Meteorology Panel (METP)

Working Group on Meteorological Operations Group (WG-MOG)

World Area Forecast System (WAFS) Work Stream

Fourteenth Meeting

(METP/WG-MOG/14-WAFS)

Virtual Meeting, 12-14 April 2021

MEETING REPORT

INTERNATIONAL CIVIL AVIATION ORGANIZATION

LIST OF WG-MOG/14 – WAFS ACTIONS

Action 14/01 – Terms of Reference

That,

a) the METP-WG/MOG meeting accepts the proposed updates to the Terms of Reference as shown in **Appendix B**;

b) the ICAO Secretariat puts the finalised Terms of Reference document onto the ICAO public website (replacing the previous copy); and

c) the finalised Terms of Reference are presented as an information paper at METP/5.

Action 14/02 – WAFC support to the HWIS Demonstration

That, the WG-MOG Rapporteur report back to the WG-MISD/HWIS Work Stream that the WAFCs can support an HWIS convective cloud demonstration project after November 2023.

Action 14/03 – Effect of COVID-19 on WAFS forecast accuracy

That, the WAFCs will:

a) continue to monitor WAFS data forecast accuracy for COVID related impacts;

b) assess the specific value gained from aircraft-based observations on the WAFS forecast verification by specific weather phenomena (wind/temperature, turbulence, icing and CB cloud);

c) examine whether the loss of aircraft observations has any impact on longer range model forecast verification; and

d) report back on their findings at the next WG-MOG (WAFS) meeting.

Action 14/04 – Turbulence Type Forecasts

That, the WAFCs in conjunction with IATA and IFALPA:

a) continue to investigate individual turbulence type forecast information (MTW and CAT only) and how this information should be presented to users;

b) develop educational material to accompany a); and

c) report back at the next WG-MOG (WAFS) meeting.

Action 14/05 – Requirement for using alternative data formats to GRIB-2

That, the WG-MOG Rapporteur presents a working paper to METP/5 to inform the Panel on the requirement to use data formats other than GRIB-2 in order to meet the objectives set out in the GANP and to deliver data to the aviation industry in an effective and efficient SWIM-compliant way.

Action 14/06 – WAFS SIGWX forecasts

That, the WAFCs will:

a) endeavour to publish test SIGWX data sets in IWXXM format in November 2021 and invite SADIS and WIFS users to visualise the data and provide feedback.

b) report back on progress at the next WG-MOG (WAFS) meeting.

Action 14/07 – Changes for Annex 3 Amendment 81 and PANS-MET pertaining to the WAFS

That, the WG-MOG Rapporteur:

a) ensure that the draft provisions in **Appendices D** and **E** be included in the consolidated proposed amendments to Amendment 81 to Annex 3 – *Meteorological Service for International Air Navigation* and the *Procedures for Air Navigation Services – Meteorology* (PANS-MET) along with the other draft provisions for other meteorological services going forward to METP/5; and

b) deliver the reasons for the changes (**Appendix F**) to the Secretariat, after METP/5, for his use in preparing Amendment 81 and PANS-MET for the Air Navigation Commission.

Action 14/08 – Next generation WAFS Information Sheet

That,

a) the Rapporteur provides the updated next generation WAFS information sheet to the rapporteurs within the METP; and

b) the Secretariat be invited to socialise the next generation WAFS information sheet with others within ICAO (such as the regional ICAO meteorological planning and implementation groups), as appropriate.

Action 14/09 – Probabilistic WAFS data

That,

a) the WAFCs, coordinating with IATA, will create example plots and case studies, to be posted on the ICAO WG-MOG/WAFS dedicated webpages or the WAFC London website, that show different ways in which probabilistic information could be presented to users, and will host this data online.

b) all WG-MOG (WAFS) participants will discuss the example probabilistic plots with their national stakeholder groups (airlines, flight planners, ANSPs etc.), gather ideas and possible requirements, and provide this information back to the WG-MOG (WAFS) meeting in 2022.

c) share the information in a) with WG-MRI and invite WG-MRI to investigate the requirements for probabilistic information during their user consultation activities.

Action 14/10 – Update on Enhanced Wind Verification

That, contingent upon IATA's validation of the usefulness of such statistics, the WAFCs begin providing wind verification in RMSE, stratified by wind speed bins.

Action 14/11 – WAFS Verification

That, the WAFCs:

a) continue to investigate how best to present verification statistics for the new 0.25 degree data sets;

b) develop explanatory material for users; and,

c) report back at the next WG-MOG (WAFS).

Action 14/12 – Job Card 10 update

That, the WG-MOG Rapporteur present the proposed updates to Job Card 10, as shown in **Appendix H**, to METP/5 for consideration.

LIST OF WG-MOG/14 – WAFS DECISIONS

Decision 14/01 – Convectively Induced Turbulence

That, the WAFCs in conjunction with IATA and IFALPA agreed that forecasts of Convectively Induced Turbulence (CIT) are used tactically, and currently not a required part of the WAFS data set.

Decision 14/02 – Requirement for using alternative data formats to GRIB-2

That, the WG/MOG/14 meeting agreed that there is a requirement to use data formats other than GRIB-2 in order to meet the objectives set out in the GANP and to deliver data to the aviation industry in an effective and efficient SWIM-compliant way.

ACTION RETAINED FROM WG-MOG/12

Action 12/05 – Tropical cyclone (TC) information beyond T+24 hours

Given that the WAFCs are not in a position to include TC forecast position information for forecasts between 27-hours and 48 hours, the ICAO Secretariat is invited to:

a) undertake a formal consultation with IATA, IFALPA, CANSO and IFATCA panel members to identify their requirements for longer range tropical cyclone advisory information;

b) in conjunction with WMO, investigate whether the TCACs will be in a position to provide the extra TC information, and a timescale on which the new forecast information could be produced;

c) provide guidance on what form this forecast information should be supplied in, who should propose these changes for Annex 3 and other associated documentation; and

d) report back on progress to the next MOG/WAFS meeting.

AGENDA ITEM 1: OPENING OF THE MEETING

1.1 The fourteenth meeting of the MET Operations Group (MOG/14) for matters pertaining to the World Area Forecast System (WAFS) took place virtually, from 12 to 14 April 2021. Mr. Jonathan Dutton, UK Met Office, and Rapporteur of WG-MOG, chaired the meeting. Mr. Dutton was assisted by Ms. Karen Shorey.

1.2 Mr. Dutton opened the meeting at 1230 UTC. He thanked the World Area Forecast Centre (WAFC) Provider States for their continued investment and improvements in the WAFS which were appreciated by all the users. Mr. Peter Lechner, Chair of the METP, addressed the meeting and thanked the WAFS Work Stream for their hard work over the past year.

1.3 Working arrangements for the meeting were presented with an emphasis on how attendees were requested to participate through the Microsoft Teams platform.

1.4 In lieu of oral introductions, all attendees were asked to provide their name, affiliation, and METP status (i.e., member, adviser, observer) in the chat window. In addition, advisors and observers were asked to provide their sponsoring METP member.

2. AGENDA ITEM 2: INTRODUCTION

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

2.2 Adoption of the Agenda

2.2.1 The agenda for the meeting, presented in **MOG/14/IP/02**, was adopted without change.

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

2.4 Working Arrangements and Terms of Reference

2.4.1 **MOG/14/SN/01 – *METP-WG/MOG Terms of Reference*** presented the status of the METP WG-MOG Terms of Reference, which is included as **Appendix B** to this report.

2.4.2 The Terms of Reference will be published on the following webpage: https://www.icao.int/airnavigation/METP/Pages/Public-Documents.aspx.

2.4.3 Only one minor change is required, that references the upcoming move of Space Weather activities into the WG-MOG. A question was asked as to whether the Terms of Reference should be presented to the METP/5 for endorsement, especially since it will be posted on the WG-MOG public webpage. After some discussion, it was agreed that it would be presented to the METP/5 as an IP.

2.4.4 The meeting agreed to the following action:

Action 14/01 — Terms of Reference

That,

a) the METP/WG-MOG meeting accepts the proposed updates to the Terms of Reference as shown in **Appendix B**;

b) the ICAO Secretariat puts the finalised Terms of Reference document onto the ICAO public website (replacing the previous copy); and

c) the finalised Terms of Reference are presented as an information paper at METP/5.

3. AGENDA ITEM 3: MATTERS RELATING TO WAFS

3.1 Status of Outstanding WG-MOG (WAFS) Actions

3.1.1 **MOG/14/IP/03 – *Actions and Decisions from METP-WG/MOG 12 Meeting*** reviewed the outstanding actions and decisions relating to WAFS.

3.1.2 It should be noted that the MOG/12 was held right at the start of the COVID pandemic, and its impacts on ICAO meetings and document updates were not known at that time. Subsequently the ICAO Annex 3 – *Meteorological Service for International Air Navigation* amendment cycle was changed. Changes that were anticipated for Amendment 80 and expected to be implemented November 2022 have now been delayed and will take place in Amendment 81 to Annex 3 in November 2023.

3.1.3 Regarding Action 12/5 – *Tropical cyclone (TC) information beyond T+24 hours*, a question was asked about any coordination with the Civil Air Navigation Services Organization (CANSO) and the International Federation of Air Traffic Controllers' Associations (IFATCA) with respect to requirements for this information. The meeting was informed that the Secretariat will look into this matter.

3.1.3.1 Regarding Action 12/6 the meeting was informed that that Tropical Cyclone Advisory Centres (TCAC) Miami and Honolulu will adjust their issuance times to align with the synoptic hours prior to November 2023.

3.1.4 Regarding Action 12/7 – *TCAC designation and areas of coverage in the Atlantic Ocean*, the meeting was pleased to hear that the World Meteorological Organization (WMO) stands ready to assist the Secretariat and MOG/WAFS if and when necessary.

3.1.5 After discussion, the meeting noted the updated status of the actions, which are included as **Appendix C** to this report.

3.2 **Interaction with Other METP Groups**

3.2.1 WAFC London and WAFC Washington presented **MOG/14/IP/04 – *Interaction with Other METP Groups*** that provided a summary of activities within the other METP working groups that is relevant to the WAFCs.

3.2.1.1 Working Group on Meteorological Information Exchange (WG-MIE)

3.2.1.1.1 WG-MIE activity 1.9 is working on development of ICAO Meteorological Information Exchange Model (IWXXM) schemas for a range of new products, including Significant Weather (SIGWX) objects for both high and low levels. Work on the IWXXM schema for WAFS SIGWX is nearly complete and expected to be published in late 2021. Information on the schema development can be found at: https://github.com/blchoy/iwxxm-testbedOne/wiki/DN-2019_01-P1.

3.2.1.1.2 The WG-MIE is developing guidance material that relates to System Wide Information Management (SWIM) (SWIM Plan, SWIM Roadmap) and has been having discussions on SWIM governance and the requirements for a SWIM registry. This will be useful information that can be used by the WAFCs in the development of the replacement systems for Secure Aviation Data Information Service (SADIS) and WAFS Internet File Service (WIFS).

3.2.1.1.2.1 During discussions, a question was asked about the SWIM registry. The meeting was informed that the Working Group on Meteorological Cost Recovery Guidance and Governance (WG-MCRGG) has been working on a policy for meteorological information and associated services on the SWIM registry.

3.2.1.2 Working Group on Meteorological Requirements and Integration (WG-MRI)

3.2.1.2.1 Excellent progress has been made within the WG-MRI regarding splitting ICAO Annex 3 into a simplified Annex 3 and the *Procedures for Air Navigation Services – Meteorology* (PANS-MET, Doc ...). At METP/5 in June 2021, the new versions of these two documents will be presented (they have been created from ICAO Annex 3 with the Amendment 79 changes) and if subsequently approved by the Air Navigation Committee will come into operation in November 2023.

3.2.1.2.2 All METP working groups are required to prepare and present any changes needed for ICAO Annex 3 Amendment 81 (November 2023) and the new PANS-MET, against these "split" documents at METP/5. The WG-MOG/WAFS work stream proposed changes pertaining to the WAFS (SN/10 – *WAFS Changes for Annex 3 Amendment 81 and PANS-MET*) will be included in this work.

3.2.1.3 Working Group on Meteorological Information and Service Development (WG-MISD)

3.2.1.3.1 Space Weather Centres are now operational, and it is expected that their oversight will move to sit under the WG-MOG as a new work stream. The three space weather centres (operated by Pan-European Consortium for Aviation Space weather User Services (PECASUS) http://pecasus.eu/, Australia, Canada, France and Japan (ACFJ) http://www.bom.gov.au/aviation/space-weather-advisories/ and the USA https://www.swpc.noaa.gov/) will be joined by a fourth centre operated by Russian Federation and China soon.

3.2.1.3.2 The Regional Hazardous Weather Advisory Centre (RHWAC) concept has evolved into the Hazardous Weather Information Service (HWIS) which aims to provide phenomena based, globally consistent, en-route hazardous weather information to its users. One of the inputs into the system might be the 6-hour validity time WAFS data sets (in particular cumulonimbus (CB) cloud, icing and turbulence).

3.2.1.3.3 The WG-MISD Volcanic Ash and Sulphur Dioxide (VASD) Work Stream has been developing the Initial Operating Capability (IOC) for a new Quantitative Volcanic Ash (QVA) service, and their proposal will be presented at METP/5. Probabilistic QVA output is planned, and lessons learned in the implementation of this will be relevant to the WAFCs for when probabilistic WAFS data is introduced (probably in 2026).

3.2.1.4 Representatives for both WAFC London/SADIS and WAFC Washington/WIFS will continue to attend METP working group meetings and be involved in their work stream activities.

3.2.2 WAFC Washington presented **MOG/14/SN/02 – *WAFC Capability to Support the Hazardous Weather Information Service (HWIS)***.

3.2.2.1 At the seventh meeting of the METP/WG-MISD HWIS Work Stream (virtual 22, 23, and 26 March 2021), the meeting reviewed the progress made to develop the concept for a HWIS, which has evolved from the RHWAC concept. The WG-MISD HWIS Work Stream agreed to the following action:

Action MISD/HWIS 7/6 – WAFS grids and polygons of cumulonimbus clouds

That, the WG-MISD Rapporteur invite the WAFCs, at the WG-MOG/14 meeting (12-14 April 2021), to consider the feasibility of making available WAFS grids and polygons of cumulonimbus (CB) clouds at time steps supporting the demonstration of the HWIS capabilities.

3.2.2.2 The HWIS draft service architecture requires gridded inputs and outputs of hazard grids for time steps T+00, T+01 and T+02 hours. It requires the grids to be updated every hour.

3.2.2.3 The WAFS hazard grids are only updated every 6 hours. They currently only provide time steps T+06, 09, 12…etc. However, the available time steps will increase to hourly time steps by November 2023. Any WAFC participation in a CB cloud demonstration for HWIS would have to wait until then.

3.2.2.4 Once the WAFCs can provide hourly CB cloud forecast grids, there is still the problem that the initial time step from each model run is T+06. This can be mitigated by using data from the previous WAFS gridded data cycle. For example, the T+01 forecast for a 14 UTC HWIS update (VT 1500 UTC) would be derived from the T+09 time step of the 06 UTC WAFS gridded data package.

3.2.2.5 The service architecture calls for polygons to be created by the HWIS database after the WAFS grids are merged with any available local or regional grids. The WAFCs are therefore uncertain if the HWIS project would use polygons created straight from the WAFC grids alone.

3.2.2.6 If the HWIS project does require WAFS polygons, they would be created using the same software the WAFCs will use to create SIGWX objects for the automated SIGWX charts. This software will not be ready to use until late 2023.

3.2.2.7 After further discussion, the meeting agreed to the following action:

Action 14/02 – WAFC support to the HWIS Demonstration

That, the WG-MOG Rapporteur report back to the WG-MISD/HWIS Work Stream that the WAFCs can support an HWIS convective cloud demonstration project after November 2023.

3.3 WAFS Operation from March 2020 to February 2021

3.3.1 WAFC London presented **MOG/14/IP/05 – *WAFC London – WAFS Upgrade Activities***.

3.3.1.1 Amendment 79 to ICAO Annex 3 brought upgraded WAFS hazard data sets to users of SADIS and WIFS in November 2020.

3.3.1.2 WAFC London first published a set of static test data sets on an ftp server (not SADIS) in February 2020, accompanied by an information sheet to inform users of the new characteristics.

3.3.1.3 On 28 May 2020, the test data feed was set up on SADIS, with 6-hourly updating data being published in a clearly marked /TEST/ directory. Feedback was received from a few early adopters which enabled a few minor errors in the data to be rectified, and by 1 September 2020 the data was in its final (unblended form).

3.3.1.4 Between September and November 2020, the SADIS manager provided information papers on the upcoming WAFS data changes to the European Region Aviation System Planning Group (EASPG) METG/30, Asia and Pacific (APAC) MET/S WG10 Meeting, and Middle East and Asia/Pacific Air Navigation Planning and Implementation Regional Group (MIDANPIRG and APANPIRG) SG/9 meetings. At the APAC and APANPIRG meeting a 1-hour training presentation was also given. An additional stand-alone training session was also delivered to attendees across the Eastern and Southern African (ESAF) and Western and Central African (WACAF) regions.

3.3.1.5 On 5 November 2020, SADIS was upgraded to move the data from the /TEST/ directories into its operational directory, and users were informed of the change via an administrative message. At this stage, the data set presented was WAFC London only data. The publication time was also delayed to 6-hours after the model run time and had a lower resilience due to only coming from one centre.

3.3.1.6 Since 5 November 2020 production of the new data sets has been fairly reliable, however, there have been a few teething problems. These are noted in the WAFC Management report and the issues have now been resolved.

3.3.1.7 Once final checks were made of the blending/harmonisation on a test system, the completed, fully operational 0.25-degree CB cloud, icing and turbulence data sets were published on SADIS from the 06 UTC run on the 29 March 2021. This release resolved the resilience issues and allowed the data publication time to be moved forwards to the 4:30 mark, which meets the ICAO target delivery time.

