International Civil Aviation Organization

STUDY NOTE

METPWGMOG/7/SN/12
11/04/18

MEETING OF THE METEOROLOGY PANEL (METP) WORKING GROUP MOG (WAFS)

SEVENTH MEETING

Offenbach, Germany, 11 to 13 April 2018

Agenda Item **3.3: Work required in support of WAFS Developments**
3.3.2 Matters relating gridded WAFS products

NEXT GENERATION WAFS GRIDDED FORECAST PRODUCTION

(Presented by the WAFC Provider States)

SUMMARY

The WAFCs have developed plans on how to deliver gridded forecasts fit for the next 10+ years through the introduction of new forecast algorithms and higher resolution grids.

This Study Note references information papers that provide more details on the changes, and then introduces the SARPS necessary to enable the changes.

Action by the METP-WG/MOG is in paragraph 4.

1. INTRODUCTION

1.1 The 2014 ICAO/WMO Meteorological Divisional Meeting and subsequent METPMOG meetings have set requirements for improvements to the WAFS grids. These requirements include increases in resolution and changes to the parameters being forecast.

1.2 The increases in resolution will result in file sizes that are not able to be handled by the current generation of WIFS and SADIS. Increased capabilities are discussed in IP11.

1.3 The changes to the grids will be phased into effect so as to not overwhelm the existing systems.

1.4 Necessary updates to Annex 3 are included in the Appendices of this Study Note.

2. DISCUSSION

2.1 Over the past 10 years, feedback has been provided to the WAFCs by States, IFALPA and IATA about the WAFS Grids not fully meeting the emerging needs of the aviation industry. Three main issues were identified:

- The low resolution grids do not fully resolve wind and temperature changes around sharp and/or fast moving troughs and ridges. They also do not fully resolve Cumulonimbus (Cb), turbulence and icing hazards.

- The turbulence and icing potential fields do not provide information about the severity of the hazards.

- Probabilistic hazard information is necessary in modern risk management applications.

2.2 The current 1.25 degree WAFS grids are based on global computer models that run at 10-13 kilometres, which is about 0.12 degrees. The output of these models is downscaled to 1.25 degrees in order to limit the size of the WAFS data files.

2.3 Testing has shown that a good compromise between resolving features and limiting file size is a horizontal resolution of 0.25 degrees. However, even this resolution results in file sizes that are up to 20 times larger than the current files. For this reason, the WAFCs will phase in resolution increases, matching the increases to increased SADIS/WIFS dissemination capabilities.

2.4 The first phase, due in November 2020, will be an increase in the resolution of the hazard grids to 0.25 degrees. Coupled with this increase, will be the replacement of turbulence and icing potential with turbulence and icing severity information. More details can be found in IP12. The associated changes to Annex Three can be found in Appendix A of this Study Note.

2.5 The second phase, due in November 2022, will be an increase in the horizontal resolution of all WAFS grids, plus the addition of several new vertical levels and time steps. More details can be found in IP13. The associated changes to Annex Three can be found in Appendix B of this Study Note.

2.6 Due to massive increases in file sizes, up to 200 times, this second phase cannot happen without improvements to the SADIS/WIFS dissemination capability. These services need to be moved to a cloud-like service that allows users to selectively receive only the data that they need, which will eliminate the need to download the entire dataset. More information about these service improvements can be found in IP11.

2.7 Appendix B details the changes needed to Annex 3 that are associated with the November 2022 improvements. It is premature for the METP/4 to endorse or approve the specific edits to Annex 3 for Amendment 80, but they are being presented to this meeting to illustrate the magnitude of the changes. It is expected that METP/5 will formally address these changes. It is possible that the content in Appendix B will be considered for the new Procedures for Air Navigation Services – Meteorological Information (PANS-MET), which is planned for late 2022.

2.8 Probabilistic forecasts for Cb, icing and turbulence are also being developed. The WAFCs will make this data available in test format by the 2022 time frame, if not sooner. The exact format will depend on the capabilities of the new SADIS and WIFS systems. Further discussion is available in IP14.

