5th Meeting of the
Volcanic Ash Scientific Advisory Group
(VASAG-5)

San Francisco, USA
11-12 December 2014

SUMMARY OF DISCUSSIONS
1. INTRODUCTION ...........................................................................................................................................1
2. REVIEW PROGRESS ON ACTIONS FROM PREVIOUS MEETING ...........................................1
3. SCIENCE REVIEW (remote participation session) ...............................................................2
4. REVIEW AND DISCUSS WORK REQUESTS FROM ICAO IAVWOPSG/8 ....................4
5. DISCUSSION ON OUTSTANDING ACTIONS AND NEW WORK REQUESTS ..........5
6. PLANNING FOR THE 7TH WMO INTERNATIONAL WORKSHOP ON VOLCANIC ASH AND AVIATION ............................................................................................................................5
7. TOPICAL DISCUSSIONS (remote participation session) .......................................................5
8. REVIEW OF VASAG GOVERNANCE AND FUTURE WORK PROGRAMME ..................6
9. ANY OTHER BUSINESS .........................................................................................................................7
10. DATE AND PLACE OF NEXT MEETING ....................................................................................7
11. CLOSURE OF THE MEETING ...........................................................................................................7
LIST OF ANNEXES

1. Agenda
2. List of Participants
3. Terms of Reference of VASAG

PICTURE
1. OPENING OF THE MEETING

The 5th meeting of the Volcanic Ash Scientific Advisory Group (VASAG-5) was held at the Marriott Marquis, San Francisco, CA, USA from 11 to 12 December 2014 and back to back with the AGU Fall Meeting (15-19 December 2014).

The meeting was attended by 12 participants (10 in the room and two joining via Skype). The list of participants is in Annex 1.

The two co-chairs, Andrew Tupper and Larry Mastin, chaired the meeting. The agenda adopted by the meeting is in Annex 2.

The documents and other materials for the meeting are available on the WMO AEM website at: http://www.wmo.int/aemp/?q=node/41

2. REVIEW PROGRESS ON ACTIONS FROM PREVIOUS MEETING

The meeting reviewed the follow-up on the actions formulated by VASAG-4, as follows:

- **Item 2.2 – Ash encounters (Marianne Guffanti):** A global data base exists that was last updated in 2009. Collaboration between USGS and DLR (Carsten Christmann) to update with 2014 data. Main source of data – EASA (voluntary reporting by pilots): 186 reports for Eyja but not all encounters; 13 encounters considered damage related; 3 more from other volcanoes.

  **Future work:** Severity classes need to be reconsidered; need to determine the best way to do that. These results will be published in some form. The question remains how to obtain information from industry. The meeting discussed a recent aviation encounter where it had proved difficult to obtain the relevant information despite repeated requests (note – this matter is now resolved).

- **Item 2.2 – Global volcano ESP database (Larry Mastin):** Plans for the establishment of a wiki site, but no progress yet. An existing database (Excel) is not updated. Use of Ash 3D model for volcanoes in unrest and VO people have to select default value or modify locally. The issue is whether the wiki will be of help if not connected to provide automatic input to models.

  o **Future work:** Skype meeting by January to discuss the outline of the wiki site. By summer – prototype of the site and 30 most active volcanoes. By end of 2015 to have all most active volcanoes with help from local volcanologists.

- **Item 3 – Infrasound (general discussion):** Information about Alaska – some local infrasound, need to make known that there is more than CTBT infrasound. David Fee (Alaska) is the person very involved in this. We should continue to monitor global best practice including ongoing CBTO links and to David Fee (Alaska) as a world leader in this field.

- **Item 4 – Scientific investigation into volcanic cloud thickness and stratification (Claire Witham, Mike Pavolonis):** An update on CALIOP research-based work into volcanic ash layering and thickness. Problem with the huge amount of data that need to be processed and processing is difficult because the lidar data are not sufficient. In 2012 there was already a report indicating thin layers away from the source. Since then more eruptions have been observed.

  o **Future work:** NASA should be encouraged to do such processing within NASA
applied research portfolio (David Green and John Murray) because it is NASA database. VASAG could encourage such research. The task to be linked to the mitigation actions by industry.

