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Comment on cp-2022-49

Anonymous Referee #2

Referee comment on "Abrupt climate change and millennial-scale cycles: an astronomical mechanism" by Alison Kelsey, *Clim. Past Discuss.*,
<https://doi.org/10.5194/cp-2022-49-RC2>, 2022

Review of **Abrupt climate change and millennial-scale cycles: an astronomical mechanism**, by Alison Kelsey

General comments:

In this manuscript Alison Kelsey presents the results of the superimposition of lunar and solar periodic signals and compares it with a reconstruction of total solar irradiance.

This comparison appears to be satisfactory. This, together with the fact that the Earth-moon distance shows a modulation on a ~ 1400 yr periodicity (among others), allows the author to develop the article upon the idea that it represents a new mechanism to explain abrupt climate changes on millennial time scales.

In my opinion, although the former finding is of interest, the manuscript is addressed in a highly biased manner making it difficult to be published under its current form.

Showing that there is a robust solar irradiance and lunar cycle oscillation around 1500 years would be of major importance to the paleoclimatology research and worth publishing, but the current way on which these results are justified and framed in the paper is, in my opinion, erroneous.

Let me develop:

The first sentence of the abstract already illustrates this flawed approach. It reads: "Contributing to the poor understanding of abrupt climate change is the lack of a known mechanism for a ~1470-yr quasi-periodicity [...]"

Firstly, I guess what you mean here instead of "mechanism" is "forcing", because even if the solar-lunar cyclicity described here is robust, the author is not contributing to the description of any mechanism that causes the climate to abruptly change on a ~1500 yr periodicity.

Secondly, I guess that what you mean by "a known mechanism for a ~1470-yr quasi-periodicity" refers in reality to a "known climate forcing", because there are several proposed mechanisms, even in the articles cited here, to explain the climate variability on that time scale.

Finally, the lack of a known mechanism (forcing) does not contribute in any way to the poor understanding of abrupt climate change. The reasons of such a poor understanding lie on the complex character of the climate system together with the sparse character of the climatic proxies which do not fully allow for a robust discrimination of causes and effects. Besides, one could simply conceive that, even if such a forcing on a 1470 yr quasi-periodicity exists, it might be irrelevant in triggering the abrupt climate changes.

This biased approach is recognizable all over the manuscript. (see specific comments)

What the author is showing is that, according to her model and the good agreement with TSI reconstructions, there is a lunar-solar cyclicity around 1500 years that can potentially influence climate on that time scale. But this is far to represent an "astronomical mechanism for abrupt climate change and millennial-scale cycles" as suggested already by the title of the paper. In fact, every time that the author tries to link both aspects it is done in an arguably manner (if not simply wrong). For example: line 499 reads: "Effectively, the interaction between TSI, solar and lunar gravitational forces trigger responses in Earth's oceans and atmospheres, such as the thermohaline current and ENSO's atmospheric transport of heat and moisture (Broecker, 2003)." The reader could interpret this sentence as if Broecker, 2003 has shown any relationship between TSI and solar and lunar gravitational forces and the cited climatic processes related to abrupt transitions. He did not. I am not saying that your sentence is false, but nowadays it is just speculative and your research does not further elaborate on the potential connection between lunar-solar cyclicity and the mechanisms causing the climate to abruptly change on millennial time scales.

Again, if your calculations are correct (I am not an expert on solar and lunar variability, so I am giving full credibility to that aspect), it is intriguing and interesting to wonder how the climate system would respond. But the author's contribution to the physical mechanism responsible for such a link is absent in the study. There could be several mechanisms making the climate system to abruptly respond to a ~1500 years solar and lunar forcing, but they are not well addressed in the paper or absent. For example, the work by Arbic (e.g. 2004 and 2008) presents the possibility of triggering Heinrich events as a response to increased tidal amplitude in the Labrador Sea. These papers are not even cited in your manuscript. Moreover, the main way for energy dissipation in the ocean is caused by tides. Current GCMs investigating DO events need to put arguably too high mixing coefficients in order to spontaneously produce the oscillations compatible with the associated abrupt climate changes. Considering a tidal forcing on glacial millennial time scales could eventually facilitate the understanding of the necessary conditions for the models to show a DO-like variability. (This last sentence is a suggestion for the author in the line of what the paper fails to address).

