# World Area Forecast System (WAFS) probabilistic forecasts

## Deterministic vs probabilistic?

The traditional deterministic forecasting approach gives a single forecast that can be used for decision making. In reality no meteorological model is perfect, and by adding in small variations in the starting conditions and running the model multiple times, it is possible to see what the spread is in the data. This allows the uncertainty to be assessed and the probability of particular events occurring to be determined. For example, large spread in turbulence solutions means more uncertainty and a lower probability of a turbulence event occurring.

It is anticipated that by integrating probabilistic forecasts into their operational planning activities operators would derive information that enables more effective flight-planning and en-route decision-making which would in turn deliver associated benefits to the safety and efficiency of operations.

**The World Area Forecast Centres (WAFCs) plan to introduce initial probabilistic forecasts of icing, turbulence and cumulonimbus in November 2028.** All of the data sets described below will be provided for T+6 to T+48 at 3-hourly intervals, and at a 0.5 degree horizontal resolution.

Table 1 gives a summary of the data that will be provided.

| Parameter | Flight Levels |
|---|---|
| **Turbulence** | |
| Probability of exceeding EDR value ≥0.45 | FL240, FL270, FL300, FL340, FL390, FL450 |
| Probability of exceeding EDR value ≥0.20 | |
| **Icing** | |
| Probability of MOD or greater severity | FL050, FL100, FL140, FL180, FL240 |
| **Cumulonimbus** | |
| Probability of CB tops exceeding FL300 | |
| Probability of CB tops exceeding FL350 | |
| Probability of CB tops exceeding FL400 | |

*Table 1 – Probabilistic WAFS data sets to be introduced in November 2028*

To maximise the potential benefits of probabilistic forecasts operators and other users of WAFC forecasts should ensure: -

- That all relevant personnel, and particularly flight crew and operations control staff are briefed on the introduction of probabilistic forecasts, and provided with training appropriate to their role; and

- That applicable software and systems used for flight planning and in-flight applications are updated as required, and

- That, where applicable, users implement systems that can process and visualise the new probabilistic data, to help realise the benefits described in the document below.

If you have questions or feedback in relation to the information in this document, please e-mail them to SADISmanager@metoffice.gov.uk

## Probabilistic Icing Forecasts

The current (deterministic) WAFS icing forecast provides a categorical assessment of the icing intensity. An example is shown in Figure 1.

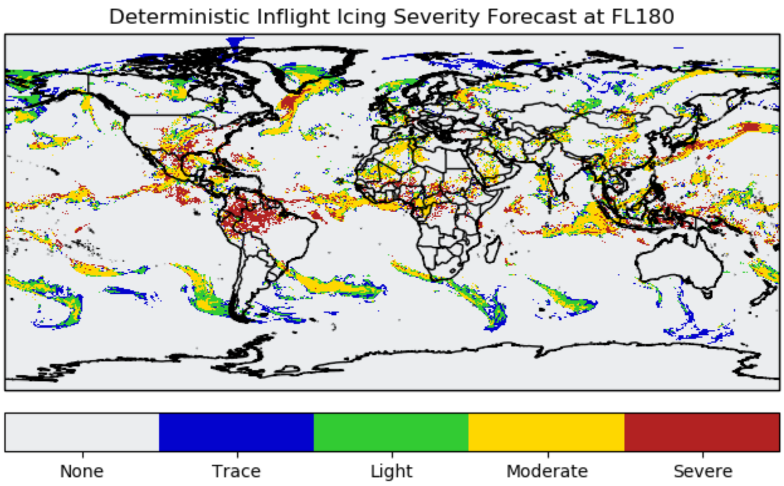


*Figure 1 – Global icing Severity forecast, at FL180.*

The probabilistic icing forecasts will indicate the likelihood that the icing intensity will be "moderate or greater". An example probabilistic forecast, alongside the deterministic forecast valid at the same date/time is shown in Figure 2

