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F. Masci and J. N. Thomas
Comment on “Ultra low frequency (ULF) electromagnetic anomalies associated with large earthquakes in Java Island, Indonesia by using wavelet transform and detrended fluctuation analysis”, by Febriani et al. (2014)

Dear Editor,
We revised the manuscript taking into account the referees’ comments and suggestions. Our responses, the revised manuscript, and the supplementary material are below.

Sincerely,
Fabrizio Masci and Jeremy N. Thomas

**Reply to referee #1**

**1)**

*The criticism in Masci and Thomas paper can be reduced to the main two statements:*
*No evidence that a preparatory phase of earthquakes really exists. (P. 5667, lines 23- 24).*
*The DFA _ exponent and the fractal dimension D of the ULF geomagnetic field are sensitive to global trends in geomagnetic activity.*

Our paper cannot be reduced to these two statements. We clearly show that the claims of Febriani et al. (2014) are invalid.

Anyway:
i) as regard to preparatory phase of earthquakes, many scientists doubt that really exists. They maintain that the hypothesis of a preparatory phase has no physical basis. See the reply to point 4).

ii) we have revisited many papers where the authors show changes in fractal parameters of the ULF geomagnetic field (e.g., the DFA α exponent and fractal dimension) before earthquakes claiming a possible seismogenic origin for the reported changes. In our papers (see the reference section of the manuscript), we have shown that these changes are, instead, global-scale variations driven by the frequent disturbances in the geomagnetic field. See also Masci and Di Persio (2012).

Reference:
Masci, F., M. Di Persio: Retrospective investigation of geomagnetic field time-series during the 2009 L'Aquila seismic sequence. Tectonophysics, 530-531, 310–317, doi:10.1016/j.tecto.2012.01.008, 2012.

**2)**

*Namely, when the geomagnetic activity decreases, the reduction of the geomagnetic field horizontal component is usually larger than the reduction of the vertical component, therefore the spectral density ratio increases. (P. 5670, lines 21-26).*

This sentence is part of the section of the manuscript from P. 5670, line 20, to P. 5671, line 11. Here, we briefly explain why many reported preearthquake changes in the ULF magnetic polarization ratio, as well as the corresponding changes in the DFA α exponent, that are claimed to be earthquake-related, are instead well correlated with changes in the global geomagnetic activity.

*From these statements two consequences follow:*
*At present ULF magnetic disturbances cannot be considered a promising candidate for developing earthquake prediction capabilities. (P. 5668, lines 14-15).*

Our thought is supported by the many invalid ULF magnetic precursors that in the last 20 years have been reported (and that continue to be reported) in the scientific literature. In these papers, a careful demonstration of causality between hypothesized precursory signals and earthquakes is not actually provided. On the contrary, clear Pcs pulsation signals are reported as seismogenic disturbances. See the reference section and the Supplementary material of our manuscript.

*Or in the strong form: "... the notion of the preparatory phase of earthquakes has no physical basis.". (P. 5668, lines 3-4).*

See below the reply to point 4).

**3)**
*The changes ... in the DFA _ exponent of the geomagnetic field vertical component and the spectral density ratio SZ/SY are too closely related with the geomagnetic _Kp index to be considered of seismogenic origin. Thus ... the preearthquake magnetic changes reported by Febriani et al. (2014) are an effect of the global geomagnetic activity. (P. 5672, lines 8-12).*

This is clearly shown in our manuscript.

**4)**
*The authors substantiated the first statement by a hypothesis that "Earthquakes ... appear to be chaotic, scale-invariant phenomena controlled by the local mechanical properties of the fault whose geometry and frictional characteristics determine the starting and stopping of the rupture ... Therefore, any small shock may grow into a stronger earthquake, and how big the quake will become is determined by how it is stopped, and not by how it starts.". (P. 5667, lines 24-26, p. 5668, lines 1-3). Such a hypothesis denies an EQ preparation phase and from our point of view is very controversial. (We consider the preparation phase as a cause and EQ as an effect). At first, the described lithospheric plates move in certain constant directions (see Fig.1 in Febriani et al., 2014) and mechanical tensions should arise at a fault area. At second, the stress growth to a critical value results in an unstable configuration which leads to a high probability of the EQ occurrence. The scale of the EQ is determined by dimensions of a high stressed zone of the fault. A period when the noticeable stress growth to the critical value we just consider as a preparatory phase of an earthquake. Such a period can be attended by the growth of a piezoelectric or piezomagnetic activity, conductivity changes and other events accompanied by ULF electromagnetic disturbances. Naturally, at critical (or unstable) phase, we cannot predict exactly the EQ onset. (Probably the authors relate the first statement just to such a situation). However, the alarm of a corresponding emergency management about high probability of EQ occurrence can be provided. So, the pre-earthquake ULF EM activity is of great interest to geophysicists as a possible warning instrument for decreasing of an EQ impact on the populated areas.*