There is also a clear flaw in this study: it overlooks (or simply ignores) a large part of the research on millennial-scale abrupt climate changes carried out in the last years.

Looking at your discussion section, particularly the paragraphs starting at line 503 and 511, the reader is invited to believe that, because the solar-lunar forcing described in the manuscript shares the time scale with the Bond cycle, DO and H events are a "natural" manifestation of the pretended "astronomical mechanism".

DO and H events are complex and intriguing manifestations of the climate system and the literature describing the attempts of explaining their physical origin is vast and rich.

If one claims that has discovered the common underlying forcing triggering their existence must explain the mechanisms translating such a forcing in their climatic imprints (see above), and also, must recognize all the previous work on such a subject.

Many important articles are not referenced in the manuscript both for the triggering mechanisms of DOs and Heinrich events. A few are cited, often incorrectly (see specific comments). I am not giving a list of the papers that should be cited. I suggest the author to carefully check the recent (and not that recent) bibliography on Heinrich and DO events.

This having said, I suggest the author to deeply reshape the manuscript. I see two ways of doing so:

- If the author wants to keep the current manner of framing her results (i.e. the implications of a newly described solar-lunar cyclicity on millennial-scale climate transitions), I suggest to address all my concerns and give a detailed, correct and humble context on which her results are presented.
- Perhaps a simpler manner of recycling the study would consist on forgetting the "climate aspect" and focus on the real novelty of the paper (i.e. the description of the solar irradiance and the Earth-moon distance cycles on millennial time scales). In my opinion, the pretension of having an "astronomical mechanism to explain abrupt climate changes on millennial time scales" heavily harms the current study. Even more when there is no need for such an approach to make the work interesting by itself.

Specific and technical comments:

Line 22: What "has the capacity to inform...?"

Introduction section: A whole paragraph describing the internal climatic theories explaining glacial millennial-scale variability is missing. (For example: Sakai and Peltier 1996, Peltier and Vettoretti 2014, Dokken et al, 2013, Alvarez-Solas et al, 2013, Basis et al, 2017 ... and many others)

Line 34: "This astronomical mechanism also explains...". The astronomical mechanism has not been described yet. Only a conjecture on its existence.

Line 34: "...tidal and solar records are synchronised in the paleoclimatic record". Is that a fact? Or just an interpretation?

Line 44: "Based on a premise that precession causes..." On what is this premise based? So far nothing has been described with a higher temporal resolution than Milankovitch.

Line 59: "... and are therefore linked to.." Why? Sentence not justified.

Line 64: "... the debate is clouded by a poor understanding of .." Speculative phrases and the citations at the end do not justify the sentence. On what Banderas et al, 2015 (for example) elaborates with respect to what the author wrote? Those papers are just trying to make it less cloudy.

Line 116: "...stochastic resonance is a possibility.." among many others.

Paragraph 116-120 is repeated from the introduction

Lines 127-131: Why is the explicit quote needed?

Line 258: "... using planetary software". Reference?

Line 268: NOVA is not defined

Legend of Figure 5: "The black solid line is the model"? Or the red one?

Line 470: "... it is now evident lunar gravitational..." Why? Explain and reference please

Line 497: "Such geographical variations..." This sentence is highly speculative

Line 499: Sentence is not appropriate nor the citation (see above)

Line 514: "... 5910 years (the same oscillation as Heinrich events)". Is that so? I do not think HEs have such a precise timing, and if so it would be a larger periodicity (see papers above).

Line 529: "These results provide a new and important understanding of the physics of climate change...". That would be nice indeed, but I am afraid this is just an obvious overstatement. Your study does not elaborate newly on the physics of climate change. (And again there is no need of such a thing for author's results to be framed appropriately and thus be published)

Line 533: "... and offers a mechanical explanation for abrupt climate change where previously none existed". Your study does not provide a "mechanical explanation" it would be an "explanation of the timing" at most. Moreover, "none existed"? Was not there any "mechanical explanation for abrupt climate change"?

