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

Annual Report of the CHR 2010

Editorial: Eric Sprokkereef

Articles:
Stephan Bader, MeteoSwiss, Zurich
Martin Barben - Federal Office for the Environment, Bern
Jörg-Uwe Belz - Federal Institute of Hydrology, Koblenz
Adrian Jacob - Federal Office for the Environment, Bern
Clemens Mathis - Office of the Provincial Government of Vorarlberg, Bregenz
Michael Mürlebach - Federal Institute of Hydrology, Koblenz
Marc Schürch - Federal Office for the Environment, Bern

Secretariat of the CHR
PO box 17
8200 AA Lelystad
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) functions as part of the International Hydrological Programme (IHP) of UNESCO and the Hydrology and Water Resources Programme (HWRP) of WMO. It is a permanent and independent international commission and has the status of a trust that is registered in the Netherlands. Commission members are the following hydrological scientific institutes of the Rhine basin:

- Federal Ministry of Agriculture and Forestry, Environment and Water, Department VII / 3 - Water Management (Central Hydrographic Office), Vienna, Austria,
- Office of the Provincial Government of Vorarlberg, Department VIId - Water Management, Bregenz, Austria,
- Federal Office for the Environment, Bern, Switzerland,
- CEMAGREF, Antony, France
- Federal Institute of Hydrology, Koblenz, Germany,
- Hessian Agency for Environment and Geology, Wiesbaden, Germany,
- IHP / HWRP Secretariat, Federal Institute of Hydrology, Koblenz, Germany
- Administration de la Gestion de l'Eau, Luxembourg
- Deltares, Delft, The Netherlands
- Rijkswaterstaat – Centre for Water Management, Lelystad, The Netherlands.

1. Hydrological Summary for the Rhine Catchment Area

Meteorological Characteristics

Austria

The total annual rainfall in the Austrian part of the Rhine catchment area was between 100 and 135% of the long-term annual average value. While the rainfall was below average from January to April and September to October, above-average rainfall was recorded from June to August and November to December.

The highest monthly rainfall of 512 mm was measured in July in Bregenz since monitoring began in 1893.

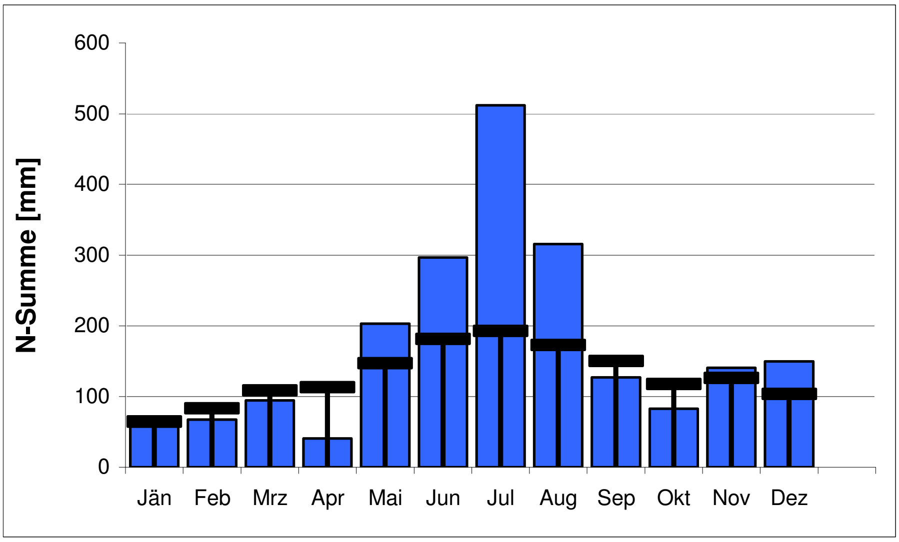

Fig. 1: Monthly rainfall totals in 2010 compared with long-term average monthly rainfall at the measuring station of Bregenz Altreutheweg

Switzerland

In the year 2010 Switzerland experienced a slightly warmer weather and shortage of rainfall especially in the west. From the beginning of the year until mid-March the weather was mainly characterised by wintry low temperatures and frequent snowfall especially in lowland areas. Onset of spring-like periods of fine weather was in late March and above all in the second half of April. The early summer from early May until the second half of June was mostly cloudy and cool and marked by unusual lack of sunlight. The period from mid-June until mid-July was persistently hot - characteristic of midsummer - very dry especially in the west. The remaining summer and autumn was dominated by changeable weather, whereby snow fell several times in the uplands and down to the lowlands in November. The year ended with a lot of fresh snow in the plains and an unusually cold December at the mountain peaks.

Switzerland has experienced the coldest January in 23 years. The first days of February brought icy cold weather. In La Brévine the temperature fell to -35.6 degrees Celsius, while in Engadine it was -25 to -30 degrees Celsius. The cold winter weather with snowfall up to the plains lasted until mid-February. The coldest winter since 30 years was recorded at the summit stations. At the Jungfraujoch and the Great St. Bernard, it was even the coldest winter in 40 years.

Winter conditions with intense snowfalls especially in the midland and persistent stormy and icy north wind dominated the first half of March. With the support of foehn, mild air masses indicating the first strong signs of spring allowed the temperatures to rise to 23 degrees Celsius on 25th March, which occurred in March the last time in 1990. The second half of April continued to be spring-like. The temperatures often rose above 20 degrees and the first summer day with a high of 25 degrees or more could be enjoyed in large parts of Switzerland around the end of April. This quiet period of pleasant weather witnessed the violent eruption of the Icelandic volcano Eyjafialla. On 17th April the ash cloud reached Switzerland, following which air traffic had to be suspended for three days.

The summer set in the last third of June and unfolded its whole force between the 8th and 21st of July in the form of a real heat wave with temperatures of above 30 degrees almost every day. However, no absolute heat record was broken. Just a month after its arrival, the summer turned its back on the north of the Alps in the last third of July for a long time. Towards the end of July, the snow line dropped below 2500 meters and to 2100 meters by early August. Higher passes were temporarily covered with snow. Warm air masses from Spain brought midsummer once again in the last third of August and treated Switzerland with the warmest night of the year (from 26th to 27th August) with unusually high temperatures of about 25 degrees.

By the end of November the cold polar air took over the weather regime in Switzerland and the temperatures dropped in the lowlands north of the Alps and in Jura to new regional lows for November. On the first of December, Switzerland was blanketed by snow. The strong snowfall led to high snowfall levels in the lowlands for December. The Bern-Wabern measuring station reported the record snowfall of 57 cm of fresh snow for December. The fresh snowfall of 58 cm in Zurich was also a record. Similar levels of snowfalls in December were witnessed only in the years 1979 and 1962.

