Corrected scaling law for traveling microbursts

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Microbursts originated from thunderstorms are kinds of strong gust and sometimes cause severe damages to crops, buildings and so on. Many experiments were made to clarify the structure of microbursts. Most of them focused on stationary microbursts that fall down normal to the ground. Lundgren et al. (1992) established the scaling law for stationary microbursts. However, actually observed microbursts are traveling ones that are flowed with their parent clouds and environmental wind. We have conducted the experimental simulation of traveling microbursts to understand their detailed structure. In the present study, we aims to establish a new scaling law for traveling microbursts.

Environmental wind was realized by circulated water in a small water channel. The microburst was simulated by high-density liquid such as salt water dropped from small tank settled in circulated water. The dynamic PIV measurements were made for 5 cases of different densities and 3 cases of different environmental flow velocities. Then, various characteristics of traveling microbursts were evaluated.

The maximum velocities of traveling microbursts were found to be different between the upstream and downstream portions of environmental wind. Its difference is larger for larger environmental velocity and smaller density difference. Therefore, These characteristics did not collapse to the lines of the scaling law for stationary microbursts. We defined correction term for traveling effect as follows,

$$T_C = R_0 / U_C, \quad U_C^* = C_1 g \frac{\Delta\rho}{\rho} T_C, \quad T^* = T - C_2 T_C, \quad h_f^* = h_f - C_3 T^* U_C^*,$$

where the first equation represent the time scale that environmental flow moves across the radius of microburst parcel, the second is corrected environmental flow velocity, the third is the time when the maximum velocity is observed in the microburst and the last is the height of the outflow of microbursts. Though three empirical coefficients are included in these equations, all data were found to collapse to their lines even the values obtained from actual observations.