Postdoc Research

National Aeronautics and Space Administration

Steric Height from JPL Cal/Val and SWOT vs. Coastal High-Frequency Radar Comparison

Dual Investigations in the California Current System

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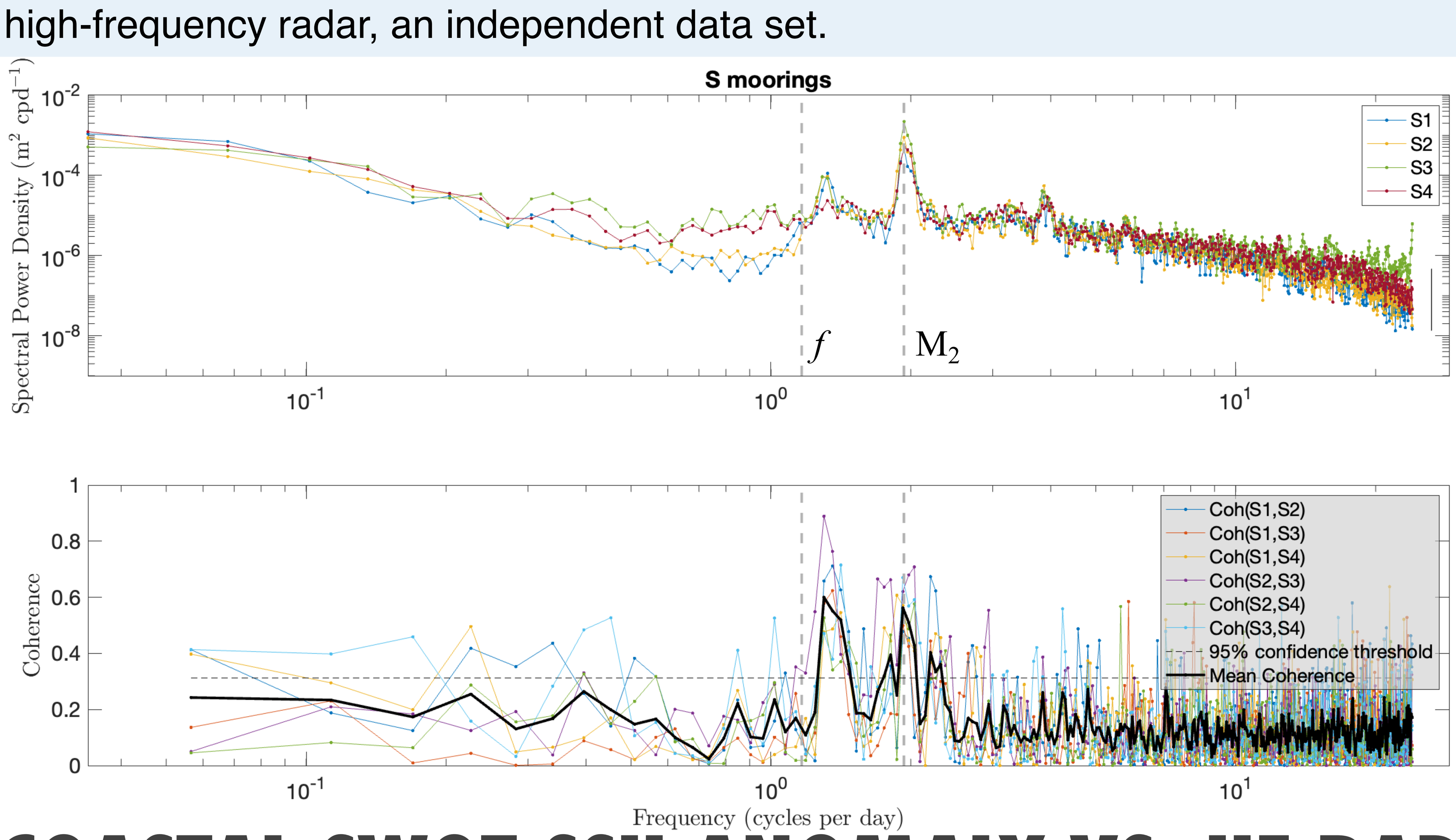
CAL/VAL STERIC HEIGHT

