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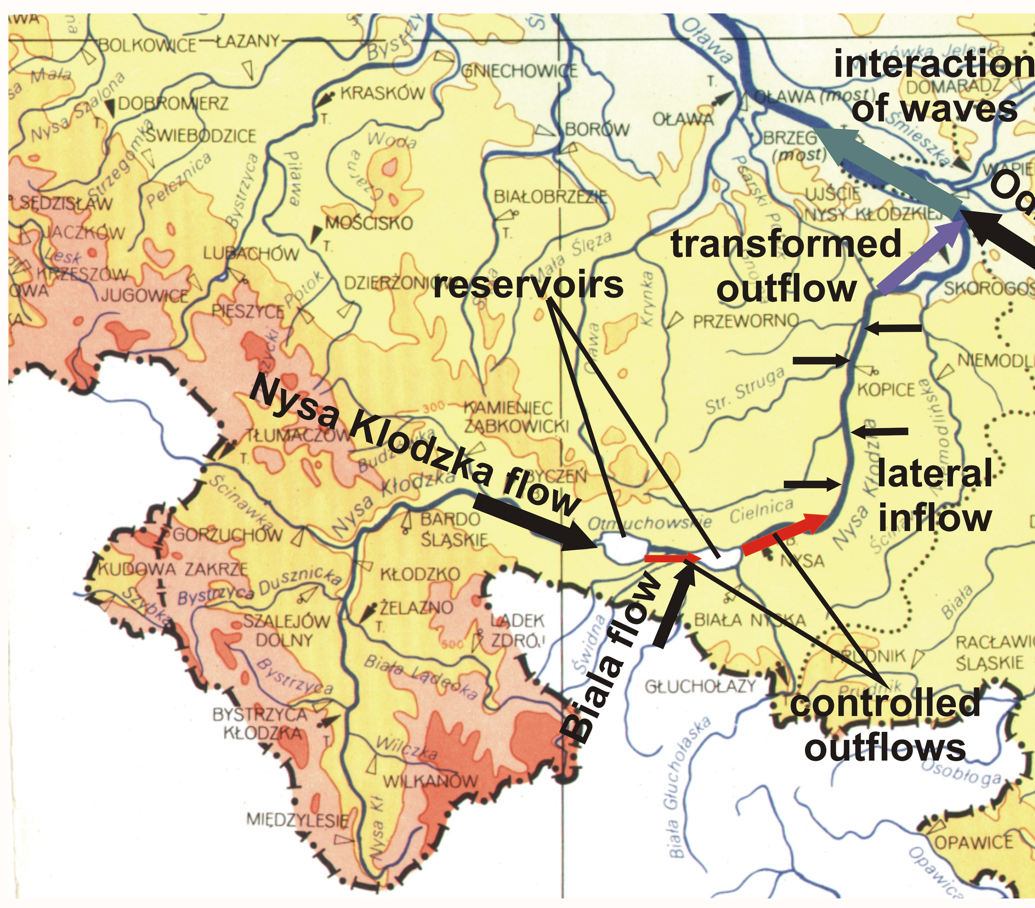
Decision Support System

