Supplementary Information for:

The potential effects of climate change on air quality across the continental U.S. at 2030 under three Representative Concentration Pathways (RCPs)

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Table S1: Total annual anthropogenic emissions in continental U.S. (Tg yr^{-1}) used in all CMAQ simulations, with percent difference relative to 2011 National Emissions Inventory.

Species	Emissions[a]	Percent Difference
CO	50.3	−33.2
NO_x	7.5	−53.8
VOC	12.9	−24.6
SO_2	3.3	−68.7
NH_3	4.0	3.7
$PM_{2.5}$	3.6	−9.9

[a]2030 emissions projection used as the reference case for Tier 3 motor vehicle standards rulemaking analyses (U.S. EPA, 2014a,b).

Emissions

Anthropogenic emissions for each year of both the historical and future periods were modeled using a 2030 emissions projection (U.S. EPA, 2014a). This projection was based on a year 2007 air quality modeling platform that assumed the implementation of previously adopted air quality policies, including the Clean Air Interstate Rule (CAIR), the final Mercury and Air Toxics Standards (MATS), and with upstream stationary and mobile sources consistent with Energy Independence Security Act (EISA) Renewable Fuel Standards (RFS2). Resulting anthropogenic NO_x, SO_2, and volatile organic compound (VOC) emissions are 54%, 69%, and 25% lower, respectively, than in the 2011 National Emissions Inventory (Table S1). Wildfire and prescribed burn emissions were estimated using average-year data. Biogenic VOC emissions were allowed to vary according to climate-driven meteorological changes. Monthly and diurnal temporal profiles were applied to other emissions source sectors, including wildfires, but did not vary across years. Emissions of NO_x due to lightning were not modeled.

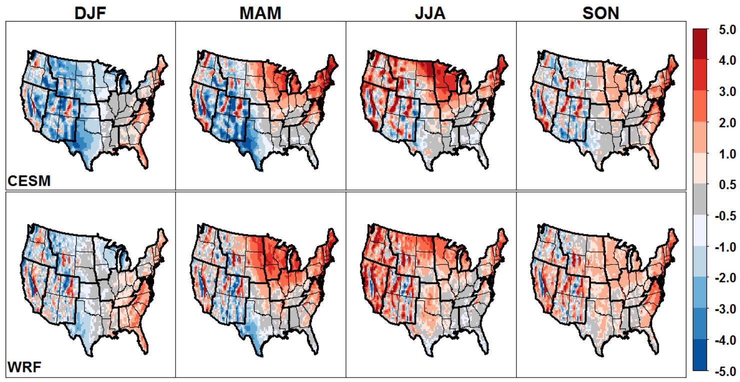

Figure S1: Seasonally averaged biases (K) in daily mean 2-m temperature compared to CFSR for 1995–2005. Top row shows biases in CESM fields interpolated to WRF grid; bottom row shows biases obtained after downscaling using WRF.

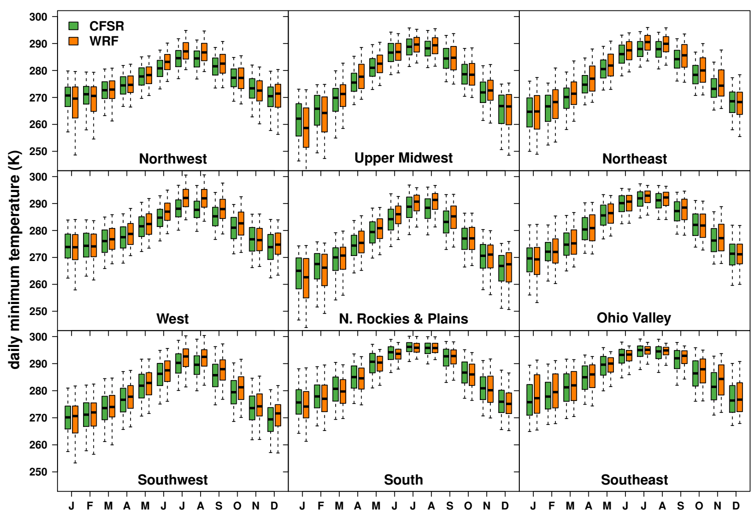

Figure S2: Monthly boxplots of daily minimum 2-m temperature simulated by downscaling CESM for the historical 1995-2005 period in comparison to CFSR for each of the U.S. climate regions shown in Figure 1. Boxes range from the 25th to 75th percentiles with the dark line denoting the median, and whiskers extend to 5th and 95th percentiles.

