International Commission for the Hydrology of the Rhine Basin (CHR)

Annual CHR Report 2023

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Internationale Kommission für die Hydrologie des Rheingebietes
International Commission for the Hydrology of the Rhine Basin

The International Commission for the Hydrology of the Rhine Basin (CHR) works within the framework of the Intergovernmental Hydrological Programme (IHP) of UNESCO and the Hydrology and Water Management Programme (HWRP) of the World Meteorological Organisation (WMO). It is a permanent, independent, international commission and has the status of a foundation registered in the Netherlands. Members of the commission include the following scientific and operational hydrological institutions of the Rhine basin:

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- Office of the Vorarlberg State Government, Water Management Division, Bregenz, Austria,
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Table of Contents

1. Hydrological Overview for the Rhine Catchment Area

1.1 Meteorological Characteristics

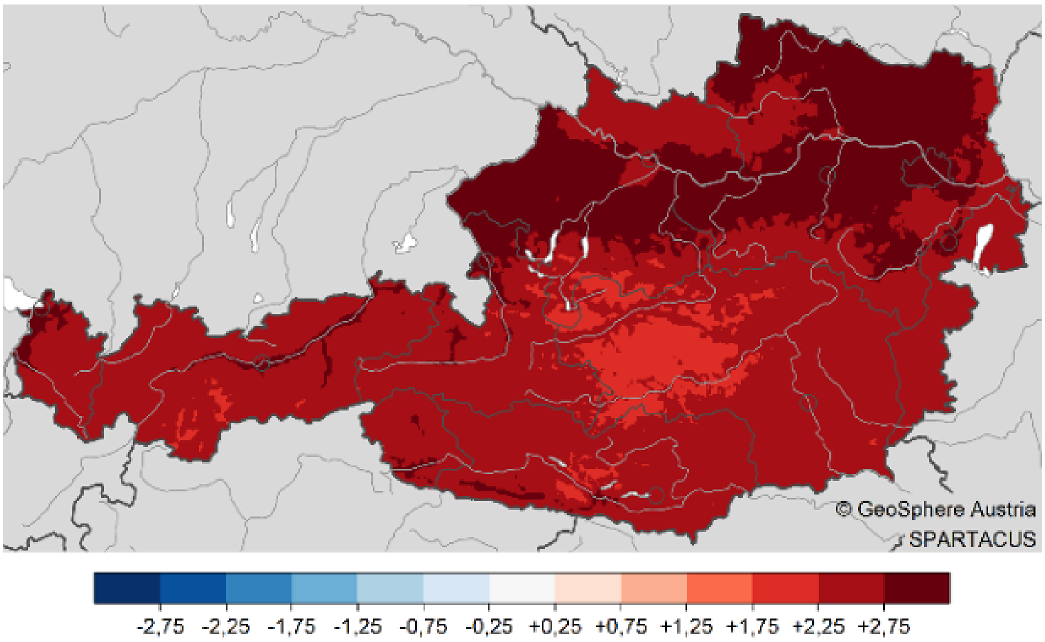
1.1.1 Austria

Source: GeoSphere Austria, Austrian Service for Geology, Geophysics, Climatology and Meteorology

Temperature
The year 2023 was marked by more than average warm phases over long stretches of time. There were hardly any periods in which the prevailing temperature level was below the multi-year averages. Even in comparison with the significantly warmer climate normal period 1991-2020, this circumstance can be observed. The first 20 days of the year were already extremely warm and on New Year's Day some new station records for January were surpassed. In general, February and March were significantly too warm. There were relatively cold temperature conditions from the beginning of April to the middle of May, and temperatures were only slightly above average in the first half of June. With the middle of the month came a midsummer phase, which lasted until September with only a short interruption, at the end of July/beginning of August. The first and relatively short heatwave started in the last third of June and lasted for four to five days. In July and August, a heatwave followed, which lasted relatively long, with up to 18 and 16 days, respectively. The last heatwave of the year began shortly before mid-September and lasted for an average of four days. But the end of the exceptionally high temperatures had not yet been reached. These continued until the end of October, which led to September and October developing into the warmest in Austrian measurement history. November was clearly too cold only above about 1000 m above sea level. At low altitudes, this month was measurably too warm. After a relatively cold start, the last month of the year finally developed into a very warm month, as the end of the year from the middle to the end of December was predominantly characterised by too mild weather.

The largest anomalies in annual mean temperatures can be found in the lower valleys from Vorarlberg to Salzburg or East Tyrol, in the non-alpine regions of Upper Austria and Lower Austria, as well as in Vienna and in northern Burgenland. Here, the year 2023 was 1.3 °C to 1.8 °C warmer than the climate average 1991-2020. In all other parts of the country, such as Vorarlberg to Salzburg above 1000 m above sea level, generally in Carinthia, Styria and Central and Southern Burgenland, deviations were between +0.7 and +1.3 °C.

Taken together over all months, this results in an annual mean temperature in the lowlands (HISTALP lowlands data set), which is 1.3 °C above the 1991-2020 average and 2.5 °C above the 1961-1990 average. Together with 2018, this makes the year 2023 the warmest year in Austria's 256-year measuring history. In the middle and high mountain regions, the year was not quite as extremely warm as in the lower valleys and outside the Alps. The air temperature anomaly of the HISTALP summit station data set for the year 2023 is +1.1 °C and +2.2 °C (1961 1990), respectively. Together with 2015, it was the second warmest year in the 173-year long series of mountain measurements.



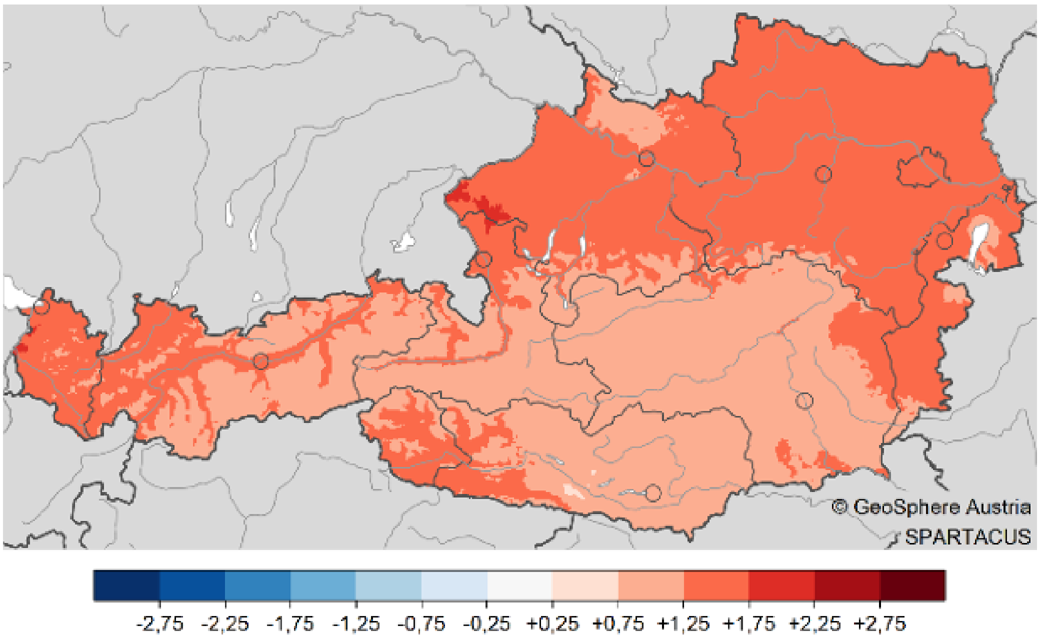


Figure 1: Temperature in Austria in 2023. Picture below compared to the average 1991-2020, picture above compared to the average 1961-1990. Source: GeoSphere Austria

Precipitation

The course of precipitation in 2023 shows an interplay of the prevailing weather conditions and the individual months were either too precipitous or too dry in their entirety. For example, in January there was a great contrast between a very dry north side of the Alps and a precipitation-rich south side. February basically showed an opposite picture and in March it was very dry, especially in the north and east of the country. April was very precipitation-intensive nation-wide and in Lower Austria there was 2.5 times more rainfall than average.

July brought 25 to 150% more rain, especially from East Tyrol to southern Burgenland, while in Lower Austria, Vienna and northern Burgenland it was very dry. The first and last week of August were characterised by sometimes extremely rainy weather. In the first week, Carinthia and Styria were affected by very large amounts of rain, which led to regional flooding and landslides. Another Italian low, especially from 26 to 28 August, once again caused high rainfall, which this time concentrated on Vorarlberg, Tyrol, Salzburg and Upper Carinthia and subsequently also on Upper Austria. With the sunny and relatively calm high-pressure weather, there was very little precipitation in September and in places in October. The last two months of the +1.3 °C year were generally very precipitation-intensive, with deviations of +93% and +111%, respectively. This results in the following spatial distribution of the deviations from the average for 1991-2020: In Vorarlberg, in the Tyrolean Oberland, in large parts of Carinthia and in western and southeastern Styria and in Burgenland, there was 20 to 35% more precipitation than on average. In the region from the Klagenfurt Basin to the Karawanks, the anomalies were exceptionally high at 35 to 50%. From the Tyrolean lowlands to the Lower Tauern as well as in parts of Upper and Lower Austria and in Vienna, precipitation increased by 5 to 20%. In Upper Styria and in parts of Upper Austria and Lower Austria (area from the Traun to the Traisen and area from the eastern Mühlviertel to the western Weinviertel), precipitation levels corresponded to the climatic average.

Over the federal Austrian territory, precipitation increased by 17%. A higher annual precipitation sum was last seen in 1966. At that time, there was 18% more precipitation than on average. Thus, the so far most precipitous years of the recent past were significantly outclassed. In 1979 and 2002, there was an increase of 14% and 13% more precipitation and in 2009 and 2014 there was an increase of 12% compared to the climate average. Significantly higher anomalies were recorded in 1965 (+22%), 1937 (+22%), 1916 (+25%), 1910 (+25%) and 1878 (+19%).

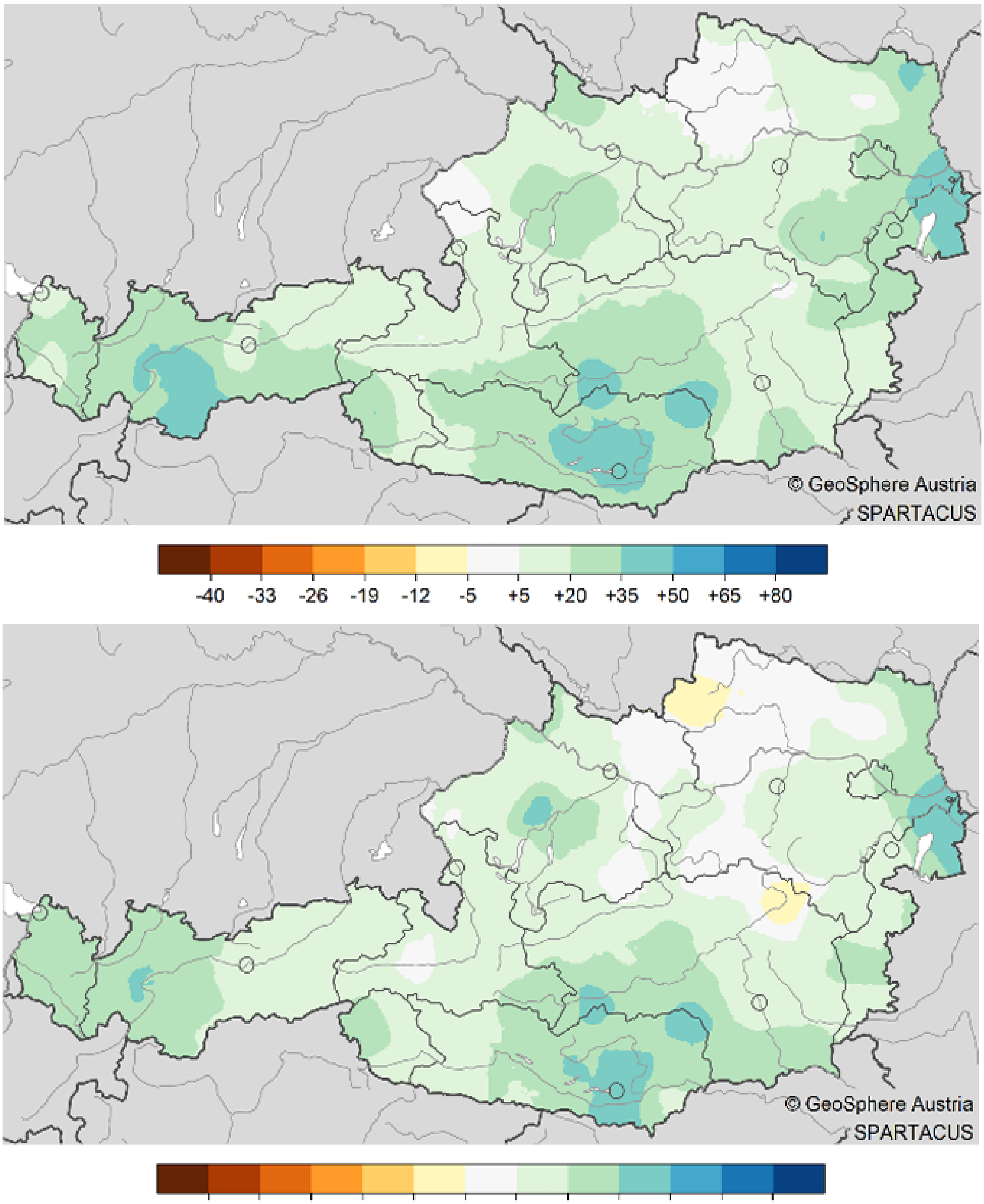


Figure 2: Precipitation in Austria in 2023: Deviation of precipitation from average. Picture below compared to the average 1991-2020, picture above compared to the average 1961-1990. Source: GeoSphere Austria

Sun

The start of the year was relatively cloudy; throughout January, the sun shone about a third less than in the climate average. then again, February brought a 14% increase in sunshine. March and April were also significantly cloudier than would normally be expected in these two months. April in particular contributed a great deal to the negative balance sheet for the year as a whole, with a deficit of 37%. It was also the least sunny April since 1989 (which brought 38%

less sun) and is one of the ten least sunny in the past 100 years. The relatively gloomy conditions continued into May, which brought 19% less sunshine throughout Austria. After a summer in which solar yield was balanced, an exceptionally sunny September followed, which, with an increase of 44% in the climate average, is one of the three sunniest in the history of measurements. October and November recorded a slight surplus of sunshine of 13 and 12% and December was only slightly sunnier than average with a plus of 5%.

