Mt. Etna volcanic aerosol and ash retrievals using MERIS and AATSR data

2nd MERIS - (A)ATSR WORKSHOP

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ABSTRACT *Envisat MERIS and AATSR data have been acquired in the framework of the Eurorisk-Preview project. The project addresses European civil protections and proposes to develop, at the European scale, new information services to support the risk management. In Italyone of the most important natural risks is due to the presence of volcanoes. Mt. Etna in Sicily, displays persistent activity, periodically interrupted by eruptions, which emit volcanic aerosol and ash to different altitudes in troposphere affecting the central Mediterranean area. In order to test the use of MERIS and AATSR data to monitor the emitted particles in troposphere the already developed remote sensing techniques has been adapted and applied to MERIS and AATSR data acquired during the Mt. Etna 2002-2003 volcanic eruption. The data have been requested via Category 1 n. 3560. In the remote sensing approach a radiative transfer inversion algorithm (Spinetti et al., 2003) has been applied to MERIS data recorded on October 2002 during Mt. Etna eruption. The algorithm use the visible channels, since scattering effects are in the short wavelength range of the solar radiation. Explosive plume particles component optical characteristics has been retrieved as a spatial distribution of optical thickness. Using multispectral TIR bands, around 11 and 12 micron, the possibility to detect the ash component during eruptive episodes has been demonstrated using the BTD method (Prata, 1989). This method has been applied to AATSR data choosing the same eruption episodes recorded by MERIS. After calculating the optical properties of the volcanic ash a radiative transfer model has been used to simulated the signal measured by AATSR. Fitting the model simulations to the data provides estimates of the optical thickness of the eruptive plume, mean radius of the ash particles and the ash loading. Using the AATSR visible and near infrared channels we have estimated the optical depth (at 550nm) and the effective radius using the ORAC aerosol retrieval algorithm, developed at Oxford University and Rutherford Appleton Laboratory. The ORAC scheme has been used and validated in several projects including NERC GRAPE and ESA Globaerosol (Thomas et al., 2008). The radiative transfer model used for the vis/nir channels takes into account atmospheric scattering and absorption as obtained by DISORT (DIScrete Ordinate Radiative Transfer) radiative transfer code. Here the algorithm is extended to include the optical properties of a volcanic aerosol model. The use of VIS and TIR bands of the two sensor demonstrates the potential to monitor the volcanic plume during eruption if frequent and high resolution data is available in near real time.*

PREVIEW-EURORISK

Geophysical Cluster Monitoring European Volcanoes

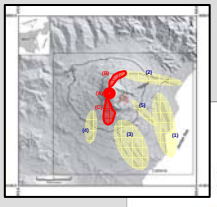
In the framework of FP6 program, Preview - Eurorisk project aims to develop tools for monitoring volcanoes using EO and ground data.

EO data have been provided by: ESA category 1 project, and by University of Oxford.

ESA Cat1 3560 - Slow surface movements detection and damage assessment from InSAR and optical data
Principal investigator Dr. C. Spinetti
Co-Investigators Dr. R.Lanari, Prof. J. Fernandez
The proposed study areas are:
Mt. Etna, Sicily, Italy and Tenerife, Canarian islands, Spain
The objectives are:
Surface displacement and volcanic emission monitoring
Data requested amount:
400 ERS-ENVISAT SAR Data and 1 Meris and 3 AATSR Optical Data

Mt. Etna Sicily Italy

Mt. Etna is one of the world's most actively volcanoes. It is a large strato-volcano with a summit height approx. of 3300 m a.s.l. and a circumference of about 100 Km at ground level; it produces alkaline and basaltic lava during summit and flank eruptions. The extremely proximity to the populated city Catania and urban and Industrial areas generate an high risk to explosive activity.



Structural features
1. Timpe fault system
2. Pernicana-Provenzana fault system
3. Nicolosi-Mascalucia-Trecastagni fault system
4. Ragalna fault system
5. Fiandaca-Zafferna fault
6. Ripa della Naca faults

Volcanic features
A. Summit craters
B. North-East Rift
C. South-East Rift

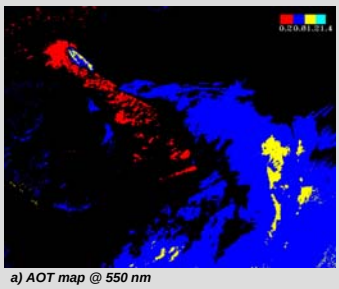
The 2002 -2003 Eruption

The 2002–03 eruption was marked by intense explosive activity beginning on 27 October 2002 and declined with the eruption ceasing on 28 January 2003. The explosions produced abundant ash emission that impacted the local economy and air traffic (Andronico et al, 2005).

