# 2.9 Selected Wet and Dry Years

Maps 2.2 to 2.6 show mean precipitation rates over the period 1961 to 1990. These maps together with Map 2.7, "Variability Coefficient of Precipitation Depth", provide a comprehensive overview of the mean spatial-temporal variability of precipitation amounts.

This map essentially offers insight into extremely wet and dry years. Here an example is used to illustrate particularly high (1966) and low (1976) precipitation depths in hydrological years (November to October) and supplements Map 2.7 by showing the range of variation between a wet and a dry year over the period 1961–1990.

Map 2.9 contains in addition two maps depicting the climatic water balance (CWB) in a wet year (1966) and a dry year (1976). Similar to the approach used in Map 2.14, the climatic water balance is computed as the difference between the corrected precipitation depth and the grass reference evapotranspiration depth.

The two years which have been singled out, 1966 and 1976, should be taken as case examples; in any region above-average precipitation depths or drought may be greater in other years.

## Map Structures

### Precipitation Depth: Wet Year and Dry Year (Maps A and B)

Maps 2.9 A and B show the precipitation depth corrected by the systematic measurement error in the hydrological years 1966 (November 1965 to October 1966) and 1976 (November 1975 to October 1976) in a gridded structure with a resolution of 1 km². The classification of the precipitation depths is similar to the one used on Map 2.5; the text accompanying Map 2.5 also addresses the problem of precipitation correction.

Both of these particular years provide an idea of the orographic impact on precipitation depths with its leeward and windward effects, as can already be seen in the mean corrected precipitation depth for the period 1961–1990 (Map 2.5).

The corrected precipitation depth in the wet hydrological year 1966 was between less than 600 mm and more than 4000 mm. At 564 mm, the lowest value on the grid was to be found at Oderbruch (Odra valley), while the greatest amount was 4306 mm in the Alps. The grid cell values varied between 312 mm on the leeward side of the Harz and 2855 mm in the Alps in the dry year 1976. Large areas whose precipitation was less than 400 mm in this dry year are to be found in the eastern loess-rich parts of the foothills of the Harz, the Spreewald, Wetterau and the loess-rich areas of Rhine-Hesse and Main-Franconia.

*Deviations of precipitation depths from the 30-year mean*
Figures 1 and 2 show the deviation in the precipitation depths in the years 1966 and 1976 from the mean over the period 1961–1990. There were particularly high precipitation depths in the wet year 1966 in the area lying between the Thüringer Becken (Thuringian Basin), Rhön and Schweinfurter Becken and the eastern edge of the Nordpfälzer Bergland (northern Palatinate Hills). The area between Hunsrück, Taunus, Vogelsberg and Spessart showed the lowest precipitation depths in the dry year 1976. Precipitation depths hovering near the long-term mean value occurred very rarely and in very limited areas in both years. The extremely high deviation from the mean value is striking on both figures. This divergence is not as evident on Map 2.5, as the mapping of the means tends to smooth out the divergence.

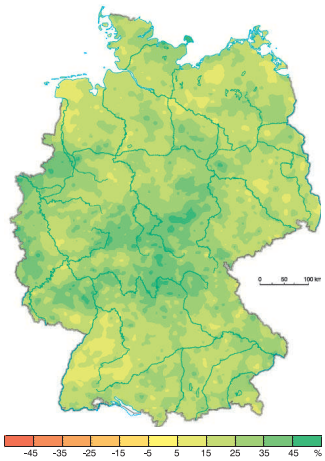


**Fig. 1** Percentage deviation of the annual corrected precipitation depth of the year 1966 to the long-term mean 1961–1990

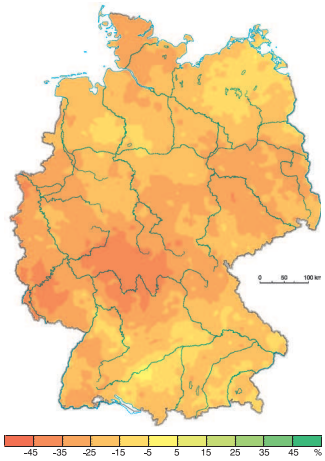


**Fig. 2** Percentage deviation of the annual corrected precipitation depth of the year 1976 to the long-term mean 1961–1990

In Table 1, a comparison is made of the precipitation depths in the hydrological years 1966 and 1976, respectively, with the mean values for the period 1961–1990. Thus, 1966 (in terms of the mean value for all of Germany) was too wet by 224 mm with 1084 mm, while on the other hand 1976 was too dry by 224 mm with a mean precipitation depth of 636 mm. The amounts of deviation from the mean precipitation were randomly the same. The deficit or surplus of 224 mm in relation to the total geographical extent of Germany corresponds to around 80 billion km³ of water – enough to fill the basin of Lake Constance about 1.7 times.

