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Can cirrus seeding counteract global warming?

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The warming effect of cirrus clouds on climate led part of the research community to the idea of artificially decreasing their frequency and optical thickness by seeding them with ice nucleating particles. Cirrus seeding relies on the competition between two distinct cirrus formation pathways: homogeneous nucleation of soluble aerosols and heterogeneous nucleation with the help of solid ice nucleating particles. Seeding attempts to transform optically thicker, longer lived, homogeneously nucleated cirrus clouds to optically thinner, shorter lived, heterogeneously nucleated cirrus clouds.

Modelling studies show large uncertainties in the estimates of the effectiveness of cirrus seeding due to different descriptions of cirrus ice nucleation and their source mechanisms, cirrus cloud radiative properties, and injection strategies. This results in a large range of globally averaged change in radiative forcing due to seeding between -2 and +2 W/m^2, leading to disputes over its physical feasibility.

We used the ECHAM-HAM general circulation model to simulate cirrus seeding by effective ice nucleating particles. Our results show that the climatic effects of cirrus seeding by aerosol particles of radii smaller than 10 μm are negligible due to competing cirrus cloud effects: a decrease in mean radius and an increase in cloud cover both lead to a positive net radiative anomaly, while the decrease in ice crystal number concentration leads to a negative radiative anomaly. The simulated microphysical changes were supported by box model simulations and can be explained by the large occurrence of heterogeneously formed cirrus clouds.

In contrast, seeding with ice nucleating particles of radii larger than 10 μm produces only a minor change in the mean ice crystal radii but significantly decreases both cirrus cloud cover and upper tropospheric ice water content due to larger sedimentation velocities of the larger seeded ice crystals.