OcCC
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Extreme Events and Climate Change

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Editorial

Kathy Riklin

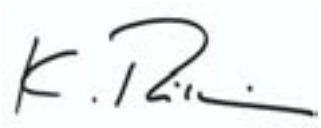
Floods, extreme storms and dangerous avalanches have caused repeated concern in recent years. Has the weather got completely out of hand?

In 2000, the The Advisory Body on Climate Change (OcCC) discussed the possibility of a connection between the increased frequency of these events and climate change, and considered what action was needed. At the suggestion of the former president of the OcCC, Gian-Reto Plattner, it was decided to prepare a report on the theme to be addressed to the wider public, members of the media and decision makers. The present publication presents a scientifically founded review of the most important results and meteorological phenomena. What are the conclusions to be drawn from the knowledge gained and what measures should be taken?

In game theory, the 'minimax' theorem is often mentioned. In games, the objective is to determine the optimum stake for each separate strategy in order to minimize the maximum gain of the opponents. Here, we are concerned not with a game but with a battle against the supposed moods of nature. In our case, the sums betted are very large and the playing board spans the entire globe. Under the minimax rule, a strategy must be selected for which the maximum possible damage is as small as possible. For this reason, political decisions should be based on the minimax rule. Also, we are concerned here – other than in game theory – with long-term damage that is to be minimized.

In the coming decades, scientists will continue to deliberate on and research the exact causes of climate change. Nonetheless, decision makers are called on to take precautionary measures here and now. The OcCC offers clear and unmistakable recommendations on page 7 of the report. The building of avalanche barriers, stonefall shelters, retention basins and dams will not suffice. Direct measures of this kind to minimize the damage are of course essential. However, it will primarily be necessary to adopt measures that are effective not only in avoiding climate change, and in providing protection against extreme events, but also have a positive influence in other spheres. This is the only conceivable way to ensure that 'spaceship earth' will remain inhabitable into the distant future. Over and above that, so-called win-win situations will arise in the short term from the measures taken. This is the case, for example, for the economical use of fossil heating and motor fuels and for the promotion of renewable energies.

Switzerland’s signature to the Kyoto Protocol on 9 July 2003 represented an important political step. Now, deeds are called for. The political parties and the leaders of industry and commerce must now be reminded of their promises. The situation is crucial. Words must be followed by deeds. The present publication reviews the risks at hand.



Dr. Kathy Riklin, National Councillor
President of the OcCC

Extreme events and climate change – status of knowledge and recommendations of the OcCC

Members of the OcCC

The term extreme events refers to infrequent weather and natural events that depart heavily from the average. Extreme events can result in very extensive damage. The term natural catastrophe is used where the capacity of the local population to deal with the damage is exceeded. The present report addresses the most important categories of extreme events in Switzerland and their relationship to climate change, namely to temperature extremes, drought, frost, forest fires, heavy precipitation, hail, floods, mass movements, avalanches and winter storms.

In one sense, extreme events and natural catastrophes can be seen as a normal aspect of the Alpine climate. Landslides and floods have actively formed the landscape over thousands of years, and this includes the characteristic structure of our mountain valleys and rivers. Indeed, even today's modern infrastructure cannot provide complete protection from extreme events. Thus our civilisation must often content itself with treating high-risk occupied areas on a separate basis, mitigating the negative consequences by timely measures and the provision of immediate assistance to the victims.

From the human standpoint, the damage unleashed by heavy storms in Central Europe in past decades is very extensive. The Swiss reinsurer, Swiss Re, for example, estimates the losses to the national economy caused by the Lothar and Martin storms at 31 billion CHF, those caused by flooding and landslides in October 2000 in Switzerland, France and Italy at 9 billion CHF, and those from flooding in Europe in July and August 2002 at 23 billion CHF (2002 prices). These figures underline the severity of extreme events in the Alpine region and in Europe as a whole. Should the character and frequency of extreme events shift as a result of climate change, this could have very serious consequences.

Current knowledge

The relationship between climate, extreme events and the extent of damage is extremely complex, and calls for a very broad range of interdisciplinary research. On the basis of current knowledge, the following general conclusions may be drawn:

