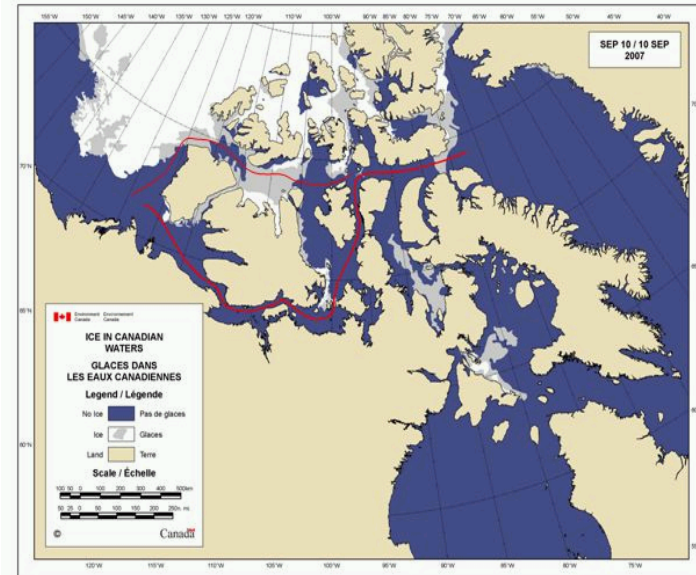
NOAA Webinar on Arctic Modeling: Improving Models and Predictions
in the Arctic, 13 January 2015

Activity Leads: Science Support and Technology Transfer Component

- Component lead: Pierre Pellerin
- Senior Scientist: Hal Ritchie
- Atmospheric Data Assimilation: Luc Fillion
- Ocean-Ice / Sea Ice and coupling model: Greg Smith
- Sea-Ice Data Assimilation: Mark Buehner
- Iceberg / Ice Hazard Models: Tom Carrieres
- Satellite Products (Atmosphere): Diane Johnston
- Wave model: Natacha Bernier (R&D), Serge Desjardins (Products & Services)

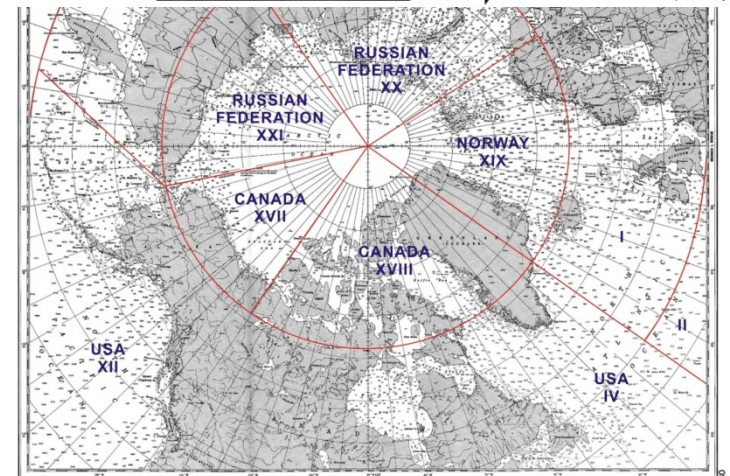
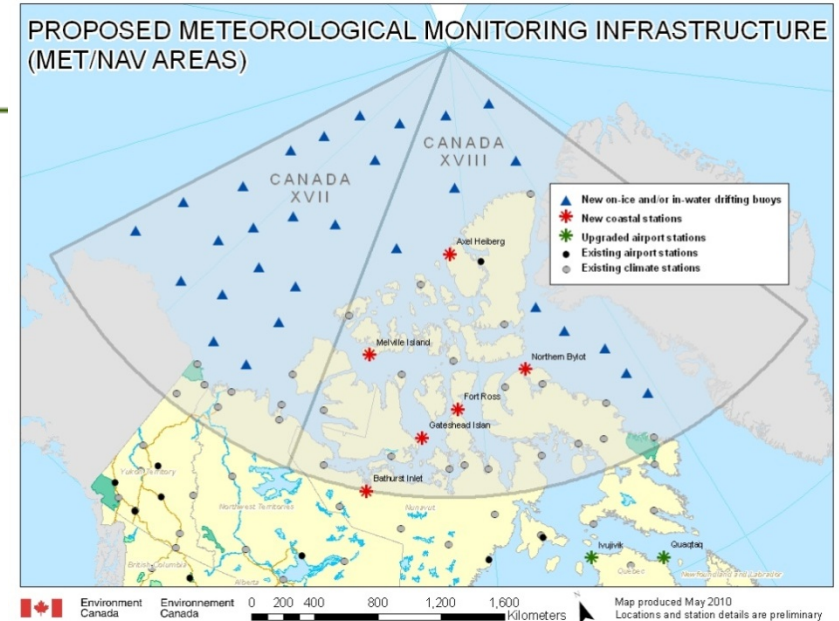
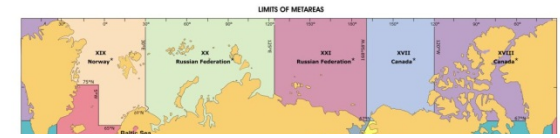
Environment Canada (EC) METAREAs Initiative: Background

- Decreasing Arctic ice cover has resulted in an increase in navigable Arctic waterways.
- In anticipation of increased marine traffic, the International Maritime Organization established 5 new METAREAs covering the Arctic.
- In 2007, EC & the Department of Fisheries & Oceans (DFO) expressed Canada's willingness to become an Issuing Service for METAREAs XVII & XVIII.
- In July 2010, EC commenced issuing meteorological Maritime Safety Information for these areas on a test basis.



Our involvement in METAREA's

- Development of an integrated marine Arctic prediction system in support of METAREA monitoring and warnings.
- Development of short-term marine forecast system using a regional high resolution coupled multi-component (atmosphere, land, snow, ice, ocean, 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)
- Improved Arctic monitoring



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Canadian METAREAs Ice Beacons

