METEOROLOGY PANEL

Meteorology Panel (METP)

Working Group on Meteorological Operations Group (WG-MOG)

World Area Forecast System (WAFS) Work Stream

Ninth Meeting

(METP/WG-MOG/9-WAFS)

Toulouse, France, 2 to 4 April 20

MEETING REPORT

INTERNATIONAL CIVIL AVIATION ORGANIZATION

LIST OF WG-MOG/9 – WAFS ACTIONS

Action 9/1 — Enhancements to the WAFC's verification programmes
That the WAFCs review their verification programmes and consider the feasibility to enhance the provision of statistics, including the feasibility to provide statistics from additional regional areas, and statistics for wind (such as errors in wind speed over a specific values or errors in wind direction at low wind speeds) and report back to the next WG-MOG (WAFS) meeting.

Action 9/2 – MOG Terms of Reference in relation to WAFS
That,
a) the Rapporteur of the WG-MOG update the MOG Terms of Reference (ToR) to include the development of SARPs for inclusion into Annex 3 – *Meteorological Service for International Air Navigation*, as well as support the METP in the maintenance of the WAFS related Job Card; and
b) provide the updated ToR to the Secretary for posting on the WG-MOG Public webpage.

Action 9/3 – Enhanced WAFS Information
That, the
a) Rapporteur provide the 4-page high-level summary (**Appendix C**) on the enhanced WAFS information to the METP rapporteurs for onward dissemination to members of their WGs;
b) Secretariat be invited to share the 4-page high-level summary on the enhanced WAFS information within ICAO and with others concerned, as appropriate; and
c) WAFCs consider the feasibility of staffing an exhibition booth at the upcoming fortieth ICAO Assembly (A40) in September/October 2019 as a means to increase awareness of the forthcoming enhancement to the WAFS information.

Action 9/4 — Draft provisions for WAFS information intended for Amendment 80 to Annex 3 - *Meteorological Service for International Air Navigation* and related guidance material in ICAO Doc 8896 - *Manual of Aeronautical Meteorological Practice*
That, the WAFCs,
a) finalize the proposed amendments to Annex 3 (Amendment 80), pertaining to the WAFS (**Appendix E**);
b) in support of a), prepare proposed consequential amendments to guidance material in Doc 8896; and
c) deliver to the next WG-MOG (WAFS) meeting for review prior to METP/5 (September 2020) consideration.

Action 9/5 – Further investigation of the need for cumulonimbus cloud (CB) height of cloud base information on WAFS SIGWX forecasts
That, all members of the MOG/WAFS, especially members from IATA and IFALPA,
a) investigate through their membership or users, the need for CB height of cloud base information on the WAFS SIGWX forecast, taking into account that the inclusion of CB cloud bases may result in more clutter and less readability with the other information on the SIGWX forecasts;
b) report results on a) to the WAFCs (Karen Shorey and Matt Strahan) by 1 November 2019; and
c) subject to the outcome of a) and b), the WAFCs to use the results to make appropriate updates to the proposed SARPs for Amendment 80 to Annex 3 (Action 9/4).

Action 9/6 – Guidance material on new WAFS SIGWX information in IWXXM form
That, the WAFCs
a) develop stand-alone guidance material on the use of enhanced WAFS SIGWX information in IWXXM form; and
b) report progress to the next WG-MOG (WAFS) meeting.

Action 9/7 —Tropical cyclone depiction on the SIGWX forecasts and provisions relating to the forecast times within the tropical cyclone advisory (TCA)

That, an ad-hoc group, consisting of Cameron, Greg, Karen (lead), Klaus, Larry, Matt and Stéphanie,

a) resolve the issues discussed at WG-MOG/9 (WAFS) pertaining to the enhancement of tropical cyclone advisory (TCA) information on the enhanced WAFS SIGWX forecasts, taking into account any ramifications on the TCA message in IWXXM form;

b) that Greg verify the use, amongst tropical cyclone advisory centres (TCAC), of the four synoptic times of 00, 06, 12, and 18 UTC for the forecasts in the TCA;

c) pending the outcome of b), prepare draft guidance material to be incorporated ICAO Doc-8896 – *Manual of Aeronautical Meteorological Practice* to encourage TCACs to adjust their forecast times within the TCAs, when appropriate, to the four synoptic times of 00, 06, 12, and 18 UTC;

d) prepare a draft amendment to Example A2-2 – *Advisory message for tropical cyclone*s of Annex 3 – *Meteorological Service for International Air Navigation* to reflect the TCA forecast times aligned with the four synoptic times of 00, 06, 12, and 18 UTC, and;

e) report progress to the next WG-MOG (WAFS) meeting.

Action 9/8 — Tropical cyclone advisory coverage areas

That, WMO be invited to:

a) consult with the tropical cyclone advisory centres (TCAC), through the WMO Tropical Cyclone Programme, regarding the suitability of the existing areas of responsibility given the potential development of tropical cyclones in the far-eastern North Atlantic and South Atlantic Oceans; and

b) report progress to the next WG-MOG (WAFS) meeting.

Action 9/9 – Provisions for tropopause height information on WAFS SIGWX forecasts within Annex 3 and related guidance material in Doc 8896

That, in response to Decision 9/2, WMO with the assistance of the WAFCs,

a) prepare proposed amendment to the Model Charts used in Appendix 1 of Annex 3 concerning tropopause height information on WAFS SIGWX forecasts for inclusion as part of Amendment 80 (November 2022), as well as related guidance material for inclusion in Doc 8896; and

b) deliver to the next WG-MOG (WAFS) meeting for review prior to METP/5 (September 2020) considerations

Action 9/10 — WAFS SIGWX Charts in Colour

That the METP-WG/MOG requests the WAFCs make available, where feasible, from November 2022, WAFS SIGWX charts on SADIS/WIFS, using the graphical and colour conventions as described below:

Parameter	Convention
Land Areas	White
Ocean/Sea Areas	Pale Blue
Jet Stream	Black Arrow, fletches and height information
Turbulence Areas	Black Dashed line, with two tone shading or hatching (to differentiate between MOD and MOD/SEV TURB). Colour scheme to be determined by the next MOG-WAFS meeting in 2020.
Cumulonimbus Cloud Areas	Red scalloped areas
Tropopause Height	Blue dotted contours

Note: Black and white SIGWX charts will continue to be shown in Annex 3 and Doc 8896.

Action 9/11 – Remit of the METP for issues pertaining to SIGMET information
That, the WG-MOG Rapporteur write to the Chair of the METP concerning the lack of a remit in the METP job cards addressing issues pertaining to the provision of SIGMET information.

LIST OF WG-MOG/9 – WAFS Decisions

Decision 9/1 — Updated table of flight levels for WAFS grid point forecasts intended for Amendment 80 to Annex 3 – *Meteorological Service for International Air Navigation*
That, the updated table of flight levels, **Appendix D**, be accepted by the METP-WG/MOG/9.

Decision 9/2 – Tropopause Height depiction on SIGWX Charts
That the METP-WG/MOG/9 agrees that from November 2022, tropopause height information should be:
a) provided in the form of contours (rather than spot values) based on the WAFS gridded data and represented by a dotted line with contour intervals appropriate to the chart size; and
b) removed from the T+24 hour BUFR format SIGWX data.

1. AGENDA ITEM 1: OPENING OF THE MEETING

1.1 The ninth meeting of the MET Operations Group (MOG/9) for matters pertaining to the World Area Forecast System (WAFS) took place at Météo-France International Conference Centre, Toulouse, France, from 2 to 4 April 2019. Mr. Colin Hord, Policy Lead MET and AIM, United Kingdom CAA, and Rapporteur of WG-MOG, chaired the meeting. Mr. Hord was assisted by Mr. Raul Romero, Technical Officer, Meteorology, ICAO Headquarters.

1.2 Mr. Hord opened the meeting at 0915 hours local time. He thanked the WAFC Provider States for their continued investment and improvements in the WAFS which were appreciated by all the users. He also thanked Stéphanie Desbios and the Météo-France for their hospitality for hosting the meeting at their headquarters in Toulouse. Ms. Desbios thanked everyone for coming to Toulouse and provided information on facility pertinent to the meeting over the upcoming week.

2. AGENDA ITEM 2: INTRODUCTION

2.1 Referenced study notes (SN) and information papers (IP) are available on the ICAO METP MOG public website, under: https://portal.icao.int/METP/MOG/Pages/MOG-Meetings.aspx.

2.2 The Agenda for the meeting, presented in MOG/09/IP/02, was adopted without change.

2.3 The list of attendees is contained in **Appendix A**.

3. AGENDA ITEM 3: MATTERS RELATING TO WAFS

3.1 Status of outstanding WG-MOG (WAFS) Actions

3.1.1 The meeting noted the status of outstanding actions relating to WAFS, which was provided to the meeting in Appendix A to MOG/09/IP/02 by the Rapporteur. After a review the meeting was pleased to note the outstanding actions were satisfactorily addressed with Action 7/4 noted as ongoing (**Appendix B**).

3.1.2 WAFS Management Report

3.1.2.1 The World Area Forecast Centres (WAFC) presented the WAFS Management Report, which covered the period from March 2018 through February 2019. The meeting was pleased to note that the WAFS Provider States continue to provide a valuable and reliable service to the aviation community, as evidenced by the availability, timeliness and verification statistics provided in the Management Report.

3.1.2.2 Both WAFCs have a Quality Management System. WAFC London, as a function of the Met Office, is ISO 9001:2015 and ISO 14001:2015 compliant. Twice per year, SGS (certification partners) visit the Met Office to monitor its compliance. Both the ISO 9001:2015 and the ISO 14001:2015 certificates are valid until 13 August 2020.

3.1.2.3 WAFC Washington, as a function of the National Weather Service's Aviation Weather Center in Kansas City, is ISO 9001:2015 compliant. The certificate is valid until December 28, 2021.

3.1.2.4 The meeting heard that there were some issues with the WAFS Internet File Service (WIFS) caused by users downloading WAFS and OPMET data are at very rapid rate, but these had been resolved in late 2018 with the addition of more servers.

3.1.2.5 While reviewing the verification statistics it was noted that some regions of the globe are not represented, such as the Middle East. It was also suggested that the WAFCs consider reporting on wind over a specific speed, e.g., 80 knots or more. After further discussion the meeting agreed on the following action:

Action 9/1 — Enhancements to the WAFC's verification program

That the WAFCs review their verification program and consider the feasibility to enhance the provision of statistics, including the feasibility to provide statistics from additional regional areas, and statistics for wind (such as errors in wind speed over a specific values or errors in wind direction at low wind speeds) and report back to the next WG-MOG (WAFS) meeting.

