Dear Editor-in-Chief,

We take this opportunity to thank you, and referee 1 for thoughtful comments on our manuscript which helped us in improving the manuscript. We hope that the answer of each major and minor comments will meet your expectations. The comments of the reviewers are shown in red color, our reply in normal font and black color, and added text or revised text is shown by highlighted color.

Yours sincerely,

Rahul Prajapati, Kusumita Arora

Reviewer comments # 1

Major comments.

Comment 1. No discrimination between quiet and disturbed magnetic days. It is known that geomagnetic external perturbations (storms, substorms, bays) produce similar effects on the signal than potential earthquake related anomalies. It is suggested to exclude periods of geomagnetic activity characterized by high values of geomagnetic indices (e.g. Kp, Dst, AE)

Answer 1. In the proposed study**, w**e have already selected the anomalies from quiet time by selecting days where kp<3and removed the anomalies correspond to kp>3 (line number 137). Additionally, following the suggestion from the comment, we again compared these anomalous signatures with the DST index for the same duration of study and found that it lies between -50 and +40, which indicates the absence of any storms or substorms (**Figure 1**). Thus, in the proposed work, the anomalies computed from the vertical component of geomagnetic data are possibly free from the effect of any external origin. We prefer to use only the kp and Dst indices because these indices are computed from lower and middle latitude observatories, and our study also lies in this region only, while the AE index is computed from observatories in the polar region to quantify the geomagnetic activity in the polar region. Thus, we have avoided using the AE index in our study.

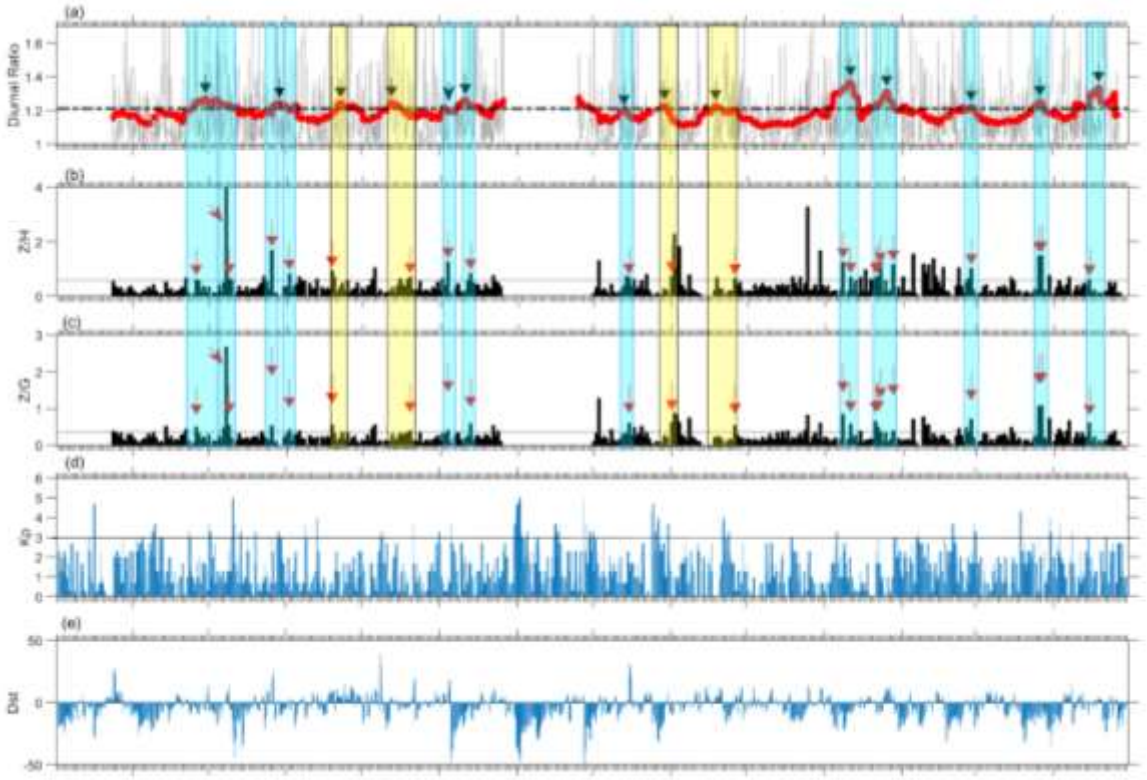

Figure 1. The anomalies from vertical component of geomagnetic data (a) diurnal ratio, polarization ratio (b) Z/H, and (c) Z/G, along with geomagnetic indices (d) Kp, and (e) Dst.

