<u>Author's responses to the Reviewer 1</u>

We acknowledge the positive and constructive criticisms made by the reviewer 1 which had helped making this manuscript much better. As detailed in the following pages, we agree with all the main suggestions made by the reviewer 1, and explain the few cases in which we were not able to follow some aspects of her/his suggestions.

This reviewer suggested significant and major changes in the manuscript.

Reviewer 1:

1) Unfortunately, the documentation of the results and the treatment of the data in the discussion over reach what can be derived from this data set. In addition, the paper suffers other flaws in regards to inadequate figures, and the lack of incorporation of important concepts from prior work on growth constraints on alkenone producers. For example: An informed treatment of seasonality and depth of growth from water column work and sediment traps would have greatly informed the analysis and interpretation of the data.

Re: We agree. All figures (1, 2 and 3) in the manuscript were modified. On the linear regressions results (new figure) were included a treatment with depth water temperatures (mixed/isothermal layer and centre of thermocline) and seasonality (summer vs. winter). In order to derive annual/seasonal mean Isothermal Layer Depth (ILD) temperatures, ILD was defined as the depth in which the temperature departs ≤ 1.0ºC from the sea surface temperature (SST; 0m depth) according to latitudinal and annual/seasonal variability of ΔT (≤ 1.0ºC). We choose the best values of ΔT the correspondence between ILD and optimal definition of mixed layer depth (MLD) recommended by Kara et al. (2003). We constructed the ILD using the annual subsurface temperature data from the NOAA World Ocean Atlas 2001 (Conkright et al., 2002) for the eastern South Pacific (equator to 55ºS). We included this information, because we feel that it is relevant to understand where is imprinting the UK'37-signal (mixed-layer/thermocline), and when occur this processes (warm/cold season).

On the other hand, although we agree with the referee, we could not found published specific information on present-day (water column and/or surface sediments) about coccolithophorid species for the coastal ocean off Chile and Peru. There are only published information on coccolithophorids (as a group) fluxes at 30°S off Coquimbo (Marchant et al., 2004; Gonzalez et al., 2004) based on sediment trap studies. In these publications it is assumed that coccoliths are the most important contributors to the carbonate fluxes (~60% of the total carbonate flux), with their highest fluxes during early-spring to summer (August – December). In fact, the majority of coccoliths retained in the trap were from E. huxleyi and C. pelagicus,and with minor contribution of others species such as Gephyrocapsa oceanica, Pontosphaera syracusana, and Calcidiocus leptoporus (Gonzalez et al., 2004). On this basis, we could assume that the maximum alkenone-production occur during spring-summer periods after the very well know upwelling's diatom blooms, followed by the assumption that the low-alkenone production occurs during autumn-winter time. On the other hand, the alkenone-production depth is the other important factor that we now consider in our dataset interpretation. By the way, both seasonal and water column depth factors have been reported in previous sediment trap's works, demostrating that the most important alkenone exportation events occur in winter (minimum) and summer (maximum). Also, these studies showed that alkenone production occurs mainly below the mixed layer depending of the water column stability, i.e., winter vs. summer (e.g., Prahl et al., 2005). Although we have not sediment trap data from different contrasting periods (winter vs summer), we include in the discussion these topics at the new version.

2) The figures are inadequate, a map of the complex study location with the currents and topography (which from such an extensive part of the discussion)

Re: We agree. This issue will be included as a new figure (i.e., core-sites locations, topography, main surface currents, etc.) and oceanographic settings.

3) The documentation of where the samples actually come from in this complex region should, at a minimum be included.

Re: This information was included in the original Data Supplement (see data supplement: http://www.biogeosciences-discuss.net/7/545/2010/bgd-7-545-2010-supplement.pdf).

4) The initial treatment of the data is a presentation of the correlation coefficients of linear regressions against winter, summer and mean annual SST. This is presented without any attending data (or figures) that place the data in context. The goodness of fit of the UK-37 derived SSTs to any of these is an exercise in mathematics, and is not wholly relevant without an understanding of when and where the plankton grew.

Re: We agree. How we mentioned at point (1) we present the data treatment (depth water and seasonal temperatures) in the new figures. Also, we included the data interpretation in the discussion.

5) There is ample evidence that incorporating the seasonality of ACTUAL growth in any interpretation of goodness of fit is more important than using simple statistical fit in interpreting accuracy of alkenone SST [Prahl et al., 1993; Prahl et al., 2010; Sikes et al., 1997]. Export production is well documented to be at a minimum in the winter.

