

**Theme 3: Modellig technique in water
resources planning and management**

Enhancements of the Simulation Library ILM-River for an Integrated Water Resources Management

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Introduction

The optimal design of an automatic control of rivers and reservoirs requires always an analytical model of the hydrodynamic behavior. If simulation techniques are used to determine the control parameters, a simulation model is necessary, which has to be constructed from the analytical model. In the last years the Fraunhofer Center for Applied System Technology has developed a library for simulating water resources systems called ILM-River which was successfully used in different projects.

The simulation library consists of two modules, River-MOD and River-CON. The module River-MOD contains the simulation models for all important parts of a surface water system. The second module River-CON implements different control strategies, for instance for reservoirs. In addition to control concepts according to operating rules also optimal control methods were developed.

Now the library is being extended with different simulation elements (interface to groundwater simulation system, chemical exposure prediction) that will be presented beside the already existing elements in detail.

Modeling library River-MOD

The simulation models for River-MOD rely on an analytical description of the hydrodynamic behavior of rivers and reservoirs. Typically, it is sufficient to know the water level and the flow at gauges which are important for control. This reduces the effort for building the simulation model since the complete spatial behavior of water flow along the river section isn't needed (figure 1). Up to now models for the most important parts of surface water systems are implemented, e.g. water flow model for rivers and channels, water level computation, retention area, sluice and reservoir models.

The current work focuses on extending the modeling library. In regions with water shortage all available resources have to be included in the allocation process. For instance, in areas with uneven rainfall during a year the groundwater plays an important role to satisfy the customer demand. Therefore an interface to the distributed groundwater simulation system FEFLOW was developed to integrate the groundwater resource into the surface water simulation system.

The second, important enhancement of the modeling library concerns the simulation of chemical concentrations. This allows assessing the water quality from the different sources and using this information for an optimal water allocation. The simulation uses one-dimensional, analytical models for the computation of chemical concentrations downstream the discharge location. Both singular and continuous discharges are possible.

Control library River-CON

The control library provides modules to compute the outflow of reservoirs. In a first stage PID and fuzzy controllers according to operational rules were developed. Especially in reservoir cascades the insulated control of single reservoirs is not optimal (for both flood protection and energy generation). Therefore, a concept for a coordinated optimal operation of reservoir cascades was implemented. Using a multi criteria objective function, this method determines the optimal outflow trajectories for all reservoirs.

STREAMFLOW FORECASTING USING NEURO-FUZZY INFERENCE SYSTEM

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Abstract: The prediction of flow into a reservoir is fundamental in water resources planning and management. The need for timely and accurate streamflow forecasting is widely recognized and emphasized by many in water resources fraternity. Real-time forecasts of natural inflows to reservoirs are of particular interest for operation and scheduling. The physical system of the river basin that takes the rainfall as an input and produces the runoff is highly nonlinear, complicated and very difficult to fully comprehend. The system is influenced by large number of factors and variables. The large spatial extent of the systems forces the uncertainty into the hydrologic information. A variety of methods have been proposed for forecasting reservoir inflows including conceptual (physical) and empirical (statistical) models (WMO 1994), but none of them can be considered as unique superior model (Shamseldin 1997). Owing to difficulties of formulating reasonable non-linear watershed models, recent attempts have resorted to Neural Network (NN) approach for complex hydrologic modeling.

In recent years the use of soft computing in the field of hydrological forecasting is gaining ground. The relatively new soft computing technique of Adaptive Neuro-Fuzzy Inference System (ANFIS), developed by Jang (1993) is able to take care of the non-linearity, uncertainty, and vagueness embedded in the system. It is a judicious combination of the Neural Networks and fuzzy systems. It can learn and generalize highly nonlinear and uncertain phenomena due to the embedded neural network (NN). NN is efficient in learning and generalization, and the fuzzy system mimics the cognitive capability of human brain. Hence, ANFIS can learn the complicated processes involved in the basin and correlate the precipitation to the corresponding discharge.

In the present study, one step ahead forecasts are made for ten-daily flows, which are mostly required for short term operational planning of multipurpose reservoirs. A Neuro-Fuzzy model is developed to forecast ten-daily flows into the Hirakud reservoir on River Mahanadi in the state of Orissa in India. Correlation analysis is carried out to find out the most influential variables on the ten daily flow at Hirakud. Based on this analysis, four variables, namely, flow during the previous time period, q_{t-1} , rainfall during the previous two time periods, r_{t-1} and r_{t-2} , and flow during the same period in previous year, q_{t-1} , are identified as the most influential variables to forecast the ten daily flow.

Performance measures such as Root Mean Square Error (RMSE), Correlation Coefficient (CORR) and coefficient of efficiency R^2 are computed for training and testing phases of the model to evaluate its performance. The results indicate that the ten-daily forecasting model is efficient in predicting the high and medium flows with reasonable accuracy. The forecast of low flows is associated with less efficiency.

Appropriate hydrological scales to achieve output uncertainty goals

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Abstract: The optimum complexity of a hydrological model depends on the objectives and area of study and may result in a so-called ‘appropriate model’. Appropriate spatial scales of dominant variables are important components of such an appropriate model. Dominant refers to the relative importance of variables with respect to flooding in a rainfed river basin. Appropriate spatial scales have been determined using an existing methodology based on a balance in uncertainties from inputs and parameters extended with a criterion based on a maximum output uncertainty. The original methodology uses different relationships between scales and variable statistics. It is extended with two different uncertainty propagation methods, the mean-value first-order second-moment (MFOSM) method and Monte Carlo analysis, and backward uncertainty propagation to obtain appropriate scales based on two uncertainty criteria. The methodology is applied to three flood estimation methods: the SCS curve number method combined with (a) the SCS dimensionless unit hydrograph and (b) a dimensionless unit hydrograph derived in the United Kingdom (UH method) and a modified version of the hydrological model HBV. The application revealed that the methodology can be used for the considered flood estimation methods under similar climatological and geographical conditions and assuming independence of all inputs and parameters. The results showed for a specific maximum output uncertainty (25%) different relative input and parameter uncertainties for the different flood estimation methods (3-6%) and different appropriate spatial scales for the dominant variables for a certain input and parameter uncertainty. For example, the appropriate spatial scales for precipitation, elevation, soil, and land use are respectively about 13 km, 65 m, 3.4 km, and 2.1 km for HBV. The input and parameter uncertainty targets probably are not achievable in practical, real world modelling. Thus, if these models are to be used, higher uncertainty must be accepted. Otherwise, one should evaluate more complex models that “might” yield higher accuracy, and evaluate these models using the methodology proposed in this study.

A New Method for Modeling Flow Duration Curves and Predicting Streamflow Regimes under Altered Land Use Conditions

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Abstract: The impact of land-use changes on water resources is an important issue in water resource management. Afforestation is a major activity in many countries. Unfortunately, the understanding of the impact of land use/cover change on streamflow at shorter time scale is limited due to the knowledge gap between the available catchment information and the detailed hydrologic processes. One way to evaluate such an impact is to examine the changes of the flow duration curve (FDC) before and after a land use/cover change. A FDC characterizes the relationship between the magnitude and frequency and hence provides a full picture of stream flow over time. Two issues need to be considered in predicting the FDC due to land-use changes: appropriate parametric forms of the FDC which can be used for all the FDCs before and after the changes, and then the parameters in the FDC have the ability to capture and characterize the land-use changes. However, fewer researches focus on the appropriate representation of the probability distribution for the annual FDC. In this paper we promote a four-parameter double exponential form as the function of FDC, where the two hydrological parameters represent the mean annual flow (Q) and the point of cease to flow (τ expressed as a percentage) while the other two parameters (α and β) determine the shape of FDC. Its properties are investigated in order to assign the parameters to cope with the land-use changes.

In order to develop a method to adjust the FDC under a land use/cover change, the effect of vegetation change on each model parameter needs to be evaluated. Note that the two hydrological parameters can be linked to other hydrological models which quantified the changes of these parameters. The mean annual water balance model by Zhang et al. (1999) and Zhang et al. (2001) provides a practical tool to predict the long-term consequence of afforestation or deforestation on the mean annual evapotranspiration at the catchment scale, and can be used to estimate the mean annual flow Q and the simple bucket model can be used to estimate the point of cease to flow τ . The two statistical parameters are estimated using the least squares. The model is used for several typical catchments in Australia and other countries for demonstration.

Keywords: Afforestation; Deforestation; Extended Burr XII distribution Flow Duration Curve (FDC); Land use/cover change.

Reservoir risk operation based on watershed modeling uncertainty estimation

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Abstract: Inflows forecasting through watershed modeling is a precondition of reservoir operation. One of the main problems of using watershed models is that various parameter sets may yield equally good results during calibration process. As a reaction of this problem, Generalized Likelihood Uncertainty Estimation (GLUE) approach introduces a population of model parameters with varying degrees of likelihood to represent the watershed at hand, and the uncertainty of modeling results can be estimated by confidence intervals of “true” flow. Under uncertain circumstance, how to combine the uncertainty estimation and reservoir operation is a practical problem. In this paper, the uncertainty estimation of Xinanjiang model parameters and the confidence intervals of inflows are introduced using GLUE approach. The performance measure used is the membership value computed by a fuzzy optimal model taking the qualificatory rate of peak discharge, peak time and total runoff volume as objectives. Then, an operational interval is obtained by operational rules or optimization methods corresponding to a confidence interval of inflows. Risks due to modeling uncertainty are analyzed for operational plans based on the forecasting result computed by a specific “best” parameter set. And a recursive forecast-operation approach is presented: likelihood measures of the parameter sets are renewed by new observed data at the interval of several time steps, and the parameter set with best likelihood measure is used to forecast-operation. This approach was used to Shuangpai reservoir, and the results show that it can estimate risk in operation, and amend forecast-operation process.

Passive Microwave Remote Sensing of Snow Depth Estimation over Iran Using Chang and Rott Algorithms

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Abstract: Precipitation is the most important source of water supply in Iran. Except in the southern Caspian plain, the precipitation regime is characterized by a winter maximum and a long summer drought. This pattern largely determines the time available for crop growth. Apart from the Caspian lowland area, most precipitation falls on regions with the highest elevation. Over the mountainous areas it is mostly in the form of snow, and snowmelt is an important component of water supply in Iran. For example, snow-melt water forms about 60% of surface water and 57% of ground water. Due to the altitude, much of the snow does not melt immediately, and may accumulate as deep pack.

Climatological investigations in Iran lack adequate meteorological observations to understand and interpret diverse climatic features. In the country as a whole, the ground observation network is not dense enough to provide the detailed information required, especially in rugged regions. Combined with this is the problem of poor accessibility to the snow-covered regions, which has resulted in the areal distribution of snow being poorly known.

The objective of this paper is to make an investigation into the potential for remote sensing application with special reference to passive microwave satellite imagery. In this respect, satellite passive microwave data have been analyzed to establish and demonstrate the utility of one remote sensing application in relation to snow depth discrimination over Iran. In order to remove the effect of scattering signatures, the Grody and Basist algorithm was used to identify snow surfaces from rain, desert sands and frozen ground. Then, two techniques were used to determine the distribution of snow depth over Iran from SSM/I data. The first technique was a radiative transfer model developed by Chang which is based on vertically polarized, 19 GHz and 37 GHz signatures. The second technique was chosen by Rott which is an empirical and multi-channel algorithm.

Results derived from these algorithms were validated against the ground truth data for a number of stations and comparison of the two algorithm products with ground-truth data indicated that results from Chang algorithm provided significant agreements with surface data ($R^2 = 0.90$) than the Rott algorithm which showed that snow depth was being underestimated throughout the snowy regions.

In contrast to the earlier work, which has suggested that passive microwave snow depth algorithm is able to detect snow depths only up to about 50 cm, results from this research showed that both algorithms were able to identify snow depths more than 50 cm in Iran.

The main conclusion of this paper is that passive microwave satellite data can provide useful information on snow depth over Iran, and should be exploited further, together with other passive microwave instruments data, for example, SMMR and ESMR, to improve the collection and

practical application of environmental data for continuous snow depth monitoring and longer term-data in Iran.

Keywords: Passive Microwave, SSM/I, Snow Depth, Algorithm, Iran.

Climate Change Impacts on Snow and Glaciers of the Hindu Kush-Himalayas: challenges of managing increasing catastrophic floods and decreasing lean flows in the Himalayas.

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Abstract: Recent observations and studies in the Hindu Kush-Himalayan (HKH) countries have shown that deglaciation is widespread and glaciers are retreating at a faster rate in recent years than before. This has led to rapid development of glacial lakes in some countries of the region, as seen from a joint study carried out by the International Centre for Integrated Mountain Development (ICIMOD) and UNEP in 2001, for Bhutan and Nepal. Some of these glacial lakes are considered to be growing dangerously and Nepal has recently completed a project to mitigate the threat of a potential catastrophic flood from the Tsho Rolpa glacial lake, situated in the road less Rolwaling Himal area at an elevation of 4580m a.m.s.l., at a huge cost with external support. Glacial lake outburst floods (GLOFs) have also been reported from many other countries of the HKH causing severe damage to life and property, agricultural land, costly infrastructures and important cultural monuments several kilometers downstream. It is also seen that the number of GLOF incidences have become more frequent in recent years than before and have affected neighbouring countries too. Similarly, catastrophic flash floods too seem more frequent in the HKH in recent years, some of which have caused alarm across the border, although there linkage with climate change is somewhat uncertain. Widespread deglaciation is also likely to decrease the lean flows in the coming years. As the Himalayan rivers are heavily dependent on snow and glaciers for their lean flows, the reduction in lean flows due to climate change could be catastrophic, particularly as most of these rivers are transboundary in nature passing through most densely populated countries of the HKH. This could even lead to an increase of conflict between riparian countries in the region, particularly for future development and management of regional waters in South Asia. In order to respond to these challenges of climate change impacts in the region, a concerted and collaborative initiative should be launched by the HKH countries in order to develop adequate capacity and knowledge by using modern and innovative techniques without further delay. The paper also discusses some of the initiatives already underway in the region, such as the Regional Flood Initiative of ICIMOD and the longterm glacier mass balance study initiated by UNESCO/ HKH-FRIEND/ICSI.

Distributed Modeling and Analysis for Regional Water Resource Vulnerability Assessment

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Abstract: Climate change and population growth are the two major factors contributing to potential future water shortage in some parts of Texas in the United States. We employ a distributed modeling and analysis approach to assess water resource vulnerability at a regional scale. In this article, we only focus our discussions on the impact of climate change on water resource vulnerability in different areas of Texas. We couple a regional climate model, RegCM3, with a macro-scale hydrologic model—Variable Infiltration Capacity (VIC)—to simulate the spatial distribution of available water resources for a 25-year period from 2006 to 2030. We simulate potential climate changes in Texas for the period from 2006 to 2030 based on the Intergovernmental Panel on Climate Change (IPCC) SRES-A2 scenario. The simulations are conducted in different areas of Texas represented by a grid with a 30km resolution. Based on the simulation results, we then estimate the availability of water resources in different parts of Texas using VIC in these 25 years. In addition, we provide an assessment of water resource vulnerability as a result of climate change for the 25 years in areas covered by each grid cell in the entire state of Texas.

Keywords: water resources, vulnerability, climate change, spatially distributed model, Texas

Study on the model of dynamic simulation of water resources' sustainable utilization on the regional scale

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Abstract: Under the guide of the water resources-ecology-economy composite system theory and the principle to construct the system dynamics models, the paper divides the whole regional sustainable utilization system of water resources into society subsystem, industry subsystem, agriculture subsystem, ecology subsystem and water resources subsystem to establish the system dynamics models (SD models), analyzes the whole structure of the SD models, cause and effect relations and feedback mechanism of each subsystem, establishes the main SD equations of the sub module of population, gross domestic product, industry, agriculture, ecology and water resources. Then, the structure and result of the SD models are tested. At last, according to the need of society and economic development and the water resources utilization, the paper put forwards five kinds of regulating and simulating schemes as natural evolution pattern, developing agriculture pattern, developing industry pattern, conservation and protecting pattern and sustainable development pattern.

At last, the paper applies SD models and dynamic simulation patterns of regional sustainable utilization of water resources to Hubei province, then according to the results presents the management measures to guarantee the sustainable utilization of hubei province's water resources.

Study on the indicators system and the model of comprehensive evaluation of the regional sustainable utilization of water resources

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Abstract: On the basic of the drive force-state-response model, the paper put forwards the indicators system's framework model of the regional sustainable utilization of water resources and its indicators system is established according to this framework model. The definitions, calculating formulae and the class of evaluation criterion are presented too. The proportion coefficients of each hierarchy are decided through the method of deciding layered. The models and method of the comprehensive evaluation are put forward by integrating the factor analysis and fuzzy comprehensive evaluation.

At last, the paper applies the indicators system and the method of comprehensive evaluation the regional sustainable utilization of water resources to Hubei province and according to the results presents the management measures.

Keywords: the drive force-state-response model, indicators system, factor analysis, fuzzy comprehensive evaluation, Hubei province

Study on a grid-based rainfall-runoff model and its hydrological modeling uncertainty by initial soil water content

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Abstract: Recent decades progresses in remote sensing technology(RS), Geographic information systems (GIS), and computer science have made a vast amount of spatially distributed data processing and distributed hydrological modeling possible. But distributed hydrology models didn't exhibit reliably better performance than lumped models (Reed S., Koren, V., Smith, M.B. Zhang, Z., et al., 2004). Moreover, it should be noted that basin topography is an important factor for flow shaping and especially it decide the concentration path of surface flow (Ren, L.L., Liu, X.R., 2000). Beven et al (1988) suggested that topography is a dominant control on the spatial patterns of hydrological response under many conditions, and should be taken into account in hydrological predictions.

