Dear Editor and Reviewers,

Thank you very much for the second-round constructive suggestions on our paper entitled “A New Method for Calculating Highway Blocking due to High Impact Weather Conditions”. They are very helpful for improving the manuscript. We have revised the manuscript accordingly. Thanks for consideration.

Yours sincerely,

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Manuscript # NHESS-2023-230

Manuscript Title: A New Method for Calculating Highway Blocking due to High Impact Weather Conditions

Responses to Reviewer #1 Round 2

General comments

The Revised manuscript and Responses to Reviewers together addressed most of the reviewers' comments and the quality of the manuscript has been improved. However, some of the responses could have been included in the revised manuscript to further clarify the methodology and results. Moreover, the figure quality was reduced dramatically, compared to the original submission. The English writing was slightly improved.

The manuscript presents a study on a topic within the scope of the Natural Hazards and Earth System Sciences (NHESS). I would recommend this manuscript for publication after addressing the following minor comments.

RESPONSE: Your points are considered carefully and text is revised. Thank you for your suggestions. All figures have been improved and figures' quality are checked. It was a copy previously.

Specific comments

1 ***In general, the discussion and elaboration in the response to reviewers should be included in the main text****. Please further include some discussion in the responses to reviewers in the revised manuscript, for example:*

- *Response to reviewer #1: Point 5 The CRITIC weigh method -> Bullet 2. The further consideration of weighting (e.g., conflicting nature of different indicators) should be included in the main text.*
- *Response to reviewer # 2: Methodology - Point 3 “The use of highly correlated data is to better fit the CRITIC method. The CRITIC method combines two dimensions, intensity of comparison and conflict, to combine the weights of indicators. Comparative strength is expressed using the standard deviation, which reflects the degree of dispersion of data within the indicator, and conflict is expressed using the correlation coefficient, which reflects the correlation between indicators.”*
- *Response to reviewer #3: Results – point 2 “Summer rainfall in mountainous areas is heavy, often accompanied by thunderstorms and short-term heavy precipitation events. Mountain terrain is special, the speed of rainwater runoff is fast, easy to form flash floods or debris flow, these natural disasters are the main reasons for blocking the highway.”*
- And more.

RESPONSE: Thank you for your suggestions. The discussion section is improved to response for your points and shown in the text now.

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2 Figure resolution was reduced significantly.

- Please increase the resolution of all figures.
- Please include the longitude, latitude and legend of all the geographic Figure 1 and 3.
- Figure 1a and 1b can indicate the regional division using different colour codes and then add a region colour legend while keeping the province labels in 1b.
- Figure 3b the scale of the vertical bar was missing in the legend.

RESPONSE: The figures have been revisited for your points and the current figs quality is improved significantly.

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3 WMO definition of "High-impact weather" was included in the revised manuscript. However, the term "adverse weather event" was also used. It is recommended to use consistent terminology.

RESPONSE: We agreed with your point and now we used only "*High-impact weather*"

Minor comments

1. *"response time in different high-impact weathers **asl** the input vectors in the calculations." Should "asl" be "as"?*

RESPONSE: revised, thank you.

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2. *Line 49-50: "The weather forecasting products, if used, the road transportation sectors can generate great economic benefit." Should be "**If** the weather forecasting products **are used**, the road transportation sectors can generate great economic benefit"*

RESPONSE: revised as you suggested, thank you.

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3. *Line 91-93: "it can be divided into two categories: planned and **unexpected**." and "**Sudden-type** blockages include…", please use the consistent category label "unexpected" or "sudden-type".*

RESPONSE: revised, now it is used as "unexpected", thank you.

Responses to Reviewer #2 Round 2

General Comment

Dear Authors, I went through the revised version of the manuscript, finding it slightly improved since the previous version. Replies and modifications partially addressed previous comments. In the cases where no modifications have been done there are no significant and substantial justifications.

Thus, in line with the previous review, I consider the manuscript potentially suitable for publication, but only after having properly addressed some issues.

I recommend the Authors to carefully deal with such comments, modifying accordingly the manuscript or justifying their choices.

RESPONSE: We went over your previous and current suggestions, and improved the text coherently. Thank you for your suggestions. The figures have been redone and their quality is improved significantly.