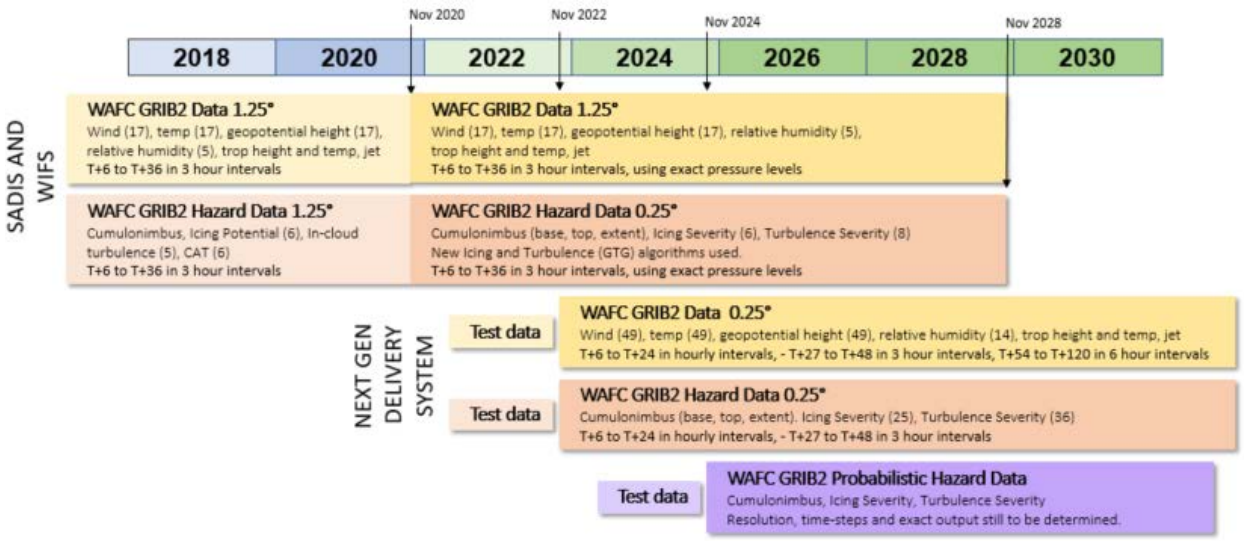
2.9 The WAFS Roadmap, last updated in 2016, calls for the provision of turbulence type forecasts in ASBU 1. Preliminary research on turbulence type forecasting indicates that it is possible to determine the difference between Clear Air Turbulence (CAT) and Mountain Wave Turbulence (MWT), but it may not be possible to provide forecasts of Convectively Induced Turbulence. This is due to a number

of factors, such as correctly predicting convection location, then predicting whether or not gravity waves will propagate from it, and in what direction. Given the small scale of such events, and lack of direct observational data, it may not be possible to tune an algorithm to forecast them. At this time, the WAFCs plan to continue working towards providing a turbulence type, even if it may be limited to only discerning between MWT or CAT.

2.10 WG-MOG/4 SN/25 "WAFS Medium Term Strategy 2018 to 2023" introduced the idea of using precise pressure levels in the calculation of flight levels to avoid the use of approximations that are currently in use. Information Paper 15 describes the planned changes.

2.11 At present, the upper limit to WAFC wind and temperature data is FL530. Study Note 13 invites the to consider whether METP-WG/MRI should be invited to determine future requirements that may arise from aviation users operating up into the stratosphere.

2.12 A timeline showing the planned changes and improvements to the provision of WAFS gridded forecast information is shown below.



3. CONCLUSION

3.1 In order for the WAFCs to deliver the next generation of WAFS Gridded Forecasts that the aviation industry requires, changes will be needed to SADIS and WIFS. The Annex 3 will also need to be updated.

3.2 Given that the WAFCs cannot move forward without better dissemination systems, the group is invited to consider the information in IP11.

3.3 The group is also invited to consider recommending to the MET Panel that it endorse the Annex 3 changes detailed in Appendix A.

Action 7/xx — Amendment 79 to Annex 3 (WAFS Gridded Forecasts)

That the proposed updates to Annex 3 for Amendment 79 relating to the provision of WAFS gridded forecast information, as shown in Appendix A, be presented at METP/4 for endorsement.

4. ACTION BY THE METP-WG/MOG

4.1 The METP-WG/MOG is invited to:

a) note the information contained in this paper; and

b) agree on the draft action presented in 3.3.

Appendix A

Annex 3 changes needed in Amendment 79 (2020 WAFS Improvements)

(New text to Annex 3 for Amendment 79 is shaded in grey.

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

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

(See Chapter 3 of this Annex.)

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1. WORLD AREA FORECAST SYSTEM

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1.2 Upper-air gridded forecasts

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

1.2.2 The grid point forecasts prepared by a WAFC shall comprise:

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

b) flight level and temperature of tropopause;

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

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

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

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

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

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

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

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

Note.— The exact pressure levels (hPa) for a), d), f), g), and i) is provided in the Manual of Aeronautical Meteorological Practice *(Doc 8896).*

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

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

1.2.4 The foregoing grid point forecasts a) through d) and h) shall be prepared by a WAFC in a regular grid with a horizontal resolution of 1.25° of latitude and longitude.

