The Role of Snow Cover in Austrian Economy During 1965 and 1995 and Possible Consequences Under a Situation of Temperature Change

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Introduction

Snow became in particular economically important with the development of the winter tourist industry. In Austria, propably the most dependent country in this context, some four percente of the national income are related to wintertourism and snow. Therefore, any change in the snowcover has economical implications. This is a trial to assess the magnitude of the economic value of snow for wintertourism.

Regional Modelling of Snow Cover

The area of Austria was analyzed using monthly mean climate data from 1965 to 1995. Monthly mean data of temperature, precipitation and snow depth/days with snow cover was used to construct snow models of smaller, climatologically more homogenous regions of Austria. Complementary results from other studies using a better time resolution with daily means could be utilized in some cases.

There do exist considerable spatial variations of snow cover in the same altitude. While temperature decreases everywhere with increasing altitude, precipitation usually increases with increase of altitude but does not have to follow such a rule. The variation of snow cover is dependent on the variations of temperature and precipitation while many more factors of possible influence like wind, radiation, inclination and others were kept constant during the 30 years period. The regional snow models of Austria describe the dependence of snowcover on temperature and precipitation in relation to altitude in each analyzed region.

The aim was to construct a gen

For this reason, Austria was split up into several more homogenous climate regions and the relation of altitude and snowcover was assessed independently.

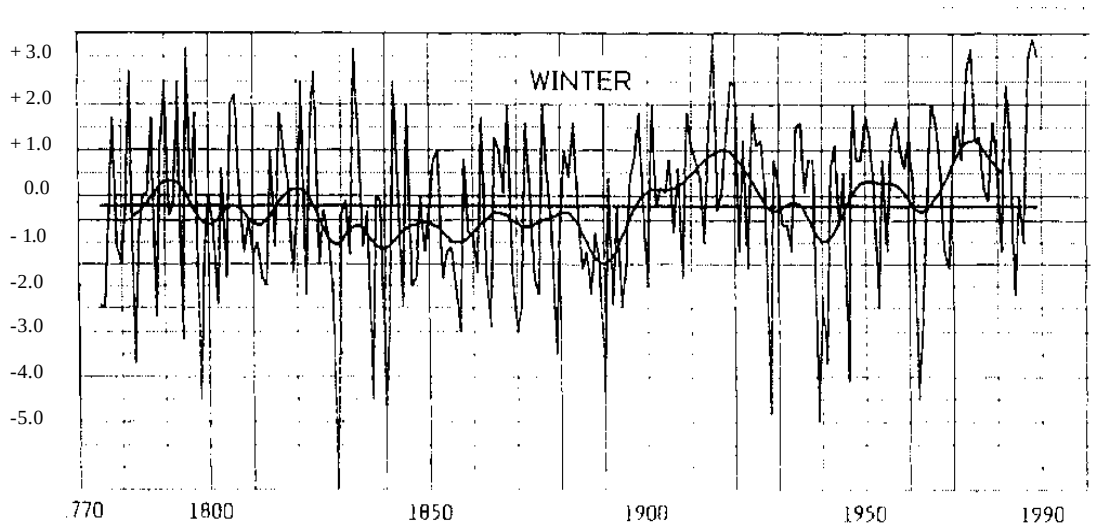
This made it possible to assess the monthly variations of single winter month as well as the seasonal variation of the winterseason.

The aim is to stimulate local activity on the community level. If risks and mechanisms are known, there is a good chance that decision makers will take them into account and use their knowledge to an optimum.

Why is snow cover and variability of climate important to the Alpine region?

The Alpine economy and the Alpine ecosystem are very dependent on the climatic conditions. Snow is the product of climate factors, mainly temperature and precipitation. If temperature changes, the amount and duration of snow cover will change too. Temperature is closely related with altitude: for every 100m in altitude the mean temperature decreases by some 0.75 degrees Celsius (IPCC 1990) while the snow cover duration increases for one week (Aulitzky 1987). The variability of the averaged curve over 5 years for the Austrian measurement net during winter covers a range of 2 degrees Celsius. Single winter periods deviate more than 6 degrees Celsius from each other within this curve. In comparison to the importance of temperature fluctuations, variations of precipitation are of minor importance for the snow cover. Snow does not seem to be a reliable product, concerning particular years, but in average one can expect that snow will return on a regular base.