Background Satellite altimetry **sea surface height** (**SSH**) has a major contribution from steric height (i.e. from density fluctuations). SWOT oceanography Cal/Val campaign focused on crossover off the US West Coast, including 11 moorings. Profilers in the upper 500 meters capture ~hourly variability in T and S, thus ρ and hence steric height. See Audrey Delpech's poster for calculating steric height. Spectral and turbulence analysis from Cal/Val period.

Objectives Characterize oceanic quantities (spectra, turbulent structure) relevant to SWOT from *in situ* measurements, then compare SWOT measurements to high-frequency radar, an independent data set.



Observations Steric height anomaly from SIO and PMEL moorings, profilers and fixed CTDs

Preliminary Results Strong tidal component and low-frequency variability, coherent at inertial and semidiurnal tidal frequencies, structure function (*McCaffrey et al. 2015*) suggests slope of wavenumber spectrum in range of -5/3 to -2, less steep than expected for SSH (e.g. *Xu and Fu, 2012*).

Impact SWOT-scale *in situ* study ascertains spectral properties of steric height, coherence at SWOT scales, and turbulence structure

Structure function

Spectral information from turbulence

$$D_{\theta,n}(d) = \overline{[\theta(x) - \theta(x+d)]^n}$$

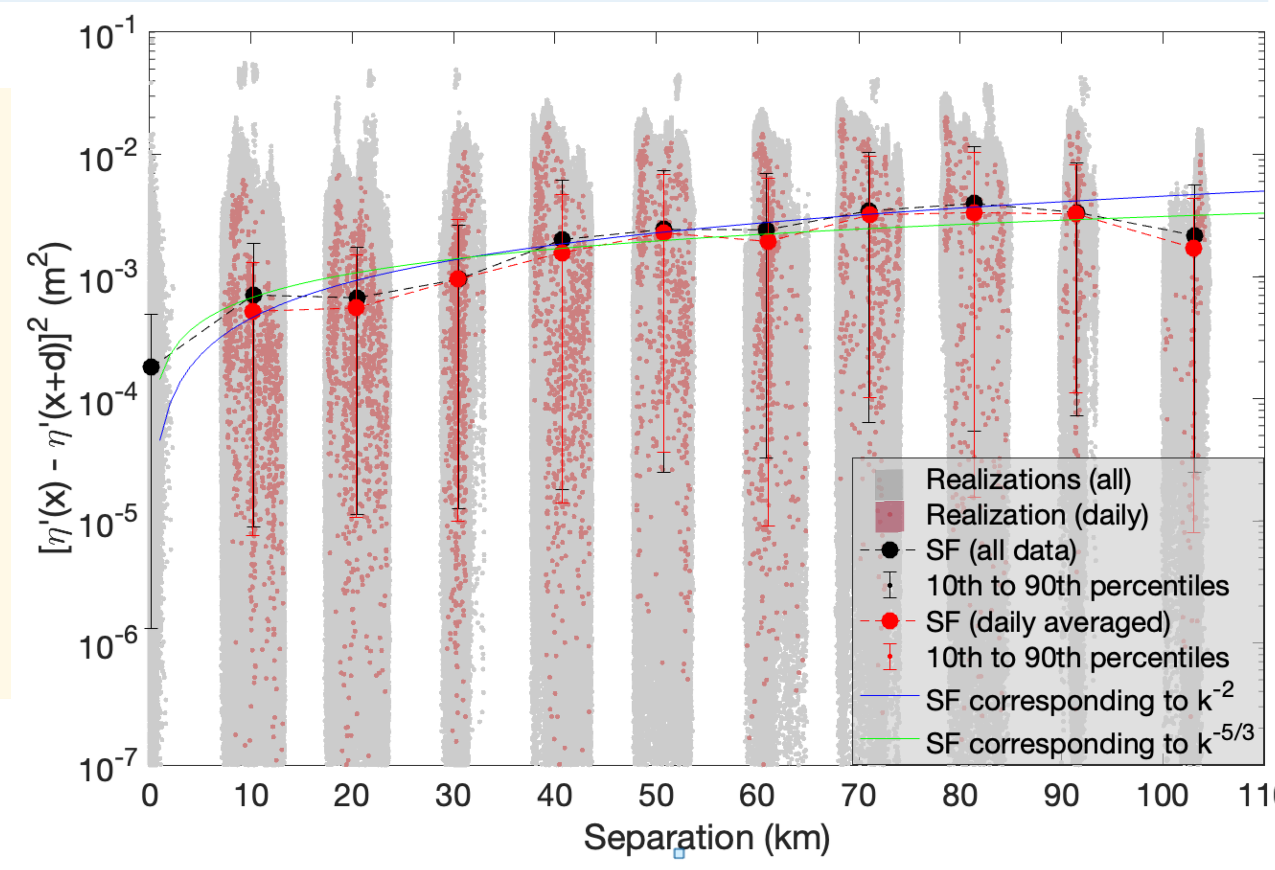
An order γ polynomial approx. of D is related to wavenumber spectrum via