- Note: Lack of clarity of what this action is about. Need to restructure the action list.

- Item 6 – WMO to consider funding to support the science workshop and also the regular VASAG (Dimitar Ivanov, Ian Lisk): WMO has already provided some support for VASAG-5, which was welcomed. The WMO AEMP has been better funded during the current financial period, due to the recognition of the aeronautical meteorology as one of the five strategic priorities of WMO, thus there is a possibility to support the VA Science Workshop (40-50K CHF). The meeting warmly welcomed this possibility and noted that this would aid a successful and appropriately attended workshop.

- Item 7 – Outreach (general discussion): Discussion on how the VASAG’s relevance and visibility can be improved. Will partly be addressed by the governance review currently being undertaken – see also 3b) below. Marianne Guffanti on EOS article detailing what has happened in VA over the 5-years since Eyjafjallajökull. Marianne Guffanti to lead the development of this short piece with significant contributions from VASAG members.

3. SCIENCE REVIEW
(remote participation session – 10 am – 12:30 pm local; 7–9:30 pm
Spain/Norway/Germany, 6-8:30 pm Iceland)

The meeting reviewed scientific developments relating to ICAO International Airways Volcano Watch since previous meeting. Members were asked to prepare for this agenda item by considering relevant literature, conference, and meeting proceedings. The following inputs from VASAG members were noted:

- Augusto Neri: Literature review sent by co-chairs had been very useful. Recent developments – modelling technics for better description of dynamics of ash dispersal. Model intercomparisson of plume dynamics, led by Antonio Costa and Yujiro Suzuki. Comparison has already been done, will be published in the next year as a special volume in JVGR. There is a need to understand better the consistencies and inconsistencies between models. New studies on validation of models, ash concentrations and deposit, including probabilities have been carried out and some abstracts for AGU also include such aspects. Grain size distribution is one of those.

- Arnau Folch: Plume model intercomparison is one of the main results. Publications are coming for different types of models (1-d, 2-d, 3-d). PhD study links these data with air traffic to assess impacts (Scaini et al., 2014)

- Claire Witham: Information about the eruption of Bardarbunga in Iceland which continues for over 100 days. A lot of preparatory work has been done for an ash-rich scenario. but actual eruption is lava effusion with SO2 degassing. The main focus is on gas emissions - SO2 at low levels recorded in Europe. Satellite information to be made available by UK to volcano observatories (Ian to provide some clarification here about the French position). US is sharing all this data. Another satellite intercomparison in parallel of SCOPE. Studies on Global risks of volcanic ash. To note – the work done by Iceland on forecasting SO2.

- Mike Pavolonis: High level summary of progress in the following areas:
  - Ash detection – greater use of probabilistic methods; advances in using hyperspectral infrared measurements to detect high level dispersed ash; improvements in detecting emergent volcanic clouds, that often elude detection
using spectral methods, through use of cloud growth rates and microwave measurements

- Retrieval of ash cloud properties – More groups are now utilizing multispectral approaches that are sensitive to ash cloud temperature;

- SO₂ detection – studies by Don Grainger’s group at Oxford; determining the height of SO₂; notable that SO₂ is much easier to detect than volcanic ash;

- Multisensor integrated approach – strongly encouraged, NOAA is pursuing multisensory approaches, similarities with WEZARD;

- Integration of observations and models – several projects – automated data assimilation and inverse modelling, first and foremost, require very good knowledge of the horizontal bounds of the ash cloud and other difficult to retrieve ash cloud properties, so there is a risk that the maturity of data assimilation and inverse modelling methods have been over-estimated for real-time operational applications – more research is needed to operationalize the integration of observations and models

- Preparing for the next generation of geostationary satellites (JMA, NOAA, KMA, CMA, EUMETSAT) – Much improved spectral, spatial, and temporal capabilities, but much larger data volumes. Will users be ready? Automated algorithms will be critical for converting the large data volumes into actionable information. JMA has already successfully launched their next generation geostationary satellite, Himawari-8.

