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

Annual CHR Report 2021

Editor: **Roel Burgers – Rijkswaterstaat, VWM, Lelystad**

Photo front page: Situation after the 2021 flood on 19 July on the Ahr (near Müsch), a tributary of the Rhine
Photo by: Struktur- und Genehmigungsdirektion Nord in Rheinland-Pfalz (Geramny)

Text contributions:

Federal Office for Environment, Department of Hydrology, Bern MeteoSchweiz, Zurich
WSL — Institute for Snow and Avalanche Research, Birmensdorf and Davos
Institute of Geography, University of Fribourg
Research Institute for Hydraulic Engineering, Hydrology and Glaciology (VAW), Swiss Federal Institute of Technology Zurich (ETH), Zurich
Federal Institute for Water Science, Koblenz
German Weather Service, Offenbach
Office of the Vorarlberg State Government, Bregenz
Central Institute for Meteorology and Geo-Dynamics, Vienna
Rijkswaterstaat, Transport and Water Management, Lelystad
Royal Dutch Meteorological Institute, De Bilt

Secretariat of the CHR
PO Box 2232
3500 GE Utrecht
The Netherlands
Email: info@chr-khr.org
Website: www.chr-khr.org

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 International Hydrological Programme (IHP) of UNESCO and the Hydrology and Water Management Programme (HWRP) of the World Meteorological Organization (WMO). It is a permanent, independent, international commission and has the status of a foundation, registered in the Netherlands. Members of the commission include following scientific and operational hydrological institutions of the Rhine basin:

- Federal Ministry of Agriculture, Regions and Tourism, Section I — Water Management — Division I/3 Water Management (HZB), Vienna, Austria,
- Office of the Vorarlberg State Government, Department VIID — Water Management, Bregenz, Austria,
- Federal Office for the Environment, Bern, Switzerland,
- INRAE, Antony, France
- Université Gustave Eiffel, Nantes, France
- Federal Institute for Water Science, Koblenz, Germany,
- Hessian State Office for Nature Conservation, Environment and Geology, Department W3 "Hydrology, Flood Protection", Wiesbaden, Germany,
- International Centre for Water Resources and Global Change, Federal Institute of Hydrology, Koblenz, Germany
- Water Management Specialist Administration, Luxembourg,
- Deltares (an independent institute for applied research), Delft, Netherlands,
- Rijkswaterstaat — Transport and Water Management, Lelystad, Netherlands.

Table of Contents

1. Hydrological Overview for the Rhine Catchment Area

1.1 Meteorological Characteristics

1.1.1 Austria

Source: Central Institute for Meteorology and Geodynamics (ZAMG)

After a series of very warm years, 2021 turned out to be a year that has not been quite so warm. Compared to the climatological average of 1961-1990, which was not yet so strongly affected by global warming, 2021 was still too hot by 1.1 °C. However, on average over the past 30 years (1991-2020), 2021 was 0.1°C colder, making it the coldest year since 2010, which was 0.5°C warmer compared to the 1961-1990 average. Compared to the 1991-2020 average, 2010 was 0.8°C colder. Despite being the coldest year since 2010, 2021 holds 21st place among the warmest years in Austria (first complete annual values from 1768). Among the top 25 of warmest years, 18 of these have occurred since the 2000s.

The spatial distribution of the air temperature deviation, which in this review refers to the normal climate period 1991-2020, was relatively uniform across the federal territory. From North Tyrol to Burgenland, temperature anomalies usually range between -0.3 and +0.3 °C. Parts of Vorarlberg, the higher parts of the Tyrolean Oberland as well as East Tyrol and Upper Carinthia were the relatively coldest regions of the country. Here, the year 2021 was colder by 0.3 to 0.7 °C compared to the climatological average.

The months of April, May and August accounted for a large share of the relatively cool overall result for 2021. April was the coldest since 1997 with an anomaly of -2.3°C, while May counts as one of the three coldest in the last 30 years with a temperature deviation of -2.2°C. A similarly cold August (dev. -1.3 °C) was last seen in 2014 (dev. -1.8 °C). It was very hot in February (dev. +1.3 °C) and September (+1.2 °C). The month with the highest positive anomaly was June 2021. With a plus of 2.4 °C, this was the third warmest in measurement history. The other months show temperature deviations from -0.7 to +0.6 °C.

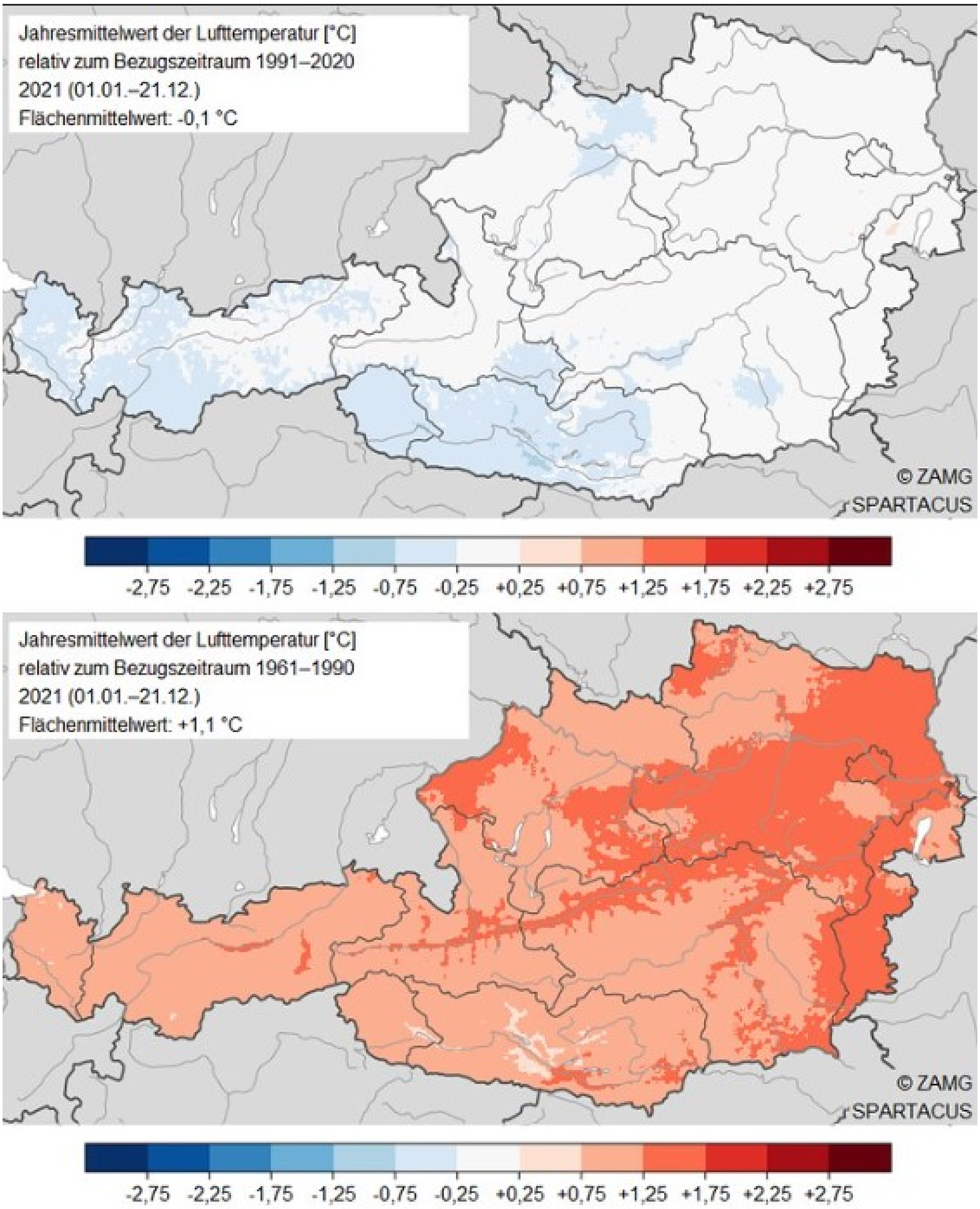


Figure 1: Temperature in Austria in 2021. Picture below compared to average 1961-1990, picture above compared to average 1991-2020. Source ZAMG

The year 2021 was repeatedly interspersed with long dry periods, which showed up in the most diverse months and regions. After a January that brought 46 percent more precipitation throughout Austria, three very dry months followed from February to April (dev. -39 to -45%). Then in May, there was increased precipitation than on average with plus 18 percent. In the very hot month of June, precipitation dropped by 44 percent. This deficit made June 2021 the twelfth driest June of the past 164 years. These dry conditions ended (except for the southeast of Austria) in July. During the two midsummer months of July and August, precipitation increased by 33 percent and 19 percent respectively. September and October, however, continued with very little rainfall and together with November, with a deviation of -34% this contributed to the driest autumn since 2006. In December, precipitation levels largely corresponded to climatological averages.

In summary, total precipitation over space and time combined in Austria in 2021 was 7 percent less and is therefore as low as the year 2018, which also showed 7 percent less precipitation. The last year dryer than 2021 was 2015, which had a shortage of 16 percent.

However, rainfall in the whole of Austria was not less than in an average year. In Vorarlberg, Tyrol, Pinzgau and Pongau, as well as in the Alpine foothills of Upper and Lower Austria, the anomalies were predominantly between -5 and +5 percent. In the Rhine Valley, it was even particularly precipitous with an increase of 10 to 20 percent. Between 75 and 95 percent of the long-term average fell in eastern Salzburg, southern Upper Austria, southern and eastern Lower Austria, Vienna, Burgenland, Styria and Carinthia. The largest shortages (-25 to -40 percent) were limited to a relatively narrow strip, starting from the Schöckl along the Mur and Mürz to the Hohe Wand.

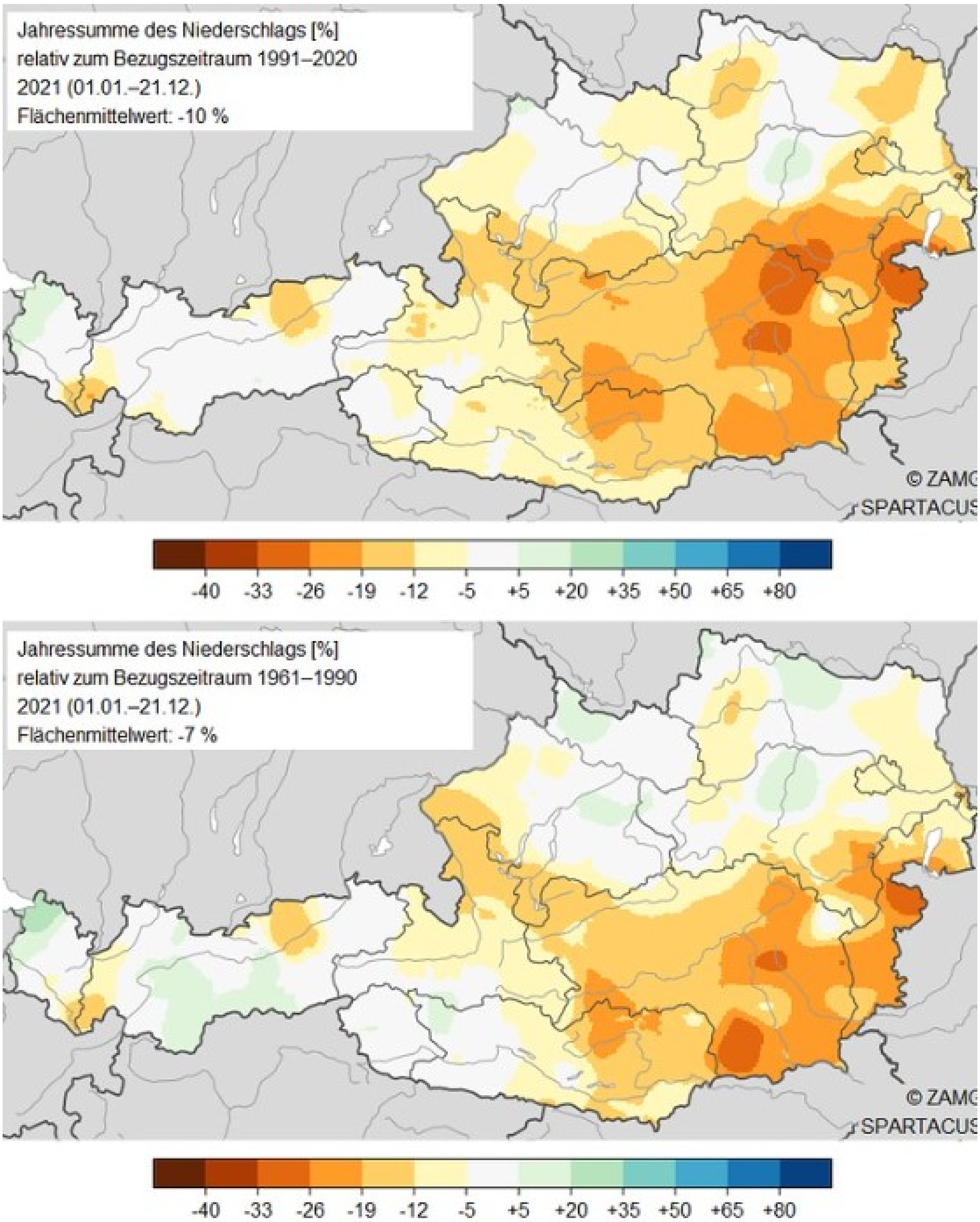


Figure 2: Precipitation in Austria in 2021: Deviation of precipitation from average. Picture below compared to the average 1961-1990, picture above compared to the average 1991-2020. Source ZAMG

The yield of direct sunshine in Austria hardly differed from the past three years. In 2021, compared to the 1991-2020 average, the sun shone four percent longer in the federal territory, as it did in 2019 and 2020. In 2018, the increase was 6 percent. Significantly sunny months in 2021 were February and June, with a sunshine anomaly of +36 and +34 percent, respectively, as well as September and October, both of which brought 24 percent more hours of sunshine. Significantly more gloomy conditions compared to the climatological average were observed in January (dev. -27%) and in May, August and December, where the sun was seen 25 percent less.

