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ULF Geomagnetic Pertubations Related With Earthquake

Case Study: 9th January 2014

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***Abstract*— On midnight, 9th January 2014, 72 km from Southwest Pandeglang, Banten, Indonesia, an earthquake happen at 23:16:43 WIB, with Magnitude 5.2 Richter Scale, depth 10 km, and felt in Binuangeun (II-III MMI). West Java is a prone location for earthquake, it means that for research of short-term earthquake prediction.**

According to with many previous research on earthquake prediction, the extreme and full of research for many years, practical short-term for earthquake prediction still have conducted sustainable research. Research on earthquake-related electromagnetic phenomena in the earth have long conducted some research has shown that many such phenomena can answer one of the methods for earthquake prediction.

The ULF geomagnetic phenomena change is the one of the many phenomena that occur and can be proven in previous studies. To that end, this report first reviews previous observational facts and present the latest results in the detection of ULF geomagnetic change by signal analyzing by NOAA data. Finally, we will further study and determine the mechanism of propagation of ULF signals associated with an earthquakes.

Key words: Short-term earthquake prediction, Earthquake-related electromagnetic phenomena, ULF geomagnetic change, ULF emissions

I. INTRODUCTION

According to Daryono (2010) [18], West-Java region is part of Indonesia tectonic framework of the system. These areas include the Mediterranean and mountain paths are in the main zone of tectonic plate collision. Meeting these two plates are converging, where both collide and one of them, namely the Indo-Australian plate, slipped under the Eurasian plate. At the meeting of plate boundary is marked by oceanic trenches, as evidenced by the discovery of a trough in the southern West Java known as Java Trench.

Indo-Australian plate movement against the Eurasian plate resulted in West Java as one of the areas that have a high enough level of seismicity in Indonesia with regard to the activity of the collision plate (plate collision). This raises the plate movement of tectonic structures that are characteristic of subduction systems, namely Benioff Zone , ocean trenches , back beyond the arc (outer arc ridge) , outer arc basin (outer arc basin) , and the arc mountains (volcanic arc). In addition to the seismic vulnerability due to plate collision activity, this region is also highly vulnerable due to a local fault geological structure in the mainland. This structure is formed by the pressure of the ocean boundary Indo-Australian plate with the Eurasian continental shelf. Based on the tectonic conditions, then in almost all parts of the southern region of West Java, the earthquake disaster events can occur at any time but occur is hard to predict exactly when and where earthquakes will occur.

West Java is also a region with a typical island trough structure, with unique physiography characteristic, because it is on a mountain that lies on the Mediterranean island of Sumatra, Java, Bali and Nusa Tenggara. The interaction between the two plates and volcanic activity of the two systems mountain make this area as one of the country prone to earthquakes with a high level of seismicity.

From History record, since 1833 to 2008 have occurred at least 28 times the incidence of strong earthquakes in West Java and cause tsunamis. West Java has a long history of destructive earthquakes, including the 1875 earthquake Brass (7 people were killed, 628 houses collapsed), Tasikmalaya Earthquake 1979 (10 people killed, 1,430 houses collapsed), Earthquake Majalengka 1990 (8,000 homes collapsed), Earthquake Sukabumi, 2000 (35 people seriously injured, 633 houses were severely damaged), Earthquake Mount Halu 2005 (139 homes damaged), Earthquake and Tsunami Pangandaran 2006 (550 deaths).

The high frequency of the seismic activity, which needs serious attention given to each occurrence of natural disasters almost always arise casualties and material losses are not small. The catastrophic events can't be avoided, but we can do is minimize the loss of life, property and the environment. The loss of life and property in the event of disasters that have been happening, more often due to lack of awareness and understanding of the government and the public against potential vulnerabilities and disaster mitigation efforts.

To reveal the high level of insecurity in the West Java earthquake disaster earth, necessary to study aspects of seismicity and tectonics local area as a whole. Because,in general, seismic activity can be viewed from the level of seismicity and regional tectonic conditions. If we observe the seismicity map of West Java, it was apparent the level of seismic activity in the area is very high . The earthquake that happens quite a lot in different variations of the magnitude and depth. Epicenter distribution in the western part of Java Island arc depth is generally dominated by variations in the depth of shallow earthquakes is less than 60 kilometers although not all shallow earthquakes that occurred vibration can be felt due to the relatively small magnitude . The distribution of earthquakes deeper appear more concentrated in the northern archipelago .