3.3.1.8 On 29 March 2021, the 1.25-degree in-cloud turbulence field was retired from SADIS and WIFS.

3.3.2 WAFC Washington presented **MOG/14/IP/06 – *WAFC Washington – WAFS Upgrade Activities***.

3.3.2.1 WAFC Washington began disseminating operational unblended 0.25-degree icing severity data in May of 2016. Files for turbulence and CB cloud information followed in July 2019. These files were originally made available on the National Oceanic and Atmospheric Administration's (NOAA) Operational Model Archive and Distribution System (NOMADS) server.

3.3.2.2 The unblended files were later moved to a test directory on WIFS in May 2020.

3.3.2.3 The two WAFCs agreed upon and exchanged code for blending, and WAFC Washington integrated the code into the next upgrade of its global model. That upgrade, originally planned for July 2020, was not installed until 24 March 2021.

3.3.2.4 The lack of blending capability on WAFC Washington's side did not affect London's ability to blend its files with Washington's files. Rather than have WAFC Washington issue unblended files, while London issued blended files, it was decided that Washington's feed should not be considered reliable until the model was fully upgraded. Instead, both WAFCs would issue London's unblended files until Washington fully completed its model upgrades and could issue blended files. That was accomplished and both WAFCs begin issuing blended data on 29 March 2021.

3.3.2.5 Once the WAFC Washington data became available for blending a coding error was discovered that was introduced during the model upgrade. This caused WAFC Washington's 1.25-degree non-hazard grids to be provided on constant height surfaces, instead of constant pressure surfaces. As this could cause significant flight planning errors, the data was temporarily shut off. The users were notified that they should use WAFC London data as a backup data source for wind, temperature, relative humidity and geopotential heights. The error was fully corrected, and data restored on 31 March at 12 UTC.

3.3.2.6 In addition to the new data, there have been some notable improvements to the WIFS dissemination system over the past year. Notably, the system is fully mirrored across two geographically separate web farms, which has greatly improved system uptime. There is also a new status page on that gives the status of gridded binary Edition 2 (GRIB2), portable network graphics (PNG), binary universal form (BUFR) and Operational Meteorological (OPMET) data on WIFS. It even shows if the aerodrome routine meteorological reports (METAR) and aerodrome forecasts (TAF) from major airports are up to date on the system (https://www.aviationweather.gov/wifs/status).

3.3.2.7 Both WAFCs have successfully completed all upgrade activities in relation to the WAFS data changes that formed part of ICAO Annex 3 Amendment 79.

3.3.3 **MOG/14/IP/07 – *WAFS Management Report***, which covered the period from March 2020 through February 2021, was presented.

3.3.3.1 Both WAFCs continue to provide a valuable and reliable service to the aviation community, as evidenced by the detailed availability, timeliness and verification statistics provided in this Management Report. The challenges presented by the COVID-19 pandemic have been successfully handled for SIGWX provision.

3.3.3.2 With respect to IWXXM on SADIS and WIFS, IWXXM format METAR, aerodrome special meteorological reports (SPECI), TAF, SIGMET information, AIRMET information, volcanic ash advisory (VAA), tropical cyclone advisory (TCA) and space weather advisory are now being published on SADIS. Presently, only a limited number of Regional Operations Centers (ROC) are exchanging IWXXM format data with each other.

3.3.3.3 WIFS has a limited set of IWXXM data. There is a problem with the U.S. IWXXM data as the schema is version 2.1 instead of version 3.0. Because of the limited amount of data and the version being out of date, WAFC Washington will hold off putting IWXXM data on operational WIFS until the NextGen Information Technology web services upgrade, which is expected in May 2021.

3.3.3.4 Routine WAFC SIGWX backup tests were conducted quarterly.

3.3.3.5 Operations at both WAFCs have significantly changed due to the pandemic. Both WAFCs ran trials to ensure their forecasters were able to do work from home to maintain WAFCs SIGWX forecasts. After the successful trials, the WAFCs have been carrying out around 70% of their SIGWX forecast shifts in a home settings, which are still continuing today.

3.3.3.6 There was only one SADIS outage on 1 February 2021 caused by problems in the Amazon Web Services region in which SADIS is hosted. The problems lasted for around 45 minutes.

3.3.3.7 WAFS Model Verification data is available at:

- The full set of WAFC London performance indicators can be found here: http://www.metoffice.gov.uk/public/weather/aviation-wafc/#?tab=wafcPerformance
- The full set of WAFC Washington performance indicators can be found here: http://www.emc.ncep.noaa.gov/gmb/icao/

3.3.3.8 With Amendment 79 to ICAO Annex 3, the production time metric for WAFS GRIB2 data was brought forward from 6-hours to 5-hours. This along with other statistics are reflected in Appendix A to MET/14/IP/07.

3.3.3.9 The WAFCs are receptive to feedback and to the continued development of the WAFC portfolio to meet the stated requirements under the Aviation System Block Upgrade (ASBU) methodology.

3.3.4 WAFC London presented **MOG/14/SN/03 – *Impact of COVID-19 on WAFC London Forecast Accuracy***.

3.3.4.1 In March 2020, there was a sudden decrease in the number of flights operating worldwide in response to the COVID-19 pandemic.

3.3.4.2 Aircraft observations form an important part of the observing network, providing large numbers of temperature and wind observations, both in the upper troposphere but also at lower levels during take-off and landing. Prior to March 2020, approximately 100,000 of these observations were assimilated into the UK Met Office Global model each day.

3.3.4.3 During April and May 2020 there was a 70% reduction in the number of aircraft observations available for use globally (over the UK there was an 80% reduction).

3.3.4.4 A Forecast Sensitivity to Observations Impact (FSOI) study carried out prior to the pandemic suggested that the forecast Root Mean Square Error (RMSE) at 24-hours could be as high as 4-7% for winds and temperatures at 250 hPa in the northern hemisphere, extra-tropics, and in the tropics if all aircraft data were removed from the Global Model.

3.3.4.5 It is important to remember that a large amount of other data types are assimilated into the model such as satellite imagery and other types of in situ observations.

3.3.4.6 In response to the reduction in the number of aircraft observations, and to mitigate against their loss, the UK Met Office quickly made some changes to the data used in the initialisation of its numerical weather prediction models by using some new data sources that were made available to assist weather forecasting organisations. The following was used:

- Global Positioning Satellite Radio Occultation (GPS-RO) data from the COSMIC-2 programme (https://www.cosmic.ucar.edu/what-we-do/cosmic-2/) and one commercial company (May to September 2020 only);
- Additional Aircraft Meteorological Data Relay (AMDAR) data from satellite-based Automatic Dependent Surveillance-Broadcast (ADS-B) data; and
- Additional Mode-S data from European Meteorological Aircraft Derived Data Center (EMADDC).

3.3.4.7 The UK Met Office comprehensively verifies its model output, at a range of resolutions and for a variety of different coverage areas. The meeting noted the statistical plots on the verification of data that were contained in SN/03.

3.3.4.8 There does not appear to be any conclusive evidence in the wind or temperature verification data to suggest that the reduction in flights due to COVID has had any more impact than the month-to-month or seasonal variability that is normally seen in the verification scores. Examination of the WAFS verification plots that are generated for other regions (using the plots available here: https://www.metoffice.gov.uk/services/transport/aviation/regulated/wafc-london-performance-indicators#?tab=wafcPerformance) also concurs with this assessment.

3.3.4.9 WAFC Washington statistics for upper-level wind and temperature verification were not really impacted since they were able to use other sources of data for verification. In the future, they are expecting to see papers showing there have been negative impacts to models with regards to the reduction in aircraft-based observations for forecasting thunderstorms and winter storms.

3.3.4.10 WAFC London remains confident in the forecasting ability and accuracy of its global model (and therefore the WAFS forecasts) even though there has been a reduction in the number of aircraft-based observations due to COVID-19. As of February 2021, aircraft movements remain significantly reduced, and the pace of recovery of flights to pre-pandemic level is unknown.

3.3.4.11 During discussions, it was noted that the ADS-B data is satellite data and that WAFC London continues to be explore integrating other data sources as they come online.

3.3.4.11.1 During discussions, it was suggested that the action was extended to include investigation to see how the future longer range WAFS data sets might be impacted, and there was a request to have a more in-depth review of impacts on the lack of aircraft-based observations separated by forecast hazard type (including regional differences).

3.3.4.12 After further discussion, the meeting agreed to the following action:

Action 14/03 – Effect of COVID-19 on WAFS forecast accuracy

That, the WAFCs will:

a) continue to monitor WAFS data forecast accuracy for COVID related impacts;

b) assess the specific value gained from aircraft-based observations on the WAFS forecast verification by specific weather phenomena (wind/temperature, turbulence, icing and CB cloud);

c) examine whether the loss of aircraft observations has any impact on longer range model forecast verification; and

d) report back on their findings at the next WG-MOG (WAFS) meeting.

3.4 Work Required in Support of WAFS Developments

3.4.1 Matters Relating to Gridded WAFS Products

3.4.1.1 The WAFC Provider States presented **MOG/14/IP/08 – *WAFS Gridded Data Set Provision from Nov 2023***. The IP informed the meeting about the WAFS grids that will become available in November 2023. The main changes are additional flight levels and additional time steps. All changes are shown in **MOG/14/SN/10 – *WAFS Changes for Annex 3 Amendment 81 and PANS-MET***.

3.4.1.1.1 It should be noted that after the MOG/12 meeting in March 2020, the ICAO Annex 3 Amendment cycle was changed and as a result the WAFS dataset changes originally planned for implementation in November 2022 (originally Amendment 80) have now been delayed for one year and will be implemented in November 2023 (Amendment 81).

3.4.1.1.2 In order to distribute these higher resolution data sets, a replacement to SADIS will be built that will provide a SWIM-compliant system which uses Application Programming Interfaces (API) and Web Coverage Services or Web Feature Services to allow users to access the data in a flexible and customisable way. Users of the new system will be encouraged to only download the data that they need and will be able to define a geographical bounding box to subset the global data set into smaller areas. WIFS will have similar capabilities.

3.4.1.2 WAFC Washington gave a presentation on ***Turbulence Type Forecasting***.

3.4.1.2.1 Three types of turbulence were discussed: Clear Air Turbulence (CAT), Mountain Wave Turbulence (MWT), and Convectively Induced Turbulence (CIT). Case studies were presented that showed what model data forecasters use to prepare turbulence forecasts in the SIGWX forecasts.

3.4.1.2.2 After the presentation, discussion was requested on the following questions:

- What is the intended use of CIT?
- Do pilots and dispatchers have the same curiosity as forecasters?
- What would they do with the turbulence information?
- How would they like the data displayed?

3.4.1.2.3 During discussions, it was noted that in reference to the different turbulence types, users prefer to see the individual types because it provides situational awareness of what is going on in the atmosphere. It was noted that CIT information is mainly for tactical in-flight operations due the level of forecasting accuracy, and therefore if there is a user requirement for it it might be more appropriate to include as part of HWIS.

3.4.1.2.4 With respect to eddy dissipation rate (EDR), users would be interested in the EDR that is applicable to each aircraft type as well as how accurate it would be. They will need some associated confidence that the EDR is going to be reasonably accurate within certain tolerances.

3.4.1.2.5 After further discussion, the meeting agreed to the following decision and action:

Decision 14/01 – Convectively Induced Turbulence

That, the WAFCs in conjunction with International Air Transport Association (IATA) and International Federation of Air Line Pilots' Associations (IFALPA) agreed that forecasts of Convectively Induced Turbulence (CIT) are used tactically, and currently not a required part of the WAFS data set.

Action 14/04 – Turbulence Type Forecasts

That, the WAFCs in conjunction with IATA and IFALPA:

a) continue to investigate individual turbulence type forecast information (MTW and CAT only) and how this information should be presented to users;

b) develop educational material to accompany a); and

c) report back at the next WG-MOG (WAFS) meeting.

3.4.1.3 WAFC London presented **MOG/14/SN/06 –** ***Requirement for Using Data Types Other than GRIB2***.

3.4.1.3.1 Traditionally, WAFS data sets have only been provided in the gridded binary (GRIB) code form, prescribed by the WMO, which is adequate for the provision of full globe, low resolution, regular gridded data sets. The WAFCs currently use GRIB-2 code form. The large increase in horizontal, vertical and temporal resolution (which will take a complete set of WAFS data for one model run from <40MB to approximately 2.1GB (2100 MB)) being delivered in November 2023 means that the WAFCs need to determine the most appropriate way to deliver this data.

3.4.1.3.2 The ICAO Global Air Navigation Plan (GANP), Doc 9750, and associated Aviation System Block Upgrades (ASBU) set out the need for capabilities to enable flexible airspace management, airborne re-routing, improved situational awareness, collaborative decision-making and dynamically optimized flight trajectory planning (AMET B2/4). There is also a requirement for the provision of MET-SWIM information services that provide quality and timely information to users in a range of formats to best enable their optimal decision making (AMET B2/4).

3.4.1.3.3 At present, the only gridded data service specified in Annex 3 is WAFS data, and the use of GRIB for the data format has been explicit. Traditionally, WAFS data has been provided with one file/bulletin for each time-step and vertical level, and the data within each file/bulletin having global coverage.

3.4.1.3.4 In November 2023, there will be a large increase in file size which could be difficult for some users to manage, unless the data is subset into smaller pieces. GRIB-2 is an efficient tool for delivering large regular grids or rectangles of raw data into any processing system and could cope with providing regular data sets bounded by lines of latitude and longitude. However, GRIB-2 lacks the capability to define bespoke shapes which do not fit into its current standard GRIB templates.

3.4.1.3.5 The WAFCs are planning to provide users with the capability to subset the WAFS data sets in GRIB-2 format (either as WAFS defined "pre-set" areas, or as user defined areas) using latitude and longitude bounding boxes. There is also a desire to provide extra capability such as user defined data sets defined by a set of points (e.g., to create the shape of a flight information region (FIR), operating region or corridor)

3.4.1.3.6 In GRIB-2, to provide an arbitrary polygon a larger rectangle would have to be created and a mask (NaN padding) applied; this is a poor solution and requires non-trivial code. For this reason, the WAFCs have been considering the use of more modern data formats that are suited for the advanced functionality that is desired, such as Network Common Data Form (NetCDF) and geographic JavaScript Object Notation (GeoJSON). A specific data format has not been chosen as yet and will ultimately be decided on the basis of user requirements gathering.

3.4.1.3.7 There are many well established open-source data formats available which handle data in different ways which may provide a better user experience than GRIB or other traditional formats. Many of these are documented by the Open Geospatial Consortium (OGC) https://www.ogc.org/docs/is. The new IWXXM data format is based on open source (Geography Markup Language (GML)) data.

3.4.1.3.8 NetCDF is an open-source format which has "profiles" for specific data sets that enable unambiguous data exchange. WMO is already looking at this for climate and forecasting data sets https://old.wmo.int/wiswiki/tiki-index.php%3Fpage=CF-workshop.html.

3.4.1.3.9 A paper was presented to a MIE working group meeting (METP/WG-MIE/6 – 28 October to 1 November 2019) which outlined the need for ICAO to support the use of non-WMO approved code forms in order to meet the GANP objectives. The MIE (Decision MIE 6-06) supported the WAFCs in their investigation of this matter, and in addition, the MIE has an ongoing work stream activity of their own that is considering which data formats would best support gridded and imagery data-based SWIM services.

3.4.1.3.10 WAFC London has approached some members of the WMO Standing Committee on services to Aviation (SC-AVI) and Standing Committee on Information Management and Technology (SC-IMT) to get their view on using different data formats. The WMO Information System (WIS) 2.0 strategy (https://public.wmo.int/en/resources/bulletin/data-sharing-sustainable-development-wmo-information-system-wis-20) talks about embracing new technology and using widely adopted open standards to discover, access and use weather and climate data, so they are aware that a wider range of data formats may be required. Once the user requirements gathering for the future is completed the SCI-AVI and SC-IMT will be consulted again.

3.4.1.3.11 The WAFCs have proposed a change to the wording included within Annex 3 and the new PANS-MET (see MOG/14/SN/10) to open out the options for the type of data formats that can be used for WAFS. For example, changing the text from "the GRIB code form" to "an appropriate gridded code form".

3.4.1.3.12 The information from MOG/14/SN/06 will be used to prepare a working paper for METP/5 meeting to highlight the need for using non-GRIB data formats so that the WAFCs can modernise the distribution of WAFS data in line with the objectives set out in the GANP.

3.4.1.3.13 After further discussion, the meeting agreed to the following decision and action:

Decision 14/02 – Requirement for using alternative data formats to GRIB-2

That, the WG-MOG/14 meeting agreed that there is a requirement to use data formats other than GRIB-2 in order to meet the objectives set out in the GANP and to deliver data to the aviation industry in an effective and efficient SWIM-compliant way.

Action 14/05 – Requirement for using alternative data formats to GRIB-2

That, the WG-MOG Rapporteur presents a working paper to METP/5 to inform the Panel on the requirement to use data formats other than GRIB-2 in order to meet the objectives set out in the GANP and to deliver data to the aviation industry in an effective and efficient SWIM-compliant way.

3.4.2 **Matters Relating to Significant Weather Provision**

3.4.2.1 WAFC London and WAFC Washington presented **MOG/14/SN/08 – *WAFS SIGWX Progress Update***. The meeting was reminded of the changes to the content of the SIGWX visualisations and data that were agreed at the MOG/12 meeting (Actions 12/3 and 12/4; Decisions 12/01 and 12/02).

3.4.2.1.1 Traditionally, WAFS SIGWX forecasts have been provided for a single forecast time-step (for 24-hours), and hand drawn by skilled forecasters. In November 2023, with Amendment 81 to ICAO Annex 3 and accompanying PANS-MET, multiple time-step SIGWX forecasts will be introduced.

3.4.2.1.2 WAFC London has been working on code that creates SIGWX features from the WAFS gridded data sets. Appendix A to MOG/14/SN/08 shows a selection of plots which compare the forecaster drawn SIGWX objects (labelled as "manual objects") with the computer drawn objects (labelled as "python objects").