In the introduction section of the manuscript, we briefly introduce the state of-the-art in the search for electromagnetic precursors of earthquakes. As you have rightly pointed out, the idea that electromagnetic precursors may appear before earthquakes is based on a hypothesis that earthquakes have a preparatory phase. We respect your opinion on the preparatory phase and precursors of earthquake. However, the existence of a preparatory phase of earthquakes is controversial within the scientific community, and many scientists disagree because:

- The movement of tectonic plates is slow. The stress increases very slowly also during the period preceding the earthquake (Lay and Wallace, 1995). There is experimental evidence that at the hypocentral depth, the level of the local stress does not significantly change during the days to minutes before the earthquake. Johnston et al. (2006) by means of high-resolution borehole strain and pore pressure measurements do not identify in the days to minutes before the 28 September

2004 M6.0 Parkfield earthquake a significant crustal stress increase that might indicate the start of the fault failure.

- The physical phenomena leading the fault in the critical state act in a very small volume whose dimension does not scale with final moment release. The magnitude of an earthquake seems not to scale with the level of stress, but it seems to be controlled by the physical properties of the fault (e.g., geometry and frictional characteristics). Consequently, the size of an earthquake is determined, not by how it starts, but by how it is stopped (Johnston, 2015).

- A recent laboratory experiment on gabbro samples saturated with electrically conductive fluid similar to those observed in active earthquake fault zones have shown that neither transients nor stress-stimulated currents were observed during several cycles of stress loading (Dahlgren et al., 2014). Because the Earth's crust is fluid saturated, they conclude that significant electric currents are not expected to be generated during the slow stress accumulation prior to earthquakes or during any slow stress release that may occur in the region of earthquake nucleation. Therefore, no electric and magnetic signals are expected to be observed on the Earth's surface.

These results casts serious doubts on the existence of a preparatory phase of an earthquake, and consequently on the possible occurrence of electromagnetic precursors of earthquakes. We have modified this part of the introduction section trying to be clearer.

References:
Dahlgren et al. (2014), Comparison of the Stress Stimulated Current of Dry and Fluid Saturated Gabbro Samples, Bull. Seismol. Soc. Am., 104(6), 2662–2672, doi: 10.1785/0120140144.
Johnston, et al. (2006), Continuous Borehole strain and pore pressure in the near field of the 28 September M 6.0 Parkfield, California Earthquake: Implications for nucleation, fault response, earthquake prediction, and tremor, Bull. Seismol. Soc. Am., 96, S56– S72, doi:10.1785/0120050822, 2006.
Johnston, M. J. S. (2015), On earthquake fault failure, 26th IUGG General Assembly, Prague, Czech Republic, June 22-July 2, 2015.
Lay, T. and Wallace, T. C.: Modern global seismology, Accademic Press, 521 pp., 1995.

**5)**

*Regarding the numerous cases of an erroneous EQ precursor finding, which are reported by the authors, it should be noted that pre-EQ ULF crustal magnetic activity is very weak and completely overlaps with Pc1-Pc5 signals from ionosphere or magnetosphere. It is a principal drawback of one point method of ULF magnetic precursor study. So the new methods for EQ precursor source localization based on multipoint measurements were developed, which allow discrimination of Pc1-Pc5 pulsation influence (see, for example, Dudkin et al., 2011 and references therein).*

*Reference Dudkin, F., Korepanov, V., Yang, D., Li, Q., Leontyeva, O., Analysis of the local lithospheric magnetic activity before and after Panzhihua MW = 6.0 earthquake (30 August 2008, China), Nat. Hazards Earth Syst. Sci., 11, 3171–3180, 2011.*

Thank you for pointing this paper out.

**6)**

*Concerning the second statement and its consequence we agree with the authors' opinion that the preearthquake magnetic changes reported by Febriani et al. (2014) relate to the global geomagnetic activity.*

We appreciate that you agree with us that pre earthquake magnetic changes reported by Febriani et al. (2014) are related to global geomagnetic activity and not seismogenic disturbances.

**7)**

*The changes Also, a small correction in the paper text should be done: P. 5667, line 10. It should be, at least, 0.001-5 Hz, instead of 0.001-10 Hz, because the frequency 10 Hz relates to the magnetometer sampling rate. (Usually the upper frequency should be less than 0.5*[sampling rate], because of anti-aliasing filtering).*

Thanks for correcting the ULF range investigated by Febriani et al. (2014)

**Reply to referee #2**

*General Comments: In this comment, Masci and Thomas (M&T) investigate the claims by Febriani et al. (2014) that they show changes in ULF magnetic field data at Pelabuhan Ratu in West Java that could be related to the M7.5 Tasikmalaya earthquake south of Java, Indonesia, on 2 September 2009 at an epicentral distance of 135 km. This earthquake occurred a few weeks later. No changes are reported by Febriani et al. (2014) coincident with the time of the earthquake when primary energy release occurred. M&T test the reality of these claims by repeating the Febriani et al. (2014) analysis results as summarized in Febriani et al.-Fig 9.*

