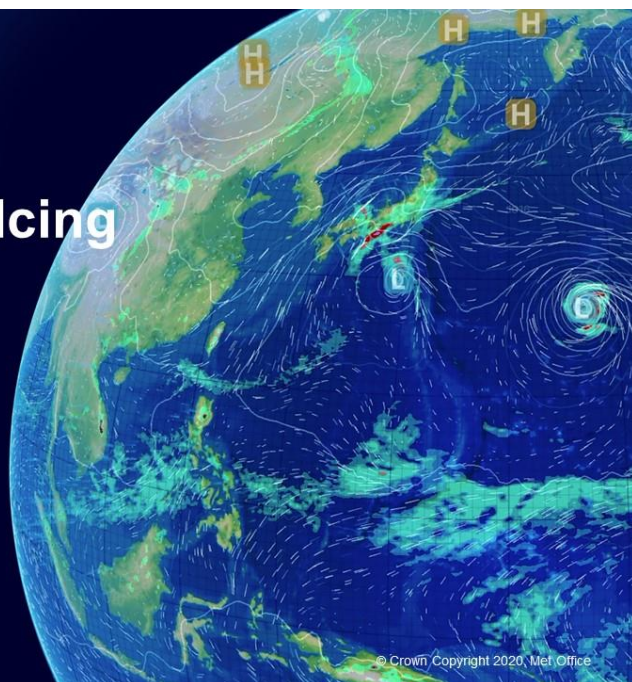


Case Study: Severe Icing

London, UK 11th May 2022

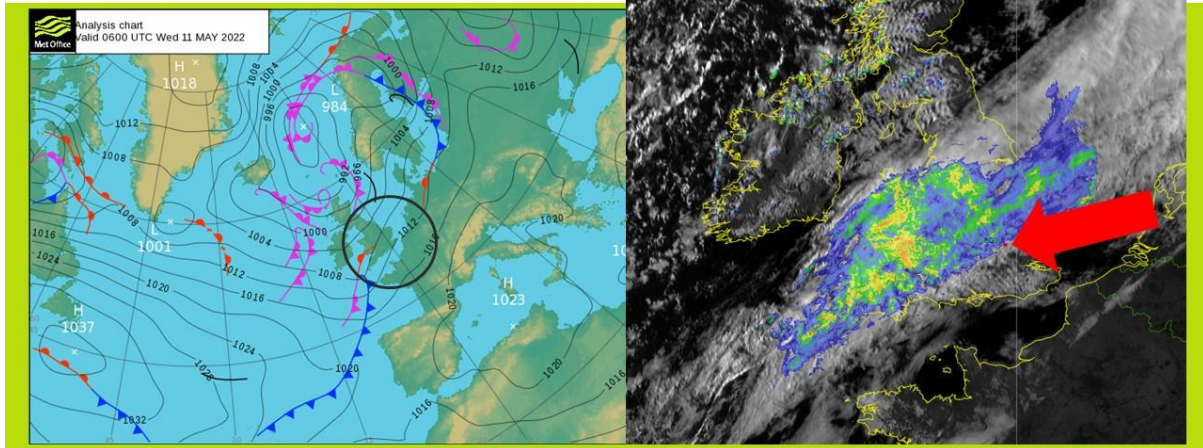
*Presented by Richard Jones, CMet,
Learning Consultant, UK Met Office*

www.metoffice.gov.uk



Welcome to this short talk, which comprises a severe icing case study from the region around London in the UK on the 11th of May 2022.

Synoptic situation



To set the scene on the weather chart on the left, we have reasonable southwesterly winds, but more importantly a warm front which is moving gradually eastwards through the day in question.

On the right hand side, I have highlighted with the red arrow the specific area in question, which is the area around London Luton and Stansted Airports.

At this point both airports just to the South of the surface warm front with frontal cloud and rain extending northwards and westwards from that location.

What was reported?

