Draft

Summary report of the EASA/EC Volcanic Ash Cloud workshop

On 21st of June an EASA/EC workshop was held in Cologne with the aim of bringing all the European expertise in the field of volcanic ash cloud measurement and modelling together.

The intention was that the 'EU measurement community' find short, medium and long term solutions to improve the volcanic ash dispersion modelling output in order to mitigate serious disruptions from future events to the aviation transport systems as we have seen in April / May 2010.

The EASA and European Commission reiterated the necessity of working together and requested the research community for a structured approach to find the solutions and 'quick wins'.

Airborne, ground and space based existing and future technologies were presented during the workshop as well as experiences during the Eyjafjallajokull eruption. It was found that many stakeholders in the measurement community have reported during the recent event their findings with regard to ash cloud observations and predictions via existing reporting channels. However, **all recognised the need for an improved architecture of data exchange** and a further build on already working existing structures.

Building also on a report and draft recommendations of an ESA-EUMETSAT workshop end-May, the need for standardisation of measuring equipment was concluded to be of high importance, as well as the exchange and assimilation of data.

In general it was concluded that atmospheric models were quite accurate under the given conditions at the time of the last eruption. **It became apparent that the accuracy of the inputs drives the corresponding accuracy of the output**. **Most significant is the information at the source, the density, intensity and characteristic of the cloud above the volcano**. Clearly improvement in this area is possible and necessary. Measures such as mobile radar and drop sondes were taken into consideration as a major contribution in the future. **Further development of airborne, ground and space based measurement technology has the potential to further enhance the accuracy of cloud dispersion and forecast models**, e.g. a standard pod which fits to almost any aircraft. Volcanologist and Meteorologist concluded that the link between them should be further explored and intensified.

The World Meteorological Organization (WMO), a specialized agency of the United Nations has brought forward that the airspace disruption has institutional, economic and technical elements, and a business case should take all the aspects into account in a pragmatic way. The WMO, ICAO and International Union of Geodesy and Geophysics (IUGG) have jointly taken the initiative to create a Scientific Expert Group that is being instituted and will become operational after the ICAO Montreal meeting in July 2010. The group is expected to represent a single voice of science by representing all important disciplines and sciences in as fair and complete way.

The workshop ended by a question and answer session between 5 chosen experts and the measurement community.

The following items were concluded:

- There shall be an immediate response, or even an anticipated response, in case of a volcano eruption, to deploy technology helping improve the ash prediction model output. In short term it is conceivable to rely on technological infrastructures of research institutes, in long term an ad-hoc dedicated operational infrastructure might be desirable;
- Data exchange between institutions and Volcanic Ash Advisory Centres (VAACs) exists, but should be further developed;

- Satellite observation technology can play an important role in a future observation, measurement, and modelling system but makes optimised data assimilation indispensible;
- Institutional architecture to exchange information and decision making needs to be researched;
- Although governance and institutional questions were not subject of the workshop a similar structure as the oil spill monitoring and vessel detection services of the European Maritime Safety Agency was suggested as an option.
- There was very little expertise and limited knowledge at decision maker level during the recent event as well as very limited capacities in observation, modelling and advisory institutions. Besides technology development training and availability of resources forms a crucial element.

A more detailed list of Observations, Conclusions and Recommendations drawn from the presentation please see Appendix 1.

Results will be presented at the AERONET workshop 30 June – 1 July where possibilities of dedicated research projects will be explored.

A follow up will be, amongst other events, a workshop session at the International Air Safety & Climate Change Conference (IASCC) 2010, in Cologne, on 8-9 September 2010.

