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Climate of the Past
Discussions

Interactive comment on "Centennial to millennial climate variability in the far northwestern Pacific (off Kamchatka) and its linkage to East Asian monsoon and North Atlantic from the Last Glacial Maximum to the Early Holocene" *by* Sergey A. Gorbarenko et al.

Sergey A. Gorbarenko et al.

gorbarenko@poi.dvo.ru

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Anonymous Referee #1 Received and published: 1 December 2016 This study presents high-resolution proxy data derived from a marine sediment record of the Northwest Pacific. Based on lithophysical and productivity proxies (e.g. magnetic properties, TOC content or chlorin measurements) the authors provide time series of millennial- to centennial-scale North Pacific climate variability from the Last Glacial Maximum (LGM) into the Early Holocene (EH). Several short-term (centennial scale)

productivity changes/cycles have been identified from 20 to 8 ka and are compared to high-resolution records reflecting changes in the East Asian Monsoon (EAM) system as well as climate variability recorded Greenland and Antarctic ice cores. The authors suggest a close relationship between changes in productivity in the northwestern Pacific, changes in EAM and Greenland/North Atlantic climate variability and further speculate about underlying mechanisms to explain North Atlantic - North Pacific climate synchronicity on centennial timescales.

General comments:

As there is currently quite some debate about the relationship of North Atlantic and North Pacific climate variability during the last glacial termination, the study of Gorbarenko et al. is a timely and relevant research topic. Unfortunately, problems regarding the English (grammar and usage) affect the clarity of the writing and sometimes it is quite difficult to follow authors' interpretations. Moreover, there are several issues that need to be discussed before the manuscript should be considered for publicationin Climate of the Past. Please find below my recommendations to improve the qualityof the manuscript: I have some major complaints about the construction of the age model for core 41-2. The first serious concern is about the use of AMS 14C ages derived from benthic foraminifera (E.pacific and U.parvoc.) to establish age control points for core 41-2. More specifically, a constant offset of 1400 years between planktic and benthicforaminifera has been used to correct benthic ages for reservoir effects according to unpublished? and total regional results? of Max et al. (2014). However, looking into the original publication of Max et al. (2014) reveals that planktic – benthic age differences (BP ages) in core 12KL (used for correlation) varied substantially during the last glacial termination and the Holocene and are not constant through time. The variability in BP ages given in core 12KL is thus in conflict with age assumptions made on benthic foraminifers in this study.

Answer. The age difference between benthic and planktic (B-P) in core 12KL has been reported (Max et al., 2014, Fig. 5) with variations between 950-1400 yr. The data of the B-P age differences since 15 ka BP has been nearly constant of ~1400 yr with more pronounced changes in the intermediate water in the Bering and Okhotsk Seas. Bottom water of core 12KL (depth of 2145 m) and core 41-2 (depth of 1924 m) is most likely originated from N Pacific deep water. . Comparing the cooling event in NGRIP at 9.3 ka with a cooling at 9.12 ka in our age model provide the additional confirmation of accepting a B-P age difference about 1400 yr for core 41-2 with very small error (less than 300-400 yr).

RC1. Moreover, there is some confusion about correlation of core41-2 to neighbor core 12KL. Several AMS 14C ages have been transferred from core 12KL to 41-2 to improve the stratigraphy. However, it has been stated by the authors that one age dating from core 12KL was not transferred to 41-2 (16.53 ka at 695 cm in core 12KL) but in the original age model of core 12KL the age in 695 cm is 15.9 ka and not 16.53 ka! I feel that the current age model needs to be revised and further improved.

Answer. We are sorry that there is a typo in our text describing the transfer of age 16.53 ka as a tie point to our core. The original calendar age at depth of 695cm in core 12KL is nearly 15.53 ka (see Table 2 in Max et al. (2012) and Table 2 in Max et al. (2014). But we did not use this depth-age as a tie point in revised age model of core 41-2 (Table 2). Instead we used key time point of core 12KL for depth 706 with age of 16.16 ka (Tiedemann/Max age model 2).

RC1. To improve the age model, it would make sense to e.g. check for correlation to well-dated core SO202-7-6 (Serno et al., 2015). This core has an excellent age model consisting of > 40 AMS 14C ages that, in principle, could be transferred to core 41-2.