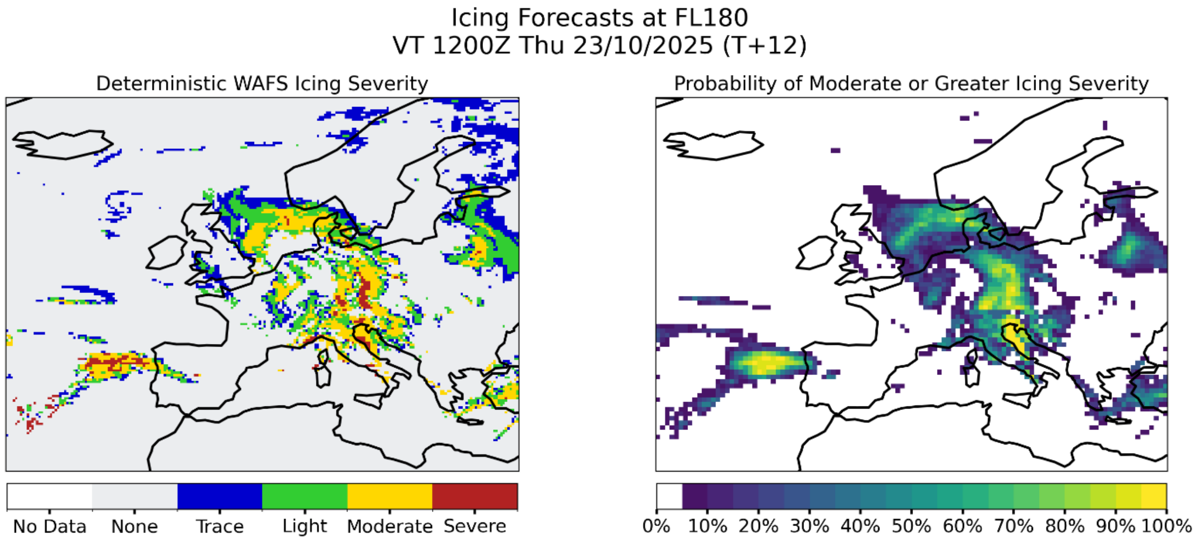


*Figure 2 – deterministic (left) and probabilistic icing forecast at FL180, valid on 23 October 2025.*

Probabilistic Icing forecasts will be provided initially for five levels: FL050, FL100, FL140, FL180 and FL240.

IATA provided the following expected benefits of probabilistic icing forecasts to the global aviation industry:

- *For the many regional operations which operate in the 5000-20000ft vertical range, the provision of probabilistic icing forecasts will provide operators to identify pre-flight areas where dangerous conditions exist to the aircraft. This will support the airline with significant pre-flight options as to how the flight can be safely planned with an optimised fuel load.*

- *For planning ETOPs operations, use of pre-flight, probabilistic icing forecasts will improve the integrity and provide the opportunity to potentially improve the efficiency of the ETOPS planning for operations where widespread icing conditions are forecast to exist.*

## Probabilistic Turbulence Forecasts

At present the WAFS data sets include a deterministic turbulence severity field which uses the Graphical Turbulence Guidance (GTG) algorithms developed by the National Centre for Atmospheric Research in the United States. It forecasts clear air turbulence, turbulence caused by horizontal wind shear and orographic wind shear as an "Eddy Dissipation Rate (EDR)" which is an aircraft independent measure of turbulence. The higher the EDR, the more turbulent the atmosphere. An example showing a deterministic forecast of severe turbulence (i.e., an EDR ≥0.45) is shown in Figure 3.

