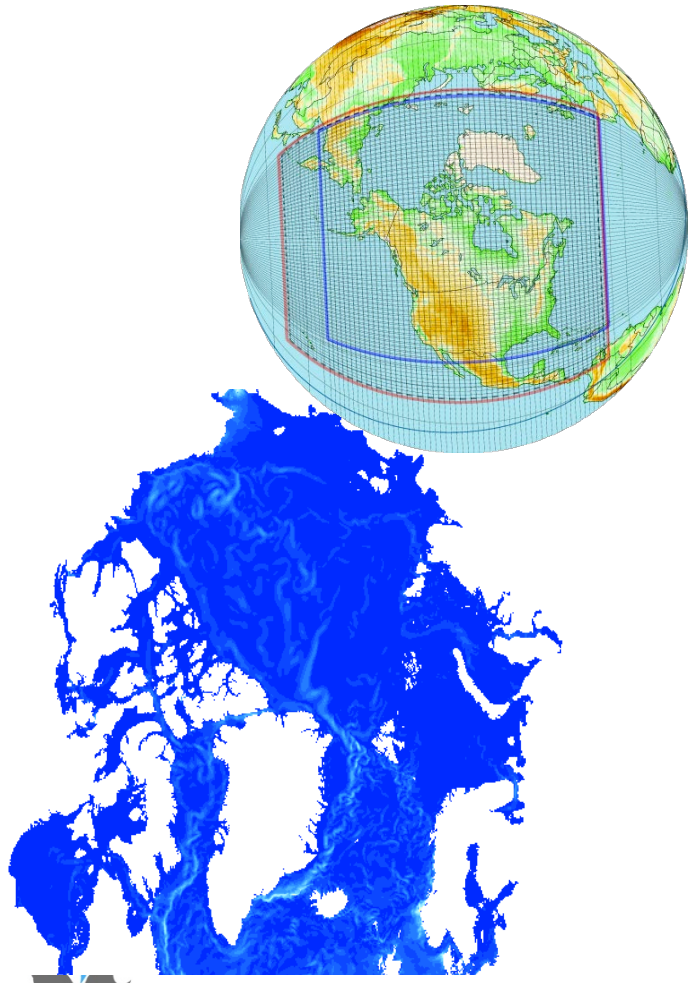
Forecasting Weather, Ocean and Ice Conditions in the Beaufort

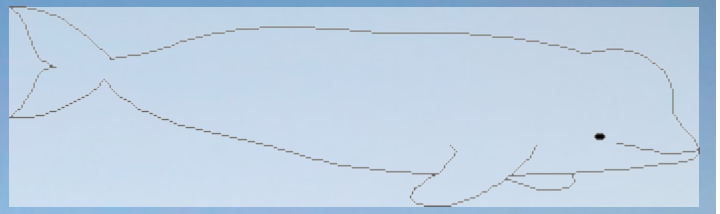


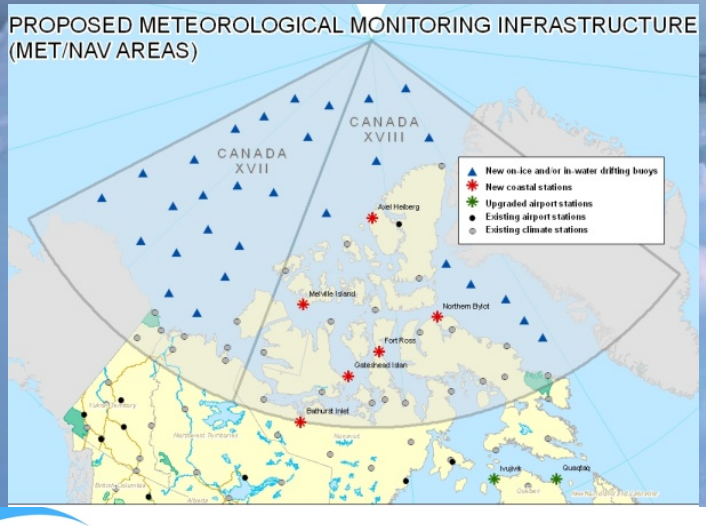
Fraser Davidson,
Fisheries and Oceans Canada
on Behalf of Joint Project
Environment Canada, McGill University and
Université du Quebec a Rimouski with
collaboration from National Defense.

Greg Smith, Youyu Lu,
Jean-Francois Lemieux, Fred Dupont,
Francois Roy, Jei Li, Simon Higginson,
Qiang Wang, Shannon Nudds,
Bruno Tremblay, Dany Dumont
+ Greg Flato EC – CCCMA

Fisheries and Oceans Canada | Pêches et Océans Canada | Environment Canada | Environnement Canada | National Defence | Défense nationale

The Beaufort Regional Environmental Assessment (BREA)





Forecasting Weather, Ocean and Ice Conditions

Purpose

- Enhance “vetted” descriptions of physical environment:
  - Strengthens environmental assessments
  - Beaufort Sea Ocean and Ice movement and properties
  - Routine accessible forecasts (web)
  - Operations + dissemination
  - Historical ocean conditions: 2002-present
  - Strengthens integrated management
- Describe and Communicate ocean conditions
  - Engage communities

BREA PRIORITY

Coupled ocean-ice-atmosphere modeling and forecasting

Improved real time descriptions of Ocean, Ice circulation

- Provides information for oil spill response
- Permits mapping of oil spill drift scenarios
- Enhances Search and Rescue operations
- Provides info for design limits
- Can be incorporated in geospatial tools
- CanSIPS:
  - define window of operation in the BeuProvide advance forecast of end of ice free operations.

Why Ocean-Ice Forecasting?

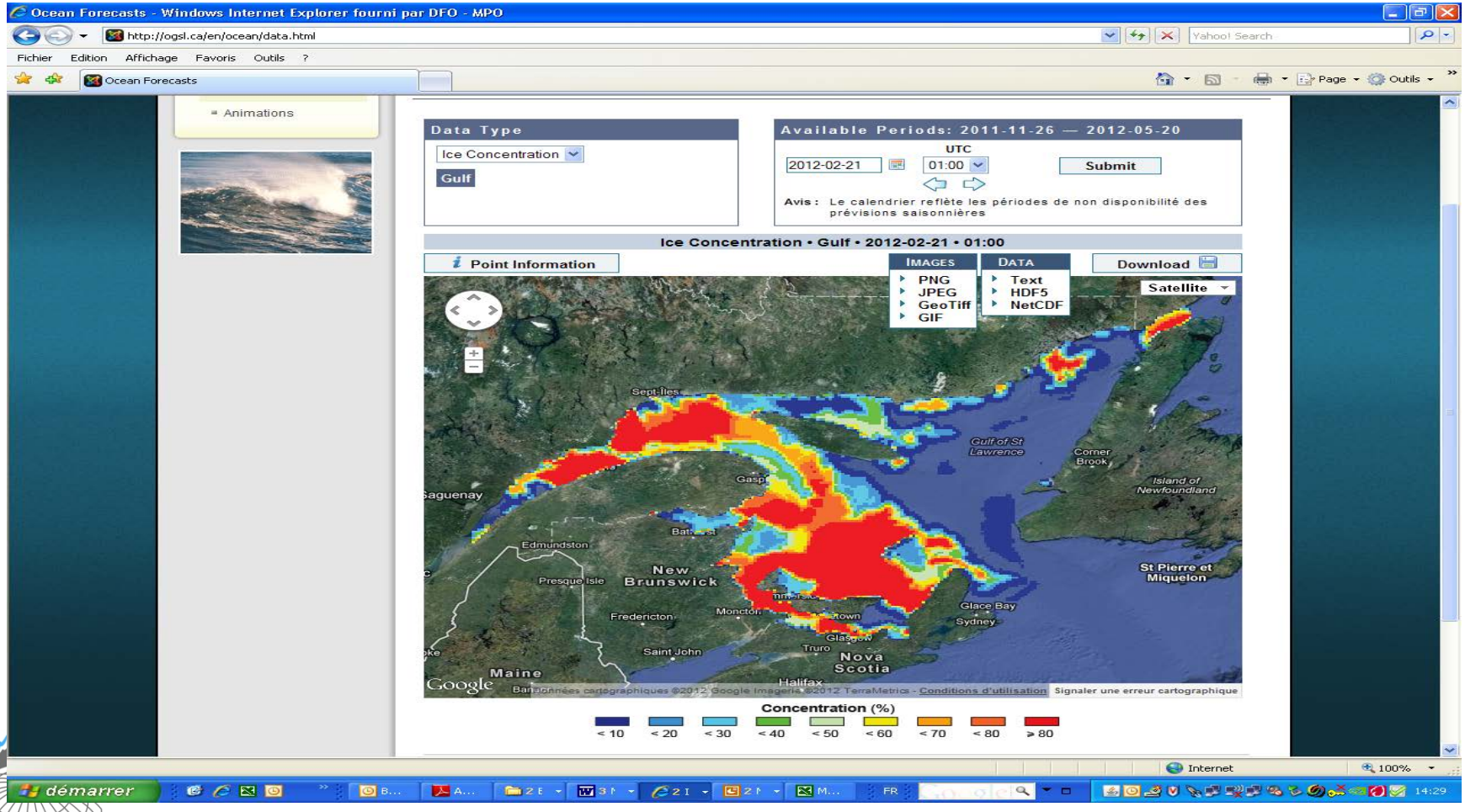
- DND:
  - Awareness of ocean conditions and acoustic properties
- DFO:
  - Improved ocean descriptions
  - State of the ocean reporting
  - Understanding the ecosystem
  - Search and Rescue
- EC:
  - Improved Weather forecast
  - Better info for oil spill track

ALL: Taking in Account Climate Change

Project Overview

- Enhancing the Canadian Metareas operational coupled ocean-ice-atmosphere analysis and forecasting system for applications
- Objective – to build on METAREA's project at EC/DFO to develop and implement an operational coupled ocean-wave-ice-atmosphere (OWIA) prediction system for short-term forecasting in the Beaufort Sea (BS).
- Improve the representation of fine-scale features in data assimilation and forecast systems, and improve the short-term forecast skill by including high-latitude coupled processes in OWIA models.
- Produce a suite of daily real-time fine-scale products in support of oil and gas operations in the BS.
- Educate and consult with the local community and industry on the improved products as well as the new ocean forecasts delivered as part of this project.

Example of Web Site Mapping Tool being developped



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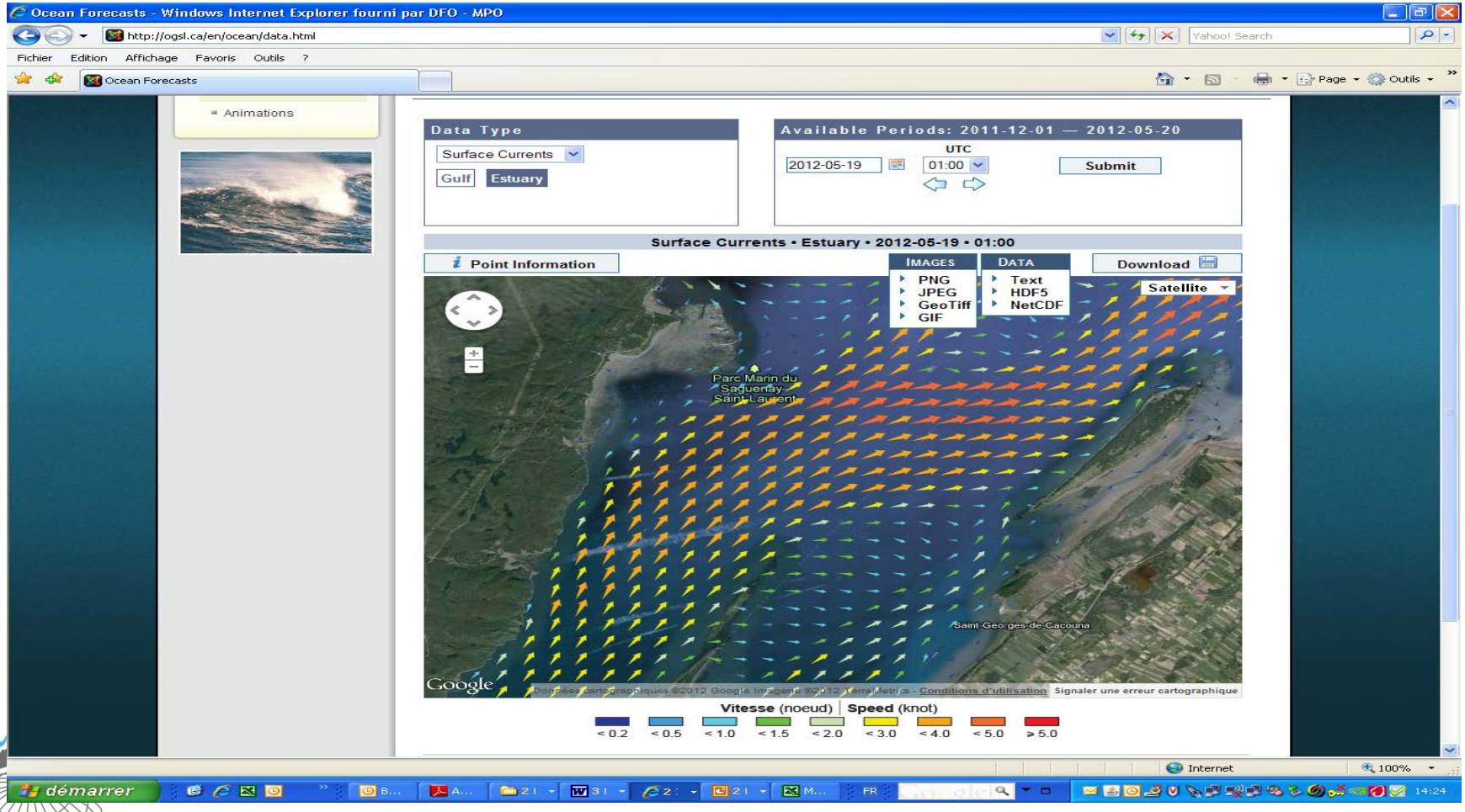

