Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

Natural Hazards and Earth System Sciences
Open Access
Discussions

Spatial and temporal analysis of fatal off-piste and backcountry avalanche accidents in Austria with a comparison of results in Switzerland, France, Italy and the United States.

Christian Pfeifer, Dr.

Institute of Basic Sciences in Engineering Science

Unit for Engineering Mathematics, University of Innsbruck

Peter Höller, Dr.

Austrian Research Centre for Forests
Institute for Natural Hazards, Innsbruck

Achim Zeileis, Dr.

Department of Statistics, University of Innsbruck

Address for correspondence:

Christian Pfeifer

Institut für Grundlagen der Technischen Wissenschaften

Arbeitsbereich für Technische Mathematik, Universität Innsbruck

Technikerstraße 13, A–6020 Innsbruck

E-Mail: christian.pfeifer@uibk.ac.at

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

Abstract

In this article we analyzed spatial and temporal patterns of fatal Austrian avalanche accidents caused by backcountry and off-piste skiers and snowboarders within the winter periods 1967/68–2010/11. The data were based on reports of the Austrian Board for Alpine Safety and reports of the information services of the federal states.

Using the date and the location of the recorded avalanche accidents we were able to carry out spatial and temporal analyses applying generalized additive models and Markov random field models.

As the result of the trend analysis we noticed an increasing trend of avalanche fatalities within the winter periods from 1967/68 to 2010/11, which is in contradiction to the widespread opinion that the number of fatalities is constant over time. Additionally, we compared Austrian results with results of Switzerland, France, Italy and the United States based on data from the International Commission of Alpine Rescue (ICAR). As the result of the spatial analysis we noticed two hotspots of avalanche fatalities (‘Arlberg-Silvretta’ and ‘Sölden’).

Because of the increasing trend and the rather ‘narrow’ regional distribution of the fatalities consequences on prevention of avalanche accidents were highly recommended.

Keywords: Snow, Avalanches, Accidents

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

1 Introduction

In the Alps, backcountry skiing has become very popular in the last 50 years. Unfortunately, there are a lot of fatal accidents due to snow avalanches caused by skiers and/or snowboarders. They are of special public interest for various reasons.

In Austria, about 25–30 fatalities caused by snow avalanches are expected every year (Neuhold, 2012; Höller, 2009). Furthermore, it is reported that in Alpine countries (such as Austria) the number of fatalities is more or less constant over the time (Brugger et al., 2001) and that there is some sort of seasonality in the data in terms of higher frequencies of accidents within a distance of 5 or 6 years (Höller, 2009; Tschirky et al., 2000). Harvey and Zweifel (2008) even denote that fatalities are decreasing over time in Switzerland, see also (Ammann, 2001).

Usually trend information for Austrian avalanche fatalities is given in the annual reports of the Austrian Board for Alpine Safety (Kuratorium für alpine Sicherheit, 2011). Considering these profiles, we notice higher frequencies of fatalities in the 1980s. However, the highest frequency in winter 1998/99 is due to avalanche fatalities in villages (Galtür, Ischgl), also affecting buildings. This is because the statistics in the reports do not distinguish between fatal avalanches in buildings, on roads, outdoors without skiing, fatalities due to skiing on slopes and backcountry skiing.

In this paper our focus is on accidents caused by out-of-bounds skiers or snowboarders which we define as those ‘leaving the ski resort in order to travel in areas that were not controlled for avalanches’ (Silverton et al., 2009). Within this group we distinguish between backcountry (using no ascent sup-

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

port) and off-piste (using e.g. a skilift or a cable car) skiers/snowboarders. Until now there has not been an investigation for this special group of avalanche incidents in Austria keeping in mind that accidents due to off-piste and backcountry skiing are by far the most common way to be involved in avalanche accidents.

Our task in this paper is to carry out a spatial and temporal analysis, identifying (potentially nonlinear) trends over time and regional patterns. In the case of trend analysis, we compare Austrian results with results of Switzerland, France, Italy and the United States.

2 Materials and methods

2.1 Data

For our study we built a data base of fatal avalanche accidents recording the

1. date,
2. municipal area where the accident took place,
3. federal state of the municipality,
4. number of persons involved,
5. number of fatalities,
6. type of activity (on/off-piste, backcountry skiing, etc.)

of fatal accident events in Austria within the winter periods 1980/81–2010/11, which are available from the annual reports of the

Austrian Board for Alpine Safety (Kuratorium für alpine Sicherheit, 2011) and the annual reports of the information services of the federal states (Amt der Tiroler Landesregierung, 2011). In order to check the reliability of the accident data, we made a cross-check between those reported in the two sources. Looking at winter 1986/87 we figured out that the reports were incomplete. However, we were able to fill this gap using records of the BFW (Austrian Research Centre for Forests, Institute for Natural Hazards, Innsbruck), e.g. see (Schaffhauser et al., 1988).

For the period 1967/68–1979/80 we used aggregated information published in the annual reports of the Austrian Board for Alpine Safety (Kuratorium für alpine Sicherheit, 2011). Starting from 1977/78 we were able to distinguish between backcountry and off-piste fatalities. Finally, further annual reports of the BFW were helpful in order to resolve classification problems of avalanche events.

Keeping in mind aspects of data quality, it seems to be that avalanche information back to the period 1967/68 is reliable for our purposes. In general information relating to fatal avalanches seems to be much more reliable than information relating only to avalanches with injured or uninjured persons. Most notably, in the case of fatal avalanches we do not expect that there are records missing.

