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The exceptional year of 2022: "deathblow" to glacier summer skiing in the Alps?

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The summer of 2022 in the European Alps was characterized by extremely warm and dry conditions which led to a record ice melt on Alpine glaciers, also due to the preceding winter season with below average snow cover. Given its dependence on natural conditions, glacier summer skiing was highly affected. We compare the number of glacier ski operating days across the Alps for 2011, 2018 and 2022 and roll forward existing time series data from Austria to include the last three seasons (i.e., 2020–2022). Results show considerable decreases in the summer half-year ski operation all over the Alps (−45.1% compared to 2011). Summer ski operation in the meteorological (−63.3%) and astronomical summer (−69.7%) declined even more. In Austria, the decline trend of summer ski operating days continues and reaches all-time lows in 2022. We sum up the impacts of the extreme summer of 2022 on Alpine glacier ski areas and discuss its short- to mid-term repercussions. In combination with demand shifts like the potential change of national ski teams' training patterns ongoing climate change induced glacier shrinkage might lead to the definite end of Alpine summer skiing in the near future.

KEYWORDS

glacier ski areas, summer skiing, climate change, heat wave, summer of 2022, European Alps

1. Introduction

Shrinking mountain glaciers are palpable indicators of climate change. The fast-progressing glacier melt in the Alps (e.g., Sommer et al., 2020) is affecting water resources, power generation, natural hazards, agriculture and tourism. Glacier tourism, a sub-category of nature-based tourism in the Alps, includes mountaineering/trekking, sightseeing/educational tours and glacier skiing (e.g., Salim et al., 2021). The latter, in particular glacier summer skiing, is affected by retreating glaciers and therefore smaller areas available for skiing, less frequent summer snowfall, and icy slopes (Fischer et al., 2011; Carver and Tweed, 2021). Given the close relationship between this specific activity and its physical base, summer skiing was regarded as the "first victim of climate change" (Mayer, 2012), as an example of "last chance tourism" (Steiger et al., 2012), and as a tourism activity "on the brink of collapse" (Schmude and Berghammer, 2015). Technical adaptation measures such as snowmaking, snowfarming and, particularly, the covering of glaciers with geotextiles proofed to be rather effective (Fischer et al., 2016; Senese et al., 2020; Huss et al., 2021), its application, however, is costly, limited to relatively small areas and "can only delay the decay of glaciers in ski resorts" (Fischer et al., 2016, p. 2950).

We recently correlated the summer ski operating days of all Austrian glacier ski areas (GSAs) with meteorological and glaciological data using time-series regression models (Mayer and Abegg, 2022). The results show that the decline in the number of operating days is related to climate change but cannot be explained with higher temperatures and shrinking

glaciers only. Other factors such as the agency of the operators (e.g., adaptation measures) and demand changes also play an important role. However, this research only includes data up to 2019. The COVID-19 years (2020 and 2021) and, notably, the meteorologically extreme year of 2022 are missing. 2022 was the second warmest year in Europe. In the Alpine countries it was either the warmest (France, Italy, Slovenia and Switzerland) or the second warmest year (Austria and Germany) (Copernicus, 2023). According to information provided by regional and national weather services (e.g., Amt für Meteorologie und Lawinenwarnung, 2022; DWD, 2022; Météo France, 2022; MeteoSchweiz, 2022; ZAMG, 2022), the year started with a mild, sunny and—at least in the Southern parts of the Alps—very dry winter, followed by a warm, sunny and dry spring. Snow cover at the end of winter/beginning of spring was below average (especially in the South), snowmelt started early and progressed quickly (also driven by a reduced surface albedo from several Saharan dust events) and, consequently, many mountain sites became free of snow at one of the earliest dates ever recorded (e.g., Weissfluhjoch in Switzerland, Zugspitze in Germany and Sonnblick in Austria—DWD, MeteoSchweiz and ZAMG, 2022). The year continued with a very warm, sunny and dry summer. It was the second warmest summer in France (since 1900, +2.3°C) and Switzerland (since 1864, +2.3°C), the third warmest in Germany (second warmest in Bavaria) (since 1881, +1.7°C) and the fourth warmest in Austria (since 1767/1851, +1.6°C lowlands/+1.7°C peak stations) (all temperature values relative to the 1991–2020 norm). Fall was also too warm, with a relatively cool September, a very warm October and a mild November.

