Nat. Hazards Earth Syst. Sci. Discuss.,
doi:10.5194/nhess-2016-232-RC1, 2016

Natural Hazards and Earth System Sciences
Open Access
Discussions

Interactive comment on "Natural hazard fatalities in Switzerland from 1946 to 2015" *by* A. Badoux et al.

Anonymous Referee #1

Received and published: 10 August 2016

1 Summary of the article

The study presents an explorative review on fatalities related to floods, landslides, rockfall, lightning, windstorm, snow avalanches and other geophysical hazards in Switzerland. The data set is based on two national databases; one focusing on fatalities of floods, landslides and rockfall spanning a period from 1972 to 2015 and the other on fatalities of snow avalanches ranging from 1936 to 2015. By conducting an archival search of the Swiss national newspaper Neue Züricher Zeitung, a third database for windstorm, lightning and earthquake fatalities was generated by the authors and also used to extend the period of the first mentioned database back to the year 1946. The combination of these three sources served as the basis for the descriptive analysis presented.

In the first part, the authors are focusing on the temporal dynamics of the fatality count. Their emphasis is on detecting trends in the total fatality count per year as well the count per hazard type per year. To quantify assumed trends, a non-parametric trend test as well as linear regression – which is in that case not the best bet – is used and confirms the trend apparent in figure 2. Beside the total count of fatalities also the crude mortality rate is shown for their study period on a yearly resolution further confirming a downward trend. Furthermore, monthly and daily frequencies are analyzed explorative. Additionally, the authors show spatial trends and comment on them in a descriptive way on the different influences of social factors such as age, location and gender.

The last part of the article is used to explain the patterns in the data and to compare the crude mortality rates to other causes of death like traffic or railroad accidents in Switzerland but also for similar hazards from other countries.

In general, the study is interesting to read, and given the scope of the target journal the contribution should be considered for final publication. The main contribution of the article is the dataset itself, another confirmation of the downward trend of fatalities due the analyzed hazard types for societies like Switzerland and the findings about the marginal importance of natural hazards as a cause of death in comparison to other causes like road accidents. However, there are some major items that caught my eyes and that should be further discussed and considered before the manuscript may become acceptable for publication.

2 Major points of critisism

1. The use of the whole population to calculate mortality rates is (technically and methodologically) misleading and may lead to a strong underestimation of the mortality rate. Although it is used by many authors working on that topic I think using a better suited definition of the population would greatly enhance the value of the study. To put it in a different manner: imagine a building with three floors. In the third floor, which is hermetical separated from the other two floors, a laboratory is situated in which new and highly deadly poison is tested. If there is an accident the poison would only spread in the third floor. Calculating now the mortality rate based on the all the people in the building would underestimate the real risk because only those working on the third floor are at risk.
2. The artificial political borders to agglomerate the data are a point that is directly related to this criticism, in geostatistics also well-known as MAUP. To analyze the spatial distribution of fatalities and the mortality rate, the authors should find a better solution (such as e.g. a regular grid raster).

3 Detailed review

In the following sections I will address in greater detail the points that lead to the aforementioned two points of major criticism refering to the sections of the stuy. When I am referring to a specific line in the article I use a `typewriter font` to detect them more easily.

3.1 Introduction (section 1 in the article)

In the first section an introduction to the topic and an overview on existing studies of fatalities due to different hazard types is given. Here it would be of added value if the authors could also include results from other Alpine countries, since a comparison with mortality rates of e.g. the US or some least-developed countries does not seem to be very targeted. For Switzerland, also the works of Schneebeli et al. (1997), Laternser and Schneebeli (2002) or Wilhelm (1997, see Table page 76 based on Laternser et al. 1995) should be acknowledged. For Austria, examples include those of Oberndorfer et al. (2007) or Luzian and Eller (2007), Luzian (2002) or Fuchs (2009). The section is continued by an overview on which spatial scales past studies were carried out and then looks in greater detail at studies regarding specific hazards typesjonk. At the end the authors are summarizing past work on fatalities caused by natural hazards in Switzerland and introduce the structure of their paper. For the different groups of hazards the authors also present some key findings.

3.1.1 Flood

The assessment of flood incidents is based on the work of Jonkman (2005) reporting an average fatality rate of 0.012 (1.2 killed of 100 affected) where the rate is fairly constant for all continents but different for different types of flooding. The most deadly ones are flash floods with a rate of 0.0362 (3.62 killed by 100 affected) followed by river floods with 0.0292 (2.92 killed by 100 affected) and drainage problems with only 0.0019 (1.9 killed by 1000 affected).