- Over the past century, the global average temperature rose by 0.6 ± 0.2°C. This temperature increase is attributed mainly to human activity. Climate simulations for the 21st century predict a faster increase in the average global air temperature at the ground of 1.4°C to 5.8°C. The entire water regime will be affected by these changes, and marked changes in the precipitation pattern are expected.
- The probability and geographical distribution of extreme events will alter gradually with the change in climate. The extent and character of the changes will differ depending on the location and character of the extreme events. It is not at present possible to give a quantitative assessment of these effects.
- At present, natural catastrophes are observed to occur more frequently. This could either be accidental, the result of natural long-term climate change, or of climate change from anthropogenic causes. For fundamental reasons, it is difficult, or may even be impossible, to identify or exclude a statistically valid trend in the frequency of rare extreme events. Indeed, it may not prove possible to positively identify long-term changes in the frequency of extreme events until their extent has become very considerable and extensive damage has been caused.
- In contrast, statistical predictions are possible for trends in 'intensive' events. It can be shown, for example, that heavy precipitation events (which do not usually lead to damage) have become more frequent since the beginning of the last century. Also, the volume of precipitation in winter has increased substantially in almost all parts of Switzerland since the beginning of the last century. Although these results cannot be applied directly to extreme events, they do point to substantial changes in the hydrological cycle over the last 100 years.

- Our present knowledge of meteorological processes suggests that the frequency and intensity of certain extreme events (heat-waves, heavy precipitation and floods in the winter months, drought to the south of the Alps in summer and in the inner Alpine valleys, and landslides) will increase with the change in climate. This anxiety is corroborated by calculations using climate models. In distinction, the frequency of days with frost and very cold periods will decrease.
- Future trends in the threat arising from extreme events will be determined not only by climatic factors but also by social changes. In the past, the increasing concentration of buildings and communal infrastructures in many areas – not least in exposed locations – has demonstrably had its effect on the losses incurred. Future changes in land use may lead to magnification – or possibly to attenuation – of the purely climatic factors.

Recommendations of the OcCC

The OcCC has identified a need for action from the part of political bodies, administration, commerce and research, on measures to protect against extreme events and combat anthropogenic climate change, and to ensure the integrity of communication.

The planning and implementation of measures must be based on a dynamic assessment of the hazard situation and take into account the need for ecological, economical and social sustainability. Priority should be given to those measures that are effective not only in combating climate change and in providing protection from extreme events, but also have positive (win-win) repercussions in other areas, and allow sufficient room for manoeuvre when they are in place (flexibility).

(a) Protection measures against extreme events

Even in the absence of climate change, there is an evident need for action to provide protection against extreme events owing to the increasing concentration of assets and their higher vulnerability, and the societie's enhanced need for protection. In recognition of the changing climate, hazard patterns, protection objectives and accepted residual risks should be periodically reviewed and solutions permitting the greatest possible flexibility sought. In the middle term, new assessment and planning methods must be developed that are able to quantify the risks under changing climatic conditions.

There is an increased need for action to provide protection from those events for which qualitative predictions of future trends are available today:

- Heavy precipitation, floods and landslides.
  Current knowledge of meteorological processes and the results of simulations point to an increase in the intensity of heavy precipitation and faster runoff in the winter months. This circumstance must be taken into account in risk assessment, planning of protection measures (reforestation, protection structures and retention areas) and in development planning. Also, the changes anticipated during the period in which the measures are in place must be considered. The same is true for the assessment of zones threatened by landslides.
- Heat waves.
  Higher temperature extremes are likely to occur as a result of climate change. It may be expected that higher mortality will result from the more frequent occurrence of extremely high temperatures. Structural measures (e.g. sun shading, insulation and greening) can increase the level of comfort and energy efficiency. Rivers, lakes, vegetation and fauna are subject to additional stress through higher temperature extremes.
- Permafrost.
  The increase in temperature will lead to receding permafrost. Slope stability will be reduced in the affected areas. Slopes and the buildings on or near them must be monitored.
- Frost.
  The frequency of days on which frost occurs is likely to decrease with the change in climate. Since the effects of this are dependent both on temperature and vegetation cover, it is not at present clear how these will change. In general, under the assumption that sowing and planting times remain the same, the risk of frost damage is likely to decline.

No assessment is at present possible of future trends in drought, forest fires, föhn, winter storms, hail or avalanches. It will be important to follow research developments carefully in these areas.

(b) Measures to combat anthropogenic climate change

Considerable uncertainty exists concerning the relationship between climate change and extreme events, and on their future variation, direction and extent. Decisions taken under uncertain conditions should be based on the so-called 'minimax' rule. This requires the strategy giving lowest possible maximum damage to be chosen.

Measures to combat the causes of anthropogenic climate change should be vigorously pursued and coordinated at national and international level between research, administration, commerce and political bodies. From the scientific standpoint, the long-term need is to reduce global greenhouse gas emission to the 1900 level. The Kyoto Protocol represents a major step in coordinating international measures. It is planned to fulfil Switzerland's reduction commitment through implementation of the CO_2 and energy laws, and by additional measures.[1] These are designed to achieve a reduction in CO_2 of 10% below the 1990 level by the year 2010. In view of the anticipated effects of climate change, it is essential for Switzerland to press for effective climate protection objectives in the negotiations on procedures to be adopted following the initial commitment period foreseen in the Kyoto Protocol. Among other countries, Switzerland stands to benefit from the measures implemented to combat climate change.

