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Study of Outgoing Long-Wave Radiations for Pre-Earthquake Signals for Pakistan Earthquake

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A B S T R A C T

The catastrophic nature of earthquake and their prediction and forecasting are complex problems, several scientific groups are engaged on this global issue. Scientists have retrospectively analyzed the 2011 Japan earthquake and using a variety of metrics, including GPS/TEC, foF2 layer, lower Earth orbit ionospheric tomography, and Outgoing Long-wave Radiation (OLR). The results of this investigation demonstrate the significant fluctuations in OLR parameters both time and space was seen few days before the Awaran, Pakistan earthquakes occurred on 24 September 2013. Ahead of the approaching earthquakes, thermal anomalies appear and are monitored above cloud cover as well as at the ground surface. Results justified the LAIC mechanism, which viable explanation for the development of a brief anomaly before to the catastrophic earthquake and suggested that the process may have been escape gases such as radon from the lithosphere along the Awaran, Pakistan faulting zone

Keywords: Catastrophic, Prediction, OLR parameters, Thermal Anomalies, Atmosphere

1. Introduction

According to the catastrophic nature of earthquakes, research on earthquake prediction and forecasting are one of the difficult task, several seismologist are engaged on earthquake prediction based research. Numerous attempts have been performed for earthquake prediction by various experts during last 20 years. The natural occurrence of earthquakes is brought about by the movement of tectonic plates, which causes them to rupture and deform1. The study of seismic events and seismic prediction are topics that spark intense discussion because to the complexity and difficulty of seismic tectonic systems. But as seismic and linked Global Navigation Satellite System (GNSS) technologies advance, it will be useful to identify the features of earthquake-induced ionosphere temporal and spatial disturbances. Anomalies arise in the ionosphere when it is disturbed by natural disasters like earthquakes, volcanic eruptions, magnetic storms, and solar flares; in contrast, the TEC remains relatively constant when the ionosphere is untouched by these external factors. Among natural disasters, earthquakes are among the most devastating and costly to civilization. Seismic waves, when they reach the surface of the land or sea, go vertically upwards. A coseismic ionospheric disturbance is an abnormality that develops in the ionosphere as a result of the seismic wave's effect on the total electron content. In the past, researchers have documented electromagnetic signals associated with powerful earthquakes over a wide variety of frequencies, including DC/Ultra Low Frequency (ULF), ELF, VLF, LF, and HF. Multidisciplinary approach by using the space and ground based satellite missions are used to identify the earthquake precursory signal before and after the impending earthquakes are shown in the figure 1. The development of unusual electric signals is one of the oldest known precursor for catastrophic earthquakes, explanation shown that the anomalous electric signals prior for approaching earthquakes and its recognized by streaming electro kinetic model. Several other explanations was also found that the perturbation of the electric current by resistivity anomaly and single rock fracturing model was put by Varotsos and Alexopoulos and it was famously introduced known as the VAN method which was highly recognized by piezo-stimulated model. This approach is the actual correlations which have been identified association between the earth electric signal and seismic activity. In the year 1964, Alaska earthquake preceded the ionospheric anomaly this phenomenon which often occurs at few hundred kilometers above the earthquake preparation zone, ionospheric anomalies and concentration of ionospheric electrons which are most likely to be the result of vertical ground electrical fields penetrating in the ionosphere. The rate of seismic energy buildup, infrasonic waves, geo-electric, crustal stress, animal behavior, magnetic storm, tide-generating force resonance, and satellite thermal data were among the precursory research demonstrated by Van Genderen. The incidence and size of oscillating current induced by a constant and oscillating ionosphere, the amplitude in which the rises onset phase of large earthquakes and are explained by different model known as the ionospheric induction model. In the year 1999, Chamoli earthquake is shown Very Low Frequency (VLF) electric field disturbances are seen as noise bursts just 16 days before the main shock. Friedemann introduced the "positive holepairs" model in 2002. In which anomalous signal may causes minerals to crystallize by introducing positive hole-pairs (PHP) into the crystal lattice. Electric signals are produced, when PHP becomes mobile and creates quickly moving charge clouds as a result of micro-fracturing in the crystal lattice. Increased stress along the fault segment alters the properties of the rock before any catastrophic earthquakes, all changes provides various precursory signals that motivate scientists to conduct multidisciplinary research for earthquake precursor. It is suggested dividing the world into 29 zones, and an early warning system has been put in place to identify those areas where there is a chance that an earthquake of more than a magnitude may occur within the next 30 days. Scientists have retrospectively analyzed the 2011 Japan earthquake using a variety of metrics, including GPS/TEC, foF2 layer, lower Earth orbit ionospheric tomography, and Outgoing Long-wave Radiation (OLR). Measurements of the OLR are possible above cloud cover (16–17 km above sea level). An abnormal increase in tectonic activity in a particular region is typically responsible for the observed increase in radon gas emissions in the vicinity of the epicenter of an earthquake. This, in turn, causes variations in air humidity to cause ionization of the nearby air and latent heat exchange. The emergence of thermal anomalies before to approaching earthquakes may be caused by this phenomenon. OLR's are energy radiations that go to space as low-energy infrared radiation from the Earth. A number of studies have been published recently that were based on the observation of notable transitory temperature anomalies preceding catastrophic earthquakes. For instance, it was discovered through OLR study for the 2004 Sumatra earthquake that an OLR anomaly of >80 W/m2 manifested five days before to the event. Transient OLR abnormalities did occur before the most recent significant earthquakes in places like Sichuan, China (M 7.9, 2008), L'Aquila, Italy (M 6.3, 2009), Samoa (M 7, 2009), Haiti (M 7.0, 2010), Chile (M 8.8, 2010), and Japan (M 9.0, 2011). These results are investigated and demonstrate significant fluctuations in both time and space which seen few days before the powerful earthquakes.

