200 ANS

# MOUNTAIN GUIDES AND CLIMATE CHANGE

## A STORY OF ADAPTATION

CHAMONIX-MONT-BLANC

La Région Auvergne-Rhône-Alpes

COMPAGNIE DES GUIDES CHAMONIX

200 ANS

CHAMONIX

SYNDICAT NATIONAL GUIDES DE MONTAGNE

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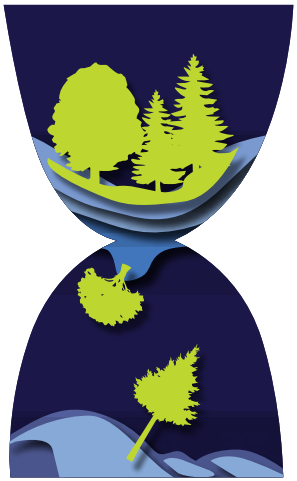


## INTRODUCTION

**Since the birth of the profession of mountain guiding 200 years ago, and really since the beginning of time in the mountains, there has been one constant: change.** In the center of modern-day Chamonix is the Maison de la Montagne. It was once a priory and today it houses the Compagnie des guides de Chamonix, but long before that, tens of millions of years ago, the Chamonix valley was filled by the Alpine Ocean, a branch of the Tethys Sea. Rocks which became the Alps were thrust skyward by the collision of the African and Eurasion tectonic plate and then shaped many times over by glaciations. What we know today as Chamonix was covered by as much as 1,600 meters of ice 28,000 years ago. Even if by comparison, the history of the guiding profession has occupied a much briefer period of history, the 200 years since the founding of the Compagnie have seen a succession of profound changes requiring perpetual adaptation.

**Today, mountain professionals are faced with a new challenge: adapting to rapidly accelerating climate change, which is occurring particularly quickly in the Alps.** As mountain guides and leaders, we are exposed to extremely fast changes in our work environment, which have a direct impact on our activities and our safety. In the years and decades to come, the challenge will be moving beyond purely reactive adaptations toward anticipating change and imagining key strategies for a more sustainable future of our profession. The next chapter of our 200-year history depends on it...as does our enduring commitment to sharing safe and meaningful experiences in the mountains with our clients, and in so doing, contributing to their overall happiness and fulfillment.

# Foreword

*Today the mission of the guiding profession is much the same as it was when it began: sharing incredible experiences in the mountains with our clients, while adapting to the conditions of the moment. But a new challenge has been added to the profession: taking into account the rapid and unprecedented changes in the mountain environment. Mountain professionals must consider changes in the seasonality of their work: "summer" conditions are moving earlier and earlier in the year. Geographic changes must also be taken into consideration as guides need to seek areas that are not impacted by permafrost melt during the hottest periods of the summer. Socio-economic changes are also afoot: many guides are diversifying their activities and pursuing other professional qualifications just as the first guides did, or complementing with other mountain-related activities. Nonetheless, we remain optimistic: our mountains will always be beautiful environments inspiring rich shared experiences. "What an evening spent reading a great book does for the spirit, a trip to the mountains does for the soul. " – André Maurouis*

***Olivier Greber***
*Mountain guide and President of the Compagnie des guides de Chamonix*


**For centuries, mountain communities existed on the margins of an often more prosperous society that was concentrated in cities or in agricultural plains**. Systems of taxation were difficult to apply to isolated high mountain valleys where local survival and solidarity were priorities. Between the 12 th and 19 th centuries, Europe's "Little Ice Age" made the lives of mountain farmers all the more challenging. During that period, winters were particularly rough, summers were often cold, and glaciers came all the way down to the fields and homes at the valley floor. Despite the tough conditions, the Chamoniards managed to eke out a living thanks to grazing and cheese production, and the sale of honey and crystals.

**When the first travelers arrived in the Chamonix valley in the 18th century, marking the very beginning of mountain tourism, local inhabitants began to slowly turn their gaze toward the summits and wonder: What if living in the mountains presented more of an opportunity than a curse? Little by little, the perception of the mountains transitioned from dangerous, "terrible peaks" to summits full of possibility for scientific and human adventure.**

**Figure 1. The Chamonix valley in the 18 th century, as seen from Col de Balme (source: Chamonix-Mont-Blanc Alpine Museum Collection).**

In 1760, the arrival of the Genevan savant **Horace Bénédicte de Saussure** marked an important shift in the way people looked at the Alps. Saussure was struck by the beauty of the landscapes that he ''discovered''. He described the valley of "Chamouni" in his book Voyages dans les Alpes[1] :

**"The valley floor forms a cradle, covered by fields, through the center of which runs a road bordered by small palisades. One by one, we discover the different glaciers that descend all the way to the valley. These majestic glaciers, separated by thick forests, and crowned by remarkably high granite rocks in the shape of massive spires mixed with snow and ice, present one of the greatest and most unique spectacles imaginable."**

Saussure's quest to explore the Alps and his desire to reach the summit of Mont Blanc were, at their origin, scientific in nature. How can we explain the formation of mountains? What are the impacts of high elevation on the human body? What plants and animals manage to live up high?

To answer these questions, Saussure offered a hefty reward to the first men able to reach the summit and called upon local "guides" to help make his scientific observations possible. They helped him to climb to the summit of the Brevent (2525 m), to scale Mont Buet (3098 m), to circumnavigate Mont-Blanc (three times!), and make several attempts at climbing Mont Blanc via the Grands Mulets and the Aiguille du Goûter.

**Figure 2. Left: Mont Blanc seen from the summit of Brevent, this "sublime" view strengthened Sausure's motivation for attempting an ascent. Top right: The pioneering guide Jacques Balmat, on his first ascent of Mont Blanc. Bottom right: Portrait of Jean-Michel Cachat, alias "the Giant", who guided Saussure and became one of the first guides of the Compagnie de Chamonix (source: Chamonix-Mont-Blanc Alpine Museum Collection).**

**These outings quickly developed into much more than purely scientific fact-finding missions, and relationships of trust developed between Saussure and his guides.**

On August 8, 1786, the summit of Mont Blanc was reached for the first time by local residents Jacques Balmat and Michel-Gabriel Paccard. The next year, Saussure became not only the man who had initiated the first ascent of Western Europe's highest summit (a feat considered by many to be the birth of alpinism), but also completed the third ascent of Mont Blanc, with the help of 18 guides, in order to carry out his own scientific experiments.

**And thus began a new chapter in which Europe's aristocracy endeavored to climb the highest summits of the Alps, and the local mountain guides were ready to accompany the most daring among them.**

**On July 24, 1821, the Compagnie des guides de Chamonix, the first company of its kind, was founded** in a decidedly dramatic context. The year before, the death of three guides in Doctor Hamel's convoy in an avalanche on the slopes of Mont Blanc inspired Chamonix's town council along with the guides themselves to establish professional regulations and, most notably, to formalize the decision-making authority of guides within their parties..

**The profession was born in challenging climatic conditions:** the eruption of Mount Tambora in Indonesia a few years earlier in 1815, produced immense dust clouds that traveled as far away as Europe. They blocked solar radiation, cooling down the atmosphere for months. **Sophie Cuenot** describes it in Le Roman de Chamonix [2] :

**"Beginning in 1816, in Europe and in the Americas, a serious cooling was observed, so significant that people spoke of a year without a summer. In Chamonix, a series of rain and snow storms destroyed crops. In desperation and to avoid starvation, people had to eat wild grasses. Argentière's consorts sold the Balme pastures to inhabitants of Les Houches in exchange for grain. This climatic accident reinforced the glaciers' advance in the valley. The Little Ice Age reached its peak during the first half of the 19th century."**

In 1818, the Bossons Glacier threatened to cut the valley in two, inspiring a hotelier to build an inn to house the travelers who found themselves stuck on the road near the Montquarts[2] hamlet. Soon after, and just before he finished construction, the glacier began to slowly recede, saving the access route to Chamonix. **Even as guides established their headquarters in the village center in 1823, living conditions remained precarious and tourism was unreliable.**

**Figure 3.** Left: **The advancing Bossons glacier at the beginning of the 19 th century.** Right: **The mountain guide's office was established in the Chamonix village center in 1823,** at the foot of the Aiguilles de Chamonix (source: Chamonix-Mont-Blanc Alpine Museum Collection).

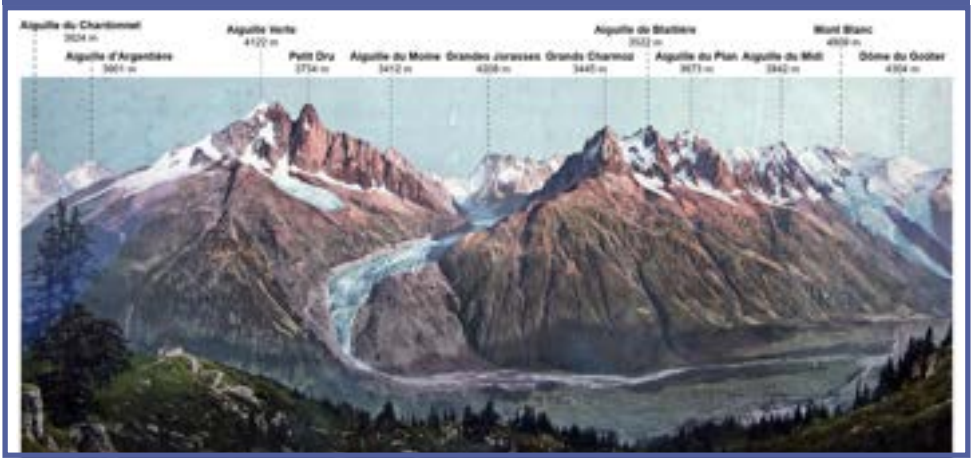
**Over the course of the 19th century, mountain tourism and guiding progressed and intensified.** By 1838, Chamonix was home to five hotels to host travelers, and more and more locals abandoned their wagons in favor of feeding, lodging, guiding and sometimes even carrying a growing number of summer tourists. Most of the guiding work was in the "mid-mountains", bringing clients on foot or on mules to the valley's many famous overlooks: la Flégère, Planpraz, la Floria, le Chapeau, Col de Balme, and especially to Montenvers, overlooking the Mer de Glace. Over the course of the summer of 1874, guides from the Compagnie carried out 24,000 mountain excursions, including 44 ascents of Mont Blanc[2]

# QUESTIONS ARISE AS GLACIERS MELT

**Figure 4: The Bois Glacier and the Arveyron cave at the beginning of the 19th century (source: Chamonix-Mont-Blanc Alpine Museum Collection). Inset: The Arveyron gorges today, showing the Mottet slabs (Photo: A. Delestrade).**

**For the first time, guides began to worry about the glaciers that they saw beginning to melt before their eyes. As time passed, the Bois glacier and the famous Arveyron ice cave, formed by the river flowing from the glacier, disappeared.** Visiting the cave had become a popular excursion and an important money-maker for guides, providing a memorable outing for their clients with minimal effort thanks to the close proximity to Chamonix. For the first time in 1853 and then again in 1857, the cave did not form in the summer. After 1873, it was never seen again. In the 1970s, a full century later, the celebrated guide **Gaston Rébuffat** recalled the changing landscapes

**Figure 5. Photograph taken from the Flégère in 1890,** indicating some of the Mont-Blanc massif's principal summits (source: Amis du vieux Chamonix Collection). At the center of the image, we see the Bois glacier, which has already receded behind the shoulder of the Mottets. **At the dawn of year-round mountain tourism, the valley was still sparsely settled, leaving ample room for agricultural and pastoral activities in the bottom of the valley as well as in higher mountain pastures.**




**"There is no gold now, and the Bois glacier is gone. Though the hike is certainly less picturesque, it remains beautiful: the river flowing from the Mer de Glace plunges into extremely deep and wild gorges."**

This episode provides us with an initial example of how guides adapted when they were faced with changes in their environment. When visiting the ice caves became impossible, they walked with their clients along the bottom of the gorge to see waterfalls. Today, the Mottet slabs on the left bank and the Chapeau slabs on the right are appreciated for their rock climbing routes, where climbers ascend smooth slabs polished by the glacier's passage, surrounded by larch, birch and spruce.

By the end of the 19th century, all of the biggest and most difficult summits of the Alps had been climbed, and always with a guide present in the rope team: the Aiguille Verte (4,122 m) and the Matterhorn (4,478 m) in 1865, the Meije (3,984 m) in 1877 and the Drus (3,754 m) in 1878 And 1879. With the advent of **so-called "acrobatic" alpinism and the desire for routes with more and more technical difficulty, guides were increasingly drawn toward high mountain summits other than Mont Blanc**. Access to the high mountains and to more technical routes was facilitated by the construction of the Montenvers train (1905-1909) and high mountain huts like the Charpoua (2,841 m) and Couvercle (2,679 m) in 1904. Once exclusively working as hiking guides and on Mont Blanc, by the start of the 20th century, guides began to offer a much wider variety of outings including les Courtes, les Drus, le Grépon, the Dent du Requin, the Dent du Géant, and the Aiguille du Moine. They also began to recognize the value of the cliffs closer to the valley floors for their pedagogical and training potential.

In 1928, at the initiative of Alfred Couttet, the Compagnie's guides cleaned and equipped the Gaillands cliff, creating a "climbing school" training area, which remains very popular today.

**Before that time, guides only worked during the short summer season, and maintained other, more traditional professional activities throughout the rest of the year. However, that practice began to change at the end of the 19th century, when Dr. Michel Payot brought the sport of skiing from Norway to the Chamonix valley.** As was the case for alpinism, early exploits in skiing were carried out by just a few pioneering adventurers. The first traverse from Chamonix to Zermatt, via what is now known as the Haute Route was completed in 1903 by guides Joseph Ravanel "the Red", Joseph Couttet and Alfred Simond, along with Docteur Payot himself. Mont Blanc was skied for the first time the following year. In 1906, the train line connecting Le Fayet and Chamonix (initially constructed in 1901), was
equipped with a snow plow, allowing visitors to travel to Chamonix year round[2] . Still, **it wasn't until 1924 and the first Winter Olympics that skiing truly took off and Chamonix began to see "year-round" tourism.**

**While a focus on tourism might seem misplaced in this work, it is crucial to understand that like climate change, tourism has had important impacts on mountain landscapes**. Humans have been modifying alpine landscapes for thousands of years. However, beginning in the 20th century, man's impact on the environment reached a new dimension. Economic growth and technological innovation led to exponential impacts on the environment on a global scale, and also locally in the Alps and Chamonix valley. The thousands of tourists arriving in the little village every year required infrastructure that the valley had never needed before. Fields were progressively replaced by more and more luxurious hotels. The valley floor became more developed and declines in traditional agricultural practices allowed the forest to begin to expand and take over alpine pastures. As societal changes took place, the 1940s were also characterized by a slight warming of the climate. Glaciers underwent a small retreat before re-stabilizing in the 1960s[4] . In 1959, the Chamonix guide and journalist **Roger Frison-Roche** described the environmental changes he observed around him and their impacts on alpinism[5] :

**Figure 6: Alpinists on the traverse of the Courtes (3,856 m) in the 1920s, with the north face of the Triolet and the Aiguilles Ravenel and Mummery in the background (photo: Georges Tairraz II, from the Chamonix-Mont-Blanc Alpine Museum collection).**

**Figure 7. Chamonix in January 1924** during the "Winter Sports Week", the first Winter Olympic Games (photo : Auguste Couttet, Archives de Chamonix, Fonds Gay-Couttet, Chamonix-Mont-Blanc Alpine Museum Collection).

**"When I look around and I recall the past, I realize that everything in the valley has changed. I saw glaciers disappear; I saw them collapse; I saw valleys inundated by dams....I saw forests disappear. Avalanche couloirs, they create open space. Some of the routes I did were easy when I climbed them 25 years ago. When I returned to them, slides had wiped everything away: some of the passages became nearly impossible..."**

**His observations highlight the perpetual changes that characterize mountain environments and which require guides to constantly adapt.** Gravitational events like rockfalls change alpine climbing routes and in most cases, increase their technical difficulty.

