Representing WAFS Significant Weather (SIGWX) Data in BUFR

Version 4.1

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World Area Forecast Centres (WAFCs) London and Washington

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Abstract This document provides guidelines for the correct depiction of WAFS SIGWX data from BUFR code produced by the two World Area Forecast Centres.		
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DOCUMENT APPROVAL

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	WAFC Washington	**Larry Burch**		**14/12/07**

DOCUMENT CHANGE RECORD

ISSUE	DATE	REASON FOR CHANGE	SECTION PAGES AFFECTED
0.3	Nov. '03	First full draft prepared for joint WAFC BUFR liaison meeting (18/12/03)	All
1.0	21/01/04	Final draft incorporating comments from WAFC liaison meeting.	All
1.1	24/03/04	Minor word change in BUFR table 020008, and some typos corrected.	1.1, 3.1, 4 12,13, 15
1.2	30/03/04	Deletion of word "Typically" to highlight the fact that only one set of frontal movement info should be assigned to each front within the BUFR bulletin.	Section 7.2
1.3	15/04/04	Change to the use of figure 12 in BUFR table 011031	Section 10
1.4	14/05/04	Modifications to jet depiction taking into account the display of the vertical height information.	Section 4
1.5	21/05/04	Inclusion of DRAFT guidance on SWM chart production.	New Section 10
2.0	11/10/04	Refinement of text in section 10, a number of additions and improvements to text throughout the document, in particular section 4.	Section 4 & 10. A few minor changes throughout the document.
2.1	01/11/04	Include modifications following Washington review.	Many sections.
2.2	02/11/04	Minor corrections.	Section 2.2
2.3	10/11/04	Editorial changes	Many sections.
2.4	12/11/04	Editorial changes	sections 2.2 and 11
2.5	16/12/04	Guidance about excluding Himalayan region from Asia South chart.	Section 10.1. New Appendix A.
2.6	22/12/04 21/03/05 09/05/05	Minor changes to text to improve clarity. Additions to text resulting from WAFSOPSG/2 Editorial changes and changes/additions to text. Include comments by Mr CM Shun. Include comments from WAFC Washington	Section 8.1 Section 10.7.2 Section 1.1 Sections 1.1, 1.3.6, 3.1 (new items 6 and 7), 4, 9, and 10.1, (delete) appendix A. Sections 1.2, 1.3.6, 3.1, 7, 10.7.2
2.7	10/05/05 18/05/05	Remove reference to replication factor used in MCLOUD bulletin. Change figure 10 in BUFR table 020008 to red coloured font, and change to explanatory text in section 11.	Section 10.7.1 Section 11

	17/06/2005	Value 6 in descriptor 020008 change to font colour red.	Section 11
	21/06/2005	Change "MID" to "MEA".	Section 10.1
	22/06/2005	Improvements to text and include more information to describe SWM chart areas.	Sections 2.2, 3.1, 4 and 10.1
	23/06/2005	New point 8 in section 3.1	Section 3.1
	29/06/2005	Feedback received and incorporated from NCEP	Section 10.1
2.8	02/08/2005	New point 9 in section 3.1	Section 3.1
		New Annex 1 (extract from Appendix 1 to ICAO Annex 3)	Annex 1 (new)
	10/08/2005	New guidance to describe depiction of revised jet depth	Section 4 (several locations)
		Figures in BUFR tables 02008 and 020012 highlighted in red font	Section 11
		Minor modification to text to include PNG charts	Section 1.1
		New chart displaying revised jet depth format.	Section 3
	19/09/2005	Incorporate changes suggested by WAFC Washington (editorial and an improvement/clarification on words used).	Sections front page (logo), 1.2, 1.3.2, 1.3.6, 2.2, 3.1, 4, 5, 6 (new graphic), 7, 8, and 11.
	04/10/2005	Minor editorials suggested by WAFC Washington	1.2, 1.3.6, 3.1 - points 6 & 7.
3.0	21/10/2005	Correction – SWH header example modified for T+24 forecast	Section 2.1
	01/02/2006	Revised implementation date for new jet depth format (26 July 2006), plus change to wording in wind symbol/fleche example.	Section 4
	02/02/2006	Include changes following review by WAFC Washington (Larry Burch). Enhanced guidance to cover new jet depth orientation and new graphic to display tropical cyclone in the southern hemisphere.	Sections 4 and 9
	10/02/2006	Explicit guidance to detail correct orientation when drawing fronts, incl guidance on quasi-stationary fronts.	Section 7
		Additional text included to enhance description of drawing cloud boundaries.	Section 6
	22/02/2006	Remove reference to crossing jets – WAFSOPSG Memo No. 11 refers. Also, changes to the numbers of figures.	Section 4, and onwards just to the figure numbers.
	16/03/2006	Further change to section 4 to cover correct jet wind fleche depiction.	Section 4
	17/03/2006	Text deletion, and new rule added.	Section 4 (deletion), section 7 (new rule)

4.0	14/03/2007 14/03/2007 14/03/2007 14/03/2007 14/03/2007 15/03/2007 15/03/2007 19/03/2007	Removal of reference to T4 formatted SIGWX charts Reference to availability of WAFC Washington BUFR data on SADIS and ISCS broadcasts, and withdrawal of reference to NWS FTP server. Reference to operational products on SADIS FTP. Changes to legend box depiction under ICAO Annex 3 Amendment 74 proposals Adoption of flight-level specific jet depth information/depiction ICAO Annex 3 Amendment 74 proposed changes to depiction of surface fronts and intertropical convergence zones (SWH and SWM), and non-CB cloud amount and type (SWM) Update to contact details Removal of reference to Thunderstorms	1.1, 1.3.6, 3.1, and sections 4, 5, 7 and 10 1.2, 1.3.6 1.3.1 3.1 Section 4 1.1 and sections 2, 3, 7 and 10 Section 12 3.1 part 9
4.1	10/12/2007	i) Change to WMO website URL ii) Removal of reference to surface fronts iii) Change HDL to AHL iv) Changes under Amendment 74 to Annex 3 v) Deleted obsolete legend box example vi) Removal of reference to Annex 3 discrepancy related to jet depth vii) Handling of WAFS BUFR bulletins that contain no data viii) Representation of 80KT jetstreams in BUFR data ix) Removal of reference to T4 chart x) Inclusion of reference to sandstorms xi) Editorials to commonly used SWM and/or SWH data xii) Update to template to depict 16th Edition practices for "*Symbols for Significant Weather*"	i) 1.1 ii) 1.1, plus sections 3, 7 and 10.6. iii) 1.3.6 iv) Footnote 2, plus sections 3.1 (part 9), 3.2 and 10 (parts 10.6 and 10.7) v) 3.1 part 3 vi) 3.1 part 10 vii) Section 3.2 viii) Section 4 ix) Section 5 x) Section 9 xi) Section 11 (020008, 020012, and 008011) xii) Annex 1

1. The BUFR format

1.1. INTRODUCTION

BUFR stands for Binary Universal Form for the Representation of meteorological data. It is a standard developed by the World Meteorological Organisation (WMO; see WMO Manual 306 Part B for technical specification, which can be obtained via the WMO web site - http://www.wmo.ch/pages/prog/www/WMOCodes/ManualCodesGuides.html) for the efficient storage of meteorological features in a machine independent form, where all the information to describe the features are contained within the data.

This document has been prepared by the World Area Forecast Centres (WAFCs) for the purpose of providing guidance to software developers who have the task of constructing WAFS SIGWX BUFR visualisation software**.** The document is designed to assist developers in the construction of compliant visualisation software that receives its data input from text files obtained from BUFR decoding software supplied by WAFC London.

The primary aim of the visualisation software should be to decode and display WAFS SIGWX data in a format that* is identical to the *equivalent WAFS PNG SIGWX chart in regard to the depiction of the meteorological phenomena (cloud type, coverage and associated icing and turbulence for medium level cloud, volcanoes, tropical cyclones, radiation events, CAT and jet-streams), and largely identical to the PNG product in regard to the display of text boxes (related to areas of cloud, volcanoes, and CAT). It is against this standard that compliances will be measured. In addition, it is recommended that visualisation software can deliver WAFS products to the standards recommended within Annex 3 to the Convention on International Civil Aviation (Meteorological Service for International Air Navigation). In particular, section 4 of Appendix 8 to ICAO Annex 3 provides recommendations related to the presentation of flight documentation. It is strongly recommended that visualisation software can deliver products to these recommended practices.

ICAO and WMO have asked WAFC London to implement a software review process that involves assessing the quality of WAFS products produced by different visualisation systems against a list of high level criteria set by the ICAO SADIS Operations Group. Subject to the continuing agreement of the owners of the reviewed software packages, the results from these reviews will be displayed on the WAFC London web site, with the purpose of assisting customers in their software procurement process. The information is currently available from URL: http://www.metoffice.gov.uk/sadis/software/index.html. It should be stressed that this review process is not considered a certification or an endorsement of one product over another, but is simply an objective analysis of the degree of compliance of the software to display WAFS products in a valid manner. By making the list of compliant software packages widely available to States and individual users via ICAO, it is the intention to use the review process as a mechanism to raise the level of software compliances.

The WAFCs have produced this document with the intention of circulating it to all interested parties. If additional guidance or advice in regard to any of the items included in this document is required, then users, software manufacturers and State Authorities are invited to contact WAFC London. A consultancy service is available to assist these users. Please contact Greg Brock for further information: - E-mail: greg.brock@metoffice.gov.uk Tel: +44(0)1392 884892.

1.2. SCOPE OF DOCUMENT

Sections 4 to 9 outline how each feature is depicted on a HIGH level WAFS Significant Weather chart (SWH) is represented in BUFR. HIGH level data covers 25,000 - 63,000 feet (FL250 to FL630).

