Integrated Wind and Turbulence Forecasts for Automated Flight Route Planning

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With recent improvements in observational techniques and computer capabilities in the Numerical Weather Prediction (NWP) models, the performance skill in forecasting upper-level winds has been increased continuously, which provides huge benefits for the aviation industry. For example, the average wind speed errors near the jet stream have decreased by about 45\% from 13 to 8 m s\(^{-1}\), which gives less uncertainty in both head and tail winds for long-haul flights, enhancing efficient flight route planning and reducing extra fuel consumptions (Ralph 2016). These improvements in wind forecasts, combined with the application of the multi-diagnostic method of the Graphical Turbulence Guidance (GTG; Sharman et al. 2006) have led to better aviation situational awareness and flight planning.

This paper introduces an example of the integrated wind and turbulence forecasts for automated flight route planning with wind-optimal and lateral avoidance trajectory modeling, which is more applicable for the most important and vertically deep weather hazards like Convectively Induced Turbulence (CIT) and Mountain Wave Turbulence (MWT). An example is provided for a case on 7 Sep 2013, for which a convection-permitting scale (dx = 3 km) high-resolution NWP model captured the background winds and convective clouds very well. Time-lagged ensembles of the GTG-like forecasts give laterally wide and vertically deep areas of potential turbulence encounters, which is applied to the flight trajectory model for a single flight route between the Los Angeles International Airport (LAX) and John F. Kennedy International airport (JFK). As a result, timely different maneuvers of the Lateral Turbulence Avoidance Routes (LTAR) along the Wind-Optimal Route (WOR) from LAX to JFK illustrate the idea of trade-offs that can be made between total flight time/fuel consumption (efficiency) and lateral turbulence avoidance (safety).

Reference