Droughts in Finland – past, present and future

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Abstract. A drought hit most of Norway, Sweden and Finland in 2002-03 with a considerable reduction in hydropower production – and a considerable increase in the price of electricity. In Sweden the second half of 2002 was one of the driest in hundred years, in southern Finland the precipitation in August 2002 – April 2003 was less than half of the average.

In general, droughts are neither frequent nor severe in northern Europe, but they do occur. In Finland the most serious 20th century drought occurred in 1940-42. Mean annual countrywide discharge was only 49% of long-term average in 1941 and 57% in 1942. These were the two driest years in the whole 20th century.

Some knowledge on droughts before the instrumental period can be inferred from tree ring-widths. Prolonged sequences of severe summer droughts took place in southern Finland in 933-946, 1173-1191, 1388-1402 and 1664-1680. Some indications of cycles corresponding to periods of approximately 23, 30 and 57 years have been detected.

In the present climate, the ratio of winter low flows to summer low flows is less than 0.5 in northern Finland, but over 2.0 in southwestern parts of the country. Climate change may alter these values significantly. Increasing trends of winter flows have already been observed in southern and central Finland.

1. Introduction

Finland is a country with abundant water resources. The amount of water available per capita is 21,500 m^3/a, which makes Finland number one within the European Union. The average for the whole EU is 3,000 m^3/a.

The Finnish water world can be also be confirmed by a set of large numbers. There are 187,888 lakes in Finland, although 131,876 of them have an area of less than one hectare. The number of lakes with an area in excess of one hundred square kilometers is 47. Finnish lakes have 98,050 islands, in addition there are 80,897 islands along the Finnish Baltic coastline.

The total number of Finnish rivers with mean flow exceeding 2 m^3/s is over six hundred; thirteen of these have a mean flow of over 100 m^3/s. The combined length of all shorelines is 314,000 km. Lakes claim 215,000 km of shorelines; 14,850 km of these are located around Lake Saimaa and its islands.

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There are 22,085 springs marked on the Finnish basic map. About ten of these gush out more than 5,000 cubic metres of water a day, the largest one in Utsjoki, northernmost Lapland, up to 30,000 m^3. The total number of classified groundwater areas in Finland is 7,141. The number of those areas important for water supply is 2,226, those suitable for such use 1,300 and other groundwater areas 3,615. The total water yield of all classified groundwater areas is 5.8 mill. m^3 per day.

Anyhow, Finland is not immune against droughts. The Fennoscandian precipitation climate has large variability in all time scales. The region is a transition zone between the North Atlantic and the continental Eurasia. In addition, recent climate model simulations show a considerable disagreement in the change of precipitation in the future climate (e.g. Rummukainen & al. 2003), although a wetter northern Europe will be more probable than a drier one.

2. Droughts in the past

Tree-rings of Scots pine *(Pinus sylvestris)* have frequently been used in northern Europe for climatic reconstructions. The growth of these trees responds significantly to variations in early-summer precipitation. Thus the widths of tree-rings also give information on the occurrence of droughts. The method can be calibrated by comparing the ring-widths of living trees and the observed precipitation values in recent decades.

The results show that prolonged sequences of severe summer droughts took place in southern Finland in 933-946, 1173-1191, 1388-1402 and 1664-1680. The drought sequences were slightly longer in duration and less variable in terms of standard deviation than the wet spells. Some indications of drought cycles corresponding to periods of approximately 23, 30 and 57 years were also detected.

Historical information is available from the drought of 1664-1680. The cultivated vegetation in southwestern Finland suffered in these years. As to the earlier droughts mentioned above, written sources do not exist.

2. Some recent droughts

The longest discharge data series from Finland extends to the year 1847. Since 1911, the observations cover all major river basins in southern and central Finland. Even the largest river in Lapland, the Kemijoki river, has flow records starting that year.

By far the most serious drought during the observation period occurred in 1939-1942. Particularly the last two years were very dry. In the first two years, the precipitation deficit was in southern and central Finland 20-30%, in Lapland 10-15%. In the year 1941, the deficit was up to 60% in western and northern parts of the country and 30-50% elsewhere. The mean annual precipitation over the whole country was 394 mm, as compared to long-term average of around 600 mm.