So the objective of this study is to develop a relative simple model, the distributed flow isochrone model (DFIM), which coupling topography in basin-scale flood forecasting based on Xinanjiang model. In the paper, the model is applied to Huangnizhuang basin of Huaihe river, China. The basin is divided into a square raster system for representation of basin spatial variability in the model. The raster system is used as the fundamental computation units and all the grids are divided into two groups such as the hillslope grids and river grids according to DigitalHydro package. And flow vectors, slope for the raster system can also be gained by the software package. The distributed flow isochrone model divided the basin into several isochrone areas by an algorithm which integrate flow concentration time with raster slope, upstream area, distance from the basin outlet, etc. The 'lag and route' method is used for hillslope grid flow routing and river grid flow routing respectively. In the model, Xinanjiang model (Zhao, 1992) is used for grid runoff yielding. The Xinanjiang model parameters were calibrated and verified by history floods (Liu J.T., 2003) of the Shiguanhe catchment was used here. Three flood events are selected for hydrological modeling. Two of them are used to calibrate the flow routing parameters and one for validation of the model. Simulated results for the three flood events showed that the performances of the model are acceptable

The Xinanjiang model is characterized by the concept of runoff formation on repletion of storage. It uses a parabolic curve to represent the spatial distribution of the soil moisture storage capacity over the basin. Here, uncertainty in hydrological simulation is studied by altering antecedent soil water content parameters of the hydrology model. It shows that initial soil water content has

prominent influence on the accuracy of hydrological modeling results, especially for the hydrological processes with rare antecedent rainfall. The relationship between observed soil volume water content and antecedent rainfall is given. The Related coefficient is high between soil volume water content and 30 days' antecedent rainfall. The experiential relationship of the observed soil volume water content, antecedent precipitation and the soil moisture parameters is researched to provide a way for combining volume water content with soil water parameters in conceptual model.

Keywords: grid, DEM, flow isochrone, Xinanjiang model, initial soil water content

Intelligent Forecasting Mode and Approach of Mid and Long Term Intelligent Hydrological Forecasting

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Abstract: Intelligent computing tools such as fuzzy optimization approaches, *BP* neural network and genetic algorithm are proven to be efficient when applied individually to a variety of problems. Recently there has been a growing interest in combing all these approaches and as a result, in this paper the author organically synthesizes fuzzy optimal selection, BP neural network and genetic algorithm and establishes intelligent forecasting mode and method. When illustrating the method by an application to forecast mid and long term hydrological process of Yamadu Hydrographic Station at Yili River in Xinjiang, China, the author first selects amount of training samples, according correlation of forecasting factors and forecasting objective to get relative membership degree matrix; then takes the matrix as input of BP neural network to train link-weights; finally the author uses gained link-weight values to verify forecasting. The results are highly promising and show that the operations speed, precision and stability of intelligent forecasting mode presented in this paper can completely meet actual requirement.

Use of Fuzzy Programming Decision model for Pollution Control System of Water Environment

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Abstract: The current methods for the programming of municipal sewage treatment system are only to minimize the treatment costs. Therefore, in view of engineering fuzzy sets, nonlinear programming method, multi-objective design environment discharge, and capital outlay and overhead costs of sewage-treatment plants that the author presents fuzzy nonlinear programming method and fuzzy optimization decision model for pollution control system of river water environment. When using the model to plan sewage system at southern part of Shenyang City that the minimal cost is took as objective function, the calculating results show that the method is reasonable and accurate.

Application in Manas river valley of distributed hydrological model on the basis of DEM

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Abstract: This text takes Manas river of Xinjiang as an example, according to the characteristics of distribution of space-time such as the climate 、vegetation、 cushion etc. On the basis of DEM, have set up the distributed hydrological model with physics foundation, under the situation that the hydro meteorological materials relatively lack and there are less weather stations of hydrology, having proposed that the hydrologic forecast question about the melt water type river of ice and snow. Using this model to imitate the flow between 1978 and 2000, the result of calculation is identical better with the surveying; simulation is relatively high in precision

Keywords: distributed hydrological model, Linear reservoir, the flow forecasting

PLSR model for Urban water demand prediction basing on uncertainty analyses

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Abstract: The prediction of urban water demand is often failed into a risk because of the disturbance of such uncertainty factors as randomness, fuzziness, grey and unascertainment. In the prediction methods widely used in many countries, some get entangled in complication for overemphasize considering all the model influencing factors of independent variable, and some excessively depend on mathematic simulation methods and neglect the analyses of multicollinearity among the model influencing factors. Thus, based on general analyses of multicollinearity and its uncertainty of model independent variables, the partial least-squares regression (PLSR) method well integrated with non-model-style data connotation analyses was advanced to simulate and predict urban water demand, and the model precision was controlled by method of cross validation test. After the model influencing factors of independent variable were selected by utilizing step regression method to eliminate subordinate factors and save significant factors, the PLSR model was established according to statistic history data and then used to predict the future urban water demands of different levels of given years. The model results show that the PLSR model established can effectively identify the multicollinearity disturbance among the selected model influencing factors and eliminate its effects on model precision of simulation and prediction, and that the regression modeling, simplifying data structure and analyzing the multicollinearity can be simultaneously carried out.

Keywords: Urban water demand; simulation and prediction; uncertainty; partial least-squares regression

Multi-person Multiobjective Fuzzy Risk Decision-Making Model for Supply Water

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Abstract: By analyzing the present situation of supply water in Hanjiang River Middle and Lower Basins, this paper proposes multi-person multiobjective fuzzy risk decision-making model for the problems of supply water. The model takes the influence of multiobjectives and experience and knowledge of decision-makers into account. In order to find an optimal alternative decided by multiple decision-maker from all the given alternatives, the relative optimal membership degree of every decision-maker to every alternative is first obtained and then the optimal membership degree of every decision-maker to every alternative is obtained which collects group preferences through two stages. The advantages of this model are simple and more adaptable to the practical problem. The model is demonstrated by application of risk of supply water resulted from the Middle Route of South-to North Water Transfer Project in Hanjiang River Middle and Lower Basins. Of course, this method can be applied in other science fields.

Keywords: decision-making; risk of supply water; multiobjective; relative optimal membership degree; weight

Small-watershed Information System and Its application in Liaoning

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Abstract: Small-watershed information system, which is built based on 3S techniques, can inosculate and deal with many kinds of information concerned with small-watershed management. The basic functions of the system are as fellows: data storage, query, image treating, statistics analysis, image output, model application, etc. According to user's demand, the convenient information service may be developed. Taking Liaoning Province as an example, a small-watershed information system is introduced. In order to meet the demand to prevent water and soil erosion, research zone was divided into 5572 small-watersheds, each of which was about 10-20km². Each small-watershed had its code. Its distribution image was drawn out, and at the same time the codes were inputted into database, which was convenient for computer search. By use of GIS, the information such as water and soil erosion, land use, physical geography, society, economy and so on, was stored into corresponding small-watershed. The system regards small-watershed as a unit, and so it can vividly show its space distribution and dynamic change. The information update of the system is done regularly by new remote sensing image. Now, the system is a useful tool in the administrative department of water and soil erosion management. The application of the system changes the small-watershed information management very much.

Keywords: small-watershed; 3s techniques; information system; digital; application

On the optimal models of the water distribution networks of field in the mixed irrigation districts in arid inland river basins in northwest China

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Abstract: The combine exploitures of surface water and groundwater in the middle and lower reaches of the dry inland river region in the northwest of China has been the important way of the explore and use of water resource, and the surface water and groundwater mixed irrigate irrigated areas relatively developed fast, and it became the important way of the explore and use of water resource in the middle and lower reaches of the dry inland river region in the northwest of China; yet because of the cognition of people to the water resource translation in these regions, and the relation and effect of the explore and use of water resource are not profundity, the no synchronization of surface water and groundwater irrigate systems, the low-level of irrigated areas programming, so there have many problems in the farm project of surface water and groundwater mixed irrigate areas, and those result in the position project chaos of irrigated areas, and the low efficiency of water use, and enlarge the investment and slowdown the construct for the save water technology reconstruct have to build two systems in the same time, and those are key factors affect the development of irrigated areas. This paper analyzed the existent problem of the water distribution networks of field in the mixed irrigation districts by surface and ground water in arid inland river basins in northwest China. According to the monitoring data, optimal models were chosen by the method of system analysis. The result showed that, it is propitious to raise water use efficiency, reduce expenditure and labors cost, mend water-saving technique reformation's pace, convenience management. Based on this, we put forward the main point of programming and proceeding.

Keywords: Arid inland river basins; mixed irrigation districts by surface and ground water; water distribution networks of field; optimal models.

Simulation and optimization of basin water resources system analysis

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Abstract: During the international economical and social development, resources management and planning are more and more important, but a very complete system because of it's time, space scale and so on. According to space scale, one of essential construction is basin water resources management which need harder work for the historical accumulation and many flowing provinces. Based on the system theory must, integrated with basin water resources system, economy and society system and ecology system, the economical, social and ecological benefits are analyzed through setting up a linear programming and the nonzero-sum game models based on minimizing the cost and maximizing the above objective one by one. By simulation how the different scene affects the three sets of optimal objectives—economical, social and ecological and cost respectively, the Nash equilibrium solution was given. It is proved that the model is very valuable for strategic decision-making in the water resources management. Sampling with the Xinsu basin, the three conclusions were showed:

(1) Continuing the before planning law of maximum economical benefit, not minding the cost, the ecological affection and social welfare, the problems about the basin water resources pollution the temperature and so on will be worse and worse to irreversible influences and infringe the intergeneration and intrageneration fair.

(2) Objective on social welfare, it is better for basin water health beside of the big input in short time and the lost of nowadays' income, but because of the public character of the benefit the country and the relative governments must give a series of laws and regulations and employ the financial ways of taxies and allotment to control the program.

(3) Objective on ecological benefit, meeting the standard of sustainable development, but it's success based on the powerful economy and the satisfying laws, the great environment protection mind and the good quality, the high social response of firms and industries.

On the basin water resources management, the theory is philosophy and the practice is difficult, which need the together participate of many countries, governments and departments. Under the condition of Chinese economy and society, it is the best way to think social welfare first and the economical benefit second.

Keywords: basin water resources management, Game Theory, Linear Program, Nash Equilibrium

Assessment of the Impact of Forestry Planting on Low Flows in the Shag River Catchment, New Zealand, Using the Topnet Model

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Abstract: Numerous small-catchment studies both in New Zealand and world-wide have shown that an increase in forest cover is associated with an increase in interception, and a decrease in annual water yield. The magnitude of the effect depends on a number of factors, including climate, forest type and forestry practices. The effects of forestry planting on low flows can be significant in small catchments. However, its impacts on low flows for larger catchments are harder to detect and depend on seasonal flow regimes. For more extreme low flows, less is known about the effects of land use change.

The Shag River catchment is in the eastern Otago Region in the South Island of New Zealand. The catchment is characterised by periodic low rainfall in the growing season. The river is an important resource for irrigation, and for town and rural water supplies. The river is also regarded as a good fishery by local anglers. The catchment has a history of user conflict during periods of low flow. Commercial forestry planting in North and East Otago began as early as the 1960's and there was a major increase in planting from the early 1960's through until the 1990's. Forestry planting in the Shag River catchment has the potential to reduce water yield, which would increase the pressure on the limited water resource in the catchment.

In this study, the Topnet model developed by the New Zealand National Institute of Water and Atmospheric Research was applied to the 544km² Shag River catchment to investigate the impact of forestry planting on low flows. Topnet is a catchment model designed for continuous simulation of catchment water balance and river flow. It models a catchment as a collection of sub-basins, linked by a branched river network. Each sub-basin is modelled using an adaptation of Topmodel. The model uses rainfall and temperature time series and map data for elevation, vegetation, soil and rainfall pattern. Parameters for the canopy, soil and geometric characteristics of sub-basins are set using GIS data for elevation, vegetation and soil type. Flow is routed through the river network and auxiliary software has been developed to automatically identify sub-basins and river networks from digital elevation data, and automatically generate the model parameter file.

The study shows that forestry planting has the potential to reduce the mean annual flow and mean annual low flow by 49% and about 45% respectively when 50% of the catchment is covered with exotic forest. Substantial forestry planting has slightly more impact on extreme low

flows than on the mean annual low flow and mean annual flow, with forestry planted on near 50% of the catchment area causing about 50% reduction in the 5-year and 10-year low flows. Small scale forestry planting in the high water yield area of the catchment could also have measurable impact on extreme low flows, with forestry planted on 9% of the catchment area causing 12-13% reduction in the 5-year and 10-year low flows.

Keywords: catchment modelling, low flow, Shag River

Research on GRID-based Dynamic Water Balance Model of Jin River Basin

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Abstract: Research on water balance is the basis on water resources assessment, planning and management. Most of the former water balance model is basis on the river basin or sub-basin. In this paper, GRID-based dynamic water balance model was developed using the GIS tools in order to model the process of water balance in the GRID unit. The space scale of the model is $1\text{km}\times 1\text{km}$ GRID, and the time scale is month. The model was calibrated by the runoff data on-the-spot survey month by month from 1995 to 1997. The model calibration result revealed that trend of the simulation runoff line was inosculated with the observation runoff line, its medium absolute error is $6.72\text{ m}^3/\text{s}$, and the correlation coefficient is 0.932. At the end, the model was used in simulation of the progress of hydrological cycle on Jin river basin, and obtained the precipitation, evaporation, soil water and groundwater of every grids month by month. The simulation results revealed that the runoff of Jin river basin is focused on the south and middle of the river basin, the runoff on the north of the river basin is lower oppositely. This distribution is related with the precipitation distribution. The soil water and groundwater has the similar distribution with the runoff. This represents that the soil water and groundwater distribution has some correlation. All of this represent that the model fitted the observed data quite well, and could satisfy the needs of the water resources assessment, planning and management in the main.

Keywords: Dynamic water balance; GIS; Jin river basin; GRID

Natural Renewability Assessment of Water Resources of Jin River Basin based on GRID Hydrological Cell

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Abstract: First of all, start with the basic concept of the natural renewability of water resources, a concept of renew rate of water resources based on the GRID hydrological cell was proposed in order to represent the natural renewability of water resources of the GRID hydrological cell. On the basis of this, a completely new method of natural water renewability assessment was developed. In the next place, on the basis of dynamic water balance simulation of Jin river basin based on the GRID, the natural water renewability of the river basin in 1996 was assessed by calculating the renew rate of water resources of the river basin grid by grid in 1996. The assessment results indicate there are quasi cycle motion law of natural water resources renewability of Jin river basin in the time scale in years. The natural renew rate of water resources of Jin river basin is between -1.5 and 1.5, and the lowest in the April and the largest in the June. All the trend is influenced by precipitation very much, and there is obvious different between the high water period and low water period. At same time, there is a obvious law of distribution of natural water renewability of Jin river basin in space. It represent concretely that natural water resources renewability is highest in the middle and the west of the Jin river basin, and the lowest in the north. This kind of space distribution of natural water resources renewability is depended on the space distribution law of the precipitation, evaporation and underlying surface of Jin river basin, such as soil and vegetation in the river basin.

Keywords: Water resources renewability; GRID; Jin river basin; Renew rate of water resources

Evaluation of Artificial Neural Networks in Forecasting Short-term and Mid-term Streamflows

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Abstract: Forecasting of streamflows is one of the major tools in water resources management. This is of great importance for reservoirs and related operations like flood control, warning and optimized exploitation. In the recent years, Artificial Neural Network (ANN), which is based on human brain computation, has successfully demonstrated its capabilities for different water resources simulation. In this investigation performance of different ANNs including BPN, RNN, RBF, and STA-BPN are assessed in order to short-term and mid-term forecasts of inflows to the Alavian Reservoir. The required forecasts with respect to dam operation's requirement consists of average three days, one week, ten days, two weeks, one month to six month lead time. All the necessary analysis used readily available data in Sofichai and Esfestanage rivers that flow into Alavian Dam and the meteorological stations. Based on hydrological and climate data two series data sets are constructed. The first one consists of solely discharge data and the second one includes combination of discharge and meteorological data with different previous lags. The results showed that the second data sets performed much better. Among the different inputs that examined in this investigation, the solar radiation had the most significant impact on the final results. Since, it there was not enough measured radiation data, a synthetic approach was used to simulate this meteorological variable.

An integrated fuzzy and grey model for groundwater quality assessment in Zhangji well field

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Abstract: In the last decade, grey model and fuzzy logic technique have been successfully applied to solving many complicated control problems such as atmosphere environment assessment, water environmental quality assessment. The advantage of the models is that a simple model can be designed to replace the conventional mathematically based methodology. Based on the Fuzzy and Grey characteristics in groundwater quality assessment, the paper incorporates the membership functions and relative grade of Fuzzy mathematics theories into Grey system situation decision-making, sets up an intergrated fuzzy and grey model for the groundwater quality assessment in Zhangji well field, and applies the evaluation procedure to assess groundwater quality in Zhangji well field. A case study shows that the Fuzzy-Grey design evaluation procedure can give more assessment information, clear calculation principle and reflect the practice objectively. Assessment results are of important guidance significance for the protection of water resource and the sustainable exploitation and use of Zhangji well field.

Keywords: An intergrated fuzzy and grey model; groundwater quality assessment; Zhangji well field

A New Algorithm for Long-term Optimal Operation of Cascade Multipurpose Reservoirs Group

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Abstract. At present, some algorithms for long-term optimal regulation had been put forward for a certain situation. But in real-operation, the constraints are usually changing and thus the structure of the model is changing too, so those algorithms are not flexible for multipurpose demand and various constraints. Therefore it is important to find a flexible algorithm for long-term optimal regulation of cascade reservoirs group with various constraints.

The cascade hydropower reservoirs group, located in the upstream of Yellow River, includes one multi-annual storage reservoir, one annual storage reservoir and five daily storage reservoirs. And these cascade reservoirs have been designed for many objectives, such as power generation, irrigation, flood control, ice prevention, and navigation requirement, etc. Thus, besides common bounding constraints, there have been several strict equation constraints which must be considered in setting up long-term optimization model of the above reservoirs group. Those constraints included fixing water levels and releases from reservoir in certain periods for ice prevention, and fixing monthly energy generation of certain hydropower reservoir for target power generation defined by system operators and decision makers. To maximize the whole energy generation of the system on the basis of achieving guaranteed output, and to keep the other objectives fulfilled, this paper has put forward a new algorithm, which combines penalty function with dynamic programming (DP) and discrete differential DP. Studies have shown that this algorithm can effectively solve long-term combining optimal regulation with complicated and various constraints.

Studying on Method for Evaluating Environmental Carrying Capacity of Ground Water

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Abstract: Groundwater is important for people to live, meanwhile, environmental carrying capacity of groundwater is more important for industry and agriculture and people and the earth to exist and develop. On basis of the matter element theory, the fuzzy-matter element model based on informational entropy is built by combining informational entropy and fuzzy theory and matter element & extension set; meanwhile it is used to evaluate environmental carrying capacity of ground water. A sample is explained to validate it is feasible and reasonable. Principal component analysis (PCA) method is applied to evaluate the environmental carrying capacity of ground water. It is shown that the evaluating result by two methods is same. The theory of fuzzy matter element model based on information entropy is clear and compact, and it is easy to realize by computer program, at the same time it provides a new idea for evaluating the environmental carrying capacity of ground water.

