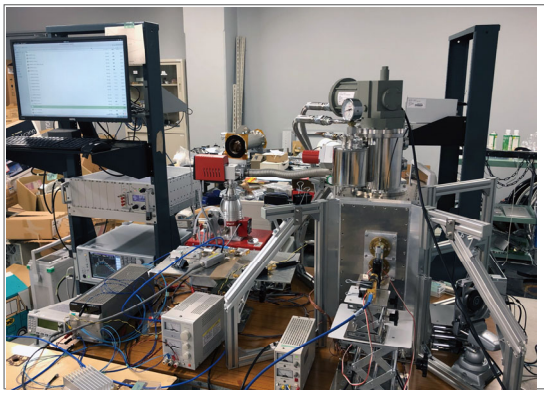
Division for Meteorological and Atmospheric Research



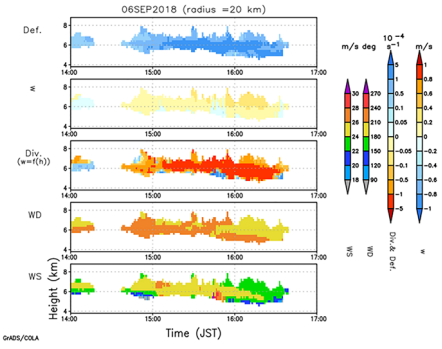
- Precipitation measurements by advanced polarimetric radars and hydrometeor videosondes
- Development of new instrumental technology
- Clouds and precipitation observed by multiple satellites
- Millimeter-wave/infrared spectroscopy of green house gases and ozone-depleting substances
- Measurements and analyses of properties and behaviors of aerosols using advanced techniques

Ongoing global warming caused by increasing concentrations of carbon dioxide and other greenhouse gases will result in both gradual climate change and intensification of weather extremes and ecological catastrophes. Among the most urgent tasks for confronting global environmental problems more effectively is a close monitoring of the atmosphere using different observation methods and a better understanding of the atmosphere through theoretical insights and numerical modeling. To address these problems, the Division for Meteorological and Atmospheric Research is dedicated to several research projects for exploring the atmosphere from various angles.

Main Activities in FY2019

New understanding of precipitation through MP-PAWR observations

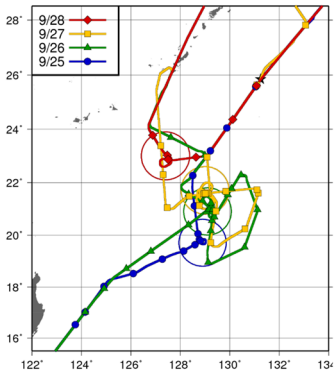
The multi-parameter phased array weather radar (MP-PAWR), with its state-of-the-art technology, can provide three-dimensional observation data within 30 s. Since the MP-PAWR can accurately capture rapidly changing convective precipitation systems, it is possible to analyze the formation mechanisms of convective storms. MP-PAWR can even be used to analyze the dynamic structure of stratiform precipitation systems, using data from various elevations.



Time series of a dynamic field of stratiform precipitation that did not produce surface precipitation.

Estimation of typhoon central pressure from dropsonde observations

Typhoon central pressure is operationally estimated from satellite observations. Consequently, its uncertainty is large for intense typhoons. The Tropical Cyclone-Pacific Asian Research Campaign for Improvement of Intensity Estimations/Forecasts performed aircraft observations of the intense typhoon Trami with the SATREPS Understanding Lightning and Thunderstorm project in 2018. During the period from September 25 to 28, 64 dropsondes were launched in and around the inner core region of the typhoon. The observed data were transmitted to the Japan Meteorological Agency in real time. There is a problem that the error of GPS height increases near the surface. We developed a new

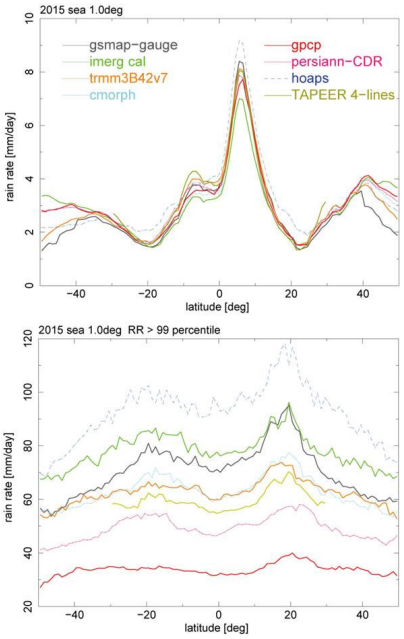


Aircraft flight passes and dropsonde launching points during the period from September 25 to 28.

method to estimate sea level pressure, with a correction for dropsonde height data. Penetration observation through the eye of Trami was achieved six times. Using the dropsonde penetration data, accurate estimations of sea level pressure were obtained. The central sea level pressure estimates were 919.6, 950.0, 956.0, and 960.0 hPa on 25, 26, 27, and 28 September, respectively. The maximum difference between the observed pressure and the Japan Meteorological Agency best track data was about 10 hPa.

