ANALYSIS OF SINGLE CELL TO MULTICELL FORMATION WITH DUAL DOPPLER AND VORTICITY ANALYSIS

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1. Introduction

The weather pattern could be observed by the weather radar for the early warning systems in disaster occurrence because its better temporal and spatial resolution, and Doppler radar is capable to estimate precipitation amounts and movement of the precipitation systems [1]. Dual Doppler analysis is established in this analysis to obtain three-dimensional wind fields using radial velocity of two radars. Meanwhile, vorticity analysis in the single cell was investigated and it was found that vorticity could be useful in the detection of Guerilla-heavy rainfall before the development of cumulus stage [2]. Furthermore, the multicell formation using vorticity analysis technique was established and the signature pattern of merging from single cell to multicell was difficult to examine due to change of core vorticity at upper-level height [3]. Therefore, the objectives of this study are to clarify the mechanism of single cell to multicell formation and further investigate the signature pattern of multicell formation using Dual Doppler and vorticity analysis.

2. Data and Methodology

The multicell storms was observed on the 10th September 2014 (2100JST-2300JST) in Kinki region, Japan. The radiosonde data from Shionomisaki station showed that the weak vertical shear occurred during the event that appropriated for the multicell formation and not affected by Baiu front or tropical cyclone. The X-band dual polarization radar namely Tanokuchi and Katsuragi station were deployed in the Dual Doppler analysis as shown in Figure 1. The distance between the two radars was 58km and wind fields were made in the region limited by angle β=20°. The Dual Doppler provides radar reflectivity (Z_h) and three-dimensional winds with the spatial resolution 1km x 1km x 0.25km. The extraction of vorticity distribution is generated by using Doppler radar estimation with the spatial resolution in each plane 50m x 50m to analyze the vortex tube qualitatively and the core vorticity quantitatively.

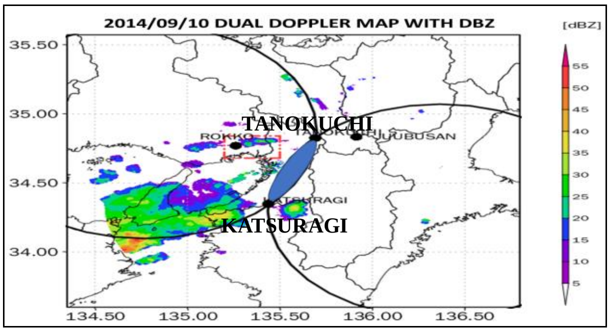

Figure 1. The Dual Doppler analysis range at target (red box), with blue color indicates blockage area.

3. Results and Discussion

In this study, the evolution of multicell formation is illustrated by Figure 2 in term of time series of Zh. During the 2 hours observation, maximum reflectivity was increased from 30 dBZ to 60 dBZ, maximum

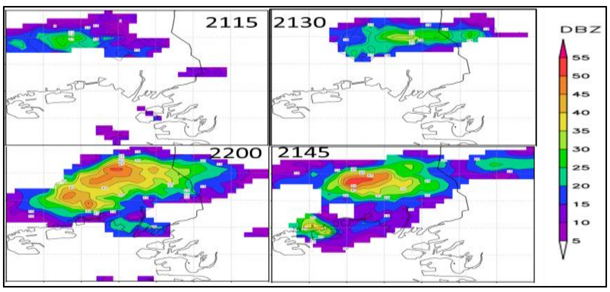

Figure 2. Time series of Zh contour at 2.25 km.

updraft speed increased from <1.5 ms^{-1} to >3.5 ms^{-1}, and maximum vorticity increased from < $1x10^{-3}$ s^{-1} to $7x10^{-2}$ s^{-1}. To understand the mechanism of multicell formation, the vertical cross-section through the storm is presented in Figure 3. We observed that the new convection appeared adjacent to older cells and connected with the parent cell from the left and the storm motion propagated to the right.

