High wavenumber variability in the California Current from new altimeters

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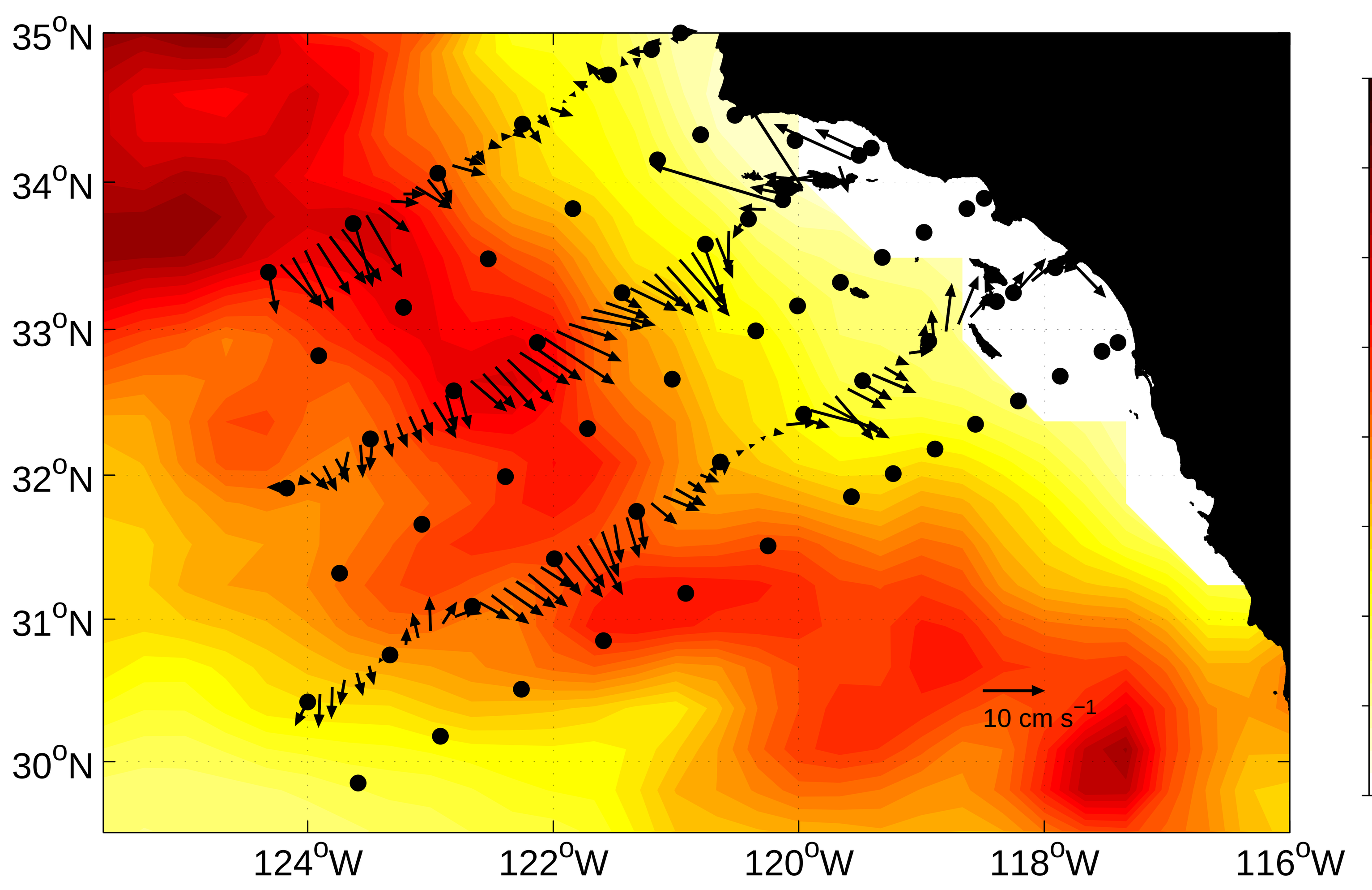
1. Introduction

Coastal regions are marked by small eddy features, meaning that the structure of spatial variability can differ from open ocean areas. The California Current region is a good place to evaluate high wavenumber variability, because of the extensive in situ monitoring carried out in the region as part of the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program. Since 1993, underway shipboard Acoustic Doppler Current Profiler (ADCP) data have been collected as part of the 4 times per year ship surveys.

