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

Annual report of the CHR 2014

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

The International Commission for the Hydrology of the Rhine Basin (CHR) operates under the International Hydrological Programme (IHP) of UNESCO and the Hydrology and Water Resources Programme (HWRP) of the World Meteorological Organization (WMO). It is a permanent, independent, international commission and holds the status of a foundation, which is registered in the Netherlands. Members are the following scientific and operational hydrological institutions of the Rhine basin:

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- Office of the Vorarlberg Provincial Government, Department VIId – Water Management, Bregenz, Austria;
- Federal Office for the Environment, Bern, Switzerland;
- IRSTEA, Antony, France,
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- Federal Institute of Hydrology, Koblenz, Germany;
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- Administration de la Gestion de l'Eau, Luxembourg;
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1. Hydrological overview of the Rhine basin

Meteorological characteristics

Austria, source: Central Institute for Meteorology and Geodynamics (ZAMG)
The year 2014 goes down in the history of the Central Institute for Meteorology and Geodynamics (ZAMG) as the warmest year in the 247 years since temperatures were recorded. In comparison to the average value of 1981-2010, the temperature was approximately +1.7 °C higher (Figure 1). Based on Austria as a whole, the past year was exceptionally wet with +13% above average compared to the average value of the 30 years from 1981 to 2010. However, regionally the differences were significant. North of the main chains of the Alps, from Vorarlberg in the west into the Mühlviertel, precipitation was up to 25% less, while on the other hand the south and the east of the country had between 10 and 75% more precipitation. The south also witnessed new station records; e.g., the station Loiblpass in Carinthia recorded 3464 mm. This is the second highest annual precipitation total that has ever been recorded in Austria. The duration of sunshine was below average in some regions and above average in others when compared to the 30-year average value.

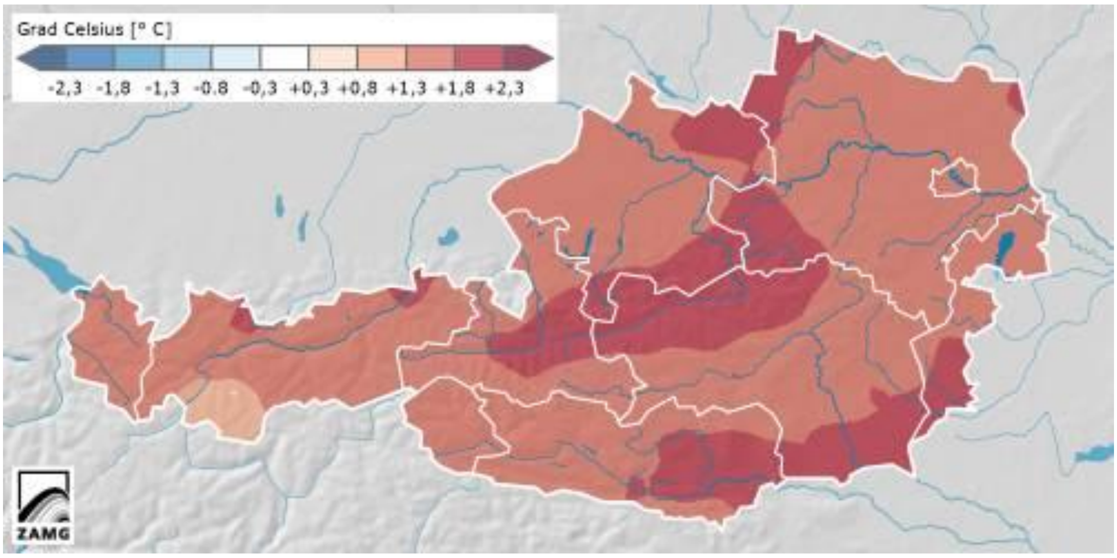

Figure 1: Temperature in Austria in 2014: Temperature deviation from the long-term average 1981-2010. Source ZAMG

Meteorological characteristics of the Austrian Rhine basin
Annual precipitation in the Austrian part of the Rhine basin accounted for 92-99% of the long-term average value. In July, total precipitation was well above the long-term average for that month, total precipitation in the months of January, May, August and December ranged in the respective monthly norm, and in the months of February, March, September, October and November precipitation were below average.

The annual mean air temperature in the Austrian Rhine basin was approx. 1.5 °C above the long-term average value.

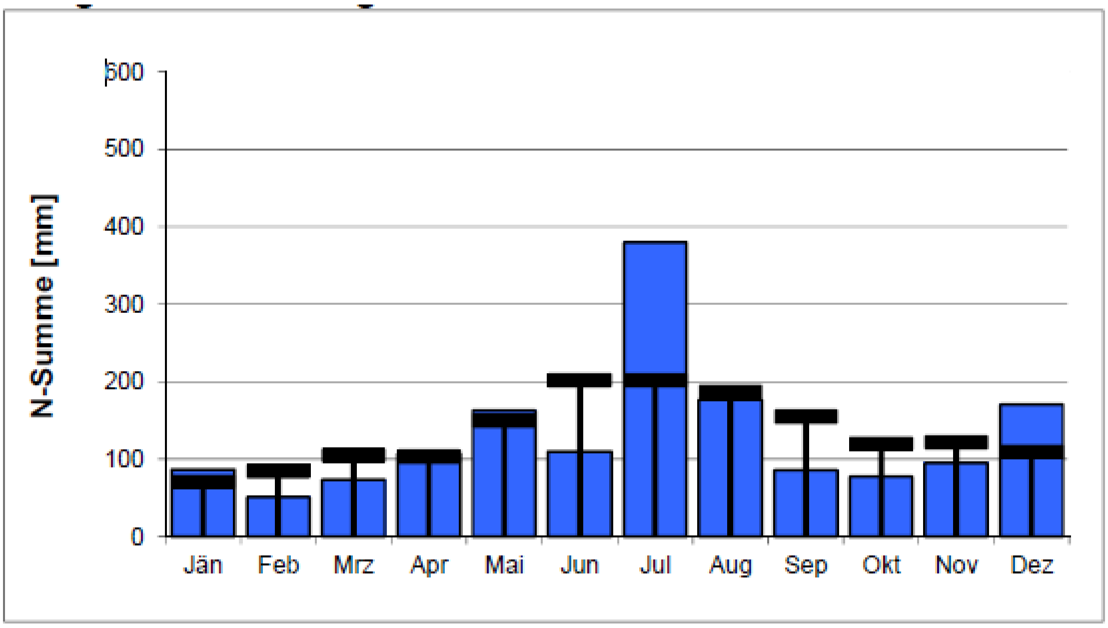

Figure 2: Monthly precipitation totals in 2014 (blue columns) compared to long-term monthly averages at the station of Bregenz, Altreuteweg

Switzerland, source: MeteoSwiss

Together with 2011, the year 2014 has been the warmest year since 1864 when temperature recording began. The annual median temperature for the whole of Switzerland in 2014 was 1.2 degrees above the norm of 1981-2010. The annual precipitation reached normal or slightly below average amounts in most of the regions. In terms of the south side of the Alps and the Engadine the year with volumes ranging from 120 to 170% of the reference value was clearly too wet. The stations of Lugano and Locarno registered amounts of 150-160%.

The year 2014 began with records measured at the Alps' southern side. Here regional records gave proof of the wettest winter by far since records began 151 years ago. The winter 2013/2014, in comparison, remained mostly green in the lowlands of northern Switzerland. The steady influx of milder air masses of subtropical origins led to the third warmest winter in Switzerland since records began in 1864. Throughout Switzerland, the temperature surplus reached 1.7 degrees in comparison to the norm of 1981-2010.

With the exception of May, the months of the first half of the year proved warmer than average. The persistent excess heat resulted in the first half of the year being the third warmest in 151 years of record keeping. The temperature nationwide averaged 1.5 degrees above the norm of 1981-2010.

However, a real summer was only felt during the heat wave of roughly one week in the first half of June. During the midsummer months July and August weather conditions were defined by frequent and strong rainfalls. Extreme amounts of rain fell mainly in July. At numerous stations in the western half and at individual stations in the eastern half of Switzerland new record amounts for July were measured. Alas, frequent rain means little sun, and Switzerland experienced a midsummer with the lowest sunlight ever since records are kept.

After a cool midsummer autumn got really hot. Throughout Switzerland, October became the fourth warmest and November the second warmest on record. Together with a mild September this resulted in the second warmest autumn averaged for Switzerland in 151 years of the Swiss measurement series.

With the extreme heat came the big rain pouring down on the southern side of the Alps. After an already rainy October the Ticino recorded regionally four to more than five times higher than average rain totals in November compared to an ordinary November month. As a result of the persistent and heavy rainfall the water levels of Lake Maggiore and Lake Lugano rose significantly. By mid-November both lakes burst their banks and flooded the areas around Lugano and Locarno for several days.

The above-average heat of autumn also continued into December. Snow only covered areas from 1000 to 1500 m above sea level, and even there the levels were below average. By mid-December the alpine snowpack had reached prevalently only 30 to 60% of its normal height. From on December 26 the weather changed from extremely mild to very cold within two days attributable to cold air coming in from the north-west and the north. From December 26 to 29 it snowed in the lowlands on the north side of the Alps.

Table 1: annual figures 2014 of selected MeteoSwiss monitoring stations in comparison to the norm of 1981 to 2010

Station	Height	Temperature (°C)			Duration of sunlight (h)			Precipitation (mm)		
	MSL	Mean	Norm	Dev.	Summer	Norm	%	Summer	Norm	%
Bern	553	10.0	8.8	1.2	1823	1682	108	1034	1059	98
Zürich	556	10.6	9.4	1.2	1714	1544	111	1076	1134	95
Genf	420	11.7	10.6	1.1	1860	1828	102	1005	1005	100
Basel	316	11.9	10.5	1.4	1699	1637	104	869	842	103
Engelberg	1036	7.7	6.4	1.3	1317	1350	98	1658	1559	106
Sion	482	11.8	10.2	1.6	2022	2093	97	530	603	88
Lugano	273	13.5	12.5	1.0	1875	2069	91	2430	1559	156
Samedan	1709	3.2	2.0	1.2	1552	1733	90	957	713	134

Norm = long-term average 1981-2010
Dev. = deviation of temperature to norm
% = Percentage relative to norm (norm = 100%)

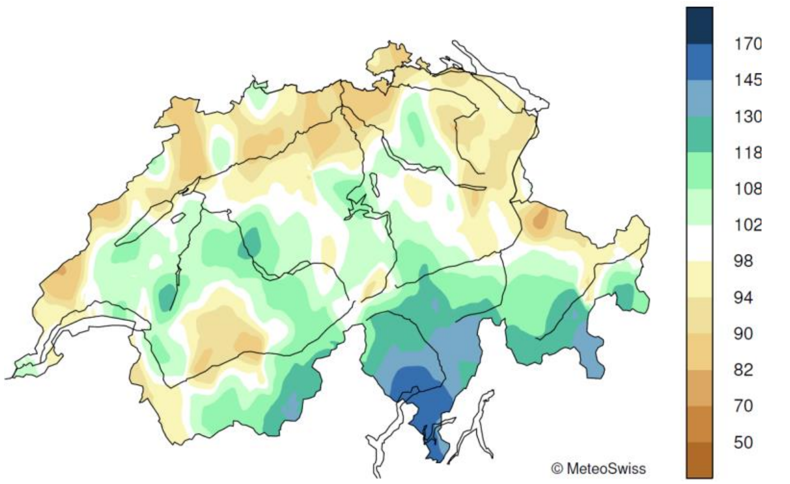

Figure 3: Annual total precipitation Switzerland 2014 in percentage of the norm (1981-2010).