Specific comments:

1. *- L108-L115: there are some repetitions here, please revise.*

RESPONSE: revised, thank you. The dataset contains 16 indicators: province name, submitting department, route name, route number, starting and ending pile number, reasons of highway blocking, blocking mileage, status, blocking type, information event classification, site description, disposal measure, time of finding blockage, submitting time, expected recovery time, and actual recovery time. (There are two nouns that need to be explained in detail: firstly, Highway pile numbers are usually combined with the milestone system and are expressed in K kilometers ± meters. That is, along the direction of the road, the pile number at the starting point is k0+000, and one pile number is marked every certain distance (such as 100 meters), and the corresponding place is marked. Second, the blocking mileage is the distance of the highways blocking, for example, due to flash floods caused by precipitation in mountainous areas, there are 100 kilometers of highway can not be used normally, we assume that the blocked mileage caused by heavy rain is 100 kilometers.) Since highway blocking information is submitted by manual statistics, there is a possibility of manual statistical errors. Therefore, all data were pre-corrected with a time series correction and then verified based on the cause of the blockage and the meteorological data of the station at the time, among other things. Quality control resulted in the retention of 95% of valid data.

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2. *- L120: we "assume" instead of "we believe".*

RESPONSE: Considering your point, text is revised, and now much improved.

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3. *-L119-L121: please revise the text and check for typos.*

RESPONSE: Text is revised, and grammatically improved.

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4. *Figure 3: Sorry, but I recall here the same comment previously reported with regards figure 3, since no replies and actions were reported/taken in the current version and Authors' reply. Figure 3 is too small. I would consider to separate the two panels. Here the comment: "Region names should be added to the map. Plots, as well as legends, should be more quantitative. Which are the values associated to the bars in pale 3b? Also, I suggest removing the lateral minor-boxes showing the islands, since it looks like there are nor results for those regions."*

RESPONSE: Fig 3 is redone based on your point, and all other figures have been revisited.

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5. *- In general, Figures are of poor quality, making difficult to read labels and results.*

RESPONSE: All figures have been redone or modified based on the Revs' comments.

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6. *In my opinion, all my previous comments on providing a deeper discussion on the methodology and results were not properly addressed. I recall the aspects risen in the previous review, which I believe was not properly addressed by the Authors in this new version.*

RESPONSE: Based on your points, now both discussion and method sections are revisited to include your comments, and we believe now that the text is improved significantly.

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7. *- L345-347 (L386-387): "I disagree with the use of losses or damages, as adopted in the discussion and in Figure 8. From what I have understood, this analysis is an exposure evaluation rather than a damage assessment. The classifications shown in Figure 7 (which can be further explained with the details of Figure 8) provide a picture of the overall highway loads over the area, which do not necessarily correspond to real damage. This is a key aspect that deserves consideration and affects the overall scope and ambition of the manuscript. Furthermore, Conclusions should be revised accordingly to such definition."*

Response : We agreed with your point, and this is clarified in the text now (4.1 Economic Losses exposure evaluation due to fog-related highway blocking; Figure 8. Economic losses exposure evaluation caused by highway blocking due to fog). Based on this point as suggested we modified the conclusions.

Also, Reviewer#3 similarly commented on this topic.

8. *- The overall discussion is lacking, with insufficient critical analysis of the strengths and limitations of the methodology.*

Response : Discussion section considering of the strength and limitations of the methodology is modified and provided below.

4. Discussions about the strengths and limitations of this methodology

Many scholars have conducted assessment studies on the economic losses caused by meteorological disasters. Due to the strong spatial distribution characteristics of meteorological disasters and the varying specific losses inflicted on different industries, the establishment of evaluation models tailored to specific industries and disasters, along with the calculated economic loss figures, are more conducive to providing scientific references for decision-makers. As provided in the current analysis, some scholars have also attempted to assess economic losses in disaster evaluation by adopting the multivariate linear regression-TOPSIS method to establish an evaluation model (Wang et al. 2023; Greema et al., 2020; Yu et al., 2020). By modeling the temporal evolution of 1.8 million trade relations between 7000 regional economic sectors, Kuhla et al (2021) studied the economic welfare loss from weather extreme events, their work found out that the regional responses to future extreme events are strongly heterogeneous in their resonance behavior.

