Ground-Based Scanning Ka-Band Cloud Radar Observations for Validation of EarthCARE Cloud Profiling Radar (CPR)

vX5.2

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Introduction

The National Research Institute for Earth Science and Disaster Resilience owns five scanning Ka-band cloud radars. Using these radars, we are planning to validate the cloud profiling radar (CPR) of the EarthCARE satellite. The EarthCARE CPR only observes along the line directly under the satellite path and has a return period of about 25 days. Therefore, we will facilitate the comparison by collecting data from what we can consider to be the similar region as the EarthCARE path.

Several comparison methods are presented in this presentation and their advantages and disadvantages are summarized.

Validation plan

1. Statistical comparison

a. CFADs/CFTDs of ground-based scanning Ka-band radars

EarthCARE CPR rarely pass directly above the ground radar. Therefore, we are planning to make comparisons by creating contoured frequency by altitude/temperature diagram (**CFAD**, Yuter and Houze, 1995, Mon. Wea. Rev.; **CFTD**, Huang et al., 2015, J. Climate) using vertical observation data of radar reflectivity (Z) and Doppler velocity (Vd) from the ground-based scanning Ka-band radar. In addition, polarimetric parameters can provide information associated with particle categories (types).

b. LWP/LWC derived from Ka-band radar and microwave radiometer

We are planning to make dataset of vertically integrated cloud water amount (LWP, liquid water path) and vertical profile of cloud water amount (LWC, liquid water content) obtained by Ka-band radar and microwave radiometer observations.

2. Direct comparison using scanning capability

The NIED Ka-band radars are possible to scan within the range of 30 km. When EarthCARE CPR observes within the observation range of the ground Ka-band radar network, **synchronized observation can be conducted** although opportunities of the direct comparison are limited and only reflectivity (Z) can be directly compared.

Summary

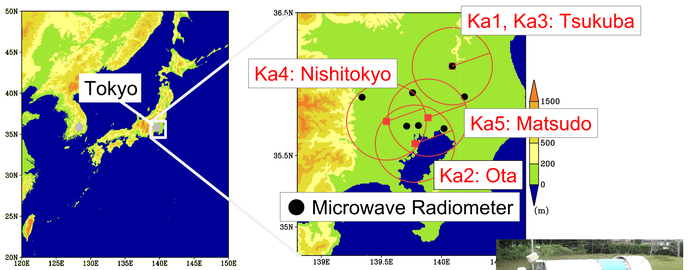
Comparison methods between EarthCARE and ground-based observations

Method	Detail	Advantages and disadvantages
statistical	climatological histogram/CFAD/CFTD	＋Can be compared even in different years. －Need enough satellite samples.
	case study histogram/CFAD/CFTD	＋Almost no time lag. －Larger errors in spatially non-uniform clouds.
direct	point-by-point	＋Almost no time and space lag. －Few chances.
	cross section of CAPPI	＋Almost no time and space lag. －Few chances. Coarse vertical resolution.

Observation instruments

Scanning Ka-band radars

Manufacturer	Mitsubishi Electric Co.
Transmitting frequency	34.8 -34.9 GHz (Ka band)
Wavelength	8.6 mm
Observation range	30 km
Resolution in the radial direction	75 m / 150 m
Beam width	0.31°
Nyquist velocity	low PRF: 3.4 m s^{-1} high PRF : 4.3 m s^{-1}
Scan	PPI and RHI scans, pointing



Microwave Radiometer

■RPG-HATPRO G4 by Radiometer Physics GmbH

■Brightness temperatures of 14 channels in the water vapor absorption band (22.24-31.4 GHz) and oxygen absorption band (51-58 GHz) are used to estimate vertical profiles of temperature and water vapor as well as liquid water path (LWP).

■Observation places

○7 sites in Kanto (around Tokyo)

Tobukan No. 3 (next to Skytree), Tsukuba (NIED), Ryugasaki (Ryugasaki Elementary School), Narashino (Chiba Institute of Technology), Shinjuku (Toyama High School), Koshigaya (Dokkyo Saitama Senior High School), Hidaka (Hidaka City Hall)

○2 sites in Kyushu (western Japan)

Amakusa, Fukue

1. Statistical comparison

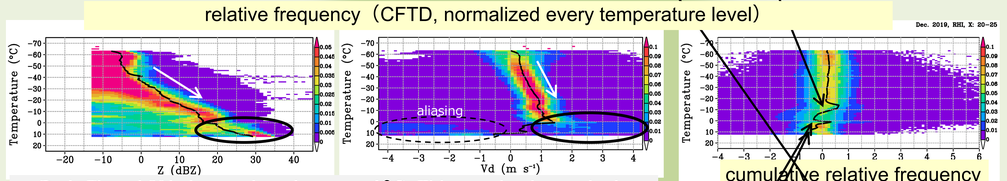
CFAD/CFTD: contoured frequency by altitude/temperature diagram

1 month CFTD (Dec. 2019)

- The peak of ZDR is present in a slightly higher temperature range than -15°C. It corresponds well with the growth temperature range of plate-like and dendritic crystals.
- The top 20% shows ZDR>1.5dB.

