Flood Forecasting and Warning System for Yellow River
The Xiao-Hua reach and the three tributaries of Qin, Yi and Luo

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1. Introduction

The Yellow River is flowing from West to East throughout the Northern China, with a total length of 5,464 km, a vertical drop of 4,830 m and a catchment area of 752,000 km2. The predominant climate is extreme continental with a drought climate to the North and humid climate to the southeast of the basin, with rainy summers and dry and cold winters. There is a seasonal rainfall alternation between both watersheds, fact that provides this area with monthly regularity, but it is subject to hard hydrous unbalances from year to year, that only allow considering its medium contribution of 52 km^3/year, as simple statistic reference.

Fig. 1: Map of the Yellow River, China

Indeed, this area is subject to an intense exploitation, mainly by the agricultural water requirement, which has risen to 48 km^3/year, has caused the yellow River to run dry at its mouth. Unfortunately, it has been observed that sudden floods occur very frequently, which destroy buildings and crops. Daily rainfalls higher than 700 mm have been measured. In order to protect themselves from these risks, the inhabitants have implemented structural measures such as canalisation, building reservoir and dams have adapted many other measures during a period of at least 4,000 years.

Fig. 2: Air view of the Xiaolangdi dam

2. Functional solution

It includes the data processing at the remote control and the main control centre, the incorporation of external data and supply this or other data to other users. The data processing at the remote controls begin with sampling, measurements and periodical interrogations by the main control centre and the structure is shown schematically in the figures below.
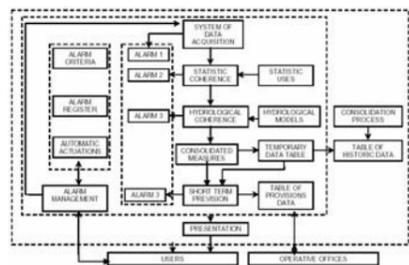

Fig. 3: Data processing system in the YRCC Basin Centre

The main objective of the Project is to support the development of an integrated management system through:
- Set up the requirements for developing a meteorological and hydrological model
- Adjust the current forecasting system to the new model
- Support the capacity building in YRCC forecasting dept.
- Propose future improvements in the flooding warning system and in dissemination of the related information

The hydrological model system is the core of the management system. The model system includes:
1. Filling techniques of series:
   - Interpolation techniques
   - Simple and multiple seasonal regression
   - ARMA models
2. Modelling techniques:
   - Basin models without enough rain gauges.
     - Definition of rainfall typical situation
     - Rainfall-runoff model
   - Basin models with enough rain gauges
     - Model of superficial precipitation
     - Model of rainfall-runoff
   - Reach models with important part unknown
     - With enough rain gauges: model of precipitation, model of rainfall-runoff and hydrodynamic model.
     - Without enough rain gauges: definition of typical pluviometric stages, model rainfall-runoff and hydrodynamic model.
     - Reach models with ineligible part unknown: hydrodynamic model.
     - Models of reservoir operation
     - Models of pipelines.

The integration of external data incorporates those data coming from satellites and meteorological radar as well as all historic and current data of physical parameters that are not automatically captured. Regarding data export, data requested by other organisations as users of the information are included. These operations are established through covenants for specific proprietary information, however, other data and results published directly on the Internet or other media can be access free of charge.

3. Software

The existing flood warning system has taken long time to develop and that fact has guided the choice of software to be installed during the present Project. During the project, we will indicate all elements susceptible of being substituted as well as circumstances could recommend. Based on new technologies, enhancements are implemented in order to adapt the new schemes of decision requirements and operator's information level.

Fig. 4: Example of use of GIS/RS in land use identification

Using this technology as starting point, our target is to feed the system in real time with basic data and work orders concerning recording, transmission, interpretation, presentation and broadcasting of useful information. For these reasons the system must satisfy some fundamental criteria:
1. Automatic system. This system must be able to function on its own, by reducing manual operations to the minimum
2. Reliable and static data. The collected information must be credible, that is, it must correspond to the real situation of the basin. Data must be consistent shall be stored in a safe place
3. User Friendliness. The system must be attractive enough for user to feel he/she is facilitated work from the beginning
4. Flexibility. System must be able to adapt the demands of different users and should allow easy extension of the monitoring system
5. Speed. System must be able to carry out its tasks on real time
6. Accuracy. Apart from static and reliable data, they must be accurate, that is, close to real value

Obviously. these issues are common to any system of this type, but it is important to highlight the priority order given to each aspect that determines completely the conceived scheme. So the high priority given to user-friendliness is underlined, and at the same time the need to strengthen the reliability with regard to mathematic accurateness. Over these qualities, physical and functional components of the system will be briefly described.

4. Application of the system

It is foreseen that the model system shall be used for short-term forecasts as well as long-term planning/design:
- Forecasts with deadlines less than a week: especially useful for preventing floods and managing of exploitation at very short time.
- Forecasts with deadlines between one week and some months: useful for long-term management (strategic planning).

Later forecasts are less reliable due to inaccuracy of meteorological forecasts, fact that led into establishing the convenience of a proved processing based on the definition of scenarios according to the following scheme:
- Statistic analysis of historic data series to cause the definition of possible scenarios. Five meteorological stages are fixed: extreme dry, dry, medium, humid and extreme humid. These scenarios are obviously referred to depending on the month of the year.
- The user establishes the conditions of exploitation according to simple rules (maintenance of current exploitation, reduction or increasing in a percentage, recovering of exploitation, goal, etc).
- Recording of the last real available data as well as last forecast at short term.
- Flood of the model starting from previous data, by integrating results. Module QSS will be used because it is longer and quicker.
- Presentation of results according to the general scheme.

Dissemination of information for short-term warning purposes as well as for long-term planning and awareness are important aspects of flood management.

Fig. 5: Documentation and dissemination

After completion, the system will be capable of assessment and analysis of historic flood data, simulation of actual flood events and forecast of river water level and flood volume for warning purposes. The modelling system will also provide facilities for overall system analysis of flood mitigation infrastructure on a catchment level.

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