Air deployment by DND

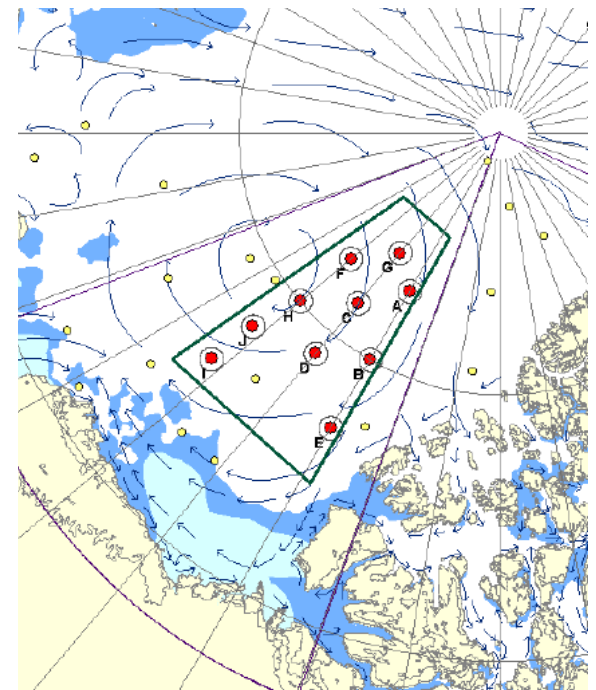


Photos courtesy of DND



Ice beacon

Deployments for 2013



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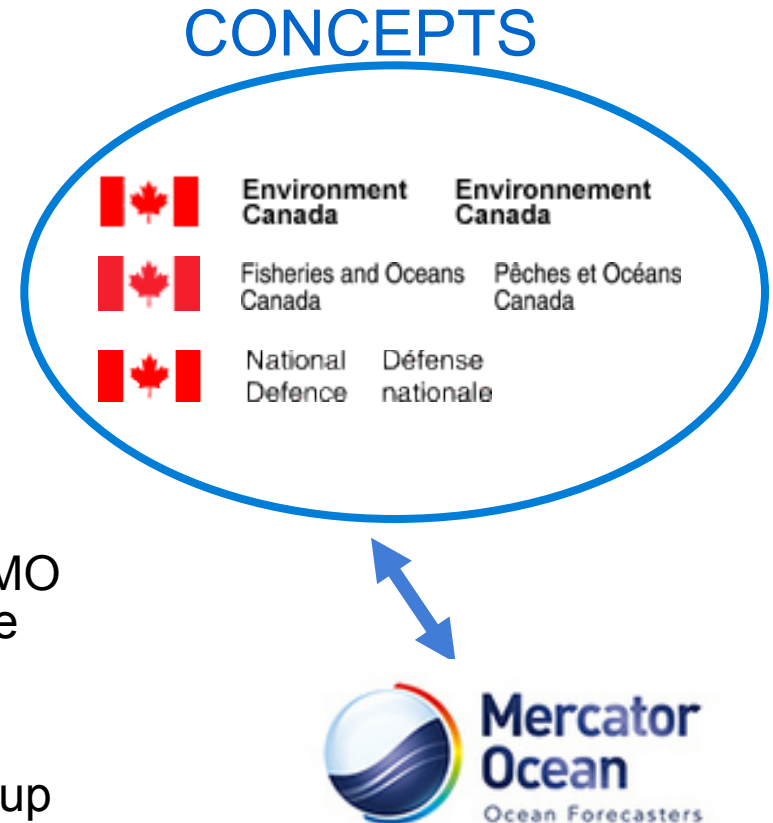
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CONCEPTS connection

- Several new coupled systems under development as part of CONCEPTS
 - Canadian Operational Network of Coupled Environmental Prediction Systems
- Tri-departmental collaboration
 - To develop coupled atmosphere-ice-ocean forecasting systems
- Model development
 - Coupling GEM (Global Environmental Multi-scale) atmospheric model to NEMO (Nucleus for European Modelling of the Ocean)
- Collaboration with Mercator
 - French operational oceanographic group

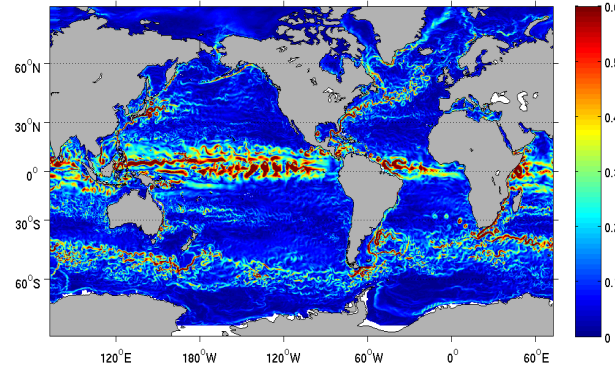


CONCEPTS Systems

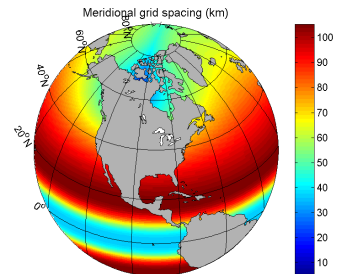
Applications and domains

- Global 1/4° resolution
 - Medium range forecasting
- Global 1° resolution
 - Monthly-to-seasonal forecasting
- N. Atlantic and Arctic 1/12°
 - Short-to-medium range forecasting
- NW Atlantic (Grand Banks)
 - Emergency response
- Great Lakes 2km
- Gulf of St. Lawrence 5km
 - Short-term forecasting

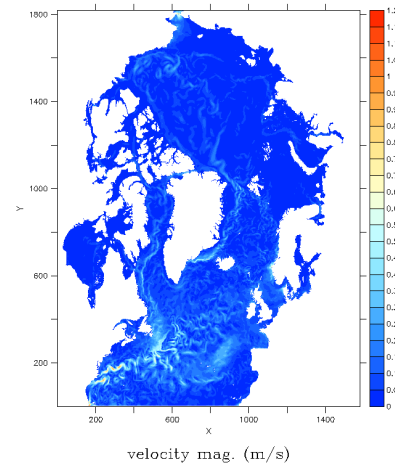
1/4° Global



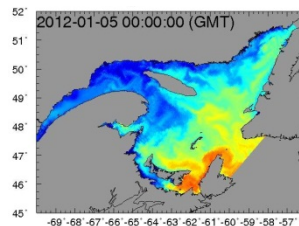
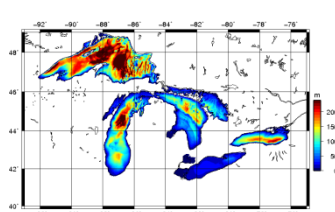
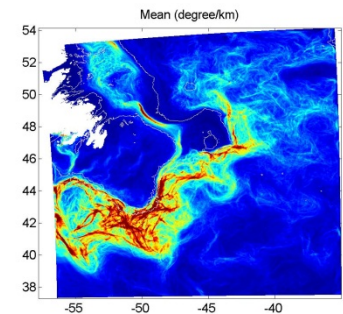
1° Global



1/12° N. Atlantic and Arctic



1/36° Grand Banks



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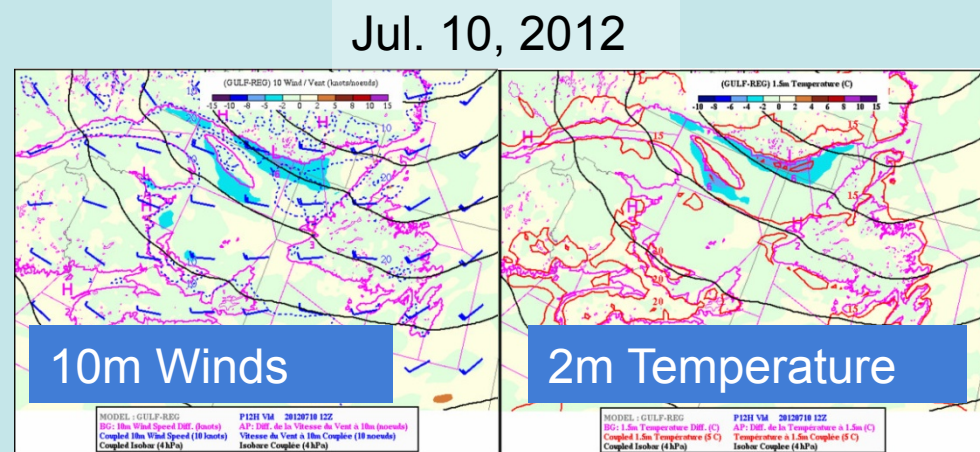
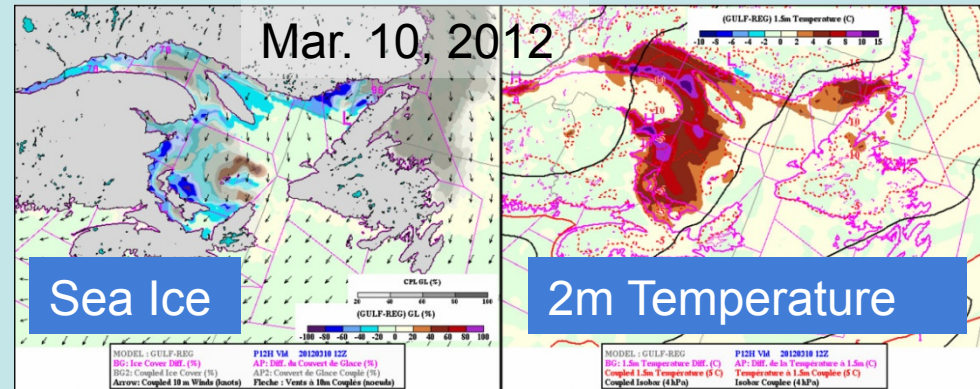