1.1.2 Meteorological Characteristics for the Austrian Rhine Region.

Source: Hydrographic Service Vorarlberg

In 2021, the annual rainfall in the Austrian part of the Rhine catchment area amounted to 107% of the long-term average. Monthly totals of precipitation in January, May, July, August and December were above the average for that month. The months of February and November recorded average rainfall, while the remaining months had significantly below-average rainfall (Figure 3). The droughts in spring and autumn were clearly prominent.

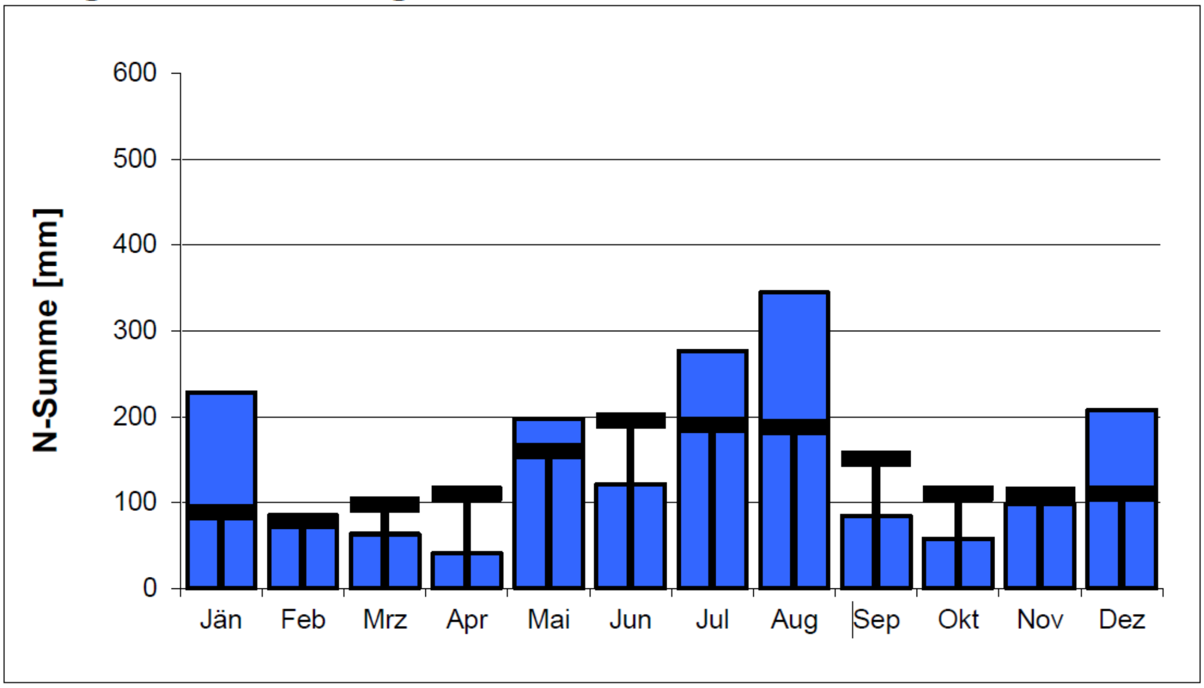


Figure 3: Monthly precipitation totals in 2021 (blue columns) compared to long-term monthly averages (1981 – 2010) at the Bregenz Altreuteweg measuring point.

In the Austrian Rhine catchment area, annual average air temperature was 0.2 °C below the long-term average of 1991-2020.

1.1.3 Switzerland

Source: Federal Office of Meteorology and Climatology (MeteoSwiss)

The months of December and January, with high precipitation and snow in some areas, resulted in widespread above-average winter precipitation. Locally, the winter of 2020/21 was one of the wettest since meteorological measurements began. February was mild, precipitation levels remained below average. Only the south received above-average quantities. In the mild air, however, precipitation often fell at greater heights than rain.

Switzerland experienced the coldest spring in over 30 years. After the two low precipitation months of March and April, most areas of Switzerland, with the exception of the southern side of the Alps, received a lot of precipitation in May. Locally, May totals rose to 250% of the standard. This was the beginning of a three-month period with unusually high precipitation levels.

North of the Alps, the summer of 2021 was one of the wettest in the long-standing records, with locally over 160% of the 1981–2010 standard. On the southern side of the Alps, summer rainfall totals reached high levels, especially in north-western Ticino. In the remaining areas of the southern side of the Alps, precipitation remained rather moderate at 100 to 140% of the standard. On the northern side of the Alps, after a lot of rain in May, summer brought the rainiest June and July since the beginning of the measurements. In addition, July was the wettest month ever since the beginning of the measurements at several measuring locations with long-term records. North of the Alps, several devastating hailstorms swept over Switzerland, especially in June. Stone sizes reached 6 to 7 cm or more regionally, which is very rare. On the southern side of the Alps, the hail caused great damage to agriculture, especially in July.

Autumn in Switzerland showed an increased lack of precipitation from September to November. Rarely since the beginning of the measurement in 1864 did so little precipitation fall north of the Alps in autumn. At the beginning of November, the Eastern Alps received plenty of snow with 4 days of fresh snow totals of 50 to 60 cm. At the end of November it snowed on both sides of the Alps and into the lowlands. Snowfall to low altitudes continued in the first days of December. At the end of the first third of December, there was an average or above-average amount of snow in many mountain areas. The snow level in the Jura was clearly above average.

Towards the end of the year, an increased volume of heavy rain fell to great heights. In mild conditions, snowfall limit was around 2500 m. At the end of the year, the daily maximum temperature rose to almost 16 °C in the north and almost 19 °C in the south.

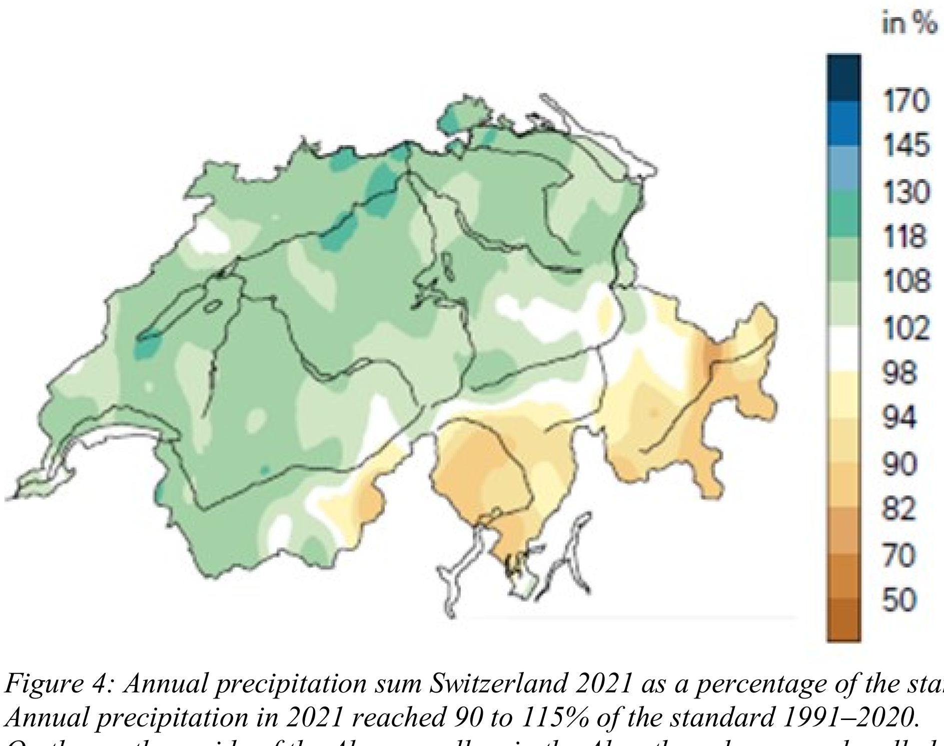


Figure 4: Annual precipitation sum Switzerland 2021 as a percentage of the standard (1981-2010). Annual precipitation in 2021 reached 90 to 115% of the standard 1991–2020.
On the southern side of the Alps as well as in the Alps, the values were locally between 80 and 90% of the standard.

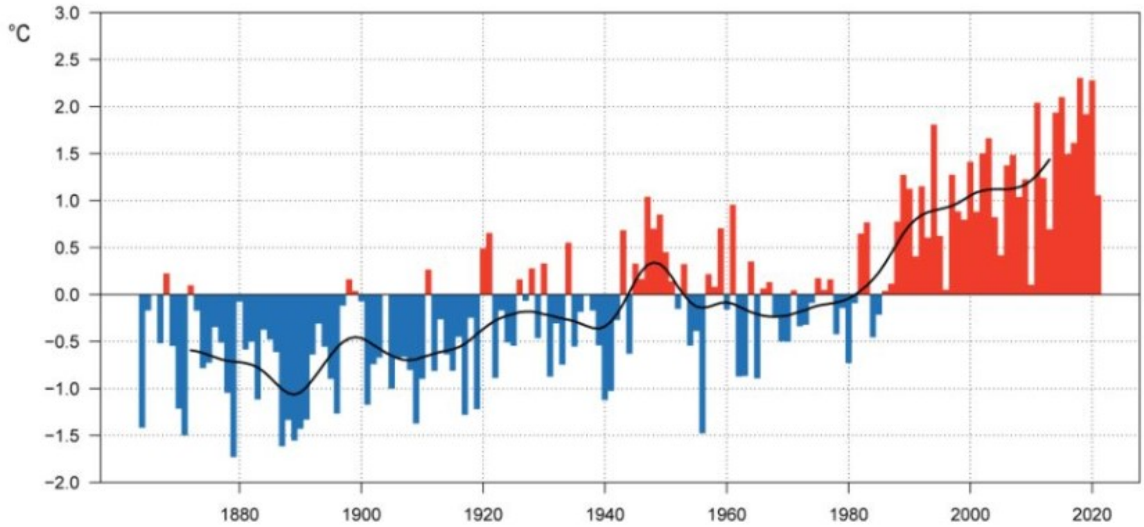


Figure 5: Long-term trend of the annual temperature averaged across the whole of Switzerland. Annual deviation of the temperature in °C from the standard 1961–1990 is shown (red = positive deviations, blue = negative deviations). The black curve shows the 20-year, weighted average. Image: MeteoSwiss.

Table 1: 2021 annual values at selected MeteoSwiss measuring stations compared to the 1991-2020 standard

Station	Height m a.s.l.	Temperature (°C)			Sunshine duration (h)			Precipitation (mm)		
		Average	Standard	Dev.	Total	Standard	%	Total	Standard	%
Bern	553	9.2	9.3	-0.1	1862	1797	104	1137	1022	111
Zurich	556	9.6	9.8	-0.2	1734	1694	102	1127	1108	102
Geneva	420	10.9	11.0	-0.1	1950	1887	103	867	946	92
Basel	316	10.6	10.9	-0.3	1671	1687	99	922	842	110
Engelberg	1036	6.6	6.8	-0.2	1362	1380	99	1679	1568	107
Sion	482	10.3	10.7	-0.4	2181	2158	101	696	583	119
Lugano	273	13.1	13.0	0.1	2297	2120	108	1444	1567	92
Samedan	1709	1.7	2.3	-0.6	1835	1767	104	647	710	91

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 series of the three low precipitation and warm years 2018 to 2020 was not continued in the hydrological year 2021 (i.e. from November 2020 to October 2021) in the two catchment areas of the Rhine area considered here (level Basel to level Mainz, 72,000 km² and level Mainz to level Lobith, 68,500 km²). For example, the annual total in both sub-basins was almost 100% (previous year: 90.6% and 94.7%) of the multi-year rainfall averages of the 1981-2010 time series. In the individual months, however, there was an extremely wide range of fluctuations. The wettest winter month was January in both subareas, where 60% more precipitation than the long-term average occurred in the sub-basin from Basel to Mainz and still 30% more precipitation in the area below (see Figure 6).