Besides record-high temperatures over much of the summer half-year (including high zero-degree lines, mild nights and infrequent frost events even at high altitudes—see DWD, MeteoSchweiz and ZAMG, 2022 for the Central and Eastern Alps), little winter snow (e.g., Scotti and Lendvai, 2022 for the glaciers in Lombardy/Italy), dirty glacier surfaces (e.g., dust, debris etc.) and hardly any summer snowfall contributed to an unprecedented glacier melt in the Alps (Figures 1c, d). Germany, for example, lost one of its five glaciers, meaning that what is left of the Südlicher Schneeferner is officially no longer considered a glacier (Bayerische Akademie der Wissenschaften, 2022). Record-high reductions in ice thickness were measured on several glaciers in Austria (e.g., Pasterze, Mullwitzkees and Sonnblick glaciers), France (e.g., Glacier d'Argentière) and Italy (e.g., South Tyrolean glaciers) (DWD, MeteoSchweiz and ZAMG, 2022; Libération, 2022). The Cryospheric Commission of the Swiss Academy of Sciences spoke of "a disastrous year" and stated that "all ice melt records were smashed" (Swiss Academy of Sciences, 2022): In 2003, in the hottest summer ever recorded in Switzerland, the Swiss glaciers lost 2.8 km^3 of ice, that was about 3.2% of the then existing ice volume. In 2022, they lost 3.2 km^3 of ice, equivalent to 6.2% of the currently existing volume (DWD, MeteoSchweiz and ZAMG, 2022). Considering that years with a loss of 2% are described as "extreme" only highlights the extraordinariness of 2022.

It is not surprising though that glacier tourism was seriously affected by this record-high glacier melt. In this research note, we focus on glacier summer skiing, roll forward existing time series data from Austria (Mayer and Abegg, 2022) to include the last three seasons (i.e., 2020–2022) and provide a comparison in the number of glacier ski operating days across the Alps for selected years (i.e., 2011, 2018, and 2022). Further, we analyze the implications for and the reactions of the operators and discuss whether a tipping point has been reached regarding glacier summer skiing in the Alps (see Figure 1 for some impressions).

2. Methods

The analysis of the effects of the extremely warm and dry summer of 2022 on the Alpine glacier ski area (GSA) operations is based on three streams of research: First, we update the operating day analysis of all Alpine GSAs (Mayer, 2012) for the years 2018 and 2022. Second, we roll forward the summer ski season operating days timeseries of Austrian GSAs (Mayer and Abegg, 2022) to include 2020 to 2022. Both operating day data sets have been compiled, respectively, updated from various sources: operators' websites and internal data, user reports and postings in skiers' online communities (sommerschi.com and alpinforum.com), websites like bergfex.com, newspaper articles (e.g., accessed via the Austrian Press Agency) and website/webcam archives like wayback machine. We aggregated the ski operating days[1] and calculated their share in relation to potential maximum operating days for the summer half-year (SHY), the meteorological (MET) summer (01.06.−31.08.), the astronomical (ASTR) summer (21.06.−22.09.) and every month. The analysis of relative shares allows to compare the operating days for the 3 years 2011, 2018, and 2022, respectively, for the nine Austrian GSAs between 2002 and 2022. Relative shares because the number of operating GSAs varied over time. Further, it is important to note that an operating day means that the summer ski slopes are open to the public (and not only to professional ski teams[2]). Finally, we observed the print, online and social media in the Alpine countries to look for reports, features and posts dealing with summer glacier skiing and the extreme weather conditions. These materials provide background information and stakeholder statements.

3. Results

3.1. Operating days of all Alpine glacier ski areas

In 2011, 41 GSAs were operating in the Alps, 80.5% (33) of them offered at least 1 day of ski operation in the summer half-year (SHY), 39.0% (16) at least 1 day of MET summer ski and 34.1% (14) at least 1 day of ASTR summer ski. The overall mean number of operating days was 201.1 (SD 69.0).

1 Between May 1 and October 31 there are 184 days. Times the number of potentially open GSAs leads to the number of days of aggregated potential ski operating days in the summer half-year. For MET summer ski, this potential maximum is 92 days, for ASTR summer ski it is 93 days. The varying number of operating GSAs and the varying length of the summer months (June and September 30 days, the rest 31) was corrected by using percentages.

2 Especially in 2022, GSAs ceased their operation for the public but continued to operate for professional ski teams (e.g., Saas-Fee).

