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Interactive comment on "Late Pliocene and early Pleistocene environments of the north-eastern Russian Arctic inferred from the Lake El'gygytgyn pollen record" *by* A. A. Andreev et al.

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With the interest I read the paper "Late Pliocene and early Pleistocene environments of the north-eastern Russian Arctic inferred from the Lake El'gygytgyn pollen record" written by A.A. Andreev et al. (CP-2013-112). The paper is very interesting and as anonymous referees 1 and 2 I believe that it is suitable for publication in Climate of the Past. The pollen stratigraphy presented is very impressive (750 samples!) and supplements very well other results available on the same core. Results presented are of extremely high scientific value. At present, the manuscript requires moderate/minor modifications before it can be accepted. The text is on my opinion too descriptive and

needs to be summarized and some figures need to be clarified. All my comments are described below.

GENERAL COMMENTS:

The manuscript presents late Pliocene and early Pleistocene (ca. 3.58-2.15 Myr) pollen assemblages from a NE Russian Arctic lake (Lake El'gygytgyn) sediment core covering the last 3.6 Myr. The pollen record is segmented in 53 pollen assemblage zones (PZ). Pollen assemblage from ca. 3.6 to ca. 2.6 Myr are dominated by tree taxa whereas those from ca. 2.6 to ca. 2.2 Myr are rather dominated by herb and shrub taxa. Environmental conditions (vegetation and climate) through late Pliocene and early Pleistocene are discussed in light of the pollen content. Environmental changes reconstructed are compared with the Marine Isotope Stage (MIS) and other records.

The pollen record presented in the current paper have been used to reconstruct biome (Tarasov et al., 2013) and climate (Melles et al., 2012; Brigham-Grette et al., 2013). The publication of the late Pliocene/early Pleistocene pollen results here is very important notably because it will help us to best understand published biome and climate reconstruction results. Collectively, these papers move a step forward our knowledges on the relationship between pollen, vegetation and climate variability.

Biome reconstruction result is presented but not quantitative climate reconstruction. The late Pliocene/early Pleistocene climate is here rather reconstructed in a qualitative way. In my opinion, climate reconstruction (MTWM and PANN) presented in Tarasov et al. and Brigham-Grette et al., should also be illustrated here.

Which follow is a observation I made that could be considered. It starts from the reading of Tarasov et al. and Brigham-Grette et al. papers and your nMDS results (Figure 5).

(1) From both published papers, a marked change is evidenced in both biome and climate records at ca. 2.7 Myr BP. In the biome record, we note that before 2.7 Myr BP tree populations were abundant on the landscape and that afterward it is rather

arctic tundra vegetation that dominated the landscape. In the climate record, a notable decrease in annual precipitation (PANN) is evidenced at ca. 2.7 Myr BP as well as an onset of cold winter temperatures. Brigham-Grette et al. (2013) suggested this climate change could illustrate the climatic impact of large Northern Hemisphere ice sheets on the Arctic basin and Beringia obtained with preliminary model simulations. In the MIS stratigraphy, 2.7 Myr BP corresponds to MIS G7/G6 transition.

(2) In your pollen record, ca. 2.7 Myr BP corresponds to PZ-19/PZ-20 transition. The first axis of nMDS analysis (Figure 5) separates tree taxa (right side) from herbaceous taxa (left side) placing most shrub in between. Lower PZ (1 to 19), prior to 2.7 Myr BP, have mainly position scores on axis 1 and upper PZ (20 to 53) have negative scores. A stratigraphic plot of axis 1 nMDS sample scores would summarize the main trend in your pollen record and then allow a comparison between the palynostratigraphy and biome and climate results.

(3) For myself and because I have a lot of interest in the relationship between pollen, vegetation and climate variability, I calculated some statistics... From ca. 3.6 to 2.7 Myr BP (ca. 900 ka), there is 36 MIS and 19 PZ. PZ averaged 44$\pm$34 ka in duration. From ca. 2.7 to 2.2 Myr BP (ca. 500 ka), there is 27 MIS and 34 PZ. PZ averaged 17$\pm$6 ka in duration. We all know that a change in pollen assemblage (i.e. transition from one PZ to another) is not always translated by a vegetation change. The pollen content of two PZ could be different but their vegetation (or biome) could be comparable. Despite this, the Lake El'gygytgyn pollen record seems to suggest that vegetation changed less frequently (or was more stable) than global climate before 2.7 Myr BP, than afterward, i.e. in early Pleistocene. In early Pleistocene, the vegetation was a tundra but its composition changed frequently (34 PZ in comparison to 19 PZ berore 2.7 Myr). For that period, changes in del 18O composition of benthic foraminifera were however more drastic than before (Lisiecki and Rayno, 2005) and this could explain why the compostion of arctic tundra vegetation changed more frequently. Arctic herbs and shrubs are more vulnerable than for example coniferous trees to climate change.

