Interannual variation in phytoplankton concentration and community composition in the Pacific Ocean

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Phytoplankton, the first level of the food chain, decrease in abundance during El Niño events coinciding with the collapse of fisheries in the Pacific Ocean. Very little is known about the spatial and temporal extent El Niño and La Niña events have on the phytoplankton composition in the temperate Pacific. Here we show that these events have the greatest impact on the phytoplankton community in the Equatorial Pacific producing a radical shift in community structure. These results provide a first line of evidence on how climate variability affects the phytoplankton community structure and may therefore alter the recruitment of higher trophic levels at a basin scale in the temperate Pacific Ocean.

Methods

The effect of climate variability on the biogeochemistry of the Pacific Ocean was evaluated using time-series of biological observations and space-based platforms (Modis and SeaWiFS) combined with an existing biogeochemical model (Fig. 1).

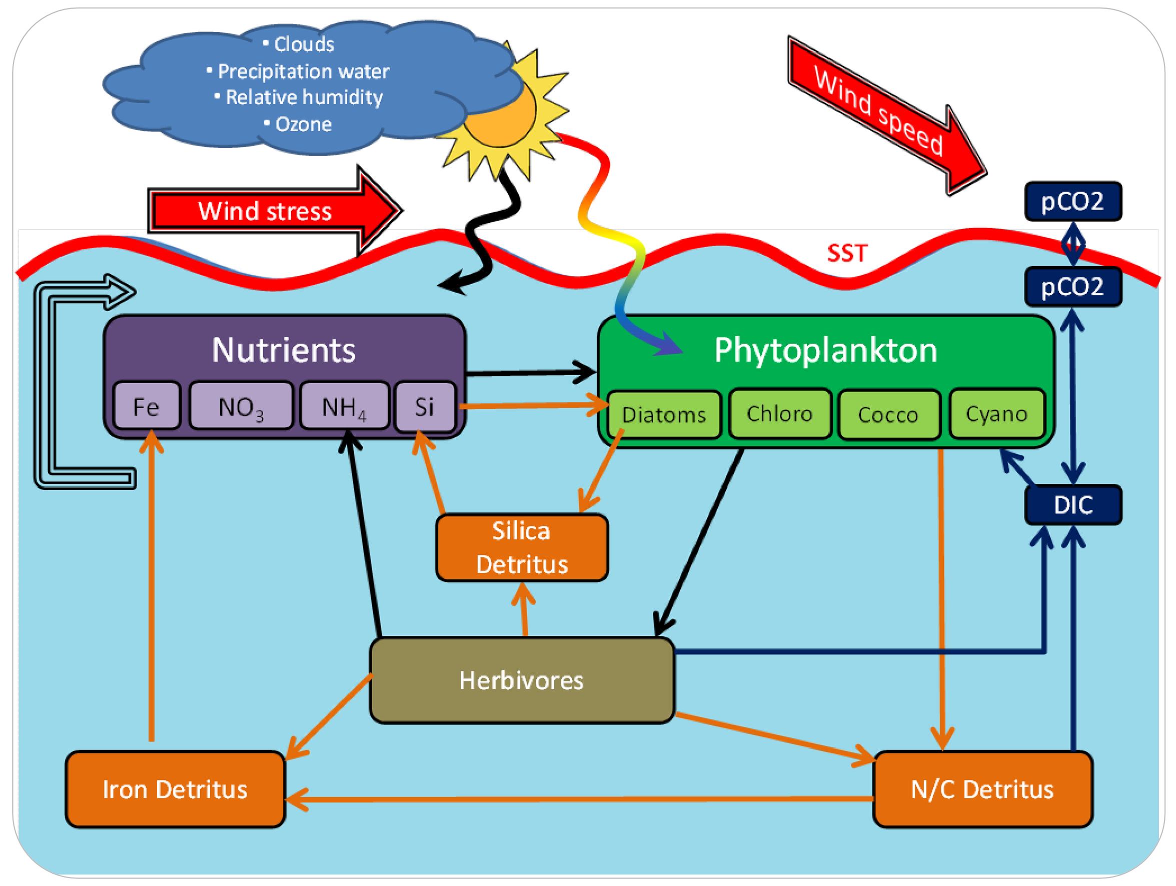

Fig. 1: Interactions among the main component of NOBM, nominal input and forcing fields.

Results : Temporal variation

The link between biology and the physical oscillation was most evident in the Equatorial Pacific: nitrate, total chlorophyll, and every phytoplankton group but one was strongly correlated with MEI ($p<0.01$).

