THE WATER BALANCE MODELING OF THE YELLOW RIVER FOR THE WATER RESOURCE MANAGEMENT

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ABSTRACT**:** Hydrological model has been developed in the Yellow River basin in China for the optimal management of water resource. This model is based on the SVAT-HYCY scheme and simulate the water balance using meteorological hydrological data and land cover type. Land cover and its change have been analyzed by means of remote sensing data. The submodels which deal with the dam operation and irrigation have been developed since human activity significantly affect the river flow. Present status of the study is reported in this paper.

KEYWORDS: hydrological model, Yellow River

1. INTRODUCTION

The Yellow River in China had been dried up since 1970s over great distances and for long periods in a year. This caused serious problems not only of water shortage but also of degradation of water quality and depletion of living aquatic resources. Since one of the main reason of dry-up is excess water use for the irrigation, this situation seems to be a human-induced disaster. The purpose of this study is to develop the hydrological model for supporting the water resource management of the Yellow River. The Yellow river basin is shown in figure 1. River discharge data used in this paper were observed at three hydrological gauges, which are located in upstream, downstream of the dams, and lower stream of two big irrigation districts.

Figure 1. Yellow River basin.

2. METHODOLOGY

2.1 Hydrological model

The water balance in the Yellow River basin is simulated by means of SVAT-HYCY (Soil-Vegetation-Atmosphere Transfer-HYdrologic CYcle) based model (Ma et al. 2003, Ma et al. 2000) in 0.1 degrees grid and daily bases. Overview of the model is shown in figure 2.

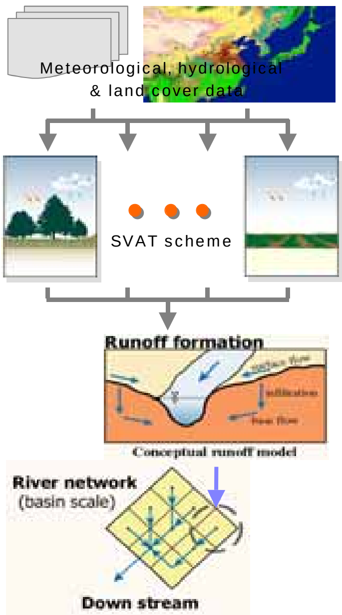

Figure 2. Overview of the hydrological model.

The model contains three submodels, i.e. SVAT, runoff, and river-flow-routing models, to describe the dynamics of water. Daily meteorological data such as precipitation, radiation, and temperature, and river discharge observed at hydrological stations are used for the calculation of the water balance in each grid. Hydrological characteristics of the land surface is defined by land cover type which derived from remote sensing data Runoff and river flow are governed by digital elevation model and river network data.

2.1 Land cover and its change

Land cover is one of the important factor in the model, because several land surface parameters such as vegetation height, minimum resistance, and roughness are defined by land cover type. There kinds of optical remote sensing data are used in this study to monitor the status and change of the land cover.. Scheme of the analysis is shown in figure 3.

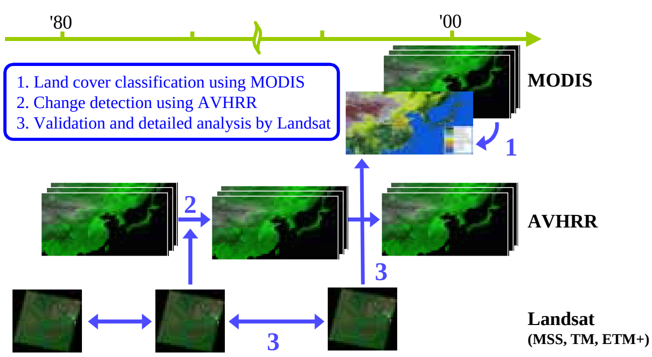

Figure 3. Scheme of the land cover monitoring.

Land cover status in 2000 is captured by means of MODIS (Moderate Resolution Imaging Spectroradiometer) which is state of the art sensor operated since 1999. Land cover classification map is generated from the time series of MODIS by means of simple decision tree method (Matsuoka et al. 2005). AVHRR (Advanced Very High Resolution Radiometer) is used in order to detect the land cover change since the data is available from early 80s. Our preliminary study using 8 km resolution Pathfinder AVHRR Land data set (Agbu et al. 1994) showed the continuous increase of normalized difference vegetation index (NDVI) in large irrigation districts. Landsat series of sensors are applied for the validation of land cover classification and change detection, and detailed analysis over drastically changed areas, since these have higher spatial resolutions.