Figure 1: Winter curve of climate variability since 1770 as a mean of up to 58 Austrian temperature stations in various altitudes Source: R. Böhm (1992) [1]



During the last 30 years, that were most relevant for winter tourism, Böhm's graph for winter seasons shows a clear trend of warming within a range of 1.5 degrees within the averaged 5 years curve. The likelihood of favourable snow conditions decline with the growth of this curve. There is hope that the temperature becomes again colder during the next decades (if climate change assumptions may turn out to be wrong) and the snow security will alter again.

Effects on the regional economy

Climate variability per se would not be a critical factor, but current socio-economic conditions, dependent on snow and winter tourism, turn it to a serious issue. Until the 1950s agriculture was the

[1] Bšhms curves, interpolating Austrian average mean temperature since 1775, became somehow popular as argument against climate change (World Climate Review 1993). It goes beyond the intention of this paper to discuss this.

most important economic branch in the Alpine region. Since then tourism developed rapidly. In the 60s and early 70s most winter tourist capacities of Austria were built out and winter tourism with some 53 million guest-nights 1991/92 (ÖSTAT 1994) generates some 4.5% of Austrian GNP, approximately the same amount as summer tourism with over 70 million guest-nights, while the agricultural income accounts only for 3%. No industrial country in the world is as dependant on tourism as Austria, which has a share between 4 and 5% of world tourism. 50% of the tourist income derives from the winter season. A couple of bad winter seasons in line with poor snow cover, similar to those experienced at the end of the 1980s may ruin the population dependent on winter income, before it can recover during climatically more suitable periods. 74% of all Austrian skilifts are situated relatively low under 1000m altitude. 69% of all winter tourist nights are spent below 1000m above sea level (Fleischhacker 1992). Therefore the sensitivity towards climate fluctuations is very high.

Table 1: Some Key figures of Austria

Area in 1000 km^2	84		
Population in mill. 1991	7.8	share in world tourism in %	4-5
% Alpine area	64	GNP in 1000 mill. US$ (10AS = 1US$) 1991	200
Tourist nights in million 1991	130	% of GNP directly dependent on tourism	9
Winter tourist nights in million 1991/92	53	% of GNP directly dependent on winter tourism	4.5
% of winter tourism under 1000m	69	% of GNP earned by agriculture	3
% of skiing transport facilities under 1000m	74	% of coverage of foreign trade deficit due to tourism	60-70

Income losses

If the climate would have remained on the minimum of the variability curve between 1960 and 1990, Austrian GNP could be up to 1.5 % higher. Some 15 days of the winter sport season are lost in connection with a warming of 1.5 degrees Celsius. In most cases the most profitable Christmas and Easter business is effected (Föhn 1989). The direct loss is more than 10 % of the winter tourist revenues or 0.5 % of Austrian GNP. Taking various economic multiplicators into account, usually the factor "3" is used, makes the total loss higher than 1.5% of Austrian GNP. This is more than half of the entire income of Austrian agriculture. On the other hand climate variability opened new business opportunities to new branches, e.g. the manufacturing of snow making equipment. This partly offsets the loss on the national scale if domestic products are used.

The local scale is more vulnerable as there are areas particularly dependent on winter sport. In a previous paper (Breiling, Charamza 1993) an econometric model in order to asses the potential losses due to warming and its impact to the employment situation was developed. The calculation for one Austrian district (Hermagor in the Eastern Alps) results in more than 2% direct loss or more than 6% of

indirect loss of the gross local product due to a warming of 1.5 degrees Celsius. Here, the loss is four times higher than the Austrian average. This change of income also has an influence on the employment structure. Less local income forces more people to stay within the agricultural sector, while less people are occupied within the service sector.

