DEVELOPING ENLARGED ACTIONS FOR SATELLITE EO & VOLCANOES: ANNEXES.

24 October, 2013. CEOS Volcano Thematic Team.

This document complements the CEOS DRM Proposal Draft concerning Volcanoes. The proposal provides ideas concerning how to accelerate the utilisation of Satellite EO for Volcanoes.

There are 6 Annexes to this document.

- Annex 1: Geohazards Supersites and Natural Laboratories
- Annex 2: CSA Volcano Watch
- Annex 3: NOAA Volcanic Cloud Monitoring
- Annex 4: Global Volcano Model
- Annex 5: EVOSS
- Annex 6: International Charter volcano activities

These annexes are open, each of them can be edited.

Annex 1: overview of GSNL

"The Supersites have data for the study of natural hazards in geologically active regions, including information from Synthetic Aperture Radar (SAR), GPS crustal deformation measurements, and earthquakes. The data are provided in the spirit of GEO, ESA, NASA and the National Science Foundation (NSF), that easy access to Earth science data will promote their use and advance scientific research, ultimately leading to reduced loss of life from natural hazards."[1]

The GSNL differentiate four types of Supersites[2]:

- Permanent Supersites
  - Highest priority
  - Threat to humans and/or critical facilities
  - Scientific investigations aim at understanding processes

- Candidate Supersites
  - … are Permanent Supersites under development.

- Event Supersites
  - Recently affected by major geological event
  - important and rare opportunity for scientific investigation
  - Substantial scientific interest internationally

- Natural Laboratories
  - Potentially larger areas
  - Potentially less densely monitored

As currently structured, the GSNL are providing large volumes of freely available SAR data for scientific analysis of geohazard risk. Supersites are assumed to provide several EO sources and in situ data and Natural Laboratories concern sites for which a space agency contributors provides an EO data collection. For Supersites, Event sites and Natural Laboratories the EO data are available to all (upon request for some of the EO sources, systematically for other EO sources).

A selection process for new Supersites has been agreed (see http://supersites.earthobservations.org/CEOS_SelectionProcessProposal.pdf) .

The GSNL Scientific Advisory Committee is responsible for proposing permanent supersites and natural laboratories, according to the following criteria:
"Potential Supersites will be selected according to three criteria.

1) *GEOSS commitment of local monitoring agency.* This includes (i) the willingness to contribute in-situ data to GEOSS, (ii) the likelihood that the data and data products will flow into geohazard assessment, and (iii) efficient communication with task leadership (e.g. articulating data requirement, providing feedback about satellite data use in particular for crisis situations, etc).

[1] From GSNL homepage at supersites.earthobservations.org
[2] http://supersites.earthobservations.org/Supersites_Definitions_final.pdf

2) *Vulnerability of population.* As laid out in the original White Paper, geohazard sites with significant populations exposed to geohazards are of higher relevance than unpopulated areas.
3) *Potential for new scientific results*. Sites with a high likelihood for new scientific results are of higher relevance because we need to demonstrate to CEOS that the satellite resources are well used.
4) *Geographical distribution*. We aim for 1 or 2 Supersites for each country of each proposed natural laboratory.

The GSNL SAC propose to rate the sites according to the three criteria. For each site a total of 10 points is available: 4 for the GEOSS involvement, 3 for the potential of new scientific results, and 3 for vulnerability. Higher numbers indicate better rating. For GEOSS commitment points are given for the provision of information (1 pt for returning the questionnaire) and for the contribution of seismic and GPS data (3 pts)."[3]

To date (April 2013) one Permanent Supersite has been confirmed (Hawaii). A second one has been proposed (Iceland) and is currently reviewed by CEOS. In addition, the are more recent supersite proposals covering Italian volcanoes, Ecuadorian volcanoes, New Zealand volcanoes, Piton de la Fournaise, and the Marmara Sea.

A number of initial supersites were chosen prior to agreeing on a selection procedure, which are expected to be reviewed and formally proposed in the near future. According to the GSNL homepage, these sites are:

Earthquake Supersites

- Istanbul, Turkey
- Tokyo, Japan
- Los Angeles, USA
- Vancouver and Seattle, Canada and USA

Volcano Supersites

- Campi Flegreii and Vesuvius, Italy
- Mt Etna, Italy
- Hawaiian volcanoes, USA

Event Supersites include:

- Tohoku-oki
- Chile
- Haiti
- Wenchuan, China

In addition to the Event Supersites, there are smaller scale events ("other events") for which the GSNL keep data:

- Van, Turkey
- Baja California, Mexico
- Yushu, China
- Eyjafjallajökul, Iceland
- l'Aquila, Italy

[3] Ibidem.