The difference between the annual amounts of precipitation in 1976 and 1966 is almost equal to the total average amount of precipitation which falls over a span of many years during the hydrological summer half-year in Germany. This is about 3 times the amount of water in Lake Constance.

*Precipitation depths in hydrological half-years*
The corrected precipitation depths in the hydrological summers and winters of 1966 and 1976 are shown in Figures 3 to 6. In the hydrological summer of the wet year 1966, less than 300 mm of precipitation fell in an area of northern Mecklenburg covering about 160 km², along the Warnow River, which is approximately 65 % of the usual precipitation depth there. The greatest part of Germany, however, received disproportionately high precipitation depths, which during the winter were double the average depth in some regions.

By comparison, precipitation depths in both hydrological half-years of the dry year 1976 were too low almost everywhere in spite of the above-average precipitation depths in January. The hydrological summer 1976 was only too wet in isolated areas (e. g. in Schwäbische Alb); for the most part it was much too dry, only registering up to 36 % of the usual precipitation. Two-thirds of total German territory received 20 % less precipitation than the 30-year mean in the whole of 1976; this same geographical space accounted for 41 % in the winter half-year and 82 % in the summer half-year.

This enormous deficit had a considerable impact on the regional precipitation rates (Figure 7) in river regions, thus also having a major effect on discharge to major rivers and streams (Table 2).

In the wet year 1966 all river basins of Germany experienced amounts of precipitation exceeding the mean, in come cases considerably more. The positive deviations were between 23 % and 28 % here. In the summer half-year precipitation varied between 4 % and 22 %, while in winter the variation, between 28 % and 48 %, was greater than the mean in the same respective half-year over the period 1961–1990. Regional amounts of precipitation in the hydrological year 1976 were between 19 % and 31 % below the long-term average (summer 15 % to 40 %, winter 7 % to 29 %).

Figure 8 shows the deviations in the corrected precipitation depths for the years 1966 and 1976 from the mean value for the period 1961–1990. This demonstrates, for example, that in the summer half-year of 1976 there were precipitation depths on 37 % of the total area of the Federal Republic of Germany which were 40 % (35 % to <45 %) less than for the period 1961–1990. In contrast, it was 30 % (25 % to <35 %) too wet compared to the 30-year mean on about 39 % of total German territory in the hydrological year 1966.

### Climatic Water Balance (CWB): Wet Year and Dry Year (Maps C and D)

*Annual values for the climatic water balance*
Maps C and D show the annual totals for the climatic water balance for the hydrological year 1966 and 1976, respectively, in a gridded structure with a resolution of 1 km². The different categories and colour scales were adopted from Map 2.14 to allow a direct comparison with the mean annual values for the climatic water balance for the years 1961–1990 shown there.

The regional distribution of the climatic water balance exhibits a striking similarity to the regional distribution of precipitation (Maps A and B) both in the wet year 1966 and in the dry year 1976. This illustrates the dominant influence of precipitation on the values of the climatic water balance under Germany's hydroclimatic conditions described in Map 2.14. Regional and temporal variability are much greater with regard to precipitation than is the case with grass reference evapotranspiration, thus accounting for the variability of the climatic water balance. The dependence on the altitude of the terrain, leeward and windward sides of mountains and the increasingly continental nature of the hydroclimate with increasing distance from the ocean are also evident when one examines regional distributions. This corresponds with an approximate adjustment to concur with distribution structures for the long-term mean climatic water balance data (Map 2.14).

Figure 13 compares the frequency distributions of grid cell values for the annual climatic water balance for the mean regional distribution 1961–1990 with the frequency distribution for the wet year 1966 and the dry year 1976.