The last three decades were accompanied by an extraordinary economic growth and the loss due to warming within climate variability was more than compensated by the expansion of new winter resorts. There is still growth within the winter tourist sector (ÖSTAT 1994). Winter tourist nights increased from 10 to 54 million guest nights within the last 30 years. The average annual growth during this period was 4%. or divided into decades 12% annual average growth in the 1960s, 5% in the 1970s and 2% in the 1980s.

The sensitivity to climate fluctuations increases in connection with other economic burdens. More than 50% of all the 80,000 Austrian tourist companies have borrowed heavily and any losses could seriously impair their possibilities of paying back the loans.

Investments for the adaptation to climate

Alpine communities are already in a stage of adaptation to climate variability. There were 127 communities with together 250 units for snow making in 1991 (Bittermann, 1993). These units cover about 20% of all Austrian skiing tracks or some 5,000 ha. Despite shrinking incomes in 1993, there was heavy investments in snow making facilities. Some US$ 1.5 billion were probably investmented in the tourist sector only in 1993 (ORF, October 1993). To equip all Austrian ski tracks, an area of about 25,000 ha (Greif 1987), with snowmaking facilities, would cost some US$ 10 billion, 2 billion US$ were already invested until 1991. This amount is considerably more than the entire income of one Austrian winter season with some US$ 8 billion. Some 0.3% of the GNP or 7% of all winter tourist incomes have to be spent for this purpose for 20 years. This means that this investment should guarantee some 10% of extra winter income to be a worthwhile venture. In the previous example of Hermagor district (Breiling, Charamza 1993) the gross local product for 20 years is 1% smaller due to this investment. Particularly lower regions have unfavourable conditions. There snow making units cost more and will not necessarily bring extra income as it can become too warm to use them. Average day temperatures of 0 degrees Celsius or less are required with night temperatures under -2 degrees Celsius.

Regional differences according to climate zones

Warmer winters mainly bring problems, but some local, higher situated areas can profit too. The climate sensitivity is not the same all over Austria. The lowlands with 56% of the population are economically less dependent on climate, the lower Alpine region is much more climate dependent than the high Alpine region. Here there are critical winter tourist resorts situated. Snow comes later and the snow cover ceases earlier. 38% of all Austrians live in this zone. In the higher Alpine region there is no climate

problem for winter tourism. An increase of the intensity of winter tourism can be expected due to the climate conditions in the lower Alpine region.

Table 2: Different climate sensitivity zones of Austria (Source: Austrian Central Statistical Office, 1992)

Altitude above sealevel in m	Communities[2]	Inhabitants	% of Austrian population	Inhabitants per community	climate impact on regional economy
117 - 400	950	4,366,101	56	4596	no
401 - 800	1026	2,959,769	38	2885	yes: losses
801 - 1780	379	469,916	6	1240	yes: benefits

Growing economic disparities within Austria

Severe economic problems may develop first in this medium region of Austria. Higher Alpine areas that are generally supposed to win from this situation may experience problems by ÒimmigrantsÓ from lower areas arriving with cars and buses in the more reliable snow areas. This may cause a conflict between hotel owners of the better off higher areas and the people letting rooms in lower areas. The first are concerned with the exclusivity of their area, the latter want to retain at least their overnight revenues by transporting their people up. The possible overuse of high Alpine areas would cause more environmental damage and make the area less attractive to tourists. As a consequence, tourists may choose other destinations and economic problems could also increase in the high Alpine region.

The associated environmental challenges and problems

The warming in relation with climate variability is not sufficient to cause a direct impact. Biological systems can tolerate temperature and precipitation change within a certain range. Nevertheless, due its impact on socio-economic conditions climate variability will be responsible for certain environment modifications.

