Rapid Response Systems for
Volcanic risk support developed for
Italy and in the GMES core services

SAFER-FP7 project
ASI-SRV project

Massimo Musacchio, Maria Fabrizia Buongiorno

Istituto Nazionale di Geofisica e Vulcanologia, Italy
OVERVIEW

- INGV activities overview
- GEMS Emergency Management: SAFER project overview
- Earthquakes and Volcanoes (E&V) Services
- Contributes to international E&V Emergencies
- ASI-SRV project for Italian volcanic risk management
Istituto Nazionale di Geofisica e Vulcanologia
INGV
INGV branches

- **Centro Nazionale Terremoti**

Roma
- Seismology and Tectonophysics
- Geomagnetism, Aeronomy and Environment

Napoli
- Osservatorio Vesuviano

Catania
- Volcanology (Etna-Aeolian Isl.)

Milano
- Engineering Seismology

Palermo
- Geochemistry

Pisa
- Volcanology and modeling

Bologna
- Seismology
- Climatology

Other observatories

- Rocca di Papa Roma
- L'Aquila
- Gibilmanna Palermo
- Ercolano Napoli
- Arezzo
- Ancona
- Messina
- Lipari Messina
- Stromboli Messina
- Grottaminarda Avellino
- Portovenere La Spezia
- Roma Via Nizza
- Roma Viale Pinturicchio
- Napoli Via Coroglio
- Genova Dept. Earth Sc.-University
INGV Monitoring Systems

- Seismic surveillance
- GPS network and geodesy
  - About 200 seismic stations
  - About 110 GPS stations
- Geochemistry network
- Marine (sub-marine) instruments
- Remote Sensing (receiving antennas and laboratory)
The project SAFER aim is to implement and to validate a preoperational version of the GMES Emergency Response Service, reinforcing the European capacity to respond to such challenges.

In first priority we want to validate an information service focusing on rapid mapping during the response phase and then to enrich this service with a wider set of thematic products.

In the long term, ERCS will provide tangible benefits for all citizens, in Europe and worldwide, in terms of better quality of life, better health, and increased safety.
Earthquakes and Volcanoes (E&V) services

Summary of Main Objectives

- Consolidate, validate and deliver thematic information at European and Worldwide level related to the geophysical risk for ERCS activities

- Creating a permanent exchange of information with user community and other partners in order to facilitate the integration, validation and use of E&V thematic services in the ERCS system
Selected products for operational services

The proposed products for E&V services were:

- **Volcanic products**
  - SO2 content and flux maps
  - HTE maps
  - ASH maps (mass, loading and dispersal modelling)
  - Sin-Eruptive deformation by DInSAR

- **Earthquake products**
  - Damage mapping by SAR (and/or by VHR optical and SAR fusion)
  - Co-Seismic deformation by DInSAR
  - SAR time series (prevention phase product)
EARTHQUAKES AND VOLCANOES SERVICES

Major events used to test the E&V thematic service products

- September 2009 Padang earthquake (Indonesia)
- January 2010 Port au Prince earthquake (Haiti)
- April-May 2010 Eyjafjallajökull eruption (Iceland)
- October-November 2010 Merapi eruption (Indonesia)
- May 2011 Grimsvotn eruption (Iceland)
- June 2011 Dubbi eruption
- October-November 2011 El Hierro eruption (Spain)
On 30th September 2009, at 17:16:10 local time (10:16:10 UTC) an earthquake with a magnitude 4.8 hit off the southern coast of Sumatra, Indonesia. The epicenter was 45 kilometers west-northwest of 220 kilometers southwest of Pekanbaru, Sumatra. The map shows a post-disaster damage assessment.

The map has been performed by Christian Bignami and Fabio Dell'Acqua.

For further information please contact Christian Bignami.
On 12 January 2010 a strong earthquake (M 7.0) hit the city of Port Au Prince and the surrounding areas.

- Deformation map
- Damaged area (BASeDaLE)
Deformation map component by means of DInSAR (left, east-west component, right vertical component)
Damage estimation map of Port Au Prince, Haiti. SAR damage map at block scale (Green= low level /no damage; Yellow= medium level damage; Red= high level damage)
SAFER was activated by the WFP User (ID of the activation is GERS063 on October 28 2010)

The data analysis and the accurate update of the local situation was carried out in coordination with FP7 MIA-VITA project

- INGV, NILU, GAMMA start to produce thematic products and forecast models
- First reports where issued towards the Center of Volcanology and Geological Hazard Mitigation (CVGHM) from the October 29th
- First SAFER news letter was sent on November 1st

- Deformation Map
- SO2 content
- Ash content
- Ash dispersion model
This RGB color composition reveals presence of new features in the area close to the crater (red pixels in the yellow box).