In order to compare Austrian results with international results we use data from the International Commission of Alpine Rescue (ICAR) which was kindly made available for us by the ICAR. The data are annual count data of fatal avalanche events (‘Statistique d’accidents d’avalanche’) based on 21 countries within the periods 1983/84–2010/11 which are categorized by the type of fatalities (backcountry skiing or snowboarding, off-piste, on-piste, alpinist without ski/snowboard, on road, buildings, snowmobile, other).

For looking at the regional distribution we built small area maps based on Austrian municipalities. For this purpose we use polygon boundaries of the small-scaled areas provided by the 'Bundesamt für Eich- und Vermessungswesen' in a shapefile.

2.2 Statistical methods

After aggregating the spatio-temporal data in terms of location (resulting in disaggregated data in terms of time) we propose the following model for capturing the trend over time:

$$\log(\mu_{\mathbf{t}}) = f(t) + x_t \tag{2.1}$$

where $\mu_{\mathbf{t}}$ denotes the expectation of the Poisson distributed number of annual avalanche fatalities over time t. The logarithms of these values are modelled as the sum of potentially nonlinear trend function $f(t)$ and a stationary remainder x_t. We use the Aikake information criterion (AIC) and the Bayesian information criterion (BIC) in order to compare the constant, linear and nonlinear model (which is in our opinion the better choice than reporting p-values for potentially nonparametric trend functions). To account for potential serial correlation and periodic variation in the remainder, we consider autoregressive moving-average (ARMA) effects.

After aggregating the spatio-temporal data in terms of time (resulting in disaggregated data in terms of location) we propose a Markov random field approach modelling the expected number of avalanche fatalities $\mu_{\mathbf{s}}$ (s,

$s \in \{1, \ldots, S\}$, denoting the region) as follows:

$$\log(\mu_{\mathbf{s}}) = Z\beta_s \tag{2.2}$$

where the $S \times S$ design matrix Z depends on the specific form of the spatial layout. The coefficients β_s are conditionally Gaussian distributed (Markov random fields) according to:

$$\beta_s|\beta_{-s} \sim N\{\frac{1}{n_s}\sum_{r\sim s}\beta_r, \frac{\tau^2}{n_s}\} \tag{2.3}$$

where β_{-s} denotes the vector of parameters without its sth component, n_s is equal to the number of neighboring regions with reference to region s, $s \sim r$ indexes all units adjacent to region s and τ^2 denotes a (unknown) variance parameter.

For fitting these models we use the `R` package `mgcv` (R Development Core Team, 2012; Wood, 2006) which applies the smoothing spline approach for fitting generalized additive models (GAM).

Further on, for looking at the regional distribution of avalanche fatalities we build small area maps based on Austrian municipalities using the geographic information system (GIS) `ArcMap`. We, of course, use Markov random field estimates as described above which helps us to identify regional hot spots of avalanche fatalities.

3 Results

3.1 Temporal results

In the following, we give the plots of temporal estimated functions of avalanche fatalities at first plotting the function for Austria in total within the winter periods 1967/68–2010/11 (see Figure 1). Additionally, we plot the trend function of exclusively off-piste fatalities starting from the winter season 1977/78 (see Figure 2). Further on, we calculate 90% confidence bands of the estimated functions in both cases as shown in the plots.

For reasons of comparison Table 1 gives the frequencies of backcountry, off-piste and total fatalities of Austria and the Austrian neighboring countries Italy and Switzerland within the winter periods 1983/84–2010/11. Additionally the off-piste percentages are reported. Furthermore, we report the results of fatalities in France, which turns out to be the country with the highest counts of fatalities in Europe, and the results of the United States, which is probably the most important country outside of Europe in terms of avalanche fatalities. For this purpose, however, we use ICAR data as described above.

For further international comparison we consider estimated functions of off-piste and backcountry avalanche fatalities (and off-piste fatalities detached) of Switzerland, France, Italy and the United States in Figures 3–6.

Finally, the Aikake information criterion (AIC) and the Bayesian information criterion (BIC) of the constant (no trend effect), linear and nonlinear models are reported for model comparison – see Table 2. Lower AIC- and BIC-values, however, indicate significantly better fits when comparing the different models.

3.2 Regional results

Figures 7 and 8 show the regional distribution of fatal avalanche events (Figure 7 in total and Figure 8 off-piste only) using colored maps based on small areas, which are the Austrian municipalities in our case. The coloring, however, is based on Markov random field estimates of avalanche fatalities as described in the previous Section; the number corresponding with each spatial unit in the plot is equal to the original count.

4 Discussion

4.1 Temporal analysis with an international overview

If we look at the trend function of Austria in total (see Figure 1) we notice an increasing trend (1969/70: approx. 12, 2009/10 approx. 22). Considering ARMA effects, we did not find any substantial serial correlation or any sort of periodicity in the remainder x_t. Further on, we notice that there is a lot of variation of the observed counts around estimated function(s).

Additionally we take notice of a peak in the 1980s ranging between 1981/82 and 1987/88. But keeping in mind that increased snowfall has an essential effect on the number of accidents (Harvey, 2008; Harvey et al., 2012; Höller, 2012), increased solid precipitation in the 1980s during wintertime (Laternser & Schneebeli, 2003; Abegg, 1996) could give some evidence for this pattern. Looking at the off-piste trend function (see Figure 2), we notice an increasing (linear) trend without any peak in the 1980s. The actual decrease of the avalanche trend in Austria is due to the very small number of fatalities in 2010/11.

