SUMMARY OF Ph.D. DISSERTATION

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Title

Investigation of Dynamics of Downburst near Ground by Laboratory Experiments

Abstract

Downburst is a meteorological phenomenon in which a strong downdraft generated by cold air impinges onto the ground and diverges outward. Associated rapid changes in wind direction and magnitude near the ground causes many disasters, in particular the aircraft accidents during take off and landing. To establish the alert and avoidance systems, the field observations should be supplemented by laboratory experiments.

The aim of this investigation is to elucidate velocity field of a downburst near the ground by laboratory simulations. As the laboratory model, 1) the uniform density vortex ring model and 2) the impinging gravity current model are proposed, since the real downburst is almost exclusively accompanied by a vortex ring.

In Chapter 1, the background and objective of this study are described. In Chapter 2, the vortex ring model is described. The vortex ring is generated by discharging the air impulsively from an orifice and impinges onto the ground. PIV measurements reveal azimuthal instability during impingement. The Reynolds number dependence of its wave number is also examined. In Chapter 3, the impinging gravity current model is described. A finite mass of high-density liquid is released into a still low-density liquid forming a downdraft and impinging onto the ground. From the ensemble average of velocity obtained by PIV, the mean and turbulence statistics are examined. The large scale circulatory flow is observed outside the downdraft region. It is basically irrational during the downdraft and impinging stages, but it engulfs the high-vorticity fluid near the ground during impingement and eventually develops into the vortex ring with azimuthal instability. In Chapter 4, these model results are compared with the real downburst. It is revealed that the impinging gravity current model provides qualitative agreement with the real observations. Even quantitative estimation based on this model is possible if are chosen properly. Finally, the F-factor for aircraft safety is estimated. Summary and conclusions are described in Chapter 5.

We can provide information about the dynamics of downburst near the ground, for example characteristics of large scale circulatory flow, vortex ring and statistics, which are not be able to obtain only by the field observations.