**Response to Reviewers – Round 1**

We thank the editor and the reviewers for their thoughtful and constructive comments on our manuscript. We appreciate the time and expertise you invested in reviewing this work. Below, we address each of your comments and suggestions in detail.

**Summary**

We've made a number of changes to the manuscript based on the thoughtful feedback from the editor and reviewer. To meet Fast Reports guidelines, we trimmed the abstract and main text and limited the number of figures. We improved the clarity and tone throughout cleaning up grammar, rephrasing technical language into more accessible terms, and making sure all figures are clearly labeled and easy to read. Scientifically, we clarified our methodology, especially around the frequency index, explaining what it means and how we use it. We also refined the way we interpret moment tensors and seismic patterns, toned down some overstatements, and added new analyses to explore both the spatial and temporal patterns of seismicity. In response to reviewer requests, we updated the Zenodo repository to include missing FI values and reorganized some figures, moving parts to the supplement and combining others for better flow.

**Reply to Editor**

1. **Comment:** Fast Reports requirements: Abstract should be 100 words or less, manuscript body should be 3000 words or less and maximum number of figures is 3.

Response: In accordance with the Fast Reports requirements, we have revised the abstract/non-technical summary to be under 100 words, reduced the manuscript body to fewer than 3000 words, and limited the number of figures to three.

1. **Comment:** Line 32: "earthquakes that occurred" instead of "occurred earthquakes"

Response: Thank you for the suggestion. However, the sentence containing "occurred earthquakes" was removed during revision due to being unnecessary and to meet word limit requirements.

1. **Comment:** Lines 34-35: This sentence about inverting waveforms needs to be cleaned up grammatically and to ensure it is truly 'plain language'.

Response: We have revised the sentence. It now reads: “Waveform analysis...” (**Line 26**)

1. **Comment:** Lines 38-39: Split the last sentence into two sentences, with the latter starting "The gathered high-quality products..."

Response: The revised text now reads: “Data products are publicly available for future research.” (**Line 28**)

1. **Comment**: Lines 44-45: Watch the tense of your verbs. I suggest "In early March, activity continued, though with fewer events and lower magnitudes."

Response: Based on the Editor’s suggestion the text has been updated (**Line 34**)

1. **Comment:** Fig 1: Label the African Plate, the Hellenic Arc, Christiana/Anydros/Santorini-Anafi/Amorgos Basins, and Christiana Islands, as they are described in text. Ensure that subfigure labels ("a)") are outside of the subfigure, ideally at the top left corner, and exist for all subfigures. Currently there are no labels for the cross-sections. Apply this to all figures.

Response: Taking into account the Editor’s comment we have updated **Figure 1** to include all necessary place names and labels.

1. **Comment:** Line 76: "offshore" of where?

Response: Thank you for the suggestion. However, the sentence containing "occurred earthquakes" was removed during revision due to being unnecessary and to meet word limit requirements.

1. **Comment:** Line 80: Ensure all islands described in text are in Fig 1 (ex: Astypalea).

Response: Astypalea is located outside the immediate area of interest and is not shown in Figure 1. Since it was not essential to the discussion, we have removed the reference to Astypalea from the text.

1. **Comment:** Line 81: Use commas between items in list of adjectives: "small, remote, inhabited island".

Response: Due to word limitations we have moved the “Data Availability” section to the supplementary material as **Text S1**, where these commas have been added.

1. **Comment:** Line 82: At the center of the current seismic activity or of all seismicity in the region? Also it's unclear why a station in the center is more useful than others in terms of preserving good azimuthal coverage for depth estimation. Please qualify.

Response: Thank you for the comment. We have clarified that the station is located near the center of the *current* seismic activity and emphasized that its contribution lies in improving event location *accuracy*, rather than azimuthal coverage. The revised text now reads: “The installation of station ANYD (03/02/2025) on a small, remote, inhabited island was a decisive improvement, as it is located close to the center of the current seismic activity. Its proximity to the active area significantly improves event detection and location accuracy.” (**Text S1**)

1. **Comment:** Line 85: Perhaps reference to your data availability statement or somewhere where you provide information about which stations, by name.

Response: We have added a reference to Figure S1, which provides details on the station names and their availability. (**Line 65**)

1. **Comment:** Line 88: What is an "attention mechanism"?

Response: The attention mechanism is a powerful concept in deep learning that allows models to dynamically focus on the most relevant parts of the input data. This enhances their ability to process complex information. In the context of EQTransformer, the attention mechanism helps the model effectively distinguish between P-wave and S-wave arrivals, even in the presence of noise. This selective focus improves the accuracy of earthquake detection and phase picking.

