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CENTRAL COMMISSION FOR THE NAVIGATION OF THE RHINE

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„Low flows in the Rhine catchment"

September 20-21, 2017
in
Basel, Switzerland

Theme of the international-scientific symposium
'Science meets practice'

What do we know about low flows in the Rhine basin and how to develop further practical instructions to better reduce negative impacts of low flow events? How can we better monitor or manage low flow events?

In recent years there has been a shift from looking not only at the implications of floods in rivers and their impacts on ecosystems but also towards low flows. During the last decades several low periods occurred with severe impacts not only on the river itself but also on the civil society. Low flow periods affect navigation, hydropower production and the environment. Indeed, just as floods, low flows are natural events which can considerably restrict different uses and functions of the river Rhine and impact water quality and the aquatic ecosystem. Therefore the management of low flows was put high on the agenda of river authorities and they had to come with practical solutions.

On 20 and 21 September 2017, 68 participants from 8 different countries met in the Dorint Hotel in Basel, Switzerland:

- to exchange knowledge about analysis methods of low flow, drought indices and related processes,
- to exchange knowledge about seasonal weather prediction and low flow forecasts,
- to exchange knowledge about the influence of climate variability and climate change on future low flow and drought periods,
- to discuss decision-making procedures and adaptation and
- to detect research deficits.

The symposium was organized by the International Commission for the Hydrology of the Rhine basin (CHR) in close cooperation with the International Commission for the Protection of the Rhine (ICPR) and the Central Commission for the Navigation of the Rhine (CCNR) and the Swiss Federal Office for the Environment (FOEN). The participants of the symposium represented various sectors like universities, national and regional hydrological and research institutes, navigation and transport, ministries of environment and infrastructure, international river commissions and industry.

The symposium was opened by Olivier Overney, head of the section Hydrology at the FOEN and Hans Moser, President of the CHR.

Mr. Overney showed the importance of low flow periods and drought in Switzerland that ask for additional measures. The drought period of 2015 showed the vulnerability of the Swiss water management. Examples of possible measures are the Swiss action plan for the adaptation to climate change, and measures for dealing with heat periods, water shortages for drinking water and agriculture. There is a need for an early detection system for drought.
Mr. Moser expressed the importance of the three Rhine commissions organizing the symposium together. After that he gave an overview of the tasks and the projects carried out by CHR dealing with climate change and water resources management. Low flow is a special theme in the work of the CHR. Therefore it was decided to organize a special symposium about this topic.

A key note with the title 'What is the problem of low flow in the Rhine catchment? Setting the scene' was given by Mr. Gregor Laaha, associated professor at the Institute of Applied Statistics and Computing (IASC) of the BOKU Vienna.
Mr. Laaha gave an overview of hydrological issues of low flows. Low flows have a broad range of impacts, e.g. environmental impacts like water quality, ecological status of water bodies, socio economic impacts like navigation, power production, reservoir management, water supply for irrigation purposes and drinking water. Drought risk is increasing in Europe due to climate change. Mr. Laaha addressed five main questions:

1. How are low flows generated? Lack of precipitation effects soil moisture, stream flow and ground water. Seasonal process, triggered by precipitation deficit in summer or freezing in winter. Besides that there are artificial influences lie abstractions from rivers and ground water , reservoir storage and land use change.
2. How to quantify low flow events? Different characteristics are used, like flow characteristics, duration and deficit volumes, extreme value statistics and recession gradients.
3. Ho can low flows be modelled and predicted? There are statistical and process based models.
4. How to manage drought events? Key words are monitoring and forecasting. The challenge is that for low flow management much longer forecasting periods are needed than for floods.
5. What effect has future climate on low flow events? Based on climate scenarios there will be a seasonal shift, but the magnitude of change is uncertain.

Session 1: Processes – Hydrology & Atmosphere – Parameters

The ASG project in relation to low flows – Jörg Uwe Belz, BfG, Germany
Mr. Belz presented the results of the CHR project ASG Rhine in which the snow and glacier melt components of streamflow of the river Rhine and its tributaries considering the influence of climate change have been quantified for the period 1901 – 2006. The most important findings are:
In average the contribution from glacier melt is low (1 – 2 %) but in dry years this contribution to the daily discharge of the Rhine at Lobith could increase to 17%. Therefore the average number of days with extreme low water levels could increase with about 75 per year at Kaub.

