JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

EARTHQUAKE EARLY WARNING FROM SPACE?

INVESTIGATING M8+ EARTHQUAKES AND Kp-INDEX FLUCTUATIONS

[1]A.Stanley Raj, [2]S.S.Abimanyu, [3]M.C.Roshan Raj, [4]T. Infant Jessly, [5]Aaron Samuel
[1,2,3,4,5] Department of Physics, Loyola College, Chennai, Tamil Nadu-600034, India.

Abstract : Earthquakes, primarily driven by tectonic plate movements, are notoriously difficult to predict due to the complex interplay of numerous factors. While seismic studies offer valuable insights after an event, they lack predictive power. This research explores a novel approach, investigating the potential link between Earth's magnetic field variations and large earthquake occurrences (magnitude > 8.0). We analyze the Kp-index, a ground-based measure of geomagnetic activity, to assess potential anomalies preceding earthquake events. This study aims to determine the significance of magnetic field variations as a precursor to major earthquakes in specific regions. The findings contribute to the ongoing quest for improved earthquake prediction methods, potentially leading to enhanced mitigation strategies and early warning systems.

Keywords- *Earthquake prediction, Magnetic field anomalies, Kp-index, Tectonic plates, Seismic studies*

I. Introduction:

Earthquake prediction is one of the biggest challenges as put forth by nature in front of mankind. It is a complete controversial topic of interest whether the prediction is plausible or impractical [1, 2, 3, 8]. Earthquake prediction is necessary to save the lives of many peoples. Though the problem is complex many researchers tried to attempt for attaining the clues involved in earthquakes. One such result is from anomalous behaviour of magnetic field during earthquake occurrence [1, 4, 5, 6, 7, 9, 10, 12, 13, 14, 15, 16, and 18]. Large number researchers studied the behavior of earthquakes using ground based instruments and satellite based instruments. The purpose of this study is to identify any significance in magnetic field anomalies over earthquake disturbance.

II. Methodology:

Geomagnetic Activity

Because of the solar wind originating from the Sun, Earth is hit by a hot, magnetized, supersonic collision less plasma carrying a large amount of kinetic and electrical energy. Some of this energy finds its way into our magnetosphere creating, e.g., geomagnetic activity which consists of storms and aurora. The Earth's magnetic field is generated in the fluid outer core by a self-exciting dynamo process. Electrical currents flowing in the slowly moving molten iron generate the magnetic field. The magnetic field of the earth has the sources in the earth’s core, in the crust and also in the ionosphere and magnetosphere. Kp index is a measure of Earth’s magnetic field from 13 magnetic observatories around the world. It varies from 0 to 9 in 3 hour intervals. Kp index is noted in logarithmic scale. In the International System of Units (SI), the unit of magnetic field is Tesla. At the Earth's surface the total intensity varies from 22,000 nanotesla (nT) to 67,000 nT. Other units are the Gauss (1 Gauss = 100,000 nT), the gamma (1 gamma = 1 nT) and the Oersted.

III. Interpretation and results

The main purpose of the standardized index Ks is to provide a basis for the global geomagnetic index Kp which is the average of a number of "Kp stations". Kp was introduced as a magnetic index by Bartels in 1949 and has been derived since then at the Institut für Geophysik of Göttingen University, Germany. Both K and Kp were officially adopted by the International Association for Terrestrial Magnetism and Electricity (IATME, which later became the International Association for Geomagnetism and Aeronomy, IAGA) in 1951 and the series of Kp was extended backwards to 1932 during the subsequent period. Kp and its related indices (ap, Ap, Cp) have been widely used in ionospheric and magnetospheric studies and are generally recognized as indices measuring worldwide geomagnetic activity. Table 1 shows the classification of kp index with appropriate values

Kp Index	B_H (nT)
0	0-5
1	5-10
2	10-20
3	20-40
4	40-70
5	70-120
6	120-200
7	200-330
8	330-500
9	>500

Table 2: Kp Index and Corresponding Magnetic Field Value

MERCALLI INTENSITY	RICHTER MAGNITUDE	DESCRIPTION
I-II	<2	Not felt by most people.
III	3	Felt by some people indoors, especially on high floors.
IV-V	4	Noticed by most people. Hanging objects swing, dishes rattle.
VI-VII	5	All people feel. Some building damage (esp. to masonry), waves on ponds.
VII-VIII	6	Difficult to stand, people scared or panicked. Difficult to steer cars. Moderate damage to buildings.
IX-X	7	Major damage, general panic of public. Most masonry and frame structures destroyed. Underground pipes broken. Large landslides.
XI-XII	8 and higher	Near total destruction.

Table 2 shows the impact of earthquake on environment

Detailed information regarding Major Earthquakes

Chile - 1960

Chile earthquake of 1960, the largest earthquake recorded in the 20th century. Originating off the coast of southern Chile on May 22, 1960, the temblor caused substantial damage and loss of life both in that country as a result of the tsunamis that it generated in distant Pacific coastal areas.

The earthquake hit at 3:11 PM approximately 100 miles (160 km) off the coast of Chile, parallel to the city of Valdivia. The shock is generally agreed to have had a magnitude of 9.5, though some studies alternately proposed that it may have been 9.4 or 9.6. A series of foreshocks the previous day had warned of the incipient disaster; one, of magnitude 7.9, caused major destruction in Concepción. The fault-displacement source of the earthquake extended over an estimated 560–620 mile (900–1,000 km) stretch of the Nazca Plate, which subducted under the South American Plate. As the quake occurred just prior to a revolution in seismologic technology in the 1960s, these figures are based mainly on post hoc analysis. Many Chilean cities, including Puerto Montt, where noticeable subsidence occurred, and Valdivia, where nearly half of the buildings were rendered uninhabitable, sustained significant damage. Though the havoc wreaked by the shaking was not inconsequential, most of the casualties resulted from the descent 15 minutes later of a tsunami that rose up to 80 feet (25 metres) high on the expanse of Chilean coastline—bounded by the cities of Lebu and Puerto Aisen—that paralleled the subducting plate. The combined effects of the disaster left two million people homeless. Though the death toll was never fully resolved, early estimates ranging into the thousands were scaled back to 1,655. About 3,000 people were injured. Fig. 1 shows the earthquake event and corresponding magnetic field variations on that day.