Appendix 1

Observations, Conclusions and Recommendations

- **Pre eruption**
  - Geophysics
    - Expanded seismic and GPS network (EPOS)
    - Gas emission monitoring and modelling
    - Research activity to improve understanding of the volcanic behavior
    - Borehole strainmeter measurements
  - Hydrology
    - Improved heat and conductivity measurements in existing stations
    - Denser gauge network around glacial volcanoes
  - Atmosphere
    - New C-band radar for better coverage of Iceland's volcanoes
- **During eruption**
  - Improved monitoring of the source plume:
    - Portable high frequency dual polarization radar (improved resolution, and better ash particle response, especially in cloudy conditions)
    - Portable or closely positioned radio-sondes for accurate local weather profiling.
    - Drop sonde capability for inside plume conditions or 50-100km downwind.
    - Network of visible and/or IR cameras.
    - Portable LIDAR, with gas and/or aerosol capability.
    - DOAS measurements (SO2)
    - Infrasound array
  - Seismic network resolution:
    - Portable seismometers to be added as needed during event
    - Portable GPS stations to be added as needed during event
  - **Ash plume modelling**
    - **Better input to VAAC by:**
      - **Better estimate volcanic ash production**
      - **Better estimate of local fallout of ash**
    - **Estimate dispersion close to source in terms of height and layering as an input to global dispersion models**
- **After eruption**
  - Ash resuspension measurements:
    - Lidar measurements
    - Ash measurements from airplanes
    - PM10 and PM2.5 meters on AWS
    - Mapping of resuspension source area and monitoring
  - Ash resuspension modelling
    - Is needed for Icelandic airports, especially Keflavik
    - Is being investigated with London VAAC

- ✓ **Access to all data sources of volcanic plume observations in Europe should be opened, accelerated and improved.**
- ✓ Existing observing capabilities within Europe should be further consolidated and enhanced by combining satellite, airborne and ground- based systems for detecting and characterizing ash clouds.
- ✓ Concerted developments should be undertaken to integrate existing advanced retrieval methods into operational processors.
- ✓ Techniques for assimilation and inversion of satellite data in dispersion models should be further developed and applied to provide quantified ash cloud advisory information.
- ✓ Relevant satellite observation systems and data products should be formally validated with observations from other sources and should, where appropriate, be certified versus quantitative requirements for volcanic plume monitoring.

- ✓ Actions should be taken to ensure that planned future European satellites will provide more efficient and guaranteed support for ash cloud related crises; both operational systems (MTG, Sentinels) and research missions (explorers).
- ✓ Studies should be made of potential new satellites and instruments dedicated to monitoring volcanic ash plumes and eruptions.
- ✓ Intensive basic research should be conducted on physical, chemical and radiometric properties of volcanic ash, from crater to aged clouds.
- ✓ European recommendations and actions should be coordinated with ICAO, as the global presiding aviation regulatory authority, and with WMO, as coordinator of the global system of VAACs.
- ✓ Follow-up workshop should be organized to review progress on these recommendations.

- **A straightforward procedure must be established by which available aircraft can be mobilized for monitoring ash plume, not only over their own territory but also where it is necessary over Europe.**
- **In-situ measurements of ash concentration, size distribution, scattering properties and density are necessary to improve plume models, and remote sensing retrieval techniques.**
- UAS (and drop sondes) can perform measurements in the core of the ash plume.
- Development of miniaturized sensors/instruments for UAS and drop sondes is required

- ▲ Ash probing is meaningful only together with measurement of what is encountered
  - Intruder equipped with measurement equipment
  - Intruder joint with research/sampling aircraft
- ▲ Installation of instruments:
  - CAPS – Cloud Aerosol and Precipitation Spectrometer
  - PCASP – Passive Cavity Aerosol Spectrometer Probe
  - LIDAR – Light Detection and Ranging
  - Particle collection device
  - Direct Sampling of Gas and Liquids
- ▲ Challenge for all direct sampling:
  - Real time display on board of concentrations
  - Calibration
  - Interpretation of measurement results
- ▲ Scientific support necessary for interpretation of measurements

- ❖ Three major elements, which should be treated carefully for data quality and comparability:
  - o Probe Tip; Isokinetic Sampling
  - o Sampling Line
  - o Dust Monitor

- ➢ Continue comparison of in flight measurements with NAME (Numerical Atmospheric dispersion Modeling Environment) model:
  - Analysis of aircraft data and comparison with model
  - Use of aircraft data to assess satellite retrieval algorithms
  - It is recognised that there is a requirement for well instrumented airborne facilities to be able to monitor ash concentrations

- Important questions to be answered:
  - How to safely measure ash mass density [mg/m3] in the atmosphere?
  - How to measure in moist areas?
  - International standardisation of measurement equipment, procedures, reporting, exchange of information.
    How and by whom?

