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

CHR Annual Report 2018

Editor: **Eric Sprokkereef — Rijkswaterstaat, VWM, Lelystad**

Photo, front page: Amsterdam Rhine Canal in summer 2018. A bubble screen to prevent salt-water intrusion

Contributions:
Federal Office for the 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 of Hydrology, 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
P.O. 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 Sustainability and Tourism, Department I/4 - of Water Resources (Hydrography), Vienna, Austria,
- Office of the Vorarlberg State Government, Department VIID — Water Management, Bregenz, Austria,
- Federal Office for the Environment, Bern, Switzerland,
- IRSTEA, Antony, France,
- IFSTTAR, Nantes, France
- Federal Institute of Hydrology, Koblenz, Germany,
- Hessian State Office for Nature Conservation, Environment and Geology, Department W3 "Hydrology, Flood Protection", Wiesbaden, Germany,
- IHP/HWRP Secretariat, Federal Institute of Hydrology, Koblenz, Germany
- Water Management Administration, Luxembourg,
- Deltares (an independent institute for applied research), Delft, Netherlands,
- Rijkswaterstaat — Transport and Water Management, Lelystad, Netherlands.

1. Hydrological Overview for the Rhine Catchment Area

Meteorological Characteristics

Austria, Source: Central Institute for Meteorology and Geodynamics (CIMG)
With a deviation from the average, measured from 1981-2010, of +1.8 °C, 2018 was the hottest year in Austria since the initiation of instrumental record-taking in 1768 (Fig. 1). Based on twentieth-century averages, the anomaly is +2.6 °C. The months of January and April contributed most to the high-temperature deviation. January was the third-warmest month in measured history, with a deviation of +3.9 °C from the average of 1981-2010. April was 4.7°C warmer than the long-term average, and was therefore extremely warm. From April onwards, all subsequent months were warmer than the recorded average and the anomalies ranged from +1.4 °C in July to +2.6 °C in May and August. This resulted in the hottest 6 months, including summer (Apr-Sep), in measured history (Abw. +2.5 °C). The fact that the average annual temperature in Austria is not even more unusual, is due to February and March in the same year, which significantly extended the winter. February was 2.0 °C colder, and March was 1.3 °C colder than the average.

Precipitation was very unevenly distributed in Austria in 2018. From Vorarlberg, into the northern Weinviertel, north of the main Alpine ridge, and along the ridge, conditions were extremely dry. While, south of the Alps, there was significantly more rainfall than in an average year. In the overall view, Austria had 10% less rainfall, i.e. slightly more than in 2011 (-15%) and 2015 (-16%) and significantly more than in 2003, where 19% less rainfall was recorded. However, rainfall deficits in these previous years were relatively evenly distributed across all the country's regions (see Fig. 2).

The number of sunshine hours in 2018 was 11 per cent higher than the average year in the country-wide evaluation. Thus, 2018 is one of the eight sunniest years since the beginning of the sunshine-duration measurement initiated in 1925.

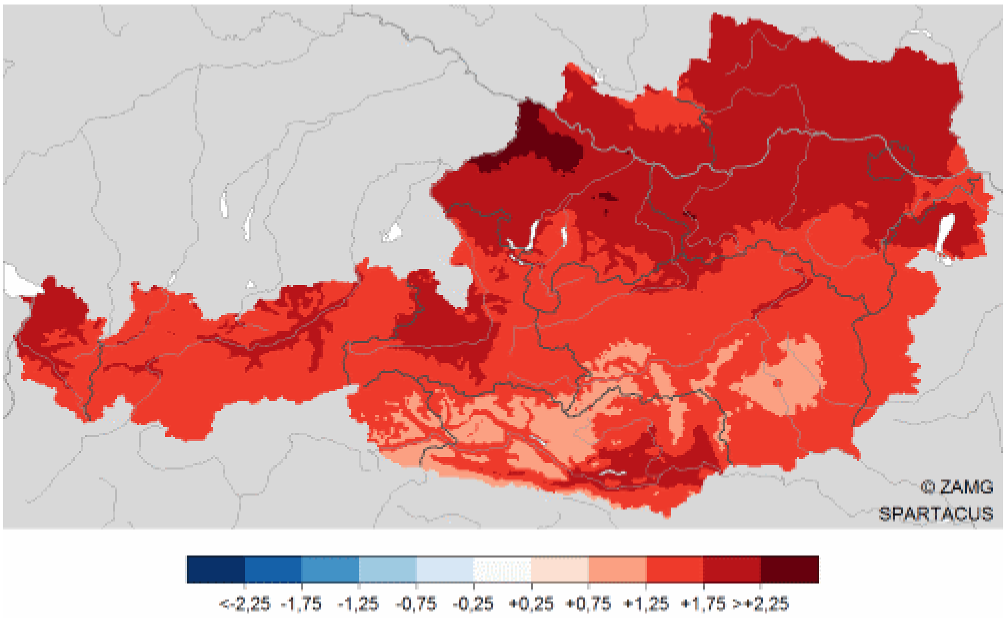


Figure 1: Temperature in Austria in 2018: Deviation of temperature from the long-term average of 1981-2010. Source ZAMG

In the inner-alpine locations, snow conditions were consistently above the average during the winters of 2017/18, both in terms of snow-cover and newly-fallen snow conditions. The total amount of new snow from the Arlberg area to most of Upper Styria, as well as in Carinthia, was around 50 to 100 per cent higher than the climatological average. There was significantly less snow from Upper Austria to Burgenland than in an average winter. The amount of fresh snow at this location was around 10 to 70 percent below average.

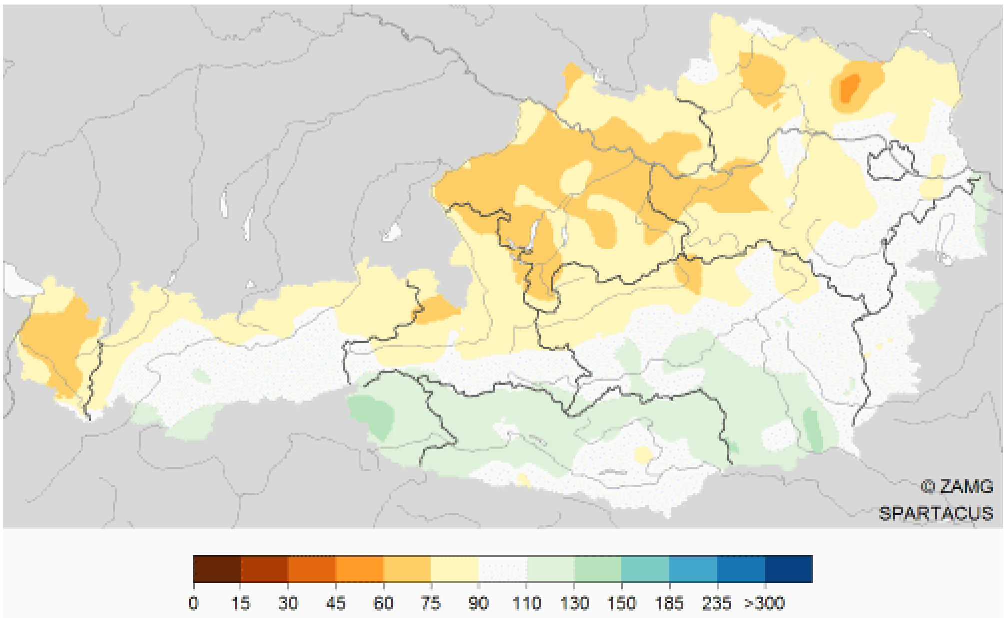


Figure 2: Precipitation in Austria in 2018: Deviation of precipitation from the long-term average 1981-2010. Source ZAMG

Meteorological characteristic for the Austrian Rhine region. Source: Hydrographic Service of Vorarlberg

The year 2018 was marked by a long period with below-average rainfall. Only the January and December monthly rainfall levels were above the average (Fig. 3). The annual rainfall in the Austrian part of the Rhine catchment area amounted to 80% of the long-term average. The average annual air temperature was 1.8 °C higher than the long-term average.

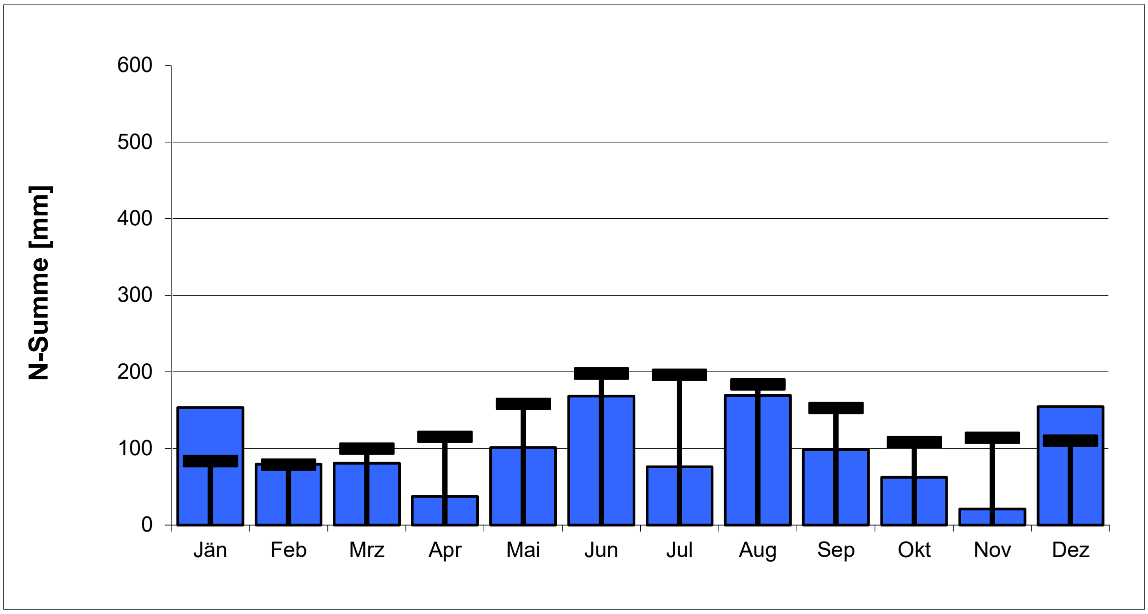


Figure 3: Monthly precipitation totals in 2018 (blue columns) compared to the long-term monthly average (1981 — 2010) at the Bregenz Altreuteweg measuring station

Switzerland, Source: Federal Office of Meteorology and Climatology (MeteoSchweiz)
Winter temperatures for 2017/18 were within the national average range for the 1981-2010 standard, but with major fluctuations from month to month. December was 0.6 degrees cooler, and February was 3.0 degrees cooler than the norm. In between, there was a record-warm January. Winter rainfall was more than 130% of the 1981-2010 standard. In Valais, the figures rose over the standard values in many areas and in Grisons, regionally, it was over 200% of standard values. In January 2018, almost 100 measuring stations registered record-high monthly rainfalls. In Valais, January 2018 brought not only the highest amount of rainfall for January, or the highest for four measuring locations in over 50 years, but also the highest monthly total ever.

Spring 2018 started off with cool weather. March remained 1 degree below the norm for the national average. The cool March was followed by the second warmest April since the beginning of recorded measurements in 1864. The persistently-high monthly figures resulted in a new heat-wave record for the summer half-year. Even the extraordinarily hot weather of the legendary summer of 2003 was slightly surpassed. After an extremely rainy April and widespread low rainfall levels in May, the summer saw extremely low rainfall. Throughout Switzerland, the rainfall, on average, amounted to only 71% of the 1981-2010 standard from June to August. In June, only 20 to 40% of the normal rainfall levels fell in some areas. Individual measurement locations in the Central and Eastern Alps, with over more than 100 years of measurement data, recorded a record deficit in June rainfall volumes. In July, there was a massive deficit in rainfall locally, in the eastern Mittelland (Central Plateau), and again along the eastern Alpine north-facing slopes, with rainfall totals of only 20 to 30% of the norm.

Switzerland experienced the third warmest autumn since the beginning of recorded measurements in 1864. The southern side of the Alps registered the warmest autumn since the beginning of recorded measurements. In the eastern part of Switzerland, the very low rainfall, which persisted from spring to autumn, has become a phenomenon of the century. Averaged across Switzerland, low rainfall measurements were recorded from April to November 2018 and earned third place; it was at 69% of the 1981–2010 standard norm.

At the end of October, 200 to 300 mm of precipitation fell on the southern side of the Alps within three days. There was also rainfall in the neighbouring Grisons region, with more than 200 mm of downfall. Much of it fell as snow. At the beginning of November, it rained heavily on the southern side of the Alps. While the total precipitation on the southern side of the Alps in October and November were significantly higher than the 1981–2010 standard norm, the same two months showed extremely low precipitation on the northern side of the Alps. It was only in December that the northern side of the Alps had above-average rainfall again, for the first time in a long time.

Table 1: Annual values 2018 at selected MeteoSwiss measuring stations, compared to the 1981-2010 standard norm

Station	Height	Temperature (°C)			Duration of sunshine (h)			Precipitation (mm)		
	m a.s.l	Means	Norm	Dev.	Total	Norm	%	Total	Norm	%
Bern	553	10.6	8.8	1.8	1969	1683	117	907	1059	86
Zurich	556	11.1	9.4	1.7	1921	1544	124	897	1134	79
Geneva	420	12.3	10.6	1.7	1979	1768	112	864	1005	86
Basel	316	12.3	10.5	1.8	1924	1590	121	698	842	83
Engelberg	1036	8.1	6.4	1.7	1471	1350	109	1451	1559	93
Sion	482	12.5	10.2	2.3	2271	2093	108	633	603	105
Lugano	273	13.9	12.5	1.4	2171	2067	105	1472	1559	94
Samedan*	1709	3.2	2.0	1.2	1744	1733	101	990	1011	98

Norm = Long-term average 1981-2010
Dev. Deviation of temperature to the norm
% = Percentage in relation to the norm (norm = 100%)
* The rainfall data for Samedan are not complete. They were replaced by the data from Segl-Maria.

