Chapter 5

Weather, Agency and Values at Work in a Glacier Ski Resort in Austria

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Our existence is literally melting away.

—Fieldnote, 8 August 2015

Reinhold, the chief technical manager of the Pitztal glacier ski resort in the Tyrol, western Austria, once more raised his concerns about the retreating glaciers and snow cover. It was the summer of 2015. We were standing in the open air at around 2,900 m elevation, when this local man, in his mid-fifties, explained the profound changes that had been occurring in the landscape around us. He pointed around the surrounding area, describing how far the glaciers reached when he had begun working in the resort in the 1980s. Since that time, all the local *Ferner*[1] (the regional term for glaciers) had been steadily shrinking, as indeed had all of the glaciers in the huge Ötztaler Alps area along the Austrian and Italian border.

During my fieldwork in Pitztal, I frequently heard similar concerns to those of Reinhold voiced by other men working in this alpine cryosphere environment. In many of these narratives, as in those of the wider local population, glaciers and snow often appeared as powerful and dangerous forces of nature. According to many, people 'go along with nature'[2] and its power. It provides their livelihood and it can bring happiness just as much as it can present them with danger, challenges and worries. Exposed to such meteorological and natural forces, workers in the glacier ski area strive simultaneously to control, manage and even dominate the 'otherness of the weather' (Hulme 2015) as much as possible. In doing so, they specifically aim to provide 'snow reliability' to the many thousands of tourists visiting the resort.

I propose that snow, like a glacier, is a unique and forceful materialization of the atmosphere and the weather. I conceive of it as a vital materiality. Similar to crevasses, icefalls, glacier-outburst floods and glacier fractures (Beniston et al. 2018; Carey 2007; Sökefeld 2012), avalanches, snowstorms, rapid snow-melt or extensive snowfall may endanger living beings, the built environment and infrastructure (Arbeitsgemeinschaft österreichischer Lawinenwarndienste 2017; Mergen 1997; Stoddart 2012). Political theorist Jane Bennett elaborates a conception of the 'vitality of materiality', or what she calls 'thing-power', in which 'vitality' indicates 'the capacity of things – edibles, commodities, storms, metals – not only to impede or block the will and designs of humans, but also to act as quasi agents or forces with trajectories, propensities, or tendencies of their own' (Bennett 2010: viii). Following Bennett's ideas, through its vital capacity, snow can not only impede or block the intentions of humans – it can also act as a power or force of its own.

Humans have been fascinated by snow throughout history and across cultures (Kirk 2013; Mergen 1997). The white appearance of snow and winter landscapes, and the former's capacity to transform quickly from soft to hard, fluid to frozen and back again, as well as its awesome, troublesome and dangerous powers, have led humans to attribute to snow a rich variety of cultural meanings, social significances and the status of a living being (Diemberger 2013; Glowacka, Washburn and Richland 2009; Gorman-Murray 2010; Kotnik 2007; McGibbon 2000; Pechtl 2015; Stoddart 2012). Western sciences for a long time viewed snow and glaciers as 'dead matter', sterile and inhospitable, though they are now acknowledging their physical vitality (Sattler, Sipiera and Psenner 2006). The vital and flexible character of snow makes it an essential atmospheric, geological and ecological actor in climate shaping, landscape and glacier formation and soil humidification. Its social and cultural capacities are no less significant, as it can act as a conduit for such vital things as lumber, sledges and snow mobiles, or people such as hikers, hunters and skiers. Conversely, it can impede the movement of humans and of modes of locomotion such as cars, trains, tractors and aircraft. In the destructive force of blizzards and avalanches, snow can destroy humans, animals, forests and the built environment. Lastly, declining natural snowfall and retreating snow cover, which are regarded as prominent casualties of global warming, have the potential to destabilize the skiing industry, which is very important for the national and regional economies of Austria.

At the same time as being a highly active and powerful materiality, snow is rendered as an abundant cultural material, a multivalent resource and a social issue by humans, who cultivate it in multiple ways, as will be discussed later. Local experiences with snow, together with vernacular forms of knowledge about it and the increased scientific knowledge gained since the early twentieth century, have enabled the cultivation and management of snow in substantial ways – or, to put it in Tsing Lowenhaupt's words: 'The agency of nature in affecting human affairs develops in tandem with human abilities to know it and manage it in particular ways' (2001: 6).