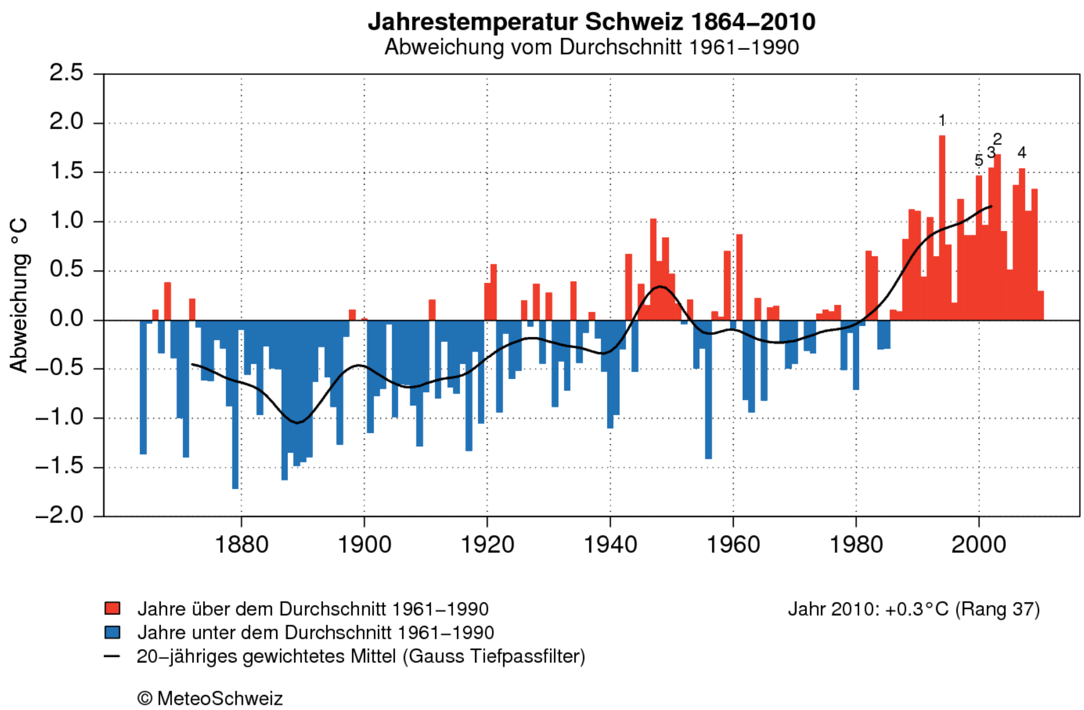

Fig. 2: The annual variation of temperature in Switzerland from the long-term average (1961-1990 standard). The very hot years are indicated dark, while the too cold years bright. Solid line: 20-year weighted average

Germany
The temperatures in the year-to-date 2010 (November 9 to October 10) in the German part of the Rhine basin were in turn too high with an average of 8.4 °C (as in previous years), even if only by +0.2 °K. Significant monthly deviations from the compared average values over the period 1961/90 were observed in November 2009 and July 2010 with +3.3 and +3.4 °K and in January 2010 with -3.1 °K. These values determined for the entire Federal Republic of Germany can also be observed at the Bendorf am Mittelrhein station of the Rhine area, as shown in Figure 3.

The distribution of rainfall in the months of November and December was approximately 125% of the long-term average observed between 1961 and 90, whereas in May it was 136% and in August 210% (regional characteristic: the rainfall of 174 mm in the Main region was even 250% of the rainfall expected normally in August). On the other hand, low precipitation was recorded in the Rhine region in April (only 30% of the long-term average), June (56%) and October (59%). Overall, the rainfall recorded over the year-to-date coincided with the long-term average.

The rainfall distribution ratio between winter and summer months of 42 to 58% as in the previous year, showed a significant increase in summer rainfall over the distribution of precipitation observed long-term (winter 48.5%, summer 51.5%).

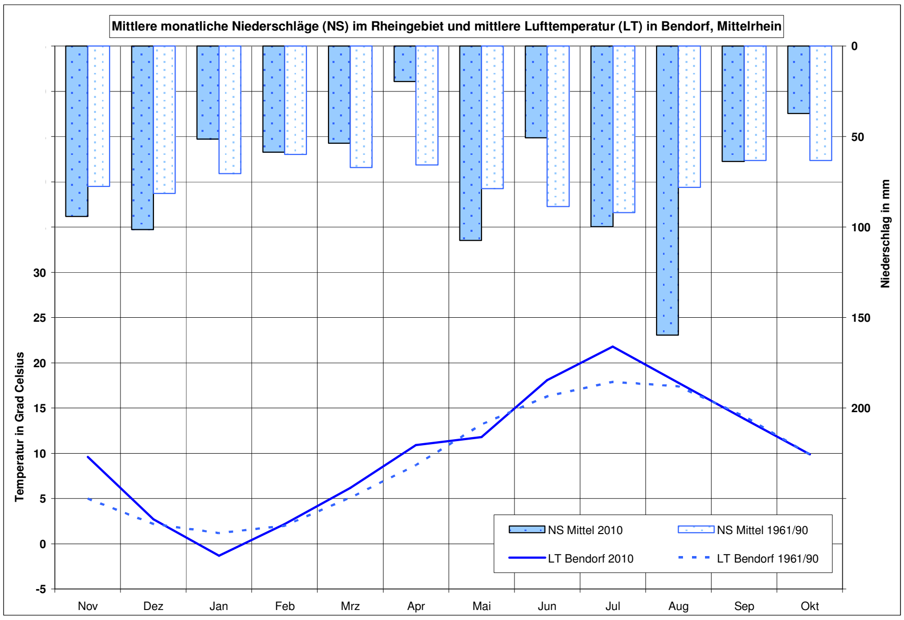

Fig. 3: Comparison of the average precipitation and temperature data observed in the year-to-date 2010 and the long-term average

Netherlands
In the Netherlands, 2010 was the coldest year since 1996. The year was also very sunny and the rainfall can be described as normal. The mean annual temperature at the measuring station De Bilt was 9.1 °C in 2010.

The year 2010 had a cold start with a lot of snowfall. The winter was the coldest in 14 years, especially the month of January was extremely cold. The average temperature in January was

-0.5 °C, where 2.8 °C is normal. After a mild spring the month of May was very cool. The mean temperature in De Bilt was 10.5 °C, the lowest level since 1991.

The first half of the summer was warm and sunny. Above all, the month of July was warm with an average temperature of 19.9 °C - where 17.4 °C is normal - and ended in the fifth place in the ranking of warmest July months since 1901.

Winter set in late November. The month of December was very cold and snowy. With an average temperature of -1.1 °C in De Bilt - where 4.0 °C is normal - December 2010 was the coldest December month over 40 years.

On average, 801 mm of precipitation was recorded in the Netherlands. The long-term average is 797 mm. In winter 2009/10, the amount of precipitation was considerably more than snow. On average, the Netherlands was snow-covered for 42 days. The long-term average is 13 days of snow cover. There had not been so many snow-covered days for 30 years now. With 170 mm - as against a normal rainfall of 62 mm - August was the second wettest August month since 1901.