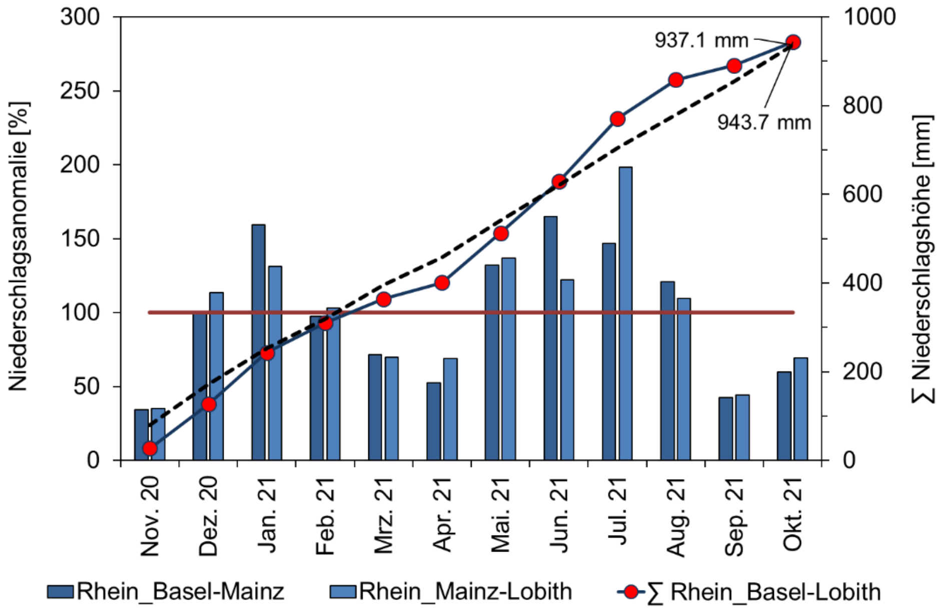


Figure 6: Monthly relative anomalies (blue bars) of the hydrological year 2021 precipitation levels in the Rhine area for the sub-basins of the Upper Rhine (Basel to Mainz including Mainz, 72,000 km²) and Middle and Lower Rhine (Mainz to Lobith, 68,500 km²) against the background of the multi-year averages of the reference series 1981 to 2010 (magenta horizontal). Plotted in black the summed monthly rainfall levels for the Rhine region from Basel to Lobith (∑) for the hydrological year 2021 (937 mm) in comparison with the cumulative line of the time series 1981 to 2010 (dashed line, 944 mm) (data source: DWD and weather services of the neighbouring countries, evaluation: Federal Institute for Hydrology)

The months of May, June and especially July continued to be extremely rainy. Thus, in the July precipitation sum in the partial catchment area from Mainz to Lobith, almost twice the mean value was observed. Of the numerous heavy precipitation events in late spring and summer 2021, the heavy precipitation event from 13 to 14 July, which occurred particularly intensively in many river areas of the smaller tributaries of the Rhine (Nette, Ahr, Erft, Sieg and Wupper) and the Moselle (Sauer/Prüm, Kyll) (see Figure 9), should be highlighted.
On the other hand, the months of November 2020, March and April as well as September and October 2021 were particularly low in precipitation. For example, in Nov. 2020 only 35% and in September 2021 only 43% of the mean value were reached.

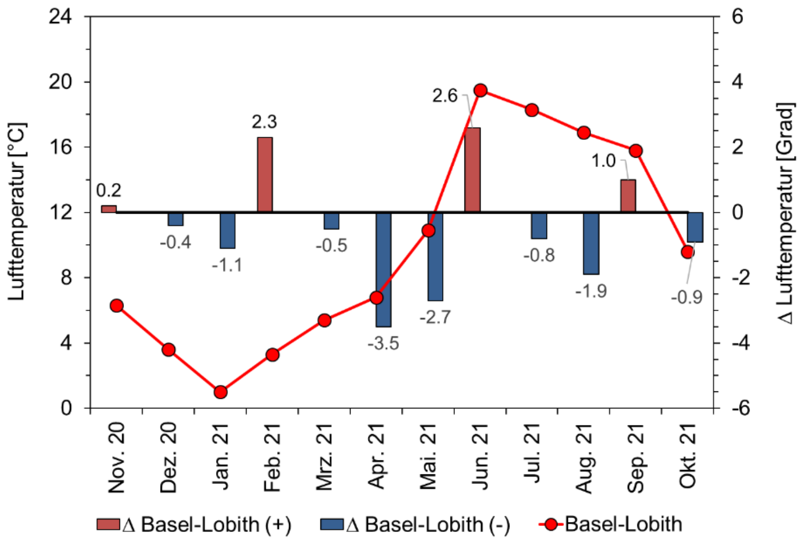


Figure 7: Monthly average and monthly anomalies of the air temperature for the partial catchment area of the Rhine from Basel to Lobith for the hydrological year 2021. The anomalies of the air temperature (Δ, right ordinate) refer to the time series 1981 to 2010 (data source: DWD and weather services of the neighbouring countries, evaluation: Federal Institute for Hydrology)

The average annual temperature in the partial catchment area from Basel to Lobith was 0.5 degrees below the long-term average of 1981-2020. The spring months of April and May as well as August were particularly cool. After the many warm months of previous years, only in February and June did above-average monthly anomalies of more than 2 degrees occur in this hydrological year.

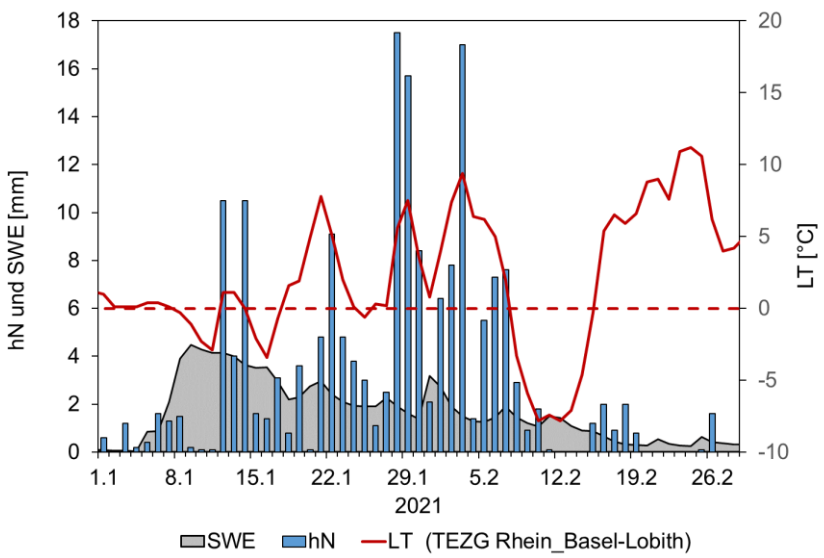


Figure 8: Daily values of precipitation (hN), snow water equivalent (SWE) and air temperature (LT) for the area average of the partial catchment area of the Rhine from Basel to Lobith for January and February 2021. The dashed red line represents the zero-degree line (data source: DWD and weather services of the neighbouring countries, evaluation: Federal Institute for Hydrology)

However, the monthly averages do not sufficiently reflect the two prominent flood events in the Rhine region, that of January/February and that of July. This shows the course of the area averages of the daily precipitation level, the snow water equivalent and the air temperature for the catchment area of the Rhine from Basel to Lobith for the months of January and February 2021 (see Figure 8). Warm and humid alternated with cool and humid weather sections and a dry, extremely cold cold wave (7 February to 15 February). For example, a snow cover was also able to build up in the low mountain ranges during January, which, together with the onset of the snow melt and comparatively high precipitation in the warmer weather sections, ensured a high drainage in the days around the January/February turn of the month.

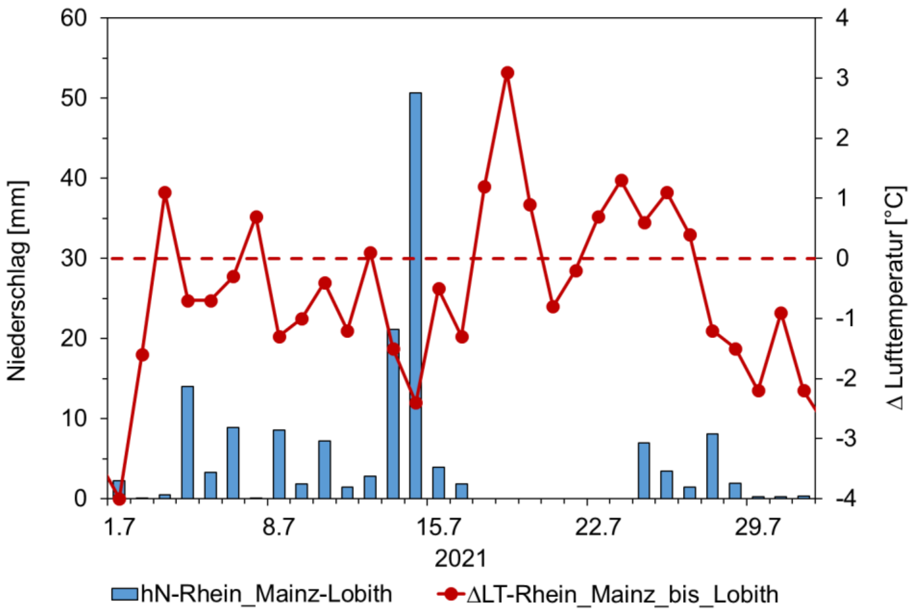


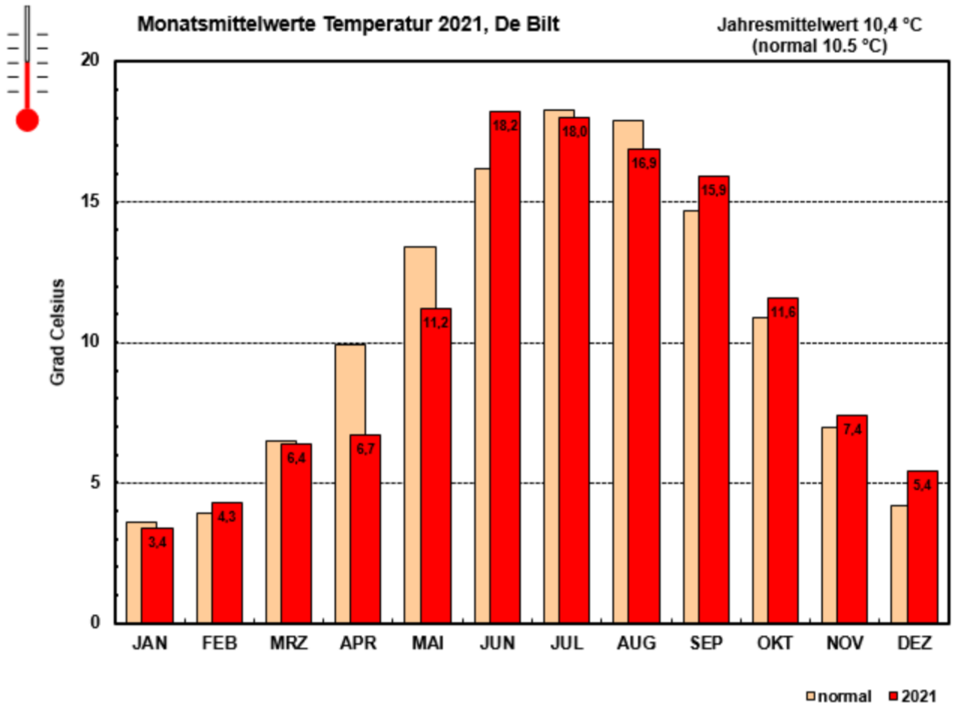
Figure 9: Daily values of precipitation (hN) and air temperature anomaly (ΔLT) for the area average of the partial catchment area of the Rhine from Mainz to Lobith for July 2021. The dashed red line represents the reference line of the temperature anomaly, here the average for 1981-2010 (data source: DWD and weather services of the neighbouring countries, evaluation: Federal Institute for Hydrology)

Figure 9 shows the area averages of the daily precipitation altitude and the daily anomalies of the air temperature (average 1981-2010) for the partial catchment area of the Rhine from Mainz to Lobith. In addition to the exceptionally rainy 14 July, the high daily precipitation of the previous day as well as the multi-day, overall moist and often cool previous period can be seen.

1.1.5 Netherlands

Source: Royal Netherlands Meteorological Institute (KNMI)

After three very warm years, 2021 was a normal year in terms of temperatures. The average temperature was 10.4 °C compared to a 10.5 °C normal. Outliers were the very cold spring and the warmest June month since 1901. After a cool August, the last four months of the year were (significantly) warmer than normal (Figure 10).



Graph 10: Monthly temperature averages at the station De Bilt 2021 compared to the long-term (1991-2020) average (source: KNMI)

In 2021, there were more hours of sunshine than normal, with a national average of 1,800 hours of sunshine compared to 1,774 hours of normal. February and June were sunny. January and August were dark months. The least amount of sunshine was in the east with 1673 hours of sunshine in Deelen. It was sunniest in coastal regions: in Vlissingen the sun shone for 1947 hours.

With a national average of 806 millimetres, almost the normal precipitation volume fell in 2021. The normal national average was 795 millimetres. In the middle of the country and in the province of Flevoland, it was much drier locally than normal. The driest KNMI station was Woensdrecht with 662 millimetres. In the south of Limburg and in the northwest it was wetter than normal. The wettest KNMI station was Leeuwarden with 939 mm. February, November and especially September were dry months. June was wet with corresponding heavy thunderstorms. In July, the extreme rainfall in southern Limburg was particularly noticeable around the middle of the month. In Friesland, it rained a lot in the end of August.

