5.050 An uncertain future for lightning and the consequences for atmospheric composition and radiative forcing.

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Abstract:

Most studies to date suggest that lighting NO_x emissions (LNO_x) will increase under climate change. Our new analysis of the ACCMIP multi-model ensemble highlights the importance of this NO_x source, which leads to about 6.5 times more ozone production than surface NO_x sources. Furthermore, we find that most ACCMIP models use a lightning parametrisation based on cloud-top height, and produce a linear increase in LNO_x of 0.44±0.05 TgN K^{-1} with respect to changes in global mean surface temperature. However, ACCMIP models using alternative lighting parametrisations suggest that increasing temperatures may yield much smaller changes or even reductions in LNO_x. This suggests that the LNO_x response to climate change is highly dependent on lightning parametrisation.

We have recently developed and evaluated a new, more physically-based lightning parametrisation using upward ice flux, which is closely linked to thunderstorm charging theory. To quantify the response of LNO_x to future climate we have performed simulations with the UKCA climate-chemistry model using both the traditional cloud-top height and our new ice flux approach. The two parametrisations simulate opposing global responses of lightning to climate change. We predict an increase in annual lightning NO_x emission of 0.44 TgN K^{-1} with the cloud-top height approach, similar to ACCMIP, but a decrease of 0.15 TgN K^{-1} with the upward ice flux approach.

The contrasting climate responses of lightning simulated with the two schemes results in substantially different effects on tropospheric ozone, OH and methane lifetime. These contrasting lightning responses lead to large differences in radiative forcing from ozone and methane, although the difference in net radiative forcing is relatively small. The dependence of the simulated climate response to the lightning parametrisation used in models constitutes a key uncertainty in projecting future tropospheric composition and its climate impacts, and this should be addressed in future chemistry-climate model studies.