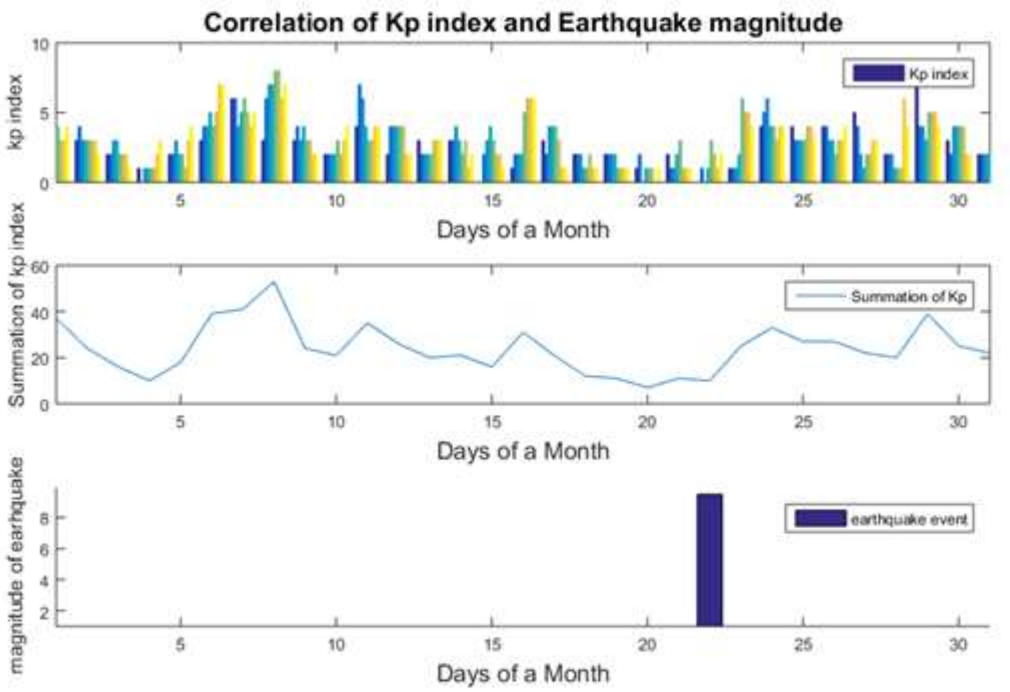

Figure 1 shows the earthquake event and corresponding magnetic field variations in Bio Bio Chile.

The enormity of the seafloor shifts that caused the tsunamis was such that the waves that arrived nearly 15 hours later in the Hawaiian Islands—6,200 miles (10,000 km) away—still crested at nearly 35 feet (11 metres) at landfall in some places. The waves caused millions of dollars of damage at Hilo Bay on the main island of Hawaii, where they also killed 61 people. When they reached the main Japanese island of Honshu 22 hours after their generation, the waves had subsided to about 18 feet (5.5 metres) and laid waste to over 1,600 homes and killed 138 people. In the Philippines, tsunami waves left 32 dead or missing. Though the oblique angle by which the waves approached the Pacific coast of the United States mitigated their force, Crescent City, California, saw waves of up to 5.6 feet (1.7 metres), and boats and docks in Los Angeles, San Diego, and Long Beach were damaged.

Alaska – 1964

Alaska Earthquake happened in March 27, 1964 with a magnitude of 9.2. It hit the Prince William region of Alaska. The rupture initially originated 25 km below the surface with the epicentre distance of 10 km east of College Fiord and 90 km West of Valdez and 120 km east of Anchorage. It lasted 4.5 minutes and it is one of the largest earthquakes in the history of United States after Chile earthquake in 1960. Fig. 2 shows the earthquake event and corresponding magnetic field variations on that day.

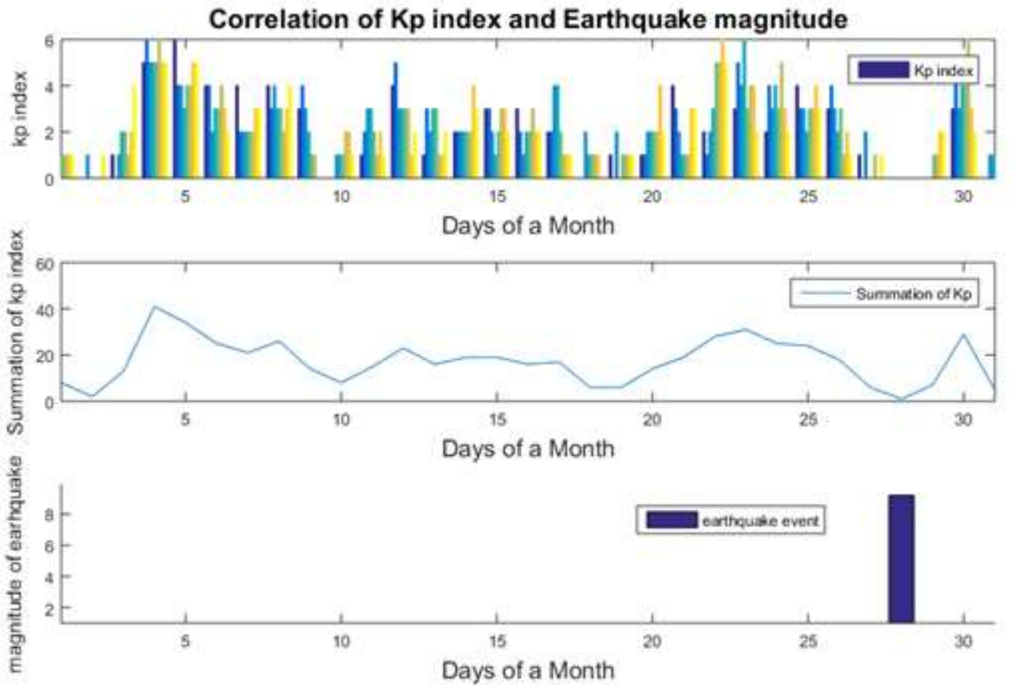

Figure 2 represents the earthquake event and corresponding magnetic field variations in Southern Alaska

Northern Sumatra - 2004

On December 26, 2004, at 7:59 AM local time, an undersea earthquake with a magnitude of 9.1 struck off the coast of the Indonesian island of Sumatra. Over the next seven hours, a tsunami—a series of immense ocean waves—triggered by the quake reached out across the Indian Ocean, devastating coastal areas as far away as East Africa. Some locations reported that the waves had reached a height of 30 feet (9 metres) or more when they hit the shoreline.

The tsunami killed at least 225,000 people across a dozen countries, with Indonesia, Sri Lanka, India, Maldives, and Thailand sustaining massive damage. Indonesian officials estimated that the death toll there alone ultimately exceeded 200,000, particularly in northern Sumatra's Aceh province. Tens of thousands were reported dead or missing in Sri Lanka and India, a large number of them from the Indian Andaman and Nicobar Islands territory. The low-lying island country of Maldives reported more than a hundred casualties and immense economic damage. Several thousand non-Asian tourists vacationing in the region also were reported dead or missing. The lack of food, clean water, and medical treatment—combined with the enormous task faced by relief workers trying to get supplies into some remote areas where roads had been destroyed or where civil war raged—extended the list of casualties. Long-term environmental damage was severe as well, with villages, tourist resorts, farmland, and fishing grounds demolished or inundated with debris, bodies, and plant-killing salt water.