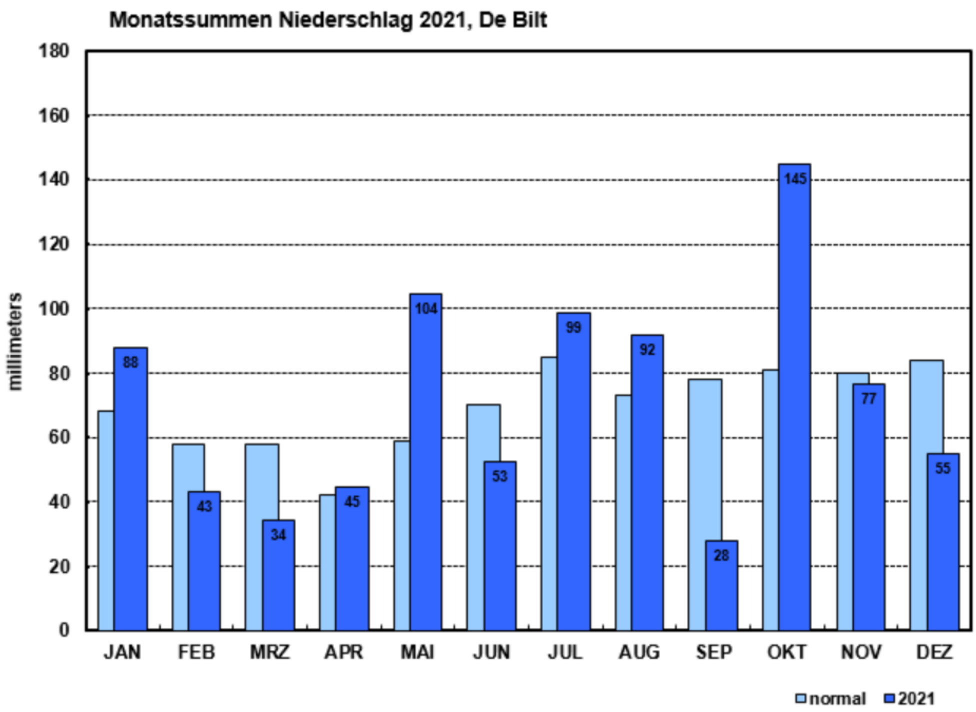


Figure 11: Monthly totals of precipitation at station De Bilt 2021 compared to the long-term (1991-2020) average (source: KNMI)

1.2 Snow and Glaciers

1.2.1 Snow

Source: WSL Institute for Snow and Avalanche Research SLF

In late October 2020, heavy snowfall led to an early arrival of winter. The snow lasted in the high mountains. Snow levels were sometimes very high for the season, although they did not constitute a new record. In the eastern Alps, snowfall in October occurs only every 10 to 40 years. After a warm November, snow fell into the lowlands several times on both sides of the Alps between December and February. This was due less to the volume of precipitation than to the combination of precipitation and sufficiently low temperatures. The temperature from November to April has been on average for the last 30 years. The amount of precipitation during the winter months was above average on both sides of the Alps, but lower than normal in March and April.

January presented itself above all on the eastern northern slope of the Alps, in parts of Graubünden and in the Obergoms as very rich in fresh snow. At 32 of around 120 long-standing stations of the WSL Institute for Snow and Avalanche Research SLF, fresh snow volumes of January 2021 are among the three highest new snow totals ever measured. In parts of the eastern half of Switzerland, it was the snowiest January in the last 50 years.

February was above average in the Upper Engadine. At some stations in this region, the 30-day fresh snow sum (13 January to 10 February 2021) was only exceeded by the avalanche winter of 1951. Except in the deepest areas and on the southern side of the Alps, the new snow totals in March were spread above average. Conversely, there was little fresh snow in April. Only a single event brought about ten centimetres of fresh snow in the eastern middle country and thus in these regions amounts of snow above the average.

Looking at the entire winter half-year of November 2020 and April 2021, new snow totals below 2000 m, with the exception of the western middle country, were strongly above average. Due to Foehn wind events, western warm-air advances and corresponding rainfall up to high altitudes, the average snow depths between November and April in the western half of Switzerland were below average in areas below 1000 m. In contrast, the average snow depths in the whole of Graubünden were above average at all stations and in the range of normal values in the entire Alpine region above 2000 m. In areas above 2000 m, the average snow depth for the period November to April was mostly in the range of normal values throughout Switzerland. The coldest spring in 30 years ensured that the snow at these altitudes lasted in the following months.

At the beginning of June, the snow depths at many measuring stations were still strongly above average. The second half of June was very warm and so at most stations above 2000 m snowmelt finally took place only one to two weeks later than normal.

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 decline of Swiss glaciers over the past three decades has been immense – one extreme year after the other. Weather-wise, in 2021 conditions were right to give the glaciers a breather. Unfortunately, in times of climate change, even a “good” year is not good enough for the glaciers: the loss of ice continued despite plenty of snow in winter and a comparatively cool and changeable summer, albeit less quickly. At the end of April, there were only slightly above-average amounts of snow on most glaciers. However, May brought a lot of extra snow in the high mountains. On the Claridenfirn (GL) at an altitude of 2890, a snow depth of almost seven meters was then measured – the highest value since observations began in 1914. The glaciers were therefore relatively well protected by the winter snow until rainy July. Nevertheless, the melt was considerable by the end of September and around 400 million tons of ice were lost throughout Switzerland during the hydrological year 2020/21, almost one percent of the remaining glacier volume.

For all 22 glaciers surveyed in 2021, the Swiss glacier monitoring network GLAMOS documents the loss of ice. Although the losses are smaller than in recent years, none of the glaciers have been found to be regaining volume. Especially in the northern Valais (Rhone Glacier, Great Aletsch Glacier), the decrease in the average ice thickness of just under 0.2 meters is moderate. In southern Valais, Ticino and north-eastern Switzerland (e.g. the Findel Glacier or Silvretta Glacier), on the other hand, the losses are hardly lower than the average of the last ten years. While on large glaciers above about 3200 m in the autumn of 2021, considerable snow reserves – i.e. "food" for the glacier – were measured, low-lying glaciers had partially completely eroded again. These are considered doomed. Even though the glaciers show the lowest ice loss since 2013 in 2021, there is no relief in sight for glacier decline.

1.3 Hydrological Situation in the Rhine catchment 2021

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

1.3.1.1 Austria

Source: Hydrographic Service Vorarlberg

From the beginning of the year to 16 April, water level of Lake Constance was above the long-term average of the series 1864 – 2020 for the respective calendar day. After that, the below-average precipitation of the months of February to April had an effect in below-average water levels or values in the range of the average until the first decade of July. The rainy months of July and August lead to above-average water levels until 25 September. The annual peak was measured on 19 July at 488 cm. From the end of September to 7 December, a period with below-average water levels followed. Heavy precipitation in December resulted in above-average water levels by the end of the year (see Figure 12).
The annual average of the water level in Bregenz was 362 cm by 17 cm above the long-term annual average (345 cm).

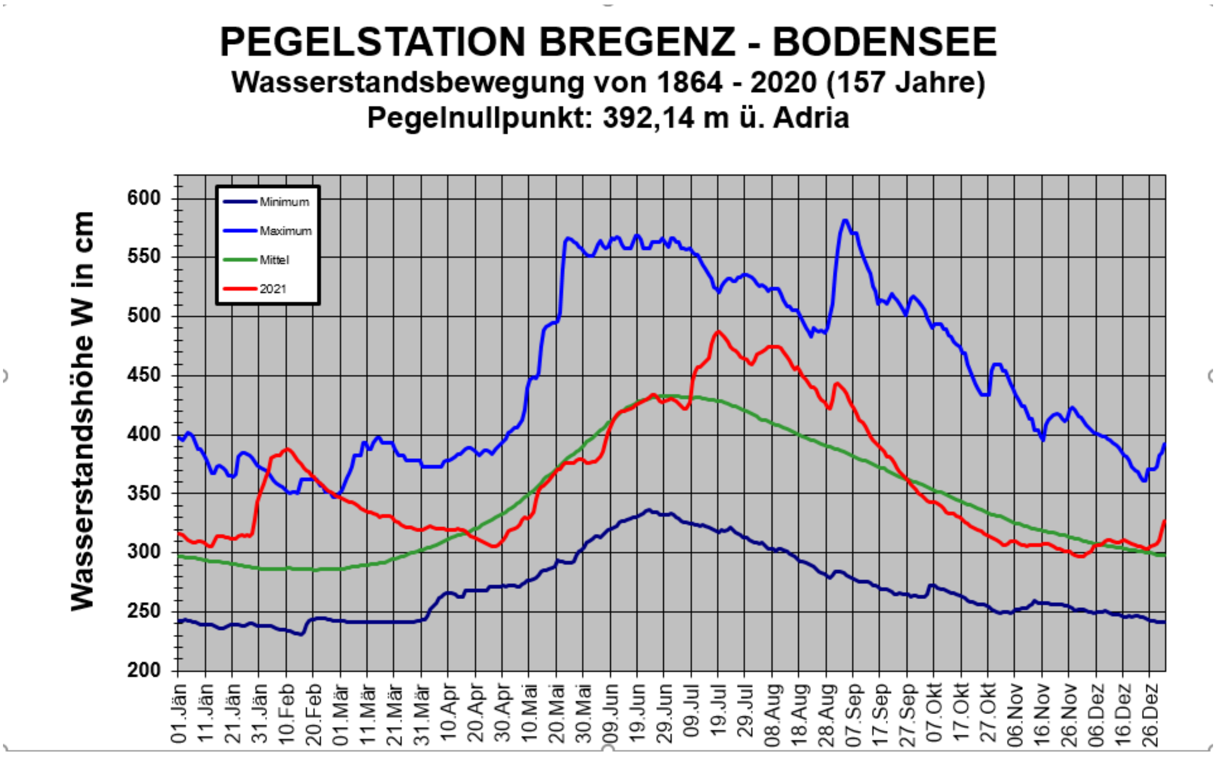


Figure 12: Hydrograph of the water level of Lake Constance at the Bregenz level in 2020 (red curve) compared to long-term minima, maxima and mean values

1.3.1.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

In half a dozen of Switzerland's large lakes, the annual mean water level is five or more centimetres above the long-term average. The largest positive deviation from the norm is recorded in Lake Constance with 26 cm in the upper lake and 10 cm in the lower lake. Lakes with above-average water levels also include the three Jura Lakes and Lake Zug. Below-average averages of more than –4 cm are seen in Lake Maggiore and Lake Lugano, as well as in Lake Walensee. At Lake Geneva, Lake Thun and Lake Brienz, Lake Lucerne and Lake Zurich, annual averages were measured that are close to the norm.

When looking at the monthly and daily mean values, the following picture emerges on the northern side of the Alps: for the season, high sea levels were observed in February and July, and rapid increases in water levels were observed at the end of the year. In the other months, water levels behaved according to the regime. This course is shown very nicely by the hydrographs of Lake Constance and Lake Neuchâtel. However, there are differences in dynamics: at the regulated Lake Neuchâtel, the hydrographs show both a steep rise and a rapid decline during flood phases. The flood events are comparatively short. At the unregulated Lake Constance, declines are slower; the floods lasted accordingly longer. Because the events at Lake Constance lasted longer, not only are the February and July monthly averages far above the norm, but the values for March and August and September are also relatively high. Lake Geneva also has increased February and July monthly averages. In addition, above-average values occurred here in May and June.

The above-average winter precipitation and mild February were responsible for the widespread high water levels in February. Thanks to the low rainfall and cold months of March and April, the levels dropped quite quickly back to normal levels. The extremely wet months of June and July caused the sharp rise in water levels in the summer.

Lake level curves on the southern side of the Alps show quite a lot of dynamics, with values far below the normal range at the end of April as well as end of-the-year and short summer highs. The difference between the highest daily average (mid-July) and the lowest daily average (end of April) is 1.81 m at Lake Maggiore. However, danger level 2 was not reached even at the highest level. At Lago di Lugano, the dynamics were similar: however, the movements of the water level took place in a smaller area. The difference between the peak of early August and the low of mid-April was 1.06 m. Danger level 3 was reached at the beginning of August for two days.

Only comparing the deviations from the norm is not always useful. This is because the range in which the regime of a lake moves and the effects of increased levels can be quite different. The regime at Lake Neuchâtel, for example, moves over a longer period of time in a narrower area than at Lake Constance. This means that Lake Neuchâtel is more sensitive to deviations from the average. This "sensitivity" is reflected in the number of days the hazard levels were exceeded: the highs during the floods in July were around 1.4 meters above the average water level on both lakes. At Lake Neuchâtel, danger level 4 (second highest level, "great flood danger") was reached on eight days, Lake Constance did not go beyond danger level 3. Another example is the comparison of the two large Bernese Oberland lakes: The difference between the largest and smallest daily values of the year is almost half a metre greater in Lake Brienz than in Lake Thun. The level of Lake Thun was in the range of the highest danger level 5 for three days, that of Lake Brienz only four days in danger level 3. Apart from Lake Thun, only Lake Biel and Lake Lucerne have reached the highest danger level. In addition to Lake Neuchâtel, Lake Zurich was also in danger level 4 for several days.

