International Civil Aviation Organization

ELEVENTH MEETING OF THE COMMUNICATIONS/NAVIGATION/SURVEILLANCE AND METEOROLOGY SUB-GROUP OF APANPIRG (CNS/MET SG/11)

Bangkok, Thailand, 16 – 20 July 2007

Agenda Item 8 (3): Implementation of the World Area Forecast System (WAFS):

(3) Review the status of implementation and utilization of the WAFS products

PERFORMANCE OF WAFS GRIDDED PRODUCTS

(Presented by Hong Kong, China)

SUMMARY

This paper presents the feedback from airlines in respect of the perceived accuracy of WAFS temperature forecast near the tropopause in the polar region and initial observations of the trial gridded icing and turbulence forecasts of WAFC London.

1. INTRODUCTION

1.1 Amendment 74 to ICAO Annex 3 requires that aerodrome meteorological offices shall use forecasts issued by WAFCs in the preparation of flight documentation, whenever these forecasts cover the intended flight path in respect of time, altitude and geographical extent unless otherwise agreed between the meteorological authority and the operator concerned. The performance of the WAFS products is thus of great importance to all airline operators.

2. ISSUES RELATED TO POLAR TEMPERATURE FORECASTS

2.1 At the 1st WAFSOPSG meeting in 2003, IATA was tasked to develop proposals for WAFS output performance indicators in close coordination with IFALPA and WAFC Provider States (Conclusion 1/4). Subsequently the performance indicators were developed and are now routinely produced by the WAFCs. The performance indicator for WAFS temperature forecast is the root mean square (RMS) temperature error for 250 hPa (FL340) at T+24 h for the Northern Hemisphere, Tropics, Southern Hemisphere, North Atlantic, North Pacific, and Asia.

2.2 While the RMS temperature errors are generally less than 1 degree and well within the operationally desirable accuracy of forecasts, the WAFS temperature forecast however is perceived by a major airline to be inaccurate over the polar region. This perception was triggered by an encounter by a flight of a sudden increase in temperature, and a corresponding loss in aircraft performance, over the polar region during the past winter. This was probably caused by a sharp temperature inversion near the tropopause. In support of the polar flights, the Hong Kong

Observatory provides tailored temperature charts for the polar region generated from WAFC London GRIB forecasts for flight levels between FL300 and FL530.

2.3 Currently, the WAFS GRIB forecasts are only given for the standard levels. Even if the model is perfect and is able to forecast the strong temperature inversion, the sharp change in temperature (which might occur over a vertical scale of only a few hundred feet) is unlikely to be identifiable from the WAFS GRIB forecasts due to the coarse vertical resolution (see analysis by WAFC London for a sample case in Appendix A). Additional vertical levels in the WAFS GRIB forecasts near the tropopause would help reveal the sharp temperature gradient if the numerical model forecasts are accurate.

2.4 The meeting may wish to note that the WAFSOPSG has been studying the improvements in the vertical, temporal and horizontal resolutions of the WAFS forecasts and the IATA member of the WAFSOPSG, in coordination with the WAFC Provider States, has been tasked to perform an analysis of the additional WAFS costs and benefits of these improvements by September 2007 (WAFSOPSG Conclusion 3/11). It would be highly desirable if the above issue with the temperature forecasts near the tropopause over the polar region could be addressed as part of this WAFSOPSG task. If not, the meeting may wish to formulate the following draft conclusion to specifically address the issue:

Draft Conclusion 11/xx – Improvements of WAFS temperature forecasts near the tropopause over the polar region

That, ICAO be invited to consider ways to improve the provision of WAFS temperature forecasts near the tropopause over the polar region for enhancing the safety of polar flights.

3. INITIAL OBSERVATIONS ON TRIAL GRIDDED FORECASTS

3.1 Recommendation 1/10 of the MET Divisional Meeting (2002) called for WAFC Provider States, other States in a position to do so, and the WAFSOPSG, to continue and if possible, intensify the development of improved detection and forecast algorithms for turbulence and icing. Since then, progress had been made by WAFC London in the development of gridded forecasts for icing, turbulence and convective clouds. After some tests in early 2006, these fields were made available to users on a trial and evaluation basis from 25 October 2006. In order to foster future implementation and correct use of WAFS gridded forecast, WAFSOPSG/3 requested WAFSOPSG Members from IATA, IFALPA and user States to evaluate the trial gridded forecasts for icing, turbulence and convective clouds available from SADIS FTP service. The following paragraphs provide some of the observations in our initial evaluation of these trial products.

