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Climate of the Past Discussions

Interactive comment on "Paleoclimate forcing by the solar De Vries/Suess cycle" *by* H.-J. Lüdecke et al.

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For clarity we numerate the objections/answers.

1. Referee#2: "The authors look at cyclicities in solar forcing and climate records with a method that, in my opinion, ampliïňĄes/extracts cyclicities on centennial time scales. They extract the most prominent cycle from this ïňĄltered/modiïňĄed record and then project this cyclicity into the future. This analysis (i) removes information about the amplitude (e.g. how much temperature change is really caused by solar forcing), (ii) in the projections it neglects that there is not a continuous ïňĄt with the extracted cyclicity and (iii) it provides no new insight into possible mechanisms behind the sun climate link".

1. Answer: (i): Our analysis is spectral - Fourier analysis, wavelets - and evaluates correlations. Amplitudes in the original T/P – spectra [°C] as in the Delta T/P – spectra [°C/t] are not considered because we did not treat the interesting question "how much °C are caused in climate variation by the cyclic part of the sun". We looked into this question and find the results interesting enough to include them into the paper (see also our answer to the referee objection no. 9).

(ii): We do not quite understand this objection. Fig. 6 in our paper shows that all difference series are well fitted each with one sine of constant phase and constant frequency over the whole length of the Delta T/P series. Further, we like to stress "7. Confidence levels" where the Monte Carlo simulation verifies that the good correlations are not by chance. Because the $\sim$ 200 yr cycle persists from the past until today it seems reasonable to project it into the future. However, we can stress in more detail, if wanted, that this exrapolation into the future can only concern the periodic part. Other parts can of course not be extrapolated. Let us, however, mention that the minima and maxima of the Delta T agree in general well with those of the sinewave, so that the same can be expected for the future.

(iii): Giving new insight into the physical mechanisms is not the scope of this work. Here the important result is to show that periodicities exist. Not to elucidate their physics. Further information about the suggested mechanisms see references "Svensmark" and "Scafetta". It has been suggested that the De Vries cycle resuls from the gravitation of Jupiter and Saturn, but since this is not undisputed we should refrain from stating this as a certainty.

2. Referee#2: "In the following I added some more detailed comments that I have regarding this study. It appears that the analysis is designed to amplify the centennial signal. It certainly acts as a low-pass ïňĄlter i.e. enhancing longer-term variability. It will also remove very long-term trends (as those will add a constant to the delta function). Therefore, it appears that the transformation calculates some kind of derivative of the original function with, however, some ïňĄltering that depends on the window size used

for the calculation. Therefore, it is remains unclear to me how important the discussed signal really is in the real (untransformed) time series".

2. Answer: The analysis attempts to find and analyse cyclicities in Delta T/P - records, in order to elucidate the question if or not the warming since 1870 is historically unusually fast. This would entail, as correctly mentioned by the referee 2, a filtering of the T records for high and low frequencies. We used the unfiltered T/P records and converted those to the pertinent Delta T/P records. For clarity about the filtering effect: it is not a filtering of the Delta T/ P data. In their generation this filtering occurs automatically and does not produce any artefacts. To visualize the effect of the filtering on T data, a spectrum of Delta T - Chr/Lju is attached (not shown in the paper. Compare with Fig. 3 in the paper). T records are not investigated here except for the overview spectra.

3. Referee#2: "In general the methods section is not easy to follow. Abbreviations are used (e.g. MC) without proper explanation. Methods are used that are not explained (e.g. detrended ïňĆuctuation analysis). It could at least be written what these analyses do. Due to this it is very difïňĄcult to assess the reliability of the analysis (e.g. the coníňĄdence analysis)".

3. Answer: The editorial staff of Clim. Past requested these abbreviations, e.g., they changed our "Monte Carlo simulation" in the Latex script to the otherwise well known "MC". We can of course to add with the first mentioning of "Monte Carlo simulation" the abbreviation "(MC)" and use from then on MC. Same for AM as "amplitude modulation". Explaining the detrended fluctuation method briefly (as would be appropriate for such a paper) is not possible. We will give appropriate references.