*M&T show in their Fig. 1 that each of the parameters used by Febriani et al. (2014) (_, SZ /SY calculated with the minimum energy method and SZ /SY calculated without the minimum energy method) either tracks (e.g. "_") or inversely tracks (all others), Dst, the equatorial geomagnetic field disturbance field, and also the more global averaged Kp disturbance index, for that matter. If data during large global disturbances were removed from the Febriani et al.-Fig. 9 plot, the plots for each parameter would be relatively flat. The M&T case could have been made even stronger if they had used a much longer time series of data to test for significance of these parameters against long-term earthquake data for this region though it is unlikely that the conclusions would change but it would show another fundamental flaw in the Febriani et al. (2014) paper.*

*Thus, this comment shows that the claims by Febriani et al. (2014) that they found a relationship between the parameters "_" and "SZ /SY" and the M7.5 Tasikmalaya earthquake are likely unfounded. The comment is important since, without such checks and attempts to replicate the various claims made and hypotheses proposed (particularly in the field of earthquake prediction), science cannot progress. I would strongly support publication of this paper after response to the minor comments and suggestions listed below and expect that it will be a very useful contribution to this field.*

We appreciate that you agree with our remarks. Thanks for your positive comment.

*Detailed Comments:*
*This paper is generally well researched and well written with few errors. Minor suggestions are: [1] P5667, L8: Replace "the global geomagnetic activity level" with "global geomagnetic disturbances" [2] P5668, L3: Insert reference "(Johnston, 2015)" after "stops."since this is a direct quote from this paper. [3] P5668, L10: Move reference "Thomas, 2009a, b" to follow "Campbell, 2009;" so these references are in chronological order. [4] P5668, L11: Replace "the geomagnetic activity" with "the frequent disturbances in the geomagnetic field". [5] P5668, L13: Replace "consistent" with "convincing and always recurring" [6] P5668, L20: Replace "an empirical" with "Dobrovolsky et al.'s (1979) empirical". [7] P5668, L26: Replace "in Fig. S1 was derived using not actual precursors" with "shown in Fig. S1 was taken from Febriani et al. (2014) and was not derived from undisputed precursors" [8] P5669, L4: Replace "vertical and horizontal magnetic ï nˇA¸eld components" with "the vertical and each horizontal magnetic ïnˇA¸eld component". [9] P5669, L8: Replace "furtherly" with "further". [10] P5669, L18: Replace "is _" with "_ is" [11] P5670, L14: Replace "scale" with "scales". [12] P5670, L25: Replace "component, therefore" with "component. Therefore" [13] P5671, L8: Replace "and" with "nor" [14] P5671, L23: Replace "on planetary scale" with "on a planetary scale". [15] P5672, L10: Replace "too closely related with the geomagnetic _Kp index to be considered of seismogenic*

*origin" with "closely related to the geomagnetic _Kp index and are unlikely to be of seismogenic origin"*

*Reference Johnston, M.J.S. (2015), On earthquake fault failure, 25th IUGG General assembly, P121, IUGG-1001, Prague, Czech Republic, June 22-July 2, 2015.*

We took into account all your suggestions.

# Comment on "Ultra low frequency (ULF) electromagnetic anomalies associated with large earthquakes in Java Island, Indonesia by using wavelet transform and detrended fluctuation analysis", by Febriani et al. (2014)

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## Abstract

We examine the recent report of Febriani et al. (2014) where the authors show changes in ULF magnetic field data prior to the M7.5 Tasikmalaya earthquake occurred south of Java, Indonesia, on 2 September 2009. Febriani et al. (2014) state that the magnetic changes they found may be related to the impending earthquake. We do not agree that the preearthquake magnetic changes shown in Febriani et al. (2014) are seismogenic. These magnetic changes, indeed, are too closely related to the global geomagnetic activity disturbances to be regarded as being of seismic origin.

## 1 Introduction

Febriani et al. (2014) report changes in Ultra Low Frequencies (ULF: 0.001–5 Hz) geomagnetic field data a few weeks before the 2 September 2009 Tasikmalaya earthquake (M7.5, hypocentral depth 57 km) from a ground-based sensor at Pelabuhan Ratu, West Java, Indonesia, 135 km from the epicenter. This was the largest, and, according to the authors, the only earthquake preceded by anomalous magnetic changes, of twelve M>5 earthquakes that occurred offshore south of Java from 1 September 2008 to 31 October 2010.

Febriani et al. (2014) suggest that the magnetic changes they reported may have been induced by an alleged preparatory phase of the earthquake. The idea that electromagnetic precursors may appear before earthquakes is based on the hypothesis that earthquakes have a preparatory phase. That is, the earthquake initiates in a preparation zone (which size depends on the magnitude of the earthquake) where physical phenomena lead to the subsequent shock and to the possible appearance of precursory signals (see, e.g., Dobrovolsky et al., 1979). However, many researchers disagree that earthquakes have a preparatory phase (see, e.g., Geller, 1997; Kagan, 1997). According to them earthquakes appear to be chaotic, scale-invariant phenomena controlled by the local physical properties of the fault whose geometry and frictional characteristics determine the starting and stopping of the rupture. Therefore, any small shock may grow into a stronger earthquake, and how big the quake will become is determined by how it is stopped, and not by how it starts (Johnston, 2015). Therefore, the notion of a preparatory phase of earthquakes appears to have no physical basis.

