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

Annual Report 2006

Editor: E. Sprokkereef

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CHR Secretariat
P O Box 17
8200 AA Lelystad
Netherlands
Email: info@chr-khr.org
Website: www.chr-khr.org

English translation:
IHP/HWRP Secretariat
Federal Institute of Hydrology
Postfach 200253
56002 Koblenz
Germany
Email: strigel@bafg.de
Website: ihp.bafg.de

1. Hydrological summary of the Rhine basin

Meteorological characteristics

Meteorologists will remember the year 2006 less for its climatological significance, but far more for its unusual range of weather events: the remarkable cold, especially in March, the huge masses of snow at the beginning of the year, the hottest and sunniest month of July of all times, an unusually humid and cool August, a very warm September and a record-breaking warm autumn.

Temperatures

Altogether, 2006 was one of the warmest years since regular records began. In the Austrian part of the Rhine basin the mean annual air temperature was 0.6 to 0.7 degrees higher than that of the years 1961-1990. In Switzerland 2006 was the fifth warmest year since 1964; in the Netherlands it was the warmest year since 1706. In the Alps the winter lasted until the middle of March, with enormous snow depths in March. Otherwise the winter was cold and dry. Thus, January in the Netherlands was the coldest January in the past ten years; in Switzerland this was true for the month of March. March and April were extremely wet.

The second half of the year was marked by extremely high temperatures. The month of July was the warmest ever, but in contrast the month of August was extremely wet and cool. September was the warmest of the last 300 years. The autumn of 2006 was one of the warmest on record. In the summer of 2006 the Swiss glaciers lost 3 to 4% of their mass compared to the previous summer. This loss is comparable to that during the hot year of 2003.

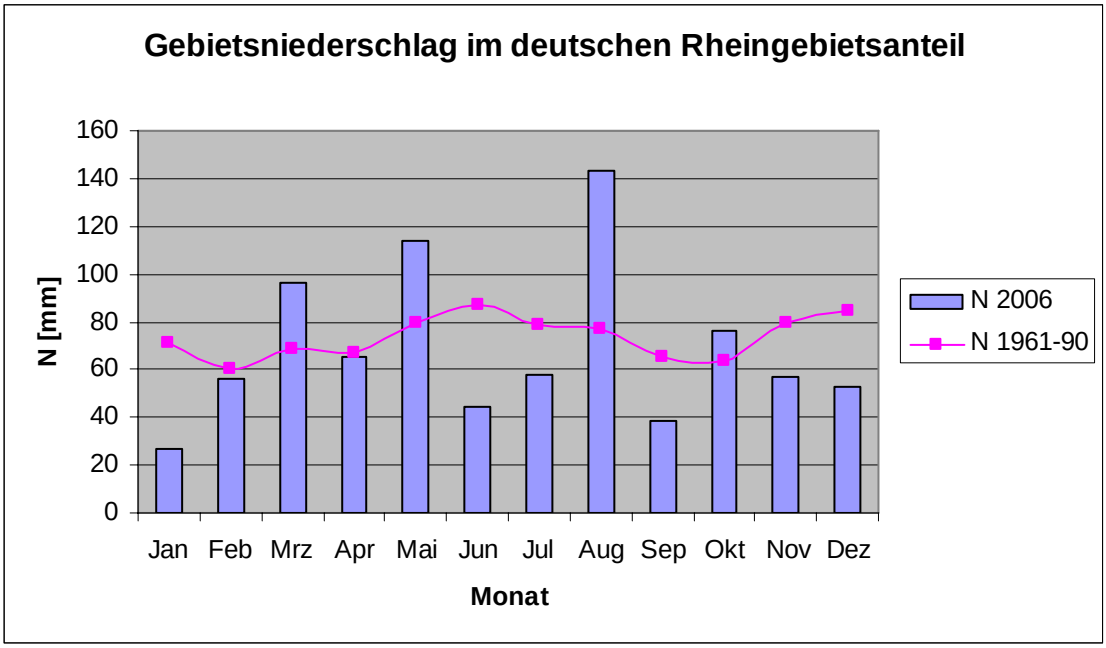
Precipitation

In Vorarlberg, Austria, the monthly total amounts of precipitation in January, February, June, July and September were all below average; they amounted in part to considerably less than 50% of the otherwise normal amounts. The remaining months, however, were clearly above average. Altogether, the annual total amounts of precipitation were 90 to 110% of the long-term yearly average.

