SWOT Altimetry to Tide Constituents

M2 near Ulukhaktok (ULUK), Canadian Arctic Archipelago

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Motivation & Why SWOT

- Sparse Arctic gauges; complex shelves. Need constituent fields from swath SSH.
- SWOT swath reduces nadir aliasing and adds **2D spatial context**.

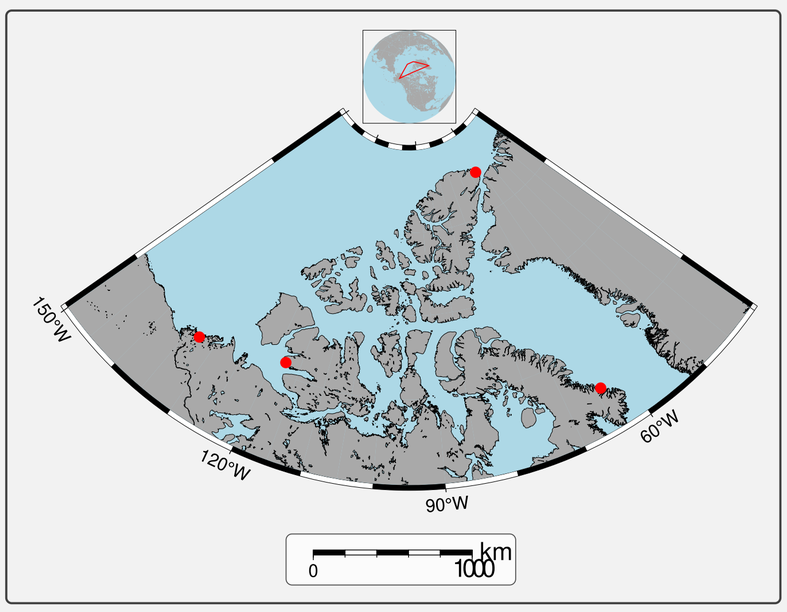


Figure 1. Canadian Arctic Archipelago (CAA) showing the locations of four continuous tide gauges (red dots). The highly complex and irregular coastline underscores the challenges of modeling tides in this region, while the sparse tide gauge coverage highlights the limited in situ observations available for validation.

Data

- SWOT L2 LR SSH expert subsets (∼350 passes); ULUK tide gauge (hourly).
- Models for cross-checks: OTIS/TPXO, FES2014b, EOT20; plus bathymetry & mask.