The multifaceted relationship between snow and humans, two vital bodies (Bennett 2010) acting upon and affecting each other in multiple ways, will be the topic of this chapter. In order to give the human–snow interconnectivity a theoretical frame, I will, as already mentioned, draw on Bennett's theorization of a political ecology of things beyond the human–nonhuman and life–matter binaries (Bennett 2010: 10), as well as proposing a theory of the distributive agency of the human–nonhuman congregation. In contrast to the dominant strand of political ecology, which often does not explicitly deal with theories of materiality or material culture, Bennett makes a plea for a change in environmentalist rhetoric towards 'vital materiality' in order to challenge the human domination of nonhumans (Martínez-Reyes 2017). During my anthropological fieldwork, I witnessed, again and again, that ski areas are highly moralized and politicized from diverging standpoints. For instance, environmentalists have accused ski-resort companies of 'destroying nature' or 'polluting the environment' by expanding ski areas and snow-making infrastructure. In turn, representatives of the ski areas have rejected such claims, blaming environmentalists and environmental laws for jeopardizing the stability and future of economically and demographically threatened alpine regions. In her theory of distributed agency, Bennett (2010) criticizes such blame games, though without depoliticizing things. This makes her theory attractive when discussing the multiple and distinct standpoints.

In this chapter, I take the glacier ski area of the high alpine valley of Pitztal, where I have conducted research on the anthropology of snow and issues of vertical globalization,[3] as an ethnographic case study. I focus on the mutual dynamics that emerge between its workers and the environment of snow and ice. I undertook several periods of fieldwork between 2012 and 2016, ranging from two to six weeks in length, in a number of different places within the Pitztal valley. Although I visited the glacier resort in each of these stays and made a broad range of contacts, formal fieldwork on the glacier itself was carried out during the winter season of 2014 and in the summer and early autumn season of 2015. The warmer season is actually the most intensive time for the workers, so my seeming paradoxical choice of timing to research snow and ice issues was perfect for learning more about occupational engagement in the alpine cryosphere.

Human–environmental dynamics in alpine cryosphere environments have only received scholarly attention in the last decade or so (Dunbar et al. 2012; Elixhauser 2015; Huggel et al. 2015; Strauss 2009). This has been primarily prompted by the profound changes and risks occurring in the alpine cryosphere due to the changing climate. Retreating glaciers and snow cover have been described as some of the most significant signs of global climate change (IPCC 2013). However, there has been almost no anthropological enquiry focusing on glacier ski areas. This is perhaps surprising because, as I argue, they provide a good site and entry point for learning more about such dynamics. In particular, they are outstanding places to gain new insights into the multifaceted processes, discrepancies and paradoxes shaping the human–snow–cryosphere relations in the European Alps, which are deeply shaped by global tourism. Glacier ski areas provide numerous sites that are specifically defined for use by a variety of people, both 'enclavic tourist spaces' and 'heterogeneous tourist spaces' (Endensor 2000) for ski tourists, open common spaces for alpinists and other visitors (especially in the warmer season), and, last but not least, open areas of environmental commons, such as water resources. This chapter highlights their significance for local people as 'occupationscapes', 'defined as landscapes formed and performed through histories of occupational behaviour' (Hudson et al. 2011: 21). This concept articulates the structural and political dimensions of landscape formation through labour and shares certain similarities with the phenomenological approach to landscape proposed by Ingold in his conception of a 'taskscape', in which 'the habitual practices of humans form familiar patterns which can become landscapes or places' (Hudson et al. 2011: 29) – or, to put it in Ingold's words, 'tasks are the constitutive acts of dwelling' and 'the entire ensemble of tasks, in their mutual interlocking' (Ingold 1993: 158) designate the concept of 'taskscape'.

Taking the abundant potentialities of snow and various other nonhuman quasi-actors along with the local workers' engagement into account, I intend to illuminate the multifaceted interactions that take place in the alpine cryosphere environment and the distribution of agency among humans and nonhumans within it. In doing so, this chapter aims to contribute to the understanding of a political ecology of snow and ice that gives nonhumans a position more comparable to that of humans.

Having clarified my approach and focus in this introduction, I will now outline the importance of snow as an economic resource in the Pitztal. By highlighting the local commitment to tourism and the value thereby generated for the 'white gold', I will show how it has contributed to the socioeconomic transformation of the Pitztal region from extremely poor to wealthy. In the subsequent section, the main part of the chapter, I explore the multifaceted dynamics characterizing the relationship between the workers in the glacier ski area, the majority of whom are men (see Carey et al. (2016) on gendered dimensions of knowledge production about glaciers), and the snow and other vital materializations of daily weather and of climate change. In my discussion of the manifold practices of snow management in the glacier ski resort, I explore the economic and social significance of, and values arising in, the encounter between the forces of snow and weather, and the various social and political attempts at controlling the weather. In the conclusion, I will sum up the main analytical findings.

