Supplemental Material

Supplementary Figure S1: JAS black carbon (BC) burden anomalies from the direct-atmospheric response simulations for (a) 1970s minus 1950s and (b) 2000s minus 1970s. Solid contours indicate the regions in which the BC burden anomaly for a given regional emissions simulation accounts for more than 50% of the total BC burden anomaly and has a magnitude greater than 5×10^{-8} kg/m^2. The geographic regions used to define the emissions from a given region are outlined using dashed lines in blue (N AM), purple (EURO), green (AFRI), and red (ASIA).
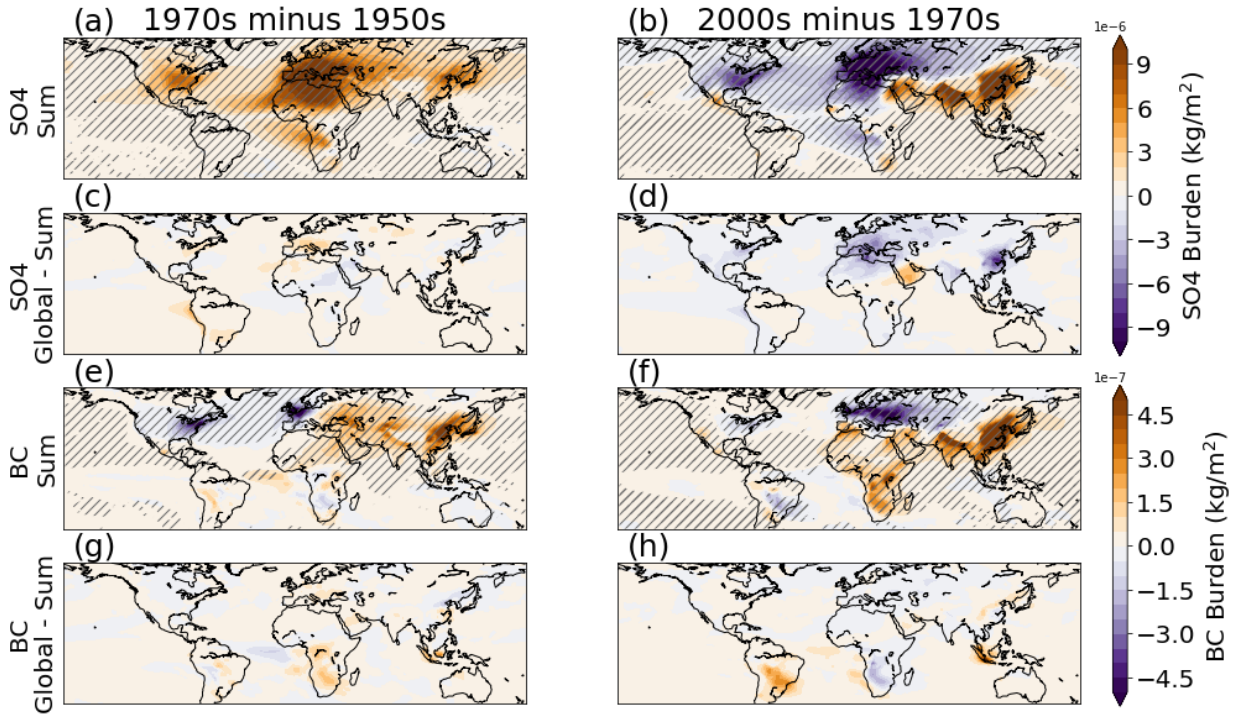
Supplementary Figure S2: Sum of (a),(b) SO4 and (e),(f) BC anomalies from the regional emission perturbation experiments for the (left) 1970s minus 1950s and (right) 2000s minus 1970s. Also shown is the difference between the sum of regional experiments and global emission change experiments for (c),(d) SO4 and (g),(h) BC. Hatching indicates grid points where the anomaly is significant at the 95% level.
