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Strategies used by French Alpine guides to adapt to the effects of climate change
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Keywords: Alpine guides, Mountaineering, Climate change, Adaptation

ABSTRACT

The effects of climate change on high mountain environments are seriously affecting summer Alpine climbing. Summer mountaineering in the Alps has become progressively more dangerous and technically difficult in recent years and good periods for mountaineering tend to be unpredictable in summer and have shifted towards spring, autumn and even winter for some routes. In this context, this research paper—based on a questionnaire survey and semi-structured interviews—examines how French Alpine guides are affected by climate change and how they adapt accordingly. This study enabled us to identify 33 methods of adaptation which we grouped in 5 main strategies. Two categories of Alpine guides were distinguished. One seems to have difficulties in adapting to the effects of climate change while the other seems to face the challenge with greater ease. This difference depends on the activities which each Alpine guide chooses to practice. In summer, those guides who mainly practice traditional mountaineering are less adaptable than those who have diversified, offering activities which can be done outside the high mountain environment. Alpine guides have the possibility to adapt through the diversification of their activities. However, this implies a redefinition of their job that does not always correspond to their preferred vision of the profession.

Management implications

Alpine guides confirm that high mountain environments are becoming more dangerous. Therefore, it is important that Alpine guides unions and politic entities start considering this situation in order to help Alpine guides implement adaptation measures and especially diversification. One of the main issue will be maintaining their economic activity without taking too much risks in the practice of mountaineering. For resort operators and local tourism officials, it is important to consider the activities Alpine guides are using to diversify their offer. It is an opportunity to develop nature-based tourism but it also implies that Alpine guides will start competing with other tourism stakeholders.

1. Introduction

Many studies have discussed the possible consequences of climate change on nature-based tourism and outdoor recreation. Most of these have concentrated on skiing and the behavioral adaptation of skiers (Rutty et al., 2015) who are facing a significant decline in the amount of snow and the duration of the snow cover (Koenig & Abegg, 2010; Rixen et al., 2011; Scott, 2011; Scott & McBoyle, 2007). On the other hand, several studies have showed that climate change can have a positive effect on summer nature-based tourism, thanks to an increase in the number of sunny days in the European Alps (Pröbstl, Haider, Hægeli, & Rupf, 2011; Pröbstl-Haider, Haider, Wirth, & Beardmore, 2015; Serquet & Rebetz, 2011). In Canada, Jones and Scott (2006b) showed that climate change will cause an increase in the number of visits to national parks from 10 to 40% by the end of the 21st century, due to an increase in daily maximum temperatures. Moreover, Wall et al. (1986) predicted that the camping season in eight

of Ontario's Provincial Parks would increase by 40 days by 2050. However, such findings are not relevant for all outdoor recreation activities, especially those which take place in high mountain environments, such as mountaineering.

Areas at high altitudes are being strongly modified by climate change. In the Alps, the total surface area of glaciers decreased by half between 1900 and 2012, and there has been a considerable acceleration of this phenomenon since the 1990s (Gardent, Rabatel, Dedieu, & Deline, 2014; Huss, 2012; Vincent et al., 2017). Concurrently, periglacial environments (*cf.*: French Hug, 2013) in the Alps, which are mainly characterized by frost-action and permafrost (lithosphere materials that remain at or below 0°C for at least two consecutive years) are tending to warm up and degrade (Haeberli & Gruber, 2009) resulting in an increase in the frequency and volume of rockfalls (Harris et al., 2001, 2009; Ravelin & Deline, 2011; Ravelin, Deline, Lambiel, & Vincent, 2013, 2017).

Thus, conditions for summer mountaineering in the Alps tend to deteriorate year by year. This leads to an increase in the danger and technical difficulty of routes (Behm, Raffener, & Schöner, 2006; Pröbstl-Haider et al., 2015; Temme, 2015; Ritter, Fiebig, & Muhar, 2011; Purdie, Gomez, & Espiner, 2015; Mourey & Ravelin, 2017) due to a growing number of detrimental geomorphological processes. As a result, good periods for mountaineering tend to be more unpredictable in summer and have shifted towards spring, autumn and even winter for some routes. As such, high mountain activities do not benefit from the positive effects of climate change on summer nature-based tourism. In this work, risk and danger are differentiated in the sense of Luhmann (1991, p. 256), risk being the way an individual comprehends and manages exposure to dangers, the latter being inherent to an activity and the environment in which it takes place (*eg.* rock falls or avalanches).

Some previous studies have examined the evolution of mountaineering routes in summer (Mourey, Marcuzzi, Ravelin, & Pallandre, 2019; Purdie & Kerr, 2018; Temme, 2015), but almost no studies have investigated how mountaineers are affected by those modifications and how they have adapted, except for example Behm et al. (2006) that questions how mountain professionals (Alpine guides, mountain leaders and ski instructors) are adapting to climate change effects in Austria. Our article focuses on French Alpine guides, well-regarded mountaineering professionals. Its purpose is to examine how they are affected by the evolution of high mountain routes, and what methods they use to adapt. Other social, economic and cultural issues affecting alpine guides in their adaptation, but not climate related, will also be discussed. Alpine guides have been the subject of many studies in various disciplines (Caille, 2002; Ferclay & Radiguet de la Bastiaie, 2015; Martinoia, 2012, 2015; Mennesson & Galissaire, 2004; Wozniak, 2011). Specifically, social sciences studies have examined the socio-cultural and economic evolution of this profession and the reasons behind it (Bourdeau, 1991). However, the evolution of the high mountain environment due to climate change as a possible factor in the evolution of the Alpine guide profession has not yet been studied in detail.

The objective of this work is to study the connections between the way in which Alpine guides organize their professional activity and how they adapt to the effects of climate change. It is based on a questionnaire survey and semi-structured interviews. Our hypothesis is that Alpine guides adapt to climate change differently depending on how they organize their professional activities (seasonality, activities practiced etc.). Moreover, thanks to a better vulnerability and adaptability assessment, this study should help guides and especially their representative bodies (such as the French National Union of Mountain Guides - SNGM) to support and lead guides in their adaptation to climate change.

2. Methodology

This study combines a quantitative method based on a survey questionnaire with a qualitative method based on semi-structured interviews.

2.1. Questionnaire survey

The questionnaire was composed of open and closed questions (q ¼ 49), structured in 5 sections. The objective of the first two sections is to get the key information on how each respondent organizes its work, and more precisely for the summer period. The objectives of the third and fourth sections are to evaluate respondents' perception of the effect of climate change, to identify adaptation strategies they employ, and to examine whether witnessing the impacts of climate change on mountaineering has made them change their personal practices to reduce their own contribution to climate change.