3.1.2.6 It was also noted that the statistics from WAFC Washington that were contained in the report were from the previous year due to a software issue. That has since been resolved and those new statistics were presented to the meeting from the web site. Matt Strahan will update the management report with the new statistics and have it reposted on the WG-MOG/WAFS web page.

3.1.2.7 Finally, the WAFCs thanked IATA for their efforts to get more turbulence reports from aircraft. The WAFCs also desire more icing reports and would greatly appreciate any efforts IATA can provide to increase the number of icing reports.

3.1.3 IP/11 by China discussed the SIGWX verification program in China. China has been producing SIGWX forecasts for their domestic aviation for many years. The paper provided a comparison of the SIGWX from the Civil Aviation Administration of China (CAAC) and those by the WAFCs. The CAAC SIGWX verification program run from March 2017 to February 2018, showed that the CAAC SIGWX forecasts, which is issued 10 hours after the WAFCs SIGWX, performed on average a better score for significant weather over the China region.

3.1.3.1 The Rapporteur thanked the member from China for providing the paper and welcomed other uses to provide details of how they verify WAFS information. The WAFCs also thanked China and welcomed them to participate in the WAFC's SIGWX coordination web chat.

3.2 **Other operational matters**

3.2.1 **Issues arising from METP/4 meeting**

3.2.1.1 The meeting reviewed IP/09 – *Information paper to FLTOPSP on changes to EDR with Amendment 79*, which was in response to Decision 6/2 from the fourth meeting of the Meteorology Panel (METP/4). Decision 6/2 asked the Rapporteur of WG-MOG to prepare an IP on the proposed changes to eddy dissipation rate (EDR) threshold values for reporting turbulence in Annex 3 – *Meteorological Service for International Air Navigation* with Amendment 79 (Nov 2020), for presentation at the next meeting of the Flight Operations Panel (FLTOPSP).

3.2.1.1.1 The Secretary will coordinate the IP, which is attached to IP/09, with the Secretary of the FLTOPSP for their meeting in Berlin, 13 to 17 May 2019.

3.2.2 **Interaction with other METP groups**

3.2.2.1 There was nothing to report.

3.2.3 **Review of MOG Terms of Reference in relation to WAFS**

3.2.3.1 The meeting reviewed the Terms of Reference (ToR) for the MOG (IP/03 – *Terms of Reference*). It was suggested that the development of Standards and Recommended Practices (SARP) for inclusion into Annex 3 – *Meteorological Service for International Air Navigation* be added to the ToR, together with reference to supporting the METP in the maintenance of the WAFS related Job Card.

Action 9/2 – MOG Terms of Reference in relation to WAFS

That,

a) the Rapporteur of the WG-MOG update the MOG Terms of Reference (ToR) to include the development of SARPs for inclusion into Annex 3 – *Meteorological Service for International Air Navigation*, as well as support the METP in the maintenance of the WAFS related Job Card; and

b) provide the updated ToR to the Secretary for posting on the WG-MOG Public webpage.

3.3 **Work required in support of WAFS Developments**

3.3.1 **Matters relating to gridded WAFS products**

3.3.1.1 SN/01 – *Next Generation (NexGen) WAFS*, by the WAFS Provider States, presented an overview of the next generation of the WAFS, including planned improvements with grid point data, significant weather (SIGWX) and the delivery system for this new information. The attachment to the SN/10 is a 4-page high-level summary of the next generation WAFS that can be shared with other working groups of the METP, other Panels within the Air Navigation Commission, as well as users of WAFS information.

3.3.1.2 It was suggested that the WAFCs consider using a different name than NexGen since that title is associated with other programs. The WAFCs agreed and chose to use ‘enhanced’. It was also asked if the WAFCs have considered providing this information sheet in the other ICAO languages. The Secretary will investigate but indicated it was very unlikely in the near term due to the language services dedicated to the the ICAO Assembly later in September-October 2019.

3.3.1.3 The meeting agreed to the following action:

Action 9/3 – Enhanced WAFS Information

That, the

a) Rapporteur provide the 4-page high-level summary (**Appendix C**) on the enhanced WAFS information to the METP rapporteurs for onward dissemination to members of their WGs;

b) Secretariat be invited to share the 4-page high-level summary on the enhanced WAFS information within ICAO and with others concerned, as appropriate; and

c) WAFCs consider the feasibility of staffing an exhibition booth at the upcoming fortieth ICAO Assembly (A40) in September/October 2019 as a means to increase awareness of the forthcoming enhancement to the WAFS information.

3.3.1.4 *Postscript: Following the conclusion of the meeting the WAFCs discussed the use of the verb 'enhanced' to describe the new WAFS services and delivery system. The WAFCs determined that the new WAFS service and delivery system is more than an enhancement. Therefore, the WAFCs will use the generic phrase 'next generation' (but not NexGen) for now and may in the future propose a formal title*.

3.3.1.5 IP/04 – *WAFS gridded data set provision from Nov 2020* reminded the meeting of the WAFC's plans for November 2020, which were previously provided at WG-MOG/7.

3.3.1.5.1 An icing severity gridded data forecast will be introduced in November 2020. This will produce a categorical output of icing severity. Also, a turbulence severity gridded data forecast will be introduced in November 2020, which will use the Graphical Turbulence Guidance (GTG) algorithms developed by United States (US) National Science Foundation's National Center for Atmospheric Research. The algorithm can calculate both clear air and orographic turbulence, therefore "Clear Air" will not be present in the name of the new turbulence parameter's name. Turbulence severity will be provided in units of EDR.

3.3.1.6 Icing severity, turbulence severity and the three cumulonimbus (CB) cloud data sets (extent, base and top) will be provided at 0.25-degree horizontal resolution from November 2020. The move to 0.25-degree horizontal resolution replaces the need for mean and maximum field data sets for icing and turbulence forecasts. The current 1.25-degree resolution turbulence potential and icing potential forecasts will continue to be provided until November 2022. The 1.25-degree resolution in-cloud turbulence field will be retired in November 2020. To compensate for the retirement, three additional turbulence severity layers at 0.25-degree resolution will be provided at flight levels (FL)100, FL140 and FL180.

3.3.1.7 SN/02 – *WAFS gridded data sets from Nov 2022* reported on the interaction with Working Group for Meteorological Requirements and Integration (WG-MRI). METP-WG/MRI/4 SN/1006 was presented to the fourth meeting of the WG-MRI (Washington, DC, 9-10 May 2018). WG-MRI/4 supported the introduction of WAFS gridded data above FL530.

3.3.1.8 The meeting reviewed SN/02 – *WAFS gridded data sets from Nov 2022*, by the WAFS Provider States, that presented an updated table of FLs for WAFS grid point forecasts, which are planned for inclusion into Amendment 80 to Annex 3 (November 2022). The two WAFCs plan to produce grid point forecasts from FL050 through FL600 at 1,000-foot increments.

3.3.1.8.1 At present WAFS grid point forecasts for icing and turbulence are calculated for a vertical layer of the atmosphere. For example, icing is provided for a 100hPa deep layer centred on FL060, in other words the icing forecast provided for FL060 contains data from FL050 through to FL070. The WAFCs will cease providing forecasts in layers when they begin providing WAFS grid point data at 1,000 foot vertical increments. They will add FL050 for the icing grid point forecasts with Amendment 80, which will incorporate the lower level of the currently provided layered forecast of FL060.

3.3.1.8.2 The meeting agreed to the following decision:

Decision 9/1 — Updated table of flight levels for WAFS grid point forecasts intended for Amendment 80 to Annex 3 – *Meteorological Service for International Air Navigation*

That, the updated table of flight levels, **Appendix D**, be accepted by the METP-WG/MOG/9.

3.3.1.9 SN/03 – *Draft Amendment 80 to Annex 3 for Next Generation WAFS* provided the meeting with an update to the information presented at WG-MOG/7 pertaining to the proposed amendments to Annex 3 for Amendment 80. The minor changes are the raising of the vertical limit of the grid point forecasts and SIGWX forecasts from FL530 to FL600, retention of tropopause height information on the SIGWX forecasts, and lowering the grid point icing forecasts from FL060 to FL050. The MOG/WAFS will be asked to support the proposed amendments at their next meeting (April 2020) before the Rapporteur submits them to the METP/5 meeting (September 2020).

3.3.1.10 It was noted that there were a few inconsistencies in the draft SARPs, particularly regarding the cessation of SIGWX in BUFR. The WAFCs will make adjustment for their next version of the draft SARPs.

3.3.1.11 In addition, the proposed amendments to Amendment 80 will require a consequential revision to ICAO Doc 8896 - *Manual of Aeronautical Meteorological Practice*, specifically Chapter 3 – *Forecasts*, section 3.7.2 – *WAFS upper-air forecasts*, and section 3.7.3 – *WAFS forecasts of significant en-route weather phenomena*. Therefore, the meeting agreed to:

Action 9/4 — Draft provisions for WAFS information intended for Amendment 80 to Annex 3 - *Meteorological Service for International Air Navigation* and related guidance material in ICAO Doc 8896 - *Manual of Aeronautical Meteorological Practice*

That, the WAFCs,
a) finalize the proposed amendments to Annex 3 (Amendment 80), pertaining to the WAFS (**Appendix E**);

b) in support of a), prepare proposed consequential amendments to guidance material in Doc 8896; and

c) deliver to the next WG-MOG (WAFS) meeting for review prior to METP/5 (September 2020) consideration.

3.3.1.12 IP/05 – *Future WAFS user consultation* informed the meeting on the efforts by the WAFC's to consult with users and stakeholders on the WAFS plans and also gaining feedback and user-requirements about service developments. There are two broad areas of user engagement: aviation industry stakeholders and other aeronautical meteorological service providers, both of whom are current and expected future users of WAFS datasets. National meteorological services may also use WAFS data in the delivery of services to aviation industry stakeholders within their respective state.

3.3.1.12.1 The user consultation activities with aeronautical meteorological service providers have included presentations at the following events:

- MIDANPIRG, November 2017

- APANPIRG, June 2018
- METG28, September 2018
- World Meteorological Organisation African Conference on Meteorology for Aviation (ACMA-2018), November 2018

3.3.1.12.2 The user consultation activities with aviation industry stakeholders has included presentations at the following events:

- Third IATA Flight Operations Support Task Force (IATA FOSTF3), March 2017
- IATA FOSTF4, March 2018
- UK user consultation event, September 2018
- IATA FOSTF5, March 2019

3.3.1.12.3 In addition, WAFC London has also been engaged, or will imminently engage, in focussed consultation with specific users on a one to one basis. This includes flight planning and software-provider organisations. It was also noted that WAFC Washington had intentions to socialize the WAFS development within the CAR/SAM region at upcoming GREPECAS Met related meetings.