Commitment to the 'White Gold' in Pitztal

As in many regions in Austria and elsewhere, in the Pitztal valley, snow provides the dominant rationale for the regional economy and identity. Snow constitutes the most important occupationscape, both for the local permanent residents and the significant numbers of seasonal migrants, who currently come mainly from Eastern European countries. Of the more than 400 ski resorts in Austria, three are located in this valley and one of these is the glacier ski area. These resorts were established between the late 1960s and the early 1980s. Although there was already some alpine tourism in the Pitztal in the nineteenth century (Pechtl 2005), modern winter tourism was initiated by provincial politicians, together with local inhabitants, in the 1960s, a decade later than in neighbouring regions. The former mentioned shared the socioeconomic and political aim of reviving the Pitztal, which at the time was extremely poor, and hoped to give its economy a more secure footing. This ambitious goal was expressed in the following commitment by local shareholders of the mountain railways in 1966: 'We will put our existence, our future, and all of our energy into tourism' (Hochzeiger Bergbahnen 2009: 6).[4] The four political communes of the Pitztal, which together currently have around 7,500 permanent residents, have since that time undergone profound socioeconomic change. They have been transformed from an extremely poor high-alpine region that in the past had an economy primarily based on agriculture into one whose wealth now derives from a service-based tourist economy. Just as in many other alpine regions, the newly discovered economic value of snow (Denning 2015) has led Pitztal inhabitants to refer to it as 'the white gold'. Tourism is supplemented by some small-scale trade and farming, mainly as a sideline, and alpine-pasture farming, which is mostly integrated into tourism. In the past there had been a pattern of seasonal (though increasingly permanent) out-migration by local residents. Tourism has brought stability to residence levels and even an increase in the population in the past few decades. However, while there is some small in-migration, out-migration has recently increased again and poses a degree of threat to the Pitztal, as it does to other alpine regions in Austria and elsewhere. Therefore, the commitment to winter tourism continues to have great economic, social, cultural and emotional power in the Pitztal. This commitment has led to the transformation of snow into a commodity circulating within the circuits of the global economy and global cultural flows.

However, this far-reaching commitment to mass-tourism skiing has in the past few decades come to be contested, due to the concomitant profound human interventions in the landscape and the changing climate, as will be discussed below.

Working with and against the Forces of Snow and Ice

Glacier ski areas share many similarities with ski resorts in nonglaciated areas, such as lift and restaurant infrastructure, piste management, snowmaking and safety measures for skiing. At the same time, they differ from them in several respects: among other things, the unique atmospheric, climatic and ecological conditions that characterize their environment. As I experienced and witnessed throughout my fieldwork, elevations of 3,000 m and above pose myriad challenges to human physiology and health, to technical apparatus,[5] to snow-making technology (see below) and to many of the plans humans make in order to engineer the cryospheric landscape.

Although glaciers in general have been shrinking since the end of the Little Ice Age in the nineteenth century, since the mid-1980s, glaciers worldwide have undergone a more or less dramatic retreat (Bender et al. 2011: 407). Glacial loss and lack of snow cover not only affect ecological balances, but also impact directly on people living in the vicinity, affecting their local economies, regional and global tourism, modes of perception and senses of place (Cruikshank 2005; Dunbar et al. 2012; Orlove, Wiegandt and Luckman 2008; Wiegandt and Lugon 2008). The retreat of the glaciers in the Ötztaler Alps, which are (still) home to the largest end-to-end glaciated area of the Eastern Alps in Europe, is particularly drastic (Fischer 2017).[6] Nevertheless, glacier ski areas are marketed to tourists as providing 'true snow reliability' when compared with resorts at lower elevations. In a similar vein, due to their high-altitude locations, glacier ski resorts have been mostly considered in climate research and tourism as exclusive future skiing reservations. Climate-research models project that ski areas in Europe located below 1,200 m will disappear towards the end of the century (APCC 2014: 16, 25; Marty et al. 2017), though a recent study has revealed that there may also be a decrease in snow depth of about 50 per cent for elevations above 3,000 m by then (Marty et al. 2017). This echoes Reinhold, who finds it difficult to imagine the Pitztal glacier ski area as having reliable snow in the long-term future: 'We will have to make even greater efforts and fight even more on the glacier in ten or twenty years. We will need more equipment and more staff' (interview, 8 August 2015). Heinrich was convinced that there will still be skiing on 'their' glacier in the next few decades at least. The high altitude combined with snow depots (huge hills of harvested snow – for details, see below) and snow-making would continue to make it possible. However, unlike Reinhold, he considered the elevation to be one of the most important criteria in this respect. However, the reliability of snow also depends on the geographical orientation of specific slopes, as was also emphasized by Reinhold.

