

Met Office User Forum 2024

Monday 25th November 2024



Housekeeping

Fire Alarm

- In the event of a fire, a siren will sound, please obey the instructions given on the voice alarm.
- If evacuation is required, please follow your guide who will escort you safely from the building.
- In the interests of your safety, please remain with your guide at all times.

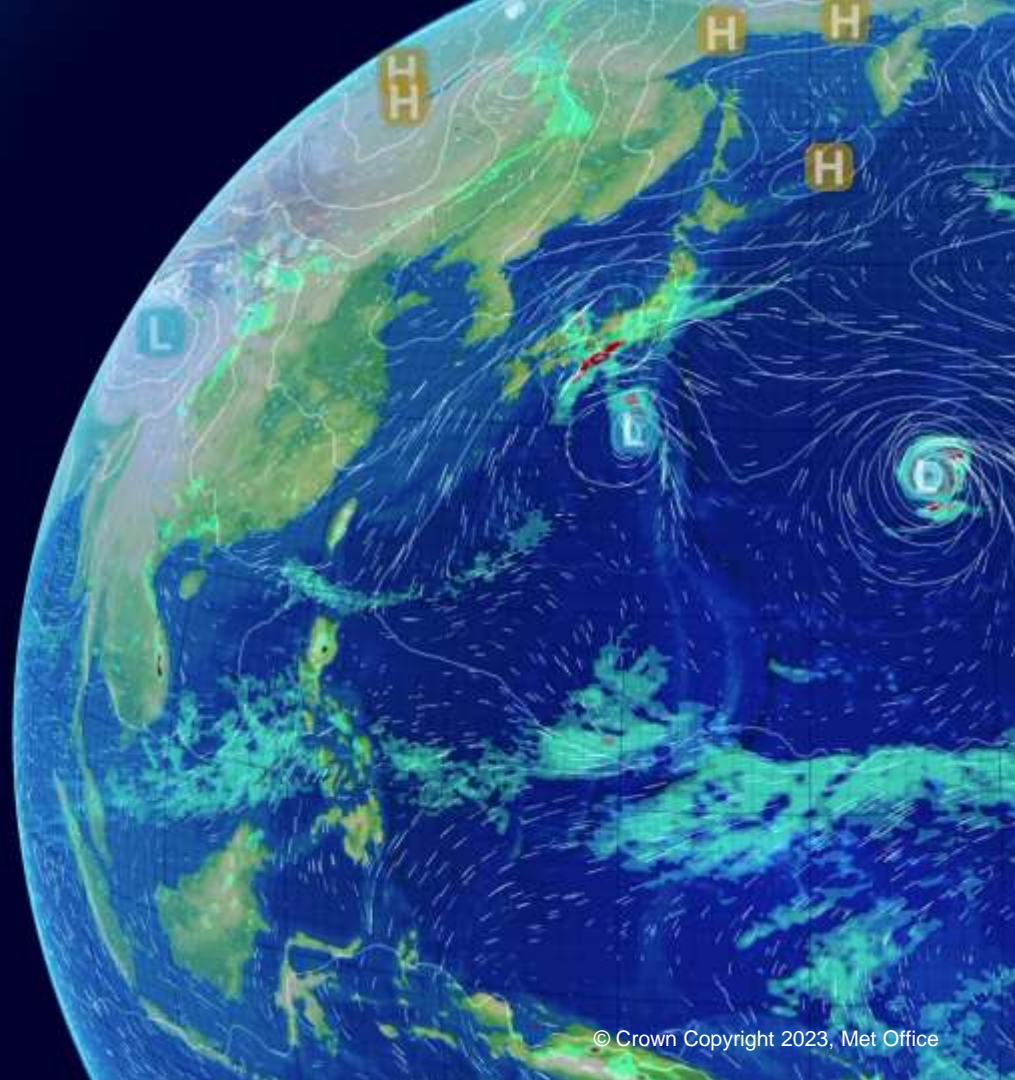


Photos

- Photos in the conference rooms, conference area balcony and outside the front of the building are permissible.
- No photos whilst on the tour please.



Welcome and Introductions to MOUF



Today's Session:

- 11:00 Welcome and Introductions
- 11:15 International Activities
- 11:45 Finances
- 12:00 National Aviation Service
- 12:30 **Lunch & Ops Centre Tour – Photo Opportunity**
- 13:30 Aviation Research and Development
- 14:00 3-month weather outlook brief
- 14:20 Specific issues raised by members
- 14:50 Any other business
- 14:55 Date of Next Meeting

Today's Speakers:



Mark Gibbs
Head of
Transport



**Lauren
Donohue** Aviation
Manager



Piers Buchanan
Aviation
Science Manager



**Andrew
Creswick**
Aviation Scientist



Graeme Anderson
Aviation Senior
Scientist

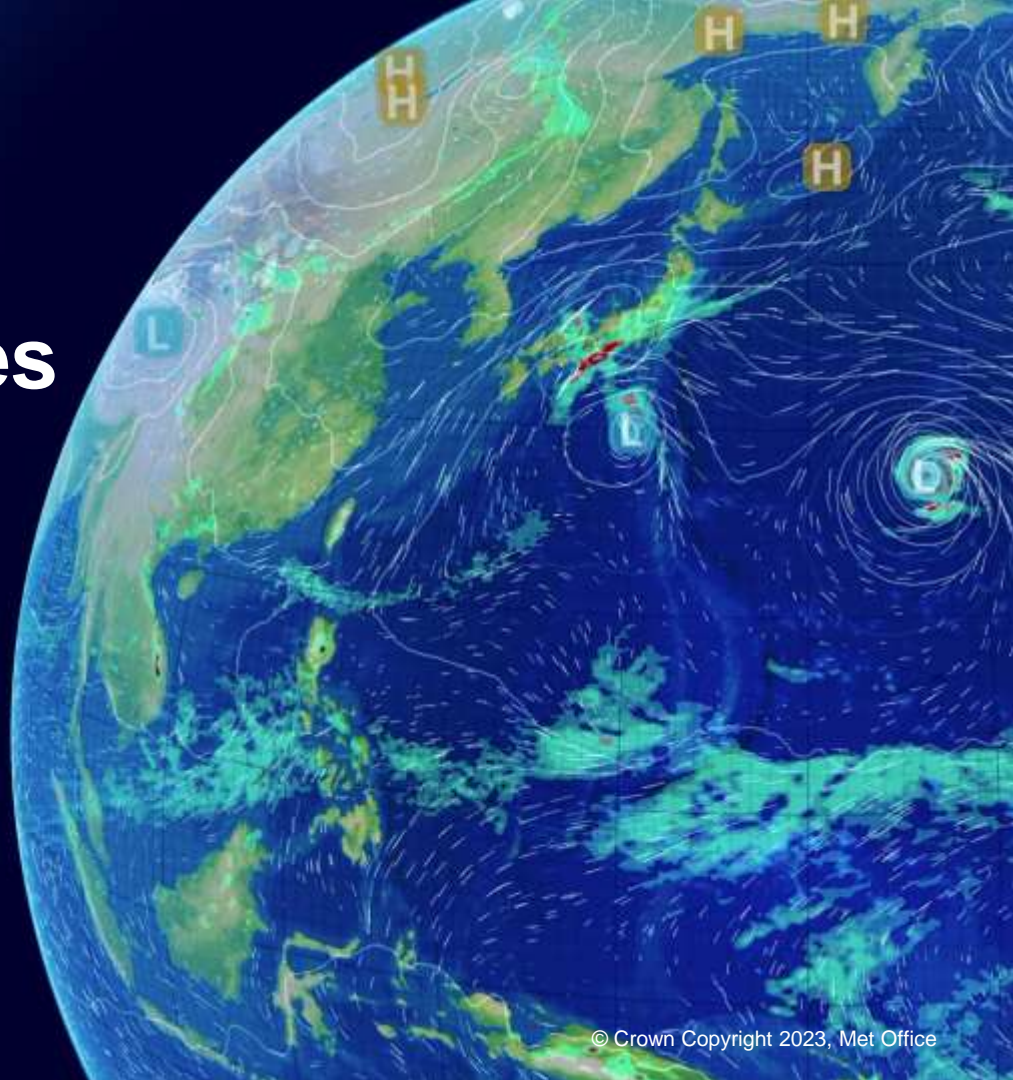


Dan Rudman
Expert Operational
Meteorologist

International Activities

Mark Gibbs

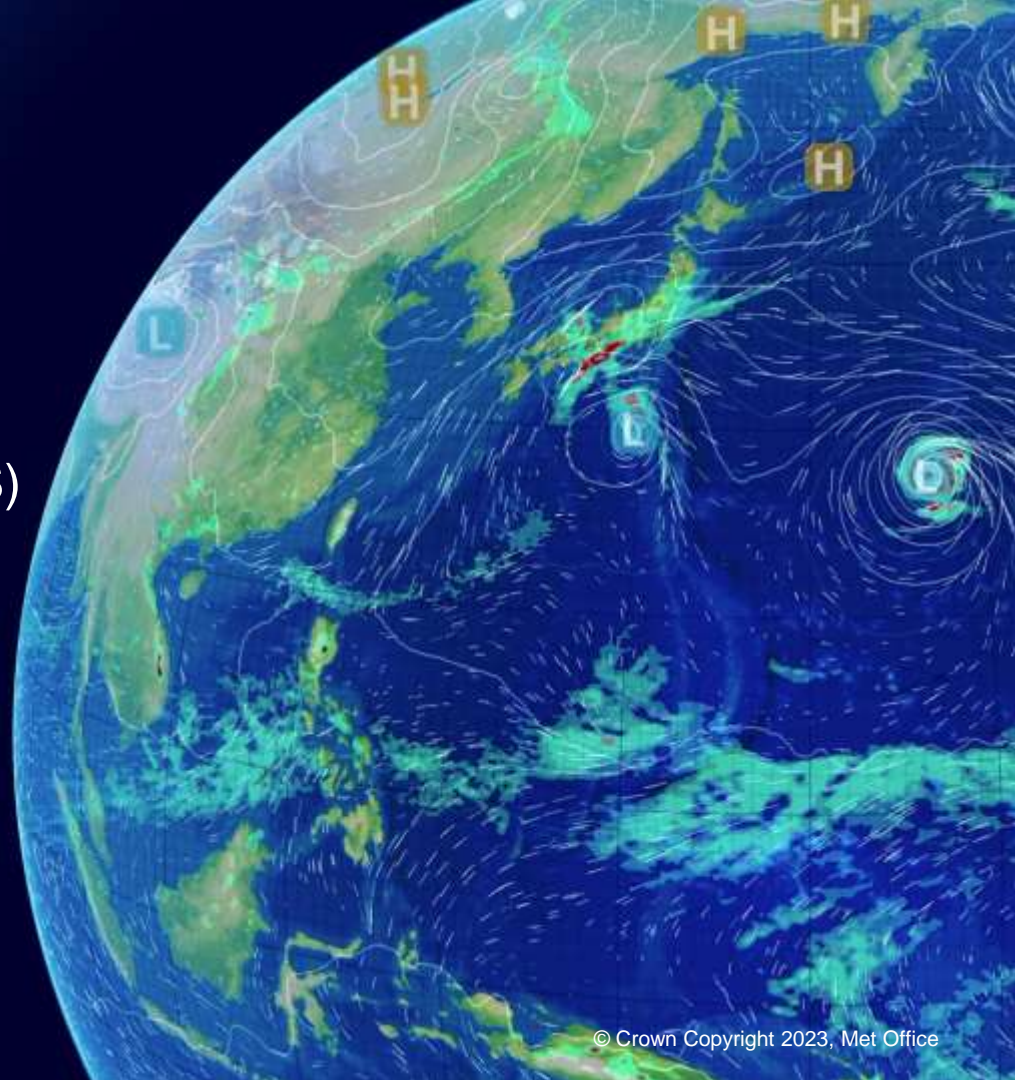
Head of Transport



Content

World Area Forecast System (WAFS)
and
Quantitative Volcanic Ash (QVA)

Changes and upgrades



World Area Forecast System (WAFS)

22nd November 2024 marked the 40th Anniversary of our WAFC provision under ICAO remit.

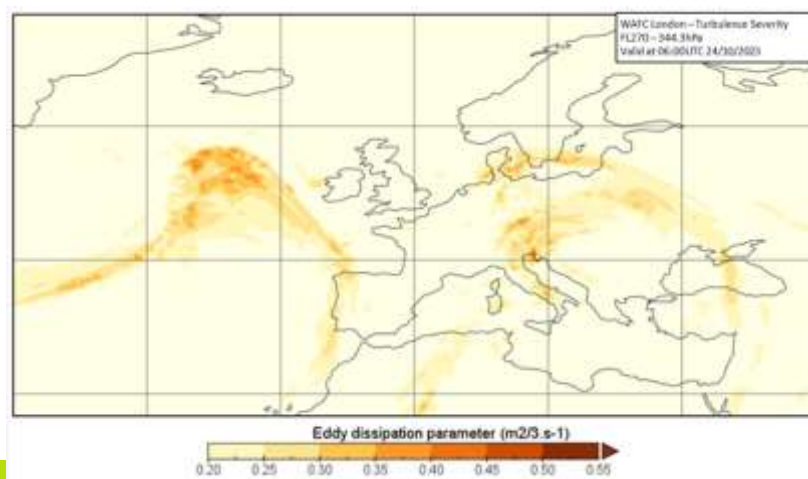
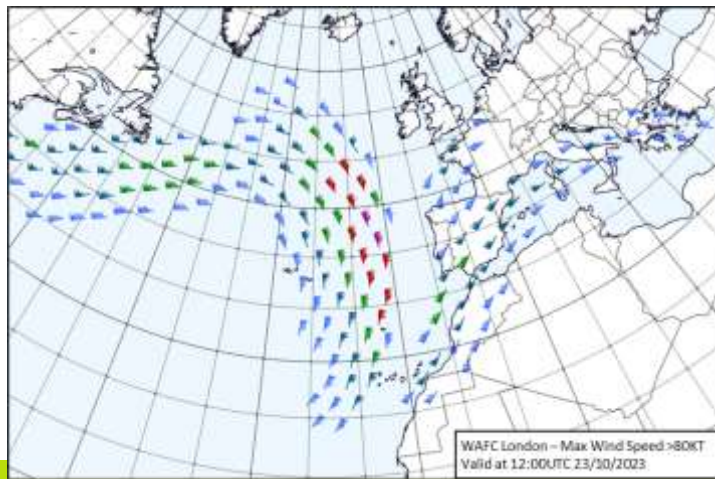
Throughout those 40 years we have been constantly evolving the service – and we are marking the anniversary with huge upgrades to our data sets, production platforms, and delivery systems.



19th March 2024:

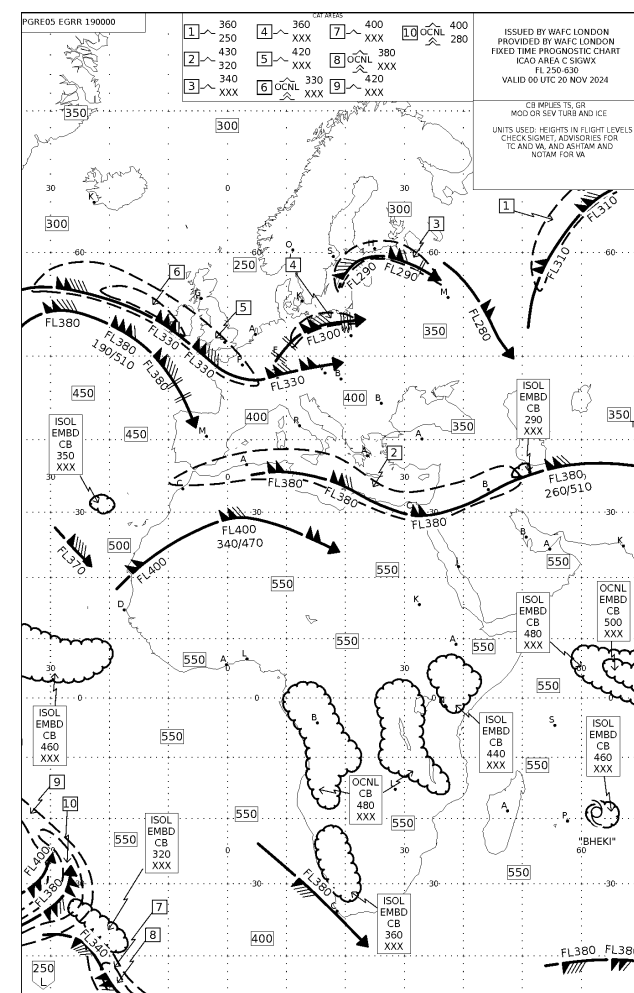
- *New WAFS gridded data sets became operational.*
- *Entirely new back-end production system*
- *Introduction of new SADIS API system to deliver the gridded WAFS data and OPMET data sets.*

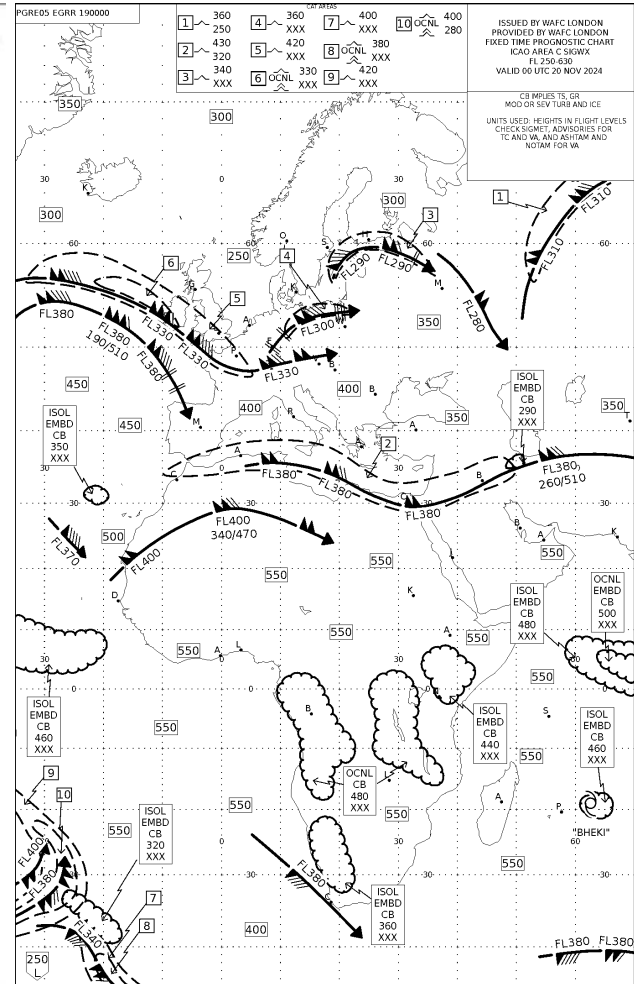
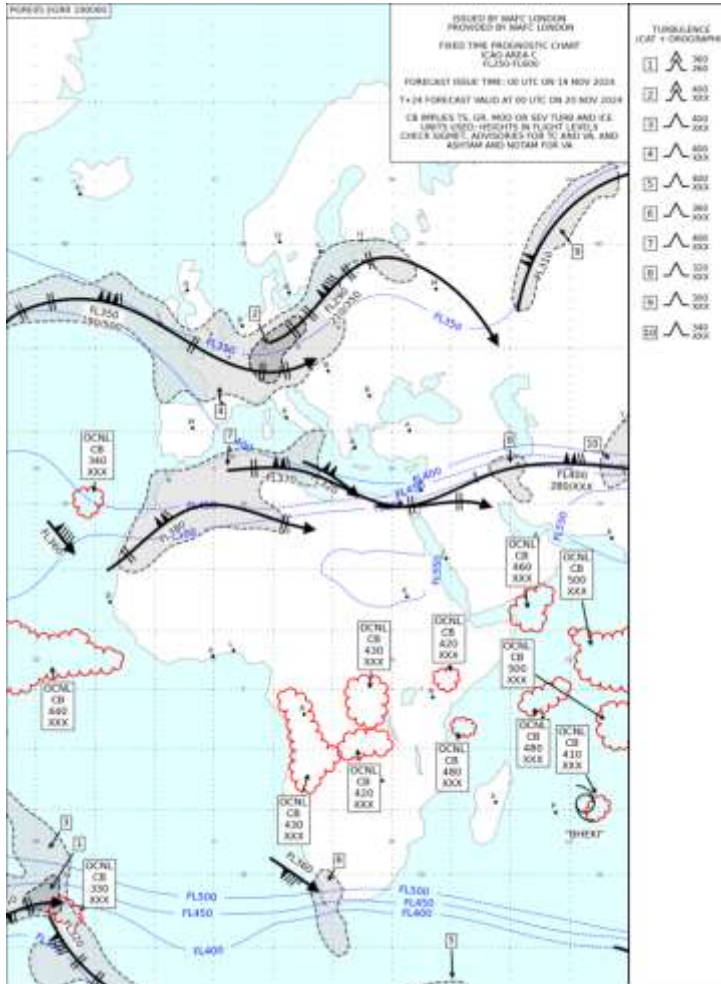
- 56 vertical levels for some parameters (was 17)
- Many more forecast timesteps with hourly data from T+6 to T+24 and stretching out to T+120
- Increased horizontal resolution for the wind temperature, relative humidity and tropopause data sets



23 January 2025:

- *Big changes to WAFS Significant Weather (SIGWX) forecasts*
- *Existing T+24 forecasts/chart production will be automated and their appearance/content will change*
- *New multi-timestep SIGWX forecasts covering T+6 to T+48 at 3-hourly intervals will be introduced (Feb 2025).*



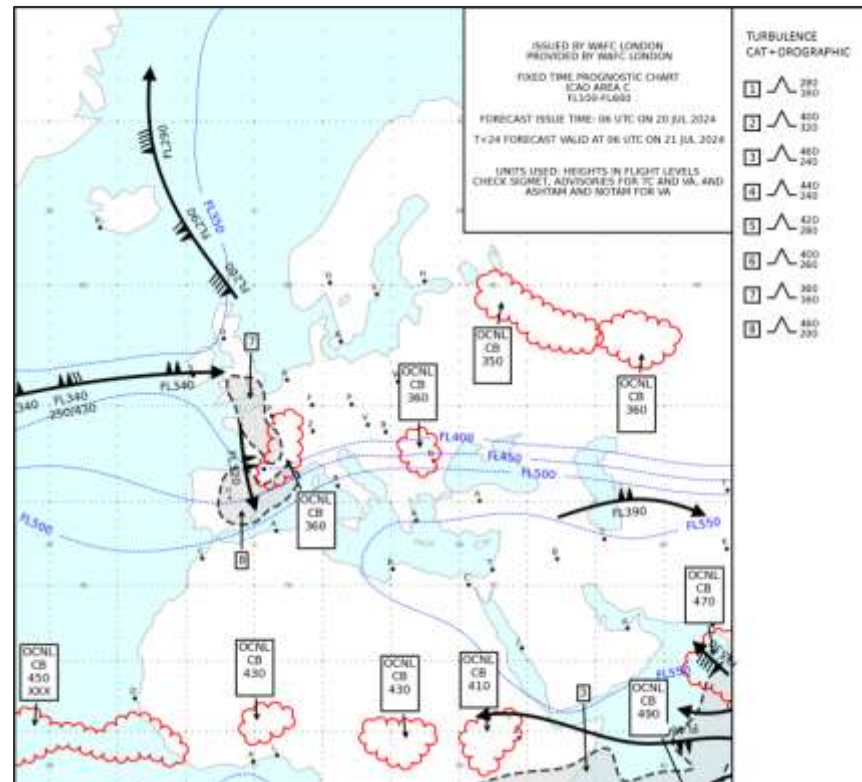


WAFC produced T+24 charts
will be in colour!

Grey = turbulence areas
Red = Cumulonimbus areas
Blue contours = tropopause height

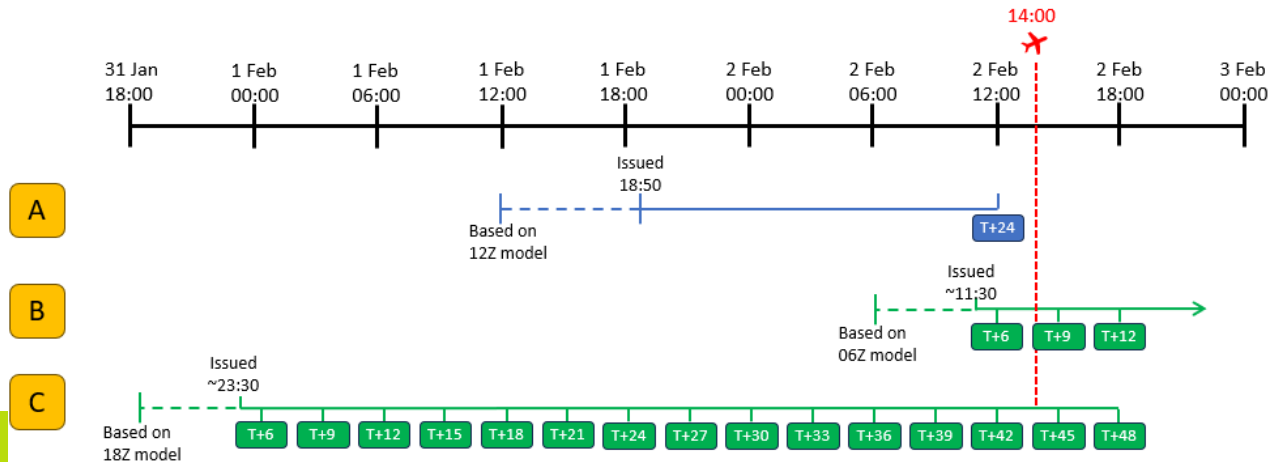
New multi-timestep SIGWX

- Spans FL100-FL600
- Tropopause height provided as contours
- Areas of occasional (OCNL) and frequent (FRQ) cumulonimbus (CB) and the flight level of the CB cloud tops
- Areas of moderate (MOD) and severe (SEV) “turbulence” areas will be forecast. This includes both clear air turbulence (CAT) and turbulence generated by mountains (orographic) turbulence types
- Global coverage icing forecasts
- New IWXXM format that users can turn into charts



Benefits of the new multi-timestep SIGWX

- Better suited to the needs of the aviation industry particularly for short haul and long-haul flights. SIGWX forecasts for a particular validity time will be available with a longer lead time and using more up to date model data.
- Consistency between WAFS gridded data and SIGWX
- Ability to see how features move and evolve



What about the existing T+24 SIGWX charts?

