SWOT Oceanographic Research and Development in Canada

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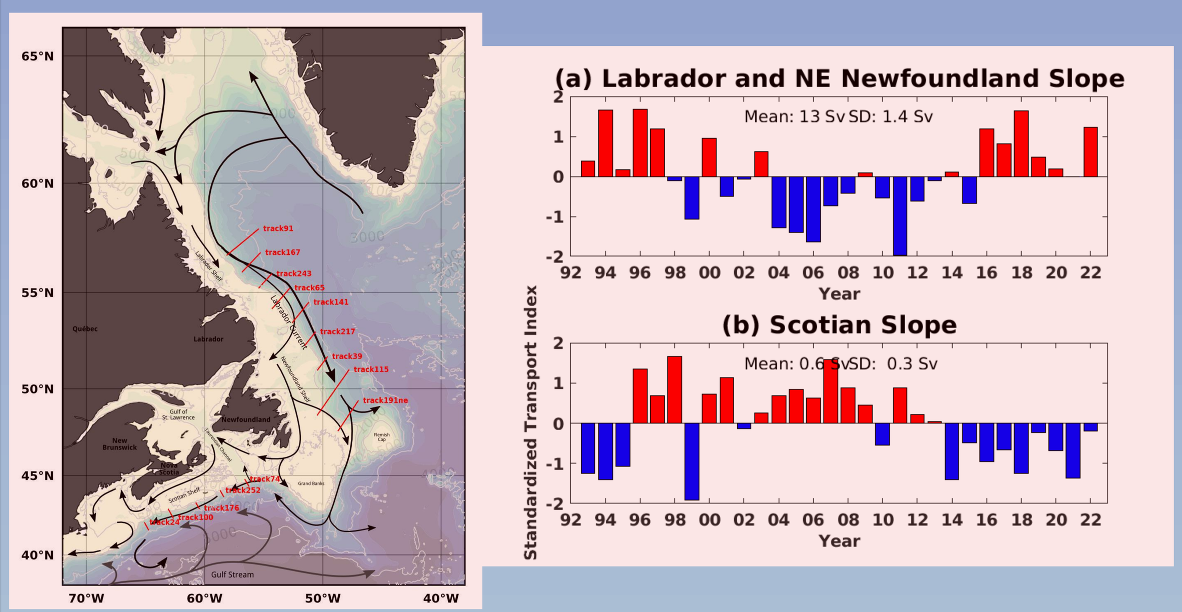
Objectives

- To improve knowledge of coastal and submesoscale processes off the Canadian coasts
- To improve coastal ocean models for understanding SWOT data.
- To disentangle submesoscale features from internal waves
- To calibrate and validate SWOT data

Coastal Currents

Multiple mission satellite altimeter data from TOPEX/Poseidon, Jason-1, Jason-2, Jason-3, Sentinel 6 have been used for coastal and shelf currents in the Canadian Atlantic and Pacific, to support the state of the ocean reporting.



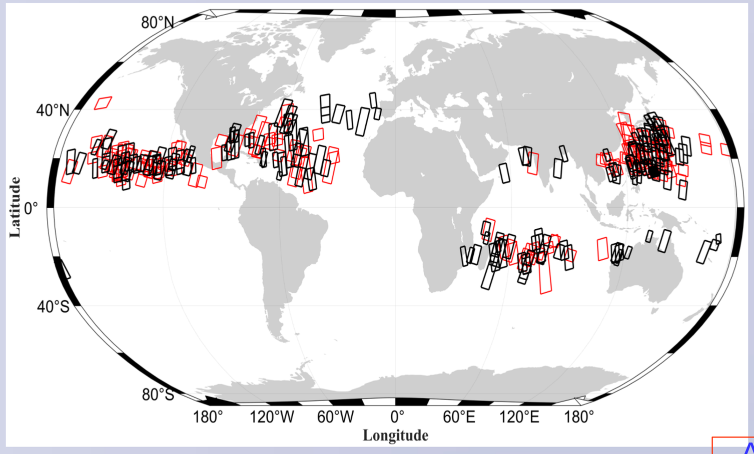
The annual-mean Labrador Current transport index shows that the Labrador Current transport over the Labrador and northeastern Newfoundland Slope was out of phase with that over the Scotian Slope for most of the years over 1993-2022 (Fig. 1). The transport over the Labrador and northeastern Newfoundland Slope was strong in the early- and mid-1990s, weak in the mid-2000s and early- 2010s, and became strong again in late 2010s. In contrast, the transport over the Scotian Slope fluctuated in a nearly opposite way. The Labrador Current transport index was positively and negatively correlated with the winter North Atlantic Oscillation (NAO) index over the Labrador and northeastern Newfoundland Slope and over the Scotian Slope, respectively.

