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INTER-PROGRAMME EXPERT TEAM ON SATELLITE UTILIZATION AND PRODUCTS

ITEM: 8.1.2

FIRST SESSION

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Original: ENGLISH

SCOPE-Nowcasting Pilot Project 2: Volcanic Ash Algorithm Intercomparison

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Summary and Purpose of Document

In support of aeronautical meteorological services, WMO organizes a satellite-based volcanic ash retrieval algorithm inter-comparison activity, to improve the consistency of quantitative volcanic ash products from satellites. The need for such an activity has been identified since (i) the value of satellite-based products has been recognized by VAACs and airlines, especially during the eruptions in the last three years, but (ii) quantifying volcanic ash parameters is difficult; (iii) there is no internationally-agreed validation protocol for such products; (iv) many products are available, and their strengths and weaknesses are not known or comparable, (v) many products are produced on an ad-hoc basis and not sustained or operationally available, (vi) there is no standard for volcanic cloud geophysical parameters endorsed by WMO.

This intercomparison activity is embedded as contributing to the WMO-sponsored SCOPE-Nowcasting initiative (Sustained Coordinated Processing of Environmental Satellite Data for Nowcasting), which aims at improved rapid access to satellite data by member states, and at improved confidence in products generated through SCOPE-Nowcasting. The activity is supported by the WMO Space Programme, the Aeronautical Meteorological Programme and the Atmospheric Research and Environment Programme.

Volcanic ash is one out of four priority themes of SCOPE-Nowcasting. At its last meeting, the SCOPE-Nowcasting ad-hoc steering group in November 2013 agreed on the Volcanic ash retrieval algorithm intercomparison activity. The WMO/IUGG Volcanic Ash Scientific Advisory Group (VASAG) endorsed the initiative.

ACTION PROPOSED

The session is invited to note the information contained in this paper;

Appendix A. Cases for Intercomparison

Appendix B. Algorithm Contributions

Appendix C. Reference Data Contributions

DISCUSSION

1. Background and Introduction

High quality quantitative volcanic ash cloud products are needed to improve the volcanic ash cloud analyses and dispersion forecasts provided to aviation users. Quantitative satellite remote sensing of volcanic ash clouds has evolved significantly over the last decade with the advent of new sensors and techniques. In order to document the current state of satellite-based volcanic ash cloud retrieval science and to determine how best to evolve the science within the context of meeting end-user needs, several actions must be taken by the international research community.

1. Using pre-selected cases, quantify the differences between satellite-derived volcanic ash cloud properties derived from different techniques and sensors.
2. Establish basic validation protocol for satellite-derived volcanic ash cloud properties
3. Document the strengths and weaknesses of different remote sensing approaches as a function of satellite sensor
4. Standardize the units and quality flags associated with volcanic cloud geophysical parameters
5. Provide recommendations to Volcanic Ash Advisory Centers (VAACs) and other users on how to best to utilize quantitative satellite products in operations
6. Create a "road map" for future volcanic ash related scientific developments and intercomparison/validation activities that can also be applied to SO_2 clouds and emergent volcanic clouds

The above activities, which were first informally discussed by an international contingent of scientists in Geneva, Switzerland in November 2013, are succinctly referred to as the "international volcanic ash intercomparison." In recognition of its importance, the World Meteorological Organisation (WMO) has provided an organized forum for the international volcanic ash intercomparison under the Sustained, Coordinated Processing of Environmental Satellite Data for Nowcasting (SCOPE-Nowcasting) initiative (http://www.wmo.int/pages/prog/sat/scope-nowcasting_en.php). The SCOPE-Nowcasting initiative seeks to provide a mechanism through which high quality satellite products can be made available simply and quickly for nowcasting applications to all users, regardless of resources and infrastructure. Results from the intercomparison activity will be presented and discussed at the WMO International Volcanic Ash Intercomparison Meeting to be held June 29 – July 2, 2015 in Madison, WI, USA (http://cimss.ssec.wisc.edu/meetings/vol_ash15). Volcanic ash satellite remote sensing experts from operational and research organizations are encouraged to participate in the intercomparison activity, which will encompass a significant number of geostationary and low earth orbit satellite sensors. The results of the study will help VAACs and other users better utilize quantitative volcanic ash cloud products to improve volcanic ash advisories. The intercomparison will focus on volcanic ash cloud properties for several pre-selected cases that span a wide range of background conditions and ash cloud properties. While volcanic sulfur dioxide satellite remote sensing is also a very important topic, this study will focus solely on volcanic ash due to time and resource constraints. Upon completion of the intercomparison meeting, a report that documents all results and discussions related to the six activities described above will be written and made available to the scientific and operational communities.

