P5.8 A NEW TORNADO SIMULATOR REPRODUCING FLOW FIELDS UNDER SUPERCELL

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1. INTRODUCTION

Only 20 % of the mesocyclones detected by Doppler radars cause tornado as stated by Wakimoto and Cai (2000). If we understand the flow condition of tornado genesis in a supercell, we can improve the reliability of nowcast for tornado outbreak. The present laboratory experiment aims to clarify the fluid dynamical conditions of tornadogenesis in a supercell.

2. EXPERIMENTS

We tried to realize the rotational updraft of mesocyclone and the gust from the rear flank downdraft of supercell in our newly designed simulator as shown in Fig.1. The mesocyclone simulator is composed of 48 guide vanes, a convection chamber of D = 900 mm in diameter and 4 fans generating updraft. It resembles conventional tornado simulators made by Snow and Lund (1997) and so on. It has, however, open space between floor and it. Then rotating updraft similar to the actual mesocyclone developed in mid air is generated in the mesocyclone simulator. The gust generator supplies dense mist made from dry ice and simulates the gust front from the rear flank downdraft. The aspect of tornadogenesis was visualized by the dry ice mist and was filmed with a digital video camera.

3. RESULTS AND DISCUSSION

The resultant flow fields were classified with 4 different patterns as shown in Fig. 2. Fig. 2(a) shows a multiple-vortex type pattern as observed by Wurman (2002). Three suction vortices are found to exist in the main tornado-like vortex. They were generated in a high shear layer at the outer edge of the gust. The number of the suction vortices varied every second because the gust was unstable. A pair of clockwise and counter-clockwise vortices is also observed as shown in Fig. 2(b). Such flow pattern has never been found in the traditional tornado simulators. But, Fujita (1981) and Bluestein et al. (2007) observed a pair of cyclonic and anti-cyclonic tornadoes. A pair of tornadoes was developed from both the side edges of the gust in the present experiment. The clockwise vortex occurs independently of the counter-clockwise rotation of the mesocyclone. Fig. 2(c) shows a simple tornado-like vortex similar to that realized in the traditional tornado simulators. But, the source of vertical vorticity is not only the tangential velocity forced by the guide vanes but also the horizontal shear at the edge of the gust.

Four flow patterns mentioned above are classified with the height, z_m/D, and the swirl ratio, S, of the mesocyclone simulator as shown in Fig. 3. It must be noted that the present swirl ratio is different from that of the traditional tornado simulator. It is very difficult to measure the swirl ratio of the actual tornadoes. On the other hand, we can measure the height and the swirl ratio of the actual mesocyclone with Doppler radars. The flow pattern changed dependent upon both the

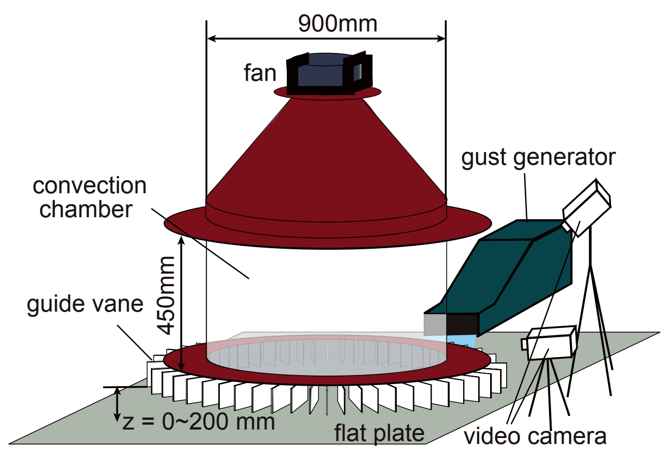

Figure 1: Mesocyclone simulator and gust generator.

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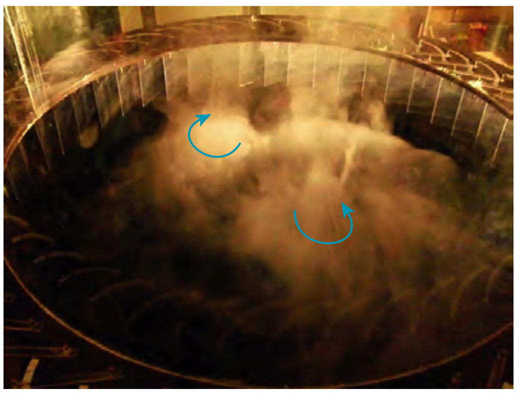
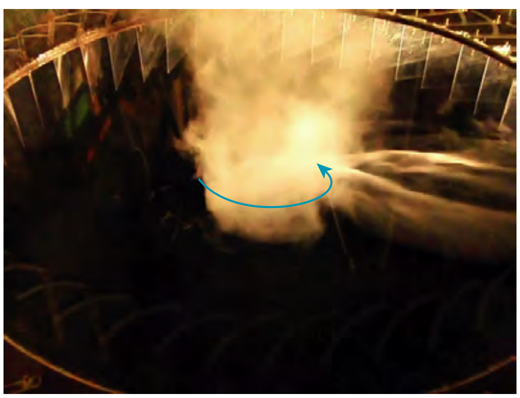
(a) multiple-vortex with three suction vortices.



(b) counter-rotating vortex pair.



(c) single vortex.

(d) no vortex generated.

Figure 2: Photos of four flow patterns.

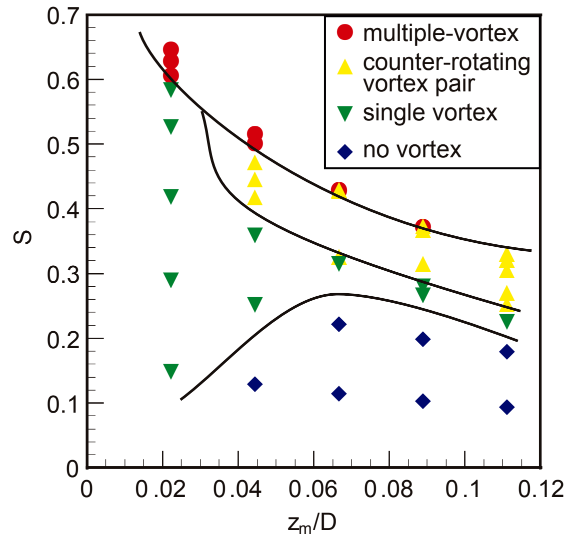


Figure 3: Regime of flow patterns realized in the mesocyclone simulator.

height and the swirl ratio. But, the principal parameter is the swirl ratio.

4. CONCLUSIONS

We were successful in realizing various types of supercell tornado in our newly designed mesocyclone simulator. The difference of vortex pattern depends mainly on the swirl ratio of mesocyclone.

5. References

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