Dear Editor and Reviewer,
Thank you very much for the 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. We sincerely hope that you will find this version acceptable to be published in Natural Hazards and Earth System Sciences.

Best regards.

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

Responses to Reviewer #2

General comment

In this study, the authors propose a new, data-driven approach to evaluating the impact of severe weather conditions on highway infrastructures across China. They suggest employing k-means and CRITIC methodologies to assess the significance of various natural phenomena and to classify the impact of highway interruptions using a set of significant variables (both technical and economic) provided by the authorities. The scope of the study is relevant and aligns with the journal's topics. However, there are critical aspects that prevent the publication of this version. Most notably, the methodological presentation requires significant improvement, necessitating more detailed explanations and changes to the current structure. Additionally, the presentation of results needs enhancement. Furthermore, the discussion and the adopted terminology require critical review. Finally, the English language usage needs improvement (a few examples are listed below, but an overall revision is recommended).

RESPONSE: Thank you for your suggestions.

Specific comments

- Weather event definition:

the term "High-impact weather condition" lacks a specific and clear definition. It is not explicitly defined within the text, and its usage could be questionable. A natural event (i.e., rainfall, ice, etc.) might be severe or not, and might cause, or not, impacts on the highway and on other infrastructures depending on their characteristics. Therefore, I suggest referring simply to weather-related conditions. Furthermore, the adoption of this term implies that you consider exclusively such events, potentially overlooking medium-impact or low-impact weather conditions (which are not defined in the text). Perhaps, on page 2, line 50, you refer to "adverse" weather, which could serve as a suitable alternative.

RESPONSE: Thank you for your suggestions. The World Meteorological Organization (WMO) defines high-impact weather as severe weather events that have significant adverse impacts on society, infrastructure, and the environment. These events can cause widespread damage, disruption, and loss of life (Marsigli, 2021).

High-impact weather refers to severe weather events that have a significant impact on human activities, infrastructure, and the environment. These events can cause widespread damage, disruption, and loss of life. In this study, we discuss the high impact weather that has an impact on highway operation.

- Data characterization:

- *Section 2.2.1: how are highway blockage events defined? What are the requirements in terms of their extent (length) or duration in order to be classified as such? Which is temporal and spatial aggregation of such events? Are those associated to a give region, district, or specific*

highway? Additional details should also be provided on the validity check you performed. The reference to "manual statistics" is not clear.

RESPONSE: Revised. Add sentences:

A highway-blocking events is a state in which a highway is impassable or forced to close for some reason. Depending on the nature and duration of the blockage, it can be divided into two categories: planned and unexpected. Planned blockages include those caused by planned events such as highway maintenance and construction, reconstruction and expansion, and major social activities. Sudden-type blockages include sudden highway blockages caused by natural disasters (such as geological disasters, severe weather, etc.), accidents and disasters, public health incidents, social security incidents and other reasons. In this study, highway blockage under the influence of natural disasters and weather is selected as the main body of the study.

Highway blockage data comes from Highway Monitoring & Emergency Response Center, and the data recording process and specifications are in accordance with the "Information Reporting System for Highway Traffic Blockage of the Ministry of Transportation and Communications of the People's Republic of China" issued by the Ministry of Transportation and Communications of the People's Republic of China. 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.

- *Section 2.2.2: how did you use the meteorological data to classifiy and attribute weather events to highway blocking scenarios? Which are the spatial and temporal aggregation you adopted for such data? How did you consider cases with multiple weather events attributions?*

RESPONSE: Revised. Add sentences:

According to the time and place of the expressway blockage, the meteorological observation data of this area during this period are checked with the weather events recorded by the observers to ensure the consistency of the data. In the case of multiple weather phenomena, we refer to the one recorded by highway blocking recaroded data.

- *Section 2.2.3: More details need to be provided to describe the data characterizing the economic aspects of the highways. What temporal and spatial resolution do the data refer to? (e.g., annual flow, daily flow?) The sentence at L103 is not clear; what is its purpose and how are these classifications used?*

RESPONSE: Revised. Add sentences: The above data are the traffic per 10 kilometers of the highway, per month(The industry classification of transportation is based on the industry classification of national economic activities, https://data.stats.gov.cn/easyquery.htm?cn=C01). The above data will be calculated and applied in 2.3.3 Calculation method of highway load.

- Abstract: there are several repetitions that could be removed, making the text more effective and clearer. Also, you should try to be quantitative while presenting the outcomes.

RESPONSE: Revised.

- Methodology:

- *Section 2.3.1: although not new, the K-means methodology needs to be better explained. The analytical formalism is unclear. For instance, what are xi1 and xi2 of P4? I suggest rephrasing and expanding the overall section.*

RESPONSE: Revised.

K-means clustering is an unsupervised machine learning method without prior knowledge (that is, no classification criteria is given before classification). The goal of this algorithm is to find groups in the data, with the number of groups represented by the variable K. One chooses the desired number of clusters, and the K-means procedure iteratively moves the centers to minimize the total within-cluster variance. Specifically, the criterion is minimized by assigning the observations to the K clusters in such a way that within each cluster the average dissimilarity of the observations from the cluster mean, as defined by the points in that cluster, is minimized (Hastie et al., 2009).

- *Section 2.3.2: similarly, mathematical formalism should be checked (see perhaps eq. 3 where the same counter (i) is used for two summations having two reference set).*

RESPONSE: Equation3-4 and the key parameters are Revised.

