



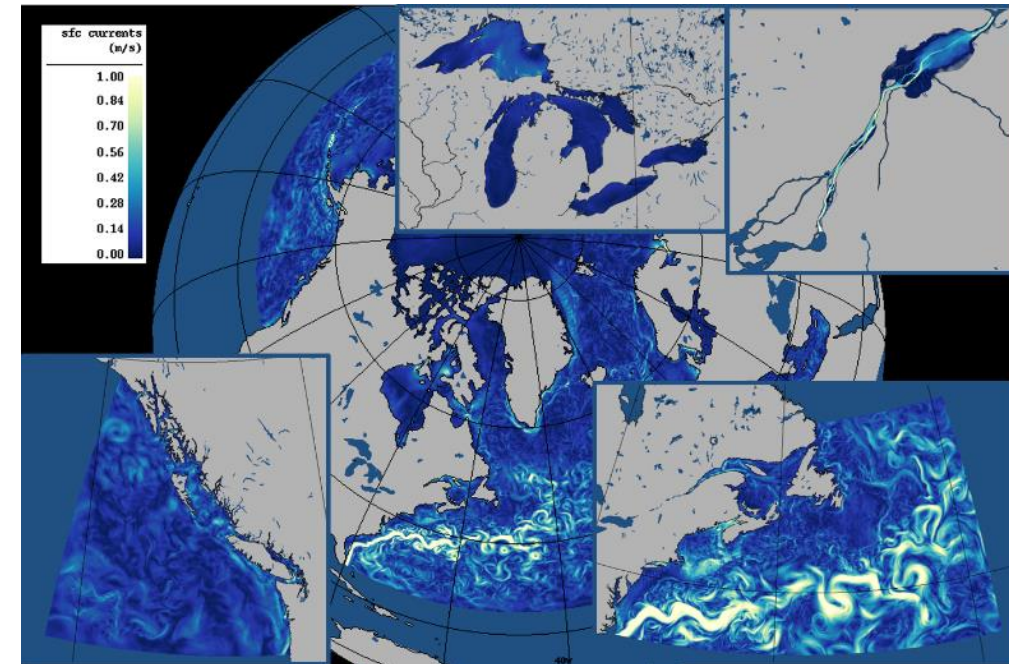
Environment and
Climate Change Canada

Environnement et
Changement climatique Canada



MERCATOR
OCEAN
INTERNATIONAL

CONCEPTS COUPLED ENVIRONMENTAL PREDICTION SYSTEMS: FROM GLOBAL TO COASTAL



Gregory Smith¹ and many collaborators!

¹ Meteorological Research Division, ECCC



CONCEPTS

CANADIAN OPERATIONAL NETWORK OF
COUPLED ENVIRONMENTAL PREDICTION SYSTEMS

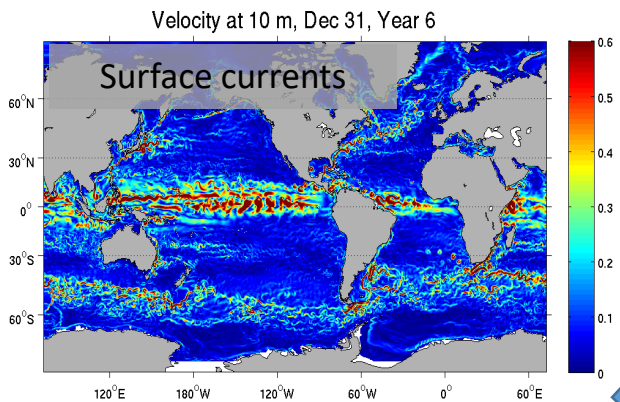
*Coastal Ocean Shelf Seas Task Team Workshop, April 12-13,
2022*