In the Swiss catchment area below Lake Constance the annual total amount of precipitation was 10 to 40% above the long-term yearly average, due to heavy rainfall in March and April and also in August. In contrast, below-average annual amounts were recorded for the catchment areas above Lake Constance.

In Germany on the other hand, precipitation in the winter of 2005/06 was, despite an abundance of snow already at the beginning of the year, distinctly below the long-term average; according to records made by the Deutscher Wetterdienst (DWD), on average only 74% of the normal winter precipitation fell across the whole of Germany. Although spring 2006 was rather wet and brought, as a result of snowmelt, considerable flooding on the river Elbe, already the month of June was yet again classified as dry; according to the DWD only 55% of the long-term average June rainfall of 85 litres per square metre fell in the whole of Germany. The hottest July since DWD's records began caused high evaporation rates due to

extremely high temperatures and brought only small amounts of precipitation. For the most part these fell as short showers and thunderstorms and ran off the ground surface very quickly. All in all, the annual precipitation total in Germany showed a slight deficit. Around 732 mm precipitation fell across all the regions of Germany, about 93% of the long-term average value.

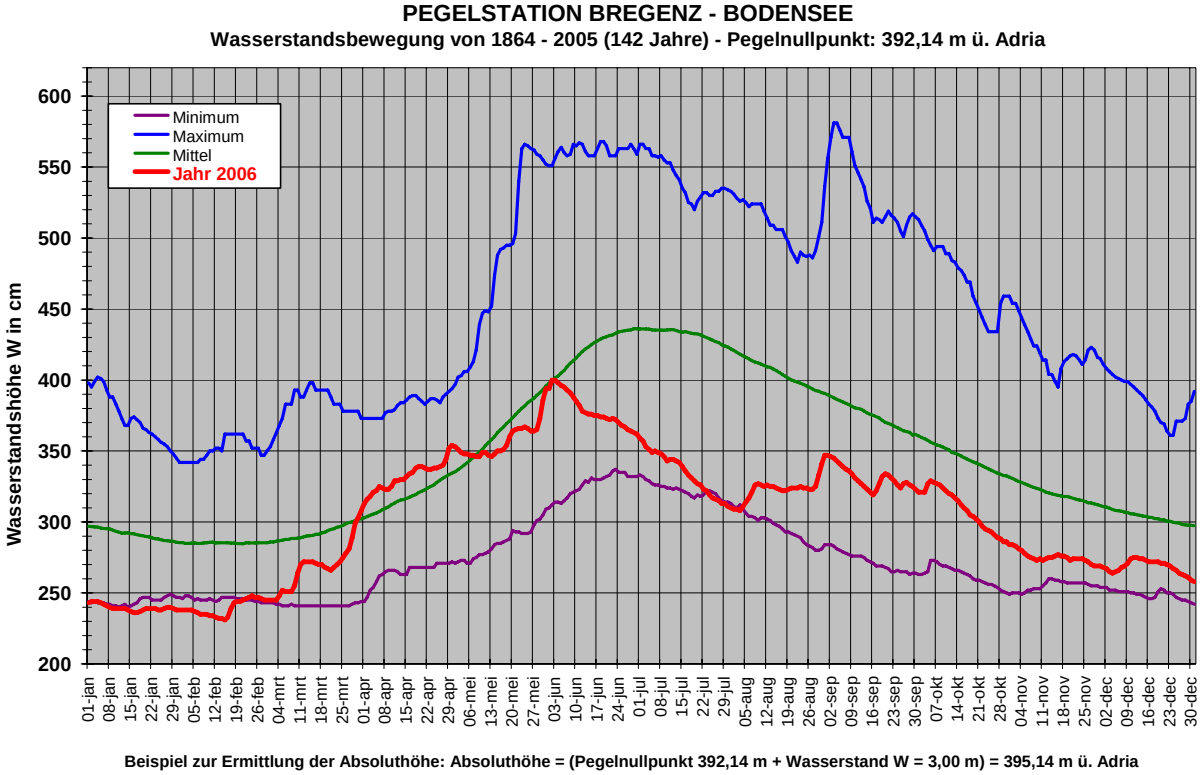


Average precipitation in the Netherlands amounted to 765 mm as against the usual 797 mm. What was remarkable was the distribution of the precipitation over the year. Only approx. 20% of the monthly average fell in January and in the summer months of June and July, while in August over 300% of the usual amount for this month was recorded.