1.3.2 Water Levels and Discharges

1.3.2.1 Austria

Source: Hydrographic Service Vorarlberg

The discharge of the Alpine Rhine in 2021 was 6% above the long-term average. The two largest tributaries from Austria, the Bregenzerach and the Dornbirnerach, also had an above-average annual load. The average annual discharge compared to the long-term average was:

- at Bregenzerach 107% (MQ 2021 = 49.6 m^3/s, long-term MQ = 46.5 m^3/s, years 1951-2020);
- at Dornbirnerach 116% (MQ 2021 = 8.17 m^3/s, long-term MQ = 7.04 m^3/s, years 1984-2020);
- at the Alpine Rhine 106% (MQ 2021 = 244 m^3/s, long-term MQ = 231 m^3/s, years 1951-2020).

1.3.2.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

In 2021, all large river areas on the northern side of the Alps have annual averages of the outflow that are above the long-term average of the 1981–2010 standard period. The deviations are 11% on the Reuss, 17% on the Thur and 18% on the Birs. It is not much less on the Doubs, the Aare and the Limmat; in these river areas the values are 7 to 9% above standard. On the Rhône, the Rhine and the Inn it is still 2 to 5%. With these above-average values, the outflows of the Aare, the Reuss and the Limmat in 2021 do not follow the declining trend of recent years. The areas on the south side of the Alps, on the other hand, show below-average outflow. The Ticino had 96% and the Maggia only 80% of the average outflow.

In large river basins, where local and regional peculiarities can largely compensate for each other due to the size of the area, the outflow events reflect the rainfall input relatively well. As expected, a more nuanced picture emerges in medium-sized areas, as other factors such as soil characteristics, exposure or altitude play an important role in addition to precipitation.

Many large and medium-sized catchment areas on the northern side of the Alps show significantly above-average discharges in February and July compared to the long-term average values of the 1981–2010 standard period. The drains in many places remained well below the norm in March and April as well as in the autumn months. Above-average winter precipitation and the mild February caused increased discharges at the beginning of the year. The months of March and April were low in precipitation and cold. The levels dropped quite quickly back to a normal or below-average level. The months of June and July were extremely wet. This led to sharp increases in levels in the summer. The months of September to November showed an increased lack of precipitation. North of the Alps, autumn was regionally one of the wettest since the beginning of the measurement in 1864.

Good examples of the outlined course from the group of large catchment areas are the river areas of the Aare, the Reuss and the Limmat. The monthly average in February at the Reuss near Mellingen was twice as high as the norm; the Aare near Brugg exceeded the long-term February average by almost 85%. In July, the Aare and the Limmat reached discharge levels that were more than twice as high as the long-term averages and the Reuss was almost 90% above normal. In the medium-sized areas, where, as mentioned above, certain local and regional effects are less balanced, the conditions described were even more accentuated in February and July. A few examples of monthly drains compared to the long-standing norm:

- Emme – Emmenmatt: February 243%, July 311%
- Thur – Andelfingen: February 210%, July 280%
- Muota – Ingenbohl: February 243%, July 192%

Even more extreme were the monthly values of the Doub at Ocourt in both positive and negative deviations: February 204%, July 433%, September 35%, October 23% and Nov. 26 %.

Deviations or variations from these general statements can occur in very large catchment areas or where the discharge regime is strongly nival or glacial. For example, at the Rhein – Diepoldsau measuring station in north-eastern Switzerland, with a catchment area of 6,300km^2: most of the drainage is formed much further south. In Diepoldsau, therefore, it is not the characteristic course of the discharge of northern Switzerland that is to be seen, but a mixed form. In a high-altitude catchment area, such as the Lütschine in the Bernese Oberland, the mild February also made itself felt and the relative deviation from the norm is quite large. However, the absolute level is low compared to the summer months and is therefore less noticeable.

In the Ticino near Bellinzona, the monthly values of June and July were significantly above the long-term average due to the high summer rainfall. Together with January, these were the only months with above-average discharges. In September, less than two-thirds of the normal discharge was recorded at the Bellinzona monitoring station. The Maggia – Locarno delivered extreme values of above- or below-average monthly values, in July with just under 300% and in September with only 25% of the norm.

In 2021, there were only a few new monthly minimums and no general picture can be drawn. New monthly maximums were measured at half a dozen stations each in January and June in the central middle country and in north-western Switzerland. The large concentration of new highs occurred in July: new July records were recorded at around 30 measuring points on the northern side of the Alps, spread over the entire middle country.

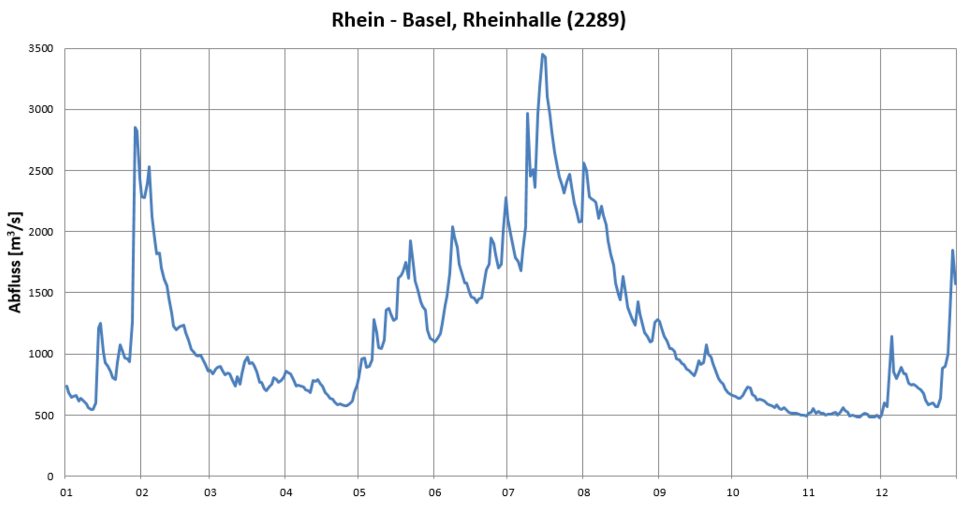


Figure 13: Discharge hydrograph at the Rhine - Basel, Rheinhalle level in 2021

1.3.2.3 Germany

Source: Federal Institute for Hydrology (BfG)

The drainage behaviour of the Rhine in the hydrological year 2021 reflected climatic conditions. On the whole, water supply of the Lower Rhine section was at the level of the long-term average, at the Upper and Middle Rhine it was even slightly above average. This was decisively attributable to the strong discharge in the summer half, whereas in the winter half, despite an discharge peak in the first third of February, overall discharge ratios were below average. Table 2 shows this in figures on the basis of the representative levels Maxau, Kaub and Duisburg-Ruhrort.

Table 2: Year-round and seasonal discharge averages for the hydrological year 2021 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 basis: WSV)

	MQ(1961/2020)	MQ(2021)		SoMQ(1961/2020)	SoMQ(2021)		WiMQ(1961/2020)	WiMQ(2021)	
	[m³/s]	[m³/s]	Verhältnis zum MQ(1961/2020 [%]	[m³/s]	[m³/s]	Verhältnis zum SoMQ(1961/2020 [%]	[m³/s]	[m³/s]	Verhältnis zum WiMQ(1961/2020 [%]
Maxau	1260	1370	109	1350	1600	119	1170	1140	97
Kaub	1690	1720	102	1640	1880	115	1740	1560	90
Duisburg-Ruhrort	2260	2270	100	1970	2300	117	2550	2240	88

As can be seen from Figures 14, 15 and 16 and Table 3, at the beginning and end of the hydrological year 2021 there were consistently smaller low-water periods along the stream, which can always be assigned to a recurrence interval of 1-2 years.

Table 3: Mean and extreme values of the discharge of the hydrological year 2021 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)

	MQ(1961/2020)	MQ(2021)	MNQ(1961/2020)	NQ(2021)		NM7Q(2021)		MHQ(1961/2020)	HQ(2021)	
	[m³/s]	[m³/s]	[m³/s]	[m³/s]	Datum	[m³/s]	Datum	[m³/s]	[m³/s]	Datum
Maxau	1260	1370	600	573	30.10.2021	674	29.11.2020	3240	4220	17.07.2021
Kaub	1690	1720	792	776	31.10.2021	849	28.11.2020	4330	5180	07.02.2021
Duisburg-Ruhrort	2260	2270	1040	999	31.10.2021	1069	29.11.2020	6640	7670	08.02.2021

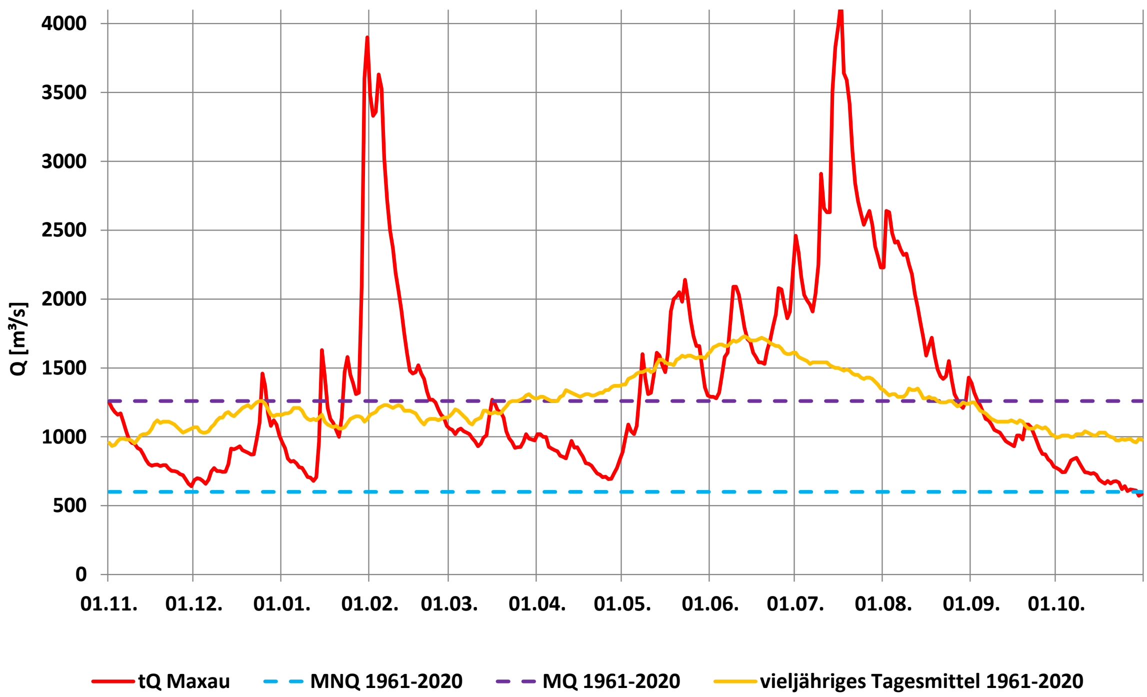


Figure 14: Daily discharges (tQ) at Maxau Upper Rhine level in the hydrological year 2021 against the background of the multi-year daily average and the MNQ and MQ values for the reference period 1961 to 2020

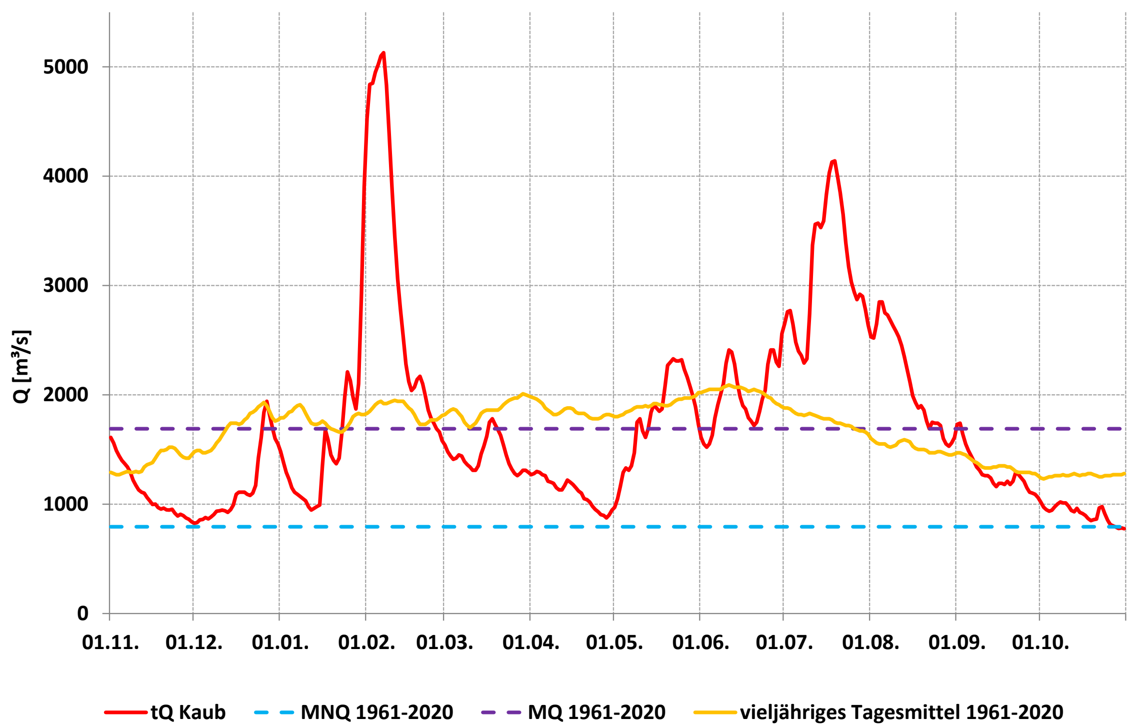


Figure 15: Daily discharges (tQ) at the Kaub Middle Rhine level in the hydrological year 2021 against the background of the multi-year daily average and the MNQ and MQ values for the reference period 1961 to 2020