The giant 2004 Sumatra earthquake ruptured the greatest fault length of any recorded earthquake, spanning a distance of 1500 km (900 miles), or longer than the state of California. Rather than tearing the land apart all at once, the rupture started beneath the epicenter marked in the figure below and progressed northward along the fault at about 2 km/sec (1.2 miles/second). The whole rupture lasted about 10 minutes. Compare this with California's 1994 Northridge earthquake, which ruptured about 20 km (12 miles) and lasted 15 seconds.

The portion of the fault that ruptured lies deep in the earth's crust, in places as much as 50 km (31 miles) below the ocean floor. There the two tectonic plates, which had been stuck together, suddenly broke free, the upper plate sliding back upward and to the west by as much as 20 m (65 feet) along the plate boundary. The rupture actually took about 10 minutes. The star is the centroid, the center of energy. (Courtesy Vala Hjorleifsdottir and Santiago Lombeyda).

When the crustal plates slipped during the earthquake, some islands in the subduction zone grew as they were lifted above the water line, while others tipped over and partially submerged as they subsided. The island in Figure 2 doubled in size during the quake; the land surrounding the green area shows how much this island was uplifted. On other islands, many homes were suddenly submerged as the land subsided during the quake.

As the rupture propagated, it caused the ocean floor to spring back to the west by as much as 6 m (20 feet), as well as uplift by 2 m (6 feet). The displacement of the ocean floor was as sudden as a hiccup, and shoved the water above it upwards. This giant push of water generated a series of tsunami waves, the first of which hit Sumatra 25 minutes after the start of the quake. The waves had grown to 100 feet (30 m) high in some places. More tsunami waves struck Thailand two hours later and other countries around the Indian Ocean were hit a few hours later. Fig. 3 shows the earthquake event and corresponding magnetic field variations on that day.

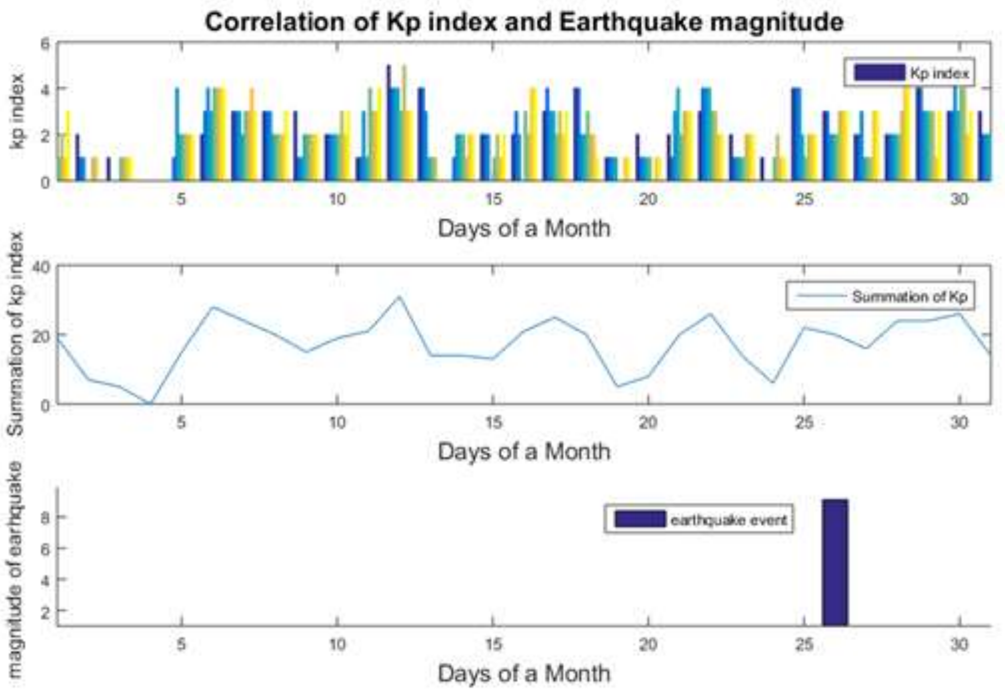

Figure 3 shows the earthquake event and Kp index variations of Northern Sumatra.

Japan - 2011

Japan earthquake and tsunami of 2011, also referred as Sendai earthquake or exquisite Tōhoku earthquake made excessive catastrophe that occurred in north eastern Japan. The event started with a effective earthquake off the north Japan coast of Honshu, Japan’s foremost island, which brought on big damage on land and initiated a sequence of massive tsunami waves that devastated many coastal regions especiallye the Tōhoku region (north eastern Honshu). The tsunami also instigated a major nuclear accident at electricity station along the coast. The earthquake magnitude 9.0 struck at 2:46 pm. (the early estimate of importance eight. 9 become later revised upward.) the epicentre is located a few 80 miles (130 km) east of the city of Sendai, Miyagi Prefecture, and the point of focus took place at a intensity of 18. 6 miles (approximately 30 km) below the ground of the western pacific ocean. The earthquake happened as a result of the rupture of a stretch of the subduction quarter associated with the Japan trench, which separates the Eurasian plate from the subducting pacific plate. (a few geologists argue that this portion of the Eurasian plate is simply a fraction of the north American plate referred to as the Okhotsk microplate.) The March 11 temblor becomes felt as a long way away as Petropavlovsk-Kamchatsky, Russia; Kao-Hsiung, Taiwan; and Beijing, China. It produced several foreshocks, including 7. 2 event centred approximately about 25 miles (40 km) far from the epicentre of the main earthquake. Fig. 4 shows the earthquake event and corresponding magnetic field variations on that day. The surprising horizontal and vertical thrusting of the pacific plate, which has been slowly advancing under the eurasian plate near japan, displaced the water above and spawned a series of exceedingly detrimental tsunami waves. A wave measuring some 33 feet high inundated the coast and flooded elements of the metropolis of Sendai, together with its airport and the encircling nation-state. In line with a few reviews, one wave penetrated a few 6 miles (10 km) inland after inflicting the Natori river, which separates Sendai from the town of Natori to the south, to overflow. Negative tsunami waves struck the coasts of Iwate prefecture, simply north of Miyagi prefecture, and Fukushima, Ibaraki, and Chiba, the prefectures extending alongside the pacific coast south of Miyagi. In addition to Sendai, other communities hard-hit with the aid of the tsunami covered Kamaishi and Miyako in Iwate; Iishinomaki, Kesennuma, and Shiogama in Miyagi; and Kitaibaraki and Hitachinaka in Ibaraki. The earthquake precipitated tsunami warnings at some stage in the Pacific basin. The tsunami raced outward from the epicentre at speeds that approached about 500 miles (800 km) in keeping with hour. It generated waves 11 to twelve feet (three. 3 to three. 6 metres) high along the coasts of Kauai and Hawaii in the Hawaiian islands chain and 5-foot (1. 5-metre) waves alongside the island of shemya within the aleutian islands chain. Numerous hours later 9-foot (2. 7-metre) tsunami waves struck the coasts of California and Oregon in north the USA. In the end, some 18 hours after the quake, waves more or less 1 foot (zero. Three metre) high reached the coast of Antarctica and prompted a part of the Sulzberger ice shelf to interrupt off its periphery. Initial reports of casualties following the tsunami positioned the demise toll in the masses, with hundreds more missing. The numbers in each class accelerated dramatically within the following days because the extent of the devastation—especially in coastal regions—have become recognized and rescue operations got beneath manner. Inside two weeks of the catastrophe, the Japanese government's authentic be counted of deaths had surpassed 10,000; a couple of and a half of times that quantity were nonetheless indexed as missing and presumed lifeless. With the aid of then it changed into glaring that the earthquake and tsunami constituted one of the deadliest natural screw ups in japanese history, rivalling the primary earthquake and tsunami that had took place off the coast of Iwate prefecture in June 1896. Because the look for victims persevered, the reliable rely of those confirmed dead or nevertheless missing rose to approximately 28,500. But, as more people thought to be lacking were discovered to be alive, that figure began to drop; with the aid of the stop of 2011 it were reduced to a few 19,300.

