2.1. Temperature extremes

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During the 20th century, the temperature level of both the hot and cold temperature extremes increased at all times of year. At high altitudes, a marked increase in the level of the hot temperature extremes in winter was observed. At low altitudes, cold extremes occurred somewhat less frequently. It is expected that the temperature level of both the hot and cold temperature extremes will increase in accordance with anticipated global warming in the 21st century.

Introduction

Long-range changes in the air temperature at the ground can have multiple effects on ecosystems (particularly on plants[1]), the water content of the ground, glaciers and permafrost (cf. Chapter 2.8). Changes in the average temperatures and the appearance of temperature extremes are of central importance in this connection. In addition to their effects on the areas mentioned, extreme hot and cold periods may cause enduring damage to ecosystems, damage commercial plants, and in some cases endanger the health of humans and animals. Whilst the pattern of extreme temperatures may vary, their duration and regional distribution are decisive. The most extreme forms are heatwaves and extremely cold periods affecting wide areas of the country. Typical examples are the very cold winter of 1962/63 and the very hot summer of 1947.[2] In analyzing trends and possible future changes, temperature extremes of this kind with very long return periods are of little value (cf. Chapter 1.4). In this chapter we shall therefore discuss the behaviour of a larger range of temperature extremes, namely the 10% hottest maxima and the 10% coldest minima during a season. For purposes of simplification, it may be assumed that the maximum temperatures occur during the day and the minimum temperatures at night.

The air temperatures at the ground are subject to large fluctuations over the year and are very sensitive to regional and local influences owing to the very varied terrain in Switzerland. A rough division will be made between Alpine regions lying above 1500 m and low-lying regions below 800 m to the north of the Alps. The Alpine region is of particular significance, since ecosystems at high altitude closely adapt to the local climate and are particularly sensitive to change. Further, temperature measurements in these remote areas are less influenced by non-natural causes (e.g. urbanisation).[3]

Observed trends in the 20th century

In the 20th century, not only in the Alps, but also in low-lying regions, the temperature level of both hot and cold temperature extremes increased at all times of the year. Since 1900, the hottest days, the hottest nights, the coldest days and the coldest nights all increased in temperature by between 0 and 3.3°C depending on time of year.[4]

In addition, the number of hot and cold temperature extremes varied (the method of determining these is explained in the legend in Fig. 22). Cold temperature extremes have become less frequent over the years, particularly in the winter months.[5] In the 1990s, the number of hot temperature extremes in winter, spring and summer was significantly higher, and the number of cold temperature extremes significantly lower, than the average for the previous 90 years. The sharpest change occurred in the hot temperature extremes in Alpine regions in winter (Fig. 22). In the 1990s, an average of 16 hot days and 17 hot nights occurred, whilst in previous periods of comparable length, only between 1 and 9 hot days and nights were recorded.

In lower-lying regions, warming tends to manifest in the form of somewhat less frequent cold temperature extremes. In the Central Lowlands, 50 frost days less were recorded in the 1990s than in the first decade of the century (cf. Chapter 2.2).[6]

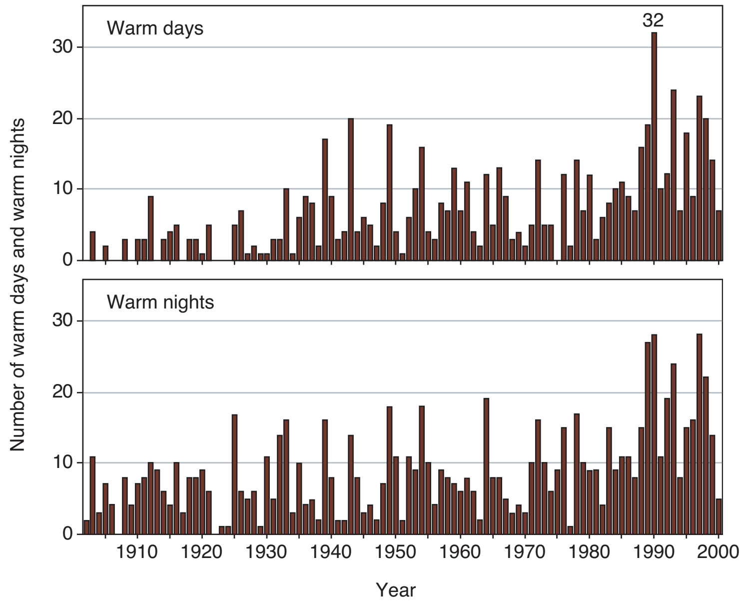

Fig. 22 Annual number of hot temperature extremes for 1902-2000 in the winter months in Alpine regions above 1500 m. The threshold value was defined as the 90 percentile of the maximum temperatures (day) and the minimum temperatures (night) for the climatological reference period 1961-1990.[4] That is to say, the threshold value was not defined according to the highest maximum (or minimum) value during the reference period, but as that value which was exceeded by 10% of the measured maximum (or minimum) temperatures.

Factors involved in climate change

Climate change can exert an influence on the temperature through a variety of coupled processes. Foremost among these is the greenhouse effect resulting from the increased greenhouse gas concentration leading to warming of the atmosphere. However, the air temperatures near the ground are also determined by dynamic processes. The origin of an air mass present at a particular location is determined by the distribution of the large-scale pressure systems over the globe. In Switzerland, a close relationship exists between the occurrence of climatological weather types[7] and the frequency of hot and cold temperature extremes (cf. Chapter 1.3). For example, the comparatively low frequency of cold winter days during the 1990s resulted from the increasing occurrence of high-pressure and west-wind weather types at the expense of those weather types involving cold north-easterly winds. This shift appears to be closely related to changes in air movements above the North Atlantic and the increase in the North Atlantic oscillation index (NAO index).[8] Whether these flow changes result from global climate change or simply from an exceptional phase lying within the normal range of climatic variation is not yet clear.

In addition to the greenhouse effect and the dynamic influences mentioned, local ground conditions and cloud cover also play a part. For example, the presence of snow cover modifies the radiation conditions, so that the anticipated reduction in snow cover in winter as a result of global warming could lead to a regional intensification of warming. This process is likely to be particularly relevant to winter temperature extremes.

Influence of climate change

The expected increase in average temperatures in the course of the 21st century will very probably be accompanied by an increase in the temperature level of the temperature extremes in Europe. The temperature extremes simulated over a 20 year period using a global climate model show a general increase in the temperature level of the minima and maxima towards the end of the 21st century.[9] Depending on the region, the minima were found to rise by over 5°C, and the maxima by between 1 and 4°C, compared to today's climate. At the regional level, the cold extremes are found to increase particularly at locations with reduced snow cover, and the hot extremes in areas with reduced ground humidity in summer. For the Alps, whilst a scenario assuming declining ground humidity would be accompanied by large uncertainties, a shortened period of snow cover in winter would be plausible. It is interesting to note that the simulated increases in the extremes are greater than the increases in the averages.[10] Care should be taken in interpreting the simulated results for cold extremes in the Alpine region, and the values cited must be regarded with caution. Changes in the large-scale air flows are an important factor in determining regional changes in the temperature extremes. In this respect, the available simulations are subject to considerable uncertainty.

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