Coastal floods where excluded from the analysis by Jonkman (2005)but the authors gave a reference to Chowdhury et al. how described a tidal surge caused by a cyclon which killed 67,000 people. Here I do not think that this reference is enough to give the statement enough confidence – there many other scientific reports about deaths caused by storm surges around that should be mentioned. At the end of this section, reports on four countries about the deaths caused by flooding are presented with no further explanation.

3.1.2 Landslides

With respect to landslides, the authors are first referring to the study of Petley (2012) who compiled a worldwide database of non-seismically triggered landslides that resulted in a loss of life from 2004 to 2010. A total of 2620 fatal landslide resulted in 32,322 deaths which is 4.3 times greater than those recorded in the EM-DAT (7431). After the general worldwide study of Petley the authors summarize an article from Dowling and Santo from the year 2014 which is explicitly focusing on debris flows. With 213 debris flows causing 77,779 fatalities the authors yielding an average of 365 fatalities per fatal debris flow. This extraordinary high number is caused by two massive events which make up nearly 50 percent of all fatalities recorded by the two authors. The median number may therefore better reflect the number of fatalities with 11 per fatal debris flow but also this number may still be very high, compared to the European Alps. To give an example, in Fuchs and Zischg (2013) an average of around 1.5 fatalities due to torrential processes is recorded annually for the Austrian Alps. The last example of analysis of fatalities caused by landslides is given in Guzetti (2000) where the same data is used and combined with data about flooding from an article of Guzetti et al. (2005). The mortality rate for floods was estimated to be 0.053 and for landslides 0.084 for the entire study period of 1861 to 2002.

An important finding is the kind of distribution the number of fatalities may show. Petley (2012) and Guzetti et al. (2005) are both fitting a power law to the data. It is not perfectly fitting in the case of the Italian data and Petley is not making any statistical tests to quantify his visual assumptions. But there is a strong indication for the power law which in turn has implications for risk assessment.

The reference to the study about landslides in South America (Sepuleva and Petley 2005) may be deleted or more information on reported findings should be given. It would also be more convenient to refer to this study before Guzetti (2000) because of its spatial scale focusing on a continent instead on worldwide data like in Dowling and Santi (2014) and Petley (2012) but on a higher scale than Guzetti (2000) who is focusing on the national scale.

3.1.3 Meteorological

Focusing on meteorological hazards, the authors are reporting studies about tornados and hurricanes on a national level. Tornados are not very common in the study region of the authors. Referring to a report of the meteorological survey of Switzerland the frequency is one to five tornados per 10 years (0.1 to 0.5 per year) which is large enough to cause serious damage. In this report four tornados are described in more detail (1890, 1934, 1926, 1971) where three of them caused fatalities. With respect to a comparison to Switzerland, of more interest are the studies about non-tornadic convective and non-convective storm events carried out by Ashley and Black (2008) and Black and Ashley (2010). For the latter, more than half of the deaths are associated with aviation accidents while for the other ones most people died in vehicles or in boats which is a finding that is also reflected in the data of windstorms for this study.

Beside extreme winds the authors are also looking at the fatalities caused by lightning. They refer to studies which were carried out in different countries.

3.1.4 Other

Because of the unimportance of hazards such as volcanic eruptions, earthquakes and tsunamis in Switzerland the author are not further considering geophysical hazards but mention an earthquake as an example of an extreme high death toll later in the discussion.

3.2 Data (section 3 in the article)

The authors made a clear description of the data used, and their approach for validating the data collection before 1972 was done in a good scientific manner. Later in the discussion the authors were also talking about the drawbacks of the data collection. I would like to jump to that section (section 5.1 in the article) and express some of my concerns.

The discussion starts with six points regarding the quality of the data

1. fatality not reported
2. spatial bias because of the language of the newspaper
3. wrong selection of keywords
4. time spans with no newspaper available
5. technical problems because of bad scans

6. wrong hazard type

The authors then conclude, based on their validation strategy, that only a small fraction of 10% of all fatal hazard events were missed. At least three of the main reasons that impair the quality of the data are subject to the first 35 years of the time span analyzed. The validation was carried out for the years 1986 to 1995. If all newspaper of that period where already digitally available problem 5 could not occur. If there were no gaps also problem 4 would be underestimated. Finally problem 6 could also be of lesser importance than in the period before 1986. So maybe expanding the validation period could damp these concerns.