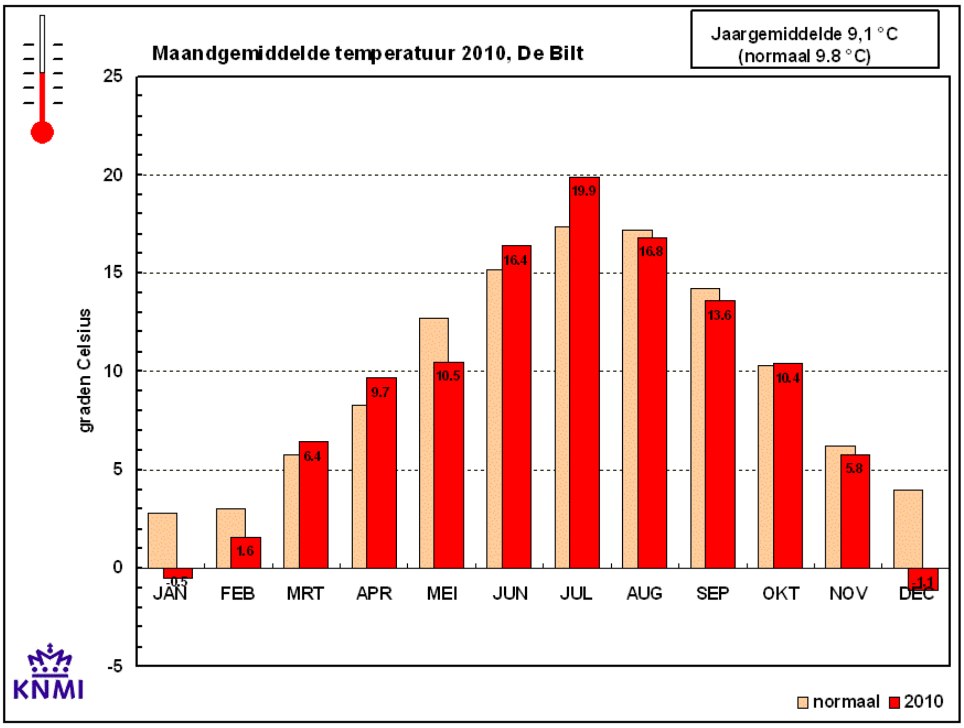

Fig. 4: Annual mean temperatures at the De Bilt station / Netherlands from 1706 until 2010 (source: KNMI).

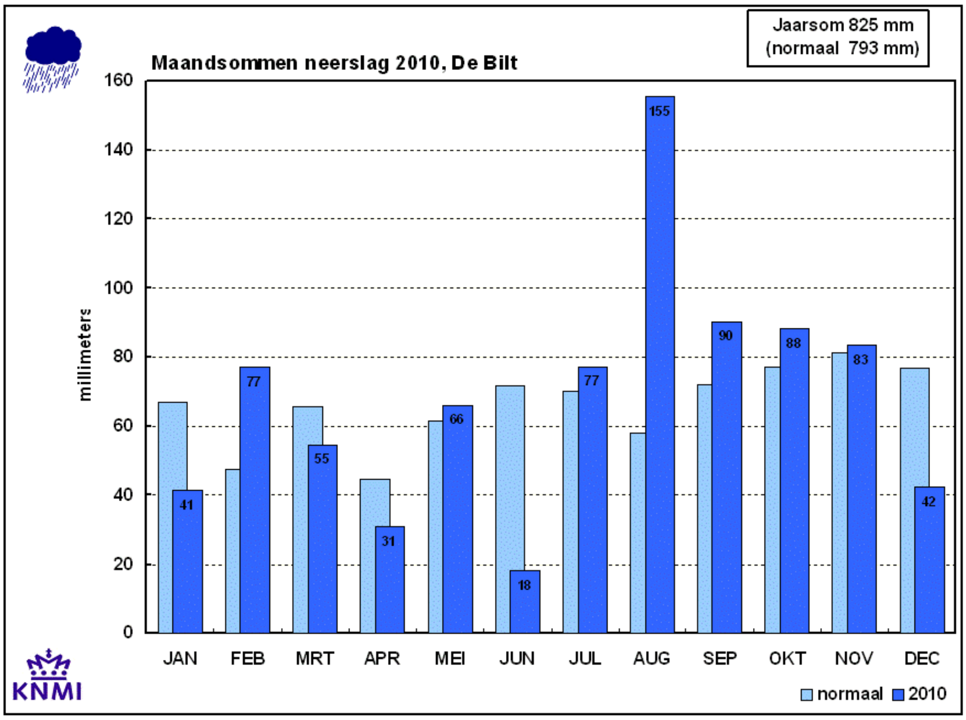

Fig. 5: Total monthly precipitation at the De Bilt station / Netherlands from 1706 until 2010 (source: KNMI).

Hydrological situation in the Rhine region in 2010

Water levels of major lakes in the catchment area of Rhine

The water level of the Lake Constance at Bregenz in the month of January was above the long-term daily average value. From February to end of July - with the exception of the period between 18th and 27th June - the water level was below the respective daily mean values of the series of observations between 1864 and 2008. The above-average rainfall in July, August, November and December led to the water level being above the long-term daily average value (see Figure 6) from the beginning of August to the end of the year with the exception of the period between 11th October and 13th November.

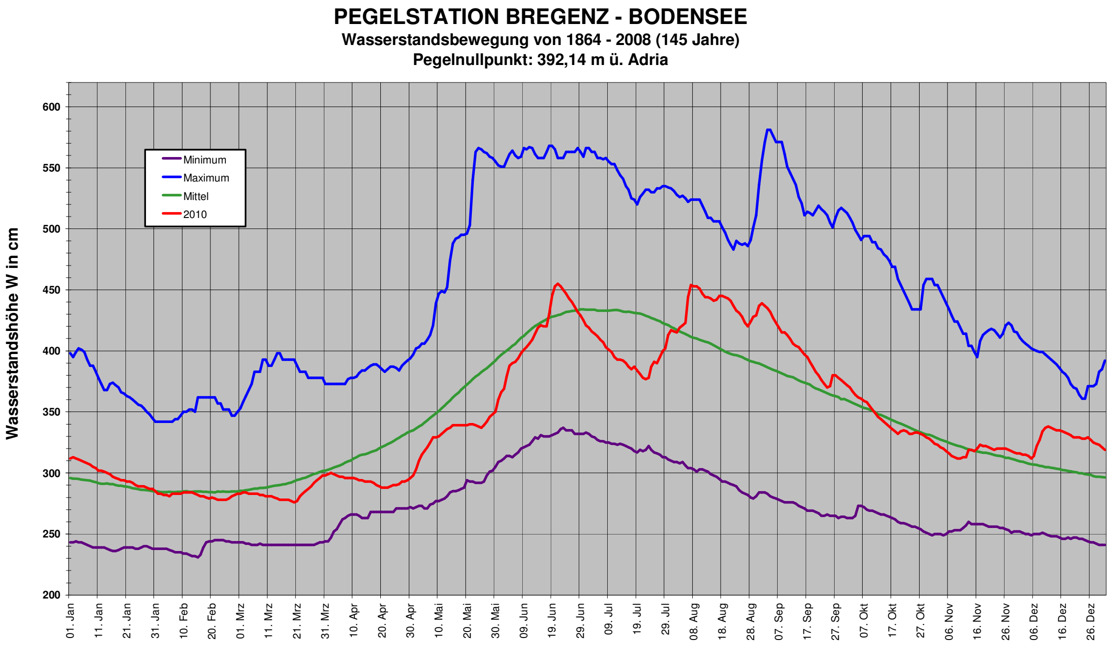

Fig. 6: **Gauging station Bregenz / Lake Constance. Hydrograph in 2010 and main values of the period from 1864 to 2008 (145 years) - gauge datum: 392.14 m above the Adriatic Sea.**

Water levels and flowing waters

The mouths of the most important tributaries to Lake Constance were above average in 2010.

