

A MULTI-SENSORS ANALYSIS OF RST-BASED THERMAL ANOMALIES IN THE CASE OF THE ABRUZZO EARTHQUAKE

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1. INTRODUCTION

The appearance of space-time anomalies in TIR (thermal infrared) satellite imagery, from weeks to days, before severe earthquakes is reported in several studies. Different authors, in order to explain the appearance of anomalously high TIR records near the place and the time of earthquake occurrence, attributed their appearance to the increase of green-house gas (such as CO₂, CH₄, etc.) emission rates, to the modification of ground water regime and/or to the increase of convective heat flux ([1] and reference herein). Among the others, a Robust Satellite data analysis Technique (RST, [2]), based on the RAT - Robust AVHRR (Advanced Very High Resolution Radiometer) Techniques – approach [3], was proposed to investigate possible relations between earthquake occurrence and space-time fluctuations of Earth's emitted TIR radiation observed from satellite. RST was already applied at first in the case of the disastrous 1980 Irpinia-Basilicata earthquake ([4], [5]), then it was successfully tested in the case of other tens of earthquakes ([1], [6], [7], [8], [9], [10], [11], [12], [13], [14]) occurred in different continents (Europe, Asia, America and Africa), in various geo-tectonic settings (compressive, extensional and transcurrent) and with a wide range of magnitudes (from 4.0 to 7.9).

2. METHODOLOGY

The RST analysis is based on a statistically definition of “TIR anomalies” and offers a suitable method for their identification even in very different local (e.g. related to atmosphere and/or surface) and observational (e.g. related to time/season, but also to solar and satellite zenithal angles) conditions. Its application to EQ prone areas has been always carried out by using a validation/confutation approach in order to verify the presence/absence of anomalous space-time TIR transients in the presence/absence of significant seismic events. Anomalous TIR patterns are identified by using a specific index, RETIRA (Robust Estimator of TIR Anomalies; [10], [14]) to be computed on the image at hand as in the equation below:

$$\otimes_{\Delta T}(\mathbf{r}, t) = \frac{\Delta T(\mathbf{r}, t) - \mu_{\Delta T}(\mathbf{r})}{\sigma_{\Delta T}(\mathbf{r})}$$

where, $\Delta T(\mathbf{r}, t) = T(\mathbf{r}, t) - T(t)$, is the value of the difference between the punctual value of the brightness temperature $T(\mathbf{r}, t)$ at the location $\mathbf{r} = (x, y)$ and acquisition time t , and its spatial average $T(t)$ over the area of interest; $\mu_{\Delta T}(\mathbf{r})$ and $\sigma_{\Delta T}(\mathbf{r})$ are the time average and standard deviation of $\Delta T(\mathbf{r}, t)$ obtained for each location $\mathbf{r} = (x, y)$ using cloud free records belonging to a homogeneous data set of observations collected in different (at least 5) years in similar (same month, same time of the day, etc.) observational conditions.

3. DATA ANALYSIS AND RESULTS

In this work, the results of RST analysis performed over the Italian peninsula at the time of the Abruzzo earthquake (April 6, 2009; Ml 5.8) are presented (see for example figure 1) and compared with an identical analysis (confutation) performed in a seismically unperturbed year. 28 years of TIR satellite records collected by 3 satellite systems (5 years of MSG/SEVIRI, 15 years of NOAA/AVHRR and 8 years of EOS/MODIS) have been used to characterize the expected signal behavior in unperturbed conditions. Note that significant (space-time persistent) TIR anomalies appear in some space-time correlation with the 3 main EQs occurred in Italy in the considered period; no similar results have been observed in confutation (year 2008).