In summary, over the federal territory, this results in sunshine duration that is 3% below average for the 1991-2020 reference period. This makes 2023 the least sunny year since 2014 (-8%). However, the anomalies of the sunshine duration show relatively large local differences. While there were balanced sunshine conditions in the Rhine Valley as well as from Upper Austria to Burgenland and in Western and Eastern Styria with deviations of +/- 5%, it was relatively cloudy in the entire alpine region from the Bregenz Forest to the Ybbstal Alps or Carinthia with deficits of 5 to 11% this year.

1.1.2 Meteorological characteristics for the Austrian Rhine region.

Source: Department of Water Management, Office of the Vorarlberg State Government, Bregenz

In 2023, annual precipitation in the Austrian part of the Rhine catchment area was above average, reaching 120% of the long-term average. Monthly totals of precipitation in April, August, November and December were quite well above the average for that month. November recorded almost 3 times the normal precipitation. The months of January, February, June and September recorded below-average precipitation, while the remaining months had average precipitation (Figure 3).

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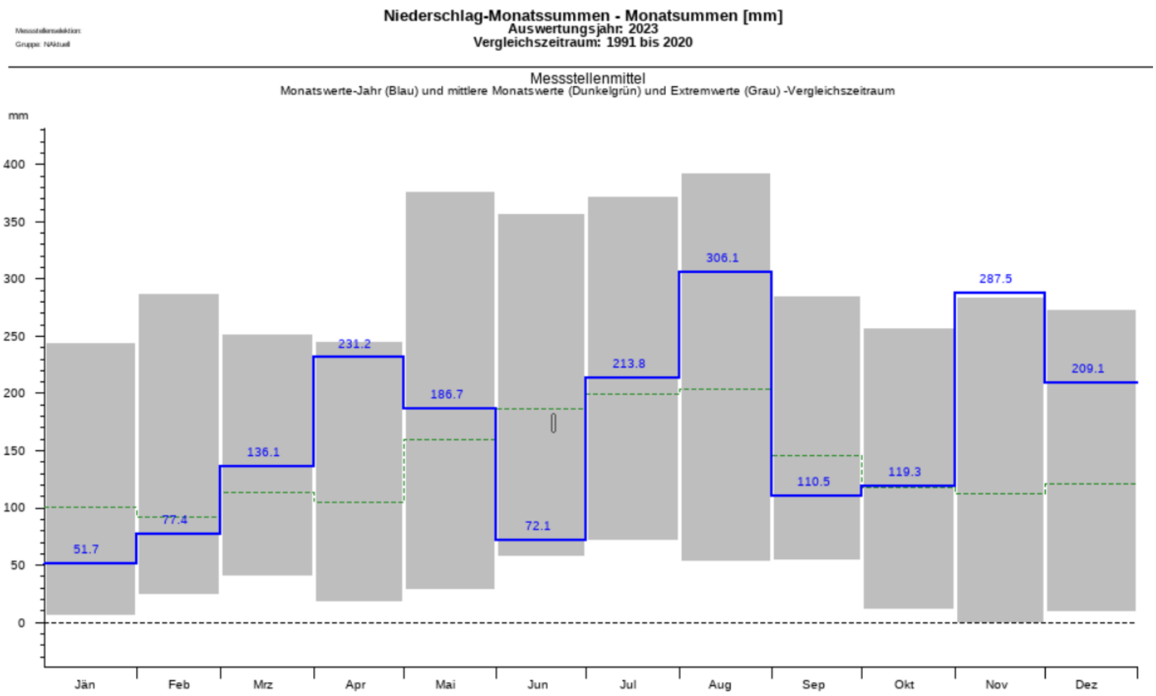

Figure 3: Monthly precipitation sums in 2023 (blue values) compared to long-term monthly averages (1991 – 2020) at the Bregenz Altreuteweg measuring point.

In the Austrian Rhine catchment area, annual average air temperature was 1.5 °C above the long-term average of 1991-2020.

1.1.3 Switzerland

Source: Federal Office of Meteorology and Climatology (MeteoSwiss)

The precipitation totals for the winter of 2022/23 reached between 40 and 65% of the 1991-2020 norm on the southern side of the Alps, in the Engadine as well as in the northern and central confederations. In the remaining areas, winter usually brought precipitation totals between 70 and 90% of the standard.

A high rainfall in March and April led to significantly above-average precipitation in the Alps and north-eastern Switzerland in the spring. In western and southern Switzerland, spring totals remained below average in some areas.

From 9 to 11 July, a first heat wave swept the whole of Switzerland. A second hit the southern side of the Alps a few days later. On 24 July, extreme wind speeds were measured during a thunderstorm in La Chaux-de-Fonds. In mid-August, a new heat period swept the whole of Switzerland. The zero degree limit reached a record altitude of almost 5300 m above sea level.

In July, monthly totals of precipitation in large areas of Switzerland were well above average. In western Switzerland, the values remained far below average. August brought a stormy period towards the end of the month with large amounts of precipitation on the southern side of the Alps and in parts of eastern Switzerland. The heavy rains were preceded by heavy thunderstorms.

A persistently very mild and sunny period in the first half of September and the first half of October led to the warmest September and the second warmest October since the beginning of the measurements. The two autumn months of September and October also showed a similar pattern in the course of precipitation. In the second half of the month, regionally strong precipitation fell in each case.

In November, persistent wet weather on the northern side of the Alps and in Valais led to far above-average precipitation. During the three autumn months, the overall amount of precipitation was above average. At the end of November, heavy snowfall in the lowlands of the north side of the Alps spread the first snow cover of the winter of 2023/24.

Between 9 and 13 December, considerable amounts of precipitation fell in large parts of western and central Switzerland. The snowfall limit temporarily rose to 1500 to 2200 m altitude, which caused the sometimes heavy precipitation to fall as rain far up the mountains, thus triggering a strong snow melt.

After a short break, on the northern side of the Alps this continued with heavy precipitation and storms. The strong inflow from the northwest also led to greater precipitation volumes north of the main Alpine ridge. The precipitation-rich weather resulted in far above-average monthly totals, especially in the canton of Grisons and in Valais.

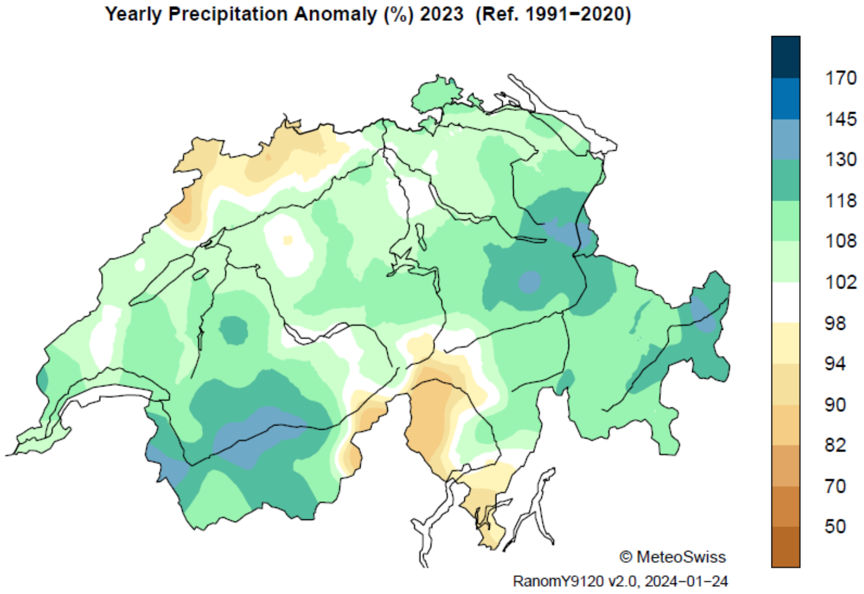

Figure 4: Annual precipitation sum Switzerland 2023 as a percentage of the standard (1981-2010). Annual precipitation in 2023 reached 90 to 120% of the 1991–2020 standard. On the eastern northern slope of the Alps and in the Valais, there were local values above 130% of the standard. Source: MeteoSwiss

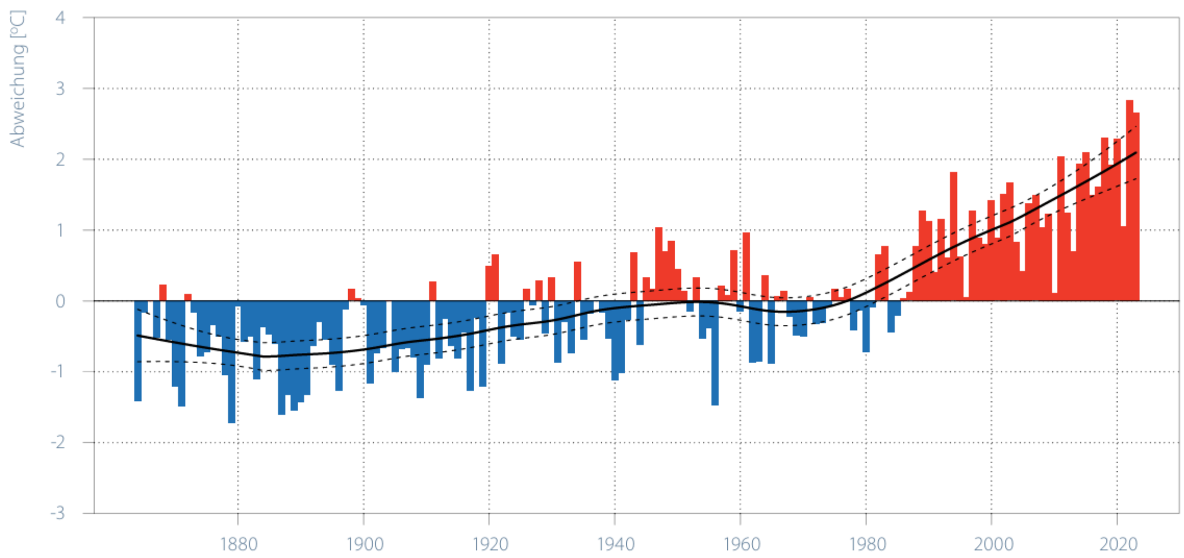

Figure 5: Long-term trend of the annual temperature averaged across the whole of Switzerland. Annual deviation of the temperature in °C from the standard 1961–1990 is shown (red = positive deviations, blue = negative deviations). The black curve shows the 30-year smoothed average (local linear regression LOESS). The dashed lines indicate the uncertainty range of this average (95%- confidence interval). Source: MeteoSwiss

Table 1: 2023 annual values at selected MeteoSwiss measuring stations compared to the 1991-2020 standard. Data source: MeteoSwiss.

