

Response to Reviewer:

I greatly appreciate your valuable comments on the manuscript. Thank you for your insightful suggestions. All of your feedback is highly significant and has provided important guidance for both our paper and our research. We have revised the manuscript in accordance with your suggestions. Below is our detailed response to each revision:

Comment 1

Cite the reference of Eq 3.

Response:

Thanks for your suggestion.

We have added a reference to the literature cited by Dobrovolsky in the original manuscript at line 174 to ensure the accuracy of the citation. A revised manuscript with the correction marked in red at **Line 173 (Page 6)** has been attached as the supplemental material entitled “revised manuscript”.

Comment 2

Section 3 is very large; authors should describe a summary of SVMMD and Informer network methods. In my opinion such detailed description of the methods it is not necessary. For a better lecture such methods can be summarize in order to focus to the analysis instead of the details of both methods.

Response:

Thanks for your suggestion.

We have refined the content and optimized the structure of Section 3, SVMMD-Informer. To improve the clarity of the explanation, we omitted the detailed description of the parameters in Equation (5) in Section 3.1 (SVMMD), retaining only an overview of the variational model and augmented Lagrangian used in SVMMD.

In Section 3.2 on the Informer network, we first removed the lengthy explanation of Informer features to reduce the number of paragraphs in the paper. Second, we condensed the original manuscript lines 261 – 266 and integrated the revised content with the paragraph starting from line 267 to ensure a more coherent narrative. Additionally, the content from lines 279 to 281 of the original manuscript has been summarized and integrated with the relevant content from lines 255 to 256 to avoid repetitive descriptions. Finally, the two paragraphs from lines 306 to 318 of the original manuscript have been merged to further reduce the number of paragraphs and enhance the overall conciseness of the expression.

Following these revisions, the content of Section 3.2 on the Informer network is now clearer, providing an overview of the Informer network’s background and its applications in other fields, introducing the Informer network, followed by a general description of its key attention mechanism, encoder, and decoder, and providing the parameters of the model trained in this paper and the upper and lower bounds of data construction during model output. Therefore, after revision, Section 3 on SVMMD-Informer is now more concise and focused, with the key points highlighted. A revised manuscript with the corrections marked in red at **Line 238 (Page 10), Lines**

240–241 (Page 10), Lines 246–248 (Page 10), and Lines 290–291 (Page 12) has been attached as the supplemental material entitled “revised manuscript”.

Comment 3

The phrase “where the query vector represents the current network output state”, in line 263 is repeated.

Response:

Thanks for your suggestion.

In Comment 2, we have already modified line 263 of the original manuscript. Therefore, the revised manuscript avoids the problem of repeated phrases.

Comment 4

Regarding the training and validation (line 324) authors should explain the criteria to chose that period.

Response:

Thanks for your suggestion.

This paper selects data from the first eight months of 2020 as the training set and validation set because the data during this period is relatively stable, with few abnormal disturbances, which can effectively optimize model training, thereby improving prediction performance and increasing the accuracy of anomaly extraction. At the same time, in order to maintain the continuity of the data in the time dimension and avoid interference with model training due to a large time span, data from this relatively stable period is selected as the training set and validation set. A revised manuscript with the correction marked in red at **Line 301-303 (Page 12)** has been attached as the supplemental material entitled “revised manuscript”.

Comment 5

Line 331 must be corrected the expression “ $1e - 7$ ”.

Response:

Thanks for your suggestion.

We have corrected line 331 of the original manuscript from “ $1e - 7$ ” to 10^{-7} , in accordance with the standard format for scientific notation. A revised manuscript with the correction marked in red at **Line 308 (Page 13)** has been attached as the supplemental material entitled “revised manuscript”.

Comment 6

In Section 5 Line 343 authors wrote “The anomalies were recognized when the raw data exceeded the corresponding upper or lower bounds.”. Where such bounds are defined?

Response:

Thanks for your suggestion.

The definition of “upper and lower bounds” in this paper is determined based on the normal distribution method, as specifically defined in (13) of the original manuscript. The bounds are computed using the following formulas:

$$\begin{aligned} \text{Lower} &= \text{Prediction} - Z \times \text{mad}, \\ \text{Upper} &= \text{Prediction} + Z \times \text{mad}, \end{aligned}$$

where *Prediction* is the predicted value output by the decoder, *Z* is the *Z* score under a normal distribution, and *mad* represents the median absolute deviation. Based on this formula, we can identify outliers for each day. Subsequently, according to the criteria for defining abnormal days in lines 351 to 354 of the original document, we extract the precursors to earthquakes.