In the Equatorial Pacific, the link between MEI and the phytoplankton community structure was through the fluctuation in nitrate concentration. The correlation between cyanobacteria and nitrate and coccolithophores and nitrate, were consistent with their abilities to survive in low nutrients (*1, 2*). The start of 1998 (El Niño conditions) was characterized by low nitrate (Fig. 2). At the same time, cyanobacteria reached their maximum concentration as diatom concentrations reached their lowest value.

In general, the output from the model agreed with historical in situ (*e.g. 3, 4*) and satellite (*5, 6*) observations of the effects El Niño and La Niña events have on the phytoplankton community.

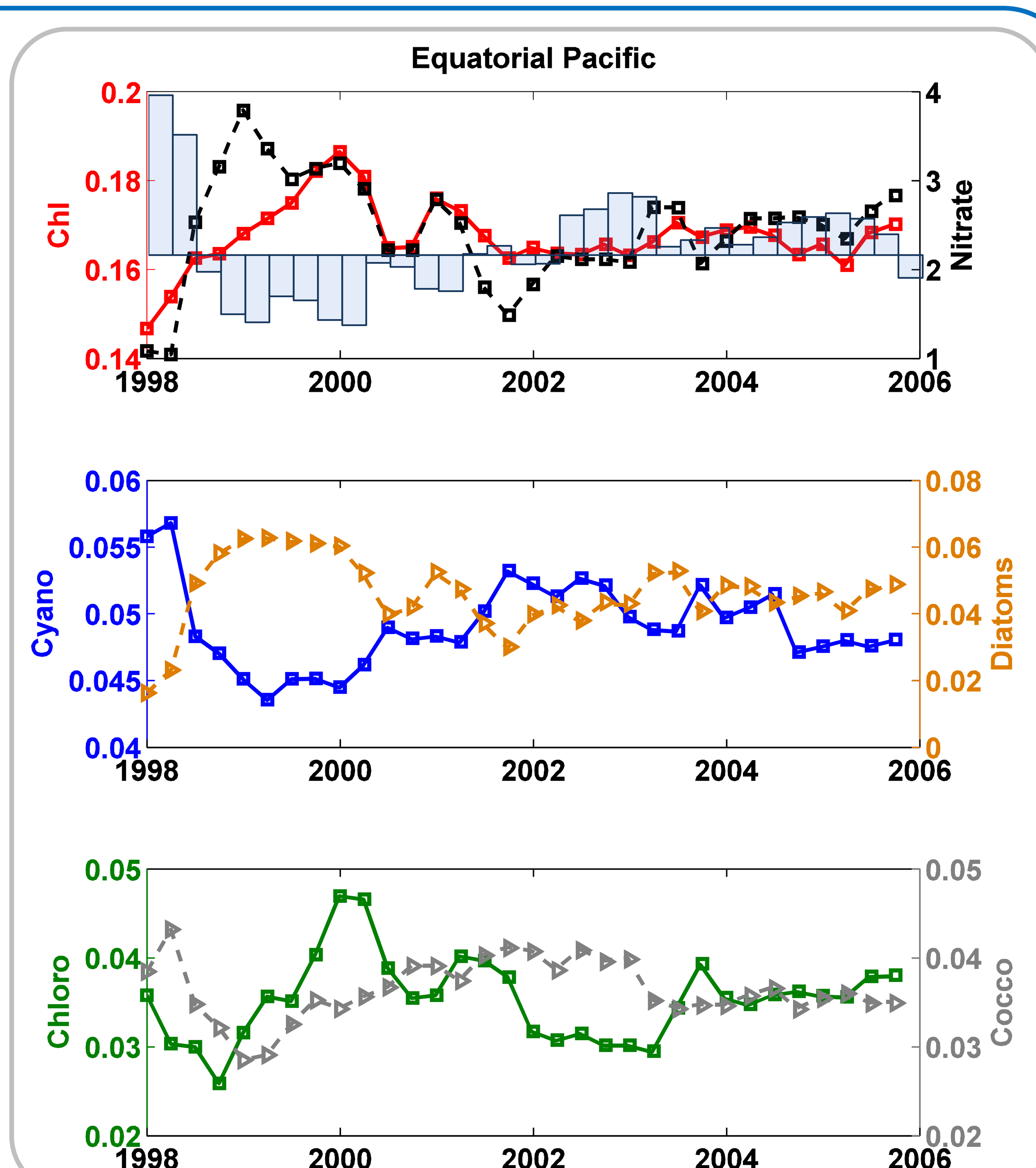

Fig. 2: Equatorial Pacific Ocean: Seasonal average (JFM, detrended, seasonal climatology removed and average added) of (a) chlorophyll *a* concentration (mg chl *a* m^{-3}) and of nitrate concentration (μM). Shaded bar represent the MEI. (b) Abundance of cyanobacteria and diatoms from NOBM (mg chl *a* m^{-3}). (c) Abundance of chlorophytes and coccolithophores from NOBM (mg chl *a* m^{-3}).

