Fisheries and Oceans

SWOT Oceanographic Research and Development in Canada

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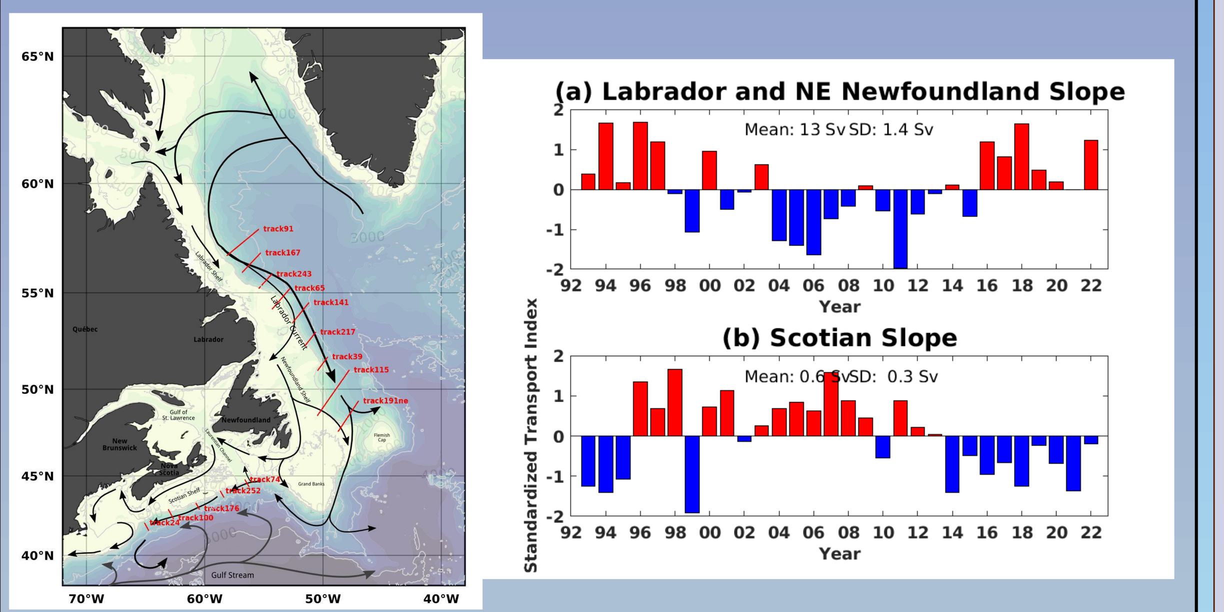
Objectives

- 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 from Nadir Altimetry

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.

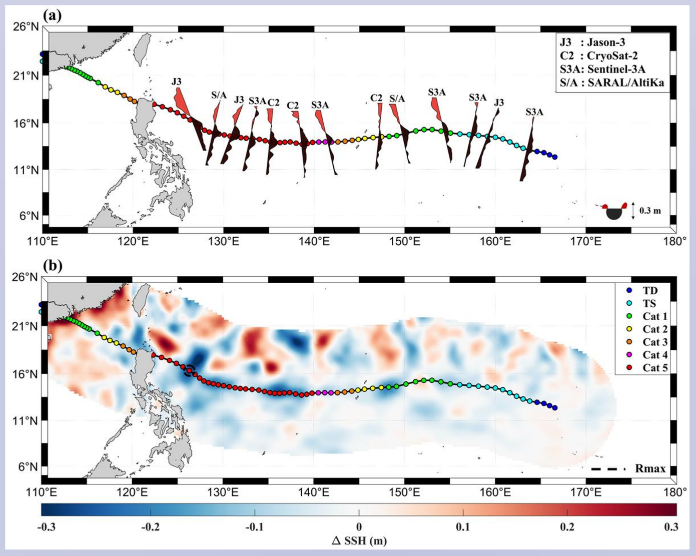


The annual-mean Labrador Current transport index shows that the Labrador Current transport over the Labrador and northeastern Newfoundland Slope was out of phase with that over the Scotian Slope for most of the years over 1993-2023. The transport over the Labrador and northeastern Newfoundland Slope 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 2023 the annual-mean transport of the Labrador Current over the Labrador and northeastern Newfoundland Slope was one standard deviation above normal, the eight consecutive years above normal. The transport on the Scotian Slope in 2023 became over one standard above normal after being below normal for nine consecutive years. The last time the transport in both regions was one standard deviation above normal was in 1996.

