

An Analysis of Off-Piste and Backcountry Accidents in France for 2003-2004

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Abstract

This independent study analyses winter sports accidents that occurred outside of open ski pistes in France during the 2003-2004 season. The aim is to see if there are any lessons to be learned by off-piste and backcountry travellers and if improvements can be made in education and safety.

Introduction

PisteHors.com has been publishing information in English about off-piste and backcountry accidents since 2000. During the 2004 winter season over 300,000 pages of content were accessed, around a third of them news articles. We have also provided background information to newspapers including The Observer, The Daily Telegraph and The Independent. We believe this is a valuable contribution towards educating skiers, snowboarders and snowshoers who are thinking about going off-piste.

We have used the term *off-piste* to describe the area within or in proximity to the ski domain but outside of open and secured ski pistes. *Backcountry* is used to describe the rest of the mountain environment which users will normally access by climbing, either from ski lifts or from the valley. Although the risks faced are similar there are certain significant differences. The term *skier* has been used to describe all winter sports enthusiasts including snowboarders and snowshoers.

The Dangers

The principal dangers faced by off piste and backcountry enthusiasts are avalanches and falls. Avalanches can kill or injure from impact with solid objects such as trees or rocks, by crushing due to the weight of snow, by suffocation where the victim is buried for a short period or by hypothermia where the victim has an airspace. In general suffocation occurs within 15 minutes of burial and hypothermia after 60 minutes. Small avalanches can also carry the victim over cliffs with serious consequences.



Figure 1: Cornices formed by prevailing winds

Falls can be due to an error in navigation leading the victim over cliffs, by slipping on steep or icy routes, by falling through cornices or by a fall into a crevasse where a snow bridge has collapsed.

There are also occasional deaths due to collisions with objects such as trees, from hypothermia where the victim has had to spend one or more nights in the open or has fallen into water and from rock and ice falls.

During the period 1st October 2003 to 6th June 2004 PisteHors.com recorded a total of 42 fatalities: 24 from avalanches and 18 from falls. The figure from falls is almost certainly an understatement of the true figure but the nature of accidents is representative for the purposes of this study.

Figure 2 shows the fatalities for the 2003-2004 season broken down by activity. 16 fatalities occurred during the 6 week Christmas and Winter vacation period, a rate of 2.67 fatalities per week. There were 26 fatalities over the remaining 29 week period, a rate of 0.89 fatalities per week. The long Easter holiday is not taken into account because the number of visits to the mountains does not increase significantly at this time¹.

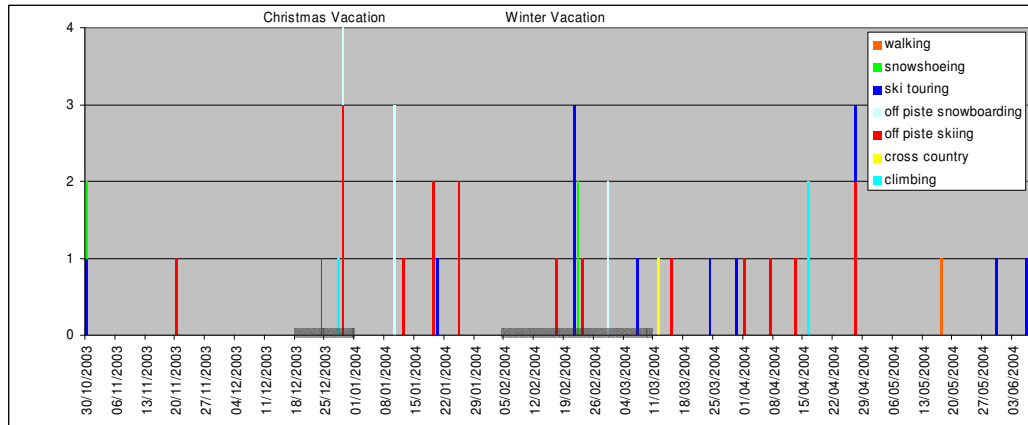


Figure 2: Off-piste and backcountry fatalities during the 2003-2004 season

Some Figures

The typical accident victim is a French adult male who probably lives locally to the mountains. He is also likely to be a skier, either off-piste or in the backcountry. In total 9 nationalities were recorded with British nationals in an, albeit distant, second place

We used the website: www.skirando.ch² to analyse backcountry group size. We took a random sample of outings in the Northern Alps covering two periods, weekdays and weekends. The average size of a backcountry skiing group is 2.61 people, however there is significant difference between weekends (3.35, mode value: 2) and weekdays (2.07, mode value: 1). In both cases groups are about 17% female. During the weekend 14% of outings were by lone skiers, this figure rose to 33% during the week.

A survey carried out in 2001-2002 for the French Tourism Ministry breaks down snow sports into the following segments: 84.8% ski, 11% snowboard, 3.9% snowblade (miniskis) and 0.3% telemark and monoski. The growth in numbers for snowboarders has flattened. This survey counted people using lifts in 15 ski resorts and therefore will not correspond exactly to off-piste or backcountry. Over 80% of snowboarders now use freestyle or freeride as opposed to alpine boards.

Interventions by rescue services in 2002-2003 showed that skiers and snowboarders had roughly the same number of accidents off-piste (around 2.4%) as a percentage of the total for their discipline. The same report showed that on piste snowboarders are 50% more likely to have an accident, possibly due to snowparks. A crude analysis would therefore conclude that snowboarders are less likely to go off-piste than skiers. However it is difficult to extrapolate a great deal from these figures. It is technically easier for a snowboarder to go off-piste although developments of all mountain and fat skis have reduced this advantage over the last 5 years. Given the average age of snowboarders (25 years) compared to skiers (35 years) one would also expect to see more of them taking part in testosterone charged radical sports. It may be that that the technical advantages of boarding means that they have

¹ Direction du Tourism, SOFRES (SDT 2000)

² Skirando is a web community for backcountry ski and snowboarders

fewer accidents off piste or that boarders are increasingly drawn to the excellent snowparks found in most resorts.

These figures differ markedly from a survey carried out by Médecins de Montage during the 2001-2002 season. The survey interviewed 1,992 people in 11 ski resorts. Of the people interviewed 38.9% of people said they went off-piste, out of this group 69.2% were skiers, the rest snowboarders. Some of the difference can be explained by the fact that the rescue service figures cover a much larger sample and the calculated figure is a percentage of total skier/days, not just occasional sorties off-piste.

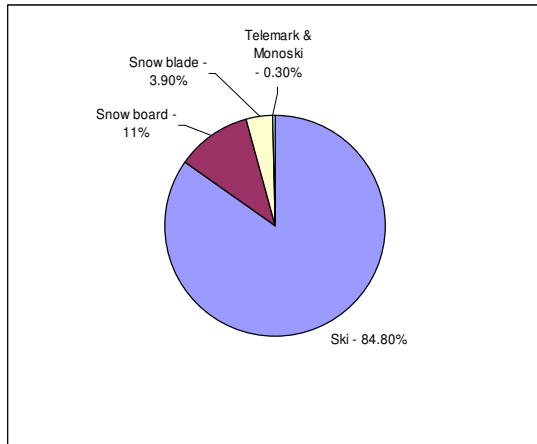


Figure 3: Snowsports by activity

For backcountry access it is clear that skiers, including telemarkers, are in a large majority. Again a survey of outings on SkiRando showed snowboarders represented around 1% of participants. This is to be expected given the technical difficulties in climbing with a snowboard, either on foot, with snowshoes or using splitboards equipped with climbing skins. Backcountry snowboarding is still a developing market with a large future potential.