**Throughout the 20th century, human activity continued to have significant environmental impacts on the Mont-Blanc massif.** Between the 1920s and 1960s, major mountain infrastructure projects contributed to the continued growth of tourism in the Chamonix valley. The Brevent became accessible via cable car in 1930, and then, in 1946 the Italian entrepreneur Lora Dino Totino announced a new ambitious program [2] : "We plan to do a vertical tour of Mont-Blanc: going under the mountain and coming back up and over it." In 1950, despite significant objective risks, including rock and ice fall, several Chamonix guides were tasked with bringing a massive cable to the summit of the Aiguille du Midi, and then lowering it down the peak's north face. Following this perilous task, in the summer of 1955 the world's highest cable car was opened, transporting 1,500 visitors to the north summit, some 3,777 meters high. Two years later, a cable was stretched across the Vallée Blanche, and cable cars transported their first skiers during the 1957 holiday season. Finally, Totino's dream became a reality in September of 1962. After four years of intense work, the head of the Italian government and the French Prime Minister met underneath Mont-Blanc for the inauguration of the 11.6 kilometer-long tunnel connecting the French and Italian sides of the massif.

The decisions made in favor of development were usually made by high-level political authorities, and rarely initiated by the mountain guides themselves. Guides were sometimes

commissioned to carry out high-elevation construction work, but most importantly, they, along with their clients, would become intensive users of the new infrastructure. **The construction of cable cars played an undeniable role in facilitating access to the high mountains and in transforming the profession and daily life of guides in the massif**. From that point on, guides could link up routes and spend entire seasons "up there". In Gaston Rebuffat's 100 Most Beautiful Climbs [3], he questions the influence of the lifts on the guiding profession:

**"The Mont-Blanc massif is a place where you can do many climbs in a short amount of time because approaches can be extremely short. I have done the traverse of the Grepon and Mont Blanc via the Brenva route in just two days...and that wasn't an impressive feat. These are classic routes and were done at a normal speed. However, it seems to me that it is actually a handicap not to have a long approach during which your spirit can rest. During those two days, and more generally during periods of good weather, linking up climbs without long approaches or descents, which is made possible by new techniques, gear and cable cars, becomes a source of constant nervous tension..."**

During the 1970s and 80s, glaciers in the Alps regained some vigor and mountain faces were plastered with large quantities of snow and ice, making for prime climbing conditions and allowing guides to reinforce their image and grow their clientele. **The accomplishments of alpinists and famous guides like Reinhold Messner, Christophe Profit, Éric Escoffier, Jean-Marc Boivin, Patrick Gabarrou, Patrick Berhault, and François Marsigny, among others, contributed to the aura around guides and elite alpinists in the eyes of the general public [6].**

Those decades experienced a slight drop in temperatures, with very snowy winters and a slight expansion in the size of glaciers. **That would be the last time the valley would see sustained cold temperatures for a long time. Beginning in 1990, temperatures in the Alps began to rise rapidly** (figure 9). The summer of 2003 was a turning point with an extraordinary heatwave in Europe, throughout the Alps and in Chamonix. Temperatures stayed above 30 °C for long periods of time, and refreeze in the high mountains was nonexistent for several weeks. **Even more than average annual temperatures, extreme events such as heatwaves have the most direct impact on mountain landscapes, and by extension, on alpinists and guides**. Rock faces, once glued together by ice, are becoming increasingly unstable. Rockfall events occurred one after another on the west face of the Drus: in 1997, 2003 and especially in 2005, when the Bonatti pillar collapsed during the night between June 29th and 30th. Summers in 2003, 2012, 2015, 2017, 2018, 2019 et 2020 experienced heatwaves more intense than ever before seen in Chamonix since the beginning of record keeping in 1934.

**Warming temperatures in recent years have also contributed to earlier spring snowmelt. Between 1,100 and 2,500 meters, the duration of snow cover has decreased by five weeks since the 1970s [7].**

**Figure 8.** Climbing on the south face of the Aiguille du Midi and summer alpine climbing on the north face of the Droites in the 1960s (source: Chamonix Archives, Fonds Contamine, Chamonix-Mont-Blanc Alpine Museum Collection). **At that time, there was significant snow and ice cover in the high mountains, even in the middle of summer.**

**"1980s: Aiguille du Midi, 3,842 meters. Clear skies and fresh powder for a nice descent of the Vallée Blanche…Having navigated the tricky and difficult sections between the Géant crevasses and seracs, skied down the Mer de Glace and passed by Montenvers, we've finished the high mountain section of the route. I can still see myself leaving the glacier, traversing to the left and then, after a couple side steps up, arriving at the Mottets without even**

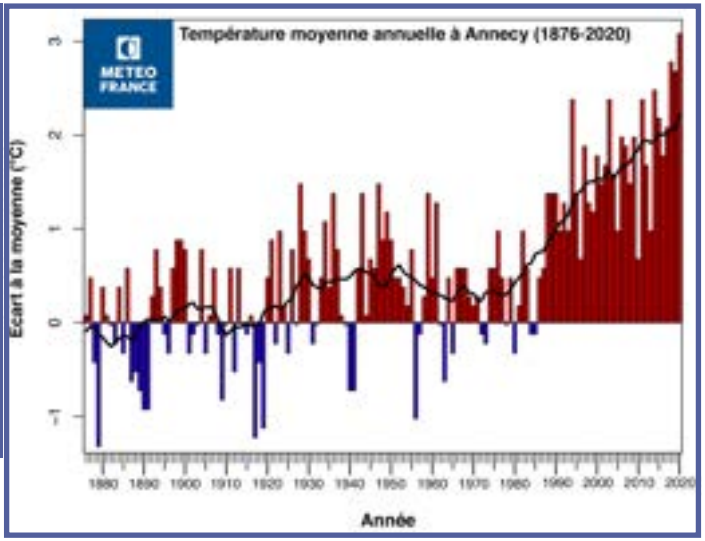



**Figure 9. Average annual temperatures measured in Annecy since 1876 illustrate the observed warming in recent years** (source: G. Brunot, Météo-France). This graph illustrates the deviation of average annual temperatures from the average established between 1876 and 1905. The black line represents a running average over a 20-year period. Between 1876 and 2020, the average temperature in Annecy increased from 9.4 to 11.7 °C, a warming of +2.3 °C.

**taking off my skis. Forty years later: The general decline of glaciers seems to smooth out the surfaces, simplifying the passage of seracs. But at the end of the Mer de Glace, there is no more glacier. We leave its terminus a few dozen meters before taking off our skis in the abandoned bed of the glacier. With skis strapped to our packs, depending on fitness, it takes 20 to 30 minutes to complete the arduous, 150-meter climb up the moraine before arriving at the Mottets. The café is located in the perfect spot for a rest to recover before taking the forest road back down to Chamonix."**

The consequences of climate warming on skiing and on summer mountaineering are immediate. **The Mer de Glace melts more and more each year, disappearing before the very eyes of the tourists at Montenvers**. It loses dozens of meters in length, and several meters in thickness every year, and up to ten meters of thickness during a strong heat wave summer.

Glacier retreat makes accessing mountain huts increasingly complicated and requires adding hundreds of meters of ladders to allow climbers to cross moraines and scale cliffs that have appeared as the ice melts. Guides must avoid snow climbs that have become too dry in July and August, adapting their practices in the face of evermore delicate conditions[8].

**Now more than ever, Mont-Blanc's natural heritage, which has made the massif the capital of mountain tourism and guiding for over 200 years, is being threatened by warming that exceeds the natural climatic variations observed by Chamonix's inhabitants over the course of centuries.**

**Figure 10. Evolution of the Mer de Glace from 1919 to 2019 (sources: Walter Mittelholzer, ETH- Zürich Library & Kieran Baxter, Dundee University).**

## THE MONT-BLANC MASSIF AND MOUNTAIN GUIDING TODAY

The profound changes that have marked the Alps and the Mont-Blanc massif and by extension, the profession of guiding since 1821, result from two major factors: first, the development of tourism which can be linked to significant societal changes, and second, climate change, which is also related to human activity at the global scale. Since the beginning of the industrial era around 1850, warming of more than +2 °C has been measured in Chamonix, and more generally in the Alps. This rise in temperatures is roughly twice that seen in the rest of the Northern Hemisphere (+1.2 °C) [9]
.

**Thus, the Mont-Blanc massif and the Alps, which are home to very sensitive natural environments, are territories that are especially impacted by global warming.**

**Even if +2 °C of warming may seem modest, its consequences on the natural environment are staggering.** Since the beginning of the 19th century, glacier extent in the Alps has decreased by half 10 . In the Mont-Blanc massif, the upper limit of the forest has risen 60 to 80 meters since the 1950s[11] , and plants have begun to grow in areas once occupied by glaciers and snowfields.

**The transition from a pastoral and agricultural economic model towards a tourism-based economy has also disrupted Chamonix's environment.** Once accessible exclusively on foot via a bumpy dirt road, Chamonix can now be reached year round by train, highway, and the Mont-Blanc tunnel. The Geneva airport is also only an hour away by car. High mountain sites are accessible by cable car on both sides of the massif. Chamonix has grown from around 30 houses in 1816, mostly located around the church, to a developed valley with nearly 14,000 inhabitants and the ability to host 2.5 million visitors each year. **The following chapters will provide a review of anticipated changes to the climate in the Chamonix valley, which reflect expected trends throughout the Alps. The current situation is really only an introduction to the changes to come, and the next pages in the history of the massif and of the guiding profession will undoubtedly be shaped by ongoing and accelerating climate change.**

**Figure 11. The village of Argentière in 1890 and 2015 (sources: Collection of Amis du vieux Chamonix and CREA Mont-Blanc).**


**Figure 12. Maps of the Mont-Blanc massif and the Chamonix valley.** Left: a map drawn in 1876 by E. Viollet-le-Duc (source: Amis du vieux Chamonix collection). Right: modern map made by the National Institute of Geographic and Forest Information (IGN); data SCAN 25® ©IGN - 2016 – replication forbidden.

# *Foreword*

*Climate change is here, and the mountains are on the front lines: melting glaciers, avalanches, floods, decreased snow cover, and threats to habitats that are home to both plants and animals. Mountain guides are in a unique position to observe these phenomena.*

*Guides are playing an essential role in the face of challenges faced by different mountain stakeholders, and helping to increase awareness of the fragility of the current tourism model and the urgency of developing resilient strategies moving forward. They are observers, early warning systems, mediators and proactive players in a shift toward a new "four-season" model. In this new approach, economic activities must be (re) combined with preservation of the natural world in a new and more meaningful form of tourism that has become even more urgent and relevant in the context of the recent public health crisis.*

*Mountain regions are home to extraordinary natural and ecological heritage. Open to all, they are unique spaces that inspire wonder and awe, and allow for the discovery of flora and fauna. The transitions ahead are a tough challenge that will require all of us to participate. I am trying to do my part, particularly with the new national strategy around protected areas. Today 43% of the area of France's mountainous regions is protected.*

*Mountain guides play an essential role in these ecosystems, thanks to their observations, their lived experiences, and their daily proximity to the natural world that we are all a part of. In protecting and defending these natural areas and the species that live in them, we are also protecting the health and wellbeing of humanity. In bettering our understanding, we learn to love and then preserve our mountains' beautiful and fragile biodiversity.*

*Thank you for being ambassadors for the mountains and for sharing them with us.*

***Bérangère Abba***
*Secretary of State, in charge of biodiversity*

## CHAPTER II - PICKING UP SPEED: CLIMATE CHANGE TODAY AND EXPECTED BY 2050

**There is no doubt among climate experts that the changes in climate observed in recent decades will continue and intensify in the years to come.** Trends that are being observed today and that are expected in the next decades can largely be explained by increases in greenhouse
gasses (GHG) in the atmosphere. Pollution in the form of particulates in the air reached a peak in the 1970s and 80s in Europe and effectively masked temperature increases due to GHGs. During those two decades, the Alps' glaciers stopped retreating and even advanced slightly. Improvements in air quality in our region since the 1980s have indirectly contributed to the acceleration of warming observed in the last 30 years in the Alps[12,13]

.

Like all continental landmasses, the Alps are warming faster than the oceans, which have greater thermal mass. In addition, melting snow exposes darker surfaces which absorb a greater proportion of solar radiation, and amplifies warming at high elevations especially during spring and summer[9]

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**On a global scale, uncertainty about the evolution of climate change over the course of the next century is caused not by a lack of scientific knowledge, but rather by uncertainties about societal behavior in the coming decades.** The scientific community is constantly making progress in its ability to understand the natural and anthropic processes that impact climate on a regional scale. **The key question for predicting our future climate is: how much greenhouse gas will we emit in the coming years?**

In this booklet, we based our work on the emissions scenario that corresponds with a "business as usual" approach: maintaining our current economic model through 2050. Nonetheless the chosen scenario has relatively little importance when it comes to impacts between now and 2050. Because of the momentum of the climate system, the consequences of decisions made and actions taken today will probably only be felt in around 30 years, after 2050. By the same logic, and in direct relation with the GHGs emitted in the last few decades, we can expect continued warming over the next 30 years regardless of our emissions today.

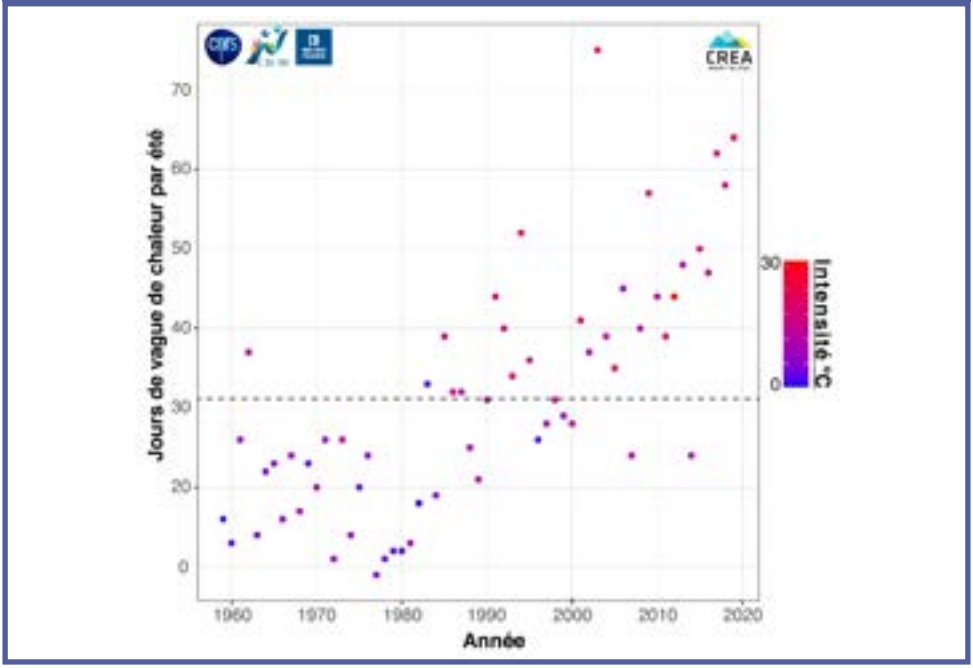
**What climatic changes can be expected by 2050?** In the French Alps and in Chamonix in particular, we can expect additional increases to average annual temperatures **between +1.5 and +2.5 °C** (as compared with the 1973-2013 average)[14]. Taking a step back, we can understand this to mean that **in the next 30 years, we will undergo warming on par with the rise in temperatures observed during the last 150 years, which is to say another +2 °C** (which will make for a total increase of 4 °C since the end of the 19th century).

**In the coming decades, increases in temperature are expected to be the most significant in the summer.** On average, we can expect a rise between +2 and +3 °C in June, July and August. In the mountains, that translates to a rise in the summer freezing line (0 °C isotherm) of about 400 meters, going from about 3,800 meters on average today to 4,200 meters in the future[14]. Heat waves, which have become more and more frequent since the beginning of the 2000s and are particularly destructive to cold mountain environments, are likely to become both longer and more intense. **In the Mont-Blanc region, mid-mountain elevations will go from seeing 5-10 heatwave days today to 20-30 heatwave days by 2050**[14]. Summer warm spells, which are less extreme than heat waves but also very detrimental to the environment, will also be longer and more intense (Fig. 13).