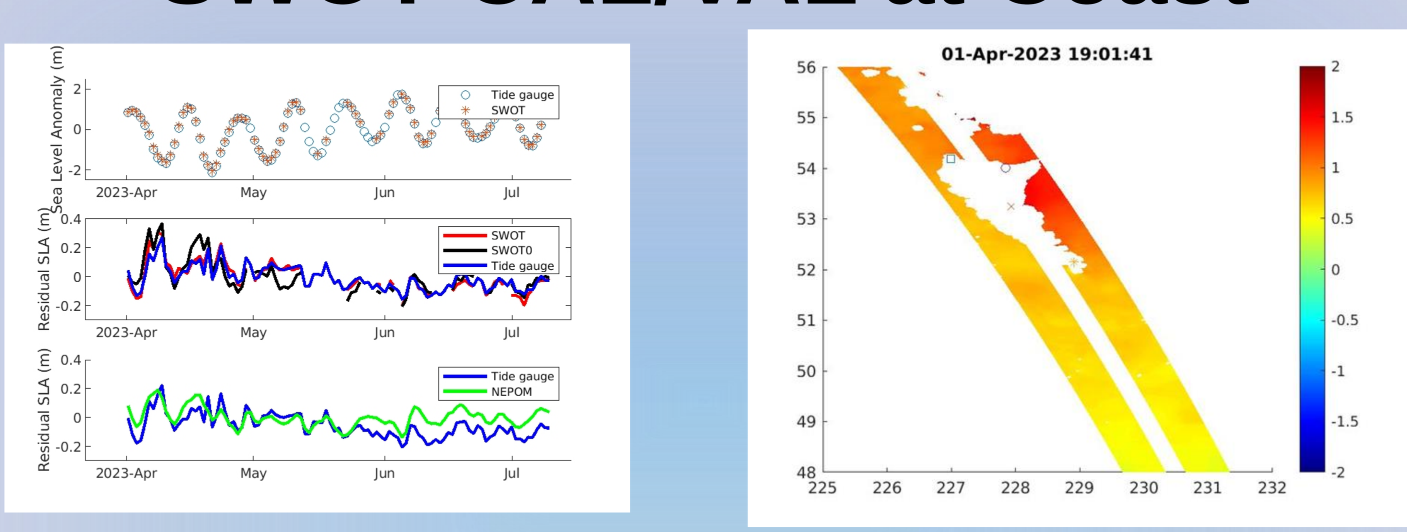
SSH Response to Typhoon

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



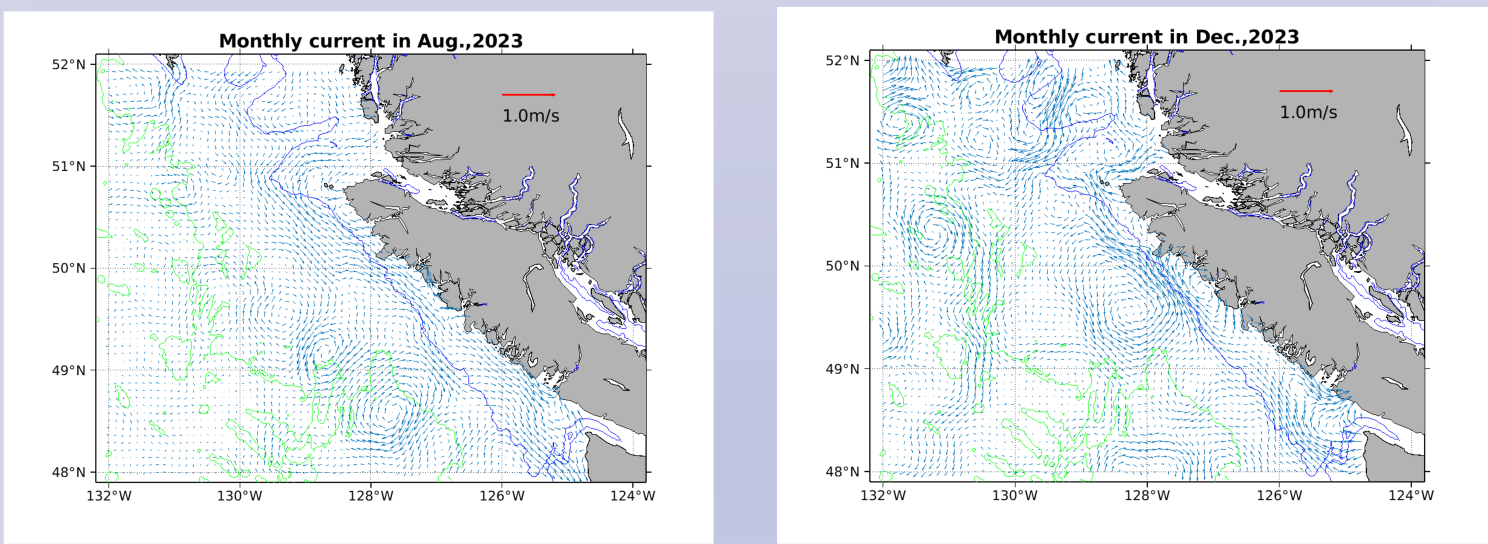
- (a) Along-track instantaneous sea surface height anomalies (elevation in red, trough in black) measured by multiple satellite altimeters (Jason-3, CryoSat-2, SARAL/AltiKa, Sentinel-3A) after the passage of Typhoon Mangkhut (2018). Scale is given in the bottom right corner. The color circles indicate the storm center location and intensity from best-track data. (b) Sea surface height variabilities before (i.e., from –10 days to –3 days) and after (i.e., from 0 to +5 days) Typhoon Mangkhut, which are derived from gridded sea surface height anomalies. The black dashed line denotes the boundary of radius of maximum wind.
- The results show sea surface depression along the center of the storm track and on the right side and the sea surface height increase to the right side

