International Civil Aviation Organization

THIRTEENTH MEETING OF THE COMMUNICATIONS/NAVIGATION/SURVEILLANCE AND METEOROLOGY SUB-GROUP OF APANPIRG (CNS/MET SG/13)

Bangkok, Thailand, 20 – 24 July 2009

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

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

FURTHER OBSERVATIONS ON WAFS TRIAL GRIDDED FORECASTS

(Presented by Hong Kong, China)

SUMMARY

This paper presents further observations on the WAFS trial gridded forecasts of icing, turbulence and cumulonimbus clouds.

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 WAFS trial gridded forecasts of icing, turbulence and cumulonimbus clouds (CB) have become available for some time for evaluation by users. The gridded forecasts of WAFC London are based on the Unified Model (UM) of the UK Met Office while those of WAFC Washington are based on the Global Forecast System (GFS) of NOAA/NCEP. The WAFS trial gridded forecasts consist of 37 parameters for icing, turbulence and CB for each valid time at T+6 h, T+12 h, … up to T+36 h. Before their operational use, the following issues need to be addressed:

(a) develop a practicable visualization scheme to present the complete suite of forecast information, including high at-a-glance products, to the end users; and
(b) ensure the quality of the forecasts, requiring systematic verification and harmonization of the forecasts from the two WAFCs.

1.2 For the first issue, a separate IP will be presented by Hong Kong, China at this meeting. For the second issue, the WAFSOPG/4 meeting formulated Conclusion 4/17 that the WAFCs Provider States, in coordination with WAFSOPG Members from IATA, IFALPA and WMO, to undertake systematic comparisons of trial gridded forecasts of icing, turbulence and cumulonimbus clouds of the two WAFC models, highlighting characteristics of areas with different values. The results of these systematic comparisons should lead to the alignment of algorithms used by the two WAFCs.

1.3 In view of the importance of evaluation of new products prior to their provision to the users for operational use, the Hong Kong Observatory (HKO) has made available selected gridded forecasts from the two WAFCs, together with the corresponding SIGWX charts and satellite pictures, on HKO's dedicated aviation weather website (http://wafs-grid-fc.weather.gov.hk/) for evaluation by aviation users. A number of observations had previously been presented in the CNS/MET SG/12 meeting last year. This paper reviews the previous observations and presents additional observations on some other aspects of the gridded forecasts generated by WAFC London (hereafter denoted as UK) and WAFC Washington (hereafter denoted as US). To facilitate comparison of the trial gridded forecasts, they are visualized using the same plotting scheme as presented in IP/18 for CNS/MET SG/12, viz. only the gridded values for each grid box are plotted, according to the defined colour scale, without smoothing nor interpolation of the data.

2. OBSERVATIONS ON GRIDDED FORECASTS

2.1 The following differences between the trial gridded forecasts of the two WAFCs were reported in CNS/MET SG/12 last year:

(a) "CB horizontal extent": CB coverage is more extensive with generally larger forecast values in the UK forecast compared with that of US. Furthermore, small values of CB horizontal extent are given almost everywhere in the UK forecast;

(b) "ICAO height at CB top": the UK forecast generally gives more extensive but lower heights of CB top (generally below 37kft) compared with that of US (above 43 kft);

(c) "Mean in-cloud turbulence potential" at FL180: the UK forecast generally gives wider range and higher turbulence potential values compared with that of US. On the other hand, small values of mean in-cloud turbulence potential are given almost everywhere in the US forecast;

(d) "Maximum icing potential" at FL180: significant differences are observed in the spatial coverage over the tropical and higher latitude regions with the US forecast giving generally higher icing potential over the tropical region and the UK forecast giving generally higher icing potential over the higher latitude regions;

(e) "Maximum CAT potential" at FL340: the UK forecast generally gives much less extensive CAT areas compared with that of US.

2.2 Figure 1 shows the above-mentioned T+24 h trial gridded forecasts of the two WAFCs based on 12 UTC on 2 July 2009, together with the absolute differences between the forecasts of the two centres. The following is observed:

(a) "CB horizontal extent" (Figure 1(a)-(c)): similar to the observation in last year, CB coverage in the UK forecast is still more extensive compared with that of US and small values of CB horizontal extent are still given almost everywhere in the UK forecast. However, the forecast values in the US forecast, reaching 50-75% (which means OCNL following the Annex 3 specification) over many areas in the tropics, now appear larger than those given in the UK forecast for the same areas, which are mostly below 3%. Due to this discrepancy in the range of values, the difference map (Figure 1(c)) appears to be the union of the forecasts of the two centres;

(b) "ICAO height at CB top" (Figures 1(d)-(f) and 1(p)-(q)): the UK forecast still generally gives more extensive CB areas compared with that of US, but the UK forecast heights now reach 37 kft and 43 kft or above. However, the difference map (Figure 1(f)) appears to be the union of the forecasts of the two centres, except over some small areas near the tropics where the two forecasts agree. Comparing Figures 1(p)-(q) with the MTSAT-1R IR satellite imagery in Figure 1(r), it is obvious that the UK significantly over-forecast CB for vast areas in the Pacific Ocean, which should be under the influence of the subtropical ridge. The US forecast appears more realistic;

(c) "Mean in-cloud turbulence potential" at FL180 (Figure 1(g)-(i)): the UK and US forecasts now give values with similar range, but the UK forecast shows small values almost everywhere. The difference map (Figure 1(i)) also appears to be the union of the forecasts of the two centres, indicating little agreement between them;

(d) "Maximum icing potential" at FL180 (Figure 1(j)-(l)): significant differences are still observed in the spatial coverage over the tropical and higher latitude regions, with the US forecast giving larger areas of high icing potential over the tropical region and the UK forecast giving larger areas of high icing potential over the higher latitude regions. The difference map (Figure 1(l)) clearly shows large discrepancies over the higher latitude regions, with smaller discrepancies over the tropical region;

(e) "Maximum CAT potential" at FL340 (Figure 1(m)-(o)): the UK forecast generally gives much less extensive CAT areas compared with that of US, except for a few areas over the Southern Hemisphere. The difference map (Figure 1(o)) also appears to be the union of the forecasts of the two centres, indicating little agreement between them.

2.3 Summarizing the above observations, it is apparent that the trial gridded forecasts of the two WAFCs have yet to be harmonized, as evidenced by the difference maps which, in most cases, appear to be the union of the forecasts of the two centres, indicating little agreement between them. The following paragraphs provide additional observations on some other aspects of the gridded forecasts.

Seasonal changes

2.4 As the observations presented in CNS/MET SG/12 and in Figure 1 of this paper pertain to the summertime in the Northern Hemisphere, it is interesting to also consider the situation for the wintertime in the Northern Hemisphere. Figure 2 shows the T+24 h gridded forecasts of the two WAFCs based on 00 UTC 6 Jan 2009.

2.5 Comparing Figure 2 with Figure 1, the observations in para. 2.2 above (which pertain to the summertime in the Northern Hemisphere) also appear applicable for this different season (wintertime in the Northern Hemisphere). The following additional observations are noted:

(a) "Mean in-cloud turbulence potential" (Figure 2(e)-(f)): large values are forecast by UK for high latitudes in both hemispheres, which are not given in the US forecast. With benefit of hindsight, Figures 1(g)-(h) also show this pattern in the UK forecast;

(b) ""Maximum icing potential" at FL180 (Figure 2(g)-(h)): at the high latitudes (up to about 55°N), large values (> 85%) are forecast by UK, but much smaller values (mostly < 30%) are forecast by US. From a recent scientific paper on icing climatology[1], it is rather doubtful to expect such high values of the icing potential at this height in the wintertime (see Figure 3 for variation of icing frequencies at different heights with the months, indicating non-occurrence of icing at FL180 in the wintertime north of 25°N);

(c) "Maximum CAT potential" at FL340 (Figure 2(i)-(j)): large values are forecast by UK for a number of isolated locations which are not evident in the US forecast. By examining consecutive forecasts, these isolated locations appear to be stationary and associated with mountainous regions such as western coast of North America, Greenland, Iceland, Scandinavia, Antarctica, southern tip of South America, New Zealand, etc.

