



*International Civil Aviation Organization*

**FOURTEENTH MEETING OF THE  
COMMUNICATIONS/NAVIGATION/SURVEILLANCE AND METEOROLOGY SUB-GROUP OF  
APANPIRG (CNS/MET SG/14)**



Jakarta, Indonesia, 19 – 22 July 2010

**Agenda Item 1411: Implementation of SIGMET and warnings**~~Regional MET support to ATM 3) review METWSG SIGMET advisory2) exchange of information on MET support for operations at aerodromes, terminal areas and en-route~~

**DEVELOPMENT OF A NEW TURBULENCE INDEX**

(Presented by Japan)

**SUMMARY**

This paper presents a new turbulence index developed in the Japan Meteorological Agency. The new index called TBindex is constructed with multiple turbulence indices derived from the numerical weather prediction model, which can predict various kinds of turbulence (clear air turbulence, cloud related turbulences, mountain waves) over all height from lower to upper layer in a comprehensive manner. Verification results show that the forecast accuracy of TBindex is significantly better than that of other conventional turbulence indices. TBindex has been in test operation since February 2010 and was upgraded in June 2010. TBindex is soon going to be utilized as one of basic data for issuance of SIGMET and the domestic SIGWX prognostic chart.

This paper relates to:

**Strategic Objectives:**

- A: Safety – Enhance global civil aviation safety
- D: Efficiency – Enhance the efficiency of aviation operations

**Global Plan Initiatives:**

- GPI-18 Aeronautical Information
- GPI-19 Meteorological Systems

**1. Introduction**

1.1 The Japan Meteorological Agency (JMA) has responsibility to disseminate SIGMET information for Fukuoka FIR, which is the region most prone to turbulences in the world; Maximum wind speeds in jet streams sometimes exceed 200kt in winter; Baiu-fronts are formed during early summer; typhoons strike in summer and autumn; and the complex terrain in Japan induces mountain waves and wind shears. Several accidents are caused by turbulence around Japan every year, which make passengers and/or crew members injured. Accurate turbulence forecast is necessary in order to reduce the risk of turbulence.

1.2 Currently, JMA mainly utilizes vertical wind shear (VWS) for turbulence forecast

since VWS has good accuracy in our verification compared to other widely used conventional turbulence indices, e.g. the Ellrod index TI1 and TI2 (Ellrod and Knapp 1992), Richardson number, horizontal temperature gradient, etc. However, as it is an index intended to predict Kelvin-Helmholtz instability (KHI), VWS is not adequate to forecast turbulences unrelated to KHI, e.g. turbulence in convective clouds, mountain waves, etc.

1.3 Therefore we developed the new turbulence index called TBindex which can predict various kinds of turbulence in a comprehensive manner (Kudo 2010). It has been confirmed through verification results that the forecast accuracy of TBindex is significantly better than that of VWS or other conventional indices.

1.4 TBindex has been in test operation since February 2010, and was upgraded in June 2010. TBindex is soon going to be utilized as one of basic data for issuance of SIGMET and the domestic SIGWX prognostic chart. TBindex is expected to contribute to flight safety.

## 2. Outline of the new turbulence index

2.1 TBindex is constructed with multiple turbulence indices as with Dutton's empirical index (Dutton 1980) or the Graphical Turbulence Guidance (GTG) system (Sharman et al. 2006). TBindex consists of independent five CAT indices (wind shear related indices, stability related indices, and a curvature related index) and five non-CAT turbulence indices (mountain wave related indices and cloud related turbulence indices) derived from the numerical weather prediction model. These indices are selected by the stepwise method based on Akaike's information criterion, and they are compounded by the logistic regression technique with Common-PIREP data (Nakazawa 2003) collected around Japan between January 2008 and December 2009. The regression equations are stratified and adjusted in every 2,000ft from 1,000ft to 41,000ft so that TBindex can predict turbulences optimally over all height at the same threshold. It means that the operators can forecast optimally at one threshold regardless of the height or the cause of turbulence.