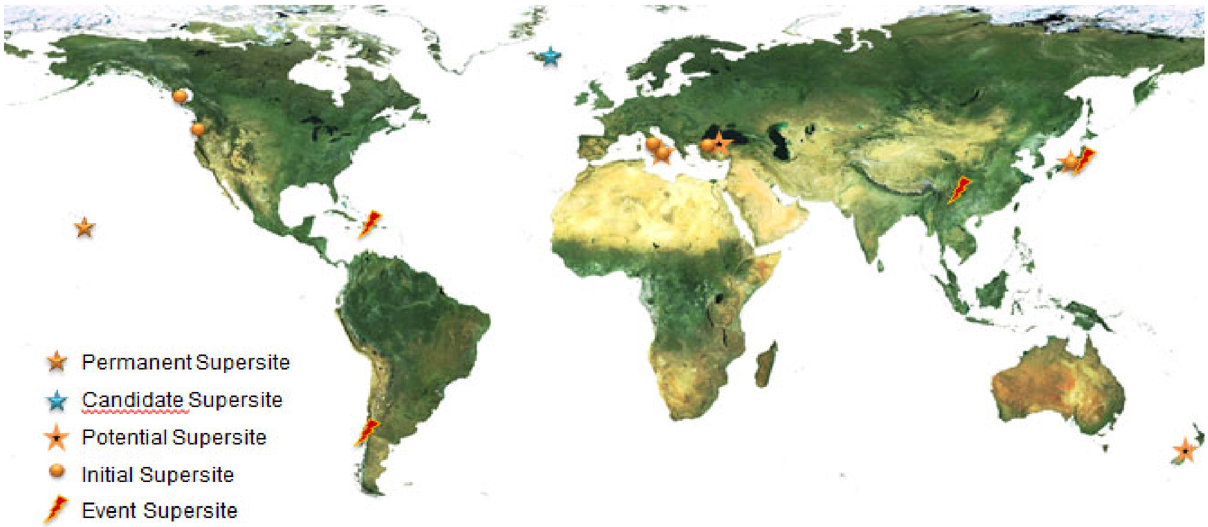


Figure 5. Overview of the GSNL sites according to supersites.earthobservations.org.

In addition to the supersites, GSNL has designated certain areas as Natural Laboratories. "Natural Laboratories are geographic regions in one or several countries characterized by relevant geohazards and a coherent tectonic setting. They are similar to Permanent Supersites but cover larger regions and are less densely monitored. They are subject to investigations aimed at broadening the scientific understanding of the causative processes and at narrowing the uncertainty in geohazard assessment. Natural Laboratories provide a framework for regional collaborations in order to promote transnational access and collaborative temporary experiments for implementing the existing observing systems. Data providers and end users would share data and products, and coordinate research and studies at regional level including activities for testing and validating new techniques, technologies and sensors.
Natural laboratories are not limited in time and will normally exist during the lifetime of the related activities or organizations and beyond that as applicable."[4]

The following Natural Laboratories are under discussion. For many, ESA data are readily available for download from EOLI SA.

- Japan Natural Laboratory.
- Turkey Natural Laboratory.
- Iceland Natural Laboratory.
- Gulf of Corinth Corinth Rift Laboratory. For access to in-situ data see The Corinth Rift Laboratory (CRL).
- Western North America: see the Earthscope Area Natural Laboratory, and the University of Utah's Research on the Yellowstone-Teton-Snake River Plain Region.
- Ocean Island volcanoes: Hawaii (see Hawaii Supersite), Piton de la Fournaise, Galapagos, Cape Verdes, and the Canary Islands.
- Southeast Asia
- Latin America (Central-Southern Andes, Northern Andes, Caribbean)
- Mexico

[4] Definition from GSNL "Supersites Definitions" document, available at www.earthobservations.org

- Alaska North Pacific Ring of Fire (Aleutians, Kamchatka, Kuriles)
- Middle East
- East African Rift
- Central Asia (Tibet , etc.)

It should be noted that discussions with the GEO Secretariat, which assumes the role of Secretary for the GSNL Steering Committee and Science Advisory Committee, indicated that a new GSNL website is planned, and that the list of supersites is being revised. A new requirement of endorsement by the CEOS Plenary has been imposed, meaning at this time there is only one official supersite: Hawaii. At the next CEOS Plenary in late 2013, GSNL is expected to present further sites for endorsement: Turkey (NAFZ), Los Angeles (San Andreas Fault), Iceland and Italian volcanoes. There is still discussion within the GSNL community to understand how many supersites would be an ideal number.