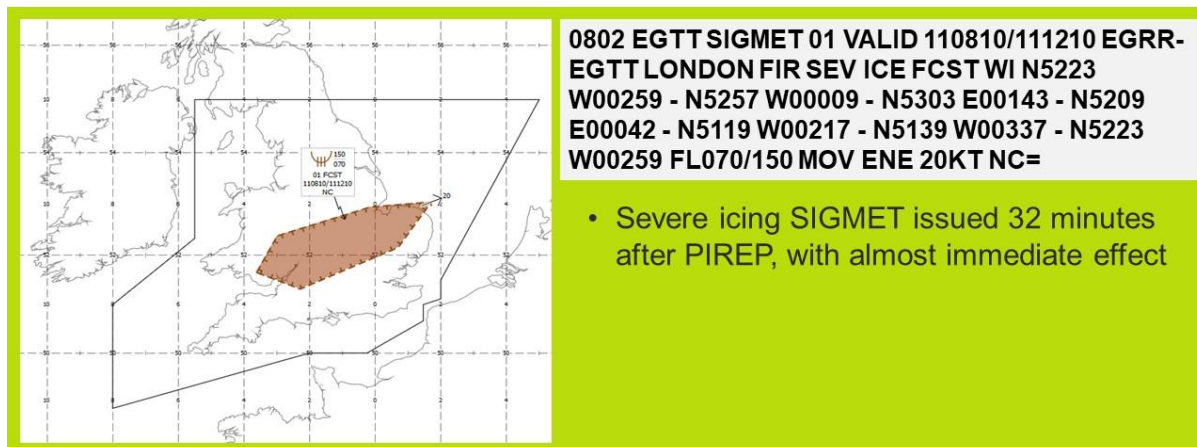
Date:	11/05/2022					
Time of report (UTC):	07:30					
Type of report:						
Turbulence:		Icing:		Dust/Sand	Smoke	Other (provide information below):
Moderate	Severe	Moderate	Severe	☐	☐	☐
☐	☐	☐	☒	☐	☐	☐
Aircraft Identification / Call Sign:				Multiple		
FIR and Position or Lat/Long:				London FIR, 10 miles of Lorel (stack between GW and SS) and between Westcott (515054N, 005819W) and Bovingdon		
Time of encounter (UTC):				0700-0725 Z Multiple reports		
Flight level (or altitude) of encounter:				FL130-FL150		
Any other information: e.g. Suspected or observed encounter? Level of confidence? Any smells reported by aircrew?						

- Pilot report (PIREP) received 0730 Z, via UK National Air Traffic Service (NATS)
- Severe icing reported between FL130 and FL150
- 2-5 aircraft reported severe icing

Moderate icing was forecast within the frontal cloud, but via a pilot report received from the UK National Air Traffic Service to the duty meteorologist, we found that severe icing was reported between flight levels 130 and 150 within the frontal zone (or approximately 13,000 to 15,000 feet above mean sea level).

Two to five aircraft reported severe icing at the time in varying locations around the region.

Response: SIGMET issued



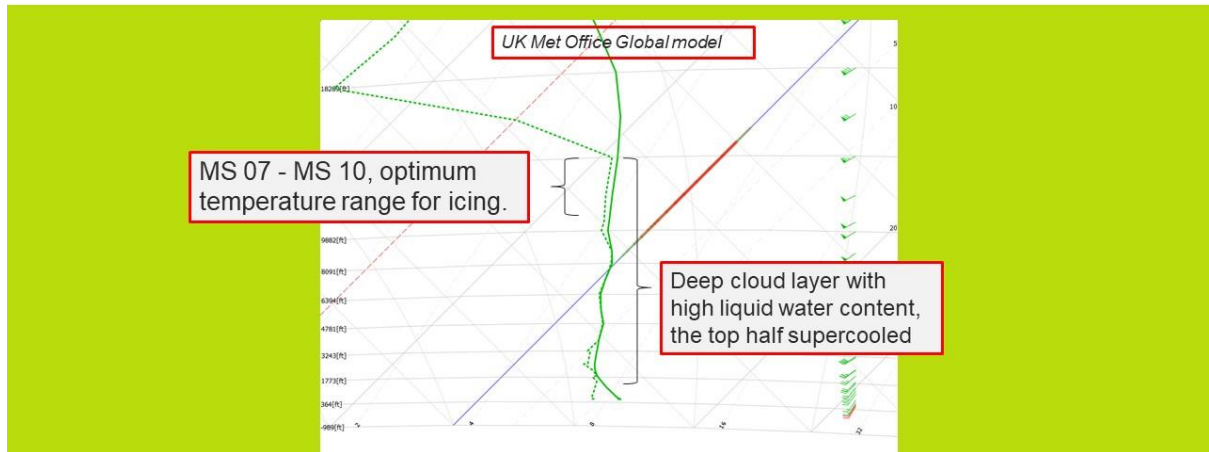
The response was to issue a severe icing SIGMET, the detail of which you can read on the slide in front of you.

The SIGMET was issued at 0802, 32 minutes after the pilot report was received, with a validity period starting with almost immediate effect from 0810 to 1210.

Prioritisation of the issuing of the SIGMET preserved flight safety and will have enabled others to be warned of severe icing and potentially take action to avoid experiencing this hazard.

