2.5 Mean Annual Corrected Precipitation Depths

Maps 2.2 to 2.4 of the Atlas illustrate mean precipitation depths in annual and semi-annual terms. Those *measured* precipitation depths are compared to the *corrected* precipitation depths in Maps 2.5 and 2.6. Corrections are necessary, since precipitation measurements with the Hellmann rain gauge are subject to measurement errors inherent to the equipment and its site. Errors in measurement are mainly due to the force of the wind, when precipitation is blown past the gauge; to wetting of the catchment funnel; and to losses that occur through evaporation before the next check. In consequence, measurements of precipitation depths are regularly too low. *Correction of precipitation measurements* eliminates such errors and enables the true precipitation depths to be determined.

In practical applications of precipitation data, both corrected and uncorrected values are used depending on the task at hand. Detailed studies of water resources and assessments of water management require sufficiently accurate data and, therefore, are founded largely on corrected precipitation values. In water management model calculations, particularly for determining the occurrence of drain-water, both corrected and uncorrected precipitation depths are used as input quantities. Furthermore, for describing spatial and temporal variations in precipitation, uncorrected values are perfectly acceptable, since correcting them does not cause any significant change. This is also valid for real-time applications of precipitation data, e.g. in high water or flood management, because the measurement error is insignificant in relative terms when precipitation leads to flooding. Since it must be assumed that correction procedures will be developed and improved in future also, the uncorrected figures must be available as a basis for comparison. For that reason, priority must be granted to the collecting and archiving of measured, that is, uncorrected data.

Methodical foundations of the correction of precipitation measurements

The problem of correcting precipitation measurements has, for some time now, been the topic of specific scientific research that has been documented in numerous publications and reports (Sevruk 1986). The results of all studies show that, because the equipment in use and the height of its exposure often already differ at the national level, and due to climate differences in precipitation regimes, no single, generally applicable procedure for correcting systematic errors of measurement can be developed. The variety of causes behind the total error makes it necessary to identify the partial errors according to their influence on the final result and combine them into a correction procedure that can be applied throughout a wider area. A particular difficulty arises when limiting this approach to such input data as are also generally available from the secondary network for precipitation measurement. An appropriate solution was developed at the Deutscher Wetterdienst (DWD, German Meteorological Service) with particular reference to measurements using the Hellmann rain gauge (Richter 1995) and has been used to prepare the present maps illustrating corrected precipitation depths.

The procedure is based on the comparative measurements, taken over many years, between Hellmann rain gauges in the standard configuration and at ground level at 25 selected stations, to determine the amount of wind-induced error; and on special studies of losses caused by wetting and evaporation. The following aspects proved to be of decisive influence on measurement errors while also being available to all stations: the precipitation depth; type of precipitation, classified into rain, mixed precipitation, and snow; and wind exposure of the site. Based on surveys of each site, the 25 stations were classified into 4 groups going from exposed to well sheltered; following an evaluation of the entire precipitation measurement network of the DWD a further category, very well-sheltered station sites, was added. Summing up the partial errors ultimately yielded a correction function for daily precipitation, whose respective coefficients varied according to the type of precipitation and degree of wind exposure.

Implementing the procedure shows that the error in precipitation measurement increases markedly with the exposure of the station. The measurement error is considerably larger in winter, since snow and mixed precipitation are more easily blown about; so is rain generally finer at this time of year than summer precipitation, which is heavier and convectional in origin. As a result, higher losses to wetting and evaporation in summer are more than compensated for by increased wind-induced error in winter. An example of this appears in Figure 1, which illustrates the average annual fluctuation of the percentage measurement error, based on the example of the Potsdam station for hypothetical stations whose exposures range from open to well sheltered. Due to the wind's strong influence on winter precipitation, an exposed station has a well distinct course of measurement errors during the year with measurement errors of up to 30 % in January/February and around 11 % in the summer months. In contrast, on a site that is well sheltered from the wind, the seasonal differences of 11 % and 8 % are comparatively low. The deviation of some 5 % due only to wetting and evaporation at a very well-sheltered station has not been represented, since annual fluctuation is very weak.

At all precipitation stations of Germany almost identical patterns can be found; although, depending on the frequency and intensity of precipitation and the proportion of snow and mixed precipitation, regional differences in degree and annual fluctuation of measurement errors do appear. For example, in northwest and western Germany, where the proportion of snow and mixed precipitation is very low, winter errors of measurement are considerably smaller too, particularly at exposed stations, where the figure lies between 20 and 10 %; whereas in the Alps and their foothills the degree of error in the summer months amounts to only 5 to 7 % due to significantly higher intensity of precipitation.