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Builds on Gulf of St. Lawrence Coupled Atmosphere-Ice-Ocean Forecasting System

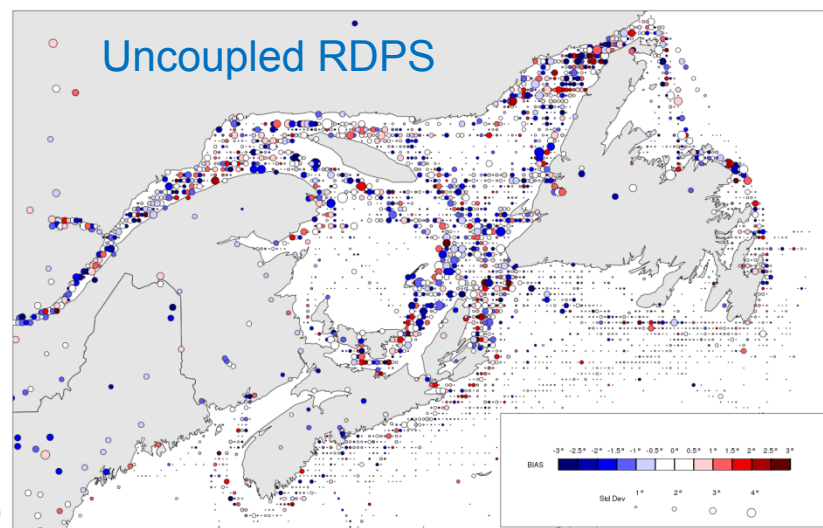
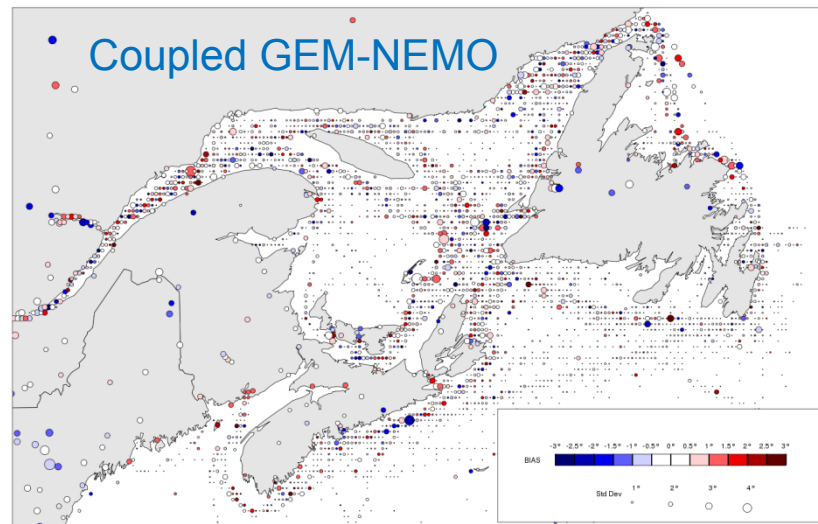
- Operational since June 2011
 - 48 hr forecasts daily at 00Z
- Coupled system:
 - Atm: GEMv3 (10km)
 - Ice: CICEv1 (5km)
 - Ocean: MoGSL (5km)
- New system (18 Nov. 2014):
 - GEMv4 (10 km)
 - NEMO-CICEv4 (5km)
- Under development:
 - GEM (2.5km), NEMO(1km)
 - Include Great Lakes

Coupled – Uncoupled differences



Impact of Coupled Forecasts over the Gulf of St. Lawrence

- Evaluation against all surface temperature observations
 - 48hr forecasts over Jan-Mar 2014
 - Colours show bias
 - Standard deviation shown by the size of each circle
- Smaller errors in coupled system over water
- GSL is an ideal laboratory for studying impacts of coupling!



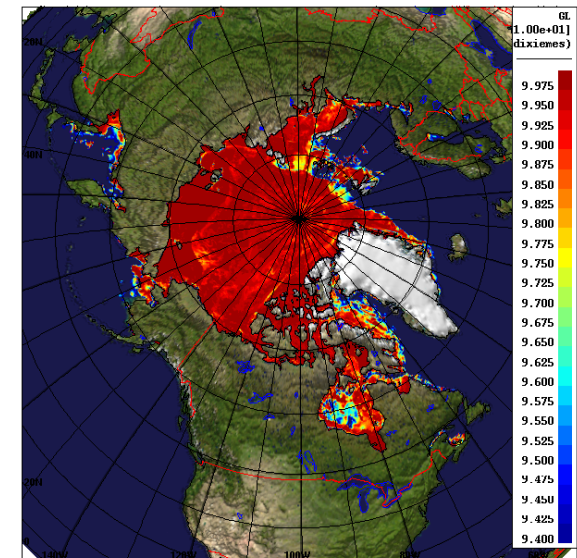
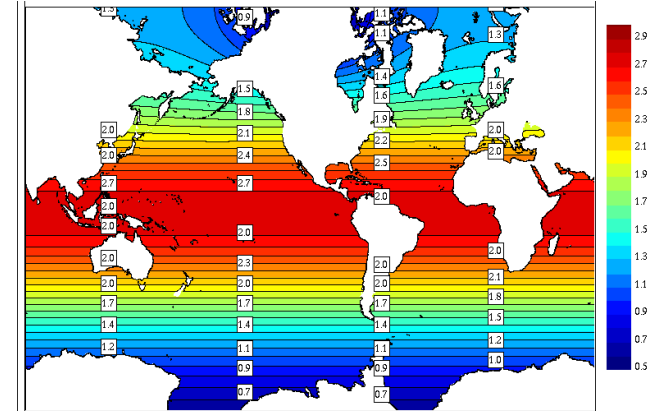
Atmospheric Model & Data Assimilation

- METAREAs is benefiting from improvements to the Regional Deterministic Prediction System (RDPS) and Global Deterministic Prediction System (GDPS), especially for surface boundary layer fields.
- Major implementation at CMC on Nov. 18 2014 including:
 - GEPS v4.0.0 (global ensemble system)
 - GDPS v4.0.0 (4DEnVar)
 - RDPS v4.0.0 (4DEnVar)
 - REPS v4.0.0 (regional ensemble system)
 - Regional coupled Gulf of St. Lawrence system
 - HRDPS v4.0.0 (2.5 km pan Canadian domain, experimental)
- Improvements up to 2 days in RDPS and 5 days in GDPS.

CONCEPTS Global Ice-Ocean Prediction System

Dorina Surcel Colan, Matt Reszka, Francois Roy, Daniel Deacu, Zhongjie He ...

- Produces daily ice-ocean analyses and 10day forecasts
 - NEMO-CICE ($\sim 1/4^\circ$), < 15km in Arctic
- Mercator Ocean Assimilation System (SAM2):
 - Sea surface temperature
 - Temperature and salinity profiles
 - Sea level anomaly from satellite altimeters
- 3DVar Ice analysis:
 - SSM/I, SSM/IS, CIS charts, Radarsat image analyses
- Experimental implementation (March 2014)
- Purpose:
 - Boundary conditions for regional systems
 - Initialize seasonal forecasts
 - Emergency response
 - Global coupled forecasting
 - Sea ice forecasting
- Product Dissemination
 - By WMS or FTP