**Route conditions experienced by guides and their clients are significantly impacted by declines in the area and length of time terrain stays frozen.** Refreeze below 4,000 meters will become increasingly unreliable, dislodging rocks usually stabilized by snow and ice, causing snow travel to be less efficient, and rendering access to to couloirs and glaciers more challenging due to snowmelt earlier in the season. In the next chapter, we'll take a closer look at the consequences of warming on high mountain environments and on mountaineering.

**When it comes to climate change, we can point to at least one piece of good news:** climate models

**Figure 13. Changes in the duration (nb. of days) and intensity (°C) of summer warm spells for June-July-August between 1959 et 2019 in the Mont-Blanc massif, at 2,100 meters.** A warm spell is defined as at least 3 consecutive days with temperatures well above the 1981-2010 norm. Pink and red points indicate particularly high temperatures. Since the 1990s and especially beginning in 2000, the duration and intensity of warm spells have risen significantly. The horizontal dotted line represents the average number of warm spell or heatwave days per summer across the whole time period (1959-2019; data source: Météo-France - CNRS (CNRM)15 ; analysis: CREA Mont-Blanc).



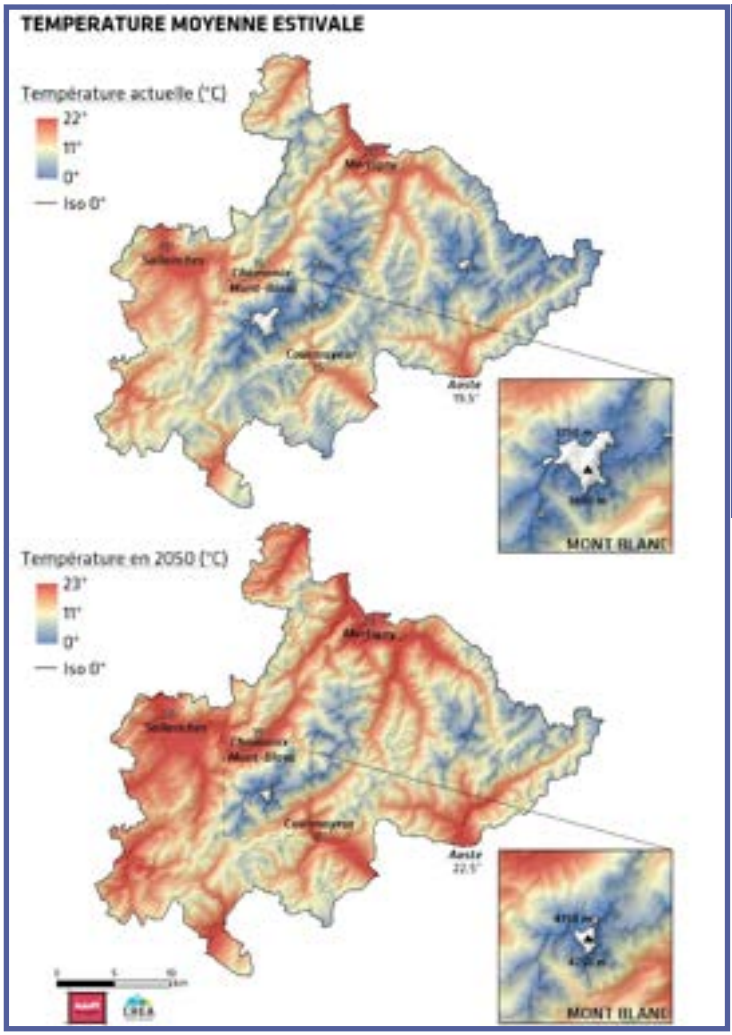
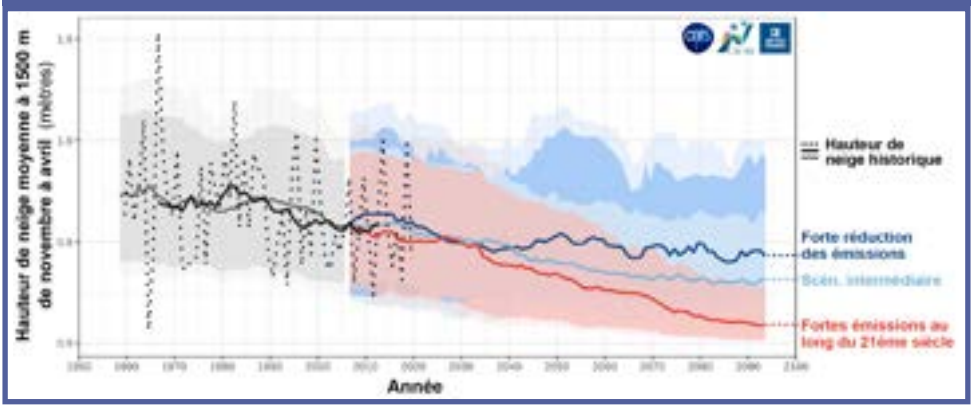



**Figure 14. Average summer temperatures in the Mont-Blanc massif, today and in 2050.** The 0 °C isotherm, which is the elevation at which temperatures remain below freezing, will rise about 400 meters by 2050. **Only the summit of Mont-Blanc and a few high peaks will remain below freezing** (source: WSL CHELSA[16], analysis: CREA Mont-Blanc, AdaPT MB project[14]).

predict an increase in the number of "excellent or pleasant" days above 1,500 meters in early summer and in the autumn[14] . **As stretches of good weather become more frequent on both ends of the summer season, these periods should become more attractive to tourists and allow mountain leaders and guides to continue to work during what is currently considered the off season.** Precipitation is a variable that is more difficult to predict with climate models in the Alps, considering that it varies significantly both geographically and seasonally. In recent decades, increasingly dry conditions in the Mediterranean basin also affected the southern Alps in the summer. In the northern Alps, however, there has been a slight increase in winter precipitation compared to the previous century. Since 1900, we have also observed an increase in intense precipitation events throughout the Alps in all seasons[17], and we expect to see a continuation of this trend over the next century[18]. **The intensification of heavy rainfall events will also increase the frequency and intensity of floods and debris flows.**

**As summer temperatures continue to rise in the Alps, we can expect droughts to become more severe in the valleys and even at mid-mountain elevations.** Other ranges, like the Ecrins or the Mercantour, which tend to receive less precipitation than the Mont-Blanc massif, will be hit even harder by drought[19] . In winter, models predict a slight increase in precipitation in the northern Alps. However, because this will be accompanied by a rise in the elevation of the rain line, it will not result in more snow in the valleys and at elevations below 3,000 meters.

**Figure 15. Changes in the depth of snow in the Mont-Blanc massif at 1,500 meters between 1959 and 2100.** The black points and line represent the depth of snow observed at 1,500 meters between 1959 and today. The gray line represents the modeled historical values. For the future, the blue line corresponds with a scenario of significant reductions in GHG emissions, reaching near carbon neutrality by 2050. The light blue line corresponds to an intermediate scenario in which emissions continue until 2050, when they begin to decline. The red line corresponds to a scenario of sustained high GHG emissions throughout the 21st century. In this last scenario, from now through the end of the century, **snow at mid-mountain elevations will become increasingly rare and will seldom reach the snow levels that we consider common today.** The color bands in the graph represent the range of possible values for each model (source: Météo-France - CNRS (CNRM), R. Samacoïts, S. Morin).




While the majority of anticipated climatic changes impacts will be concentrated during the summer months, it is still essential to understand the expected changes in snow cover. Snow cover is dependent on two factors: precipitation and temperature. If temperatures are below or near 0 °C, precipitation falls as snow. We expect a rise of +1-2 °C in winter and spring temperatures, which is slightly less pronounced than in summer 14. Nonetheless, **when a rising rain line in winter is combined with warmer springs, the result is a decrease in the duration of snow cover, especially on sunny aspects.** By 2050, the duration of snow cover on south-facing slopes will likely diminish by between 30 and 40 days compared to today, depending on elevation, but with the most significant reductions seen below 2,000 meters (Fig. 16). Impacts on north-facing slopes will be a little less extreme, but still significant: they will lose approximately 20 to 30 days of snow cover by 2050 14. Above 4,000 meters, temperatures should stay sufficiently cold to maintain snow cover conditions nearly equivalent to today. However, this represents a very small portion of the area that guides work in on a daily basis. Pronounced changes in temperature and precipitation, associated with a

significant decrease in snow cover and the near-disappearance of alpine glaciers by the end of the 21st century, will also have strong effects on the runoff of alpine streams and rivers. **Models predict that in a "high emissions" scenario, the flow of the Arve river will increase by 85% in winter and be reduced by 40% in summer[20]**

in the near-term. Because it takes about 30 years for the impacts of emissions to become apparent, it will be the next generation that will benefit (or suffer the consequences) from climate policy decisions and actions affecting GHG emissions that we make today.

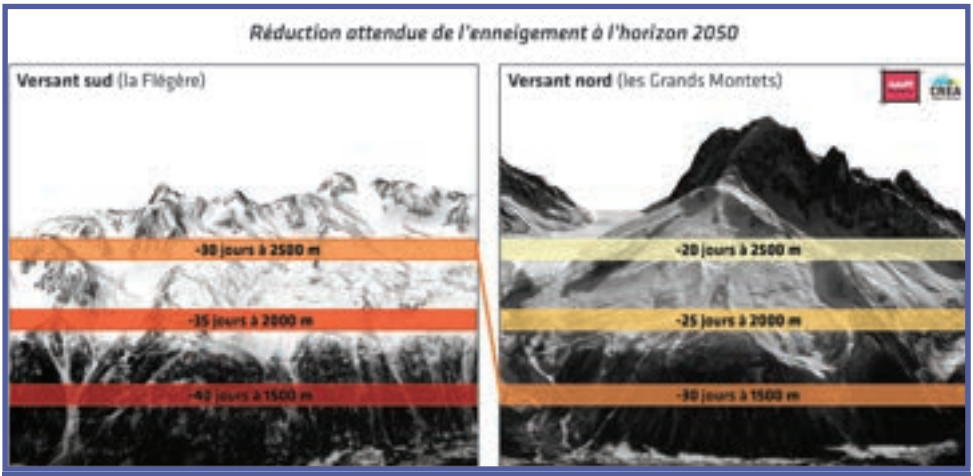



**Figure 16. Reduction in the duration of snow cover** (number of days with snow on the ground) anticipated by 2050 on south and north facing slopes. Loss of snow will be more significant on south-facing aspects and below 2,000 meters (source: WSL CHELSA 16, analysis: CREA Mont-Blanc, AdaPT MB project[14] ).

**The acceleration of climate change that we are witnessing today greatly exceeds the climatic variations observed and experienced by guides over the last 200 yearsThe link between climate change and human activities is clear: it is occuring in an incredibly short time period and is directly caused by our GHG emissions.** Unlike the climatic changes seen during the Little Ice Age, **this is absolutely not a natural variation of climate.**

**The speed of warming presents unprecedented adaptation challenges, not only for guides, but for all inhabitants of mountain regions.** We must take on these challenges in the coming years, regardless of policies for GHG emissions at the global scale, because, due to the inertia of the climate system, warming is bound to continue

**It is our responsibility to act immediately and collectively, not only to limit climate change in the coming decades, but also in the face of many other environmental crises that are equally immediate and urgent, including habitat degradation and biodiversity loss.**
**Today we face the challenge of implementing solutions that will simultaneously address these environmental imperatives and bring about positive change both in the short and long term.**

*This year, 2021, the Compagnie des guides de Chamonix celebrates its 200th birthday. This anniversary is an occasion to honor a prestigious institution, its values and the men and women thanks to whom it has withstood the test of time. Its exceptional longevity is a sign of its incredible capacity for adaptation over the years.*

*Today, the Compagnie des guides, like the rest of society, is facing what is certainly its greatest challenge: climate change. This new reality calls into question our present and future ways of life. This bicentennial is also an opportunity to reflect on this important subject.*

*When faced with the accelerated impacts of climate change in the mountains, management of the Mont-Blanc massif requires a global approach in order to find common solutions. This is the conviction that forms the base of the Espace Mont-Blanc's response to this issue.*

*It was in 1991, at the initiative of the French, Italian and Swiss Ministries of the Environment, that a new political structure, the Mont-Blanc Transboundary Conference, was created. The commitment of the trilateral Espace Mont-Blanc to a dialogue-centered approach allows the entire territory to apply common policies around the protection and promotion of both natural and cultural heritage.*

*Today, the 50 municipalities, situated in Haute-Savoie, Savoie, Vallée d'Aoste and in the Valais, implement consistent public policies across borders. This cooperation allows us to share skills and areas of excellence and expertise unique to each side of Mont-Blanc.*

*Though initially focused on the environment, areas of cooperation have diversified with the implementation of numerous tools allowing for coordinated territorial management of natural hazards, tourist visitation, innovation, transport, mountain agriculture, natural and cultural heritage management and adaptation to climate change.*

*The scientific project "Adapt Mont-Blanc" is an excellent illustration of this cooperation. Its goal is to develop, using a participatory and cross-sector approach, land-use planning and management tools for climate change adaptation. The Research Center for Alpine Ecosystems (CREA Mont-Blanc), commissioned for this project by the Communauté de Communes de la Vallée du Mont-Blanc, was an important contributor to this project, many of the results of are included in this booklet, proof of their relevance and reliability.*

*Mountain guides act as our first witnesses of a changing climate in the mountains that they work in every day. In this booklet, they provide us with their testimony of changes over the last 200 years, and the evolution of their profession in response. This booklet also offers, with pragmatism, recommendations for reinventing their trade once again.*

***Éric Fournier***
*Mayor of Chamonix-Mont-Blanc*
*President of the Communauté de Communes de la Vallée de Chamonix-Mont-Blanc*

Between the middle and the end of the 19th century, Alpine glaciers receded because of a decrease in precipitation caused by natural climate variability, leading to a decrease in snow accumulation. **Starting at the beginning of the 20th century, and especially during the last three decades, glacier retreat has accelerated due to rising air temperatures caused by substantial increases in greenhouse gas (GHG) emissions.**

Whether we are referring to large valley glaciers or to small patches of ice perched on north faces, **glaciers are not the only features impacted by climate change in the mountains**. Above a certain elevation, rock faces are affected by permanent freezing (permafrost), which helps to maintain their cohesion thanks to the presence of stabilizing ice which acts like glue in cracks and fissures. As air temperatures rise, rock faces heat up and stabilizing ice deteriorates, which can cause entire cliffs to fall off. **Mountain recreationists and guides in particular are on the front lines of these climate changes and bear witness to the degradation of the environment they frequent. Alpinism, one of the most emblematic activities in the high mountains, is probably the sport most severely impacted by climate change**.

In 1973, after three decades working as a guide, notably as an instructor at the Ecole nationale de ski et d'alpinisme (ENSA, the French National School of Skiing and Alpinism) and the Ecole Militaire de Haute Montagne (EMHM, High Mountain Military School) and as a member of the Compagnie des guides de Chamonix, **Gaston Rébuffat (1921-1985) published the first guidebook in his legendary collection Les 100 plus belles courses**[3] *(100 Most Beautiful Climbs)*.

He selected 100 routes in the Mont-Blanc massif, ranging from introductory climbs to the most prestigious and difficult. Among the first itineraries listed, Rébuffat proposes the famous Bossons glacier "ice school", where many generations of alpinists tried out crampons and ice axes for the first time. He goes on to describe the 100th climb, a "major alpine route": the Freney Central Pillar on the Italian side of Mont Blanc.