Figure 4: Skiers and Snowboarders in the Backcountry

26% of snowsport enthusiasts also participate in cross-country skiing as part of their winter break. Snowshoeing is also a growing segment; recently snowshoe sales have overtaken those of cross country skis. There are 1.4 million snowshoers in France and 350,000 pairs of snowshoes. Over 50% of snowshoers go off marked trails.

About a third of visitors to the mountains are not French: British, Italian Dutch, Belgium and Eastern Block countries form the bulk of foreign tourists. The Northern Alps represent over 75% of the economic activity of French Ski stations. Ski resorts have about 50% more visitors during the peak February winter holiday period. Curiously only just over half of winter tourists in ski resorts practice a winter sport.

Avalanches

The main changes in avalanche fatalities compared to last year were in ski touring and off piste snowboarding. The ski touring deaths were affected in the 2002-2003 season by a major avalanche in early December 2002 which killed four members of a group belonging to the French Alpine Club (CAF). The three snowboard deaths occurred in two incidents on the same day. The majority of fatalities occurred when the avalanche risk for the area was 3 (considerable) on the five point international scale (see Table 3 at the end of the document)

Table 1: Comparison of avalanche accidents by activity

Activity	2004	2003
Ski Touring	6	10
Off Piste Skiing	8	9
Snowboard Touring	0	0
Off Piste Snowboarding	3	1
Snowshoeing	3	3
Climbing	3	0
Walking	1	0

The Savoie and Haute Savoie departments were particularly badly hit with 15 deaths, 6 of them in the Tignes/Val d'Isère resort. This series over two weeks included a British national skiing with an instructor and attracted the interest of the UK media. The walking accident was most unusual. It happened late in the spring and involved a Dutch tourist who had strayed onto a closed section of the Galibier pass at the same time as highway workers were ploughing snow higher on the pass.

Where there was an indication in the reports, 9 of the 24 avalanche victims were either experienced skiers or skiing with instructors. The reported altitude of avalanche accidents was plotted as a polynomial trend line. It decreased towards the second half of January, rising at the end of the season.

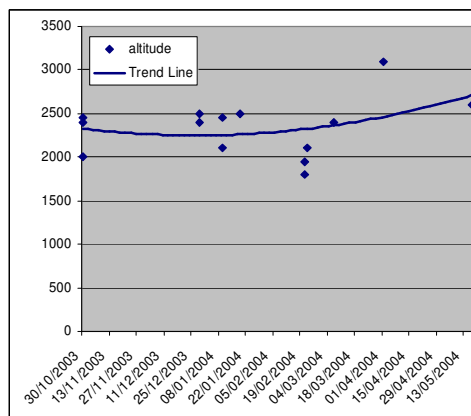


Figure 5: Reported altitude of avalanche accidents

Lack of Equipment

Lack of rescue equipment was noted in seven of the reported fatalities. In January a Boston resident disappeared close to Chamonix after leaving marked pistes, his body was only recovered in May. Later in the month a former ski instructor from Auron, near to Nice, was hit by an avalanche while backcountry skiing with two friends. They were able to locate him under the slide using their avalanche transceivers but did not have probes or shovels to complete the rescue. They had to wait for the arrival of the rescue services, a delay that may have proved fatal.

A month later a ski tourer was hit by a large avalanche close to La Rosiere. Neither he nor his friend had avalanche transceivers, the man's body was found by rescue workers. On the same day two ski

tourers were hit by a slide in the Belledonne Mountains close to Chambéry. One of the victims was found rapidly by witnesses using avalanche transceivers but the second victim was only found some 3 hours later by rescue workers. Météo France had originally estimated the avalanche risk for the sector as 1 on a scale of 5 but a deepening weather system brought greater snowfall and rain than expected. Updates to the bulletin were issued on Friday night.

In Valloire, a man was killed by an avalanche skiing close to the pistes despite the rapid intervention of the piste patrol. On the same weekend two snowshoers, members of the French Alpine Club disappeared. There was a large search at the time but their bodies were only found with the spring thaw. They had removed their snowshoes to cross a steep slope and had apparently triggered a large avalanche, neither was equipped with transceivers which may have at least saved the rescue services time in searching in difficult conditions.

Skiing Alone

Four of the fatalities involved people skiing alone. A member of the high mountain police disappeared close to Avoriaz. An experienced backcountry skier, despite his young age, he had failed to find a partner for his trip. A large rescue operation was put in place and the man's body was found a couple of days later after his mobile phone company was able to give searchers his rough location. We've already mentioned the Boston resident who left his companion on the slopes of the Brevet in Chamonix to return to the valley by an off-piste route and the Valloire skier killed close to the pistes. An experienced skier was also killed at La Grave skiing in a steep couloir. At least in the last two incidents witnesses were on hand to alert the rescue services who were rapidly on the scene.

Small Avalanches

An avalanche doesn't have to be big to kill you. In 2 of the 20 accidents involving fatalities, death was caused by impact with rocks after the skiers were carried by small avalanches or snow sluffs. Pioneering extreme snowboarder André-Pierre 'Dédé' Rhem and Alain Géloen, both Chamonix mountain guides, were killed in separate incidents on the Italian side of Mont Blanc after being carried over cliffs by small avalanches. Patrick Berhault, Jérôme Thinières, Edouard Baud and Eric Peymirat complete the list of French professionals killed in mountain accidents during the season.



Figure 6: Small snow sluff

The Weather

The principal driver of avalanches is the weather and its effect on snowpack. Snow or rainstorms, strong winds, warm weather, and prolonged cold dry periods are all important in avalanche formation and release. The 2003/2004 season got underway with localized snow early in October that fell down to mid-mountain areas (1000-1500 meters). According to Jacques Villecroise, an expert from Météo France, this had only happened once, during October 1974, over the last forty years.

These early snows soon melted and the first real winter weekend was at the end of October. Despite large snowfall in the last week of November the unusually warm weather meant that snow cover was patchy until just before Christmas which saw conditions more like the start of a season.

In the new year there was a pattern of warm periods followed by frequent, moderate snowfalls right through to the late spring. In May it was possible to ski powder snow down to 1600 meters in the Vanoise and even lower in the Belledonne.