2. Timeline of Activity

February 16, 2015 – deadline for accepting invitation to submit data to the intercomparison study and attend the intercomparison meeting in Madison, WI, USA

April 10, 2015 – submission deadline for algorithm data sets to be included in intercomparison analysis

June 15, 2015 – results of intercomparison are distributed to all participants for review.

June 29 – July 2, 2015 – results of intercomparison are discussed in detail at meeting in Madison, WI, USA

3. Roles and Responsibilities

Each algorithm provider is responsible for providing data in the proper format by April 10, 2015. In order to ensure that a robust intercomparison can be performed, algorithm data submissions from at least 1 sensor are expected for each of the pre-selected cases (Appendix A) unless existing processing capabilities do not allow for processing of at least 1 sensor that is relevant to a particular case. In addition, all algorithm providers must agree to the fully transparent intercomparison methods described in this document, and provide all requested algorithm information. An external research contractor will generate the agreed upon intercomparison analysis and make the results available to all participants by June 15, 2015 so that the analysis can be reviewed prior to the intercomparison meeting in Madison, WI, USA. All data used in the intercomparison will be available to all participants and the software used by the external contractor to generate the intercomparison analysis will also be available. Software used by algorithm providers to run their algorithms does not have to be made available to participants of this intercomparison. A summary of the algorithm contributions is given in Appendix B and a summary of the reference data contributions is given in Appendix C.

Appendix: A

Cases for Intercomparison

The cases utilized in the intercomparison study were chosen to coincide with independent measurements that can serve as "truth" for at least some retrieved parameters (e.g. ash cloud height). In addition, an effort was made to cover a broad range of ash cloud properties and background conditions within different geostationary satellite coverage areas and VAAC regions. All of the selected cases produced large ash clouds with large-scale (e.g. regional and greater) impacts on aviation. The larger scale events allow for more robust intercomparison/validation statistics to be computed (e.g. many pixels can be analyzed). Smaller eruptions are also important and far more common than eruptions that produce large amounts of ash. The tools developed for the intercomparison can be applied to ash eruptions that produce more localized impacts at a later time through collaborations brought about by the intercomparison exercise or as a possible organized follow-on activity. The following cases will be evaluated: Eyjafallajökull (2010), Grimsvötn (2011), Sarychev Peak (2009), Kelut (2014), Puyehue-Cordón Caulle (2011), and Kirishimayama (2011). Algorithm providers should provide data (specific dates and times are provided in Section 9) for as many cases and sensors as their processing capabilities allow. The rational for selecting each case is as follows:

Eyjafallajökull (2010) – This long-duration, high impact, event is well captured by a modern geostationary satellite sensor and "validation" data (ground, aircraft, and space-based) are plentiful. Anticipated satellite sensors of relevance: AIRS, AVHRR, CALIOP, IASI, MISR, MODIS, and SEVIRI.
Volcano information: http://www.volcano.si.edu/volcano.cfm?vn=372020

Grimsvötn (2011) – This eruption is well captured by a modern geostationary sensor and the emergent, ash-rich, cloud provides an opportunity to assess retrieval performance in a high mass loading scenario. A fair amount of "validation" data (ground and space-based) is also available for this event. Anticipated satellite sensors of relevance: AIRS, AVHRR, CALIOP, IASI, MISR, MODIS, SEVIRI, and SSMIS.
Volcano information: http://www.volcano.si.edu/volcano.cfm?vn=373010

