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PRELIMINARY OBSERVATIONS OF SMALL SCALE WAKES GENERATED BY COMPLEX TERRAIN USING A PORTABLE X-BAND RADAR

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1. INTRODUCTION

The purpose of this paper is to discuss close range and high resolution radar observations of wakes generated by complex terrain. The fine-scale data of wakes obtained with the portable radar are important as they provide unique reflectivity information, which can be used to help to understand the fine structures of wakes and verify the theory of mountain airflow disturbances.

2. DESCRIPTION OF THE RADAR

The observation data described herein were obtained using a portable X-band radar, developed by Mitsubishi Electric Tokki Systems Corporation (Table 1 and Fig. 1). An important aspect of this radar is its portability (i.e., small-size and low power consumption). In mountainous regions, radar observations are usually affected by beam blockage, which makes it nearly impossible to interpret the wake structures. Even if unobstructed radar data are obtained, the high-resolution observations would be precluded due to radar beam spreading because radar deployment is forced to relatively far from the mountain ridge. The radar can deploy close to ridges and observe modification of the precipitation pattern by the topography.

3. THE STUDY AREA

Figure 2(a) shows the topographical map showing the locations of the Sea of Japan, Mikuni Mountains, and the study area (in the square). The arrow shows the direction of the monsoon flow. Under typical atmospheric conditions during winter, the cold northwesterly monsoon, accompanied by a strong Siberian high and active cold surges, persists and blows over the Sea of Japan. Shallow convective clouds appear in a well-developed mixed layer over the Sea of Japan, advect southeastward, and land at the Sea of Japan side. These clouds typically continue to move onshore to the mountain side and heavy snowfall frequently occurs. Figure 2(b) shows the location of the radar as well as the surrounding terrain. The area consists of mountains, valleys, and dams, and the elevation varies from about 700 to 2000 m.

Wavelength	3.1cm
Peak tranmitted power	25kW
Observation range	30km
Antenna ratation rate	2rpm
Range resolution	60m
Beamwidth	2.0deg
Antenna gain	36dB
Total weight	less than 150kg
Power consumption	less than 1kVA (100V, single phase)
Doppler capability	currently under development

Table 1. Characteristics of the portable X-band radar.

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4. PRELIMINARY ANALYSIS OF WAKES

Numerous fine-scale wake structures are revealed in the reflectivity fields during the field program. Associated with wakes, it is evident that elongated strong reflectivity regions with sharp edges. Two cases provide good examples of wake structures in the lee of the Mt. Tanigawadake (1963-m altitude). In both examples, widespread snow occurred over the western side of the central mountain range of Japan associated with a cold westerly monsoon.

On 1st March 2005, the single line of cells associated with wakes in the lee of the Mt. Tanigawadake was observed. Fig. 3 is a typical PPI scan of reflectivity at an elevation angle of 5.5 degree. Reflectivity time series along the line A-B is shown in Fig. 4. Usually, wake length exceeded 15 km and 1km-scale cells occurred at intervals of 2 minutes and moved southeastward. It is suggested that relatively weak eddies were generated quasi-periodically in the lee of the ridge and carried directly by the ambient flow.

On 3rd March 2005 (Figs. 5 and 6), the two lines of cells associated with wakes in the lee were observed. Wake length also exceeded 15 km and 1-2 km-scale cells occurred at intervals of 3 minutes and moved southeastward. Moreover, the vortex street broadens downstream. It is suggested that positive and negative vortices had formed in the lee of the ridge, were shed downstream quasi-periodically, and advected itself into eddies.

5. CONCLUDING COMMENTS

The feasibility of the portable X-band radar observations in mountainous regions has been demonstrated. The results of this study suggest that the radar would be particularly useful for documenting sub-km-scale reflectivity fields near the ridge with fine special and temporal resolution. The primary conclusion of our study is that wake eddies are common in the lee of the ridges of the Mikuni Mountains during winter. We will perform more quantitative analysis of eddy lifetime, vortex shedding, and impact on precipitation. Further studies using the radar with Doppler capability, currently under developed, will permit single -Doppler study of wakes.

Fig. 1 The portable X-band radar on the rooftop of the building during the orographic snow cloud modification field program.