- New or improved near-realtime experimental satellite data for volcanic cloud applications – Support to Aviation Control Service (SACS) SO₂ and ash alerts (http://sacs.aeronomie.be/); NOAA Volcanic Cloud Analysis Toolkit (VOLCAT) imagery and quantitative ash products covering 1447 volcanoes (~93% of the world’s volcanoes) and LEO/GEO sensor automated alerting capability (http://volcano.ssec.wisc.edu/); USGS VolcView LEO and GEO satellite images (http://volcview.wr.usgs.gov/)

- **David Schneider**: Works with Mike Pavolonis on how to operationalize some of this work. Eruption in Kamchatka (Pavlov) – up to 10 km, lots pf SO₂ and some ash but difficult from satellite perspective. There was a SIGMET but no ash detection. Issues with issuing the SIGMET for high and low level. Explanation about how the AVO works as a collaboration between Alaska govt, USGS and University. It is very much about the use of satellite data. Spread of knowledge has been an important outcome.

- **Charles Holiday**: Research on a new VA sensor to be mounted on a UAV (*further info needed about the type of the sensor*). Recent tests on March 2014 and plans for next spring. Still a lot to be done both on the sensor itself and the vehicle.

- **Barbara Stunder**: Data assimilation research will be presented at AMS. Good progress in initializing the model with observation. Model verification data base has been built using satellite data.

- **Marianne Guffanti**: VIPR-III ash testing in June 2015. Using Mazama ash from central Oregon USA, lots of work on the ash distribution rig and stability of the nozzle injector.

- **Ian Lisk**: Reports on:

  - EUR/NAT Contingency plan – get out the concentration maps from it. Replace with ash mass (or column) load product. New products coming next year.
SIGMET issue. Discussion about the new type of models.

- Experimental electrostatic volcanic ash detector now being tested on a BA B747.
- Notes some industry discussion about Kelut encounter and damage. Some evidence that extensive economic (rather than catastrophic) damage was done to engines by aircraft flying for around 10 minutes in ash concentrations estimated to be as low as 20 mg/m³.
- University of Reading – drop-sonde particle sensor under development.
- WMO VAAC best practice workshop for 4-days beginning 5 May in London.

- **Andrew Tupper:** General update relating to satellite and modelling work including inverse modelling research; BoM research group is catching up; some volcano observatories progressing well; assistance to Indonesia; work on the use of radar data.

- **Larry Mastin:** ESP eruption database update as per ‘Ins and Outs’ recommendations (https://vhub.org/resources/2431). Lots of research into fundamental issue of plume height continuing to be the first order error for VA modelling. For VEI-4 and larger eruptions, modelling of umbrella clouds, developed by Fall3d modellers and also used by Ash-3D, improves model accuracy. Bent plume dry air entrainment R+D ongoing.

- **General discussion:**
  - The meeting discussed the need to streamline the reporting on scientific developments. It was agreed that each VASAG members will prepare a short report on the issues presented above. The list of recent, relevant publications needs to be kept up-to-date. There is a need for more visibility and outreach.
  - The science agenda should be structured to cover the standard topics and based on this report back to ICAO. This structure should cover: modelling, remote sensing, engine impacts, etc. Other items of interest include the use of weather radars based on experience from Iceland and Indonesia; the global volcano model (news expected at AGU);
  - Information was provided on the pilot SCOPE-Nowcasting project on the intercomparison of satellite techniques for studying VA cloud properties. A work plan has been agreed with focus on ash (SO₂ to be added eventually at a later stage). Data sets are to be prepared by operational and research institutions and a workshop is scheduled for June 2015 in Madison, WI USA. VAACs will be invited to contribute descriptions of each case chosen for intercomparison and independent manual analysis will be conducted to assess ash detection techniques. Other reference data sets will be used to assess ash cloud height and loading.

