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# INTERNATIONAL CIVIL AVIATION ORGANIZATION

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## Use of Turbulence Information and the World Area Forecast System (WAFS) Enhancements

Second Meeting of the North American, Central American and Caribbean Working  
Group (NACC/WG) Aeronautical Meteorology (MET) Task Force (TF) (MET/TF/02)  
Mexico City, 27 February to 1 March 2024

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Presented by

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and

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# Turbulence Forecasts

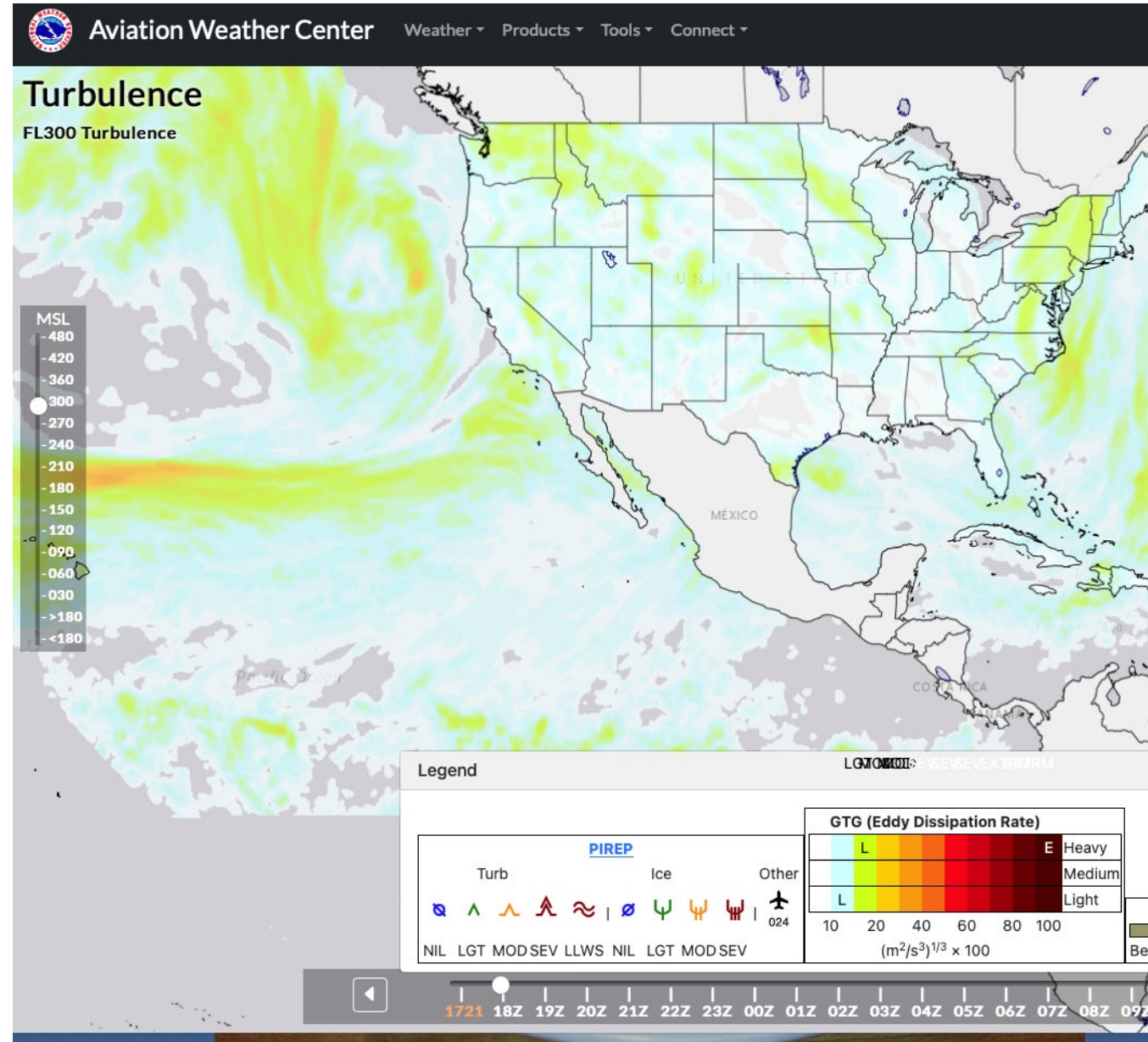
- The U.S. National Weather Service (NWS) and ICAO's WAFS turbulence forecasts are based on the U.S. National Science Foundation's National Center for Atmospheric Research (NCAR) Graphical Turbulence Guidance (GTG) algorithm and forecast system
- GTG has evolved over the past 20+ years and was included in the WAFS forecasts in 2013
  - During a 10-year period (2004-2013) 128.3 million United Airline (UAL) B-737 and B-757 (medium-sized aircraft) EDR reports were recorded and used to improve the GTG forecasts

