International Civil Aviation Organization

INFORMATION PAPER

TWENTIETH MEETING OF THE METEOROLOGY SUB-GROUP (MET SG/20) OF THE ASIA/PACIFIC AIR NAVIGATION PLANNING AND IMPLEMENTATION REGIONAL GROUP (APANPIRG)

Bangkok, Thailand, 6 – 9 June 2016

Agenda Item 6: Research, development and implementation issues in the MET field

6.1 Observations, reports, forecasts, advisories and warnings

DEVELOPMENT OF A COMPREHENSIVE TURBULENCE INDEX BASED ON THE GLOBAL MODEL TO SUPPORT THE ISSUANCE OF SIGMET

(Presented by Japan)

SUMMARY

This paper presents a comprehensive turbulence forecast index developed by the Japan Meteorological Agency (JMA) to support the issuance of SIGMET. Known as the TBindex, this metric is a composite of multiple turbulence indices that enables prediction for various kinds of turbulence at all heights. It was originally developed for SIGMET in the Fukuoka FIR and for domestic SIGWX prognostic charts covering areas around Japan, and the related forecast area was recently expanded to the Asia-Pacific region. The TBindex helps to reveal areas of moderate and greater (MOG) turbulence events more accurately than other conventional turbulence indices. The TBindex will be put into operation in June 2016, and is expected to help improve forecast accuracy.

1. INTRODUCTION

1.1 Turbulence is a major hazard for aircraft in flight. Especially when sudden and strong, it can cause discomfort and even injury to passengers and crew. Against such a background, highly accurate turbulence forecasting is necessary to support flight safety and efficiency.

1.2 The Japan Meteorological Agency (JMA) developed a turbulence index called TBindex that can be comprehensively used for the prediction of various kinds of turbulence (CNS/MET SG/14-IP/26). As the index is derived from a regional numerical weather prediction model, it is used for the issuance of SIGMET in the Fukuoka FIR and domestic SIGWX prognostic charts covering areas around Japan.

1.3 JMA's recent development of the TBindex based on the Agency's global numerical weather prediction model was intended to support the issuance of SIGMET advisories in the Asia-Pacific region. The results of related verification showed that the index improves forecast accuracy significantly over that observed with conventional turbulence indices. The TBindex has been in test operation since December 2015, and will be put into full operation in June 2016.

2. OUTLINE

2.1 The TBindex is a combination of multiple turbulence indices such as the Graphical Turbulence Guidance system (Sharman et al. 2006). It consists of five independent CAT indices (wind shear-related and curvature-related) and five non-CAT turbulence indices (mountain wave-related and cloud-related) derived from JMA's global numerical weather prediction model. These indices were selected using a stepwise method based on Akaike's information criterion, and are compounded via logistic regression using common-PIREP data (MET/14-IP/29 CAeM-15/INF. 29) for the period from December 2013 to November 2015. Approximately 1.5 million PIREPs including coverage of around 14,000 moderate or greater (MOG) turbulence events from this period were used for the development of the TBindex. The regression equations are stratified and adjusted for every 2,000 ft from FL010 to FL550, allowing the TBindex to predict turbulence optimally over all heights at the same threshold (TBindex = 3.0).

2.2 Figure 1 shows results from TBindex verification for MOG turbulence reported using common-PIREP. The verification period was from December 2015 to April 2016, which is independent of the study period. Approximately 230,000 PIREPs including coverage of around 3,000 MOG turbulence events were collected during this time. To highlight accuracy, the figure also shows verification results for Ellrod's turbulence index (TI1) (Ellrod and Knapp 1992), vertical wind shear (VWS), and the Richardson number (Ri). A relationship between the hit rate (Hr) and the volume rate (Vr) for various thresholds is observed, where Hr and Vr represent the numerical ratio of correct forecasts to all MOG events and that of events reported in the forecast region to all events, respectively. In the figure, forecasts with large Hr and small Vr values have high forecast accuracy. That is, curve proximity to the upper left corner of the diagram represents superior precision. It can be seen that the TBindex improves forecast accuracy significantly over that observed with other conventional indices. For example, MOG turbulence forecasting with TBindex = 3.0 produces values of Vr = 0.029 and Hr = 0.23, while nearly twice the forecast volume (Vr = 0.057) is necessary to obtain the same hit rate (i.e., Hr = 0.23) with TI1.

