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Climate of the Past Discussions

Interactive comment on "Biological proxies recorded in a Belukha ice core, Russian Altai" *by* T. Papina et al.

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First of all we would like thanks a lot our Referee 3 for great work and for the very constructive comments and remarks.

General comments:

1. The goal of the paper is to compare the biological proxies with circulation patterns (especially with circulation patterns resulting in high precipitation) at the Belukha ice core site. I am not convinced by the authors' arguments that times of high precipitation are the times of the highest deposition of biological material. For example the authors mention that the highest percentage of diatoms are from bottom communities. The authors mention that the Aral Sea is a likely source of many of these biological products.

However, during the 1981-2008 time frame, the Aral Sea has substantially decreased in size and exposed many of its sediments (including these bottom-dwelling diatoms) that are now available for transport. These sediments and associated diatoms could be deposited on the glacier surface through dry deposition. Is there a possibility that any of the diatoms and algae are from seasonal lakes in the surrounding arid areas? If so, then there is also the possibility that these biological materials could be deposited with dry deposition as during the dry season the lake bed sediments are entrained in the atmosphere and regionally transported. The highest concentrations of both diatoms and coniferous pollen and one of the highest concentrations of hardwood pollen occur during 1983. Can this reflect increased wind speeds rather than increased precipitation? How much is known about wind speeds for each of the ECMs? This examination of daily precipitation combined with ECMs cries out for a least some comparison with the stable isotopic information determined in the same core. Do times of increased precipitation result in relatively decreased stable isotopic ratios (ie amount effect)? Such a comparison could shed light on if the biological material are deposited by wet precipitation.

Answer: The biological species in an ice core of inland glaciers as the biological species in a sediment cores of lakes are proxies for the paleo climatic changes at the adjacent territories (first of all they reflect a change of climatic zones). The high resolution of the ice core layers (up to one year) can provide additional possibility to use the biological species as proxies for estimation of other atmospheric characteristics. Glaciers located on the boundary between contrasting climatic and vegetation zones are of most interest in this context. The main goal of our work was to show that changes of concentrations of the biological objects in the layers of the Belukha ice core can reflect the changes in the structure of precipitation in Altai region (i.e. can reflect changes of the contribution of different EMC's to annual precipitation). In this case the biological objects (species) in the Belukha ice core can be the proxies for the changes in the structure of precipitation in Altai region. The second goal of our work was to identify the sources of biological objects discovered in the Belukha ice core. Additionally, results of

our work can be used for the different aspects of the transboundary atmospheric transport of substances. The main position based for our article was the common thesis that the vast majority of aerosols (about 80% of the total quantity) fall out to the ground surface with precipitation and only near 20 % fall out through dry depositions [Croft et al., 2010]. This thesis is a result of numerous investigations and measurements. The biological objects transported for a long distance as other aerosols being the nucleus of atmospheric moisture condensation can easy involve in precipitation.Therefore we can assume that the biological objects as a component of aerosols mainly enter to the glacier surface with precipitation and not through dry depositions. About "increased wind speeds rather than increased precipitation". Of course updrafts and wind speeds promote to enter the biological species in the atmosphere, but after transporting for a long distance precipitation (not dry depositions) determine their falling on the ground surface (in our case on the glacier surface).

Based on your comments we understand that we have to clarify the methodology of our work. The methodology used for performing the main goals of our work was the following (step by step):

1). We provide a high-resolution analysis of biological species in the Belukha ice core with annual resolution and get the records of the biological object concentration changes in the Belukha ice core for the period 1964-2000. The methods used for getting these results were described in section 3 "Methods" (in subsections 3.1 "Sampling" (unfortunately this subsection was wrongly named as "Methods" in our paper), 3.2 "Dating", and 3.3 "Analyses of diatoms, spores, and pollen").

2). Using the daily data on the frequency of synoptic patterns (daily calendar of successive change of ECMs - elementary circulating mechanisms) observed in the Northern Hemisphere [Kononova, 2009] and instrumental data of daily precipitation from the Kara-Tyurek weather station (located close to Belukha glacier) we calculated the contribution (in %) of each from 41 EMCs in annual precipitation in the study area for the period 1964-2000 (for each year and for period in whole). In other words, we calculated

how much precipitation fall down in the Altai region at different types of ECMs during a year, and then calculated the percentages relatively the total annual precipitation.