Lower AIC- and BIC-values (see Table 2) indicate that the nonlinear model is preferable to the constant or linear model – in case of ‘Austria off-piste’ the linear model seems to be the better one.

Comparing Austrian fatal backcountry and off-piste counts within

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

1983/84 – 2010/11 with results of counts in Switzerland, France, Italy and the United States (see Table 1) we notice, led by France (677, 24.18 fatalities per year), the second largest number of total avalanche fatalities (589, 21.04) in Austria. Having a focus on backcountry fatalities only, Austria is leading (405, 14.46) followed by France (355,12.68) and Switzerland (335, 11.96). In Austria a share of 31.24% of total fatalities are due to off-piste accidents (largest value France: 47.56%; smallest: Italy 27.47%).

Comparisons with total fatality profiles of France, Switzerland and Italy result in:

1. high frequencies in the 1980s,
2. low counts in the 1990s,
3. increasing trend beginning in 2000,

which in turn is rather similar to the results of Austria.

However, if we consider the results of the United States in Figure 6 (250 total fatalities, 32% off-piste) we note a positive almost linear trend without any peaks in the 1980s. The AIC- and BIC-values indicate that, with the exception of the United States (linear model), nonlinear models are preferable (whereas the BIC-values of France almost indicate that there is no effect at all in case of France).

If we compare the off-piste trends of the countries we notice quite different shapes to those of Austria (positive trend without peak in the 1980s):

1. Italy: similar to shape as seen in case of total counts.
2. Switzerland: difference to total trend function, peak of off-piste trend around year 2000.

3. France: decrease of off-piste counts in recent years.
4. United States: almost no increase; because of the lowest AIC-value, the constant model turns out to be the best one.

Such as in the ‘total’ case above, lower AIC- and BIC-values indicate that, with the exception of the United States (constant model), nonlinear models are best-performing. Usually trend information is given as a linear function in the literature for avalanche data, see e.g. (Tschirky et al., 2000; Harvey & Zweifel, 2008; Spencer & Ashley, 2011; Page et al., 1999). Our investigations - see AIC- and BIC-values in Table 2 - showed that (with the exception of the US-data) linear models are not appropriate.

4.2 Regional analysis

In Figure 7 we explore the regional or spatial distribution of avalanche fatalities in Austria within the years 1981–2010. Here the total area of Austria is divided into small areas, equal to the areas of the Austrian municipalities (194 municipalities with at least one reported fatality). Around the municipalities ‘St. Anton a. Arlberg’ and ‘Sölden’ in the western part of the Austrian federal state Tyrol we observe 2 clusters or hot spots of increased fatalities:

The first cluster, centered around the regions Arlberg and Silvretta, is including the municipalities St. Anton a. Arlberg (number of avalanche fatalities: 29), Kaisers (7), Klösterle (8), Lech (20) in Arlberg, and the municipalities St. Gallenkirch (6), Gaschurn (8), Galtür (21), Ischgl (9) in Silvretta.

The second cluster, located in the southern part of Ötztal, Kühtai and

Stubai, is including the municipalities Sölden (43), St. Leonhard i. Pitztal (17), Längenfeld (9) in the Ötztal Alps, and the municipalities St. Sigmund i. Sellrain (8), Silz (13), Sellrain (5), Neustift i. Stubaital (10) in Kühtai-Stubai.

Further on, we observe some smaller spots in the federal states:

– Tyrol (Tuxer Alpen): Navis (8), Schmirn (5), Tux (9)

– Salzburg (Saalbach): Saalbach-Hinterglemm (10), Niedernsill (13)

– Styria (Triebener Tauern – Seckauer Tauern): Gaal (5), Wald am Schoberpaß (6), Hohentauern (6).

Figure 8 plots the distribution of the off-piste fatalities (without backcountry fatalities; 70 municipalities with at least one reported off-piste fatality). As a conclusion we notice 2 hot spots of off-piste fatalities which are: ‘St. Anton a. Arlberg’ - ‘Lech’ - ‘Ischgl’ (Arlberg, Ischgl) and ‘Sölden’ (southern part of Ötztal).

Some single areas with increased frequencies, e.g. Werfenweng (15) and Niedernsill (13), are due to disastrous single avalanche events (Höller, 2012).

We are not able to compare our regional results with other countries in Table 1 because of lack of information. However, we recommend to do this regional analysis in other countries in a similar way.

5 Conclusion

As the result of the trend analysis we notice an increasing trend of off-piste and backcountry avalanche fatalities within the winter periods from 1967/68 to 2010/11. This clearly contradicts the widespread opinion that the number of fatalities is constant over time.

Comparing results of off-piste and backcountry avalanche fatalities in Austria with other relevant countries we notice the second highest number of off-piste and backcountry fatalities in Austria and the largest number of backcountry fatalities in Austria. We notice similar estimated functions if we compare Austrian results with results of the relevant European countries. However, the off-piste trend function of Austria is quite different to those of the other relevant European countries (but similar to those of the United States).

As the result of the regional analysis we notice two hot spots of avalanche fatalities in Figure 7: ‘St. Anton a. Arlberg (29)’ (Arlberg-Silvretta) and ‘Sölden (43)’ (southern part of Ötztal, Stubai-Kühtai).