There are many papers (see the References section in Masci, 2010, 2011a, 2013) where the authors report pre-earthquake changes in ULF magnetic field data suggesting a possible relationship between the changes they identified and the impending earthquake. Conversely, recent reports (see e.g. Campbell, 2009; Thomas, 2009a, 2009b; Masci, 2010, 2011a, 2011b, 2012, 2013; Masci and De Luca, 2013; Masci and Thomas, 2013a, 2013b, 2015) have shown that many of these preearthquake changes are, indeed, global-scale variations driven by the frequent disturbances in the geomagnetic field, or are generated by instrumental malfunction. These papers have cast into serious doubt the idea that ULF magnetic anomalies are convincing and always recurring phenomena preceding large earthquakes. Therefore, at present ULF magnetic disturbances cannot be considered a promising candidate for developing earthquake prediction capabilities. We note that Febriani et al. (2014) ignore the findings of the recent reports where it has been shown that many ULF magnetic changes reported to occur before earthquakes are not precursors. They, in fact, refer to these invalid precursors as support of the search for precursory signatures of earthquake in ULF magnetic data (see Tables S1 in the supplementary material). In support of their findings, they also refer to an empirical relationship between the earthquake magnitude and the distance from the earthquake epicenter of the ULF station where the preearthquake anomaly has been detected (see Febriani et al., 2014, Fig. 10). In Fig. S1 of the supplementary material, we show this relationship where we have highlighted with red dots alleged ULF magnetic precursory changes that have been proven invalid. In Table S2 of the supplementary material we report the papers in which these alleged precursors have been denied. Note that the empirical relationship shown in Fig. S1 is taken from Febriani et al. (2014) and is not derived from undisputed precursors. Thus, we conclude that Febriani et al. (2014) were motivated to search for precursory signals in magnetic data by reports of false precursors of earthquake.

## 2 Comments

Febriani et al. (2014) analyze nighttime (16:00–21:00 UT) geomagnetic field data in the frequency range 10±3 mHz. They calculate the ratio between the spectral intensity of the vertical and each horizontal magnetic field components, i.e., the so-called spectral density ratio. According to Febriani et al. (2014), the magnetic data analyzed are very disturbed by artificial noise even during nighttime. Thus, before performing the spectral analysis based on wavelet transform, they remove the intense transient signals. Then, they use the minimum energy method in an attempt to further reduce the noise. More precisely, for each day, they divide four hours (16:30–20:30 UT) of magnetic data in eight 30-min intervals. Data before 16:30 UT and after 20:30 UT are excluded due to the edge effect of the wavelet transform. Then, the energy of the geomagnetic field vertical component Z (the component usually more disturbed by artificial noise) is calculated in each 30-min interval. Finally, the spectral density ratio is calculated in the interval where Z shows the minimum energy. Febriani et al. (2014) investigate the scaling proprieties of the geomagnetic field components by means of detrended fluctuation analysis (DFA) as well. DFA is a well-established method to extract quantitative time dynamic in time series. The DFA $\alpha$ exponent can be considered as an indicator of the roughness of the time series: the higher $\alpha$ is, the smoother the time series (Peng et al., 1995). $\alpha$ may be related to the fractal dimension D by the relationship $D=3-\alpha$.

In Fig. 1 we show the spectral density ratio $S_Z/S_Y$ (where $Y$ is the east-west component of the geomagnetic field) and the DFA α exponent of the Z component, as reported by Febriani et al. (2014, Figure 9) 30 days before and after the 2 September 2009. According to them, a magnetic anomaly is identified when the exponent α, and the ratio $S_Z/S_Y$ exceed the threshold value of $\left(\overline{\alpha}-2\sigma_{\alpha}\right)$ and $\left(\overline{S_Z/S_Y}+2\sigma_{S_Z/S_Y}\right)$, respectively. Mean values and the corresponding σ are calculated over the 2 months period in Fig. 1. Based on their definition of an anomaly, Febriani et al. (2014) report to have found anomalous changes prior to the Tasikmalaya earthquake. More specifically, a few weeks before the earthquake, they note a decrease of the exponent α which corresponds to an increase of ratio $S_Z/S_Y$ (see shadow areas in Fig. 1). Febriani et al. (2014) maintain that the decrease of α in correspondence with the increase of the spectral density ratio identifies a precursory signature of the Tasikmalaya earthquake in magnetic data. No changes in $S_Z/S_Y$ and α are shown coincident with the earthquake when the primary energy is released.