3.4.2.1.3 Comparing the two plots shows that the computer drawn features generally match well with their forecaster drawn equivalents. It should be noted that there will be some differences due to forecasters having their own distinct drawing style which means that the "manual" features can have a stylised appearance. They are also able to draw lines that link polygons, whilst the computer will draw closed polygons.

3.4.2.1.4 There are also some more subtle differences between the plots. Computer drawn objects use the new 0.25-degree WAFS turbulence severity data set which forecasts both CAT and orographic turbulence. Moderate and severe thresholding is applied by using the EDR turbulence thresholds set out in Annex 3. Forecaster drawn objects only include areas of CAT which are based on a different underlying data set.

3.4.2.1.5 The new multi-time-step SIGWX datasets will be produced in IWXXM format. This is being developed under the oversight of the METP/WG-MIE and by the WMO Task Team on Aviation Data (TT-AvData, formerly TT-AvXML). Information on the elements that have been considered in its development can be found here: https://github.com/blchoy/iwxxm-testbedOne/wiki/DN-2019_01-P1. The IWXXM SIGWX is not trying to re-create the capabilities of the old BUFR format, and the WMO task team has been encouraged to use whichever formatting they think is most appropriate. For each time-step, a single IWXXM file will be produced which contains all the information required to make a global SIGWX visualisation.

3.4.2.1.6 The WAFC London development system is currently able to create most of the elements needed for the IWXXM file (except for tropical cyclone, volcano and radioactive symbols). The next stage is for WAFC Washington to decode and plot these files.

3.4.2.1.7 WAFC Washington is working on label plotting software, and will soon look at processing TCA, VAA and Nuclear Emergency messages in order to be able to mark tropical cyclones, volcanoes and radioactive release in the IWXXM file.

3.4.2.1.8 The IWXXM SIGWX schema will go through the WMO Fast-track procedures in July 2021 (see https://community.wmo.int/amendment-processes-wis-manuals-and-guides) in order to be adopted by the President of WMO on behalf of the Executive Council before it is published in November 2021. WAFC London is planning to make test files available to SADIS users in November 2021.

3.4.2.1.9 There is one key matter that still needs to be resolved by the WAFCs: turbulence, icing and CB cloud polygons are created from the blended/harmonised gridded data sets while wind and tropopause fields are not. A decision still needs to be made whether to use single centre wind/tropopause data or whether to blend these fields whilst making sure that the data retains its integrity. For example, the turbulence field is a function of the wind field, and improper blending of the wind data could risk blending out the peaks in the wind speed and under-forecasting the strength of the jet.

3.4.2.1.10 There have also been requests by WAFS data users for SIGWX to be produced in GeoJSON format. This may be something that is offered alongside IWXXM output.

3.4.2.1.11 Work will continue to refine the polygon and jet depiction with a view to publishing some test data sets for software providers once the IWXXM schema is published in November 2021. Verification of the new data will continue to be carried out and will be reported at the MOG meeting in 2022.

3.4.2.1.12 After further discussion, the meeting agreed to the following action:

Action 14/06 – WAFS SIGWX forecasts

That, the WAFCs will:

a) endeavour to publish test SIGWX data sets in IWXXM format in November 2021 and invite SADIS and WIFS users to visualise the data and provide feedback; and

b) report back on progress at the next WG-MOG (WAFS) meeting.

3.4.2.2 A demonstration of SIGWX auto labelling capability was given by WAFC Washington.

3.4.2.3 The meeting was reminded that global numerical prediction models, such as used by the WAFCs, are not able to discern embedded CB clouds from CB clouds. Therefore, the SIGWX forecasts will only include “Occasional CB” and “Frequent CB”.

3.4.3 Matters Relating to Delivery Mechanism of WAFS data

3.4.3.1 This topic is covered by papers presented at the MOG/15 (SADIS) meeting.

3.4.4 **WAFS Related Documentation**

3.4.4.1 WAFC London presented **MOG/14/SN/10 – *WAFS Changes for Annex 3 Amendment 81 and PANS-MET***. SN/10 was supported by Flimsy 01, which presented editorial changes to the draft provisions in Annex 3 and the PANS-MET. The editorial changes were made by the contractor for the Secretariat during his review of all the proposed amendments from all the METP working groups.

3.4.4.2 The meeting was informed that proposed changes had not changed since the last meeting, except that the technical specifications and means of compliance were placed in the new PANS-MET. Editorial changes were also made to the restructured Annex 3 and PANS-MET.

3.4.4.2.1 The attachments to the MOG/14/SN/10 apply those agreed changes to the new Annex 3 (Amendment 81) and PANS-MET documents, in line with the MRI recommendation.

- **Appendix D** are the proposed revisions pertaining to the WAFS in the restructured Annex 3 intended for Amendment 81.
- **Appendix E** are the proposed revisions pertaining to the WAFS in the new PANS-MET.
- **Appendix F** gives a detailed explanation of each proposed change, which is intended for the Secretariat to use when preparing Amendment 81 and the PANS-MET for the review by the Air Navigation Commission.

3.4.4.2.2 The MOG/14/SN/10 will form the basis for the METP/5 MOG submission to the METP/5.

3.4.4.2.3 After further discussion, the meeting agreed to the following action:

Action 14/07 – Changes for Annex 3 Amendment 81 and PANS-MET pertaining to the WAFS

That, the WG-MOG Rapporteur:

a) ensure that the draft provisions in **Appendices D and E** be included in the consolidated proposed amendments to Amendment 81 to Annex 3 – *Meteorological Service for International Air Navigation* and the *Procedures for Air Navigation Services – Meteorology (PANS-MET)* along with the other draft provisions for other meteorological services going forward to METP/5; and

b) deliver the reasons for the changes (**Appendix F**) to the Secretariat, after METP/5, for his use in preparing Amendment 81 and PANS-MET for the Air Navigation Commission.

3.4.4.3 **MOG/14/IP/09 – *Doc 8896 Changes Relating to Amendment 81 Of Annex 3*** was presented.

3.4.4.3.1 At the MOG/12 (23 to 25 March 2020) an initial draft update to Doc 8896 – *Manual of Aeronautical Meteorological Practice* was presented that provided a preview of changes needed to reflect the changes being introduced for Amendment 81 (was Amendment 80) to ICAO Annex 3.

3.4.4.3.2 A large number of changes are being made to Annex 3, and the new PANS-MET in November 2023 to cater for the next generation WAFS and SIGWX data sets. This needs to be reflected in Doc 8896.

3.4.4.3.3 Attachment 1 to MOG/14/IP/09 shows the tracked changes on top of those already passed on to the Secretariat to go with Amendment 79.

3.4.4.3.4 The key changes pertaining to the WAFS in the document include:

- A major re-write of 3.7.2 (WAFS gridded data) and 3.7.3 (WAFS SIGWX forecasts) to cater for the new data sets, a change in how SIGWX corrections will be issued, and a new template for administrative messages.
- Guidelines of SIGWX chart provision to pilots in 5.3.3 are updated in line with the next generation SIGWX data sets.

3.4.4.3.5 References throughout the document to Annex 3 will need to be updated and changed to PANS-MET when appropriate. This can be done at a later date.

3.4.4.3.6 The meeting was invited to examine the draft of Doc 8896 provided in Attachment 1 to MOG/14/IP/09 and provide feedback on the document to Karen Shorey. This draft does not need to be taken to METP/5 so there is additional time to further update and refine the proposal over the coming year, particularly once the 13th Edition of the document has been published.

3.4.4.4 WAFC London presented **MOG/14/SN/11 – *Update to Next Generation WAFS Information Sheet***.

3.4.4.4.1 At the METP/WG-MOG/9 meeting (2-4 April 2019), a four-page information sheet that could be shared within ICAO and the rapporteurs of the different METP working groups was presented to the meeting (WG-MOG/9/SN/01). It aimed to provide a quick and easily digestible guide to the planned WAFS development activities.

3.4.4.4.2 The general plan for upgrading the WAFS gridded data sets, SIGWX forecasts, and WAFS data delivery systems has not changed. However, due to COVID-19 and a change in the Annex 3 amendment schedule means that this document now requires an update.

3.4.4.4.3 To help readers visualise the changes a timeline of changes has been added into the information sheet. A selection of other editorial changes has been made to help readability.

3.4.4.4.4 The information sheet (see **Appendix G**) is intended to be shared with other working groups of the METP, and other Panels within the Air Navigation Bureau, as well as users of WAFS information.

3.4.4.4.5 After further discussion, the meeting agreed to the following action:

Action 14/08 – Next generation WAFS Information Sheet

That,

a) the Rapporteur provides the updated next generation WAFS information sheet to the rapporteurs within the METP; and

b) the Secretariat be invited to socialise the next generation WAFS information sheet with others within ICAO (such as the regional ICAO meteorological planning and implementation groups), as appropriate.

3.5 WAFS Science Capabilities

3.5.1 Modelling Developments and New Capabilities

3.5.1.1 WAFC London presented **MOG/14/SN/07 – *Probabilistic WAFS Data***. SN/07 was also supported by several presentations from the scientists at WAFC Washington and WAFC London.

3.5.1.1.1 After the high resolution WAFS deterministic gridded data sets are introduced in November 2023, the focus by the WAFCs will move to the provision of probabilistic data sets. Whilst the WAFCs are already working on the technical capability, the question of "what data does the user actually need" remains unresolved.

3.5.1.1.2 The new Turbulence Severity diagnostic (which uses NOAA's Graphical Turbulence Guidance (GTG) algorithms) provides output as an EDR and can be included within the ensemble modelling capability at both WAFC London and WAFC Washington.

3.5.1.1.3 One way of presenting the probabilistic information is the "probability of exceedance" approach. This would not be a true probability, but a probability calculated from the ensemble members. This could take the following forms:

- The probability that the wind speed exceeds a certain threshold. Appendix A to MOG/14/SN/07 shows this applied to a 10m wind field, but could equally be applied to the winds aloft.
- For turbulence, the probability that the turbulence severity exceeds a particular EDR value or values can be calculated – perhaps using the thresholds shown in Annex 3 as an initial capability Appendix A to the MOG/14/SN/07 shows an example of this approach. Or perhaps data that shows where there is high confidence of there being no MOD/SEV turbulence is appropriate.
- For icing, the category of the icing could be expressed by a weighted combination of the likelihood and severity or perhaps the probability of exceeding a particular value of super-cooled liquid water content.
- For CB cloud, the probability that the CB cloud top exceeds 30,000ft (or other heights) could be provided. Appendix A to MOG/14/SN/07 shows an example plot.

3.5.1.1.4 WAFC London has developed a risk matrix approach for icing. Appendix A to MOG/14/SN/07 shows how icing severity information can be combined with icing probability information to create a matrix. These are displayed as 1-9 at present but it may be more appropriate to label them differently to make it clear that it is not a linear scale. It may be possible to provide a risk matrix for the turbulence and CB cloud fields as well.

3.5.1.1.5 An appropriate resolution for the new data sets will need to be considered, as will the timesteps. The operational decisions that will be made from the data influence this, so perhaps probabilistic wind information is useful for flight planning five days ahead whilst CB cloud, icing, and turbulence information is not needed until closer to the flight time.

3.5.1.1.6 An Initial Operating Capability for the new probabilistic forecasts could be introduced with Amendment 82 to Annex 3, currently planned for November 2026.

3.5.1.1.7 The METP/WG-MISD has been developing the IOC for new QVA forecasts, expected to be introduced by Volcanic Ash Advisory Centres (VAAC) in a position to do so in November 2023. The progress of this work will be followed as the requirements and implementation have some synergy with the work the WAFCs will be undertaking.

3.5.1.1.8 Work will continue over the next couple of years to develop and then operationalise the underpinning ensemble capability that is needed to create any new WAFS probabilistic product. The most important and pressing next step however is to seek user requirements from the aviation industry. To facilitate this, the WAFCs will prepare example plots, and case studies that can be used as a focus for discussions and will host these online for easy access.

3.5.1.1.9 It was noted that WG-MRI has a task looking at requirements (mainly in the airport domain). A part of that work will be a more detailed consultation process with the user community and panels. The proposed WAFC's work could be a joint effort with the WG-MRI in order to avoid overlapping activities.

3.5.1.1.9.1 During discussions, it was noted that users need to understand the benefit that probabilities bring over deterministic forecasts:

- How can this information be used to in operational decision making,
- Thresholds – do the relevant thresholds change over time?
- Might forecasts of "no hazard" be useful

3.5.1.1.10 After further discussion, the meeting agreed to the following action:

Action 14/09 – Probabilistic WAFS data

That,

a) the WAFCs, coordinating with IATA, will create example plots and case studies, to be posted on the ICAO WG-MOG/WAFS dedicated webpages or the WAFC London website, that show different ways in which probabilistic information could be presented to users, and will host this data online.

b) all WG-MOG (WAFS) participants will discuss the example probabilistic plots with their national stakeholder groups (airlines, flight planners, ANSPs etc.), gather ideas and possible requirements, and provide this information back to the WG-MOG (WAFS) meeting in 2022.

c) share the information in a) with WG-MRI and invite WG-MRI to investigate the requirements for probabilistic information during their user consultation activities.

3.5.1.2 The UK Met Office gave a presentation titled ***ICAO METP-WG/MOG14 Probabilistic CB, turbulence and icing***.

3.5.1.2.1 A probability product should be:

- Useful – It presents something the user understands and wants or at least wants when they become aware of the product's existence and how they might use it
- Useable – Does it integrate with the decision-making process the user is following? Does it integrate with other products / data (possibly non weather) that the user is using?
- Used – Does it run reliably from a technical point of view (hopefully yes but this issue applies to a lot of trial products)? Does it produce a product available at an appropriate time (European Centre for Medium-Range Weather Forecasts (ECMWF) model in particular runs later / post processing of ensembles takes longer)? Does it give the user a better outcome than with what they currently already use?

3.5.1.3 WAFC Washington gave a presentation that provided an update on *Probabilistic Turbulence*.

3.5.1.3.1 Currently, work is underway coordinating with U.S. requirements for the provision of Global Probabilistic Turbulence and research by laboratories to determine potential methods for probabilistic production.

3.5.1.3.2 A MWT case study was presented. In the study, it was noted that probability goes from 0% to 100% very quickly, which is a problem researchers have encountered. They are working to resolve this and other issues.

3.5.2 **Verification**

3.5.2.1 WAFC Washington presented **MOG/14/SN/09 – *Enhanced Wind Verification***.

3.5.2.1.1 The meeting recalled Action MOG/WAFS 9/1.

Action 9/1 – Enhanced WAFS Verification Statistics

That, the WAFCs be invited to consult further with the user community (including drawing on the expertise of the WMO expert team on meteorological hazard science) and IATA to determine the best way to present enhanced verification scores such as those provided the WAFS management report (MOG12/SN20), and to report back to the next meeting.

3.5.2.1.2 WAFC London stratified wind speed and direction errors by discreet speed bins (refer to the figures in MOG/14/SN/09). This stratification provides more detail than simply providing errors for all speeds, plus for speeds only over 80 knots. The WAFCs want to know if flight planners find this level of precision to be useful, particularly with respect to wind speed. It was also suggested that the speed error could be represented as a percentage of the forecast wind speed.

3.5.2.1.3 WAFC London also provided the same information in Mean Absolute Error (MAE). This statistic weights all errors the same, while RMSE gives significantly more weight to large errors.

3.5.2.1.4 The advantage of RMSE is that it prevents a small number of large errors from being washed out by a large number of smaller errors. The advantage of MAE is that it provides a true average absolute error. The MAE will always be smaller than the RMSE.

3.5.2.1.5 The WAFCs consulted with the WMO's Expert Network for Meteorological Hazards Science. That group felt that RMSE was a safer way to present error when the error is to be used for flight planning purposes. They did not comment on the utility of providing error by speed bins.

3.5.2.1.6 WAFC Washington has maintained a rudimentary capability of providing wind speed error for winds over 80 knots and wind direction error for winds below 10 knots. These can be found online at https://www.emc.ncep.noaa.gov/gmb/icao/.

3.5.2.1.7 The WAFCs have not calculated the cost of providing these statistics, but do not wish to develop and maintain this capability if it is not useful for flight planning purposes. The IATA could provide some advice as to the usefulness of these statistics.

3.5.2.1.8 The meeting agreed to the following action:

Action 14/10 – Update on Enhanced Wind Verification

That, contingent upon IATA's validation of the usefulness of such statistics, the WAFCs begin providing wind verification in RMSE, stratified by wind speed bins.

3.5.2.2 The UK MET Office gave a presentation titled ***Provisional WAFS hazard verification which compared the old 1.25 degree hazard data sets with their new 0.25 degree versions.***

3.5.2.2.1 Turbulence and icing both have changes to the diagnostics:

- Turbulence now uses GTG, a blend of multiple predictors rather than just one.
- Icing now uses an icing severity rather than icing potential.

3.5.2.2.2 The ROC plots show significant improvements to skill and value from the 0.25 degree GTG turbulence forecasts compared to the operational WAFC London forecast at 1.25 degrees. However, 2020 saw a dramatic reduction in aircraft turbulence observations making verification less robust. Further studies changing the resolution are required to determine resolution benefit.

3.5.2.2.3 The new CB cloud 0.25 degree forecasts also provide a good level of skill and value with increased resolution. The forecasts have similar skill where thresholds correspond. The 1.25 degree forecasts can achieve higher hit rates, but at the expense of slightly increased false alarm rates.

3.5.2.2.4 With respect to icing verification, assuming that moderate icing potential is the same as moderate icing severity, the 0.25 degree forecasts had an improved frequency bias and false alarm rates. The overall hit rate was worse, but may be due to a "double penalty" problem of increased resolution. The results were not sensitive to the choice of validation grid.

3.5.2.2.5 Further work includes:

- Assessment of whether 0.25 degree verification (particularly for icing) is carried out in the most appropriate way. It is also important to determine how users are likely to use the gridded data.
- Observations for turbulence used by WAFCs for verification purposes stopped at the end of December 2020. Alternatives need to be sourced to continue verifying WAFS turbulence forecasts.