Maybe all this could be discussed? If you illustrate on a same figure the PZ stratigraphy along with the MIS number and the global marine isotope stack what I discussed above will be best evidenced.

SPECIFIC COMMENTS:

(1) Introduction

* Page 4604, lines 6-9. “General geographical information concerning the geology, modern climate and vegetation cover of the study area has been described in Andreev et al. (2012) as well as other papers in this special issue and therefore is not repeated in the current paper.” OK, but I suggest you to at least add a short description on what is the palynological signature of Holocene samples. In comparison to late Pliocene and early Pleistocene record, Pinus and Larix pollen grains on Holocene sediments are less abundant and Cyperaceae pollen percentages are higher.

(2) Results

* The late Pliocene/early Pleistocene palynostratigraphy of the Lake El'gygytgyn sediment record is described in details. All 53 pollen assemblage zones (PZ) are described! Is it necessary? Furthermore, the pollen content of the PZ is afterward described again on the discussion section (Part 4). Maybe give the description of the 53 PZ summarily on a Table??

* In the present paper, 53 PZ have been recognized. In Brigham-Grette et al. (2013) (Figure S6), 40 PZ are illustrated. Why? The pollen analysis was not fully completed at that time?

(3) Interpretation and discussion

* The 53 PZ have been grouped and environmental conditions are discussed for 29 periods. These 29 periods come from where? They are based on what? For myself, I illustrated them on your Figure 3 and I do not undestrand more on what they are based. . . Adding a sentence explaining that would be appreciated.

* Quantitative climate reconstructions have been done on this late Pliocene/early Pleistocene pollen record and results are published (Brigham-Grette et al., 2013 and Melles et al., 2012). In the current paper, climate interpretation of the pollen record is mainly discussed in a qualitative way (for example, warm and wet or cold and dry). I do not understand why quantitative results were not taken into account and that results are not illustrated.

* Along the text, you always associated a warmer climate to wetter hydrographic condions and colder climate to drier conditions. Pliocene climate has never been warm and dry or cold and wet?

* The PZ are frequently discussed in light of the MIS stratigraphy. However, MIS numbers are not indicated on your figures. We must always look at other publications to follow you, notably those of Tarasov et al. (2013) and Brigham-Grette et al. (2013).

* In the text, when you refer to pollen grains, sometimes you talk about "pine pollen" and other times about "Pinus pollen". Maybe use latin names when you talk about pollen abundance in the PZ (e.g., increase in Pinus pollen) and common english names of the taxa only when you talk about vegetation on the landscape (e.g., dense stone pine communities).

* Page 4619, line 14. "… confirm that open habitats were common in the study area." This is clearly illustrated with the landscape openess curve illustrated on the Fig 7B of Tarasov et al. (2013). Adding this curve on you figure 6, along with biome reconstruction, would help to best understand your discussion.

* Page 4624, lines 17-18. "Around 3.025 Myr contents of birch and alder shrub pollen significantly decrease in the spectra BP (PZ-13), while pine, spruce and larch ones increase." What is the spectra BP? Pinus pollen percentage indeed increased from PZ-12 to PZ-13 but not Picea and Larix pollen abundance. If yes, this is not clearly evidenced on the pollen diagram. For me, the percentage of these two taxa in PZ-12 and PZ-13 looks like comparable.

* Page 4625, lines 18-19. "After 2.91 Myr BP (PZ-16) further increases in coniferous, Cyperaceae and Ericales pollen percentages reflect that the climate conditions became wetter and warmer." I agree, this assemblage could be interpreted as warmer conditions, but wetter…? Add a reference that link an increase in these taxa with wetter conditions. An increase in Cyperaceae pollen could indeed be associated with wetter conditions but coniferous and Ericales pollen?

* Page 4625, lines 20-21. "The climate amelioration is also suggested by an increase in the long-distance transported pollen influx." I do not follow you... Precise how an increase in long-distance pollen grains can be interpreted as a climate amelioration. If thermophilic pollen grains are more abundant in the assemblages (here PZ-16) than before (PZ-15), I could be in agreement with you.

