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Contributions of wildland fire to terrestrial ecosystem carbon dynamics in Arctic-Boreal North America from 1990 – 2012

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Burn area and the frequency of extreme fire events have been increasing during recent decades in arctic and boreal ecosystems of North America, and this trend is expected to continue over the 21st century. While many aspects of the North American carbon budget have been intensively studied, the net contribution of fire disturbance to the overall carbon flux at the continental scale remains uncertain. Based on comprehensive, spatially-explicit and long-term fire data, along with the improved model parameterization in a process-based ecosystem model, we simulated the impact of fire disturbance on both direct carbon emissions and net terrestrial ecosystem carbon balance across the Arctic-Boreal region of North America. Based on our synthesis and harmonization of available wildfire databases, more than 5,500 and 20,000 km^2/yr burned on average over the 1990-2012 time period in Alaska and Canada, respectively. Over that time period, fire-caused direct carbon emissions were 18.23±2.74 Tg C/yr in Alaska and 57.87±8.68 Tg C/yr in Canada. However, the net ecosystem carbon balance associated with fire was -10.92 and 11.87 Tg C/yr for Alaska and Canada, respectively, indicating that most of the emitted carbon was re-sequestered by the terrestrial ecosystem. Direct carbon emissions showed an increase in Alaska and Canada during 1990-2012 as compared to prior periods due to more extreme fire events, resulting in a large carbon source from these two regions. Among all continental biomes, the largest carbon source was found to be from the boreal forest, primarily due to large reductions in soil organic matter during, and with slower recovery after, fire events. The interactions between fire and environmental factors reduced the fire-caused ecosystem carbon source. Fire disturbance only caused a weak carbon source as compared to the best- estimate of the terrestrial carbon sink in North America owing to the long-term legacy effects of historical burn area coupled with fast ecosystem recovery during 1990-2012.