Etna's explosive eruptions threaten aviation in Central Mediterranean region and highlight the need of an efficient ash-cloud monitoring system using MSG images

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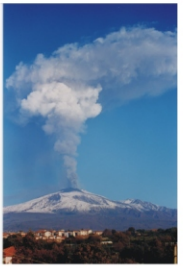
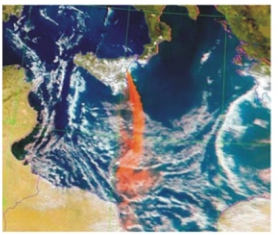
Since 1979 explosive activity of Etna produced many short-lived ash-plume forming eruptions that created several problems to the operations of Catania and Reggio Calabria airports. In 2001 and 2002 a prolonged explosive activity caused continuous tephra injection in the atmosphere for several weeks. Lapilli and ash blanketed the volcano slopes down to Catania airport 35 km far from the vent, and fine particles reached hundreds of km of distance up to northern Africa coast. The effects have been very serious disrupting the Catania airport operations for many days during three months as never was happened in Italy since the last Vesuvius eruption occurred in 1944.



Picture of a typical ash-plume of Etna

Italian Institute of Geophysics and Volcanology (INGV) is in charged for monitoring the eruptive phenomena of Etna volcano. It have to furnish to Catania International Airport Direction, Italian Agency for Civil Aviation (ENAC) and Italian National Civil Protection data on ash cloud dispersion on Sicilian airspace and on ash fallout on Catania airport. To put in operation an efficient ash-cloud monitoring system we will use the remote sensing IR images transmitted in real time by MSG satellite and by a network of ground-based IR cameras observing the volcano summit.



2002 Etna-s ash-plume dispersed on Mediterranean region, courtesy of NASA

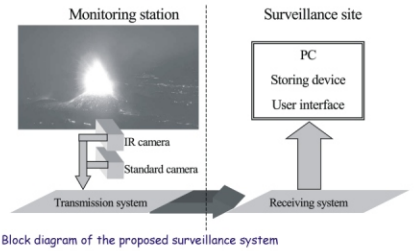
The proposed system for ash cloud monitoring

The ground-based sensor network will be formed by 5 observation stations with IR and visible cameras, located in places that permit a detailed vision of both eruptive columns and ash clouds.

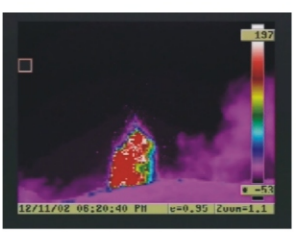
To furnish a instrumental support to the aviation authorities one of the station will be installed at Sigonella Airport (40 km south from the Etna's summit vents) where the Italian Air Force Meteo Service, is based and issus the NOTAM and ASHTAM in case of ash-cloud forming eruption of Etna.

The other place will be Taormina and Centuripe at 25 km from the Etna's summit vents to observe the ash cloud from North and from West because the dominant wind carry on the clouds mainly toward East and SE. Two stations will be devoted to the proximal observation of the eruptive columns and the initial ash clouds, and will put at Nicolosi (15 km southward from the summit vents) and Milo (10 km eastward from the summit vents). In these place the IR cameras will be termographers to enhance the capability to track the transition from normal (often long-lived) explosive activity (strombolian explosions or fire fountains) to ash-cloud forming eruptions, using temperature data.

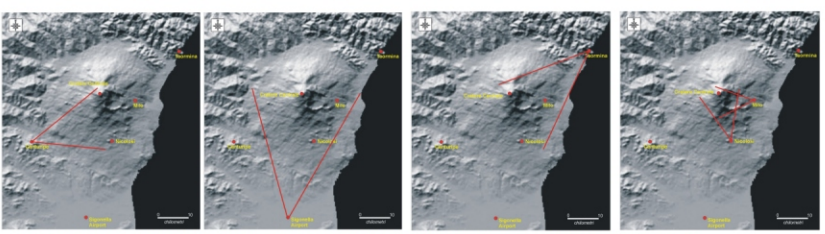
All the IR cameras will operate on a large IR spectra (7-14 ìm) and alternately, using filters, on the two bands (from 10.3 to 11.3 ìm, and from 11.5 to 12.5 ìm) where it is possible discriminate volcanic ash cloud from normal meteorological clouds. All images collected (visible, total IR, and filtered IR) will be sent in real-time to the Operative Room of INGV Catania, where a software will compare automatically the images from MSG and from ground-based stations for each of the used bands. An archive of all images will be done on DVD.



Block diagram of the proposed surveillance system



An image of Etna activity Recorded by IR camera on 12 November 2002



Map of Mt. Etna with the sites of the ground based stations and the field of view for each camera system

Thermal image data from two channels of the Advanced Very High Resolution Radiometer (AVHRR) were used in this study. Band 4 (10.3 to 11.3 um) minus band 5 (11.5 to 12.5 um) brightness temperature difference images are used to detect the volcanic cloud, and distinguish it from meteorological clouds. Volcanic clouds are known to have negative band 4 minus 5 brightness temperature differences (Prata, 1989a; Schneider et al., in press; Wen and Rose, 1994), while meteorological clouds generally have positive brightness temperature differences (Yamanouchi et al, 1987). The images of the Mt. Spurr cloud (below) demonstrate the band subtraction technique. The image on the left is a band 4 image, and shows how difficult it is to distinguish the volcanic cloud. The image on the right is a band 4-5 image, and shows the volcanic cloud clearly. SEVIRI on SMG having the same bands will permit the ash volcanic cloud detection at a higher rate respect to AVHRR. We think that the fusion of images of the this phenomenon taken in the same IR bands from both space and ground positions will improve the capability of volcanic ash detection in troposphere, increasing the effectiveness of our monitoring system.

IR Band subtraction technique