Outcomes from the 1st IUGG-WMO workshop on Ash Dispersal Forecast and Civil Aviation (November 18-20, 2010)

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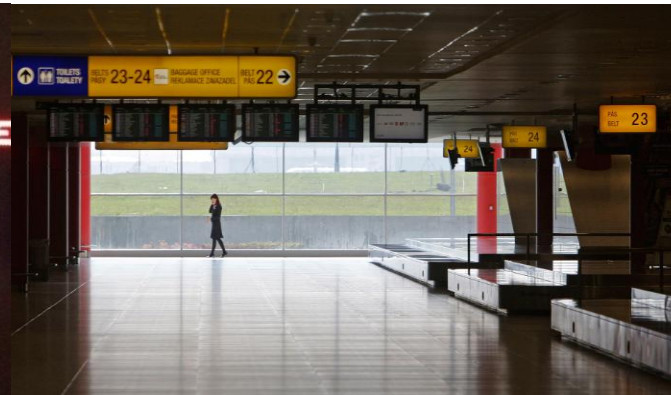
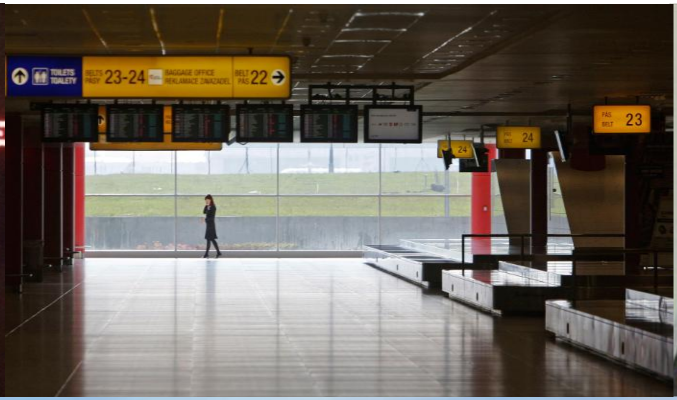
13:19 15-APR
LONDON LUTON AIRPORT ADVISES PASSENGERS THAT DUE
TO AN ASH CLOUD GENERATED BY AN ICELANDIC
VOLCANIC ERUPTION FLIGHTS MAY BE DELAYED
OR CANCELLED. PLEASE CONTACT THE RELEVANT
HANDLING AGENT FOR FURTHER INFORMATION.




London Evening Standard
VOLCANIC ASH CLOUD SHUTS ALL AIRPORTS
MILLION PASSENGERS HIT BY WORST CHAOS SINCE SECOND WORLD WAR
MANY MAY NOT GET COMPENSATION
'LAVENDER' SUNSET OVER LONDON


Countries with AIRSPACE affected by the eruption:
Austria
Belgium
Czech Rep.
Denmark
Estonia
Finland
Germany
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Netherlands
Poland
Romania
Slovakia
Slovenia
Sweden
Switzerland
UK
Economic consequences:
European economy lost $1.9 BILLION in the first 6 DAYS.
Aviation industry lost $200 MILLION PER DAY.
TOTAL FLIGHTS CANCELED 100,000
TOTAL PASSENGERS STRANDED 7 MILLION



Lessons to be learnt? How can the scientific community help?

- The regulatory response to the 14 April 2010 Eyjafjallajökull eruption resulted in severe disruption to air traffic
- By 21 April, the UK CAA and Eurocontrol had pioneered a new way to manage the crisis based on ash concentration thresholds