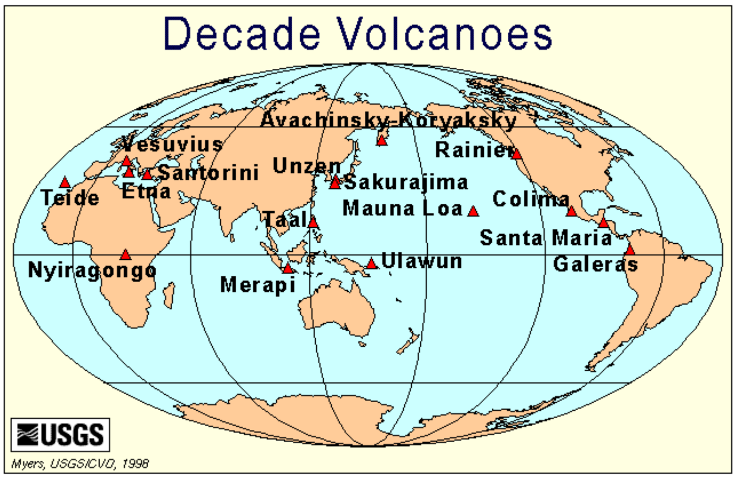
The GSNL Scientific Advisory Committee is chaired by Falk Amelung of CSTARS (University of Miami) and aims to be representative of both hazards and regions. Its current members are: Tim Ahern of IRIS, USA; Falk Amelung of Univ. Of Miami, USA; Massimo Cocco of INGV, Italy; Florian Haslinger of ETH, Switzerland; Chuck Meertens of UNAVCO, USA; Hisao Ito of JAMSTEC, Japan; John Townend of Univ. of Auckland, New Zealand; Susanna Zerbini of WEGENER, Italy.

A separate body made up of space agency representatives, the Steering Committee, has as secretary the GEO Secretariat. Its members are: DLR (chair): J. Hoffmann, CSA: C. Giguère, ASI: S. Zoffoli, JAXA: Kazuo Umezawa and Shizu Yabe, CNES: S. Hosford, ESA: Wolfgang Lengert, NASA: Francis Lindsay.

Annex 2: overview of CSA Volcano Watch

The Volcano Watch program began in 2007 at the launch of Radarsat-2, with the monitoring of the 16 Decade Volcanoes 4 times a year. The data from the program are collected and stored unprocessed in the CCRS archive.

Specifications:
Mode and Beam: Multi-Look Fine, 8m resolution, HH+HV
Timing: Four times a year (March, June, September and December)



Location map of the 16 "Decade Volcanoes" selected for Volcano Watch, identified by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI)

1. Avachinsky-Koryaksky, Kamchatka, Russia (53°15'00"N 158°50'00"E)
2. Colima, Jalisco and Colima, Mexico (19°34'00’’N 103°36’00’’W)
3. Mount Etna, Sicily, Italy (37°45’18”N 14°59’43”E)
4. Galeras, Nariño, Colombia (01°13’00”N 77°22’00”W)
5. Mauna Loa, Hawaii, USA (19°28’46”N 155°36’10”W)
6. Mount Merapi, Central Java, Indonesia (07°32’27”S 110°26’41”E)
7. Mount Nyiragongo, Democratic Republic of Congo (01°31’00”S 29°15’00”E)
8. Mount Rainier, Washington, USA (46°51’10”N 121°45’37”W)
9. Sakurajima, Kagoshima Prefecture, Japan (31°35’00"N 130°39’00"E)
10. Santamaria/Santiaguito, Guatemala (14°45’22”N 91°33’07”W)
11. Santorini, Cyclades, Greece (36°25’12"N 25°25’54"E)
12. Taal Volcano, Luzon, Philippines (14°00’07”N 120°59’34”E)
13. Teide, Canary Islands, Spain (28°16’15”N 16°38’21”W)
14. Ulawun, New Britain, Papua New Guinea (05°03’00”S 151°20’00”E)
15. Mount Unzen, Nagasaki Prefecture, Japan (32°45’24”N 130°17’40”E)
16. Vesuvius, Naples, Italy (40°49’00"N 14°26’00"E)

In 2010, CSA increased our coverage by including the volcanoes covered by ESA as part of the GlobVolcano Initiative, monitoring 56 volcanoes 4 times a year.

