Characterizing wavenumber spectra in altimetry: An ADCP perspective

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Introduction

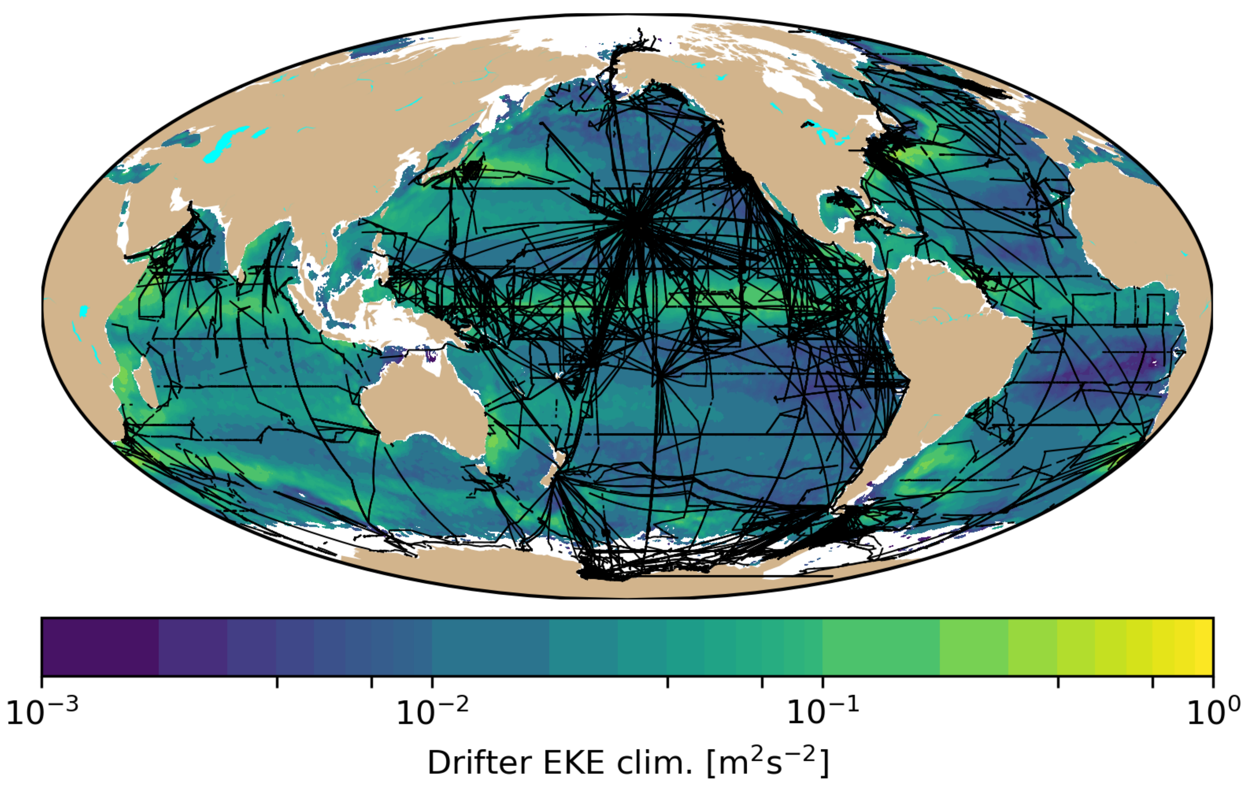


Fig. 1: Ship tracks with underway **ADCP** data post-processed from the **JAS-ADCP** archive. After additional QC the zonal and meridional currents are rotated into **cross**-track and **along**-track components to produce kinetic energy **KE** spectra consistent with input requirements of the **1D Helmholtz decomposition** (Buhler et al 2014).