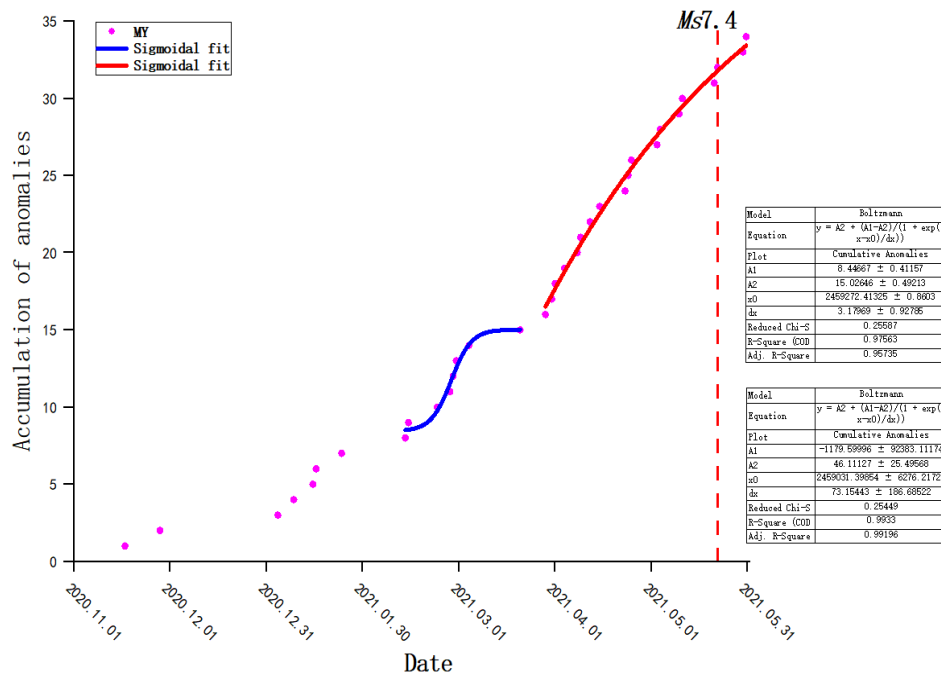
Comment 7

In Figure 8 there are points from 2020/11/01 until 2021/01/30. Is there some interpretation of such period?

Response:

Thanks for your suggestion.

In the original manuscript Figure 8, although it includes some data points from November 1, 2020, to January 30, 2021, our analysis found that there were only a few abnormal days between November 1 and December 31, 2020, and the overall data trend from November 1, 2020, to January 30, 2021, was relatively stable, without showing a significant surge trend. Therefore, we do not consider the period from November 1, 2020, to January 30, 2021, to be a distinct phase of abnormal accumulation.



Original manuscript Figure 8. Cumulative results of anomalous days of borehole data at Menyuan station (MY). The red dashed line indicates the date of the earthquake, and the blue and red curves indicate the results of the S-fit function for the first and second phases, respectively.

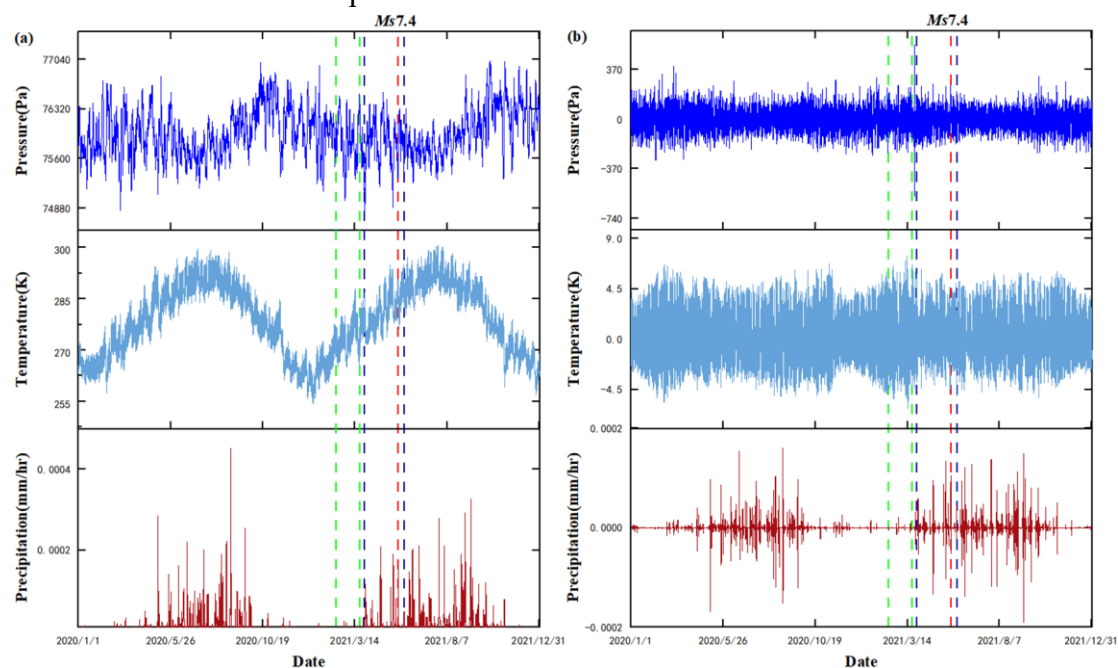
Comment 8

In the meteorological parameters showed in Figure 10 It is not clearly distinguish the anomalies described in the section. Can the authors identify such anomalous behavior?