Specifications:

<u>Mode and Beam:</u> Multi-Look Fine, 8m resolution, HH+HV

<u>Timing:</u> Four times a year (March, June, September and December)

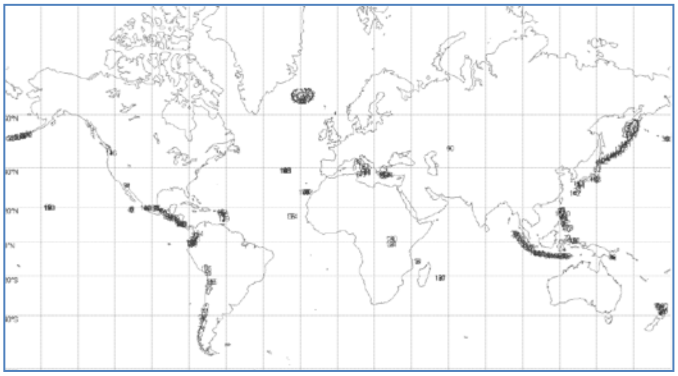
1) Fogo,	12) Tungurahua,	23) Santa Maria,	34) Unzen,	45) Taal,
2) Lascar,	13) San Miguel,	24) Marapi,	35) Colima,	46) Pico-Azores,
3) Osmo,	14) Santa Ana,	25) Merapi,	36) Popocate,	47) Terceira,
4) Galeras,	15) Karthala,	26) Talang,	37) Ulawun,	48) Avachinsky,
5) Nevado Del Ruiz,	16) Piton De La Fourn.,	27) Flegreii,	38) Auckland,	49) Cumbre Vieja,
6) Arenal,	17) Soufriere,	28) Etna,	39) Cerro_Negro	50) Teide,
7) Poas,	18) Nisyros,	29) Stromboli,	40) Masaya,	51) Soufriere,
8) Nyamuragira,	19) Pinchincha	30) Vesuvius,	41) Momotombo,	52) Kilauea,
9) Nyriagongo,	20) Santorini	31) Vulcano,	42) San Cristobal,	53) Mauna Loa,
10) Cotopaxi,	21) Fuego	32) Miyakejima,	43) Telica,	54) Rainier,
11) Guagua,	22) Pacaya,	33) Sakurajima,	44) Rabaul, Katla.	55) St-Helens,
				56) Katla.

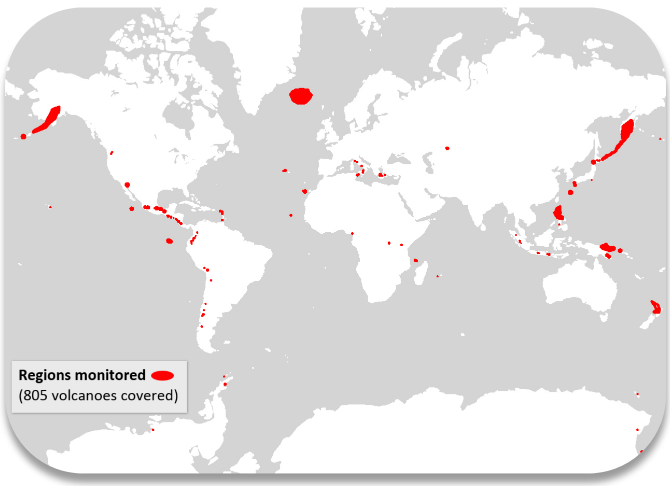
In 2012, CSA increased coverage again by including all major volcanoes featured in Google Earth, monitoring 805 Volcanoes 4 times a year. All major volcanoes covered.

Specifications:

<u>Mode and Beam:</u> Various

<u>Timing:</u> Four times a year (March, June, September and December)





Source: March 2013 Presentation to CEOS Volcano Thematic Team by Christine Giguere, CSA

Annex 3: overview of NOAA Volcanic Cloud Monitoring

It is well known that meteorological satellites are a vital component of the observing system required to monitor volcanic activity and track airborne volcanic ash clouds. Existing operational methods for extracting quantitative information on volcanic ash cloud properties from meteorological satellites have significant limitations and no published method is capable of utilizing all volcanic cloud relevant components of the space-based observing system to detect and characterize every type of volcanic ash cloud (e.g. ash plumes/dispersed ash clouds and ice rich/opaque ash clouds) with the exceptional skill needed for automated alerting and for real-time quantitative modeling applications. In addition, a comprehensive monitoring system that combines satellite observations with other types of observations (when available) does not exist. In an effort to contribute to the development of a comprehensive system for quantitatively analyzing volcanic clouds in near real-time, the National Oceanic and Atmospheric Administration (NOAA), in collaboration with the University of Wisconsin, has developed new, globally applicable, techniques for automatically identifying volcanic clouds in satellite imagery with much greater skill than previously demonstrated. The NOAA algorithm suite also contains procedures for automatically retrieving important volcanic cloud properties and alerting forecasters when a volcanic cloud is detected. The NOAA methods are applicable to virtually any satellite sensor that takes measurements in the visible to infrared portion (~0.40 – 15 µm) of the electromagnetic spectrum and can actually utilize combinations of satellite sensors to produce high quality results with greater consistency. Measurements that rely on the presence of sunlight are used when available, but are not required by the NOAA approach.