Some current challenges in setting up and operating sub-seasonal to seasonal predictions of low flows in Switzerland – Massimiliano Zappa, WSL, Switzerland
Mr. Zappa presented the HEPS system for monthly ensemble low flow predictions that is operational since 2015 in Switzerland. In Switzerland the conditions for long term forecasting are challenging, due to the high mountains and small basins. For the first HEPS provide skillful forecasts. Going beyond day 32 is close to gambling.

Hydro-geologic controls on low flow dynamics– Philip Brunner, University Neuchatel, Switzerland
The core of Mr. Brunner's presentation was, that climate change can increase the occurrence of water shortage, but that process understanding is limited and current tools are inadequate. The main conclusions for the alpine area is that bedrock is an essential hydrogeological unit for catchment low-flow dynamics, quaternary alluvial deposits can also contribute significantly to low-flows, the slope gradient of the contributing hydrogeological unit can influence low-flows significantly.

Low flow in Switzerland on different spatial and temporal scales – Rolf Weingartner, Uni Bern, Switzerland
Rolf Weingartner divided his presentation into two parts. In the first part he concentrated on the low flows of the Rhine at Basel. The runoff time series since 1870 shows an increase in low flows which usually occur in winter due to increasing temperatures and the intensive hydro power production after the 1950ies. Due to future climate change, summer will be the main low flow season in Switzerland.
In the second part, a hydrological structure of Switzerland was presented from the perspective of low flows. The studies by Rolf Weingartner show that the low flow situation has already changed significantly as a result of climate change, increasing the winter low flows in the Alpine region and decreasing the summer low flow in the Plateau. Hydrological simulations suggest that the low flow situation in the Plateau will worsen in the future, so that water management measures will be indispensable.

Monthly and seasonal predictions of Rhine low flows and water levels based on hydrologic, atmospheric and oceanic data – Monica Ionita Scholz , Alfred Wegener Institute, Germany
Mrs. Ionita-Scholz presented a project in which large scale predictors for monthly and seasonal streamflow (low flow, mean flow and high flow) and water levels for the Rhine, Elbe, Weser and Danube rivers have been identified. A statistical algorithm for the monthly and seasonal prediction has been developed and the possibility to use the proposed methodology as an operational system for monthly and seasonal outlook was tested.
The advantages of this methodology are that it is inexpensive in terms of computationally and human resources, it does not require the use of a hydrological model, it does not require the access to operational ensemble forecast data and it deals, at least partially, with the issues of stationary/non-stationary relationship between two variables.
The German federal Institute for Hydrology (BfG) is developing monthly to seasonal forecast products for the German waterways based on this statistical approach.

Session 2: Low Flow Impacts

Low flows and impacts on the Rhine – (recent) study results of the ICPR expert group Low Flows – Gerhard Brahmer, HLNUG, Germany
Mr. Brahmer presented the work of the ICPR expert group on low flows. The expert group is assigned to do a survey of knowledge on low flow in the Rhine catchment. Therefore selected extreme low flow events are analyzed and described, impacts of these events are compiled, impacts of climate change on low flows are investigated and information on national low flow monitoring, management and transboundary aspects are exchanged.
A preliminary conclusion of the expert group is that compared to the first half of the last century, recent low flow events can rather be designated as minor to moderate. It seems difficult to imagine direct possibilities of intervention. Low flow events in summer together with high water temperatures seem to indicate a new challenge.

Low flows and impacts on navigation – Norbert Kriedel, CCNR, France
Low flow periods lead to a reduction of the loading degree of vessels and a decrease in total transport volumes. The result is a strong increase of prices and a deterioration of the competitive position of inland shipping compared to other modes of transport and thus loss of market shares.