1. Type of guiding work (7 questions). Respondents were questioned on the way they organize their job such as the number of days of work per year, the activities practiced, the main period of work during the year, etc.
2. Summer work (5 questions). Specific questions on their summer activities were asked such as the kind of clientele, the activities practiced, the main mountain ranges and the kind of mountaineering routes frequented etc.
3. Perception of climate change and adaptation to its effects on mountaineering routes (22 questions). This is the main section of the survey, questioning the respondents on the effects of climate change on high mountain environments, the processes involved and their impacts on mountaineering (eg. risk taking, evolution of the routes, periods of good conditions etc.). Then, respondents were questioned on their need to adapt the way they work and to describe, in an open question, what adaptation measures they implement. Using a ten-point scales, they also had to evaluate their difficulty to adapt and the evolution of their economic activity because of climate change. In both cases they were also asked to explain their answers in an open question and to describe their feelings, sparked by climate change effects.
4. Actions to reduce their own contribution to climate change (9 questions). In this section, respondents were questioned on their motivation to reduce their own contribution to climate change and how they do so.
5. Socio-professional profile (6 questions)

In order to i) validate the questionnaire, ii) make sure it would answer the main issues addressed, and iii) be suitable for every Alpine guide, it went through two testing stages. First it was sent to a group of 15 Alpine guides who have very different ways of organizing their day to day work, before being finally validated by a group of experts made up of researchers and members of the SNGM directing committee.

The base-population of this study are guides who are members of the SNGM (N ¼ 1332). They represent the great majority of active French Alpine guides (1332 out of 1515 in 2017). The questionnaire was self-administered, sent by e-mail as a Google form on November 27th, 2017, with two reminders two weeks apart. In order to ensure the best response rate, it was sent in autumn as this is the least busy period for an Alpine guide. It is a period when Alpine guides are assessing their activity and are more disposed to answering questions about it.

Questionnaire answers were analyzed with Sphinx IQ2 (Ganassali, 2014, p. 234), a survey and statistical analysis software tool. A codification process was used to analyze the open questions. Most of the analyses came from flat sorting and cross-tabulated results. The significances of statistical relations between variables were evaluate running chi-square tests. A Factorial

Correspondence Analyses (FCA; Benzecri, 1992; Dore et al., 1996) was also carried out to study in more detail the relationship between the four levels of difficulty to adapt and the 33 adaptation methods implemented. It is important to note that all the answers are the result of a self-evaluation and inevitably variable from one respondent to another.

2.2. Semi-structured interviews

During the same period, 26 semi-structured interviews were carried out with Alpine guides so as to complete the questionnaire survey with qualitative data. The interviews were structured along three main questions: (i) how do you organize your work as an Alpine guide, (ii) what are the impacts of climate change on high mountain environments and mountaineering and, (iii) how are you adapting accordingly? On average, the interviews were 1 h long and allowed us to discuss the results of the questionnaire. The interviewees were not representative of the base-population. They were chosen in order to represent a very diversified sample (seniority, place of residency, type of guiding activity), representing the diversity of the base-population and the very variable behavioral adaptations to the effects of climate change.

All the semi-structured interviews were transcribed. We performed an individual thematic analysis, based on the same framework as the questionnaire as a closed categorization procedure (Ghiglione & Matalon, 1998, p. 104). Then, a comparative data analysis was done with the questionnaire results which allowed us to illustrate and identify the limits of the behavioral adaptations identified thanks to the questionnaire. Also, the results from the interviews are mainly used in the second section of the results, which put into perspective the questionnaire results, presenting the difficulties and limits in the implementation of adaptation strategies.

3. Results

3.1. Sample characteristics

230 Alpine guides responded to the questionnaire survey, out of the 1332 contacted. The sample representativeness of the base population has been assessed, running chi-square goodness of fit tests (Laurencelle, 2005), using data of the base-population provided by the SNGM, and considering the location (department of residency) and the seniority of Alpines guides. Those two variables are considered in this study as crucial to the perception and adaptation to climate change. To run the chi-square test, some departments of residency were grouped according to the principal mountain range when necessary. Therefore, all departments of the Pyrenees (5 departments, 4.10% of the respondents) and the Alpes du Sud (3 departments, 2.3%) were grouped together (Table 1). The departments that do not cover a mountain range were grouped in the "others" category (21 departments, 6.6%). For the two variables, chi-square values calculated for the sample are inferior to the theoretical chi-square value for the base population, which means that the sample distribution appears to be identical to the theoretical sample needed. Then, considering those two variables, the sample is representative of the base population.

Table 1
Seniority and department of residency of the sample (n = 230).

Variable	Subcategory (yr)	Respondents (%)	Base-population (%)
Seniority	<1 and aspirants	8.9	8.7
	1 to 10	25.7	25.2
	11 to 20	19.6	22.6
	21 to 30	25.7	23
	31 to 40	15.9	13.5
	>40	4.2	6.9
Department of residence	Haute Savoie	40.5	42.4
	Savoie	17.6	14.7
	Isère	9	9.4
	Hautes Alpes	20.3	15.2
	Pyrénées	4.1	6.7
	Alpes du Sud	2.3	4.2
	Others	6.6	6.9

In terms of seniority, most respondents are Alpine guides for 1–10 years (25.7%) and 21–30 years (25.7%). The majority of respondents live in the northern French Alps, and especially in Haute Savoie (40.5% of the respondents).

On average, respondents work as certified Alpine guides for 102 days per year, of which 48 days are in summer (May to October). The substantial interquartile ranges, 90 and 30 days respectively, illustrates the high level of heterogeneity in individuals' professional situations. 64% are multi-active (*i.e.* they have a second professional activity). The main mountain activities practiced are mountaineering by 77% of respondents, rock climbing (36%) and glacier hiking (30%). The Mont Blanc massif is the most frequented one (73% of respondents consider it is one of the three massifs they mostly frequent), followed by the Ecrins massif (40%) and the Valais Alps (31%). In general, the overall difficulty of the mountaineering routes which are guided is “*Peu Difficile*” (slightly difficult – 62%) and “*Assez Difficile*” (quite difficult – 56%). On average, respondents work 17 days for a guides' cooperative (Compagnie or Bureau), but the standard deviation is high (17,23) which also illustrates the large variety of possible individual professional situations (min. ¼ 0 day, max. ¼ 80 days).

3.2. Alpine guides facing climate change effects

All respondents observed an evolution in the high mountain environment due to climate change. This is mainly construed as being negative, arousing feelings such as anxiety (63%), sadness (52%) and nostalgia (32%). Only two relatively positive feelings were observed, each with a very low proportion: curiosity (13%) and optimism (4%). However, 86% of respondents still think mountaineering is as enjoyable as in the past.

A large majority of respondents (71%) consider that the effects of climate change have been significant for the sport of mountaineering since the 1990s, which corresponds to the accelerating pattern of warming and the resultant ice melting (IPCC, 2014) since the 1990s. Glacial shrinkage (Gardent et al., 2014) and more frequent rockfalls (Harris et al., 2009) are the two main processes identified (by 77% and 29% of the respondents respectively). As a result, 84% of respondents consider that high mountain environments become more dangerous for mountaineers in summer than in the past. However, it is important to note that 60% of respondents consider that they are not taking more risks due to the effects of climate change. This suggests that Alpine guides are taking into consideration the fact that high mountains are more dangerous than before and adapting the way they work in order to reduce the level of risk.

