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Climate of the Past Discussions

Interactive comment on "Detailed insight into Arctic climatic variability during MIS 11 at Lake El'gygytgyn, NE Russia" *by* H. Vogel et al.

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We would like to thank both reviewers for their high quality reviews and valuable suggestions that will help improving our manuscript.

We would like to make use of the open discussion option and briefly respond to the major suggestions and comments raised by the reviewers here. Major suggestions and comments along with minor corrections and suggestions by the reviewers will also be addressed in the revised version of the manuscript.

Response to comments by Reviewer 1 (anonymous)

Reviewer comment: 2a. Most of the records used in this study (i.e. BSi, TOC, TOC/TN, Ti, Mn/Fe) are of great resolution (decadal-to-centennial-scale), however, the relation

to climate is partly not visible (i.e. in case of the Mn/Fe-record) or remains hardly constrained (i.e. TOC, TOC/TN). This is also reflected in the manuscript text, as the records seems to offer a substantial degree of freedom in interpretation. Speculations occur at several occasions in the text (see line-by-line comments). I suggest to reduce the speculative sections in the manuscript.

Author response: We fully agree that the climatic interpretations drawn from proxies (sedimentological, geochemical, palynological) used in this study are not always straightforward. Our intention was to approach these issues by offering several possible explanations or in some cases use the most likely explanation based on our multiproxy evaluations. This may in some cases seem speculative and we tried to point out if we could not find a single but multiple interpretations of our proxy records. The text of the revised version of the manuscript will be formulated more careful and clear. We feel, however, that it may also be important to hypothesize possible mechanisms for the observed climate fluctuations during MIS11c and we tried to formulate these as cautious as possible. We will try to express these issues in an even more cautious way in the revised version.

We make use of the Mn/Fe ratio to support our interpretation of annual lake ice cover disintegration and annual mixis/reoxygenation of the water column during the climatic optimum of MIS11c. Increased Mn/Fe values, interpreted as being indicative for more oxic conditions in the water column and the surface sediments, nicely coincide with reddish lithologies (rich in Fe(III)-(hydroxy)oxides) in the respective section. We believe that lake ice cover stability and mixis at Lake El'gygytgyn is closely tied to climate.

In addition to BSi concentrations we use TOC concentrations as an indicator for in-lake productivity and supply of particulate OM from the catchment to the lake. To differentiate between terrestrial and aquatic sources of OM we also make use of the TOC/TN ratio. We provide explanations for the different mechanisms that influence TOC concentrations in Lake El'gygytgyn and are aware of the fact that TOC concentrations alone are unsuitable for climate reconstructions at Lake El'gygytgyn. However, we

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agree that the text needs to be improved to better justify the conclusions drawn from the BSi, TOC and TN data.

Reviewer comment: 2b. The BSI-record seems to be a useful climate proxy since BSI-values are a measure for the diatom frustules frequency which is strongly influenced by duration of ice cover at Lake El'gygytgyn, and hence by climate. Thereby, the BSI-record from El'gygytgyn reflects the MIS 11c signal known from globally integrating ice-volume proxies (L&R 04 stack, or relative sea level), Antarctica, European pollen records and Lake Baikal. I suggest to make stronger use of the BSI-record.

Author response: We fully agree that BSi is a useful climate indicator at Lake El'gygytgyn. The pattern produced by BSi in the course of MIS11c and the remaining sediment record from Lake El'gygytgyn indeed matches those of the benthic oxygen isotope stack and the Antarctic ice cores in very high detail. We will make stronger use of the BSi-record in the revised version of the MS.

Reviewer comment: 2c. The record which offers the most detailed and direct insight into climate change, i.e. the pollen record, is unluckily much too low in resolution (20 samples for a 35-kalong interval) to draw robust conclusions. In addition, if the pollen percentage data are meant to reflect open (tundra) versus closed vegetation (forest-tundra or taiga), then the 100 % reference sum should include representatives of open vegetation such as Poaceae; whereas Spores should not be included in the reference sum. I strongly recommend to recalculate the percentages based on a reasonable reference sum; and plott the pollen data in a more informative way (for details see specific comments).

Author response: The 21 samples investigated for pollen and spores originate from a ca. 150 cm long core interval. Thus the resolution is rather high according to pollen study standards, however, additional analyses are envisaged to improve out understanding of vegetation changes during MIS 11 in the future. We furthermore believe that the available and published pollen data (PANGEA database) nicely sup-

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ports and supplements our conclusions drawn from the high-resolution geochemical/sedimentological dataset. The pollen percentages are calculated according to pollen study standards. Hence, spores are not included in the sum for calculating pollen percentages. More details concerning the pollen sampling, preparation and calculation employed are presented by Melles et al. (2012) and Lozhkin and Anderson (this issue), however, we will modify and slightly expand the description of the methods used in order to address the respective reviewer's comments.

