Plate 2.2 Mean Annual Corrected Precipitation Depths 1951–1980

Introduction

Precipitation is one of the most significant climatic elements. Research on its spatial distribution is based on the results of measurements taken at as many sites as possible. By introducing the systematic precipitation measurement error, the present precipitation map differs considerably from the ones published previously in Switzerland. As the Kriging method was used for the temporal and spatial interpolation, an objective, easily comprehensible map was produced. The interpolated precipitation values on a 1 km * 1 km grid are also available in digital form.

Due to a systematic measurement error, the precipitation data have to be corrected; yet the wind-induced and wetting losses should be considered in particular. Corrected precipitation measurements are subject to strong temporal and spatial fluctuations. By taking into account the measurement error, the measured values increase by roughly 5–40 %.

In Switzerland, the correction method was established by [2]. The method applied presently is an extension of the original one and is described in map 2.3.

The extent of the measurement error depends on the type of rain gauge, and especially on both the altitude and aspect of the observation station. To complete the checking actual data material, the station sites and the instruments have to be investigated in order to consider their influence on the measurement results. For the present map, the measured precipitation depths were corrected consistently with the systematic precipitation measurement error. The extent of the corrections, that is, the difference between the corrected and the uncorrected precipitation depths, is the focus of map 2.3. It provides a link with conventional precipitation maps [1,3] that did not include correction of wind and wetting influences.

Data base

The map of mean annual corrected precipitation depths is based on the measurement series of the stations network of the Swiss Meteorological Institute. The lines of equal rainfall (isohyets) are based on measurement results of approximately 400 sites: 310 stations with daily precipitation measurement (80 climatological stations and 230 rain gauging stations) and 30 precipitation storage gauges, set up mostly in the high alpine region, as well as 50 stations in the border zone of Switzerland.

With regard to the development of an areal map for a region of more than 40 000 km^2, the total of four hundred measurement points is rather low. In addition, the stations are spread irregularly throughout the country, and the regions with the least data are similar to those in which precipitation often varies greatly within short distances. This is particularly relevant for the high alpine region.

The influence of orography

The influence of orography is best seen in the increase of precipitation with altitude. It should be noticed, however, that this dependency is only valid for the general level of altitude in a more or less defined area. Spurs, narrow valleys, and large hollows on the lee side of mountain ranges often show considerable deviations from the mean precipitation amount of their corresponding altitudes. In general, the precipitation distribution between windward and lee sides of mountains is basically different. The precipitation distribution in alpine valleys tends to show that an increase in precipitation begins only at a certain altitude above the valley. These indications reveal the wide range of spatial variation in precipitation measurements. Closely related is the question of spatial representativity of the individual measurement sites.

Checking and use of the measurement series

Only part of the measurement series of the stations mentioned above cover the entire evaluation period 1951–1980. To extend the data base, additional measurement series for the period 1961–1980 were therefore included. The reduction, i.e. the conversion of these shorter measurement series into the reference period of 1951–1980, was carried out by means of the so-called quotient method. For all the basic measurement series, the ratio of precipitation for the period 1951–1980 to the period 1961–1980 were then calculated and, using the Kriging analysis method, spatially processed. Based on these calculations, the measurement series of the period 1961–1980 were converted into the reference period 1951–1980.

For a spatial interpolation, the status of the climatological examination of the individual measurement site must be emphasised. The conversion of precipitation data taken at individual points into a fairly large precipitation area has to be done very carefully, particularly in regions with a varied orographic structure. For this reason, data of precipitation depths taken at individual points were also investigated with regard to their spatial representativity. A first step consisted of a Kriging analysis of the initial data. Using the resulting residual values as a basis, the initial data can then be compared to the data of the individual sites. The mean value and standard deviation of the residual values form a statistical basis for the assessment of the individual station values in the general picture of the spatial precipitation distribution. In a step-by-step process, the stations with residual values exceeding the standard deviation by a factor of two were subject to a climatological examination. Sites with deviations such as this generally can not be considered as representative.

Spatial interpolation method

The methodical approach to the mapping of mean annual precipitation is based on a spatial optimization process by means of a Kriging analysis on a digital elevation model with a grid size of 1 km * 1 km.

In general, the mean precipitation amounts increase with the altitude above sea level. Due to a wide range of regional differences, a precipitation gradient valid for all of Switzerland can not be indicated.

In order to eliminate the orographic influence inherent in the data, the precipitation depths were reduced to a standard level of 1000 m a.s.l. This allows the regional differences in precipitation distribution to be revealed. This reduction of precipitation values, individually taken at various altitudes, is the core of this approach. In a step-by-step optimization process, a conversion factor was determined, allowing the measurement values to be reduced to the 1000 m level. This factor is 0.8 mm precipitation per meter of difference in altitude.

By means of a Kriging method, the precipitation depths taken at individual points and converted to the 1000 m level were then spatially processed and interpolated to a 1 km * 1 km grid. In a subsequent step, the grid values at the 1000 m level had to be assigned the real relief, again applying the factor of 0.8 mm/m.

By means of the described method, the values taken at individual points can be shown on a digital grid model, representing the starting point for a depiction of the isohyets.

Map of the mean corrected precipitation depths

Taking into account the systematic precipitation measurement error, the corrected precipitation values increase, on average by 14 %, compared to the uncorrected values (for the period 1951–1980). However, significant regional and altitude related differences are present. In the Ticino, for example, the precipitation corrections amount to 4 % in the valleys and up to 30 % in the high alpine regions. In basins with rather small spatial precipitation variability and low precipitation depths, the selected isohyet intervals of 200 mm and more are too large to adequately quote a correction dependent increase in precipitation at a range of 100 mm. Working with the map, it is therefore advisable to interpolate further isohyets or grid points very carefully by means of the precipitation depths given at nearby stations. Areal precipitation data in the flat and small basins (< 500 km^2) of the Swiss midlands, determined on the basis of the corrected precipitation map, may contain errors of 5 % (cf. map 2.3).

References

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