- 118% at Bregenz (MQ 2010 = 54.9 m³/s, a long-term MQ = 46.3 m³/s);

- 101% at the Alpine Rhine (MQ 2010 = 233 m³/s, a long-term MQ = 230 m³/s);

Along the Aare river and to the west of it there was low rainfall in 2010. In many places, only 70 to 75% of the normal annual totals were measured (reference period 1961-1990). Above-average rainfall was witnessed from central to the north-east of Switzerland. Along the Alpine foothills, there were surpluses as a result of severe summer storms.

The annual runoff into the Rhine at Basel corresponded almost exactly to the long-term average. Sub-basins with annual runoffs well below average (< 75% of long-term average value) are mostly found in the Aare catchment (e.g. Mentue, Areuse, Dünnern). Sub-basins with above-average runoffs are the Töss, the Sihl or the Thur.

In August, widespread above-average runoffs occurred. High values were especially witnessed in the Dünnern, the Sihl, the Limmat and the Thur. In the above-mentioned catchment areas of Areuse and Dünnern only August and December showed discharges above the long-term monthly average. The remaining months were too dry.

Very large events have not occurred in the larger rivers of the Rhine area in 2010. In June, the runoff in Basel increased to 2,755 m^3/s, an event with a recurrence interval of nearly two years. At the Aare in Brugg, the Reuss Mellingen, the Limmat in Baden and the Thur in Andelfingen there was a biennial runoff event respectively.

The Lake Constance showed largely normal water levels in the course of the year. From early April until mid-June, the water level was below the level normal for the season. Shortly after the lake had reached its high for the year, the water level dropped rapidly and was below the seasonal averages in the whole of July. In August and September and then again in December, the water level was above the averages.

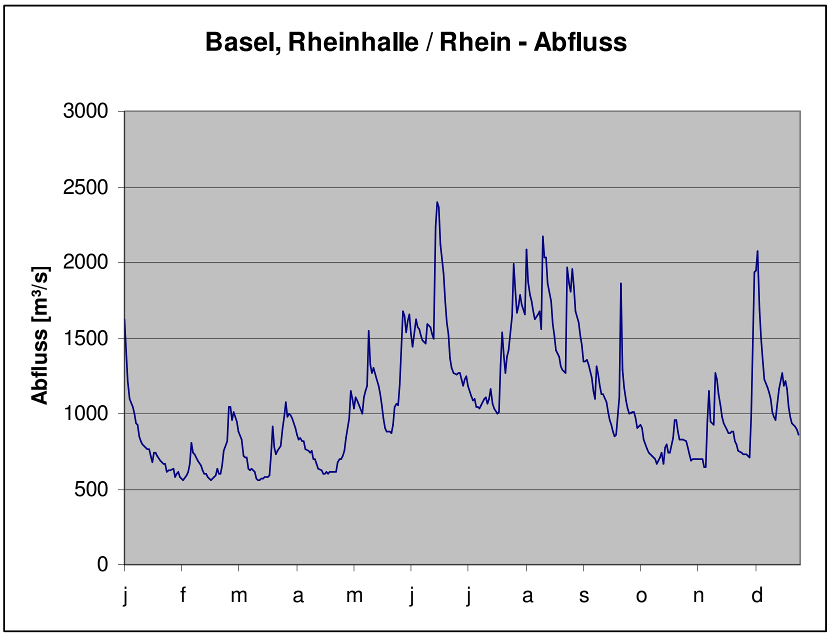

Fig. 7: Discharge hydrograph at the gauging station of Basel-Rheinhalle (Rhine) in 2010 in m³/s

The runoff event between November and middle of December was marked by unusually mild and wet weather. This led to about 10% above-average runoffs when compared to the long-term reference values observed at the gauge points in the Rhine area. A warm and humid weather pattern at the end of December brought snowmelt from the south even at higher elevations and heavy rainfall, resulting in a minor flood peak in the first days of January. The latter winter half-year was predominated by snow precipitation that did not initially contribute much to the runoffs. Only in the second half of March, temperature rise led to snowmelt, which along with heavy rains led to a flood wave at end of the month. This represented the most prominent "flood peak" during the entire annual runoff for the right-bank tributaries of Rhine and the Lower Rhine (Cologne gauge 5,290 m³/s; HQ < 2). In April, dry conditions prevailed with rainfall of only about a third of the annual average. The runoff values at the Rhine gauges therefore dropped below the monthly MNQ (e.g. Cologne 1,190 m³/s). The second half-year brought two significant rainfall peaks in May and especially in August. This led to late summer monthly MQ in the Rhine and Main that was significantly higher than the average. Overall, the runoffs in the second half-year on the Neckar were around MQ, and between MNQ and MQ on Lahn and Mosel.

The number of days of dropping below the monthly MNQ was particularly striking on the Rhine in the months of April (see above) and July. The latter coincided with the extremely high temperatures occurring in July, e.g. at the Bendorf gauging station shown in Figure 3 the maximum daily value for the Federal Republic of Germany was 10.7 at 38.8 °C. At the gauging station of Maxau, MNQ was undershot on 49 days in winter and 28 days in summer. At the gauges of Kaub and Cologne, the ratio was considerably more balanced with 30 to 25 days or 30 to 33 days.

Likewise, as mentioned above, significantly higher summer rainfall at the gauge of Maxau showed a similar distribution for the runoffs: in winter, 42% of runoff volume flowed out, whereas it was 58% in summer. At the Middle Rhine gauge of Kaub the ratio between winter and summer was 47 to 53%. In the area of the Lower Rhine, the picture was different: at the gauge of Cologne 53% of the total runoff volume flowed out in winter - compared with 47% in summer. This is because of the fact that the runoff profile of the river below the mouth of the Mosel is already strongly influenced by the rains in the face of the major tributaries flowing in. Their seasonal runoff distribution shows significantly higher runoff in winter than summer: Neckar and Main discharged about 60% of the runoff volume in winter, Lahn and Mosel as high as 77% of runoff on average in the winter months.

In comparison to the values observed long-term, the annual runoff in 2010 at the gauges of Maxau and Cologne was 96% and the annual average of 1,660 m³/s in Kaub corresponded to almost exactly the long-time average calculated (1,650 m³/s). On the Neckar and Main, there was a slight increase (2.2 or 3.8%), at the Lahn gauging station of Kalkofen a runoff lower by 5% and with 88% (277 m³/s) on the Mosel, a significantly lower average annual runoff was recorded.

To illustrate the event described above, the annual cycle of runoff at different gauges is shown in Figures 8-11.