Sarychev Peak (2009) – This event allows for algorithm comparisons over a broad range of ash optical depth and background meteorological conditions. In addition, ash from this eruption was tracked by three VAACs (Tokyo, Anchorage, and Washington). Many CALIOP overpasses are available to serve as "validation" data. Anticipated satellite sensors of relevance: AIRS, AVHRR, CALIOP, IASI, MODIS, and MTSAT.
Volcano information: http://www.volcano.si.edu/volcano.cfm?vn=290240

Kelut (2014) – Large amounts of ash were produced by a highly explosive eruption in a very moist tropical environment where satellite remote sensing methods sometimes struggle. A jet aircraft encounter also occurred a few hours after the start of the eruption. Some CALIOP overpasses are available to serve as "validation" data. Anticipated satellite sensors of relevance: AIRS, AVHRR, CALIOP, CrIS, IASI, MODIS, MTSAT, and VIIRS.
Volcano information: http://www.volcano.si.edu/volcano.cfm?vn=263280

Puyehue-Cordón Caulle (2011) – This is the most silicic major eruption of the satellite era so it provides an unprecedented opportunity to assess the sensitivity of satellite retrieval algorithms to the composition of the ash. Many CALIOP overpasses are available to serve as "validation" data. Anticipated satellite sensors of relevance: AIRS, AVHRR, CALIOP, IASI, MODIS, and SEVIRI.
Volcano information: http://www.volcano.si.edu/volcano.cfm?vn=357150

Kirishimayama (2011) – This case allows for intercomparisons within a sub topical environment with plentiful background boundary layer liquid water cloud cover, which sometimes severely impacts the retrieval of the overlying ash cloud properties. The analysis for this case will be centered around a single CALIPSO overpass. Anticipated satellite sensors of relevance: AIRS, AVHRR, CALIOP, IASI, MODIS, and MTSAT.
Volcano information: http://www.volcano.si.edu/volcano.cfm?vn=282090

Appendix: B

Algorithm Contributions (as a function of satellite sensor, case, and institution)

Case / Sensor	Sarychev Peak (2009)	Eyjafallajökull (2010)	Grimsvötn (2011)	Puyehue-Cordón Caulle (2011)	Kirishimayama (2011)	Kelut (2014)
AIRS						
AVHRR	11	9, 11	9, 11	11	11	11
CrIS	NA	NA	NA	NA	NA	
IASI	10, 11	6, 10, 11	6, 10, 11	6, 10, 11	10, 11	10, 11
MODIS	7, 10	3, 7, 10	3, 7, 10	7, 10	7, 10	7, 10
MTSAT	4, 7, 9	NA	NA	NA	4, 7, 9	4, 7, 8, 9
SEVIRI	NA	1, 2, 7, 9, 10	1, 2, 7, 9, 10	1, 2, 7, 9, 10	NA	NA
VIIRS	NA	NA	NA	NA	NA	7
GOME-2/AVHRR/IASI)	2	2	2	2	2	2
MISR		5	5			

NA: Not Applicable

1: DLR
2: EUMETSAT
3: INGV
4: JMA
5: NASA Goddard/JPL
6: Université Libre de Bruxelles
7: NOAA/NESDIS
8: BoM
9: UKMO
10: Oxford
11: Planeta

Appendix: C

Reference Data Contributions

Case / Data Source	Sarychev Peak (2009)	Eyjafallajökull (2010)	Grimsvötn (2011)	Puyehue-Cordón Caulle (2011)	Kirishimayama (2011)	Kelut (2014)
BAe-146	NA	X	NA	NA	NA	NA
CALIOP	X	X	X	X	X	X
DLR-Falcon	NA	X	NA	NA	NA	NA
EARLINET	NA	X	X	NA	NA	NA
IMO RADAR	NA	X	X	NA	NA	NA