



## **Multi-sensor Integration of Space and Ground Observations of Pre-earthquake Anomalies Associated with M6.0, August 24, 2014 Napa, California**

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We integrate multiple space-born and ground sensors for monitoring pre-earthquake geophysical anomalies that can provide significant early notification for earthquakes higher than M5.5 worldwide. The latest M6.0 event of August 24, 2014 in South Napa, California generated pre-earthquake signatures during our outgoing tests for California, and an experimental warning was documented about 17 days in advance.

We process in controlled environment different satellite and ground data for California (and several other test areas) by using: a) data from the NPOES sensors recording OLR (Outgoing Longwave Radiation) in the infrared; b) 2/GNSS, FORMOSAT (GPS/TEC); c) Earth Observing System assimilation models from NASA; d) ground-based gas observations and meteorological data; e) TIR (Thermal Infrared) data from geostationary satellite (GOES). On Aug 4th, we detected (prospectively) a large anomaly of OLR transient field at the TOA over Northern California. The location was shifted in the northeast direction about 150 km from the Aug 23rd epicentral area. Compared to the reference field of August 2004 to 2014 the hotspot anomaly was the largest energy flux anomaly over the entire continental United States at this time. Based on the temporal and spatial estimates of the anomaly, on August 4th we issued an internal warning for a M5.5+ earthquake in Northern California within the next 1-4 weeks.

TIR retrospective analysis showed significant (spatially extended and temporally persistent) sequences of TIR anomalies starting August 1st just in the future epicenter area and approximately in the same area affected by OLR anomalies in the following days.

GPS/TEC retrospective analysis based on GIM and TGIM products show anomalies TEC variations 1-3 days, over region north from the Napa earthquake epicenter. The calculated index of atmospheric chemical potential based on the NASA numerical Assimilation weather model GEOS5 indicates for abnormal variations near the epicentral area days before the quake;

Our real-time and post-event integration of several atmospheric parameters from satellite and ground observations during the M6.0 on 08.24.2014 in Napa California demonstrated the synergy of related variations of these parameters implying their connection with the earthquake preparation process.