Monitoring the tropical ocean: the importance of small vertical scale velocity features

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Abstract

The tropical oceans are our best monitored regions of the World's Oceans. The observing arrays have been designed to capture the basin–wide variations in the velocity and tracer fields. Here we present recent measurements of the velocity field in the Pacific Ocean. We argue that the present observing system misses a sizable fraction of the structure of the velocity field which potentially contributes significantly to ocean mixing. Figure 1 (upper panel) shows the zonal component of velocity along 156°E measured using a high (600kHz) lowered ADCP. A striking aspect of the flow shown is the numerous small vertical scale features superimposed on the major currents. The strength of the small vertical scale features is such that the cores of the EUC and NECC are split into multiple maxima.

Figure 1 (lower panel) shows the data after a high–pass filter has been applied in the vertical and then plotted on constant potential density surfaces at the mean depth of the individual surfaces. Numerous small vertical scale features (SVSs) are present across the width of the section. A number of these features are seen to stretch over more than one sampling location with some being in excess of 100km. Shear spectra averaged over a number of latitudes

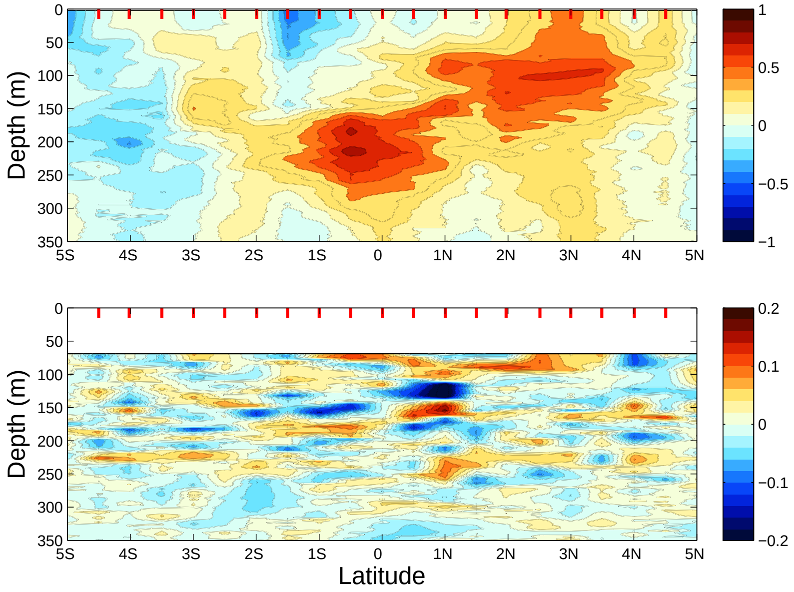

Figure 1: Upper panel: The zonal component of velocity measured by a high frequency (600kHz) LADCP along 156°E in July 2008 from the R/V Mirai. Units: ms^{-1}. Lower panel: The same data after a high-pass filter has been applied in the vertical. The data are plotted on constant potential density surfaces at the mean height of individual density surfaces. Units: ms^{-1}. The red lines at the top of each panel indicate the location of individual profiles.

are shown in Figure 2. Distinct peaks in the shear spectra are seen at vertical wavenumbers ranging from 15-50m. For comparison the spectrum from a moored 150kHz ADCP is also shown. The lower frequency ADCP does not capture the smaller scale features. Potential causes of the SVSs include instability of the current system through inertial and parametric subharmonic instabilities and direct forcing by the wind.

The amplitude of the SVSs is such as to suggest they contribute significantly to both lateral and vertical mixing. The implication is that mixing is controlled by factors other than the shear of the larger scale currents. Little is known, however, of the temporal and spatial variations of the properties of these small scale features and their potential contribution

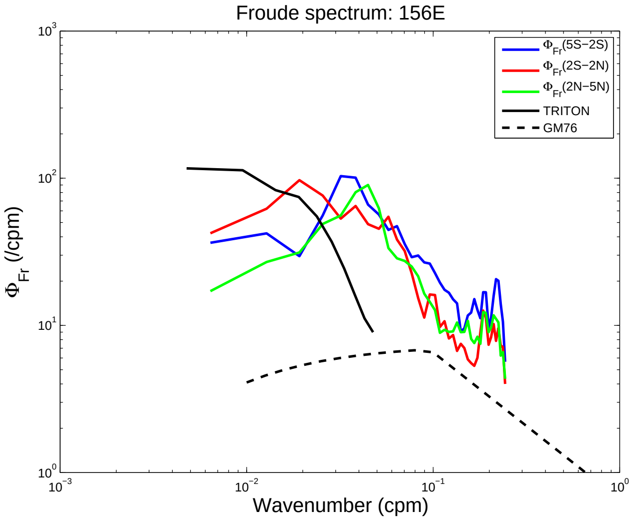

Figure 2: Vertical wavenumber Froude spectra, Φ_{Fr}, (the shear spectrum normalized with the buoyancy frequency) for three latitudinal bands along 156°E for velocity shear data between 100–250m depth. Spectra from individual profiles have been averaged over the latitudinal bands: 5°S–2°S, 2°S–2°N and 2°N–5°N. For comparison the spectrum from a moored 150kHZ ADCP at the equator and same longitude is shown, as well as the Garrett and Munk spectrum

to scale-interactions linking mixing scales to basin-scale dynamics. We propose a series of process studies focussed on elucidating the properties and impact of SVSs combined with a larger scale monitoring. Because of its ease of operation, a lowered high frequency ADCP could be made a part of routine measurements that are at present made in conjunction with maintenance of the tropical arrays.