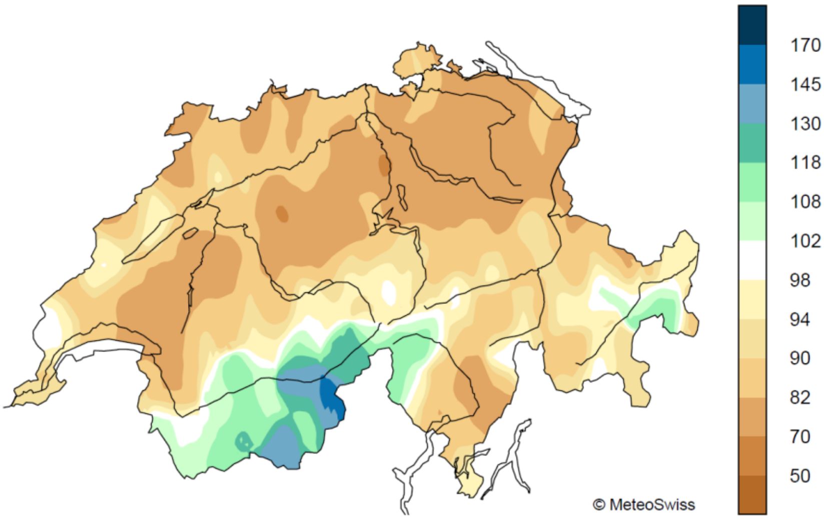


Figure 4: Annual rainfall in Switzerland 2018 in percentages of the norm (1981-2010).

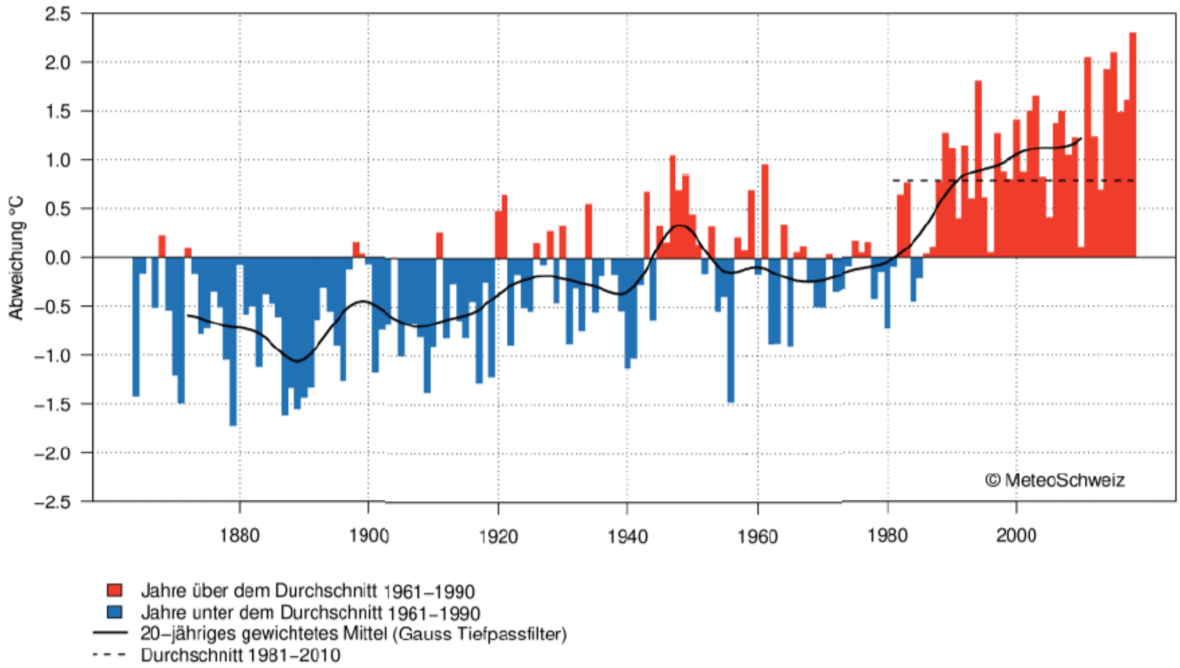
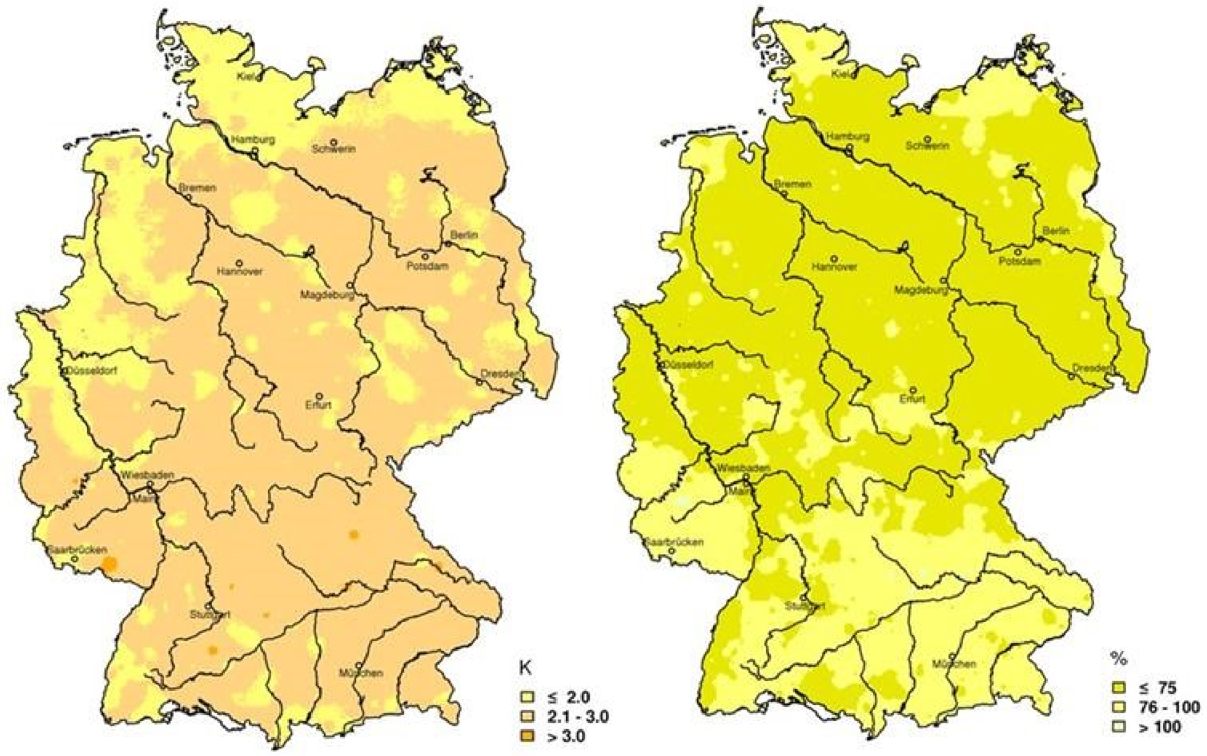


Figure 5: Deviation from the Swiss annual temperature in 2018 from the long-term average (reference period 1961-1990). The overly-warm years are coloured red; the overly-cold years are coloured blue. The black line shows the temperature progression averaged over 20 years.

Germany, source: Deutscher Wetterdienst (DWD) (German Weather Service)
From a global viewpoint, the 2018 calendar year was once again particularly hot, albeit not quite as hot as 2017. For Germany, however, 2018 was the year with the highest annual average air temperatures since 1881[1]. Other characteristics of the year were long, supra-regional dry phases and loads of sunshine. As figure 6a shows, average temperatures in many regions were more than 2 degrees above the normal value when compared to the reference period, 1981-2010. Specifically, the value was 10.4 °C, Germany-wide, and therefore 1.5 K higher than the average of the reference period, at 8.9 °C and 0.8 K higher than the previous calendar year (source: DWD[2]).

The annual precipitation totals (see figure 6b) were significantly below the normal values for the reference period north of the main and in western and southern Baden-Württemberg. In the Moselle and Nahe regions, and in the southern Danube catchment area, these anomalies were not quite as extreme (deviations were partly < 25%, source: DWD).

[1] https://www.dwd.de/DE/klimaumwelt/klimaatlas/klimaatlas_node.html, accessed on 7.10.2019
[2] https://www.dwd.de/DE/presse/pressemitteilungen/DE/2018/20181203_rekordjahr_news.html?nn=344870, abgerufen am 7.10.2019



Figures 6a and 6b: Germany: Deviations of mean air temperatures (figure 6a, left, in K) from the reference period 1961/1990 and the overall percentage of precipitation totals (figure 6b, right) in the calendar year 2018, against the multi-annual average (Source: DWD, National Climate Monitoring Products[3])

The relative variations in precipitation levels for the Rhine region in the hydrological year 2018 (Nov 2017 - Oct 2018) show, as in the rest of Germany, dominating dry to drought conditions from February to November of the observation period (Fig. 7a). In the first quarter (Nov 2017 - Jan 2018), on the other hand, disproportionately high rainfall was recorded, with between 44% and 47% of the annual rainfall occurring in these three months, i.e. 44% in the Rhine region (Main area) and 47% (along the Rhine, above the River mouth).

The seasonal rainfall statistics showed a significantly higher rainfall for the winter half-year than the summer half-year, when comparing the hydrological winter and summer months (Nov - Apr and May - Oct respectively) along the Rhine, both above and below the Main river mouth, with an average of 62 to 38%, while for the Main catchment area the distribution was 61 to 39%. Overall, the total rainfall was 439 mm across the Rhine basin and 272 mm in the summer half-year. However, the entire Rhine region is 79% below the annual average, in terms of rainfall, compared to the reference period 1981/2010.

Looking at the monthly rainfall compared to the average monthly values over many years, there is a significant deficit of between 4 and 52 mm for all months, from February to October. The driest month was February 2018, with only 21 mm of rainfall. Values exceeding the long-term monthly rainfall recordings, was measured at 15 to 49 mm in the period from November 2017 to January 2018. The peak of the monthly totals was 124 mm in January (166% of the mean reference, see Fig. 7.a).

[3] https://www.dwd.de/DE/leistungen/rcccm/nat/rcccm_nat_monthly.html

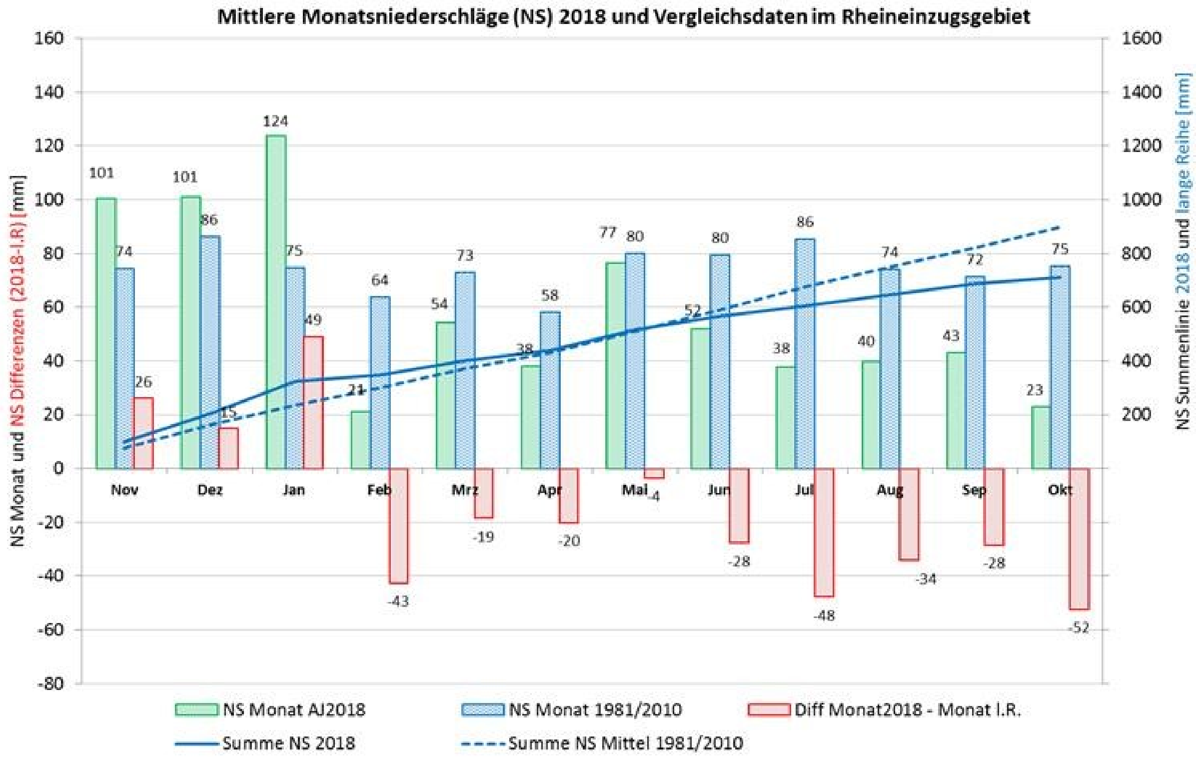


Figure 7.a: The German Rhine catchment area: A comparison of the monthly areal precipitation in the hydrological year 2018 compared to the long-term averages 1981/2010 (Source: DWD/Mon. Climate status Germany 2018)

The outflow year 2018 can be classified as a very warm year with regard to the Germany-wide average temperature of 10.4 °C. For the Cologne measuring point, the annual average was 11.1 °C with a deviation of +1.5 K compared to the climate reference period 1981/2010, with a deviation of +2.3 K in the summer half-year. In January, April and May 2018, the average air temperature was measured at +3.0 to +4.0 K, and was highest yet recorded, when compared to the average monthly average. Negative deviations from the reference period averages occurred in February (2.8 K) and March (1.9 K).

