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Idealised Simulations of Turbulence Near Thunderstorms

D. Zovko Rajak and T. Lane

School of Earth Sciences, University of Melbourne, Melbourne, Australia (d.zovkorajak@student.unimelb.edu.au, tplane@unimelb.edu.au)

Atmospheric turbulence is a significant hazard to the aviation industry because it can cause injuries, damage to aircraft as well as financial losses. A number of recent studies have been conducted in order to explain the mechanisms that are responsible for convectively induced turbulence (CIT), which can occur within the cloud as well as in the clear air regions surrounding the cloud. The majority of these studies were focused on above cloud turbulence, however, relatively little is known about the mechanisms that generate turbulence around thunderstorms. This type of turbulence, also known as near-cloud turbulence, is of particular interest because it is much more difficult to avoid than turbulence within clouds since it is invisible and undetectable using standard hazard methods (e.g. on-board and ground-based radars).

This study examines turbulence generation by organised convection (viz. supercells) using three-dimensional (3D) simulations conducted with the Weather Research and Forecasting model. Results from several high-resolution idealised simulations will be shown, with a focus on the role of 3D cloud-induced flow perturbations on turbulence generation and their sensitivity to different background flow conditions like wind shear. High resolution numerical modeling is necessary for more realistic treatment of deep convection and turbulence processes on a scale that affect aircraft (these are on the order of 100 m). Since conducting 3D simulations with cloud-resolving scales is very computationally expensive it is necessary to use nesting in order to resolve these small scale processes. The simulation results show regions of turbulence that extend more than 100 km away from the active deep convection (i.e. regions with high radar reflectivity). These turbulent regions are related to strong upper-level storm outflow and the associated enhanced vertical shear. Simulations also show localised modulation of the outflow jet by small-scale gravity waves ($\sim$ 4 km wavelength) that contribute to further destabilisation and susceptibility to turbulence. The results of these simulations and their implications for turbulence avoidance by aircraft will be discussed.