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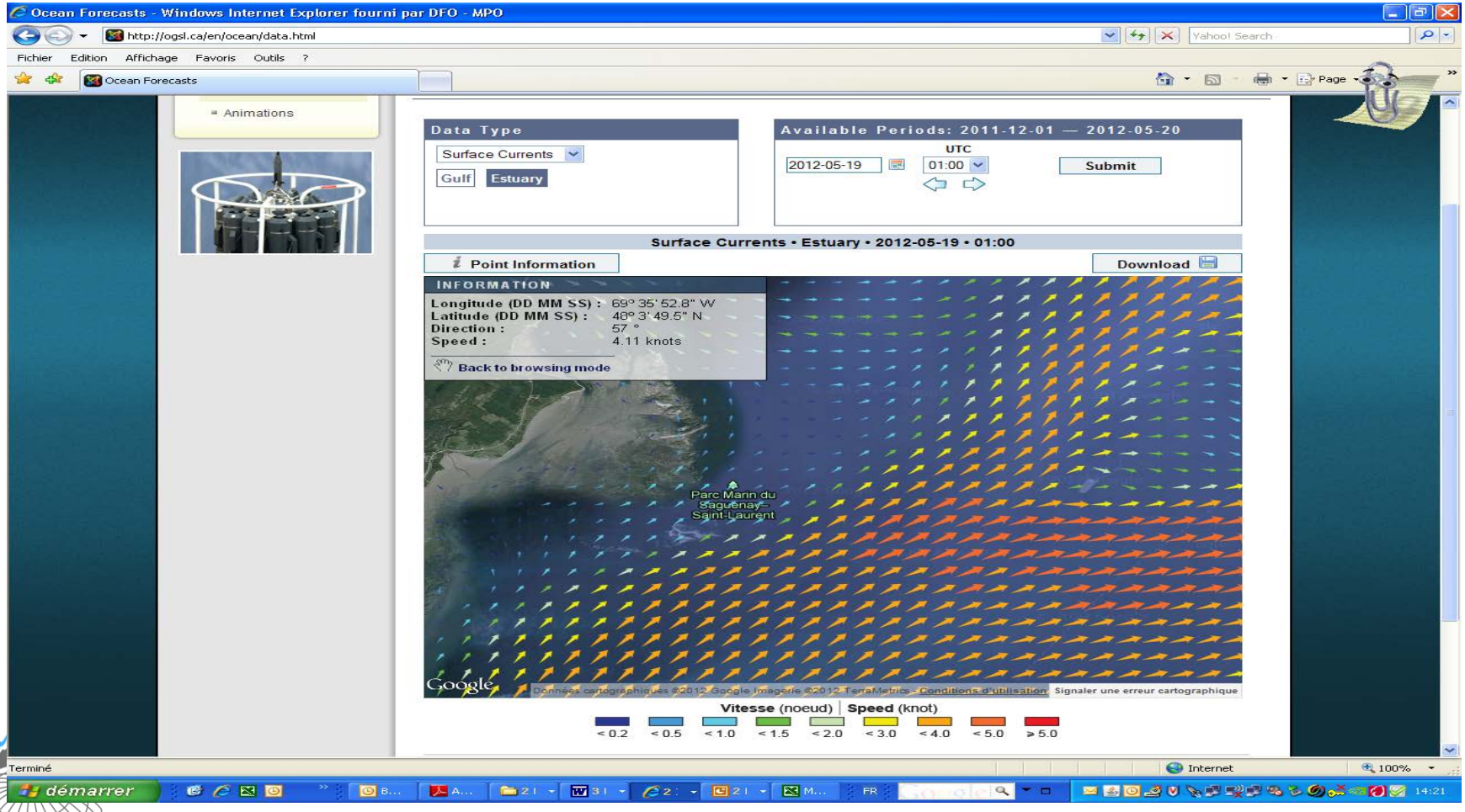
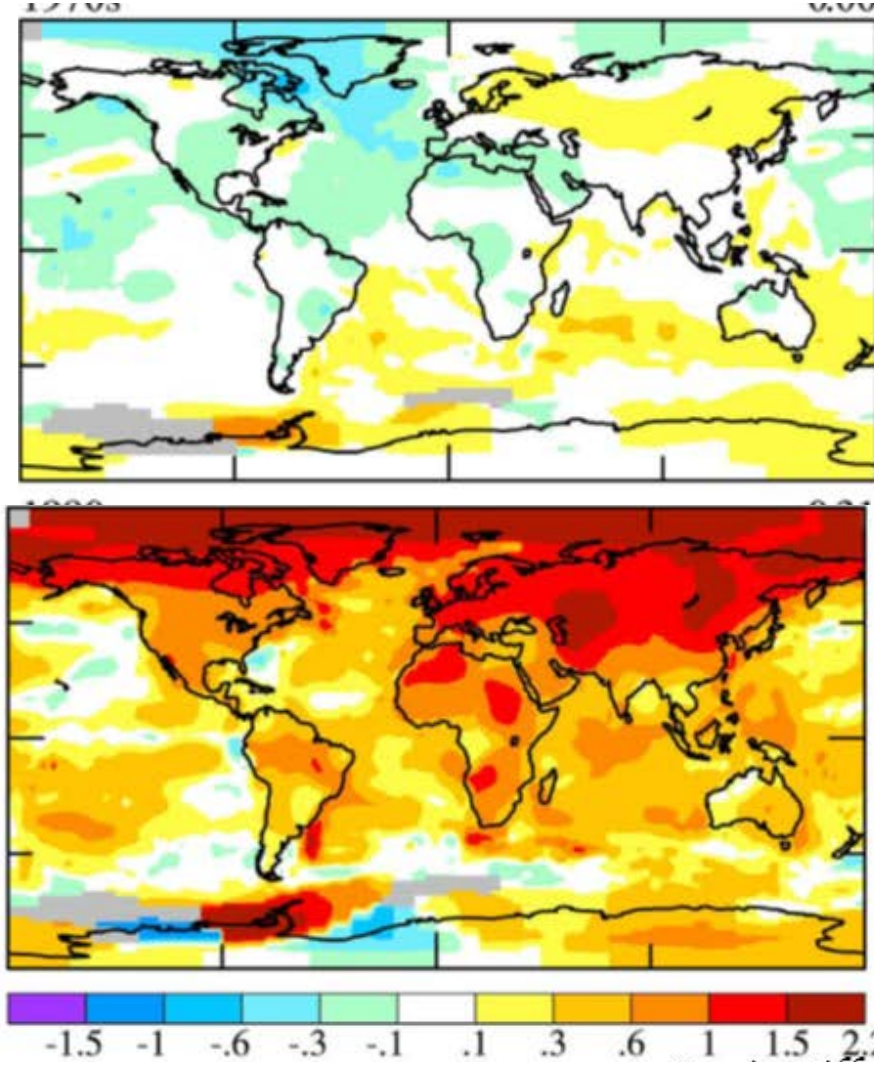


Assimilation of Data takes in account climate change

- Arctic Getting warmer
  - Hansen et al 2010, Rev. Geophys
- Analysis system with observations
  - Takes warming in account