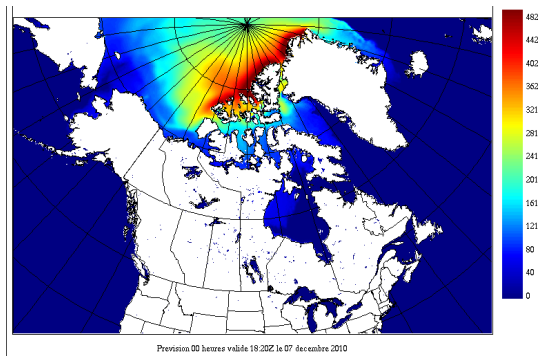


Regional Ice Prediction System RIPS 2.1

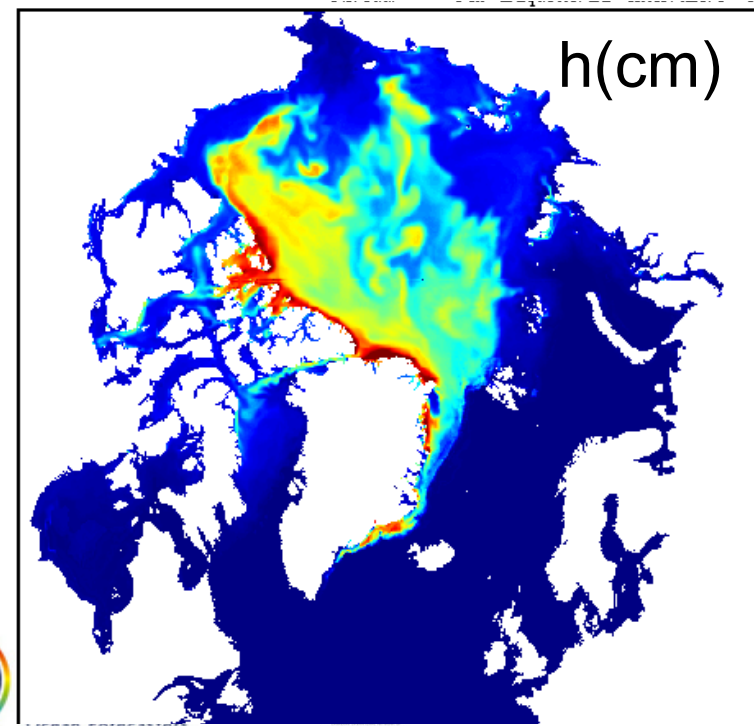
Improvements

- Pan-Arctic grid ($1/12^\circ$)
- Use fields from GIOPS (Global Ice-Ocean Prediction System) for initialization (instead of climatology)
- MLD, SST, currents, thickness

RIPS 2.0



RIPS 2.1



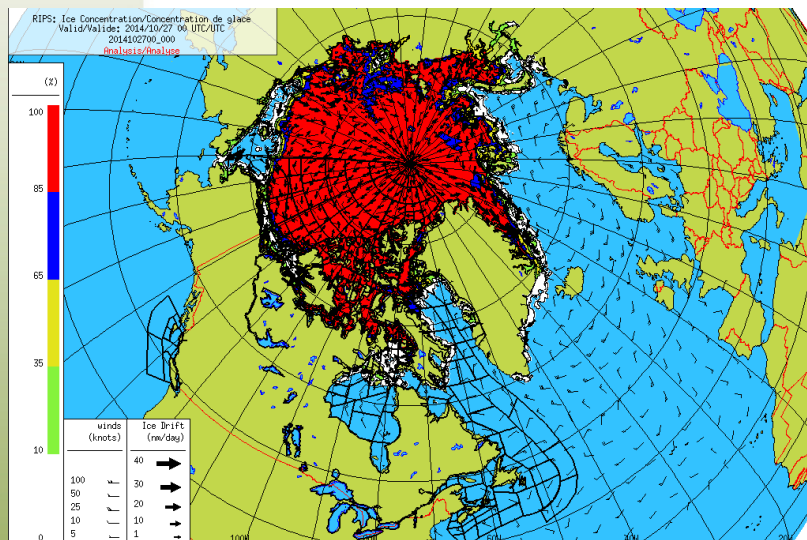
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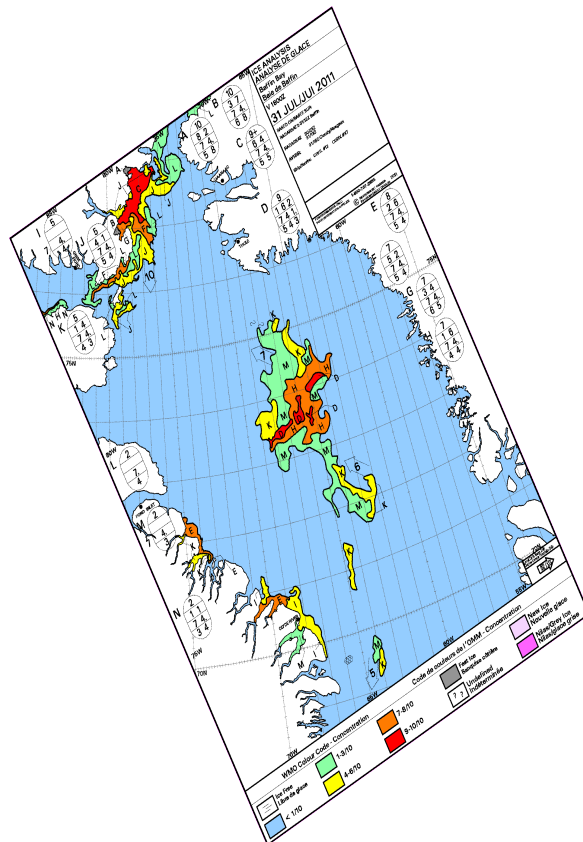
Regional Ice Prediction System



- RIPS 2.1 (in experimental mode since 31 July 2014):
 - 0.045° (between 4.7 and 5.0 km) resolution
 - 4 analyses and forecasts (00, 06, 12, 18 UTC) each day
- Analysis system (Buehner et al. 2014, accepted)
 - total sea ice concentration and analysis-error estimate
 - background = analysis 6 hours earlier
 - observation types assimilated:
 - CIS image analyses and daily ice charts, lake bulletins
 - SSM/I (DMSP-15), SSM/IS (DMSP16-17-18)
 - ASCAT
 - ice is removed where CMC SST > 4°C
 - See Alain Caya's presentation
- Forecast system (Lemieux et al. 2014, submitted)
 - CICE model forecasts up to 48h

