How the Eyjafjallajökull crisis influenced developments in volcanic ash forecasting science

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Outline

• Very brief 2010 recap
• Heighted activity
• The challenge
• Forecasting developments
  • Science and operations
• The legacy
• Ongoing steps and challenges
The Crisis
Some numbers

The Economic Impact of Air Travel Restrictions
Prepared for Airbus

Overview

Scheduled commercial flights were first affected in April, declining 27.1% from the previous week, according to Eurocontrol. Traffic steadily declined over the following days as the cloud moved over the continent with cancellations reaching their zenith of 80% on 18 April. Air traffic volumes were nearly 20,000 lower than in the previous week at a rate of 5,000 flights compared with 25,000.

For the seven day period from 15–21 April, more than 100,000 fewer flights traversed European airspace than in the previous week, a 53% fall.

Air traffic resumed to near-normal levels on 22 April with over 27,000 flights to and/or from European airports. However, some flight schedules have remained lagged into the subsequent week as airlines balance the demands of canned and current itineraries.

Figure 1-1: European Flights Operating

Total

Global GDB Cost
US$5.0 billion

First Week

Global GDP Cost
US$4.7 billion lost GDP

First Week Aviation Sector Costs
US$2.2 billion

Source: Eurocontrol
Quantifying the hazard

• Europe moved to concentrations
  • Aim– to allow more flights though more information
  • Implemented in haste
  • Widely discredited as a viable operational approach

• Quantitative science and engineering clearly has value though…. 

• Outcome
  • Science, engineering, operations, regulators all thinking anew about the challenge

• Similar potential disruption will happen again
  • No field of human activity has ever benefited form standing still
A HEIGHTENED STATE OF ACTIVITY
A Busy Time

2010 2011 2012 2013 2014

Multiple Meetings
- IVATF/IAVWOPSG
- IUGG-WMO Geneva
- VAAC BP
- VA Satellite

WMO-SCOPE

VASAG 2015

VASAG

Bilateral activities, direct collaborations/engagements

AGU/AMS/EGU/IUGG/etc

Modelling Ins-Outs

WMO VA Workshop

2010 2011 2012 2013 2014 2015

VAST, SMASH, SACS2

VIPR-III

FUTURE EVOLVE

MED-SUV

WEZARD

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A Busy Time

Papers by title: “Eyjafjallajökull”

Published Items in Each Year

Papers by topic: “Eyjafjallajökull”

Published Items in Each Year

Numbers from Web Of Science search

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THE CHALLENGE
Themes & Recommendations
IUGG-WMO 2010 & 2013; VAAC modelling; VAAC BP, etc

Collaboration
Communications
Dispersion model improvements
Inversion / Data Assimilation
Model validation

More NRT observations
Source terms: observations and modelling
Quantitative observations + modelling is way forward

Probabilistic modelling
Communication of uncertainty

Understanding & reducing uncertainty in observations and modelling

Need to quantify hazard to engines
Re-suspension
Volcanic Gasses i.e. SO$_2$

Data on aircraft encounters
Some developments

SCIENCE
Observations

14 Feb 2014, 02:32 UTC

Total mass = 0.49 Tg
Max = 26.63 g/m²
Mean = 0.22 g/m²

Prata et al 2012

Kristiansen et al 2015

WMO SCOPE: VA Satellite Inter-comparison (Pavolonis et al)
Observations

Ceilometers and LIDAR

Aircraft

Dusseldorf University

DLR

Radar

New sensors

ZEUS sensor

Marzano et al (2013)
Ash properties
Impact of observations and models

Ash mass: 4 different refractive indices

(a) London VAAC operational and (b) Non-spherical particles with $\Psi_R = 0.4$ and the density distribution attributed to Eyjafjallajökull 2010 ash

Travel distance for different diameter, density, shape


Stevenson et al 2015

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Francis et al 2012
Modelling
Ash3d, Fall3d, Flexpart, HYSPLIT, LPDM, MLDP0, NAME, Puff, VOL-CALPUFF, etc

- Growing body of Validation
  - Ash and SO₂
- Process investigation and development
  - Layering; umbrella clouds; plume rise; deposition; treatment of convection; non-sphericity; re-suspension; aggregation; etc
- Assessment of prediction uncertainties and ensemble approaches

Model vs Observations

Re-suspension over Argentina

Webster et al (2012)

Folch et al (2014)
Modelling

University of Bristol Web Interface to Woodhouse et al plume rise model

Plume rise model inter-comparison

Costa et al (Submitted)
Modelling + Observations
Inversion and data assimilation

- Complex 4-dimensional scaling
- Not a silver bullet
- In infancy but being worked on

Model run(s) x scaling = Observations

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Stohl et al (2011)

SEVIRI

FLEXPART aposteriori

FLEXPART apriori

Altitude [km]

50 55 60 65

50 55 60 65

0 1 2 3

0 1000

0 μg m⁻³

SEVIRI

apriori

aposteriori

London VAAC operational inversion
Forecast Process

Source Terms

Observations

Modelling

Forecast
Research to Operations

Not that easy

Research

Significant addition effort

To complex

Not usable NRT

Benefits not verifiable

Relatively Little Operationalised

Drop outs
VAAC Changes

- Access to and processing of more observations
- Improved use of observations
- Improved and adoption of new models
- Improved use/initialisation of models
  - Deposition, PSD, plume rise, etc
- Some use of ensembles/uncertainty
- Inversion
- Stronger links with
  - Each other
  - Volcano observatory
  - Researchers
Legacy

- A great data set
- Significant advances
- Significant increase in research effort
- More instruments, focus and thought
  - We are extracting more understanding from each eruption
  - Awareness of collaborative and cross-disciplinary nature of work
- Better models
- A strong multidisciplinary international community
On going steps and challenges

- Science
  - Quantitative observations & modelling
  - Model + Observation fusion
  - Quantification of uncertainty
- Forecasting
  - Managing fusion of information
  - Communication of certainty
- Aviation
  - Pilots role in ‘local in flight’ information
  - OEM data