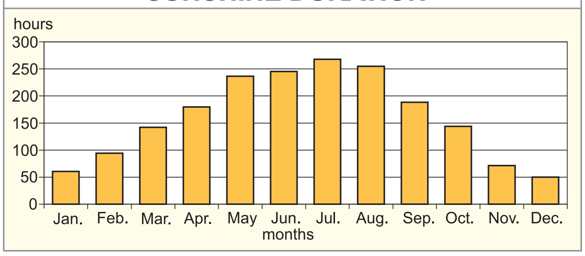
Climate

Hungary's climate is influenced by its latitudinal position, location of the country amidst a belt of westerly winds, the cyclonic activity of the temperate climate zone, and finally by its distance from the Eurasian continental interior, the Atlantic Ocean and the Mediterranean Sea. Due to these factors the climate of the country shows large variability. Despite the small territory and the relatively low relief, regional differences can be significant. Hungary is under the varying influence of the continental, oceanic and Mediterranean climates, any of which could be temporally dominant. The Carpathians, Alpine and the Dinaric mountain ranges are high enough to substantially modify the flow of air masses.

Sunshine

The quantity of annual sunshine varies between 1,750 and 2,050 hours, and the spatial distribution shows a north-west–south-east gradient. The monthly values for the countrywide average are between 50 and 260 hours (*Figure 22*).

Fig. 22 MONTHLY AVERAGE OF SUNSHINE DURATION



The annual course is similar to that of temperature, but there are small differences according to the effects of cloud cover. The absolute maximum of annual sunshine hours was 2,501 hours (in 2003) in the south-east and the absolute minimum was 1,398 hours (in 1972), which occurred in the north-western part of the country. In spite of that, the longest period with no sunshine was in the south-eastern region (35 days).

The fast development of automatic weather stations has reduced the manual measurement of sunshine duration, and at present they are substituted by global radiation measurements. The annual values fluctuate between 4,500 and 4,800 MJ/m^2 in most of the country.

Winds

The prevailing wind direction would be north-westerly without the effect of orography (*Figure 23*). The highest wind speeds generally occur before Easter, and are therefore called Lent-winds. Stronger winds cross the mountains and have north-westerly and northerly directions; other air masses are deflected, and cross the mountains at passes or other lower parts of the Carpathians, and they could even have an easterly component. This is mostly characteristic of the north-eastern part of the country. The secondary maxima of wind direction have a southerly component almost everywhere (orographical effect). The wind speed is relatively low (2–4 m/s annual average) because of the basin effect. In spite of this, wind has lately been increasingly used for the purposes of electricity generation. The maximum measured wind gust has been 44.5 m/s, but only rough estimations exist about the wind speeds in tornados, that have been observed with increasing frequency in recent times.

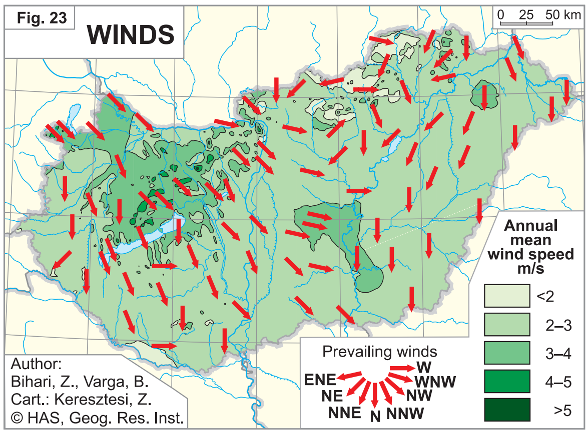


Fig. 23 WINDS

Temperature

The annual mean temperature has a north-west–south-east gradient, slightly modified by local topography (*Figure 24*). It had already reached 11°C in some places in the south of the country and on the south-western slopes during the 1971–2000 period. The country predominantly exhibits an annual average of between 9–11°C. The map illustrating the annual temperature average clearly shows the influence of local topography. Climatologically, the coldest month is January