Medium and High level T+24 “Paper copy” (.png) charts will still be provided via SADIS FTP until 2028. There will be some change in their content and appearance:

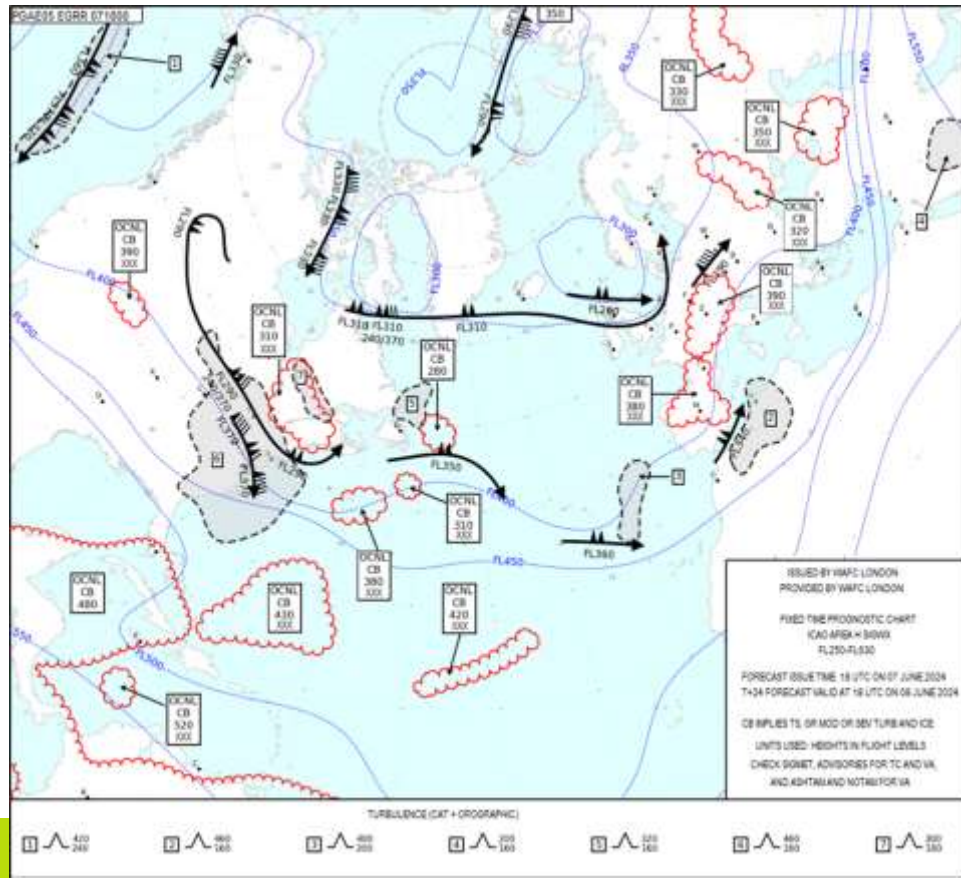
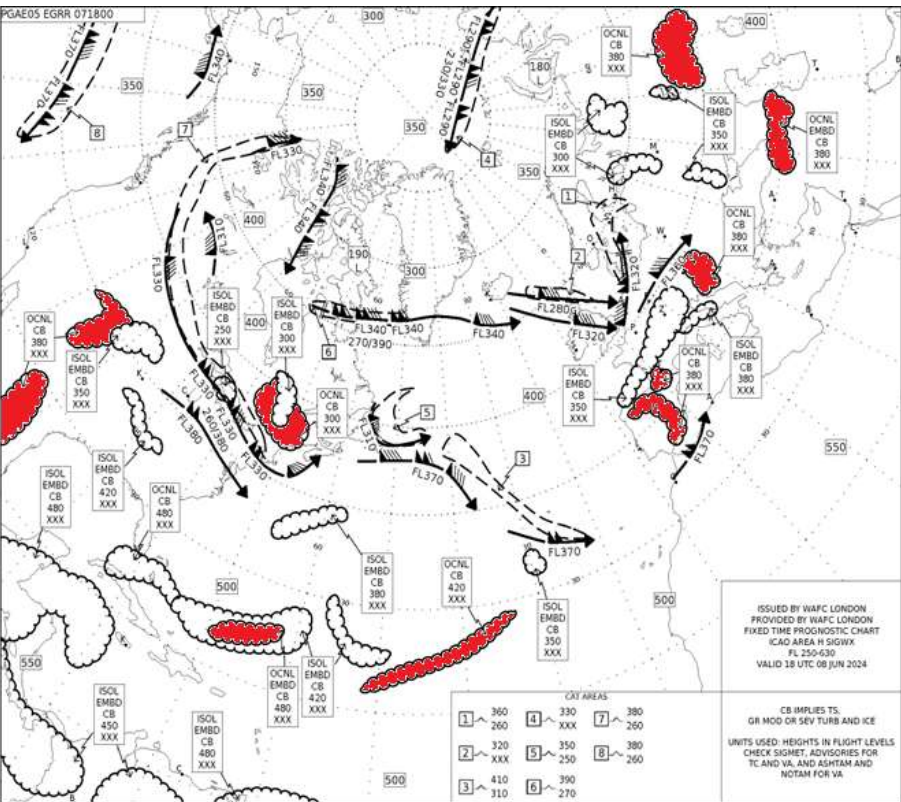
- They will be provided in colour
- The high level SIGWX will change to span FL250 to FL600 (changing from FL250 to FL630).
- They will be produced earlier than they are now (by approx. 1 hr)

What will change in the T+24 SIGWX charts?

- Embedded cumulonimbus cloud will not be included.

This means that ISOL EMBD CB, OCNL EMBD CB and FRQ EMBD will not be shown.
Instead only OCNL CB and FRQ CB will be forecast.

There will be more areas of OCNL CB forecast than they are now.



What will change in the T+24 SIGWX charts?

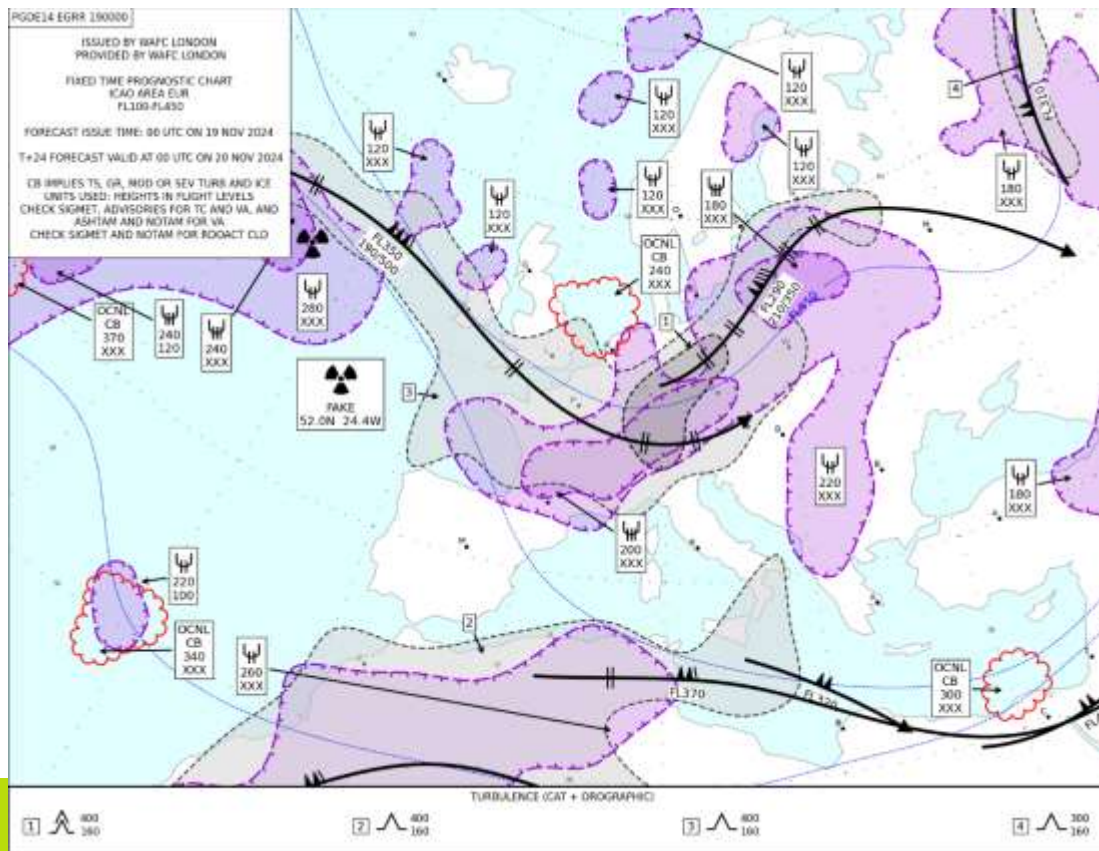
- Embedded cumulonimbus cloud will not be included.

This means that ISOL EMBD CB, OCNL EMBD CB and FRQ EMBD will not be shown. Instead only OCNL CB and FRQ CB will be forecast.

- Clear Air Turbulence (CAT) areas will become “Turbulence”. Moderate (MOD) and severe (SEV) turbulence areas include turbulence due to CAT and orographic turbulence types and if it is strong enough turbulence within non-convective clouds.
- On the medium level SIGWX the combined in-cloud turbulence and icing areas will change to only show icing intensity areas (MOD and SEV).

WAFC produced medium level SIGWX will look like this:

Purple = icing areas



SIGWX Verification

Satellite imagery, lightning observations and aircraft turbulence measurements have been used to ensure the new T+24 SIGWX is at least as accurate as the manually drawn SIGWX forecasts.

We aren't trying to make the new T+24 forecasts match the manually drawn T+24 forecasts as they aren't "the truth". We have tuned the new SIGWX forecasts to achieve highest forecast performance we can.

Both WAFC's are liaising with their State regulators to file a difference against the applicable Annex 3 provisions to notify airspace users of the changes to the T+24 SIGWX forecasts during the period 23 January 2025 to November 2025 (when Amendment 83 to ICAO Annex 3 - *Meteorological Service for International Air Navigation* becomes effective).

The UK CAA has issued an Aeronautical Information circular that regarding the upcoming SIGWX changes.

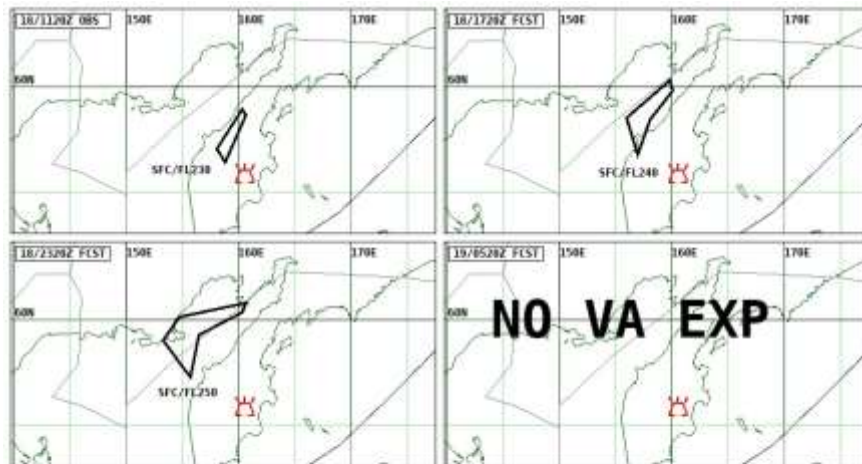
<https://www.aurora.nats.co.uk/htmlAIP/Publications/2024-07-25/html/eAIC/EG-eAIC-2024-131-P-en-GB.html>

More information:

<https://www.metoffice.gov.uk/services/transport/aviation/regulated/international-aviation/wafc/upcoming-changes>

Quantitative Volcanic Ash (QVA)

At present ICAO mandated Volcanic Ash forecasts are:

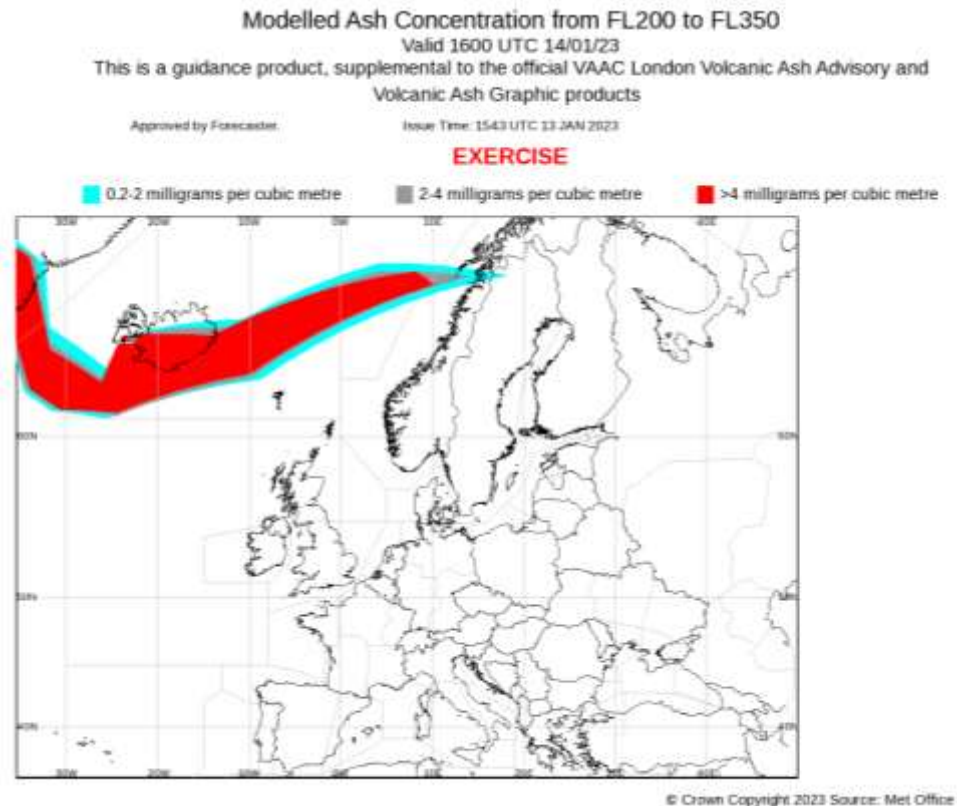


VA ADVISORY
DTG: 20231018/1200Z
WAC: TOKYO
VOLCANO: BEZPNIANNY 300250
AREA: RUSSIA
SUMMIT ELEV: 2002M
ADVISORY NR: 2023/38
INFO SOURCE: NEMMARI-9
AVIATION COLOUR CODE: NIL

ERUPTION DETAILS: VA CONTINUOUSLY OBS IN
SATELLITE IMAGERY
RMK: SOME PART OF VA OBSCURED BY MET CLOUD.
VA HEIGHT UPDATED TO FL230 BASED IN
SATELLITE DATA.
NXT ADVISORY: 20231018/1000Z

FVXX22 KINES 100646
VA ADVISORY
DTG: 20231018/0646Z
VAAC: WASHINGTON
VOLCANO: REVENTADOR 352010
PSN: S0005 W07739
AREA: ECUADOR
SUMMIT ELEV: 11686 FT (3562 M)
ADVISORY NR: 2023/679
INFO SOURCE: GOES-16, NWP MODELS.
ERUPTION DETAILS: OCNL EM
OBS VA DTG: 18/0620Z
OBS VA CLD: SFC/FL150 N0001 W07743 - S0004 W07738
- S0006 W07741 - S0002 W07746 - N0001 W07743 MOV
NW 10KT
FCST VA CLD +6HR: 18/1230Z SFC/FL150 N0004 W07752
- S0004 W07738 - S0007 W07740 - S0000 W07755 -
N0004 W07752
FCST VA CLD +12HR: 18/1830Z SFC/FL150 N0005
W07751 - S0004 W07738 - S0006 W07740 - N0001
W07754 - N0005 W07751
FCST VA CLD +18HR: 19/0030Z SFC/FL150 N0004

- Since 2010 VAAC London and VAAC Toulouse have provided ash concentration forecasts
- Data provided as charts, and simple data files
- Frustration for the customers/stakeholders outside of Europe where these products are not available.



This product has three vertical levels, three concentration bands and four timesteps

Quantitative Volcanic Ash (QVA)

- New QVA ICAO provision builds on the concentration charts idea.
- VAACs meet regularly together with stakeholders (IATA, IFALPA, ICCAIA) and all have agreed to work towards this QVA approach. An Initial Operating Capability has been defined.
- QVA will comprise of three data sets
 - Gridded deterministic data set
 - Gridded probabilistic data set
 - An object/feature data set

QVA will be issued for “Significant” eruptions

- [1. A deterministic gridded output \(expected concentration\).](#)

-

| <i>Descriptor</i> | <i>Ranges</i> |
|------------------------|---|
| Very high | Equal to or above 10 mg/m ³ |
| High | Equal to or above 5 and below 10 mg/m ³ |
| Medium | Equal to or above 2 and below 5 mg/m ³ |
| Low ^{a)} | Equal to or above 0.2 and below 2 mg/m ³ |
| Very low ^{b)} | Below 0.2 mg/m ³ |

a) 0.2 mg/m³ is the agreed quantitative threshold for discernible ash.

b) Ash that may be detectable by more sensitive satellite and other remote sensing or in-situ monitoring capabilities.

| Descriptor | Ranges |
|------------|---------------------------------|
| High | >4 mg/m ³ |
| Medium | 2 – 4 mg/m ³ |
| Low | ≥ 0.2 and < 2 mg/m ³ |

Current thresholds (being retired)

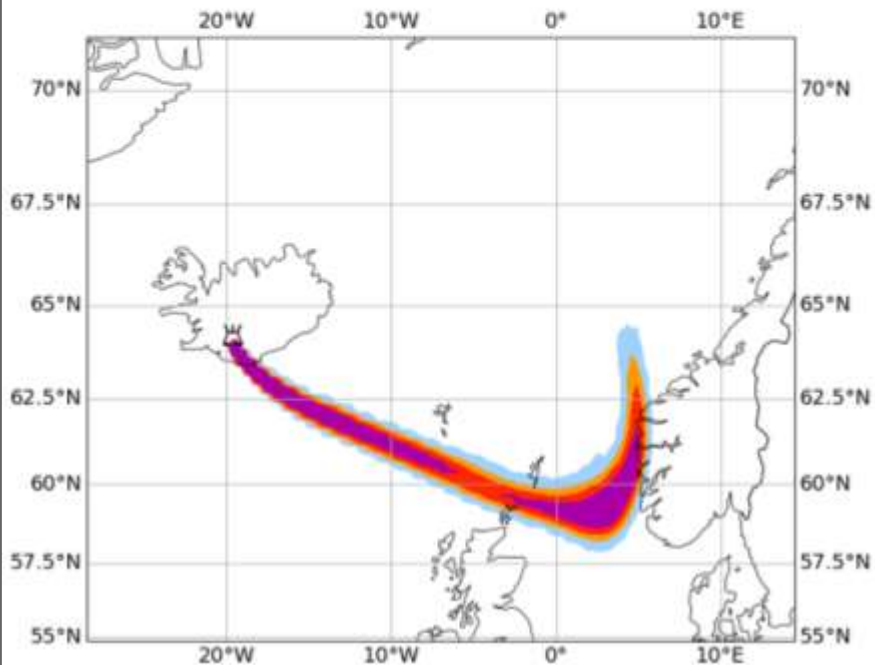
Modelled Ash Concentration
From FL250 to FL300
For HEKLA
Valid at 0700 UTC 08/08/2024

This chart displays QVA compliant concentration data from VAAC London

Issue Time: 1300 UTC 07 Aug 2024

TEST TEST TEST

Low 0.2 - 2.0 mg m⁻³ Medium 2.0 - 5.0 mg m⁻³ High 5.0 - 10.0 mg m⁻³ Very High > 10.0 mg m⁻³



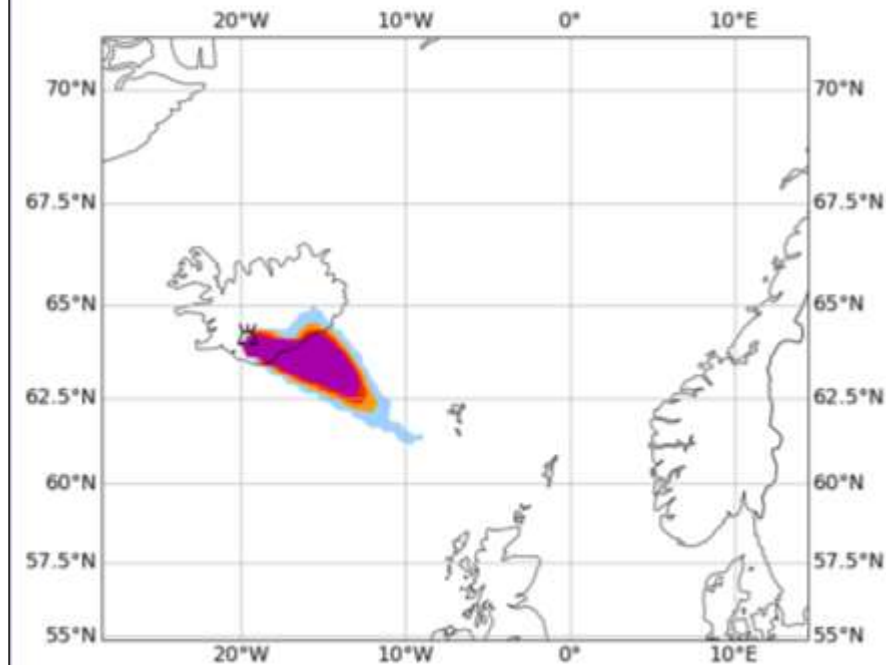
Modelled Ash Concentration
From FL400 to FL450
For HEKLA
Valid at 0700 UTC 08/08/2024

This chart displays QVA compliant concentration data from VAAC London

Issue Time: 1300 UTC 07 Aug 2024

TEST TEST TEST

Low 0.2 - 2.0 mg m⁻³ Medium 2.0 - 5.0 mg m⁻³ High 5.0 - 10.0 mg m⁻³ Very High > 10.0 mg m⁻³



- 2. Probability of exceeding four different concentration thresholds.

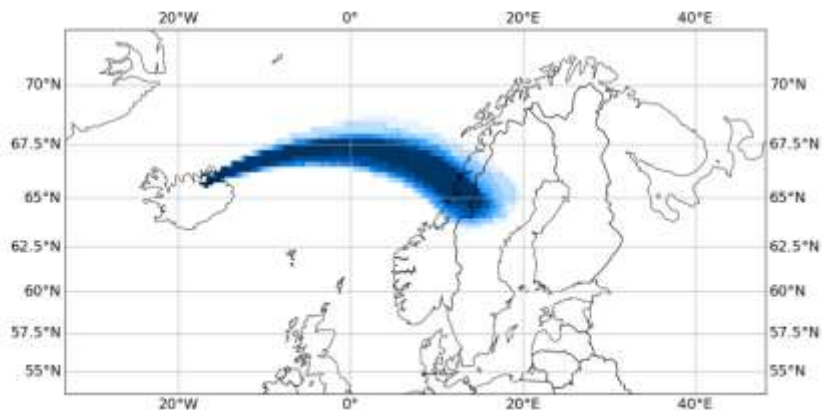


Probability of Exceeding 0.2 mg m^{-3}
From FL300 to FL350
For KRAFLA
Valid at 0400 UTC 03/10/2024

This chart displays OVA compliant probabilistic data from WAAC London

Issue Time: 1600 UTC 02 Oct 2024

TEST TEST TEST

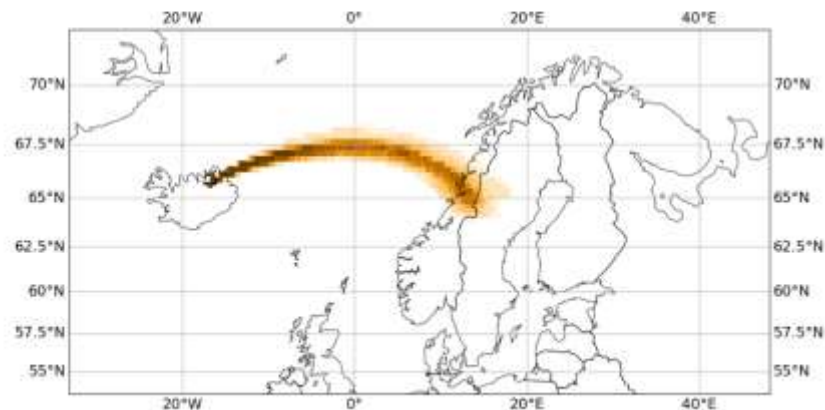


Probability of Exceeding 2.0 mg m^{-3}
From FL300 to FL350
For KRAFLA
Valid at 0400 UTC 03/10/2024

This chart displays OVA compliant probabilistic data from WAAC London

Issue Time: 1600 UTC 02 Oct 2024

TEST TEST TEST



Not shown: probability of exceeding 5 mg m^{-3} and probability of exceeding 10 mg m^{-3}

- ***Probability calculation:***
- Meteorological Uncertainty: VAACs London will use its global ensemble model with 18 members
- Eruption Source Term Uncertainty: Some VAAC's may use this to cater for uncertainty in what is being throw from the volcano.