Glacier ski areas incorporate a whole range of legal provisions (including environmental assessment regimes) and standard operating procedures as a prerequisite for their establishment and maintenance. Many of these regulations relate to particular weather, ice and snow conditions. Familiarity with these regulations is very important when carrying out field research in order to fully comprehend the diverse tasks and narratives of the workers. Among other criteria, rapidly changing weather, snow and ice conditions must be monitored several times a day by the staff in order to make, and keep, the ski area safe for skiers. Beside the daily weather forecast, measurement of the wind is especially crucial, as members of the technical staff are individually responsible for immediately stopping the lifts once the wind speed becomes a risk factor. To put it more precisely, the unique and rapidly changing wind conditions at high elevations directly impact on the safety of mountain railways and hence on the security of humans and the stability of business economy. Thus, the relevant staff need to acquire and apply sound knowledge about the weather and wind, among other things, and must observe them in detail. More recently, staff have begun to use wind-sensing technology affixed to the cable-car pylons to measure wind force. Depending on the position of the lifts, their weight and the cable technology, they must be shut down once wind velocities reach 40–80 km per hour. Some workers report that many tourists do not understand that it is necessary to stop lifts under these circumstances and they complain aggressively that they have paid for their lift tickets. The movement of glaciers, crevasses and the breaking-up of ice are further potential dangers to skiers, and thus must also be monitored and appropriately managed (Amt der Tiroler Landesregierung n.d.: 21–22).

In particular, so-called ‘atypical dangers’ such as avalanches, a piste entirely freezing, crevasses that cannot be filled in or ablation (i.e. the melting of snow and ice cover over large areas) must be constantly safeguarded against and/or eliminated. If this is impossible, then pistes must be closed (Amt der Tiroler Landesregierung n.d.: 23). In the early years of the Pitztal glacier ski area, the workers frequently had to experiment with different methods to find the most suitable for dealing with such circumstances. Through trial and error, they discovered, for instance, how to fill crevasses with snow and ice rather than with other materials such as straw. When glaciers move, they have an impact similar to that of melting permafrost and destabilize the towers of the T-bar lift. As a consequence, each year workers must adjust and relocate the lift towers. Ablation poses another challenge, as I saw during my fieldwork. Bare rock, debris or permafrost soil appears in ablated areas, which must then be adapted into a ‘piste-friendly’ base by flattening the ground. Drilling and blasting technologies are used to break up the rocks and vast amounts of stones are removed in trucks. In this context, workers would warn me, again and again: ‘Pay attention and keep away the next few minutes!’

While these tasks are mainly defined by provincial piste-security regulations, other practices, widely described as snow management, have emerged from the economic and competitive imperative for ‘snow reliability’ and are interrelated to the changing global climate. These are regulated by environmental assessment legislation. However, both categories of practice intersect with each other, insofar as they share the safety of tourists and piste security as their prime principles. ‘Snow reliability’ in ski resorts has received the greater attention in studies of tourism and climate change and its impact on the cryosphere since the turn of the millennium (Mayer, Steiger and Trawöger 2007). Among other effects, glacial retreat and permafrost degradation in alpine rocks, debris and soils are considered to be major hazards in alpine regions. They cause the break-up of rocky slopes and consequent rock falls that endanger the built environment and infrastructure, and cause casualties (Krautblatter and Leith 2015: 147). To Heinrich, who is in charge of piste security, melting permafrost poses the most serious problem:

> Really my biggest concern up here is the permafrost … This is very dangerous because you never know when it starts falling apart. But once it is melting, the rocks break apart and rockslides then become a big danger to our guests and all of us … I know when and how to trigger avalanches for security reasons.

> But we do not know how to deal with the melting of permafrost except by covering some areas with textiles. (Interview, 14 November 2014)

From a somewhat different perspective, which is shaped by his senior management position, Reinhold has identified three major problems facing the company:

> We do not have sufficient snow. We already need to make it snow up to 3,000 m. As you can see, we do have the snow depots and the snow cannons, but at the same time we do not have enough water for making snow. And another problem is our enormous energy needs and the extremely high costs of it for the company … However, with our photovoltaic solar power plant we will save money. (Interview, 5 December 2014)

Making Snow Reliable: Practices and Values

Against this backdrop of challenges, problems and dangers facing the company's workers, in this and the next section I describe the three most important practices of making 'snow reliable' and the pistes secure on the Pitztal glacier ski area (which is similar in this respect to many other glacier ski resorts). These are making snow depots and covering these with geotextiles,[7] covering sensitive and dangerous areas of the glacier and permafrost with textiles, and making snow by means of technology. As I will demonstrate, this mixture of practices can be understood in terms of Lévi-Strauss' notion of 'bricolage' (Lévi-Strauss 1966): different available materialities are combined with a variety of experimental and technological or scientific forms of knowledge to ensure snow reliability. While these practices are mainly linked to the economic value of snow, I show that they also have social significance and value for the workers.

