M. Mudelsee (Referee)

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It is not possible to base a meaningful spectrum estimation on as few as 32 data points.

Reply to comment of the referee Prof. M. Mudelsee:

Thank you very much for sparing your valuable time to critically evaluate our paper.

We express our high regards to your expertise in time series spectral analyses, especially for un-equidistal data sets, which often land in spurious cycles due to red-noise process. We have used your RED-FIT program with stringent criterion developed by you to achieve our spectral results, and details are elaborated in page no. 7 (under 3. Results and discussions).

Your main concern is impossibility "to base a meaningful estimation on as few as 32 data points".

First, we accept the limitation of having only 32 data points. We hope that you will appreciate our efforts to detect meaningfully - a ~400-ka eccentricity cycle, even in such a small data set, which is derived from a 32 mm thick Fe-Mn crust, and not from sediment core with several meters long record.

We address your concern after doing exercises with two different well known and widely used spectral programs as following:

1) Online continuous wavelet transform program by Torrence and Compo (1998, http://ion.researchsystems.com/cgi-bin/ion-p?page=wavelet.ion).

   We did CWT analyses of (A) last 30 years (2009-1979) sunspot yearly data (2 less than our 32) retrieved from www.sidc.be site, and (B) 240 years (1990-1750) data in sunspot icon of the online program with option of both (i) red noise background spectrum. Results of both data set show 11 year sunspot cycle in the figure attached below (Fig. 1, A-B).

Thereafter, we used the option of no noise in spectral background, and analyzed both the 31 year (C) and 240 year (D) sunspot datasets. Results of both data set show 11 year sunspot cycle in the figure attached (Fig. 1, C-D).

2) SPECTRUM program by Schulz and Stattegger (1997)

We also used (i) 30 year sunspot yearly data and 10 time larger (ii) 309 years sunspot data from 1700-2009 retrieved from www.sidc.be site to analyze in SPECTRUM program. We used similar setting of Welch window, significance level, Hifac levels in both data sets. Both the data sets (30 year and 309 years of sunspot) produced 11 years cycle (Fig. 1 E, F) meaningfully.

Result: Both the exercises with both data sets, and in two different programs with identical setting in spectral run, resulted in the11 year sunspot cycle prominently.

Conclusion: Thus, the above results indicate that if the 30 data point in sunspots can derive a meaningful 11 year solar cycle, then the 32 data points as the basis of our results should not be considered as a limitation.

We humbly submit that it is not a serious point to ignore and discard the otherwise sound and meaningful spectral result, only on the basis of notion that no meaningful estimation is possible on 32 data points.

If the cycle is real (as is the case with ~400-ka eccentricity cycle reported in numerous studies), the number of data points, although matters a lot, may not be a criterion to rule out and negate our findings. (R. Banerjee & S.M. Gupta)

Fig. 1

A

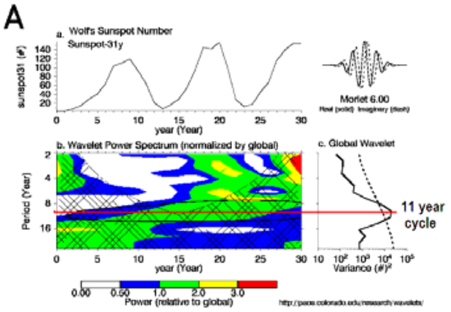


Fig. **A** (a) Sunspot numbers for last 31 years (2009- 1979). (b) The wavelet power spectrum. The power has been scaled by the global wavelet spectrum (at right). The cross-hatched region is the cone of influence, where zero padding has reduced the variance. Black contour is the 10% significance level, using a red-noise (autoregressive lag1) background spectrum. (c) The global wavelet power spectrum (black line). The dashed line is the significance for the global wavelet spectrum, assuming the same significance level and background spectrum as in (b). Reference: Torrence, C. and G. P. Compo, 1998: A Practical Guide to Wavelet Analysis. Bull. Amer. Meteor. Soc., 79, 61-78.

