Chemical composition and droplet size distribution of cloud and new particle formation at Mount Tai, China

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Chemical composition of 39 cloud samples and droplet size distribution in 24 cloud events were investigated at the summit of Mt. Tai (1530 m ASL) from July to October 2014. Inorganic ions, organic acids, metals, HCHO, H_2O_2, sulfur(IV), organic carbon, element carbon as well as pH and electrical conductivity were analyzed. The microphysical properties showed that cloud droplets were smaller than 26.0 μm and the most were in the range of 6.0–9.0 μm. The maximum droplet number concentration (N_d) was associated with droplet sizes of 7.0 μm. Cloud droplets exhibited a strong interaction with atmospheric aerosols. High $PM_{2.5}$ level resulted in higher concentrations of water soluble ions and smaller sizes with more numbers of cloud droplets, and further gave rise to relatively high acidity. High degrees of relative humidity facilitated the formation of large cloud droplets and led to high liquid water contents under low $PM_{2.5}$ level. Measurements of particle size distributions, gas species, meteorological conditions and $PM_{2.5}$ were performed at Mt. Tai from 25 July to 24 October 2014 (I), 21 September to 9 December 2014 (II) and 16 June to 7 August 2015 (III). The results showed that: i) 66 NPF events were observed during 164 days, corresponding to an occurrence frequency of 40 %. Formation rates, growth rates and condensation sinks were in the range of 1.10-57.43 cm^{-3} s^{-1}, 0.58-7.76 nm h^{-1} and 0.40×10^{-2}-6.32×10^{-2} s^{-1}, respectively, and Mt. Tai appeared to show the larger formation rate and smaller growth rate relative to other locations in China. The mean value of sulfur dioxide on NPF days was 46 % higher than that on non-NPF days, and a higher sulfur dioxide concentration could improve the possibility of rich precursors for NPF. ii) Sulfuric acid condensation contributed to 16.20 % of growth rate, and sulfuric acid proxy showed an obvious correlation with total particle concentration of 3-6 nm ($N_{3\text{-}6\ nm}$). iii) Low $PM_{2.5}$ was favourable for nucleation, and NPF days with limited higher $PM_{2.5}$ seemed to have larger growth rates which might be related to particles recombination in close sizes. iv) Particles formed via NPF on both clean and polluted days mainly contributed to Aiken mode eventually, and $PM_{2.5}$ variation was always in accordance with particle total volume concentration.

Keywords: Chemical compositions, Cloud droplet size distribution, Cloud scavenging, Mount Tai