How will the occurrence of extreme precipitation events in the Alps change by the end of the 21st century?

This information sheet is one in a series describing how the frequency and intensity of extreme weather events may change by the end of the 21st century in response to global warming. The regional information presented here was obtained using state-of-the-art climate modeling and regional downscaling techniques developed during the STARDEX European Union-funded research project. These methods and the STARDEX approach are described in an accompanying overview information sheet.

Extremes in the Alpine region

Roughly speaking, there are two types of heavy precipitation in the Alps: short and intense, and longer and less intense.

Heavy rain of short duration (one to several hours) and high intensity (40-80 mm per hour) occurs mainly in summer in connection with thunder-storms, and is confined to the actual path of the storm. Extreme events can lead to overflowing of streams and smaller rivers, and also to debris flows in the mountains. In cities these events can lead to flooding. An example of such an extreme 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 the 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 large rivers and lakes, and to debris flows and landslides. Examples in this category are the enduring precipitation event in October 2000 in southern Switzerland, and that of August 2005 in northern Switzerland (see Figure 1). Most affected by the August floods was an elongated area along the northern Alpine slopes from central Switzerland to eastern Austria and Bavaria; 2-day rainfall amounts were well above the 100-year level in central Switzerland; estimated damages amount to 2.5 billion Swiss francs (IRV 2005).

The damage from heavy precipitation does not usually arise directly but via intermediate effects such as floods, landslides, avalanches and hail. Therefore the resulting damage depends not only on the duration and intensity of the precipitation, but also to a large extent on pre-existing conditions and hydrological history in the area (OcCC 2003).

At the other extreme, the lack of precipitation over longer periods can lead to droughts. Droughts have a detrimental effect on humans, animals and plants. The record warm summer of 2003, during which only about 50% of the average summer precipitation fell in Switzerland, caused large losses in agriculture (over 500 Mio Swiss francs in Switzerland alone, Keller and Fuhrer 2004).

Past changes in extremes

Precipitation in the Alpine region fluctuates strongly from one year to another. Depending on the time of year and the region considered, wet and dry years may differ by factors of 2 to 4. Observations show that in northerly and westerly regions of the Alps, average wintertime precipitation increased by 20-30% in the course of the 20th century (Figure 2). In contrast, average precipitation in the Mediterranean part of the Alps in autumn has decreased by a similar amount (Schmidli et al. 2002).

Reliable estimates of trends in extremely heavy precipitation are not possible, since events of this nature are too rare. Thus trend analyses are confined to more frequent events having intensities well below those

Figure 1: Ascona during the October 2000 flood of the Lago Maggiore.

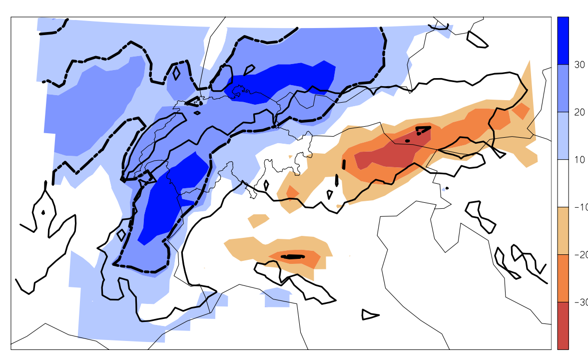

Figure 2: Trend of mean winter precipitation (in percent per 100 years) for the period 1901-1990.

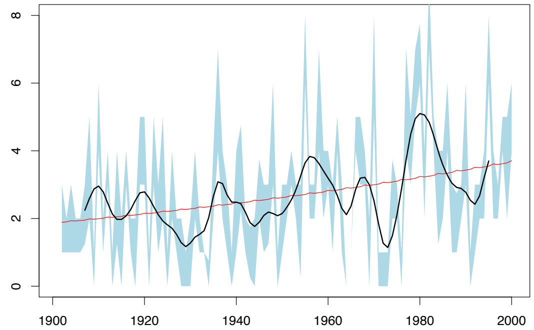

Figure 3: Number of intense precipitation events in winter for northern Switzerland.

leading to damage. In the Swiss Central Lowlands, and at the northern fringe of the Alps, the number of days with intense precipitation have increased in winter and autumn (Figure 3). The increase is of the order of 20-80% per 100 years. No systematic trends are evident for intensive daily summer precipitation values (Frei and Schär 2001, Schmidli and Frei 2005).