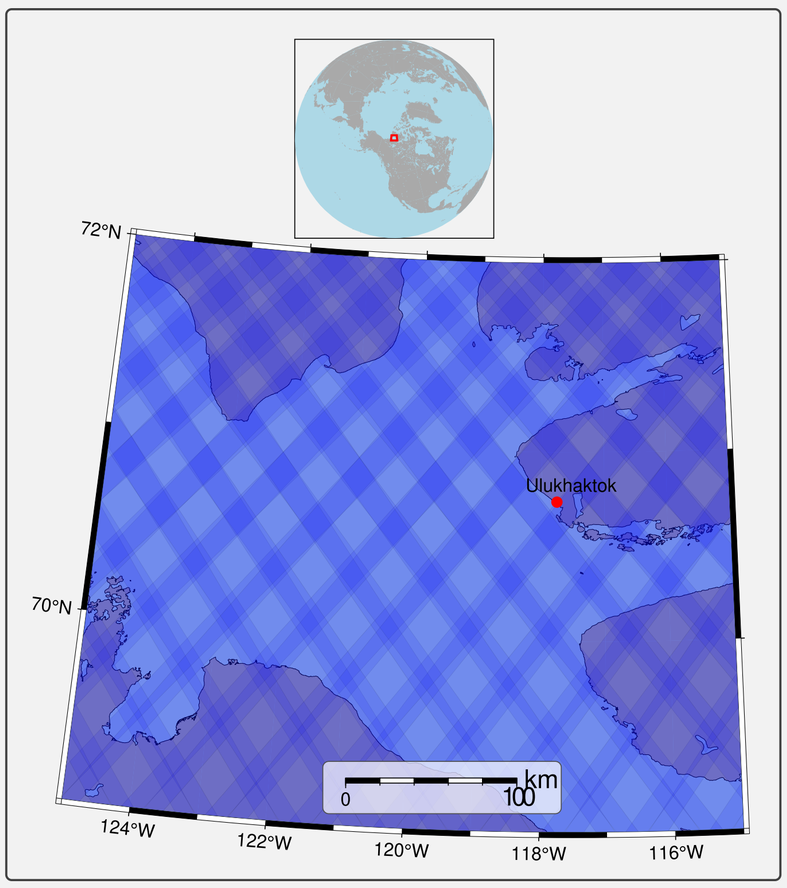


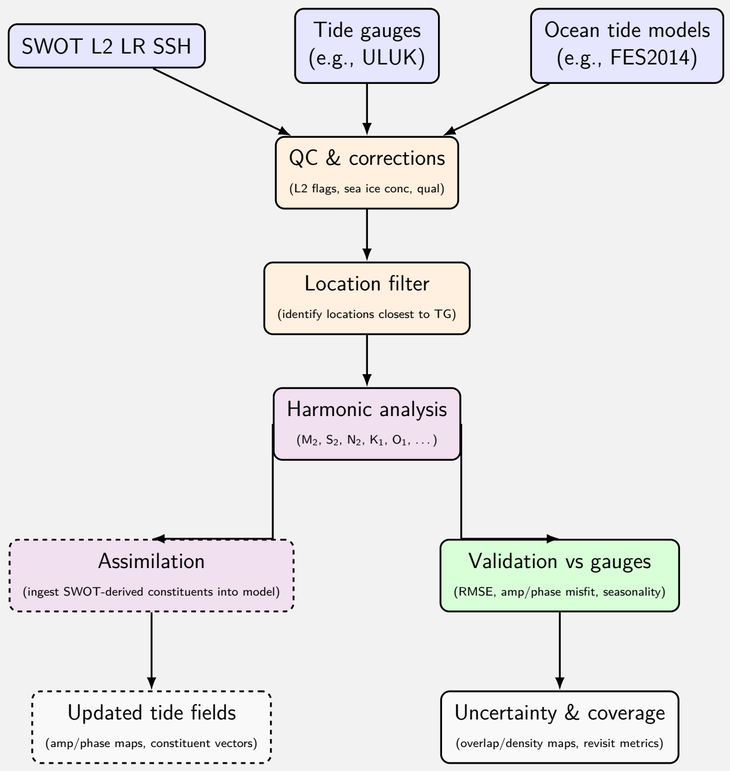
Figure 2: SWOT swath coverage near Ulukhaktok, Canada. Each blue bar represents a single swath measurement during the 21-day repeat cycle. Darker blue shading indicates areas with greater overlap from multiple passes, highlighting regions of denser sampling.

Methods

Harmonic analysis (per bin/station):

$$\eta(t) = Z_0 + \Sigma\, H_n f_n \cos(\sigma_n t - g_n + (V_n + u_n))$$

- **Gauge:** QC, 8–10 constituents.
- **SWOT:** bin SSHA (∼2 km); fit where sampling is stable.
- **Cross-checks:** nearest-neighbor extraction from models.



Aliasing & Sampling

- Nadir orbits alias M2 to ∼7.35 cpy while swath alias to ∼15.56 cpy.

