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Unexpected climatic impacts of orbital forcing out of the Quaternary

Gilles Ramstein (1), Zhongshi Zhang (2,6), Guillaume Le Hir (3), Camille Contoux (4), Yannick Donnadieu (1), Christophe Dumas (1), Mathieu Schuster (5), and Camille Li (2)

(1) CE Saclay, LSCE / DSM, Gif sur Yvette, France (gilles.ramstein@lsce.ipsl.fr), (2) Bjerknes Centre for Climate Research, Uni Research Climate, Bergen, Norway (Zhongshi.Zhang@uni.no), (6) Nansen-Zhu International Research Centre, Institute of Atmospheric Physics, Chinese Academy of Sciences, Beijing, China, (3) Institut de Physique du Globe de Paris, Paris, France (lehir@ipgp.fr), (5) Institut de Physique du Globe de Strasbourg, Strasbourg, France (mschuster@unistra.fr), (4) CEREGE, Aix en Provence, France (contoux@cerege.fr)

For Quaternary, the impact of orbital variations on climate is huge and well documented. Especially, during the last million years, drastic climate changes occurred, consisting in transitions from glacial to interglacial periods driven by changes in 65°N summer insolation with 100 kyears periodicity. Nevertheless, the imprint of so-called Milankovic forcings has also been found for Tertiary and Secondary, as for instance during mid-Cretaceous period (Herbert et al., Nature, 1986, Giorgioni et al, Paleoceanography, 2012) or during Devonian period (De Vleeschouwer et al, EPSL, 2013). For both periods, the climatic imprints of orbital forcings are recorded in a warm world without ice sheet. Here, we show through simulation studies the large impact of orbital forcing in very different geological contexts, pointing out the important role of Milankovic cycle throughout Earth history.
The first and most striking result depicts the role of insolation changes during the melting of the Marinoan snowball [635 Ma] (Benn et al, Nature Geoscience 2015). This is one of the oldest imprints of orbital forcing on climate. Our result solved a long lasting controversy concerning the melting of the last snowball episode between a huge deglaciation at very high CO_2 level and data showing glacial/interglacial cycles occurring during that melting. Our modelling studies focusing on Svalbard high resolution records (Benn et al, Nature Geoscience 2015) demonstrate that the glacial/fluvial oscillation was related to orbital forcing in a context of very high CO_2 level.
Much more recently, during the Tortonian period [11-7 Ma], the orbital cycles shaped the environment and drove the hominin dispersal in Africa. During Tortonian, the ultimate shrinkage of a huge epicontinental sea, that extended from Eastern Europe to Western Asia, has been shown to produce major changes on Asian monsoon (Ramstein et al, Nature, 1997) and triggered the onset of Sahara desert (Zhang et al, Nature 2014). Moreover, this shrinkage drastically enhanced the climate response to orbital changes at the emergence of early hominins in North Africa. Through these two illustrations, it appears that the consequences of Milankovic forcing on climate are strongly dependent on geological context.