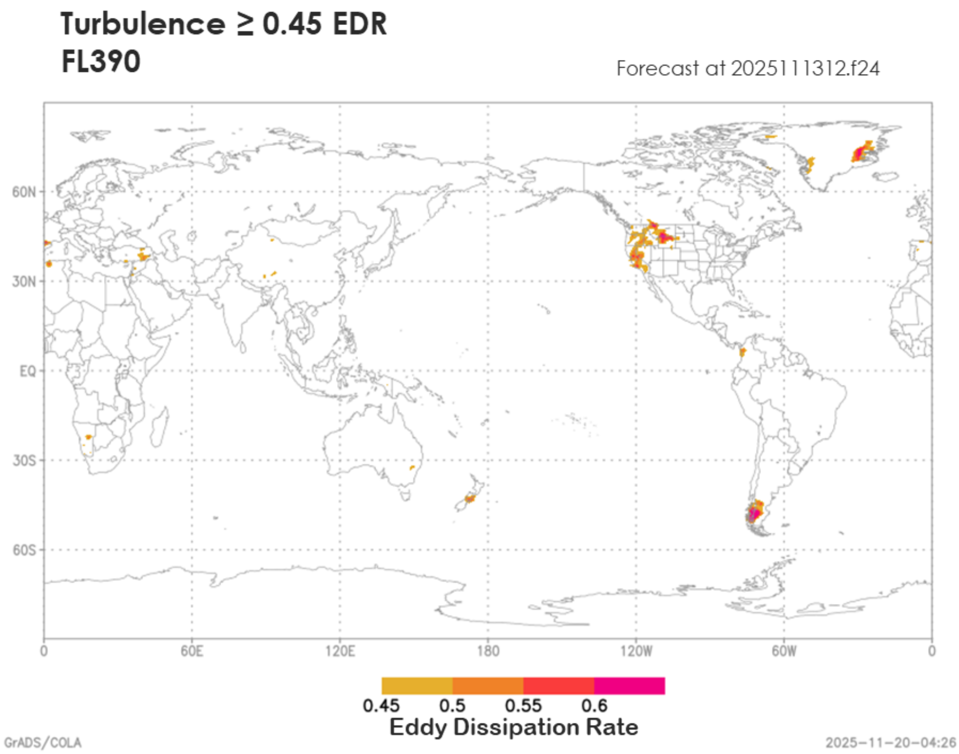


*Figure 3 – Deterministic Turbulence Severity forecast (EDR ≥ 0.45 at FL390).*

ICAO Doc 10157 - Annex 3 – Procedures for Air Navigation Services Meteorology (PANS-MET) paragraph 3.1.4.6.2 contains information that relates turbulence for a medium sized aircraft to a particular EDR. Information for other sizes of aircraft has not been published, but for a particular EDR value, the physical impact will be greater on a small aircraft and lesser on a large/heavy aircraft.

The initial probabilistic turbulence offering will use the thresholds in ICAO Annex 3, and therefore will give the likelihood that the EDR value will be ≥0.2 (moderate),and ≥0.45 (severe).

Figure 4 shows an example of the probabilistic turbulence forecast valid at the same time/level as Figure 3. In figure 4 it is possible to see a couple of areas where turbulence wasn't forecast in the deterministic forecast (e.g., Asia and South America), but that might warrant attention since there is nonzero risk of severe or greater turbulence happening within the ensemble, but not in the deterministic control member.