Indeed, 99% of the respondent answered “yes” to the question “Do you have to adapt the way you work because of the effects of climate change?”. This first finding raises the following questions: What are these methods of adaptation? Are they difficult to implement? Are all Alpine guides adapting in the same way?

3.3. Adaptation methods and strategies

In order to identify the methods of adaptation, an open question was asked: “How are you adapting your everyday work to the effects of climate change”. 33 methods of adaptation were identified and regrouped into 5 main strategies (Fig. 1).

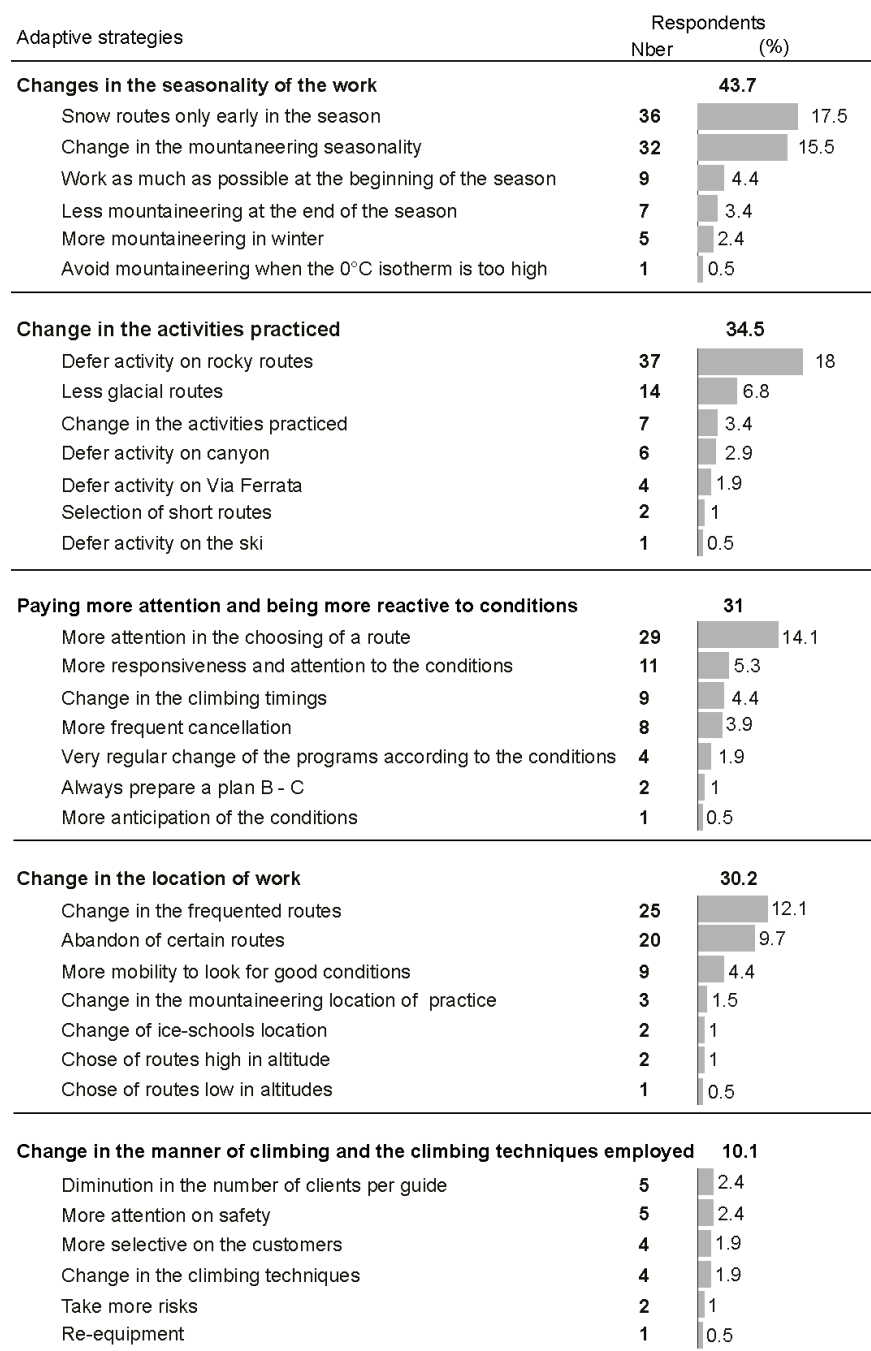


Fig. 1. Adaptation strategies implemented

The most mentioned strategy (43.7% of respondents) has been the change in seasonality of the work. This consists mainly in shifting summer mountaineering activities to spring, early summer and/or autumn, when routes are in good conditions. 17.5% of respondents are now only guiding snow routes early in the summer season when they are still in good condition.

A change in the main guiding activity has been the second-most mentioned strategy (34.5% of respondents). It mostly consists of prioritizing rock routes (18% of respondents), which are considered the least affected by climate change (Bourdeau, 2014; Mourey et al., 2019). It also consists of increasing the amount of winter mountaineering and diversifying summer activities (*e.g.* canyoning and *via ferrata*).

The third-most mentioned strategy (31% of respondents) has been to pay more attention and be more responsive to high mountain conditions. This mostly means spending more time assessing conditions in the high mountains, for example using weather forecasts and professional social networks. 14% of respondents are more careful in choosing routes which are in sufficiently good condition.

The fourth-most mentioned strategy (30.2% of respondents) has been to change the location of work. This mainly consists of avoiding routes that are in bad condition (9.7%). This has been made possible through increased mobility which has enabled guides to go where conditions are good for mountaineering. 54% of respondents consider they have to be more mobile between mountain ranges in order to find good mountaineering conditions. For example, when rock falls occur in the *Goûter Couloir* on the normal route up Mont Blanc (Mourey, Moret, Descamps, & Bozon, 2018), the Saint Gervais and Chamonix Guides' Companies (the two largest French guiding cooperatives with respectively 70 and 200 members) have taken the decision over recent years to stop guiding this route until conditions improve. Instead they try to persuade their clients to climb another 4000 m summit such as Monte Rosa (4634 m a.s.l.) in Switzerland or the Grand Paradiso (4061 m a.s.l.) in Italy (pers. comm. P. Chapelland and Y. Delvaux, Alpine guide and Directors of Saint Gervais and Chamonix Guides' Companies). Finally, the least mentioned strategy (10.1% of respondents) is for guides to change their way of climbing and the techniques employed. This mainly consists of reducing the number of clients per guide (2.4%), especially when a route becomes more technically difficult. The equipping of some passages with ladders, new bolts and belay anchors etc. occasionally eases/restores the difficulty that may have increased because of the effects of climate change. It also improves safety, which in some cases, enables guides to stay with the same number of clients on their rope, with no need to reduce it.