The wet year 1966 shows positive annual climatic water balance data over the period of the hydrological year almost everywhere in Germany. Weak negative balance data only occur in isolated grid cells in some regions of north-eastern Germany characterised by low precipitation, mainly in the Oderbruch region and on the lower Odra. The total percentage of German territory with a negative annual CWB value was below 0.5 % for 1966, while this percentage was 6.5 % for the mean annual CWB values over 1961–1990. In the areas characterised by a negative annual CWB in the mean regional distribution for 1961–1990, balance values of up to +100 mm occur more frequently in 1966 (in the rain shadow area of the Harz Mountains on the lower Saale and middle Elbe, central Brandenburg and the Lausitz) and more than +100 mm

**Table 1** Precipitation depths in mm/a und precipitation volumes in km³/a in the years 1966 and 1976 in comparison to the time period 1961–1990 (rounded values)

| | winter | | summer | | year | |
|---|---|---|---|---|---|---|
| | mm | km³ | mm | km³ | mm | km³ |
| **period 1961–1990** | 400 | 143 400 | 459 | 164 600 | 859 | 308 000 |
| **year 1966** | 553 | 198 000 | 531 | 190 100 | 1 084 | 388 100 |
| **difference 1966 to mean 1961–1990** | 153 | 54 700 | 71 | 25 400 | 224 | 80 100 |
| **year 1976** | 320 | 114 600 | 316 | 113 200 | 636 | 227 800 |
| **difference 1976 to mean 1961–1990** | −80 | −28 800 | −144 | −51 400 | −224 | −80 200 |
| **difference 1966 to 1976** | 233 | 83 400 | 215 | 76 900 | 448 | 160 300 |

**Table 2** Corrected precipitation depths in Germany and its major river basins as percentage of the long-term mean 1961–1990

| | 1966 | | | 1976 | | |
|---|---|---|---|---|---|---|
| **catchment** | **winter** | **summer** | **year** | **winter** | **summer** | **year** |
| Danube | 124 | 122 | 124 | 75 | 85 | 81 |
| Rhine | 127 | 114 | 127 | 71 | 66 | 69 |
| Ems | 123 | 106 | 123 | 85 | 66 | 75 |
| Weser | 128 | 116 | 128 | 86 | 64 | 74 |
| Odra | 124 | 118 | 124 | 97 | 63 | 78 |
| Elbe | 125 | 116 | 125 | 89 | 60 | 74 |
| Baltic Sea | 123 | 104 | 123 | 93 | 70 | 80 |
| North Sea | 126 | 112 | 126 | 83 | 61 | 72 |
| Germany | 126 | 115 | 126 | 80 | 69 | 74 |

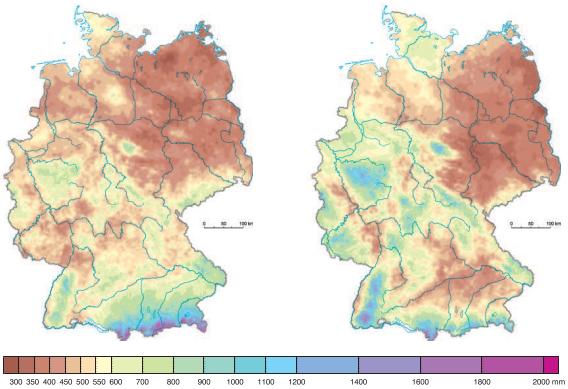


**Fig. 3** Corrected precipitation depth of hydrological summer half-year 1966

**Fig. 4** Corrected precipitation depth of hydrological winter half-year 1966

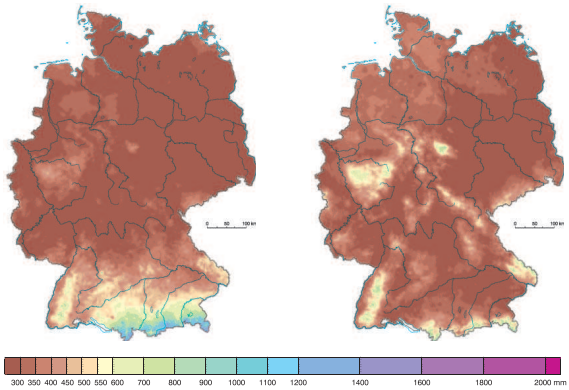


**Fig. 5** Corrected precipitation depth of hydrological summer half-year 1976

**Fig. 6** Corrected precipitation depth of hydrological winter half-year 1976

# 2.9 Selected Wet and Dry Years – Continuation

in south-western Germany (Alzeyer Hills and Schweinfurter Becken). The peak values for the annual climatic water balance exceeded 4 000 mm in the Alp region in 1966.