Distribution moderate earthquake had a depth of 60-300 kilometers is considered less dangerous . That is because hiposenternya quite deep and its influence on the surface is not very significant , except for the earthquake which happened to have a very large magnitude that its influence can be felt on the surface in a broad spectrum . Meanwhile , the earthquake had a depth of over 300 kilometers no harm given activity are very deep in the earth . Earthquakes of this type generally occur in the ocean plate subduction system . Earthquake in northern Java looks very tight distribution reflecting a seismic earthquake activity in high enough so that it can be explained that the earthquake hypocenter northward deeper patterns .
Based on a review of the aspects of seismicity and tectonics , it can be concluded that the high seismic activity of the region of West Java caused this archipelago has two generators of earthquake sources , ie from the south island arc in the form of plates subduction activity , and the presence of several active faults in mainland . Shallow earthquake is one of the main characteristics of earthquake activity due to the active faults . Seismicity and tectonics picture frame above would be enough to give a thorough overview that West Java is very vulnerable to terrestrial disasters , such as earthquakes and tsunamis .

Some research for possible correlations between the earthquakes, have many hypotesis, there are the variations of magnetic fields, Earth's horizontal and vertical currents in the atmosphere, was born when in early 1988, the historical data on the Black Sea was systemized [Mavrodiev, 1996].

The achievement in the Earth surface tidal potential modeling, with the ocean and atmosphere tidal influences being included, makes an essential part of the research. In this sense, the comparison of the Earth tides analysis codes (Venedikov et al., 2003; Milbert, 2011) is very useful. The possible tidal triggering of earthquakes has been investigated for a long period of time (Knopoff, 1964; Tamrazyan, 1967, 1968; Ryabl at al., 1968; Shlien, 1972; Molher, 1980; Sounau et al., 1982; Burton, 1986; Shirley, 1988; Bragin, 1999).

The last-years laboratory results in modeling the earthquake processes in increasing stress conditions support, at least qualitatively, the quantum mechanic phase shift explanation of the mechanism of generation of electromagnetic effects before and during earthquakes (Freund et al., 2002; St-Laurent et al., 2006; Vallianatos et al., 2003).
Some progress in establishing the geomagnetic filed and Eart tides variations as imminent precursors for increasing regional seismicity was presented in several papers (Mavrodiev, Thanassoulas, 2001; Mavrodiev, 2002a, b; 2003a, b, c; Mavrodiev, 2004; Mavrodiev, Pekevski, 2008; Mavrodiev, Pekevski, Jimseladze, 2008).

The model of earthquake-related part has to be infinitely repeated in the "theory–experiment–theory" process, using nonlinear inverse problem methods in looking for correlations between the different fields in dynamically changing space and time scales. Each approximate model supported by some experimental evidence should be included in the analysis (Varotsos et al., 2006; Thanassoulas et al., 2001a, b; Eftaxias at al., 2001, 2002; Duma, 2006). The adequate physical understanding of the correlations among electromagnetic precursors, tidal extremes and a impendant earthquake is related to the progress of an adequate Earth magnetism theory and electrical currenets distribution, as well as to the quantum mechanical understanding of the processes in the earthquake source volume before and during the earthquake. According to Strachimir,2008, geomagnetic earthquake precursor improvement formulation on the earthquake minimum ±1 day and maximum ±2 days before an earthquake occur.

The analysis of more accurate at space and time measuring sets for the Earth crust condition parameters, including the monitoring data of the electromagnetic field under and ver the Earth surface, from the temperature distribution and other possible precursors, would be the basis of nonlinear inverse problem methods. It could be promising for studying and solving the "when, where and how" earthquake prediction problem and in this paper we discuss some results reflect on ULF emissions observed few days prior to some of the recent seismic activities in Indonesia, especially West-Java. These Emissions are fund to occur as pertubations in the ionospheric and have been detected by Satellite (NOAA).

According to above, the research of seismo-electromagnetic effect refer to the magnetic and electric field disturbances that are observed during the earthquake. According that statement, there are many methods of studying and innovations such anomalies involve the application of space based technology by satellites data and using the ground based sensors to recording the continuous data to analyzing the results. In this paper, we present and analyze about the electromagnetic field disturbances in ULF range detected by satellite for some earthquakes that have occurred especially in West Java, Indonesia. The earthquake happen in the Indonesia region and the measured considerably strong magnitude on Richter Scale. The data we got from NOAA, and implemented to form of magnetic and electric sensors that keep in line variations constantly.

II. Observational Method

In this paper, observational method thats we used there is some encourage studis related with earthquake and and some phenomenon simultaneously by satellite (NOAA), this part for studies and investigation of the ionospheric pertubations related with major geophysical hazard. This paper explain about disturbations related to Satellite Environment, Solar Cycle Sunspot, Solar Cycle Radio Flux Progression, Solar Cycle Ap Progression, the results of Magnetometer, X-Ray Fluxs and Kp Indext.

The study case of this paper is an earthquake 9th January 2014, 72 km from Southwest Pandeglang, Banten, Indonesia, an earthquake happen at 23:16:43 WIB, with Magnitude 5.2 Richter Scale, depth 10 km, and felt in Binuangeun (II-III MMI).

