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Long-term observation of initial droplet growth of activated CCN at Noto peninsula, Japan

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Atmospheric aerosols affect the climate indirectly by changing optical property and lifetime of clouds through their ability to act as cloud condensation nuclei (CCN). Size of cloud droplets is an important factor to consider in the climate predictions because it can influence cloud albedo and frequency of precipitation. Important factors controlling the growth of cloud droplets are; 1. water vapor supersaturation (SS), 2. CCN size and 3. CCN chemical composition. Chemical composition of aerosols is a very important factor controlling the initial droplets growth. Recent studies indicate that there is high mass fraction of organics in the CCN relevant particles, and the droplet growth kinetics following the activation of such organic containing CCN is not fully understood.

East Asia is regarded as one of the most aerosol (hence CCN) dense regions in the world, but long-term monitoring of CCN properties in this region is relatively scarce. In this study, we conducted in-site and year-round measurement of CCN activity of submicron aerosols and related cloud droplet growth kinetics at NOTOGRO (acronym for NOTO Ground-based Research Observatory) located Suzu city, Noto Peninsula. A CCN counter (CCNC, CCN-100, DMT) was operated at four different super-saturation conditions (SS=0.1%, 0.2%, 0.5%, 0.8%). The diameters of cloud droplets activated from ambient aerosols ($D_{ambient}$) were compared to those activated from ammonium sulfate (D_{AS}) which is regarded as representative inorganic CCN. In order to identify factors that can potentially influence the initial cloud droplet growth, simultaneously measured chemical composition of aerosols with an Aerosol Chemical Speciation Monitor (ACSM, Aerodyne Inc.).

The measurement result showed that $D_{ambient}$ was not significantly difference from D_{AS} under higher SS conditions (i.e. SS=0.5% and 0.8%) throughout all seasons. However, there are periods that droplet growth was inhibited under lower SS conditions (i.e. SS=0.1% and 0.2%) especially during spring and autumn. Therefore, it was suggested that droplet growth under lower SS condition was more sensitive to other factors (other than SS). Based on the ACSM results, chemical composition of CCN was mainly contributed by various organics, ammonium and sulfate during the entire measurement period. The periods with limited droplet growth coincided with the periods with high organic mass fraction, and the negative correlation was found between the cloud droplets' diameters and organic mass fraction within atmospheric aerosols in CCN relevant sizes. On the other hand, we did not observe significant fluctuation in the cloud droplet diameters in winter. The measurement site is under the strong influence of winter monsoon especially during winter and the chemical species comprising CCN that are carried to the site may be considerably different from other seasons.

Keywords: cloud condensation nuclei, cloud droplet, chemical composition