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Predominance of Homogeneous Ice nucleation during the Formation of Cirrus Clouds

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Cirrus cloud formation proceeds either by homogeneous freezing (HOM) of liquid droplets or by heterogeneous ice nucleation (HET) on ice nuclei. Liquid droplets are ubiquitous in the upper troposphere and HOM is commonly associated with high concentrations of ice crystals. On the other hand ice nuclei are very scarce in the upper troposphere and cirrus clouds produced by HET tend to have low ice crystal concentration. Recent studies have suggested that observed ice crystal concentration in cirrus is more consistent with a HET scenario than with cirrus clouds formed by HOM. Here we revised such picture and show that although heterogeneous ice nucleation has a significant influence on cirrus formation, when considered over a global basis homogeneous ice nucleation is the predominant mechanism of ice formation. Modeling experiments were carried out with NASA Global Observing System (GEOS). The ice nucleation parameterization in GEOS has been updated to account for the effect of competition between HOM and HET mechanisms, water vapor deposition onto preexisting ice crystals, and parcel history during cirrus cloud formation. When these factors are considered, the ice crystal concentration produced by HOM and HET become comparable. Moreover, over extended areas in the West coast of North and South America, as well as Central Asia HET becomes the predominant path of the ice crystal production. These regions are typically the focus of field campaigns and this may explain the predominance of heterogeneous ice nucleation observed in collected ice crystal residuals. However over the rest of the world, and particularly over most of the Southern Hemisphere, ice crystal production is dominated by HOM. This picture reconciles model results and field campaign observations.