CGMS

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ON QUANTITATIVE RETRIEVALS OF PRODUCTS RELATED TO VOLCANIC ERUPTIONS - EUMETSAT'S RESPONSE TO THE EYJAFJALLAJÖKULL ERUPTION

The 14 April to 23 May 2010 explosive eruption at the Eyjafjallajökull volcano in Iceland caused widespread and unprecedented disruption to aviation, thus having a high economic impact. A clear demand and need exists for qualitative and quantitative volcanic ash and SO_2 products, where especially ash cloud concentration and ash cloud height are important.

EUMETSAT is currently conducting two science studies with external partners with the aim to assess available quantitative retrieval techniques to be applied to Meteosat Second Generation (MSG) observations. The Eyjafjallajökull event, which led to a wealth of ground based and air-borne data measured during this time period, will be used as an evaluation and validation test bed.

The overall aim of these activities is to soon operationally provide users with well tested and understood volcano products.

Action/Recommendation proposed:
CGMS is invited to comment and discuss own ongoing work toward operational volcanic ash detection.

On Quantitative Retrievals of Products Related to Volcanic Eruptions - EUMETSAT's Response to the Eyjafjallajökull Eruption

1 INTRODUCTION

The 14 April to 23 May 2010 explosive eruption at the 1666 m high, ice-capped Eyjafjallajökull volcano in southern Iceland rather unexpectedly caused widespread and unprecedented disruption to aviation and everyday life in large parts of Europe, resulting in economic difficulties that were felt across the globe. Three key factors contributed to producing this widespread problem: (a) unrelenting explosive activity, (b) high proportion of ash, and (c) quasi-stationary circulation that directed the ash plume towards Europe. Prior to this event, the volcano had not been particularly active with only three small eruptions since ~900 AD.

A first attempt to provide a full inventory of collected data during this event, of available products on the operational and research side, and of demands by the model community, which ultimately feeds into the Volcanic Ash Advisory Centres warnings, was made at the ESA-EUMETSAT Volcanic Ash Workshop, held on 26 and 27 May at ESA-ESRIN in Frascati/Italy. Many of the workshop's recommendations are also reflected in this document.

2 VOLCANO PRODUCTS DERIVED FROM SATELLITE OBSERVATIONS

2.1 Data Sources

No one single sensor provides information regarding all aspects of volcanic eruptions. However, the suite of globally available sensors is a powerful observational tool, as one can build upon the strength of each individual observation. Advantages and disadvantages of today's sensors are:

- UV sensors are hampered by light levels
- IR sensors are hampered by clouds, i.e. are more sensitive to meteorological conditions
- Sensor footprint size is important
- Most observations delineate either volcanic and/or SO_2, typically presented in units of column integrated amount (e.g. DU, gm^{-2}), as brightness temperature difference or some form of a qualitative index
- SO_2 is generally easier to quantify than volcanic ash due to its distinct and narrower spectral signature
- Vertically resolved quantitative information (as e.g. ash concentration) is most needed, but typically not available in near-real-time.

A (preliminary) assessment of the satellite products gathered during this eruption is

- The observations, primarily from OMI, AIRS and IASI, of the amount of SO_2 produced during the magmatic phase increased in line with petrologic estimates
- AIRS retrievals accurately show the transition from basaltic to magmatic glass dominating the fine ash. This was corroborated by laboratory studies of the ash undertaken by the Icelandic Meteorological Office
- CALIOP, the satellite-based Lidar, albeit not regularly available due to its narrow swath, provided critical information on height and layering of volcanic ash

MSG has the ability to map SO2 in two infrared channels and volcanic ash in the split window channels, and thus delivered the most regular insight into the cloud's evolution

Figures 1-4 below provide some example of the nature of the products.

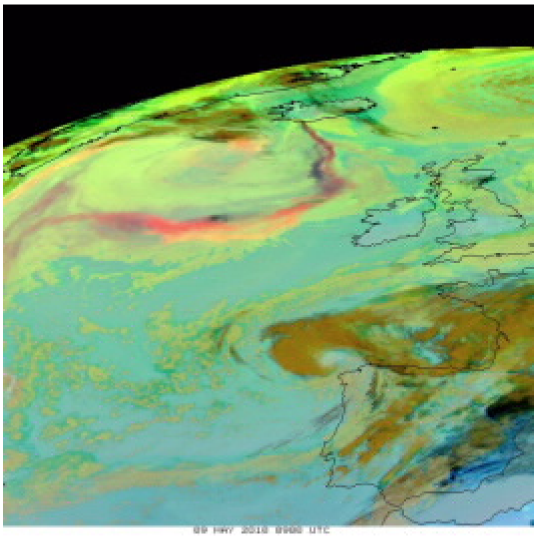

Figure 1: MSG RGB composite using channels IR8.7, IR10.8 and IR12.0 for 09 May 2010, 0030 UTC. The bright pink/red colour well depicts the ash cloud.
(source: EUMETSAT)

