Geophysical Research Abstracts
Vol. 21, EGU2019-4740, 2019
EGU General Assembly 2019

Vegetation migration and terrestrial carbon variation in past warm and cold climates

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About one-third of the current anthropogenic carbon dioxide (CO_2) emissions are absorbed by the terrestrial biosphere. The uncertainty as to how this uptake might respond to projected future climate change can be constrained by knowledge of its behavior during glacial-interglacial cycles. Previous investigations of the vegetation and land carbon storage during the glacial period suggested a reduction of forests, productivity and biomass. Nevertheless, an evaluation based on a historical warm period is needed to better understand the implications for the future, and to understand the roles of temperature, moisture and CO_2 concentration (pCO_2) in the climate transition, which are currently still poorly understood. Consistent with paleo-vegetation and carbon cycle-related reconstructions, here we show the vegetation migration and terrestrial carbon variation in both past cold and warm climates, simulated by the Dynamic Global Vegetation Model LPJ-GUESS. We find that the vegetation extent is mainly determined by temperature anomalies, especially in a cold climate, while precipitation forcing is limited on a regional scale to shape vegetation patterns. The pCO_2 change controls the global carbon balance with higher pCO_2 linking to higher vegetation coverage, an enhanced terrestrial carbon sink and increased terrestrial carbon storage. Our results indicate a coherent transfer of carbon from ocean and permafrost/peat to biosphere and atmosphere from cold to warm climate scenarios. We further highlight the importance of expansion of the terrestrial ecosystem carbon stock in slowing atmospheric pCO_2 growth.