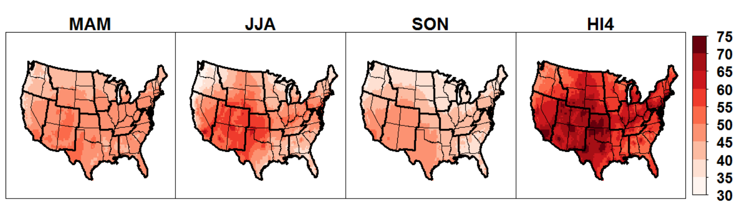

Figure S3: Maximum daily 8-h average (MDA8) O_3 mixing ratios (ppb) using meteorology downscaled from CESM for the historical period 1995–2005 and 2030 anthropogenic emissions projections provided in Table 1. Values shown are 11-year averages of spring, summer, and autumn seasonal means as well as 4th-highest annual values.

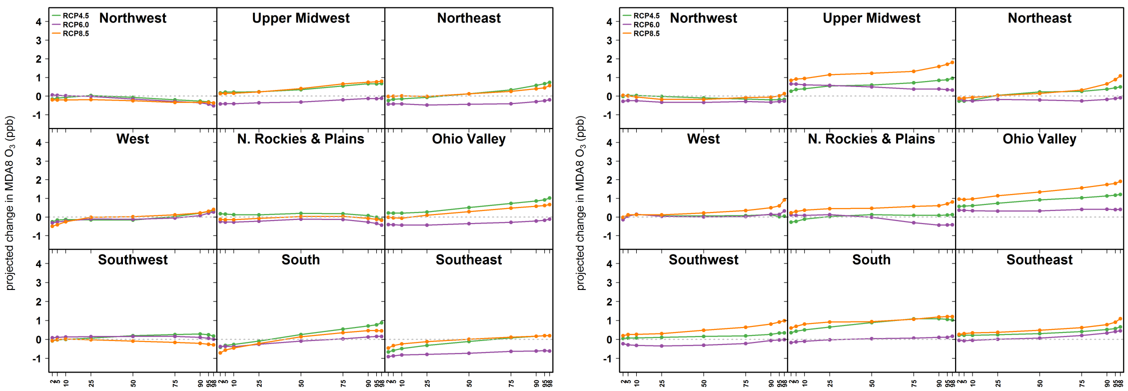

Figure S4: Projected changes in percentiles of spring (left) and autumn (right) average maximum daily 8-h O_3 mixing ratios (ppb) simulated by CMAQ between 1995–2005 and 2025–2035 under RCP4.5, RCP6.0, and RCP8.5 within each of the U.S. climate regions shown in Fig. 1.

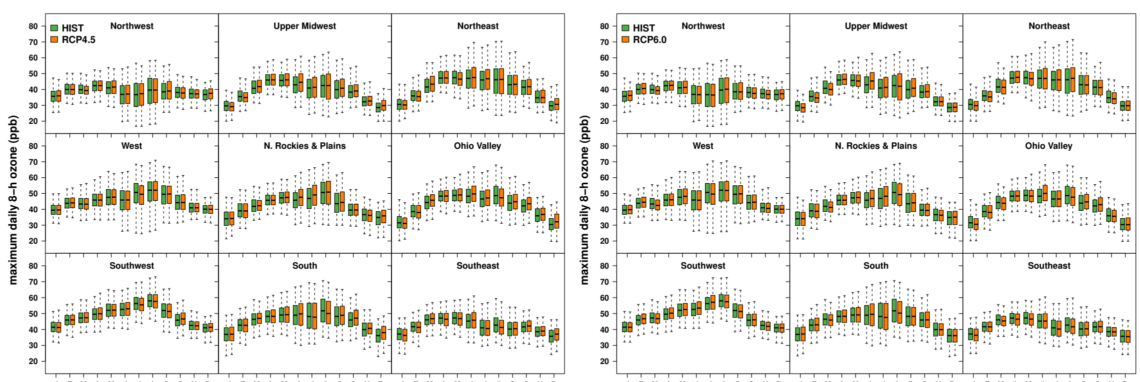

Figure S5: Monthly boxplots of maximum daily 8-h O_3 simulated for 1995–2005 and 2025–2035 under RCP4.5 (left) and RCP6.0 (right) for each of the U.S. climate regions shown in Fig. 1. Boxes range from the 25th to 75th percentiles with the dark line denoting the median, and whiskers extending to 2nd and 98th percentiles.