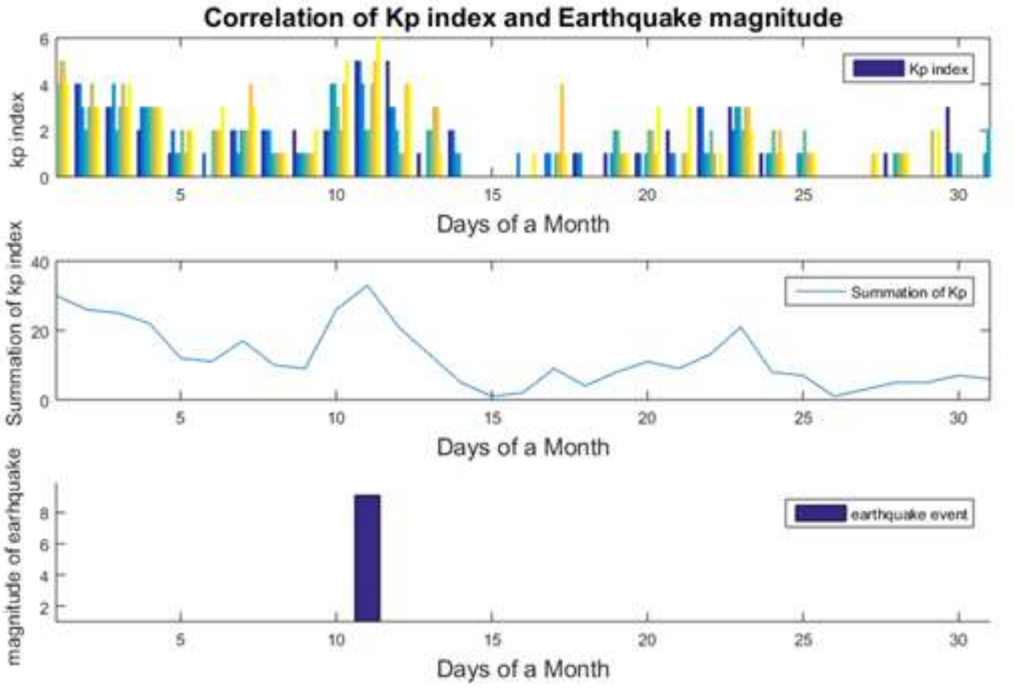

Figure 4 shows variations in Honshu, Japan.

Kamchatka, Russia - 1952

An earthquake of magnitude 9.0 hit the coast of Kamchatka along a 350-mile subduction zone fracture, on November 4, 1952. The epicenter was twenty-five miles beneath sea level. Within fifteen minutes of seismic recognition of the earthquake, the Tsunami Warning System (TWS) that had been set up four years earlier in Hawaii began to follow the path of the expected tsunami.

Years of experience told authorities that an earthquake of magnitude 9 or even magnitude 7 in Kamchatka would give rise to destructive tsunamis. TWS had been set up after the devastation inflicted on Hawaii from the Alaska tsunamis that were triggered by the Unimak Earthquake of 1946. It was estimated that the first tsunami waves from Kamchatka's 1952 event would arrive about seven hours after the quake and they did arrive with very destructive force.

The warnings that were periodically issued served to alert people to the dangers. The waves beached boats, caused houses to collide, destroyed piers, scoured beaches, and broke up road pavements. A farmer on Oahu reported that six of his cows were killed. In Honolulu harbor, waves tore a cement barge from its moorings and hurled it against the freighter Hawaiian Packer. At Pearl Harbor, Oahu, the tsunami was evidenced by the periodic rise and fall of the water, but no damage was done.

A boathouse worth $13,000 was demolished in Hilo where the highest wave levels were seen, twelve feet above normal sea level. Property damage from these waves amounted to one million dollars. Fortunately, no lives were lost but it seems that TWS failed to alert people to the nature of tsunami waves, especially their number. In Honolulu sightseers ran toward the beach at the second wave instead of running away from it, apparently unaware of the great potential danger from subsequent waves.

At the source of the 1952 earthquake severe damage was caused to Kamchatka Peninsula with waves reaching heights of from 50 to one hundred feet. A settlement on the Kuril Islands just south of the epicenter experienced tsunami waves sixty-five feet above sea level. The settlement was completely destroyed. The height of the waves and amount of destruction in Alaska were surprisingly, small. However, on Midway Island, as the tsunami moved toward the Hawaiian chain, six-foot and nine-foot waves flooded the island, lifted buildings, washed debris and barges ashore, and deposited quantities of sand on an airfield.

Tidal gauges all along the west coast of the United States registered higher water levels, all of them five inches or less in height. The west coast of South America experienced much higher water levels than on the west coast of the United States and was damaged significantly. In Peru, several houses were flooded. Fig. 5 shows the earthquake event and corresponding magnetic field variations on that day.