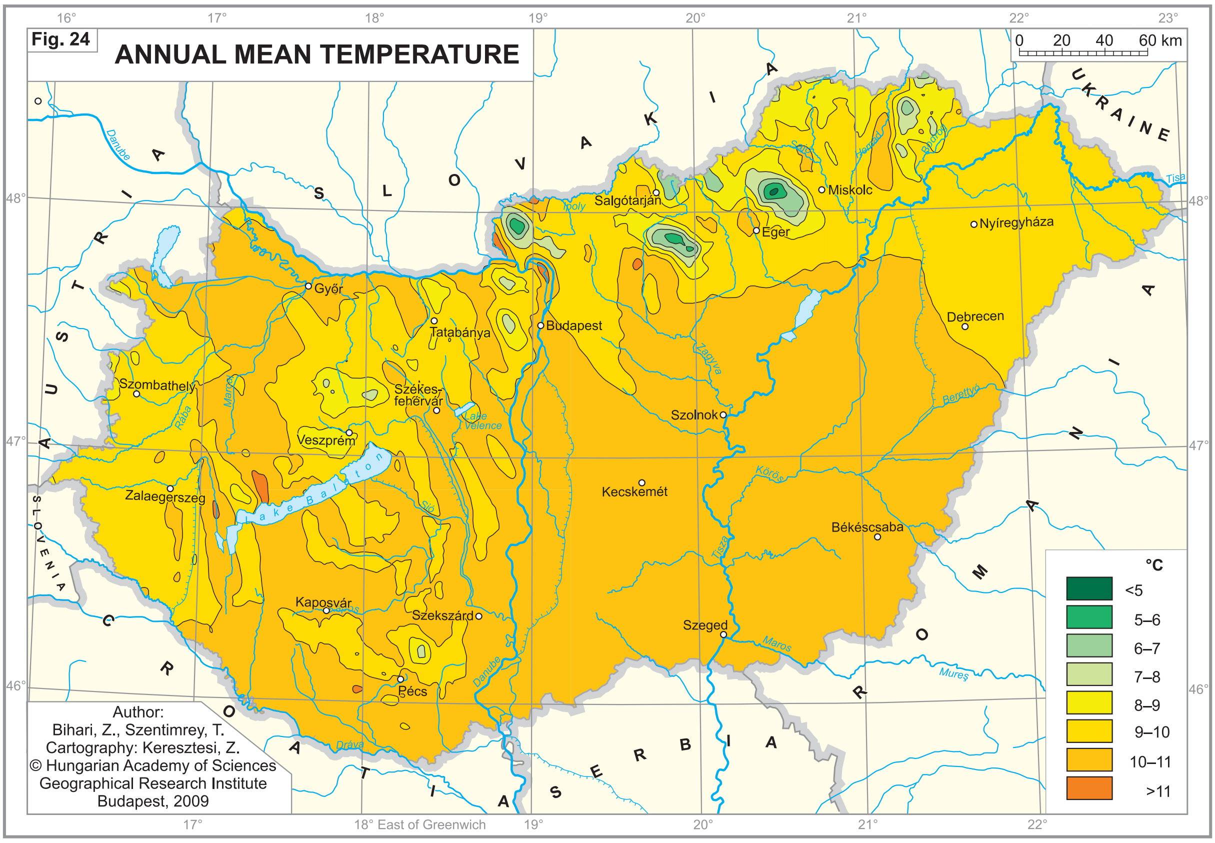
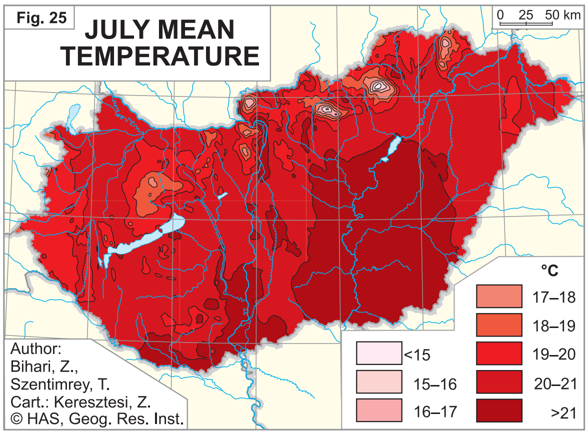
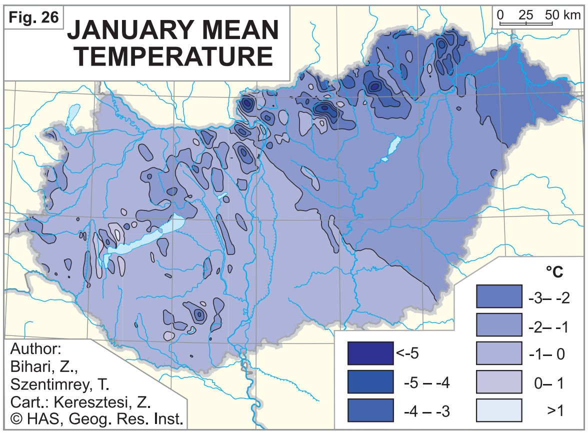