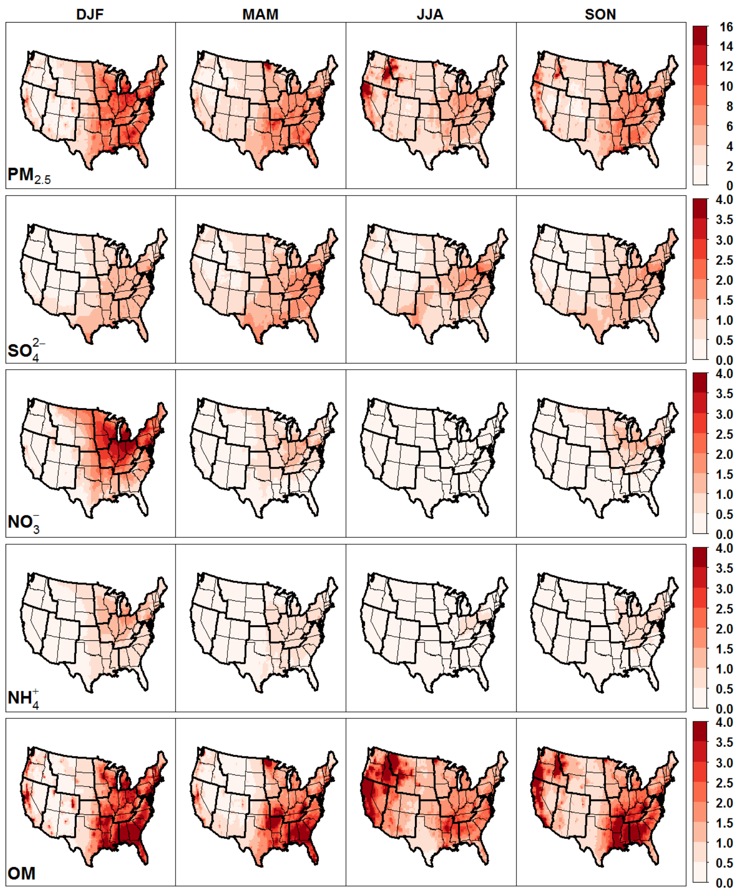

Figure S6: Seasonal mean $PM_{2.5}$ concentrations (μg m^{-3}) simulated for 1995–2005 using 2030 emissions projections provided in Table 1. (a) Total $PM_{2.5}$; (b) sulfate; (c) nitrate; (d) ammonium; and (e) organic matter.

