

Robust Satellite Techniques for thermal monitoring of seismically active areas: main findings and methodological advances

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Abstract

Over the past decades, long-term studies have been conducted to investigate the potential spatial-temporal correlations between anomalies in Earth's thermally emitted infrared (TIR) radiation and earthquake occurrence. These investigations have utilized TIR data acquired from both geostationary and polar-orbiting satellites across several seismically active regions worldwide.

The Robust Satellite Technique (RST), applied to ultra-decadal TIR data across different seismic contexts, has enabled the identification of Significant Sequences of TIR Anomalies (SSTAs) potentially associated with impending earthquakes. These anomalies are rare (<0.05% of the analyzed space-time domain) and exhibit a false positive rate of approximately 25%, varying by region. Molchan error diagram analyses support a non-random correlation between SSTAs and the occurrence of seismic events. However, the RETIRA (Robust Estimator of TIR Anomalies) index, previously used for anomaly detection, suffers from limitations due to its reliance on large-scale thermal background estimations, which are sensitive to meteorological cloud cover. To address this, a novel indicator—RETIRSA (Robust Estimator of TIR Slope Anomalies)—has been developed, enabling local-scale filtering of transient warming events without large-scale averaging.

This study presents a critical review of the main findings and methodological advancements gained during the past twenty years of research. In particular, we discuss the results obtained through the application of the RST to long-term (>10 years) TIR datasets from geostationary sensors, including SEVIRI (onboard MSG) over Greece, Italy, and Turkey, and JAMI and IMAGER (onboard MTSAT satellites) over Japan, as well as the preliminary results achieved by using the RETIRSA index in recent earthquake worldwide.