Answer. Thanks for reviewer's suggestion. Core SO202-7-6 (Serno et al., 2015) has been well-dated and presented an excellent paper. However, we feel the main obstacle of doing correlation to this core is the time resolution SO202-7-6 core record is much lower than in core 41-2 and 12KL as well. The resolutions of these three cores are ~220 yr, 30yr and 15yr respectively, which means that the resolution of our core LV41-

2 reported here is nearly 10 times higher core SO202-7-6. In fact we cannot see clearly centennial-millennial environmental cycles in core SO202-7-6 but we are able to see them in cores 41-2 and 12KL.

RC1. A major point that has been made is that the NW-Pacific experienced a sequence of millennial – centennial-scale productivity changes during the last 21ka. The authors further suggest an in-phase behavior between changes East Asian Summer Monsoon and to some extent links to Greenland sub-interstadials. I suggest adding another table, which should give the reader information about the occurrence and length of proposed events.

Answer. Thank you, we will add millennial – centennial-scale productivity changes in the table 3.

RC1. I also recognized that cross-correlation has been done to compare time-series of the EAM and Greenland ice core data. What I'm missing here is crosscorrelation between 41-2 and Greenland and EAM records. I strongly recommend cross-correlation between 41-2 and Greenland and EAM records because this could, from a statistical point of view, strengthen the main conclusion of this study. Ideally, the time window for cross-correlation should be reduced (< 1000 years) according to the centennial-scale variability in 41-2 and other climate records.

Answer.Correlation of the millennial scale climate events between N. Pacific and N Atlantic is very important, you are right. But, we think that so correlation have be estimated between best dated N. Pacific and N Atlantic records. Until now, the best dated records for N Pacific region may be the East Asia monsoon records, which strongly linked with NW Pacific paleoceanography; ones for N. Atlantic may be Greenland δ18O ice core records (NGRIP and GISP2). However, an age model of our core 41-2 constructed both, by AMS 14C data of cores 41-2 and 12KL and correlation of productivity cycles with δ18O records of Chinese speleothems. Both approaches are good matched. Nevertheless, age model of core 41-2 is not enough strong compare to Chinese EAM time scale because it based on it. That is why we prefer to correlate the best dated original records. If we will reduce the time window less than 1000yr, errors in dating of these records will influence on related cross-correlation. That is why we confirm time windows as 1000yr, 2000yr and 3000yr with less influence of age's errors.

Specific comments/Technical corrections:

Abstract:

RC1. Line 17: "The core age model" sounds strange. Better is "The age model of core 41-2 is. . .

Answer. Thank you, we will do this.

RC1. Line 19: Please replace "SO-201-2-12KL" by "SO201-2-12KL"

Answer. Thank you, we will do this.

Introduction:

RC1. Line 38-41: Some references (e.g. Kienast et al., 2001 or Seki et al., 2002) are related to studies in the Northeast Pacific. Accordingly, "NW Pacific" should be replaced by "North Pacific"

Answer. Thank you, we will do this.

RC1. Line 42: A more proper citation would be Kühn et al. (2014)

Answer. We present citation of paper of Kuehn et al. (2014) where Dr. Kühn is coauthor.

RC1. Line 49: "atmospheric teleconnections" Please elaborate a little bit more in the Introduction the mechanisms behind atmospheric coupling.

Answer. Thank you, we do this.

RC1. Line 52: . . .Riethdorf et al. (2013) further suggest. . .

Answer. Thank you, we do this.

RC1. Line 57-61: This sentence is quite long and should be subdivided into two sentences. Though a recent study by Praetorius and Mix(2014) based on multidecadal-resolution foraminiferal oxygen isotope records from the Gulf of Alaska reveals a synchronicity of rapid climate shifts between the N Atlantic/Greenland (NGRIP core record) and the NE Pacific between 15.5 to 11 ka, inverse relationships between the Atlantic/Pacific during the Holocene and Heinrich Event (HE) 1 are suggested, while the short-term variability is either not sufficiently resolved or decoupled.

Answer. Thank you, we do this.

RC1. Line 77: "With our methodologically robust age controls". . .please see major complaint about the age model above. It is probably more accurate to say that the age model (in principle) allows to investigate centennial-millennial scale productivity. .