Diurnal changes

2.6 Apart from the seasonal aspect, it is also interesting to look at diurnal changes. Figure 4 shows the T+24 h gridded forecasts of "ICAO height at CB top" issued by the two WAFCs valid at 00 UTC and 06 UTC (i.e. 08 H and 14 H local time in Hong Kong) on 18 August 2008. Figure 5 shows the MTSAT-IR infrared satellite imageries, with deep convection indicated in red (see separate information paper for CNS/MET SG/13 on the method for identifying deep convection on satellite imageries), which correspond to these times for comparison. The UK forecasts are obviously giving much more extensive CB areas compared to the US forecasts, corroborating with the observations in para. 2.2(b) above. The satellite imageries show much smaller CB areas which correspond better with the US forecasts. Furthermore, while the weather was generally fine over southern China throughout the period (Figures 5(a)-(b)), both UK and US forecasts appear to over-forecast CB occurrence over this region at 06 UTC (14 H local time), probably due to difficulties of the models in handling the CB development induced by daytime solar heating.

CB associated with tropical cyclones

2.7 The satellite imageries in Figure 5 clearly show the deep convection associated with a tropical cyclone (TC Nuri) east of the Philippines. However, the UK forecasts of "ICAO height at CB top" (Figures 4(a) and 4(c)), covering extensive areas of the Pacific Ocean and South China Sea, cannot distinguish the CB associated with the TC. On the other hand, the US forecasts indicate an area of CB in good agreement with the TC location, even though it is very difficult, if at all possible, to identify this area to be associated with a TC without referring to the satellite imageries. Figures 6 and 7 show a recent case for TC Linfa and the above observations are still valid. As pointed out in the other information paper on visualization of the gridded forecasts, there is indeed a need to consider including safety-related SIGWX features such as TC in the high "at-a-glance" products for the users.

3. ACTION BY THE MEETING

3.1 The meeting is invited to note and exchange views on the information provided in this paper.

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[1] Bernstein, B.C. and Christine LeBot, 2009: An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops Part II: Europe, Asia and the Globe, *Journal of Applied Meteorology and Climatology*, American Meteorological Society.

WAFC London T+24 h Gridded Forecasts (based on 12 UTC 2 July 2009)	WAFC Washington T+24 h Gridded Forecasts (based on 12 UTC 2 July 2009)	Absolute Difference in the T+24 h Gridded Forecasts of the two WAFCs (based on 12 UTC 2 July 2009)

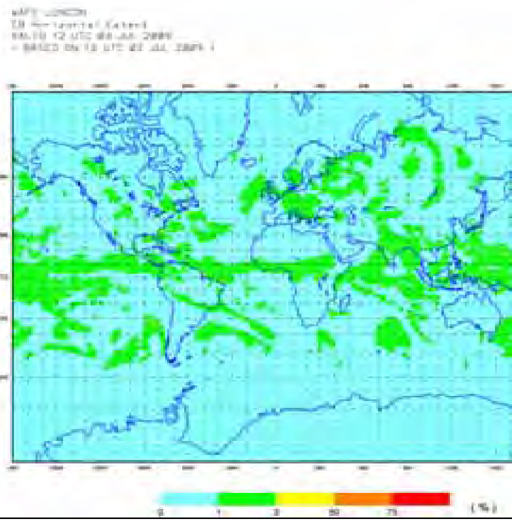
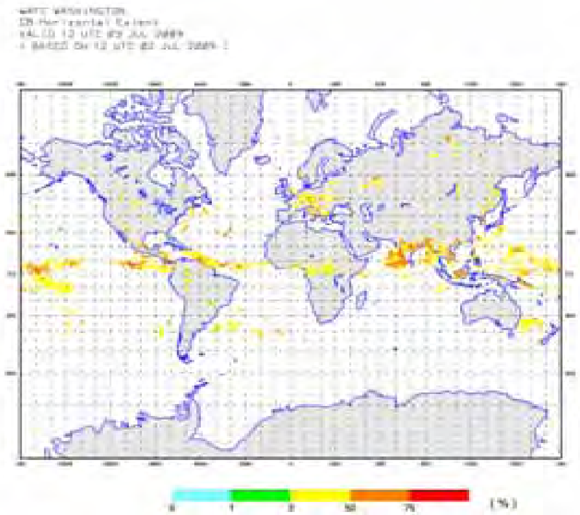
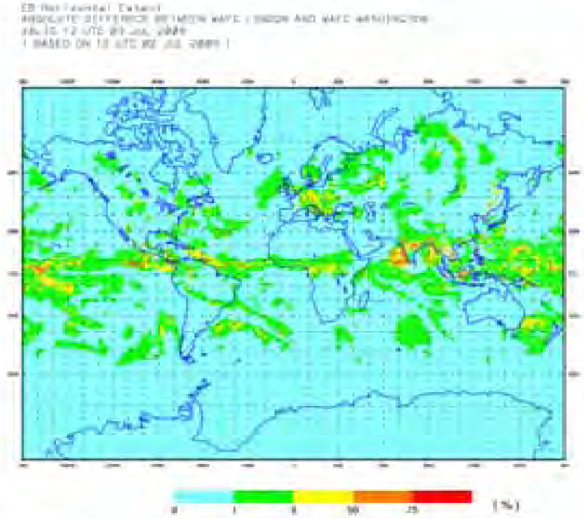

		

Fig. 1(a) “CB horizontal extent” [UK]	Fig. 1(b) “CB horizontal extent” [US]	Fig. 1(c) “CB horizontal extent” [UK-US]

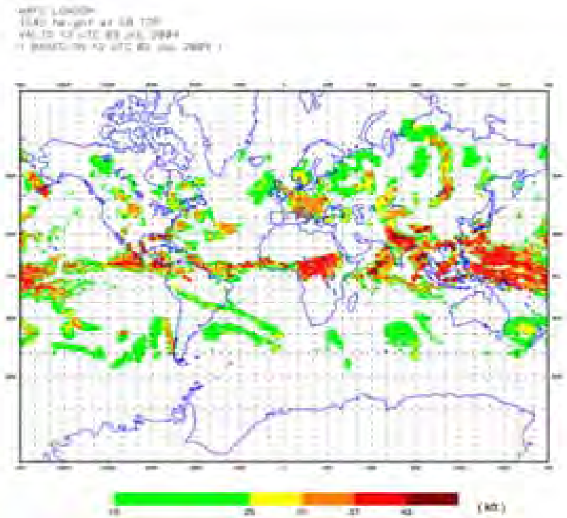
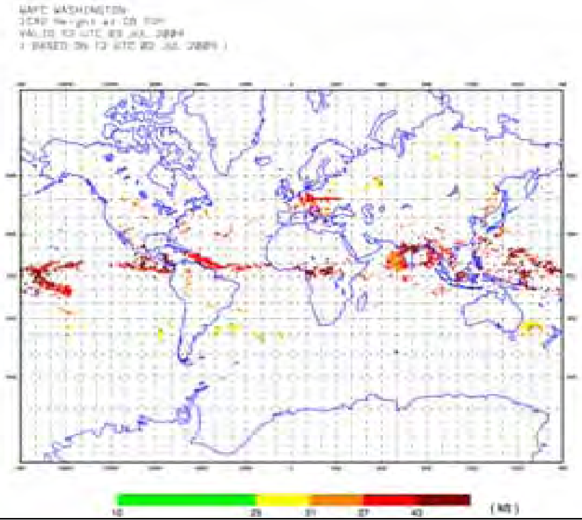
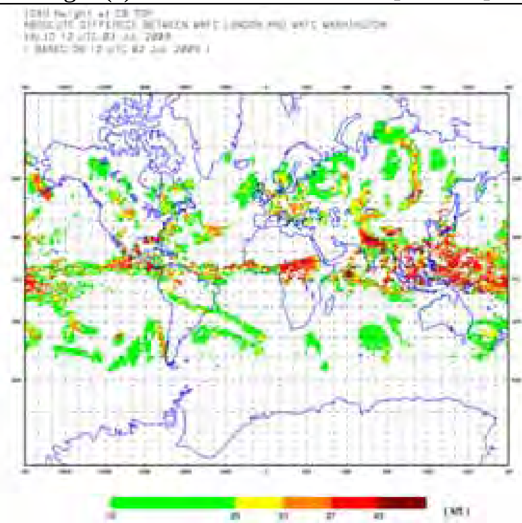

