Paper 1B.3

Response of the London Volcanic Ash Advisory Centre to the Eyjafjallajökull Eruption

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1. INTRODUCTION

The Met Office is home to the London Volcanic Ash Advisory Centre (VAAC) which is responsible for monitoring and forecasting the movement and dispersion of volcanic ash **originating from** volcanoes in the north-eastern part of the North Atlantic Ocean. Although this is a relatively small area, see Fig 1, it covers some of the busiest airways in the world. During a volcanic eruption on Iceland, the London VAAC liaises closely with the Icelandic Meteorological Office which itself is in close contact with the Nordic Volcano Institute.

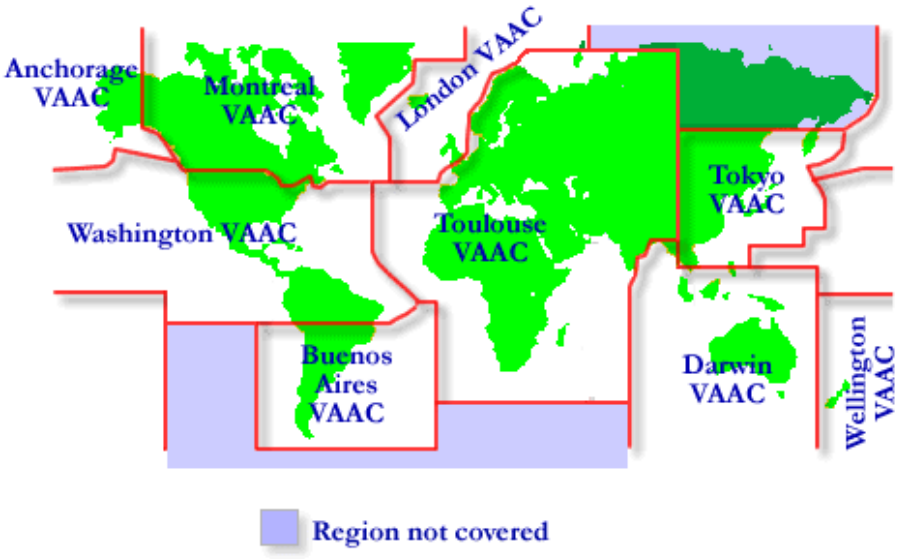

Fig 1: VAAC Areas of Responsibility

The Eyjafjallajökull eruption of April and May 2010 continues to present a huge challenge to the Met Office and has required a significant diversion of resources. During the eruption user requirements evolved continually and the organisation had to react to these as quickly and as effectively as possible as well as coordinating or participating in other volcanic ash related activities in the UK, Europe and other parts of the world.

The London VAAC Advisories, see Fig 2, consistently described volcanic ash affecting large parts of northern Europe between 15th and 21st April 2010. Large areas of European airspace were subsequently closed resulting in widespread travel disruption. This unsurprisingly led to increasing pressure from the aviation industry and indeed governments for an urgent European review of the International Civil Aviation Organisation (ICAO) International Airways Volcano Watch (IAVW) 'no ash' policy.