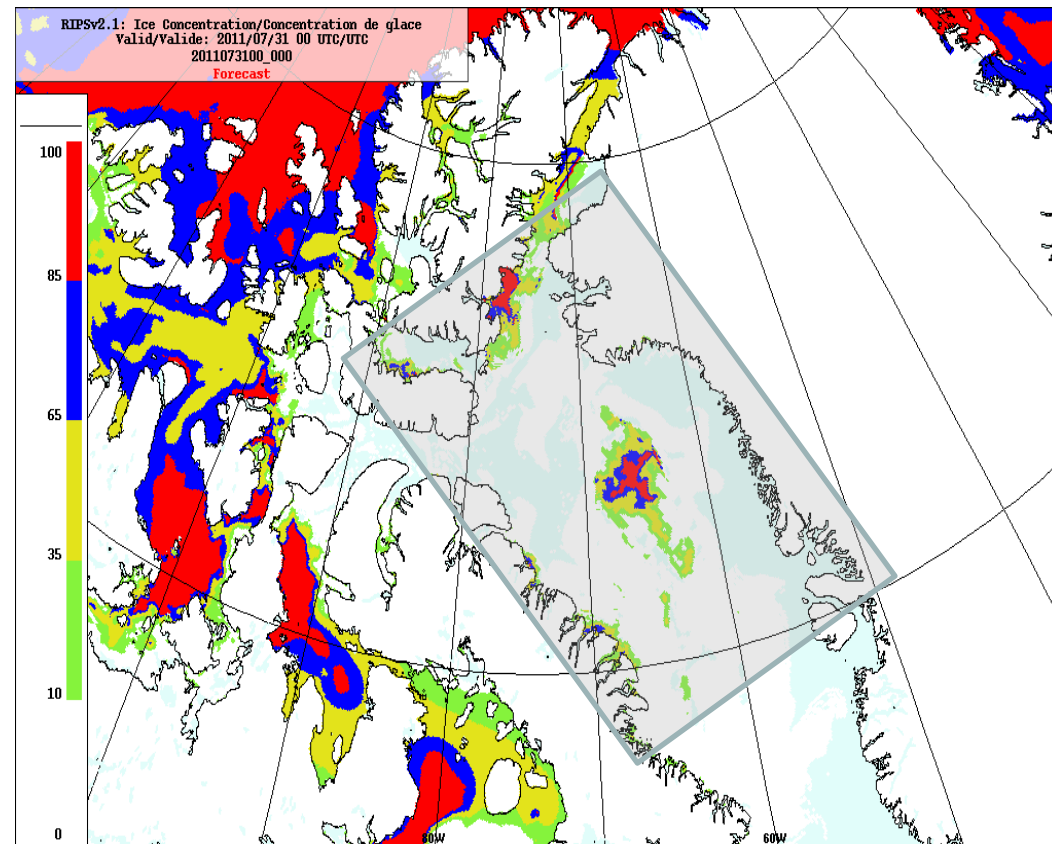
Example for Baffin Bay: Jul 31, 2011

CIS Daily Ice Chart



RIPsv2.1

00th hour initialization



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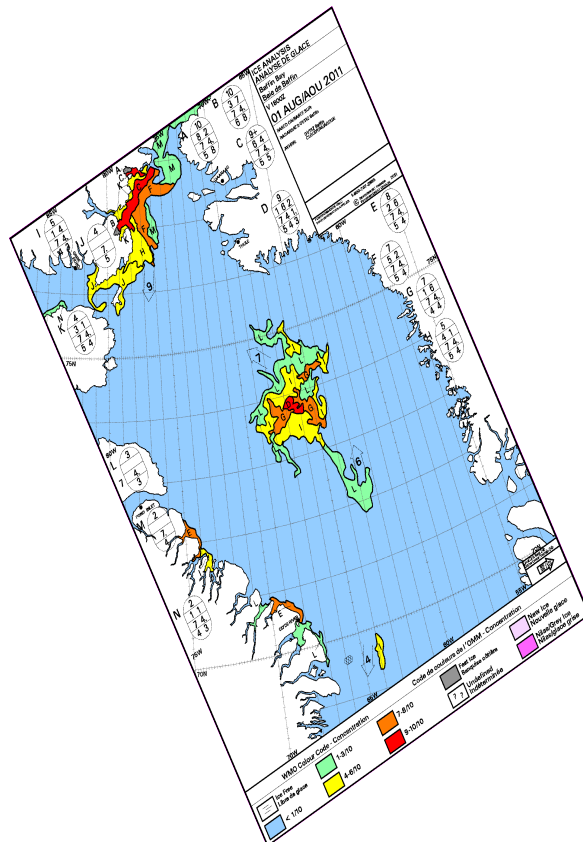
Ocean
Ocean Forecasters



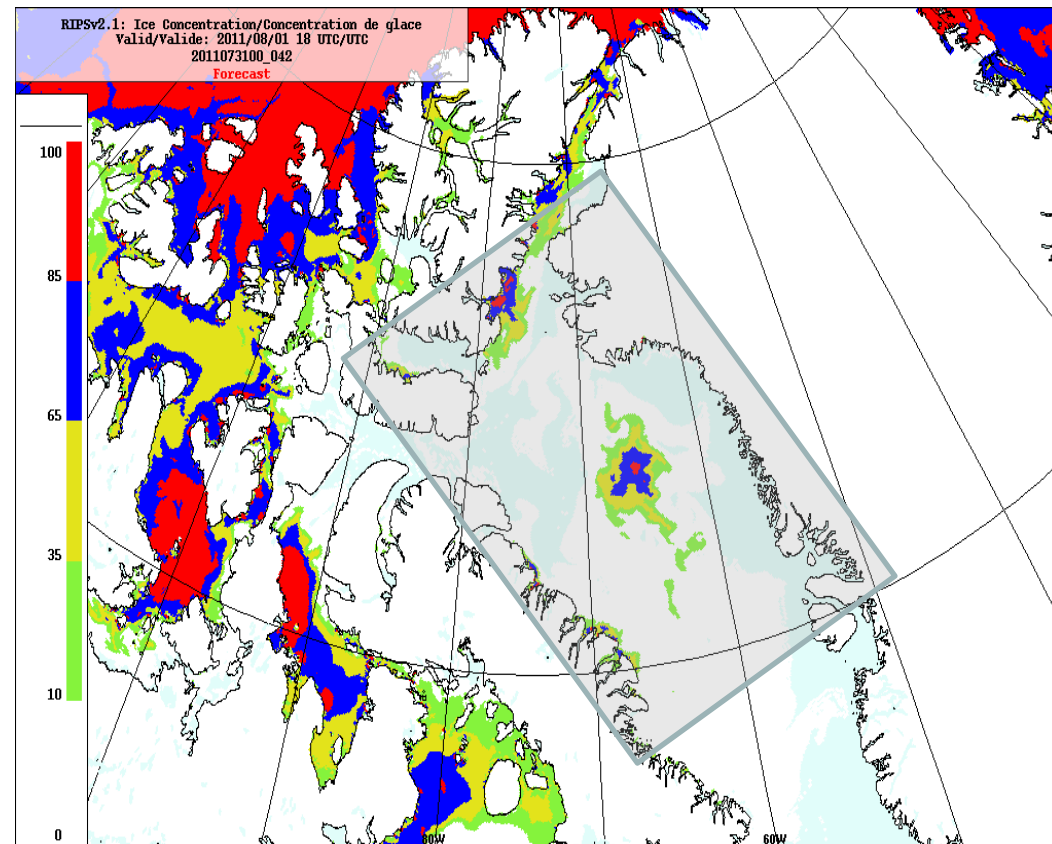
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Example for Baffin Bay: Aug 1, 2011

