Development of Monostatic Antenna System for W-band FMCW Cloud Radar

Poster1-49 **New and Emerging Radar Technology**

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1. INTRODUCTION

Observation of clouds with radars in millimeter wave range is one of the most powerful remote sensing methods to derive information on interior of clouds. We have developed and are operating a cloud profiling FMCW (Frequency Modulated Continuous Wave) Doppler radar named FALCON-I (FMCW Radar for Cloud Observations) in W-band at 95GHz. FMCW type radars have many advantages to pulse type radars. Transmitted power of an FMCW radar which is continuously transmitted is only 1/1000 of that of a pulse radar. Because of this lower power, an FMCW radar can be constructed without tube for oscillator. FALCON-I is a bistatic antenna system, which is usually used for FMCW radar, and consists of two 1m-diameter antennas with high spatial resolution of 0.18 degrees FWHM. A high range resolution of 49 m is realized with the FMCW type radar, which is about 10 times higher than that of normal pulse type radar. FALCON-I has enough sensitivities for faint clouds at high altitude and has high resolution in Doppler measurements.

FALCON-I, however, have a sensitivity reduction because of parallax, which are discrepancies of fields of view of the transmitting and receiving antennas. Thus, it is necessary to compensate the sensitivity reduction for each height. In order to avoid the parallax, we have developed a monostatic antenna system of FMCW cloud radar named “FALCON-X”.[1][2][3]

2. DEVELOPMENT OF MONOSTATIC ANTENNA SYSTEM FALCON-X

The developed radar FALCON-X improves the radar sensitivity by changing the antenna diameter from 1m to 1.4m with 0.13 degrees FWHM beam. By using one antenna instead of two, the overall size of the facility is reduced to about half. A monostatic antenna system does not have any beam discrepancies between the transmitting and the receiving antenna. FALCON-X is implemented monostatic antenna by using a device called circulator for connecting the transmitter, antenna and the receiver. The block diagram of FALCON-X is shown in Fig.1.

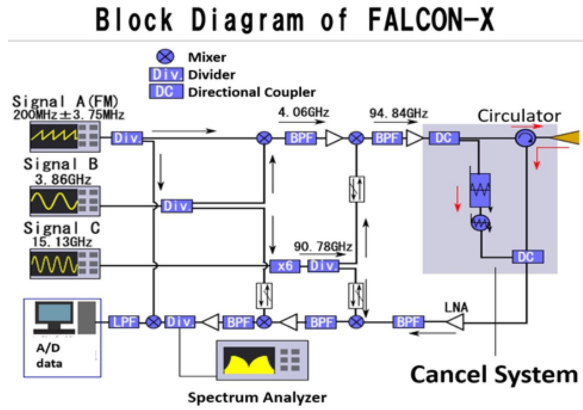

Fig.1. Block diagram of the monostatic antenna system of millimeter wave Doppler radar FALCON-X. It has the cancel system which reduces leaking transmitting power into the receiving section.

The circulator passes the signal only in the determined direction. One of the most difficult points for a monostatic antenna system is contamination of the transmitting power into the receiving section because of an FMCW radar performs transmission and reception at the same time. Thus, part of the transmitting power passes into the receiving section. A Cassegrain antenna is used and reflected waves at the primary horn aperture, which is one of the largest contamination powers, cause saturation of LNA (Low Noise Amplifier). In order to reduce the contamination power, we introduce a cancel system of power in the frontend of FALCON-X.

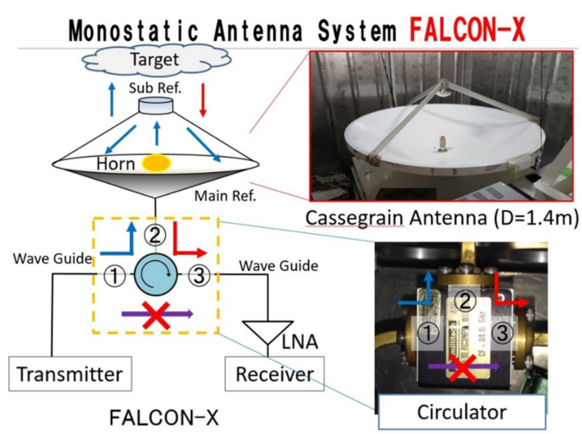

Fig.2. Schematic figure of dividing system between transmitting and receiving part with the circulator.

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The cancel system consists of a power splitter, an attenuator, and a phase shifter in W-band and produces an antiphase signal against to the contamination power. By using the cancel system, we can reduce the contamination power by -53 dB from 2.4 dBm to -51.0 dBm as shown in Fig.3. We suppressed contamination power into lower than the power limit (-20 dBm) of LNA consequently.

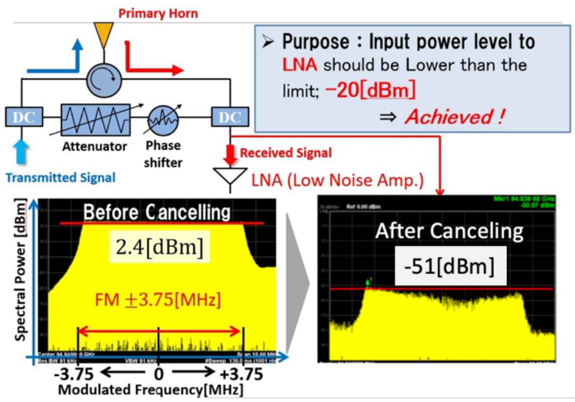

Fig.3. Suppression of signal contamination is about -53 dB from 2.4 dBm (left panel) to -51.0 dBm (right panel) after tuning of the cancelling system. This power level is lower enough for maximum power limit of LNA (-20 dBm) in the receiving system.

3. RESULT

We made simultaneous observations of clouds with FALCON-I and FALCON-X at Chiba, Japan. Observation time was from 20:00 to 22:00 (UTC) on June 8, 2019. Both radars observed in the zenith direction. The distance between both radars is about 5 m. The results of observations are shown in Figure 4. We can see quite similar structures of clouds at the height of 4 – 8 km and precipitation of 0 – 4 km in both maps, although, at height of 0 - 4 km, lateral noises appear in the cloud map of FALCON-X. The reflection of clouds with FALCON-X is 5 dB upper than those with FALCON-I. We were able to observe clouds using monostatic antenna system of the W-band FMCW radar FALCON-X.

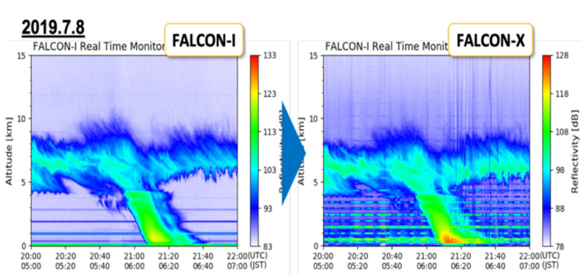

Fig.4 Results of simultaneous observations of clouds with FALCON-I and FALCON-X

4. CONCLUSION

We are developing a monostatic antenna system of FMCW Doppler radar FALCON-X. In order to reduce the contamination of transmitting power into the receiving section, we introduce a cancel system of power in the frontend of the radar. The cancel system consists of a power divider, an attenuator, and a phase shifter in W-band and produces an antiphase signal against the contamination power. Using the system, we can reduce the contamination by -50 dB and consequently, contamination power is supressed into lower than the power limit of LNA (Low Noise Amplifier).

We made simultaneous observation of FALCON-I and FALCON-X. we were able to observe clouds using monostatic antenna system of the W-band FMCW radar FALCON-X.

REFERENCES

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