EGU2020-10864, updated on 29 Jan 2023
https://doi.org/10.5194/egusphere-egu2020-10864
EGU General Assembly 2020


# The continental Middle Miocene Climatic Transition in Southern Europe as derived from clumped isotope analyses

**Niklas Löffler**[1,2], Andreas Mulch[1,2], Wout Krijgsman[3], Emilija Krsnik[1,2], and Jens Fiebig[1,2]
[1]Senckenberg Biodiversity and Climate Research Centre, Senckenberganlage 25, 60325 Frankfurt (Main), Germany (niklas.loeffler@senckenberg.de)
[2]Institute of Geosciences, Goethe University, Altenhoeferallee 1, 60438 Frankfurt (Main), Germany
[3]Paleomagnetic Laboratory "Fort Hoofddijk", Utrecht University, Budapestlaan 17, 3584 CD Utrecht, The Netherlands

Reconstructing Cenozoic terrestrial paleoclimate is frequently limited by temporal resolution and suitable quantitative tools to reliably assess changes in temperature and aridity. The dynamics of ocean temperatures[1] and chemistry[2], varying $pCO_2$[3], and faunal assemblages are known to a certain extent, however, terrestrial data on temperatures, which are mostly indirectly derived from fossil assemblages and palynologycal data[4] are rare. This study contributes to the understanding of the dynamics and variability of terrestrial temperatures during one of the most extreme Neogene climate changes, the Middle Miocene Climate Transition (MCT). The comparison of $pCO_2$ forecasts for the coming century and reconstructed Mid-Miocene $pCO_2$ levels suggest that the Mid-Miocene is an important time interval for ascertaining suitable model projections of the future anthropogenic impact on climate. In order to establish an appropriate understanding and modeling of the natural variability of the European/Mediterranean climate system, quantitative climate information of the European continental Mid-Miocene is mandatory. This would facilitate the identification of main drivers of climate evolution in an area which is exposed to the present climate change and its subsequent natural hazards.

This study presents a profound and well-dated terrestrial clumped isotope ($\Delta_{47}$) paleosoil carbonate dataset from Spain that ranges from 13.0 to 15.1 Ma (100 kyr resolution) and hence covers an interval that was previously classified as the MCT. The $\Delta_{47}$ data is supported by stable carbon and oxygen isotope analyses that are in agreement with previously published continental and oceanic records. A distinct decline in apparent $\Delta_{47}$-based temperatures between 13.7 and 14.1 Ma reveals a substantial drop in continental temperatures and indicates changes in seasonality of pedogenic carbonate formation. The major cooling thereby coincides with a change in Milanković periodicities and can be linked to oceanic isotope records[5]. While the transition into the MCT shows a high temperature variability indicating varying environmental conditions, calculated oxygen isotopic values of the soil water point to a rather stable moisture source across the MCT in Southern Europe.

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