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Chronomics of tree rings gauge climate change

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As an aspect of chronomics, assessing broad time structures (of chaos, trends and cycles) in physiological and physical environmental variables and their interactions, the fractal nature of tree rings is here determined. The average measurements of 11 sequoia trees covering 2189 years were analyzed by the power spectrum obtained with the Maximum Entropy method (MEM). A robust line-fitting algorithm of log (power) on log (frequency) was used between 10^{-4} and 0.50 cycles/year, where the relationship appeared to be linear, to obtain an estimate of the slope (β). Analyses were repeated over an interval of 200 years progressively displaced by 5 years throughout the 2189 years, realizing that the interval's length may obscure or miss short-term effects. Overall, the slope (β) is -1.0017, similar to the slope of -1.0543 characterizing the MEM spectrum of sunspots between 1700 and 2000. A slope of about -1.00 is known to represent fractal nature. Whereas the slope usually assumes a value of about -1.00 in most intervals considered, in a few episodes the slope deviates from this value, reaching values closer to zero or slightly positive ones, suggesting a disruption of the fractal nature. Seven such episodes are found, the last two corresponding to the Spörer and Maunder minima. The other five episodes, occurring around 100 BC, 500, 700, 820 and 880 AD, may also correspond to climatic changes that happened during times when no record of sunspots is available. Whether changes in the 1/f structure of tree rings actually correspond to changes in solar activity or climate also should be scrutinized in auroral sightings or in other long records of reconstructed solar activity such as those based on the ^{10}Be concentration in polar ice. No change in slope was observed during the Dalton/Hallström minimum of solar activity (1790-1830) or around 1050 and 1300, corresponding to the Oort and Wolf minima, respectively. A 200-year interval was chosen since tree rings are only available at yearly intervals and the 1/f behavior needs to be documented over a wide enough frequency range. Our prior analyses of these data had found a periodicity of about 534 years as the

most prominent feature with matching periods in and around us. By a combination of methods focusing on both specific spectral components like the Schwabe cycle and on 1/f behavior, as a feature of chaos, chronomics estimated an association of climate change, which occurred globally. The same combination of chronomic methods detects elevated illness-risks for the prevention of diseases of individuals, such as myocardial infarctions and strokes, and, equally important, aims at resolving illnesses of societies, such as crime and war, all exhibiting cycles mapped with their uncertainties, that are indispensable for the study of underlying mechanisms.