Development and Application of a Machine-Learning-Based Objective Consensus Track System (TOPCON) and a Web-Based Typhoon Forecast Verification Platform

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Abstract

With the operational deployment of AI-based weather models such as ECMWF AIFS, NCEP AIGFS, and Google DeepMind FGN/GenCast, the number of typhoon track forecast sources available to forecasters has grown substantially. Objectively integrating multi-model guidance while monitoring model performance in real time has therefore become an important operational challenge. This study presents two complementary systems. The first is TOPCON, a machine-learning-based objective consensus track system. Using a gradient-boosted decision tree model (LightGBM), TOPCON predicts the expected track error of each individual model forecast point based on features including forecast lead time, model category and data latency, storm position, intensity, and motion at initialization, cross-model ensemble spread, and recent rolling error statistics. The consensus track is then synthesized through inverse-error weighting of member positions. Validation adopts leave-typhoon-out cross-validation and compares against two baselines: a median consensus and a static weighting scheme based on historical errors. Results show improvement at short-to-medium lead times, while a weight-shrinkage strategy toward the median consensus maintains robustness at longer lead times. The second system is a web-based typhoon forecast verification platform built on a pure front-end architecture, in which DuckDB-WASM directly queries a Parquet-format track database in the browser. It supports three verification modes—non-homogeneous, homogeneous, and operationally synchronized (shifting forecast lead times according to each model's data latency)—and interactively computes track, intensity, and translation-speed errors, along with year-by-year verification of official forecasts and subjective forecasts from international agencies. The platform has no external dependencies, making it suitable for offline deployment within the agency's intranet. Together, the two systems provide forecasters with end-to-end decision support, from multi-model consensus guidance to real-time performance verification. Future work will incorporate additional AI model members and expand the verification metrics.

Keywords: typhoon track forecast, consensus forecasting, machine learning, forecast verification, DuckDB-WASM