The most crucial practice in providing 'snow reliability' takes place at the beginning of the season in September and consists of making pistes out of the snow stored in huge outdoor depots. These are made by workers either during the season, or at its end in May, when they use snow groomers to collect the snow, ready for redistribution again in August and early September. Once distributed, this snow has the appearance of thick (50 cm) white stripes running across the brown-grey rocky landscape. This method has been in use for more than a decade. This harvested snow comprises two-thirds natural and one-third technologically produced snow, which together amounted to approximately 3,000–4,000 m^3 in 2015. These depots present a materialized assemblage of natural snow, the bacteria within it, glacier water and the technical snow that is made from it, weather, human labour, snow-making technology, snow groomers, diesel, textile materials and, last but not least, environmental legislation. Moreover, they are of social significance to workers, as illustrated by Heinrich, who emphatically stated: 'These depots stand for my job future!' (fieldnote, 29 July 2015). What is important to note in his statement is the double meaning that for him, the snow depots are both powerful representations of snow reliability and of his secure occupational future.

Depending on the weather, producing the snow depots takes between four and six weeks. Once collection is complete, the workers cover the hills with large white geotextiles in order to prevent the snow from melting too soon. During my fieldwork stay in 2015, there were seven such huge hills of snow awaiting distribution and 7.5 hectares of textiles were protecting them. Usually the textiles can be reused for three seasons. However, as was explained to me by Heinrich, some covered snow depots might, depending on the natural snow cover on the glacier, stand there as long as three seasons without melting. However, snow conditions were different in 2015, when Heinrich lamented: 'There was nearly no snowfall this summer. It might be then that there will not be enough snow in the depots to open in September. However, if so, then we must go along with nature and not against it.' 'And what does this mean?', I asked him. He responded: 'It means that we have to open the season later' (fieldnote, 29 July 2015).

In addition to the snow depots, certain glacier and permafrost areas are also covered with textiles during the summer period. The aim of this is to prevent the ice and permafrost from rapid melting and to keep the pistes safe. The specific 'sensitive' and dangerous zones protected in this way are around the ski-lift towers, the rocky outcrops on the glaciers, and retreating and collapsing glacier terminuses (Mayer, Steiger and Trawöger 2007: 165; Olefs 2009: 35). The covering method has been exploited at various lower glaciers in Europe since the mid-1990s (Mayer, Steiger and Trawöger 2007: 165 fn. 12), but the fleece textiles were first used in Austria, including in the Pitztal glacier resort, in the early 2000s, as a consequence of the extremely hot summer in 2003 ('Ein Pflästerli für die Gletscher' 2006: 8). This was before glaciologists from the University of Innsbruck had experimented with project with different textiles to protect glaciers in ski areas in Austria, including the Pitztal, between 2004 and 2008. This research has shown that the covering method resulted in a 60 per cent decrease in ice and snow ablation (Fischer, Olefs and Abermann 2011: 95). These scientific findings were echoed in the narratives of several glacier workers when they attributed a social and ecological value to the snow-management practices. 'We are sometimes blamed by environmentalists for destroying the glacier', Heinrich emphasized with strong feeling. He continued: 'But the opposite is the case. We are protecting the glacier and caring for it!' (fieldnote, 29 July 2015). However, as he and others stated in various conversations, it is impossible to cover the whole glacier and so stop it melting. In contrast to the research cited above, the use of textiles has been criticized by ecologists and environmentalists. According to their critique, textiles mar the appearance of the landscape and impact negatively on the micro-organisms of the snow and ice (see Bundesministerium für Wissenschaft, Forschung und Wirtschaft (2017) on research project Cover Up). These distinct and competing scientific standpoints are reproduced in the differing national-regional environmental regimes on the use of textiles: in contrast to Switzerland, for instance, where covering with textiles must be approved by the respective canton's planning administration ('Die Gletscher sind wieder abgedeckt' 2013), in Austria it is defined by environmental regulations as part of the maintenance of a glacier ski area (Bundesministerium für Wissenschaft, Forschung und Wirtschaft 2017).

Snow-Making: Attempts to Imitate and Modify the Weather

Unlike the use of snow depots and textiles, snow-making by means of 'modern' technology goes back as far as the 1930s. The first experiments were initiated in a laboratory in Japan by the physicist Ukichiro Nakaya, whose research on the composition and capacities of snow is still relevant for today's meteorologists. The current broad range of experiments with snow-making and its widespread application globally are opening up global trajectories of weather modification (Nöbauer 2017, 2018).

Snow-making can be conceived of as a sociotechnological-ecological system shaped and driven by a political ecology. The political ecology consists of numerous actors and quasi-actors standing in particular relations to each other. The most significant human actors include lift-company shareholders, ski-resort managers and workers, as well as various experts, such as technicians and researchers, and managers within the construction and snow technology industries, environmentalists and political administrators. An essential precondition and effect of enabling the snow production described above are the consumers, the tourists and competitive sportspeople who ski on the snow. The most prominent nonhuman actors are the weather forces, weather-measurement technology, environmental-impact assessments and water legislation; also relevant are vast amounts of water and the infrastructure for storing and distributing it, energy and the infrastructure for producing and distributing it, machinery for making snow (primarily snow cannons) and, last but not least, the computer systems that control and activate the daily making of snow.