Reviewer comment: 3. The authors conclude that the warmest and wettest phase of the interglacial associated with MIS 11c was between 418–415.5 ka. In specific the authors argue "Coinciding peaks in MTWM, PANN, spruce pollen, and TOC (Fig. 3b, g, i, k), together with the occurrence of OM-rich lenses in the sediment record between 418–415.5 ka (Fig. 2), indicate the warmest and wettest phase at Lake El'gygytgyn during MIS 11." This would imply that the warmest and wettest phase of the interglacial associated with MIS 11c was in the early part of the interglacial, which is in contrast to what we know from that interglacial, i.e. the climate optimum in the upper part. Closer inspection of the El'gygytgyn data shows that the data do not support a warmest and wettest phase between 418–415.5 ka since: (i) the highest values of spruce MTWM, PANN, and the TOC data (which integrate the occurrence of OM) are at around 401, and not between 418–415.5 ka (ii) the BSI record which seems to be a useful climate proxy, shows highest values in the upper part of the interglacial, as known from globally dirstributed sites. Thereby, the conclusion that the warmest and wettest phase in El'gygytgyn was in the early part of the interglacial is not substantiated by data.

Author response: We agree with the reviewer that our assumptions were primarily based on the pollen-based climate reconstructions and lithological peculiarities and not enough on the valuable BSi record. The reliability of the pollen-based climate reconstructions - in case of MIS11c at Lake El'gygytgyn showing two climate optima with similar T and P values for 418-415.5 ka and 401 ka - may indeed be too small to draw such a far reaching conclusion. We will modify these paragraphs in the revised

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manuscript and make stronger use of the BSi record.

Reviewer comment: 4. The same applies to the conclusion about a precipitation anomaly at 401 ka that is (according to the authors) “associated with a significant increase in soil erosion”. The data do not support that since: (i) the pollen sample at this depth indicates highest Picea percentages together with lowest values of taxa indicative for open vegetation. Hence the pollen data indicate that the vegetation cover at 401 ka was dense; a finding that does not support soil erosion. (ii) The PANN values at 401 are not significantly higher than between 418 and 415 ka (iii) The authors use the peaks in the TOC and TOC/TN records at 401 ka to argue for a precipitation anomaly. However, these peaks indicate an increased input of OM into the lake and as the peaks correlate with peaks of Spruce, it rather seems like that the TOC and TOC/TN peaks reflect the input of litter form tree populations surrounding the lake.

Author response: We agree that this is another very interesting and sound interpretation of our proxy records for the ‘anomaly’ at 401ka. We will include this interpretation in the revised version of the manuscript.

Reviewer comment: 5. The authors conclude that full and remarkable stable interglacial conditions persisted for ca. 27 kyrs between ca. 425 and 398 ka BP. Given that the interval in question is not constrained by an independent chronology but tuned to the orbital target the conclusion seems not too robust. Apart from chronological issues the reader may raise the question why Picea percentages are reduced between 415 and 405 ka BP (this may indicate a muted cooling within the interglacial). Since percentages of total trees and shrubs don not decline within this interval, it would be good to learn which tree or shrub taxa gained during that interval (In the specific comment – for page 6320 lines 15 to 30 – I suggest steps that will help to get from pollen data better information on vegetation change). The answer to this question could tell us how stable the climate conditions were in the high northern latitudes during MIS 11c.

Author response: We fully agree that precise chronological constraints on the duration

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of MIS11c interglacial conditions at Lake El'gygytgyn (and most other terrestrial and marine climate records) are hampered by relatively large age model errors. We tried to stress these errors in the manuscript but we will make it more clear in the revised version by adding the actual errors of the applied age model. As of Nowaczyk et al. (this issue) the age model error in the respective time interval can be up to 4kyr (similar to marine and ice core records) - taking this into account we can assume a duration of full interglacial conditions at Lake El'gygytgyn of c. 27 +/- 4kyr (min. 23kyr, max. 31kyr).

Picea percentages are indeed slightly reduced between 415 and 405 ka BP. However, at the same time percentages of Alnus and Pinus are slightly increased. It is difficult to say if these changes may indicate a muted cooling within the interglacial. A muted cooling, if present, should also be indicated by increased contents of Cyperaceae, Poaceae and other herbs, however, we do not see these changes in the pollen record. For more details on the respective pollen record please see Melles et al. (2012) and Lozhkin and Andersen (this issue).

Interactive comment on Clim. Past Discuss., 8, 6309, 2012.