Observation of clouds by 95GHz cloud profiling radar (CPR)

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Objectives

Clouds are known to affect primarily the energy and water cycle in the climate system. However, their interactions with aerosols, with many chemical particles in the atmosphere, and with the radiative energy transfer are still not understood. For Mirai MR01-K02 cruise, we work for studying vertical distribution and microphysics of clouds and aerosols by using cloud profiling radar (CPR) of Communications Research Laboratory (CRL) in collaboration with the lidar systems of National Institute for Environmental Studies (NIES). One of the great advantages in the active remote sensing is that these sensors provide cloud boundaries with high accuracy. The basic elements of observations are cloud boundaries, cloud microphysics such as effective radius and ice/liquid water content (IWC/LWC), fall velocity of the cloud particles, depolarization (non-sphericity), and vertical distribution of aerosols. In addition, for this cruise, we expect to study longitudinal and latitudinal distribution of clouds and aerosols over Pacific Ocean near Japan. These data sets will also contribute to the APEX project directed by Prof. Teruyuki Nakajima (University of Tokyo) in a way that comparing these data sets with the modeling and satellite data should bring a breakthrough for the cloud-aerosol interaction studies.

Measured parameters

CRL has developed an airborne W-band CPR named SPIDER operating at 95GHz. For the cruise of Mirai vessel, the CPR system was modified to be suitable for shipborne measurements (Fig. 1). The CPR was operated in the vertical pointing mode and measured backscattering intensity of cloud particles by dual polarization. The radar measurements provide radar reflectivity factor, Doppler velocity, and linear depolarization ratio (LDR) in the vertical direction. (The lidar measurements provide backscattering coefficients in the vertical direction.) The microwave radiometer with dual-frequencies (23.8GHz and 31.4GHz) was also installed. This provides water vapor amounts and liquid water paths of water clouds.

Method

The CPR and the lidar system were co-located inside the same container on the upper deck of Mirai. Thus it is possible to perform radar/lidar algorithm to retrieve vertical profiles of effective radius and ice/liquid water content of ice and thin water clouds. The combination of the CPR and the microwave radiometer is used to retrieve cloud droplet effective radius and liquid water content of thick water clouds. Since the lidar instrument has a capability to detect aerosol signals, we might expect to study cloud-aerosol interactions. These studies will bring significant progress in our understandings of a role of clouds in relation to the cloud feedback processes and climate impact of anthropogenic aerosols through the cloud-aerosol interaction processes.

Results

Figure 2 shows a time-altitude cross-section of the received power observed by the CPR on 22 May 2001. The vertical axis indicates altitude between 0 and about 12km with every 82.5m range resolution. The horizontal axis denotes time (JST). Mirai was on a voyage to the north around 33^{o}N and 146^{o}E at that time.

Data archive

The CPR operation started from 14 May 2001 and has continued almost all day to 28 May 2001 unless it was clear sky or bad weather (Fig. 3). The basic operating parameters for CPR measurements are listed in Table 1. Observation data will be available after the data reduction for level 1 products.

Fig.1: 95GHz cloud profiling radar for shipborne measurement.

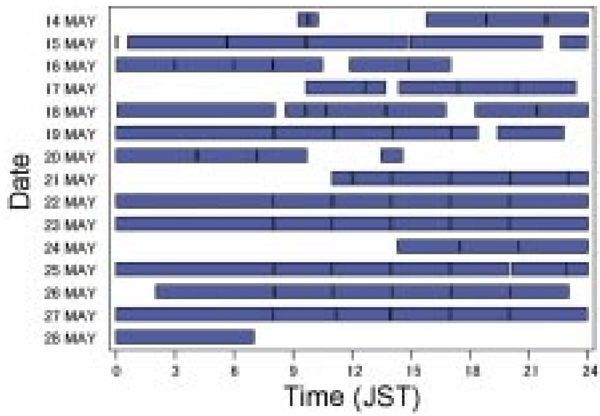

Fig. 3: Circumstance of data acquisition by CPR observations.

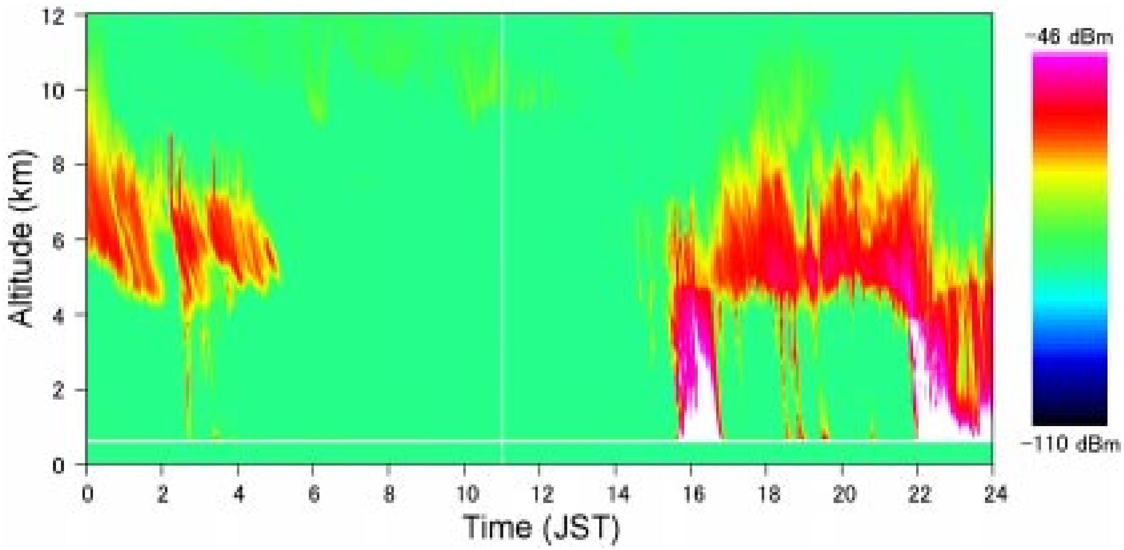

Fig. 2: The radar signals scattered from clouds for CPR observations on 22 May 2001.

Table 1. Basic operating parameters for CPR measruements

Mode	PPMAG4	PPMAG4
Pulse Width (nsec)	1100	2125
Filter (MHz)	1.0	0.5
Polarized Wave	HHVV	HHVV
Doppler	cc, cc, cc	cc, cc, cc
Pulse Spacing Time (μsec)	110, 110, 110, 7670	220, 220, 220, 4340
Number of Noise Samples	8	8
Number of Range Gates	144	73
Gate Spacing (m)	82.5	162.5
Range Gate Delay (m)	150	150
Maximum Range (m)	12030.0	12012.5
Average Number	56	108
External Average	1	1
Acquisition Time (msec)	448	540