Coastal-to-open ocean exchange in the California Current System from new altimetry

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Introduction

How can new high-resolution altimeter products help assess fluxes between the near-coastal regime and the open ocean? In the **California Current System (CCS)** these exchanges are strongly modulated by mesoscale and submesoscale variability that is geostrophic to leading order. Our goal is to quantify these fluxes by combining satellite altimetry with *in situ* data sets from the CCS.

The first question is to what extent altimetry captures the smaller features linked to the cross-shelf exchanges? In situ data (Figs. 1 and 2) allow us to examine signal-to-noise characteristics.

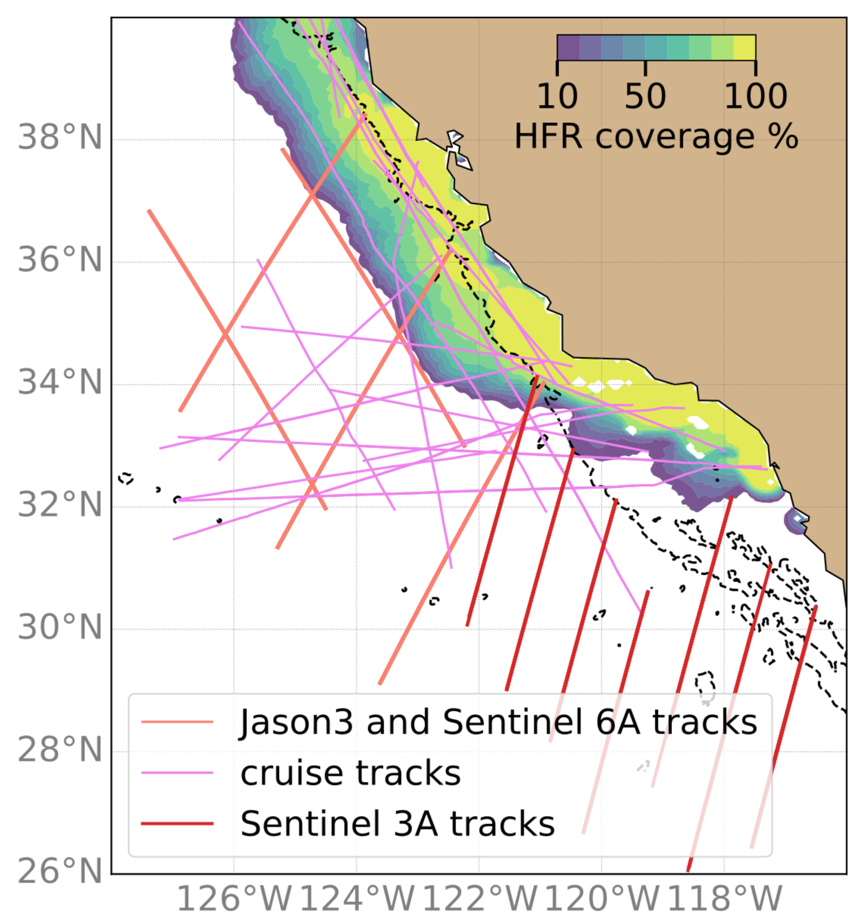


Fig. 1: Map with ship tracks for ADCP, satellite tracks, and coastal HFR data distribution.