Zh from vertical obs. (Zh>-13dBZ) | Doppler velocity（Vd） | ZDR (Zh>-9dB)

relative frequency（CFTD, normalized every temperature level）

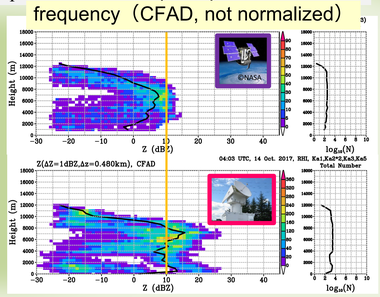


- Both Zh and Vd change abruptly across 0°C. This may be due to the large difference between liquid-phase particles and solid-phase particles.

Another thin ZDR peak is present at the melting layer.
Negative ZDR could be due to large attenuation of horizontally polarized waves. The effect of Mie scattering may also be a factor.

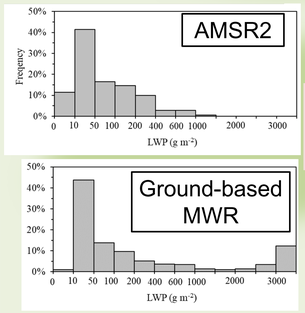
Case study (CFAD)

frequency（CFAD, not normalized）

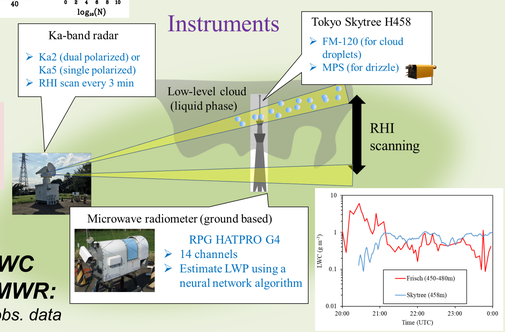


- CloudSat's and Ka-band radars' Z agree well, in the upper levels.
- At Z>～10 dBZ, differences are large. (Probably, non-Rayleigh scattering of CloudSat W-band radar).
- In the lowest levels, attenuation and/or surface clutters may cause some differences.

LWP from MWR



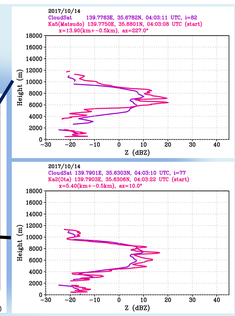
Roughly good agreement except for < 10 g m^{-2} and > 1000 g m^{-2}.



Derivation of LWC using radar and MWR:
Comparison with in-situ obs. data

2. Direct comparison

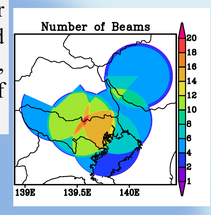
point-by-point comparison

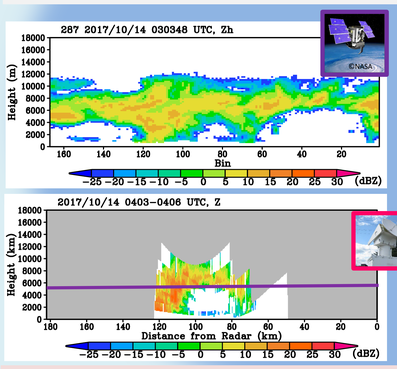


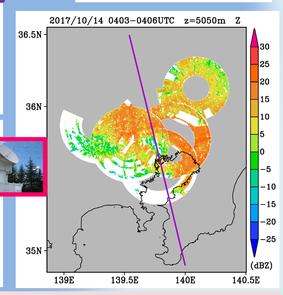
- Roughly speaking, CloudSat's and Ka-band radars' Z agree well.
- At Z> ～ 10 dBZ, differences are large. This may be due to non-Rayleigh scattering of CloudSat W-band radar.

Comparison using vertical cross section created from a CAPPI of Ka-band radar

A comparison with CloudSat was made using past Ka-band radar observations. The number of elevation angles is not sufficient because the scans were not set up specifically for comparison. CAPPI was created using PPI and SPPI scanning data from 5 radars in 3 minutes, and a vertical cross section along the path of CloudSat was created.







Vertical structure is not well represented. Scans with a sufficiently number of elevation angles will be required for comparison.