The coordinate points are given, and the box plotted on the map on the left hand side. The base of severe icing in the SIGMET was given at flight level 070, the top to 150 (or approximately 7,000 to 15,000 feet above mean sea level), and the whole zone moving towards the East NE at 20 knots. No change in severity expected through that time.

Possible explanations: Analysis of Luton (EGGW) tephigrams



In hindsight and investigation there are several factors which may well have enhanced the severity of icing an aircraft experienced.

The first thing to consider is the aircraft activity. All aircraft that reported severe icing were found to have descended downwards through cloud layers. This means they were not spending a long period of time within cloud.

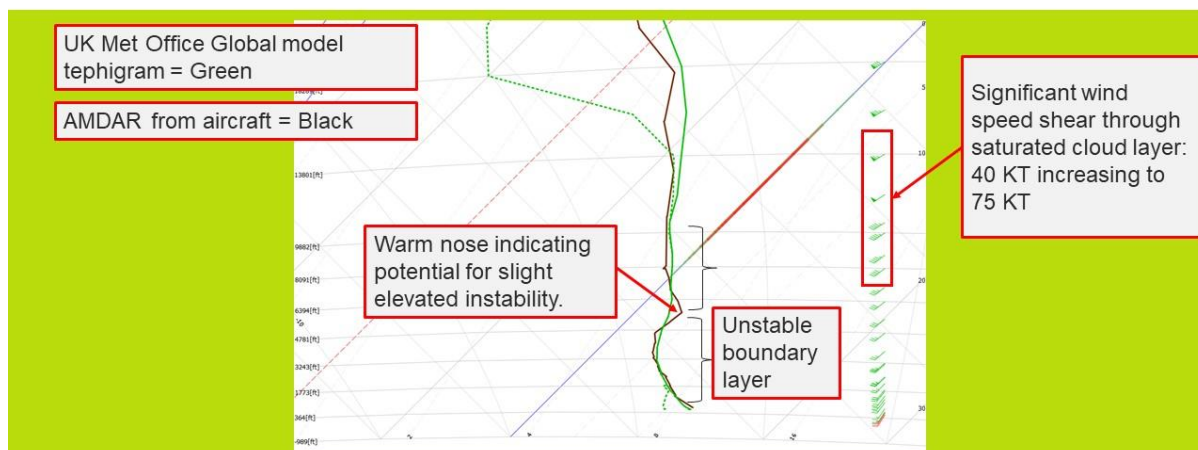
It does raise the possibility however, that the airframe temperature would have been particularly cold (or cold soaked) which may well have increased the severity of icing experienced.

We can now have a look at meteorological factors or explanations and to start this I have a tephigram from Luton Airport, taken from our UK Met Office Global Model.

You can see a very deep cloud layer with high humidity and high liquid water content, top half becoming supercooled.

At the top of the cloud temperatures between minus 07 and 10 Celsius, which is optimum for airframe icing and a temperature range where clear ice will dominate rather than rime ice. Clear ice of course developing more severe icing within cloud when compared to Rime ice for varying reasons discussed in a previous video.

Possible explanations: Analysis of Luton (EGGW) tephigrams & AMDAR



We can include an actual temperature profile from the timing question, and there is an AMDAR taken from an aircraft operating through Luton airport at the time - that is the black line, the green line is the model tephigram underneath.

In general, the temperature profile handled quite well in the global model, but with one or two important differences.