# Eddy Dissipation Rate (EDR)

- The GTG is expressed in terms of EDR
- EDR is an aircraft-independent measure of turbulence. However, the relationship between the EDR value and the perception of turbulence is a function of aircraft type and the mass, altitude, configuration and airspeed of the aircraft.
- From Annex 3 (Appendix 4):
  - Turbulence for medium-sized aircraft (e.g. B-737):
    - Severe when the peak value of EDR equals or exceeds 0.45
    - Moderate when the peak value of EDR is equal to or above 0.20 and below 0.45
    - Light when the peak value of EDR is above 0.10 and below 0.20
    - Nil when the peak value of EDR is below or equal to 0.10

# GTG Turbulence Forecasts

- Can be viewed on NWS Aviation Weather Center's webpage
- <https://aviationweather.gov/gfa/#turb>
- The domain is the US and adjoining ocean waters. It does cover the Caribbean but is blanked out over Mexico, Central and parts of South America



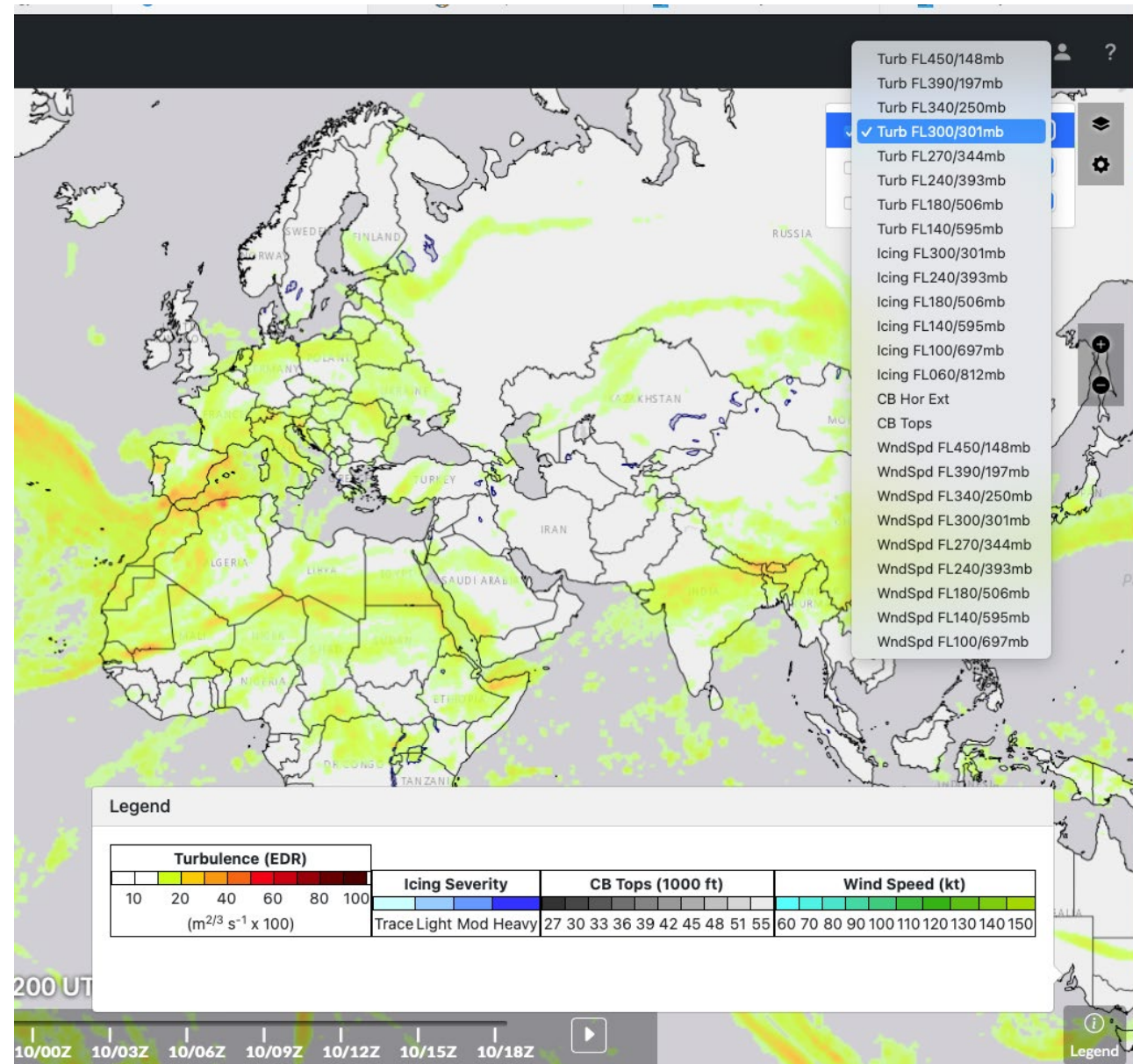


# WAFS Forecasts

- WAFS grid point forecasts are used for flight planning
- The full suite of grid point forecasts is available through the WAFS Internet File Service (WIFS)
- A subset of the WAFS grid point forecasts can be viewed on the NWS Aviation Weather Center's webpage
  - <https://aviationweather.gov/wafs/>
- WAFS forecasts also include Significant Weather (SIGWX) charts

