

Climate-carbon cycle feedback during glacial cycles

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Paleoclimate records reveal a close link between global ice volume and atmospheric CO₂ concentration, at least, through the last 800,000 years. Despite many efforts over the last two decades, mechanisms of glacial-interglacial CO₂ variability and its role for the glacial cycles remain elusive. Here using the Earth system model of intermediate complexity CLIMBER-2 which includes all major components of the Earth system – atmosphere, ocean, land surface, ice sheets, terrestrial biota, eolian dust and marine biogeochemistry – we performed simulations of the last glacial cycles employing variations in the Earth's orbital parameters as the only prescribed climatic forcing.

In the experiments with constant CO₂ concentration, temporal dynamics of the simulated glacial cycles strongly depend on the CO₂ level. For CO₂ concentrations about and above preindustrial one, the model simulates only short glacial cycles with precessional and obliquity frequencies. However, for lower CO₂ concentrations the model simulates long glacial cycles with dominant 100 kyr periodicity. Simulated glacial cycles agreed favorably with paleoclimate reconstructions, but their amplitude is underestimated compared to those of the simulations with time-dependent CO₂ concentration. These results confirm that the positive climate-carbon cycle feedback plays an important role in amplification of long glacial cycles. Experiments with fully interactive CO₂ shed some light on the mechanism of climate-carbon cycle feedback during glacial cycles. Forced by orbital variations only, the model is able to reproduce the main features of CO₂ changes: the 40 ppmv CO₂ drop during glacial inception, the minimum concentration at the last glacial maximum being 80 ppmv lower than the Holocene value, and the relatively abrupt CO₂ rise during the deglaciation. The main drivers of atmospheric CO₂ evolve with time: changes in sea surface temperature and volume of bottom water of southern origin exert CO₂ control during glacial inception and deglaciation, while changes in carbonate chemistry and marine biology are dominant during the first and second parts of the glacial cycles, respectively.

Evaluation of marine primary organic aerosol emission schemes

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In the last decade, there has been an increase in research concerning primary organic aerosol (POA) emissions from the ocean. Global source of ocean-emitted POA has been shown to be comparable to primary organic carbon particles emitted from combustion [1] and are sometimes found in concentrations more typical of organic aerosols in urban areas [2]. Due to their importance, several attempts have been made to better quantify the emission rate of marine POA for use in air quality and global climate models. In this work, we present results from the chemical transport model GEOS-Chem in which five distinct emissions schemes [1, 3, 4, 5, 6] of marine POA are implemented using a consistent sea spray function and chlorophyll-a concentrations ([Chl-*a*]). Model simulations are evaluated against long- and short-term observations collected in multiple coastal sites.

Calculations show that these schemes emit marine POA at different magnitudes and have distinct temporal/spatial distributions. Three of the emission schemes [3, 4, 5] are strongly tied to the wind speed dependence of the sea spray function and to a much lesser extent the [Chl-*a*]. On the other hand, the Spracklen *et al.* [1] emission scheme is primarily driven by [Chl-*a*] and is insensitive to surface wind speed. Between these two extremes is the Gantt *et al.* [6] scheme, which is affected by both wind speed and [Chl-*a*].

Preliminary results show that the emission schemes with strong wind speed dependence overpredicted concentrations in the winter relative to the summer at sites in the Northern Atlantic and Southern Ocean [7, 8]. The high organic concentration episode at Mace Head [2] was not reproduced well by any scheme, although the emissions with wind speed dependence outperformed the emissions based solely on [Chl-*a*]. This study shows that large uncertainty in marine POA emissions exists and requires further evaluation.

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