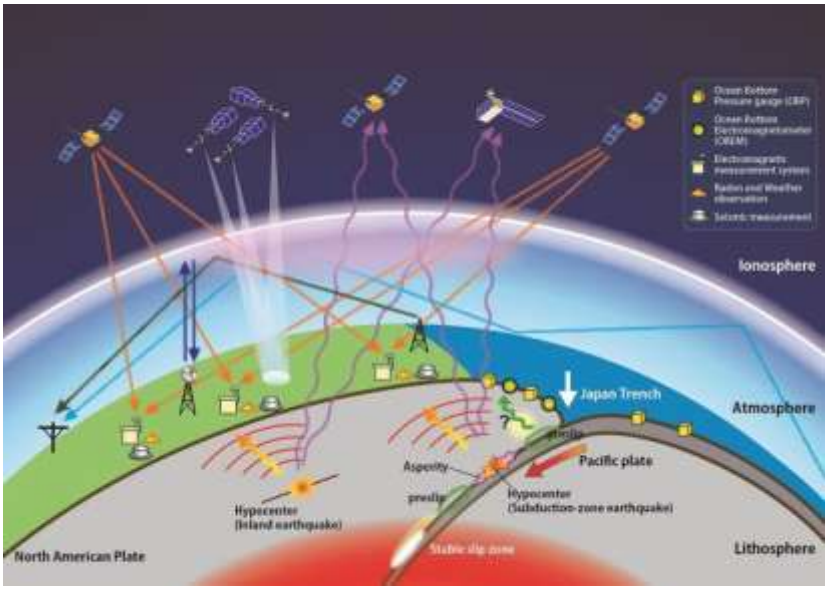

Fig 1 Satellite and Ground Based Technique for Earthquake Precursor

2. Data Methodology

The National Oceanic and Atmospheric Administration (NOAA) satellite data system observed total OLR radiation for investigation the earth radiation, present methodology is investigated the possible correlation between seismic activities with measured real-time OLR (NOAA) satellites data which are available on http://www.cdc.noaa.gov. The NOAA, Climate Prediction Center (http://www.cdc.noaa.gov) provides an algorithm for analyzed the Advanced Very High Resolution (AVHRR) in the range of 8–12 radiometers. To generate the OLR data which are characterize the radiation and an unusual flow of latent heat over the seismic region which are likely to increasing tectonic activity in an around the seismic zone. Short-lived thermal abnormal radiation may be associated with atmospheric thermodynamic processes as well as tectonic stress. The Lithospheric–Atmospheric–Ionospheric Coupling (LAIC) may required critical energy to identify the changes in the OLR flux in space-time it is necessary to select the earthquake has magnitude greater than 5. To calculate the anomalous OLR flux over the seismic region, change in critical energy index. In the present research work Pakistan earthquake occurred on 24, September 2013 is selected with magnitude 7.7 with depth 10 km at Awaran, Pakistan. This region is highly tectonic belt in the southern Pakistan area comes under the Arbain subduction zones, several faults are responsible for earthquake in this region. To measure the OLR in the above region OLR measurement is the mixture of radiations from the ground, lower atmosphere, and clouds, OLR analysis algorithm are used to find the anomalous radiation and statistically determined value of maximum change in the rate of OLR for a particular space and time with geographical locations during the Pakistan seismic event. To precise and accurate measurements of real-time analysis of real-time OLR data be interpreted correctly and meaningful, NOAA/AVHRR OLR daily data between 2006 and 2012 are used as a standard values, OLR real-time values which computed prior to the occurrence of 24 September 2013 Awaran, Pakistan earthquakes. To determine the change in energy index, the difference between the daily current field OLR and the daily base field OLR has to be determined. If the value is greater than the "+2 sigma" confidence limit in the base field OLR, the corresponding change in energy index is considered abnormal. The short-term OLR anomaly is noticeable before the earthquake mentioned earlier. It would be wrong to say that the occurrence of OLR anomaly is often related to the intensity of the earthquake because sometimes there are some external factors which are related to the intensity of the earthquake which may occur several days / months before the earthquake. The critical energy calculations in terms of OLR's value are as follows:

$$dE_{index} = \frac{Daily\ current\ field\ OLR - Daily\ base\ field\ OLR}{Standard\ Deviation}$$

3.Results

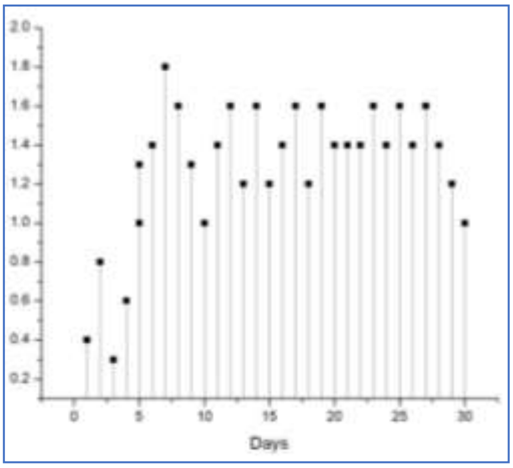

Fig 2 OLR energy index value over the Seismic Region

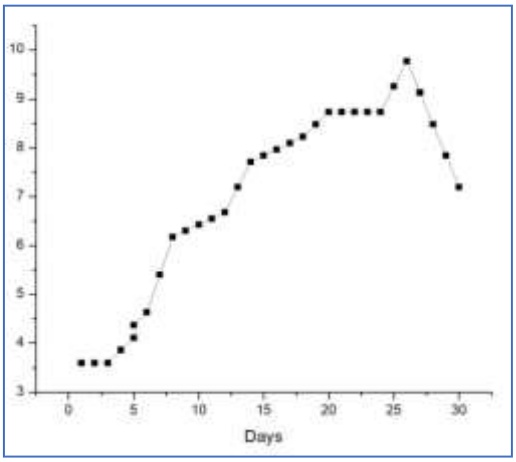

Fig 3 OLR energy flux value over the Seismic Region

In the figure 2, OLR energy index value over the seismic region shows the vertical bar chart where the x-axis represents the days likely from day 1- day 30 and y –axis represents the OLR energy index ranging from 0.2 to 2.0. Based on these results, the variation in the Outgoing Longwave Radiation (OLR) energy index over a seismic region across a 30-day observation window, the values demonstrate fluctuating OLR indices, with a significant number of days recording peaks around 1.4–1.8 units. These elevated OLR values, particularly concentrated between Days 8 to 25, which may suggest increased thermal anomalies associated with lithospheric processes prior Pakistan earthquake. In the figure 3, OLR energy flux value over the Awaran, Pakistan Seismic Region, x-axis represent the days from 1-30 and y-axis shown the OLR (Outgoing Longwave Radiation) energy flux values (ranging from 0 to 13). The results trends shows the gradual increase in OLR energy flux from day 0 to around day 10, steeper rise between day 10 and day 20 and peak around day 25 (value around 12) which decline from day 25 to day 30.

4. Conclusions

The LAIC mechanism, behind this studies as a viable explanation for the development of OLR anomaly before to the catastrophic Awaran Pakistan earthquake, it is suggests that the process may have been set off by the escape of gases such as radon from the lithosphere around the faulting zone as a result atmospheric air becomes more ionized over the seismic region. Due to atmospheric conductivity varies and condensation of the ionized gases releases latent heat over the seismic region. The atmospheric energy flux is the dynamic processes and suggested the LAIC model for seismic prediction. The results are shown that the OLR values are changes during the process of Awaran Pakistan earthquake and analyzed data from the NOAA satellites revealed that the OLR anomaly can be used as a trustworthy pre-earthquake signal. Such anomalies can be indicative of potential seismic precursors which may often used in geophysical or atmospheric science studies to observe anomalies in OLR values and it can be linked to seismic activity which reinforcing the hypothesis that OLR monitoring can be a useful tool in earthquake-related studies.

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