The monthly water temperatures measured at the Cologne gauge (Fig. 7.b) showed significant deviations from February onwards. The unusually low air temperatures resulted in water temperatures which remained at 5 °C in March and thus about 2 K below the long-term average. The air temperature cold phase merged, going directly into a pronounced positive anomaly from March to April, which continued until October and also resulted in significantly increased water temperatures, going over 25 °C. Over the course of the hydrological year, the air temperature average of Cologne in April to August exceeded 2.7 K, on average; water temperatures increased by an average of 1.7 K in these five months (Fig. 7.b).

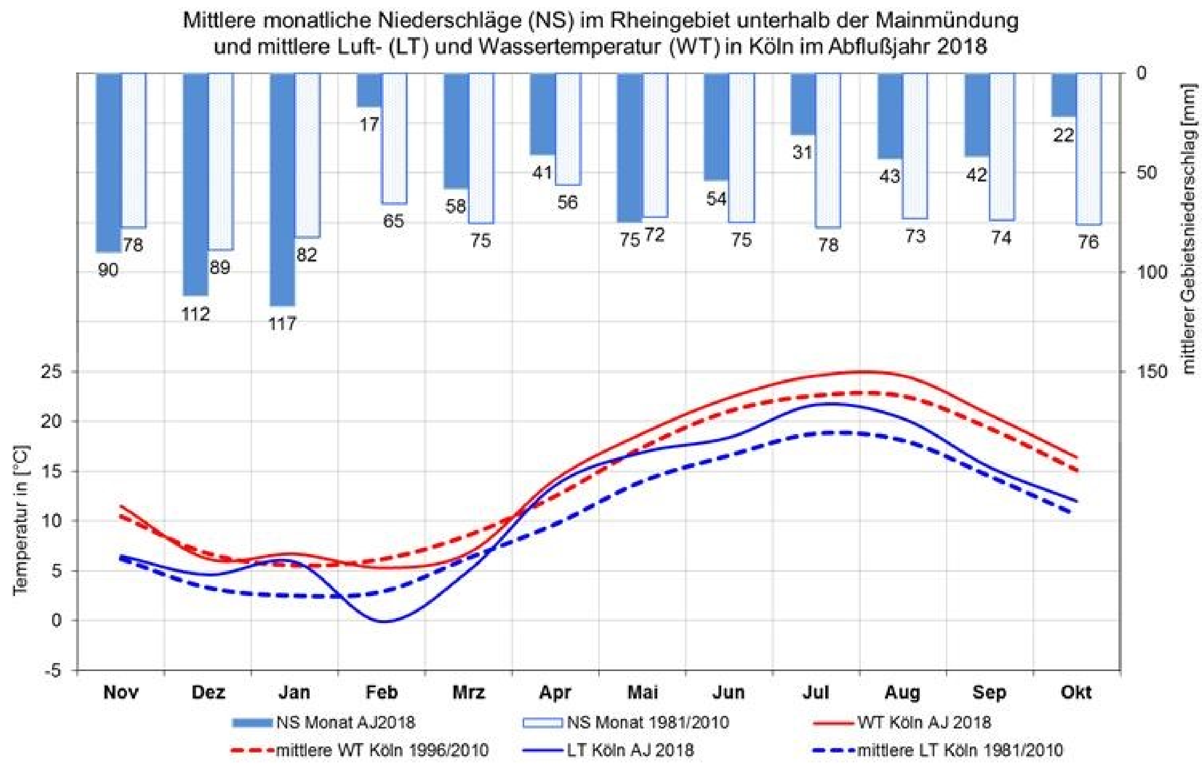


Figure 7.b: The Rhine catchment area/Example station Cologne: Comparison of monthly temperature and precipitation data in the 2018 hydrological year compared to the long-term average values (data sources LT and NS: DWD; WT: WSV)

The Netherlands, source: Koninklijk Nederlands Meteorologisch Instituut (KNMI) (Royal Dutch Meteorological Institute)

2018 was the fifth very warm year in a row, with an average temperature of 11.3 °C at the De Bilt station. After 2014 (11.7 °C), 2018 was the warmest year since the beginning of recordings. The emerging picture fits in with the trend of a warming climate overall. All months, except February, March, September and November, were at least 1 degree warmer than normal.

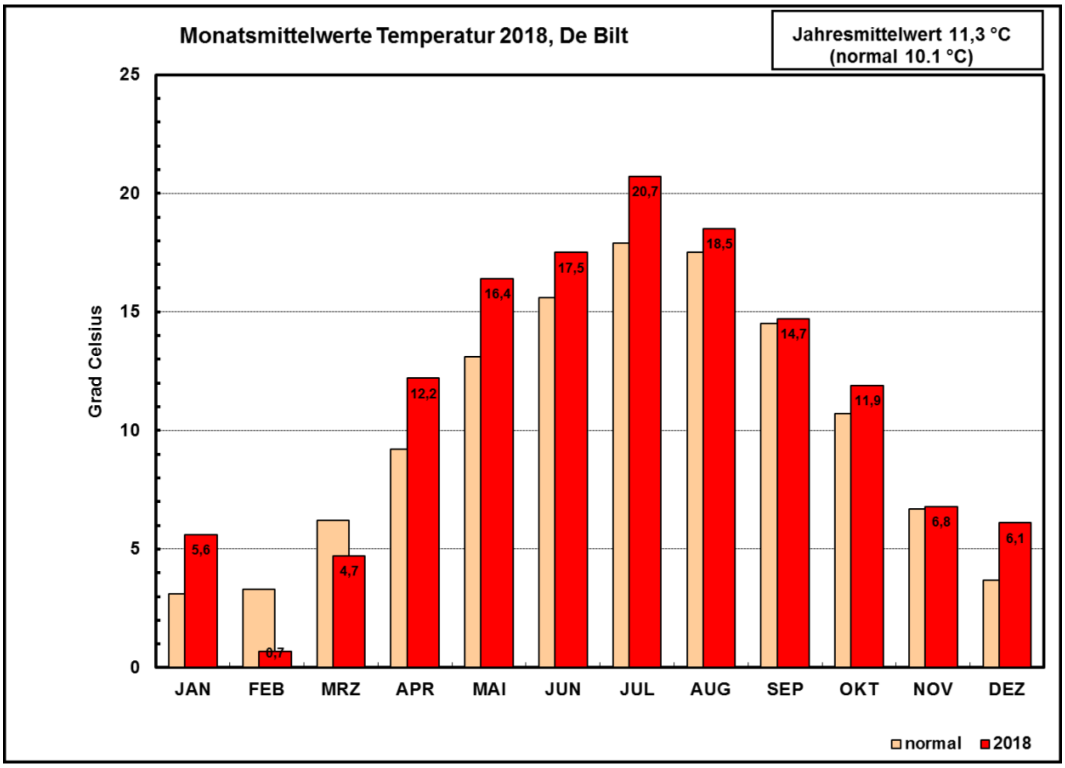


Figure 8: Monthly average temperature values at the De Bilt station in 2018, compared to the perennial (1981-2010) mean value (source: KNMI)

January was very mild, with an average temperature of 5.6 °C, with no real wintry conditions. February was cold at 0.7 °C, with a period of frost towards the end of the month and in the first few days of March. On 28 February, the lowest temperature of the year was measured at the station Woensdrecht at -10.5 °C. Spring was generally very mild, but showed her various moods. March was too cold, on average, while April was very mild and very wet. In April there were two summery periods. Precipitation often fell in a short time and in intense showers. May 2018 was the warmest May month in at least 300 years, with an average temperature of 16.4 °C. A long period of summer weather began in May, interrupted by short cooler periods, up to and including September.

The summer of 2018 was the warmest in De Bilt since 1901, with an average temperature of 18.9 °C. It was also very sunny and dry. June was almost 2 degrees warmer than normal, averaging of 17.5 °C. The month was also especially dry. July was the second warmest July month since 1901, with an average temperature of 20.7 °C. On July 26, the highest temperature of the year was measured, at 38.2 °C, at the Arcen station. This value was only 0.4 °C below the highest-ever measured temperature since 1901 in the Netherlands. The month of August was also very hot, but after a very hot and dry start, the weather became more changeable, with lower temperatures.

Autumn was mild; the sun has not shone as consistently since 1901. Autumn was dry too. September started out warm, but ended up being cold with the first frost of the winter season showing up at the end of the month. On average, the temperatures were normal. October was mild and very sunny. At the end of the month, it was cool and wet, and the south of the country even had wet-snowfall. November was very sunny and December was very mild, at 6.1 °C.

With 2090 hours of sunshine, 2018 was an extremely sunny year. The multi-annual average is 1639 hours. All months, except for January, were sunnier than normal.

With an average of 607 mm of precipitation, 2018 was particularly dry. The multi-annual average value is 847 mm. The dry, hot summer caused a water shortage, especially for agriculture and shipping. The Rhine reached its lowest water level since the beginning of recorded observations at the Lobith gauge, in November.

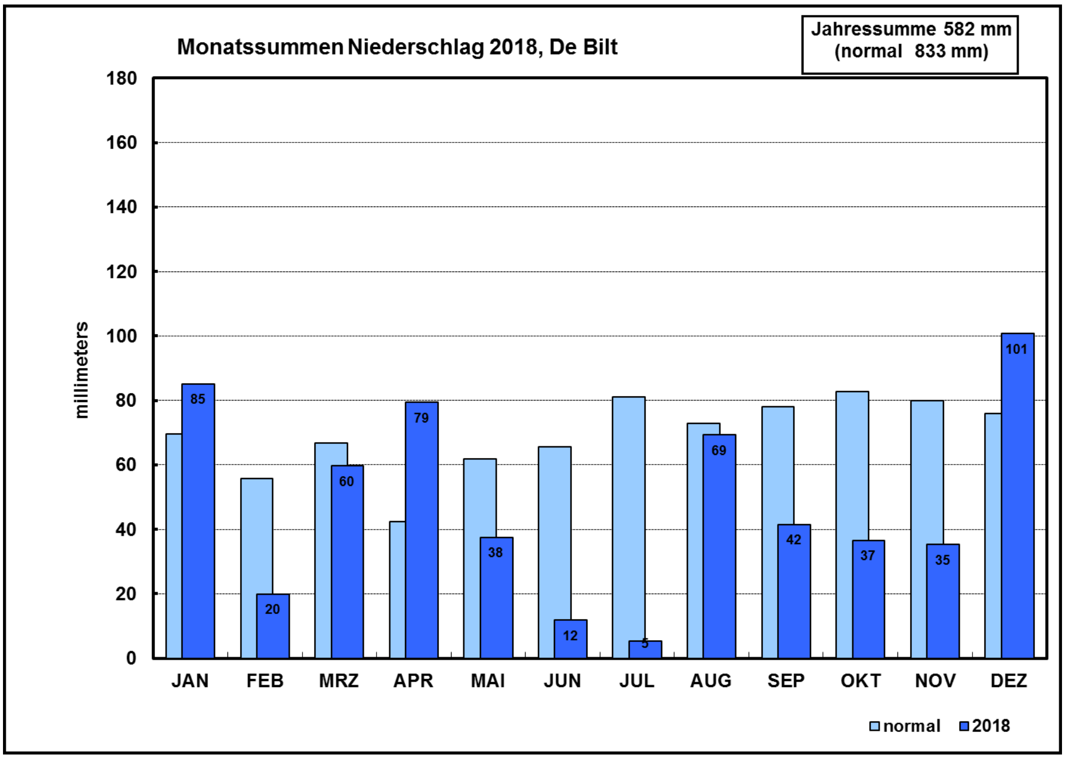


Figure 9: Monthly sums of precipitation at the De Bilt station 2017 compared to the multi-annual (1981-2010) mean value (source: KNMI)

Almost no snow fell. During the short cold period at the end of February/beginning of March, some snow fell in various places but quickly disappeared again.

Snow and glaciers

Source: Snow: WSL Institute for Snow and Avalanche Research SLF
Glacier: Geographical Institute of the University of Fribourg and Research Institute for Hydraulic Engineering, Hydrology and Glaciology (VAW)

At the end of October 2017, the weather was already quite wintery above the 2500 m above sea-level mark. In the west and south, however, October was extremely dry, and the mountains were mostly snow-free, right up into the high mountains. Throughout November, it snowed every weekend, sometimes quite intensively. Seen throughout the month, the snow depths in November were above average in the mountains of the northern Alps and the northern Valais. Otherwise, they were slightly below average. In low altitudes there was much less snow than usual. Overall, snow depths along the main ridge of the Alps were below average in December, from Upper Valais to the Upper Engadine, and in the lowlands of German-speaking Switzerland, above average in all the other areas. Above-average snow quantities covered the northern slopes of the eastern Alps, also in the valley soles of Valais and Ticino.

The new year started off with extremely rainy and mild conditions. By January 23, 2.5 to 5 m of snow had fallen in the higher altitudes, within a period of 25 days. Even though conditions remained essentially dry afterwards, the snow depths in January were clear in the medium and to high altitude range, even massively above average in Valais. In low altitudes, however, the amount of snow was significantly below average.

Hardly any snow fell in the lowlands throughout February. Thus, the same picture of snow depths emerged as had already been the case at the end of January.

In March, several weak snowfalls in the north also temporarily provided some snow to the lowlands. With the heavy rainfall at the end of the month, slightly above-average new-snow values were recorded. At the end of March, 2 to 4 m of snow was measured in the entire Swiss Alp area, except for central and southern Ticino and parts of the Engadine. Thus, the snow depths were one and a half to two times as high as usual in various locations. However, even when viewed over the whole of March, the snow depths were higher in altitude, while, in contrast, in low elevations, they were below average.

Snow-melting proceeded rapidly in April. At high altitudes, the snow depths decreased by more than one meter, north of the Rhône. To the south of this region, the decrease was just under one meter. By the end of April, the snow depth had approached the long-standing average, even in higher altitudes.

May was also exceptionally warm and, despite continued thunderstorms, low rainfall was recorded in most areas. The snow depths continued to decrease rapidly. At high altitudes, they were below average on the central and eastern slopes of the Alps, in Grisons and in Ticino, at the end of the month. In the west, there was still slightly above average snow-depth, in the Vispert valleys, and in the Simplon area, above average.

