ROBUST SATELLITE TECHNIQUES (RST) FOR ACTIVE VOLCANOES MONITORING

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1. INTRODUCTION

From decades satellite remote sensing is used to study and monitor active volcanoes thanks to global coverage and high frequencies of observation at generally low costs. Among the more recent satellite techniques developed for thermal volcanic activity monitoring an original scheme of data analysis, named RST (Robust Satellite Techniques, [1]), has shown high performances in detecting hotspots, assuring a high reliability under different observational conditions, together with a good sensitivity to subtle hotspots [2]. Such an approach has been implemented in automatic processing chain developed at Institute of Methodologies for Environmental Analysis of National Research Council and at Department of Engineering and Physic of the Environment of University of Basilicata (IMAA-DIFA) in order to monitor Italian volcanoes in near real time, processing data provided by NOAA-AVHRR (National Oceanic and Atmospheric Administration-Advanced Very High Resolution Radiometer) and EOS-MODIS (Earth Observing System-Moderate Resolution Imaging Spectroradiometer) polar satellite platforms [3]. Recently, this method has also been implemented MSG-SEVIRI (Meteosat Second Generation-Spinning Enhanced Visible and InfraRed Imager) sensor data, particularly suitable to monitor space-time evolution of thermal volcanic phenomena in a quasi-continous way (thanks to best frequency of observation currently available of 15 minutes). In this paper, some recent RST results will be presented. The potential of geostationary satellite sensors like SEVIRI for a prompt volcanic hotspot detection will also be analyzed and discussed.

2. RST APPROACH

The RST approach computes a local variation index, named ALICE (*Absolutely Local Index of The Change of Environment*), in order to automatically identify hotspots. Such an index compares each satellite signal acquired in the MIR spectral band, the most suitable to identify high temperature surfaces, with its normal behavior,

derived processing long-term historical series of homogenous satellite records [2]. The ALICE index gives an indication of the relative hotspot intensity, with higher value of this index related to stronger thermal anomalies.
The ALICE index is for construction intrinsically protected by local and atmospheric effects [2], assuring a high level of reliability under different observational (day/night) and atmospheric conditions [2], even thanks to the application of an original cloud mask procedure on daytime data [4,5]. Different levels of the ALICE index are generally used in order to discriminate volcanic hotspots, with lower levels of the same index more suitable to identify subtle thermal anomalies. As an example, some possible thermal precursors were detected a few days before the Mount Etna eruption of 27 October 2002, just in the area where a new fissure opened [2,6].
In next section, recent RST results of satellite monitoring of active volcanoes will be shown and discussed.

3. RESULTS

Starting from the beginning of November 2009 a new eruptive activity, still in progress at time of writing, has taken place at Stromboli and Etna volcanoes (Italy). These eruptions have been monitored in near real time by the automatic system developed at IMAA-DIFA, which generates hotspot products in a few minutes after the sensing time, processing NOAA-AVHRR and EOS-MODIS data. Such products report geographic location and relative intensity of detected thermal anomalies, together with date and time of hotspot detection, sensor which made the sensing, etc.

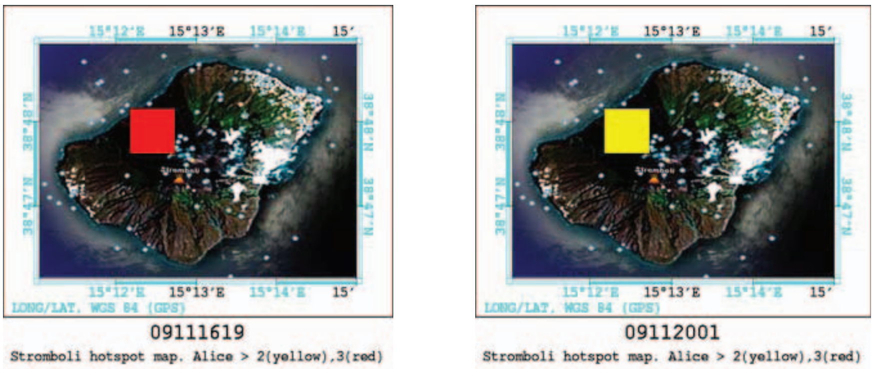

Fig. 1: Example of thermal anomaly maps automatically generated at IMAA-DIFA during the Stromboli eruption of 16 and 20 November 2009. High intensity hotspots are depicted in red, low intensity hotspots are depicted in yellow