3.3.1.13 The WAFCs sought guidance from the meeting regarding the need for CB cloud bases on the SIGWX forecasts and grid point data sets (SN/14 – *WAFS cumulonimbus cloud (Cb) bases* refers). Historically the WAFCs have labelled CB bases on the SIGWX charts with "XXX" to denote that the bases were below the vertical domain of the SIGWX chart, i.e., FL250 for the SIGWX high-level and FL100 for the SIGWX medium-level forecasts.

3.3.1.13.1 The primary reason for removing the CB cloud bases from the SIGWX charts is the reduction of clutter, i.e., the readability of the SIGWX charts would be improved significantly by leaving the CB bases out of the CB labels. The reduction in the size of the label boxes will help user software that automatically creates charts from BUFR[1], and later IWXXM[2] as it will be easier to find space for the labels. It will also help the WAFCs provide charts in multiple time steps as automated label placement is critical to the success of that effort.

3.3.1.13.2 The meeting was informed that the WAFCs informally surveyed the IATA FOSTF5 meeting in Dallas, Texas the week of 4 March 2019. There was a total of 6 respondents: none wanted to always keep CB cloud bases on the chart, one attendee wanted to put it on the chart only if it were not going to be XXX, four respondents said to omit it, and one had no preference. IATA plans to survey their members and report back to the WAFCs. The Rapporteur welcomed all members of the WG-MOG/WAFS to survey their users regarding the need for CB cloud base information of the SIGWX charts.

3.3.1.14 The WAFCs also believe that there are important emerging issues with providing a global grid of CB cloud bases. Some meteorological services are working to provide a gridded height of cloud base forecast. These gridded ceiling forecasts can be much higher in resolution and updated much more frequently than the global WAFS grids. They will even be detailed enough to serve as the height of the cloud base information for automated terminal aerodrome forecast (TAF) production. The WAFCs are concerned that the WAFS CB cloud base grid will be inconsistent with such height of cloud base grids. It could also be inconsistent with TAFs, regardless of how the TAFS are produced. Finally, height of cloud

[1] Binary Universal Form for the Representation of meteorological data (BUFR)
[2] ICAO Meteorological Information Exchange Model (IWXXM)

base forecasts are primarily useful in the terminal area, and not during the en-route phase of flight. WAFS grids are intended for use in the en-route phase of flight as opposed to the terminal area.

3.3.1.14.1 After discussion the meeting agreed to the following:

Action 9/5 – Further investigation of the need for cumulonimbus cloud (CB) height of cloud base information on WAFS SIGWX forecasts

That, all members of the MOG/WAFS, especially members from IATA and IFALPA,

a) investigate through their membership or users, the need for CB height of cloud base information on the WAFS SIGWX forecast, taking into account that the inclusion of CB cloud bases may result in more clutter and less readability with the other information on the SIGWX forecasts;

b) report results on a) to the WAFCs (Karen Shorey and Matt Strahan) by 1 November 2019; and

c) subject to the outcome of a) and b), the WAFCs to use the results to make appropriate updates to the proposed SARPs for Amendment 80 to Annex 3 (Action 9/4).

3.3.2 **Matters relating to Significant Weather provision**

3.3.2.1 An overview of the planned changes to the WAFS SIGWX forecasts beginning in November 2022, with Amendment 80 to Annex 3, was presented to the meeting (IP/06 – *Next generation WAFS SIGWX forecasts* refers). IP/06 was written to inform new members to the WG-MOG/WAFS on the significant improvements that will be made to the WAFS SIGWX forecast information, as well as inform the meeting of minor, but necessary changes, since WG-MOG/7, which are discussed in other paragraphs of this meeting's report.

3.3.2.2 The WAFCs gave a PowerPoint presentation on the use of digital enhanced SIGWX (IP/07). The presentation clearly showed the benefits of the new digital SIGWX, including:

- Ability to toggle objects off and on to make customized SIGWX
- Pan and zoom options
- Change colour scheme
- Integrate SIGWX with other SWIM data, such as flight tracks, aeronautical information, Tropical Cyclone Advisory, Volcanic Ash Advisory.

3.3.2.3 After further discussion the meeting agreed to the following action:

Action 9/6 – Guidance material on the new WAFS SIGWX information in IWXXM form

That, the WAFCs

a) develop stand-alone guidance material on the use of enhanced WAFS SIGWX information in IWXXM form; and

b) report progress to the next WG-MOG (WAFS) meeting.

3.3.2.4 The provision of tropical cyclone (TC) information on the WAFS SIGWX forecasts remains an open issue. Three study notes were presented on the topic.

3.3.2.4.1 SN/04 – *Proposed enhancement of tropical cyclone advisory information in support of the proposed enhancement of WAFS SIGWX forecasts* presented the findings that the World Meteorological Organization (WMO) member obtained from the tropical cyclone advisory centres (TCAC) regarding the feasibility of providing tropical cyclone advisory (TCA) information at 3-hourly time-steps from T+6 to T+48 hours.

3.3.2.4.1.1 The proposed increase in the temporal resolution (3-hourly time-steps) and extended range (up to T+48) of the TCA information will have implications on *all* TCACs in respect of their forecast production processes and, as importantly, on aviation users in respect of the (increased) volume of information that users will have to interrogate as part of the TCA information they receive.

3.3.2.4.1.2 The WAFCs were asked whether they needed both TC position and intensity. The WAFCs replied that they only need the position information in the current context of the WAFS SIGWX forecasts.

3.3.2.4.2 SN/05 – *Next generation SIGWX depiction of tropical cyclones* presented options to use for the provision of TC information on the SIGWX if it was determined that it wasn't practical for the TCACs to provide the extended TC forecast information through 48-hours.

3.3.2.4.2.1 Five options from SN/05 were presented to the meeting. The meeting also noted that adjustments may need to be made to the template for the TCA, and that this would require changes in the IWXXM schema.

3.3.2.4.2.2 The meeting was informed (SN/06 – *Provisions for the issuance of tropical cyclone advisories* refers) that there was a need for guidance material in ICAO Doc-8896 - *Manual of Aeronautical Meteorological Practice* to encourage TCACs to provide forecast times in their advisories to coincide with the four synoptic times of 00, 06, 12, and 18 UTC, so that alignment can be made with the enhanced WAFS SIGWX forecasts. Annex 3 does not stipulate when a TCA should be issued. It would not be appropriate to mandate TCACs to issue the initial advisory on one of the four synoptic times of 00, 06, 12, and 18 UTC, since it is not possible, at this time, to know when a developing storm system will reach tropical cyclone strength.

3.3.2.4.2.3 After further discussion the meeting agreed to the following action:

Action 9/7 —Tropical cyclone depiction on the SIGWX forecasts and provisions relating to the forecast times within the tropical cyclone advisory (TCA)

That, an ad-hoc group, consisting of Cameron, Greg, Karen (lead), Klaus, Larry, Matt and Stéphanie,

a) resolve the issues discussed at WG-MOG/9 (WAFS) pertaining to the enhancement of tropical cyclone advisory (TCA) information on the enhanced WAFS SIGWX forecasts, taking into account any ramifications on the TCA message in IWXXM form;

b) that Greg verify the use, amongst tropical cyclone advisory centres (TCAC), of the four synoptic times of 00, 06, 12, and 18 UTC for the forecasts in the TCA;

c) pending the outcome of b), prepare draft guidance material to be incorporated ICAO Doc-8896 – *Manual of Aeronautical Meteorological Practice* to encourage TCACs to adjust their forecast times within the TCAs, when appropriate, to the four synoptic times of 00, 06, 12, and 18 UTC;

d) prepare a draft amendment to Example A2-2 – *Advisory message for tropical cyclone*s of Annex 3 – *Meteorological Service for International Air Navigation* to reflect the TCA forecast times aligned with the four synoptic times of 00, 06, 12, and 18 UTC, and;

e) report progress to the next WG-MOG (WAFS) meeting.

3.3.2.4.3 The meeting was also informed of a recent tropical cyclone that occurred near Brazil. As that oceanic area is not currently under the responsibility of a TCAC, there was resultant uncertainty within the WAFCs on whether to include in the SIGWX forecast. It was also noted that, in accordance with ICAO regional air navigation agreement, TCAC services were not currently required in, for example, the far-eastern North Atlantic and South Atlantic Oceans. After further discussion the meeting agreed to the following action:

Action 9/8 — Tropical cyclone advisory centre areas of coverage

That, WMO be invited to:

a) consult with the tropical cyclone advisory centres (TCAC), through the WMO Tropical Cyclone Programme, regarding the suitability of the existing areas of responsibility given the potential development of tropical cyclones in the far-eastern North Atlantic and South Atlantic Oceans; and

b) report progress to the next WG-MOG (WAFS) meeting.

3.3.2.5 The WAFCs presented SN/07 – *Tropopause height contours* that discussed the merits of presenting tropopause height information on the next version of the SIGWX charts using contours instead of spot height values. The WAFCs explained to the meeting the need for considering the use of contours as the largest changes in tropopause heights is often found in close proximity to the jet stream, whilst tropopause minima can be co-located with areas of cumulonimbus cloud. Due to the lower priority of tropopause height data on SIGWX charts, this often means that no spot height value can be included, or has to be located some distance away from its true forecast position. To illustrate the issue, the WAFC provided example comparisons of spot values and contours on a SIGWX chart.

3.3.2.5.1 The WAFCs sought guidance on this issue at the IATA FOSTF5 meeting. The contours were preferred over the spot values by the members. One member of the FOSTF was already using tropopause height contour information on their SIGWX forecast charts, based on the gridded data.

3.3.2.5.2 The opinions of the METP-MOG IFALPA representative and his colleagues was also sought ahead of the meeting. Following discussions, they concluded that "*Tropopause height contours were preferred over spot values however they should be selectable on/off. On SIGWX charts spot values are preferred due to perceived cluttering*".

3.3.2.5.3 The WAFCs also discussed the options for contour intervals (i.e., spacing). Intervals of tropopause height contours at 2,000 ft, 4,000 ft and 6,000 ft were shown to the meeting. Whilst including 2,000 ft contour intervals on the PNG[3] format charts produced by the WAFCs would lead to an overly cluttered chart, there is benefit in including them within the IWXXM file for users using a higher level of zoom on their maps. The meeting agreed that the contouring of tropopause height information should be include in SIGWX charts using intervals appropriate for the chart, and should users require different spacing they can create those from the gridded data sets.

3.3.2.5.4 It was noted that the change to tropopause height contours in WAFS SIGWX forecasts would require amendments to the model charts used in Appendix 1 of ICAO Annex 3 and the WAFCs would assist WMO to prepare those changes in the next version of the draft SARPs for Amendment 80, as well as appropriate changes to ICAO Doc 8896.

3.3.2.5.5 The WAFCs have agreed to continue providing SIGWX forecasts for T+24 in BUFR format until November 2024. But representing tropopause height contours within BUFR will be difficult/impossible (as BUFR was not designed for this purpose) therefore the WAFCs wish to discontinue the tropopause field on the BUFR SIGWX in November 2022.