## DETERIORATION OF THE MOST BEAUTIFUL CLIMBS

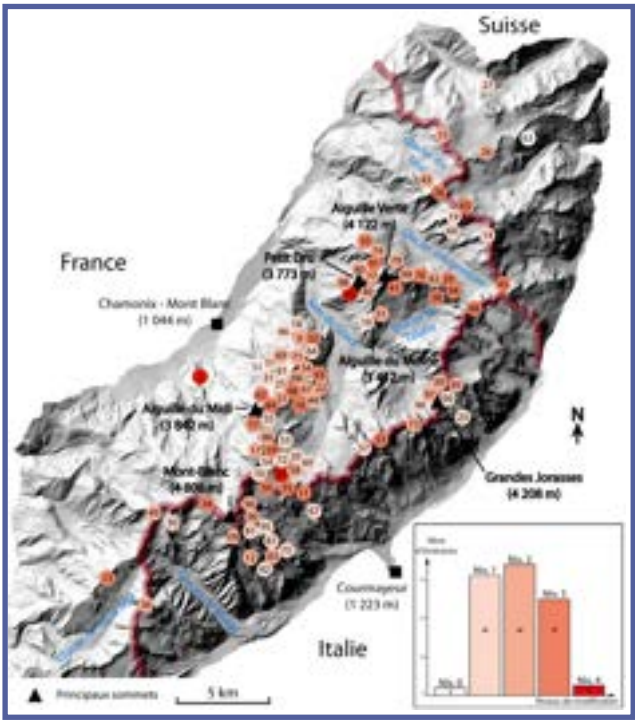



**Figure 17. Location of G. Rébuffat's (1973) 100 plus belles courses du massif du Mont-Blanc** (100 Most Beautiful Climbs of the Mont-Blanc massif) **and the evolution of routes resulting from climate change, rated from level 0 (no change) to level 4 (a route that has entirely disappeared)[8].**

**Nearly half a century later, Rébuffat would be surprised to see the extent to which the climbs he selected in 1973 have been transformed by climate change**. A research project[8], cited in the last IPCC report and largely relayed by the media, quantified these changes. The results of the study are staggering: 34 routes have been moderately changed, 26 significantly changed and 3 have disappeared entirely (Fig. 17). More than a third of the described routes have become impracticable in mid-summer, unless you are ready to take on extremely difficult and dangerous conditions. Only two routes remain unchanged since 1973.

**Among the routes that provide the clearest example of accelerating climate change, we need look no further than the west face of the Drus. There, we find the most impressive and visible evidence of warming**. Nonetheless, this case is a bit reductive because the collapse of the Drus in June 2005, as impressive as it was with the 292,000 cubic meters of destabilized granite and the disappearance of famous climbing routes (Fig. 18), was caused by a single process related to climate change: melting permafrost.

**Overall, the Mont-Blanc massif's climbing routes are affected by 25 glacial and geomorphologic processes, which can be directly tied to climate change**. For example, the traverse of the Dômes de Miage is subject to 20 different processes: crevasses are becoming more and more present, the summit ridge is narrower, what was once a snow descent is now ice, rockfalls are more frequent on the Aiguille de la Bérengère, etc..

**In the following pages, we take a mountaineer's approach to describing some of these processes, starting from the bottom and going to the top.**

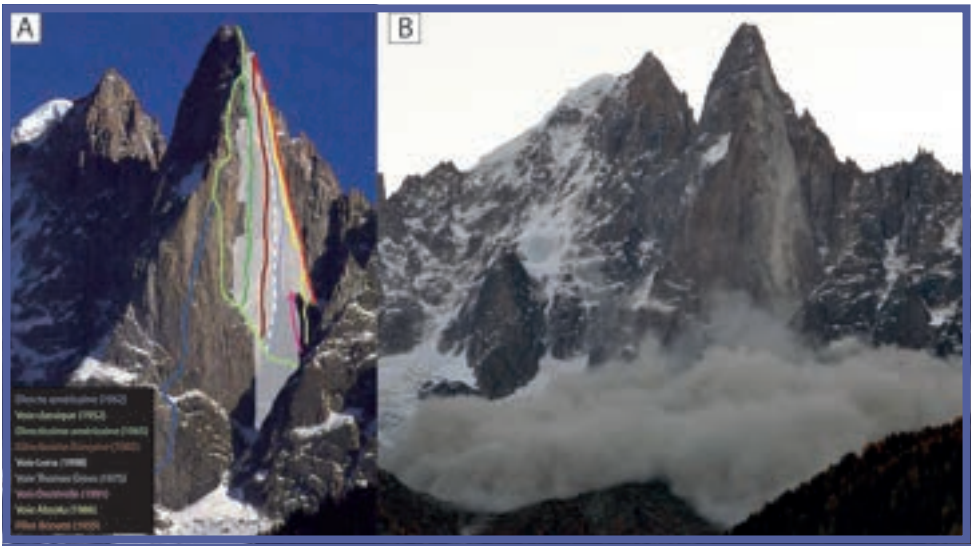



**Figure 18. The west face of the Drus** (3,754 m). A: Swept by a major rock fall event between June 29 and 30, 2005 (the affected area is shown in white), the face lost about 12 climbing routes. B: The most recent important rockfall event occurred in October 2011.

## GLACIER RETREAT AND ITS VARIOUS CONSEQUENCES ON ALPINISM

**Alpinism has two main "gateways" for entry into the sport: what the French call the "climbing school" for learning the basic techniques of rock climbing, and "ice school" for learning to use crampons, handle your ice axe and walk while roped up**. In the past, people came to Chamonix for an introduction to rock climbing at the Gaillands cliff, where the Chamonix guides started to bring their clients nearly a century ago. Today, rock climbing has seen its début in the Tokyo Olympics, and the sport benefits from the proliferation of urban climbing gyms. There are now around 100 gyms in France, which may serve to further distance tomorrow's climbers from the high mountains.

**Discovering and practicing basic mountaineering techniques on a glacier is becoming increasingly difficult because the 'schools' themselves (the low-elevation toes of glaciers) are disappearing**.

Since the end of the Little Ice Age, French glaciers have lost more than half of their surface area, and one fourth of that has disappeared since the middle of the 1980s[10] . Naturally, low elevation glacial areas have been the most impacted. It is precisely these gently sloping and easily accessible sectors that, for decades, provided the venue for the initiation of new climbers and training of more experienced ones. Through the mid-1990s, the perfect site for this was the toe of the Bossons Glacier. Its terminus was situated at just 1,200 meters, and its morphology allowed for a wide variety of difficulties (Fig. 19). In the last 30 years, the glacier has lost nearly a kilometer of length, and the toe is now inaccessible and very dangerous. A little higher, at 1,750 meters, the Pyramids Plateau has also been abandoned because serac fall and avalanches have made it too dangerous. For this reason, the "schools" have mostly been moved to the Mer de Glace (1,650 meters).

**Once feasible as a half-day outing, today these "schools" require a full day because of decreases in the thickness of the glacier (-140 meters below Montenvers since 1986, Fig. 20), lengthier access routes, and the development of a rocky debris cover over the entire lower part of the glacier**. You need to walk for an hour and half, above the "Angle" and continue in crampons to the "Moulins" before finding a steep area. The Argentière glacier (2,500 m), the Col des Grand Montets (3,230 m), and even the Col du Géant (3,356 m, which is mostly a "snow school") are now commonly used as alternative sites.

**Figure 19. A "stroll" on the toe of the Bossons Glacier at the beginning of the 20th century (photo: Séeberger Frères).**


**Figure 20. Decrease in thickness of the Mer de Glace near the old station, downstream of the cable car leading to the ice cave[22] . Top: views up glacier. Bottom: views down glacier. Today, the surface of the glaciers is situated 140 meters lower in elevation.**

**Glacier melt, which is particularly visible because of the decrease in the length and thickness of glaciers at their terminus, has also made access to the high mountains much more difficult. This is especially the case for mountain huts, which are situated, on average, at an elevation around 3,000 meters and are key to facilitating alpine climbing. The Mer de Glace basin provides us with an emblematic example of this phenomenon 23 .**

**The adaptation strategies put in place to maintain access to the five mountain huts in the basin** (equipment and hardware, Fig. 21) **are effective, but raise financial, ethical and legal questions**. Since the beginning of the 20th century, and especially since the 1990s, losses in the thickness of the glacier and the related degradation of lateral moraines have given rise to numerous route modifications in order to maintain access to the huts Mer de Glace basin. Despite these modifications, getting up and over moraines has become increasingly dangerous and requires evermore equipment (currently more than 650 vertical meters of ladders are in place), calling into question the future of access to the huts.

**Sometimes, glacier retreat can even threaten slope stability**. Glacier moraines destabilize, but adjacent rock faces can also become more unstable, sometimes much later on through a process called "post-glacial decompression". When a glacier fills a valley, it exerts pressure on the valley's bottom and sides. When it retreats, the slopes relax, which can cause rocks to shift and move.

**Certain mountain infrastructure may even be impacted**, as seen at the Moosfluh gondola station on the right bank of Switzerland's Aletsch glacier (the largest glacier in the Alps, measuring 22 kilometers), or at the **Pilatte**.

**Figure 21. Maintaining access to high mountain huts through the installation of equipment: a challenging construction project. Left: 90 meters of ladders connect the Montenvers train to the Mer de Glace (photo: J Mourey). Right: a 190-meter suspension bridge above the toe of the Corbassière Glacier (Valais, Switzerland) to allow access to the Panossière cabin (2,641 m; photo: J.-L. Pitteloud).**

**Impacts of shrinking glaciers are not only visible at the toes of glaciers. Further up, glaciers lose thickness year after year, having other impacts on mountaineering: rock routes are getting longer**. Slightly higher than the junction where Tacul and Leschaux glaciers combine to form the Mer de Glace, the "Dalles sous l'Envers" (slabs below the Envers) sector (on the Tacul side) was well-loved for its rock climbing routes on slabs polished by the glacier. In the 1980s, routes like 20,000 lieues sous la neige (20,000 leagues under the snow) and Le Pilier des rhodo-dindons (Rhodo-dindon pillar) were put up by the prolific route-setter Michel Piola. Today, the historic starts of these routes are perched nearly 80 meters above the surface of the glacier (Fig. 22) and the new pitches to access them are much more difficult than the initial routes. As a result, these routes are mostly abandoned, and only accessible via rappel from above on the trail to the Envers des Aiguilles hut (2,493 m). To a lesser extent, we can find a similar situation at even higher elevations. On the southeast pillar of the Aiguille du Midi, the historic start of the Rébuffat-Baquet route, which was opened in 1956, is now 35 meters above the surface of the Géant glacier. Even there, in the accumulation zone, glaciers are shrinking. **Many routes are becoming inaccessible and less logical or aesthetic, depending on the nature and difficulty of recently deglaciated areas**.


**Figure 22. The historic starts for different rock routes on the lower Envers des Aiguilles slabs are now located dozens of meters above the glacier** (photo: L. Ravanel).

Higher still, and often on north faces, **we can find small, little-known glaciers that are also bearing the brunt of climate change, which are called "ice aprons"**. The negative temperatures found on these thin masses of ice effectively glue them to rock, and often provide a route for alpinists. We can find many examples on north faces: the Aiguille Verte, the Droites, the Grandes Jorasses (and notably the "Linceul"), the Tour Ronde, the Triangle du Tacul, etc. The last three on that list have been studied specifically for the changes in their surface area [24] .

All of the snow aprons shrank between the end of the Little Ice Age and the 1950s, before growing again up to the 1990s. However, ice aprons have substantially diminished in size since the beginning of the 21st century. On the north face of the Aiguilles des Grands Charmoz, for example, the ice disappeared entirely after the 2017 heat wave[22] (Fig. 23).

**The consequences for alpinists are significant. Snowy slopes which were once straightforward to ascend with crampons are more and more often characterized by ever-steeper exposed ice,** requiring greater technical skill to ascend them, and increasing the risk of falling. In addition, **many sectors** where the ice has melted **are now rocky and unstable**, since there is no longer an icy coating to hold the blocks together. At the end of the summer, we can often see what looks like scree fields on the glacier at the foot of these ice aprons. These have been observed in recent years at the foot of the north face of the Tour Ronde.

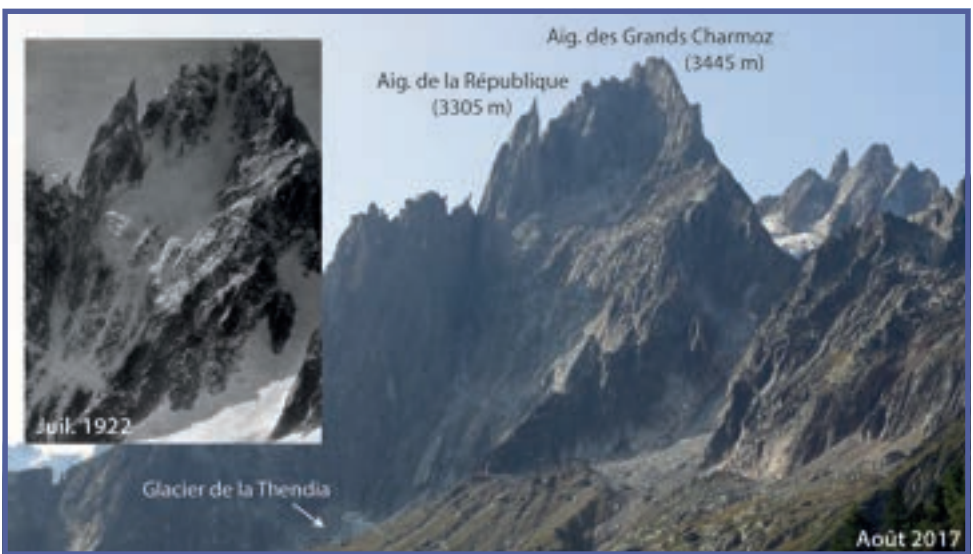



**Figure 23. The north face of the Aiguille des Grands Charmoz** once had a large snow apron covering nearly half the height of the face[22] . Successive summer heat waves have had their impact: **by the end of the 2017 heat wave, the face had lost all of its year-round ice.**

Just like ice aprons, **hanging glaciers** are "cold" glaciers, which means that the temperature of the ice they are made of is well below zero, allowing them to stick to underlying rock. Unlike ice aprons though, hanging glaciers have a steep and prominent snout from which seracs (blocks of ice) can detach. Serac fall poses a non-negligible risk to alpinists. However, the biggest risk from climate change is yet to come and could have impacts all the way down at the valley floor, if massive volumes of ice suddenly detach.

