

Interactive comment on “Pollen-based temperature and precipitation changes in the Ohrid Basin (western Balkans) between 160 and 70 ka” by Gaia Sinopoli et al.

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After a debate among authors, we decide to reply more in detail to the referees clarifying how we intend to improve the manuscript. We would ask the editor and the referees to consider this version.

Thank you for the opportunity to comment on this manuscript. The manuscript titled ‘Pollen-based temperature and precipitation changes in the Ohrid Basin (western Balkans) between 160 and 70 ka’ covers a sound data set of great value to the palaeoecological community as climate reconstruction for the last interglacial-glacial cycle from this sensitive area are scarce. Overall, I think the work is good and should be published

C1

in CP but there are a number of important details that need to be considered and corrected first. In many instances these are related to terminology, definition of terms and ambiguity or circularity in the phrasing. One important example of this is the use of different nomenclatures, e.g., from alpine region (Riss/Würm glacial), from northern/central Europe (Eemian interglacial), and the special nomenclature from France for interstadials/stadials. Regarding the last interglacial, be careful with the statement that the Eemian was not a stable phase in the Balkan region. The last interglacial at LO clearly shows a classical interglacial with an early warming at the beginning of MIS 5e, a climate optimum and a progressive cooling towards the end of the last interglacial. In general, I suggest to interpret the LO record with regard to further regional climate reconstructions (mentioned in the chapter ‘Introduction’, e.g., LGdM and Ioannina) and use it as a basis for discussing in more global scale with possible correlations to the France, speleothem records, MIS, etc. These important issues and more are detailed below along with some suggestions for grammatical corrections. Page, Line. Comment

Referee: P1, 17. The presented archive covers the period between 160 to 70ka. This includes not only MIS 6 and MIS 5, but also the early part of MIS 4. The authors mentioned it in the conclusion by themselves. (P14, 8).

Authors: OK

P1, 25-28. According to the anonymous referee #1. The last interglacial at Lake Ohrid shows a classical interglacial cycle with pre-temperate phase (early warming), temperate phase (climate optimum), and a post-temperate phase (progressive cooling), which is also well described by Tzedakis, 2007. Be careful with this general conclusion of an unstable last interglacial in the Balkan region!

OK, WE WILL ADJUST THE TEXT

P2, 3. Insert ‘...’MIS’ – 6 (penultimate glacial) and MIS 5 (last interglacial complex) are. . .’

C2

OK

P2, 6. '...the penultimate glacial (or Riss Glaciation) ...' in comparison to P2, 12. 'The Eemian. ...' Please pay more attention to a uniform nomenclature. The term 'Riss glaciation' is normally used in the alpine area. In northern and central Europe, the penultimate glacial belongs to the 'Late Saale/Saalian Complex'. If you want to continue with the term 'Eemian' for the last interglacial (MIS 5e), you should use the nomenclature of the northern and central Europe. Another example is the '(Early) Weichselian glacial' instead of 'Early Würm' (P2, 34).

OK

P2, 7. Please pay more attention to uniformity. The LIC lasts from ca. 130-80 ka in the chapter 'Introduction', whereas the LIC covers the period from ca. 128-70 ka at page 3, 25. Please check the dates, there are several more discrepancies.

OK, WE MADE IT CLEARER. THE MIS 6 TO MIS 5 TRANSITION AT LAKE OHRID HAS BEEN THE SUBJECT OF AN ACCURATE ALIGNMENT AND SYNCHRONIZATION (ZANCHETTA ET AL., 2016) RESULTING IN AN OFFSET OF 2 KA WITH OTHER RECORDS (E.G. GOVIN ET AL., 2015; RAILSBACK ET AL., 2015).

P3, 2-4. The authors mentioned that Ioannina and LGdM have done climate reconstructions based on pollen data. Unfortunately, these two archives were not used for comparison (e.g. in Figure 5) or were not discussed in detail in the text (chapter 5.3), although these records are much closer to Lake Ohrid than the archives in France. Due to the fact that you mentioned in P3, line 15 that the Balkan Peninsula is a key region between the Mediterranean area and the Northern/Central Europe. It would be nice to see how these few southern European records differ from the northern European ones. What about the direct comparison with Lake Prespa, which covers the last ~90 ka. I am not sure if they have done climate reconstructions, but are there any similarities or differences to your record?

