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Solid Earth
Discussions

Interactive comment on "Using spectral analysis to detect singular events such as jerks in the geomagnetic field time series" *by* B. Duka et al.

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Reply to Ref. 2

General comments

1. "The paper presents some well-known methods which are applied onto both real and synthetic data"

Reply:

We don't agree with this comment. We think the methods we used are not all well-known: for example, the d1 coefficient analysis and the way of jerk detecting are both original. Please read also the general comment by the first referee: "The paper includes

some methods which have not been tried before…",

2. However, I am afraid that some characteristics of the main field geomagnetic models have not been taken into account and directly impact onto the results given in this paper."

Reply:

This opinion is related to the remarks (comments nr. 10 and 24 of the "Specific and Technical comments") about cubic spline approximation of the main field geomagnetic models (CM4 and Gufm1) and the reply on this opinion will be found in the specific answers to these remarks.

Specific and Technical comments:

1. Page 617, Introduction, line 0 to 5: The definition of geomagnetic jerks by Courtillot et al.(1978) was slightly upgraded by the work done in Alexandrescu et al. (1996). Indeed the regularity of the event is not seen as 2 but closer to 1.5. Please, slightly correct the definition accordingly

Reply:

We will upgrade the jerk definition like the following, replying also to the referee comment about the regularity of 1.5: The short-term variations of geomagnetic field, internal in origin, the so-called geomagnetic jerks, can be defined as sudden changes (a V-shape like change) in the slope of the secular variation (the first time derivative of the Earth's magnetic field), or an abrupt (step-like) change in the secular acceleration (the second time derivative). As a very first approximation, the secular variation can be described as a set of linear changes over some years to some decades, separated by geomagnetic jerks occurring on a time-scale of a few months when the nearly constant secular acceleration changes sign (and, eventually, its magnitude) abruptly. For a more detailed characterization of geomagnetic jerks, we have to consider the findings of Alexandrescu et al (1996). Indeed, when the wavelet technique has been applied to series of monthly means, it appears that the event reveal a singular behavior with a regularity close to 1.5. This interesting behavior is useful to analyze the geomagnetic jerks at the place of their origin, indeed the top of the core. However, in the present analysis, we prefer to consider the geomagnetic jerks as singularities simply defined as discontinuities of the second order derivative of the signal.

2. Page 617, Introduction, line 28 to 29: The third method proposed appears to be power spectra of the secular acceleration Gauss coefficients along with time. The term “spatial spectral analysis in spherical harmonics” appears confusing here.

Reply:

The common aspect of both methods, STFT in one side and second time derivative of spherical spectra in other side, is the spectral analysis by harmonic functions: in case of STFT by temporal harmonics and in case of PSHS by spatial spherical harmonics. We don’t agree to call the second method as “power spectra of the secular acceleration Gauss coefficients along time”, , however we understand that the previous name could be confusing so following the suggestion of the first referee, we call it now “Spherical Harmonic Power Spectra (SHPS)”of the secular acceleration of the geomagnetic field.

3. Page 618, section 2, line 7: “The first kind of dataset is superior (...)” The adjective “superior” is not properly chosen here. The data are not superior. Their nature is different. Some data are real, direct measurements of the field, whereas the other type of data are synthetic ones, computed from geomagnetic field models.

Reply:

We agree with this remark, thus we reformulated the sentence according to the referee’s suggestion.

4.Page 618, section 2, line 11: “In addition, some synthetic data have been generated by means of specific functions to simulate geomagnetic jerks (...)” What are these specific functions ?

Reply:

Such functions are specified in the subsections: 3.2.2 (Synthetic data) and 3.2.3 (Synthetic data). Here we can say only: “see 3.2.2 and 3.2.3”

5. Page 619, sub-section 2.1.2: This sub-section may be directly added to the section 2.1. The sub-levels are not necessary here.

Reply:

Yes It will be done.

6. Page 619, sub-section 2.1.2, line 18: What are the longer and shorter times series ? What are the chosen duration thresholds for the selection of observatories data ?

Reply:

We added the words: “longer than 50 years”

7. Page 619, sub-section 2.1.1 : This sub-section is a recall of what was extensively already underlined in many papers. I do not think this recall is necessary here. The associated Figure 1 may be advantageously summed up in only 6 panels by overlapping the monthly and yearly data series. The monthly ones been scattered in front on the yearly ones, obviously

8. Page 619, sub-section 2.1.2: This sub-section may be directly added to the section 2.1. The sub-levels are not necessary here.

Reply to 7 and 8:

Yes, we will reduce these subsections in only one. But reducing figure 1 means that we have to cancel some of our remarks (lines 10-15 of page 619) that we think significant to be made.

9. Page 619, sub-section 2.1.2 Please, erase the sentence: ”Although all the components of geomagnetic field have been studied, we will present below mainly the results

for the Y-component." The fact that the authors considered the Y component, as the clearer component for describing the geomagnetic jerks, has already been explained extensively (page 617, line 11 to 15).

