

BEST PRACTICES FOR FLOOD FORECASTING AND WARNING SYSTEMS: THE COMPAGNIE NATIONALE DU RHÔNE'S EXPERIENCE IN FLOOD FORECASTING AND THE ADVANTAGES IT CAN PROVIDE FOR THE LOWER MEKONG WATERSHED

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SUMMARY

CNR and its role as concession holder of the Rhône river:

The Compagnie Nationale du Rhône (CNR, France) holds the concession for developing and operating the Rhône from the Swiss frontier to the Mediterranean Sea. This concession requires the fulfilment of three main missions: hydropower production, development of navigation and irrigation. Consequently, CNR has built a series of 18 run-of-the river hydropower development schemes along almost 500 km.

In order to monitor the very varied hydrological characteristics of the Rhône and its main tributaries, CNR has been making use of a hydrological measurement network for over 40 years. The network is composed of about 150 stations for a watershed of about 100,000 km². The multiplex transmission system permits a real-time monitoring of hydrological phenomena and floods in particular.

In order to manage this network, collect the data, analyse and process it, then make this information available to both internal and external clients (and other stakeholders) in real-time, CNR developed the **THALIE** software at the beginning of the 1990s. Since 2000, it has put its experience of the Rhône to good use by developing the **HYDROMET** software in partnership with IRD (Institut de Recherche et Développement – formerly ORSTOM). CNR and IRD have installed HYDROMET in several countries, especially in Latin America and Africa.

HYDROMET is designed to perform the following functions:

- Acquisition and collection of all hydrometeorological data (heights, flow rates, gauging, stage-discharge curves, water quality parameters, rainfall, temperatures, hygrometry, wind speed, etc.) using different resources: telephone, GSM, satellite, radio, Internet, etc.
- Data storage in an ORACLE database ensures integrity,
- Automatic real-time or batch processing of base data (calculation of averages, minima-maxima, flood volumes, statistical adjustments, etc).
- Alarm management (hydrological alarms, sensor alarms, systems alarms, etc.);
- Making available the information stored in the base by the different means of communication: client station, Intranet, Internet.

CNR centralises the data collected by **HYDROMET** from its hydrometric network, meteorological observations, 2-day forecasts supplied by **Météo France** and the 4-day meteorological forecasts supplied by the **OPALE** system based on the analogue method and developed by CNR.

These data are used automatically by the **PHARE** tool that uses robust hydrological models to formulate flow rate predictions for the tributaries of the Rhône.

These forecasts are then introduced in the **CRUE** hydraulic propagation software that models the entire length of the Rhône and its development schemes. To do this it uses Barré de Saint Venant equations that permit making flow rate and water height predictions at any point of the river.

CNR's experience in Paraguay:

The experience acquired by CNR was used on the watershed of the Paraguay river in the framework of an international development project carried out by France and Paraguay and finalised in 2005. The Paraguay river is 2,500 km long; its average flow rate at its outlet is 4,300 m³/s for a watershed covering 900,000 km².

Setting up an automatic measurement network

A network of 35 automatic meteorological, hydrological, hydrometric and water quality stations have been installed along the Paraguay river and its main tributaries. The data collected are sent automatically by satellite to a data collection and analysis centre. They are then stored and analysed with the **HYDROMET** hydrometeorological data processing software.

Hydrological models of the Paraguay river's main tributaries

The Paraguay river's 5 main tributaries have been modelled to obtain 4-day flow-rate forecasts. The models used are multiple regression statistical type models. The input data used for the model are, for each of the tributaries: the daily flow rates and rainfalls of the 9 days previous to day D of the forecast. The flow rate predictions obtained permit forecasting sudden floods caused by the contribution of these tributaries during heavy tropical rainfall.

