The impact of poor winter seasons on ski tourism and the role of snowmaking as an adaptation strategy

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Abstract

In many alpine regions, ski tourism is the most important contributor to the local economy. This study examined the impacts of poor winter seasons on the accommodation sector and the adaptive capacity of snowmaking with regard to climate change in Tyrol. In lower elevated destinations a significant correlation between the number of winter sport days and overnight stays ($r^2 = 0.6$) can be found. A degree-day model and a climate scenario of +2°C were used to assess future ski season length. Current snowmaking intensity will not be sufficient for lower areas to reach the necessary ski season length. But with an intensification of 150% this goal could be achieved. Thus technical snow-reliability would be given in 92% of Tyrolean ski resorts. Nevertheless rising snowmaking costs and decreasing skier days will accelerate the structural change in the winter sport industry.

Keywords: adaptation strategy, Austria, global warming, ski tourism, snowmaking

1 Introduction

Ski tourism is highly dependant on climatic parameters like low temperatures and sufficient snowfall and therefore a segment of tourism that attracts much attention of the media when dealing with impacts of global warming. As temperatures and the average snowfall line are to rise with an ongoing warming trend resulting in less snow depth, ski resorts are assumed to be one of the first losers of global warming. Since the 1980s, several studies have been carried out for example in Switzerland (Abegg 1996, Bürki et al. 2005, Müller & Weber 2007), Austria (Breiling et al. 1997, Kromp-Kolb & Formayer 2001, Wolfsegger et al. 2008), Germany (Harrer 1996), Australia (Galloway 1988, König 1999, Hennessy et al. 2003), Canada (McBoyle et al. 1986, McBoyle & Wall 1992, Scott et al. 2002, 2003) and the U.S. (Lipski & McBoyle 1991, Scott et al. 2006). Except Hennessy et al. and Scott et al. including snowmaking in their modelling, these represent the 1st generation of climate impact studies on winter tourism, analysing natural snow-reliability and the perception of climate change by tourists and stakeholders. The recent OECD report (Abegg et al. 2007) provided an overview of natural snow-reliability all over the Alps. It concludes that with a 2°C warming only 60% of today's skiing areas (total 666) will remain snow-reliable, declining even to 30% in a 4°C scenario (Abegg et al. 2007). Snowmaking as an adaptation strategy is not considered, but its implementation in coming studies is essential, as for example in Tyrol 75% of all ski slopes are covered by snowmaking facilities (Fachverband der Seilbahnen Österreichs 2008), even reaching into high elevations like in Obergurgl (up to 3,027 m). Although the diffusion of snowmaking cannot be attributed solely to shortening ski seasons length and rising temperatures (Mayer et al. 2007, Pröbstl 2006), it is the most utilised adaptation strategy to climate change. Scott et al. (2002, 2003, 2006) developed a complex ski season model including snowmaking for the first time and applied it in Canada and the U.S. They found out that former studies significantly overestimated the reduction of ski season length and therefore the impacts on ski tourism. In this study, a more simple approach, first carried out for ski resorts in the Bavarian Alps (Steiger 2007a), was expanded and applied on Tyrol.

2 Impact of winter seasons with poor snow conditions on the accommodation sector

The extraordinary warm 2006/07 winter season all over the Alps with winter temperatures in Tyrol 3.5–4.0°C above the 30-year average 1971–2000 (ZAMG 2007) represents an average season in the PRUDENCE regional climate model projections (+2.0 to +4.0°C in the Alps) for the period 2071–2100 (Christensen et al. 2007).

Analysing the tourism statistics and climate data from 1975/76 to 2006/07, a correlation between snow conditions (number of winter sport days; days with a minimum snowbase of 30 cm) and overnight stays can be found at low elevated ski resorts in the Kitzbühel region compared to the climate station "Hopfgarten" at 600 m (figure 1): A certain dependency seems to exist ($r^2 = 0.6$), but less than expected. There is no coherence of above/below average snow conditions in one year and change of overnight stays in the following year ($r^2 = -0.1$). Other factors like the economic situation in the tourists' country of origin (e.g. the slump 1993/94 to 1996/97 caused by the recession in Germany, the most important market), or general tourism trends (e.g. reduced length of stay) have significant influence on tourism statistics.