Picture 1. The Earthquake event at 9th January 2014 (Source BMKG from Antara News.com)

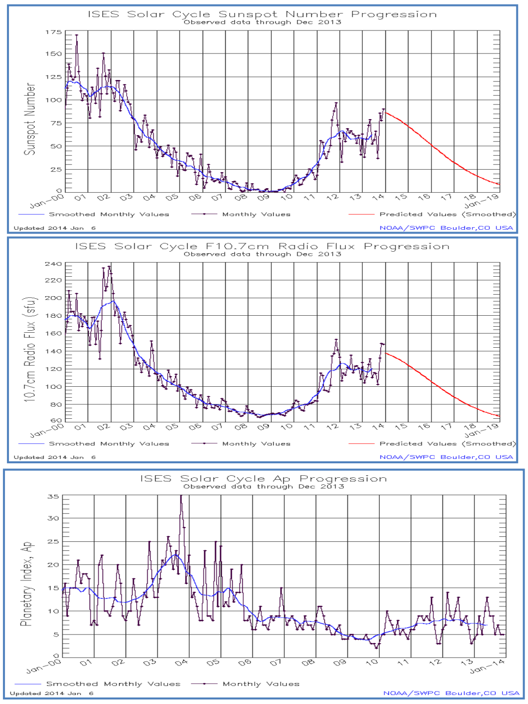
III. Results and Disscussion

The solar cycle (or solar magnetic activity cycle) is the periodic change in the sun's activity (including changes in the levels of solar radiation and ejection of solar material) and appearance (visible in changes in the number of sunspots, flares, and other visible manifestations). Solar cycles have an average duration of about 11 years. They have been observed (by changes in the sun's appearance and by changes seen on Earth, such as auroras) for hundreds of years. (Wikipedia)

Solar variation causes changes in space weather, weather, and climate on Earth. It causes a periodic change in the amount of irradiation from the Sun that is experienced on Earth. It is one component of solar variation, the other being aperiodic fluctuations. Evolution of magnetism on the Sun. Powered by a hydromagnetic dynamo process, driven by the inductive action of internal solar flows, the solar cycle:

- Structures the Sun's atmosphere, its corona and the wind;
- Modulates the solar irradiance;
- Modulates the flux of short-wavelength solar radiation, from ultraviolet to X-ray;
- Modulates the occurrence frequency of solar flares, coronal mass ejections, and other geoeffective solar eruptive phenomena;
- Indirectly modulates the flux of high-energy galactic cosmic rays entering the solar system. (Wikipedia)

We show that The Solar cycle resluts every day before and after the earthquake:



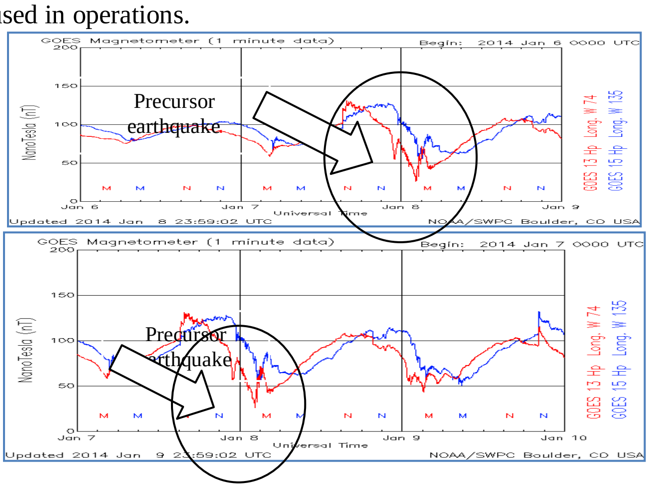
Picture 2. Diagram show the Solar Cycle from Satellite data of NOAA (a) Solar Cycle Sunspot Progression, (b) Solar Cycle Radio Flux Progession, (c) Solar cycle Ap Indext Progression

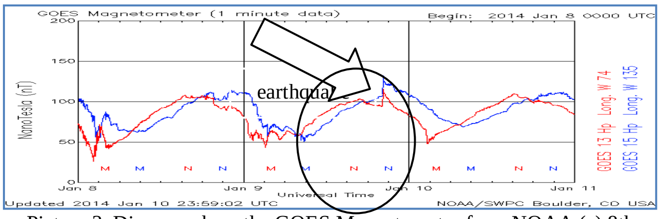
Picture 1 explain about Sunspots may exist anywhere from a few days to a few months, but they eventually decay, and this releases magnetic flux in the solar photosphere. This magnetic field is dispersed and churned by turbulent convection, and solar large-scale flows. These transport mechanisms lead to the accumulation of the magnetized decay products at high solar latitudes, eventually reversing the polarity of the polar fields. (Wikipedia).