On the Swiss glaciers, huge snow depths were measured in April and May 2018. These were 20 to 70% deeper than the norm. Especially in Valais, the glaciers were extremely well-covered in snow at the beginning of the melting period. However, the warm spring and early-onset summer months have added to the snow coverage and the ice quickly became devoid of snow. Due to the level of dryness, there was no significant snowfall on the glaciers throughout the summer. In average years, fresh snow occasionally still falls in the summer months, and thus the melt is significantly reduced for a few days. In the very hot month of August, continuing until the end of September 2018, the melting of glaciers was extreme.

According to measurements on 20 glaciers, the glacier mass balance, i.e. the balance between growth due to new snow and loss due to melting, is once again a negative mass balance in all parts of the country. The protection of the thick snow cover was far from sufficient to ensure a stabilized balance, given the ongoing hot phases: the glaciers have reduced massively in volume. Many glaciers experienced reductions in its average ice thickness, ranging from 1.5 m to 2 m, some significantly more. Thanks to the increased amounts of snow during the winter period, the glacier's reduction in thickness in southern Valais was less than 1 m lower (than before) (e.g. on the Allaling Glacier, the Findelen Glacier and the Glacier de Giétro).

An overall loss of about 1400 million cubic meters of ice is estimated for all of the 1500 Swiss glaciers, in the hydrological year 2017/18. The current existing overall glacier volume has therefore decreased by more than 2.5% this year. In total, over the past ten years, nearly one-fifth of the remaining glacier ice has been lost. This could cover the entire area of Switzerland evenly in 25 cm's of water. The glacier melt in the summer of 2018 was exceptional. It was only due to the enormous amount of snow in the winter of 2017/18 that a record loss of glacier ice was prevented. For example, 2018 is on the same level as the exceptionally hot summers of 2015 and 2017, after 2003. However, the accumulation of extreme years is especially challenging for the stability of small glaciers, especially. Many of them are swiftly disintegrating.

Hydrological Status of the Rhine Region in 2018

Water Levels of the Large Lakes in the Rhine's Catchment Area.

Austria
At the beginning of the year, the water level of Lake Constance was slightly above the long-term average value, measured from 1864 - 2017, for the respective calendar days. The above-average rainfall in January, together with mild temperatures, meant that the highest daily averages, when compared to calendar days, were measured since 1864, between January 21 and February 11. The below-average rainfall in February and March reduced the water level to a seasonal average by the end of March. The melting of snow in the Alps in mid-April led to a rise in the water level, with the highest level being reached on June 14, 2018. Subsequently, until the end of November, below-average conditions prevailed. Only as a result of the rainfall in December, did the water level rise again significantly, and from December 24 to the end of the year, the values were above the average for the respective calendar days within the observation period: 1864-2017 (see Fig. 10).

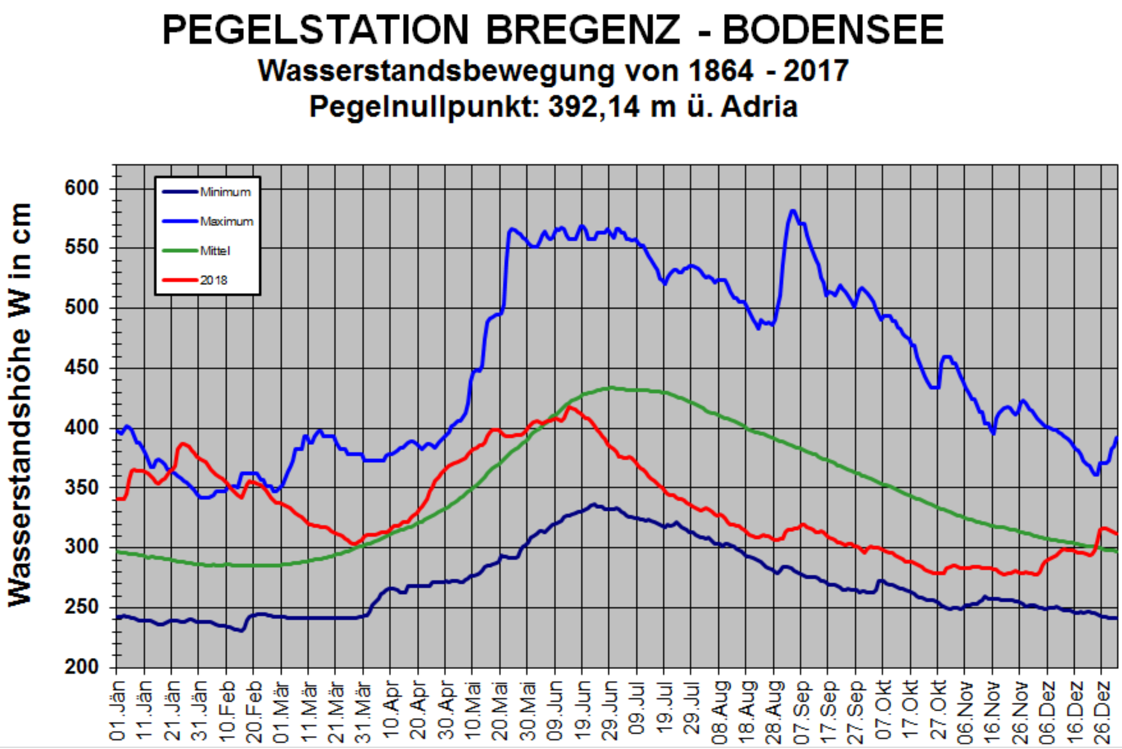


Figure 10: Water level measurement values from existing charts for Lake Constance at the gauge level in Bregenz in 2018 (red curve), compared with long-term minimum and maximum values, as well as the averages

Switzerland
In 2018, the distinct lack of rainfall also became evident in the lake water levels: the annual average for the water levels for most of the large lakes were below the long-term average. At -21 cm, Lake Maggiore deviated most from the norm. There were also two-digit deviations in Lake Constance (Untersee), Lake Walensee and Lake Zug. Such major deviations are not unusual for Lake Constance, Lake Walen and Lake Maggiore, but it is unusual for Lake Zug. The measurement was at -13 cm; the last time a deviation of more than 10 cm was recorded, was in 2003. The water level fluctuated within much narrower parameters on regulated Lake Zug than on some other lakes. The difference between the highest and lowest measured values at Lake Zug, for the entire measurement period, is 135 cm. For comparison: Lake Constance's fluctuation is over 330 cm, Lake Walensee's is around 420 cm and Lake Maggiore's is more than 550 cm. None of the great lakes of Switzerland showed the lowest annual averages. Not even on Lake Zug: On August 22, the level equalized again, at 413.11 m above sea level. However, the annual average in 2018 remained at 10 cm above the value for 1949, and at Lake Zurich, the annual average was only 1 cm above the lowest average in 1951.

Due to the exceptionally high rainfall in January, the levels of Lake Constance and the Jurarand lakes reached very high levels for the season. Lake Neuchâtel, Lake Biel and Lake Constance showed new maximum values for January. At Lake Constance, the maximum value for February was also the highest since measurement first began. Lake Constance had already started off the new year at a high level. Except for a short period from the end of March to the middle of April, the water levels until the end of May were partly well above the long-term seasonal average. While the high-water levels on Lake Neuchâtel did not reach the threshold of flooding risk level 2 in January, this status was reached at Lake Biel for a short time.

In contrast to the high levels from the beginning of the year, the low levels stood out in the second half of the year, due to the continued drought. New monthly lows were recorded at Lake Constance and Lake Lucerne in July; in July and August at Lake Zugersee and Lake Zurich, and Lake Walensee in August. New November minimum values have been registered for the Jurarand lakes. Apart from September, Lake Zurich recorded a new monthly minimum value, for all the months of the second half of the year. This resulted in a very low annual average of 405.89 m above sea level. At Lake Geneva, apart from three short phases with above-average water levels, the well-worn routine followed, i.e. the second half of the year, the levels were recorded within very tight parameters,

At Lake Maggiore, thresholds relevant to the flood warning were exceeded at the beginning of November for about two weeks. The highest water level of the year was 195.36 m above sea level, measured on November 7. This value is 86 cm above the risk level 2 threshold. Only one month before, on October 8, the level was still at 192.27 m above sea level, the lowest level of the year. Rapid increases in levels are observed from time to time at Lake Maggiore. However, a rise of 3 meters in just a few days is a rare event, even for this location. At Lake Lugano, flooding risk level 2 was not attained. The highest value of the year remained 2 cm below the corresponding threshold.

Water levels and draining of flowing waters

Austria

The outflow of the Alpine Rhine was below the long-term average in 2018. In the case of the other inflows into Lake Constance from Austria, the below-average rainfall also led to below-average outflows. Annual volumes compared to the multi-annual average (1951 — 2017 Alpine Rhine, Bregenzerach and 1984-2017 Dornbirnerach)

- at Bregenzerach 83% (LT Avg. (LT Avg.= Long-term Average) for 2018 = 38.8 m^3/s, LT Avg. = 46.6 m^3/s);
- at Dornbirnerach 61% (LT Avg. 2018 = 4.31 m^3/s, LT Avg. = 7.11 m^3/s);
- at the Alpine Rhine 92% (LT Avg. 2018 = 212 m^3/s, LT Avg. = 231 m^3/s).

Switzerland

From 30% below to 30% above the values of the 1981-2010 standard period: this is the considerable range within which the annual means of outflow ranged in 2018 in the large river areas. The Thur forms the lower boundary of the area, and the Maggia the upper boundary of the area. In between, the average annual outflows of the Limmat and Birs attained about 80% of the norm; about 90% was measured at Aare, Reuss, the Alpine Rhine, Inn and Ticino. The outflow of the Doubs was very close to the long-term average and that of the Rhone slightly more than 10% above average.

In the medium-sized catchment areas, the annual average outflow was only slightly higher than in the large river basins. At the bottom end, with drainage volumes ranging between 65 to 70% of the standard volumes, with their catchment areas are mainly found in Central (Lorze, Suhre) and north-east Switzerland (Murg, Glatt, Sitter). The same figures appply to Broye and Brenno. For the Lorze, 1.9 m^3/s is the lowest annual average of the entire measurement period, since 1983 (previously 2.1 m^3s in 1997). The modest tributary which flows to Lake Zug resulted in its water level in August to have been the lowest level ever measured there. Unsurprisingly, the outflow from the heavily glaciated catchment area of the Massa was significantly above average: the annual outflow from the Aletsch Glacier was more than 30% above the long-term average.

When you switch your viewpoint from annual outflows to monthly and daily outflows, there are several special situations that stand out:

- On the northern side of the Alps, from western to eastern Switzerland, as well as in Valais, there were two major run-off events in January, followed by a third, smaller event in February. On the northern side of the Alps, two discharge waves were also clearly and visibly flowing during the course of December.
- In barely-glaciated, or non-glaciated areas, drainage volumes fell from mid-June to early December. The steady decline in water volumes was only interrupted by a few small events. In areas with a greater degree of glaciation, the outflows from the melt were above-average, from April to June. In areas with a high proportion of glaciers, such as the Massa catchment area, the surface of which is covered over 50% with ice, the outflows for the summer and autumn months were significantly higher than the corresponding values for the standard period.
- On the southern side of the Alps, at the end of October and early November, the two large Ticino catchments and the Maggia, showed a rapid and distinctive increase in outflow volumes.

The record-high rainfall in January caused numerous stations in the drainage network to experience the highest January maximum volumes ever recorded, as well as extraordinary monthly averages. The monthly average was frequently more than double (e.g. Aare, Reuss, Limmat, Thur), and in some catchment areas three to four times the corresponding long-standing average values (e.g. Emme, Lütschine, Muota, Maggia). Two events at the beginning of the year deserve a special mention: Low pressure event Burglind crossed Europe on the 2nd and 3rd of January. The intense rainfall led to 2-yearly outflow peaks at around 20 stations on the northern side of the Alps; at ten stations the annual disparity was even greater. From January the 20th, very moist and mild air pushed into Switzerland from the northwest, in several surges. The snow and rains in combination with a thaw in the already-heavily-pre-loaded catchment areas, led to similarly high, or even higher, drainage peak volumes and lake volumes when they occurred at the beginning of the month. At Lake Biel, Neuchâtel and Lake Constance, levels rose to new peaks for January. After the dry summer, above-average rainfall only occurred again on the northern side of the Alps in December. After striking levels at the beginning of the month, there was a moderate flood risk at Thur, Töss, Sihl, Hochrhein, along the Aare below Lake Biel, and on the Simme rivers.

The pronounced lack of rainfall in the summer can be easily traced in the discharge curves. The most extreme example is probably the Thur near Andelfingen, where the 2018 monthly outflows did not rise above 70% compared to the 1981-2010 standard period, with only 17% in July, and 15% in November. From June to December, new monthly minimum values were recorded at numerous measuring stations.

At the end of October and early November, intense rainfall occurred on the southern side of the Alps. Even though both the river drainage systems and the lakes were at low levels at the beginning of the event, flooding did not occur despite strong discharge volumes. At Ticino, near Bellinzona, and at the Maggia, near Locarno, the largest discharge volume of the year occurred on October 29. At Ticino, flooding risk level 2 was not reached by a clear margin, but the Maggia had risen to this risk level.

Several violent thunderstorms have led to mudslides and flooding in small and medium-sized catchments in 2018.; these are not all equipped with measuring stations. For example, at the beginning of July a devastating flood occurred in the Val d'Anniviers.