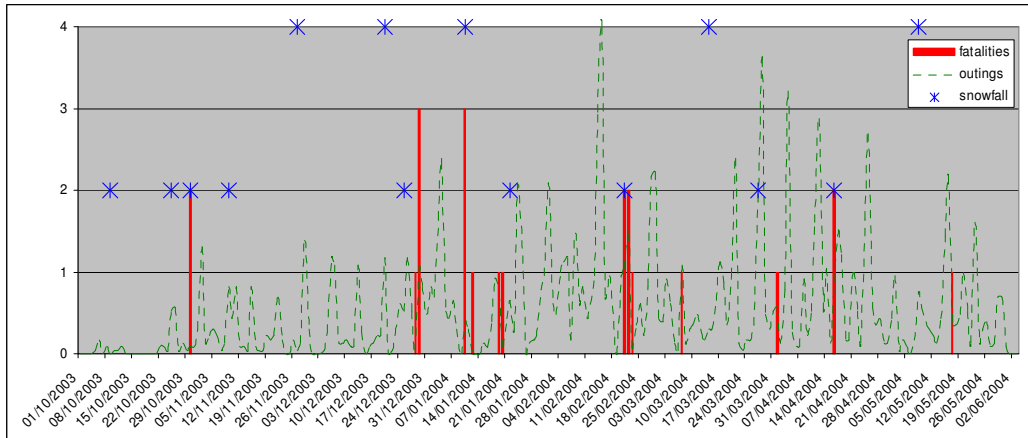


Figure 7: 2004 Avalanche fatalities plotted against outings by backcountry skiers and snowfall events

Figure 7 shows snowfall greater than 20cm with a blue snowflake. This quantity of snow is considered to have an adverse effect on the stability of the snowpack, larger episodes (around 40cm of new snow) are marked with a higher flake. Snowfall data was obtained from figures recorded by Météo France at their research centre located at 1320 meters on the Col de Porte in the Chartreuse Mountains. This information was correlated against the automatic monitoring stations situated close to Chamonix, La Plagne and La Grave. Overall the Col de Porte registered some 150 days of snowcover, slightly less than the previous forty year average of 169 days. This sums up a season of excellent snowfall above 2000 meters but somewhat below average at lower altitudes.

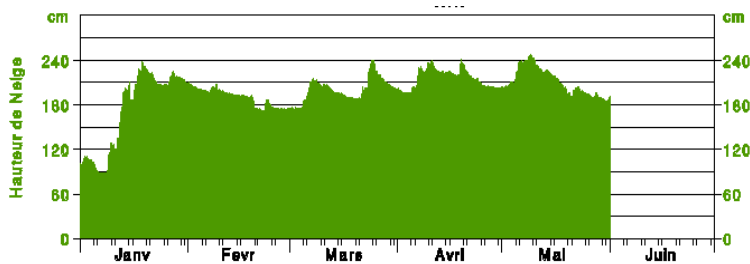


Figure 8: Snowpack depth at the Bellecote (La Plagne) weather station

Wind is also a significant actor in the conditions that lead to avalanches. Studies show that as much snow is moved by wind as is deposited by precipitation. Wind removes snow from the windward side of ridges and deposits it on lee slopes. It also breaks down the delicate structure of snow crystals and is instrumental in forming potentially unstable snow slabs.



Figure 9: Wind transport of snow on ridgelines

Wind speeds greater than 25km/h can move snow around, more than 80 km/h the snow disperses in the air and does not resettle. The public data from Météo France weather stations give wind speed but not direction. Figure 10 shows the wind speed recorded by the Ecrins station. This information is used by avalanche forecasters when preparing daily bulletins for backcountry travellers.

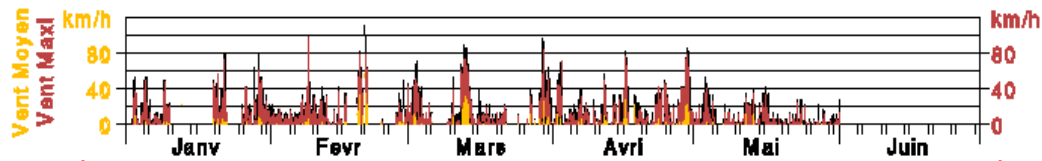


Figure 10: Wind speed recorded by the Ecrins weather station

The green line on Figure 7 shows the frequency of outings in the Northern Alps extracted from SkiRando. The SkiRando data also includes human observations on snow pack and weather. An analysis of the frequency of outings to weather during the winter season (15th December – 30th April) when there is usually sufficient snow cover to ski showed that the figure is extremely sensitive to weather conditions. Although the SkiRando database is extensive, over 15,000 outings are recorded worldwide with 3000 recorded in the Northern Alps last season, most of the data is free text format making it hard to automate analysis.

The start of the season was marred by two fatal avalanches and a drama that nearly cost the life of another backcountry skier. An avalanche on the Côte Belle Mountain near the ski resort of l'Alpe d'Huez, a favourite with early season backcountry enthusiasts because of its good road access, hit a group of three experienced backcountry skiers burying one. It took the two rescuers 35 minutes to find and free their friend from the snow. Rescue helicopters arrived on the scene 10 minutes later but were unable to land due to the weather conditions.

A particularly bad day on the 29th of December saw four deaths, all off-piste, two of them in the Espace Killy. In two incidents the avalanches were triggered by other users higher on the slope. In one accident the overall avalanche risk on the day was 2 (moderate) on a scale of 5. However, the local risk was 3 (considerable) for the sector where the avalanche occurred. Late on the 10th of January three snowboarders were struck by an avalanche above a lake in the ski resort of Tignes. Two died after being carried into the freezing waters by the slide. Rescue workers had to lay cables across the 250 meter frozen lake and string up floodlighting in order to search for the victims. A boarder was killed in Val d'Isère, also late in the afternoon. On the 12th of January a skier was killed after going off piste alone in Chamonix.

All of the above victims were caught in slab avalanches. A slab avalanche is a layer of cohesive snow that slides on a surface underneath, often a weak snowpack layer. Slabs are difficult to identify, especially when they are covered by fresh snow. Even carrying out tests on similar slopes has been shown to be a poor indicator of stability on suspect slopes. Slab avalanches account for the majority of avalanche fatalities. Skiers often assume that thin snowpacks present little danger as there isn't much snow, but a slide measuring 200x300x0.5 meters would mobilize around 7,500 tonnes of snow. If the skier is carried into a narrow valley or hollow or even if there is a sudden change in slope angle he could be buried under several meters of snow. Locations where one can be buried unusually deeply are known as terrain traps.



Figure 11: A buried weak layer

Thin snowpacks can also form significant weak layers especially when temperatures are cold and skies clear. Large temperature differences arise between the ground, which is close to zero degrees, insulated under its blanket of snow, and the snow surface which is cooled by ambient mountain air and cooling radiative effects. A temperature gradient of 5°C acting over 50cm of snow will have the adverse effect of driving water vapour through the snowpack, forming weakly bonded, angular ice crystals known as depth hoar or gobelets. The dangers of thin snowpacks were noted by Claude Rey and Alain Duclos in

their study: How to improve the avalanche knowledge of Mountain Guides presented at the 2002 International Snow Science Workshop.

Depth hoar is not the only danger. Surface hoar is critical in nearly half of all avalanche deaths³. At night or on northern slope aspects the snow surface radiates a lot of heat and becomes very cold. Moisture from still, warm air above the snow will condense onto the surface, forming crystals. This means that surface hoar has an erratic and unpredictable distribution.



Figure 12: Surface hoar at Val d'Isère (8th Jan 2004)

Surface hoar forms a thin but very fragile layer. Both depth and surface hoar are extremely persistent, sometimes lasting until the end of the ski season, and probably played a role in the other avalanche accidents during the winter. The fresh snowfalls on the 9th and 10th of January both buried surface hoar layers and would have overloaded any other weak layers making them sensitive to triggering by skiers or boarders. Weak layer collapse is characterised by a characteristic '*whoumphing*' noise.