Re: We agree, although it is accepted that alkenone-temperatures on a global scale are closely related to the annual-SST (0-10m depth) (e.g., Müller et al., 1998), it is also known that alkenones can be produced at the subsurface chlorophyll maximum rather than in the surface mixed layer when the water column becomes stratified (e.g., Prahl et al., 1993; Sikes et al.,

2005). Thus, in a dynamic area like the Peru-Chile margin, where stratification is common in the summer and breaks down during upwelling (spring) and winter storms, we could assume that the alkenone production to be predominant in summer periods and below the mixed layer. Thus, according this evidence, we addressed our result analyses and discussions in two contrasting period (winter vs. summer), and water column depths (mixed/isothermal layer vs. thermocline).

6) Also essential in analyzing any sediment data set in a complex region is an understanding of possible inter-annual differences in the production [Müller and Fischer, 2001]. This is an important factor when the sedimentation rates are not known in the cores from which the analyses are based. The essential point here is that there is a disconnect from the relationships the authors are trying to draw from their sedimentary data which has an unknown time range with surface water conditions – temperature, nutrients, thermocline depth that will change with season and interannually. If the top centimeter represents 100 years – how relevant are the UK37 values to the data they are trying to make correlations with? These can have changed hugely over such time frames. This is an essential issue that the authors must address to establish the validity of the correlations and conclusions they have in the paper.

Re: We agree, this is an important issue and we have been very careful in using core tops which have been previously published in the study area (e.g., Romero and Hebbeln, 2003; Prahl et al., 2006).

Several published records along the Peru-Chile margin, have described that the sedimentation rates of near-surface sediments range around between 0.04 and >0.20 cm yr^{-1}, increasing successively southward off Chile (e.g., Hebbeln et al., 2001; Muñoz et al., 2004). This latitudinal pattern responses to different climate/oceanographic regimes, the resulting terrigenous/marine inputs, topography, winnowing, and also bioturbation effects (mixed layer thickness); factors that strongly determine if the near-surface sediments represent over the past hundred (e.g., sediments off Peru and northern Chile) or few thousand years because of winnowing and/or bioturbation effects (e.g., sediments off central Chile) (e.g., Hebbeln et al., 2001; Muñoz et al., 2004).

Although surface sediments may cover the last several hundred years of deposition, they are all of Holocene age, and thus can be considered suitable for the objectives of this study. In fact, the use of alkenone-based unsaturation-index has been vigorously employed to estimate the physical properties of water masses in paleoceanography (e.g Müller et al., 1998). Furthermore, this method is based upon the presumption that the C_{37}-alkenones compositions in coccolithophorids are determined by the temperature changes in the ambient water mass where coccolithophorids grew and thus, the difference in the unsaturation-index values from alkenones-producer species could serve as an effective monitor of the structure of the upper water column, like others paleoceanographic proxies in sediment used along the Peru-Chile margin (e.g., Mohtadi et al., 2005). However, several complex processes such as the physiological effects by nutrient/light-stress (e.g. Prahl et al., 2006), may overprint alkenone-based environmental record (e.g., Conte et al., 2006). By the way, we based in the previously published information plus statistical approaches proposed by the referees, we try to argue that alkenone-signal recorded in sediments from the Peru-Chile margin, should reflect the several changes produced by latitudinal, seasonal, offshore and water column depth factors, and how potentially these can be quantified.

7) The essential assumption made on page 552 is that maSST and nutrients are the same interannually – the data set they are using is from one year. This is could be a very biased time sliced. How representative is 96-97 of the multi-year picture?

Re: We are not agree, because we do not used one year dataset. On this study, the data set was obtained from the NOAA World Ocean Atlas 2001, which is a climatology for the last ~50 years that includes 96-97' datasets (Conkright et al., 2002).

8) In the treatment of the correlations there is insufficient (virtually no) treatment of the possibility that a substantial portion of the production of the alkenones may be occurring deep in the mixed layer (or at the thermocline) [Prahl et al., 2001; Prahl et al., 1993; Sikes et al., 2005] and or seasonality of growth [Popp et al., 2006; Thomsen et al., 1998]

Re: We agree. like in the point (5)… alkenones can be produced at the subsurface chlorophyll maximum rather than in the surface mixed layer when the water column becomes stratified (e.g., Prahl et al., 1993; Sikes et al., 2005). Thus, in a dynamic area like the Peru-Chile margin, where stratification is common in the summer and breaks down during upwelling (spring) and winter storms, we could assume that the alkenone production to be predominant in summer periods and below the mixed layer. Thus, according this evidence, we addressed our result analyses and discussions in two contrasting period (winter vs. summer), and water column depths (mixed/isothermal layer vs. thermocline).