Because of the increasing trend and the rather ‘narrow’ regional distribution of the fatalities, consequences on prevention of avalanche accidents are highly recommended, e.g. starting a ‘campaign against avalanche accidents’ in the centers of the clusters St. Anton and Sölden. This should especially be done in order to prevent the large number of off-piste (freerider) fatalities in St. Anton-Lech-Ischgl and Sölden.

Unfortunately, we are not able to verify the influence of increased number of backcountry and off-piste skiers over time because there is no valid information about frequencies of backcountry and off-piste skiers in general. However, there is no doubt of the increasing number of backcountry and off-piste skiers; e.g Techel et al. (2014) states: ‘From lodging statistics of the mountain huts of the Swiss Alpine Club (SAC) we found a prominent increase of winter overnight stays since the late 1970s, which is also an evidence for increasing backcountry activity'. Finally, we do not hesitate to mention that further research is needed, e.g. to explore the influence of new fallen snow, temperature, etc. on the number of fatalities. For this purpose, further and more precise data are necessary.

Financial/Material Support: None

Disclosures: None

References

Abegg B. Klimaänderung und Tourismus: Klimafolgenforschung am Beispiel der Wintertourismus in den Schweizer Alpen. Zurich, Switzerland: vdf Hochschulverlag AG; 1996.

Ammann W, Tschirky F. Epidemiological trends in avalanche accidents. Widerness Environ Med 2001; 12:139.

Amt der Tiroler Landesregierung. Schnee und Lawinen. Jahresberichte. Innsbruck, Austria: Raggl; 1973–2011.

Brugger H, Durrer B, Adler-Kastner L, Falk M, Tschirky F. Field management of avalanche victims. Resuscitation 2001; 51(1):7–15.

Harvey S, Zweifel B. New trends of recreational avalanche accidents in Switzerland. Proceedings of the ISSW2008. Whistler, Canada; 2008.

Harvey S. Mustererkennung in der Lawinenkunde. Sicherheit im Bergland. Jahrbuch des Kuratoriums für alpine Sicherheit. Vienna, Austria: Kuratorium; 2008:53–72.

Harvey S, Rhyner H, Schweizer J. Lawinenkunde: Praxiswissen für Einsteiger und Profis zu Gefahren,Risiken und Strategien. Munich, Germany: Bruckmann Verlag; 2012.

Höller P. Avalanche cycles in Austria: an analysis of the major events in the last 50 year. Nat Hazards 2009; 48(3):399–424.

Höller P. The cumulation of avalanche accidents in certain periods - an analysis of backcountry events in Austria. Proceedings of the ISSW2012. Anchorage, USA; 2012:32–339.

Kuratorium für alpine Sicherheit. Sicherheit im Bergland. Jahrbücher des Kuratoriums für alpine Sicherheit. Vienna, Austria: Kuratorium; 1973–2011.

Laternser M, Schneebeli M. Long-term snow climate trends of the Swiss Alps. Int J Climatol 2003; 23(7):733–750.

Neuhold T. 25 Lawinentote werden akzeptiert. Pressebericht zum Lawinenkolloquium 2012 Salzburg. Der Standard Printausgabe 16.1.2012. Vienna, Austria: Standard Verlagsgesellschaft m. b. H.; 2012.

Page C, Atkins D, Shockley L, Yaron M. Avalanche deaths in the United States: A 45-year analysis. Wilderness Environ Med 1999; 10:146–151.

R Development Core Team. R: A language and environment for statistical computing. Vienna, Austria; 2012. Available from: http://www.r-project.org/

Schaffhauser H. Lawinenereignisse und Witterungsverlauf in Österreich. Winter 1986/87. FBVA-Berichte 35. Vienna, Austria: Österreichischer Agrarverlag; 1988.

Silverton NA, McIntosh SE, Kim HS. Risk Assessment in Winter Backcountry Travel. Widerness Environ Med 2009; 20:269–274.

Spencer J, Ashley W. Avalanche fatalities in the western United States: a comparison of three databases. Nat Hazards 2011; 58(1):31–44.

Techel F, Zweifel B, Winkler K. Patterns of recreational backcountry usage - analyzing data from social media moutaineering networks and avalanche statistics. Proceedings of the ISSW2014. Banff, Canada; 2014:1148–1152.

Tschirky F, Brabec B, Kern M. Lawinenunfälle in den Schweizer Alpen – eine statistische Zusammenstellung mit den Schwerpunkten Verschüttung, Rettungsmethoden und Rettungsgeräte. 2000. Available from: http://www.slf.ch/praevention/lawinenunfaelle/unfallstatistik-de.pdf

Wood SN. Generalized Additive Models: An Introduction with R. Boca Raton, USA: Chapman and Hall/CRC; 2006.

