Author's reply to the comment by Z. Bora ÖN*

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1 Reply to General Comments of CC1

I am grateful to Ön who kindly accepted to read and provide feedback on this current version of the paper[1]. I hereby gratefully acknowledge his encouragement and friendship. Ön gave up some of his precious time to comment on this initial manuscript. I hope my replies below answer some of his comments/questions[2]:

1. The article gives the impression as the ice age concept is proposed by Agassiz. But, unlike Agassiz, the text should also give credit to Venetz, de Charpentier (see, Berger, 2012) or even to Hutton (see, Davies, 1968) and Playfair (see, Seylaz, 1962). Furthermore, mentioning Jens Esmark (Andersen, 1992, pp. 102) as the first scientist to propose an astronomical solution (even it is very primitive) would be better.

   I think that the point you raised is a sound one. It's a good idea to briefly highlight the contributions of the scientists you mentioned, just before proceeding to Agassiz. Frankly, a similar suggestion came from Jan Mangerud, who reached me via e-mail. Along with the articles you mentioned, I will also use the article he recommended [3] in the final version of my manuscript.

2. In the 6 th section the astronomical parameters (lines between 201–254)are given with too much detail. They can be simplified. Furthermore,figures 3, 4 and 5 can be presented in a single figure.

   I agree with your suggestion about combining the figures. I will also try to eliminate any unnecessary detail -especially in lines between 201–254.

*CC1-Community comment. Comment on the Paper: Pioneers of the Ice Age Models: A Brief History from Agassiz to Milankovitch. 21 Jan 2022

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[1] https://doi.org/10.5194/hgss-2021-17-CC1

[2] Ön's comments are colored brown, Authors' replies are black

[3] https://onlinelibrary.wiley.com/doi/10.1111/bor.12260

3. The formulas between 2 to 9 distorts the integrity of the text. I believe these formulas and the paragraphs describing them should be rewritten from scratch just by referencing the original sources.

   I agree with your comment. Additionally, this comment is largely in agreement with the first (Anonymous) and second referee's (Andreas Schmittner's) concerns. Consequently, the equations from (2) to (9) will not appear in its original form. Instead you will find equations explained descriptively. To enhance the accessibility of the text, I will state Milankovitch's equations in words.

4. In text it is sometimes written the earth and sometimes Earth . It should be consistent. If I were Ateş, I would follow the recommendation of Şengör (2017) and use it as the earth not Earth

   I will consider this suggestion as well.

2 Line based recommendations of CC1 and My opinions/replies

- Line 38 (L38): Change "our climate is subject to certain periodical changes" to "the earth's climate is subject to certain quasi-periodic changes"

  Done.

- L41-42: Change "Whether periodically or not, the Earth has witnessed, and probably will continue to witness numerous glacial and interglacial periods." to "Whether periodic or not, the earth has witnessed, and probably will continue to witness numerous glacials and interglacials."

  Done.

- L45: "than their previous ones?" or "than some other ones?"

  I will follow your suggestion. Using "than some other ones" is more appropriate.

- L49: I would delete the first sentnce of this paragraph, starting with "There are many causes of major glaciation,...".

  I agree with your suggestion.

- L50: Consequently, I would change the sentence " Among all these, however, the main cause responsible to initiate an ice age period is plate tectonics." to "Without the feedback mechanisms initiated by plate tectonics, long term oscillations of climate (as illustrated in Figure 1) would be completely different."

  Done. Thanks for the suggestion.

- L51 A comma after meteorologist.

  OK

- L51 “this hypothesis”, which hypothesis?

  The whole paragraph has been revised in light of this comment. Thanks.

- L52 Change had to was .

  Done

- L53: This sentence is odd. The first part, till the comma, the reader understands it as Wegener’s theory revealed the mechanisms of ice ages. Maybe it can be, “He spent his time primarily in Greenland and his field research was mainly focused on continental drifts that led him to develop the revolutionary theory of plate tectonics, which brought a useful explanation for long term climate changes.”

  Thanks for all the suggestions. The last five comments above are all related to one passage (L49-54). So accordingly the first paragraph of Sec.2 has been deleted and replaced as follows:

  Without the feedback mechanisms initiated by plate tectonics, long term oscillations of climate (as illustrated in Figure 1) would be completely different. So to speak, the main cause responsible to initiate an ice age period is plate tectonics. Alfred Wegener (1880–1930), the German geologist and meteorologist, has laid the groundwork for this idea. He spent his time primarily in Greenland and his field research was mainly focused on continental drifts that later led Harry Hess (1906–1969) to develop the revolutionary theory of plate tectonics which brought a useful explanation for long term climate changes. The theory of plate tectonics was not peculiarly aimed to find out the mechanism of glacial periods, but it provided a useful framework for how these periods occur.

  One more thing. I realized that I forgot to mention Hess in this initial manuscript. Thus, I hereby took the opportunity to mention his name in the passage.

- L58: Don’t use “beneath”, maybe “south” is better.

  OK.

- L 81 Delete “has”.

  Done.

- L 82 Change “an extensive ice age about 350–250 million years ago, also the era when Pangaea existed. This can also be seen in (Fig .1), where one of the lowest points of the curve denotes this period.” to “an extensive ice age about 350–250 million years ago, also the era when Pangaea existed (Fig .1)”

  Thanks, I follow your suggestion.

- L93: Referencing a first year textbook, Lutgens et al. (2012)... I am not sure if it is a good idea. Furthermore, this is the second time up to now and these are direct quotations.

Yes, this is a fair comment. I will paraphrase the information in my own words.

