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Climate of the Past Discussions

Interactive comment on "Terrigeneous material supply to the Peruvian central continental shelf (Pisco 14 S) during the last 1100 yr: paleoclimatic implications" *by* F. Brice no Zuluaga et al.

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We are thankful to the anonymous reviewer 1 for the critical and constructive comments, which will help to greatly improve our manuscript. We think that our paper provides a substantial contribution to scientific progress because in this paper we show evidence for a mechanistic understanding of the large changes that occurred in the Eastern Topical South Pacific during the last millennia. In the new version we will carefully revise the whole manuscript in order to separate the new contribution of this manuscript from the previously published works. In the submitted manuscript we did not explain in detail the methodology and omitted important aspects. In the new ver-

sion of the manuscript we will explain in more detail the rationale behind our method. We will also include more information about the site and the composite record.

SPECIFIC COMMENTS

Remarks 1: The paper does not present any description of the sedimentary record (no sedimentary log), no description of physical setting of both cores (depth, bathymetry, seismic profile, physical parameters of the water column,: : :), no chronological information and no information about how the composite profile as been established. The paper only refers to other papers, but the information is spread over several paper and difficult to synthesize in order to follow the authors rationale.

Response 1: We agree with the reviewer that we didn't include the full sedimentological characteristics of the cores used in this study since they have been fully described in other papers as in Gutierrez et al., 2006; Sifeddine et al., 2008 and Salvatteci et al., 2014) for core B06. In the revised version we will add more information about the site and the composite record as suggested by the reviewer.

Remarks 2: The paper should also explain what are the phenomenons behind the formation of laminations.

The Pisco continental sediments are characterized by a succession of darkness and lightness laminae.

This laminae structure is related to a complex interplay of factors including temporal variations in the quantity of terrigenous sediments supplied to the shelf by rivers and then by bottom currents as well as variations in the fluxes of siliceous and organic components to the sediment floor,which in turn are a function of upwelling-driven productivity and dissolution in the water column (Brodie and Kemp, 1994, Salvatteci et al., 2014 Mar Geo). Finally, the existence of strong oxygen minimum zone (OMZ) inhibiting bioturbation (Gutiérrez et al., 2006) and low currents actions allow the hemipelagic sedimentation (Suess et al., 1987). We will add in the revised version of the manuscript

CPD
11, C1860–C1869, 2015

more relevant information about the formation of laminations and how we can use them to assemble composite records.

Remarks 3: Moreover, it is impossible to find a description of core G-10 in the Salvatteci et al 2014 (Clim Past) from the reference list.

Response 3: The stratigraphic approach, sediment sub-sampling, age model of core G10 are presented in the supplementary data (SM1, SM2 and SM3) of Salvatteci et al., 2014b (Clim. Past). In the revised version of the manuscript we will include more information about core G10 and how the composite record was assembled.

Remarks 4: However, I found another paper by Salvatteci et al. 2014 in Marine Geology, describing the stratigraphy of core B-6, but there is no mention of G-10 in this paper. This latter paper shows that the link between two cores in this setting is difficult to do because of slumps induced by earthquakes. It is therefore critical to explain how the composite section has been built for this paper, and have a comprehensive description of the sedimentary sequence and the geological setting. It raises some concerns about the reproducibility and the traceability of results.

Response 4: We agree with the reviewer that is critical to explain how the composite record was assembled. We will do this in detail in the revised version. The paper by Salvatteci et al., Mar Geo, shows that it is difficult to establish the link between cores but it has been done for several cores off Pisco including B6 and G10 (see figure SM1 in Salvatteci et al CPD supplementary material). The paper published by Salvatteci et al (Mar geology) raises concerns reproducibility of the results only if a careful sediment logical description of the cores by X-ray images means is not done. For example two cores collected 300 km show the same centennial-scale variability during the last 700 years (Gutierrez et al. 2009). These two cores (one of them is B6) have independent chronologies based on several 210Pb and 241Am data points, several 14C ages, and the identification of sedimentological structures by X-ray images.

Remarks 5: Another problem is that authors are mentioning a southward redistribution

CPD

11, C1860–C1869, 2015

of river sediments because of currents, a feature that is indeed credible. However, authors should at least discuss the possibility of countourite that could occur in this kind of settings, i.e. continental slope. This is critical, because countourites are capable of moving/depositing sediment such as coarse silts and fine sands. Sedimentological analyses demonstrate that slope-parallel currents lead to winnowing of fine particles and (re)deposition of allochtonous material, which alters the grain-size populations, (see for instance Mulder et al., 2013) and the paleoclimatic reconstruction that are performed using these kind of sediments (for instance Keigwin, L. D., and M. A. Schlegel (2002)).