Section 10 outlines how each feature is depicted on MEDIUM level WAFS Significant Weather chart (SWM) is represented in BUFR. Medium level data (SWM) which covers 10,000 - 45,000 feet (FL100 to FL450), and includes additional in-cloud moderate and severe TURBULENCE (TURB) and ICING data.

WAFC London and WAFC Washington BUFR encoded SWH and SWM data is available from SADIS and ISCS satellite broadcasts and the SADIS FTP server.

Additions or changes to the way in which features are depicted on the SWH and SWM charts may occur during the next few years. This document will be updated and re-circulated prior to the introduction of these changes.

This document outlines the text format used by both the WAFCs to encode and decode HIGH and MEDIUM level SIGWX data in BUFR.

1.3. CONCEPTS

To produce a BUFR file, two elements are needed. Namely:

i) a file of raw data; and
ii) a set of tables containing descriptors.

When the raw data is encoded, each data value is attached to a descriptor which defines what that data represents. The decoding process reads the BUFR file, looks up the descriptor in the relevant table, and writes out the information in whatever format is needed.

1.3.1. BUFR TABLES

The binary BUFR files contain a set of tables' descriptors and data values. To be able to understand what the values represent, the descriptors need to be decoded from a set of common tables that sit on the local machine. This format means that the BUFR messages are very small and are machine independent. They can be understood and decoded by *any* BUFR decoder which has the latest tables available.

WAFC London and WAFC Washington use an ASCII file to store the raw data. This file is processed to produce a BUFR message. A similar procedure is used to decode BUFR messages into ASCII at the user end.

Examples of this ASCII text format are used throughout this document to explain how SIGWX data is represented in BUFR. The encoder, decoder, and example binary BUFR files, are available on request to WAFC London. Operational, real-time, files are also available from the SADIS FTP Service which is available to all approved SADIS and ISCS users, and manufacturers of commercial WAFS visualisation software.

1.3.2. REPRESENTATION

Data held in the BUFR format is completely independent of the way in which the data is depicted on SIGWX charts. Only the information that describes the feature is encoded. For example, a CLOUD area is a list of points with the height of the base and top, the cloud type and cloud amount attributes attached. There is nothing in the BUFR bulletin about how the cloud area should be drawn, or how the attributes are to be displayed. On SIGWX charts, this is shown as a box, sometimes with a call-out arrow pointing to the area – but this depiction is determined by the graphical display program. This document has been produced to provide a standard in this regard. It is recommended that the overall aim of BUFR visualisation, as stated in section 1.1, should be carefully considered.

1.3.3 STANDARDS

Although no information is given in BUFR on how to visually represent the data, rules have been laid down by the International Civil Aviation Organisation (ICAO) and WMO. The ICAO requirements are laid out in *Annex 3, Meteorological Service for International Air Navigation* in the *International Standards and Recommended Practices* document. The ICAO documentation specifically relates to such elements as the World Area Forecast System (WAFS), how the forecasts should be prepared, the default chart areas (ICAO areas) that should be available and when the charts should be issued. They also include guidance on how the meteorological features are to be depicted on the charts. Further detailed information about these standards is available from WAFC London.

WMO Manual 306 Part B should be the standard used for the BUFR code itself.

1.3.4 OPEN/CLOSED AREAS

The boundaries of areas of cloud and CAT are described as being either “open” or “closed”, such that:

i) closed areas are defined as regions that have identical first and last coordinates; and
ii) open areas have different start and end coordinates.

Both open and closed areas are used by the WAFCs to represent cloud and CAT boundaries. When call-out arrows are used to link these open or closed areas to associated text boxes, it may assist the visualisation if the arrows point to the boundaries of the areas, though this is not mandated by ICAO.

Areas are encoded with an orientation of the area being to the left of the boundary when drawn in the order of points given, i.e. area boundaries are encoded in an anti-clockwise direction.

1.3.5 UNIT CONVERSIONS

On WAFS SIGWX charts, heights are shown in 100’s feet (Flight Levels) and speeds in knots. However, in BUFR, these are represented metrically. To convert between imperial and metric measurements, the following conversions can be used:

1 foot = 0.3048 metres 1 knot = 0.51444 metres/second

1.3.6 WMO MESSAGE HEADER IDs

WAFC London and WAFC Washington produce operational HIGH and MEDIUM level SIGWX BUFR messages issued 4 times a day, and available on the SADIS and ISCS satellite broadcasts and the SADIS FTP service.

The messages and the corresponding WMO abbreviated headers (AHL) are shown in Figure 1.

BUFR FEATURES	COMMON NAME	WMO HEADER used by WAFC London	WMO HEADER used by WAFC Washington
Jet-streams	JETS	JUWE96 EGRR	JUWE96 KKCI
Clear Air Turbulence (C.A.T.)	CAT	JUCE00 EGRR	JUCE00 KKCI
Embedded Cumulonimbus	CLOUD	JUBE99 EGRR	JUBE99 KKCI
Tropopause height	TROP	JUTE97 EGRR	JUTE97 KKCI
Frontal Systems	FRONTS	JUFE00 EGRR	JUFE00 KKCI
Tropical Cyclone, Sandstorms & Volcanoes	V_T_S	JUVE00 EGRR	JUVE00 KKCI
SWM Tropopause height	M-TROP	JUOE00 EGRR	JUOE00 KKCI
SWM jet-streams	M-JETS	JUTE00 EGRR	JUTE00 KKCI
SWM fronts	M-FRONTS	JUJE00 EGRR	JUJE00 KKCI
SWM cloud, in-cloud icing and turbulence	M-CLOUD	JUNE00 EGRR	JUNE00 KKCI
SWM Clear Air Turbulence (C.A.T.)	M-CAT	JUME00 EGRR	JUME00 KKCI

Figure 1 - WMO headers for SIGWX BUFR messages issued by WAFCs London and Washington

NOTE: Bulletin JUVE00 EGRR/KKCI is applicable to both high and medium level data.

There is a requirement for the visualisation software to clearly depict the limited coverage areas of the BUFR encoded SWM data. Unlike SWH data, the two WAFCs only issue SWM data in

BUFR for the areas currently forecast at medium level in PNG format – i.e. medium level chart areas EURO, MEA, ASIA S (from WAFC London) and NAT (from WAFC Washington). To ensure that users do not try and produce SWM charts from BUFR data over user defined regions that *do not* contain forecast data, it is recommended that the software indicates, by way of diagonal hatching lines, all geographical areas that are *not* covered by forecast data. The areas for which data is produced at medium level will be described within the SWM bulletins.

2 HEADER Representation

A BUFR message will always be packaged between the characters 'BUFR' and '7777'. Before the data representing the features appears, a header is always found that details where the message has come from, the date and validity times and the flight levels it is valid for. At present each feature is encoded into a separate file, each of which have their own header; apart from the volcanoes, storms and radiation events, and SWM cloud[1], SWM in-cloud icing and in-cloud turbulence, which are all included together. In instances where 'no data' is to be represented within a BUFR bulletin, users should refer to section 2.3 below.

2.1 MESSAGE HEADER FOR SWH

Contains general data concerning the origin and validity time for the data.

```
 93                          Originating centre.
 2001  01    30    18    00   DATA Time - Year, month, day, hour, minute
 2001  01    31    18    00   FORECAST Time - Year, month, day, hour, minute
      7620        19200       Flight level boundaries (base and top)
```

2.2 MESSAGE HEADER FOR SWM

Contains general data concerning the origin and validity time for the data, plus information about the areas of data coverage.

```
93                          Originating centre.
 2004  04    04    12    00   DATA Time - Year, month, day, hour, minute
 2004  04    05    12    00   FORECAST Time - Year, month, day, hour, minute
      3050        13720       Flight level boundaries (base and top)
  21.4  -21.6,  46.6  -56.6,  58.7   68.4,  26.4   33.4.     Area EURO
  10.0   17.0,  44.0   17.0,  44.0   70.0,  10.0   70.0.     Area MEA
   0.0   53.0,  36.0   53.0,  36.0  108.0,   0.0  108.0.     Area Asia South
  17.2  -54.1,  44.7 -101.7,  50.7   60.3,  19.7   10.0.     Area NAT
```

Note: This is an example of a WAFC London header. Areas MEA and Asia South are both Mercator projection charts. Areas EURO and NAT are both polar stereographic projection charts.

The last four lines of digits contain the latitude and longitude points of the corners of the standard ICAO chart areas for which data is included in the BUFR bulletin. The latitude (lat) and longitude (long) points are plotted in the following orientation:

BLHC_lat BLHC_long, TLHC_lat TLHC_long, TRHC_lat TRHC_long, BRHC_lat BRHC_long

where BLHC=bottom left hand corner, TLHC=top left hand corner, TRHC=top right hand corner, and BRHC=bottom right hand corner. Negative latitude values are located in the southern hemisphere, and negative longitude values in the western hemisphere. Complete descriptions of the four SWM areas (EURO, MEA, NAT, and Asia South) are provided in section 10.1.

In the example the last row of digits represents the corner points for the North Atlantic (NAT) SWM chart normally produced by WAFC Washington. Forecast data for this area will normally only be included in a SWM BUFR bulletin issued by WAFC London when London is backing up WAFC Washington. On the majority of occasions, this additional row of digits will be replaced by free text indicating that Washington backup is not in operation.

```
93                          Originating centre.
 2004  04    04    12    00   DATA Time - Year, month, day, hour, minute
 2004  04    05    12    00   FORECAST Time - Year, month, day, hour, minute
      3050        13720       Flight level boundaries (base and top)
21.4  -21.6,  46.6  -56.6,  58.7   68.4,  26.4   33.4.
  10.0   17.0,  44.0   17.0,  44.0   70.0,  10.0   70.0.
   0.0   53.0,  36.0   53.0,  36.0  108.0,   0.0  108.0.
NO WASHINGTON BACKUP
```

Note: This is an example of a WAFC London header.