3.4. Difficulty of adaption depending on the strategies implemented

52% of respondents consider that these adaptation strategies were “quite difficult” to implement, while 48% consider them to be “quite easy”. This second observation raises the following question: Which Alpine guides consider the adaptation easy to implement, which ones consider it difficult and why?

Our starting hypothesis was that the difficulty to adapt depends on the way an Alpine guide works *e.g.* seasonality of the work, mono- or multi-activity, the proportion of work coming from a company/bureau (guiding cooperative), the department of residency, seniority, type of activity, main mountain range frequented, etc. However, no significant statistical relationships were found within those variables. In the end, we only found three variables that have a significant relation with the level of difficulty to adapt and help better characterize the alpine guide of each category (adaptation “quite easy” or “quite difficult”). The first two significant relationships are based on risk-taking and the economic activity. 60% of Alpine guides consider they are taking more risks and 56% consider their economic activity is decreasing because of

the effects of climate change. There is a very significant relation between those three questions (Fig. 2): Alpine guides who consider the adaptation as “quite difficult” (48%) also consider they take more risks (X2 ¼ 10.37; p < 0.01) while their economic activity is also affected (X2 ¼ 51.15; p < 0.01). On the other hand, the ones who consider their adaptation as “quite easy” (52%) do not consider they take more risks and do not consider that their economic activity has been affected. Therefore, two categories of Alpine guides can be identified: one seems to accumulate difficulties because of the effects of climate change while the other seems to deal with it with relative ease.

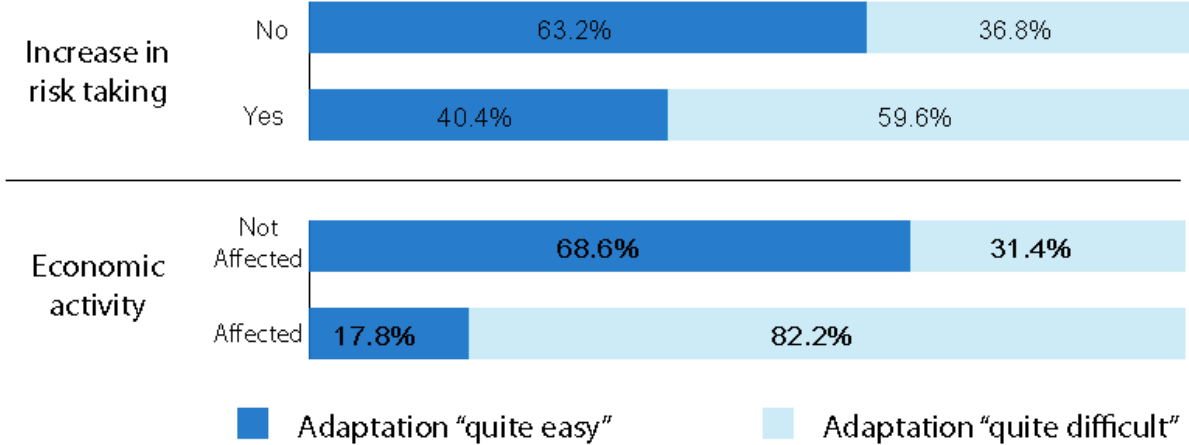


Fig. 2. Variations in the difficulty of adapting to climate change relative to a perceived increase in risk taking and a decrease in economic activity due to the effects of climate change. Each line presents Alpine guides' difficulty of adaptation, according to their answers to the questions “Do you take more risks because of climate change effects?” and “Is your economic activity decreasing because of climate change effects?”.

Then, the third significant relationship that allows to better characterize the guides considering their level of difficulty to adapt, is based on the adaptation methods implemented (X2 ¼ 86.33; p ¼ 0.05; Fig. 3). Respondents who consider that their adaptation to climate change is “very easy” or “easy” are diversifying their guiding work with activities which take place outside the high mountain environment, such as *via ferratas* or canyoning. They do not try to maintain a large part of their income through traditional mountaineering. Respondents who consider that their adaptation is “difficult” or “very difficult” are the ones who continue to work in traditional mountaineering, without trying to diversify. Those who consider their adaptation as “difficult” are nonetheless trying to adapt their mountaineering methods, especially by paying more attention and being more responsive to high mountain conditions and by changing the routes they frequently climb, while respondents considering their adaptation as “very difficult” endure the effects of climate change and do not really adapt their work. They thus take more risks and they change their trip plans very often. They work as much as possible at the beginning of the season – when conditions are still good for mountaineering – and must frequently cancel their mountaineering-orientated programs. Prioritizing rock climbs over snow/ice/mixed routes is one of the most implemented adaptation methods and respondents considering their adaptation as “very difficult” are the ones that are implementing it the least. Our findings show that the type of guided activity and the way individual Alpine guides work stand as determinant factors in their level of difficulty to adapt.