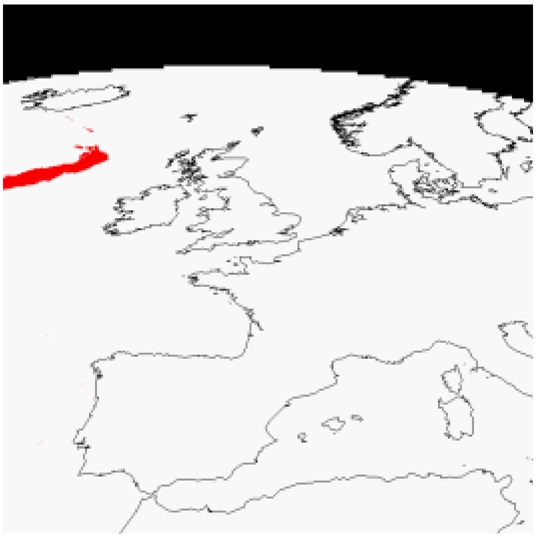

Figure 2: Volcanic ash index derived from a split-window thresholding technique also shows the extent of the ash plume, however in less detail than on the RGB above (product is for same time as Figure 1)
(source: EUMETSAT)

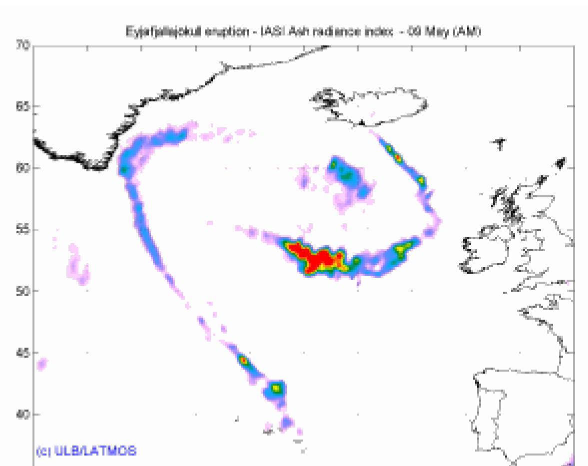

Figure 3: Ash index derived from the 09 May 2010 morning IASI orbit
(source: Free University Brussels)

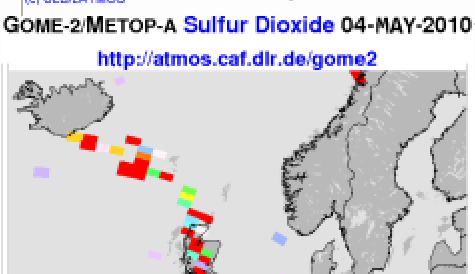

Figure 4: SO_2 product from the GOME instrument onboard Metop-A; example is for 04 May 2010.
(source: EUMETSAT)

2.2 Current and Future EUMETSAT Activities

A number of quantitative retrieval techniques exist, based on MSG data, to estimate ash mass loading, total column SO_2 and under certain circumstances also ash cloud optical thickness and ash cloud height, as e.g. published in

> Prata, A. J., and J. Kerkmann, 2007, Simultaneous retrieval of volcanic ash and SO_2 using MSG-SEVIRI measurements, ***Geophys. Res. Lett***. **34**, L05813, doi:10.1029/2006GL028691

EUMETSAT is currently conducting a science study with SAVAA-NILU (Support to Aviation for Volcanic Ash Avoidance – Norwegian Institute for Air Research) which addresses these quantitative retrievals: Available methods are applied to the Eyjafjallajökull eruption and compared to the wealth of other data (ground base, air-borne, space-borne) that were collected in Europe during this time. The outcome of this evaluation will also show the potential of combining data of different data sources (focus is here on the EUMETSAT satellites MSG and Metop).

In parallel, a second science study, also funded by EUMETSAT, is carried out with RAL (Rutherford Appleton Laboratories), also with the aim to find a quantitative retrieval mechanism for volcanic ash based on an optimal estimation method
applied to observations in all MSG channels. In this study, RAL will use
their spectroscopic database for volcanic ash, as published in http://www.atm.ox.ac.uk/project/aerosol/spectra.html.

This study will also address the issue of validation, by checking temporal consistency and comparing results to other data sources.

Aim of the two studies is to get a consolidated list of possible product retrieval schemes and their respective strengths and weaknesses, which will show the way forward towards an operationally available product from EUMETSAT.

Both studies will be finalisedd by the end of 2010.

3 CONCLUSIONS

The Eyjafjallajökull eruption has highlighted the need for qualitative and quantitative volcanic ash and SO2 products. Especially ash cloud concentration and ash cloud height are important information for air traffic routing. Present research activities show the high potential of the EUMETSAT satellite observations to support such needs. Future operational availability of volcano products will also support the stringent timeliness requirements.

CGMS is invited to comment and discuss own ongoing work toward operational volcanic ash detection.