- ☼ Improve information exchange (needs, potential)
- ☼ Define required quantities (resolution, range, accuracy, etc.)
- ☼ Define required infrastructure (specifications, operator, and quality control)
- ☼ Collect data from Eyjafjallajökull event (data sets, models, initiate research)

☼ Strengthen research activities (refractive index, shape, mass-extinction)

⇨ In-situ measurements and ceilometer data support and complement each other, qualitatively as well as quantitatively
⇨ The ceilometers have shown their potential for aerosol retrieval and its usage as "early-detection" system for volcanic ash plumes.

We still need an integrated observing system consisting of
⇨ Fully equipped LIDAR stations in Europe (like EARLINET)
⇨ Aircraft measurements (like the DLR Falcon measurements)
⇨ Satellite observations (like space-borne LIDARs and IR-radiometers).

✓ Respond to further changes in regulatory requirements to facilitate safe air traffic management and airline operations,
✓ Continue to evaluate ash forecasts against observations,
✓ Reduce uncertainty of the volcanic source term using vulcanological models and/or real-time calibration with observations,
✓ Extend the forecasts to include SO_2 and related pollutants,
✓ Improve temporal and vertical resolution of products to facilitate flight planning,
✓ Develop products which represent the uncertainty in the volcanic source & meteorology to enable better-informed risk assessment.

➢ What about non monitored volcanoes for which no data for mass rate and plume height will be available in real time?
➢ How to estimate the uncertainty in the source term of models (mass rate)? Once known, how to reduce it?
➢ How to improve the vertical information concerning presence and concentration – fixed layers can be misleading?

- Source terms of volcano eruption are paramount, including:
  - Eruption height as proxy for mass flow rate
  - Need for mobile Radar
  - Chemical/physical properties , particle size spectra
  - SO_2 probably very important for corrosive potential
- Plume measurements:
  - Vicinity of Eruption to corroborate «absolute no fly zone»
  - Downwind (> 200 NM) for « inverse calibration » of source terms where model errors are still negligible
  - In Traffic Areas for sound Risk Assessment
- Instrument Systems
  - Operational, with need for adaptation:
    - Remote Sensing (Ash/Dust product, SO2, etc.)
    - Ceilometer networks or any other appropriate networks
  - Research instruments with the option to transition to operational system, at least as short and mid term solution:
    - LIDAR
    - Ground based instruments
    - Drop Sondes
    - Airborne instruments, possibly including UAS)
    - On-board sensors (LIDAR, cameras, etc.)
  - For low contamination post eruption: airborne sensors carried on board commercial aircraft,
- Need for harmonised and standardised regulations and services through ICAO and WMO,
  - Scientific Advisory Group (SAG) expected to represent "single voice of science", by representing all important disciplines and sciences in a fair and complete way
  - SAG to be integral part of International Volcanic Ash Task Force (IVATF),
  - Multi-class regulations at high granularity may be best avoided,
  - Separation of business and safety case to be sought

- Defined certification envelope needed to avoid surprises in terms of corrosion by exposure to light and moderate concentrations of volcanic ash cloud.
- Urgent need to achieve « safety net » by remote sensing, automated monitoring etc. for currently un-monitored volcanoes near international airways.

- ✓ Use measured data to improve VAAC prediction methods including Satellite and LIDAR observation methods,
- ✓ Install ensemble models to quantify ash loading together with information on the probability of exceeding thresholds,
- ✓ Prepare for visibility predictions,
- ✓ Prepare improved instrumentation including aerosol-Lidar, suite of in-situ sensors and drop sondes for measurements in dangerous air masses,
- ✓ Make use of multiwavelength-polarization-Raman Lidars including airborne intercalibration in addition to standard Ceilometers,
- ✓ Install onboard-sensors for particles and SO_2 on airliners
- ✓ Analyze ash mass uptake by aircraft engines with/without damages in European airspace from verified models,

Make high-quality secondary information available to decision makers!