The dipolar component of the solar magnetic field is observed to reverse polarity around the time of solar maximum, and reaches peak strength at the solar minimum. Sunspots, on the other hand, are produced from a strong toroidal (longitudinally directed) magnetic field within the solar interior. Physically, the solar cycle can be thought of as a regenerative loop where the toroidal component produces a poloidal field, which later produces a new toroidal component of sign such as to reverse the polarity of the original toroidal field, which then produces a new poloidal component of reversed polarity, and so on. (Wikipedia). The results show that the Solar variations is decrease ± 1 day before an earthquake at 9th January 2014, it seems that this solar cycle can explain about precursor before an earthquake happen in Indonesia Region, especially West-Java Region.

The Geostationary Operational Environmental Satellite - R Series (GOES-R) is the next generation of geosynchronous environmental satellites which will provide atmospheric and surface measurements of the Earth’s Western Hemisphere for weather forecasting, severe storm tracking, space weather monitoring, and meteorological research. GOES-R is a follow-on to the current GOES system which is utilized by NOAA's National Weather Service for weather monitoring and forecasting operations as well as by researchers for understanding interactions between land, ocean, atmosphere, and climate. The GOES-R series program is a collaborative development and acquisition effort between NOAA and NASA to develop, deploy, and operate the satellites. The overall program is managed by NOAA with an integrated NOAA-NASA program office organization co-located at NASA’s Goddard Space Flight Center in Greenbelt, Maryland. GOES-R is scheduled for launch in early 2016. The GOES-R series of satellites (GOES-R, S, T, & U) will extend the availability of the operational GOES satellite system through 2036. (NOAA)

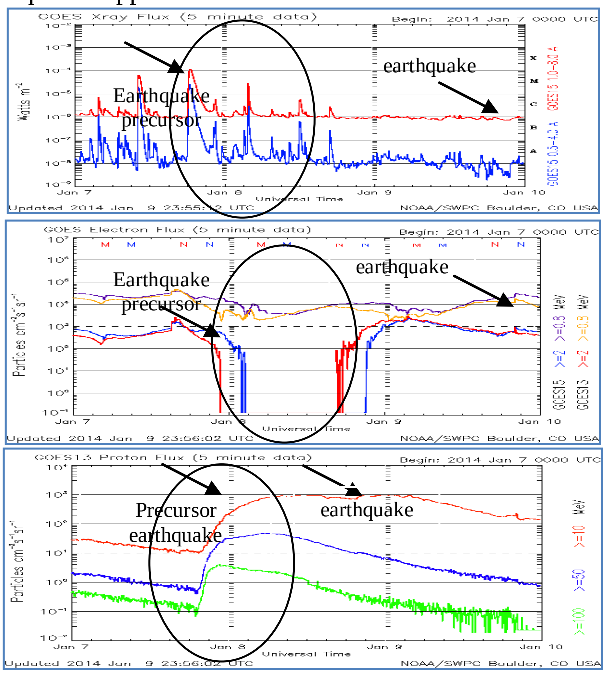
The GOES-R Magnetometer will provide measurements of the space environment magnetic field that controls charged particle dynamics in the outer region of the magnetosphere. These particles can be dangerous to spacecraft and human spaceflight. The geomagnetic field measurements will provide alerts and warnings to satellite operators and power utilities. GOES-R Magnetometer data will also be used in research. The GOES-R Magnetometer products will be part of NOAA space weather operations, providing information on the general level of geomagnetic activity and permitting detection of sudden magnetic storms. In addition, measurements will be used to validate large-scale space environment models that are used in operations.





Picture 3. Diagram show the GOES Magnetometer from NOAA (a) 8th January 2014, (b) 9th January 2014, (c) 10 January 2014

Picture 2 explain about decrease of space magnetic field that controls charged particle dynamics in the outer region of magnetosfer before the earthquake at 9th January 2014. The general level of geomagnetic activity and permitting detection of sudden magnetic storms. In addition, measurements will be used to validate large-scale space environment used in operations by ULF/ELF studies. At 8th January 2014 models that are , it seems that the GOES Magnetometer recorded the space magnetic space with disturbance signal before the earthquake happen.



Picture 4. Diagram show the GOES from NOAA (a) Xray Flux 9th January 2014, (b) Electron Flux 9th January 2014, (c) Proton Flux 9th January 2014