[1] Note that under ICAO Annex 3 Amendment 74 (effective 7th November 2007), non-CB cloud amount and type was withdrawn from the SWM products.

Example areas assigned to WAFC Washington headers:

During backup mode,

```
21.4  -21.6,  46.6  -56.6,  58.7   68.4,  26.4   33.4.
10.0   17.0,  44.0   17.0,  44.0   70.0,  10.0   70.0.
 0.0   53.0,  36.0   53.0,  36.0  108.0,   0.0  108.0.
17.2  -54.1,  44.7 -101.7,  50.7   60.3,  19.7   10.0
```

During standard mode,

```
  NO LONDON BACKUP
  NO LONDON BACKUP
  NO LONDON BACKUP
 17.2  -54.1,  44.7 -101.7,  50.7   60.3,  19.7   10.0
```

3 Features Represented

The chart in Figure 2 shows an example of SIGWX data and includes the following HIGH level features:

- Jet-streams
- Clear Air Turbulence (CAT)
- CB Cloud
- Tropopause heights
- Volcanoes

Note that fronts are no longer depicted on WAFS SIGWX forecasts in line with Amendment 74 to ICAO Annex 3 (effective 7th November 2007)

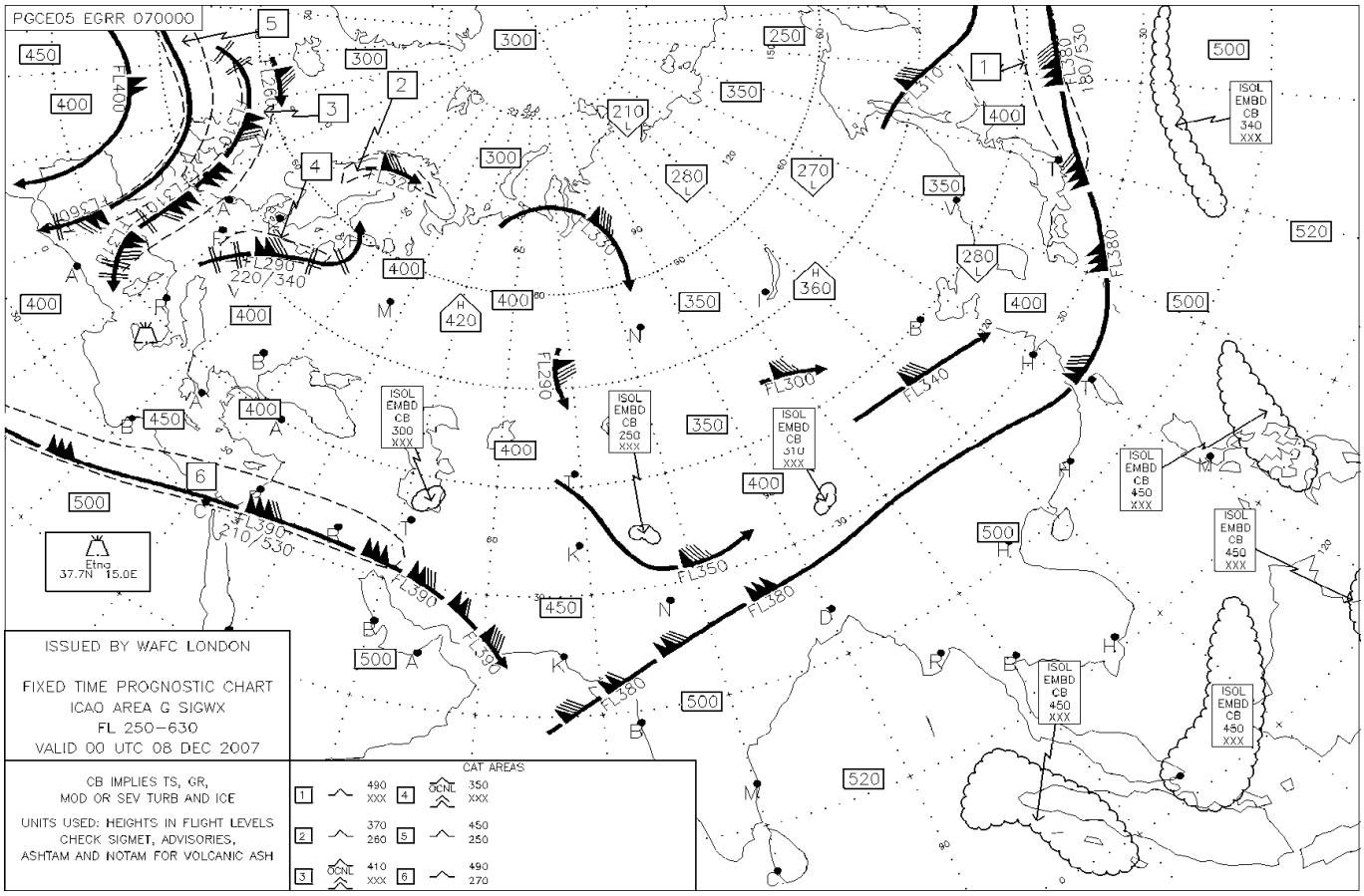


Figure 2 - Example High Level WAFS SIGWX (SWH) chart

Note that Tropical Cyclones, Sandstorms and Radiation events are not depicted in the above SIGWX chart, but would be placed on the chart if the situation dictated.

3.1 GENERAL GUIDANCE AND RECOMMENDED PRACTICES

1. The standard against which software will be reviewed is for WAFS SIGWX charts produced from BUFR to be identical to the equivalent PNG SIGWX chart in regard to the depiction of meteorological information, and largely identical to the depiction of non-meteorological features, which include cloud text boxes, volcano legend boxes and CAT boxes. In addition, it is recommended that visualisation software can deliver WAFS products to the standards recommended within Annex 3 to the Convention on International Civil Aviation. In particular, section 4 of Appendix 8 to Annex 3 provides recommendations related to the presentation of flight documentation. It is strongly recommended that visualisation software can deliver products to these recommended practices.

2. Legends assigned to charts constructed from BUFR should state the production source of the BUFR data used to create the chart (i.e. WAFC London or WAFC Washington). However, if the user modifies *any* of the meteorological information contained on the chart, the software must *automatically* remove any reference to the originating source. The addition of new meteorological information, e.g. interpolated jet speeds, using techniques *specified in this document* is permissible. The physical positions of cloud text boxes and CAT boxes can be modified without needing to remove reference to the source of the data.

3. Legends are required to contain the same text as assigned to a PNG SIGWX chart legend. An example now follows:

4. The standard ICAO areas (namely A, B, B1, C, D, E, F, G, H, I, J, K and M), with their correct projections, should be available to users as default areas. These include the ability to produce a chart which spans the International Date Line.

5. Production of SIGWX charts for these standard areas should be attainable via an automated process which requires no human intervention to “de-clutter” overlapping or misaligned text boxes. An auto-placement algorithm will need to be employed to determine the location of information that is not assigned with a position in the BUFR message, e.g. the location of cloud text boxes, CAT boxes. It is recommended that a manual editing facility is available to users so that the physical locations of these boxes can be changed if required. Attention must be given to the distance of the text boxes from the associated cloud. This is especially important when cloud areas straddle the edge of the depicted area.

6. Particular emphasis should be given to the correct depiction of tropical cyclones, radiation events, and volcanic eruption symbols and associated information. New standards have been agreed with ICAO regarding the depiction of any of these features that are co-incident or partially overlapping. The order of priority for these features is as follows:

   i) volcanic eruptions; followed by
   ii) radiation events: followed by
   iii) tropical cyclones.

   These features should be given a plotting priority greater than all other features displayed on the chart. In the event of any of these features being co-incident or partially overlapping then the item with highest priority should be placed at the location of the event, and an arrow should be used to link the location of the other item(s) to its associated symbol or text box.

7. ICAO Annex 3 (Appendix 8, section 4.2.1.1 point d refers) recommends that major aerodromes should be displayed on WAFS SIGWX charts as a dot and identified by the first letter of the name of the city the aerodrome serves as given in Table AOP of the relevant air navigation plan. It is strongly recommended that visualisation software conforms to this ICAO requirement as a minimum, and in addition, ensures that the dots and corresponding letters are not over-plotted by non-meteorological features, which include cloud text boxes, and volcano legends. Over-plotting by all meteorological phenomena (e.g. cloud areas), chart legend and CAT boxes is permitted.

8. Examples of decoded BUFR bulletins are included in this document. These examples include a "Feature Header", and "Type of Feature" description. It should be noted that the "Type of Feature" is included in this document for clarity purposes, but is not included in the operational BUFR bulletins.

9. Amendment 74 to ICAO Annex 3 (effective 7th November 2007) eliminated the requirement for depiction of surface fronts and well-defined convergence zones (e.g. ITCZ) on WAFS SIGWX forecasts (in BUFR-code and PNG chart form). Due to the downstream implications on users of completely withdrawing the BUFR bulletins related to frontal systems (namely JUFE00 EGRR, JUFE00 KKCI, JUJE00 EGRR and JUJE00 KKCI), it was decided to continue to disseminate these bulletins, but to ensure that they contain no data (i.e. they are empty apart from message header information as described in 2.1 and 2.2 above). Subsequently, the FEATURE HEADER and FEATURE DATA elements of the following BUFR bulletins are no longer shown: JUFE00 EGRR, JUFE00 KKCI, JUJE00 EGRR and JUJE00 KKCI. Further information in section 3.2 below.