2.2 Figure 1 is an example of TBindex forecast, which shows 10-hour forecast based at 21UTC on 27 February 2010 for (a) FL350, (b) FL250, (c) FL150, (d) FL050. Red, yellow, green, blue, and light blue color indicate severe, moderate, light-plus, light, and light-minus turbulence respectively. TBindex is derived from the operational meso scale model (MSM) 8 times a day up to 15 hours (00, 06, 12, 18UTC initial) or 33 hours (03, 09, 15, 21UTC initial) from the initial time.

2.3 Figure 2 shows a performance of TBindex. The verification data used here are the Common-PIREP data collected around Japan over 5 months between January 2010 and May 2010, which are independent on the training data. In order to compare the forecast accuracy, verification results of TI1, VWS, Richardson number (Ri), horizontal temperature gradient (TEMPG), and horizontal wind shear (HWS), are also depicted in the same figure. The figure shows the relationship between PODy and 1-PODn for various thresholds, where PODy indicates probability of detection of moderate or greater turbulence reports and PODn indicates probability of detection of no moderate or greater turbulence reports. A larger PODy is better among the fixed 1-PODn forecast, and a smaller 1-PODn is better among the fixed PODy forecast. That is, the closer a curve locates upper left corner of the diagram, the better the forecast accuracy is. As we can see in Figure 2, TBindex has the best accuracy compared to other conventional indices.

## 3. Action by the Meeting

3.1 The meeting is invited to note the issues presented above.

### References

- Dutton, M. J. O., 1980: Probability forecasts of clear-air turbulence based of numerical model output, *Meteorological Mag.*, **109**, 293-310.
- Ellrod, G. P. and D. I. Knapp, 1992: An Objective Clear-Air Turbulence Forecasting Technique: Verification and Operational Use, *Wea. Forecasting*, **7**, 150-165.
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Nakazawa, S., 2003: The common criteria for magnitude of turbulence in Japan airspace, METLINKSG/7-IP/13.

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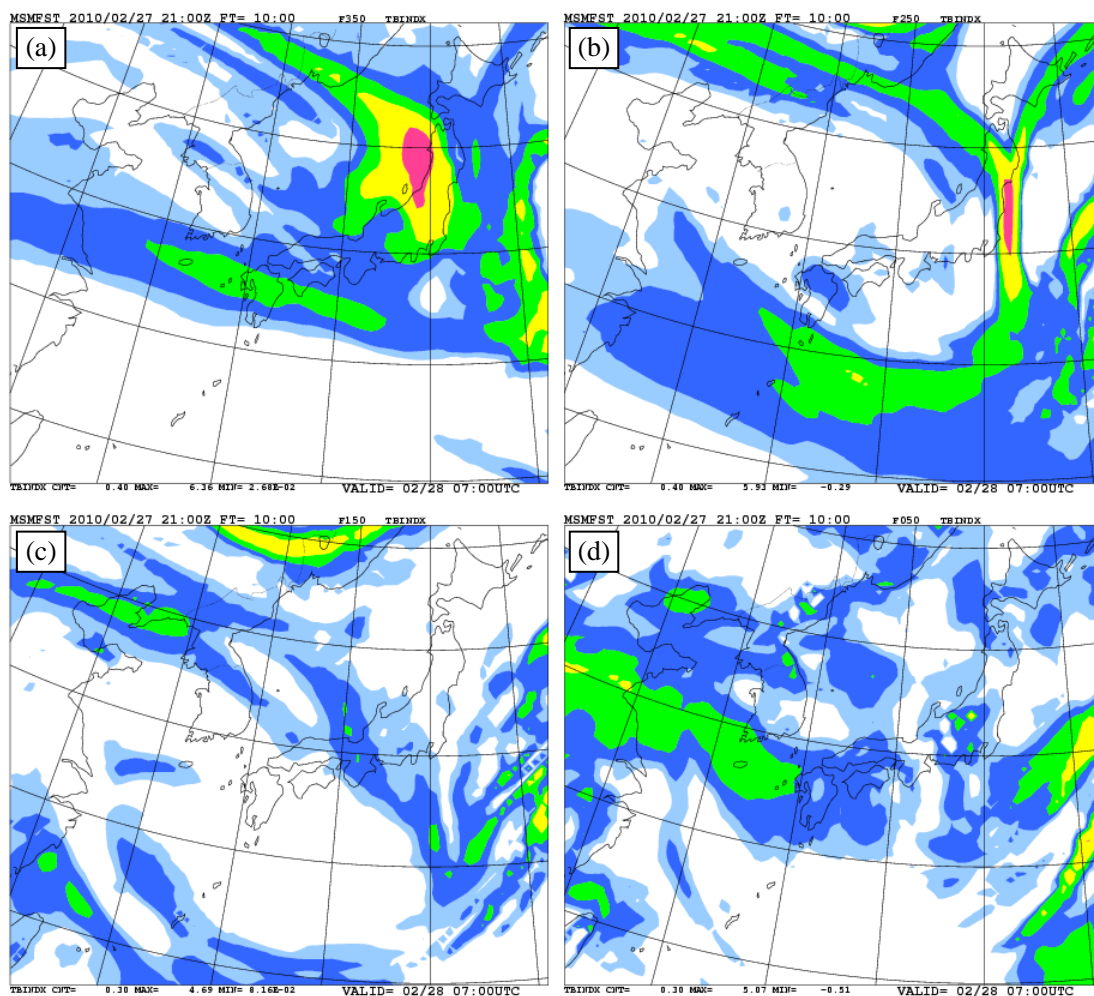