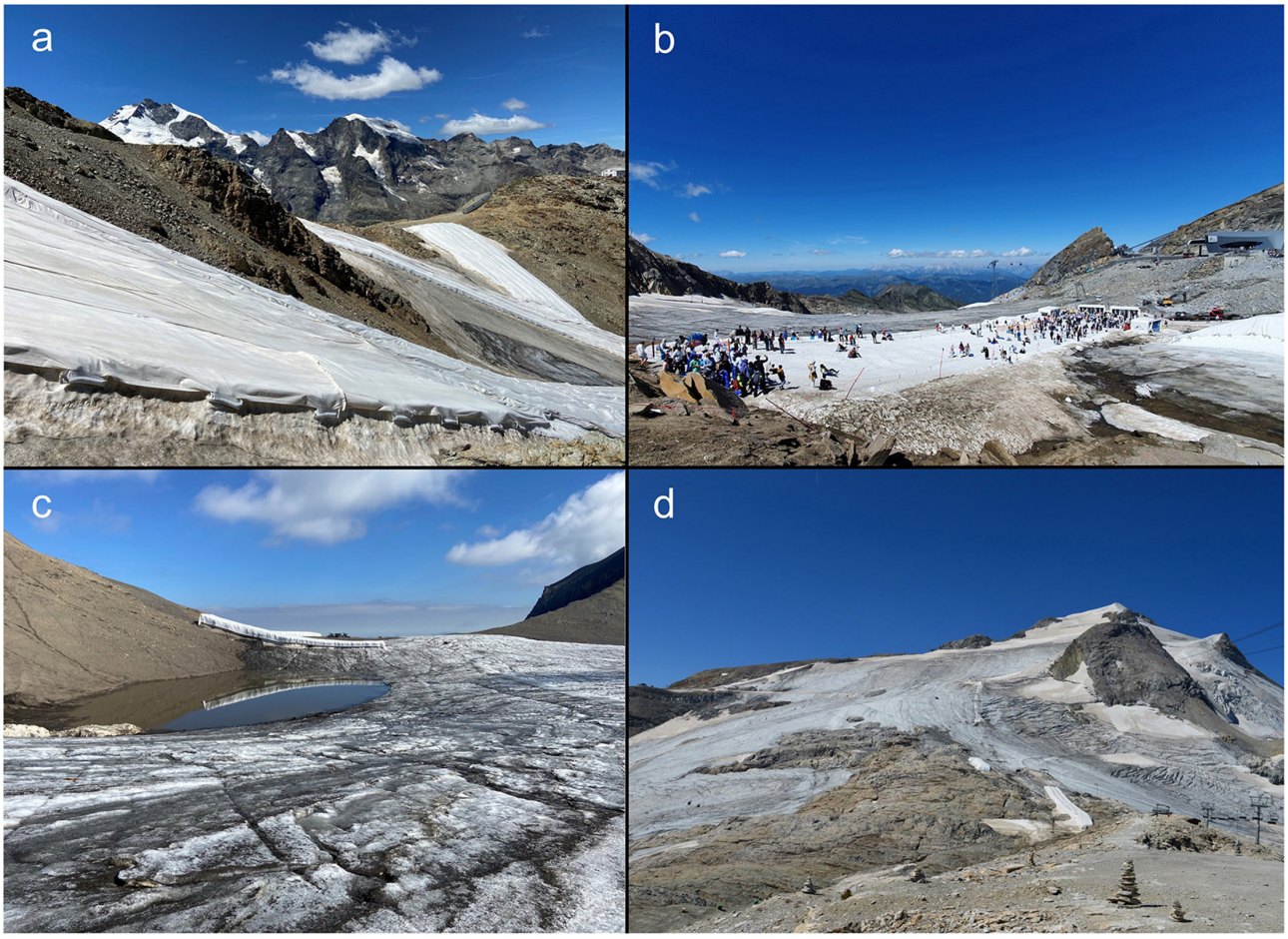

FIGURE 1
Alpine glacier ski areas in the summer of 2022. **(a)** Diavolezza, Grisons, Switzerland, July 12, 2022: the ski slopes on the remains of the glacier (Diavolezzafirn) have been covered with white geotextiles for years to reduce further ablation. In combination with snowmaking this allows an early opening of the ski season in mid-October. **(b)** Kitzsteinhorn, Salzburg, Austria, August 3, 2022: non-skiing visitors (often from the Middle East) enjoy a summerly snow experience on a small area nurtured from a snow depot (right). The glacier behind (Schmiedingerkees) is mostly snow-free. Ski operation was stopped after June 30, 2022. Until 2006, skiing was offered here year-round. **(c)** Glacier 3000/Les Diablerets, Vaud/Valais, Switzerland, August 10, 2022: the Tsanfleuron glacier is completely snow-free. Melting water run-off is apparent on its surface. In the background, a snow depot covered with white geotextiles is visible. Summer skiing was stopped here from 2004 onwards. **(d)** Grande Motte, Tignes, Savoy, France, July 22, 2022: even though located higher than 3,000 meters, the Grande Motte glacier is mostly snow-free, and no summer skiing was possible after July 1. The massive rocks in the middle and below left only appeared in the last 10 years. Until the early 2000s, skiing was practiced year-round, and until the 2010s through July to end of August. Because of its location in the core zone of the Vanoise National Park, no technical adaptation measures can be taken in this GSA. Sources: 1a, 1c © Bruno Abegg, 1b © Nadine Scharfenort, 1d © Cloé Vial-Pailler.

In 2022, the results looked different: 37 GSAs were operating (among them Jungfraujoch without any operating days due to the COVID-19-related lack of guests from overseas), 70.3% (26) with SHY, 18.9% (7) with MET, and 21.6% (8) with ASTR summer ski operation. The overall mean number of operating days declined to 174.1 (SD 65.7), i.e., −13.4%.