		

Fig. 1(d) “ICAO height at CB top (kft)” [UK]	Fig. 1(e) “ICAO height at CB top (kft)” [US]	Fig. 1(f) “ICAO height at CB top (kft)” [UK-US]

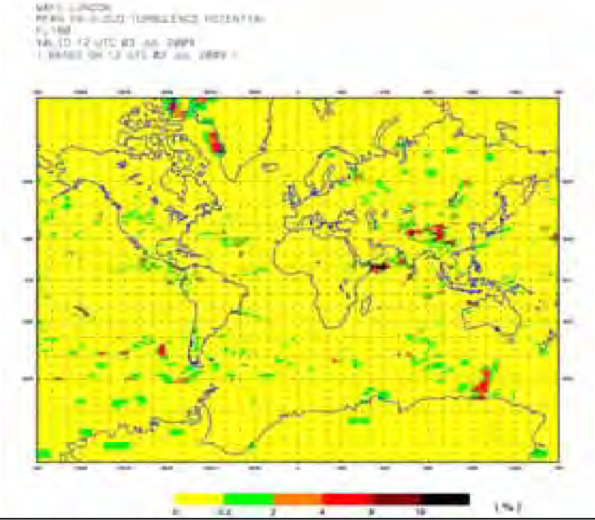


Fig. 1(g) "Mean in-cloud turbulence potential at FL 300" [UK]

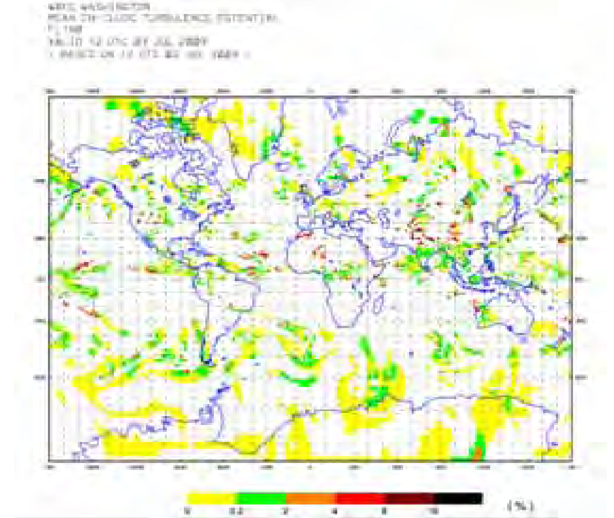


Fig. 1(h) "Mean in-cloud turbulence potential at FL 300" [US]

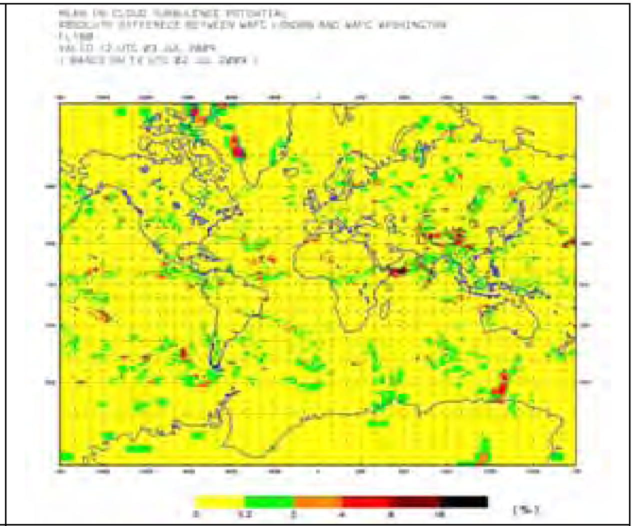


Fig. 1(i) "Mean in-cloud turbulence potential at FL 300" [UK-US]

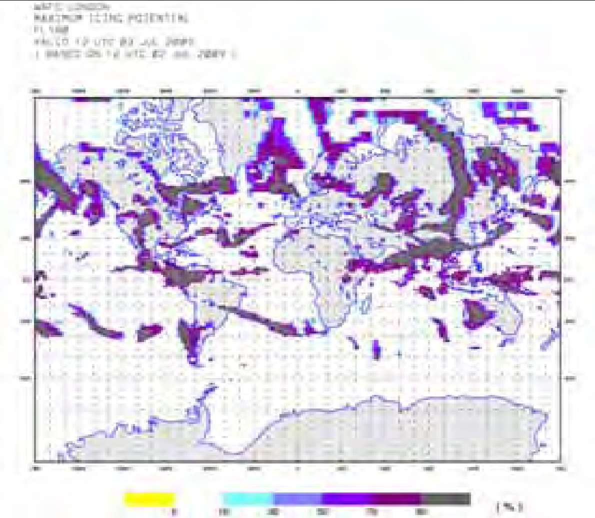


Fig. 1(j) "Maximum icing potential at FL180" [UK]

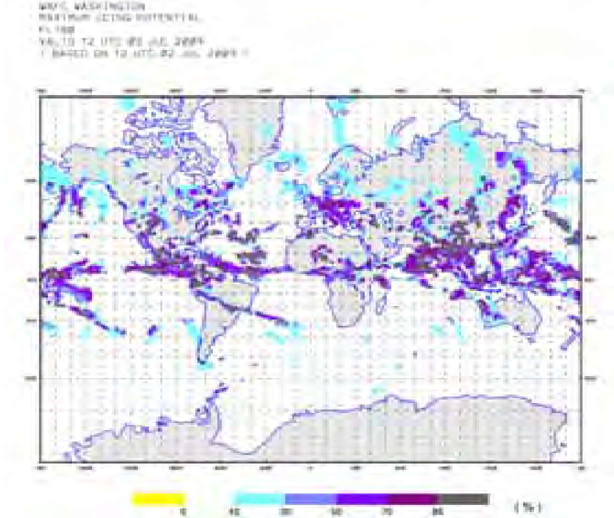


Fig. 1(k) "Maximum icing potential at FL180" [US]