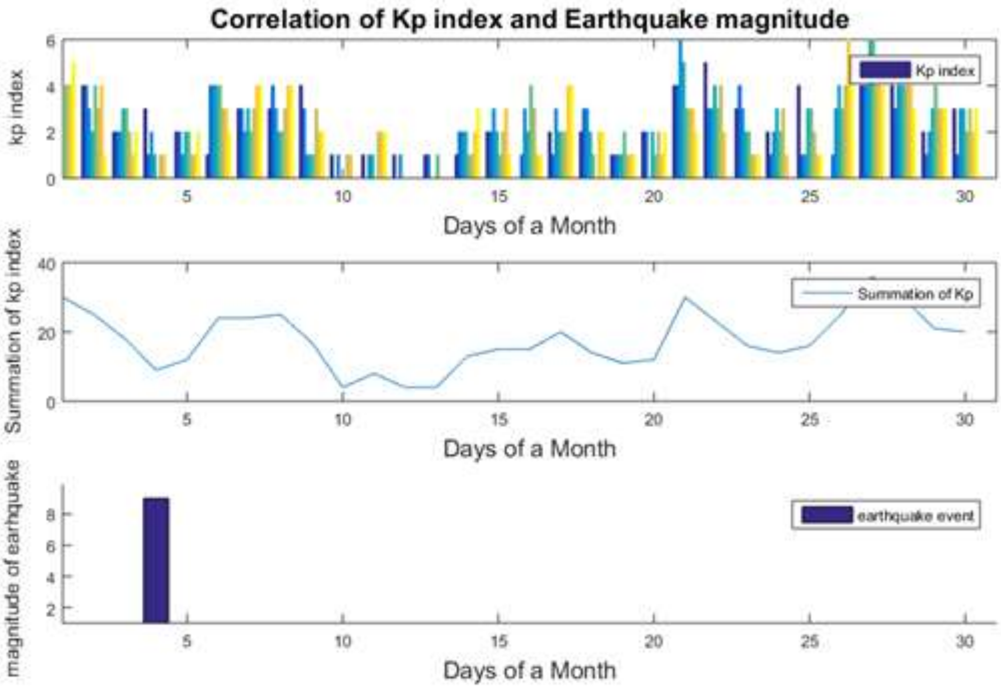

Figure 5 shows variations in Russia.

Chile – 2010

Chile earthquake struck coast of south central Chile happened on February 27, 2010 and it triggered Tsunami waves that made 500 deaths. The earthquake magnitude is 8.8 with its epicentre at 325 km south west of Santiago at a depth of 35 km below the Pacific Ocean. It created a fault between South American plate and Nazca plate. The Tsunami waves rose to a height of 15 metres and it completely devastated the Chilean town of constitution. The earthquake generated Tsunami also hit Juan Fernandez Islands at 675 km from the coast of Chile. Fig. 6 shows the earthquake event and corresponding magnetic field variations on that day.

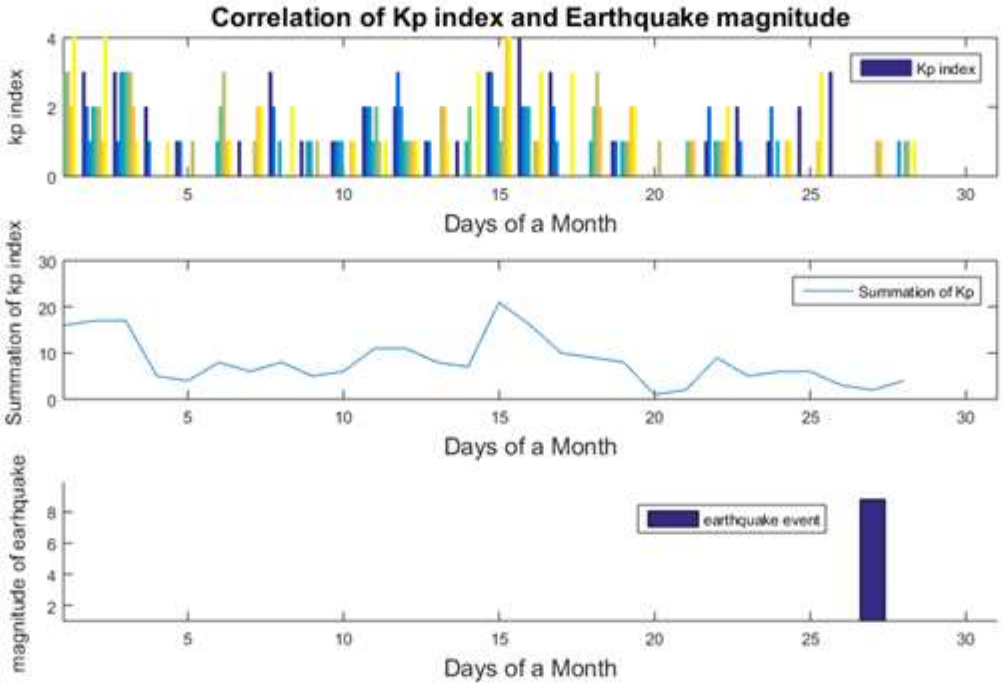

Figure 6 shows the earthquake event and corresponding magnetic field variations in Bio Bio Chile, 2010.

Alaska – 1965

Alaska 1965 earthquake with a magnitude of 8.7 also called Rat island earthquakes occurred at the convergent boundary of Pacific and North American crustal plates. It hit Rat Islands on Feb 4, 1965 ruptured 600 km of Aleutian Islands. Fig. 7 shows the earthquake event and corresponding magnetic field variations on that day.

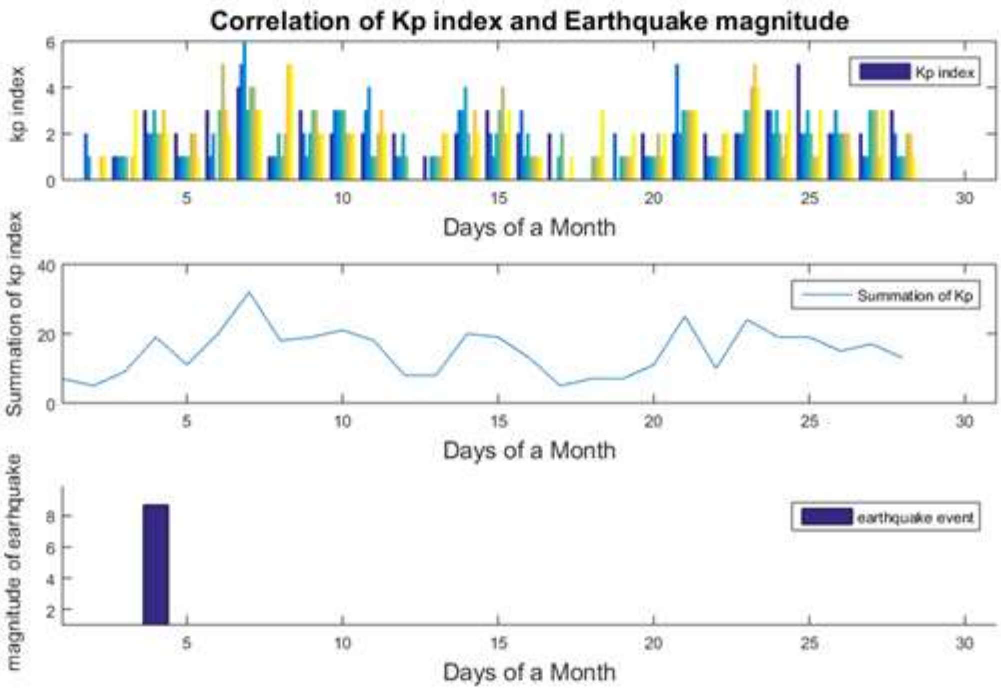

Figure 7 shows the earthquake event and corresponding magnetic field variations in Alaska, 1965.