Gridded data will be provided at a 0.25-degree horizontal resolution and for 5000ft slices of the atmosphere between the surface and FL600.

| |
|---|
| From mean sea level to and including flight level (FL) 50 |
| Above FL 50 to and including FL 100 |
| Above FL 100 to and including FL 150 |
| Above FL 150 to and including FL 200 |
| Above FL 200 to and including FL 250 |
| Above FL 250 to and including FL 300 |
| Above FL 300 to and including FL 350 |
| Above FL 350 to and including FL 400 |
| Above FL 400 to and including FL 450 |
| Above FL 450 to and including FL 500 |
| Above FL 500 to and including FL 550 |
| Above FL 550 to and including FL 600 |

Current vertical levels (being retired)

| |
|--|
| From mean sea level to and including FL200 |
| Above FL200 to and including FL350 |
| Above FL350 to an including FL550 |

Temporal Resolution?

- Currently we provide a temporal resolution of 6 hrs to T+18.
- QVA information will be provided in the following three hourly valid time increments: 0, 3, 6, 9, 12, 15, 18, 21 and 24 hours. QVA information will be updated as necessary but at least every six hours until the volcanic ash cloud is no longer considered a hazard.

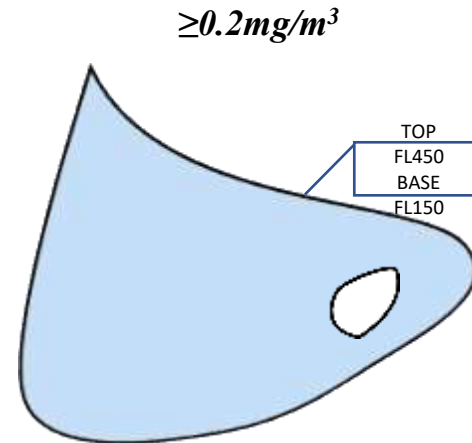
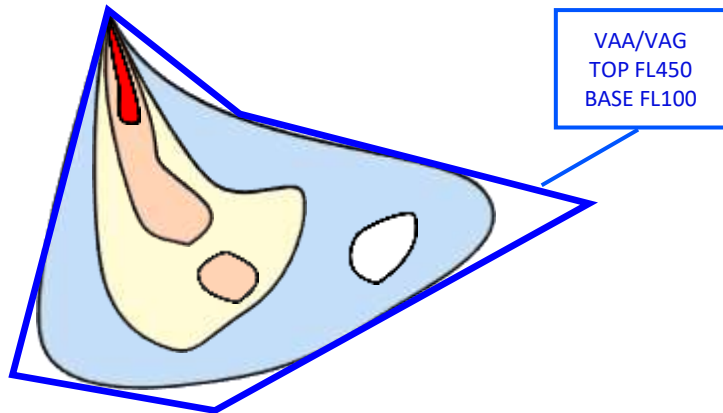
Data format

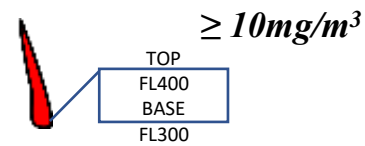
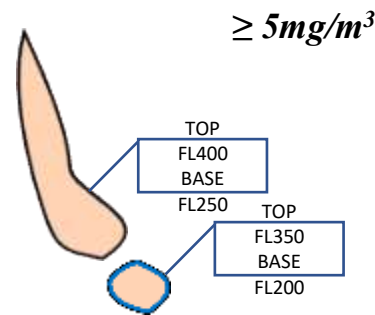
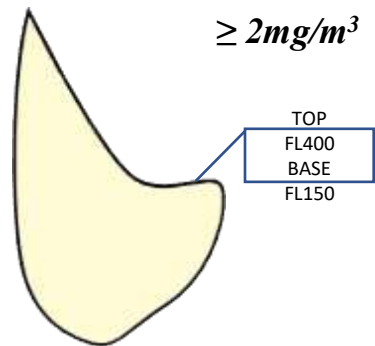
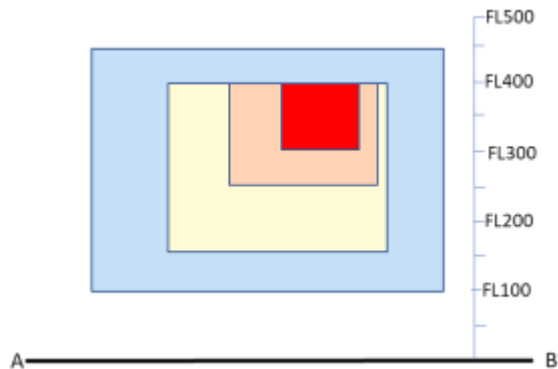
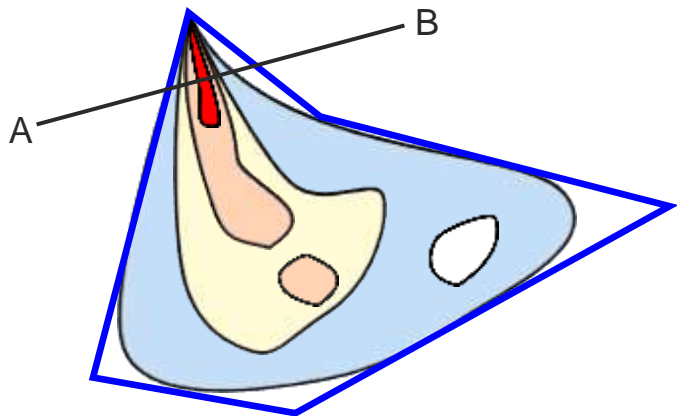
- Currently .csv (being retired)
- QVA will be provided in NetCDF format. The geographical extent will cover the entire plume from that volcano, however big that is.
- IWXXM format

Object/feature data set

SIGWX like data set that can be used for situational awareness. They will be created from (and therefore will be consistent with) the deterministic gridded QVA data.

The data will be provided in ICAO's Meteorological Information Exchange Model (IWXXM) format





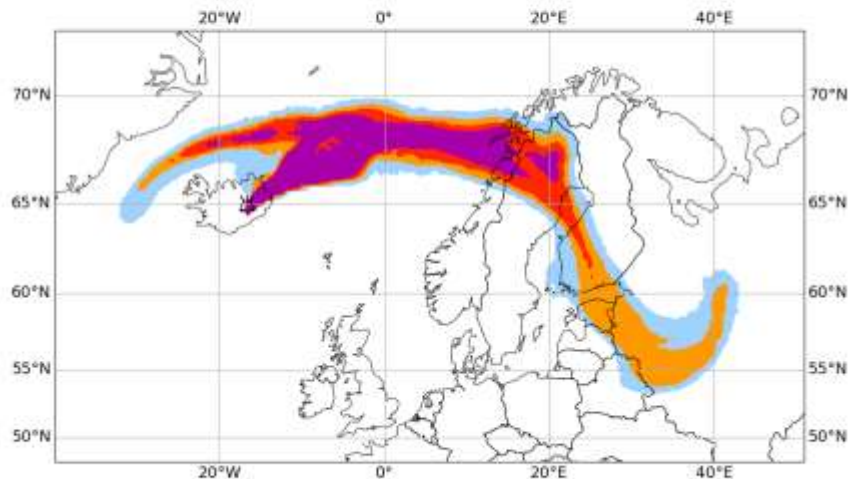
Modelled Ash Concentration
From FL000 to FL600
For KVERKFJOLL
Valid at 1500 UTC 23/10/2024

This chart displays OWA compliant concentration data from VAAC London.

Issue Time: 1500 UTC 22 Oct 2024

TEST TEST TEST

Low 0.2 - 2.0 mg m⁻³ Medium 2.0 - 5.0 mg m⁻³ High 5.0 - 10.0 mg m⁻³ Very High > 10.0 mg m⁻³



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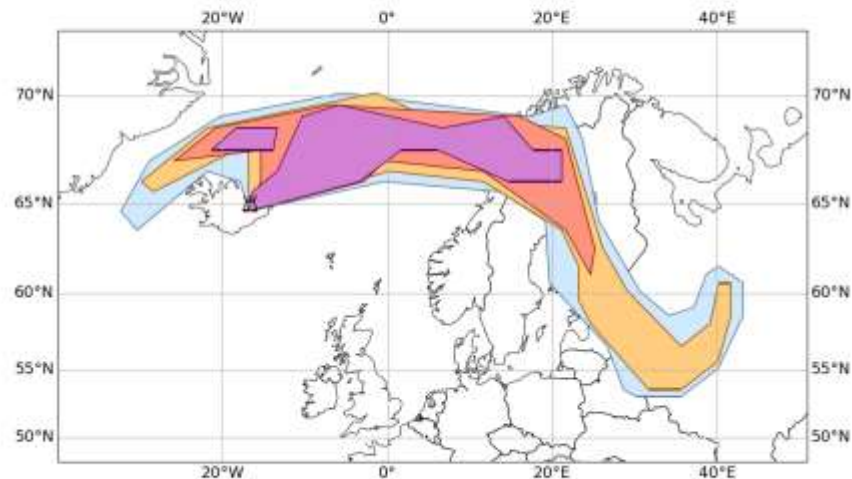
Modelled Ash Concentration
From FL000 to FL600
For KVERKFJOLL
Valid at 1500 UTC 23/10/2024

This chart displays OWA compliant concentration data from VAAC London.

Issue Time: 1500 UTC 22 Oct 2024

TEST TEST TEST

Low 0.2 - 2.0 mg m⁻³ Medium 2.0 - 5.0 mg m⁻³ High 5.0 - 10.0 mg m⁻³ Very High > 10.0 mg m⁻³



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How to get the QVA data

A VAAC London QVA API will be introduced in early June 2025

Data will be provided via an API, with an accompanying notifications system that users can subscribe to (to know when new data is published)

QVA implementation

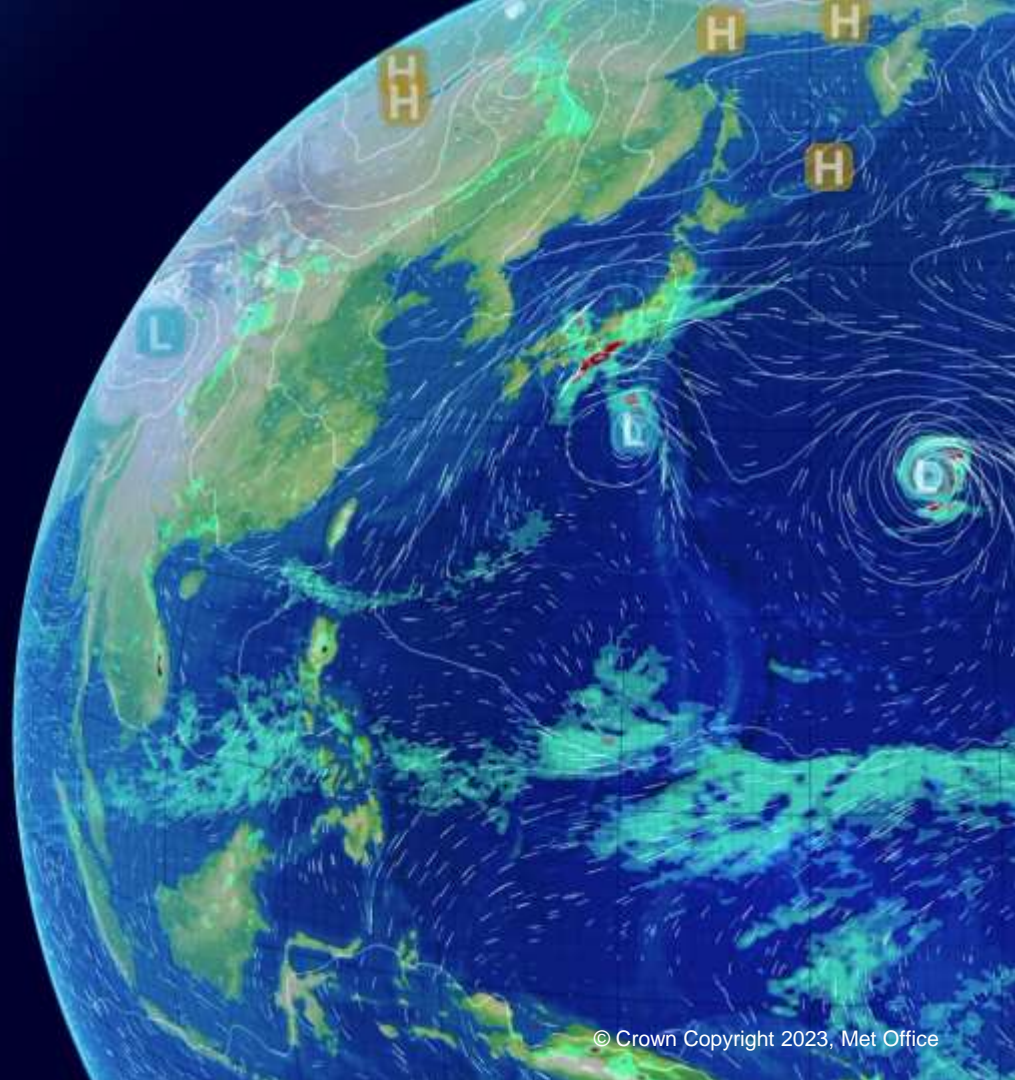
- Test/exercise QVA data will be regularly published (in absence of a real eruption)
- Old concentration charts will be phased out (potentially end of 2026)
- Volcanic Ash Advisory messages and graphics will continue until at least 2030

Thank you for listening

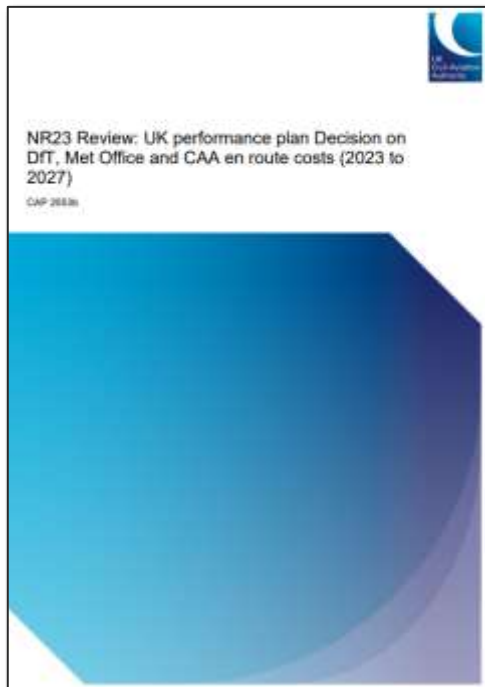
Update on Finances

Mark Gibbs

Head of Transport Business



NR23 Decision (CAP2553b)



Our Decision

2.10 For the reasons set out above and in our Initial Proposals, our Decision on Met Office Determined Costs for NR23 is as set out in Table 2.2 below.

Table 2.2 Met Office NR23 Determined Costs (nominal and 2020 prices)

| £m | 2023 | 2024 | 2025 | 2026 | 2027 | NR23 Total |
|---|------|------|------|------|------|------------|
| National Capability and International Subscriptions | 19.2 | 23.6 | 25.8 | 25.9 | 26.4 | |
| Aviation MET Service Delivery | 8.2 | 8.1 | 6.8 | 6.7 | 6.6 | |
| Aviation MET Service Development | 7.6 | 7.5 | 6.7 | 6.6 | 6.8 | |
| Total Determined Costs (nominal) | 35.0 | 39.2 | 39.3 | 39.2 | 39.7 | 192.4 |
| Total Determined Costs (2020 prices) | 29.5 | 32.7 | 32.8 | 32.5 | 32.5 | 160.0 |

Source: Met Office



Met Office NR23 costs were originally set in 2022 prices. This means the updated inflation data has had a minor impact on both nominal and 2020 CPI prices.

2023 Actual v Determined cost

| Met Office | Actuals | |
|-------------------------|---------------|---------------|
| £'000 | 2022 | 2023 |
| Staff | 15,882 | 19,596 |
| of which, pension costs | 2,879 | 3,540 |
| Other operating costs | 8,318 | 8,725 |
| Depreciation | 2,755 | 3,201 |
| Cost of capital | 3,054 | 3,857 |
| Exceptional items | - | - |
| Total costs | 30,009 | 35,379 |

both yrs

65,388

Determined cost

31,632

34,980

66,612

Act v determined

-5%

1%

-2%

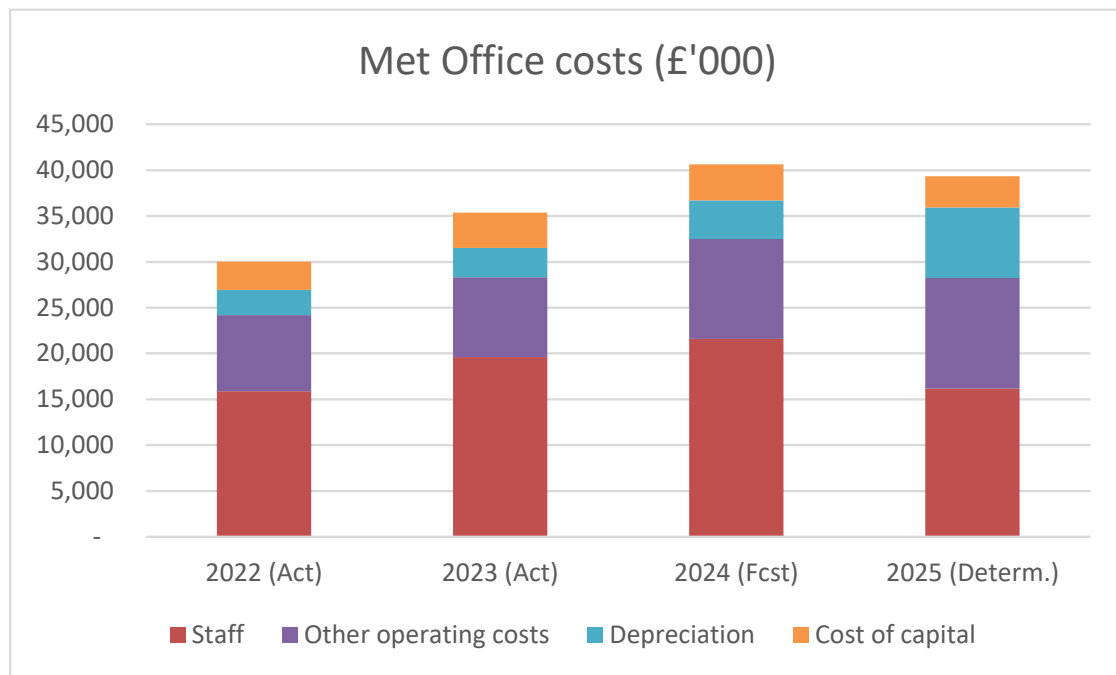
- Increase in line with original NR23 plan.
 - Recovery of work postponed during COVID
 - Transitioning of services from products to Information Services
 - Replacement legacy systems

Future costs

| Met Office £'000 | Determined 2024 | Current fcst 2024 | Determined 2025 |
|-------------------------|--------------------|----------------------|--------------------|
| Staff | 17,052 | 21,595 | 16,170 |
| of which, pension costs | 3,529 | 4,470 | 3,347 |
| Other operating costs | 11,919 | 10,904 | 12,066 |
| Depreciation | 6,646 | 4,201 | 7,703 |
| Cost of capital | 3,539 | 3,934 | 3,394 |
| Exceptional items | - | - | - |
| Total costs | 39,155 | 40,634 | 39,334 |

- Continued investment
 - development of Information Services
 - Lifecycling of legacy systems
- 2024 reduction in depreciation due to delay in EUMETSAT programme
- Any annual underspend is carried forward onto future years

Profile of spend 2022-2025



No requirement to change NR23 plans or unit rate

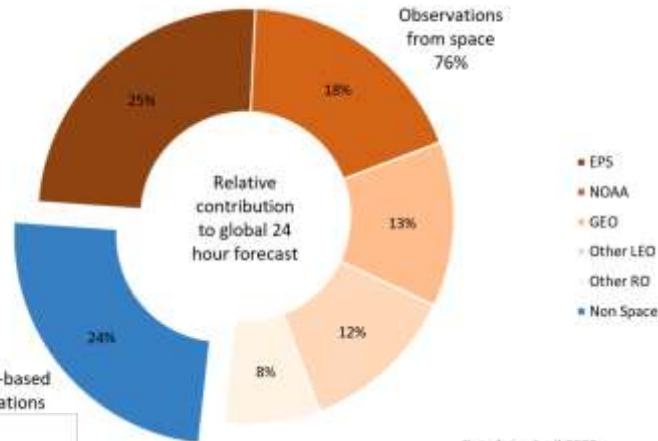
NR23 Plan

| £,000 | 2023 | 2024 | 2025 | 2026 | 2027 |
|---|--------|--------|--------|--------|--------|
| National Capability & International Subscriptions | 18,047 | 22,065 | 24,092 | 24,092 | 24,092 |
| Designation Agreement Services | 7,740 | 7,547 | 6,358 | 6,199 | 6,044 |
| Additional Services & Development | 7,173 | 6,965 | 6,253 | 6,087 | 6,187 |
| Total | 32,960 | 36,577 | 36,703 | 36,378 | 36,323 |

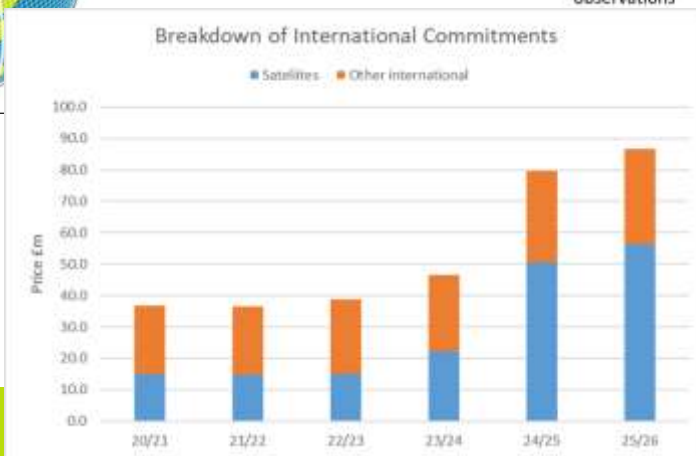
Annex 3 services

Service development

National Capability & International subscriptions



Data from April 2023



Additional Services & Development

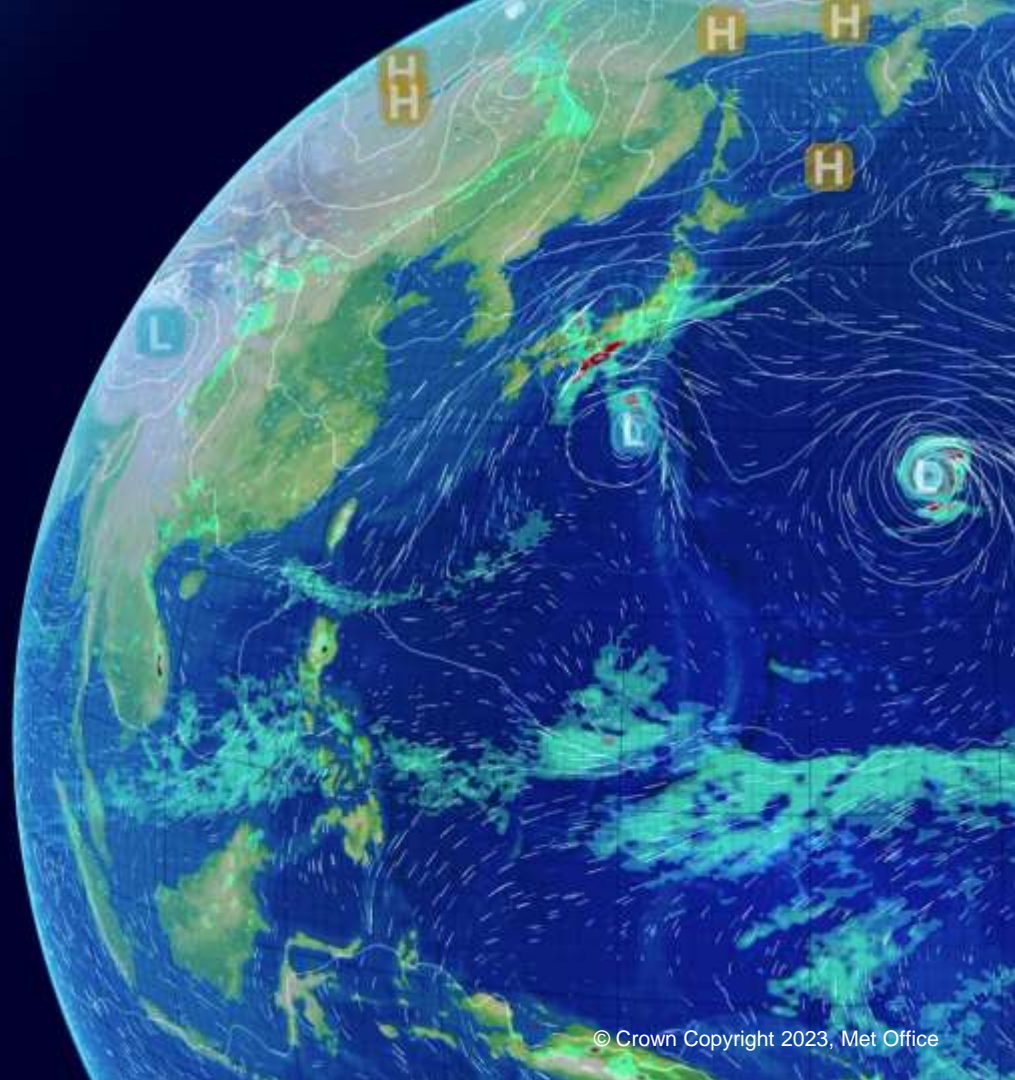
Key 2024 activities

- WAFS & SADIS developments
- QVA development
- Embedded NATS team
- Re-development of Visualisation services – MAVIS
- Refurbishment of Volcanic Ash observing network (kick-off)
- Scientific Research & development

Thank you for listening

National Aviation Services

Lauren Donohue





NATS





- 7 user specific tools
- Varying age of infrastructure and technology options
- New meteorological information services
- Ensure access to regulated and key information for decision making



Our mission

Empowering the aviation industry to make safe and efficient decisions.