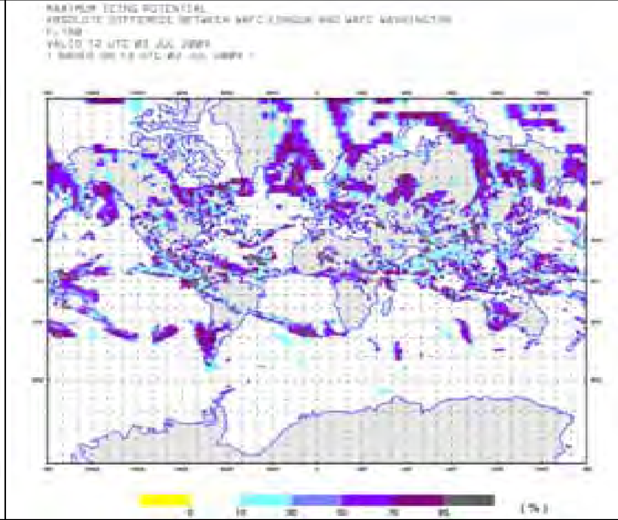


Fig. 1(l) "Maximum icing potential at FL180" [UK-US]

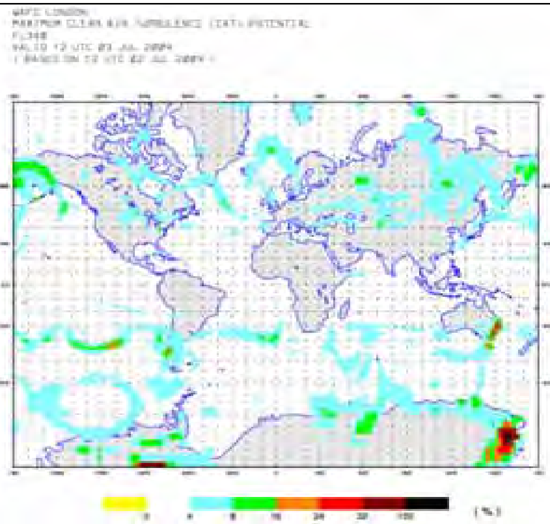
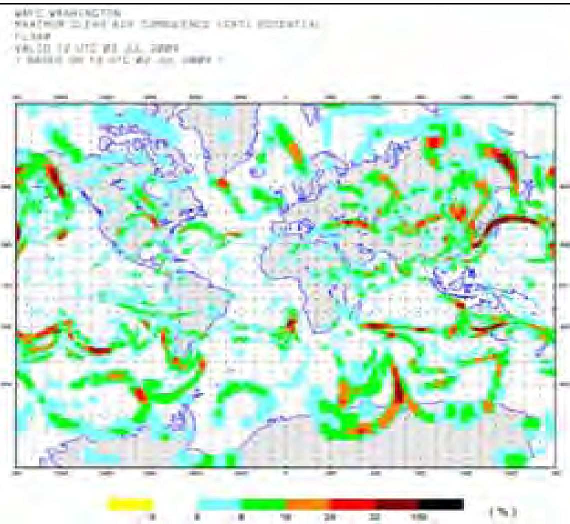
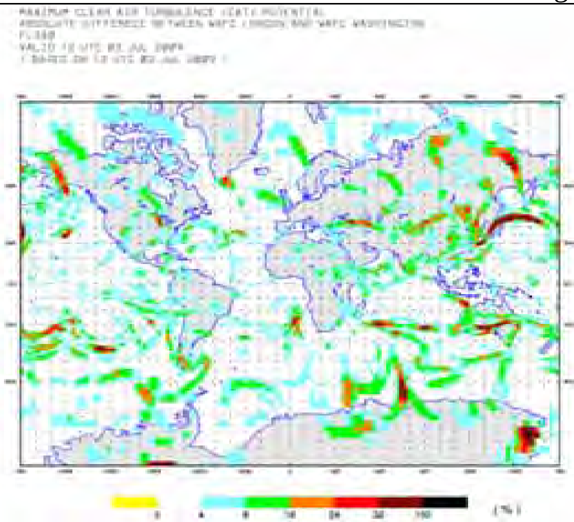
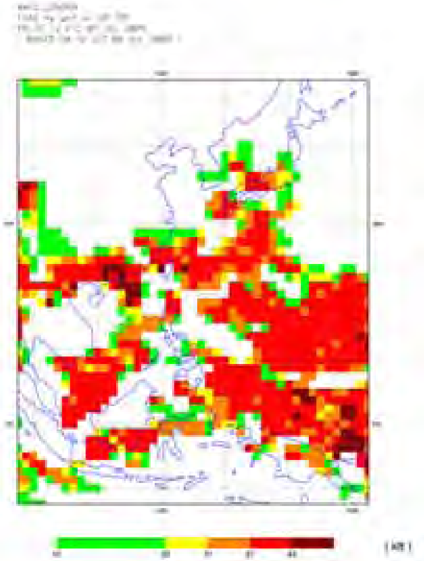
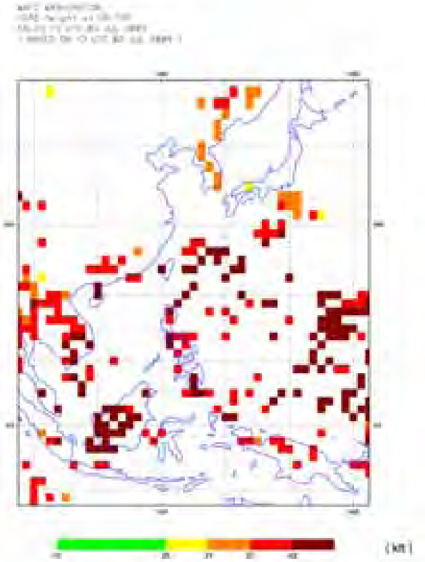
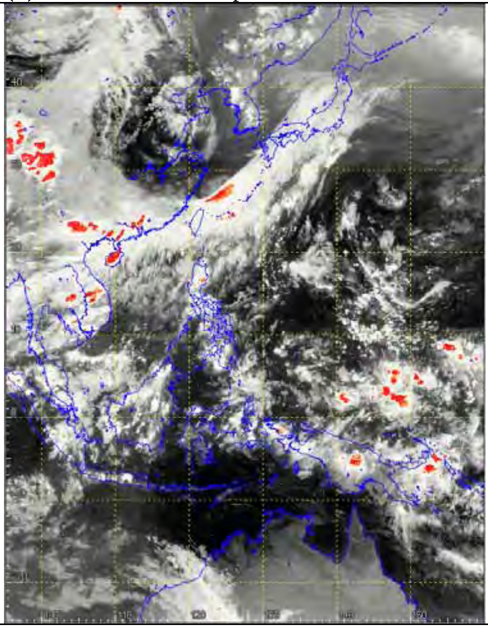
		

Fig. 1(m) "Maximum CAT potential at FL340" [UK]	Fig. 1(n) "Maximum CAT potential at FL340" [US]	Fig. 1(o) "Maximum CAT potential at FL340" [UK-US]
		