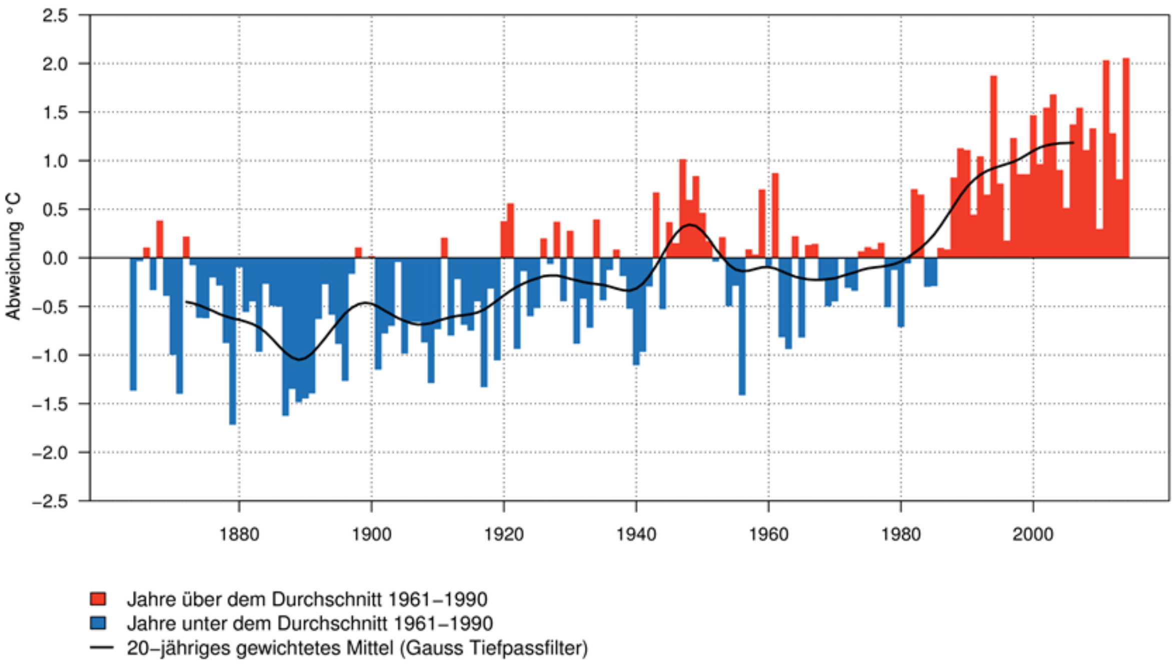

Figure 4: The annual deviation of the temperature from the long-term average (reference period 1961-1990) Switzerland 2014. Red indicates years that are too warm; blue years, which are too cold. The black line shows the temperature curve averaged over 20 years.

Germany, source: German Weather Service

The hydrological year 2014 (Nov. 2013 to Oct. 2014) was the warmest year in Central Europe since regional weather records began and, according to the calendar, it is also regarded as the warmest year globally. Temperatures established for the territory of the Federal Republic of Germany exceeded the long-term observed mean of the series 1981/2010 with the computed value of 10.2 °C by 1.4 °K. For the first time the annual recorded average value lies in the 2-digit range. As Figure 5 shows, the highest mean temperatures were notably recorded in large parts of the Rhine basin.

Compared with the reference period of 1981/2010 deviations of the monthly averages, with the exception of May and August, remained consistently in positive territory (see. Figure 6a). February recorded the largest positive difference with +3.4 °K, while August with 1.5 °K was clearly too cold. In total six of the calculated monthly means rank among the three to ten warmest since 1881.

As shown in Figure 6b by the example of the station in Cologne and despite some deviations, the main tendencies calculated for entire Germany are also representative for the German Rhine basin. In terms of

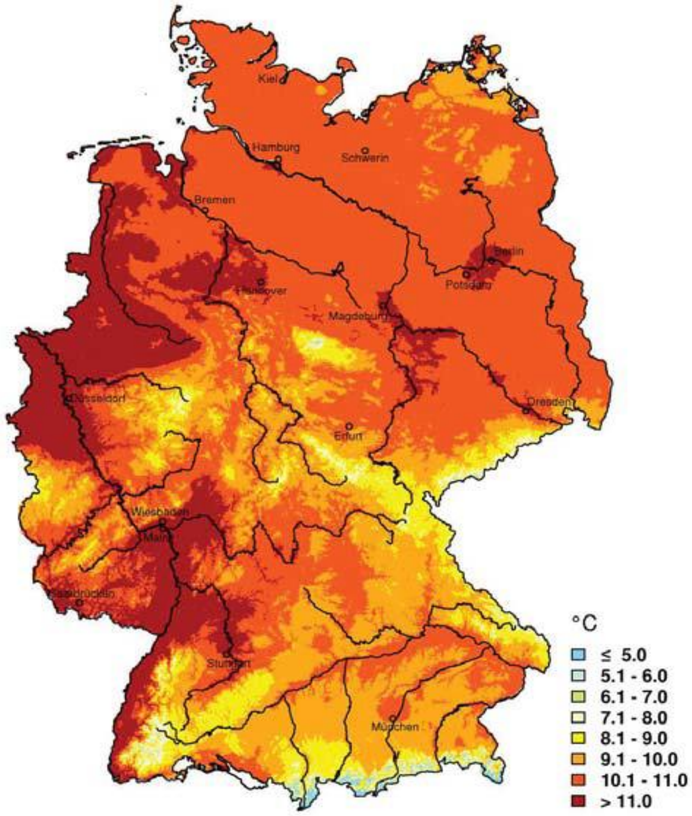

Figure 5: Mean temperature values all over Germany for the calendar year 2014 (source: DWD Witterungsreport Express year overview 2014)

precipitation, the hydrological year in the Rhine basin was unusually dry between December and April.

March in particular was affected; the monthly average value of areal precipitation (surface area normal 14 mm) was only 19% based on the normals of the international climatological base period 1981/2010. That makes March the fifth-driest in the Rhine region since 1881. However, while during the months of July and August, 180% and respectively 155% of the long-term observed normals of the reference series were recorded, the relative rainfall for the period from December to April with an average of 58% (41 mm) ranked significantly lower compared to the values of the comparative period.

This shaped also the seasonal statistics as the distribution of rainfall between the winter and summer months showed a blatantly obvious increase of summer precipitation proportions with 36% to 64% compared to the long-term observed precipitation totals of the series 1981/2010 (winter 48%, summer 52%). A total precipitation of 288 mm was established for the winter months and thus represents only 67% of the normal for the period 1981/2010. For the summer months 509 mm and respectively 109 mm were recorded which is slightly above the average total precipitation normal for the corresponding period.

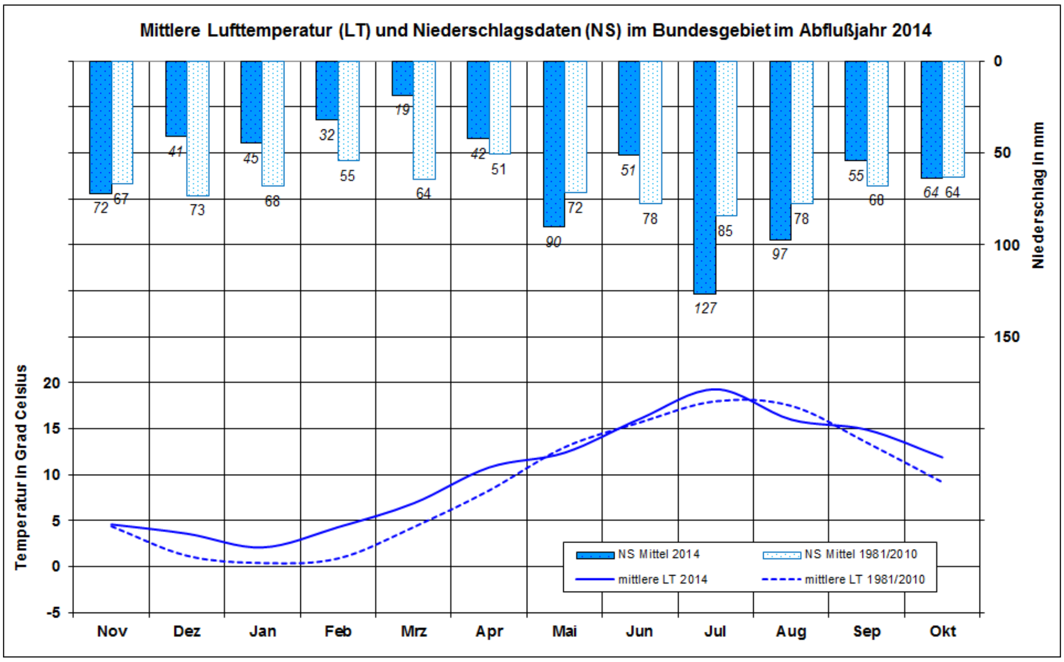

Figure 6a: Federal Republic of Germany: Comparison of monthly temperature and precipitation data of the water year 2014 to the long-term normal 1981/2010 (Source: DWD / monthly WitterungsReports 2014)

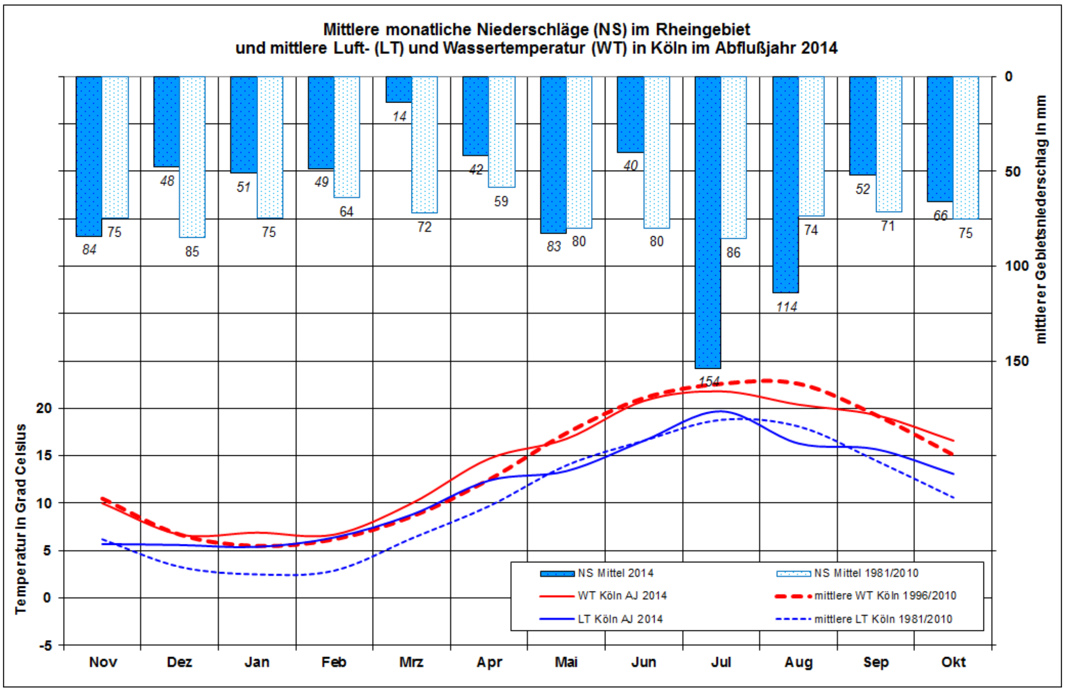

Figure 6b: The Rhine basin / station example, Cologne: Comparison of monthly temperature and precipitation data of the water year 2014 to the long-term average 1991/2010 (Data sources: T and NS - DWD, WT - WSV)

The Netherlands, source: Royal Dutch Meteorological Institute - KNMI

Based on the median annual average temperature of 11.7 °C measured at the Station de Bilt in comparison to the long-term average (1981-2010) of 10.1 °C, 2014 is the warmest year since regular temperature recording began in the year 1706. The old maximum of 11.2 °C dates back to the years 2006 and 2007. Except for August temperatures of all other months were higher than normal. The year started off with a very mild winter. In some places along the coast, temperatures throughout the winter months did not drop below zero. Spring was the second warmest in three centuries. Especially the months of March and April were very mild (see Figure 7).