The cyan areas are representative of decrease of scattering in the 6/11 image, probably related to ash or pyroclastic deposits.
The change detection analysis on COSMO-SkyMed data acquired the 1/5/2010 e l’8/11/2010 shows the presence of the pyroclastic flow on the southern flank of Merapi, the white color detects the presence of material which has filled up the old channel, the black color detects the pyroclastic material that has covered the area around the channel.

NASA-JPL has furnished ASTER data starting from 26 of October 2010. The cloud coverage was very high, the ASTER data acquired on 11-01-2010 shows clearly the presence of hot material which has reported a pyroclastic flow.
SO$_2$ detection and analysis (IASI)
ASH detection from MTSAT

[Graph showing BTD (°C) over a geographic area with a focus on Merapi]
Ash cumulative ground deposit modelled
During the still on going el Hierro volcanic crisis INGV has been activated in order to deliver services available for supporting the re-action of the Spanish authorities. INGV was able to publish in less then 12 hour the following web based service for the RT analysis of surface thermal state of El Hierro island.

http://labtel2.rm.ingv.it/rapidresp/hierro/index.html

- **Surface thermal analysis**
- **SO2 and ASH preliminary detection (for sub aerial eruption)**
INLAND RT monitoring activity of El Hierro Volcano

The following graphs show the radiance values and brightness temperature values derived from MSG-SEVIRI data. Each curve represents the values derived from the pixel on toppling El Hierro island according to the two following red boxes:

- Red box
  - Upper Left corner: lat. 27.8327° N, lon. 18.1605° E
  - Lower Right corner: lat. 27.7335° N, lon. 17.8609° W

Radiance daily variation analysis by means of 4th channel
(1.58 micron, MSG-SEVIRI, time in the figures is UTC)

OFF SHORE South El Hierro surface thermal analysis.

The following graphs show the brightness temperature values derived from MSG-SEVIRI data measured on South El Hierro off shore.

Each graph includes the values derived from seven different N-S transects. Transects S1 and S2 are composed by 7 pixels, transects S3 and S7 by 6 pixels, transects S4, S5 and S6 by 5 pixels and transect S6 by 4 pixels.

- Transect S1

UL coordinates: Lat 32.73056° N, Long 30.54320° W
LR coordinates: Lat 22.29398° N, Long 5.36175° W

Preliminary ASH detection analysis:
Brightness temperature difference (BTD) image obtained by using the MSG-SEVIRI channels 9 and 10 centered around 10.8 and 12 micron. Negative BTD values (red pixels) may be indicative of an ash cloud's presence.

Preliminary SO2 detection analysis:
Pseudo color image generated by means of decorrelation stretch procedure using the MSG-SEVIRI channel 6, 7 and 9 centered respectively at 7.3, 8.7 and 10.8 micron. Due to the strong SO2 absorption in channels 6 and 7, the technique can be used to identify the volcanic SO2 clouds.
ASI-SRV

Sistema Rischio Vulcanico

SRV: a pre-operative system for Volcanoes monitoring

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REFERENCE USERS
Italian Department of Civil Protection

Chiara Cardaci, Pierluigi Soddu, Chiara Christiani, Antonio Ricciardi, Domenico Mangione

ASI-SRV TEAM CREDITS
M.Fabrizia Buongiorno, Malvina Silvestri, Massimo Musacchio, Stefano Corradini, Claudia Spinetti, Valerio Lombardo, Luca Merucci, Marco Neri, Giuseppe Puglisi, Sven Borgstrom, Borsis Behncke, Massimo Aranzulla, Sergio Teggi, Eleonora Bertacchini, Francesca Despini, Sergio Pugnaghi, Lorenzo Guerrieri, Matteo Gangale, Rosamaria Di Manzo, Eugenio Sansosti, Pietro Tizzani, Giuseppe Solaro Stefano Vognoli, Sergio Perelli, Angelo Amodio, Marco Gregnanin,
ASI-SRV Project Main Objectives:

1. Development of demonstrative system with pre-operational capability to integrate EO data and ground measured data to support the decision system of Italian Civil Protection Department (DPC) for Volcanic Risk management

2. Support the scientific research to develop specific product procedures based on Remote Sensing data processing and analysis based on User Requirements

3. Develop specific User Interfaces that could be integrated with the already existent DPC Volcano Surveillance System
ASI-SRV TEST AREA
Etna is characterized by a persistent volcanic activity with frequent effusive episodes, in the last decade has shown an increase of explosive episodes. Etna is one of the most important natural laboratory to develop and test EO product.
ETNA
The volume of erupted products was very high during the 17th century, followed by a period of low activity lasted about 100 years.