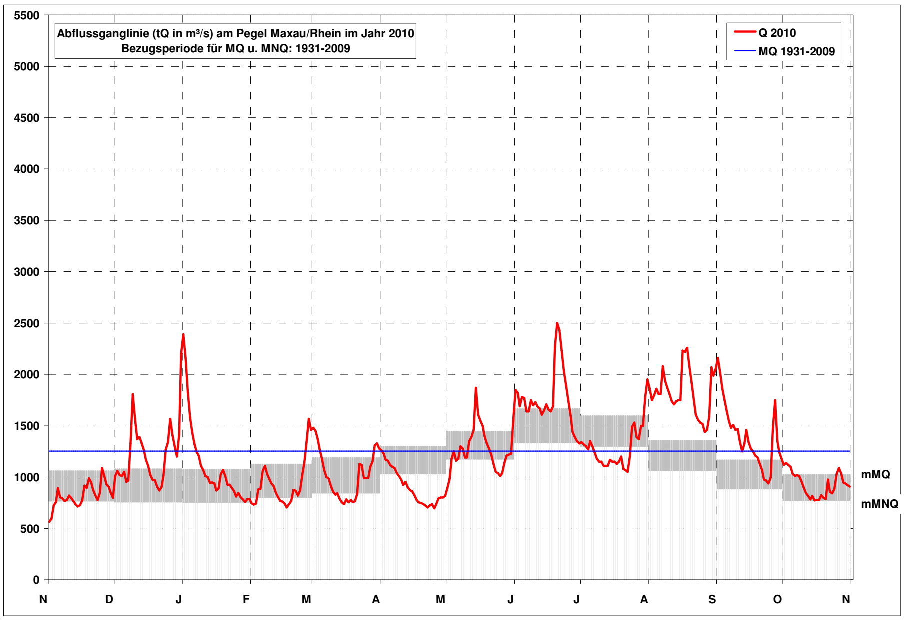

Fig. 8: **Discharge hydrograph (tQ) at the gauging station of Maxau (Rhine) in 2010 in m³/s (reference period for MQ, mMQ and mMNQ: period: 1931 -2009)**

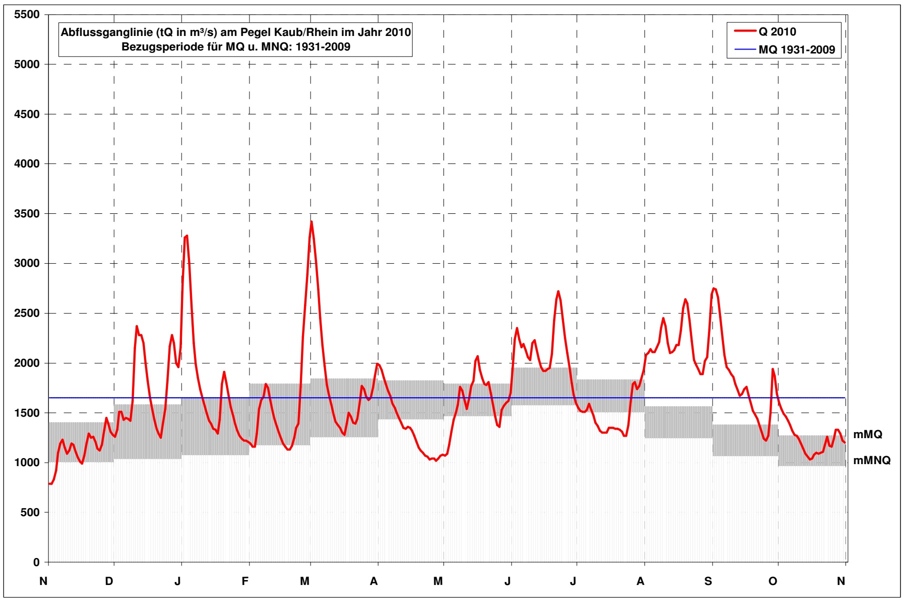

Fig. 9: Discharge hydrograph (tQ) at the gauging station of Kaub (Rhine) in 2010 in m³/s (reference period for MQ, mMQ and mMNQ: period: 1931 -2009)

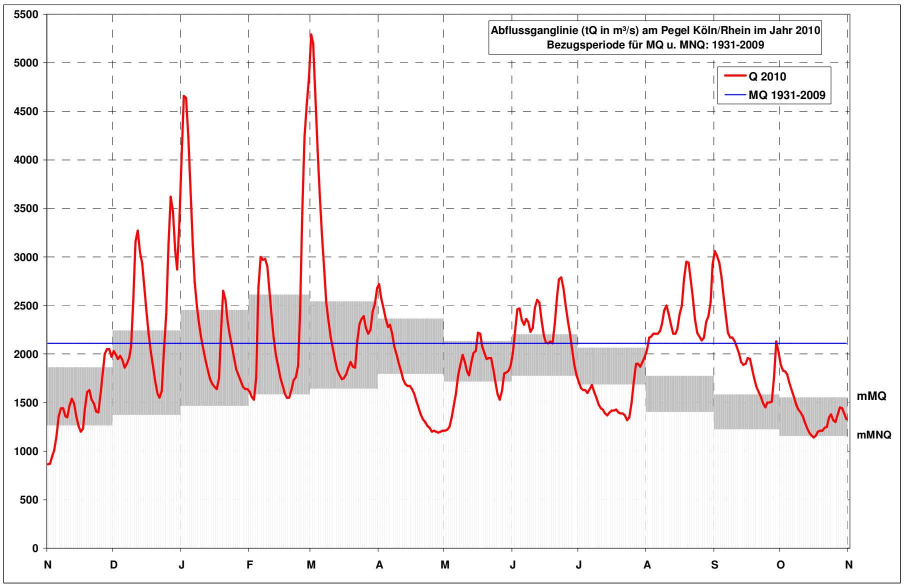

Fig. 10: Discharge hydrograph (tQ) at the gauging station of Cologne (Rhine) in 2010 in m³/s (reference period for MQ, mMQ and mMNQ: period: 1931 -2009)

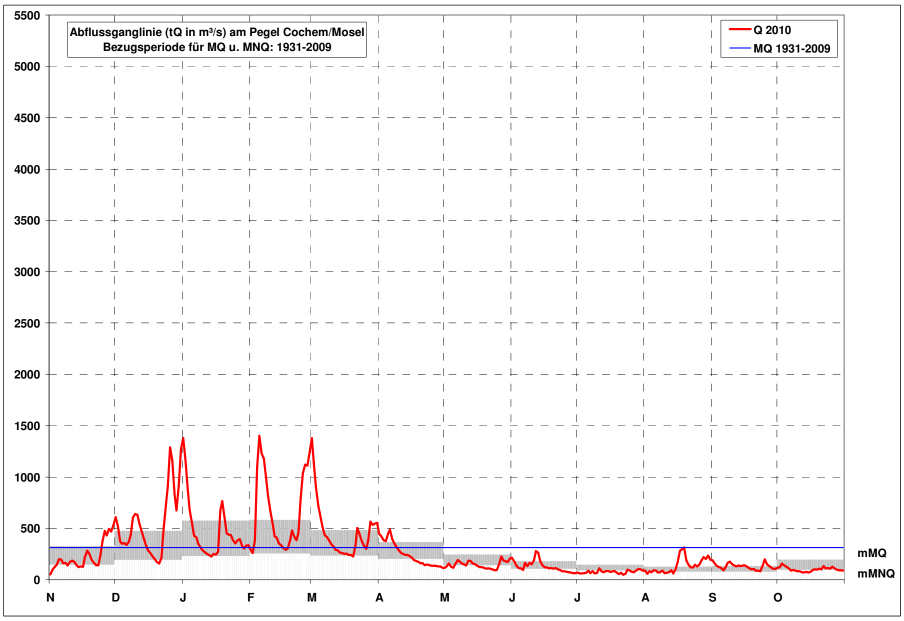

Fig. 11: **Discharge hydrograph (tQ) at the gauging station of Cochem (Mosel) in 2010 in m³/s (reference period for MQ, mMQ and mMNQ: period: 1931 -2009)**

Water temperatures

With 11.7 °C the annual mean water temperature of Lake Constance was slightly below the long-term average of 11.8 °C. In July and August record values were partly measured, whereby highs were recorded in July and lows in August. The year was marked by frequent alternation of days with below and above-average water temperature.

