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Simulation of correlation between aerosols and clouds in pristine airs over oceans using a global aerosol transport model

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It is important for estimating aerosol radiative forcing to understand not only an aerosol level in the present but also one in the pre-industrial era, that means, we have to understand impacts both of anthropogenic aerosol and of natural aerosol to radiation budget and climate, simultaneously. In this study, we have concentrated on aerosol-cloud interactions in pristine air conditions, where we assume to estimate relationships of natural aerosols to clouds.

In such clean airs over oceans, major aerosols are comprised of sea-salt particles and sulfate particles formed from dimethyl sulfade (DMS) [e.g., Andreae et al., 1999]. These aerosols can act as cloud condensation nuclei (CCN) and they can strongly affect to cloud optical properties such as cloud optical thickness (COD) and cloud droplet effective radius (Re). At Cape Grim [144E, 44S] where it is relatively clean, for example, Boers et al. [1994] showed a clear seasonal correlation between COD and CCN. In this case, seasonal variations of both COD and CCN are strongly related to those of DMS concentrations [Andreae et al., 1999].

In this study, we use a global three-dimensional aerosol transport-radiation model, SPRINTARS, coupled with CCSR/NIES/FRCGC-MIROC AGCM [Takemura et al., 2005]. The model can treat aerosols including sea-salt particles and sulfate formed from DMS. The aerosol-cloud droplet relationship is parameterized with aerosol number concentrations, aerosol size distributions, aerosol chemical properties, and updraft velocity [Ghan et al., 1997; Abdul-Razzak and Ghan, 1998, 2000, 2002].

Simulated correlations between CCN and COD and those between CCN and Re can be comparable to observed ones in the pristine airs over oceans. From sensitive experiments of sea-salt and of DMS, in order to get the observed correlations, it is important to properly simulate not only seasonal variations of DMS emission and DMS and sulfate concentrations, but also CCN from sea-salt, sea-salt size distribution and sea-salt number concentrations. This means that in the conditions where larger-size sea-salt exist, such sea-salt can activate into CCN more easily, then super-saturation in the system decreases and sulfate from DMS tend to less activate into CCN.