Low-flow forecasting : principles, outcomes, and operational implementation of the French PREMHYCE project – Pierre Nicolle, IRSTEA, France
Mr. Nicolle presented the PREMHYCE project: a comparative evaluation of hydrological models for low-flow forecasting on French catchments. In this project the ability of forecasting tools to anticipate low-flow situations (magnitude, maximum lead-time) has been assessed and an operational low-flow forecasting tool was developed.
In the study it has been concluded that there is no superior model on all catchments or criteria. Data assimilation or post-correction methods are less interesting with increasing lead-time. Performances are quite good on influenced catchments, with various simple methods to account for influences.

Ecological aspects of low flow – Laura Gangi, Secretariat ICPR, Koblenz, Germany
Mrs. Gangi presented abiotic and biotic processes influenced by low flows, vulnerability, impact of low flows on flora and fauna and mitigation measures, based on an ICPR report from 2013. Parameters that are mostly influenced by low flows are water temperature, quantity and velocity, oxygen content and nutrient and pollutant concentration.
The results can be mitigated by reconnecting alluvial waters and floodplains to the river and by designation or improvement of nature protection areas.
The effects of higher water temperature can be mitigated through restoration of river continuity (reconnect backwaters to the main stream), facilitate exchange between river and ground water, increase shading by planting shrubs on the river banks and limit thermal discharges.

Focus on fresh water supply in the Dutch Rhine Delta – Vincent Beijk, RWS-WVL, The Netherlands
Mr. Beijk presented the dependency on fresh water and the main sources of fresh water in the Netherlands. A specific concern for the Netherlands is salt intrusion either through open waterways or via ship locks. Fresh water flow is normally used as a natural barrier against salt water intrusion. However, during low flows the amount of fresh water may not be enough and salt intrusion occurs further eastward, reaching the various drinking water inlets.
In the Netherlands the national Coordination Committee on Water Allocation (LCW) is active during

times of low flows and/or drought. LCO advises on possible measures for water allocation, based on a priority sequence (by law).

Drought impact inventory (EU database) – Irene Kohn, Uni Freiburg, Germany
Mrs. Kohn presented the European Drought Impact Inventory in which drought impacts across Europe are reported. Currently 5389 impact report entries with approximately 8000 impact types for 38 countries are reported. The inventory can be used to analyze the link between drought indicators and impacts, to evaluate indicators and as a proxy for vulnerability to drought risk.

Impacts of low flows on the (water) energy sector – Damien Puygrenier, Division Technique Générale, EDF, France
Mr. Puygrenier presented the management of low flows at EDF on the basis of a case study for the rivers Rhine and Moselle.
Water is for EDF a free renewable energy for hydraulic production, a cold source for the classic nuclear and thermal productions, a threat for the installations and a resource shared with other users (agriculture, tourism, environment).
EDF produces hydro-meteorological forecasts to ensure safety & security of installations, meet environmental standards, improve water resources management and optimize power plant production.

Session 3: Measures to cope with low water/ water shortage

Low flow management and local water scarcity – Samuel Zahner, BAFU, Switzerland
In his lecture Mr. Zahner described a strategy to deal with increasing water scarcity. Problems will increase due to climate change, economic growth and settlement pressure. The Swiss method for low flow management consist of 3 modules, of which 2 are preventive and 1 dealing with short term management.
In the first module risk areas are identified. The end product of this module are water scarcity reference maps. The maps display which water scarcity problems can be expected at which locations.
Module 2 deals with long term management of water resources. The module supports strategical planning of water resources.
Module 3 is a tool box to manage residual risk. It contains measures for coping with conflicts of use and to avoid damage for water users and the ecology of watercourses, principles in relation to the balancing of interests and priorities in the event of conflicts of use and case studies concerning specific forms of organization and possible procedures for dealing with exceptional situations.

Instruments for low flow management in Bavaria based on LAWA-guidance – Werner Wahliss, Bayerisches Landesamt für Umwelt, Germany
Mr. Wahliss presented low flow management in Bavaria, based on a guidance of the German federal states working group for water.
In Bavaria there is a large difference in water availability between the northern part (Main basin) and the southern part (Danube basin). The availability per person in the north is only one third from that in the south. In order to compensate for this large difference, a water transfer system has been installed between the rivers Danube and Main. This transfer system consists of a canal and three reservoirs. The water transfer system can increase the low flow discharge in the Main up to 50%.
The starting point for low flow management is information management. In Bavaria a low flow information service (NID - free on internet) is available. This system provides up to date data from the monitoring networks (water levels, precipitation, temperature). A low flow status report is published and updated every few days. This report describes the current situation and evaluates the further development based on the weather forecast. Forecasts of water temperature one week ahead will be available by the end of the year.