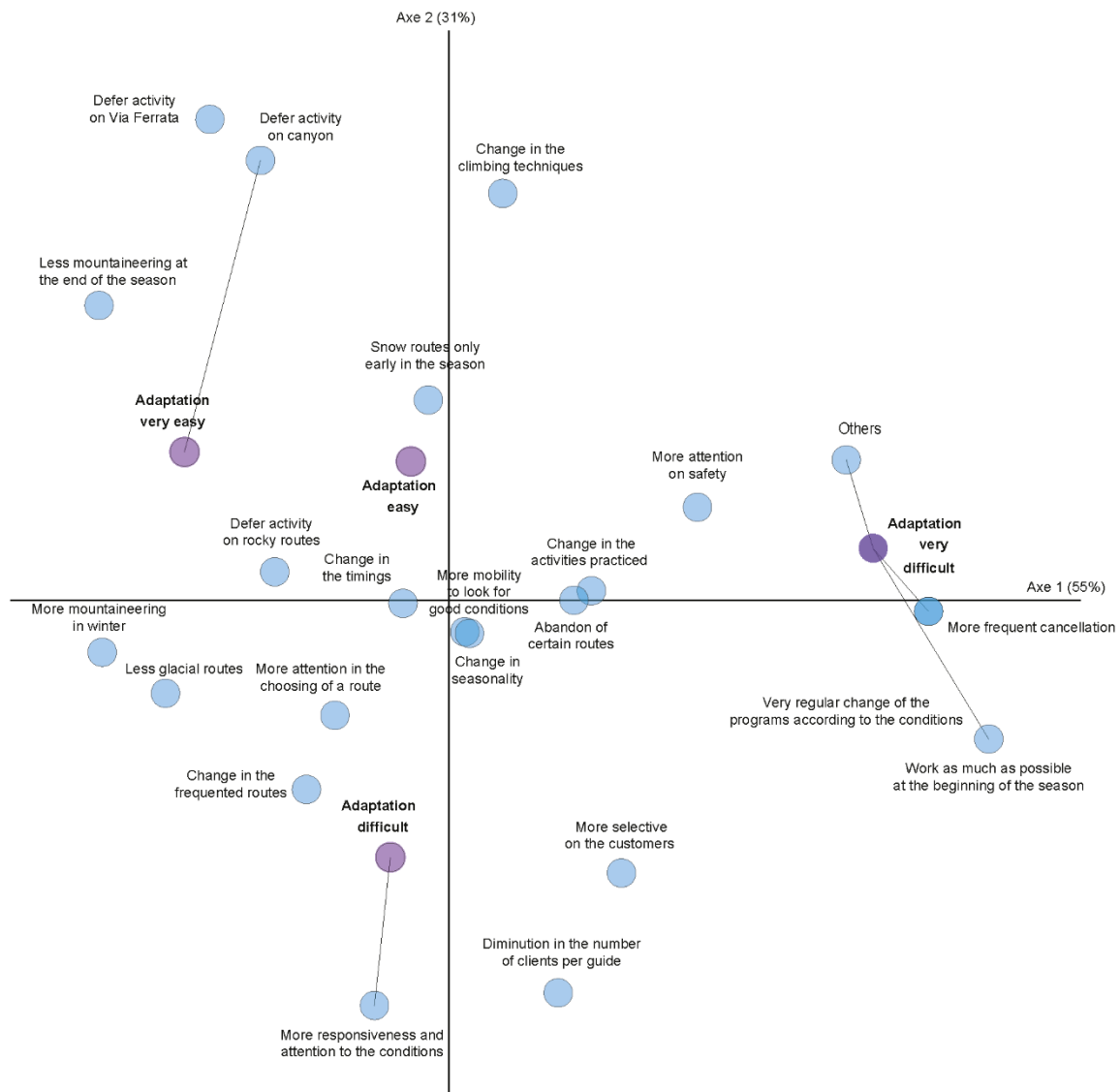


Fig. 3. Graphical representation (FCA-type) of the relationship between the variables: (i) the difficulty to adapt (purple circles) and (ii) the adaptation methods implemented (blue circles). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

3.5. Difficulties and limits in the implementation of adaptation strategies

While implementing the identified adaptation methods and strategies, Alpine guides face a number of difficulties and limitations. The following results are mainly drawn from the semi-structured interviews performed. Those difficulties can be grouped into two categories: i) organizational issues and ii) type of clientele.

The strategies employed highlight that the effects of climate change are forcing Alpine guides to become more flexible and mobile. Changing activities, locations, seasons, etc. requires more flexibility in time and space and it is therefore difficult to establish and sell set programs in advance as guides can no longer rely on long periods of good mountaineering conditions. This causes financial and logistical issues because travel and accommodation arrangements must be more flexible. This inevitably means a bigger workload for guides. They regularly have to

reorganize because of changing conditions as summer progresses and they must try to make the most of any short and unpredictable periods of good conditions. It is important to note that the development of digital technologies has helped them to adapt, particularly the use of social media networks, specialized websites (La Chamoniarde, CampToCamp, Skitour, etc.) and professional mailing lists which inform them about the daily of conditions in the mountains. For example, SNGM guides have set up an email service and several WhatsApp groups, particularly in the Chamonix and Tarentaise valleys (personal com. C. Jacquier, Alpine guide and SNGM president).

On the other hand, from the point of view of the Alpine guides interviewed, the clientele may not have the ability and/or may simply refuse the constraints that these adaptation strategies require. For many people, it is not easy to go mountaineering in spring or very early in the summer season, because these periods are outside the traditional summer holiday period which runs from July to August. Moreover, the clients may refuse to change their preferred activity and/or may not have the physical and technical abilities to do something else. For example, prioritizing rock climbs – which is one of the most implemented adaptation modalities (18% of the respondents to the questionnaire survey) – requires higher technical and physical skills, especially when compared to glacier hiking and easy mountaineering routes. Therefore, this method cannot be implemented with every client. Many Alpine guides who work in mountaineering and make a significant portion of their income in summer were interviewed. It turns out that the type of clients a guide works with, plays an important role in being able to tackle these difficulties. A guide who works mostly with private clients has generally less difficulty in adapting. A relationship of trust has already been developed between guide and client and it is easier for the guide to change the program, to propose different routes and periods when conditions for mountaineering are good, or to propose another activity if the one for which the guide was first contacted cannot be carried out. For example, at the end of December 2016, there was not enough snow to ski in Chamonix and some guides managed to go rock-climbing in the Pre-Alps massifs with the clients who had hired them for skiing. In most cases, this was made possible because they knew each other beforehand. However, an Alpine guide who works mostly with clients who book through a company or bureau, often finds it more difficult to adapt. This type of “daily” clientele is usually present for a short period of time, defined in advance (accommodation and transport booked in advance) and during the summer holidays (July–August), *i.e.* the period when conditions for mountaineering are most uncertain. In addition, this clientele often hires a guide to do glacier hiking or easy Alpine routes which are often in bad condition very early in the season, or the ascent of prestigious summits such as Mont Blanc. But they are not necessarily interested in doing something else if the coveted summit is not in good condition.

In both cases, increasingly unpredictable conditions for summer mountaineering and a higher level of technical difficulty and danger, mean that Alpine guides must negotiate with their clients. They have to work on their communication skills in order to persuade their clients to climb different routes, or change activity and dates, but there is nevertheless a risk of losing clients and working less. As a result, according to the questionnaire survey, 98% of respondents are trying to educate their clients about climate change. 60% consider that their clients are aware that high mountain environments are evolving because of climate change while 82% think that their clients are ready to adapt to these changes.

3.6. Is climate change redefining the job of the Alpine guide?

It is interesting to note that, according to the questionnaire survey, there is a significant relationship between Alpine guides who no longer consider that the high mountain environment

corresponds to their personal mental image (47% of respondents) and their difficulty to adapt ($X^2 \frac{1}{4} 16.6$; $p \frac{1}{4} 0.01$). This illustrates that high mountain environments can be idealized, and the effects of climate change are creating a discrepancy with regards to a traditional and nostalgic view of mountaineering which has become difficult to implement. Indeed, climate change and the adaptation responses that Alpine guides have implemented to maintain their professional activity has contributed to redefine the job. It has become more diversified and is increasingly practised outside the high mountain environment. "I am no longer into adaptation, I am into reorganization. That's it, I have passed the turning point" (F. Meyer, Alpine guide since 2002). In the questionnaire survey, when respondents were asked if they think that, in the future, the effects of climate change will force guides to reorganize and reconsider the way they work as Alpine guides, the majority (60%) consider this would be very much the case (8–10 on a scale of 10).