Our vision

Unrivalled, personalised weather visualisations in one place for aviation.

Tiered access



←

←

←

All users eligible, most likely airports, airlines



NATS



Offshore helicopters



Emergency service helicopters

←

←

All users

GA (Private, recreational, work)

BizJet

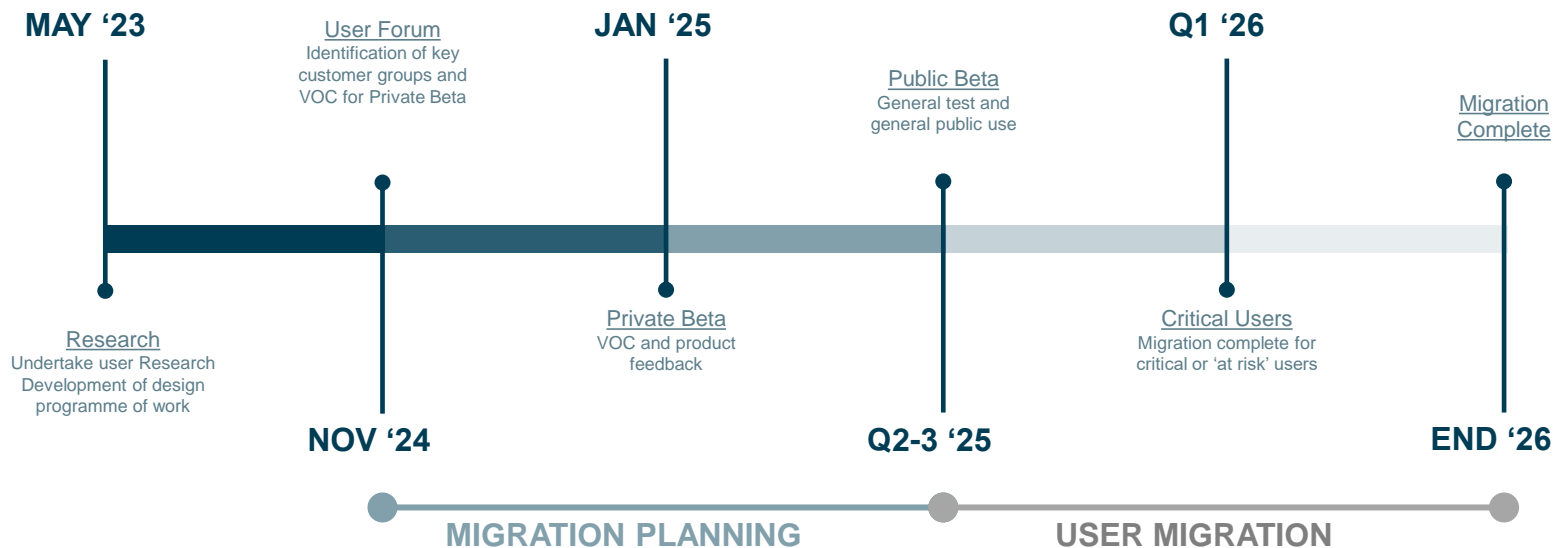
Airport

Airline

Commercial helicopters

ATS

Milestones / Timelines

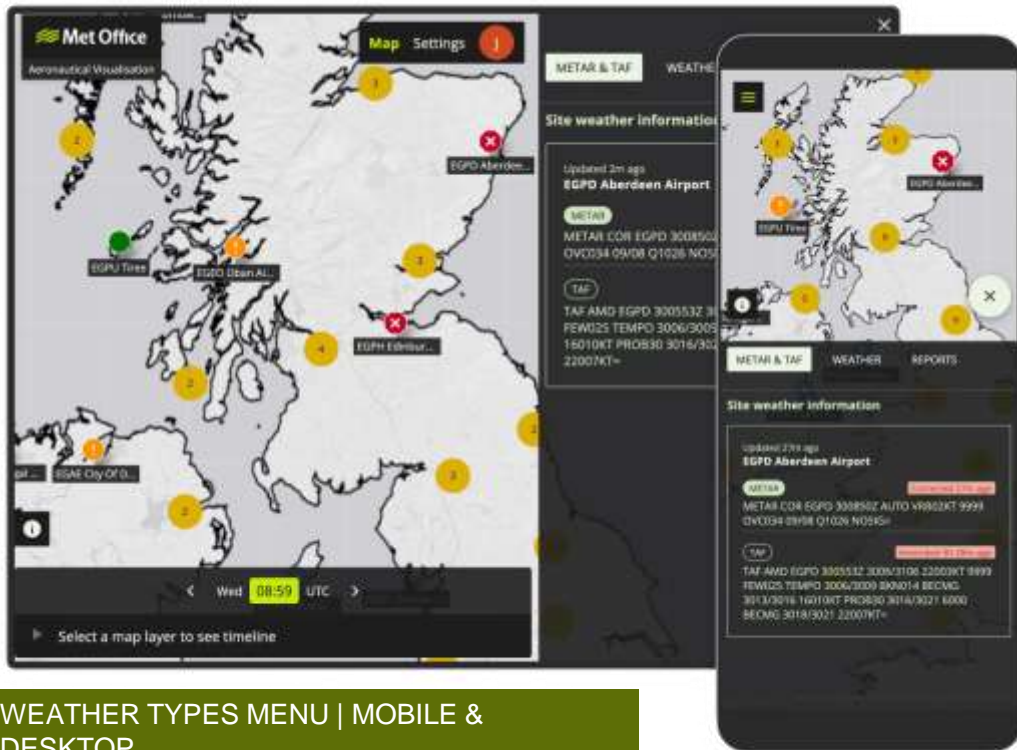


Designs

Basemap, Aerodrome Locations.



BASEMAP



The image shows a desktop view of the Met Office website. The main area is a map of the United Kingdom with several aerodrome locations marked by yellow and red circles. A sidebar on the right displays weather information for EGPD Aberdeen Airport, including METAR and TAF data. The METAR data is: METAR COR EGPD 300850Z 070304 0908 Q1026 NOS. The TAF data is: TAF AMD EGPD 30053Z 31 FEW025 TEMPO 3006/3008 1601KT PROB30 3016/3022007KT=.

WEATHER TYPES MENU | MOBILE & DESKTOP

METARs, TAFs and warnings



SITE ICONS

SITE WEATHER

PINNED SITES

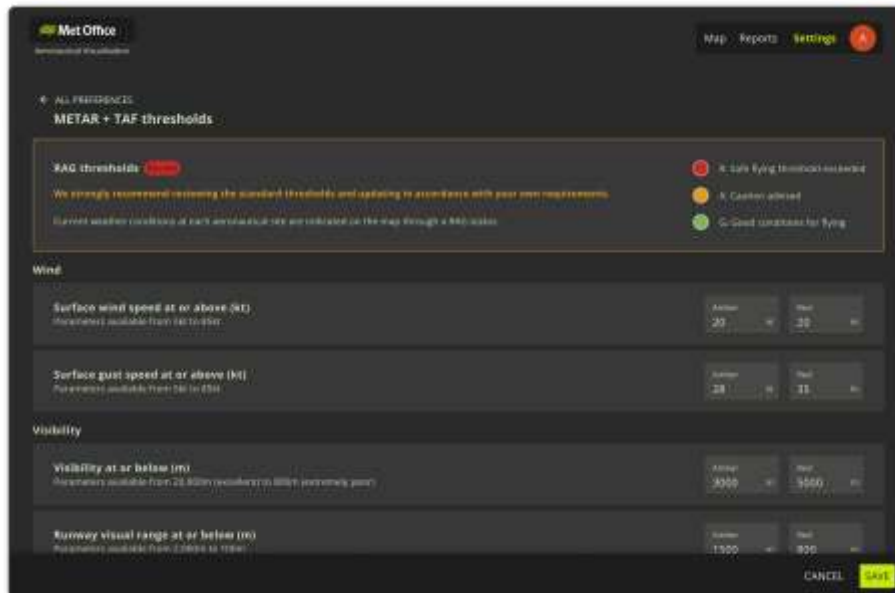
Timeline



DESKTOP WITH ISSUE TIME WARNING

PIN FAVORITE LAYERS

RAG thresholds



Met Office
International Weather

Map Reports **Settings**

← ALL PREFERENCES
METAR + TAF thresholds

RAG thresholds (1/2023)

- R - Safe flying threshold exceeded
- R - Caution advised
- G - Good conditions for flying

We strongly recommend reviewing the standard thresholds and updating to align with your own requirements.
Current weather conditions at each airport are also indicated on the map through a RAG colour.

Wind

Surface wind speed at or above (kt)
Parameters available from 04:00 to 05:00

| | | |
|----------|----|----|
| Aviation | 20 | 20 |
|----------|----|----|

Surface gust speed at or above (kt)
Parameters available from 04:00 to 05:00

| | | |
|----------|----|----|
| Aviation | 28 | 31 |
|----------|----|----|

Visibility

Visibility at or below (m)
Parameters available from 20:00m resolution to 000m (precision path)

| | | |
|----------|------|------|
| Aviation | 3000 | 3000 |
|----------|------|------|

Runway visual range at or below (m)
Parameters available from 2000m to 100m

| | | |
|----------|------|-----|
| Aviation | 1500 | 800 |
|----------|------|-----|

CANCEL SAVE

DEFAULT RAG THRESHOLDS

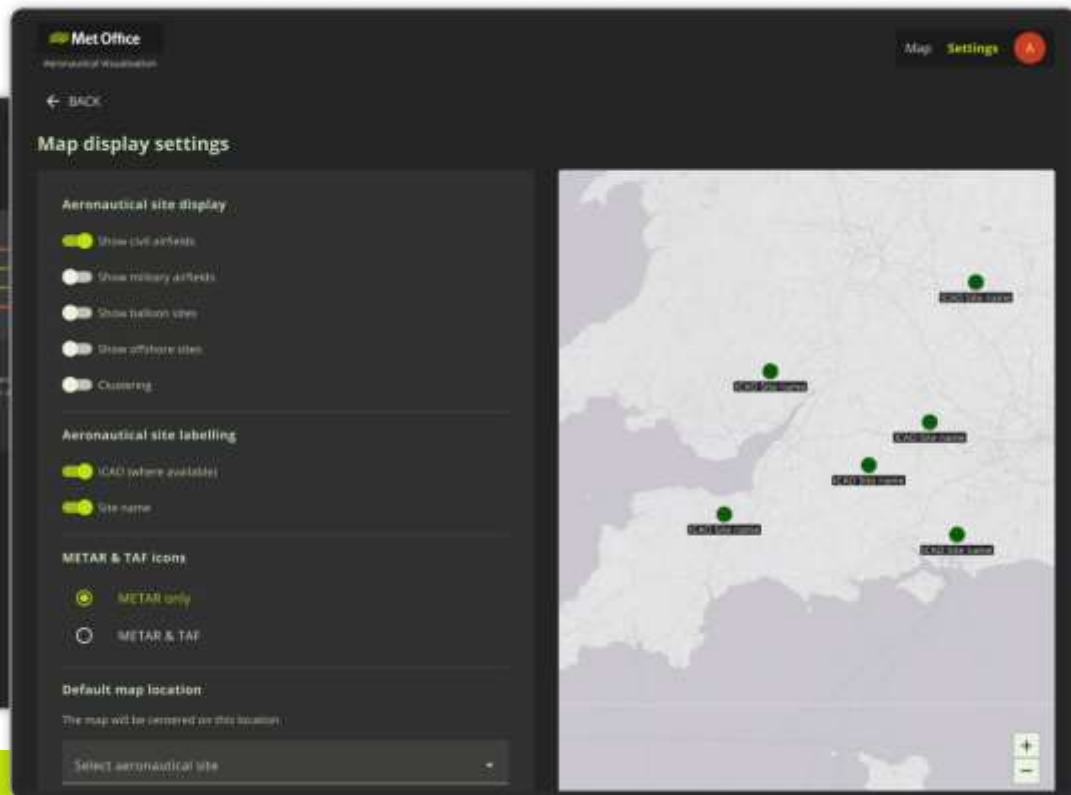
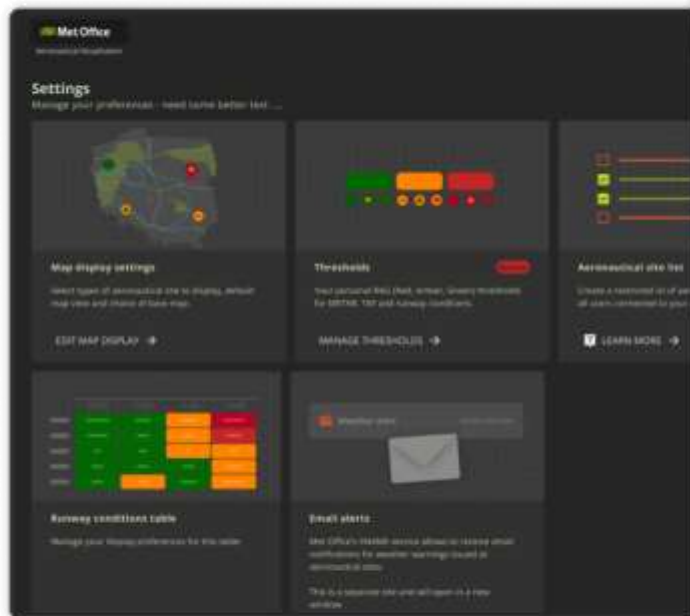


Weather map showing RAG thresholds for various airports. The map displays a grid of airports with their corresponding RAG status (R, G, or A) and color-coded boxes (red, orange, or green) indicating the threshold level. The map includes a legend for RAG thresholds and a list of airports with their RAG status.

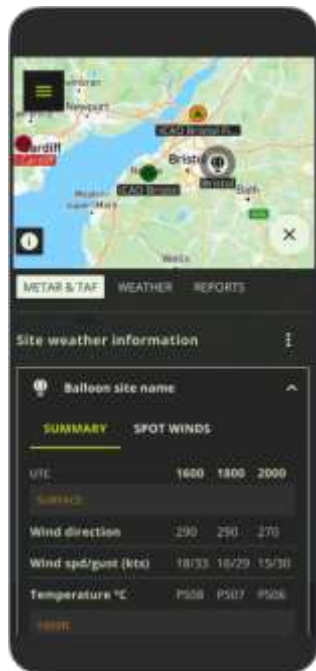
| Airport | RAG Status |
|---------|------------|
| EG | R |
| EGG | G |
| EGN | R |
| EGP | R |
| EGS | R |
| EGT | R |
| EGU | R |
| EGV | R |
| EGW | R |
| EGX | R |
| EGY | R |
| EGZ | R |
| EGAA | R |
| EGAB | R |
| EGAC | R |
| EGAD | R |
| EGAE | R |
| EGAF | R |
| EGAG | R |
| EGAH | R |
| EGAI | R |
| EGAJ | R |
| EGAK | R |
| EGAL | R |
| EGAM | R |
| EGAN | R |
| EGAO | R |
| EGAP | R |
| EGAQ | R |
| EGAR | R |
| EGAS | R |
| EGAT | R |
| EGAU | R |
| EGAV | R |
| EGAW | R |
| EGAX | R |
| EGAY | R |
| EGAZ | R |
| EGBA | R |
| EGBB | R |
| EGBC | R |
| EGBD | R |
| EGBE | R |
| EGBF | R |
| EGBG | R |
| EGBH | R |
| EGBI | R |
| EGBJ | R |
| EGBK | R |
| EGBL | R |
| EGBM | R |
| EGBN | R |
| EGBO | R |
| EGBP | R |
| EGBQ | R |
| EGBR | R |
| EGBS | R |
| EGBT | R |
| EGBU | R |
| EGBV | R |
| EGBW | R |
| EGBX | R |
| EGBY | R |
| EGBZ | R |
| EGCA | R |
| EGCB | R |
| EGCC | R |
| EGCD | R |
| EGCE | R |
| EGCF | R |
| EGCG | R |
| EGCH | R |
| EGCI | R |
| EGCJ | R |
| EGCK | R |
| EGCL | R |
| EGCM | R |
| EGCN | R |
| EGCO | R |
| EGCP | R |
| EGCQ | R |
| EGCR | R |
| EGCS | R |
| EGCT | R |
| EGCU | R |
| EGCV | R |
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| EGCZ | R |
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| EGDB | R |
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| EGDF | R |
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| EGDS | R |
| EGDT | R |
| EGDU | R |
| EGDV | R |
| EGDW | R |
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| EGET | R |
| EGEU | R |
| EGEV | R |
| EGEW | R |
| EGEX | R |
| EGEY | R |
| EGEZ | R |
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| EGFE | R |
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| EGZT | R |
| EGZU | R |
| EGZV | R |
| EGZW | R |
| EGZX | R |
| EGZY | R |
| EGZZ | R |

WEATHER PREFIX RAG

Individual site RAG thresholds



Runway conditions



Runway conditions Updated: 24m ago
London Heathrow

Mon 04 Mar 12:20 - Tue 05 Mar 15:00 UTC

| | 12:20 | 12:50 | 13:20 | 13:50 | 14:20 | 14:50 | 15:20 | 16:00 | 17:00 | 18:00 |
|----------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| SURFACE | | | | | | | | | | |
| WIND DIRECTION | 140 | 140 | 140 | 140 | 140 | 140 | 140 | 134 | 132 | 139 |
| WIND SPEED | 16 | 17 | 14 | 16 | 15 | 16 | 21 | 21 | 21 | 19 |
| GUST SPEED | | | | | | 29 | 31 | 34 | 33 | 31 |
| CEILING | | | | | | | | | | |
| RUNWAY 1 | 14 | 14 | 13 | 12 | 14 | 14 | 14 | 13 | 13 | 13 |
| RUNWAY 2 | 16 | 17 | 14 | 16 | 15 | 16 | 21 | 21 | 21 | 19 |
| RUNWAY 3 | 21 | 20 | 22 | 19 | 19 | 29 | 31 | 34 | 33 | 31 |
| RUNWAY 4 | | | | | | | | | | |
| UPPER WIND | | | | | | | 140 | 134 | 132 | 139 |
| DIRECTION | | | | | | | 27 | 27 | 25 | 19 |
| SPEED | | | | | | | | | | |
| SCALES | SCT | BRN | BRN | BRN | BRN | BRN | BRN | OVC | BRN | BRN |
| AMOUNT | 2100 | 2200 | 2100 | 2000 | 1900 | 1500 | 1300 | 1700 | 800 | 800 |
| BASE | | | | | | | | | | |
| WEATHER | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 14 |
| VISIBILITY | | | | RA | RA | RA | RA | D | D | RA |
| WEATHER | | | | | | | | 0 | 0 | 0 |
| LOWERING | | | | | | | | 1.5 | 0.1 | 0.3 |

Runway conditions Updated: 24m ago
Bristol Airport

Mon 04 Mar 12:20 - Tue 05 Mar 15:00 UTC

Hide rows with no warnings

| | 12:20 | 12:20 | 12:20 | 12:20 |
|----------------|-------|-------|-------|-------|
| SURFACE | | | | |
| WIND DIRECTION | 12345 | 12345 | 12345 | 12345 |
| WIND SPEED | 12345 | 12345 | 12345 | 12345 |
| GUST SPEED | 12345 | 12345 | 12345 | 12345 |
| WAVE | 12345 | 12345 | 12345 | 12345 |
| SECTION NAME | | | | |
| VALUE 1 | 12345 | 12345 | 12345 | 12345 |
| VALUE 2 | 12345 | 12345 | 12345 | 12345 |
| VALUE 3 | 12345 | 12345 | 12345 | 12345 |
| VALUE 4 | 12345 | 12345 | 12345 | 12345 |
| SECTION NAME | | | | |
| RST | | | | |
| RUNWAY 1 | 1.5 | 1.5 | 1.4 | 1.6 |
| RUNWAY 2 | 1.5 | 1.5 | 1.4 | 1.6 |
| RUNWAY 3 | 1.5 | 1.5 | 1.4 | 1.6 |

Runway conditions Updated: 24m ago
Cardiff Airport

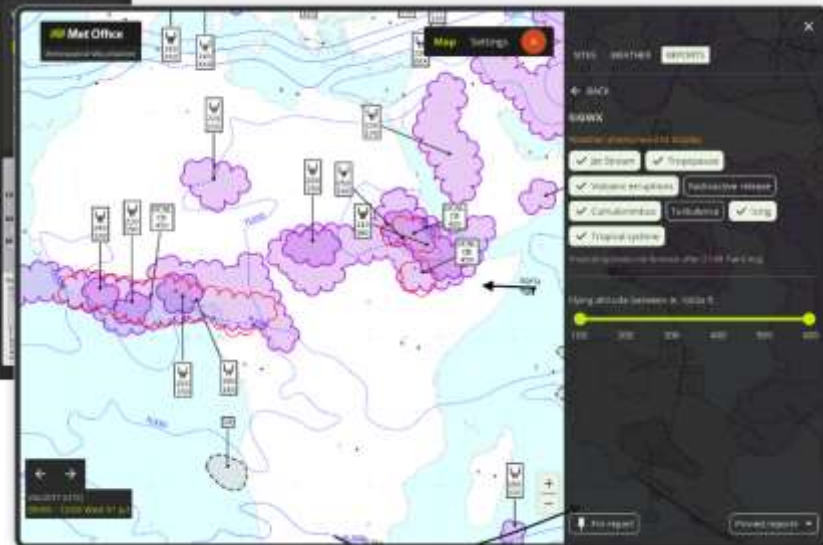
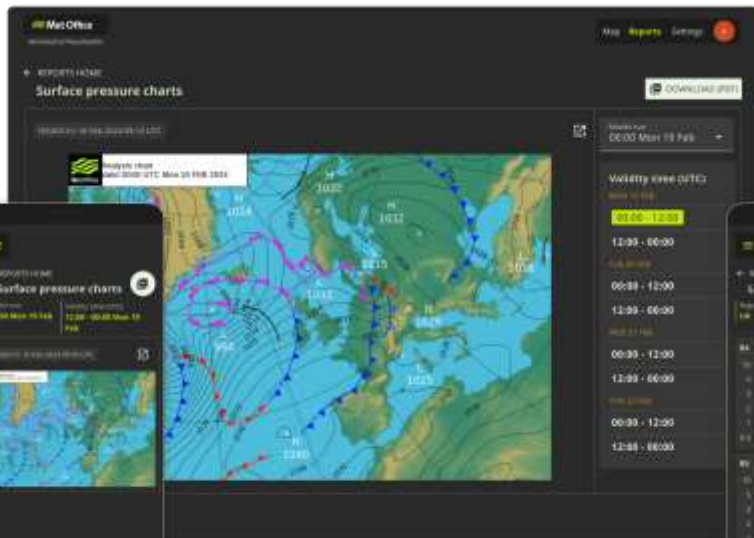
Mon 04 Mar 12:20 - Tue 05 Mar 15:00 UTC

Hide rows with no warnings

| | 12:20 | 12:20 | 12:20 | 12:20 |
|----------------|-------|-------|-------|-------|
| SURFACE | | | | |
| WIND DIRECTION | 12345 | 12345 | 12345 | 12345 |
| WIND SPEED | 12345 | 12345 | 12345 | 12345 |
| GUST SPEED | 12345 | 12345 | 12345 | 12345 |
| SECTION NAME | | | | |
| WAVE 1 | 12345 | 12345 | 12345 | 12345 |
| WAVE 2 | 12345 | 12345 | 12345 | 12345 |
| SECTION NAME | | | | |
| RST | | | | |
| RUNWAY 1 | 1.5 | 1.5 | 1.4 | 1.6 |
| RUNWAY 2 | 1.5 | 1.5 | 1.4 | 1.6 |
| RUNWAY 3 | 1.5 | 1.5 | 1.4 | 1.6 |

DEFAULT RAG THRESHOLDS

Charts & reports



Your turn


Met Office Aeronautical Visualisation

 <https://mouf.ci.mavis.service.metoffice.gov.uk>

Register via link. Will only work until 4pm today.