Hydrological situation in the Rhine basin in 2006

Water levels of the large lakes in the catchment area

At the beginning of 2006 the water levels of the large Swiss lakes were low. At Lake Constance the water levels in January and February at the Bregenz gauge were below the seasonal minimum values of the observation series 1864-2005. The level of February 2006 fell below that of January 1949, the lowest ever recorded, as shown on the following diagram. At the beginning of February the water level of the lake at the Constance gauge was approx. 55 cm below the normal value for February. Lower water levels were last measured here in February/March 1858.



As a result of abundant rainfall, especially in March, and snowmelt as from April, the water level of most of the lakes in proximity of the Alps rose considerably again and reached in many cases the long-term average values at the beginning of the summer. Despite this temporary recovery, the water levels of the lakes fell rapidly again as from June 2006. At the end of July they again fell short of the seasonal minimum values at the Bregenz gauge. The water level of 309 cm at the Constance gauge on Lake Constance on 31 July 2006 was the lowest water level since the beginning of the 20th century. As a result of the warm and relatively dry autumn, lower than normal water levels were measured in almost all the lakes in proximity of the Alps at the end of 2006.

River water levels and discharges

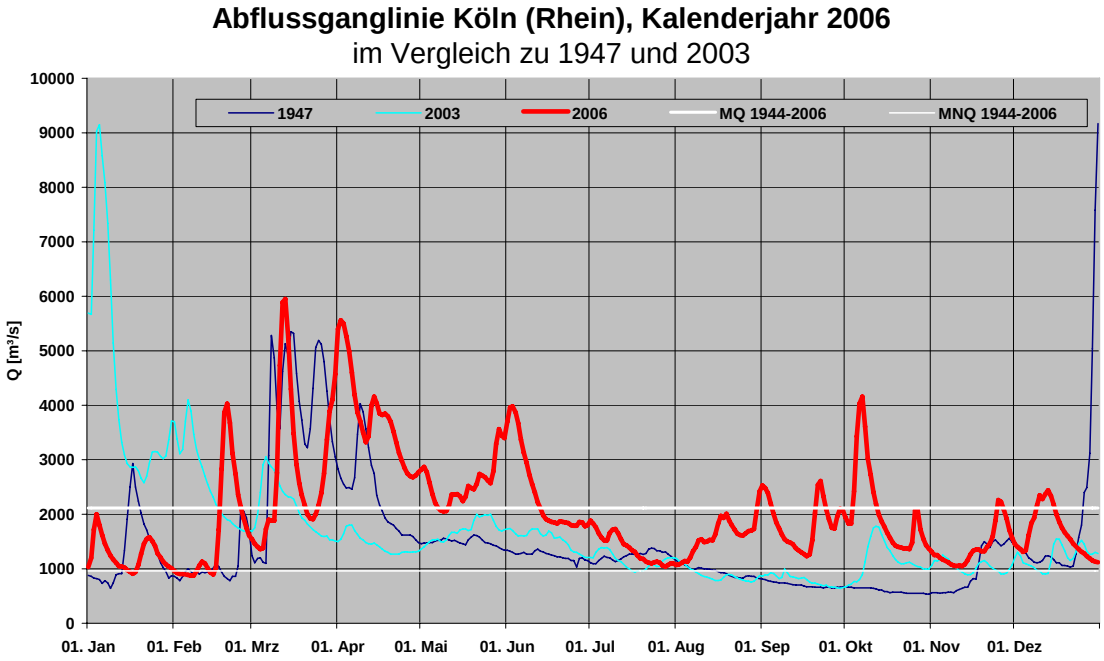
In 2006 the discharges of the most important tributaries from Vorarlberg to Lake Constance were on average below the long-term mean:

- 97% on the Bregenzerach (av. Q 2006 = 45.3 m³/s, long-term av. Q = 46.6 m³/s)
- 98% on the Dornbirnerach (av. Q 2006 = 6.78 m³/s, long-term av. Q = 6.95 m³/s)
- 77% on the Rhine (av. Q 2006 = 179 m³/s, long-term av. Q = 232 m³/s).

