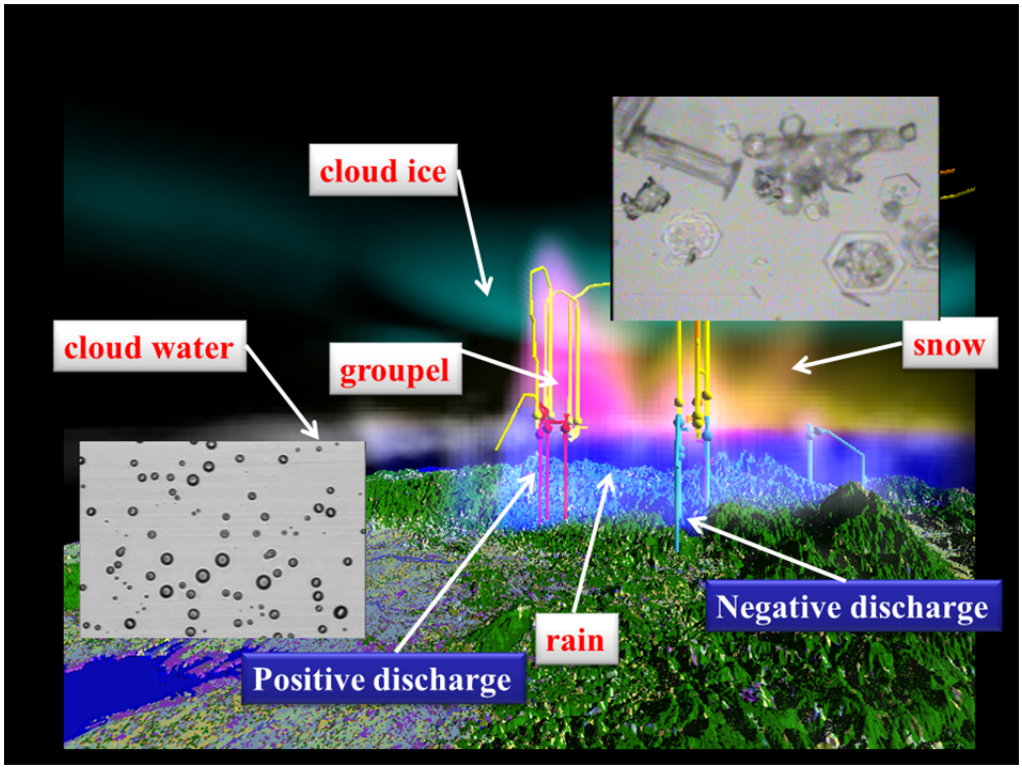
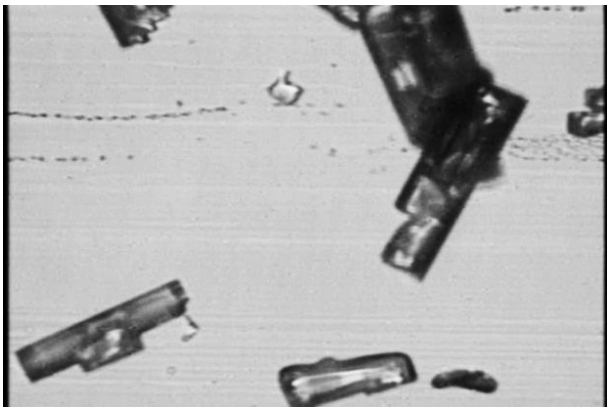
Project for Aerosol and Cloud Formation

Hydrometeors and aerosols closely interact with each other in their generation and dissipation, and play important roles in atmospheric water circulation, formation of convective clouds and typhoons, as well as in the Earth radiation budget. However, they are some of the most unknown quantities in the atmosphere. Thus far, hydrometeors and cloud-precipitation systems have been studied in the Hydrospheric Atmospheric Research Center, whereas aerosols and related processes have been studied in the Solar-Terrestrial Environmental Laboratory. In the joint research program, researchers from both centers will cooperate to study the interaction between aerosols and hydrometeors, their variations in the formation of precipitation, and cloud-aerosol-radiation interactions by field observations and numerical simulations. On the basis of field observations, the numerical model will be improved for quantitative simulation of cloud and aerosol processes. In cooperation with the Center for Orbital and Suborbital Observations, we will conduct in situ observations of typhoons using an aircraft, balloons, and drones. This research will improve CReSS and study the impact of aerosols on typhoon clouds.



