2.5. Heavy precipitation

Christoph Frei

In Switzerland, heavy precipitation may either be intensive and of short duration in connection with summer thunderstorms, or less intensive and of several days duration in connection with stationary weather systems. Extremely heavy precipitation can lead to floods, rivers overflowing their banks, debris flows and landslides. In the course of the 20th century, the frequency of intensive daily precipitation events has increased over wide areas of the Central Lowlands and at the northern fringe of the Alps. Trend predictions on extremely heavy precipitation cannot be made. Most simulations based on climate models indicate a future increase in the average intensity of precipitation and the frequency of intensive daily precipitation. Assuming an acceleration of the hydrological cycle, intensive precipitation of long duration could become more frequent in the Alps.

Types of heavy precipitation in Switzerland

Roughly speaking, there are two types of heavy precipitation in Switzerland: short and intensive, and longer and less intensive.

Heavy rain of short duration (one to several hours) and high intensity (40-80 mm per hour) occurs mainly in summer in connection with thunderstorms, and is confined to the actual path of the storm (several kilometres to several dozen kilometres long). Extreme events can lead to overflowing of streams and smaller rivers, and also to debris flows in the mountains (cf. Chapter 2.7 and 2.8). In inhabited areas, should the capacity of the drainage systems be exceeded, this can lead to flooding. Occasionally, short and intensive rainfall is accompanied by hail (cf. Chapter 2.6). An example of an extreme short-range heavy precipitation event is that of the Sachseln thunderstorm of 15 August 1997.

Heavy precipitation of longer duration (one to several days), but lower intensity (100-400 mm per day), can occur at any time of year in connection with intensive and/or more-or-less stationary large-scale weather systems. Extreme and persistent rainfall can lead to floods and possibly also to overflowing of larger rivers and lakes, and to debris flows and landslides (cf. Chapter 2.7 and 2.8). Examples in this category are the enduring precipitation events in May 1999 in eastern Switzerland, those of October 2000 in Valais and Ticino, and the devastating extreme precipitation in Central Europe in August 2002. Extreme and enduring precipitation in the form of snow can cause widespread and large-scale avalanche falls (cf. Chapter 2.9).

The damage from heavy precipitation does not usually arise directly but via intermediate effects such as floods, landslides and avalanches (cf. Chapter 2.7, 2.8 and 2.9), or hail (cf. Chapter 2.6). Therefore the resulting damage depends not only on the duration and intensity of the precipitation, but also to a large extent on existing conditions in the area (e.g. ground humidity and effects such as melting snow).

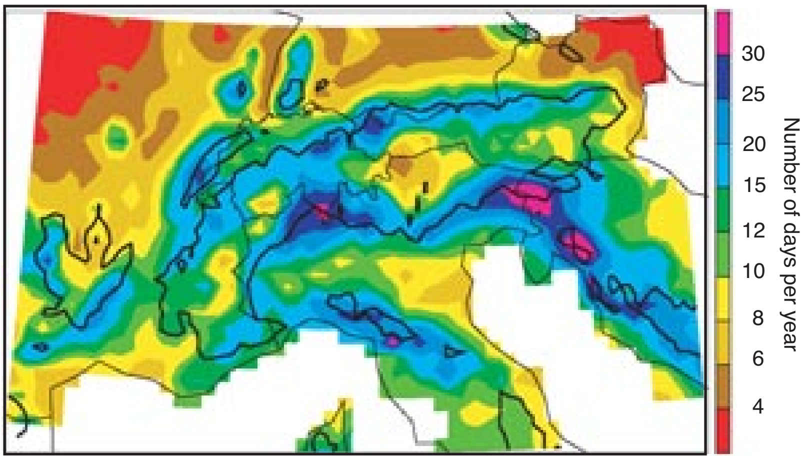

Fig. 29 Climatological frequency of daily precipitation values greater than 20 mm per day in the Alpine region between 1971 and 1990 (number of days per year).

Climatology

Topographical effects such as the uplift of air-masses by the Alps, and triggering of thermals over hills and mountain chains, play a significant role in the generation of heavy precipitation in Switzerland. Thus the topography is mainly responsible for determining where, and how frequently, heavy precipitation occurs. Precipitation rates of 20 mm per day and above occur more frequently along the northern and southern fringe of the Alps and in the Jura than in the Central Lowlands and the inner Alpine valleys (Fig. 29). Ticino is affected about twice as frequently as the Central Lowlands. In fact, the large number of heavy precipitation events in Ticino is exceptional for the Alpine region.