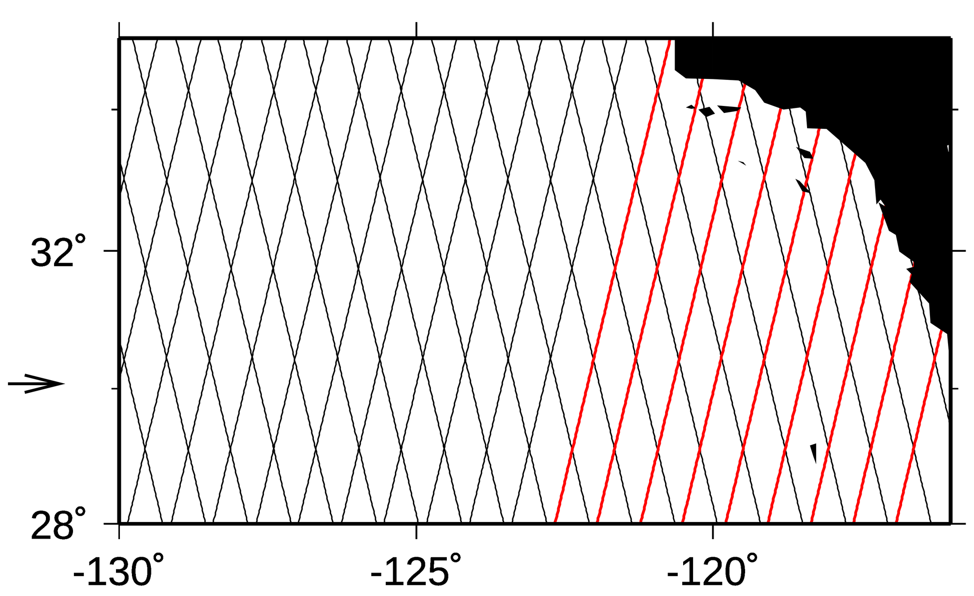
Small-scale features are difficult to observe in conventional altimetry but should be more accessible from newer higher-resolution instruments, including AltiKa, Sentinel-3, CryoSat (in SAR mode). Future instruments, including SWOT and Jason-CS should provide further insights into high wavenumber processes.



Time-mean currents from 11 years of ADCP data, superimposed on eddy kinetic energy from the gridded Aviso altimeter product.

2. Data

AltiKa ground tracks in the CalCOFI region, provide dense spatial coverage of the region. Descending tracks, which are roughly perpendicular to the coastline, were selected for this study (indicated in red) to provide data that are roughly consistent with the CalCOFI sampling lines, albeit more meridional.

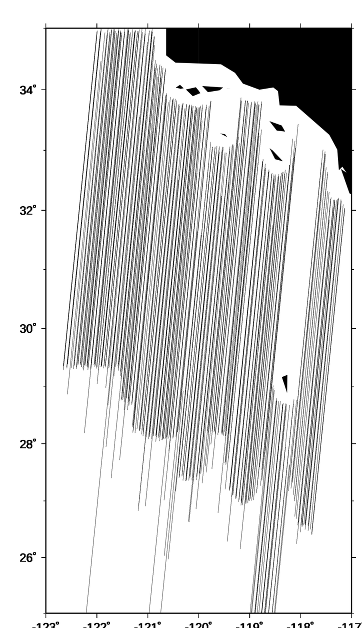


ADCP velocity data serve as an in situ point of reference against which to compare the altimeter observations (see figure in panel 1):

1. 6 lines, with roughly 5-km horizontal resolution
2. Depth range: 20 m to 300 m
3. Time period: 1993-2004, with sampling $4\times$ per year.