Landscape management in remote areas

Moderate changes due to climate variability may be co-responsible for a lack of money to finance necessary work within the Alpine region. There is a tendency towards deintensified use of the Alpine areas. The level of maintenance has decreased as it does not give adequate income.
Considerable parts of the high Alpine forests are no longer in a good shape. Several stands of non productive, protective forest are overage and can not rejuvenate as high kept game populations eat

[2] The districts of Vienna are counted as communities

the new seedlings. Thinning out stems in marginally productive Alpine forests to gain fuel-wood is neglected. Dense forest populations become easier victims of parasites, that weakens the forest system. The root system of badly managed forests has a lower capacity to store water and to buffer consequences of extreme weather events. In addition, some Alpine areas are severely affected by acidification which further decreases the buffering capacity of Alpine forest systems.
Marginal agricultural land is afforested, which is a problem in case of monocultures or the use of non local species. The pasture landscape needs permanent care and a continuation of the agricultural use. If grass is not consumed by animals or cut, long grasses will freeze into the snow-ice layer above. In spring this layer can move and take grass and humus with it. Erosion plots are a consequence, which are enlarged during summer by heavy rainfalls and may later on exaggerate the impact of extreme events. The combination of various tasks of landscape management is responsible influences the degree of Alpine safety and the resilience against natural catastrophes.

Urbanisation

Winter tourism was responsible for a major urbanisation in the Alpine areas. This means construction of houses and infrastructure. In many cases there are considerable shortcomings in the development of urban structures. Often there is a lack of basic infrastructure such as water supply which is most scarce during winter, or cleaning facilities like sewage treatment plants or waste disposal.
Climate problems in lower regions may cause intensified use in the higher region with more appropriate snow conditions. There they induce serious trouble due to lacking capacities of the existing infrastructure. Problems will become more frequent in connection with tourists coming just for the day. There are not enough parking lots, restaurant places or sanitary facilities.

Endangered ecosystems

A possibly intensified use in the high Alpine region due to more appropriate climate conditions higher up may further endanger rare plants and biotopes which have to suffer additional stress. The high Alpine zone reacts severely to any disturbance. Snow making units have the potential for larger environmental conflicts, as they modify the hydrological system and have an impact on the vegetation cover. Damages to the thin top soil layer may last 100s of years before the soils can regenerate naturally. The recultivation of skiing tracks or forest roads is only done if there is a related economic activity. Several bad winter tourist seasons could kill the motivation to sustain the environment. In the case of skiing tracks often non appropriate plant material from lower zones is used in the high Alpine zone. The recultivation may be successful in climatically favourable years, but cannot survive the regularly returning extreme conditions.

Aesthetic degradation in the Alpine landscape

The sense of aesthetics is based on the individual taste of inhabitants and tourists and connected with the perception of the Alpine environment. A badly managed landscape with erosion plots, neglected pastures and inaccessible forest is not attractive. A too technical landscape with a lot of cables and wires is not beautiful either. Garbage from tourists destroys the attractiveness of the area far away from the actual tourist resort. The variety of landscape is diminished by afforestation and intensified agricultural practices in the Alpine area.

Conclusion: Influencing the decision makers on the local level

Alpine communities do not have to focus on possible global climate change some decades ahead. The observed variability of climate in combination with various other local circumstances is able to destabilise both the economy and the environment of the Alps. Each of the mentioned economic and environmental issues, like income losses, costs for adaptation, regional differences and incomedisparities, landscape management, urbanisation, ecological problems or aesthetic degradation calls for action on the local level. Working with each of the individual tasks will also improve the overall resilience of the Alpine area and help communities to cope with the possible consequences of the fluctuating climate on the local level. To start with, I can give the following recommendations:

- study processes that could be influenced by climate and its variability
- develop long term strategies to decrease economic dependence on climate
- develop plans to solve climate induced conflicts between the lower and higher Alpine region.

There will not be a general overall solution. Different areas will have to develop individual concepts. No area, location or community is equal to the other one and local information has to be combined with overall information on the climate problem.

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