In Ticino, heavy precipitation occurs particularly frequently in the autumn. Here, weather fronts and low-pressure areas enter the Mediterranean region on more southerly paths than in summer, resulting in massive humidity transport towards the southern Alps. During the heavy precipitation event of October 2000, the quantity of water impinging on the Alps from the south over a period of 5 days was estimated to equal the total volume of Lake Geneva (Fig. 30). Also, Valais and Puschlav are often affected by southerly flow phenomena of this kind.

Trends observed in the 20th century

Precipitation in the Alpine region fluctuates heavily from one year to another. Depending on the time of year and the region considered, humid and dry years may differ by factors of 2 to 4. Observations show that in northerly and westerly regions of the Alps, average winter precipitation increased by 20-30% in the course of the 20th century.[1] In contrast, average precipitation in the Mediterranean part of the Alps in autumn has decreased by a similar amount.

Reliable predictions of trends in extremely heavy precipitation are not possible, since rare events of this nature are poorly ascertainable from the statistics (cf. Chapter 1.4). Trend analyses are confined to more frequent events having intensities well below those leading to damage. At most of the stations of long-standing in the Swiss Central Lowlands, and at the northern fringe of the Alps, intensive daily precipitation values (return period 30 days) have increased in winter and autumn (Fig. 31).[2] The trend is significant at about 30% of the stations, the increase being of the order of 20-80% per 100 years. Similar trends have been demonstrated for intensive precipitation of 2-5 days' duration. No systematic trends are evident for intensive daily summer precipitation values (Fig. 31).

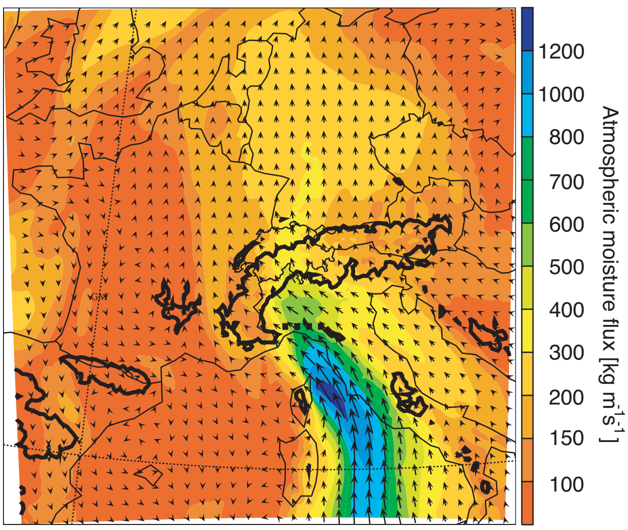

Fig. 30 Vertically integrated atmospheric moisture flux on 15 October 2000. Between 12 and 16 October, the quantity of atmosphere-borne water impinging on the Alps from the south was estimated to equal the total volume of Lake Geneva.

Despite this, the possibility of trends in the intensity of summer thunderstorms cannot be excluded. Owing to the short duration of thunderstorms, trend analyses based on hourly precipitation intensity would be more conclusive. For this, the time resolution of the long-range measurements is insufficient.

As in Switzerland, an increase in average and intensive winter precipitation values has been observed in neighbouring parts of Europe.[3] Changes in autumn precipitation to the south of the Alps – where the average is decreasing and intensive events are increasing – have been confirmed by trend analyses for Italy.[4]

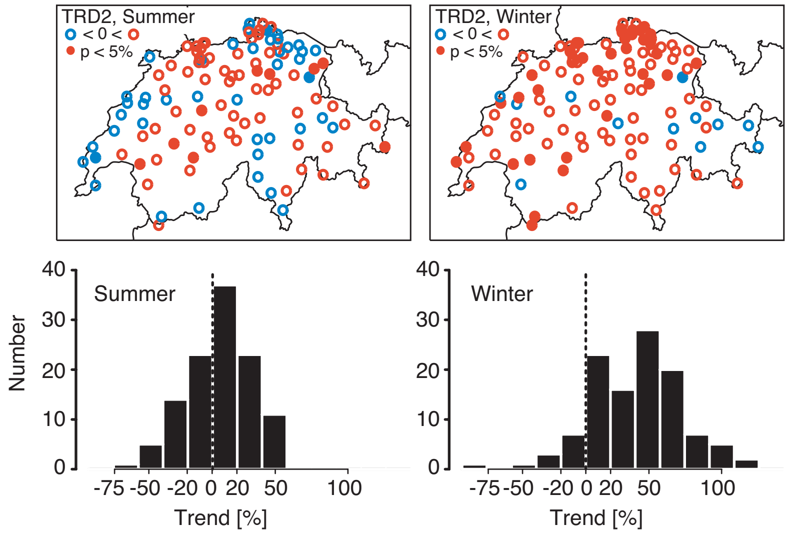

Fig. 31 Trend in the frequency of intensive daily precipitation values (one event per month on average) at 110 Swiss precipitation stations in the period 1901-1994. Top: stations with an increase (in red), and with a decrease (in blue). Full circles for stations with statistically significant changes. Bottom: histograms of the percentage change (change in probability) since 1901 for all stations.[2]

