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Cenozoic Biosphere-Climate Interaction, a Challenge for Earth System Models

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What are the reasons for Earth's climate shift from extremely warm "greenhouse" conditions during the Cretaceous to the present "icehouse" state? And what is the reason for the reduced meridional temperature gradient which is characteristic of Cenozoic climate reconstructions? Various hypotheses have been invoked to explain the Cenozoic climate evolution but, by some means or other, most of them are at odds with proxy data evidence.
Climate physics suggests that tectonic events like the uplift of major mountain ranges or changes of critical ocean gateways may have caused large-scale circulation shifts, which in turn altered poleward heat and moisture transports and resulted in polar ice sheet growth and global cooling. However, tectonic forcing fails to explain the deglaciation of Antarctica during the late Oligocene and the subsequent global warming which lasted until the early-middle Miocene. Moreover, simulations including a Central American seaway between the Atlantic and Pacific fail to reproduce the reconstructed meridional temperature gradient.
Alternatively, it is thought that the Cenozoic climate evolution was governed by a secular drawdown of atmospheric carbon dioxide. This drawdown is manifest in reconstructions and could be due to increased silicate weathering rates, or result from enhanced organic carbon burial on continental margins. One problem with this hypothesis is that, according to most reconstructions, carbon dioxide levels have been remarkably constant and low since the Oligocene, including during the early-middle Miocene climatic optimum.
The contradictory findings are a challenge for earth system mod(eller)s. If there are no unknown biases in the proxy data records, we have to rethink our current understanding of the climate system. Further forcing factors or feedbacks may have been effective during the Cenozoic. Potential candidates are other greenhouse gases such as methane or nitrous oxide, and biogeophysical interactions involving the land biosphere.
The presentation gives an overview of the various modeling efforts that have been undertaken to understand the Cenozoic climate evolution, and discusses shortcomings as well as perspectives.