## MONT-BLANC'S GRANITE FACES... DESTABILIZED BY CLIMATE CHANGE!

**The long, steep slopes of the high mountains amplify geomorphological processes**. Sometimes, entire faces can become destabilized, as was recently seen on Piz Cengalo (3,369 m, Bernina massif, Switzerland), which experienced multiple rock slides (volumes of rock greater than 100 cubic meters), and rock avalanches (volumes greater than 1 million cubic meters) in connection with the

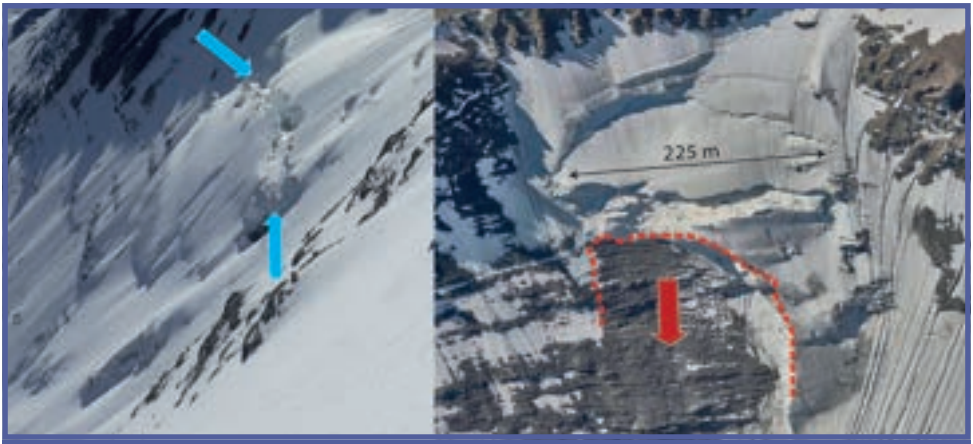



**Figure 24. Partial destabilization to the hanging glacier on the north face of the Grande Casse (3,855 m, Vanoise massif) in spring 2020. Left: the development of a transversal crevasse. Right: the glacier after the ice fall, as seen from a helicopter (source : RTM/IGE).**

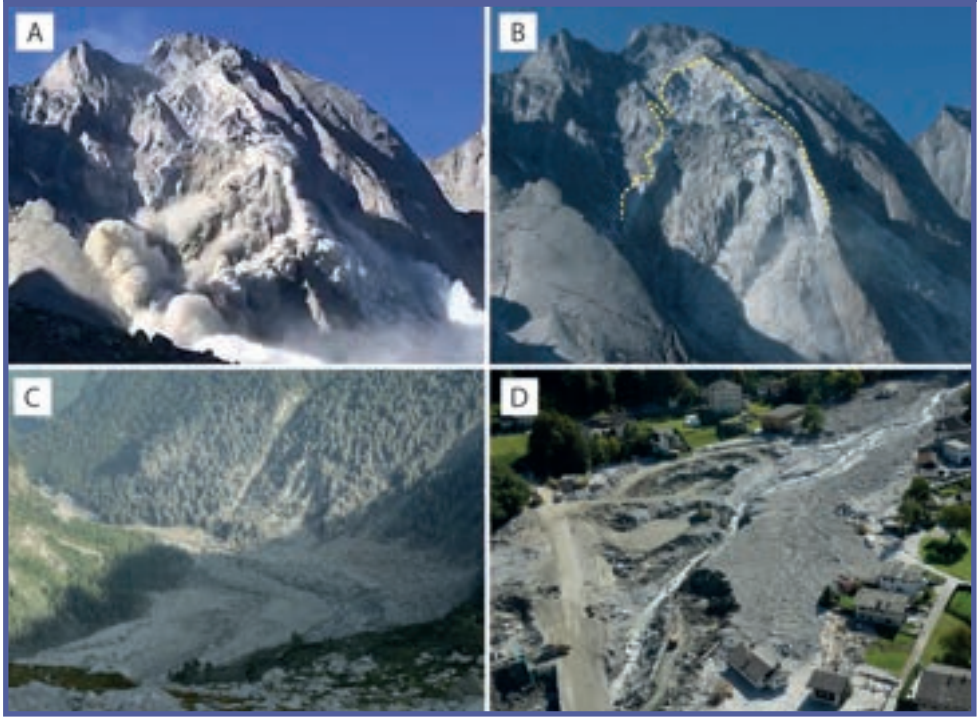
**When the ice of these glaciers warms to around 0 °C (becoming "temperate" ice), it no longer adheres to steep rocks, and the glacier begins to slide, triggering an avalanche.** In recent years, some of these detachments have already been observed. For example, in the Vanoise massif in late spring 2020, a piece of the small hanging glacier located high on the north face of the Grand Casse (3,855 m) slid off the face (Fig. 24.)

degradation of permafrost. On August 23, 2017, a rock avalanche with an estimated volume of 3.1 million cubic meters triggered a mudslide that reached the village of Bondo (Fig. 25). Fortunately, an early warning system that had been put in place after an earlier rockfall event meant the village had been evacuated. Nonetheless, eight alpinists and hikers lost their lives.

This major event was added to a list of many others that occurred during especially hot summers and heat waves, which are themselves connected to climate change. Studies show[21] that **rockfalls have become more frequent in the last thirty years, and especially since the summer of 2003, which is remembered as a very unfavorable season for mountaineering. That summer raised awareness among alpinists, and reinforced the hypothesis of a close relationship between the degradation of permafrost (the warming of areas that were permanently frozen) and the destabilization of high mountain faces**.

**The climate change - rockfall connection has been verified over the last 150 years on the emblematic west face of the Drus** [21] , where eight rock collapses occurred between 1905 and 2005, releasing a total volume of about 335,000 cubic meters. Successive rockfalls led to the steady erosion of the Bonatti Pillar, which began to accelerate in 1950 with increasing volume and frequency in relation to rising air temperatures in the Alps, and eventually leading to the total disappearance of the pillar in the rockfall event of 2005. The same dynamics were observed in studies[26] of changes on the north aspect of the Aiguilles de Chamonix, which stretches for 5 kilometers above the valley (Fig. 26). A total of 67 rockfall events with volumes of 500 to 65,000 cubic

**Figure 25. Rock avalanche on Piz Cengalo (3,369 m), August 23, 2017 (Bernina massif, Switzerland)[25]. A: Collapse of 3.1 million cubic meters of rock on the Vadrec dal Cengal glacier. B: Photo of the northeast face of Piz Cengalo, after the collapse. C: The rock avalanche which swept the base of the Val Bondasca. D: the village of Bondo (elevation, 800 m) after the mudslide. Around one hundred buildings were seriously damaged or destroyed.**



meters have been documented since 1862, indicating a strong correlation with the warmest periods. Overall, these events also demonstrate the major role played by the melting of permafrost. For example, the average elevation of rockfalls is found near the lower limit of permafrost, where degradation (warming) is the most active. We also see rockfall affecting ridges (like the collapses on the Cosmiques Arête in August 2018), spurs and pillars, whose topography accelerates the degradation of permafrost due to propagation of lateral heat flows from areas exposed to solar radiation. **Scorching hot summers like 2003 and more recently 2015, 2017, 2018, 2019 and 2020 accelerate the destabilization of high mountain faces**.

**Permafrost describes any lithospheric material (soil, bedrock, surface formations) whose temperature remains negative for at least two consecutive years with or without the presence of ice. In the Mont-Blanc massif, permafrost covers between 45 and 79% of the 86 square kilometers of steep rock walls in the massif** (Fig. 27). In some sectors, permafrost can be present beginning at 1,900 meters on north faces and 2,400 meters on south faces, but it is only found on all faces above 3,600 meters[27]. The degradation of permafrost can lead to different geomorphological processes depending on the kind of terrain, slope angle, and makeup of the ice. In high mountain surface formations (scree, moraines and rock glaciers), permafrost melt can cause fast-moving and dangerous phenomena (acceleration or destabilization of rock glaciers, extra sediment added to debris flows, etc.). **Within rock faces, melting ice in cracks is less able to play a stabilizing role and cement rocks together**. Simulations have been done to quantify the past and future evolution of the thermal state of permafrost[28]. Over the course of the last two centuries, permafrost has disappeared from slopes below 3,300 meters and sometimes even higher. Temperate permafrost (near 0 °C) was present down to 3,300 meters on north faces and 3,850 meters on south faces.

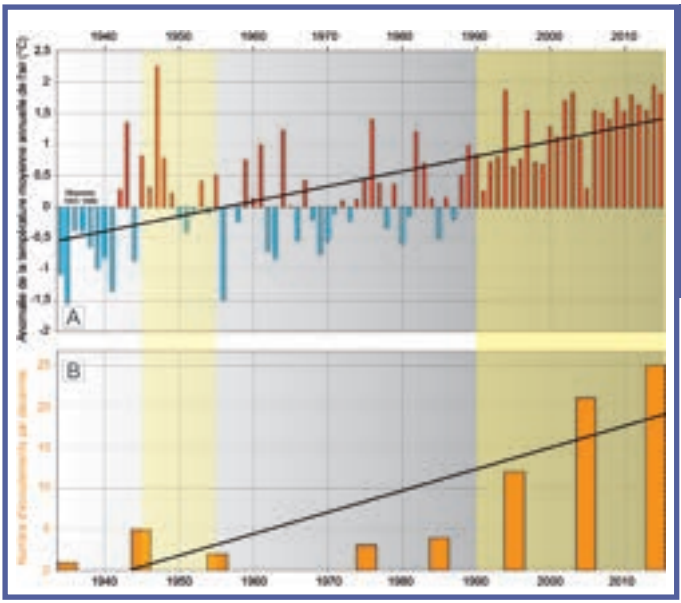



**Figure 26. Average air temperature in Chamonix (1,040 m) from 1934 to 2015, and the number of rockfall events by decade on the west face of the Drus and the north side of the Aiguilles de Chamonix[21,26]. Trend lines represent linear regressions. NB: the last period only covers 5 years, from 2011-2015.**

In the most pessimistic scenario, by the end of the 21st century (Fig. 27) and in the most pessimistic scenario, **permafrost will disappear from south faces below 4,300 meters, while temperate permafrost should reach 3,850 meters on northern slopes.In view of recent changes to permafrost and predictions for the future, we can expect that the rate and volume of rockfall events in the high mountains will continue to increase. It is crucial that alpinists, both today and in the future, become more attentive and aware of the signs pointing to imminent rock destabilization. There are several clues to look for: gradual or sudden widening of cracks, flowing water on cliffs or emerging out of the cliff base,, more frequent falling rocks, rock that squeaks or groans, gravel or sand falling in cracks, etc. In short, keep an eye out and listen up!**

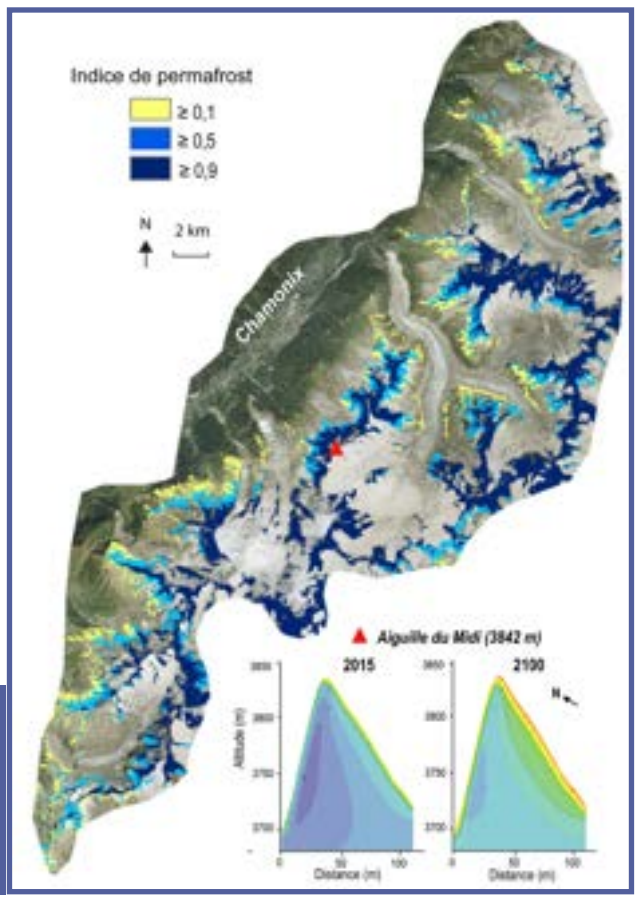



**Figure 27. Permafrost index map for the slopes of the Mont-Blanc massif[27] and permafrost conditions on the Aiguille du Midi in 2015, and in an optimistic scenario for the end of the 21st century** (reductions in GHG emissions) [28] **. The index indicates the likelihood of permafrost in a given area.**

**In the Mont-Blanc massif, the duration of snow cover between 1,100 and 2,500 meters has already drastically diminished (five fewer weeks) since the 1970s[7] . However, the economic viability of operating a ski resort requires that it be open for at least 100 days a year**, according to a 2018 report by the Cours des comptes (Court of auditors). At the scale of the Alps, many ski resorts are already facing serious economic challenges. Even if the early winter 2020-2021 had ample snow and cold, offering excellent nordic ski conditions at the base of the valley, it was unfortunately an exception to the trends being observed today. Because many of Chamonix's ski areas are located at high elevation, for the time being, the valley is relatively sheltered from the dramatic decreases in snow cover duration affecting lower-elevation ski areas. But how long will this
last?

The practice of backcountry skiing has rapidly grown in popularity since the beginning of the early 2000s. Official uphill skiing itineraries have been created within ski resorts, and mountain huts are opening earlier and earlier in the season to take advantage of the trend. **The main impacts of climate change on backcountry skiing are reductions to the length of the season and decreases in the amount of terrain conducive to the activity**. For example, skiers will have to look for trailheads at higher and higher elevation that they can ski from, and some lines (steep faces, especially) will be in condition less often.

**Yet another consequence of climate change is that snow conditions are becoming less and less predictable, and powder is less and less common. "Spring" snow conditions will increasingly become the norm, even mid-winter**.

Changing weather patterns will also modify the Alp's avalanche regime. As less snow falls, the number and the size of avalanches below 2,000 meters is decreasing. However, they appear to be increasing at higher elevations [29]. Across elevations, the number of powder snow avalanches is decreasing, but the rate of wet slides is rising to match it [29].

**In the high mountains, melting glaciers are also impacting backcountry ski routes**. The main problem is a (sometimes massive) reduction in the thickness of glaciers. Some routes have become more dangerous or difficult to ski, while others have simply become impossible (Fig. 28). While the majority of ski resorts in the Alps will no longer be functional by 2100, predictions are a little less extreme for backcountry skiing. Even if snow will become more and more scarce, backcountry skiers have the advantage of being able to move and adapt their activities in order to take advantage of more favorable areas and conditions. The flip side is that there may be an even higher concentration of skiers in a limited number of sectors. This tendency is accentuated by other socio-economic and cultural factors including decreasing risk tolerance and a desire for activities that are easily accessible with few logistical hurdles.

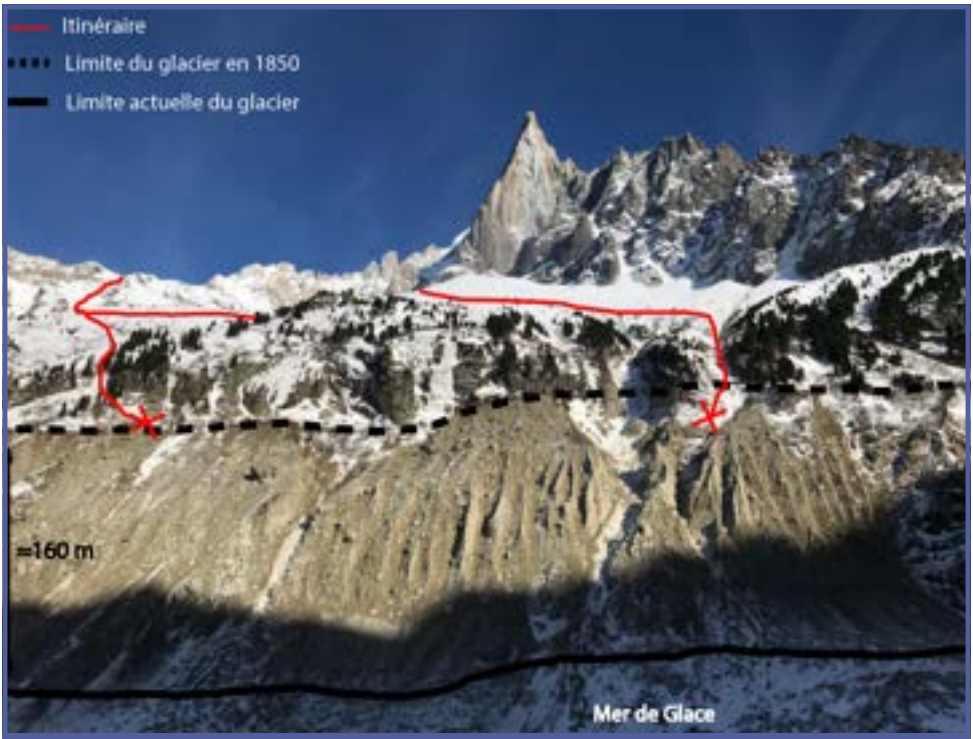



**Figure 28. Where the "Pas de Chèvre" ski descent meets the Mer de Glace lateral moraine** (Feb. 2020; photo: J. Mourey). As the moraine becomes increasingly impassable, the classic Pas de Chèvre line becomes less and less feasible.

