Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AAS021-14 Room:102 Time:May 23 12:00-12:15

Impact of new particle formation on the concentrations of aerosol number and cloud condensation nuclei around Beijing

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New particle formation (NPF) is one of the most important processes to determine the concentrations of aerosol number (condensation nucleus, CN) and cloud condensation nuclei (CCN) in the atmosphere. In this study, we developed NPF-explicit WRF-chem model with 20 aerosol size bins from 1 nm to 10 um and with activation-type nucleation parameterization, which was recently suggested. This model was applied to Beijing region for the periods during the CARE-Beijing 2006 campaign conducted in August and September 2006.

Model calculations reproduced the timing of NPF (21 days out of 26 days measurement available) and the rapid growth of nucleated particles (NP) up to several-tens nanometers reasonably. NPF was mostly observed and calculated in ”sweeping” periods when 0-3 days after the cold front passages with the inflow of clean air from the north, while there were few NPF events in ”stagnant” periods when Beijing region was influenced from high-pressure system with the accumulation of trace gases and aerosols. The difference of NPF frequency between sweeping and stagnant periods could be explained by the balance of growth rate and condensation and coagulation sink of NP. This result suggests that once the reasonable nucleation rates of cluster formation at 1 nm were given, model calculations can represent the timing of NPF (contrast of ”NPF” and ”no-NPF” days) and further growth up to several-tens nanometers through the theoretical calculations of condensation and coagulation processes.

The contribution of NPF to the CN concentrations larger than 10 nm (CN10) was estimated to be 20% in Beijing in period average. This contribution became maximum in the noontime (12-16 LT): 73% in NPF days and 17% in no-NPF days, respectively. The impact of NPF on CCN concentrations was dependent on supersaturations (S): CCN concentrations were increased (by 100-200% in maximum) at higher supersaturations ($S > 0.2\%$) but decreased (by 50% in maximum) at lower supersaturations ($S < 0.1\%$) by NPF. This is likely because NPF suppresses the increases in size and hygroscopicity of pre-existing particles through the competition of condensable gases between smaller secondary particles and larger pre-existing particles.

Sensitivity calculations were also conducted with the reduction of primary aerosol emissions (black carbon and primary organic aerosol). We will show the sensitivity of CN and CCN concentrations to primary aerosol emissions in the presentation.

Keywords: New particle formation, Aerosol number concentration, Cloud condensation nuclei, Regional three-dimensional model, Mega city