3.3.2.5.6 After additional discussion the meeting agreed to the following action:

Decision 9/2 – Tropopause Height depiction on SIGWX Charts

That the METP-WG/MOG/9 agrees that from November 2022, tropopause height information should be:

a) provided in the form of contours (rather than spot values) based on the WAFS gridded data and represented by a dotted line with contour intervals appropriate to the chart size; and

b) removed from the T+24 hour BUFR format SIGWX data.

Action 9/9 – Provisions for tropopause height information on WAFS SIGWX forecasts within Annex 3 and related guidance material in Doc 8896

That, in response to Decision 9/2, WMO with the assistance of the WAFCs,

a) prepare proposed amendment to the Model Charts used in Appendix 1 of Annex 3 concerning tropopause height information on WAFS SIGWX forecasts for inclusion as part of Amendment 80 (November 2022), as well as related guidance material for inclusion in Doc 8896; and

b) deliver to the next WG-MOG (WAFS) meeting for review prior to METP/5 (September 2020) considerations.

3.3.2.6 The WAFCs discussed changing the WAFC produced SIGWX charts from black and white to colour in November 2022 (SN/08 – *Colourful SIGWX charts* refers).

3.3.2.6.1 Changing the charts so that land masses could be more easily identified is a simple change, and one that instantly makes it easier for users to orient themselves with the map. The WAFCs have

[3] Portable Network Graphic (PNG)

experimented with different colouring conventions. Feedback from user testing indicated that a pale blue ocean and white land was the preferred option.

3.3.2.6.2 CB clouds pose one of the largest hazards to aviation, so a bright and bold colour was chosen to draw the users' eye to them. The convention of using a scalloped line was retained, however the scallops will now be drawn in a bright red colour.

3.3.2.6.3 Clear air turbulence areas will become "turbulence" areas in November 2022. To help differentiate between MOD and SEV turbulence, two different tones of coloured shading was applied. This makes it easier to identify the areas of severe turbulence, which have a darker shade, compared to the moderate turbulence areas. Both blue and grey was tested.

3.3.2.6.4 User consultation was carried out to help determine an appropriate colour scheme; advisors representing IATA were consulted, and attendees of the IATA FFOST5 meeting were given a presentation and invited to provide feedback on a range of colourful SIGWX proposals. The METP-MOG member from IFALPA was invited to share with colleagues a variety of different coloured SIGWX charts, which they expressed support for the colour scheme preferred by the WAFCs.

3.3.2.6.5 A widespread, digital survey on SIGWX charts will be run by IATA and distributed amongst its members during spring 2019. The feedback will be incorporated into the final SIGWX design in time for the next MOG-WAFS meeting in 2020.

3.3.2.6.6 A variety of tropopause contour colours were assessed, with bright blue providing a good contrast to the other elements.

3.3.2.6.7 The meeting discussed the need to provide charts in colour, including human factors consideration on the part of the providers and consumers of WAFS SIGWX information, and concluded that the WAFC could provide the SIGWX in colour on SADIS/WIFS where feasible, but that the black and white SIGWX charts will continue to be shown in Annex 3 and Doc 8896.

3.3.2.6.8 After further discussion the meeting agreed to the following action:

Action 9/10 — WAFS SIGWX Charts in Colour

That the METP-WG/MOG requests the WAFCs make available, where feasible, from November 2022, WAFS SIGWX charts on SADIS/WIFS, using the graphical and colour conventions as described below:

Parameter	**Convention**
Land Areas	White
Ocean/Sea Areas	Pale Blue
Jet Stream	Black Arrow, fletches and height information
Turbulence Areas	Black Dashed line, with two tone shading or hatching (to differentiate between MOD and MOD/SEV TURB). Colour scheme to be determined by the next MOG-WAFS meeting in 2020.
Cumulonimbus Cloud Areas	Red scalloped areas
Tropopause Height	Blue dotted contours

Note: Black and white SIGWX charts will continue to be shown in Annex 3 and Doc 8896.

3.3.2.7 SN/09 – *Representation of WAFS SIGWX in IWXXM* called attention to the need for WG-MOG/WAFS to work with the Panel's Working Group on Meteorological Information Exchange (WG-MIE) as well as the World Meteorological Organization's (WMO) Task Team on Aviation XML[4] (TT-AvXML) to ensure that the WAFS significant weather (SIGWX) forecasts can be represented in IWXXM form in time for Amendment 80 to Annex 3. As stated in IP/6 the WAFCs plan to transition to the IWXXM form beginning in November 2021 (in demonstration mode), which will provide a 1-year lead time before operational implementation in November 2022 with Amendment 80 to Annex 3. The WAFCs will retire SIGWX forecasts in BUFR code format in 2024 and PNG format in 2028.

3.3.2.7.1 The meeting is informed that the WG-MIE has formulated Activity 1.6 in their Work Plan.

WG-MIE Activity 1.6: IWXXM data representation of SIGWX elements

In conjunction with WMO and WG-MISD, investigate how to represent the elements/information currently within a SIGWX in IWXXM form.

3.3.2.7.2 The meeting was reminded that Action 7/4 is ongoing and pertains to the interaction by the WG-MOG WAFS with the WG-MIE. Thus, the WAFCs will inform the Rapporteur of the WG-MIE that the group referenced in Activity 1.6, which is WG-MISD, should be replaced with WG-MOG WAFS.

3.3.3 **Matters relating to Delivery mechanism of WAFS**

3.3.3.1 A summary of the ongoing activity to assess the future options for backup arrangements for the provision of WAFS services between WAFC London and WAFC Washington was presented (IP/08 – *WAFC future backup arrangements from Nov 2022* refers.) The implementation of the changes is expected from November 2022, in line with the next generation of SADIS and WIFS Systems. Several options were described, which will be explored fully by the SADIS and WIFS providers whilst also considering cost and complexity of operation. WAFC London and WAFC Washington will work together to ensure a resilient backup capability between SADIS and WIFS is provided. Further information will be presented at the next WAFS MOG meeting.

3.3.3.2 The WAFCs sought guidance from the meeting regarding how long WAFS data sets should be archived (SN/13 – *WAFS Data Archiving* refers.) The increase in horizontal, vertical and temporal resolution of the next generation WAFS data sets will result in a single gridded data set being approximately 240 times larger than it is now. The next generation SADIS system will also offer users the ability to subset the data they are downloading meaning different data "payloads" are provided to different SADIS users.

3.3.3.2.1 The SADIS provider has been evaluating the benefits of archiving the complete gridded data set compared to the individual payloads as there are pros and cons to each. Archiving the payloads means that it would be possible to track exactly what data was sent to each user, and would permit the examination of the file if any issues or an incident was reported. Archiving all payloads indefinitely is not a feasible solution and the cloud storage costs would quickly mount up.

3.3.3.2.2 The meeting was informed that Annex 3, Chapter 9, 9.3.4 states that:

[4] Extensible Markup Language (XML)

9.3.4 The meteorological authority shall retain information supplied to flight crew members, either as printed copies or in computer files, for a period of at least 30 days from the date of issue. This information shall be made available, on request, for inquiries or investigations and, for these purposes, shall be retained until the inquiry or investigation is completed.

3.3.3.2.3 After additional discussion the meeting decided not to form a specific action and, instead, to allow the WAFCs to determine a data archive period appropriate to their operations and the requirements of the respective MET Authority.

3.4 **Review of Job Cards**

3.4.1 The job card for the WAFS was presented (IP/10 – *METP Job Card 10* refers.) Very minor edits were suggested and will be undertaken by the WAFCs and presented to the next meeting.

3.5 **Science capabilities**

3.5.1 **Modelling developments and new capabilities**

3.5.1.1 Several presentations were given by the WAFCs, UK Met Office, Météo-France, and Air France. The presentations covered developments of probabilistic forecasting, SIGMET coordination, forecasting of turbulence, nowcasting of convection, cross border experiment, and electronic flight-planning displays.

3.5.1.2 The meeting expressed gratitude to the presenters for their presentations. The presentations will be posted on the WG-MOG Public webpage as appropriate.

4. AGENDA ITEM 4: SIGMET RELATED DOCUMENTION

4.1 The meeting noted that issues pertaining to the provision of SIGMET information is not a remit of the METP as there is no related job card. Understanding that, the meeting did make time to hear two study notes pertaining to SIGMET issues.

4.2 SN/10 – *SIGMET cancellation during volcanic ash exercises* reported on action 7/16 from METP-MOG/7 (WAFS) seeking to ensure that SIGMETs produced at the end of volcanic ash exercises are clear and reduce the risk of pilot confusion.

4.2.1 The ICAO Technical Regional Officer for the ICAO EUR and NAT office has oversight of exercises such as the Volcanic Ash Exercises (VOLCEX). After considerable discussion it was agreed that this matter should be handled by the Meteorology Group (METG) for the European Air Navigation Planning Group.

4.3 SN/11 – *Radioactive release cylindrical SIGMET* informed the meeting that members of the METG's SIGMET ad-hoc group have been tasked with updating EUR014 - *European SIGMET Guide*. Part of the remit of that group is to provide guidance to assist EUR states with SIGMET coordination across flight information region (FIR) boundaries. The use of "WI nnKM (or nnNM) OF...." for radioactive release had been discussed regarding cross-FIR SIGMETs and the ad-hoc group are now seeking guidance from the METP-WG/MOG.

4.3.1 Two options were presented to the meeting. Option 1 – the neighbouring MWO would not issue a SIGMET for the portion of the radioactive release which extends into their FIR as there is no way to describe the remaining part of the 30KM (16nm) circle. Option 2 – the neighbouring MWO issues an additional SIGMET for which the central point of the cylinder lies outside of their FIR boundary.

4.3.2 Noting the forgoing considerations given at 4.1, after discussion it was agreed that this matter be returned to the METG for their resolution.

4.3.3 After additional discussion the meeting agreed to the following action:

Action 9/11 – Remit of the METP for issues pertaining to SIGMET information

That, the WG-MOG Rapporteur write to the Chair of the METP concerning the lack of a remit in the METP job cards addressing issues pertaining to the provision of SIGMET information.

5. AGENDA ITEM 5: TIMETABLE AND FUTURE MEETINGS OF WG-MOG (WAFS)

5.1 The next meeting of the WG-MOG (WAFS) will be held at the facilities of the UK Met Office in Exeter, UK from 24 to 26 March 2020.

6. AGENDA ITEM 6: AOB RELATING TO WG-MOG (WAFS)

6.1 None.

7. AGENDA ITEM 7: CLOSURE OF THE MEETING

7.1 The meeting expressed its gratitude to those from Météo-France for their kind hospitality and excellent arrangements during this meeting.