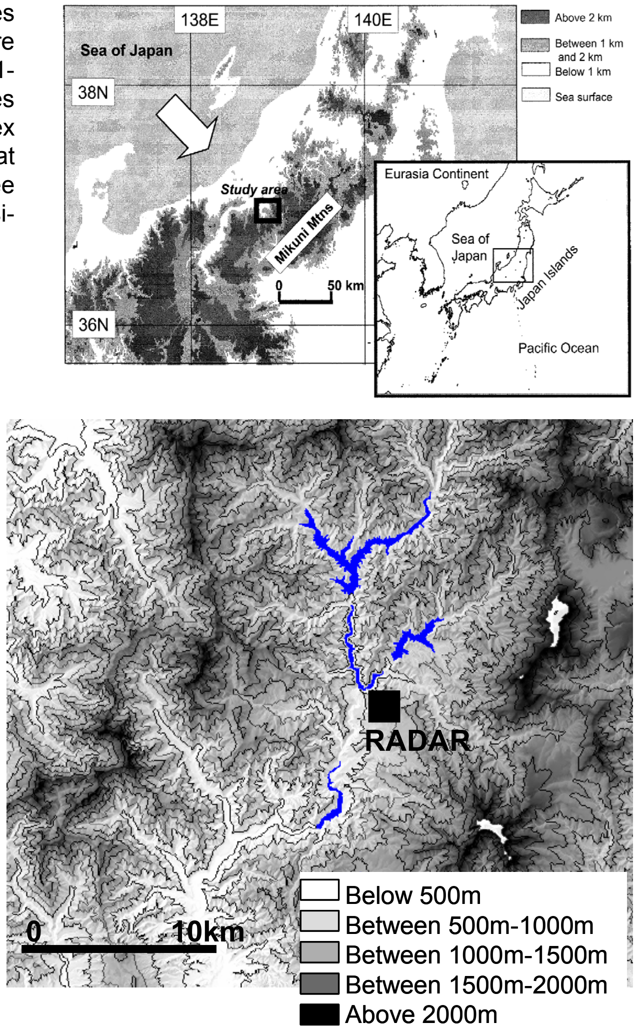

FIG. 2 (a) Topographical map showing the locations of the Sea of Japan, Mikuni Mountains, and the study area (in the square). The arrow shows the direction of the monsoon flow.
(b) Enlarged map around the study area.

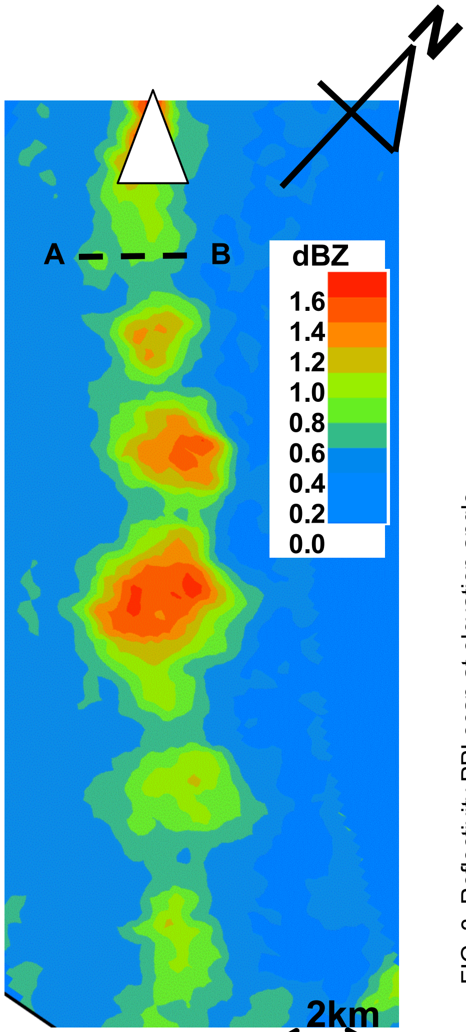

FIG. 3. Reflectivity PPI scan at elevation angle of 5.5 at 0028JST on 1 Mar 2005.