Assam - Tibet - 1950

The 1950 Assam - Tibet earthquake also known as the Assam Earthquake occurred at 2:09pm on the 15th of August. The epicentre was located RIma and the earthquake itself was destructive in both Assam and Tibet. This was known to be the 10th largest earthquake in the 20th century. As well as, the Assam earthquake is the largest to not have been occurred by an oceanic subduction. Instead it was caused by two continental plates converging.

In the Nyingchi-Qamdo-Zhamo (Rima, Zayu) area of eastern Tibet around 78 people were killed and many buildings were damaged. The earthquake was felt at Lhasa and in Sichuan and Yunnan Provinces, China. Severe damage also occurred in the Sibsagar-Sadiya area of Assam, India and in the surrounding hills. Over 70 villagers were affected in the Abor hills, though mostly by landslides. 8 days later a natural dam broke, creating a 7m wave which destroyed several villages and killed almost 536 people. The magnitude of the earthquake was 8.6 in Ritcher scale. Fig. 8 shows the earthquake event and corresponding magnetic field variations on that day.

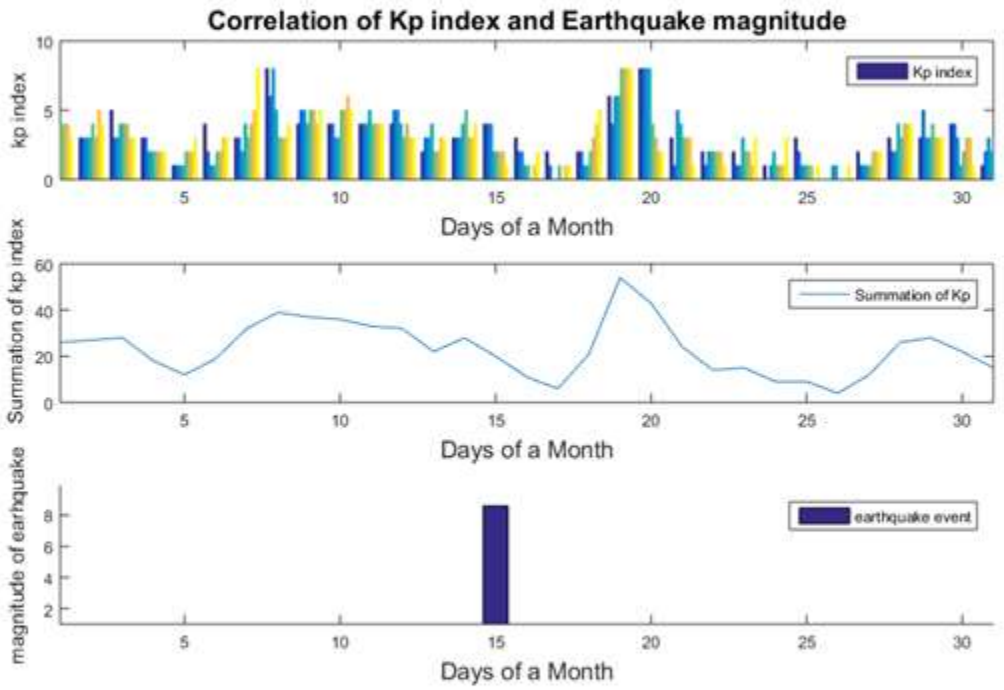

Figure 8 shows the earthquake event and corresponding magnetic field variations in Assam, Tibet.

Northern Sumatra-2005:

Northern Sumatra 2005 earthquake also called as 2005 Nias-Simeulu earthquake occurred on March 28, 2005 along the west coast of Northern Sumatra, Indonesia. The earthquake lasted about two minutes happened 30 km below the surface of Indian Ocean. It triggered massive Tsunami waves and Tsunami warnings were issued by Pacific Tsunami Warning Centre opened by National Oceanic and Atmospheric Administration (NOAA). Fig. 9 shows the earthquake event and corresponding magnetic field variations on that day.

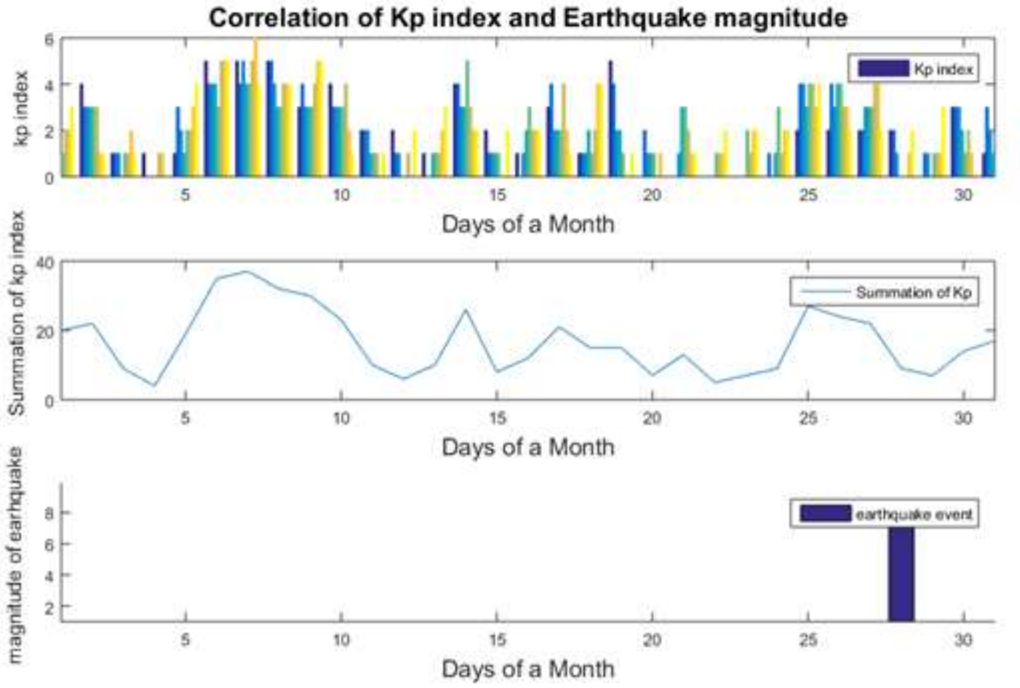

Figure 9 shows the earthquake and corresponding magnetic field anomalies in Northern Sumatra, 2005.