After many relatively wet years, a drought occurred in Finland, together with Sweden and Norway, in 2002-2003. Because hydropower is important in these countries, electricity had to be generated by fossil fuels and the price of electricity increased considerably. A shortage of water was a major problem in rural areas, but most municipal water companies were still able to supply their customers. Navigation in inland waterways had difficulties due to abnormally low water levels.

As compared to the drought of 1939-1942, this recent drought was considerably milder. It was much shorter, too. The comparison of monthly river flows during these two droughts is presented in Fig. 1.

The mean discharge from the whole Finnish territory was only 1,579 m^3/s in 1941, as compared to the mean of 3,200 m^3/s. This was the smallest value for the 20^{th} century; the year 1942 was the second driest, 1,874 m^3/s.

As to the annual hydrological cycle, Finnish rivers have two low flow periods. One occurs in late winter, the other in late summer. In northern Finland the annual low flows occur during the first one, in southern and central Finland normally during the latter. The ratio of winter low flows to summer low flows changes gradually from less than 0.5 to over 2.0 when moving from north to south. In some recent winters the ratio has deviated from this average pattern; winter flows in the south have been even four times larger than summer flows.

The influence of physiographic factors to low flows has been extensively studied in Finland, mainly by utilizing the network of small, lakeless basins, operated since the late 1950s. The network consists of almost 50 basins, most of them having areas between 1 and 50 km^2. Main factors explaining the low flow variation include the percentage of coarse soils, mean slope of the basin and the volume of growing stock in forests. In addition, the influence on man-made changes, particularly the extensive drainage of peatlands, has been studied (Seuna 1983).

2. Future changes in droughts

Most of Europe was hit by a serious drought in the summer of 2003. At the same time, a record-breaking heat wave affected the continent. In a large area, mean summer temperatures exceeded the 1961–90 mean by 3 °C. The meteorological causes are not very clear. One feature was the shifting of the hot Saharan air mass to Europe. While this brought great heat to the north, it also caused unprecedented rainstorms across Africa from Senegal to Eritrea. The prolonged duration of the hot and dry period is another puzzle to meteorologists.

