Forum Reply

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Fossil forest reveals sunspot activity in the early Permian

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The Chemnitz Fossil Forest is an *in situ* Permian T^0 assemblage that was formed instantaneously during a volcanic catastrophic event. This "Permian Pompeii" in the northern hemisphere of tropical Pangea is significant because it offers the possibility to study a late Paleozoic forest ecosystem in its entirety. Strong monsoonal seasonality is indicated for this site by paleopedological and tree-ring records (Luthardt et al., 2016). Tree-ring analyses revealed significant results on anatomical and ecophysiological responses of different plant species. Among the pycnoxylic gymnosperms, medullosans, and calamiteans, we found similar growth patterns in ~30 trees living at the same time within the same habitat (Luthardt and Rößler, 2017). An unintended but inevitable secondary result of the study was a 10.62 yr cyclicity based on a mean curve of individual ring curves and their treatment with standard statistics. We provocatively favored an interpretation of these results as 11 yr sunspot cycle. Consequently, we welcome any encouragement to scrutinize our results and interpretations (St. George and Telford, 2017). Nevertheless, here a few critical points need to be raised.

Based on statistical analysis of worldwide tree-ring data, Telford et al. (2015), in a conference poster, concluded that climatic effects induced by solar cyclicity are generally not recorded in modern tree rings, although a number of studies seem to contradict their reasoning, in both modern and fossil trees (e.g. D'Arrigo et al., 2006; Muraki et al., 2011; Esper et al., 2012). Consequently, St. George and Telford (2017) doubt the existence of a solar-induced 11 yr cyclic pattern in fossil tree-ring sequences from Chemnitz. We do not feel challenged with the denial of sunspot cycle record in modern trees as argued by St. George and Telford. We want to underline the difficulty in directly comparing any modern trees, forests, and their situation with that of extinct plants, their paleogeographic, paleoclimatic, environmental, and taphonomic response.

The late Paleozoic paleoclimate is assumed to have been more extreme and distinctly different with regard to modern global climate (e.g. Tabor and Poulsen, 2008), supposing different preconditions, which controlled interrelation of solar forces, paleoclimate and tree-ring formation. A comprehensive tree-ring database for the late Paleozoic would contribute to following up this hypothesis, but this is currently not available. Nevertheless, preliminary results from lacustrine varve bundles from the early Permian Thuringian Forest Basin also seem to reflect a decadal cyclicity.

Another critical point is that Telford et al. (2015) only considered geographic position, but not the environmental conditions of sample localities. However, to identify climate variations in tree rings, selection of sample locality is essential, taking the following environmental factors into account: (1) dry regional climate, under which trees are highly sensitive to minor variations, (2) shallow root systems of trees, and (3) well-drained soil. All these criteria are fulfilled for the Chemnitz Fossil Forest (see Luthardt et al., 2016).

Nevertheless, fossil tree data are always underlain with a certain taphonomic bias (e.g., partial preservation of trees down to cell anatomy, loss of organic compounds), which can distort the quality of the data archive to achieve statistically robust results by high-standard methods usually applied to modern tree-ring sequences. For our study, we have chosen 11 ring sequences showing low taphonomic bias and the longest possible record. Re-assessed application of time series analysis to individual raw data curves using a simple periodogram (Fig. 1) reveals that six of eleven sequences show a distinct power peak at a periodicity of 9–12 yr, whereas two sequences (K349 and K6044) are statistically robust ($p < 0.05$). After reducing noise effects by applying the 3 yr moving average, five sequences are statistically robust. Hence, apart from cross-correlation and the calculated mean curve, we are able to show that several of our individual ring sequences reflect statistically robust evidence of ~11 yr cyclicity, thus rejecting that this represents a random phenomenon.

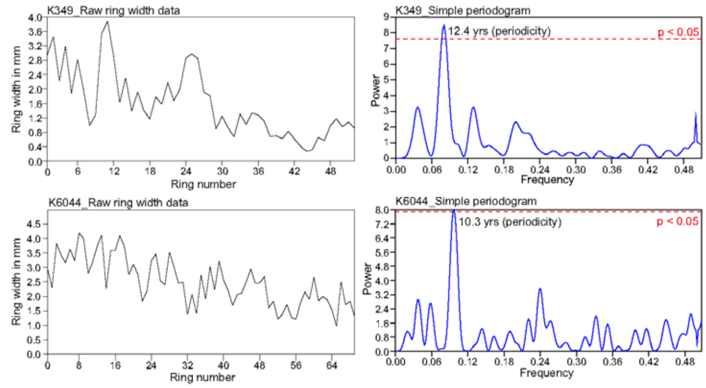

Figure 1. Time series analysis (simple periodogram) on two raw-data ring sequences of pycnoxylic gymnosperms (specimens K349 and K6044) showing statistically robust signals ($p < 0.05$) at periodicities close to the 11-yr solar cycle.

We want to emphasize that the 11 yr solar cycle was not the dominant force of early Permian global paleoclimate, as interpreted by St. George and Telford (2017), but did have a measurable impact on forest productivity in the Chemnitz site, and thus speculatively on regional paleo-precipitation patterns. Because the present does not directly compare to the past, our results cannot contribute to the comprehension of modern climate principles.

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