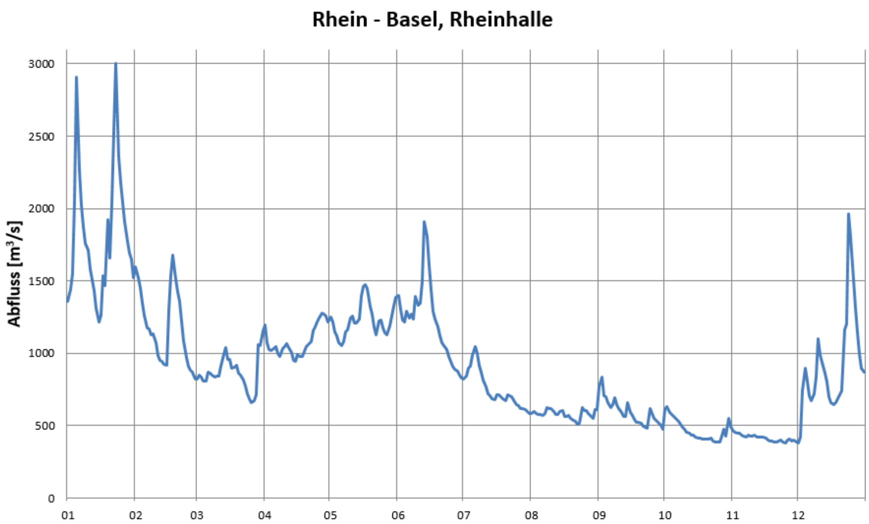


Figure 11: Water level measurement values at the Rhine - Basel, Rheinhalle in 2018

Germany

The water volumes in the 2018 hydrological year was initially characterised by significantly increased rainfall in the first three months (Nov-Jan), so that in December 2017 and, especially in January 2018, there were inter-regional flood situations associated with the snow-melts (illustrated in the discharge curves in Figures 12 to 17, see also BfG status reports[4]). In February, the influx of cold polar air on the southern edge of a strong northern European high-pressure area in Germany led to cold, sunny and dry weather (source: DWD[5]). The rainfall remained significantly below the average values throughout Germany, which affected the low water supplies and were reflected in the low recorded water levels.

In 2018, the annual LT Avg. at the gauges on the Rhine was close to the annual average (94 - 100%, see Tab.2) due to the largely compensating winter flood and summer low water phase. The Neckar and the Main also deviated by only -5% and +4% respectively. On the Moselle, the

[4] https://www.bafg.de/DE/07_Nachrichten/Archiv/2018/20180105_hw.html

[5] https://www.dwd.de/DE/leistungen/pbfb_verlag_monat_klimastatus/monat_klimastatus.html

LT Avg.2018 was 117% compared to the LT Avg. obtained from the long-term recordings (1931-2011).

The ratio of the winter to summer LT Avg. for the Rhine had reversed at the Maxau level against the long-term observations, for example, the winter half of 2017/2018 accounted for 63% of the discharge volumes, compared to 45% in the long-term average. At the Kaub gauge and at Cologne on the Rhine, as well as Rockenau/Neckar and Cochem/Moselle, seasonality did not reverse conditions, as in Maxau, but also showed much higher discharges in the winter half of the year than in many previous years' comparison (period 1931/2011).

Table 2: Comparison of average discharges (LT Avg.) in 2018 for selected gauges in the Rhine region, as well as in relation to the long-term comparative period (1931/2011) except Rockenau, Raunheim)

Level	*LT Avg. (Long-term Average)*			*LT Avg. 2018*		
	2018	*1931-2011*	*LT Avg. 2018 as a % of LT Avg. of the long-term comparative period*	*Winter*	*Summer*	*% Wi-/Su (comparative period of several years)*
Maxau (Rhine)	1169	1250	94%	1462	876	63/37 (45/55)
*Rockenau (Neckar) * 1951-2011*	130	137	95%	202	57	78/22 (64/36)
*Raunheim (Main) * 1981-2011*	230	221	104%	362	98	79/21 (68/32)
Kaub (Rhine)	1609	1650	98%	2154	1063	67/33 (51/49)
Cochem, Moselle	367	314	117%	619	114	84/16 (64/36)
Cologne (Rhine)	2104	2110	100%	2982	1227	71/29 (55/45)

As Figures 12 to 17 show, annual average discharges (LT Avg.) at the Rhine gauge Maxau were below 232 days, 91 days in the winter and 141 days in the summer. In Kaub there were less than 230 days (winter 69 to summer 161) and in Cologne, on 226 days (54 to 172). The inflows were below the average values for the observation period to Neckar and Main at 269, 234, and 224 days respectively, with the winter/summer ratio to Neckar (89/180) and Main (52/182) and the Moselle (48/173).

In the MNQs, which had been determined for many years, the average underflow-volume levels for the Rhine were 63 days, in Rockenau/Neckar, 46 days, in Raunheim/Main it was 30 days, the Cochem/Mosel level was the most extreme, with 92 days.

Underflow-volumes in the summer half-year was established, with the monthly outflows (LT Avg.) observed in Maxau at 246 (winter 71/summer 175) days, in Kaub at 251 days (78/173) and in Cologne at 247 (76/171) days. At Rockenau/Neckar, it was at 288 (115/173) days, at Raunheim/Main at 251 (78/173) days and at Cochem/Mosel at 196 (43/153) days.

Similarly, significant underflow-volumes, below the average monthly lowest outflows, (mMNQ) were recorded at the Rhine levels: an average of 140 (2/138) days, 158 (23/135) days for Rockenau/Neckar, 115 (13/102) for Raunheim/Main and Cochem/Mosel were below the mMNQ at 134 (13/121) days.

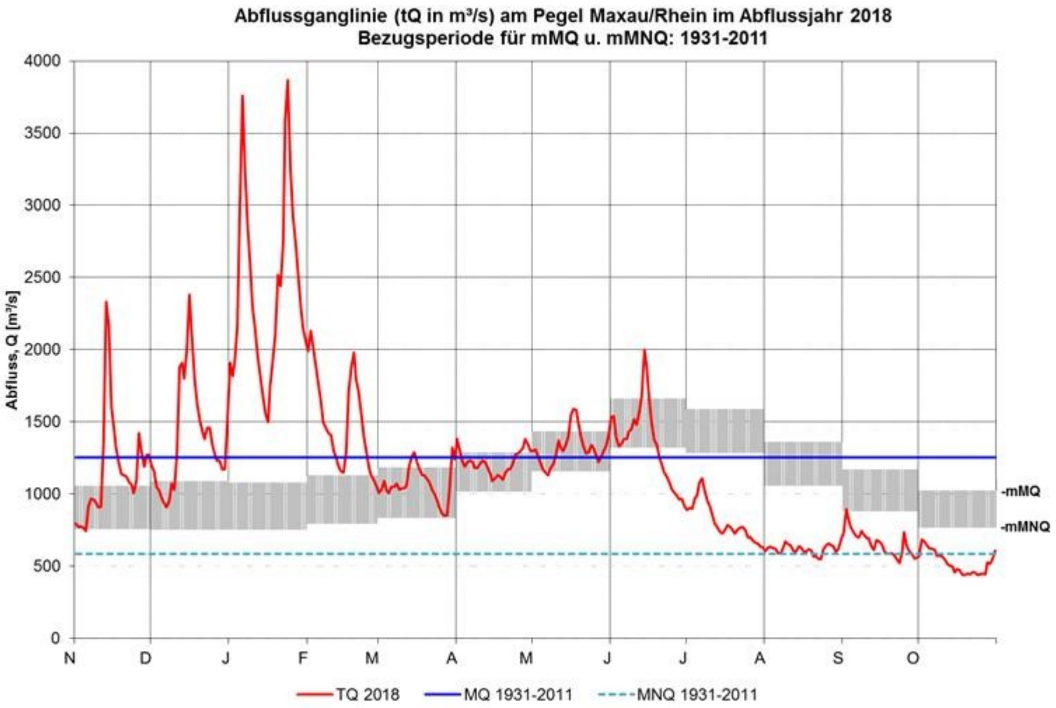


Figure 12: Daily discharges (tQ) at the gauge Maxau (Rhine) in 2018 compared to long-term averages in m³/s (reference period for MQ, MMQ and MMNq: period 1931-2011)

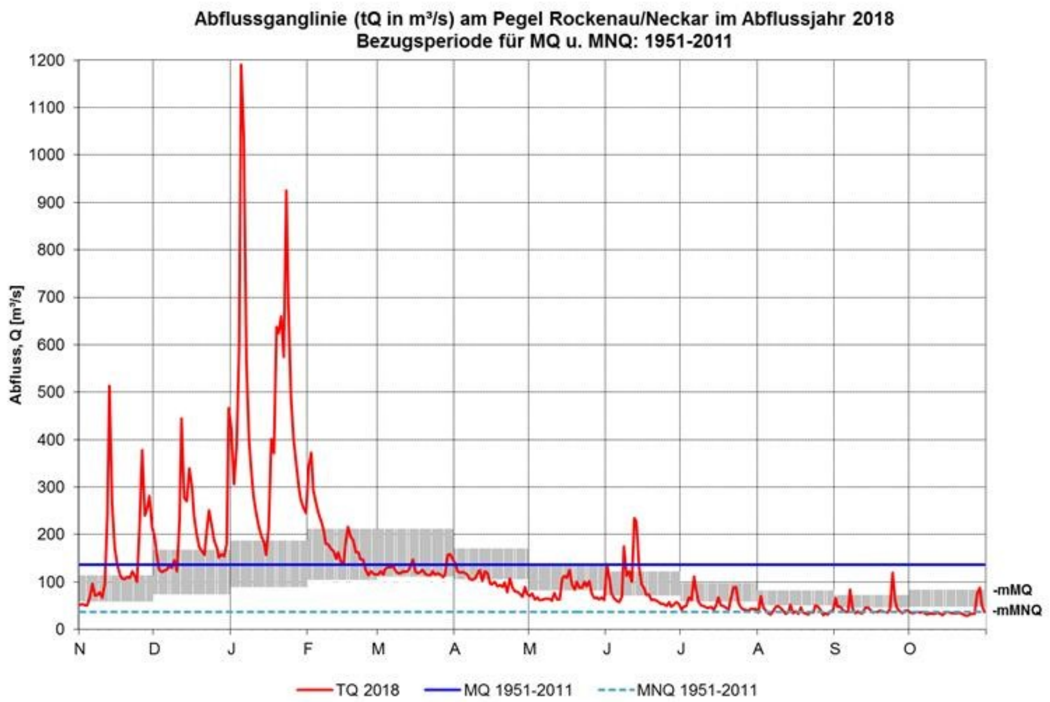


Figure 13: Daily discharges (tQ) at Rockenau (Neckar) gauge in 2018 compared to long-term averages in m³/s (reference period for MQ, MMQ and mMNQ: period 1951-2011)

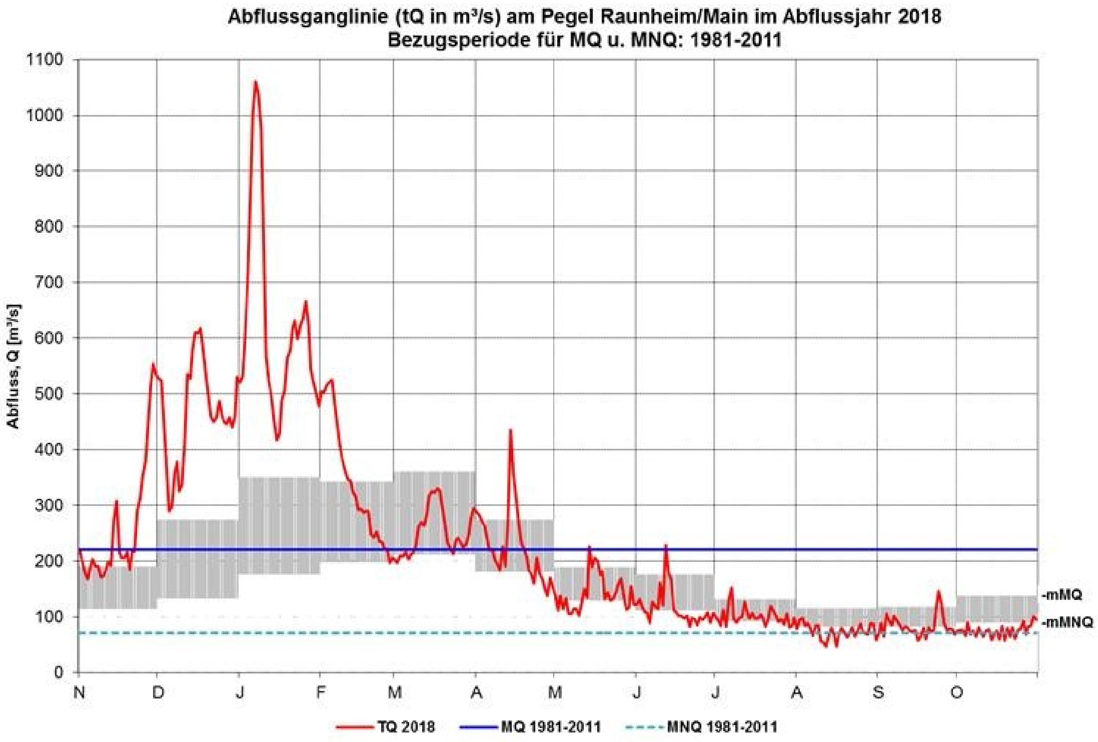


Figure 14: Daily discharges (tQ) at the gauge Raunheim (Main) in 2018 compared to long-term averages in m³/s (reference period for MQ, MMQ and mMNQ: period 1981-2011)