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

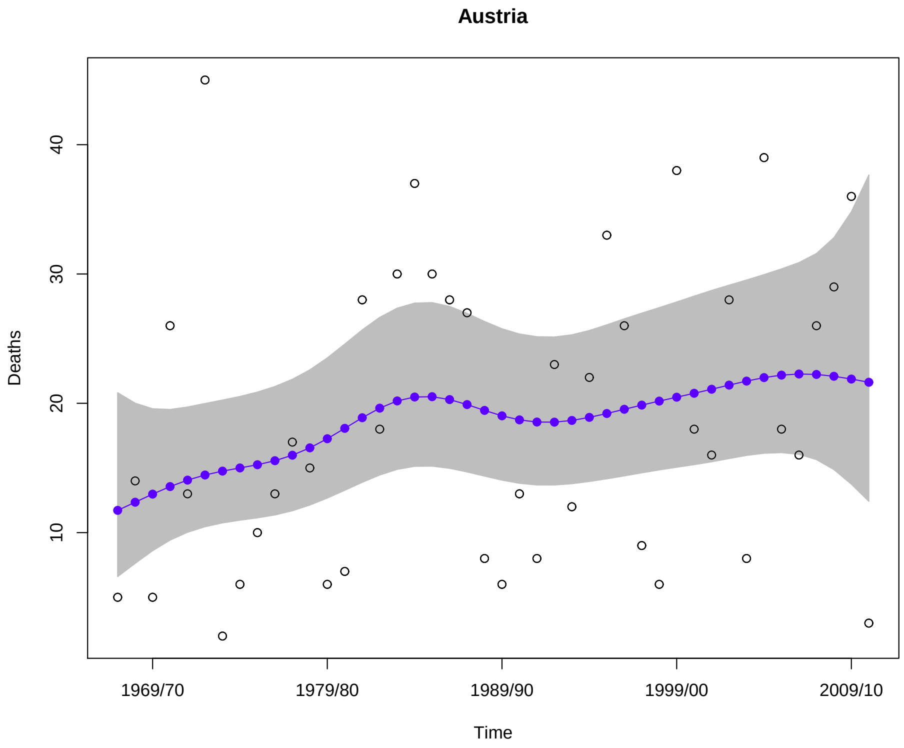

Figure 1: Observed (○) and estimated (●) annual total avalanche fatalities (off-piste and backcountry) in Austria within 1967/68–2010/11.

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

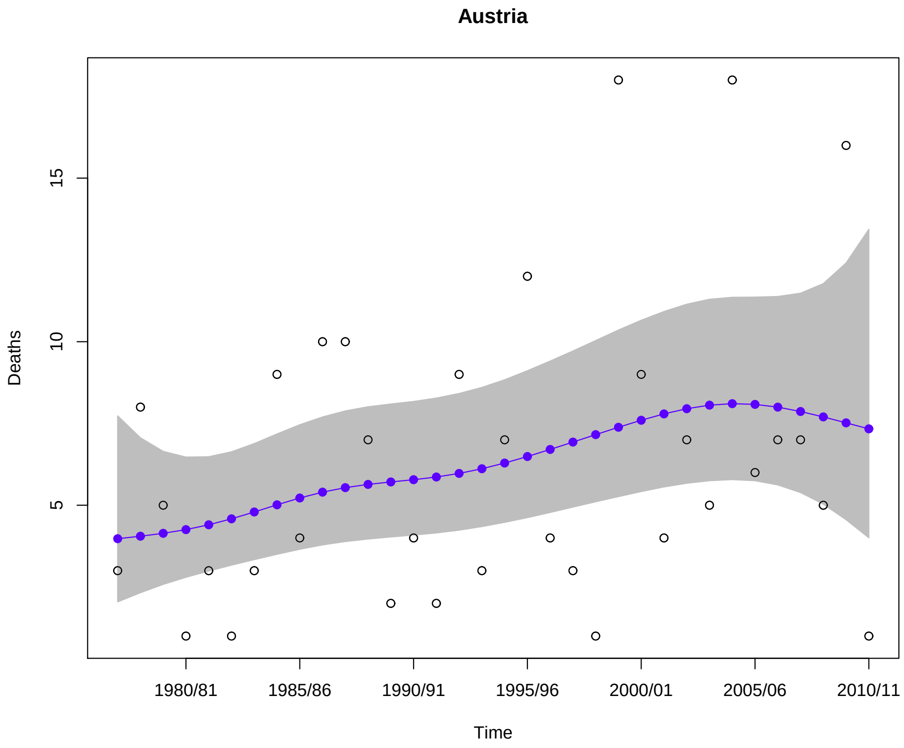

Figure 2: Observed (○) and estimated (●) annual off-piste avalanche fatalities in Austria within 1977/78–2010/11.