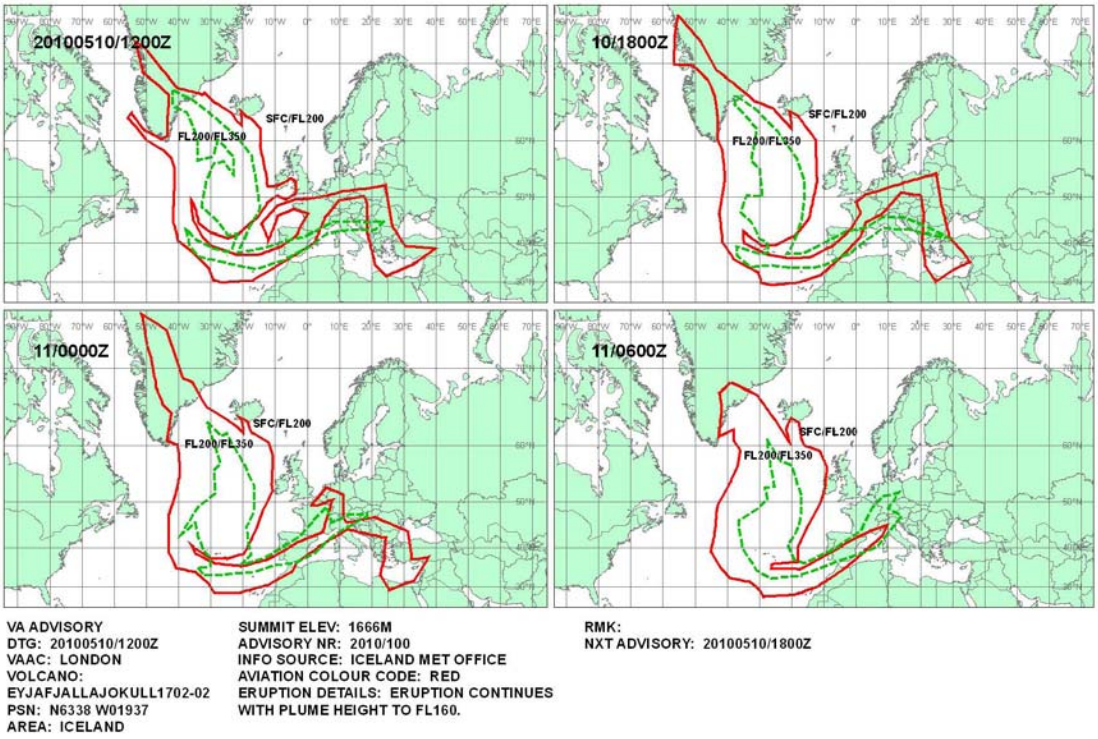

Fig 2: London VAAC graphical Advisory Product

2. MET OFFICE SUPPLEMENTARY VOLCANIC ASH CONCENTRATION CHARTS

The UK aviation regulator, the Civil Aviation Authority (CAA), after consultation with European Transport Ministers, European Aviation Safety Agency and advice from the airline engine manufacturers ultimately sanctioned the production of **supplementary** volcanic ash concentration charts on 20th April based on engine manufacturers quoting a potentially hazardous engine ingestion rates equating to forecast ash concentration levels of $2x10^{-3}g/m^3$ and higher.

The supplementary ash concentration charts do **not** fall within the scope of the IAVW and have currently only been produced for the London VAAC responsibility area by the Met Office as requested by the UK CAA and in line with the guidance described in the latest version of the ICAO EUR/NAT regional contingency plan. The estimated volcano release rates for Eyjafjallajökull indicated that the 'traditional' IAVW 'ash' threshold equated to volcanic ash concentrations of $2x10^{-4}g/m^3$. This zone is depicted by a 'red' (low contamination) zone on the supplementary charts and approximates to the traditional volcanic ash areas shown on the official VAAC London Advisories. The $2x10^{-3}g/m^3$ threshold used to be depicted by a 'black' zone on the supplementary charts but following directions from the UK CAA on the 18th May this zone is now depicted as grey (moderate contamination) and a 'new' black (high contamination) area depicting $4x10^{-3}$ g/m^3 has been added, see Fig 3.