Contrast intensity, expressed as a standard deviation, indicates the dispersion degree of an indicator. The larger the standard deviation is, the greater the dispersion degree is, the larger the differences between samples are, and the larger the assigned corresponding weights are. The standard deviation *S* can be expressed in Eq. (3).

$$S_j = \sqrt{\frac{\sum_{i=1}^{p}\left(x_{ij}-\frac{1}{n}\sum_{i=1}^{n}x_{ij}\right)^2}{n-1}} \quad \textbf{(3),}$$

where x_{ij} denotes the data processed by standard deviation, S_j the standard deviation of the *j*th indicator, *n* the total number of samples, and *p* the total number of indicators.

Correlation is expressed as the correlation coefficient between indicators. The stronger the correlation between indicators is, the higher the repetition rate of information expression. Therefore, the corresponding weights of the indicators can be reduced to a certain extent. The correlation coefficient *R* can be expressed in Eq. (4).

$$R_j = \sum_{i=1}^{p}(1-r_{ij}) \quad \textbf{(4),}$$

where, R_j indicates the correlation coefficients of the *j*th indicator with the other indicators, and r_{ij} denotes the correlation coefficient of the *i*th indicator with the *j*th indicator.

- *Section 2.3.3: please define "express capacity". I believe a table summarizing the overall set of variables you adopted would benefit the methodology presentation. Which is the specific unit area that you adopted to calculate the highway density? L154-155: this sentence is definitely not clear: which are the items you are referring to? If there is strong correlation among some data, you should not consider all of them. Have you tried to perform a principal component analysis to evaluate such aspects?*

RESPONSE: Revised.

The adopted highway density is the sum of highway mileage per unit square kilometer, and "express capacity" is the volume of express delivery, which includes not only parcels, but also documents and other types of documents, and also plays an important role in information transmission, so we chose it as one of the reference quantities.

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.

- *Also, lines 155-157 should go to previous section (2.3.1).*

RESPONSE: they are not the same methods. section (2.3.1) is clustering analysis, and 2.3.3 is CRITIC .

- Results

- *The inner pie graph of figure 2 is not described within the text. Differences among the two plots are not clear, I suggest just keeping the external plot. Also, icing is not shown in the figure.*

RESPONSE: Revised. The inner pie graph of figure 2 is deleted.

- *• Figure 3 is too small. I would consider to separate the two panels. 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: Revised. The inner pie graph of figure 2 is deleted.

- *L188-191 need to be rephrased.*

Response：Revise. "There are large seasonal differences in highway blocking in various regions of China due to differences in geographical environment and climatic characteristics (Fig. 4a), and high-impact weather types (Fig. 4b), such as dense fog, snowfall (snow cover), rainfall (road slippery) and icing, etc."

- *what do you mean for "basic resources of the road"? P10L233.*

Response：Revised. the road miles per unit area, the higher the density of road network per unit area, the more abundant road network resources.

- *Presentation of the severity classes should be moved to the methodological section. Specifically, text from the beginning of section 3.3 to line 247 is more appropriate in section 2. Then, in section 3 you present the results. Concerning such results, I suppose that the outcomes in Table 3 would be more readable if shown through graphs.*

Response：We tried to carry out Tables 3 and 4 to present them with graphs, but found that, with more information, the results were not satisfactory, and the tables can be carried out to quantify the characteristics of different regions in different seasons.

- *Figure 7 is qualitative. I do not see much values on such plots unless, at least, upper and lower bounds are shown.*

Response：Revised.

- *Table 6: labels adopted for the items are different from those used within the text. Please revise and be uniform.*

Response：Revised.

- Discussion

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

Response：Revised.

In order to assess the economic losses caused by highway blockages due to high-impact weather events, we previously collected data and established a model for evaluating economic losses. We then used this model to calculate the economic losses caused by highway blockages resulting from high-impact weather events. Below, we compare specific high-impact weather events with actual loss data to verify the accuracy and reliability of our assessment model.

- 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：in eq. 8, Hd the highway density, ΔTFload the load capacity of freight transport for per kilometer, GDPtrans the added value of the GDP generated by transportation, ΔPload the number of people for per kilometer, VD the vehicle density, EP the number of express packages, TFload the total freight transport,

Pload the number of people, and Vprivate the number of private vehicles. These parameters are all related to the economic losses

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- *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：Thank you for you suggestions. The economic parameters are calculated in eq.8, thus the results are using the exposure evaluation to estimate the economic loss parameters.

Minor comments:

- *P2, L(line)40-45: please check the sentence structures here and rephrase.*

Response: Revised. The road surface with snow or icing can lead to slower vehicle speeds and a decrease in fuel combustion efficiency (Hallegatte 2008; Min et al., 2016). The work of Min et al. (2016) showed that when 10% improvement occurs in road surface conditions, 0.6–2% reduction in air emissions amount can occur. The weather forecasting products, if used, the road transportation sectors can generate great economic benefit. Frei et al. (2014) found that the use of meteorology in the road transportation sector in Switzerland generates an economic benefit to the national economy 75.1-91.2 million U.S. dollars (cost/benefit ratio of around as 1:10).

- *P2, L54: HIW acronym is not defined.*

Response：Revised.

- *P4, L8: please check the sentence starting with "For the classification…". It looks uncomplete.*

Response： Revised. The goal of this algorithm is to find groups in the data, with the number of groups represented by the variable K.
