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Orbital component extraction by time-variant sinusoidal modeling.

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Accurately deciphering periodic variations in paleoclimate proxy signals is essential for cyclostratigraphy. Classical spectral analysis often relies on methods based on the (Fast) Fourier Transformation. This technique has no unique solution separating variations in amplitude and frequency. This characteristic makes it difficult to correctly interpret a proxy's power spectrum or to accurately evaluate simultaneous changes in amplitude and frequency in evolutionary analyses. Here, we circumvent this drawback by using a polynomial approach to estimate instantaneous amplitude and frequency in orbital components. This approach has been proven useful to characterize audio signals (music and speech), which are non-stationary in nature (Zivanovic and Schoukens, 2010, 2012). Paleoclimate proxy signals and audio signals have in nature similar dynamics; the only difference is the frequency relationship between the different components. A harmonic frequency relationship exists in audio signals, whereas this relation is non-harmonic in paleoclimate signals. However, the latter difference is irrelevant for the problem at hand.

Using a sliding window approach, the model captures time variations of an orbital component by modulating a stationary sinusoid centered at its mean frequency, with a single polynomial. Hence, the parameters that determine the model are the mean frequency of the orbital component and the polynomial coefficients. The first parameter depends on geologic interpretation, whereas the latter are estimated by means of linear least-squares. As an output, the model provides the orbital component waveform, either in the depth or time domain. Furthermore, it allows for a unique decomposition of the signal into its instantaneous amplitude and frequency. Frequency modulation patterns can be used to reconstruct changes in accumulation rate, whereas amplitude modulation can be used to reconstruct e.g. eccentricity-modulated precession. The time-variant sinusoidal model is applied to well-established Pleistocene benthic isotope records to evaluate its performance.

Zivanovic M. and Schoukens J. (2010) On The Polynomial Approximation for Time-Variant Harmonic Signal Modeling. IEEE Transactions On Audio, Speech, and Language Processing vol. 19, no. 3, pp. 458–467. Doi: 10.1109/TASL.2010.2049673.

Zivanovic M. and Schoukens J. (2012) Single and Piecewise Polynomials for Modeling of Pitched Sounds. IEEE Transactions On Audio, Speech, and Language Processing vol. 20, no. 4, pp. 1270–1281. Doi: 10.1109/TASL.2011.2174228.