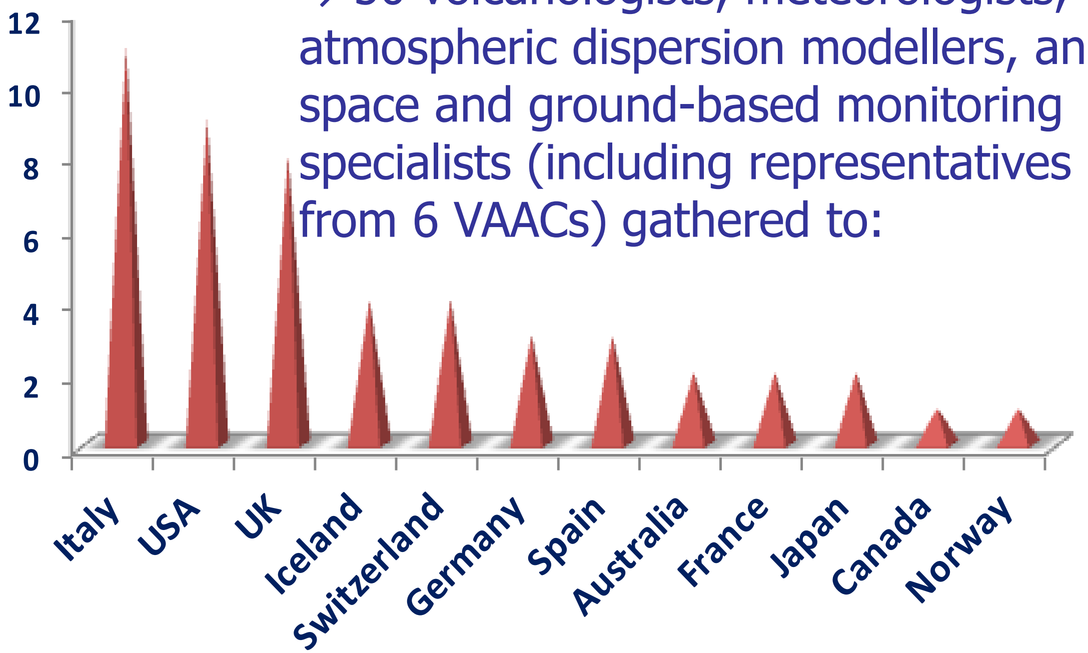
→ require more accurate information on the ash mass in the eruption since downwind concentrations depend on the source

1st workshop on Ash Dispersal Forecasting and Civil Aviation

18-20 October, 2010, Geneva

www.unige.ch/hazards/Workshop.html

IUGG (International Union of Geodesy and Geophysics) and WMO (World Meteorological Organization)



→ 50 volcanologists, meteorologists, atmospheric dispersion modellers, and space and ground-based monitoring specialists (including representatives from 6 VAACs) gathered to:

1. discuss the needs of the ash dispersal modelling community,
2. investigate new data acquisition strategies,
3. discuss how to improve communication between the research community and operational agencies.

→ Pre-meeting benchmark exercise
→ Keynote talks, breakout sessions and plenary discussions

→ Outputs: Consensual Document, Benchmark Document, Models and Data-Acquisition Summary Documents

In association with: CERG, Université de Genève, Barcelona Supercomputing Center – Centro Nacional de Supercomputación, BGS, WMO, République et Canton de Genève, IAVCEI

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MAIN CONCLUSIONS

→ model developers, meteorologists, volcanologists and stakeholders (e.g. aviation sector) need to work closely together in order to develop new and improved strategies for ash dispersal forecasting

1. improve the definition of the source term and critical aspects of particle sedimentation,
2. design models and forecasting strategies that can better characterize uncertainties,
3. explore the best ensemble strategies that can be adapted to ash dispersal forecasting,
4. identify optimized strategies for the combination of models and observations.