# Current WAFS Grid webpage

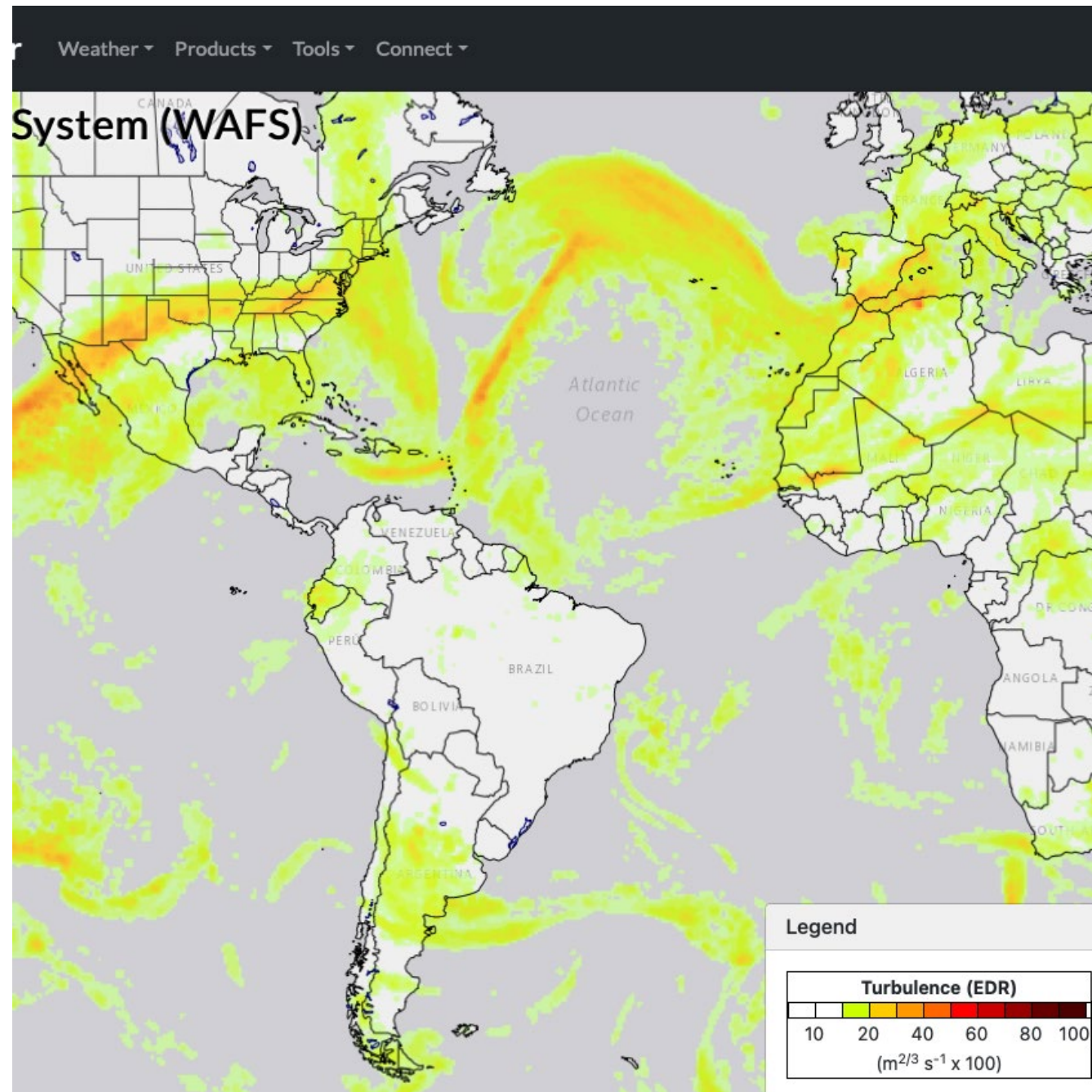
- Operated by NWS Aviation Weather Center and WAFC Washington
- <https://aviationweather.gov/wafs/>
- Global display of:
  - Upper-air winds
  - Turbulence
  - Icing
  - Cumulonimbus (CB) cloud coverage and CB tops
- Pull down menu to select up to 3 products can be displayed
- Slider bar on the bottom to select valid times
- Webpage will be updated in late 2024 when new WAFS forecasts become operational





