In situ measurements of aerosol and cloud microphysical properties and cloud seeding experiments over the UAE: Part 2

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Our field campaign of aircraft observations had successfully been conducted over the UAE regions in the summer of 2017. This campaign has mainly two objectives. First, in situ measurements of aerosols and clouds contribute to investigation on microphysical processes in seeded and unseeded clouds as well as elucidation of the mechanism responsible for precipitation augmentation. Secondly, the field observation data is useful to validate numerical simulations of cloud and precipitation and to improve the accuracy and reliability of numerical models.

We had deployed two aircraft whose base was Al Ain International Airport, as well as one ground-based observation site next to the aircraft hangar. One aircraft for in situ measurements was B200T operated by Diamond Air Service Inc., and the other for cloud seeding was C-90 operated by UAE National Center of Meteorology (NCM). We performed 14 research flights from Sep. 5 to Sep. 24. The B200T installed meteorological instruments, hot-wire water content probes, cloud microphysical probes for in situ measurements, aerosol size distribution instruments, sampling mesh device for electron microscopic analysis, cloud condensation nuclei (CCN) counter, and ice nucleating particle (INP) counter. The C-90 dispersed two types of seeding materials through burn-in-place flare racks: $CaCl_2$ hygroscopic (HYG) and silver iodide (AgI) flares.

The physico-chemical properties of BG aerosols as well as flare seeding particles in the atmosphere are requisite to conduct an effective and efficient cloud seeding experiment. As one of the flight patterns, seeding plumes generated from the C-90 were sampled and measured with the instrumented B200T which followed the C-90. We collected in situ data for background (BG) aerosols and seeding plume particles generated by the HYG flare, the AgI one, or simultaneously generated by the both types. In general, the flare particles of around 0.1 μm in size are dominant in both types. The whole size distributions can be fitted with two lognormal distributions. The mode size of HYG flare particles are larger than that of the AgI ones, which is consistent with the results from laboratory experiments at MRI.

The CCN activation spectrum of BG aerosols is also requisite for hygroscopic cloud seeding and for basic information on natural cloud formation. The measured cloud droplet concentrations near cloud base were typically on the order of 10^2 cm^{-3}_stp. When comparing the number concentrations of aerosols, cloud droplets, and CCN near cloud base, BG aerosols larger than about 0.1 μm are assumed to be activated into cloud droplets at a supersaturation between 0.1% and 0.5%. In each flight, the CCN spectrum below cloud base was obtained, which showed large variability from case to case. When we analyze the observed CCN spectrum with the updraft velocity and cloud droplet number concentrations near cloud base, it can be evaluated whether the cloud droplet number concentration is adequately predicted as a function of updraft velocity by the Twomey's (1959) theoretical approach.

Except for the seeding experiments, several flights provided us in situ measurements of summertime diurnal convective clouds. We sometimes encountered relatively developed clouds whose top temperature was warmer than -10 C, and some clouds had ice crystals and graupels. In order to comprehend spatial distributions of cloud and precipitation particles, the relationship among number

concentrations and mean diameter of cloud droplets or ice particles, and liquid water content. The lower number concentrations of ice particles with larger size were frequently distributed in the updraft core, whereas the higher concentrations of ice particles with smaller size were extended in its neighboring regions. Those basic data will be useful to fully understand the mechanism of ice formation over the UAE regions and to verify the numerical simulations dealing with natural cloud and precipitation.

Keywords: Aerosol-Cloud Interactions, Cloud Condensation Nuclei/Ice Nucleating Particles, Cloud Seeding, Hygroscopic Particles