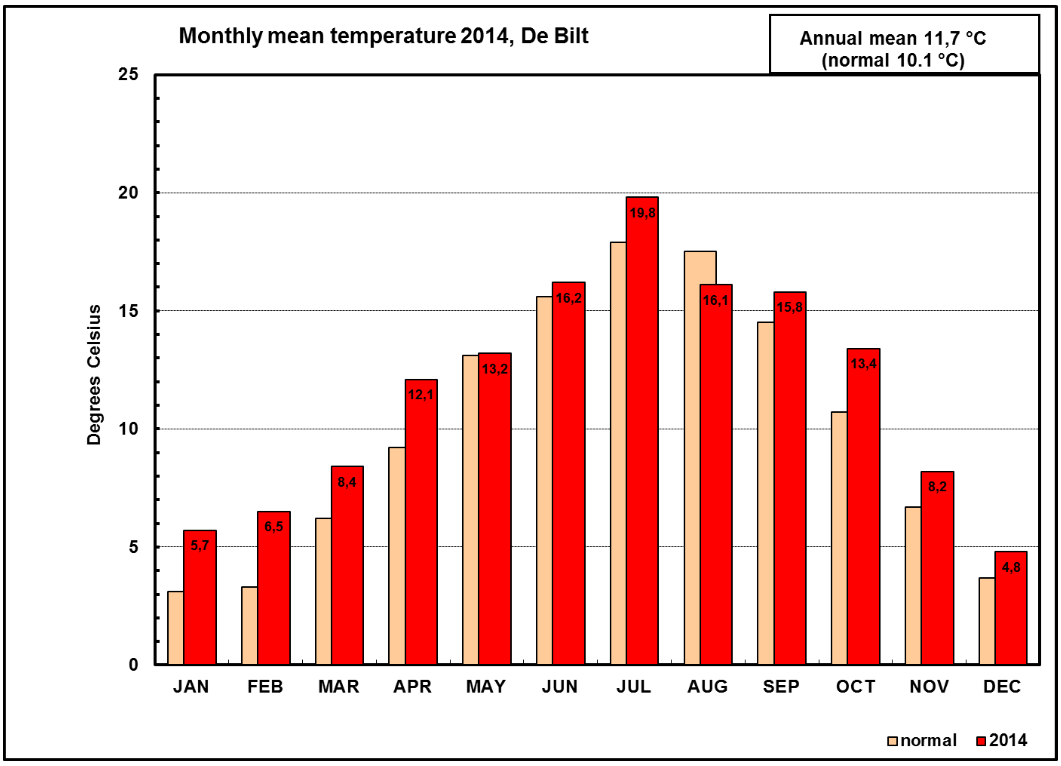

Figure 7: Monthly mean temperature at the Station De Bilt / Netherlands 2014 in comparison to the long-term (1981-2010) median value (source: KNMI)

The summer featured some extremes: The very warm month of July was followed by a particularly cool month of August. Two days came with tropical temperatures (30.0 °C or higher). Autumn like spring was the warmest since 1706. All three months were mildly above average. The first frost in De Bilt came late on November 25.

The year 2014 was a relatively dry year. For the whole of the Netherlands precipitation measured 776 mm, compared to the 849 mm normal. However, the regional differences were huge. Some stations, particularly in the country’s north and southwest, measured only 600-650 mm of rainfall while the centre and southeast of the country received above average rainfall (up to 998 mm).

Noticeable was the torrential rain on 28 July which started in the west and later extended to the central and eastern parts of the country. That day more than 75 mm was measured at various points over 24 hours. Besides July and August also the month of May was exceptionally wet. March and September were dry months. There was hardly any snow. The northeast of the country was covered under a blanket of snow by the end of January and after Christmas it snowed a little in the centre and south of the country. The station De Bilt recorded 873 mm of precipitation compared to the 832 mm normal (see Figure 8).

The amount of sunshine in 2014 was slightly more than normal. Across the Netherlands 1844 hours of sunshine were counted compared to the norm of 1639 hours. Especially the months of March and September had above average sunshine.

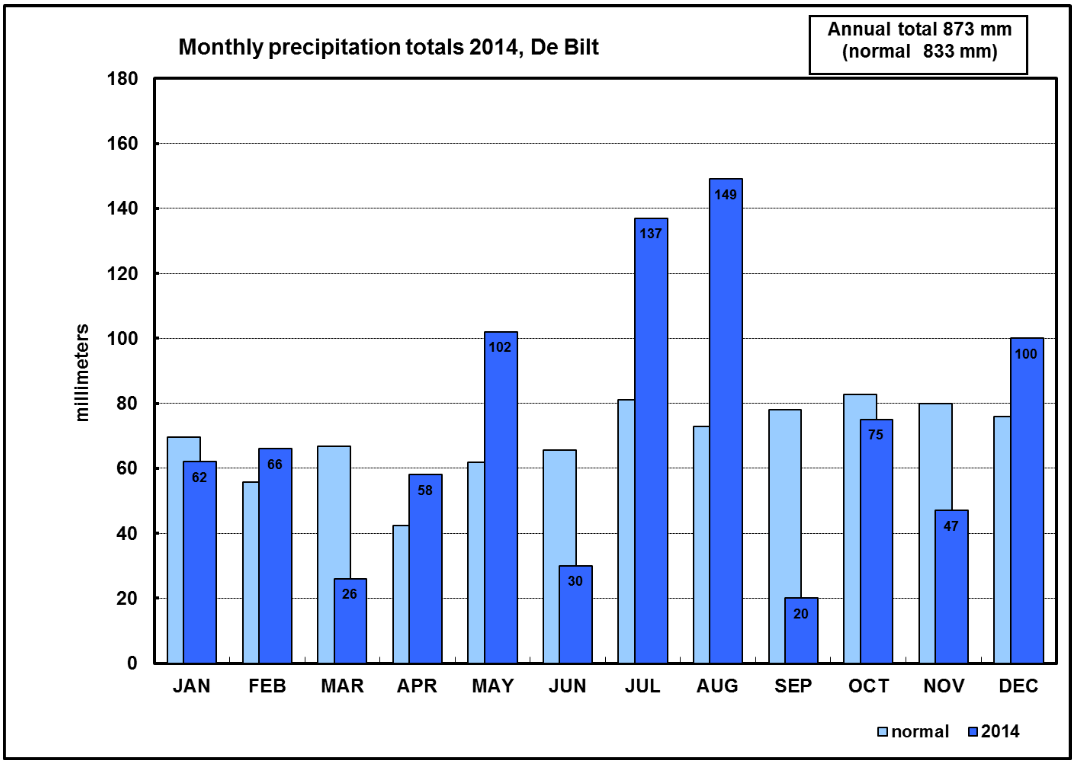

Figure 8: Monthly precipitation totals at the station De Bilt / Netherlands in 2014 compared to the long-term (1981-2010) median value (source: KNMI)

Snow and glacier

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

Snow had already fallen in four stages at high altitudes and in the high mountain range in October . In mid-October it also snowed in lower lying regions. Many monitoring stations all over the Swiss Alps observed new snow depths maxima on the days from October 11 – 15.

All regions also frequently received snow in November. The most concentrated periods of precipitation lasted from November 19 to 23, and the regions from Simplon to the western part of the Ticino accumulated 80 to 120 cm of snow. The snow depth for that time of the year reached above average values in Valais and on the western and central northern flanks of the Alps, normal averages on the northeastern flank of the Alps and in Grison and rather below average values in the Ticino.

The first two decades of December featured little rain, plenty of sunshine and overall mild temperatures. Snow cover was accordingly thin. On December 20, the snow depth for the season was well below average in all regions. Christmas day saw snow and on the southern flank of the Alps snowfall was severe. The snow accumulation on Thursday, December 26 was exceptional. The station San Bernardino estimated a value of 120 cm, the largest value ever since records began 63 years ago. Although due to this major snowfall the snow depths at the southern flanks of the Alps reached remarkable above average values by the end of December, the results throughout the month, however, remained modest.

In January it snowed again and the southern regions saw most of the snow, which resulted in great snow depths. The key regions were located in the western Lower Valais, in northern and central Ticino, in the Upper Engadine and in the southern valleys of the canton Grison. Also in February more periods of precipitation in short intervals followed and the southern flank of the Alps received large amounts of snow. The most intensive precipitation period lasted from February 2 to 6 and the Simplon region and the northern and central Ticino regions received 140 to 180 cm of snow. Some stations in the northern and central Ticino observed overall 3 to 3.5 meters of snow in February. The count of the new snow days until the end of February shows that it had snowed every other day in the elevated regions of the south flank of the Alps since the beginning of the precipitation around Christmas time.

March had snowfall only at the beginning of the month. Besides that March recorded sunny and mild weather. In the beginning of the month new snow accumulation peaks emerged from stations in the south, then the snow depths decreased significantly as a result of the melt, especially up to medium altitudes. Snow depths at the northern flank of the Alps were well below average values by the end of the month. A few stations with long-term measurement series, however, recorded new snow depth peaks.

At the end of April larger amounts of snow accumulated reaching approximately one meter within three days. Particularly affected was the main chain of the Alps from the Matter Valley in the Goms region. The snow depths quickly reached the long-term average in the already snowiest regions of the south, although in other areas they remained significantly lower. In May significant amounts of snow were mainly received at the high altitudes of the Valais, the northern flank of the Alps and Grison. Simultaneously, snow reduction continued, but was delayed at the beginning and middle of the month caused by a drop of the freezing level below 2500 m.