- L124–L129: The story about Agassiz is not that innocent (Berger, 2012, pp. 109, 2 nd column)

  I acknowledge the comment of the reviewer. I will add extra information about the issue.

- L149: How would it be to change the wording here from "discovery" to "hypothesis"?

  Thanks for the suggestion, but I prefer to keep this word as it is.

- L167: Comma after Milankovitch.

  Done.

- L176: "Until the era of Milankovitch, the mainstream methodology on particular issues in geology was descriptive.", is this sentence necessary? Or, even true?

  Thanks for the comment. I will rewrite or eliminate this sentence.

- L189–L193: "Milankovitch approached the problem was quite original.", but in this paragraph what you explain is similar to Croll's approach. What is original?

  To clarify, what I have intended to say is that Milankovitch's approach is similar to Croll in a general sense. What differs Milankovitch from Croll is that he takes all relevant orbital elements (not only eccentricity and precession but also *obliquity*) into account Thank you for your comment, I will clarify the issue by emphasizing this point in the final manuscript.

- L217: There is no need to show the computational line. The second line can be given in text, of course without that much precision, such as e = 0 . 016.

  OK.

- Fig3: Please note that it is today's condition.

  OK

- L236: Are following sentences really necessary? "This tilt can be measured easily at solstices and equinoxes. In order to do that, it is sufficient to take the inverse tangent of the value which is found by dividing an object's height by its shadow length, at that particular time."

  Thanks for the comment. Of course it is not necessary, but this is a short explanation or an extra piece of information which I see as harmless. So I prefer to keep this sentence as it is.

- L243: Yes, it is true that the precession of the equinoxes cycle lasts approximately 26,000 years. However, the climate is not affected by the sole effect of precession, but by the effect of the precession of the equinoxes modulated by the changes in the eccentricity of the earth's orbit. On average, its period is 21,700 yrs. Please see Berger (Table 1 in 1977).

  Thanks for this comment. Here I am not considering the effect of precession on the climate. This passage merely intends to define the precession of the equinoxes cycle.

- L245: Will Polaris once again be the North Star after 13,000 years or after 26,000 years? I suspect, there is a small mistake here.

  Today the polar axis of the earth points to Polaris; after 13.000 yrs it will point to Vega, and after 13.000 yrs it will once again point to Polaris. Perhaps a clarification is required here. Thank you.

- L255-261: It would be appropriate if you give original references of these studies.

  OK.

- L275: I am not sure, but would it be OK to add that Croll was aware of the continental distribution of the earth?

  OK. Thank you for pointing this out to me.

- L321: "It is because all three cycles operates independently of each other.", I didn't understand the causality of being independent and being in a superposition of these cycles for a significant global climate change.

  True. What I have in my mind is as follows: These cycles are neither singly nor jointly the direct cause of glaciation; instead they merely determine the crucial levels of insolation. Thus, glaciation (as well as inter-glaciation) process causally connected with the amount of solar insolation, not with the orbital cycles of the Earth. However, these cycles, incorporate as modulating elements of main causal factor (i.e. incoming solar radiation) that eventually influence global climate change.

- L323: "When the quantity of the heat decreases, a glacial period begins. In the opposite situation, when the quantity of heat increases, the global temperature significantly rises up and an interglacial period begins consequently.", I don't think this is true. Insolation is not the marker of beginning of glacials and interglacials (cf. PAGES, 2016). I believe, these are all of Milankovitch's ideas or part of Milankovitch's model. They are not true for today. Therefore it should be explicitly emphasized.

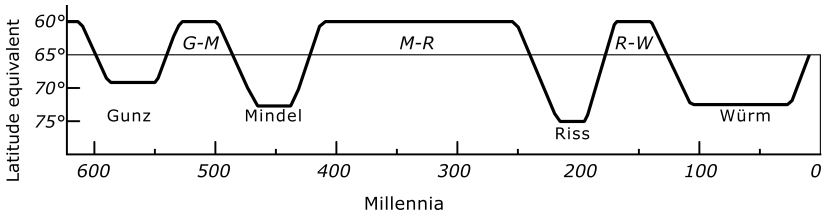
  True, I need to (and I will) stress this point in the final manuscript.

- L395: "This could be evaluated as an indication of a relatively cold summer for the northern hemisphere ."

  I agree.

- L399: Is the following sentence correct? "Both scientists were already presented their results in a graph."

  This sentence is deleted. The revised text is as follows: *Soon after completing his work, Milankovitch sent this radiation curve graph to Köppen. The graph must have been intriguing for Köppen, as it was in agreement with the findings of two German geographers Albrecht Penck (1858–1945) and Eduard Brückner (1862–1927).* ~~*Both scientists were already presented their results in a graph (Fig. 8).*~~*Penck and Brückner were researching on Alpine glaciers and about 15 years before Milankovitch's work, they identified four great glacial periods in Earth's history by examining successive gravels, plant remains and moraines in the European Alps (Anderson et al., 2013 p. 8). They displayed these different periods in a graph and named them chronologically as Günz, Mindel, Riss, and Würm in their 1909 book 'Die Alpen im Eiszeitalter' (Fig. 8).*



  Kindly notice that the above figure (fig.8 with certain revisions its number most probably will change) is redrawn as a vector image. So, the image's initial poor quality will not remain.

- L418: Is it true with human effects? Please check this. See also Fig. 6 of Paillard (2010) for possible future scenarios.

  Thanks for the comment. As you point out, the issue about human effects seems controversial. I will make additional statements to clarify this specific issue.