Changes in flood risk due to the presence of dams in the German part of the Rhine catchment

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Introduction

Dams play an important role in the management of water resources and are a significant flood control measure in Germany. The Rhein catchment is one of the most regulated rivers in Germany, where changes in annual maximum discharges were attributed to river training measures.

Simple Basin Model & dam module

Simple Basin Model:

We have developed the Simple Basin Model (SBM) which is composed of a catchment model and a routing scheme. The catchment model is the HBV model, and the routing component is based on the Streamflow Synthesis & Reservoir Regulation (SSARR).

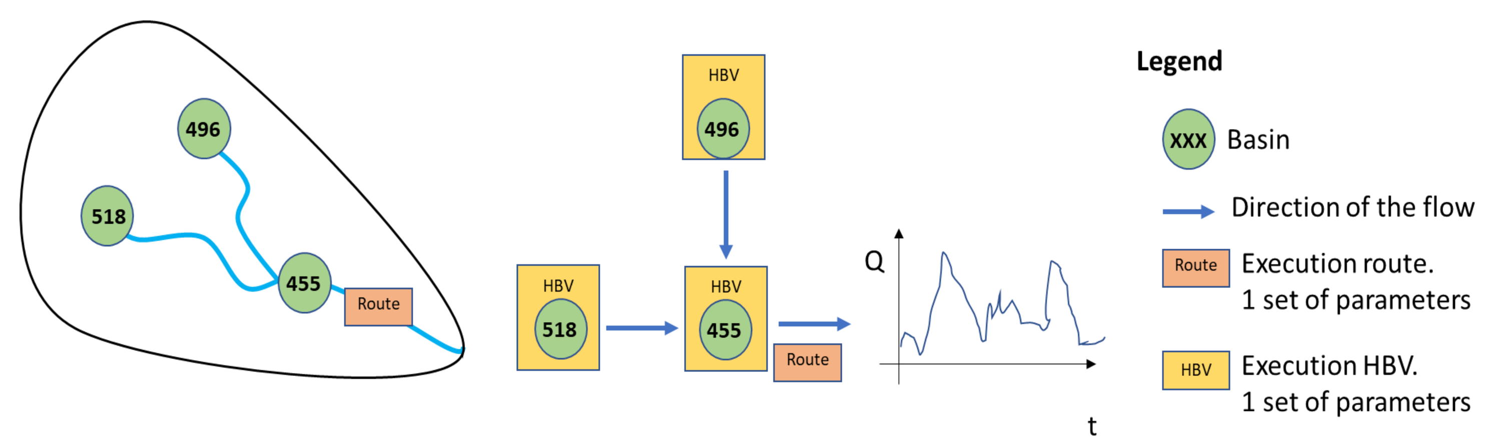

Figure 1: Overview of the representation of the Simple Basin Model (SBM).

The HBV model has 15 parameters, while the routing procedure has 3 (KTS, n, and nbr). KTS and n controls the time of storage (Eq.1). T_s *is* time of storage per increment in hours.

KTS is a positive coefficient and may represent physical properties of river reach. O is the discharge and n is the a coefficient that varies between -1 and 1.

The routing equation is described in Eq. 2.

$$T_s = \frac{KTS}{O^n} \; (Eq.1) \qquad O_{t+\Delta t} = O_t + \frac{\Delta t * (I_m - O_t)}{T_{sm} + \frac{\Delta t}{2}} \quad \text{(Eq.2)}$$

O_t is the outflow at beginning of period.
$O_{t+\Delta t}$ is the outflow at end of the period.
Δt is the time duration of computational period.
T_{sm} is the mean time of storage.
I_m is the mean inflow.

Dam module:

A simple module was developed to represent the dams at the Rhine catchment. Water storage and water released are based on threshold values from the hydrograph. Figure 2 shows the concept of the dam operation. The water reserved at the dam is release after the flood wave.