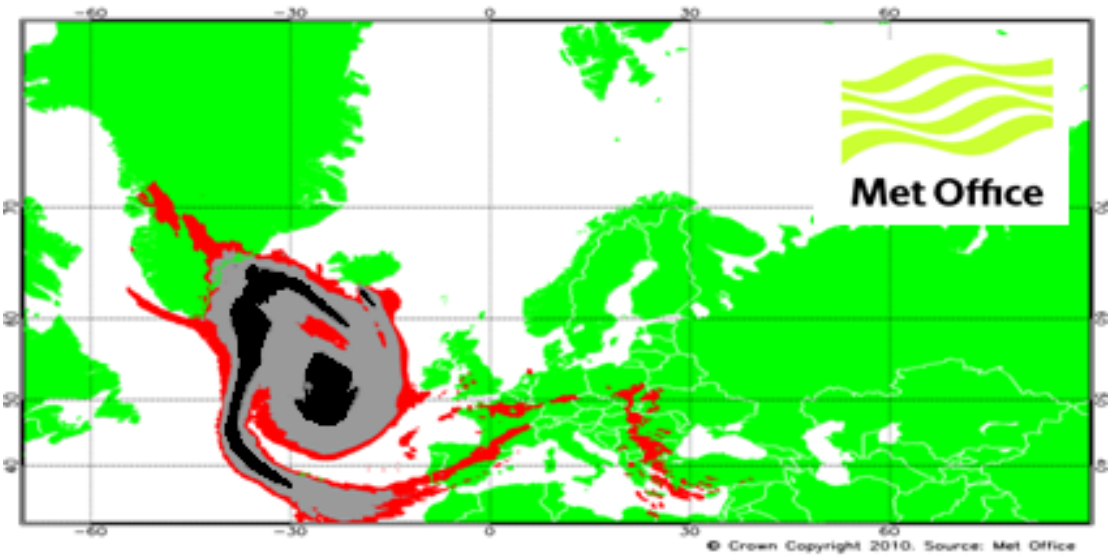

Fig 3: Met Office Supplementary Volcanic Ash Concentration chart.

Between 21st April and the cessation of volcanic activity on 24th of May there were further occasional incursions of 'low' and 'higher' concentration volcanic ash over Western Europe. The resultant airspace closures were however shorter lived, less extensive and therefore less disruptive though still economically significant.

3. MET OFFICE DISPERSION MODEL

The Met Office's capability to predict the transport and spread of pollution is delivered by the NAME (Numerical Atmospheric-dispersion Modelling Environment) computer model. NAME development began following the Chernobyl accident in 1986 and since that time it has been used to model a wide range of atmospheric dispersion events, including previous volcanic eruptions and the Buncefield industrial explosion near London in 2005. NAME provides a flexible modelling environment which is able to predict dispersion over distances ranging from a few kilometres to the whole globe and for time periods from minutes upwards.

NAME models natural ash deposition processes i.e. sedimentation, wet/dry deposition and is driven by the meteorology of the Met Office Unified Model (UM). NAME therefore retains volcanic ash from previous model runs that has not yet been deposited. During the Eyjafjallajökull eruption NAME output validated consistently well against the equivalent VAAC Toulouse and VAAC Montreal dispersion model output.

The **largest uncertainty** in the computer modelling of ash dispersion and transport is the ability to accurately reflect the status of the eruption at model initialization. This is less of a modelling issue and much more a case of being able to accurately and safely observe what the volcano is doing in real time, in particular, the:

- Height, diameter and time variance of eruptive column;
- Assessment of ash concentration and particle size/distribution;
- Ash deposition close to the volcano i.e. ash that is not available to be transported.

The introduction of the supplementary ash concentration charts has placed significant new demands on the NAME model and other operational dispersion models used at the VAACs. Verification has proved that NAME is very good at spatial forecasts of ash dispersion and is has significant skill in forecasting the location and value of peak ash concentration levels. The primary source of error though, continues to originate from the definition of the eruptive source term and in order to address this it will be necessary to develop an improved observational capability close to the Icelandic volcanoes themselves. This will allow greater accuracy in determining how much ash is coming out of a given volcano in the first place and then, after initial fallout, how much ash and in what dimensions is left to be dispersed and transported. In simple terms, if there is too much volcanic ash (and vice versa) at initiation then there will be too much ash (and vice versa) throughout the forecast. The loan to Iceland from Italy of a mobile dual polarisation weather radar in November 2010 is expected to significantly improve the future accuracy, continuity and consistency of volcanic eruptive source observations. A permanent version of this type of radar is due for deployment in Iceland in the summer of 2011.

4. VOLCANIC ASH OBSERVATIONS

Satellite imagery was utilised extensively to observe volcanic ash as it moved away from the eruption, see Fig 4, but it became clear that the development of an integrated (space-based; airborne; surface and upper air) real-time and operationally resilient volcanic ash observing capability would be vital to:

- Improve the initialization of dispersion models;
- Verify dispersion model output;
- Improve forecasters' ability to 'add value' to raw dispersion model outputs;
- Provide an assessment of volcanic ash concentration levels and;
- Facilitate ongoing and future research and development.