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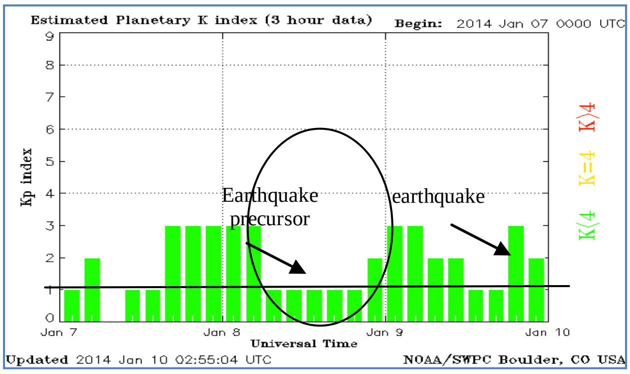
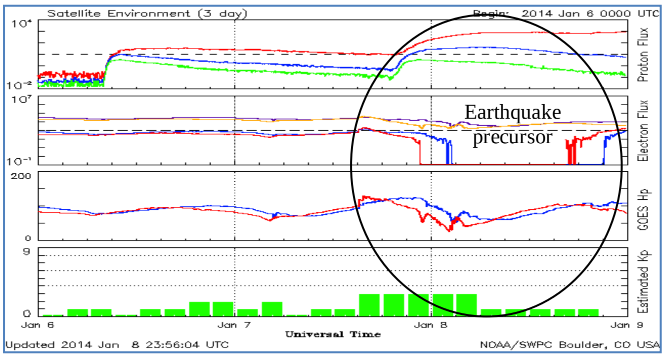
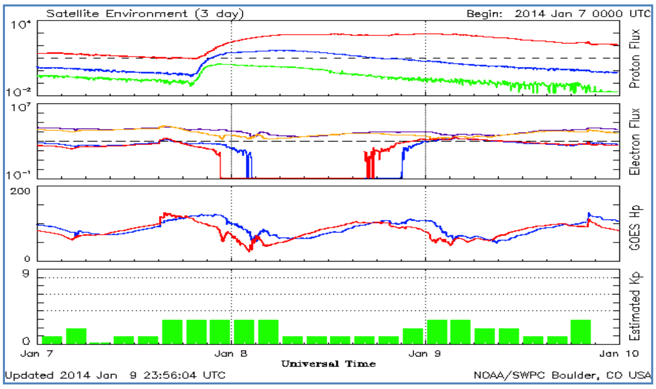
The K-index quantifies disturbances in the horizontal component of earth's magnetic field with an integer in the range 0-9 with 1 being calm and 5 or more indicating a geomagnetic storm. It is derived from the maximum fluctuations of horizontal components observed on a magnetometer during a three-hour interval. The official planetary **Kp index** is derived by calculating a weighted average of K-indices from a network of geomagnetic observatories. Since these observatories do not report their data in real-time, various operations centers around the globe estimate the index based on data available from their local network of observatories.

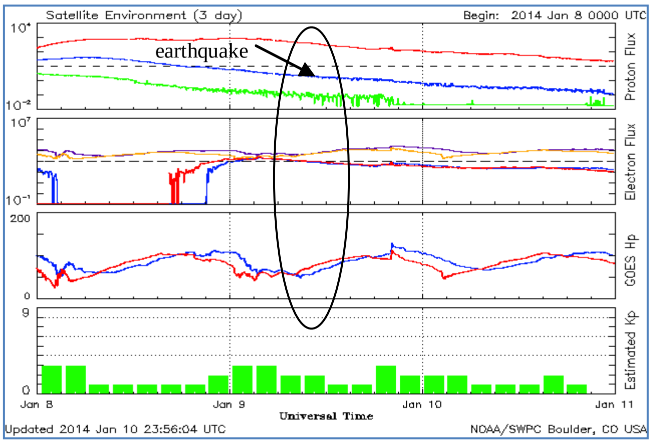


Picture 5. Diagram show the Estimated K indeks from NOAA, at 10th January 2014

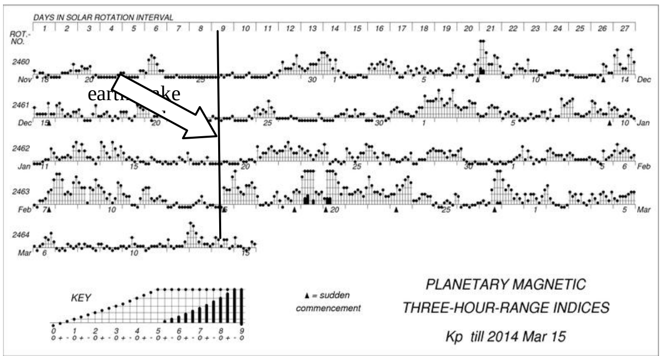
Picture 4. Explain about The K_p index is used for the study and prediction of ionospheric propagation of high frequency radio signals. Geomagnetic storms, indicated by a K_p of 5 or higher, have no direct effect on propagation. However they disturb the F-layer of the ionosphere, especially at middle and high geographical latitudes, causing a so-called *ionospheric storm* which degrades radio propagation. The degradation mainly consists of a reduction of the maximum usable frequency (MUF) by as much as 50%.[6] Sometimes the E-layer may be affected as well. In contrast with sudden ionospheric disturbances (SID), which affect high frequency radio paths near the Equator, the effects of ionospheric storms are more intense in the polar regions. From the result, we can see that the increase of K index estimated ±1day before the earthquake occur.