Specific ADCP results are presented in Teri Chereskin's talk.

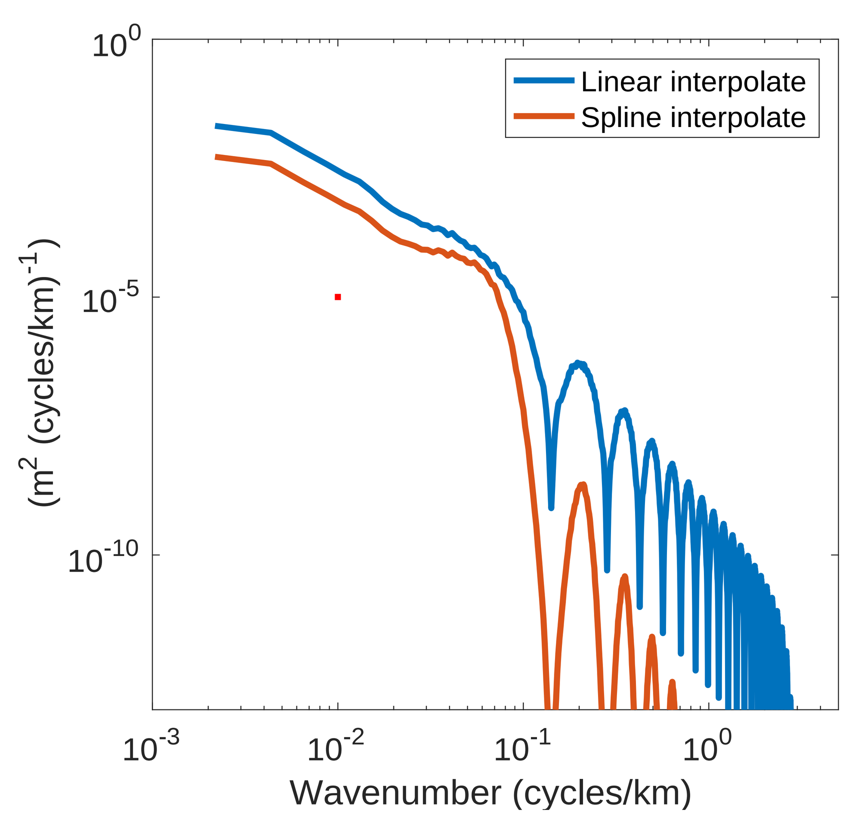
Model output from the MITgcm, run at $1/24^\circ$ (llc2160) and $1/48^\circ$ (llc4320) resolution are also evaluated following the approach of Rocha et al (2016a, b).