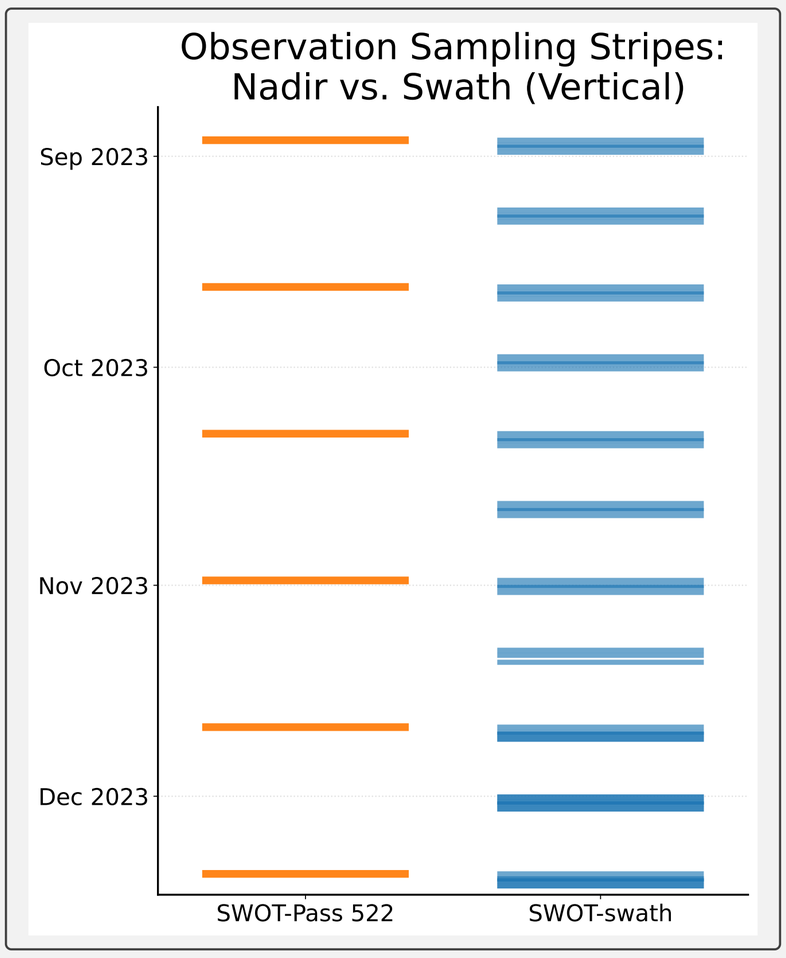


Figure 3: Sampling stripes of SWOT altimetry observations shown with time on the vertical axis. The orange marks indicate nadir tracks from pass 522, while the blue stripes represent swath measurements. Darker regions reflect greater overlap of repeated passes. This highlights the temporal density of sampling within the 21-day repeat cycle.

Key Results: M2 at ULUK

Source	Amp (cm)	Phase (°)
Gauge	16.8	59.2
SWOT	14.9	60.3
TPXO	17.8	58.7
FES2014b	17.4	63.6
GOT4.10c	15.4	62.5

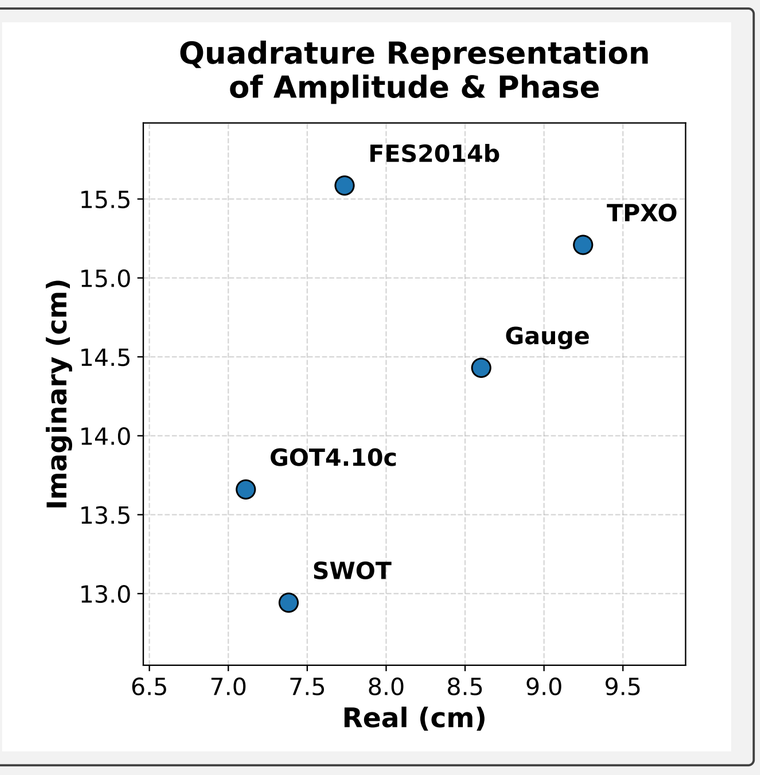


Figure 4: Quadrature representation of observed (Gauge) and modeled (SWOT, TPXO, FES2014b, GOT4.10c) tidal constituents. Each point encodes the complex amplitude, with the real axis representing the in-phase component and the imaginary axis the quadrature component. This highlights agreement and offsets in both amplitude and phase across sources.

Takeaways & Next Steps

- **SWOT adds 2D spatial context** — reduces nadir aliasing and improves regional coverage.
- **ULUK validation** — SWOT M2 aligns well with tide gauge and models.
- **Multi-constituent expansion** — extend beyond M2 to full uncertainty maps.
- **Bathymetry-regularized fields** — improve realism in complex Arctic shelves.
- **More validation** — include additional gauges and seasonal comparisons.
- **Automated pipeline** — streamline SWOT–tide model integration.

Acknowledgments

OSU, NGA collaborators, and tide-model developers.

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Links

https://github.com/pomath