Station	Altitude m a.s.l.	Temperature (°C)			Sunshine duration (h)			Precipitation (mm)		
		Average	Standard	Dev.	Total	Standard	%	Total	Standard	%
Bern	553	11.0	9.3	1.8	1993	1797	111	1080	1022	106
Zurich	556	11.4	9.8	1.6	1812	1694	107	1160	1108	105
Geneva	420	12.7	11.0	1.7	2059	1887	109	1016	946	107
Basel	316	12.7	11.0	1.7	1789	1687	106	775	842	92
Engelberg	1036	8.3	6.8	1.5	1407	1380	102	1834	1568	117
Sion	482	11,8	10.7	1.1	2182	2158	100	822	583	141
Lugano	273	14.3	13.0	1.3	2309	2120	109	1462	1567	93
Samedan	1709	3.8	2.4	1.4	1745	1767	99	872	710	123

Standard = Long-term average 1991-2020
Dev. = Deviation of the temperature from the standard
% = Percentage in relation to standard (standard = 100%)

1.1.4 Germany

Source: German Weather Service (DWD)

The year 2022, which is to be classified as a "dry year" with 786 mm of annual precipitation in the Rhine region, was followed by a "normal year" with the hydrological year 2023 (November 2022 to October 2023). This is evident in the two catchment areas of the Rhine area considered here (Basel level to Mainz level, AEo 62,309 km² and Mainz level to Lobith level, AEo 61,690 km²). Averaged over both sub-basins, almost 100% of the multi-year precipitation average of the 1981-2010 time series was reached in 2023 with 918 mm, previous year 76% (see Figure 6).

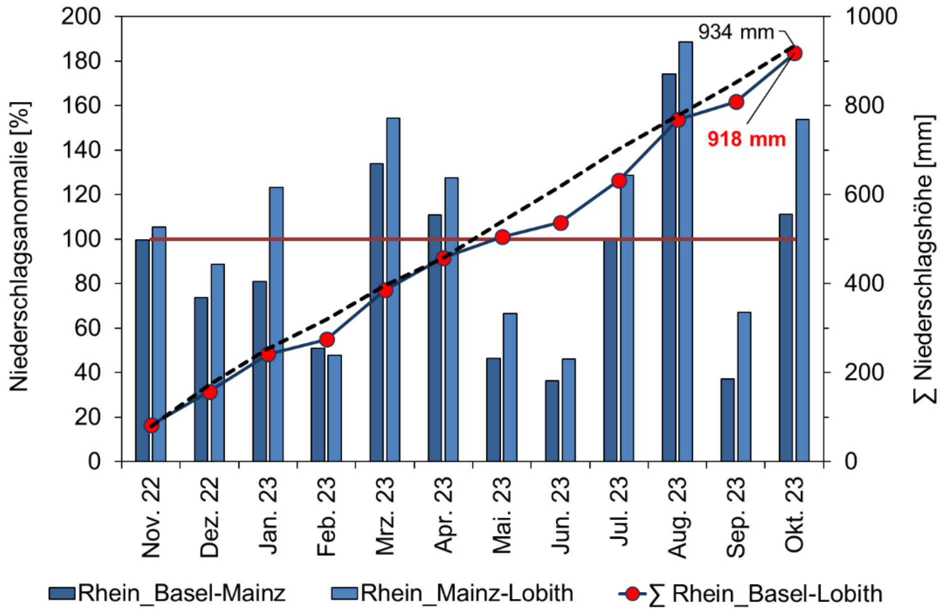

Figure 6: Monthly relative anomalies (blue bars) of the hydrological year 2022 precipitation levels in the Rhine area for the sub-basins of the Upper Rhine (Basel to Mainz including Mainz, 62,309 km²) and

Middle and Lower Rhine (Mainz to Lobith, 61,690 km²) against the background of the multi-year averages of the reference series 1981 to 2010 (magenta horizontal). Plotted in black the summed monthly precipitation levels for the Rhine region from Basel to Lobith (∑) for the hydrological year 2023 in comparison with the cumulative line of the time series 1981 to 2010 (dashed line). DataSource: DWD and weather services of the neighbouring countries, evaluation: Federal Institute for Hydrology.

However, the distribution of monthly precipitation within the year was quite different. The months of March, August and October were very precipitous, with relative anomalies of 145%, 182% and 134%, respectively, based on the Rhine area between Basel and Lobith. These were contrasted by the four very dry months of February, May, June and September (rel. deviations of 49%, 56%, 41% and 53%). On the other hand, the months of April and July were moderately precipitous (120% and 114%, respectively). Slightly below normal or approximately normal were the winter months of November and December 2022 and January 2023 (103% 82% and 105%). In almost all months, the northern part of the Rhine (Middle and Lower Rhine with Moselle) was wetter than the Upper Rhine and Main areas (Figure 6). The differences were particularly striking due to the special weather character in January and October 2023 (see below).

The average annual temperature in the area between Basel and Lobith was 11.0 °C, +1.7 degrees (previous year 1.6 degrees) above the long-term average from 1981 to 2010. Compared to the warm previous years, the annual average temperature was thus again comparatively high. Only in April did the monthly average air temperature slightly fall below the multi-year average of the reference period. Otherwise, temperatures moved up in the majority of months, in some cases very significantly above the average. With deviations above +3 degrees, these were especially the months of June and September. However, air temperatures in November 2022, January and October 2023 were also significantly above the reference value from 1981 to 2010 at +2.5 degrees and more (see Figure 7).

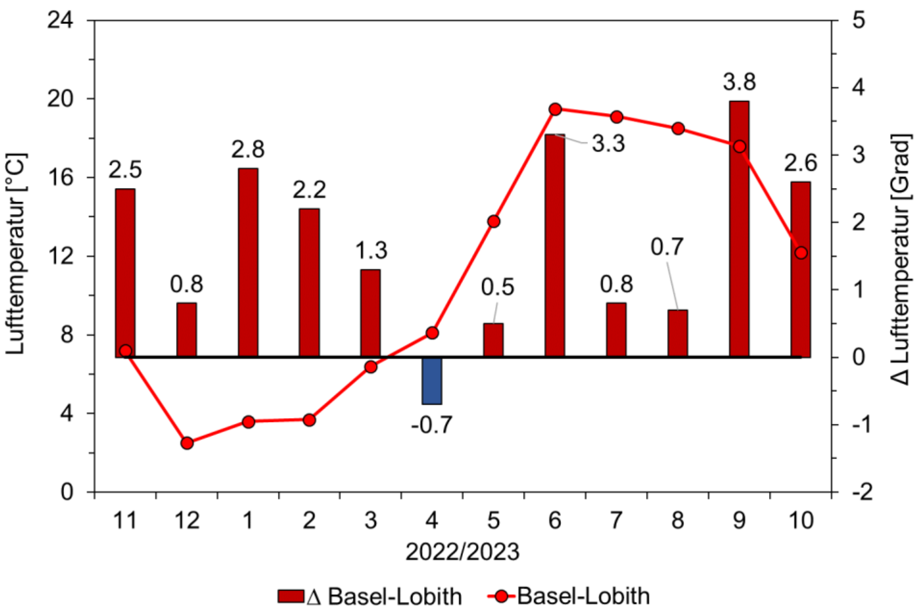

Figure 7: Monthly average and monthly anomalies of the air temperature for the partial catchment area of the Rhine from Basel to Lobith for the hydrological year 2023. The anomalies of the air temperature (Δ, columns, referring to right ordinate) refer to the time series 1981 to 2010. Data source: DWD and weather services of the neighbouring countries, evaluation: Federal Institute for Hydrology.

With a focus on the German Rhine region share, the weather character of the individual months of the hydrological year 2023 can be characterised as follows (cf. German Weather Service (2024)):

In the first half of November 2022, low air pressure initially prevailed. Several continuous depressions weakened during their relocation via Germany from west to east. A strong high subsequently caused cloudy and moderately cold weather in the lowlands, while it was predominantly mild and often sunny at high altitudes. In the second half of November, it often remained mild, cloudy and rainy in southwestern Germany.

At the beginning of December, high pressure dominated with partly sunny, partly cloudy and partly frosty winter weather. Low pressure systems crossed or grazed Germany repeatedly – the precipitation mostly fell as snow. The transition to lively southwest and west currents at the beginning of the last ten days initiated a significant mitigation. Precipitation gradually turned into rain from west to east. The month ended with warm record temperatures.

January began erratically; disturbances crossed Germany over and over again. It was mild and stormy at times. In the second half of the month, the temperature initially fell significantly and it snowed down to low altitudes. Gradually, cloudy and cold high-pressure weather prevailed with frosty nights. At the end of the month, low pressure influence followed again with rain, snow and storms. South of Nahe and Main, it was drier than the long-term average, while from the Westerwald to the Sauerland and further north, the average values were sometimes exceeded by more than 50%.

February was also marked by low pressure systems with mild, partly rainy and stormy weather. In between were repeated high pressure phases of several days in which it was partly sunny, partly cloudy and often frosty at night. At the beginning of the month as well as on the two weekends at the end of the month, precipitation partly also fell as snow.

At the beginning of March, sunny high-pressure weather was still decisive. Against the background of the low rainfall winter months, the associated drought and low meltwater inflows resulted in an unusually low water level of the Rhine. Towards the middle of the month, a rainy phase began. Disturbances repeatedly crossed Germany from the west. They brought partly heavy precipitation (also as snow), thunderstorms, hail and storms. There was further rainfall, some of it intense, at the end of the month. For example, some stations had double or more of the usual monthly precipitation levels.

In April, high-pressure areas led cold air to Germany from the east via Scandinavia. Stored in the eastern current, lows crossed Germany. There was a change from sunny periods and clouds, but also sometimes thunderous showers with heavy rain and hail. After milder air had temporarily prevailed at the beginning of the last three days, it was soon replaced by a northwest current with variable weather. Even in April it still snowed occasionally, but only at higher altitudes a new snow cover formed. Nevertheless, there were also areas where there was less precipitation than expected on average over many years. For example, on a small scale in the west and southwest of Germany.
The daily precipitation levels and daily mean temperatures as well as the snow water equivalents calculated with the LARSIM-ME water balance model are shown for the hydrological winter half-year in Figure 8. Two phases of snow cover build-up are clearly visible: beginning to mid-December 2022 and mid-January 2023. This was followed by corresponding snowmelt periods due to predominantly mild weather situations.

The hydrological summer half-year began with the month of May, initially alternately. The Rhine region was under the influence of low pressure. There, showers developed, sometimes with thunderstorms, heavy rain and hail. Around the middle of the month, high-pressure influence became widespread. However, individual cold fronts also moved southwards over Germany, which were accompanied by showers and thunderstorms. Heavy rain partly with hail continued on 23 May. Detmold, the Siegerland and Sauerland, the Ruhr area and the Saarland under water. However, these events were short-lived and locally limited; overall, May was rather dry in the German Rhine region (Figure 6).

A high-pressure edge caused a lot of sun and dry weather during the first half of June. Only a few strong thunderstorms occurred. From 17 to 23 June, more humid air came to Germany from the southwest. This was associated with heavy thunderstorms, locally extreme heavy rain, large hail and hurricane gusts. The last week of June was volatile. In addition to sunny phases, there were other showers and thunderstorms. Overall, June was dry in Germany and with around 304 hours of sunshine, it was the second sunniest June since 1951.

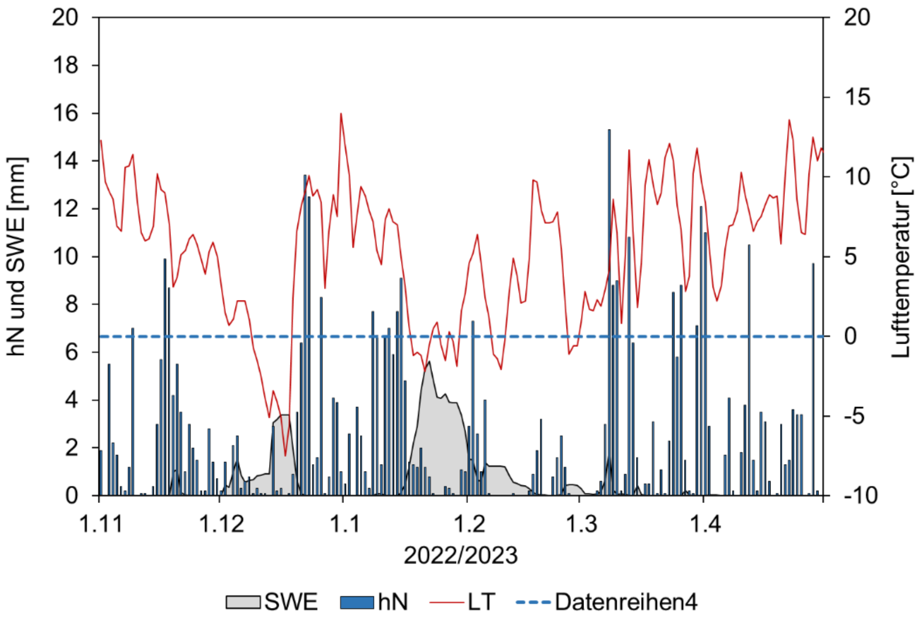

Figure 8: Daily values of precipitation (hN), snow water equivalent (SWE) and air temperature (LT) for the area average of the partial catchment area of the Rhine from Basel to Lobith for the hydrological winter half-year 2023 (1/11/2022 to 30/4/2023). The dashed blue line represents the zero-degree line. Data source: DWD and weather services of the neighbouring countries, evaluation: Federal Institute for Hydrology.