Comment 2. No confutation analysis. The method must be validated considering a comparable period without seismicity to see how the method behave. If the number of anomalies are comparable, the method does not work.

Answer 2.

Thank you for the point. In this regard, we have tested the same method on the data of the mid-latitude geomagnetic observatory in Hyderabad, India, from March 2019 to March 2020, which has nearly the same duration as the Campbell Bay data. The geomagnetic observatory of Hyderabad is located in Deccan-Shield, which is a completely aseismic zone. The final result we

obtained from the Hyderabad data was compared with the final result of the Campbell data, and we noted that in the diurnal ratio, the only anomaly of 28–29 November 2019 partly matches the anomaly of the Hyderabad data from October 22 to November 2, 2019, which is completely absent in the polarisation ratio of Hyderabad. Apart from that, the anomalies in the polarisation ratio of Campbell Bay and Hyderabad are not comparable to any extent. Thus, we believe that the data recorded in the tectonic active region is more likely to record the EM signatures from pre-earthquake processes, and the significant enhancements that appear within an acceptable range of days prior to earthquakes show that the method works well. The comparative figure of the final result of Hyderabad and Campbell data is shown in the below figure.

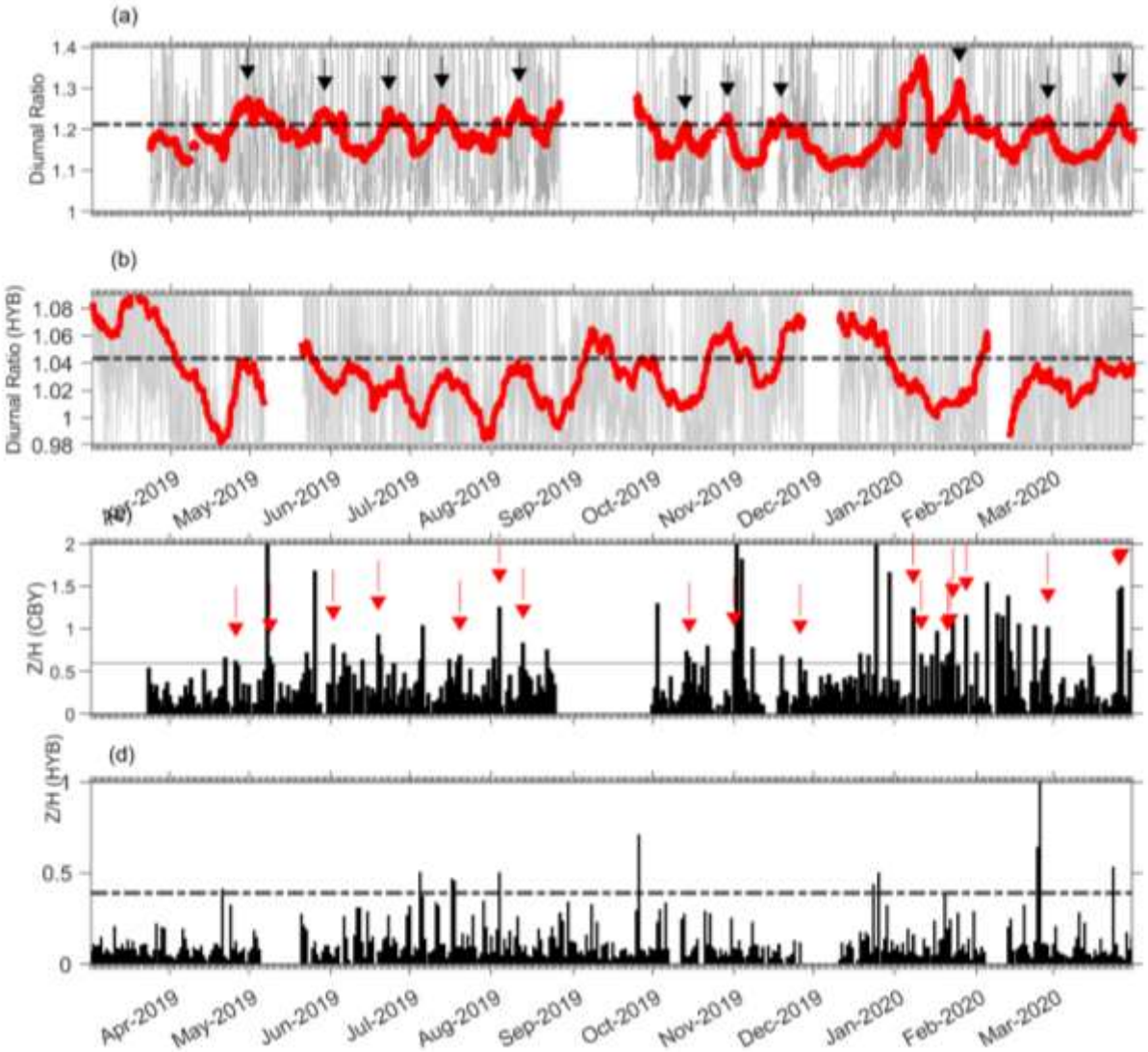

Figure 2. Diurnal ratio anomalies from vertical component of geomagnetic data (a) Campbell data, (b) Hyderabad data. Polarization ratio anomalies (c), Campbell data (d), Hyderabad data.

Comment 3. Range in earthquake magnitudes just limited between 4.5 and 5.3. One would expect that magnitude and distance of earthquake with respect to the geomagnetic station affect the geomagnetic field differently, increasing the amplitude of anomaly with magnitude or with inverse of distance. To have a reliable statistic a large range of magnitudes is necessary. In addition, the work considered 63 earthquakes, then selected 15 "groups" of earthquakes (Figure 8), that were then reduced to 14 (Table 2).

Answer 3.

In the proposed study, from May 2019 to Apr 2020 (duration of study) faces the earthquakes with magnitude range from 4.5 to 5.3 the duration of study. Thus, due to insufficient length of data it was difficult to achieve such objective in present study. The similar type of work is also carried out by Bulusu et al. (2023) and Ida et al. (2012) which supports our study. Bulusu et al. (2023) has identified the anomalous EM signatures (from