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Does ENSO Affect Global Clear-Air Turbulence?

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Clear-air turbulence (CAT) is a major hazard to flying aircraft. It is generated by vertical wind shear instabilities in the upper troposphere and lower stratosphere. The El Niño–Southern Oscillation (ENSO) is known to affect the global atmospheric circulation, including the Walker and Hadley cells and the mid-latitude jet streams. Therefore, ENSO has the potential to influence global CAT, both locally in the tropics and remotely in the extra-tropics via teleconnections. Anecdotal evidence supports such an association: there was a large increase in pilots reporting turbulence when flying over the USA during the winter of 1997–98, coinciding with one of the strongest El Niño events on record. However, the influence of ENSO on CAT has not previously been studied.

Here we use reanalysis data to investigate linkages between ENSO and vertical wind shear (and hence CAT) in northern hemisphere winter. Global maps of the anomalous vertical wind shear at 250 hPa are produced from composites of the five strongest El Niño and La Niña events since 1979. These maps indicate that the shear is significantly modified throughout the ENSO cycle across large parts of the globe, including the mid-latitudes and polar regions. The changes are quantified by regressing wind shear in selected high flight-density areas from each winter since 1979 against sea-surface temperature anomalies in the Niño 3.4 region. In the USA and Mexico, for example, we find a sensitivity of around 0.5 m s^{-1} (100 hPa)$^{-1}$ °C^{-1}, such that the shear increases by around 50% from 4 m s^{-1} (100 hPa)$^{-1}$ during a strong La Niña event to 6 m s^{-1} (100 hPa)$^{-1}$ during a strong El Niño event. Significant ENSO–shear relationships are also found in South America, the North Atlantic Ocean, East Asia, South-East Asia, Australia, and Africa.

This study provides the first evidence that ENSO has the potential to influence CAT globally. ENSO's predictability could be exploited to produce seasonal CAT forecasts globally up to 12 months ahead, which may have practical benefits for the aviation sector, not least because turbulence increases aircraft fuel consumption.