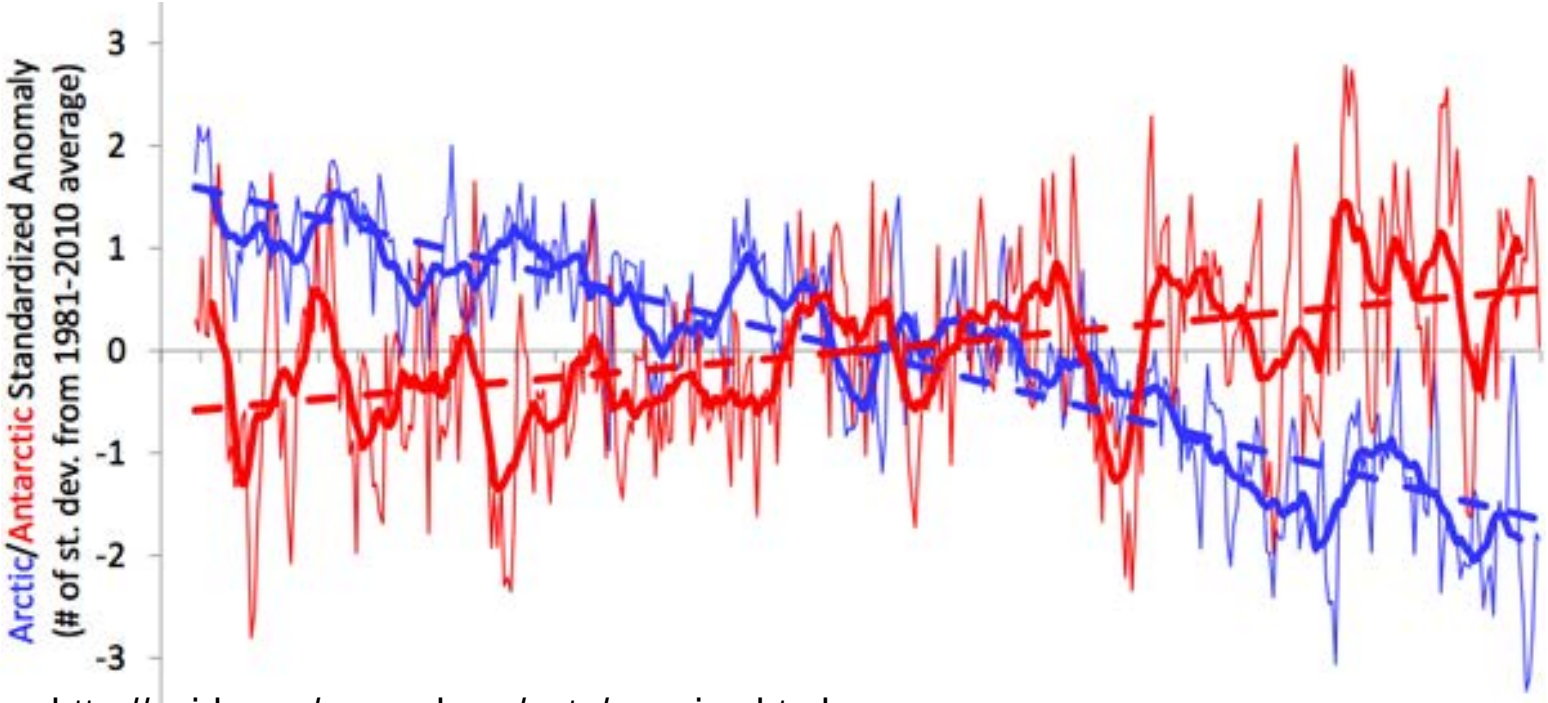
1970s

2000s



Combing models and real time data takes in account changing climate

- Artic Ice Decreasing
- Antarctic Ice Increasing



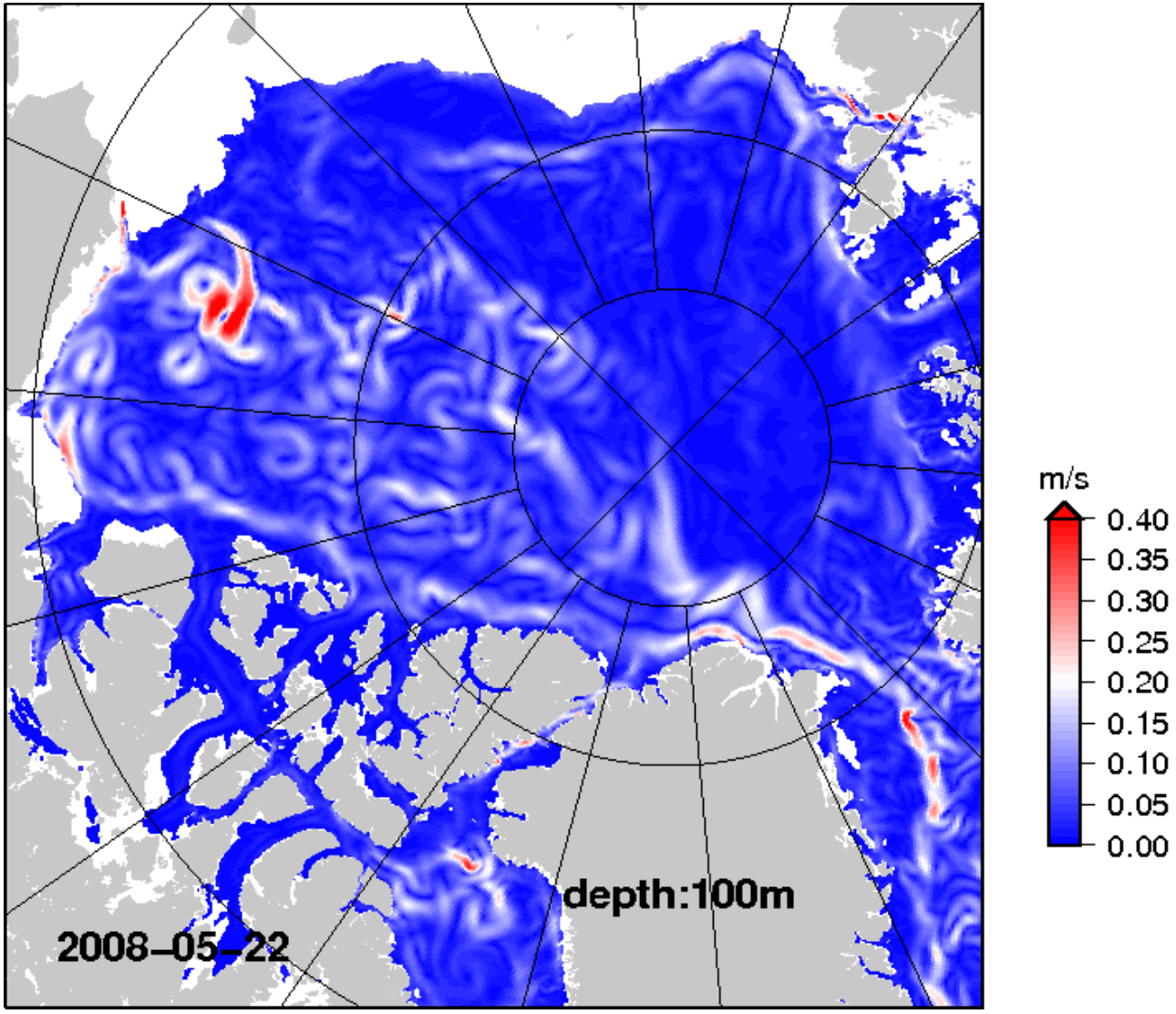
http://nsidc.org/cryosphere/sotc/sea_ice.html

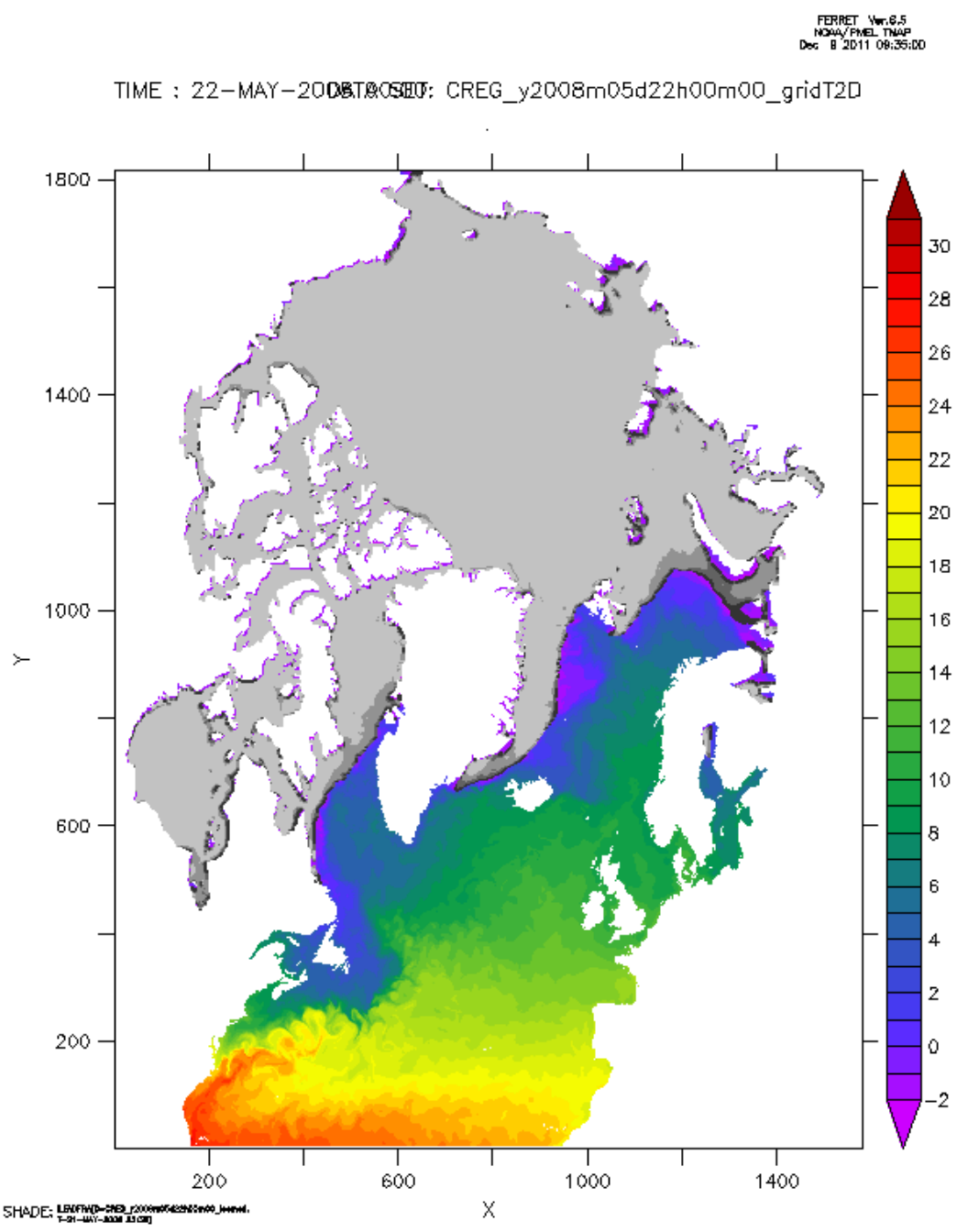
Example of Ocean Circulation

From model hindcast
For 2008
Eddies can be seen

Model resolves circulation on 2x2 km Mesh

Permits eddies



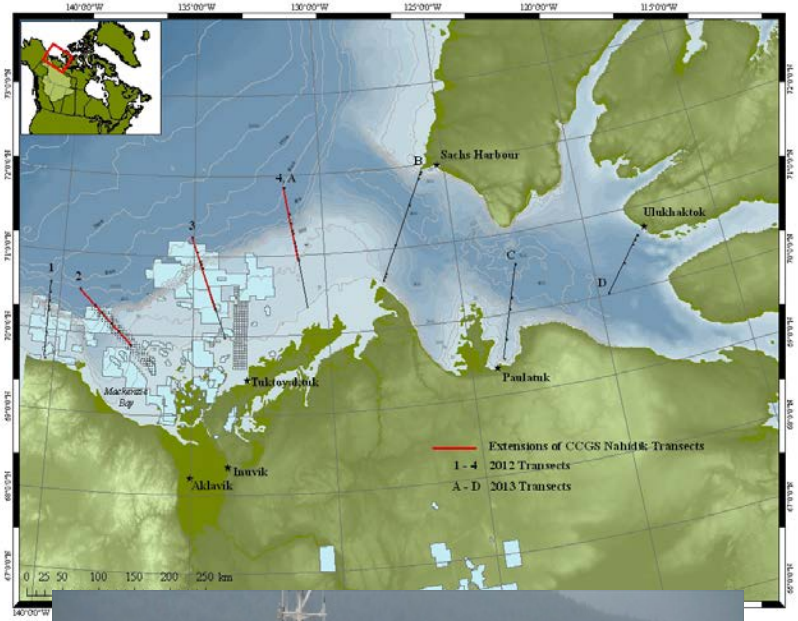


Temperature (C)

National Defence / Défense nationale

Links with other BREA work

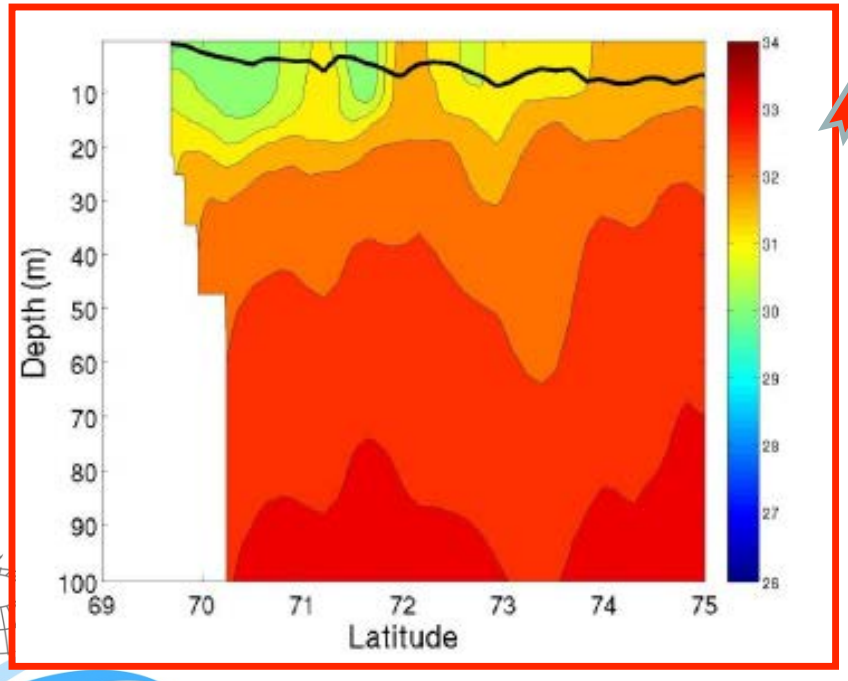
- DFO conducting ecosystem survey 2012 & 2013
- Provides CTD transect data to project

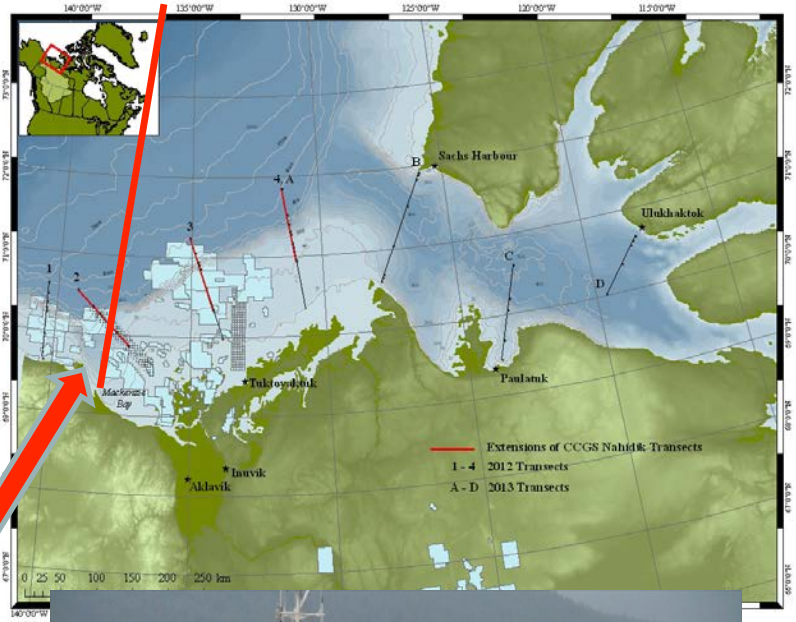


- Our Project contributes circulation details:
  - Ecosystem Model of Beaufort Sea developed by DFO ERI
  - DFO Climate Change Adaptation Program: Artic component