3.5.2.2.6 During discussion, it was noted that the grids on www.aviationweather.gov are still the 1.25 degree grids. They are working to update them to the 0.25 degree grids.

3.5.2.3 WAFC Washington gave a presentation that examined how turbulence verification differed when using the IATA Turbulence Aware data compared to a U.S. only data set.

3.5.2.3.1 IATA's data provides a much greater coverage of impactful turbulence, whilst the US data is oversaturated by NULL observations. The WAFCs both consider the IATA Turbulence Aware data to be a valuable resource.

3.5.2.3.2 It was asked if there is any benefit in including live turbulence data in created WAFS Turbulence forecasts. Whilst there would not be a direct benefit to the WAFS data because of the timescales involved (the first timestep is the 6-hour forecast) it could be used in model initialisation and tuning. The U.S. national GTG nowcast will use it to modulate the field.

3.5.2.3.3 Based on the presentations and subsequent discussions, the following action was agreed to:

Action 14/11 – WAFS Verification

That, the WAFCs:

a) continue to investigate how best to present verification statistics for the new 0.25 degree data sets;

b) develop explanatory material for users; and

c) report back at the next WG-MOG (WAFS) meeting.

4. AGENDA ITEM 4: REVIEW OF JOB CARDS RELATED TO WAFS

4.1 **MOG/14/SN/13 – *METP Job Card 10*** was presented.

4.1.1 Changes to the Job Card were proposed at the MOG/12 meeting (23-25 March 2020) with the intention that they would be taken to the METP/5 meeting in September 2020. The METP/5 meeting was been delayed until June 2021 and some activities listed on the job card have now been completed, so a further review of the Job Card has been carried out.

4.1.2 The proposed changes to Job Card 10 are shown in **Appendix H**. The key changes are:

- The tasks that relate to Amendment 79 of Annex 3 are now complete. New tasks originally planned for Amendment 80 have now been re-baselined into tasks that relate Amendment 81.
- The activity in relation to the (electronic) regional Air Navigation Plans (eANP) does not sit well in a Job Card about WAFS development. Instead, a new activity has been added that relates to publicising the new WAFS data sets and changes to SADIS and WIFS that are coming in 2023.
- A new task related to the development of probabilistic data sets has been added.

4.1.3 The Secretariat requested that completed items be shown as "completed" instead of removing them from the Job Card.

4.1.4 After further discussion, the meeting agreed to the following action:

Action 14/12 – Job Card 10 update

That, the WG-MOG Rapporteur present the proposed updates to Job Card 10, as shown in **Appendix H**, to METP/5 for consideration.

5. AGENDA ITEM 5: ANY OTHER BUSINESS

5.1 None.

6. AGENDA ITEM 6: TIMETABLE AND FUTURE MEETINGS OF WG-MOG (WAFS)

6.1 The next meeting of the WG-MOG (WAFS) is planned for the week commencing 25 April 2022. Mr. Dutton said the UK Met Office will gladly host the meeting but welcomed others in Europe to volunteer.

7. AGENDA ITEM 7: CLOSURE OF THE MEETING

7.1 Mr. Dutton expressed his gratitude to those who attended the virtual meeting and closed the virtual meeting at 2300 UTC on 14 April 2021.

APPENDIX A: ATTENDEES

List of attendees

NAME	STATE or ORGANIZATION
Lethlean, Cameron	Australia
Dumas, Karine	Canada
Maynard, William	Canada
Zou, Juan	China
Xu, Jian Liang	China
Österberg, Kari	Finland
Weidemann, Clemens	Germany
Lechner, Peter	New Zealand
Chapman, Vic	South Africa
Khambule, Gaborekwe	South Africa
Tshifaro, Maluta	South Africa
Dutton, Jonathan	United Kingdom and WAFC London
Shorey, Karen	United Kingdom and WAFC London
Buchanan, Piers	United Kingdom and WAFC London
Canning, Mark	United Kingdom
Murphy, Michael (Pat)	United States
Burch, Larry	United States
Chuang, Huiya	United States
Hoprich, Amanda	United States
Moosakhanian, Alfred	United States
Pettegrew, Brian	United States
Strahan, Matt	United States and WAFC Washington
Diori, Saley	ASECNA
Lapsley, Rosalind	EUROCONTROL
Oleh, Shulimov	IATA
Rennie, Graham	IATA
Szalasny, Slawomir	IATA
Ryuzaki, Jun	ICAO
Sievers, Klaus	IFALPA
Wigniolle, Stéphanie	WMO

APPENDIX B: METP-WG/MOG TERMS OF REFERENCE

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- Deleted text is shown with red ~~strikeout~~

METP Meteorological Operations Group (MOG) Terms of Reference

The aim of the MET Operations Group is to ensure that the following systems meet the agreed user requirements:

- WAFS
- SADIS / WIFS
- IAVW

~~In the longer term it is considered that Space Weather and Regional Hazardous Weather Centres will be added to the remit of the working group.~~ Note - Space weather is expected to be added to this working group following the METP/5 meeting.

The MET Operations group should:

- Establish Key Performance Indicators for the provision of services based on the performance requirements in coordination with other METP WGs and final agreement by the METP
- Define the continuity / availability of services based on the performance requirements, in coordination with the other METP WGs and final agreement by the METP.
- Arrange for the reporting of KPIs from each provider State (e.g. verification and timeliness metrics)
- Receive reports from each provider State on the management of their system(s)
- Set out, review and maintain the back-up arrangements and include relevant details in management reports
- Ensure that coordination and harmonisation takes place between WAFCs, VAACs, and SADIS / WIFS providers
- Monitor, assess and provide advice on potential scientific and technological developments to meet the current, future and evolving performance requirements to the METP in coordination with WMO.
- Assess the financial and technical implications of proposed developments to services and their implementation.
- Ensure that developments have measurable success criteria for implementation
- Establish the times scales, pre-operational tests and implementation of services
- Maintain and, when required, create guidance material on the implementation and provision of services.
- Identify any weaknesses in the current service provision and coordinate updates to the requirements with other Working Groups of the METP
- Ensure that the necessary remedial actions are in place when necessary to overcome identified deficiencies.
- Where necessary assist the Secretariat in the coordination of the arrangements between the various international organizations
- Propose changes to the job cards when required
- Maintain an up to date set of actions

Following each meeting provide a report and make it available on the METP website

APPENDIX C: WAFS ACTIONS AND DECISIONS FROM WG-MOG/12

Item	Status
Action 12/01 — Terms of Reference That; a) the METP-WG/MOG12 meeting accepts the proposed updates to the Terms of Reference as shown in Appendix C; and b) the ICAO Secretariat puts the finalised Terms of Reference document onto the ICAO public website (replacing the previous copy).	Complete
Action 12/02 – Turbulence type forecasts That, IATA is invited to include the WAFCs in their investigations of whether turbulence type forecasts (initially MTW or CAT, and potentially in future CIT) are useful for aviation, bearing in mind the limitations of verifying these forecast types. IATA is invited to report back to the next MOG/WAFS meeting.	IATA reports that they would like turbulence type forecasts.
Action 12/03 – Depiction of flight level of tropopause on WAFS SIGWX forecasts That, the WG-MOG Rapporteur, be invited to submit the proposed amendment to ICAO Annex 3 – *Meteorological Service for International Air Navigation* regarding the depiction of the flight level of tropopause on world area forecast system (WAFS) significant weather (SIGWX) forecasts, as given at Appendix D and at **Appendix F** to this report, as part of a consolidated package of WAFS-related Amendment ~~80~~ 81 proposals.	Now delayed to Amendment 81 an integrated into our proposal for the new PANS-MET. Will be presented as a SN at METP/5.
Action 12/04 – Tropical cyclone inclusion on SIGWX charts in time for Amendment ~~80~~ 81 That the METP/MOG informs METP/5 on the following proposed changes pertaining to the inclusion of tropical cyclone (TC) positions on the WAFS SIGWX forecasts for Amendment ~~80~~ 81; 1. TC positions will be plotted on forecasts valid between 6-hours and 24-hours at 6-hour intervals 2. The 6-hour forecast position will be used for SIGWX forecasts valid at 9-hours, the 12-hour forecast position will be used for forecasts valid at 15-hours, and the 18-hour forecast position will be used for forecasts valid at 21-hours. 3. The SIGWX chart legend will be updated to state when TC position information is not available or a time-steps three hours earlier is used.	Now delayed to Amendment 81 an integrated into our proposal for the new PANS-MET. Will be presented as a SN at METP/5.
Action 12/05 – Tropical cyclone (TC) information beyond T+24 hours Given that the WAFCs are not in a position to include TC forecast position information for forecasts between 27-hours and 48 hours, the ICAO Secretariat is invited to: a) undertake a formal consultation with IATA, IFALPA, CANSO and IFATCA panel members to identify their requirements for longer range tropical cyclone advisory information;	In-progress It is understood that both IATA and IFALPA confirmed their requirement for longer range TC forecasts with the Secretariat. Work on the remainder of this action still needs to take place.

b) in conjunction with WMO, investigate whether the TCACs will be in a position to provide the extra TC information, and a timescale on which the new forecast information could be produced; c) provide guidance on what form this forecast information should be supplied in, who should propose these changes for Annex 3 and other associated documentation; and d) report back on progress to the next MOG/WAFS meeting.	
Action 12/06 – Tropical Cyclone Advisory forecast position guidance That WAFC Washington be invited to work with RSMC/TCACs Miami and Honolulu to request that their advisories are produced using the main synoptic hours in time for Amendment ~~80~~ 81.	Update to be provided at the MOG meeting.
Action 12/07 – TCAC designation and areas of coverage in the Atlantic Ocean That, the ICAO Secretariat be requested to: a) consult respectively with the ICAO European and North Atlantic Office and the ICAO South American Office to ascertain the status of tropical cyclone advisory centre (TCAC) designation and TCAC areas of coverage in the far eastern part of the North Atlantic and the western part of the South Atlantic; and b) provide a report on the outcomes of a) to the next MOG/WAFS meeting. *Note. — The report should include, to the extent possible, information on the mechanisms used (or intended to be used) to enable the provision of tropical cyclone advisory information by ICAO-designated TCACs, including amendments to ICAO regional air navigation plans.*	The European eANP at its next update is adding the requirement for TCAC Miami to provide TCA information that covers the Atlantic facing European Countries (this does not change working practices at TCAC Miami) It has been decided that TCA provision is required for the South Atlantic (at the PPRC/5 meeting), but it will take a number of years before a new TCAC is stood up. The World Meteorological Organization (WMO) stands ready to assist the Secretariat and MOG/WAFS.
Action 12/08 – Tropical Cyclone Job Card That the ICAO Secretariat, in conjunction with the Rapporteur prepare a paper for METP/5 which highlights to the Air Navigation Commission the need for a tropical cyclone job card, given the number of issues that have been identified regarding the provision of tropical cyclone advisory information.	A paper is being drafted in conjunction with the METP Chair as there are other met provisions (e.g. SIGMET) that have no job card.
Action 12/09 – Format of future WAFS data sets That, the WAFS Provider States prepare, on behalf of the WG-MOG Rapporteur, a working paper for METP/5 to inform the METP of the requirement to be able to offer WAFS data sets in other formats (in addition to GRIB) in order to meet the requirements set out in the Global Air Navigation Plan.	SN06 will be turned into a paper for METP/5 after MOG.
Action 12/10 – Proposal Amendment ~~80~~ 81 to Annex 3 - *Meteorological Service for International Air Navigation* for the WAFS and the associated changes for Doc 8896 That, an ad hoc group consisting of Karen, Larry, Greg, Stéphanie, Graham, Oleh, Raul and Klaus, and co-led by Karen and Larry;	a) complete. The proposal also includes changes for the new PANS-MET. See SN10 b) complete. See IP09

<table>
<tr><td>a) continue to mature the draft provisions pertaining to the WAFS for Amendment ~~80~~ 81 (included as Appendix F) and to prepare a paper for METP/5
b) further develop the changes needed in Doc 8896 - Manual of Aeronautical Meteorological Practice, that relate to the Annex 3 Amendment ~~80~~ 81 proposal and ensure that the limitations and processing applied to SIGWX charts in line with Decisions 12/01 and 12/02 are properly explained.
c) review the WAFS ~~CONOPS~~ roadmap to ensure the document reflects the changes that are being proposed for Amendment 80.
d) report back to the next MOG/WAFS meeting</td><td>c) The reference to the CONOPS is incorrect, this action relates to the WAFS roadmap. The Roadmap is updated in SN11</td></tr>
<tr><td>Action 12/11 – Doc 8896 changes relating to Amendment 79 of Annex 3
That, the WG-MOG/WAFS accept the proposed amendments to Doc 8896 (included as Appendix G) considering any agreed changes during the meeting, and that Larry Burch and Karen Shorey, on behalf of the WG-MOG Rapporteur, work with the rapporteurs of the other working groups, or their representatives, to prepare a consolidated working paper presenting all the proposed amendments to Doc 8896 that relate to Amendment 79 of Annex 3 and provide these to the ICAO secretariat as soon as possible.</td><td>Complete.
However, it is believed that the update to 8896 in relation to Amendment 79 was only partially completed and our changes/corrections will need to be re-proposed against the new 13th edition at METP/5.</td></tr>
<tr><td>Action 12/12 – Job Card 10 update
That, the WG-MOG Rapporteur present the proposed updates to Job Card 10, as shown in Appendix H, to METP/5 for consideration.</td><td>Due to the delay in METP/5, and the completion of many tasks, the Job Card is updated further. See SN13.</td></tr>
<tr><td>Action 12/13 – Enhanced WAFS Verification Statistics
That, the WAFCs be invited to consult further with the user community (including drawing on the expertise of the WMO expert team on meteorological hazard science) and IATA to determine the best way to present enhanced verification scores such as those provided the WAFS management report (MOG12/SN20), and to report back to the next meeting.</td><td></td></tr>
<tr><td>Action 12/14 – Probabilistic forecasts
That IATA will investigate the requirements for probabilistic forecasts with their members, supported by the WAFCs who will provide examples of what is technically feasible, and report back at the next MOG/WAFS meeting</td><td></td></tr>
<tr><td>Decision 12/01 – Amendment ~~80~~ 81 proposals for SIGWX forecasts
The METP/MOG agrees that as part of Amendment ~~80~~ 81 WAFS SIGWX forecasts will;
a) be comprised of the elements and products as detailed in the table below:
<table>
<tr><th colspan="2">WAFC SWH SIGWX FORECASTS</th></tr>
<tr><td colspan="2">Global coverage of all parameters, and extending from FL100 to FL600.
Forecast timesteps: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 and T+48
Forecasts produced: 4x daily</td></tr>
<tr><td>All Timesteps
IWWXM format</td><td>In addition to the provision for all timesteps – the following will</td></tr>
</table></td><td></td></tr>
</table>

PNG format 'ground truth' charts: 1x Mercator covering 180W to 180E and 60N to 45S 1x Northern Polar Stereographic extending out to 30N 1x Southern Polar Stereographic extending out to 30S	also be produced for the SIGWX forecast valid at 24-hours SWH BUFR files will be produced until Nov 2024. PNG format SWH charts (black and white) covering areas A, B, B1, C, D, E, F, G, H, I, J, K, L, and M *Note: the BUFR files will differ from the IWXXM provision in the following way: they will not contain tropopause height or icing information*		
SIGWX parameters			
Jet Stream	Position and speed, jet core height and jet depth will be forecast, and marked on charts using current conventions and styles		
Cumulonimbus (CB) cloud	Areas of OCNL or FRQ CB cloud will be forecast. CB base and top information will be contained within the digital data, but only CB top information will be plotted on WAFC produced SWH charts. Areas of CB cloud will be marked on charts within scalloped areas		
Turbulence	Areas of moderate (MOD) or severe (SEV) turbulence, and the base and top of the hazard will be forecast (Note: this field encompasses both clear air turbulence and orographic turbulence types). Areas of turbulence will be marked on charts using current conventions and styles		
Icing	Areas of MOD or SEV icing, and the base and top of the hazard, will be forecast and contained within the digital file, but will <u>not</u> be plotted on WAFC produced charts.		
Tropopause Height	5000ft interval contours will be forecast Tropopause height contours will be marked by a thin dashed line and a three-digit number which indicates the flight level		
Tropical Cyclones	Included on forecasts up to and including 24-hours if a Tropical Cyclone Advisory has been issued for it. For forecasts charts valid at 9-hours, 15-hours and 21-hours the tropical cyclone position for three hours earlier will be used.		

Volcanic Eruptions	Marked if a volcanic ash advisory has been issued
Radioactive Release	Marked if a radioactive release has been reported
Sand/dust storms	Marked if a heavy sand or dust storm has been reported in a SIGMET

b) use the blended hazard data sets for CB cloud, icing and turbulence, and each WAFC will use their own data in the production of jet stream and tropopause height information
c) not carry out backups

Decision 12/02 – SIGWX chart legend

That the METP/MOG agrees that as part of Amendment 80 WAFS SIGWX chart legends will take the form shown in **Appendix E** and will;
a) state "T+XX VALID AT <HH> UTC ON <DD> <MMM> <YYYY> to describe the validity of the forecast
b) have an additional legend that states "TC POSITION FOR 3-HOURS EARLIER IS SHOWN" on the T+9, T+15 and T+24 timesteps;
c) say "TC INFORMATION IS NOT AVAILABLE FOR THIS TIMESTEP" for timesteps between T+27 and T+48; and,
d) say "TC/VA PROCESSING ERROR" if the processing of the input IWXXM files has failed in some way

APPENDIX D: PROPOSED REVISION TO THE RESTRUCTURED ANNEX 3 INTENDED FOR AMENDMENT 81

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ANNEX 3

CHAPTER 3. GLOBAL SYSTEMS, SUPPORTING CENTRES AND METEOROLOGICAL OFFICES

~~3.1 World area forecast system~~

~~The objective of the world area forecast system (WAFS) shall be to supply meteorological authorities and other users with global aeronautical meteorological en-route forecasts in digital form. This objective shall be achieved through a comprehensive, integrated, worldwide and, as far as practicable, uniform system, and in a cost-effective manner, taking full advantage of evolving technologies.~~

3.~~2~~1 World area forecast centres within the framework of the world area forecast system

Note.— The objective of the world area forecast system (WAFS) is to supply meteorological authorities and other users with global aeronautical meteorological en-route forecasts in digital form. This objective is achieved through a comprehensive, integrated, worldwide and, as far as practicable, uniform system, and in a cost-effective manner, taking full advantage of evolving technologies.