Inter-product biases in global precipitation extremes

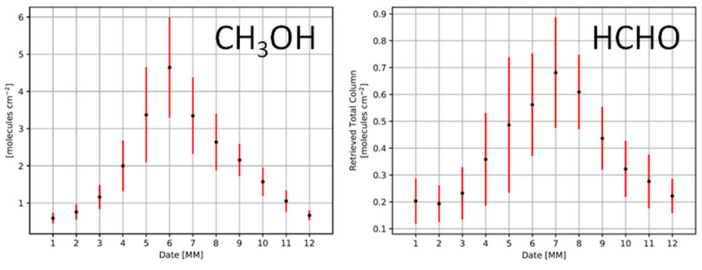
Given the importance of monitoring extreme precipitation for disaster prevention, we studied the reliability of global precipitation data products. Biases in climatological and extreme-precipitation estimates were assessed for 11 global observational datasets constructed from merged satellite measurements and/or rain gauge networks. Extreme precipitation was defined by a 99th percentile threshold (R99p) in a daily 1° × 1° grid, for 50 °S–50 °N. The spatial pattern of extreme precipitation lacks distinct features, such as the ITCZ that is evident in the global climatological map, and the climatology and extremes share little in terms of the spatial characteristics of inter-product biases. The time series, when analyzed from 2001 to 2013, showed relatively consistent decadal stability in the climatology over the ocean, while the dispersion was larger for the extremes over the ocean. This contrast is not observed over land. Overall, the results suggest that the inter-product biases apparent in the climatology are a poor predictor of the extreme-precipitation biases, even in a qualitative sense.



Inter-product comparison of zonal mean precipitation (2015 annual mean) over the ocean for climatology (top) and extremes (bottom).

Monitoring of greenhouse gases and atmospheric minor constituents using a high-resolution infrared spectrometer

In collaboration with the National Institute for Environmental Studies (NIES), solar absorption spectra have been continuously measured using a ground-based high-resolution Fourier transform infrared spectroscopy instrument operated at Rikubetsu, and the total column amounts and vertical profiles of 14 molecular species, including O_3, CH_4, and CO, are retrieved from the spectrum. This year, in addition to HCHO (which was analyzed last year) we started to analyze CH_3OH, which is produced through the oxidation of biogenic volatile organic compounds. The observed column amount of CH_3OH reached its maximum in June, although that of HCHO was in July. The difference between the two maximum periods is mainly owing to the difference in the loss rate of oxidation by OH.

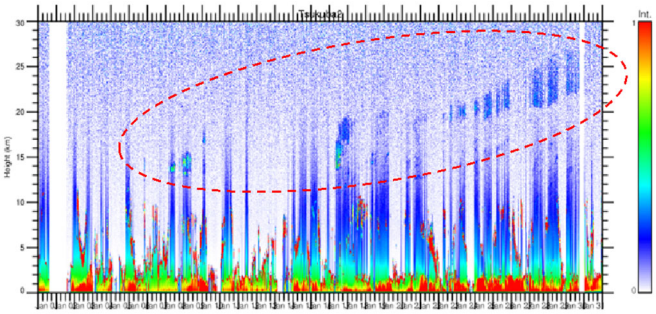


Seasonal variations of the total column amount of CH_3OH (left) and HCHO and (right) observed with FTIR at Rikubetsu.

Aerosol and UV/ozone observations in Patagonia, South America

ISEE and the NIES have been operating an observation network, named SAVER-Net, monitoring aerosol and UV/ozone in Argentina and Chile with the support of KAKENHI and ISEE International Joint Research. Some lidar

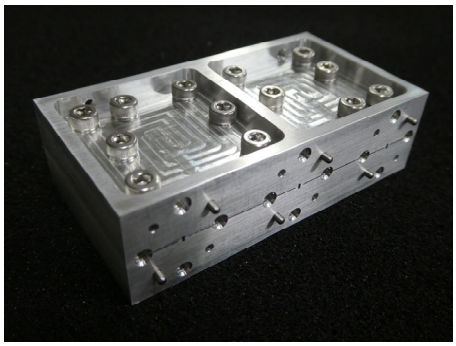
observations were suspended owing to age-related instrument changes and damage to a laser in 2018, but the optical system was changed to improve its stability in this fiscal year. At the end of the year, five of the nine lidars—Aeroparque, Cordoba, Neuquen, Comodoro, and Punta Arenas—were operating well. We will restart operation of the remaining four lidars next year. The millimeter-wave spectrometer for ozone measurement was almost suspended during the year because of serious damage to the water chiller of the cryogenic system for the superconducting receiver system. We must discuss essential improvements with the manufacturer to fix the problem. In terms of observational results, we detected the long-distance transport of an aerosol plume that may have originated from a large Australian forest fire in late 2019. The plume was detected in Punta Arenas and Buenos Aires and had reached stratospheric altitude.