We have also updated the original sentence to improve clarity to: “EQTransformer is a deep-learning picker based on an attention mechanism, which allows the model to focus on relevant features in the waveform data.” (**Line 68**)

1. **Comment:** Line 91: Define "VCSEIS". Describe what you mean by "it quickly became evident that volcanic activity might be involved". Was a non-volcanic training dataset also used, to look for tectonic signals?

Response: We have clarified the meaning of "VCSEIS". The benchmark dataset includes both volcanic and tectonic seismic signals. This ensures the model's applicability to a range of seismic sources. We have also expanded on what led us to suspect volcanic activity: spectrograms showed characteristic patterns, and moment tensor analysis indicated non-double-couple components. The revised sentence now reads: “We adopted the model trained on the VCSEIS benchmark dataset...it quickly became evident that volcanic activity might be involved, based on characteristic features observed in the spectrograms and supported by moment tensor analysis” (**Line 72**)

1. **Comment:** Lines 93-94: Can you make this a bit more clear, and less vague/subjective? It sounds like you're saying that this approach doesn't work well for this type of data, but that a different model is potentially better.

Response: Thank you for the helpful comment. We have clarified the statement to be more clear and specific from: “Zhong and Tan (2024) demonstrated that existing deep-learning-based phase pickers perform poorly in volcanic environments, but their model could overcome existing issues.” to “Zhong and Tan (2024) demonstrated that the performance of existing deep-learning-based phase pickers tends to decline in environments with lower-frequency earthquake signals, such as volcanic regions. However, their proposed model showed improved performance, making it particularly well-suited to our specific monitoring context.” (**Line 75**)

1. **Comment:** Line 95: Has PyOcto been used before for similar data? How does it work, in one sentence?

Response: To our knowledge, PyOcto has not yet been applied to data exactly like ours, as it is a relatively new tool. In addition, we have added a brief description in the text to clarify how it works: “The independently identified phases were associated and initially located using PyOcto (Münchmeyer, 2024), a 4-D space–time node partitioning algorithm that identifies and validates, through a grid search approach, space–time nodes from which a set of picks most likely originates.” (**Line 79**)

1. **Comment:** Line 97-98: I suggest saying something like "more accurately" instead of just "accurately", as it is still just a model.

Response: The sentence has been changed in **Line 83.**

1. **Comment:** Line 100: The events were located with PyOcto, then with NonLinLoc, and then with SSST. It seems misleading to refer to this as an "initial" relocation. could you provide at least one sentence about why you use 4 different approaches to locate the events, and whether the order matters? Have there been other studies using this 4-step approach?

Response: We agree that calling this step an "initial" relocation could be misleading, and we have removed the word for clarity. Each step in our workflow serves to progressively improve the event locations. PyOcto performs the initial phase association and provides a coarse event location. NonLinLoc then computes a more accurate *absolute* location using a 1D velocity model. SSST improves these *absolute* locations further by minimizing travel-time residuals. GrowClust further refines the solution by performing *relative* relocation using cross-correlation values. Multi-step approaches based on similar logic have been commonly used in recent studies (e.g. Lomax and Savvaidis, 2021; Zhang et al., 2022). We also added a sentence explaining the rationale behind the multi-step approach. (**Line 101**)

1. **Comment:** Line 106: what error threshold is used to determine the "well-located" events?

Response: Thank you for the comment. To identify an earthquake as a "well-located" event in the SSST catalog, we applied the same criteria used in the NonLinLoc step: azimuthal gap <300°, average RMS <0.5 s, and horizontal and vertical location errors <5 km. However, as shown in Figure S3, the events exhibit values well below these thresholds.

1. **Comment:** Line 111: Is there a reference for the 0.7 threshold? It seems that 0.9 is common for identifying co-located events based on CC.

Response: There is no strict rule for selecting a CC threshold, as it depends on data quality and station coverage. Based on the distribution shown in Figure S4, we decided that a threshold of 0.7 provides a good balance between ensuring waveform similarity and keeping a sufficient number of event pairs to perform a robust and well-populated CC relocation. We have also added references to studies that have used similar or even lower thresholds, such as Schaff and Waldhauser (2005), Trugman et al. (2020), and Lin et al. (2022), to support our choice. (**Line 97**)

1. **Comment:** Line 121: Briefly describe the "classic" ISOLA approach.

Response: We have added a brief description of the classic ISOLA approach. (**Line 108**)

1. **Comment:** Lines 122-123: Not sure this sentence about the updated version is needed, if you are supplying references to the updated version and have already described it in the previous sentence (assuming the update is the 4D grid).