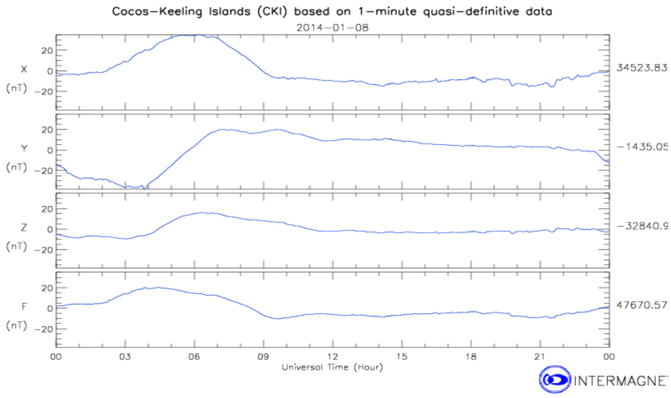




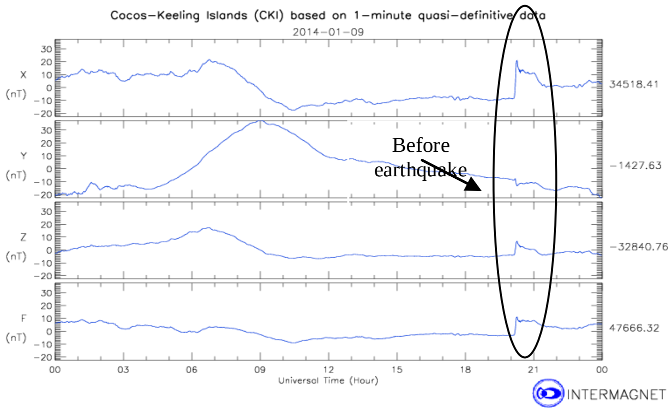
Picture 6. Diagram show the Satellite Environment from NOAA; (a) 8th January 2014, (b) 9th January 2014, (c) 10 January 2014



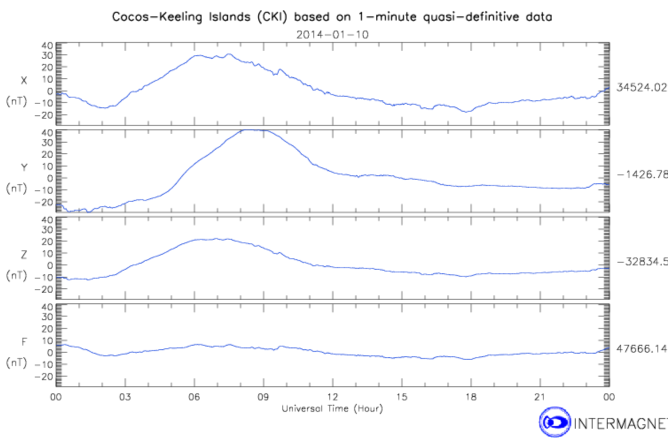
Picture 7. Plenetary Magnetic Three Hour Range Indices



(a)

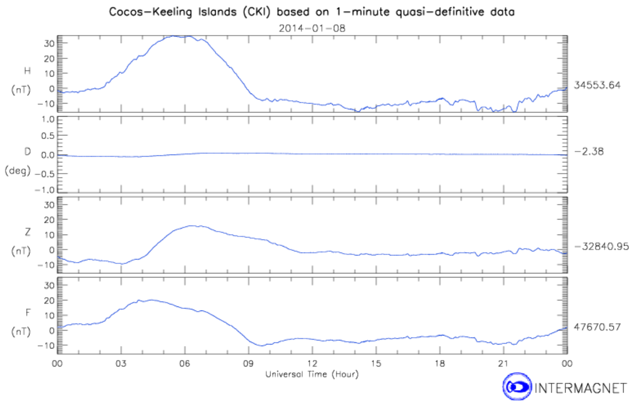


(b)

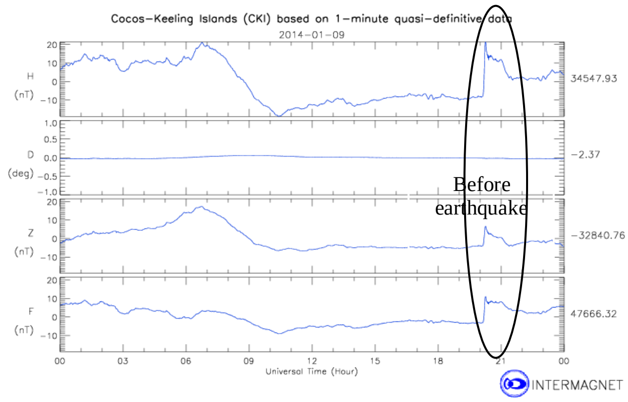


(c)

Picture 8. Diagram shows that COCOS (X, Y, Z, F magnetic component) (a) date 08th January 2014, (b) date 09th January 2014, and (c) date 10th January 2014 (Intermagnet)



(a)