CIS Daily Ice Chart



RIPSV2.1
42 hour forecast



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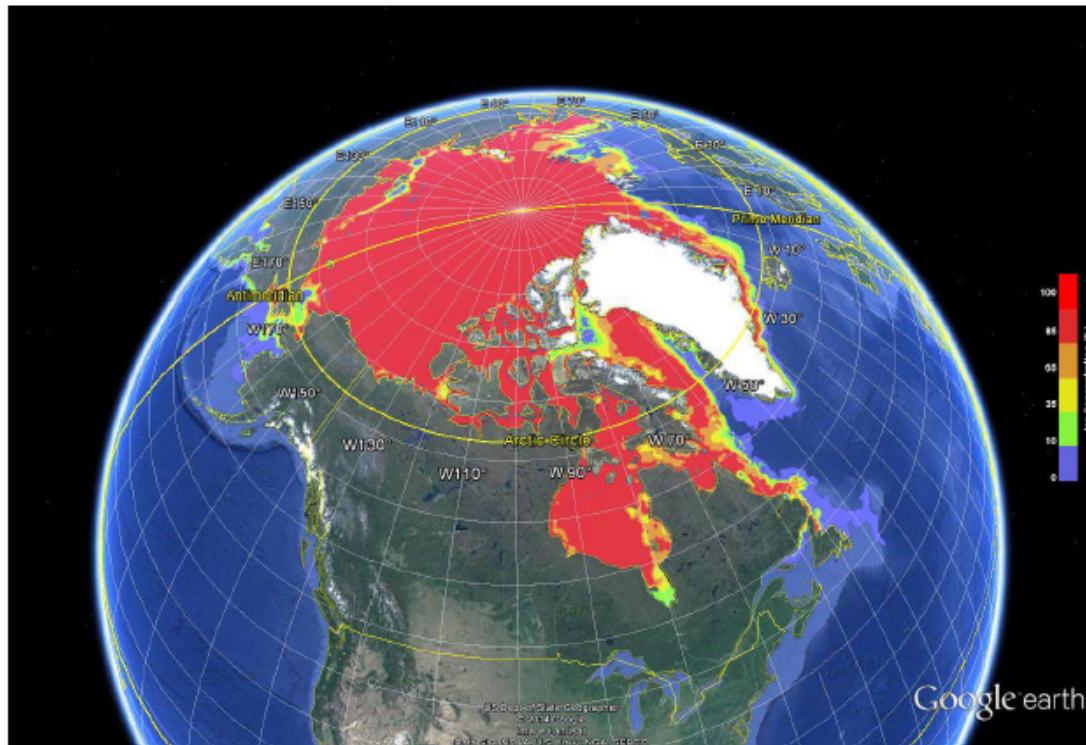
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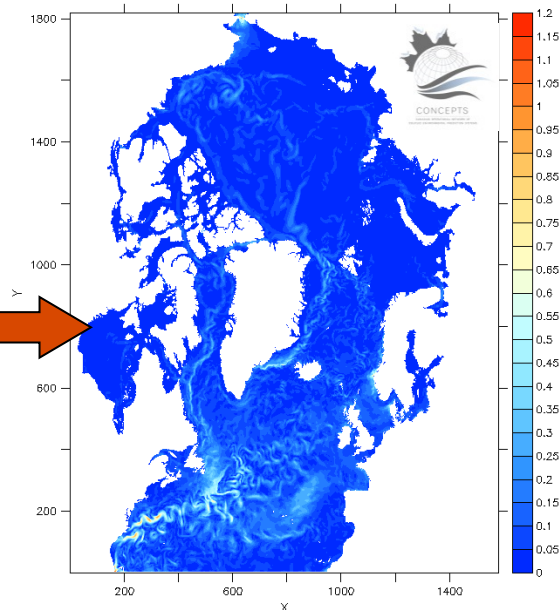
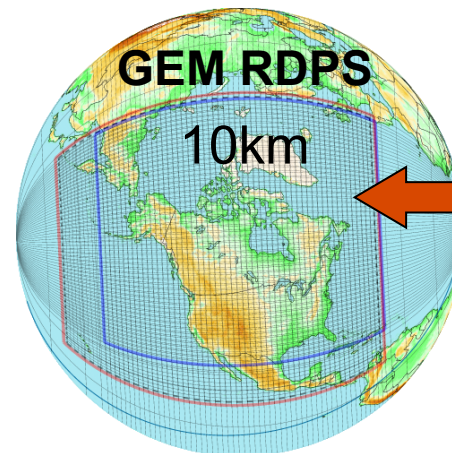
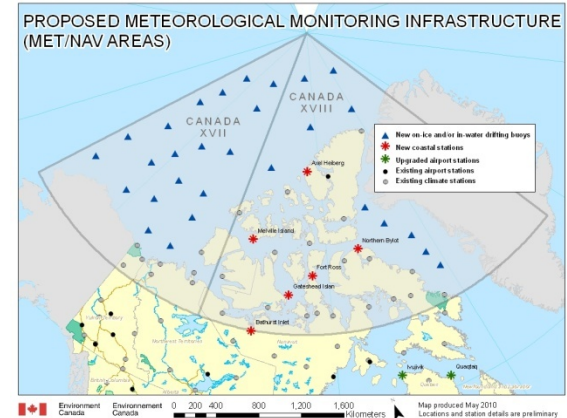
Model Visualization

- Sea ice analysis and forecast output tools have been developed including on CIS ice analysis workstations (ISIS and Polaris), CMC SPI and WMS systems, VizaWeb and Ninjo



METAREA Integrated Marine Prediction System

- Coupled atmosphere-ice-ocean model
 - GEM (10km)
 - NEMO-CICE (3-8km) and WW3
 - Tides, landfast ice, wave-ice coupling
 - 3-5 day ensemble forecasts

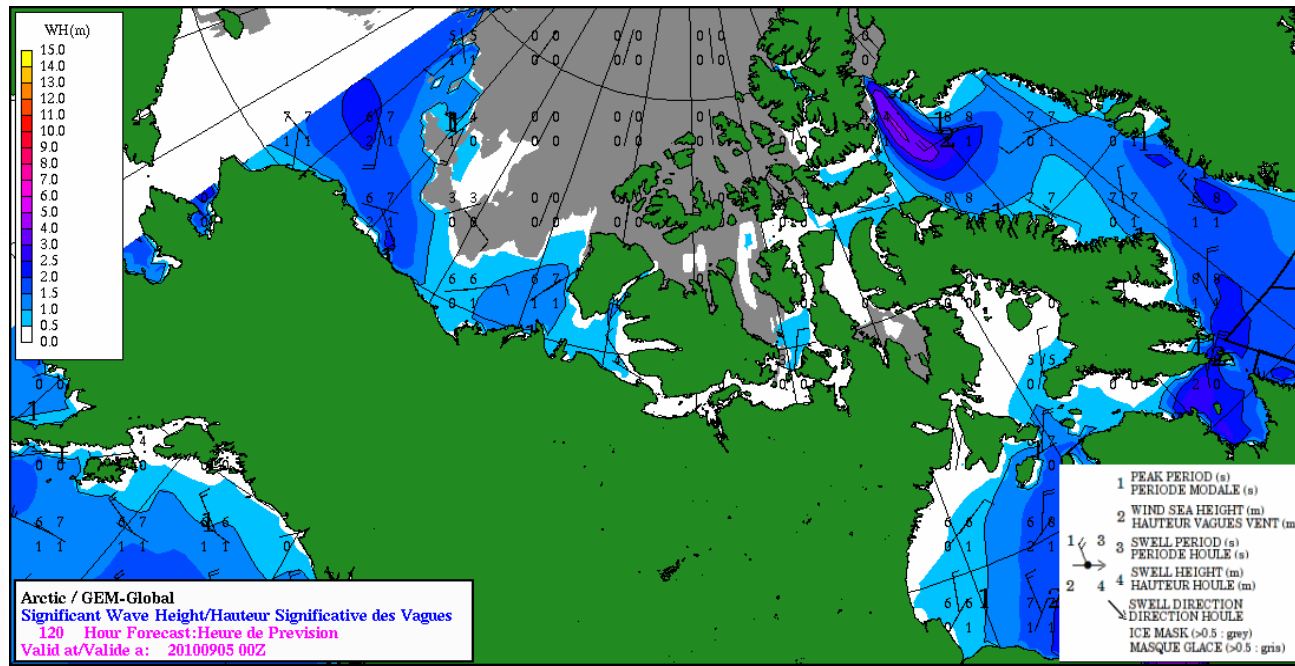


Iceberg/Ice Hazard Models

- Automated Sea Ice Tracking System (ASITS) has been revised to remove spurious vectors near image/land edges and system has been operationally implemented
- Three target detection s/w packages have been acquired for evaluation (DND OceanSuite, DRDC IAPRO, C-CORE IDM)
- Ground truth data was collected and a prototype ship/iceberg discrimination tool has been developed
- Development work continues on the ice island and ensemble iceberg forecast model as well as probabilistic iceberg products

Wave model- Arctic Domain

- Regional Arctic domain operational with WAM-EC 4.5.1 implementation on May 7/2012.
- Arctic domain is a lat/lon rectangular grid (0.4x0.8 degree resolution) from 49N to 85N and from 45W to 165W
- Arctic domain forced with 10m winds from GEM-Regional (4x/day to 54 hrs) and by GEM-Global (2x/day to 120 hrs)
- Ice mask is stationary and supplied by the CMC regional and global analyses
- Model outputs (sig. wave height) are feeding both the regional and global Scribe Marine Matrices



R&D on waves-ice interactions

- Via ongoing Beaufort Regional Environmental Assessment project “Enhancing the Canadian METAREAs Operational Coupled Ocean-Ice-Wave-Atmosphere Analysis and Forecasting System for Fine-scale Applications in the Beaufort Sea”, Dumont et al. component.
- Via a new 2 year CSA funded project, EC (Bernier and Lemieux), DFO (Perrie), and UQAR (Dumont) will develop a new framework for wave-ice forecasting. (See Dumont and Perrie presentations).
- We are changing from WAM to WAVEWATCHIII® which will be coupled with CICE4 to study the impact of waves on ice floe distribution and the impact of ice floe distribution on waves. The objective of this research is to improve forecasts of waves, ice, and of the location of the Marginal Ice Zone.
- Radarsat imagery will be used to study and parameterize the interaction between waves and ice so they can be represented in the coupled wave-ice forecast system.