Response: The update of the software concerns the full MT inversion that is not available in the supplying references and is scheduled to be added to the next official release. Therefore, we have kept this note in the text to inform readers about this important difference.

1. **Comment:** Line 129: "fails to meet at least two of the previously mentioned parameters": move this sentence after the sentence where you set the limits of the parameters.

Response: The sentence has been moved based on the suggestion.

1. **Comment:** Lines 135-136: What is the early evidence? If not referenced or shown in this paper then not appropriate to point to. Can easily omit this sentence.

Response: We agree with the Editor’s recommendation and have removed the sentence from the text.

1. **Comment:** Line 137: Can you provide an example reference for this approach of using frequency content as an "indicative metric"?

Response: In response to the Editor’s comment, we re-evaluated the use of the term “indicative” and replaced it with “quantitative,” which more accurately reflects the nature of the metric discussed in the text (**Line 125**). References supporting this quantitative metric are all included in the same paragraph.

1. **Comment:** Lines 140-141: The sentence about not using this technique for classifying volcanic earthquakes is somewhat confusing as you say at the start of this paragraph that your goal is to identify types of signals. So why not use it to classify, and also how does the analysis of frequency content provide different/superior information?

Response: Thank you for the comment. We agree that the original wording was unclear and have revised the sentence to better reflect our intent. The updated text now reads: “Although FI is often utilized to classify events presumed to be volcanic, this study exclusively employs it to examine the distribution of frequency content and to potentially distinguish between different seismic signal signatures.” (**Line 129**). Our primary goal is not to classify events in a categorical sense, but rather to analyze the frequency content of the signals to gain insight into the nature of the seismic sources. This approach helps identify trends and characteristics that may suggest different source processes without enforcing rigid classifications.

1. **Comment:** Line 144: why only these 2 stations?

Response: As the goal of this analysis is to quantify the frequency content of the seismic signals as clearly as possible, we chose stations located close to the activity area in order to minimize path effects, which can significantly distort the observed frequency content. The ANYD station is the closest to the activity after its installation, and THERA was the nearest high-quality broadband station available before ANYD became operational. Including more distant stations would introduce greater path effects and variability, which would reduce the reliability of the frequency content analysis. In the revised manuscript we have included only FI values from the ANYD station as we later decided, based on the comment of the reviewer, that the THERA station is not close enough to guarantee limited path effects in the seismicity of the Kolumbo area that was active before the ANYD installation.

1. **Comment:** Fig 2: Is the black outline in (a) Anydros Island? If so, indicate in text. It seems the colorbar for FI is redundant because the inset histogram achieves the same goal. Do all MTs have FI of 1-2, or are MTs plotted in red regardless of FI? Would it be too unorthodox to plot strikes from 0-180 instead of 0-360, to better show the preferential alignment?

Response: Yes the black outline represents Anydros Island and we have added the description in the caption of the figure. In addition the FI colorbar was removed. Based on a comment of the reviewer we have added a new figure in the supplemental material **(Fig. S10c)** that depicts the relationship between FI values and the DC components of the moment tensors. The majority of events exhibit negative FI values, indicating dominant low-frequency content. Additionally, the strike/dip/rake panels have been moved from Figure 2 to the supplemental material **(Fig. S7)**.

1. **Comment:** Line 147: Cite Fig 2 in Section 2.3 as well.

Response: The citation has been added. (**Line 120**)

1. **Comment:** Line 150: Please include a link to the online preprint in the reference to Papazachos et al., 2025.

Response: As the work by Papazachos et al. (2025) has not yet been published or made available as a preprint, we have updated the reference to indicate it as a personal communication. “As already analyzed (Papazachos, 2025, personal communication)” (**Line 141**).

1. **Comment:** Line 152: Suggest moving the reference to Fig S8 to the end of the sentence, as Fig 1 shows days, and therefore rate, also. The current configuration makes it seem that Fig S8 is needed to support one of your conclusions, which would suggest that S8 should be moved into the main text, which you don't have room for in this format.

Response: Based on the Editor’s proposal the Fig S8 has been moved to the end of the sentence. (**Line 146**)

1. **Comment:** Line 156: Again, include commas between items in a list of adjectives: "linear, vertical, narrow pattern".

Response: The commas have been added. (**Line 149**)

1. **Comment:** Lines 163-167: I think this is somewhat over-interpreting, based on what is shown in Fig 1. If you want to claim "small linear branches", "vertical dipping structures" and "antithetic structures" you should annotate those on a version of your cross-sections. Currently, I can't confidently identify what you are talking about.

Response: We have added annotations to Figure 1d, g to highlight the interpreted branches, vertically dipping structures, and antithetic features, as referenced in the text. Moreover the caption of the figure has been updated.