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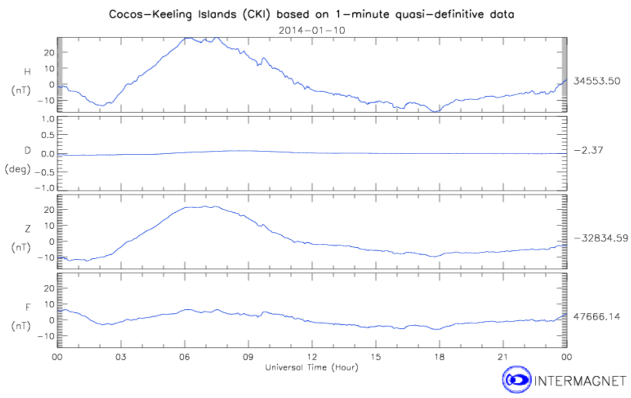
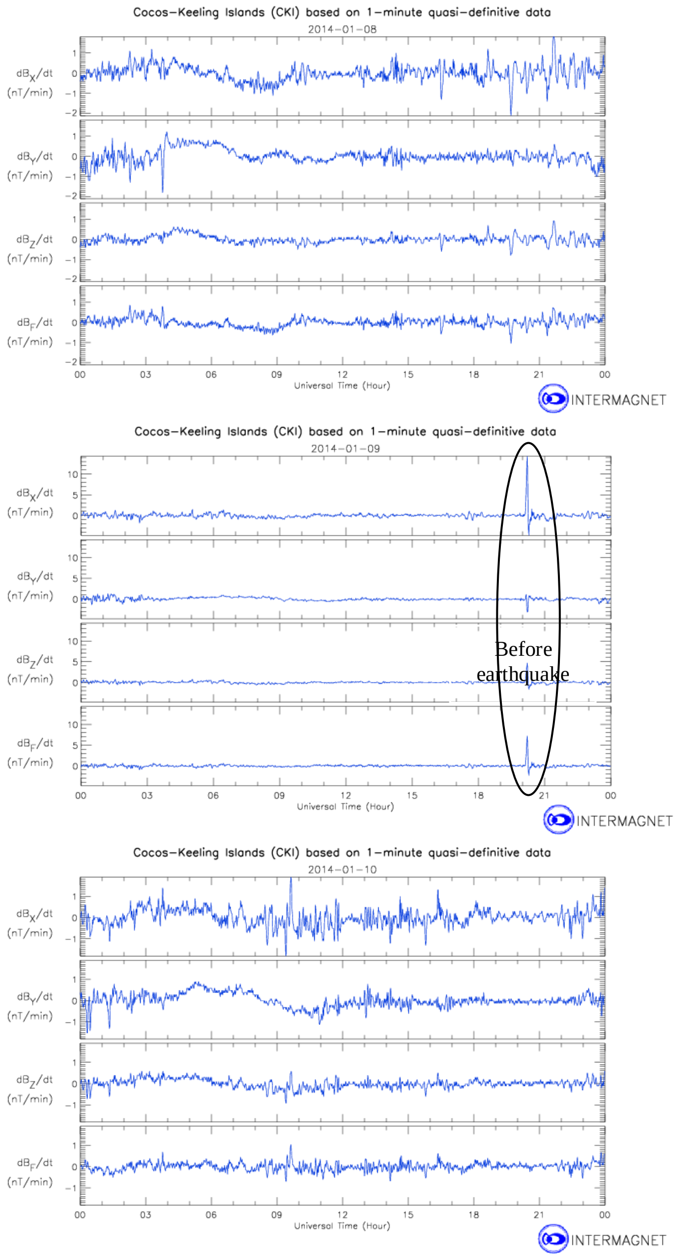


(c)

Picture 9. Diagram shows that COCOS (H, D, Z, F magnetic component) (a) date 08th January 2014, (b) date 09th January 2014, and (c) date 10th January 2014(Intermagnet)



Picture 10. Diagram shows that COCOS (dBx/dt, dBy/dt, dBz/dt and dBf/dt magnetic component) (a) date 08th January 2014, (b) date 09th January 2014, and (c) date 10th January 2014(Intermagnet)

IV. Conclusion

The correlations between magnetism and electric field activities and incoming earthquakes, which occur in the time defined from the next minimum (±1 day) or maximum (±3days) of the Earth Satellite data observations is tested statistically. The distribution of the time difference between predicted and occurred events decrease in the time. This result can be interpreted like a possible first reliable approach for solving the "when" earthquakes prediction problem. On the basis of electromagnetic monitoring under, on and over Earth surface is proposed research for solution of "when, where" earthquake prediction probably by ULF/ELF results . Under the hypothesis the current has a big vertical component the data of two geomagnetic vector devices are enough for determination of the future epicenter. The three devices will permit to research the correlation between Earth surface distribution of precursor function Sig and the Magnitude of the incoming earthquake. The complex questions for solving the "when, where and how" earthquake prediction problem is very shortly presented.

