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Testing palaeoclimate and palaeovegetation model reconstructions with palaeovegetation data: an application to the Middle Miocene

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The Miocene is a relatively recent epoch of the Earth's history with warmer climate than today. The Middle Miocene (Langhian, near 15 Ma) was particularly warm. Although the cause of the warming is presumably not only attributable to CO_2, but also to the change in orography and configuration of ocean gateways, this time interval represents an ideal case study to test the ability of climate models to simulate warm climates comparable to those that the Earth may experience in the near future.

The NECLIME database offers a unique opportunity for such an evaluation of palaeoclimate model reconstructions. This database gathers data of the fossil flora recorded at many localities around the world at different times of the Miocene. These fossil floras do not provide direct information on climate, but on flora and vegetation. Hence, it is necessary to reconstruct palaeoclimate from the fossil flora before being able to compare these data with climate model results, using for instance the coexistence approach. François et al. (Palaeogeography, Palaeoclimatology, Palaeoecology, 304, 359–378, 2011) have presented an alternative method where palaeovegetation is simulated from the outputs of the climate model, using a dynamic vegetation model. Model vegetation reconstruction can then be compared to the vegetation cover indicated by the fossil flora record at the various localities, provided that a common classification of plant functional types (PFTs) is used for the data and the model. The advantage of the latter method is that, at least in theory, it allows taking into account non-climatic factors potentially influencing plant species distributions, such as atmospheric CO_2, soils or seed dispersal capacities.

Here, we apply this method to the Middle Miocene. We test the results of a high-resolution climate simulation performed for this time period with the LMDZ4 climate model. Palaeovegetation is simulated with the CARAIB dynamic vegetation model in which an upgraded vegetation classification involving 26 PFTs has been implemented. With 560 ppmv of CO_2, the model is able to produce tropical and subtropical PFTs in Europe consistently with the data. However, the presence of tropical PFTs is exaggerated with respect to the data, indicating a slightly too warm climate for the European continent where abundant data are available. This excessive warming is possibly related to the overestimate of the CO_2 mixing ratio in the climate simulations.