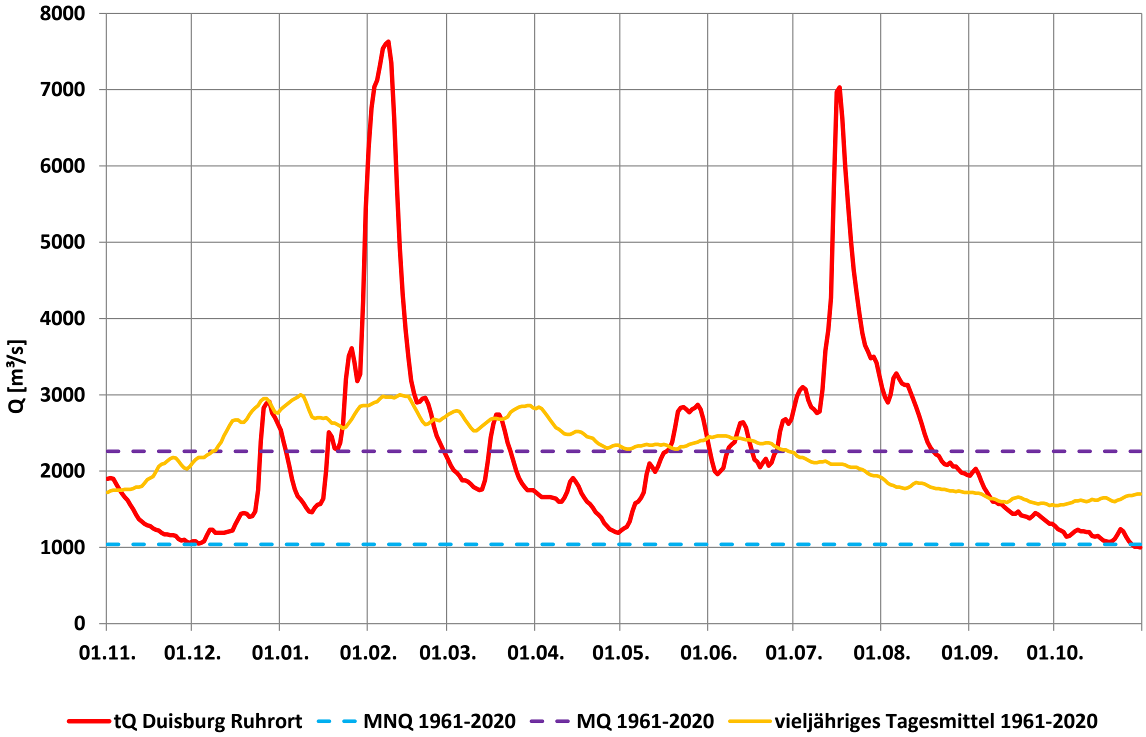


Figure 16: Daily discharges (tQ) at the Duisburg-Ruhrort Lower Rhine level in the hydrological year 2021 against the background of the multi-year daily averages as well as the MNQ and MQ values for the reference period 1961 to 2020

More striking are the two flood events, both of which (although to varying degrees) affected the entire course of the Rhine: a rain-on-snow event after a large-scale influx of moist-warm air masses at the end of January/beginning of February 2021 and a flood after several days of intensive summer rainfall. The summer event in the Upper Rhine with a recurrence interval of 10-20 years (4220 m³/s at the Maxau level) was more extreme than the winter flood there (annual recurrence 2-5a). The flood intensity of both the winter and summer events in the further course of the current is usually attributable to a recurrence interval of 2-5 years; in the Middle Rhine, the July flood (at only 4150 m³/s at the Kaub level) even had an interval of no more than 1-2a. Accordingly, the Upper Rhine wave gradually shrank in the direction of the Middle Rhine, the water supply of which was then replenished with the influx of the Moselle.

This replenishment was the result of a heavy precipitation event from 13 to 14 July 2021, which occurred particularly intensively in many river areas of the Rhenish Slate Mountains in western Germany (Eifel, Bergisches Land, Sauerland). Since previous rains had already initiated a saturation of the soil water holding capacity, these intense precipitations led to extremely rapid swelling of the discharges, especially in smaller flowing waters in more relieved terrain. Also flash floods occurred regionally. This resulted in massive, sometimes catastrophic floods; especially small tributaries of the Rhine (Nette, Ahr, Erft, Sieg, Wupper and Ruhr) and the Moselle (Sauer, Prüm, Kyll) were affected.

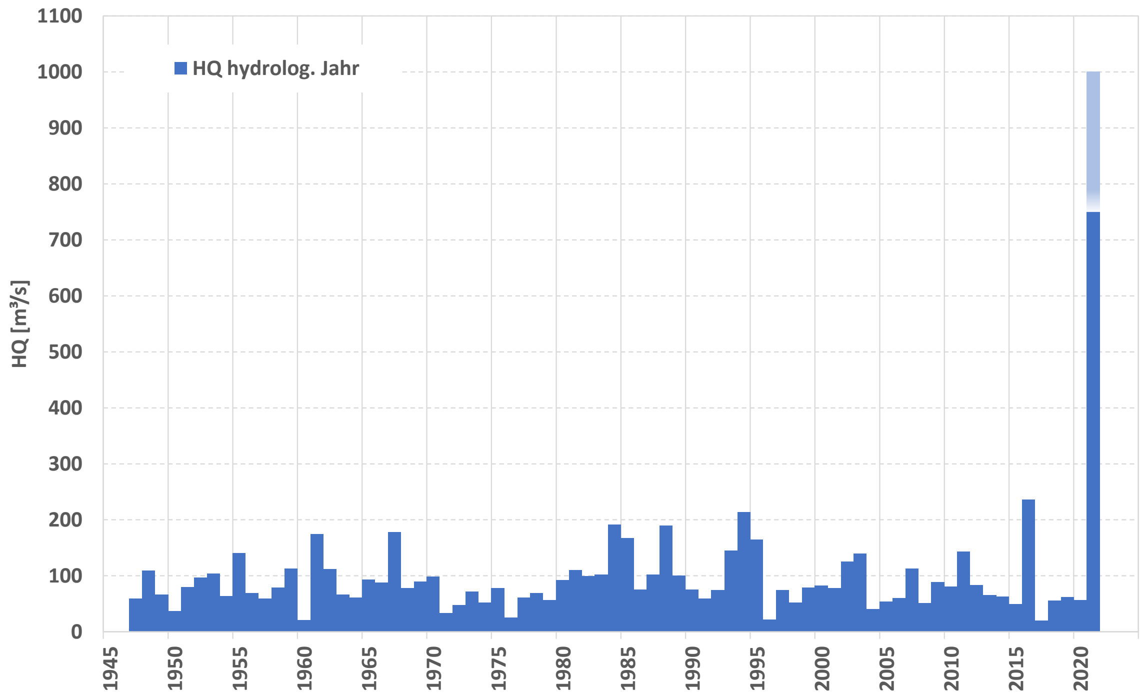


Figure 17: Annual discharge maxima (hydrolog. years since 1947) at the Ahr: Level Reimerzhoven (before 1992) / Altenahr (from 1992). According to the reconstruction status October 2022, the annual maximum value in the discharge year 2021 is within a range of 750 - 1000 m³/s (data and reconstruction calculation for the 2021 event: LfU Rheinland-Pfalz)

Thanks to the limited regional extent of the event and its greater drainage capacity, the Rhine itself and its large tributary, the Moselle, reacted only with (for their conditions) moderate drainage increases; neither in the Moselle nor in the Rhine below the Moselle and Ahr estuary were drainage-related recurrence intervals of 5 years exceeded.

This is different in the case of the affected smaller rivers, where the Ahr in particular was in focus. Here, all relevant measuring stations were destroyed by the rapidly rising floods. Records could only incompletely capture the respective wave rise, never the apexes. Reconstruction calculations for the event have not yet been completed.

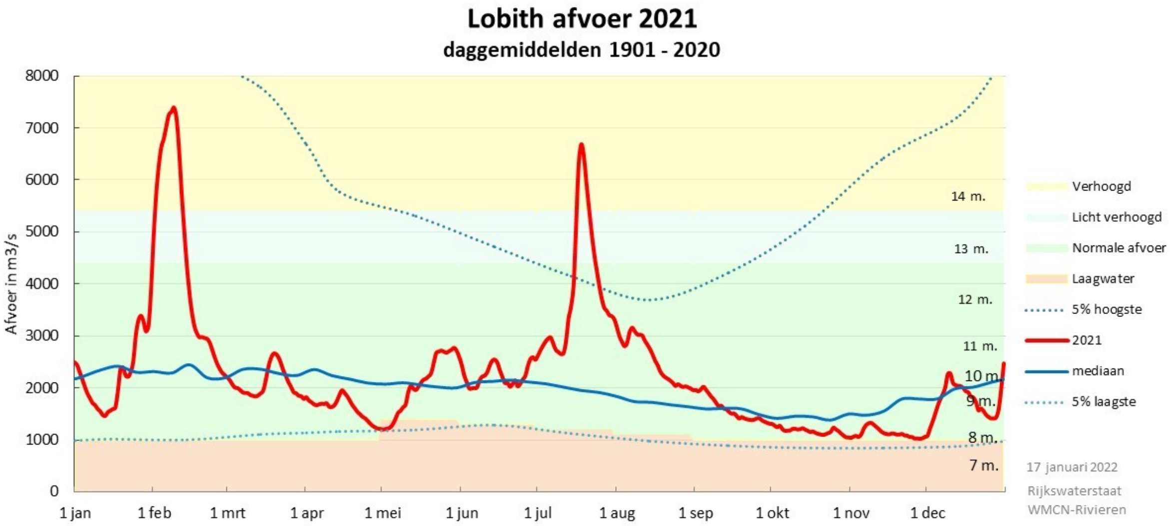
Figure 17 gives an impression of the dimensions that have occurred: According to the reconstruction status October 2022, the peak discharge on 14/07/2022 at the Altenahr level (predecessor level Reimerzhofen) was between 750 - 1000 m³/s. This is, roughly estimated, three to four times the previous "century flood" of 2016. The assignment of a recurrence interval is still pending. Historical flood events of 1804 and 1910 reached approximately comparable high water levels as 2021, as evidenced by historical flood marks and records; associated runoff figures are uncertain.

1.3.2.4 Netherlands

Source: Water Management Center, Rijkswaterstaat (RWS)

At the beginning of February, a moderate winter flood occurred on the Rhine in the Netherlands. Since the end of January, the water levels of the Rhine have risen under the influence of persistent western low pressure areas that moved across the catchment area and snow melt in the Alps. On February 9, a maximum water level of 14.53 m +NAP was reached at Lobith, with an discharge of 7390 m3/s. Such a water level or discharge occurs on average once every 2-3 years.

In mid-July, a second discharge wave occurred on the Rhine, which was influenced by abundant rainfall in large parts of the catchment area. The water level in Lobith reached a peak of 14.08 m +NAP on July 18 with an discharge of about 6800 m3/s. Such water levels/discharges are not special in themselves and occur approximately every 2 years. The special thing about this flood, however, was that it took place in the summer. The discharge peak of 6800 m3/s was the highest summer discharge since measurements began at Lobith.



Graph 18: Hydrograph of the daily average discharge at Lobith gauge in 2021 (red curve) compared to long-term minima, maxima and averages of 1901-2020

1.3.3 Water Temperatures

1.3.3.1 Austria

Source: Hydrographic Service Vorarlberg

The annual average of the water temperature of Lake Constance at the Bregenz harbour level was 12.5 °C, 0.4 °C above the long-term average of 12.2 °C. From the beginning of the year to the beginning of October, periods alternated with above- and below-average daily averages. Subsequently, daily averages remained above the daily averages of the 1976-2020 series until the end of the year (see Figure 19).