3.3 Results temporal analysis (section 4.2 in the article)

First general statistics about the data are given. These mostly basic statistics are then used to describe the importance of multi-fatality events. The short sentences about the number of events per year may be enforced by adding the number of events to figure 2 (see also comments on figure 2 in section 4.2 of this review).

The determination of a trend in the data is done in two ways: with the non-parametric Mann-Kendall test and by checking the significance of the slope of a linear regression. The choice of the non-parametric test is a good one but the linear regression performed on the normal scale of the data is not appropriate for count data and I suggest to use a Poisson regression or a regression on the natural log scale if the authors still want to use the slope as an indicator of the trend.

The fatality rate is used wrongly in `line 283` (and in other places) since according to my understanding the authors are referring to a mortality rate. Because it is not age-adjusted the term crude death rate would be in better accordance with epidemiological terms.

3.4 Results monthly distribution (section 4.2.2 in the article)

The key findings are the two peaked distribution of fatal natural hazards in Switzerland. The winter season dominated by avalanches and the summer season by lightning. The authors mentioned earlier that they see declining and rising trends in the annual temporal distribution and it may contribute to the monthly results if the authors would check for trends in seasonality also displaying figure 6 as a - maybe paneled - seasonal plot or adding some words to the text.

3.5 Results spatial distribution (section 4.3 in the article)

The authors explained in a clear manner the spatial distribution of the fatalities caused by the different hazard types. They also refer to the geomorphological region which makes their introduction at the former chapter plausible. A suggestion would be to use different maps for every hazard type and to count the number of fatalities divided by the number of events in a predefined raster or other geometrical grid. The authors may ask why my criticism is again aiming at the graphical representation this is because of the explorative nature of the topic. Paneling the hazard types would go perfectly with the excellent structured text of that chapter.

The next paragraph is dealing with the distribution of mortality rates per political region. My main concern about this result is the use of the political borders as an artificial subdivision of the space with no further connection to the underlying nature of the hazards. As an example the Canton of Bern has more than the half of its population in the five largest cities (Bern, Biel, Brugdorf, Interlaken, and Thun). Dividing the fatalities by the population incorporates a lot of people not even at risk to individual hazard types, and may therefore bias the shown results.

3.6 Results regarding different social factors (section 4.4 in the article)

The results section is nearly completed with the analysis of different factors, like the age or the accident circumstances. This section boils down to the presentation of different $n \times n$ tables which are then described by words. Using tables in transporting information is mostly not a good choice (transporting data it is one of the best). To be sure that my critic is not just the normal table-bashing I got the data of table 2 and made a circos plot which I printed out and had it a the side while reading the text. In this fashion the text transports more information and is better understood than with the table.

So I strongly recommend to find prober graphical ways (mosaic, circos tec.) to present the categorical data from table 2 and 3 (see attached figure 3 to this review).

3.7 Disscussion fatality numbers (section 5.3 in the article)

At `line 529` the authors state that they assume that about half of all flood deaths can be ascribed to inappropriate behavior, for example when victims are carried away by floodwaters or surprised in their home by rapidly intruding surface water in contrast at `line 585` being surprised is not considered inappropriate.

How could being surprised be an inappropriate behavior when the water is also rapidly intruding?

3.8 Disscussion about the historical events in Switzerland

The events of the database are by far not the most devastating that occurred in Switzerland; three events are described in detail that caused 1500, 600 and 457 lives. Alltough this is an interesting information I do not see the direct connection to the article that is primarily concerned about trends and proportions in the fatality record.

Maybe this section should be presented in a more condensed way in the introduction.

4 Comments on figures

I liked how the authors stayed coherent with the use of colors and I can literally feel their agony in choosing the right figures that capture all the information they want to transport. The presentation of count data is difficult as is the analysis of count data. There are few standard techniques of handling count data graphically: the bar, cumulative, scatter or line chart. The authors decided to go with the bar chart which is in my opinion not the perfect solution although this might be a question of taste.