4. **REVIEW AND DISCUSS WORK REQUESTS FROM ICAO IAVWOPSG/8**

The meeting noted that VASAG submitted a report to IAVWOPSG/8 (Melbourne, February 2014) providing information on the activities being undertaken to follow up IAVWOPSG/7 on:

- Conclusion 7/18 concerning reducing dispersion model output uncertainty;
- Conclusion 7/31 concerning validation dataset for benchmarking current and future satellite based retrieval schemes;
- Conclusion 7/32 concerning scientific investigations into volcanic cloud thickness and stratification; and,
• Conclusion 7/33 concerning the provision of advice on appropriate methods for assessing aviation hazards and risks.

IAWOPSG welcomed the information provided and requested that the WMO-IUGG VASAG should continue its work on these science matters.

IAWOPSG/8 formulated a new Conclusion 8/22 inviting VASAG to “further progress aerosol observation capabilities and related activities, such as improved volcanic ash monitoring, as part of the on-going science work items relating to volcanic cloud thickness and stratification and reducing dispersion model output uncertainty; and report to the IAWOPSG/9”.

The meeting noted that ICAO was yet to decide on a new structure of bodies including a successor of the IAWOPSG. This was expected in the first half of 2015.

5. DISCUSSION ON OUTSTANDING ACTIONS AND NEW WORK REQUESTS

Among the outstanding tasks is the idea for the establishment of a volcanological office at WMO, eventually under the GEO secretariat. Some initial talks have been conducted but there are a number of operational and institutional issues. Further coordination needs to be done.

The meeting further discussed how to further improve the visibility and access to the work done by VASAG in support of the IVATF. The group noted the strong engagement of ICAO (through the IVATF and IAWOPSG) with science issues, and relevant examples of significant policy outcomes (eg, the recommendation to discontinue work on concentration charts). The group was also instrumental in mobilizing the scientific community.

Recalling that 2015 will mark 5-years since Eyjafjallajökull, it would be a good time to prepare a summary of activities and main achievements. To that end, an Eos article is under consideration (as discussed earlier), Marianne Guffanti and Andrew Tupper have contributed a chapter to an Elsevier book, ‘Volcanic Hazards, Risks and Disasters’ (2015), and are contributing towards a chapter in a forthcoming Springer book, ‘Volcanic Crisis Communication: observing the volcano world’. This will be a good opportunity to demonstrate the influence of science on the industry during a time when it needed strong support for informed decisions.

6. PLANNING FOR THE 7TH WMO INTERNATIONAL WORKSHOP ON VOLCANIC ASH

The meeting agreed that the 7th International Workshop on Volcanic Ash should be organized in 4Q of 2015 (preferably October) and appreciated the proposal by David Schneider for hosting it in Anchorage, USA. The theme of the workshop should be related to the transfer of research results into operations.

<table>
<thead>
<tr>
<th>Actions:</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1 Send a letter by the PR of USA to WMO Secretariat to offer the hosting of the Workshop in Anchorage; done</td>
</tr>
<tr>
<td>6.2 Set up a local organizing committee;</td>
</tr>
<tr>
<td>6.3 Set up a scientific programme committee.</td>
</tr>
</tbody>
</table>

7. TOPICAL DISCUSSIONS (remote participation session)

7.1 Capturing good science from aviation encounters – what did we learn from Kelut?

*Presentation by Mike Pavolonis*

Following the Kelut eruption, an ad-hoc group of experts including several VASAG members coordinated the rapid sharing of information for the information of the aviation industry,
which experienced at least one significant ash encounter as discussed earlier. Kelut was an intensive but short eruption with an umbrella cloud and ash up to 27 km. JMA MTSAT was running at 10-min update cycle which provided excellent opportunity. Estimating concentration is very uncertain; a 3-D plume model run should be used to better constrain the 3-D cloud structure and its development. The AGU Fall Meeting (immediately following VASAG) had several expected presentations on this eruption.