Drought monitoring and assessment at EU level through a novel low-flow index – Carmelo Cammalleri, Joint Research Center, Ispra, Italy
Drought is an extended period of water shortage affecting different components of the hydrological cycle. A key major difference between meteorological drought and hydrological drought events is the temporal nature of the two variables: Precipitation – intermittent and Streamflow – continuous. Time-aggregated indices (e.g., SPI-like) are not suited for continuous variables.
A hydrological drought index needs to capture the time-continuous nature of streamflow data and the occurrence of water deficit.

A monitoring system needs to be regularly updated in near-real time, reflecting the latest water deficit conditions.
Research goals in the presented project were to develop a low-flow index that exploits the daily outputs of a spatially distributed hydrological model, to evaluate the reliability of this index during past well-documented hydrological drought events and to implement this index within the modelling framework of the operational European Drought Observatory (EDO).
A novel hydrological drought index is proposed, which takes into account the temporal-continuous nature of streamflow data.
The proposed index fully exploits daily long-term records to define the low-flow river regime (95th percentile).
The approach avoids the need of a pre-defined accumulation period (i.e., month), allowing long events across different consecutive months.
Consistency between the JRC EDO and the EFAS (flood monitoring) systems is ensured by the use of the same Lisflood-based river discharge datasets.
The index has been successfully implemented into operational EDO since early 2017.

LOOKING BACK AND DISCUSSION
Dealing with a transdisciplinary setting with three forms of knowledge:

1. System knowledge – how is the system working, what are the processes?
2. Target knowledge. The knowledge regarding the needs of the stakeholders.
3. Transformation knowledge. How can we transform the scientific knowledge in to operational useful information?

Ad 1.: Has the Rhine a low flow problem today? Mr. Overney concluded that one cannot say that actually the Rhine has a low flow problem because these problems already occurred at the beginning of the 20th century. There are indices that there are negative trends in the last decade. If this will continue, we will most certainly have a very big challenge in the near future. The near future is defined as the coming 20 years. This was supported by a representative from the Flanders hydraulic institute. He said that there is no problem in the Rhine basin at the moment. A problem is something we cannot manage. We have the knowledge and the resources to solve all of the discussed potential problems.
The hydrological situation is not very different from that of the beginning of the 20th century. However society and the economical system have changed dramatically and have become much more vulnerable. Navigation needs more water depth, agriculture needs more water, power plants need more cooling water.
In our society we are strong to react. If we see a problem we react and take measures. But here we see a challenge for the future, which means that we have to take proactive measures for the future. So not wait till we have the problem but start to take measures now, e.g. improve water management, build multi-purpose storage reservoirs.
Maybe the conclusion is that in quantitative hydrology we don't have a problem now but most probably in future, but in qualitative hydrology the problem is already there.
Global change has a climate part and a socio economic part. At the moment the problems occur for a socio economic reason. In future the climate part will become more important and therefore the problems will be more severe.
Socio economic changes will probably be more important in near future than climate change. We need an interdisciplinary approach with cooperation between natural sciences and socio economic sciences.
Examples of such projects are the Dutch Delta program and the Swiss NFP61 project.

Ad 2.: There is a very clear statement that navigation does not benefit from low water levels. Some people in the barging industry can maybe earn more money for a limited period, but on the mid and long term it leads to a loss of market share.
Navigation asks for improved forecasts for the coming three to five days. The forecasts that are currently provided via ELWIS are not accurate enough. Secondly a long term forecasts (2 till 3 months) would be a big help, even it is not 100% correct. Such a forecast could give the industry an idea how to react.
Long term weather forecasts in our climate area are very difficult. What is needed more is information on weather situations under specific summer conditions. There is a lot of research going on. More information on weather patterns will become available, but a very accurate forecast for 30 days ahead is not expected. What can be done is provide probabilities that the actual weather pattern persists or will become dryer or wetter than normally, based on the preconditions in the system.
The way to improve the short term forecasts is also to know how the forecasts are used. Hydrological forecasts are more and more developing into probabilistic forecasts. Is this the