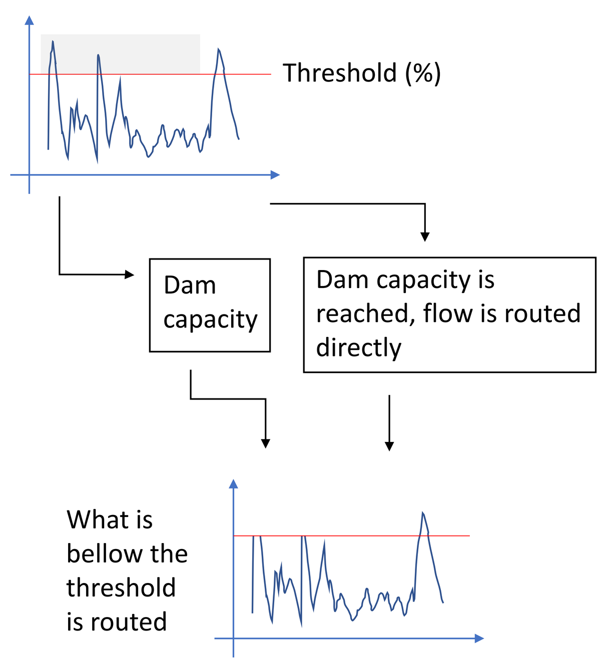

Figure 2: Schematic representation of dam module operation.

The study area is at the Rhine catchment (Fig. 3), where most of dams were constructed between 1950-2000. After calibration, discharges are going to be used to calculate the return period which it will be combined with the Regional Flood Model (RFM) output (Sairam et al 2020) in order to estimate the flood damages for the Rhein catchment.

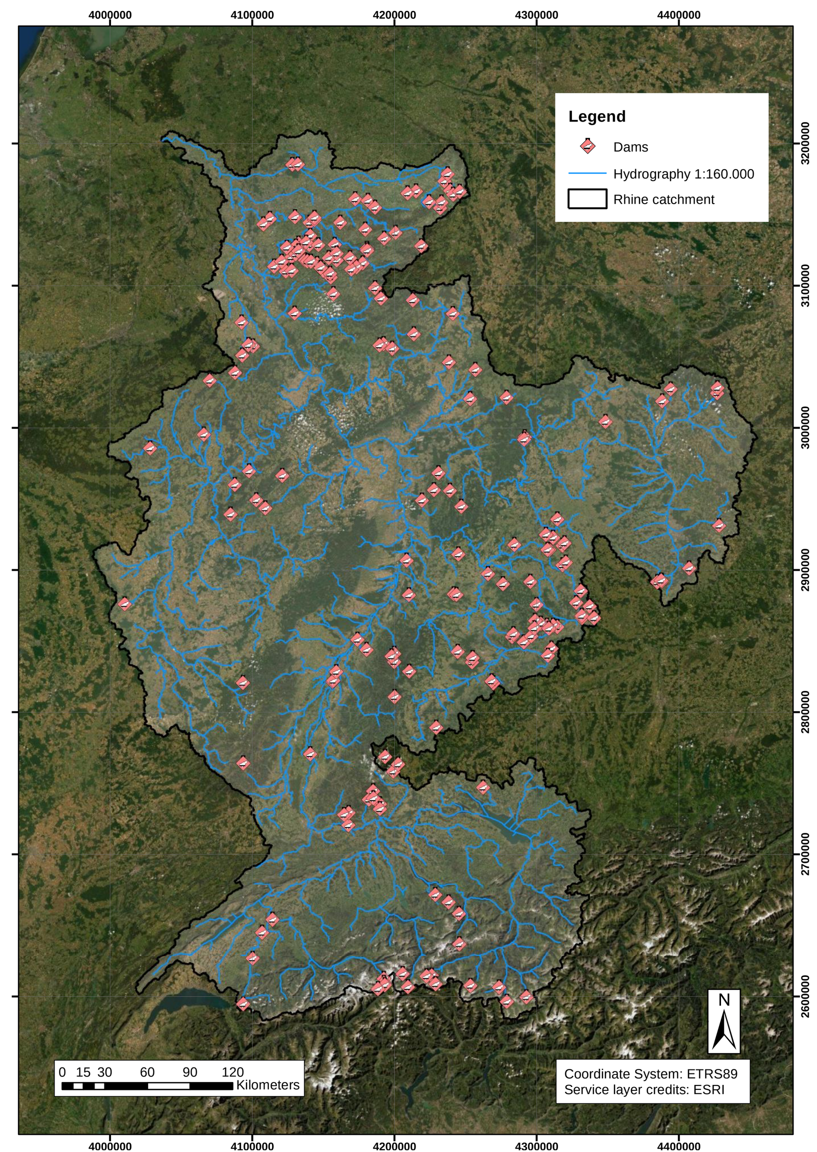

Figure 3: Location map of the study area.