vertical component of geomagnetic signal) associated with moderate magnitude earthquakes ($3.5 \leq M \geq 5$) occurred near to Main Central Thrust (MCT) in Kumaun Himalaya region, India. Similarly, Ida et al. (2012) analysed ULF geomagnetic data at Kashi station, China approximately for four years where several moderate earthquakes ($5 \leq M \geq 6$) occurred within 100-125 km radius of recording station and reported significant changes in vertical component of geomagnetic field prior to the earthquakes.

Figure 8 represents the amplitudes of anomalies of diurnal ratio and polarization ratio correlatable with earthquakes occurring during or after these anomalies. The first dense cluster of 45 earthquakes occurring from end of March 2019 to mid-April 2019 are not included in this figure, as the data length before the occurrence of this cluster is insufficient. The horizontal axis represents earthqaurs or group of earthquakes, which are possibly associated with preceded anomalous signatures instead of whole declustered earthquake from earthquake CatLog.

Comment 4. Lines 178-191. The chosen thresholds (from one sigma to 0.125 sigma, at 0.5 interval of standard deviation) are not robust to detect anomalies. An anomaly should be some signal that clearly emerges from the background. For the chosen thresholds, this is not the case: in this case the anomalies could be simply due to chance.

Answer 4. Han et al. (2015) used threshold value $\mu + 3\sigma$ and found a single anomalous signature in vertical component of geomagnetic field prior to two month of Tohoku earthquake M9.0. Similarly, Yousof et al. (2019) used threshold value $\mu + 2\sigma$ to identify the anomalous signature in vertical component of geomagnetic field and found a single anomaly two weeks before the Visayas, Philippines earthquake M6.9, 2012. Habora et al. (2004) used threshold condition $\mu + \sigma$ and identified the anomalous signature in geomagnetic data prior to earthquake occurred on Izu island of magnitude between 6 and 6.5. Habora et al. (2004) also tested $\mu + 1.2\sigma$ threshold condition and noted the isolated anomalies correspond to same earthquakes. Moreover, Arora et al. (2012) analysed the geomagnetic signal of Koyna region to study the anomalous EM signatures from earthquakes occurred due to induced reservoir seismicity with magnitude 2.5 to 4.0 and noted few anomalous signatures in polarization ratio. In this study, Arora et al. (2012) used mean value of polarization ratio by adding 0.27 and 0.72 as a threshold condition to identify the significant variation in polarization ratios.