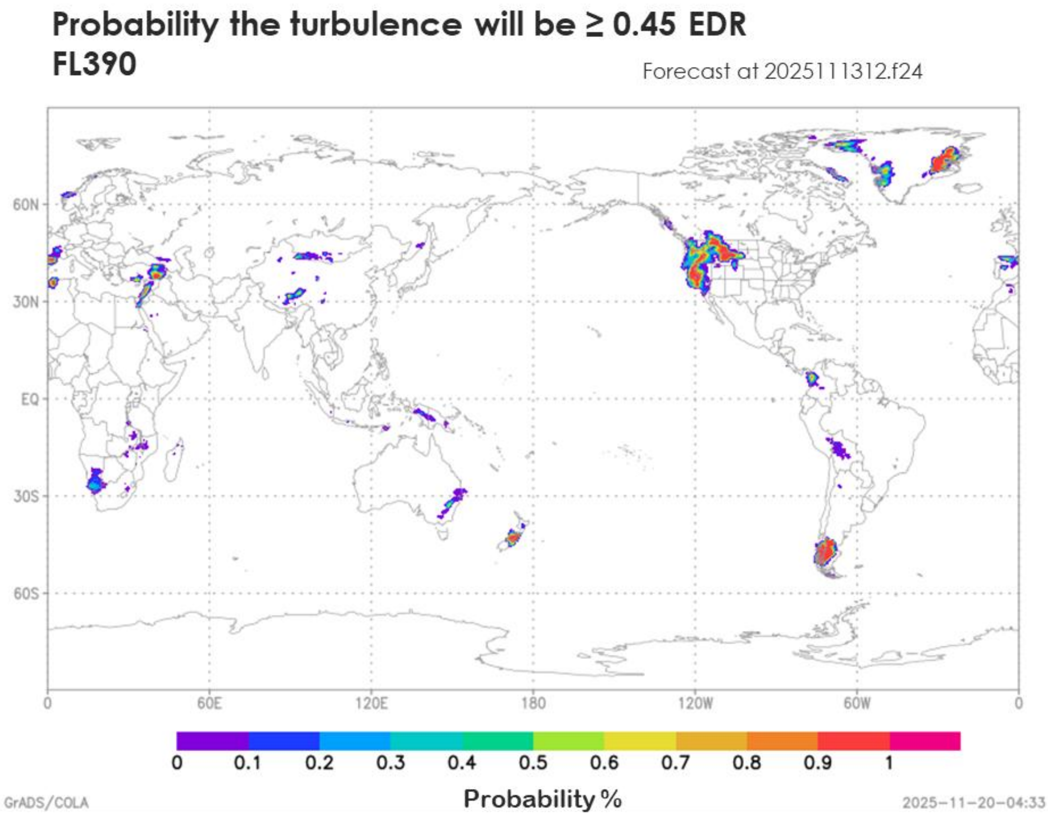


Figure 4: P*robabilistic turbulence forecast at FL390 indicating the likelihood that the EDR will be ≥0.45.*

IATA anticipates the following expected benefits of probabilistic turbulence forecasts:

- *Given the expected airspace conditions into the future and initiatives such as trajectory-based operations, it will be important for continuously improving probabilistic data for turbulence be available for each phase of flight. In the future this is expected to become increasingly specific relative to the actual forecast EDR. This improved probabilistic forecast information will support airlines to better identify areas of risk to the fuel burn. In addition, used with performance-based flight planning systems, this temporal probabilistic information will improve the decision making around the pre-flight horizontal and vertical tracking of aircraft.*
- *This information will also assist pilots to better identify areas of turbulence to support their flight management of onboard services such as food cart service timings and seat belt actions for both passengers and crew.*
- *Significantly, the use of probabilistic forecasts will support the airline to identify threats and better manage the associated risks. Importantly, the pre-flight fuel load will improve the ability of the airline to optimise for the enroute conditions.*
- *This pre-flight information will then dovetail into the tactical severe weather environment supporting pilots to improve their awareness and management of changes in enroute conditions.*

## Probabilistic Cumulonimbus Forecasts

The existing WAFS data sets include three deterministic cumulonimbus (CB) cloud fields: CB extent, CB base and CB top.

Figure 5 shows an example of existing WAFS CB extent and top data (which in this plot ranges from 25,000ft to above 50,000ft). It can be used to see where CB are forecast to be and how high into the atmosphere they extend.