Selected VATDMs

	ASH3D	ATHAM	FALL3D	FLEXPART	HYSPLIT	JMA	MLDP0	MOCAGE	NAME	PUFF	TEPHRA2
Operational											
Approach (1)	E/H	E	E	L	H	L	L	E	L	L	E
Method (2)	N	N	N	N	N	N	N	N	N	N	A
Coverage (3)	LRG	L	LR	LRG	LRG	G	LRG	G	LRG	LRG	L
Physics											
Topography											
H wind advection											
V wind advection											
H atm. diffusion								See (5)			
V atm. diffusion											
Particle sed.											
Other dry dep.											
Wet deposition											
Dry part. aggr.											
Wet part. aggr.											
Particle shape											
Gas species											
Chemic. processes											
Granulometry											
Variable size class.											
Variable GS distr.											
Variable size limits											
Source term											
Mass distribution(4)	LN	O	ALL	PS/L/U/P/O	PS/L/U/P/LN	PS/L/U/P/LN	PS/L/U/LN	PS/L	PS/L/O	PS/L/U/P	L/U/LN

(1) L=Lagrangian, E=Eulerian, H=Hybrid
(2) A=Analytical, S=Semi-analytical, N=Numerical
(3) L=Local, R=Regional, G=Global
(4) PS=Point Source, L=Linear, U=Umbrella-type, P=Poisson, LN=Log-normal, BP=Buoyant Plume, O= Other.
(5) Neglected. Diffusion of numerical origin appears to be sufficient, with particularly good results at 0.5°.

Selected data-acquisition techniques

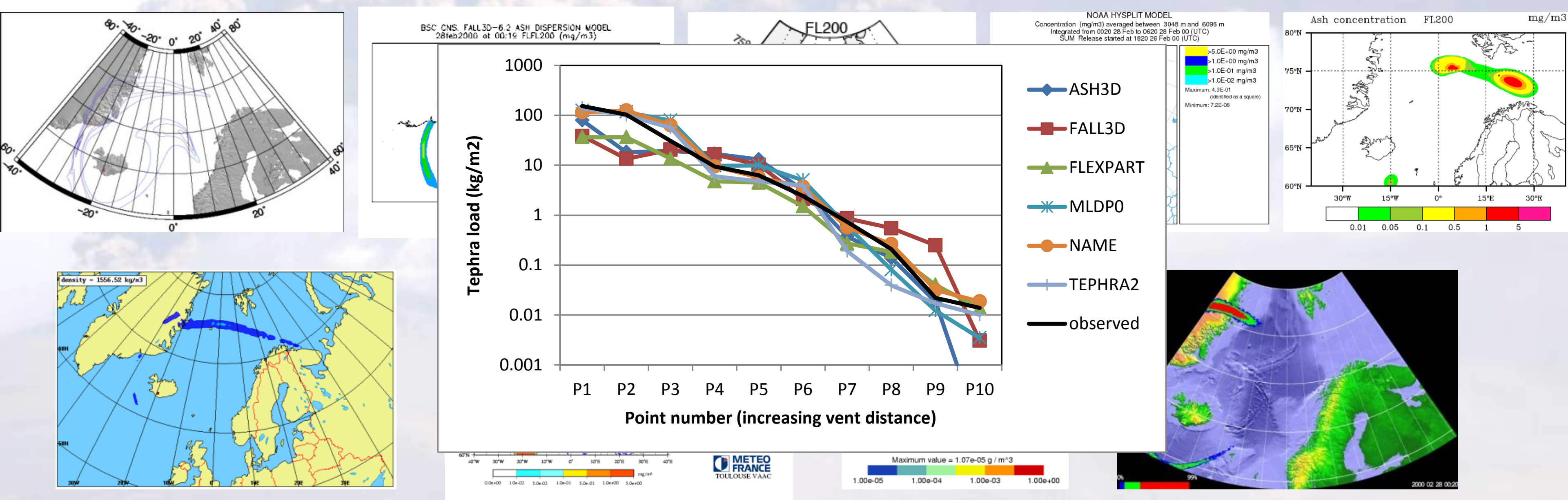
	Eruption start / end	Plume Height	MER/MTR	Mass	Grain size	Cloud Concentration	SO_2
AVHRR		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effect. radius: 0.1-15μm	Mass loading	
GOES-11 Imagery		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effect. Radius: 0.1-15μm	Mass loading	
GOES-12,13,14,15 Imagery		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effective radius 0.1-15μm	Mass loading	
Grimm EDM 107					Size range: 250nm-32μm	Mass/volume Number/volume	
Grimm Sky OPC					Size range: 250nm-32μm	Mass/volume Number/volume	
Doppler radar			Local MTR		> 30 μm (Ka band) > 100 μm (X and C band) > 1 mm (S band)		
Infrasound		From source MER	Source MER				
ASTER							SO_2 burden
LIDAR		Altitude		Size range: 100nm-2μm	Size range: 100nm-2μm	Mass/volume Number/volume	Possible using DIAL
MISR		Altitude		All particle sizes		Mass Loading	
MODIS		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effective radius 0.1-15μm	Mass loading	SO_2 burden
MTSAT		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effective radius 0.1-15μm	Mass loading	
OMI							SO_2 burden
AIRS		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effective radius 0.1-15μm	Mass loading	SO_2 burden; Vertical distr.
IASI		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effective radius 0.1-15μm	Mass Loading	SO_2 burden; Vertical distr.
PLUDIX (X-band)*					Effect. radius >100μm		
Seismic data		From seismic amplitude and reduced displacement					
SEVIRI		Altitude, Temperature, Pressure	Local MTR	0.1-100μm	Effective radius 0.1-15μm	Mass loading	SO_2 burden
Thermal Camera							
UV Camera				Ash Opacity			SO_2 line of sight burden
VOLDORAD* (L-band)	Data acq. rate (10 Hz)	Max detection limit: 12 km	Source MER		~All particle sizes	Pixel size (~150m)	