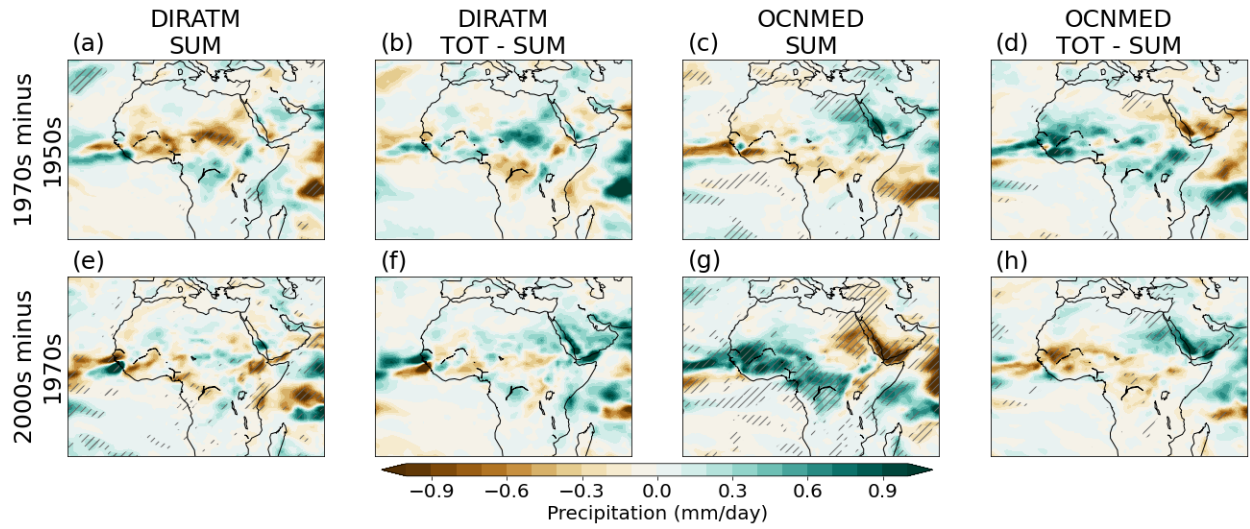
Supplementary Figure S3: Sum of precipitation anomalies for the (a),(e) regional emission and (c),(g) regional SST perturbation experiments for the (top) 1970s minus 1950s and (bottom) 2000s minus 1970s. Also shown are (b),(f) the difference between the global emission change experiments and the sum of regional emission experiments and (d),(h) the difference between the sum of regional SST experiments and global SST experiments. Hatching indicates grid points where the anomaly is significant at the 95% level.
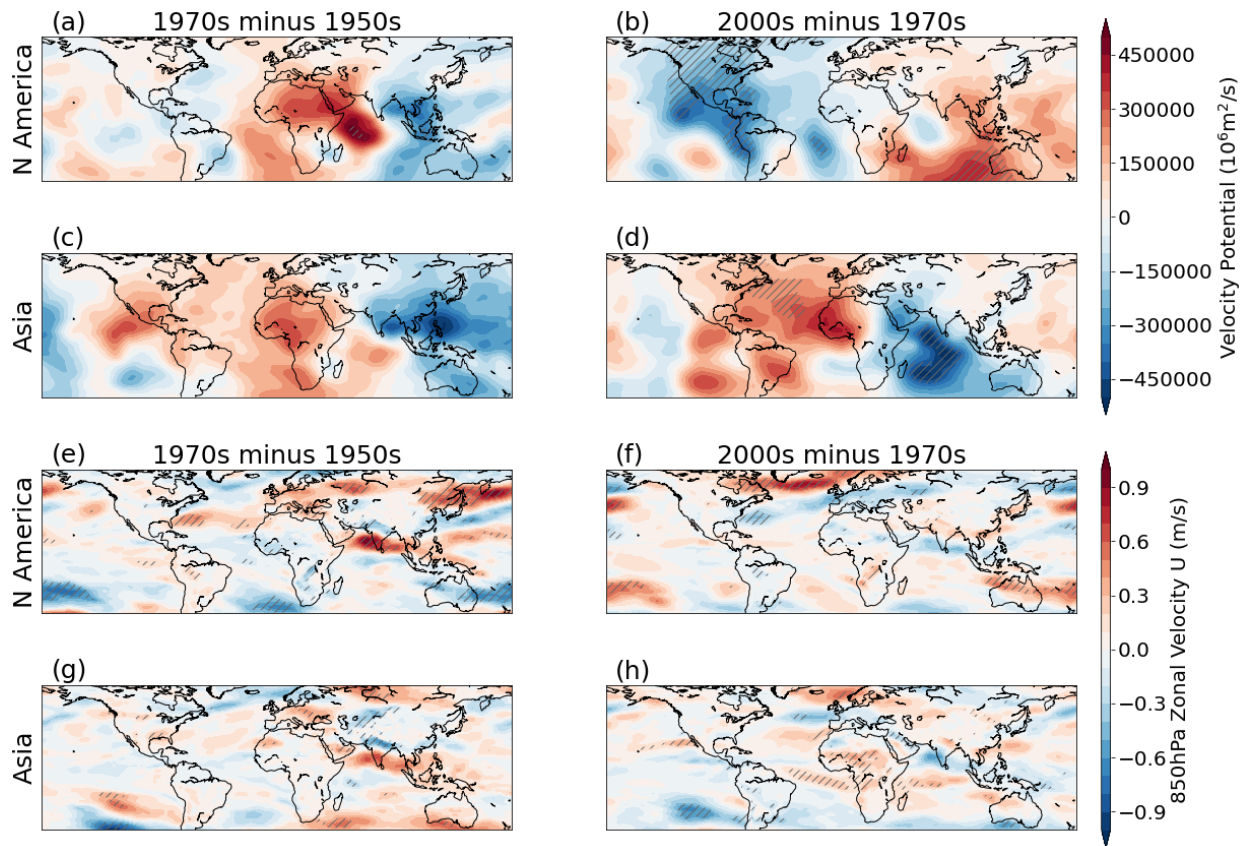
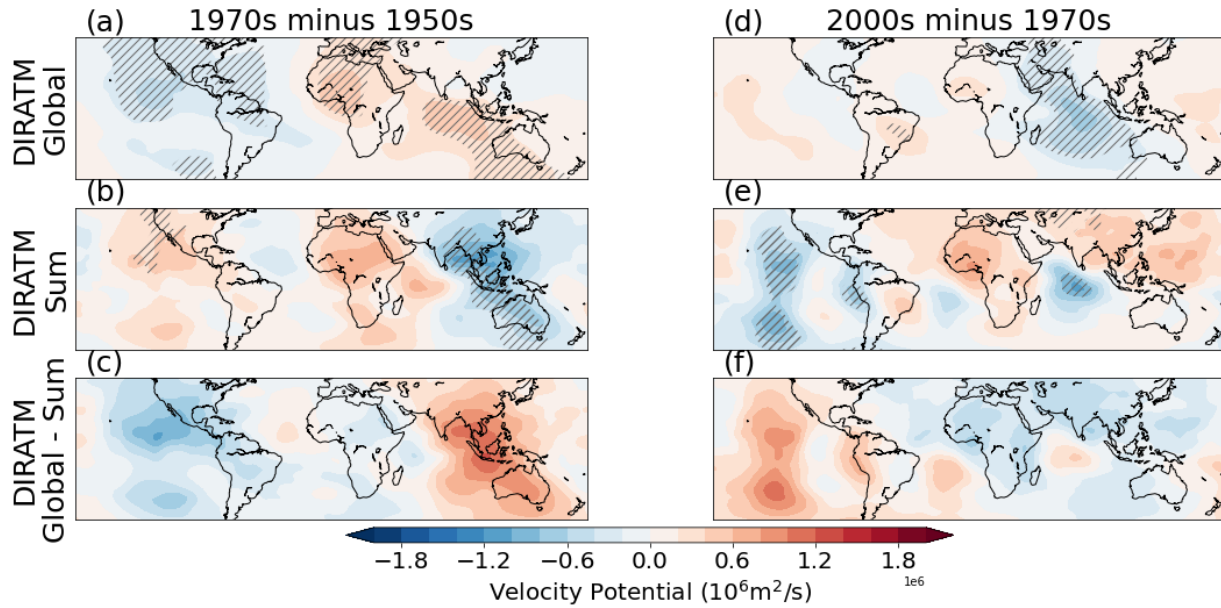*Supplementary Figure S4: (a)–(d) 200-hPa velocity potential and (e)–(h) 850-hPa zonal wind anomalies from the North American and Asian emission experiments for the (left) 1970s minus 1950s and (right) 2000s minus 1970s. Hatching indicates grid points where the anomaly is significant at the 95% level. The FDR criterion is calculated but returns a threshold of p = 0; thus no grid points pass the FDR test.*
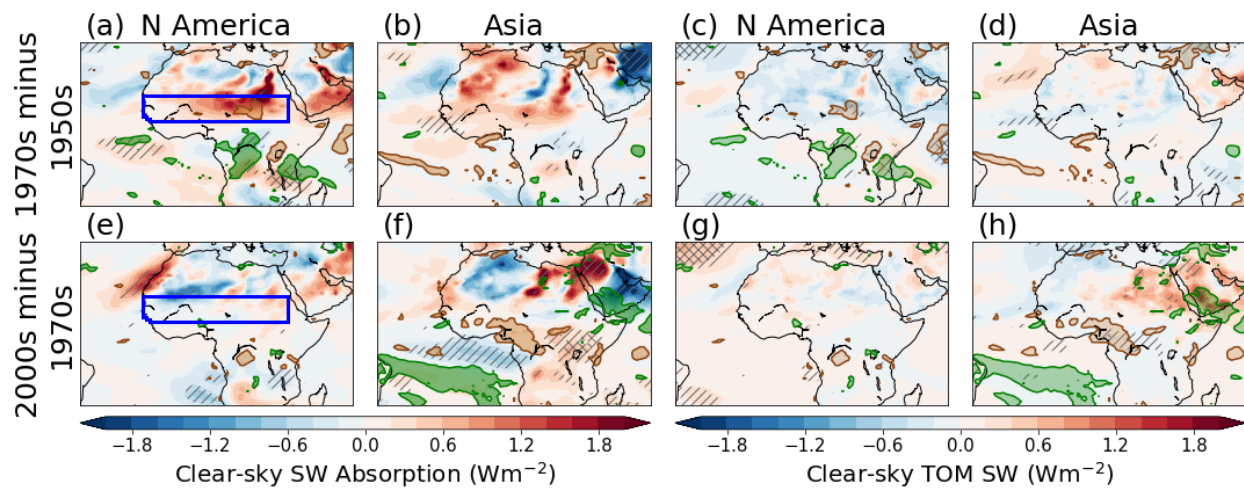
Supplementary Figure S5: Clear-sky atmospheric SW absorption shortwave anomalies for (a),(e) North America and (b),(f) Asia and clear-sky top-of-model (TOM) shortwave anomalies for (c),(g) North America and (d),(h) Asia for (top) 1970s minus 1950s and (bottom) 2000s minus 1970s emission change simulations. Hatching indicates regions of statistical significance, while cross hatching indicates regions that additionally pass the FDR criterion. Grid points in which there are statistically significant (p < 0.05) drying (brown) or wetting (green) signals are shown in contours.