Results : Spatial variation

The spatial pattern shifts were especially notable for the phytoplankton functional extremes: diatoms and cyanobacteria (Fig. 3).

During El Niño events, cyanobacteria were predominant in the tropical Pacific Ocean. Diatoms, in contrast, were restricted to the extreme eastern edge of the equatorial Pacific. During La Niña events, when the upwelling was restored and nutrients replenished, diatoms expanded westward to the date line along the cold tongue while cyanobacteria retreated to the gyres and the extreme western portion of the tropical Pacific.

In the Equatorial Pacific, chlorophytes responded positively (r=--0.74, $p<0.05$) to La Niña conditions by increasing just north and south of the equatorial cold tongue and east of 160°W. During La Niña events, coccolithophores occupied the western edge of the cold tongue. During El Niño, coccolithophores expanded eastward along a narrow band in the Equatorial Pacific.

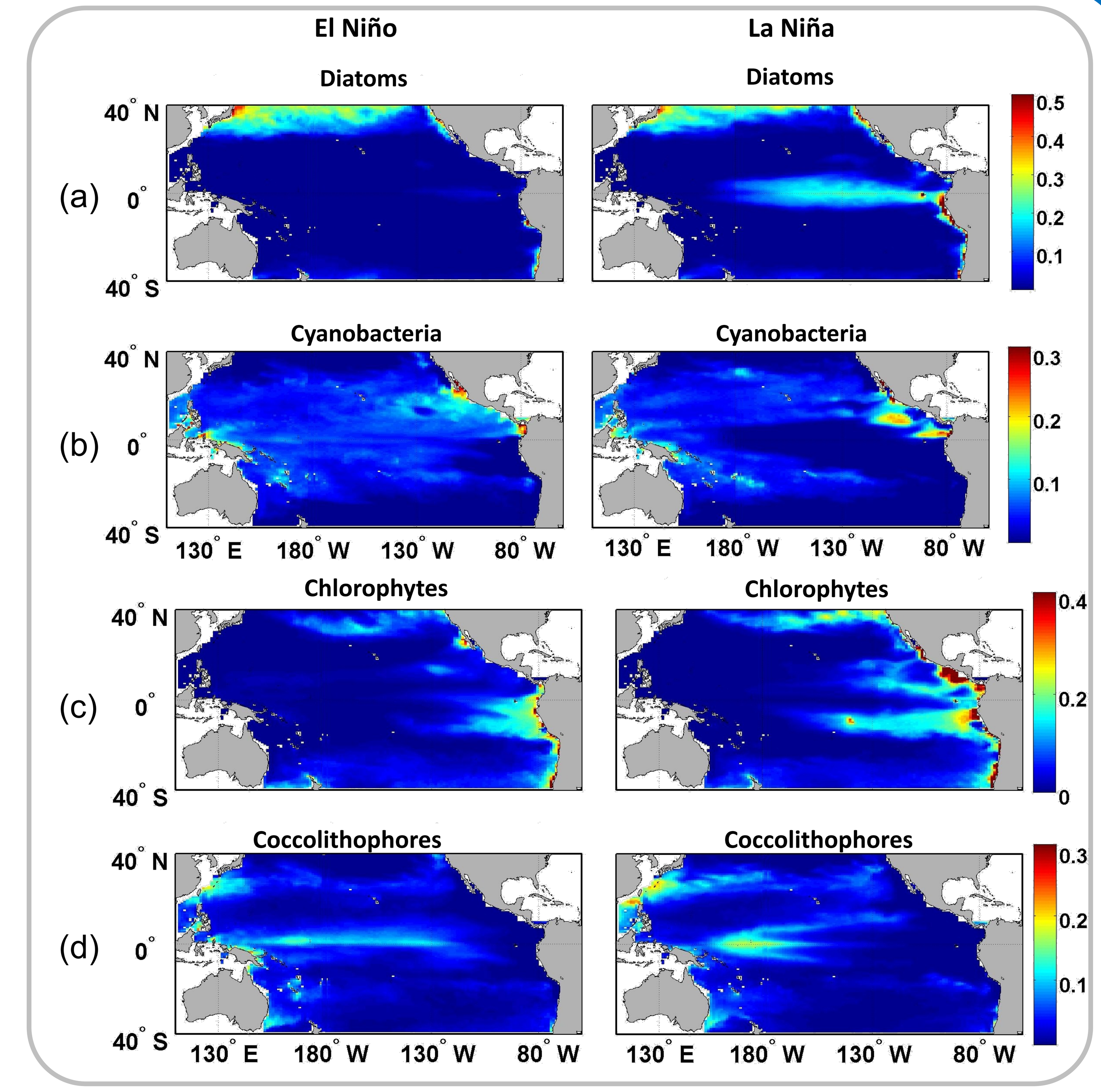

Fig. 3: Effect of climate variability on concentration (mg chl *a* m^{-3}) of (a) diatoms, (b) cyanobacteria, (c) chlorophytes and (d) coccolithophores during El Niño (January-March 1998) and La Niña events (January-March 2000).