1. **Comment:** Line 167: Omit either "shows" or "suggests".

Response: The word "suggests" has been omitted. (**Line 156**)

1. **Comment:** Lines 167-168: The Santorini Amorgos Fault in Fig 1 is a little bit hard to understand. It looks like the label indicates a set of curved faults bounding a basin (possibly even meeting one another just outside of the boundary of 1b). Is this true? Is it still active? Seems like it would be less likely to host major earthquakes than the more linear Amorgos and Santorini-Anafi Faults. I would therefore suggest changing this sentence to say that the seismicity aligns with the Amorgos Fault.

Response: Thank you for your thoughtful comment. In this case, we are referring to secondary seismicity occurring near the main area of activity. We agree that the shape of the “fault” appears unusual, and we also share your reservations. However, this information is present in the fault database. To address this concern, we have removed the “Santorini–Amorgos Fault” label from the map, and the text has been revised to: “Additionally, earthquakes seem to cluster near other significant geological structures, running parallel to the main activity (near Amorgos Fault)” (**Line 158**).

1. **Comment:** Line 168-170: Rather than referring to these as "upward migrated events", which is a somewhat confusing term, I would refer to these as a shallow cluster of events at depths of less than 5km.

Response: The text has been revised from “...there is a significant number of upward migrated events to shallower depths near the surface…” to “...there is a significant number of shallow clustered events at depths of less than 5km…”. (**Line 159**)

1. **Comment:** Fig 3: Ensure this figure is referenced before it appears. As it shows the rate of migration, in 2D, it could be useful to reference this around line 152? Provide more information about this SW-NE line — is it the a-b cross section line in Fig 1? And what is the width, perpendicular to the line, in which seismicity is concluded. Suggest flipping the depth color bar so deeper is on the bottom. Are M>4.5 events all at ~13km depth or are they automatically colored red for emphasis? It's generally hard to read the depths on this figure, especially in insets with the moving average overprinting.

Response: Taking your recommendations into account, we have updated Figure 3 as follows: 1) The depth color bar has been flipped so that deeper events are shown at the bottom. 2) We clarified in the caption that M > 4.5 events are automatically colored red for emphasis. 3) The figure has been resized for improved readability, and we adjusted the layout to reduce overprinting from the moving average in the insets. 4) We already have clarified in the figure caption and in the Y-axis the position of the start/end of the SW–NE line. The width of the projection window was chosen to include all the seismicity along the SW–NE profile and this information has now been added to the figure caption.

1. **Comment:**Lines 172-175: This is not an especially strong argument, in my opinion. Only inset (d) shows a somewhat convincing "back-and-forth", to me, as the black-dashed rate basically aligns with the moving average. Insets (b) and (c) seem to show seismicity occurring across the swath basically simultaneously, hence the moving average stays more or less in the middle. The argument about the ISO and CLVD is also difficult because Fig 2 doesn't give us any temporal information from which to determine if events at certain times had a strong non-double-couple component. Therefore, you could make this argument about all of the seismicity or you will need to redo Fig 2/3 somehow to support this case.

Response: We appreciate your thoughts in Figure 3 and we agree that we should be more careful here in the interpretation. To address this, we have revised the sentence from: “The spatiotemporal seismicity migration patterns are characterized by back-and-forth seismic activity from February 2 to February 14, during which most of the area was activated.” to “The spatiotemporal seismicity shows possible back-and-forth migration patterns, with the most prominent activity occurring between February 11 and February 14.” **(Line 163).** We also included a short movie we created that clearly depicts the suggested migration, which is available in the Zenodo repository and is mentioned in the “Data and code availability”.Moreover, to address the argument regarding the lack of temporal information for ISO and CLVD components, we have removed the phrase “during this period” to ensure that the statement refers to the entire seismic sequence rather than implying a specific time window.

1. **Comment:**Line 177-178: Could you explain why this requires careful consideration, aside from general caution?

Response: By “careful consideration,” we intended to emphasize the importance of assessing additional parameters—such as local seismotectonics and frequency content, when interpreting non-double-couple components. These values can be affected by numerical or modeling artifacts, and without supporting context, they may lead to misleading interpretations. To make this clearer for readers, we have revised the sentence from “However, their interpretation remains uncertain and requires careful consideration” to: “However, their interpretation requires careful consideration and assessment of other seismicity parameters, as non-double-couple values can also reflect inversion artifacts.” This change also aligns with the reviewer’s helpful suggestion to cite Rösler et al. (2024), which we have now included. (**Line 169**)

1. **Comment:** Line 184: Since you only use this acronym once, I suggest writing out "double couple" instead of "DC".