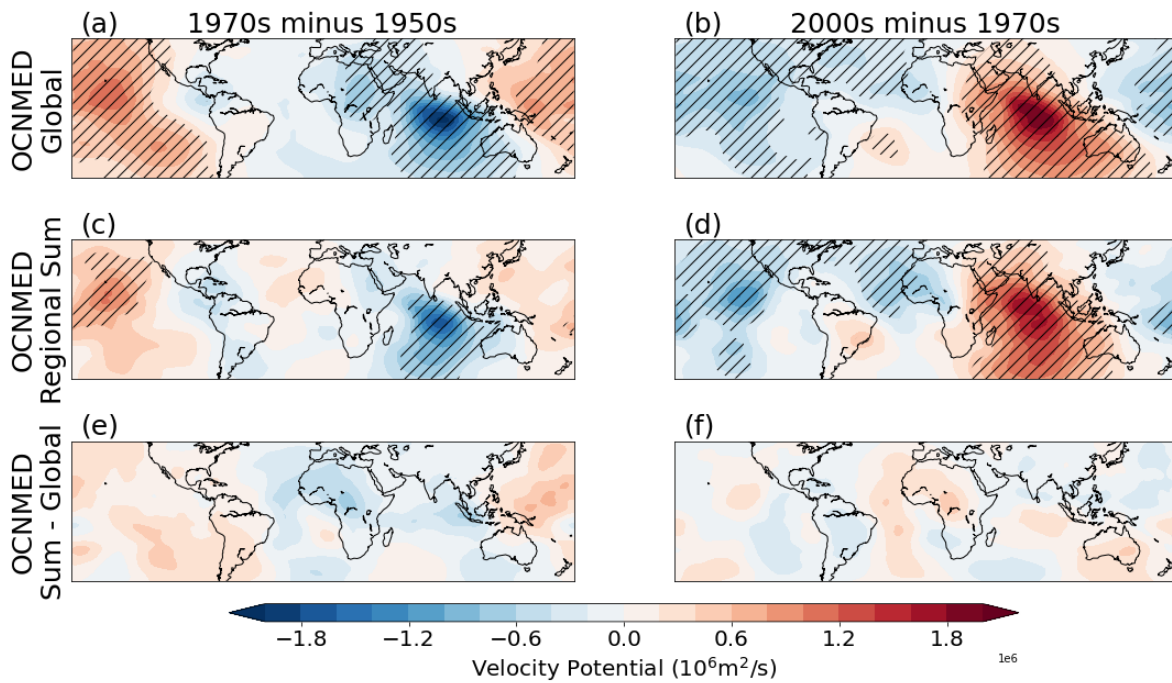
Supplementary Figure S6: JAS 200-hPa velocity potential anomalies from the (a),(b) global SST and (c),(d) sum of regional SST perturbation experiments for the (left) 1970s minus 1950s and (right) 2000s minus 1970s. Also shown are (e),(f) the differences between the global SST experiment and the sum of regional SST experiments.

Supplementary Figure S7: JAS 200-hPa velocity potential anomalies from the (a),(d) global emission and (b),(e) sum of regional emission perturbation experiments for (left) the 1970s minus 1950s and (right) the 2000s minus 1970s. Also shown are (c),(f) the differences between the global SST experiment and the sum of regional SST experiments.