ON Nat Lab for Nowcasting and Remote Sensing (NORM) - Satellite Projects

- Develop single channel enhancement imageries using MODIS data to improve weather monitoring
- Develop multi-spectral (RGB) imageries using MODIS data to improve the detection of various earth, ocean and atmospheric features (E.g. fog/stratus, snow, ice, ice clouds, water clouds, etc.)
- A Satellite-Model Based Algorithm to Detect Fog and Icing.
- Advance satellite data processing using Ninjo formula language and/or TeraScan scripts for nowcasting applications
 - E.g. To determine cloud/no cloud, stratiform vs convective clouds, cloud top height, and cloud top characteristics for severe weather signatures.

Satellite products in support of the METAREA project (MODIS RGB)

- A number of GOES and MODIS RGB (multi-spectral) products have been configured in the latest version of NinJo 1.7. Documentation has been prepared.
- For METAREA project, only RGB product from MODIS data is relevant because it covers the Arctic domain.
- Training on the use of these RGB products has been delivered to various users in the past year. More training is being delivered as needed. Evaluation of these RGB products is in progress.
- For a full documentation on RGB, please visit http://juan.ontario.int.ec.gc.ca/NoRM_Lab_Ont/Satellite/Satellite_RGB.html
- Examples of RGB applications on earth and atmospheric monitoring are being added to the website.

Example of applying MODIS RGB to monitor ice cover over Hudson Bay (ice in “red”)

June 15, 13



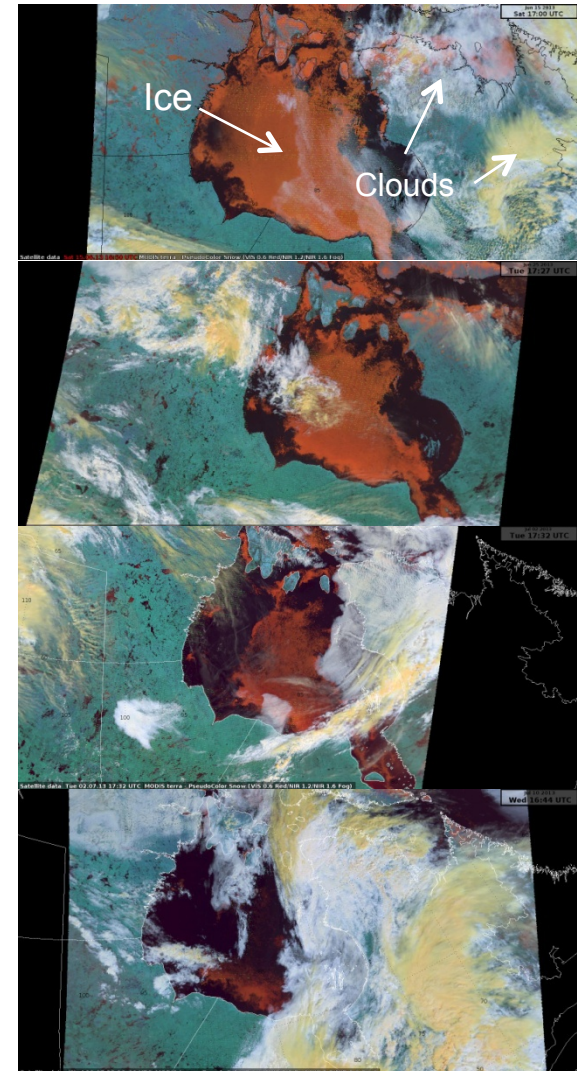
June 25, 13



July 02, 13

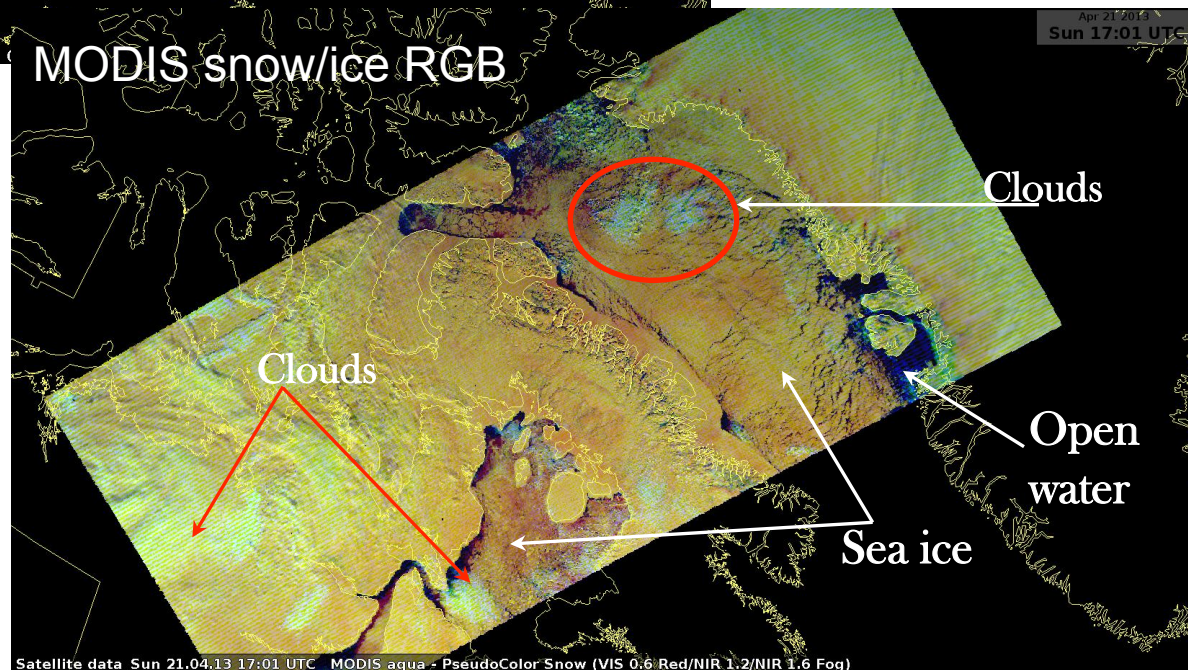
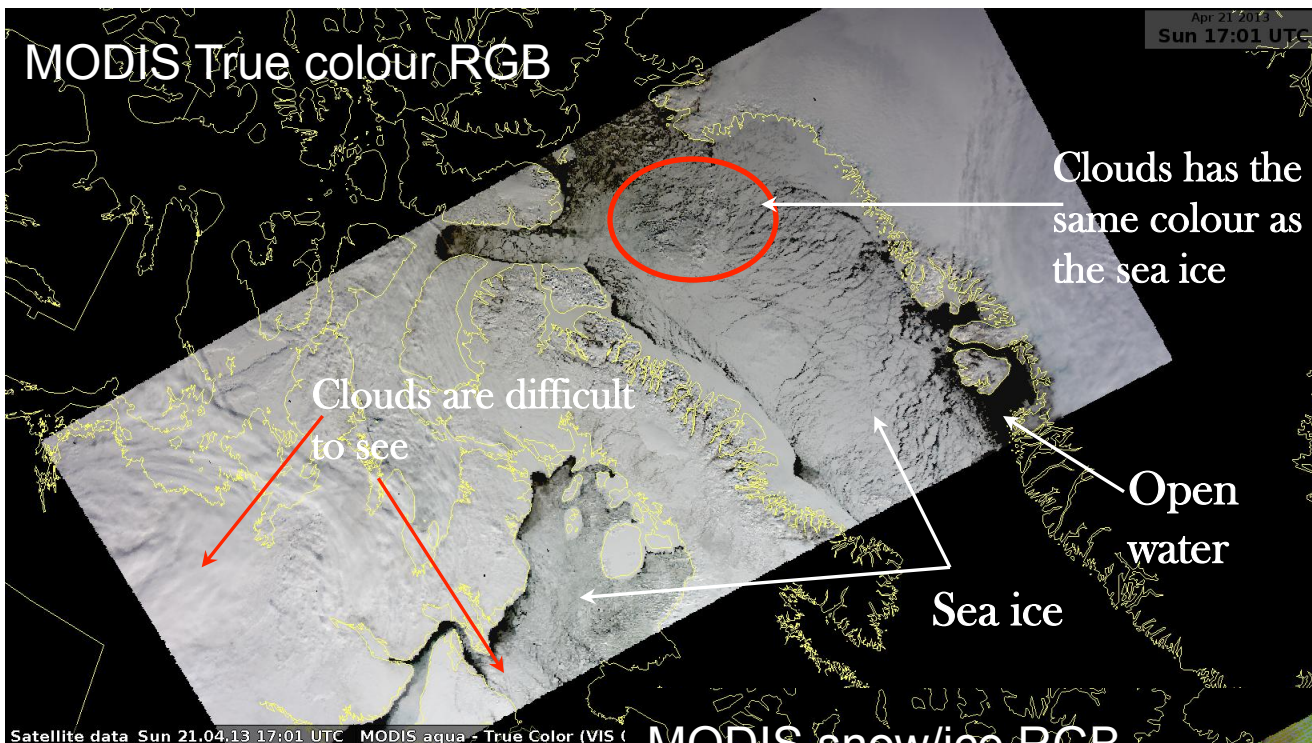