3.~~2~~1.1 A Contracting State, having accepted the responsibility for providing a world area forecast centre (WAFC) within the framework of the WAFS, shall arrange for that centre:

…

e) to ~~establish and maintain contact with~~ receive information on volcanic activity from volcanic ash advisory centres (VAACs) for the ~~exchange of information on volcanic activity in order to coordinate the~~ inclusion of such information ~~on volcanic eruptions~~ in SIGWX forecasts.

3.~~2~~1.2 In case of interruption of the operation of a WAFC, its functions shall be carried out by the other WAFC.

~~*Note.— Back-up procedures to be used in case of interruption of the operation of a WAFC are updated by the Meteorology Panel (METP) as necessary; the latest revision can be found on the ICAO METP website.*~~

…

CHAPTER 6. AERODROME AND EN-ROUTE METEOROLOGICAL FORECAST INFORMATION

…

6.3 En-route meteorological forecast information

6.3.1 Forecasts by world area forecast centres

Note.— Procedures and technical specifications related to this section are given in the PANS-MET (Doc ...), Section 5.1.

Global upper-air gridded and significant weather forecasts shall be issued by world area forecast centres (WAFCs). ~~WAFCs shall adopt~~ in uniform formats and codes for the supply of such forecasts using:

a) an appropriate gridded code form for upper-air gridded forecasts, as specified in the PANS-MET (Doc ….), 5.1.1.3; and

b) an information exchange model for significant weather forecasts, as specified in the PANS-MET (Doc ….), 5.1.2.1.3.

…

CHAPTER 11. USE OF COMMUNICATIONS TO EXCHANGE METEOROLOGICAL INFORMATION

…

11.1 Requirements for communications

…

11.1.3 Suitable telecommunications facilities shall be made available to permit world area forecast centres to supply the required world area forecast system ~~products~~ forecasts to aerodrome meteorological offices, meteorological authorities and other users

…

11.2.2 World area forecast system ~~products~~ forecasts

11.2.2.1 **Recommendation.** — *The telecommunications facilities used for the supply of WAFS ~~products~~ forecasts should be the aeronautical fixed service or the public Internet.*

11.2.2.2 **Recommendation.**— ~~*World area forecast system*~~ *WAFS* ~~*products in digital form*~~ *forecasts should be transmitted using* ~~*binary*~~ *digital data communications techniques. The method and channels used for the dissemination of the products should be as determined by regional air navigation agreement.*

…

_____

APPENDIX E: Proposed Revision to the New PANS-MET

- New text is shaded in grey or labelled as inserted
- Deleted text is shown with red ~~strikeout~~

PANS-MET

Editorial Note.— Throughout the PANS-MET, *replace* all reference to "a WAFC" with "the WAFCs".

CHAPTER 5. EN-ROUTE METEOROLOGICAL FORECAST INFORMATION

5.1 FORECASTS ISSUED BY WORLD AREA FORECAST CENTRES

5.1.1 Upper-air gridded forecasts

5.1.1.1 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, 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 ~~at 6, 9, 12, 15, 18, 21, 24, 27, 30, 33 and 36 hours~~ as specified in Appendix 5, Tables A5-1 and A5-2 ~~after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based~~. Each forecast shall be ~~disseminated~~ made available as soon as technically feasible but not later than 5 hours after standard time of observation for the forecasts with a validity up to 36 hours.

5.1.1.2 The grid point forecasts 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)~~;

…

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

…

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)~~;

~~*Note.— Layers centred at a flight level referred to in f) have a depth of 100 hPa.*~~

g) 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

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) 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 h) is provided in the Manual of Aeronautical Meteorological Practice *(Doc 8896).*

Note.— Flight levels and exact pressure levels (hPa) for grid point forecasts listed in a), d), f), g), and h) are specified in Appendix 5, Tables A5-3 and A5-4.

5.1.1.3 The foregoing grid point forecasts shall be issued by a WAFC in binary an appropriate gridded 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 Appropriate gridded code forms prescribed by the WMO are contained in the volumes of the Manual on Codes (WMO-No. 306).*

5.1.1.4 The foregoing gGrid point forecasts listed under 5.1.1.2 a), b), c), d) and h), shall be prepared by a the WAFCs in a regular grid with a horizontal resolution of 1.25° 0.25°of latitude and longitude as specified in Appendix 5, Table A5-3.

5.1.1.5 The foregoing grid point forecasts listed under 5.1.1.2 e), f) and g) shall be prepared by a WAFC in a regular grid with a horizontal resolution of 0.25° of latitude and longitude.

5.1.1.5 A subset of the grid point forecasts in 5.1.1.4 shall be prepared by the WAFCs in a regular grid with horizontal resolution of 1.25° of latitude and longitude as specified in Appendix 5, Table A5-4.

5.1.2 Significant weather (SIGWX) forecasts

5.1.2.1 General provisions

5.1.2.1.1 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 at 24 hours as specified in Appendix 5, Table A5-5 after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based. Each forecast shall be disseminated made available as soon as technically feasible but not later than 7 hours after standard time of observation under normal operations and not later than 9 hours after standard time of observation during backup operations.

5.1.2.1.2 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.*

5.1.2.1.2 SIGWX forecasts shall be issued by a WAFC for flight levels 100 to 600 inclusive.

5.1.2.1.3 As of 4 November 2021, SIGWX forecasts should shall be disseminated by a WAFC in IWXXM GML form in addition to the dissemination of SIGWX forecasts in accordance with 5.1.2.1.2 Appendix 5, Table A5-5.

Note. ~~1~~.— The technical specifications for IWXXM are contained in the Manual on Codes *(WMO – No.306), Volume I.3, Part D —* Representations Derived from Data Models. *Guidance on the implementation of IWXXM is provided in the* Manual on the ICAO Meteorological Information Exchange Model (IWXXM) *(Doc 10003).*

~~*Note 2. — Geography markup language (GML) is an encoding standard of the Open Geospatial Consortium (OGC).*~~

5.1.2.1.4 A subset of SIGWX forecasts in 5.1.2.1.3 shall be issued by the WAFCs in portable network graphics (PNG) format as specified in Appendix 5, Table A5-5.

~~5.1.2.2 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*~~

5.1.2.~~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);

Note.— Tropical cyclone is included in SIGWX forecasts based on tropical cyclone information provided by a tropical cyclone advisory centre.

~~b) severe squall lines;~~

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

~~d~~c) moderate or severe icing;

Note.— Icing is included in SIGWX forecasts made available in IWXXM form but not in SIGWX forecasts made available in PNG format.

~~e~~d) widespread sandstorm/duststorm;

~~f~~e) 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.*~~

~~g~~f) flight level of tropopause;

~~h~~g) jet streams;

~~i~~h) 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

~~j~~i) 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 5.2.

5.1.2.~~4~~3 Criteria for including items in SIGWX forecasts

The following criteria shall be applied for SIGWX forecasts:

~~a) items a) to f) in 5.1.2.3 shall only be included if expected to occur between the lower and upper levels of the SIGWX forecast;~~

~~b~~a) 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;~~

~~c~~b) 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;

~~d~~c) 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

~~e~~d) in the case of co-incident or the partial overlapping of items a), ~~i~~h) and ~~j~~i) in ~~5.1.2.3~~5.1.2.2, the highest priority shall be given to item ~~i~~h), followed by items ~~j~~i) 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.

5.1.3 Use of forecasts issued by the ~~world area forecast centres (WAFCs)~~ WAFCs

…

5.1.3.2 In order to ensure uniformity and standardization of flight documentation, the WAFS ~~GRIB and BUFR~~ gridded ~~data received~~ and~~, as of 4 November 2021,~~ IWXXM data received~~,~~ from the WAFCs shall be decoded into

standard WAFS charts in accordance with relevant provisions in this PANS and Annex 3, and the meteorological content and identification of the originator of the forecasts provided by the WAFCs shall not be amended.

Note.— The word 'chart' refers to the visualisation of WAFS gridded and IWXXM data.

5.1.4 Notification of WAFC concerning significant discrepancies

Aerodrome meteorological offices using ~~WAFS BUFR or, as of 4 November 2021, IWXXM~~ SIGWX data issued by the WAFCs shall notify the WAFC concerned ~~immediately~~ if significant discrepancies are detected ~~or reported in respect of its SIGWX forecasts concerning:~~ between the SIGWX forecast and conditions reported by aircraft.

~~a) icing, turbulence, 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).*

…

CHAPTER 8. METEOROLOGICAL SERVICE FOR OPERATORS AND FLIGHT CREW MEMBERS

…

8.1.2 Format of meteorological information for pre-flight planning and in-flight replanning

8.1.2.1 Upper-air gridded information supplied by the world area forecast centres (WAFCs) for pre-flight planning and in-flight replanning shall be in ~~the GRIB~~ a gridded code form.

Note.— ~~The GRIB code form is contained in the~~ Manual on Codes *~~(WMO No. 306), Volume I.2, Part B — Binary Codes.~~ Appropriate gridded code forms prescribed by the WMO are contained in the volumes of the Manual on Codes (WMO-No. 306).*

~~8.1.2.2 Information on significant weather supplied by WAFCs for pre-flight planning and in-flight replanning shall be in the BUFR code form.~~

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

8.1.2.~~3~~2 ~~As of 4 November 2021, information on significant weather~~ SIGWX forecasts supplied by WAFCs for pre-flight planning and in-flight replanning ~~should~~ shall be in IWXXM ~~GML~~ form~~, in addition to the supply of this information in accordance with 8.1.2.2~~ and, a subset thereof in the portable network graphics (PNG) format.

Note 1.— The technical specifications for IWXXM are contained in the Manual on Codes *(WMO – No.306), Volume I.3, Part D —* Representations Derived from Data Models. *Guidance on the implementation of IWXXM is provided in the* Manual on the ICAO Meteorological Information Exchange Model (IWXXM) *(Doc 10003).*

~~*Note 2.— Geography markup language (GML) is an encoding standard of the Open Geospatial Consortium (OGC).*~~

Note 2.— Details of SIGWX forecasts in IWXXM form and the PNG format supplied by WAFCs are specified in Appendix 5, Table A5-5.

…

8.2 FLIGHT DOCUMENTATION

Note.— The word 'chart' used hereinafter refers to the visualisation of WAFS gridded and IWXXM data.

8.2.1 Presentation of information

…

8.2.1.3 When forecasts of upper wind and upper-air temperature are supplied in chart form, they shall be fixed time prognostic charts for flight levels as specified in ~~5.1.1.2 a)~~ Appendix 5 Tables A5-1 and A5-2. When forecasts of SIGWX phenomena are supplied in chart form, they shall be fixed time prognostic charts for an atmospheric layer limited by flight levels as specified in 5.1.2.1.2 and 5.2.4.2.

…

8.2.2 Charts in flight documentation

…

8.2.2.2 Set of charts to be provided

8.2.2.2.1 The minimum number of charts for flights ~~between~~ operating at and above flight level ~~250 to flight level 630~~ 100 shall include a ~~high level~~ WAFS SIGWX chart (flight level ~~250~~ 100 to flight level ~~630~~ 600) and a forecast ~~250 hPa~~ wind and temperature chart appropriate for the flight level and route of flight. The actual charts provided for pre-flight and in-flight planning and for flight documentation shall be as agreed between meteorological authorities and users concerned.

…

CHAPTER 10. USE OF COMMUNICATIONS TO EXCHANGE METEOROLOGICAL INFORMATION

…

10.1.2 ~~Forecasts issued by world area forecast centres (WAFCs)~~ Upper-air gridded forecasts

10.1.2.1 Quality requirements for charts

Where upper-air gridded forecasts ~~issued by WAFCs~~ are disseminated in chart form, the quality of the charts received should be such as to permit reproduction in a sufficiently legible form for flight planning and documentation. Charts ~~received~~ should be legible over 95 per cent of their area.

…

10.1.2.3 ~~Heading of bulletins containing forecasts issued by WAFCs~~ Transmission of upper-air gridded forecasts

~~Meteorological bulletins containing forecasts issued by WAFCs in digital form to be transmitted via aeronautical fixed service or the public Internet shall contain a heading as given in 10.1.1.3.~~ Upper-air gridded forecasts should be transmitted using the aeronautical fixed service or the public Internet using an appropriate gridded data format.

…

APPENDIX 1.FLIGHT DOCUMENTATION — MODEL CHARTS AND FORMS

…

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

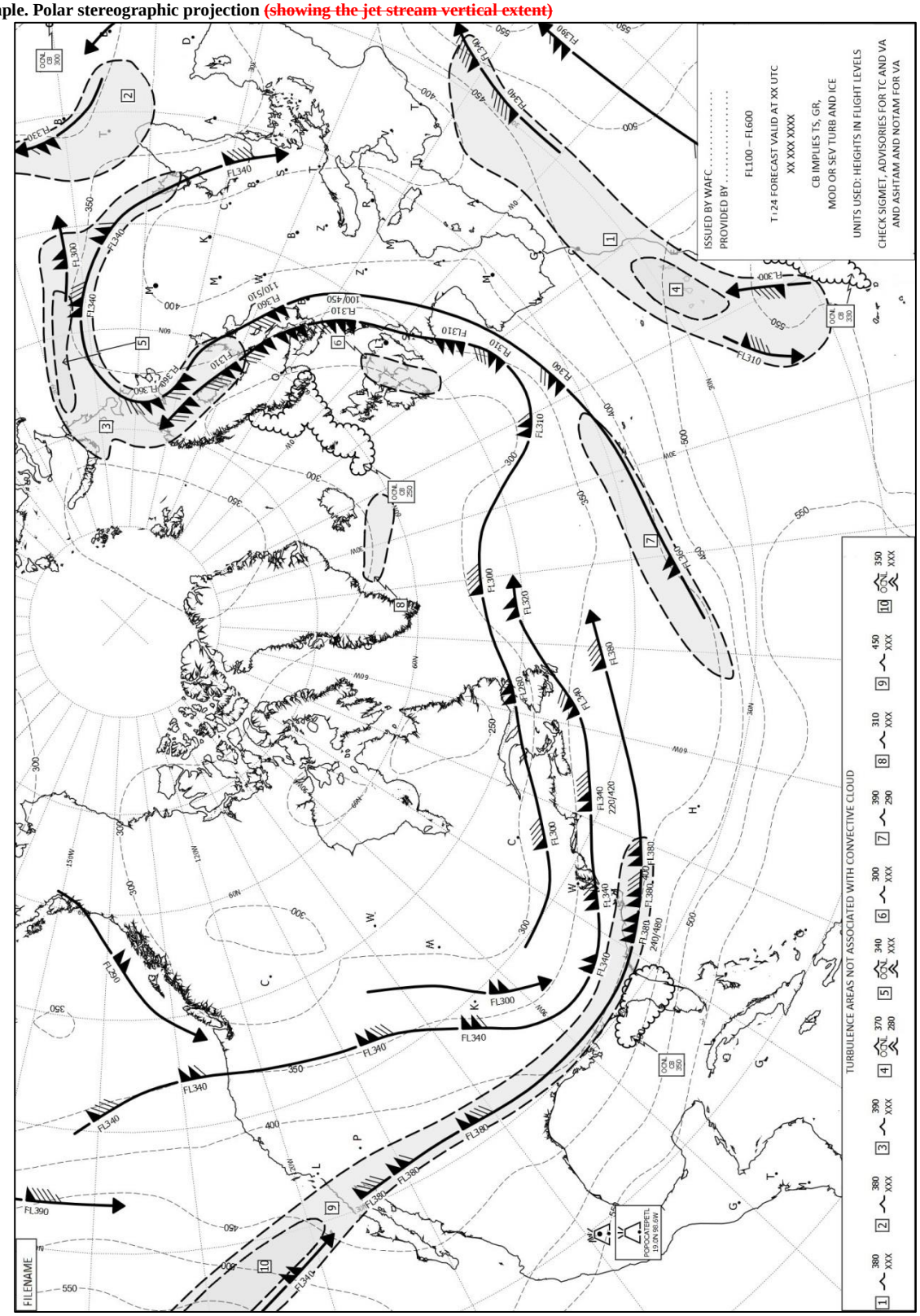
~~MODEL SWM Significant weather chart (medium level)~~

…

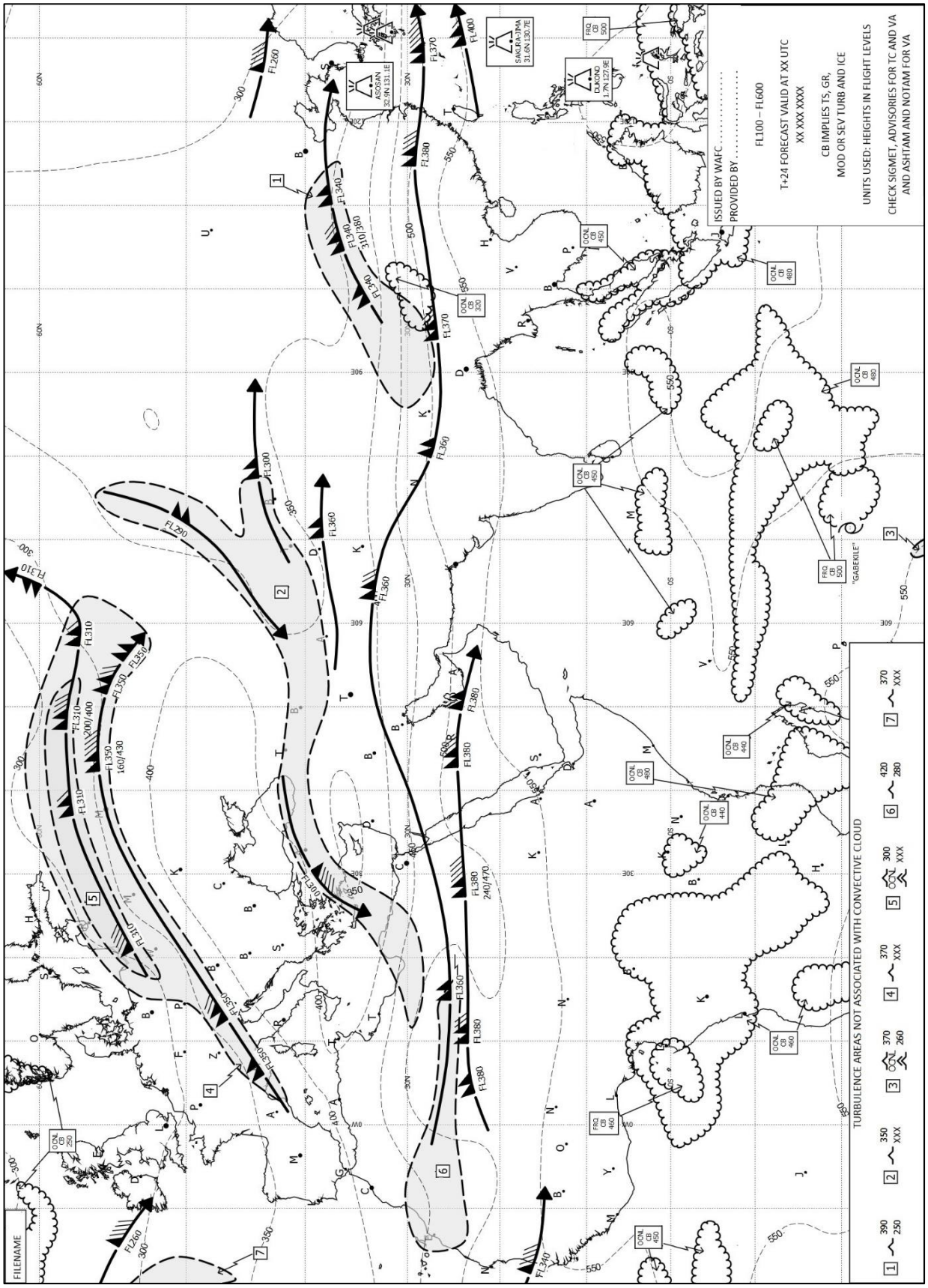
Replace the existing MODEL SWH and MODEL SWM examples in *toto* by the following new MODEL SWH examples, in polar stereographic projection and Mercator projection respectively.