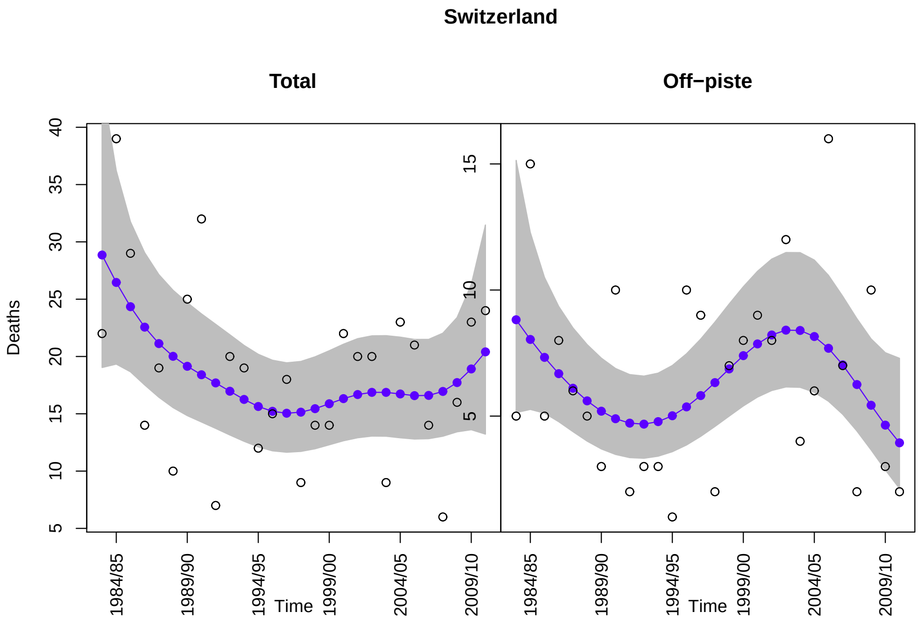

Figure 3: Observed (○) and estimated (●) annual avalanche fatalities (off-piste and backcountry, i.e. total, on the left and off-piste on the right) in Switzerland within 1983/84–2010/11.

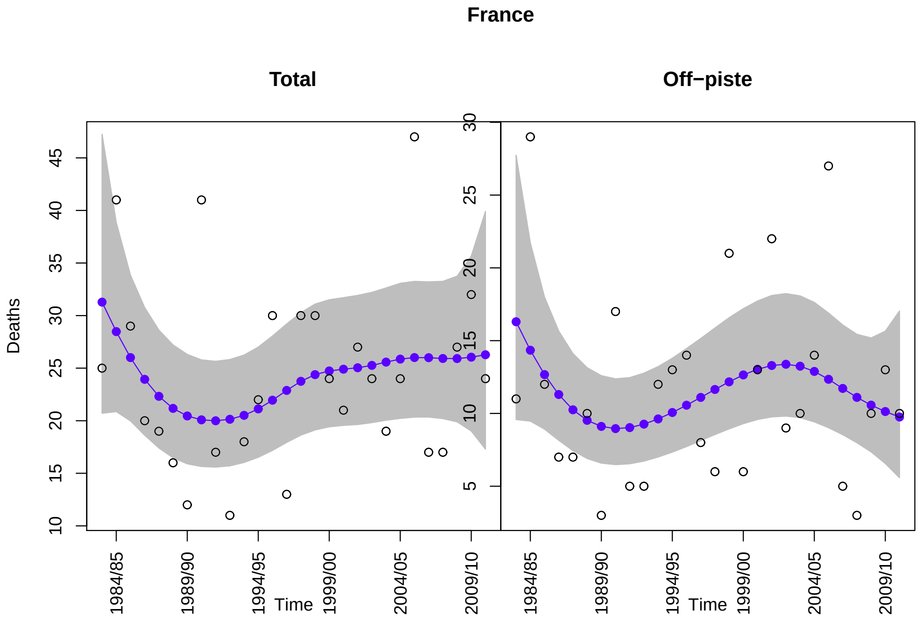

Figure 4: Observed (○) and estimated (●) annual avalanche fatalities (off-piste and backcountry, i.e. total, on the left and off-piste on the right) in France within 1983/84–2010/11.

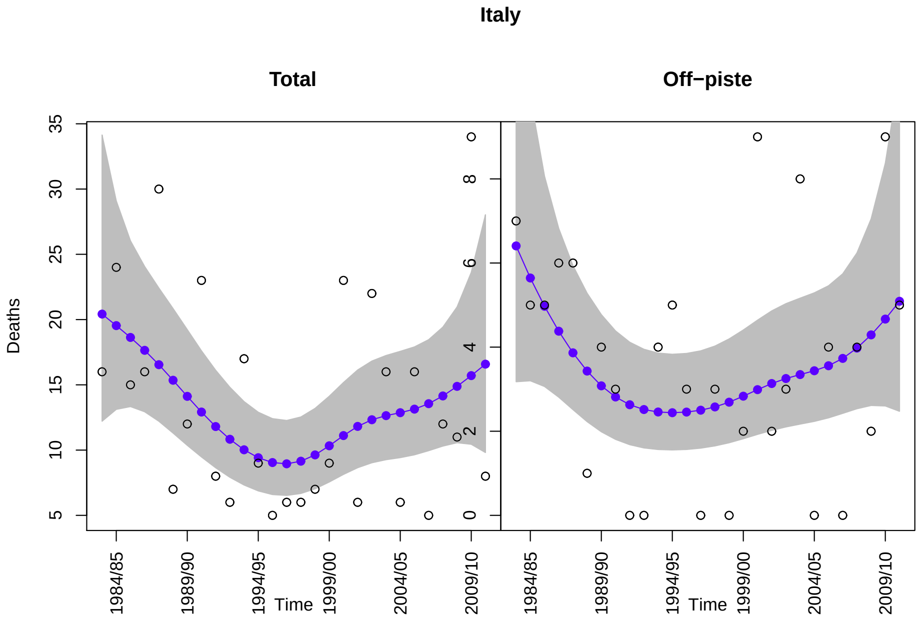

Figure 5: Observed (○) and estimated (●) annual avalanche fatalities (off-piste and backcountry, i.e. total, on the left and off-piste on the right) in Italy within 1983/84–2010/11.