At the beginning of January the Rhine had a discharge of 140 m³/s at Lake Constance. The normal amount for January is 250 m³/s. The large amounts of precipitation that fell in March allowed the discharge at this point to rise by the middle of March to an average value for this time of year; this situation lasted until the beginning of July. The dry and hot summer resulted in very low discharges until the end of August. The Rhine discharge at the Neuhausen gauge was about 300 m³/s at the beginning of August, which is 175 m³/s below the mean for this month. A wet August and a relatively dry and warm autumn caused the discharge at the Lake Constance outflow to be slightly below the long-term mean from August to December.

At the Rheinfelden gauge (Switzerland) the Rhine discharge was under 500 m³/s at the beginning of the year. The average discharge for January is usually just under 800 m³/s. One month later the discharge had decreased to 350 m³/s – the mean discharge for February is approximately 830 m³/s. In March snowmelt and rainfall resulted in an increase in the discharge at the Rheinfelden gauge to about 1,000 m³/s and even in a small flood at the beginning of June with a peak discharge of 2,150 m³/s. During the course of the month of June the discharge at Rheinfelden dropped again quickly, from 2.150 m³/s on 1 June to 1,284 m³/s on 30 June. At the end of August the Rhine discharge at Rheinfelden was only 700 m³/s, an extremely low discharge for this time of the year (400 to 500 m³/s below the long-term mean). At the end of 2006 the discharge situation at the Rheinfelden gauge was reasonably normal.

At the Cologne gauge (Germany) the average discharge (av. Q) from January to December 2006 was at 2,040 m³/s only slightly, namely about 40 m³/s, less than the long-term mean. However, 2006, based on the duration of the lower deviation from the av. Q, is more likely to be classified as a low-flow year as discharge fell short of the av. Q on almost two thirds of all the days of the year. In order to put this into perspective, the diagram below also shows the hydrographs for the particularly dry years of 1947 and 2003.



It can be seen that several times between the middle of January and the middle of February discharges fell below the long-term mean low-flow discharge (MNQ). This period of less discharge was, however, superseded as from 18 February by above-average water levels of long duration. The crest of the flood wave on 13 March 2006 was, however, at 5,950 m³/s not unusually high – floods of such magnitudes are expected in Cologne about every one to two years.

As from the middle of June water levels and discharges of the Rhine at Cologne were, apart from a few temporary exceptions, always below the long-term average discharge value. What was particularly remarkable was the extremely rapid falling of the water level, a phenomenon,

by the way, that was observed in July throughout the whole of Germany. Because of the early and widespread melting of the snow in the Alps, the Rhine reached a level already in early summer that otherwise only occurs in the typical low-flow months of October and November. The wet month of August, however, benefited the discharges and prevented the already feared formation of exceptionally extreme low flows, as had occurred in 1947 and 2003. However, in view of the mainly warm weather with little precipitation, there was no permanent stabilisation of the discharges at an average discharge level by the end of the year.

At the Lobith gauge (Netherlands) a discharge of 1,600 m³/s was measured at the beginning of January 2006, about 1,000 m³/s too little for this time of the year. The last time such low discharges occurred in January was in 1973. In the last 100 years comparable discharges in January occurred seven times. In February the discharge at the Lobith gauge fell further to about 1,300 m³/s. The average discharge for February is approximately 3,000 m³/s. As a result of the flood wave from the south of the catchment caused by snowmelt, the discharge at the Lobith gauge rose for a short while in March to 5,690 m³/s. Following this small wave, the discharge fell again to about 1,800 m³/s at the beginning of June and to 1,200 m³/s at the beginning of August. Both these figures are far below the long-term mean for the months in question. At the beginning of September the discharge was slightly more than the long-term mean. At the end of December the discharge was 1,250 m³/s, about 1,400 m³/s less than normal for this time of the year.