WAFS SIGNIFICANT WEATHER CHART ~~(HIGH LEVEL)~~ **MODEL SWH**

Example. Polar stereographic projection ~~(showing the jet stream vertical extent)~~



Example. Mercator projection


FILENAME
ISSUED BY WAFC
PROVIDED BY
FL100 – FL600
T+24 FORECAST VALID AT XX UTC
XX XXX XXXX
CB IMPLIES TS, GR,
MOD OR SEV TURB AND ICE
UNITS USED: HEIGHTS IN FLIGHT LEVELS
CHECK SIGMET, ADVISORIES FOR TC AND VA
AND ASHTAM AND NOTAM FOR VA
TURBULENCE AREAS NOT ASSOCIATED WITH CONVECTIVE CLOUD
1 390 250
2 350 XXX
3 370 260
4 370 XXX
5 300 XXX
6 420 280
7 370 XXX
"GABEKILE"
ASOSAN
32.9N 131.1E
SAKURAJIMA
31.6N 130.7E
DUMONG
1.7N 127.9E

...

SHEET OF NOTATIONS USED IN FLIGHT DOCUMENTATION **MODEL SN**

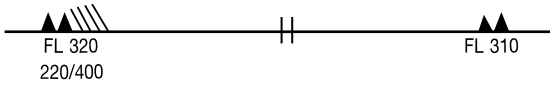
Update the following sections in the existing MODEL SN as shown below.

MODEL SN

...

2. FRONTS AND CONVERGENCE ZONES AND OTHER SYMBOLS USED

	Cold front at the surface	FL 270	Position, speed and level of maximum wind
	Warm front at the surface		Convergence line
	Occluded front at the surface	0°:100	Freezing level
	Quasi-stationary front at the surface		Intertropical convergence zone
H 460	Tropopause high	10	State of the sea
270 L	Tropopause low	18	Sea-surface temperature
380	Tropopause level	40	Widespread strong surface wind*
---- 350-----	Tropopause level contour		



Wind arrows indicate the maximum wind in jet and the flight level at which it occurs. If the maximum wind speed is 60 m/s (120 kt) or more, the flight levels between which winds are greater than 40 m/s (80 kt) is placed below the maximum wind level. In the example, winds are greater than 40 m/s (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 40 m/s (80 kt) is forecast.

‡ Symbol used whenever the height of the jet axis changes by +/–3000 ft or the speed changes by +/–20 kt

* This symbol refers to widespread surface wind speeds exceeding 15 m/s (30 kt).

...

3.3 Heights

Heights are indicated on ~~SWH and SWM~~ WAFS SIGWX charts in flight levels (FL), top over base. When XXX is used, tops or bases are outside the layer of the atmosphere to which the chart applies. The heights of the cloud base of cumulonimbus clouds are not shown on WAFS SIGWX charts.

In SWL charts:

(a) Heights are indicated as altitudes above mean sea level;

(b) The abbreviation SFC is used to indicate ground level

4. DEPICTING OF LINES AND SYSTEMS ON SPECIFIC CHARTS

4.1 Model~~s SWH and SWM~~ – WAFS ~~S~~significant weather charts ~~(high and medium)~~

Scalloped line	=	demarcation of areas of ~~significant weather~~ cumulonimbus cloud
Heavy broken line	=	delineation of area of ~~CAT~~ moderate or severe turbulence not associated with convective cloud
Heavy solid line interrupted by wind arrow and flight level	=	position of jet stream axis with indication of wind direction, speed in kt or m/s and height in flight levels. The vertical extent of the jet stream is indicated (in flight levels), e.g. FL 270 accompanied by 240/290 indicates that the jet extends from FL 240 to FL 290.
~~Flight levels inside small rectangles~~	~~=~~	~~height in flight levels of tropopause at spot locations, e.g. 340. Low and high points of the tropopause topography are indicated by the letters L or H, respectively, inside a pentagon with the height in flight levels. Display explicit FL for jet depths and tropopause height even if outside forecast bounds.~~
Dashed line interrupted by a three-digit number	=	tropopause level contour where the number represents the flight level of the tropopause

...

…

APPENDIX 5. TECHNICAL SPECIFICATIONS RELATED TO FORECASTS ISSUED BY WORLD AREA FORECAST CENTRES (WAFCs)

…

Insert new text and tables as follows:

Table A5-1. Fixed valid times of available WAFS upper-air gridded forecasts with a horizontal resolution of 0.25°of latitude and longitude

Upper-air gridded 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			

* after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based

Table A5-2. Fixed valid times of available WAFS upper-air gridded forecasts with a horizontal resolution of 1.25° of latitude and longitude

Note.— WAFS forecasts with a horizontal resolution of 1.25° are provided for users unable to process WAFS forecasts with a horizontal resolution of 0.25°.

Upper-air gridded 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	

* after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based

Table A5-3: Availability (marked by X) of WAFS upper-air gridded forecasts with a horizontal resolution of 0.25° of latitude and longitude as a function of flight level

Flight Level	*ICAO Standard Atmosphere pressure level (hPa)*	*Geopotential Altitude*	*Wind*	*Temperature*	*Turbulence*	*Icing*	*Humidity*
FL 050	843.1	X	X	X	—	X	X
FL 060	812.0	X	X	X	—	X	X
FL 070	781.9	X	X	X	—	X	X
FL 080	752.6	X	X	X	—	X	X
FL 090	724.3	X	X	X	—	X	X
FL 100	696.8	X	X	X	X	X	X
FL 110	670.2	X	X	X	X	X	X
FL 120	644.4	X	X	X	X	X	X
FL 130	619.4	X	X	X	X	X	X
FL 140	595.2	X	X	X	X	X	X
FL 150	571.8	X	X	X	X	X	X
FL 160	549.2	X	X	X	X	X	X
FL 170	527.2	X	X	X	X	X	X
FL 180	506.0	X	X	X	X	X	X
FL 190	485.5	X	X	X	X	X	—
FL 200	465.6	X	X	X	X	X	—
FL 210	446.5	X	X	X	X	X	—
FL 220	427.9	X	X	X	X	X	—
FL 230	410.0	X	X	X	X	X	—
FL 240	392.7	X	X	X	X	X	—
FL 250	376.0	X	X	X	X	X	—
FL 260	359.9	X	X	X	X	X	—
FL 270	344.3	X	X	X	X	X	—
FL 280	329.3	X	X	X	X	X	—
FL 290	314.9	X	X	X	X	X	—
FL 300	300.9	X	X	X	X	X	—
FL 310	287.4	X	X	X	X	—	—
FL 320	274.5	X	X	X	X	—	—
FL 330	262.0	X	X	X	X	—	—
FL 340	250.0	X	X	X	X	—	—
FL 350	238.4	X	X	X	X	—	—
FL 360	227.3	X	X	X	X	—	—
FL 370	216.6	X	X	X	X	—	—
FL 380	206.5	X	X	X	X	—	—
FL 390	196.8	X	X	X	X	—	—
FL 400	187.5	X	X	X	X	—	—
FL 410	178.7	X	X	X	X	—	—
FL 420	170.4	X	X	X	X	—	—

Flight Level	*ICAO Standard Atmosphere pressure level (hPa)*	*Geopotential Altitude*	*Wind*	*Temperature*	*Turbulence*	*Icing*	*Humidity*
FL 430	162.4	X	X	X	X	—	—
FL 440	154.7	X	X	X	X	—	—
FL 450	147.5	X	X	X	X	—	—
FL 460	140.6	X	X	X	—	—	—
FL 470	134.0	X	X	X	—	—	—
FL 480	127.7	X	X	X	—	—	—
FL 490	121.7	X	X	X	—	—	—
FL 500	116.0	X	X	X	—	—	—
FL 510	110.5	X	X	X	—	—	—
FL 520	105.3	X	X	X	—	—	—
FL 530	100.4	X	X	X	—	—	—
FL 540	95.7	X	X	X	—	—	—
FL 550	91.2	X	X	X	—	—	—
FL 560	87.0	X	X	X	—	—	—
FL 570	82.8	X	X	X	—	—	—
FL 580	79.0	X	X	X	—	—	—
FL 590	75.2	X	X	X	—	—	—
FL 600	71.7	X	X	X	—	—	—

Table A5-4: Availability (marked by X) of WAFS upper-air gridded forecasts with a horizontal resolution of 1.25° of latitude and longitude as a function of flight level

Note.— WAFS forecasts with a horizontal resolution of 1.25° are provided for users unable to process WAFS forecasts with a horizontal resolution of 0.25°.

Flight Level	*ICAO Standard Atmosphere pressure level (hPa)*	*Geopotential Altitude*	*Wind*	*Temperature*	*Humidity*
FL 050	843.1	X	X	X	X
FL 080	752.6	X	X	X	X
FL 100	696.8	X	X	X	X
FL 140	595.2	X	X	X	X
FL 180	506.0	X	X	X	X
FL 210	446.5	X	X	X	—
FL 240	392.7	X	X	X	—

Flight Level	*ICAO Standard Atmosphere pressure level (hPa)*	*Geopotential Altitude*	*Wind*	*Temperature*	*Humidity*
FL 270	344.3	X	X	X	—
FL 300	300.9	X	X	X	—
FL 320	274.5	X	X	X	—
FL 340	250.0	X	X	X	—
FL 360	227.3	X	X	X	—
FL 390	196.8	X	X	X	—
FL 410	178.7	X	X	X	—
FL 450	147.5	X	X	X	—
FL 480	127.7	X	X	X	—
FL 530	100.4	X	X	X	—

Table A5-5: Availability (marked by X) of WAFS SIGWX forecast as a function of fixed valid time

	SIGWX forecast in	
*Fixed Valid Time**	*IWXXM form*	*PNG format*
6 hours	X	—
9	X	—
12	X	—
15	X	—
18	X	—
21	X	—
24	X	X
27	X	—
30	X	—
33	X	—
36	X	—
39	X	—
42	X	—
45	X	—
48	X	—

** after the time (0000, 0600, 1200 and 1800 UTC) of the synoptic data on which the forecasts were based.*

End of new text and tables.

Replace the figures from Annex 3, Amendment 79, Appendix 8, A8-1, A8-2 and A8-3 with the following new images for the PANS-MET

…

Figure A5-1 - Fixed areas of coverage of WAFS forecasts valid for 24 hours in chart form — Mercator projection

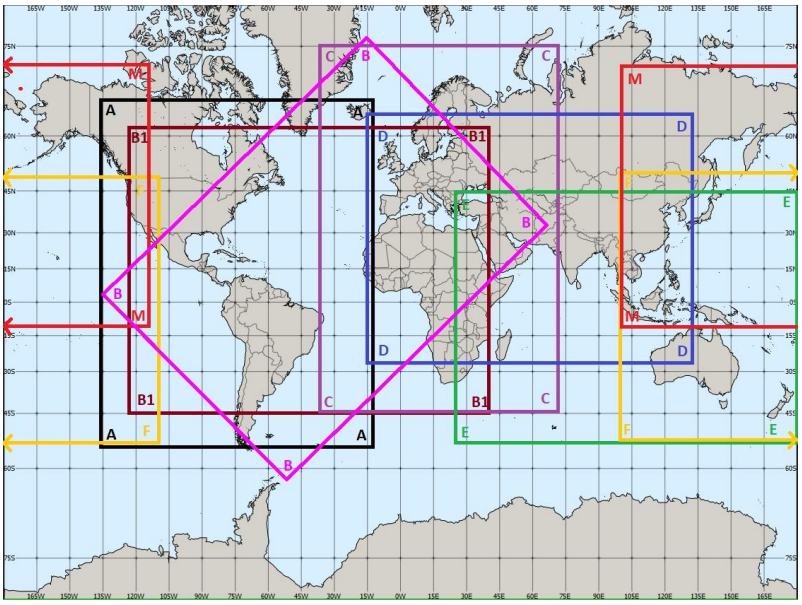


CHART	LATITUDE	LONGITUDE	CHART	LATITUDE	LONGITUDE
A	N6700	W13724	D	N6300	W01500
A	N6700	W01236	D	N6300	E13200
A	S5400	W01236	D	S2700	E13200
A	S5400	W13724	D	S2700	W01500
~~ASIA~~	~~N3600~~	~~E05300~~	E	N4455	E02446
~~ASIA~~	~~N3600~~	~~E10800~~	E	N4455	E18000
~~ASIA~~	~~0000~~	~~E10800~~	E	S5355	E18000
~~ASIA~~	~~0000~~	~~E05300~~	E	S5355	E02446
B	N0304	W13557	F	N5000	E10000
B	N7644	W01545	F	N5000	W11000
B	N3707	E06732	F	S5242	W11000
B	S6217	W05240	F	S5242	E10000
B1	N6242	W12500	M	N7000	E10000
B1	N6242	E04000	M	N7000	W11000
B1	S4530	E04000	M	S1000	W11000
B1	S4530	W12500	M	S1000	E10000
C	N7500	W03500	~~MID~~	~~N4400~~	~~E01700~~
C	N7500	E07000	~~MID~~	~~N4400~~	~~E07000~~
C	S4500	E07000	~~MID~~	~~N1000~~	~~E07000~~
C	S4500	W03500	~~MID~~	~~N1000~~	~~E01700~~

Figure A5-2 - Fixed areas of coverage of WAFS forecasts valid for 24 hours in chart form — Polar stereographic projection (northern hemisphere)

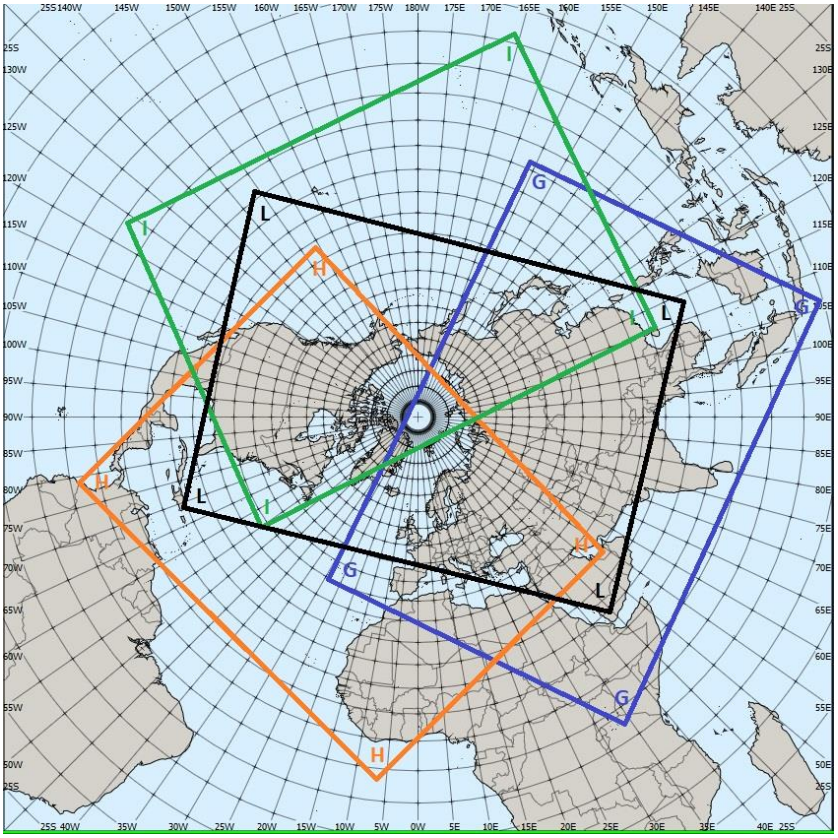


CHART	LATITUDE	LONGITUDE	CHART	LATITUDE	LONGITUDE
~~EUR~~	~~N4633~~	~~W05634~~	I	N1912	E11130
~~EUR~~	~~N5842~~	~~E06824~~	I	N3330	W06012
~~EUR~~	~~N2621~~	~~E03325~~	I	N0126	W12327
~~EUR~~	~~N2123~~	~~W02136~~	I	S0647	E16601
G	N3552	W02822	L	N1205	E11449
G	N1341	E15711	L	N1518	E04500
G	S0916	E10651	L	N2020	W06900
G	S0048	E03447	L	N1413	W14338
H	N3127	W14836	~~NAT~~	~~N4439~~	~~W10143~~
H	N2411	E05645	~~NAT~~	~~N5042~~	~~E06017~~
H	S0127	W00651	~~NAT~~	~~N1938~~	~~E00957~~
H	N0133	W07902	~~NAT~~	~~N1711~~	~~W05406~~