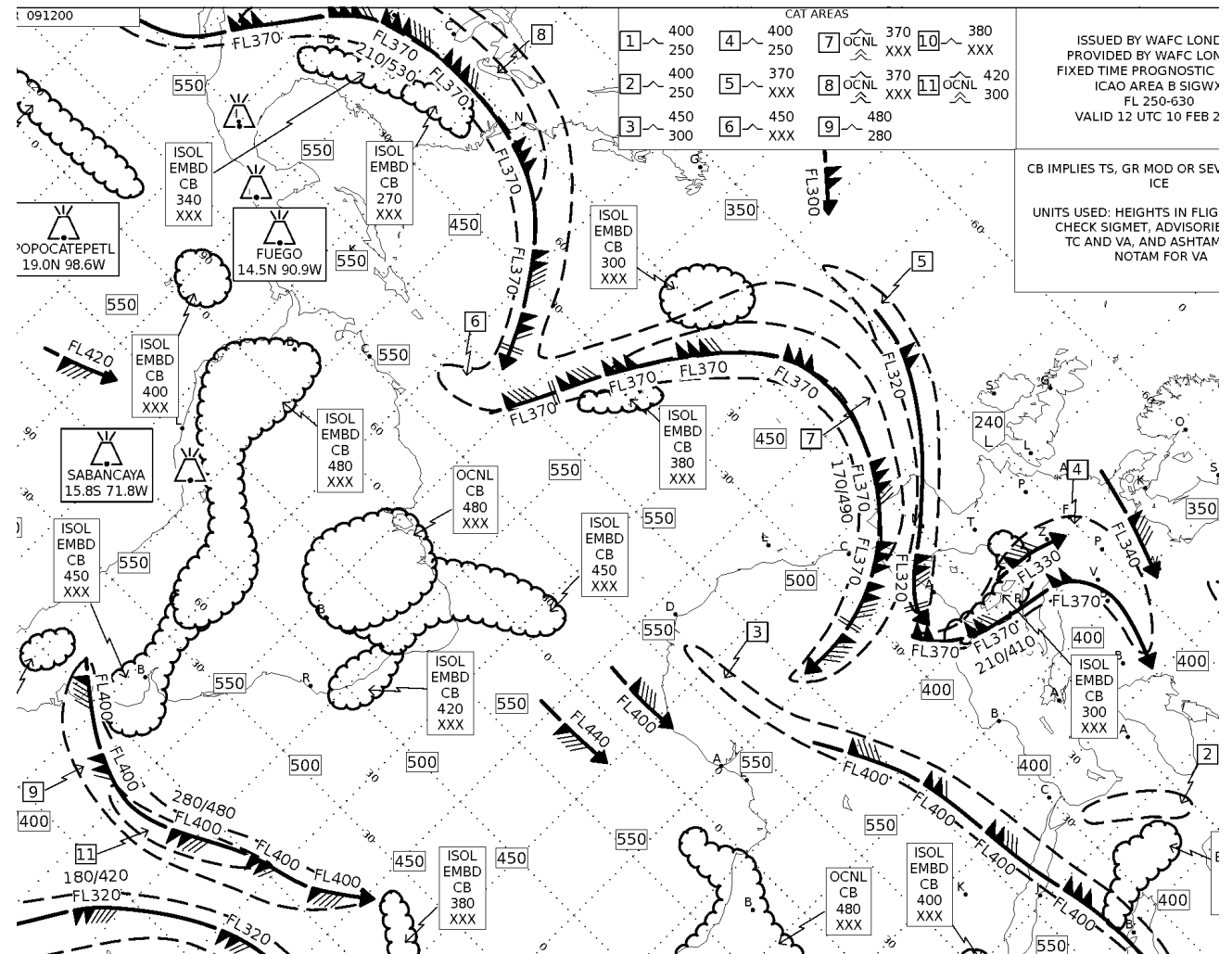
# WAFS Grid Point Turbulence Forecasts

- Intensity is expressed in terms of EDR
- Currently provides forecasts valid at 6, 12, 18, 21, 24, 27, 30, 33 and 36 hours



# Current Significant Weather (SIGWX) charts

- Operated by NWS Aviation Weather Center and WAFC Washington
- <https://aviationweather.gov/fax/>
- Current SIGWX charts depict a 24-hour forecast of:
  - Jet stream
  - Turbulence (above FL250)
  - Cumulonimbus (CB) clouds
  - Tropopause height
  - Location of erupting volcanoes
  - Tropical cyclones
- Webpage will be updated in late 2024 when new WAFS forecasts become operational



# WAFS Enhancements

- WAFS grid point forecasts will get a large upgrade:
  - Many more vertical levels
  - More forecast timesteps
  - Finer grid point resolution
- WAFS SIGWX forecasts will also get a large upgrade
  - Increased vertical level
  - More forecast timesteps
- These changes are expected to be implemented in November 2024.

