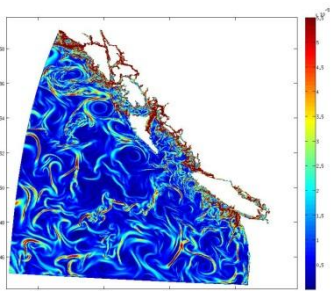
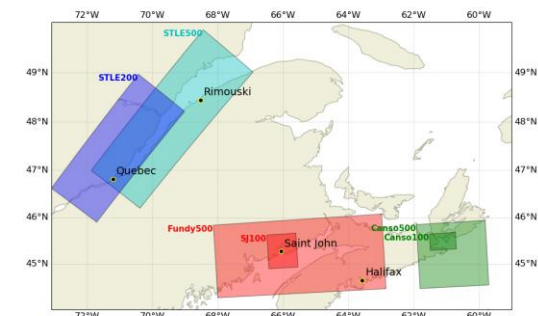
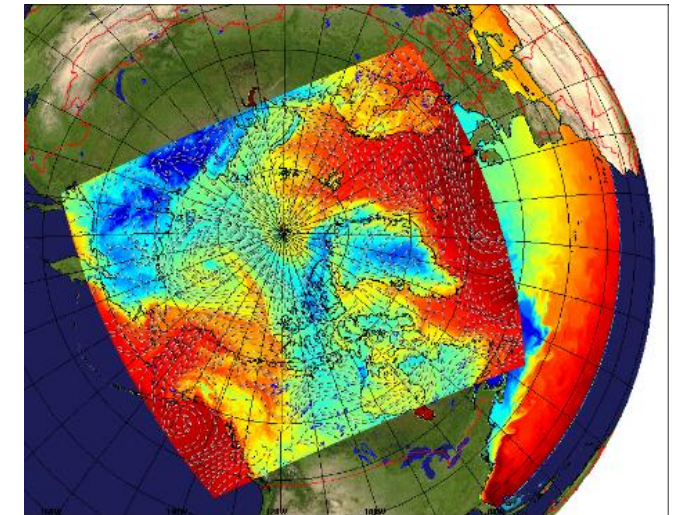
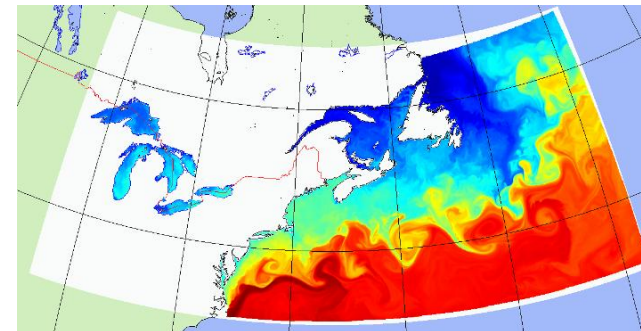
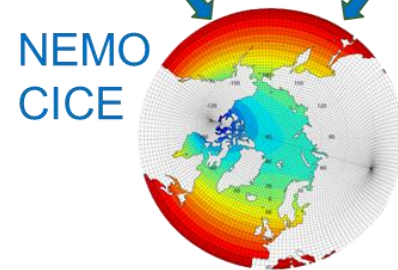
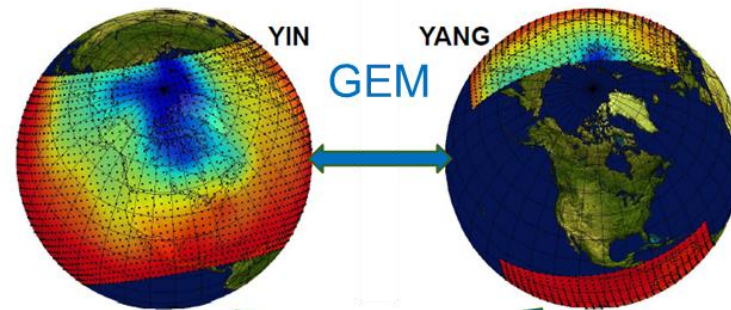
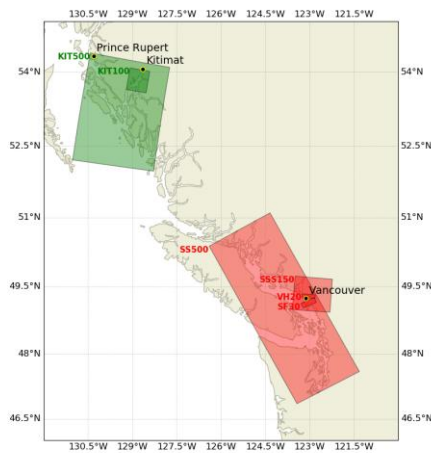




CONCEPTS Prediction Systems Update

Gregory Smith (ECCC)

OPST12, Apr 15, 2026

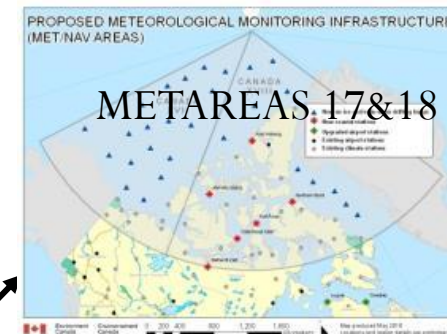




DFO Applications

- Fisheries and Aquaculture management
- Ocean climate monitoring
- Marine Protected Areas

