Characteristics of three-dimensional wind field of Line-Shaped Rain Bands around Sapporo.

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1.Introduction

Line Shaped rain-bands (LSRBs) are one of heavy rainfall pattern in the meso-convective system of Japan, and a line of cumulonimbus clouds repeatedly generates and disappears, leading to local heavy rainfall (kato et al. 2006). Recently, the number of natural disasters due to LSRBs has increased, and may result in the disaster having the name of the area, such as the Kanto-Tohoku heavy rainfall in 2015, and the heavy rainfall in northern Kyushu in 2017. For the same precipitation pattern that it is very difficult to predict the location and size from the weather map, it is necessary to make mesoscale discussions using radar observations.

Many of LSRBs are back-building type, and the necessary elements to continue this phenomenon are (1)the inflow of water vapor necessary for the replenishment of raindrops, and (2)the air in the lower layer atmosphere up to the free convection height. It is considered as the convergence zone necessary for carrying, (3) the lower layer flow to move the generated convection cell and prepare for the generation of the next cell. Therefore, in order to examine this phenomenon, an accurate three-dimensional wind velocity field in the rainfall area is required.

The target is heavy rain that occurred in Sapporo(Central Hokkaido) area in September 2014, which is a typical back-building type. This is the first case of heavy rainfall special warning alert in Hokkaido for the Ishikari and Iburi districts. In this study, the three-dimensional wind velocity field (Bousquet and Chong, 1998) obtained by applying the variational method to three C-band radars and X-band MP radar around the rainfall area observation. The meteorological field was verified from the equivalent temperature calculated using the analysis values of the meteorological model, and the features of the linear convection system configured were shown.

2.Data and Method

We used the analysis data of the Japan Meteorological Agency meso scale Model (MSM). The analyzed values of MSM are three-dimensional wind velocity u, v, w, temperature t, relative humidity RH. The mixing ratio w and the condensation temperature TL were given to this, and the equivalent temperature theta-e was obtained by the following approximate expression (1).

For the three-dimensional wind field, the variational Doppler radar analysis method is used. The same method uses the variational principle on a two-dimensional plane as compared to the analysis using the conventional vertical integration method, and weights the low altitude value with high observation frequency and calculates it in the orthogonal coordinate system The accuracy of the indicated vertical wind velocity is improved.

Furthermore, it is adapted to deep convective clouds by considering mass flux in each grid. Spatially smoothing the analyzed wind velocity u, v, w contributes to the reproduction of a realistic wind field. As for the detailed expression system, Please refer to Yamada 2013.

3.result

Figure 1 shows the spacial distribution of equivalent potential temperature theta-e [K] and horizontal wind velocity [m/s] on the 500 hPa, 925 hPa altitude surface calculated from the analysis values of MSM. The time is 3:00[JST] on September 11, 2014 at the time of LSRB generation, and the contour in the figure

indicates the equivalent potential temperature, the arrow indicates the wind speed, and the circle indicates the rainfall area. Figure 1 (a) shows the air mass flow that is colder and drier than southwest in the middle troposphere. On the other hand, in the lower troposphere zone shown in Fig. 1 (b), a warm and moist air mass showing high equivalent potential temperature flows in at the southern end of the rainfall area. This also means convective instability in the synoptic meteorological field.
Figure 2 shows the convergence and divergence distribution of the wind speed in each cross section obtained by the variational method at the same time. Convergence are occurred at the southern part at every altitude, and it suggests that rising air flow is generated in this area and contributed to the continuous formation of cumulonimbus in consideration of the water vapor inflow shown in Fig.1. In addition, it can be read that convergence and divergence are distributed like stripes in the rainfall area at altitudes of 1400 m and 2100 m, suggesting the construction of a convective system. Such a distribution can not be confirmed at an altitude of 700 m and 2800 m.
In Fig. 3, in vertical cross section 3 (a) where LSRB is cut at the same time, (c) vertical circulation occurs on the east side due to the inflow, and (b) reflection intensity on the west side reaches high altitude It extends, and the same structure continues for several tens of kilometers. The vertical cross section shown in Fig. 3 (b) is the cross section of the west side of LSRB, and there are some convection cells. On the other hand, the vertical cross section shown in Fig. 3 (c) is on the east side of the precipitation area, and the precipitation cells shows strong reflection intensity are concentrated at about the height of 4 km. At the southern end, it is suggested that the sudden downdraft like downburst contributes to the movement of cumulonimbus clouds.

4.Summary
In this study, the presence of damp air mass flowing into the edge of LSRB is clarified from the analysis value by MSM, and from the three-dimensional wind field by the Doppler radar to the existence of the convergence part at the same point and the movement direction of the convection cell. The lower layer flow is shown. Furthermore, the distribution of convection cells is likely to be related to the wind field, and it is expected that it will be reproduced in the meteorological model assimilation of the wind field in the future work.

Keywords: MUSCAT, Line-Shaped Rain Bands, Meso Convective System

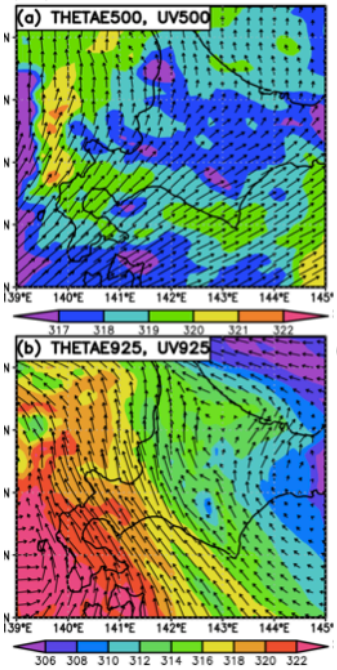
Back-building type

(1)the inflow of water vapor necessary for the replenishment of raindrops

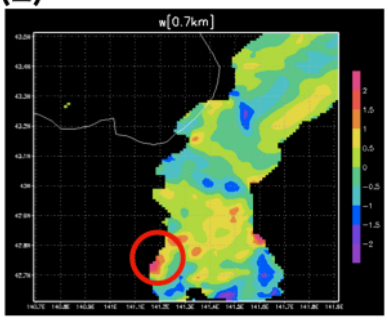
(2)the air in the lower layer atmosphere up to the free convection height.

(3)the lower layer flow to move the generated convection cell

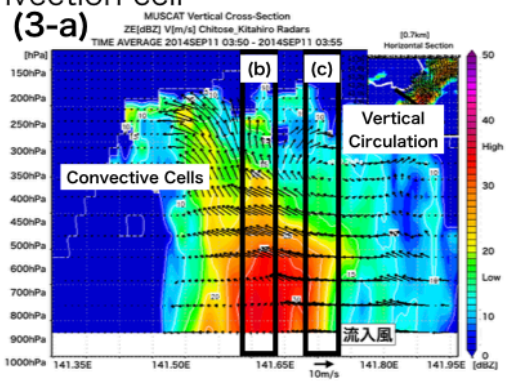
(1)



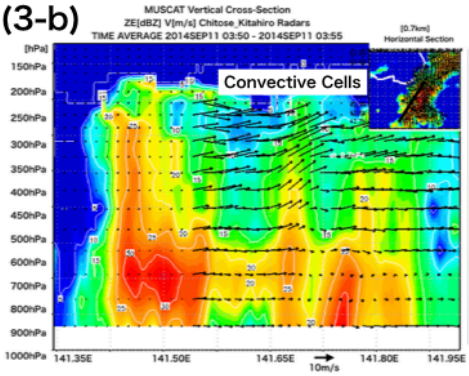
(2)



(3-a)



(3-b)



(3-c)