P-10

# The APhoRISM project: MACE integrated approach for volcanic products

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**and the APhoRISM project partners**

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## APhoRISM

APHORISM project addresses the development of innovative products based on space and ground sensors and ground data to support the management and mitigation of the volcanic and the seismic risk. The objective of the project is to demonstrate that satellite remote sensing data and ground data, appropriately managed by means of novel methods, can provide new and improved products able to be used by the stakeholders for managing volcanic and seismic crisis and, stemming from a wider exploitation of available instruments, to achieve new performances in terms of accuracy and quality of information. APHORISM project proposes the development and testing of two new methods to combine in a fruitful way Earth Observation satellite data from different sensors and ground data. The first one involves the development of remote sensing methods related to monitoring volcanic crisis. The second one concerns the generation of products dealing with seismic crises events. Concerning volcanic crisis, the outcome is the Multi-platform volcanic Ash Cloud Estimation (MACE). The MACE method will exploit the complementarity between GEO (Geosynchronous Earth Orbit) sensor's platform, LEO (Low Earth Orbit) satellite sensors and ground measurements to improve the ash detection and retrieval and to fully characterize the volcanic ash clouds from source to the atmosphere. The basic idea behind the proposed method consists to meaningfully improve (calibrate and integrate), in a novel manner, the volcanic ash retrievals at the space–time scale of typical geostationary observations using both the LEO satellite estimations and in-situ data. The typical ash thermal infrared (TIR) retrieval will be integrated by using a wider spectral range from visible (VIS) to microwave (MW) and the ash detection will be extended also in case of cloudy atmosphere or steam plumes. APHORISM methods have been defined in order to provide products oriented toward the next ESA Sentinels satellite missions.

## The MACE method

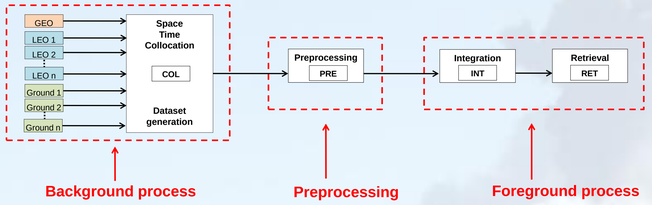
Multi-platform volcanic Ash Cloud Estimation: MACE
❑A new set of ash cloud products for volcanic crisis management.
❑Integration of all the available information on volcanic ash clouds in the widest possible spectral range, from VIS to MW.
❑Ash detection is extended in the case of cloudy atmosphere or steam plumes.

The basic idea of MACE is to provide the best achievable volcanic ash products by continuous update and integration of all the ash retrievals obtained using GEO and LEO satellites and ground-based systems.

Input products: GEO and LEO space- and ground-based retrievals in VIS-TIR-MW spectral range

**MACE**

**new integrated ash products**




1. volcanic ash retrieval from available GEO measurements and ground-based data (e.g., weather radars and/or lidars, if available).
2. collocation of GEO/LEO/ground sensor data: projection on the same coordinate system of all available measurements which are close in space/time.
3. A new data set is generated, containing the co-located pixel based ash retrievals derived from LEO and GEO data.

The background process is continuously on-going, since new ground data and new LEO/GEO data are continuously ingested depending on available satellite data.

A preprocessing stage is accomplished after each background process to check if the conditions for further processing are matched.

Eventually started to derive the new ash-observables (e.g. ash mass, effective radius, AOD, height and thickness of the ash cloud) once the data set has been updated.

1. - integration step: every time a new set of LEO/ground-based data is added for a given region, GEO-based retrievals are updated using the most recent combined data
2. - retrieval step: new ash product retrievals from GEO-IR measurements in the given region using the new integrated data