Response 5: The formation of countourite is one of characteristic off north Peru but not in the Pisco area because Reinhardt et al., 2002; Suess et al., 1987 and Gutierrez et al., 2006 have described the sedimentary facies in the Peruvian shelf as well as the role of currents in the erosion and redistribution processes over the Peruvian continental shelf. These works have showed that high resolutions sediment record should be present only in specific localities of the continental margin (high rate sedimentation zones). First, Suess et al, (1987) described the formation of two sedimentary characteristic facies between 6 – 10°S and 11 – 16°S. The first area (6 – 10°S, Salaverry basin) is characterized by the absence of sediment accumulation due to strong undercurrents. This area could be a good candidate for studying the contourites (if any) and the undercurrents effects considering the diagnostic criteria described in Rebesco et al., (2014). The second area (11 – 16°S, Lima Basin) is characterized by lens shape of depositional center of organic-rich mud facies favored by the oceanographic dynamic within the continental shelf, such as the position and velocity of the southward poleward current (Gutiérrez et al., 2006; Reinhardt et al., 2002; Suess et al., 1987). In addition to the works quoted above, high resolution profile was obtained with ecosounder Bathy 2000P during the “Paleomap 2006” cruise. The identified upper mud lenses are characterized by fine grain size, diatomaceous, hemiplegic mud and high organic carbon and the absence of erosive and bioturbation processes. We will add more information about this in the revised version of the manuscript.

CPD
11, C1860–C1869, 2015

Remarks 6: The grain size distributions presented here also are quite similar to the grain-size distributions smaller than 200 μm found in other countourites. This is a serious problem because the technique used here does not include the fraction > 200 μm. Therefore, it should be essential to provide the reader with quantities of sediment that were removed from the grain-size analysis because of this filtering. Authors should also justify why they used the Flow Particle Image Analyzer technology rather than regular techniques that are capable of analyzing the full size range of sediments, and demonstrate this is not important for the interpretation of the results.

Response 6: We apologize for this misunderstanding, we forgot to mention in the submitted version that particles coarser than 200 μm were never found in any samples after sieving. That means that the sediment samples do not contain such coarse particles, and that the grain-size distributions displayed in this study well represent the whole samples. As a consequence, the use of the Flow Particle Image Analyzer (with its restriction on measurable size ranges) has no consequence on the results and their interpretation. Moreover, such grain-size analyzer allows us to obtain images of all the detected particles and therefore, to check the efficiency of the chemical pretreatment of the samples, which is an important step in the grain-size analysis.

TECHNICAL COMMENTS

L61: GSD is not mixed since laminations are preserved, and I therefore suggest the following wording: "Grain size distribution in laminated marine sediments may indicate different sources and/or deposition processes, expressed as polymodal distributions.

Response: Thank you for the suggestion; we will modify this sentence as suggested.

L65: I suggest the following: "(: : :) identifying the different sedimentary processes and the past environmental conditions behind them (: : :)"

Response: Agree, we will change the sentence.

L96-97: I'm sorry, but there is little about the sedimentary processes sensu stricto in

CPD
11, C1860–C1869, 2015

the paper. For instance, authors are not really explaining what type of current/process leads to deposition of riverine material.

Response: In fact, there is a wealth of information on sedimentary processes on the continental shelf explaining the dispersion and deposition that were eventually cited in the document. Optionally we could written a brief summary indicating works such as Reinhardt et al., (2002); Smith, (1983); Suess et al., (1987).

L101-111: The information presented here is not sufficient to have a self-sustaining paper. A lot more information about the cores and the site should be included in the paper.

Response: We agree with this suggestion and will include more information about the study area, the cores, the composite record to have a self-sustaining paper.

L112-121: I understand what you are aiming for, but the practical explanations remains unclear. Please rephrase this section.

Response: We will rephrase this part for a better comprehension.

L123-127: The sample thickness is missing. It is important because it would provide an idea of the number of laminations included in each analysis. It should be also a good idea to provide the variation of the number of laminations through time.

Response: Sample thickness in core B6 ranges from 0.5 cm to 1.0 cm, and usually includes 2-3 laminaes in core G10 each sample is 1 cm thick and usually include 3-4 laminae. In our manuscript we are not focusing on sub-decadal or decadal-scale time series. We focus on centennial-scale changes in terrigenous input and thus we were not interested at the laminae scale variations that will be an interesting work especially for the last 100 years of the record.