2.3 Handling of human activities in the model

One of the reasons of dry-up is excess water use for the irrigation, and additionally river flow is affected by dam operations. Therefore, human activities should be implemented in the hydrological model. The simple submodel for dam operation is developed by means of three variables, i.e. normalized outflow derived from measured discharge, inflow and storage of the dam. Schematic diagram is shown in figure 4.

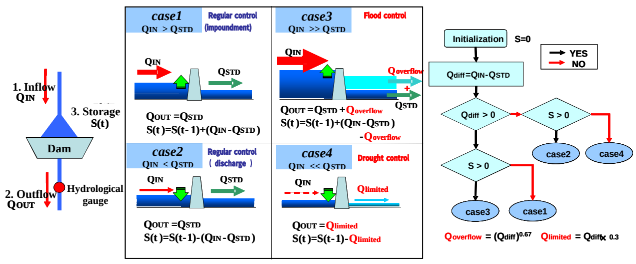

Figure 4. Scheme of the dam submodel.

Annual profile of water intake for two irrigation districts are derived by subtraction of river discharges in two hydrological gauge located in upstream (Lanzhou) and downstream (Toudaoguai) of irrigation districts. This profile is applied in order to analyze the irrigation pattern of the districts, and to correct the river discharge.

3. Results and discussions

Figure 5 shows the comparisons of simulated and measured hydrograph at three hydrological gauges. Human activities i.e. dam and irrigation were not taken into account in this simulation. Tangnaihai shows good agreement over the whole period, because there are no dam and large irrigation district in the upstream. Lanzhou shows poor agreements after late 80s due to the impact of Longyangxia dam which started the operation in 1987. Completely different seasonal trends are shown in Toudaoguai because discharge is affected by dam and irrigation.

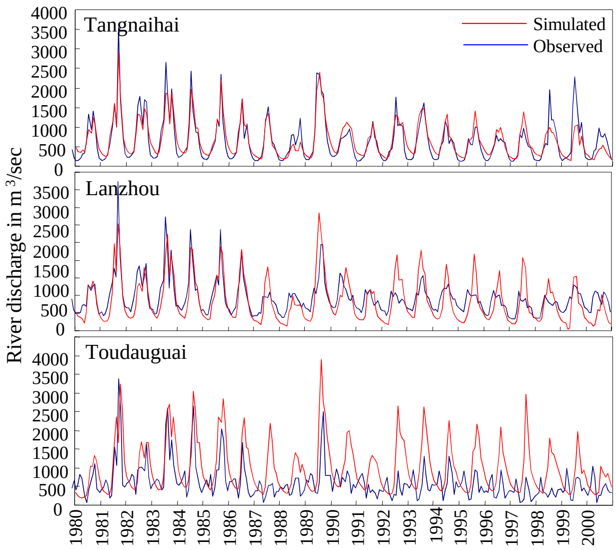

Figure 5. Hydrograph at three gauge stations.

Upper three figures in figure 6 shows the normalized discharge from the dams estimated by the observed discharge at Lanzhou station. Since no dam had been operated before 1968, left panel shows the natural situation. Center panel indicates the impact of Liujiaxia which has been operated since 1968. After 1987, river flow has been affected by Liujiaxia and Longyangxia. Discharge has been regularized, that is, both seasonal variation (peak discharge) and inter-annual variation are decreased. Lower figure in shows the river discharge at Lanzhou simulated by improved model which include the dam submodel. Result shows much better agreement compared with figure 5.

Upper figures in figure 7 shows the estimated profile of the irrigation. Inter-annual variation was decreased gradually, and water uptake in May and June has been increased. Lower figure shows the river discharge corrected by irrigation profiles. The result indicates that these regular cycle are strongly related with the water loss between two gauges, that is, water use in irrigation districts.

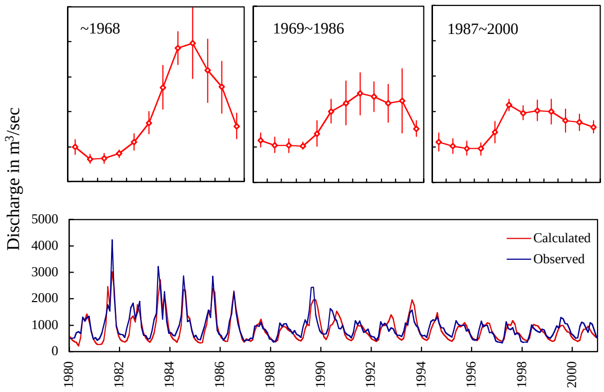

Figure 6. Normalized discharge from the dams (upper) and river discharge in Lanzhou (lower).