Finally, according to our questionnaire survey, 69% of respondents consider their potential influence to limit climate change in the Alps as "very low" but 64% are trying to reduce their own contribution to climate change, which also contributes to the ongoing redefinition of their job. It shows that most of them have an awareness of climate change issues, even though they generally choose to prioritize the implementation of adaptation strategies in order to maintain their professional and economic activity. Actions taken to reduce personal carbon output include: i) organizing carpooling with clients and colleagues (for 45% of respondents), ii) reducing travel (25%), iii) using public transport (13%), iv) not going far abroad or at least reducing the number of expeditions away from France (9%) and v) refusing to guide on heli-skiing excursions (5%). As an illustration of how some Alpine guides are motivated to combat climate change, a new type of guide bureau has been created. The "*Immersion Alpine Bureau des Guides*" – mainly composed of young guides – promotes a different way of working as an Alpine guide, in particular by limiting their contribution to climate change and by having a role as sentinels and raising awareness of the effects of climate change on high mountain areas. This bureau will also try to change the way high mountains and mountaineering are marketed by selling a "mountaineering experience rather than a specific summit or route" (Y. Borgnet, aspirant Alpine guide).

4. Discussion

4.1. French Alpine guides as tourism stakeholders who are very aware of climate change

Many studies have examined the impacts of climate change on mountain outdoor recreation and tourism (e.g. Hewer & Gough, 2017). According to Bourdeau (2009), mountain tourism is under stress because of climate and geo-cultural changes.

Our work confirms studies which have focused on high altitude and latitude activities such as those conducted by Behm et al. (2006), Bourdeau (2014), Temme (2015), Purdie et al. (2015) or Pröbstl-Haider, Dabrowska, and Haider (2016), which conclude that climate change has negative effects. It leads to increased danger due to more intense and frequent climate-related processes and a shortening of the summer season. Optimal periods for mountaineering are less predictable and shift towards spring and autumn.

However, unlike other mountain tourism stakeholders (outdoor activities center manager, hut keepers, hotel manager, etc.) (Saarinen & Tervo, 2006), high mountain guides are very aware and mindful of the effects of climate change. For example, when Alpine guides already started to consider and adapt to climate change in the 1990s, small tourism entrepreneurs in New Zealand considered climate change a medium to long term issue (5 to 10 years) (Hall, 2006) and considered other more immediate business concerns as being more important to business

survival. The main characteristics of Alpine guides adaptation strategies (temporal and spatial substitution) were also identified in Ontario, especially with regards to expert skiers (Rutty et al., 2015). The level of commitment to an activity seems to be a key factor in the implementation of adaptive strategies, because participants wish to continue doing their chosen activity as often as before. Moreover, our results confirm some of Behm's results (2006) which demonstrated that 93% of Alpine guides, mountain leaders and ski instructors have had to adapt to the effects of climate change. The main adaptation methods identified by Behm's are very similar to those we identify in this study: the abandonment of certain routes (75% of respondents), the modification of activities (56%) and increased mobility between mountain ranges (percentage unknown). However, Behm concluded in 2006 that—at that time—the consequences of climate change were not considered important by respondents. Conversely, our results show that the effects of climate change are contributing to the redefinition of the Alpine guide profession. Different hypotheses may explain this difference: (i) in our study, we focused only on French Alpine guides whereas (Behm et al. (2006)) studied Alpine guides, mountain leaders and ski instructors in the same time, (ii) the two studies are separated by a period of 12 years, during which the effects of climate change have intensified (Beniston et al., 2018), (iii) it is possible that the evolution of mountaineering routes due to climate change follows different patterns in the Eastern Alps, and (iv) the socio-economic context and the tourism industry are very different in the Eastern and the Western Alps.

4.2. The social, economic and cultural context affecting the adaptability of Alpine guides

Alongside climatic issues, risk-taking and its social acceptance are factors which influences the way in which Alpine guides conduct their work and their ability to adapt to climate change. Giddens (1990, 27) explains that modern society is characterized by a trust in the “expert system [...] that organizes large areas of the material and social environments”. As a consequence, although risk is permanent in these systems, it is seen as being made up of calculated and controllable factors to which an individual becomes desensitized creating an impression of permanent safety. However, mountaineering is an activity which exposes participants to numerous objective and subjective dangers (Opaschowski, 2000, p. 29). These dangers are hard to predict and measure – especially because of the effects of climate change – and, consequently, there is a continual high level of risk taking. This idea of risk taking and the fear of a potentially fatal accident, which has been largely encouraged by the media, is perceived as a negative factor and discourages people from going mountaineering. Therefore, in a societal context pushing to limit risk taking, it is harder for Alpine guides to maintain their activity on mountaineering, and especially as climate change effects make the practice more dangerous. However, we can also ask whether the increased danger of high mountain environments due to climate change might have a positive impact on Alpine guiding by legitimatizing the role and expertise of the guide?

The ability of Alpine guides to adapt is also determined by the duration of the holiday period, the type of activities that tourists want to do and the average household budget. Until the 1990s, it was not uncommon for a guide to be hired several times by the same person during tourists want to do several fun activities (mountain biking, white water sports, bathing, treetop adventure ropeways, etc.) during an average stay of 11 days (INSEE data, 2004). Alpine guides are also partly responsible for the diversification of activities proposed in Alpine resorts through the development of new products and new activities such as canyoning, *via ferrata*, treetop ropeways etc., which are less dangerous than mountaineering. Moreover, household budget for leisure and cultural activities is decreasing. In France, in 2005, it represented 7.4% of the household budget, whereas in 2015 this had reduced to 6.3% (INSEE data, 2017). Therefore,

in a context where the duration and the budget dedicated for the holidays are decreasing and the expectations of customers are changing and turning to the consumption of varied and fun activities, the time available and the motivations for the practice of mountaineering – which generally requires two days and is relatively expensive - tend to decrease and make Alpine guides adaptation more difficult.

Furthermore, while reducing the number of clients per guide can be linked to safety and technical concerns as a climate related adaptation method, it can also be linked to economic interests. This can be especially true for guiding companies and bureaus (cooperatives) that have a lot of demand for prestigious summits such as Mont Blanc. Reducing the number of clients per guide potentially multiplies the number of days of work, which ensures work for a greater number of guides and over a longer period of time. It also enables prices to be increased. Finally, mountaineering is the traditional activity of Alpine guides and remains their most common form of work. However, for social and economic reasons (Martinez, 2015), combined with the effects of climate change, guides are diversifying their offer and proposing activities that are done outside the high mountain environment. However, individual motivations and dispositions acquired during socialization process (Lahire, 2003) which influences the conception of guide's profession are important factors in explaining why some Alpine guides find it more difficult to adapt than others. According to F. Pallandre (Alpine guide since 1990 and instructor at ENSA, the National School of Skiing and Mountaineering): "The adaptability level is variable from one guide to another, depending on their skills and motivations". Thus, guides who have a "technicist" conception of mountaineering (Hoibian, 2001, p. 342) do not accept to diversify their professional activity towards practices, such as canyoning, in which clients look for sensations but do not wish to learn the practice's techniques. This shows that the professional field of mountain professions, such as Alpine guide, are characterised by tensions and competitions for the legitimate definition of the activity and the exercise of the profession (Hoibian, 2015).