10. Data held within the BUFR bulletins does not include a description of the graphical representation of the phenomena, e.g. information describing the volcano symbol graphic, or the symbol used to indicate moderate CAT. Software will need to be designed so that it displays phenomena using the standard depictions included in Appendix 1 to ICAO Annex 3. Part of this appendix is included in Annex 1 to this document to assist developers. However, it should be noted that not all of the elements included in this Annex are utilised on WAFS SIGWX charts. The elements that are utilised include: Tropical Cyclone, Moderate Turbulence, Severe Turbulence, Moderate Aircraft Icing, Severe Aircraft Icing, Radioactive Materials in the Atmosphere, Volcanic Eruption, Widespread Sandstorm or Dust Storm, Tropopause High, Tropopause Low, Tropopause Level, and Position, Speed and Level of Maximum Wind. Note that if the maximum wind speed is 240km/h (120kt) or more, the flight level between which winds are greater than 160km/h (80kt) is placed below the maximum wind level. The scheme depicted in section 4 of this document is in accordance with this recommended practice.

3.2 HANDLING OF WAFS BUFR BULLETINS THAT CONTAIN NO DATA

As alluded to above, under the direction of Amendment 74 to ICAO Annex 3 (effective 7th November 2007), the WAFCs are no longer required to depict surface fronts and well-defined convergence zones (e.g. ITCZ) on WAFS SIGWX forecasts (in BUFR-code and PNG chart form).

Due to the downstream implications on users of completely withdrawing the BUFR bulletins related to frontal systems (namely JUFE00 EGRR, JUFE00 KKCI, JUJE00 EGRR and JUJE00 KKCI), it was decided to continue to disseminate these bulletins, but to ensure that they contain no data (i.e. they are empty apart from message header information as described in 2.1 and 2.2 above).

This practice is in accordance with WMO guidelines related to the encoding of BUFR data, whereby BUFR will simply not encode feature types or feature data when there is no data.

Subsequently, the FEATURE HEADER and FEATURE DATA elements of the following WAFS BUFR bulletins are no longer shown (as routine):

i) JUFE00 EGRR;

ii) JUFE00 KKCI;

iii) JUJE00 EGRR; and

iv) JUJE00 KKCI.

An example BUFR decode of i) and iii) is now provided as guidance. Users will note that only the MESSAGE HEADER information is depicted, whilst FEATURE HEADER and FEATURE TYPE have been eliminated:

i) SWH fronts bulletin example (JUFE00 EGRR):

```
          93
        2007           11           06           00           00
        2007           11           07           00           00
        7620        19200
```

iii) SWM fronts bulletin example (JUJE00 EGRR):

```
          93
        2007           11           06           00           00
        2007           11           07           00           00
        3050        13720
21.4  -21.6,  46.6  -56.6,  58.7   68.4,  26.4   33.4.
10.0   17.0,  44.0   17.0,  44.0   70.0,  10.0   70.0.
  .0   53.0,  36.0   53.0,  36.0  108.0,    .0  108.0.
NO WASHINGTON BACKUP
```

It is advisable that workstation software is capable of handling BUFR fronts bulletins (outlined above) that contain no data points.

Important note: There may be occasions where a BUFR bulletin, apart from fronts, contains no data. For example, if there was no VTS occurring (volcanoes, tropical storms, sandstorms or radiation events), then the VTS bulletins JUVE00 EGRR and JUVE00 KKCI would contain no feature header element and no feature data elements (i.e. they would be empty apart from the message header). Therefore, workstation providers may consider it advisable to develop software that is capable of handling *any* BUFR bulletin that contains no data, irrespective of type, so that a SIGWX product can be generated.

4 JET STREAM Representation

The JET STREAMS shown in Figure 2 can be represented in a text form which the BUFR encoder will understand. It will then be able to code up this data into a BUFR message.

A JET is made up of a series of CORE points, wind symbols (fleche marks) and change bars. The wind symbol at the location of maximum jet speed/speeds also contain vertical depth information in the format J_L/J_U, where J_L = the *flight level* of the 80kt isotach below the maximum wind speed level, and J_U = the *flight level* of the 80kt isotach above the maximum wind speed level. The convention for indicating specific *flight levels* in the jet depth information, as opposed to earlier +/- depth notation, was adopted by the WAFCs in July 2006. Flight level specific jet depth notation is now the required standard. Only jet streams with a speed of 120 knots or more will contain vertical jet depth information.

Core points are encoded in BUFR with a designated latitude and longitude, but no speed or flight level. All of these core points should be used to plot the location of jet-streams. An appropriate smoothing technique such as a cubic spline should be used to smooth the jet-stream curve plotted between these core points. It is not recommended that any other points within the BUFR bulletin are included within the cubic spline routine for smoothing. Care should be taken when applying smoothing techniques not to over-smooth, causing significant deviations from the depicted lines on the equivalent PNG SIGWX charts.

Latitude and longitude points assigned to wind symbols should not be included in the process used to draw the axis of the jet-stream. The wind symbols should be plotted separately along the length of the jet displaying the speed and flight level information assigned to them within the BUFR message. The latitude and longitude points that are assigned to each wind symbol should be viewed as a first estimate of the position of each wind symbol. This position may be a short distance away from the axis of the jet-stream depending on the degree of alignment between the smoothing algorithms employed at the production and user sites. It is recommended that the end users software utilises a function that computes the nearest position along the jet axis to the location of each wind symbol as provided in the BUFR messages, and automatically plots the wind symbol at this position.

For user defined chart areas that do not contain a jet max wind vertex we recommend that no vertical depth information is derived through interpolation. On such occasions we recommend that the jet is plotted with no vertical depth information, i.e. interpolated jet height values are not used.

If there is insufficient space (less than 15 characters) on the jet-stream to display a full wind symbol, a change bar may be used instead. A change bar depicts a change of speed of 20 knots. Please note that change bars are not used to depict changes in jet height.

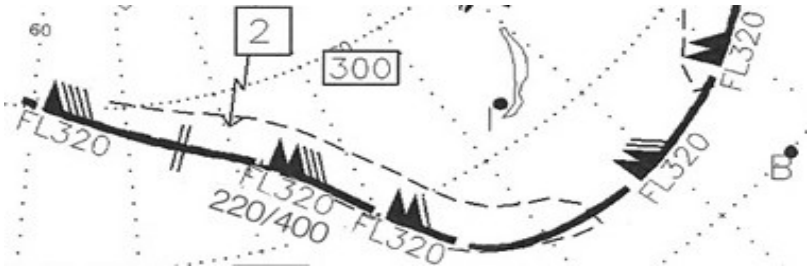


Figure 3 – Example Jet Stream

Note: vertical depth information values are only included for jet-streams with a maximum speed of 120KT or more.

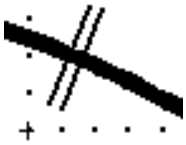
Crossing jets are no longer depicted by the WAFCs on SIGWX products and therefore reference to the depiction scheme from the BUFR encoded data has been removed from this document.

Northern hemisphere example.

Southern hemisphere example.

The WIND SYMBOLS (sometimes called WIND FLECHES) indicate the wind speed, flight level and jet depth (at the point(s) of maximum speed only) for the locations it is positioned at. Each black triangle represents 50 knots, each line 10 knots and each half line 5 knots. The flight level is written in terms of how many 100's feet it is at. The first example (northern hemisphere orientation) gives a speed of 130 knots at 35,000 feet. The second example (southern hemisphere orientation) gives a speed of 130 knots at 40,000 feet. The additional information displayed on both these examples relates to the jet depth. The format of the jet depth information is as follows: J_L/J_U where J_L = the flight level of the 80kt isotach below the maximum wind speed level, and J_U = the flight level of the 80kt isotach above the maximum wind speed level. Only jet streams with a speed of 120 knots or more will contain vertical jet depth information.

For a jet that starts in the northern hemisphere, the speed symbols are displayed to the left of the jet core (as drawn in the order of encoded core points). For a jet that starts in the southern hemisphere, the speed symbols are displayed to the right of the jet axis. The jet height and depth information are displayed on the opposite side of the jet axis to the speed symbols, with the height information closest to the jet axis for jets in the northern hemisphere, and the jet depth information closest to the jet axis for jets displayed in the southern hemisphere – see examples to the left.



The CHANGE BAR represents a change of 20 knots along the JET. By ICAO definition, a JET will always start and finish at 80 knots. By using change bars and wind symbols, the speed of a JET can be plotted anywhere along its course. It is recommended that change bars are only plotted when there is insufficient space, less than 15 characters, between WIND SYMBOLS.

It is recommended that the software always plots the maximum wind (using a wind symbol) along the length of the jet-stream, and then works laterally along the length of the jet in both directions using a combination of wind symbols and change bars as appropriate. This approach makes the change bars *maximum speed relative* as opposed to minimum wind (80 KT) relative, i.e. the change bars represent 20-knot steps from the maximum speed rather than from the 80-knot end points.

In BUFR, change bars are not explicitly encoded. The scale of the chart being drawn and the area it covers will determine the proportion of wind symbols to change bars. This will need to be worked out by the graphics program that constructs the chart.

Under ICAO recommended practices, the WAFCs are required to depict jetstreams of speed 80 knots or more on their SIGWX products. Therefore, on occasion, the WAFCs may include a jetstream of maximum speed 80 knots (as shown left). It has been commented that, under the guidance outlined above, some workstations may not adequately handle the visual representation of the 80 knot jet from the BUFR data – since, the 80 knot data value is also the maximum wind value. In these instances, it is advisable that workstations develop sufficient software code to adequately visualise the 80 knot jet from the BUFR data.