Icing Potential

3.2 Icing potential is the fraction of cloud in the layered cloud between -20 to 0°C temperature range. To assess the performance, the T+24 h icing potential forecasts were compared against the satellite imageries. In general, the product was able to capture the feature identified as potential icing area from the multi-channel satellite icing product based on Ellrod and Nelson (1996) although the exact location might differ slightly (see Figure 1).

3.3 Icing potential is also forecast for convective systems although it is supposedly a measure of the likelihood of encountering icing conditions in layered clouds. This might mislead users to think that no icing would be present in convective systems if not forecast. Furthermore, icing

was also reported in convective systems at altitudes above 300 hPa – beyond the highest level at which icing potential is currently available.

CAT potential

3.4 CAT potential is a measure of the likelihood of encountering moderate or severe clear air turbulence (resulting from windshear or mountain waves) per 100 km of route flown. According to SADIS FTP Service documentation V4.0, typical values of CAT potential for shear generated CAT are 0 to 25% and those for mountain wave generated CAT are 0 to 60%. Values greater than 4% indicate moderate to severe CAT.

3.5 Two moderate turbulence events near Hong Kong in May 2007 were studied to evaluate the performance of the CAT potential forecast. For the first case, the T+24 h forecast CAT potential was close to 3% nearest the event location. For the second event, while the T+24 h forecast CAT potential nearest the event location was only 0.5% and did not suggest the presence of turbulence, an area of CAT potential greater than 4% was forecast just to the south of the reported location (see Figure 2). Comparing the forecast CAT potential against the water vapour channel satellite imagery valid at the forecast time, it appears that the icing algorithm possesses some skills but further tuning with reference to pilot reports will be needed. It is also noted that no CAT was forecast by the WAFS SIGWX forecast for both events. The availability of this new gridded forecast is of value to the users.

In-cloud turbulence potential

3.6 In-cloud turbulence potential is a measure of the likelihood of encountering turbulence in layered cloud. According to SADIS FTP Service documentation V4.0, typical values of the forecast in-cloud turbulence potential range from 0 to 0.1. However, no suggested threshold for moderate or severe turbulence is given in the documentation.

3.7 Since there were no reports of in-cloud turbulence during the evaluation, no comparison could be made. However, it is noted that the association between the in-cloud turbulence potential forecast and the location of layered clouds does not appear high (Figure 3). Furthermore in-cloud turbulence potential is also forecast for convective systems. This might mislead users to think that no turbulence would be present in convective systems if not forecast.

3.8 The above observations were made based on a small number of selected events only. To ensure harmonization, guidance from WAFSOPSG on the use, interpretation and presentation of the new gridded WAFS forecasts are required before they could be put into operational use.

4. ACTION BY THE MEETING

4.1 The meeting is invited to:

(a) note the information provided in this paper; and

(b) consider the proposed draft conclusion.

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Appendix A

Analysis of a Sharp Temperature Inversion Case by WAFC London

I have looked for an example of a strong temperature inversion at the tropopause and I did not have to look long. Below are selected pressure and temperatures for a radiosonde ascent from Fort Nelson, Canada, WMO number 71945 at 12UTC on12 Apr 2007.

Hpa	m	FL	Temp
400.0	6880	225	-44.5
357.6	7620	250	-49.7
337.0	8010	263	-52.5
325.0	8246	271	-51.7
302.0	8726	286	-48.7
300.0	8770	288	-48.9
296.8	8839	290	-49.3
283.3	9144	300	-51.3
275.0	9337	306	-52.5
264.0	9601	315	-52.1
256.0	9803	322	-46.7
250.0	9960	327	-47.3
246.3	10058	330	-47.8
239.0	10257	336	-48.7
224.6	10668	350	-47.1
203.0	11340	372	-44.5
200.0	11440	375	-45.1

As you can see, there is a sharp temperature inversion, an increase in temperature of 5.4C between FL315 and FL322. Now, let us assume for the purposes of this illustration that the WAFS forecast is 'perfect' and the same as the radiosonde ascent.

In this example, the temperatures distributed via WAFS will be for the standard levels 400, 300, 250, 200 Hpa etc. Thus forecast temperatures would be:

400hpa Ms45
300hpa Ms49
250hpa Ms47
200hpa Ms45

The sudden change from MS52 to MS46 at 260 Hpa would not be apparent from this forecast.