Helmholtz decomposition

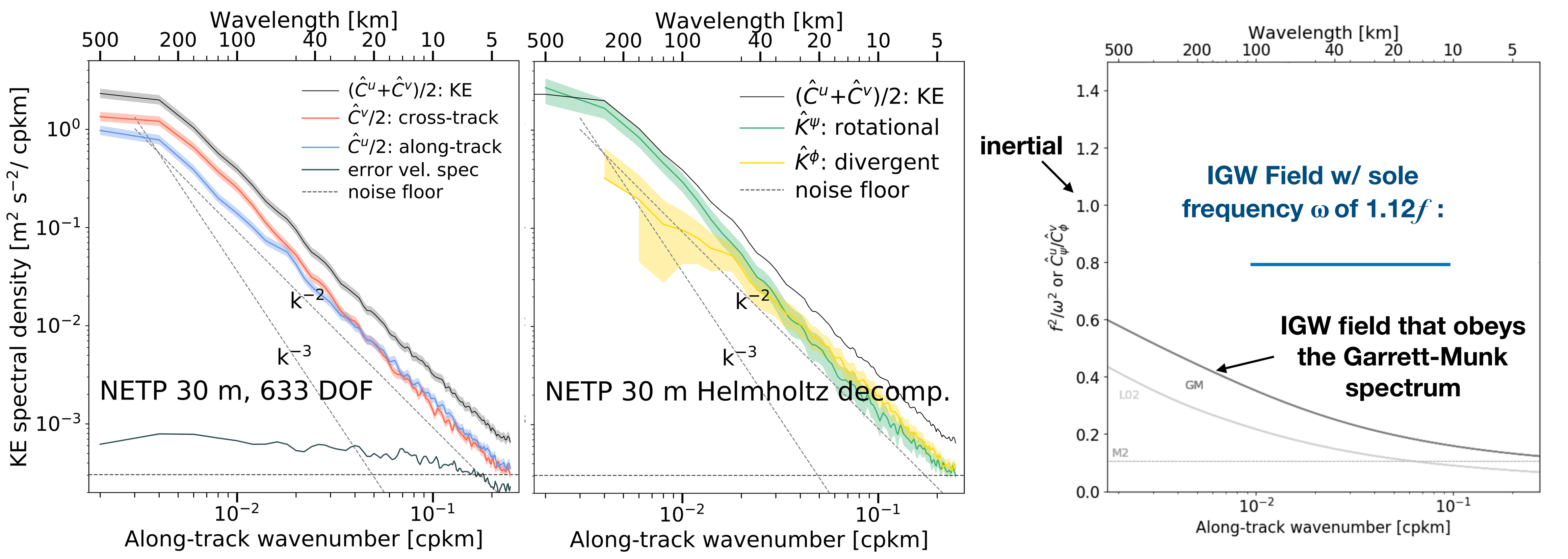


Fig. 2: Example **KE** spectra for ADCP data collected in the northeast tropical Pacific (NETP). (a) total KE, **cross**- and **along**-track components; Helmholtz KE decomposition into **rotational** (geostrophic) and **divergent** (ageostrophic) components. Assumes isotropy. (c) Ratio of rotational/divergent energies can be interpreted as an inverse frequency. Grey lines show model predictions for ratio: **GM** for the Garrett-Munk model (Garret and Munk, 1972), **L02** for the Levine (2002) version of GM and **M2** stands for an M2 mono-frequency internal tide.

KE spectra in 4 key regions

In the interior gyre regions (STNEP, NETP, SETP) the KE spectra are similar but differ in the ratio of rotational to divergent and its depth dependence. In the SETP (Fig. 5) divergence dominates scales less than 150-100 km. The Pacific southern ocean (Fig. 6) is a sharp contrast to this and all other areas.