First impressions survey and sign up for user testing & research

 <https://forms.office.com/e/NLUT3XRuYE>



Lunch/Tours

1 group at 1230

1 group at 1300



Aviation R&D

Piers Buchanan, Graeme
Anderson and Andrew Creswick
Aviation Applications Team

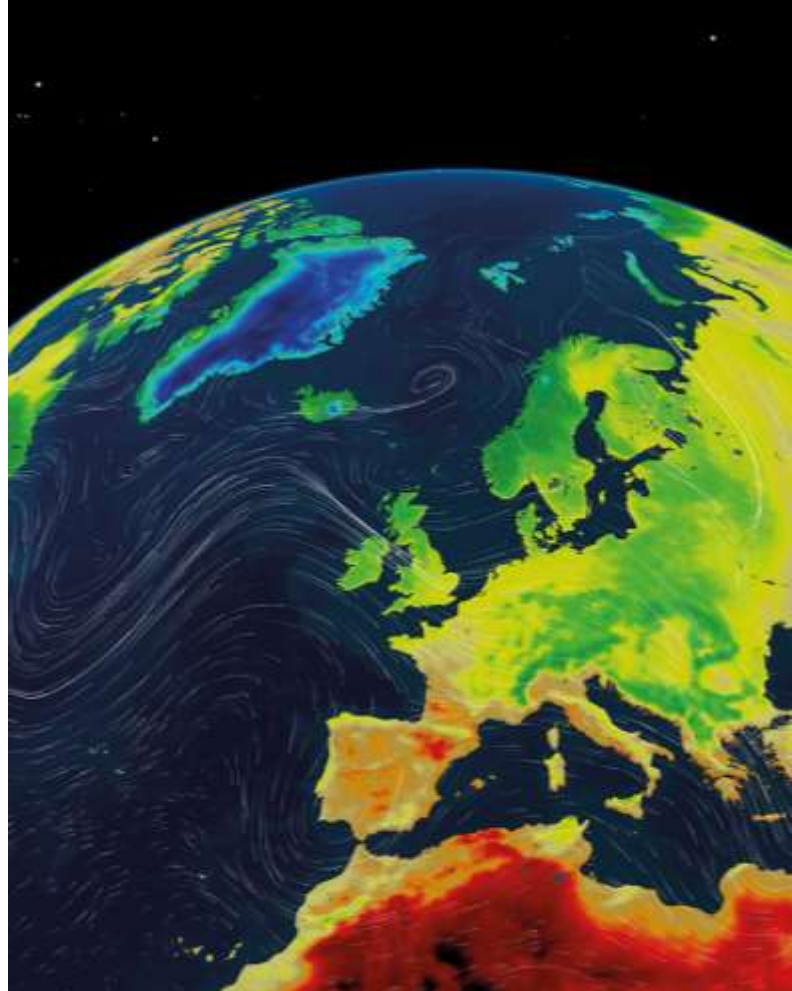


Talk Structure

- R&D Updates
 - Andrew Creswick – Cb forecast updates
 - Graeme Anderson – SigWx implementation work
 - UK updates
- Future NWP plans

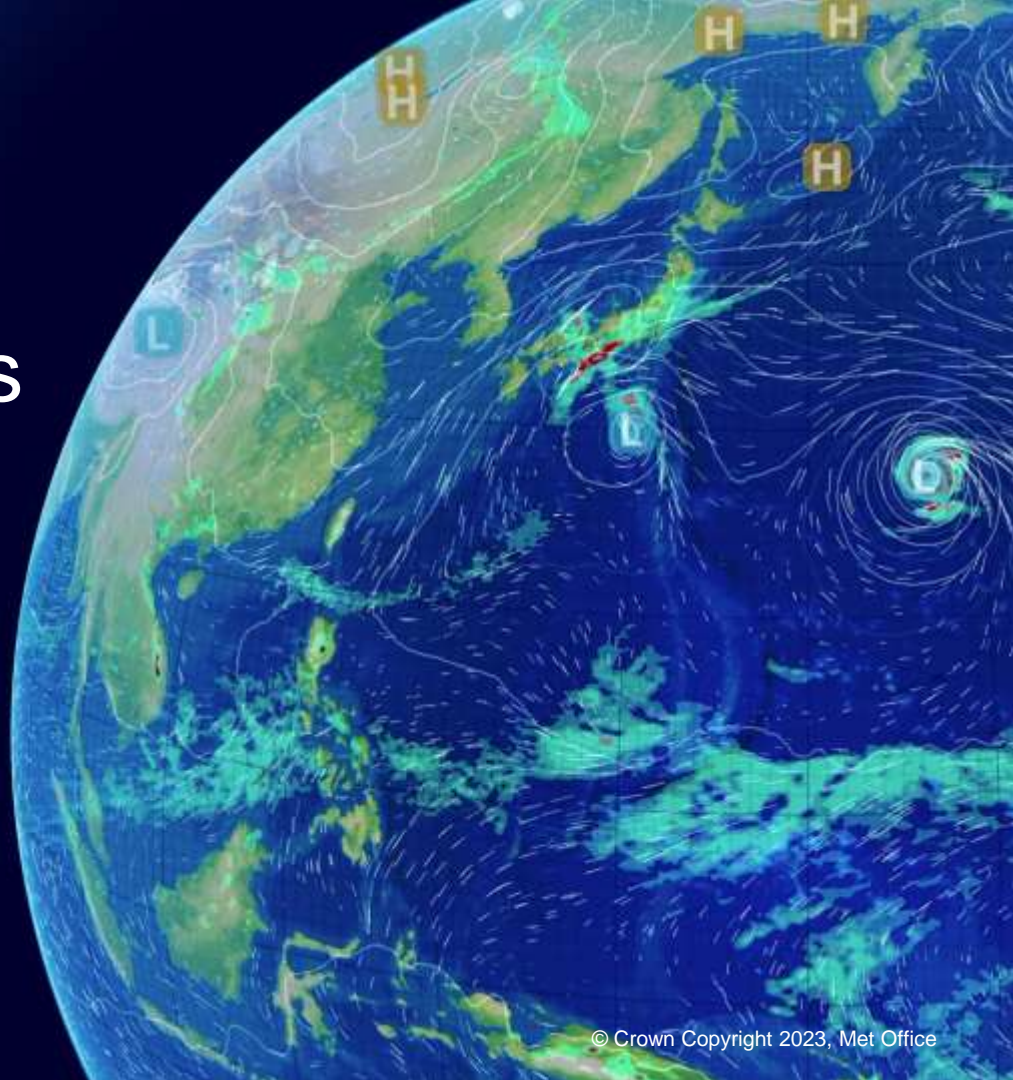
Purpose of global aviation R&D programme

- To support WAFS service with updated science.
- To monitor and improve WAFS datasets for Icing, Turbulence and Cb forecasts
- To develop ability to produce rapid multi-timestep Significant Weather Charts



EPOCH Probabilistic Forecasts of Cumulonimbus Clouds

Met Office User Forum, Nov 2024
Andrew Creswick,
Aviation Applications Scientist





Future WAFS Upgrades

- Probabilistic forecasts of hazards.
- Probability of Cb top height exceeding 30,000 ft, 35,000 ft and 40,000 ft.
- 0.5 degree horizontal resolution
- T+6 to T+48 in 3 hour timesteps

EPOCH

- Ensemble Prediction of Convective Hazards.
- Simple threshold tests determine Cb occurrence for each ensemble member.
- MOGREPS-G and ECMWF global ensembles.

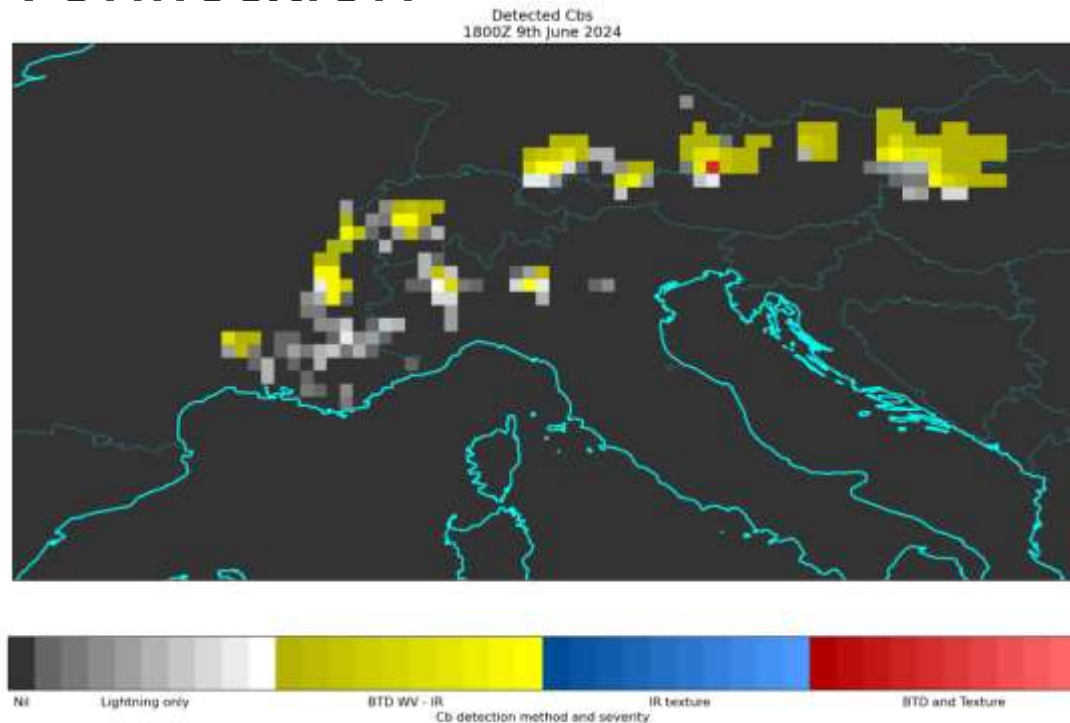


EPOCH thresholds

| | |
|---|---|
| Most Unstable CAPE | 200 J/Kg |
| Accumulated Precipitation from Convective Parametrisation | 2 mm |
| Outgoing Longwave Radiation at Top of Atmosphere | <ul style="list-style-type: none">• < 275 Wm⁻² 30,000ft• < 235 Wm⁻² 35,000ft• < 195 Wm⁻² 40,000ft |



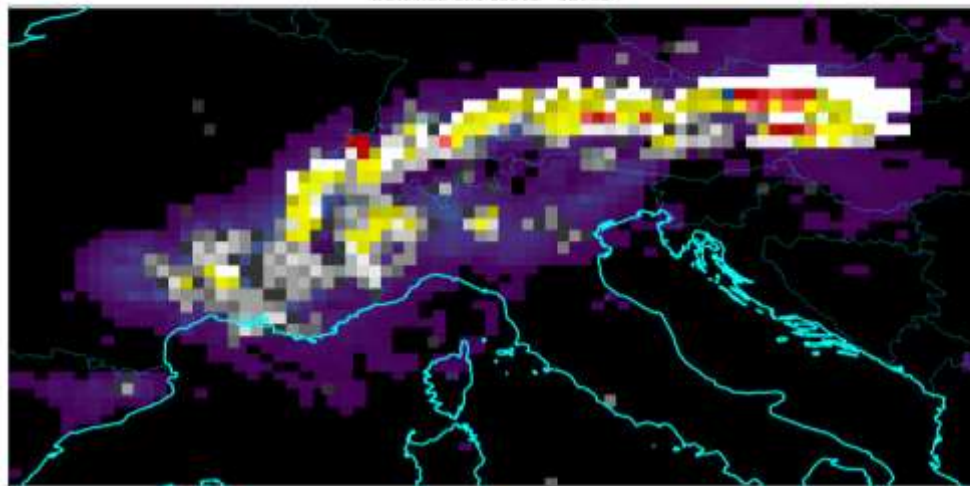
Verification



- Satellite based Cb detection algorithm.
- Uses characteristics of overshooting tops in IR and WV channels.
- Input from lightning detectors.

Construct Reliability Diagrams

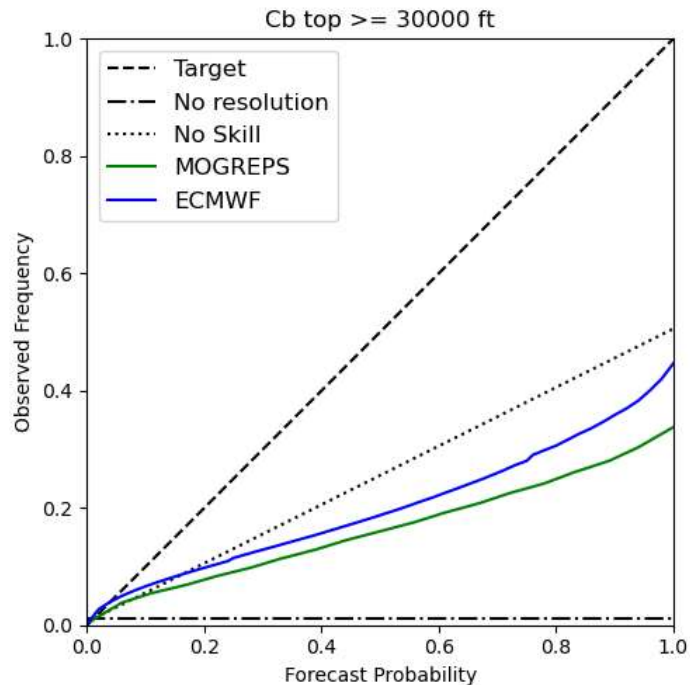
Probability of Cb Top > 30000 ft and detected Cbs.
Forecast VT 1800Z 9th June 2024 (T+18)
Detected Cbs 1530Z - 1800Z



- Compare forecast probability with max detected Cb severity in 3 hour window.
- Point-by-point.

Initial results show poor reliability

- January – June 2023
- Compares forecast probability to how often Cbs are observed.
- These match for a perfectly reliable forecast.
- The results would lie on the dashed line.

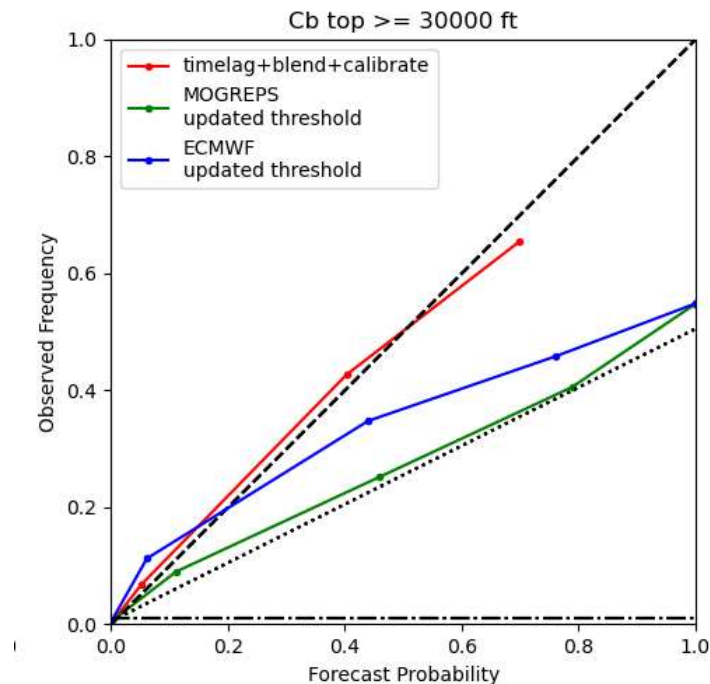


To improve reliability and resolution

- Update EPOCH thresholds
 - Accumulated Precipitation from Convective Parametrisation - ~~2 mm~~ **6 mm**
- Timelag over last 4 cycles.
- Blend MOGREPS-G and ECMWF forecasts

Improved reliability

- Updating threshold leads to some improvement in reliability.
- Combining different sets of forecasts and then calibrating the result gives further improvements.



Summary

- EPOCH produces global probabilistic forecasts of Cbs.
- Forecasts verified against satellite observations of Cbs.
- Post-processing steps and calibration improves statistical reliability.

SQ321 Case Study

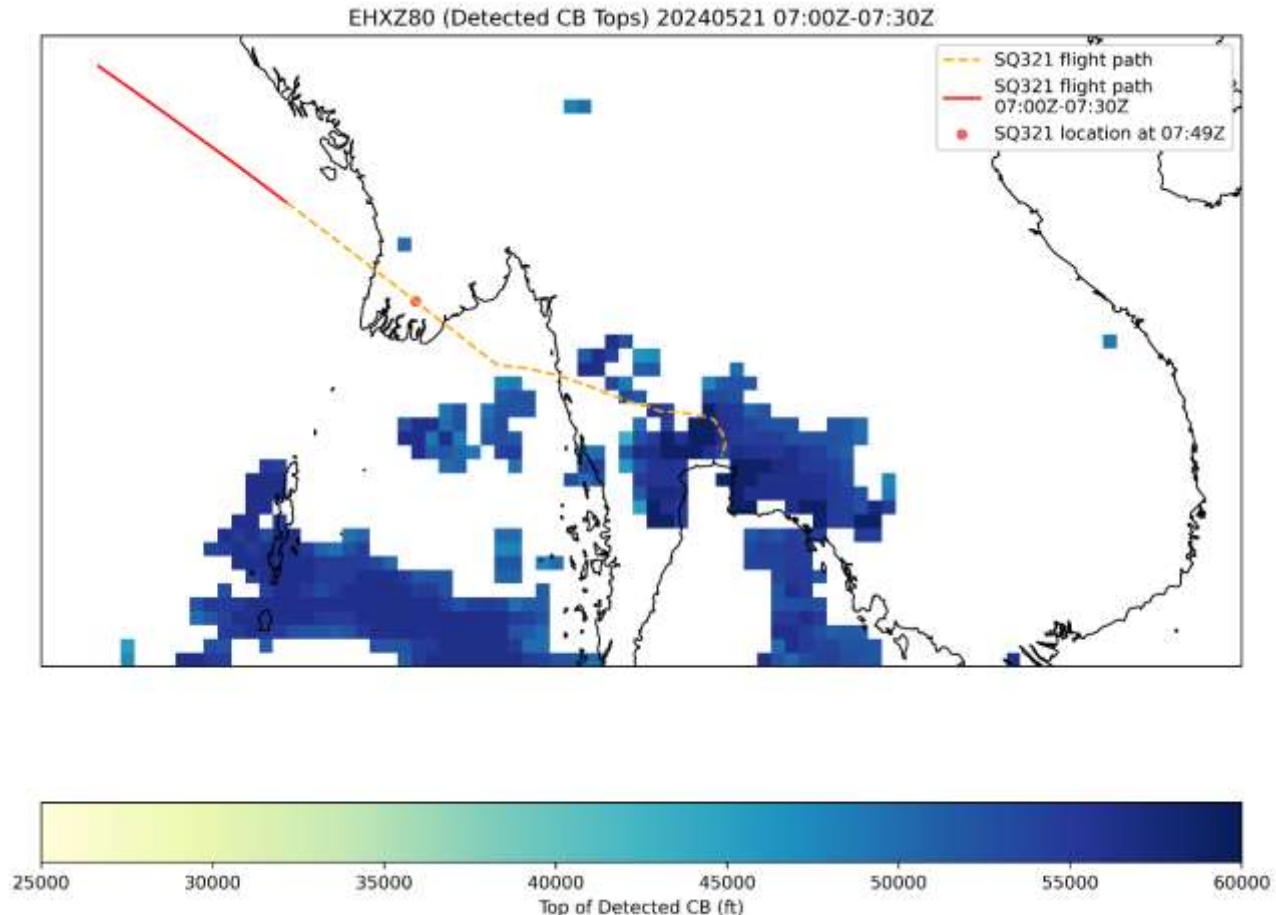
Observations and comparison with EPOCH forecasts

Cloud Top Height for detected Cbs at 30 mins before incident.

N.B. uses a 30 minute window for detection.

Cb detection based on Overshooting Tops detection methods [1].

- IRW texture [2]
- WV-IR BTD [3]
- Lightning detection (LEELA)

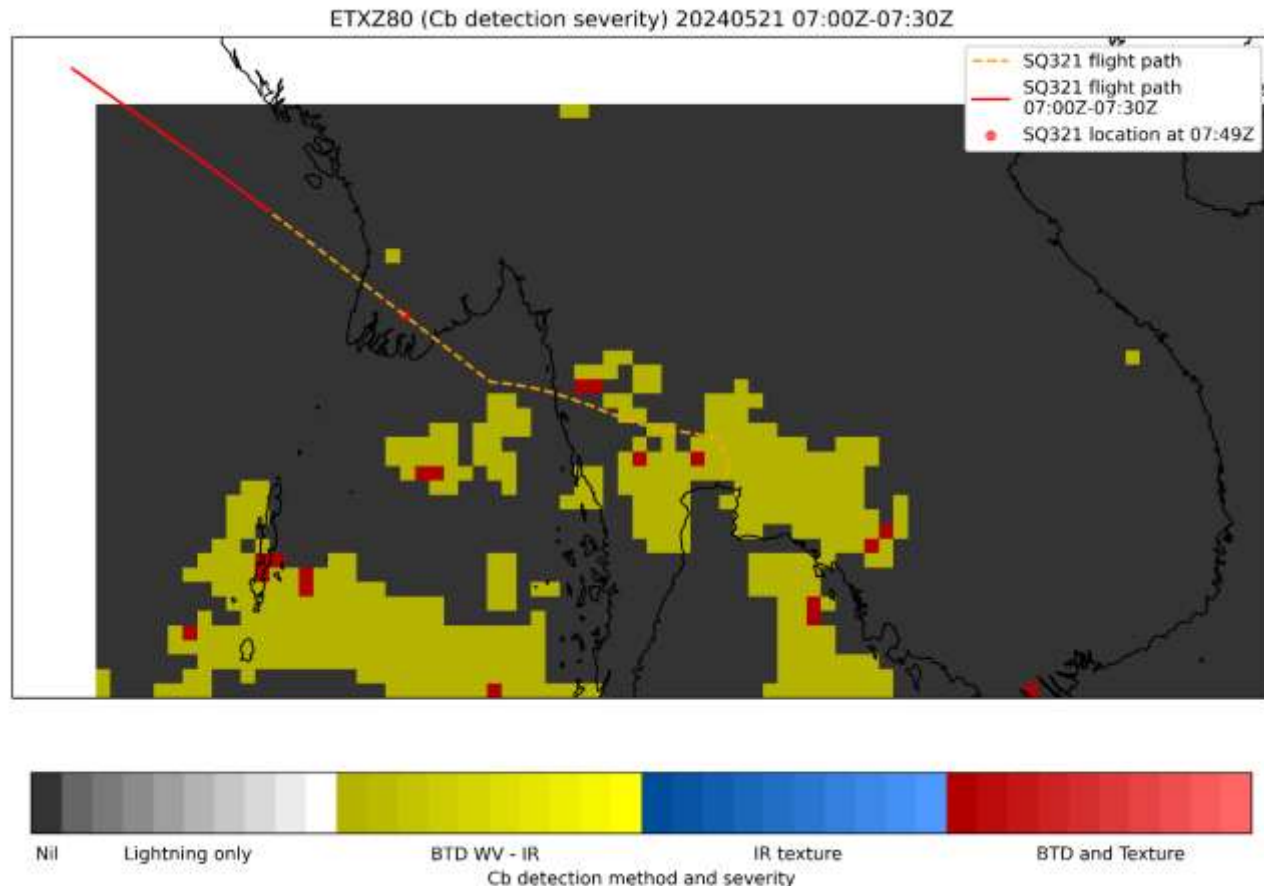


Cb detection severity at 30 mins before incident.

N.B. uses a 30 minute window for detection.

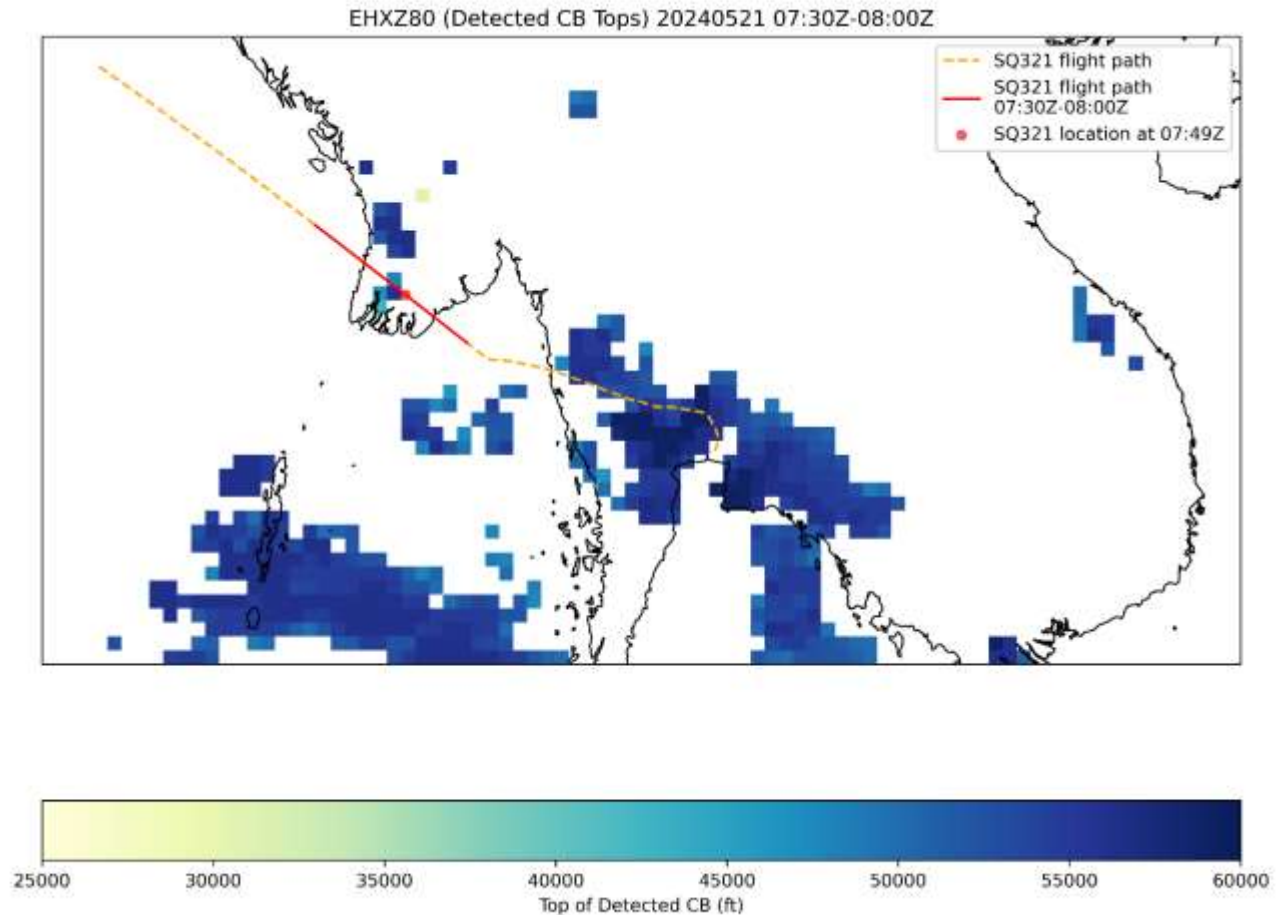
Cb detection based on Overshooting Tops detection methods [1].