(4) References

* Could you please give a reference that link high Botryococcus abundance with lower water-level and drier climate? Here is one: Andreas Clausing (1999) Palaeoenvironmental significance of the green alga Botryococcus in the lacustrine rotliegend (upper carboniferous âĂŘ lower permian), Historical Biology: An International Journal of Paleobiology, 13:2-3, 221-234, DOI: 10.1080/08912969909386582

(5) Figures

* Figure 5. At first sight, this figure is difficult to understand. We must look carefully at it. Maybe illustrate PZ 1 to 19 in a different way?? (see my general comments).

* Add a synthesis figure that compare all results based on pollen data? This figure could replace to the current Fig. 6, which is from Tarasov et al. (2013). You could use the Fig. 7 of Tarasov et al., published in the same issue of Climate of the Past, and add to it (a) PZ numbers and (b) stratigraphic plot of axis 1 nMDS sample scores (see my general comments). The stratigraphic plot will clearly illustrate the late Pliocene/early Pleistocene transition (ca. 2.7-2.6 Myr BP) in the pollen record. You could also illustrate

on this figure the 29 periods used in the discussion. In my opinion, the comparison of the PZ chronology with the MIS one could be very interesting. Is there a synchronicity or not between both stratigraphical results? What is the relationship between vegetation and climate variability through late Pliocene/early Pleistocene in north-eastern Russian Arctic? Illustrate together all results discussed in the paper will add strong value to the manuscript.

TECHNICAL CORRECTIONS:

At the reading of the manuscript, I must admit that the chronology of the PZ, environmental changes, etc. confusing me. The chronology is not constant throughout the text. For some successive PZ, their upper and lower chronological limits do not match. Along the text, the dates in Myr are given with a precision of 2 or 3 decimals. Why? The precision of the chronological scenario of the lacustrine sediment record of Lake El'gygytgyn is different along the core? You will find below all chronological typing errors I found but the authors should check all dates giving in the text.

(1) Abstract

* The regional paleoenvironmental history for the past 3.6 Myr in northeastern Russian Arctic discussed in your paper is essentially based on palynostratigraphic changes (pollen assemblage zone – PZ) recorded in the lacustrine sediment record in Lake El'gygytgyn. Therefore, timing of environmental changes "should" correspond to the chronology of the PZ. It is not the case. The chronology of the major events giving in the abstract do not always correponds to the chronology of the PZ. See below.

* Page 4601, line 10. "A very pronounced environmental changes took place at ca. 3.305-3.275 Myr BP". This chronological frame is associated to the PZ-8. In the results (page 4606, line 28), you mentionned that chronological limits of the PZ-8 are ca. 3.310-3.283 Myr BP. Why such change? I suggest you to rather say that "a very pronounced environmental changes took place at ca. 3.3 Myr BP".

* Lines 16-17. "... interrupted by colder and drier intervals ca. 3.04-3.02, 2.93-2.91, and 2.725-2.695 Myr BP." These chronological limits do not match PZ limits. (1) "3.04-3.02" this corresponds to PZ-12 (3.060-3.025 Myr). (2) "2.93-2.91" this corresponds to PZ-11 (2.924-2.910 Myr). (3) "2.725-2.695" this corresponds to PZ-20 (2.735-2.712 Myr) and PZ-21 (2.712-2.695 Myr). Why here giving three decimals and before (1)(2) only two?

(2) Results

* The upper and lower chronological limits of successive PZ do not always match. Below is a list of some unmatchings I found by I suggest the authors to carefully check all the chronological limits of the PZ giving in the text. I can even myself have done some typing errors in my text below...

* Page 4608. PZ-24 (ca. 2.665-2.646 Myr BP) and PZ-25 (ca. 2.645-2.625 Myr BY). 2.646 or 2.645?

* Page 4609. PZ-29 (ca. 2.578-2.556 Myr BP) and PZ-30 (ca. 2.560-2.552 Myr BP). 2.556 or 2.560?

* Page 4610. PZ-41 (ca. 2.373-2.368 Myr BP) and PZ-42 (ca. 2.354-2.343 Myr BP). 2.368 or 2.354?

* Page 4610. PZ-44 (ca. 2.330-2.305 Myr BP) and PZ-45 (ca. 2.307-2.290 Myr BP). 2.305 or 2.307?

* Page 4610. PZ-51 (ca. 2.198-2.180 Myr BP) and PZ-52 (ca. 2.181-2.163 Myr BP). 2.180 or 2.181?