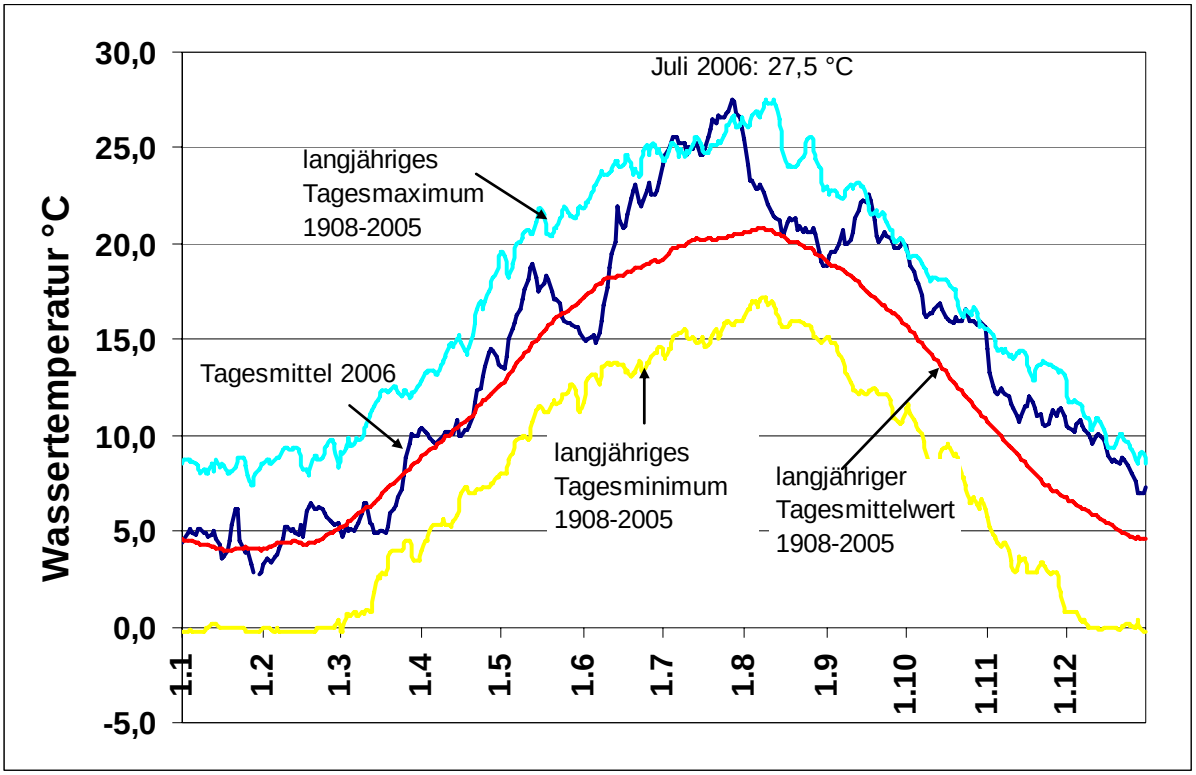
In the Rhine basin the rivers Neckar, Main, Lahn and Mosel also recorded very low discharges that often fell short of the long-term average low-flow discharge values. However, due to the flow impoundment and regulation of these rivers, the water levels were, despite low discharge values, sufficiently maintained that navigation was, in general, not greatly restricted.

Although the gauges of the river Rhine recorded low water levels and discharges in July, there were no extreme low flows associated with great restrictions for navigation and other uses. Compensation in the form of low-flow surcharges could, however, be imposed by cargo shipping companies, as, for example, when on 31 July 2006 the water level at the Kaub reference gauge fell short by 29 cm of the water level mark of 150 cm.

Water temperatures

Parallel to falling water levels and discharges, river water temperatures rose almost everywhere during the long heat wave. This had varying consequences for the ecological communities in and on the rivers and some uses, e.g. cooling water abstractions, were also affected. The situation is well illustrated in the following diagram. On 27 July 2006 the highest ever water temperature of 27.5°C was recorded at Lobith. This high figure was reached following a steep rise in temperature from the beginning of June, despite very low water temperatures at the beginning of the year. The mean daily temperatures calculated from constant measurements in 2006 were clearly higher that the maximum values for July of measurements recorded since 1908.

Also in Switzerland at some gauges (e.g. Rheinau) higher temperatures were recorded in July 2006 than in August 2003. However, then, August 2006 was wet and cool so that the situation eased up.