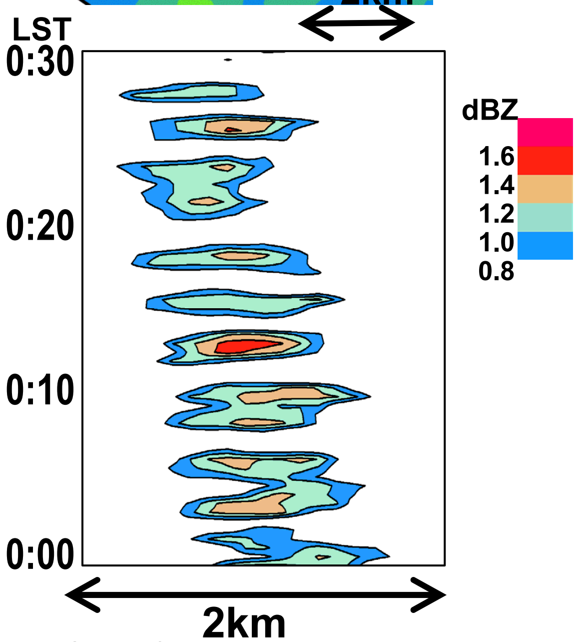

FIG. 4. Reflectivity time series on 1 Mar 2005 along the line A-B (FIG. 3).

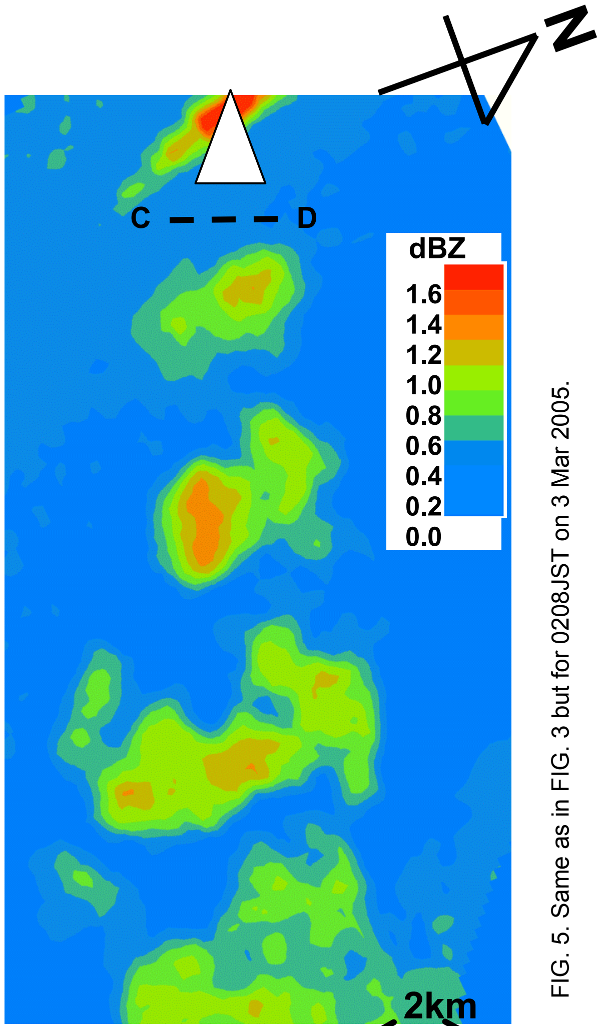

FIG. 5. Same as in FIG. 3 but for 0208JST on 3 Mar 2005.

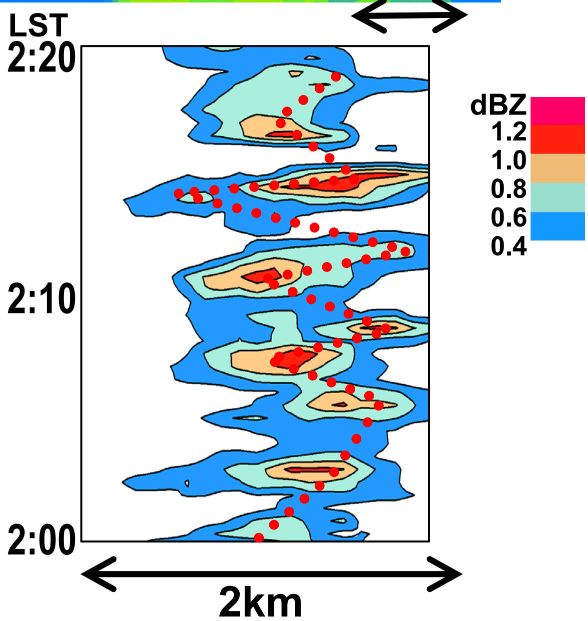

FIG. 6. Same as in FIG. 4 but for 3 Mar 2005 along the line C-D (FIG. 5).