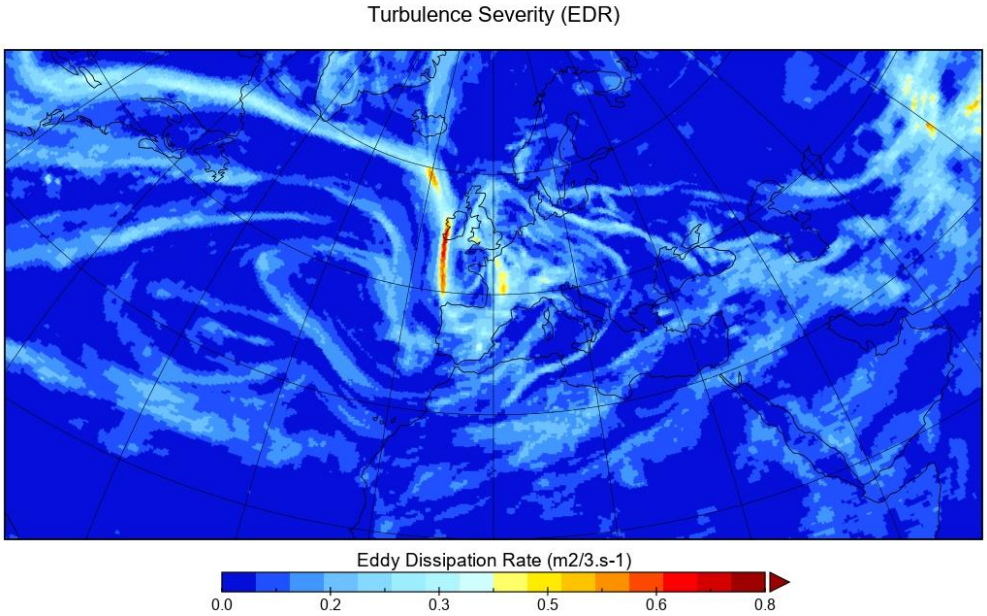
Probabilistic Turbulence Data

At present WAFS data sets includes 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. This field is created by blending (harmonising) the output from WAFC London and WAFC Washington.



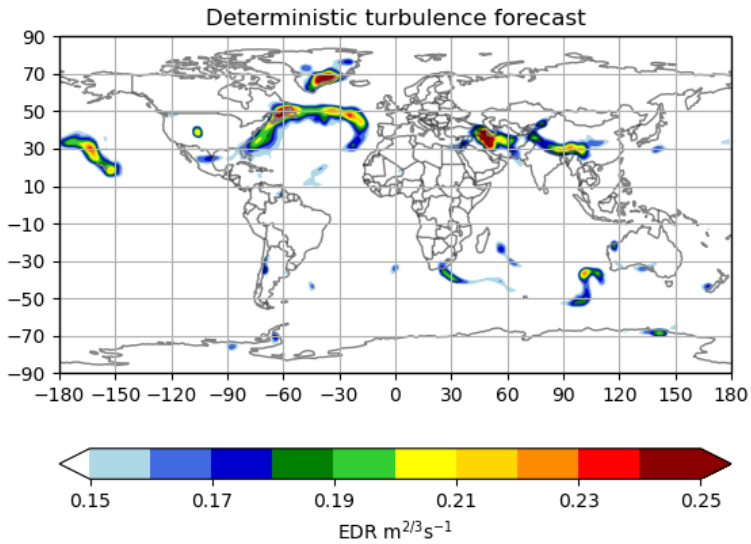
The plot above shows an example of a current WAFS turbulence severity field in which higher values of Eddy Dissipation Rate (EDR) indicate an increasingly turbulent atmosphere. ICAO Annex 3 – *Meteorological Service for International Air Navigation* (Appendix 4, Paragraph 2.6.2) contains the following information on how the EDR value equates to a turbulence intensity for a medium sized aircraft.

> 2.6.2 Interpretation of the turbulence report
>
> Turbulence shall be considered:
>
> a) severe when the peak value of EDR equals or exceeds 0.45;
>
> b) moderate when the peak value of EDR is equal to or above 0.20 and below 0.45;
>
> c) light when the peak value of EDR is above 0.10 and below 0.20; and
>
> d) nil when the peak value of EDR is below or equal to 0.10.