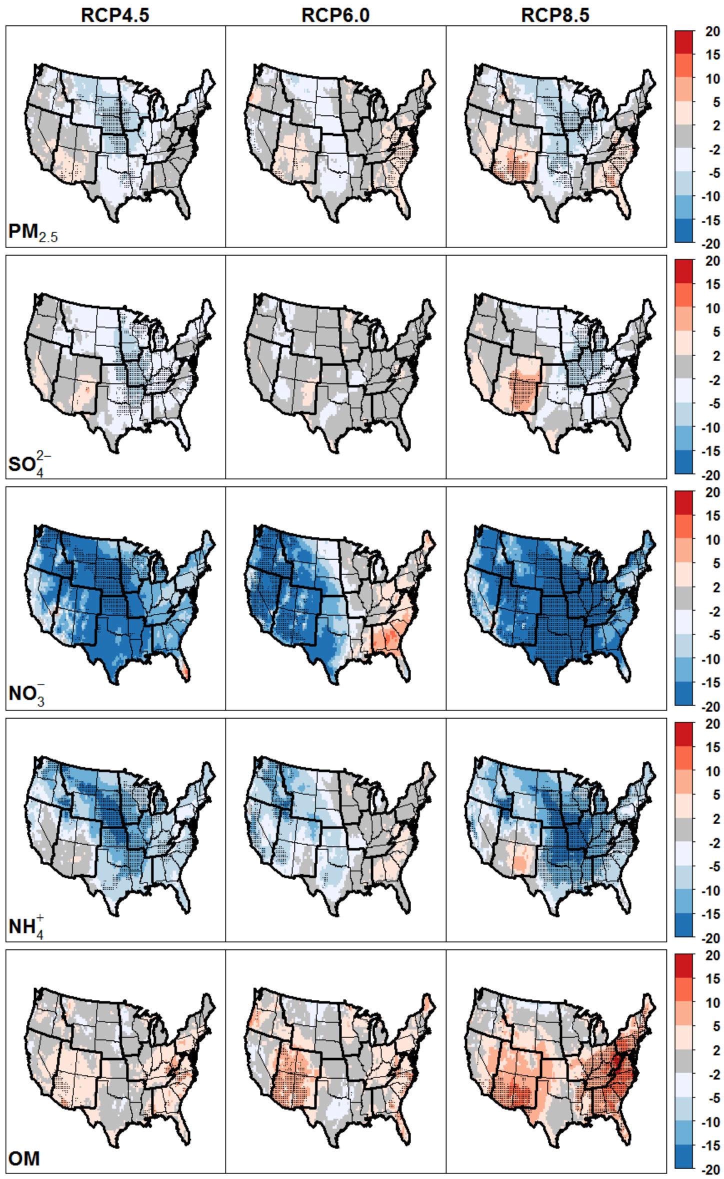

Figure S7: Projected relative changes (percent) in annual mean concentrations of total $PM_{2.5}$ and principal $PM_{2.5}$ components from 1995–2005 to 2025–2035 under RCP4.5, RCP6.0, and RCP8.5. Dark pixels show where differences are significant by Student's t-test ($p < 0.05$).

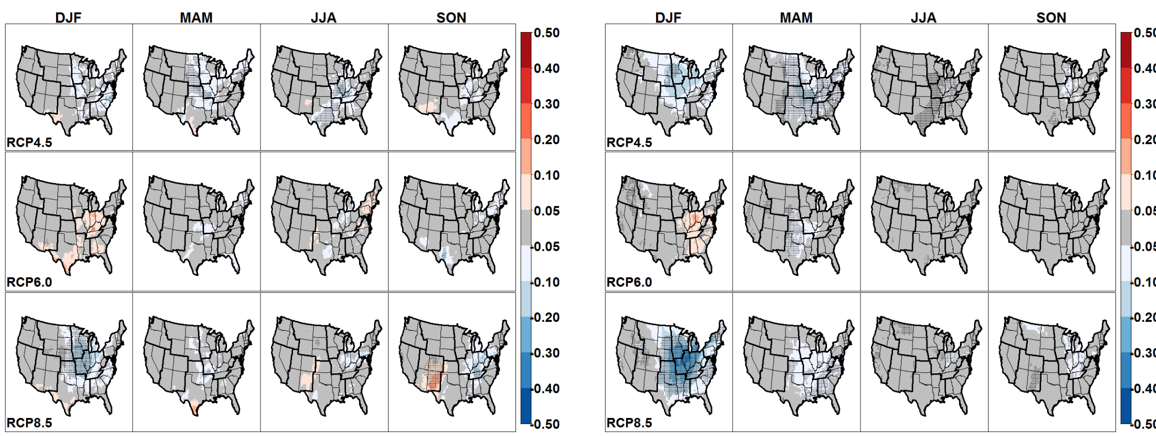

Figure S8: Projected changes in seasonal mean concentrations (μg m^{-3}) of PM$_{2.5}$ sulfate (left) and ammonium (right) from 1995–2005 to 2025–2035 under RCP4.5, RCP6.0 and RCP8.5.

