Impact of Large-Scale Climate Variability to Long-Haul Flight Route

Jung-Hoon Kim, NOAA/NWS/NCEP/Aviation Weather Center
jung-hoon.kim@noaa.gov; jhkim99.phd@gmail.com

co-authors: Matt Strahan (NOAA/AWC), Robert Sharman (NCAR/RAL)
speaker: Jung-Hoon Kim

Mid-latitude jet streams have seasonal and inter-annual variabilities in strength and position, which are correlated with large-scale climate variabilities like the North-Atlantic Oscillation (NAO) and El-Nino Southern Oscillation (ENSO). Near the jet stream, Clear-Air Turbulence (CAT) frequently occurs, mainly due to the shear instability. For safe and efficient strategic flight planning, it is beneficial to study the impact of large-scale climate variability on flight planning and CAT.

Wind-Optimal Route (WOR) is calculated using the global reanalysis data with 0.5 × 0.5 degree of horizontal grid spacing, which considers wind variations in the flight trajectory modeling to minimize total flight time between two city points anywhere in the world. Then, overall flight times and potential CAT encounters from turbulence along the simulated routes are calculated using the longer-term reanalysis data. We conducted two experiments. The EXP1 is for a city pair between John F. Kennedy International Airport (JFK) in New York and Heathrow Airport (LHR) in London during the wintertime of extremely positive (2004-05) and negative (2009-10) NAO periods to see the impact of NAO pattern to flight route and CAT. Another (EXP2) is for a city pair between Hawaii and western coast of US during extremely positive (1997-98) and negative (1998-99) ENSO periods.

In EXP1, the Eastbound (EB) WORs from JFK to LHR are shifted northward to take advantage of the strong tail winds (to reduce total flight time/fuel used), while Westbound (WB) WORs from LHR to JFK disperse to avoid the strong head winds near the jet stream during the positive NAO phase (2004-05) period. On the other hand, in negative NAO phase (2009-10), the EB WORs shift southward to take an advantage of southerly shifted jet stream, while the WB WORs are close to Great Circle routes (shortest distance) due to an absence of strong head winds. Turbulence encounters along the WORs are higher in EB than WB, because EB generally flies close to the strong jet stream to benefit from the tail winds.

In EXP2, EB WORs from Hawaii to the West coast are shorter and faster in positive ENSO period than those in negative ENSO period, because + ENSO modulates the mid-latitude Pacific jet to be elongated to further East. Turbulence potentials are higher in + ENSO than – ENSO period. This suggests a good relationship between the large-scale climate weather patterns and optimal (i.e., minimum fuel used and minimum chance of turbulence encounters) long-haul flight routes, which can be useful for long-term strategic planning for aviation.

Reference