(3) Interpretation and discussion

* Page 4611, line 13. "Dry and steppe elements... are placed in the lower right part... of the plot". Change right by left.

* Page 4613, lines 1-2. "mean January temperatures are estimated to be -13-17°C" ...

“mean July temperatures -14-17°C”. Before 3.6 Myr BP January T were comparable to July T?? The use of the minus symbol is confusing. Is it rather “mean January T are estimated to be -13 to -17°C” and “mean July T 14 to 17°C” ?

* Page 4614. Unconformity in the chronology (upper and lower limits) of the 4.3 and 4.4 title sections. 4.3 title: ca. 3.575-3.520 Myr. 4.4. title: ca. 3.55-3.48 Myr. In the 4.3 title, change the upper limit (3.520) by 3.550.

* Page 4617, line 4. “... which coincide well with the MIS MG8.” This section (4.5) discuss environmental conditions at ca. 3.48-3.45 Myr BP. MIS MG8 is dated ca. 3.53 Myr. The MIS close to 3.45 Myr is rather MG6 (see Fig. 7 of Tarasov et al., 2013). Change MG8 by MG6.

* Page 4618. The date 3.39 Myr of both 4.6 and 4.7 titles. The 4.6 section, is a discussion on the PZ-5. The 4.7 section, is a discussion on the PZ-6 and 7. From these two titles, the transition between PZ-5 and PZ-6 occurred at ca. 3.39 Myr BP. However, on page 4606 (section 3.1) you mentionned that this transition (PZ-5 to PZ-6) occurred at 3.38 Myr BP. Which one is the correct chronology?

* Page 4622, line 10. Temperature (MTWM) of the PZ-11 (3.20-3.06 Myr). “... temperature of the warmest month might have reached 16-17°C (Brigham-Grette et al., 2013).” From the Fig 3A of Brigham-Grette et al. (2013), averaged value of PZ-11 is about 15°C (horizontal line on Fig. 3A). Later on line 11-12. “Generally, the interval 3.20-3.06 Myr, which coincide well with the PRISM interval (Dowsett et al., 2010) was not as warm or wet as it was between 3.58 and 3.40 Myr (PZs 1-5).” Ok, but averaged values of both periods are very comparable (ca. 15°C) (horizontal lines on Fig 3A of Brigham-Grette et al. (2013).

* Page 4626, line 4. “Generally, environmental conditions between 2.800 and 2.735 Myr BP (PZ-17, Fig. 3c)...” Change 2.735 by 2.750. The chronology of the PZ-17 is ca. 2.80-2.75 Myr BP (see page 4608, line 1).

* Page 4628, line 9. Change “saga pollen” by “sage pollen” or Artemisia pollen.

* Page 4628, line 17. “Around 2.625 Myr (PZ-26) the pollen spectra reflect a retreat of pine and larch in the area presumably as a consequence of some climate amelioration.” It is the reverse! It is rather an advance of pine and larch that is evidenced from the pollen diagram. Pinus and Larix pollen percentages are higher in PZ-26a than in PZ-25. Change “retreat” by “advance”.

* Page 4632, lines 7-9. “The retreat of larch forests with shrubby birch and alder in understory took place between 2.428 and 2.400 Myr BP (PZ-38) as reflected by much higher percentages of Larix, Alnus, and Betula pollen.” Same comment as above. Change “retreat” by “advance”. For me, higher pollen percentages should reflect higher abundance of the taxa on the landscape, not the reverse.

(4) Conclusion

* Page 4637, line 2. “ca. 3.305-3.28 Myr BP”. This is the chronology of PZ-8. In the abstract, you mentionned 3.275 instead of 3.28. Later, line 7. Botryococcus. “2.55, 2.45, etc”. In the abstract you mentionned 2.53 instead of 2.55. Please keep consistency.

(5) Figures

* Figure 3. Add x100 below “total pollen concentration” in Fig. 3a. Add “Algi” group in Fig. 3a as in Fig 3c. In Fig. 3a and 3c add the units (grains/cc) of total pollen concentration.

* Figure 5. PZ 1, 5, 11, 18, 28, 31, 34, 53 are not illustrated. Ok, you mentionned in the text that assemblages with a pollen sum below 150 were not taken into account for nMDS. Maybe add this in the caption. Samples from PZ-1 have indeed a pollen sum below 150, but not the samples from other PZ upcited.

Finally, I want to acknowledge for my english and hope that you were able to carefully understand my thoughts.

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