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An earthquake precursor- Outgoing Longwave Radiation (OLR) observed over the Indian and Indonesian regions during high-magnitude earthquakes (M≥ 6.0)

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ABSTRACT

The Earth prepares itself before an earthquake and during this time, several precursory signs have been seen across the ocean, land, and atmosphere. Earthquakes inflict significant harm to both human lives and property. Therefore, monitoring and understanding the strange behaviour of various geophysical parameters as precursors, have become extremely important. The Outgoing Longwave Radiations (OLR), emitted by the surface during the recent ten high-magnitude (M ≥6.0) earthquake (EQs) events, have been examined in the present work using the Data on OLR from the NCEP website. To analyse the OLR as precursory signatures of earthquakes, the climatological analysis for the seismic precursor identification (CAPRI) methodology was carried out. An apparent change in the OLR during 2 months before the earthquake events was observed. The maximum and minimum anomalies in OLR before all ten events were analysed. The maximum and minimum anomalous increase in OLR varied from 1.16 to 1.25 and 0.71 to 1.11 times greater during the earthquake years compared to historical time series respectively, during all the ten EQ events. The study indicates a strange shift in Outgoing Longwave Radiation during periods, influenced by the seismic activity. The extent of anomalies in OLR during earthquake events is maximum over the ocean than on the land. This is because the accumulation of water vapour traps the outgoing radiation, causing an elevation in temperature over the epicentre and Earthquake Preparation Zone (EPZ)

Keywords: - Earthquake precursor, Outgoing Longwave Radiation (OLR) anomaly, Earthquake Preparation Zone (EPZ), High magnitude earthquakes, Epicentre. India and Indonesia

INTRODUCTION

Earthquakes are highly destructive natural disasters that occur without warning, making prediction crucial for impact mitigation. Despite efforts, precise prediction remains challenging due to the complexity of seismic events. The various ground, atmospheric, and ionospheric precursors have been studied over the past few decades, offering insights into potential early warning signs. These precursors range from ground deformation (Pulinets and Boyarchuk, 2004), mechanical deformation (Niu, 2008), gas emissions (Pulinets et al., 2003), electromagnetic precursors (Uyeda et al., 2009), changes in ionospheric parameters (Liu et al., 2004), and thermal anomaly (Pulinets et al., 2006; Zhang et al., 2013; Bardhan et al., 2022; Ghosh et al., 2024; Sharma et al., 2024; Qasim et al., 2024).

This work examines thermal precursors, which are temperature anomalies in the Earth's crust or near-surface environment that occur before seismic activities. Thermal anomalies have been detected in areas of earthquake preparation zones, several days prior to the seismic events (Tronin et al., 2002; Tramutoli et al., 2005) and are often attributed to thermal flux emanating from the Earth's crust in seismically active regions (Ouzounov and Freund, 2004). Several investigations about the occurrence of pre-earthquake thermal anomalies in locations like India, Japan, China, Sumatra, Italy, Iran, and Haiti, have been studied by several researchers (Tronin et al., 2002; Ouzounov and Freund, 2004; Tramutoli et al., 2005; Choudhury et al., 2006).

Schulz et al. (1997) observed latent heat anomalies associated with earthquakes, using remote sensing satellite data. In various regions of the world, efforts have been initiated to utilise thermally associated satellite observations to identify anomalous indicators connected to earthquakes, which include infrared/microwave brightness temperature (Jing et al., 2018), surface temperature (Tronin et al., 2002), air temperature (Weiyu et al., 2018), OLR (Ouzounov et al., 2007), and Surface Latent Heat Flux (SLHF) (Bardhan et al., 2022; Sharma et al., 2024). In the epicentral zones and along the faults, these anomalous thermal signals were observed for two months before significant earthquakes (Pulinets et al., 2006).

A key parameter used to describe Earth's radiation environment is the measurement of Outgoing Longwave Radiation (OLR) (Liebmann and Smith, 1996). The Earth's surface absorbs solar energy in the form of shortwave (SW) radiation. Due to the surface's low thermal conductivity, the absorbed heat doesn't penetrate deeply. Instead, it is mostly re-emitted at night as long wavelength radiation (LWR) energy. OLR which is associated with the top of the atmosphere, integrates emissions from the ground, lower atmosphere, and clouds and is primarily used for studying Earth's radiative budget and climate dynamics (Gruber and Krueger, 1984).

Several research studies have been performed related to OLR (Ouzounov et al., 2007; Rawat et al., 2011; Fu et al., 2020). Studies have revealed that abnormal thermal patterns, identified through OLR or thermal infrared radiation (TIR), frequently emerge prior to or during the earthquake preparation phase (Tramutoli et al., 2005; Pulinets et al., 2006). Rawat et al. (2011) studied earthquakes in the Indian and Italy regions and found 30-45 Wm^{-2} more energy than the normal period at the Earth's surface. Shah et al. (2019) reported significant OLR anomalies up to 21 days before major earthquakes in Pakistan