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Measurement of the three dimensional velocity field of tornado-like vortex by the experimental study

Saki Tanimoto (1), Koji Sassa (2), and Hanaka Watanabe (2)
(1) Railway Technical Research Institute, Tokyo, Japan (saki@rtri.or.jp), (2) Kochi University

When tornadoes occur, flying debris from tornadoes can be expected to cause various damage. Though it is significant for warning and mitigation of tornado disasters to observe mesocyclones and tornado vortices by radar, we also need to establish evaluation methods of debris damage to transportation systems and structures. It is assumed that the impact of debris damage increases with the speed of flying debris. The speed of debris can be evaluated from the wind speed of tornadoes near ground surface with the equation of motion of flying debris. However, even if high resolution Doppler radars are used, it is difficult to measure 3-D velocity fields around tornadoes near the ground surface due to grand clutter, shade by structures and so on.
The final objective of our research is to establish the evaluation methods of the damage of flying debris. In this presentation, authors introduce the results from the laboratory experiment for obtaining 3-D velocity of the tornado-like vortex. The updraft fan of 90 mm in diameter and the outflow simulator were used for the experiment. The outflow simulator is a kind of blow down type wind tunnel which has cooling system. The size of the outlet of the outflow simulator is 100mm in length and h=40mm in height. The velocity fields of the tornado-like vortex were evaluated by the stereo-PIV measurement. Horizontal planes at several heights, z/h=0.125, 0.25 and 0.5, were illuminated by two laser sheet lights and filmed by hi-speed cameras at 2000 fps in frame rate. The mist from ultrasonic humidifier was used as tracer for visualization. The 3-D velocity components of the tornado-like vortex were obtained by using stereo PIV method.
Horizontal distributions of vertical velocities around tornado-like vortices showed the existence of downdraft near the tornado-like vortex. Converging flow toward to the center of the tornado-like vortex core was also clearly observed at horizontal planes near the surface.