Links with other BREA work

- Can provide best estimate of ocean conditions for any given transect 365 days a year



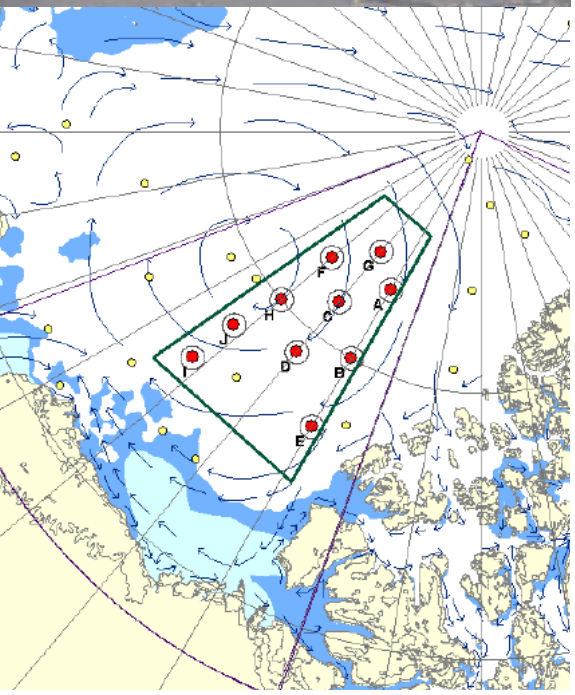


Why this project

- Align operational EC METAREA analysis and modelling tools with environmental assessment (EA), risk management, and policy and regulation development.
- Need environmental Information to
  - improve planning and operations in the Beaufort Sea
    - Oil spills
    - transport safety and efficiency
    - Offloading from production platforms
    - Evacuation, Search and Rescue
    - ice management
    - infrastructure design, etc.) in the BS;
    - support EA via open access to advanced knowledge of the environment;
    - Reconstruct historical BS physical conditions

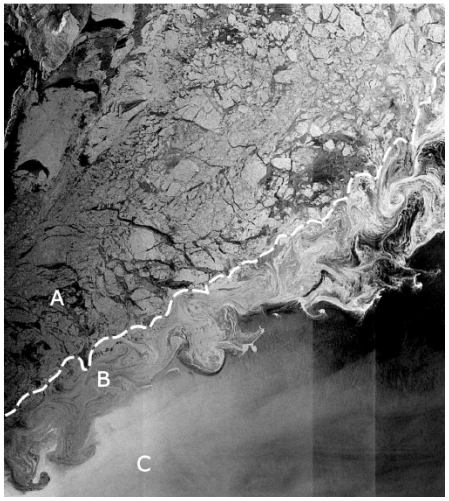
This project will available Ocean and Ice Observations into

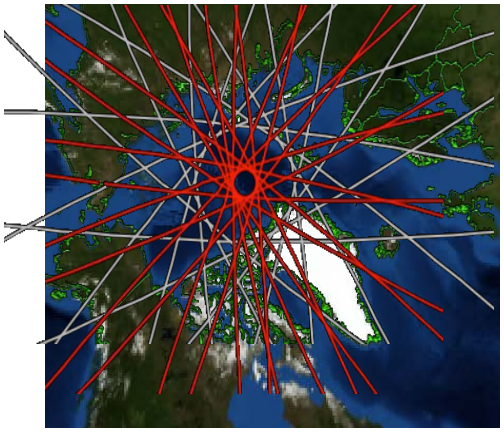
- Daily maps of ocean and ice estimated properties up to 10 days into the future
  - Ocean: Currents, Temperature, Salinity
  - Ice: Ice thickness, Ice Percentage cover, width of marginal ice zone
- Enhancements to METAREA weather forecasts through coupling of Ocean and Ice Forecasts
- Operational delivery of Ocean Currents and Ice Information Products for use by: CCG, Operations…

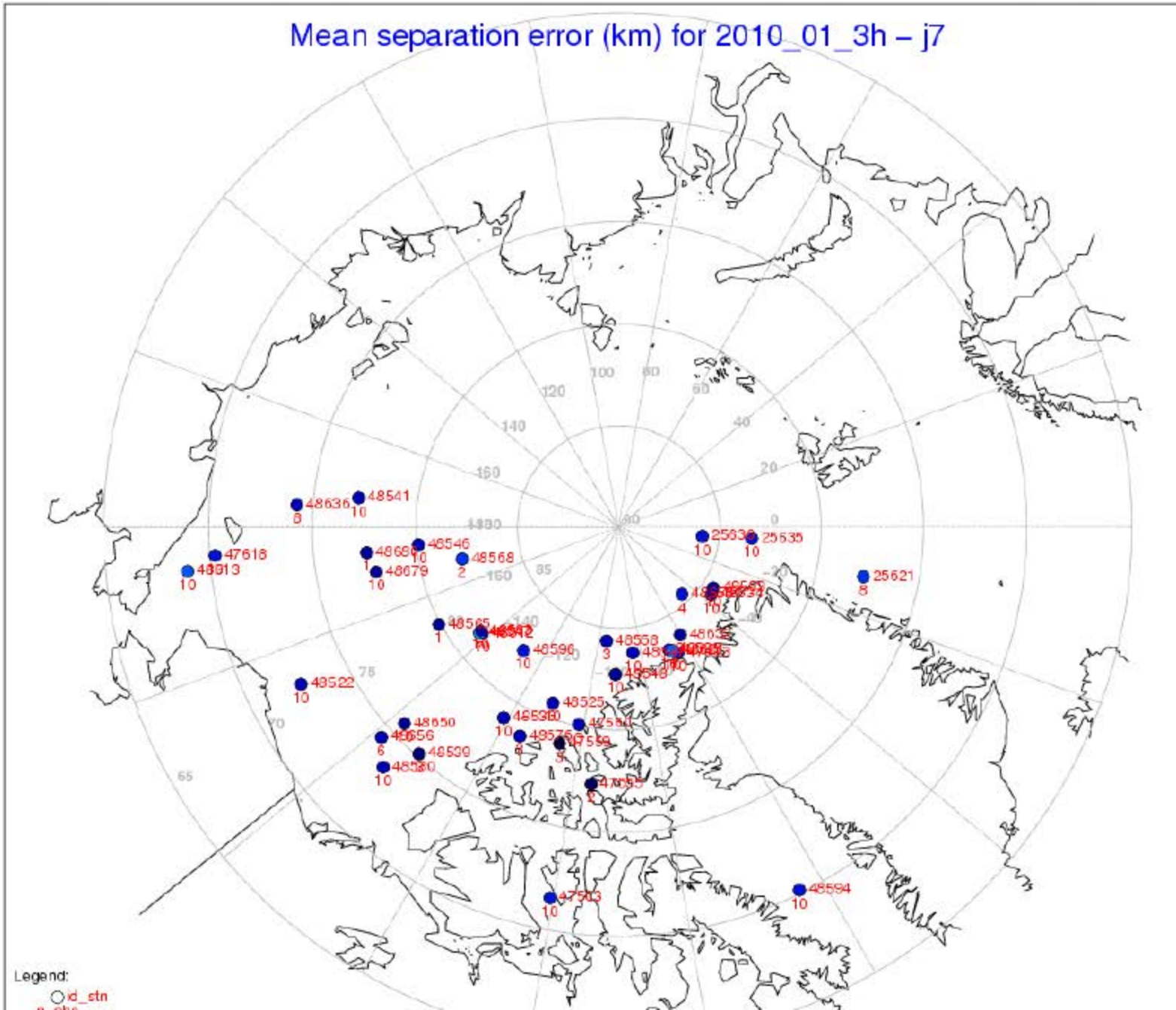


How and Where

- Ice Obervations → tracking & forecas system
  - Ice drifter Buoy
  - Satellite Observations
  - Local Measurements
  - Valuable for validation

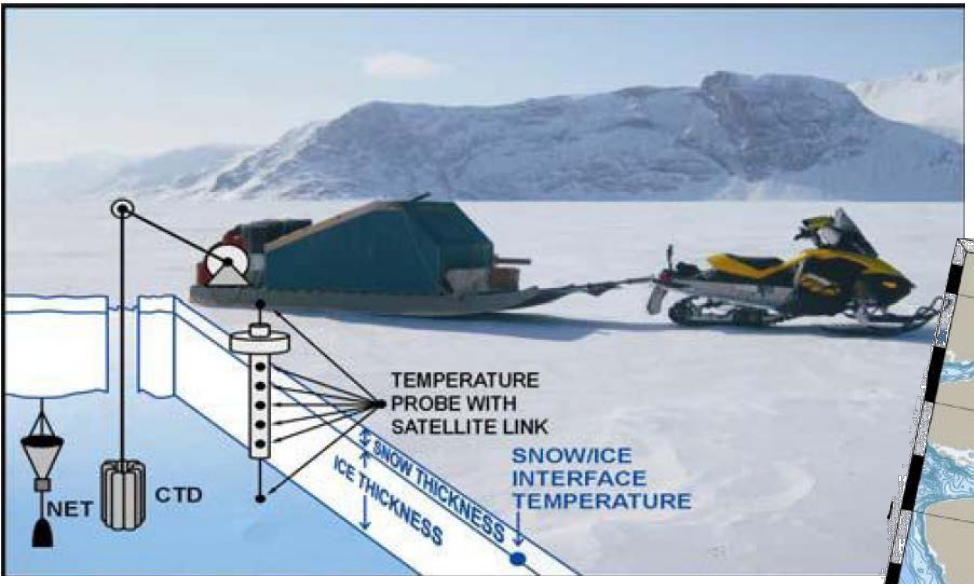





Mean separation error (km) for 2010_01_3h – j7
Legend:
id_stn

New possibilities for Data

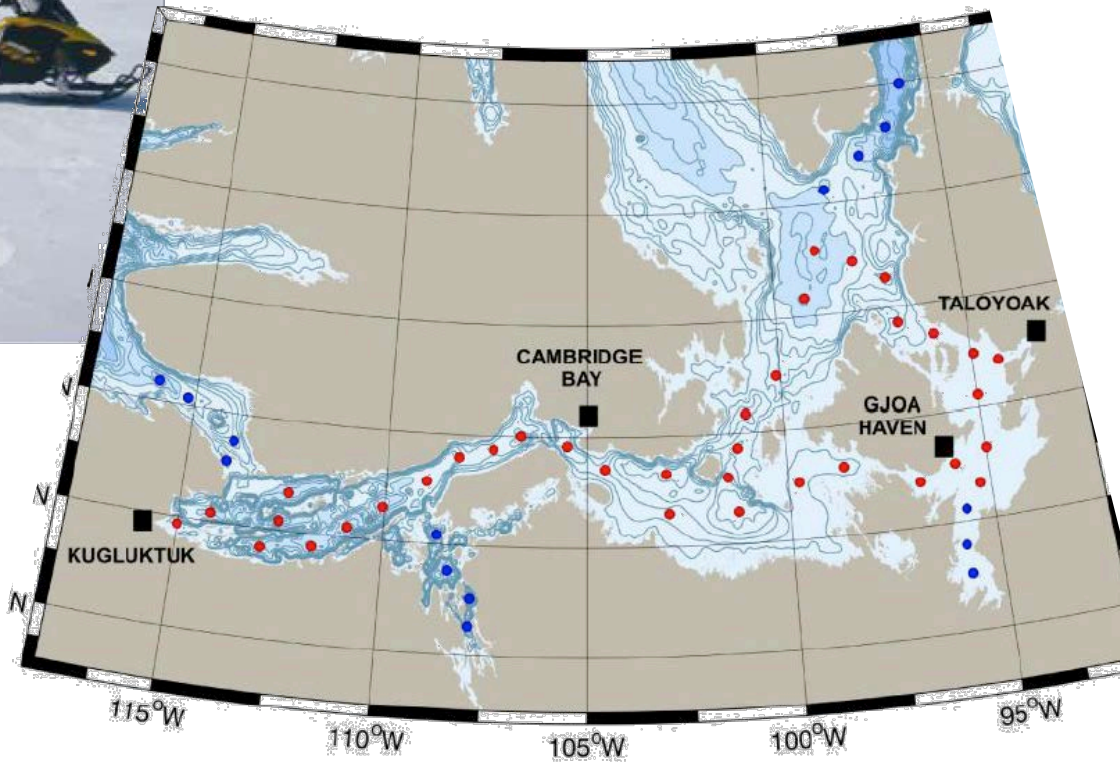
Canadian Ranger Ocean Watch Program (CROW)