Figure 2 shows a clear operating pattern of Alpine GSAs (41 in 2011, 39 in 2018, 37 in 2022): While they reach a very high level of operation between the end of December and the end of April, there is a sharp decline at the beginning of May when the majority of GSAs starts to close down operation. A reverse pattern, although less pronounced, can be observed in the fall season when a continuous increase in operation starts at the end of September. In the winter half-year, the level of GSA operation was rather stable and varied between 83.7% (2011), 85.0% (2018), and 80.7% (2022) of all potential operating days. In the summer half-year (SHY), though, the level of ski operation was much lower and decreased over time: from 27.0% in 2011 to 21.6% in 2018 and 14.8% in 2022 (−45.1% compared to 2011). MET and ASTR summer ski declined even more, by 63.3 and 69.7%, respectively (from 25.6 to 9.4% MET and from 23.8 to 7.2% ASTR). On a monthly basis, the reduction of summer ski operation was strongest: In August, for example, the share of operating days decreased by 88.6% (from 23.7% in 2011 to 2.7% in 2022). In 2011, 9.7 GSAs were operating in the Alps (average number in the month of August); in 2022, it was only one (Hintertux in Austria) offering a single skiable slope. October and November 2022 also showed reduced operating levels, but with −10.0% (Oct) and −14.5% (Nov) on a much smaller scale compared to the decreases in the summer months. The dry and warm weather conditions in the fall of 2022 (particularly in October) delayed the resumption of the glacier ski operations. A prominent example was the cancellation of the FIS World Cup Downhill Races in Zermatt/Cervinia which were scheduled for late October/early November (Eurosport, 2022).

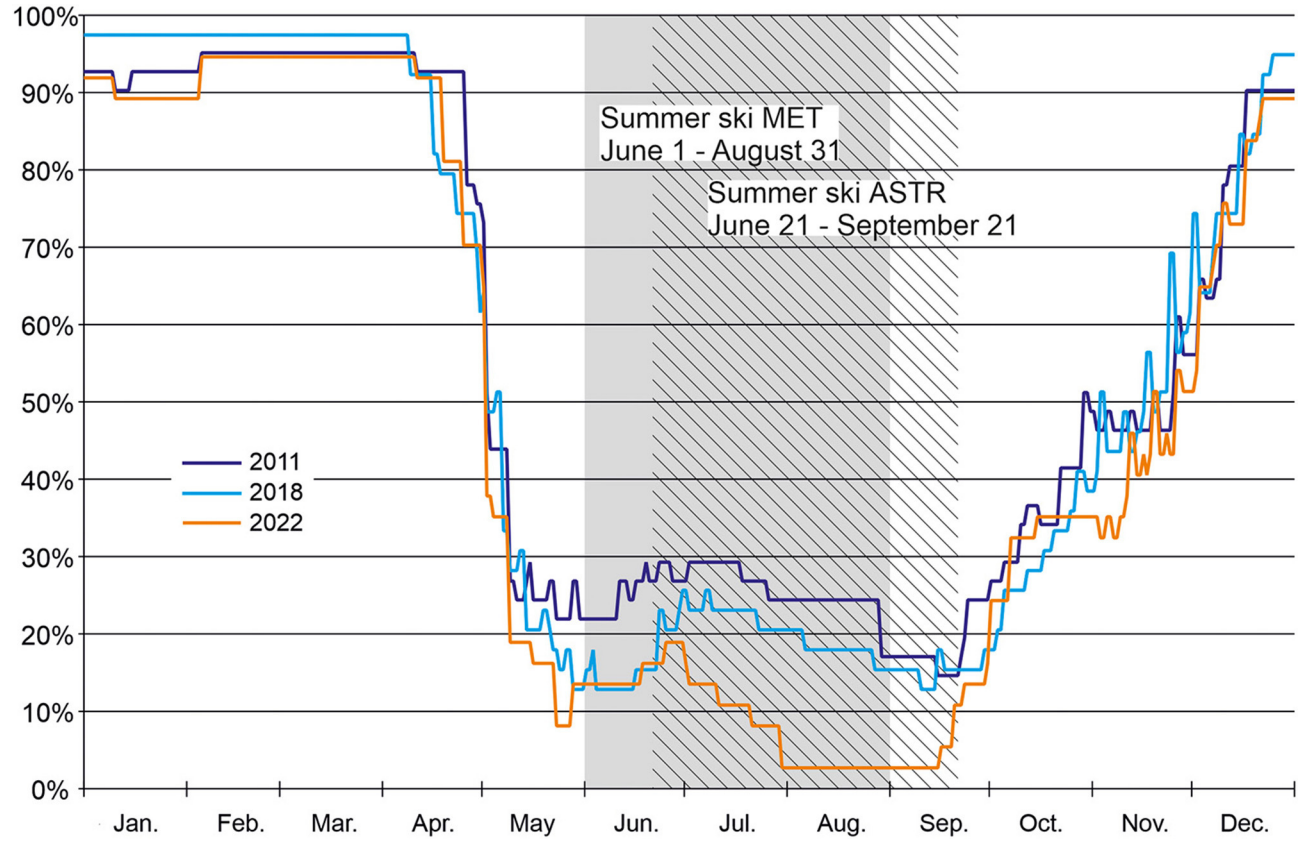

FIGURE 2
Operating days of Alpine glacier ski areas in 2011, 2018, and 2022. Source: own draft, updated from Mayer (2012).

