

## HOW WILL CLIMATE CHANGE AFFECT FLIGHT ROUTES AND TURBULENCE?

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**Abstract.** The atmosphere's meteorological characteristics affect flight routes, journey times, and turbulence. Therefore, climate change has potentially important consequences for aviation.

To investigate the influence of climate change on turbulence, we diagnose an ensemble of 21 clear-air turbulence measures from climate model simulations. We find that turbulence strengthens significantly under climate change, all around the world, in all seasons, and at a wide range of aircraft cruising altitudes. For example, within the transatlantic flight corridor in winter at around 39,000 feet, the occurrence of light turbulence increases by an ensemble-mean value of 59% (with an intra-ensemble range of 43–68%), moderate by 94% (37–118%), and severe by 149% (36–188%). The prospect of more unplanned deviations around turbulence threatens to increase fuel consumption and emissions, at a time when the aviation sector has committed to lowering them.

To investigate the influence of climate change on journey times between London and New York, we feed atmospheric wind fields generated from climate model simulations into a flight routing algorithm. We find that a CO<sub>2</sub>-induced strengthening of the prevailing jet-stream winds causes eastbound flights to shorten and westbound flights to lengthen in all seasons. For example, eastbound and westbound crossings in winter become approximately twice as likely to take under 5 hours 20 minutes and over 7 hours, respectively. Even assuming no future growth in aviation, these results suggest that transatlantic aircraft will collectively be airborne for an extra 2,000 hours each year, burning an extra 7.2 million gallons of jet fuel at a cost of \$22 million, and emitting an extra 70 million kilograms of CO<sub>2</sub>.

The above examples illustrate how climate change may inadvertently increase the environmental impact of aviation. The two-way interaction between aviation and climate change is an emerging research area that deserves further study.

**Keywords:** turbulence, jet stream, flight routes, flight times