The changeable weather continued at the beginning of July. At the end of the first ten days, a heat wave began to spread. Local showers and thunderstorms with heavy rain, hail and gusts caused damage during this time. In the second half of the month, low foothills increasingly determined the weather with a current turning to the west. They brought local heavy rain, hail, gusts of wind and cooler weather. In some cases, the monthly rainfall levels in the Lower Rhine region were more than twice as high as was to be expected after the long-term average.

Low-pressure areas provided for changeable, predominantly humid and partly cool weather in the first ten days of August. With a current turning to the southwest, it then became significantly warmer. Over several days, an air mass border running across the Rhine region separated very warm and humid Mediterranean air in the southeast from less warm Atlantic air in the north-west. Along and south of this border, showers and thunderstorms developed, which were locally accompanied by heavy rain, gusts and hail in the storm area. At the beginning of the third decade, humid hot air caused a high heat load. At the end of the month, slightly cooler air came to Germany from the north. Where this air mass met the existing muggy air, showers and thunderstorms developed again. Precipitation was above average.

Warm air from the south and plenty of sunshine determined the weather in September. Only individual disturbances clouded this picture. As in the previous months, the showers and thunderstorms were partly accompanied by heavy rain, hail and storms, such as from 11 to 13 September and on 21 and 22 September The precipitation surpluses were mainly attributable to individual heavy rain events. With 247 hours, September was the second sunniest in Germany since records began in 1951.

October started as a late summer. In the southern half of Germany, the sunny and warm high-pressure weather in October initially continued, while low-pressure activity in the north provided for changeable and windy weather. A cold front then led to a temperature drop in Central Europe on the 14th with storms and rain. From the 18th, lows caused rainy and stormy weather at times. Towards the middle of the month, the focus of precipitation shifted more to the south. However, the areas south of Nahe and Main were often spared from the excess precipitation; there it was significantly drier than on average.

1.1.5 Netherlands

Source: Royal Netherlands Meteorological Institute (KNMI)

Temperature

With an average temperature of 11.8 °C, 2023 was the warmest year since Dutch measurements began in 1901. So far, 2014 and 2020 were the warmest years with an annual average temperature in De Bilt of 11.7 °C, normal is 10.5°C. The lowest temperature, -10.1 °C, was measured on 1 December in Leeuwarden. The highest temperature, 34.8 °C, was measured on 9 July in Arcen.

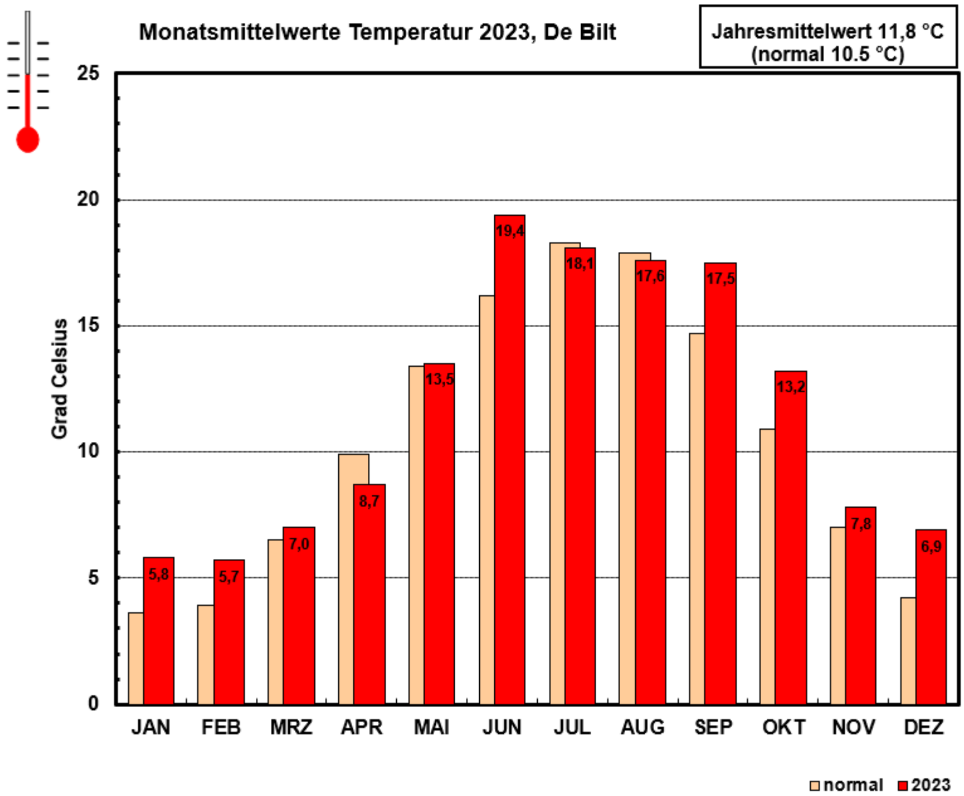

Figure 9: Monthly temperature averages at the station De Bilt 2023 compared to the long-term (1991-2020) average (source: KNMI)

Precipitation
The year 2023 was the wettest since Dutch precipitation measurements began. On national average, 1060 mm fell at the KNMI weather stations, compared to the normal 795 mm. At a selection of 13 (P13) precipitation stations, 1155 mm fell. The wettest year to date was 1998 with a national average of 1108 mm at all KNMI precipitation stations and 1109 mm at P13. At the KNMI weather stations, 1054 mm fell at that time.

It was least wet in the southwest of the Netherlands. The driest KNMI station was Westdorpe, where 881 mm fell, 95 mm more than normal. The KNMI station Deelen was the wettest station with 1273 mm, over 400 mm more than normal.

In 2023, the drought was much less pronounced than in previous years. By mid-July, the precipitation deficit had risen to a national average of 200 mm. At that time, the summer season was among the 5% driest years. At the end of September, the deficit was around 120 mm, which is not uncommon. In the very wet months that followed, groundwater reserves were fully replenished in most places.

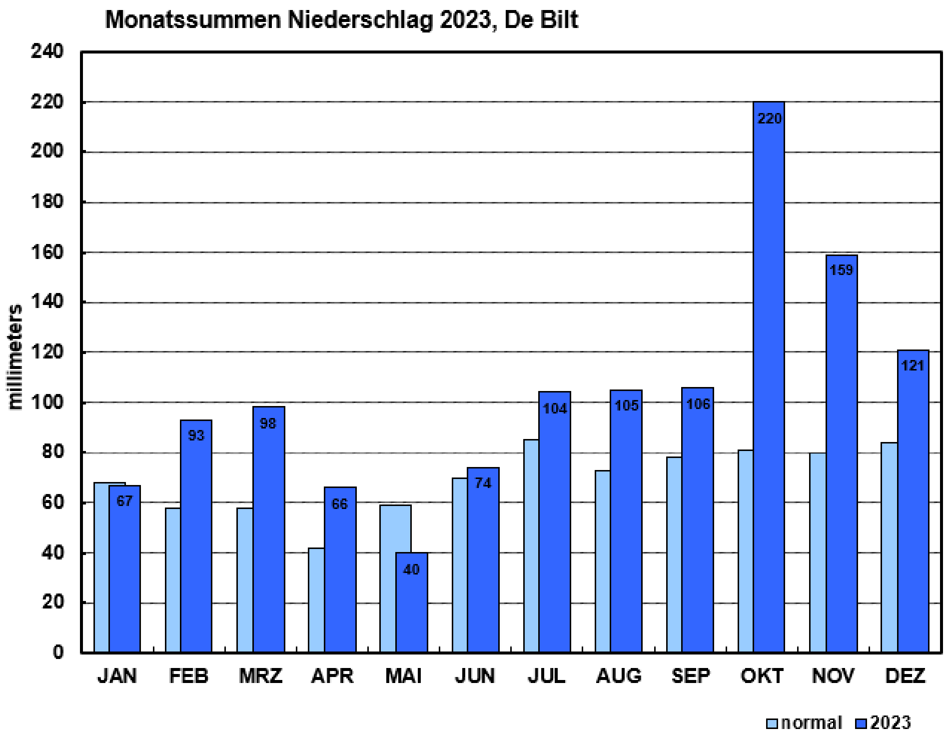

Figure 10: Monthly totals of precipitation at De Bilt 2023 station compared to the long-term (1991-2020) average (source: KNMI)

Sun

The year 2023 was a very sunny year in the Netherlands. Nationwide, the sun shone for an average of 1913 hours. The normal average is 1774 hours. Most of the surplus was attributable to a very sunny summer with a sunny record month of June.

The combination of an extremely wet and a very sunny year is unusual. Earlier wet years were usually gloomy as well. The very wet months of October and November still brought the normal amount of sunshine. December, which was also very wet, was cloudy.

It was sunniest on the coast: in Vlissingen, the sun shone for 2067 hours, compared to the long-term average of 1889 hours. It was least sunny in Deelen with 1775 hours, still 131 hours more than normal.

1.2 Snow and Glaciers

1.2.1 Snow

Source: WSL Institute for Snow and Avalanche Research SLF

The winter of 2022/23 was characterised on both sides of the Alps above all by great low precipitation and above-average temperatures between November and February. This resulted in greatly below-average snow depths at all stations. Above 1000 m above sea level, the average snow depth between November and April was lower than ever before. Between 1000 and 2000 m above sea level, there was around 70% less snow than normal. In particular, the period from the end of February to the beginning of March was extremely low in snow. At 1500 m above sea level, there was only about 20 cm of snow instead of the usual 75 cm. Larger snowfalls only followed between April and May, so that the snow heights at higher altitudes at the end of May – during fewer days - were almost average. In contrast, rainfall was frequent at medium altitudes, resulting in record low amounts of new snowfall for the period from November to May at some long-term stations on both sides of the Alps. Due to the dry and very warm month of June, thaw took place two to four weeks earlier than normal.

A similar picture also shows the development of the snow water equivalent over time. The winter period 2022/23 is well below the long-term average for Switzerland as a whole. From February to March, the snow water equivalent reached new minima compared to the last 24 years. The fifth warmest summer since the start of the measurement and a partly record-high zero degree limit until September were responsible for the fact that the traces of the few summer snowfalls, which spread down to around 2000 m above sea level, had disappeared again after a week, even at high altitudes in many places.

1.2.2 Glaciers

Source: Department of Geosciences at the University of Freiburg and Laboratory for Hydraulics, Hydrology and Glaciology (VAW) at ETH Zurich

The glaciers of Switzerland are melting faster and faster. The acceleration is dramatic: in just two years, as much ice was lost as in total between 1960 and 1990. The two extreme years in a row lead to the disintegration of the glacier tongues and the disappearance of many small glaciers. For example, the measurements at St. Annafirn (UR) had to be stopped.

The massive ice loss is due to very low snowfall in winter and high temperatures in summer. The glacier melt affected the whole of Switzerland. In the south and east of Switzerland, the glaciers are melting almost as fast as in the record year 2022. In southern Valais and Engadine, an ice melt of several meters was again measured at over 3200 m above sea level – an altitude at which glaciers were still in equilibrium until recently. The average ice thickness loss there is up to three metres (e.g. Griesgletscher (VS), Ghiacciaio del Basòdino (TI), Vadret Pers (GR)) and is significantly above the values of the heat summer of 2003. The situation between the Bernese Oberland and Valais (e.g. Grosser Aletschgletscher (VS), Glacier de la Plaine Morte (BE)) is somewhat less dramatic, as there was some more snow there in winter. Nevertheless, the loss is very high with over two meters of medium ice thickness.

The third warmest summer since the start of the measurement and a temporarily record-high zero degree limit until September were responsible for the fact that occasional summer snowfalls usually melted quickly again and therefore could hardly feed the glaciers.

1.3 Hydrological Situation in the Rhine Region 2023

1.3.1 Water Levels of Large Lakes in the Catchment Area of the Rhine

1.3.1.1 Austria

Source: Department of Water Management, Office of the Vorarlberg State Government, Bregenz

From the beginning of the year to the middle of April, water level of Lake Constance was in the range of the long-term average of the series 1864 – 2022 for the respective calendar day. After that, the above-average precipitation from April to mid-May resulted in above-average water levels. Subsequently, water levels fell until the end of August. The flood event of 28 August caused the water level to rise by over 80 cm. After a decline in water levels in September and October, there were rising water levels with the extraordinarily high precipitation volumes in November and December and also record values in December. From 10 December, the previous maximum water levels for the month of December since the beginning of the measurement were exceeded. The annual average of the water level in Bregenz was 348 cm, by 2 cm above the long-term annual average (346 cm).