In Switzerland, measures going beyond the CO_2 and energy laws are needed to combat anthropogenic climate change and to establish low-emission lifestyles and industrial processes. Thus in order to foster sustainability in general and to ensure that investments are compatible with climatic needs in particular, the processes and commercial relationships in private enterprise need to be made more transparent. This may be aided by suitable legislative provisions. Partnerships between government and private enterprise (or industry) need to be established and promoted, thereby ensuring that climate protection measures and adaptation strategies are implemented. 'Clean' technologies and particularly renewable energies will need to assume a central role in future.

(c) Communication

Measures against anthropogenic climate change and for protection against extreme events must be planned on a long-term basis, but at a time when only qualitative forecasts of the future climate are available. The promotion of awareness on the part of the public, political bodies and the business sector is therefore crucial. Political leaders and the media will play a decisive role in achieving this.

In reporting on climate change and extreme events, note that extreme events do not represent reliable climate indicators. For this, better indicators are available, e.g. temperature increase and melting Alpine glaciers. There is a danger that the coupling of extreme events and climate change in the public mind could lead to dramatising the climate problem at times when extreme events are frequent, and to trivialising it at times when few extreme events occur.

Although an increase in the frequency of certain extreme events (e.g. heavy precipitation and floods) is consistent with the forecasts of climate models and with our physical understanding of the processes involved, this does not allow individual extreme events to be causally attributed to climate change.

(d) Research

Adequate knowledge is available today enabling measures to be taken to combat climate change and to protect against extreme events. Of course, research will continue in future to increase our knowledge and diminish the uncertainties.

In handling extreme events, integral analyses involving the natural, social, engineering and economic sciences are called for. Reliable measurement networks are of central importance in early diagnosis and analysis. They form the backbone of warning systems and provide the data basis for the detection of long-term changes. Careful system analyses of observed events can help to show which processes led to the event, whether the necessary conditions for similar events are present, and whether the change in climate may alter the probability of similar events occurring. Analytical models and computer simulations are also becoming of increasing importance internationally for short-term forecasts and issuing warnings. These instruments are also applicable in estimating and quantifying the dangers arising under future climatic conditions.

Research projects in progress in Switzerland and abroad (e.g. NCCR-Climate and EU research projects) are leading to a better understanding of

climate change and extreme events. Notwithstanding these efforts, the relationship between climate and extreme events is still only partly understood. The thrust of future research must be aligned with the latest report of the Intergovernmental Panel on Climate Change (IPCC)[2,3,4,5] and take the local situation and particular structures of the Alpine region into account.The central objective is to forecast the negative effects on society and the economy at an early date, and to propose suitable measures to combat them. The newly-gained knowledge should be constantly introduced into the ongoing planning and decision-making processes. It is essential for Switzerland to continue to actively participate in international research programmes and to foster the discussion between science, political bodies, the business sector and the administration.

1 For example the SwissEnergy programme for the promotion of renewable energies and of measures to increase energy efficiency.

2 IPCC, Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K., 881 p., 2001.

3 IPCC, Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K., 1032 p., 2001.

4 IPCC, Climate Change 2001: Mitigation. Contribution of Working Group III to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K., 752 p., 2001.

5 IPCC, Climate Change 2001: Synthesis Report. Cambridge University Press, Cambridge, U.K., 397 p., 2002.

Introduction

Roland Hohmann and Christoph Frei

The term 'climate' is always applied to the average weather, and this is characterised in turn by average meteorological values. Extreme events are episodes during which the weather departs substantially from the long-term average and from the fluctuations typical of particular locations and times of year. Extreme events are an integral part of the climate of a region, and have a decisive influence on the landscape and the conditions of life. They can, however, cause serious damage to communal facilities and commercial plants. It is therefore essential for society to have a knowledge of their frequency and intensity. This is needed for planning purposes and for the provision of protection measures.

The recent past has seen a multitude of extreme events in Switzerland. A small selection of these are listed here:

- In 2003, a heatwave brought Switzerland the warmest June since temperature measurements began in 1864. The long-term average monthly temperature was exceeded by 6°C.
- Following heavy precipitation in the Cantons of Grisons, Uri and Ticino in mid November 2002, mud avalanches caused serious damage. The villages of Schlans and Rueun presented a scene of destruction.
- In October 2000, almost 500 mm of rain fell within two days in October 2000. On 14 October 2000, the barrier above the village of Gondo broke. The resulting landslide with earth flow destroyed parts of the village and claimed 13 lives.
- In December 1999, the hurricane Lothar passed over Western Europe, causing extensive damage in France, Germany and Switzerland. Switzerland mourned 13 deaths. Forest damage totalled 12.7 million m^3 of timber.
- In July 1999, an large storm system with embedded thunder cells traversed Central Switzerland and the Alpine foothills from West to East. Over 500 communities reported hail damage in agriculture.
- In early 1999, in the course of three precipitation periods that followed each other at short intervals, over 300 cm of snow fell over large areas of Valais, northern Grisons and in lower Engadine. As a result, a total of some 1200 avalanches causing damage in the Swiss Alps occurred.

