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The biomass burning contribution to climate-carbon cycle feedback

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Temperature exerts strong controls on the incidence and severity of fire. Warming is thus expected to increase fire-related carbon emissions and thereby atmospheric CO_2. But the magnitude of this feedback is very poorly known. We use a single-box model of the land biosphere to quantify this positive feedback based on satellite-based estimates of biomass burning emissions for 2000–2014 and sedimentary charcoal records for millennium before the industrial period. We derive a satellite-era estimate of the centennial-scale feedback strength of 6.5 ± 3.4 ppm CO_2 per degree of land temperature increase. However, this estimate is poorly constrained, and is largely driven by the well-documented dependence of tropical deforestation and peat fires on climate variability patterns linked to the El Niño-Southern Oscillation. Palaeodata from pre-industrial times provide the opportunity to assess the fire-related climate-carbon cycle feedback over a longer period, with less pervasive human impacts. Past biomass burning can be quantified based on variations in either on the concentration and isotopic composition of methane in ice cores (with assumptions about the isotopic signatures of different methane sources), or on the abundances of charcoal preserved in sediments, which reflect landscape-scale changes in burnt biomass. These two data sources are shown here to be coherent with one another. The far more numerous data from sedimentary charcoal are then used to infer a feedback strength of 2.9 ± 1.1 ppm CO_2 per degree of land temperature, implying a gain of 0.05 $\pm$ 0.02 (assuming a mid-range climate sensitivity of 3 K). This finding indicates that the positive feedback from increased fire provides a non-negligible contribution to the overall climate-carbon cycle feedback on centennial time scales.