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Does vegetation solve the problem of modelling the 'equable' Early Eocene climate?

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The Early Eocene (55-50 Million years ago) ranks among the warmest period in the Cenozoic (past 65 Million years) with a global mean temperature higher than modern and with ice-free poles. Warm climates as the Early Eocene are characterised by a pole-to-equator temperature gradient and a seasonality in the mid and high latitudes lower than present day. Modelling these features still remains challenging. In many studies, the simulated annual global mean temperature for the Early Eocene agrees with proxy data. However, the climate at the poles remains too cold and the seasonality is too strong in the models.
In order to investigate the impact of the terrestrial biosphere on the 'equable' Early Eocene climate, we perform four model simulations with MPI-ESM including dynamic vegetation. In all simulations, the same Early Eocene boundary conditions are chosen except for different globally homogeneous soil albedo values and vegetation cover. Two simulations are run with desert conditions and low (0.1) and high (0.4) soil albedo, respectively, and another two simulations with continents completely covered by forests and low and high soil albedo, respectively.
The dark desert world is the warmest of all simulations. Sea ice is absent in this case and some snow occurs in winter only. The simulations with trees are cooler than the dark desert simulation, and the bright desert simulation is the coolest. In the bright desert world, even sea ice occurs seasonally.
These results suggest that vegetation cools Early Eocene climate in the dark soil case and warms it in the bright soil case. The driving mechanisms for the cooling by vegetation in the dark soil case are associated with changes in the water cycle. The cooling initiated by vegetation is amplified in the high latitudes as the snow cover increases in winter leading to a surface albedo increase. In the bright soil case, vegetation lowers the surface albedo efficiently and leads to a warming. This warming causes the seasonal sea ice cover to vanish and the snow cover to decrease. The resulting albedo feedback amplifies the warming in the high latitudes.
After 400 years of simulation, we let the vegetation cover develop dynamically. In all simulations, the vegetation cover evolves nearly to the same equilibrium. However, regional multiple equilibria occur. The resulting vegetation distribution matches vegetation reconstructions for the Early Eocene well. In a subsequent step, the plant functional types used in the model are adapted to nearest living relatives of the Early Eocene vegetation.