Designed for climate monitoring
Can be part of near real time ocean assessment and forecast system

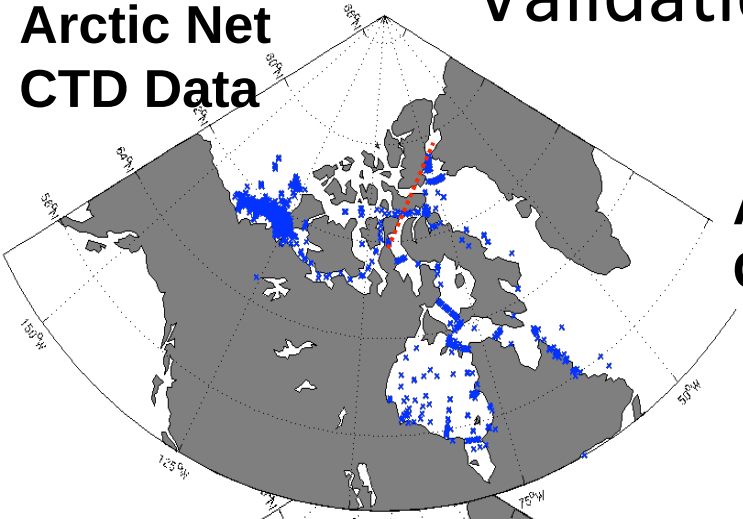
Are there suitable Ranger missions in the Inuvialuit regions?

Field Program Feb-March 2013

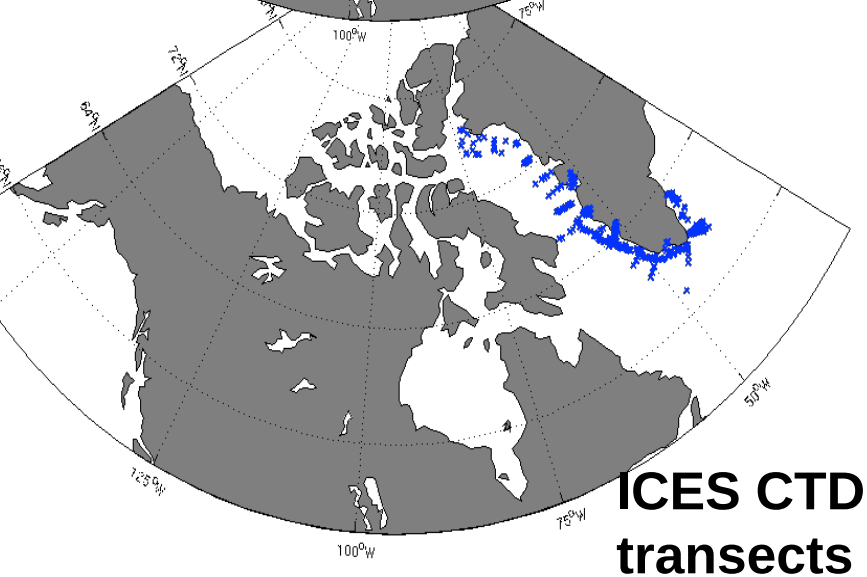


In Situ / Sat. Data for Validation → & Assimilation

Arctic Net CTD Data

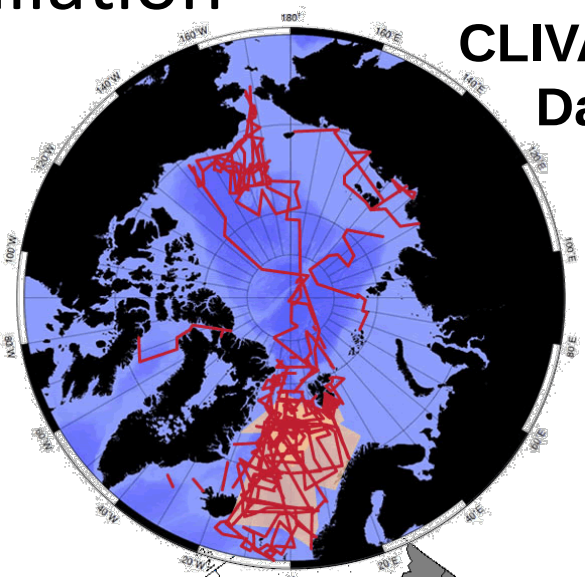


Arcic Net CTD Data

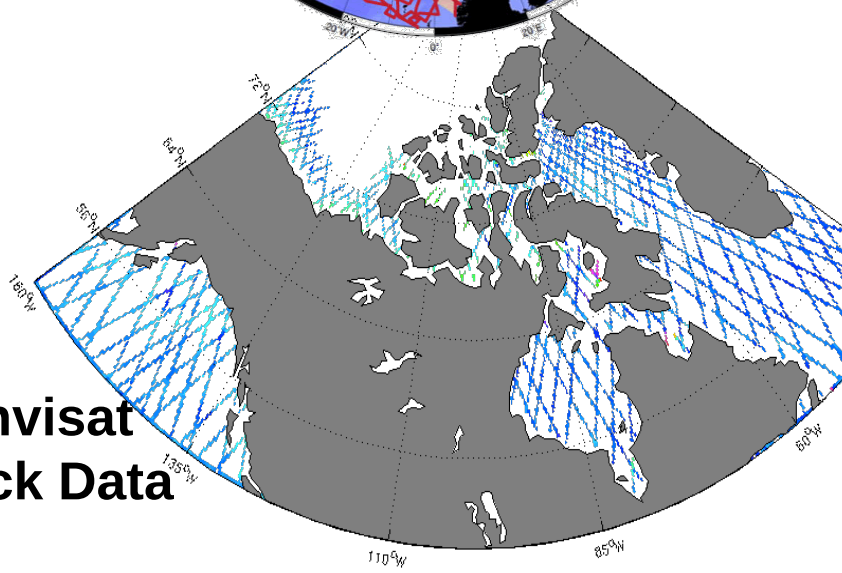


ICES CTD transects

CLIVAR Data

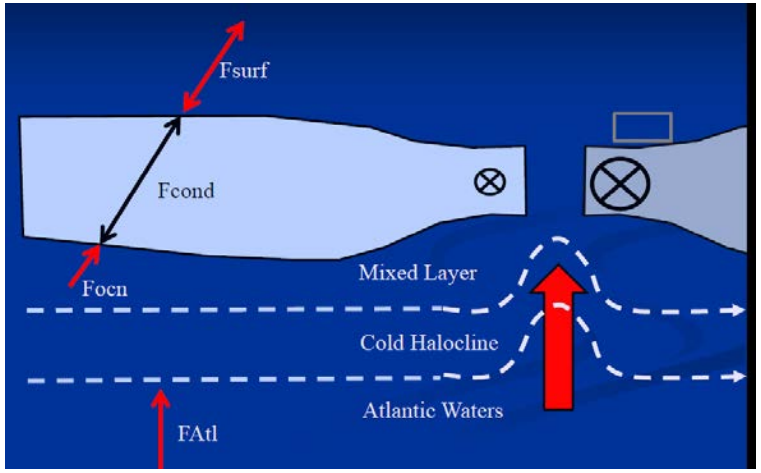


Envisat Track Data

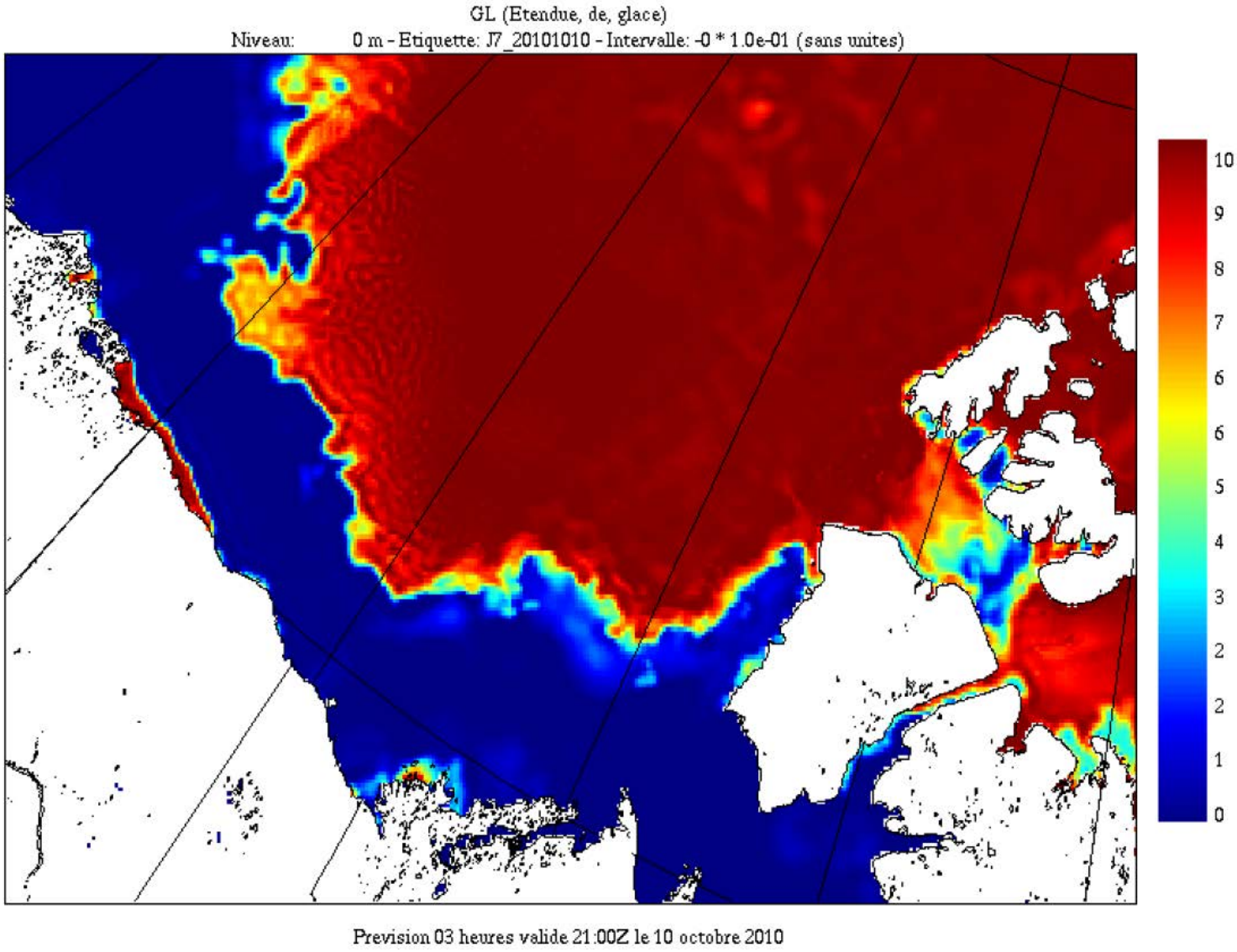


How and Where

- Improved Ice Models for Forecast and Analysis system
  - Large computers
  - Better modelling of ice stresses
- Improving ice lead forecast prediction in Beaufort
- Important for coupling with Atmospheric Forecasts