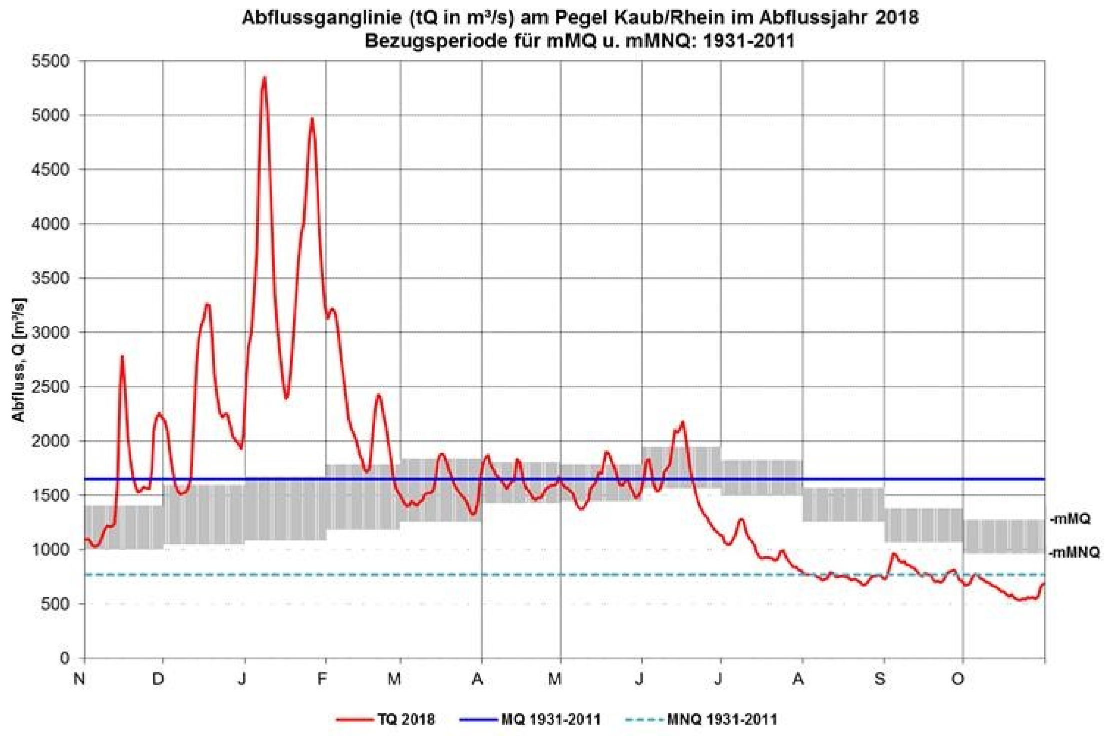


Figure 15: Daily discharges (tQ) at Kaub (Rhine) gauge in 2018 compared to long-term averages in m³/s (reference period for MQ, mmQ and mMNQ: period 1931-2011)

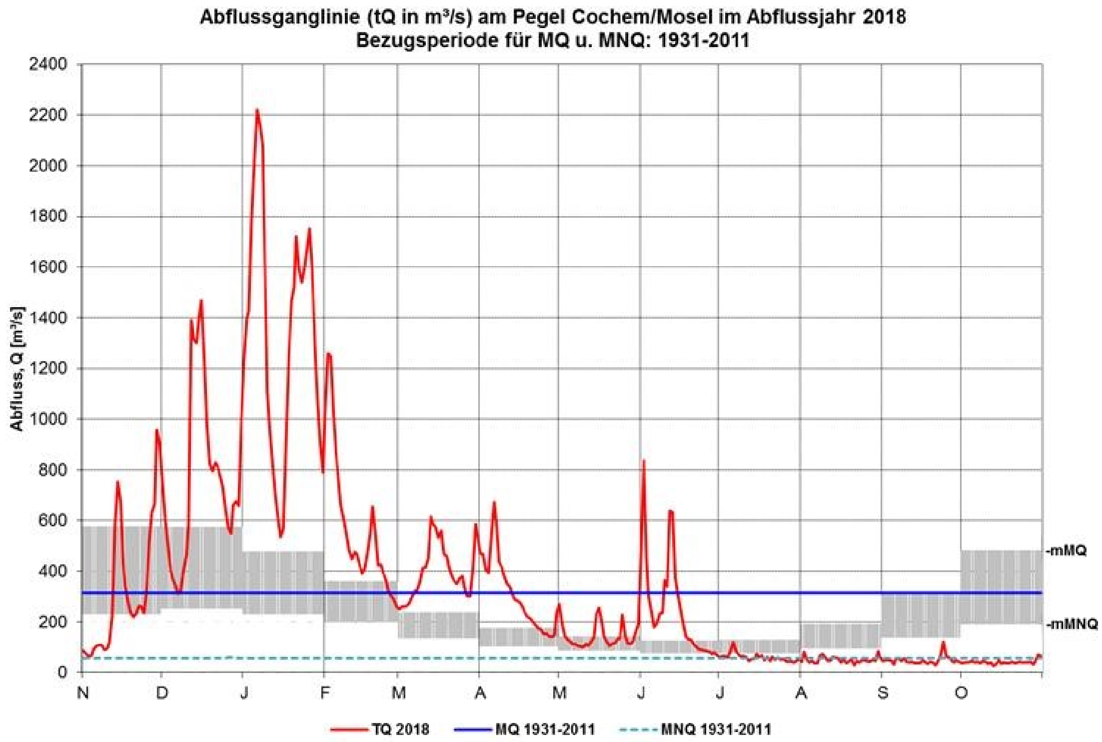


Figure 16: Daily discharges (tQ) at the Cochem (Mosel) gauge in 2018 compared to long-term averages in m³/s (reference period for MQ, MMQ and mMMQ: period 1931-2011)

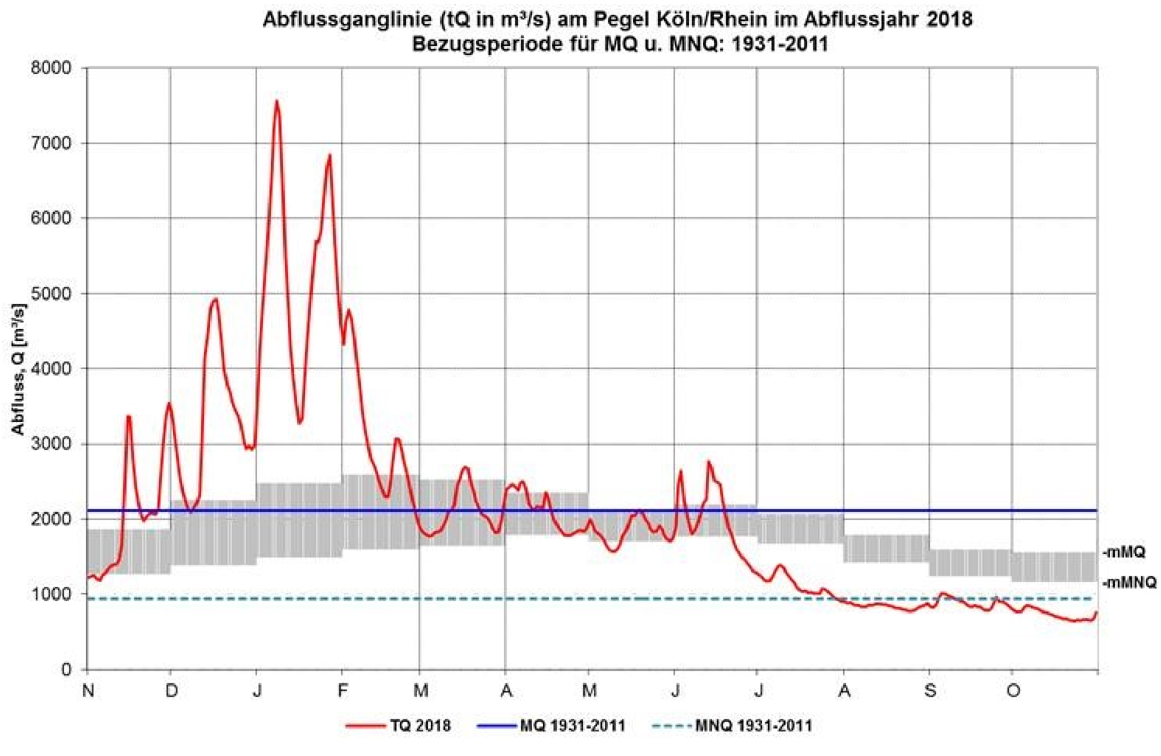


Figure 17: Daily discharges (tQ) at the Cologne (Rhine) gauge in 2018 compared to long-term averages in m³/s (reference period for MQ, MMQ and mMNQ: period 1931-2011)

The Netherlands
2018 has been one of the driest years for the Netherlands since the very beginning of regulated recordings. Since 1901, there have been only four drier summers than the summer of 2018; there were only two years in which the discharge of the Rhine at the Lobith gauge was lower than in autumn 2018, and the water level was the lowest since measurements were initiated. As a result, there was a water deficit, which necessitated that available water had to be distributed according to priority.

The low water levels from March - December is a contrasting scenario to the beginning of the year. In January 2018, there were two periods with increased water levels that led to flood reports and the warning code: "yellow". The maximum water level of 2018, at the Lobith gauge, occurred on January 10, with a value of 14.64m +NAP (7530 m3/s). This increased water level situation was followed by a new wave, with a peak of 14.20 m +NAP (6900 m^3/s) on January 28. Comparable levels have a recurrence period of 2 to 5 years.

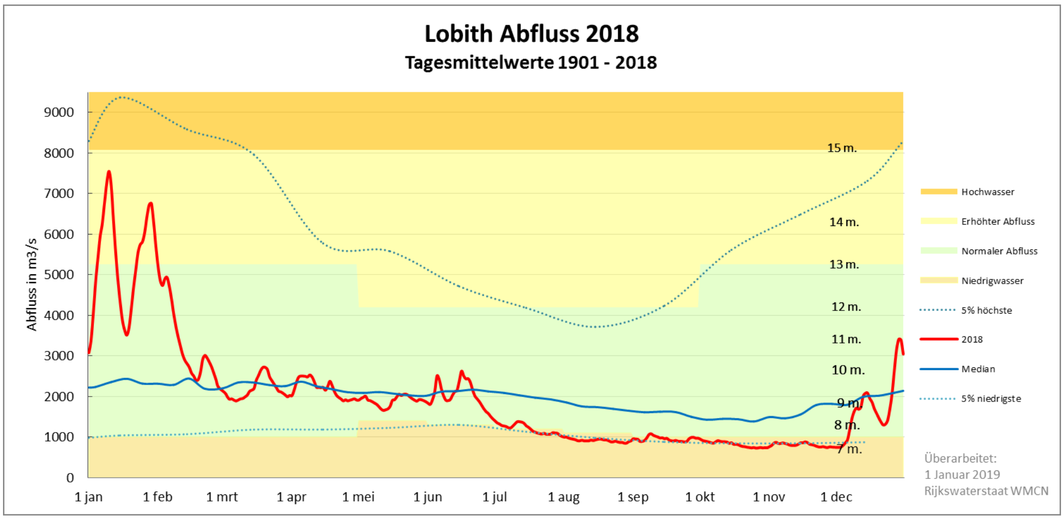


Figure 18: Daily average discharges at the Lobith gauge in 2018 (red curve) compared to the long-term minimum, maximum and average levels for the years 1901-2018

Water Temperatures

Austria
The annual water temperature average of Lake Constance was 13.9 °C, which is 1.9 °C above the long-term average value of 12.0 °C at the Port of Bregenz. Both in winter, in January, and in summer, in July and August, new daily maximums for the respective calendar day have been recorded, since the beginning of continuous measurement of water temperatures, initially observed in 1976. With few exceptions, the daily average was higher than the daily average of the multi-annual period 1976-2017 (see Fig. 19).

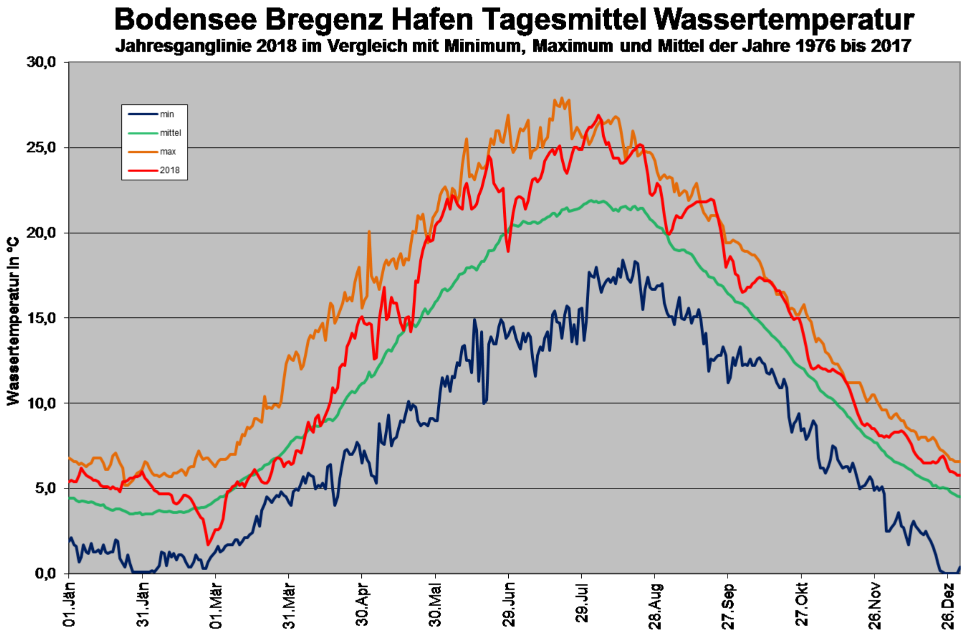


Figure 19: Measurement values of the water temperature of Lake Constance at the Bregenz gauge in 2018 (red curve), compared with the long-term minimum, maximum and average levels for the years 1976-2017

Switzerland

The annual air temperature averages reached record heights in 2018. This was also a new record year of annual temperature averages for Swiss flowing water temperatures. Compared to the previous extreme years of 2011, 2014 and part of 2015, new maximum annual average water temperature values were measured in 2018 at an exceptional number of measurement stations. In total, this affects more than 50 stations within the measuring network. The record figures are mainly found in Jura, in the Rhine valley below Lake Constance, in the Mittelland (Central Plateau) and in southern areas such as the Lake Geneva region and the Southern Alps (TI and GR).

At the beginning of 2018, more intensive heat surges had already occurred. For most rivers, the outcome was significantly above-average water temperatures, already evident in January and partly also until February. As early as February, water temperatures again decreased, and then in March, to some extent, it fell significantly below the longstanding average. At some stations in the Mittelland (Central Plateau), in the western and eastern central Alps, as well as in the southern flank of the Alps. This cooling-down effect led to the lowest values ever for this month, since the beginning of the recorded measurement period.

