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Convectively-generated gravity waves and clear-air turbulence (CAT)

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Upper-level turbulence is a well-known hazard to aviation that is responsible for numerous injuries each year, with occasional fatalities, and results in millions of dollars of operational costs to airlines each year. It has been widely accepted that aviation-scale turbulence that occurs in clear air (CAT) at upper levels (upper troposphere and lower stratosphere) has its origins in Kelvin-Helmholtz instabilities induced by enhanced shears and reduced Richardson numbers associated with the jet stream and upper level fronts. However, it is becoming increasingly apparent that gravity waves and gravity wave "breaking" also play a major role in instigating turbulence that affects aviation. Gravity waves and inertia-gravity waves may be produced by a variety of sources, but one major source that impacts aviation seems to be those produced by convection.

The relation of convectively-induced gravity waves to turbulence outside the cloud (either above cloud or laterally away from cloud) is examined based on high resolution cloud-resolving simulations, both with and without cloud microphysics in the simulations. Results for both warm-season and cold-season cloud systems indicate that the turbulence in the clear air away from cloud is often caused by gravity wave production processes in or near the cloud which once initiated, are able to propagate away from the storm, and may eventually "break." Without microphysics of course this effect is absent and turbulence is not produced in the simulations. In some cases the convectively-induced turbulence may be many kilometers away from the active convection and can easily be misinterpreted as "clear-air turbulence" (CAT). This is a significant result, and may be cause for a reassessment of the working definition of CAT ("turbulence encountered outside of convective clouds", FAA Advisory Circular AC 00-30B, 1997).