Canada

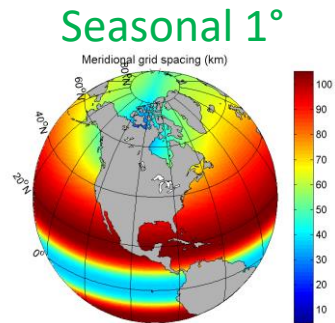
ECCC Ice-ocean forecasting with



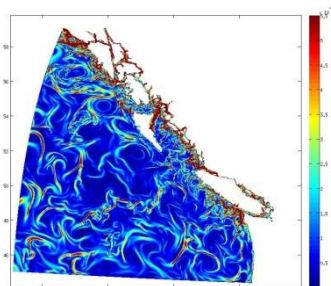
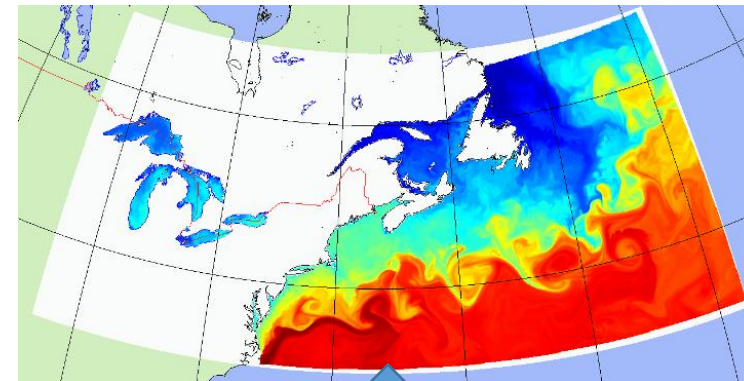
Operational
Experimental



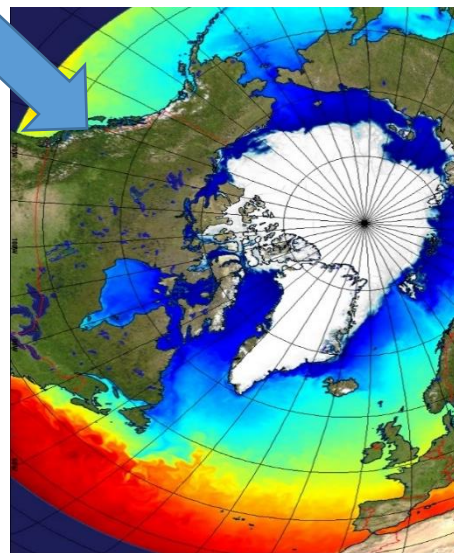
GIOPS: 1/4° Global, Coupled to GDPS (10day) and GEPS (16day and monthly)



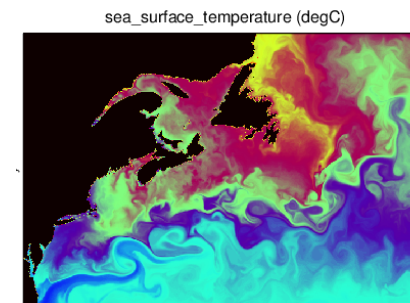
Water Cycle Prediction System Great Lakes 1km+East Coast (1/36)