CONCEPTS Users and Applications

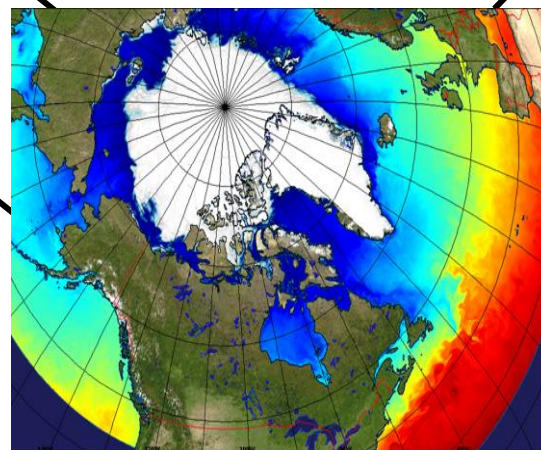


Canadian Ice Service Operations

- High-pressure ridges
- Automated analyses
- Iceberg drift

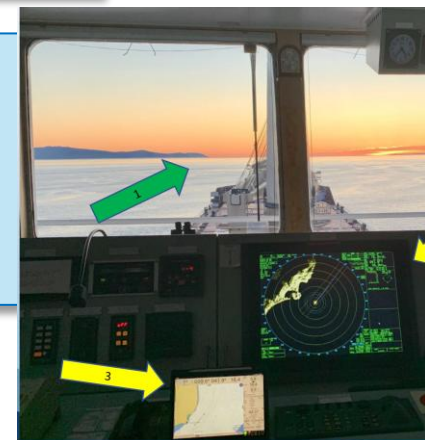
DND Applications

- Situational awareness
- Anti-submarine warfare
- Operational support



E-NAVIGATION Dynamics Maps

- Currents, sea surface height
- Waves, wind, ice



Canadian Coast Guard

- Search and Rescue
- Environmental Emergency Response

National Environmental Emergency response Centre (NEEC)

- Oil spill

Marine NWP services

- NWP, waves, storm surge
- Air-sea-ice interactions and feedbacks

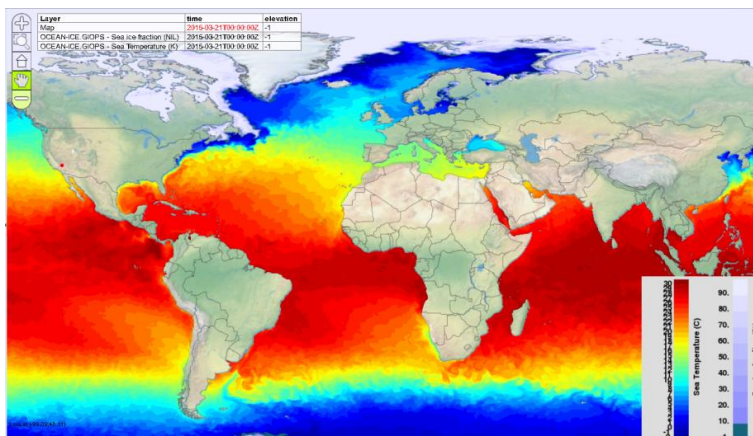


CONCEPTS Ice-ocean forecasting with



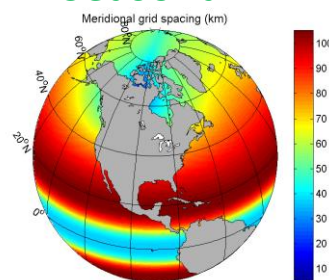
+ CICE

Operational
Experimental

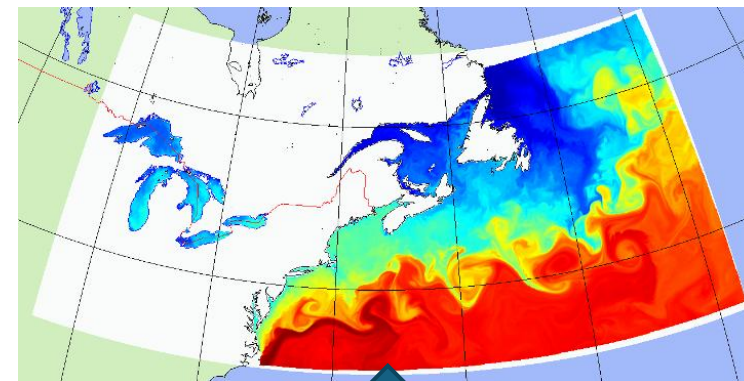


GIOPS: 1/4°Global, Coupled to GDPS (10day) and GEPS (16day and monthly)

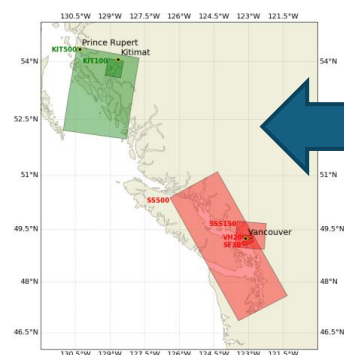
Seasonal 1°



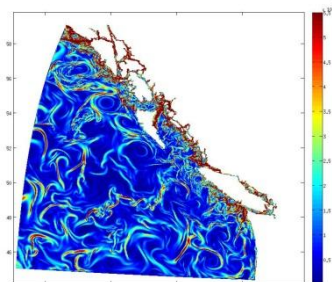
**Water Cycle Prediction System
Great Lakes 1km+East Coast (1/36)**



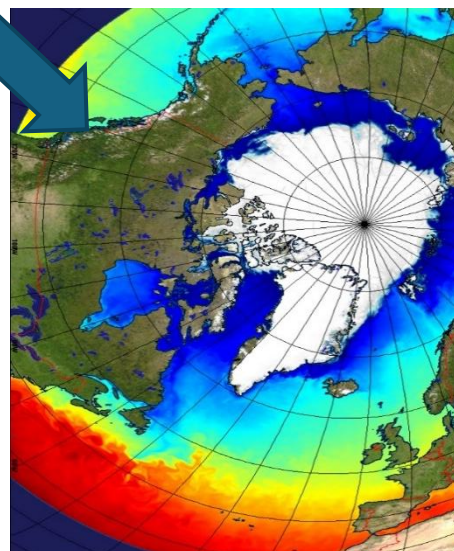
POPS: St. Lawrence Estuary, St. John and Canso Harbours



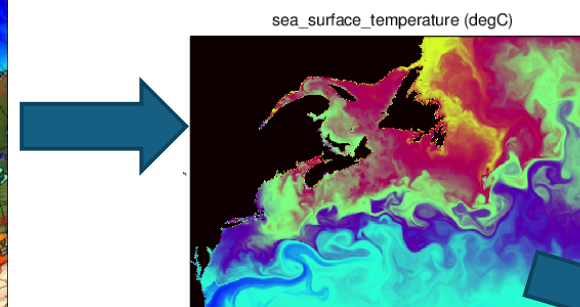
POPS: Kitimat, Fraser River and Vancouver Harbour