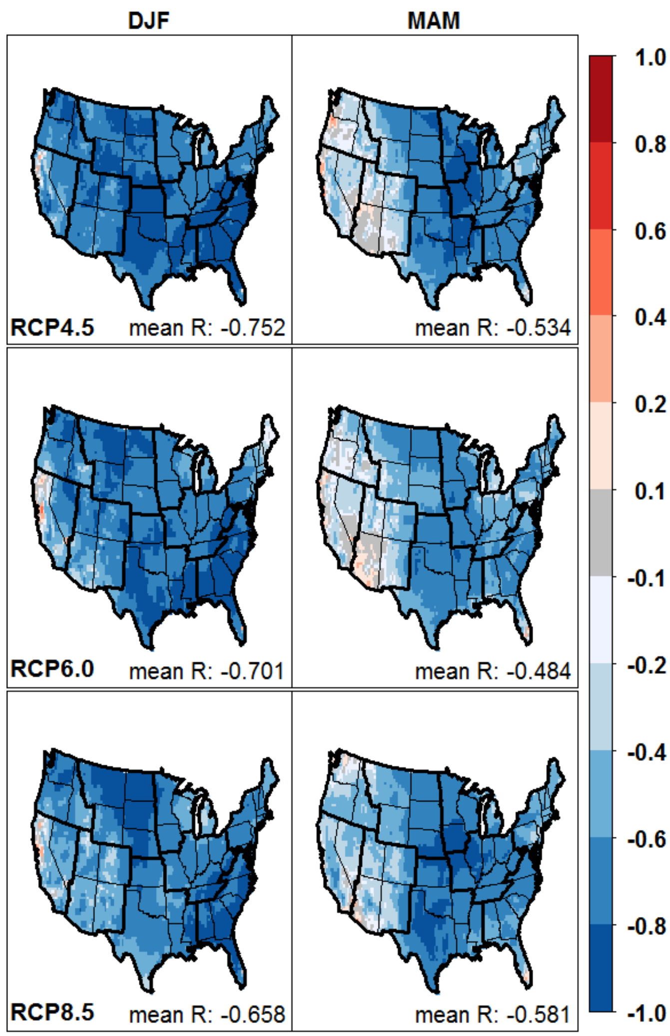

Figure S9: Correlations of projected changes in daily maximum temperature with changes in $PM_{2.5}$ nitrate during winter and spring from 1995–2005 to 2025–2035 under RCP4.5, RCP6.0, and RCP8.5.

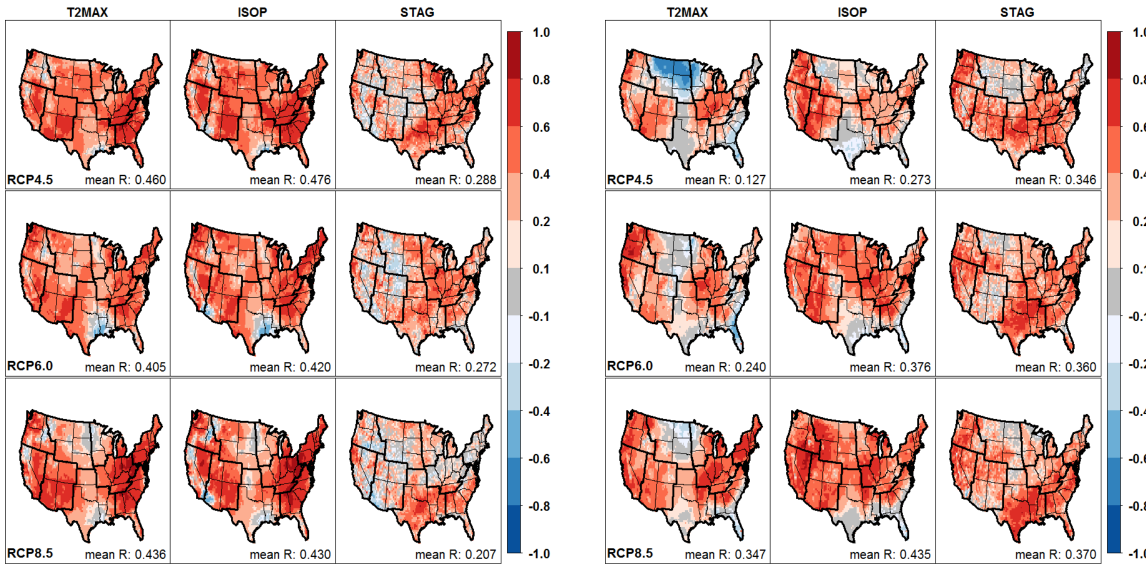

Figure S10: Correlations of projected changes in $PM_{2.5}$ organic matter with changes in daily maximum temperature, biogenic isoprene emissions, and the number of stagnation days (Horton et al., 2012) during summer (left) and autumn (right) from 1995–2005 to 2025–2035 under RCP4.5, RCP6.0, and RCP8.5.