This illustrates that the coarse vertical resolution of the WAFS forecast temperatures is unlikely to identify a sudden increase in temperature at the tropopause.

The addition of 2 extra levels at 275 and 225 Hpa which is being considered by the WAFSOPSG would provide the following:

300hpa Ms49
275hpa Ms53
250hpa Ms47
225hpa Ms47
200hpa Ms45

In this case, the temperature inversion is identified correctly between 275 and 250hpa (FL306-327). However we know that the change occurs over a vertical depth of 700 feet. (in reality it is probably even sharper than this).

The indication is that additional vertical levels will help resolve the temperature changes at the tropopause.

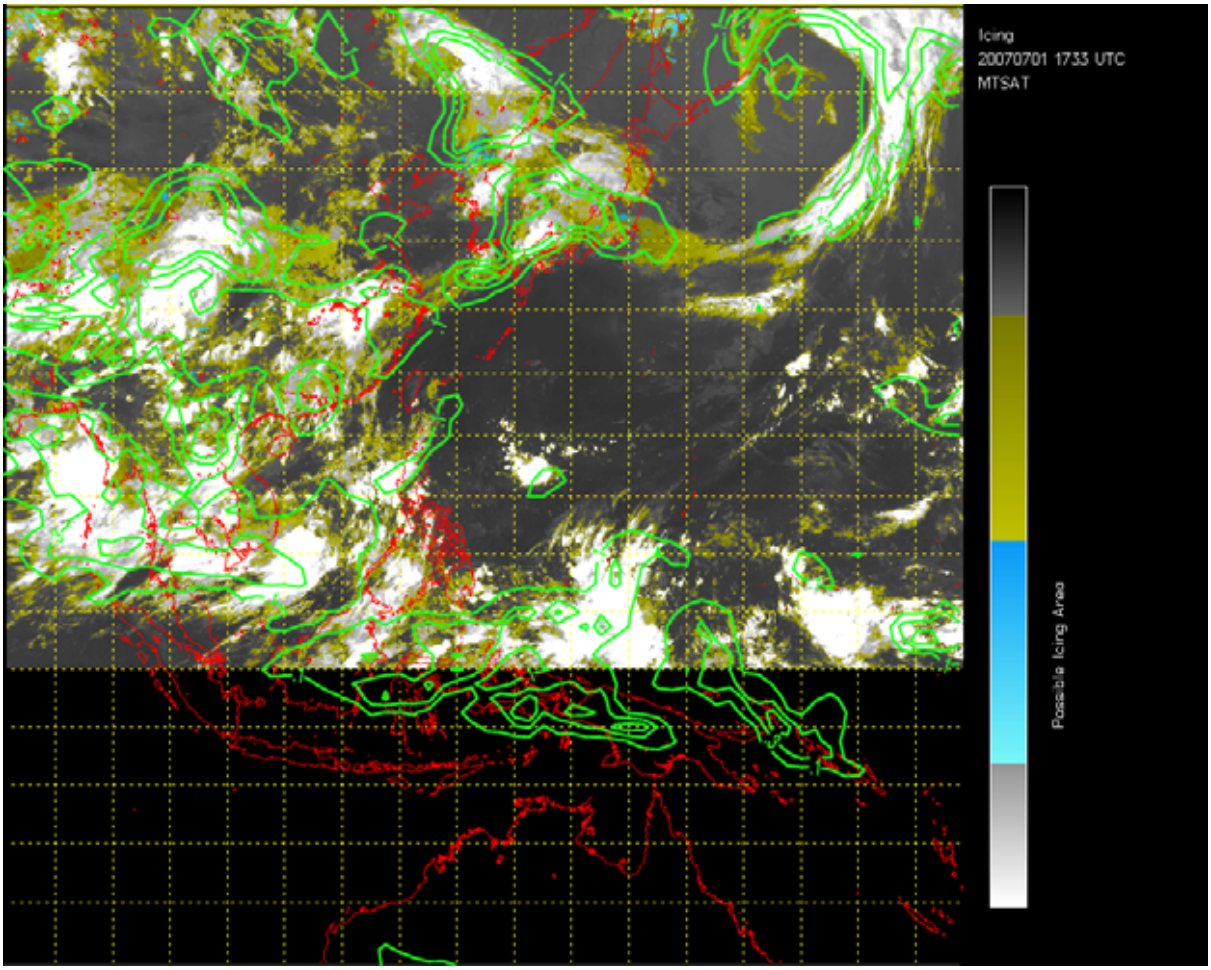

Figure 1. T+24 h forecast icing potential at 700 – 300 hPa valid for 1800Z 1 July 2007 overlaid on top of the MTSAT IR4-IR1 satellite picture at 1733Z on the same day.