For higher elevated ski resorts like Sölden or St. Anton, no correlation can be found ($r^2 = -0.1$, resp. $r^2 = 0.2$). This can be explained by the altitudinal range of the skiing areas (Sölden 1,353–3,249 m and St. Anton 1,290–2,810 m), with major parts above 2,000 m, which can be considered as natural snow-reliable (Abegg et al. 2007).

Surprisingly, a positive effect of snowmaking on the dependency of overnight stays on snow conditions cannot be seen, although the variability of operating days of the skiing area has been significantly reduced since the implementation of snowmaking (Steiger 2007b). From 1975/76 to 1990/91, a period where most of the ski regions of the research area did not have snowmaking, the correlation between overnight stays and snow conditions in the Kitzbühel region was less ($r^2 = 0.4$) than from 1991/92 to 2006/07 ($r^2 = 0.7$), although in 2006 at least 50% of the slopes in each skiing area were covered by snowmaking facilities, with highest values reaching to 95% (Steiger 2007b).

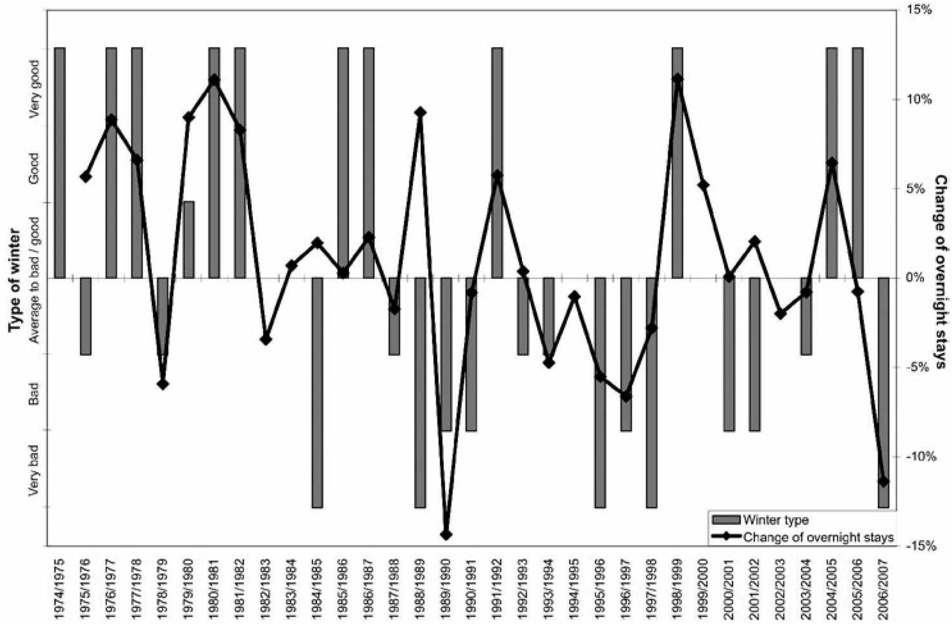

Figure 1: Type of winter season and change of overnight stays in the Kitzbühel region from 1974/75–2006/07. The type of winter season is defined by the difference of the number of winter sport days compared to the 30-year average (median). Very bad= –100%, bad = –95%, average to bad = –50%, average to good = +50%, good = +100%, very good = >+100%.

3 The suitability of snowmaking as an adaptation strategy to climate change

Snow reliability is the key factor for the success of a winter destination. As it is a rather abstract term, Abegg (1996) formulated the 100-days-rule as a definition for natural snow-reliability: ski resorts can be considered as snow-reliable if, in 7 out of 10 winters, a sufficient snow depth of at least 30–50 cm is available for ski sport on at least 100 days between December 1 and April 15. Using snow data, the line of snow-reliability can be assessed easily. Hence, if the middle-point of a ski area is above that line, the ski resort is snow-reliable. Following this methodology, today 76% of all Tyrolean ski resorts are snow-reliable, in a 2°C warmer future scenario it would drop down to 41%.

The area-wide use of snowmaking requires an embedding of snowmaking in this definition. To differentiate between natural snow-reliability and snow-reliability achieved by snowmaking, the latter will be called technical snow-reliability.

3.1 Methodology

The snowmaking module integrated in the snow model consists of three major components: A threshold in daily average temperature for the start of snow production, average snowmaking capacity derived from interviews with ski resort managers, and the calculation of snowmelt. With current snowmaking technology snow can be produced starting at −3°C, if humidity is below 80% (Pröbstl 2006). As producing snow with marginal temperatures results in higher energy costs, less capacity and poor snow quality, a temperature threshold of −6°C (Steiger 2007a, Breiling et al. 1997) is being used.

