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Drivers of global radiative forcing from tropospheric ozone change, 1990 – 2010

K. Harper and N. Unger
School of Forestry & Environmental Studies, Yale University, New Haven, USA (kandice.harper@yale.edu)

Driven by changes in land cover, anthropogenic air pollution emissions, and global climate, the concentrations and spatial distributions of tropospheric ozone have changed dramatically over the last few decades, perturbing the Earth's radiation balance. We use the NASA ModelE2-Yale Interactive Terrestrial Biosphere (NASA ModelE2-YIBs) global carbon-chemistry-climate model to quantify the impact of changes in the short-lived climate pollutants (SLCPs), including tropospheric ozone, on the Earth's radiation budget over the period 1990 – 2010. Sensitivity studies are performed to compare the size of the contributions of the different drivers of ozone concentration change to the total radiative forcing from tropospheric ozone over this period. NASA ModelE2-YIBs has a dynamic land carbon cycle model and a fully interactive gas and aerosol chemistry module, supporting integrated study of ecosystem-atmosphere-climate interactions. Time-slice simulations are nudged with large-scale winds from the MERRA reanalysis, apply sea ice distributions and sea-surface temperatures from the Hadley Centre dataset, and prescribe monthly anthropogenic air pollution emissions from the MACCity emissions inventory. We calculate a global-average radiative forcing > 100 mW/m2 from all SLCPs for the period 1990 – 2010, with a contribution from tropospheric ozone on the order of +70 mW/m2. When considering the cumulative impact of all SLCPs, the change in emissions of reactive air pollutants induced a larger radiative forcing than did the change in the physical climate state. For ozone, climate change had a stronger influence than precursor emission changes on ozone concentrations in the mid- and upper-troposphere, with zonal-average ozone concentrations increasing by as much as 10% in the tropical upper-troposphere due to climate change; consequently, the climate-change-induced ozone radiative forcing exceeded the emissions-driven forcing over this period. We evaluate the simulated atmospheric chemical composition changes using MODIS AOD and TES vertically-resolved ozone concentrations.