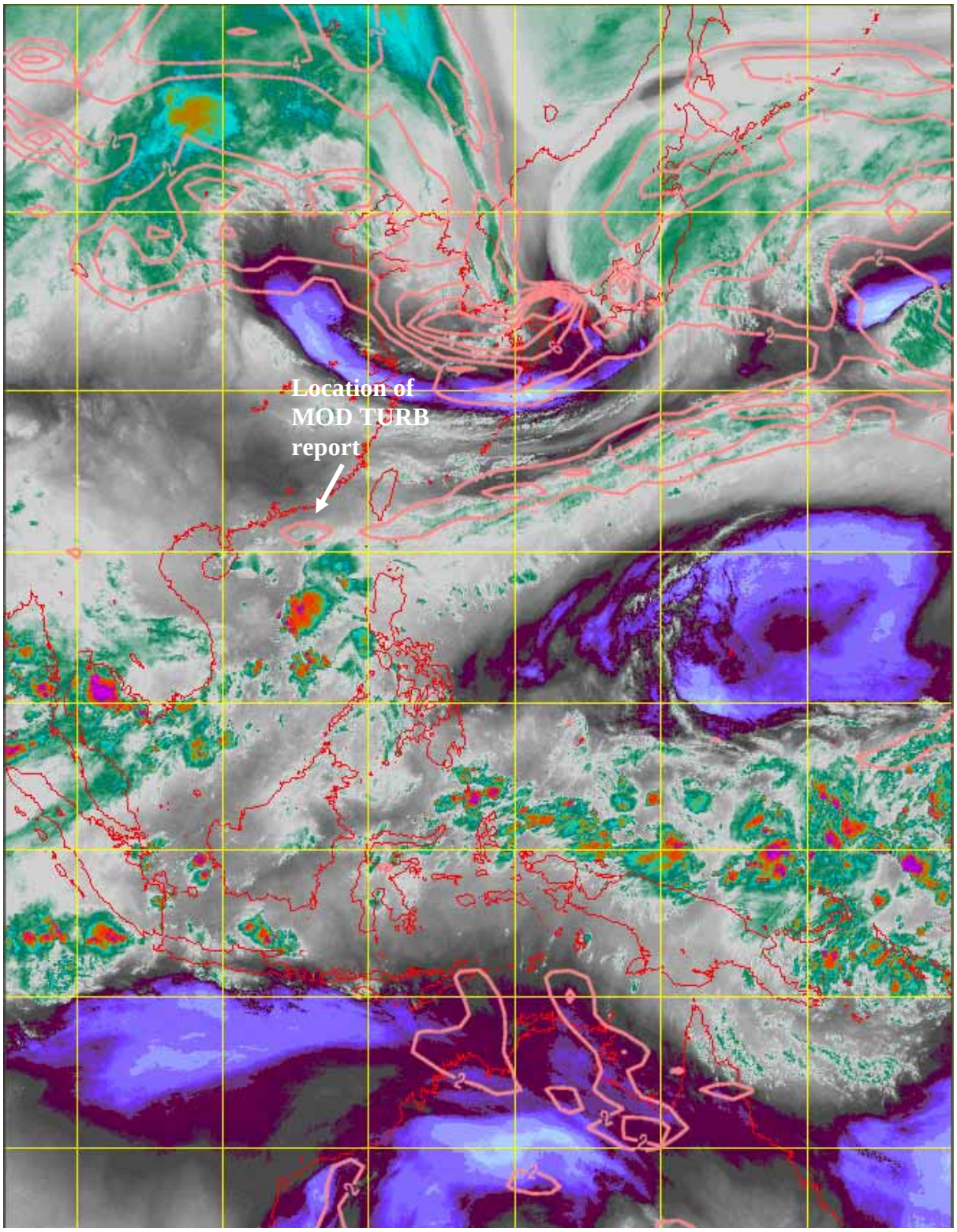

Figure 2. T+24 h forecast CAT potential at 200 hPa valid for 0000Z 10 May 2007 overlaid on top of the MTSAT water vapour channel satellite picture at 0038Z on the same day. Moderate turbulence was reported at 160 NM to the east of HKIA at 0050Z.