$$S_\theta(k) \propto k^{-\gamma-1}$$

Nonlinear least squares fit to data:

$S_\theta(k) \sim k^{-5/3}$ *Fit to all data*

$S_\theta(k) \sim k^{-2}$ *Omitting last point (100 km)*



COASTAL SWOT SSH ANOMALY VS. HF RADAR CURRENTS

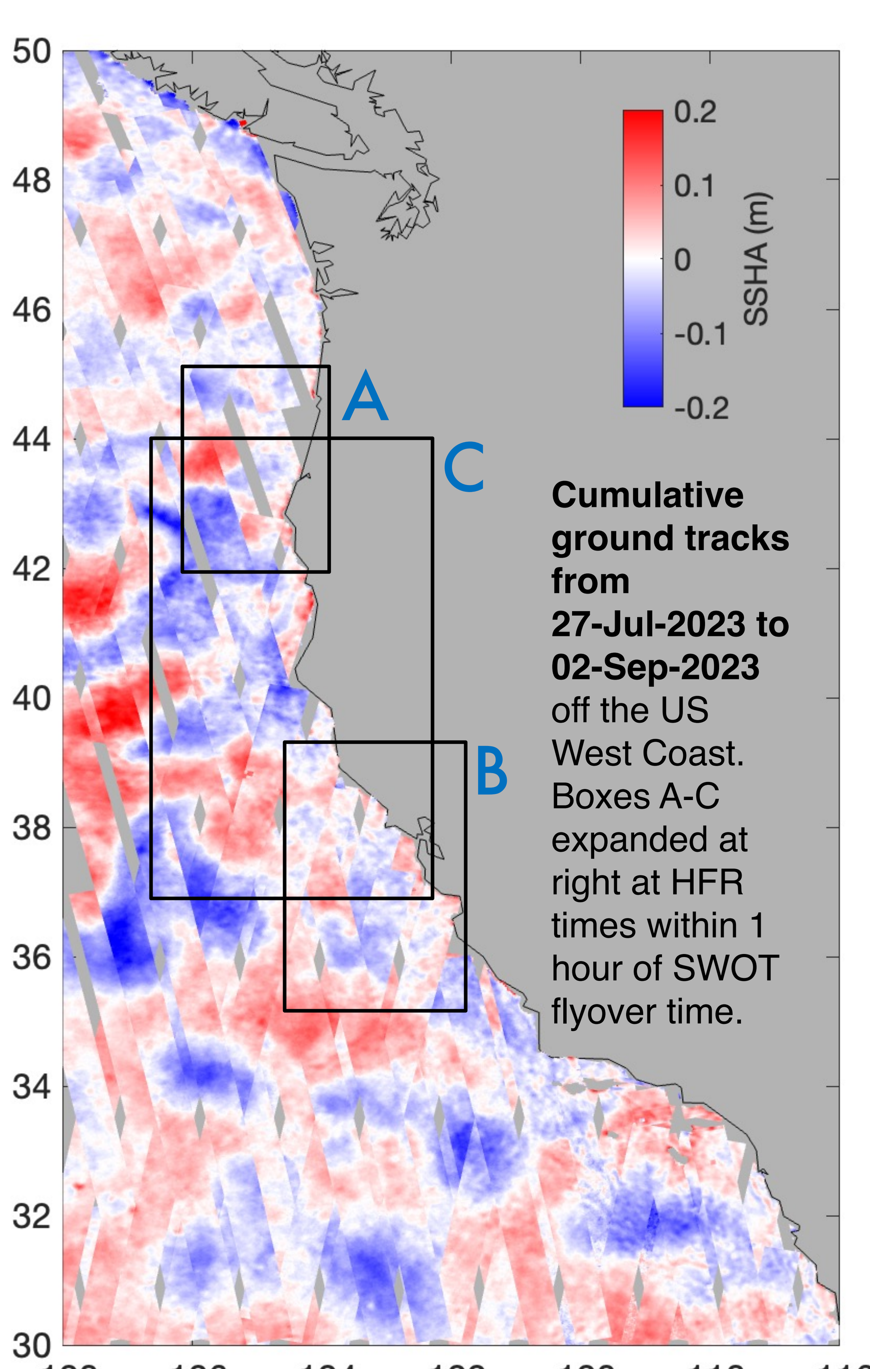
SWOT SSHA – SCIENCE ORBIT

- Third cycle in science orbit in progress
- US West Coast is passed over ~5 minutes
- USWC surface currents **u** well sampled by HF radar (*Terrill et al. 2006*)
- Total surface currents contain multitude of signals: is there discernable geostrophic and/or quasi-geostrophic flow?