Lessons learned:

- Even though for this case we know a lot about the path through the cloud, it is very difficult to derive information about concentrations.
- Need to obtain data through ICAO about the impact in order to make some conclusions.
- Need to model this case to get the layered structure.
- From aviation perspective – the message is to not fly through such areas; also that we cannot give more information about concentration or concentration maps. Helps discuss uncertainties.
- Calculation of mass eruption rate was also done – from scientific point of view – very interesting case – and there was an encounter. The very rapid vertical development is interesting.

### Actions:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1</td>
<td>Larry's postdoc (Alexa Van Eaton) to be approached to do modeling of the 3-D dynamics of plume rise and commit to a paper;</td>
</tr>
<tr>
<td>7.2</td>
<td>Request information from ICCAIA;</td>
</tr>
<tr>
<td>7.3</td>
<td>Larry could do 3-d modelling of ash dispersal, starting with conditions constrained from Alexa’s plume modelling – to estimate what inputs are required to match what we observe;</td>
</tr>
<tr>
<td>7.4</td>
<td>VASAG could prepare a non-scientific paper.</td>
</tr>
</tbody>
</table>

Note: immediately following VASAG, further discussions occurred in this regard, which will be reported back to the next meeting.

### Ice in volcanic clouds

NIL

### Grain size assumptions

NIL

### Operational plume-rise models, and the recent 1-D model intercomparison

*Presentation by Larry Mastin on plume model intercomparisons*

A key finding was the different results produced by the plume different plume rise models for a given set of inputs. The variability raises questions about which model(s) to use and how to judge the coefficients and formulations used in them.

### Next generation of geostationary weather satellites - are the user and research communities ready to fully utilize for volcanic cloud applications?

*Presentation by Mike Pavolonis*
Expected new capabilities - more frequent images that would improve detection of explosive eruptions, more spectral information that will improve the detection and characterization of dispersed ash, and higher spatial resolution for earlier detection of volcanic activity; VAACs need to be made aware about the new capabilities coming from improved satellite monitoring; continuous learning process. Cases should be posted on the web to allow others to learn. COMET may not be the best e-learning platform for this because they are good in the basics, but not so useful for the VAACs. The burden for providing training is on research – content of training material to be done by scientists.

**Actions:**

7.5 Scientists to be engaged when necessary on global basis;
7.6 Consider using a blog;
7.7 Consider the best platform.

8. **REVIEW OF VASAG GOVERNANCE AND FUTURE WORK PROGRAMME**

The meeting reviewed the history of the group and its governing mechanisms, VASAG-5/Doc. 8 available at


It was agreed to propose to the WMO Executive Bodies the re-establishment of the VASAG as a more formal form of collaboration between WMO and IUGG, based on the existing working arrangements between the two Organizations that date back to 1954. It was noted that these arrangements envisage the establishment of “joint committees” on matters of common interest. The revised draft terms of reference of the VASAG are in Annex 3 to this report.

9. **ANY OTHER BUSINESS**

VASAG discussed information from Claire Witham about training proposed by the WOVO in the form of a summer school for VOs and participants from aviation. There will be two components – one in Iceland and one in Indonesia with the objective to improve the way volcanic observatories work with the VAACs. The meeting agreed that Claire Witham will circulate the draft programme and VASAG members will provide comments.

10. **DATE AND PLACE OF NEXT MEETING**

The group proposed that the 6th VASAG meeting should be organized back-to-back with the 7th WMO International Workshop on Volcanic Ash in Anchorage (4Q of 2015).