- IRW texture [2]
- WV-IR BTD [3]
- Lightning detection (LEELA)



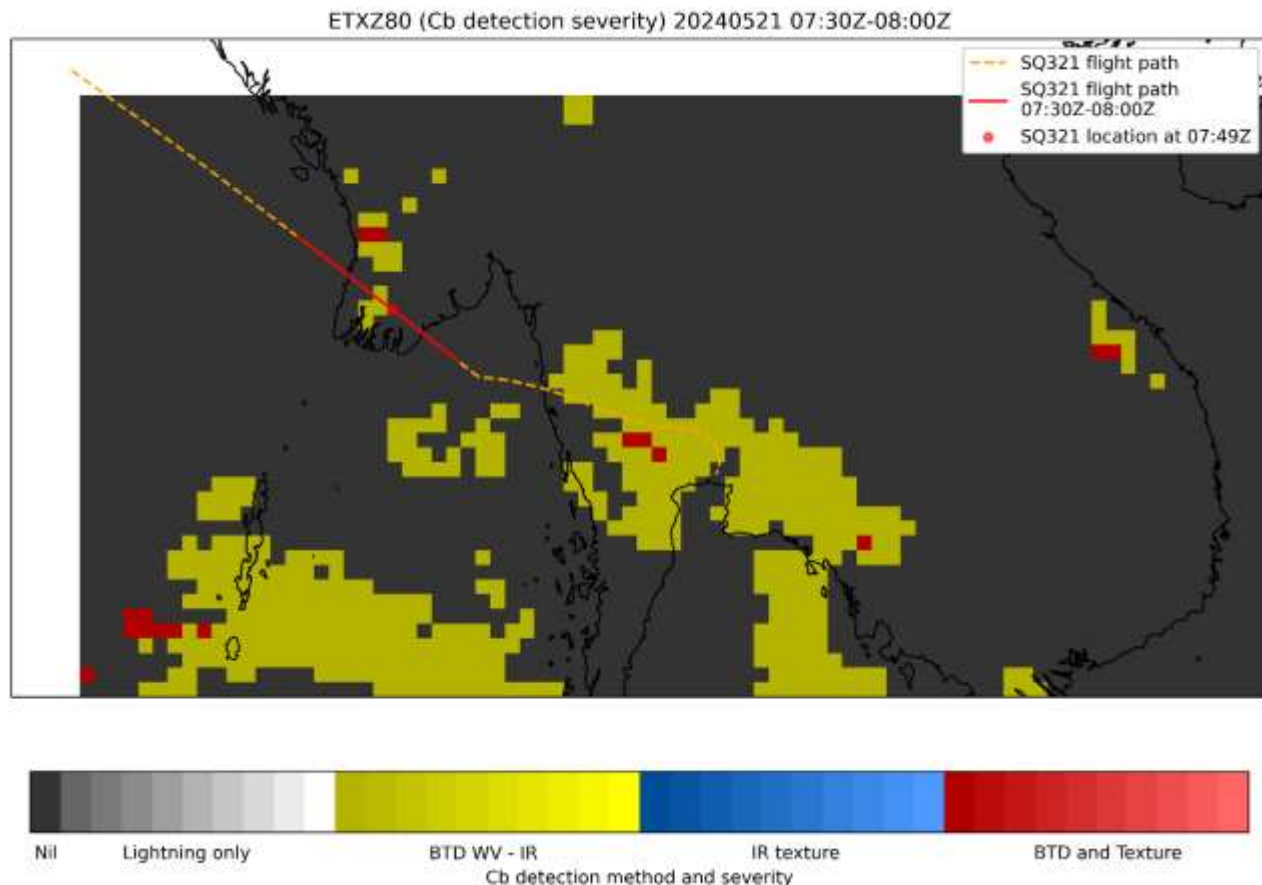
Cloud Top Height for detected Cbs at time of incident.

Shows Cbs detected in vicinity of incident in the time window that incident occurred.



Cb detection severity at time of incident.

Shows Cbs detected in vicinity of incident in the time window that incident occurred.

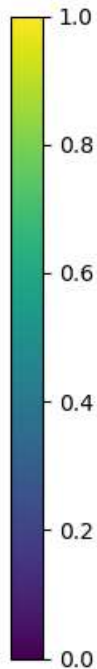
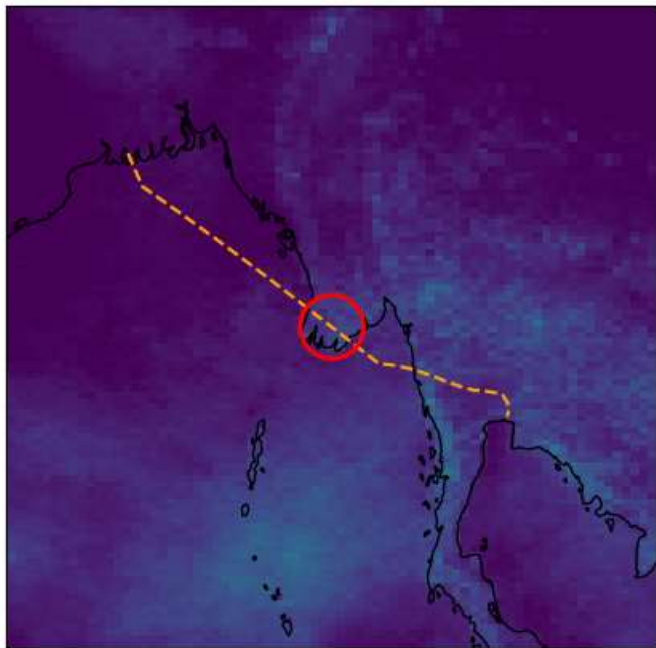


EPOCH Forecasts

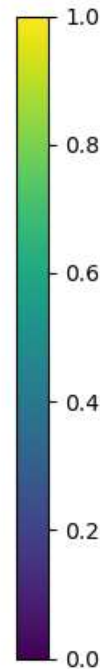
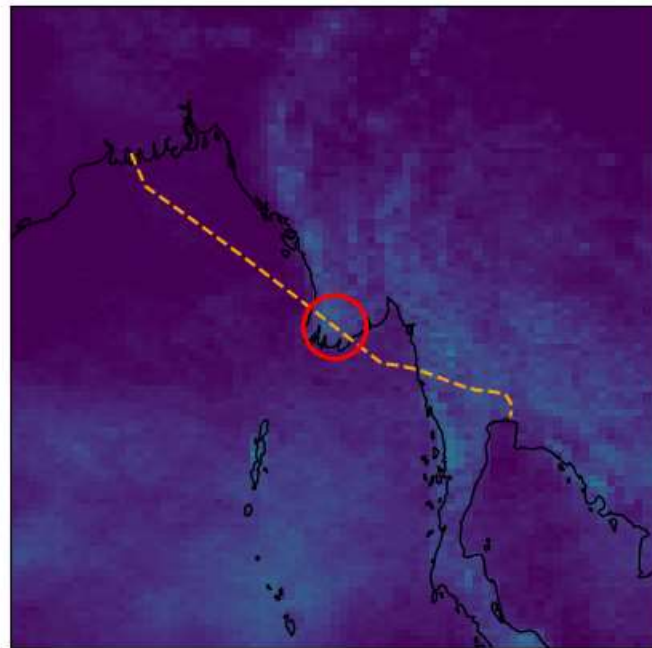
06Z run on 20th May

EPOCH forecasts (blend_calibrated) 20240520T0600Z
Probability of Cb tops > 30ft

20240521
06:00Z



20240521
09:00Z



SIGWX Objects

Graeme Anderson
Met Office User Forum
25th November 2024

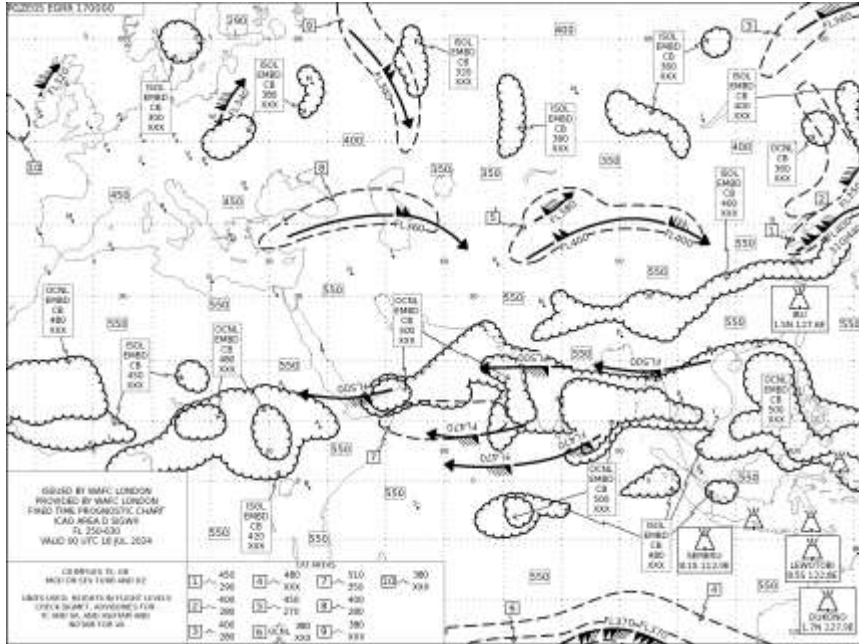


Contents

- SIGWX Charts
- Object Generation
- Plotting

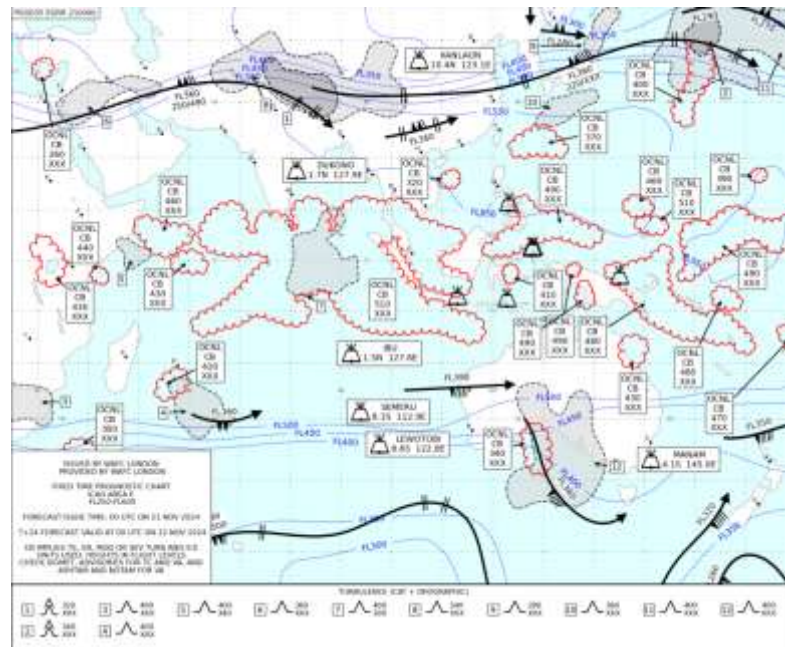
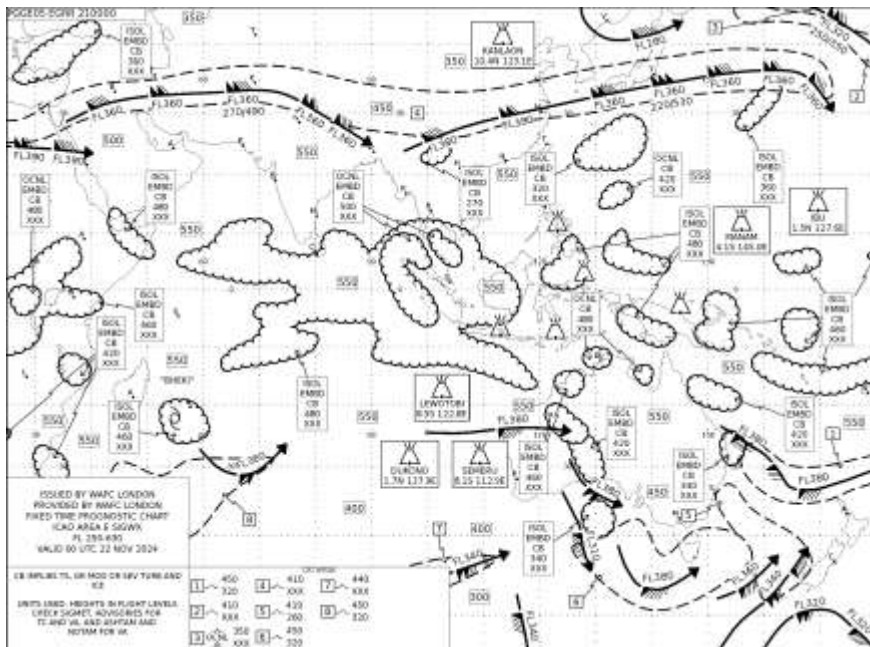
SIGWX Charts

SIGWX Charts



- Situational awareness charts
- Part of WAFS
- Manually produced
- T+24 only, every 6 hours
- FL100-450 and FL250-630
- Hazards:
 - Convection (CBs)
 - Clear Air Turbulence (CAT)
 - Jet streams
 - Tropopause height
 - Volcanic eruptions
 - Tropical cyclones
 - Nuclear releases

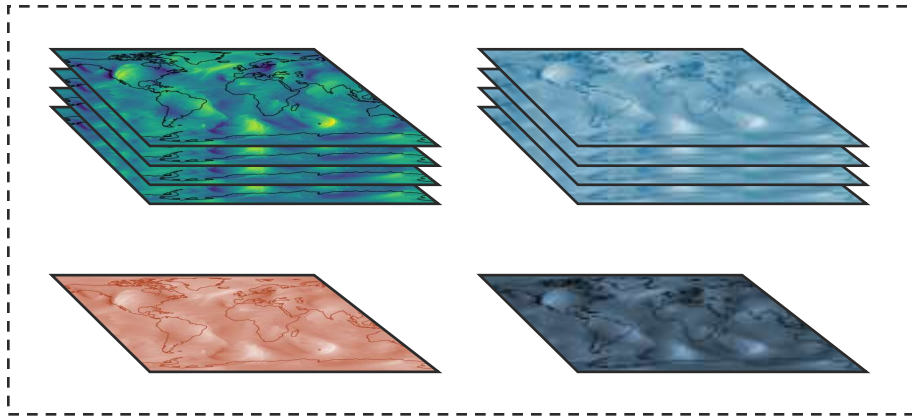
SIGWX Charts



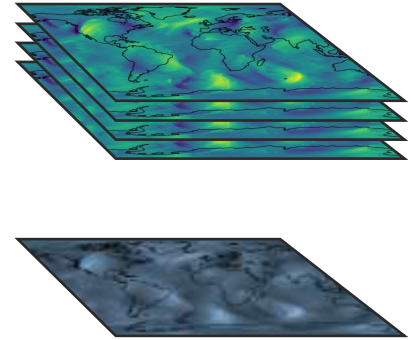
Object Creation

Read Data

- CB, ICING, JET, TROP, TURB

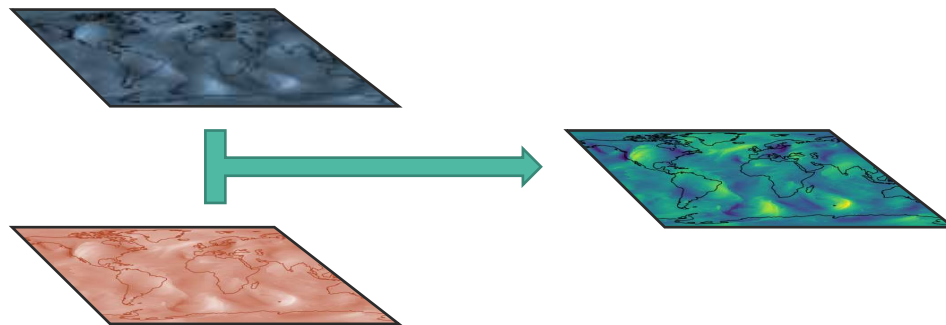


WAFS gridded data file

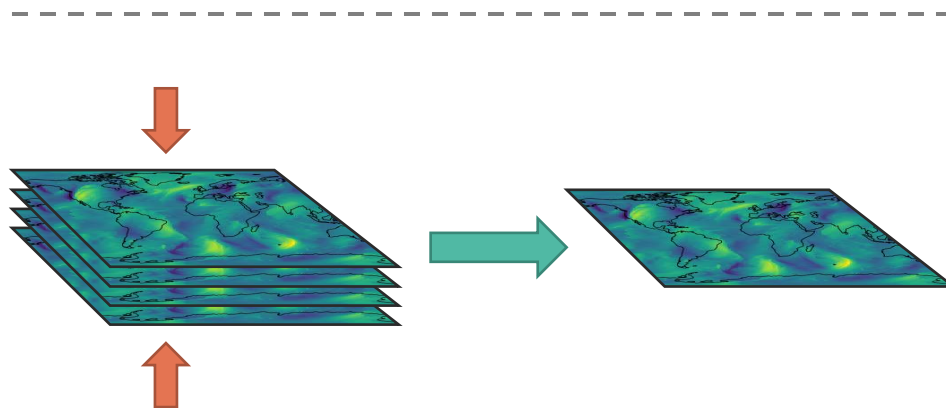


Pre-process Data

- JET:
Calculate speed and bearing

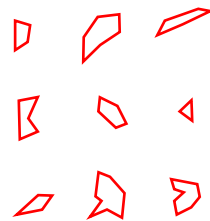
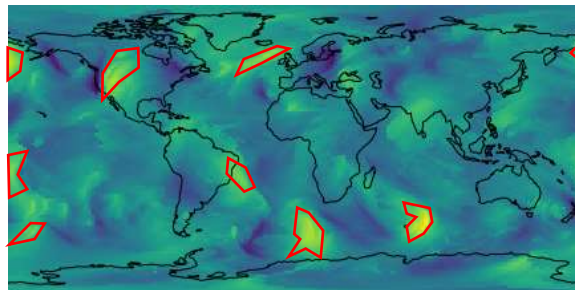
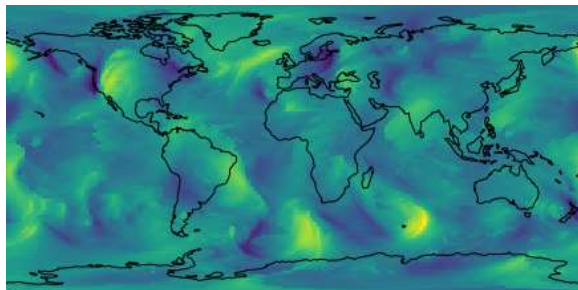


- ICING, TURB:
Collapse 3D to 2D

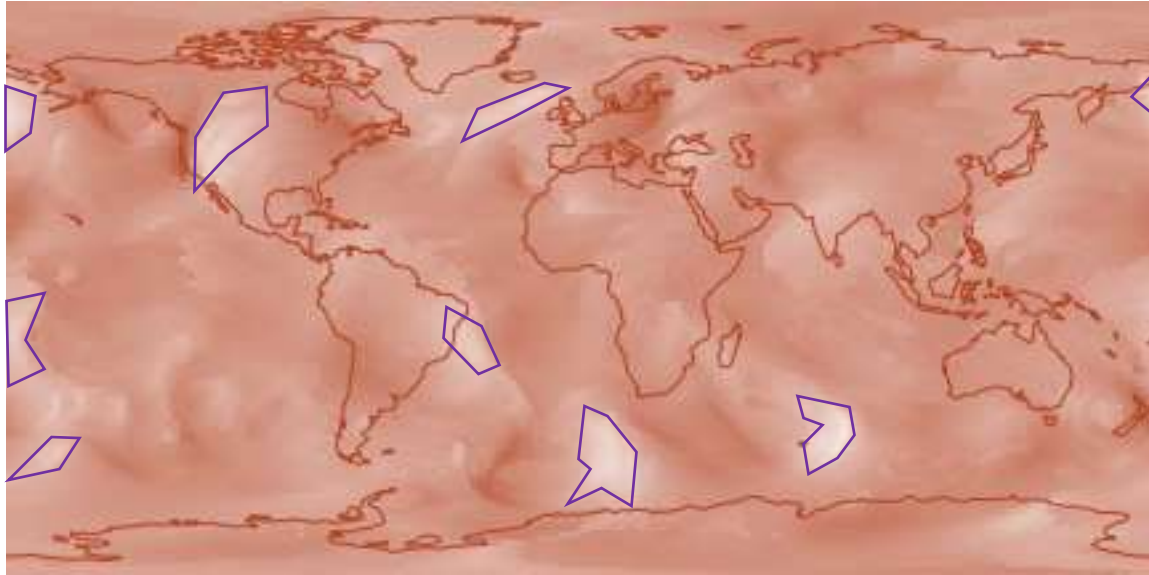


- CB, ICING, TURB, TROP:
Smooth data

Find Objects



Find Object Characteristics



Smooth Objects

Input shape



Dilated shape



Eroded shape



Dilate-Erode-
Erode-Dilate



Input shape



n=3



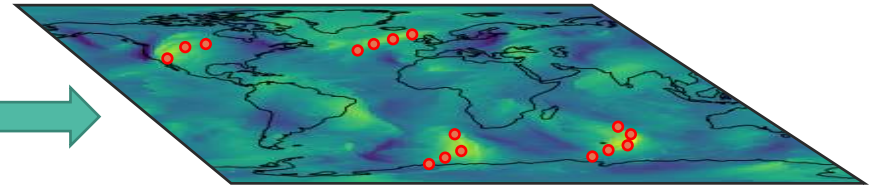
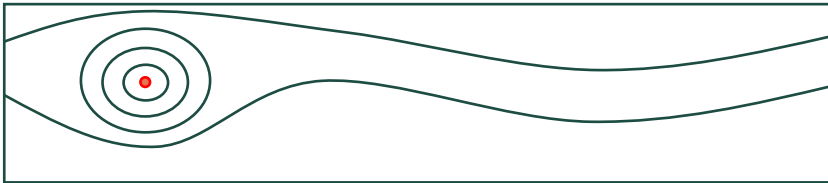
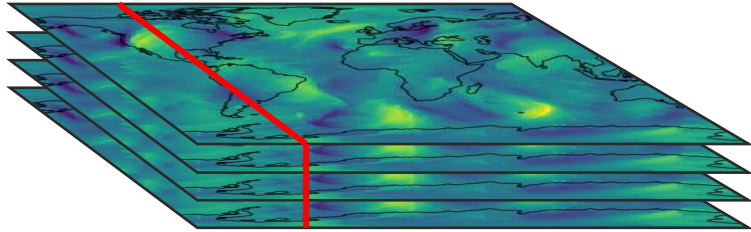
n=4