Figure 1 Example of TBindX. 10-hour forecast based at 21UTC on 27 February 2010. (a) FL350, (b) FL250, (c) FL150, and (d) FL050. Red, yellow, green, blue, and light blue color indicate severe, moderate, light plus, light, and light minus turbulence respectively.

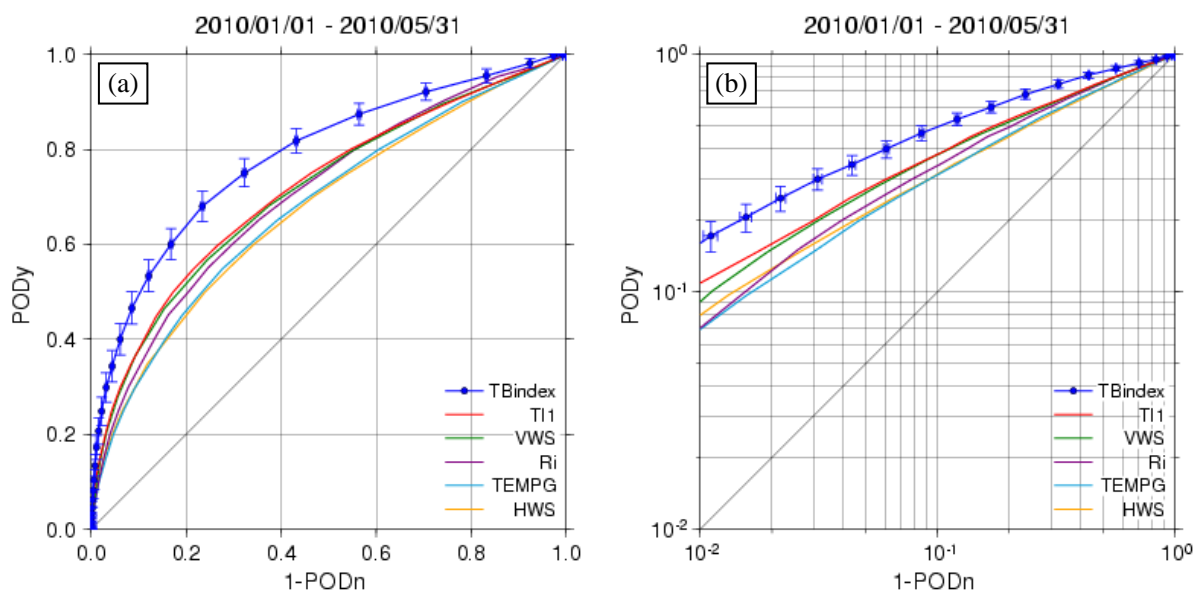


Figure 2 The relationship between PODy and 1-PODn for various thresholds: (a) linear plot and (b) log-log plot. The error bars indicate 95% confidence interval.