We disagree with Febriani et al. (2014). First, there is no physical reason that magnetic anomalies, whatever might be their origin, are identified when the exponent α, and the spectral $S_Z/S_Y$ exceed the threshold values they assumed. Then, their method for checking the geomagnetic conditions by means of the Dst index is not rigorous. We agree that geomagnetic activity should be a key parameter in interpreting observed preearthquake ULF magnetic changes (see Balasis and Mandea, 2007). ULF disturbances from the ionosphere and magnetosphere, indeed, may lead researchers to interpret erroneously the origin of magnetic anomalies they identified (see, e.g., Masci 2010, 2011a). The 3-h global geomagnetic index Kp and the daily sum ΣKp are usually used as representative of the geomagnetic activity over planetary scales (Menvielle and Berthelier, 1991). Conversely, the Dst index that Febriani et al. (2014) use for checking the geomagnetic conditions is designed to monitoring the strength of the Equatorial Electroject, and it is usually used as indicator of the geomagnetic storm level and ring current intensification (Mayaud, 1980).

As expected, in Fig. 1 we note many decreases of α in correspondence to increases in the spectral density ratio. This inverse correspondence may be explained taking into account that the spectral density ratio, the DFA α exponent, and the fractal dimension D of the ULF geomagnetic field are sensitive to global trends in geomagnetic activity (see Masci 2010, 2011a; Wanliss et al., 2014). Namely, when the geomagnetic activity decreases, the reduction of the geomagnetic field horizontal component is usually larger than the reduction of the vertical component. Therefore the spectral density ratio increases. At the same time, the decrease of the geomagnetic activity indicates that the magnetosphere evolves toward a lower degree of organization (see, e.g., Balasis et al., 2009). Thus, the fractal dimension of the geomagnetic field increases, while the DFA α exponent decreases. On the contrary, an increase of the geomagnetic activity induces a decrease of the spectral density ratio (because the increase in the geomagnetic field horizontal components is larger than the increase of the vertical component) and a decrease of the fractal dimension and an increase of α (because the magnetosphere evolves towards a higher degree of organization). Thus, we expect to find an inverse correspondence between ΣKp and the spectral density ratio and the fractal dimension of the geomagnetic field, and a direct correspondence between ΣKp and the α exponent. However, due to global averaging used to calculate Kp, this correspondence is not expected always nor everywhere. In this perspective, recent papers (see Masci, 2010, 2011a, 2013, and other papers reported in Tables S1 and S2 of the supplementary material) have demonstrated that many preearthquake ULF magnetic changes hypothesized to be seismogenic are, instead, part of global geomagnetic activity changes. In Fig. 1 we have used the same approach adopted in these papers by comparing the exponent α and the ratio $S_Z/S_Y$ reported by Febriani et al. (2014) with the ΣKp index. In Fig. 1a, as expected, we note a close correspondence between α and ΣKp, both before and after the earthquake. A close inverse correspondence can be also seen in Fig. 1b between ΣKp and the ratio $S_Z/S_Y$ calculated without the minimum energy method. However, we would like to point out that we should not expect to always find this correspondence, since: i) as stated by Febriani et al. (2014) the high environmental noise in the geomagnetic field components was not attenuated enough after removing intense transient signals; ii) several gaps are present in α and $S_Z/S_Y$ time series; iii) $S_Z/S_Y$ shows many inexplicable zero values; iv) α and $S_Z/S_Y$ are calculated from local magnetic data, whereas, as already mentioned above, ΣKp is representative of daily averaged geomagnetic disturbances on a planetary scale. Contrary to Fig.1b, however, in Fig. 1c we see a lower correspondence between $S_Z/S_Y$ calculated applying the minimum energy method and ΣKp. The lower correspondence may be explained considering that for each day Febriani et al. (2014) calculate the spectral density ratio, using the minimum energy method, in one of the eight 30-min intervals between 16:30 UT and 20:30 UT. Since ΣKp is representative of global daily averaged geomagnetic disturbance, by reducing the period of analysis, it is likely that the correspondence between geomagnetic data and ΣKp becomes less noticeable. Thus, the high dispersion of $S_Z/S_Y$ values in Fig. 1c may be due to the short time interval (30-min) used in the spectral analysis, as well as because the $S_Z/S_Y$ time series consists of values that are calculated in different 30-min intervals.

## 3 Conclusions

We have reviewed the findings of Febriani et al. (2014) that show preearthquake changes in magnetic field record before the M7.5 Tasikmalaya earthquake occurred on 2 September 2009 south of Java. We have shown that the changes they reported in the DFA α exponent of the geomagnetic field vertical component and the spectral density ratio $S_Z/S_Y$ are closely related to the geomagnetic ΣKp index and are unlikely to be of seismogenic origin. Thus, we conclude that the preearthquake magnetic changes reported by Febriani et al. (2014) are an effect of the global geomagnetic activity.