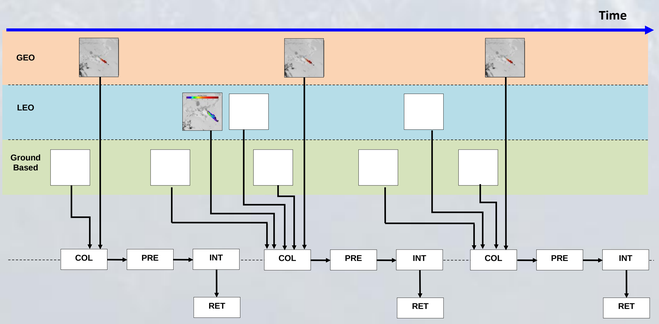
## NEW PRODUCTS

| Instrument | Product Description | Meas. Unit | Product Name | Responsible |
|---|---|---|---|---|
| SEVIRI | TIR Ash mass map | t/km² | SEV-ASHM | INGV-RM |
| | TIR Ash effective radius map | µm | SEV-ASHR | |
| | AOD at 0.55 mm | - | SEV-ASHA | |
| | TIR Ash Concentration map | mg/m³ | SEV-ASHC | |
| MODIS | VIS-TIR Ash mass map | t/km² | MOD-ASHM | |
| | VIS-TIR Ash effective radius | µm | MOD-ASHR | |
| | AOD at 0.55 mm | - | MOD-ASHA | |
| | VIS-TIR Ash Concentration map | mg/m³ | MOD-ASHC | |
| MERIS | AOD at 0.55 mm | - | MER-ASHA | |
| IASI | TIR Ash mass map | t/km² | IAS-ASHM | UNIOX |
| | TIR Ash effective radius map | µm | IAS-ASHR | |
| | AOD at 0.55 mm | - | IAS-ASHA | |
| | Ash Height map | km | IAS-ASHH | |
| | Ash TIR Concentration map | mg/m³ | IAS-ASHC | |
| AATSR | Ash Mass map | t/km² | AAT-ASHM | |
| | TIR Ash effective radius map | -m | AAT-ASHR | |
| | AOD at 0.55 mm | - | AAT-ASHA | |
| | Ash Height map | km | AAT-ASHH | |
| | Ash Concentration map | mg/m³ | AAT-ASHC | |
| MISR | VIS Ash effective radius map | µm | MISR-ASHR | INGV-CT |
| | Ash Height map | km | MIS-ASHH | |
| SSMIS | MW Ash mass map | t/km² | AME-ASHM | UNIRM |
| | MW Ash Concentration map | mg/m³ | AME-ASHC | |
| AMSU-A | MW Ash mass map | t/km² | AMA-ASHM | |
| | MW Ash Concentration map | mg/m³ | AMA-ASHC | |
| CALIPSO | Ash Concentration map | mg/m³ | CAL-ASHC | |
| | Ash Height | km | CAL-ASHH | |
| SAR-C | Ash Detection | - | SAR-ASHD | BRGM |
| GPS | Ash Detection | - | GPS-ASHD | INGV-CT |
| MW Radar | Ash detection map | - | RAD-ASHD | UNIRM |
| | Ash Concentration map | mg/m³ | RAD-ASHC | |
| | Ash Height map | km | RAD-ASHH | |

**GEO, LEO and ground based products that will be integrated in MACE**

| Product Description | Meas. Unit | Responsible | Note: product delivered in | Inputs | Product Name |
|---|---|---|---|---|---|
| Ash Mass map | t/km² | INGV-UNIOX | clear sky conditions | SEV-ASHM MOD-ASHM IAS-ASHM AAT-ASHM SSM-ASHM AMA-ASHM | RET-ASHM |
| Ash Effective Radius | µm | INGV-UNIOX | clear sky conditions | SEV-ASHR MOD-ASHR IAS-ASHR AAT-ASHR | RET-ASHR |
| Ash AOD at 0.55 µm | - | INGV | clear sky conditions | SEV-ASHA MOD-ASHA MER_ASHA IAS-ASHA | RET-ASHA |
| Ash Concentration map | mg/m³ | INGV-UNIRM | clear sky conditions | SEV-ASHC MOD-ASHC IAS-ASHC AAT-ASHC SSM-ASHC AMA-ASHC CAL-ASHC RAD-ASHC | RET-ASHC |
| Ash Height map | km | INGV-UNIOX | clear sky conditions | IAS-ASHH AAT-ASHH MIS-ASHH CAL.ASHH RAD-ASHH | RET-ASHH |
| Ash Detection map | | INGV-BRGM | cloudy sky conditions | SAR-ASHD RAD-ASHD GPS-ASHD | RET-ASHD |

**MACE integrated products**



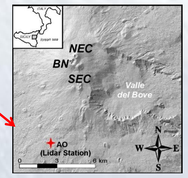

## VALIDATION

***Test events***
MACE ash products will be tested on three recent eruptions representative of different eruption styles in different clear or cloudy atmospheric conditions :
- Eyjafjallajokull (Iceland) 2010
- Grimsvotn (Iceland) 2011
- Etna (Italy) 2011-2012

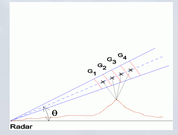
***Validation***
Satellite sensors ash products retrievals are compared in the MACE integration that can be seen as a continuous validation process.

Some integrated MACE ash products will be validated using data from ground based instruments deployed on Etna volcano:

**ash concentration**
Lidar part of the EARLINET network




**ash column height**
radar Doppler (VOLDORAD ) to validate the temporal evolution of the ash column height.




The area and the sounding geometry of the Doppler radar beam above the Etna's summit craters

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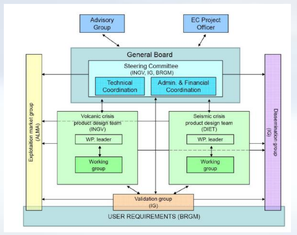
## CONCEPT AND OBJECTIVES

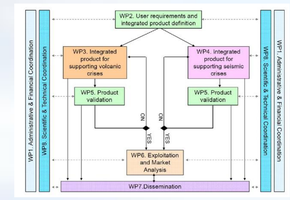
**Advanced PRocedures for volcanIc and Seismic Monitoring: APhoRISM**

❑development of innovative products derived from space- and ground-based data
❑ wider exploitation of available and upcoming instruments for new performances in terms of accuracy and quality of information.
❑aims at providing new tools for managing seismic and volcanic crisis

APhoRISM objective is to demonstrate that space and ground-based remote sensing data, appropriately managed and integrated, can provide new improved products useful for seismic and volcanic crisis monitoring and management.

