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

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Our field campaign of aircraft observations had successfully been conducted over the UAE regions, as well as ferries between UAE and Japan, in the summer of 2017. This campaign has mainly two objectives. First, in situ measurements 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 (~30 hours in total) from Sep. 5 to Sep. 24. Thirteen of the B200T flights were coordinated with the C-90 flights. As shown in Fig. 1, 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.

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 excellent data for background (BG) aerosols and seeding plume particles generated by HYG flares, AgI flares, or simultaneously generated by the both types of flares.

In order to investigate cloud seeding effects, the B200T measured the evolution of aerosols and cloud particles from cloud base to upper levels before and after the C-90's flare seeding. Based on the same strategy and method as in previous studies on Japanese field campaigns, the flight data quality check and data analysis have been processed, and results of initial cloud droplet size distributions in terms of the seeding signatures are shown from several cases. In general, it was difficult to find clear seeding signatures in any cases.

Except for the seeding experiments, several flights provided us in situ measurements of natural clouds. We sometimes encountered relatively developed clouds whose top temperature was warmer than -10 C, and most of such clouds had ice crystals and graupels. Those basic data will be useful to fully understand the mechanism of ice formation over the UAE regions and to verify the numerical simulations of cloud and precipitation.

In order to conduct an effective and efficient cloud seeding experiment, it is essential to know the physico-chemical properties of BG aerosols in the atmosphere and to observe their spatial and temporal distributions before the experiment. The vertical profiles of aerosol number concentrations (corrected for STP conditions) showed rather constant below cloud base height. The IN and CCN abilities of BG aerosols

are also essential information to accurately simulate cloud formation and precipitation development. The analysis of number concentrations of INP and CCN is shown from a few cases. The INP concentrations were typically ranged on the order of 1 to 10 L^{-1} and there were no significant height dependency. The CCN concentrations were typically several hundreds cm^{-3}_stp and generally depended on the space and time.

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

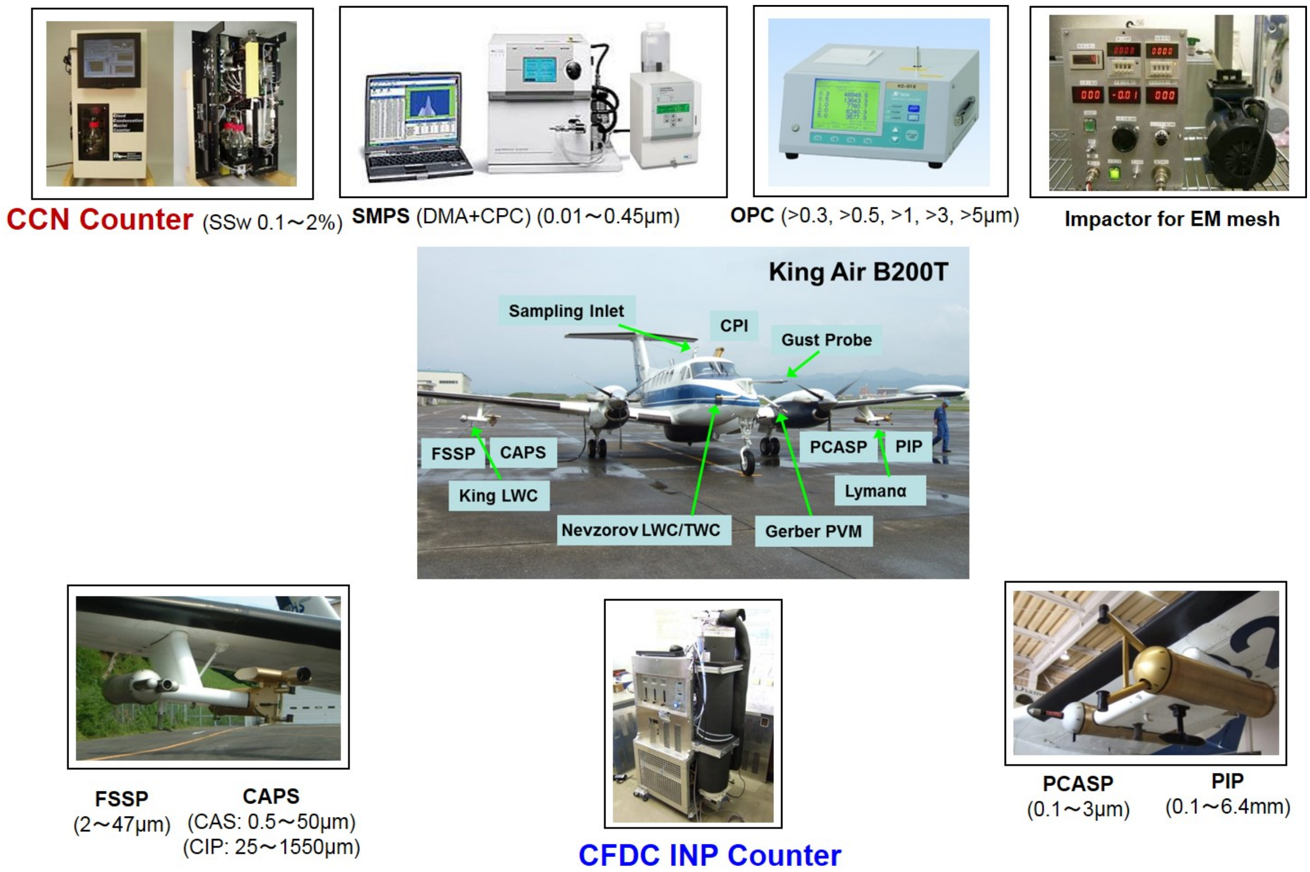

Fig. 1 Aircraft instrumentation.