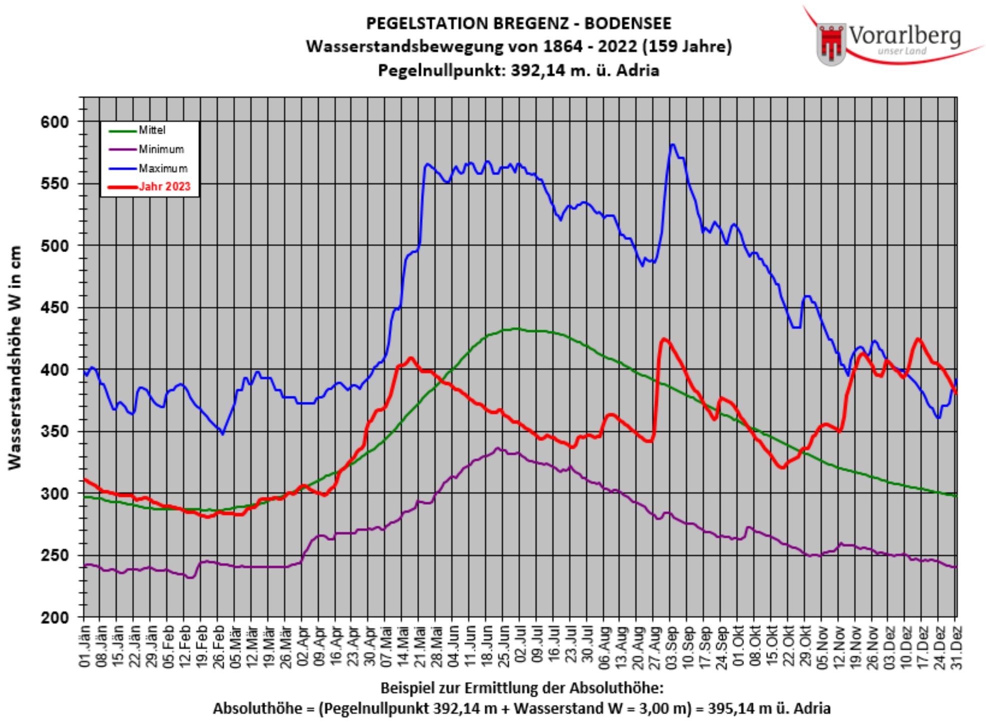

Figure 11: Hydrograph of the water level of Lake Constance at the Bregenz gauge in 2023 (red curve) compared to long-term minima, maxima and mean values

1.3.1.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

If you only look at annual averages of the water levels on the large lakes, the year 2023 seems to have been quite balanced. The deviations from the long-term averages have been significantly greater in recent years. However, the multiple alternations of low water and flood situations have also made themselves felt in the lakes.
At Lake Constance, premature snow and glacier melt can be seen. These discharge components were then missing in the middle of the year, which led to a very low water level for the summer. The floods from late August to early September and from November and December led to significantly increased lake levels. However, these never reached danger level 2 during both events.

Until the beginning of November, the water level of Lake Neuchâtel was close to the course of the middle hydrograph of the standard period. However, the winter floods in the tributaries caused the level to rise rapidly despite predictive sea regulation. In mid-December, it reached danger level 3 for a few days. The annual high in 2023 was not a new absolute record, but a new high for the month of December.

Lake Maggiore once again shows very rapid changes from low to high water levels. The first increase came after a long period of low water at the end of April, and another after a marked summer low at the end of August. After a third steep climb, the lake reached danger level 2 for a short time. However, the floods of the second half of the year were not able to compensate for the low water levels of the beginning and middle of the year. The annual average remained 19 cm below the long-term standard.

The regulated Lake Geneva, whose level is usually very close to the long-term average course, showed very restless behaviour in 2023: The level remained above standard from the beginning of the year to mid-May. The second half of the year was characterised by relatively large fluctuations for this lake. In mid-November, the water level reached danger level 2 for a few days, in mid-December it reached level 3 for a few days.

1.3.2 Water Levels and Discharge Volumes of Watercourses

1.3.2.1 Austria

Source: Department of Water Management, Office of the Vorarlberg State Government, Bregenz

In 2023, the discharge of the Alpine Rhine was 3% **above** the long-term average. The two largest tributaries from Austria, the Bregenzerach and the Dornbirnerach, also had an above-average annual load. On 28 August, a 5-10 yearly flood event occurred at the Alpenrhein and Dornbirnerach. At the Bregenzerach, the flood peak was at annuality 1.

The average annual discharge of the flowing waters compared to the long-term average was:

- at the Bregenzerach 116% (MQ 2023 = 53.9 m^3/s, long-term MQ = 46.5 m^3/s, years 1951-2022);
- at the Dornbirnerach 118% (MQ 2023 = 8.32 m^3/s, long-term MQ = 7.03 m^3/s, years 1984-2022);
- at the Alpine Rhine 103% (MQ 2023 = 237 m^3/s, long-term MQ = 231 m^3/s, years 1951-2022).

1.3.2.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

In 2023, the annual average discharge values of the large river areas were mostly in a normal range compared to the long-term average values of the standard period 1991 – 2020. As the only large catchment area, the Thur near Andelfingen had a significantly above-average annual discharge of 115%. The Ticino at Bellinzona and the Birs at Münchenstein remained at under 90% of the standard; the Maggia at Locarno was clearly below average.

Among the medium-sized catchment areas, the range of deviations of the annual mean from the standard values is greater and ranges from -35% on the Saltina to +35% on the Gürbe. The majority of the catchment areas had normal (90 to 110% of the standard) or above-average discharge (110 to 130%).

The year 2023 started very dry. As a result, discharge volumes in February and early March were generally lower than usual for the season. At around one third of all FOEN discharge measuring stations, low water levels were observed, such as occur statistically only every two years or less frequently. The Rhine and the Aare, in particular, had clearly below-average discharge volumes.

With the exception of southern Switzerland, the months of March and April were then widely wet. In May, a lot of precipitation fell, especially on the central and eastern northern slope of the Alps and in parts of Graubünden. At some measuring stations in eastern and central Switzerland, discharge peaks were reached in mid-May, such as occur statistically at most every two years. At the higher altitudes on the northern side of the Alps and in Valais, the previously existing snow deficit could be compensated for by the precipitation. In the south, snow depths remained strongly below average.

In turn, June brought very little precipitation throughout Switzerland. As a result, water levels on the northern side of the Alps also fell below the seasonal norm. In the Plateau in particular, various smaller and medium-sized rivers led to low tide, but large bodies of water, such as Lake Constance or the Rhine in Basel, were also affected. Only in the still snow-covered or glaciated catchment areas were above-average discharge quantities observed.

In the months of July and August, rainfall totals in the western half of Switzerland continued to be below average, intensifying the low-water situation in this region. In particular, some tributaries to Lake Geneva had exceptionally low discharge volumes, such as the Venoge and the Aubonne. Although there was slightly more precipitation in the other regions, discharge remained less than usual, apart from some short-term increases after thunderstorms. The water levels of the Ticino lakes were also very low. The situation is different in the heavily glaciated catchment areas, where distinct daily discharge levels were also observed due to the massive glacier melt.

Towards the end of August, a Genoa low provided intensive rainfall. From 26 to 29 August, large amounts of precipitation fell initially on the southern side of the Alps, later also in Graubünden and other parts of eastern Switzerland. Precipitation in Ticino and Misox was particularly abundant. Here there were 3-day totals from 200 to 300 mm, locally even up to 400 mm.

The waters reacted quickly to the large precipitation volumes. At many FOEN measuring stations in southern, central and eastern Switzerland, discharge volumes were recorded, such as occur on average every two to five years, for some only every five to ten years or even less frequently. The previous low water situation helped prevent, however, that the floods were more severe. In earlier years, the levels rose significantly more after comparable precipitation. Despite the large amounts of rain, new highs for the month of August were observed at only a few measuring stations. This particularly affected stations in the Engadine. At the Rosegbach in Pontresina, a new absolute maximum of 116 m^3/s was even recorded. Since the snowfall limit was exceptionally high, most of the precipitation fell in the form of rain and was not stored as snow even in the high mountains.

In western Switzerland and the Jura, heavy precipitation was not only absent during the severe weather situation at the end of August, but – with some local exceptions on Lake Geneva – continued to be so throughout late summer until mid-October. The low-water situation became increasingly severe in these regions. Rivers in the Jura were particularly affected, where widespread low water levels were observed, such as occur statistically every ten years or even less frequently. But also along the foothills of the Alps and in eastern Switzerland, low water levels were recorded at many measuring stations, such as occur only every two to ten years.

However, the year ended with above-average rainfall: it had already rained a lot from mid-October and soils were damp. Both in November and December, large amounts of rainfall were widespread, which could no longer be absorbed everywhere by the already wet soils. Because the snowfall limit moved at times above 2000 m above sea level, precipitation fell in many areas as rain and intensified the snowmelt where there was already snow. As a result, this led to flooding in numerous bodies of water. Southern Switzerland, the canton of Grisons and Upper Valais were not affected.

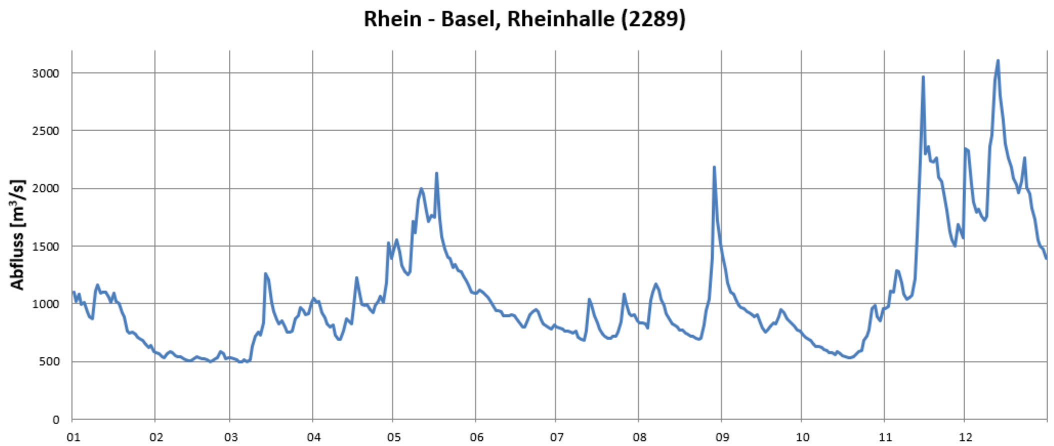

Figure 12: Discharge hydrograph at the Rhine - Basel, Rheinhalle gauge in 2023

1.3.2.3 Germany

Source: Federal Institute for Hydrology (BfG)

After very weak discharge volumes in the previous year, low water was also determining 2023, but in a less pronounced form than in 2022. As described, this was due to a low precipitation winter 2022/2023 and (with regional exceptions in north-eastern Switzerland) a dry early spring. In the following months from March to May, however, precipitation-rich phases occurring in short succession still ensured discharge levels that[1] oscillated around MQ. After a dry warm early summer, the water levels and discharge volumes had already[2] fallen to values close to the multi-year MNQ in July; however, precipitation in August and September provided for an interim recovery of the water supply of the surface waters. Another drought then led to a decline down to the annual discharge in October 2023. The annual discharge flow, differentiated in sections in the Upper Rhine (Maxau gauge), Middle Rhine (Kaub gauge) and Lower Rhine (Duisburg-Ruhrort gauge), can be seen in Figures 13, 14 and 15.

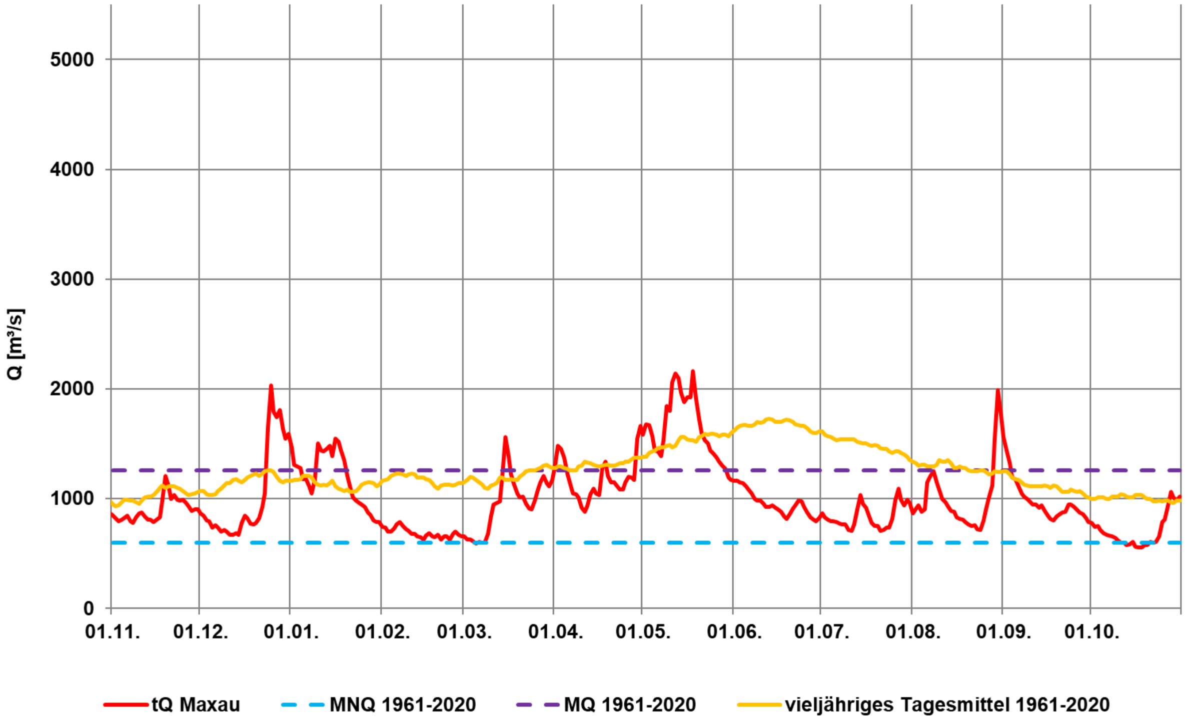

Figure 13: Daily discharge volumes (tQ) at Maxau Upper Rhine level in the hydrological year 2023 against the background of the multi-year daily average and the MNQ and MQ values for the reference period 1961 to 2020

