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Quantifying dust impacts on ice generation in supercooled stratiform clouds from CALIPSO and CloudSat measurements

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Dust is one of the major components of atmospheric aerosol. Dust particles can be elevated into atmosphere by strong wind and transported around the globe, and thus have a great impact on the global climate. Although dust particles are widely regarded as effective ice nuclei (IN), there still are large uncertainties on the effectiveness of dust particles as IN at relatively warm temperatures as highlighted by recent laboratory experiments and field observations. The impacts of dust particles on the ice generation in supercooled stratiform clouds in the global scale were investigated by using four years collocated CALIPSO and CloudSat measurements. The results showed that the dusty mid-level stratiform clouds not only have higher mixed-phase fraction but also have larger layer maximum radar reflectivity than that of non-dusty cases at a given cloud top temperature (below than -6oC) and cloud top lidar total attenuated backscattering (TAB, which is directly related to the liquid water content) in the same geographical region. By examining the dust particles properties (i.e., total backscatter attenuation, layer depolarization ratio and color ratio) around the supercooled stratiform clouds, it was found that the dust number concentration and particle shape have great impact on the effectiveness of dust acting as good IN. To quantify the dust particle impacts on the ice generation, the relationship of ice number concentration and layer maximum radar reflectivity were investigated from both in situ measurements and 3-D cloud resolving model simulations. Dust particles originated from different source regions also showed different ice nucleation abilities, which might be related to their different chemical components and aerosol aging. These global results will significantly improve our capability to better represent dust aerosol impacts on climate and weather models.