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Exploring the middle Pleistocene transition

Tommaso Alberti (1), Peter Ditlevsen (2), Vincenzo Carbone (3), Fabio Lepreti (3), and Antonio Vecchio (4)

(1) INAF-Istituto di Astrofisica e Planetologia Spaziali, via del Fosso del Cavaliere 100, 00133, Roma, Italy, (2) Niels Bohr Institute, Juliane Maries Vej, DK-2100 Copenhagen O, Denmark, (3) Dipartimento di Fisica, Università della Calabria, Ponte P. Bucci Cubo 31C, 87036 Rende (CS), Italy, (4) LESIA-Observatoire de Paris, 5 place Jules Janssen, 92190 Meudon, France

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. Several external and internal components lead variations in temperature from decadal to multi-millennial timescales with differences between glacial and interglacial climates [Shao and Ditlevsen, 2016]. On multi-millennial timescales, glacial cycles are related to periodic and quasi-periodic changes in the insolation due to variations in Earth's orbit around the Sun. Particularly, the climate response is $\sim$100 kyr glacial cycles since the middle Pleistocene transition (MPT) around 1 Myr ago, where the climate has shifted regularly between the glacial and interglacial climate states, while prior to 1 Myr BP a "41-kyr world" was observed. This observed behavior does not indicate any noticeable difference in the orbital forcing, with the climate response appearing far from to be structurally different before and after the MPT.

Here, we applied the Empirical Mode Decomposition (EMD) to the global ocean benthic foraminifera δ^{18}O stack record [Lisiecki and Raymo, 2005], which is a proxy for the global ice volume. We analyse the time series during the last 2 Ma to investigate amplitude-frequency changes between glacial and interglacial climate states. We found that both 41-kyr and 100-kyr periodicities are present during the last 2 Ma although amplitudes changes in time producing the well-known separation between "100-kyr world" and "41-kyr world". This suggests that the observed behavior is not related to changes in frequency. Moreover, we also found a larger timescales component and a monotonic non-decreasing trend. Finally, from a dynamical system point of view we found that both 41-kyr and 100-kyr components can be seen as a single-state forcing, while smooth transitions between three different climate states can be obtained by using larger timescales component, in agreement with previous works [Paillard, 1998; Ashwin and Ditlevsen, 2015].

References

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