

Space Based Precipitation Measurement with a CubeSAT

An X-Band Phased Array Radar Payload for Precipitation Measurement

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Introduction

The Cloud Profiling Radar on satellite is developed under cooperation of National Institute of Information and Communications Technology (NICT) and Japanese Aerospace Exploration Agency (JAXA) in Japan
Space borne Doppler radar for cloud and precipitation

Method

Develop a X-Band Phased Array Payload
Test the Phased Array on Ground for Precipitation Measurement
Calibrate and Test

OBJECTIVES of external calibration

- ✓ Define calibration factor of radar in Radar Equation
- ✓ Define transmitting power
- ✓ Define receiving power
- ✓ Define antenna pattern (Beam Pointing)

Radar Equation

$$P_r = \frac{P_t G^2 \lambda^2 \theta^2 c \tau}{2^{10} \pi^2 (\ln 2) R^2 L} \frac{1}{\lambda^4} \pi^5 |K|^2 10^{-18} \cdot Z \cdot 10^{-0.2 \int_0^R k dr}$$

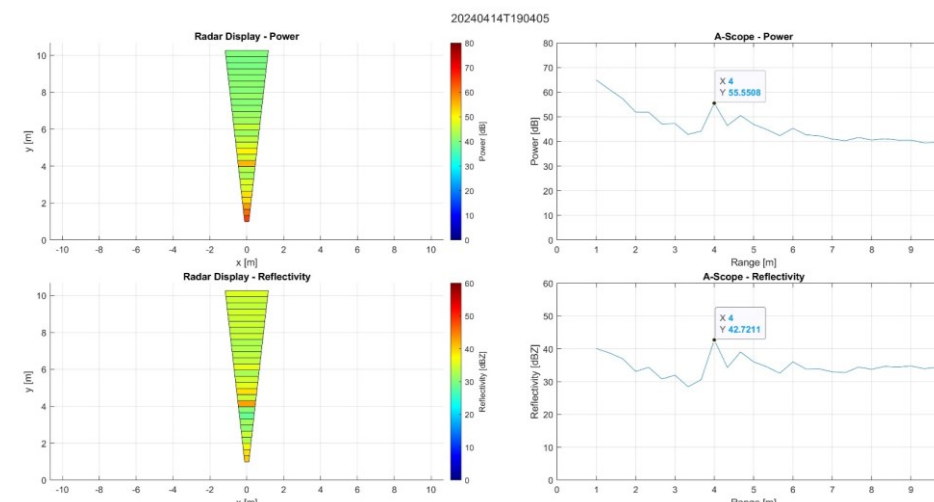
Radar Equation
 Pt: Transmitting Power at Antenna Feed [mW]
 Pr: Received Power at Antenna Feed [mW]
 λ: Wave Length [m]
 G: Antenna Gain [dBi]
 θ: Half Power Antenna Beam Width [(radian)]
 c: Velocity of Light [m/s]
 τ: Pulse Width [s]
 R: Range from CPR to surface [m]
 K: Dielectric Constant = (m²-1)/(m²+1) [unit]
 m: diffractive index of target
 k: Attenuation Coefficient (cloud and atmosphere) [dB/km]
 Z: Radar Reflectivity Factor [mm⁶/m³]
 L: Calibration Factor or System Loss [unit]

Purpose

- CPR has two objectives, which are to measure profile of clouds reflectivity and to measure up/down velocity of clouds
- Then the requirement of sensitivity is -35dBZ after 20km integration and the requirement of Doppler velocity measurement accuracy is less than 1 m/s after 10km integration for more than -22 dBZ of clouds
- The large antenna has large footprint and uses phased arrays

Results

- The performance of external calibration using ARC is shown by the feasibility experiment.
- The amplitude measurement results including the reception of cross-polarized signal by accident are agreed within sufficient error.
- From the phase measurement result, the antenna pointing is estimated not within the range of error.
- The X band system is now under consideration for CubeSAT deployment
- A larger array can be used for improved resolution



Contact information

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