NOAA has developed a suite of globally applicable satellite remote sensing techniques for automatically identifying volcanic ash clouds in satellite imagery with a skill that is generally comparable to that of a well-trained human analyst. In addition, the NOAA algorithms automatically estimate the ash cloud top height, mass loading, and effective particle radius. The NOAA methods can be applied to any meteorological satellite sensor using the same algorithm software, while taking full advantage of each sensor's (volcanic ash relevant) spectral, spatial, and temporal capabilities, and can optionally utilize combinations of satellite sensors to further improve product accuracy. The system is capable of using virtually any combination of spectral channels centered near 0.65, 3.9, 6.7, 7.3, 8.5, 11, 12, and 13.3 µm, depending on sensor specifications and solar zenith angle. The NOAA products are currently being generated in near-realtime using GOES-13, GOES-15, MTSAT-2, Met-10, S-NPP VIIRS, *Terra* MODIS, *Aqua* MODIS, NOAA-15 AVHRR, NOAA-16 AVHRR, NOAA-18 AVHRR, and NOAA-19 AVHRR (see Figure 1 below). While acceptable ash detection results are often achievable using nearly any meteorological sensor, the accuracy of the ash cloud properties (height, loading, and effective radius) more strongly depends on the sensor spectral capabilities. More specifically, ash cloud top height will be most accurate when derived from sensors that have at least two infrared window channels located between 10 – 13 µm and one CO_2 absorption channel centered around 13.3 µm. For sensors that lack these channels, greater ash cloud top height accuracy is achieved by utilizing the retrieval results from the more capable satellite instruments (e.g. MODIS) to constrain the retrievals via the *a priori* in an optimal estimation framework. Ash clouds that lack a clear spectral signature because the cloud is opaque or the ash is obscured by ice can also be detected by the NOAA system through identification of anomalous time trends.

A web based portal for the NOAA products is under development.

Annex 4: overview of Global Volcano Model

http://www.globalvolcanomodel.org

This project aims to develop a major international collaboration to create a Global Volcano Model (GVM) that provides systematic evidence, data and analysis of volcanic hazards and risk. The GVM project addresses hazards and risks on global, regional and local scales, and develops the capability to anticipate future volcanism and its consequences.

The project builds on initiatives over the last several years to establish a global database of volcanic hazards (VOGRIPA) and to develop analysis and modelling tools to assess volcanic hazard and risk. The GVM project also complements and interfaces with other major international initiatives, notably including the Global Volcanism Programme of the Smithsonian Institution, WOVOdat (a database on precursors to volcanic eruptions), VHub (a US-led effort to develop an online collaborative environment for volcanology research and risk mitigation, including the development of more effective volcanic hazards models), the Volcano Observatory Best Practices Programme and the International Volcanic Health Hazards Network.

The GVM project has parallels with the Global Earthquake Model in intention and scope of providing an authoritative source for assessing volcanic hazard and risk. There is a strong international consensus that GVM is an essential and timely undertaking. This project, which is within the natural hazards theme of NERC's strategy, provides a unique opportunity for the UK to play a leading role in a major international effort to address volcanic hazard and risk.

Objectives

The GVM project will:

- create an integrated database system of volcanic hazards, vulnerability and exposure and develop internationally agreed metadata standards
- make this system globally accessible
- design, develop and maintain the system
- establish methodologies for analysis of the data (eg vulnerability indices) to inform risk assessment
- develop complementary hazards models
- create relevant hazards and risk assessment tools, and
- maintain a strong, long-lasting GVM community

Methodology

The GVM network will work principally through holding workshops and secondments of staff and students, supplemented by mainly virtual meetings and online collaboration via vhub.org. The first project meeting and subsequent workshop will seek agreement on database content, database architecture, standards, protocols, definitions, methodologies and critically, division of labour between the partners. Exchanges and secondments will allow partners to work closely together to develop the data, methodologies of analysis, write papers together where novel research results emerge, and to develop the outreach side of the project.

Annex 5: overview of EVOSS

EVOSS is an FP-7 funded project that ended in 2013. Project website (possibly no longer supported): **http://www.evoss.eu**

EVOSS is driven by 'end user pull' instead of being 'technology-pushed', notwithstanding the use and the development of state-of-art technologies in spaceborne Earth observation (EO). It fosters a service for the EO on Africa, the European Union (EU) and its dependent territories, restricted to EO of volcanic activity alone, ranging between sustained unrest and eruption. The EVOSS' services are focused on three categories:

(i) high-temperature ground volcanic features - as lava flows, lava domes and lava lakes;
(ii) volcanic emissions - mainly volcanic ash and sulfur dioxide; and
(iii) major ground deformations - typically following and/or accompanying major eruptions.