3). To determine the atmospheric processes that contribute to the deposition of biological objects at the Belukha glacier in the period 1964-2000, we compared the changes in the amount of precipitation in the Altai region at different types of ECMs for years with maximum and minimum concentrations of biological proxies in the ice core. For this purpose for years with the highest concentration of biological proxies, we identified the types of atmospheric circulation pattern providing in the period of flowering and sporulation the higher amount of precipitation relatively to the average of these types for the corresponding circulation period. For years with the minimum concentration of biological proxies, we identified the types of atmospheric circulation pattern providing the less amount of precipitation relatively to the average of these types.

4). If for years with the highest and the minimal concentrations of biological proxies we determined the same types of ECMs then it meant that these ECMs can define the deposition of biological objects at the Belukha glacier. For these ECMs we calculated pearson's correlation coefficient between concentrations of biological objects in the layers of the Belukha ice core and contribution (in %) of EMC in annual precipitation.

We understand that in our paper the introduction, the goals of our work, and the description of the used methods are not satisfying (all three Referees have pointed it), so we will completely revise the introduction and the description of goals and methods (methods especially for general methodology of the study and the Classification of circulation mechanisms by Dzerdzeevskii) at the revised version of the paper. Maybe it will be better to rename our paper as "Biological objects recorded in a Belukha ice core (Russian Altai) as proxies for atmospheric regional processes".

2. P. 2597: I agree with the approach that the authors use to separate their data by the two main circulation periods (1964-1980, and 1981 – 2008). However, if the maximum concentrations of all biological material occur during the 1980s and 1990s, I do not

understand why the authors used 1981-2001 as their mean values. The arguments that the authors present in this section suggest that contrasting the results from the two dominant circulation regimes may be more valid than using 1981-2001 as a representative time period.

Answer: The period 1981-2008 was limited to the 2001year because of the ice core was retrieved from the Belukha glacier in 2001 (after 2001 we have no any data about ice core)

3. Methods section in general: I agree with Reviewer 1 that the methods section needs substantial clarification, especially regarding if the ECMs are defined elsewhere and the statistics linking the precipitation patterns and the biological data. Such clarification is essential before the paper is publishable.

Answer: see the answer on the general comment No 1.

4. Section 4.2 Figures 5, 6 and 7. The authors use one anomalous year to determine source regions. The highest amount of coniferous pollen occurs during 1983, and not 1986 as mentioned in the caption for Figure 7. 1986 contains the minimum coniferous pollen concentrations. Is this just a typo? If so, it needs to be clarified or these paragraphs and their associated figures do not make sense. Figure 7 does not show the main air masses arriving from West Siberia as the authors mention in the text. If the authors consider this area north of Belukha to be West Siberia, this needs to be explicitly stated. This is especially important if "We can conclude that the main sources of conifer pollen in layers of the Belukha glacier were taiga forests of North-Siberia".

Answer: There is a mistake in the caption for Figure 7 (instead of "maximum year1986" to have be "maximum year1983"). Yes, we say that boreal forests of West Siberia are located to the north of Altai Mts, and these forests are the main source of conifer pollen in the ice core.

Specific comments:

Abstract: Does the ice core record sub-annual differences? If you are comparing daily precipitation and synoptic meteorological data with annual ice core records, the abstract should contain a phrase demonstrating how the daily data were combined to allow such a comparison.

Answer: We compare contribution (in %) of EMCs in annual precipitation with annual ice core records. It will be pointed in the revised version of the paper.

P.2590 Line 19: "Different waterbodies": Local waterbodies versus oceanic sources? Streams versus lakes?

Answer: It can be lakes or rivers are situated in the region of the glacier, but not oceans, of course. The littoral part of lakes and shoreline of rivers can be a source of diatoms from which they can be transported with air masses.

P.2590 Line 10: "Coniferous tree pollen" not "coniferous trees pollen"

Answer: agree

P 2590-2591 Lines 25 -5: Confusing word order. Why would the coincidence of seasonality in precipitation and pollen and algae production negate their deposition due to wet precipitation?

Answer: see the answer on the general comment No 1.