Acknowledgment

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References

[1] Mavrodiev S.Cht., Thanassoulas C., "Possible correlation between electromagnetic earth fields and future earthquakes", ISBN 954-9820-05-X, Seminar proceedings, 23-27 July, 2001, INRNE-BAS, Sofia, Bulgaria, 2001

[2] Knopoff, L, Earth tides as a triggering mechanism for earthquakes, Bull. Seism. Soc.Am. 54:1865–1870, 1964

[3] Tamrazyan G.P., Tide-forming forces and earthquakes, ICARUS, Vol.7, pp.59-65, 1967

[4] Tamrazyan G.P., Principal ragularities in the distribution of major earthquakes relative to Solar and Lubar tades and other Cosmic forces, ICARUS, Vol.9, pp.574-592, 1968

[5] Venedikov, A. and Arnoso, R.: Program VAV/2000 for Tidal Analysis of Unevenly Spaced Data with Irregular Drift and Colored Noise, J. Geodetic Society of Japan, 47,1, 281–286, 2001

[6] Venedikov, A. P., Arnoso, R., and Vieira, R.: A program for tidal data processing, Computer & Geosciences, 29, 4, 487–502, 2003

[7] Alexandrov L., Autoregularized Gauss-New-ton-Kantorovich iteration Process, Comm. JINR, P5-5515, Dubna, 1970

[8] Alexandrov L., Regularized computational process of Newton-Kantorovich type, J. Comp. Math. And Math. Phys., 11, Vol. 1, 36-43, 1971

[9] Alexandrov L., The program REGN (Regularized Gauss-Newton iteration method) for solving nonlinear systems of equations, Comm. JINR P5-7259, Dubna, 1973

[10] Alexandrov L., Program code REGN, PSR 165 RSIK ORNL, Oak Ridge, Tennessee, USA,1983

[11] Mavrodiev S. Cht., On the reliability of the geomagnetic quake as a short time earthquake's precursor for the Sofia region, Natural Hazards and Earth System Sciences (2004) 4: 433–447, SRef-ID: 1684-9981/nhess/2004-4-433

[12] Mavrodiev, S. Cht., and Pekevski, L., Complex Regional Network for Earthquake Researching and Imminent Prediction, Electromagnetic phenomena related to earthquakes and volcanoes, Editor: Birbal Singh, Publ., Narosa Pub. House, New Delhi, pp. 135-146, 2008

[13] Mavrodiev, S. Cht., Pekevski, L., and Jimseladze, T. Geomagnetic-Quake as Imminent Reliable Earthquake's Precursor: Starring Point for Future Complex Regional Network, Electromagnetic phenomena related to earthquakes and volcanoes, Editor: Birbal Singh, Publ., Narosa Pub. House, New Delhi, pp. 116-134, 2008,

[14] Mavrodiev S. Cht., Pekevski L., On the Balkan- Black Sea- Caspian Complex NETWORK for earthquake's Researching and Prediction, NATO Advanced research workshop management of urban earthquake risk in Central Asian ans Caucasus countries, Istanbul, 14-16 May, 2006

[15] Rusov, V. D.; Vaschenko, V. N.; Linnik, E. P.; Cht. Mavrodiev, S.; Zelentsova, T. N.;Pintelina, L.; Smolyar, V. P.; Pekevski, L., Mechanism of deep-focus earthquakes anomalous statistics,EPL (Europhysics Letters), Volume 91, Issue 2, pp. 29001 (2010)

[16] Rusov, V.D. et all, Solar Dynamo as host power pacemaker of Earth global climate, EU FP7 IRSES 2011 Project, "Complex research of Earthquake's Forecasting Possibilities, Seismicity and Climate Change Correlations", ISBN978-9989-631-04-7, Ohrid, Macedonia, BlackSeaHazNet Series, Volume 1, 2-5 May, 2011

[17] Daryono, Kerangka Tektonik dan Sejarah Panjang Gempabumi Jawa Barat, BMKG, 19 May, 2010

[18] Bhattacharya, et all. Study of ULF/ELF Pertubation Associated With Earthquake, Electromagnetic phenomenon related to earthquake an Volcanoes, 41-47, 2008.

[19] wikipedia.org

[20] noaa.usgs.gov

[21] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.

[22] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740-741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].

[23] M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[24] www.intermagnet.org

[25]Hayakawa, Mashashi et.all. Monitoring ULF Geomagnetic Variation Associated With Earthquakes, Sensors, 2007

[26] Hatori, Katsumi. ULF Geomagnetic Changes Associated with The Large Earthquakes. TAO. Vol.15, No.3, 329-360, September, 2004

[27] www.bmkg.go.id

[28]www.antaranews.com(http://www.antaranews.com/berita/413377/gempa-52-sr-guncang-pandeglang-banten)