Later in the season the sun begins to play a more significant role. The balance of warming solar effects stabilizes the snow pack. Days are longer and the sun rises higher in the sky, striking the snow surface more directly. The whole snowpack approaches zero degrees and melting begins weakening bonds. At lower altitudes water can percolate down to grass below and act as a lubricant. Depth hoar layers, formed at the start of the season, weaken easily and may fail. Full depth avalanches, called climax avalanches present obvious high risk.

More commonly, loose, wet avalanches, called sluffs become a potent force in springtime because of the high density of water-saturated snow. Backcountry skiers can usually avoid these slides by restricting activity to earlier in the day and avoiding the terrain traps, such as gulleys, where these avalanches flow.



Figure 13: Effect of the sun on spring snow

At altitudes over 3000 meters average air temperatures are still usually quite cold. Winter conditions can exist at any time of the year above this elevation. Fresh snowfall is common and slab avalanches possible. A small slab at 3,100 meters killed a skier training for the Derby de la Meije at La Grave at

³ Schweizer and Jamieson, International Snow Science Workshop, 2000

the start of April. A year earlier a German guide was killed in the same area by a large slab avalanche at 3000 meters. Figure 5 shows that the reported altitude of fatal avalanches increases towards the end of the season.

Out of Season Accidents

The period from the 1st of May to the 15th of December is considered to be outside the main ski season. Except for limited glacier skiing in the summer and autumn ski domains are closed during this period. In general accidents involve climbers, backcountry skiers and snowboarders. JP Zuanon analysed this period over 23 years using statistics from the ANENA and found that 20% of avalanche accidents occurred out of season but there was considerable variation between one year and another.

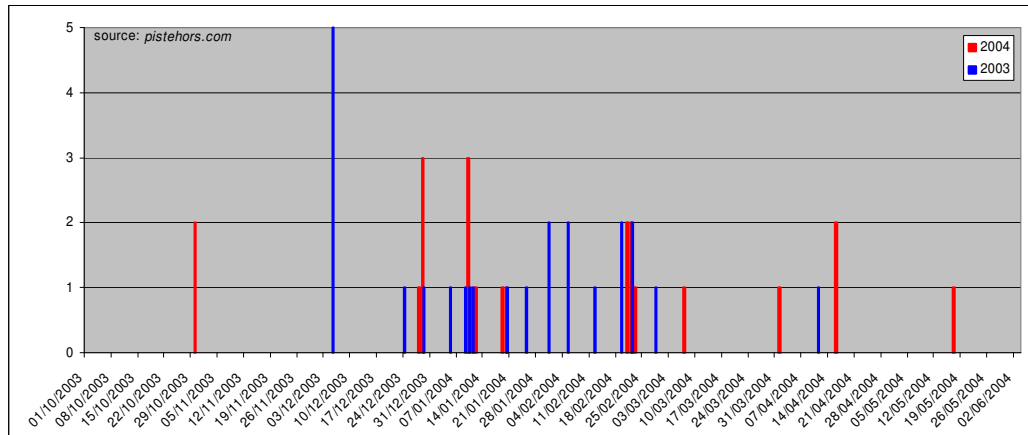


Figure 14: Comparison of avalanche fatalities for 2004 against 2003

Figure 14 compares the dates of avalanche fatalities for the 2003 and 2004 seasons. The 2003 season was characterised by heavy snow over Christmas and during January followed by an extended period of stable conditions (high pressure) during February and March with little fresh snowfall. Most of the avalanches were concentrated during the winter. After the 13th March there was only a single avalanche fatality.

Figure 15 shows outings for the Northern Alps taken from the SkiRando website for the seasons 2003 and 2004 plotted as a seven day moving average. There were 2580 outings entered in between the 1st October 2002 and the 31st May 2003 and 3020 outings entered during the same period in 2004. It seems reasonable to assume that this increase is not due to a sudden rise in popularity of backcountry skiing. One factor is the longer season in 2004 and another is the increase in popularity of the Internet especially with always-on 'broadband' connections which grew 72% in Europe over the period. In order to compare the two seasons each day was plotted as a percentage of the total outings for the season.

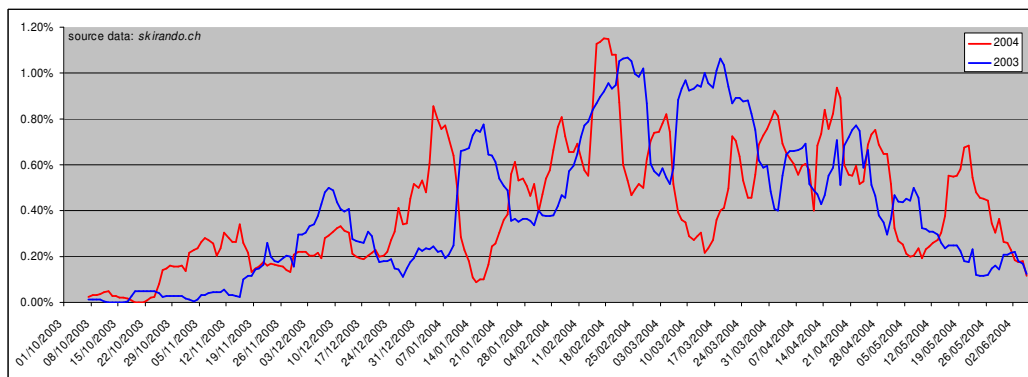


Figure 15: Backcountry outings for Northern Alps plotted as 7 day moving average

The graph clearly shows that the 2004 season started about three weeks earlier than 2003. The long period of good weather in February and March 2003 meant that there were more outings over this

period but the figures for 2003 tail off rapidly with the start of the summer heat-wave at the end of the spring. After a period of poor weather in late April and early May 2004, the snowfall it brought gave a boost to the figures for the end of the season. As an additional random data-point the gap used for the Galibier road gap competition held in mid-May was 8 meters high in 2003 and 13 meters in 2004.

Weekends

One common complaint for 2004 was that the weather was poor for a lot of weekends but was this born out by fact? Around half of all outings take place at the weekend. We also know that weekend groups are larger, 3.35 people on average as opposed to 2.07. Between the 15th of December and the 30th of April there were 2099 outings in 2003 and 2298 outings in 2004 for the Northern Alps region. Figure 16 shows weekend outings plotted as a percentage of total outings for the period.

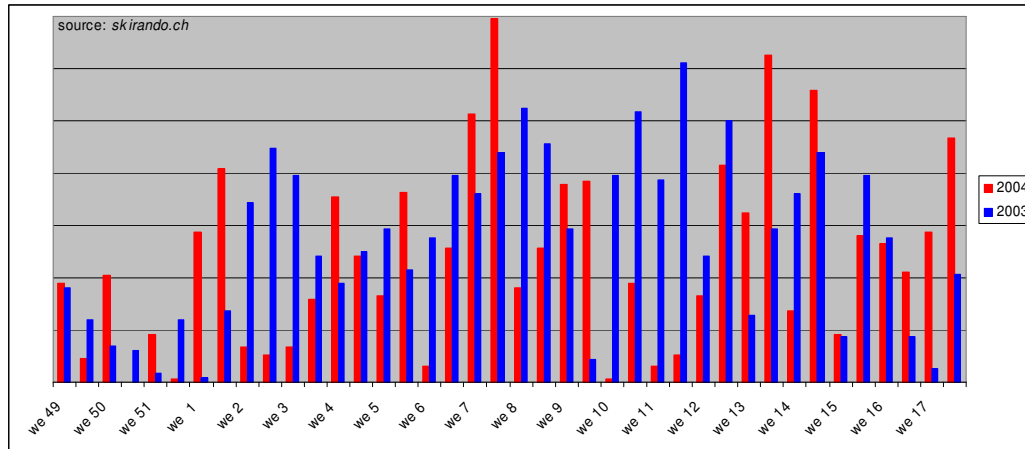


Figure 16: Weekend outings over the winter season

Calculating the standard deviation of outings gives 18.79 for the year 2003 and 23.52 for 2004. If outings are an indication of weather conditions then the weekend weather in 2004 was more volatile compared to 2003. During the period covered by Figure 16 there were 1258 outings over the weekends in 2003 and 1259 outings over the weekends in 2004. Expressed as a percentage, 59.9% of outings occurred at weekends in 2003 as opposed to 54.7% of outings in 2004. This may imply that the weekend weather conditions were less favourable in 2004.

