MuDak-WRM

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Using hydrological models to plan and manage reservoirs with respect to water quantity

Context

In order to plan new reservoirs or to manage existing reservoirs, it is essential to know:

- overall inflow into the reservoir
- temporal distribution of inflow throughout the year
- extreme inflow conditions

Hydrological models can provide this information. Therefore, their application can be helpful at different stages of reservoir management:

- planning of new reservoirs
- long-term management of existing reservoirs
- operational short-term management of existing reservoirs

Planning new reservoirs

Water balance models provide potential inflow into a planned reservoir. Along with the planned reservoir volume and the withdrawal, this is the basis for sound planning of new reservoirs. In addition, extreme conditions (flood and drought inflows) can be evaluated. In this way, it is for example possible to compare potential locations for a new reservoir, assess the availability of drinking water from the reservoir or optimize its volume. To illustrate the planning process, Figures 1 and 2 show time series of Passaúna reservoir water volume resulting from simulations with varied drinking water abstraction and varied minimum ecological outflow.

Long-term management of reservoirs

Similar to the application of water balance models in the planning of new reservoirs, they can also be applied in the long-term management of existing reservoirs. Their application allows the assessment of potential changes in the long-term operation of the reservoir, e.g. increased drinking water abstraction (Figure 1), higher ecological minimum discharge (Figure 2) or changes in reservoir volume from silting or modification of the dam. Furthermore, the potential impact of changes in the catchment (e.g. climate change effects, land use changes) can be assessed. To illustrate this, Figure 3 contains example results for time series of Passaúna reservoir water volume with modified precipitation input, which might be regarded as an example for the effects of very dry climatic conditions.

Operational short-term management of reservoirs

Water balance models can also be applied in the operational short-term management of existing reservoirs. To do so, forecasts of meteorological data are needed. In this way, the short-term operation of reservoirs can be optimized based on the actual initial conditions and expected weather conditions. For example, operational forecasting may be used to optimize drinking water abstraction during drought periods or to improve flood retention under wet conditions.

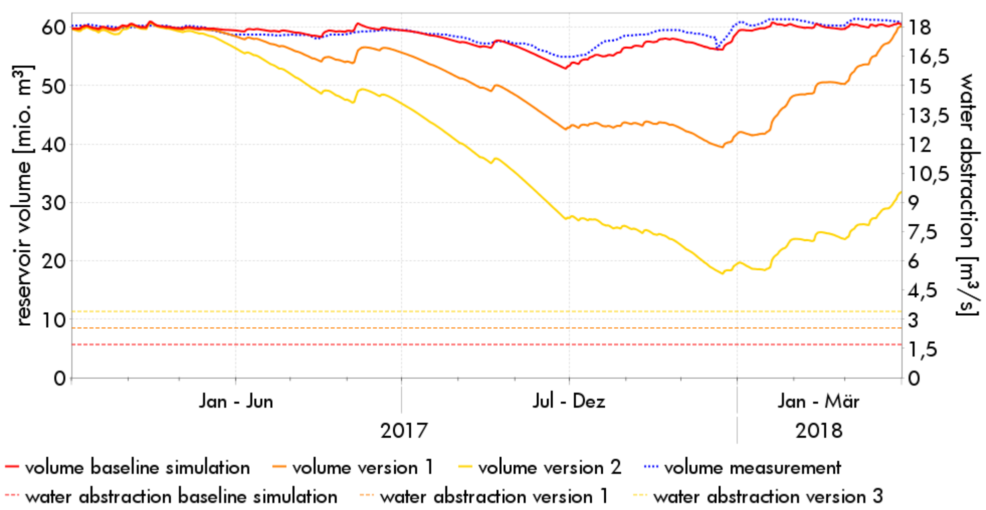

Figure 1: Comparison of three different simulations of the volume in Passaúna reservoir for the years 2017/2018 (solid lines, left y-axis). The versions differ only with respect to drinking water abstraction (broken lines, right y-axis). The baseline simulation assumes an abstraction of 1.7 m³/s, version 1 of 2.55 m³/s (+50%) and version 2 of 3.4 m³/s (+100%).