Etna increased his effusive rate progressively between 18th and 19th centuries, culminating since 1950 in an significant increase of the volume of erupted products.
Vesuvio and Campi Flegrei area
Vesuvio is a quiescent volcano and it is constantly monitored due its very high risk.
Campi Flegrei volcanic system is thermally active and presents an high surface deformation.
Vesuvio  (INGV-OV)

Eruption of 1906
Vesuvio
Campi Flegrei
ASI-SRV DEVELOPMENT
ASI-SRV data processing algorithms have been selected during the feasibility study on the following characteristics:

- Consolidated Scientific background and robust procedures
- Portability for different EO data
- Integration with ground measurements
- The algorithms implemented in the ASI-SRV have been developed within the scientific and industrial team in order to permit modifications and upgrades
- Choerence between the ASI-SRV products and GMES services for Volcanic and Earthquake Risks
ASI-SRV products related to Volcanic Risk Phases

- Pre-eruptive:
  - Lava flows mapping
  - Lava flows thickness
  - Ash deposits
  - Surface deformation

- Post-eruptive:
  - Thermal anomalies
  - Surface deformation
  - Gas emissions
  - Volcanic aerosols

- Sin-eruptive:
  - Lava flow T flux effusion rate
  - Sin-eruptive deformation
  - Ash clouds
  - So2 eruptive plumes
## Products for phases and test areas

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<th>PHASE</th>
<th>EO PRODUCTS</th>
<th>GEOGRAPHICAL AREA</th>
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<td>Multiparametric Analysis product</td>
<td>Etna and Vesuvio – Campi Flegrei</td>
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<td></td>
<td>Deformation Map from DinSAR product (time series)</td>
<td>Etna and Vesuvio – Campi Flegrei</td>
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<td></td>
<td>Surface temperature and Thermal flux</td>
<td>Etna, Campi Flegrei, Vesuvio</td>
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<td></td>
<td>Degassing Plumes analysis product</td>
<td>Etna</td>
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<td>Crisis Phase</td>
<td>Deformation Map from InSAR product (sin eruptive)</td>
<td>Etna</td>
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<td></td>
<td>Deformation Map from DinSAR produsc (time series)</td>
<td>Etna</td>
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<tr>
<td></td>
<td>Thermal Flux, Effusion Rate</td>
<td>Etna</td>
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<td></td>
<td>Volcanic Plumes and Clouds analysis product</td>
<td>Etna</td>
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<td>Post Crisis Phase</td>
<td>Deformation Map from DinSAR product (time series)</td>
<td>Etna</td>
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<td>Volcanic thickness product</td>
<td>Etna</td>
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<td></td>
<td>Ash and lava distribution map product</td>
<td>Etna</td>
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Ground monitoring data and atmospheric profiles acquired in the ASI-SRV system

<table>
<thead>
<tr>
<th>DATA TYPE</th>
<th>SCHEDULING</th>
<th>ETNA</th>
<th>VESUVIO</th>
<th>CAMPI FLEGREI</th>
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</thead>
<tbody>
<tr>
<td>GPS</td>
<td>Weekly (satellite passages)</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Leveling</td>
<td>On availability base</td>
<td></td>
<td>X</td>
<td>X</td>
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<tr>
<td>SO2 (doas/cospec)</td>
<td>Continuously</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Video Cameras</td>
<td>Every 15 minutes</td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Geological observations</td>
<td>Periodically</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Temperature</td>
<td>Based on Satellite passages</td>
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<td>X</td>
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<tr>
<td>Geochemical (CO2)</td>
<td>Daily</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Atmospheric profiles</td>
<td>Daily (3 times)</td>
<td>X</td>
<td>X</td>
<td>X</td>
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INGV Observatories and University of Modena and Reggio Emilia
The dissemination module (DIS) has been developed for the User access to ASI-SRV with two objectives:

1. User evaluation of the implemented products during the volcanic activity phases (Etna)
2. Test on the data formats and assimilation procedures in the USER environment

User access to the DIS is made by a web link where the products could be visualized and downloaded in ESRI “shape file formats
DIS tool: Map Viewer
Example of ASI-SRV product: SAR velocity map on ETNA
Map Viewer: Toolbar Get Feature Info

Feature Selection

- Add Points
- Values Interpolation

Feature Selection report

Ascending Deformation Time Series. Deformation time series relevant to Mt. Etna volcano. Ascending ERS-1/2 and ENVISAT I2 SAR data. Time interval 1992-2010. The time series show the complex deformation phenomena affecting the eastern and western volcano flanks as well as the northern Catania area.
CONCLUSIONs

- Since SAFER was started the INGV and partners had produced (when activated by Users or by SAFER) information following the products proposed in the Volcanic and Earthquake service to demonstrate their use.

- The SAFER thematic products by means newsletters, web or ftp have been delivered both to USER and local Authorities receiving positive feedbacks.

- The collaboration with other projects such as FP7 project MIA-VITA (under Environment) and ASI-SRV (for volcanic service) has demonstrated the importance of integration of procedures and results.

- These events allowed to test the use of the products almost in real time.

- They were a very nice examples of coordination between GMES service SAFER, which has demonstrated the very effective tools to provide satellite products, specific research activities carried out in other FP7 projects and effective local requests and needs.

- The ASI-SRV has been fully tested and could be implemented for operational use.
Thank You