**Natural Hazards
and Earth System
Sciences**
Discussions

Interactive comment on "Identification of traffic accident risk-prone areas under low lighting conditions" *by* K. Ivan et al.

K. Ivan et al.

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Dear dr. Németh,

We are thankful for your opinions and valuable suggestions. We will answer point-by-point to all questions.

REFEREE: Preparing better maps (with geographic information, coordinates etc) overview maps and where the Authors use locality names, these should be shown in the figures and as citations in the text. For instance not everyone knows where Cluj is.

ANSWER: From this very pertinent remark we understand to complete the paper with

two aspects. The localities Turda, Zalău, Gherla and Huedin will be indicated on the new map, while cited in the text. Also, we will make sure the geographical coordinates are shown, as well as a contour of South-Eastern Europe for a better location of Cluj-Napoca city, which is the most important urban center in Transylvania, with almost half a million inhabitants during the academic year. In the final version of the paper we will prepare a new map with the elements mentioned above.

REFEREE: While I think the paper presents a solid statistical solution to support the link between lighting conditions and traffic accidents, in order to make a sensible conclusion in natural environments, where multiple parameters are commonly "translated" into a single ("common") parameter a solid discussion is needed.

ANSWER: We acknowledge the fact that there are more parameters involved, as you mentioned in your comment, but several objective causes prevent us from making "multiple regression", as it would be asked of us. It is true that we hold some information received from the Police Inspectorate referring to some features specific to the circumstances of the accidents. For example, we have data on - the traffic restriction on the segment where the accident occurred, according to the closest traffic sign; - the cause of the accident according to the report issued by the traffic police officer; - the age and sex of the driver; - how the accident occurred; All these elements are alphanumerically expressed in default of a grid to transpose the qualitative aspects according to a quantitative grid. Secondly, the data recorded by the police covers only a three, maybe four full years interval, which means a micro-sample, which is why we cannot consider yet that the qualitative information might represent a statistic "sample" per se of an unknown "population". Conversely, in case of the numerical values referring to the lighting duration, we are convinced that these represent a real statistic sample unbiased by a potential transformation of a qualitative scale in a quantitative one. Speaking about a few years only, the above mentioned qualitative aspects cannot be inserted in a multiple regression as we risk generating artifacts.

REFEREE: 1) The Authors do not state by which conditions an "accident" is defined.

Is it by fatality, damage, damage to what, how much damage etc.?

ANSWER: In this paper, traffic accidents refer both to the number of dead and injured persons, as we do not have separate data for the number of dead persons, accident being thus expanded to all injured persons.

REFEREE: I also think the sample "pool" needs to be better described to make the reader see clearly how and under what basis an "event" was defined.

ANSWER: In this paper we considered all accidents, regardless of the fact that these events have led to death or only to injuries.

REFEREE: It would also be interesting to consider how the study would develop if individual events were weighted by some pre-defined parameter (e.g. the seriousness of the accidents; how could we compare 10 light accidents against two major ones with high damage to property and humans).

ANSWER: In this statistical analysis one cannot differentiate between a light accident and major accident. In this stage of the study, which is a pioneering study, the selection within the short data base (only 4 years) to separate the second category of accidents, would lead to "biased selection" and "biased samples".

REFEREE: I think that a further paragraph, or even section, in the dataset description would be very beneficial for the clarity of the paper.

ANSWER: Yes, certainly this is possible. To remove any uncertainty regarding the data base, we will describe into more details all the information we used, both those describing traffic events, and those related to lighting.

REFEREE: 2) Following the previous point, I also think that in the discussion several important points need to be addressed. For instance, while the study identified that the main accident prone regions are – not surprisingly – located along the main artery road network of the City, it is also quite an expected result as there is more traffic (car and human) along those roads. However, this made me wonder what correlations there

would be to accident numbers if the type of traffic were examined (e.g. expressing in a formula the number of heavy vehicles, total number of vehicles, common traffic directions and position in relevance to landmarks and natural obstacles etc.). This type of information could be captured in a GIS based "overlayer" method, which the Authors could then analyze.