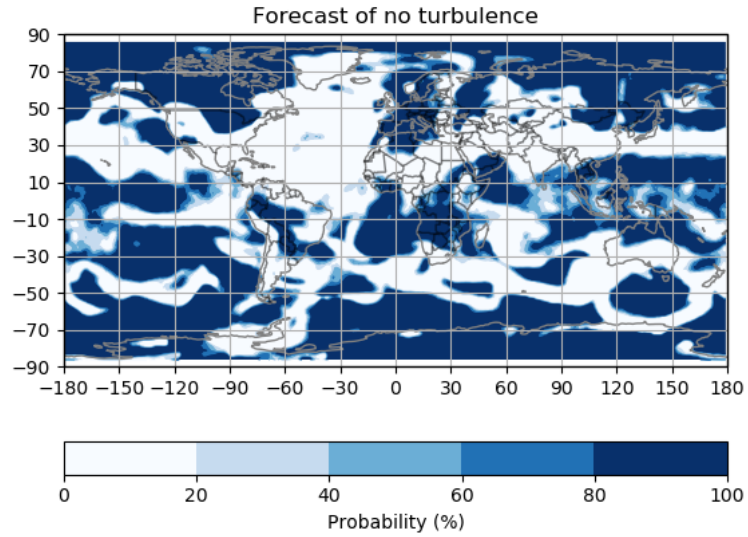
By creating an ensemble of forecast models, it becomes possible to see the spread of forecast values and makes it possible to identify the probability of a threshold being exceeded. At the longer forecast periods there will be more spread in the data than at short forecast periods.

In the examples that follow the medium sized aircraft thresholds are used.

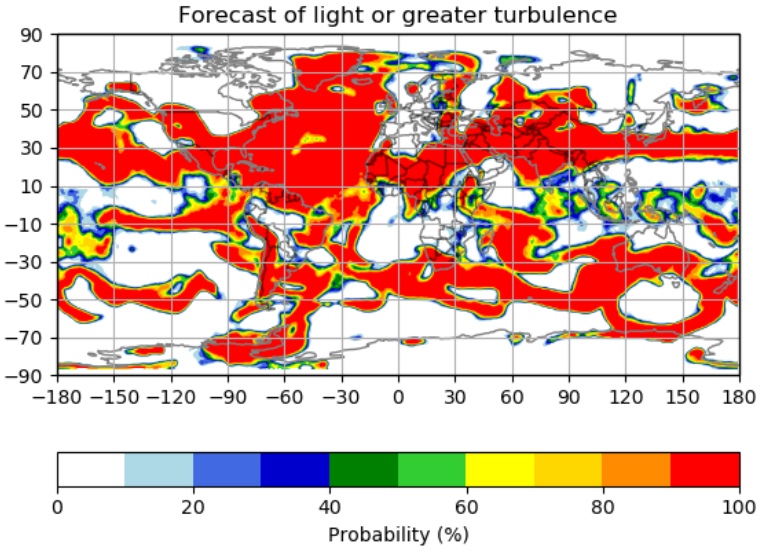
The plots below show a variety of different probabilistic turbulence forecasts for the same model run for 250hPa (approx. FL340). The deterministic plot is shown in image a).



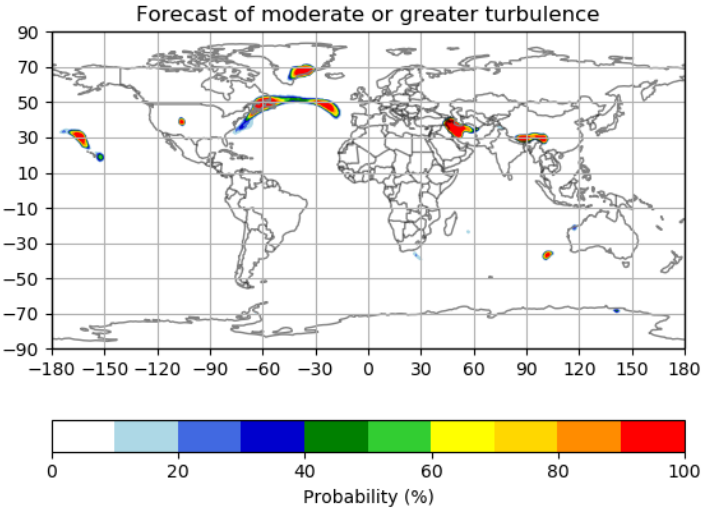
a) Deterministic forecast of turbulence severity. Output in EDR.



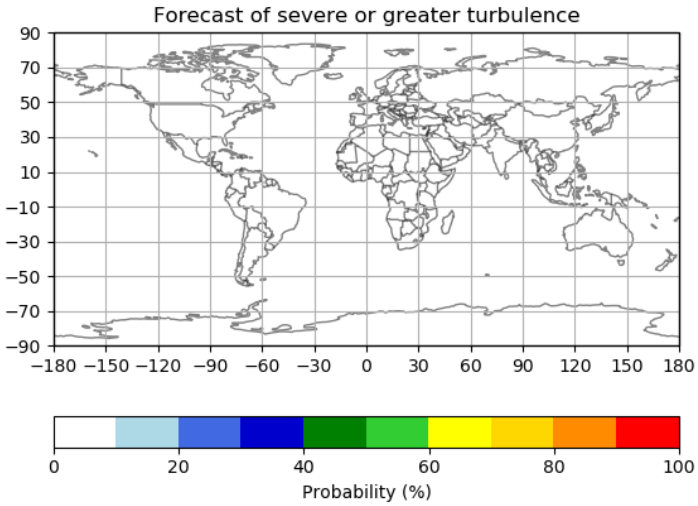
b) This plot shows where there is high probability that there will be no turbulence (i.e. the forecast EDR is **≤0.1 m$^{2/3}$s^{-1}**).