Fig. 24 ANNUAL MEAN TEMPERATURE





and the warmest is July, although in certain cases, any of the winter months can be the coldest and generally July or August is the warmest.

July's mean temperature is more than 21°C in the southern part of the country, over large areas of the Alföld (Great Hungarian Plain), and on southern and south-western slopes of mountains (*Figure 25*). Only small tracts with higher elevation show values below 17°C. Significantly cooler areas can be found in the North Hungarian Mountains. Convective motions are important in summer, therefore the latitudinal distribution of temperature is less influenced by large-scale horizontal flows.

The absolute maximum recorded temperature was 41.9°C on 20 July 2007. The warmest period of the year is the end of July and very early August, the coldest around the second week of January. The long-term mean temperature for January is sub-0°C practically all over the country (*Figure 26*). The distribution of the mean temperature shows a clear south-west–north-east gradient that is a consequence of the warming effect of the Mediterranean Sea and the cooling effect of the Siberian anticyclone.

The influence of topography is evident, but the vertical temperature gradient is more complicated. Inversions occur frequently in winter, when the temperature does not decrease with altitude, it rather increases up to the height of the inversion. The cold air pillow has an influence on the vertical temperature gradient; it is not unknown for areas with higher elevation to be warmer, because they are already out of the cold air mass on the bottom of the Carpathian Basin.

Precipitation

Precipitation shows large temporal and spatial variability. Monthly precipitation could be zero in any month and at any place, but it could equally be near to, or above 200 mm. The lowest amount of monthly precipitation recorded countrywide was 1.8 mm (February 1998) and the highest was 178 mm (August 2005). The year-to-year variability of annual precipitation is significant and has probably had a stronger impact on nature and the economy thus far, than its downward trend during the 20th century.

The absolute maximum daily precipitation sums used to be at least about 100 mm. The heaviest daily precipitation ever recorded was 203 mm and the largest estimated daily amount is 260 mm. The climate of Hungary is not warm enough to produce long lasting heavy rains. Larger amounts of daily precipitation as a rule not only have thermal triggers, but topographical reasons as well. Recently, there has been a greater incidence of flash floods, probably partly caused by the growing precipitation intensity. The annual precipitation figures show a south-west–north-east gradient, which is the effect of the Mediterranean Sea. Its amount varies mostly between 500 and 750 mm (*Figure 27).*

Summer is the wettest season and winter is the driest one. But winter precipitation is as

