1.71 Is climate change increasing atmospheric turbulence?

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Earth's atmosphere is a fluid that exhibits turbulence on length scales ranging from the planetary scale of thousands of kilometres to the Kolmogorov scale of a few millimetres. An important mechanism for generating atmospheric turbulence is the Kelvin–Helmholtz shear instability, which occurs mainly in the jet streams. The resulting clear-air turbulence is invisible and hazardous to flying aircraft. Anthropogenic climate change is modifying the jet streams by strengthening the vertical wind shear at aircraft cruising altitudes. Such a strengthening is expected to increase the prevalence of the shear instabilities that generate clear-air turbulence.

Here we use numerical simulations of the global atmospheric flow to analyse how shear-driven turbulence responds to climate change. We find that the probability distributions for an ensemble of 21 transatlantic wintertime clear-air turbulence diagnostics generally gain probability in their right-hand tails when the atmospheric carbon dioxide concentration is increased. By converting the diagnostics into eddy dissipation rates, we find that the ensemble-average airspace volume containing light turbulence increases by 59% (with an intra-ensemble range of 43%–68%), moderate by 94% (37%–118%), and severe by 149% (36%–188%). We find similar increases in all seasons worldwide, with some busy flight routes experiencing several hundred per cent more turbulence.

Our results suggest that clear-air turbulence will intensify in all aviation-relevant strength categories as the climate continues to change. We conclude that aircraft flights will become significantly bumpier in future. Flight paths may need to become more convoluted to avoid patches of turbulence that are stronger and more frequent, in which case journey times will lengthen and fuel consumption and emissions will increase.