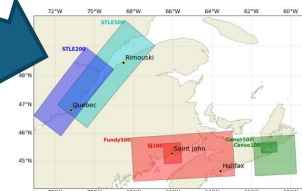
CIOPS-W: Northeast Pacific 1/36° + 500m Salish Seas



RIOPS: Regional 1/12° CAPS Coupled YOPP (3km atm)



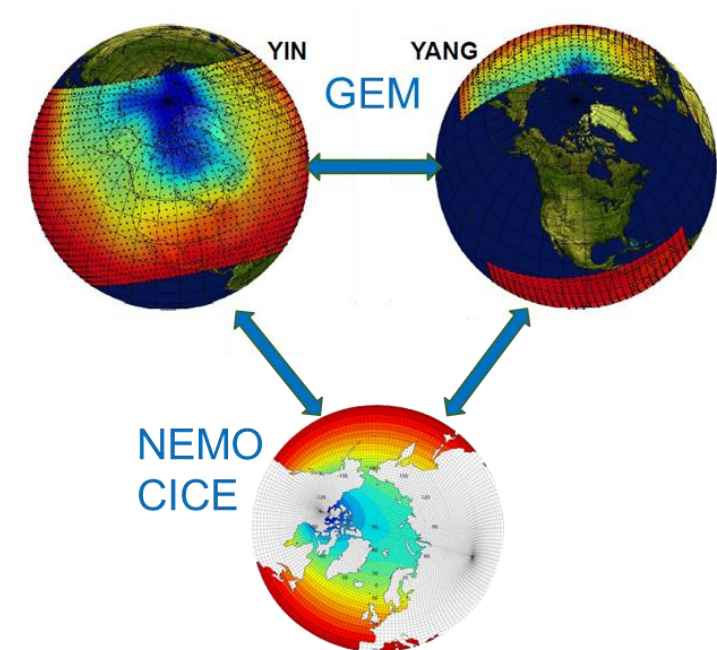
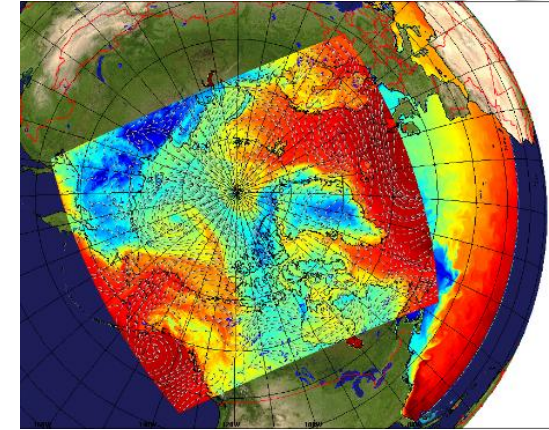
CIOPS-E: Coastal East Coast 1/36°



ECCEC Coupled Forecasts

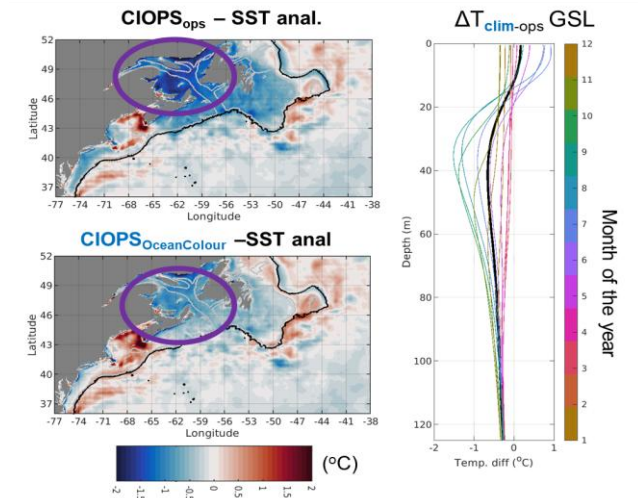
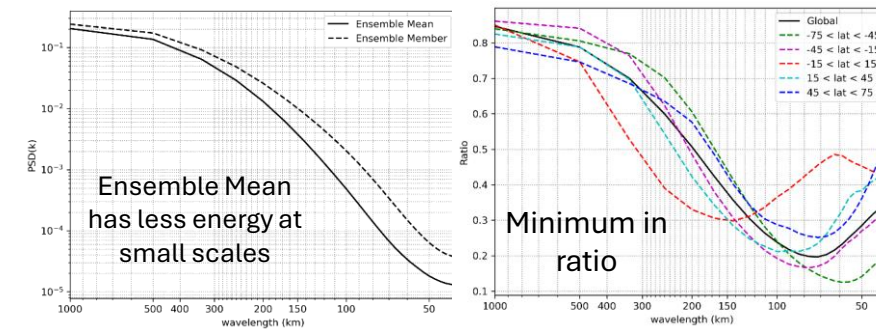
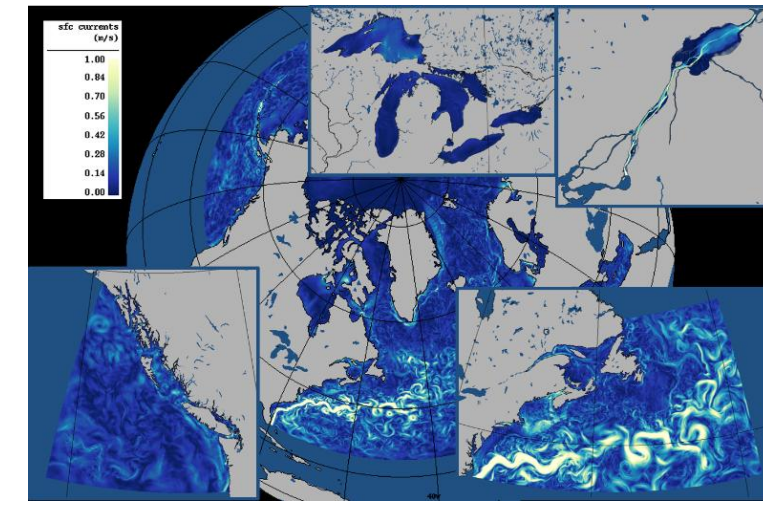