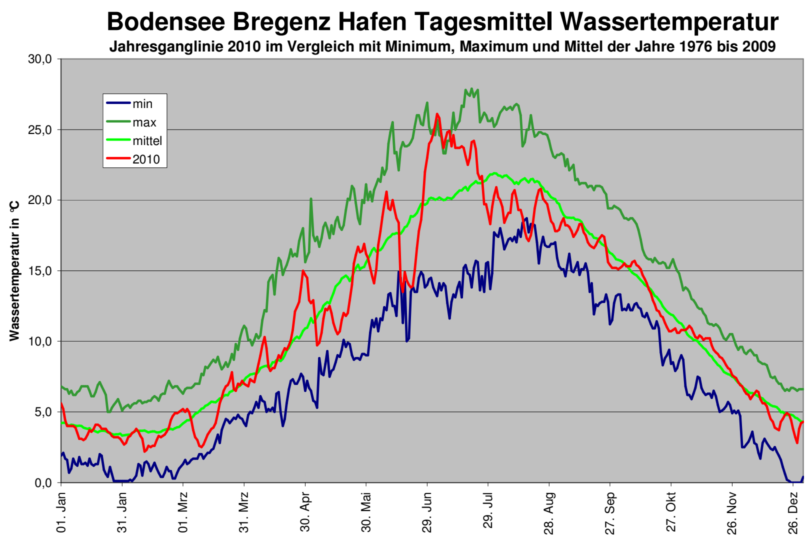

Fig. 12: **Long-term comparison of water temperatures at the gauging station of Bregenz (Lake Constance) in 2010**

Compared with the last 20 years, the water temperatures in 2010 were below average. This was mainly due to the cool months of January, February and December. The water temperatures in these months were mostly below the long-term average. Also early March and late June low temperatures were measured at many stations, in some cases even new daily lows of the measurement periods.

The summer of 2010 broke the heat record of 2003, especially in Eastern Europe and Russia. The months of April, June and July were also very warm in Switzerland. Late April, early May and in July, water temperatures in the range of the maxima of the respective measurement series were recorded for these seasons.

Very low precipitation was recorded in 2010 in the west of Switzerland and Valais. Widespread dry weather was witnessed especially in the months of January, April and October. The wet months of May and August compensated part of the shortage in rainfall during the previous months. These weather conditions led to water temperatures in the affected area which were partly below the long-term average.

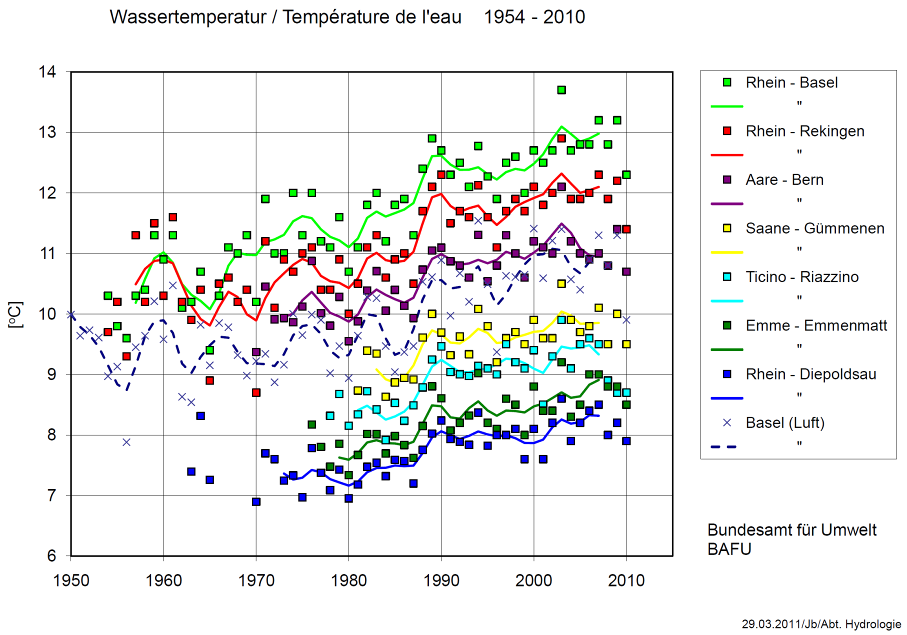

Fig. 13: Long-term comparison of water temperatures in 2010 at some gauges in Switzerland

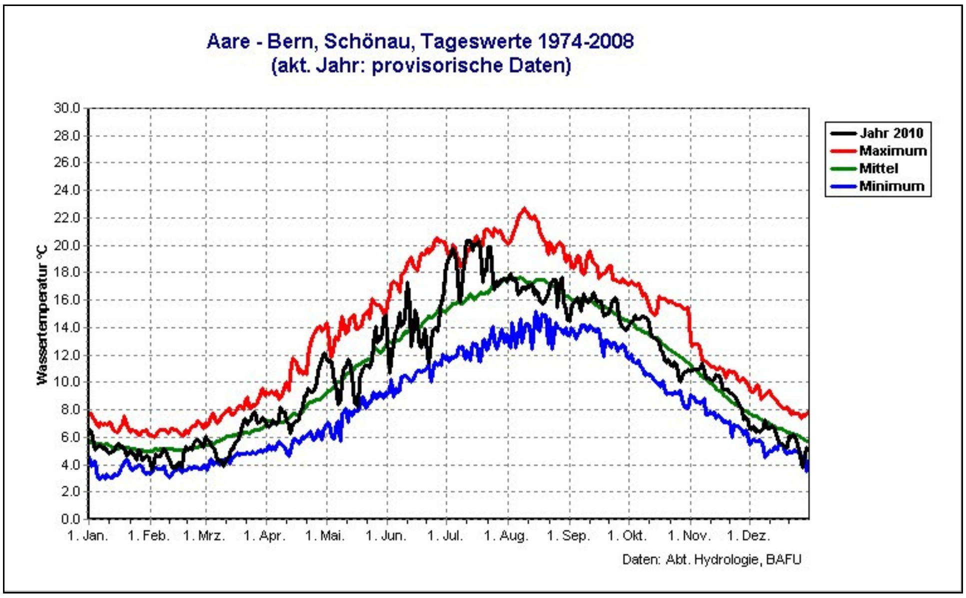

Fig. 14: Water temperatures in 2010 at the gauging station of Bern, Schönau / Aare

The course of the water temperatures measured daily is different at the selected measurement points. With 13.5 °C the annual average recorded in the observation period at the measurement point of Kaub is lower by 0.4 °C over the calculated long-term average (1996-2010), whereas with 13.2 °C at the gauge of Cologne, it is lower by 0.1 °C. The differences are much greater if one takes a closer look at the period between March and July. While the daily values recorded in Cologne were on average below the long-term average by 0.2 °C, the comparison in Kaub shows an average that is higher by 1.2 °C.