Hydraulic model of the Paraguay river

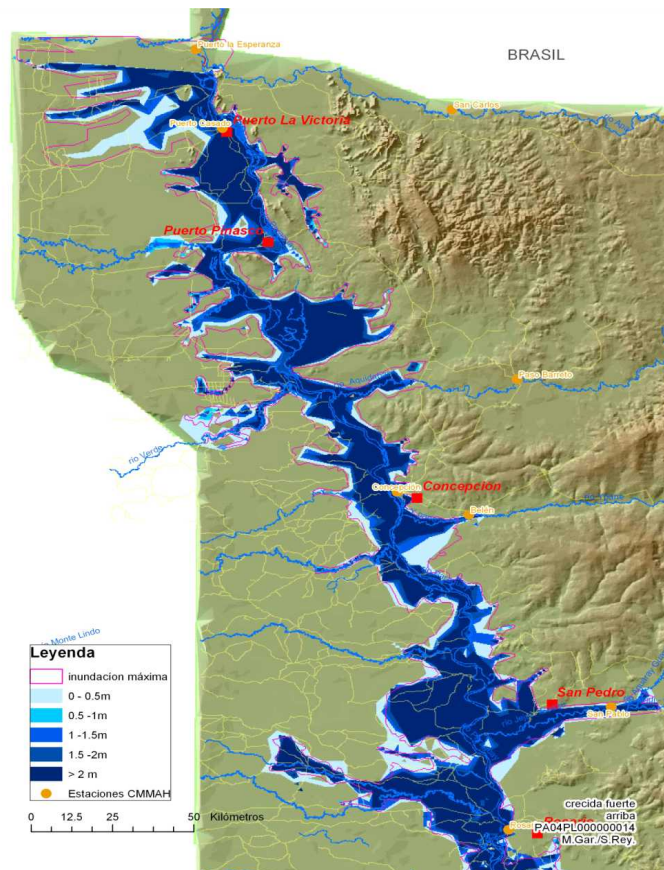
This model covers 1,200 km of the Paraguay river and permits making water height forecasts as well as low water and flood simulations. The forecasts are accurate to within approximately 5 days in the case of fast flooding of the tributaries, and to within 15 to 20 days in the case of slow flooding fed from upstream. These forecasting times allow the public authorities to react within good time in the case of heavy flooding, in order to warn and protect the populations exposed to flood risks.

The hydraulic propagation model applied is the CRUE software that has been developed, used and regularly upgraded by CNR for over 25 years. It is supplied with the following data:

- The flow-rate upstream and the downstream water height of the Paraguay river,
- The flow-rates observed and forecast of the 5 main tributaries for which a rainfall/flow-rate model exists (mentioned above).

Cartographic representation of the results

Linked with the numerical land model of Paraguay, the results for the water level forecasts of the Paraguay river can be mapped easily in 3D, permitting fast visualisation of the areas likely to undergo flooding. Animated views of the progression of the flood through time can also be obtained and give valuable information on the morphology of the flood (filling and emptying of floodable areas, flood routing areas, etc).



Example of the numerical map of water heights built on the basis of results of modelling heavy flooding of the Paraguay river

A similar project is currently in progress in Bolivia and Brazil, in the watershed of the Upper-Paraguay.

Lastly, mention should be made of the participation of CNR's experts in the **ISLAND "Information Systems for Local Authorities Needs to Face Disasters"** programme financed by EUROPEAid, which has given rise to a large number of exchanges with MRC, including the organisation of workshops among others in the framework of the Flood Management and Mitigation Programme and the 3rd Annual Mekong Flood Forum).

How to apply these practices in the Lower Mekong Basin

All these experiences and flood forecasting tools could be integrated in the Mekong River Basin in order to complete and improve the existing flood forecasting and warning systems.

Within the **MEKONG Hycos programme**, which will include the installation of 50 measurement stations on the main tributaries of the Mekong river and the integration of a Hydrometeorological data system in the framework of the "MRC Hydro-met Network Improvement program", an important step will be made to improve the knowledge of these tributaries' hydrology conditions.

A second step could be the development a discharge forecasting model for each main tributary, like CNR did in the Rhône river in France or in the Paraguay river in South America among others. These tributaries models would permit flood forecasting at the national or local scale, and then, associated to the mainstream hydraulic propagation model, improve the precision of the hydrological forecasts in the Mekong river itself.

In association with the development of a geographic information system of the Mekong river basin, the results of the forecasts or the simulation would easily be visualized in a 2D or a 3D map for simulations or in real-time. This would represent a useful tool for an emergency centre dedicated to flood prevention. Indeed, technical or political decision makers would thus benefit from a synoptical view of the flood situation and its probable evolution. That is an important operational asset to take appropriated emergency measures.

CONCLUSION

The Compagnie Nationale du Rhône has developed flood and low-water level forecasting tools, calling on know-how in France and abroad. These tools are extremely useful operationally, for both managing navigation, irrigation and for flood forecasting services, as they permit the rapid deployment of emergency plans relating to flood risks. This flood forecasting system could perfectly complement and be integrated in systems that already exist or that have been planned by MRC, like **MEKONG Hycos programme**, and thus contribute to the aims of FMMP, i.e. to minimise, prevent or mitigate loss of life and suffering, and economic losses due to floods.