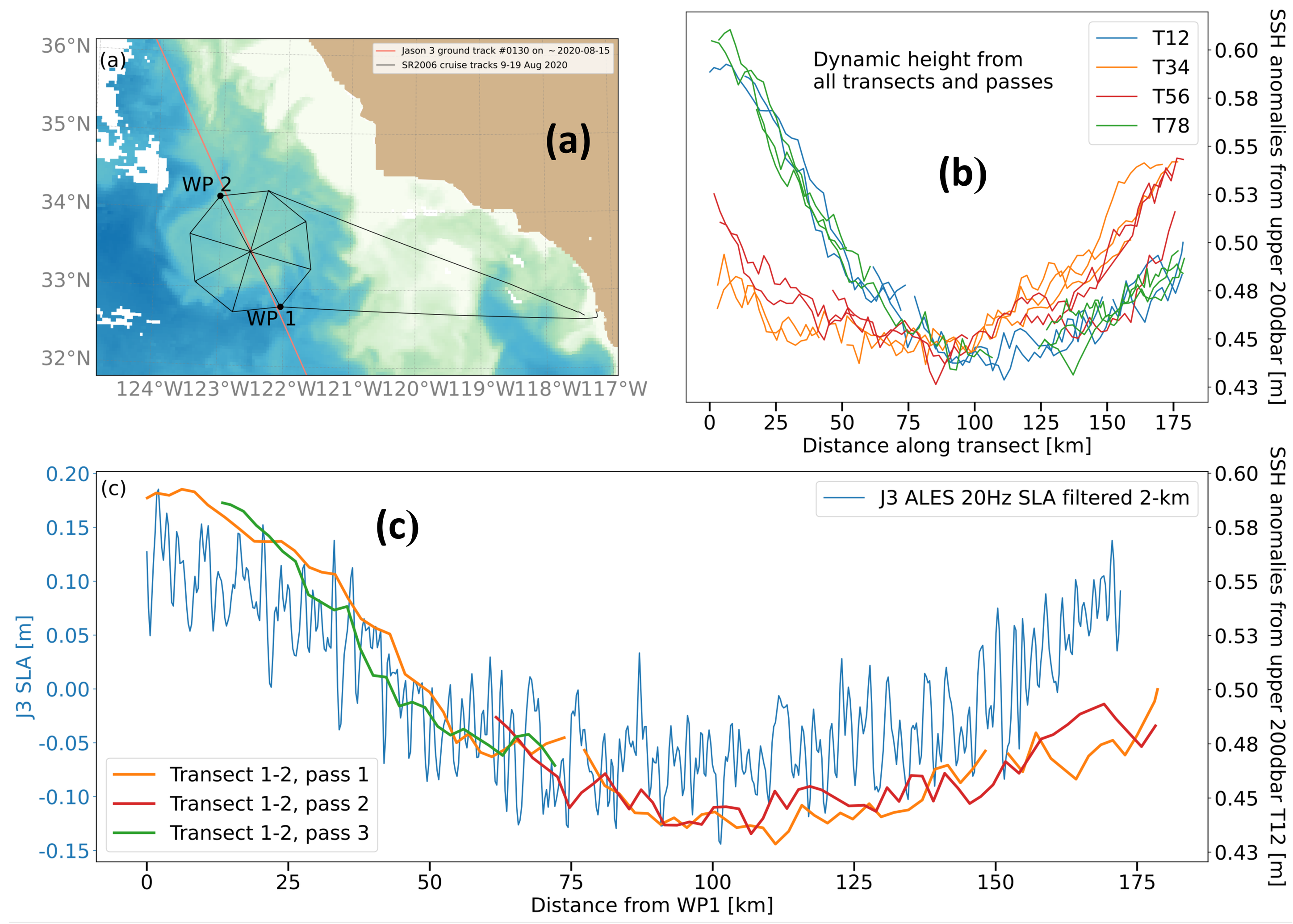


Fig. 2: (a) Cruise tracks overlaying GLOBCOLOUR chlorophyll during August 2020. (b) All dynamic heights estimated from the underway CTD casts taken along the 4 inner lines of the tracks. (c) comparison of dynamic heights and ALES J3 SSH.

Altimetry and uCTD

In the CCS the SSH spectra roll off as k^{-4} at larger scales. The spectra will then display flattening below 100 km and may plateau at around 50 km wavelength.

This is consistent among altimetric products, whether using the latest SAR technology or the latest reprocessing algorithms.