Using daily average temperatures, it is necessary to relate these to daily minimum temperatures. By dint of Fliri's (1974) climate tables, a strong correlation could be found between −2°C daily average temperature and −6°C daily minimum temperature. Thus days with a daily average temperature of −2°C will be defined as potential snowmaking days. Furthermore snowmaking is only considered reasonable if it can balance out the loss by snowmelt per month. Natural snowfall is not included in the model because of two reasons: the range of precipitation changes calculated by climate models is too high to be implemented in the model (Christensen et al. 2007). Besides that a snowmaking system must be able to provide snow-guarantee independent of natural snowfall due to high investment and operating costs, therefore natural snowfall must not be included in the model when speaking about technical snow-reliability.

Snowmaking capacity varies from one skiing area to another depending on the type of snowmaking system (fan guns, air water guns), the density of snowmaking guns on the ski slopes and of course if the system is state-of-the-art or older technology. An average of 5 snowmaking days to be able to open the ski slope was derived from interviews with ski resort managers (Steiger 2007a).

Snowmelt is calculated by a degree-day model with a degree-day factor-range of 2 mm and 3 mm respectively, which seems to be suitable for winter months in the research area (Steiger 2007a). The run-off water equivalent can be converted to snowmelt using the average density of groomed technical snow of 523 g/l (Rixen et al. 2004), thus 1 mm run-off water equivalent means 1.91 mm melted snow depth.

The minimum snow depth for alpine skiing is 30 cm and 50 cm respectively in stony areas with poor vegetation (Abegg 1996). As technical produced snow-density is higher than natural snow-density, 20 cm of groomed technical snow are required in order to get an adequate ski slope (Steiger 2007a). Using the following formula the required number of snowmaking days can be calculated:

$$\textit{Required number of snowmaking days} = [((\textit{Degree-days/month}) * F) * 1.91] * Sc$$

with F = degree-day factor (2 mm and 3 mm respectively) and Sc = snowmaking capacity. Hence, if the number of potential snowmaking days per month is greater than the required number of snowmaking days, the month can be defined as suitable for snowmaking. To compare these results with older studies not including snowmaking, the line of technical snow-reliability is calculated similar to the line of natural snow-reliability: Using the 100-days rule (Abegg 1996), elevations where snowmaking can provide 100 wintersport days (min. 20 cm) without any natural snowfall in 9 out of 10 winter seasons can be defined as technical snow-reliable.

3.2 Compliance of climatological requirements for snowmaking at three Tyrolean climate stations

With these prerequisites, datasets (1971–2000) of three climate stations in Tyrol were analysed: Kufstein 495 m, St. Anton 1,275 m and Patscherkofel 2,247 m. Monthly varying vertical temperature gradients could be calculated thus inter- and extrapolating temperature from 500 to 2,400 m.

Figure 2 identifies the problem of generalised statements about the suitability of snowmaking. At present (30-year average 1971–2000) snowmaking can guarantee snow-reliability at elevations above 1,000 m (Dec–Feb) in 90% of all winters. With an expected warming of 2°C (timeline 2021–2050) current snowmaking intensity (5 snowmaking days for 20 cm groomed technical snow) will not be sufficient below 1,400–1,600 m. This implicates severe problems for Tyrolean ski resorts as today 92% are technical snow-reliable, but in the +2°C scenario only 41% can be considered as technical snow-reliable.

One possible and the most used technical adaptation strategy is to increase snowmaking capacity to be able to produce sufficient snow in less than 5 days. The snowmaking industry's target snowmaking time to adapt to rising temperatures is 48 hours (Mountain Manager 2007). Some ski resorts recently upgraded their facili-