The physical principle of snow-making imitates natural snowfall. The formation of snow basically relies on a specific interplay of air and wind, to which water and energy are added by humans using technological means. To produce snow, the water droplets that are sprayed out from snow cannons under high pressure must freeze. Cold air temperature (usually between -4 and 0°C), low relative humidity and cold water temperature (around 0°C) are essential conditions. The drier the air, the more snow can be produced. Large amounts of water and energy are required for this process. The water is taken from communal water sources, collected in large, specifically constructed pools and then pumped through a wide network of pipes to the snow cannons. Snow-making may be activated by a fully automated computer system or manually by workers. The quantity and quality of water used is strictly regulated by provincial and national legislation in Austria (see below). Glacier water is used for snow-making in the Pitztal glacier resort. Two-thirds of the energy required is taken from the Tyrolean power grid (widely based on hydropower) and one-third is derived from the glacier company's own photovoltaic solar-power plant. Thus, to be precise, it is not the snow itself that is technical; rather, it is the application of technology and energy to make snow out of water that can be described as such. The glacier workers, like many people in Austria, use the term 'technical snow' instead of the more widely used 'artificial snow'. Like some of his colleagues, Heinrich emphasized this difference in several of our discussions: 'There is nothing in it; I mean there are no chemicals or the like in our technical snow. It is not artificial snow. We have very strict regulations' (fieldnote, 14 November 2014). Here he is referring to the specific legislation regarding snow-making in Austria, which prescribes both the quality and quantity of water to be used. While I will return (below) to the Tyrolean government's water legislation known as the Wasserbuch (literally, 'water book'), at this point I need to explain the so-called 'water purity rule' cited above by Heinrich. According to the Austrian Industrial and Commercial Standards ÖNORM (No. M 6257), ski areas are obliged to ensure the use of good-quality water so as to protect the soil and the health of skiers, and children in particular. As a consequence, chemical or bacterial additives are prohibited. Countries such as Italy and Germany share this commitment. By contrast, other countries, such as Switzerland, Canada and the United States, permit the use of chemical additives in snow-making.

Snow-making has given rise to a significantly broader and stronger critique of its ecological impact than has the use of textiles. This is primarily due to its high consumption of energy and water (de Jong 2013; Gross and Winiwarter 2015). A whole range of scientific and technological projects have been established in Austria and elsewhere to reduce the amount of energy and water used. Contrasting environmentalist standpoints are echoed by equally contrasting scientific discourses on snow-making. However, the different environmental legislative frameworks related to the use of water and the diverse energy sources (fossil fuels, hydropower and solar power) are often not taken into account in the controversy about the ecological impacts of snow-making.

Around 67 per cent of all ski pistes (which in total amount to around 23,700 hectares) are currently supplied with technically produced snow in Austria (WKO 2016). This high percentage puts Austria, together with Italy, among the leading countries in Europe in the use of human-made snow for alpine ski tourism. Ski-lift companies consider snow-making indispensable for securing winter tourism. Annually, they invest approximately €150 million into snow-making infrastructure (WKO 2017). Meanwhile, the snow-making technology industry has entered the global economy, with an annual turnover in the billions of euros. In the province of Tyrol, which has by far the most ski areas in Austria (totalling 7,300 hectares), nearly all slopes are supplied with technically made snow (Steiger and Abegg 2015: 323). All three ski resorts in the Pitztal valley use snow-making systems. However, each has a distinct technological system at work: one resort employs a fully automated system operated exclusively by computer systems, while two (including the glacier resort) have adopted a technological mixture composed of manually operated and part-automated snow cannons. Workers on the glacier need to check the temperature and air condition, and physically move the snow cannons within the landscape. In addition, a unique machine otherwise found only in Switzerland, called the 'all weather snow-maker', is installed on the glacier (see below). On the glacier, around 15 per cent of its 85 hectares of piste is supplied with technically produced snow. Compared with the Austrian average, and with other (glacier) ski areas,[8] this proportion of technically made snow is rather small. However, the snow-making is frequently seen as surprising for somewhere at such a high elevation. Many people would expect there to be sufficient natural snow cover on Austria's highest glacier ski resort – even more so as it is marketed as an area that still has natural snow reliability.