VATDM variability (benchmark exercise)

Complete report at http://www.unige.ch/hazards/Workshop/results.html

- A model benchmark exercise (based on the Hekla 2000 eruption in Iceland) was carried out before the workshop.
- The benchmark exercise was performed by 12 VATDMs (ASH3D, ATHAM, FALL3D, FLEXPART, HYSPLIT, JMA, MLDP0, MOCAGE, NAME, PUFF, TEPHRA2, and VOL-CALPUFF). This includes the vast majority of the VATDM in use worldwide and all models currently operative at VAACs.
- Outputs: maps of airborne concentration (mg/m^3) every 6h at 4 FL; vertical concentration profiles at a given point; tephra ground load maps.

FL200 after 30h



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Goals:

i) to define model characteristics and application limits rather than to rank or validate VATDMs,

ii) to understand the influence of the parameterization of different sedimentation processes and source term treatments on the model outputs.

Conclusions:

i) there are some discrepancies in model outputs (likely due to different model physics, different parameterization of the source term and slightly different input choices, e.g., NWP, grainsize classes),

ii) discrepancies increase with time (i.e., distance from vent) and, for this particular benchmark case, become important and generalized after 36h,

iii) discrepancies are also different at different altitudes,

iv) models could be clustered in a few groups based on these discrepancies. Discrepancies will need to be analysed in more detail by the modellers in order to assess their actual origin and to investigate if these discrepancies could eventually be exploited in ensemble forecasting.

KEY RECOMMENDATIONS:

- **Ash Dispersal Modelling**
- **Uncertainty and Ensemble Model Forecasting**
- **Forecasting Strategies and Combining VATDMs with Observations**
- **New Communication Strategies**
- **Research Priorities**

KEY RECOMMENDATIONS:

Ash Dispersal Modelling

1. Ash dispersal models considered during this workshop have been found to accurately describe important aspects of transport of volcanic particles (e.g. advection and diffusion). However, other aspects, such as the definition of the source term, convective transport, or the removal of airborne ash by specific sedimentation processes, could be better characterized.

2. Source Term in VATDM: i) Mass Eruption Rate (MER), ii) vertical distribution of mass and grainsize, iii) column height, iv) Total Grainsize Distribution (TGSD) and particle properties (i.e. density and shape), v) eruption onset and end time, vi) source position, and sometimes vii) the fraction of fine ash.