SWOT CAL/VAL at Coast



- SLA and non-tidal SLA are compared with tide-gauge data at five stations on Canada's west and east coasts during the cal/val phase.
- The RMS difference are 3-5 cm between SWOT and tide gauges.
- SWOT data have smaller difference from tide-gauge data than a 2-km ocean circulation model does.

Coastal Currents From SWOT

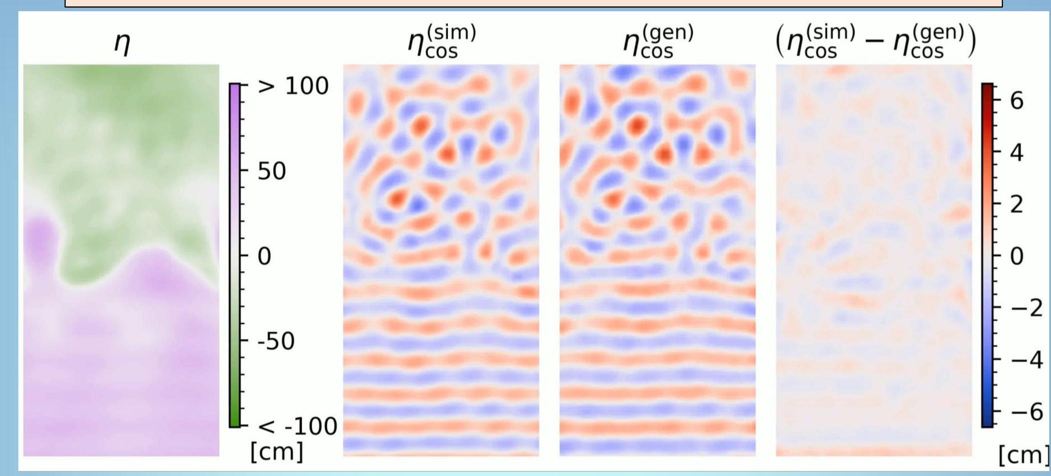


- SWOT SSH anomalies are mapped daily off Canada's west coast from Aug 2023 to Jan 2024. Working on improving mapping method.
- Weekly and monthly SSH maps and geostrophic current anomalies are calculated.
- SWOT monthly results show expected seasonal changes in the major coastal and shelf edge currents. Weekly results are to be evaluated.
- Need improved coastal/shelf MSS/Geoid for absolute currents.

The research is supported by SWOT- Canada, Canadian Space Agency, and Fisheries and Oceans Canada.