## THREATS TO NATURAL HERITAGE

**The changes observed in natural mountain environments in the last few decades have been extremely rapid, and promise to become even more so in the years to come. Studies show that the Alps' glaciers are expected to lose 85-95% percent of their surface area by 2100 (Fig. 29). And the situation for permafrost, and the domino effect of rockfall, is no less dire. Alpine landscapes will be profoundly changed.**

**Skiers and mountaineers will have no choice but to adapt to these changing environments where periods of favorable conditions will be shorter and more unpredictable**. In the face of climate change, mountain professionals are already following the example set by mountain flora and fauna (Fig. 30) by moving up in elevation to find better conditions. But this approach has its limits, and guides are already implementing (both consciously and unconsciously) other adaptation strategies, which will be described in the next chapter [30,31]. For now, **guides and mountain leaders are both witnessing these changes first hand, and acting as symbols of a natural and cultural heritage [32] under threat. Our behavior as a society, and the reduction of GHG emissions will be key in limiting the negative effects of climate change as much as possible, and in safeguarding traditional activities in the high mountains.**

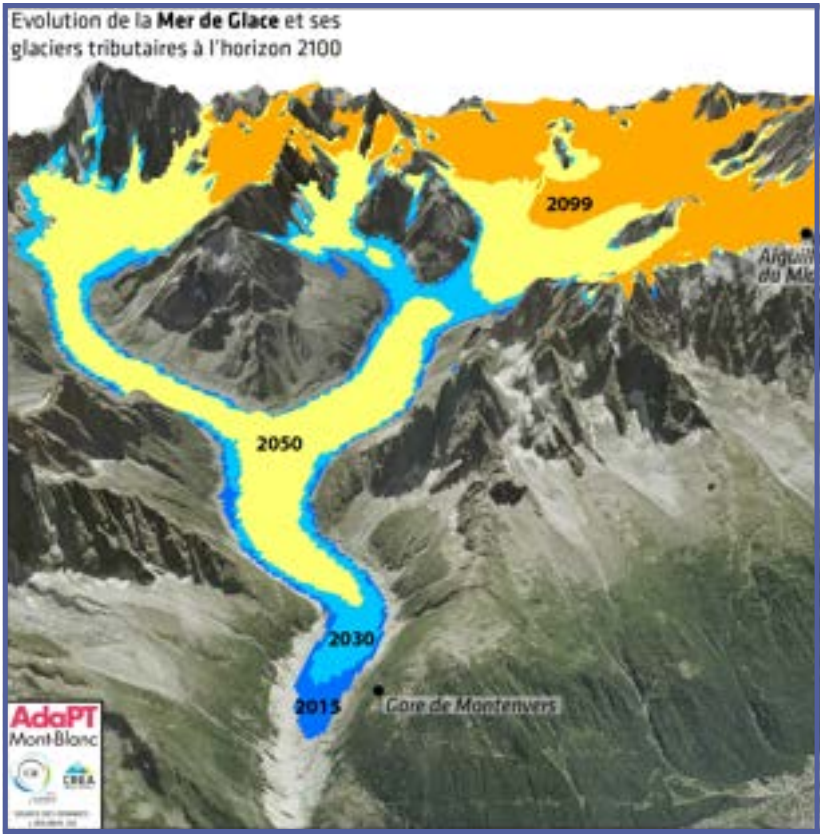



**Figure 29.** The Mer de Glace in 2030, 2050 and 2099 according to a middle GHG emissions (source : IGE/CREA Mont-Blanc, *AdaPT MB Project*[14]).

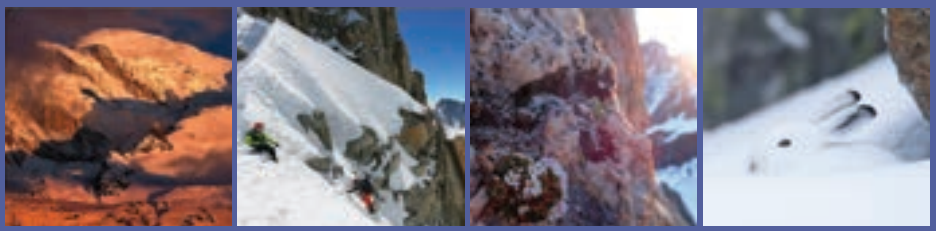
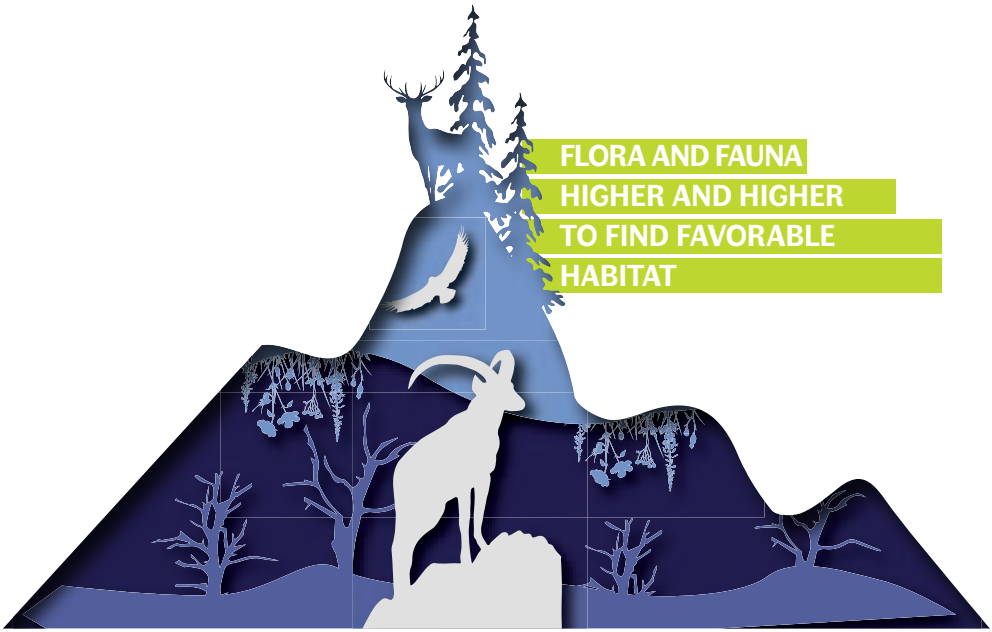


**Figure 30. Examples of natural and cultural heritage[32] threatened by climate change in the Mont-Blanc massif.** Top left: the north side of Mont Blanc (photo: É. Courcier) **with its glaciers and frozen rock faces**. Top right: **a mountain guide** belaying their client on the Aiguille Verte (photo: Compagnie des guides de Chamonix). Bottom left, **Saussure's rock jasmine** *(Androsace saussurei)*, a new species, typical of the Mont-Blanc massif and first described for science in 2020[33] , seen here above 3,500 meters, on the Rocher l'Heureux Retour on the historic route up Mont Blanc (photo: S. Lavergne/ LECA-CNRS). Bottom right: **a mountain hare** *(Lepus timidus)* seen high above the Chamonix valley (photo: D. Rodrigues). **All of these "elements" of our heritage rely on the cold for their survival.**




Guides are far from being the only living things impacted by climate change. The mountains' "true" inhabitants - wild plants and animals - have evolved over millions **of years to adapt to the extreme alpine environment**: snow for six to eight months of the year, polar temperatures in winter, solar radiation equivalent to the Sahara desert and violent storms year round. Even if organisms are accustomed to surviving in these conditions, **climate change is posing a whole new challenge for mountain flora and fauna. Will they be able to adapt to such rapid changes to the climate and to their habitats? In order to adapt to their environment, species typically employ one of two different strategies: stay put and adapt by acclimatizing or undergoing genetic changes, or migrate to find more favorable conditions. In nature, these two strategies are already being implemented in response to climate change and can be observed in mountain ecosystems**. The combination of early snowmelt and rising spring temperatures allows many species to begin their life cycles earlier in the spring. By the same token, warmer fall temperatures allow plants to extend their growing season later in the year. Since 2006 in the Alps, the citizen science program Phénoclim (phenoclim.org) has demonstrated that **ash and birch trees begin budburst** (when the buds become covered in soft fuzz, swell and burst open) **four to six days earlier in the spring each decade[34]. Mountain tree species are also migrating higher in elevation. In the Mont-Blanc massif, treeline, or the upper limit of the forest, rose by 60 to 80 meters between 1952 and 2006[11].**

**A "greening" trend has also been observed in mountains over the last 35 years**. Warmer temperatures and shorter periods of snow cover have allowed plants to colonize rocky and snowy areas. **Near the Couvercle hut (2,687 m), the number of plant species found**

**has doubled in the last 150 years, going from 61 species identified in 1860, to 121 species today**. Among the new arrivals, we can find shrubs (including blueberry) and a tree (silver birch) growing among typical alpine species. **These changes in biodiversity are profoundly changing mountain landscapes**, even in the heart of the Mont-Blanc massif.

**"Arctic-alpine" species are the most vulnerable to climate change**, including the rock ptarmigan *(Lagopus muta helveticus, Fig. 31)*, the mountain hare (Lepus timidus) and the dwarf willow (Salix herbacea). Today, they can be found in the far north and high in the Alps. But these plants and animals, which are relics of the much colder ice ages of the past, once had habitats that extended across a large swath of the European continent. Now, they hide out at high elevation as temperatures in the lowlands have become too warm. Climate change is forcing these species to move higher and higher up the mountain, but this strategy cannot work forever. Because of the conic shape of the mountains, as species move up slope, the total surface area, and therefore available habitat decreases (Fig. 31).

**Because of the Mont-Blanc massif's exceptionally high elevation, it constitutes a "refuge" zone that will be key for the future survival of these species. Preserving these last cold zones in Europe is an essential challenge, not just for guides, but also for the conservation of biodiversity. Why discuss plants and animals in a work dedicated to the adaptation of mountain guides to climate change? First, because climate-driven changes in mountain ecosystems modify not only the habitats of these wild species, but also our own.** For hikers and skiers, forests that are higher and denser will modify routes and viewpoints on many classic itineraries in the Mont-Blanc massif (Fig. 32). In addition, **our clients' experiences are enriched by encounters with remarkable plants and animals while they are out in mountains that still feel wild and mysterious**.

It is up to us to respect these species and not to disturb animals at critical times in their life cycles (especially winter and spring). Finally, in Arctic-alpine species, mountain guides can see a reflection of their own fragility and the immediacy of the need to adapt. **If, in the years to come, we can manage to preserve these emblematic species that require cold temperatures and snow for their survival, perhaps we will also be able to preserve our own professions and identities?**

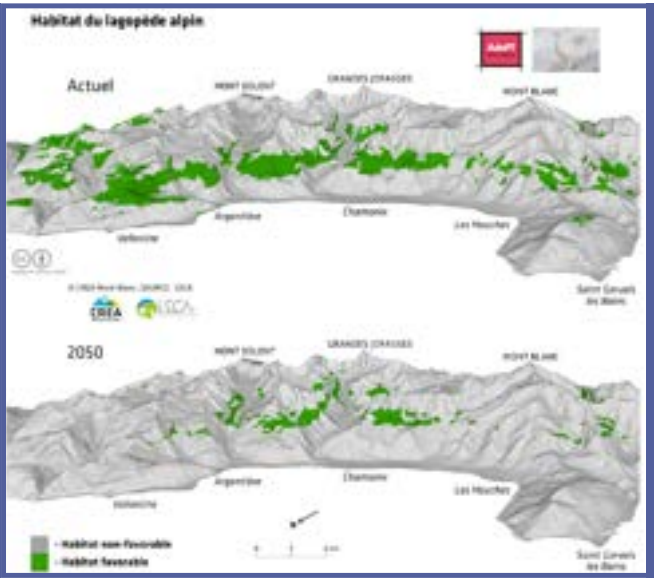



**Figure 31. Favorable habitats for the rock ptarmigan in the Mont-Blanc massif today and in 2050.** This species, which spends the winter in igloos dug into the snow, needs snow and cold temperatures to survive and reproduce. The early snow melt in the spring not only threatens their habitat, but also the birds themselves which become more visible to predators: they are stuck with white plumage in a landscape without snow. **Models predict a 90% decrease in their favorable habitat by the end of the century in the Mont-Blanc massif** (source: CREA Mont-Blanc, LECA-CNRS, *AdaPT MB project*[14] ).

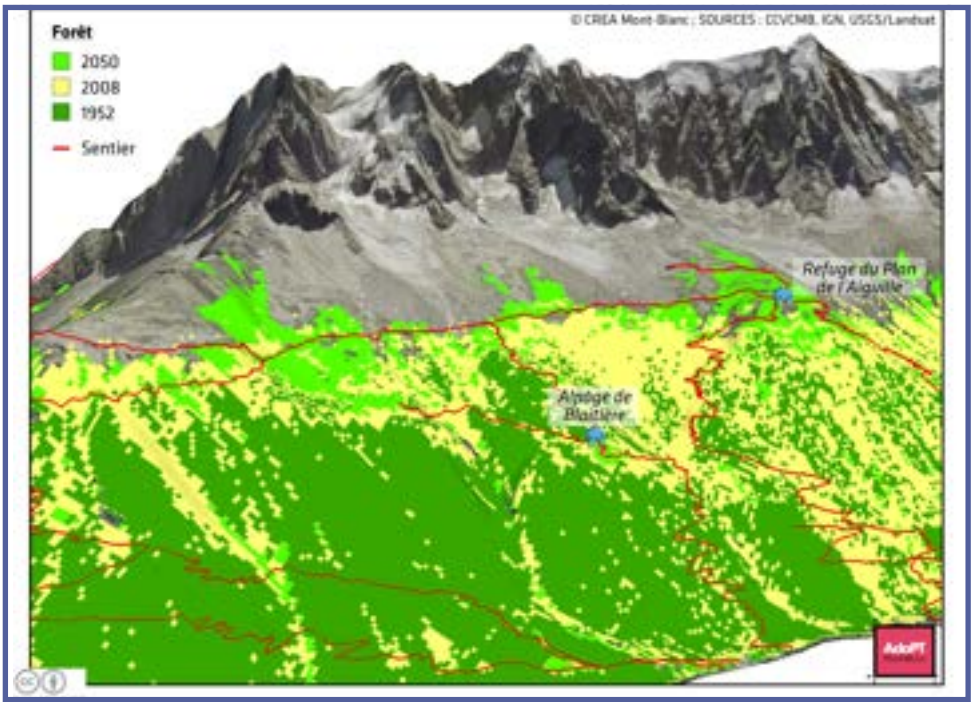



**Figure 32. The forest above Chamonix, on the Plan de l'Aiguille side of the valley** in 1952 (dark green), in 2008 (yellow) and projected in 2050 (light green). Since the beginning of the 20th century, the total surface area occupied by forests grew by 80% in the Mont-Blanc massif. Forest expansion is due to climate change, but also to agricultural abandonment: once pastures have been abandoned, they are quickly recolonized by trees (source: CREA Mont-Blanc, *AdaPT Mont-Blanc project*[14]).