[1] MQ = mean arithmetic discharge of a reference period, here 1961 to 2020
[2] MNQ = mean low water discharge of a reference period, here 1961 to 2020

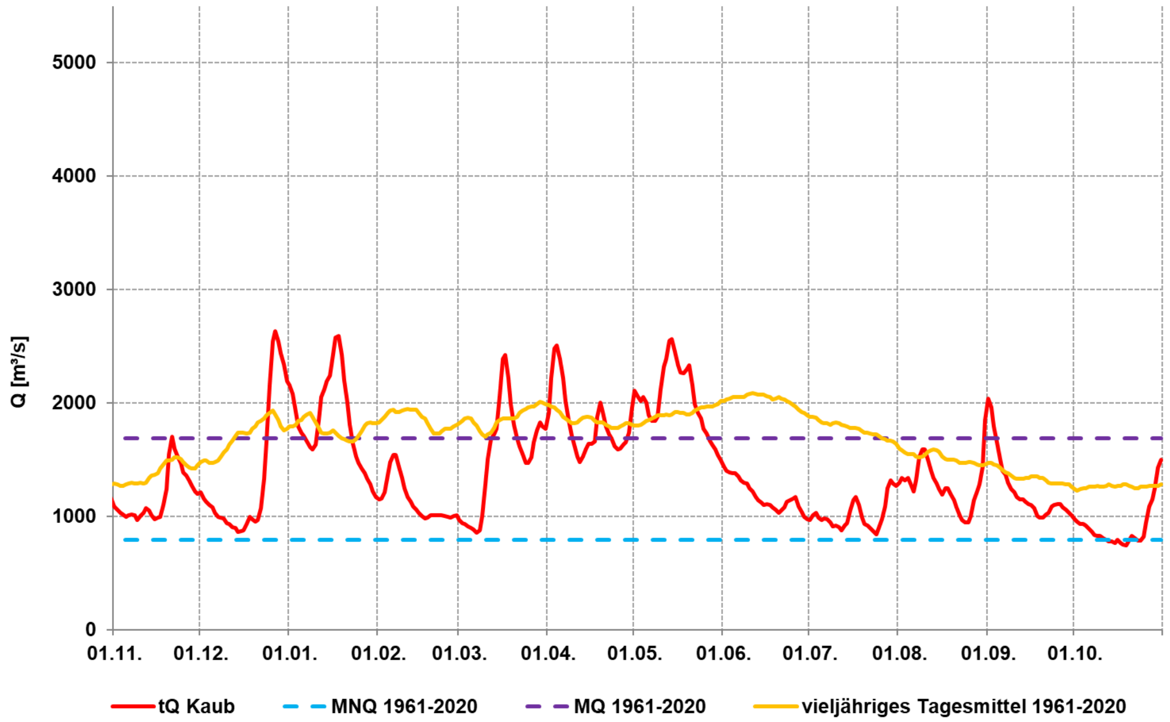

Figure 14: Daily discharge volumes (tQ) at the Kaub Middle Rhine gauge in the hydrological year 2023 against the background of the multi-year daily average and the MNQ and MQ values for the reference period 1961 to 2020

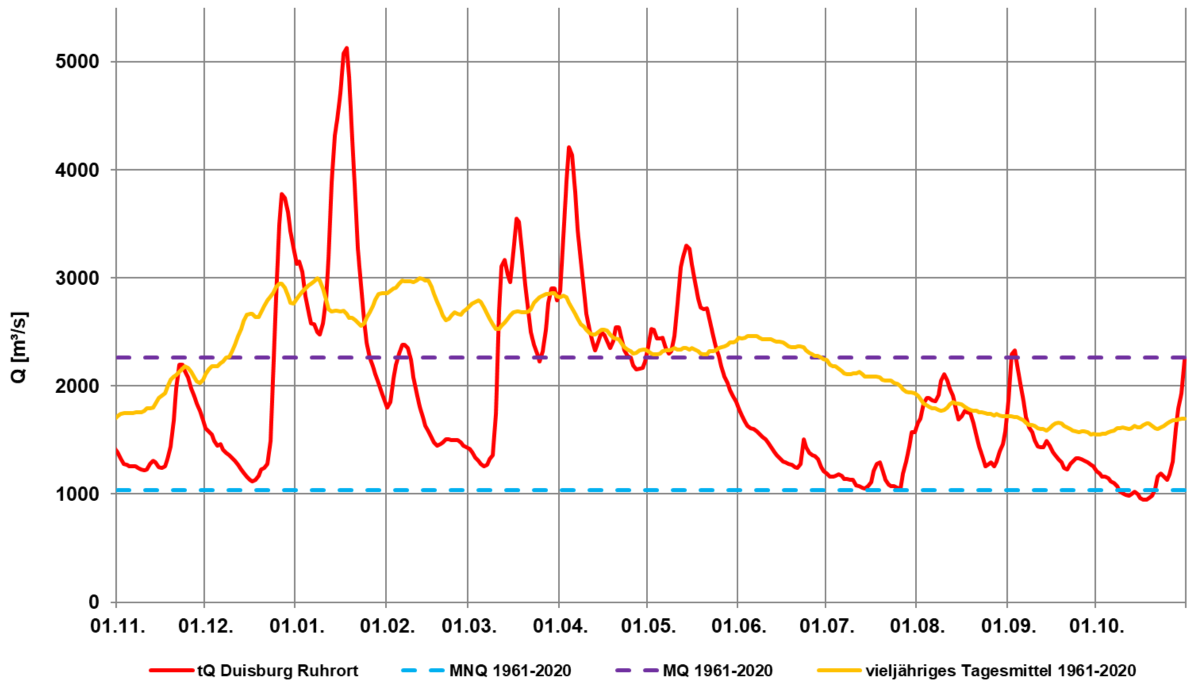

Figure 15: Daily discharge volumes (tQ) at the Duisburg-Ruhrort Lower Rhine gauge in the hydrological year 2023 against the background of the multi-year daily averages as well as the MNQ and MQ values for the reference period 1961 to 2020

As Table 2 shows, the average annual discharge in 2023 was between 15 and 20% below the long-term average. The Middle Rhine and especially the Lower Rhine, not only in absolute numbers, but also relatively speaking, showed higher discharge volumes than the Upper Rhine. Also, discharge deficits compared to the multi-year seasonal means were generally less noticeable in the winter half-year than in the summer half-year.

Table 2: Year-round and seasonal discharge averages for the hydrological year 2023 compared to the long-term reference values for the period 1961 to 2020 at the gauges Maxau /Upper Rhine, Kaub / Middle Rhine and Duisburg-Ruhrort / Lower Rhine (data basis: WSV)

hydrologische Jahre	MQ(1961/2020)	MQ(2023)		SoMQ(1961/2020)	SoMQ(2023)		WiMQ(1961/2020)	WiMQ(2023)	
	[m^3/s]	[m^3/s]	Verhältnis zum MQ(1961/2020 [%]	[m^3/s]	[m^3/s]	Verhältnis zum SoMQ(1961/2020 [%]	[m^3/s]	[m^3/s]	Verhältnis zum WiMQ(1961/2020 [%]
Maxau	1260	1010	80	1350	1020	76	1170	987	84
Kaub	1690	1380	82	1640	1270	77	1740	1470	84
Duisburg-Ruhrort	2260	1910	85	1970	1590	81	2550	2230	87

No high water level was reached at any time during the year in terms of daily discharge; the multi-year MHQ level[3] remained consistently well out of reach: the HQ(a) was about a quarter below the multi-year MHQ at the three example gauges in the Upper Rhine and about a third below the multi-year MHQ in the Middle and Lower Rhine (Table 2). The median water threshold was significantly lower than exceeded in the hydrological year 2023 (Table 4).

Table 3: Mean and extreme discharge values of the hydrological year 2023 compared to the long-term reference values for the period 1961 to 2020 at the levels Maxau /Upper Rhine, Kaub / Middle Rhine and Duisburg-Ruhrort / Lower Rhine (data: WSV)

hydrologische Jahre	MQ(1961/2020)	MQ(2023)	MNQ(1961/2020)	NQ(2023)		NM7Q(2023)		MHQ(1961/2020)	HQ(2023)	
	[m^3/s]	[m^3/s]	[m^3/s]	[m^3/s]	Datum	[m^3/s]	Datum	[m^3/s]	[m^3/s]	Datum
Maxau	1260	1010	600	552	18.10.2023	574	20.10.2023	3240	2240	18.05.2023
Kaub	1690	1380	792	744	19.10.2023	767	19.10.2023	4330	2690	27.12.2022
Duisburg-Ruhrort	2260	1910	1040	947	17.10.2023	947	20.10.2023	6640	5150	18.01.2023

Table 4: Days below the long-term main values MQ (mean discharge) and MNQ (mean low water discharge) of the reference period 1961 to 2020 at the gauges Maxau /Upper Rhine, Kaub / Middle Rhine and Duisburg-Ruhrort / Lower Rhine in 2023 (data basis: WSV)

hydrologisches Jahr 2023	Unterschreitungstage	
	MQ (1961/2020)	MNQ (1961/2020)
Maxau	299	11
Kaub	280	11
Duisburg-Ruhrort	257	13

As can be seen from Figures 13, 14 and 15 and Table 3, discharge maxima for the year were in the Upper Rhine in late spring (May) and in the Middle and Lower Rhine in winter (December/January). The recurrence intervals of HQ(a) were always <1 year. The less extreme discharge minima occurred uniformly at the end of the second third of October and are to be assigned to a recurrence interval of 2-5 years across all routes (Table 5).

Table 5: Low water extremes NM7Q(2023) on the Upper, Middle and Lower Rhine and their recurrence intervals (data basis: WSV)

[3] MHQ = mean flood discharge of a reference period, here 1961 to 2020

hydrologisches Jahr 2023	NM7Q [m³/s]	Wiederkehr-intervall [Jahre]
Maxau	574	2-5
Kaub	767	2-5
Duisburg-Ruhrort	947	2-5

1.3.2.4 Netherlands

Source: Water Management Center, Rijkswaterstaat (RWS)

In November and December 2023, the water level of the Rhine in the Netherlands rose significantly. Heavy rains in conjunction with the saturation of the Rhine basin led to a rapid increase in water levels and discharge volumes. On November 21, the water level at Lobith exceeded 13.00 meters above sea level due to heavy rainfall, accompanied by a discharge of 5620 m3/s. The Rhine discharge remained remarkably high and reached its peak during this period. Due to the wet autumn, the catchment area of the Rhine was heavily saturated, so that precipitation impulses caused a relatively rapid increase in discharge. In December, discharge reached its peak again. On December 28, a flood wave with a height of NAP +14.52 m (7,500 m3/s) passed near Lobith.

In 2023, there were also low water periods on the Dutch Rhine, but discharge volumes were not below the criteria for low water. However, notable differences were noted in the timing and duration of these low-water periods. At the end of March, a discharge was measured on the Rhine near Lobith that was below the long-term average. Nevertheless, the measured discharge of 2400 m3/s remained above the national low-water criterion of 1000 m3/s for the month of April.

The average daily discharge of the Rhine at Lobith for the year 2023 is shown in Figure 16.