APhoRISM:
1. products are strongly oriented to the developments of innovative Copernicus products
2. methodologies are suitable to be implemented in the next generation of Earth Observation ESA SENTINEL missions.


## PARTNERS

| APhoRISM partners | Short name | Country |
|---|---|---|
| ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA | INGV | Italy |
| CONSORCI INSTITUT DE GEOMATICA | IG | Spain |
| BUREAU DE RECHERCHES GEOLOGIQUES ET MINIERES | BRGM | France |
| UNIVERSITA DEGLI STUDI DI ROMA LA SAPIENZA | DIET | Italy |
| GAMMA REMOTE SENSING RESEARCH AND CONSULTING AG | GAMMA | Switzerland |
| THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF OXFORD | UOXF | United Kingdom |
| ALMA SISTEMI SAS DI DI IORIO ALESSIO & C | ALMA | Italy |

| Partner | Institution | Name | Role |
|---|---|---|---|
| 1 | INGV | Salvatore Stramondo | Coordinator/WP1 & WP8 leader |
| | | Sofia Mariano | WP1 & WP8 co-leader |
| | | Luca Merucci, Stefano Corradini | WP3 leader |
| 2 | IG | Michele Crosetto | WPS/WP7 leader |
| | | Marta Agudo | Support in technical coordination in WP8 |
| 3 | BRGM | Marcello de Michele | WP2 leader |
| 4 | DIET | Nazzareno Pierdicca | WP4 leader |
| 7 | ALMA | Alessio di Iorio | WP6 leader and support in technical coordination in WP8 |

## RELATED PROJECTS

**Previous projects**

International Charter **Space and Major Disasters**

**PREVIEW** (PREVention and Early Warning) FP6 project

**SAFER** (Services and Applications For Emergency Response) FP7

**SAVAA** (Support to Aviation for Volcanic Ash Avoidance)

other ESA GMES initiatives: **RESPOND**, **RISK-EOS**, **TERRAFIRMA**

**Ongoing projects**

**FUTUREVOLC**, volcanological supersite in Iceland

**VAST** (Volcanic Ash Strategic-initiative Team)

**SACS2** (Support to Aviation Control Service 2) on volcanological themes

**SMASH** (Study on an end-to-end systeM for volcanic ASH plume monitoring and prediction)

**Starting projects**

**MED_SUV**, Mediterranean Supersite Volcanoes, Mt. Etna

**APhoRISM**

## TOWARDS FUTURE EO MISSIONS

**Other missions**

*MW radiometers aboard Metop-A and –B:*
European Polar Satellite Second Generation (EPS-SG, Microwave Imager and Ice Cloud Imager payloads).

*Lidar and cloud radar:*
EarthCARE (Cloud and Aerosol Estimation) European small satellite to be launched by ESA in few years.

All the GEO and LEO ash retrievals procedures used will be directly implemented in the next generation of EO sentinel missions.

MACE integration method will be suitable to be implemented as well

| sensor | new sensor | | notes | mission |
|---|---|---|---|---|
| SEVIRI | FCI | Eumetsat's Flexible Combined Imager embarked on the MTG-Imager (MTG-I) | additional channels with better spatial, temporal and radiometric resolution | SENTINEL-4 |
| IASI | IRS | Eumetsat's InfraRed Sounder (IRS) embarked on the MTG as part of the SENTINEL 4 mission | IRS Full Disk data every 60 minutes, with a spatial resolution of 4 km | |
| MODIS | OLCI | Ocean Land Colour Instrument | VIS-TIR spectral range with higher SNR and spatial resolution for volcanic aerosol and ash cloud detection and retrievals | SENTINEL-3 |
| | SLSTR | Sea and Land Surface Temperature Radiometer | | |
| MERIS | OLCI | | OLCI additional 6 bands in the NIR spectral range | |
| AATSR | SLSTR | | SLSTR dual view for stereo matching retrieval of volcanic plume altitude | |
| C-band SAR | | | continuity of C-band SAR systems ERS-1, ERS-2, ENVISAT and Radarsat data | SENTINEL-1 |

## The MACE method

**APhoRISM project will start in December, 2013**

**The most pressing challenges related to this project are**
Improving retrieval algorithms' inputs with updated ash refractive index database and more accurate ash cloud height and thickness measures (**see Poster 12**).
Improving the integration and fusion of the ash cloud parameters retrieved with different methods and data (i.e. the integration of the different ash cloud mass maps derived from the datasets collected by different sensors such as MODIS, SEVIRI, IASI ecc)
Improving the integration of modelled dispersal and transport forecasts and satellite retrievals