# LA MEIJE, OR LIFE'S MANY ADAPTATIONS

**La Meije, or life's many adaptations August 7, 2018. Thousands of cubic meters of gneiss collapse from above the Carré glacier, on the south face of the Meije (3,984 m). Boulders tumble more than 600 meters down the face, and by some miracle, spare the few alpinists who were on their way up the historic route to the summit. One rope team found themselves in the line of fire, and somehow lived to tell the tale. One of the climbers shared his recollections: "I thought it was over. I was sure that either he or I was going to pitch off into the void." Of the rope that once linked them, all that is left are tattered bits.**

The imposing south face of the Grand Pic is cut vertically by two geologic faults and can be divided horizontally into two large rock formations: a solid granite lower part, and an upper part made of a more crumbly gneiss. The transition between them is marked by a horizontal ledge located at 3,600 meters: the Carré glacier ledge (Fig. 33). **The role of melting permafrost in triggering the rockfall was clear: in the scar left behind by the collapse, a mass of bare ice was clearly visible, attesting to the below-freezing temperatures that were dominant in the sector.** Climate change is responsible for this impressive collapse which was widely reported by the press. The point where the Carré glacier ledge intersects with the western fault is precisely the zone where climbers set foot onto the glacier. In 1878, the famed duo, father and son Gaspard, were attempting their second ascent of the Meije with Guillemin et Salvador de Quatrefages. On the way back down, as he stepped onto the ledge, Guillemin discovered a **"hanging garden"**comprised of Arctic-alpine forget-me-nots (Eritrichium nanum; Fig. 33), **alpine toadflax** (Linaria alpina) and **purple saxifrage** (Saxifraga oppositifolia). He recalled that he had to hoist himself onto Gaspard's shoulders in order to take a few samples... impressive motivation, given the severe surroundings!
Between 2015 and 2018, temperature loggers were installed near this hanging "garden". At 3,600 meters, summer highs above 40 °C were recorded multiple times, with a record 49 °C registered in 2018. **These plant species thus are able to survive in thermal conditions similar to those of the Sahara desert, with daily temperature ranges exceeding 50 °C**. Their capacity to adapt is truly unique. They can shift from winter dormancy under the snow, to the summer temperatures worthy of the most arid deserts. It is easy to understand then, how such extreme temperature peaks could cause permafrost melt and lead to rockfall events like the one in 2018.
After the rockfall event, the regular route of the Meije was deserted. The following winter, with the goal of preparing for the next season, local guides supported by the Oisans-Écrins guide company organized a meeting bringing together many different actors: the Ecrins National Park, hut caretakers, mountain rescue services and elected officials. Together, they put together funding for the next year to re-establish the regular route up the Meije. The first step was to use a drone to carry out a reconnaissance of the regular route up to the collapse site in an attempt to detect possible changes to the route. Once the snow melted, a team spent two days between the Promontoire hut and the rockfall zone with two main objectives. The first was to evaluate the damage and, if possible, clear the regular route. The second was to explore possible variations to the historial regular route that would provide a passage which would be less exposed to falling rocks.

The first objective proved to be a success: after only two days of purging rocks and the addition of a few pitons, the 1877 route was climbable again. However, the route's commitment factor is no longer the same. Climbing beneath an unstable rockfall zone requires rope teams to move much more quickly to limit the amount of time they are exposed from above.
The second was a failure. They had to face the facts: the "elders" truly had found THE most logical route up the mountain. **The warnings voiced by mountain professionals have profoundly changed visitation trends**. Two years on, the results are positive. For the Promontoire hut (3,092 m), visitation rates have stayed stable, but with a more homogenous distribution across the season. Before 2018, reservations largely outpaced the capacity of

the hut when the weather was good, but as soon as there was a cloud in the forecast, alpinists jumped ship. Today, in addition to alpinists, hikers are coming to the hut, which has become an objective in and of itself. The same phenomenon has been observed on the other side of the mountain at the Aigle hut (3,449 m). The number of climbers on the route has also changed. Before 2018, there was an average of more than 10 rope teams on the route per day, with sometimes as many as 20. Today, there are at most five rope teams per day. And at the same time, interest in other routes in the area around the Meije has been renewed, decreasing congestion on the historical route. When should you climb the Meije? Historically, alpinists usually waited for the route to be dry and for good weather without storms. Today, the equation is a bit more complicated. The snow cover on the Carré glacier determines the degree of exposure of the route. **Climbers must find a balance between having enough snow on the glacier to glue rocks in place, but not so much that you have to wear crampons on the rest of the climb.**
**This rockfall event not only fundamentally changed the regular route, but also required local actors to adapt to new constraints. Hopefully lessons learned from the Meije will help us prepare for challenges that we are likely to face more and more in the future.**

**Figure 33**. Inset: **Arctic-alpine forget-me-not (Eritrichium nanum aka "the King-of-the-Alps") can be found on the Carré glacier ledge** (photo: C. Dentant). **The main photo was taken by drone, following the rockfall that occurred on the Meije's Carré Glacier in August 2018** (photo: B. Ribeyre, with authorization from the Ecrins National Park).

# *Foreword*

*The very essence of the profession of guiding lies in our ability to adapt. Adapting to climatic conditions, to the difficulties of a route, to the technical level and fitness of clients, to exhaustion, to fear...Guides draw from a box of tools and techniques that they build through accumulated experiences and shared adventures in order to safely navigate through hostile environments, and make it back home. The original job of a mountain guide was to bring people under their responsibility from one point to another, going around or over the obstacles in their way. Over time, that job has evolved into a profession. First as a response to the human thirst for discovery and conquest with the goal of reaching high summits or the unknown, but also for the simple pleasure of gaining altitude and experiencing adventure.*

*Today the radical impacts of climate change on the mountains are requiring that we adapt, but also that we reconsider our profession. In a world where everything is going faster and faster, these profound changes to our environment are calling into question our values, our relationship to time, the balancing act between action and contemplation, and our place in nature. We must mourn for the past and the present as we know it. It is a deeply difficult process, but one that is necessary if we are to make space for a new vision of our identity and our role. Finding our place in an unbalanced universe... no small feat!*

*Guides are an integral part of a natural and human ecosystem that is vulnerable, but also gifted with an incredible capacity for resilience. We have treasures to share with those who are curious, and who want to reconnect with a wilder and more animal part of our human nature. The constraints of such fast changes have the power to stimulate our creativity, and the difficulties ahead may strengthen the ties between all of us who must face them together. It is up to us, the actors and inhabitants of the mountains, to cooperate and together construct a sustainable future in the mountains - to continue to be able to live in this changing and fabulous world, and to share extraordinary experiences with those who visit us.*

***Dorian Labaeye***
*Mountain guide and President of the Syndicat national des guides de montagne (SNGM, the French Mountain Guide Association)*

# *Chapter IV* - ACTIONS AND ADAPTATIONS OF THE GUIDING PROFESSION IN RESPONSE CLIMATE CHANGE

## ADAPTING TO WHAT?

**This chapter will focus on how guides can and are adapting to climate change. Mountain professionals, however, must also adapt to other constraints, including social and cultural transformations among their clientele, digital innovations that transform how work is marketed, as well as other financial, administrative and legal insurance obligations.**

In recent years, **clients' expectations** have become characterized by demand for fun and accessible outdoor activities, with a tendency toward quickly switching from one activity to another. Looking to "do" rather than to "experience", clients seek products that are "all-inclusive" and expect them to be "zero-risk" in mountains transformed into a list of products for sale. These new expectations fail to take into account the many uncertainties we face, and as a result, **we are seeing a concentration of users, all on the same itineraries: those which are the easiest, the most well-equipped, and the most symbolic** (Mont Blanc, Tour du Mont-Blanc, Dôme des Écrins, Grand Paradis, Monte Rosa massif).

Meanwhile, the **rapid development of new digital marketing tools is calling into question the role of guide companies and offices**. As digital marketing platforms based on the Uber model arrive on the scene, the collective approach that guide companies were founded upon finds itself under threat.

**When it comes to paperwork, guides and mountain leaders are faced with evermore administrative requirements**, especially for working in neighboring Alpine countries. Guides feel that these legal hoops are a hindrance to freedom of movement and have no visible benefit in the short term. In addition, preparing and marketing mountain travel in particular and projects more generally, has become considerably more complex in recent years due to laws concerning the sale of "all-inclusive" products.

In this context of socio-cultural changes, climate change feels like an additional burden that makes taking into account and adapting to these new constraints all the more difficult. Therefore, if we want these adaptations to a changing climate and socio-cultural context to be successful, they must be comprehensive and collective.

**The challenge for guides is to maintain as much freedom as possible with respect to social and cultural constraints in order to limit their vulnerability to climate-driven changes to their environment.**

**Two studies[30,31] carried out in collaboration with the SNGM (which represents 90% of French guides) demonstrated that climate change has required nearly all guides to adapt their practices.** For the vast majority of respondents, the impacts of climate change were described as "worrying", particularly because mountain activities are becoming more dangerous. As a result, 40% of guides say that climate change is causing them to take more risks[30], and 67% said that their economic model is threatened[31].

**In order to continue to work in the context of climate change, guides have implemented both individual and collective adaptation strategies.** The many different approaches can largely be classified into two categories: **short-term, reactive strategies** which allow guides to adapt immediately to sudden changes and **proactive, long-term strategies which allow them to anticipate profound and necessary changes to the profession.** For both guides and mountain leaders, the goal is to continue to practice their trade with the same high standards for both safety and enjoyment, in spite of changes to the environments in which they work.

## THREE SHORT-TERM CLIMATE CHANGE ADAPTATION STRATEGIES[30]

**Shifting seasons** require that the "standard" periods for different activities must be shifted to coincide with changes in the environment. The best windows for summer alpinism have become shorter and more unpredictable.


Overall the season has shifted from July and August to the months of April, May and June. Hiking season is following the same trends, with an extension of the season so that it now runs from the end of May through the end of October. The backcountry skiing and snowshoeing season will also need to take into account the late arrival of snow in the fall and early melting in the spring, as well as changes

to snowpack due to mid-winter thaws.
Changing seasonality is not without its own obstacles. For example, May, June and July are not the typical periods for vacations. **The time periods that are now the most favorable for mountaineering no longer line up with the periods when clients typically have the most availability**. In addition, rapidly changing conditions require that guides and their clients react quickly to take advantage of ever shorter and more unpredictable windows when the conditions are favorable. This means that it is becoming harder for guides to plan their season in advance, for example trip planning and taking care of logistics (reserving huts, etc.). Often, there is also a new pedagogical challenge in order to teach clients about the unpredictability of conditions.

Another important obstacle to these temporal adaptations has to do with the availability of tourism infrastructure in the mountains during time periods historically considered to be the "off season". Ski lifts, gear stores, vacation rentals, huts and restaurants are often closed in the spring and fall. **Guides and mountain leaders are confronted with tourism services that function with a two-season model (summer and winter) that must transition toward a "four-season" tourism model, in order to allow mountain professionals to adapt to changing conditions**.

**Spatial adaptation** implies leaving one area for another in search of more favorable conditions. While these changes can be voluntary, they are becoming increasingly imposed by conditions. By the middle or end of July, the majority of guides are changing which massif they are working in, or leaving zones with permafrost and glaciers entirely, in favor of lower elevation sectors or the so-called "Pre-Alpine" ranges. **In the coming years, a major challenge will be learning to adapt without traveling**, by identifying local-scale adaptation strategies for single valley or massif that are consistent with changes to seasonal conditions.

**Glacier melt in the years to come will also impact the boundaries between the territory traditionally reserved for high mountain guides, and that of mountain leaders**.
Mountain leaders may be able to work at higher elevations in less steep glaciated massifs like the Vanoise (Fig. 34), or in some sectors of Mont-Blanc or the Ecrins. Melting glaciers may also mean that ski instructors can expand the areas where they can instruct backcountry skiing. In the future, it is likely that the steepness and technical difficulty of terrain will be more determinant than the presence of snow or ice in determining what is "mountain guide terrain" and what is mountain leader or ski instructor terrain.As those first two strategies are being implemented, some mountain professionals are choosing to **pursue other activities**. For guides, that can mean migrating toward rock climbing rather than high mountain alpinism, or pursuing other activities that are less vulnerable to climate change, such as via ferrata or canyoning (as long as there is still enough water in the rivers!). **The mountain leader profession is also likely to be impacted by rising summer temperatures**. With more intense heat waves, even mid-mountain activities (hiking, mountain biking, etc.) could become unpleasant and unsafe in some sectors and during some periods of the summer.

**Today in part because of the impracticability of the mountains, many guides and mountain leaders are going on family vacations in August, which would have been unthinkable even a few years ago.**

**Figure 34. Glacier retreat zones: a key area for the transition of environments and mountain professions** (Réchasse Point, 3,212 m, Vanoise; photo: Y. Borgnet). **In these recently de-glaciated areas, where will the border between mountain guide terrain and mountain leader terrain be? Will guides be able to appreciate and attract clients to a mountain landscape devoid of glaciers?**

## THE FUTURE OF THE GUIDING PROFESSION: PROPOSED LONG-TERM ADAPTATION STRATEGIES

### EVOLUTION OF THE CORE CURRICULUM

Recently accepted to the Intangible Cultural Heritage list by UNESCO, alpinism has begun to receive some well-deserved recognition for all that it brings to both society and its practitioners since its conception. However, this recognition does not change the extreme fragility that is becoming apparent. **In their emerging role as sentinels of climate change, mountain guides are charged with the heavy responsibility of raising awareness of the vulnerability of both the activity but also the environment in which it is practiced.**

**Over the last few years, the core curriculum at the Ecole nationale de ski et d'alpinisme (ENSA, the French National School of Skiing and Alpinism), emphasis has been put on the issue of climate change, which is having ever greater impacts on guiding**. Today, the question of transport and the carbon footprints is becoming an important topic for learning and discussion.

Three years ago, the ENSA added a new week of training to the curriculum, focused on the professional environment and during which the future of the profession is discussed in thematic round tables. Guides-in-training exhibited high levels of maturity and heightened awareness of the environmental and climatic issues related to their profession. **We now know that these issues, which are already important, will**

**become essential in the future and that the survival of our profession will depend on the level of intelligence with which we face them. We are counting on the young guides to show us the way!**

## TRANSITIONING TO AN EXPERIENCE-BASED APPROACH TO THE MOUNTAINS

Faced with the fundamental changes to the mountain environment, both guides and clients can begin to explore new ways to think about projects in the mountains. As described in Chapter III, climate change is threatening many classic mountain routes, and rendering conditions more difficult and unpredictable.

I**n the context of growing uncertainty, choosing a climbing objective six months in advance is becoming an increasingly risky bet** and can lead to trip cancellations, disappointment for the client or acceptance of higher levels of risk for the guide and rope team. When possible, **a promising adaptation strategy consists of proposing a mountain experience (a massif and a project), rather than selling a specific route or a summit.**

**Co-constructing more open-ended projects gives guides and their clients more space to optimize and adapt their final route choice according to conditions**. In making the goal a lived experience rather than a specific objective, guided parties not only gain flexibility but also create more space for other priorities such as teaching skills, observing and contemplating the mountain environment, or even appreciating local culture. All of these facets of the mountain experience are less dependent on conditions. Such an approach would require **valuing and promoting mountain experiences**, especially for their immersive (multi-day, bivouacs), pedagogical (teaching autonomy or safety skills), and naturalist aspects.

For example, **bivouacking** encourages us to reconsider the classic rhythm of climbs. Well-known routes in the Mont-Blanc massif, like the Arête du Jardin on the Aiguille Verte or the traverse of the Courtes can be done over the course of three days rather than two, with a bivouac on each of the summits. This option reinforces the immersive character of the experience while also adapting to climate change because the descents can be done early in the morning. As bivouacking gains popularity, it will become crucial to offer educational opportunities and environmental tools to reduce the impact of nights spent outside of huts.

**Climate change is also pushing us to reconsider both interactions among guides and between guide and client**. With more and more uncertainties limiting the predictability of routes, sharing information about conditions and decision-making processes constitutes a valuable adaptation strategy. In recent years, **chat groups on digital platforms have become an indispensable tool enabling exchanges between professionals about route conditions, risks and dangers encountered in the field. Teaching clients skills for gaining autonomy also allows guides to share risk management and decision-making within the rope team**. A process of managing uncertainty replaces the pursuit of a fixed objective, allowing clients to become actors in the project. This kind of training may also allow rope teams to climb more safely.

**Figure 35. A bivouac at sunset on the summit ridge of the Droites (4,000 m). As long as parties can manage their environmental impact, bivouacking can be a tool to slow down the rhythm of a climb and adapt to changing conditions,** including a 0 °C isotherm that is much higher. This photo portrays the "classic" image of the high mountains that we have so effectively transmitted over the course of decades, and shows a landscape that is as beautiful as it is fragile in the face of climate change (photo : Y. Borgnet).

**Highlighting the experience over the objective allows mountain professionals to become more free to observe the environment around them**. Studies have already identified guides and mountain leaders as valuable witnesses and observers of mountain environments and the changes they undergo. Mountain professionals are not just the first to be impacted by climate change, but they are also in a unique position to collect scientific data in the field. Their observations can include natural phenomena (collapses, rockfalls, avalanches), which is already done in the Mont-Blanc massif, but also the species of plants and animals that they encounter.