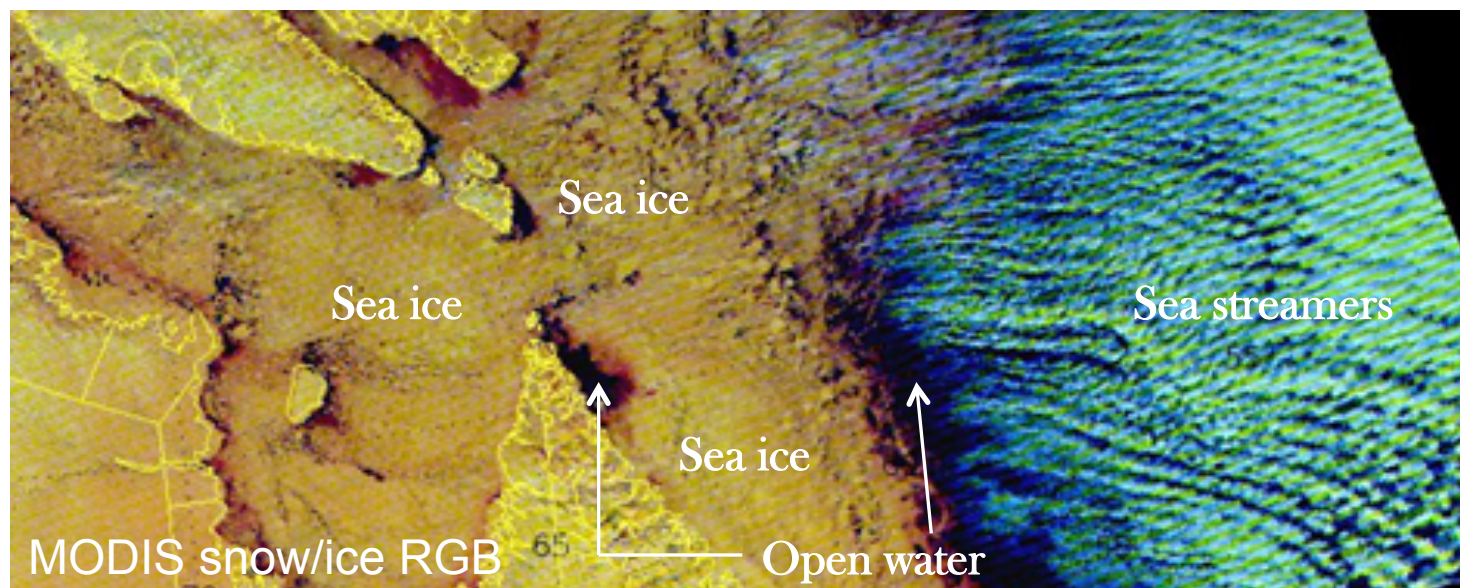
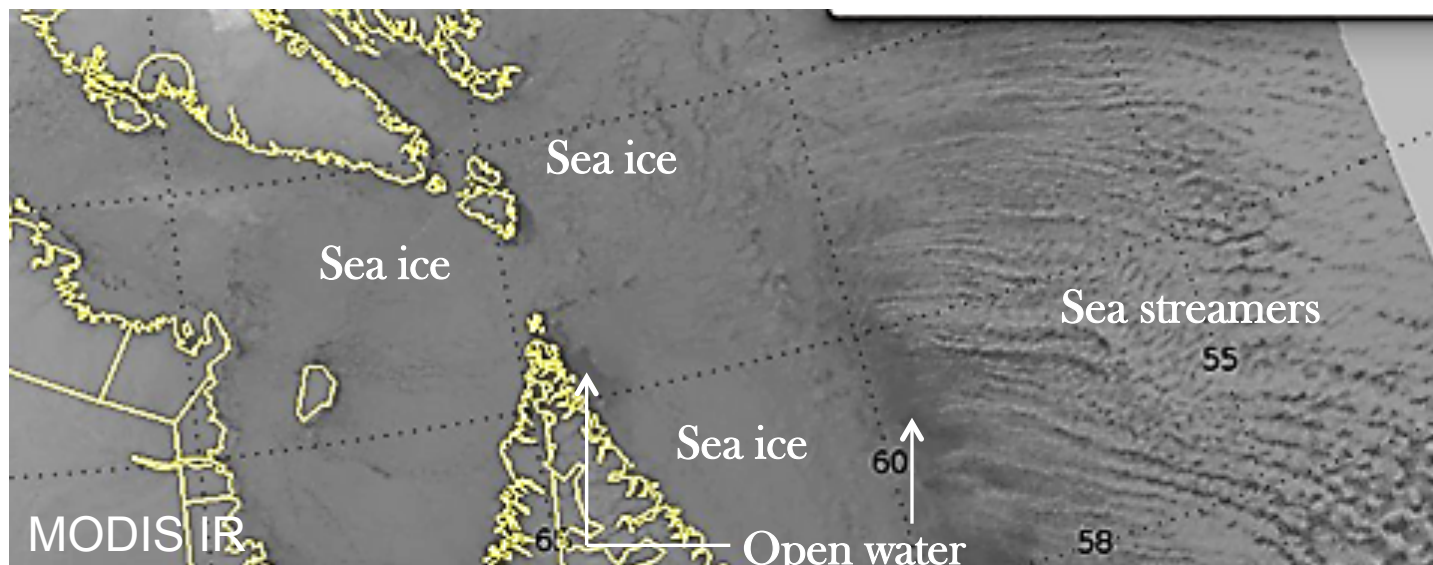
July 10, 13



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Summary & conclusion

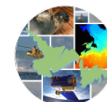
- Building on the operational coupled atmosphere-ocean-ice forecast system for the Gulf of St. Lawrence, an integrated marine Arctic prediction system is being developed in support of METAREA monitoring and warnings.
- Wave model, sea ice model and sea ice data assimilation component systems have been developed and are being implemented operationally.
- Good progress is being made on improvements to all components and combining them for implementation of the fully coupled system.
- This is a flag-ship Signature Project of the Meteorological Service of Canada.
- A phase 2 proposal is under consideration.



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