



Establishing a Cyclone Generator to Study the Rotation and Advance Characteristics of Tornadoes

Yuanzhuo Zeng¹, Yanjie Fu², and Chenglin Lyu³

¹Ocean University of China, College of Oceanic and Atmospheric Sciences, Department of Marine Meteorology, Qingdao, China (zengyuanzhuo@163.com)

²Ocean University of China, College of Information Science and Engineering, Department of Computer Science and Technology, Qingdao, China (fuyanjie@stu.ouc.edu.cn)

³Ocean University of China, College of Oceanic and Atmospheric Sciences, Department of Marine Meteorology, Qingdao, China (1146860790@qq.com)

The prediction of tornado trajectories has always been a crucial yet difficult problem in meteorology. In this research, an original and effective tornado simulator was designed and produced to study the travel trajectory characteristics of tornadoes through geoscience instrumentation and theoretical analysis.

First, tornado simulators designed by senior scientists were researched, and they all have one defect in common, which is failing to move freely. As a result, those tornado simulators cannot be used for studying the travel law of the tornado. Based on pioneers' experience and real tornadoes' features, an innovative tornado simulator that can move freely has been completed in this research. A stable wind field which basically has the necessary characteristics of a tornado can be produced by it upon observing the wind field of the simulator.

Second, in order to research the tornadoes' behavior in a stable external wind field, the simulator was placed floating on the water in a wind tunnel during the experiments. The experimental parameters such as the velocity of the simulator's flow, and the velocity of the flow in the wind tunnel were carefully arranged, in order to systematically simulate different wind field conditions and observe the trajectory of the tornado simulator. Meanwhile, a tornado trajectory prediction model was made according to fluid dynamics including the Bernoulli Principle and the Precession Principle. The dynamics analyses of both real tornadoes and the simulator were carried out through formula derivation and numerical methods.

Third, by analyzing data of the trajectory of the simulator in detail through MATLAB, it was found that the offset degree was positively correlated to the rotation velocity of the tornado simulator, and negatively correlated to the wind velocity of the incoming flow, therefore verifying and enriching our model.

Fourth, the general flow function of the flow field of the simulator and tornadoes were respectively created by superposition of a flow around the symmetric cylinder function and a vortex flow function, perfecting the theoretical model. The "asymmetric flow around a cylinder" model for

formula derivation in this research has been established, obtaining the numerical relationship of the velocity of the incoming flow and the simulator's flow regarding the offset degree. The field data of the simulator and tornadoes demonstrated the validity of the theoretical assumption.

In conclusion, the Bernoulli Effect, precession effect and asymmetric flow of the tornado simulator were studied through experiments and theoretical modelling, which provided new insight and methods into the study of the trajectory of tornadoes. The experimental results conform to the theoretical assumption. This research is trail-blazing and inspiring as using mechanical devices in a wind tunnel to study the trajectory of tornadoes is unprecedented. It provides experience of how to combine engineering and geoscience in researches. The findings can help to predict the path of the tornado by monitoring the wind field of the area where the tornadoes occur, providing guidance for rescue operations.