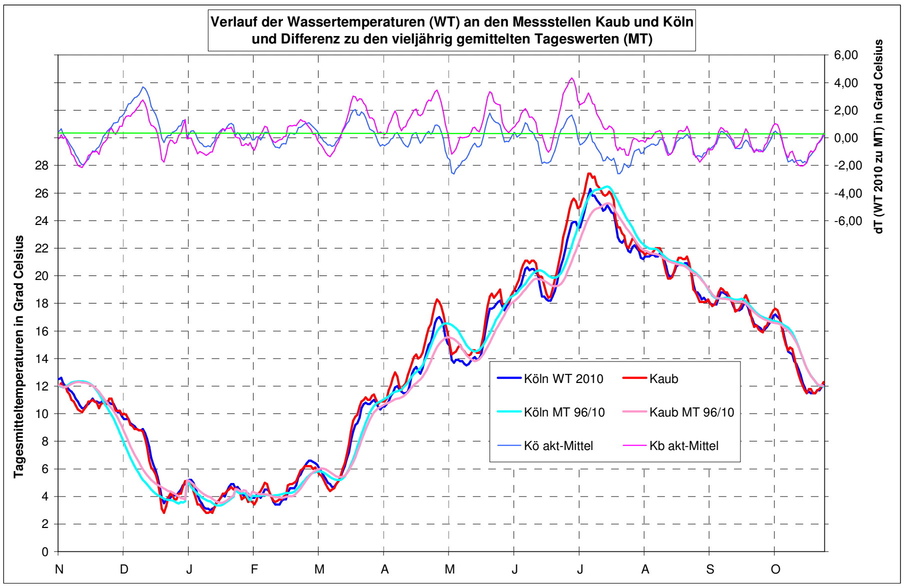

Fig. 15: Water temperatures in comparison to the long-term averages

At the gauge of Lobith the mean water temperature of 13.2 °C was about 0.2 °C above the calculated long-term average (1961-2010).

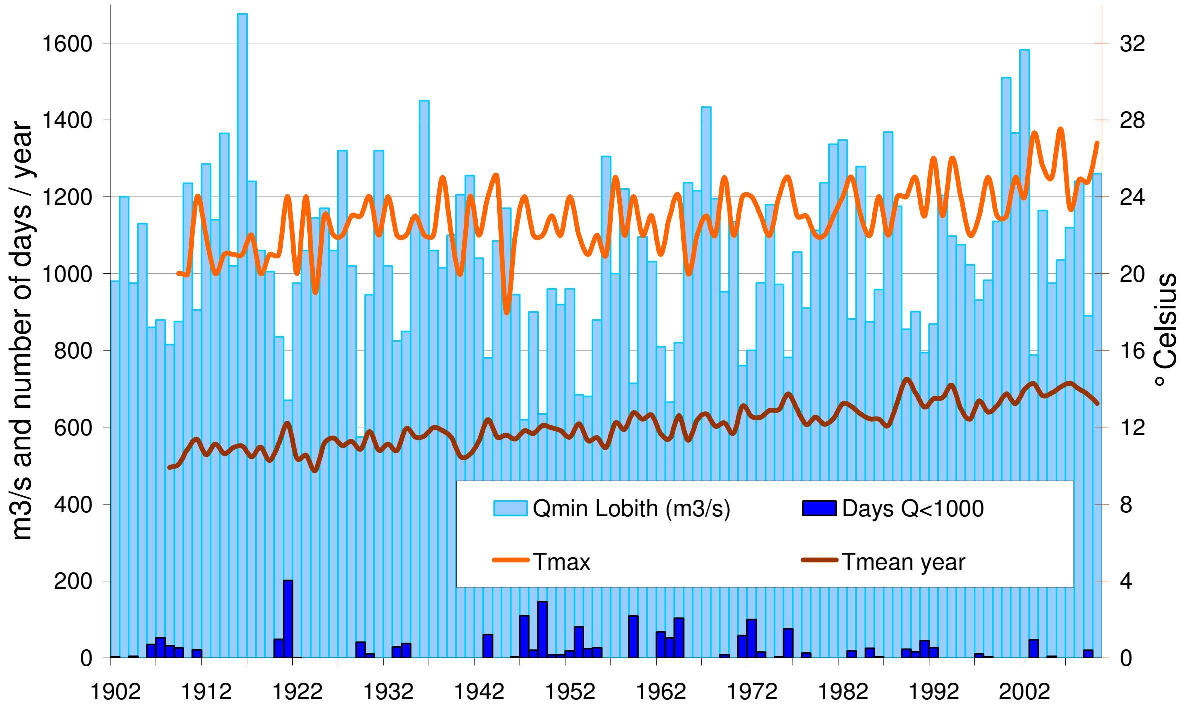

Fig. 16: Mean and maximum water temperatures at the gauging station of Lobith / Rhine

Groundwater

Groundwater levels in Vorarlberg were usually below the mean values in the first half and above the mean values in the second half of the year. New highs were partly measured during autumn.

Groundwater levels and spring discharges in 2010 were below average in the western part of Switzerland (catchment area of the Aare River) as a result of low rainfall. In eastern Switzerland (catchment area of the high Alps and the Rhine) above-average groundwater levels and spring discharges were mostly observed due to high rainfall.

Occurrence and characteristics of suspended matter in the German part of the Rhine in 2010

To get an overview of the suspended fractions, the data from the measuring point at Maxau (for the Upper Rhine), and Weißenthurm (for the area below the main tributaries) were evaluated, see also Figures 17a and 17b.

In Maxau the annual suspended fraction amounted to 0.536 million tonnes and thus corresponded to about 42% of the long-term average (reference period 1965-2007). Weißenthurm with 1.789 million tonnes was comparatively calculated to be 58% of the mean.