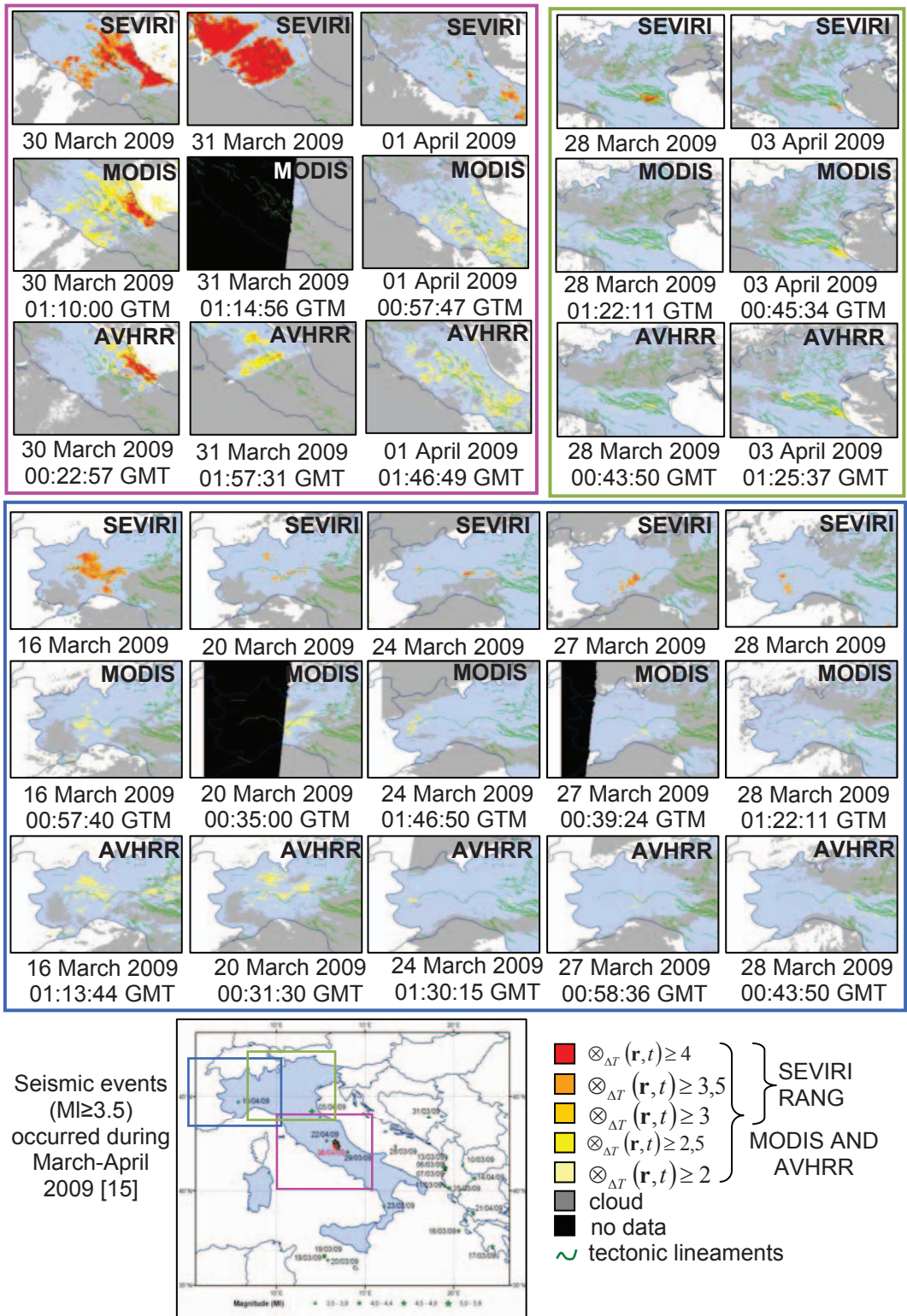


Figure 1 – Validation analysis. Only SEVIRI images at 00:00 GMT having pixels with RETIRA>4 are reported (and compared with MODIS and AVHRR) and grouped according with their space/time persistence. Upper left side: Abruzzo EQ sequence; upper right side: Forlì (5 Apr 09, M=4,6); central part: Bra EQ (19 Apr 09, M=3,9), bottom side: earthquakes (MI≥3.5) during March-April '09[15] .

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