1. Introduction

Small-scale, high-wavenumber processes are difficult to sample with ships, not well-resolved by altimeters that have ~10-km footprints, and not resolved in many numerical models. For velocity, surface quasi-geostrophy theory predicts spectral slopes of $k^{-4}$, interior quasi-geostrophy predicts spectral slopes of $k^{-3}$, and internal tides can lead to flatter spectral slopes of $k^{-2}$. We use AltiKa altimetry, shipboard acoustic Doppler current profilers data, and a high resolution (1/48) version of the MITgcm to examine the high-wavenumber structure of Drake Passage.

2. Data

- Drake Passage crossings 2–4 times per month in all seasons;
- 20-22 transects annually, 1999-2013;
- 2-day crossing;
- Data recorded as 5-min averages (~1.5 km resolution at 5 m s$^{-1}$ ship speed (10 kts));
- Grid to 10 km, implying 20 km Nyquist wavenumber;
- 300 m vertical range (N8150);
- 1000 m vertical range (O938).

Altimeter data are not colocated with in situ observations. Mapping from one sampling grid to the other would smooth out high-wavenumber variability.

3. Velocity Spectra Consistent with Interior QG Theory

Velocity wavenumber spectra from ADCP have spectral slopes between $k^{-2}$ and $k^{-3}$, with no variation with depth, consistent with interior quasi-geostrophic theory.

For scales larger than ~50 km, the ratio between cross-track and along-track velocities is about 1.5. Since this is less than 3, it implies anisotropic or ageostrophic motions. (See also Callies and Ferrari, 2013; Wang et al, 2010.)

For scales smaller than 40 km, spectra flatten out, and cross-track and along-track spectra converge, consistent with horizontally divergent motions (e.g. tides and internal waves.)

The Helmholtz decomposition splits flow into non-divergent and irrotational parts (Bühler et al, 2014). The non-divergent part dominates for large scales, but not for small scales.

4. Model Consistent with ADCP

Wavenumber spectra from model output are consistent with ADCP data. Using model data, we can average in time (dashed lines) to suppress effects due to tides and internal waves. This suppresses spectral flattening at high wavenumbers.

5. Model SSH: Spectral Flattening

Wavenumber spectra for model sea surface height are between $k^{-2}$ and $k^{-3}$ at low wavenumbers, consistent with kinetic energy spectra. Spectra flatten markedly at high wavenumbers. This flattening is suppressed by daily averaging (dashed lines) to minimize impact of tides and internal waves.

6. Altimeter Spectra: Noise Floor

AltiKa sea surface height spectra are consistent with model output at low wavenumbers. Spectral flattening from 40-4 km is associated with small-scale noise. Spectral flattening for scales smaller than 4 km is from multiple looks at the same patch of water, so represents instrument noise.

7. Conclusions

- ADCP, altimeter, and model provide a consistent view of spectral slopes, with QG-like behavior for larger length-scales and spectral flattening for smaller scales.
- Decomposition indicates a transition from non-divergent to irrotational behavior at about 40 km.
- Small-scale irrotational motions appear to be dominated by internal waves.
- Further details, Rocha et al. On the horizontal wavenumber spectra in Drake Passage: The 10-200 km range, in prep for JPO, 2015