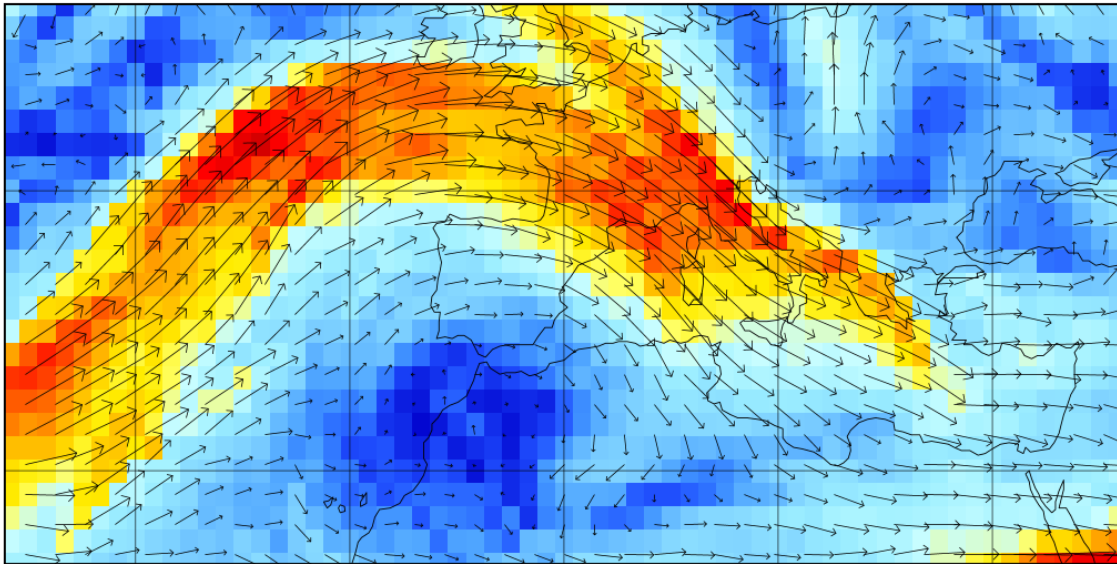
# WAFS grid point forecasts

- The new data will all be provided at 0.25 degree horizontal resolution.
- The 1.25 degree wind, temperature, relative humidity, and tropopause and geopotential height data will still be provided for the levels and timesteps produced now (T+6 to T+36 at 3 hourly intervals)

# WAFS grid point forecasts

*Current 1.25 degree resolution*

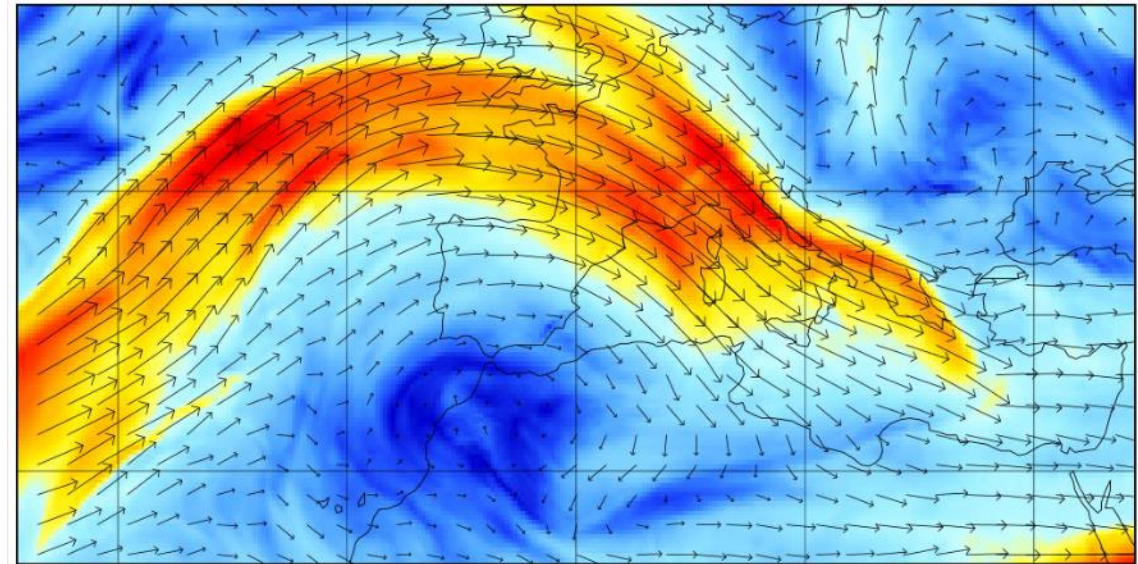
wind vector @ FL300 (300hPa)



$\text{Sqrt}[(\text{u-component of wind @ Isobaric surface})^2 + (\text{v-component of wind @ Isobaric surface})^2]$   
0.0 24.0 48.0 72.0 96.0 120.0 40.0  
Data Min = 1.3, Max = 109.0

