Japan Geoscience Union Meeting 2012
(May 20-25 2012 at Makuhari, Chiba, Japan)

MIS26-07 Room:203 Time:May 23 15:45-16:00

Simulation study on bi-stability of cloud-rain system and cosmic ray influence on climate

KUSANO, Kanya[1*], Shin-ichiro Shima[2], Koichi Hasegawa[3]

[1]Solar-Terrestrial Environment Laboratory, Nagoya University, [2]Graduate School of Simulation Studies, the University of Hyogo, [3]ChudenCTI Co.,Ltd.

Although it has been pointed out many times that there is the correlation between solar activity, such as the Schwabe (11 year) cycle and the Maunder-type minima, and climate variability, the mechanism whereby the sun may affect climate is not yet well understood. Svensmark & Friis-Christensen (1997) proposed that galactic cosmic ray may control cloud through the ionization of atmosphere and the ion-induced nucleation. Recently, Kirkby et al. (2011) indicated in basis of experiments with artificial cosmic ray that the ion-induced nucleation is possible in the atmosphere if some conditions for chemical compounds and temperature are satisfied. However, although the experimental data show that the ion-induced nucleation rate for 1.7 nm diameter cluster J_1.7=10^-2 to 10^1cm^-3s^-1, it is not yet clear how this rate affects cloud and climate.

In this study, aiming at clarifying how the cloud-rain system depends on the change in the formation rate of cloud condensation nuclear, we have performed a systematic simulation study using super-droplet cloud model. The super-droplet cloud model is a novel computational technique to calculate the macro- and micro-physics of clouds (Shima, Kusano et al. 2009). We have implemented the super-droplet method on the cloud resolving model CReSS (Tsuboki & Sakakibara 2006), and developed an add-on function to create aerosols dynamically. Using it, we have surveyed the quasi-equilibrium state of cloud-rain system for different formation rate of 30 nm diameter aerosol J_30. The initial and boundary conditions are given by the data-set of RICO (Rain In Cumulus over the Ocean) project.

As the results of simulations for J_30 from 10^-6 to 10^0 cm^-3s^-1, we find that the cloud water path remains about 5 gm^-2 when J_30 is smaller than 10^-3cm^-3s^-1, but it quickly increases to 20 gm^-2 for J_30=10^-2cm^-3s^-1 and it keeps the value for higher J_30. On the other hand, the rain water path is about 6 gm^-2 for J_30 smaller than 10^-3cm^-3s^-1, but it drastically decreases to smaller than 1 gm^-2 for J_30 larger than 10^-3cm^-3s^-1. These results suggest that the cloud-rain system has the two different equilibrium states which are controlled by the formation rate of aerosols. Although the quantitative relation between the cosmic ray induced nucleation and the bifurcation of cloud-rain system is still unclear, our results implies how susceptible is the cloud-rain system on the nucleation rate.

Keywords: cloud, aerosol, space climate, cosmic ray, super-droplet, simulation