3. Enhance collaboration amongst VATDM developers, volcanologists and meteorologists in order to improve the definition of the source term and critical aspects influencing particle sedimentation (i.e., particle aggregation and wet deposition).

4. A systematic sensitivity analysis of all VATDMs have to be performed in order to assess the effect of different inputs (e.g., MER, plume height, erupted mass, TGSD) on model outputs and to prioritize data acquisition. This is also important for the construction of future ensemble on input variables.

KEY RECOMMENDATIONS:

Uncertainty and Ensemble Model Forecasting

1. Volcanologists and volcano observatories should identify appropriate PDFs and activity scenarios for each given volcano to be used for the initial forecasting.

2. VATDM developers should design models and forecasting strategies that can better deal with uncertainties in model inputs.

3. VATDM developers should identify the best ensemble strategies that could optimize operational ash forecasting.
Four different types of ensemble forecasting could be envisaged: i) ensemble of input variables (according to activity scenarios and data uncertainties), ii) ensemble of VATDM (multi model) (on a single or different NWP), iii) ensemble on NWP and iv) both VATDM and NWP.

4. Ensemble forecasting should be carried out in order to better characterize uncertainty rather than to hide gaps in our understanding.

5. VATDM modellers should work with ICAO to treat uncertainty, eventual probabilistic approaches and design output products that are immediately understandable and meaningful to stakeholders.

KEY RECOMMENDATIONS:

Forecasting Strategies and Combining VATDMs with Observations

1. The pre-eruption forecasting and the first simulation, assuming no observations are available, should be based on a probability assessment of eruptive activity scenarios (PDFs) for each volcano. If observations, scenarios and PDFs are not available, standard ESP may be used accounting for related uncertainties.

2. A real-time comprehensive definition of the source term can only be accomplished through the combination of various monitoring/measurement techniques.

3. MER is hard to measure directly. If MER is calculated from plume height, then the most appropriate parameterization should be used (e.g., strong plume vs weak plume empirical and theoretical relations. A range of techniques that could help constrain MER (of selective particle sizes) include radar, lidar, ground-based IR or UV camera, satellite, seismic energy release, infrasound, and in situ aircraft for local MER.

4. Ash concentration measured in the ash cloud can be useful for data assimilation or model validation.

5. SO_2 and aerosols may be a hazard in themselves and should also be monitored and modelled.

KEY RECOMMENDATIONS:

New Communication Strategies

1. Volcano observatories and VAACs are encouraged to agree on mutual expectations and requirements before volcanic crises, if they have not already done so.

2. Operational institutions are encouraged to investigate new operational strategies such as:

i) integration of outside experts and strategic research that could facilitate various operational stages;

ii) construction of an official database with the objective of sharing high-quality data from multiple sources during a volcanic crisis.

3. Existing monitoring networks across Europe (e.g. EARLINET, EUSAAR) are valuable but coordination of resources, data management and resource availability are priorities. Some networks currently work well at a national level but need to develop the means to coordinate with European partners. The aim is to make data available as soon as possible to the VAACs.

KEY RECOMMENDATIONS:

Research Priorities

1. Research and operational institutions to establish long-lasting collaborations in order to optimize strategies of ash dispersal forecasting. Research priorities include:

i) data assimilation,

ii) aggregation processes,

iii) plume dynamics (in particular of weak plumes) and better characterization of the source term (e.g. based on validation with 3D models),

iv) magma fragmentation, particle characterisation and size distribution from proximal to distal environments,

v) separation of SO_2 from ash clouds,

vi) chemistry analysis of plumes (particles, sulphuric acid aerosols, H_2S, halogen chemistry) and,

vii) aerosol transformations. Implicit is the need for reference observations and corresponding source-term information with which to evaluate the models.

Photograph courtesy of J. Elíasson