4.1 Figure 1 of the article

The authors use this figure to set the spatial frame of the study introducing important categories like the cantons and the geomorphological classes of Switzerland. The hillshade was a good choice because it gives a good impression of the topography, only the use of the blue for the Swiss Plateau may be problematic because of the low distance in color space to the rivers and lakes.

4.2 Figure 2 of the article

The authors want to introduce their database and the trends in the number of population and the number of fatalities. I like how they plotted the mean and median

which enforces the understanding of their data and has a direct link to the text. Another important point about that plot is that the authors use it to show the declining trend in the number of fatalities as well that the first 35 years include 73% of all fatalities.

To get this information clearly transported I would suggest the following: the use of a second axis to show the population growth does not contribute to the topic – to be honest I find it distracting. By erasing it, the figure would get clearer. The most prominent feature of the figure is given by the two extremes in the year 1951 and 1965 with the high number of deaths. These two years masking the trend the authors found and I would therefore use a transformation of the count. Typically the natural logarithm is chosen because of is direct connection to the link function of the Poisson regression model. Adding a running mean with the size of 10 years - to have a connection to Figure 3 - to the transformed data will enhance the trend apparent in the data.

Another point in the text is the fact that 73% of the total fatalities occurred in the first 35 year period of the database. This fact and the declining “fatality growth” will be better shown - in my opinion - using a cumulative chart of the fatalities. This chart also has the advantage that its behavior can be used to infer if a simple Poisson process is generating the fatalities – which would be a straight line. Maybe the number of events per year as a third panel below the yearly number of fatalities would help to transport the severe multi fatality arguments of the authors.

4.3 Figure 3 of the article

The authors want to show the general decline in the number of fatalities over the years, especially the decline in the deaths caused by avalanches and lightning.

I think that the information of that figure can be also transported with an enhanced version of figure 1 and a slightly changed version of figure 4.

4.4 Figure 4 of the article

The authors want to describe how the number of fatalities is changing over time per hazard type or more general show the temporal behavior (also that there are no fatalities at all) and the differences between the hazard types. The x-axis is the same for all plots and therefore combining these without repeating the x-axis is recommended organizing the plot as a 3 by 3 panel. A problem may arise from the higher numbers of avalanche fatalities but this could be overcome by using a square root or logarithmic transformation of the x-axis and labeling the axis with the real number of fatalities. To better detect the temporal trend adding a running mean or other smoothing would help. Also it may be better suited to plot the cumulative number instead the number per year as a step function which would also indicate when there are no fatalities.

4.5 Figure 5 of the article

The key massage is the decline in crude mortality rate over the years. The same critiques as for figure 2 are true for figure 5. Because of the high spread of the rate the figure gets clumped and the distinction between the processes is hard. This is especially a problem when the figure is compared to the text from `lines 286` to `288`, since I am not able to see the distinct decline in mortality rate. Maybe transforming and paneling the data would help also in this case.

Final remark

I believe these shortcomings are manageable by the authors, and they may wish to revise their manuscript accordingly. To underpin my remarks, I included three Figures (Agetable, Figure 2 and Figure 4) as a supplement.

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-232, 2016.

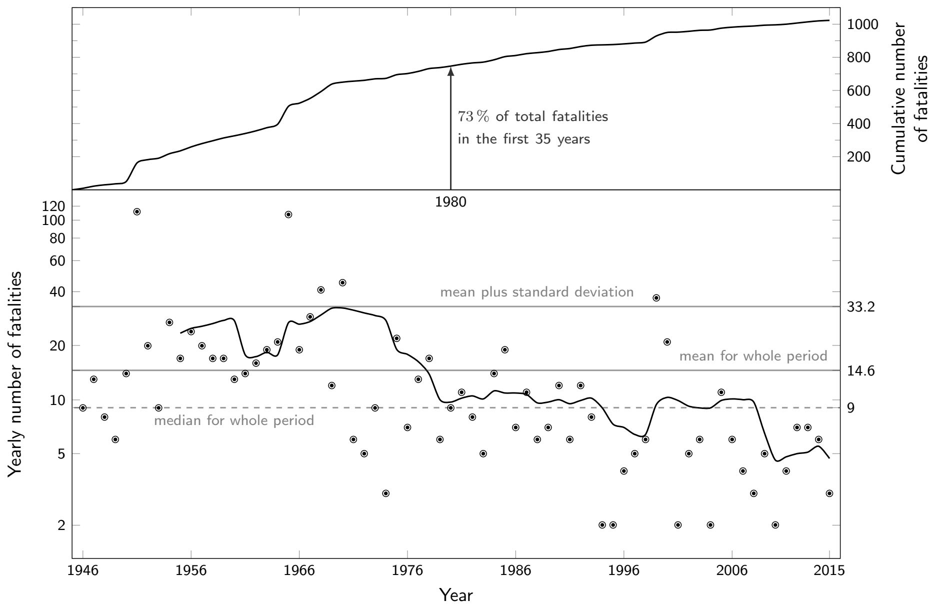

Fig. 1. Suggestion for figure 2.