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



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



CIOPS-E: Coastal East Coast 1/36°



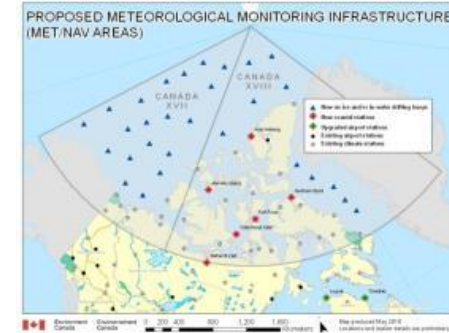


DFO Applications

- Fisheries and Aquaculture management
- Ocean climate monitoring

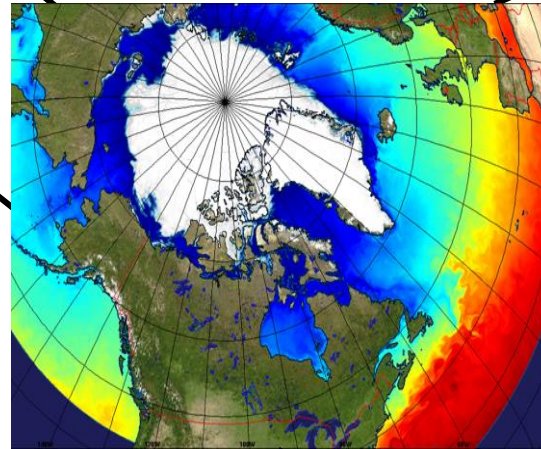
RIOPS Users and Applications

METAREAS 17&18



DND Applications

- Situational awareness
- Anti-submarine warfare
- Operational support



Canadian Ice Service Operations

- High-pressure ridges
- Automated analyses
- Iceberg drift



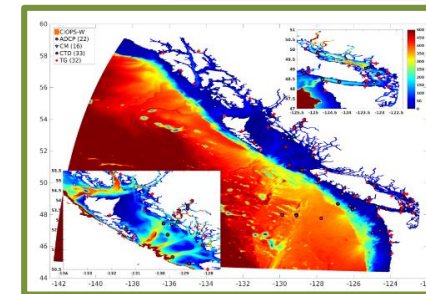
Canadian Coast Guard

- Search and Rescue
- Environmental Emergency Response

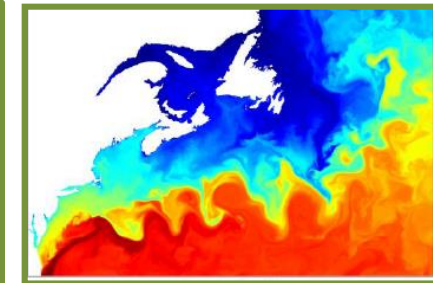
Downstream systems
CIOPS, e-Nav, Waves, Storm surge

National Environmental Emergency response Centre (NEEC)