To mitigate against so-called "edge effects", when jet speed and height information is missing from jets plotted near chart boundaries, it is permissible (indeed recommended) for the software to deduce the flight level at the start and end of jets near chart borders, and at any points in between as required, by assuming that the flight level at a point is the same as it is at the nearest available wind symbol. Similarly, it is recommended that the software applies, when necessary, linear interpolation between wind symbols to establish the speed at any point along a jet axis.

4.1 FEATURE HEADER

Contains the type of data to follow and the number of features in the list.

```
JET                 Type of feature
      2             Number of jets in list
```

4.2 FEATURE DATA

The first row for each jet lists the number of points (both core and wind symbol) in it. Six columns containing latitude, longitude, height information, speed data, height of 80 knot isotach located above jet, and height of 80 knot isotach located below jet follow. Height is stored in metres and speeds in ms^{-1}. The visualization software needs to express the data on charts using conventional Flight Level and knots values.

```
11                                                              Number of points to follow (1st jet)

35.4  -104.7  -9999999.0  -9999999.0  -9999999.0  -9999999.0  Core point (no height and speed data)
36.1  -101.6     10668.0        51.5  -9999999.0  -9999999.0  Wind Symbol (speed and height data given)
36.6   -99.6  -9999999.0  -9999999.0  -9999999.0  -9999999.0
36.9   -97.7     15240.0        61.8     15240.0     13716.0  Wind symbol at position of max speed
37.4   -94.9  -9999999.0  -9999999.0  -9999999.0  -9999999.0
38.3   -92.3     15240.0        51.5  -9999999.0  -9999999.0
39.2   -90.3  -9999999.0  -9999999.0  -9999999.0  -9999999.0
40.7   -88.1     15240.0        61.8     16154.0     14326.0  Wind symbol at position of max speed
41.5   -86.3  -9999999.0  -9999999.0  -9999999.0  -9999999.0
42.0   -82.7      9144.0        51.5  -9999999.0  -9999999.0
41.9   -78.9  -9999999.0  -9999999.0  -9999999.0  -9999999.0

8                                                               Number of points to follow (2nd jet)

41.1  -101.8  -9999999.0  -9999999.0  -9999999.0  -9999999.0  Core point (no height and speed data)
42.0   -98.8     10668.0        51.5  -9999999.0  -9999999.0  Wind Symbol (speed and height data given)
42.2   -98.5  -9999999.0  -9999999.0  -9999999.0  -9999999.0
44.3   -96.9     12192.0        61.8     12802.0     11278.0  Wind symbol at position of max speed
45.2   -96.5  -9999999.0  -9999999.0  -9999999.0  -9999999.0
45.8   -96.3     12192.0        51.5  -9999999.0  -9999999.0
49.6   -95.5  -9999999.0  -9999999.0  -9999999.0  -9999999.0
51.4   -95.5  -9999999.0  -9999999.0  -9999999.0  -9999999.0
```

5 CAT Representation

Clear Air Turbulence (CAT) is represented on a SIGWX chart by a dashed area and a number (See Figure 4). This number relates to the base, top and type information held in the CAT legend box. In BUFR, how the data is depicted is not specified. Only the points describing the line and the attributes associated with that line are held.

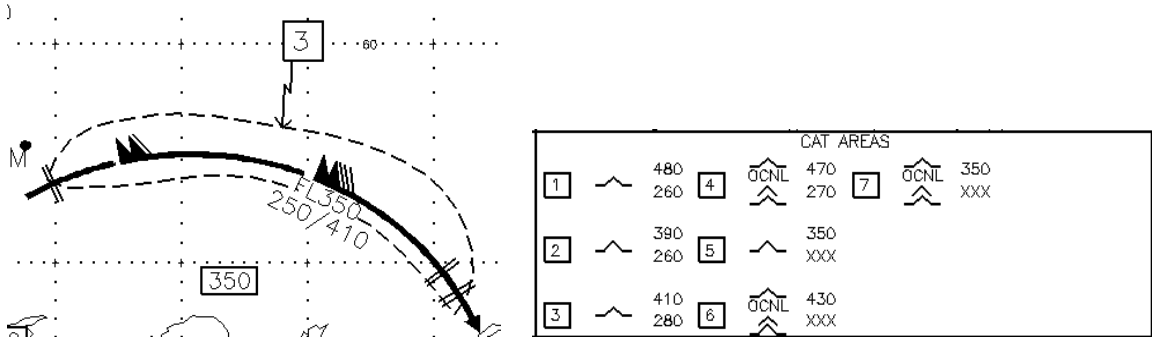


Figure 4 - CAT area and legend box

It is recommended that a cubic spline technique is employed to ensure that a smooth continuous line is plotted between vertices. However, care should be taken when applying smoothing techniques not to over-smooth, causing significant deviations from the depicted lines on the equivalent PNG charts.

Please note that open and closed boundaries are used for encoding CAT information – see section 1.3.4.

If call-out arrows are used to link areas of CAT to boxed numbers then it is recommended that the call-out arrows point to the CAT boundaries as opposed to inside the areas of CAT. This is not mandatory (and is not always followed by the WAFCs when constructing PNG formatted SIGWX charts), but may simplify the process of displaying "open" cloud and CAT areas.

5.1 FEATURE HEADER

Contains the type of data to follow and the number of features in the list.

```
TURB              Type of feature
      2           Number of CAT areas in list
```

5.2 FEATURE DATA

1st row = heights of CAT base and top in meters, 2nd row = number of points in area. These are followed by two columns containing latitude and longitude data. A single number in the last row indicates the degree of turbulence (6=MOD, 7=SEVERE, 19=MOD OCNL SEVERE).

```
   10363.2     12192.0        BASE and TOP of CAT area (metres)
17                            Number of points in CAT area
  44.5      -96.8             Latitude and longitude values
  44.6      -94.2
  46.0      -89.1
  44.8      -75.8
  45.2      -63.5
  44.6      -57.2
  44.4      -50.0
  44.8      -34.3
  46.8      -32.8
  51.5      -38.9
  52.2      -47.1
  52.6      -59.4
  54.6      -69.0
  55.3      -84.3
  52.2      -91.6
  47.0      -97.7
  44.5      -96.8             CLOSED area because the last point matches the first
          6                   Degree of turbulence (see Section 11 - table 011030)


   11887.2         13716.0    BASE and TOP of CAT area (metres)
 12                           Number of points in CAT area
  72.2      -58.5             Latitude and longitude values
  69.9      -59.8
  67.1      -49.8
  63.8      -35.3
  61.0      -25.3
  57.6      -16.0
  53.6       -7.1
  58.0        4.3
  62.1        3.9
  69.4      -11.6
  74.4      -39.0
  72.2      -58.5             CLOSED area because the last point matches the first
          6                   Degree of turbulence (see Section 11 - table 011030)
```

6 CLOUD Representation

CLOUD areas (see Figure 5) are shown on the charts as a scalloped area and an information box, sometimes shown with an arrow if the box is not inside the area. It may assist the visualisation software if the arrow points to the boundary of the cloud area. As with CAT, only the data is held in BUFR, so the box itself, its position and the arrow are all added by the drawing package.

Open and closed cloud boundaries are encoded in BUFR – see section 1.3.4.

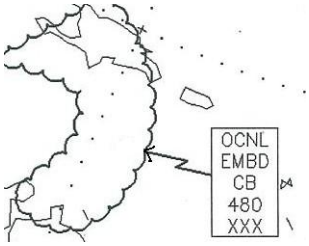


Figure 5 - CLOUD area and data box

It is recommended that a cubic spline technique is employed to ensure that a continuous scalloped line is plotted between vertices.

Cloud areas are encoded with an orientation of the cloud area being to the left of the boundary when drawn in the order of points given. To replicate this orientation at the client side, ensure that cloud scallops point to the right when cloud areas are drawn in the order of points given.

6.1 FEATURE HEADER

Contains the type of data to follow and the number of features in the list.

```
CLOUD              Type of feature
      2            Number of CLOUD areas in list
```

6.2 FEATURE DATA

1st row = heights of CLOUD base and top in meters, 2nd row = number of points in area. These rows are followed by two columns containing latitude and longitude data. The numbers in the last row indicate the distribution and type of the CLOUD.

```
-9999999.0      12496.8              BASE and TOP of CLOUD area (metres)
     9                               Number of points in CLOUD area
  26.7      -84.7                    Latitude and longitude values
  24.2      -84.2
  19.0      -79.6
  19.6      -74.9
  23.0      -72.2
  28.2      -72.2
  31.7      -77.9
  28.6      -85.1
  26.7      -84.7
     9          9            CLOUD distribution (see Section 11 - table 020008)
                                    CLOUD type (see Section 11 - table 020012)

 -9999999.0      11887.28            BASE and TOP of CLOUD area (metres)
    8                                Number of points in CLOUD area
  28.2      -57.0                    Latitude and longitude values
  28.4      -49.2
  28.0      -41.4
  26.0      -30.7
  30.7      -25.0
  33.4      -33.1
  31.7      -52.6
  28.2      -57.0
    11         9            CLOUD distribution (see Section 11 - table 020008)
                                    CLOUD type (see Section 11 - table 020012)
```

7 FRONT Representation, including Convergence Zones (e.g. ITCZ)

IMPORTANT NOTE: Amendment 74 to ICAO Annex 3 (effective 7th November 2007) eliminated the requirement for depiction of surface fronts and well-defined convergence zones (e.g. ITCZ) on WAFS SIGWX forecasts (in BUFR-code and PNG chart form). Due to the downstream implications on users of completely withdrawing the BUFR bulletins related to frontal systems (namely JUFE00 EGRR, JUFE00 KKCI, JUJE00 EGRR and JUJE00 KKCI), it was decided to continue to disseminate these bulletins, but

to ensure that they contain no data (i.e. they are empty apart from message header information as described in 2.1 and 2.2 above).