In the hydrological year 2013/2014 measurements were taken at approximately 20 Swiss glaciers to calculate the mass balance. These included the determination of the amount of winter snow and the melt during summer. In mid-April below average amounts of snow on the glaciers were established for the north side of the Alps and predominantly above-average for the southern side of the Alps. After a period of extreme snowmelt in June, July and August were characterized by changing weather conditions. This was especially favorable for the glaciers at high altitudes as frequent new snowfalls had significantly reduced the glaciers melt. However, the relatively warm September promoted further melt.

On glaciers of the southern main ridge of the Alps and the Engadine (e.g., Findelen, Allalinglacier, Vadret dal Murtèl), balanced or even slightly positive mass balances were measured. The Ghiacciaio del Basòdino in the Ticino, however, lost mass slightly. The studied glaciers on the northern ridge of the Alps showed a moderate mass loss (e.g., Rhone Glacier, Glacier du Tsanfleuron). With a reduction of ice thickness of 400 to 900 mm water equivalent, this was not overly dramatic. Glaciers in the northeast of Switzerland (Silvretta Glacier, Pizol Glacier) showed a significant thickness loss of more than one meter.

The regional differences of the mass balance of a glacier were particularly severe this year. The asymmetry between the northern and southern side of the Alps is the result of the frequent occurrence of orographic lift in the south during winter and spring. Due to the altitude of the glacier, the differences were intensified: Much of the precipitation during the summer months came down in the form of rain in the lower lying glaciers on the north side of the Alps, however, especially the glaciers in the south of Valais benefited from frequent snowfalls during the summer.

When applied to all of the glaciers in Switzerland, the result is an estimated mass loss of 380 million cubic meters within the hydrological year 2013/2014. This is equivalent to the reduction of Switzerland's current ice volume by around 0.75%. Despite low mass gains in some regions the negative mass balance of glaciers prevails across Switzerland. On the whole, the weather trend 2013/2014 for the glaciers of the Swiss Alps can still be described as relatively favorable. Since 2002, the glacier only showed a similarly low mass loss in the year 2012/2013. We cannot speak of a trend reversal, while the glacier melt was less dramatic than the long-term average.

Hydrological situation in the Rhine region in 2014

Water levels of the large lakes of the Rhine basin

Austria

The water level of Lake Constance was in the range of the respective long-term daily averages at the station of Bregenz from the beginning of the year to mid-April. After that, the small amount of snow during the winter 2013/2014 with below-average proportions of snowmelt impacted the discharge and the water level remained below the daily average of the calendar day until the end of June. The above-average rainfall in July resulted in the rise of the water level, which reached an annual peak level of 456 cm on August 1, and also an above-average seasonal water level from July 22 to October 1. The below-average precipitation in September and October resulted in below-average seasonal water levels from October 2 to 22. After that, the water level increased again above the respective daily means of the observation series 1864-2013 (see Figure 9) until the end of the year.

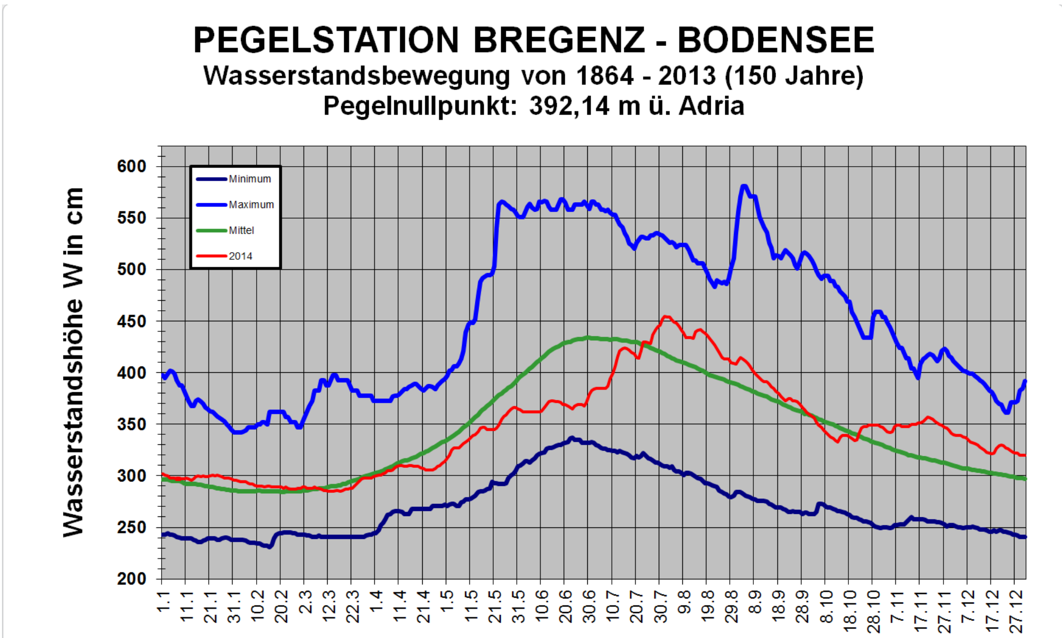

Figure 9: hydrograph of the water level of Lake Constance in Bregenz in 2014 (red graph) in comparison to the long-term minima, maxima and mean values of the period 1864 – 2013

Switzerland

The annual averages of the water levels of most of the larger lakes on the north side of the Alps were close to the averages of the standard period 1981-2010 in 2014. However, Lake Walen showed greater, negative deviations. The annual average of 13 cm was clearly below the norm value.

Naturally the differences are greater when individual monthly figures are compared to the annual mean. Above average water levels were measured in most of the months. Despite an apparent low-water level at Lake Constance in June, the water levels from on July were all above the mean of the norm period with the largest deviation of approximately half a meter in August and September. The rainy summer manifests itself in the readings of the hydrographs of Lake Neuchâtel: July and August 2014 were above the norm with 17 respectively 11 cm.

The daily average of the water levels at Lake Constance barely drifted outside of the range of the 5% quantile and the 95% quantile. In July, August and November, the upper limit was almost reached. Unlike Lake Neuchâtel: The persistent rain on the northern side of the Alps in July and August left its marks. The two phases of high water resulted in the hydrological system of the lakes in the Jura region reaching its limit.

Water levels and discharge of rivers

Austria

Discharges of Lake Constance's main feeders were diverse in 2014. While the inflow amounts of Bregenzerach and the Dornbirnerach were below the long-term annual average, the Alpine Rhine carried an above-average load. The annual discharge in comparison to the long-term mean was:

- on the Bregenzerach at 88 % (MQ 2014 = 40.8 m³/s, long-term MQ = 46.5 m³/s);
- on the Dornbirnerach at 92 % (MQ 2014 = 6.49 m³/s, long-term MQ = 7.06 m³/s);
- on the Alpenrhein at 105 % (MQ 2014 = 244 m³/s, long-term MQ = 232 m³/s).

Switzerland

On the north side of the Alps the annual outflow mean of the large river basins were below or close to the 1981-2010 norm. The Rhine, Aare, Reuss and the Limmat leveled off in the normal range (90 to 110%). Outflow from the Thur, Doubs and the Rhone was less than 90% of amounts expected. Inn, Ticino and Maggia were clearly above the long-term average. The medium-sized catchment basins compared with the annual mean of discharge show a differentiated yet not entirely different picture. On the northern side of the Alps, the figures travelled regionally between 80 and 110%. Below this range were the Dünnern at Olten (70%) and the Seyon at Valangin (74%) and above average the Gürbe with almost 140%.

The monthly averages of discharge amounts show a pronounced positive as well as a pronounced negative departure from the norm. In terms of the Aare, Reuss, Limmat and the Thur the months from March to June were too dry, while July and August and to some extend November were too wet. The Rhine at Diepoldsau showed a similar picture, although March and April were not dry, but rather quite accurately in accordance with the norm.

In terms of the day discharge values the hydrographs at Aare, Reuss and Limmat are similar: During the first half of the year dry conditions were prevalent, which were interrupted by intermittent periods of normal or slightly above-average outflows. The two high-water months in July and August impacted the hydrographs on the north side of the Alps. At ten measuring points between the Aare and the Reuss new large peak flows were recorded for July. Among these stations are the Aare in Bern, the Emme in Eggiwil and the Engelberger Aa in Buochs. After a relatively quiet autumn the outflows have considerably risen again in November, although without generating large high water peaks.

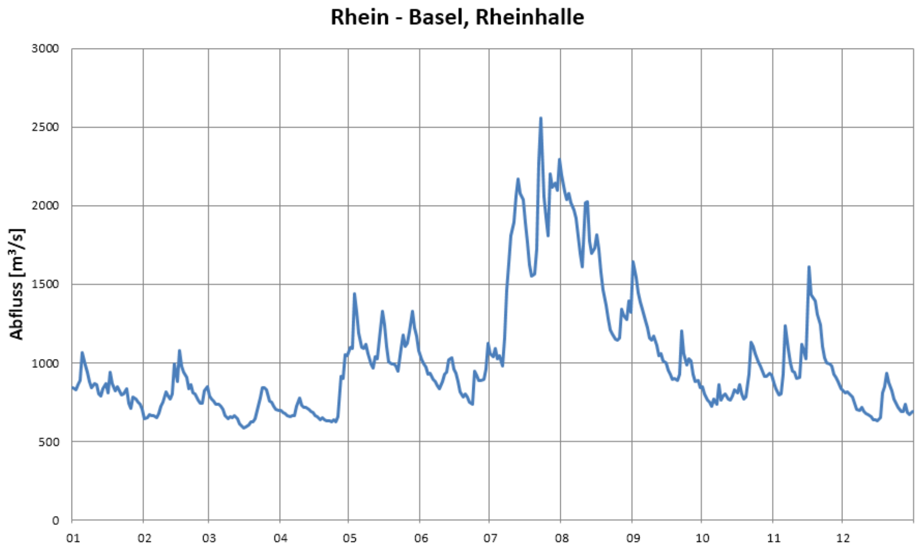

Figure 10: hydrograph on the Rhine- Basel, Rheinhalle, 2014 (provisional data)

Flood events in July and August 2014

In general a flood event only takes a day or a few. It is rather uncommon that individual events can barely be distinguished from one another due to phases of heavy precipitation over a longer period when an event succeeds the other. Many will remember July 2014 as a very rainy month. The rain in fact lasted - intermittently- several weeks. Recurrent heavy rainfalls accompanied by regional thunderstorms were also severe. According to the Federal Office of Meteorology and Climatology, MeteoSwiss, in July 2014 large parts of Switzerland received twice, in some places even triple the amount of rain that is typical for July. Numerous stations measured new record amounts for the month of July, in particular west of the Reuss. But also the eastern Switzerland selectively recorded new peak values for July

Even with extensive precipitation that summer no single, large-scale event occurred, unlike in 2005 or 2007. On the contrary, the streams in Switzerland frequently showed modest flood levels regionally that are statistically recorded every 2 to 5 years. Occasionally, however, higher annual instances were recorded. In some places also the lake levels increased. Some rivers registered seasonal or even new absolute records, such as the Gürbe, Emme, Albula and the Simme. The large discharge volumes have regionally led to partially major damage.

