Plate 2.3 Mean Annual Corrections of Measured Precipitation Depths 1951–1980

Introduction

For the period 1951–1980, the map shows the spatial distribution of absolute correction values of the systematic error of precipitation measurement. These values indicate the general scale of the corrections for a time span beyond the period 1951–1980.

Corrections are essential for the following reasons: precipitation is measured by can-type instruments installed above the ground and acting as an obstacle to air flow. At the same time, smaller and lighter precipitation particles are borne away from the orifice of the precipitation gauge, and thus are withheld from measurement. Moreover, part of the precipitation adheres to the inner surfaces of the precipitation gauge and part of it evaporates. These losses need to be corrected and are not yet considered in the published precipitation data.

The corrections given in the map are calculated from the difference between corrected and uncorrected values of precipitation depths interpolated on a grid of 1 km * 1 km. Thus, both the interpolation method (Kriging) and the data set were equally applied to map 2.2.

Correction methods

The correction methods are based on simplified physical concepts. It is of prime importance to consider whether or not the precipitation gauge is equipped with a wind shield to reduce wind influence, and whether all the variables required for the correction are available at the gauging site. Thus the correction method depends on the type of precipitation gauge and the measurement station; although climatological and rain measurement stations are fitted with the same Hellmann precipitation gauge, they differ in the availability of meteorological data on wind and air temperature conditions required for the correction. While these data are directly available at the 80 climatological stations analysed, they have to be inferred for the 230 rain measurement stations. Only at seven exposed high altitude sites the Hellmann gauges are fitted with a wind shield. For them the wind speed was reduced 40 %, otherwise the corrections were made equally to all other Hellmann gauges (without wind shields) according to the method described in [2]. Corrections were assessed on a monthly basis for the 10-year period 1971–1980 and used for the 30-year reference period. For the 30 storage gauges fitted with a wind shield, a new method was developed. The correction values were estimated based on the station altitude. For the measurement stations beyond the Swiss border, the spatial situation was also taken into account.

Wetting and wind-induced losses

Wetting losses occur with the moistening of the inner walls of the precipitation gauge. They depend on the shape and the material used for the measurement instrument, as well as on the type and frequency of precipitation. For the Hellmann gauge they amount to an average of 0.3 mm on a rainy and 0.15 mm on a snowy day.

In the case of wind influence, losses depend on wind speed and on the weight of the precipitation particles. They are also affected by the aerodynamics of the precipitation gauge and the wind exposure of the gauging site. At protected sites (e.g. forest clearings, parks, village centres or farms) losses are normally low, whereas at exposed sites (e.g. open lee slopes, mountain passes or lakeshores) they are high. The gauging sites are divided into the four exposure classes described in table 1. The assessment of exposure class is based on site history recorded in the archives of the Swiss Meteorological Institute, documented by photos, sketches, and written reports, as well as on topographical maps at a scale of 1:25 000.

Wind-induced losses are determined from the difference in the measurement values of the exposed and the protected precipitation gauges. This difference is then related to the average wind speed at the site altitude during precipitation periods, as well as to the precipitation intensity or, lacking further data, to the air temperature [2]. Field experiments at certain selected sites are therefore required. The difference ranges from 3 % for light wind and rain to 80 % for strong winds and fine snow. The precipitation gauges recording only the total of precipitation, the air temperature data had to be considered to estimate the parts of rain and snow. It also parameterises the precipitation intensity, the snow structure and the fraction of snow of the total precipitation. To assess the altitude dependency of the air temperature, a data set of 104 climatological stations was used (period 1971–1980). By means of this altitude dependency, the air temperature was estimated for the 230 rain measurement stations. The average monthly fraction of snow was determined in a similar way, though only 54 stations for the span of 1959–1970 were available.

For the storage gauges, most of them situated at higher altitude, the wind-induced loss was estimated by comparing the measured precipitation to the water equivalent of the surrounding snow cover [1]. At altitudes of 2000–3000 m a.s.l. the wind-induced losses amount to approximately 30 % during the winter half-year and approximately 15 % during the summer half-year (tab. 2).

Determination of wind speed

Problems arise when determining the wind speed. It is only measured at climatological stations, at a height of more than 10 m above ground, and in most cases only three times a day. For the remaining sites, the wind speeds had therefore to be estimated. In addition, the wind speeds had to be converted into the height of the precipitation gauge as well as into the periods of precipitation.

Using the similarity principle, the average annual wind speed was transferred from measured to unmeasured sites, taking into consideration the regional wind fields and the exposure class of the gauging site (tab. 1). By means of the ratio of the average annual and the winter values, the seasonal wind speeds were also estimated. They were also regarded as approximate values for each month of the winter or summer half-year.

Empirical coefficients were used for the reduction to precipitation periods, assuming that the wind speeds during precipitation were greater than the climatic values [2]. Ticino is an exception: average wind speeds were used for the days of precipitation.

Basing on the logarithmic wind profile and the vertical angle of obstacles around the gauging site, the wind speed was reduced to the site altitude of the precipitation gauge [2]. This angle characterises the average vertical elevation above the horizon of the surrounding obstacles; it can be estimated by means of the exposure class (cf. tab. 1).

Altitude dependency of the correction values

The correction values increase absolutely and relatively with increasing altitude, from approximately 100 mm to 800 mm; this corresponds to 5–30 % of the measured values. At lower altitudes, the wind speed tends to be low as a result of the greater roughness (forests and built-up areas) and the topographic barriers. The small fraction of snow and the substantial wind protection of the stations also have a positive effect. Compared to this, the correction values in the snow-rich and wind-exposed high alpine regions are excessively high.

The extent of the corrections, however, is also influenced by the type of instrument used. For the Hellmann precipitation gauge (without wind shield) they are considerably greater than for the storage gauge fitted with a wind shield. Table 2 emphasises the altitude dependency of the correction values for storage gauges.

Regional correction values

Correction values are subject to the influence not only of altitude but also of regional differences. They are the result of differentiated wind speeds and precipitation intensities. For stations in the Swiss midland and in the valleys of Ticino and Valais, only small corrections need to be made, larger ones are required for stations in northern and western Switzerland, the Jura and the lower alpine regions, and major corrections are necessary for the stations in high alpine regions. Table 3 shows the comparison of correction values for nine selected regions in Switzerland. They range from 8 % to approximately 20 %.

Figure 1 allows a rough estimate of the correction values at stations with Hellmann gauges: referring to the region (large river basin) or the station number of the Swiss Meteorological Institute (cf. map 2.1) and to the exposure class, it is possible to determine the curve which is likely to best represent the conditions at a given station. By means of this curve, the magnitude of the average annual correction values can then be defined as a function of station altitude. For practical reasons, the classification of the correction values was chosen according to large river basins, although an examination of regional features could lead to more differentiated results.

Bibliografia

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