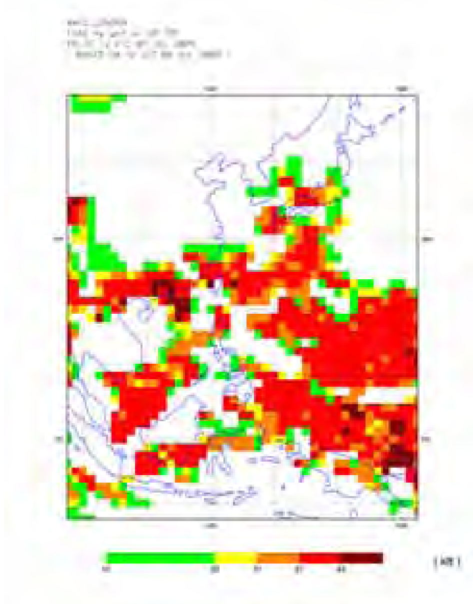
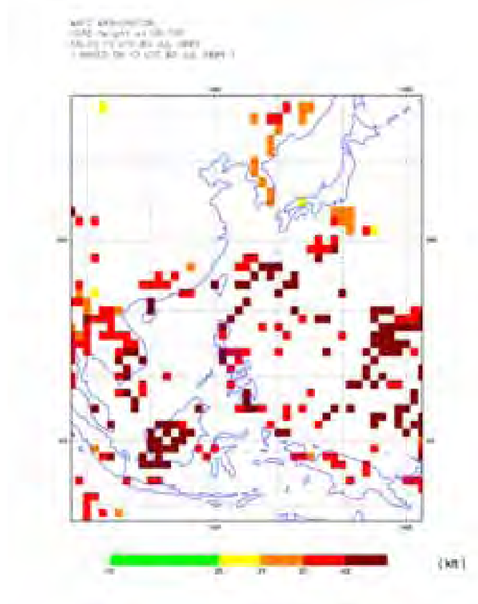
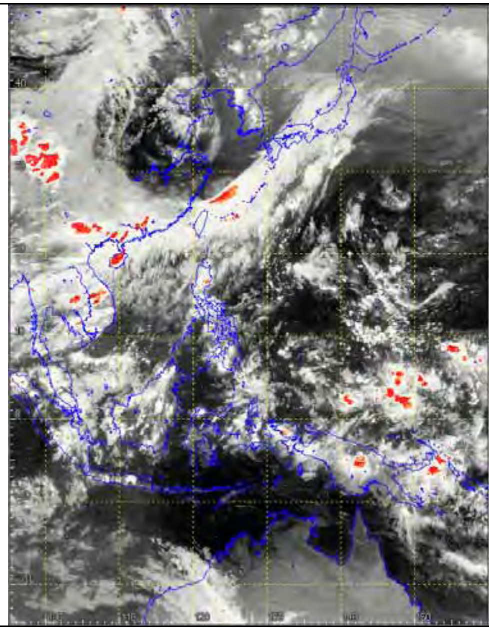
		

Fig. 1(p) “ICAO height at CB top (kft)” [UK]	Fig. 1(q) “ICAO height at CB top (kft)” [US]	Fig. 1(r) MTSAT-1R IR satellite picture, with deep convection indicated in red, at 11:30 UTC 3 July 2009

WAFC London T+24 h Gridded Forecasts (based on 00 UTC 6 January 2009)	WAFC Washington T+24 h Gridded Forecasts (based on 00 UTC 6 January 2009)

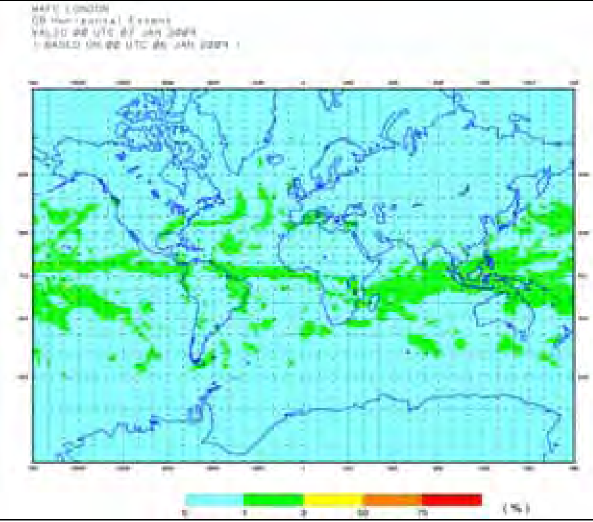
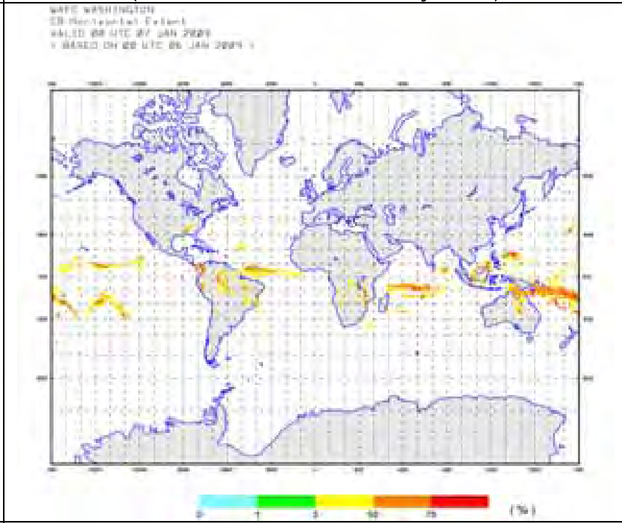

	

Fig. 2(a) “CB horizontal extent” [UK]	Fig. 2(b) “CB horizontal extent” [US]

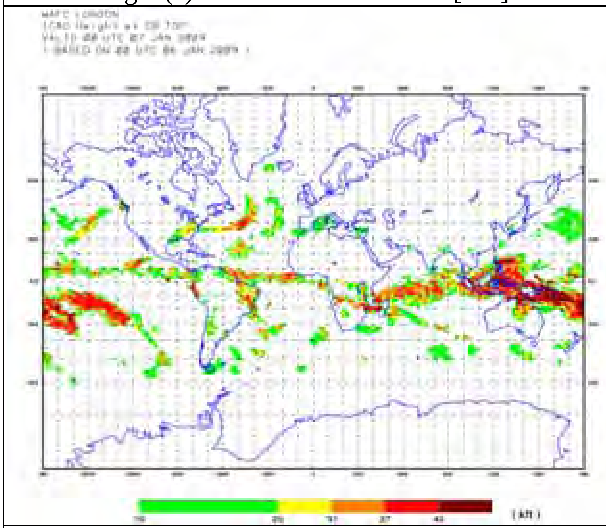
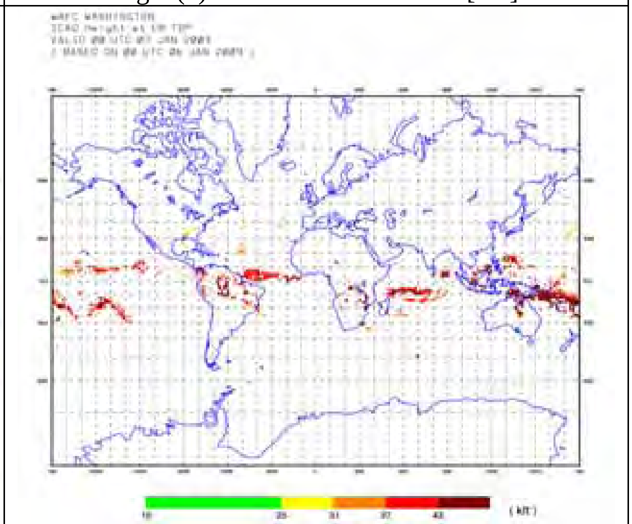

	

Fig. 2(c) “ICAO height at CB top (kft)” [UK]	Fig. 2(d) “ICAO height at CB top (kft)” [US]