Keywords: information entropy; Fuzzy theory; matter element theory; environmental carrying capacity

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Conjunctive Use of AVSWAT and ORYZA2000 Model to Study the Scale Effect of Water Productivity for Rice in Small Watershed of Irrigation System in South-China

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Abstract: As a result of scale effect, field scale can't be a substitute for irrigation system scale, and irrigation system scale is too complex for study, therefore, the concept of small watershed of irrigation system (SWIS) was defined in this paper. As the basal ecology unit of irrigation system, SWIS was the aggregation of a great deal of fields. The scale effect of water productivity for paddy rice from field to SWIS scale was studied using AVSWAT and ORYZA2000 model.

Yangshudang SWIS, with an area of about 43km², was selected as a pilot small watershed of irrigation system. It is a small watershed of Zhanghe Irrigation System located in the Hubei Province north of the Yangtze River. Based on measured irrigation and drain data, simulation models at three different scales, field, mezzo level (a subunit of Yangshudang SWIS) and small watershed level were performed to obtain the whole water balance components. Indicators of Water Productivity (WP) and Water Depletion Proportion at three different scales were calculated and used to assess the water use efficiency. The three Water Productivity indicators considered were: $WP_{irrigated}$ (yield / irrigation), WP_{gross} (yield / gross) and $WP_{ET}(rice)$ (yield / ET), all expressed in kg yield per m³ water. And five Water Depletion Proportion indicators considered were: $PF_{gross}(rice)(ET/gross)$, $PF_{available}(rice)(ET/available)$, $PF_{depleted}(rice)(ET/depletion)$, $DF_{gross}(depletion/gross)$, $DF_{available}(depletion/available)$.

A paddy rice field was selected in the Yangshudang SWIS. The hydrological analysis and crop growth simulation at the field scale were performed using the ORYZA2000 model. The AVSWAT distributed hydrological model was applied at the mezzo level to simulate the impact of irrigation management practices on water balance and crop productivity. The small watershed scale analysis was also performed using the AVSWAT model.

The results showed that $WP_{irrigation}$ gradually decreased from the field to the mezzo level, and to the lowest point at the mezzo level. Then it increased quickly from the mezzo level to the small watershed scale, as return flow collected by the ponds was used to irrigation again. Trend of WP_{gross} change was similar to $WP_{irrigation}$, and WP_{gross} was not higher for the small watershed scale in comparison with field, which indicated utilization of irrigation and rainfall was very high at the field scale. Extent of WP_{ET} change was very small from the field scale to the small watershed scale.

The results also indicated PF_{gross} was the highest for the field scale, but it decreased to the nadir for the mezzo scale as a consequence of a great deal of outflow, then PF_{gross} for the small watershed scale increased as a result of the recycling of the outflow. The trend of $PF_{available}$ change at different scale was alike to PF_{gross} . $PF_{depleted}$ gradually decreased from the field to the small watershed scale, which had a close relation with the planting proportion of paddy rice at the different scale. Both DF_{gross} and $DF_{available}$ decrease from the field to the mezzo scale, and then increased from the mezzo scale to the small watershed scale.

The Water Productivity and Water Depletion Proportion were useful methods of describing the status of water resources in a practicable way. And reasonable simulation efficiency was gained with the conjunctive use of AVSWAT and ORZAY2000 model.

Keywords: scale effect; water productivity; small watershed of Irrigation system (SWIS); model

Game Analysis of Water Rights Transaction in Optimizing Allocation of Water Resources

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Abstract: With the fast development of social economic, the shortage phenomenon of water resources in our country is obvious day by day, the supply and demand pressure is more and more tense too. How to do a good job of optimizing allocation of water resources becomes the key issue of sustainable development of water resources in the whole society already. Realizing the market-based water rights transaction progressively and using market mechanism to collocate water resources are one feasible way to solve this problem. In a certain valley, because the users' income is unequal and utilization ratio of water resources is different in the course of using water, so this text brings forward water rights transaction game model regarding the most optimal income as the goal. The model solves the market behavior strategies of water users in the case of the equilibrium condition and gets the feasible, optimum water rights transaction scheme for water users in water market.

THE CONSTRUCTION OF BASIN RUNOFF GENERATION MODEL WITH CONSIDERATION ON HUMAN ACTIVITIES

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Abstract: With the evolution of human, the impact of human activities on basin hydrological processes is increasing. The need to simulate the basin hydrological processes under the condition of impact of human activities is a pressing problem. Conventional hydrological models cannot solve this problem thoroughly. Only through the use of models that have a physical basis and allow for spatial variations within a catchment can these problems be tackled.

In order to build a basin runoff generation model considering affect of human activities, this paper put forward a hypothesis: to any type of basin underlayer, its hydrological response is constant and independent of its area and location. So for basin runoff generation, the affect of human activities on hydrological processes is only the variation of the composition of all possible underlayers. From this hypothesis, all problems come down to find the hydrological response of every type of basin underlayer. And three methods were tentatively put forward to build basin runoff generation model considering human activities: experimentation method, statistic method and hydrological model method.

On the basis of the theory of basin statistic comparability and the feature of precipitation-runoff correlation, and starting with statistic characteristic of basin underlayer, the distributed statistic basin runoff generation model was constructed in this paper.

Hydrologic station of Dage, Chaobaihe, Beijing was selected as the object to build a model. Firstly, the 59 hydrological data from 1980 to 1991 that has rainfall duration of one day were selected to find the optimal function form of the $R \sim (P+Pa)$ relation suitable for the basin of Dage, and $R_i = a_i \cdot (P+Pa) + b_i \cdot (P+Pa)^2, i=1,2 \dots n$ was selected for higher correlation coefficient and relative simple form, and the function form was assumed same as that of every underlayer located in the basin. Secondly, the area composition of different underlayers was obtained by overlaying the map of soil type, land use and slop with boundary of basin and accumulating the grid of every underlayer. Because the basin runoff was the accumulation the runoff from every underlayer, the basin runoff generation model was built

as: $R_j = \sum_{i=1}^n a_i \cdot (P+Pa) \cdot (S_{i,j} / S_j) + b_i \cdot (P+Pa)^2 \cdot (S_{i,j} / S_j)$, in which n is count of different underlayer

type, R_j is total basin runoff (mm), S_j is total basin area (km^2), $R_{1,j}, R_{2,j} \dots R_{n,j}$ is runoff from every underlayer (mm), $S_{1,j}, S_{2,j} \dots S_{n,j}$ is area of every underlayer (km^2). Finally the parameters used in the model for every underlayer were obtained by using multiple stepwise regression method with the 54 hydrological data. And the validity of the model of Dage basin

was affirmed by 5 precipitation-runoff tests. From the result, it could be affirmed that statistic method provides a simple but efficient approach to build basin runoff yielding model considering human activities.

Keywords: Runoff yielding, Human activity, Underlayer, Statistic Model

Use of unit source area and small watershed data for model calibration and assessment of downstream runoff and sediment response for a watershed in Southwestern Oklahoma, USA

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Abstract: Recent interest in tracking environmental benefits of conservation practices on cropland throughout the United States has led to the development of USDA's Conservation Effects Assessment Project (CEAP). The focus of CEAP is to assess environmental benefits derived from implementing various USDA conservation programs. Watershed scale, hydrologic simulation models such as the Soil and Water Assessment Tool (SWAT) will be used to relate principle source areas of contaminants to transport paths and processes. SWAT simulations will also be used to determine the existing and potential benefits of conservation measures on reducing contaminant concentrations and loads in streams and waters downstream of agricultural areas. In this study unit source area and watershed data were used to develop a strategy for calibrating model parameters in SWAT that govern the runoff and sediment response of the Little Washita River Experimental Watershed (LWREW) in Southwestern Oklahoma, USA. LWREW winter wheat and pasture unit source watersheds (smaller than 5 ha in size) and two small subwatersheds referred to as 483 (4.5 km²) and 442 (33.3) km² were used to calibrate parameters in SWAT that govern the surface runoff response of the model. Next, available data from the 160 km² LWREW subwatershed 526 were used to calibrate model parameters that govern subsurface, basin, and sediment response. Long term runoff and sediment responses were then simulated on subwatershed 526, assuming that the upper 10% of the watershed was sown completely as winter wheat. Model simulations were then repeated assuming a 10% conversion from winter wheat to bermudagrass, and model output was compared at LWREW locations 528 (56 km²), 527 (102 km²) and 526 downstream of the cropland conversion. Runoff and sediment reductions due to cropland conversion were most pronounced on subwatershed 528, and became increasingly less pronounced downstream on subwatersheds 527 and 526, due to the dampening effect of averaging model output yields from larger, contributing watershed areas. This investigation demonstrates that caution must be exercised in utilizing unit source area data to estimate parameters for watershed scale models so that values selected

are representative of watershed conditions. Results of this study point to the need to develop scaling strategies that link unit source area data to watershed areas. Results also point to the need to employ remote sensing techniques for evaluating the condition of crop, range, and pasture lands to better estimate spatial and temporal differences in the rainfall runoff Curve Number and the Universal Soil Loss Equation cover and management C factor across the landscape.

Keywords: conservation practices, unit source area watersheds, watershed simulation, runoff, sediment, SWAT, watershed scaling

A Distributed Time-Variant Gain Model applied to the Yangtze River

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Abstract A Distributed Time-Variant Gain Model (DTVGM) was developed and applied to analyze the impact of climate changes and human activities on the runoff in the Yangtze River basin. The large-scale DTVGM consists of many modules: a) runoff generation module based on the concept of TVGM, a nonlinear system approach; b) evapotranspiration estimation module related to land use types; c) water loss module due to the water-soil conservation projects; d) water use module due to human activities; e) reservoir regulation module. Observed runoff data at the hydrological stations of five main water systems in the upper reaches of the Yangtze River basin (Min River, Jialing River, Wu River, Kingsha River, Tuo River) in the 1981 and 1998 was used to calibrate and test the model. The relative errors between simulated and observed runoff series were within 5%; the Nash-Sutcliffe Efficiency Criteria were greater than 0.80.

The average runoff during the flood period (from May 1 to September 30) at Cuntan station in the upper reaches of the Yangtze River in 1981 was 25965m³/s and it was 28715m³/s in 1998, increased by 10.59% compared with that in 1981. And the maximum peak discharge at the Cuntan station in 1981 was 85700m³/s, and it was 58000m³/s in 1998, decreased by 32.32%. The DTVGM was used to simulate the impact of climate changes and human activities on the runoff at the Cuntan station. The simulation results indicate that the contribution rates of climate change and human activities on the average runoff during the flood period are 3/5 and 2/5 respectively. So the climate changes are the main reason for the average runoff change. However, the contribution rates of climate changes and human activities on the maximum peak discharge are 1/3 and 2/3 respectively. So the human activities are the leading factors for the maximum peak discharge change.

Keywords: distributed hydrological models; Time-Variant Gain Model; climate changes; human activities; Yangtze River basin;

Reasonable Allocation and Dispatching Model Of Water Resource System for Bao'an Distinct, Shenzhen City

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Abstract: The characteristic and structure of the network system of water supply source of Bao'an Distinct are introduced. For the reasonable allocation and dispatching of the water resource system, a large-system and multi-objective coordination decomposition hierarchical model is developed, and mathematical models are also established for reasonable allocation and dispatching of feeding reservoir group. According to the characteristic of the mathematical models at different levels, different solutions are given. Moreover, a decomposition-aggregation method is discussed to reflect the difference in importance among various users. The present model is applied to the study of reasonable allocation and dispatching model of Water Resource System for Baoan Distinct, Shenzhen City, and the results are reasonable.

Keywords: urban water resource system, feeding reservoir group, reasonable allocation and dispatching, joint operation, aggregation-decomposition,

The optimal planning mathematical model and application of water saving irrigation engineering in the arid region

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Abstract: In the arid region of Northwest China, the land resources are fully rich, the agriculture development potential is great, but the shortage of water resource is key restriction condition, so that developing of water saving irrigation valid method to resolve this issue. The key is to determine development scale, type and layout of different water saving irrigation engineering in establishing agriculture water saving irrigation planning. The optimal planning mathematical model of water saving irrigation engineering in the arid region, in which the available irrigation water quantity , water resources type , crop planting composition, engineering present situation and water saving irrigation technique adaptability etc are enough considered, is established based on realizing optimal allocation of agriculture water and land, to study optimal planning of water saving irrigation engineering. To adopt the mathematical model, we can obtain the region optimal planning of minimum investment which is optimum composition pattern of irrigating type, crop and water resources based on available irrigation water quantity to guarantee crop irrigation .The optimal planning of water saving irrigation engineering of Xinjiang Hetian region in 2020 year is gained based on objective of minimum investment to applying the optimal mathematical model .It is need that the increasing water saving irrigation area is 16.96×10^5 hectares which includes high efficiency water saving irrigation (such as sprinkler and drip irrigation) 8.09×10^5 hectares and furrow border irrigation 8.87×10^5 hectares, and the increasing engineering total investment is 133514.90×10^5 Yuan. To compare with the conventional planning ,the saving investment of the optimal planning is 33216.10×10^5 Yuan and 19.92%, so that adopting optimal planning method has the prominent economic and social benefit.

Keyword: water saving irrigation; engineering; optimal planning, mathematical model

Simulation of rainfall-runoff process by artificial neural networks and HEC-HMS model (case study Zard river basin)

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Abstract: The rainfall-runoff modeling is nonlinear process according to the temporal and spatial distribution of the rainfall, and it is not possible to explain the response catchment system with the simple models. In the present research simulation of the rainfall-runoff process were carried out by Artificial Neural Networks (ANNs) and HEC-HMS model. The ANN models of, Multi Layer Perceptron (MLP) with two structures of one and two hidden layer, and Radial Basis Function (RBF), was used for simulation of this process. It has been applied to the Zard river basin in Khuzestan province using daily rainfall and runoff data, during the period of 1991-2000. In this period, 14 flood events were selected for simulation of the HEC-HMS model. The obtained results of the above models were compared with the observed data from Zard river basin. This comparison shows that RBF model has much more power than MLP and HEC-HMS models for simulating of the rainfall-runoff process in Zard river basin.

Keywords: Artificial neural network, HEC-HMS, Rainfall-runoff process

Research on Application of SD-MOP integrated Model in Water Resource planning--A Case Study of Tianjin city

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Abstract: A new planning approach for eco-environmental system, which is to integrate the System Dynamics (SD) and Multi-objective Programming (MOP) is presented and thereafter a new model called SD-MOP is proposed. The new model is characterized by fully reflecting the initial trends of the system development, accurately explaining both of the structure and function of the system, objectively finding the sensible points of the system (which is defined as the factors that have greater influences on the system), and finally achieving the optimum solution of the model.

In this article the SD-MOP model is applied to the Tianjin Water Resource Sustainable Use Planning as a case study. The using steps are as follows: First, the overall development trends, based on the current development status, can be assimilated, and then relevant information of water supply-demand can also be available; Second, the constraints of water resource emerged from structural analyses of uses of water resource, and accordingly the planning proposals of uses of water resource are formulated, based on the optimum research of the urban overall structure and structure of uses of water resource; Finally by the running of SD model, based on the assumption of implementation of the formulated planning proposals, the social, economic as well as the environmental responses have been estimated reasonably.

Keywords: water Resource; Balance of Supplying-Demanding; SD-MOP model Sustainable Development; Tianjin

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The Evolution Law of Water Resources in Weihe Basin Based on Distributed Hydrological Model

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Abstract: The Weihe Basin is the largest subbasin of the Yellow River Basin, China. It is one of the three main sources of flood in the downstream of the Yellow River and one of main sources of sand in the Yellow River. The water resources in Weihe Basin change a lot accompanying climate change, water resources exploitation, conservation of water and soil and other human activities. The evolution law of Weihe Basin is studied in this paper based on a physically based hydrological model (WEP-L). In this paper, the total of the surface water resources and ground water resources is the traditional water resources, namely, specialized water resources. The total of the specialized water resources and the water resources directly utilized by human or ecological system is called the generalized water resources. A simulation of water cycle in Weihe Basin of 45 years from 1956 to 2000 is performed. The simulation result shows that the surface water resources decreased by 7.3%, the ground water resources not overlapping with the surface water resources increased by 20.2%, the specialized water resources decreased by 2.1%, the water resources directly used by human and ecological system decreased by 1.9%, the general water resources decreased by 2.0%, comparing the water resources from 1980 to 2000 with those from 1956 to 1979. The surface water resources decreased by 26.5%, the ground water resources not overlapping with the surface water resources increased by 23.6%, the specialized water resources decreased by 17.0%, the water resources directly used by human and ecological system decreased by 5.6%, the general water resources decreased by 7.7%, comparing the water resources from 1990 to 2000 with those from 1956 to 1979. As well as water resources at present, Water resources in the future is evaluated based on WEP-L taking account of water use change and land use change. The volume of surface water resources in 2020 is predicted to be 8.160×10^9 m³, 0.320×10^9 m³ less than those in 2000. The volume of ground water resources in 2020 is predicted to be 5.563×10^9 m³, 0.463×10^9 m³ more than those in 2000. The volume of ground water resources not overlapped with surface water in 2020 is predicted to be 2.462×10^9 m³, 0.027×10^9 m³ less than those in 2000. The volume of specialized water resources in 2020 is predicted to be 10.621×10^9 m³, 0.348×10^9 m³ less than those in 2000. The volume of water resources directly utilized by human and ecological system in 2020 is predicted to be 48.716×10^9 m³, 0.305×10^9 m³ more than those in 2000. The volume of generalized water resources in 2020 is predicted to be 59.337×10^9 m³, 0.430×10^9 m³ less than those in 2000.

Stochastic space-time regional rainfall modeling adapted to historical rain gauge data

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Abstract: Stochastic rainfall models are important tools both for practical issues and in studies of weather- and climate-sensitive systems. We propose a new, event-based, two-dimensional model that describes the regional-scale ground surface rainfall by a Boolean random field of rain patches. The model creates complex continuous-scale space-time structures with a mathematically tractable framework. The estimation procedure bridges the gap between widely available historical data at individual rain gauges and the spatial nature of the rainfall process and the model. We assessed the model through simulations as well as theoretical calculations, and confirmed the model's capability to reproduce important statistics of the rainfall process. Hourly historical data at eight rain gauges in Alabama are used to illustrate the model. The model has potential applications in a variety of fields.