Falls

The second major cause of death for off-piste and backcountry enthusiasts are falls. In the table below crevasses were responsible for 2 of the ski touring falls and one of the off-piste falls. 6 of the 17 victims were non-French, a higher percentage compared to avalanche fatalities. There was also a higher percentage of off piste accidents. The most recent study by the SNOSM covering the 2002/2003 winter season recorded 7 deaths off piste from falls and collisions.

Table 2: Comparison of accidents by activity

Activity	Fatalities
Ski Touring	5
Off Piste Skiing	8
Off Piste Snowboarding	4
Cross Country Skiing	1

These accidents can be broken down into falls from cliffs, falls into crevasses and slides on steep terrain. Falls from cliffs were more likely to involve off piste skiers and snowboarders.

On Christmas Eve a man fell 80 meters over cliffs in the Pyrenean resort of Gavarnie while skiing off piste. In mid-January a Belgium man skiing alone fell thirty feet over cliffs in the resort of les Deux Alpes. He'd been returning alone to the resort in poor weather. In February a 17 year old British man

fell 70 meters over cliffs in Méribel after following tracks off-piste with friends. Later in the month two Dutch snowboarders perished after falling 80 meters over cliffs in the Grandes Rousses sector of l'Alpe d'Huez. The routes through the Grandes Rousses are difficult to navigate and it was their first day in the resort. A month later a Danish skier died in the same resort after falling over cliffs in the Sarenne sector. He'd been skiing alone.

The notorious off-piste fissures at Flaine continue to claim victims. These deep, narrow cracks in the rock are formed by chemical erosion. Early in the season they are concealed by fragile snow bridges and the off-piste domain presents the same dangers as crevasses on a glacier. On the 29th of December a French snowboarder was killed after falling 50 meters and a British girl, also on a snowboard, had a lucky escape after spending 2 hours trapped at the bottom of one of the cracks.

After last summer's heat wave, glaciers had limited snow cover as the 2004 season began, and many crevasses were poorly bridged. In November a German skier died, after leaving pistes on the Grande Motte glacier in Tignes, and at the end of March, there were three fatal falls into crevasses on Mont Blanc. In two cases, the skiers had become separated from their group. In the third, the skier was alone.

In March there was a rare cross-country ski fatality when a man left the marked trails and slid, colliding with trees. In April, an off piste skier was killed after sliding 200 meters in a steep couloir in la Grave, and a ski tourist fell from cliffs below the Crêtes d'Argentière, near Valloire. In both cases the icy conditions may have been a contributory factor. At the start of June, a ski tourist fell from the ridge leading to the Aiguille du Grand Fond above Bourg St Maurice. He'd been skiing alone.

Finally Edouard Baud, son of extreme ski pioneer Anselm, was killed in the steep Gervasutti Couloir below the Mont-Blanc du Tacul. He was hit by a sérac (ice) fall. Sérac falls are not predictable.

Conclusions and Further Steps

As has been shown, the 2003-2004 season was longer than the previous year, but with fewer avalanche fatalities: 24 as opposed to 26. In the 13 years to 2002, the ANENA calculated the average number of avalanche deaths per year at 30.8. One possible factor behind the relatively good figures last winter is poor weekend weather during the main winter season which reduced the number of outings. The risks of off-piste and backcountry skiing should not be exaggerated, especially when the increase in popularity of the activity is taken into account. The growth in snowboarding and snowshoeing may have an adverse impact on the figures in the future. To put some kind of perspective on the fatality figures, during the summer season 90 people drown off the coasts of France and there are around 100 deaths in the mountains, over half of them walkers. When proposing methods to reduce deaths and injuries, an inevitable cost/benefit analysis must be made.

Lack of suitable personal rescue equipment was noted in seven of the avalanche fatalities. It is impossible to determine if this would have made any difference in the outcomes, but it would certainly have aided the rescue services. Rescue workers are exposed to risk while searching and rescuers in dog or probe line searches reduce the resources available to respond to other incidents. Swiss research on accidents between 1980 and 1999 found that victims were buried on average 150 minutes before being found by rescue services, a delay that in most cases proved fatal. A victim is 4 times more likely to survive if found by his companions.

The principal search tool is the avalanche transceiver. The average burial time over the period studied is 20 minutes with a 50% survival rate; but this has improved to 15 minutes over the last 5 years with a 75% survival rate. This improvement is probably a result of better training and the significant improvement in transceiver technology (note: digital transceivers were not in widespread use in 1999). In the Swiss study, 75% of survivors were buried less than 80cm from the surface. Deeply buried victims are harder to locate, take longer to dig out, and are more likely to be injured or suffocated. Skiers crossing avalanche prone slopes should consider the consequences of a slide by asking questions like: Are there cliffs? Are there terrain traps or a rapid change in slope angle that will increase deposition? In the case of the Tignes accident, snowboarders swept into a frozen lake had minimal survival chances.

The chance of a successful rescue by the emergency services is affected by a number of factors:

1. Travel time. In general it takes longer to arrive at the scene of a backcountry incident and it is harder to mobilize a large rescue effort.

2. Weather. If there is low cloud helicopters may not be able to land.
3. The hour. In the case of the Tignes avalanche mentioned above, rescue workers had to lay cables and flood lighting to search as the avalanche occurred after nightfall.
4. Mobile phone coverage In many backcountry areas phone coverage is poor to non-existent.

Off-piste and backcountry skiers should take all these factors into account.

It can be seen that transceivers are not a guarantee of survival and should not be an excuse to take on more risk. A skier should always ask himself if he would be willing to cross the slope in question without a transceiver. The Swiss study found that 97% of partly buried victims survive. Releasable ski and snowboard bindings and swimming in an avalanche (not easy when it consists of a hard blocks of snow) can keep a skier on the surface. The ABS system, a device consisting of two gas filled balloons, can aid buoyancy, but is less helpful against injury from collisions or falls. In 40 avalanches where victims wore an ABS, only one victim was completely covered by snow and died due to being buried in a terrain trap. In 6 cases the skier failed to activate the device, and in 2 cases there was a possible technical failure. Increased use of the ABS would save lives and the devices can now be rented in specialist shops in Chamonix, Tignes and Val d'Isère. As with transceivers, ABS devices should not be used to take on more risk. It should be remembered that even with an ABS, a skier may need assistance to free himself from the slide. There are arguments of cost (currently about 500 €), weight (1.8kg), and volume which are significant factors for backcountry skiers. Last season Tignes, Val d'Isère and Valfrejus equipped their piste patrols with ABS and a further 300 sets were sold to the public in France. The AvaLung™, a device that helps a skier breathe under snow, may also give rescuers a longer window of opportunity.