- Coupled Global Medium-range Deterministic System
 - 10 day forecasts (soon with hybrid ML model)
- Coupled Global Ensemble Forecasts
 - 15d (daily) and 32d (weekly) forecasts
- Seasonal Predictions (CanSIPS)
 - 12 month forecasts
- Water Cycle Prediction System (WCPS)
 - Great Lakes and East Coast
- Canadian Arctic Prediction System (CAPS)
 - Pan-Arctic high-resolution coupled forecasts (for DND)



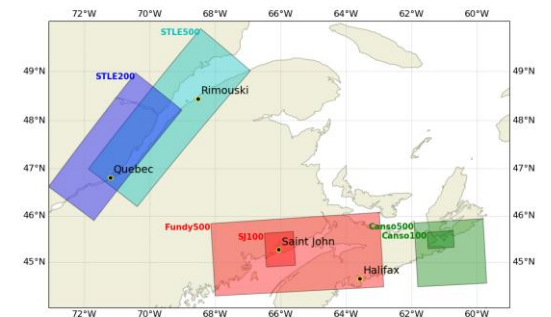
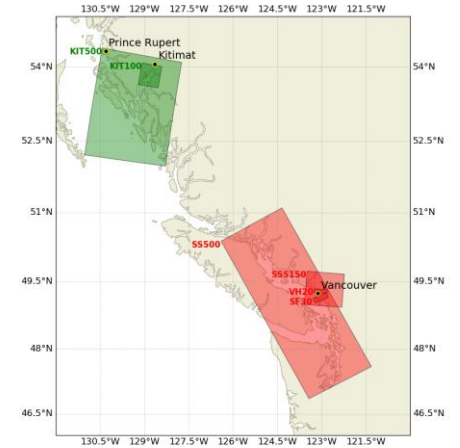
Innovation Cycle 5 (July 2027)

- **General improvements:**
 - Various improvements to assimilation system, ice thickness assimilation, ice form drag, NEMOv4, use common sequencer suite
- **GIOPS:** Ensemble SEEK analysis, MIDAS-LETKF daily analysis
- **RIOPS:** SWOT and improved coastal assimilation
- **CIOPS:** Ocean colour
- **GDPS:** Hybrid ML forecasts
- **GEPS:** Ensemble ocean initial condition. Increase in atm res (15km)
- **CAPS:** Improved cloud scheme, IRIS coupler, pseudo-analysis using spectral nudging



POPS Development Plans

- Migrate all POPS to NEMO4.2
 - Initial work with Fundy500, STLE500, SSS150 provides framework
 - Use wetting and drying if relevant
- Couple ice model (CICE6) to STLE systems
- Grid / domain adjustments for STLE and BoF systems
- Investigate ML emulators for STLE and VH20
- Continue and expand work on AGRIF
 - May be able to consolidate systems
- Incorporate hydrological modelling (RAVEN) in west coast systems
- Prepare for change in output formats with IC-5 (no more tarballs)



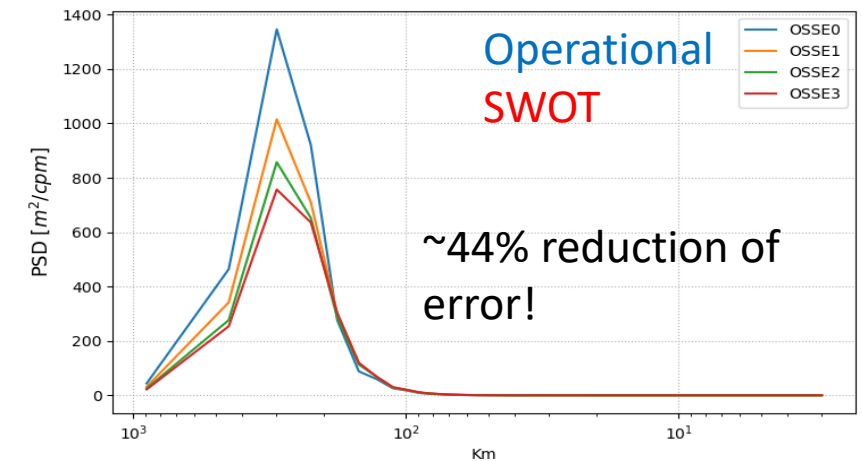
Assimilation of SWOT

Collaboration with Will Perrie (DFO), Mounir Benkiran (MOi), Guoqiang Liu (Dal)