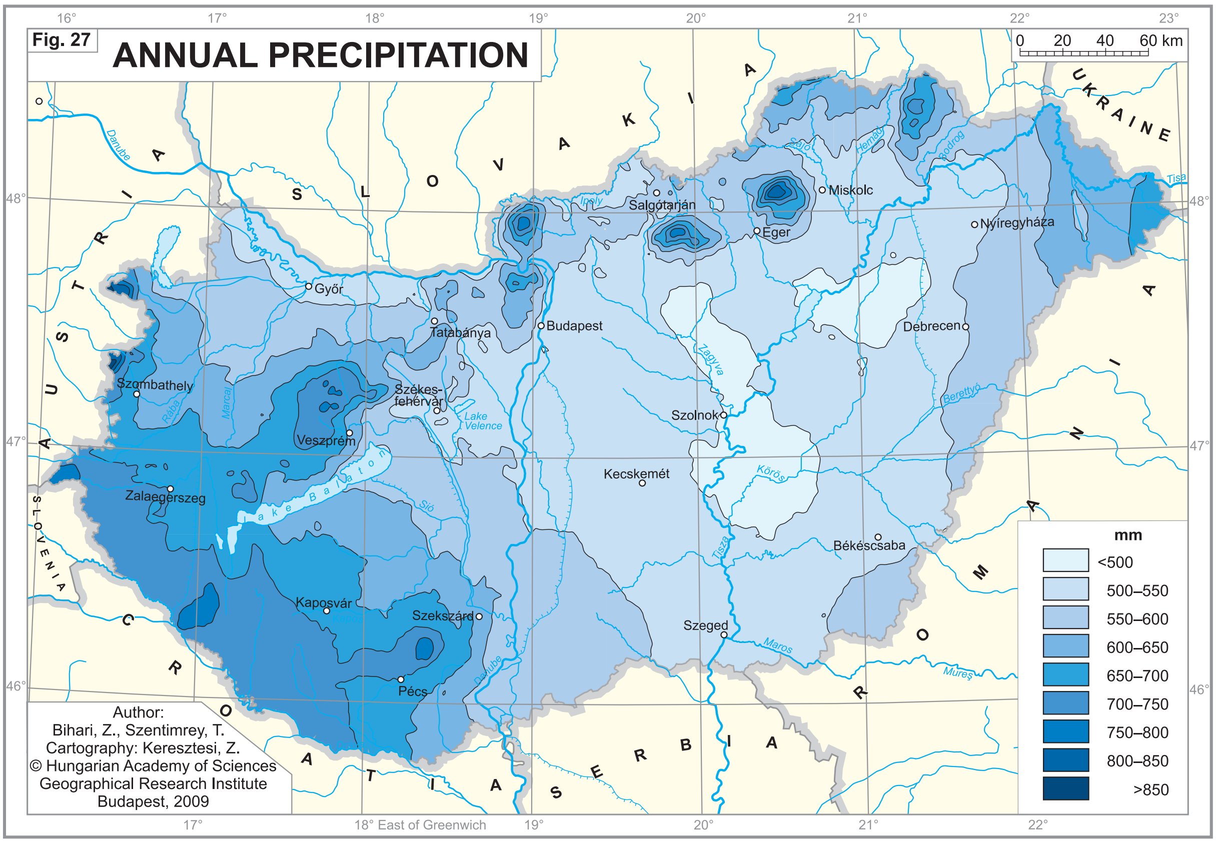


Fig. 27 ANNUAL PRECIPITATION

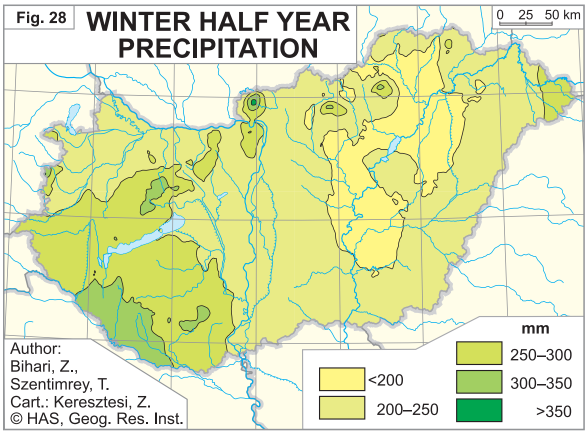


Fig. 28 WINTER HALF YEAR PRECIPITATION

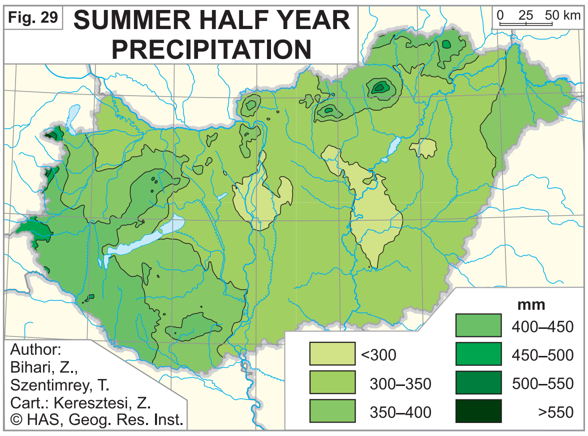


Fig. 29 SUMMER HALF YEAR PRECIPITATION

important as that of summer due to the higher seasonal storage capacity of the soil. The most frequent precipitation quantity is 200–300 mm in the six months of the winter season and 300–400 mm in the remaining spring and summer months (*figures 28 and 29*).

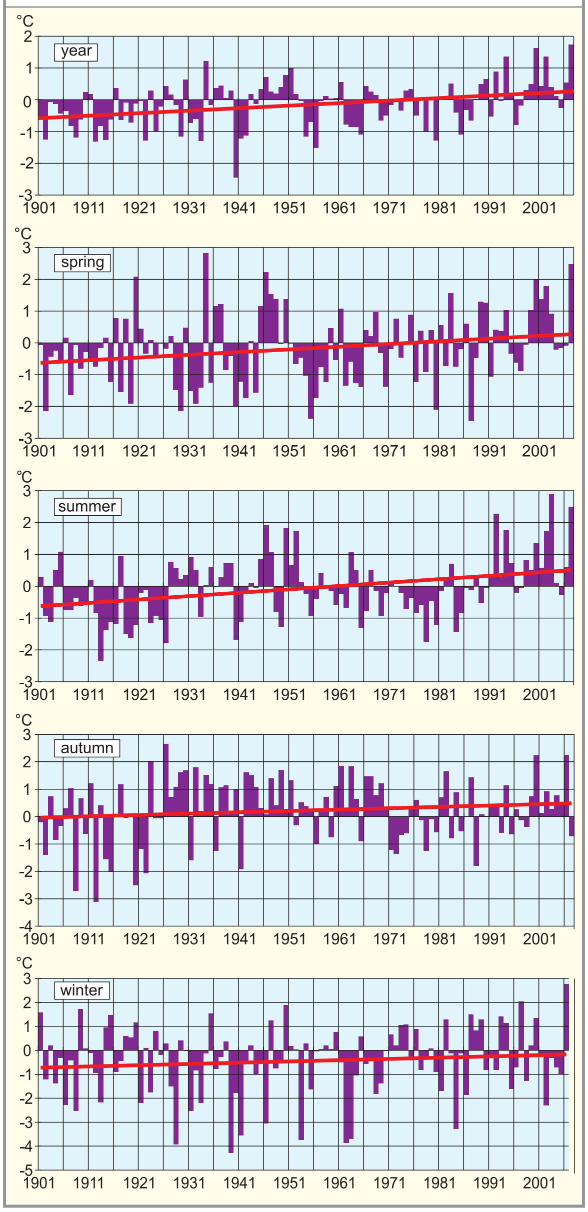
The spring and summer period offers a much more fragmented picture because of the large amount of convective precipitation. The increasing temperature reduces the snow/rain ratio in winter and it adds to the precipitation intensity, especially in the summer, further deteriorating the surface water balance and water supply situation.

The recent frequency with which floods and droughts have been occurring is alarming. Flood and drought events could happen in the same location, and even in the same year. The Tisza valley often suffers from both.