C3

THE IOANNINA AND MONTICCHIO CLIMATE RECONSTRUCTIONS HAVE BEEN DONE BY BREWER ET AL. (2008); WE HAVE NOT USED THEM FOR COMPARISON IN FIGURE 5 BECAUSE THIS STUDY ONLY FOCUSES ON THE EEMIAN PART, BUT WE HAVE USED THESE SITES IN FIGURE 6 (EEMIAN PART) FOR COMPARISON WITH OHRID (SOUTH EUROPE CLIMATE CURVE IS BASED ON IOANNINA, MONTICCHIO AND 2 MARINES CORES); SO, YES WE HAVE USED IOANNINA AND MONTICCHIO SYNTHETIC CLIMATE RECONSTRUCTIONS TO COMPARE OUR DATA WITH A MORE GENERAL SOUTH EUROPEAN CURVE (FIG 6). THERE IS NOT A QUANTITATIVE CLIMATE RECONSTRUCTION FOR LAKE PRESPE, AND THE CHRONOLOGY FOR BOTTOM CORE IS NOT WELL CONSTRAINED.

P3, 14. ...glacial-interglacial cycle. (?)

OK

P4, 1-2. The first sentence is not necessary.

OK

P4, 11. Avoid the repetition of 'karst aquifers' at the end of line 11.

OK

P4, 12-13. Rephrase: '...small streams, rivers, and by direct precipitation.'

OK

P4, 18. Rephrase: '...during winter and south-southeasterly (or southerly to south-easterly) winds during. ...'

OK

P4, 21. This context is not clear – please rephrase. What are the four zones? Which species dominate which zone?

OK, WE WILL CORRECT IT

C4

P5, 1-3. Please check. This sentence is written in a different language.

OK, WE WILL DELETE IT

P5, 15. What is 'new' in the high-resolution pollen data, presented in this manuscript, when it is already published in Sinopoli et al., 2018? Did you analyse more 'new' samples for this manuscript, which are not shown in the Sinopoli et al. paper? Please clarify!

OK, WE WILL MAKE IT CLEARER.

P5, 34. Which 'six modern analogues'? This subject should be further explained and clarified in the text.

SEE THE ANSWER TO REVIEW 1, WE WILL CHANGE THE TEXT ACCORDINGLY.

P6, 18. It is not clear to me what do you mean with the '...first analogue and the last analogue. ...'? More details are needed.

THE FIRST ANALOGUE CORRESPONDS TO THE CLOSEST ANALOGUE, BASED ON THE CHORD DISTANCE CALCULATION; THE LAST ONE IS THE ANALOGUE WITH THE CHORD DISTANCE. WE WILL CORRECT IN THE TEXT AND IN FIGURE A2

P6, 35-36. Please check. This sentence is written in a different language.

OK, WE WILL DELETE IT

P7, 1. '...and annual precipitation between 350 and 600 mm/yr),...'. It depends on what method you looking at. For MAT, I can recognize a fluctuation from 100 to ca. 300 mm/yr in the mean annual precipitation. For WALPS, it fluctuates between 500 to 700 mm/yr. What is the explanation for this huge difference? Please clarify and add some more explanations.