Time series of attenuated backscattering coefficient at 532 nm in Buenos Aires in January 2020. Dashed circle indicates the aerosols thought to originate from the large forest fire in Australia.

Development of a new millimeter-wave spectrometer for multi-line observation in Syowa, Antarctica

We developed the front-end and back-end for a wide-band receiver system in the millimeter wavelength range, and a new observation project "multi-line simultaneous observation of minor atmospheric molecules" in Syowa station, Antarctica, has been started. For the front-end, the waveguide-type multiplexer was developed through collaborative research with the National Institute of Communication and Technology. We measured its performance in cryogenic temperatures using a superconducting mixer in the laboratory, and a good image rejection ratio (>25 dB) was obtained. For the back-end, a multi-channel intermediate frequency circuit using a superconducting dual-band filter, which was designed and developed in Yamanashi University, was successfully developed for the observation of the O_3, NO, NO_2, HO_2, and CO molecular lines with the 2-GHz bandwidth digital Fourie spectrometer. This observation system was transported to Syowa station with the 61st Japanese Antarctic Research Expedition. We are constructing the new millimeter-wave spectrometer to start multi-line observations in 2020.

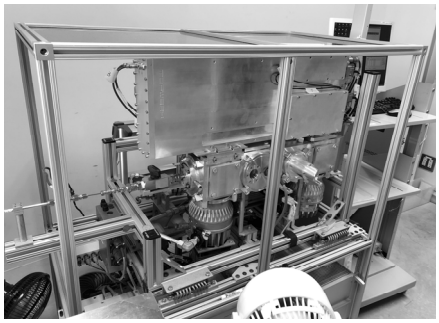


Newly developed waveguide-type multiplexer.

Analysis of the chemical structure and sources of atmospheric organic aerosol

Organic matter is one of the major components of atmospheric aerosols. Our current knowledge on the budget and properties of organic aerosols (OAs) is limited, although it is important for understanding the effects of aerosols on air quality and climate. In this study, extracts from atmospheric aerosol samples collected in an urban area were atomized, and the generated particles were transferred into an aerosol mass spectrometer to obtain their mass spectra. The spectra were analyzed by positive matrix factorization, and the factors associated with the sources and formation processes of OAs were obtained. Further, excitation-emission matrix (EEM) fluorescence spectroscopy was applied to forest aerosol samples, which are thought to be influenced by biogenic secondary organic aerosols (BSOAs). The contributions of

different fluorescent components to the EEM spectra were obtained, and are expected to be useful for the analysis of OA sources. Moreover, rainwater and aerosol samples were collected in an urban area and the samples were subjected to EEM fluorescence spectroscopy and Fourier transform infrared spectroscopy. Through further analysis of these samples, we expect to find clues to understanding the formation and aging of OA components in cloud water. Atmospheric aerosol samples were also collected from a forest site in Australia, for the analysis of the chemical structures of BSOA and biomass-burning OA, and for the analysis of their contribution to the abundance of OA.



Aerosol mass spectrometer for the analysis of aerosol sample extracts.

Analysis of the surface tension of atmospheric aerosol components from the perspective of cloud droplet formation

Surface active materials in atmospheric aerosols are thought to promote the activation of aerosol particles to form cloud droplets, by lowering the surface tension of the particles. In this study, to investigate the possible effect of water-soluble inorganic salts on surface tension via the salting-out effect, surface tension measurements were performed for aqueous solutions containing water-soluble components from atmospheric aerosol samples collected in an urban area, in the presence of different concentrations of ammonium sulfate. We obtained preliminary results showing the relationships between surface tension and the concentrations of water-soluble organic carbon and ammonium sulfate, and are planning to analyze the effects of surface tension reduction at the time of cloud droplet formation, based on the results of the surface tension measurements.

Evaluation of the method for the long-term measurements of black carbon aerosols

In the Arctic, where the surface temperature is increasing more rapidly than the global average, the forcing and feedback mechanisms associated with light-absorbing aerosols, such as black carbon (BC), need to be elucidated. Long-term surface measurements of BC at various locations are important to understand the spatial and temporal variations of BC and to validate the numerical models that estimate BC climate impacts. However, the measurement uncertainty of the filter-based instrument (COSMOS) used for the long-term observation of BC mass concentration has not been fully evaluated. In this study, we analyzed the data obtained simultaneously by the COSMOS and a single-particle soot photometer (SP2, based on a laser-induced incandescence technique) at three locations, including a remote Arctic site (Ny-Ålesund in Spitsbergen). Thus, we evaluated the uncertainty of the COSMOS measurements. On average, the BC mass concentrations measured by the COSMOS and SP2 were consistent to within 10% at all the sites and the COSMOS measurements depended little on variations of BC microphysical properties, such as size distribution and mixing state. Our results demonstrate the high reliability of COSMOS measurements under various environments.