Germany

With the absence of high and low water extremes, the discharge events in the hydrological year 2014 (illustrated by the hydrograph representations in figures 11 to 16) were very balanced on the Rhine. The highest annual outflows were reached in the entire catchment basin by the beginning of November; only the station of Maxau recorded slightly higher daily averages at the end of July. Subsequently, the hydrographs at all measuring points fell relatively constantly until by the end of June the lowest outflows were recorded (except Maxau, here by the end of April). In accord with the summer months, which received high precipitation, the discharge values of the Rhine, often exceeded - at times significantly - the respective long-term monthly means from on July 2014. Later on the Rhine stations recorded above long-term MQ1931-2011 values, which dropped again below the norm, by the end of the observation period. At the gauging stations of Main and Neckar the monthly median discharge (mMQ) of the long series dropped below only on a day basis during the last trimester; a reverse trend was observed on the Mosel where the monthly median outflow (mMNQ) temporarily dropped considerably during the last two months.

The annual MQ 2014 at the measuring points on the Rhine remained in the range of the long-term annual averages (see Table 2). The MQ on the Neckar dropped just below average, the Main recorded a clear deficit (-28%), the MQ 2014 on the Mosel stood at 91% compared to the long-term mean series (1931-2011), however, the gauging station at Cochem showed that already two-thirds of the total annual outflow was discharged in the first four months alone.

Table 2: Comparison of the mean discharges (MQ) for selected stations in the Rhine region

Station	MQ			MQ 2014		
	2014	1931-2011	MQ 2014 / MQ long series [%]	Winter	Summer	% Wi/Su
Maxau (Rhine)	1246	1253	99	1113	1379	**45**/55
Rockenau (Neckar) * 1951-2011	121	137*	88	140	102	58/**42**
Raunheim (Main) * 1981-2011	162	225*	72	195	129	60/**40**
Kaub (Rhine)	1620	1650	98	1572	1669	49/51
Cochem (Mosel)	285	314	91	442	128	77/**23**
Cologne (Rhine)	1990	2110	94	2106	1875	53/**47**

The ratio of winter to summer MQ shows for the Rhine with an increasing catchment basin clearly the impact of the central mountain inflows. The median outflow prevailed in Maxau during the summer months; downstream in Cologne an increase in the winter months was thus recorded. For the feeder streams Neckar and Main which are regulated by reservoirs on averages of 59% of the total annual discharge in the winter season (Nov-Apr) and 41% in the summer months were observed. The Mosel recorded a clear surplus in the winter half-year outflow totals with 78% (see Table 2).

The shortfalls in the annual MQ were on the Rhine on average of 232 days, in Maxau the ratio of the lower deviations days for the winter and summer months was 133 to 100, at Kaub balanced and in Cologne 101 to 130 days. Lower deviations at the feeder streams stood for Neckar and Mosel at 251 days, and for the Main even at 315 days, whereby the largest share was reported for the summer months in terms of the Neckar with 152 days and Main and Mosel on average 180 days even. The number of days on which the monthly mean discharges (MMQ) were low, were on average 209 days for the Rhine and were distributed in favor of the winter months at the ratio of 118 to 91 days.

Noteworthy lower deviations from the mean annual lowest discharge (MNQ) were recorded for the entire Rhine catchment basin only during the winter season at the Mosel (Cochem) with 23 days. The lowest monthly mean discharge (mMNQ) occurred mainly between March and July on the Rhine with an average of 90 days, and 105 days at the feeder streams, with the exception of the Mosel. Most of the mMNQ lower deviations happened during the months of September and October on the Mosel, at the Cochem station.

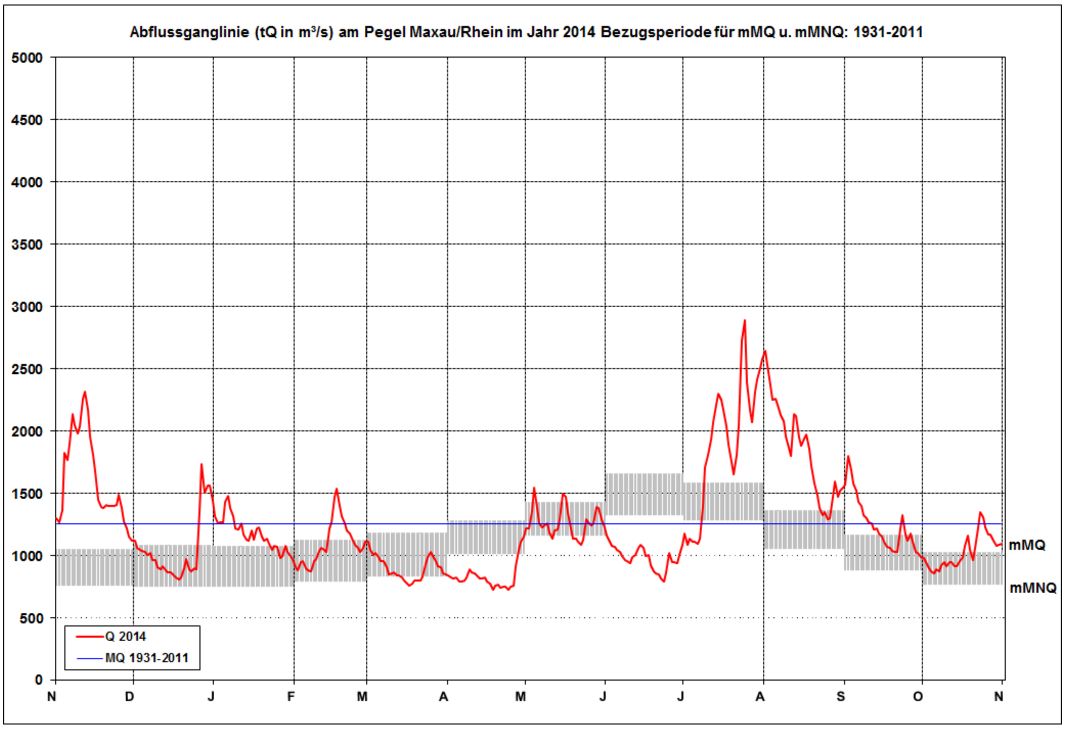

Figure 11 hydrograph (tQ) at the station of Maxau (Rhein), 2014, in m³/s (Reference period for MQ, mMQ and mMNQ: 1931-2011 period)

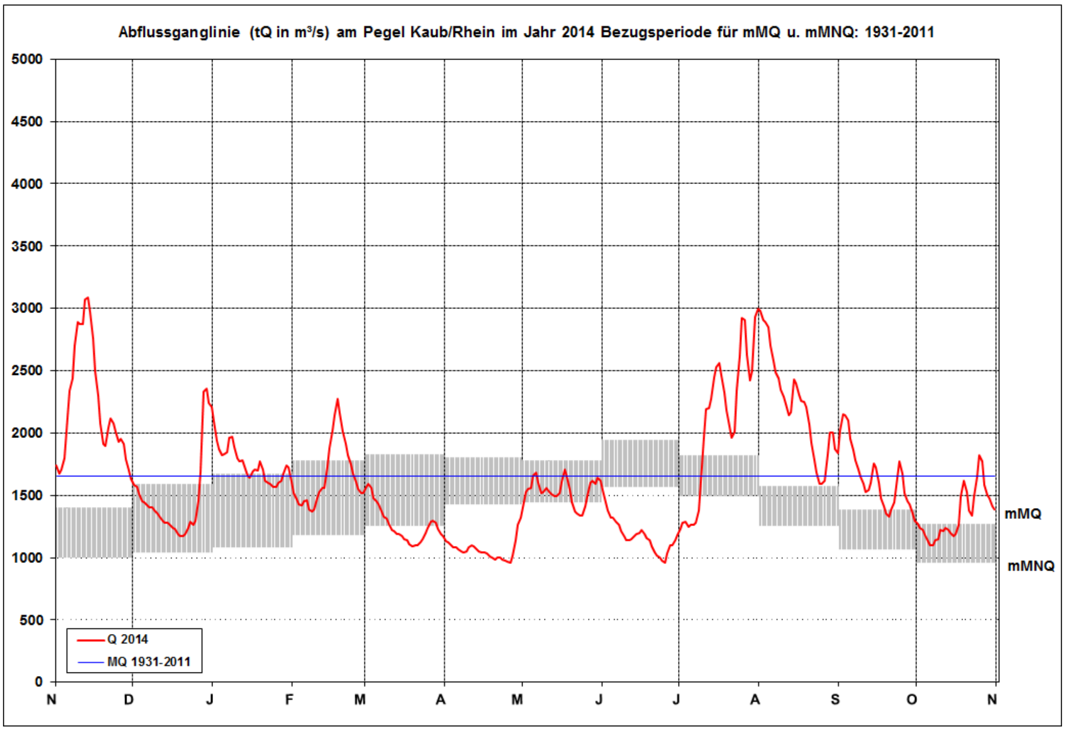

Figure 12: hydrograph (tQ) at the station of Kaub (Rhine) in 2014 in m³/s
(Reference period for MQ, mMQ and mMNQ: 1931-2011 period)

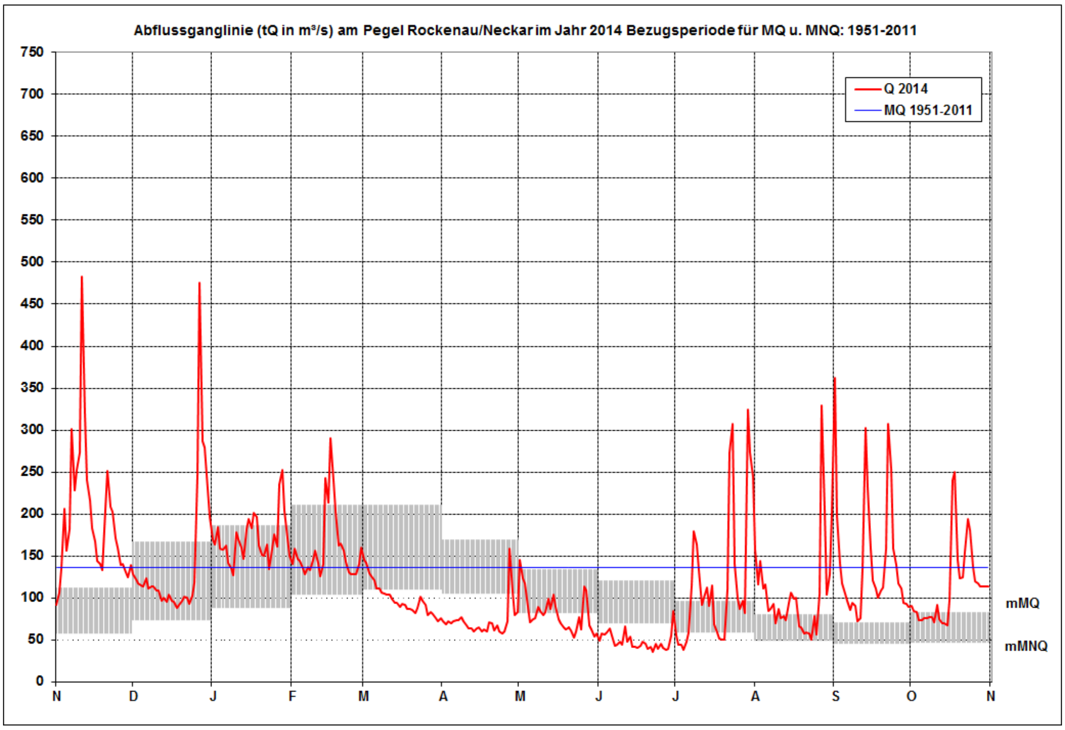

Figure 13: hydrograph (tQ) at the station of Rockenau (Neckar) in the water year 2014 in m³/s
(Reference period for MQ, mMQ and mMNQ: 1931-2011 period)

