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Cascade of abrupt transitions in past climates

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The Earth's climate has experienced numerous abrupt and critical transitions during its long history. Such transitions are evidenced in precise, high-resolution records at different timescales. This type of evidence suggests the possibility of identifying a hierarchy of past critical events, which would yield a more complex perspective on climatic history of the than the classical saddle-node two-dimension representation of tipping points. Such a context allows defining a tipping, or dynamical, landscape (Lucarini and Bódai, 2020), similar to the epigenetic landscape of Waddington (1957).

To illustrate a richer structure of critical transitions, we have analyzed 3 key high-resolution datasets covering the past 66 Ma and provided evidences of abrupt transitions detected with the augmented Kolmogorov-Smirnov test and a recurrence analysis (Bagniewski et al., 2021). These time series are the CENOGRID benthic $d^{18}O$ and $d^{13}C$ (Westerhold et al., 2020), the U1308 benthic $d^{18}O$, $d^{13}C$ and the d^{18}bulk carbonate (Hodell and Channell, 2016), and the NGRIP $d^{18}O$ (Rasmussen et al., 2014) records. The aim was to examine objectively the observed visual evidence of abrupt transitions and to identify among them the key thresholds indicating regime changes that differentiate among major clusters of variability. This identification is followed by establishing a hierarchy in the observed thresholds organized through a domino-like cascade of abrupt transitions that shaped the Earth's climate system over the past 66 Ma.

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