*New 0.25 degree resolution*

wind vector @ FL300 (300.9hPa)



$\text{Sqrt}[(\text{u-component of wind @ Isobaric surface})^2 + (\text{v-component of wind @ Isobaric surface})^2]$   
0.0 24.0 48.0 72.0 96.0 120.0 40.0  
Data Min = 0.0, Max = 113.2

# New WAFS grid point forecasts

<i>Upper-air grid point forecasts</i>	<i>1-hourly intervals</i>	<i>3-hourly intervals</i>	<i>6-hourly intervals</i>
Wind (56), temperature (56), geopotential altitude (56)	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 (14)			
Cumulonimbus extent, base and top	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 (26)			
Turbulence (36)			

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

*The number in blue shows the number of vertical levels that will be available.*

# WAFS Grid point forecasts

Flight Level	ICAO Standard Atmosphere pressure level (hPa)	Geopotential Altitude	Wind	Temperature	Turbulence Severity	Icing Severity	Humidity
FL050	843.1	X	X	X		X	X
FL060	812.0	X	X	X		X	X
FL070	781.9	X	X	X		X	X
FL080	752.6	X	X	X		X	X
FL090	724.3	X	X	X		X	X
FL100	696.8	X	X	X	X	X	X
FL110	670.2	X	X	X	X	X	X
FL120	644.4	X	X	X	X	X	X
FL130	619.4	X	X	X	X	X	X
FL140	595.2	X	X	X	X	X	X
FL150	571.8	X	X	X	X	X	X
FL160	549.2	X	X	X	X	X	X
FL170	527.2	X	X	X	X	X	X
FL180	506.0	X	X	X	X	X	X
FL190	485.5	X	X	X	X	X	
FL200	465.6	X	X	X	X	X	
FL210	446.5	X	X	X	X	X	
FL220	427.9	X	X	X	X	X	
FL230	410.0	X	X	X	X	X	
FL240	392.7	X	X	X	X	X	
FL250	376.0	X	X	X	X	X	
FL260	359.9	X	X	X	X	X	
FL270	344.3	X	X	X	X	X	
FL280	329.3	X	X	X	X	X	
FL290	314.9	X	X	X	X	X	
FL300	300.9	X	X	X	X	X	
FL310	287.4	X	X	X	X		
FL320	274.5	X	X	X	X		
FL330	262.0	X	X	X	X		
FL340	250.0	X	X	X	X		
FL350	238.4	X	X	X	X		
FL360	227.3	X	X	X	X		
FL370	216.6	X	X	X	X		
FL380	206.5	X	X	X	X		

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

Data shown in blue is what is currently available.

Note: Data will be produced for exact pressure levels e.g. 392.7hPa for FL240 instead of the current 400hPa

# Enhanced WAFS SIGWX

- SIGWX forecasts will be produced for more than just a 24-hour forecast
- New SIGWX forecasts will be valid at 3-hourly periods from 6-hours to 48
  - 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 36, 39, 42, 45 and 48-hours
- The new SIGWX forecasts will extend from FL100 to FL600





# Other Turbulence Information

- IATA's Turbulence Aware

- <https://www.iata.org/en/services/statistics/safety-data/turbulence-platform/>
- A global, industry-wide, data exchange platform, Turbulence Aware receives the existing airline data from ground servers, performs quality control, deidentifies data, and provides the data back to airlines via a ground-to-ground system-to-system connection.
- Integration with in-house or third-party flight planning or in-flight weather tools – To speed up decision-making
- The website indicates that there are 15 participating airlines
- A demonstration can be requested from IATA (refer to the website)

# Other Turbulence Information

- IATA's Annual Safety Report (2022)
  - <https://www.iata.org/contentassets/95e933e1ad794068812f073cf883cb08/recommendations-for-accident-prevention-in-aviation.pdf>
- IATA's Interactive Safety Report
  - <https://www.iata.org/en/publications/safety-report/interactive-safety-report/>

Questions