Response: We have replaced the acronym “DC” with “double-couple”. (**Line 166**)

1. **Comment:** Lines 186-187: P and T axes aren't shown in Fig 2 and you haven't yet stated what P and T axes would be "suggested by the distribution of the seismicity", so I suggest omitting this sentence.

Response: We have removed the sentence to avoid confusion and replaced it with “The extensional regime is also suggested by the calculated stress axes (Fig. S10)”. (**Line 177**)

1. **Comment:**Line 188-190: You haven't yet explained what high or low FI means, physically. Perhaps that should be in the methods? I don't really know how to interpret what you're telling me about the values, as a result. Also the histogram in Fig 2b shows more negative events than positive ones, at odds with the sentence in line 189-190.

Response: Thank you for this helpful comment. You're absolutely right that the physical meaning of high or low FI values wasn’t clearly explained in the Methods, and we’ve revised that section accordingly. In brief, FI quantifies the ratio of high- to low-frequency energy in an event. In order to make this clear to the readers we have added the following sentence in the Methods: “A high (positive) FI signifies the prevalence of high-frequency energy characteristic of brittle failure or volcano-tectonic earthquakes, while a low (strongly negative) FI denotes the predominance of low-frequency energy, frequently linked to fluid-driven mechanisms such as the resonance of fluid-filled fractures or conduits triggered by pressure transients in the fluid.” (**Line 131**).

We’ve also corrected the interpretation of the histogram in Fig. 2b and corrected the particular sentence from “Examining this FI spatial distribution, we observe that medium- to high-FI events are abundant in the area, while low-FI events are also present.” to “Examining the spatiotemporal distribution of FI values, we observe that medium- to low-FI events are abundant in the area, with high-FI events also present” (**Line 180**)

1. **Comment:**Line 190-192: Again, you haven't established that low FI means less tectonic contribution, so this statement is not yet well-supported. Also my inspection of 2a is that there appear to be more negative FI events at the northern edge of the NE-SW elongate cluster, meaning more negative FI events in the NW. Can you better describe how you decide where there are more negative vs positive FI events, if it is not immediately clear from inspection of the same figure? Also line 191, "disposal" should be "pattern".

Response: The Editor is correct regarding the spatial distribution of the FI values. So we have revised the sentence to acknowledge the negative FI events at the northern edge of the NE-SW elongate cluster (**Line 182**). In addition, the “disposal” has been replaced with “pattern”. More details about the physical meaning of FI have been provided to **Comment 40**.

1. **Comment:**Line 192-195 and Fig 4: It is unclear what these signals mean and why they are being included. More text is needed to describe how such signals are interpreted elsewhere and what it means for the tectonic vs volcanic nature of events in this sequence. As it is, I suggest omitting this figure and text until perhaps it can be further elaborated upon in a future paper.

Response: These signals are two representative examples illustrating the range of frequency characteristics observed in the seismic activity, highlighting the complexity and variability of the signals. In **Line 132,134**, we now include citations to studies that interpret similar signals, though a more detailed discussion is beyond the scope of this report and constrained by word limits. As requested by the Reviewer, Figure 4 has been removed, with relevant parts integrated into Figure 2.

1. **Comment:** Line 203: As already stated, I don't think the "back-and-forth" is well established and should therefore be presented tentatively or omitted from the conclusions.

Response: We kindly refer the Editor to our response to Comment 37, where we address this point again.

1. **Comment:** Lines 206-207: As already mentioned, the FI metric needs to be better explained in order to preserve this as a conclusion.

Response: In response to the Editor’s recommendation **(Comment 40)**, we have already expanded the explanation of the FI.

1. **Comment:**Line 212: From the abstract and introduction, I thought there would be more discussion of the daily operational monitoring. Perhaps you could include a sentence or two here about how this data was used for that purpose.

Response:Due to the word limit, it was not feasible to include additional details about the daily operational monitoring. For that reason, references to it were largely removed from the abstract.

1. **Comment:** Line 232: "earthquake" should be "earthquakes".

Response: The word has been corrected. (**Line 132**)

1. **Comment:** References: While you currently meet the requirement of providing doi's for most of your references, we invite you to include them wherever possible. This includes: Anderson et al.; Andinisari et al., 2021; Bonhoff et al., 2006; Dimitriadis et al., 2010; Heath et al., 2019; Jolivet et al., 2013; Le Pichon et al., 1979; Lomax & Savvaidis, 2022; Papadimitriou et al., 2015; Papanikolaou, 1993; Papazachos et al., 1997; Preine et al., 2022; Sakellariou et al., 2010; Sigurdsson et al., 2006; Tsampouraki-Kraounaki et al., 2021.