The strikingly warm spring temperatures from April caused sharply-rising and above-average temperatures for the waters. However, the exceedance of the previous maximum values for the corresponding months was not evident.

Only during the summer months, with its long, hot periods, the sunshine hour records and the decreasing drainage, massive warming of Swiss flowing waters occurred. While in July, some stations in the Upper Rhine Basin, the Mittelland (Central Plateau) and the Southern Alps had already exceeded the previous maximum values for the long-term measurement period; in August there was a significant increase in the number, i.e. more than 30 stations, exceeding the previous maximum temperatures. This affected mainly the western plateau, the Upper Rhine

Basin, the Lake Geneva region, and once again, the southern flank of the Alps. In September, this trend declined significantly.

From July to September, some stations had also exceeded the previous maximum values for each consecutive month. At the Vorderrhein-Ilanz station, the temperature fluctuations were so extreme that not only the highest-ever values were measured, but also the lowest-ever, in August.

From September onwards, especially in south-eastern Switzerland, the exceedance of the monthly peaks decreased; at the same time, the previous lowest levels were also increasingly exceeded.

In December, the number of stations, where only the previous temperature maximums were exceeded, increased slightly. Some minimums were below previous measurements. However, not for both minimum and maximum values. During the same period, however, both the maximum and minimum values were exceeded at three stations in the western Mittelland (Central Plateau), and at one station in the Southern Alps (GR).

Germany

The average water temperatures (WT) recorded for the observation period (Nov — Oct) is 0.2 K above the annual average at 14.1 °C at the Kaub measurement gauge. At the Cologne gauge, the average was exceeded aby 0.9 K at 14.9 °C. The greatest negative deviations for the monthly average, from the respective average measurements, were recorded at the Kaub measurement station in March with -2.6 K, and in Cologne in March with a value of -1.8 K. The greatest positive deviation from the monthly averages was at Kaub in July, with a value of 1.7 K and Cologne with a value of 2.0 K in August.

The maximum negative deviation with respect to the daily values in Kaub was -4.4 K on 02.03.2018 and at the Cologne measurement point -5.3 K on 01.03.2018. The greatest positive deviation was 3.9 K in Kaub on 09.06.2018 and 4.9 K in Cologne on 22.04.2018.

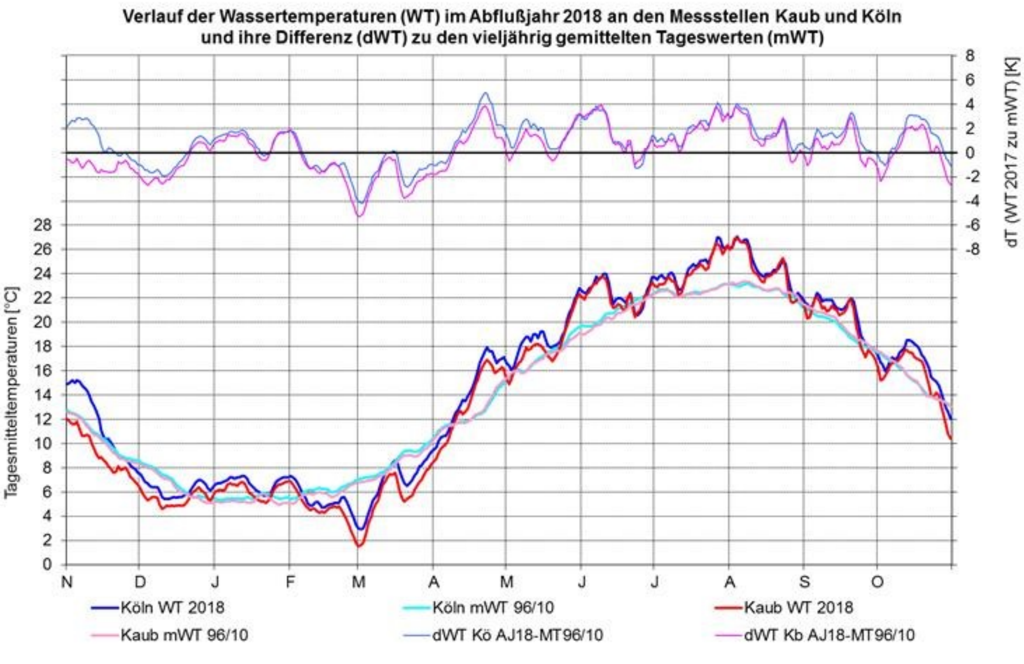


Figure 20: Water temperatures compared to the long-term averages (AJ=hydrological year; source: WSV)

The Netherlands

At the Lobith gauge, the average water temperature measured 15.7 °C, which was about 2.6 °C above the annual average calculated over multiple years (1961-2018) (see Fig. 21). For the highest average water temperature measurements over multiple years, 2018 came out tops (measurement period 1908-2018).

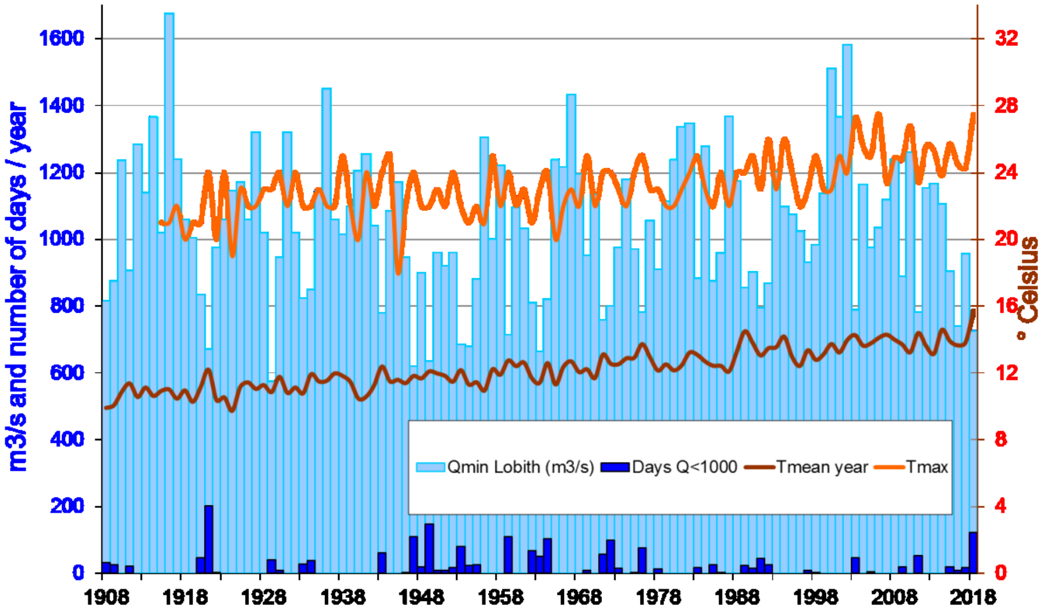


Figure 21: Mean and maximum water temperatures in 2018 at the Lobith/Rhine gauge

Groundwater

Austria

Groundwater levels were above average at the beginning of the year; they reached new maximum levels at some measuring points in January, with respect to this time of year Due to low rainfalls, groundwater levels fell almost continuously until November, only interrupted occasionally, by short periods when levels rose slightly. New minimum groundwater levels were recorded at more than a quarter of the measuring stations in 2018.

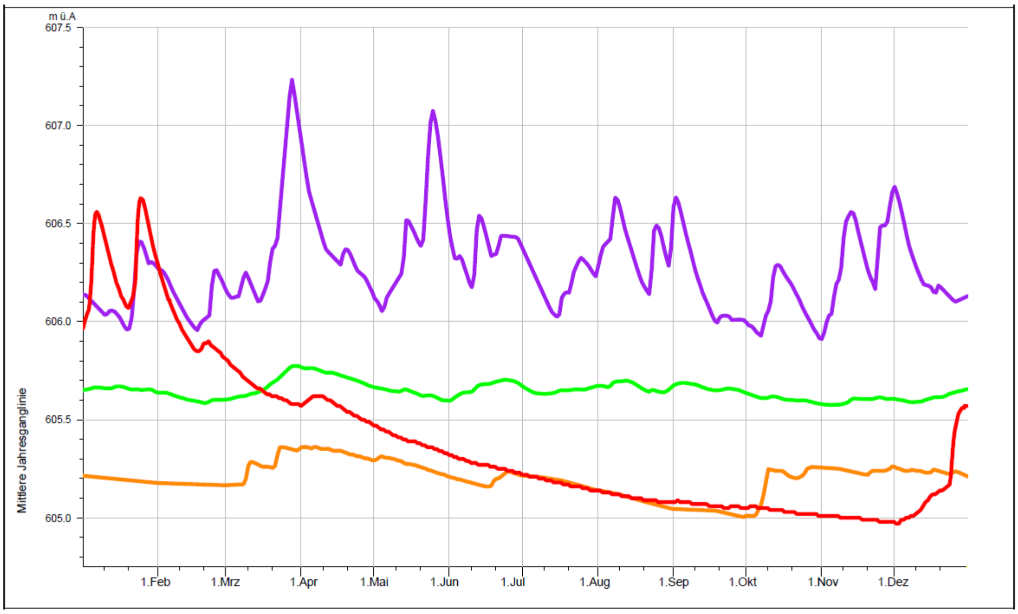


Figure 22: The graphs of the groundwater level in 2018, compared to long-term minimums and maximums- as well as averages (1985 — 2017) measuring point Andelsbuch Bl 30.1.03 (Bregenzerwald)

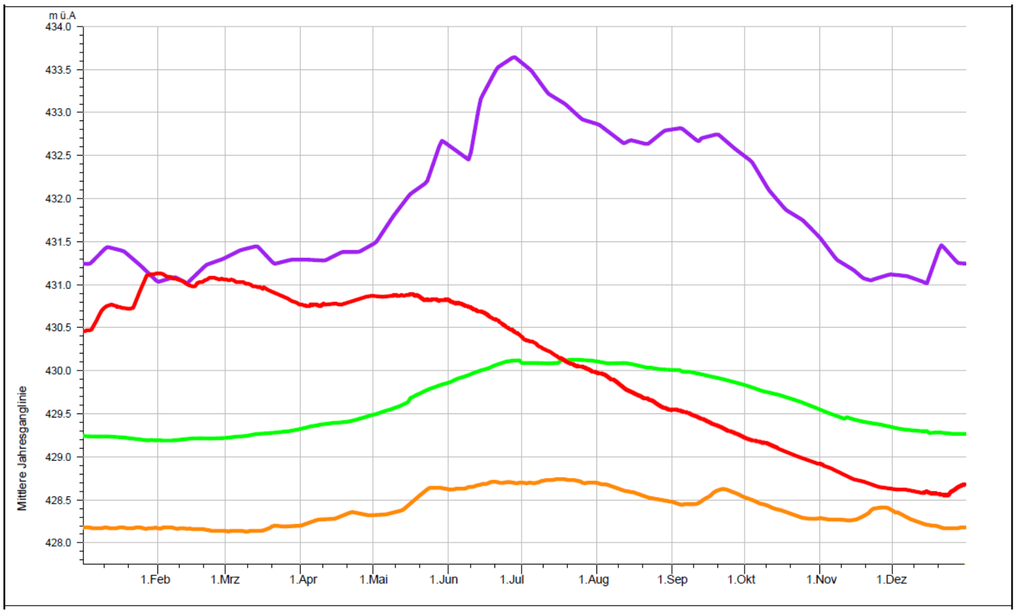


Figure 23: The graphs of the groundwater level in 2018 compared to long-term minimums and maximums- and averages (1954 — 2017) measuring point Feldkirch-Altenstadt, Bl 01.32.01 A.

Switzerland

In accordance with the long-term weather conditions (temperature and precipitation), Switzerland's groundwater levels often show perennial periods with rather low, and rather high, groundwater levels. In this regard, 2018 is in a period that has been continuing since 2015 with rather low groundwater levels and source drains.

At the beginning of 2018, groundwater levels and source drains were in the normal range, or above national levels, due to the high rainfall in December 2017. On the other hand, February 2018 was low in precipitation, with the consequence that the beginning of March there showed a widespread decrease groundwater levels and water-source drainage was within the normal range.

In April and May 2018, groundwater levels in Lockergestein's aquifers outside the river valleys decreased steadily due to the overall below-average rainfall; so, by the end of May, the first measurements with low groundwater levels were observed in Central and Eastern Switzerland. In the valley plains of the large rivers from the Alps, however, groundwater levels remained within the normal range due to the high rate of snow-melt.

As a result of the continued drought, the number of measuring points across the country which had low groundwater levels and water-source drainage increased from July to October. In October, for example, groundwater levels and water-source drainage in Switzerland were low at 60% of the measuring points. Occasionally, new monthly minimum readings resulted.

The intense rainfall in Ticino and Grisons from the end of October and early November caused groundwater levels and spring spills to rise there. On the northern side of the Alps, above-average rainfall fell only in December, which influenced mainly the shallow rock and karst aquifers close to the surface. In December, however, groundwater levels and source drains were still low at every third measuring point.

Suspended Solids

Austria

At 1.5 million tonnes, annual suspended solid volumes at the Lustenau measuring station in 2018 was almost 30% lower than the average for the years 2009 - 2017 (approx. 2.05 million tonnes). Distinct flood conditions were not evident in 2018. The highest monthly volumes were measured from April to June with the melting of snow from the Alps at about 300 000 ts for each month. June had the highest monthly volume with about 308 000 ts. This represents about one-fifth of the total annual volume.

The lowest daily volume was recorded in the winter months, measuring less than 60 tonnes; the highest daily volume was recorded on 30.10.2018 with a volume of 94 256 tonnes (6% of the annual volume).