c) This plot shows the probability that the turbulence will be light or greater, i.e. the forecast EDR is **≥0.1 m$^{2/3}$s^{-1}**. It is the inverse of plot b.



d) This plot shows the probability that the turbulence will be moderate or greater, i.e. the forecast EDR is **≥0.2 $m^{2/3}s^{-1}$**



e) This plot shows the probability that the turbulence will be severe, i.e. the forecast EDR is **≥0.45 $m^{2/3}s^{-1}$**

Each of the plots above shows the total turbulence severity, and includes components that relate to clear air turbulence (CAT) and orographic turbulence. This type of information could allow informed decisions to be made in line with the users risk appetite.

Questions

The WAFCs would like to find out the following information to help inform what a useful WAFS probabilistic data set would look like:

1) Would knowing the probability that the turbulence severity (EDR) exceeds a particular value be useful operationally? If so, please explain why, and what change to operating practices it might have?

2) What EDR threshold(s) would be useful for operational use?

3) Would all forecast probability values be of interest? Or is a certain degree of certainty required before the forecast data is useful (for example >50% or >70%)

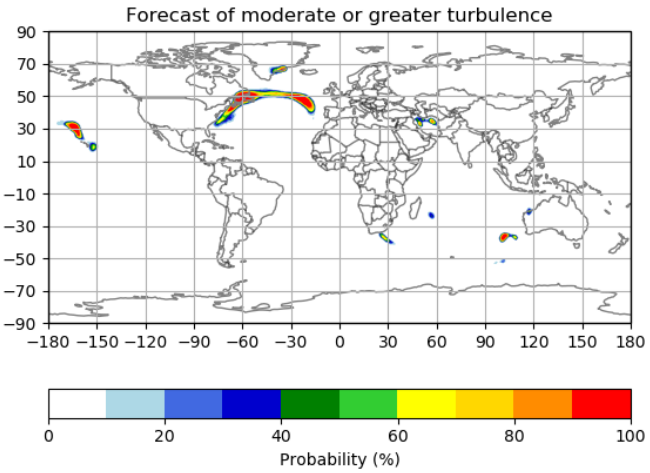
4) Would the significant probability change for different turbulence intensities? Some scenarios are shown in the table below. Would the operational decision change in each instance?

	Probability	Turbulence intensity	Operational Decision
Scenario A	10%	Moderate+. ≥0.2 $m^{2/3}s^{-1}$	
Scenario B	50%	Moderate+. ≥0.2 $m^{2/3}s^{-1}$	
Scenario C	90%	Moderate+. ≥0.2 $m^{2/3}s^{-1}$	
Scenario D	10%	Severe ≥0.45 $m^{2/3}s^{-1}$	
Scenario E	50%	Severe ≥0.45 $m^{2/3}s^{-1}$	
Scenario F	90%	Severe ≥0.45 $m^{2/3}s^{-1}$	

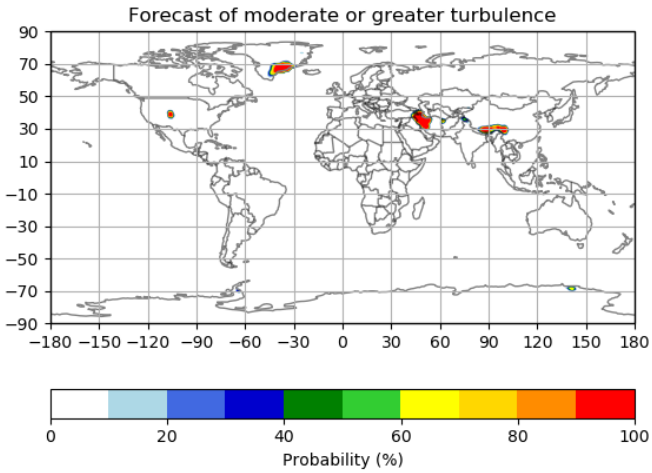
5) Is knowing where there is high probability of no turbulence (plot b) useful? If so, how would you use it operationally?

6) What forecast period would be useful? (maximum possible is 5 days)

Turbulence severity includes both clear air turbulence and orographic turbulence components, and it therefore the probability of each turbulence type could be forecast separately. This is shown in the two plots below:



a) wind shear (CAT) component



b) orographic turbulence component

7) Is knowing the probability of each type useful? If so, how would you use it operationally?

8) If there are any other ideas of what probabilistic turbulence information might help with operational decision making, please let us know.