Answer. We believe that our age model based on the AMS 14C datum and correlation of productivity cycles and the relative paleomagnetic intensity variability between cores 41-2 and 12KL, present robust chronology of cores 41-2 and 12KL that allow us to say about linkages of productivity cycles with sub-interstadials in δ18O records of the East Asian monsoon. We had strongly improved age model part in revised version.

Material and methods:

RC1. Line 87: Is there any citation (cruise report?) available?

Answer. We have not published cruise report with core 41-2. We have this cruise report only for internal use in our Institute.

RC1. Line 106: Please replace "computing" by "calculating"

Answer. Thank you, we do this.

RC1. Line 109-110: A better beginning of these sentence would be: "It has been shown that variability in color b*. . .."

Answer. Thank you, we do this.

RC1. Line 112-124: Please see comments above regarding the robustness of the age model. Do you use the Intcal09 and Marine09 dataset as stated in Line 123-124 or Marine13 calibration curve as stated in Table 1???

Answer. We correct text: All reservoir age corrected 14C data were converted into calendar age by using Calib Rev 6.0 (Stuiver and Reimer, 1993) with the Marine 13 calibration curve (Reimer et al., 2013).

Results:

RC1. Line 180-183: This sentence is confusing. Please clarify.

Answer.Time resolutions of measured in core 41-2 chlorin content and color b*, TOC, CaCO3 content plus magnetic parameters (PM, MS and RPI), and Ba-bio, Br-bio, Si-bio concentration over the LGM-YD periods are nearly 30 years, 15 years and 60 years respectively.

RC1. Line 200-225: This chapter ("Age model") describes the correlation to neighbor core12KL (please see major comments above) and EAM records. I think the whole chapter should be shifted to the beginning of the Results followed by the paragraph describingother parameter (productivity proxies, CF etc.) derived from sediments. At this point it would make sense to give ages (onset and duration) of the centennial-scale productivity events (e.g. by adding another Table; see main comments above)

Answer. Our age model is based on AMS 14C data of core 41-2 plus projected AMS 14C data of core 12KL on the depth of core 41-2. But projection of AMS 14C data of core 12KL on the depth of core 41-2 are based on correlation of the productivity cycles (color, chlorin, TOC CaCO3) and RPI and PM proxies. That is why we need first to present results of the productivity proxies and then their correlation. OK, we will present additional Table with centennial-scale productivity events.

Discussion:

RC1. Line 243-285: This chapter deals with centennial-scale NW-Pacific productivity events and linkages to EAM records and Greenland ice core data. Thus, I suggest to modify the name of this chapter from "N-S hemispheres climatic linkages of. . .." to "Northern Hemisphere climatic linkages. . .". However, studied records are also compared to EPICA data (from the beginning of line 286) and it would make sense to shift this information to another chapter named e.g. "Southern Hemisphere influence on centennial millennial scale productivity. . .."

Answer. May be you are right. But here we combine the Northern Hemisphere centennial-millennial scale climatic cycles and ones in the southern Hemisphere in one figure and try to show N-S Hemispheres linkages.

RC1. There is also other proxy-data available from core12KL (e.g. SST data; Max et al., 2012 or sea-ice variability data; Méheust et al., 2016), which should be discussed. Accordingly, it could make sense to add SST and/or sea ice variability data from core 12KL to Figure 5, which serve as additional evidence for millennial-scale variability in the NW Pacific.

Answer. We added only productivity cycles of the NW Pacific derived from the cores 41-2 and12KL in the Figure 5. The Fig. 4 with productivity proxies and magnetic properties of cores 41-2 and 12KL is overcrowded and additional records will be problematic for figure reading. But we had added the changes in SST derived from core 12KL (Max et al., 2012) in discussion.

RC1. Line 259: missing citation (e.g. Ruth et al., 2007).

Answer. Thank you, we add this citation

RC1. Line 278-279: "stronger winter monsoon supplies more dust to the loess plateau". Please clarify.

Answer. Using a coupled climate model simulation Sun et al. (2011) investigated the effect of a slow-down of AMOC on the monsoon system and found that a stronger winter EAM accompanied with a reduction in summer monsoon precipitation over East Asia supplies more dust to the Chinese Loess Plateau.

RC1. Line 355-410: These chapters deal with NW Pacific productivity trends over the LGM-HE1 and the Early Holocene. I suggest moving these chapters to the beginning of the Discussion, followed than by discussion of possible mechanisms to explain productivity events (e.g. one chapters describing links to Northern Hemisphere/Southern Hemisphere).