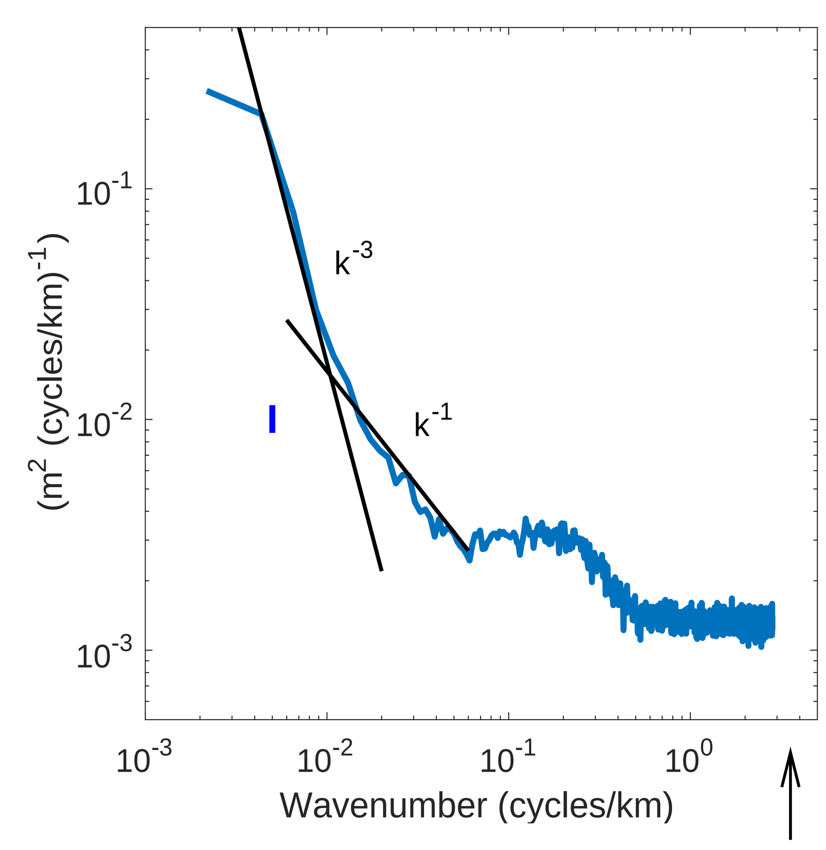
CryoSat ground tracks are non repeating. A total of 317 CryoSat passes have been identified in the study region. Sea surface height anomalies are computed relative to a multi-mission reference mean sea surface.

3. Environmental corrections: A cautionary note

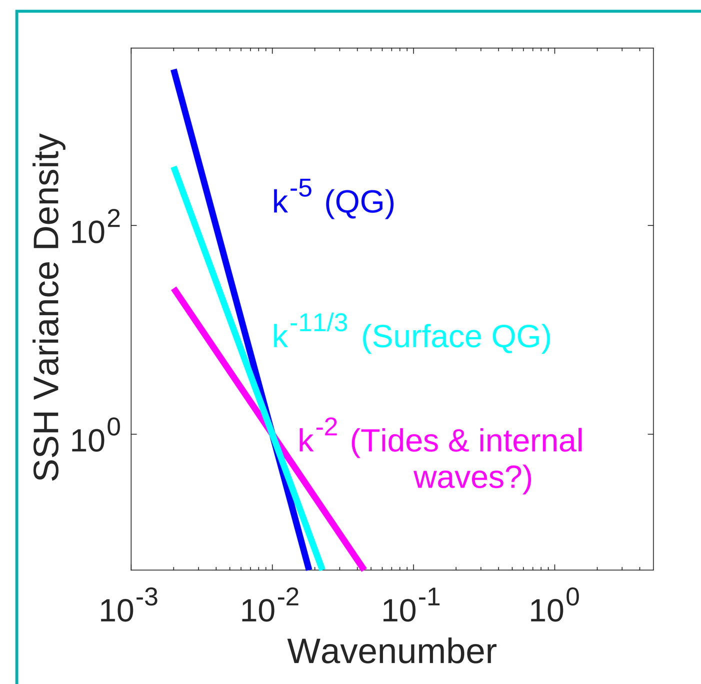
Environmental corrections for AltiKa are reported at 1 Hz, while the data themselves are available at 40 Hz. Standard practice is to interpolate the 1-Hz corrections onto the 40-Hz sea surface heights. The process of interpolation should not create an artificial signal where no data are available, here illustrated with the steep spectral slopes for lengthscales shorter than can be sampled by the 1-Hz data. This also means that there is effectively no environmental correction for scales smaller than 1 Hz. (This does not tell us whether sea surface heights might need environmental corrections at small scales.)