To address these issues and in collaboration with other meteorological and geophysical services, research institutes and universities, a variety of new volcanic ash observing technologies are being actively researched and developed. In addition to ongoing post-processed satellite imagery development these include:

- Aerosol sensors mounted on unmanned airborne vehicles, dropsondes and radiosondes;
- Enhanced ground-based LIDAR and;
- The use of Met Office lightning detection network, *ATD-net*.

The Met Office has also placed a contract for the provision of a dedicated Met Office Civil Contingency Aircraft. This twin piston engine Cessna aircraft is being equipped with a range of instrumentation to detect volcanic ash and to measure associated concentration levels. The aircraft is currently being modified and will become operational in April 2011.

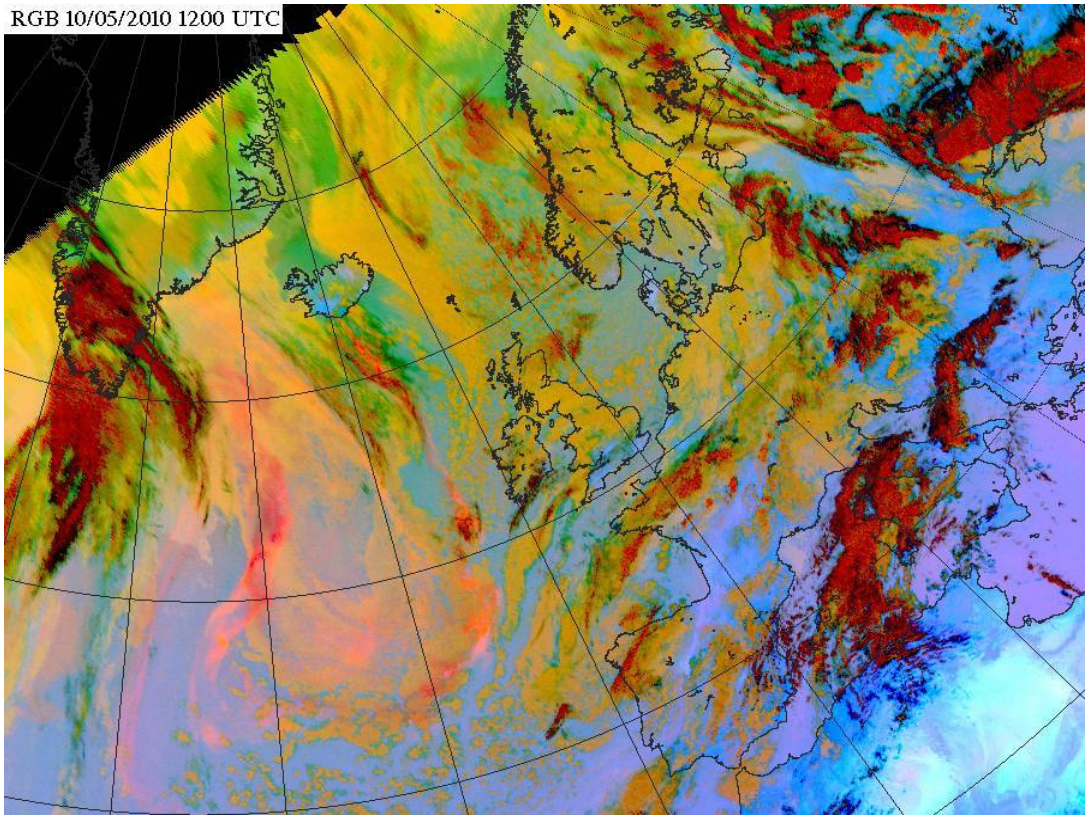

Fig 4: Derived Volcanic Ash Satellite Imagery Product

5. COORDINATION AND COLLABORATION

The Met Office is continuing to explore opportunities for greater international collaboration, particularly with the other VAACs and is also an active member of the World Meteorological Organisation Volcanic Ash Scientific Advisory Group and the ICAO International Volcanic Ash Task Force. A new Met Office Volcanic Ash Programme has been created to coordinate these activities over the next three years and ensure that the necessary international links and responsibilities are being developed and maintained. A greater emphasis is also being placed on proactively liaising with users to better understand their needs, manage expectations and provide guidance and education as appropriate.