## Acknowledgements

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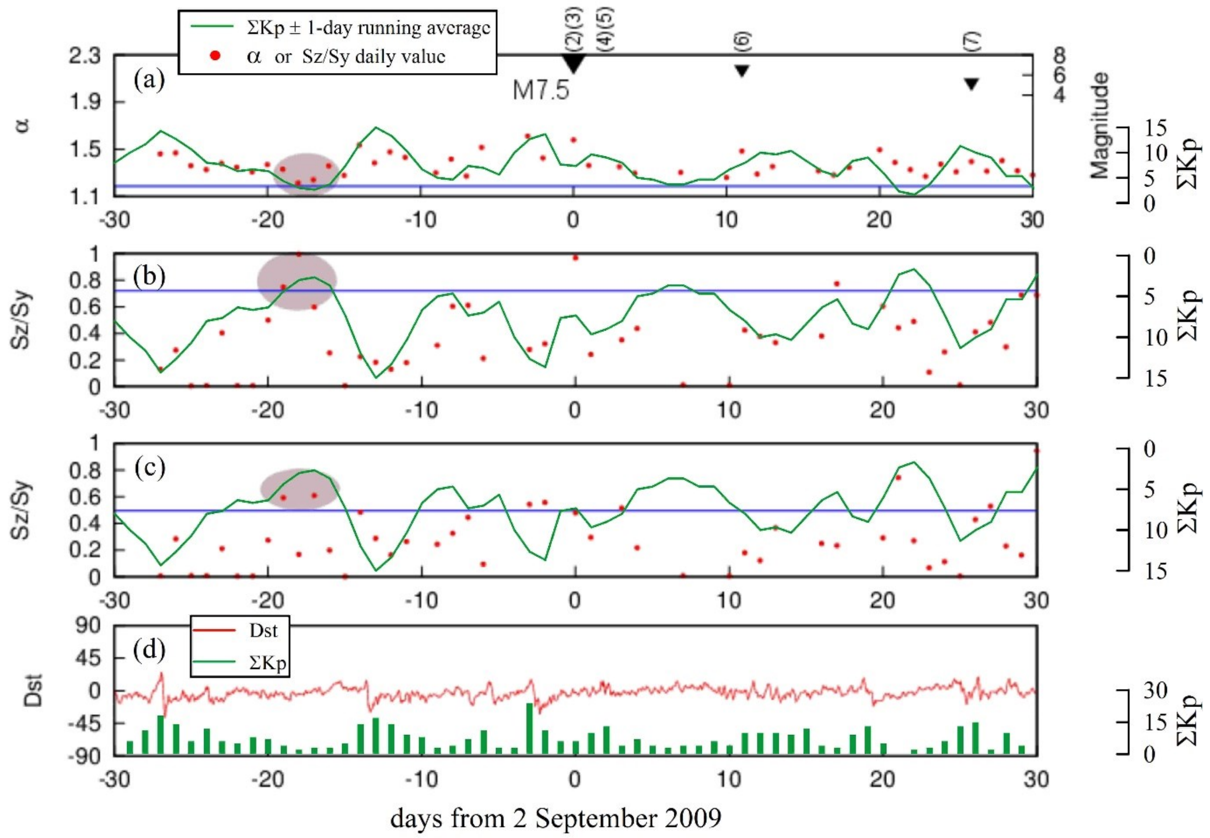


**Fig. 1.** ULF analysis (10±3 mHz) at the time of the 2 September 2009 Tasikmalaya earthquake as reported by Febriani et al. (2014, Fig 9). Day=0 is the day of the earthquake. (a): DFA α exponent of the magnetic field vertical Z component. The horizontal blue line refers to $\left(\overline{\alpha}-2\sigma_{\alpha}\right)$. (b) and (c): spectral density ratio $S_Z/S_Y$ calculated without and with the minimum energy method. The horizontal blue line refers to $\left(\overline{S_Z/S_Y}-2\sigma_{S_Z/S_Y}\right)$. Shadow areas refer to the anomalies stated to be precursors of the 2 September Tasikmalaya earthquake by Febriani et al. (2014). (d): Dst index. ΣKp index time-series has been superimposed onto the original views. See text for details

# Supplementary material for:

# Comment on “Ultra low frequency (ULF) electromagnetic anomalies associated with large earthquakes in Java Island, Indonesia by using wavelet transform and detrended fluctuation analysis”, by Febriani et al. (2014)

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The supplementary material includes two Tables, S1 and S2, and Fig. S1.

