



ICAO

*International Civil Aviation Organization***INFORMATION PAPER****Twenty-fourth Meeting of the Meteorology Sub-group (MET SG/24) of the Asia and Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG)**

Web-conference, 16 – 20 November 2020

Agenda Item 5: Research, development and other initiatives**DEVELOPMENT OF ETE FOR PROVISION OF HIGH RESOLUTION
TURBULENCE FORECAST**

(Presented by Hong Kong, China)

SUMMARY

This paper presents the verification results of ETE, an hourly turbulence guidance product based on the consensus of a suite of forecast turbulence indices derived from NWP forecasts for Electronic Flight Bag meteorological application for enhanced turbulence mitigation in flight.

1. INTRODUCTION

1.1 The airline operators and flight crews had repeatedly expressed the need for turbulence forecast in the form of turbulence intensity rather than turbulence potential at various international and local forums. In order to meet the immediate needs of the users and taking the opportunity to develop an Electronic Flight Bag (EFB) meteorological application - MyFlightWx in collaboration with Cathay Pacific Airways (CPA) which allows for the provision of additional high spatial and temporal resolution data, the Hong Kong Observatory (HKO) had developed an in-house turbulence forecast product based on Ellrod index which forecast turbulence based on vertical wind shear, deformation and convergence ([MET/S WG/8-IP/09](#)) to provide additional guidance in respect of turbulence intensity. To enhance the turbulence guidance available on EFB, the HKO has recently developed the ETE (stands for **En-route Turbulence in EDR**). This paper reports on the verification results of ETE based on actual turbulence measurement from CPA B777 fleet.

2. DISCUSSION

2.1 ETE is an hourly turbulence guidance product with intensity given in ICAO adopted turbulence metric, the eddy-dissipation rate (EDR). The forecast is available at a spatial resolution of 0.125° at 6 vertical levels from FL140 to FL390, covering the most common flight levels of en-route flights in the region. There were plans to further extend the vertical extent of ETE.

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2.2 ETE is a consensus forecast based on a suite of turbulence indices from NWP forecasts. The forecast consensus is the result of weighted average of normalized turbulence indices in a way similar to that in the Graphical Turbulence Guidance (GTG) developed by National Center of Atmospheric Research (NCAR). The weight of individual indices were optimized locally using the EDR derived from the data recorded by the Quick Access Recorder (QAR) on board of CPA and Cathay Dragon (HDA) aircrafts where turbulence was reported between June 2015 and April 2018.

2.3 With the fleet of CPA Boeing 777 enhanced to equip with an on-board software to derive and report EDR values in 2019, the performance of ETE was validated against these reported EDR values over the period between May 2020 and September 2020.

2.4 Given the expressed user need is for high spatial and temporal resolution EDR information, validation was conducted in a stringent way with each EDR observations verified against the forecast EDR in the nearest forecast grid (in a resolution of $0.125^\circ \times 0.125^\circ$, 16 km in equatorial region) valid at or on the hour of the observations, i.e. at EDR observation at 05:40 UTC is validated against the forecast valid at 05:00 UTC. The horizontal resolution of $0.125^\circ \times 0.125^\circ$ is chosen to match with the EDR observations, which were reported at frequency of up to every minute and corresponds to a spatial distance of 15 km when the EDR is above pre-set threshold.

2.5 The performances of ETE at two EDR thresholds of moderate severity are shown in Fig. 1 and Fig. 2. The forecast from ETE for a turbulence case in May 2020, overlaid with the EDR observations from a CPA flight, is shown in Fig. 3. The Area under ROC curve (AUC) for Moderate or Greater (MOG) is 0.653 and out-performs that of existing turbulence intensity forecast based on Ellrod index. While the AUC is a bit lower compared with the 3-hourly GTG turbulence intensity forecast at 0.25° grids, considering the stringent verification requirements adopted here, the result is considered not bad.

3. FUTURE PLAN

3.1 ETE is currently available to HKO aviation forecasters for internal trial. Further tuning would be conducted based on a larger sample size. With the overlaying of real-time EDR from earlier flights on MyFlightWx for easy comparison, the ETE should provide the pilots with a good appreciation of the turbulence intensity ahead. Pending agreement of user, HKO plans to replace the Ellrod index in EFB with ETE.