4. Wavenumber spectra

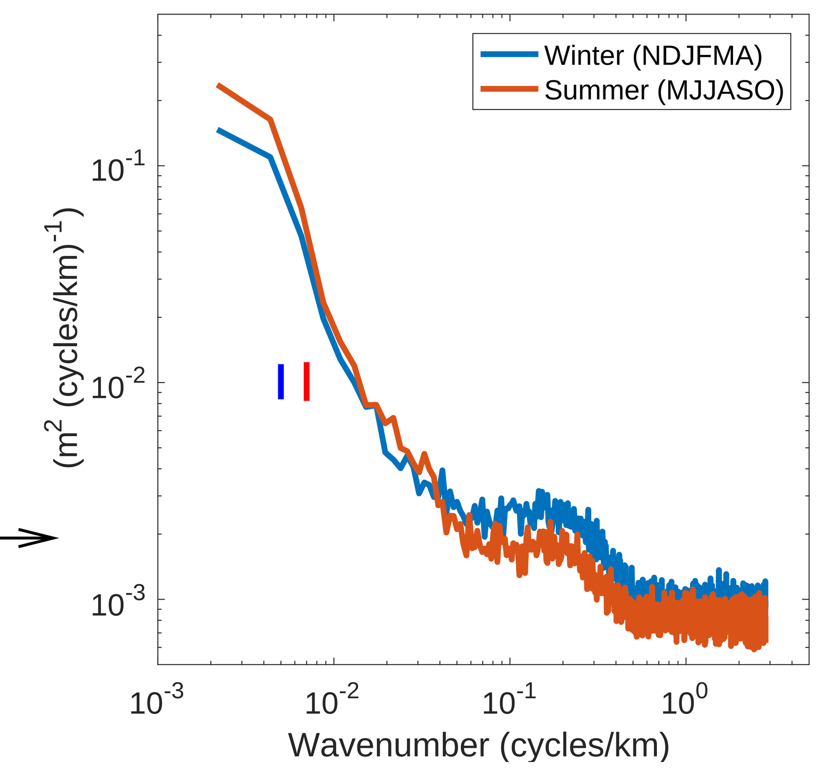


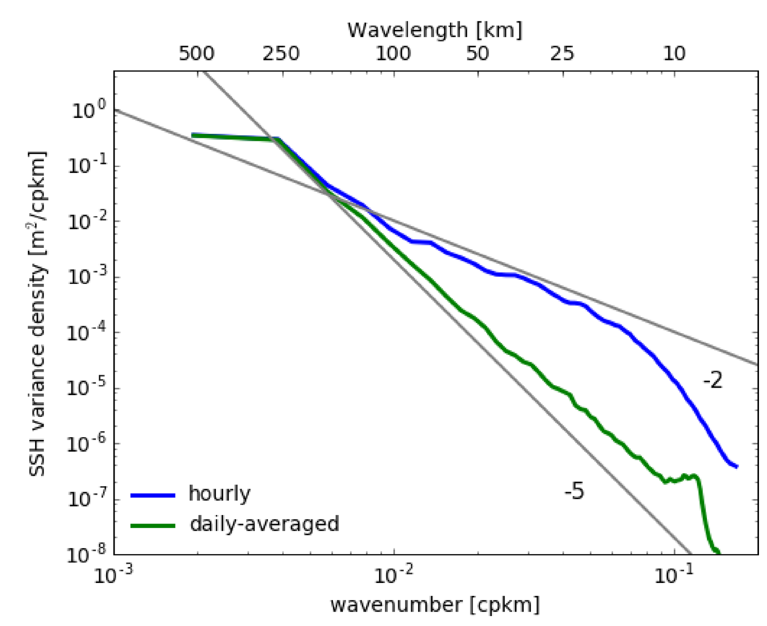
AltiKa 40-Hz data from the California Current show spectral slopes that are steep for large scales (though not as steep as predicted for QG systems). Spectra flatten out for high wavenumbers and show a characteristic spectral bump in the 2-10 km range. Zhang and Sandwell (2016) suggest that a two-pass retracker can minimize this bump.



Predictions for sea surface height wavenumber spectra suggest that quasi-geostrophic flows should have spectral slopes of k^{-5}, while internal wave motions would be expected to have flatter spectra.

