

Maps of Finland's Water Balance Elements

Risto Lemmelä and Reijo Solantie

National Board of Waters and Meteorological Institute
Helsinki, Finland

Maps of water balance elements, i.e. precipitation, water equivalent of snow cover on March 16, runoff and evapotranspiration are presented for the period 1931-1960.

Methods for preparing the precipitation, runoff and evapotranspiration maps are given, as well as information on the accuracy of the maps.

Introduction

Finland is situated between the 60th and 70th parallels and is bounded in the west by the Scandinavian peninsula and in the east by the European continent.

The area of the country is 317,000 km² of which 9.4 per cent is covered by lakes.

Almost the entire country lies in the subarctic, i.e. in the snow and forest climate group. The climate is humid and the annual precipitation is 500-750 mm, Fig. 1 (Helimäki and Solantie), the mean value being 630 mm, i.e. 210 km³/year. Of this amount the mean value of rainfall is 51%, that of dry snow 28%, wet snow 11% and drizzle 10%.

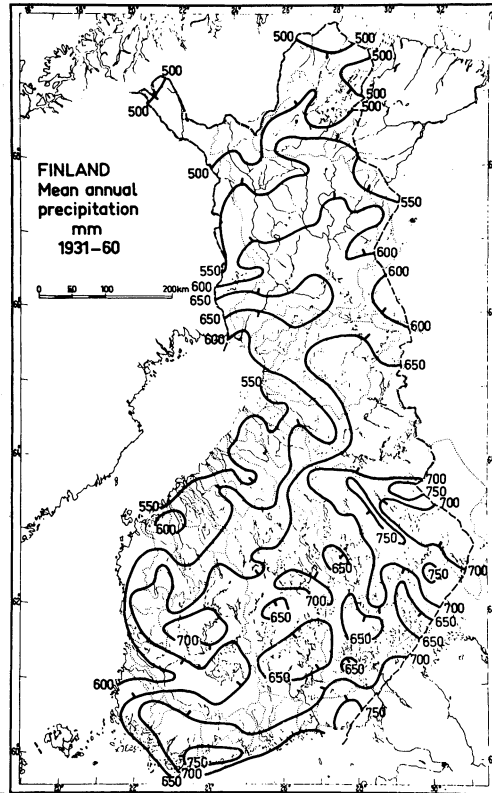


Fig. 1. Mean annual precipitation (mm) 1931-1960

Snow

Snow is important since it constitutes a considerable proportion of the precipitation in Finland. In southern parts of the country some 20 to 30 percent of the annual precipitation comes as snow, the duration of the snow cover being about four months. In the north snow accounts for about 50 percent of precipitation, with the snow cover lasting up to seven months. Fig. 2 shows the mean water equivalent of the snow cover on March 16th, (Hydrological Yearbook 1969-1970).

Precipitation

Correction of point values

The precipitation stations and snow courses are shown in Fig. 3. The Finnish precipitation gauge, like the corresponding Nordic ones, gives values that are too low, especially during winter.

The main sources of error are aerodynamic, evaporation and adhesion errors. The

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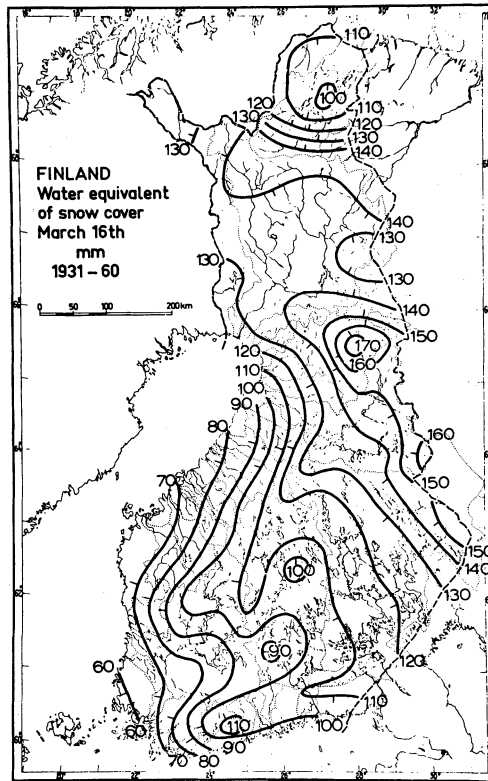


Fig. 2. Water equivalent of snow cover on March 16th (mm) 1931-1960

magnitude of the first two errors depends on the openness of the measurement site. The error is smallest in forest clearings and largest in open fields.