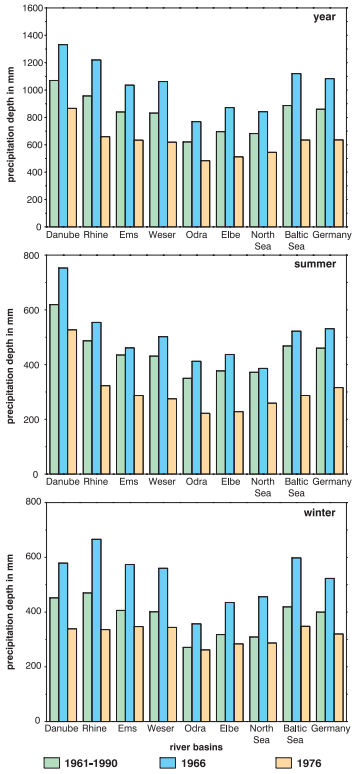


**Fig. 7** **Areal values of correctec precipitation depth in Germany and its river basins**

The example of the dry year in 1976 shows that below-average climatic water balances can occur over a broad geographical area. A negative annual value for the climatic water balance can be seen on 54 % of German territory in 1976 – compared to a geographical extent of 6.5 % for the mean annual balance values for 1961–1990. Positive annual values for the climatic water balance were only to be found in lower-lying parts of northern Germany, the higher altitudes of the uplands, the foothills of the Alps and the Alps themselves in 1976. But the average values for the 1976 CWB were far below their average values in these areas as well. Annual CWB values of >600 mm were only recorded on 3 % of German territory in 1976; this figure was about 10 % for the mean CWB over 1961–1990 and 20 % in the wet year 1966. The peak values for the climatic water balance in Germany only exceeded the annual total of 2 000 mm (this is about half the annual total recorded as the maximum value in the wet year 1966) in a few isolated grid cells of the Alps region in the dry year 1976.

*Climatic water balance for the hydrological half-years*

Figures 9 to 12 show the regional distribution for the climatic water balance in the hydrological half-years 1966 and 1976.

In the wet year 1966 (Figures 9 and 10) the high annual CWB values were due to the above-average precipitation rates or balance rates for the winter half-year. The summer half-year of 1966 showed balance values throughout Germany which were scarcely higher than the mean for the summer half years 1961–1990. The percentage of area with a negative half-year balance declines very little in comparison to the average percentage of area in the 30-year reference series. The regional focal point for the deficitary CWB values in Germany in the summer half-year 1966 was in Mecklenburg and central Brandenburg, where in some places there were considerably greater deficits in the half-year CWB totals than in those areas which had the greatest deficits in the climatic water balance in terms of the long-term mean (e. g. in the rain shadow area of the Harz Mountains, in the Lausitz or in south-western Germany).

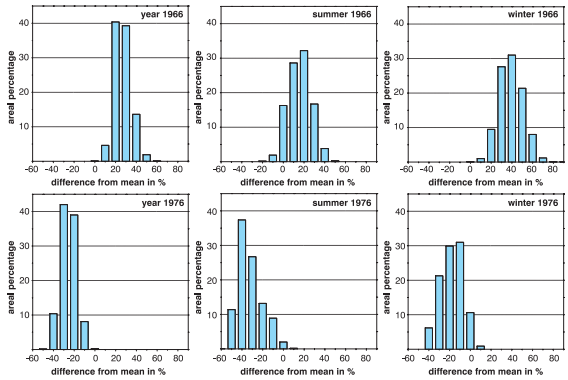


**Fig. 8** **Deviation of corrected precipitation depths for the wet year 1966 and the dry year 1976, respectively, from the long-term average 1961–1990** (areal percentage of total area of Germany)