4. ACTION BY THE MEETING

4.1 Note the information contained in this paper.

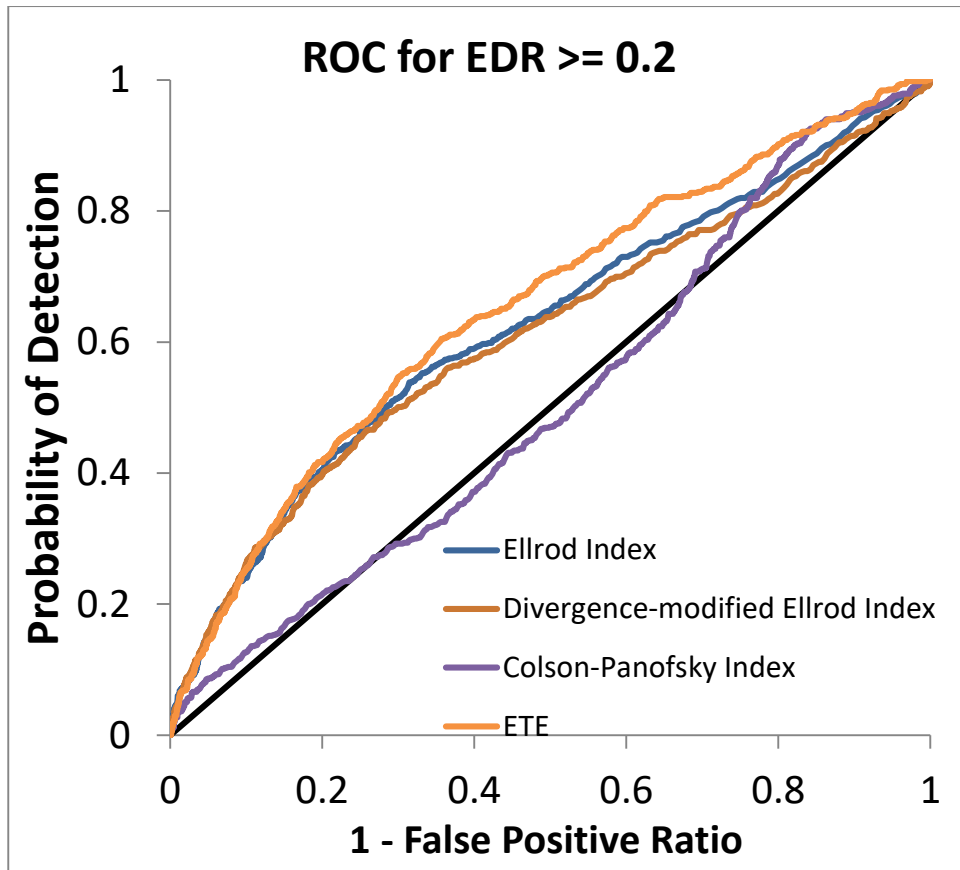


Fig. 1 shows the performance of ETE in forecasting the 1-minute peak EDR validated against the EDR values reported by the Boeing-777 flights of CPA over the period between May 2020 and September 2020. For comparison, the performance of a handful of common turbulence indices under the same validation methodology is also included. Ellrod index is the turbulence intensity product currently made available on MyFlightWx.

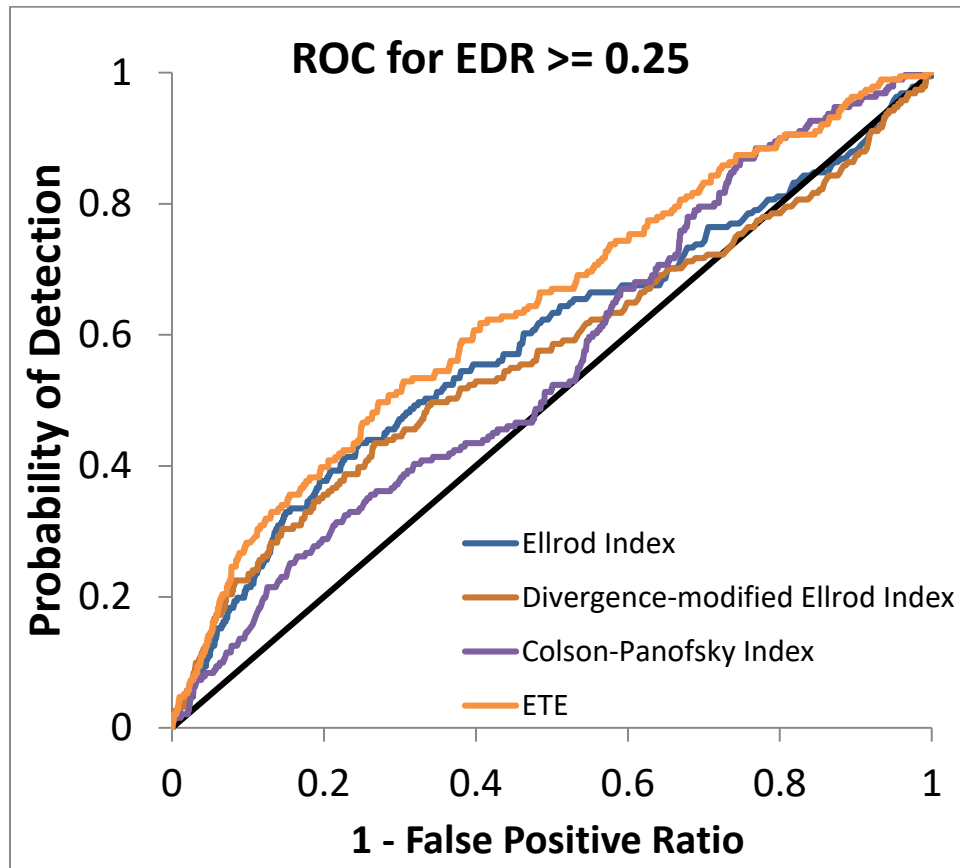


Fig. 2 same as Fig. 1 except the EDR threshold is 0.25.