Nevertheless, snow-making on glaciers is not a recent innovation. It was already used on a few glacier termini in the 1980s. What is new, since the mid-1990s, is its employment for economic reasons at high elevations. These areas hold sufficient natural snow cover, but are supplemented with technically made snow so that the ski-lift companies can plan a definite opening to the season in September, when there is otherwise insufficient snow to cover the rocky base (Mayer, Steiger and Trawöger 2007: 161–63). This economically driven provision of 'snow reliability' in autumn thus correlates with 'technical snow reliability', as Steiger and Mayer (2008: 292) term it. The first snow-making system (based on snow cannons) was introduced on the Pitztal glacier in 1991, ahead of the trend elsewhere. However, a couple of workers already retrospectively associated this early installation with 'climate change' in their accounts to me during my fieldwork. The retreat of glaciers back then had already begun to disrupt the courses of the slopes. Facing these changes, and the decrease of skiers during the summer, the company decided to reduce the skiing season from twelve to eight months.

The subsequent turn to snow-making in the early 2000s was aimed at 'beschneien' (literally, 'snowing on' or 'making it snowing'), even on huge areas of glacier. Tourism researchers have identified this latest employment of snow-making as an effect exclusively caused by global warming (Mayer, Steiger and Trawöger 2007: 161–62). A recent scientific study even claims that the albedo ('whiteness' reflectivity) effect[9] caused by snow-making could to some extent be an effective method of inhibiting climate change (Schwaiger et al. 2017).

In addition to the snow-making system using snow cannons in the Pitztal glacier ski area since the early 1990s, another specialized piece of technology was adopted in the autumn of 2009. While it is largely based on the same network of snow cannons, it is organized around a huge and multi-ton machine called the 'all-weather snow-maker', which is fixed into a building specially constructed for it, at an elevation of around 2,900 m. As its name indicates, the machine, which made a long and challenging journey from Israel to the Pitztal glacier, works independently of the weather and is capable of producing snow even at ambient temperatures as high as 30°C. The desire for such weather-independent technological capability on a glacier attracted my interest from the very beginning of my research on snow and in fact prompted my decision to conduct fieldwork in the Pitztal in particular. The 'snow-maker', as it is called by the workers and the majority of local people, is, in contrast to the snow cannons, based on vacuum ice. The principle of transforming water into ice and snow by using a vacuum has been applied in various extreme environments and at varying heights and depths (such as in sea-water desalination and gold mining) in different regions of the world. After the resolution of countless problems due to its emplacement at high altitude, in 2009 it began operation for the first time in the alpine cryosphere environment (for details, see Nöbauer (2017, 2018)).

A few workers expressed their ambivalent attitude towards the snow-maker in their conversations with me. Even though they did not deny the importance of snow-making with snow cannons, they criticized the power consumption of the snow-maker as being 'much too high'. Heinrich explained that this machine goes 'against nature because it would be unnatural to have snow at warm temperatures' (interview, 14 November 2014). According to him, 'technology should always go along with nature and not against it' (interview, 14 November 2014).

In these final passages, I will illustrate how the vitality of the glacier water and the water legislation are appearing, as powerful actors and quasi-actors, so as to block both the all-weather snow-maker and the glacier managers' plans. As the snow-maker is enclosed within a building and was inaccessible to me during my previous stays, by the time of my fieldwork in 2015, I was curious to witness its snow-making procedure. Its operation was expected to start one month before the intended opening of the season. However, I was to be disappointed because I could see only occasional, small batches of snow slowly 'spat out' and transported on its conveyor belt to the outdoor space. I had heard from a few workers that 'there would not be enough glacier water' and that the snow-maker 'would not be compatible with the glacier water'. I asked them and myself: 'What does this mean?' It took me some time to find the explanation for this awkward relationship between glacier water and a machine meant to bring independence from weather. The difficulty was grounded in the vital materiality of glacier water and water legislation. These two entities have the power to impede and block both the seemingly autonomous will of humans to engineer the cryosphere landscape and a form of technology associated with autonomy from the weather. The first power arises from glacier water, which has a high potential to impede and block by its very nature because it carries debris and sand from the rocky environment. When glacier water passes through the pipes to the vacuum pump inside the snow-maker's building, the debris in the water is sedimented on the wings of the vacuum pump, transforming into a kind of cement. The dried, hard material regularly blocked the pump. A worker was responsible for removing this cement and cleaning the system, again and again. The second power emerges from the environmental impact assessment and water policy, as regulated by the Tyrolean government's Wasserbuch. Both can and must be considered as materialities that are able to impede or block either the entire construction of a water-storage system or the use of water for snow-making. During my fieldwork stay, the glacier company's managers were stressed and angry that they had to wait for a considerable period of time for the formal permission to expand the water sources that were to be taken from clean spring water. However, they have still not received this permit by the end of 2019 (Reinhold, personal communication, 7 December 2019). In order to cope with the ongoing problems that the glacier water was causing to the all-weather snow-maker, the company thus decided, after the end of my fieldwork, to modify its water storage pool. The proposed new pool material and technology would be able to significantly dispose of the sediment in the pool (Reinhold, personal communication, 14 September 2017) so that it would no longer block the pump. It is important to mention that the water policies would have no power were it not for the actions of the environmental activists and the political administrators of environmental regimes. However, to put it another way, these humans' activities would be less effective if they were not able to rely on legislation. Agency here is distributed among manifold humans and nonhumans.

