Lightning and Climate

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Slide 2: Global distribution of lightning from the LIS/OTD NASA satellites. Five year climatology showing lightning mainly over continental regions

Slide 3: Thunderstorms and lightning depend on the stability (or instability) of the atmosphere, determined by the adiabatic lapse rates.

Slide 4: While the atmosphere is weakly unstable over the oceans, the atmosphere is much more unstable over the continents, leading to rainfall in both locations, but little lightning over the oceans. For electrification of clouds we need strong updrafts in clouds.

Slide 5: While rainfall and lighting are positively correlated on time scales of individual storms, on climate spatial and temporal scales, rainfall is negatively correlated to lightning, with drier regions having more lightning.

Slide 6: Nevertheless, most studies looking at climate impacts on lightning show increases in lightning activity as temperature increases.

Slide 7, 8: examples

Slide 9: What about future warming, which is not uniform around the globe?

Slide 10: Not only is surface temp. important, but also changes in the lapse rate. It is possible that we can have a warming at the surface, but a larger warming aloft, stabilizing the atmosphere, resulting in less thuderstorms.

Slide 11: While climate models do imply a stabilizing of the atmosphere in the future, they also show and increase in lightning activity. Paradox?

Slide 12: An analogy may be shown looking at the El Nino phenomenon in the Pacific Ocean.

Slide 13: During the 1997/8 El Nino, severe drought conditions were experienced in Indonesian and SE Asia, but with a 57% increase in lightning activity. It was shown that there were less thunderstorms overall, but they were more intense than normal.

Slide 14: In the future models predict and intensification of the hydrological cycle, with the Mediterranean drying out, with decreases of 20% in rainfall. This may imply less thunderstorms, but more lightning?

Slide 15: Aerosols (CCN and IN) are also important in cloud microphysics and cloud electrification.

Slide 16: Depending on the amount of aerosols in the atmosphere, you can either see an invigoration of thunderstorms, or a decay of thunderstorms. Here we studied the impact of smoke in the Amazon on lightning activity in thunderstorms.

Slide 17: Too much smoke and aerosols will stabilize the atmosphere.

Slide 18: Lightning itself is important in climate due to the NOx gases produced by the lightning discharge, which is a precursor for ozone production, a strong greenhouse gas.

Slide 19, 20: Model studies showing the importance of lightning in influencing the concentrations of tropospheric ozone.

Slide 21: Lightning can also be used as a tool to study the climate variability related to important circulation patterns in the atmosphere.

Slide 22: examples

Slide 23, 24, 25: link between lightning and upper tropospheric water vapor.

Slide 26: Summany and conclusions, with feedback processes and interactions.

References:

Price, C., and D. Rind, 1994: Possible implications of global climate change on global lightning distributions and frequencies , *J. Geophys. Res*., 99, 10823-10831.

Price, C., J. Penner and M. Prather, 1997: NOx From Lightning, Part I: Global Distribution Based on Lightning Physics*, J. Geophys. Res*., 102, 5929-5941.

Price, C., 2000: Evidence for a link between global lightning activity and upper tropospheric water vapor, *Nature*, 406, 290-293.

Price, C., and M. Asfur, 2006: Can lightning observations be used as an indicator of upper-tropospheric water vapor variability? *Bull. Amer. Meteor. Soc*., 87, 291–298.

Price, C., 2009: Will a drier climate result in more lightning ? *Atmos. Res*., 91, 479-484.

Price, C., 2009: Thunderstorms, Lightning and Climate Change, in *Lightning : Principles, Instruments and Applications*, ed. H.D. Betz, U. Schumann and P. Laroche, Springer Publications, 521-536.

Williams, E.R., 2005: Lightning and climate: A review, *Atmos. Res*., 76, 272-287.