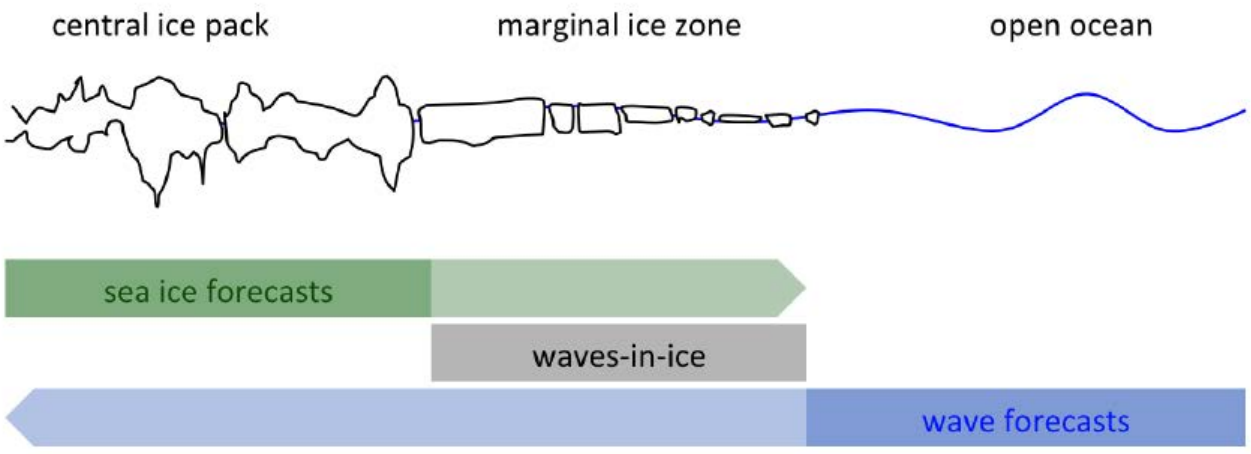


How and Where
Ice Analysis



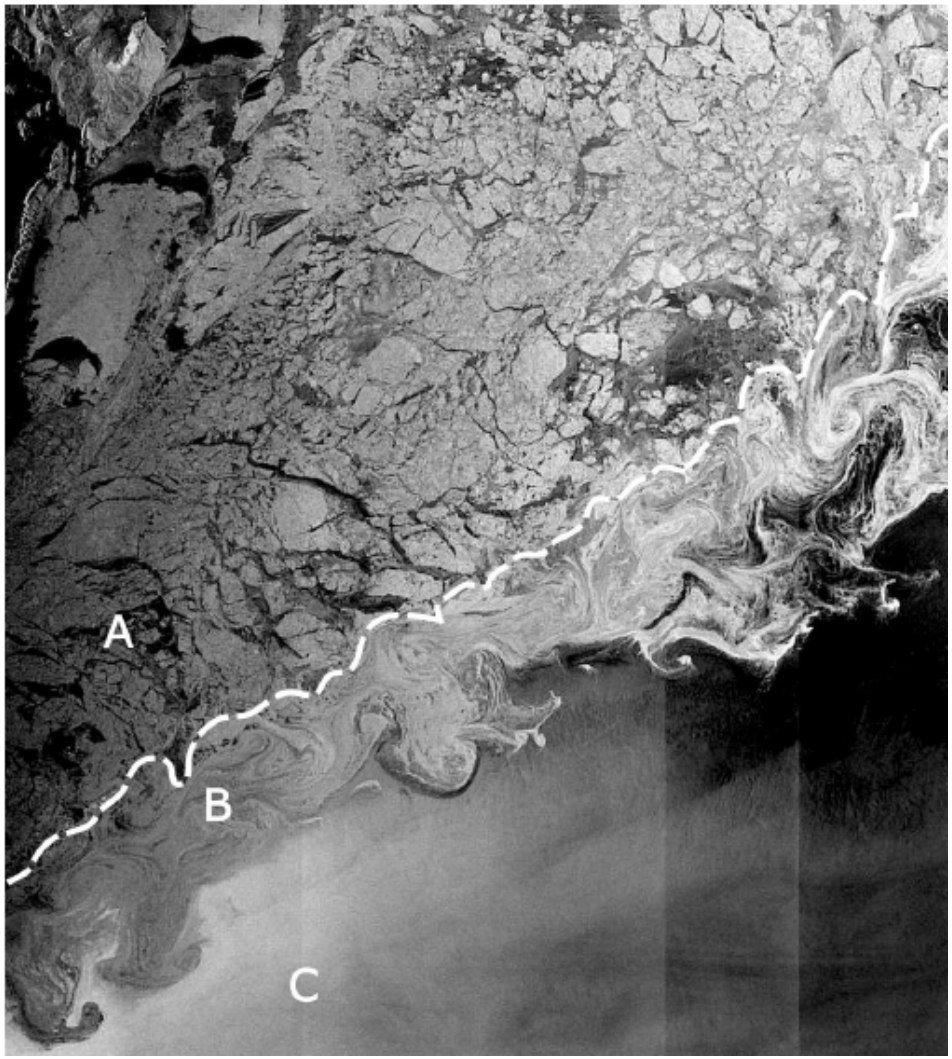
Adding information on Marginal Ice Zone

- How big is marginal ice zone
- Width of Marginal Ice Zone
- Impact of ocean waves on ice
- Exchange between ice model and ocean wave model

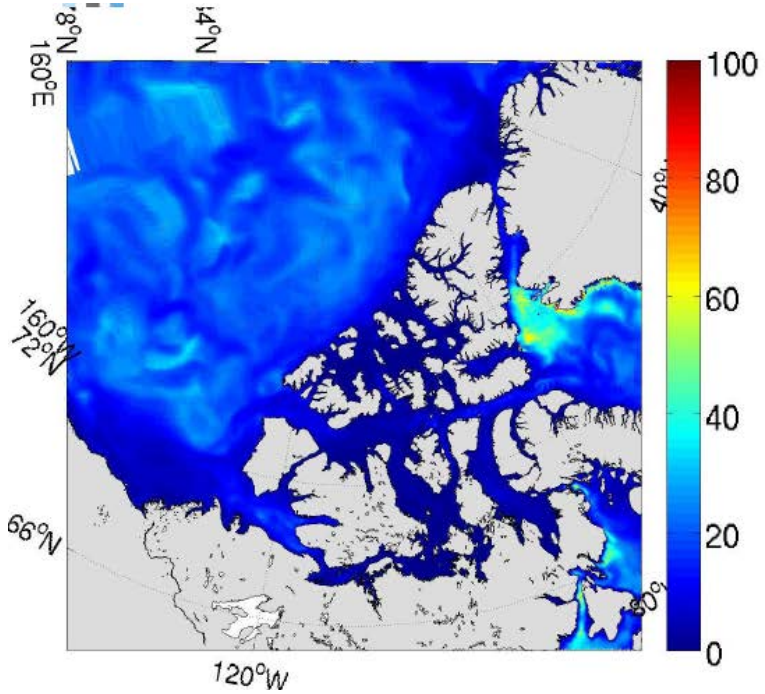


Adding information on Marginal Ice Zone

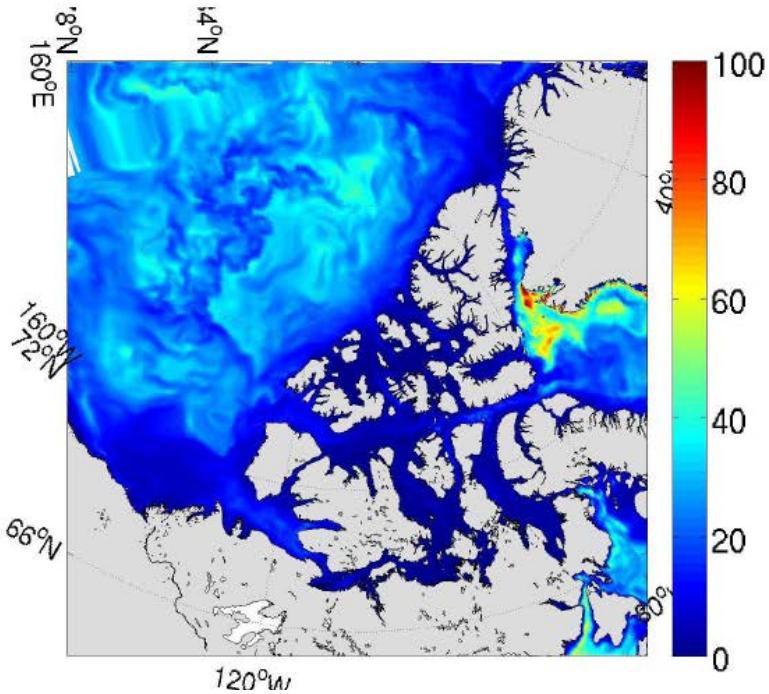
- Combining wave and ice model
- Determining flow size and width of Marginal Ice Zone



Tuning Mixing in the Ocean Model



Old Method TKE

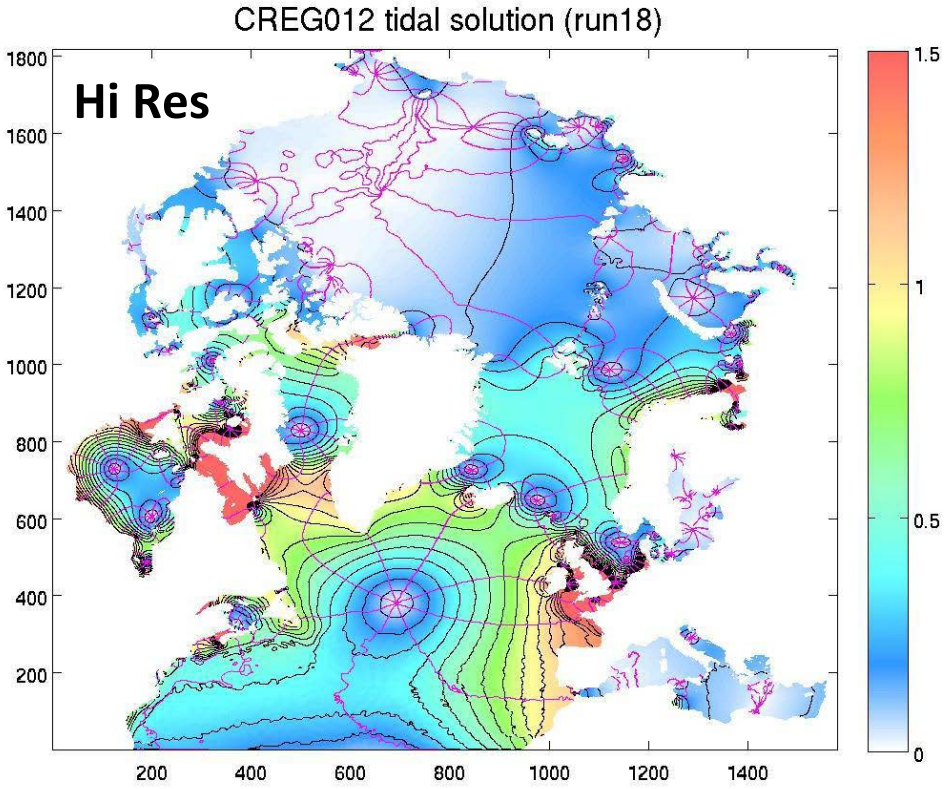


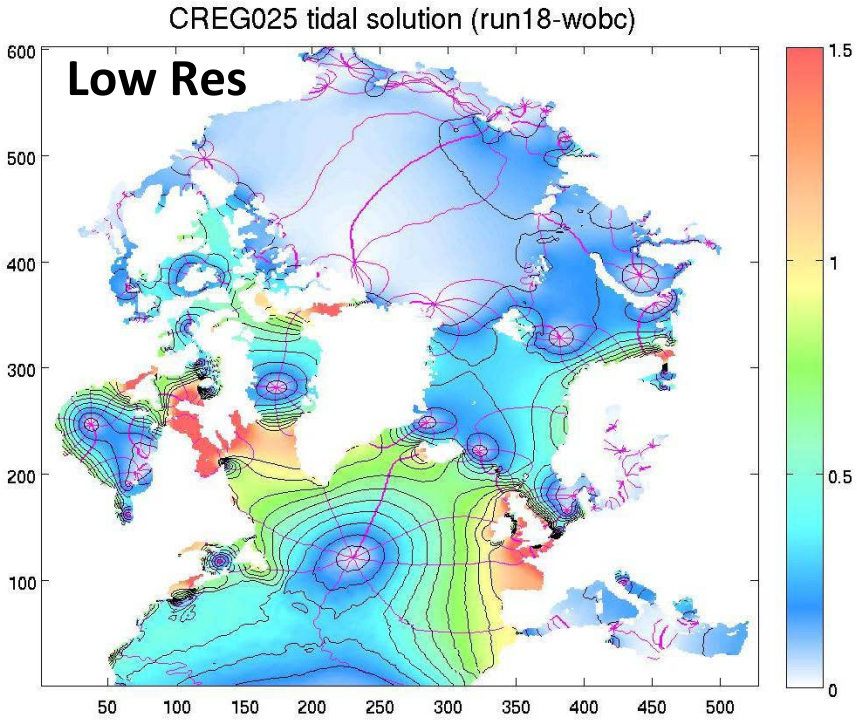
NEW proposed Method K-E

Depth of Mixed Layer (m)

