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Increased light, moderate, and severe clear-air turbulence in response to climate change

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Anthropogenic climate change is expected to strengthen the vertical wind shears at aircraft cruising altitudes within the atmospheric jet streams. Such a strengthening would increase the prevalence of shear instabilities, which generate clear-air turbulence. Climate modelling studies have indicated that the amount of moderate-or-greater clear-air turbulence on transatlantic flight routes in winter will increase significantly in future as the climate changes. However, the individual responses of light, moderate, and severe clear-air turbulence have not previously been studied, despite their importance for aircraft operations.

Here we use climate model simulations to analyse the transatlantic wintertime clear-air turbulence response to climate change in five aviation-relevant turbulence strength categories. We find that the probability distributions for an ensemble of 21 clear-air turbulence diagnostics generally gain probability in their right-hand tails when the atmospheric carbon dioxide concentration is doubled. By converting the diagnostics into equivalent eddy dissipation rates, we find that the ensemble-average airspace volume containing light clear-air turbulence increases by 59% (with an intra-ensemble range of 43–68%), light-to-moderate by 75% (39–96%), moderate by 94% (37–118%), moderate-to-severe by 127% (30–170%), and severe by 149% (36–188%). These results suggest that the prevalence of transatlantic wintertime clear-air turbulence will increase significantly in all aviation-relevant strength categories as the climate changes.