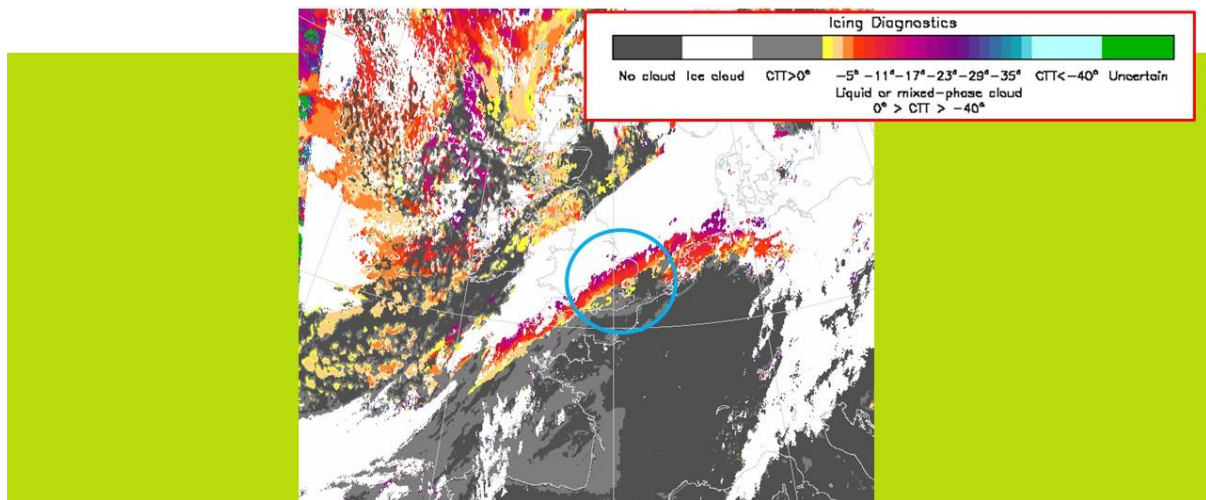
Firstly, you can see an unstable boundary layer at the surface and most importantly there is the presence of a warm nose, which indicates the potential for elevated instability and the generation of elevated convective cloud within that frontal layer.

This something which would increase the liquid water content by increasing the size and density of cloud droplets within the area experienced and reported by aircraft.

On the right hand side, we can also see there is significant wind speed shear through the saturated cloud layer, with 40 knots at the base around the zero degree isotherm increasing to 75 knots at the top of the cloud.

Wind shear being a factor known to increase airframe icing experienced. Although there is no directional wind shear there, nonetheless a significant increase in speed through that cloud layer.

Possible explanations: MSG Aircraft Icing Diagnostics

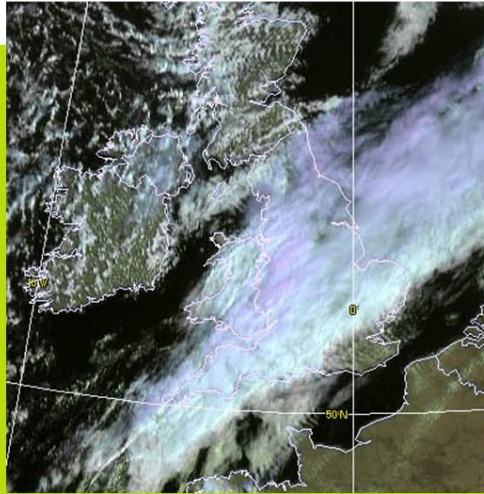


We can also look at satellite imagery from the time in question and this is an aircraft icing diagnostic which has been introduced in our previous video from MSG satellite. This confirms our tephigram analysis by showing the presence of liquid or mixed phase clouds within the temperature ranges most optimum for airframe icing.

Possible explanations: Mountain waves

“Ripples” in cloud structure are an indication of mountain waves.

Updraughts from which could have been an enhancing factor in icing in this case by increasing liquid water content.



Another possible explanation would be the presence of mountain waves and this satellite image taken again from the time in question.

There are lots of ripples through the cloud which are an indication of mountain waves, both in the southeast of the UK and all the way up to the north of the UK.

Strong updrafts associated with mountain waves would be an enhancing factor in increasing liquid water content within cloud within the frontal layer, and yet another factor which may well have increased the severity of icing experienced.

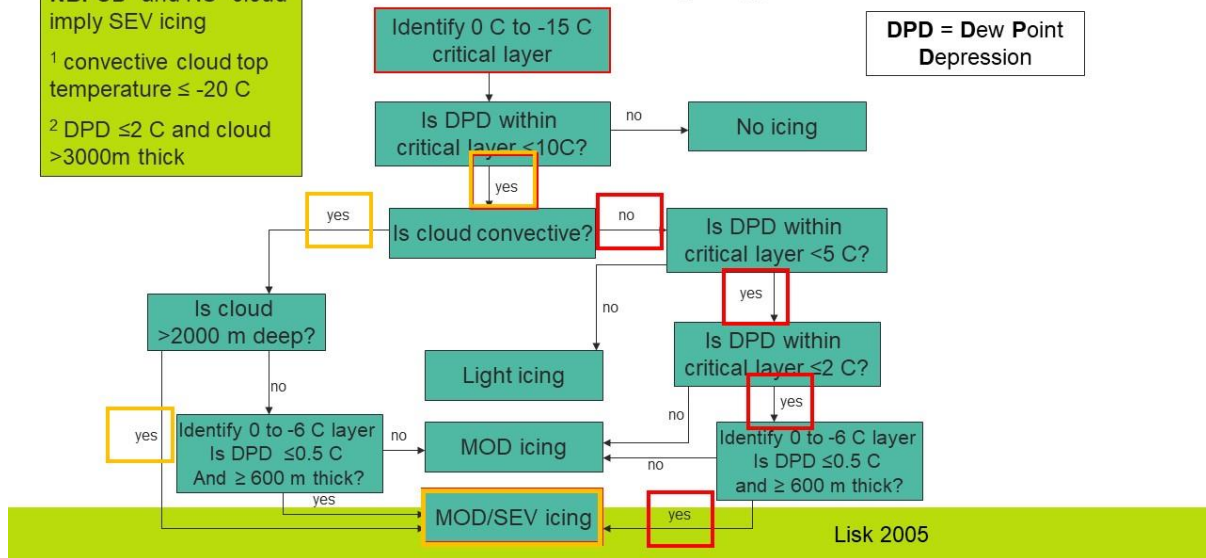
Identifying & Analysing Icing using a Tephigram

