

4.233 The equilibrium response of climate and composition to lightning.

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Abstract:

Climate change can affect atmospheric composition through perturbation of natural processes, leading to complex feedbacks. The primary atmospheric oxidants OH and ozone are highly sensitive to emissions of nitrogen oxides (NO_x) from lightning, and therefore so are the subsequent chemical perturbations to reactive greenhouse gases (e.g., methane) and aerosol chemistry and physics. Meanwhile, cloud electrification responds to both meteorology and composition (aerosol particles). Key to understanding the ultimate impact of lightning on air quality and climate is the long-term methane feedback. Here, we present simulations from the GISS ModelE2 chemistry-climate model in which we isolate the response of Earth's radiative budget and composition to lightning NO_x in the present day and future by allowing the model to re-equilibrate following removal of the source. Whereas lightning initially contributes to surface ozone enhancements, longer-term feedbacks via methane reduce surface ozone on multi-decadal time scales in the northern midlatitudes. These methane feedbacks lead to a strong negative radiative forcing (-0.6 W m^{-2}), reflecting the higher chemical efficiencies and efficacy of longwave absorption in the free troposphere. In addition to influencing tropospheric composition, we find significant changes in stratospheric dynamics and composition driven by changes in the tropical tropopause height. We test the sensitivity of our results to multiple parameterizations for global lightning activity, which remains a key uncertainty for future forecasts.