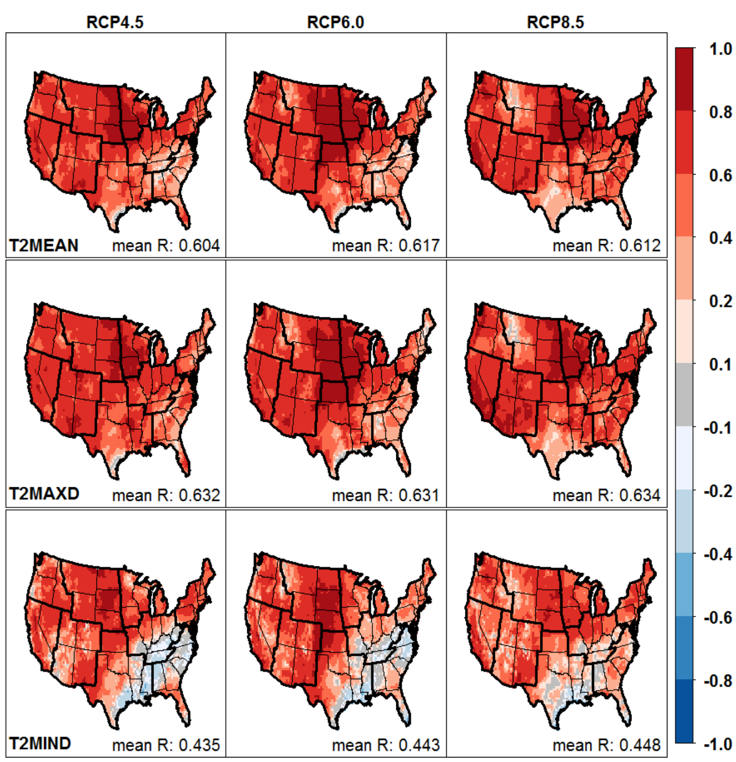

Figure S11: Correlations of projected changes in daily mean, daily maximum, and daily minimum 2-m temperatures with MDA8 O_3 during summer.

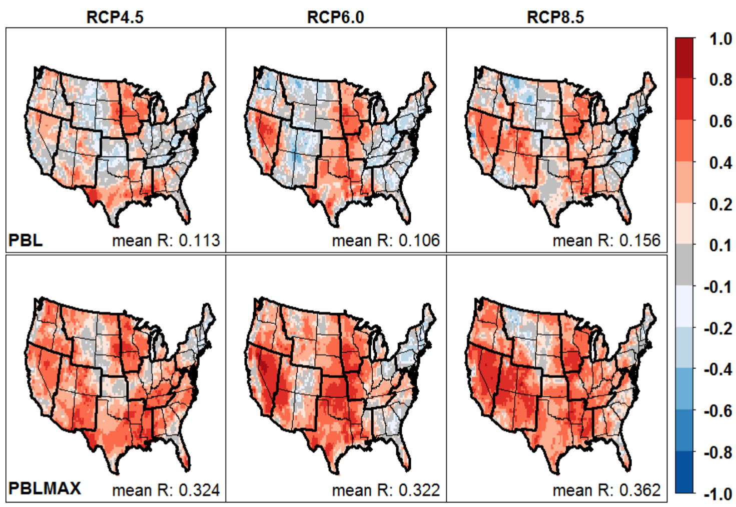

Figure S12: Correlations of projected changes in daily mean and daily maximum PBL heights with MDA8 O_3 during summer.