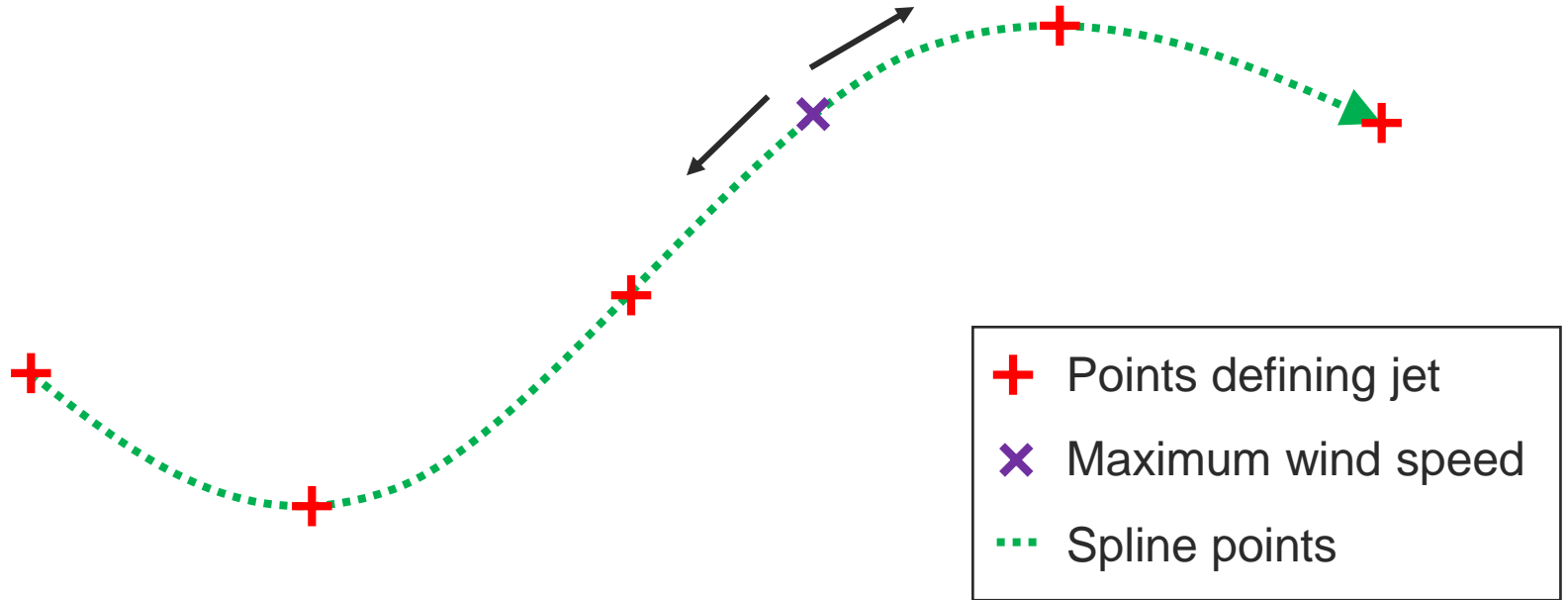
n=5



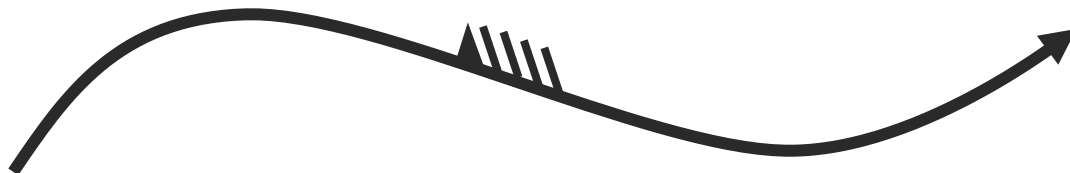
Find jets



Find Fleches



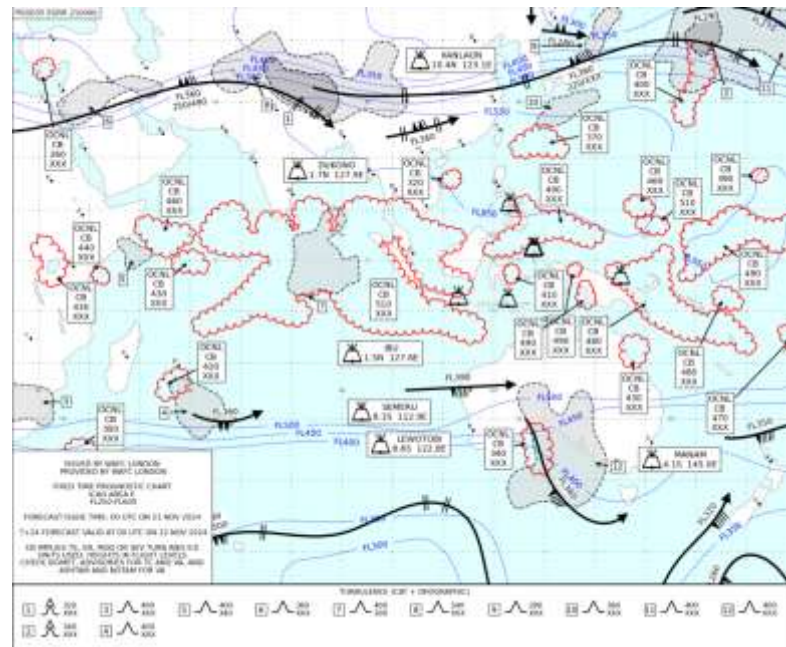
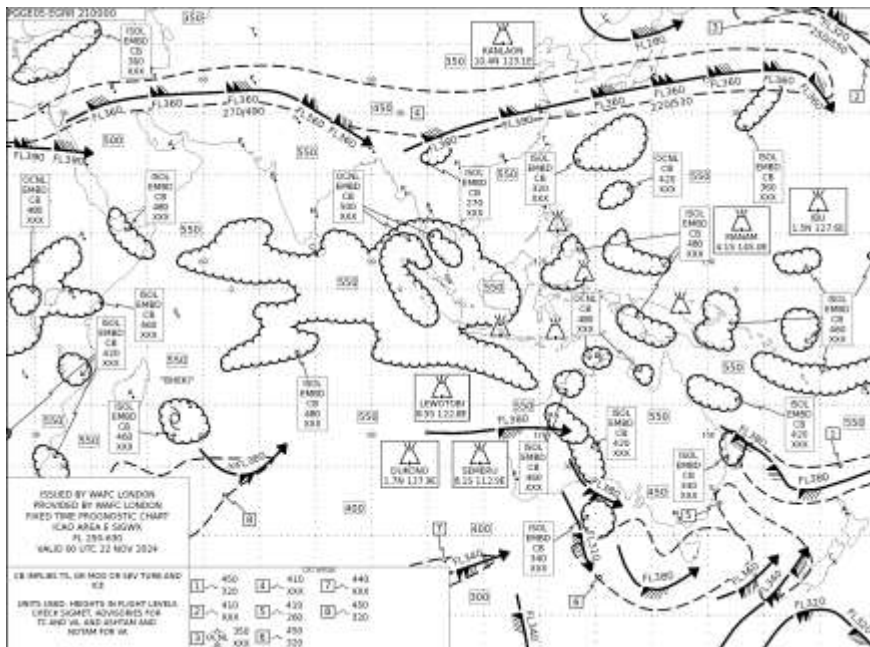
Write Data



```
<!-- JET Object #1 -->
<iwxxm:feature>
  <iwxxm:MeteorologicalFeature gml:id="uuid.a0000000-0000-0000-0000-000000000000">
    <gml:identifier codeSpace="http://wafs/sigwxobj">a0000000-0000-0000-0000-000000000000</gml:identifier>
    <iwxxm:phenomenon xlink:href="http://codes.wmo.int/49-2/MeteorologicalFeature/JETSTREAM"/>
    <iwxxm:phenomenonGeometry>
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        <gml:segments>
          <gml:CubicSpline>
            <gml:posList> -61.248572 175.399151 -62.874363 179.102867 -63.182597 180.457510 -64.582977 189.518028 ...
            </gml:posList>
            <gml:vectorAtStart> -39.97667 53.92996 </gml:vectorAtStart>
            <gml:vectorAtEnd> 48.93476 45.82039 </gml:vectorAtEnd>
          </gml:CubicSpline>
        </gml:segments>
      </gml:Curve>
    </iwxxm:phenomenonGeometry>
    <iwxxm:phenomenonProperty>
      <iwxxm:WAFSJetStreamWindSymbol gml:id="uuid.a0000000-0000-0000-0000-000000000000">
        <iwxxm:location>
          <iwxxm:ElevatedPoint gml:id="uuid.a0000000-0000-0000-0000-000000000000" srsDimension="2" axisLabels="Lat Long" srsName="http://www.opengis.net/def/ers/EPSPG/0/4326">
            <gml:pos> -62.66272 178.33860 </gml:pos>
            <iwxxm:elevation uom="FL">300</iwxxm:elevation>
            <iwxxm:verticalReference>MSL</iwxxm:verticalReference>
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        </iwxxm:location>
        <iwxxm:windSpeed uom="kn_i">90</iwxxm:windSpeed>
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</iwxxm:feature>
```

Plotting

Examples

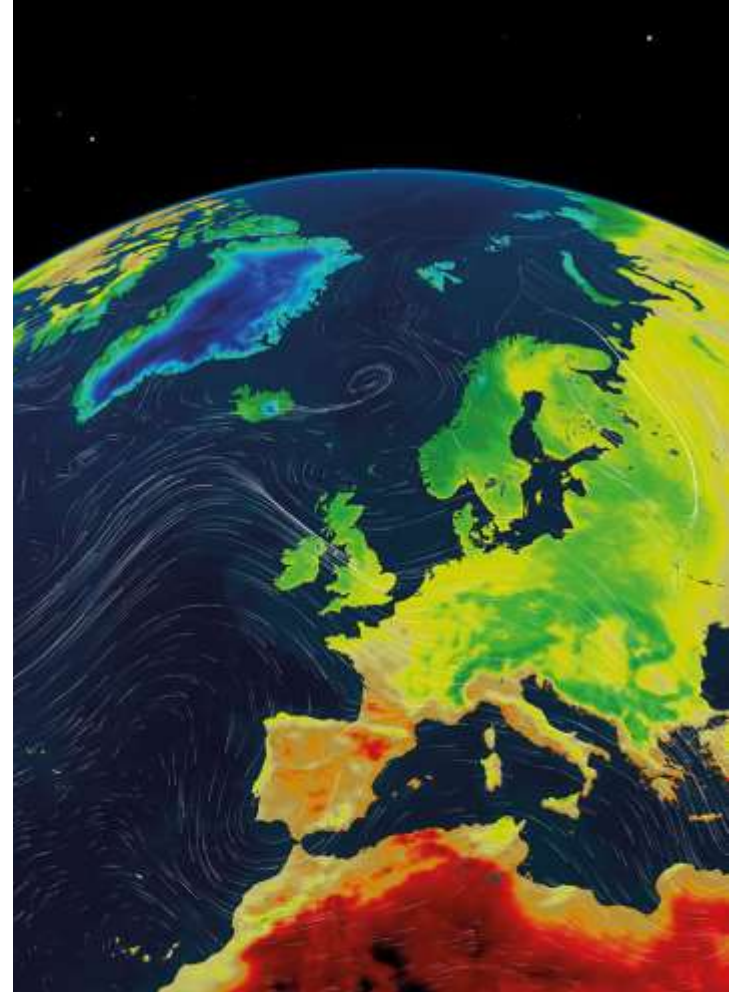


Summary

- Production of SIGWX charts has been automated
- Automation will improve timeliness, consistency and number of forecast timesteps available
- Due to go live January 2025

Purpose of UK aviation R&D programme

- Improving forecasting and understanding of convection, fog and low level cloud.
- Understanding ways to automate (and verify) forecasts currently produced manually.
- Improving weather forecasts for low level aviation.



Semi-Autonomous TAFs

IMPROVER TAFs

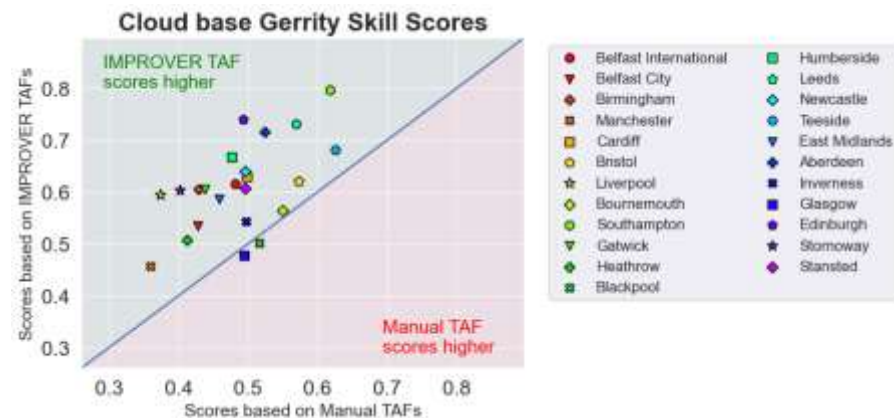
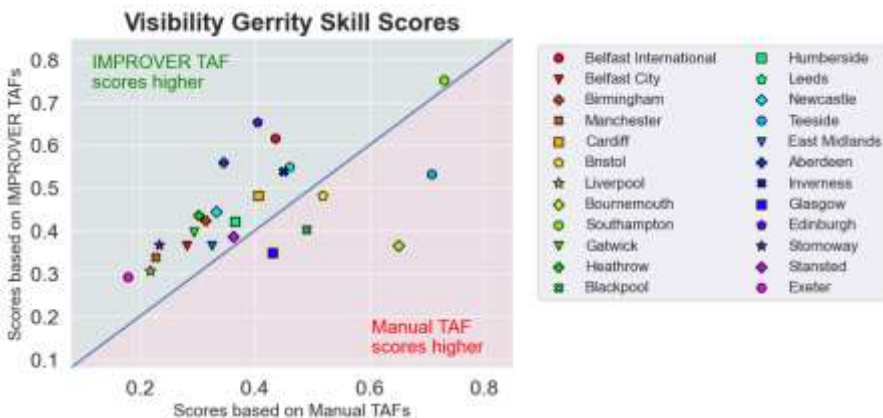
Norwich:

TAF EGSB 100800Z 1009/1018 25004KT 8000 FEW045
 PROB40 TEMPO 1013/1018 9999 BKN013=

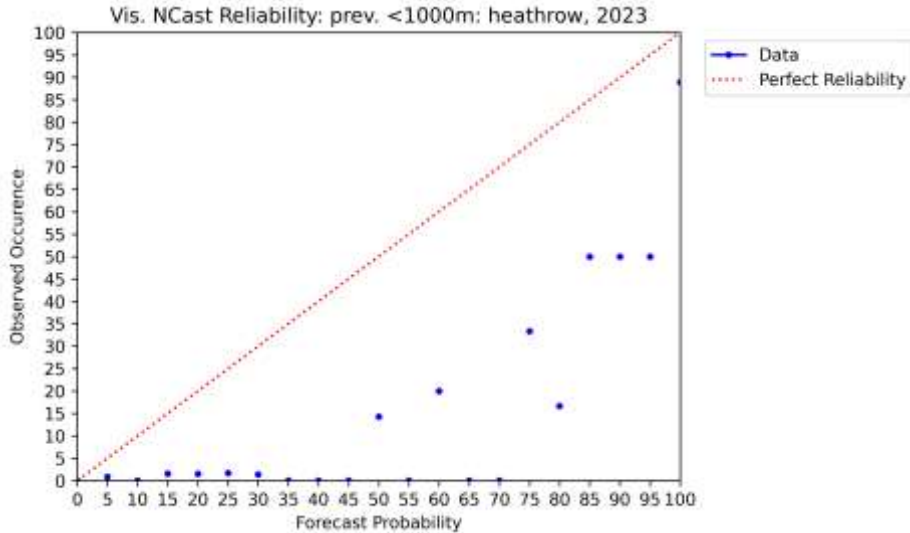
Issued TAFs

Norwich

TAF EGSB 100756Z 1009/1018 26006KT 7000 BKN025
 TEMPO 1009/1018 6000=



Machine Learning for Visibility Nowcasting



- Plot: Visibility Ncast compared against METAR observations of visibility
- Visibility Nowcast tends to over forecast
- Utilize machine learning to correct the nowcast output

WMO Aviation Research Demonstration Project Phase Two (AvRDP2)

- Successful third meeting in Exeter in September following on from meeting at NCAR, USA last year.
- Demonstration Project for the HKG to SIN route happening now.
- Enhanced prototype products for LHR-JBG route under development.



WMO AeroMetSci Conference 2024 (last one 2017)



- Successful conference in Geneva discussing aviation weather and climate issues
- Report in 2025 will have key recommendations of improvements / new developments.
- Machine learning important but only as **part** of an ongoing programme of work understanding weather and climate issues.



Contrail Mitigation

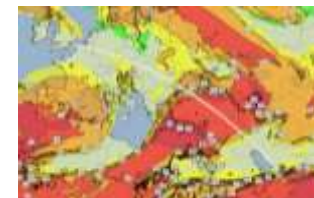
Aircraft exhaust emissions mix with environmental air → ice crystals
In cold and humid air they can persist and form clouds

~25,000 aircraft; only ~150 sensing humidity profiles, ~10 cruise humidity
Potentially solve with novel techniques / ML



Contrails are short-lived climate forcers

Climate impacts from contrails may be **greater** than from aviation CO₂ emissions¹



[2]

Supercomputer Update

 **Met Office** Our future supercomputing capability

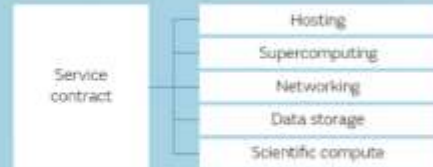
STRATEGIC ACTION

Delivering our future supercomputing capability

10 year strategic collaboration



Full service supplied through a single provider



2 generations of supercomputing refreshed after 5 years



Generation 1

6x

Phased introduction of capability



Generation 2

~18x

Increase over current capability



Creating one of the world's most environmentally sustainable supercomputing capabilities

Powered entirely by sustainable energy



Based in the South of the UK



Investment will deliver many £ billions of socio-economic benefits to the UK over 10 years

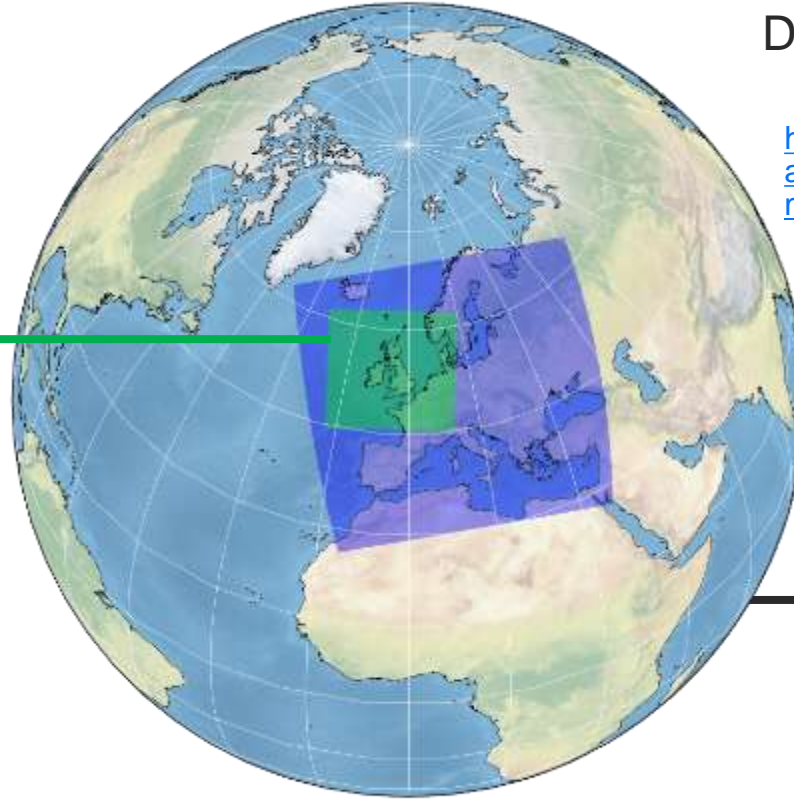
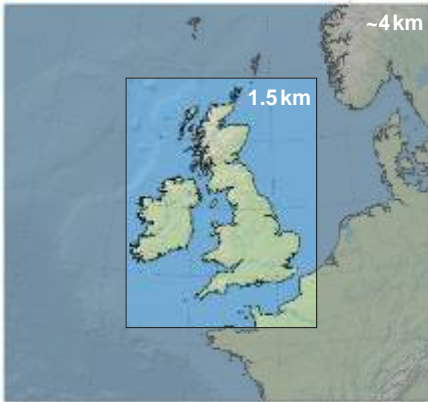


Deterministic models

<https://www.metoffice.gov.uk/research/approach/modelling-systems/unified-model>

UK

1.5 km resolution (inner)
54 hour forecast (6× daily)
120 hour forecast (2× daily)
12 hour nowcast (hourly)
Ensemble 2.2km resolution to 5d, 18 time-lagged members, updated hourly.



Global

10 km resolution
Up to 6 day forecast (4 × daily)
70 vertical levels (to ~80 km)
Initial conditions from a 44-member global ensemble
Ensemble 20km resolution to 7 days, 36 members

Global NWP Plans

- Increase global ensemble forecast range out to 14-days.
- Retire main deterministic global forecast.
- Upgrade to 10km resolution global ensemble forecasts.
- More frequent (3-hourly) global analyses.
- Continue to research 5–6km forecasts as first step towards a future km-scale global ensemble forecast system.

UK regional NWP

- Retire UKV forecasts beyond the T+12 “NWP nowcast”.
- Upgrade to 1.5km resolution UK ensemble forecasts.
- Introduce 300m resolution regional ensemble(s) to improve forecasts for urban areas and high-impact weather.

R&D highlights - Globally

**MTG opportunities
for aviation
investigated.**

**WAFS Probabilistic
trial analysed and
vn1 finalised**

**Cb capability
demonstrated
via AVRDP2**

R&D highlights - UK



**Fog visibility
forecasting role of
machine learning
better understood**

**Convection
nowcast
demonstrated in
real time**

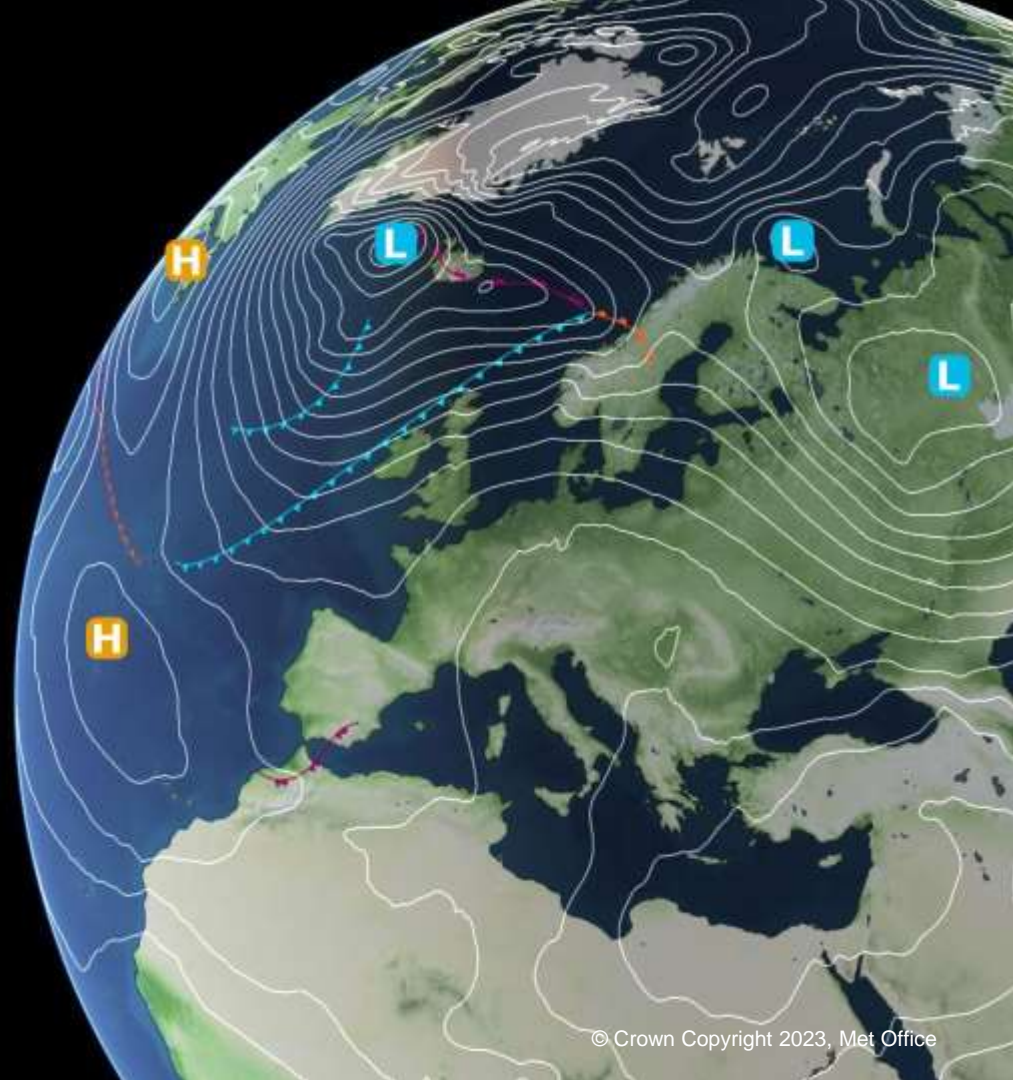
**Ongoing
investigations
about how to
improve low level
turbulence
forecast**



Questions?

3-month Outlook

Dan Rudman
Expert Operational Meteorologist



Contents

- 1- and 3-month outlook headlines
- What is ‘normal’?
- Observations from recent years
- Forecast reasoning
 - *Teleconnections*
 - *Seasonal predictions*
- Key points

1- and 3-month outlook

The following forecast is for the average of the December to February period for the United Kingdom as a whole.

This forecast content is based on information from observations, numerical prediction systems from modelling centres around the world, and expert judgement.

1-month outlook (December) - Summary

| <u>Temperature</u> | <u>Precipitation / Wind</u> |
|---|---|
| <p>The chance of a cold month is close to normal</p> <p>Nevertheless, this level of likelihood is greater than typically seen in recent years</p> | <p>There is a slight increase in the chance of a dry month compared to normal</p> <p>There is an increased chance of a calm December compared to normal</p> |

1-month outlook



3-month outlook (Dec, Jan, Feb) - Summary

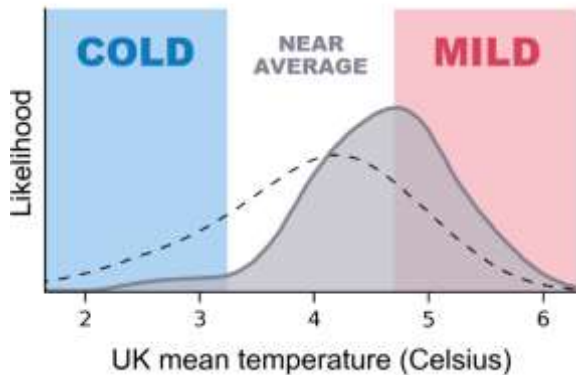
| <u>Temperature</u> | <u>Precipitation / Wind</u> |
|--|---|
| <p>Overall, the chance of the winter being cold is lower than normal</p> <p>This doesn't preclude some cold spells and related impacts</p> | <p>There is an increased chance of the winter overall being wetter and windier than normal</p> <p>Stormy conditions, and impacts from high winds, are more likely than normal</p> |

3-month outlook

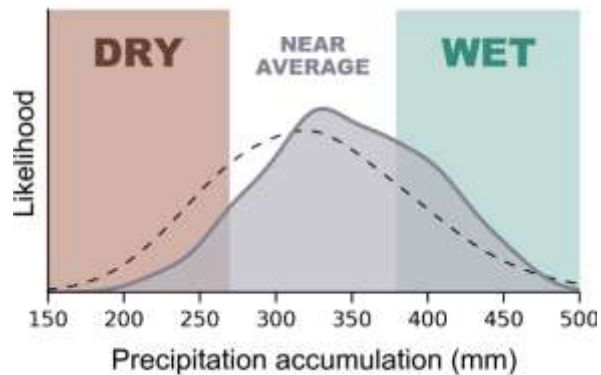


3-month outlook - context

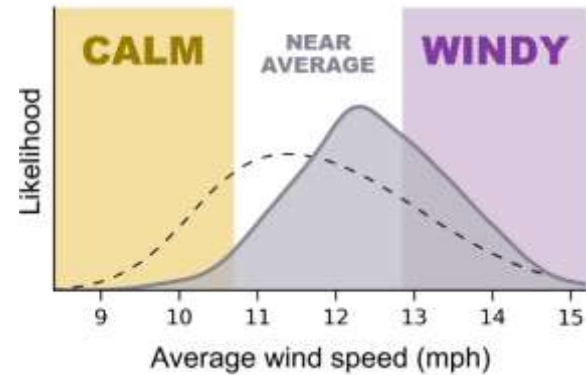
■ Dec-Feb Outlook
-- Normal likelihood



■ Dec-Feb Outlook
-- Normal likelihood



■ Dec-Feb Outlook
-- Normal likelihood

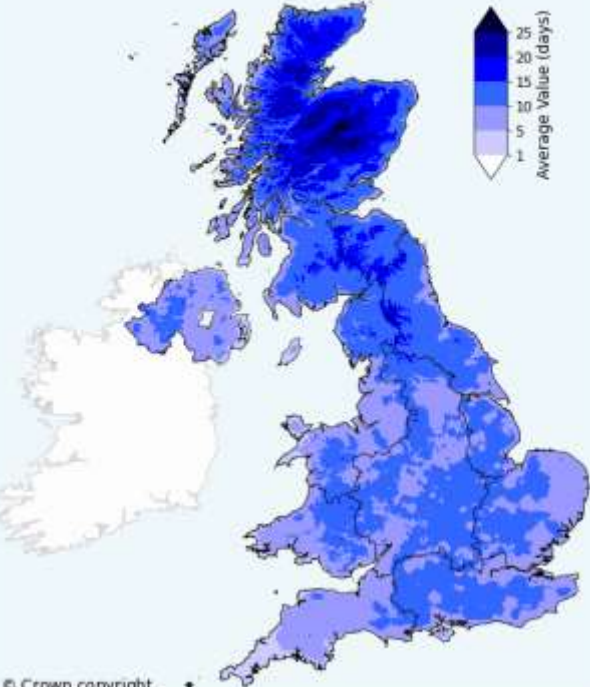


What's normal?