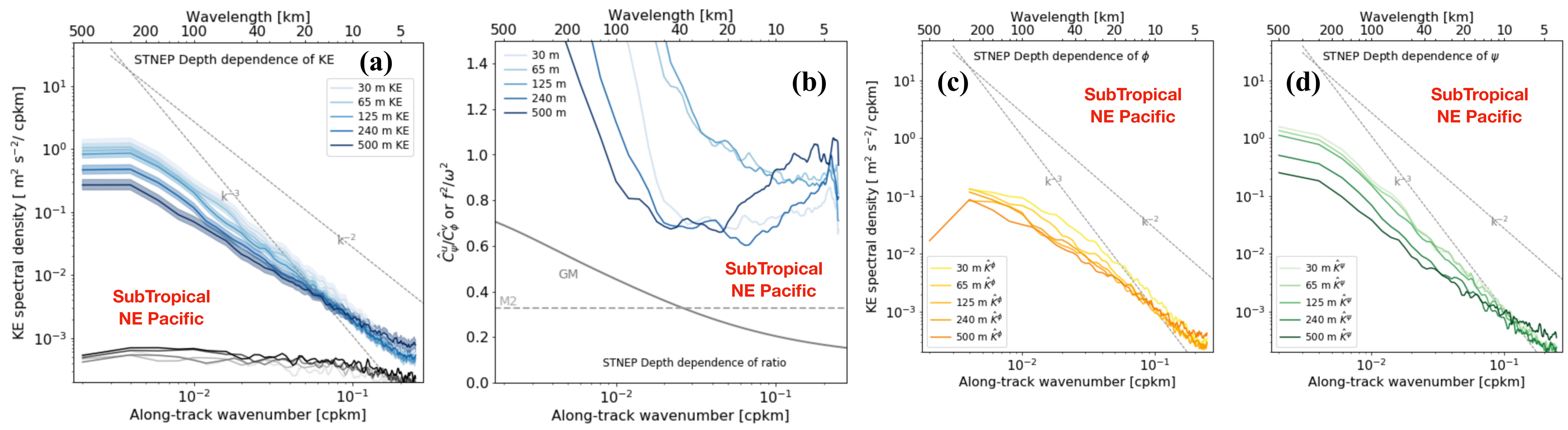


Fig. 3 (above): Depth structure of the KE spectra (a) and the ratio of rotational to divergence (b) in the **STNEP**. (c)-(d) Helmholtz decomposition. **Note that the divergence varies less with depth than the rotational. This is common to all regions.**