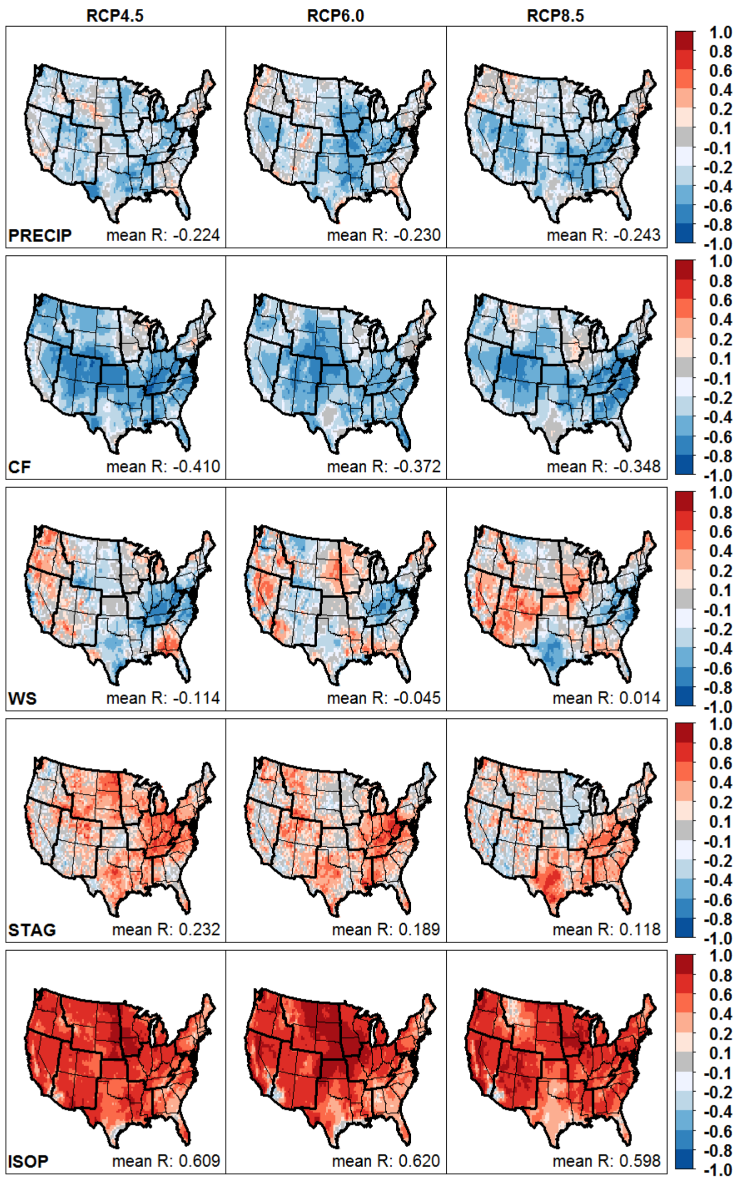

Figure S13: Correlations of projected changes in precipitation, cloud fraction, 10-m wind speeds, stagnation days, and biogenic isoprene emissions with projected changes in MDA8 O_3 during summer.

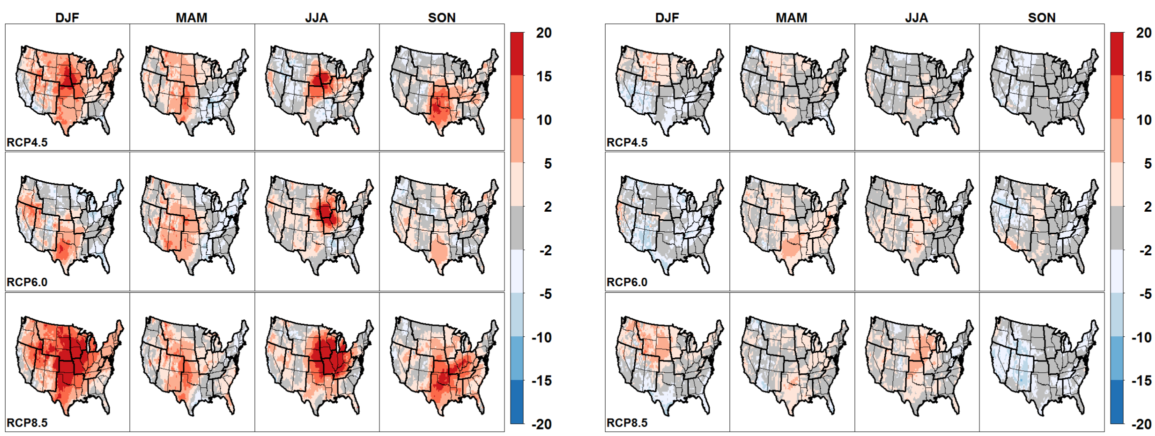

Figure S14: Percent changes in seasonal averages of daily maximum PBL heights (left) and mean 10-m wind speeds (right) from 1995–2005 to 2025–2035 under RCP4.5, RCP6.0, and RCP8.5.

References

Horton, D. E., Harshvardhan, and Diffenbaugh, N. S.: Response of air stagnation frequency to anthropogenically enhanced radiative forcing, Environ. Res. Lett., 7, https://doi.org/10.1088/1748-9326/7/4/044034, 2012.

U.S. EPA: Emissions Modeling Technical Support Document: Tier 3 Motor Vehicle Emissions Standards, Air Quality Assessment Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, NC 27711, EPA-454/R-14-003, URL http://nepis.epa.gov/Exe/ZyPDF.cgi/P100HX5N.PDF?Dockey=P100HX5N.PDF, 2014a.

U.S. EPA: Final Rule for Control of Air Pollution from Motor Vehicles: Tier 3 Vehicle Emission and Fuel Standards, U.S. Environmental Protection Agency, URL http://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-control-air-pollution-motor-vehicles-tier-3, last accessed 22 May 2018, 2014b.