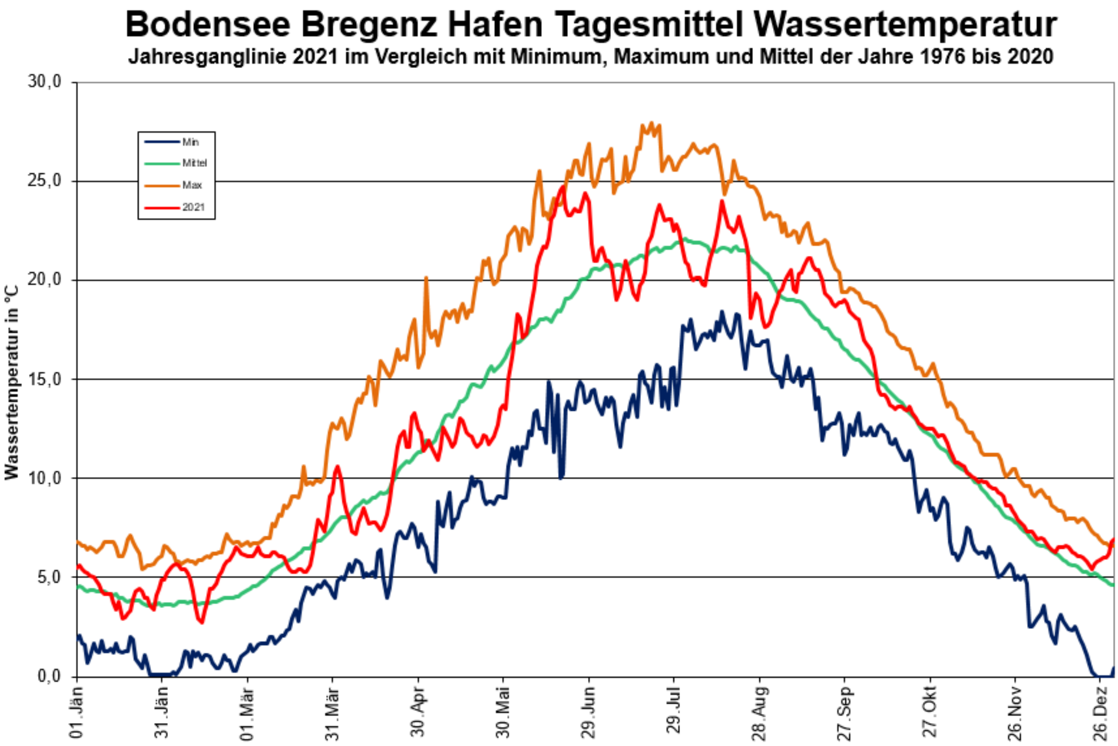


Figure 19: Graph of the water temperature of Lake Constance at the Bregenz level in 2021 (red curve) compared to long-term minima, maxima and average values of the years 1976-2020

1.3.3.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

The year 2021 was characterized by extensive rainfall. There were neither periods of significantly high air temperatures nor long periods of drought. This had a favourable effect on the annual values of the water temperature in the rivers. Exceeds of the long-term annual maximum values were not observed. At the same time, however, there were no significant undershoots of the annual minimum values at the federal measuring stations.

The rather mild winter and above all the significantly increased air temperatures towards the end of February and the beginning of March led to occasional exceedances of the previous monthly maximum. These exceedances were mainly observed at the stations on southern river bodies.

Due to the rather cooler spring, the lowest values of water temperatures at individual stations in the Alps were below the long-term monthly minima.

The wet summer with only locally isolated hot days meant that there were no significant exceedances of the previous monthly maximum values of water temperatures. However, the lowest values of the water temperatures were only occasionally below the previous minima for the summer months.

Although autumn, especially in September and October, showed a lot of sunshine, the monthly values were in the range of the previous years. There were very few overshoots in September and very few undershoots of the previous monthly maximum in November. -Minimums. Despite the mild end of the year, the water temperatures in December were also in the range of the usual values for the season.

1.3.3.3 Netherlands

Source: Water Management Center, Rijkswaterstaat (RWS)

At Lobith, the average water temperature of 12.8 °C was about 0.5 °C below the calculated long-term average (1961-2020) (Figure 20).

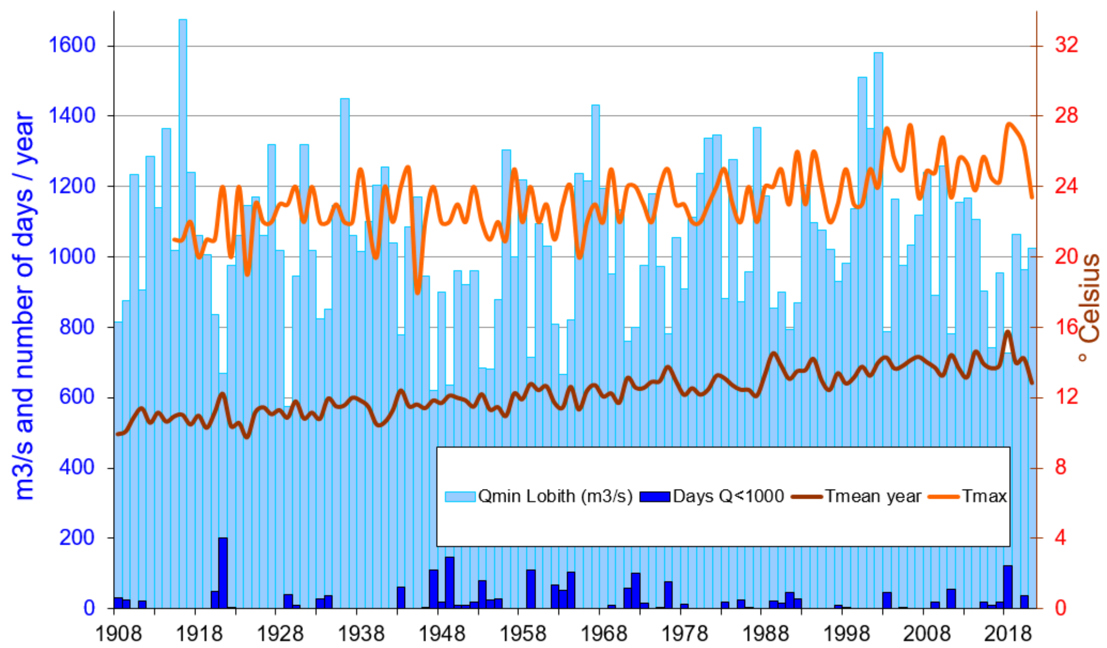


Figure 20: Average and maximum water temperatures 1908-2021 at the Lobith/Rhine level

1.3.4 Groundwater

1.3.4.1 Austria

Source: Hydrographic Service Vorarlberg

At the beginning of 2021, groundwater levels in the Austrian part of the Rhine region were above average. At some measuring points, the highest groundwater levels of the year were reached in February after the snow melt in the valley layers. At the other measuring points, the highest groundwater levels were measured as a result of the heavy precipitation of the months of July and August at the end of August or the beginning of September.

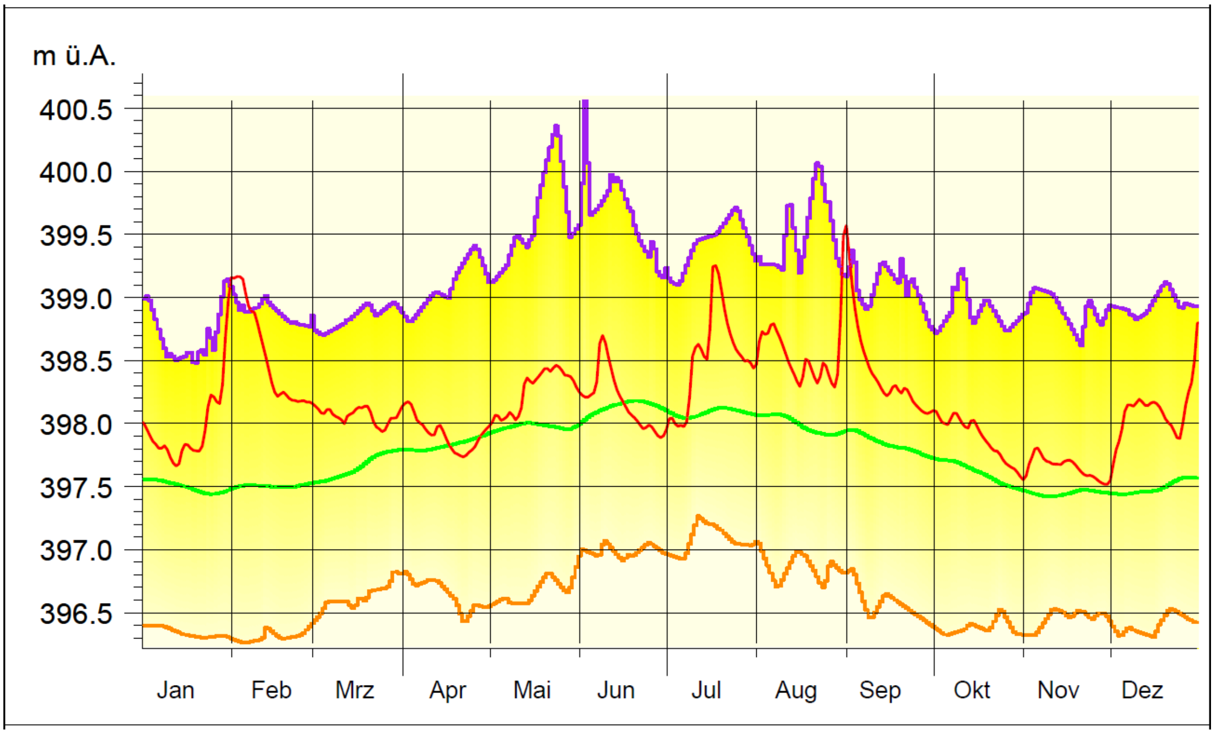


Figure 21: Hydrograph lines of the groundwater level in 2021 compared with long-term minima, maxima and mean values (1964 – 2019) Bregenz measuring point, folio 50.1.09 B

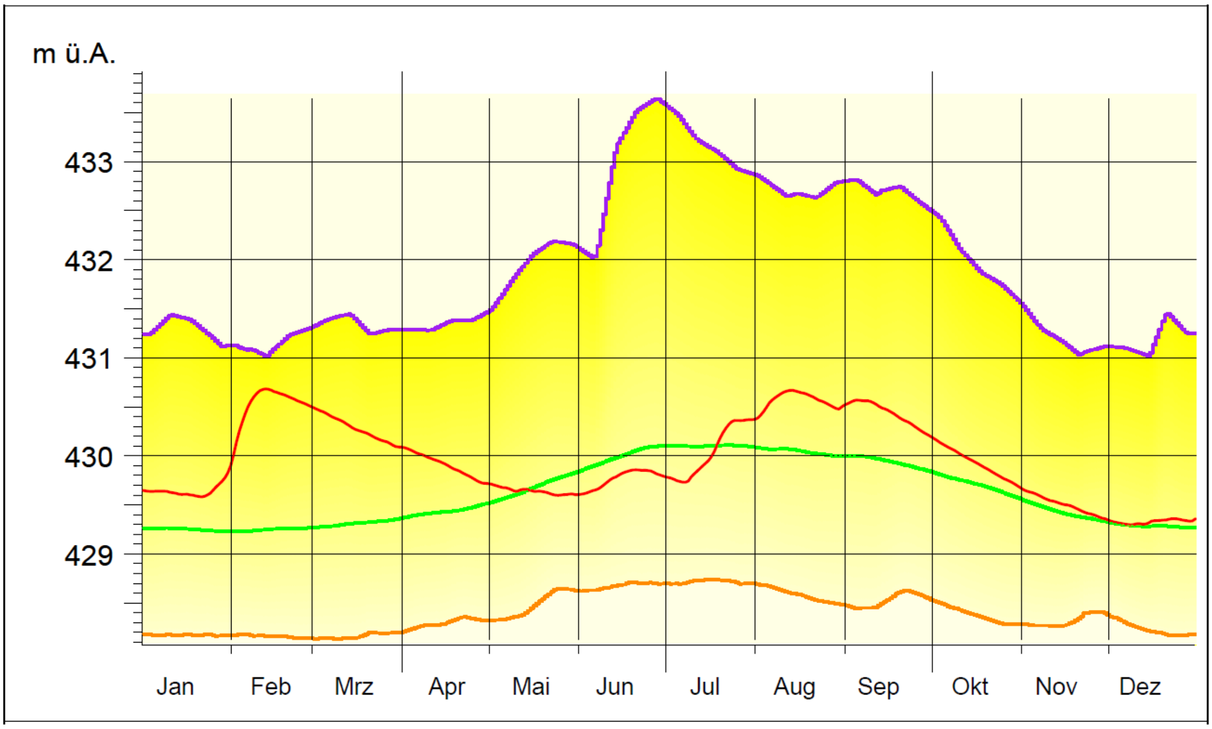


Figure 22: Hydrograph lines of the groundwater level in 2021 compared to long-term minima, maxima and mean values (1962 – 2020) Feldkirch-Altenstadt measuring point, folio 01.32.01 A

1.3.4.2 Switzerland

Source: Swiss Federal Office of the Environment (BAFU)

The continuous observation of groundwater level or spring runoff at about 100 measuring points as part of the NAQUA National Groundwater Observation makes it possible to map the current state and the development of the groundwater quantity at the national level compared to long-term data series. This can also indicate possible long-term effects on groundwater resources as a result of climate change, for example due to the predicted increase in extreme events such as floods and droughts.

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, 2021 is in a period with high groundwater levels and spring runoff compared to many years ago.

At the beginning of 2021, normal groundwater levels and spring runoff were widely observed. The above-average rainfall in January resulted in high groundwater levels and spring runoff at around two-thirds of the measuring points at the beginning of February. Low rainfall in March to May led to normal, sometimes deep groundwater levels and spring runoff in the beginning of June. Precipitation in June, and in particular the persistent heavy precipitation in July, caused groundwater levels along the rivers and spring runoff to rise. At the beginning of August, around two-thirds of all measuring points showed high groundwater levels and spring runoff. Due to the low rainfall from late summer and autumn, the high groundwater levels and spring runoff, which were still widespread at the beginning of August, fell steadily. Thus, at the beginning of November, the first low groundwater levels and spring runoff were recorded in loose rock groundwater deposits in the Pre-Alps. December was again rainy, so that at the end of the year normal, sometimes high groundwater levels and spring runoff with inconsistent tendency prevailed.