Subsequently, the FEATURE HEADER and FEATURE DATA elements of the following BUFR bulletins are no longer shown:

SWH frontal bulletins: JUFE00 EGRR and JUFE00 KKCI
SWM frontal bulletins: JUJE00 EGRR and JUJE00 KKCI.

8 TROP Representation

Three different types of tropopause (TROP) labels are used on SIGWX charts (see Figure 8). Namely, TROP highs, lows and spot values. These are represented as three different types in BUFR.

It is strongly recommended to display as many of the spot values encoded in the BUFR bulletin as possible but ensuring that chart clutter does not occur

Figure 8 - High, low and spot value trop boxes

8.1 FEATURE HEADER

Contains the type of data to follow and the number of features in the list.

```
TROP                Type of feature
      3             Number of types of TROP boxes in list
```

8.2 FEATURE DATA

1st row = type of tropopause box (e.g. low, high). 2nd row = number of trop boxes of this type, followed by three columns containing latitude, longitude and height data. Heights are in metres.

```
-9999999                              Type of TROP box (see Section 11 - table 008023)
       4                              Number of TROP boxes of this type
    57.6     -116.9    14020.8        Latitude and longitude location and height value
    78.7      -78.1    14020.8
    73.6       14.1    14020.8
    45.4       36.3    14020.8

       3                              Type of TROP box (see Section 11 - table 008023)
       1                              Number of TROP boxes of this type
    55.0       30.0    11582.4        Latitude and longitude location and height value

       2                              Type of TROP box (see Section 11 - table 008023)
       1                              Number of TROP boxes of this type
    31.8      -13.7    13716.0        Latitude and longitude location and height value
```

9 VOLCANOES, SANDSTORMS, TROPICAL CYCLONES and RADIATION Representation

Volcanoes, sandstorms, tropical cyclones and radiation events are all held in one file. The symbols on the charts are shown in figure 9 and 10. The data for each feature is held in BUFR as shown below, though no details of *how* these are to be depicted is given. The convention outlined in ICAO Annex 3 should be followed. Information contained in this BUFR bulletin is equally applicable to SWM charts and SWH charts.

Important Note: *Guidance has been included under item 6 in section 3.1 of this document regarding the depiction of co-incident or partially overlapping features.*

Figure 9 - Volcano, Tropical Cyclone (TC "FRED", northern hemisphere orientation), Tropical Cyclone (TC "BOLOETSE", southern hemisphere orientation) and Radiation symbols

Please note that the applicability of this data to SWM and SWH charts is reflected in the message header of the bulletin. The flight level boundaries span the base of a SWM chart (3050 m) to the top of an SWH chart (19200 m) – see below.

```
93                                  Originating centre.
 2006  01    30    00    00        DATA Time - Year, month, day, hour, minute
 2006  01    31    00    00        FORECAST Time - Year, month, day, hour, minute
      3050        19200             Flight level boundaries (base and top)
```

9.1 FEATURE HEADER

There are 3 possible headers in this file, each indicating the type of data to follow and the number of features in the list.

```
STORM                   Type of feature (covering Tropical Storms (TC) and Sandstorms)
       1                Number of STORMS in list

VOLCANO                 Type of feature
       1                Number of VOLCANOES in list

RADIATION               Type of feature
       1                Number of RADIATION incidents in list
```

9.2 FEATURE DATA

Each feature follows a different set of data as shown below.

STORM

```
FRED                    Name – 'UNKNOWN' used if it's a sandstorm.
25.0      -78.0         Latitude and Longitude of storm
2                       STORM type (See Section 11 - table 019001)
```

VOLCANO

```
Etna                    Name of volcano
37.7       15.0         Latitude and longitude of volcano
2003       11        25       9        30
                        Eruption time (Year, month, day, hour and minute;
                        the date and time of eruption is not routinely included in the
                        BUFR bulletins produced by the two WAFCs. This is because the
                        information is not normally available to the WAFC forecasters.)
```

RADIATION

```
-9999999                Location of incident (Not used at present)
  53.2       -24.1      Latitude and longitude of incident
-9999999   -9999999    -9999999   -9999999   -9999999
                       Eruption time (Year, month, day, hour and minute;
                       Year and month are not used)
```

Note 1: The SIGWX BUFR encode software inserts a replication factor of 1 for each volcano. This replication factor is not explicitly displayed when the UK Met Office decoder is used.

Note 2: As described above, the storm name "UNKNOWN" is used if widespread sandstorm/duststorm is to be depicted in the forecast. To represent widespread sandstorm/duststorm, the following symbol is used:

Figure 10: Symbol representing widespread sandstorm/duststorm.

10 Medium Level SIGWX (SWM) Data

IMPORTANT NOTE*: In accordance with the implementation of ICAO Annex 3 Amendment 74 (effective 7th November 2007) the depiction of surface fronts, the inter-tropical convergence zone and cloud on SWM forecasts issued by WAFC London and WAFC Washington changed. Under Amendment 74 recommendations, for SWM forecast data, the WAFCs were no longer required to:*

i) depict surface fronts;
ii) depict the inter-tropical convergence zone (ITCZ)s; and
iii) indicate non-CB cloud type or amount. Reference will therefore only be made to the degree of CB activity or in-cloud icing and turbulence.

10.1 GENERAL

WAFS SWM data is valid between FL100 and FL450. Currently, data for only four regions of the world are included in the SWM bulletins: three regions are routinely included in the SWM bulletins issued by WAFC London, and a single region (NAT) is included in the SWM bulletins issued by WAFC Washington. During periods of backup, data for all four regions are included in the SWM bulletins issued by the operational WAFC. Global SWM data is not provided in the SWM bulletins. The areas for which data is provided correspond to the following PNG chart areas: NAT, EURO, MEA and ASIA SOUTH. Refer to Figure 10 for relevant headers.

SWM Area	Originating WAFC	WMO Header
EURO	Routine: London	PGDE14 EGRR
MEA	Routine: London	PGCE14 EGRR
ASIA SOUTH	Routine: London	PGZE14 EGRR
NAT	Routine: Washington	PGNE14 KKCI

Figure 11 – SWM forecast areas, and corresponding headers of PNG charts

The current SWM production schedule requires WAFC London to produce data for areas EURO, MEA and ASIA SOUTH, and for Washington to produce data for area NAT. This will result in WAFC London issuing BUFR data for its three areas of responsibility using bulletins of WMO format JU**** EGRR, and WAFC Washington issuing data for its single area of responsibility using bulletin headers of format JU**** KKCI. During periods of backup when one of the centres is unavailable the other (operational) centre will produce data for all four regions - and include this complete data within its routine bulletins JU**** EGRR/KKCI.

It is required that the visualisation software clearly depicts, when necessary, the limited coverage areas of this data to ensure that users do not try and produce SWM charts from BUFR data over user defined regions that do not contain forecast data. It is strongly recommended that the software indicates, by way of diagonal hatching lines, all geographical areas that are not covered by forecast data. The areas for which data *is* included are described below.

NAT
Northern Polar Stereographic Projection

BLHC_LATITUDE	=	+17.2
BLHC_LONGITUDE	=	-54.1
TRHC_LATITUDE	=	+50.7
TRHC_LONGITUDE	=	+60.3
VERTICAL_LONGITUDE	=	-20.0

MEA
Mercator Projection

BLHC_LATITUDE	=	+10.0
BLHC_LONGITUDE	=	+17.0
TRHC_LATITUDE	=	+44.0
TRHC_LONGITUDE	=	+70.0

EURO
Northern Polar Stereographic Projection

BLHC_LATITUDE	=	+21.4
BLHC_LONGITUDE	=	-21.6
TRHC_LATITUDE	=	+58.7
TRHC_LONGITUDE	=	+68.4
VERTICAL_LONGITUDE	=	+11.1

ASIA SOUTH
Mercator Projection

BLHC_LATITUDE	=	+0.0
BLHC_LONGITUDE	=	+53.0
TRHC_LATITUDE	=	+36.0
TRHC_LONGITUDE	=	+108.0

where BLHC=bottom left hand corner, TLHC=top left hand corner, TRHC=top right hand corner, and BRHC=bottom right hand corner. Negative latitude values are located in the southern hemisphere, and negative longitude values in the western hemisphere.

All of these four areas are used on rectangular displays. Appropriate cartographic routines will need to be employed to ensure that these defined areas remain valid when displayed on different map projections, e.g. when data for the area ASIA SOUTH is displayed on a Northern Polar Stereographic projection.

The chart areas for which data is produced at medium level will be described within the SWM bulletins.

All of the information that is required for SWM charts is contained in the following bulletins:-

BUFR FEATURES	COMMON NAME	WMO HEADER used by WAFC London	WMO HEADER used by WAFC Washington
Tropical Cyclone, Sandstorms & Volcanoes	V_T_S	JUVE00 EGRR	JUVE00 KKCI
SWM Tropopause height	M-TROP	JUOE00 EGRR	JUOE00 KKCI
SWM jet-streams	M-JETS	JUTE00 EGRR	JUTE00 KKCI
SWM fronts	M-FRONTS	JUJE00 EGRR	JUJE00 KKCI
SWM cloud, in-cloud icing and turbulence	M-CLOUD	JUNE00 EGRR	JUNE00 KKCI
SWM Clear Air Turbulence (C.A.T.)	M-CAT	JUME00 EGRR	JUME00 KKCI

Figure 12 – Bulletins containing SIGWX data applicable to SWM charts

***Important Note**: The bulletin that contains tropical cyclone, sandstorm and volcano information (JUVE00 EGRR and JUVE00 KKCI) is the same bulletin used for producing SWH charts. This bulletin is equally applicable to SWM and SWH charts.*

10.2 SWM CLEAR AIR TURBULENCE (CAT)

All CAT information that is applicable to SWM is contained in the bulletin JUME00 EGRR/KKCI. Section 5 of this document provides an example of how this information is presented within a CAT bulletin applicable to SWH. This format is identical to the format used for SWM CAT with the only exception that the FEATURE HEADER is modified to:

```
MTURB                Type of feature [Medium level Clear Air Turbulence]
```

10.3 SWM VOLCANOES, SANDSTORMS, TROPICAL CYCLONES and RADIATION

All information relating to these types of features is contained in the same bulletin that is used to construct SWH charts (JUVE00 EGRR and JUVE00 KKCI). See section 9 of this document to review the format of how this information is presented. Please note that *all* of the features contained within these files are applicable to the SWM charts, i.e. the phenomena are not height dependent.