4. Referee#2: "I do not agree that Delta T and Delta P can "reasonably" be represented a sine function (maybe this depends on the deïňĄnition of "reasonably"). It appears that the Delta functions maximises the variability in the 200 yr band. Therefore "reasonable" agreement between the Delta functions and the sine wave is not unexpected. Never-

theless, there are signiïňĄcant differences visible in ïňĄgure 6. The authors compare the results in ïňĄgure 6 and 7 to the wavelet analysis and say that there is agreement. Therefore, I am wondering why the authors feel that they need to do this transformation at all".

4. Answer: Our goal was not a transformation or smoothing whatsoever for the original data but the search for $\sim$ 200 yr cycles in time series of T/P differences. Here we found agreement with high correlation with single sines that we ascertained by Monte Carlo simulation against random chance (see "7. Confidence Levels" as essential part of the work).

Wavelet transform reveals, as opposed to Fourier transform, at which times cyclicities are strong or weak. Because e.g. the correlation gaps in Fig. 7 are mirrored in the wavelet spectra, a good agreement for the time dependence of the De Vries/Suess signal can be stated based on two different methods (wavelets and correlation from nonlinear optimization). In our answer to referee#1 we gave further reasons for studing Delta T/P.

5. Referee#2: The authors conclude that the Delta T etc...series show comparable signals in the 20th century showing "the warming rate during the 20th century lies within the natural rates of change". This is all based on the proxy data used for the study. As visible on ïňĄgure 2 there is no exceptional trend in these records for the last 100 years. Therefore, I am left with the question if these records are suitable to identify the recent warming trend i.e. allowing the authors to draw the conclusion they draw.

5. Answer: The conclusions are based on the proxy records used in the study which are composed of a high number of individual temperature time series scattered over the northern hemisphere and one representation in the southern atmosphere (Fig. 1). With these records it results that the recent 100-yr warming lies at least within the limits of the past 2000 years. There are no more proxies available with the same quality (similar length and time resolution of 1 yr). The Delta T records obained from the T

proxies agree with the instrumental temperature measurements since 1780. Thus we do not see why they would be unsuitable to elucidate the temperature history of the last century.

6. Referee#2: “I think the prediction aspect is very speculative. The authors conclude that the cycle agrees partly with the data and then they continue to predict the climate with this cycle. It neglects that there is no perfect ïňĄt in the past and it neglects other forcing mechanisms”.

6. Answer: We emphasised in “8. Tentative prediction of the climate future” caveats of the prediction: amplitude and phase of the reconstructed sine waves vary from one data set to the other (nonetheless are stable) and other conceivable forcings such as anthropogenic influences can not be taken into account. We mentioned that other publications come to qualitatively the same results.

7. Referee#2: “The radionuclide data has on average a cyclicity of about 220 yrs (average in table 3). This appears to contradict the identiïňĄcation of the 207 yr cycle in the data. Figure 3. The spectral peaks do not agree in the different records i.e. questioning that these really represent the same cycle/cause”.

7. Answer: The solar activity data of only the last 2500 years can be compared with the temperature data, since the latter are only available for the last 2500 years (solar activity period $\sim$ 200 yr, Delta T period $\sim$ 190 yr). We discussed this appropriate objection which is valid for practically all comparisons of external forcings on climate as for example for Milankovitch cycles detailed in “9. Summary and discussion”.

8. Referee#2: “It appears that the signiïňĄcance levels in ïňĄgure 5 are severely misrepresented (right part of the ïňĄgure). This can arise from the artiïňĄcially increased resolution by interpolating data (especially when comparisons to Stei/Beer are made). As it is now the ïňĄgure seems to suggest strong & signiïňĄcant covariability in radionuclide and climate records for the last 2000 years basically in all frequency bands with periodicities longer than 100 years”.

8. Answer: For all analyses in the paper no record was interpolated except for the necessary interpolation of Stei/Beer with an original resolution of 22 yrs for the wavelet analysis. For the wavelet analysis 1 yr resolution is necessary (the Fourier analysis of Stei/Beer was done with the original data). The Fourier analyses of the (necessarily) interpolated Stei/Beer data compared with the the original Stei/Beer data showed no differences and, thus, no misrepresentation should occur for the wavelets because wavelets are nothing else than Fourier transformation including time dependance. It is correct that also for lower frequencies covariabilities exist, we mentioned this in "9 Summary and discussions”. We feel (not more than that) that some of this can be seen in the records. Since the lower frequencies are not essential to draw conclusions about the last few centuries, we did not attempt their analysis.