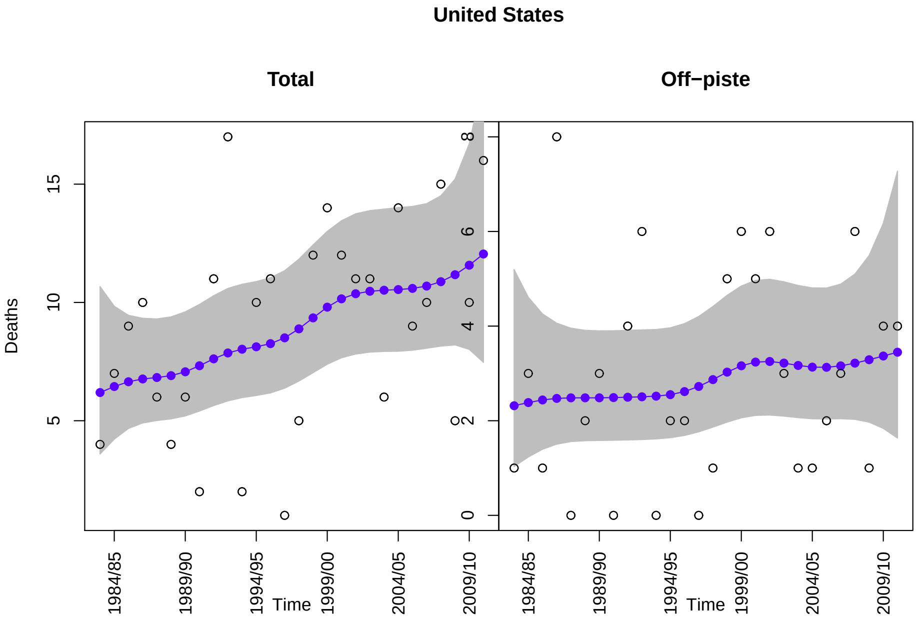

Figure 6: Observed (○) and estimated (●) annual avalanche fatalities (off-piste and backcountry, i.e. total, on the left and off-piste on the right) in the United States (USA) within 1983/84–2010/11.

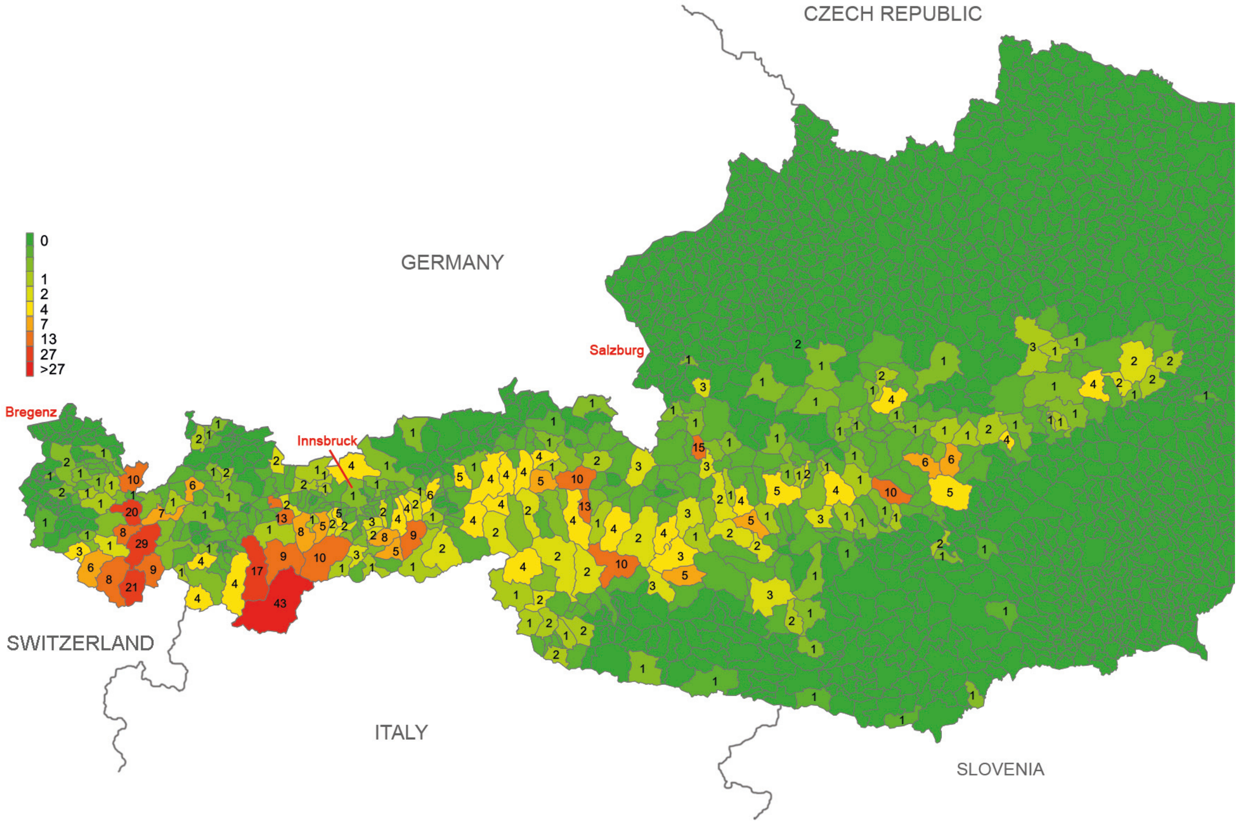

Figure 7: Regional distribution of avalanche fatalities (off-piste and backcountry) in Austria within 1980/81–2009/10.