for flood control in Nysa Klodzka catchment

Nysa Klodzka catchment

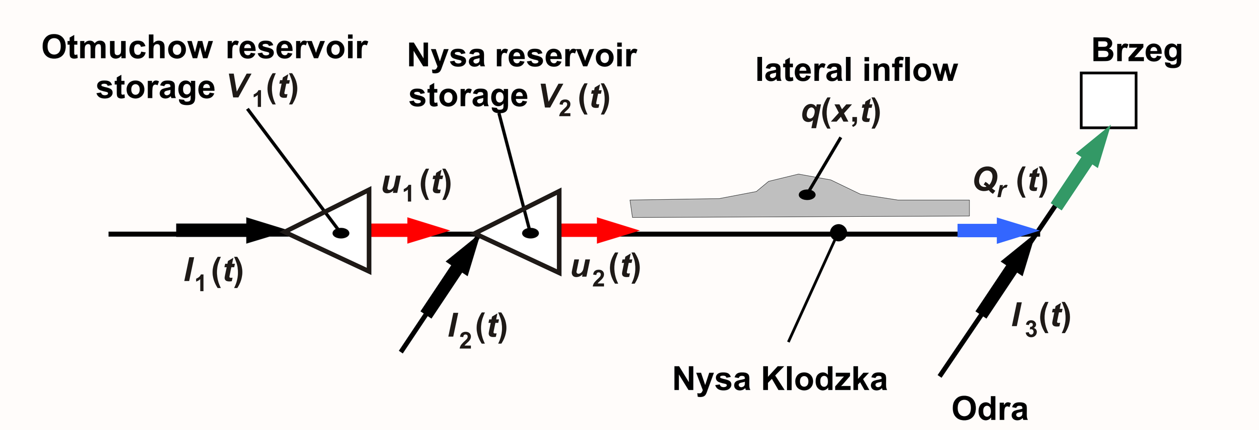
area 4565,7 km^2 **length 181,7 km**



The catchment of Nysa River is located in the southern part of Poland. The hydrological features of the upper part of this catchment are characterized by massive rocky underground covered only by small layer, and an average yearly precipitation of about 900 mm. The missing ability of storing water underground leads to dangerous floods. To achieve the ability to handle this problem two reservoirs were built, and two are under construction. The considered reservoir system, then, is formed by two major rivers: Odra river, its tributary Nysa Klodzka river, and two retention reservoirs. The system inflows, namely main inflow to the upper reservoir, lateral inflow to the lower one, Odra river flow and lateral inflow along the channel are to be determined on the basis of measured and forecasted precipitation. The outflow from the reservoirs is routed in the Nysa Klodzka and the main aim of the control is to reduce damages in the city of Brzeg below the junction of Nysa Klodzka and Odra rivers.

To describe the behaviour of the system the following mathematical models are used: standard mass balance equations for both reservoirs (with constraints on the storages and outflows), and de Saint Venant equations or kinematic wave model for the river reach down the lower reservoir. The channel reach connecting the reservoirs is so short that the transformation model for this part is not required. The main goal of the control is the protection of the user against flooding by minimizing the maximum peak of the superposition of waves on Nysa and Odra rivers. This can be achieved by desynchronization of the flow peaks via accelerating or retarding of a flood wave on the Nysa River. The second objective is the storing water for future needs after flood.

System structure



$$\frac{dV_1}{dt} = I_1 - u_1 \qquad \frac{dV_2}{dt} = u_1 + I_2 - u_2$$ **standard mass balance equations**

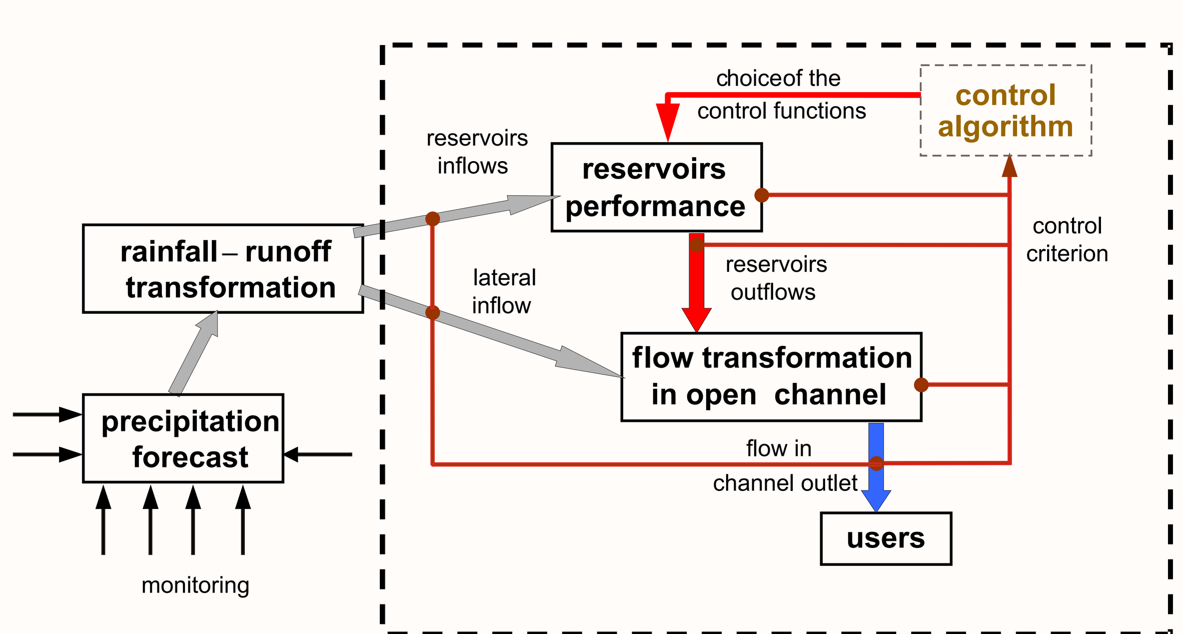
$$Q_r(t) = \varphi[u_2, q](t)$$ **hydrodynamic flow transformation model**