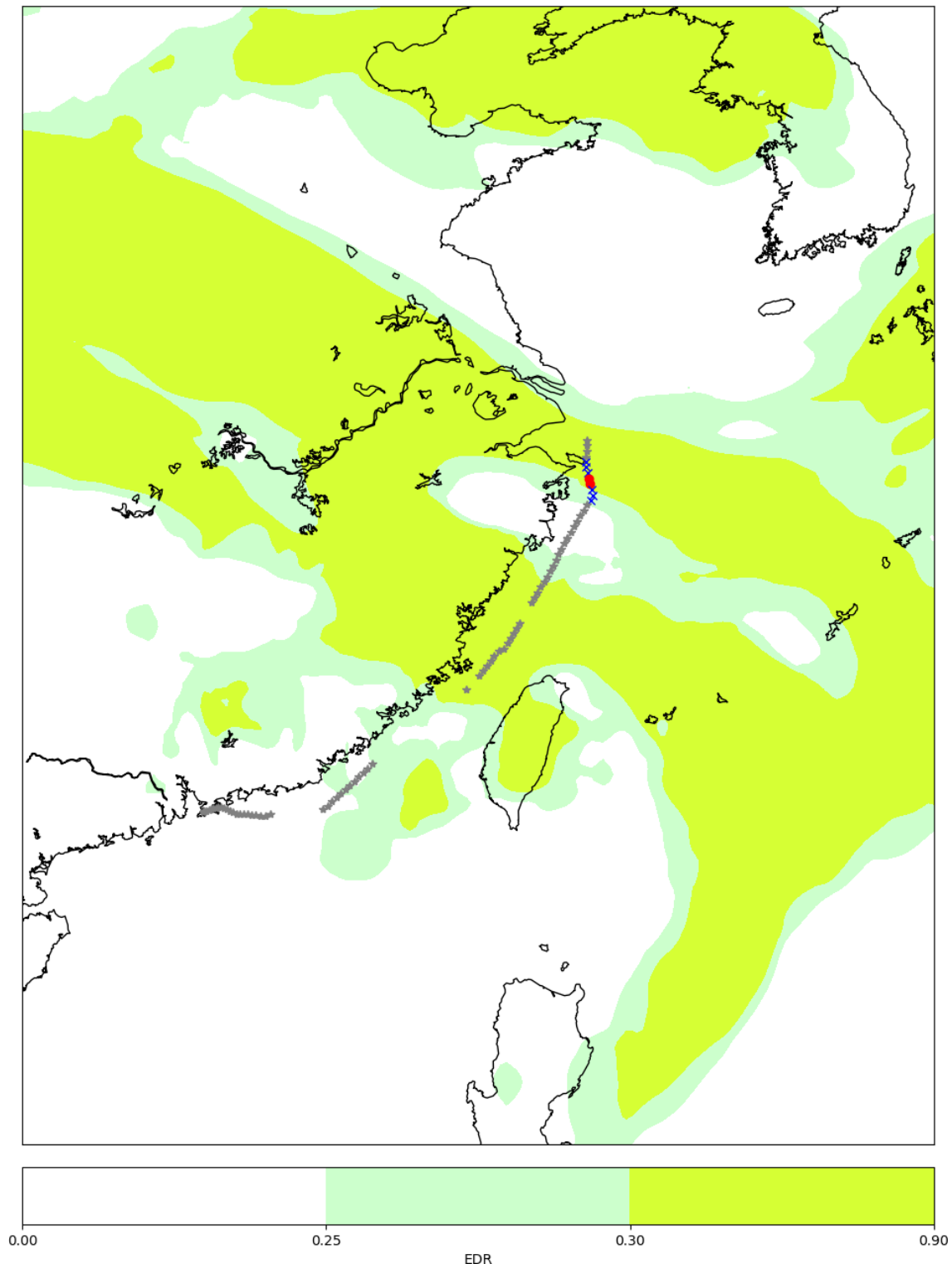


Fig. 3 shows the EDR forecast from ETE overlay with the EDR observations (markers of various types) from a CPA flight in the region. The observed EDR is indicated by the colors and type of the markers. Red circles are EDR observation with $EDR \geq 0.25$, while blue crosses are for $EDR < 0.25$. Grey asterisk are other EDR observations made either at a different flight levels, or paired to forecast from ETE at a different valid time. When turbulence is detected by the aircraft, the reporting frequency of the EDR will increase from every 20 minutes to every 1 minute. The exact date and flight level of the forecast is not shown for confidentiality of the CPA EDR observations.