Long-Term Temperature and Precipitation Trends

Hungary is largely affected by climatic warming trends. There has been a significant increase in temperature in each season (*Figure 30*), but statistically, these have been for different reasons. The summer season has been warming most notably (by 1.12°C since 1901), and the main factor behind this steepest linear trend among the seasons has been the recent hot summers. The winters have warmed the least (by 0.42°C since 1901), and their warming can be explained by the disappearance of serious cold snaps by the end of the 20th century, with temperatures averaging near to those in the period between 1971 and 2000. Autumns were cold at the beginning of the studied period, and warm in the mid-20th century. Springs have shown a similar tendency to summers, with lower values of positive anomalies.

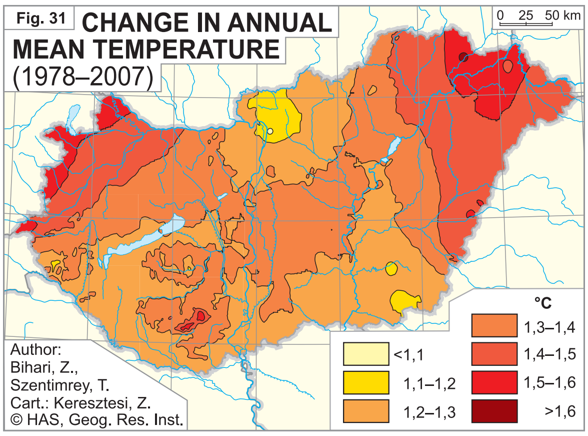
Fig. 30 **ANNUAL AND SEASONAL MEAN TEMPERATURE ANOMALIES WITH LINEAR TREND 1901–2007, RELATIVE TO 1971–2000 MEAN**



Warming has accelerated since the mid-70s, but its significance is relatively low because of the short time period, although it has been 2–3°C over the last 30 years (*Figure 31*). In line with the warming tendency, heat waves occur with ever greater frequency. They could be observed at the beginning of the 20th century, but practically disappeared during a cooling phase from first half of the 50s until the mid-70s and became increasingly frequent from the mid-80s onwards. Nowadays, heat waves are a common feature of the Hungarian climate.

Another indicator of a warming climate is the positive anomaly in mean monthly temperatures. 12 consecutive months had positive temperature anomalies from September 2006 until August 2007. This long, warm period (with average temperatures about 2–3°C higher than the 1971–2000 long-term average) makes the natural environment and humans much more sensitive to less than average precipitation. Increasing temperatures and decreasing precipitation levels are the characteristic features of basic Hungarian climate trends, therefore the changes are more appropriate to the South European region than alternative locations along the same latitude.

Fig. 31 **CHANGE IN ANNUAL MEAN TEMPERATURE** (1978–2007)



The temperature trends in Hungary are similar to that expected of global warming. The figures exhibit more noise due to the smaller territory, but they have a similar shape. 2007 was the warmest year since 1901 followed by 2000, 1994 and 2002. The warm years are drier than usual with the exception of 2007, when greater than average precipitation fell. Seasons show the same picture and the warmest seasons have occurred in recent years; spring in 2007, 2000 and 2002; summer in 2003, 2007, 1992, 1994 and 2002; autumn in 2000 and 2006; and winters 2006/2007 and 1997/1998.

No connection has of yet been detected between the short, late spring and early autumn frosts on the one hand, and the warming tendency on the other. One of the most serious agricultural disasters happened on 2 May 2007, when the minimum temperatures dropped to -6°C in the north-eastern part of the country causing severe frost damage in the apple orchards.

Long-term precipitation shows a decreasing trend (*Figure 32*), but sometimes increasing precipitation is visible as a shorter term tendency (*Figure 33*). No significant change can be observed in summer precipitation and there has been a slight decrease in that for winter (6% since 1901), which runs counter the results of climate projections obtained from dynamic models.