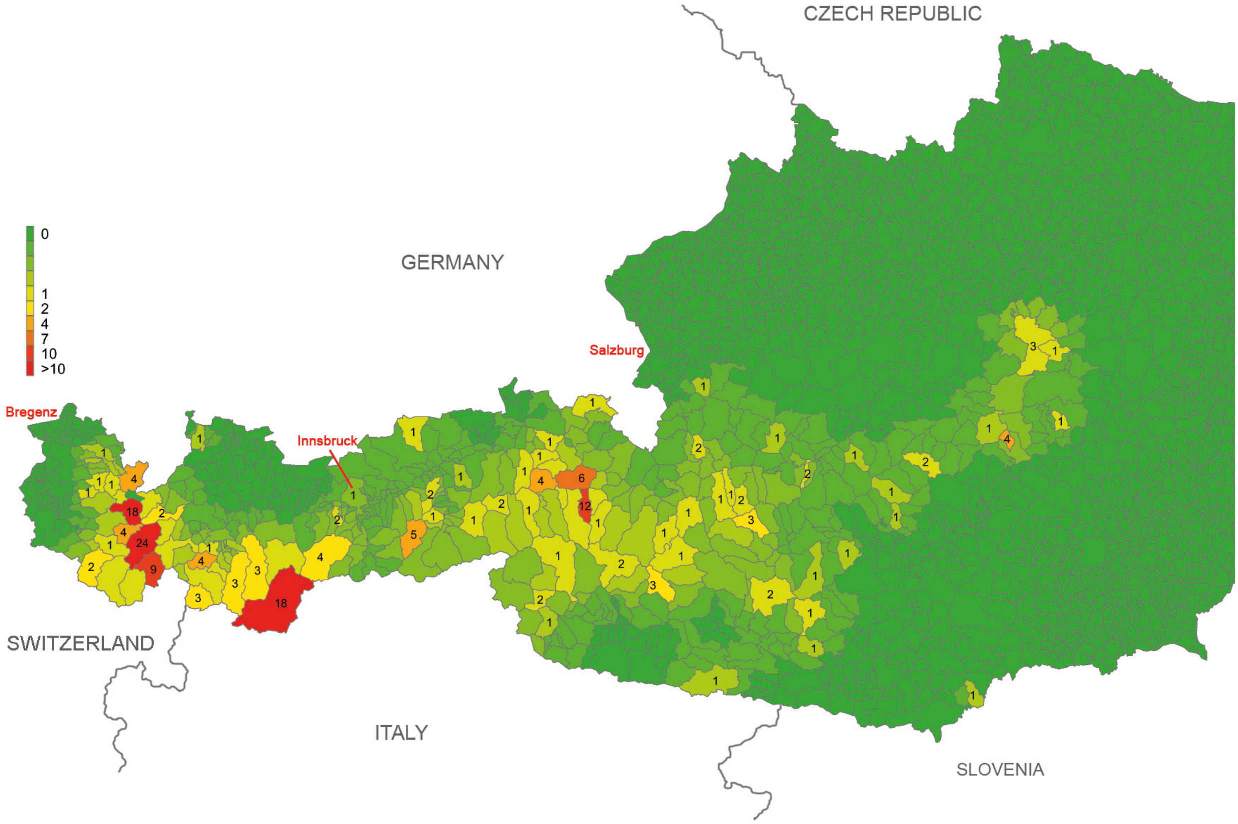

Figure 8: Regional distribution of avalanche fatalities (off-piste) in Austria within 1980/81–2009/10.

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

Country	Backcountry		Off-piste		Total		
	number	per year	number	per year	number	per year	% off-piste
Austria	405	14.46	184	6.57	589	21.04	31.24%
Switzerland	335	11.96	181	6.46	516	18.43	35.08%
France	355	12.68	322	11.50	677	24.18	47.56%
Italy	264	9.43	100	3.57	364	13.00	27.47%
USA	170	6.07	80	2.86	250	8.93	32.00%
sum	1529	54.61	867	30.96	2396	85.57	36.19%

Table 1: Number of avalanche fatalities and annual average (off-piste, backcountry and total) of 5 countries within the winter periods 1983/84–2010/11.

Nat. Hazards Earth Syst. Sci. Discuss., doi:10.5194/nhess-2016-369, 2016
Manuscript under review for journal Nat. Hazards Earth Syst. Sci.
Published: 17 November 2016

		total			off-piste		
		const	linear	nonlin.	const	linear	nonlin.
Austria	AIC	513.02	498.80	488.36	221.23	213.92	215.61
	BIC	514.80	502.37	497.02	222.76	216.97	221.66
Switzerland	AIC	216.83	212.97	205.34	166.36	168.36	159.93
	BIC	218.16	215.63	211.84	167.69	171.02	165.26
France	AIC	223.70	225.22	220.83	214.46	216.44	208.39
	BIC	225.03	227.88	227.67	215.79	219.10	214.34
Italy	AIC	241.18	241.18	223.08	145.41	147.28	140.37
	BIC	242.51	243.84	229.20	146.74	149.94	145.20
United States	AIC	175.46	167.91	171.34	125.97	126.77	128.80
	BIC	176.79	170.57	177.00	127.30	129.44	133.42

Table 2: AIC and BIC of the constant, linear and nonlinear trend model considering data of Austria total and off-piste (Figure 1, Figure 2), Switzerland total and off-piste (Figure 3), France total and off-piste (Figure 4), Italy total and off-piste (Figure 5) and United States total and off-piste (Figure 6).