7.2 The Meeting was closed at 1230 hours by Mr. Colin Hord, Rapporteur of the METP WG-MOG.

APPENDIX A

List of participants

NAME	STATE or ORGANIZATION
Lethlean, Cameron	Australia
Dumas, Karina	Canada
Zou, Juan	China
Xu, Jian Liang	China
Stéphanie Desbios	France
Meise, Gabriele	Germany
Lechner, Peter	New Zealand
Hord, Colin	United Kingdom
Dutton, Jonathan	United Kingdom and WAFC London
Shorey, Karen	United Kingdom and WAFC London
Buchanan, Piers	United Kingdom and WAFC London
Murphy, Michael (Pat)	United States
Strahan, Matt	United States and WAFC Washington
Burch, Larry	United States
Diori, Saley	ASECNA
Lapsley, Rosalind	EUROCONTROL
Shulimov, Oleh	IATA
Oehl, Thorsten	IATA
Pignon, Laurent	IATA
Romero, Raul	ICAO
Sievers, Klaus	IFALPA
Brock, Greg	WMO

APPENDIX B

WAFS Actions from WG-MOG/7

Item	Status
Action 7/1 — Outstanding actions from the MOG/WAFS/4 That the meeting reviewed the outstanding actions from their last meeting (MOG/WAFS/4) and was pleased with the work done by the WAFS Provider States and the group (**Appendix B)**. The meeting agreed to add new actions from the seventh meeting to this listing and review the accomplishments at the next meeting.	Complete.
Action 7/2 — Content within the WAFS Management Report That the WAFCs, in an effort to streamline the content of the management report, reduce the content and primarily report on system outages, including back up services (simulated or actual), concerns raised by users on the delivery of WAFS information services, and a small sample of performance statistics.	Complete.
Action 7/3 — Doc 8896 amendment, notifying WAFCs of discrepancies in SIGWX forecasts That, a) The WG-MOG acknowledge the current procedures in Doc 8896 – *Manual on Aeronautical Meteorological Practice* for notifying the WAFCs of discrepancies in the SIGWX forecasts are outdated, given that the provisions to amend WAFS SIGWX no longer exist, accept the proposed updates to Doc 8896 as shown in **Appendix C**; and b) the WAFC Provider States prepare a working paper, on behalf of the Rapporteur, for METP/4 to enable the Secretariat to make the necessary changes to Doc 8896 to take place.	Complete. METP/4 – WP4202.
Action 7/4 — Interaction with WG-MIE for WAFS information in the SWIM environment That the WG-MOG continue to interact with WG-MIE on planned improvements and developments of WAFS information services and the associated delivery within the SWIM environment.	Ongoing. SN/09.
Action 7/5 — Terms of Reference That the Secretary be invited to replace the legacy WAFSOPSG Terms of Reference with the WG-MOG Terms of Reference (**Appendix D**) on the WG-MOG Public website under MOG-WAFS Reference Documents.	Complete.
Action 7/6 — Improvements to the WAFS Gridded Forecasts in support of the GANP That the WAFC Provider States, on behalf of the Rapporteur, prepare a working paper for METP/4 on the planned improvements to WAFS gridded forecast information based on the information presented in SN/21 with reference to IPs (i.e., IP/11, IP/12, IP/13, IP/14 and IP/15) that described, *inter alia*, finer grid point resolution, increased levels and time-steps in the grid point forecasts planned through 2024.	Complete. METP/4 – IP/4204.

Action 7/7 — Amendment 79 to Annex 3 That the WAFC Provider States, on behalf of the Rapporteur, prepare a working paper for METP/4 requesting endorsement on the proposed updates to Annex 3 for Amendment 79 relating to the provision of WAFS gridded forecast information (**Appendix F**) and the related addition of information on exact pressure levels for flight levels to be included in Doc 8896 – *Manual on Aeronautical Meteorological Practice*.	Complete. METP/4 – WP4205
Action 7/8 — Wind and Temp data above FL530 That the Rapporteur of METP WG-MOG deliver the study note in Attachment A of SN/13 to the Fourth Meeting of the WG-MRI inviting them to investigate the need to establish any requirement for the WAFCs to produce wind and temperature gridded data above FL530.	Complete. SN/02
Action 7/9 — Next Generation WAFS SIGWX forecast information That the WAFC Provider States, a) on behalf of the Rapporteur, prepare a working paper for METP/4 on the planned improvements to the provision of WAFS SIGWX forecast information based on SN/21, with reference to SNs 22 and 23, to describe the planned enhancements (e.g., multiple time steps) as well as note the necessary changes to the content to facilitate the production of these improvements; and b) communicate, via a to be determined forum, these planned changes with users over the course of the coming year and report back to the next meeting.	Complete. a) METP/4 – IP/4206 b) IP/05
Action 7/10 — BUFR Format SIGWX data That the WAFC Provider States, on behalf of the Rapporteur, include in their working paper to METP/4 on the planned improvements to the provision of WAFS information, that the production of SIGWX forecasts in BUFR format will cease in November 2024.	Complete. METP/4 – IP/4206
Action 7/11 — Tropical Cyclone depiction in SIGWX forecasts That the WAFC Provider States, on behalf of the Rapporteur, prepare a working paper to METP/4, requesting the Secretary to the Panel invite WMO to consider the planned improvements to WAFS SIGWX forecast information and that these improvements can be enhanced with the inclusion of tropical cyclone advisory information by TCACs that include the position of tropical cyclones from T+0 to T+48 hours at 3-hourly time-steps.	Complete. SN/04, SN/05, SN/06.
Action 7/12 — Next generation SADIS and WIFS That the WAFC Provider States, on behalf of the Rapporteur, prepare an information paper for METP/4 on the concepts being investigated by the WAFCs to improve the delivery mechanism of WAFS information, i.e., SADIS and WIFS to accommodate the planned improvements in WAFS gridded forecast and SIGWX forecast information by 2022.	Complete. METP/4 – IP/4302.

Action 7/13 — Draft updates to Job Card 10 relating the WAFS That, the WG-MOG meeting a) accepts the proposed updates to Job Card 10 as shown in **Appendix G**; and b) the WAFC Provider States, on behalf of the Rapporteur, prepare a working paper for METP/4 requesting their endorsement on the proposed changes to Job Card 10.	Complete. METP/4 – WP/4001.
Action 7/14 — 2018 Update to the Regional SIGMET Guide Template That the meeting approves the proposed changes to the Regional SIGMET Guide Template (**Appendix A to SN/30**[5]), to be presented to METP/4 for final approval and publication.	Complete. METP/4 – WP/4002.
Action 7/15 — Revised eddy dissipation rate (EDR) threshold values in Annex 3 - *Meteorological Service for International Air Navigation* That, a) the WG-MOG (WAFS) concur with the proposed changes to Annex 3 relating to EDR (**Appendix H**); and b) the draft Working Paper presented as Attachment to SN/35 be submitted by the WG-MOG rapporteur to the METP/4 meeting for consideration.	Complete. METP/4 – WP4208.
Action 7/16— Enhancement of guidance to cancel a SIGMET during an exercise That Karen and Stephanie review the material pertaining to the cancelation of SIGMETs during an exercise and prepare any proposed revisions for consideration at the next WG-MOG/WAFS meeting.	Complete. SN/10
Action 4/1 — WAFCs to prepare a paper on how backup arrangements may change in the SWIM environment for the next meeting. (Deferred to MOG/WAFS in 2019)	Complete. IP/08

[5] The Regional SIGMET Guide Template is 80 pages in length and nearly 5 MB in file size, thus it not a provided as an appendix to the meeting report.

APPENDIX C

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METEOROLOGY PANEL

The next generation of the World Area Forecast System (WAFS)

Introduction

This document describes the next generation of the World Area Forecast System (WAFS) forecasts for international air navigation, provided by the World Area Forecast Centres (WAFC), in support of the International Civil Aviation Organization's (ICAO) Global Air Navigation Plan (GANP) and associated Aviation System Block Upgrades (ASBU).

Specifically, this document describes the next generation of WAFS grid point forecasts, WAFS Significant Weather (SIGWX) forecasts, and WAFS delivery system, i.e. Secure Aviation Data Information Service (SADIS) and the WAFS Information File Service (WIFS).

This document provides more detail about the new WAFS service than the Concept of Operations (ConOps) for the WAFS and the Roadmap for the WAFS, which were written by the ICAO Meteorology (MET) Panel.

This document is intended as information for other Panels and bodies within ICAO and users of WAFS information.

WAFS grid point forecasts

Major changes and improvements are coming for the WAFS grid point forecasts. These include a significant increase in the horizontal, vertical and temporal resolutions of the forecasts, including forecasts out to 5 days (120 hours), as well as the introduction of probabilistic forecasts.

Grid point forecast resolution

Horizontal resolution

The next generation of WAFS grid point forecasts will have a horizontal resolution of 0.25 degrees latitude and longitude. This is an increase from the current 1.25 degree latitude and longitude horizontal resolution.

Vertical resolution

The vertical resolution of the new grid point forecasts will increase and be provided at every 1,000 foot flight levels (FL).

Wind and temperature forecasts will begin at FL050 and continue through FL600. Other elements will have different vertical ranges, but all will have the same 1,000 foot vertical resolution. For example, humidity will range from FL050 through FL180, icing severity will range from FL050 through FL300, and turbulence severity will range from FL100 through FL450.

Current WAFS grid point forecasts are only provided for select FLs.

Temporal resolution

The temporal resolution of the new grid point forecasts will increase as follows:

- 1-hour intervals for forecasts valid from 6-hours through 24-hours
- 3-hour intervals for forecasts valid from 27-hours through 48-hours
- 6-hour intervals for forecasts valid from 54-hours through 120 hours.
  Note: Grid point forecasts of turbulence, icing, and cumulonimbus clouds will be provided through 48-hours.

Current WAFS grid point forecasts have a temporal resolution of 3-hour intervals from 6-hours through 36-hours.

The new WAFS grid point forecasts will continue to be made available 4-times a day.

Probabilistic forecasts

Probabilistic forecasts for cumulonimbus cloud, icing and turbulence are also being developed and will become part of the new WAFS grid point forecasts.

The traditional approach to weather forecasting is known as deterministic, with only one forecast outcome. Whilst this can provide good advice, deterministic forecasting may not provide the users with a full understanding of the possible range of outcomes, or the risks of encountering specific phenomena.

Grid point forecasts of meteorological phenomena

WAFS grid point forecasts will be provided for the following:

- Upper wind (including detail of the maximum wind)
- Upper air-temperature
- Upper air-humidity
- Tropopause height and temperature
- Turbulence severity
- Icing severity
- Cumulonimbus cloud extent, base and top height

The above are the same phenomena as provided by today's WAFS grid point forecasts with two exceptions. Turbulence severity replaces turbulence potential and in-cloud turbulence potential, and icing severity replaces icing potential.