**In the coming years, guides and mountain leaders could develop a new set of skills as sentinels of the mountain environment.**

**These new iterations of our trade will never replace what has truly been the DNA of our profession for the last 200 years: accompanying our clients in the mountains, climbing over passes and up to summits, facilitating unique experiences and never forgetting the heart of our profession: ensuring safety at all times.**

## RECONSTRUCTING OUR IMAGE OF THE HIGH MOUNTAINS

**Since the birth of the guiding profession, we have helped construct a collective image and narrative of the high mountains and of mountaineering**[35]. The "invention" of Mont Blanc by Saussure erected the first cairns in this social history of the Alps. That path led us from a belief that the mountains were cursed, to a vision of them as terrain ripe for discovery and wonder, described by Gaston

Rébuffat[36] as an "enchanted garden". **For 200 hundred years, the Compagnie des guides de Chamonix has been a central protagonist in this story.**

**Our perception and image of the mountains has evolved over time, including in recent history**. This imaginary world has been created around symbolic elements of idealized landscapes (Fig. 35, 36): a snowy mountain forest, a snow ridge sculpted by the wind, an immaculate glacier, or a granite pillar reigning over a glacial landscape. **However, the facts are clear: if we continue to exclusively convey these images in connection with our profession, there is a great risk that we will not be able to deliver on the promise of this alpine fantasy in the years to come**.

These changes will not be immediate, **but our history inspires us to think beyond the days and weeks to come, toward the decades to come. The science outlined in the previous chapters shows us that by the end of this century, we will see the disappearance of glaciers below 3,500 meters, and potentially even higher, as well as a 70% reduction of snow cover in the Alps (Fig. 37)**. Though these anticipated changes depend in part on our GHG emissions in the coming years, some of them have already begun and are irreversible. **Our actions today will influence the scale of future impacts, but can no longer reverse these trends**.

This new context can make us nostalgic for the past, but as mountain guides and leaders we can rely on an important asset: **the true value of our profession is not based on snow and ice, but rather on enabling safe and meaningful adventures in the mountains**. Our trade is built on a foundation of shared experience and immersion in the world of the mountains. Snow and ice are not the determinants of alpine experiences, they are only one possible backdrop.


**Figure 36. Affiche de Samivel de 1970** (source: Amis de Samivel, Coll. Musée alpin de Chamonix-Mont-Blanc).

**Mountain landscapes will continue to evolve, but these changes should not call into question the richness of experiences**. Even 50 years from now, at elevations between 1,000 and 4,800 meters, we will still be able to find an exceptional diversity of species and environments, moving from montane forests to alpine grasslands, and finishing atop dramatic high summits - surely less snowy than they once were, but still challenging and conducive to mountaineering.

**Our challenge then is as follows: how can we develop a collective vision of the mountains that takes these changes into account, and communicates the beauty of all mountain environments rather than just the uppermost reaches of snow and ice? It is up**


**Figure 37. Aquarelles du paysage de la Mer de Glace en 2015 et en 2050** par l'artiste Claire Giordano, d'après les cartes de retrait glaciaire et de colonisation végétale à l'horizon 2050 (source : CREA Mont-Blanc).

**to us to convey a passion for adventure that is stronger than the effects of climate change that will continue to reshape the Alps**.

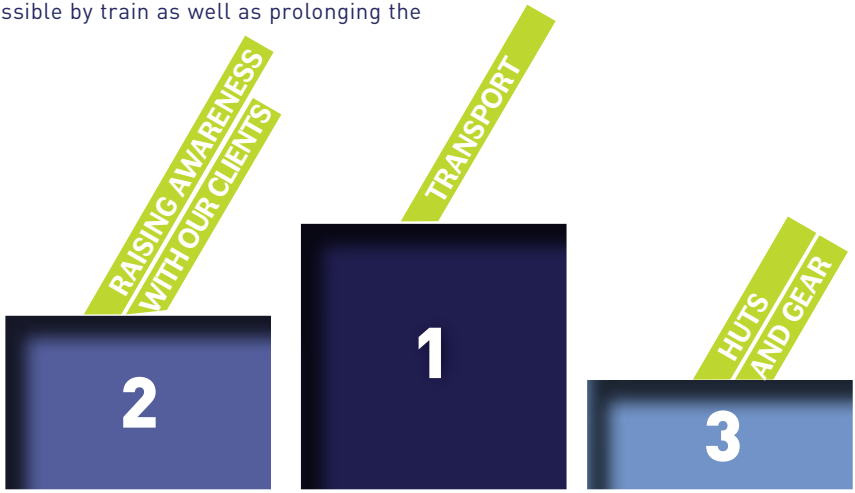
## REDUCING OUR IMPACT: A FOCUS FOR THE NEXT DECADE

**Guides and mountain leaders should not only adapt to climate change, but also participate in the collective effort to limit GHG emissions. The vast majority (86%) of the guides** who responded to the survey "Guides and climate change"[30] **said they were sensitive to the emissions linked to their profession**, and many of them highlighted an increasingly difficult paradox: working in an environment that is severely impacted by climate change while also contributing to those impacts. In addition, some climate adaptation strategies involve traveling further and more frequently in response to difficult conditions, meaning that guides are facing a new dilemma: continue to work or reduce their impact?

**The principal impacts related to guiding are linked to modes of transport for getting to the mountains**. The question of air travel remains the trickiest. Reducing the number of trips, favoring closer destinations and those that are accessible by train as well as prolonging the duration of trips are some of the mitigation strategies adopted by guides who travel. Many guides (64%) report implementing new practices to reduce their own GHG emissions, especially by carpooling with colleagues and clients (45%) and reducing the number of long-distance trips (25%).

**In the context of guiding in the Alps, emissions reduction strategies concern the guides themselves, but also their clients**. Guides are largely dependent on their personal vehicles to go to work, with the exception of guides that live close to trailheads, ski lifts and the start of climbs, including some guides from the Chamonix, Saint-Gervais or La Grave companies. **Simon Elias** provided his vision of a local approach to guiding:

**« We have a historic opportunity to adapt the guiding profession to the complex situation we are experiencing, and to take it in a new, more ethical direction that will allow both our trade and our passion for the mountains to stand up to the test of time. After 20 years of guiding, and to**




THE TOP THREE SECTORS IDENTIFIED BY THE MOUNTAIN GUIDES AND LEADERS OF THE COMPAGNIE DES GUIDES DE CHAMONIX AS PRIORITIES:

**bring my own career to a close, I want to restore the mountains to their original scale, to their remoteness and their majesty, and, in the minds of my clients, to plant the seeds of the respect, preparation and awe that the mountains deserve. In my own case, I have decided to limit my trips to a minimum, both in terms of flights and car travel to neighboring valleys, and to return from multi-day ski tours by train when possible. Beginning a trip from the base of the valley and without ski lifts allows me to experience a different reality, to create an adventure where one didn't exist before. With a local approach to the high mountains, I try to better understand the mountains and the glaciers that I can see from my window - less as an athlete, more as a shepherd."**

**Often, the largest impacts come from clients' travel to the Alps, oftentimes from far away**. Guides can play a role in finding locations that can be accessed by train or carpooling, at least for the final kilometers. In this regard, the Compagnie des guides de Chamonix has committed to proposing a discount to clients who travel to Chamonix using public transport, outside of air travel. In partnerships with hotels, trips of longer duration will also be encouraged and promoted to foreign clientele.

When we take into account the environmental impacts of client travel, another possibility is to encourage clients to offset the carbon emissions of their travel, or to make a donation towards the study or protection of the environment. The climate expert Jean-Marc Jancovici made an original suggestion: during an organized mountain outing, all of the different actors are remunerated (the mountain professional, the hut caretaker, the ski lift company, etc.) except the environment itself, even when it is the environment which provides much of the "service" to the client. **Finding ways to give back to the environment before, after or during our outings could constitute a promising opportunity for taking positive action in the years to come**.

Transport is not the only aspect of guiding that has an environmental impact. Despite significant efforts made by some outdoor brands, **textiles have a substantial environmental cost in terms of GHG emissions** linked to materials, manufacturing, and transport, in addition to their impact through use (shedding of synthetic fibers). The Compagnie des guides de Chamonix is exploring one mitigation strategy that would involve working with gear manufacturers and local repair services to implement clothing recycling and repair initiatives.

**As a general rule, actual time in the field guiding activities (skiing, hiking, climbing, etc.) generates minimal impact; the main impacts come from the services that facilitate the activities. Like outdoor clothing, mountain huts represent an important mechanism for reducing the GHG emissions linked to our work.** Concrete action is difficult to initiate and requires significant concertation between different socio-professional sectors and local decision-makers (Alpine clubs, hut caretakers, national and regional parks and municipalities).

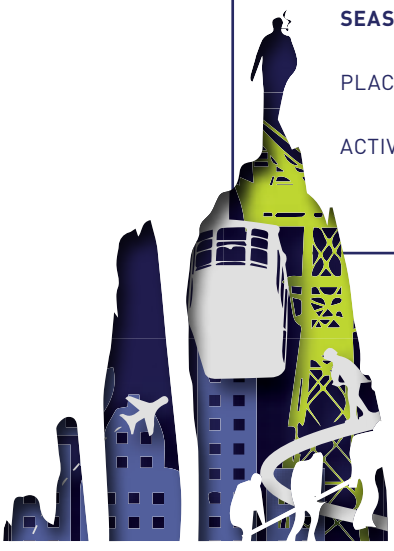
At this point, we have begun to consider different strategies for huts, which need to be analyzed with the needs and perspectives of different stakeholders in mind, for example: reducing the amount of meat included in meals, favoring the use of local water sources that can be purified, or when that is insufficient, providing huts with water in the form of giant tanks rather than individual plastic bottles, installing solar panels,

and improving wastewater treatment systems and installing composting toilets in huts where they have not yet been added. At the same time as concrete impact mitigation actions are being put in place, thanks to the **interdisciplinary research program Refuges Sentinelles, mountain huts are also becoming key locations for raising awareness** and involving mountain recreationists in citizen science programs aimed at observing high mountain environments.

**In huts and out in the mountains, guides and mountain leaders are responsible for educating their clients about the consequences of climate change in the Alps**. Oftentimes, our clients have substantial leverage and decision-making power in the business world or in other sectors of our society.

As guides, we have an important role to play as **environmental educators**. Nowhere else are the impacts of climate change as visible as they are in the mountains, which provide us with an ideal medium for presenting the direct impacts of human behavior on the environment.

**We hope that positive experiences in the mountains can strengthen or even establish links between our clients and nature, and motivate them to take action to preserve these exceptional places.**



| ADAPTATION STRATEGIES FOR GUIDES | |
|---|---|
| **SHORT-TERM** | **LONG-TERM** |
| **SEASON** | MODIFY THE EDUCATIONAL CURRICULUM |
| PLACE | VALUE EXPERIENCES OVER OBJECTIVES |
| ACTIVITY | BUILD A NEW NARRATIVE AND IMAGE OF THE HIGH MOUNTAINS |

**AND CERTAINLY MANY OTHER STRATEGIES TO COME....**

# Conclusion

## WORKING TOWARD SUSTAINABILITY: HOW DO WE KEEP THE DREAM ALIVE?

**Today, guides and mountain leaders find themselves at a pivotal moment in history**. We, mountain professionals, must ask ourselves questions that are both profound and complex. In the face of the rapid environmental degradation that we are witnessing on a daily basis, how can we limit our own impact? How can we take meaningful action at a local level in the face of a problem that is both massive and global? What is the future of our profession in a changing and unstable societal and environmental context? This publication cannot, on its own, provide exhaustive answers to all of the challenges posed by climate change and that go far beyond our field of action as mountain professionals, guide companies and national associations. However, we hope that in the context of the 200th anniversary of our profession, this document will help us **to take stock of the situation and inspire a collective discussion about the direction we should take in the years to come**.

**Historically, mountain guides have been able to overcome the main social and environmental difficulties that have, on multiple occasions, threatened the very existence of the the profession**: the calling into question of alpinism by the European aristocracy following the 1865 accident on the Matterhorn, two world wars, a loss of 50% of the glacial surface area since the beginning of the profession, and a recent and growing disconnect between humans and nature, just to name a few. Nonetheless, **the biggest challenges are surely yet to come**.

**The crises that society is facing today are inspiring a burgeoning desire and need for people to (re)discover the mountains**. In this context, we have a crucial role to play: allowing this new audience to learn skills, to escape daily routine, to safely experience new adventures, to test their own physical capabilities, to reconnect with nature, and undoubtedly for some, to discover a new passion or vocation.

**Fanny Tomasi-Schmutz**, mountain guide and leader of the **Groupe jeune alpinisme** Mont-Blanc (Mont-Blanc youth alpinism group) attests to the enthusiasm expressed by the next generation of mountain recreationists and professionals:

**"Despite the bleak reports, the passion for climbing and the desire - the need - to spend time up there will always exist. We will adapt to changes by modifying our relationship to seasons, activities and certain places...We will invent new practices and new ways of guiding our clients. Given that the young people in our training program are just as starry-eyed as we are when they talk about the mountains and about alpinism, perhaps the future of our trade and shared passion for the mountains is not so bleak after all!"**

The mountains will always be there to inspire us and enable incredible shared experiences. Ultimately, we are the source of uncertainties about the future of guiding and alpinism: will we be able to adapt our perceptions and our activities to mountains that are changing? To maintain space for risk and for adventure in our society? To maintain the opportunity and in some ways, the luxury of being able to spend

time up high ? And finally, to implement the ecological transition that is necessary for saving not only mountain environments but in the end also our own habitat?

In **1989**, the alpinist Walter Bonatti had already understood that the environmental crisis is first and foremost actually a human problem[37] :

**"We lament that things are going badly, but in the final analysis we ourselves are res ponsible, all of us: we are like so many drops of water making up an ocean. At the very start of any wide-ranging, practical discussion aiming to conserve nature, we must never forget that only by conserving humanity itself, and our ethical and cultural heritage, will we come to protect the environment in all its complexity...We must become ever more human and more moral, if we wish to survive in the "new world" we alone have created, for ourselves."**

The words written by Bonatti 30 years ago confirm that **understanding is one thing, but effecting profound change through our actions and our collective decisions is quite another. We are, today, aware of the facts. Now, the most important work lies ahead**.

**BEAR WITNESS • ADAPT • REDUCE OUR IMPACT**

## ACKNOWLEDGMENTS

The authors of this work owe a debt of gratitude to Laure Decomble at the Chamonix Alpine Museum, as well as to Françoise Simond, Anne AgenÐs and Christine Boymond Lasserre at the Amis du vieux Chamonix for the essential role they played in providing historic iconography of the valley. We also wish to thank the teaching staff at the École nationale de ski et d'alpinisme (ENSA) for initiating many inspiring discussions upon which Chapter IV was based. A hearty thanks also to Martine Colonel for her warm welcome and help at the ENSA Library. Finally, we are grateful for the contributions of our guide friends and colleagues who participated in many informal exchanges about these subjects, and who took the time to respond to the different questionnaires sent out about the environment.

This work is dedicated to Anne Revilliod, who was a key advocate of mountain risk prevention and who worked tirelessly to raise awareness about the impacts of climate change in the Chamonix valley. Victim of an avalanche in the Fiz massif in February of 2021, she worked for 20 years as the energetic leader of the "Pôle montagne risk", a vital information and training center at La Chamoniarde, which is a nonprofit mountain rescue and risk prevention organization. Anne was known for her talent and insight; she knew how to communicate important messages about risk prevention to tens of thousands of students, young outdoorsmen and women, and visitors to the valley.

Anne Revilliod

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## PARTENAIRES PRINCIPAUX

## PARTENAIRES.

Livret réalisé dans le cadre des 200 ans de la Compagnie des guides de Chamonix,
en partenariat avec le Syndicat national des guides de montagne (SNGM).

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