In Fig.1 two examples of volcanic hotspot maps are reported. The figure shows as the same AVHRR pixel, detected as a thermal anomaly on the eastern flank of Stromboli volcano, had a variation in intensity on two different AVHRR overpasses, in accordance with field observations [7].
After four months of quiescence, a new eruptive activity has also began at Mount Etna. In Fig. 2 some low intensity hotspots correctly detected by RST, related to gas emissions from summit craters [7], are reported. These

results confirm RST sensitivity in detecting subtle hotspots, as well as in monitoring space-time evolution of thermal volcanic phenomena. The recent implementation of RST on SEVIRI data has shown that sudden and abrupt increases in thermal signal, related to the beginning of new eruptive events, may also be successfully recognized. A strong explosion at Jebel al Tair volcano (Red Sea, Yemen) of 30 September 2007 was, in fact, timely identified [8] some hours before the first MODVOLC warning [9,10]. Another abrupt change in thermal signal was also promptly detected at beginning of a new eruptive event at Mount Etna [11]. The latter, could be potentially identified even half an hour before, and with a higher signal to noise ratio, using an advanced version of RST approach currently under test. These preliminarily results suggest that further improvements of RST in terms of sensitivity are possible, and may be suitable to better identify low intensity thermal signals at volcanoes.

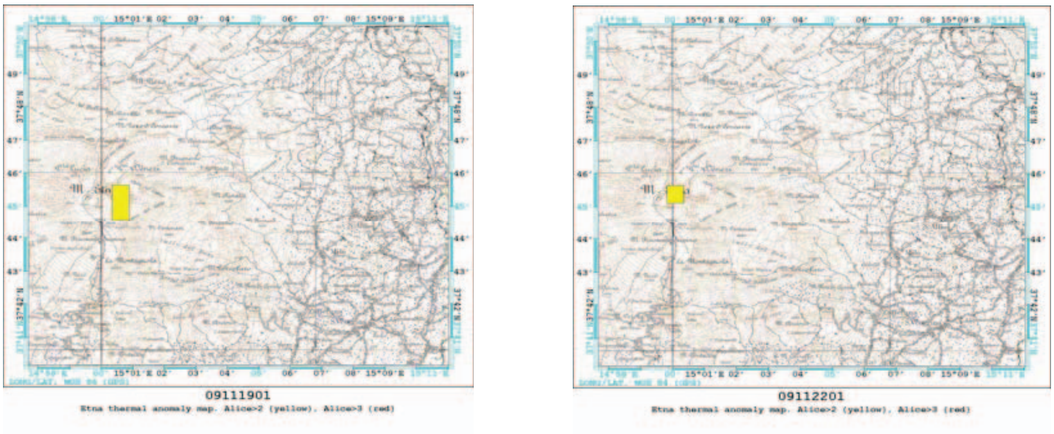

Fig. 2: Thermal anomaly maps automatically generated at IMAA-DIFA during the last Mt. Etna activity on 19 and 22 November 2009. Detected hotspots, of low intensity, are depicted in yellow on the maps.

4. CONCLUSIONS

In this paper some recent RST results of satellite monitoring of active volcanoes have been presented. An advanced configuration of RST approach is also currently under test, in order to verify possible improvements in volcanic hotspot detection. Its implementation on SEVIRI data, which assure a reduction of observational noise, thanks to a natural co-location of satellite images and more homogeneous time slots, should further increase RST performances in timely identifying hotspots, allowing us to better identify low intensity anomalous thermal signals, sometimes occurring before new volcanic eruptions.

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