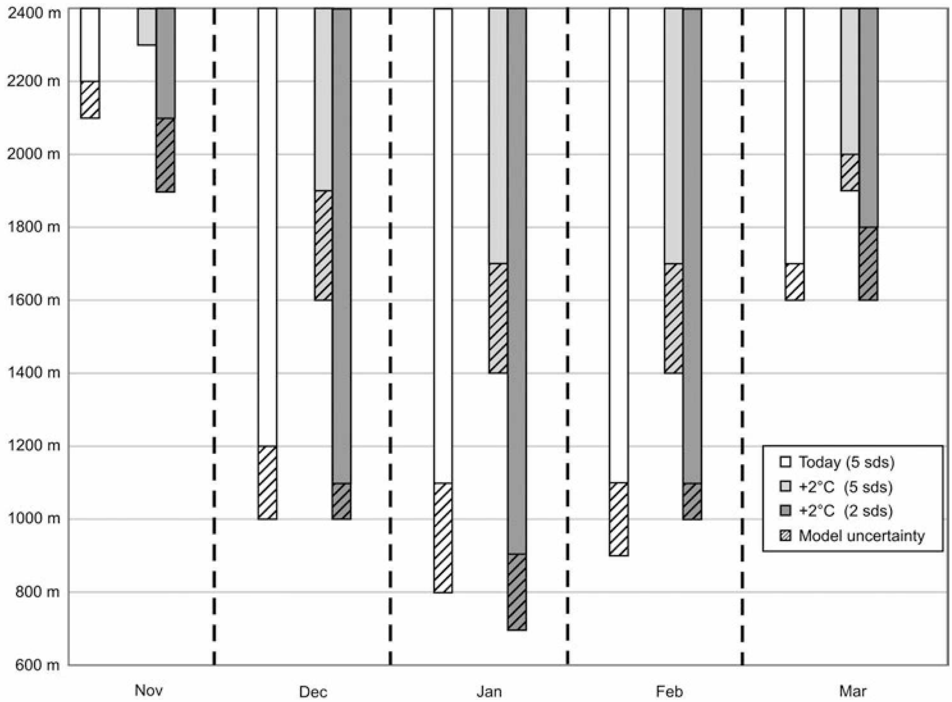

Figure 2: Elevations suitable for snowmaking today and with a 2°C warming. To calculate today's technical snow-reliability it is assumed that 5 snowmaking days (sds) are required. The figure illustrates the possibility to adapt to warming by increased snowmaking capacity to 2 snowmaking days. The range of uncertainty depends on the degree-day factor (2 mm/3 mm) chosen

ties to open the ski runs after 3 days of snow production giving competitive advantages especially for the season opening and Christmas holidays (e.g. Schladming, Reiteralm, Saalbach-Hinterglemm).

An intensification of snowmaking capacity by 150% (2 instead of 5 snowmaking days) would enable ski resorts to keep current technical snow-reliability (92% of ski resorts would be technical snow-reliable).

From a technical point of view, snowmaking will be possible in the future as there will still be some days suitable for snowmaking even at low elevations. This, however, will be at much higher cost than today as:

1. potential snowmaking days will decrease by 21–44%[1] and
2. the demand for technical snow will rise by 71–166%[1] due to a higher snowmelt rate (higher temperatures).

These two factors put together can be defined as snowmaking intensity, which will have to be increased by 174–280%[1] to reach equal snow depth on the ski slopes compared to today.

4 Discussion and conclusion

The aforementioned 1st generation impact studies on ski tourism rightly attracted a lot of attention in the 1990s as consequence of some consecutive bad winter seasons at the end of the 1980s and early 1990s. The rapid diffusion of snowmaking and the shift from punctual snowmaking to area-wide snowmaking demands a 2nd generation of impact studies to assess future chances and risks of regions dependant on ski tourism. This study's approach showed, that global warming will not have as dramatic impacts on ski resorts and on snow-reliability as assumed by 1st generation studies. Nevertheless it would be blue-eyed to perceive snowmaking as a panacea for all ski regions. Rising energy prices, rising demand in snow production, shorter ski seasons, a rather declining number of skiers not least because of the demographical change, might intensify competition and some financially weak skiing areas will drop out of the market.

The research gap for 2nd generation impact studies is challenging: More complex snow models like in Scott et al. (2003) have to be established and implemented. As snowmaking is not driven by daily average temperature but by the number of hours with adequate temperature-humidity conditions, it is necessary to calculate these potential operating hours with more detailed climate data. The modelled results should be compared to measured data in the skiing areas (produced snow, operating hours, etc.) to adjust model parameters. Besides snow modelling, findings in the cost of snowmaking and consequently in the profitability of skiing areas are fundamental for any conclusion on the suitability of ski tourism. Moreover, further research in the development of demand is needed. Thanks to the 2006/07 season, an analogue year is available representing an average season in the future. The real behaviour of skiing tourists and the influence of mass media coverage of bad snow conditions

[1] values depending on elevation and month

on their perception should by analysed and finally, a standard of modeling snow-reliability should be aspired (Scott et al. 2003).

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