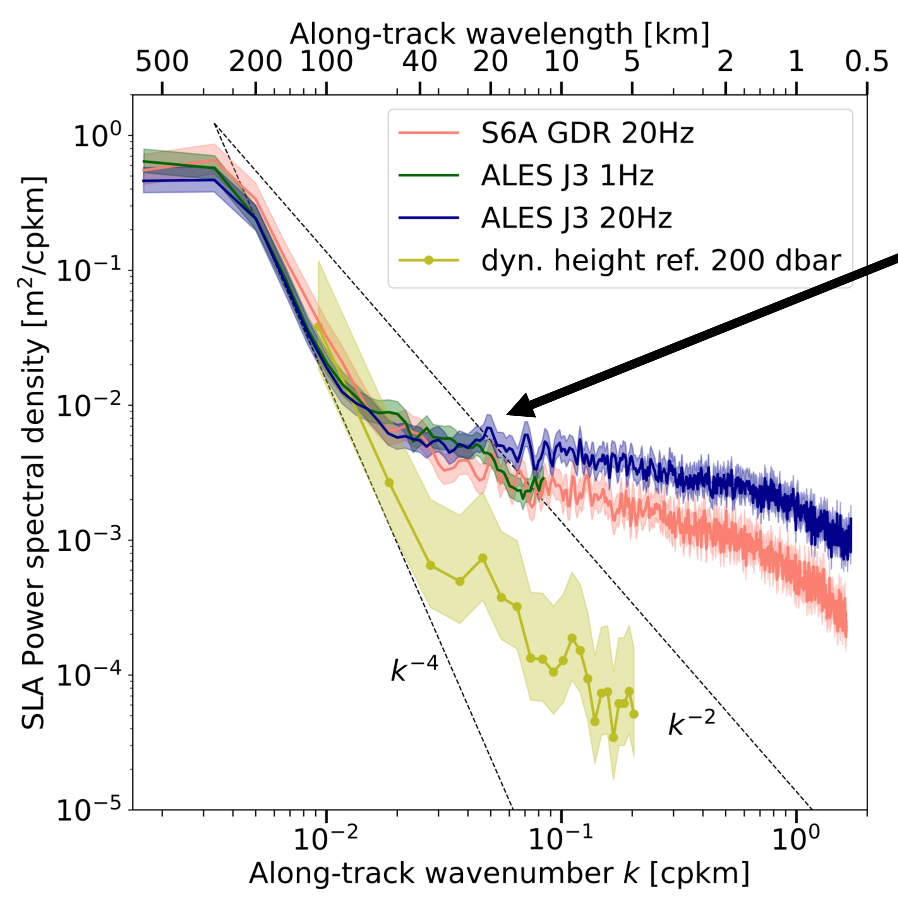
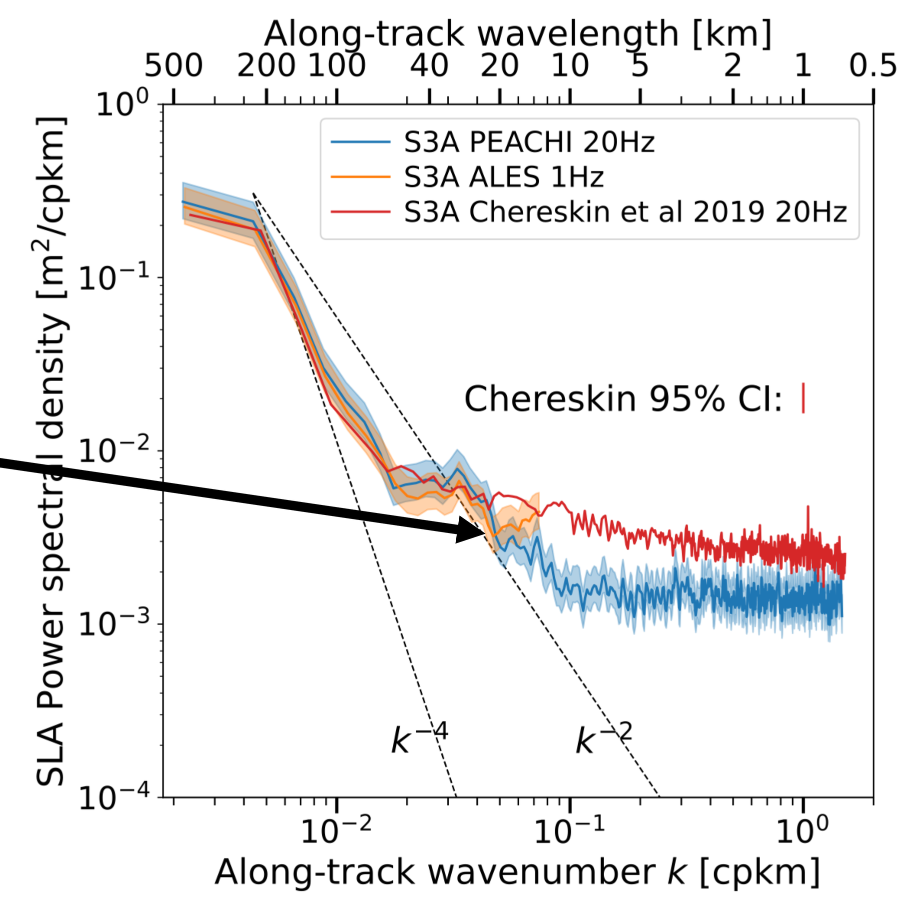


Fig. 3: Altimeter spectra show white noise for scales shorter than 50 km; in situ data do not.

Fig. 4: White noise plateau appears in altimeter data (here Sentinel 3A) regardless of processing approach.