Response: Thank you for the suggestion. We have added the DOI information for the dominant majority of the references listed, wherever available.

1. **Comment:** Line 239: Anderson et al., is missing the year.

Response: The year has been added. (**Line 236**)

1. **Comment:** Figure S1 (b) is not color-blind friendly. Please replot.

Response: Figure S1(b) has been updated using a color-blind-friendly palette

1. **Comment:**Ensure subfigure labels are consistent: outside of the subfigure plot, to the top left.

Response: We have updated all the subfigure labels to ensure consistency.

1. **Comment:**Figure S6 (a), ensure there is a label for the solid blue line.

Response: We have now added a label for the solid blue line in Figure S6(a).

1. **Comment:**Figure S8: Can you be clearer about how you are assigning seismicity to Santorini versus Anydros/"the rest"? Also, what is the "relative day"? Since you already show the temporal evolution of seismicity away from Santorini in Fig 1, and since the main text doesn't have much of a comparison of seismicity in Santorini versus elsewhere, you may not need this figure at all.

Response: We have clarified the criteria used to assign seismicity to Santorini versus offshore (Anydros activity) and explained the meaning of "relative day." These clarifications have been added to the caption of Figure S8.

1. **Comment:**Fig S9: I don't think this was referenced in the main text (line 186-187). Include reference there, as this is an interesting plot to keep, but I still think you should be careful about drawing any major conclusions from this figure as P and T axes are not a major component of the paper.

Response: The previous Fig S9 now Fig S10 was referenced in **Line 178.**

**Reply to the Reviewer**

1. **Comment:**Is it possible to access the FI values? Apparently the `catalog.txt` in the zenodo repository (https://zenodo.org/records/15074928) does not store the associated column. I also dug into the `mts.xml` file, but I couldn't easily find the values. It would be great if the authors could make the FI values available in the relocated catalog or as a separate file in the zenodo repository.

Response: Thank you for pointing this out. You are correct — the FI values were unintentionally omitted from the original upload to the Zenodo repository. We have now updated the repository to include a separate file named **FI.txt**, which contains the FI values for the relocated catalog (https://zenodo.org/records/15213701).

1. **Comment:**Are there any reasons why the FI values along the c-d cross section (Fig. 1) are not displayed in Fig. 2? Is it due to the noise level? I am curious because, If the statement in L191 is true ("medium to low-FI events are more prevalent to the southwest"), I would expect the region beneath the Kolumbo to be dominated by the low-FI events.

Response: We also attempted to plot the FI values along the c–d cross-section. Although the FI values generally ranged from ~0 to 1, we decided not to include this cross-section because, during this stage of the seismic sequence, only the stations on Santorini Island were operational in the area. Their distance from the seismicity cluster may introduce significant path effects that could impact the interpretation of the results. Considering these factors, we have removed the FI results from the THERA station in Figure 2, as the seismicity near and northeast of Kolumbo occurred at a considerable distance from THERA prior to the deployment of the ANYD station. Therefore, the FI results presented in the rest of this work are based on data from the ANYD station.



1. **Comment:** Have the authors looked in a temporal pattern of the FI values (as displayed in Fig. 3)? Do the authors think that the possible spatial difference of the FI values (low FI events prevalent in the southwest region) are primarily controlled by the in-situ structural difference or rather by the time-dependent source characteristics that might be associated with the potential fluid flow?

Response: To explore the temporal and spatial patterns of the FI values, we added Figure S11. Panel (a) shows the daily number of low-FI events (FI ≤ -0.5), highlighting a clear temporal trend with a peak in early February, followed by a gradual decline (**Line 183**). Panel (b) shows the spatial distribution of events with FI ≤ -0.5 (in blue), which tend to cluster in the southwestern part of the activated area. Based on this, we support the idea that the patterns are likely influenced by evolving source processes, potentially linked to fluid movement or magmatic activity.

1. **Comment:**Figure 4 is great to highlight that a series of seismic events in the associated region involves such diverse seismic signatures. Is the associated event in Fig. 4(b) located close to the one in Fig. 4(c), or located very separately? I would appreciate it if the authors could show the location somewhere in the map for the two events.

Response: Due to the fast report length limitations, we had to remove the original Figure 4 from the current version of the manuscript. However, key aspects of the analysis have been retained and are now incorporated into the revised Figure 2. In this updated figure, the locations of the events formerly shown in Figures 4(b) and 4(c) are indicated on the map.

1. **Comment:**Figure 4: I also feel the waveforms and spectrograms might be convenient to be displayed together in Figure 2. Could it be possible to merge Figures 2 and 4 into one figure? I would keep Fig. 2(a), Fig. 2(b), Fig. 2(f), Fig. 4(b), and Fig, 4(c) in a figure, and move other panels to the supplement.