P 2590-2591 Lines 25 -5: The dominant atmospheric circulation pattern results in the most precipitation? This is taken as a given in this paragraph, but in p. 2592 Lines 9-10 the correspondence between atmospheric circulation patterns and precipitation is also outlined as one of the goals of the paper.

Answer: The dominant atmospheric circulation pattern results the higher amount of precipitation relatively to the average of this type for the corresponding circulation period. Additionally see the answer on the general comment No 1.

P. 2591 Lines 5-6: "Most typical inland glaciers" Of the region? For Central Asia? For

inland glaciers anywhere in the world?

Answer: most common (typical) inland glaciers for inland glaciers anywhere in the world

P. 2591 Lines 19-20: Why would moisture from the Mediterranean Sea be considered to be an “internal moisture source”? Do you consider any source that is not an open oceanic source as an internal moisture source?

Answer: Since the Mediterranean Sea is surrounded on all sides by land (only the Strait of Gibraltar connects it to the ocean) it can be viewed as “internal moisture source”.

P.2592 Lines 19-29: Confusing word order. How can the atmospheric circulation patterns providing the highest mounts of precipitation influence the minimum concentrations of biological proxies. The crux of the author’s arguments is that maximum precipitation = maximum biological proxies, and so this sentence does not support their main argument.

Answer: see the answer on the general comment No 1.

P. 2595 Lines 13-15: A figure with examples of the SEM images of different species would add to the scientific value of the paper. The Table 2 summary of determined species should also define the concentrations. Are these mean concentrations? Is the units/L a mean count per liter?

Answer: units/L or per liter – it is the same.

P. 2595-6 Lines 14-5: Are the cyclones included in the ECMs? P. 2596 Lines 3-5 suggest that they are. Do all cyclones arrive from the south? This paragraph is fundamental to the rest of the paper, but the meaning is unclear. The following paragraph (P.6 Line 26-P.7 Line 6) and associated tables helps clarify this section, but section 3.4 should be rewritten for clarity. For example, the 6 “areal sectors including the Siberian region” should be defined (although references are given). It is unclear from these paragraphs and from Figure 1 and Table 1 if the 13 ECM types are unique to this paper

and these data or if they correspond with the types outlined by Kononova et al., 2009 (ie Figure 2).

Answer: Paragraph 3.4., Đřs well as figures and tables will be corrected in accordance with your comments.

P. 2598 Lines 7-9: What are the implications that most of the diatoms are from bottom communities? Does this imply that some of the lakes are seasonal? (Ie exposing their sediments at least part of the year). Could this reflect the dramatic drying of the Aral Sea during the 1980 -2000 time period?

Answer: The most part of diatoms revealed were a bottom forms that habitat littoral part of different waterbodies, i.e. lakes, small and large ones, rivers, the banks of rivers. When the water level is decreasing stones with diatoms as a periphyton near the shoreline can be dried and algae can be flown out with the wind and be transported with air masses.

P. 2599 Lines 24-25. What are the implications for the maximum precipitation occurring during the winter in 1986 and when coniferous trees are not emitting pollen?

Answer: The implication is that 1986 was “untypical year” when the major precipitation of 8d(s) occurred in the autumn and winter periods instead of the spring and summer periods.

Figure 10: Better to state “0 =lack of pollen” or “no pollen were present”. With the current form it is unclear if you did not analyze these samples if you did not find any pollen.

Answer: agree

Section 4.4 If 1981-2001 is dominated by zonal circulation, do you have an explanation for the years where pollen was not present in the ice core? Figure 10 is the only diagram where there is almost a complete step change in the presence of or lack of biological components in the ice core, and so separating 1981-2000 from appears to

make sense. However, it would be interesting if you expanded your explanation in this section to look at the ECMs for 1982, 1987, 1990, 1995-1997 when no pollen was found in these samples but the circulation is still predominately zonal.

Answer: Zone of hardwood forests with Betula pendula is located in western low mountain areas of Altai Mts., a few hundreds kilometers west of Belukha Glacier. East of it are located treeless high mountain landscapes and steppes of Mongolia. Predominantly zonal circulation means movement of air masses either from west to east (with hardwood pollen) or from east to west (with no hardwood pollen). It is known that high mountain areas produce much less amount of pollen than forested areas (Roberst, 1998). Additionally, you can see the answer on the general comment No 1.

Interactive comment on Clim. Past Discuss., 9, 2589, 2013.