Application of Multi-objective optimization for water supply system decision support

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Abstract: In many optimization problems, analysts are often confronted with multi-objective decision problems. The most common purpose of an analysis is to choose the best trade-offs among all the defined and conflicting objectives. However, this type of problems is usually formulated as a single-criterion one whose goal is to find the ‘best’ solution which corresponds to the minimum or maximum value by imposing constraints on the other criteria, or by incorporating multiple criteria into a single objective function using weighting factors. A priori a compromise between the criteria considered has to be defined in such case. This type of optimization is useful to provide decision makers with insights into the nature of the problem, but usually cannot provide a set of alternative solutions that trade different objectives against each other.

In the presence of multiple and conflicting objectives, the resulting optimization problem gives rise to a set of optimal solutions, instead of one optimal solution. Genetic algorithms (GA) have been successfully applied to numerous water resources problems, including problems with multiple objectives or uncertainty. GAs tackle multi-objective optimization by using three basic principles – advancing the non-nominated frontier; maintain diversity in the population through various techniques such as sharing, niching and crowding; and using an elitist. Over the past decade, a number of multi-objective GA methods have been suggested in pursuit of finding multiple Pareto-optimal solutions in one single run. Non-dominated Sorting Genetic Algorithms-II (NSGA-II) (Srinivas and Deb) is one of the robust multi-objective GA methods and has seen increasing applications.

The Sydney system consists of a network of nine interconnected surface and subsurface reservoirs and presently provides drinking water, wastewater and some stormwater services to more than four million people. Such systems are complex, exhibit nonlinear behavior, and are subject to stochastic forcing. Optimization of operations for such multipurpose systems is difficult due to the mix of quantitative and qualitative objectives. This problem has become more important in recent years with the increased concerns on environmental, recreational, and in particular drought security issues. In this paper, the NSGA-II is applied on the Sydney water supply headworks system with three objective functions. This paper demonstrates that tools such as multi-objective genetic algorithms can serve as an interface between the design and planning of the physical system and the human decision process.

Water Quality Classification Model: The Bagmati River in Kathmandu Valley, Nepal

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Abstract: This study deals with the Bagmati River Water Quality Classification of the Kathmandu Valley, Nepal. The river together with its tributaries is the main source of water for domestic use, irrigating agricultural land and industrial use. Since the last few decades, the water quality of all these rivers has been degraded due to discharge of untreated sewage and industrial effluents into them.

An attempt is made here to classify the Bagmati river into different water quality classes based on the Saprobic approach and each Saprobic water quality class has been described in terms of benthic animals, bacteriological and physico-chemical conditions.

- A total of 73 sample sites along the Bagmati river in the valley were selected. The geographical and physical conditions of each site were recorded on the field survey protocol and meanwhile, qualitative sampling of benthic invertebrates and water samples were collected from each sample site. for both bacteriological and chemical analysis.
- The Saprobic approach has been used to classify the water quality in terms of diversity and abundance of benthic macroinvertebrates. Four main standard saprobic water quality classes (SWQC) such as Class I-non-polluted (Oligosaprobic), Class II-moderately polluted (Beta-mesosaprobic), Class III-heavily polluted (Alpha-mesosaprobic) and Class IV-extremely polluted (polysaprobic) have been identified Index.
- Each SWQC has been described in terms of indicator bacteriological and chemical parameters.
- Altogether 71 families, 136 genera and 157 species of macrozoobenthos along the Bagmati river were identified. Two new species *Aphelocheirus nepalensis* ZETTEL and *Aphelocheirus pradhanae* ZETTEL have been identified.
- With regard to bacteriological analysis, the number of heterotrophic count (cfu/ml) has increased rapidly along with the poor Saprobic classes. A strong correlation between HPC and SWQC was observed, indicating deteriorated water quality due to organic pollution. E. coli and faecal streptococcus count (cfu/100ml) were present in all Saprobic classes with increasing numbers in each of the successive poorer classes.
- In regard to chemical analysis, mean temperature was recorded the lowest in SWQC I that included all sites of headwater region but not much varied among other SWQ classes. DO was highest in SWQ classes I and I-II and lowest in class IV. In contrast to DO, BOD₅ was low in SWQC I and gradually increased in other Saprobic classes such as II-III and then remarkably increased in class III, indicating increasing organic pollution.

- Values of other parameters such as phosphate, chloride, $\text{NH}_4\text{-N}$, conductivity and total hardness were low in Saprobic class I and then increased along with the poorer saprobic classes. High concentration of chloride, $\text{NH}_4\text{-N}$ and conductivity in the poor Saprobic classes indicates the influence of domestic sewage or organic pollution.
- To sum up, regarding bacteriological parameters with respect to Saprobic classes, SWQC I with simple physical treatment and disinfection (A1), SWQC I-II with full physical and chemical treatment with disinfection (A2) and SWQC II with intensive physical and chemical treatment with disinfection (A3) can be used as raw water for drinking water abstraction.

Effects of Vegetations on Infiltration Processes and Soil Water Contents in Taihang Mt.

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Abstract: Taihang mountain is one of main recharge areas for the groundwater in North China Plain (NCP) where there occurs a serious problem in short of water. In order to understand the processes of soilwater movement as well as the effect of vegetations on the groundwater recharge in mountain area, two experimental slopes have been chosen in the ecological experimental station of Taihang Mountain, CAS. One is covered by *Robinia Pseudoacacia* L., and other by ruderal, both are the representative vegetations in this region.

Tensiometers and soil water samplers were set at the depth of 10, 20, 30, 50, 70, 90, and 110cm. Soil water sections were measured every day from April to September, 2004. Soil waters were taken once a week. The rainfall and throughfall were measured by automatic rain gauges set above and under the canopy robinia slope. The stable isotope of D and ¹⁸O were analyzed by mass analyzer (MAT 253).

The results showed that the soil water potentials over 50cm in depth in both slopes were similar with values of less than -35kPa in spring. With high coverage density and soil pore in robinia slope, rainfall could infiltrate into 100cm after heavy rain summer. During the succession rain days, the infiltration ratio measured up to 70% in robinia slope, with 2% higher than that in ruderal slope. However, the infiltration amount in ruderal slope was less than that in the slope covered by robinia. Soil in ruderal slope was the driest in autumn.

It was found that the local meteoric water line as well as the relation between δD and $\delta^{18}O$ of soil water for the slopes as the following.

$$\delta D = 7.346\delta^{18}O - 0.244 \quad \text{for rain}$$

$$\delta D = 7.642\delta^{18}O - 2.180 \quad \text{for robinia}$$

$$\delta D = 6.964\delta^{18}O - 7.243 \quad \text{for ruderal}$$

Based on the isotopes analysis results, it was found that isotopes varied with depths, which gives some evidences to show infiltration responding to the rainfall events, and evaporation from soil in the slopes during the fine days.

Finally, the effects of vegetation on the amounts of infiltration and the recharge processes of rainfall to groundwater have been discussed by comparing data measured from the both slopes.

Keywords: vegetation; soil water; infiltration, stable isotopes, Taihang mountain

Operating rules optimization for multipurpose water-supply reservoir

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Abstract: In China most reservoirs are designed for multipurpose water supply, such as agricultural, industrial and municipal water supply. These water uses often are of different priority and reliability. But traditional water-supply reservoir operating rules focused on single-purpose (lumped) water supply with little attention to multipurpose water supply. So it is important to explore multipurpose water-supply operating rules especially when enough water is not available. This paper proposes operating rules for multipurpose water supply by zoning the reservoir storage based on the number of different water uses. Each storage zone is guided by respective operating policy. Through combining hedging rules the proposed rules make trade-offs not only between current and future water uses but also between current competing water uses during periods of drought. To minimize the total water deficit index under the constraints of keeping single period shortage of each water use within an acceptable range, a model combining reservoir simulation and genetic algorithms is used to optimize the parameters defining the operating rules. The genetic algorithms use real-valued code, arithmetic crossover, mutation and elitism to generate successive sets of possible solutions. Each solution is then evaluated using reservoir simulation to compute a performance index. The solutions with better performance are then used as a basis for generating new sets of possible solutions. The process of improved solution generation and evaluation is repeated until stopping criterion is satisfied. The operation rule is developed and demonstrated through a case study of a reservoir located in the north of China. The results indicate that the proposed rule is better than the single-purpose water supply operating rules used as comparison in terms of total shortage and the capability to handle different water supply simultaneously.

Keywords: Water supply; operating rules; reservoir; genetic algorithms; optimization

A comprehensive benefit evaluation for Xiangjiang river basin treatment

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Abstract: Basin treatment involves extensive engineering measures of land use, water resources, soil and water conservation and ecological environment rehabilitation. In China Basin treatment is now one of the most important actions for basin's sustainable development, especially for sustainable water resources development. The treatment of Xiangjiang river basin, the main economic region of Hunan province, was implemented under the context of increasing floods, droughts and water environment pollution. The Xiangjiang river basin treatment project mainly included reservoir construction, embankment reinforcement, and vegetation and water environment protection, and related to flood control, hydroelectric generation, irrigation, navigation, migration and water ecology. To quantify the benefits and impacts of the basin treatment project and find out its advantages and weakness, it is necessary to comprehensively evaluate this basin treatment project from multiple perspectives. So this paper proposes a multiplayer assessment index system with considerations of flood control, social economy and ecological environment. Each index of different categories within the index system was standardized and its weight was determined through adopting information entropy-based assessment method, which integrated subjective and objective assessment. The proposed assessment index system was used to evaluate the flood control, social economy and ecological environment benefits (positive and negative) of the basin treatment project. The evaluation results indicated the basin treatment enhanced the flood control capability, boosted regional social economy development and improved basin's ecological environment. Except for some slight impacts of migration, the benefits in the three aspects were remarkable with good resistance against risk. The conclusion drawn is the Xiangjiang river basin treatment is successful and corresponds to needs of basin's sustainable development.

Keywords: Basin treatment; assessment index; entropy weight;

Integrated Statistical Prediction of Monthly Runoff for Reservoir Inflows

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Abstract: Long-term runoff prediction including the monthly runoff forecasting plays an important role in flood and drought prevention. In making the forthcoming annual plan of water resources utilization and reservoir operation, the predication of future monthly runoff is one of the dominant factors. Long-term runoff prediction is still in the way of developing and stays much immature, because of the complexity of the influencing factors with the increasing length of lead-time. Even though methods based on the numerical weather simulation have achieved obvious advances, the strictly dependent on meteorological and climatic data of these approaches limits their practical application in most cases, therefore a method with less data requirement is of more practical use. In this paper, integrated statistical predication coupling with several statistical models for monthly runoff is presented which uses statistical relations between the runoff of reservoir inflow and some elements in three meteorological fields namely the 100hpa and 500hpa height, and the west pacific Sea Surface Temperature (SST) field. The key procedure of the method includes the following three main steps: (1) Select influencing factors. Statistical relations between the meteorological factors and monthly runoff, as well as relations among other factors and runoff, are construed using correlation analysis and F-test method. Based upon the analysis, influencing factors for runoff predication are predetermined. (2) Calibrate statistical predication models. For quantitative predication, in total three kinds of models are selected and calibrated in this study, including the stepwise regression model, the Autoregressive time series analysis model (AR), the artificial neural network model (ANN). For qualitative predication, the Multi-discriminant model and Fuzzy Cluster Analysis (FCA) are adopted to predict the scale or classification of monthly runoff. (3) Integrate prediction models. A unique prediction is provided by weighing results from different models, the weight coefficient for each model is supposed to be inverse proportional to the model's root mean square error. Both the quantitative and qualitative predication models are integrated respectively.

As an example, monthly inflow predication for Panjiakou reservoir is presented. Panjiakou reservoir locates at the mainstream of Luanhe river, Hebei province, china, the watershed of Luanhe river is within the north scope of the monsoon region with subtropical climate characteristics. Forecasting models are calibrated by using data from 1980 to 1991, and verified by using data in 1992 and 1993, including monthly meteorological records of the 100hpa, 500hpa geopotential height, SST, and the corresponding rainfall and runoff observations. Results indicate that both the integrated quantitative and qualitative models can provide reasonable predication for of monthly runoff inflows for the reservoir. Especially, the approach presented by this study is with a loose data requirement, the easy acquisition of data makes it be of valuable and an alternative for operational forecast.

Key words: long-term runoff prediction, meteorological elements, statistical models.

Socioeconomic Developing Modes and Water Demand Prediction in Pearl River Delta

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Abstract: The socioeconomic development achieved in Pearl River Delta is very typical among regions in developing countries. Propelled by the strong economic force from the neighboring developed cities such as Hong Kong and Macao, this region has witnessed rapid economic development which has also brought with it many serious problems, within which the rapid increase of water demand for socioeconomics is unneglectable. Therefore the research on the driving mechanism for the impacts of socioeconomic factors on water demand and the rational methods of water demand prediction is of important significance in terms of securing the regional sustainable development. The in-depth research on the present regional socioeconomic regulation and future government planning in this paper suggests several feasible regional developing modes providing different scenarios for water demand prediction. Probing into the correlation between socioeconomic quotas and water demand quotas, taking into account some crucial non-socioeconomic factors and their impacts, this paper proposes a mathematical model of water demand prediction based on the research of the developing modes.

Keywords: Water demand prediction; Developing mode; Socioeconomics; Sustainable development

Application of a New Flood Stochastic Simulation Model Developed by a Russian Hydrologist in the Basin of Qiantang River

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Abstract: In order to simulate flood process better, the study focus on the application of a new flood stochastic simulation model developed by Prof Andli, a Russian hydrologist, which could describe the characteristics such as rapid rise and slow fall and multi flood peak for flood hydrograph with less number of model parameters, in the southern region of China. The flood process in the basin of Qiantang river is selected as a case study. Due to shortage of application experience for the new model, there are several simple empirical treatment even no treatment for some segments in the model, for example, rise time distribution et al. In terms of the case study, some reasonable treatments are pointed out. In the case study, a lot of stochastic tests have been done for the new model, including the test of annual maximum peak flow, annual flood volumes. The results show that flood process simulated may pass all tests, so it's said that the new model is feasible to simulate the flood process for the basin. Otherwise, the new model is compared with the conventional models, including seasonal AR(1) model and the Disaggregation model by statistical test for simulation flood process. The results show that the new model is better than the other two's model

Keywords: flood simulation, Russian simulation model, seasonal AR(1) model, Disaggregation model, Qiantang river, application, statistical test

Long-Term Prediction for the Annual Highest Tide Stage at Huangpu Park in Shanghai

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Abstract: The annual highest tide stage in the coming year at Huangpu park is a very important index in the flood defense decision for Shanghai, so how to predict it with a high accuracy is paid more and more attention by Chinese hydrologists. It's said that the affecting factors for annual highest tide stage doesn't only include the flow of upstream of Huangpu river, a tributary of Yangtze river, but also the runup of astronomical tide and typhoon, so there is a large difficulty for predicting it well by using the time series analysis methods, such as AP(p) model, Grey model GM(1,1), and threshold autoregressive model. For the high water tide stage years in 1981, 1997, 2000, there is a large error for its prediction, in which the mean absolute error is about 0.9m. For improving its prediction accuracy, some physical genetic analysis methods are used to make the prediction in the paper. In term of correlation analysis, some ocean temperatures, Southern Oscillation index and sunspot number are considered as prediction factors. The prediction methods includes the stepwise multiple regression, the empirical orthogonal function(EOF), the projection pursuit regression(PPR). By comparing with all other predictions methods mentioned, the results show that EOF is the best method to predict the annual highest tide stage with the absolute errors less than 0.5 m for all prediction period from 1981 to 2000, and the mean absolute error less than 0.3 m for the years in 1981, 1997 and 2000. In a word, it's said that the physical genetic analysis method is feasible to make a prediction of the annual highest tide stage.

Keywords: long term prediction; annual highest tide stage ;Shanghai; stepwise multiple regression; empirical orthogonal function; projection pursuit regression; ocean temperature; Southern Oscillation index.

Effect of Urbanization on Evapotranspiration in Shenzhen, China

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Abstract: Evapotranspiration as part of the hydrologic cycle plays an important role in the redistribution of water on the Earth's surface and is critical to the available water resources and runoff. It is affected by a multitude of processes at the interface between soil, vegetation and atmosphere. Urbanization, the most remarkable human intervention on nature, which leads to land use and land cover change and other changes, greatly affects the evapotranspiration on regional scale. Shenzhen, located at the south of Guangdong Province and neighboring to Hong Kong, has been undergoing urbanization process at an unprecedented speed since its establishment as a *Special Economic Zone* in 1980. Dramatic change has thus happened to the land use and land cover in this region. Its effect on the region's evapotranspiration, however, is still unknown. By combining remote sensing and DEM data with ground-based measurements, a distributed model for determining the spatial evapotranspiration was developed and verified for the study region, which was then used to compute evapotranspiration at different stages of urbanization process in Shenzhen. The changes of evapotranspiration were then mapped using GIS techniques. Multivariable regression model was also constructed between the change of evapotranspiration and changes in land use/land cover and climate factors. The results show that urbanization leads to a general decrease of evapotranspiration in the study region, but the speed varies for different periods. Land use and land cover change has played an important role in the change of evapotranspiration, while the role of climate change is insignificant. Different land use and land cover change types have also played different roles.

Keywords: evapotranspiration, urbanization, land use and land cover change, remote sensing, Shenzhen

Analysis of the effect of two dominant vegetation covers on the hydrological course in slope plots in Mountain area in North China

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Abstract: The Pine and wild grass are two kinds of the dominant vegetation covers in Mountain area in North China. The analysis of the differences in the hydrological course between the two vegetation covers can give a reference to the advanced research on the hydrological course in this area. Our study is taken in two slope experiment plots, which are in the Chongling valley, Hebei Province, with the same area ($5 \times 15 \text{m}^2$), similar geologic and topographic condition but different vegetation cover. One slope plot is covered with mixed Chinese Pines and bushes (we call it the *Pines Plot*), the other is covered with mixed bushes and wild grass (*Wild Grass Plot*). Both the plots are set with the Data Logging rain gauges, the TDRs, the tensiometers, the Triangular-notch Weirs with Water Level Recorder etc. The data of the rainfall course, soil moisture, surface flow and subsurface flow were auto-monitored while the total soil-water potential was manually observed. Based on the observation data and analyzing hydrogen and oxygen isotopes composition indoors, the differences of the soil water changing in different depts. between the two plots have been compared. The result shows that the Pines Plot has a larger total soil-water potential with more smooth variation than the Wild Grass Plot. The soil layers of the Pines Plot with the larger storage capacity of water could generate an obvious delay and storing effect on the runoff generation process. The conclusion is, the forest cover changes the soil feature and causes the changing of runoff generation process.