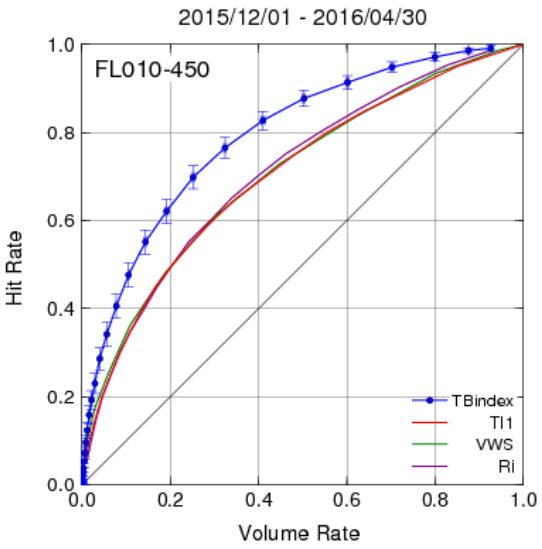

Figure 1. Results of turbulence index verification for MOG turbulence. Error bars indicate a 95% confidence interval.

2.3 Figure 2 (a) shows Common PIREP data for the area around FL230 covering the period between 02 and 04 UTC on 29 February 2016. The red, yellow, green, blue, light-blue and white dots indicate severe, moderate, light-plus, light, light-minus and nil turbulence, respectively. A large number of moderate turbulence events were reported around eastern Japan during this time. Figures 2 (b) and (c) show 15-hour forecasts with TBindex and TI1 for FL230 starting at 12 UTC on 28 February 2016. It can be seen that use of the TBindex resulted in accurate turbulence prediction, while accuracy with TI1 was insufficient.

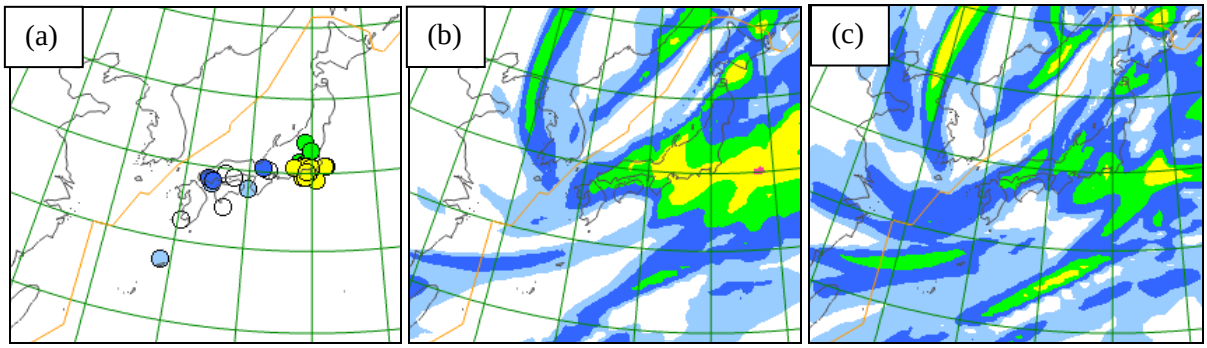

Figure 2. Results obtained with TBindex and TI1 for a 15-hour forecast starting at 12 UTC on 28 February 2016: (a) reported turbulence events; (b) TBindex; and (c) TI1. Red, yellow, green, blue, light-blue and white shading indicates severe, moderate, light-plus, light, light-minus and nil turbulence, respectively.

3. ACTION BY THE MEETING

3.1 The meeting is invited to note the information contained in this paper.

References

Ellrod, G. P. and D. I. Knapp, 1992: An Objective Clear-Air Turbulence Forecasting Technique: Verification and Operational Use, Wea. Forecasting, 7, 150-165.

Sharman, R., C. Tebaldi, G. Wiener, and J. Wolff, 2006: An Integrated Approach to Mid- and Upper-Level Turbulence Forecasting, *Wea. Forecasting*, **21**, 268-287.

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