During the period without snow cover, the aerodynamic error is measured between the results of the rain gauges at the level of the ground surface and at the normal height, 1.5 m above the ground surface.

During the winter the correction is calculated using the values measured at the stake stations and using snow course measurements compared with the results of precipitation gauge measurements at the same sites.

The aerodynamic error was 2-3% for rainfall and 17% for wet snowfall. For drizzle and dry snowfall the error rose to 35%.

On the basis of wetting experiments, the mean value of the adhesion correction was 0.18 mm for precipitation over 1.0 mm and 0.10 mm for precipitation of 0.1-0.9 mm.

The evaporation error was estimated at 0-1% for rainfall and 2% for wet snowfall; for dry snowfall it rose to 4% in autumn and spring.

The total correction for precipitation is 5-10% for rainfall, rising to 44% for dry snowfall, Fig. 4.

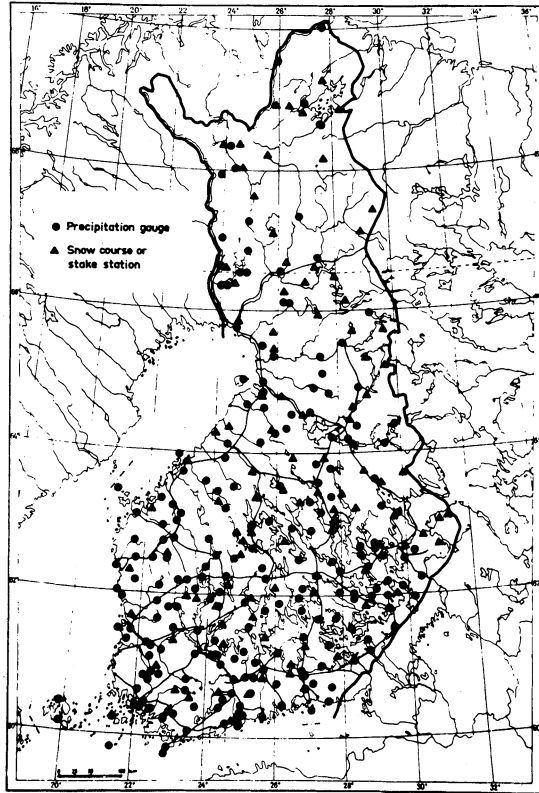


Fig. 3. Precipitation stations and snow courses in Finland

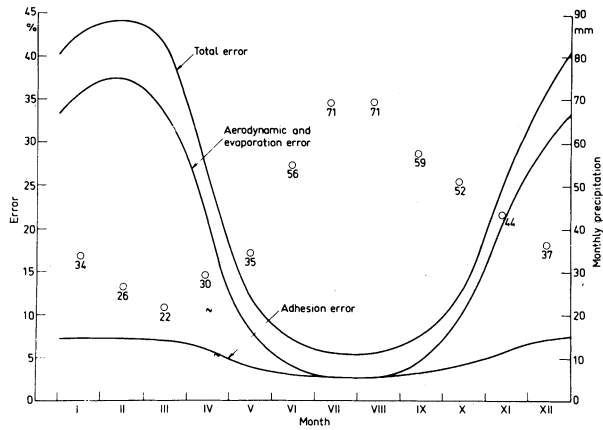


Fig. 4. Mean annual course of error of precipitation measurement in Finland due to the use of the Finnish rain gauge

Areal Precipitation

The monthly precipitation values, added up to give the annual precipitation value, were calculated in four different ways in different parts of the country owing to areal variations in the station network and the climate.