1.2.5 The foregoing grid point forecasts e) through g) shall be prepared by a WAFC in a regular grid with a horizontal resolution of 0.25° of latitude and longitude.

…

— END —

Appendix B

Annex 3 changes needed in Amendment 80 (2022 WAFS Improvements)

- New text to Annex 3 for Amendment 79 is shaded in grey.
- Deleted text for Amd 79 is shown with red ~~strikeout~~
- PANS-MET 2022:
  - Entire section, including tables to the PANS-MET
  - New text for 2022 is in blue (without strikeout)
  - Deleted text for 2022 is in blue ~~strikeout~~.

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1. WORLD AREA FORECAST SYSTEM

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1.2 Upper-air gridded forecasts

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

1.2.2 The grid point forecasts prepared by a WAFC shall comprise, in accordance with Table X-3 and X-4:

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

b) flight level and temperature of tropopause;

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

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

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

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

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

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

~~*Note 1.— Layers centred at a flight level referred to in f) and h) have a depth of 100 hPa.*~~

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

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

~~*Note.— The exact pressure levels (hPa) for a), d), f), g), and i) is provided in the* Manual of Aeronautical Meteorological Practice *(Doc 8896)*~~.

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

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

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

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

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

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

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

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

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

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Wind	Temperature	Turbulence	Icing	Humidity
FL050	5000	843.1	X	X			X
FL060	6000	812.0	X	X		X	X
FL070	7000	781.9	X	X		X	X
FL080	8000	752.6	X	X		X	X
FL090	9000	724.3	X	X		X	X
FL100	10000	696.8	X	X	X	X	X
FL110	11000	670.2	X	X	X	X	X
FL120	12000	644.4	X	X	X	X	X
FL130	13000	619.4	X	X	X	X	X
FL140	14000	595.2	X	X	X	X	X
FL150	15000	571.8	X	X	X	X	X
FL160	16000	549.2	X	X	X	X	X
FL170	17000	527.2	X	X	X	X	X
FL180	18000	506.0	X	X	X	X	X
FL190	19000	485.5	X	X	X	X	
FL200	20000	465.6	X	X	X	X	
FL210	21000	446.5	X	X	X	X	
FL220	22000	427.9	X	X	X	X	
FL230	23000	410.0	X	X	X	X	
FL240	24000	392.7	X	X	X	X	
FL250	25000	376.0	X	X	X	X	
FL260	26000	359.9	X	X	X	X	
FL270	27000	344.3	X	X	X	X	
FL280	28000	329.3	X	X	X	X	
FL290	29000	314.9	X	X	X	X	
FL300	30000	300.9	X	X	X	X	
FL310	31000	287.4	X	X	X		
FL320	32000	274.5	X	X	X		
FL330	33000	262.0	X	X	X		
FL340	34000	250.0	X	X	X		
FL350	35000	238.4	X	X	X		
FL360	36000	227.3	X	X	X		
FL370	37000	216.6	X	X	X		
FL380	38000	206.5	X	X	X		
FL390	39000	196.8	X	X	X		
FL400	40000	187.5	X	X	X		
FL410	41000	178.7	X	X	X		

FL420	42000	170.4	X	X	X		
FL430	43000	162.4	X	X	X		
FL440	44000	154.7	X	X	X		
FL450	45000	147.5	X	X	X		
FL460	46000	140.6	X	X			
FL470	47000	134.0	X	X			
FL480	48000	127.7	X	X			
FL490	49000	121.7	X	X			
FL500	50000	116.0	X	X			
FL510	51000	110.5	X	X			
FL520	52000	105.3	X	X			
FL530	53000	100.4	X	X			

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

Flight Level	Geopotential Altitude (FT)	ICAO Standard Atmosphere pressure level (hPa)	Wind	Temperature	Humidity
FL050	5000	843.1	X	X	X
FL080	8000	752.6	X	X	X
FL100	10000	696.8	X	X	X
FL140	14000	595.2	X	X	X
FL180	18000	506.0	X	X	X
FL210	21000	446.5	X	X	
FL240	24000	392.7	X	X	
FL270	27000	344.3	X	X	
FL300	30000	300.9	X	X	
FL320	32000	274.5	X	X	
FL340	34000	250.0	X	X	
FL360	36000	227.3	X	X	
FL390	39000	196.8	X	X	
FL410	41000	178.7	X	X	
FL450	45000	147.5	X	X	
FL480	48000	127.7	X	X	
FL530	53000	100.4	X	X	

— END —