Response:

Thanks for your suggestion.

To better illustrate that the anomalies we extracted are not influenced by meteorological factors, we marked the anomalous time periods of the borehole strain data in Figure 10 of the original manuscript (two green dashed lines indicate the first phase of anomalies, and two royal blue dashed lines indicate the second phase of anomalies). In Figure 10(a) of the original manuscript, atmospheric pressure and temperature exhibit synchronous fluctuations within a certain range, while precipitation reaches its peak annually during summer and then gradually declines, showing a significant annual cyclical pattern. However, there is no obvious correspondence between this cyclical pattern and the anomalies discussed in this paper. Additionally, to eliminate the influence of cyclical variations, we applied differential processing to the three-hour meteorological factors in the region. As shown in Figure 10(b) of the original manuscript, the processed results still do not show a clear correspondence with the anomalies discussed in this paper. Therefore, we conclude that the extracted anomalies are unrelated to meteorological factors and are more likely associated with the earthquake incubation process. Finally, we have provided supplementary explanations in the original manuscript. A revised manuscript with the corrections marked in red at [Lines 404–406 \(Page 17\)](#), [Lines 409–412 \(Page 17\)](#), and [Lines 418–419 \(Page 18\)](#) has been attached as the supplemental material entitled “revised manuscript”.



Original manuscript Figure 10. (a) Three-hourly regional variations of barometric pressure, temperature and precipitation in the Menyuan area during the period from January 1, 2020 to May 31, 2021. (b) Differential processing results of three-hourly regional variations of barometric pressure, air temperature and precipitation in Menyuan area during the period from January 1, 2020 to May 31, 2021. The red dashed line indicates the date of the earthquake, the two green dashed lines indicate the first phase anomaly, and the two royal blue dashed lines indicate the second phase anomaly.

Comment 9

The conclusions must be improved.

Response:

Thanks for your suggestion.

We have optimized the conclusion section. Specifically, Lines 442–453 of the original manuscript have been revised to: “The method addresses the issues of slow computation speed and memory limitations in traditional VMD by adopting SVMD, and significantly improves the accuracy and stability of long-sequence time series prediction by integrating the Informer network. By analyzing the borehole strain data from the Menyuan station, we successfully identified two distinct phases of anomalous cumulative acceleration preceding the Maduo earthquake, occurring approximately three and two months before the event, respectively. The cumulative anomaly curves exhibited a characteristic S-shaped growth pattern. This finding is consistent with the fault synergy process theory proposed by (Ma et al., 2014), further supporting the correlation between borehole strain anomalies and the Maduo earthquake. With the continued progress of machine learning technology and the ongoing accumulation of seismic observation data, this method is expected to provide higher-precision technical support for earthquake prediction and help reduce seismic disaster risk.”. A revised manuscript with the corrections marked in red at **Lines 422–431 (Pages 18–19)** has been attached as the supplemental material entitled “revised manuscript”.

References

Ma, J., Guo, Y., and Sherman, S. I.: Accelerated synergism along a fault: A possible indicator for an impending major earthquake, *Geodynamics & Tectonophysics*, 5, 387-399, 10.5800/gt-2014-5-2-0134, 2014.

Other red markings in the revised manuscript explain

Line 248 (Page 10), Lines 251-254 (Pages 10-11), Line 257 (Page 11), Line 273 (Page 11), Line 292-293 (Pages 12).

Correct modification of the formula.

Line 270 (Page 11).

Correct order of images.

Lines 294-295 (Page 12).

Modify to italics corresponding to the formula.

Line 331 (Page 14).

The word “fulfill” here modifies “meet”.

Line 353 (Page 15).

The word “leveled” here modifies “levelled”.

Lines 465-466 (Page 19).

Correct reference format.

Lines 472-473 (Page 20).

Correct reference format.

Lines 505-507 (Page 20).

Correct reference format.

Line 534 (Page 21).

Correct reference format.

Lines 227 (Page 9), Lines 567-568 (Page 21).

Correct reference format.

All pages.

All instances of “mengyuan” have been corrected to “menyuan” throughout the revised manuscript.