THESE DIFFERENCES ARE DISCUSSED IN THE DISCUSSION PART: DURING

C5

THE FIRST PART OF MIS 6 (CA. 160-143 KA), EVEN IF THE PRECIPITATION CURVES PRODUCED BY BOTH METHODS SHOW THE SAME TREND, RECONSTRUCTED VALUES BY MAT ARE ROUGHLY 300 MM LOWER THAN THOSE RESULTING FROM WAPLS. MODERN ANALOGUES METHODS ARE VERY SENSITIVE TO MINOR VARIATIONS IN THE POLLEN ASSEMBLAGES, ESPECIALLY DURING GLACIAL PERIODS (BREWER ET AL., 2008). SIMILAR DISCREPANCIES ASSOCIATED WITH MAT ALSO OCCUR IN THE RECONSTRUCTION OF LA GRANDE PILE AFTER THE EEMIAN THERMAL OPTIMUM BY BREWER ET AL (2008). AMBIGUOUS OUTCOMES MAY OCCUR PARTICULARLY FOR PAST GLACIAL AND COLD INTERVALS (STADIALS). THE MAJOR PROBLEM APPEARS TO BE THE LACK OF MODERN ANALOGUES OR ONLY LIMITED SIMILARITY WITH PAST GLACIAL VEGETATION (GUIOT ET AL., 1993; PEYRON ET AL., 1998). INDEED, AS REPORTED IN SEVERAL STUDIES (GUIOT, 1987; GUIOT ET AL., 1993; KLOTZ ET AL., 2003), GLACIAL STEPPE VEGETATION DOMINATED BY HIGH PERCENTAGES OF AMARANTHACEAE (AS AT LAKE OHRID, FIG. 2) HAS NO PRESENT-DAY ANALOGUE IN EUROPE. FOR THIS REASON, WE HAVE USED MODERN SAMPLES FROM COLD STEPPE, PRINCIPALLY FROM THE TIBETAN PLATEAU AND FROM RUSSIA AS "POTENTIAL" ANALOGUES FOR GLACIAL PERIODS (PEYRON ET AL., 1998, 2005) AND THESE SAMPLES ARE CHARACTERIZED BY LOW PRECIPITATIONS VALUES.

P7, 11 and 14. Which 'other methods'? If necessary, add references.

WE ARE NOT SURE WE SHOULD LIST ALL OF THEM, AS WE REFER TO THE ORIGINAL PUBLICATIONS (BREWER ET AL, 2008 AND KUHL ET AL 2010 FOR MULTI-METHOD APPROACHES); WE WILL ADD THE PDF METHOD IN THE TEXT.

P7, 34-36. Which is the third part? Furthermore, an additional verb is missing. Please rephrase this sentence.

MELISEY II AS SHOWN IN TABLE 1, YES "ARE" IS MISSING. WE WILL ADJUST IT

C6

P8, 17 and following. Describe the 'end of MIS 6' within chapter 4.1

YES, HERE IS JUST USED AS A COMPARISON

P9, 8 -16. This section should be mentioned in the chapter 'Materials & methods'.

WE DON'T AGREE: THIS SECTION TRIES TO EXPLAIN THE DIFFERENCES IN THE RESULTS, DUE TO THE DIFFERENT METHODS; SO IT'S BETTER TO KEEP IT IN THE DISCUSSION PART.

P9, 19-20. To be consistent with the text, could you add the discussed pioneer shrubs (e.g. Juniperus) to the selected pollen diagram (Figure 2).

OK

P9, 28 and following. For the better understanding and demonstration, it would be very helpful to show the comparison of your Eemian climate reconstructions with those from the JO2004 record. Please insert the JO2004 climate reconstruction, for example, in Figure 4.

THE CLIMATE RECONSTRUCTION BASED ON THE JO2004 RECORD DONE WITH A MULTI-METHOD APPROACH (PEYRON ET AL., PERS. COMM.) IS NOT YET PUBLISHED; SO IT'S NOT POSSIBLE TO INCLUDE IT FOR COMPARISON IN FIG .4.

P10, 12. The phrase '...export of terrestrial organic matter...' sounds a bit odd. Please rephrase.

OK

P10, 18 and 19. Delete '...inferred from pollen.' due to the repetition from the previous sentence. At this point, it is obvious that TANN and PANN were calculated from pollen.

OK

P10, 18-29. There seem to be some logical steps missing. I cannot work out how lake level changes can be visible in the pollen record. I also cannot see a decline

C7

in terrestrial vegetation at the end of MIS 6 - in fact, quite the opposite. It shows a continuous increase in mesophilous and coniferous trees! In addition, I assume that significant lake level changes should be reflected in the TIC /TOC values, but again I cannot see any changes in these proxies at the DEEP site. Furthermore, the 'clearly seen' change in the pollen record of Co2012 is not presented in this manuscript! These subjects should be explained more clearly in the text.