Reply:

Yes, we will erase this sentence.

10. Page 620, sub-section 2.2.1, line 13 to 15: "The capacity of this model to represent geomagnetic jerks has been already investigated (Sabaka et al., 2002; Chambodut & Mandea., 2005). " The limitation of the model to represent the geomagnetic jerks has also been investigated. Indeed, time-dependant geomagnetic field models, such as CM4, are using B-splines modeling for the time-dependency of the Gauss coefficients. Thus, the position of the B-splines nodes will necessarily appear in any wavelet analysis of a synthetic series calculated from such model (That was the reason why wavelet analysis were only performed onto real data in Chambodut & Mandea (2005)).

Reply:

Yes, in principle the position of B-splines nodes could appear in any wavelet analysis of synthetic series calculated from such model". But the effect of jerks are much larger, so the B-splines nodes are not really important in our analyses. When you calculate the field elements or their SV at a place and given time t, the program calculates the values of Gauss coefficients at this time as the combinations of the values of Gauss coefficients at 4 or 5 (depends from the order or B-splines) nodes that are the most near to time t. The coefficients of such compositions depend on the time distances of the node to the time t. Such coefficients are different for different time t, even when the same near nodes are used. Therefore the values of Gauss coefficients changes with time and when we shift the time t month by month, the received values do not reflect the positions of the node, that are 2.5 years apart each other. Anyway, as we have not presented the wavelet analyses for time series generated by CM4 model, we can say that this model is used to receive the time dependency of Gauss coefficients.

11. Page 621, sub-section 3.1.1: This part is extremely similar to textbook material, it would be better to place it in an appendix

Reply:

Yes, we will move it to the appendix

12. Page 621, sub-section 3.1.1, line 21: "Its obvious that considering (...)" Please, if this is obvious, DO NOT indicate it.

Reply:

We will cancel it.

13. Page 622-623, sub-section 3.1.2.: Onto Figure 2, please, indicate the data analyzed (first difference of the synthetic signal) under its spectrogram

Reply:

In the figure 2 caption is told that the signal is defined with the formula (3) given in page 623. We think it is not necessary to write in the figure caption the formula of this signal.

14. Page 623-624, sub-section 3.1.3: Onto Figure 3, please, indicate the data analyzed (first difference of the Y component at NGK observatory) under its spectrogram. Reply:

In the figure caption is indicated that data are SV of annual mean values of Y-component at NGK Observatory. Following the suggestion of the other referee we will change it to: "The spectrogram derived from application of STFT on the SV series of annual mean values of Y-component recorded at NGK Observatory (1891-2005)".

15. Page 623, sub-section 3.1.3, line 21: "Its obvious that spectrograms (...)" Please, if this is obvious, DO NOT indicate it

Reply:

We will cancel it.

16. Page 623, sub-section 3.1.3, 22, footnote number 1: If an element is not presented here, there is no need to explain anything about it. If you would like to explain the “shift toward the higher frequencies”, please, show the spectrogram of the SA.

Reply:

If we will present the spectrogram of SA then the paper would be longer one! We will cancel the phrase.

17. Page 624, sub-section 3.1.4, line 7 to 22: The topic of the running-average to avoid noisy signals has already been extensively discussed in the literature and particularly in the geomagnetic jerks’ literature. This part may be erased. The associated Figure 4 is useless. This figure even jeopardizes your demonstration : Indeed, why to apply STFT and calculate spectrograms whereas the 12-month running-average onto data is sufficient to see the date of jerks occurrence? What is the final aim of such an application in this paper?

Reply:

We don’t think that “only an 12-month running-average onto data is sufficient to see the date of jerks occurrence”. If the referee thinks so, then most of the studies on the jerk occurrences would be in vain. This figure can tell that by using the running-average the results received by the methods of jerk detection would be improved, because the signal is cleaned from most of the field of external origin.

18. Page 624-625, sub-section 3.1.4, from page 624 line 23 to page 625 line 22: Why speaking about “Huber average” if you conclude that you cannot “gain too much in the cleaning of the data by using a new method of averaging”? The interest of this paragraph is difficult to handle.

Reply:

Yes, we can reduce this subsection telling only the conclusion: we cannot gain too much in the cleaning of the data by using a new method of averaging

19. Page 625-626-627-628, sub-section 3.2.1: This part is extremely similar to text-book material, it would be better to place it in an appendix. Please, consider also other references such as: - Grossmann A, Holschneider M, Kronland-Martinet R and Morlet J 1987 Detection of abrupt changes in sound signals with the help of wavelet transforms Inverse Problems: An Interdisciplinary Study (Adv. Electron. Electron. Phys. 19) (San Diego, CA: Academic) pp 298-306. - Holschneider M 1995 Wavelets: An Analysis Tool(Oxford: Oxford University Press) - Meyer – 1992, Wavelets and operators - Meyer – 1993, Wavelets: Algorithms and Applications.