information that is needed for decision makers? Cooperation between hydrologists and decision makers is needed. Scientists need to understand how the forecasts are used and users need to understand wat causes the uncertainty in the forecast.
Supply chain is risk management and the barging industry can work with probabilities. The problem is when a forecast changes dramatically from one day to another.
A representative from the Flanders hydraulic institute concluded that there is no problem in the Rhine basin at the moment. A problem is something we cannot manage. We have the knowledge and the resources to solve all of the discussed potential problems. There is no quantification of the problems.

We discussed a lot the predictions for low flow and the accuracy of these predictions. But a very accurate prediction is probably useless when at the gauging station Kaub only 400 m3/s are available? So maybe we should not invest money in trying to improve the accuracy of our forecasting models but in an assessment of the damage of extreme low flows for our highly industrialized society. And then we have something to decide. Maybe we can live with the expected low flows during a limited time of the year.

Mr. Andréassian thinks that the conversation we have in this symposium is one of 'spoiled children'. From the hydrological point of view we have seen that we have much less low flows now than we had before. But we are scared about the future. We should not be scared, because the situation now is better than in the past. From the ecological point of view the situation in European surface waters is much better than it was 40 years ago. But still we are scared about the future situation of ecology. Maybe the future is a black box, but there are solutions for all challenges. E.g. if there is not enough water for navigation in summer we can store water in large reservoirs, like it is done in many countries. A representative from navigation called this a need for a water battery.

WRAP UP
The sub title of the symposium was 'Science meets Practice'. At the end of the symposium science asked practice were they think the knowledge gaps are and on which science should concentrate in the coming years.
We have three main steps:

1. Data management. Observations and indices of low flows.
2. Interpretation. Giving advice on the actual situation. We have heard from navigation that there is a need for longer and more accurate forecasts and we have seen from science what are the possibilities now and what are still difficulties in forecasting low flows.
3. When you have the data and the forecasts, you need management plans and strategies to deal with the low flow and drought. A good overview on management plans was given during the symposium, especially from a sectoral point of view.

Practice has learned a lot about what is available today and what might be available tomorrow. But the next question is: what are we going to do with this information? Are we going to translate this in plans and measures or do we wait and see what happens?
A proposition was made that we should not invest so much in further science about the processes, but more in the assessment of the socio economic impact of low flow and drought. Science can establish some definition/identification of the processes. With that e.g. forecasts can be improved. But then it is up to the sectors to discuss with the authorities the interpretation and implementation of these forecasts and translate them in measures. It is impossible for the authorities to propose any measures implementing the results of the scenarios and forecasts without a dialogue with the sectors.
If we speak about tomorrow, this can be the coming years. In that time frame scientists should keep working on better predictions based on the needs of the sectors. If you look further in future the challenges become more socio economic. We more or less know what the future climate will be. But knowledge about socio economic influences is lacking.
The hydrologists in the symposium were very proud of what they showed. But hydrologists in fact can do very little. Forecasting hydrology is still very limited. Forecasting doesn't mean that we can add water to the system. We can do nothing about the quantity of the water. There is no major break-through expected in hydrological science, making us able to forecast six months. There is a major gap in time scale between what we can and what we need. In the discussion of adaptation and mitigation measures we did not hear agriculture, which is and will be even more a fundamental player. If people are hungry, then what really matters is feeding yourself and your family. If the population of the world keeps growing, providing food to the world will be a major issue and under these conditions no scientist or industry can prevent farmers to irrigate their crops. Water will be mostly withdrawn from ground water, so with a delayed effect on surface water.

Where are the possibilities to improve predictions?

We have a dialogue problem. Information is available but must be interpreted correctly. It should be understandable for policy makers, decision makers, people in the street. Every sector has specific expectations about forecasts, but the priorities are not clear.

If we would have a six month forecasts, how would society react to that? Maybe a farmer would start to irrigate months in advance knowing the forecast. What we really need is a model that can simulate this interaction.