New algorithms will be used to calculate the turbulence and icing severity forecasts. The new turbulence algorithm is a multi-diagnostic algorithm that includes turbulence indicators that were not in the previous WAFS algorithm. The turbulence forecast will be in the ICAO standard of Eddy Dissipation Rate (EDR).

The icing algorithm contains improved cloud physics that result in better performance scores. The icing forecast will be in categorical (none, light, moderate, severe) severity types.

WAFS SIGWX Forecasts

Major changes and improvements are coming for the WAFS SIGWX forecasts. These include a significant increase in the available forecasts, and the move to the ICAO Weather Exchange Model (IWXXM) format, for use in the System-Wide Information Management (SWIM) system thereby enabling greater sharing of this information with other users and systems.

Additional valid times

The WAFCs will produce SIGWX forecasts for T+6, T+9, T+12, T+15, T+18, T+21, T+24, T+27, T+30, T+33, T+36, T+39, T+42, T+45 and T+48 hour valid times.

For decades, WAFS SIGWX forecasts were only a 24-hour forecast, i.e., the weather shown on a SIGWX forecast only represented the expected weather 24-hours in the future, which is referred to as a T+24 hour SIGWX forecast. A key requirement for the new WAFS SIGWX provision was to provide data for more than just the T+24 hour valid time. Short-haul flight planning require data for the T+6 to T+18 timeframe, while ultra-long-haul flight planning requires data beyond T+24 hours.

Increased vertical and horizontal domain

The new WAFS SIGWX forecasts will be broadly consistent with today's WAFS SIGWX forecasts, however they will not be split into "high-level" (FL250 to FL630) and "medium-level" (FL100 to FL450) data sets as much of the data is simply duplicated. The new SIGWX will have a vertical range from FL100 to FL600.

Current SIGWX medium-level forecasts are only provided for four select regions of globe. The new SIGWX forecasts expands the domain to a global coverage down to FL100. The WAFCs will retire the existing medium-level SIGWX charts (4 areas), which only cover part of the globe, in late 2022.

Format

The WAFCs currently provide WAFS SIGWX forecasts for the graphical elements as objects in BUFR code and PNG formats. The new WAFS SIGWX will provide these objects in IWXXM format.

IWXXM format

The new SIGWX will be in IWXXM format, which will be the new standard with ICAO. The WAFCs plan to begin using the IWXXM form in test and demonstration mode in 2021. The new multiple time-

step SIGWX forecasts, in IWXXM format only, are planned to be operational by later 2022.

BUFR format

SIGWX forecasts are currently provided in BUFR Edition 3 format, which has not been supported by WMO since 2012. The WAFCs chose not to transition to BUFR Edition 4 and instead await the implementation of the IWXXM format in order that States and software providers would not need to make two sets of changes.

The WAFCs plan to cease production of SIGWX forecasts in BUFR format in late 2024.

PNG format

The majority of users will be able to utilize IWXXM formatted SIGWX forecasts but there will be some that may require SIGWX forecasts in PNG format for flight documentation for a few years. The WAFCs plan to continue producing a T+24 hour SIGWX forecast that covers the current 13 SIGWX high level chart areas in PNG format until 2028.

WAFS Delivery System

The increases to the horizontal, vertical and temporal data resolutions means that a complete download of one run of WAFS grid point forecast data set will increase from 28MB to approximately 6.5GB, which an increase of 230 percent. In order to deliver these new, much larger, data sets the WAFCs are developing the next generation of SADIS and the WIFS.

It is planned that the new system will be a cloud-like service, which will deliver key benefits such as the ability to scale dynamically according to demand. This will result in fast, reliable data downloads without any slowdown at peak periods. Cloud hosting also increases operational availability as the system is hosted on an extensive underlying network of servers, so should one server fail the system will seamlessly migrate to another.

The new system will enable users to download only the data they are interested in (for example covering a particular area, or selection of vertical levels) and will be interoperable with other SWIM systems.

The WAFCs plan to host test servers for the new WAFS products and IWXXM formatted OPMET data for demonstration and testing. This will enable users and workstation providers to prepare and adapt their systems in advance of these new data sets becoming available on the next generation of the SADIS and WIFS system in late 2022.

Implementation of the new WAFS

The next generation of the WAFS information will be implemented in phases.

Phase 1 – late 2020

- Partial implementation of the new grid point forecasts
  - Increase the horizontal resolution of the hazard grid point forecasts to 0.25 degrees
  - Introduction of new turbulence and icing severity forecasts
  - Produce grid point forecasts using exact pressure levels (to accommodate the increase in vertical resolution in phase 2)
  - Retirement of the in-cloud turbulence forecast products.

Phase 2 – late 2022

- Implementation of the new WAFS (SADIS/WIFS) dissemination system
- Implementation of the new WAFS SIGWX forecasts
- Cease production of existing “medium level” SIGWX charts
- Continued partial implementation of the new WAFS grid point forecasts
  - Implement increased horizontal resolution of the remaining grids point forecasts (e.g. wind, temperature)
  - Implement increased vertical resolution of the grid point forecasts to 1,000 foot flight levels
  - Implement additional forecast time steps
  - Implement probability forecasts of cumulonimbus clouds, icing severity and turbulence severity in demonstration mode
  - Cease production of Icing Potential and Clear Air Turbulence Potential data sets.

Phase 3 – late 2024

- Full implementation of all the new grid point forecasts
  - Implement probability forecasts of cumulonimbus clouds, icing severity and turbulence severity in operational mode
- Cease production of SIGWX forecasts in BUFR format

Phase 4 – late 2028

- Cease production of SIGWX forecasts in PNG format

Using the new WAFS information

WAFS grid point forecasts

Technological advances mean that there are now better ways of exposing data to users, in a way that can be customised to their particular requirements through "custom query" functions. In the future a user will be able to request "wind data, for FL300, FL310, FL320, FL330 and FL340 over a defined area, for T+9 and T+12" and receive this in a file containing only the information they require. Flight planning operations could request high resolution wind, temperature and hazard data that is relevant to the flight trajectory.

WAFS grid point probabilistic forecasts of turbulence and cumulonimbus clouds will enable operators and flight crew to select routes that avoid turbulence of specific levels of severity and cumulonimbus clouds based on their operational specifications. For example, Operator A has determined through its safety management system (SMS) that its aircraft model X-123 needs to find a trajectory around an area with a forecast of 70 percent probability of EDR greater than 0.30, while Operator B through its SMS will fly around a 50 percent probability of EDR greater than 0.30.

WAFS grid point wind forecasts with finer resolution and more accuracy will enable operators to select more fuel-efficient flight routes. Wind forecasts valid out to 5 days (120 hours) will allow operators to choose more fuel-efficient routes much earlier than with today's 36 hour forecasts.

WAFS forecasts of turbulence severity will also help flight crews mitigate injuries should they encounter turbulence by proactively turning on seat belt signs, and by helping them decide how best to avoid turbulence.

WAFS icing severity forecasts will enable users to select routes that avoid icing per operation specific levels of severity. WAFS icing forecasts will be especially useful in Extended Diversion Time Operations (EDTO).

WAFS SIGWX forecasts

Finally, after over a quarter of a century, WAFS SIGWX forecasts will be made available for more than just one time-step, i.e. T+24 hours. WAFS SIGWX forecasts with 3-hourly time-steps from T+6 through T+48 hours will provide flight crew and operators with SIGWX forecasts that can be used for short-haul through ultra-long-haul flights as well as extended flight planning.

The increasing adoption of Electronic Flight Bags, and the increasing sophistication of commercial software/systems means that the true value of the new SIGWX forecasts can be realised. These systems will enable the following types of functionality and flexibility:

- Customisable and zoom-able map areas
- User defined colour schemes
- Facility for SIGWX data to be included as part of the SWIM environment
- The ability to toggle different SIGWX layers on and off
- The option to only show SIGWX layers relevant to the operating altitude
- The ability to add other flight specific information to the chart, e.g., flight path
- The ability to display WAFC gridded data and WAFC SIGWX data at the same time.
- The ability to quickly step through different time steps of chart

- END -

APPENDIX D

WAFS Gridded data sets – to be available from Nov 2022

Note: Levels produced prior to November 2022 are shown in blue font.

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Wind	Temperature	Turbulence Severity	Icing Severity	Humidity
FL050	5000	843.1	X	X		X	X
FL060	6000	812.0	X	X		X	X
FL070	7000	781.9	X	X		X	X
FL080	8000	752.6	X	X		X	X
FL090	9000	724.3	X	X		X	X
FL100	10000	696.8	X	X	X	X	X
FL110	11000	670.2	X	X	X	X	X
FL120	12000	644.4	X	X	X	X	X
FL130	13000	619.4	X	X	X	X	X
FL140	14000	595.2	X	X	X	X	X
FL150	15000	571.8	X	X	X	X	X
FL160	16000	549.2	X	X	X	X	X
FL170	17000	527.2	X	X	X	X	X
FL180	18000	506.0	X	X	X	X	X
FL190	19000	485.5	X	X	X	X	
FL200	20000	465.6	X	X	X	X	
FL210	21000	446.5	X	X	X	X	
FL220	22000	427.9	X	X	X	X	
FL230	23000	410.0	X	X	X	X	
FL240	24000	392.7	X	X	X	X	
FL250	25000	376.0	X	X	X	X	
FL260	26000	359.9	X	X	X	X	
FL270	27000	344.3	X	X	X	X	
FL280	28000	329.3	X	X	X	X	
FL290	29000	314.9	X	X	X	X	
FL300	30000	300.9	X	X	X	X	
FL310	31000	287.4	X	X	X		
FL320	32000	274.5	X	X	X		
FL330	33000	262.0	X	X	X		
FL340	34000	250.0	X	X	X		
FL350	35000	238.4	X	X	X		

FL360	36000	227.3	X	X	X		
FL370	37000	216.6	X	X	X		
FL380	38000	206.5	X	X	X		
FL390	39000	196.8	X	X	X		
FL400	40000	187.5	X	X	X		
FL410	41000	178.7	X	X	X		
FL420	42000	170.4	X	X	X		
FL430	43000	162.4	X	X	X		
FL440	44000	154.7	X	X	X		
FL450	45000	147.5	X	X	X		
FL460	46000	140.6	X	X			
FL470	47000	134.0	X	X			
FL480	48000	127.7	X	X			
FL490	49000	121.7	X	X			
FL500	50000	116.0	X	X			
FL510	51000	110.5	X	X			
FL520	52000	105.3	X	X			
FL530	53000	100.4	X	X			
FL540	54000	95.7	X	X			
FL550	55000	91.2	X	X			
FL560	56000	87.0	X	X			
FL570	57000	82.8	X	X			
FL580	58000	79.0	X	X			
FL590	59000	75.2	X	X			
FL600	60000	71.7	X	X			

