Geophysical Research Abstracts, Vol. 8, 01700, 2006
SRef-ID: 1607-7962/gra/EGU06-A-01700

The role of fire disturbance in the response of historical carbon dynamics in the boreal forest from 1950-2002

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In the boreal forest, wildfire is a common occurrence, and changes in the fire regime have consequences for carbon dynamics as well as water and energy feedbacks to the climate system. Changes in climate and atmospheric CO_2 concentrations may also affect carbon dynamics through their effects on ecosystem processes. However our ability to project future temporal and spatial changes in carbon dynamics is limited by our understanding of how the temporal and spatial aspects of fire influence historical carbon dynamics.

To evaluate the temporal and spatial changes of carbon dynamics in response to CO_2, climate, and fire disturbance, we developed a fire module for the Terrestrial Ecosystem Model (TEM) and simulated carbon dynamics for the pan-boreal region north of 45˚ N from 1950-2002. We conducted three simulations: CO_2 fertilization only, CO_2 and climate variability, and CO_2, climate, and fire disturbance.

For fire simulations, information on historical fire return interval (FRI) was used for backcasting fire disturbance prior to the start of the historical fire records. We used cokriging estimates based on data for the IGBP high latitude transects in Eurasia and estimated FRIs for North America based on spatially and temporally explicit fire records for the period 1950-2002.

Simulation results for the pan-boreal region north of 45˚ N indicate that C storage increased in response to CO_2, climate, and fire at a rate of 344 Tg C yr^{-1}between 1950 and 2002. Partitioning the effects of CO_2, climate, and fire for North America indicates that from 1950-2002, atmospheric CO_2 was responsible for sequestering 37.52 Tg C yr^{-1}(3.48 g C m^{-2} yr^{-1}), climatic variation was responsible for sequestering 38.09 Tg C yr^{-1}(3.54 g C m^{-2} yr^{-1}), and fire was responsible for releasing 7.01 Tg

C yr^{-1} (0.62 g C m^{-2} yr^{-1}). For Eurasia, atmospheric CO_2 was responsible for sequestering 126.31 Tg C yr^{-1}(4.96 g C m^{-2} yr^{-1}), climatic variation was responsible for sequestering 70.87 Tg C yr^{-1}(2.78 g C m^{-2} yr^{-1}), and fire was responsible for sequestering 78.64 Tg C yr^{-1} (3.08 g C m^{-2} yr^{-1}).

Our analysis suggests that CO_2, climate, and fire each play important roles in carbon dynamics across the pan-boreal region. It also shows that it is important to incorporate fire in a temporally and spatially explicit manner when estimating the effects of fire on carbon dynamics for the boreal forest region. Our next step in this study is to develop a fire model that can be coupled to TEM to evaluate carbon dynamics across the boreal forest for future scenarios of climate change.