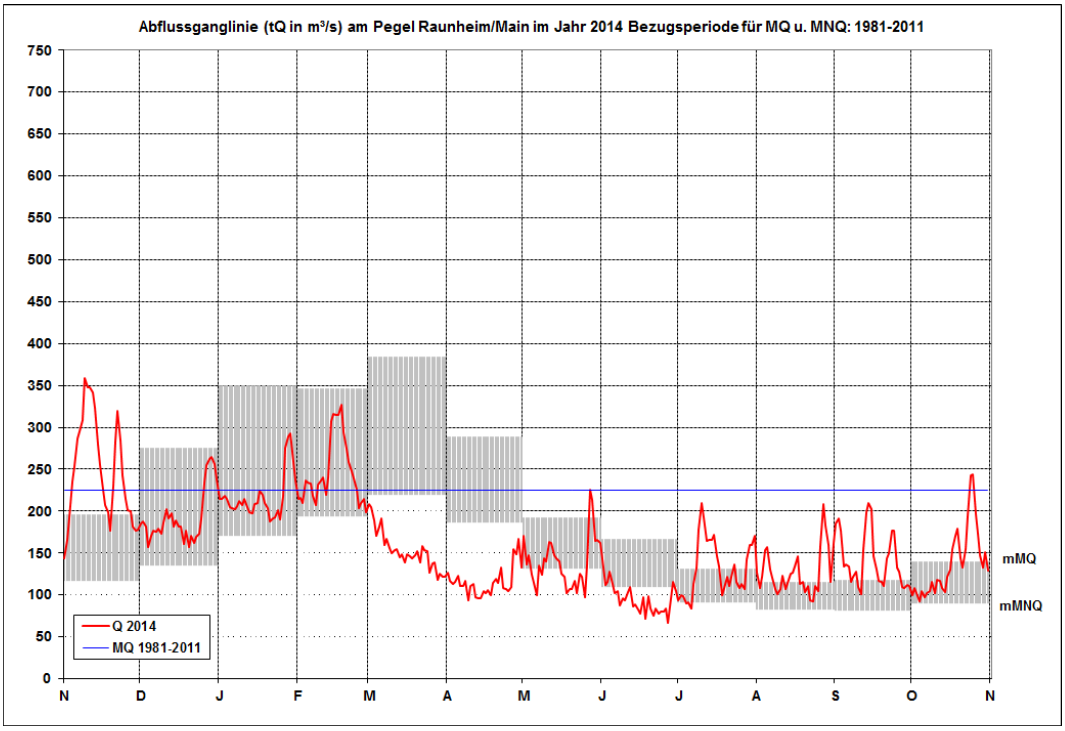

Figure 14: hydrograph (tQ) at the station of Raunheim (Main) in the water year 2014 in m³/s
(Reference period for MQ, mMQ and mMNQ: 1981-2011 period)

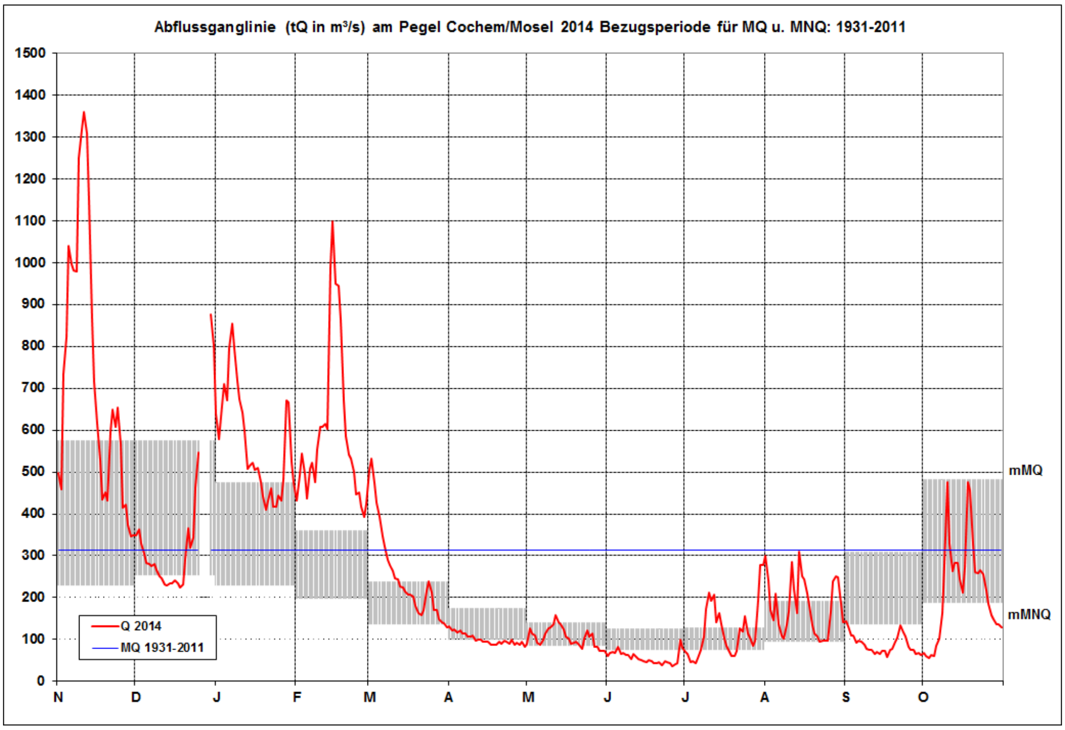

Figure 15: hydrograph (tQ) at the station of Cochem (Mosel) in 2014 in m³/s (Reference period for MQ, mMQ and mMNQ: 1931-2011 period)

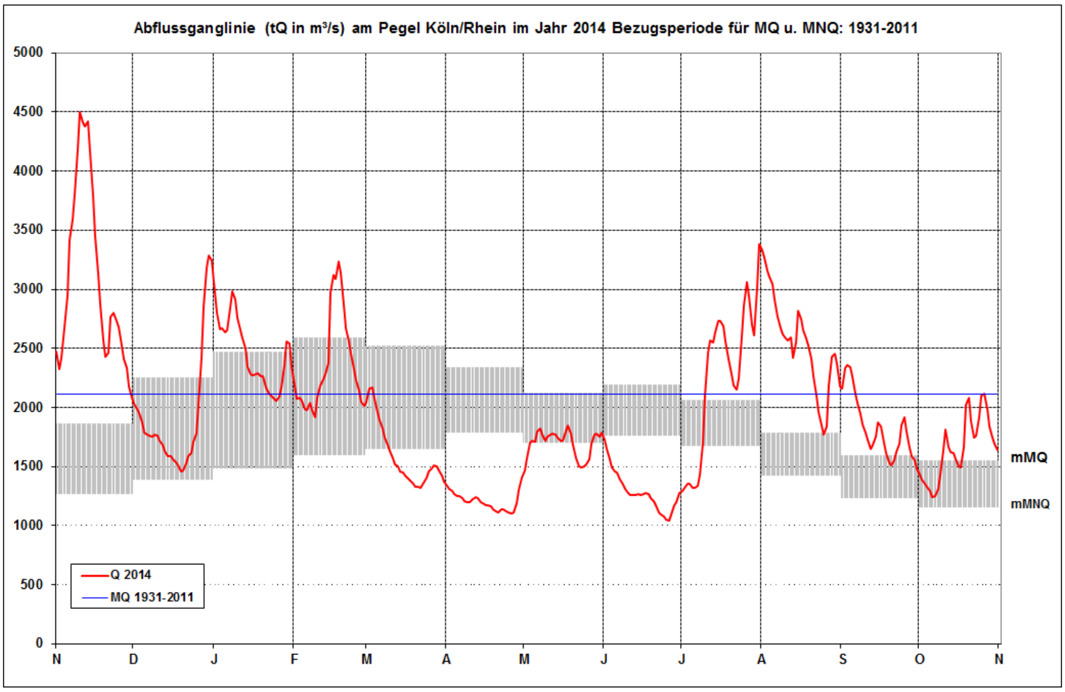

Figure 16: hydrograph (tQ) at the station of Cologne (Rhine) 2014 in m³/s (Reference period for MQ, mMQ and mMNQ: 1931-2011 period)

Water temperatures

Austria

The annual mean water temperature of Lake Constance reached 13.3° C and was 1.4 °C above the long-term average of 11.9 °C.

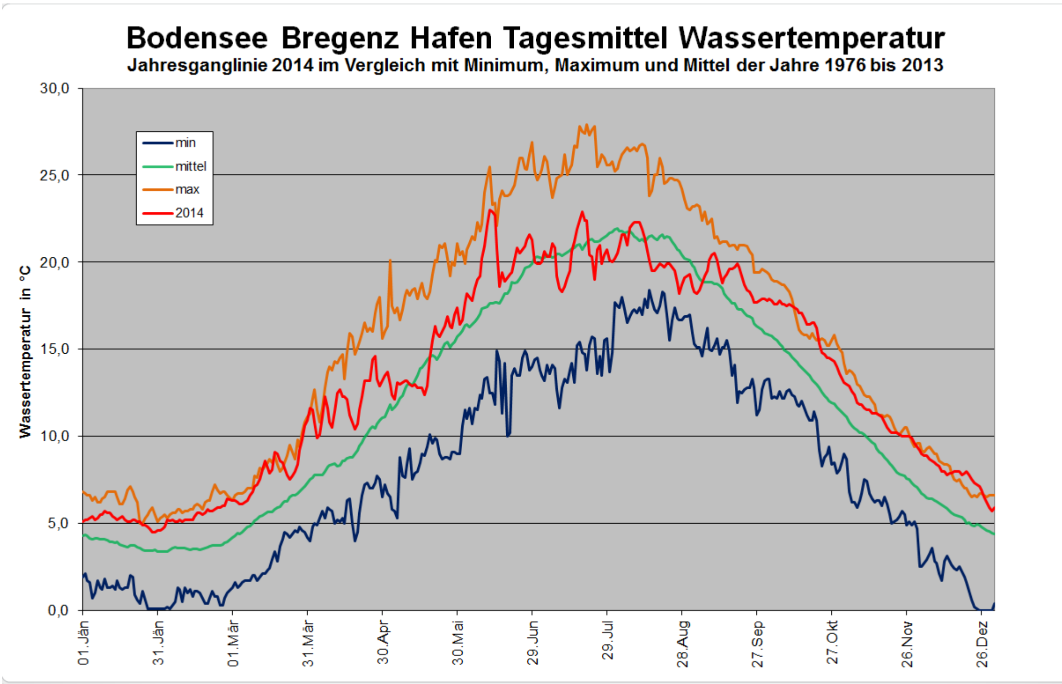

Figure17: hydrograph of the water temperature of Lake Constance at station Bregenz 2014 (red graph) in comparison to long-term minima, maxima and mean values of the years 1976-2013

Switzerland

2014 went down in recorded history as an extremely warm year. The annual average values of the water temperatures reflected higher air temperatures. In the larger river basins, the deviations from the mean values of the norm period 1981-2010 ranged between + 0.5 °C and + 1.1 °C. Some stations recorded high annual averages similarly to the record year 2011.