No changes are being proposed to the following parameters (additional data sets):

- Tropopause Height
- Tropopause Temperature
- Maximum U and V wind component
- Maximum wind Height
- Cumulonimbus Extent
- Cumulonimbus Base Height
- Cumulonimbus Top Height

Temporal resolution of all parameters:

- T+6 to T+24 (1hr intervals),
- T+27 to T+48 (3 hr intervals)
- T+54 to T+120 (6 hour intervals)

Note: WAFC Hazard Gridded data will stop at T+48

APPENDIX E

- New text to Annex 3 for Amendment 79 is shaded in grey.
- Deleted text for Amd 79 is shown with red ~~strikeout~~
- For Amendment 80 (or PANS-MET 2022 if available):
  - New text for 2022 is in blue (without strikeout)
  - Deleted text for 2022 is in blue ~~strikeout~~.
  - Tables X-1 through X-5

CHAPTER 9. SERVICE FOR OPERATORS AND FLIGHT CREW MEMBERS

…

9.1 General provisions

…

9.1.3 Meteorological information supplied to operators and flight crew members shall be up to date and include the following information, as agreed between the meteorological authority and the operators concerned:

a) forecasts of:

1) upper wind and upper-air temperature;

2) upper-air humidity;

3) geopotential altitude of flight levels;

4) flight level and temperature of tropopause;

5) direction, speed and flight level of maximum wind;

6) SIGWX phenomena; and

7) cumulonimbus clouds, icing and turbulence;

Note 1.— Forecasts of 1) through 5) ~~upper-air humidity and geopotential altitude of flight levels~~ are intended for ~~used only in~~ automatic flight planning and need not be displayed.

Note 2.— Forecasts of cumulonimbus clouds, icing and turbulence are intended to be processed and, if necessary, visualized according to the specific thresholds relevant to user operations.

…

9.1.6 Charts generated from the IWXXM form ~~digital~~ forecasts provided by the WAFCs shall be made available, as required by operators, ~~for fixed areas of coverage as shown in Appendix 8, Figures A8-1, A8-2 and A8-3~~ for the valid times and coverage applicable to the route of the flight.

9.1.7 ~~When forecasts of upper wind and upper-air temperature listed under 9.1.3 a) 1) are supplied in chart form, they shall be fixed time prognostic charts for flight levels as specified in Appendix 2, 1.2.2 a).~~ When forecasts of SIGWX phenomena listed under 9.1.3 a) 6) are supplied in chart form, they shall be fixed time prognostic charts for an atmospheric layer limited by flight levels between 250 and 630. ~~as specified in Appendix 2, 1.3.2 and Appendix 5, 4.3.2.~~

9.1.8 The forecasts of upper wind and upper-air temperature and of SIGWX phenomena ~~above flight level 100 requested for~~ pre-flight planning and in-flight replanning by the operator shall be made available ~~supplied~~ as soon as technically feasible ~~they become available, but not later than 3 hours before departure~~. Other meteorological information requested for pre-flight planning and in-flight replanning by the operator shall be supplied as soon as is practicable.

…

APPENDIX 1. FLIGHT DOCUMENTATION — MODEL CHARTS AND FORMS

…

~~MODEL IS Upper wind and upper-air temperature chart for standard isobaric surface~~
~~Example 1. Arrows, feathers and pennants (Mercator projection)~~
~~Example 2. Arrows, feathers and pennants (Polar stereographic projection)~~

MODEL SWH WAFS ~~S~~significant weather chart ~~(high level)~~
Example. Polar stereographic projection ~~(showing the jet stream vertical extent)~~

~~MODEL SWM Significant weather chart (medium level)~~

…

~~UPPER WIND AND UPPER-AIR TEMPERATURE CHART FOR STANDARD ISOBARIC SURFACE MODEL IS~~
~~Example 1. Arrows, feathers and pennants (Mercator projection)~~

<Remove chart>

…

~~UPPER WIND AND UPPER-AIR TEMPERATURE CHART FOR STANDARD ISOBARIC SURFACE MODEL IS~~
~~Example 2. Arrows, feathers and pennants (Polar stereographic projection)~~

<Remove chart>

…

WAFS SIGNIFICANT WEATHER CHART ~~(HIGH LEVEL)~~ MODEL SWH
Example. Polar stereographic projection ~~(showing the jet stream vertical extent)~~

<New SWH to be prepared and given to WMO, which removes jet depths and CB bases>

...

~~**SIGNIFICANT WEATHER CHART (MEDIUM LEVEL) MODEL SWM**~~

<Remove chart>

...

SHEET OF NOTATIONS USED IN FLIGHT DOCUMENTATION MODEL SN

<New text to be prepared for Table 2 and given to WMO, which removes Tropopause Heights>

<New text to be prepared and given to WMO to remove jet depths as well as CB bases>

...

APPENDIX 2. TECHNICAL SPECIFICATIONS RELATED TO WORLD AREA FORECAST SYSTEM AND METEOROLOGICAL OFFICES

1. WORLD AREA FORECAST SYSTEM

…

1.2 Upper-air gridded forecasts

1.2.1 The forecasts of upper winds; upper-air temperature; and humidity; direction, speed and flight level of maximum wind; flight level and temperature of tropopause, areas of cumulonimbus clouds, icing, ~~clear-air and in-cloud~~ turbulence, and geopotential altitude of flight levels shall be prepared four times a day by a WAFC and shall be valid for fixed valid times in accordance with Table X-1 and Table X-2 ~~at 6, 9, 12, 15, 18, 21, 24, 27, 30, 33 and 36 hours~~ after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based. ~~The dissemination of e~~Each forecast ~~shall be in the above order and~~ shall be ~~completed~~ made available as soon as technically feasible but not later than ~~6~~ 5 hours after standard time of observation.

1.2.2 The grid point forecasts for the following parameters prepared by a WAFC shall comprise:

a) wind and temperature data for flight levels ~~50 (850 hPa), 80 (750 hPa), 100 (700 hPa), 140 (600 hPa),~~

~~180 (500 hPa), 210 (450 hPa), 240 (400 hPa), 270 (350 hPa), 300 (300 hPa), 320 (275 hPa), 340 (250 hPa), 360 (225 hPa), 390 (200 hPa), 410 (175 hPa), 450 (150 hPa), 480 (125 hPa) and 530 (100 hPa)~~;

b) flight level and temperature of tropopause;

c) direction, speed and flight level of maximum wind;

d) humidity data for flight levels ~~50 (850 hPa), 80 (750 hPa), 100 (700 hPa), 140 (600 hPa) and 180 (500 hPa)~~;

e) horizontal extent and flight levels of base and top of cumulonimbus clouds;

f) icing for layers centred at flight levels ~~60 (800 hPa), 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 240 (400 hPa) and 300 (300 hPa)~~;

g) ~~clear air~~ turbulence for layers centred at flight levels ~~100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 240 (400 hPa), 270 (350 hPa), 300 (300 hPa), 340 (250 hPa), 390 (200 hPa) and 450 (150 hPa)~~; and

~~h) in-cloud turbulence for layers centred at flight levels 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 240 (400 hPa) and 300 (300 hPa); and~~

~~*Note 1.— Layers centred at a flight level referred to in f) and h) have a depth of 100 hPa.*~~
~~*Note 2.— Layers centred at a flight level referred to in g) have a depth of 100 hPa for flight levels below 240, then 50 hPa for flight levels 240 and above*~~.

h~~i~~) geopotential altitude data for flight levels ~~50 (850 hPa), 80 (750 hPa), 100 (700 hPa), 140 (600 hPa), 180 (500 hPa), 210 (450 hPa), 240 (400 hPa), 270 (350 hPa), 300 (300 hPa), 320 (275 hPa), 340 (250 hPa), 360 (225 hPa), 390 (200 hPa), 410 (175 hPa), 450 (150 hPa), 480 (125 hPa) and 530 (100 hPa)~~.

~~*Note.— The exact pressure levels (hPa) for a), d), f), g), and i) is provided in the* Manual of Aeronautical Meteorological Practice *(Doc 8896)*~~.
Note.— The details for the flight levels for a), d), f) and g) are provided in Table X-3 and X-4.

1.2.3 The foregoing grid point forecasts shall be issued by a WAFC in binary code form using the GRIB code form prescribed by the World Meteorological Organization (WMO).

Note.— The GRIB code form is contained in the Manual on Codes *(WMO-No. 306), Volume I.2, Part B* — Binary Codes.

1.2.4 The ~~foregoing~~ grid point forecasts, in Table X-3, shall be prepared by a WAFC in a regular grid with a horizontal resolution of 0.25° of latitude and longitude.

1.2.~~4~~5 In addition to 1.2.4, t~~T~~he ~~foregoing~~ grid point forecasts, in Table X-4, shall be prepared by a WAFC in a regular grid with a horizontal resolution of 1.25° of latitude and longitude.

1.3 Significant weather (SIGWX) forecasts

1.3.1 General provisions

1.3.1.1 Forecasts of significant en-route weather phenomena shall be prepared as SIGWX forecasts four times a day by a WAFC and shall be valid for fixed valid times, as detailed in Table X-5, ~~at~~

~~24 hours~~ after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based. ~~The dissemination of e~~Each forecast shall be ~~completed~~ made available as soon as technically feasible but not later than ~~9~~ 7 hours after standard time of observation ~~under normal operations and not later than 9 hours after standard time of observation during backup operations~~.

~~1.3.1.2 SIGWX forecasts shall be issued in binary code form using the BUFR code form prescribed by WMO.~~

~~*Note.— The BUFR code form is contained in the* Manual on Codes *(WMO-No. 306), Volume I.2, Part B — Binary Codes.*~~

1.3.1.2~~3~~ **~~Recommendation~~**~~. — *From xx November 2021, in addition to 1.3.1.2,*~~ SIGWX forecasts shall ~~should~~ be made available in IWXXM form as detailed in Table X-5.