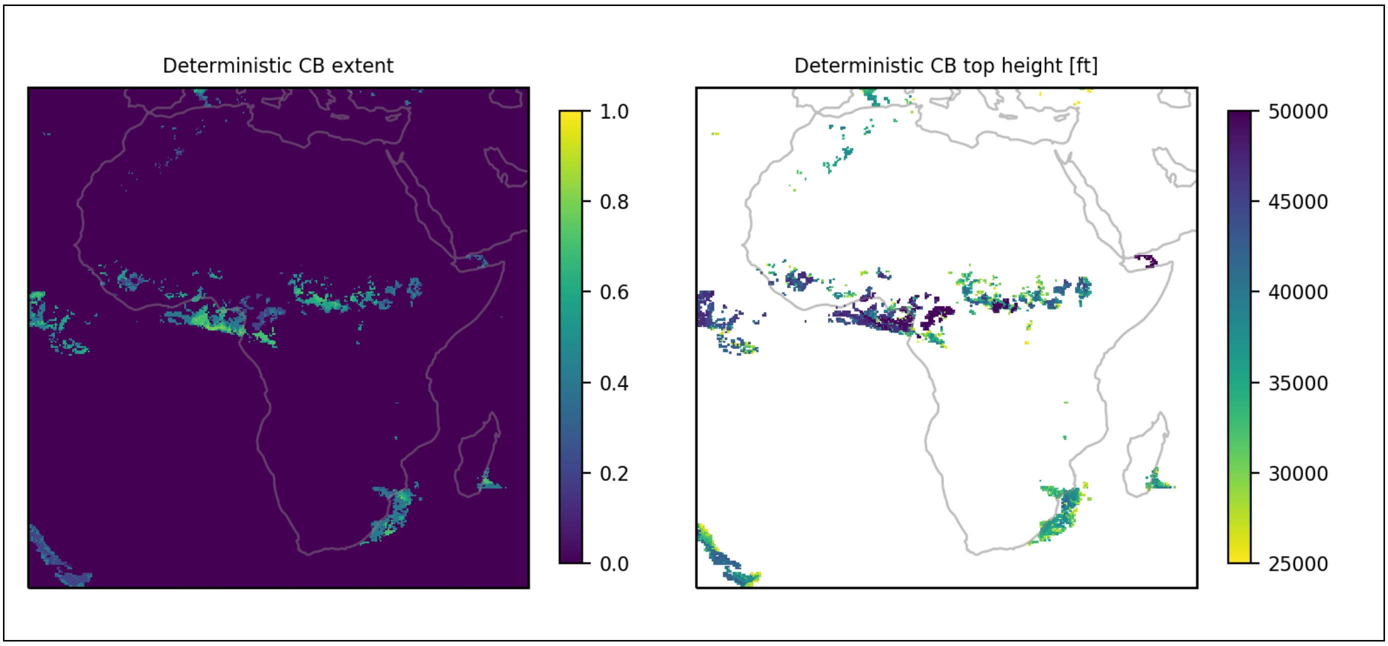


*Figure* 5 – Deterministic CB extent and CB top forecast

Figure 6 shows the probability of the CB top heights extending above a particular threshold value, in this case 30,000ft, alongside its corresponding deterministic plot. This type of information could allow informed decisions to be made in line with the user's risk appetite.

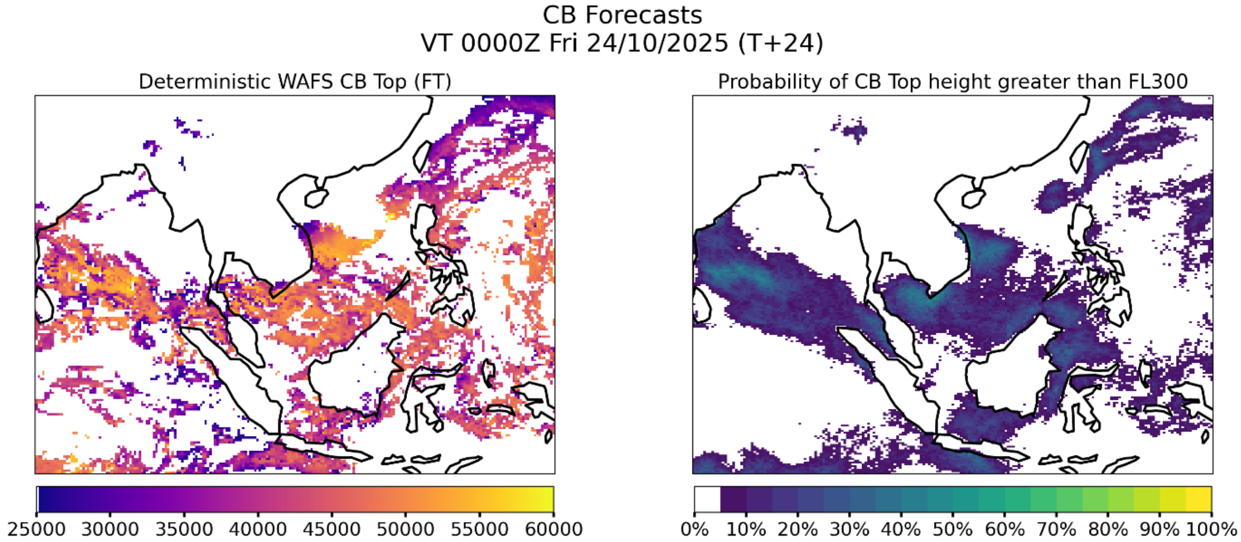


*Figure 6 – Deterministic (left) cumulonimbus cloud top height and (right) probability that the CB tops will exceed FL300, valid at the same time.*

Similar to other probabilistic forecasts to be provided to global aviation partners, IATA anticipates the following implementation benefits:

- *Cumulonimbus (CB) areas are highly dynamic and can significantly affect flight safety and fuel consumption. Providing probabilistic pre-flight information for each flight phase to improve hazard identification will enhance safety and support optimising the fuel load for the expected conditions.*
- *Pilots can also use this information to better time onboard services and ensure seat belt compliance.*
- *Integrating pre-flight planning information with real-time severe weather updates will help pilots more effectively detect and avoid CB activity.*

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