$$V_{\min j} \leq V_j(t) \leq V_{\max j} \qquad U_{\min j} \leq u_j(t) \leq U_{\max j}$$ **constraints**

control criterion $$\min_{u_1,u_2}\left\{\beta_1 \max_{t\in[0,T_H]}\left(Q_r(t)+I_3(t)\right)+\beta_2\sum_{j=1}^{2}\left[V_j(T_H)-V_{\max j}\right]^2\right\}$$

The elements of the Decision Support System

Cooperation of DSS modules



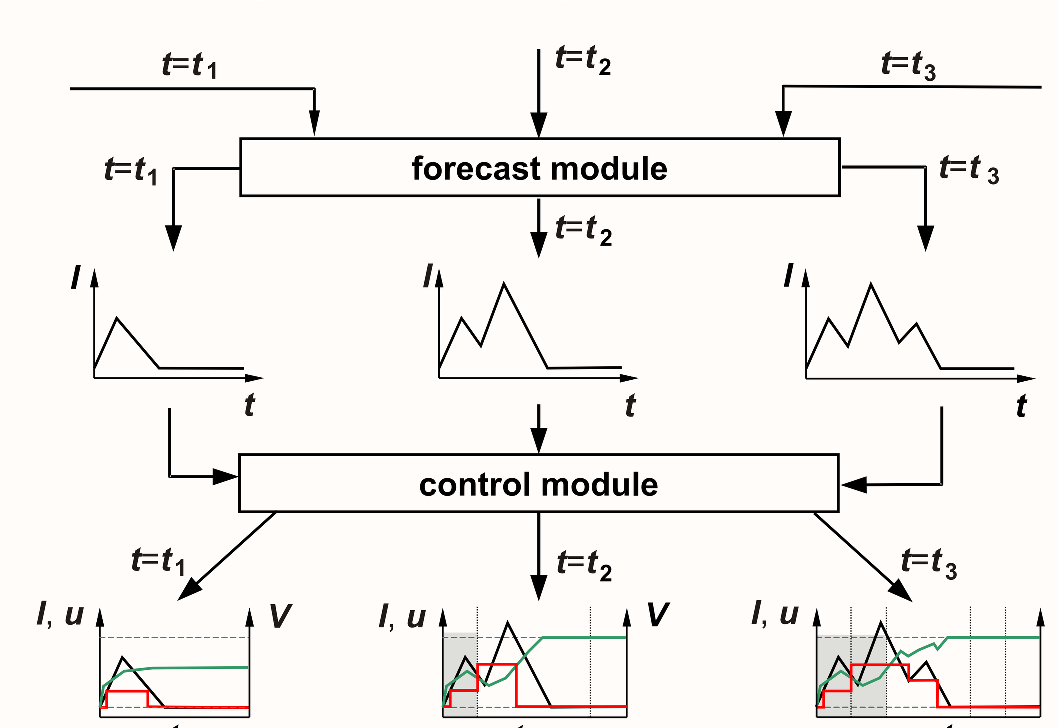
The Decision Support System for flood control in Nysa Klodzka catchment includes parts responsible for precipitation forecast, rainfall-runoff transformation, reservoirs performance, unsteady flow routing and the optimisation structure controlling the performance of the system.

