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SUPPLEMENTARY MATERIAL: Spatial and temporal variability in nutrients and carbon uptake during 2004 and 2005 in the eastern equatorial Pacific Ocean

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Abstract

This supplementary material includes 4 Figures (S1, S2, S3, S4) and an associated description of presented results.

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1 Periodograms

In order to verify the presence and relative contribution of TIW-scale events to observed patterns of variability in physical and biological fields, we analyze power density spectra of detrended 2004–2005 three-day time series of key physical and biological model variables at two locations: (i) 125° W and 0° N, and (ii) 125° W and 2° N (Fig. 1 to Fig. 4). Both locations represent good case studies for investigating the effect of TIW activity on biological production. For example, during the EB04 cruise Parker et al. (2011) classified 125° W, 0° N as a 'biological hotspot' characterized with exceptionally high nutrient uptake rates and diatom biomass in the wake of a passing TIW. At 2° N, further away from the center of equatorial upwelling, TIW signatures are generally more visible in the physical and biogeochemical fields (Chelton et al., 2001; Vichi et al., 2008; Evans et al., 2009). Climatological hydrographic conditions along 125° W vary little if at all compared to the 120° W along which Vichi et al. (2008) chose their TIW case studies.

Power density spectra in Fig. 1 reveal that not all variables have a marked or dominant peak
¹⁵ within the 20–35 period window said to be dominated by TIW activity. In that period window, there is one broad peak in SST coinciding with that of surface Si(OH)₄ concentration confirming strong 20-35 day oscillations in both fields. There are no distinct peaks in the vertical flux of Si(OH)₄ at 75 m depth, especially when compared to large amplitudes in the high frequency end of the spectrum. Regardless, it appears that the frequency distribution of this flux is well
²⁰ correlated with that of vertical velocity and not Si(OH)₄ concentration at 75 m depth. On the contrary, at the low frequency end, beyond 100 days period, it is the Si(OH)₄ concentration at depth that seems to determine the shape of the nutrient flux distribution. In fact, it is the low frequency end that holds the largest contribution to the spectra for all parameters except vertical velocity. This confirms that at 0° N it is the seasonal variability in equatorial upwelling that

At 2° N the power density spectra are clearly dominated by variability in the 20–35 day period (Fig. 2). Large peaks in SST and surface $Si(OH)_4$ are coincident with each other and also with their respective 20–35 day peaks from 0° N. Vertical flux of $Si(OH)_4$ at 75 m depth is again well

correlated with vertical velocity and not linked to $Si(OH)_4$ concentration at depth. The 20–35 day signature is now the strongest across the entire spectrum. Still, we expect the 20–35 day variability to be affected by seasonality in TIW intensity (e.g., Vichi et al., 2008; Evans et al., 2009). Our results are consistent with known signatures of TIWs in this region and provide further evaluation of model performance with respect to capturing the physical dynamics due to TIWs.

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Lack of TIW-scale signature in the $Si(OH)_4$ concentration at depth may suggest that vertical velocity is a good enough proxy for estimating vertical flux of this nutrient when considering the effect of TIWs. This is consistent with the fact that deep water nutrient concentrations generally respond to longer than intra-seasonal basin-scale changes in sources and circulation (Dugdale et al., 2002).

In Fig. 3 we show the 0° N spectra of biological fluxes in order to compare them with the physical ones. There are marked peaks in depth-integrated PP, $\rho Si(OH)_4$, S2 and ZZ2 biomass in the 20–35 day window. The location of peaks is coincident with peaks in SST and surface

- ¹⁵ Si(OH)₄ but is difficult to match with the distribution of w or vertical flux of Si(OH)₄ (Fig. 1). While most of variability in PP can be attributed to lower frequency, seasonal and longer oscillations, S2 and ZZ2 biomass seem to respond most strongly to episodes with the frequency related to TIW events. This observation is consistent with the episodical shifts in EEP phytoplankton composition that is on average dominated by S1 (Chavez, 1989; Balch et al., 2011;
- ²⁰ Parker et al., 2011). The power spectrum at 2° N is similar but appears to be shifted towards the lower end of the frequency range (Fig. 4). Main peaks in S2, ρ Si(OH)₄ and PP match well with the peaks in vertical flux of Si(OH)₄ and surface Si(OH)₄ concentration. Highest amplitude in ZZ2 variability is now just left of the 20–35 day window suggesting that perhaps not all TIW events can stimulate a visible shift in mesozooplankton biomass.

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Fig. 1. Periodograms (power density spectrum vs period) from 2004–2005 time series at 125° W at 0° N plotted for all low frequency components with periods larger than 10 days. Dotted square boxes mark the 20–35 day period window characteristic for TIWs and used to filter the model SST and vertical velocity fields. Parameters plotted from top to bottom are: SST, *w* at 75 m depth, vertical flux of Si(OH)₄ at 75m depth, Si(OH)₄ concentration at 75 m depth and surface Si(OH)₄ concentration

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SST 0.1 0.05 ok 2 Γ × 10⁻³ W at 75m _ W*Si(OH)₄ at 75m 0.2 0.1 Si(OH)₄ at 75m Si(OH)₄ at 0m 0.1 0.05 period [days]

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Fig. 2. Same as in Fig. 1 but at 2° N.

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Fig. 3. Same as in Figure 1 but periodograms are constructed for biological fields. Parameters plotted from top to bottom are: PP, ρ Si(OH)₄, S2 and ZZ2 biomass.