- New method changes way mixing occurs near surface
- Determines how deep you go for a 1^{O}Cel difference from Surface Temperature

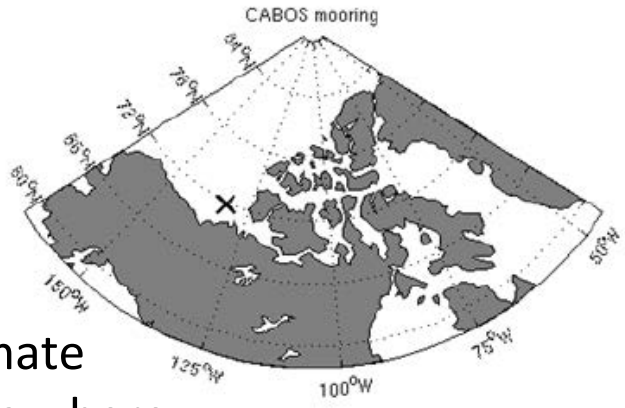
Tides Implemented at High Resolution



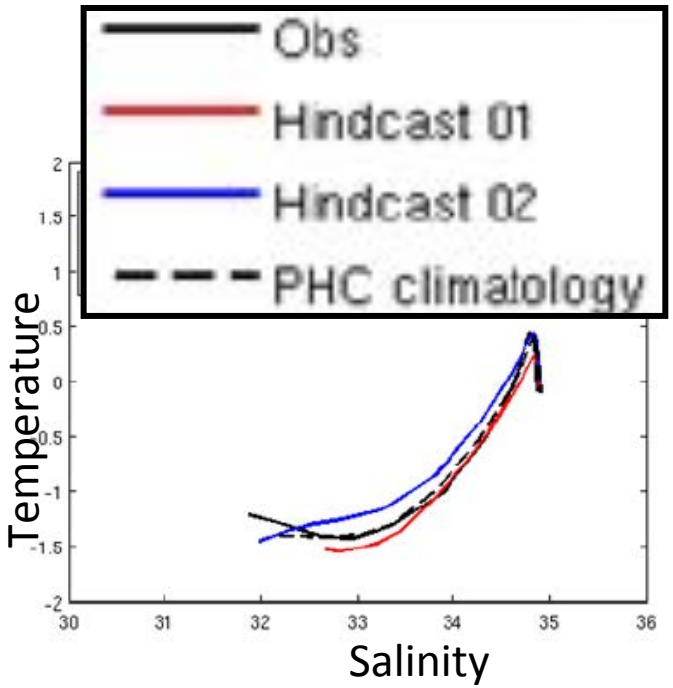


- Tidal solutions good for Beaufort
  - Not so good for Hudson Bay

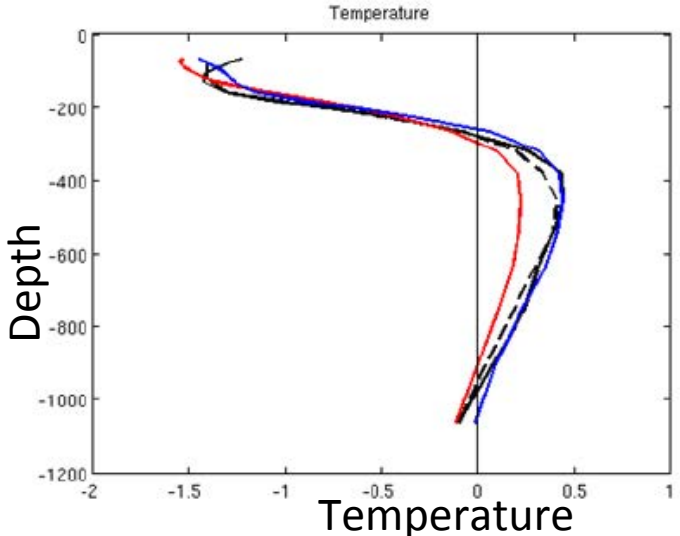
Validation of Ocean Models with Observations

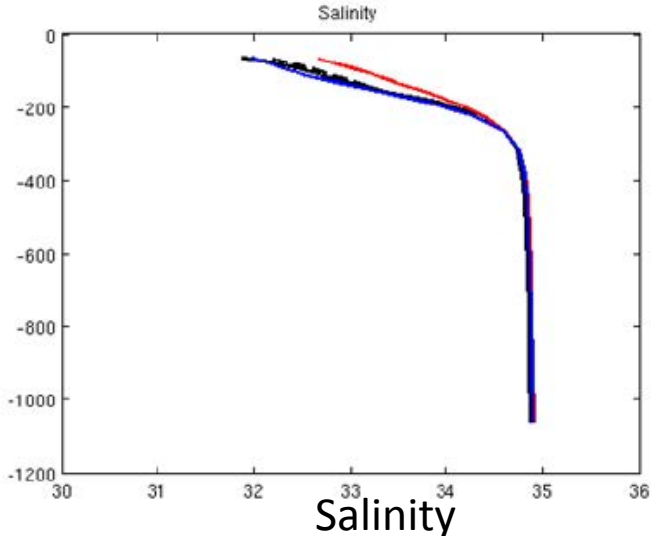


The forecast system can be used to estimate temperature profiles where there is no observations

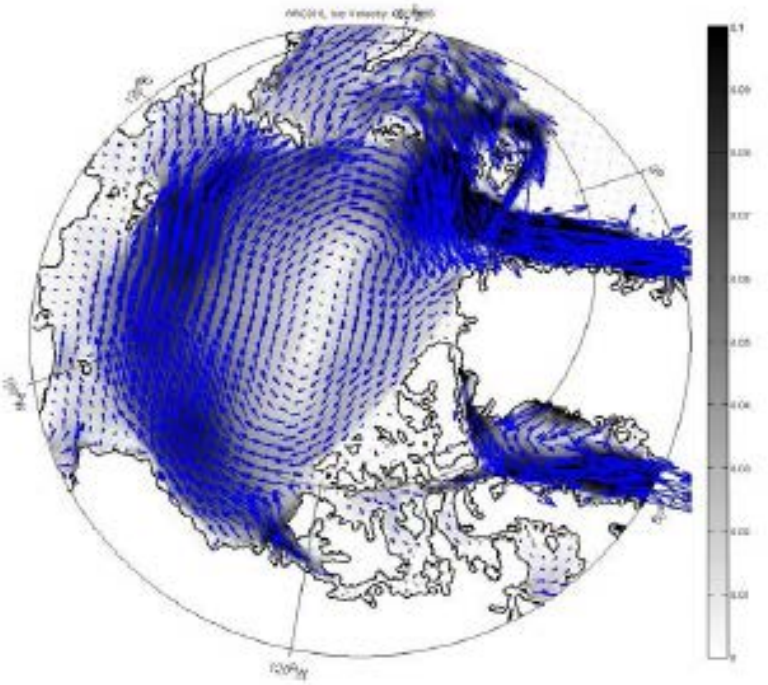


0m

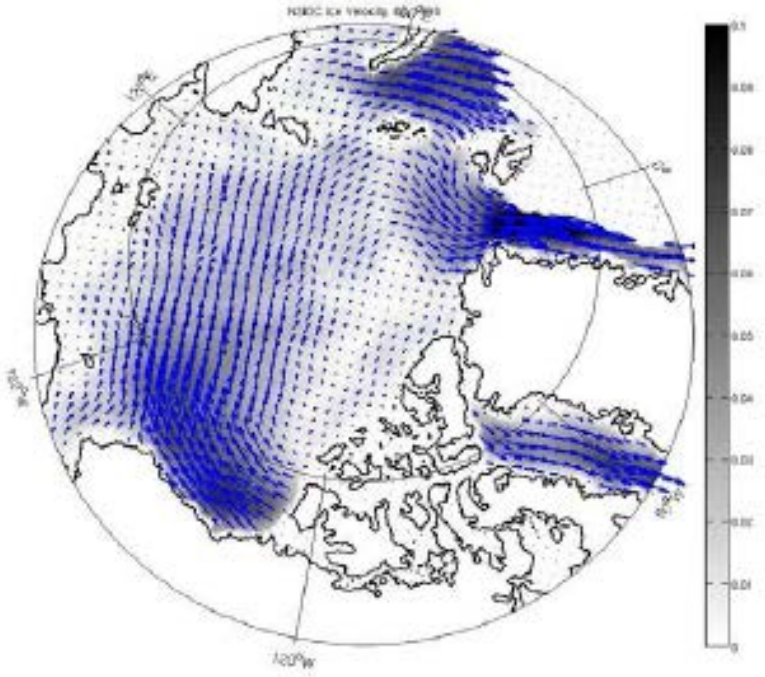




Working to Reduce Ice Velocity

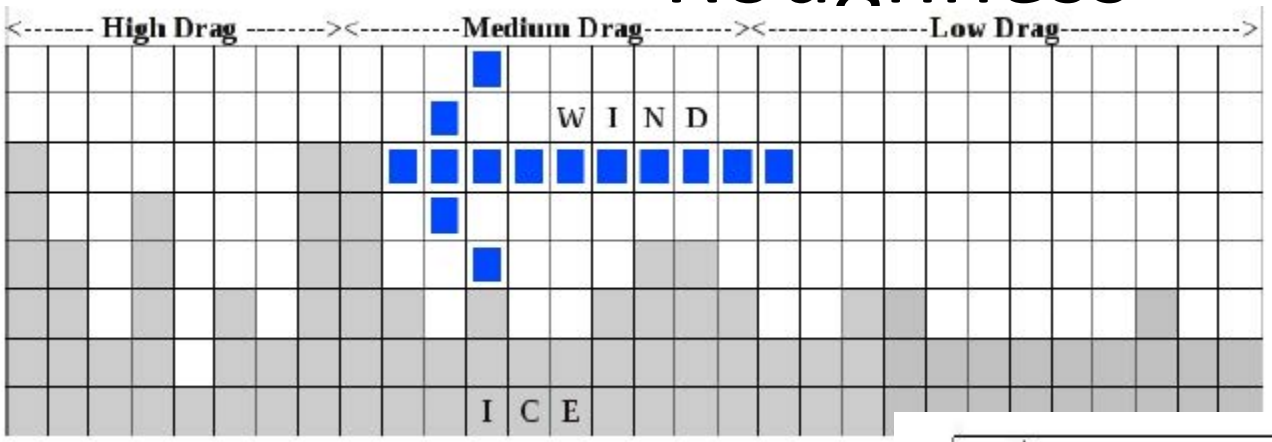


Model (Mar 1998)

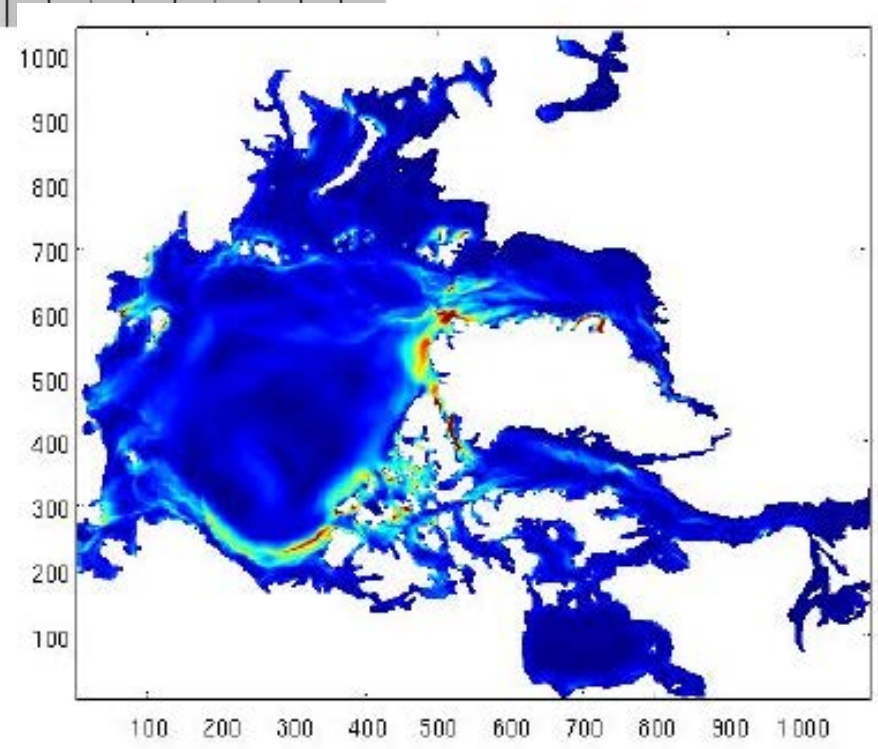


Observations

Adjusting Ice Speed for Sea Ice Roughness



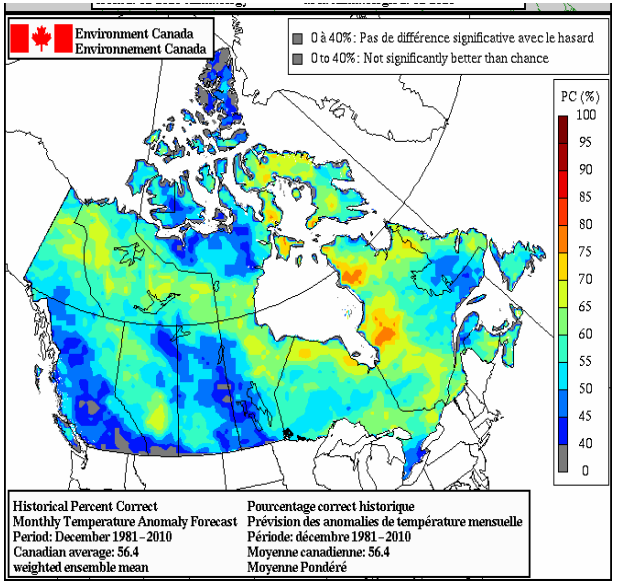
- Looking into adjustments to slow modelled/forecast ice down
- Link roughness to ice speed variability