11. **CLOSURE OF THE MEETING**

After the customary exchange of courtesies, the meeting closed at 16h00 on Friday, 12 December 2014.
ANNEX 1

World Meteorological Organization
International Union of Geodesy and Geophysics

5th meeting of the Volcanic Ash Scientific Advisory Group (VASAG-5)

Marriott Marquis, San Francisco, CA, USA
11-12 December 2014

Provisional Agenda

Thursday 11 December 2014

1. Welcome and apologies

2. Review progress on actions from previous meeting
   (brief reports from each action holder – discussion on outstanding actions to be held over until Agenda Item 5)

3. Science review - remote participation session – 10 am – 12:30 pm local
   (7–9:30 pm Spain/Norway/Germany, 6-8:30 pm Iceland)
   Scientific developments relating to ICAO International Airways Volcano Watch since previous meeting. Each member is asked to prepare for this agenda item by considering relevant literature, conference, and meeting proceedings, and if possible preparing a summary to talk to. Suggested topics include:
   a. AVOID
   b. Geneva workshop Nov 2013
      (http://www.unige.ch/sciences/terre/mineral/CERG/Workshop2/results-2.html)
   c. Update on the international volcanic ash retrieval inter-comparison activity within the WMO SCOPE-Nowcasting aviation pilot project
   d. VolcATS - Volcanic ash impact on the Air Transportation System
   e. Global Volcano Model
   f. Use of weather radars for volcanic cloud monitoring
   g. Infrasound

4. Review and discuss work requests from ICAO International Airways Volcano Watch Operations Group, IAVWOPSG/8
   http://www.icao.int/safety/meteorology/iavwopsg/IAVWOPSG%20Meetings%20Metadata/IAVWOPSG.8.REPORT.pdf

5. Discuss outstanding actions and new work requests
Friday 12 December 2014

6. Planning for 7th International Workshop on Volcanic Ash and Aviation  
   *Assumed for late 2015 in European region*

7. **Topical discussions - remote participation session** – 10 am – 12:30 pm local  
   (7–9:30 pm Spain/Norway/Germany, 6-8:30 pm Iceland)
   a. Capturing good science from aviation encounters – what did we learn from Kelut?  
   b. Ice in volcanic clouds  
   c. Grain size assumptions  
   d. Operational plume-rise models, and the recent 1-D model intercomparison  
   e. The next generation of geostationary weather satellites - are the user and research  
      communities ready to fully utilize for volcanic cloud applications?

8. Review of VASAG governance and future work programme

9. Date and place of next meeting

10. Closure of the meeting
LIST OF PARTICIPANTS

1. PARTICIPANTS

<table>
<thead>
<tr>
<th>COUNTRY / ORGANIZATION</th>
<th>NAME</th>
<th>E-MAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUSTRALIA</td>
<td>TUPPER, Andrew</td>
<td><a href="mailto:a.tupper@bom.gov.au">a.tupper@bom.gov.au</a></td>
</tr>
<tr>
<td>UK</td>
<td>LISK, Ian</td>
<td><a href="mailto:ian.lisk@metoffice.gov.uk">ian.lisk@metoffice.gov.uk</a></td>
</tr>
<tr>
<td>UK</td>
<td>WITHAM, Claire</td>
<td><a href="mailto:claire.witham@metoffice.gov.uk">claire.witham@metoffice.gov.uk</a></td>
</tr>
<tr>
<td>USA</td>
<td>GUFFANTI, Marianne</td>
<td><a href="mailto:guffanti@usgs.gov">guffanti@usgs.gov</a></td>
</tr>
<tr>
<td>USA</td>
<td>HOLIDAY, Charles (USAF) (observer)</td>
<td><a href="mailto:charles.holliday@us.af.mil">charles.holliday@us.af.mil</a></td>
</tr>
<tr>
<td>USA</td>
<td>MASTIN, Larry</td>
<td><a href="mailto:lgmastin@usgs.gov">lgmastin@usgs.gov</a></td>
</tr>
<tr>
<td>USA</td>
<td>PAVOLONIS, Michael</td>
<td><a href="mailto:michael.pavolonis@noaa.gov">michael.pavolonis@noaa.gov</a></td>
</tr>
<tr>
<td>USA</td>
<td>SCHNEIDER, David (observer)</td>
<td><a href="mailto:djschneider@usgs.gov">djschneider@usgs.gov</a></td>
</tr>
<tr>
<td>USA</td>
<td>STUNDER, Barbara (observer)</td>
<td><a href="mailto:barbara.stunder@noaa.gov">barbara.stunder@noaa.gov</a></td>
</tr>
</tbody>
</table>