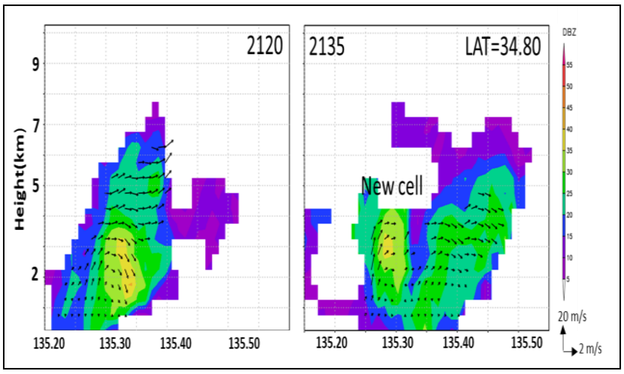

Figure 3. The height-longitude cross-section of multicell.

The signature pattern of multicell formation using the vortex tube analysis was investigated before and after the merging of cells. We discovered that the changing position occurred at lower and upper-level height. Additionally, we analyzed quantitatively core vorticity at each cell and found that the position of core vorticity was moved at the certain level due to the changing of direction of wind field in the storm as shown in Figure 4 for cell A only. We observed that the core vorticity for both cells moved its position between 2-4 km height before and after merge which described in Figure 5(a) and Figure 5(b).

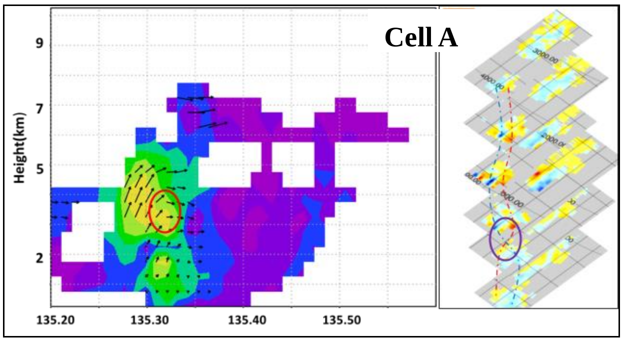

Figure 4. Analysis of changing vorticity related to the wind motion in the storm for cell A.

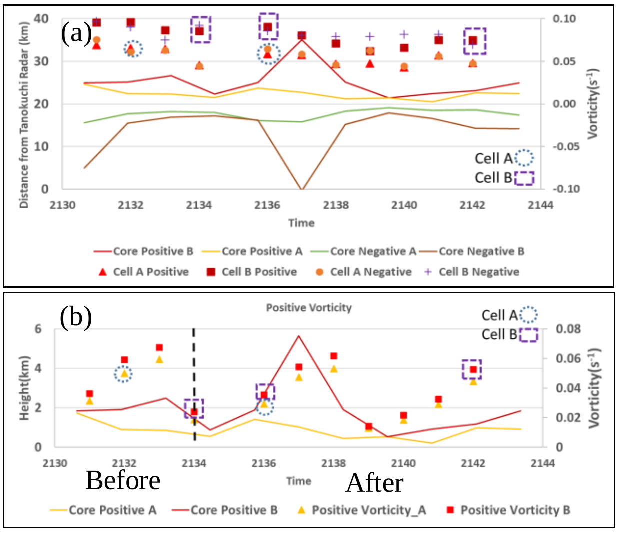

Figure 5. (a)Time-distance for merging cell A and cell B (b)Time-height of positive vorticity for merging cell A and B.

4. Conclusion

From this study, the three-dimensional wind fields derived from dual Doppler analysis are examined to investigate the role of wind fields in the merging of single cell to multicell formation related to the vertical vortex tube analysis. The core vorticity mainly shifted due to the changing of wind fields and the new cells frequently appeared on the preferred flank with condition of weak shear keeps the gust front near the storm updraft. More cases study is suggested to obtain the indicator of signature pattern of core vorticity in term of the shifted height and its intensity.

5. References

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[2] Nakakita, E., et al., (2017). Early Identification of Baby-Rain-Cell Aloft in a Severe Storm and Risk Projection for Urban Flash Flood. Advances in Meteorology (Article ID 5962356).

[3] F.Ahmad. et al., (2020). Investigation of Single Cell to Multicell in the Cluster Thunderstorms using Vorticity Analysis, Journal of JSCE, B1(Hydraulic Engineering), Vol 76, No.2, I_187-I_192.