5. Conclusions and perspectives

The evolution of high mountain environments due to climate change has had an impact on the way in which Alpine guides work, and so guides have had to adapt and change the way they operate. This study identified 33 adaptation methods, which can be grouped into 5 main strategic categories. Half of the respondents consider these changes as being difficult to implement. However, the difficulty depends on the activities Alpine guides choose to offer to their clients. In summer, those who mainly offer traditional mountaineering excursions are less adaptable than those who are willing to diversify and offer activities outside the high mountain environment. Then, adapting to climate change can be considered as an innovation (Bourdeau, 2014) and some Alpine guides are developing a "climatic intelligence" (Bourdeau, 2014) by developing new products and new ways of working. Thus, Alpine guides have the possibility to adapt through diversification but this implies a redefinition of their work that they are not always comfortable with. Furthermore, their ability to adapt is limited by organizational issues, the type and the characteristics of the clientele and socio-cultural and economic factors, including some which are also driving guides away from traditional mountaineering routes during the summer season.

In the future, other aspects of the impact of climate change on Alpine guiding could be studied, and in particular the number of accidents. This could be considered an indication of the effectiveness of the guides' adaptation strategies. Will accidents become more frequent and severe because of the effects of climate change? Comparative analysis can also be made by studying Alpine guides in other areas in the European Alps or in other mountain ranges in the

world. Do they adapt in the same ways? Do they face the same difficulties? These are some of the questions, in the time when mountaineering may be facing the greatest challenge in its almost 250-year history.

Author contributions section

Jacques Mourey: Conceptualization, Methodology, Formal Analysis, Writing original draft, Clémence Perrin-Malterre: Resources, Formal Analysis, Validation, Writing and reviewing, Ludovic Ravanel: Funding acquisition, Validation, Writing and reviewing, Supervision.

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References

- Behm, M., Raffeiner, G., & Schöner, W. (2006). *Auswirkungen der Klima-und Gletscheränderung auf den Alpinismus* (Vol 99). Vienna, Umweltdachverband.
- Beniston, M., Farinotti, D., Stoffel, M., Andreassen, L. M., Coppola, E., Eckert, N., et al. (2018). The European mountain cryosphere: A review of its current state, trends, and future challenges. *The Cryosphere*, 12, 759–794.
- Benzecri, J. P. (1992). Correspondence analysis handbook. Series: Statistics, textbooks and monographs (Vol 125). New York: Marcel Dekker.
- Bourdeau, P. (1991). Guides de haute montagne. Territoire et identité. Recherche sur la territorialité d'un groupe professionnel. *Journal of Alpine Research*, 288. Special issue.
- Bourdeau, P. (2009). Mountain tourism in a climate of change. Global change and sustainable development in mountain regions, COST strategic workshop. *Alpine Space – Man and Environment*, 7, 160.
- Bourdeau, P. (2014). Effets du changement climatique sur l'alpinisme et nouvelles interactions avec la gestion des espaces protégés en haute montagne. Le cas du parc national des Ecrins. Rapport de recherche. *Association Observation des Dynamiques et du Développement Territorial*, 38.
- Caille, F. (2002). Le guide comme professionnel de l'alpinisme : Perceptions et enjeux du traitement judiciaire de la responsabilité dans le domaine des sports de montagne. In *Deux siècle d'alpinismes européens : Origines et mutations des activités de grimpe* (pp. 369–384). L'Harmattan.
- Dore, J.-C., Ojasoo, T., Okubo, Y., Durand, T., Dudognon, G., & Miquel, J. F. (1996). Correspondence factor analysis of the publication patterns of 48 countries over the period 1981–1992. *Journal of the American Society for Information Science*, 47(3), 588–602.
- Ferclay, R., & Radiguet de la Bastaie, C. (2015). *Accidents des guides de haute montagne français de 2003 à 2013 : Etude rétrospective de 286 cas et de leurs conséquences*. Thèse de Doctorat de Médecine. Université Joseph Fourier.
- French Hugh, M. (2013). *Periglacial environment* (3rd ed., p. 480). John Wiley and Sons.
- Ganassali, S. (2014). *Enquêtes et analyse de données avec Sphinx*. LM Pearson.
- Gardent, M., Rabatel, A., Dedieu, J. P., & Deline, P. (2014). Multitemporal glacier inventory of the French Alps from the late 1960s to the late 2000s. *Global and Planetary Change*, 120, 24–37.
- Ghiglione, R., & Matalon, B. (1998). *Les enquêtes sociologiques. Théories et pratique*. Paris, A. Colin.
- Giddens, A. (1990). *The consequences of modernity*. Cambridge: Polity Press.
- Haeberli, W., & Gruber, S. (2009). Global warming and mountain permafrost. In R. Margesin (Ed.), *Permafrost soils* (Vol 16, pp. 205–218). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Hagenmuller, J. F., Marsigny, F., & Pallandre, F. (2016). *L'alpinisme - des premiers pas aux grandes ascensions*. Grenoble: Glénat.