River Rhine water temperatures in 2006 at Lobith compared with long-term values

Groundwater

The discharge situation in 2006 intensified in some regions because the compensational effect of available groundwater supplies took place only on a moderate scale. In contrast, in 2003 the groundwater levels were considerably higher due to above-average precipitation during the previous five years. Since 2003, although most groundwater levels have been in line with the long-term mean, they have been significantly lower than those of 2003, due to low renewal rates during the winter. Thus, the rivers had less groundwater available as inflow.

Conditions were similar in the Swiss catchment, as groundwater levels between Chur and Lake Constance show.

2. Activities of the International Commission for the Hydrology of the Rhine Basin (CHR) in 2006

Changes within the CHR

On 26 June 2006 Ms Alberty Terlou commenced work at the CHR Secretariat. She replaces Ms Ilonka Zaborszky who left RIZA at the end of April 2006. Ms Alberty Terlou has been working at Rijkswaterstaat RIZA in Lelystad in the Netherlands since 2002 and will assist the Secretary in the work of the Secretariat.

Mr Herman Winkels, representative of the Netherlands, took leave from the CHR at the 58th meeting of the CHR. The Netherlands' new representative in the CHR is Mr Frans Claessen, Head of the Department of National Water Management at RIZA in Lelystad.

Professor Dr S. Demuth, representative of Germany, has taken over new assignments in the Division of Water Sciences of UNESCO. His successor as representative of Germany will be, as from June 2007, Dr J. Cullmann.

Activities in the CHR projects

In January 2006 the project group "Changes in the discharge regime of the Rhine" held a meeting, at which the regional interpretations of the analysed data series were discussed and decisions on further action taken. In July all the interpretation texts had been submitted in draft form. In many respects, however, further revision and adjustment were considered necessary, a task that was not yet completed at the end of 2006. The draft of the final report is expected at the beginning of 2007.

The Rhine Alarm Model, managed by CHR, was adjusted in 2006 according to the wishes expressed at a meeting of the users in 2005 when CHR discussed the question of whether the Rhine Alarm Model should be developed to include more flexible functionality. Furthermore, there is a need for a model for the simulation of thermal discharges.

Within the framework of the International Sediment Initiative (ISI) of UNESCO various case studies in several catchments throughout the world are being carried out. The case studies for the Rhine and the Rio Parana are being prepared in accordance with an agreement between the CHR and the Rio Bermejo Commission. The contents of the report on the Rhine have been planned. In Switzerland the Federal Department of the Environment has commissioned the section on the alpine area of the catchment. The section on the Rhine delta has been prepared by RIZA. The BfG has taken over the preparation of a report on the Middle Rhine stretch. It was decided to publish the case study of the Rhine as a report in the CHR publication series.

At the 58th meeting of the CHR in September 2006 various project proposals were presented and discussed. The most important are:

- Climate scenarios
  This is a project proposed by the BfG and RIZA for the preparation of coordinated climate and discharge projections for the Rhine basin. The creation of a database with historical hydrometeorological and hydrological data for the Rhine basin was proposed. Various climate scenarios are to be statistically evaluated and computed

with hydrological models. The project will lead to coordinated climate scenarios for the Rhine basin. A working group was formed, that will check, in time for the next CHR meeting, which partners would like to participate in this project, the project's strategy and how the project can be financed.

- Water balance
  A project proposed by the BfG and RIZA consists of the creation of a mutually accepted database for the Rhine basin as a basis for the discharge modelling of the Rhine from Lake Constance to the North Sea. With these data a water balance can be established for a longer time series. The main objective of this project is to improve the hydrological and hydraulic models, e.g. for discharge prediction systems. In the Netherlands preliminary studies are being made at Delft Hydraulics to determine the problems concerning the water balance in the Rhine basin. The results of the Delft Hydraulics study could be used as a foundation for this CHR project.

- Discharge ensemble prediction
  This proposed project deals with the analysis of discharge ensemble prediction on the basis of the weather ensemble predictions of the European Centre for Medium-Range Weather Forecasts (ECMWF). Switzerland is participating in the MAP D-PHASE project in which studies on the operational application of ensemble prediction, especially for the alpine region, are being carried out. It was proposed to coordinate a relevant CHR project with the MAP D-PHASE project. The decision concerning CHR's participation in this project will be taken in 2007.