L127-129: It is essential to provide the reader with quantities of sediment that were removed from the grain-size analysis because of this filtering. The interpretation of the data highly depends on that. Response: As mentioned above (Response 5), this

CPD

11, C1860–C1869, 2015

information is unfortunately missing. We will add it in the text in section 2.1 - Grain size analyses as follows: “In practice, particles larger than 200 μm had never been encountered in any samples” We apologize for this misunderstanding, we forgot to mention in the submitted version that particles coarser than 200 μm were never found in any samples after sieving. We processed the whole sample, nothing was removed from the sample. We will modify this accordingly in the revised version of the manuscript.

L185-186: Sun et al. (2002) indeed write that, but in the frame of loess sediments. The exact citation is: “In loess deposits, the wide size range of the fine component and the low degree of sorting suggest that they are slowly and continuously deposited throughout the year ÂËŹz. This is not applicable here.

Response: This assumption is applicable too for our scenario because the assumption that the fluvial input particles is a slowly and continuously deposited throughout the year.

L189: What are these favorable erosional soil properties? Are they consistent with the situation here?

Response: favorable conditions are for erosion are: lack of vegetation, low threshold friction velocity, surface roughness and low soil moisture. For more details, see Iversen and White, (1982) and Marticorena and Bergametti, (1995). Such conditions prevail in the studied area since the central coastal Peru consists of a sandy desert area characterized by no rain, a lack of vegetation and persistent wind (see, for instance, Haney and Grolier, 1991). This will be better addressed in the paper. Haney, E.M. and M.J. Grolier, Geologic map of major Quaternary aeolian features, northern and central coastal Peru, IMAP 2162, USGS Publications Warehouse, 1991

L192: The sample that is the most influenced by wind in Stuut et al. 2007 (core GeoB7108) has a mode that is 400μm, something that the authors in this study would have missed because of the technique used. Moreover, the grain-size analyses interpreted by Stuut et al (2007) were only described for the samples from water depths

CPD
11, C1860–C1869, 2015

>1000 m. Since cores are collected at much shallower depths in this study is the Stuut et al (2007) interpretation still valid? Again, this is critical to address this issue to support your interpretation.

Response: As already mentioned, we didn't miss any size-mode and our samples do not contain any particles coarser than those detected. On the other hand Stuut, et al (2007) related the presents of typical distribution of wind-blown transport near to $\sim$80μm ($\sim$29°S North of Chile) which is consistent with our results. In this case the relationship between distance and wind force and conditions of sedimentation is more important than depth.

L193: Flores-Aqueveque et al., 2015; these authors are mentioning particle >100 μm and actually in their figure 7, they measured grains up to 400μm, which would not have been measured by the grain-size technique used in this study. Response: We didn't miss any size-mode and our samples do not contain any particles coarser than those detected, we did not explain in detail in the submitted manuscript but will do in the revised version. Moreover, there is no Figure 7 in Flores-Aqueveque et al., 2015. So, we don't know to which paper the reviewer is referring.

L197-198: Is this last sentence really useful?

Reponse: Maybe not. Thus, this part could be rewritten to better understanding of the reader

L199-201: Contourite and hyperpycnal flows can transport these coarse grains. Moreover, some of the co-authors of this paper reported the presence of slumps in this area in another paper; slumps can transport coarse grains. Authors should carefully and comprehensively argue that these phenomena do not affect sedimentation here, otherwise their interpretation falls apart.

Response: Suess et al, (1987) described the formation of two sedimentary characteristic sedimentary facies between 6 – 10°S and 11 – 16°S. The first area (6 – 10°S,

CPD
11, C1860–C1869, 2015

Salaverry basin) is characterized by the absence of sediment accumulation due to strong undercurrents. This area could be a good candidate for studying the contourites (if any) and the undercurrents effects considering the diagnostic criteria described in Rebesco et al., (2014). The second area (11 – 16°S, Lima Basin) is characterized by lens shape of depositional center of organic-rich mud facies favored by the oceanographic dynamic within the continental shelf, such as the position and velocity of the southward poleward current (Gutiérrez et al., 2006; Reinhardt et al., 2002; Suess et al., 1987). This should be explaining in details in the new version of the paper. L219-220: McCave writes in the abstract: "We cannot use size distributions to distinguish the nature of the currents.

Response: In fact, the aim of this paper is not to see the nature of the currents but particles sources.

L230-231: Again, the composite record should be described in this paper.

Response: We agree with the reviewer, more details about the composite record will be added to the revised version of the manuscript

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