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Jet streams in a changing climate: evidence for large increases in shear and turbulence since 1979

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The jet streams are a crucial part of the global atmospheric circulation. Jet streams are highly sheared regions of the atmosphere, leading to Kelvin–Helmholtz instability and the generation of clear-air turbulence (CAT), which affects flying aircraft. Wind shear and CAT at flight cruising altitudes are projected to increase in response to future climate change, as the meridional temperature gradient across the jet streams strengthens, largely due to amplified warming at low latitudes associated with the tropical upper-tropospheric warming hotspot. However, our understanding of past trends in jet stream wind shear and CAT is currently limited. Here we 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%, and 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 during 1979–2020 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). Future projections using climate models indicate a 17-29% increase in vertical wind shear in the upper-level jet streams by 2100, as well as a possible tripling in the amount of severe CAT. We conclude that the jet streams are becoming more sheared because of climate change, generating more turbulence, with important implications for the future of air travel.