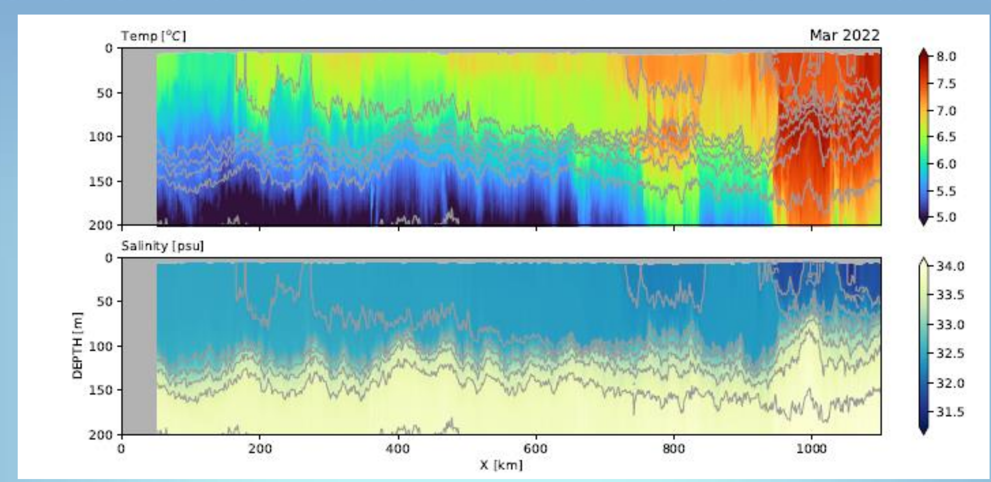
Image Translators

N. Grisouard, H. Wang (U Toronto)



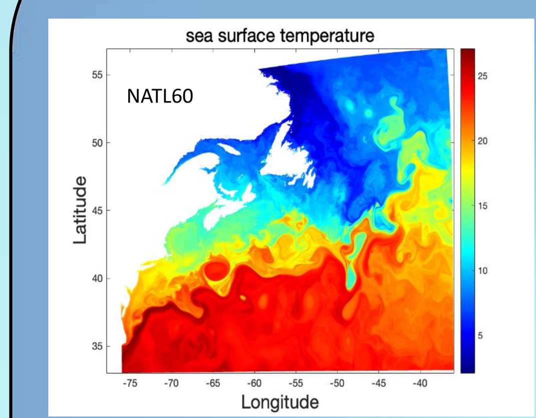
- We trained a generative deep-learning model, TITE (Toronto Internal Tide Emulator), to associate a raw SSH snapshot with the corresponding SSH internal tide signature. In the testing phase, we fed raw SSH snapshots to TITE and were able to re-generate the ("deep-fake") SSH signature of the internal tide for each snapshot. TITE circumvents the need for time series, and by extension, for the perfect coherence assumption, which bodes well for future methods to process SWOT data.
- Figure 4: an example of internal tide generation by TITE. From left to right: raw SSH; "true" internal tide signature obtained by harmonic analysis; internal tide signature generated by TITE, based only on the left panel; and difference between "true" and generated internal tide signature.

Mesoscale & Internal waves



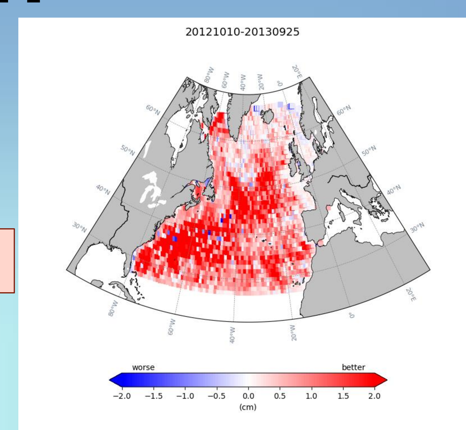
- Example of Moving Vessel Profiler data in NEP, offshore to the left, the coast on the right. In both, isopycnals are contoured in grey. Note the small eddy near X=1000 km that should be resolvable by SWOT.
- Data was collected in Feb 2022, Aug 2022, May 2023, Aug 2023, and Feb 2024 from the CCGS Tully along a 1100-km transect at scales ideally matched to SWOT altimetry and to high resolution ocean models; this work was largely funded by the Canadian Space Agency with in-kind support from DFO. Data collected from each deployment included ocean temperature, salinity from a rapidly profiling instrument (Moving Vessel Profiler, MVP), and ocean currents from an Acoustic Doppler Current Profiler (ADCP). Profile density is approximately every 1-km and the MVP data reaches to 200 m, while the ADCP data to approximately 500 m (Figure 3).
- We will use SWOT and in situ data to disentangle mesoscale and internal waves

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)
- Four OSSEs. OSSE0: No data assimilation; OSSE1: Assimilation of (synthetic) conventional observations (SLA, SST, T/S profiles); OSSE2: Assimilation of (synthetic) SWOT data with a 7km sampling; OSSE3: Assimilation of both conventional and SWOT observations
- The various OSSEs were run for a full year. Results show that assimilation of SWOT (OSSE2) in place of conventional altimetry provides analyses of roughly equivalent quality in terms of RMS and mean errors. However, when SWOT is assimilated in addition to conventional altimetry (OSSE3), an additional benefit is found.