Conclusions

The effect of climate variability on phytoplankton community composition showed radical shifts, as shown in an idealized conceptual diagram derived from the results (Fig. 4, spatial distributions of phytoplankton concentrations are provided in Fig. 3). This shift in the phytoplankton composition has implications for the oceanic carbon cycle. A phytoplankton community dominated by the fast-growing, usually large, diatoms can lead to increasing sinking rate and transfer of carbon to deeper waters and to higher trophic levels.

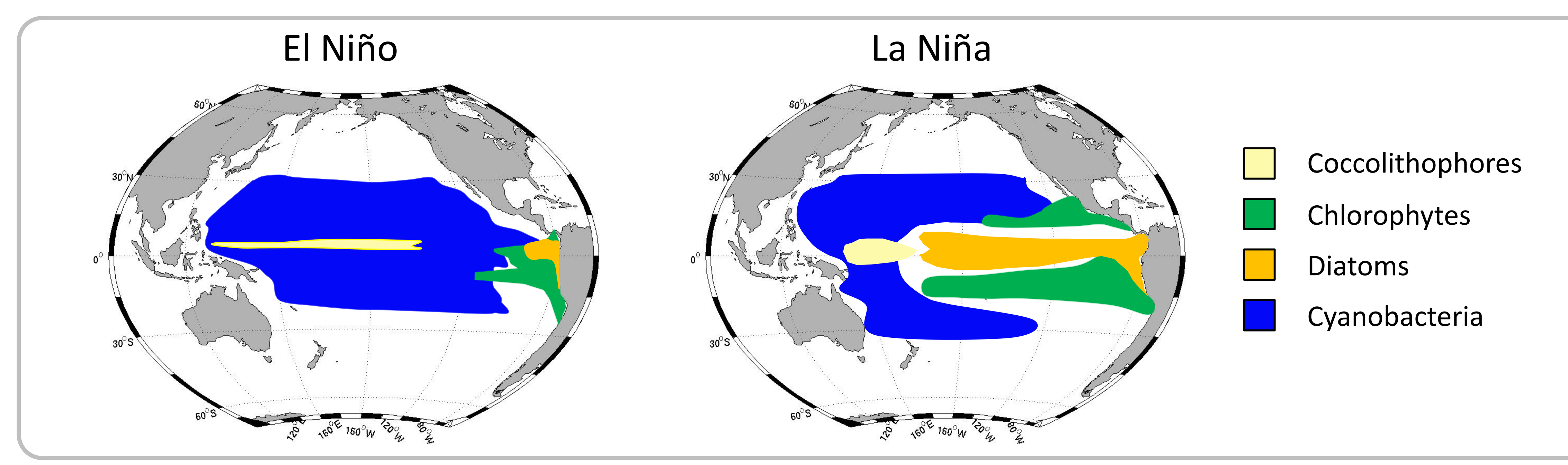

Fig.4: Conceptual description of the effect climate variability has on the distribution of phytoplankton community structure in the Pacific Ocean. An average for JFM 1998 was used as representative of El Niño conditions and an average for JFM 2000 was used as for La Niña. The spatial patterns loosely approximate predominance, except for coccolithophores where presence is depicted because they are rarely predominant.

Acknowledgments

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