Acoustic Doppler Current Profiler (ADCP)

ADCP data come from transits in the CCS, available in the JAS-ADCP archive. These previously unanalyzed data yield a Helmholtz decomposition consistent with Chereskin et al (2019): at submesoscales divergent energy is approximately equivalent to rotational energy.

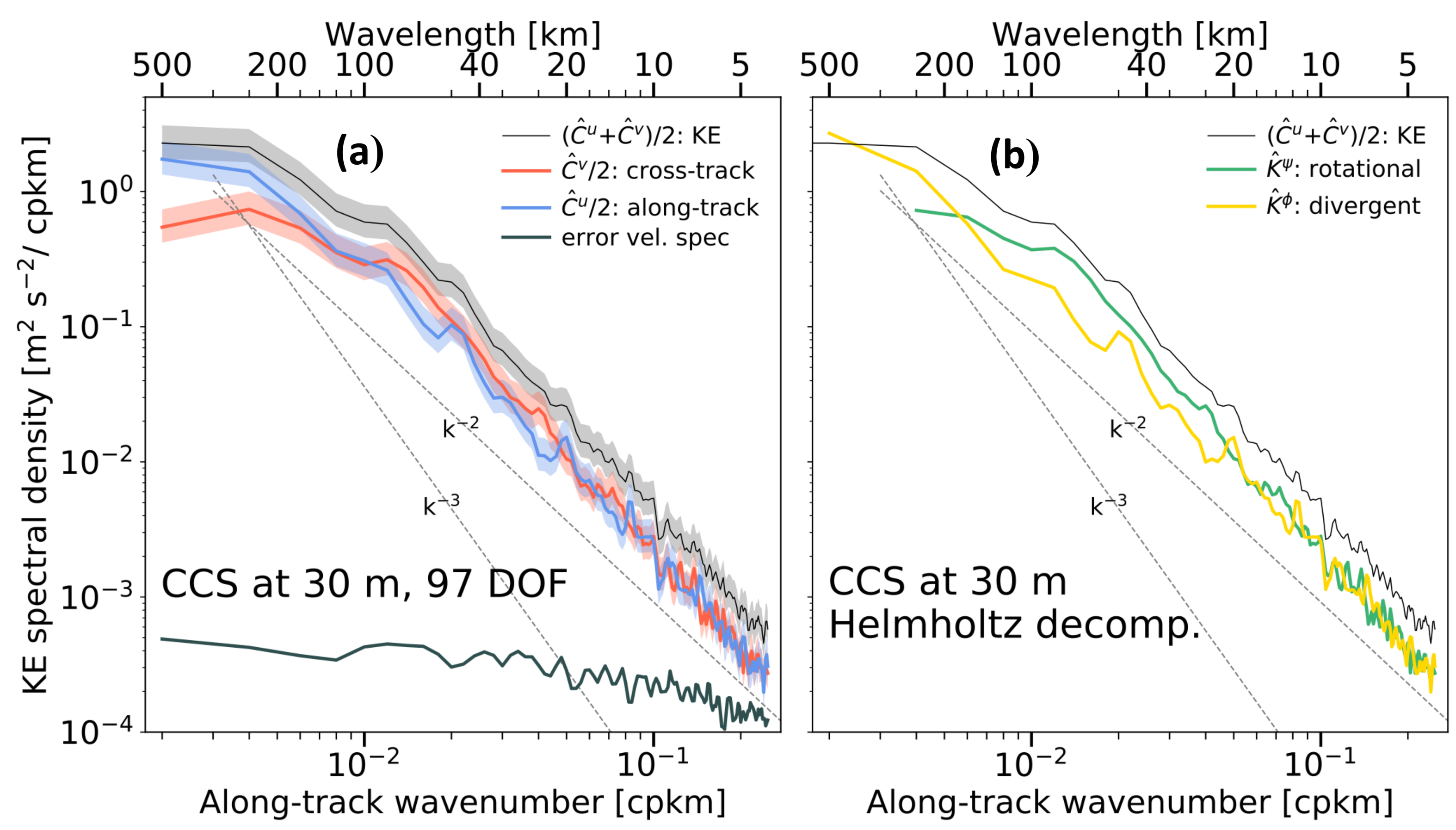


Fig. 5: Example **KE** spectra for ADCP data collected in the California Current System (CCS). (a) total KE, cross- and along-track components; (b) Helmholtz KE decomposition into rotational (geostrophic) and divergent (ageostrophic) components. Assumes isotropy.