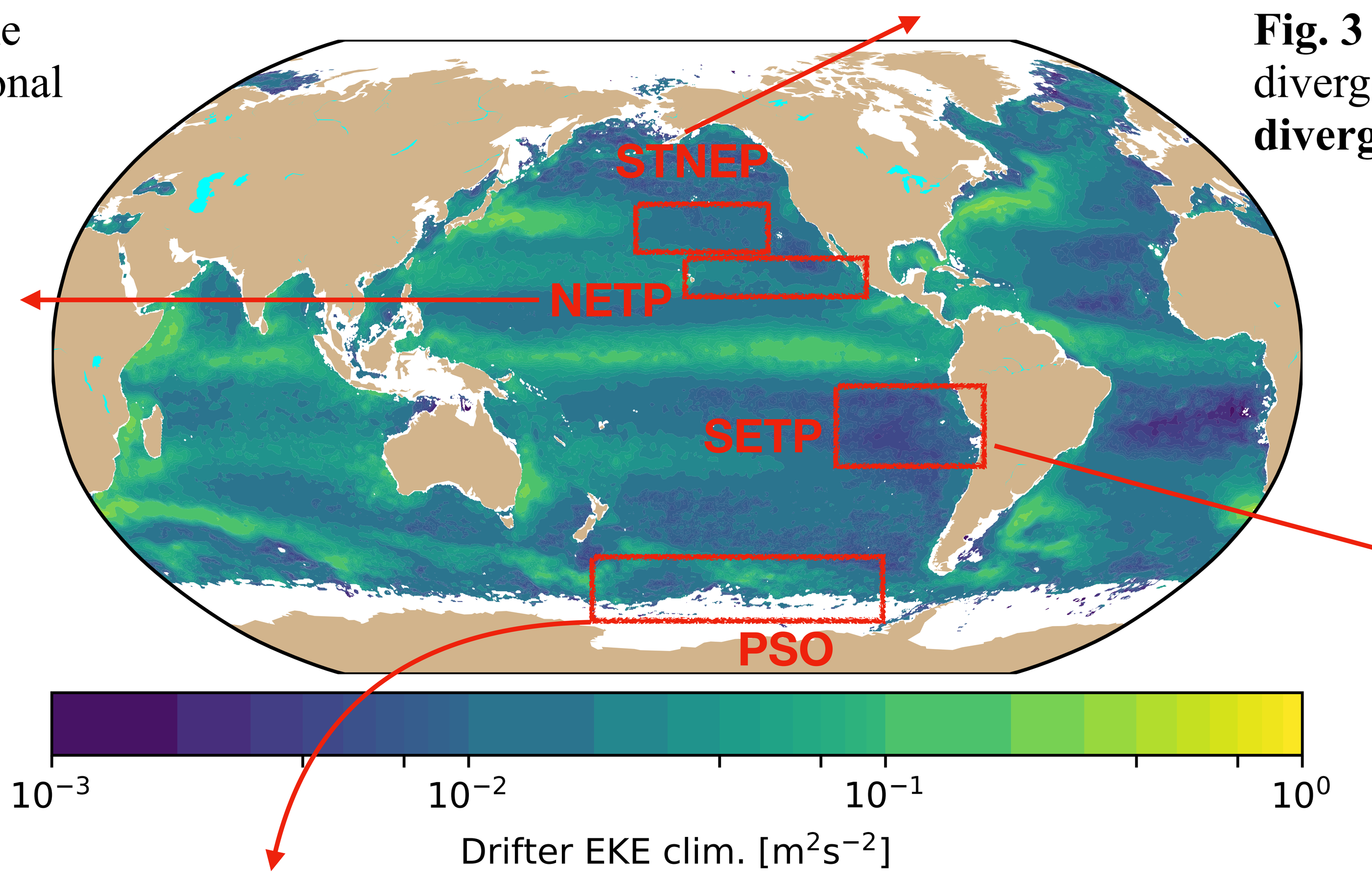