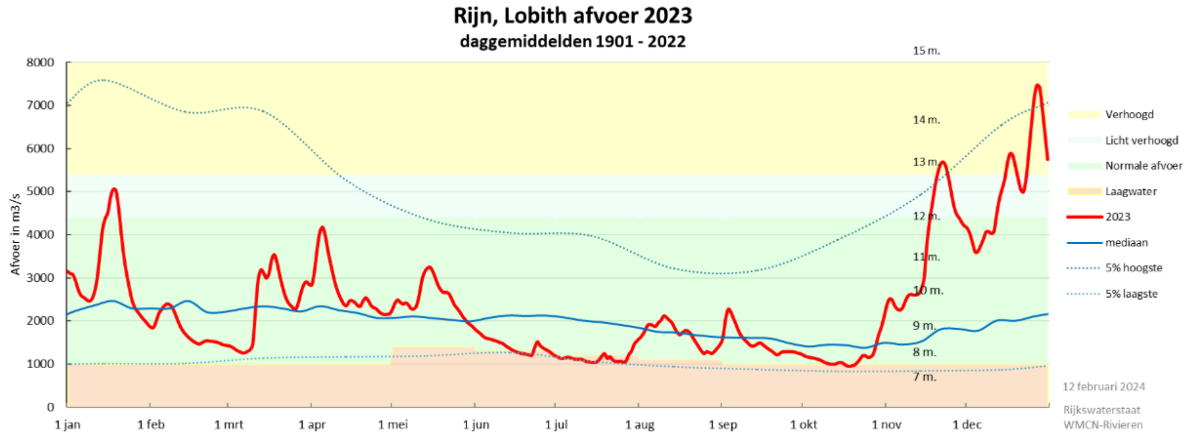

Figure 16: Hydrograph of the daily average discharge at the Lobith gauge in 2023 (red curve) compared to long-term minima, maxima and averages of 1901-2022.

1.3.3 Water temperatures

1.3.3.1 Austria

Source: Department of Water Management, Office of the Vorarlberg State Government, Bregenz

The annual average of the water temperature of Lake Constance at the Bregenz harbour gauge was 13.7 °C, 1.5 °C above the long-term average of 12.2 °C. With few exceptions, the daily averages from the beginning of the year to the end of the year were above the daily averages of the 1976-2020 series (see Figure 17).

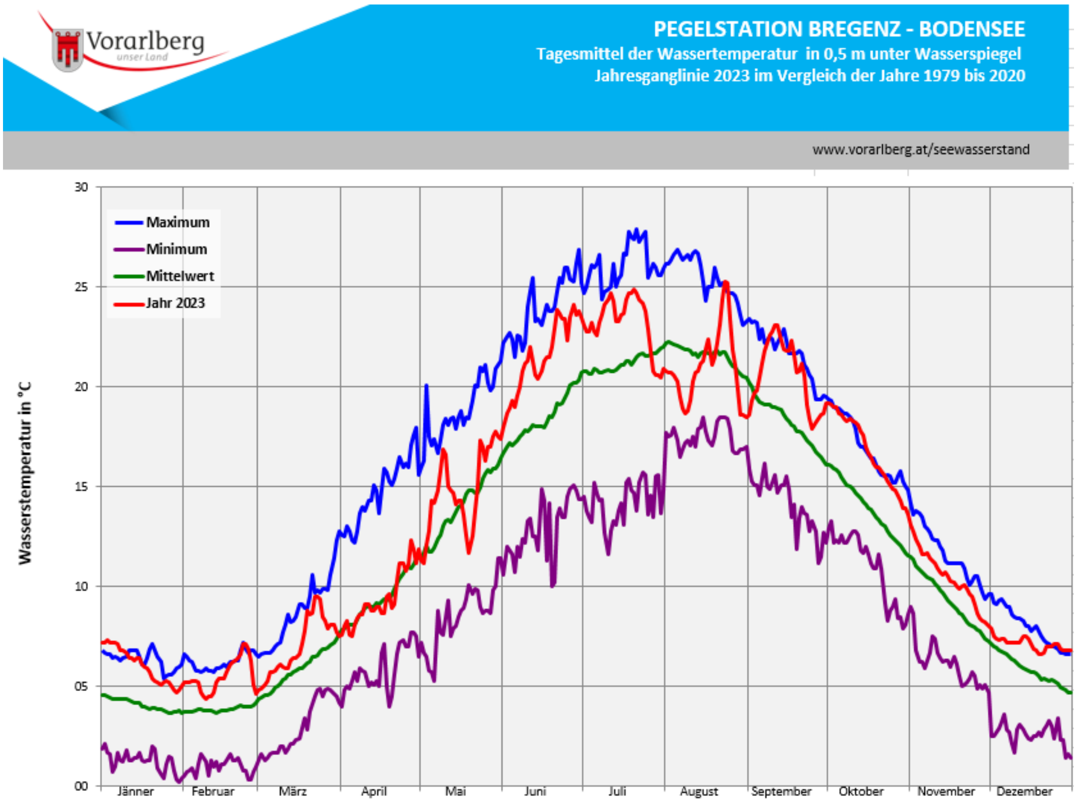

Figure 17: Hydrograph of the water temperature of Lake Constance at the Bregenz gauge in 2023 (red curve) compared to long-term minima, maxima and mean values

1.3.3.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

Although 2023 was the second warmest year according to MeteoSwiss, there were no new maxima or minima in the annual averages of water temperatures in the rivers. The range of mean values ranges between 1.2 °C (lowest annual mean value, mass for sheets at Naters) and 16.2 °C (highest annual mean value, Tresa at Ponte Tresa).

The limit of 25 °C was exceeded significantly less frequently in 2023 than in previous warm years. Compared to 2022, only half as many stations registered more than 25 °C. In the very warm years of 2018 or 2003, this had been the case at over 200 stations. On the Goldach near Goldach, the daily maximum in July 2023 exceeded the 30 °C mark.

At the beginning of the first quarter of 2023, water temperatures at many stations were higher than the long-term measured values. This led to the previous monthly maximum being exceeded, especially in January at around half of the stations, but also in some waters in the months of February and March. This is especially true of rivers in the Plateau, in the Lake Geneva region, along the Alps and in Ticino. New lowest monthly averages were observed in the Alpine region.

In July and August, the water temperatures at individual stations, first in the Alpine region, then also in the Plateau and Jura, reached values above the previous, long-term monthly maxima. The warm September led to new highs for this month at other stations – mainly in the Plateau and the Jura.

1.3.3.3 Netherlands

Source: Water Management Center, Rijkswaterstaat (RWS)

At Lobith, the average water temperature of 14.1 °C was about 1 °C higher than the calculated long-term average (1961-2020) (Figure 18).

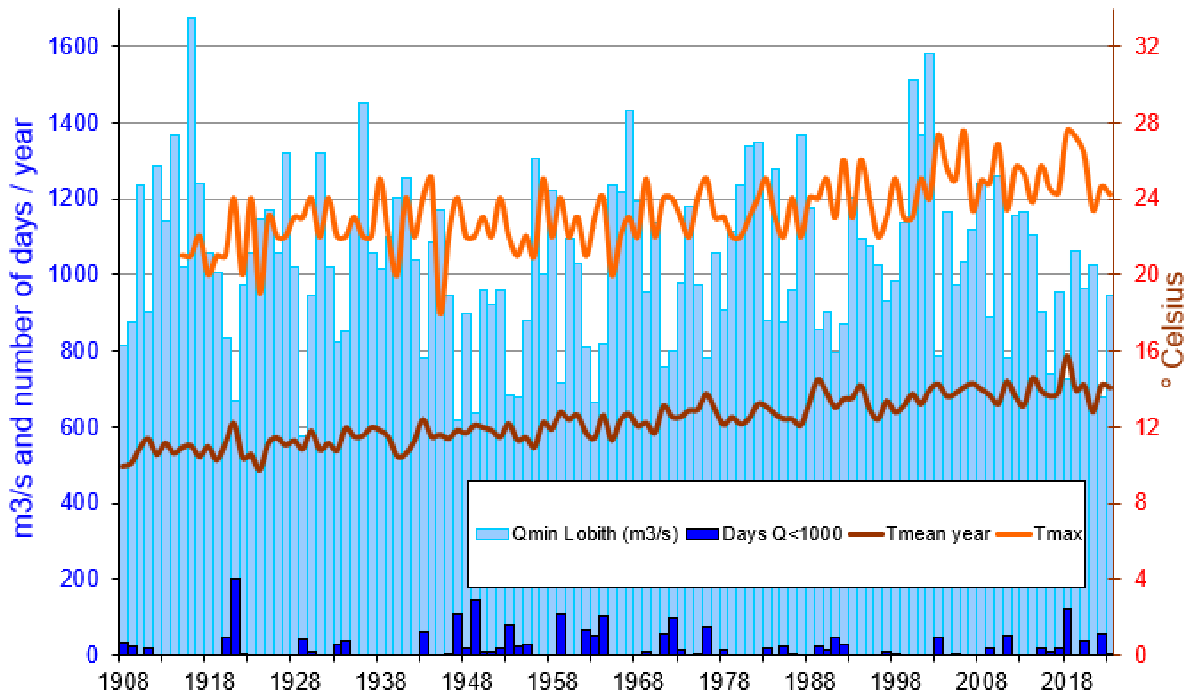

Figure 18: Average and maximum water temperatures 1908-2023 at the Lobith/Rhine gauge

1.3.4 Groundwater

1.3.4.1 Austria

Source: Department of Water Management, Office of the Vorarlberg State Government, Bregenz

At the beginning of 2023, groundwater levels in the Austrian part of the Rhine region were average to slightly below average. Due to abundant precipitation in the spring, groundwater levels rose slightly above the average values. Over the summer months, the water levels have fallen to the usual values for the season. In autumn, there was above-average precipitation. As a result, groundwater levels have also risen to above-average levels.

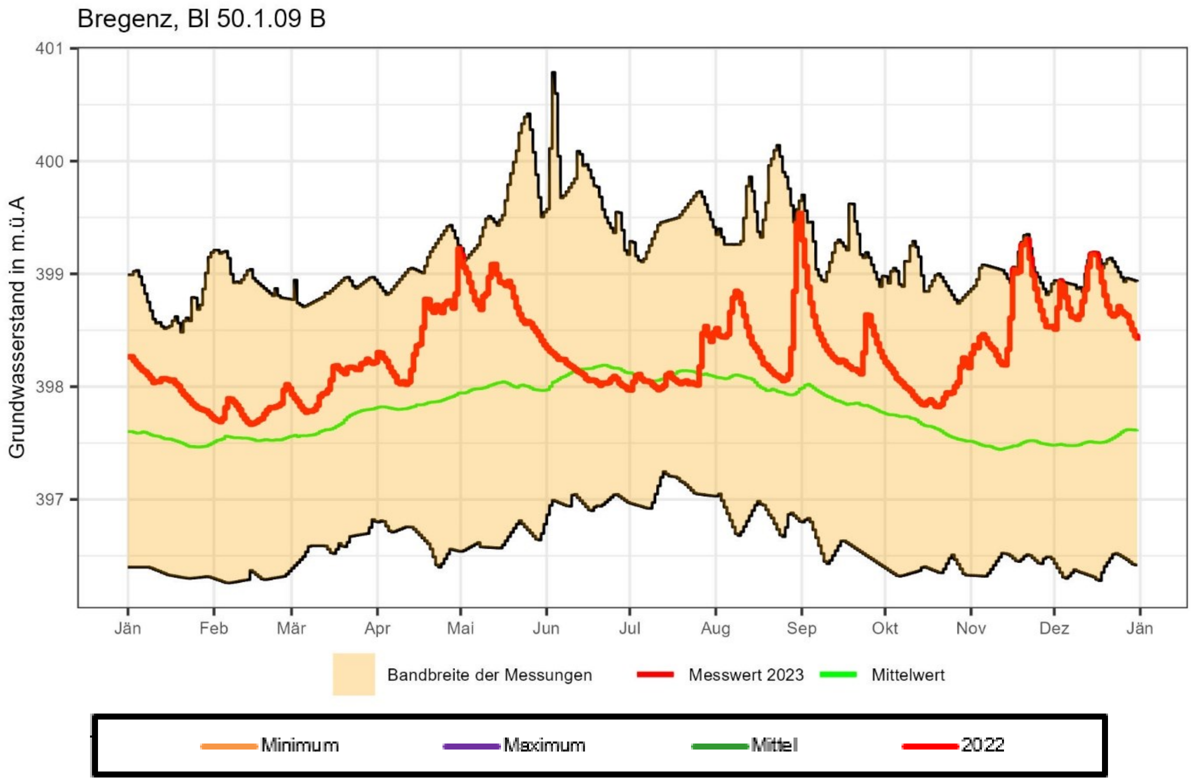

Figure 19: Hydrographs of the groundwater level in 2023 compared with long-term minima, maxima and mean values (1964 – 2021) Bregenz measuring point, folio 50.1.09 B