- 1) In most parts of southern and central Finland the square map (20×20 km), constructed from uncorrected precipitation values, was corrected using the proportion of solid snowfall to the total precipitation.
- 2) In those areas in southern and central Finland where the station network was sparse or the stations exceptionally open, the precipitation was corrected for each station separately.
- 3) In most parts of northern Finland the summer precipitation was corrected in the same way as in southern and central Finland, but the winter precipitation was corrected according to the results from the stake stations and snow course measurements.
- 4) In the northernmost part of Finland, where the coniferous forest changes into tundra and where orographic variation is greater than elsewhere in Finland, the total annual precipitation was calculated from the results of areal runoff and evaporation.

Runoff

The catchment areas for which the runoff values have been measured cover $2/3$ of the total area of Finland. For those areas where it could not be measured, the runoff was calculated as the difference between the corrected precipitation and evaporation.

The mean annual specific discharge from Finland's watercourses ranges between 8 and 12 l/s km^2 , Fig. 5, (Hydrological Yearbook 1969-1970).

The mean annual total discharge from all the rivers in Finland is $3,100 \text{ m}^3/\text{s}$, the maximum being $14,000 \text{ m}^3/\text{s}$ and the minimum $1,200 \text{ m}^3/\text{s}$.

The mean value of discharge for the whole country is 300 mm, i.e. $100 \text{ km}^3/\text{year}$, Fig. 6, (Helimäki and Solantie).

Finland's solid unweathered bedrock, which lies mainly at a depth of 3 to 4 m (mean 8.6 m), is so near the surface everywhere that ground water runoff may be considered negligible. In Sweden, where the Pre-Cambrian bedrock is of the same quality as that in Finland, the ground water runoff is said to be 0.4% of annual discharge, i.e. 1 mm/year , (Falkenmark and Mikulski, 1974).

Ground Water

In Finland ground water for the municipal water supply can be obtained mainly from certain glaciofluvial formations; however, the amount suitable for this purpose is only about $80 \text{ m}^3/\text{s}$.

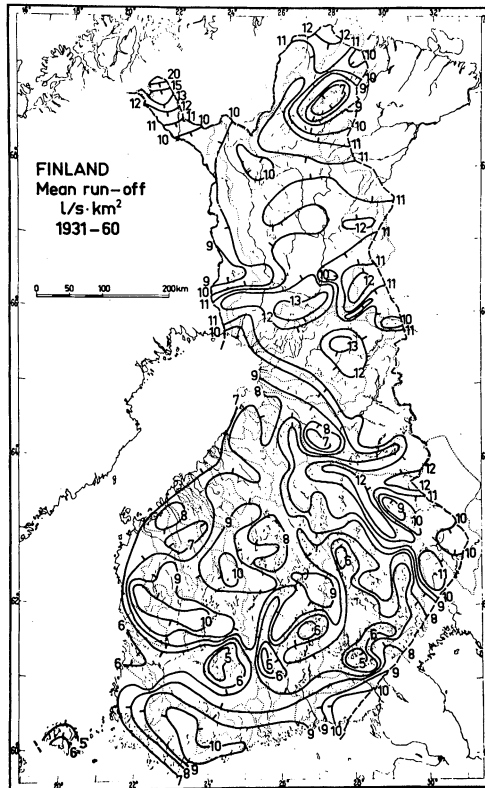


Fig. 5. Mean runoff ($l/s\ km^2$) 1931-1960

Evapotranspiration

Evapotranspiration was calculated as the difference between corrected precipitation and runoff for the 33 different catchment areas covering 2/3 of the total area of Finland. From this material a regression equation was constructed to calculate evaporation. In the equation the following parameters were used: the sum of effective temperature ($T > 5.0^\circ\ C$), percentage of forest area, volume of growing stock, percentage of lakes, and a Dalton-type lake evaporation term. The model explained 98.5% of the variance of evapotranspiration, the residual deviation being 9 mm. For the areas where evapotranspiration could not be calculated as the difference between corrected precipitation and measured runoff the above regression equation was used. Evaporation from lakes was checked according to three methods: the mass-transfer method, the water balance method, and direct measurement using GGI-3000 evaporation pans installed on special floating constructions.