During the first half of 2014, stations registered for all months, with the exception of May, regionally average to above-average water temperatures with new monthly maxima. After an ordinary and cool summer, water temperatures rose to levels far above the norm between September to December. Along with October, also December turned out to be exceptionally warm, reaching new monthly maxima at numerous stations.

Typically in Rekingen the Rhine reaches the highest annual temperatures in August. The year 2014, however, featured an extreme rise in temperatures due to a severe heat wave in early June, so that the annual maximum temperature was already reached on June 14. The heat wave of one week in the first half of June led to excess temperatures in June with a monthly average of 3.1 °C above the 1981-2010 norm. During the coming summer months the temperatures fell below the norm. Alpine streams like the Rhone at Porte du Scex were an exception. Here the extreme shortage of sunlight in the summer of 2014 caused a reduced inflow of cold melt water which led to relatively high temperatures.

After a largely cool summer, water temperatures rose to unusually high levels from September to October. The record-breaking warm period at the end of September came to an end on the evening of October 21 with an active cold front and inflowing cold polar air from the North West. The abrupt drop in temperature is clearly evident in the annual graph of the water temperature. Relative to the norm, the temperatures rose again to high values at most stations after the prominent temperature drop, and remained high until the end of the year.

Germany

The mean of the water temperatures (WT) recorded during the period of observation at the station of Kaub is 0.1 °K below the average of the long-term calculated annual average at14.0 °C, the lower deviation recorded at the station Cologne is 0.2 °K at 14.3 °C. The largest deviations of the monthly means in the form of a deviation below the averages were recorded in August at the station Kaub with -2.6 °K and in Cologne with -2.2 °K, and the largest positive deviation of monthly averages was recorded in April with 2.2 °K each. The maximum negative deviation from the daily means occurred in Kaub with -4.2 °K and -3.8 °K at the station Cologne, each in mid-August; the largest positive deviation was 3.6 ° K in Kaub, and in Cologne 3.1 °K, always early April.

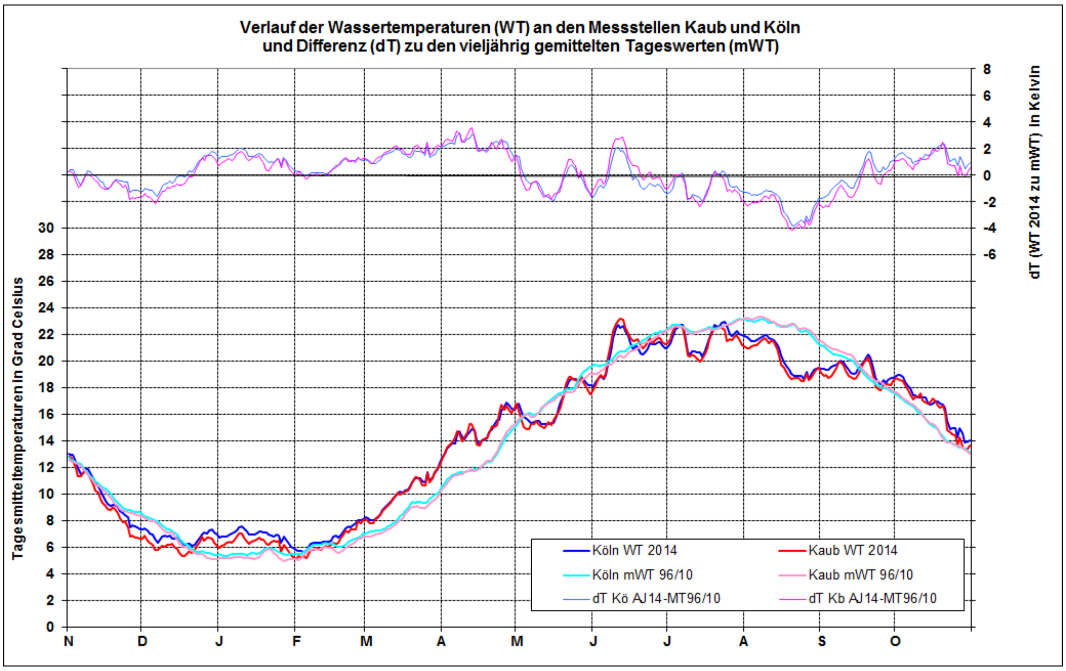

Figure 18: Water temperatures in comparison to the long-term averages

The annual hydrograph of the daily calculated WT at selected measuring points shows that the daily averages stood at approximately 13 °C at the beginning of the hydrological year and then dropped until mid-December where they remained at 7 °C until mid-February. After that, they steadily increased until the maximum value of about 23 °C was reached in early June, only to drop again from early August until the end of October with an average value of 14 °C.

During the first half of the year water temperatures developed rather evenly with an average of 9.0 °C (+ 0.75 °K) at both stations. The second half of the year had significant variations on average 19.1 °C (-0.5 °K), whereas in July and August the water temperatures dropped on average 1.75 °C (and thus drastically) below the mean values. For the period from September to October deviations in the positive range were recorded (on average 0.5 °K).

The Netherlands

At the station Lobith the average water temperature was with 14.6 ° C about 1.6 °C above the long-term (1961-2014) calculated annual average (see Figure 19). Since 1908 the average water temperature has never been higher.

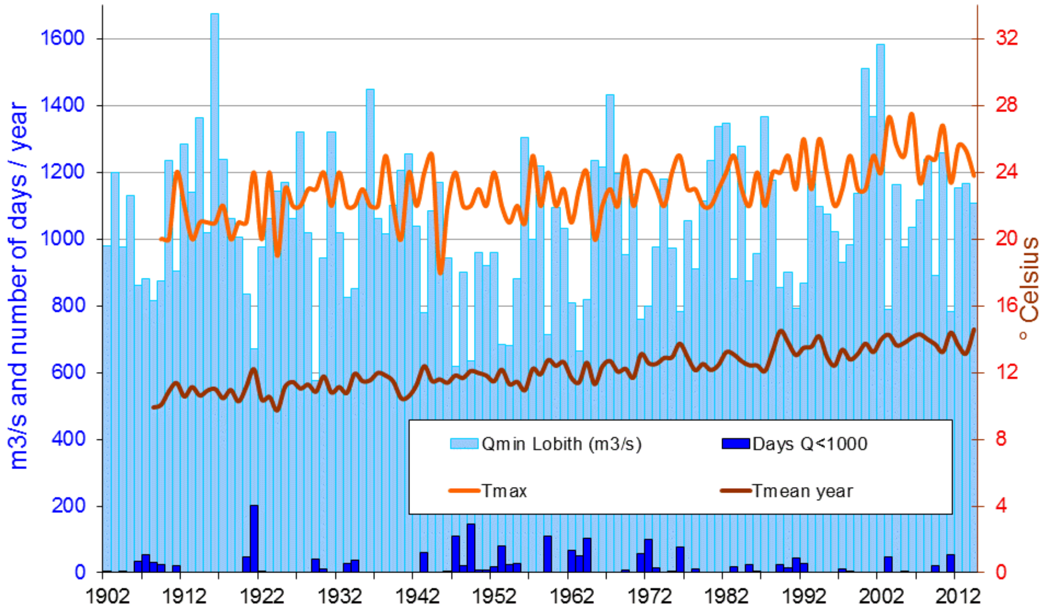

Figure 19: median and maximal water temperatures at the station Lobith/Rhine

Groundwater

Austria

The small amounts of snow of the winter 2013/2014 impacted multiple groundwater levels resulting in lower averages in the first half of 2014. The above-average rainfall in July led to rising groundwater levels. Thus, some stations recorded the highest groundwater levels in 2014 at the end of July and early August respectively.

Switzerland

Switzerland observed largely normal groundwater levels and spring discharges within the year 2014. The groundwater levels and spring discharge in 2014 are as follows:

On the north side of the Alps the high groundwater levels and spring discharges at the beginning of 2014 largely returned to normal primarily due to below-average precipitation in February and March; while still high on the south side of the Alps due to the large amounts of precipitation.

As a result of below-average precipitation during the three months of spring, the groundwater levels and spring discharges dropped nationwide. The groundwater levels of the Talschotterebenen in the Swiss Plateau were in normal range in June, locally even deep. The spring discharges of the karst groundwater aquifers in the Jura were partially low due to below-average rainfall in the previous months.

Persistent torrential rains in July led locally to high groundwater levels and spring discharges. The heavy precipitation caused the river level in the catchment basin of the Aare to rise, which led to an increased river water infiltration. Consequently, a rapid rise in groundwater levels occurred along the Aare and Emme. Late June's low spring discharges returned quickly to normal as a result of above average rainfall.

The high groundwater levels and spring discharges from early August returned to normal due to various amounts of precipitation received in September and October. At the beginning of November, the groundwater levels throughout Switzerland were back to normal. .

History and characteristics of suspended matter in Germany's section of the Rhine 2014

In order to obtain an overview of the suspended matter, the data of the stations Maxau (on the Rhine at km 362.3) for the Upper Rhine and Weißenthurm (on the Rhine at km 608.2) for the region of the lower Middle Rhine / Lower Rhine (below the largest feeders) were evaluated, see also Figures 20a and 20b.

Extreme peaks during daily loads are causally the result of heavy rain events in summer and the melting season in winter.

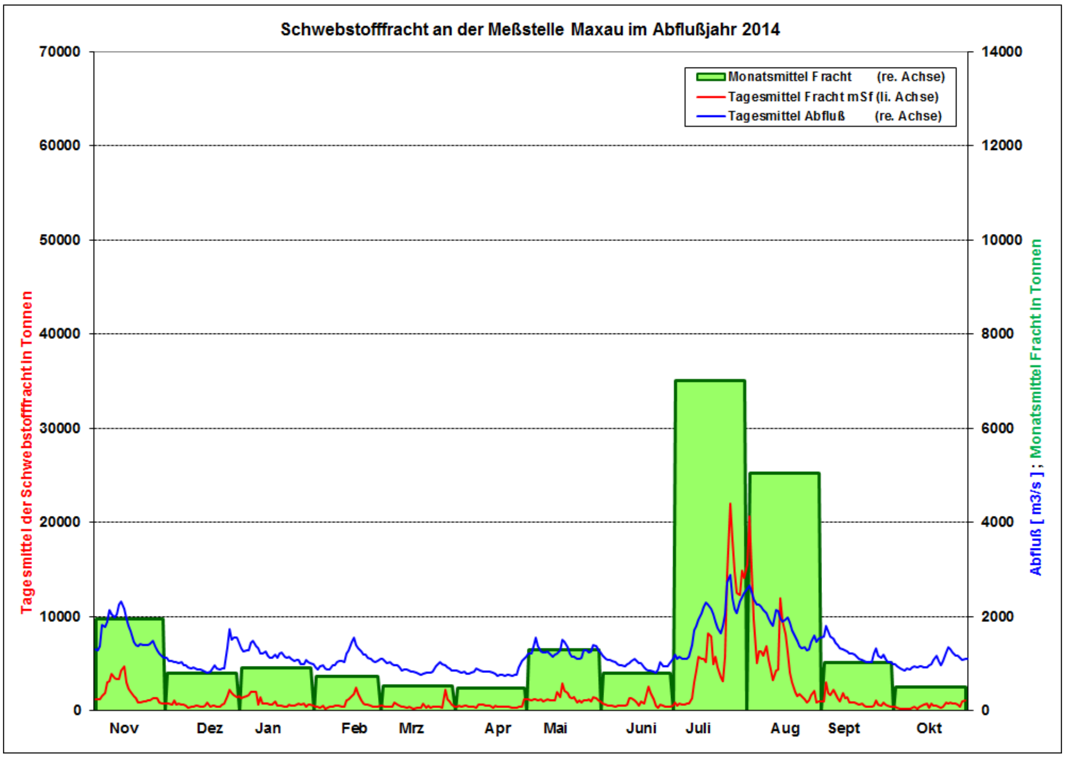

Figure 20a: Measuring point for suspended matter at the station of Maxau on the Rhine at km 362.3

At Maxau (on the Rhine at km 362.3) the annual suspended matter load was 646724 t, which is approximately 51% of the long-term average of the reference period 1965/2007.