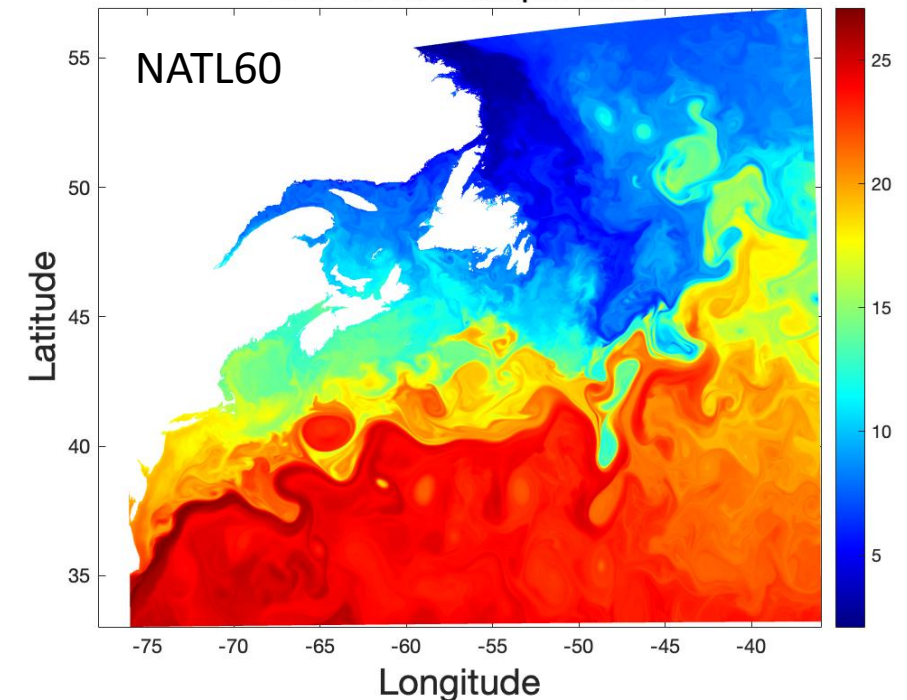
- Evaluation using synthetic SWOT observations in an Observing System Simulation Experiment (OSSE)
 - Produced several 1-yr simulations assimilating SWOT
 - Use NATL60 (J. LeSommer) as “truth”
 - Synthetic obs using JPL SWOT Simulator
 - Assess benefits of SWOT and constrained scales
- Evaluation of real SWOT observations
 - SWOT launched in late 2022. Entered Science orbit in Sept. 2023. Evaluation using early-release version of L3 data.
 - Evaluating impact in RIOPS on eddies and surface currents
- Ongoing work to maximize use of SWOT in coastal areas and for Canadian Arctic in RIOPS

Liu et al., 2024

Wavenumber spectrum of SSH errors



sea surface temperature



Canadian Arctic Prediction System (CAPS)



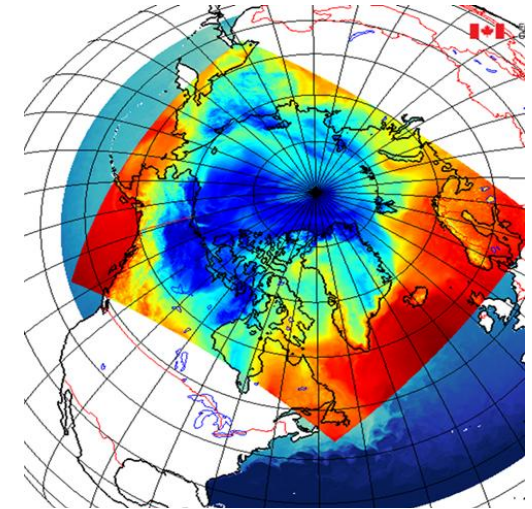
- CAPS is a fully coupled atmosphere-ocean-sea ice prediction system installed initially for YOPP and recently re-installed in operations in June 2025.
- 3-km atmospheric GEM configuration coupled to a 1/12° NEMO-CICE configuration (RIOPS)
- Performs 48h forecast twice daily
- Support Canadian Navy activities

Active areas of research

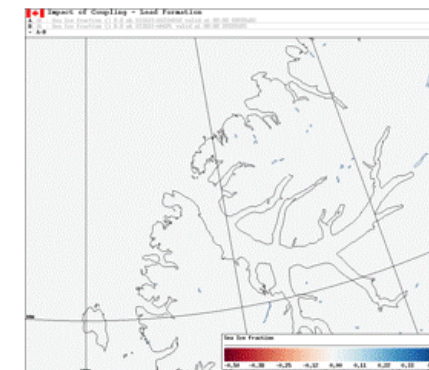
- Detailed evaluation against in situ observations (IGP, Svalmiz, ...)
- Development of "pseudo-analysis" spectral nudging suite
- Wave-ice coupling, form drag parameterization for sea ice

Proposal: Production of a 30-yr coupled CAPS reanalysis

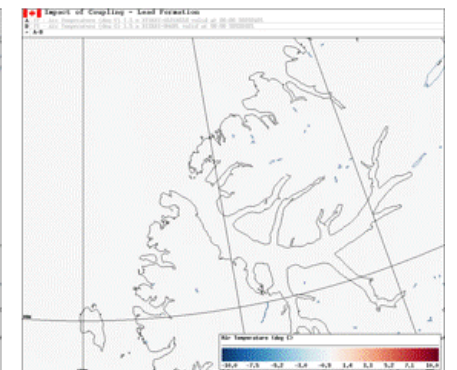
- Effort to collect all Canadian historical in situ T/S observations



GL Cpl - Ucnpl



TT Cpl - Uncpl

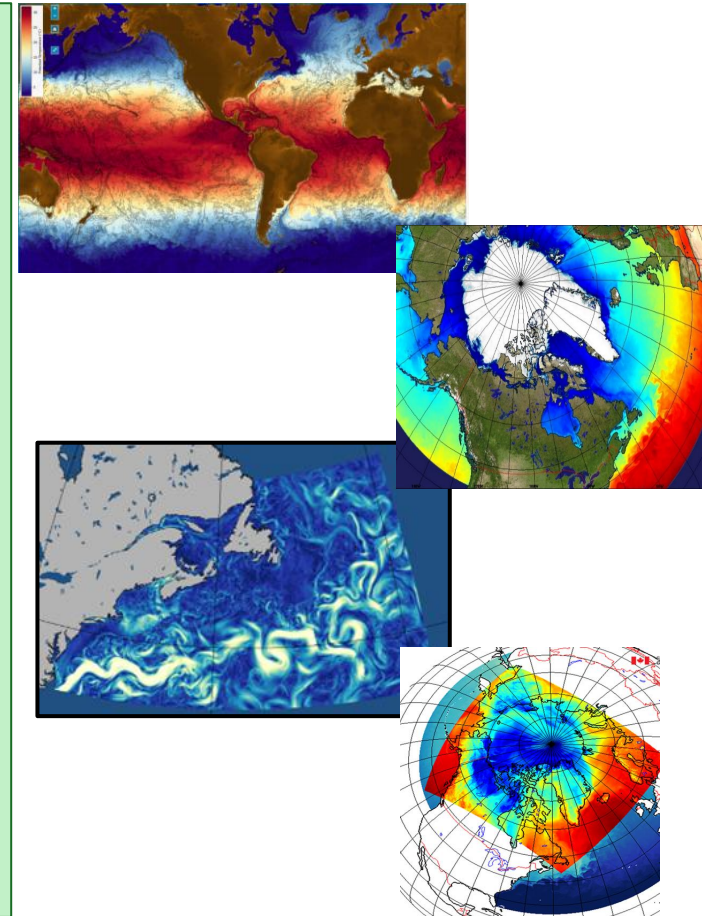


Historical reconstructions (reanalysis)