- Hall, C. M. (2006). New Zealand tourism entrepreneur attitudes and behaviors with respects to climate change adaptation and mitigation. *International Journal of Innovation and Sustainable Development*, 1(3), 214–228.
- Harris, C., Arenson, L. U., Christiansen, H. H., Etzelmüller, B., Frauenfelder, R., Gruber, S., et al. (2009). Permafrost and climate in Europe: Monitoring and modelling thermal, geomorphological and geotechnical responses. *Earth-Science Reviews*, 92, 117–171.
- Harris, C., Davies, M. C., & Etzelmüller, B. (2001). The assessment of potential geotechnical hazards associated with mountain permafrost in a warming global climate. *Permafrost and Periglacial Processes*, 12, 145–156.
- Hewer, M., & Gough, W. (2017). Thirty years of assessing the impacts of climate change on outdoor recreation and tourism in Canada. *Tourism Management Perspectives*, 26, 179–192.
- Hoibian, O. (2001). *Les alpinistes en France 1870-1950. Une histoire culturelle*. Paris: L'Harmattan.
- Hoibian, O. (2015). La montagne redéfinie. L'exercice professionnel aux prises avec les évolutions de la demande. In M. Attali, dir (Ed.), *L'ENSA à la conquête des sommets. La montagne sur les voies de l'excellence* (pp. 345–362). Grenoble, PUG.
- Huss, M. (2012). Extrapolating glacier mass balance to the mountain range scale: The European Alps 1900–2100. *The Cryosphere*, 6, 1117–1156.
- IPCC. (2014). *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Core Writing Team, R.K (p. 151). Geneva, Switzerland: Pachauri and L.A. Meyer (eds.)]. IPCC.
- Koenig, U., & Abegg, B. (2010). Impacts of climate change on winter tourism in the Swiss Alps. *Journal of Sustainable Tourism*, 5, 46–58.
- Lahire, B. (2003). From the habitus to an individual heritage of dispositions. Towards a sociology at the level of the individual. *Poetics*, 31(5–6), 329–355.
- Laurencelle, L. (2005). Testing the representativeness of a sample. *Lettres statistiques*, 12, 131–146.
- Luhman, N. (1991). *Soziologie des Risikos* (p. 256). Berlin, Germany: De Gruyter.
- Martinez, M. (2015). La formation des guides de haute montagne depuis 1948. A la croisé des évolutions sociétales, du savoir-faire de l'ENSA et de la profession de guide. In M. Attali, dir (Ed.), *L'ENSA à la conquête des sommets. La montagne sur les voies de l'excellence*. Grenoble (pp. 149–169). PUG.
- Martinoia, R. (2012). Coproduction de service : La prestation dyadique des guides de haute montagne. *Annales des Mines – Gérer et comprendre*, 2, 66–76.
- Martinoia, R. (2015). Du « serviteur » au « seigneur ». Une relecture historique de la domination dans la relation guide-client, au prisme de l'institutionnalisation du métier. In M. Attali, dir (Ed.), *L'ENSA à la conquête des sommets, la montagne sur les voies de l'excellence* (pp. 125–146). Grenoble, PUG.
- Mennesson, C., & Galissaire, R. (2004). Les femmes guides de haute montagne : Modes de socialisation et identités sexuées. *Recherches Feministes*, 17(1), 111–141.
- Mourey, J., Marcuzzi, M., Ravanel, L., & Pallandre, F. (2019). Effects of climate change on high Alpine environments: Evolution of mountaineering routes in the Mont Blanc massif (western Alps) over half a century. *Arctic Antarctic and Alpine Research*, 1938–4246.
- Mourey, J., Moret, O., Descamps, P., & Bozon, S. (2018). *Accidentology on the normal route up to Mont Blanc from 1990 to 2017* (Vol 20). Fondation Petzl.
- Mourey, J., & Ravanel, L. (2017). Evolution of access routes to high mountain refuges of the Mer de Glace basin (Mont Blanc massif, France) - an example of adapting to climate change effects in the Alpine high mountains. *Journal of Alpine Research*, 105.
- Opaschowski, H. W. (2000). *Xtrem : Der kalkulierte wahnsinn, Extremsport als zeitphonmen*. Hamburg: German press.
- Probstl, U., Haider, W., Hægeli, P., & Rupf, R. (2011). Klimawandel und Bergtourismus-Wahrnehmung und Bewertung von Naturgefahren als Folge von Gletscherschwund und Permafrostdegradation. (Hrsg.), *Wandel als Chance für den alpinen Tourismus. Schweizer Jahrbuch für Tourismus 2011. St. Galler Schriften für Tourismus und Verkehr*, 3, 83–89.
- Probstl-Haider, U., Dabrowska, K., & Haider, W. (2016). Risk perception and preferences of mountain tourists in light of glacial retreat and permafrost degradation in the Austrian Alps. *Journal of Outdoor Recreation and Tourism*, 13, 66–78.

- Probstl-Haider, U., Haider, W., Wirth, V., & Beardmore, B. (2015). Will climate change increase attractiveness of summer destinations in the European Alps? A survey of German tourists. *Journal of Outdoor Recreation and Tourism*, 11, 44–57.
- Purdie, H., Gomez, C., & Espiner, S. (2015). Glacier recession and the changing rockfall hazard: Implications for glacier tourism. *New Zealand Geographer*, 71–3, 189–202.
- Purdie, H., & Kerr, T. (2018). Aoraki Mont Cook : Environmental change on an iconic mountaineering route. *Mountain Research and Development*, 38(4), 364–379.
- Ravanel, L., & Deline, P. (2011). Climate influence on rockfalls in high-Alpine steep rockwalls: The north side of the Aiguilles de Chamonix (Mont Blanc Massif) since the end of the “Little Ice Age”. *The Holocene*, 21, 357–365.
- Ravanel, L., Deline, P., Lambiel, C., & Vincent, C. (2013). Instability of a high Alpine rock ridge: The lower Arête des Cosmiques, Mont Blanc Massif, France. *Geografiska Annaler A*, 95, 51–66.
- Ravanel, L., Magnin, F., & Deline, P. (2017). Impacts of the 2003 and 2015 summer heat waves on permafrost-affected rockwalls in the Mont Blanc massif. *The Science of the Total Environment*, 609, 132–143.
- Ritter, F., Fiebig, M., & Muhar, A. (2011). Impacts of global warming on mountaineering: A classification of phenomena affecting the alpine trail network. *Mountain Research and Development*, 32, 4–15.
- Rixen, C., Teich, M., Lardelli, C., Gallati, D., Pohl, M., Pütz, M., et al. (2011). Winter tourism and climate change in the Alps: An assessment of resource consumption, snow reliability, and future snowmaking potential. *Mountain Research and Development*, 31(3), 229–236.
- Rutty, M., Scott, D., Johnson, P., Jover, E., Pons, M., & Steiger, R. (2015). Behavioural adaptation of skiers to climatic variability and change in Ontario, Canada. *Journal of Outdoor Recreation and Tourism*, 11, 13–21.
- Saarinen, J., & Tervo, K. (2006). Perceptions and adaptation strategies of the tourism industry to climate change: The case of Finnish nature-based tourism entrepreneurs. *International Journal of Innovation and Sustainable Development*, 1(3), 214–228.
- Scott, D. (2011). Why sustainable tourism must address climate change. *Journal of Sustainable Tourism*, 19(1), 17–34.
- Scott, D., & McBoyle, G. (2007). Climate change adaptation in the ski industry. Mitigation and Adaptation Strategies for Global Change, 12(8), 1411–1431.
- Serquet, G., & Rebetz, M. (2011). Relationship between demand in the Swiss Alps and hot summer air temperatures associated with climate change. *Climatic Change*, 108, 291–300.
- Temme, A. J. A. M. (2015). Using climber’s guidebooks to assess rock fall patterns over large spatial and decadal temporal scales: An example from the Swiss Alps. *Geografiska Annaler A*, 97–4, 793–807.
- Vincent, C., Fischer, A., Mayer, C., Bauder, A., Galos, S. P., Funk, M., et al. (2017). Common climatic signal from glaciers in the European Alps over the last 50 years: Common climatic signal in the Alps. *Geophysical Research Letters*, 44, 1376–1383.
- Wozniak, S. (2011). *Contribution à la caractérisation de l’anglais de l’alpinisme, par l’étude du spécialisé des guides de haute montagne Etats-Uniens*. Thèse de doctorat. Bordeaux.