Note.— Guidance on IWXXM is provided in the Manual on the ICAO Meteorological Information Exchange Model (IWXXM) *(Doc 10003).*

1.3.1.3 SIGWX forecasts shall be made available PNG form in accordance with Table X-5.

1.3.1.4 SIGWX forecasts shall be issued for flight levels between 100 and 600.

~~1.3.2 Types of SIGWX forecasts~~

~~SIGWX forecasts shall be issued as high-level SIGWX forecasts for flight levels between 250 and 630.~~

~~*Note.— Medium-level SIGWX forecasts for flight levels between 100 and 250 for limited geographical areas will continue to be issued until such time that flight documentation to be generated from the gridded forecasts of cumulonimbus clouds, icing and turbulence fully meets user requirements*~~

1.3.~~3~~2 Items included in SIGWX forecasts

SIGWX forecasts shall include the following items:

~~a)~~ tropical cyclone provided that the maximum of the 10-minute mean surface wind speed is expected to reach or exceed 17 m/s (34 kt);

~~b)~~ ~~severe squall lines~~;

b~~c~~) moderate or severe turbulence ~~(in cloud or clear air)~~ not associated with thunderstorms;

c~~d~~) moderate or severe icing not associated with thunderstorms;

Note.— Icing to be included in SIGWX in IWXXM form but not in SIGWX in PNG form.

de) widespread sandstorm/duststorm;

ef) cumulonimbus clouds associated with thunderstorms ~~and with a) to e)~~;

~~*Note.— Non-convective cloud areas associated with in-cloud moderate or severe turbulence and/or moderate or severe icing are to be included in the SIGWX forecasts.*~~

fg) flight level of tropopause;

gh) jet streams;

hi) information on the location of volcanic eruptions that are producing ash clouds of significance to aircraft operations, comprising: volcanic eruption symbol at the location of the volcano and, in a separate text box on the chart, the volcanic eruption symbol, the name of the volcano (if known) and the latitude/longitude of the eruption. In addition, the legend of SIGWX charts should indicate "CHECK SIGMET, ADVISORIES FOR TC AND VA, AND ASHTAM AND NOTAM FOR VA"; and

ij) information on the location of a release of radioactive materials into the atmosphere of significance to aircraft operations, comprising: the radioactive materials in the atmosphere symbol at the location of the release and, in a separate text box on the chart, the radioactive materials in the atmosphere symbol, latitude/longitude of the site of the release, and (if known) the name of site of the radioactive source. In addition, the legend of SIGWX charts on which a release of radiation is indicated should contain "CHECK SIGMET AND NOTAM FOR RDOACT CLD".

~~*Note 1.— Medium-level SIGWX forecasts include all the items above.*~~

Note ~~2~~.— Items to be included in low-level SIGWX forecasts (i.e. flight levels below 100) are included in Appendix 5 of Annex 3.

The following criteria shall be applied for SIGWX forecasts:

~~a) items a) to d) in 1.3.3 shall only be included if expected to occur between the lower and upper levels of the SIGWX forecast;~~

a~~b~~) the abbreviation "CB" shall only be included when it refers to the occurrence or expected occurrence of cumulonimbus clouds~~:~~

~~1)~~ affecting an area with a maximum spatial coverage of 50 per cent or more of the area concerned;
~~2) along a line with little or no space between individual clouds; or~~

~~3) embedded in cloud layers or concealed by haze;~~

b~~c~~) the inclusion of "CB" shall be understood to include all weather phenomena normally associated with cumulonimbus clouds, i.e. thunderstorm, moderate or severe icing, moderate or severe turbulence and hail;

c~~d~~) where a volcanic eruption or a release of radioactive materials into the atmosphere warrants the inclusion of the volcanic eruption symbol or the radioactive materials in the atmosphere symbol in SIGWX forecasts, the symbols shall be included on SIGWX forecasts irrespective of the height to which the ash column or radioactive material is reported or expected to reach; and

d~~e~~) in the case of co-incident or the partial overlapping of items a), h~~i~~) and i~~j~~) in 1.3.3, the highest priority shall be given to item h~~i~~), followed by items j~~j~~) and a). The item with the highest priority shall be placed at the location of the event, and an arrow shall be used to link the location of the other item(s) to its

associated symbol or text box.

2. AERODROME METEOROLOGICAL OFFICES

2.1 Use of world area forecast system (WAFS) products

…

2.1.2 In order to ensure uniformity and standardization of flight documentation, the WAFS GRIB~~, and BUFR~~ and IWXXM data received shall be decoded into standard WAFS charts in accordance with relevant provisions in this Annex, and the meteorological content and identification of the originator of the WAFS forecasts shall not be amended.

2.2 Notification of WAFC concerning significant discrepancies

Aerodrome meteorological offices using WAFS ~~BUFR or~~ IWXXM data shall notify the WAFC concerned immediately if significant discrepancies are detected or reported in respect of WAFS SIGWX forecasts concerning:

a) icing, turbulence, and cumulonimbus clouds ~~that are obscured, frequent, embedded or occurring at a squall line, and sandstorms/duststorms~~; and

b) volcanic eruptions or a release of radioactive materials into the atmosphere, of significance to aircraft operations.

The WAFC receiving the message shall acknowledge its receipt to the originator, together with a brief comment on the report and any action taken, using the same means of communication employed by the originator.

Note.— Guidance on reporting significant discrepancies is provided in the Manual of Aeronautical Meteorological Practice *(Doc 8896).*

APPENDIX 8. TECHNICAL SPECIFICATIONS RELATED TO SERVICE FOR OPERATORS AND FLIGHT CREW MEMBERS

…

2. SPECIFICATIONS RELATED TO INFORMATION FOR PRE-FLIGHT PLANNING AND IN-FLIGHT REPLANNING

…

2.2 Format of information on significant weather

~~2.2.1~~ Information on significant weather supplied by WAFCs for pre-flight and in-flight replanning shall be in the ~~BUFR~~ IWXXM code form.

~~*Note.— The BUFR code form is contained in the* Manual on Codes *(WMO-No. 306), Volume I.2, Part B — Binary Codes.*~~

~~2.2.2 **Recommendation**. — *From xx November 2021, in addition to 2.2.1, information on significant weather supplied by WAFCs for pre-flight and in-flight replanning should be in the IWXXM form.*~~

Note.— Guidance on IWXXM is provided in the Manual on the ICAO Meteorological Information Exchange Model (IWXXM) *(Doc 10003).*

…

Table X-1. Fixed valid times for WAFS upper-air gridded forecasts with 0.25 degree horizontal resolution

Upper-air grid point forecasts	1-hourly intervals	3-hourly intervals	6-hourly intervals
Wind, temperature, geopotential altitude	6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24 hours	27, 30, 33, 36, 39, 42, 45 and 48 hours	54, 60, 66, 72, 78, 84, 90, 96, 102, 108, 114 and 120 hours
Flight level and temperature of tropopause			
direction, speed and flight level of maximum wind			
Humidity			
Horizontal extent and flight levels of base and top of cumulonimbus clouds	6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 and 24 hours	27, 30, 33, 36, 39, 42, 45 and 48 hours	Not provided
Icing			
Turbulence			

Table X-2. Fixed valid times for WAFS upper-air gridded forecasts with 1.25 degree horizontal resolution

Upper-air grid point forecasts	3-hourly intervals
Wind, temperature, geopotential altitude	6, 9, 12, 15, 18, 24, 27, 30, 33 and 36 hours
Flight level and temperature of tropopause	
direction, speed and flight level of maximum wind	
Humidity	

Table X-3: Upper-air grid point forecasts with 0.25 degree horizontal resolution for the following flight levels.

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Wind	Temperature	Turbulence	Icing	Humidity
FL050	5000	843.1	X	X		X	X
FL060	6000	812.0	X	X		X	X
FL070	7000	781.9	X	X		X	X
FL080	8000	752.6	X	X		X	X
FL090	9000	724.3	X	X		X	X
FL100	10000	696.8	X	X	X	X	X
FL110	11000	670.2	X	X	X	X	X
FL120	12000	644.4	X	X	X	X	X
FL130	13000	619.4	X	X	X	X	X
FL140	14000	595.2	X	X	X	X	X
FL150	15000	571.8	X	X	X	X	X
FL160	16000	549.2	X	X	X	X	X
FL170	17000	527.2	X	X	X	X	X
FL180	18000	506.0	X	X	X	X	X
FL190	19000	485.5	X	X	X	X	
FL200	20000	465.6	X	X	X	X	
FL210	21000	446.5	X	X	X	X	
FL220	22000	427.9	X	X	X	X	
FL230	23000	410.0	X	X	X	X	
FL240	24000	392.7	X	X	X	X	
FL250	25000	376.0	X	X	X	X	
FL260	26000	359.9	X	X	X	X	
FL270	27000	344.3	X	X	X	X	
FL280	28000	329.3	X	X	X	X	
FL290	29000	314.9	X	X	X	X	
FL300	30000	300.9	X	X	X	X	
FL310	31000	287.4	X	X	X		
FL320	32000	274.5	X	X	X		
FL330	33000	262.0	X	X	X		
FL340	34000	250.0	X	X	X		
FL350	35000	238.4	X	X	X		
FL360	36000	227.3	X	X	X		
FL370	37000	216.6	X	X	X		
FL380	38000	206.5	X	X	X		
FL390	39000	196.8	X	X	X		

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Wind	Temperature	Turbulence	Icing	Humidity
FL400	40000	187.5	X	X	X		
FL410	41000	178.7	X	X	X		
FL420	42000	170.4	X	X	X		
FL430	43000	162.4	X	X	X		
FL440	44000	154.7	X	X	X		
FL450	45000	147.5	X	X	X		
FL460	46000	140.6	X	X			
FL470	47000	134.0	X	X			
FL480	48000	127.7	X	X			
FL490	49000	121.7	X	X			
FL500	50000	116.0	X	X			
FL510	51000	110.5	X	X			
FL520	52000	105.3	X	X			
FL530	53000	100.4	X	X			
FL540	54000	95.7	X	X			
FL550	55000	91.2	X	X			
FL560	56000	87.0	X	X			
FL570	57000	82.8	X	X			
FL580	58000	79.0	X	X			
FL590	59000	75.2	X	X			
FL600	60000	71.7	X	X			

Table X-4: Upper-air grid point forecasts with 1.25 degree horizontal resolution for the following flight levels.

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Wind	Temperature	Humidity
FL050	5000	843.1	X	X	X
FL080	8000	752.6	X	X	X
FL100	10000	696.8	X	X	X
FL140	14000	595.2	X	X	X
FL180	18000	506.0	X	X	X

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Wind	Temperature	Humidity
FL210	21000	446.5	X	X	
FL240	24000	392.7	X	X	
FL270	27000	344.3	X	X	
FL300	30000	300.9	X	X	
FL320	32000	274.5	X	X	
FL340	34000	250.0	X	X	
FL360	36000	227.3	X	X	
FL390	39000	196.8	X	X	
FL410	41000	178.7	X	X	
FL450	45000	147.5	X	X	
FL480	48000	127.7	X	X	
FL530	53000	100.4	X	X	

Table X-5: SIGWX forecast fixed valid times and tropical cyclone information

	SIGWX forecast fixed valid times	
Time	IWXXM form	PNG form
T+6 hours	X	
T+9	X	
T+12	X	
T+15	X	
T+18	X	
T+21	X	
T+24	X	X
T+27	X	
T+30	X	
T+33	X	
T+36	X	
T+39	X	
T+42	X	
T+45	X	
T+48	X	