If we look at the four main glacier ski markets in the Alps, we see considerable differences: the relative decline of operating days between 2011 and 2022 was strongest in France for SHY (−60.7%), followed by Switzerland (−59.4%), Italy (−47.5%), and Austria (−37.3%). For MET summer ski, the decline was highest in Switzerland (−73.4%), followed by Italy (−66.1%), Austria (−59.7%), and France (−55.4%). Finally, ASTR summer ski declined strongest in Switzerland (−83.2%), followed by France (−71.6%), Italy (−70.1%), and Austria (−58.0%). Thus, the relative importance of Austria for summer glacier skiing increased for all three summer ski definitions, while Switzerland and France lost in all categories. Italy lost market shares for SHY, but slightly gained for MET and ASTR. This geographically differentiated analysis shows that in terms of summer ski operations the lower elevated Eastern Alps with their—in general—smaller glaciers gained importance compared to the Western Alps with their, in theory, better natural preconditions.

3.2. Updated operating days of Austrian glacier ski areas

Figure 3 shows that the long-term declining trend of summer ski operation in Austria continues (the trend lines all have higher R^2 compared to the 2002–2019 trends) and that the warm and dry summer of 2022 led to an all-time low of SHY, MET and ASTR alike. SHY operating days were reduced by more than a fifth (−21.7%) between 2021 and 2022, MET by −45.3% to reach 14.7%, and ASTR by −44.3 to 12.3%. Twenty years ago, these ski operating day shares were higher than 70% (SHY) and 60% (MET, ASTR), respectively.

On a monthly basis, the declines compared to the summer of 2021 were strongest in July (from 30.8 to 11.1%, −64.0%), June (from 38.9 to 22.2%, −42.9%), September (from 23.7 to 14.4%, −39.1%), and October (from 78.9 to 73.5%, −6.8%), while August only showed a slight decline (from 11.5 to 11.1%, −3.1%), probably due to the already very low level. However, the previous all-time low of August 2003 was reached again in 2022.

However, these results mask how marginal the situation in the summer of 2022 actually was. Hintertuxer Gletscher, Austria, was the only Alpine GSA open for the public throughout the complete summer season. Between July 25 and September 17, skiing was only possible on a single, 800 m long slope which is equipped with snowmaking facilities. While technological adaptation made it possible, it was mostly the operator's insistence not to stop the ski operation which explains the situation, despite negative comments from media, public and politics.

Most GSAs did not change their routines because they already had stopped operation in the critical time of the summer. The decline between 2019 and 2022 can primarily be attributed to the changes in the Mölltal GSA where only eight SHY and zero MET and ASTR skiing days were offered in 2022, compared to SHY, MET and ASTR averages of 132.9, 69.0, and 83.2 between 2010 and 2019. The new operating company, in contrast to its predecessor, apparently has no interest in international training groups in the summer season, most likely due to insufficient revenues (pers.

