Effectiveness of Hygroscopic Cloud Seeding in Initiating Warm Rain

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Operational cloud seeding with hygroscopic flares is practiced extensively in India and elsewhere. However, it is shown here that hygroscopic seeding requires two orders of magnitude more hygroscopic agent than can be delivered by flare technology for producing raindrop embryos in concentrations for detecting by cloud physics aircraft the microphysical signature of rain initiation. An alternative method of finely milled salt powder is shown to be capable of achieving this goal. The CAIPEEX Phase 2 is designed at further testing of the findings presented here based on few case studies.

Hygroscopic seeding experiments with SF_6 gas tracer to tag the exact seeded cloud volume failed to identify a clear microphysical seeding signature from the burning of hygroscopic flares. This uncertainty with respect to hygroscopic flare-seeding experiments prompted an experimental and theoretical search for optimal hygroscopic seeding materials. This search culminated in the production of a salt-powder having 2-5 μm diameter particle sizes that are optimal according to model simulations, and can be distributed from a crop-duster aircraft. Such particles act as giant CCN (GCCN). Any potential broadening of the DSD at cloud base by the competition effect, i.e., when the seeded aerosols compete with the natural ambient aerosols for water vapor, occurs when the seeding agent has still not diluted much, and hence affects a very small cloud volume that dilutes quickly. Therefore, the main expected effect of the GCCN is probably serving as raindrop embryos. The salt-powder seeding method is more productive by two orders of magnitude than the hygroscopic flares in producing GCCN that can initiate rain in clouds with naturally-suppressed warm rain processes, due to combination of change in the particle size distribution and the greater seeding rate that is practical with the powder. Experimental seeding of salt powder in conjunction with the simultaneous release of SF_6 gas tracer produced strong seeding signatures, indicating that the methodology works as hypothesized. The efficacy of the accelerated warm rain processes in altering rainfall amounts may vary under different conditions, and requires additional research that involves both observations and simulations. This study was published recently by Rosenfeld et al. (Journal of Applied Meteorology and Climatology, 2010).