10.4 SWM TROPOPAUSE (TROP) HEIGHT

See section 8 of this document to review how tropopause height information is presented. Tropopause heights applicable to medium level charts are contained in the SWM tropopause height bulletin (JUOE00 EGRR and JUOE00 KKCI). This information should be plotted on the SWM charts using the same formats applied to the SWH tropopause heights. The only difference between the SWM and SWH TROP height bulletins is the FEATURE HEADER. The FEATURE HEADER assigned to the SWM TROP height bulletin is as follows:

```
MTROP              Type of feature [Medium level Tropopause height]
```

10.5 SWM JET STREAMS

See section 4 of this document to review how jet stream information is presented. Jet streams applicable to medium level charts are contained in the SWM jet stream bulletin (JUTE00 EGRR and JUTE00 KKCI). This information should be plotted on the SWM charts using the same formats applied to the SWH jet-streams.

```
MJET               Type of feature (Medium level jet-stream)
```

10.6 SWM Fronts

IMPORTANT NOTE*: As alluded to in Section 7 above,* Amendment 74 to ICAO Annex 3 (effective 7th November 2007) eliminated the requirement for depiction of surface fronts and well-defined convergence zones (e.g. ITCZ) on WAFS SIGWX forecasts (in BUFR-code and PNG chart form). Due to the downstream implications on users of completely withdrawing the BUFR bulletins related to frontal systems (namely JUFE00 EGRR, JUFE00 KKCI, JUJE00 EGRR and JUJE00 KKCI), it was decided to continue to disseminate these bulletins, but to ensure that they contain no data (i.e. they are empty apart from message header information as described in 2.1 and 2.2 above).

Subsequently, the FEATURE HEADER and FEATURE DATA elements of the following BUFR bulletins are no longer shown:

SWH frontal bulletins: JUFE00 EGRR and JUFE00 KKCI
SWM frontal bulletins: JUJE00 EGRR and JUJE00 KKCI.

10.7 SWM Cloud, In-Cloud Icing and Turbulence

On SWM charts, reference is made only to the degree of CB activity or in-cloud icing and in-cloud turbulence. See figure 13 for an example.

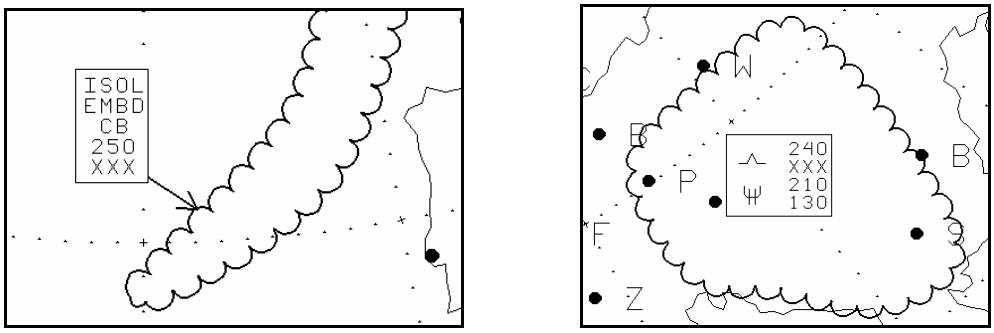


FIGURE 13 – Example Cloud, in-cloud icing and turbulence depiction

10.7.1 FEATURE HEADER

Contains the type of data to follow and the number of features in the list.

```
MCLOUD                  Type of feature
```

10.7.2 FEATURE DATA

1st row = number of points in area. These rows are followed by two columns containing latitude and longitude data. The number in the next row indicates information about the non-CB cloud. Since Amendment 74 to Annex 3 removed the requirement for this information, this entry will always be zero. This is followed by information about the degree of in-cloud turbulence and/or in-cloud icing. Finally, information is provided about CB activity. If in-cloud turbulence and/or in-cloud icing and/or CB activity is not present, then this is specified in the message (=0), and subsequent descriptive information about this element is not included.

```
 8                              Number of points in CLOUD area
28.2      -57.0                Latitude and longitude values
28.4      -49.2
28.0      -41.4
26.0      -30.7
30.7      -25.0
33.4      -33.1
31.7      -52.6
28.2      -57.0
 0                              Number of NON-CB CLOUD distributions (see section 11
                                - descriptor 031001). Will always be 0 and there is
                                no following row listing CLOUD distribution.
 0                              Number of NON-CB CLOUD types (See Section 11 –
                                descriptor 031001). Will always be 0 and there is no
                                following row listing types because there are no NON-
                                CB TYPES.
 1                              TURBULENCE section (=1 if turbulence, 0 if not - in
                                which case next 2 rows are excluded)
 -9999999       7315            BASE and TOP of TURBULENCE area (metres)
 2                              DEGREE of TURBULENCE (See Section 11 – table 011030)

 1                              ICING section (=1 if icing, 0 if not - in which case
                                next 2 rows are excluded)
 3353           6706            BASE and TOP of ICING area (metres)
 5                              DEGREE of ICING (See Section 11 – table 020041)

 1                              Optional CB section (=1 if CB, 0 if not - in which
                                case next 3 rows are excluded)
 -9999999       10668           BASE and TOP of CB CLOUD (metres)
 9                              CLOUD distribution (see Section 11 - table 020008)
 9                              CLOUD type (=CB)(See Section 11 – table 020012)
```

11 RELEVANT BUFR TABLES

Elements that are commonly used in SWM and/or SWH data are highlighted in **red**. Other items are never used or only infrequently.

001031 ORIGINATING/GENERATING CENTRE

```
  1   AMMC MELBOURNE
  2        MELBOURNE
  4   RUMS MOSCOW
  5        MOSCOW
  7   KWBC WASHINGTON WAFC
  8   KWXX US W/SERVICE (NWSTG)
  10  HECA CAIRO  RMC
  11       CAIRO  RMC
  12  GOOY DAKAR  RMC
  13       DAKAR  RMC
  14  HKNA NAIROBI RMC
  15       NAIROBI RMC
  16  FMMD ANTANANARIVO       (not in Manual)
  17       ANTANANARIVO       (not in Manual)
  18  DTTV TUNIS-CASABLANCA
  19       TUNIS-CASABLANCA
  20  SPLP LAS PALMAS
  21  DAMM ALGIERS
  22  LPLG LAGOS  RMS         (not in Manual)
  23       LAGOS  RMS         (not in Manual)
  24  FAPR PRETORIA
  25  FME  LA REUNION
  26  RUKH KHABAROVSK
  27       KHABAROVSK
  28  DEMS NEW DELHI
  29       NEW DELHI
  30  UNNN NOVOSIBIRSK
  31       NOVOSIBIRSK
  32  RUTK TASHKENT
  33       JEDDAH
  34  RJTD TOKYO
  35       TOKYO RMC
  36  VTBB BANGKOK
  37  MNUB ULAN BATOR
  38  BABJ BEIJING
  39       BEIJING
  40  RKSL SEOUL
  41  SABM BUENOS AIRES
  42       BUENOS AIRES
  43  SBBR BRASILIA
  44       BRASILIA
  45  SCSC SANTIAGO
  46       BRAZILIAN SA - INPE
  51  KMIA MIAMI
  52       MIAMI  HURRICANE CENTRE
  53  CWAO MONTREAL RMC
  54       MONTREAL RMC
  55  KSFO SANFRANCISCO
  57  KARS US AIR FORCE (ARGOS COMMUNICATIONS CENTRE, LANDOVER, MD)
  58  KMRY US NAVY, MONTEREY
  59  KBOU BOULDER (NOAA FORECAST LAB)
  60       NCAR
  61       Service ARGOS (Landover)
  62       US Naval Oceanographic Office
  64  PHNL HONOLULU
  65  ADRM DARWIN
  66       DARWIN
  67  AMMC MELBOURNE
  69  NZKL WELLINGTON
  70       WELLINGTON
  71  NFFN NADI (FIJI)
  74  EGRR UK MET OFFICE
  75       UK MET OFFICE
  76       MOSCOW
  78  EDZW OFFENBACH
  79       OFFENBACH
  80  LIIB ROME   RMC
  81       ROME   RMC
  82  BGSF SONDRE/STROMFJORD GREENLAND ??? (Manual says Norrkoping)
  83  ESWI NORRKOPING RMC
  84       Toulouse
  85  LFPW TOULOUSE
  86  EFKL HELSINKI
  87  LYMB BELGRADE
  88  ENMI OSLO
  89  LKPR PRAGUE
  90  LCRO EPISKOPI
  91  LTAA ANKARA
  92  EDDZ FRANKFURT/MAIN
  93  EGRR LONDON WAFC
  94  EKCH COPENHAGEN
  95  LERT ROTA
```

```
96  LGAT ATHENS
97  EESA ESA
98  ECMF ECMWF
99  EHDB DE BILT
110 VHHH HONG KONG
160      NOAA/NESDIS
210      FRASCATI (ESA/ESRIN)
211 LFRO LANNION
212 LPPT LISBOA
213 BIRK REYKJAVIK
214      MADRID
215 LSZH ZURICH
216      ARGOS (Toulouse)
217 LZIB BRATISLAVA
218 LHBP BUDAPEST
219 LJLJ LJUBLJANA
220 EPWA WARSAW
221 LDZA ZAGREB
254      EUMETSAT
```