NB: CB¹ and NS² cloud imply SEV icing

¹ convective cloud top temperature ≤ -20 C

² DPD ≤ 2 C and cloud >3000 m thick

DPD = Dew Point Depression



I hope you found that case study useful. In the previous video we introduced this decision tree, which may be helpful in forecasting severity of icing.

I will now use the case study information to see what severity of icing the decision tree will indicate.

There are two scenarios we can use here. One which is our initial thinking, which does not include convective cloud (scenario 1), and another which does include the potential for that elevated convective cloud, which we saw the possibility of (scenario 2).

Decision tree continued...

Scenario 1 (red boxes)

We must identify the zero to minus 15 Celsius critical cloud layer.

First question, is the dew point depression within that layer less than 10 Celsius? The answer being a resounding yes in this case.

Our second question is the cloud convective? On a first scenario, we will say no and move to the right hand side.

Our next question – is the dew point depression less than 5 degrees Celsius within that critical layer? The answer is yes.

The answer will also be yes to our next question – is the dew point depression less than or equal to 2 degrees Celsius?

Our final question here is to identify the zero to minus 6 Celsius layer and ask a two-part question. Is the dew point depression less than or equal to 0.5 degrees Celsius and is that layer more than or equal to 600 metres thick? The answer is yes. The dew point depression is almost zero within that layer and the depth of that layer is around 900 metres thick.

We say yes to that question and that leads us to *moderate or severe icing*.

Scenario 2 (orange boxes)

Let us now take our second scenario where we do include the possibility of convective cloud.

First question we still must answer, yes.

Our second question – is cloud convective? We will again answer yes and move to the left hand side.

The next question asks us is the cloud in total more than 2000 metres deep (or around 7000 feet)?

The answer is yes, the cloud depth in question is 3000-4000 metres deep, so once again we get to *moderate or severe icing* at the end.

Whether or not you forecast moderate or severe icing, you must go deeper and carefully consider other enhancing factors – such as the presence of convective cloud or any other of the reasons stated in this case study, though certainly not limited to those factors.

Summary

- Moderate icing was forecast but severe reported by several aircraft
- Severe icing SIGMET issued quickly, prioritising flight safety
- Further investigation gives reasoning for the presence of severe icing
- Use of decision tree to decide the severity of icing expected

In summary, we have looked at our case study where moderate icing was forecast but severe icing experienced by several aircraft.

Issuing a severe icing SIGMET prioritised flight safety and enabled others to keep themselves safe, particularly by doing so very quickly.

Further investigation gave several reasons why an aircraft may well have experienced severe icing rather than moderate.

We have also used our decision tree to help us decide the severity of icing expected, as an example.

Questions?

- On the page forum
- Live sessions

If you have any questions, please do ask either on the page forum and we will get back to you as soon as we can or bring your questions to our live sessions in the beginning of November.

Live session discussion points

- In-flight icing
 - What types of icing are common in your area?
 - What impact do these have on aviators?
- Forecasting icing
 - Which methods discussed are most suitable for your area?
 - Are there additional methods or resources you use to forecast icing?
- Case study
 - Are there examples from your own area to share and discuss?

You are very welcome to join us in those live sessions. There will be a light structure in mind, and we have some suggested discussion points here.

Here are all our suggested discussion points:

- In-flight icing:
 - What types of icing are common in your area?
 - What impact do these have on aviators?
- Forecasting icing:
 - Which methods discussed are most suitable for your area?
 - Are there additional methods or resources you use to forecast icing?
- Case study:
 - Are there examples from your own area to share and discuss?

I hope you have found that useful. Thank you.