Some scholars use the non-interoperable input-output model (IIM) to estimate the economic lost; They have emphasized the importance of providing knowledge on the most vulnerable areas from the point of view of causing disasters, as well as the importance of the economic losses of the most vulnerable areas. In addition, by introducing exposure and sensitivity as filtering processes, critical paths for interactions between components within the hazard system are constructed and practically applied. Overall, studies mentioned above are combined with already identified occurrence hazardous data and are aimed at loss studies in water resources, agriculture, and economy, ignoring the assessment of losses in transportation, and a distinction between hazard categories (Bhattacharyya et al., 2021; Khalid et al., 2020; Dhunny et al., 2020). Therefore, this paper attempts to use the existing disaster record data and combine it with economical data to make a loss assessment analysis.

During the implementation process, following points need to be evaluated carefully and found to effect the results significantly: 1. Ensure the quality and accuracy of the data to obtain reliable assessment results. 2. Consider the impact of different regions and various types of high-impact weather events on highway blockages, in order to develop more targeted management strategies. 3.

Regularly update the assessment model to adapt to the continuously changing environment and societal needs. Through the newly established method, we can better evaluate the economic losses caused by highway blockages due to high-impact weather events, thereby providing strong support for highway management and control.

Few studies have assessed disasters caused by high-impact weather on highway traffic losses. In the current analysis, the relationship between high-impact weather and economic losses on highways was studied through data mining. The weight coefficients representing the extreme weather events were derived entirely from high-impact weather and economic data without any human intervention, and a strong correlation was found between the variables. Owing to the large geographical area covered by the data and the short time series, the observed differences vary across provinces. We hope that future research will further explore the sensitivity of severe weather indicators.

Through the analysis of Economic Losses due to Fog-Related Highway Blocking in Section 3.5, we found that the differences between Figures 7 and 8 mainly stem from variations in economic indicators within each province, leading to different economic loss values. Thus, the sensitivity of the outcome responds well to parameter variations. Additionally, different provinces experience high-impact weather in different seasons, resulting in corresponding variations in economic indicators and economic losses. Therefore, the equation (Eq. 8) is directly related to the various economic indicators of the corresponding provinces as well as the seasons in which high-impact weather occurs.

Overall, our analysis based on Eq. 8 can effectively estimate and evaluate the economic losses caused by highway congestion owing to high-impact weather events. However, the limitation of our approach is that the lack of economic data in different regions can lead to bias in the results. Therefore, the evaluation model in the present study needs to be updated regularly to adapt to changing environmental and social conditions.

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9. - The weights shown in eq. 8 are quite uniform among the considered items. What is the sensitivity of the outcomes to variations in such weights? Any comments on their values? It would have been beneficial to consider additional data or to remove some of those already considered.

Response： We evaluated your points and explained below. Note that sensitivity of outcomes to variable weights are critical and important, this is emphasized now. It is found out that 20% change of one the weights resulted in the outcomes at about 30%, suggesting that your point is very important and this is discussed now. Thanks for this critical point.

Using Eq. 8 and the results of Table 6 and Table 7, it can be seen that the weights shown in eq. 8 are quite uniform among the considered items. This is primarily due to our data normalization of the relevant economic indicators. Through the analysis of Economic Losses due to Fog-Related Highway Blocking conditions in Section 4.1. We can also see that the differences between Figures 7 and 8 comes from mainly variations in economic indicators foreach province, leading to different economic loss values, it is found out that 20% change of one the weights resulted in the outcomes at about 30%. And thus, the sensitivity of the outcomes to variations become important. Additionally, different provinces experience various high-impact weather types in different seasons, resulting in corresponding variations in economic indicators and economic losses.

In reviewing previous research, few have mentioned the assessment of disasters caused by high-impact weather on highway traffic losses. Because of this issue, our work primarily using data mining analysis, explores the relationship between high-impact weather impact on economic losses

related to highways. The weight coefficients are derived entirely from high-impact weather and economic data without any human intervention. Due to the large geographical area covered by the data used in this study and the short time series, the observed differences are relatively small, but the results vary across different provinces. It is hoped that future research will further explore the sensitivity of these indicators over much smaller regions. Therefore, after weighing the pros and cons, we chose to set the weight coefficients relatively close to each other to reflect the relative importance of these indicators in the overall assessment. On the other hand, if the analysis were performed over much smaller regions, the results would be the strong function of those weight values and this will be considered in a future work.