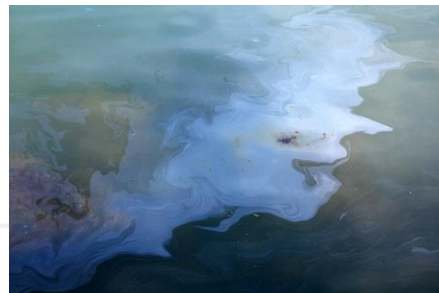
- Oil spill



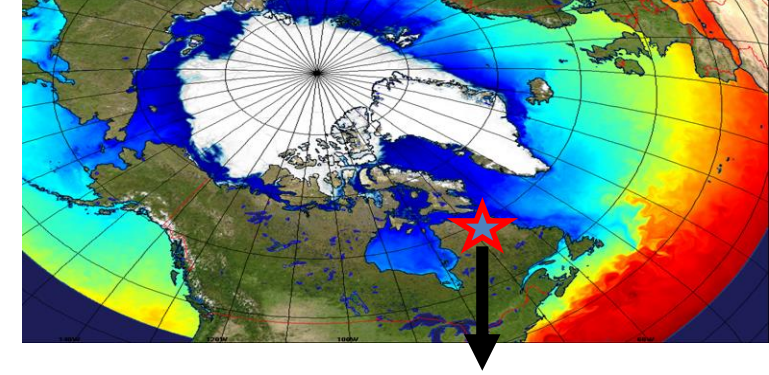
CIOPS-West



CIOPS-East



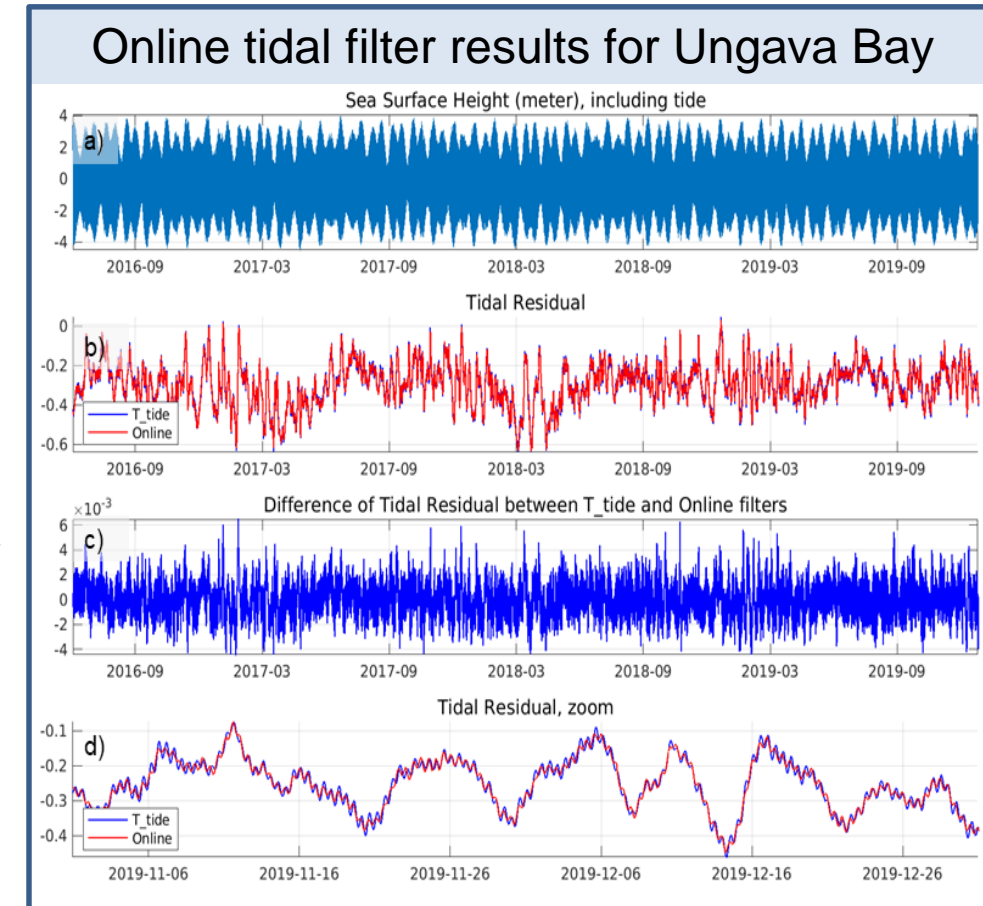
CONCEPTS OCEAN DATA ASSIMILATION



ECDC has two operational ocean assimilation systems:

- **GIOPS (1/4°)**
 - Coupled A-I-O (10d; 21 member 16d and 32d fcsts)
- **RIOPS (1/12°)**
 - 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)