- Global and regional systems required for assessing extreme events, climate impacts and **machine learning**!
- Global reanalysis needed for initializing Monthly and Seasonal systems

Projects

- **GIOPS Reanalysis (1993-2022):**
 - Uses IC5 SAM2v2 configuration (ORCA025-L50)
 - Initialized from EN4, assimilates CORA T/S profiles, CMC SST and various nadir altimeters
 - Prototype with no sea ice assimilation produced. Results broadly consistent with GLORYS4v2 and GLORYS12.
 - Next steps:
 - Production of a separate sea ice reanalysis underway.
 - Working on new method to assimilate pseudo-Argo profiles (pre-2005) to correct water mass biases.
- **1/12th Three-Oceans multi-decadal hindcast (1958-2024)**
 - Assess longer-term variability and trends in water masses, circulation and sea ice around Canada
- **CLOPS Retrospective Simulation (1993-2022)**
 - Regional downscaling of GLORYS12 using spectral nudging offshore
 - Analysis of variability, extremes and trends underway
- **CAPS/RIOPS “reanalysis” (PROPOSED):**
 - RIOPS reanalysis following approach used for GIOPS
 - Include additional Canadian coastal observations for 3 oceans (Pac, Arc, Atl)
 - Use CAPS coupled configuration with spectral nudging in the atmosphere toward ERA5.



ONGOING PROJECTS

- Arctic Observing System Studies
 - Assess how to best use observations in the Arctic given rapid changes and scarcity of obs
 - SWOT OSSE/OSEs
 - Assess and further develop capacity to assimilate SWOT to improve representation of fine-scale features in coastal waters (NWA36)
 - Development of relocatable model for Canadian waters
 - Use Port model infrastructure and modelling capacity for nearshore forecasting
 - Development of next-generation environmental prediction systems
 - Higher-resolution global and regional systems (CREG36)
 - Improved representation of surface fluxes of heat, moisture and momentum (CAPS)
 - Integration of Artificial Intelligence
 - Investigate how we can harness AI for new approaches and to improve efficiency
-

Contributions to 5-year workplan

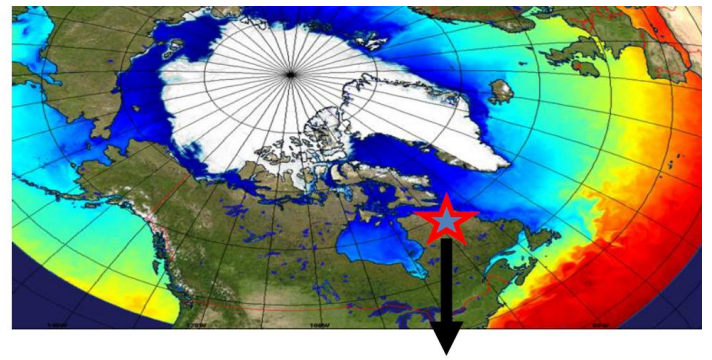
- ORL assessment
- Engagement with WMO
- Preparing for IPY
- Assessment of machine learning approaches
- User-relevant verification and products (unconstrained scales, probabilistic products, eddy features)

Key challenge:

- Integration of machine learning into operational systems

Extras

ECCC OCEAN DATA ASSIMILATION



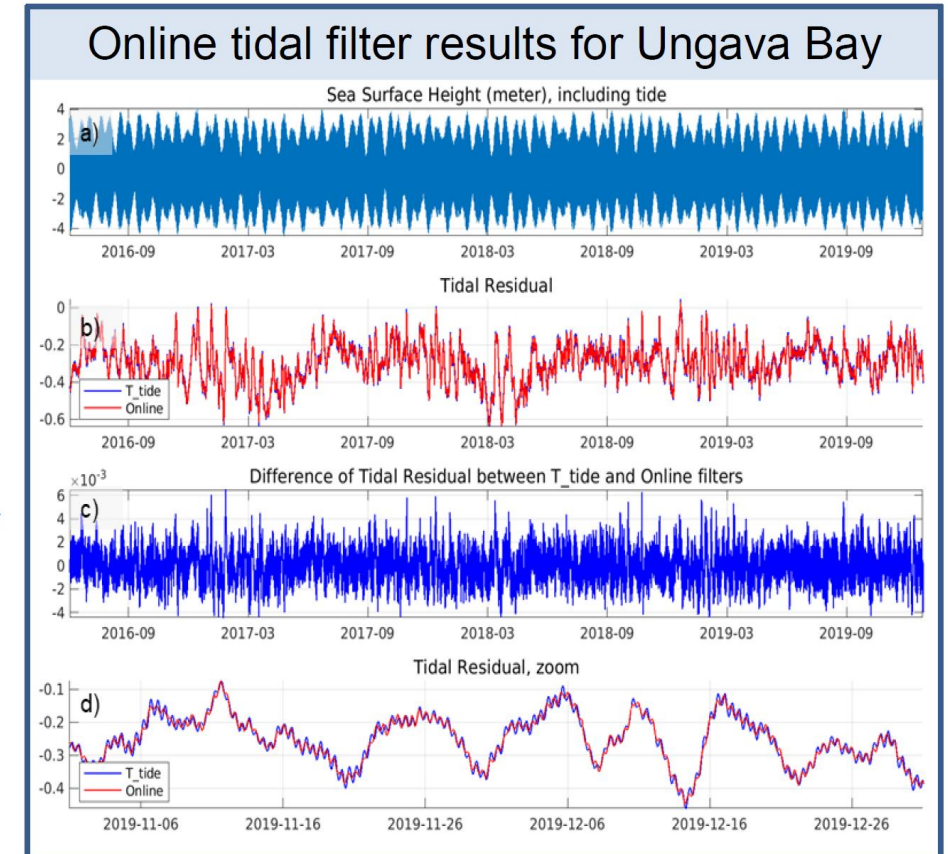
ECCC has two operational ocean assimilation systems:

- **GIOPS ($1/4^\circ$)**
 - Coupled A-I-O (10d; 21 member 16d and 32d fcsts)
- **RIOPS ($1/12^\circ$)**
 - 84hr Ice-ocean forecasts
- **Data Assimilation**
 - Multivariate SEEK filter (SAM2)
 - Background error from multi-year hindcasts
 - Assimilates SLA, SST, in situ T/S profiles
 - Blended with 3DVar ice analysis (CIS charts, SSMI, SSMI/S, AVHRR, AMSR2)
 - 3DVar T/S bias correction
 - IAU: GIOPS (1d), RIOPS (7d)
- **Key recent developments for CleanArctic**
 - RIOPS includes tides and atm pressure
 - online sliding window tidal filter allows non-stationary tides (e.g. due to sea ice)
 - Permits the improved use of satellite altimetry to constrain surface currents

Smith et al. (QJRM2015, MWR2018, GMD2021)



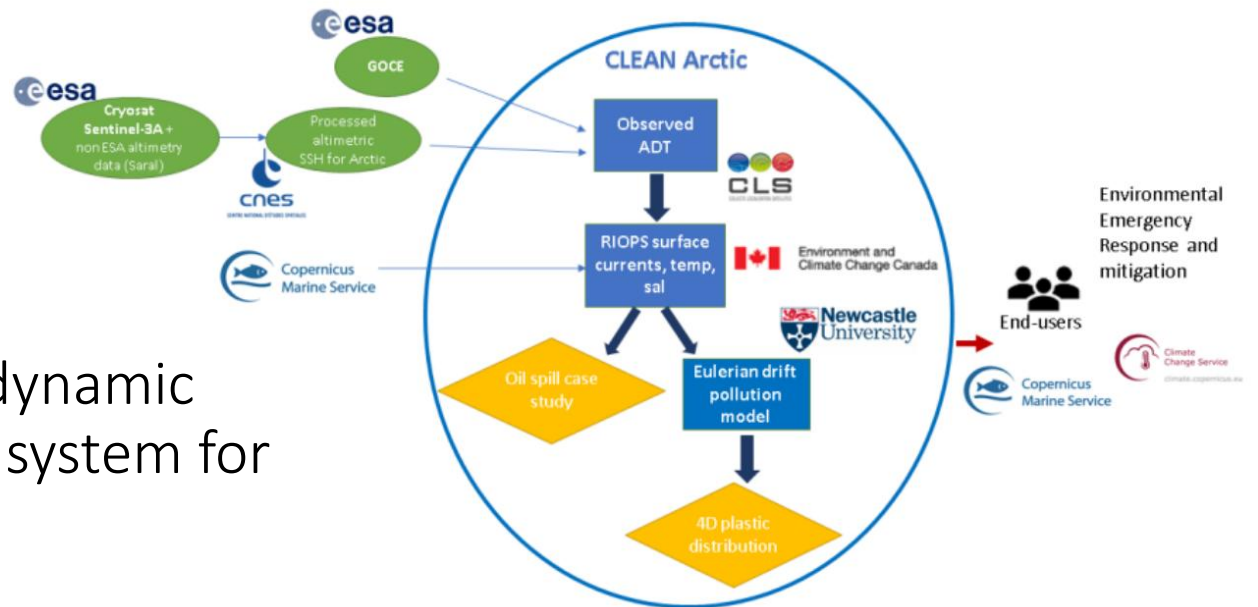
[G,R]IOPS = [Global, Regional] Ice Ocean Prediction System



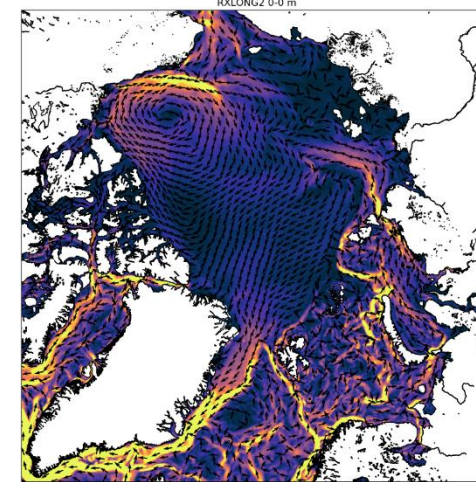


Clean Arctic: Assimilation of absolute dynamic topography data in an ocean assimilation system for the Arctic

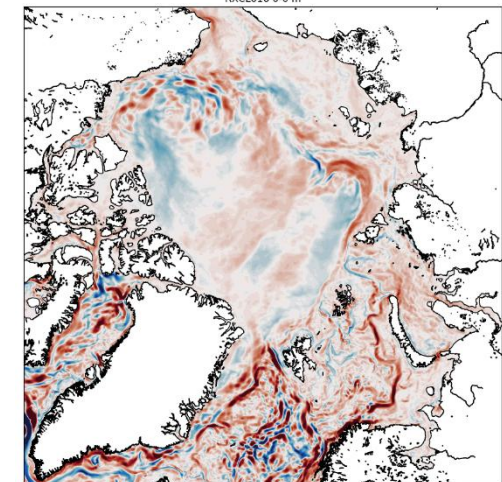
- Developed new Absolute Dynamic Topography (ADT) dataset over the Arctic.
 - Avoids the need for Mean Dynamic Topography (as for SLA assimilation)
- Assimilated ADT in Regional Ice-Ocean Prediction System
 - Required various adaptations for spatial scales and under-ice assimilation
- Significant impact on basin-scale sea level and transports through key Arctic gateways