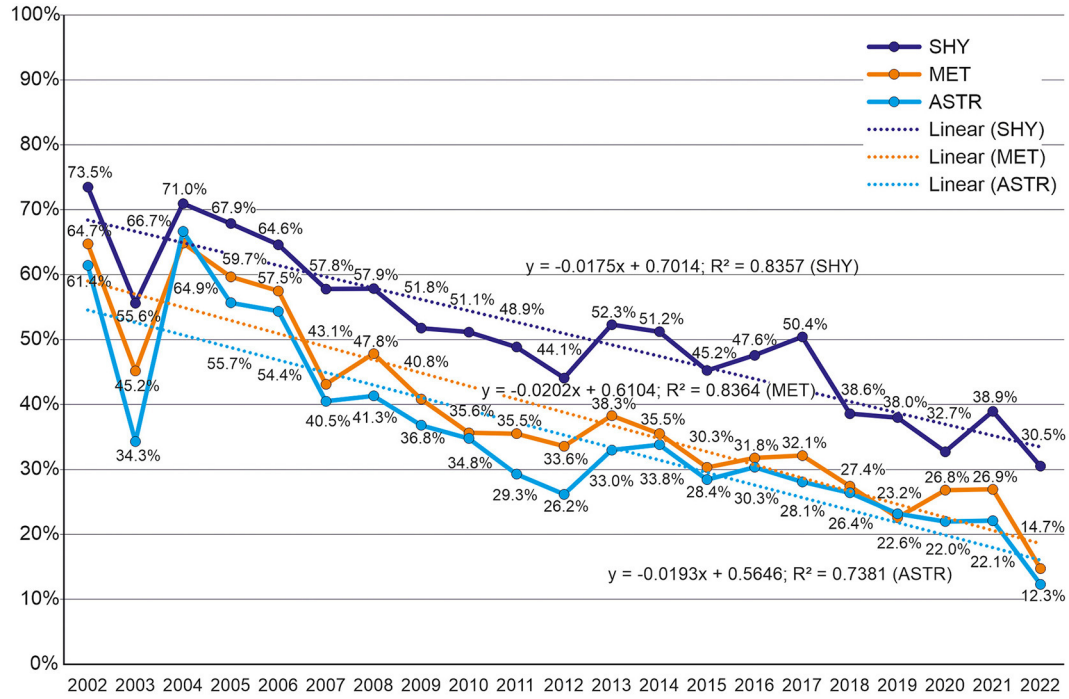

FIGURE 3
Development of summer ski operating days in Austrian glacier ski areas 2002–2022. Source: Mayer and Abegg (2022), updated.

comm.). In addition, the Kitzsteinhorn GSA reduced MET and ASTR operation by 24 days from 2021 to 2022 because of high temperatures and quick snowmelt. The loss of SHY days in Pitztal, finally, is related to a COVID-19 effect: In 2021, the Pitztal GSA offered some May and June skiing (for the first since more than 15 years) to compensate for the lockdown periods in the 2020/21 season. This was not repeated in 2022.

Figure 4 visualizes the long-term evolution in the number of operating GSAs in Austria. Three features can be highlighted: (1) The extreme summer of 2003. This summer was then called a once-in-a-hundred-years event and is still the hottest summer (MET) on record but not the hottest summer half-year (May–October); that was in 2022, at least in the higher elevations of the Central and Eastern Alps (DWD, MeteoSchweiz and ZAMG, 2022). In the summer of 2003, nearly all Austrian GSAs had to cease operation from the end of July to mid-September for the first time. (2) The declining trend expressed by the accumulating appearance of reddish color shades over time. (3) The summer half-year of 2022 with the lowest average number of operating GSAs (2.74 compared to 6.61 in 2002). Further, it must be noted that the complete shutdown of glacier ski operation in May 2020 was not related to climate issues but due to COVID-19 restrictions in Austria (Mayer et al., 2021; Bichler et al., 2022).

3.3. Impacts and reactions in the glacier ski destinations

The major impacts on and reactions of the GSA operators can be summarized as follows (see Supplementary Table 1 for further information):

a) The combination of a snow-scarce winter 2021/22 (especially in the Western and Southern Alps), Sahara dust deposits, and the dry and very warm weather conditions in May and June led to an untimely termination of glacier ski operations throughout the Alps as many glacier ski slopes became snow-free already in June and early July.
b) Even though public ski operations at the height of summer were stopped at all GSAs except for Hintertux, Austria, some GSAs remained officially (Saas-Fee) or unofficially (Zermatt, Stelvio) open for training groups and ski athletes as important target groups. This implies that the conditions were tolerable for professional skiers (at least very early in the morning) but unsuitable for recreational skiers (e.g., bare ice in the morning, slushy ice at noon). It is also possible that the operators want to avoid negative marketing due to (social) media reports about the deplorable glacier conditions (e.g., Facebook, 2022a,b; Twitter, 2022a)—these reports are much more unlikely to be given by professional skiers who need the GSAs as training areas. The same phenomenon of earlier or exclusive GSA opening for training groups was also observable in fall.
c) The extraordinary glacier melt of 2022 caused immense adaptation work for the operators. Examples include: the filling of crevasses, the preparation of the ski lift tracks and the mounting of the lift pylons, the removal of debris and rocks from ski slopes, and the securing of the passages from glaciated to non-glaciated areas etc.
d) The warm fall (except for a period in late September) restricted the use of snowmaking as an adaptation strategy to compensate for ice mass losses and/or lacking precipitation. To guarantee early openings, the operators rely more and more on snow depots, even in glacier-free areas. In many GSAs the scheduled fall openings were delayed by several weeks which reduces the