The mean annual total evapotranspiration in Finland ranges between 100 and 500 mm, the mean value being 330 mm, i.e. $110\ km^3/year$, Fig. 7 (Helimäki & Solantie). The mean annual value for evaporation from lakes amounts to 510 mm.

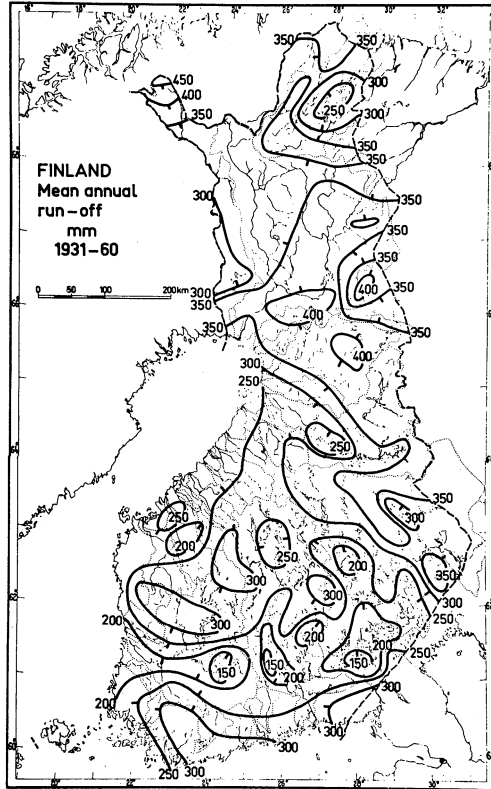


Fig. 6. Mean annual runoff (mm) 1931-1960

Accuracy of Precipitation, Evapotranspiration and Runoff

For the period 1931-60 the following annual mean values were obtained for the main components of the water balance:

- Precipitation 630 mm, i.e. 210 km³
- Runoff 300 mm, i.e. 100 km³
- Evaporation 330 mm, i.e. 110 km³

The 90 percent confidence limit for the total correction of the annual precipitation was ± 35 mm, so the mean precipitation in Finland, with 90 percent probability, was between 595 and 665 mm; evaporation, with the same probability, was between 295 and 365 mm. The areal runoff value obtained is considered to be practically without error given with an accuracy of 10 mm.

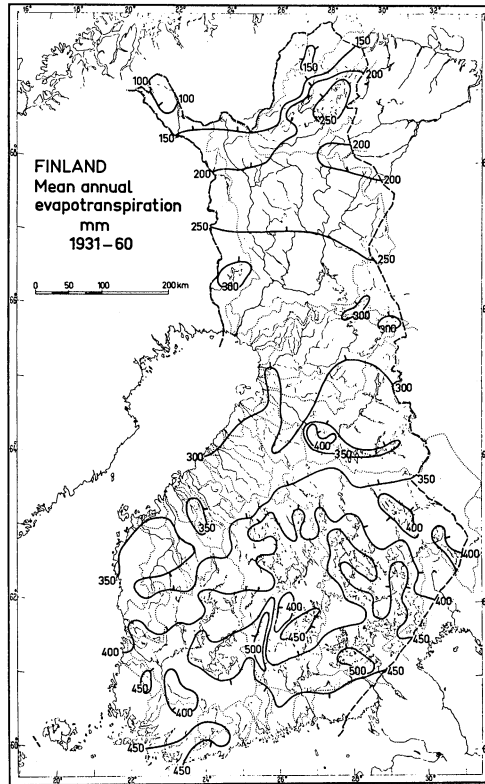


Fig. 7. Mean annual evapotranspiration (mm) 1931-1960

References

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Helimäki, U. I. and Solantie, R. The main components of the water balance in Finland as means of the period 1931-1960. Unpublished.
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Address:

Risto Lemmelä,
National Board of Waters,
P. O. Box 250,
00101 Helsinki 10,
Finland.

Reijo Solantie,
Finnish Meteorological Institute,
P. O. Box 503,
00101 Helsinki 10,
Finland.