Methodology for Evaluating Community Vulnerability Related to Flood Mitigation Planning

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Abstract: Natural disasters result from the interaction of hazard and vulnerability. In the case of natural disasters, hazard represents the likelihood of occurrence, and potential severity of adverse events, such as droughts, floods and earthquakes. While vulnerability represents the set of social, economic, political and physical factors that determine the amount of damage a given event will cause. So the research of vulnerability is useful to mitigation and risk management. China is exposed to a wide range of natural hazards. However, compared with the research of hazards, vulnerability research is so limited in China that affects local sustainable development.

Therefore, this paper focuses on evaluating community vulnerability of flood in China. In order to identify the properties and structures which is actually vulnerable to flood damage, and then to help local risk management and mitigation planning, a regression methodology with a GIS-based product offered by NOAA is used. The city of Changsha, the capital of Hunan Province, and the most important city in Dongting Lake and Xiangjiang River Basin where floods occur often, is used as a case study.

Keyword: vulnerability; flood; Changsha; community Vulnerability;

Simulation of Groundwater Flow in Fractured Media

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Abstract: In order to simulate the water flow in karst-fracture aquifers, according to karst-fracture's sizes and the function to water flow, the pores in aquifers are divided into three types, large fractures networks dominating flowing action, medium-small cracks and pores storing waters, and cracks, drill holes located under coal floor which act as vertical passages for bursting water. Then three different kinds of water flow models are established. The discrete fracture networks flow model is for the water flow in large fractures by the cubic law of fractural water. The continuous media permeability tensor flow model is for the medium-small fractures and pores. The tube flow model is for the passages of bursting water. The couple of the three models forms a generalized triple porous media flow model, which has been applied to simulate the karst water flow in karst-fracture networks at Jiaozuo coal mine. The results show that the generalized triple porosity media flow model can describe the anisotropy and uncontinuity of the karst-fracture water flow effectively and is a new method to calculate and forecast the water bursting discharge in karst-fracture networks aquifer.

Keywords: Groundwater flow; Simulation model; Fractured Media

Application of Hydrologic models in Sanchuanhe River Basin of the Loess Plateau

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Abstract: Conceptual hydrologic models are often believed to be useful in assessing the impact of environmental changes on regional hydrology. However, the selected hydrologic model must be qualified to runoff simulation for the study basin. The principles of 6 hydrologic models of SIMHYD, SARC, TANK, AWBM, SMAR, and YRWBM were introduced briefly in the paper. 15 years of daily rainfall in Sanchuanhe River basin of Loess Plateau, as well as daily potential evaporation and daily discharge were prepared for models comparison. And results indicate that all of models can simulate monthly discharge well while have poor simulation results for daily discharge. Compared with the other hydrologic models, YRWBM model and SIMHYD model not only have simpler structure, fewer parameters, but also have significant advantages of accuracy, flexibility, and ease of use. Nash-Sutcliffe efficiency coefficients of the two models for monthly discharge simulation at Houdacheng station are 86.1% and 90.7% respectively, and relative errors are also less than 5%. Therefore, the two models are sufficient to assess hydrologic effects of environmental change in a larger temporal scale.

Keywords: hydrologic models, Sanchuanhe River Basin, comparison, parameter calibration

The Application of AFOSM Method on Reliability Analysis in evaluation of the Groundwater Allowable Withdrawal

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Abstract: Based on analysis of the spatial and temporal distribution of some hydrogeological parameters, source and sink items, and the process of establishing numerical model for groundwater flow simulation in Jining city, Shandong province, China, the conclusion is obtained that both subjective and objective uncertainties are inevitable features in the groundwater resource evaluation, which affects directly the precision of groundwater allowable withdrawal (GAW). The assessment of GAW is a very important task for groundwater resource evaluation. Unfortunately, the traditional deterministic method associated with these uncertainties has a number of limitations and faces a great challenge. Moreover, the “risk” is closely related with the “uncertainty” and is usually generated by the uncertainties. In this study, the result of the GAW obtained from the traditional method was $14.76 \times 10^4 \text{ m}^3/\text{d}$ in 1987, the groundwater abstraction was $14.35 \times 10^4 \text{ m}^3/\text{d}$, but groundwater level was still decreasing. The Monte-Carlo (M-C) method also demonstrates that there indeed exists risk in the groundwater evaluation results obtained from the traditional method, and the reliability of the GAW of $14.76 \times 10^4 \text{ m}^3/\text{d}$ is only 56.42%. Hence, a new method of Advanced First-Order Second Moment (AFOSM) in determining the GAW was used on the basis of the brief introduction of risk analysis. The AFOSM method makes use of the statistic parameters of the random variables to deduce the groundwater systems behavior by analyzing the water-balance equation and taking into account the uncertainties. The results obtained by using the AFOSM method shows that the GAW is $8.3 \times 10^4 \text{ m}^3/\text{d}$ and the corresponding reliability is 85% in the above case. The study shows that the AFOSM method is a much more practical, reasonable and reliable evaluation method of GAW than the traditional methods. It can not only minimize the losses from overdraft of groundwater resources, but also provide important information for the risk management of groundwater resource extraction in the future.

Keywords: groundwater allowable withdrawal; risk analysis; AFOSM method; uncertainties

Early Warning and Prediction of Flood Abnormalities for Improved Public Safety using A Modified Adaptive Neuro-Fuzzy Inference System

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Abstract: It is widely accepted that an efficient flood alarm system may significantly improve public safety and mitigate economical damages caused by inundations. In this paper, a modified adaptive neuro-fuzzy system is proposed to modify the traditional neuro-fuzzy model. This new method employ a rule-correction based algorithm to replace the Error Back Propagation algorithm that is employed in the traditional neuro-fuzzy method. The final value obtained during the backward pass calculation using the rule-correction algorithm then considered as the mapping function of the learning mechanism of the modified neuro-fuzzy system. Effectiveness of the proposed identification technique is demonstrated through simulation study on the flood series of the Cilalawi River in Indonesia. We used the data for the first 4 years (1987 to 1990) for model training/calibration, while the other remaining data (1991 to 2002) was used for testing the model. The number of antecedent water level that should be included in the input variables was determined by two statistical methods, i.e. autocorrelation and partial autocorrelation between the variables. Performance accuracy of the model was evaluated in terms of two statistical indices i.e. mean average percentage error (MAPE) and root mean square error (RMSE). The results indicate that the modified neuro-fuzzy model applied to the flood prediction seems to have reached encouraging results for the river basin under examination. The comparison of the modified neuro-fuzzy predictions with the observed data was satisfactory, where the error resulted from the testing period was varied between 2.632% and 5.560%. In addition, the comparison between the two models indicated that the modified neuro-fuzzy model performed better than the traditional neuro-fuzzy model with respect to the overall statistical indices. At the next task, a graphical user interface program is developed and implemented for flood data processing. The main data processing includes the gauging station selection, input generation, lead-time selection/generation, and length of prediction. This program enables users to process the flood data, to train/test the model using various input options and to visualize results. The program code consists of a set of files, which can be modified to match other purposes as well. This program may also serve as a tool for real-time flood monitoring and process control.

Keywords: Modified neuro-fuzzy, prediction, flood, graphical user interface.

Determining quick groundwater artificial recharge method and recharge zones based on numerical model and optimization method (Jining, China)

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Abstract: As an important measure in integrated management of water resource, groundwater artificial recharge offers a good method to recover the depleted aquifer and to regulate spatial and temporal uneven of regional water resource. Due to over-exploitation, groundwater table of Jining City has been dramatically declining in the last two decades and has led to many geological problems. Therefore it is urgent to find a quick artificial groundwater recharge method and suitable recharge zones in this area. In this paper, firstly a digital groundwater flow model was developed and calibrated to gain a better understanding of the aquifer dynamics and to estimate its capacity for artificial recharge; then several scenarios, simulating different methods of artificial recharge, including surplus canal water releases, tube wells, recharge basins etc., are installed to this model over an 8 year period to compare effect of each and the best suitable and quick method in the study area is obtained. On the quick recharge style, the optimization method is used to determine the best scheme of recharge in terms of yearly input-output water balances and groundwater table increase. Finally, a specific guideline of this city to implement this quick groundwater recharge scheme is brought forward which might ensure a sustainable use of the aquifer in the future.

KEYWORDS groundwater artificial recharge, quick recharge method, numerical model, optimization method

Urban Planning and Springs Conservation in Jinan City, China

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Abstract: According to the research of groundwater system structure, the hydraulic relation between Jinan Urban and western suburb karst groundwaters is confirmed based on pumping test, reinjection test and hydrodynamic analysis. The reason of springs drying out and groundwater quality deterioration is disturbed hydrologic cycle, which is induced by irrational groundwater development and urban planning and construction.

The 3D geological model near the springs occurring is established by using visualization technique, so the 3D space inquiry can be realized, and the deep foundation construction scope can be determined. For the springs conservation in the entire catchment area, the vulnerability of karst groundwater has been evaluated relying on such elements as depth to groundwater level, aquifer recharge, lithology of overlying layers, topography, karst water network, conductivity of aquifers, etc. It is believed that the current city planning will directly influence the spring recharge and groundwater environment. In the view of hydrogeology, the urban planning and development of Jinan city toward southern and southwestern direction must be strictly controlled. The concrete ranges of conservation areas are divided in this paper. It is suggested that the 2020 master planning of Jinan city be improved, on the base of sufficient consideration between new urban layout and geological environment protection, along with implementation of groundwater development layout optimizing and groundwater reinjection.

Keywords: urban planning, spring conservation, karst water, vulnerability, 3D geological modeling

Study on the Sensitivity of Groundwater Environment under The Influence of Human Activity

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Abstract: The groundwater environment includes two aspects, which are: the groundwater dynamic environment and the groundwater chemical environment. The groundwater environment responds sensitive to human activity function. The severely interfere of Human Activity to the groundwater environment produces series of environment and resource effects. Through comprehensive analysis of lasting and dynamic monitoring about groundwater mining quantity, water level, water quality, ground collapse, etc. This paper researched the sensibility of response and feedback on the interfere of human activity to the groundwater environment, and disclosed the correlation between the groundwater environment system and the exterior environment such as human activity.

The groundwater dynamic environment has sensibility of response and feedback on human activity function. Firstly, the temporal and spatial variation of groundwater level is an indicator of human activity function. Secondly, The formation and expand of the descent funnel of groundwater level has a close relationship with the intensity of human activity. Thirdly, the variety of the buried condition of groundwater is the severely feedback on human activity function. Fourth, the variety of groundwater flow field is the result of human activity function.

The groundwater chemical environment was very sensitive to the response and feedback on human activity function, which the groundwater chemical environment in pore water system had sensibility obvious higher than in karst water system. Firstly, The chemical environment of Quaternary pore water changes obviously under human activity function. Secondly, it is obvious that the characteristic of sensitiveness which the chemical environment of Karst water system to human activity function. Thirdly the sensitiveness of the groundwater chemical environment mainly effected by the contaminative rivers, sewage irrigation, groundwater funnels, karst collapses, etc. The change of the groundwater chemical environment changed with the intensity of social economic activities.

Science cognition of the sensitiveness of the groundwater environment to human activity function is the key to development the groundwater resource reasonably, and to realize sustainable utilize of groundwater resource.

Keywords: Groundwater environment, Human activity function, Response and feedback, Sensitiveness

Study and Application of Two-Dimensional Layered Flow Model in Wind-Driven Current Modeling of Reservoir

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Abstract: According to layered characteristic of reservoir, considering the influence of surface wind stress, Coriolis force, bottom shear strength and frictional force of water layers, A new two-dimensional layered flow model of reservoir which simulated the calculation of three-dimensional water flow was brought forward in the paper. Take Xinxi River Reservoir of Jieyang city as an example, the impact on water flow of eight wind directions were studied through the application of two-dimensional layered flow model with the cross-grid –point method. The conclusions of the research were as follows:(I) The calculation and application of two-dimensional layered flow model is effective. The model has stronger application and has drawn some rules that the wind influenced the water flow of the reservoir. (II) Flow Velocity of surface-layer is obviously bigger than that of vertical mean two-dimensional model; flow velocity of lower level and that of the two-dimensional model are almost the same. (III) Wind-driven current deriving from different wind directions have the similarity. (IV) Water circumfluence form has the close relation with wind direction, which determines the velocity of the wind-driven current. The flow field between the neighboring wind fields presents the transition characteristic. (V) Wind influences little the flow velocity; the direction of water flow is from the water inlet to the water outlet.

Keywords: two-dimensional layered flow model; the cross-grid –point method; Xinxi river reservoir; wind-driven current

GRID BASED RAINFALL - RUNOFF MODELING USING REMOTE SENSING AND GIS

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Abstract: Rainfall - runoff modeling is complex hydrologic phenomena. In hydrological modeling runoff estimation is important for planning and operation of reservoirs, irrigation project, flood controlling and construction of hydraulic structures. There are numerous methods available to predict runoff from a watershed. The model should represent spatial and temporal parameters such as soil, landuse and topography. Lumped models ignore the spatially distributed parameters and considering only averaged input values. The influences of spatial and temporal parameters are represented in distributed models. Geographic Information System (GIS) is an effective and continent tool for the hydrological modeling to study the basic characteristic of the watershed and their influence on runoff.

In this study an attempt has been made to develop a spatially distributed unit hydrograph model for the estimation of runoff from a hilly watershed using GIS. The study was conducted for the Kateri Watershed in Nilgiris district, Tamilnadu, South India. The Digital Elevation Model (DEM) was developed using the contour maps collected from the Survey of India Toposheets of scale 1:50,000 for the Kateri watershed.

The ARC/INFO 8.0.GRID module was used to extract flow direction, flow accumulation, flow length, slope and watershed boundary from the filled DEM of 30-meter size grid cells. Landuse and hydrological soil classification has been done using Indian Remote Sensing satellite IRS-IC LISS II data. The excess rainfall hyetograph has been developed based on landuse, hydrological soil and Antecedent Moisture condition (AMC) using Soil Conservation Service-Curve Number method (USDA, 1985), due to its simplicity and less number of parameters involved.

The cell-to-cell flow path to the watershed outlet was determined from the watershed DEM. A constant flow velocity was assigned to each cell. Arc Macro Language (AML) program was written and used to find the distance and travel time of each cells in the watershed to the outlet. Overland flow travel times were calculated by Kinematic wave equation and channel flow travel times were based on the Manning and continuity equations.

The watershed Time-Area isochrones were developed by summing up the time of concentration in each cell. S-hydrograph technique (Chow et al., 1998) has been used to derive spatially distributed unit hydrographs. The distributed unit hydrograph has been convoluted with one hour rainfall excess hyetograph to get the direct runoff hydrograph for the particular storm event.

The developed GIS based model was applied to nine storm events and observed that the derived flood hydrograph of this model was closely matching with the flow records of the watershed. This model is capable of predicting the runoff for given storm event of rainfall and deriving direct runoff hydrograph for the required storm event.

Keywords: Grid based modeling, remote sensing, GIS, rainfall-runoff modeling, SCS- CN, time - area diagram, isochrones, distributed unit hydrograph.

Augmenting groundwater recharge from traditional water harvesting practices in semi-arid regions: Case study from Alwar, Rajasthan, India

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Abstract: Groundwater is the most important and significant source of water in semi-arid and arid zones of Rajasthan. Despite groundwater's critical role in these rural economies, it is often recognized at a stage when its recuperation is physically difficult to sustain the livelihoods or uneconomical. A major challenge in many of the aquifer management strategies has been sustaining normal groundwater extractions for agricultural, livestock and domestic needs. Augmenting aquifer recharge is one alternative to the water sustainability crisis occurring in many dry regions. Intermittent and intense rainfall events over semi-arid watersheds can lead to extended periods of scarcity with short spans of surface water availability. Without the proper management of this water resource, the excess precipitation can be quickly lost to the high evaporative environment or as quick runoff to downstream areas. By ensuring that the available surface water remains within the catchment in the form of stored groundwater, a sustainable flux of water is obtained for the region. Communities in Alwar district of northeastern Rajasthan in India have revived a traditional method of designing and maintaining an effective groundwater recharging system. The system consists of series of earthen embankments built across ephemeral stream paths in cultivated and barren lands along with field bunds that captures, spreads and infiltrates rainwater and runoff. This practice has enabled assured groundwater supply for 2-3 agricultural crops a year during normal years and water for minimum sustenance during drought years. In areas dependent on irrigated agriculture, the reliability of groundwater sources and the high crop yields generally achieved as a result, often enable farmers with small landholdings to increase income. This paper presents a detailed investigation of the hydrological impacts and its linkages to agrarian and socio-economic transformation of the region.

The Characteristic of *Panicum repens* on Water and Soil Conservation and Its Application on Water Fluctuation Belt at the Reservoirs in Southern China

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Abstract :The water-fluctuation belt is the land between high and low water levels along the bank of reservoirs and rivers, which often appears above and submerges under the water alternately. Because few plants can well grow in such environment that is either very wet or very dry, usually the belt appears as a bare slope and has serious soil erosion and other ecological problems. After long term observation and selection, *Panicum repens* is used as a plant to re-vegetate the water-fluctuation belt at reservoirs such as Xinfengjiang Reservoir, Liuxihe Reservoir and Nanshui Reservoir in Guangdong Province, Southern China, and is proved to be with specific characteristics of anti-drought and anti-submergence and can be effectively used to protect and improve the environment, to prevent further soil erosion, to enhance the aesthetic value of the water-fluctuation belt, etc. As an example, *Panicum repens* was planted in the water-fluctuation belt in the year 2000 and 5 years of observation is taken afterwards. This grass can grow well in the land if proper measures are taken to ensure the enough growing period of the plant before water submerges it. When the water level go down and the grass reemerged, it regenerate new seedlings quickly and grows well even when in dry weather conditions. After re-vegetation, the runoff can be reduced by over 50% in light rain and 30% in heavy rain, and soil erosion can be reduced by 97% at any rainy time, furthermore, the micro-environment can be improved. There are large areas of water fluctuation belt in the reservoirs and along the rivers bank, where usually is bare and need revegetation, therefore, it is a great achievement to find such a kind of plant and used in revegetation in the fluctuation belt successfully. Further study on the mechanism of anti-drought and anti-submergence of this plant and its revegetation effect on water-fluctuation belt is needed.

Keywords: Reservoir; Southern China; Water-fluctuation belt; *Panicum repens*; Revegetation

A multi-objectives and semi-structural consolidation assessment method

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Abstract: Many assessments in water resources system such as post-assessment are multi-objectives and semi-structural problems that include qualitative objectives and quantitative objectives. A fuzzy multi-objective semi-structural analysis assessment method is proposed in this paper including the two above objectives and applied into water resource assessment. Firstly, the qualitative objectives are determined by fuzzy group decision-making method. Then, a consolidation assessment method is given depending on the combination of the fuzzy recognition and fuzzy optimum model. Finally, a practical case shows that the methodology is reasonable and feasible.