In 2022 the annual-mean transport of the Labrador Current over the Labrador and northeastern Newfoundland Slope ceased the weakening trend that began in 2019 and became over one standard deviation above normal. The transport on the Scotian Slope in 2022 remained below normal for nine consecutive years but was close to normal.

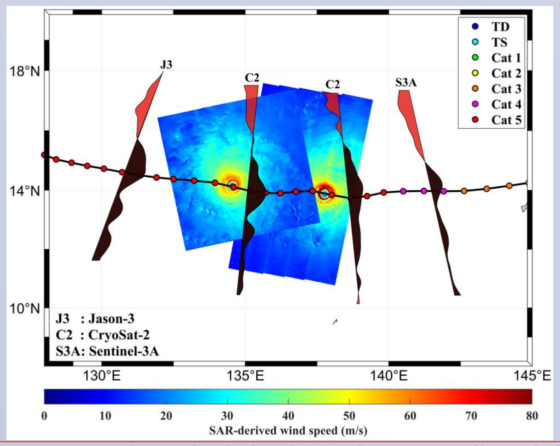
We plan to integrate SWOT data into the monitoring of coastal currents.

Submesoscale Processes

W. Perrie (DFO), B. Zhang (Dal and DFO), G. Liu (Dal and DFO)



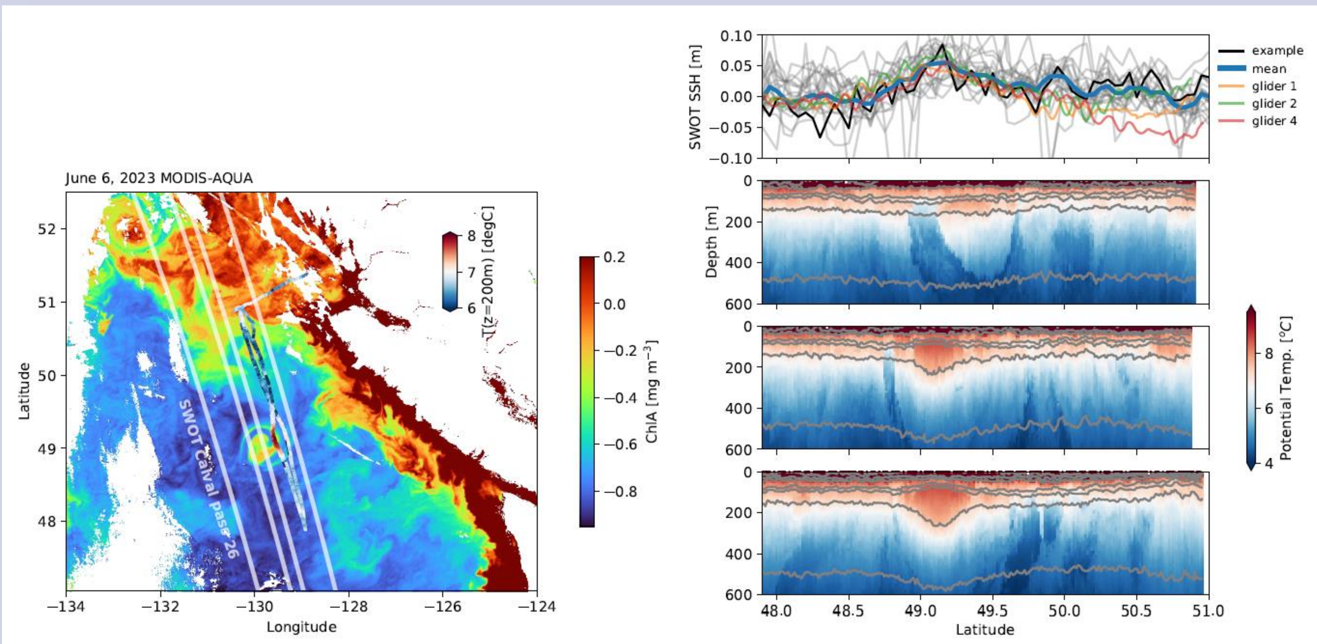
Locations of SAR acquisitions of 286 TCs. The red and black squares denote RS-2 and S1-A/B, respectively.