The synthetic specifications for EVOSS, an EO based volcano observatory system, are:

a) a capacity to provide information when needed, in particular when the personnel is tied up by emergency operations, or when the intensity of activity forces withdrawal of operators from the field or even displacement of the operations centre;

b) a system centred on the electro-optical payloads EO at high temporal and high spectral resolutions, suited to the real- or near-real-time processing of quantitative physical parameters, and on the use of innovative Radar interferometry techniques for the accurate estimate of volume changes;

c) adaptive task scaling from a simple monitoring in quiet phases up to a complete monitoring in case of extreme events;

d) a system scaled on the monitoring of spatially scattered, long lasting crises simultaneously occurring at any place in the whole of EU and in Africa (or abroad, if applicable), lasting months to years or even decades;

e) a capacity of acting in a supra-regional operations theatre. EVOSS centralises multi-parametric EO information on surface thermal anomalies and aerosols from EU and African volcanoes showing unrest;
f) a high priority for sustainability of data provision. On one hand, the cost of space-borne data is increasingly non-compatible with the real duration of unrest cycles; on the other, requested top refreshment rates (hours to minutes) are fit by geostationary and some low Earth orbit (LEO) platforms, fostering the constructive tradeoff with meteorological services, supported by customized business models.

Region of interest and test-and-demonstration sites

The region of interest of EVOSS corresponds to the whole of Europe, Africa and the Eastern Caribbean. It includes about one hundred volcanoes that underwent at least one eruption in recent historical times (the last millennium), and 14 whose eruptions were observed from 2004 onwards with one or more spaceborne payloads that are still operating. They are: Stromboli and Etna (Italy), Jebel-al-Tair (Red Sea), Manda Harraro, Dalafilla, Dabbahu and Erta'Ale (Ethiopia), Ol'Doinyo Lengai (Tanzania), Eyjafjallajökull (Iceland), as well as Karthala (Comoros), Nyiragongo and Nyamuragira (Congo), Piton de la Fournaise (Reunion) and Soufriere Hills (Montserrat). The Eyjafjallajökull (Iceland), whose eruptive style suddenly turned into ash eruption on mid-April 2010, was included although it was not a part of the original proposal. Same policy shall apply to any volcano of the Region of Interest entering major activity during the project time.

Project results:

Volcanic emissions: Trace gas and ash data from polar orbiting ultraviolet (UV) / visible (VIS0 payloads UV/VIS data products are the absorbing aerosol indexes and SO2 columns from the SCIAMACHY, OMI and GOME-2 payloads, onboard ENVISAT, AURA and METOP respectively. The retrieval algorithm(s) development mainly concerns the GOME-2 SO2 data products. Usually, SO2 is retrieved using the differential optical absorption spectroscopy (DOAS) in the UV wavelength region between 315 - 326 nm. As the classical DOAS approach is limited to optically thin conditions, the use of alternative methods (direct fitting, modified DOAS) was investigated, with the aim to improve the retrieval of high total SO2 columns. Using the daily GOME-2 SO2 observations, the degassing of the Virunga volcanoes (D.R. of Congo), was analysed for 2007 - 2009, finding patterns associated to major activity in the summit lava lake of Nyiragongo.

Volcanic emissions: Trace gas and ash data from polar orbiting infrared (IR) payloads Activities focused on one hand, on the development of retrieval algorithms, i.e. derivation of data products related to atmospheric gases and aerosols from Infrared measurements with payload IASI; on the other, on near-real-time computing and dissemination of results to the task leader. For the detection of volcanic aerosols, both an Ash and an Ice indexes were developed, based upon brightness temperature differences. For sulfur dioxide (SO2), the research went beyond what was initially proposed in WP3.2 (the calculation of an SO2 index): indeed, a computational efficient way of calculating SO2 total columns subject to different altitude assumptions, was developed. Currently, near-real-time estimates of SO2 total columns are done assuming plume altitudes between 5-30 km, in case of the detection of volcanic SO2. A dissemination stream of these products has been established and is currently fully operational.

Volcanic emissions: Trace gas and ash data from geostationary IR payloads An ash indicator algorithm was developed for the geostationary SEVIRI payload onboard MSG. This index is based on the brightness temperature differences of SEVIRI channels 12.0 and 10.8 micron, in combination with information from the 10.8 and 8.7 micron channels, and can be used to determine the horizontal extent of the ash plume. Using this index to identify ash plumes, a second algorithm has been developed, which, based on brightness temperatures of the 10.8 and 12.0 micron channels, determines the vertical distribution of the ash using ECMWF real time weather analysis and forecast temperature data. Implementation of this algorithm to provide near-real-time data is scheduled for late spring 2011. Furthermore, work will be done with regard to validation of the various products, in particular the ash height. High temperature volcanic features service Research and technological development (RTD) activities were carried out to improve, generalise, analyse and compare the two algorithms MyMET and MyMOD created for the unsupervised processing of data acquired by payloads SEVIRI (onboard MSG-1, -2 and -3) and MODIS (onboard Terra and Aqua). These algorithms exploit the detection of hot-spot pixels to compute an estimate of physical parameters such as the radiant flux power and - if appropriate - the effusion rate of each hot-spot pixel. They were analysed, tested against the state-of-art in thermal EO of volcanoes and wildfires, and accepted as robust enough to run the EVOSS high temperature volcanic feature service.