High Frequency Radar (HFR)

HFR provides hourly surface velocities at ~10 km spatial resolution. In a 120 x 120 km box near Pt Conception, we apply a 2D Helmholtz decomposition and examine the 3D spectrum. Both frequency and wavenumber (azimuthally averaged) show strongly divergent KE, in agreement with the ADCP.

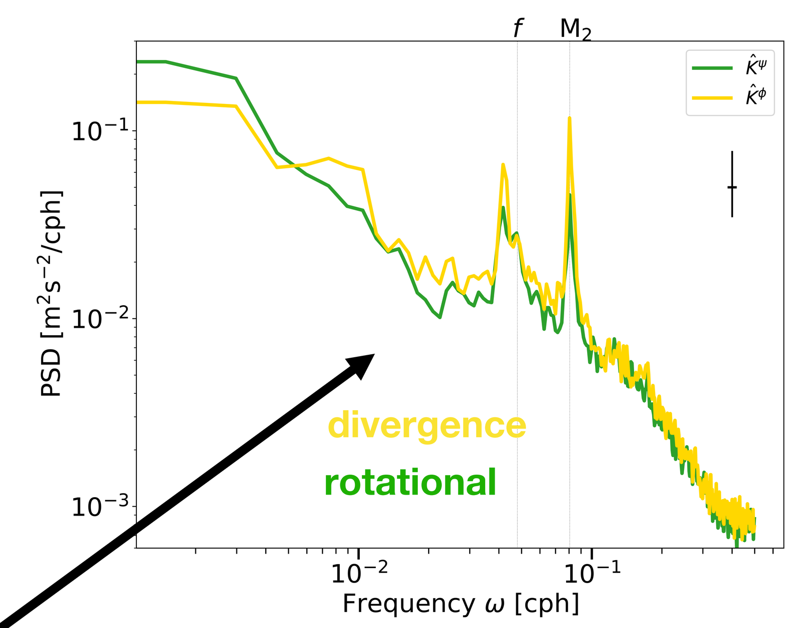


Fig. 6: Helmholtz decomposition of HFR frequency spectrum shows large divergence at sub-inertial frequencies.

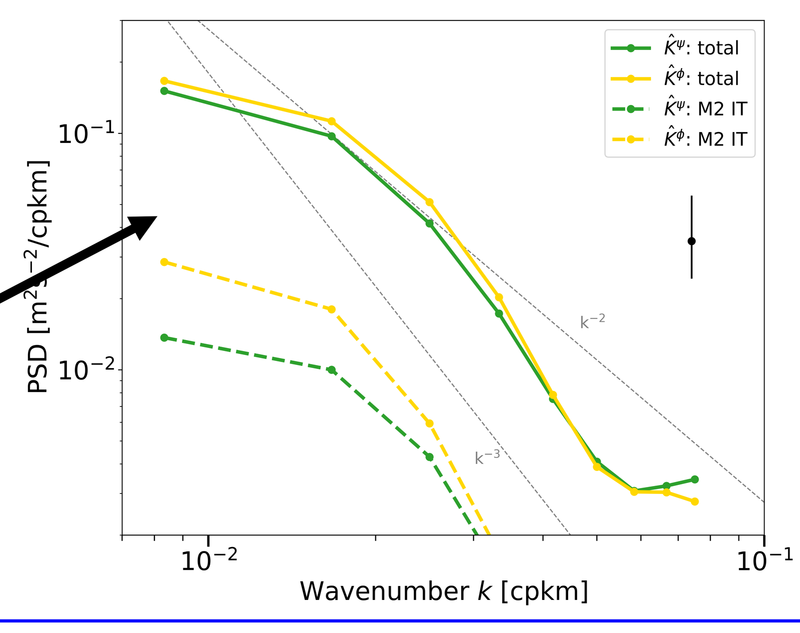


Fig. 7: In wavenumber space, Helmholtz decomposition shows that divergent KE exceeds rotational KE everywhere and particularly at M2 tidal frequency.

Key points

- Altimetry and in situ steric heights diverge at scales ≤60 km.
- The white plateau in radar altimetry is consistent with instrument noise, as previous studies have inferred. The nature of this noise merits further scrutiny.
- We hypothesize that aliased surface gravity waves will pose challenges for radar altimetry at scales shorter than ~60 km.
- At submesoscales (<100 km), divergent (ageostrophic) energy is at least as large as rotational (only potentially geostrophic) energy. This divergence is not dominated by the internal tide band, suggesting that detided flow is also divergent.