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Analysis of Antarctic Ice Core Data (EPICA Dome C) with Flicker-Noise Spectroscopy

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Evolution of Earth's climate system over the past 800,000 years represents a complex process with successions of uneven glacial and interglacial periods. The length, amplitudes, and development of each climate cycle depend on a number of different factors, including the orbital parameters attributed to insolation and the complex responses of the Earth system to solar radiation primarily through the amplification by Earth's albedo and greenhouse gases and secondarily through a system of heat reservoirs, such as ice sheet and deep ocean, distributed throughout our planet. The purpose of this study is to analyze the transitions related to climate cycles in Antarctic ice core data (EPICA Dome C) of deuterium composition and dust concentration recorded for the past 800,000 years [1] using Flicker-Noise Spectroscopy (FNS), an analytical toolset for the extraction and analysis of information in stochastic time and space series, containing both regular and chaotic components, by using power spectra and difference moments (structural functions) of various orders [2].

The FNS nonstationarity factors for the deuterium composition and dust (logarithm) concentration, which represent the normalized discrete derivative of the second-order structural function of the source signal with respect to a given shifted "window" interval, were built for different intervals of averaging to identify the major changes in the dynamics of both time series and their precursors. It is shown that when displayed together with the source signals, the positive peaks in the nonstationarity factors provide more reliable estimates of the transition of the climate system from one sub-period to another within a specific climate cycle as compared to predefined thresholds in dust or deuterium values. For climatic transitions, the power spectral estimates of the nonstationarity factors contain several periodicities in addition to the orbital ones. These frequencies may be attributed to specific heat accumulation and discharge processes in the climate system. The results of this study demonstrate the potential of FNS in the analysis of climate data series and may be used in refining climate transition models.

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