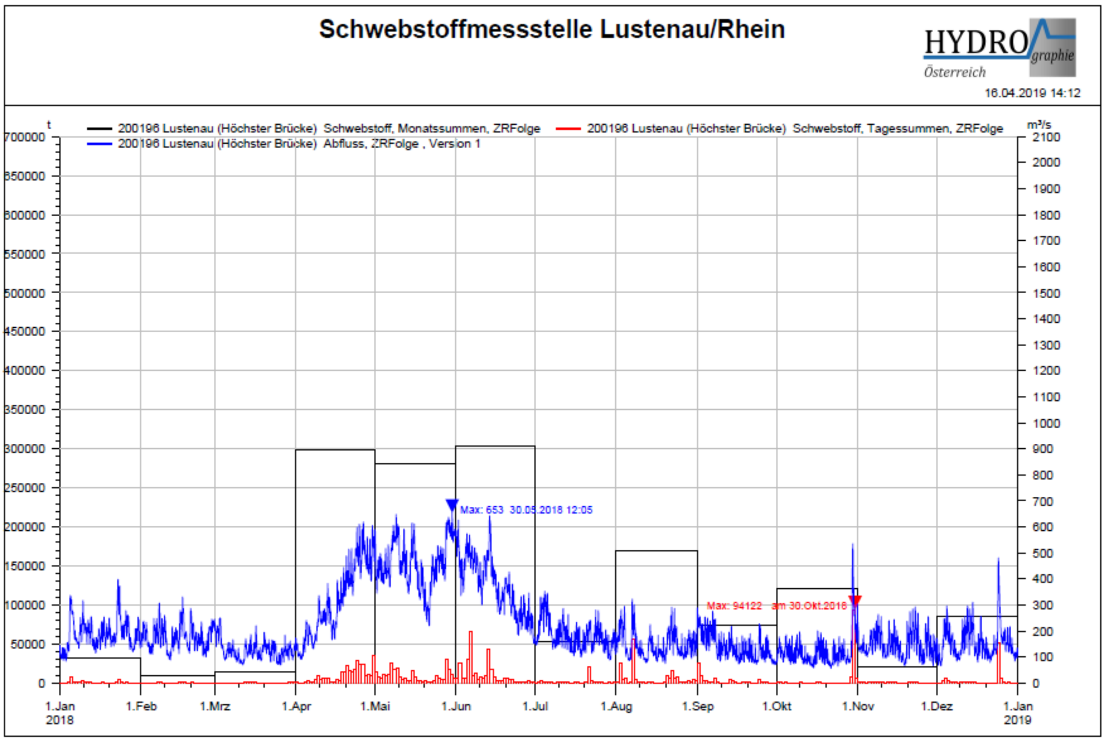


Figure 24: Monthly suspended solids in the Alpine Rhine at the Lustenau station in 2018, with daily volumes (red curve)

Germany
In order to obtain an overview of suspended solid volumes, data from the measuring points from Maxau (Rhine, along 362.3 km), for the Upper Rhine region, were evaluated (see also Fig. 25). For the lower Middle Rhine region (below the largest inflows), data could not be provided in sufficient form at the Weißenthurm measurement point (Rhine km 608.2), due to changes in the measurement methodology for the observation period.

As a rule, extreme peaks in daily volumes are caused by heavy rain events in summer, or by the onset of the thaw in winter. In January 2018, in addition to the unusually mild weather, heavy rainfall fell across Germany, especially above the central Rhine catchment area.

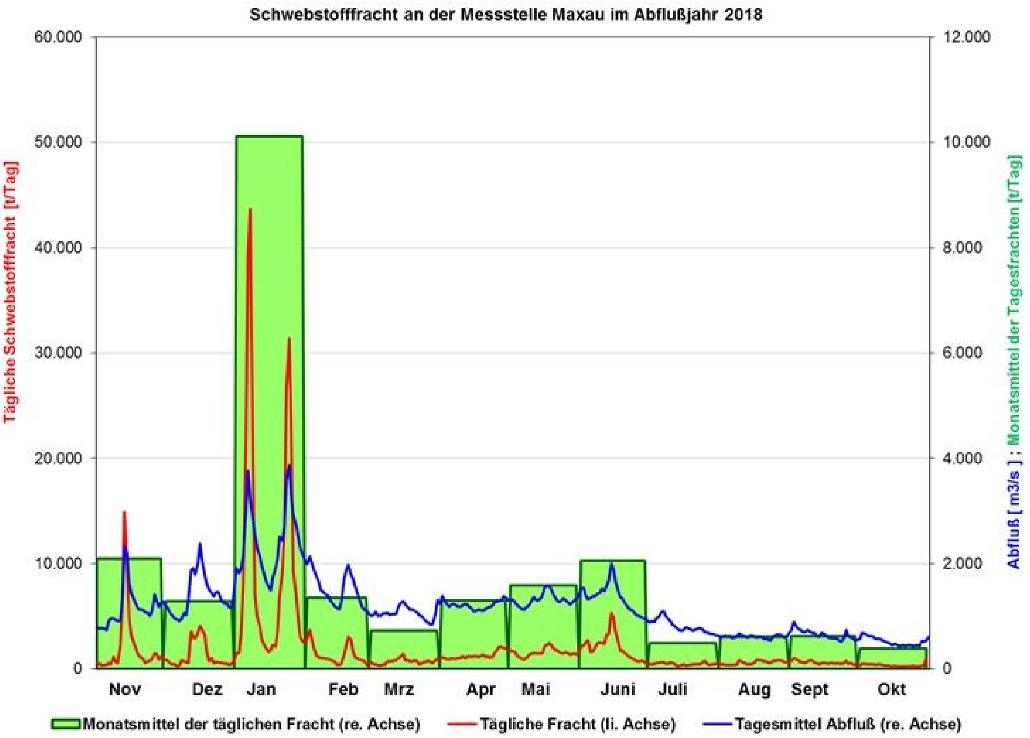


Figure 25: Maxau suspended solids measuring point, Rhine-km 362.3

At Maxau, the suspended solids volume for the 2018 outflow year (Nov - Oct) amounted to 690.358 tonnes, which corresponds to approximately 54% of the multi-year mean of the reference period 1965-2007.

The highest monthly suspended solid volume was measured at the Maxau measuring point in January 2018, at 313.350 t (monthly average: 10,108 t/day), which corresponds to approximately 45% of the total annual volume, the lowest monthly suspended solid freight was calculated at only 11,960 t for October 2018 (monthly average: 386 t/day).

The lowest daily suspended solids volume was recorded at the Maxau measuring point, at 230 t on 27.10.2018 with an average outflow of 516 m³/s and 43.679 t as the largest daily volume, with an average daily outflow of 3220 m³/s on 07.01.2018.

2. International Commission for the Hydrology of the Rhine basin (CHR) in 2018 Activities

The CHR met twice in 2018, on March 19 and 20, in Metz (France) and on September 20 and 21, in Kampen and Zwolle (Netherlands)

Personnel Changes within the CHR
During the spring session of 2018 in Metz, (Prof) Dr (of Engineering) Helmut Habersack was elected as the new chairman by the country representatives of the CHR for the next three years. Mr Habersack succeeds Mr Moser as President of the CHR. Prof. Habersack is a university professor at the University of Natural Resources and Life Sciences (BOKU) in Vienna, Institute for Water Management, Hydrology and Constructive Hydraulic Engineering (IWHW). During the spring session Prof. Dr Siegfried Demuth, as a representative of Germany, gave a farewell statement. Mr. Demuth retired in mid-2018. During the autumn session, the BfG representative, Ms Herzog, informed the CHR members that Prof. Demuth's successor had taken up his duties. This is Mr Harald Köthe of the Federal Ministry of Transport and Digital Infrastructure. Mr. Köthe will be the German CHR representative from 2019.

Current and Future Activities Within The Framework of CHR Projects
Sediment
The drafting of the in English language version of the Executive Summary report, "From Source to Estuary" has not progressed. At the autumn meeting of the CHR, it was found that a speedy delivery of the report was not possible. It was therefore decided not to publish the English language version of the summary.
In the autumn session, it was found that the Rhine sediment issue is still very topical. The CHR members were of the opinion that the CHR should continue to ensure that this issue is given ongoing attention. There is a lack of information with regard to the sediment balance when it comes to the displacement of suspended solids and sand.
For Rijkswaterstaat, sediment research is primarily about its practical application, often together with ecology, but also about the stability of infrastructure and river-bed stability. This is becoming increasingly important in terms of the Rhine river-bed erosion. It is important for the Netherlands to gain more insight into the sediment balance for the entire Rhine basin, today and in the future.
Germany also considers this to be a particularly important issue and is of the opinion that collaborative expert efforts within the river basin is very necessary, even imperative.
The possibility of a new project should be coordinated with the ICSR. It was agreed that the CHR would have come to an expert opinion by the next meeting, then inform the ICSR, and come to an initial vote.

ASG-Rhine: Contribution of snow and glacier-melt to the Rhine drainage.
The second phase of the ASG project started in 2018. An expert workshop on climate scenarios was held in April. A first meeting of the Steering Group (SG) took place in mid-2018. The Steering Group discussed four questions and has also asked the CHR members of the to comment on this:

1. What interests the CHR, in particular, are the changes in the glaciers, the rate of melting, or is it the changes in drainage rates?
   Answer: The focus is on changes in drainage; however, the melting components certainly also deserve attention.

2. Should we focus on extreme events in the near future, or on averages in the distant future?
   Answer: The focus is on medium-term changes for long-term timelines and on the extremely dry and low water-level years in the medium-term.
3. What should the time-focus be? 2050 or 2100?
   Answer: Focus on 2050.
4. Which emission scenarios should be expected?
   Answer: In the SG session, the scenarios were discussed as follows: In any case, scenarios 2.6 and 8.5 are incorporated. The different climate scenarios are roughly the same until the year 2050. The RCP 8.5 (Worst Case) scenario should then be expected for the long-term timeline.

Lake Constance as a Water Reservoir — A Literature Study
The CHR had commissioned the Technische Universität München (Technical University of Munich) to carry out an evaluation-analysing literature study. The report was published in 2018, with a circulation of 280 copies, as the CHR Report I-26 in the "blue" CHR publication series. The report is available on the website as a PDF file for download.

Climate Change
At the CHR meeting in Luxembourg in April 2017, Mr Hattermann of the Potsdam Institute for Climate Impact Research (PIK) presented a study conducted by PIK on behalf of an insurance company. Ensemble scenarios were carried out on all German rivers, with a view to analysing changes in flood damage. No further evaluation has been made. With the help of the data emanating from these studies, the Hessian State Office for Nature Conservation, Environment and Geology has determined the impact of climate change on the outflow conditions in the Rhine. Mr Brahmer presented the preliminary results of this study at the autumn session 2018. The results for mean-flow conditions correspond to the CHR-"Rheinblick2050" results. The results for low water in summer are much drier, and those for low water in winter are "wetter" than the "RheinBlick" results. The flood results are comparable to the "RheinBlick" study.

In Germany, in the context of the GAS (German Adaptation Strategy), the research institutes concerned are commissioned to establish a prediction and projection service for climate and water.

Socio-economic influences on the low-water regime of the Rhine
At the beginning of March 2018, the CHR had organised another workshop on this topic. Until the CHR autumn meeting, the calculations were completed with the data provided by the national representatives, and a concept report was made available. The focus points of the study are irrigation and valley-barrier operation. In the next phase of the project, the focus should be on:
1. Current and future water consumption/need for irrigation;
2. The current and future effects (influence) of the valley-barrier operation on the Rhine outflow;
3. Integration (incorporation) of the sub-studies into the overview.

Hydrological memory of the Rhine

A short discussion between Mr Krahe and Prof Herget (Institute of Geography of the University of Bonn) took place on March 15th, 2018.

The project proposal consists of 2 phases (2018-2020/2021++) and delivery schedule:

1. Study, Quantification of Historical Floods on the Rhine
2. Concept Study, Hydrological Memory of the Rhine Basin

The project objectives are:

- Sourcing, recording and processing of hydrologically relevant data;
- Analysis, classification and evaluation of data;
- Sustainable digital storage and access to the collected data;
- Publications.

Danubius

In the spring session of 2018, Mr Brils of Deltares presented the Danubius project. The idea for the Danubius project was born 15-20 years ago in the Danube Delta, where scientists worked on topics such as sediment management and coastal erosions. A so-called road-map was created in 2016. This created an opportunity to submit a project proposal within the framework of the EU programme "Horizon 2020". Funding for the 3-year preparatory phase started in December 2016. The main task is to support hydrological research (river-sea-systems) in the EU by making databases accessible, as well as the evaluation, harmonisation and dissemination of methods and research instruments, scientific networking and the concrete processing of research needs.

It was agreed that all members would inquire about their country's position regarding Danubius, in their respective countries. The topics of interest to the CHR can be found in the CHR agenda.

At the autumn meeting, it was found that it was difficult to make a CHR recommendation, due to the long term and financial commitment required.

It would be important for the CHR to understand the costs involved in playing an "observer role". The topic will have been put back onto the agenda of the CHR meeting in spring of 2019.

CHR's Strategic Orientation

The autumn session of 2018 discussed the strategy of the CHR for the coming decade. The Dutch representative Mr Groen offers to entrust a staff member of his department with the preparation of a draft strategy text. The text will be prepared on the basis of interviews with all CHR members and relevant stakeholders and the result will be presented at the next meeting.

CHR Anniversary 2050

CHR 2020 wants to celebrate its 50th anniversary with a symposium. All former commissioners etc. will also be invited to the symposium. A jubilee publication will also be printed.

The CHR secretariat prepares a concept programme for 2019.

Collaboration with Other Organizations

A technical visit to the Rhine region by representatives of the Huaihe River Commission in China took place in May 2018. The BfG and the ICPR secretariat in Koblenz were visited.

The CHR was invited to the conference "A 150-Year Record of Mannheim" by the Central Commission for Navigation on the Rhine (CCNR) on October the 17th.

CHR Publications
The CHR report "The Regulation of Lake Constance - Planning and Realization Approaches over Two Centuries" was published as CHR Report I-26.

The CHR published the Hydrological Annual Report 2017.