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Projecting policy-relevant metrics to characterize changing ozone extremes over the US: Variations by region, season and scenario

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Nitrogen oxide (NO_x) emission controls have led to improved air quality (particularly in the Eastern US) over the past two decades, but concerns have been raised that climate warming may offset some of these gains in the coming decades. Here we address these concerns by analyzing the effect of projected future changes of emissions and climate, in isolation and combination, on US surface ozone (O_3) during the 21st century in an ensemble of simulations (3 members per scenario) performed with the GFDL chemistry-climate model CM3. We analyze two Representative Concentration Pathway (RCP) scenarios: RCP4.5 and RCP8.5. Under both scenarios, NO_x emissions decrease by $\sim$80% over North America by 2100. In additional 3-member ensemble simulations, termed RCP4.5_WMGG and RCP8.5_WMGG, well-mixed greenhouse gases follow the respective RCP but O_3 and aerosol precursor emissions are held at 2005 levels. These simulations enable us to isolate the role of well-mixed greenhouse gas induced climate change from that of emission reductions. Another set of simulations, following RCP8.5 but with methane (CH4) held fixed at 2005 levels, termed RCP8.5_2005CH4, allows us to quantify the background influence of CH4 on O_3. For each season, we examine changes in the surface O_3 distribution over the US during the 21st century, calculating policy relevant statistics: days above the current national ambient air quality standard (NAAQS) of 75 ppb and other proposed future levels, as well as the probabilistic 1-year return levels for maximum daily 8-hour average ozone (MDA8 O_3), within each model grid cell. Specifically, we analyze: (i) regional and seasonal changes in the frequency and return level of high O_3 pollution events during the 21st century, as well as (ii) differences among the RCPs by the middle and end of the 21st century. We find that the response of surface O_3 to changes in emissions and climate varies strongly, seasonally and spatially, with certain regions more prone to a 'climate penalty' (e.g., the Northern US) or a 'climate benefit' (e.g. the Southeast).