In order to share and work on near real-time data, a procedure was set up to create cropped multispectral images of each test-site volcano listed above, upon close of each MSG 15-minute delivery cycle. Currently, some supplementary work is done on the MyMET source code in order to make it running automatically upon close of each data acquisition cycle, as to provide results fully exploiting the 15-minute refresh rate allowed by payload SEVIRI. A parallel work is conducted on the continuous cross-calibration / cross-validation of SEVIRI and MODIS products to be carried out up to four times daily. The simultaneous carrying out of two independent measurements of same physical parameters on the same volcanic spot, done taking into due account eruptive styles and downwards view geometries, is meant to allow validating the results immediately, without relying upon later releases of - often qualitative - ground truth. In view of the forthcoming validations, both the SEVIRI-based and the MODIS-based processing chains are already run on all current eruptions, although behind real-time.

Ground deformation service

The ground deformation service design was based on:

(i) the definition of a state-of-art in the field of spaceborne DEM construction and differential ground deformation monitoring;
(ii) the definition of the service according to the user requirements; and
(iii) the identification of the suitable sequence of development activities.

In the preliminary service definition, all RTD activities were planned for application to X-band spaceborne radar data, in order to exploit the joint potential of short revisit intervals and very-high ground resolutions provided by the new generation sensors: the Italian constellation Cosmo-SkyMED, and the German pair TerraSAR-X /Tandem-X. Since no such data were yet available at To+12, the development of the new methodology of multi-baseline approach to very-high precision DEMs was launched and tested on C-band, ERS-1/-2 Tandem data, available in-house for Mount Etna and acquired between 1995 and 2000. Special attention was devoted to the definition and estimate of statistical parameters that allow the definition of quality indicators for the final result. The development is considered successful.

EO-based volcano observatory and its sustainability

The EVOSS virtual volcano observatory infrastructure - that is, an efficient merge of seven different leading-edge techniques providing them with real-time or near real-time capacity, and with a geographic interface towards the external world (of end-users), acts on a detection-and-monitoring concept addressed as follows: - In local peace-time (no unrest detected): standard EVOSS products generate internal alerts if abnormal situation is detected. Local improvement (eight out of five volcanoes) with ground deformation monitoring by high resolution space-borne radar platforms, if appropriate. - In local mild crisis: at the onset of surface emissions, thermal parameters, SO2 concentrations and ash plume signatures could be released with very-high temporal frequency - 15 minutes to hourly. The debate about a 'push' or 'pull' configuration of the post-processed data repository is still open, with impact on the SWOT analysis. - In local major crisis: multi-parameter remote control with provision of ground thermal, gas and ash plume parameters at tactical refresh rates. There is a general agreement on the 'push' information transfer, as the End-User is supposed not to be in control of the flow of data and their interpretation. The cost analysis and the search for the sustainability drivers, to be completed at To+18 together with the design of the virtual volcano observatory system and the start of the validation phase, are expected to clarify which technical asset will make the project sustainable, also with respect to major choices to be done in terms of services to propose and cost of data and qualified human resources required for running the system at the continental geographic scale, chosen on reasons of pure technical feasibility. Implementation of the test-and-demonstration sites Physical, chemical and lithological parameters were retrieved and assessed for the whole of the above 14 volcanoes, that constitute the all-encompassing test-site for near-realtime operations (high temperature volcanic ground features and volcanic aerosols products, both updated with 'tactical' refresh rates - from minutes to hours). Following a request by one of the core end-users - the volcanological observatory of Goma (Congo) - the list of volcanoes selected as the test-sites for validation and service demonstration of the Ground Deformation service products by spaceborne radar interferometry, was implemented including Nyiragongo and Nyamuragira (Congo), because of the high risk and the high frequency and magnitude of eruptions. For reasons of economic feasibility, comparative low risk and low frequency and magnitude of eruptions, one volcano (Stromboli) of the previous list was discarded, and the remaining three were kept: Karthala (Comoros), Piton de la Fournaise (Reunion) and Soufriere Hills (Montserrat).

