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Application of Random Forest to a Global Low-level Aviation Turbulence Forecasting System

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The mechanisms of turbulence in the lower troposphere are significantly more complex than in the mid- and upper troposphere, resulting in poorer aviation turbulence forecasting at lower levels (below 10,000 ft). Recent advances in machine learning can offer promising solutions for improving turbulence forecasts in these lower levels. In this study, we developed a Random Forest (RF) model to predict low-level turbulence and evaluated its performance against observations and the global Korean aviation Turbulence Guidance (G-KTG) system used by the Korea Meteorological Administration (KMA). The RF model was trained with about 2 million observation-prediction pairs and 78 turbulence diagnostics from Global Data Assimilation and Prediction System (GDAPS) for 2022. The observational data included in-situ flight eddy dissipation rate (EDR) from the International Air Transport Association (IATA). The RF model demonstrated exceptional performance, with a high correlation coefficient and an area under the ROC curve (AUC) exceeding 0.9. It outperformed the G-KTG system, particularly in predicting moderate-to-severe turbulence and reducing overestimation of null intensity turbulence. Optimization reduced the input variables from 78 to 13 without significantly compromising performance, proving the model's practical effectiveness. The RF model also showed reliable prediction patterns consistent with physical phenomena like orography and convective activity, though its accuracy was lowest during June-August.

Key words: Low-level turbulence (LLT), Random Forest, in-situ flight EDR, GTG system, forecast