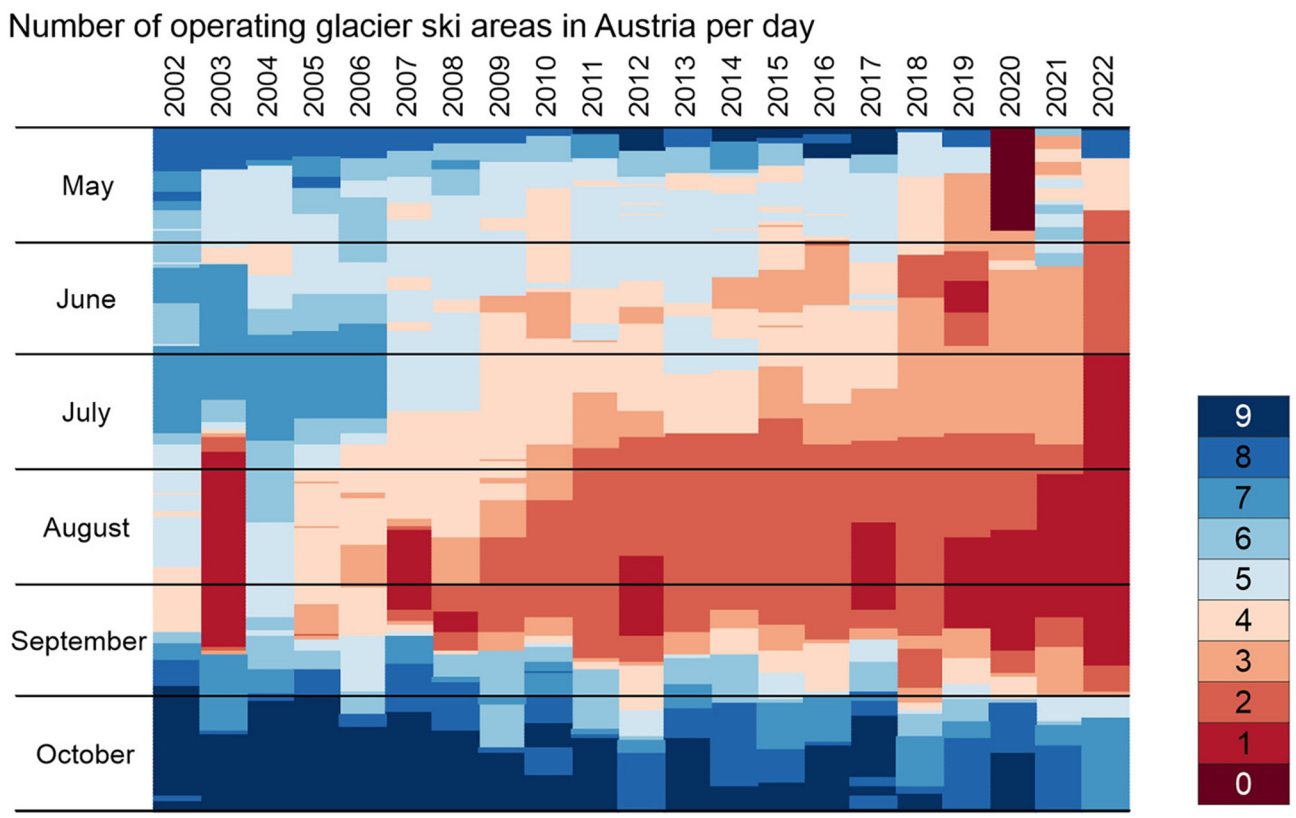

FIGURE 4
Visualization of operating Austrian glacier ski areas 2002–2022. Source: based on a draft by K. Hasenjäger and own data compilation.

operating time in a part of the season when GSAs used to have the USP of reliable snow conditions.

e) The combination of these phenomena led many operators to rethink their strategies: The Austrian Dachstein did not open for skiing in the winter of 2022/23 due to the extreme ice ablation and problems with crevasses and lift tracks—"There will be no new ice age", says the CEO of Planai-Hochwurzen-Bahnen (Kleine Zeitung, 2022). In March 2023 operators decided to stop ski operation for good and the demolition of all ski lifts began (Steiermark.orf.at, 2023). Kitzsteinhorn will shorten SHY operation by seven weeks in 2023 and stop ski operation at the end of May to preserve the glacier and to safe energy costs (Der Standard, 2022b). Also in Tignes, the former self-titled "capital of summer skiing", a change seems unavoidable: large parts of the GSA are not usable anymore in the summer season (Figure 1d) and are planned to be demolished in order to get permissions to introduce adaptation measures like snow farming in the National Park core zone (Vial-Pailler, 2020). Thus, 2022 with its record-high glacier melt could be the tipping point for many of the remaining GSAs operating in the SHY to further shorten or cease these operations and to continue the transformation to "normal" winter ski areas with an early start and a somewhat extended ending. However, Zermatt and Hintertux, the only year-round GSAs left in the Alps stated to continue their operation policy, at least in the short- to mid-term (Tiroler Tageszeitung, 2022; ZBAG, 2022).

4. Discussion and conclusion

Alpine summer skiing has been facing a decline for years. 2022 was not a singular event but part of a series of exceptionally warm years, however topping previous temperature and glacier melt records and, therefore, reinforcing the decline. A simple extension of the existing trends (e.g., Figure 3) would likely lead to the disappearance of Alpine summer skiing in a couple of years.

Previous research revealed that the evolution of glacier summer skiing in the Alps cannot be explained by climate change only (Mayer and Abegg, 2022). Non-climatic factors such as the GSA operators' agency (e.g., their business strategies, their willingness and capacity to technically adapt etc.) play an important role. The summer of 2022, however, demonstrated the limitations of these adaptation measures (Figure 1a) and how much time and effort is needed to provide even a marginal supply of skiable slopes. Thus, the cost-income ratio becomes ever more disputable, as exemplified in Mölltal GSA where the new owners abstain from technically feasible adaptation measures for profitability reasons. Further, it should be noted that glacier ski operations with their energy consumption (e.g. grooming, snow depots, snowmaking) and related carbon footprint (e.g., visitors' access to the destinations) also contribute to climate change—the very phenomenon glaciers are suffering from.