Potential impact:

Volcanic emissions services

The main objective of the volcanic emissions services is the delivery in near-real time (i.e. within two to six hours after observation) of data from measurements by satellite-based instruments regarding sulphur dioxide (SO2) and aerosol (ash and ice) emissions possibly related to volcanic eruptions. 1. The SO2 data set up within the support to aviation control service (SACS) of GSE-PROMOTE will be continued and extended using data from additional (notably IR) satellite instruments and providing addition data types (e.g. a volcanic ash indicator and an aerosol index). 2. Improved retrieval algorithms will be tested to provide more information on the elevation and extent of the volcanic cloud. And the potential of other trace gases - notably BrO and CO2 - for notifying volcanic activity will be investigated. 3. Backward and forward trajectories will be run, starting from a limited number of altitude levels at the location of the SO2 peak and driven by meteorological fields from the ECMWF, to facilitate the determination of the origin of the SO2 cloud and its forthcoming motion. 4. All data, maps and related information will be available through the common EVOSS infrastructure, based on a web portal. Apart from the near-real time data and the alerts, the website will also contain an archive for validation purposes and for case studies.

Thermal anomalies services

The detection, measurement of surface thermal anomaly physical parameters, and the dynamic tracking of high-temperature volcanic features is dealt with in EVOSS by involvement of opto-electronic, Infra-red payloads SEVIRI onboard the European geostationary platform MSG located at 0° longitude and MODIS onboard NASA quasi-polar satellites Terra and Aqua. 5. During the R&D phase, hot spot detection, volcanic radiant flux and instant effusion rates of lava flows will be simultaneously estimated using multi-spectral infrared observation by SEVIRI for the 13 volcanoes within the SEVIRI full-disk that underwent eruption from 2004 to present. They are: Mount Etna (Italy), Stromboli (Italy), Piton de la Fournaise (Reunion Island), Soufriere Hills (Montserrat, B.W.I.), Karthala (Comoros), Nyamuragira (Congo), Nyiragongo (Congo), Jebel-al-Tair (Yemen), Ol'Doinyo Lengai (Tanzania), Manda Hararo (Ethiopia), Erta'Ale (Ethiopia), Dabbahu (Ethiopia) and Dalaffilla (Ethiopia). 6. For each test site, results in hot spot detection, radiant flux and instant lava effusion rate provided by use of thermal, mid and short Infrared bands of SEVIRI, will be assessed by exploitation of the simultaneous MODIS overpasses by Terra and Aqua, up to four times daily. 7. An additional research activity will be conducted to investigate suitability of other geostationary systems deployed across the Americas and Southeast Asia, such as GOES and MTSAT, for quantitative volcano monitoring worldwide through radiant flux computation.

Ground deformations services

The analysis of ground deformation and the topography changes involve the use the new SAR platforms COSMO-SkyMed and TerraSAR-X. The main features of these instruments allow improving the PS density, and short revisit times allow a better temporal sampling of the deformation phenomena thus reducing problems of temporal decorrelation and phase unwrapping. 8. A stack of SAR data will be used for designing as a RTD product a post-event DEM correction approach in order to map the fast and huge topography changes induced by a volcanic eruption. The processing approach is based on PSInSARTM that provides precise deformation information (i.e. submillimeter displacement measurement and atmospheric delay estimation). 9. The R&D activities mainly concern the definition of a methodology based on PSInSARTM for post-event DEM correction, stating from pre-event digital elevation models. This is an innovative methodology, conceived upon indication of Core Users to be defined during the project evolution. 10. Besides of the RTD activity for DEM correction, other activities will concerns the analysis of user requirements, the review of core services and products, the analysis of new SAR instruments and data (X-band), evaluation of their capability, tuning of the PSInSARTM approach to X-band and high resolution SAR yearly updated. 11. Ascending and descending PS are used for planimetric vertical and easting displacement computation. The test site will be selected according to the users' requirements and data availability. For each test site SAR ascending and descending dataset will be acquired and processed. The use of both ascending and descending passes allows the estimation of Vertical and Easting displacement components. On the basis of these results, the DEM correction will be performed. As the baseline, COSMO-SkyMed and/or Envisat data will be used. If COSMO-SkyMED data will not be available, TerraSAR-X data will be used as a backup. TerraSAR-X data are assumed to be provided by ESA.

Annex 6: overview of International Charter volcano activities

The Charter website provides a summary overview of how the Charter works:
http://www.disasterscharter.org/home

The International Charter aims at providing a unified system of space data acquisition and delivery to those affected by natural or man-made disasters through Authorized Users. Each member agency has committed resources to support the provisions of the Charter and thus is helping to mitigate the effects of disasters on human life and property.

The International Charter provides a mechanism to obtain satellite EO data and value-added products (but not interferometric data and products) for two weeks following a major volcanic event if the Charter is activated by an authorised user.