REAL-TIME FLOOD MANAGEMENT BY PREVENTIVE OPERATIONS ON MULTIPLE ALPINE HYDROPOWER SCHEMES

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Floods are part of the major disasters in alpine valleys and cause every year important damages. Located in the centre of the Alps, the Rhone River catchment area is hit by heavy precipitations due to a combination of wet streams coming from the Mediterranean Sea and influence of the Alps. The resulting floods have typically a response time of three days. The region is also characterized by the numerous existing hydropower plants with large accumulation reservoirs and supply networks, which allowed a significant reduction of the peak discharge during the three last major flood events.

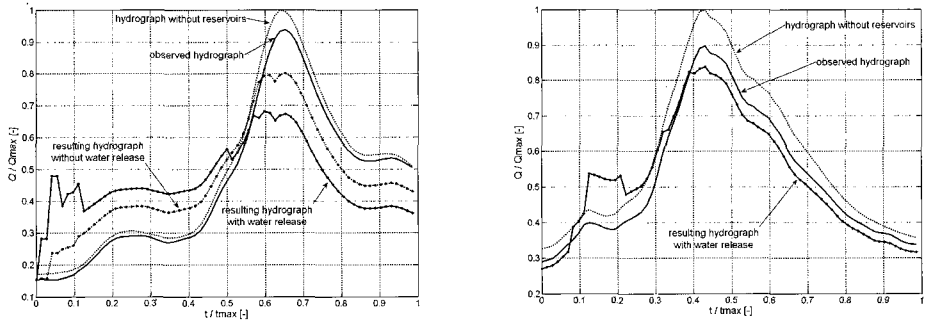
The management of numerous hydropower plants during floods requires a global overview of the catchment area. The influence of turbine, pump or gate operation is not only important for the dam safety, but also for the safety of the downstream river. The actual local-focused flood management evolves into a global-focused one and a new operation strategy during floods is emerging. Preventive turbine and gate operation before the peak discharge is replacing the actual emergency rules during the flood peak. This allows maximizing the water routed during flood peaks and reducing the discharge in the downstream river.

For these reasons, a new flood prediction model is developed for the Rhone River catchment area, with the aim to improve the management of the existing hydropower plants during such crisis periods. Using the weather forecasts provided by the Swiss Weather Service as well as real-time precipitation, temperature and discharge measurements, this model will give within a 72 hours lead time hourly discharge predictions. The 5520 km^2 catchment area has been divided in 239 sub-catchments, which are divided in 500m elevation bands. This model makes possible to take into account multiple hydrological processes such as snow melt, glacier melt, soil infiltration, runoff and river routing. All the major hydropower plants are modelled, including water intakes, transfer and power tunnels, reservoirs, powerhouses and pumps. The model also allows modelling the typical operation and emergency rules.

A new flood management model of the Rhone River based on flood predictions is presented, including the 10 major existing hydropower plants. By computing the predicted inflows at the intakes and reservoirs 72 hours in advance, the model gives the maximum possible inflow in the main hydropower plant reservoirs. Pump operation is considered in order to increase the possible inflow during the peak discharge. Preventive turbine and gate operations are determined by comparing the maximum predicted inflow with the available storage volume. Limitations of these operations are considered by computing

their influence downstream to avoid overloading the peak discharge.

A performance analysis of the computed flood management strategies showed the significant positive influence of such preventive operations. Two major historical flood events with about 100 year occurrence period were simulated. The reduction of the observed peak discharge due to the accumulation reservoirs lied between 6% (September 1993) and 10% (October 2000) at the outlet of the Rhone River catchment area. With an appropriate flood management strategy 50 hours in advance, the reduction of the peak discharge would have been increased by 15% without gate operation and 28% with gate operation during the flood of September 1993 (Fig. 1a). An additional reduction of 7% of the peak discharge would have been obtained during the flood of October 2000 with preventive operation 34 hours in advance (Fig. 1b).



(a) September 1993 (b) October 2000

Fig. 1 influence of the flood management strategies during two major floods in the Rhone River catchment area.

The presented results show the gain of safety obtained by using a flood prediction model coupled with the optimization of the preventive operation of the existing hydropower plants. Minimal operation periods of 30 hours before the peak discharge are sufficient to reduce significantly the total costs of the damages. If the preventive operation of the hydropower plants represents a valuable alternative for the flood management, the associated risks have to be considered. They consist of inappropriate water and economical losses due to wrong inflow forecasts.

Keywords: Flood prediction; Flood management; Hydropower plants; Alpine reservoirs; Preventive operations; Decision making tool