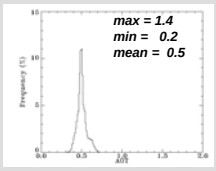
VOLCANIC AEROSOL

MERIS AOT inversion algorithm

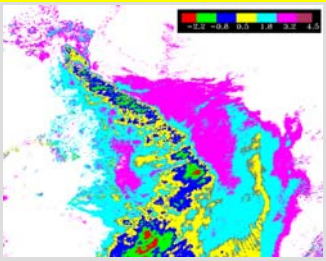
The distribution of the volcanic aerosol optical thickness has been derived (a) by applying an inversion algorithm developed by Spinetti el 2003 to MERIS data. The map shows that two volcanic plume are well identified, especially the lower one emitted from North fracture. From the spectral behavior of AOT Angstrom parameter Alpha has been derived (c), showing the presence of bigger particles in the main eruptive plume.



a) AOT map @ 550 nm



b) AOT Histogram

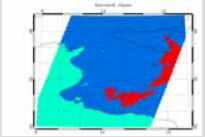


c) Angstrom parameter Alpha

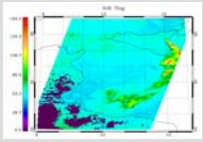
AATSR AOT inversion algorithm

Aerosol proprieties has been derived applying the Oxford-RAL retrieval of Aerosol and Clouds (ORAC) optimal estimation method (Thomas et al 2008) to AATSR data. ORAC is being used in the NERC GRAPE and ESA Globaerosol projects (Thomas talk -> Friday 8.40).

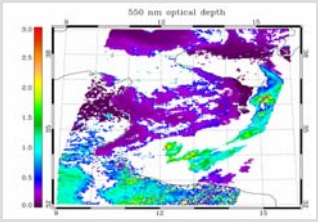
ORAC identify volcanic aerosol and ash (d,e) and calculate optical thickness and effective radius of identified plume (f,g).



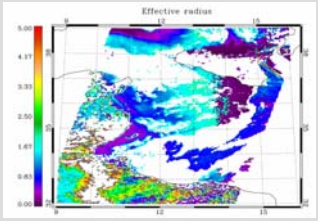
d) Aerosol identification



e) Ash identification



f) AOT



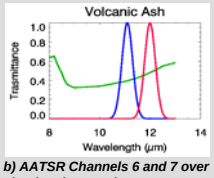
g) Particle Radius

VOLCANIC ASH

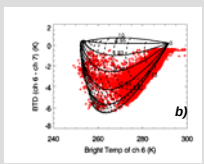
AATSR ASH Retrieval algorithm

INGV processed the Thermal channels of AATSR data by applying the split window technique BTD (Prata, 1989) (a) . The technique is based on different absorption between channels around 11 and 12 mm (b). Fitting the pixels identify as ash with the brightness temperature simulations (c), the plume ash AOT (d,e), the ash particles effective radius (f) and the ash mass (g) has been retrieved (Corradini et al., 2008).

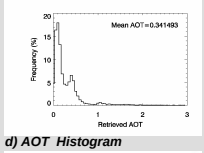
a) Volcanic ash plume identify by BTD



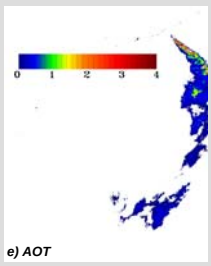
b) AATSR Channels 6 and 7 over simulated transmittance in presence of volcanic ash



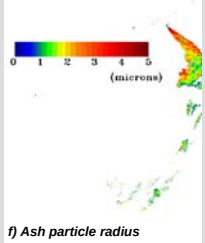
c) BTD Bell-shaded curves



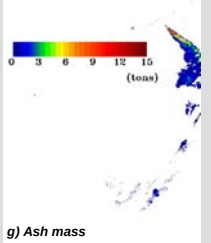
d) AOT Histogram



e) AOT



f) Ash particle radius



g) Ash mass

Conclusions

Results have been presented from three different methods of retrievals which have been applied to simultaneously acquired AASTR and Meris data over Mt. Etna during the 2002-03 eruption using same volcanic particles optical properties.
The AOT and Angstrom parameter resulting from MERIS identify two volcanic plumes: the main eruptive one composed of bigger particles (> 1 μm) and a second composed of smaller particles.
The ORAC forward model retrieves aerosol optical depth at 0.55 μm and effective radius for the eruptive plume.

The BTD calculates ash particle size and the total ash mass resulting in 11440 t. The comparison shows that the ash plume is well identify by the tree method. Each one add a parameter that characterize the plume. The methods that use Visible channels are most sensitive to the finer particles while BTD methods using TIR is well suited for ash component retrieval.

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