Northern Sumatra – 2012

On April 11, 2012 the largest earthquake that happened in Indonesian Island of Sumatra with a magnitude of 8.6. It is the eleventh largest earthquake recorded in the history which is one of the rare intraplate earthquakes. It happened at a depth of 22.9 km and 610 km south west of Banda Aceh, Indonesia. The epicentre is located within the Indo-Australian plate. Fig. 10 shows the earthquake event and corresponding magnetic field variations on that day.

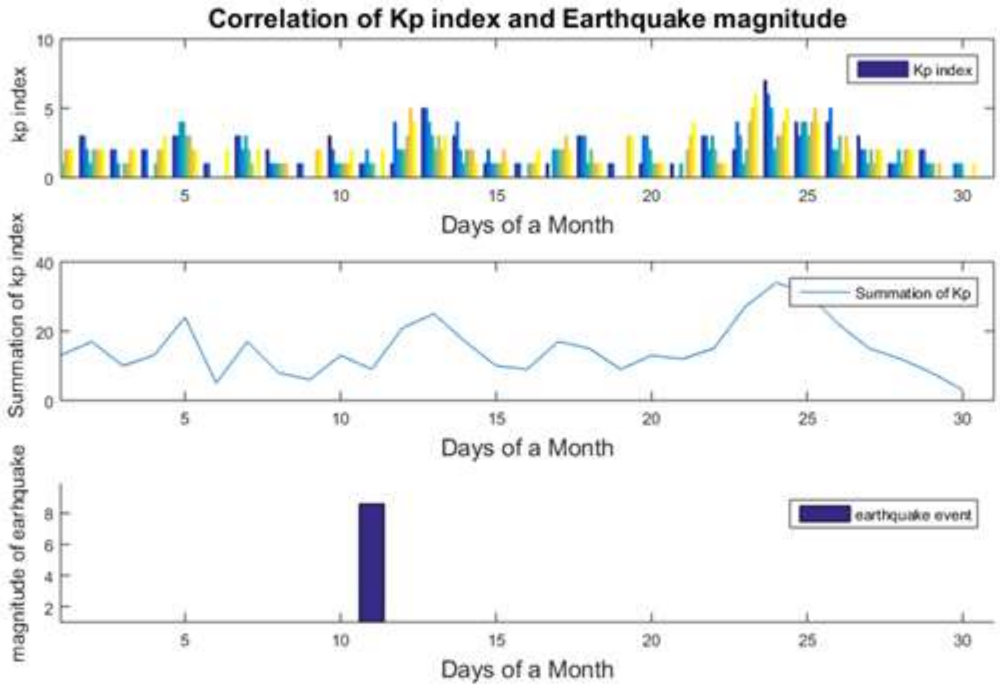

Figure 10 shows the earthquake event and corresponding magnetic field variations in Northern Sumatra, 2012

IV. Results and Discussion:

Given below is the analysis of the ten major earthquakes in the world with the kp indices of the respective day of the month in which earthquake event had happened.

Bio-Bio, Chile – 22/05/1960

The sum of the kp indices on the respective earthquake event day corresponds to the value – 10 for the 9.5 M earthquake.

Southern Alaska – 28/03/1964

The sum of the kp indices on the respective earthquake event day corresponds to the value – 1 for the 9.2M earthquake.

Coast of Northern Sumatra – 26/12/2004

The sum of the kp indices on the respective earthquake event day corresponds to the value – 20 for the 9.1 M earthquake.

Honshu, Japan – 11/03/2011

The sum of the kp indices on the respective earthquake event day corresponds to the value – 33 for the 9.1 M earthquake.

Kamchatka, Russia –04/11/1952

The sum of the kp indices on the respective earthquake event day corresponds to the value – 9 for the 9.0 M earthquake.

Bio-Bio, Chile – 27/02/2010

The sum of the kp indices on the respective earthquake event day corresponds to the value – 2 for the 8.8 M earthquake.

Rat Islands, Alaska – 04/02/1965

The sum of the kp indices on the respective earthquake event day corresponds to the value – 19 for the 8.7 M earthquake

Assam – Tibet – 15/08/1950

The sum of the kp indices on the respective earthquake event day corresponds to the value – 20 for the 8.6 M earthquake.

Coast of Northern Sumatra – 11/04/2012

The sum of the kp indices on the respective earthquake event day corresponds to the value – 9 for the 8.6 M earthquake.

Northern Sumatra – 28/03/2005

The sum of the kp indices on the respective earthquake event day corresponds to the value – 9 for the 8.6 M earthquake.

Geomagnetic Kp-Index and Earthquake Correlations:

This study investigated the potential link between large earthquakes (M > 8.1) and variations in the Earth's magnetic field, as represented by the Kp-index. Analysis revealed a possible correlation between significant Kp-index fluctuations (> 30 or < -20) and the occurrence of earthquake events.

Key Observations:

- **Threshold Kp-values:** Earthquakes appear to be more likely when the Kp-index reaches extreme values (highly disturbed magnetosphere), suggesting a potential triggering mechanism.

- **Geomagnetic Storms:** The maximum Kp-values (> 30) often coincide with intense geomagnetic storms triggered by coronal mass ejections (CMEs) from the Sun. This strengthens the link between solar activity and earthquake occurrences.

Limitations and Future Research Directions:

- **Complexity of Earth's Interior:** The internal fluid dynamics of the Earth are highly intricate, making it difficult to definitively establish causal relationships using solely statistical methods.
- **Regional Variations:** The study suggests a potential association, particularly in the Pacific Rim region. Further investigation is needed to confirm and refine this regional trend.
- **CME Correlation:** A more robust correlation analysis between Kp-index variations, earthquake occurrences, and specific CME events is necessary.
- **Ionospheric Effects:** Including ionospheric observations during earthquake events could provide valuable insights into the potential coupling mechanisms.

Uncertainties and Challenges:

- **Prediction Accuracy:** While the observed correlation suggests a potential link, it's crucial to acknowledge the limitations in earthquake prediction. More research is required to refine the methodology and improve prediction accuracy.
- **Statistical Significance:** Further statistical analysis with larger datasets is necessary to strengthen the observed correlations and account for potential random coincidences.

Moving Forward:

- **Advanced Techniques:** Utilizing advanced intelligent algorithms such as Artificial Intelligence (AI) could potentially enhance the analysis of complex geophysical data and improve our understanding of earthquake triggering mechanisms.
- **Multi-disciplinary Approach:** Integrating magnetospheric, seismological, and ionospheric data through a multi-disciplinary approach will offer a more holistic perspective on the potential earthquake-geomagnetic field connection.