Figure 17: ABS, Transceiver, Shovel and Probe

In nine of the accidents, victims were either experienced or skiing with an instructor. Four other victims were local. A similar figure was noted for the previous season. Local and experienced skiers as well as guides and instructors spend many more days skiing than casual recreational skiers and often tackle more challenging terrain. In some cases it seems that technical ability exceeds avalanche knowledge. Interestingly research by McCammon has shown that groups with some avalanche training use this training to take on more risk.

Research has shown that 90% of fatal avalanches are human triggered and therefore potentially avoidable. In at least two cases avalanches were triggered by people riding above the victims. On popular itineraries, off-piste users must be aware of people below them. Where there is a risk of avalanche, the rule of skiing/snowboarding one at a time should apply. Skiers should also remember that the second they leave pistes they are at risk, as the 9 off-piste accidents, particularly the accident close to the pistes at Valloire demonstrate. French off piste domains are generally too large to secure. Avalanche control is carried out in accordance with a document called the PIDA (Plan d'Intervention et de Déclenchement des Avalanches) to secure ski pistes. A survey of ski resorts by Montagnes Magazine at the start of last season found around a third of them do avalanche control on popular off piste runs, a measure they don't publicise. Over 40% of resorts will also close lifts which give access to

itineraries considered at risk from avalanches. Skiers must remember that even early in the season when there is little snow cover, there is a high risk of slab avalanches; and that this risk can persist at altitude late into the season. At lower altitudes, the risk is more often from wet snow avalanches on slopes exposed to the sun for any period of time. The exposure of a slope to terrain traps such as lakes, hollows, narrow valleys and cliffs can make even small avalanches deadly.

The French Weather service, Météo France, publishes an avalanche bulletin (BRA) every day at 16h00 during the winter season. This gives a headline avalanche risk on a five point international scale for each department in the Alps, Pyrénées, and Corsica. A weekly summary bulletin (BSH) is published in the late autumn and spring. The bulletin goes into detail about localised risks. Most of the avalanche accidents during last season occurred at risk 3 (considerable) or 4 (high). At these risk levels, it is considered probable that a single skier, snowboarder or snowshoer can trigger an avalanche. There is no evidence that any of the victims consulted the avalanche bulletin; but from conversations with other skiers, they state that the overall risk rating is used when making decisions to go off piste. Most consider 1-3 to be a go, 4-5 stay in bed. It is notable that the majority of avalanches happen at level 3 and 2. Figure 7 shows that many fatalities occur immediately after snowfall, the phenomenon of the 'first sunny day' and 'powder fever'.

Météo France is not infallible. On Friday the 20th of February the avalanche bulletin covering the Belledonne Mountains gave the risk as 1 (low) for the following day. A deepening weather system brought large quantities of snow, accompanied by wind, and led Météo France to revise its risk to 3 (considerable). Two skiers were caught by an avalanche in the region. Rather than criticise Météo France for 'getting it wrong', there is no evidence that the two victims even consulted the bulletin, this incident serves as a reminder that a bulletin is advisory. Backcountry travellers must complement it with their own observations on the ground. Avalanche scoring systems such as the NivoTest™ and the Munter 3x3 Method could prove their worth in many cases. An avalanche scoring system is a statistically-based procedure for determining the avalanche risk based on an analysis of the terrain, nivological (snow) and weather conditions, group size and dynamics.

This incident does highlight the need to improve the distribution of alerts. Jacques Villecrose, the late director of the Centre d'Etude de la Neige assisted SkiRando (a Swiss private limited company) in setting up a distribution of French avalanche bulletins by email but there is no mention of this service on the Météo France website. This channel could be improved. It would also be useful to be able to consult past bulletins, at least for the last week from the website. All of this could be subsidized with limited and targeted advertising. In the case of a number of recent natural disasters, Météo France did announce extreme weather alerts through the mainstream media and this mechanism might also be better used for avalanche warnings, particularly on local radio stations.

The survey by Montagnes Magazine found that 80% of ski resorts publish the avalanche bulletin. Most also display coloured warning flags around the station but the Médecins de Montage survey showed that these were not always clearly understood. A study by Parks of Canada using focus groups found that 79% participants understood a symbol portraying a buried skier.



Figure 18: Steep and Deep

There is a dearth of information for non-French speaking skiers (who make up over 30% of the visitors to the French mountains). Météo France publishes the avalanche bulletin in French. Only 10 resorts offer an English translation and 3 offer translations in other languages. The avalanche bulletin uses many standard phrases; it should be possible to codify it to simplify either human or automated translation using a software package trained for the task. In addition research shows that subtle differences in wording that can occur with free text warnings can affect the information conveyed to

people⁴. In fact a prototype of such a system, INFOLOG, was developed in the mid-90s by Swiss researchers. INFOLOG consists of a specialised editor with a number of standard terms and phrases and can publish avalanche bulletins simultaneously in five languages.

Despite the *extreme sports* image it can be seen that few snowboarders are involved in fatal accidents off-piste. Just 6 out of 41 fatalities for avalanches and falls were snowboarders, 14.6% of all accidents. However, this is in line with the number of participants. 75% of fatal avalanches occur in the Northern Alps; that is, the two Savoies and Isère, including the Ecrins Mountains. The Northern Alps resorts account for 75% of visitors for ski resorts. On SkiRando, 86% of the outings last season were from this region. It should be remembered that the Northern Alps lie in the Rhone-Alpes region, an affluent and technologically savvy area and is probably over-represented in the SkiRando database. Prices in the Northern Alps ski resorts are generally higher than elsewhere, so the turnover figures probably over estimate the number of skiers in the region. Still, there is an indisputable link between skier/days and accidents.

It would be interesting to calculate the avalanche fatality rate for skier/days (outings). French ski resorts record about 50 million skier/days per year. Comparing extensive figures for on and off piste interventions by the rescue services, about 2.5% skier/days are spent off-piste. With 11 off-piste deaths last season (the 13 year average is 8.5), this gives an approximate fatality rate of 1 per 96,000 skier/days for off-piste skiing. If the rate is similar for backcountry accidents, this would imply that at present only about 2% of outings are recorded in the SkiRando database. The figures in this paragraph are presented more as an academic exercise and should be treated with caution.

Off piste solo skiing is often regarded as a near suicidal activity. The SkiRando database shows that 14% of outings are by lone skiers on weekends, rising to 33% on weekdays. This is probably because fewer partners were available. The overall figure is 25%; but only 1 of the 6 ski touring avalanche fatalities involved a lone backcountry skier. It would seem that lone skiers take less risk than groups, though this conclusion is in conflict with other published studies such as McCammon. Given the number of lone outings on popular routes such as the Chamchaude, above Grenoble, it is possible lone skiers favour well-tracked routes that will be stabilized by skiing. The accident rates for lone skiers rises for off-piste incidents and falls. It is highly recommended that crevassed and avalanche prone terrain are environments where skiers should never venture alone. Obviously the consequences of an accident for a lone skier are severe.