Along-track sea surface height (SSH) anomalies (elevation in red, trough in black) from Jason-3, CryoSat-2, Sentinel-3A after passage of Typhoon Mangkhut (2018). RS-2 and SI-B swaths were selected to map the winds. Color circles give two storm center locations and intensities from best-track data.

- This study focuses on the characteristics of the sea surface height (SSH) response to tropical cyclones (TCs), based on a statistical analysis of long time series of two-dimensional (2D) gridded data, based on satellite altimeter observations.
- SSH anomalies on both sides of TC tracks depend on storm intensity and translation velocity. Large sea surface troughs occur for strong, slowly moving TCs.
- The most striking trough features occur in the vicinity of TC centers. Amplitudes of wedge-shaped troughs decay in the direction normal to the storm tracks.
- In extreme weather, troughs are often caused by vertically displaced isopycnals in the thermocline. The magnitude of the sea surface depressions can reach –21 cm.
- Spatial distributions of SSH anomalies tends to be asymmetric for fast moving TCs, becoming more symmetric for slower storms.
- We also have a semi-empirical model to estimate SSH anomalies, using TC and ocean stratification data. Using maximum wind speed and wind radius from high-resolution synthetic aperture radar (SAR), this agrees well with altimeter data.
- These results suggest that indirect calculations of SSH anomalies may serve as an important complement for TC inner-cores, when altimeter data are unavailable.

SWOT CAL/VAL



Concurrent observations from the SWOT Cal/Val mission.

Left) Clorophyll-A off Western Canada. SWOT Cal-val track 26 is overlain for comparison, and glider data is shown from June 2023 as a colored track representing temperature at 200 m. Note that the glider and the SWOT track coincide with a small anti-cyclonic eddy, but that there is also lots of other important variability in the region. The small eddy is likely just on the edge of detection for existing altimetry products, but should be resolvable with SWOT.

Right) data collected from SWOT Nadir data (top) and concurrent glider data (geostrophic heights, referenced to 1000 m). Bottom panels are three of the passes through the small eddy, showing both the eddy and the complex stirring structures in the temperature field around it. In the top panel, note the good agreement between the average SWOT altimetry and the glider data, but also note the pass-by-pass variation/noise in the altimetry (grey lines).

