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# On the feasibility of cirrus cloud thinning: Dependence of homo- and heterogeneous ice nucleation on latitude and season

David Mitchell (1), Anne Garnier (2,3,4), and Melody Avery (3)

(1) Desert Research Institute, Division of Atmospheric Sciences, Reno, United States (david.mitchell@dri.edu), (2) Science Systems and Applications, Inc., Hampton, Virginia, (3) NASA Langley Research Center, Hampton, Virginia, (4) Laboratoire Atmosphères, Milieux, Observations Spatiales, UPMC-UVSQ-CNRS, Paris, France

While GCM testing of cirrus cloud climate engineering (CE) reveals some advantages over stratospheric aerosol injection, cirrus CE will not work when ice is primarily formed through heterogeneous nucleation for T < -38°C. Field campaigns have shown that ice in cold cirrus is generally produced heterogeneously, but these campaigns have not addressed the cirrus at high latitudes that would determine the effectiveness of cirrus CE.

This presentation introduces a new understanding of the satellite retrieved "effective absorption optical depth ratio", or $\beta$eff, based on the 12.05 and 10.60 $\mu$m channels of the imaging infrared radiometer (IIR) aboard the CALIPSO satellite. Using $\beta$eff calculations from in situ data, it is found that $\beta$eff is tightly related to the N/IWC ratio, where N = ice particle number concentration and IWC = ice water content. This is because N is primarily determined by the smallest ice particles, and $\beta$eff is primarily due to differences in wave resonance (i.e. photon tunneling) absorption, a process that is only significant when ice particle maximum dimension $D < \sim 60$ $\mu$m (i.e. when wavelength and effective particle size are comparable). Thus $\beta$eff is a measure of the concentration of small ($D < 60$ $\mu$m) ice crystals relative to the concentration of larger ice particles. Since homogeneous ice nucleation generally results in N > 500 liter-1, with a relatively high concentration of small ice crystals, $\beta$eff may be used to determine when homogeneous nucleation dominates in a region for T < -38°C. Satellite retrievals of $\beta$eff from anvil cirrus having N > 500 liter-1 (based on co-located/coincident in situ measurements) suggest that homogeneous nucleation dominates when $\beta$eff > $1.15 \pm 0.05$.

A global analysis of $\beta$eff was conducted for the boreal summer (July-Aug.) and winter (Jan.-Feb.) of 2007 and 2008, respectively. Using $\beta$eff to discriminate between regions of homo- and heterogeneous ice nucleation for cirrus clouds having emissivities between 0.4 and 0.7 and T < -38°C, our preliminary results suggest that homogeneous ice nucleation is very common during the winter months at high latitudes. This is consistent with GCM predicted concentrations of mineral dust at 200 hPa, which are minimal during winter at high latitudes.

Regarding cirrus CE, it was recently shown that seeding only 15% of the globe with the highest solar noon zenith angles at any given time (i.e. the high latitudes during late fall-winter-spring) produced a mean global cooling of 1.4°K, with much stronger cooling at high latitudes. Our preliminary findings suggest that homogeneous ice nucleation may dominate in winter at high latitudes, a necessary condition for this seeding strategy to be viable.