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Middle Miocene climate and vegetation interactions modelling with Planet Simulator and CARAIB

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In a long-term climatic cooling trend, the Middle Miocene represents one of the last warm periods of the Neogene, culminating with the Miocene Climatic Optimum, MCO (17-15 My). Palynological studies suggest that the warmer climatic conditions prevailing during the MCO allowed warm forests types to expand poleward of the subtropical zone, with evergreen forests proliferating notably in Eurasia. Such a change in the vegetation cover is expected to lead to significative surface albedo and roughness length modifications. Both effects may in turn contribute to maintain warm climatic conditions at MCO.

In this work, we used the Planet Simulator (Fraedrich et al., 2005, Meteorol. Z. 14: 299-304 and 305-314), an Earth system model of intermediate complexity, to carry out several simulation experiments, where we have assessed the effects of the absence of ice on the continents, the opening of the Central American and Eastern Tethys seaways, the lowering of the topography on land and the effect of various atmospheric CO2 concentrations. We produced several vegetation distributions, using the dynamic vegetation model CARAIB (Otto et al., 2002, Global Planet. Change 33: 17-138, 2002; Galy et al., 2008, Quat. Sci. Rev. 27: 1396-1409), to analyse if the climatic forcings considered are sufficient to explain the expansion of warmer forest types to higher latitudes. We then forced the Planet Simulator with boundary conditions derived from the reconstructed vegetation distributions to assess how they influence climate in turn.

Our results indicate that a lowering of the topography and an increase of atmospheric CO2 concentration, higher than the present-day one, are necessary to allow warm forest types to expand poleward. The development of subtropical and evergreen forests at mid-latitudes produces additional warming, especially in Eurasia and disturbs the precipitation distribution in the tropics.