Lidar-Measurement-Integrated Simulation of Wake Turbulence

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Wake turbulence is one of the factors which restricts airport's landing and takeoff capacities. Numerical simulation of wake turbulence has been performed using large eddy simulation and direct numerical simulation. Although the numerical simulation could reproduce detailed flow structure of wake vortices, it is difficult to incorporate the effect of actual weather conditions at airport which affects the decay process of the wake vortices. Lidar is an effective tool to measure the wake turbulence of operating aircrafts. For the understanding of flow structure of wake turbulence; however, there are some drawbacks such as the lack of spatial resolution in the line-of-sight direction and the difficulty in tracking wake vortices for long periods due to the disturbance of ambient winds.

For the consideration of actual atmospheric conditions in the numerical simulation, the present study attempts to integrate lidar measurements into the numerical simulation using a data assimilation technique. Specifically, Four-dimensional variational (4D-Var) method was applied to integrate lidar measurements with the three-dimensional computational fluid dynamics simulation, in which actual scanning processes of the lidar was simulated as a measurement operator of the 4D-Var method. And a bogus vortex technique was adopted to ensure the existence of a vortex pair in the flow field. The validation of the method was performed by idealized test cases using the virtual lidar measurement which was produced by the reference simulation of a vortex pair. Then, the method was applied to actual lidar measurements at Sendai Airport in Japan.