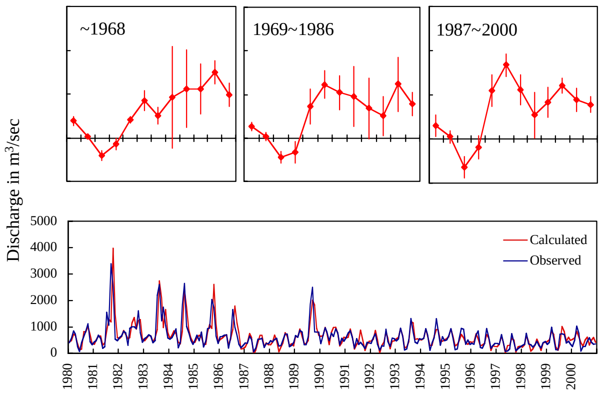

Figure 7. Estimated irrigation profiles (upper) and modified discharge in Toudaoguai (lower).

Figure 8 shows the land cover classification map derived from the time series of MODIS in 2000. Agricultural fields were divided into five subcategories for hydrological purpose, because agricultural water use has large variations in hydrological characteristics due to crop type and cropping systems. This land cover map is used as the base map in the hydrological model.

Figure 9 shows the preliminary result of change detection by means of 8 km resolution AVHRR data set. Upper image shows the annual maximum NDVI in 1982, which shows the most active status of vegetation in the year. Lower two figures show the time series of the distribution of annual maximum NDVI in Qingtongxia and Hetao irrigation districts. In Qingtongxia, widely distributed NDVI in 1982 has been concentrated to higher NDVI in 2000. In Hetao, concentrated lower NDVI has wholly increased year by year. Though the trend is not similar, These increase of NDVI is seems to be the increase of agricultural fields.

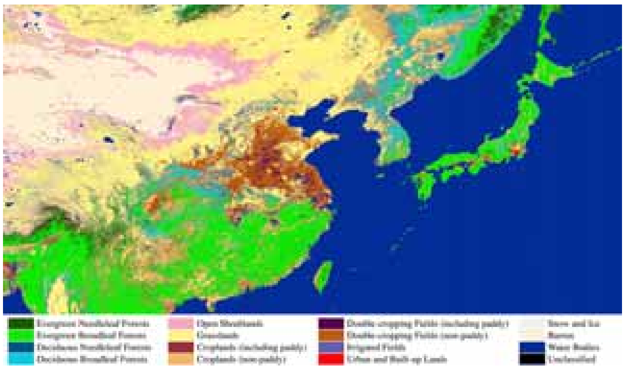

Figure 8. Land cover classification map

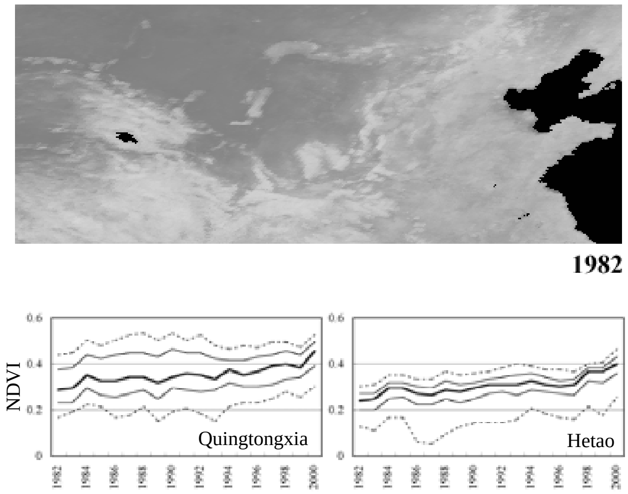

Figure 9. Increase of annual maximum NDVI in Qingtongxia and Hetao irrigation districts.

4. CONCLUSION

Current status of the study on the hydrological modeling of the Yellow River was described in this paper. The model is based on the SVAT-HYCY scheme. Several submodels have been developed in order to take human activity such as dam operation and irrigation into account. Remote sensing data has been analyzed to provide land cover and its change for the model. Respective developments and analyses should soon be integrated for the optimal management of water resource.

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