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Sensitivity of pre-industrial tropospheric ozone and ozone radiative forcing to historic land cover change.

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Estimates of anthropogenic radiative forcing due to changes in tropospheric ozone are based on model simulations of present day and pre-industrial tropospheric ozone distributions. However, there are large uncertainties in simulations of the pre-industrial tropospheric ozone budget, and there is evidence to suggest that models may overestimate pre-industrial surface ozone concentrations compared with a limited set of observations from the turn of the nineteenth century. Here, we use a coupled Earth system model (HadGEM2-ES) with interactive vegetation and photosynthetically-driven isoprene emissions, to investigate the impacts of 1865 to present-day land cover change on tropospheric ozone. We investigate separately the impacts of changes in climate, land surface cover and atmospheric CO_2 on dry deposition of ozone and precursors, and on biogenic isoprene emissions.

Our results show that changes in dry deposition from differences in the vegetation surface resistance produce localised decreases of several ppbv in surface ozone. Changes in isoprene emissions produce large-scale ozone distribution changes, with localised decreases in ozone in regions of increased isoprene and low NO_x loading. Widespread ozone increases are produced in the remote background atmosphere under 1865 climate and land cover due to tropical isoprene increases under pre-industrial CO_2 and resultant enhanced PAN formation from biomass burning–sourced NO_2. Our simulations produce a pre-industrial ozone burden of 200-221 Tg with the range resulting from differences in the model land vegetation distribution, the CO_2 mixing ratio the vegetation is exposed to and the model climate setup. The response of ozone concentrations to land cover changes is greater than the response to changes in the CO_2 mixing ratio the vegetation is exposed to. The resultant estimated range in pre-industrial to present day radiative forcing from our simulations is 0.227 to 0.244 Wm^{-2}.