Abstract:

Long-term ecosystem and carbon cycle responses to climate change are needed to inform mitigation policy, yet our understanding of how these responses may evolve remains highly uncertain. Important feedback pathways include reduced growth of tropical forests from warming and drying, permafrost loss, accelerating rates of decomposition of soil organic matter, and the slowing of ocean overturning. Using the Community Earth System Model (version 1.0), we quantified climate-carbon feedbacks from 1850 to 2300 for the Representative Concentration Pathway 8.5 (and its extension). In three simulations, land and ocean biogeochemical processes experienced the same trajectory of increasing atmospheric CO₂. Each simulation had a different degree of radiative coupling for CO₂ and other greenhouse gases and aerosols, enabling diagnosis of feedbacks. In a fully coupled simulation, global mean surface air temperature increased by 9.3 K from 1850 to 2300, with 4.4 K of this warming occurring after 2100. Excluding CO₂, warming from other greenhouse gases and aerosols was 1.6 K by 2300, near a 2 K target needed to avoid dangerous anthropogenic interference with the climate system. Ocean contributions to the climate-carbon feedback increased considerably over time, and exceeded contributions from land after 2100. The sensitivity of ocean carbon to climate change was found to be proportional to cumulative ocean heat uptake, as a consequence of this heat modifying transport pathways for anthropogenic CO₂ inflow and solubility of dissolved inorganic carbon. Regional influence of climate change on carbon stocks was largest in the North Atlantic Ocean and tropical forests of South America.