Results

Initial results show that the model has been able to represent flow correctly in selected catchments. Our dam module has also been able to represent water volume variations at the dams (Figure 4).

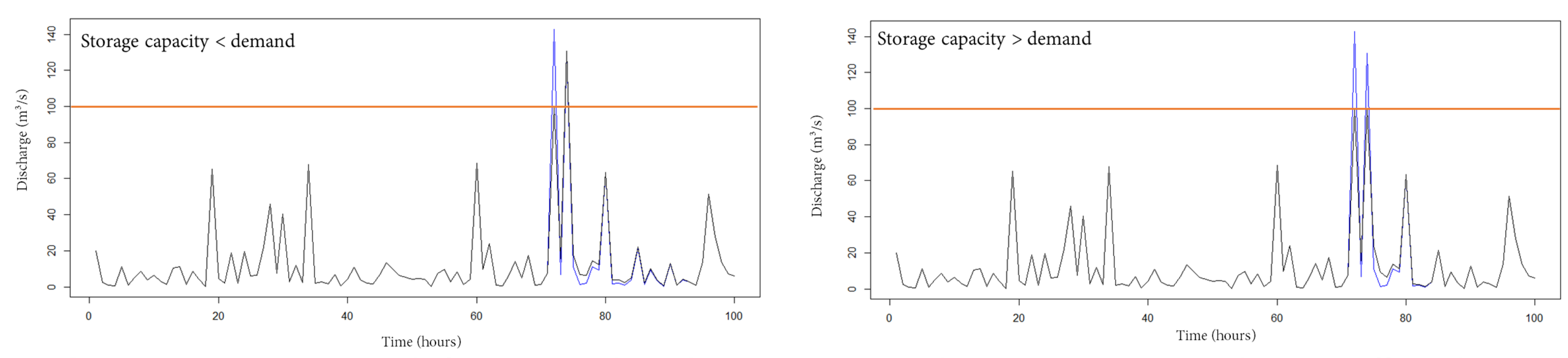

Figure 4: Dam module operation for 2 cases: a) storage capacity smaller than the water demand and b) storage capacity of the dam higher than the demand.

Our simplified routing approach (which requires no direct information on river geometry) has been able to adequately represent flow variation. This approach requires less computational power and can be as an alternative for flood modelling.

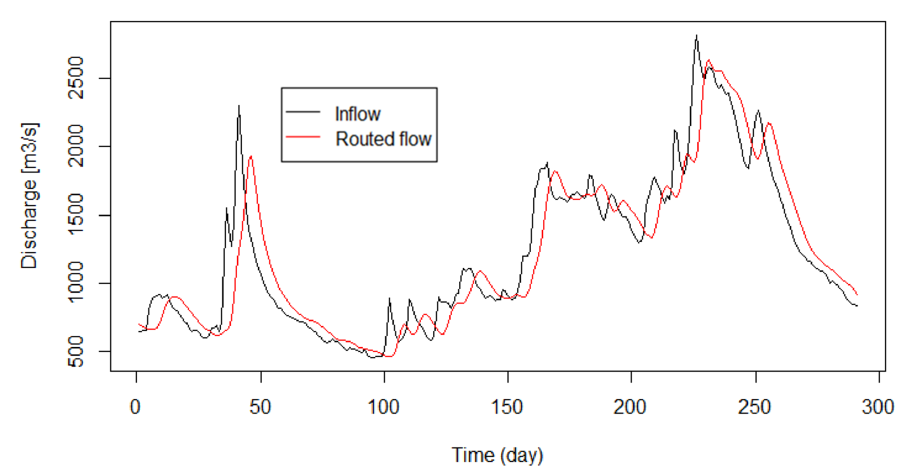

Figure 5: Example of model routed flow.

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References

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DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service

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