 - RIOPS includes tides and atm pressure
 - online sliding window tidal filter allows non-stationary tides (e.g. due to sea ice)

Smith et al. (QJRM2015, MWR2018, GMD2021)



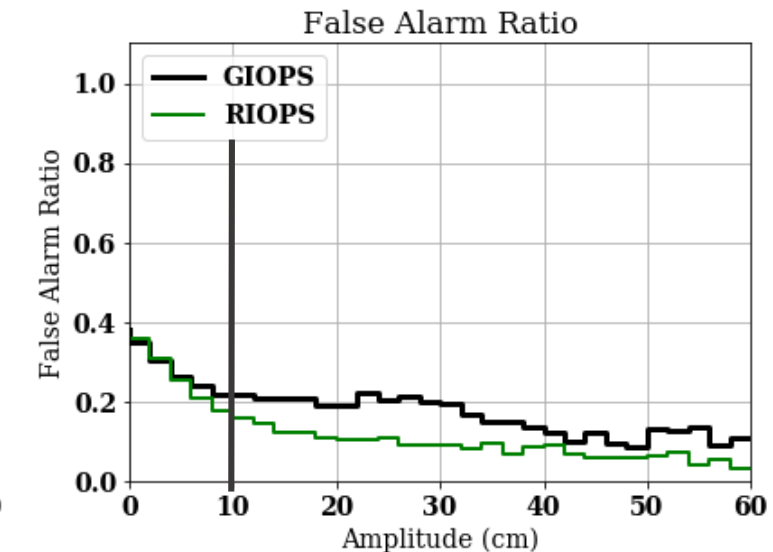
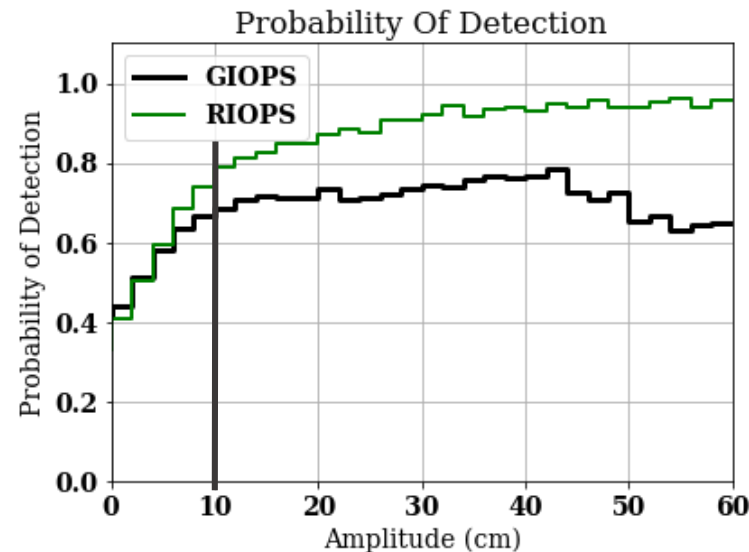
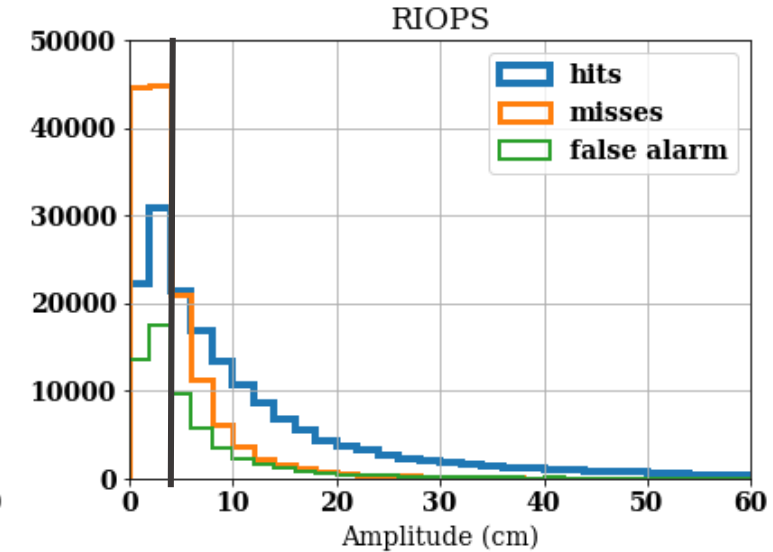
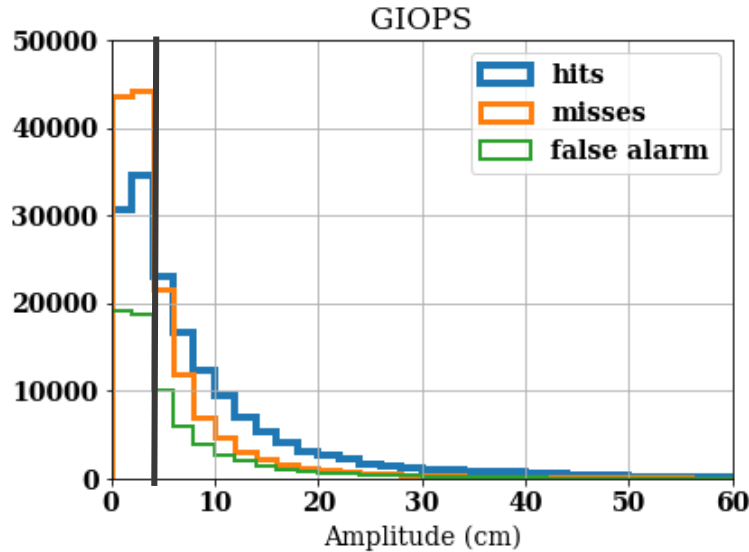
Can we demonstrate added-value of regional systems in terms of eddy features?