Effects of global climate change

Three chains of causation may be discerned connecting the frequency of extreme precipitation with global climate change:

(a) It is expected that climate change will lead to more pronounced warming in polar than in tropical regions, and that the vapour content of the atmosphere will increase. Both of these factors could influence the intensity, frequency and path of low-pressure areas in central latitudes. Changes of this kind may be directly coupled to changes in the geographical distribution and intensity of precipitation in Europe, with the inclusion of the Alpine region.

(b) In central latitudes, warming of the atmosphere is associated with an increase in the vapour content of approx. 6% per degree (Clausius-Clapeyron equation). At present, it seems fairly well established that the resulting intensification of the hydrological cycle will contribute to an increase in the average intensity of precipitation. The intensification will also have a disproportionately large effect on the frequency of heavy precipitation.[5]

(c) The intensification of the hydrological cycle is also associated with increased evaporation. In regions with a long dry season such as the Mediterranean, this could lead to a decrease in the water content of the ground in summer and autumn. This in turn could affect the thermodynamics of the lower troposphere and the precipitation dynamics. The possible significance and extent of this effect on the Alpine region are not yet fully understood.

Several global climate simulations for the second half of the 21st century were analysed for characteristic indicators of heavy precipitation. The majority suggest a global increase in the average intensity of precipitation and the frequency of intensive daily precipitation values.[6] This tendency is confirmed by the available regional model analyses for Europe, which show an increase in the maximum annual daily precipitation values of 10-25%. Increases by a factor of 2 and more have been identified in the frequency with which the current yearly and the current 50-yearly extreme precipitation values will be exceeded.[7] An analysis of the results of 19 global climate models shows that the frequency of winters with extreme precipitation (current return period 40 years) could in fact be exceeded by factors of 3-5 (Fig. 32)[8]. In the winter months, the increases are expected to affect the whole of the European continent, and in summer particularly central and northern Europe.

The increases in heavy precipitation found in many of the models is interpreted primarily as a result of the intensification of the hydrological cycle arising from global warming (chain of causation b). It is now regarded as probable that the hydrological cycle will intensify over the entire continent during the winter months.[9] In the Alpine region, this could result above all in increased heavy precipitation of long duration. This effect depends not only on the particular weather constellation but also on the quantity of water vapour borne in by the atmosphere. The particularly extreme autumn events to the south of the Alps could also be in this category.

Note, however, that the models display wide differences in the regional patterns of change. The differences are attributable to the fact that the typical paths and intensities of the low-pressure areas (chain of causation a) change to a different extent in the models. Thus it is still not clear how, and where, any changes in large-scale weather dynamics would accelerate – or compensate for the intensification of – the hydrological cycle. Therefore, the quantitative results for the Alpine region should be regarded as no more than rough approximations. At present, neither qualitative nor quantitative estimates may be made of heavy precipitation in the Alpine region in summer. No model analyses are available based on hourly time intervals, and existing models display large systematic errors in summer. Furthermore, the interactions between soil hydrology, vegetation and precipitation dynamics in summer (chain of causation c) are still not sufficiently understood, and are therefore not yet included with sufficient precision in the models.

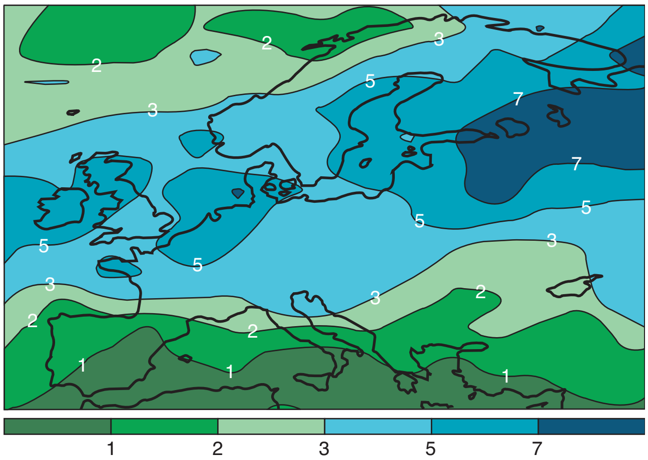

Fig. 32 Relative change in the frequency of extremely wet winters for a doubling of the CO_2 content of the atmosphere. For current winter precipitation intensities occurring on average every 40 years, simulations show an increase over Central and Northern Europe of a factor of 3-5. Results of 19 coupled climate models.[8]

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