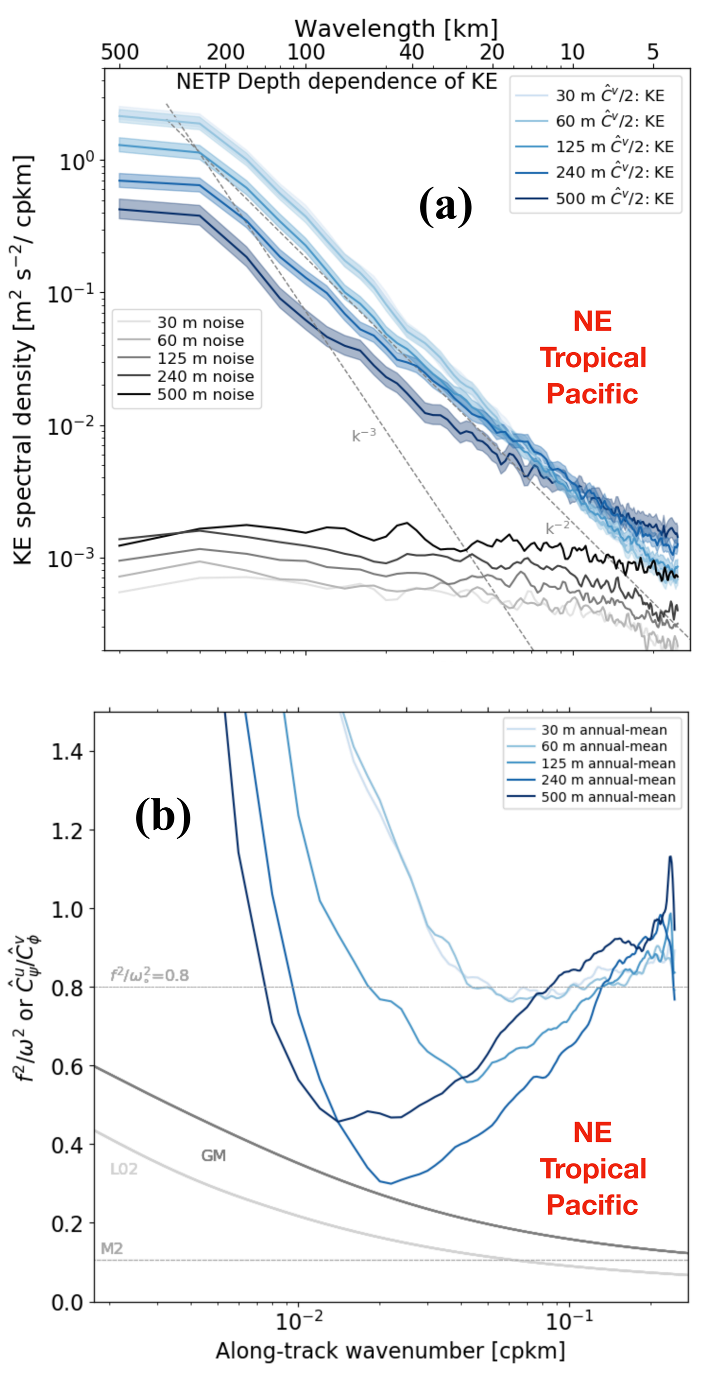