$$POD = \frac{Hits}{Hits + Misses}$$

$$FAR = \frac{False\ Alarms}{Hits + False\ Alarms}$$

- Apply py-eddy-tracker, a closed-contour approach (Mason et al., 2014)
- Use AVISO L4 SSH as truth
- Once eddies have been identified, match them between products using a cost function based on amplitude, radius and distance
- Use dichotomous verification metrics
- For eddies of amplitude greater than 10 cm:
 - RIOPS has POD values 10-30% higher with FAR values 5-10% lower than GIOPS
- Accuracy of “truth” a limiting factor
 - Potential for SWOT?

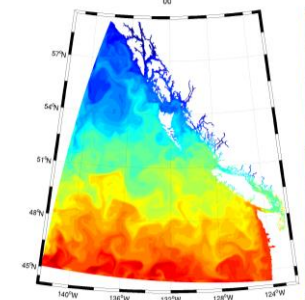
Smith & Fortin (Oc. Mod. 2022)



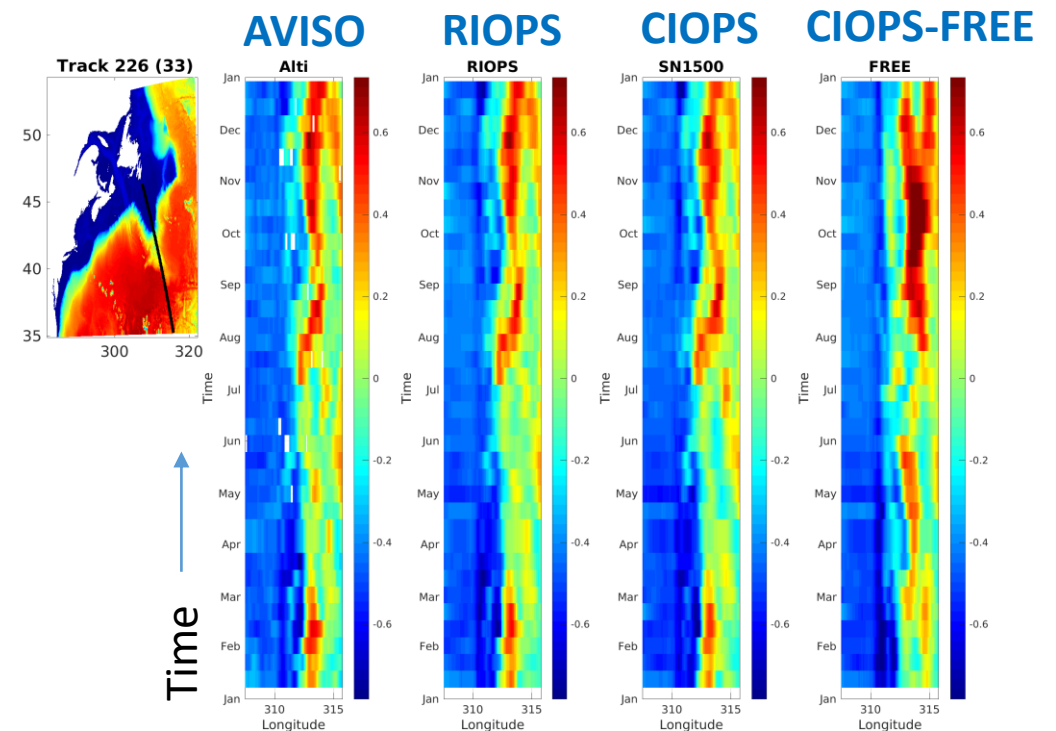
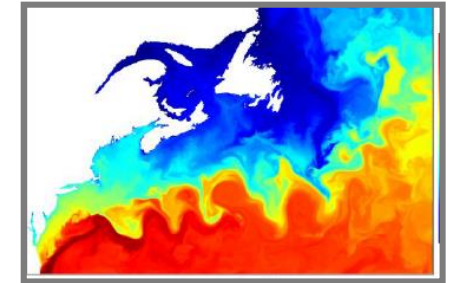
Coastal Ice Ocean Prediction System (CIOPS)

- Two $1/36^\circ$ (2km) configurations have been developed specifically to provide best estimates of surface currents for Environmental Emergency Response
- Evaluation made in tight EC-DFO collaboration
 - Water level, currents, in situ profiles, drifters
- Spectral nudging to RIOPS analyses offshore
 - Able to constrain SSH mesoscale features and provide more accurate cross-shelf exchanges
- Developing methods to estimate uncertainty in surface currents
 - based on ensembles and unconstrained variability
 - drift error
 - A priori estimates by component (tides, geostrophic, Ekman, ..)