DATA

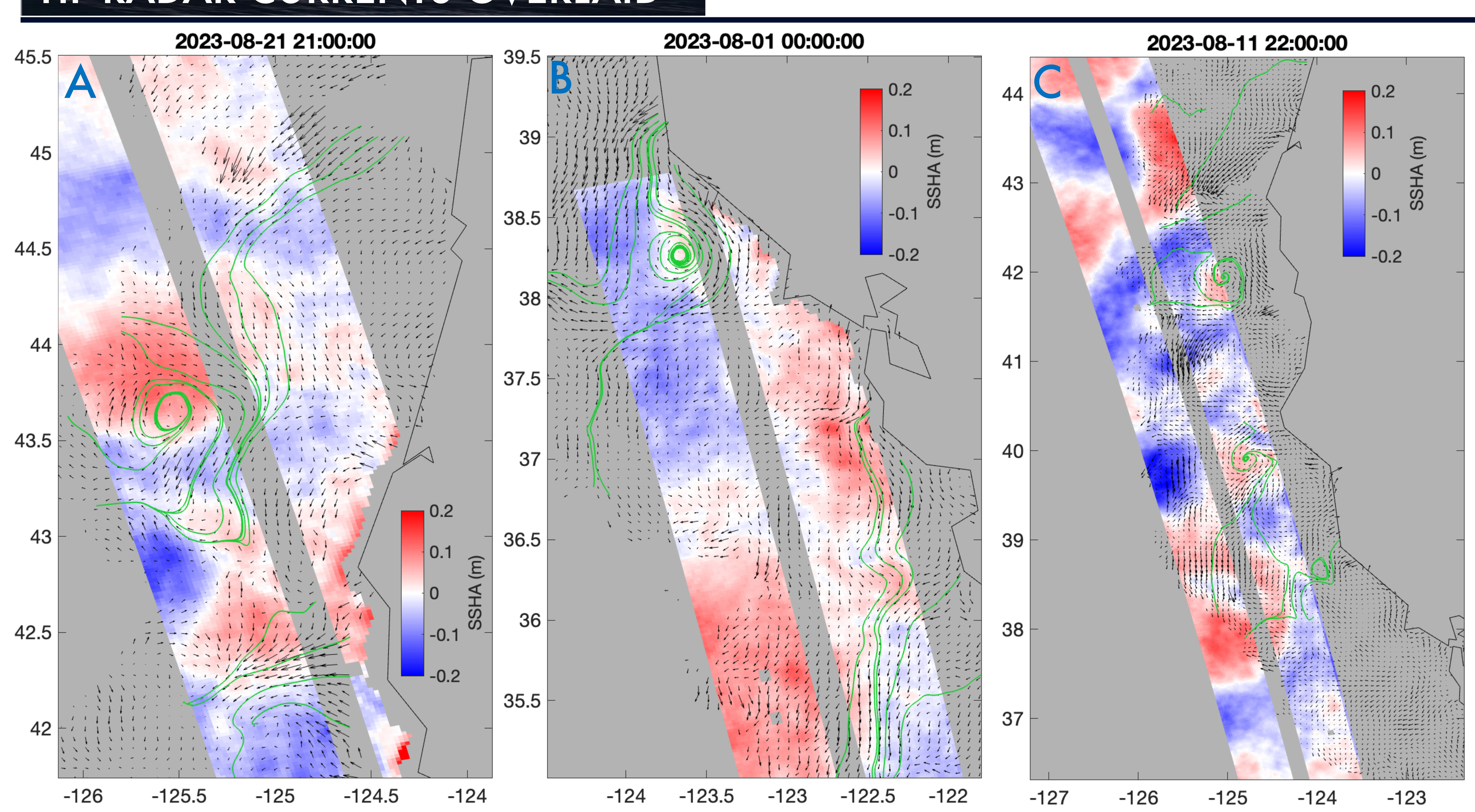
High-Frequency Radar
- Near-real time vector surface currents
- Bragg scattering, radar frequencies of 5-40 MHz
- Radial obs. gridded to 6 km (available at 1km and 2km, unused here)
- Matched to within 1 hour of SWOT flyover time

SWOT SSH Anomaly
- Variable `ssha_karin_2` displayed: `"ssh_karin_2 – mean_sea_surface_cnescls – solid_earth_tide – ocean_tide_fes – internal_tide_hret – pole_tide – dac."`
- Detrended via along-track moving mean, window ~2000 km



Cumulative ground tracks from 27-Jul-2023 to 02-Sep-2023 off the US West Coast. Boxes A-C expanded at right at HFR times within 1 hour of SWOT flyover time.

HF RADAR CURRENTS OVERLAID



A: ***<100 km anticyclonic eddy*** resolved by HFR coincident with positive SSHA in SWOT. HFR streamlines in green.

B: ***~50 km anticyclonic eddy*** resolved by HFR coincident with positive SSHA in SWOT. Also streamlines perpendicular to SSHA gradient.

C: Several <100 km eddies coincident with positive SSHA in SWOT.

PRELIMINARY RESULTS

- Eddies less than ~100 km across are resolved by HFR coincidental with SSH anomalies.
- Flow consistent with geostrophy is observed perpendicular to $\nabla\eta$
- Unbalanced motion (e.g. diurnal currents and tides) likely strong in region and may explain additional structure in **u**.

FUTURE WORK

- What fraction of surface currents can SWOT predict? Useful for regions inaccessible to land-based HFR.
- Investigate transition scales from quasi-geostrophy to fully unbalanced motion.
- Remove near-inertial and tidal flow using models.
- SWOT produces detailed SSH snapshots near coasts compared to past altimeters, while HFR is only possible along coastlines.

Significance to JPL/NASA

1st half: Calibrates and validates SWOT data using in situ observations, necessary for mission.

2nd half: Demonstrates usefulness of SWOT and informs potential future NASA scatterometry missions

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This work was presented September 21, 2023 at the SWOT Science Team Meeting in Toulouse, France. It was presented under the same title.

References

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