Conclusion

This chapter has focused on the dynamics emerging between the vital forces of the weather and workers in the Pitztal glacier ski area in the Austrian Alps. Taking Bennett's theory of vital materiality as a starting point, I have considered snow as a vital materialization of the weather and of climate change. In doing so, I have given snow a theoretically and methodologically more comparable position to that of humans in my exploration of nonhuman and human powers to mould the alpine cryosphere. I have demonstrated that some materializations of the weather, especially the retreat of snow and glaciers, appear as powerful actors that deeply impact upon workers' affects, experiences, tasks and work on the glacier area. These workers counter the power of the weather with a strong social, political and individual will to control and manage it, as much as possible, with established practices of snow management, such as making snow depots, covering glacier and permafrost areas with textiles, and making snow using technology. Their efforts to manage those forces, which are never entirely controllable, not only stabilize and promote the economic value of snow as a commodity, but also provide the workers with a sense of existential and economic security, and of their masculine and rural identity. Moreover, the workers attribute the social and ecological value of 'protecting the glacier and caring for it' to these practices and the dominant economic value of making snow reliable. This valorization stands in stark contrast to the environmentalist narratives about their work. However, the value of glacier protection, as seen by the glacier workers, is, I propose, shaped and probably promoted by the powerful societal position of specific sciences, and especially of the glaciologists (Carey et al. 2016), who suggest the use of textiles for covering the glaciers and permafrost areas. As explained, the contrasting ethical and political positions towards 'good' and 'bad' actions in the cryosphere environment can be either supported or, sometimes at the same time, contested and rejected by scientific standpoints and evidence. Thus, the powerful position of sciences such as technology and glaciology in Austria and elsewhere should be considered if we are to critically analyse the metaphors used for describing human agency in the natural world (Hulme 2015: 236) and the 'protection of the glacier'. Like snow and other vital materialities, scientific materials are, according to their particular relations with other actors, highly significant actors in the political ecology of the alpine cryosphere.

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Notes

1. 'Ferner' literally means 'snow from previous years' and is the term used to refer to glaciers in this alpine region of western Austria.
2. The metaphor of 'going along with nature' is widely used in the Pitztal. While it may be applied in various contexts and even in (sometimes seemingly) antithetic senses, it basically expresses that local people consider their relationship to nature as one of adaptation.
3. I use 'vertical globalization' to describe the increasing flows of people, ideas, infrastructure, communication technology, trade and finance oriented towards environments of high elevations, including high mountain areas and the sky. While this orientation is geographically directed upwards, vertical globalization may also be directed downwards beneath the surface of the earth (e.g. towards the maritime areas or in the extraction of diverse resources).
4. German original:'Wir legen unsere Existenz, unsere Zukunft und all unsere Kraft in den Tourismus' (Hochzeiger Bergbahnen 2009: 6).
5. At high elevations of 3,000 m and above, there is a lower level of oxygen, which rapidly causes fatigue and exhaustion, and sometimes headaches and dizziness. Therefore, the staff must drink five litres of water a day in order to stabilize their blood circulation. The specific atmospheric conditions also affect technical apparatus, such as coffee machines and cooking equipment, which must be constantly re-adjusted. For instance, the temperature at which water boils is lower at high altitudes, while more coffee is needed per cup when brewing at higher elevations.
6. On average, the glaciers in the Pitztal region retreated more than 24 m in 2016; the year before, their shrinkage was even greater, with nearly 66 m the average (Fischer 2017: 23).
7. Some Austrian glaciologists (Fischer, Olefs and Abermann 2011; Olefs 2009) have experimented with various materials (including different colours and thicknesses) for coverings, such as membranes, biodegradable textiles and nonwoven fabric. Their results have shown that white-coloured geotextiles comprising nonwoven fabric that is breathable and permeable are the most effective. Even prior to the glaciologists' experiments, the Pitztal glacier resort had applied exactly these latter textiles. After three seasons of use on the glacier, these textiles are sent to be reused in the construction industry.
8. In the neighbouring Ötztal glacier ski areas, 77 per cent of the 111 km of pistes are covered with technically made snow (www.soelden.com/schneeanlagen).
9. The albedo effect (from the Latin word for 'whiteness') is a measure of the reflectivity of a surface such as the Earth. The brighter a surface (such as snow cover), the more of the sun's energy is reflected back into the atmosphere. The more solar radiation is reflected back, the more the Earth and global temperatures are cooled. Thus, the retreat of snow cover has a warming effect on the Earth's climate.

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