CIOPS-W SST



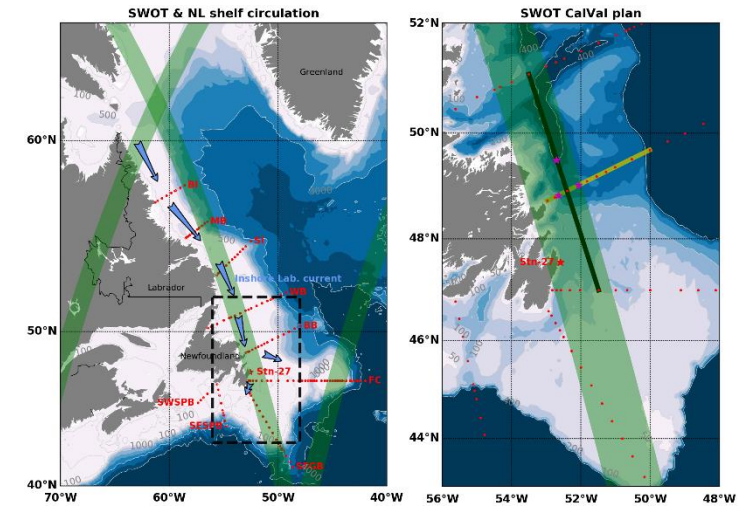
CIOPS-E SST



Assimilation of SWOT over the Northwest Atlantic Ocean

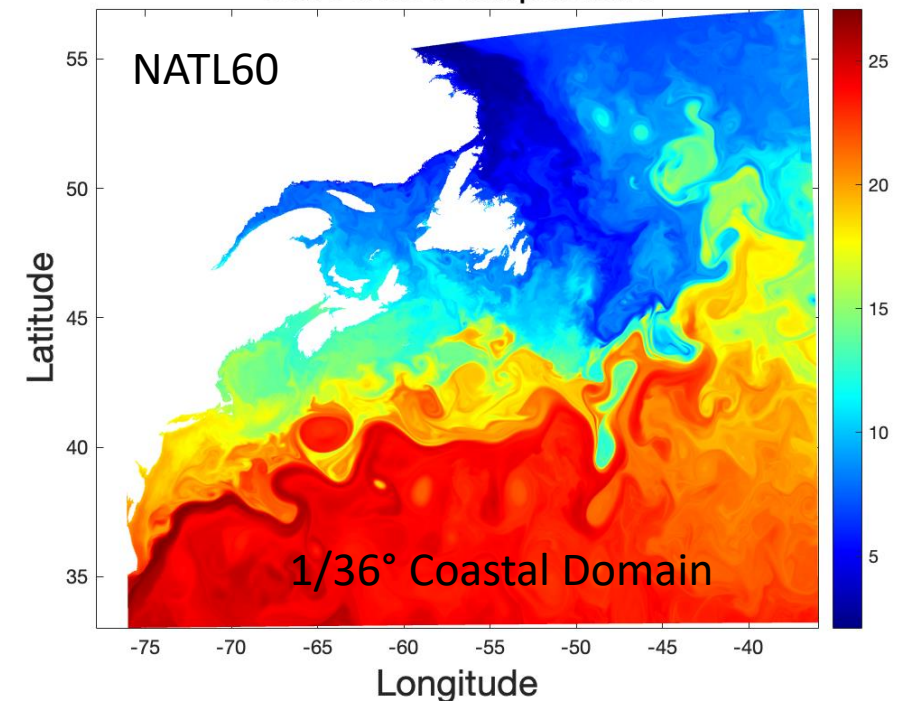
Collaboration with Will Perrie (DFO), Mounir Benkiran (MOi), Guoqiang Liu (Dal), Yimin Liu (ECCC)

- Evaluation using 1/36° Coastal Assimilation System
 - Gulf Stream region
 - Gulf of Maine, Gulf of St. Lawrence and Labrador Shelf
- Perform OSSE of SWOT data
 - Build on previous efforts (Carrier et al., 2016; Bonaduce et al., 2018; D'Addezio et al., 2019)
 - Use NATL60 (J. LeSommer) as Nature Run (Fraternal twin)
 - Synthetic obs using JPL SWOT Simulator
 - Assess benefits of multiscale approach and constrained scales
- OSE: SWOT Cal/Val swath on Labrador coast
 - Eval impact on eddies and surface currents using RCM



Han&Cyr Cal/Val Plan

sea surface temperature



WATER CYCLE PREDICTION SYSTEM

Evaporation from coupled model improves precipitation leading to lower streamflow errors

Dynamic ice cover affects fluxes throughout forecasts leading to improved weather forecasts