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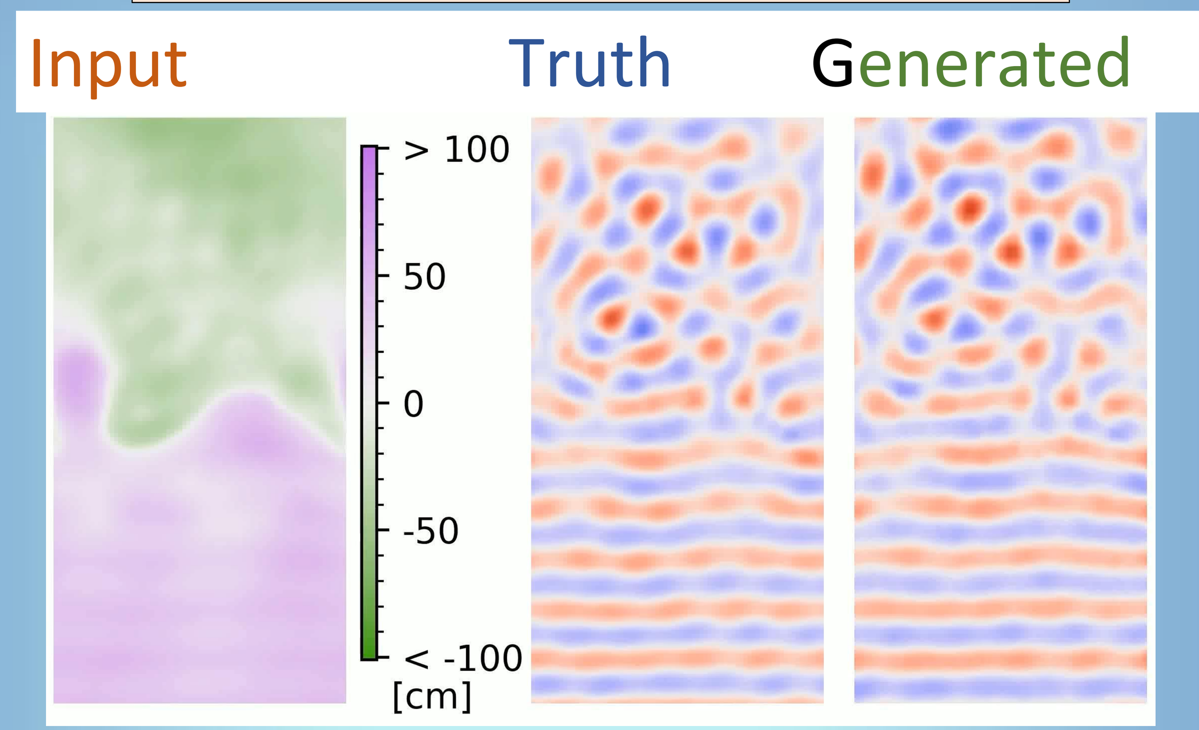
Image translators

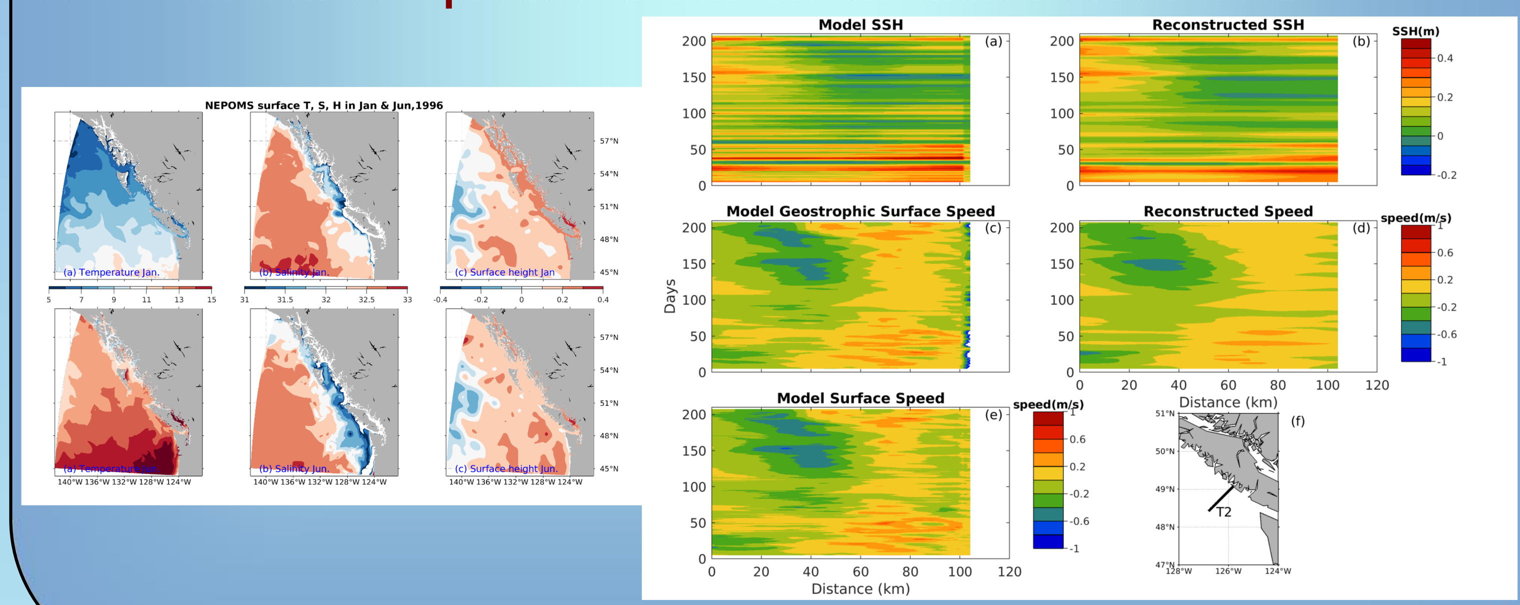
N. Grisouard, H. Wang (U Toronto)