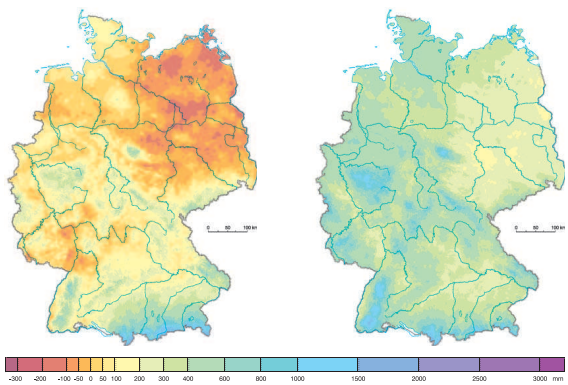

**Fig. 9** **Climatic water balance of the hydrological summer half-year 1966**



**Fig. 10** **Climatic water balance of the hydrological winter half-year 1966**

Positive balance values can be seen almost everywhere in Germany for the winter half-year in the dry year 1976 (Figures 11 and 12). These positive half-year balances are the result, however, of unusually high precipitation depths in the month of January. In most of the other months in the winter half-year 1975/1976 below-average monthly climatic water balances are more frequent, some of them negative. The dry year 1976 with its high deficits in the climatic water balance is interesting in hydroclimatic terms due to the fact that the previous year 1975 must be categorised as a dry year, too. The period with below-average climatic water balance over much of Germany lasted roughly from the spring of 1975 to the end of 1976 – for the most part only interrupted by the heavy precipitation in January 1976 mentioned above. The summer half-year of 1976 was marked by continued low precipitation depths, lots of sunshine and weather that was too warm, making 1976 the lowest summer half-year CWB value over large areas for the time period 1961–1990. Figure 11 shows that negative summer half-year values marked the climatic water balance at higher altitudes of the German uplands in 1976. Only 13 % of Germany had positive CWB totals in Germany in the summer half-year 1976 – compared to an average of 55 % of German territory in 1961–1990 and 72 % in the wet year of 1966.

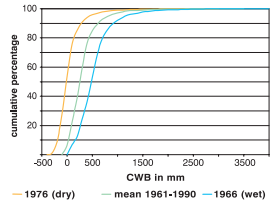


**Fig. 13** **Relative cumulated frequency of the annual values of climatic water balance** (100 % = all grid cells in Germany)

*CWB for shorter periods of time*

When using climatic water balances, one usually requires these detailed values over the time of a year, as individual months with heavy or low precipitation can have a significant impact on half-year and annual balances or be compensated for in the sum totals (cf. the remarks made on the 1976 winter half-year).

Figure 14 shows the cumulative total monthly climatic water balances in comparison with mean values over the period 1961–1990 and the two case examples 1966 and 1976. The comparison shows two regions with very different hydroclimatic conditions – the higher altitude German uplands in the Schwarzwald (Black Forest), which only has positive climatic water balance values, and the low-precipitation region in the rain shadow of the Harz Mountains, with negative annual climatic water balance values on the average.

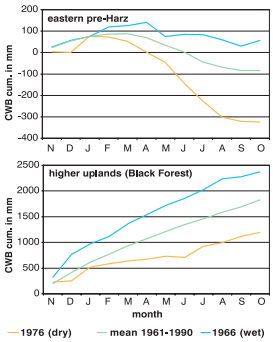


**Fig. 14** **Cumulated monthly values of climatic water balance for the hydrological wet year 1966 and the dry year 1976, respectively, in comparison to the long-term average for two exemplary regions**

Looking at the example of the eastern foothills to the Harz Mountains, an increasing surplus of precipitation over the grass reference evapotranspiration rate, i. e. a cumulatively rising climatic water balance from November to March, can be seen. Beginning in April the surplus precipitation is used up, leading to an annual deficit by the end of the summer half-year. The surplus precipitation in the winter half-year rose in the wet year 1966, and the total CWB values remain in the positive range throughout the entire year while only showing low balance deficits in a few months of the summer half-year. In the dry year 1976, the deficit in the climatic water balance rose on the other hand from month to month. The impact of greater precipitation depths in January on the annual CWB amounts is evident here.

Positive monthly climatic water balance values are typical of the higher altitudes of the Black Forest in the mean annual course and in the examples of the wet and dry year, causing the cumulative sum totals to produce a mounting surplus of precipitation. The difference between average conditions and a wet/dry year can only be inferred from a rise in the CWB curves.

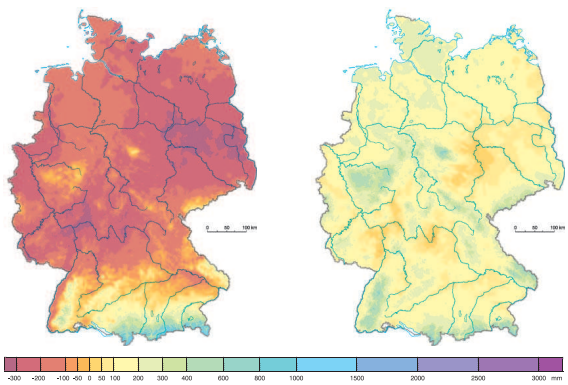

**Fig. 11** **Climatic water balance of the hydrological summer half-year 1976**



**Fig. 12** **Climatic water balance of the hydrological winter half-year 1976**