Keywords: water resources assessment; fuzzy pattern recognition;

The New Lerma Chapala Basin Surface Water Agreement: an step forward to the Integrated Water Resources Management of Mexico

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Abstract:The Lerma Chapala basin has 2% of the Mexican territory, 11 million people and produces the third part of the Gross National Product. Also 5 million people live outside the basin but use its water resources. Although the economic development is very high still 40% of the population has low income according to national standards. The irrigation of 1 million hectares use 6450 hm³ per year (87% of the total water use) is the principal water user followed by the urban water supply. In the lower part of the basin is the main national lake with a maximum storage of 8 000 hm³, a water flooded area of 11 100 km² and 1 500 hm³ of annual evaporation. The surface water balance shows an annual deficit of 677 hm³ and 20 of the 39 groundwater basins are overexploited with a joint deficit of 1125 hm³ per year. The economic development has also polluted the main course and its affluent whose water quality index indicate a range of contaminated to highly contaminated surface water.

Due to these problems the National Water Authority supported on the National Water Law created in 1989 the Lerma Chapala Basin Council where the five governors, water user representatives and organized society participate in developing strategies and actions to make the water sustainable.

Because of the water irrigation deficits and a decreasing Chapala Lake level in 1991 the Governmental representatives of the Lerma Chapala Basin Council signed a Surface Water Agreement with a water allocation rules based on a hydrological algorithm. Since that time the water use was assigned but a ten year drought period made the Agreement insufficient. At 2000 the Basin Council agreed to revise the water allocation rules and in 2004 a new Agreement was signed but now the water user representatives also participated in its development and signature. The document contains new water allocation rules and procedures based on a genetic optimization algorithm embedded in two digital simulation and optimization models as well as many water management strategies and actions beyond the original scope of the first Agreement. Within the main water management actions are the water market strengthening by specific water transfers and a water bank, the temporal use of flood control dams for water supply purposes, a hydrological accountability information system, the irrigation infrastructure modernization and the relationship with the groundwater management plans and regulations. The new water allocation rules were evaluated with hydrological considerations but also with economic, social and environmental parameters. The Agreement establishes that every year should be revised and a water regulation based on the National Water Law will be signed.

These new Agreement is unique in its kind in México and in many countries due to its ample social participation development process and its innovative water management concepts. The Mexican Authority is committed to replicate it in other water conflictive basins such as the Bravo, Balsas and Valley of Mexico basins because it is a step forward to the Integrated Water Resources Management.

THE MEXICAN WATER MANAGEMENT MODERNIZATION PROGRAM: EIGHT YEAR EVALUATION AND PERSPECTIVES

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Abstract: In 1992 a brand new Mexican Water Law was issued and updated water management concepts were included. From that time the Mexican Water Authority (National Water Commission) prepared and launched in 1997 a Water Management Modernization Program to face the challenge of implementing the new water regulation. The Program called PROMMA had a national scope and involved 5 major components: Technical Assistance and Institutional Development, Water cycle monitoring system modernization, Surface and groundwater availability determination, Water Right System and Law enforcement, National and Regional Water Planning and Water Basin Councils Implementation. Later in 2000 a sixth major component was included called Sustainable Groundwater Management. After eight years of the application and annual evaluations by experts of the World Meteorological Organization and of the World Bank in the different components the achievements are in general satisfactory. The total cost of the program was 124 million dollars and involved studies and assessments, institutional capacity building, on the job training, minor water works and instrumental procurement for water cycle monitoring. Some of the major achievements are the almost complete modernization of the National Meteorological Service; the fully operational hydrometric and climatological digital national data system; the redesign and operational water quality monitoring network and laboratories; the updated national, regional and state water planning system with 2025 as a horizon plan; the establishment of the National Water Rights Registrar at the national and regional level with more of 420 000 water rights issued and registered (95% of the universe); a National Water Finance System that inputs in average more than 800 million dollars per year to the National Treasure; 25 Water Basin Councils that include more than 100 Water Users Organizations established and working; and more than 1000 course offered to update the knowledge of 2500 engineers and technical personnel. The most important result was not that the National Water Authority is now able to cope with the Water Law that was issued in 1992 but it has the cornerstones and the human resources to face the new challenge that is the National Water Law reform that was issued in April 2004. The infrastructure, systems, data and personnel capacity of the National Water Commission acquired through the PROMMA Program set the bases to face the Integrated Water Resources Management strategy that is the core of the Water Law reform. The achievements in the five pilot projects of the Sustainable Groundwater Management component gave the national strategy for the more than 100 overexploited aquifers and the 20 water scarce hydrological regions and basins. Mexico is preparing a new phase to implement that emphasizes the water users and local governments participation in the water planning decision making as well as the action implementation. The new Mexican Water Management System needs also be strengthened at the regional level but the pathway to a sustainable water resources development is set and in progress.

Relationships between three dispersion measures used in Flood Frequency Analysis

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Abstract: Three dispersion measures of a random variable, i.e., the standard deviation, the mean deviation about the mean and the second L -moment, are analyzed in terms of their properties and mutual relationships. Emphasis is placed on the mean deviation, as it is less recognized than two other dispersion measures. The relationships between the dispersion measures are derived for distributions commonly applied in flood frequency analysis (FFA). For distributions that are unbounded, there is a distribution-dependent constant value of the ratio of dispersion measures, or equivalently of respective coefficients of variation. For two-parameter distributions that are lower-bounded, the relationship between the coefficients of variation is also distribution dependent and is not linear. For lower-bounded three-parameter distributions, the dispersion measure ratios, or equivalently the ratios of coefficients of variation, depend on the coefficient of skewness and show a strong distributional dependence. For selected distributions, the three dispersion measures are compared both in terms of the robustness to the largest samples element and the accuracy of upper quantile estimation. The mean deviation statistics may be highly competitive to the two other dispersion measure statistics if applied in FFA for parameters estimation.

Three Gorges Reservoir's Flood Season Staged Based On Fractal Theory

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Abstract: Controlling the limited water level of reservoir by stage is an important content in the management of reservoir's flood water utilization for the sake of more benefits, and the partition of the stage in flood season is the precondition of controlling the limited water level by stage. The fractal theory and the computation of capacity dimension are introduced, taking the Yichang Gauging Station of Three Gorges Reservoir as an example, using the traditional statistics method and the dynamic fractal dimension method, the number divided the flood season is presented, and the capacity dimensions of all stage are computed, thus the final flood season staged is given. The results indicate the periods of Three Georges Reservoir determined by using fractal theory are consistent with that from traditional method, but the method using fractal theory is much more objective, and also show this method is feasible and need further discussion and application.

Keywords: flood season staged fractal capacity dimension dynamic fractal dimension
flood water utilization Three Gorges Reservoir

Application of continuous ant colony optimization algorithm to parameter calibration of hydrology model

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Abstract: The successful application of a hydrology model depends on how well it is calibrated. For the highly complex nonlinear characteristic of hydrology model, it is really hard to obtain unique optimal values for their parameters using automatic calibration methods, if not impossible. The aim is to introduce the traditional ant colony algorithm optimization (ACO) which is fit in combined optimization into optimization problem in continuous space to identify hydrological model parameters. The new continuous ant colony optimization algorithm (CACO) combines ACO with evolutionary algorithms (EA). The CACO algorithm merges both population and genetic concepts of EA and preserves the original form of feasible solutions of the continuous problems. In the proposed algorithm, the ant is divided into global ants and local ants, which do global exploratory optimization and local exploitation optimization respectively. Ants deposit pheromone on the individuals that they selected and share the information in the ant colony, which leads to the positive feedback mechanism and accelerates the optimization process. The CACO algorithm and standard genetic algorithm (SGA) are used to evaluate the parameters of the Xinanjiang model (a conceptual rainfall-runoff model widely used in the humid area of China). The result shows that CACO algorithm is an effective method for solving the CRR model optimization problem, and more efficient and effective over SGA.

Keywords: parameter optimization; hydrological model; continuous ant colony algorithm; standard genetic algorithm

The spatial and temporal variability of soil moisture on grasslands on the Loess Plateau of China

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Abstract: Soil moisture is one of the most important factors to limit the plant growth on the Loess Plateau of China. Soil water content of 300 cm-depth at 20 cm intervals on three different grasslands were determined respectively on forage grass beginning growth stage (on May) and on stopping growing stage (on November) during the period from 1987 to 1999 to evaluate its spatial and temporal variability. The results showed that the soil water content at 0~20 cm and 160~300 cm were significantly higher than those at 40~140 cm. The soil water content of corresponding soil layers at 0~200 cm were higher on May than on October, especially on 0~80 cm. However, the 200~300 cm soil layer on October contained more water than on May. These results indicate that during the grass growth period (May to October), the topsoil water was further consumed, and the soil water in deep-seated soil layer was supplied. During 1987~1999, the variation coefficients of soil water content on each soil layer on May was significantly ($p < 0.05$) higher than those on October. This may be attributed to the factor that most rainfall (accounts for 80% of annual precipitation) occurred in the period. In addition, the variation coefficients at 200~300 cm soil layer were higher than those at 0~200 on both May and October. The water storage of 0~300 cm (WS) had a significant linear relationship with rainfall during May to October (RR) ($WS = 1.7483 RR + 34.804$, $*r=0.554$), rather than annual precipitation.

Keywords: Soil moisture; grassland; rainfall; long-term field experiments; Loess Plateau of China

Methods for System Programming of South-to-North Water Transfer Project in China

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Abstract: As the rapid development of society and economy in China, the heavy population and environment pollution have brought serious challenges in the water supply for domestic, industrial and agricultural sectors around the country, especially in the Huang-Huai-Hai area in North China. To support the sustainable development in the area, the South-to-North Water Transfer Project has been being developed to transfer water from a region with water surplus to a region with a water deficit. The project consists of three routes namely the Eastern Route, Middle Route and Western Route running through a number of provinces, and realizing a relational water resources allocation in the areas of Chinese four major basins. By 2050, the annual total water transfer will reach about 45×10^9 m³. To some extent, the success of the project, which is a large scale water infrastructure project without precedent, depends on intelligent research and planning. Therefore, how to design and plan it scientifically becomes more and more important. This paper mainly presents a set of methods for system programming based on recent research achievements to cope with the project's planning and optimizing. Specific ones are given here, for example Self-optimization simulation, Multi-layer disassemble and corresponding, Multi-objective conflict analysis and Marginal index optimization with different frequencies for project scale, among which the first is introduced in detail. The authors carried out several years' studies which demonstrated that the Self-optimization simulation technique was very effective in water resources planning and management for large-scale reservoir system. On the basis of the method, the Disallowing Water Transfer Line and Economical Water-cumulating Line were given and an optimum feasible area was determined subsequently. When applied to the South-to-North Water Transfer Project, the results revealed that the volume of water transfer and energy consumption could be reduced about 15% and 10% respectively. Besides, all other methods mentioned in the paper have been applied to optimal planning and operating of the East Route and Middle Route too, which received satisfactory results that could make the project all the more economic and rational, and also advanced water resources utilization ratio greatly.

Keywords: South-to-North Water Transfer Project, System programming, Method, Self-optimization simulation technique

Flood Prevention Paradigm for a Sustainable Society

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Abstract: Flooding should be expected. Similar to any other natural disasters, flooding is a natural phenomenon that occurs naturally and cannot be prevented. The best that human can do to prevent or to minimize destruction from flooding is to predict its occurrence and move away from it before it causes any catastrophic damage or to mitigate its hazardous impact through increased preparation for its arrival. This is the conventional flood mitigation paradigm widely adapted by the societies in the World today. As the starting point of most efforts for flooding problem, the results are very much going in line with the initial thought. Many flooding problems were successfully mitigated but almost none of these problems were entirely prevented. An analysis was done on the methodologies used by societies in the World on flooding problem. The objective was simply to identify the different mindsets of people in various places toward this problem. This paper presents the result of the analysis.

Flood risk in Asia – observations and predictions

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Abstract: In the last decades, there has been a worldwide tendency of dramatic increase in global flood damage, and even a stronger increase in insured flood damage. There are a number of reasons explaining this increase, which are related to changes in socio-economic, terrestrial-hydrological and climatic systems. One important factor triggering growth in flood damage is the anthropopressure. There has been a strong population growth, globally, and in developing countries of Asia. People increasingly encroach into flood plains. Some changes in land-use, which lead to changes in land-cover, such as deforestation and urbanization, also increase the flood risk. Traditionally, structural flood defenses are incorrectly interpreted by many stakeholders as a guarantee for flood safety. However, when (properly dimensioned) dikes break, there is a considerable damage potential, since riparians living behind the dikes trust that they are adequately protected. Finally, although no single flood event can be attributed as being caused by climate change, observed climatic changes such as increase in intense precipitation in some areas may lead to flood risk increase. Discussion of flood risk in developing countries of Asia is offered, both in terms of observations and projections for the future. The Asian continent has been subject to several record-high flood disasters in the last decade. The 1998 floods in China caused material damage at the level of about 30 billion US\$, beating the world record of all times, while the 1996 flood in Bangladesh caused inundation of over two thirds of the area of this densely populated country. The projections for the future are rather dramatic. Further growth of anthropopressure due to large increase in population is projected, exacerbating flood risk and flood vulnerability in the developing countries of Asia. Moreover, according to several scenarios and models, climate change signal is also likely to aggravate the flood risk in many areas. It is likely that intense precipitation and floods will increase in the warmer climate, consistently with the Clausius-Clapeyron equation. It is necessary to strengthen flood protection systems, since the present level of protection cannot be achieved with existing means and nations expect improvement of the flood protection level accompanying economic growth.

Soil moisture dynamic characteristics of Well-irrigation areas in Beijing Plain under comparatively deep groundwater table conditions

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Abstract: Since the 1980s, more and more groundwater resources have been extracted in the northern plains of China due to the lack of rainfall. As a result, the farm-land groundwater table has decreased while the storage capacity of soil has increased in the well irrigation areas. It is necessary to adopt suitable measures to reduce the runoff and evaporation losses, and to use flood water and runoff to recharge the local groundwater. In this paper, four years data on rainfall, groundwater and soil moisture from the water resources experimental area in south-eastern suburb of Beijing was processed in order to identify the dynamic characteristics of soil water under deep groundwater table conditions. The data was divided into three phases for each year--the period of spring irrigation, the rainy season and the period from late autumn to early spring, in order to analyze the dynamic characteristics of soil moisture in different seasons. The results showed that during the dry season, a small quantity of irrigated water or precipitation ($p < 80\text{mm}$) is mainly stored in 0~1m deep soil whereas during the rainy season, when the top of soil is relatively damp, the water will be mainly stored in 1~2.5m deep soil layer without surface flow appearing if the rainstorm ($p = 100\sim 150\text{mm}$) occurs. The research also shows that soil reservoir had very good regulation capacity and 85% of the normal annual precipitation was stored in the 3m deep soil (namely the soil reservoir depth). Therefore, if appropriate measures are undertaken on farmland before a heavy rainstorm occurs, there will be minimal runoff appearing and most of the precipitation will be stored in the soils.

Keywords: well irrigation areas; rainfall and runoff; groundwater; soil water dynamic state

Study on Evapotranspiration of Typical vegetation Communities in Taihang Mountains, China

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Abstract: In this research, the amount of evapotranspiration (ET) was measured for three typical vegetation communities in the Taihang mountainous areas using no-weighing drainage lysimeter, with size of 2.5×1.5×1.2 m (length×width×height). The vegetation communities include the local grass *Themeda japonica*, the local shrub *V. negundo* var. *heterophylla* Rehd, and the mixture between them. The impacts of slope on the measured ET was also examined by comparing the lysimeters constructed on the ground and slope. The effects of plastic cover on ET were compared for both the ground and slope lysimeters. The results indicated that ET has obvious seasonal change, with the peak in August. The amount of ET from July to September accounts for 66.3%-79.4% of total ET during the entire growing season. The total amount of ET in the mixture community is higher ET than *Themeda japonica* and *V. negundo* var. *heterophylla* Rehd. In addition, *Themeda japonica* has higher amount of ET than *V. negundo* var. *heterophylla* Rehd and the mixture community from May to June. These two months are typically dry in Taihang Mountain. *V. negundo* var. *heterophylla* Rehd has higher Water consumption rate per dry weight than *Themeda japonica* and the mixture community during entire growing season. The results indicated that the mixture community could be a good choice for vegetation recovery in Taihang Mountains.

Keywords: Evapotranspiration *Themeda japonica* Tanaka, *V. negundo* var. *heterophylla* Rehd Taihang Mountains

Evaluation of country water resources by a distributed global water balance model: A case study in Asia developing countries

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Abstract: Limitations in water quantity and quality are among the greatest socio-economic problems brought by population pressure and social transformations in Asian countries. Present and future estimations on water availability are crucial for various country level decisions. However, model estimation of runoff is meaningful only within nature catchment boundaries. New techniques are needed to simulate runoff exchanges along arbitrary administrative boundaries. Such exchanges create inter-dependence between political regions, e.g., nature water import or export from one country to another. Currently available water resources assessments at country level are based mainly on hydrological information on the main rivers extrapolated to areas where direct measurements were not available. The methodology used can not ensure consistency in the assessment methods from one country to another. In order to improve the comparability of the water information at the country level, in this study we provided model estimates of Asian country water resources. A global water balance model WASMOD-M was first implemented in the Asian land area. The model simulated runoff generation distributedly at a 0.5*0.5 degree resolution. Discharges at gauged stations can be reproduced exactly and discharges in ungauged areas were simulated based on best regionalized model parameters. Water flows were then tracked across country boundaries. Internal and external renewable water resources, and dependence ratio, i.e., the part of the total renewable water resources originating outside the country, among other factors, were obtained for each Asian country. Those factors were compared with previous estimates from various data compilations. The comparison has indication on quality of both the model simulated flow in ungauged regions, and those country water resource compilations. This study has the advantage of presenting a homogenous methodology for computing the country level water balance across the continent. The study also provides reliable information required for joint management of internationally shared water resources.

Estimation of evapotranspiration using Three-Temperatures Model (3T model)

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Abstract: Soil evaporation (E) and plant transpiration (T) are two main components of water consumption in ecosystem. Estimation of E , T , and evapotranspiration (ET) is highly required by water saving agricultural and sustainable use of water resource. To accurately estimate E , T , and ET , there are three challenges. One is the difficulty to separate ET into its two components, E and T . The second challenge is the heterogeneous of land cover because most of the available methods are applicable only to flat and uniform area, which is rarely ever exist in the natural ecosystem or even in farmland. The third challenge is that most of the conventional models for ET estimation is based on the measurements at points. Scale up of ET model to a heterogeneous area or to a regional level is difficult.

