Climate impact of anthropogenic aerosols on large-scale cirrus clouds

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Cirrus clouds have a net warming effect on the atmosphere and cover about 30% of the Earth's area. Aerosol particles initiate ice formation in the upper troposphere through modes of action that include homogeneous freezing of solution droplets, heterogeneous nucleation on solid particles immersed in a solution, and deposition nucleation of vapor onto solid particles. I will first review our past model studies on the formation of cirrus particles in our model including the representation of updrafts as well as which particles may act as ice nuclei. We use a representation of updrafts based on observations of gravity waves, and we follow ice formation/evaporation during both updrafts and downdrafts using a simplified parcel model. We develop a hybrid method for the treatment of the freezing of sulfate particles, since the number of sulfate particles that freeze in our simplified parcel model is unreliable. I will examine the possible change in ice number concentration from anthropogenic sulfate, anthropogenic soot originating from surface sources of fossil fuel and biomass burning, and soot from aircraft particles that have previously formed ice in contrails. Results show that important negative forcings can result. I also discuss new results showing an increase in ice particle number in the NH as a result of the 2020 impact of reduced aircraft travel. Estimates of forcing are highly uncertain depending on the treatment of natural heterogenous IN, and whether our assumed fraction of aircraft soot emissions that act as heterogeneous IN is too large.