Publications and public relations

In August 2006 the CHR published a flyer entitled "Prepared for climate change in the Rhine river basin?". The flyer was produced by a working group and is based on the results of the CHR workshop "Climate changes and their impact on the water balance and water management in the Rhine basin", that took place in the Netherlands in 2002. The text of the flyer was also published in the journals "Wasserwirtschaft" and "Hydrologie und Wasserbewirtschaftung". The English version was sent to, amongst others, the WMO and UNESCO. The flyer can be ordered on the CHR website or downloaded as a pdf file.

Since August 2004 the CHR website has been updated in both German and English. The menu has been extended to include the button "Events", under which details of workshops and meetings of experts organised by CHR are given. The layout of the website was revised at the end of 2005 in order to make it clearer and to simplify its management. Following this improvement the number of site visitors increased considerably. The website is proving to be a suitable medium for, above all, information on events and the provision of results of studies.

Events in 2006

CHR workshop "Ensemble prediction and uncertainties in flood forecasting"
30 – 31 March 2006, Bern, Switzerland

In the last decade unusually long-lasting rainfall events have led to severe flooding, namely the floods of the Oder in 1997, the 1999 Whitsun floods in Switzerland, western Austria and southern Germany, floods in England in 2000, and the Elbe and Danube floods in 2002. Extreme flooding in the alpine region caused severe damage in 2005. Snowmelt in high

altitude areas combined with heavy rainfalls caused an extraordinary flood situation on the Elbe also in 2006. The trend of increased precipitation and flooding appears to be continuing and this calls for action from politicians, relief organisations, and the economic and industrial sectors to be prepared with protective measures against extreme events. Decisions depend on the flood forecasts and how uncertainties in flood forecasting are conveyed. Therefore forecasts should provide not only the best possible estimations but also a range of possible outcomes. Ensemble prediction can be used for this purpose, as it draws on a wide range of information sources for hydrological prediction. Working with ensemble prediction and uncertainties in flood forecasting is a relatively new discipline. Until recently this technique was hardly suitable for flood forecasting. Due to an increase in computation power and data transmission rates it is now possible to use ensemble prediction effectively.

The International Commission for the Hydrology of the Rhine Basin (CHR), together with the WMO, held the international workshop "Ensemble prediction and uncertainties in flood forecasting" in Bern, Switzerland. The topics dealt with by the workshop covered the following questions:

- How can ensemble weather forecasts be used for hydrological forecasts?
- How can ensemble prediction be verified, also for big events, and how can reliable results be achieved?
- How should ensemble prediction be used for operational application (computing time, selection of representative single components)?
- How can uncertainties in hydrological models, model parameters and the initial hydrological conditions be presented in hydrological ensemble prediction?
- How can uncertainties in weather forecasting be regarded for hydrological prediction?
- How can uncertainties be conveyed to decision-makers?

The papers submitted to this workshop have been placed on the internet and can be viewed on the website www.CHR-KHR.org.

Events in 2007

CHR workshop "Morphology", 8 and 9 February 2007, in Koblenz, Germany

CHR workshop "Low flows and droughts", 25 and 26 September 2007, in Würzburg, Germany

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 Resources Programme (HWRP) of the WMO. It is a permanent, autonomous, international commission and has the status of a foundation that is registered in the Netherlands. Members of the Commission are the following scientific and operational hydrological institutions of the Rhine basin:

- Ministry for Agriculture, Forestry, Environment and Water Management, Division VII/3 – Water Management, Vienna, Austria
- Federal state Vorarlberg, Division VIId – Water Management, Bregenz, Austria
- Federal Office for the Environment, Bern, Switzerland
- EAWAG, Zürich, Switzerland
- Federal Institute of Hydrology, Koblenz, Germany
- Institute for Environment and Geology of the federal state Hessen, Wiesbaden, Germany
- IHP/HWRP-Secretariat, Federal Institute of Hydrology, Koblenz, Germany
- Direction régionale de l'Environnement DIREN Lorraine, Metz, France
- Agence de l'eau Rhin-Meuse, Metz, France
- Administration de la Gestion de l'Eau, Luxembourg,
- Rijkswaterstaat – RIZA, Lelystad, Netherlands.