Based on energy balance theories, a model to use surface temperature to detect of E and T is proposed. Because three temperatures are the key components for the proposed model, it is referred as “three temperatures (3T) model”. As shown below, the critical components of 3T model are five equations.

Using a Linked Tidal Prism and Watershed Modeling System to Support Management of Bacterial Sources for Coastal Embayments in the Chesapeake Bay

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Abstract: Shallow coastal embayments in the Chesapeake Bay support highly productive living resources and serve as pathways through which terrestrial inputs enter the aquatic system. The possible transmission of waterborne disease has been a matter of concern among the water quality issues and public health problems in these shallow waters. The presence of bacteria in water can threaten public health through consumption of shellfish contaminated with these high bacterial concentrations. In the Virginia and Maryland portions of the Chesapeake Bay, there are numerous coastal shallow embayments designated for shellfish growing that are impaired by fecal coliform. Large amounts of bacteria have been discharged into the embayments resulting from surface runoff, failing of septic, and direct deposition from livestock and wildlife. To protect water quality for the public and control pollutant sources in the drainage area, there is an urgent need to know the spatial and temporal variations of fecal coliform in the embayment in response to loading changes from the watershed and establish assimilative capacities for these coastal embayments

To support the management of bacterial sources in the watershed, the Virginia Institute of Marine has developed an innovative source assessment and modeling system to address a variety of case-specific requirements related to water quality criteria, water use designations, source pollution conveyance methods, and establishment of assimilative capacities for coastal embayments. The system uses a database support technique and integrates a geographical information system (GIS), comprehensive data storage and management capabilities, a dynamically linked watershed-tidal prism model, and a data analysis/post-processing system into a convenient, PC-based windows interface. The GIS tools provide a capability for conducting spatial analysis to track bacterial sources in the watershed and to provide loads to the watershed model based on landuse categories. The watershed model, driven by hourly precipitation, simulates hydrology processes, bacterial accumulation, decay, and transport processes in the watershed. Simulated surface runoff and subsurface flow, as well as bacterial loads from the watersheds, are discharged to the tidal prism model. The tidal prism model simulates long-term bacterial transport in the embayment. The system has been successfully applied to establish assimilative capacities for coastal embayments for the states and proven to be efficient, easy to use, and coast-effective. A case study of the applied modeling system in the Poquoson watershed is also presented in this study to demonstrate the feasibility of simulating the fecal coliform distribution in the embayment and the capability of using the system to support management needs.

Experimental Studies on Soil Moisture and Photosynthesis of Fruit Tree by Using Super Absorbent Polymers

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Abstract: The experiment on fruit tree growth by using super absorbent polymers in these two years, analyze its effects on soil moisture, fruit growth, fruit yield and photosynthesis under the condition of using it together with Fulvic Acid. The result shows that super absorbent polymers can increase soil moisture, accelerate fruit growth, increase fruit yield and improve photosynthesis of the leaves. The production increased by 3600-4590kg per hectare and the economic benefit increased by 5480-6000yuan per hectare.

Keywords: Super absorbent polymers, Soil moisture, Fruit tree growth, Photosynthesis

Determination the Regional Relations of Floods in West of Mazandaran

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Abstract: There are various statistical and experimental methods to estimate the flood discharge. Results acceptability assurance necessitates considering limitations as well as environmental and hydrological conditions. In this research it is tried to analyze the floods in west of Mazandaran considering studying area separation to monotones hydrological units using different statistical methods like Index flood, Correlation equations series and Correlation equation method and proportions average. Finally according to the results, The best regional relations of floods in each monotones unit determined. The results show that correlation equations series and correlation equations with proportions average are used to analyze rivers with rainy-snowy flow regimes and snow-rainy regimes, respectively. In rivers with rainy flow regime, Index flood method is determined as the best way to analyze the flood.

Keywords :Flow regime, Index flood, Flood, Maximum discharge, Regional relations

Modelling and Predicting the Unsaturated Hydraulic Transport Properties with a New Characteristic Model

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Abstract: A recently developed water retention characteristic model for unsaturated porous flow has been incorporated with a statistical model of the unsaturated hydraulic conductivity [Mualem 1976]. Because the new water retention model provides an explicit expression of matric potential varying with water saturation, the combined model is able to investigate the connection between hydraulic conductivity and diffusivity. As a further test and application of the new water retention characteristic model, a set of soil data from UNSODA, which provides a complete measurements including saturation, water head, hydraulic conductivity and hydraulic diffusivity, has been modelled using the proposed combined model. The modelling results have been analysed, and good agreement with experimental data is demonstrated.

Keywords: Water retention characteristic, hydraulic conductivity, hydraulic diffusivity

The Integrated Use of Ground and Surface Water in Coastal Water-Absence Irrigation Region

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Abstract: Simulation and optimization methods of integrated use of ground and surface water have been used widely to determine operating strategies for regional water supplies. But in the studies of the integrated use of ground and surface water in coastal irrigation regions absent the investigation of ground water dynamic movement aroused by human and natural activities. So introducing the investigation of ground water dynamic simulation model into the integrated use of ground and surface water system in coastal irrigation regions is signification to the research of the integrated use of ground and surface water and sustaining development of irrigation in coastal irrigation regions. A coupled model, which can provide a method of the integrated use of ground and surface water with avoiding or controlling seawater intrusion, is developed to determine optimal water allocation policies for hydraulically connected time variant surface and ground water supplies in a hypothetical system. Coupling operation between sub-models can make the best use of the existent information and resources, and insure the share among parameters and validation each other, as a consequence, which increases the precision and efficiency of the integrated use of ground and surface water in coastal irrigation regions.

The main objectives of this paper are to (1) develop a ground water dynamic simulation model in coastal irrigation region;(2) develop a optimization model of water demand allocation of crops in coastal irrigation regions; (2) develop a coupled simulation-optimization model for ground and surface water supplies by considering ground water dynamic movement; (3) apply the coupled model in Weihai irrigation demonstration region.

The coupled model, maximizing economy net benefit and involving three decision variables: growing area of crops, allocation policies of ground water and of surface water in each sub-regions, is composed with two sub-models. Seawater intrusion is a common water-resources management problem in coastal irrigation regions. So one sub-model is ground water dynamic simulation model which is calculated by numerical simulation and can simulate ground water table with recharge and pump to avoid or control seawater intrusion, and another sub-model is optimization model of water demand allocation of crops which is calculated by the method of system analysis combined with development programming and can optimizes water demand allocation of crops. Use VB6.0 to program for the coupled model.

Applying the coupled model in Weihai irrigation demonstration region and eliciting the scheme of the integrated use of ground and surface water. The integrated use of ground and surface water project, controlling seawater intrusion, increases the volume of water supply by up to 151 percent than surface raw water supply in droughty years. The simulation indicates that the investigation is accord with the fact and is able to avoid or control seawater intrusion, and that the maneuverability of the research of the investigation is good.

Keywords: seawater intrusion , ground water , surface water, integrated use, coupled model

The Application of MAF Model for Flood Analysis On Upstream Citarum River Basin, West Java, Indonesia

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Abstract: Citarum River located in West Java Province, Indonesia with catchment area 6.080 Km², flow from the Mt.Wayang (1.700 msl) to Java Sea. Along the Citarum River, there are three reservoirs for hydroelectric power to generate about 1.350 MW and irrigating paddy fields more than 225.000 Ha.

Upstream Citarum River Basin is a mountain caldera with 8 tributaries and hold Bandung City, which known as Kotamadya and the capital city of West Java Province, with 2,5 million people. Related with rapid population and economic growth in this area, there have been changing in water cycle, shown by the increasing flood in the rainy season and water shortage in the dry season.

The annual flood in Upstream Citarum River Basin contains residential, industrial, and agriculture area inundated. Causing a great number of loses and inconvenient living among the people. The government has conducted several attempton for flood control, such as normalized the river flow by deepening and widening constructions as well as through reboisation, although it hasn't been able to reduce area inundated, due to land used change and land cover change (LUCC).

As anticipation to reduce the loses caused by flood, research was held to draw flood mapping for Upstream Citarum River Basin using Mean Annual Flood (MAF) method. This method has been appleid as National Flood Analysis Manual for Sumatera and Java Islands.

Research result of the flood mapping related to its return period can be used to identify the area and depth of area inundated. This flood mapping information can also be used as input for flood management conducted by the government with publics participation.

Application of Artificial Neural Networks to Modeling Flood Forecast

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Abstract: At present, researches on application of artificial neural networks to modeling flood forecast mostly focus on rebuilding the networks structure and optimizing training mode, viz. focus on ANN itself. But anything has itself form reason, and flood is impacted by rainfall characteristic and soil characteristic etc. The physical reason of rainfall-runoff is essence, but ANN is only method. So researches on how to combine effectively the physical reason of flood forecast with ANN is significant. At firstly, flood forecast model is divided into two kinds, one has many input joints and a single output joint, another has many input joints and many output joints, at the same time their applicability, existing problems and some things noticed are respectively analyzed. Secondly, some improving advice on selection of sample, disposal of input and output data, etc is proposed based on the form reason of rainfall-runoff and existing problems of flood forecast model. Finally, some previous rainfall and runoff data are used to demonstrate the viewpoints proposed. The chief contents and conclusions are following:(1) The physical reason of rainfall-runoff should be earnestly and carefully considered when model flood forecast using ANN;(2) Simulation of concentration of flow is better than runoff yield using ANN;(3) Propose a calculation mode in which rainfall series are input and runoff coefficients calculated in real time are used to revise the output. The mode is not only applicable to single-output model, but also to many-output model. Some previous data measured are used to check this mode, the results reveal that the mode can increase the calculation precision and stability of ANN flood forecast model.

Keywords: Artificial neural networks, flood forecast model, the physical reason of rainfall-runoff.

Allocation model of urban Multi-water resources for Multi-user and its application

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Abstract: With the development of society and economy, and constant enlargement of urban production capacity, the strain status of using water shortage frequently appears in many cities. Facing to the water resources shortage, the conflict between water supply and demand in city stands out; On the other hand, the disasters of flood and waterlog occur frequently; the amount of sewage (waste) water is increasing year after year, and the water environment is worsening, however the disposed sewage is let out without being used. In this paper, through analyzing the characteristics of Multi-water resources and Multi-user in city in detail, an urban multi-water resources system allocation model has been built. The multi-objective linear programming (MOLP) technique was applied to allocate multi-water resources among multi-user reasonably. The constraint set consists of the limitations of capacity of various water resources, the limitations of users for quality and quantity of water, the limitations of social economy and environment, etc. Taking the supply-demand of water in Dalian city in 2010, 2015 and 2020 as a case, by using the multi-objective compromise programming technique and the simplex method, the results show that the superior water for domestic is increasing gradually; the superior water for industrial and environment is decreasing, however the inferior water for industrial and environment is increasing; the water for agricultural is debasing. The allocation method also indicates an idea of supply water by water quality, which the superior water for the higher user, the inferior water for the lower user. In this way, the demand for fresh water will be less in city, and the conflict between water supply and demand will be alleviated; at the same time, the sewage from city will be reduced, and the urban water environment will be improved.

Keywords: urban water resources; reasonable allocation; model; Multi-water resources; Multi-user;

Measuring sustainable development of water resources with Aquatic Ecological Footprint in Guangzhou Based on ARIMA model

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Abstract: The emergence of Ecological Footprint Theory and calculation method affords us a reasonable tool to quantitatively analyze the impact that human's activities given on the ecosystem. For the sake of tracking the changes and basic characters of ecological footprint recently, time series method was used to deal with the long-term data. Based on statistics materials, this paper calculates the Aquatic Ecological footprint (AEF) of Guangzhou from 1949 to 1998 and analyzes its characteristics in different period. Aquatic Ecological footprint of Guangzhou can be divided into two periods: steady period (before 1978) and strikingly ascending fluctuant period (after 1978). The ecological footprint of aquaculture production is the dominant factor in Aquatic ecological footprint and its annually increasing extent is 6.37% on average between 1978 and 1992, which is notably related with the AEF; the deficit of AEF has also been quickly increasing since 1978, which seriously threatens the carrying capacity of the aquatic environment in Guangzhou. The predictability of Ecological Footprint (EF) is one of the concerns about the application research of EF for a long time. In this case study of Guangzhou, AEF was calculated and the calculated results were analyzed using time series method (ARIMA model). The results show: ARIMA (2,2,2) approximates the alteration of the AEF of Guangzhou from 1949 to 1993 well, the correlation efficient is about 0.98 and the prediction error around 5% between the calculated and the predicted data of Guangzhou AEF from 1994 to 1998, ARIMA(2,2,2) was used to predict AEF of Guangzhou(1999~2003) because it can interpret the trends of AEF well, the results are 0.5935hm², 0.6562 hm², 0.7147 hm², 0.7790 hm², 0.8402 hm² respectively. They suggest that the AEF will ascend in five years that possibly resulted by some social economical factors such as city development, the rising of population or demand for aquiculture production etc.

Keywords: the consumption of aquaculture production; aquatic ecological footprint; sustainable development; ARIMA model; time series

Neural network groundwater table Prediction model based on Levenberg -Marquardt Algorithm

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Abstract: Major factors influencing the groundwater table of irrigation are analyzed by the correlation method, and a neural network groundwater table prediction model was built based on Levenberg-Marquardt algorithm. The Levenberg-Marquardt algorithm is the combination of the steepest decent algorithm with the Gauss Newton algorithm, Compared with a conjugate gradient algorithm, an additional momentum algorithm or a variable learning rate algorithm, the Levenberg Marquardt algorithm is much more efficient than either of them on the training steps and accuracy, it is suitable for simulation of the nonlinear dynamic system. Therefore, it can be applied to predict groundwater table. The groundwater level prediction model is created using training data from the Hedong irrigation areas, Ningxia, the model is demonstrated that Levenberg-Marquardt algorithm is better than traditional nonlinear statistical methods, accuracy is improved distinctly in simulation of groundwater system, the learning rate is increased, Less coefficient of determination are needed to feed and easy to handle.

Keywords: groundwater table; correlation analysis; neural network; LM algorithm;

A Simple Method for Simulation of Flood Submerging Range based on GIS

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Abstract: The fundamental work in the Flood Risk Analysis is to simulate the flood submerging range that is included in the computation of flood process. The essential of the flood submerging simulation is to simulate the flood spreading process on the geographic space, the flood submerging range, submerging depth and the extent of disaster that was caused by the flood under various designed levels.

In this paper, Volume method was put forward to simulate the flood submerging range, which is based on Geographic Information Systems (GIS). The essential of the Volume method is that according to gravity characteristics that flood flows from high position to low and variation of terrain, the principle is used to simulate the flood submerging range, which could be expressed as that the flood volume bursting from the river equals the flood volume in the submerging range. Following this principle, the theoretical formula of the Volume method to compute the flood submerging range was put forwarded firstly; and then the discrete method was used to solve the numerical solution of this formula; finally, the model based on Volume method was built. And the computer program was developed to achieve the whole computing processes.

Data needed for Volume method are: (1) the flood volume bursting from river; (2) discrete elevation data in the submerging range. The formula of the broad-crested weir without bank was used to calculate the dike burst. And the whole process was realized with the computer programs written in FORTRAN. In addition, grid format of GIS was used to establish the discrete elevation data of the flood submerging range.

Finally, Volume method was used in analyzing Mudanjiang urban flood submerging simulation and the flood submerging simulation under the condition of the dam burst caused by one percent frequency flood was given.

Keywords: Volume method, flood risk analysis, flood submerging simulation, flood submerging range

Debris flow Investigation and Assessment in Panxi Area based on 3S technique

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Abstract: Debris flow hazards take place frequently in Panxi area, which are threatening people's life and their property directly or indirectly, and which have become a noticeable restriction factor of the sustainable development of social economy, therefore it is necessary to investigate the distribution of debris flow, assess its distributing characteristics, forecast its occurrence and take reasonable measures. The paper takes TM images, ETM images and SPOT images as the foundation information sources, and takes topographic maps and DEM as references. The RS images (TM images, ETM images and SPOT images) mentioned above are preprocessed through color synthesis, image fusion, and principal component analysis. Debris flow distribution information has been completely interpreted and mapped from the RS images preprocessed, through image recognizing and interpreting technologies based on geology knowledge. The environmental factors which gestate and trigger the debris flow such as the vegetation cover, the rock category, the ditch and slope, the basin plane shape, the terrain landform, the rainfall, the human activity et al are gained through other GIS analysis methods. The relationship between the environmental factors at different states and the development of debris flow are concluded and assessed, through the method of sample statistics.

A Simple Regional Evapotranspiration Model by Weather and Field Data

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Abstract: Hetao irrigation district is the third biggest one in China. Annual precipitation is no more than 200mm, nevertheless annual evaporation is approximately 2200mm. Therefore, crop water demand is supplied by irrigation. It commonly takes 5.1 billion m³ water for agriculture from the Yellow River every year. Annual irrigation occupies over 70% of annual evapotranspiration, so estimating regional evapotranspiration is of significance in water resources evaluation and management.

In this paper, a test area named Yonglian is chosen to study regional evapotranspiration. Test area has a size of 28.66 km², and the plantation's area is approximately 13.47 km², as much as 50% of the total area. Test area's evapotranspiration is estimated at different time scale (10d, 30d) by water balance method. Then the relation between main factors (intake water, soil moisture, depth of groundwater, land use and weather) and evapotranspiration in every time scale is analyzed, and a simple regional evapotranspiration model based on regional crop, soil, weather factor is established.

In the model, regional crop factor is determined using a function with growing degree days (GDD) as variable, and then regional soil factor is computed using soil water content and underground water depth as variables. ET₀ is computed by Penman-Montieth equation as weather factor, and regional evapotranspiration is estimated by multiplying these three factors. The verification is reasonable by hypothesis testing. This model provides a simple method for estimating regional evapotranspiration, at the same time, as test data are relatively limited, the model needs further test and maybe need a little revisal.

Keywords: water balance, regional evapotranspiration, growing degree days (GDD), ET₀

Study on Control Model of Optimal Allocation of Regional Water Resources

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Abstract: In this paper, the optimal allocation of water resources is studied from the viewpoint of cybernetics. The dynamic development in the optimal allocation of water resources is emphasized, and with the mended input-output model which is used to describe the compound system composed of regional water resources and social economy and environment, the optimal control model of sustainable-development-oriented optimal allocation of water resources is set up. Making use of the established model, the research on the optimal allocation of water resource under different water saving schemes in Jiangsu Province is carried out, datum such as production value and amount of water required in every sectors under different schemes in the period of planning are got and the pertinent advice are put forward which give reference for decision-making.