THE REFEREE IS RIGHT, LAKE LEVEL CHANGES ARE NOT VISIBLE IN THE POLLEN RECORD! WE USED OTHER EVIDENCES FROM PUBLISHED ARTICLES: "THE DISTINCT HIGH-AMPLITUDE FLUCTUATIONS INFERRED FROM POLLEN DURING THE FINAL PART OF MIS 6, COULD AT LEAST PARTLY BE DUE TO LAKE LEVEL CHANGES AS THE WATER TABLE DURING THIS PERIOD WAS GENERALLY ON THE RISE (LINDHORST ET AL., 2010, HOLTVOETH ET AL., 2017; WAGNER ET AL., 2017)". THIS IS IN VERY GOOD AGREEMENT WITH "A CONTINUOUS INCREASE IN MESOPHILOUS AND CONIFEROUS TREES" AS EVIDENCED BY REFEREE 2. ANYWAY, IT APPEARS THAT WE HAVE NOT BEEN CLEAR ENOUGH, WE WILL TRY TO BE MORE EFFECTIVE.

P10, 31-34. In my opinion, a difference of 500 years is NOT a discrepancy. The authors should soften the language.

WE THOUGHT THAT USING "SLIGHT" COULD HAVE BEEN ENOUGH, AND IT IS NOT FOR REFEREE 2... BUT REFEREE 1 SAYS IS NOT THAT SLIGHT... SO THE OPPOSITE "THIS SLIGHT DISCREPANCY" (NAMELY 500 YEARS) "IS PROBABLY DUE TO DIFFERENCES IN THE CHRONOLOGY ESTABLISHED FOR THE TWO CORES". WE WILL EMPHASIZE THAT THE TWO CHRONOLOGIES HAVE BEEN ASSESSED INDEPENDENTLY.

P10, 39-41. Please avoid the use of so many 'and' in this sentence. Please rephrase.

OK

C8

P10, 42 and following. There is something odd about the line of reasoning here. It is not clear to me what do the authors mean with 'from 120 ka and culminating at 119.4 ka'? In Fig. 4, I cannot identify a 'culmination' in the TIC decrease during this interval. At the DEEP site, the TIC and TOC values already continuously decrease after ca. 126 ka! In addition, how can a progressive drying (P11, 3) take place when precipitation increases at the same time (P11, 1)? By the way, I cannot see an increase in precipitation after 120 ka! Please clarify.

OK, WE WILL CLARIFY THIS PART IN THE TEXT

Chapter 5.3. It would be nice to see a direct comparison of climate parameters between Lake Ohrid, LGdM, Ioannina, and the records in France (e.g., in Figure 5). Unfortunately, the southern European records are only summarized in Figure 6. I think it would be helpful for your argumentation. Be careful with simplification of complex interactions! When I am looking at the comparison between LO, Northern Europe, and Southern Europe (Figure 6), I can recognize several different responses to global climate changes in all records. In my opinion, the authors should make it unequivocally clear the transitional position from Mediterranean climate influenced climate to more temperate northern European climate conditions with, e.g., a distinct temperature decrease after 125 ka, which is not that pronounced at LO (more comparable to the southern European records).

WE AGREE WITH YOU. THE IOANNINA AND MONTICCHIO CLIMATE RECONSTRUCTIONS HAVE BEEN DONE BY BREWER ET AL. (2008); FOR IOANNINA NO SINGLE CURVE FOR CLIMATE RECONSTRUCTION IS AVAILABLE, THE CLIMATE RECONSTRUCTIONS HAVE BEEN USED TO BE INCLUDED AS SUMMARY CURVE FOR SOUTHERN EUROPEAN SITES. MOREOVER, WE CANNOT USE THEM FOR COMPARISON IN THE FIGURE 5 BECAUSE THIS STUDY ONLY FOCUSES ON THE EEMIAN PART. THEREFORE, WE HAVE USED THESE SITES IN THE FIGURE 6 (EEMIAN PART) FOR COMPARISON WITH OHRID (SOUTH EUROPE CLIMATE CURVE IS BASED ON IOANNINA, MONTICCHIO AND 2 MARINES CORES);