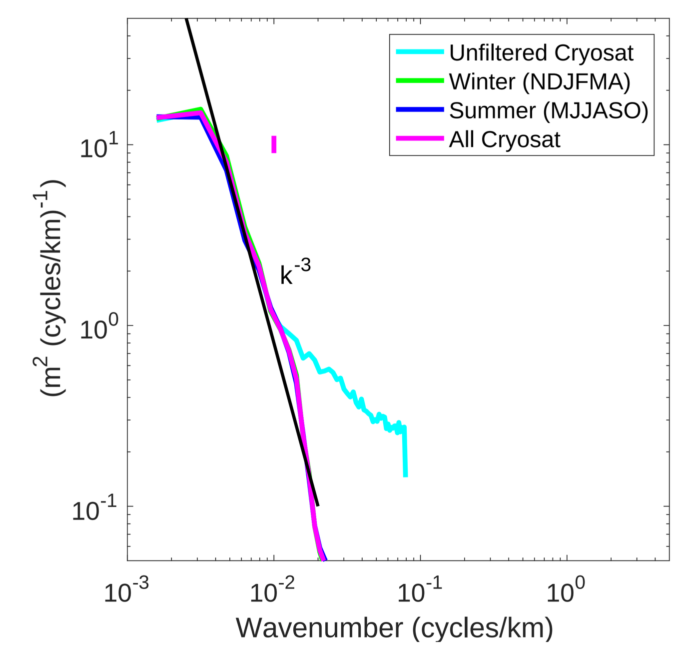
Seasonal differences in AltiKa indicate more long-wave energy and less high-wavenumber variability in summer.





Model sea surface heights from the 1/48∘ MITgcm (llc4320) indicate spectra for hourly data that are consistent with the altimetry, with steeper slopes at low wavenumbers and flatter slopes at high wavenumbers. Spectra from daily-averaged data are consistent with quasi-geostrophy.

Spectra from CryoSat for filtered data show k^{-3} spectral slopes for low wavenumbers. High wavenumbers are suppressed in the filtered CryoSat data product, and the spectral curves appear overly smooth compared with their error bars, implying that small-scale variability has been suppressed. The unfiltered CryoSat product retains more high wavenumber variability. The origins of the high wavenumber signal could be a result of the geoid or ocean variability.



5. Discussion

- Spectra from AltiKa indicate k^{-3} spectral slopes for wavenumbers larger than about 100 km and k^{-1} slopes for smaller scales. The transition from steeper spectral slopes to flatter spectral slopes occurs at longer scales in the California Current than in more energetic regions such as Drake Passage (Rocha et al, 2016a) or the Kuroshio Extension (Rocha et al, 2016b). We hypothesize that this is because geostrophic energy levels are lower in the California Current, so wave-related processes dominate over a broader range of scales.
- AltiKa data suggest seasonal differences; more data would be needed to infer a clear signal.
- CryoSat (low-resolution mode) data could be contaminated by residual geoid because of the satellite's infrequent repeats. The filtered CryoSat product is potentially over-filtered to minimize geoid contamination.
- Environmental corrections are a possible concern at high wavenumbers.

Next steps

- Improvements in the analysis might be achieved by retracking AltiKa data using the two-pass procedure developed by Zhang and Sandwell (2016).
- Once the Sentinel 3 data are available, they should provide higher resolution information along the same groundtracks as AltiKa.

References

Rocha, C., T. K. Chereskin, S. T. Gille, and D. Menemenlis, 2016. Mesoscale to submesoscale wavenumber spectra in Drake Passage, J. Phys. Oceanogr., 46, 601-620.

Rocha, C., S. T. Gille, T. Chereskin, D. Menemenlis, 2016b. Seasonality of submesoscale dynamics in the Kuroshio Extension, in press, Geophys. Res. Lett.

Zhang, S. and D. T. Sandwell, 2016. Retracking of SARAL/AltiKa radar altimetry waveforms for optimal gravity field recovery, revised for Marine Geodesy.

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Photo panorama of Channel Islands by Jamie Holte.