ANSWER: The idea to make a correlation between the number of accidents and the type of traffic (heavy, light) is excellent, just that it does not fit out case study, as Cluj-Napoca municipality has only two heavy traffic routes which include only a few peripheral streets. It is interesting mentioning the fact that on the peripheral streets, despite the heavy traffic, accidents are fewer. Obviously, the highest frequency on the main streets represents the most accident-prone environment under low lighting conditions. The maps achieved by GIS procedures illustrate in fact the road segments where accident frequency is higher.

REFEREE: 3) Another important aspect of the study that I would recommend addressing in a discussion section is the human factor, which has been completely overlooked from the calculations.

ANSWER: In this study, the human factor was considered when calculating the vulnerable areas, by determining the injury rate (number of victims/number of accidents), but without taking into account the behavior of the drivers involved in the accidents. This is due exclusively to the fact that we do not have data on their behavior at the time the traffic incident occurred. However, in terms of behavior, we could insert the blood alcohol level of the driver; this parameter could be added in the final version of the paper.

REFEREE: For instance, it would be interesting to see the ratio of non-local versus local drivers along various roads. My natural instinct would be that in regions where more local drivers use the road network, the accident number would be lower than along the main artery roads, where transit traffic is commonly loaded with heavy trucks. This

may be a more important factor than the driving conditions in specific time period.

ANSWER: It would be very interesting to see the differences, patterns, hot-spots, formed by the accidents caused by the local drivers vs. accidents caused by the transient drivers. Unfortunately, the Police Inspectorate could not provide us data on the address of each driver. This idea is not to be ignored and we are seriously considering implementing it if we get this dataset. After all, the purpose of this paper is to influence the public authorities to introduce artificial lighting earlier, because, as we have shown, low natural lighting clearly causes the higher frequency of the traffic accidents.

REFEREE: 4) The link between the number of events and the time of the day, the day of the week etc. needs to be explored, beyond just thinking about the lighting conditions.

ANSWER: In a previous study, we analyzed the number of accidents depending on the time of the day, week, and year and on rush hours. The study is cited in this paper and we consider that it would be appropriate to conduct the same analysis again. The coordinates of this study are: Ivan, K. and Haidu, I. (2012) "The spatio-temporal distribution of road accidents in Cluj-Napoca". Geographia Technica, vol. 7, no.2, 32–38.

REFEREE: 5) I also think that it is important for the Authors to demonstrate that the lighting has been treated as an independent controlling parameter. For instance, no data are presented on what the main rush-hour is in general in town, and what the common time is (during a day and during the week, month, year) when transit traffic is expected to be heavier.

ANSWER: In the same study mentioned above, we also performed the analysis of accidents evolution depending on the rush hours.

REFEREE: 6) I would recommend that the Authors address some of the human sociology, human behaviour or psychological issues of "driving" that could contribute significantly to accidents. For instance, while it is general common sense that in low-light

conditions, we see less and therefore we may cause accidents, I do not think that this is a linear correlation. Many human behaviour studies have demonstrated that under certain levels of stress, concentration levels in fact increase, hence potential accident-triggering actions are reduced until a threshold value. This issue is certainly worthwhile addressing in the paper.

ANSWER: This paper does not demonstrate the existence of a linear relationship between the low-light conditions and the number of accidents. Figure 3 does not show a simple linear relationship for the data ensemble, but it clearly shows that there are three seasonal clusters. In each cluster, the relationship is linear, but the fact that the value pairs "low-light conditions; number of accidents" describe independent clusters shows the inexistence of a simple correlation. For the moment, this is what could be done in this pioneering work. We should cumulate a few more years of observations to develop the paper in the well pointed out direction mentioned by dr. Németh.

REFEREE: In a similar way, I would have liked to have seen some analysis on other factors that may influence the distribution of accidents. For instance, are there periods of the day / days of the week when alcohol or lack of sleep could be significant factors in causing accidents?