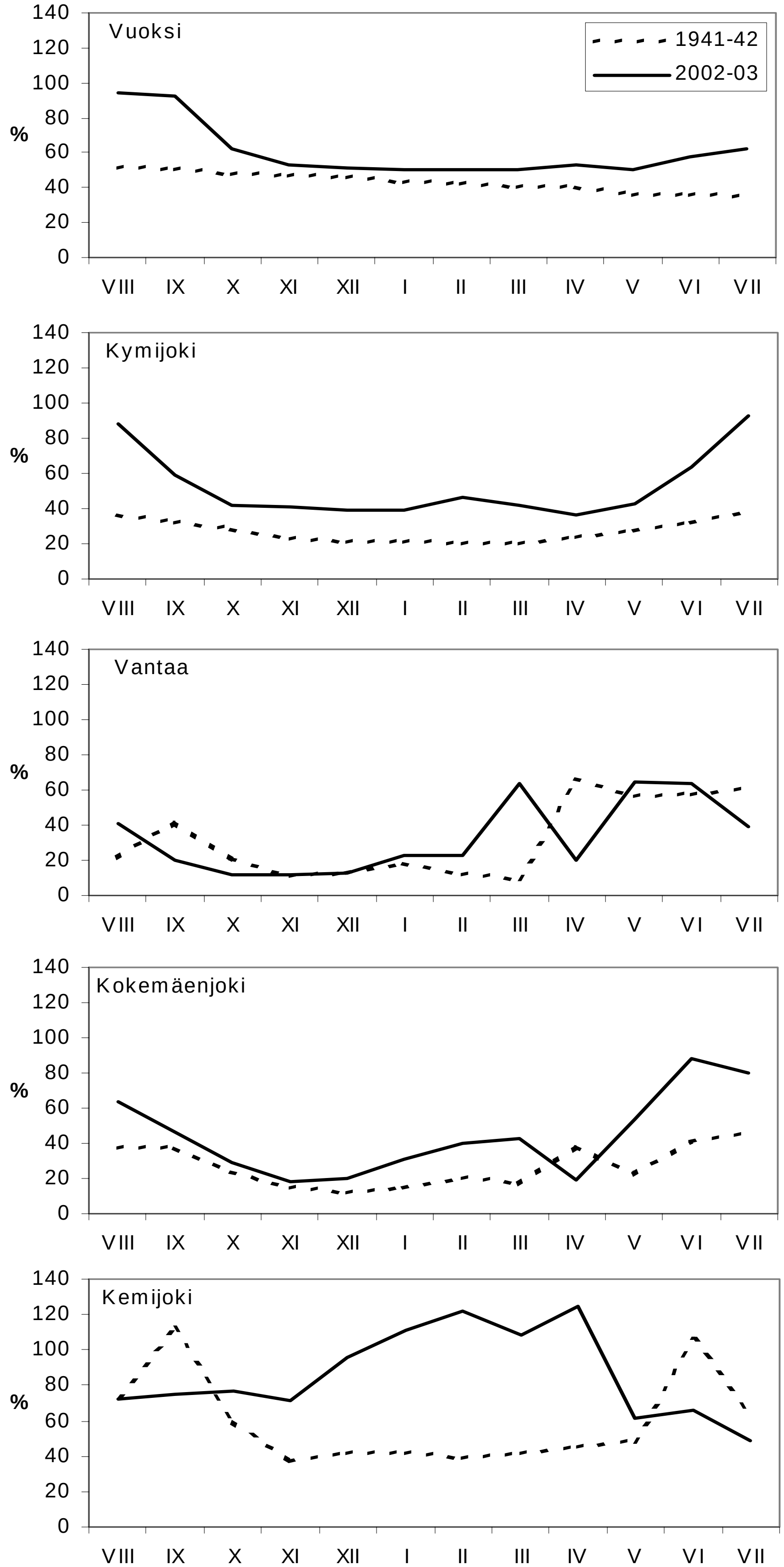

Fig. 1. Monthly flows of some major rivers in Finland in August 1941–July 1942 and in August 2002–July 2003. The values are given as percentages from long-term averages.

The climate change scenarios for Europe vary to a considerable extent, but their general pattern is rather similar. Annual temperatures are expected to increase by 0.1-0.4°C/decade, the warming being greatest over southern and northeastern Europe, and least along the Atlantic coast. In the winter season, the continental interior of eastern Europe and western Russia warms more rapidly than other regions. In summer, the pattern of warming displays a strong latitudinal gradient, with southern part of the continent warming at twice the rate of the northern part.

The pattern for precipitation change indicates an increase of 1-2%/decade in northern Europe, rather small decreases across southern Europe and small changes in central Europe. Most of the continent gets wetter in winter, between 1-4%/decade. In summer northern Europe would get an increase of up to 2%/decade, while the south would dry by up to 5%/decade. The largest inter-model differences tend to occur in southern and northern Europe (Parry 2000).

Regional climate change scenarios for Finland have been given by Jylhä & al. (2004). With four different SRES scenarios, the mean annual temperatures in 2050 would be 1.8-5.2 degrees higher than today, while the increase of annual precipitation would be 7-21 per cent. The warming would be most pronounced in the cold season, and precipitation would also have the highest increase in winter. Summer precipitation might also slightly increase, but the intensification of droughts seems possible because of higher evaporation and longer summer season.

The main mechanism explaining the projected climate change in Finland is the enhanced greenhouse effect, but the change is also related to altered atmospheric circulation. As to precipitation, the temperature-generated increase in atmospheric water vapor content would be an essential factor.

Finland's water resources are so abundant that serious water shortages cannot be anticipated in the future. Water use has also declined in recent decades and this development might continue. Some measures to improve the reliability of water supply systems are, however planned. The drought of 2002-2003 gave some warnings, which have to be remembered.

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