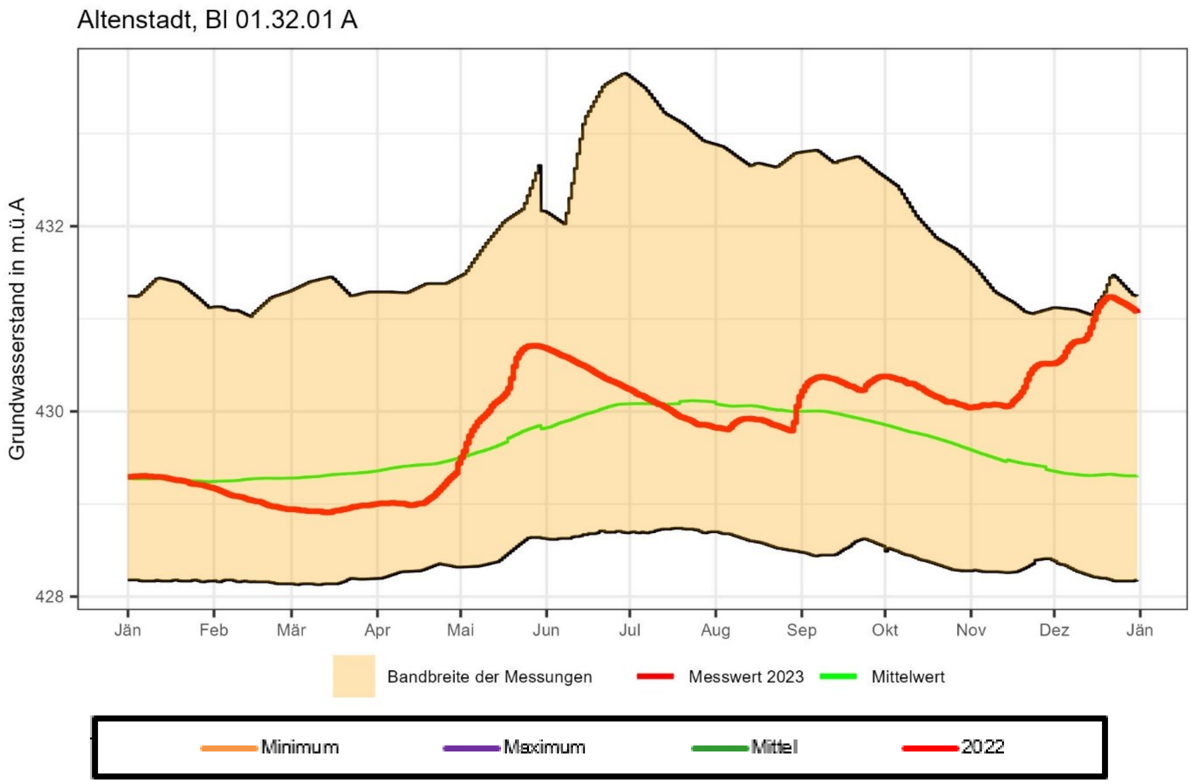

Figure 20: Hydrographs of the groundwater level in 2023 compared to long-term minima, maxima and mean values (1962 – 2021) Feldkirch-Altenstadt measuring point, folio 01.32.01 A

1.3.4.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

According to the multi-year weather pattern (temperature and precipitation), longer periods with rather low or rather high quantitative states of groundwater conditions can often be seen in the groundwater of Switzerland. In this respect, 2023 is in a period with high groundwater levels and spring discharge compared to many years ago. However, the extensive rainfall at the end of the year has meant that the proportion of measuring points with high groundwater levels and spring discharge was comparatively high.

In January 2023, groundwater showed a usual picture for the season. Groundwater levels and spring discharge were in the normal range expected for the season. In near-surface and small groundwater reserves, they were slightly lower in some places – as a result of several consecutive dry weeks of the previous year. With the snowless winter and low precipitation in January and February 2023, the number of groundwater measuring points with low values rose steadily. Thus, in March, low groundwater levels were recorded at around every third measuring point.

The months of March and April were precipitous in many areas on the northern side of the Alps and had a below-average duration of sunshine. On the southern side of the Alps, however, it was persistently dry. While in May normal groundwater levels and spring beds were observed on the northern side of the Alps, they were low on the southern side of the Alps.

From June to August, low groundwater levels and spring discharge were present at around every third measuring point.

The large amounts of precipitation in the last few days of August led to a rapid increase in the levels of rivers and lakes, especially in southern and eastern Switzerland, as well as flooding in some places. Along the rivers, a rapid rise in groundwater levels was also observed there. In western Switzerland and the Jura, on the other hand, low amounts of precipitation fell, so that normal groundwater levels were recorded here with a stagnating to declining trend.

From October to December, large amounts of rainfall were widespread. In November and December, for example, high groundwater levels and spring discharge were present at more than every second measuring point.

1.3.5 Suspended Solids

1.3.5.1 Austria

Source: Department of Water Management, Office of the Vorarlberg State Government, Bregenz

The annual load of suspended solids on the Alpine Rhine at the Lustenau measuring point in 2023 was around 2.50 million tonnes on average for the 2010-2020 year series (around 2.3 million tonnes). The highest monthly load was determined for August at approx. 1.3 million tonnes. This corresponds to approximately 52% of the total annual load.

The largest day load was for 24 May with a load of 534,000 tonnes (approx. 21% of the annual load) (see Figure 21).

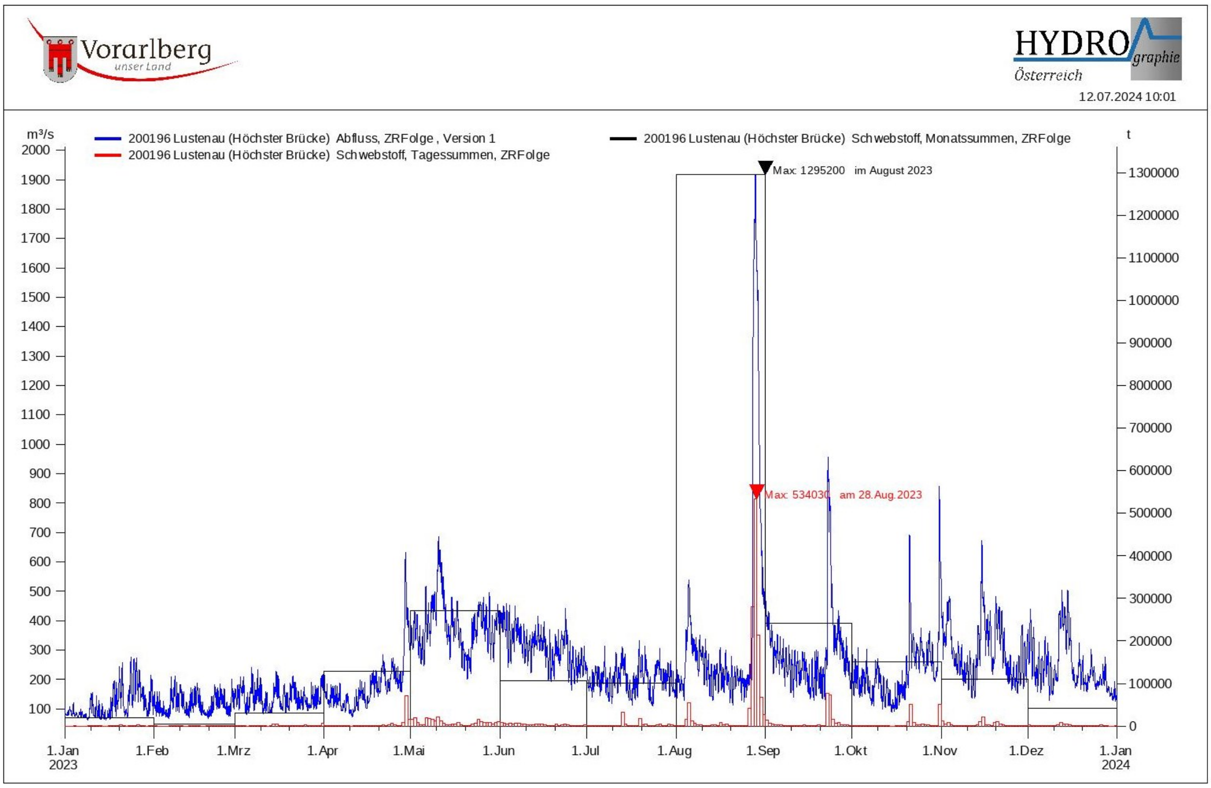

Figure 21: Monthly suspended solids loads of the Alpine Rhine at the Lustenau gauge in 2023 with day loads (red curve) and discharge hydrograph (blue curve).

2. Activities of the International Commission for the Hydrology of the Rhine Basin (CHR) in 2023

CHR meetings
Two official CHR plenary meetings took place in 2023. The spring meeting (No. 91) was held on 30 and 31 March in Biel, Switzerland. The autumn meeting (No. 92) took place on 16 and 17 November in Luxembourg City.

Personnel changes within the CHR
In 2023, Mr Eric Gaume (CHR member since 2015 from the Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux – IFSTTAR in Nantes) stepped down from the CHR as French representative. No other personnel changes took place in 2023.

Ongoing activities in CHR projects

Climate change: ASG2 completed, on to the next Rheinblick study
Following the completion and publication of the ASG2 project in 2022, the CHR made preparations for a new future climate project in 2023. In the spring of 2023, a small brainstorming workshop was held in Arnhem, where a few CHR representatives drew up a position paper providing an overview of future tasks relating to climate change in the Rhine river basin.
This paper was further developed into a project plan during a writing session in Koblenz in the summer of 2023 with several CHR members. The project, called Rheinblick2027, is the successor to the CHR Rheinblick2050 study from 2010-2011. The project plan was officially approved at the autumn meeting, after which preparations were made for a call for applications for a project coordinator in 2024. The project is scheduled to start in 2024 and run until 2027. The project is similar to the previous Rheinblick, namely focusing on future discharges taking into account actual datasets, multiple available hydrological models and the latest climate scenarios. In addition, attention will be paid to a number of additional themes such as stress test scenarios, flash floods, groundwater, extreme events, sea level rise and the Meuse (with regard to the delta area).

Socio-economic Scenario's (SES) and influences on the low-water regime of the Rhine
The CHR SES project works closely with the Stars4Water project, which has been running since 2022. The Stars4Water project provides support for a number of components of the SES project. More information about Stars4Water can be found below.
Prior to the spring meeting in Biel, a successful SES/Stars4Water workshop took place. Various stakeholders, such as the CCNR and ICBR, actively contributed to the workshop. An inventory was made of the wishes of the three Rhine commissions with regard to the socio-economic scenarios.
Furthermore, in 2023, the first model runs with RIBASIM were carried out using various datasets about water users in the river basin provided by member states.
Finally, as part of the SES project, a report was published with an inventory of impacts of cooling water consumption by power plants within the Rhine Basin; the publication can be found here.

Sediment
With the completion of the state-of-the-art Sediment Report (containing an inventory of sediment-related knowledge, activities, research and monitoring at river basin level) in 2022, a solid foundation has been laid for further action. After all, we hope to create an up-to-date knowledge

base about sediment(balance) which is essential to establish a sediment management plan which is mentioned in the work programme 2040 of the ICPR. In 2023, the CHR further elaborated three possible follow-up themes in fact sheets, namely:

1. Influence of climate change and land use change on the sediment regime.
2. Alteration and improvement of sediment balance and continuity, sediment transport, and morphology in the context of the spatial and temporal development of river engineering and management in the Rhine River and major tributaries.
3. Harmonisation of monitoring strategies and consideration of new monitoring techniques and optimisation of sediment budgeting.

In 2024, these three themes must be further developed and integrated into more concrete activities (project).

Hydrological Memory of the Rhine

In the autumn meeting 2018, the CHR expressed its interest in a project in which historical data are collected and made available. To this end, a cooperation contract was signed in spring 2022 between the BfG and the University of Bonn (Prof. Herget). Within this contract, progress was made in 2022 and 2023 on data studies on the Rhine and Main, as well as a literature study on historical low-water events. In addition, research has taken place on documentation and measurements of some flood events using historical flood stones.

In November 2023, the CHR organised a successful workshop in Bonn in collaboration with the University of Bonn and the BfG entitled "Historical flood and droughts of the Rhine and its tributaries: Inventory and application". During this workshop, several experts from universities, governments and knowledge institutes discussed historical high and low water marks and events of the pre-instrumental period. More information can be found here.

CHR Information System

In 2022 a first version of a prototype of the CHR information system was developed by the German company Terristris. The prototype includes a first set of (historical) map material including a set of time series of a number of measurement sites along the Rhine. In 2023, the CHR further coordinated internally on how to take the next step toward a public-friendly version. The steering committee met several times for this purpose. No further development of the information system took place in 2023. This is planned for 2024.

Stars4Water

The 4-year Stars4Water project was launched at the end of 2022. Funded by the European Horizon Framework Programme, this collaborative project aims to increase understanding of the impacts of climate change on water availability and vulnerability to ecosystems, society and the economy at river basin scale. Within the project, a consortium led by Deltares is working together within 7 different river basins in Europe to develop, among other things, models, information systems and data sets. Several CHR organisations are active in the consortium. The project may also provide an opportunity to support certain CHR projects such as the SES project where work can be done to improve the RIBASIM model or work out social economic scenarios. Since 2022, the CHR has as well designated a member to participate in the advisory board of the Stars4Water project.

Strategic Orientation of the CHR

Also in 2023, CHR operates in line with its strategy set for the period 2020-2030.

Public Relations
In August 2023, the CHR participated in the Vienna Water Conference 2023 and presented several of its projects. The secretariat also attended a meeting of the Danube Commission and explained how the CHR is organised.

Publications of the CHR
The CHR has published the Hydrological Annual Report 2022 for the Rhine region in two languages.