B

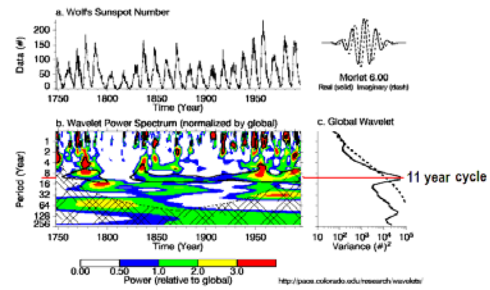


Fig **B**: (a) Sunspot numbers for the last 240 years (1990-1750). (b) The wavelet power spectrum. The power has been scaled by the global wavelet spectrum (at right). The cross-hatched region is the cone of influence, where zero padding has reduced the variance. Black contour is the 10% significance level, using a red-noise (autoregressive lag1) background spectrum. (c) The global wavelet power spectrum (black line). The dashed line is the significance for the global wavelet spectrum, assuming the same significance level and background spectrum as in (b). Reference: Torrence, C. and G. P. Compo, 1998: A Practical Guide to Wavelet Analysis. Bull. Amer. Meteor. Soc., 79, 61-78.

C

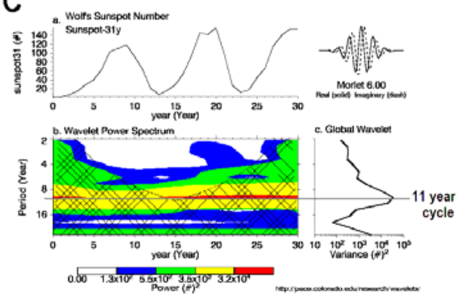


Fig. **C** (a) Sunspot numbers for the last 31 years (2009-1979). (b) The wavelet power spectrum. The contour levels are chosen so that 75%, 50%, 25%, and 5% of the wavelet power is above each level, respectively. The cross-hatched region is the cone of influence, where zero padding has reduced the variance. (c) The global wavelet power spectrum. Reference: Torrence, C. and G. P. Compo, 1998: A Practical Guide to Wavelet Analysis. Bull. Amer. Meteor. Soc., 79, 61-78.

D

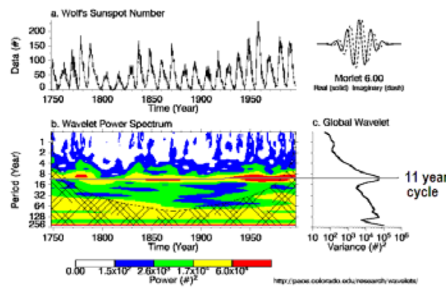
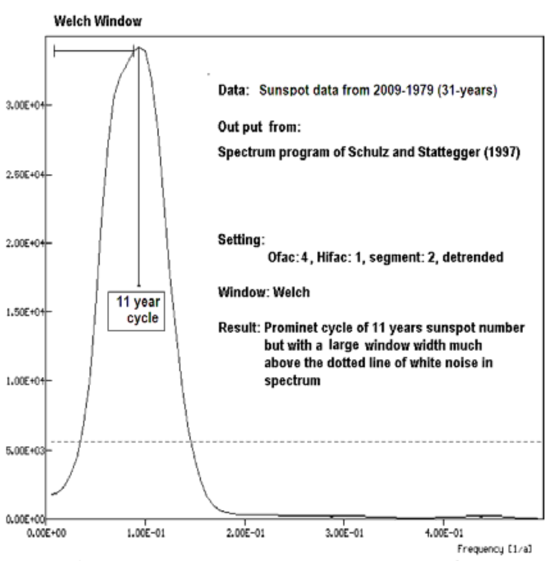


Fig. **D** (a) Sunspot numbers for the last 240 years (1750-1990). (b) The wavelet power spectrum. The contour levels are chosen so that 75%, 50%, 25%, and 5% of the wavelet power is above each level, respectively. The cross-hatched region is the cone of influence, where zero padding has reduced the variance. (c) The global wavelet power spectrum. Reference: Torrence, C. and G. P. Compo, 1998: A Practical Guide to Wavelet Analysis. Bull. Amer. Meteor. Soc., 79, 61-78.

http://ion.researchsystems.com/cgi-bin/ion-p

E



F