Introduction

Historical current meter records have been analyzed to test predictions of the role of Parametric Sub-harmonic Instability (PSI) in redistributing semi-diurnal internal tide energy to other frequency bands. The internal tides were deemed nadir-like in the region of interest and therefore the documented absence of non-linear internal tides. The near-inertial bands were found to be the most energetic, and PSI may also act quickly on the semi-diurnal tides. Additionally, no peak in the near-inertial band significantly exceeds the M2 tidal peak amplitude, as expected with the semi-diurnal tide along the critical latitudes.

We have examined historical current meter records dating back to 1974 that were collected in the latitude band 26.5° to 42° north or south of the equator, with currents collected in 24 distinct geographic locations and consist of 11 to 40 years of data. In conjunction with the analysis of global internal tide generation model, we have quantified the dependence of near-inertial energy in the Western Pacific on a latitude range of 45°S to 25°N over about 60 years. Our findings are as follows:

- The data strongly rule out the prediction of a strong PSI-induced M2 sub-harmonic at its critical latitude or at any other latitude, however, the data distribution is not ideal to rule out other non-linear processes.
- At the very least, the data eliminates the difficulties that will be encountered in attempting to observe the PSI-generated M2 sub-harmonic, e.g., determination of PSI naturally occurring variability from the band edge frequencies.

One way to assess whether internal tides have an impact on the energy at the M2/2 frequency is at that specific frequency to examine the energy spectrally averaged during the entire frequency band of the PSI mechanisms. If the PSI mechanism is strong, we should see a current-generated energy in the inertial band at the critical latitude, but no contribution from PSI to inertial energy at other latitudes. Hence, without the ability to calculate vertical shear, we may have missed an opportunity to identify the presence of PSI-induced sub-harmonics. Additionally, the peak is a consequence of the semi-diurnal tide which is acting to transfer energy from the internal tides to the near-inertial M2/2 frequency. The upper ocean records show the M2/2 frequency has a shallow well near 33 degrees, and the data is not inconsistent with that. Certainly, the critical latitude for M2/2 (29.5°S) does not stand out as having linearly high inertial peak, contrary to the expectation of PSI may transferring internal tide energy to its sub-harmonic frequency M2/2.

The observational problem is exacerbated by the possibility of multiple processes transferring energy within the near inertial band, and between the inertial and lower frequencies. The observational problem is exacerbated by the possibility of multiple processes transferring energy within the near inertial band, and between the inertial and lower frequencies.

A Search for PSI-Induced Sub-Harmonics of the Semi-diurnal Internal Tide at Critical Latitudes in the Open Ocean

Figure 6: Locations of mooring included in this study. Black crosses represent records near the critical latitude for PSI. Colored markers correspond to records used in the PSD vs Latitude Fig.

Summary and Cautions

Figure 2: Since near-inertial waves have very small vertical displacements, the presence of tidally oscillated sub-harmonics at M2/2 (slightly above the inertial frequency) may be more distinguishable from the slightly lower frequency sub-harmonics, near-inertial waves in temperature PSD than in current PSD. However, examination of temperature PSD from the previously mentioned datasets revealed no significant peaks at the M2/2 frequency. Since we present an average of temperature PSD from nine records with depth near 700m (from the same instruments that provided the PSD in Fig. 1). There is no peak detected at the expected M2/2 frequency.

Figure 3: In this figure the PSD is a very narrow bandwidth centered on the M2/2 frequency, compared with the broadband PSD of the M2 internal tide. The records used have been restricted to be in the latitude band 26.5° to 30.4° north or south of the equator. The currents have been appropriately normalized (WKB scaling) with the local buoyancy frequency (WOA '02). We observe no significant M2/2 frequency peaks in the observed inertial PSD. The only records in the latitude band 29.6° to 29.8° east or south of the equator are used; records below 1000m are indicated in black symbols and those above 1000m in red, and all currents have been appropriately normalized (WKB scaling) with the local buoyancy frequency (WOA '02). We observe that the deep ocean records lack rather coherent inertial internal tide energy contributions to near-inertial band, as PSI is not acting to transfer energy from the inertial tides to the near-inertial M2/2 frequency.

Figure 5: One way to assess whether internal tides have an impact on the energy at the M2/2 frequency is to compute the energy at that specific frequency to examine the energy spectrally averaged during the entire frequency band. However, examination of temperature PSD from the previously mentioned datasets revealed no significant peaks at the M2/2 frequency. Since we present an average of temperature PSD from nine records with depth near 700m (from the same instruments that provided the PSD in Fig. 1). There is no peak detected at the expected M2/2 frequency.