Ocean, Ice, Weather Predictions 1- 12 months

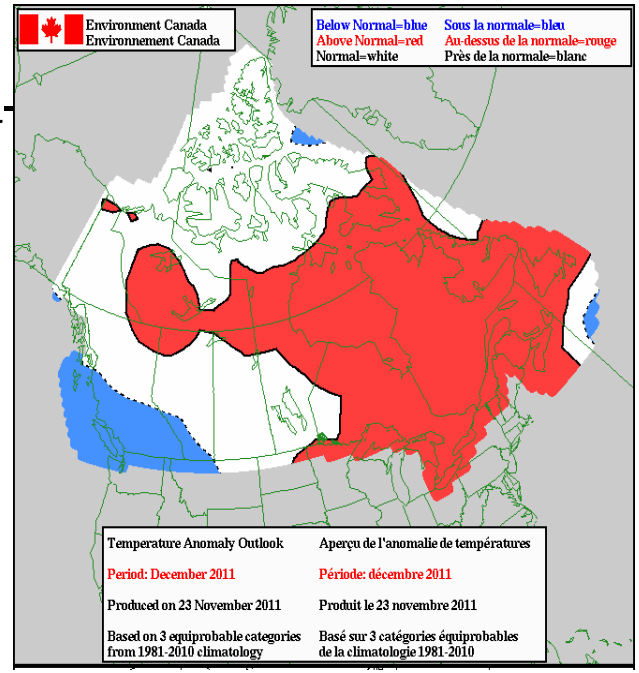
How long will an ice free state last this summer?
How severe will this winter's ice cover be.

CanSIPS is your tool for these questions

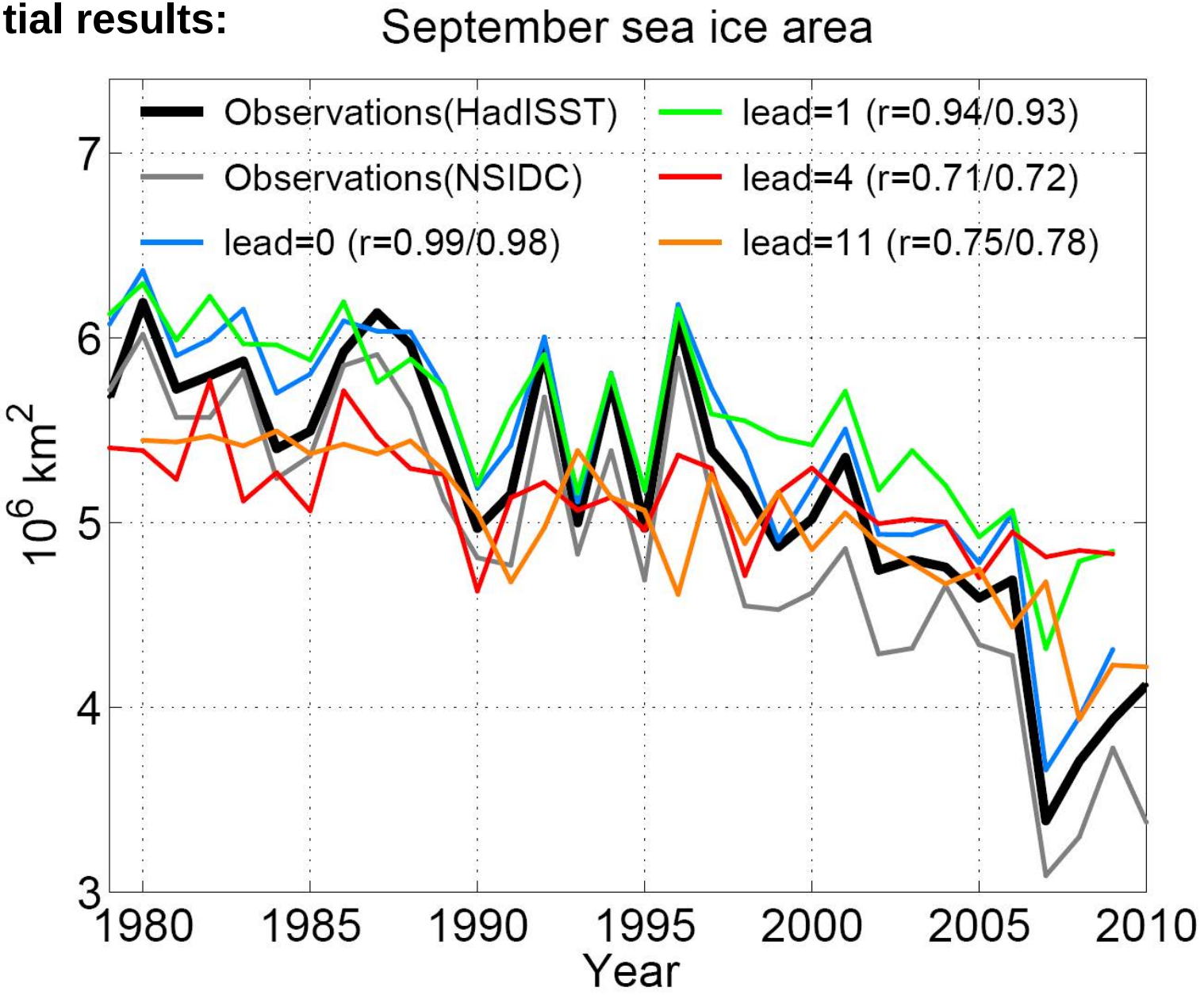


- Canadian Seasonal to Interannual Prediction System: multi-model, global, coupled climate prediction system
  - atmosphere, ocean, land surface and sea-ice.
  - Developed by CCCMA operated by CMC

- Project Purpose: evaluate the ability of CanSIPS to make quantitative predictions of sea-ice extent at lead times up to 12 months.



Initial results:



Sigmond et al., Geophys. Res. Lett. (2013)

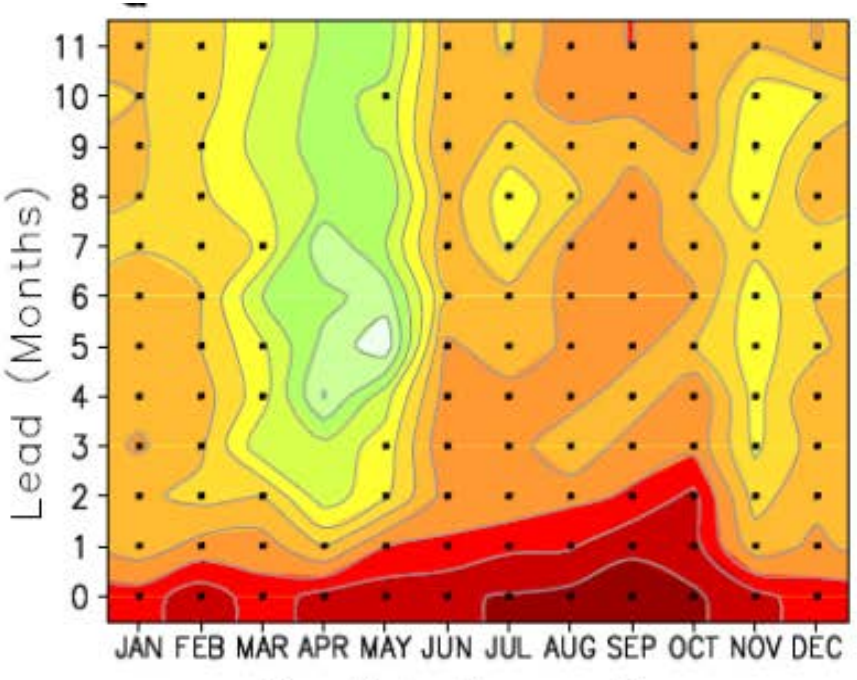
Ocean, Ice, Weather Predictions 1- 12 months Conclusions

- Seasonal predictions of Arctic sea-ice area and regional concentration have “statistical” skill.
- Short term skill (<= 1month) comes anomalies around seasonal signal don’t change that quick.
- Longer term skill (11-12 months) comes from climate change trend.
- Coupled climate prediction systems provide enhancement of skill but so far not huge.

Room for Improvement

- assimilate snow amount or ice thickness
- Get operational ocean data in ice-covered areas.
- Adding sea ice prediction to Env Canada’s long range forecasts

Sigmond et al., Geophys. Res. Lett. (2013)



Why do we want Ocean-Ice Forecasting?

- DND:
  - Awareness of ocean conditions and acoustic properties
- DFO:
  - Improved ocean descriptions
  - State of the ocean reporting
  - Understanding the ecosystem
  - Search and Rescue
  - Climate Change Adapation
  - Integrated Management
- EC:
  - Improved Weather forecast
  - Better info for oil spill tracks
  - Improved seasonal predictions

Why do you want Atmosphere-Ocean-Ice Forecasts

- **Communities:**
  - Access to better ice, ocean and weather forecasts
  - Access to Ocean Current descriptions and forecasts
- **Inuvialuit Game Council:**
  - Access to circulation pattern descriptions for the entire region
  - Linking to observed changes in wildlife
- **Regulators:**
  - Accessible operational ocean ice forecast systems that can be used for operational and strategic decisions
- **Industry:**
  - Access to vetted ocean circulation forecasts for use in oil spills, environmental asessements…
  - Planning/Logistics
- **Academia:**
  - Better understanding of physical oceanographic environment in interpreting biological observations.

ENHANCING THE CANADIAN METAREAS IN THE BEAUFORT SEA

Questions?

I have some questions for you:

- What's on your mind when you think about movement of water in the Beaufort?
- What information on the ocean and the ice do you want access too?
- What do you currently use computers for?
- Can a interactive web site be useful?

ACRONYMS

- CONCEPTS: Canadian Operational Network of Coupled Environmental PredicTion Systems Collaboration between 3 Government Departments
- DFO: Fisheries and Oceans Canada
- EC: Environment Canada
- CMC: Canadian Meteorological Centre
- NEMO: A Community Ocean Model used widely in Europe, and implemented in Canada for development of new coupled short term Atmosphere, Ocean and Ice predictions from 1-10 days.
- CCCMA: Canadian Center for Climate Modeling and Analysis
- CanSIPS: Canadian Seasonal to Interannual Prediction System. A coupled Atmopshere, Ocean and Ice system for fusing in observed data and making longer term predictions 1-12 months

Contacts:

Fraser Davidson
Research Scientist
Fisheries and Oceans Canada
Northwest Atlantic Fisheries Centre
80 East White Hills Rd
PO Box 5667 St. John's NL A1C 5X1
Tel: 709-772-2418
Fraser.Davidson@dfo-mpo.gc.ca

Greg Flato
Manager
Environment Canada
Canadian Centre for Climate Modelling and Analysis
3800 Finnerty Road, SCI A203
Victoria, British Columbia V8P 5C2
Canada
Telephone : 250-363-8233 Fax : 250-363-8247
Greg.Flato@ec.gc.ca