1.3.5 Suspended Solids

1.3.5.1 Austria

Source: Hydrographic Service Vorarlberg

The annual load of suspended solids on the Alpine Rhine at the Lustenau measuring point in 2021 was around 2.2 million tonnes, in the range of the average for the 2010-2020 year series (around 2.3 million tonnes). The highest monthly load was determined for July at approx. 0.68 million tonnes. This corresponds to approximately 31% of the total annual load.

The largest day load was for the 09. July with a load of 158 520 tonnes (approx. 7% of the annual load) (Figure 23).

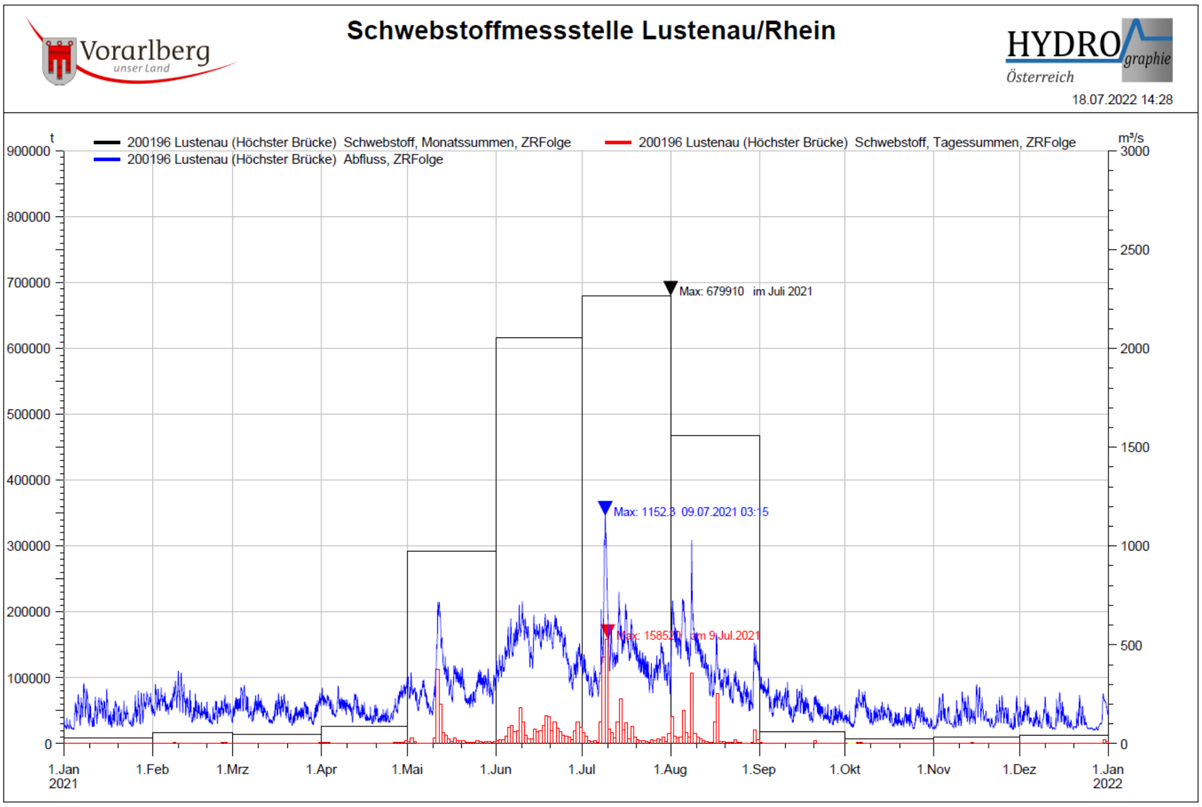


Figure 23: Monthly suspended solids loads of the Alpine Rhine at the level

2. Activities of the International Commission for the Hydrology of the Rhine Basin (CHR) in 2021

CHR Sessions
Two official CHR meetings took place in 2021. The spring meeting (No. 87) was held online on March 8 due to COVID-19 restrictions. The autumn meeting (No. 88) took place on 20 October in Wageningen (Netherlands) in combination with the 50th anniversary of the CHR.
In addition, two more online meetings were held in the spring, on 26 April on ongoing projects and on 12 May on the work programme and future activities.

Personnel changes within the CHR
In 2021, there were no personnel changes in the CHR

Ongoing activities in CHR projects

ASG-Rhein 2 (ASG2): Contribution of snow and glacier melt to the Rhine runoff
The second phase of the ASG project (ASG2) started in 2018. In ASG1, snow and glacier melt has been studied over the past 100 years. In ASG2, we focused on how snow and glacier melt will develop over the next 100 years and how this will relate to the Rhine runoff.

In 2021, the steering group of ASG 2 met live in Freiburg on 6 and 7 October 2021. This was the last and 7th. session of the ASG Steering Group. The draft synthesis report (final report) of the project was discussed. An agreement was also reached on the preliminary results of the study, which are to be presented at the end of October 2021 on the occasion of the 50th anniversary of the CHR.
The final report will be presented at the beginning of 2022, after which a final symposium will be organised in Switzerland in mid-2022.

The results of the draft synthesis report (final report) are:
"This project quantified daily proportions of drainage components for a future climate scenario in all tributaries and along the main stream. The ensemble of climate projections points to wetter winters and drier summers in the future. Driven hydrological model simulations show that the rain component will dominate the seasonal runoff fluctuations more strongly in the future than in the past. Snow melts earlier in winter and spring, resulting in lower seasonal water retention in the snowpack. The melting of the glaciers will continue and despite different retreat speeds of individual glaciers, the ice melting component in the main stream of the Rhine is projected to rapidly decrease and almost disappear by the end of the century. Overall, according to the simulations, the runoff variability and low water extremes will increase."

Socio-economic influences on the low-water regime of the Rhine (SES)
At the beginning of 2021, a report on the RIBASIM model was prepared as part of the project. RIBASIM is a generic model package for simulating the behaviour of river basins under different hydrological conditions. At the 87th session of the CHR (8 March), it was recommended to further develop these models in 2021, based on the guiding principles of participatory approach, integration and exchange of local data and co-creation of knowledge.
A small SES steering group met in October and reiterated that all partners consider the project to be important. The data collection for RIBASIM, in particular water use and reservoirs, and the topic of "governance" were discussed in detail. In some countries in the Rhine river basin, not all data is public, making it difficult to collect data and perform the required analyses. The

RIBASIM model and the analyses form a good basis for the CHR for further development, e.g. in the direction of Rheinblick 2 with the coupling of climate and socio-economic scenarios.
At the end of 2021, additional budgetary resources were released for the continuation of the project. In the first step, an interview round is organized by the SES project (depending on the corona situation either online or live). What wishes, possible contributions to data and finances are there? It starts in the Netherlands and then continues upstream.

Sediment
In 2021, the University of Natural Resources and Life Sciences (BOKU) and Blueland (Dutch consultancy) continued work on the sediment project, which included a basin-level inventory of knowledge, problems, research, monitoring, etc.. Therefore 22 interviews were conducted with experts from Switzerland, Austria, France, Germany, Luxembourg and the Netherlands. The interviewees named or delivered reports and publications. The steering group for this project also met twice this year.
The first results of this project were presented at the 50th anniversary celebration in October. Some recommendations for further research relate to the effects of climate change on the sediment budget, updating the sediment balance and trends as well as sediment transport process and management - national and bilateral projects.
The final completion of the project is expected in early 2022.

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. It was decided to conduct a preliminary study first. The BfG will award a contract for a 2-year project including a post-doc to the University of Bonn.
Corona and the floods in 2021 have postponed the original schedule for the time being. The planned work in 2021 is divided into a preliminary study (on behalf of the BfG) and a main study (with the CHR and all Rhine states). In the preliminary study, the basics are compiled. This is done on the basis of archives, old lists and the database from 1900 onwards. If possible, the database should be completed even further back than 1900. The preliminary study has not yet begun until the end of 2021. Award negotiations between the BfG and the University of Bonn are progressing. However, administrative hurdles must be removed and framework conditions observed. These are expected to be resolved in early 2022.

CHR Information System
In 2021, the CHR launched a new project, the CHR Information System, with which we want to share current data and project data about the Rhine area online with the outside world. In 2021, the CHR commissioned the German consultant Mundialis with an inventory (definition study) of the ideas of the various CHR members about this information system. Interviews with some CHR members were held in advance and asked what one imagines in the CHR and what the way might look like. The basic recommendation is: "Start small and grow". Other requests are:

1. Secure a well-established CHR for the next 50 years;
2. Generate added value from data from Europe, actual state and target state;
3. There are many similar states, but different data types and requirements;
4. Current measurement data and historical data (mostly analogue) and scenarios for the Rhein basin? How can they be made accessible?
5. Use the FAIR Principle.

For 2022, the CHR plans to continue its efforts to develop a prototype under the leadership of a steering committee.

Community of Practice Young River Professionals
The CHR attaches great importance to the involvement of young talents and experts in the Rhine region. That is why the CHR supports the project "Youth for the Rhine". Project manager Luke Somerwill explained the project at our 50th anniversary symposium in Wageningen in October.

Strategic Orientation of the CHR
Work on the strategy document for the next 10 years continued in 2021. The final CHR strategy was finally presented by our president at the CHR anniversary in October 2021, and printed versions (EN, D, FR) were distributed to the guests. After the event, the document was published on our website.

Figure 24: CHR's strategy & work programme presented at the symposium

KHR 51st Anniversary Conference
On 21 and 22 October 2021, the CHR celebrated its 51st anniversary in Wageningen (Netherlands). After a long wait due to COVID-19, this anniversary could finally take place live. The event was dedicated to cooperation between countries and organisations and the topics on which the CHR is working.

The CHR consists of organisations from the Rhine countries Austria, Switzerland, France, Germany, Luxembourg and the Netherlands. All countries were represented at the event and a new cooperation agreement was signed. Jaap Slootmaker, Director General of the Dutch Ministry of Infrastructure and Water, opened the event and, together with the other delegates, signed the resolution of the cooperating states in the CHR. Representatives of the International Commission for the Protection of the Rhine (ICPR), the Central Commission for the Navigation of the Rhine (CCNR), the IHP-UNESCO and the World Meteorological Organization (WMO) were also present to congratulate the CHR and sign the renewed cooperation agreement.

Dutch Delta Commissioner Peter Glas explained the challenges that the Netherlands will face in the coming decades due to climate change. These challenges fit perfectly with the new strategy and work programme presented by CHR chairman Helmut Habersack. The CHR will start with Rheinblick II to carry out impact assessment studies on these topics and to further expand a scientifically sound hydrological-morphological knowledge base. Ultimately, this work should lead to an information portal with open data on the Rhine. Other speakers reviewed current and historical projects of the CHR. Current topics of the CHR are climate change, socio-economic scenarios for land and water use and sediment(management).

The Secretariat of the CHR has been located in the Netherlands since its founding in 1970. Over the past 20 years, Eric Sprokkereef (Rijkswaterstaat) had acted as its secretary. During the symposium Eric handed over this task to new secretary Roel Burgers (Rijkswaterstaat).

Figure 25: Signatory to the CHR 50th anniversary of signing cooperation agreements between the CHR Member States and with the ICPR, UNESCO, WMO and CCNR. Left to right: Karine Siegwart (Deputy Director, Federal Office for the Environment, Switzerland), Günter Liebel (Head of the Directorate-General I Water Management, The Ministry for Agriculture, Regions and Tourism, Austria), Jaap Slootmaker (Director-General of the Dutch Ministry of Infrastructure and Water), Manfred Spreafico (former President KHR), Sophie Dorothée Duron (online screen, Deputy Director water marine and biodiversity, The Ministry of Ecological Transition, France), Helmut Habersack (President KHR), Norbert Salomon (Director-General for Waterways and Shipping in the Federal Ministry of Transport, The Federal Ministry of Transport and Digital Infrastructure, Germany), Tom Schaul (Conseiller du Gouvernement, The Ministry of the Environment, Climate and Sustainable Development, Luxembourg), Bruno Georges (General Secretary Central Commission for the Navigation of the Rhine) and Veron Manicafredi (President International Commission for the Protection of the Rhine).
Not in the picture, but participating online in the symposium: Abou Amani (Director, Division of Water Sciences, Secretary, Intergovernmental Hydrological Programme, UNESCO IHP) and Johannes Cullman (Director, Division of Climate and Water, World Meteorological Organisation)

Figure 26: Adoption of the Secretary of the CHR. From left to right: Ute Menke (Secretariat CHR), Helmut Habersack (President CHR), Eric Sprokkereef (former Secretary CHR), Roel Burgers (new Secretary CHR)

Public Relations

The new CHR website (www.chr-khr.org) was published at the beginning of April 2021. All information is now easily accessible from different devices. There is also a secure part for members.

Publications of the CHR

The CHR has published the Hydrological Annual Report 2020 for the Rhine region in two languages.
In addition, the official CHR Strategy 2030 as well as the brochure on the 50th anniversary were published, in which much is reported on the work of the last 50 years.