Alpine summer skiing is a niche market. An important target group within this small market are ski athletes (e.g., the national ski

teams from various countries), and a few GSAs—year after year—have tried hard to offer good training conditions to these athletes. Many a time, however, professional skiing was hardly possible, or only very early in the morning. Prominent skiers repeatedly expressed concern about the fate of the glaciers (e.g., Mikaela Shiffrin, the most successful skier ever, in an interview on Swiss TV, Aug 7 2022) and/or made critical remarks regarding summer training on glaciers (e.g., Felix Neureuther, Süddeutsche Zeitung, 2022a). National ski associations such as Swiss Ski are actually thinking about a change in their summer training routines—a change that would ultimately mean to abandon midsummer glacier training in the Alps (SRF, 2022). Without the ski athletes, an important target group would be lacking, and it seems highly questionable whether the GSAs still offering summer skiing would continue to do so for the small number of amateur skiers alone.

Anyway, the most important target group of GSAs in summer are non-skiing visitors (Mayer and Abegg, 2022). GSAs provide easy access to high-alpine environments and offer unique experiences. Excursionists, for example, can enjoy the panoramic views, explore ice caves and/or have some fun on snow fields (Figure 1b). Quite often, the snow and ice experience is combined with an educational note (e.g., National park gallery Kitzsteinhorn). It can be assumed that the GSA operators will further upgrade these offers. Some of these attractions, however, can only be maintained with extensive adaptation efforts and/or are prone to disappear with continuing warming. Mountaineers use the transport facilities to get closer to the peaks. Mountaineering, though, is another activity highly affected by climate change. The impacts of climate change on mountaineering are well-documented (e.g., Mourey et al., 2019, 2022), and a number of incidents in the summer of 2022 illustrated how far-reaching, severe and threatening these impacts are (e.g., the Marmolada glacier collapse, the closing of the Matterhorn and Mont Blanc routes etc., Süddeutsche Zeitung, 2022b,c,d,e).

Glacier melt and its implications on summer skiing were prominent topics in the media. The reports were mostly critical, the comments, particularly in the social media, highly critical (Summer skiing does not fit in times of climate crises, Der Standard, 2022a), sometimes even spiteful. GSA operators, for example, were called "stubborn" and "greedy", glacier skiers "stupid", "sick" or "crazy" (Der Standard, 2022a; Twitter, 2022a,b). The public discussion is highly emotional. This might be related to the fragility of the glacier landscapes, the diverging attitudes toward the exploitation of glacier landscapes and the dismal prospects of glacier landscapes in times of climate change. The topic also became political. In Tyrol (Austria), for example, Anton Mattle (then member, now head of the provincial government) stated that "the days of summer skiing on glaciers are over" (Tiroler Tageszeitung, 2022). This is a remarkable statement from a politician representing a conservative party known for its strong support for the tourism industry.

Did we finally reach a tipping point? Quoting a Bob Dylan song, one could say: "Not dark yet, but it's getting there" (Dylan, 1997). It is not the climatic conditions of a single year (however bad they were) but the long-term evolution, together with increasing adaptation costs, changing demand patterns and the missing public acknowledgment (e.g., scorching criticism, vanishing political backup etc.), that will define the future prospects of summer glacier skiing. Most likely, other GSAs (in addition to the ones that made respective announcements in 2022) will shorten the summer ski season and/or completely cease operation at the height of summer. In the years to come, the GSAs might still offer some spring (and early summer) skiing, depending on the operators' strategies, the winter snow accumulation and the weather conditions. Summer skiing, though, is expected to be further reduced. An interesting case is the fall season: a very early start to the winter season used to be a unique selling proposition for many GSAs (Abegg et al., 1994; Mayer, 2012). In the recent past, and particularly in 2022, dry and warm conditions repeatedly hampered the slope preparations and delayed the restart in fall. Further, it could be observed that snow depots played an ever more important role. Depot snow, however, is not bound to glacier slopes; quite the contrary, it is often easier to prepare a ski slope from depot snow in a glacier-free area (e.g., for years at Kitzbühel-Resterhöhe between 1,500 and 1,800 m asl in mid-October).

It will be interesting to see how Alpine glacier skiing will further evolve, to investigate the medium and long-term repercussions of 2022, and to assess the future impacts of climate change. Interesting research topics include, for example, the GSA operators' adaptation strategies (in particular with regard to non-skiing visitors) and the future role of the glaciers/GSAs for the tourism destinations. A lot could probably be learned from a systematic analysis of the social discourses related to glacier skiing. And, finally, a comprehensive review of Alpine glacier skiing covering the different phases of the evolution is still missing.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fhumd.2023.1154245/full#supplementary-material

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