Figure 19: Another incident for the rescue services

French ski areas generally have large off-piste domains which are difficult to secure. In particular, it is difficult to signpost every hazard. Case law currently obliges resorts to signpost dangers on off-piste routes that are accessible by lift; and, because of the configuration of the ski domain, regularly used by skiers. Hazards are rarely obvious from above. Skiers need to familiarize themselves with hazards they will encounter by reading route descriptions in guide books and by examining the terrain from the safety of ski lifts or pistes before venturing off-piste.

⁴ Warnings and risk communication. Wogalter, MS. DeJoy, D. Laughery, K

Some falls may be mitigated by changes to clothing, such as using fabrics which offer more grip on snow. Freeride skiers have generally adopted helmets and dorsal protection but this is generally done to take on more risk.

Group management was a factor in at least two of the crevasse falls where a group member was not missed until long after the accident.

The image presented by ski resorts is somewhat conflicting. Tourist office brochures are full of pictures of skiers and boarders having fun in deep, off-piste powder; often doing risky things such as jumping cornices. Ski lifts, unless they are the latest, powerful model, and pistes rarely feature. At the same time there is a hardening of attitudes by piste security. This year saw the attempted prosecution of two skiers who triggered an avalanche in the off-piste domain of Saint-Jean-Montclar injuring a pisteur. The resort of Superbagnères considered prosecuting four snowboarders who triggered an avalanche which hit skiers on a piste. Some resorts (Montgenèvre and La Mongie) have experimented with local by-laws banning people from going off-piste when the avalanche risk is 3 (considerable) or above. Such bans are legal only when they are temporary in nature and respond to a clear danger. They are difficult to police and fail to recognize that some routes are practical, even when the overall risk is considerable. On a more constructive note, the Swiss resort of Zinal has experimented with automatic 'avalanche gates' which only let skiers pass when they are equipped with an avalanche transceiver. This may be a model that will be followed in France.

The rate of fatalities during the winter holiday period is nearly three times higher than during the rest of the season. This is alarming as ski resorts have only 50% more guests, and SkiRando shows that there are only 40% more outings during this period. Given that this is the main school and university holiday period, it is possible that this population of skiers is less 'mountain aware'.

Although a number of bodies are involved in winter sports accident prevention, the French Avalanche Research Association (ANENA) has the primary role in educating winter sports enthusiasts to the risks posed by avalanches. Established after the major avalanches of 1970 that resulted in over 100 deaths in France, the ANENA works with the SNOSM, Météo France, Cemagref, Mountain Rescue Services, and Piste Security, as well as with researchers in French universities. Last season the ANENA distributed 22,000 leaflets giving basic avalanche information to ski mountaineers and snowshoers. This information was also reproduced in the catalogues of some winter sports shops. A further 50,000 leaflets, aimed at freeriders were distributed by Glénat in their ski, snowboard, and mountaineering magazines. A set of information panels were produced in English and displayed in UCPA and Club Med centres. An educational weekend for freeriders was organized at la Grave.



Figure 20: Examining the snowpack

There are also a number of other initiatives. Avalanche talks and transceiver training are organized by Henry Schniewind⁵ in Val d'Isère (last season the author gave a talk on route finding). Les Deux Alpes offers weekly 'Free Respect' sessions appealing to younger winter sports enthusiasts. La Grave has built a permanent transceiver training centre in conjunction with Mammut / Barryvox. The piste patrol

⁵ <http://www.henryavalanchetalk.com>

at Tignes also organizes regular transceiver training. There is a permanent avalanche training centre⁶ in the resort of Valfrejus.

Given that budgets are restricted, currently ski resorts spend only around 4% of their budgets on safety, further education initiatives should prioritize some of the issues raised in this study. An off-piste safety campaign should focus on the main winter holiday periods. This could include information where skiers congregate such as lift pass offices. Information should be available at the very least in English. Lift companies provide limited safety information on piste maps. This is not always translated into English, and where it is, there are sometimes confusing errors. Piste patrols could also be more proactive in providing information. Representatives of Tour Operators could be given short off-piste awareness sessions focusing on the risks, particularly from falls; and give information about guides and rental safety gear in the resorts. These initiatives would have to be tackled in a sensible way, as ski resorts are understandably reluctant to over-dramatize dangers.

There is also a need to improve awareness of existing backcountry travellers. The growing activity of snowshoeing should be addressed with warnings about the dangers of thin snowpacks (snow shoers find it easier than skiers or snowboarders when snow cover is limited), group spacing in dangerous terrain and the risk of walking along cornices. This could be accomplished through magazine articles and internet resources such as bulletin boards and eZines (online magazines). Some of the excellent initiatives mentioned above could also target this community.

To cater for the increased interest in free-riding, ski resorts could provide more secured off-piste itineraries. In the more litigious culture, there are obviously some reservations about doing this. Recently Tignes and Méribel have created freeride areas by not grooming existing pistes. Whether these limited areas can respond to demand remains to be seen.

Endnote

In addition to analysing the avalanche reports found on PisteHors.com this study has shown that mining databases such as SkiRando can provide additional insights into the motivations of backcountry skiers beyond the intentions of the database designer.

During the course of this study, we became aware of some improvements that could be made to the SkiRando database to simplify this kind of analysis, in particular; by providing standard definitions for weather conditions rather than free text. It might also be valuable to add a field for the number of participants in an outing and adding another field for avalanche risk.

We obtained our data through the public web interface of SkiRando using the Client URL Request Library and a program written in the Bash scripting language.

Disclaimer

The source data for this report comes from eye-witness and media sources. Only a small proportion of non-fatal accidents get reported to us. The figures for avalanche fatalities correspond with those collected by the ANENA directly from the rescue services and are believed to be accurate. Given the relatively small amounts of data available for a given season readers should be aware about drawing rigid conclusions from any particular incident. However the figures are in line with incidents reported over previous years by IKAR⁷ countries.

None of the comments in this report should be taken as a criticism of the conduct of the parties involved.

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⁶ <http://valfrejus.avalanche.free.fr/>

⁷ International Commission for Alpine Rescue

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Glossary

ANENA	Association Nationale pour l'Etude de la Neige et des Avalanches < url http://www.anena.org >
Average	The sum of data values divided by the number of data values (arithmetic mean)
Backcountry	Terrain outside of the ski domain reached by climbing, either on touring skis, snowshoes or foot
Cemagref	Public agricultural and environmental research institute. Evaluates avalanche risks to buildings
Mode	The mode is the most common (frequent) value.
Moving Average	An average of data over a certain prior time period divided by the number of samples.
Nivological Year	1 st October to the 30 th September of the following year
Off-piste	Parts of the ski domain outside of opened pistes that can be reached by gravity from the ski lifts
Skier/Days	A skier day counts each day lift pass sold. On average a skier covers 4,500 vertical meters in a day. We also use it to cover an off-piste outing.
SNOSM	Système National d'Observation de la Sécurité en Montagne, part of the Ecole National du Ski (ENSA)
Standard Deviation	Standard deviation is the square root of the variance of a data set. It is a measure of volatility of the data.
Transceiver	Radio transmitter that enables skiers to be located under snow
Winter Season	15 th December to 30 th April