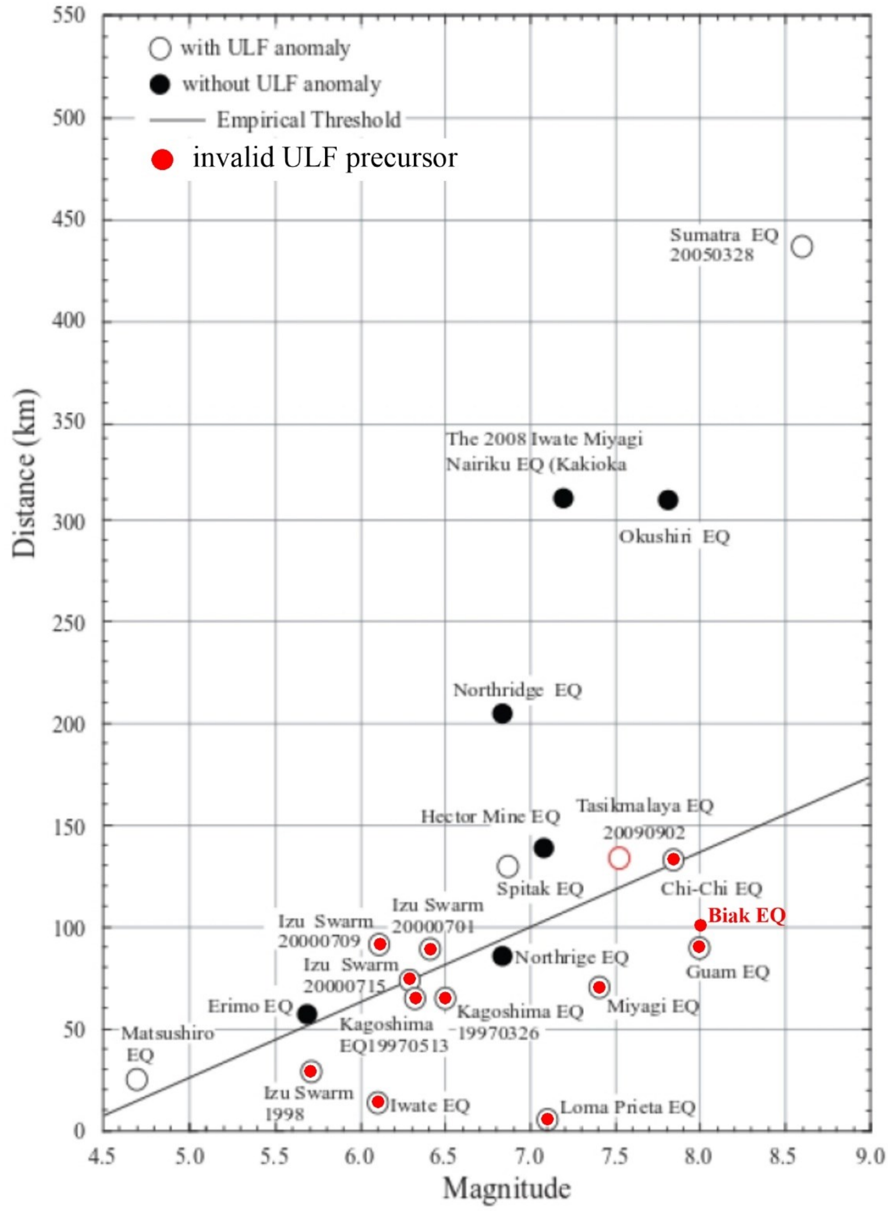


**Figure S1**. The black continuous line indicates the empirical relationship (R= 40M – 180) between the earthquake magnitude M and the distance R from the epicenter of the ULF station where the anomaly was observed (see Febriani et al., 2014, Fig. 10). We have included the Biak earthquake as in the original views by Hattori et al. (2004) and Hayakawa et al (2007). Note that the relationship was derived using invalid ULF precursors (see Table S2).

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**Table S1**. Papers cited by Febriani et al. (2014) (and corresponding reviews) that have reported invalid ULF magnetic precursors.

| Papers | Earthquake | Reviews |
|---|---|---|
| Akinaga et al., 2001. | 1999 Chi-Chi earthquake | Masci, F., 2011a, doi:10.1016/j.pepi.2011.05.001 |
| Fraser-Smith et al., 1990. | 1989 Loma Prieta | Campbell, 2009, doi:10.1029/2008JA013932 *<br>Thomas et al., 2009a, doi:10.1016/j.pepi.2008.11.014 |
| Hattori, 2004. | 1998 Iwateken Nairiku Hokubu<br>1997 Kagoshimaken-Hokuseibu | Masci, F., 2011a, doi:10.1016/j.pepi.2011.05.001 |
| Hattori et al., 2002. | 1997 Kagoshimaken-Hokuseibu | Masci, F., 2011a, doi:10.1016/j.pepi.2011.05.001 |
| Hattori  et al., 2004a. | 1998 Iwateken Nairiku Hokubu | Masci, F., 2011a, doi:10.1016/j.pepi.2011.05.001 |
| Hattori et al., 2004b. | 2000 Izu | Masci, F., 2011b, doi:10.5194/nhess-11-2193-2011. |
| Hayakawa et al., 2008. | 1993 Guam | Masci, F., 2010, doi:10.1029/2010JA015311.<br>Masci, F., 2013, doi:10.5194/nhess-13-187-2013. |
| Hayakawa et al., 1996. | 1993 Guam | Masci, F., 2011a, doi:10.1016/j.pepi.2011.05.001<br>Thomas et al . 2009b, doi:1029/2009GL039020 |
| Hayakawa et al., 2007. | 1997 Kagoshimaken-Hokuseibu | Masci, F., 2011a, doi:10.1016/j.pepi.2011.05.001 |
| Hirano and Hattori, 2011. | 2008 Iwate–Miyagi Nairiku | Masci, F., 2012, doi:10.1016/j.jseaes.2012.06.009. |
| Ida and Hayakawa, 2006. | 1993 Guam | Masci, F., 2010, doi:10.1029/2010JA015311. |
| Ida et al., 2006. | 1993 Guam | Masci, F., 2013, doi:10.5194/nhess-13-187-2013 |