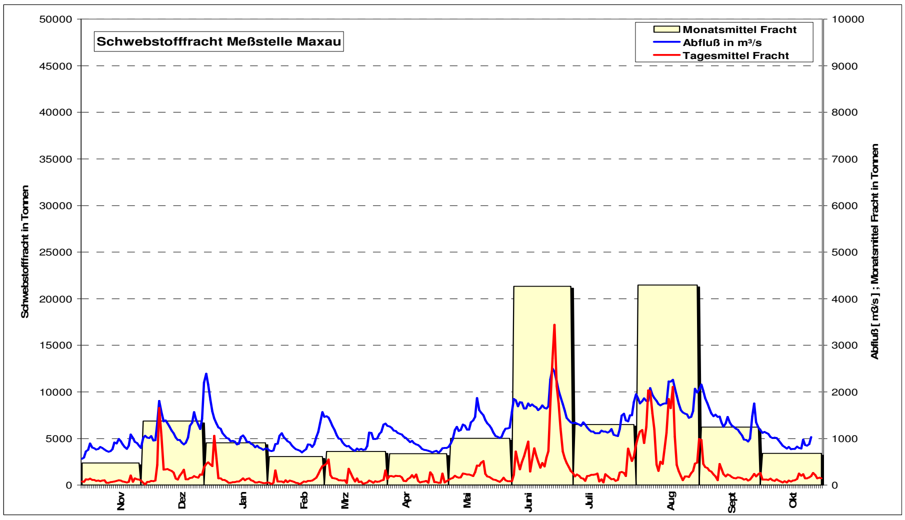

Figure 17a: Suspended matter at the gauging station of Maxau, Rhine-km. 362.3

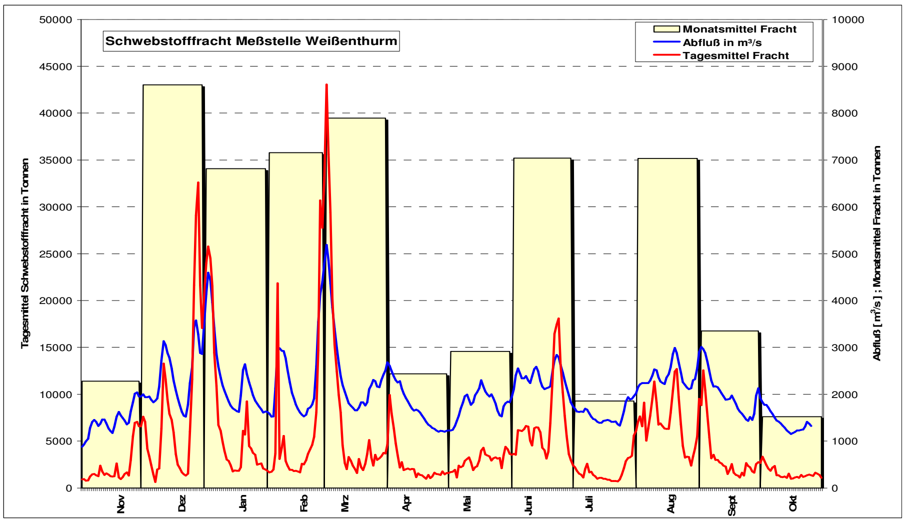

Figure 17b: Suspended matter at the gauging station of Weißenthurm, Rhine-km. 608.2

The highest monthly transport of suspended matter was at the measuring point of Maxau in August (0.133 million tonnes), whereas it was 0.264 million tonnes in Weißenthurm in December. The largest and smallest daily suspended fractions were detected at Maxau with 17,216 tonnes and 92 tons in December and June respectively. Comparable values in Weißenthurm were 43,048 tonnes in March and 643 tonnes in December. The extreme peaks in the daily suspended fractions are the cause of heavy rainfalls in summer and thaw conditions in winter.

2. Activities of the International Commission for the Hydrology of the Rhine Basin (CHR) in 2010

The CHR has met twice in 2010, on the 26th and 27th of May in Alkmaar (Netherlands) and on the 14th and 15th of October in Bonn (Germany).

Changes within the CHR
At the end of the 65th session, the Commission discharged the Luxembourg representative, Mr Robert Kipgen. He leaves the CHR after 28 years and is succeeded by Ms Christine Bastian. The representatives from the Swiss Federal Office for the Environment, Mr Hanspeter Hodel and the Dutch Centre for Water Management, Mr Gerard Blom have also left the CHR. Mr Hodel was succeeded by Ms Petra Schmocker-Fackel. Mr Blom started his work with Deltares on 1 August 2010. His successor is Mr Klaas Groen, Head of International Cooperation in the Centre for Water Management.

Activities in the CHR Projects

Changes in the discharge regime
The final report of this study was published in 2008. A detailed summary and a flyer were drafted last year. A detailed summary can be downloaded from the website. The flyer for the project was printed, can be downloaded and ordered via the CHR website.

RheinBlick2050
The final report of the project was printed and sent to the CHR members. Just before the CHR session in Bonn, the report was presented on a two-day colloquium. A PDF version of the report is available for download. The project page on the CHR website has been updated. The project group has yet to make a decision on which project data will be made available. Eventually there will be a link from the CHR website to a data server at one of the project partners.

HYMOG
In the first phase of this project consistent data series are created for the Rhine from Lake Constance to Lobith. These data should lead to improvement in the databases for hydrological and hydraulic models for the Rhine basin. The model improvements should be carried out in the second phase. The project is on schedule and the first phase is almost complete. The project results will be presented at the next CHR session (March 2011).

Paper on snow and glacier melts leading to the Rhine runoffs
An ad-hoc working group was established in preparation for a possible award of implementation work on this project. This group consisted of representatives from Austria, Switzerland, France and Germany. The working group met in August and discussed common interests and relation to on-going work within the framework. CCHydro and NFP61 are considered the most important "supplying" projects. Redundancy should be avoided in these projects, but elaborated results should be taken into account there.
The project is expected to run for three years. The work will be awarded and the project is followed up by a support group. Financing of the project is still unclear. Based on the discussions held at the CHR session, the working group will continue to work on the service specification and the arrangements for project financing.

Sediment
An article on the ISI Case Study Rhine was filed with the Dutch magazine "Land en Water". The various ISI case studies are currently being analysed by the ISI office. The results are then made available in a database.

Length of the Rhine:
Following discussions earlier this year about the actual length of the Rhine, the CHR has now defined the "official length" of the Rhine on the basis of national surveys in Switzerland, Germany and the Netherlands. The results will be presented as a newsletter on the CHR website.

Conferences and Workshops
In cooperation with the COST731 action, the Swiss Federal Office of Environment, the Dutch and German IHP / HWRP National Committee, the German Technical Association for Hydrological Sciences and the Dutch Water Services, the CHR has invited scientists, policy makers and stakeholders in the field of flood forecasting, flood prevention and crisis management to a 2-day workshop on "Advancements in flood forecasting and the implications for risk management". This workshop was held on 25-26 May 2010 in Alkmaar, The Netherlands.

In this context, the International Commission for the Hydrology of the Rhine Basin (CHR) implemented the "RheinBlick2050" project, which aims at the development and interpretation of common and consistent runoff projections for the international Rhine catchment area. The underlying records and information have been compiled from various national research projects of Netherlands, Germany, France and Switzerland and are based on the latest climate projections. The results will assist in the assessment of future changes to the hydro-meteorological regime in the Rhine catchment area and the impact of such hydrological and hydraulic processes. Potential users of the results and data, stakeholders and policy makers were involved.
The CHR has presented the results of RheinBlick2050 project in a two-day colloquium on the 13^{th} and 14^{th} of October 2010 in Bonn. In addition to the project results, the results of other projects in the field of global and regional climate changes and their effects on the hydrology of the Rhine basin were presented by different speakers.