Figure A5-3 - Fixed areas of coverage of WAFS forecasts valid for 24 hours in chart form — Polar stereographic projection (southern hemisphere)

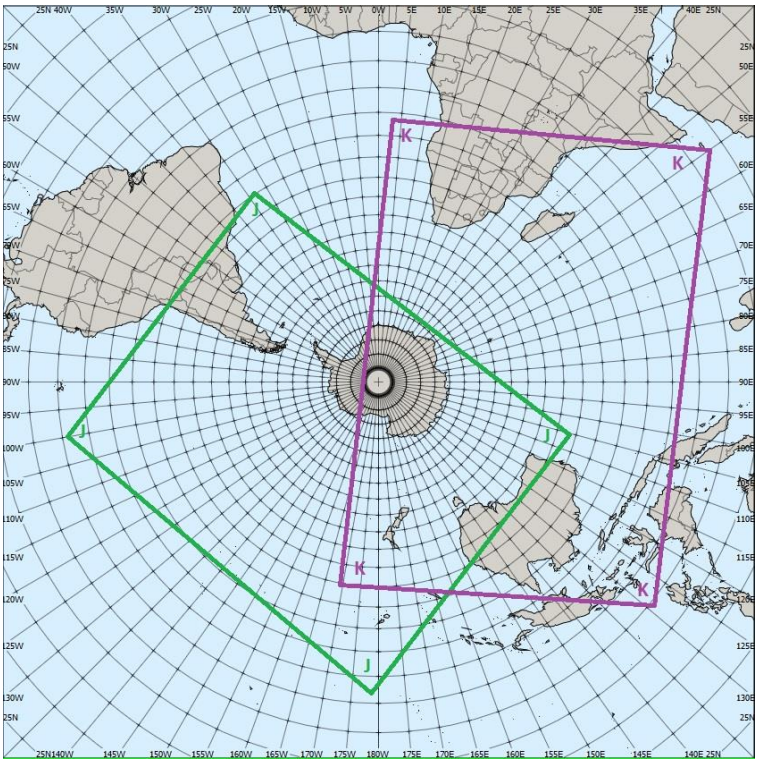


CHART	LATITUDE	LONGITUDE
J	S0318	W17812
J	N0037	W10032
J	S2000	W03400
J	S2806	E10717
K	N1255	E05549
K	N0642	E12905
K	S2744	W16841
K	S1105	E00317

APPENDIX 7. TECHNICAL SPECIFICATIONS RELATED TO METEOROLOGICAL FORECAST INFORMATION CONTAINING ADVISORIES, ALERTS AND WARNINGS (SIGMET, AIRMET)

…

Table A7-2. Template for advisory message for tropical cyclone

Key: M = inclusion mandatory, part of every message;
C = inclusion conditional, included whenever applicable;
= = a double line indicates that the text following it should be placed on the subsequent line.

Note 1.— The ranges and resolutions for the numerical elements included in advisory messages for tropical cyclones are shown in Appendix 6, Table A6-4.

Note 2.— The explanations for the abbreviations can be found in the PANS-ABC (Doc 8400).

Note 3.— Inclusion of a colon after each element heading is mandatory.

Note 4.— The numbers 1 to 21 are included only for clarity and are not part of the advisory message, as shown in the examples.

	Element	*Detailed content*	*Template(s)*		*Examples*	
1	Identification of the type of message (M)	Type of message	TC ADVISORY		TC ADVISORY	
2	Status indicator (C)[1]	Indicator of test *or* exercise	STATUS:	TEST *or* EXER	STATUS:	TEST EXER
3	Time of origin (M)	Year, month, day and time in UTC of issue	DTG:	nnnnnnnn/nnnnZ	DTG:	20040925/~~19~~1200Z
4	Name of TCAC (M)	Name of TCAC (location indicator *or* full name)	TCAC:	nnnn *or* nnnnnnnnnn	TCAC:	YUFO[2] MIAMI
5	Name of tropical cyclone (M)	Name of tropical cyclone *or* "NN" for unnamed tropical cyclone	TC:	nnnnnnnnnnnn *or* NN	TC:	GLORIA
6	Advisory number (M)	Year in full and message number (separate sequence for each cyclone)	ADVISORY NR:	nnnn/[n][n][n]n	ADVISORY NR:	2004/13
7	Observed position of the centre (M)	Day and time in UTC and position of the centre of the tropical cyclone (in degrees and minutes)	OBS PSN:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	OBS PSN:	25/~~1800Z~~1730Z N2706 W07306
8	Observed CB cloud[3] (C)	Location of CB cloud (referring to latitude and longitude (in degrees and minutes)) *and* vertical extent (flight level)	CB:	WI nnnKM (*or* nnnNM) OF TC CENTRE *or* WI[4] Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – [Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn] – Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]] *and* TOP [ABV *or* BLW] FLnnn	CB:	WI 250NM OF TC CENTRE TOP FL500

9	Direction and speed of movement (M)	Direction and speed of movement given in sixteen compass points and km/h (*or* kt), respectively, *or* stationary (< 2 km/h (1 kt))	MOV:	N nnKMH (*or* KT) *or* NNE nnKMH (*or* KT) *or* NE nnKMH (*or* KT) *or* ENE nnKMH (*or* KT) *or* E nnKMH (*or* KT) *or* ESE nnKMH (*or* KT) *or* SE nnKMH (*or* KT) *or* SSE nnKMH (*or* KT) *or* S nnKMH (*or* KT) *or* SSW nnKMH (*or* KT) *or* SW nnKMH (*or* KT) *or* WSW nnKMH (*or* KT) *or* W nnKMH (*or* KT) *or* WNW nnKMH (*or* KT) *or* NW nnKMH (*or* KT) *or* NNW nnKMH (*or* KT) *or* STNR	MOV:	NW 20KMH
10	Changes in intensity (M)	Changes of maximum surface wind speed at time of observation	INTST CHANGE	INTSF *or* WKN *or* NC	INTST CHANGE:	INTSF
11	Central pressure (M)	Central pressure (in hPa)	C:	nnnHPA	C:	965HPA
12	Maximum surface wind (M)	Maximum surface wind near the centre (mean over 10 minutes, in m/s (*or* kt))	MAX WIND:	nn[n]MPS (*or* nn[n]KT)	MAX WIND:	22MPS
13	Forecast of centre position (+6 HR)[5] (M)	Day and time (in UTC) (6 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +6 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +6 HR:	25/~~22~~1800Z N2748 W07350
14	Forecast of maximum surface wind (+6 HR)[5] (M)	Forecast of maximum surface wind (6 hours after the "DTG" given in Item 3)	FCST MAX WIND +6 HR:	nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +6 HR:	22MPS
15	Forecast of centre position (+12 HR)[5] (M)	Day and time (in UTC) (12 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +12 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +12 HR:	26/~~04~~0000Z N2830 W07430
16	Forecast of maximum surface wind (+12 HR)[5] (M)	Forecast of maximum surface wind (12 hours after the "DTG" given in Item 3)	FCST MAX WIND +12 HR:	nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +12 HR:	22MPS
17	Forecast of centre position (+18 HR)[5] (M)	Day and time (in UTC) (18 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +18 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +18 HR:	26/~~10~~0600Z N2852 W07500
18	Forecast of maximum surface wind (+18 HR)[5] (M)	Forecast of maximum surface wind (18 hours after the "DTG" given in Item 3)	FCST MAX WIND +18 HR:	nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +18 HR:	21MPS
19	Forecast of centre position (+24 HR)[5] (M)	Day and time (in UTC) (24 hours from the "DTG" given in Item 3); Forecast position (in degrees and minutes) of the centre of the tropical cyclone	FCST PSN +24 HR:	nn/nnnnZ Nnn[nn] *or* Snn[nn] Wnnn[nn] *or* Ennn[nn]	FCST PSN +24 HR:	26/12~~16~~00Z N2912 W07530

20	Forecast of maximum surface wind (+24 HR)[5] (M)	Forecast of maximum surface wind (24 hours after the "DTG" given in Item 3)	FCST WIND +24 HR:	MAX nn[n]MPS (*or* nn[n]KT)	FCST MAX WIND +24 HR:	20MPS
21	Remarks (M)	Remarks, as necessary	RMK:	*Free text up to 256 characters or* NIL	RMK:	NIL
22	Expected time of issuance of next advisory (M)	Expected year, month, day and time (in UTC) of issuance of next advisory	NXT MSG:	[BFR] nnnnnnnn/nnnnZ *or* NO MSG EXP	NXT MSG:	20040925/2000Z

Notes.—

1. To be ~~U~~used only when ~~the message issued to indicate that~~ a test (TEST) or an exercise (EXER) is taking place. When the word "TEST" or the abbreviation "EXER" is included, the ~~message~~ advisory may contain information that should not be used operationally or will otherwise end immediately after the word "TEST". ~~*[Applicable 7 November 2019]*~~
2. Fictitious location.
3. In the case of CB clouds associated with a tropical cyclone covering more than one area within the area of responsibility, this element can be repeated, as necessary.
4. When disseminated in abbreviated plain language in accordance with 6.2.2, t~~T~~he number of coordinates should be kept to a minimum and should not normally exceed seven.
5. As far as practicable, forecast times are to coincide with main synoptic hours, i.e., 00, 06, 12 and 18 UTC. When the time of origin is not at one of the main synoptic hours, the forecast times are to coincide with the nearest main synoptic hour.

Example A7-2. Advisory message for tropical cyclones

TC ADVISORY	
DTG:	20040925/~~1900~~1200Z
TCAC:	YUFO*
TC:	GLORIA
ADVISORY NR:	2004/13
OBS PSN:	25/~~1800~~1130Z N2706 W07306
CB:	WI 250NM OF TC CENTRE TOP FL500
MOV:	NW 20KMH
INTST CHANGE:	INTSF
C:	965HPA
MAX WIND:	22MPS
FCST PSN + 6 HR:	25/~~2200~~1800Z N2748 W07350
FCST MAX WIND + 6 HR:	22MPS
FCST PSN + 12 HR:	26/~~0400~~0000Z N2830 W07430
FCST MAX WIND + 12 HR:	22MPS
FCST PSN + 18 HR:	26/~~1000~~0600Z N2852 W07500
FCST MAX WIND + 18 HR:	21MPS
FCST PSN + 24 HR:	26/~~1600~~1200Z N2912 W07530
FCST MAX WIND + 24 HR:	20MPS
RMK:	NIL
NXT MSG:	20040925/~~2000~~1800Z

*Fictious location

APPENDIX F: RATIONALE FOR THE PROPOSED REVISIONS TO ANNEX 3 AND PANS-MET

ICAO Annex 3

Chapter	Original paragraph number	Reason for change
Chapter 3	3.1	Restructuring of initial paragraph make this chapter more consistent with other chapters.
	3.2.1e	Altered to better describe how volcanic ash information will be used for SIGWX production
	3.2.2 note	Both WAFCs will produce identical SIGWX data sets, so the backup should one experience problems is simply to use the data sets from the other WAFC. There will be no backup procedures or backup tests.
Chapter 6	6.3.1	SIGWX forecasts will be provided in IWXXM format, and the proposed change in text explains this.
Chapter 11	11.2.2	Use of the word 'products' could be a problematic for the future 'information service' world. 'forecasts' is a better description
	11.2.2.2	'digital' is a better description for modern data communication methods.

PANS-MET

Chapter/Annex	Original paragraph number	Reason for change
Context: In November 2023 the horizontal, vertical and temporal resolution of the WAFS gridded data sets will be increased. In order to deliver this data effectively to users new data dissemination techniques will be implemented and users will for the first time be able to subset the global data set to download only the information that they are interested in.		
Chapter 5	5.1.1.1	There will be a large increase in the number of timesteps that WAFS data is provided for. This can be more clearly represented by presenting it in tabular form so this has been updated and moved to a new table in Appendix 5. Data up to 120-hours will be provided as part of the new WAFS gridded data sets, and at present it is not possible to know exactly what time the complete set will be available to users. The 5-hour target has been adjusted to only apply to data up to 36-hours (36-hours is the current final timestep)
	5.1.1.2	There will be a large increase in the number of levels that WAFS data is provided for. This can be more clearly represented by presenting it in tabular form so this has been updated and moved to a new table in Appendix 5.

		The improved vertical granularity for the icing and turbulence forecasts mean that data no longer needs to be averaged over a depth of atmosphere, therefore note 1 and 2 can be removed.
	5.1.1.3	The GRIB code form may not be the best way to disseminate WAFS gridded data to users in the new SWIM, data centric world (for example it could not easily be used to provide WAFS data appropriate for a specific flight corridor, or an irregularly shaped FIR). Being able to use an "appropriate gridded code" form will enable the WAFCs to provide data in ways that better meet the needs of the users and to meet more of the requirements set out in the GANP.
	5.1.1.4	All WAFS data sets from November 2023 will be provided at a horizontal resolution of 0.25 degrees of latitude and longitude.
	5.1.1.5	To assist users of WAFS data, 1.25 degree horizontal resolution data will be retained for some parameters.
Context: From November 2023 SIGWX forecasts will be produced for multiple timesteps, with features and polygons generated directly from the WAFS gridded data sets (improving harmonisation between the two types of WAFS data). Multiple timesteps will better meet the needs of the aviation industry, particularly short haul and ultra-long haul flights. Both WAFCs will produce the full set of products.		
Chapter 5	5.1.2.1.1 and 5.1.2.1.3	Information on the available timesteps has been updated and moved to a new table in Appendix 5. A change to the SIGWX production methods mean that there will no longer be a backup process. Users will be expected to use the forecast data produced by the other WAFC in the event of a production failure by one WAFC. SIGWX forecasts will be produced in IWXXM format from November 2023, and the BUFR version will be retired two years later.
	5.1.2.1.2 and 5.1.2.2	The existing "high" and "medium" level SIGWX forecasts will be consolidated into a single SIGWX forecast reducing duplication and enabling provision of all parameters across the globe. The new SIGWX will cover FL100 to FL600.
	5.1.2.1.4	To enable users to migrate to digital format SIGWX, the 24-hour SIGWX forecasts will continue to be produced in PNG format for several years (anticipated to be completely retired by November 2028)
	5.1.2.3a	Note added to explain that the WAFCs will use published tropical cyclone advisory messages to decide whether to mark a tropical cyclone on the SIGWX charts.
	5.1.2.3b	Cumulonimbus polygons on SIGWX charts will be calculated from the WAFS gridded cumulonimbus data sets. Therefore it will not be possible to identify squall lines
	5.1.2.3c and 5.1.2.3.f	The "turbulence severity" WAFS gridded data will be used to calculate turbulence polygons for the SIGWX charts. This data set is able to forecast both orographic and clear air turbulence types. "not associated with convective cloud" is added to make it clearer what it refers to.

		In-cloud turbulence gridded data sets were retired with Amendment 79 to Annex 3, and therefore cannot be included as a separate field within the SIGWX forecast.
	5.1.2.3.d	In the WAFC produced PNG format SIGWX charts (see 5.1.2.1.4) including icing objects on these plots will make them too cluttered to use. Therefore icing SIGWX polygons will only be provided in digital format.
	5.1.2.3.j	The note can be removed as there will only be a single SIGWX forecast covering FL100 to FL600.
	5.1.2.4a	All SIGWX parameters will be included if the occur within the FL100 to FL600 range, therefore this note isn't needed
	5.1.2.4.b	Cumulonimbus polygons on SIGWX charts will be calculated from the WAFS gridded cumulonimbus data sets. Therefore it will not be possible to determine whether they are "along a line with little or no space between them", or "embedded in cloud or concealed by haze) Only OCNL CB and FRQ CB will be included on SIGWX forecasts.
	5.1.3.2	Reference to GRIB replaced with "gridded" – see comments for 5.1.1.3 The WAFS SIGWX forecasts will move from BUFR format to IWXXM format in November 2023. There has been no requirement for the WAFS to produce "paper copy" charts for some years, and instead users are expected to process the digital data sets and turn them into relevant charts for themselves. The proposed note is intended to make this clearer.
	5.1.4	The WAFCs are interested differences between the observed weather (which will mainly come from aircraft reports) and all parameters in the SIGWX forecast as this information can be used in post event analysis and verification.
Chapter 8	8.1.2	Changes are in line with what has been proposed for chapter 5 in related to the gridded data format, the retirement of BUFR, and clarification that only the 24-hour SIGWX forecasts will be in PNG format
	8.2	There has been no requirement for the WAFS to produce "paper copy" charts for some years, and instead users are expected to process the digital data sets and turn them into relevant charts for themselves. The proposed note is intended to make this clearer.
	8.2.2.2	Updated for the changes to SIGWX forecast chart upper and lower ranges, and enable the wind and temperature chart provided to be more relevant to the flight.
Chapter 10	10.1.2	In the coming years many more data/forecast services will be developed in order to meet the requirements in the GANP. The guidance in this chapter is relevant for all services of that type and not just WAFC/WAFS.
	10.1.2.3	It will not be possible for the WAFCs to use the bulletin header structure defined in the Manual on the Global Telecommunication System *(WMO-No. 386)* for the new November 2023 WAFS data sets (it is not flexible enough to enable different resolutions of data, hourly

		timesteps or data out to 120-hours, or user definable sub-setting of data). Other new data/forecast services are also expected to be similarly affected.
Appendix 1	MODEL SWH and MODEL SWM	New example charts have been created that take into account the changes to the SIGWX forecasts described in Chapter 5.1.2.3 and 5.1.2.45 as well as - tropopause level depicted as contours instead of spot height values. - shaded turbulence areas (to aid readability) - no cumulonimbus bases (as they are almost always XXX) - new turbulence legend description - new chart labelling (to accommodate multiple timesteps)
	MODEL SN	Updated to cater for tropopause level contours (and removal of the old tropopause spot height information). Addition of a note that explains that the cumulonimbus base information is not shown (this data will be provided within the digital data for users to visualise if they choose to), and an adjustment to make it clear that the marked turbulence areas will not just be for clear air turbulence (CAT)
Appendix 5	Table A5-1 to A5-5	WAFS gridded data sets and WAFS SIGWX forecast information explained via a series of tables. In order to produce data for the increased number of vertical levels that make up the new WAFS gridded data set, the data will be calculated at exact ICAO Standard Atmosphere pressure levels. These values are shown in the tables.
	Figure A5-1 to A5-3	These figures are updated to reflect the retirement of the medium level SIGWX charts. For the new multiple timesteps SIGWX forecast, users will be encouraged to choose the map area/projection/colour scheme that meets the needs of their users and not be limited to the predefined map areas shown here.
Appendix 7	Table A7-2 and example A7-2	Example shown for the tropical cyclone advisory message changed to encourage the provision of tropical cyclone position data for the main synoptic hours of 00, 06, 12 and 18 UTC (most Tropical cyclone advisories already do this). This will aid the WAFCs in marking tropical cyclone positioning on the WAFS SIGWX forecasts.