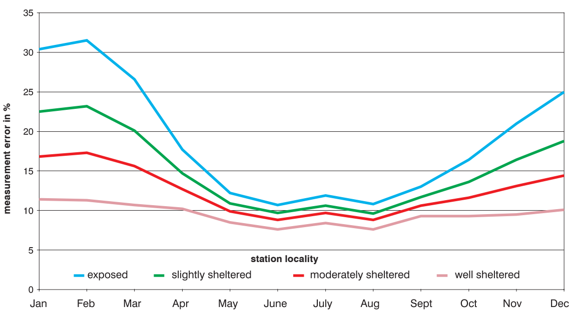

Fig. 1 Average annual fluctuation of the precipitation measurement error in dependence on the wind exposure of the site Potsdam, 1961-1990

In any case, this does not yield conclusive results regarding an absolute error since, in terms of precipitation depths, an average error of 12 % in northeast Germany represents approximately 70 mm/a, while an error of about 8 % in an alpine region represents well above 100 mm/a. It is striking that the percentage error in all regions does not indicate any conclusive influence by orography, which is surely due mainly to two factors: first, the decline in errors of measurement with the increasing proportion of higher daily totals and correspondingly heavier precipitation, and second, the increase in measurement errors as the proportion of snow and mixed precipitation grows. Both factors have opposite effects at increasing elevations and, therefore, largely cancel out the effects of orography.

That compensating effect means that climate-induced differences in precipitation measurement errors carry more weight. Therefore, sub-classification that is largely unaffected by orography is possible. The result appears in Figure 2, which illustrates how, based on over 500 stations, Germany has been divided into 11 regions with the same precipitation correction, where each region shows typical differences in annual fluctuation of the measurement error.

This division into regions should be seen as one of the foundations for the implemented correction to precipitation measurement. Another key element is the standardised wind exposure based on evaluation of all the stations and the applicable correction function. The correction function approaches that of a well-sheltered station site. Its application to a selected number of representative stations from the 11 regions yielded the respective annual fluctuation for precipitation correction in each region. The resulting annual and semi-annual correction figures constitute the basis for calculating corrected precipitation depths according to the digital data represented on Atlas Maps 2.2 to 2.4. Another solution would have been to correct the precipitation depths of each individual station based on the actual circumstances or on-site conditions of the last 30 years. With such an approach, preparing a digitalised map of the adjusted precipitation depths would not have been possible because input data was not available from many stations.

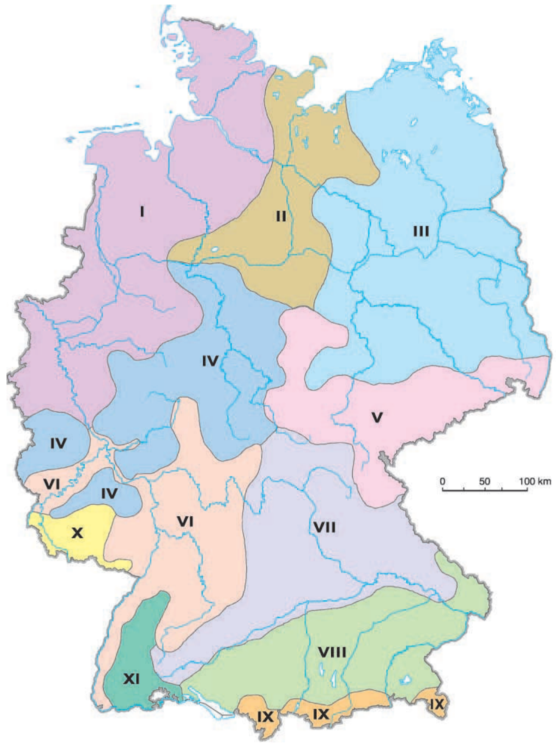

Fig. 2 Regions with the same precipitation correction in Germany (regional representation of the average percentage error of precipitation measurement in Map 2.6, Table 1)

Map Structures

As was to be expected, upon comparing corrected and uncorrected data the regional distribution of annual and semi-annual precipitation depths does not vary significantly. Therefore, the comments on general precipitation patterns in Germany that accompany Maps 2.2 to 2.4 are also valid with regard to corrected precipitation depths and require no further explanation. However, the amplitude of precipitation depths does change, as appears from the respective expansions in the area shares with higher precipitation depths. This is most obvious in the annual precipitation depths for the north German lowlands, including the entire northeast of Germany, which has low precipitation. The regions with annual amounts < 500 mm disappear. True, for some areas, increases in precipitation do not lead to a colour change on the map because the amount of the increase is too small relative to classification into a higher precipitation class.

More accurate information is provided by the real differences between the corrected and uncorrected precipitation depths as illustrated by Atlas Map 2.6, Map C, where the annual correction appears directly in millimetres of precipitation. Thus, for large areas of the northeastern lowlands of Germany and the plains of major rivers, corrections of 40 to 60 mm/a are made, while higher up in the uplands those figures vary from 120 to 140 mm/a. Correction values are greater only for the higher Alps and several peaks of the uplands, where the proportion of snow in overall precipitation exceeds 25 to 30 %.

Practical Information

The representation of corrected precipitation depths provides initial, summary information on the probable measurement errors by the Hellmann rain gauges in standard use. Such representation does not say anything about possible variations that may be due, for example, to annually varying proportions of snow and mixed precipitation, or to very dissimilar site conditions of two rain gauges at stations close to one another. Indeed, the percentage difference in measurement errors of two neighbouring stations, one exposed and the other well sheltered, is higher than that of two equally exposed stations where one is located in the north German lowlands and the other in the Danube region. A single, overall correction of precipitation time series at particular locations is not advisable, therefore. Rather, for a precise study of water resources, or for drainage model calculations, detailed figuring should be done based on the actual station situation and precipitation conditions. Only for a wide-range look at long-term average values average correction values can be used, such as appear in the text commenting Map 2.6 of the Atlas, for example.