Extreme events and the damage they cause are a painful blow to the local population. They are also the subject of extensive media coverage. In the knowledge that global temperatures are rising, the question as to the relationship between extreme events and climate change is posed time and again. Have extreme events become more frequent as a result of climate change?

Climate change and its consequences are set out in detail in the latest Assessment Report of the *Intergovernmental Panel on Climate Change* (IPCC[1,2,3,4]). In the course of the 20th century, the global average temperature increased by approx. 0.6°C, and continental precipitation in central and high latitudes of the northern hemisphere increased significantly. The greater part of the temperature rise over the past 50 years is probably attributable to human activity. It is anticipated that during the 21st century, the rise in the global temperature will accelerate and the precipitation will alter significantly, and to a degree depending on the region.

The global change in the climate will also influence the frequency and intensity of extreme events. There are indications that the frequency of extreme events could react extremely sensitively to climate change. This is attributable partly to physical feedback mechanisms. A further part is played by statistical effects, by virtue of which the frequency of the extremes could be affected more strongly by climate change than that of 'normal' weather phenomena (Fig. 1 illustrates the statistical sensitivity in the case of temperature extremes). This anticipated high sensitivity, taken in conjunction with the vulnerability of modern civilisation, calls for scientific forecasts of extreme events and an assessment of their significance to humans and the environment.

The present report reviews the current status of knowledge on the relationship between extreme events in Switzerland and global climate change as seen by the members of an interdisciplinary expert panel. The analysis addresses the causal chain extending from global climate change via changes in extreme weather

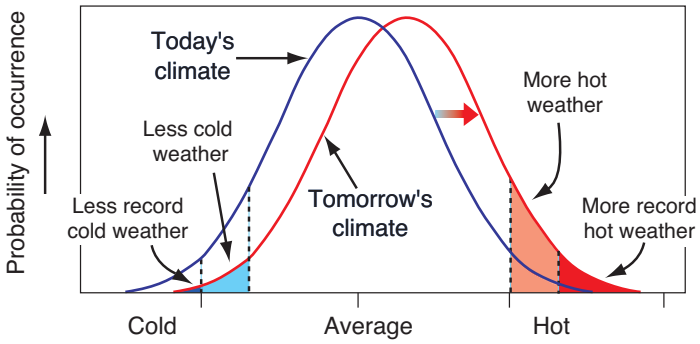


Fig. 1 Hypothetical influence of climate change on the frequency of extreme events for the example of temperature extremes.[1] The blue line shows the statistical distribution of today's temperatures. Whilst average temperatures are frequent, extremely cold (blue areas under the curve) and extremely hot (red areas under the curve) weather is seldom. The changing climate causes the average temperature and the entire temperature distribution to be shifted to the right (red line). The effects of this shift are particularly marked where the frequency of extreme events is concerned, extremely hot weather becoming much more frequent, and extremely cold weather much less frequent. For average temperatures, the relative changes are less pronounced.

conditions in the Alpine region through to changes in the resulting damage and to the economic consequences. The report seeks to adopt a differentiated approach in which aspects of natural science, possible effects on the habitat, and non-climatic influences on the level of risk (e.g. changes in use and the value of assets at risk) all play a part. It is addressed to political decision makers, the authorities, the media and the public.

The report is divided into two main parts. In the first part, the terminology used is defined, the scientific methods described (where necessary for an understanding of the results) and some of the scientific principles referred to later explained. The second part reviews current knowledge on those categories of extreme events of greatest relevance to Switzerland (i.e. temperature extremes, frost, drought, forest fires, heavy precipitation, hail, floods, mass movements, avalanches and winter storms). Where possible, and as far as this seemed reasonable, a common scheme was adopted in all sub-chapters covering the sensitivities of the respective category, conclusions drawn from changes in the past, and future perspectives.

A summary of the main results and the recommendations is given at the beginning of the report.

In total, 24 authors collaborated in the report. The contents were assessed by 7 professionals. The members of the OcCC reviewed and adopted the text at their meetings on 27 February and 28 May 2003.

1 IPCC, Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K., 881 p., 2001.

2 IPCC, Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, U.K., 1032 p., 2001.

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