Figure 1: Diagram showing potential chemical feedbacks on climate involving lightning. Red arrow targets are positively correlated with their tails; blue negatively correlated, black unknown/uncertain.

Figure 2: (a) Left to right: Climatological (1995-2013) lightning distribution from satellites (Godd et al., 2014), and ModelE2-simulated climatologies using three different lightning parameterizations. The global integrated mean flash rate is shown, as well as the spatially averaged Pearson correlation coefficients for each simulated climatology versus the satellites (with 144 latitudes × 100 longitudes = 12 months). (b) The resulting present-day annual mean NOx reservoir profiles from each mechanism. (c) The simulated change in the flash distributions in the 2080s relative to the 2000s. The global integrated change is given.

Figure 3: Tropospheric burdens of radiatively important species for each lightning and climate scenario.

Figure 4: Radiative forcing (RF; W m⁻²) from lightning NOx production at the top of the atmosphere (TOA). From left to right is shown the direct longwave and shortwave effect from NOx-driven changes in ozone (ignoring changes in methane), nitrate, sulfur, and their sum. The lightning contribution is calculated by differencing a full simulation with one containing zero lightning generation. Gray shading marks regions that do not have statistically significant signals at the 95% confidence level. The global integrated forcing is given at the top of each panel.

Figure 5: Radiative forcing (W m⁻²) at the TOA resulting from lightning NOx for the 2000s (left column) and the 2080s RCP4.5 scenario (right columns), colored by component and shown for each parameterization. The dashed line shows the net radiative forcing. Ozone and aerosol forcings are not shown. The blue box utilizes the model methane direct (o3, 30S-30N) and indirect effect as ozone (o3, 30S-30N) are derived from our simulations changes in CH₄ and temperature.

4. Radiative forcing and feedbacks from lightning

• Lightning-driven changes in Earth’s radiative balance from ozone and aerosols, neglecting methane changes.

5. Conclusions and Next Directions

• We have updated the lightning NOx treatment in the GISS ModelE2 chemistry-climate model, and test the sensitivity of chemistry and climate across the 21st century to three different lightning flash rate schemes.

• We calculate the net radiative forcing from lightning NOx to be about -0.25 W m⁻² in all scenarios, slightly larger than that of present-day anthropogenic NOx emissions relative to the preindustrial (IPCC, 2013).

• Our results are consistent with a small net negative RF for lightning on ozone (O3+O3, CBH) in the present (Wild et al., 2008). However, in the future, we find the lightning-ozone RF to become positive.