EGU21-2218
https://doi.org/10.5194/egusphere-egu21-2218
EGU General Assembly 2021

Future increases in lightning-ignited boreal fires from conjunct increases in dry fuels and lightning

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Fire is the most important landscape disturbance in the boreal forest of North America. The boreal region is the largest terrestrial biome and stores approximately 35 % of the global soil carbon (C). Burned area has increased over the last decades and is projected to increase further in the future, potentially altering boreal forest ecosystems from a net sink of C to a source of C. Approximately 90 % of the burned area in the region originates from wildfires ignited by lightning strikes. It is therefore important to understand the drivers of lightning-induced wildfires to evaluate the consequences of possible future changes in lightning activity and ignition efficiency. Here, we evaluated lightning ignition efficiency, i.e. the probability that a lightning strike starts a fire, for Alaska and Northwest Territories between 2001 and 2018 in function of three sets of drivers: lightning characteristics, topography, and fire weather. Further, we projected the lightning ignition efficiency under the RCP8.5 scenario and combined it with predictions of future lightning activity to assess future lightning ignition.

The logistic model demonstrated an overwhelming influence of fire weather on lightning ignition efficiency (area under the curve > 0.83), whereas lightning characteristics and topography contributed relatively little to the model performance. We found that short-term drying of the organic soils is the most important requirement for a lightning strike to start a fire. The average lightning ignition efficiency for Alaska and Northwest Territories increased with 54 ± 32 % and 44 ± 44 by 2100. Combined with future projections of lightning activity, we predicted a total increase in lightning ignition of up to 230 ± 20 % and 92 ± 56 % for Alaska and Northwest Territories by 2100. Future increases in lightning ignitions in the boreal forest will likely induce additional burned areas in regions with C-rich peatland and permafrost soils. Our research showed that the increased availability of dry fuels and increases in lightning will reinforce each other leading to more boreal fires and consequent C emissions.