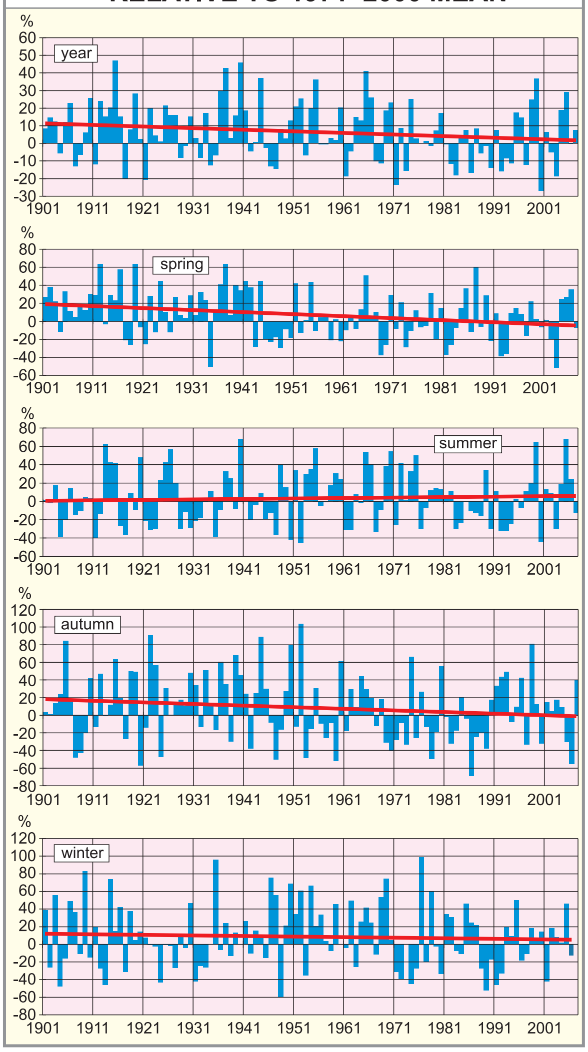


Fig. 32 ANNUAL AND SEASONAL MEAN PRECIPITATION ANOMALIES WITH LINEAR TREND 1901–2007, RELATIVE TO 1971–2000 MEAN

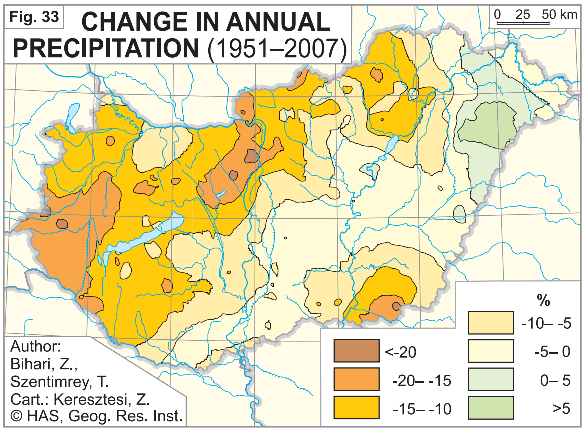


Fig. 33 CHANGE IN ANNUAL PRECIPITATION (1951–2007)

The largest reduction in seasonal precipitation was measured in spring (20% since 1901). Autumn has been affected by a smaller, but quite substantial degree, showing a 17% reduction in precipitation. It is likely that the year-to-year variability has a stronger impact upon the natural environment and humans, than the long-term tendency towards decrease.

In spite of the decreasing annual amount, the precipitation intensity has increased. There has been a growth in the number of days with a higher amount of precipitation. This fact deteriorates the surface water balance, due to the increasing runoff component.

Remarks

Only homogenised data from the Hungarian Meteorological Service (OMSZ) was used for this chapter. The homogenisation procedure was realised by MASH (Multiple Analysis of Series for Homogenisation), the smoothed maps by MISH (Meteorological Interpolation based on Surface Homogenised databases) software. Both were developed by, and are available from the Hungarian Meteorological Service. Maps show the climate norms of the 1971–2000 period. The statistical values are calculated since 1901.