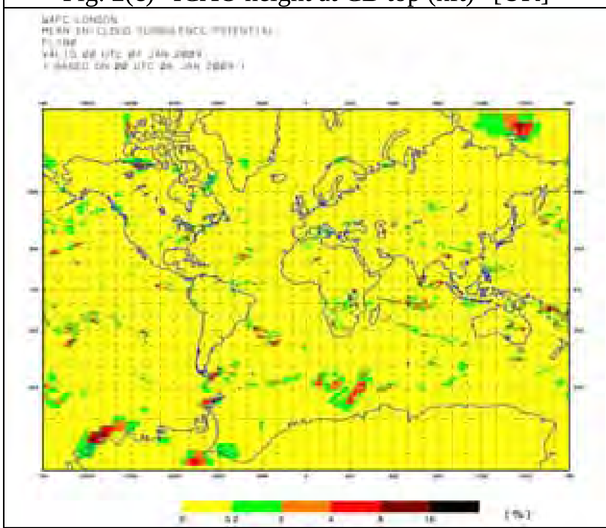
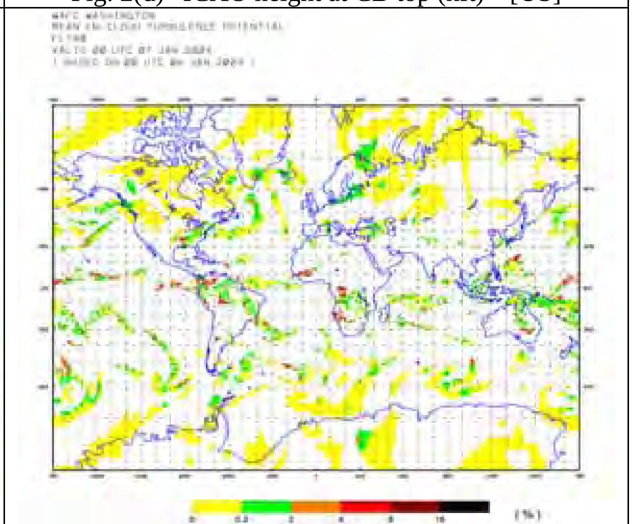

	

Fig. 2(e) “Mean in-cloud turbulence potential at FL 300” [UK]	Fig. 2(f) “Mean in-cloud turbulence potential at FL 300” [US]

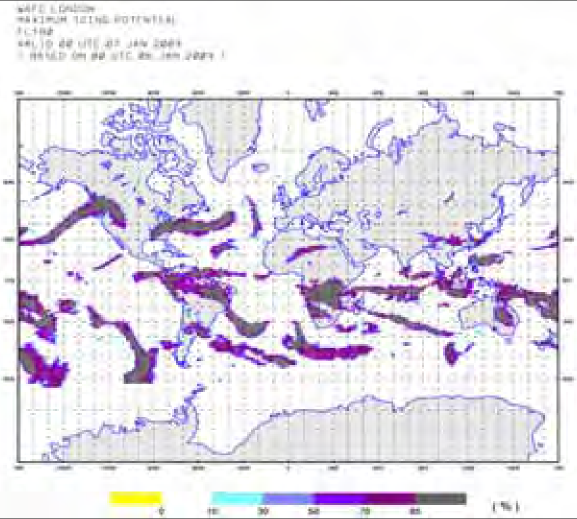


Fig. 2(g) "Maximum icing potential at FL180" [UK]

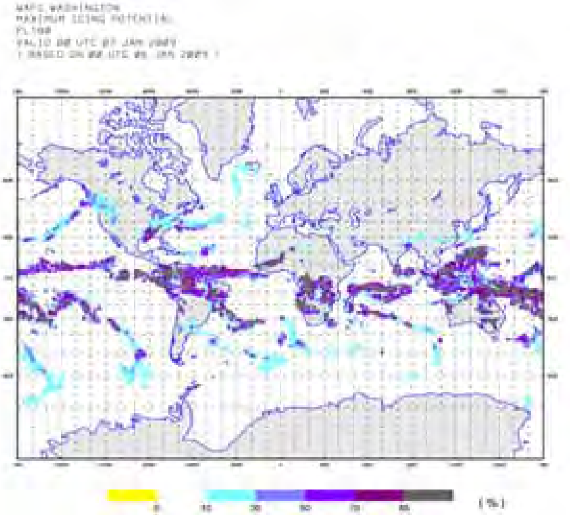


Fig. 2(h) "Maximum icing potential at FL180" [US]

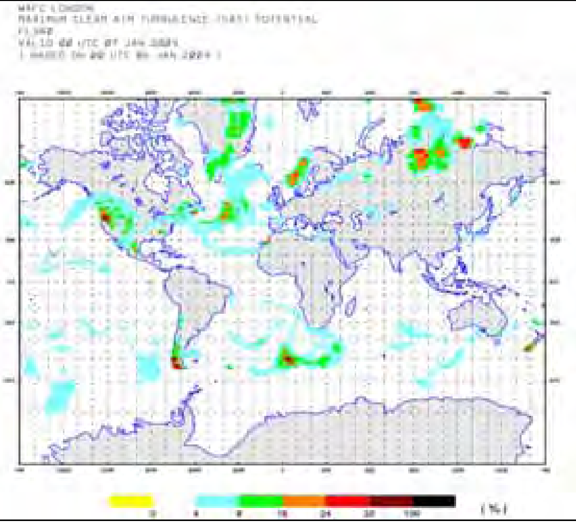


Fig. 2(i) "Maximum CAT potential at FL340" [UK]

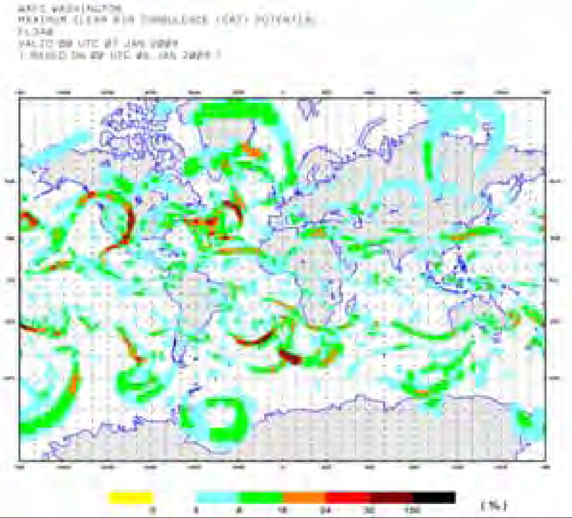


Fig. 2(j) "Maximum CAT potential at FL340" [US]

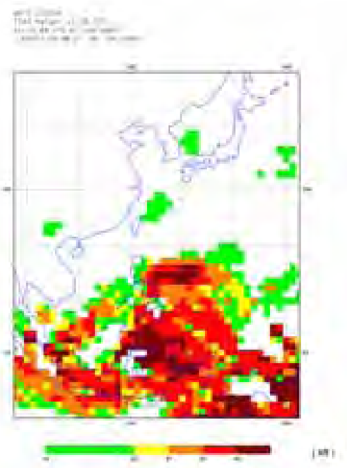


Fig. 2(k) "ICAO height at CB top (kft)" [UK]

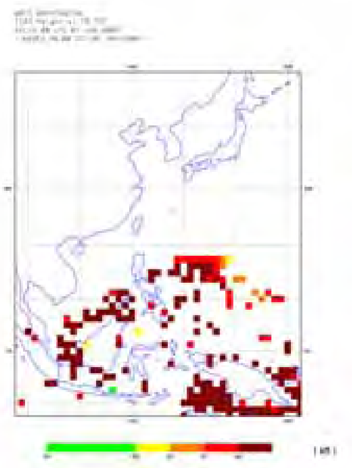


Fig. 2(l) "ICAO height at CB top (kft)" [US]

