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# Observations and simulations of cloud ice and aerosol

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Cloud ice composing cirrus clouds and aerosol have large impacts on climate and weather by an interaction with radiation. They are one of the large uncertainties for the projections of the climate change. Upper layer cirrus clouds surrounding a typhoon strongly control the upper layer temperature around the typhoon. Consequently, their characteristics are related to typhoon intensity. So far, we have been using hydrometeor videozondes (HYVISs) to observe cloud particles in the upper troposphere. The HYVISs can observe cloud particles ranging from 10 micrometer to 1 mm. It shows size, shape and number concentration of cloud particles with high vertical resolution. We conducted field observations using HYVISs for various types of clouds associated with heavy rainfall systems and typhoons in Okinawa, Japan and Palau in the tropics. The observation results show characteristics of cloud particles and are used to improve the cloud processes in a cloud-resolving model.

To perform simulations and numerical experiments of high-impact weather systems such as heavy rainfall systems and typhoons, and convective/stratiform clouds, we have been developing a cloud-resolving numerical model named the Cloud Resolving Storm Simulator (CReSS) since 1998. The cloud processes are important part of the CReSS model. Typhoons bring about strong wind and heavy rainfall occasionally and cause severe disasters in East Asia. The recent studies projected future increase of typhoon intensity with the climate change (Tsuboki et al. 2015). Accurate predictions of typhoon intensity and the associated rainfall are important for disaster prevention. A recent statistics of the typhoon prediction accuracy showed that typhoon track prediction has been significantly improved, while intensity prediction has not for the last 20 years. Since the inner core of typhoon is composed of intense convective clouds, cloud-resolving simulation at a high-resolution (less than 2 km in a horizontal direction) is essentially required for accurate prediction of typhoon intensity. We apply CReSS for simulations of observed typhoons and for projection experiments of future change of typhoons associated with the climate change.

The CReSS model was designed for a large parallel computer and performed simulation experiments at the Earth Simulator and the Kei Computer. It is a non-hydrostatic and compressible equation model using terrain-following coordinates. Prognostic variables are 3-dimensional velocity components, perturbations of pressure and potential temperature, water vapor mixing ratio, sub-grid scale turbulent kinetic energy (TKE), and cloud physical variables. Cloud physical processes are formulated by a bulk method of cold rain. The bulk parameterization of cold rain includes mixing ratio of water vapor, rain, cloud, ice, snow, and graupel and number concentrations of solid hydrometeors. Parallel processing is performed using the Massage Passing Interface (MPI). The OpenMP is also available for intra-node communications. More detailed explanations are found in Tsuboki and Sakakiara (2002) and Tsuboki (2008). To investigate the interaction of aerosol and cloud particles, it is necessary to install more detailed nucleation processes for liquid cloud and ice crystals. These are future subjects in this field.

キーワード: cloud ice, aerosol, cloud resolving model, typhoon, hydrometeor videosondes (HYVISs)
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