C9

SO, YES WE HAVE USED IOANNINA AND MONTICCHIO CLIMATE RECONSTRUCTIONS TO COMPARE OUR DATA WITH THE MORE GENERAL SOUTH EUROPEAN CURVES (FIG 6).

P11, 26. The period from 135-105 ka comprises the late MIS 6 to MIS 5c, as you already mentioned it in the next sentence!

YES, THE REFEREE IS RIGHT. WE USED IN FACT THE VERB "INCLUDES", MEANING THAT IS NOT ONLY THE WHOLE EEMIAN: "THE PERIOD 135- 105 KA, WHICH INCLUDES THE WHOLE EEMIAN"

P11, 29. In the direct comparison between LO and Grande Pile & Bouchet, there are opposite trends in the anomalies at the end of MIS 6. Between ca. 140-133 ka: high anomalies at LO, low at GP; between ca. 133-128 ka: low anomalies at LO, high at GP. Please clarify.

OK, DUE TO THE PROBLEMS ALREADY LISTED IN HAVING PRESENT-DAY ANALOGUES FOR AMARANTHACEAE STEPPE, IT'S NOT APPROPRIATE TO GO IN THESE DETAILS

P12, 11. Delete the repetition of 'Fig.5'.

OK

P12, 18. As I already wrote above, add the 'other pollen records from Lake Ohrid' to the figures. It would be helpful for the following of your argumentation.

THE REFEREE IS RIGHT, BUT A COMPARISON OF THE DIFFERENT POLLEN RECORDS (NOT ALL AVAILABLE TO US) FROM LAKE OHRID IS NOT THE TOPIC OF THIS PAPER AND JUSTIFY A SEPARATE PUBLICATION

P12, 24-35. What is the 'striking feature' of these interstadials, just the occurrence? Add some more explanations. I think these two short-term interstadial can be correlated with the Dansgaard-Oeschger events DO 19 and 20, which are also visible in

the eastern Mediterranean records, such as Thenaghi Philippon (Müller et al., 2011) and Lake Van (Pickarski et al., 2015), even though the climate was significantly more continental during this time.

YES, THEY CAN BE PROBABLY CORRELATED WITH THE DANSGAARD-OESCHGER EVENTS DO 19 AND 20. WE DO NOT UNDERSTAND “EVEN THOUGH THE CLIMATE WAS SIGNIFICANTLY MORE CONTINENTAL DURING THIS TIME”, MAYBE THE REFEREE INTENDS IN THAT REGION.

P13, 17 & 23. The ODP-976 record is not presented in the manuscript!

YES, THE REFEREE IS RIGHT, IT'S A MISTAKE

P13, 16-24. There are some important differences visible between LO and other records (e.g., at ODP-977, Villars cave) especially at the early Eemian, which are not discussed in the text. Be careful with generalization! Please add more details and discussed that differences a bit more.

YES, THERE ARE DIFFERENCES, WE ARE AWARE OF, DIFFICULT TO EXPLAIN. IT ANYWAY GOES BEYOND THE SCOPE OF THIS PAPER TO EXPLAIN ALL DIFFERENCES WITH OTHER RECORDS IN DETAIL.

P13, 25 -34. There are some logical steps missing. Which event centered at ca. 115? Melisey I? C25? I am a bit lost in this section! In addition, C25 event is not visible in the SST record! Please clarify!

OK, WE WILL CLARIFY THIS PART.

P14, 5. A period is missing at the end of the sentence.

OK, WE WILL CLARIFY THIS PART.

P14, 8. Insert ‘...Last Interglacial Complex (LIC, 128 to 70 ka),...’ due to the used abbreviation in the next sentence.