On the basis of measurement at meteorological stations located in the catchment and UMPL atmospheric model (a mesoscale version of the UKMO Unified Model implemented to the region of Central Europe centered over Poland) the rainfall forecast is formed for the nearest 48 hours. This forecast allows to determine the hydrographs of inflows to the reservoirs system and channels. The forecasted or assumed inflows scenario is the data supply to the control module.

The control structure consists of the model of reservoirs performance, transformation of flow in open channels and evaluation of control effects. Its effectiveness depends on the quality of forecast module results. The precipitation forecast and the rainfall-runoff transformation model form the second module.

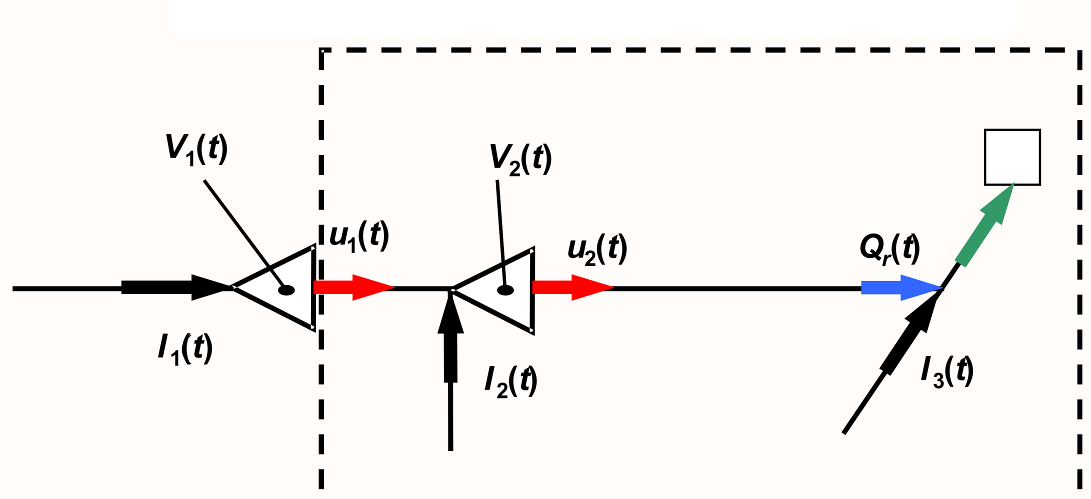
After some period of time, for a new forecast, the inflows to the system are updated. Then the optimisation procedure is repeated and the new reservoirs outflows trajectories are calculated for the shifted time horizon.

Operational performance



The basis of the control algorithm

Sequential optimisation, part 1



To solve this problem the sequential optimisation algorithm is developed and applied. This technique enables the control of a system of reservoirs in series. It is based on the decomposition of the system in space. Hence the general problem is divided into two local problems related to two reservoirs in the system.

It may be noticed that if the outflow from upper reservoir is known the problem is simply reduced to the control problem of lower reservoir. The possible modification of the lower reservoir behaviour does not require any modification of the upper reservoir performance.

However, if the outflow and the storage of lower reservoir are known, the problem is also reduced to the control of one reservoir but the upper reservoir influences the behaviour of the lower one. So, every modification of the upper parameters involves the corresponding modification of the lower reservoir performance. For the sake of the simplicity only one of these functions may be changed. It is assumed this function is outflow from the system.

Sequential optimisation, part 2