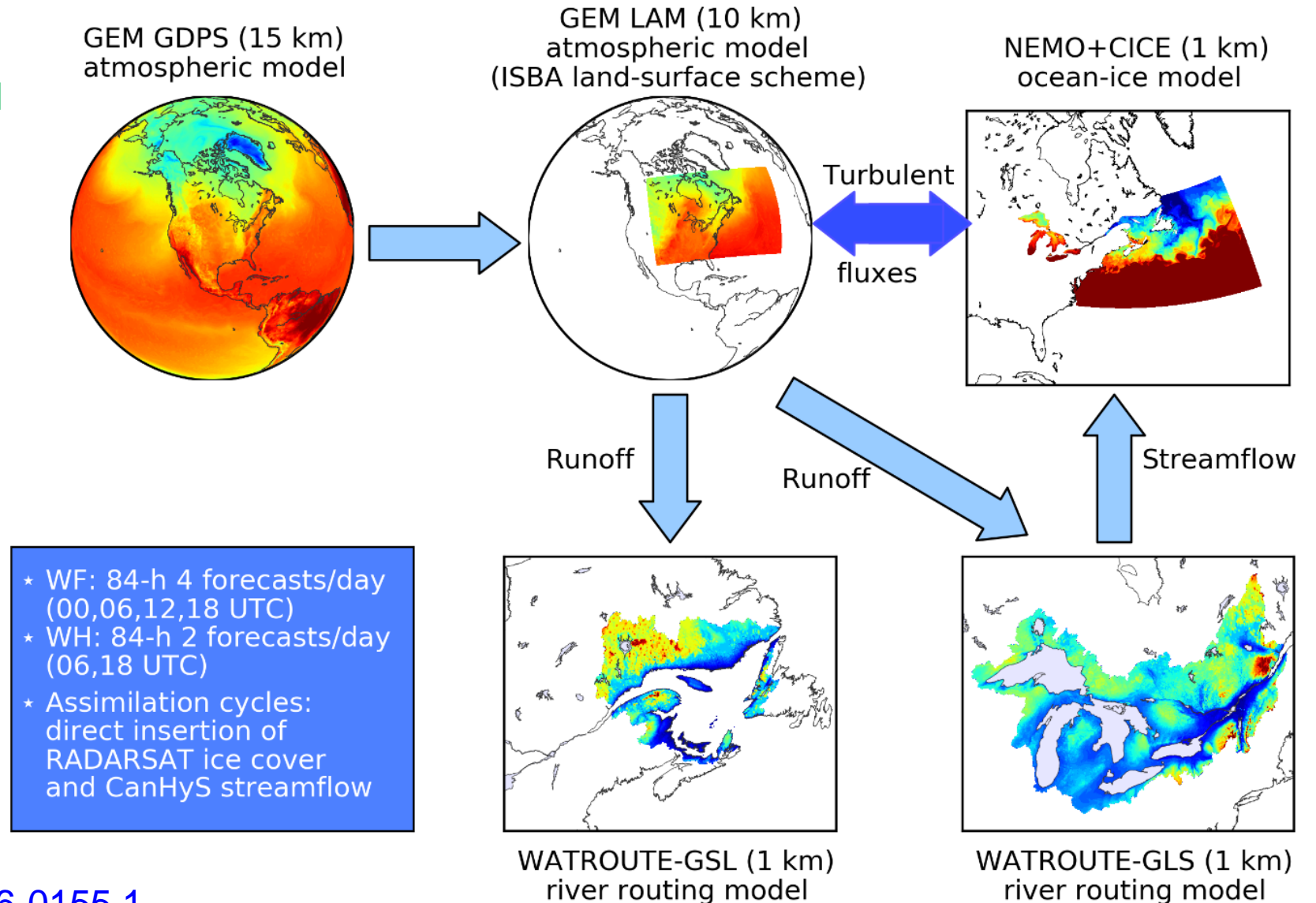
- Coastal polynya formation
- Rapid ice formation

Coastal upwelling of cold winter waters can affect fog formation

- Upwelling not typically represented in SST analyses used in NWP

Durnford et al. (BAMS, 2018)

<https://doi.org/10.1175/BAMS-D-16-0155.1>



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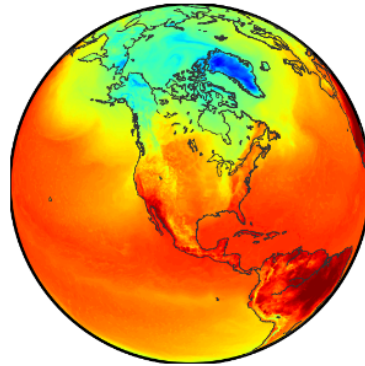
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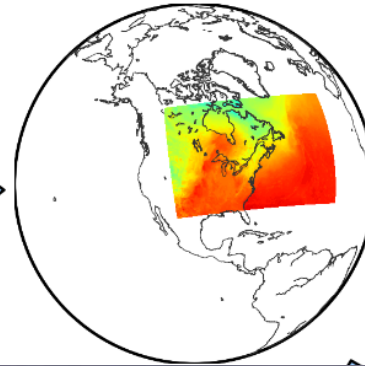
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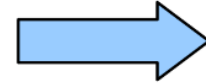
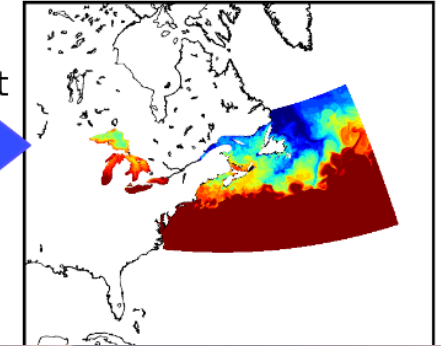
GEM GDPS (15 km) atmospheric model



GEM LAM (10 km) atmospheric model (ISBA land-surface scheme)



NEMO+CICE (1 km) ocean-ice model



Turbulent fluxes

- * WF: 84-h 4 forecasts/day (00,06,12,18 UTC)
- * WH: 84-h 2 forecasts/day (06,18 UTC)
- * Assimilation cycles: direct insertion of RADARSAT ice cover and CanHyS streamflow



Thank you!



MODIS

29 février / February 29, 2008

**Golfe du Saint - Laurent
Gulf of St. Lawrence**