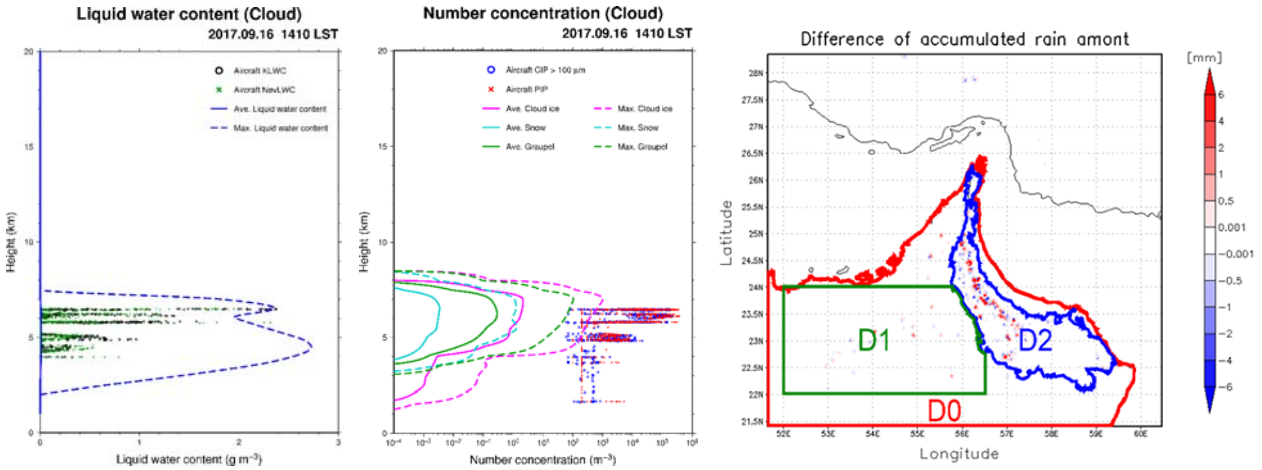


Upper: A mesoscale convective system and hydrometeors simulated by the CReSS model.
Lower: The superimposed images show hydrometeors expected to be present in the convective system. Balloon observation of typhoon clouds. Launching balloon (left) and observed hydrometeors (right).

Main Activities in FY2018

Cloud and aerosol observation in UAE and aerosol modeling

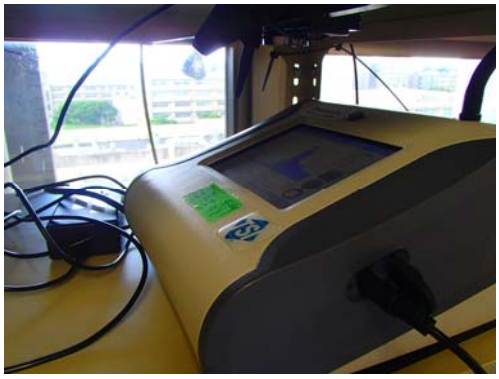
Physico-chemical properties of atmospheric aerosols and microphysical structures of diurnal convective clouds, which had been observed over the United Arab Emirates (UAE) using an instrumented aircraft in September 2017, were simulated by the CReSS model implemented with a new cloud microphysics scheme and a simplified cloud condensation nuclei (CCN)/ice nucleating particle (INP) scheme and the influence of CCN/INP abundance was also investigated. The CReSS well-simulated the diurnal convective clouds, except for high concentrations of ice crystals, which activated the mineral dust particles present at high concentrations in the boundary layer. Doubling the CCN number concentrations suppressed the conversion from cloud water to rainwater, and more cloud water was transported to upper subfreezing levels and froze there. The latent heat release invigorated the diurnal convective clouds, especially cumulus congestus clouds. We are planning to evaluate more accurately the impact of mineral dust particles acting as INP using an aerosol, cloud, and precipitation-integrated model currently being tested and improved.



Comparison of cloud water content (left) and snow particle number concentration (middle) obtained from aircraft observation (dotted line) and numerical simulation (dashed line). Increase and decrease of surface precipitation when CCN concentration is doubled from default value of 500 cm^{-3} (right).

Observation of aerosol particles during passage of typhoon through Okinawa

As part of the KAKENHI research project (PI: K. Tsuboki), we measured the size distribution of aerosol particles from August to October 2018, and PM2.5 mass concentrations continuously from August 2018, using an optical particle analyzer and a low-cost sensor, respectively (Fig.) at the Univ. of the Ryukyus in Okinawa. Two typhoons Trami and Kong-Rey passed 40 and 100 km west of the Okinawa Island on September 29 and October 4, respectively. The mass concentration of coarse-mode particles increased in proportion to the wind speed and the mass-based mode diameter was found to decrease as Trami approached. Chemical analyses of the aerosol particles collected on quartz filters before, during, and after the passage of these typhoons found that the mass and fraction of sea salt in the aerosols increased significantly during the passage of these typhoons.



Optical particle analyzer used during the observation at University of the Ryukyus.