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Clear-air turbulence in a changing climate

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Clear-air turbulence (CAT) is projected to intensify in response to future climate change, as the meridional temperature gradient across the jet streams strengthens at flight cruising altitudes, largely due to amplified warming at low latitudes associated with the tropical upper-tropospheric warming hotspot. However, our understanding of past trends in the jet streams and associated CAT is currently limited.

Here we first analyse past trends in jet stream vertical wind shear in three different reanalysis datasets since 1979. We find that the shear at flight cruising altitudes has strengthened by 15%. We show that this change is attributable to the thermal wind response to the enhanced upper-level meridional temperature gradient.

We then analyse CAT trends globally since 1979 in a reanalysis dataset using 21 diagnostics. We find clear evidence of large increases around the globe at aircraft cruising altitudes. For example, at an average point over the North Atlantic, the total annual duration of light-or-greater CAT increased by 17% from 466.5 hours in 1979 to 546.8 hours in 2020, with even larger relative changes for moderate-or greater CAT (increasing by 37% from 70.0 hours to 96.1 hours) and severe-or-greater CAT (increasing by 55% from 17.7 hours to 27.4 hours).

We conclude that CAT has increased around the globe over the past four decades. Future projections using climate models indicate a doubling or trebling in the amount of severe CAT in the jet streams in the coming decades. These projections suggest the need for various scientific and technological interventions, such as improved CAT forecasts, in order to prevent the increased volume of CAT in the atmosphere from translating into increased CAT encounters by aircraft.