As the magnitudes of the earthquakes in study duration are moderate (4.5<M<5.3) and occurrence frequency is monthly on an average, it was necessary to lower the thresholds in order to detect the anomalies at all. Also, we have used nighttime data for polarization ratio as well as restricted the values of Kp and Dst indices. Hence we feel that the current thresholds are justified. In Figure 2 above, we see that application of the same thresholds on data from an aseismic site does not produce any anomalies, which further validates our approach.

Minor points:

1. The sentence from line 12 to line 13 has no verb. I suggest to insert “has been analysed” in line 13, just after “region”.

Answer: Revised (line number 13)

2. Line 15. Please correct “seasonal effects”.

Answer: Corrected ((line number 13)

3. Line 42. Please delete “been” in “have been studied”.

Answer: corrected ((line number 42)

4. Line 54. Please correct “earthquakes”.

Answer: Corrected ((line number 54)

5. The sentence that starts from line 75 is not clear. There is a list of earthquakes, probably earthquakes occurred before 2000. Therefore, specify it.

Answer: Sentence revised ((line number 74-78)

6. In line 78 the magnitude attributed to the Dec. 26 2004 earthquake is 9.0, while in the next line 83, is attributed as 9.1 Mw.

Answer: Corrected ((line number 83)

7. Figure 1. The acronym AS (Andaman Trench of the Sumatran Fault System) mentioned in the caption, is not found in the figure. By the way, the caption is poorly written: for instance, it is not clear which geomagnetic station is represented by a triangle (Campbell Bay, Great Nicobar, mentioned in the Data?).

Answer: Figure 1 is replaced by revised figure including the correction of AS by AT. The figure caption is also revised (Page No. 5).

8. Line 105. What is “MSL”? mean sea level? Please specify.

Answer: The sentence is revised by specifying the MSL as mean sea level ((line number 106).

9. Lines 120-121. The distance is probably taken from earthquakes and geomagnetic station. Please specify.

Answer: Sentence is revised (line 123)

10. List of earthquakes in Table 1. It is evident that no declustering was applied: there are many earthquakes very close in time.

Answer: Table 1 showing the all earthquakes available in ISC CatLog, while Table 2 showing the declustured earthquakes with details of preceding anomalies or possible EM signature from pre-earthquake processes.

11. Line 140. Please correct "indicates"

Answer: Corrected ((line number 142)

12. Figure 3. Please insert "the anomaly" before "detection" ((line number 149-150).

Answer: Revised

13. Line 156. The sentence "A ratio >1 indicates the suppression in amplitude of Z-component." is not clear to me. The ratio is Z/H. Do you mean "…in amplitude of H-component"?

Answer: in this section we discussed about diurnal ratio i.e. ratio of regular diurnal and daily diurnal. The regular diurnal constructed from best quiet days of each month, by taking the ratio the background signal in daily diurnal is minimised and close to 1. But if there is small amplitude of diurnal field (due to superimpose of other field) the ratio will be greater than 1. Thus from time series of ratio of regular and daily diurnal ratio, it is easy to identify the anomalous Z-field by tracing the ratio greater than 1.

14. Line 182. Please delete "is" before "significantly".

Answer: Corrected

15. Line 256. What is "CBY"? Is it the station Campbell Bay? Please specify (of course the first time you introduce the geomagnetic station).

Answer: Sentence is revised (line 258).

16. Line 330. It is introduced the concept of skin depth without any definition or reference.

Answer: Sentence is revised (line 332-333).

17. Line 334. Please correct "H field"

Answer: Corrected ((line number 337)

18. Line 344. Please correct "2 months before at stations ESA and MR"

Answer: Sentence revised ((line number 347-348)

19. Line 373. Please write "up to"

Answer: sentence revised (line 377)

20. Lines 400-402. Please add some references.

Answer: Sentence is revised and reference added ((line number 404-406).

21. Line 416, Please write "may facilitate to understand" (delete "to facilitate")

Answer: sentence is corrected (line number 420).