EGU25-19191, updated on 19 Mar 2025
https://doi.org/10.5194/egusphere-egu25-19191
EGU General Assembly 2025

A Source of Clear-Air Turbulence? Tracking Gravity Wave Formation in Inertially Unstable Regions

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Turbulence was responsible for 71% of all weather-related aviation accidents and incidents in the US between 2000–2011 [1], leading to structural damage, injuries, and US$200 million in unforeseen costs for airlines each year [2]. With only 14% of turbulence encounters being attributable to convection [3], clear-air turbulence (CAT) is a leading cause of these encounters and thus poses a major risk to travellers.

A variety of dynamical mechanisms can be responsible for CAT, including shear instabilities, inertial instabilities, and gravity waves; however, differentiating between the distinct roles of each mechanism when more than one is present remains difficult. In fact, it is the precise evolution of these atmospheric instabilities and waves, and their potential for generating CAT, which remain uncertain in our current scientific understanding.

In this study, we investigate the relationship between CAT and gravity waves, with a specific focus on tracking the formation of these waves around regions of inertial instability. Previously, [4] showed the emission of inertia–gravity waves following the release of inertial instability using idealised model simulations. Here, we use the WRF model to consider some real-world examples of where regions of low potential vorticity (PV) in the vicinity of the jet stream are associated with inertia–gravity waves. We track the waves as they propagate and investigate whether the causal link found by Thompson and Schultz can be observed in more realistic simulations.

We present results from several case studies exhibiting this behaviour, identifying the sources of the gravity waves observed in simulations. The characteristics of these waves will be compared to those in the idealised model simulations, and gravity-wave parameters will be calculated. Finally, we widen our analysis by examining the broader upstream pattern that contributes to the development of the initial inertial instabilities and explore the different regimes under which these phenomena occur.

References:

[1] Gultepe, I. et al. (2019), "A review of high impact weather for aviation meteorology." Pure and Applied Geophysics, 176, pp.1869–1921.
[2] Williams, J. K. (2014), "Using random forests to diagnose aviation turbulence." Machine Learning, 95, pp.51-70.
[3] Meneguz, E., Wells, H. and Turp, D. (2016), "An automated system to quantify aircraft encounters with convectively induced turbulence over Europe and the Northeast Atlantic." Journal of Applied Meteorology and Climatology, 55(5), pp.1077-1089.
[4] Thompson, C. F. and Schultz, D. M. (2021), "The release of inertial instability near an idealized zonal jet." Geophysical Research Letters, 48(14), e2021GL092649.