Fig. 4 (below): Depth structure of the KE spectra (a) and the ratio of rotational to divergence (b) in the **NETP**.



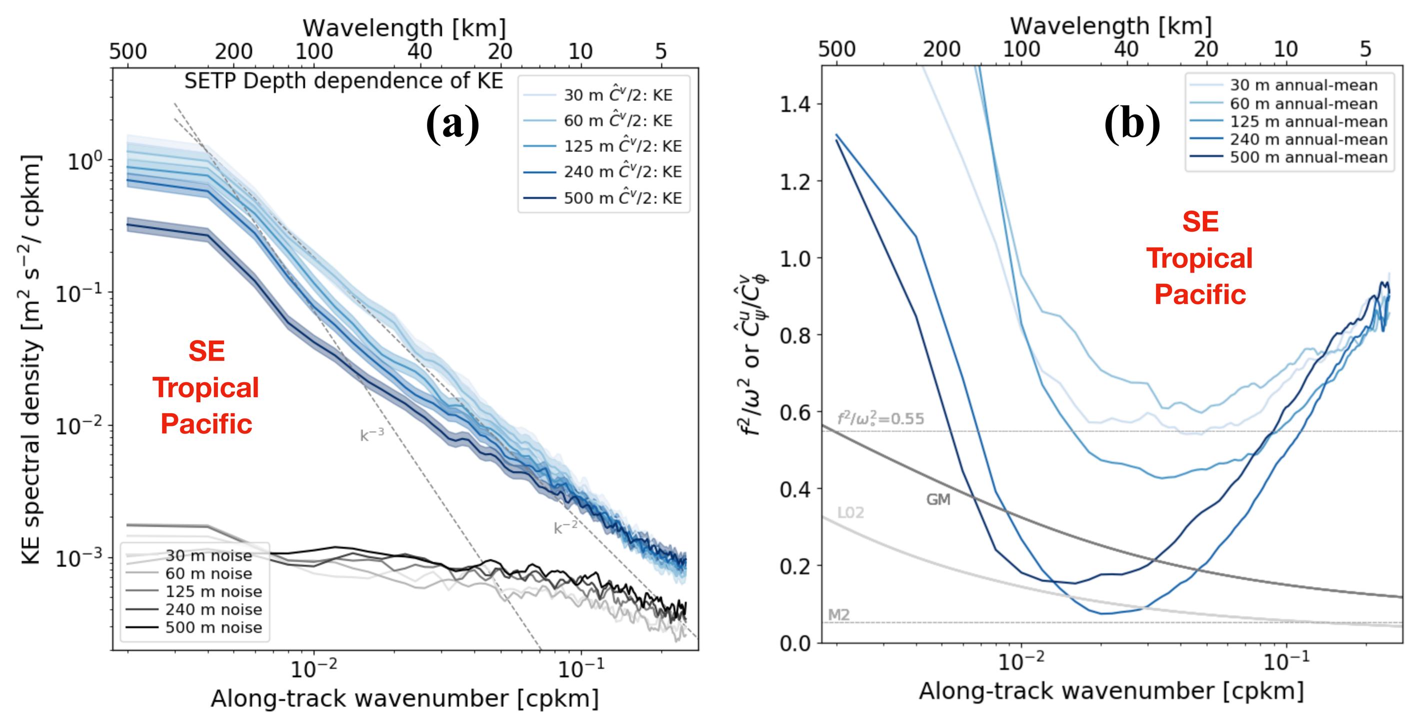
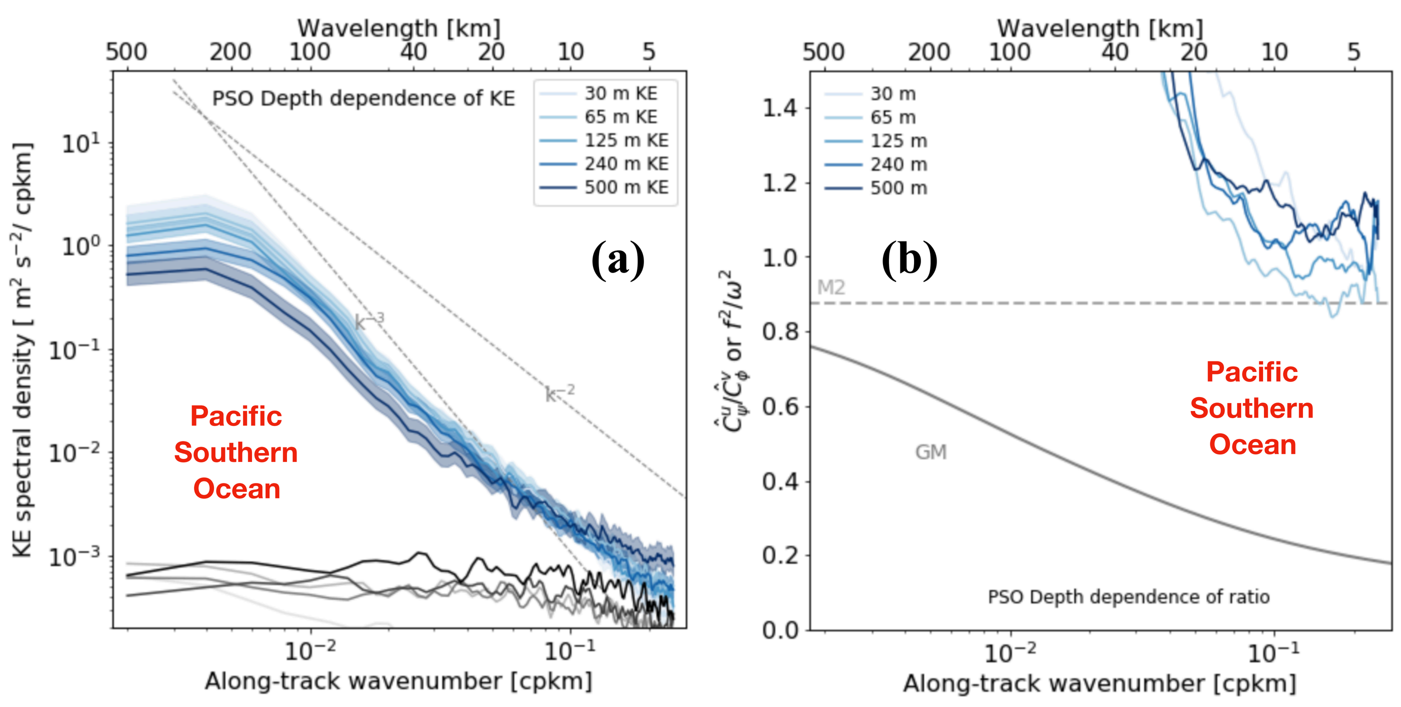


