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Global-scale Aircraft Observations and Simulations of Cirrus Clouds and Aerosol Indirect Effects

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Cirrus clouds have widespread coverage over Earth's surface area. Cirrus cloud radiative forcings are directly affected by the microphysical properties of cirrus clouds, including ice water content (IWC), ice crystal number concentration (Nice), and mean diameter (Dice). In this work, in-situ observations obtained from seven flight campaigns funded by the U.S. National Science Foundation are used to examine key factors controlling the formation and evolution of cirrus clouds. These key factors include thermodynamic conditions (i.e., temperature and relative humidity), dynamic conditions (i.e., vertical velocity), and aerosol indirect effects from larger and smaller aerosols (> 500 nm and > 100 nm, respectively). After isolating the effects from thermodynamic and dynamic conditions, we found that when aerosol number concentrations (Na_{500} and Na_{100}) increase, IWC, Nice and Dice all increase. In particular, IWC and Nice increase significantly when Na is about 3 – 10 times larger than the average Na conditions (Patnaude and Diao, GRL, 2020).

Simulations of cirrus clouds by a global climate model – the U.S. National Center for Atmospheric Research (NCAR) Community Atmosphere Model version 6 (CAM6) are evaluated against in-situ observations (Patnaude, Diao, Liu and Chu, ACP, accepted). Observations show higher Nice in the northern hemisphere (NH) midlatitude than southern hemisphere (SH) midlatitude. CAM6 simulations show “too many” and “too small” ice crystals in most of the regions except NH midlatitude, where simulations show lower Nice than the observations. Weaker aerosol indirect effects on cirrus clouds are also seen in the simulations compared with observations.