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Modeling Anthropogenic Drivers of Fires

Brian Magi (1), Elena Shevliakova (2), Sergey Malyshev (3), and Stephen Pacala (4)

(1) Princeton University, Atmospheric and Oceanic Science, Princeton, United States (brian.magi@noaa.gov), (2) Princeton University, Ecology and Evolutionary Biology, Princeton, United States (elena@princeton.edu), (3) Princeton University, Ecology and Evolutionary Biology, Princeton, United States (malyshev@princeton.edu), (4) Princeton University, Ecology and Evolutionary Biology, Princeton, United States (pacala@princeton.edu)

Biomass burning is a major disturbance in terrestrial ecosystems and a large source of carbon to the atmosphere. Natural and anthropogenic fires have been a part of the Earth system for millennia, but our understanding of global fire activity and the subsequent impacts on ecosystems and the atmosphere has only advanced significantly in the past three decades. While climate is generally considered to be the dominant control on the distribution and timing of global fires, human activities directly shape global fire distribution through practices such as land-clearing, crop and pasture management, and fire suppression, and indirectly through anthropogenically driven climate change.

We present a new prognostic fire model for use in coupled carbon cycle-climate models. Similar to other modeling approaches, fire occurrence is a function of moisture, fuel, and the presence of ignition sources (i.e. humans or lightning) and suppression of fires (based on population density). A novel feature of our fire model is that the number of fires, burned area, and emissions are determined not only by the climate and population density, but also by the history of land use changes. Although the fire patterns of both natural and managed ecosystems depend on the same fundamental variables (moisture, fuel, ignition sources), the actual parameterizations depend on the type of land use management and fire.

The fire model simulates seasonal patterns in fire activity, burned area, and fire emissions, accurately reproducing timing and magnitude at regional scales when compared to available observationally-based constraints such as fire counts from NASA Moderate Resolution Imaging Spectroradiometer (MODIS), Global Fire Emissions Database (GFED), and biomass burning emissions inventories. Global mean annual fires simulated by the fire model are within about 15% of the total number of fires reported by MODIS, with a spatial correlation of $r = 0.70$. Zonally-averaged fires from the fire model and MODIS are highly correlated with $r = 0.95$, indicating that overall location of the simulated fires is in close agreement with MODIS. Zonally-averaged fires display a distinct double peak in the Northern and Southern Hemisphere tropics.

Zonally-averaged burned area from the fire model is within 20% ($r = 0.93$) of the burned area from GFED. Well over half the global burned area each year is due to agricultural fires, with higher contributions in regions of the world where fire is the primary management tool for cropland and pastures. Comparisons of mean monthly burned area are in close agreement with GFED for most regions of the world, while some regions clearly deviate from the strong climate control on seasonal fire occurrence as a result of human intervention.