Manuscript Revision Note for

"Hidden-State Modelling of a Cross-section of Geoelectric Time Series Data Can Provide Reliable Intermediate-term Probabilistic Earthquake Forecasting in Taiwan"

We have made the following changes to the manuscript, to improve the manuscript according to the results of the online interactive discussion.

Changes applied (11 May 2022)

1) Added explanations of why our HMM model provide short-to-medium-term earthquake forecasting (**end of Sect. 3.3**)
2) Removed the parts in the Introduction about large historical earthquakes (**start of introduction**)
3) Relocate mathematical contents in Sect. 2.4 and 2.5 to the Supporting Information to aid the flow (**Sect. 2.4 and 2.5**)
4) Add into Conclusion: emphasizing the novelty of our work (**Conclusion**)

Record of interactive discussion

RC1: 'Comment on nhess-2021-378', Anonymous Referee #1, 15 Jan 2022

Review on the manuscript entitled "Hidden-State Modelling of a Cross-section of Geoelectric Time Series Data Can Provide Reliable Intermediate-term Probabilistic Earthquake Forecasting in Taiwan" by Haoyu Wen, Hong-Jia Chen, Chien-Chih Chen, Massimo Pica Ciamarra, Siew Ann Cheong

General Comments: In this manuscript (ms), the authors follow up a recent model (GEMSTIP) that uses the skewness and kurtosis of geo-electric time-series (TS) to make statistically significant short-term earthquake (EQ) risk assessments by applying the Hidden Markov Model (HMM). Twenty geo-electric measuring stations located at Taiwan (see Fig. 1) are used in this study. HMM is applied on the correlation, variance, skewness, and kurtosis of the EW and NS geo-electric TS that form an 8-vector to identify two Hidden States (HS) with different distributions of these statistical indices in each one of the 20 geo-electric measuring stations. This is achieved by employing k-means clustering and the Baum-Welch algorithm (see Fig.5). The authors test whether these HS could separate time periods into eras of higher/lower EQ risks and find that the HS TS are useful for potential EQ risk assessments in appropriate cells, which are cells whose discrimination reliabilities are above a user-defined threshold. This is achieved by dividing the map of Taiwan into a 16X16 grid map (see Fig. 6) and quantifying how well the HS TS could separate times of higher/lower EQ risks in each cell in terms of a discrimination power measure D that the authors propose in Eq.(15). They conclude that geo-electric TS indeed contain EQ-related information with a statistically significant forecasting skill and the HMM approach can extract this information regardless of the choice of the hyperparameters used.

The ms is original both in its combination of mathematical methods and in its application. As such, it advances our understanding of forecasting natural hazards. The methods used are scientifically sound and *the presentation is clear, concise, and well-structured. According to my opinion this a ms of excellent scientific significance and quality.*

Specific Comments: The authors should add a link in the ms to the Supporting Information, mentioned in lines 291, 337, 499, 512, 591, which is not available to the reader in the present version of the ms.

Technical Corrections: Although, I carefully went through the ms I couldn't find any point other than the one mentioned above in the Specific Comments.

Summary: In view of the above, I gladly suggest the publication of the ms in Natural Hazards and Earth System Sciences upon the addition of the link to the Supporting Information.

AC1: 'Reply on RC1', Haoyu Wen, 30 Jan 2022

We would like to thank the referee for his/her detailed comments. We apologize for the inconvenience regarding the lack of Supporting Information in the current preprint format. We will make sure the Supporting Information will be available for the manuscript's formal publication.

RC2: 'Comment on nhess-2021-378', Anonymous Referee #2, 18 Feb 2022

The paper concerns the study of possible correlation between extreme events in geoeletrical time series and seismic critical state of the earth crust. The study area is Taiwan and the data are coming from a modern geoelectrical network with 20 stations. The authors applied robust statistical methodologies to analyse and characterize the geoelectrical time series. In particular, I greatly appreciated the use of the Hidden Markov Chain. The manuscript is well organised and sounds with the current state-of-the-art.

I have only a critical comment: the claims concerning the possible use of the geoelectrical time series analysis in medium-long term earthquake forecasts are measleading. The results are interesting and well characterise the spatio-temporal dynamics of the electrical anomalies and seismic events in the study area. To-date, it appears questionable the use of this approach in earthquake forecasting.

Furthermore, I have only some other minor comments: i) there are some redundant parts (i.e. the introduction about large earthquakes occurred in the past); ii) the is a lot of mathematical formulae that could easily presented in a Appendix or quoted in the text; iii)there are many phrases that are not directly related to the main objectives of the papers and could be omitted; iv) the conclusions are quite generic.

The reduction of some parts could make the paper more readable.

I suggest the publication of this paper after a minor revision.

AC2: 'Reply on RC2', Haoyu Wen, 25 Feb 2022

We thank the referee for his/her careful review and constructive suggestions. We apologize to the referee for the confusion. We understand that for all earthquake forecasting, whether short-, medium-, or long-term, we must specify a time window, a space window, and the magnitude of the earthquake expected. We realize that these three elements were not clearly explained in our sentence claiming that our method is equivalent to a medium-term earthquake forecasting method. We shall explain that carefully here, and also in the updated manuscript.

Time window

Let us consider an HMM that started out in the passive state (note: in the passive state, earthquakes of all magnitudes are less frequent, compared with the active state). In most stations that we tested, we noticed that once an active state has persisted for a few weeks, it is unlikely to switch back to the passive state until *a few months have elapsed. This minimum lifetime found in historical data can be used as a prediction time window. Based on this time scale, we can say that our HMM model can be useful for short-to-medium-term earthquake forecasting, depending on the station of interest.*

Space window

Next, let us consider the grid cells covering Taiwan. For a given grid cell, it may be satisfactory (Discrimination Reliability being high-enough) for stations A, B, …, and X. The more stations in this list becoming persistently active, the more likely large earthquakes within this grid cell should occur. This is the spatial window we work with for making 'predictions'.

Magnitude

Finally, let us describe how our HMM model can help assessing the magnitudes of earthquakes expected. To answer this question, we can examine the distribution of earthquake frequencies across magnitudes 3.0 to 6.0 for both active states and passive states (in Section E, Supporting Information). It turns out that for a given grid cell with high Discrimination Reliability, the active state has proportionally more earthquakes than the passive state across all magnitudes. Therefore, we expect earthquakes of all magnitudes to be more frequent in a positive 'prediction'.

For the minor comments from the referee, we will remove the parts in the Introduction about large historical earthquakes. We will also relocate some mathematical contents in 2.4 and 2.5 to the Supporting Information to aid the flow. For minor comment iii), we apologize for not knowing which phrases the referee is referring to. Please let us know and we will make improvements accordingly. For minor comment iv), we are not so sure what the referee means by 'generic'. We therefore apologize for not knowing how we should improve. We would like to hear more from the referee to make further improvements.

RC3: 'Reply on AC2', Anonymous Referee #2, 03 Mar 2022

Dear authors,

I greatly appreciated your effort to improve the quality of the paper.

As it concerns the term "generic" in the last paragraph, I specify that it is important to better emphasize the novelty of your results respect to the current state-of-the-art.

AC3: 'Reply on RC3', Haoyu Wen, 09 Mar 2022

We are grateful for the referee's clarification. We agree that the Conclusion can be improved by emphasizing the novelty of our work. We will make such a change in the revised manuscript by adding a sentence:

"To the best of our knowledge, while there have been previous applications of HMM for earthquake forecasting, this paper is the first to demonstrate the ability to do so with statistical confidence."