* Reply: Fraser-Smith et al., (2011), Comment on “Natural magnetic disturbance fields, not precursors, preceding the Loma Prieta earthquake” by Wallace H. Campbell, J. Geophys. Res., 116, A08228, doi:10.1029/2010JA016379.

**Table S2**. Papers where alleged ULF precursors highlighted in Figure S1 by red dots have been denied.

| Earthquake | Reviews |
|---|---|
| Loma Prieta EQ 17-10-1989 | Campbell, W. H. (2009), Natural magnetic disturbance fields, not precursors, preceding the Loma Prieta earthquake, J. Geophys. Res., 114, A05307, doi:10.1029/2008JA013932.*<br>Thomas, J. N., Love, J. J, Johnston, M. J. S.: On the reported magnetic precursor of the 1989 Loma Prieta earthquakes, Phys. Earth Planet. Int., 173, 207-215, doi:10.1016/j.pepi.2008.11.014, 2009. |
| Guam EQ 08-08-1993 | Thomas, J. N., Love, J. J, Johnston, M. J. S., Yumoto, K.: On the reported magnetic precursor of the 1993 Guam earthquake, Geophys. Res. Lett., 36, L16301, doi:10.1029/2009GL039020, 2009.<br>Masci, F.: On claimed ULF seismogenic fractal signatures in the geomagnetic field, J. Geophys. Res., A10236,115, doi:10.1029/2010JA015311, 2010.<br>Masci, F.: On the seismogenic increase of the ratio of the ULF geomagnetic field components. Phys. Earth Planet. Int., 187, 19-32, doi:10.1016/j.pepi.2011.05.001, 2011.<br>Masci, F.: Brief communication “On the recent reaffirmation of ULF magnetic earthquakes precursors”, Nat. Hazards Earth Syst. Sci., 11, 2193–2198, doi:10.5194/nhess-11-2193-2011, 2011.<br>Masci, F.: On the multi-fractal characteristics of the ULF geomagnetic field before the 1993 Guam earthquake, Nat. Hazards Earth Syst. Sci., 13, 187–191, doi:10.5194/nhess-13-187-2013, 2013. |
| Biak EQ 17-02-1996 | Masci, F.: On claimed ULF seismogenic fractal signatures in the geomagnetic field, J. Geophys. Res., A10236,115, doi:10.1029/2010JA015311, 2010.<br>Masci, F.: 2011, On the seismogenic increase of the ratio of the ULF geomagnetic field components. Phys. Earth Planet. Int., 187, 19-32, doi:10.1016/j.pepi.2011.05.001, 2011. |
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| Iwate EQ 03-09-1998 | Masci, F.: 2011, On the seismogenic increase of the ratio of the ULF geomagnetic field components. Phys. Earth Planet. Int., 187, 19-32, doi:10.1016/j.pepi.2011.05.001, 2011. |
| Izu Swarm April-May 1998 | Masci, F.: 2011, On the seismogenic increase of the ratio of the ULF geomagnetic field components. Phys. Earth Planet. Int., 187, 19-32, doi:10.1016/j.pepi.2011.05.001, 2011. |
| Chi-Chi EQ 21-09-1999 | Masci, F.: 2011, On the seismogenic increase of the ratio of the ULF geomagnetic field components. Phys. Earth Planet. Int., 187, 19-32, doi:10.1016/j.pepi.2011.05.001, 2011. |
| Izu Swarm June-August 2000 | Masci, F.: 2011, On the seismogenic increase of the ratio of the ULF geomagnetic field components. Phys. Earth Planet. Int., 187, 19-32, doi:10.1016/j.pepi.2011.05.001, 2011.<br>Masci, F., and J.N., Thomas: On the relation between the seismic activity and the Hurst exponent of the geomagnetic field at the time of the 2000 Izu swarm, Nat. Hazards Earth Syst. Sci., doi:10.5194/nhess-13-2189-2013, 2013. |
| Miyagi EQ 13-06-2008 | Masci, F: On the ULF magnetic ratio increase before the 2008 Iwate–Miyagi Nairiku earthquake by Hirano and Hattori (2011), J. Asian Earth Sci., 56, 258–262, doi:10.1016/j.jseaes.2012.06.009, 2012. |

* Reply: Fraser-Smith et al., (2011), Comment on “Natural magnetic disturbance fields, not precursors, preceding the Loma Prieta earthquake” by Wallace H. Campbell, J. Geophys. Res., 116, A08228, doi:10.1029/2010JA016379.