Fig. 5 (above): Depth structure of the KE spectra (a) and the ratio of rotational to divergence in the **SETP**.



Some of these results & methods are in Soares et al 2022 JPO https://doi.org/10.1175/JPO-D-21-0139.1

Fig. 6 (left): Depth structure of the KE spectra (a) and the ratio of rotational to divergence (b) in the **PSO**. **This region has the lowest levels of divergent energy.**

Rossby number

The number R_o is a proxy for the timescale of the submesocale eddies. It is at most O(10^{-1}) in all regions, due to submesoscale eddy velocities being ~5 cm/s. This implies that quasi-geostrophy and long timescales of evolution for the eddy field and that divergence is dominated by waves.

Internal wave SSH signal

The signal is estimated through the use of the GM internal wave model to determine and then convert the wave KE to SSH (Fig. 8). The conditions to do this are only met in the SETP.

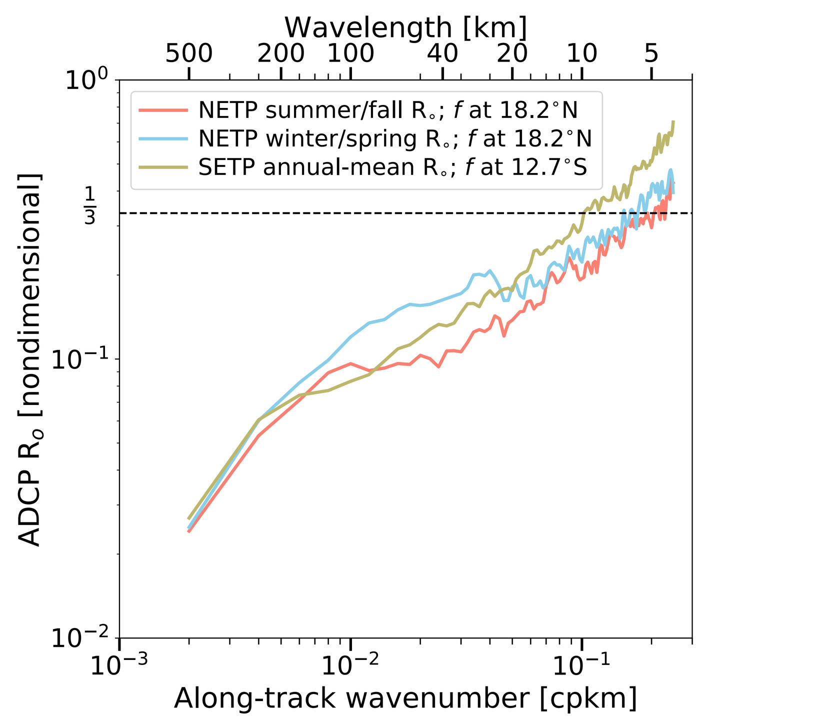


Fig. 7: Surface Rossby number per scale at the select regions. It is lower at higher latitudes. Assumes all the rotational KE is eddy KE.

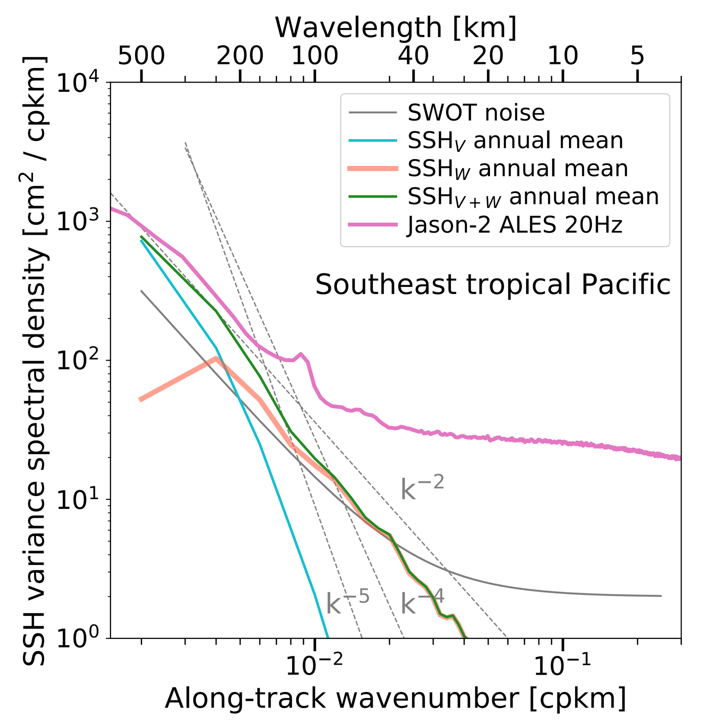


Fig. 8: SSH spectra in the SETP from Jason 2 ALES reprocessed vs. the SSH inferred from ADCP analysis and its components (V:eddy, W:waves).

Key points

Divergent (wave) energy dominates the submesoscales (< 100 km) in the tropics but not as much elsewhere.

The internal wave field appears to be much more near-inertial given the high ratios of rotational/divergence. In the SETP where the waves are most energetic and closer to the GM levels, we estimate that the wave SSH signal is near or below the SWOT noise floor.