9. Referee#2: “In ïňĄgure 6 all information about the amplitude of change is lost. How can it then be argued that the data shows a signiïňĄcant part of the signal. The authors should go back to the original data and explain how much the signal contributes to temperature variations (in $^{\circ}$C)”.

9. Answer: We think that the data show a significant part of the signal because of their excellent correlation with a sine which is not by chance (see Monte Carlo simulations described in “7 confidence levels”). Fig. 6 does not show amplitudes but gives a graphical impression of the correlations. As already mentioned, our results are evaluated from the Fourier spectra, wavelets and nonlinear fitting. An quantitative answer to this question will require more analysis. If the referee would request, we could do this.

10. Referee#2: “Details: The introduction reads like a list of publications that support the conclusions of this analysis. A more balanced introduction would be useful as there are many other papers that would not agree with this clear cyclicity on climate records (i.e. allowing prediction)”.

10. Answer: The large number of papers (not all were mentioned in the introduction) which show the influence of the solar De Vries cycle analyse local measurements.

Thus, the motivation for a study of global temperatures. Our paper is about $\sim$ 200 yr cycles, i.e. about the de Vries/Suess cycle. We found no papers about cycles in the $\sim$ 150 - 250 yr period range which discuss other causes than the Sun or influences of planetary orbits. If there are papers stressing other factors, could the referee be so helpful as to give us the references for including and mentioning in the introduction or discussion?

11. Referee#2: “Page 283: -7404 BP => 7404 BC”

11. Answer: Typing error will be corrected.

12. Referee#2: Why do 25000 zeros provide optimum interpolation of the DFT spectra?

12. Answer: Zero-padding yields no addituonal information but improves the interpolation. Naturally, 25 000 are not an optimum only a sufficient number of zeros here. We will correct the formulation in the text appropriately.

13. Referee#2: “MC simulation => write Monte-Carlo simulation”

13. Answer: See objection/answer 3.

14. Referee#2: What are Hurst exponents? Please add explanation and/or reference.

14. Answer: The Hurst exponent characterizes the autocorrelation strength of a time series. There are no short descriptions, we will add appropriate references.

15. Referee#2: “Why is there a need for abbreviations such as AM”

15. Answer: See objection/answer 3.

Interactive comment on Clim. Past Discuss., 11, 279, 2015.

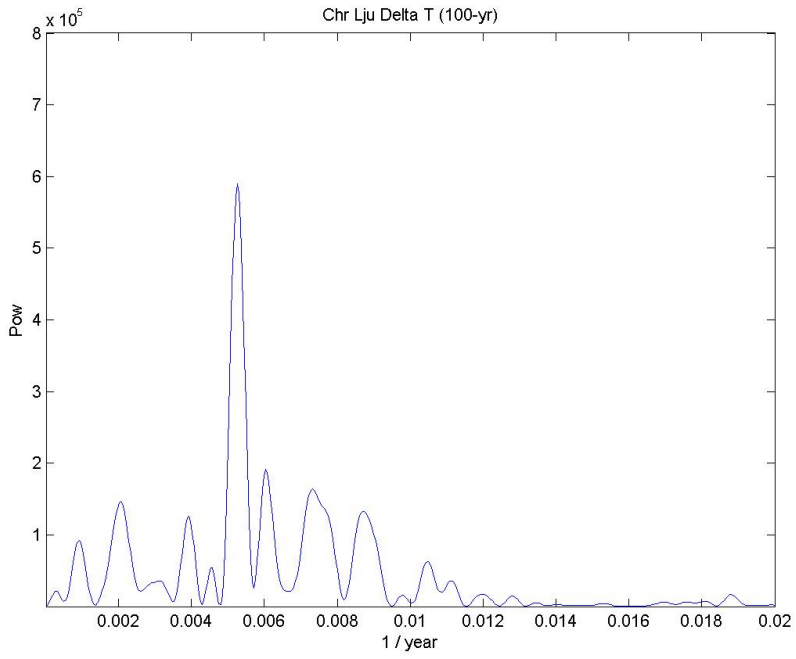

Fig. 1.