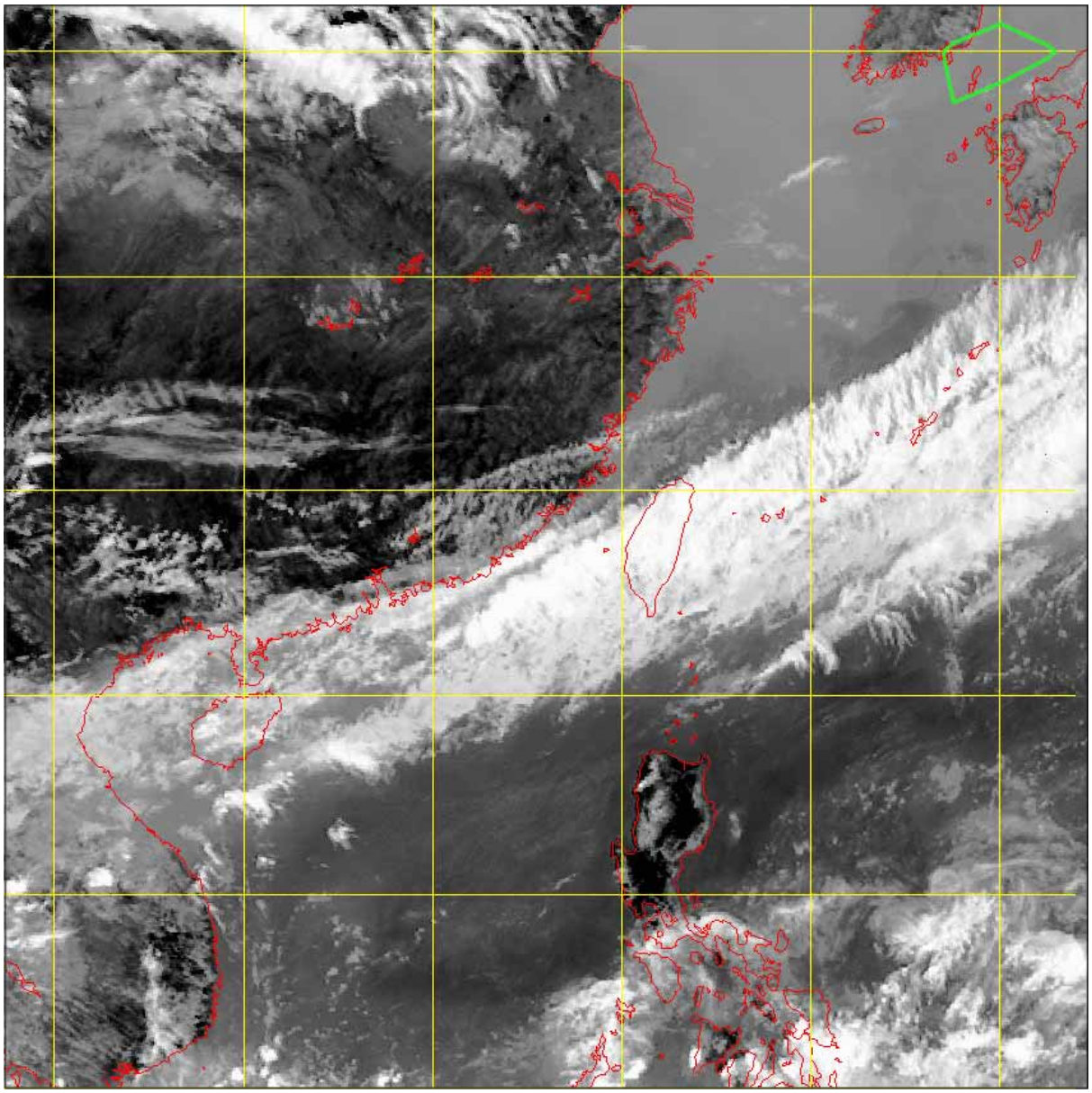

Figure 3. T+24 h forecast mean in-cloud turbulence potential at 400 hPa valid for 0600Z 2 May 2007 (green feature near top right hand corner) overlaid on top of MTSAT infrared channel satellite picture at 0638Z on the same day.