9) The authors give little acknowledgement, nor sufficiently draw on a vast body of alkenone literature from surface waters and sediment traps that would greatly inform this paper. Relevant papers that have been published on the subject should be included. In addition to the papers already cited the following are also relevant here: [Herbert et al., 1998; Sicre et al., 2002; Ternois et al., 1996; Ternois et al., 1997].

Re: We included more information about previous relevant works.

10) Figures and tables.
Need here are a map figure showing the placement of samples relative to the filaments in coastal jets and upwelling referred to in the discussion.

Re: A map and oceanographic settings were added to the introduction.

11) A table of the actual core depths and locations would be helpful.

Re: Previous version of this paper included a table with this information as supplementary material.

References:

Conte, M. H., Sicre M. A., Rühlemann C., Weber J. C., Schulte S., Schulz-Bull D., and Blanz T.: Global temperature calibration of the alkenone unsaturation index (UK'37) in surface waters and comparison with surface sediments. Geochem. Geophys. Geosyst., 7, Q02005, doi:10.1029/2005GC001054, 2006.

Conkright, M. E., Locarnini R. A., Garcia H. E., O'Brien T. D., Boyer T. P., Stephens C., and Antonov J. I.: World Ocean Atlas 2001: Objective Analyses, Data Statistics, and Figures, CD-ROM Documentation. National Oceanographic Data Center, Levitus S. (Ed.), Silver Spring, MD, 17 pp. 2002.

González, H.E., Hebbeln, D., Iriarte, J.L., and Marchant, M.: Downward fluxes of faecal material and microplankton at 2,300 m depth in the oceanic area off Coquimbo (30ºS), Chile, during 1993-1995. Deep Sea Research II, 51, 2457-2474, 2004.

Hebbeln, D. and cruise participants: PUCK, report and preliminary results of R/V Sonne cruise SO 102, Valparaiso (Chile)-Talcahuano (Chile), March 29-May 14, 2001. Berichte Fachbereich Geowissenschaften, 182. Universität Bremen, Bremen, 195 pp. 2001.

Kara, A.B., P.A. Rochford, and H.E. Hurlburt : Mixed layer depth variability over the global ocean, J. Geophys. Res., 108, C3: doi: 10.1029/2000JC000736, 2003.

Marchant, M., D. Hebbeln, S. Giglio, C. Coloma and H. González: Seasonal and interanual variability in the flux of planktic foraminifera in the Humboldt Current System off central Chile (30ºS). Deep-Sea Res. II, 51, 2441-2455, 2004.

Mohtadi, M., Hebbeln D., and Marchant M.: Upwelling and productivity along the Peru-Chile Current derived from faunal and isotopic compositions of planktic foraminifera in surface sediments, Mar. Geol., 216, 107-126, 2005.

Müller, P. J., Kirst G., Ruhland G., von Storch I., and Rosell-Melé A.: Calibration of the alkenone paleotemperature index based on core-tops from the eastern South Atlantic and the global ocean (60°N-60°S), Geochim. Cosmochim. Acta, 62, 1757-1772, 1998.

Muñoz, P. , Lange C. B., Gutierrez D., Hebbeln D., Salamanca M. A., Dezileau, L. Reyss J. L., and Benninger L. K.: Recent sedimentation and mass accumulation rates based on 210Pb along the Peru-Chile continental margin, Deep-Sea Res., Part II: Topical Studies in Oceanography, 51, Oceanography in the eastern South Pacific: Part I, 2523-2541, 2004.

Prahl, F.G., R.B. Collier, J. Dymond, M. Lyle and M.A. Sparrow: A biomarker perspective on prymnesiophyte productivity in the northe).ast Pacific Ocean. Deep Sea Res. Part A, 40, 2061–2076, 1993.

Prahl, F. G., Mix A. C., and Sparrow M. A.: Alkenone paleothermometry: Biological lesson from sediment records off western South America, Geochim. Cosmochim. Acta, 70, 101-117, 2006.

Prahl, F. G., Popp, B. N., Karl, D. M., and Sparrow, M. A.: Ecology and biogeochemistry of alkenone production at Station ALOHA. Deep Sea Research Part I. Oceanographic Research Papers, 52, 699–719, 2005.

Romero, O. and D. Hebbeln: Biogenic silica and diatom thanatocoenosis in surface sediments below the Perú-Chile Current: controlling mechanisms and relationship with productivity of surface waters. Marine Micropaleontology, 48, 71-90, 2003.

Sikes, E. L., O'Leary, T., Nodder, S. D., and Volkman, J. K. : Alkenone temperature records and biomarker flux at the subtropical front on the Chatham Rise, SW Pacific Ocean. Deep Sea Research Part I. Oceanographic Research Papers, 52, 721–748, 2005.