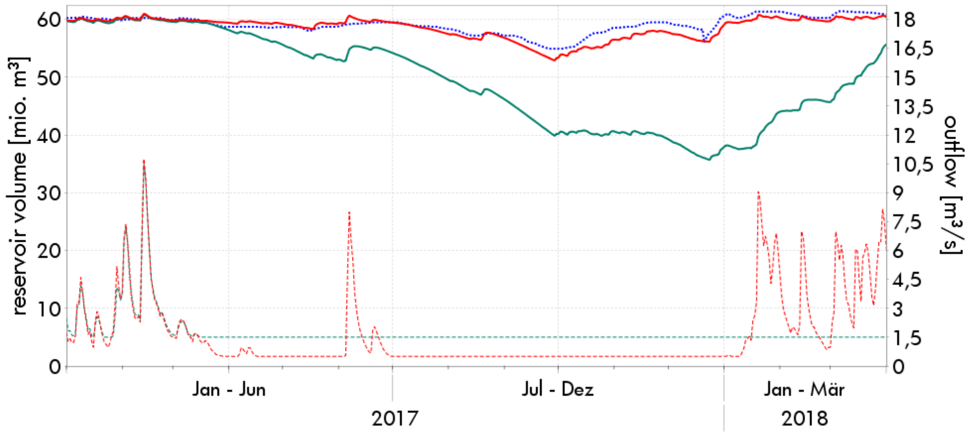

Figure 2: Comparison of two different simulations of the volume in Passaúna reservoir for the years 2017/2018. The versions differ with respect to minimum (ecological) outflow. The baseline simulation assumes a min. outflow of 0.5 m³/s, version 3 of 1.5 m³/s (total outflow as broken lines on right y-axis).

Potential results

For all three types of application, water balance models can provide the following relevant results:

- inflow into the reservoir
- water volume in the reservoir
- water level in the reservoir (if volume/level relation is known)
- discharge downstream of the reservoir

All results can be provided in high temporal resolution. Therefore, the results are not only valuable with respect to water quantity, but also to deduce information for the assessment of water quality, e.g.:

- number of days during which the water level decreases below a critical value
- (mean) residence time
- number of days with critical (matter) inflow

Advantages of the application of water balance models for reservoirs

In comparison to other methods for the assessment of reservoirs, water balance models have a high temporal resolution and thereby can easily consider temporal evolution e.g. of storage volume, which is essential to assess for example inter-annual effects. They can also provide information for non-observed parts of the catchment and on complex spatial interaction, e.g. the effects of several parallel or sequential reservoirs. Physically-based water balance models, such as LARSIM, are also capable to predict the impact of changing environmental conditions (e.g. climate change). Once set up, they are thus reliable and versatile tools to assess the effects of changing conditions and potential counteractions. The consideration and comparison of various scenarios is quite simple.

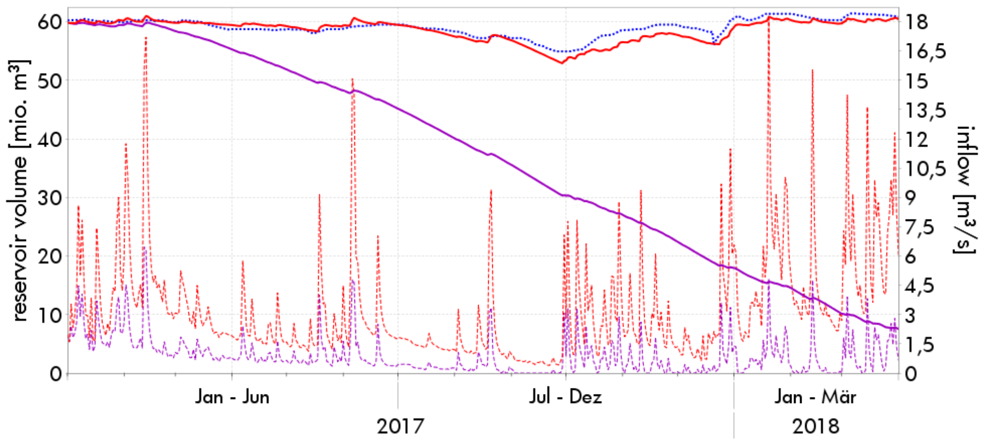

Figure 3: Comparison of two different simulations of the volume in Passaúna reservoir for the years 2017/2018. The versions differ only with respect to precipitation input (broken lines, right y-axis). In version 4, actual precipitation is reduced by 50%.

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