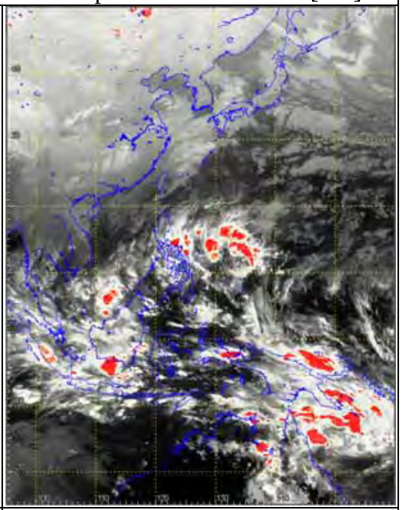


Fig. 2(m) MTSAT-1R IR satellite picture, with deep convection indicated in red, at 23:30 UTC 6 January 2009

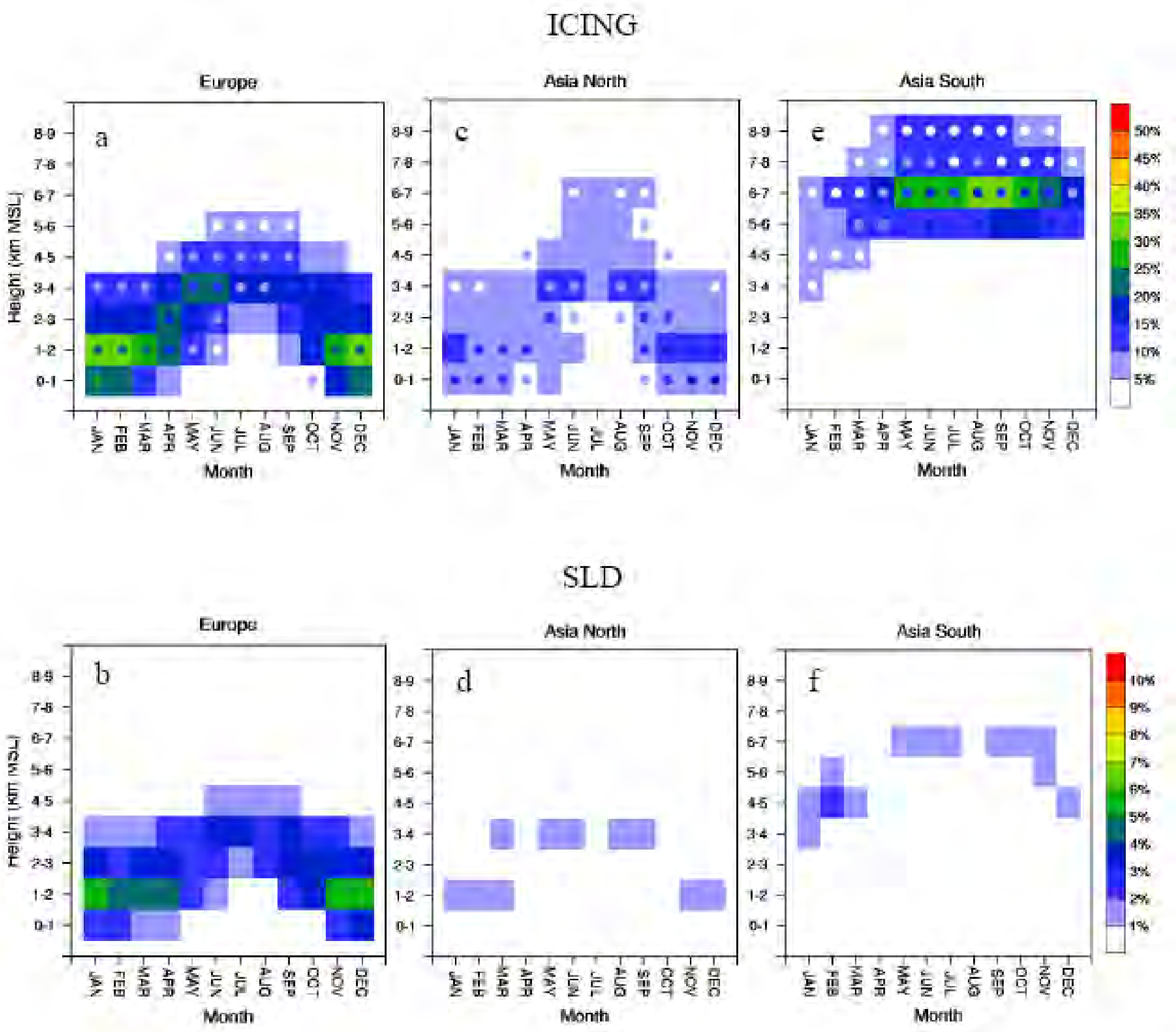


Fig. 5. Time-height plots of icing frequencies for all European stations (a, b) and Asian stations to the north (c, d) and south (e, f) of 25°N latitude. CIP-sonde values are shown as filled boxes, while SIGMA-index values are shown as embedded dots (icing only). Note that when icing frequencies from the two techniques fall into the same range, that the SIGMA-index dot will not be visible (e.g. at 2-3km over Europe during January).

Figure 3 Time-height plots of icing/supercooled large drop (SLD) frequencies for Europe, Asia North and Asia South (Ref.: Bernstein, B.C. and Christine LeBot, 2009: An Inferred Climatology of Icing Conditions Aloft, Including Supercooled Large Drops Part II: Europe, Asia and the Globe, *Journal of Applied Meteorology and Climatology*, American Meteorological Society.)

WAFC London T+24 h "ICAO height at CB top (kft)" Forecasts	WAFC Washington T+24 h "ICAO height at CB top (kft)" Forecasts

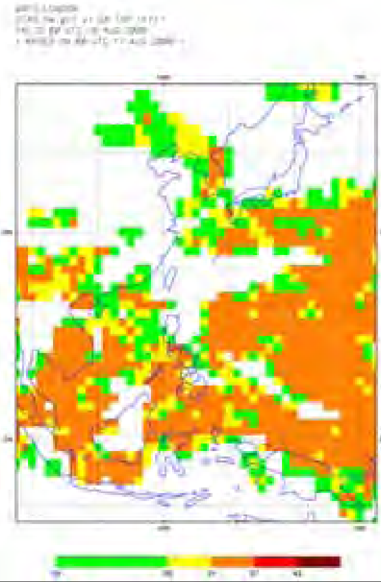
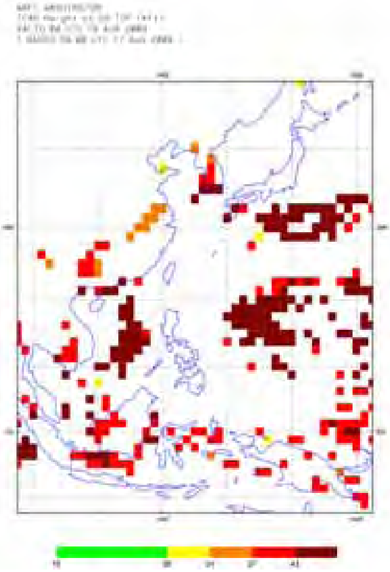

	

Fig. 4(a) Based on 00 UTC 17 August 2008 [UK]	Fig. 4(b) Based on 00 UTC 17 August 2008 [US]