C11

OK. JUST IN CASE SOME READERS ARE JUST READING THE CONCLUSIONS.

P14, 12. ‘. . . occurring during the late MIS 6, MIS 5 and the early MIS 4.’ Table 1 Please use a uniform nomenclature. It would be nice if you could mark the different MIS 5 stages (MIS 5e to a) in the ‘Marine Stratigraphy’ column.

WE WILL DO A ROUGH SCHEME, BUT AS FAR AS WE KNOW THE DIRECT CORRESPONDENCE BETWEEN TERRESTRIAL PHASES AND MARINE STRATIGRAPHY WAS NOT YET PRECISELY ESTABLISHED.

Figures Figure 1 Where is the ‘Struga meteorological station’ located? Can you mark it on the map? Please pay more attention to the consistence of facts between the text and the figures. For example, you mentioned in P4, 7 that Lake Ohrid is located at 693 m asl. In your figure 1, it is written 694 m asl. The same discrepancy is evident in the mean annual temperature at Lake Ohrid (P4, line 15).

OK, THANK YOU

Figure 2 Perhaps it is better to use the terms ‘Mesophilous taxa/biome’ and ‘Mediterranean taxa/biome’ instead of ‘trees’, because Hedera is not a tree, it is a liane, and Cistus (depending on the species) grows also as shrub. The figure caption is a bit confusing. If you are showing, e.g., only Poaceae within the group of grasslands then delete the additional information that grasslands consist of Poaceae and Cyperaceae. The same goes for ‘Steppe’. Please, show in the first column (left) the MIS 6 to 4 and in the second column the nomenclature of the northern and central Europe. That goes also for the other figures.

WE USED THE SAME CATEGORIES AND NAMES USED IN SINOPOLI ET AL. 2018 AND SADORI ET AL. 2016 FOR UNIFORMITY.

Figure 3 MAT method is shown in a blue line, not in black! Regarding GDD5: The legend of the figure is not clear to me. Are these 1000-3000 years over 5°C per year/season/? Are these 1000-3000°C. Please, clarify! Delete the repetition of

C12

'Blue shading indicates cold periods (Riss glacial and Early Würm glacial stadials)' in the figure caption.

OK, WE WILL ADJUST IT; GDD5, THE GROWING DEGREES DAYS OVER 5 IS DEFINED AS THE SUM OF POSITIVE TEMPERATURE (PER DAY) OVER A PERIOD (YEAR) ABOVE A CERTAIN THRESHOLD BASE TEMPERATURE (HERE 5°C)

Figure A1 What do you mean with 'The last graph represents the . . .'? Figure A2? What outline the different red lines? More details are needed.

IT'S A MISTAKE: THE SENTENCE "THE LAST GRAPH REPRESENTS..." CORRESPONDS TO THE CAPTION OF THE FIGURE A2; WE WILL CORRECT IT. IN THE FIGURE CAPTION OF FIG. A2, TEXT WILL BE ADDED FOR CLARITY: THE FIRST ANALOGUE CORRESPONDS TO THE BEST OR CLOSEST ANALOGUE WITH THE LOW CHORD DISTANCE; THE LAST ANALOGUE CORRESPONDS TO THE ANALOGUE WITH THE HIGHER CHORD DISTANCE

References Müller et al., 2011. The role of climate in the spread of modern humans into Europe, QSR 30. 273-279. Pickarski et al., 2015. Abrupt climate and vegetation variability of eastern Anatolia during the last glacial. CP 11. 1491-1505. Rasmussen et al., 2014. A stratigraphic framework for abrupt climatic changes during the Last Glacial period based on three synchronized Greenland ice-core records: refining and extending the INTIMATE event stratigraphy. QSR 106. 14-28. Tzedakis, 2007. Seven ambiguities in the Mediterranean palaeoenvironmental narrative. QSR 26. 2042-2066. I hope my comments help improving the manuscript.âĀĀ

YES, THEY DID. THANK YOU VERY MUCH

Interactive comment on Clim. Past Discuss., <https://doi.org/10.5194/cp-2018-71>, 2018.