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Satellite-based investigation of anomalous nocturnal TIR gradients possibly associated to impending earthquakes in Italy

Nicola Genzano[1], Roberto Colonna[1], Carolina Filizzola[2], Mariano Lisi[1], Nicola Pergola[2] and Valerio Tramutoli[1]

[1] School of Engineering, University of Basilicata, Potenza, Italy
[2] Institute of Methodologies for Environmental Analysis of the National Research Council, Tito Scalo (PZ), Italy

nicogenzano@gmail.com

Abstract. Several satellite data analysis methodologies have been proposed until now highlighting anomalous space-time transients of Earth's emitted TIR (Thermal InfraRed) radiation in some relation with earthquake occurrence. Among these, the general change detection approach named RST (Robust Satellite Techniques, Tramutoli 1998, 2007) has been successfully applied to time-series of satellite TIR radiances for long term (>10 years) studies performed over Greece (Eleftheriou et al., 2016), Italy (Genzano et al, 2020), Japan (Genzano et al., 2021) and Turkey (Filizzola et al., 2022).

Multi-annual monthly averages (and standard deviations) computed at each location (x,y) were used as reference in order to identify (and classify in terms of relative intensities) thermal anomalies possibly related to earthquakes occurrences.

In order to reduce false positive proliferation due to occasional warming (related to the year-to-year climatic changes and/or season time-drifts which usually affect near-surface temperature at a regional scale, Tramutoli et al., 2005), in all the previously quoted papers, instead than the TIR radiance $T(x,y,t)$ (measured at the time t at the location (x,y)) the excesses $\Delta T(x,y,t) = T(x,y,t) - T(t)$ were considered being $T(t)$ the spatial average of $T(x,y,t)$ over the whole image. This way just local anomalous $T(x,y,t)$ transients are expected to be identified filtering-out those due to larger scale effects. The limitations related to this approach have been firstly reported by Aliano et al. (2008) who denounced the strong dependence of $\Delta T(x,y,t)$ values on clouds spatial distribution across the scene with possible proliferation of spurious TIR anomalies in the warmer part of the scene.

In this paper a more simple and efficient way to identify TIR anomalies even in presence of a variable (at large scale) background is proposed by applying the same RST methodology to the night-time TIR temporal gradients $T(x,y,t+\Delta t) - T(x,y,t)$ which are expected to be normally negative in the last hours of the night. As a consequence of a "nocturnal heating effect" (NHE) - firstly reported by Bleir et al. 2009 in relation with earthquakes occurrences, such gradients are instead expected to increase (even up to reach positive values). The identification of such

anomalous nocturnal TIR gradients (which are intrinsically protected from meteorological/climatological warming effect) can be performed operating on a single pixel at a time without the need to use of $\Delta T(x,y,t)$ values which can be conditioned by the distribution of meteorological clouds across the scene. Main advantages and the impact of this different approach in reducing false positives will be presented with reference to recent earthquakes occurred in Italy (e.g. Amatrice earthquake, August 24, 2016, Mw 6.0).

Keywords: TIR anomalies, Seismic hazard forecast, Satellite Remote Sensing, Robust Satellite Techniques (RST), Nocturnal Heating Effect

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