ANSWER: Some of these things were approached in the above mentioned paper (Ivan, K. and Haidu, I. (2012) "The spatio-temporal distribution of road accidents in Cluj-Napoca". Geographia Technica, vol. 7, no.2, 32–38.). However, we should wait for the development of the data base over time for an "unbiased" statistical approach.

REFEREE: 7) Finally, from a more natural hazard perspective, the paper completely lacked any tests of the event distribution against meteorological events, such as rain fall, strong winds, fog etc. This issue is similar to other time-series tests I think should have been applied to the data set. There are inconsistencies in the data where I would have imagined that the weather conditions could have played major part. For example, in late Fall or Winter, the darkness may not be the main cause of accidents, rather it

could be the poor weather conditions. With a good meteorological data set from the National Meteorological Survey, this issue could be solved.

ANSWER: We regret, but we only agree partially with point 7 as our paper shows also the fact that the number of accident depends on the weather conditions. If it were not for this dependency on the weather conditions, the three seasonal clusters would not have occurred, but instead we would have had a single curve of the relationship "number of accidents = f (low-light conditions)".

a) In temperate continental latitudes, as is the case of Cluj-Napoca, winter ends only in March, when the snow and ice layer disappears from the roads. The lighting duration increases each month, parallel to the average temperature and the convective processes. As a result, the nature of spring and early summer rainfalls is irregular, with predominantly storm and torrential rainfalls. This explains the fact that there is a cluster and a specific relation for these months of "torrential rainfall": Accident per month = 0.015 Hours of darkness + 8.6

b) After the summer solstice, the duration of natural lighting starts to decrease. At the same time, in July-August the amount of precipitations reaches a minimum, and then, from one month to another, the amount of rainfall successively increases until November. The rainfalls have a frontal character, and the humidity increases also, while in autumn, fog occurs. Thus, the "increasing humidity" cluster forms which is defined by: Accident per month = 0.059 Hours of darkness - 58.2

c) After November, in Cluj-Napoca, the precipitations change into solid precipitations, and this determines the occurrence of another relation of the "snowy and icy" type, especially due to the fact that authorities do not always manage to completely clean the roads from the icy snow layer: Accident per month = 0.01 Hours of darkness + 11.7

We believe that it is clear that the three relations of the form "number of accidents = f (low-light conditions)" depend also on the meteorological factors, even if we did not build complicated relations which would have breached the "parsimony" principle,

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widely accepted by the statistical community. Of course, we will take into account your suggestions and we will describe into more details, based on some meteorological datasets, the explanatory relation "number of accidents = f (low-light conditions; meteorological event) "

REFEREE: Overall I think this is a good pilot project and worthy of publication in NHESS. However, I would expect the Authors carry out a robust self-evaluation of the validity of their statements (even if it is just a largely text-expressed discussion). A stronger introduction to the data set they used for the analysis and an expanded discussion, addressing the points listed above, would make the paper a much more interesting piece of work that would be worthwhile for city planners and other end users to read. At the end of the discussions, some statements about potential future work would also be a good.

ANSWER: As mentioned above, in the final version of the paper, beside the low lighting factor, we will consider inserting also the drivers' behavior (the alcohol consumption) and the meteorological factors, in highlighting the risk areas. After all, the purpose of this paper is to influence public authorities to introduce artificial lighting earlier, to act more rapidly for cleaning the roads from the snow layer and last but not least, to warn the drivers to be as restrictive as possible in terms of alcohol consumption.

Finally, we acknowledge the "pilot paper" character of this work, but only due to the fact that the recorded data sampling interval is rather short, only 3-4 years. We also believe, like you, that this should not hinder the publication of results, as they are revealed by small sampling data. Of course, after accumulating new data, at least for another 2-3 years, we would be able to perform specific selections and conduct a more detailed research. We would like to thank you for your constructive remarks and suggestions and we would like to assure you that in the final version of the paper we will try, where possible, to implement as many of these recommendations as possible.

Sincerely, Ivan, Haidu, Benedek, Ciobanu

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