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Date	Injuries	Deaths	Range	Department	Location	Experience	Activity	Cause	Remarks	Rescue	Nationality	Time	altitude	Aspect	Risk
30-Oct-03	0	1	Alps	Hautes-Alpes	Col de la Rouanette		Snow Shoeing	Avalanche		Transceiver	French	13h00	2400		n/c
30-Oct-03	1	0	Alps	Isère	Côte Belle	Experienced	Ski Touring	Avalanche		Transceiver	French		2450	N	n/c
30-Oct-03	0	1	Alps	Haute-Savoie	Avoriaz/Arare-les-Crozats	Mountain Police	Ski Touring	Avalanche	Skiing Alone	Probe/Mobile Phone	French		2000		n/c
01-Nov-03	1	0	Alps	Savoie	Tignes/Gd Motte		Off Piste Snowboarding	Avalanche		Pisteurs	British				n/c
20-Nov-03	0	1	Alps	Savoie	Tignes/Gd Motte		Off Piste Skiing	Fall	crevasse/head injuries	Pisteurs	German		3300		
24-Dec-03	0	1	Pyrénées	Hautes-Pyrénées	Gavarnie		Off Piste Skiing	Fall	80 meters		n/c				
28-Dec-03	0	1	Pyrénées	Hautes-Pyrénées	Gèdre		Climbing	Avalanche			Spanish				
29-Dec-03	0	1	Alps	Savoie	Tignes/Tufs Couloirs	With Instructor	Off Piste Skiing	Avalanche	Impact with rocks	Transceiver	British	12h30	2500	NW	3
29-Dec-03	1	1	Alps	Savoie	Val d'Isère/Gd Vallon		Off Piste Skiing	Avalanche	Triggered by boarder	Probe/Dogs	French	16h00			3
29-Dec-03	0	1	Alps	Haute-Savoie	La Clusaz/Balme		Off Piste Skiing	Avalanche	Triggered by skiers	Dogs	French	15h30	2400	NW	2 to 3
29-Dec-03	1	1	Alps	Haute-Savoie	Flaine/Gde Platière		Off Piste Snowboarding	Fall	fissure		GB/FR	18h45			
10-Jan-04	1	2	Alps	Savoie	Tignes/Tufs		Off Piste Snowboarding	Avalanche	Carried into lake	Dogs/Probe	French	16h45	2100	NW	4
10-Jan-04	0	1	Alps	Savoie	Val d'Isère/S. Santons	Experienced	Off Piste Snowboarding	Avalanche			French		2450		4
10-Jan-04	1	0	Alps	Savoie	Val d'Isère/Fornet		Off Piste Skiing	Avalanche	broken femur						4
12-Jan-04	0	1	Alps	Haute Savoie	Chamonix/ Aiguilles Rouges		Off Piste Skiing	Avalanche	alone	body found 3/May	American	late			4
19-Jan-04	0	1	Alps	Savoie	Ste Foy/Col de l'Aiguille	Piste Patrol	Off Piste Skiing	Avalanche	Securing Piste	Transceiver	French	16h00	2500		4
19-Jan-04	0	1	Alps	Isère	Les Deux Alpes		Off Piste Skiing	Fall	30 meter fall in bad viz.		Belgium	late			
20-Jan-04	0	1	Alps	Alpes-Maritimes	Auron/Mont Ténibre	Instructor	Ski Touring	Avalanche	No probe/shovel	Transceiver	French	12h00			2
25-Jan-04	0	1	Alps	Savoie	Tignes	With Instructor	Off Piste Skiing	Avalanche		Transceiver	Belgium				3
25-Jan-04	0	1	Alps	Isère	Les Sept Laux		Off Piste Skiing	Fall	100 meter fall		French				
17-Feb-04	0	1	Alps	Savoie	Méribel	Young	Off Piste Snowboarding	Fall			British	14h30			
21-Feb-04	0	1	Alps	Savoie	La Rosière	Local	Ski Touring	Avalanche		PGHM	French	12h00	1950		3
21-Feb-04	0	2	Alps	Isère	Allevard/Refuge Oule	Local	Ski Touring	Avalanche	No Transceiver	PHGM/Friends	French	12h00	1800		2
22-Feb-04	0	2	Alps	Savoie	Val-Premont/Pralognan	Local	Snowshoeing	Avalanche	Experienced CAFiste	PGHM	French		2100		3
23-Feb-04	0	1	Alps	Savoie	Valloire/Sétaz		Off Piste Skiing	Avalanche	parallel to piste	Piste Patrol					3
29-Feb-04	0	2	Alps	Isère	Grand Rousses/Alpe d'Huez		Off Piste Snowboarding	Fall	slipped on steep slope		Dutch		2150	S	
07-Mar-04	0	1	Pyrénées	Hautes-Pyrénées	Aure/Pic de Cuneille	Local/Young	Ski Touring	Avalanche		PGHM/Friends	French	12h00	2400		3
12-Mar-04	0	1	Alps	Isère	Vercors/Correçon		Cross Country	Fall	off piste						
15-Mar-04	0	1	Alps	Haute-Savoie	Mont Blanc/Mont Vallet		Off Piste Skiing	Crevasse	alone/seen by witness						
23-Mar-04	1	0	Alps	Hautes-Alpes	La Grave/Girosse		Ski Touring	Crevasse	Alone/30 hrs in Crevasse	PGHM	Czech				
27-Mar-04	0	1	Alps	Haute-Savoie	Mont Blanc/Vallée Blanche		Ski Touring	Crevasse	Separated from friend	PGHM			3000		
30-Mar-04	0	1	Alps	Haute-Savoie	Mont Blanc/Gd Mulets		Ski Touring	Crevasse	Separated from group	PGHM	Polish		3200		
01-Apr-04	0	1	Alps	Hautes-Alpes	La Grave	Experienced	Off Piste Skiing	Avalanche	head injuries	Witnesses	French	16h00	3100	N	3
06-Apr-04	0	1	Alps	Isère	Alpe d'Huez/Sarenne		Off Piste Skiing	Fall		CRS	Danish				
13-Apr-04	0	1	Alps	Hautes-Alpes	Orcières-Merlette	Gendarme	Off Piste Skiing	Fall	Fall skiing alone		French				
16-Apr-04	0	2	Alps	Hautes-Alpes	Monetier-les-Bains		Climbing	Avalanche		PGHM/Dog	Italian			N	3
24-Apr-04	0	1	Alps	Hautes-Alpes	La Grave	Elderly	Off Piste Skiing	Fall	200 meter slide						
27-Apr-04	0	1	Alps	Savoie	Valloire/Crêtes d'Argentière	Elderly	Ski Touring	Fall	Alone	PGHM	French				
17-May-04	0	1	Alps	Savoie	Col du Galibier	Tourists	Walking	Avalanche	Snow Clearance	PGHM	Dutch	18h30			2 (est)
30-May-04	1	1	Alps	Haute-Savoie	Couloir Gervasutti/Mt Blanc	Ski Instructor	Ski Touring	Fall	cornice/sérac collapse	PGHM	French	10h40	4200	N	2 (est)
05-Jun-04	0	1	Alps	Savoie	Aiguille du Grand Fond		Ski Touring	Fall	Alone	Ski Tourist	French				

Table 3: Off Piste and Backcountry Accidents in 2003/2004. Source: <http://www.pistehors.com/articles/avalanche/avalanche-accidents.htm>