Answer. The main questions in our MS are the centennial -millennial productivity/climate cycles of the NW Pacific. That is why we mostly focus on these cycles and then on the trends in productivity/climate changes over studied period.

RC1. Line 379-384: How does enhanced intermediate water ventilation promotes more nutrients to the euphotic layer? Most studies in the NW Pacific found substantially reduced nutrients/productivity during HS1 (e.g. Riethdorf et al., 2013). The enhanced formation of intermediate water during HS1 has been related to strong expansion of sea-ice and brine rejection as main processes to intensify mid-depth ventilation (e.g. Rella et al., 2012).

Answer. We explain the enhanced formation of intermediate water during HS1also by other reasons: "The diminished AMOC resulted in a major cooling of the N Atlantic surface water and, most likely, reduced water evaporation in the N Atlantic and therefore Atlantic–Pacific moisture transport. This condition facilitates a reduction of precipitation and hence an overall increase of surface water salinity and decrease of surface stratification in the N Pacific. Moreover, this condition promotes an intensification of the intermediate water ventilation in the N Pacific and also nutrient supply into euphotic layer."

RC1. Line 413-415: Millennial-scale climate events are also well known from the North Atlantic during the Holocene (Bond cycles; Bond et al., 1997). Is there any relationship to millennial-scale events in the North Atlantic?

Answer. Thank you. We input record of Bond et al., 2001 in Fig. 5

RC1. Figure 1: The core locations are hardly visible in this figure. Please modify.

Answer. We modify this figure.

RC1. Figure 3: Please remove all datasets, which are not necessary for age model construction. Please blow up a little bit more the y-axis to help the reader identifying variability in the given records, which is hard to recognize in the current figure.

Answer. We make small changes in this fig. (2). But all proxies are very important for understanding.

RC1. Figure 4: Please see comments to Figure 3.

Answer. We significantly modify fig. 3 and instead of number of proxies for core 41-2 present calculated stack.

RC1. Figure 5: It would make sense to implement one proxy dataset from core 41-2 (e.g. Si-bio) for comparison.

Answer. Thank you. We had implement stack of productivity and color "b" (analog of Si-bio) as proxy dataset from core 41-2 in Fig .5.

RC1. References: Bond, G., W. Showers, M. Cheseby, R. Lotti, P. Almasi, P. deMenocal, P. Priore, H. Cullen, I. Hajdas, and G. Bonani (1997), A pervasive millennial-scale cycle in North Atlantic Holocene and glacial climates, Science, 278(5341), 1257-1266. Max, L., L. Lembke-Jene, J. R. Riethdorf, R. Tiedemann, D. Nurnberg, H. Kuhn, and A. Mackensen (2014), Pulses of enhanced North Pacific Intermediate Water ventilation from the Okhotsk Sea and Bering Sea during the last deglaciation, Climate of the Past, 10(2), 591-605. Meheust, M., R. Stein, K. Fahl, L. Max, and J. R. Riethdorf (2016), High-resolution IP25-based reconstruction of sea-ice variability in the western North Pacific and Bering Sea during the past 18,000 years, Geo-Mar Lett, 36(2), 101-111. Rella, S. F., R. Tada, K. Nagashima, M. Ikehara, T. Itaki, K. Ohkushi, T. Sakamoto, N.

Harada, and M. Uchida (2012), Abrupt changes of intermediate water properties on the northeastern slope of the Bering Sea during the last glacial and deglacial period, Paleoceanography, 27. C6 Ruth, U., M. Bigler, R. Rothlisberger, M. L. Siggaard-Andersen, S. Kipfstuhl, K. Goto- Azuma, M. E. Hansson, S. J. Johnsen, H. Y. Lu, and J. P. Steffensen (2007), Ice core evidence for a very tight link between North Atlantic and east Asian glacial climate, Geophysical Research Letters, 34(3). Serno, S., G. Winckler, R. F. Anderson, E. Maier, H. J. Ren, R. Gersonde, and G. H. Haug (2015), Comparing dust flux records from the Subarctic North Pacific and Greenland: Implications for atmospheric transport to Greenland and for the application of dust as a chronostratigraphic tool, Paleoceanography, 30(6), 583-600.

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