Mean sfc currents



Impact of ADT assim



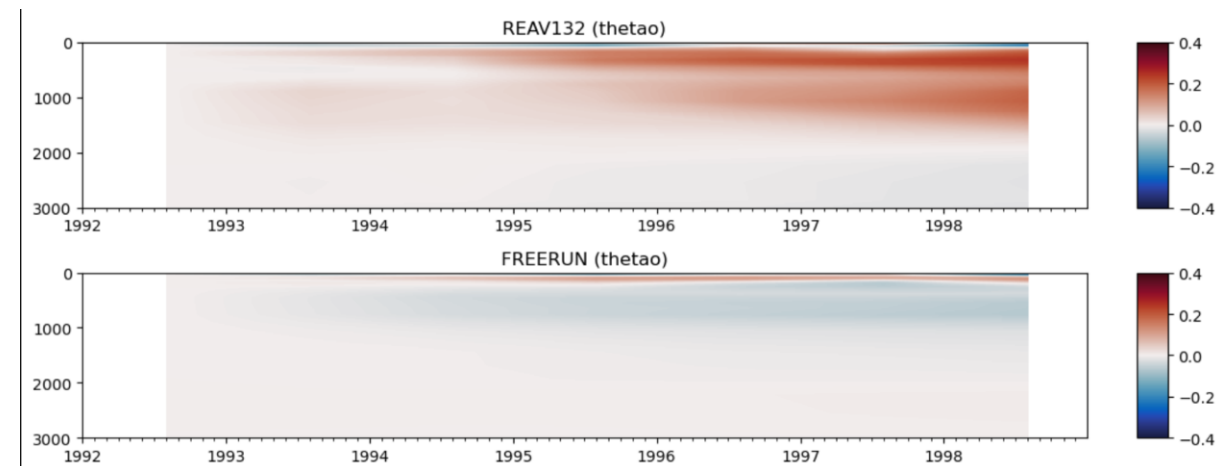
G. Smith¹, C. Hébert-Pinard¹, A.A. Gauthier², A. Peterson¹, F. Roy¹, P. Veillard³, Y. Faugère³, S. Mulet³, Miguel Morales Maqueda⁴

¹ Meteorological Research Division, ECCO ; ² Meteorological Service of Canada, ECCO ; ³ Collecte Localisation Spatiale (CLS), France ; ⁴ University of Newcastle, UK

Smith et al. (Frontiers, 2024)

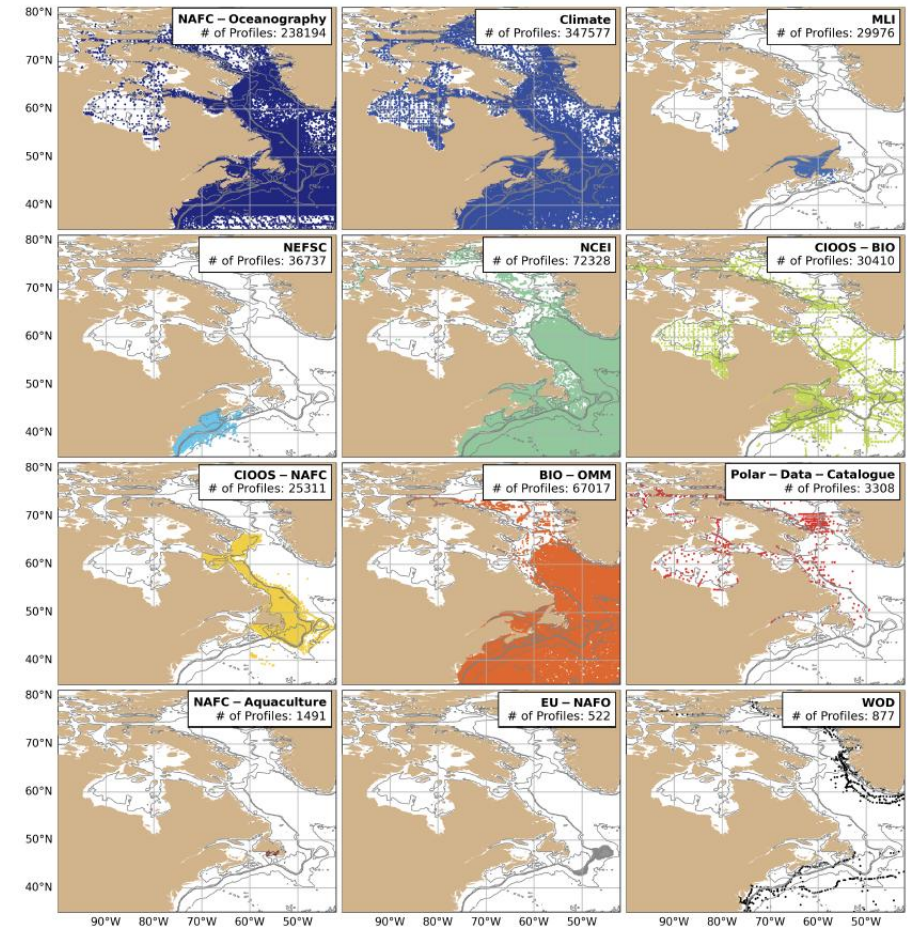
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- No ice direct insertion for now. Production of a separate sea ice reanalysis underway.
- Results broadly consistent with GLORYS4v2 and GLORYS12.
- Working on new method to assimilate pseudo-Argo profiles (pre-2005) to correct water mass biases.



Acquire and prepare international near-real-time in situ T, S data for operational model assimilation

- Developed a stand-alone version of DFOQC
- Code enhancements include removal of legacy components, expanded thinning options, improved handling of high-resolution time series, and addition of a configurable on-land check (enable/disable) to avoid false positives for observations nearshore or within narrow fjords.
- U3 migration of cleaned-up code underway, improvements to be considered for the next IC
- Processing of DFO datasets for development of reanalyses



Distribution of CASTS T/S Profiles Ingested into DFOQC by Data Source (after [Coyne et al., 2025](#), Fig. 4)

RELIOPS Development Plans

- Expand modeling coverage to Pacific and Atlantic Canada
- Migrate to NEMO4.2
 - Initial work with hindcast simulations
 - Evaluate AGRIF 2-way nesting capability
- Incorporate sea ice (leveraging POPS progress)
- Develop targeted case studies