- Developing a deep-learning method to predict ("Generated") internal tidal signals ("Truth") from ocean Sea Surface Height snapshots ("Input")
- Using generative deep neural nets
- Possible extensions:
  - incorporate more satellite data streams (SST, SSS, surface currents…),
  - translate into more outputs (mixed layer depth, upwelling…)
  - expand beyond oceanography

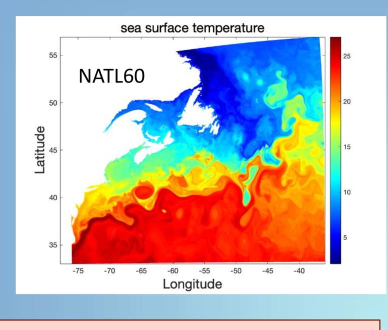
Reconstruction

A 1/36-degree ocean model developed for the Northeast Pacific. The model has been used to study storm surges, extreme sea levels, currents and eddies. Simulated SWOT data were generated from March-September 2017. Sea surface heights from the simulated SWOT data were reconstructed using optimal interpolation. The geostrophic currents are derived from the reconstructed sea surface height. It has been found that the coastal currents off Can ada's west coast can well be reproduced from the simulated SWOT data.

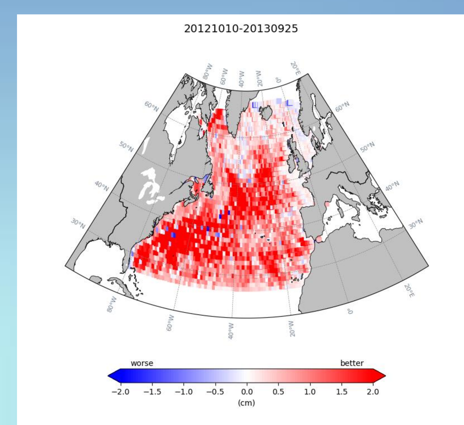


Assimilation

G. Smith (ECCC), W. Perrie (DFO), G. Liu (Dal), A.-A. Gauthier (ECCC) and M. Benkiran (MOi)



Reduction in RMS Cryosat2 SLA innovation when adding SWOT



- Evaluation using Regional Ice Ocean Prediction System (RIOPS)
  - Focus on Gulf Stream region
  - Gulf of Maine, Gulf of St. Lawrence and Labrador Shelf
- Perform Observing System Simulation Experiment (OSSE) using synthetic 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, constrained scales and impact on coastal circulation and mesoscale features using eddy tracking methodology