APPENDIX G: THE NEXT GENERATION OF THE WORLD AREA FORECAST SYSTEM (WAFS)

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 Internet File Service (WIFS).

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

Next generation WAFS grid point forecasts

Major changes and improvements are coming for the WAFS grid point forecasts in late 2023. 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

Next generation WAFS grid point forecasts will have a horizontal resolution of 0.25 degrees latitude and longitude. Whilst the cumulonimbus, icing and turbulence fields were upgraded in November 2020 to this resolution, this will be an increase from the current 1.25 degree latitude and longitude horizontal resolution for the other WAFS fields.

Vertical resolution

The vertical resolution of the next generation 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 next generation 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 published 4-times a day.

Probabilistic forecasts

Probabilistic forecasts for cumulonimbus cloud, icing and turbulence are also being developed and will become part of the next generation 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

Next generation 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.

Next generation 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 Meteorological Information 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 next generation 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 next generation 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

Next generation WAFS SIGWX forecasts will be broadly consistent with today's WAFS SIGWX forecasts today 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. Next generation SIGWX will have a vertical range from FL100 to FL600.

Current SIGWX medium-level forecasts are only provided for four select regions of globe. Next generation SIGWX 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 2023.

Format

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

IWXXM format

Next generation SIGWX will be in IWXXM format, which will be the new standard with ICAO. The WAFCs plan to provide example forecasts in the IWXXM form in November 2021. The new multiple time-step SIGWX forecasts, in IWXXM format only, are planned to be operational by later 2023.

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 2025.

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.

Next generation 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-hosted 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 next generation 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 SADIS and WIFS system in late 2023.

Implementation of the next generation WAFS

Next generation WAFS information will be implemented in phases.

Phase 1 – completed 5 November 2020

- Partial implementation of next generation 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
  - Retirement of the in-cloud turbulence forecast products.

Phase 2 – planned for late 2023

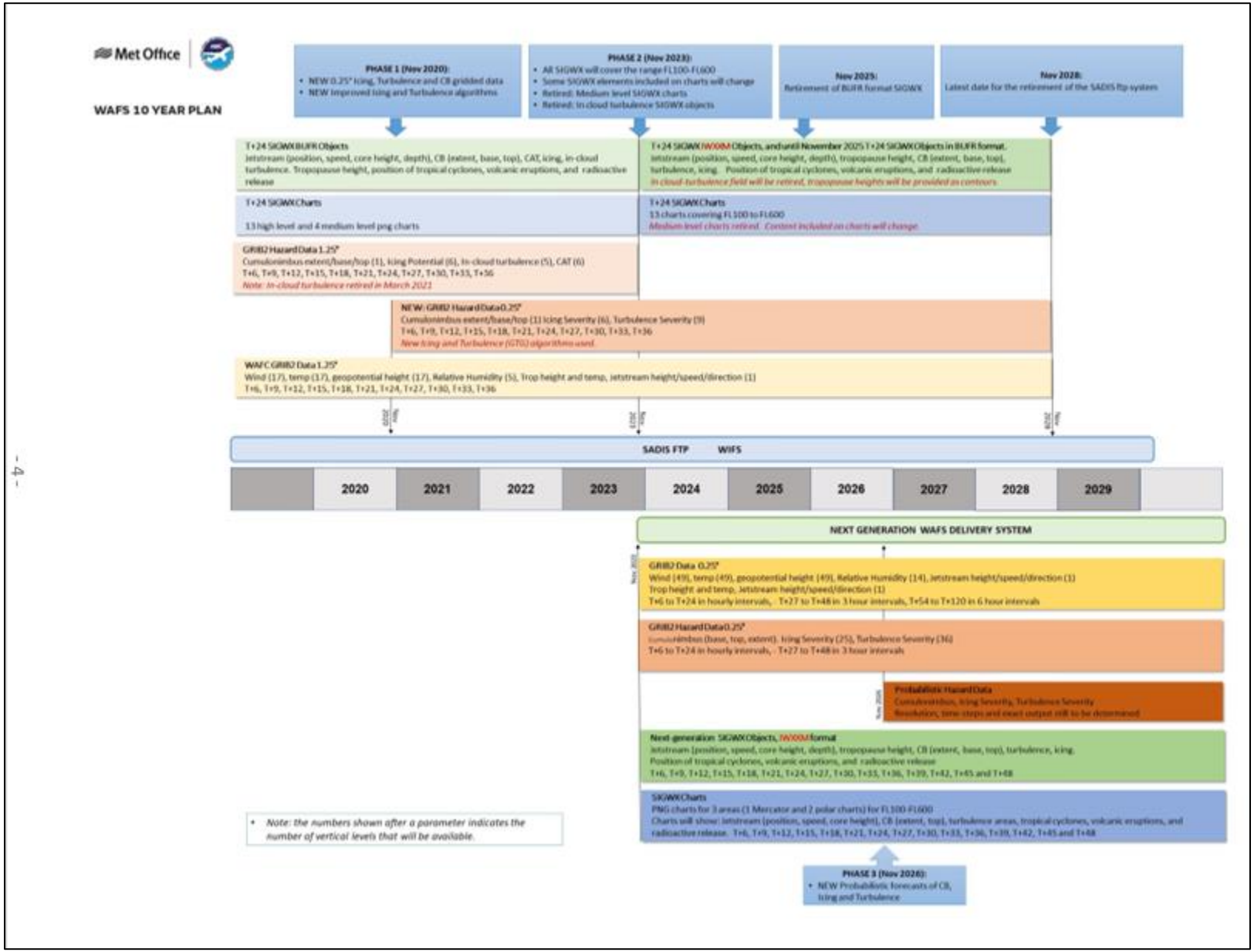
- Implementation of the next generation WAFS (SADIS/WIFS) dissemination system
- Implementation of next generation WAFS SIGWX forecasts
- Cease production of existing "medium level" SIGWX charts
- Continued partial implementation of next generation WAFS grid point forecasts
  - Implement increased horizontal 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 – planned for late 2026

- Full implementation of next generation 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 – planned for late 2028

- Cease production of SIGWX forecasts in PNG format


Met Office
WAFS 10 YEAR PLAN
PHASE 1 (Nov 2020):
• NEW 0.25° Icing, Turbulence and CB gridded data
• NEW Improved Icing and Turbulence algorithms
PHASE 2 (Nov 2023):
• All SIGWX will cover the range FL100-FL600
• Some SIGWX elements included on charts will change
• Retired: Medium level SIGWX charts
• Retired: In cloud turbulence SIGWX objects
Nov 2025:
Retirement of BUFR format SIGWX
Nov 2028:
Latest date for the retirement of the SADIS ftp system
T+24 SIGWX BUFR Objects
Jetstream (position, speed, core height, depth), CB (extent, base, top), CAT, Icing, in-cloud turbulence. Tropopause height, position of tropical cyclones, volcanic eruptions, and radioactive release
T+24 SIGWX IWXXM Objects, and until November 2025 T+24 SIGWX Objects in BUFR format.
Jetstream (position, speed, core height, depth), tropopause height, CB (extent, base, top), turbulence, icing. Position of tropical cyclones, volcanic eruptions, and radioactive release
In cloud turbulence field will be retired, tropopause heights will be provided as contours
T+24 SIGWX Charts
13 high level and 4 medium level png charts
T+24 SIGWX Charts
13 charts covering FL100 to FL600
Medium level charts retired. Content included on charts will change.
GRIB2 Hazard Data 1.25°
Cumulonimbus extent/base/top (1), Icing Potential (6), In-cloud turbulence (5), CAT (6)
T+6, T+9, T+12, T+15, T+18, T+21, T+24, T+27, T+30, T+33, T+36
Note: In-cloud turbulence retired in March 2021
NEW: GRIB2 Hazard Data 0.25°
Cumulonimbus extent/base/top (1) Icing Severity (6), Turbulence Severity (9)
T+6, T+9, T+12, T+15, T+18, T+21, T+24, T+27, T+30, T+33, T+36
New Icing and Turbulence (GTG) algorithms used.
WAFC GRIB2 Data 1.25°
Wind (17), temp (17), geopotential height (17), Relative Humidity (5), Trop height and temp, Jetstream height/speed/direction (1)
T+6, T+9, T+12, T+15, T+18, T+21, T+24, T+27, T+30, T+33, T+36
SADIS FTP
WIFS
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
NEXT GENERATION WAFS DELIVERY SYSTEM
GRIB2 Data 0.25°
Wind (49), temp (49), geopotential height (49), Relative Humidity (14), Jetstream height/speed/direction (1)
Trop height and temp, Jetstream height/speed/direction (1)
T+6 to T+24 in hourly intervals, T+27 to T+48 in 3 hour intervals, T+54 to T+120 in 6 hour intervals
GRIB2 Hazard Data 0.25°
Cumulonimbus (base, top, extent), Icing Severity (25), Turbulence Severity (36)
T+6 to T+24 in hourly intervals, T+27 to T+48 in 3 hour intervals
Probabilistic Hazard Data
Cumulonimbus, Icing Severity, Turbulence Severity
Resolution, time steps and exact output still to be determined
Next-generation SIGWX Objects, IWXXM format
Jetstream (position, speed, core height, depth), tropopause height, CB (extent, base, top), turbulence, icing.
Position of tropical cyclones, volcanic eruptions, and radioactive release
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
SIGWX Charts
PNG charts for 3 areas (1 Mercator and 2 polar charts) for FL100-FL600
Charts will show: Jetstream (position, speed, core height), CB (extent, top), turbulence areas, tropical cyclones, volcanic eruptions, and radioactive release. 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
• Note: the numbers shown after a parameter indicates the number of vertical levels that will be available.
PHASE 3 (Nov 2026):
• NEW Probabilistic forecasts of CB, Icing and Turbulence

Using next generation WAFS information

Next generation 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.

Next generation 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.

Next generation 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.

Next generation WAFS forecasts of turbulence 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.

Next generation WAFS icing 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).

Next generation 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. Next generation 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 next generation 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 H: JOB CARD 10

Additions are shown in highlighted text, whilst deletions are shown with ~~strikethrough~~.

METP.010.03	Further development of the World Area Forecast System (WAFS)
Source	MET Divisional Meeting 2014 (Recommendations 2/2 and 2/3 a) and b)), METP/~~2~~4
Problem Statement	The world area forecast system (WAFS) is a worldwide system established to provide aeronautical meteorological en-route forecasts in uniform standardized formats. The WAFS needs to be maintained and further developed, including the integration of the information provided into the future system wide information management (SWIM), in support of the aviation system block upgrade (ASBU) methodology.
Specific Details	The WAFS provides global aeronautical meteorological en-route WAFS forecasts in digital form to meteorological authorities and other users on a global basis by two Provider States. The WAFS information is made available via the Secure Aviation Data Information Service (SADIS) and the WAFS Internet File Service (WIFS)). Following the recommendation by the MET Divisional Meeting (Recommendations 2/5, 2/5 and 2.12), the METP, in close coordination with WMO, continue to further develop the requirements for the WAFS consistent with the Global Air Navigation Plan (Doc 9750), including the integration of the information produced by the system into the future system wide information management (SWIM) environment. It was further recommended by the MET Divisional meeting (recommendation 2/4 b) iv)) that this includes the development of guidance for States concerning how their ICAO obligations may be met in the context of local, sub-regional, regional, multi-regional and global MET, including cost recovery and governance considerations.
Expected Benefits	The resolution of WAFS gridded data sets will be increased vertically, horizontally and temporally, and SIGWX data will be provided for multiple time-steps in IWXXM format. This will assist aviation users in accurate flight planning, and will be delivered in a way which meets GANP and SWIM objectives. SIGWX forecast provision will be extended to cover multiple time-steps. Probabilistic data sets will enable users to make more informed operating and safety decisions.
Reference Documents	Annex 3 — Meteorological Service for International Air Navigation, Procedures for Air Navigation Services – Meteorology (PANS-MET Doc …) Global Air Navigation Plan (Doc 9750), Manual of Aeronautical Meteorological Practice (DOC 8896), Manual on Coordination between Air Traffic Services, Aeronautical Information Services and Aeronautical Meteorological Services (Doc 9377), Meteorology (MET) Divisional Meeting Report (Doc 10045) Agenda Item 2, Appendices A, B and F, Meteorology Panel (METP) deliverables (through its Working Groups), SADIS User Guide (Part 1 and Part 2), WIFS User Guide and guidance material available at the MOG Website.
Deliverable Expert Group	Meteorology Panel (METP)

ID	Document Affected	Description of Amendment proposal or Action	Supporting Expert Group	Status	Expected Dates		
					Delivery Date	Effective	Applicability
1708	Actions	Assist ICAO in the coordination of the arrangements between the Provider States comprising the WAFS and in ensuring that the global requirements for WAFS information are met.		~~On Schedule~~ On-going			~~Nov 2020~~ Nov 2023
~~10096~~	~~Annex 3~~	~~Develop proposals for inclusion in Amendment 79 to Annex 3 to meet operational requirements in preparation for the operational implementation of the next generation of WAFC services.~~	~~FLTOPSP ATMRPP~~	~~On Schedule~~	~~Q1 2018~~	~~Jul 2020~~	~~Nov 2020~~
	Annex 3	Develop proposals for inclusion in Amendment 81 to Annex 3 to meet operational requirements in preparation for the operational implementation of the next generation of WAFC services.	FLTOPSP ATMRPP	On Schedule	~~Q1~~ Q2 2021	Jul 2023	Nov 2023
	PANS-MET	Develop proposals for the new PANS-MET which reflect the next generation WAFS services.	FLTOPSP ATMRPP	On Schedule	Q2 2021	Jul 2023	Nov 2023
~~9594~~	~~Electronic Air Navigation Plans (eANP)~~	~~Based on Annex 3 amendment, update of the eANPs as necessary~~		~~On Schedule~~	~~Q3 2018~~	~~Nov 2020~~	~~Nov 2020~~
	Actions	Socialise changes to the WAFS and OPMET data sets, and technology changes with the regional ICAO meteorological planning and implementation groups. Assist in providing training sessions where necessary		On Schedule	Q3 2023	Nov 2023	Nov 2023
9596	Manual of Aeronautical Meteorological Practice (Doc 8896)	Update guidance material to support the implementation of Annex 3 Amendment 81		On Schedule	Q3 ~~2018~~ 2021	~~Nov 2020~~ Nov 2023	~~Nov 2020~~ Nov 2023
9597	Manual on Coordination between ATS, AIS and AMS (Doc 9377)	Update guidance material to support the implementation of Annex 3 Amendment 81		On Schedule	Q3 ~~2018~~ 2023	~~Nov 2020~~ Nov 2023	~~Nov 2020~~ Nov 2023
9595	GANP (Doc 9750)	Review latest version of GANP to ensure that WAFC deliverables are on schedule		~~On Schedule~~ On-going	Q3 ~~2018~~ 2023	~~Nov 2020~~ Nov	~~Nov 2020~~ Nov 2023

						2023	
10098	Actions	Increase the horizontal, temporal and vertical resolution of WAFC gridded data in line with the GANP requirements. Deliver scientific improvements to the algorithms used into the production of hazard data sets.		On-schedule	Q4 3 2022 2023	Nov 2022 Nov 2023	Nov 2022 Nov 2023
10099	Actions	Develop the WAFC SIGWX data provision to provide multiple time-steps of data in SWIM compliant IWXXM format		On-schedule	Q4 3 2022 2023	Nov 2022 Nov 2023	Nov 2022 Nov 2023
10097	Annex 3 and PANS-MET	Develop proposals for inclusion in Amendment 80 2 to Annex 3 and PANS-MET regarding the development and provision of probabilistic forecasts to meet operational requirements of users ~~the aviation industry in preparation for the operational implementation of the next generation of WAFC services~~.	FLTOPSP ATMRPP	On Schedule	Q3 ~~2020~~ 2026	~~Jul 2022~~ Jul 2026	~~Nov 2022~~ Nov2026

Status:	Priority:	Initial Issue Date:	Date Approved by ANC:	Session / Meeting:
Approved		17 Jun 2015	12 March 2019	210-8