A look at average conditions and a look back at recent years for the corresponding period

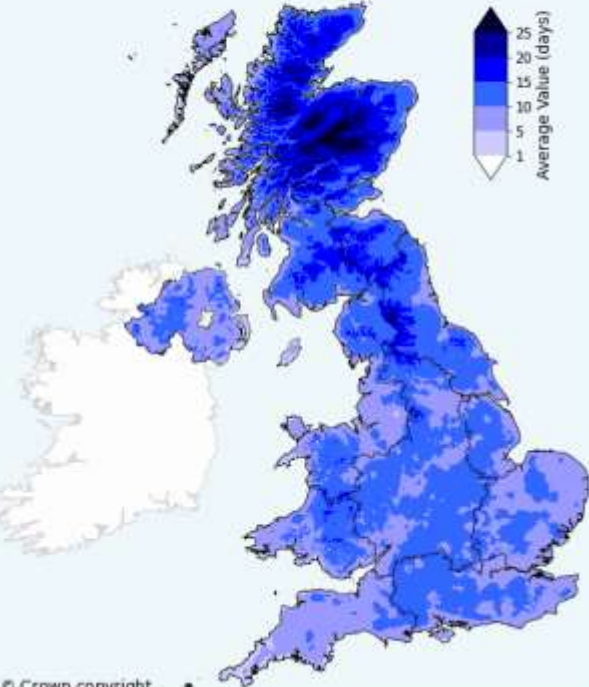
 **Met Office**

Days of Air Frost
December Average
1991-2020



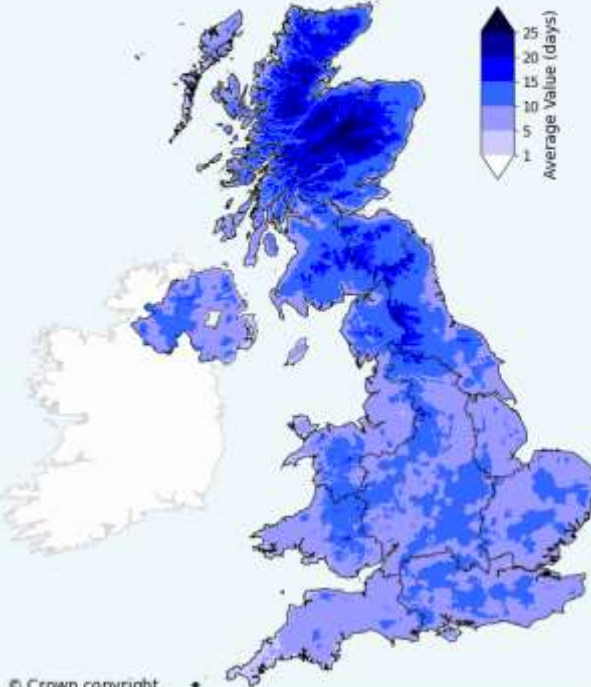
 **Met Office**

Days of Air Frost
January Average
1991-2020

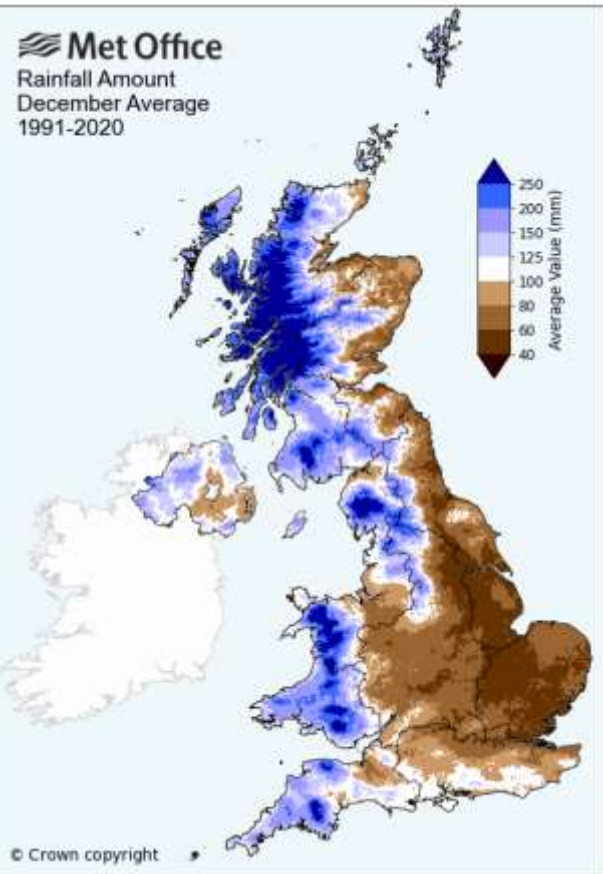


 **Met Office**

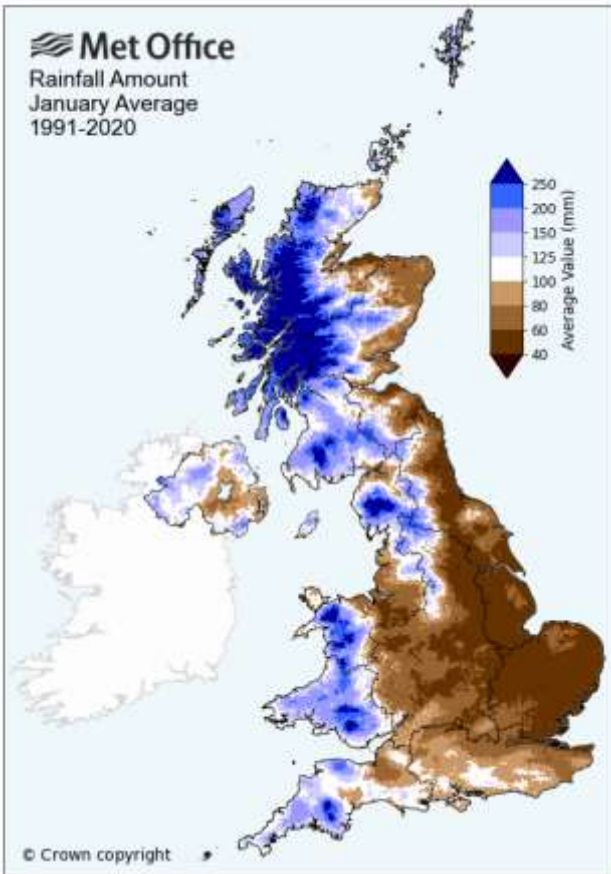
Days of Air Frost
February Average
1991-2020



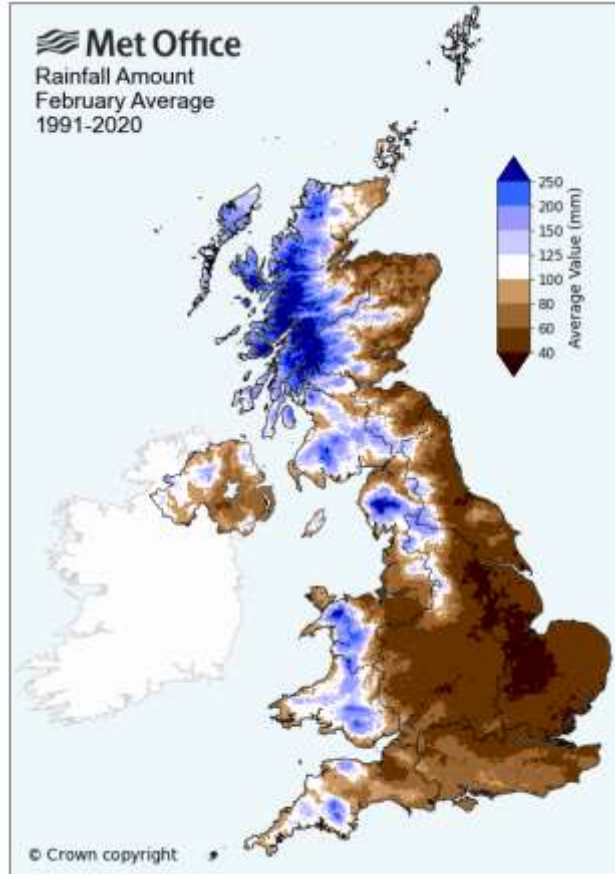
 **Met Office**
Rainfall Amount
December Average
1991-2020

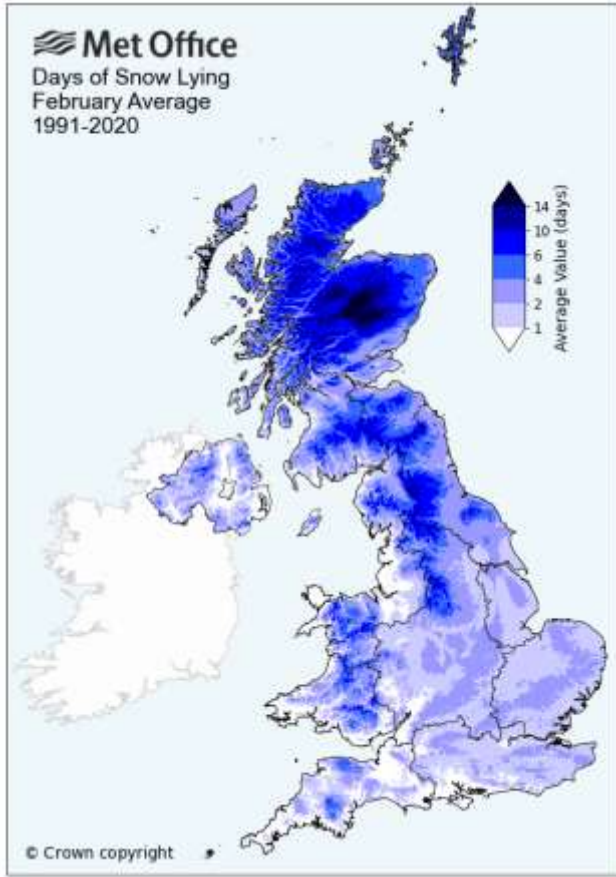
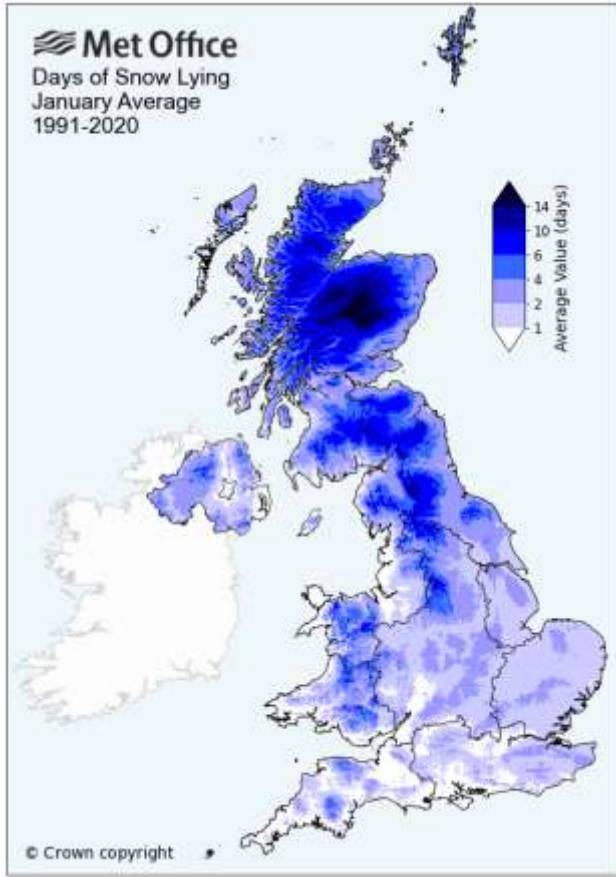
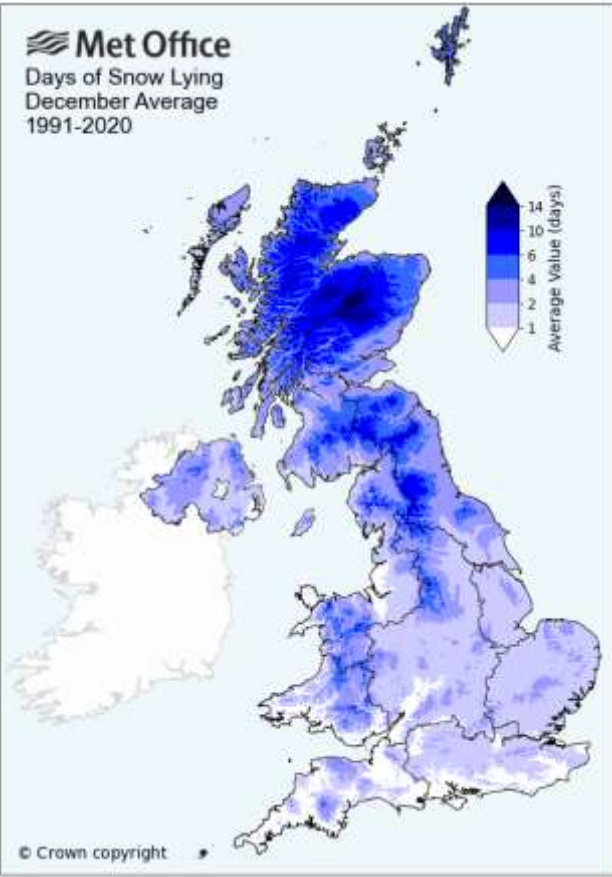


 **Met Office**
Rainfall Amount
January Average
1991-2020



 **Met Office**
Rainfall Amount
February Average
1991-2020





Decembe

| 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|--------------|
| NEAR AVERAGE | MILD | MILD | NEAR AVERAGE | MILD | NEAR AVERAGE | NEAR AVERAGE | MILD | COLD | MILD |
| NEAR AVERAGE | WET | DRY | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | WET |
| NEAR AVERAGE | WINDY | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE |

December-January-February

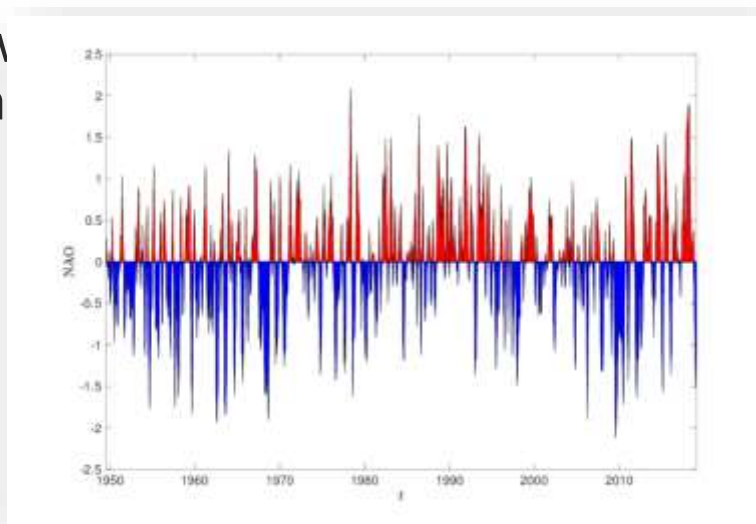
| 2014-15 | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 |
|--------------|--------------|--------------|--------------|-------------|--------------|--------------|--------------|--------------|--------------|
| NEAR AVERAGE | MILD | NEAR AVERAGE | NEAR AVERAGE | MILD | MILD | NEAR AVERAGE | MILD | NEAR AVERAGE | MILD |
| NEAR AVERAGE | WET | DRY | NEAR AVERAGE | DRY | WET | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | WET |
| NEAR AVERAGE | WINDY | NEAR AVERAGE | NEAR AVERAGE | CALM | WINDY | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE | NEAR AVERAGE |

Teleconnections and forecast reasoning

A look at the global drivers behind this forecast.

North Atlantic Oscillation (NAO)

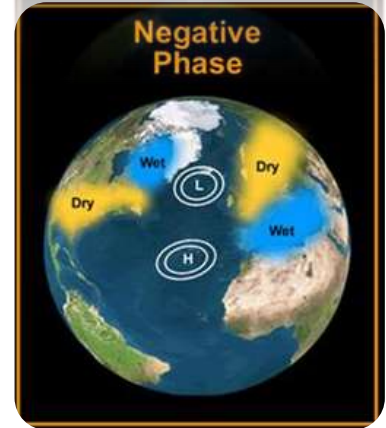
- Explains much of the variability of the weather in the North Atlantic region, particularly during winter.
- The phase of the NAO affects the intensity and track of storm
- Seasonal prediction systems – such as the Met Office GloSea 6 system - have skill in predicting the NAO phase several months ahead.



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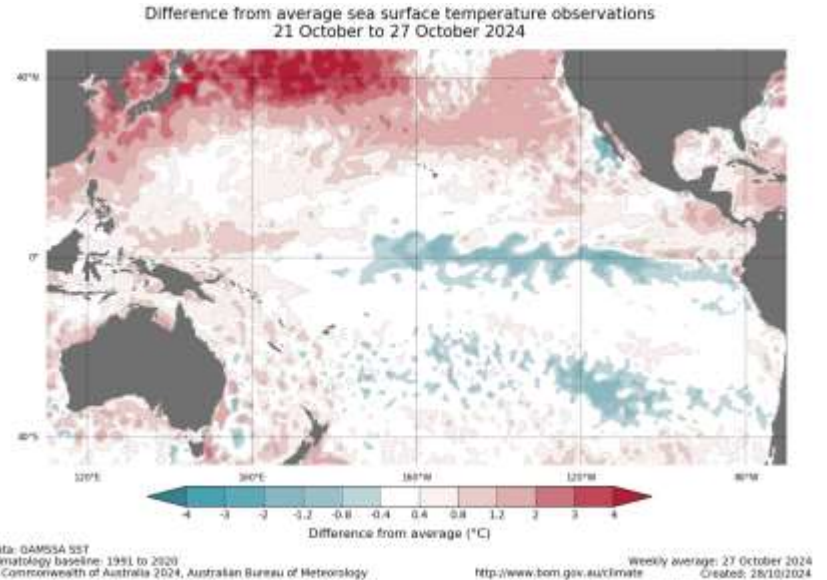
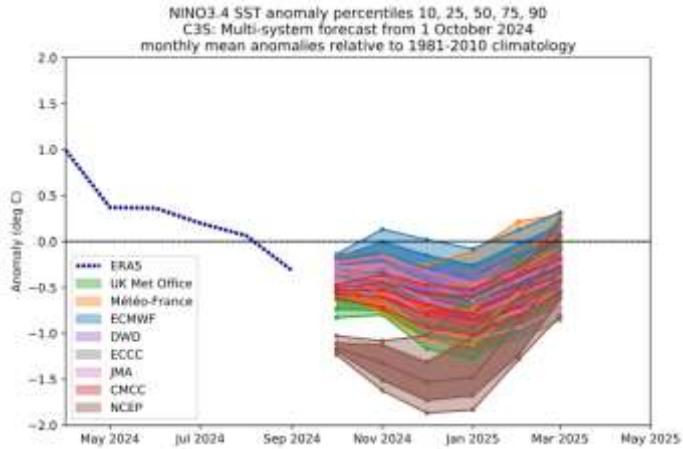
North Atlantic Oscillation (NAO)

- **Positive** and **negative** phases of the NAO are defined by the differences in pressure between the persistent low near Iceland and the persistent high near the Azores.
 - **Positive** - enhancement of westerly winds leading to milder- and wetter-than-average conditions. Higher frequency of windstorms, but lower frequency of snow. (Winter 2013-14; 2015-16; 2019-20)
 - **Negative** - reduction in westerly winds leading to colder- and drier-than-average conditions. Lower frequency of windstorms, but higher frequency of snow. (Winter 2009-10; 2010-11)
- Many factors can influence the NAO phase including the stratospheric polar vortex, patterns of tropical rainfall and patterns of sea-surface temperatures in the Atlantic Ocean.



El Niño-Southern Oscillation

- Strongest driver of global weather patterns, influence greatest in the tropics but extends to the mid-latitudes in winter
- Moderate chance of La Nina over the next couple of months



Teleconnections summary

| <u>Positive NAO</u> | <u>Negative NAO</u> |
|--|--|
| <ul style="list-style-type: none">• <i>Possible La Nina (late winter)</i>• Westerly QBO | <ul style="list-style-type: none">• <i>Possible La Nina (late autumn/early winter)</i>• MJO (sub-seasonal, late December) |

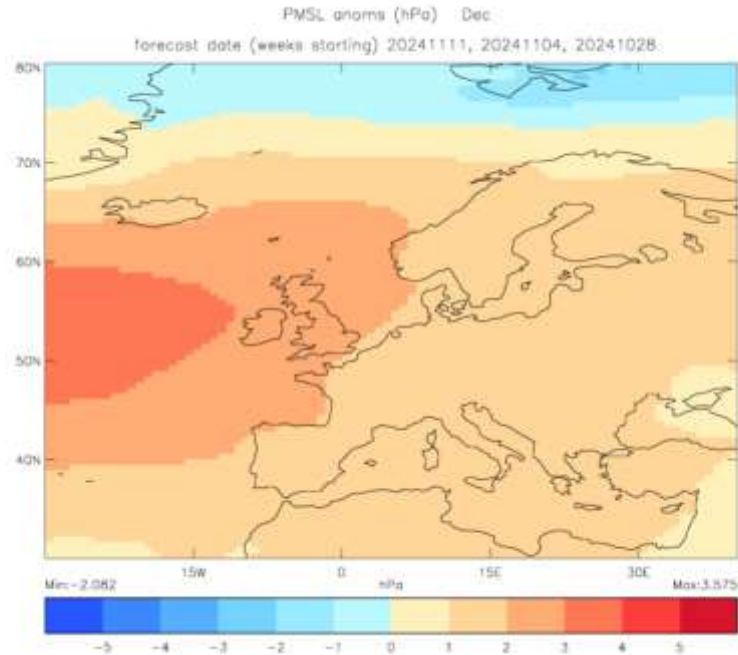
Seasonal Predictions

December-January-February

MSLP anomalies

December

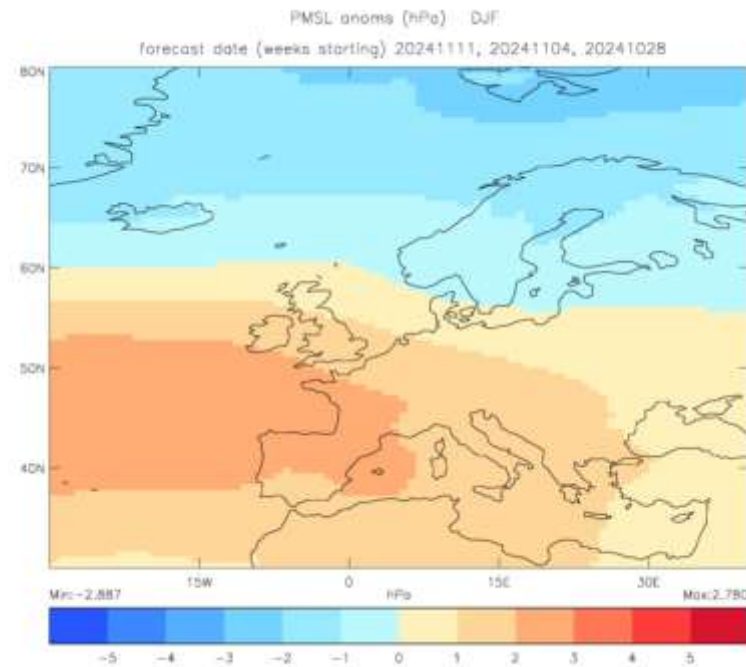
- Greater chance of blocking patterns than normal
- Increases the likelihood of spells of northerly or northwesterly winds



MSLP anomalies

December-January-February

- Patterns likely to change later in the winter
- Westerly winds favoured with a lower likelihood of blocking later in this period



Key points

- As during a typical winter, rain and wind likely to be hazards at times. However, may be more likely later in the winter.
- Signalled patterns for winter suggest rainfall more likely to above normal in northern and western areas.
- Consistent with our warming climate, the likelihood of the period as a whole being cold is very low.
- Cold spells and related impacts still likely at times.

Any questions?



Time to discuss:

- Any issues raised by attendees
- Any other business
- Date of Next MOUF

Stay in touch

Our you following our [Aviation page](#) on LinkedIn?

Read regular updates from the Met Office with an aviation angle.

General enquiries can be directed to:
transport@metoffice.gov.uk



Opportunity for feedback

We value your feedback and would love to hear about your experience. Your input will help us improve and make future events even better.



**Thank you for attending
the MOUF 2024 event**