The highest monthly sediment load was recorded at the gauging station Maxau in July 2014 with a total of 217715 t (equal to a median daily load of 7023 t that month, see Figure 20a). This is approximately 34% of the total annual load; the lowest monthly total of sediment load was established in April 2014 with only 14692 t.

In terms of the daily loads at the Maxau station, the lowest load was 215 t recorded on March 14 at an average discharge of 828 m³/s, while on July 24 the largest daily load was 21973 t at an average daily discharge of 2890 m³/s.

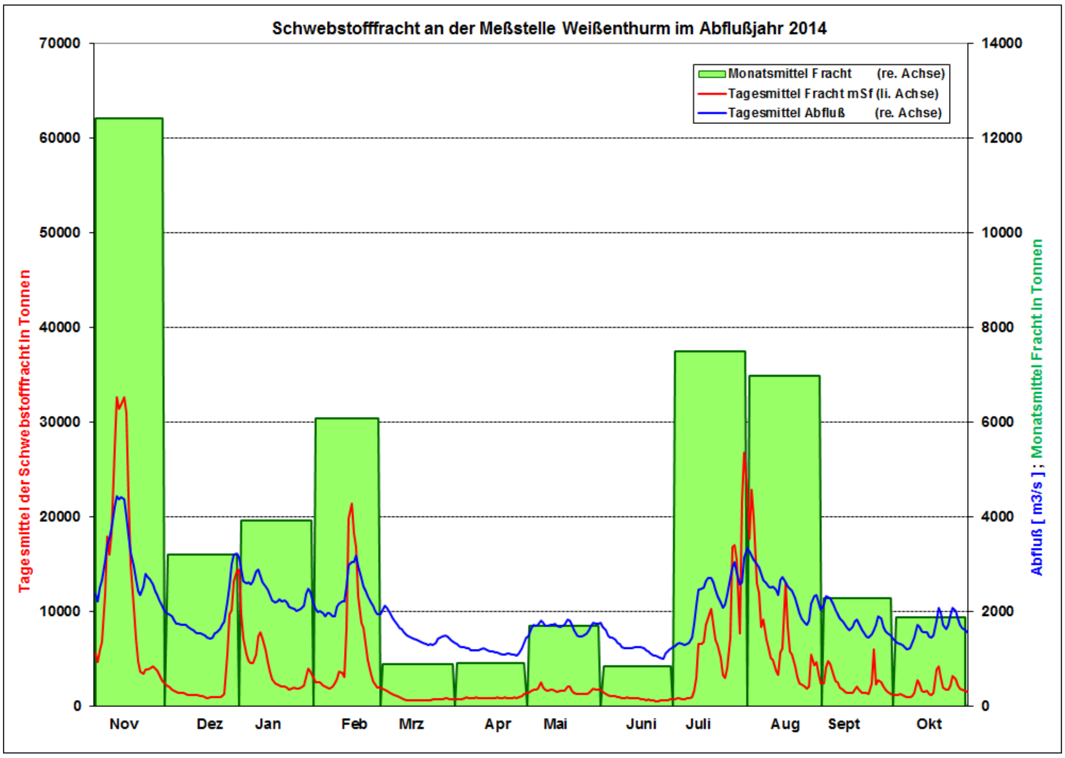

Figure 20b: Measuring point for suspended matter at the station of Weißenthurm on the Rhine at km 608.2

Weißenthurm on the lower Middle Rhine (reference station here is the Andernach gauge on the Rhine at km 613.8) recorded the annual sediment load of 1471372t; this is roughly equivalent to 48% of the long-term average of the reference period 1965/2007.

The highest monthly sediment load recorded at the station of Weißenthurm was 372229 t in November 2013 (monthly average: 12408 t/day) at an average monthly discharge (MQ) of 3035 m³/s; the lowest with only 27412 t was recorded in April 2014 (MQ = 1187 m³/s).

The lowest daily load at the station of Weißenthurm was 555 t on 24 June 2014 at an average discharge of 1040 m³/s. In contrast, the largest daily load of 32673 t was recorded on 10 November 2013 (at an average daily discharge of about 4430 m³ /s).

Explanation for the determination of suspended matter data at the Weißenthurm station:
Due to lack of staff at the relevant WSA in the hydrological year 2014, suspended matter measurement were taken at the Station Weißenthurm on a few days only. Data from the data series of the stations KAA Koblenz/Rhine (continuous station for turbidity), Cochem/Mosel (continuous station for turbidity) and Kalkofen/Lahn (daily scoop samples), were used to calculate and sum up the daily loads, then from the daily totals the daily values for the concentration in Weißenthurm were calculated using the discharge sequence of Andernach.

2. Activities of the International Commission for the Hydrology of the Rhine Basin (CHR) 2014

The CHR has met twice in 2014, on 27 and 28 March in Bregenz (Austria) on 17 and 18 September in Brig (Switzerland).

Personnel changes within the CHR

Mr. Wolfgang Grabs has left the WMO on 1 April 2014 and returned to the BfG in Koblenz. Mr. Paul Pilon (Canada) holds now the position as head of the Division 'Hydrological Forecasting and Water Resources' at the WMO. The CHR plans to engage Mr. Pilon as the new WMO Representative for the CHR conferences.

The participation of France in the CHR was discussed again. The new French representative at the CHR is Mr. Eric Gaume from the Institut Français des Sciences et Technologies des Transports, de l'Aménagement et des Réseaux – IFSTTAR in Nantes. The CHR will also try to engage a representative of the DREAL for the meetings of the Commission, so that regional aspects are duly reflected.

CHR project activities

Climate change

Various Rhine States have created new climate scenarios. In the course of CHR's 74th meeting, the question was discussed whether these new findings could be a cause for the revision of the RheinBlick2050 report.

It is the view of the CHR representatives that the new findings should be analyzed. It was agreed to discuss the issue in 2015 in detail. The following issues should be included on the agenda:

- What changes to the flow regime would the new climate scenarios bring about?
- Is there a need for further research or new research questions?

ASG-Rhein: Contribution of snow and glacier melt to the Rhine discharges

Mr. Belz gave an account on the progress of the project during the 73rd CHR conference in Bregenz. Strenuous effort was made in terms of collecting and processing data. The period covered is 1951-2006. A self-developed analog-day method is used to reconstruct data for climate data for the period 1901-1950, which is not covered by HYRAS. Snow calculation and modelling needs further optimization. As part of an additional contract funded by the FOEN snow water equivalent maps were produced by the SLF for the period 1972 – today. Various potentially suitable models for handling issues in the head catchment basins were studied by comparison.

On 27 and 28 May 2014 a project meeting took place in Fribourg.

During the 74th CHR meeting in Brig, the project progress was presented by prof. Seibert of the University of Zurich.

The first phase of the project will end in 2015 and will be presented in a colloquium. A possible second phase would be dedicated to the possible future contribution of snow and glacier melt under the influence of climate change.

Sediment

The CHR supports the project "From the source to the mouth - a sediment balance of the Rhine" conducted by the BfG and the University of Aachen. The Project Advisory Committee (Advisory Board) met in Koblenz at the end of January 2014. The project was completed in end 2014.

The project activities were presented at the 74th meeting in Brig by Mrs. Hillebrand of the BfG. Some partial reports on the work carried out are already available. Furthermore, some (inter)national publications have been published in the course of the project. The project builds primarily on existing data. Only for the Upper, Middle and Lower Rhine new selective data for the clarification of certain issues were collected.
Project results will be presented in a symposium in 2015.

Socio-economic influences on the low water regime of the Rhine
On the occasion of a symposium organized in March 2014 in Bregenz/Austria, the subject was discussed during the 74th CHR meeting in Brig. The report on the Bregenz seminar contains approaches for a possible CHR project. Further discussions will take place in 2015

Lake Constance as high and low water storage - a literature study
The CHR commissioned an evaluative-analyzing literature study to be conducted by the Technical University Munich. During the 74th CHR meeting in Brig, the project was presented by Mr. Hansinger of the Technical University of Munich.
Lake Constance, one of the unregulated large lakes in the Alpine region, shows in the long-term average during the course of a year water level fluctuations of approximately 2.40 m. This margin in principle provides good prerequisites for the use as high and low water storage within the natural fluctuation span. The ideas to the use Lake Constance as water reservoir are not new. The development of the idea materialized due to the recurring and prolonged high water levels on Lake Constance (affected is in particular the upper lake) in the mid-19th century. Mr. Hansinger presented an overview of the envisaged structural actions gained from various projects and described the hydrological effect.

Cooperation with other organizations
The CHR has sent an application for observer status to the Central Commission for Navigation on the Rhine (CCNR) in Strasbourg on 17 April 2014. The observer status of the CHR was approved at the CCNR plenary session in December 2014.

CHR organized events
In March 2014, the CHR organized a two-day colloquium in Bregenz on “Socio-economic influences on the low water regime of the Rhine”. The symposium gathered 40 participants from across the Rhine river basin. All contributions will be available as downloads on the CHR website and the results have been summarized.

On 8 and 9 May 2014, the CHR in cooperation with the ICPR and the Mekong River Commission organized the first joint Rhine-Mekong River symposium. The report with the results of the symposium is available on the CHR website.

Future activities
Based on the first joint Rhine-Mekong symposium at the BfG Koblenz future cooperation was rated as desirable by both river basins. Mr. Wolfgang Grabs of the BfG is the contact person and coordinator of the next steps. A second joint symposium is planned.

In 2020 the CHR celebrates its 50th anniversary. On this occasion a new Rhine monograph shall be published. The new monograph aims at creating a common database for future generations. Prof. Siegfried Demuth (until today UNESCO Paris) has been proposed as the project manager of an international task force.

During the 74th CHR meeting, Mr. Hauser of the University of Bern presented the development of HADES (Hydrological Atlas of Switzerland). The concept of the HADES website is very interesting and offers prospects for the publication of the new Rhine monograph. The aspiration of the CHR is the publication of a new common basis of the Hydrology of the Rhine that fits today's digital age, yet factoring in the historical data as completely as possible.