Future changes in extremes

The precipitation climate in the Alpine region is investigated for the future period 2070-2100, based on HadAM3 A2 emission scenario integrations. The emission scenario corresponds to a doubling of the current CO2 levels by 2090. The assessment is based on the HadAM3 GCM, three regional climate models (RCMs) and five statistical downscaling models (SDMs); see the STARDEX overview information sheet for further information on the models and methods.

The GCM and the RCMs show an increase of mean winter precipitation north of the Alpine ridge and a transition to small changes or decreases near the Mediterranean (Figure 4). The increases are mostly between 10-30%. Note the finer spatial detail of the RCM results, indicating the added value of downscaling. Further analysis shows that the increase in mean precipitation originates about equally from increases in the occurrence of wet days and precipitation intensity. This increase in precipitation volume, together with the larger fraction of liquid precipitation due to higher winter temperatures, is expected to lead to an increase of runoff and a higher risk of flooding. These results are consistent between all downscaling methods.

In summer, there is an increased tendency to dryness and drought. The RCMs predict an increase of the maximum dry-spell length by 50-100%. The results for summer are, however, less certain, than for other seasons. There are large differences between the downscaling methods. No statement can be made with respect to changes in the frequency and intensity of hail events.

In autumn, there is a tendency to fewer wet days and a reduction of mean precipitation. Nevertheless, the downscaling models predict an increase in intense precipitation by about 10%. This is indicative of an increased risk of extreme precipitation and flooding in sensitive areas along the southern rim of the Alpine ridge, which is already prone to such events in the present climate.

In summary, substantial changes in the precipitation climate are expected.

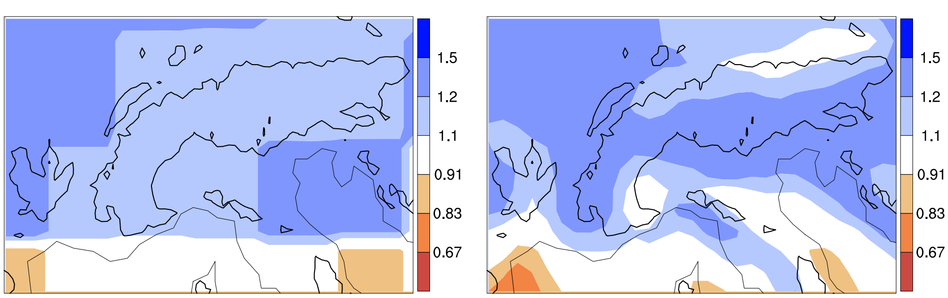

Figure 4: Ratio (2071-2100 / 1961-1990) of mean precipitation in winter (DJF). Results from the GCM (left) and the mean from three RCMs (right).

While the confidence in the results for winter is quite high, the differences between the downscaled scenarios are still relatively large for the other seasons, especially for summer.

References and further reading

OcCC, 2003: Extreme events and climate change, OcCC, Bern, 88pp.

Frei, C. and C. Schär, 2001: Detection probability of trends in rare events: Theory and application to heavy precipitation in the Alpine region. J. Climate, 14, 1568-1584.

Schmidli, J. and C. Frei, 2005: Trends of heavy precipitation and wet and dry spells in Switzerland during the 20th century. Int. J. Climatol., 25, 753-771.

IRV, 2005: Hochwasser August 2005, Schadenanalyse – ein Monat danach, Interkantonaler Rückversicherungsver-band, Bern, 26pp.

Séller, F. and J. Fuhrer, 2004: Die Land-wirtschaft und der Hitzesommer 2003, AgrarForschung, 11, 403-410.

Schmidli, J., C. Schmutz, C. Frei, H. Wanner, C. Schär, 2002: Mesoscale precipitation variability in the region of the European Alps during the 20th century. Int. J. Climatol., 22, 1049-1074.

Schmidli, J., C. Frei, C. M. Goodess, M. R. Haylock, Y. Hundecha, J. Ribalaygua, T. Schmith, 2005: Statistical and dynamical downscaling of precipitation: An evaluation and comparison of scenarios for the European Alps, submitted to JGR.

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