2. REMOTE PARTICIPANTS

<table>
<thead>
<tr>
<th>COUNTRY / ORGANIZATION</th>
<th>NAME</th>
<th>E-MAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITALY</td>
<td>NERI, Augusto</td>
<td><a href="mailto:neri@pi.ingv.it">neri@pi.ingv.it</a></td>
</tr>
<tr>
<td>SPAIN</td>
<td>FOLCH, Arnau</td>
<td><a href="mailto:arnau.folch@bsc.es">arnau.folch@bsc.es</a></td>
</tr>
</tbody>
</table>

3. WMO SECRETARIAT

<table>
<thead>
<tr>
<th>NAME</th>
<th>E-MAIL</th>
</tr>
</thead>
<tbody>
<tr>
<td>IVANOV, Dimitar</td>
<td><a href="mailto:divanov@wmo.int">divanov@wmo.int</a></td>
</tr>
</tbody>
</table>
Revised Terms of Reference
for the WMO/IUGG Volcanic Ash Scientific Advisory Group (VASAG)

INTRODUCTION:

The Volcanic Ash Science Advisory Group (VASAG) is established in accordance with the Working Arrangements between the WMO and the IUGG (WMO-No.60, V.1 – V.2), paragraph 4, as a “joint committee … to deal with matters of common interest”.

The objective of the group is to provide scientific advice combining expertise in the field of atmospheric sciences and volcanology, to support informed decisions by ICAO and other aviation stakeholders concerned with the volcanic ash hazard to aviation.

COMPOSITION:

VASAG shall comprise two co-chairs and a core group of around ten scientists and technical experts from the relevant geophysical and meteorological disciplines. The appointment of the co-chairs will be through consultation between the WMO and IUGG Secretariats with each Organization nominating one co-chair. VASAG core membership and the selection of co-chairs shall be formally reviewed at the 4-yearly sessions of the WMO Commission for Aeronautical Meteorology (CAeM). Any inter-session membership changes will be decided upon by the VASAG co-chairs in consultation with the two Secretariats and the president of the CAeM.

TERMS OF REFERENCE:

In the context of international aviation, VASAG shall:

1. Address requests from ICAO and other relevant stakeholders for specific scientific advice or assistance relating to the fields of volcano monitoring, volcanic ash and other volcanic contaminants.

2. Use appropriate networks, contacts, meetings and other opportunities, to gather cross-discipline and cross-industry scientific advice from the international community.

3. Promote research and inform community on recent scientific achievements related to aviation hazards related to volcanic ash and other volcanic contaminants.

4. Provide support to the organization of the regular WMO International Scientific Workshop on Volcanic Ash’.

WORKING ARRANGEMENTS:

The VASAG will be supported by the WMO Secretariat including limited funding, within the available WMO budget for the AEM programme, for delivering its priority activities.

Meetings should be conducted in consideration with ICAO requirements, associated delivery deadlines, available funding, and opportunities to meet in conjunction with other relevant events to VASAG members. Requests by and recommendations for non-core experts to attend VASAG meetings as observers will be decided upon by the co-chairs in consultation with the two Secretariats.
**Reporting:** The VASAG shall provide scientific reports to meetings of the relevant WMO and ICAO groups. Reports on activities should be provided to the WMO executive bodies through the CAeM. (reporting to IUGG??)

**Dissemination:** The VASAG will publicize the outcomes of its work through appropriate channels to ensure outreach to the research and operational communities. A VASAG web page on the WMO Aeronautical Meteorology Programme (AeMP) website will be used as a main reference point. Appropriate links to other relevant information sources, including scientific and research institutions of core members will also be provided.