

## ***Interactive comment on “An astronomical correspondence to the 1470 year cycle of abrupt climate change” by A. M. Kelsey et al.***

### **Anonymous Referee #2**

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This paper suggests some relationships between different astronomical frequencies and climate changes in the millennial frequency range. This could be interesting, if the authors were cautious to explain in details all the difficulties involved in such interpretations. This is unfortunately not the case here. As noted by Eric Wolff and Peter Ditlevsen, the motivation exposed in the introduction is already problematic since the mere existence of a 1470 climatic cycle is not well established. This might also be the case for several "solar" cycles mentioned in the paper. Furthermore, the methodology used by the authors is not clearly exposed : they are combining trigonometric series without explaining what they are doing in a mathematical way (eg. what respective amplitudes for each component ? which assumptions on sunspot cycle phase ?...). It is therefore impossible to understand what their model actually is. Besides, the text is

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very confusing. As it stands, I do not recommend publication of this manuscript.

Main comments:

1 / Celestial dynamics vs. solar dynamo

There is some fundamental differences between cycles based on celestial mechanics (precession cycle, metonic cycle, ...) for which we have a rather good physical understanding, and on the other hand, cycles based on, or linked to solar dynamo (sun spot cycle, SdV, etc..) for which such an understanding is not currently available. In particular, a simple sinusoidal description of these latter cycles might be misleading... The sun-spot cycle is not regular (durations between 9.8 and 12.0 years) and it is known that the involved dynamics is chaotic. The nature of longer cycles (SdV, Hallstatt, ...) is still rather hypothetical and their "solar" nature subject to debate. It is therefore very dangerous to make arithmetics (e.g. computing harmonics, adding sinusoidal signals) with such not so well defined "cycles". In particular adding, or combining, the solar Schwabe cycle with an astronomical cycle (ie. a cycle based on celestial mechanics) is probably meaningless since their phase relationship is fully unpredictable.

2 / Is solar forcing necessary in this paper ?

By reading the manuscript, I got the feeling that the solar forcing is not the main player in the authors' results. Unfortunately, it is not possible, from the manuscript, to know precisely what such things like the "metonic-sunspot" cycle actually are... Examples: a/ The "description" of the model reads, page 4900, line 19: "This study presents a simple trigonometric model involving the superposition of mean values of three variables: (i) Schwabe sunspot cycle; (ii) Metonic cycle of lunations associated with the current perihelion, and (iii) the anomalistic year, the time for Earth's passage from perihelion to perihelion (365.2596 days). This in turn determines the time of Earth's rotation and revolution (RRA)" This is extremely misleading, since RRA is obviously not linked to solar radiation or sunspots. It depends only on (ii) and (iii). b/ page 4904, line 5, and Fig.3: "The RRA-Metonic (Fig.3a) ... is closer to the SdV cycle than ...(the

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one)... based on interaction between the sunspot cycle and Earth's rotation (Fig.3b). These findings suggest that both the SdV and Hallstadt cycles result from the superposition of solar and lunar forcing." If I understand well (again, I am not so sure about that), Fig.3a (RRA+metonic) has no "solar forcing" in it (no sunspot) in contrast to Fig.3b (RRA+sunspots) but is "closer to SdV" (ie. to observations). So the above two sentences appear to be fully contradictory... This might be due to a lack of precise definition. What do the authors call "solar forcing" ? Is it solar variability (11-year cycle), or Earth orbital variations (solar radiation) or gravitation tidal effect (as a possible consequence of RRA) ? As it stands, the manuscript is extremely confusing. If RRA is the main topic of the manuscript (I think it is...), I would advise the authors to remove entirely the sunspot cycle and re-focus the paper on this RRA point. This would provide a clear scientific message. This would also address entirely my first comment on unpredictable sunspot cycle phase. In contrast, if celestial mechanics alone is not sufficient, then the authors should pay particular attention to defining precisely each individual factor. Again, equations could be useful in this respect. In any case, I believe the manuscript needs a complete rewriting.

3/ Unnecessary confusion... For instance (page 4898, line 6): "The Moon is responsible for nutation (Lowrie, 2007: 58). Nutation, which is a cyclical wobbling of the Earth's axis over a 18.6 yr periodicity, alters the latitudinal perspective to incoming solar radiation. As Milankovitch demonstrated through his radiation curves..." Why mentioning the 18.6 yr nutation ? The amplitude of these instantaneous obliquity changes is very small (9" or a few hundred meters in latitude) and are not related to the Milankovitch forcing (ie. changes in mean obliquity, several degrees amplitude, a few hundred kilometers in latitude, 41 kyr periodicity). Nutation is not used in the manuscript at all. What is the point of mentioning it ?

4/ page 4897, line 24 "Based on the similarity in lengths of this millennial-scale climate cycle and the Sothic cycle of Egyptian chronology..." So here is the TRUE starting point...!! Then the authors should expand a bit, explain what the Sothic cycle is, why

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it is unlikely to act on climate and, finally, why they are building a "RRA-metonic" cycle to provide a new hypothesis. This would make a much more interesting story than the current very confuse presentation and discussion of the many different astronomical cycles, some being entirely irrelevant.

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