Response: As we answered in **Comment 4** we adopted the reviewer’s proposals and we have merged parts of Figure 4 with Figure 2.

1. **Comment:**L177: For the interpretation of the non-DC value (especially its uncertainty in moment tensor inversion), perhaps Rösler et al. (2024, Seismica) might be worth being mentioned for the relevant contexts.

Response: This reference provides important context regarding the interpretation and uncertainty of non-DC components. We have added it to the main text (**Line 169**)

1. **Comment:** L205–207: "... the presence of positive ISO and CLVD components suggests the involvement of magmatic and fluid processes. The spectral analysis of seismic signals, with the FI metric, further supports this interpretation".

Response: Thank you for the comment. To support and clarify this interpretation, we have added a new panel (Figure S11c) showing a scatter plot of FI versus double-couple (DC) percentage. The plot demonstrates that most events, even those with DC% above 80, exhibit negative FI values (signals dominated by lower frequencies). We have also added a sentence in the main text (**Line 185**).

**Response to Reviewers – Round 2**

We thank the Editor for the thoughtful and constructive comments on our manuscript. Below, we address each of your comments and suggestions in detail.

**Summary**

In response to the Editor’s comments, we clarified the use of the Frequency Index as a tool to explore signal characteristics rather than classify events, justified the station selection based on proximity and minimal path effects, and replaced a personal communication reference with a figure citation. Terminology was refined, and we simplified the nontechnical summary for broader accessibility. We improved Figure 2 by enlarging labels, changing moment tensor beach ball colors to black to avoid confusion, and correcting figure references. We also updated wording for clarity and accuracy.

**Reply to Editor**

**1. Comment:**

Comment I: Lines 140-141: The sentence about not using this technique for classifying volcanic earthquakes is somewhat confusing as you say at the start of this paragraph that your goal is to identify types of signals. So why not use it to classify, and also how does the analysis of frequency content provide different/superior information?

Response: Thank you for the comment. We agree that the original wording was unclear and have revised the sentence to better reflect our intent. The updated text now reads: “Although FI is often utilized to classify events presumed to be volcanic, this study exclusively employs it to examine the distribution of frequency content and to potentially distinguish between different seismic signal signatures.” (**Line 129**). Our primary goal is not to classify events in a categorical sense, but rather to analyze the frequency content of the signals to gain insight into the nature of the seismic sources. This approach helps identify trends and characteristics that may suggest different source processes without enforcing rigid classifications.

Comment II: The updated text does not reflect the nuance as explained in the response to the editor (above). Please incorporate this, as “seismic signal signatures” is still unclear.

**Response:** We understand that the revised version still lacked precision. The updated text now reads from: *“Although FI is often utilized to classify events presumed to be volcanic, this study exclusively employs it to examine the distribution of frequency content and to potentially distinguish between different seismic signal signatures.”* to “Although FI is often used to classify events presumed to be volcanic, in this study it is applied solely to explore the frequency content distribution of the signals. This allows us to identify patterns that may suggest different underlying source processes, without assigning events to fixed categories.” (**Line 127**).

**2. Comment:**

Comment I: Line 144: why only these 2 stations?

Response: As the goal of this analysis is to quantify the frequency content of the seismic signals as clearly as possible, we chose stations located close to the activity area in order to minimize path effects, which can significantly distort the observed frequency content. The ANYD station is the closest to the activity after its installation, and THERA was the nearest high-quality broadband station available before ANYD became operational. Including more distant stations would introduce greater path effects and variability, which would reduce the reliability of the frequency content analysis. In the revised manuscript we have included only FI values from the ANYD station as we later decided, based on the comment of the reviewer, that the THERA station is not close enough to guarantee limited path effects in the seismicity of the Kolumbo area that was active before the ANYD installation.

Comment II: Again, please incorporate this justification in text.

**Response:** Thank you for the helpful comments. The revised text now reads: “...which was the closest station to the events origin, to minimize path effects that could distort the frequency content.” (**Line 135**)

**3. Comment:**

Comment: Line 150: Please include a link to the online preprint in the reference to Papazachos et al., 2025.

Response: As the work by Papazachos et al. (2025) has not yet been published or made available as a preprint, we have updated the reference to indicate it as a personal communication. “As already analyzed (Papazachos, 2025, personal communication)” (Line 141).

Comment II: Seismica does not generally consider personal communications for references. I think it would be more appropriate to point to Figure S9, or an extended version of it, than to use personal communication.