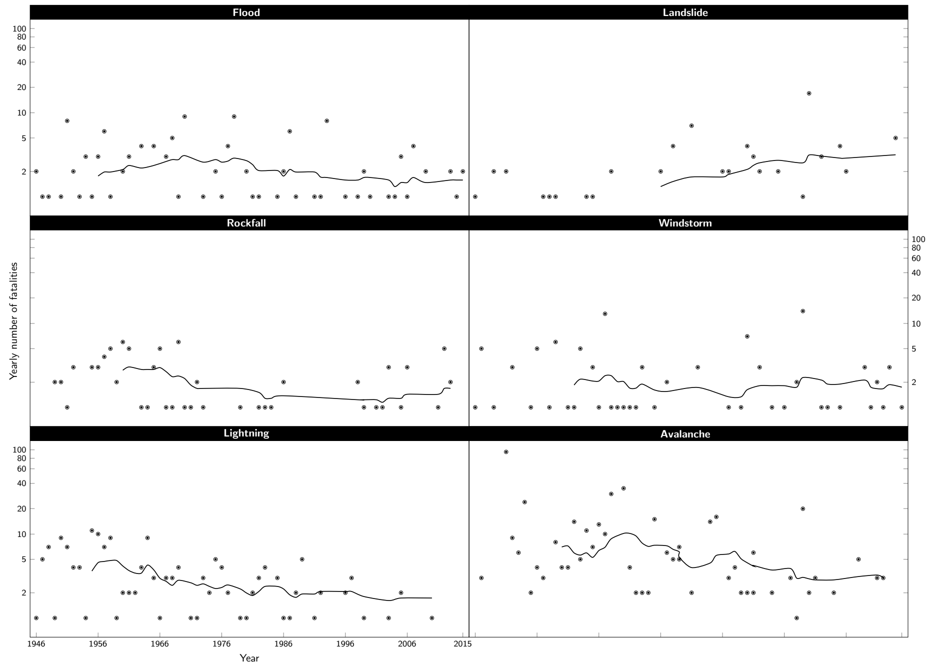

Fig. 2. Suggestion for figure 4.

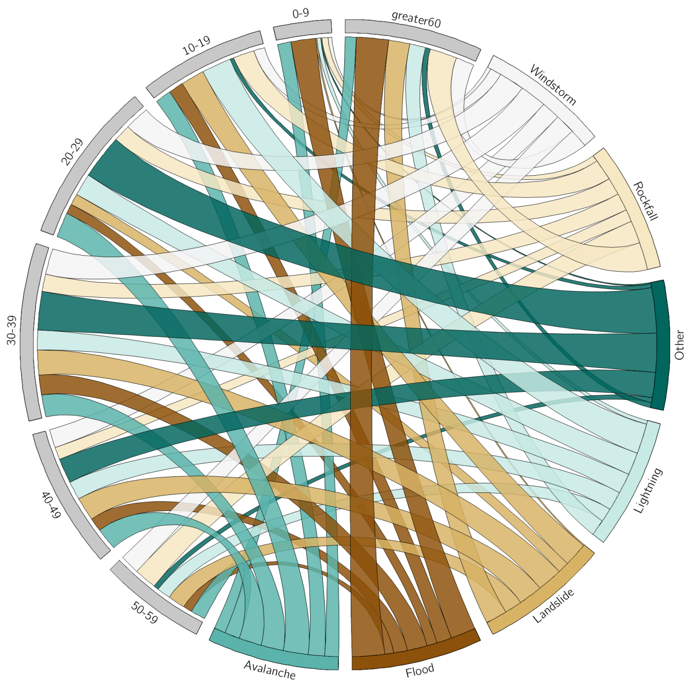

Fig. 3. Suggestion for a graphical display of the social data presented in tables.