High-wavenumber spectra from historical ADCP transits in the tropical Pacific (and elsewhere)

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Spectra: IIc4320 model

Acoustic Doppler Current Profiler data: High-wavenumber currents



Shipboard ADCP Data

- Underway shipboard data collected on GO-SHIP hydrographic cruises
- Especially useful data from uninterrupted transects (continuous steaming, no stations)...
- But these are often transits, with no chief scientist badgering to process data
- Focus on CryoSat SAR region (black box)

Cruise tracks in JAS (red) and UH (blue) CODAS databases



Archived ADCP data UH CODAS: not processed JAS-ADCP: processed Inferring dynamics from horizontal wavenumber spectra:

What do we expect for kinetic energy spectra?

Isotropic Quasi-Geostrophy:
interior QG predicts k⁻³
(Charney,1970)
surface QG predicts k^{-5/3}
(Blumen, 1978)

Ageostrophic motions can project onto similar scales, e.g., inertia-gravity waves k⁻² can flatten QG spectral slopes (Garrett & Munk, 1975)



Inferring dynamics from horizontal wavenumber spectra:

What has been observed for kinetic energy spectra?

Real ocean spectra from strong baroclinic jets (Gulf Stream, ACC, Kuroshio) are consistent with • interior QG (k⁻³) at meso- to

- submeso-scales
- k⁻² at submesoscales

(e.g., Callies & Ferrari, 2013; Rocha et al., 2016; Qiu et al., 2017)

Is this ubiquitous? What do we find in weak mean flow regions such as eastern boundary currents? Or in tropics?



Inferring dynamics from horizontal wavenumber spectra:

Some properties of isotropic spectra:

•The 1-D (alongtrack) spectra will follow the same power law as 2-D (k^{-n})

• Ratio of across/along track KE components is useful diagnostic

Across-track K_u and along-track K_v are related through the exponent n:

K_u = n K_v purely rotational (nondivergent)

K_v = n K_u purely divergent (irrotational)

•Helmholtz decomposition of 1-D spectra separates rotational and divergent components (Buhler et al., 2014) (e.g., Callies & Ferrari, 2013; Buhler et al., 2014; Rocha et al., 2016)



ADCP: Ocean Surveyor 75 kHz

- What characterizes spectra?
- What transition do we see from geostrophic to ageostrophic motions?



Spectral slopes: little variation with wavenumber

- k⁻² spectra
- Flattens for scales < 15 km
- Ratio of alongtrack to crosstrack near 1, except for scales
 > 100 km
- Transition scale
 > 100 km



Tracks in the tropical Pacific

Southeast Tropical Pacific/CryoSat area: cruise tracks OS75 and NB150



More questions

- Does frequency of ADCP matter? (NB150 vs OS75)
- How robust are the spectral estimates? (Are there regional variations?)
- Does continuity of transect matter? (Long transit vs GO-SHIP line with stations)

Does frequency of ADCP matter?



 No major differences between different frequency ADCP sampling

Are there regional variations? Look at sub-domains



- 4 sub-domains (CC from top right): NE box, SE box, SW box & NW box
- Examine the 125 m spectra

Regional sub-domains largely agree



What if the ship stops for stations?



What if the ship stops for stations?



What do altimeter data say?

- Nearly flat spectra not expected from ADCP spectra (k⁻² in velocity implies k⁻⁴ in sea surface height)
- High-wavenumber noise distorts spectral slope?
- Working to add AltiKa, Sentinel-3, and CryoSat if possible



Conclusions

- In tropics, KE spectra follow k⁻² power law. Transition between rotational and divergent flow at scales > 100 km. Divergence dominates at small scales, perhaps due to equatorial wave energy?
- Slope and large scale of transition also seen in California Current and consistent with Qiu et al (2017) findings from northwest tropical Pacific.
- ADCP data appear consistent, regardless of frequency of ADCP (75kHz vs 150kHz) and geographic sub-domain. Ship stations could be issue if tides more energetic than signal.
- Altimetry shows flat slopes, perhaps suggesting high-wavenumber noise. Will SWOT differ?
- Cleaned up ADCP data \rightarrow JAS-ADCP.



Cruise tracks in JAS (red) and UH (blue) CODAS databases



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Southeast Tropical Pacific/CryoSat area: cruise tracks OS75 and NB150



- Focus on ADCP data in CryoSat SAR region?
- Look for long, uninterrupted transects
- Cleaned up data to be released through JAS-ADCP