**Response:** We understand and respect Seismica’s policies so for that reason we have removed the personal communication reference and instead we refer to Figure S9 (**Line 140**).

**4. Comment:** Figure 1: “activated” structures is somewhat over-representing. I suggest calling these “inferred” or “inferred activated” structures.

**Response:** Following the editors suggestion the “activated” statement was replaced by the “inferred activated” (**Figure 1 Caption**).

**5. Comment:** In future, please ensure you include a “tracked changes” version of the manuscript, where you clearly document all changes between the initial submission and the updated version. The one you attached highlights pieces of text that relate to comments, but I had to open the original submission and compare sections manually to see the full scale of changes.

**Response:** Thank you for pointing this out, and we apologize for the inconvenience. In future revisions, we will provide more detailed documentation of all modifications.

**6. Comment:** Could you try making the nontechnical summary a little less technical? It is still not understandable to the general public. I recommend using an approach like primarily limiting yourself to the 10,000 most common words in English:<https://www.mit.edu/~ecprice/wordlist.10000>. This won’t be possible for all terms, but for example, “waveform analysis” and “magmatic fluids” are very technical, whereas “by looking at earthquake waves” and “magma” are simpler.

**Response:** We agree that the original version of the non-technical summary included language that was too specialized. Following your advice, we revised the summary to use simpler and more accessible terms.

**7. Comment:** Line 60-61: Specify, in a couple of words, how you determined the “type”.

**Response:** To clarify the “type” analysis, we added the phrase “...and we analyzed the type of events using automatic frequency content analysis” to the text (**Line 59**).

**8. Comment:** Line 64-65: Add a couple of words to explain why you chose this time.

**Response:** Taking into account the Editor’s recommendation we have incorporated to the manuscript the phrase “...as it captures the onset and peak of the activity” (**Line 64**).

**9. Comment:** Line 95: Please specify what an “adequate” signal to noise ratio is. SNR is only used twice, so please write the full term out both times instead of establishing an acronym.

**Response:** The acronym SNR was removed and replaced with the full term. Additionally, “adequate” signal-to-noise ratio was clarified by specifying a threshold: “...after being tested for an adequate signal-to-noise ratio (≥5)” (**Line 94**).

**10. Comment:** Line 110-112: Is this updated version available publicly for others to use? Can include this in the statement on data and code availability.

**Response:** Thank you for the suggestion. At present, the updated version is not publicly available, as it is still under development and will be released once additional features have been implemented. We have clarified this in the Data and Code Availability section (**Line 222**).

**11. Comment:** Figure 2: labels on (h) are too small to read when viewed at 100%. Please enlarge. Also color bar for (h) has no values.

**Response:** We enlarged the labels in panel (h). Additionally, we updated the color bar.

**12. Comment:** Line 123-124: The sentence about “moment tensor solutions and spectrogram analysis” is a bit vague because you haven’t really presented these results to the reader yet, so we are forced to take your word for it. I suggest omitting this sentence and augmenting the sentence after to say something like “To better characterize potential complexity of these events, we adopted an automated approach…”.

**Response:** We agree that the original sentence was vague and potentially confusing, so as recommended, we have removed the sentence and revised the manuscript: “To better characterize potential complexity of these events, we adopted an automated approach to analyze the frequency content of earthquakes as a quantitative metric.” (**Line 122**)

**13. Comment:** Line 131-135: Really nice work on expanding this explanation. Where do tectonic earthquakes fall on the FI range? I’m guessing positive (brittle failure), but might be nice to state more explicitly by adding them to the list: “energy characteristic of brittle failure, tectonic earthquakes, or volcano-tectonic earthquakes…”.

**Response:** Thank you for that. Yes, for that reason we have updated the text (**Line 130**).

**14. Comment:** Fig 3 and S9: Specify what name convention you use for dates: MM-YY?

**Response:** Yes, as we also mentioned in the caption of Figure 1 “DD:MM:YYYY format used throughout the text”

**15. Comment:** Line 166: Reference to 2f should be 2h, I believe.

**Response:** Yes, we agree with your suggestion. The reference was corrected (**Line 174**)

**16. Comment:** Line 184-186: Could you just plot the MTs in Fig 2 using the same color scale as used for FIs? The use of red already somewhat implied high FI, which was a bit confusing. You may need to swap to blue – grey – red instead of using white in the middle.

**Response:** We have updated the beach balls in Figure 2 to black to avoid confusion with the FI color scale. We did not apply the FI color scale to the MTs, as not all MTs were relocated using cross-correlation due to their relatively larger magnitudes.

**17. Comment:** Line 197: “suggested” instead of “confirmed”.

**Response:** The word was replaced (**Line 176**).