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To what extent can global warming events influence scaling properties of climatic fluctuations in glacial periods?

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The Earth's climate is an extremely unstable complex system consisting of nonlinear and still rather unknown interactions among atmosphere, land surface, ice and oceans. The system is mainly driven by solar irradiance, even if internal components as volcanic eruptions and human activities affect the atmospheric composition thus acting as a driver for climate changes. Since the extreme climate variability is the result of a set of phenomena operating from daily to multi-millennial timescales, with different correlation times, a study of the scaling properties of the system can evidence non-trivial persistent structures, internal or external physical processes.

Recently, the scaling properties of the paleoclimate changes have been analyzed by distinguish between interglacial and glacial climates [Shao and Ditlevsen, 2016]. The results show that the last glacial record (20-120 kyr BP) presents some elements of multifractality, while the last interglacial period (0-10 kyr BP), say the Holocene period, seems to be characterized by a mono-fractal structure. This is associated to the absence of Dansgaard-Oeschger (DO) events in the interglacial climate that could be the cause for the absence of multifractality. This hypothesis is supported by the analysis of the period between 18 and 27 kyr BP, i.e. during the Last Glacial Period, in which a single DO event have been registred.

Through the Empirical Mode Decomposition (EMD) we were able to detect a timescale separation within the Last Glacial Period (20-120 kyr BP) in two main components: a high-frequency component, related to the occurrence of DO events, and a low-frequency one, associated to the cooling/warming phase switch [Alberti et al., 2014]. Here, we investigate the scaling properties of the climate fluctuations within the Last Glacial Period, where abrupt climate changes, characterized by fast increase of temperature usually called Dansgaard-Oeschger (DO) events, have been particularly pronounced. By using the MultiFractal Detrended Fluctuation Analysis (MF-DFA), we show that a multifractal structure exists for both high- and low-frequency fluctuations in Northern and Southern hemispheres, with different scaling exponents, thus indicating a long-range persistence of the climatic variability within the whole Last Glacial Period. Our results evidence that both DO events and cooling/warming cycles must be considered as processes of the internal component of the Earth's climate, rather than processes related to external forcings. This study should be helpful for investigation of the internal origin of climate changes.

References

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