V. CONCLUSION

Earth’s magnetic field is varying constantly and could not be mapped distinctly. It varies in both directions and intensity of the field. It changes from places to places as it is very difficult to measure it exactly to get a good picture of the spatial distribution. Because of the anomalous behavior, it is impossible to predict the field variations in future. Geophysicists are investigating the field variation and make the mathematical models to observe the phenomenon.

The magnetic reversals have occurred about 700,000 years ago. With no distinct pattern, magnetic reversals happened in the past 200 million years taken place every half million years ago. Earth magnetic field B, generates electromagnetic force, known as Lorentz force $F = J \times B$. To identify the relation of earthquakes and Lorentz force, kp index is used to measure the magnetic field deviation.

The Kp index of earth’s magnetic field and earthquake event of magnitude greater than 8.1 -9.5 is analysed. Summation of Kp index data and the earthquake event of different parts of the world shows some significant result in predicting earthquakes. The analysis of earth’s geomagnetic surge and seismicity indicates the synchronizing behaviour pattern with numerical signatures evidently. Whenever there is a change in the geomagnetic kp index earthquake event happened typically and creates the correlated pattern. More precisely, geomagnetic storm kindles the major factors includes the triggering of earthquake also. The result indicated that when the kp index is maximum (>30) or minimum (>20) earthquake event happened. The maximum intensity refers to the interplanetary consequences of coronal mass ejections (CME) of sun which creates the intense geomagnetic storm (>=300 nT). Nandita Srivatsava and Venkatakrishnan, 2002 [11] showed that the CME of March 29, 2001 triggers the geomagnetic storm.

The internal dynamics of fluid flow is highly complex and conventional statistical methods could not be used for estimating the deeds of earthquake. The significant results were obtained in the regions of Pacific Rim region. Further investigation need to be carried out to correlate with CME so that the extensive can be made to understand and predict it clearly. Moreover the variations in ionosphere region during the earthquake also need to be analysed to predict earthquakes. Predicting earthquake is not a simple task but understanding the phenomenon exactly will pave the opening to the gates of saving many lives during the disaster. Conventional analysis and statistical methodologies result in laying the foundation stone to predict earthquakes. Advanced intelligent techniques like Artificial Intelligence (AI) algorithm

References:

[1] Geller, R.J., **1991**. Shake-up for earthquake prediction. *Nature* **352**, 275–276.

[2] Normile, D., **1994**. Japan holds firm to shaky science. *Science* **264**, 1656–1658.

[3] Campbell,W.H., **1998**. A misuse of public funds: U.N. support for geomagnetic forecasting of earthquakes and meteorological disasters. EOS, *Trans. Am. Geophys. Union* **79**, 463.

[4] Hayakawa, M. and Y. Fujinawa **1994**. Electromagnetic Phenomena Related to Earthquake Prediction, TerraSci. Pub. Co. Tokyo, Japan.

[5] Hayakawa, M., Kawate, R., Molchanov, O.A., Yumoto, K., **1996**. Results of ultralow- frequency magnetic field measurements during the Guam earthquake of 8 August 1993. *Geophys. Res. Lett.* **23**, 241–244.

[6] Hayakawa,M., Itoh, T., Hattori, K., Yumoto, K., **2000**. ULF electromagnetic precursors for an earthquake at Biak, Indonesia on 17 February 1996. *Geophys. Res. Lett*. **27**,1531–1534.

[7] Hayakawa, M. and O.A. Molchanov (Eds.) **2002**. Seismo Electromagnetics: Lithosphere – Atmosphere – Ionosphere Coupling, Terra Sci. Pub. Co., Tokyo, 477 pp.

[8] Jordan, T.H., **2006**. Earthquake predictability, brick by brick. *Seismol. Res. Lett.* **77**, 3–6.

[9] Kessel, R., F. Freund and G. Duma **2006**. ULF energy transfer in the solar wind – magnetosphere – ionosphere – solid Earth system, *Geophys. Res. Abstr*. **8**, 01705

[10] Kopytenko, Yu A., Matiashvili, T.G., Voronov, P.M., Kopytenko, E.A., Molchanov, O.A.,**1993**. Detection of ultra-low frequency emissions connected with the Spitak earthquake and its aftershock activity, based on geomagnetic pulsation data at Dusheti and Vardzia. *Phys. Earth Planet. Int.* **77**, 85–95.

[11] Nandita Srivastava P. Venkatakrishnan, Relationship between CME Speed and Geomagnetic Storm Intensity, Geophysical research letters, 29(9), 2002.

[12] Moldovan, I.A., A.S. Moldovan, C.G. Panaiotu, A.O. Placinta and Gh. Marmureanu **2009**. The geomagnetic method on precursory phenomena associated with 2004 significant intermediate-depth Vrancea seismic activity, **Rom. J. Phys. 54** (1-2), 249-261.

[13] Stanica, D., M. Stanica, M. Visan and M. Popescu **2006**. Anomalous behaviour of the electromagnetic parameters associated to intermediate depth earthquakes, *Rev. Roum. Geophysique*, **50**, 41- 47.

[14] Stanica, D. and M. Stanica **2007**. Electromagnetic monitoring in geodynamic active areas, *Acta Geodyn. Geomater*. **4**, 1(145), 99-107.

[15] Stanica, D. and D.A. Stanica **2009**. Constraints on correlation between the anomalous behaviour of electromagnetic normalized functions (ENF) and the intermediate depth seismic events occurred in Vrancea zone (Romania), *Terr. Atmos. Ocean. Sci.* **21** (4), 675- 683, 2010; doi: 10.3319/TAO.2009.09.09.01(T).

[16] Takla, E.M., K. Yumoto, P.R. Sutcliffe, F.M. Nikiforov and R. Marshall **2011**. Possible association between anomalous geomagnetic variations and the Molise Earthquakes at Central Italy during 2002, *Phys. Earth Planet. Int*. **185**, 29-35.

[17] Uyeda, S., Hayakawa, M., Nagao, T., Molchanov, O., Hattori, K., Orihara, Y., Gotoh, K., Akinaga, Y., Tanaka, H., **2002**. Electric and magnetic phenomena observed before the volcano-seismic activity of 2000 in the Izu Island region, Japan. Proc. Natl. Acad. Sci. U.S.A. **99**, 7352–7355.

[18] Yumoto, K., S. Ikemoto, M.G. Cardinal, M. Hayakawa, K. Hattori, K.J. Liu, S. Saroso, M. Ruhimat, M. Husni, M. Widarto, E. Ramos, D. McNamara, R.E. Otadoy, G. Yumul, R. Ebora and N. Servando **2009**. A new ULF wave analysis for seismo-electromagnetics using CPMN/MAGDAS data, *Phys. Chem. Earth*, **34**, 360- 366.