Reply:

Yes, we will move the major part of this subsection to an appendix. We will consider references suggested by referee.

20. Page 629-630: What is the interest of using wavelets to de-noise the signal ? Some methods such as the one proposed in Alexandrescu et al.(1995) directly analyzed the monthly means series, the time of occurrence is determined together with the regularity of the event. The present method needs the calculation of the derivative (SV) then its denoising before the spectrogram computation. Please, what are the benefits and scientific advances of such a method?

Reply:

In the figure 6, we give an example of a synthetic signal composed by several line segments of different slopes and a noise. If you compare the spectrogram of the composed signal and the de-noised signal, you can see the improvement of the quality of spectrogram. We can receive better results from different methods when we apply de-noising before.

21. All spectrogram Figures: Please, for each figure, indicate from which method is computed the spectrogram. Indeed, the STFT show breakdowns of the spectrogram at the time of jerks (Figures 2, 3 and 5), whereas the DWT show a maxima of the

spectrograms (Figures 6 and 7).

Reply:

In this point the referee posed a problem that we tried to explain (in page 629 lines 17-26 that continues to page 630 lines 1-4), by the particularities of the spectrogram of the synthetic composed signal. The question of the referee should be clarified, because the figures 2, 3, 5 are always spectrograms and are not produced from DWT of the signal,. The problem is why these figures show the breakdowns of the spectrogram at the "time of jerks" while the fig. 6 shows breakdowns in the middle of the slopes and maxima at points of abrupt changes of the slope. Maybe the reason is not well explained in the paper, but we think the chosen composed signal, at first sight similar to SV signal, is far away from a real SV signal. In the composed signal, the abrupt change of the slope happens exactly in a point, while in a real signal the slope change happens during several points (several months). When we analyzed some real signal of SV that have such abrupt changes in the slope (see for example KAK observatory at year 1952), we have seen the same as in the composed signal happened: the breakdown of the spectrogram corresponds to the middle of the slope. We hope this explanation satisfies the Referee.

22. Figure 7: The API spectrogram does not get the same abscissa as the de-noised signal presented above it.

Reply:

Yes. We should correct this figure

23. Figure 10: Please, replace the green square that covers the lowest part of the graph by a dashed line at the average value of d1 coefficients. I would like very much to see the hidden part

Reply:

Yes. We will change this figure

24. Page 633-634-635, sub-section 3.2.4. and Figure 11: Did you check that the DWT does not extract preferably the nodes time used in the B-spline construction of the model? Indeed, the CM4 model is using B-splines of order 5, whose 21 nodes are separated by 2.5 years. The Gauss coefficients are calculated up to order 4 derivative. The Gufm1 model is using B-splines of order 4, whose 163 nodes are separated by 2.5 years. May the lowest order of the B-splines introduce an apparent "better analysis" for the Gufm1 model (page 634, line 7 to 9) rather than the effect of the longer synthetic time series ?

Reply:

Having in mind the explanation given in the reply of point 10, at this point we can reply like this: we have not checked the differences in the results of two models when the DWT is applied in the same length of signal generated from both models. Therefore we can cancel any reference in the paper regarding the application of DWT on the series generated by CM4 model and the comparison of the Gufm1 model with CM4 model

25. Page 635-636-637, Sub-section 3.3: The table 2 does not appear convincing especially when the Figure 12 is observed in parallel. Would it be possible that the B-splines nodes appear, may be superimposed to a real signal? Would it be possible to give a more neutral, objective and factual explanation? What would be the reason for a particular signature of geomagnetic jerks into the odd spherical harmonic degrees rather than the even? The authors are saying that this question is beyond the scope of this paper (page 636, line 24 to 29), nevertheless what are the assumptions of the authors?

Reply:

We are trying to find a more reasonable estimate of the jerk occurrences and the maxima or minima of the graphs of different degrees n. And we will substitute the table with new results. But, we don't understand how the B-spline would superimpose a real signal, when we have not a real signal but only gauss coefficients calculated by B-spline technique, as we explained in the reply of point 10. According to the new results of the table 2, we will try to better (and objectively) establish the possible differences of odd and even harmonics.

26. Page 637-638, section 4: A too large part is given to the supplemental material (movie). The main results have to be recall, especially the position and possible nature of the preferable four longitudinal paths for the occurrence of the geomagnetic jerks and the possibility that the jerks are more dominant in the odd spherical harmonic degrees.

Reply:

We will reduce the description of the supplemental material (movie), letting reader to see the movie. We need to keep the movie. They are very useful not only for understanding the spatio-temporal behavior of jerks, but also for general presentations.

Interactive comment on Solid Earth Discuss., 3, 615, 2011.