008001 VERTICAL SOUNDING SIGNIFICANCE (7-BIT FLAG TABLE)

```
1  SURFACE
2  STANDARD
3  TROPOPAUSE
4  MAX WIND
5  SIG TEMP
6  SIG WIND
```

008005 METEOROLOGICAL ATTRIBUTE SIGNIFICANCE

```
0  Automatic
1  STORM CENTRE
2  STORM EDGE  OR OUTER LIMIT
3  MAXIMUM WIND
```

008007 DIMENSIONAL SIGNIFICANCE

```
0  POINT
1  LINE
2  AREA
3  VOLUME
```

008021 TIME SIGNIFICANCE

```
0
1  TIME SERIES
2  TIME AVERAGE
3  ACCUMULATED
4  FORECAST
5  F/C TIME SER
6  F/C TIME AVE
7  F/C ACCUM
8  ENSEMBLE MEAN
9                 9-15 ARE AS 1-7 FOR ENSEMBLE MEAN
10
11
12
13
14
15
16 ANALYSED
17 START OF PHENOMENON
18 SONDE LAUNCH
19 ORBIT START
20 ORBIT END
21 ASC NODE
22 WIND SHIFT
23 Monitoring  period
24 Agreed limit for report reception
25 Nominal reporting time
26 Last known position time
27 FIRST GUESS
28 START OF SCAN
29 END OF SCAN
```

008040 CBS Flight Level Significance

0	High resolution data sample
1	Within 20hPa of surface
2	<10hPa
3	Base pressure level for stability index
4	Begin T,ht doubtful
5	Begin missing data (all elements)
6	Begin RH missing
7	Begin T missing
8	Highest level reached before balloon descent
9	End T,ht doubtful
10	End missing data (all elements)
11	End RH missing
12	End T missing
13	0C crossing for RADAT
14	Std pressure
15	Operator added level
16	Operator deleted level
17	Balloon reascended beyond previous highest level
18	Sig RH
19	No more RH
20	Surface
21	Sig T
22	Mandatory T
23	Flight termination
24	Tropopause
25	Aircraft report
26	Interpolated level
27	Mandatory wind
28	Sig wind
29	Max wind
30	Increm wind
31	Increm height
32	Wind termination
33	100-110hPa
40	Inversion
41	Sig RH (NCDC criteria)
42	Sig T (NCDC)
60	80kt FL above jet (flight level of 80-knot isotach)
61	80kt FL below jet (flight level of 80-knot isotach)

011030 – EXTENDED DEGREE OF TURBULENCE

Code figure		
0	Nil	in cloud
1	Light	
2	Moderate	
3	Severe	
4	Nil	in clear air
5	Light	
6	Moderate	
7	Severe	
8	Nil	cloud/clear not specified
9	Light	
10	Moderate	
11	Severe	
12	Extreme, in clear air	
13	Extreme, in cloud	
14	Extreme, cloud/clear air not specified	
15	Light ISOL MOD	
16	Light OCNL MOD	
17	Light FRQ MOD	
18	MOD ISOL SEV	
19	MOD OCNL SEV	
20	MOD FRQ SEV	
21	SEV ISOL EXTREME	
22	SEV OCNL EXTREME	
23	SEV FRQ EXTREME	
24-62	Reserved	
63	Missing value	

020008 CLOUD DISTRIBUTION FOR AVIATION

0	SKY CLEAR	
1	FEW	
2	SCATTERED	
3	BROKEN	
4	OVERCAST	
5		
6	SCT/BKN	scattered/broken
7	BKN/OVC	broken/overcast
8	ISOLATED	
9	ISOL/EMBED	isolated/embedded
10	OCCASIONAL	
11	OCNL/EMBED	occasional/embedded
12	FREQUENT	
13	DENSE	
14	LAYERS	

020012 CLOUD TYPE

0	CI
1	CC
2	CS
3	AC
4	AS
5	NS
6	SC
7	ST
8	CU
9	CB
…	…
40	CH

020090 SPECIAL CLOUDS

0	
1	NACREOUS
2	NOCTILUCENT
3	WATERFALL
4	FIRE CLOUDS
5	VOLCANIC

023002 ACTIVITY OR FACILITY INVOLVED IN INCIDENT

0	
1	GROUND REACTOR
2	SEA REACTOR
3	SPACE REACTOR
4	NUC.FUEL FAC
5	RAD.WASTE
6	WASTE TRANSP
7	WASTE STORAG
8	MANUF.ISOTOP
9	ISOTOPE USE
10	ISO STORAGE
11	ISO DISPOSAL
12	ISO TRANSPRT
13	ISO POWERGEN

031001 is described as DELAYED DESCRIPTOR REPLICATION FACTOR

This is a numeric value indicating how many times a feature is replicated and is NOT a BUFR table.

008011 METEOROLOGICAL FEATURE

```
0  QSTAT FRONT
1  QFRONT ALOFT
2  WARM FRONT
3  WFRONTALOFT
4  COLD FRONT
5  CFRONT ALOFT
6  OCCLUSION
7  INSTAB LINE
8  TROPIC FRONT (ITCZ)
9  CONVERG LINE
10 JET STREAM
11 CLOUD CLEAR
12 CLOUD
13 TURBULENCE
14 STORM
15 AIRFRANE ICING
16 PHENOMENON
17 VOLCANO
18 ATMOSPHERICS
19
20 SPECIAL CLOUDS
```

008023 SIGNIFICANCE OF FOLLOWING VALUE (FIRST ORDER STATISTICS)

```
0
1
2  MAXIMUM
3  MINIMUM
4  MEAN
5  MEDIAN
6  MODAL
7  MEAN ABS ERROR
8
9  STD DEV (N-1) BEST ESTIMATE
10 STD DEV (N)
11 HARMONIC MEAN
12 RMS VECTOR ERROR
13 ROOT MEAN SQUARE
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32 VECTOR MEAN
```

019001 TYPE OF SYNOPTIC FEATURE

```
0  DEPRESSION
1  TROP DEPRESS
2  TROPIC STORM
3  SEVERE STORM
4  TYPHOON
5
6
7
8
9
10 DUST/SANDSTORM
```

```
020041 AIRFRAME ICING
       0  NONE
       1  LIGHT
       2  LIGHT (CLOUD
       3  LIGHT (PRECP
       4  MOD
       5  MOD (CLOUD)
       6  MOD (PRECIP)
       7  SEV
       8  SEV (CLOUD)
       9  SEV (PRECIP)
       10 TRACE
       11 TRACE (CLOUD)
       12 TRACE (PRECIPITATION)
```

12 CONTACT DETAILS

WAFC London can provide a consultancy service to assist individual clients or States in the construction of WAFS visualisation software that is fully compliant with ICAO Annex 3 and the software criteria that has been constructed by the ICAO SADIS Operations Group. Please contact WAFC London via the contact details below for further information.

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ANNEX 1 – SYMBOLS FOR SIGNIFICANT WEATHER
(Extract from Appendix 1 to ICAO Annex 3, Sixteenth Edition, July 2007)

IMPORTANT NOTE: Not all of the elements included in this Annex are utilised on WAFS SIGWX charts. See section 3.1 point 9 for a list of those symbols that are used.

1. Symbols for significant weather

	Tropical cyclone		Drizzle
	Severe squall line*		Rain
	Moderate turbulence		Snow
	Severe turbulence		Shower Hail
	Mountain waves		Widespread blowing snow
	Moderate aircraft icing		Severe sand or dust haze
	Severe aircraft icing		Widespread sandstorm or dust storm
	Widespread fog		Widespread haze
	Radioactive materials in the atmosphere**		Widespread mist
	Volcanic eruption***		Widespread smoke
	Mountain obscuration		Freezing precipitation ****

* In-flight documentation for flights operating up to FL100. This symbol refers to "squall line".

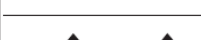
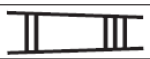
** The following information should be included at the side of the chart: radioactive materials symbol; latitude/longitude of accident site; date and time of accident; check NOTAM for further information.

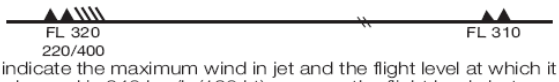
*** The following information should be included at the side of the chart: volcanic eruption symbol; name and international number of volcano (if known); latitude/longitude; date and time of the first eruption (if known);
Check SIGMETs and NOTAM or ASHTAM for volcanic ash.

**** This symbol does not refer to icing due to precipitation coming into contact with an aircraft which is at a very low temperature.

NOTE: Height indications between which phenomena are expected, top above base as per chart legend.

2. Fronts and convergence zones and other symbols used

	Cold front at the surface		Position, speed and level of max. wind
	Warm front at the surface		Convergence line
	Occluded front at the surface		Freezing level
	Quasi-stationary front at the surface		Intertropical convergence zone
	Tropopause High		State of the sea
	Tropopause Low		Sea-surface temperature
	Tropopause Level		Widespread strong surface wind *



Wind arrows indicate the maximum wind in jet and the flight level at which it occurs. If the maximum wind speed is 240 km/h (120 kt) or more, the flight levels between which winds are greater than 160 km/h (80 kt) is placed below the maximum wind level. In the example, winds are greater than 160 km/h (80 kt) between FL 220 and FL 400.

The heavy line delineating the jet axis begins/ends at the points where a wind speed of 160 km/h (80 kt) is forecast.

* This symbol refers to widespread surface wind speeds exceeding 60 km/h (30 kt).