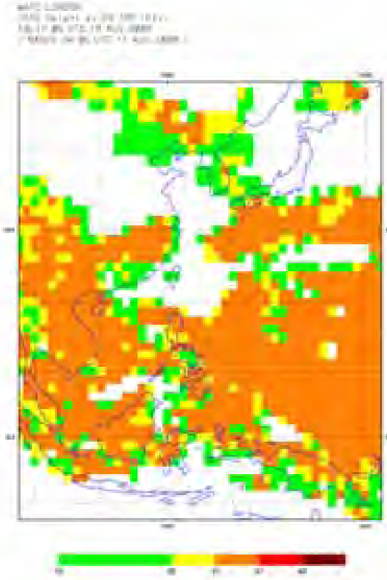
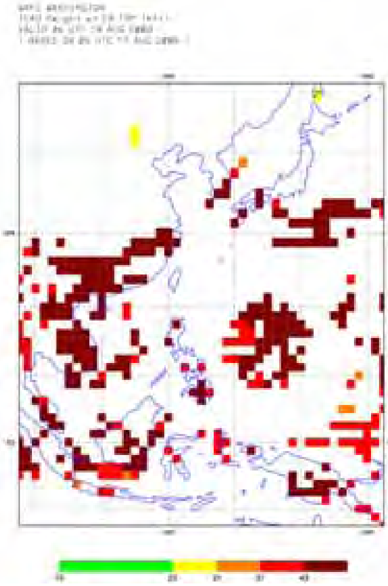

	

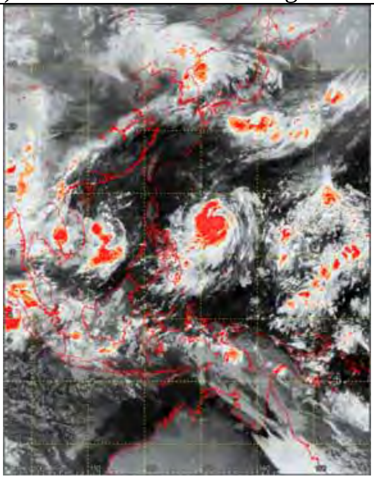
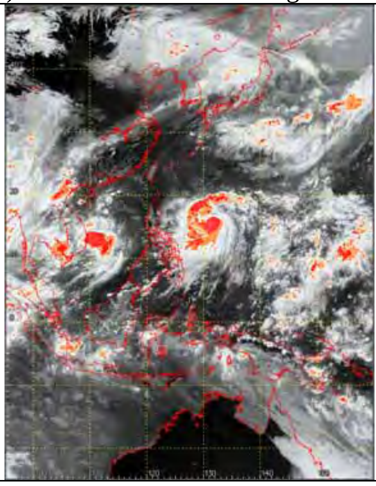
Fig. 4(c) Based on 06 UTC 17 August 2008 [UK]	Fig. 4(d) Based on 06 UTC 17 August 2008 [US]
	

Fig. 5(a) MTSAT-1R infrared satellite imagery, with deep convection indicated in red, at 23:30 UTC on 17 August 2008	Fig. 5(b) MTSAT-1R infrared satellite imagery, with deep convection indicated in red, at 05:30 UTC on 18 August 2008

WAFC London T+24 h “ICAO height at CB top (kft)” Forecasts	WAFC Washington T+24 h “ICAO height at CB top (kft)” Forecasts

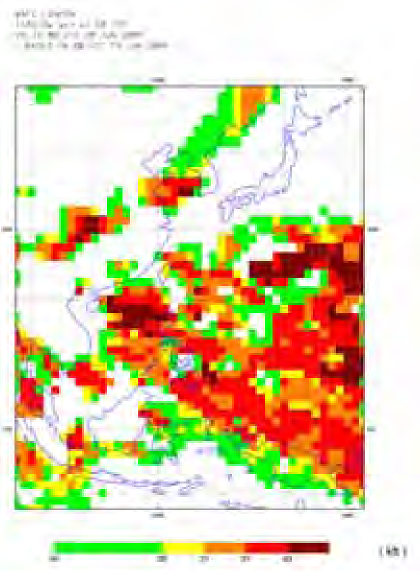
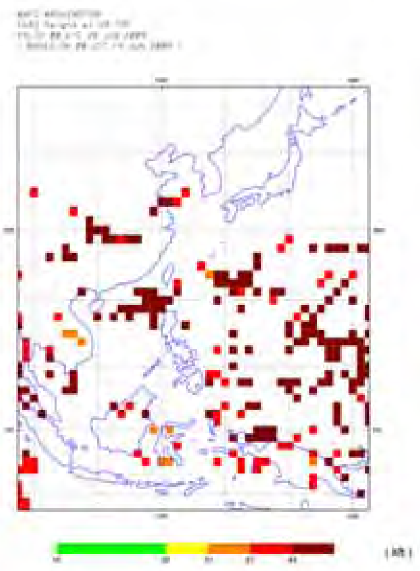

	

Fig. 6(a) Based on 00 UTC 19 June 2009 [UK]	Fig. 6(b) Based on 00 UTC 19 June 2009 [US]

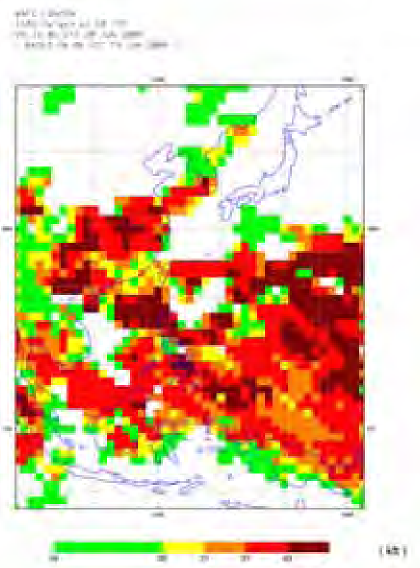
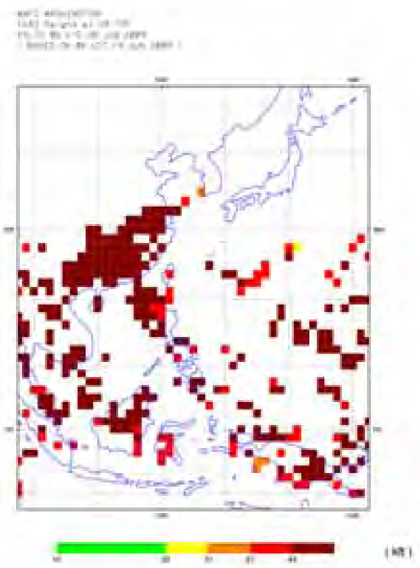

	

Fig. 6(c) Based on 06 UTC 19 June 2009 [UK]	Fig. 6(d) Based on 06 UTC 19 June 2009 [US]

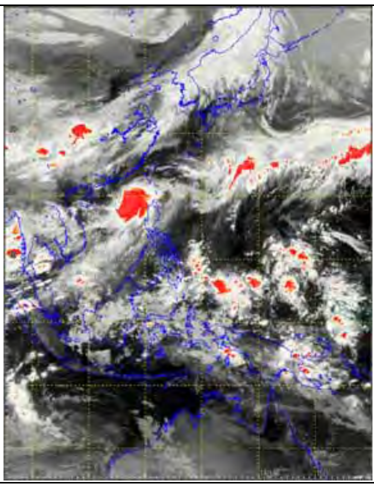
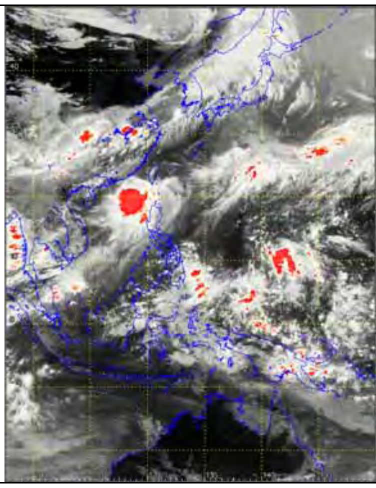
	

Fig. 7(a) MTSAT-1R infrared satellite imagery, with deep convection indicated in red, at 23:30 UTC on 19 June 2009	Fig. 7(b) MTSAT-1R infrared satellite imagery, with deep convection indicated in red, at 05:30 UTC on 20 June 2009