Keywords: water resources; optimal allocation; sustainable development; optimal control; input-output

The Study of time dependent boundary model of unconstant well flow in unconfined aquifer ground water flow due to hydrodynamic lag

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Abstract: In this paper, the author summarizes achievements of principles and technical knowledge relating to flow in porous medium, and takes the Initiative to study hydrodynamic lag in ground water flow systematically. Due to hydro dynamic lag character in phreatic aquifer, the ground water flow field can be divided into pertubating part and nopertubating part, that illustrates the boundary of phreatic aquifer is changeable .The degrees that the change of impervious boundary exerts influence over calculation of isolated well model in phreatic aquifer is analyzed. Thus, a physical model with time—dependent boundary in phreatic aquifer is established. The model with time dependent boundary can be superposition of a series of isolated well model with variable impervious boundary. Applied superposition principle, analytical solution of the model is derived.

Keywords: The groundwater flow in unconfined aquifer; The principle of hydrodynamic lag; Influence radius; Computation model of time—dependent boundary

A New Runoff Generation Model of a Basin Based on Physics Mechanism

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Abstract: At present, many basin runoff generation models are applied in hydraulic engineering practices all over the world. However, most of these models are regional with weaker theories and worse expanding attribute. The author thinks that in a rainfall, when rain intensity is larger than infiltrate intensity, ground net rain will form, or else ground net rain will be zero. When water quantity of soil attains field capacity rather than maximal holding water quantity of basin, the infiltrate intensity tends into stability and topsoil begins saturating, the water in the topsoil begins to infiltrate at a changeless velocity because of the pull of gravity. When gravity water arrives at the surface of shallow layer underground water, underground net rain forms. The intensity of underground net rain is as same as the infiltrate intensity of gravity water. When the last part of gravity water arrives at the surface of shallow layer underground water, underground net rain will end. According to the above runoff generation mechanism, this paper advances a new runoff generation model of a basin, which will get a rainfall time distributing of ground net rain and shallow layer underground net rain informed by measured mean rainfall、compositive infiltration curve、antecedent soil water、field capacity、maximal holding water quantity of a basin and so on. At last, the paper compares the model with others through an instance. The result indicates that the error of the model is less and it's attribute of expanding is better for its stronger theory.

Keywords: Runoff Generation Model; Ground Net Rain; Underground Net Rain; Field Capacity; Maximal Holding Water Quantity of a Basin

Evaluating the effects of land use changes on catchment hydrology by a modified Xin'anjiang eco-hydrological model

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Abstract: Land use changes have a great impact on hydrology including evapotranspiration, soil moisture, runoff generation, etc. In a large river basin there may be considerable variations in both climate and land use across the region. The potential impact of these variations on hydrological regime was assessed for the Hanzhong watershed in the upper reach of the Hanjiang River in China, using an approach of physically based modeling. Predictions of evapotranspiration and streamflow were made for various scenarios of land use and climate based on daily and hourly streamflow simulations by a modified Xin'anjiang eco-hydrological model. Results from the simulations show that land uses changes have a significant effect on the hydrology of the studied region. In the case of long-term daily streamflow simulations, converting forests to short vegetation covers generally leads to lower evapotranspiration losses and thus generates higher runoff rates. Meanwhile the hourly flood event simulations show that compared with short vegetation covers, forest covers usually produce lower flood peaks and delayed flood timing. This highlights the importance of the effects of land cover attributes on the hydrological cycle.

Research on Flood Water Resources Utilization of River Networks in littoral Area of South China

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Abstract: The river networks in littoral area of south China are generally developed areas. But with the rapid increase in water demands and gradual deterioration in water environment in recent years, the situation of inadequate water supply and drought-defying task becomes severe, which has affected local economic development and life quality. Therefore, it's necessary to research on flood water resources utilization of river networks in littoral area of south China. So far, research on flood water resources utilization focus on reservoir projects, which are based on the theory of dynamic control of the limited elevation in the flood season. However, the related research on plain river network is not paid close attention to. This paper discusses the problem from the point of optimal control of target control level.

The proposed target control level is the expected level of flood dispatch's terminal, and it lies on rainfall probability and water demand in following control periods. The higher target control level is, the more water resources are utilized. The supply task from reservoir to irrigated area is also relieved. Meanwhile, the flooded risk is also increased accordingly. In this paper, the model between target control level and potential losses is set up in accordance with computation for flood risk frequency, water demand in following control periods and analysis for history flood disaster. By solving the optimal problem the best equilibrium point, that is the optimized value of target control level, can be obtained.

By applying the proposed method, contradiction between flood dispatch and supply dispatch can be relieved, and losses of flood disaster and drought disaster can be reduced too. Moreover, this makes it possible to utilize flood water resources sufficiently and relieve serious supply-demand states. In this paper, a case of the WenHuang plain river network in TaiZhou city is studied. The dispatch results indicated that social benefit and economic benefit are satisfying.

Key works: flood water resources utilization; target control level; river networks

The establishment of evolvement model of saltwater intrusion based on GIS in Pearl River estuary, South China

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Abstract: The need and imminence of saltwater monitoring and predicting in river net of Pearl River Delta are clarified basing on the occurring and review of saltwater disaster historically. However, nowadays, most works still depend on field measurement, which spends a great deal of manual and material resources with low efficiency. Chlorosity, wind speed and velocity of runoff data of each observation station have been collected in recent years at Pearl River estuary, South China, when salt water intrusion occurred. The intensity, scope and time of saltwater intrusion are analyzed by spatial analysis of GIS combing local vector map based spatial data, and dynamic process which saltwater occurred, developed and weakened is simulated with advanced GIS. At the same time the relation among salinity, runoff, tidal current and wind speed is analyzed, then their function relation is induced, finally the evolvement model of salt water intrusion is established at Pearl River estuary, South China, which can provide decision basis for quick reaction after hyperspectral remote sensing monitoring of saltwater intrusion. So, corresponding measures are earliest adopted and disaster of salt water is reduced to minimization.

Keywords: Pearl River estuary, saltwater, GIS, evolvement model

Study on Flood Operation Model of Xiaoqing River Basin

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Abstract: Flood is one of the largest disaster in world, so some measures are taken to resist the flood. Reservoir flood operations are used extensively. A new linear programming method is brought forward to operate the reservoirs in the study area . The operation objective function is the maximal reservoirs storage obligated at each time interval . Some restrictions are put forward according to Xiaoqing River Basin. The ameliorative Fangshe Method is used to calculate the equation. The results show the model and method that are established in the paper are reasonable and feasible.

The use of Eigenvalues of reservoir bottom sediment particle diameter for determining the hydraulic conductivity and Estimating the leakage loss of the Beitang Reservoir

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Abstract: The status of water shortage in the coastal area of Tianjin City necessitated the planning and implementation of the Beitang Reservoir as means of regulating water supply and as a standby reservoir of the Middle-line Project of South-North Water Diversion. However the risk of massive water loss through leakage is a reality and needs to be reevaluated urgently. The hydraulic conductivity is one of the most important parameters in estimation of leakage; however, most of the methods for obtaining the hydraulic conductivity are rigorous. The Beitang reservoir water depth is about 6.0m and a barrier to in-situ hydraulic conductivity determination. Based on the particle-size analysis, the eigenvalues of reservoir bottom sediment particle diameter were obtained and the hydraulic conductivity of the same determined by using an empirical equation. Leakage loss is calculated using Darcy's law. The results shows that vertical hydraulic conductivity (K_z) values of the reservoir bottom sediment is 2.61×10^{-5} cm/s, which is close to the value obtained by the previous researchers (2.25×10^{-5} cm/s) before the rebuilding of the Beitang Reservoir. The total volume of leakage loss is $1116.16 \text{ m}^3/\text{d}$, and is close to the value obtained previously and much less than the evaporation loss, $2.33 \times 10^4 \text{ m}^3/\text{d}$. The results of the experiment also show that the region with higher risk is located at the northwest part of the reservoir. Considering hydraulic conductivity values determined previously as reference values, it is found that if direct methods are not available, it is of certain significance to determine hydraulic conductivity values of reservoir bottom sediment in the Beitang Reservoir, and the places with the same condition, by using particle-size distribution analysis tests. All the results are significant and could provide some useful suggestions for the future work.

Keywords: Leakage loss, Hydraulic conductivity, reservoir bottom sediment, Particle-size analysis

Analysis of Durative Drought Based upon Accumulated Aridity Index

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Abstract: The drought, especially durative drought, is a kind of natural disasters and become more and more important problem during the recent years that affected increasingly society, economy and environment. It was difficult to describe the phenomena of inter-annual durative drought by the Aridity Index because it was only a kind of the year or season drought index. In this paper a new drought index called Accumulated Aridity Index (AAI) was firstly presented to

express the characteristics of durative drought and the AAI was defined as $D_{acc} = \sum_{i=0}^n W_i D_i$

based upon the Aridity Index expressing as $D = \frac{E}{p}$ where D_i and W_i are the aridity and the weight of the i^{th} years respectively, n is the accumulated years, especially, if $i=0$, then $W_0=1$, $D_{acc} = D_0$, namely, Aaridity Index is the particular case when AAI equal zero. The weight W_i is better showed by harmonic progression expressed as $W_i = \frac{1}{2^i}$ where accumulated years $i=0,1,\dots,k$.

According AAI, it is gotten that the antecedent drought make persistent impact on the late and that effects and degree are different with antecedent drought status.

In this paper the durative drought were analyzed using the data of drought and flood from 1961 to 2001 in Tianjin region of China where it is a big city nearby the Beijing of China, and the characteristics of inter-annual persistence drought were well obtained by AAI. In Tianjin region of China the 2.91 is assigned as boundary marking the start of mild drought, 3.41 separating mild to moderate drought, 3.91 separating moderate to severe drought, and 4.41 separating severe to extreme drought. The results showed that the antecedent drought influence on the late drought is stronger when the antecedent drought is more severe, that the influence on the late is lesser when the antecedent drought is mild, that the influence on the late will be stronger when the severity drought years is nearby the late, and that the effects are milder when the severe drought years is far from the late. Therefore the AAI was much more feasible than the aridity to describe the drought, especially persistence drought.

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Groundwater recharge from precipitation in agricultural field in the piedmont region of the Taihang Mountains

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Abstract: Sustainable water use in the piedmont region of the Taihang Mountains in the northern part of the North China Plain (NCP) is under serious crisis due to the rapid depletion of groundwater caused mainly by pumping for agricultural irrigation. Assessing the amount of groundwater recharge is necessary in order to make suitable water use plan to limit the groundwater drawdown and to work out a best plan for irrigation and the South-to-North Water Transfer. However, there is still a large difference in quantifying groundwater recharge from precipitation from the earth surface. Wheat and corn are the two staple crops in the region, covering over 70% of the total cultivated areas and 46% of the total land area. To find out the possible recharge of precipitation to groundwater through infiltration in agricultural field, DSSAT-wheat and DSSAT-corn was run continuously through 1987-2001. The simulation results suggest that since there is a very large soil water storage capacity in the top 2 m soil profile (over 400 mm water from wilting point to field capacity), precipitation in most cases, will be kept by the agricultural field aside from one or two times of large rainfall events for instance the heavy rainfall in 1996, which caused large flooding in the plain. This was consistent with the analysis of field long-term soil moisture measurement. It is concluded that recharge from precipitation in agricultural field will be extremely limited.

Keywords: DSSAT-wheat model; Winter wheat; Corn; Precipitation; Irrigation; Groundwater recharge.

Study on Flood Prevention and Disaster Reduction Decision Support System in Xiu River, China

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Abstract: River Xiu is one of five tributaries in the river systems of Poyang Lake, eastern China. It flows through 11 counties (city and district) of Jiangxi Province with total drainage area of 14,493 in the upper reach of Yongxiu country, which accounts for 9.1% of the total area of Jiangxi Province, and the river extends 354 km. Zhelin reservoir, the largest soil dam built in China, is located at the end of middle stream of Xiu River, it controls 63.5% of total drainage area (14,700 km) of Xiu River and is a controlling works in Poyang lake area which functions on both power generation and flood detention. Generally, Xiu River suffers from flooding every 3 or 4 years. The over-basin floods occurred in 1954, 1977, 1981, 1983, 1995, 1996. Among those the floods 1977 was the largest. In 1977, the total flooding area was 63,000 hectares, most of the inundated located in the down stream of Xiu River as well as in middle and lower stream of Liao River. The Xiu river flood prevention and Reduction Decision Support system is a complex system centered at Zhelin reservoir and composed of reservoir, dykes, and flood detention regions. It is on the basis of timely and accurate information, precise forecast, efficient operation and proper decision-making that a decision-making supporting system for flood prevention and disaster reduction bring into play its functions. Such a system focusing on the Zhelin reservoir is necessary for the Xiu River flood prevention and it enhances the capacity of flood forecasting, flood control and disaster reduction for the whole basin. After accomplishment for 4 years since 2001, the system had become a necessary component to the Flood Control and Command System of Jiangxi Province, and it also serves for the National Flood Control and Command System, with significant contributions to the region's social and economic development as well.

Keywords: Flood prevention and Reduction, Flood forecasting, Flood control, Decision Support system, Xiu River

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Use of Variable Fuzzy Sets Methods for Desertification Evaluation

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Abstract: Many factors affect the desertification and the factors generally are not in the same scope, it also brings about a great difficulty for evaluating desertification. Under global view of system that the variable fuzzy sets method is presented to set up comprehensive evaluating model for desertification degree and transform the qualitative assessment into quantitative one. The method can scientifically and reasonably determine and relative membership functions of disquisitive indexes at level interval that relating to desertification, also it can fully use one's experience and knowledge, qualitative and quantitative information of index system to obtain weights of indexes for operating comprehensive evaluation. The numerical example of the dry and hot valley of Jinsha River has shown that the proposed method is feasible and effective, and it provides a new theory for desertification study.

Mid- and long term hydrologic forecasting of drainage area based on wavelet neural network and fuzzy optimization model

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Abstract Mid- and long term hydrologic forecasting of drainage area is a difficult issue in engineering design and hydrological process simulation. Combined with wavelet neural network to calculate and forecast the weight of model, fuzzy optimization model is used to fit and predict mid- and long term hydrological phenomena, and the regression equation with correlation coefficient that more than 0.90 is adopted as fit equation to evaluate and verify this process. The result shows that this method is reasonable and simple, and it can be applied for forecasting work.

Study on the Application of WPI in Assessment of Water Security of Main Basins in China

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Abstract: The factors that threaten water security include water resources shortage, water quantity problem caused by flood damage and water quality caused by water pollution etc. They cover such aspects as natural resources, environment, ecology, society, politics and economy. Due to the intrinsic characteristics and the lacking of essential information, the stochastic variety or uncertainty is obvious among these factors. So the quantitative assessment of water security is still unresolved and a continuing need for researching so that the situation of water security in a basin or region can be described clearly. In this paper, Water Poverty Index—WPI , which is a kind of monitoring index for reflecting the development of water section, is introduced for the assessment of water security. Combined with the actual conditions in China, WPI is improved in the aspect of calculation basis, and applied to six main large basins, i.e., the Yangtze River Basin, the Yellow River Basin, the Pearl River Basin , the Haihe River Basin, the Huaihe River Basin and the Songliao Basin.

WPI has five sub-components, including Resource(R), Access(A), Use(U) ,Capacity(C) and Environment(E). In this paper, the conventional composite index approach is used to calculate WPI by collecting the data of society, economy and that related with water quantity and quality in China. The results that WPI is used in the six main river basins show that WPI can provide the assessment for the development of water sector and water resource management, help the policy maker to carry on water resource management effectively and also illuminate clearly the factor that threaten water security of basins. Additionally, a grade-based method is suggested to classify the degree of water security, which is helpful for the building of warning mechanism of water security accidents.

Theory and Application of Urban Water Ecosystem Carrying Capacity

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Abstract: Urban water ecosystem is the principal part and key factor of urban ecosystem. The author first defines urban water ecosystem carrying capacity in terms of sustainable development theory, emphasizing its active function in keeping urban water ecosystem healthy. Then by applying the Controlling Theory, the author puts forward the theoretical model of urban water ecosystem carrying capacity, based on which the quantitative model including natural carrying capacity (NCC) and social renewable carrying capacity (SRCC) is presented. In addition, the author describes the health state of urban water ecosystem after making a comparative transformation relationship between carrying capacity and pressure. Last, the author takes Zhengzhou City as an example and analyses the relationship between carrying capacity and pressure in the local urban water ecosystem before making a reasonable evaluation for the health state of the system. It is shown in the conclusion that with the application of both Hydro-ecological Water System Construction in eastern part of Zhengzhou City and the Project of South to North Water Transfer, health state of the water ecosystem of the city is improved effectively in accordance with the request of sustainable development.

Keywords: urban water ecosystem, carrying capacity, pressure, health, Zhengzhou city.

The research of improving water resources security by floodwater utilization

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Abstract: Water resources security is an important part of water security. The conflict between the shortage of water resources and the flood disasters has threatened the water resources security greatly. To resolve the problem, this paper has mainly discussed the floodwater utilization, which can improve the local water resources security, meet the water requirement of regional development, and increase the water resources carrying capacity. The measures of floodwater utilization are introduced and the comparisons of the regional water resources security index before and after the floodwater utilization are made in this paper. The results show that the floodwater utilization is an effective way to improve the regional water resources security.

Keywords: water resources security; floodwater utilization; water resources carrying capacity; ISWD

An AHP-Based Fuzzy Evaluation Approach to Sustainable Resources Management

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Abstract: Resource is the basis of sustainable development. Water is the source of life. It is essential for survival and development of human beings. It is directly related to the national economy and the people's livelihood, the social development and the prosperity of nations. Disasters brought about by too little or too much water as well as water pollution restrict the sustainable development of the national economy. So it is imperative for us to solve the water problem and to carry out sustainable water resources management.

This paper summarizes the researching status quo of sustainable water resources management, analyzes and selects the evaluation indexes, and then establishes the analytical hierarchy figure. Aiming at the complexity and fuzziness of water resource system, this paper combines fuzzy theory with analytical hierarchy process and puts forward an AHP-based fuzzy evaluation approach which converts quantitative analysis into qualitative analysis. The method mainly consists of three procedures: establishment of hierarchy index-system, single-index evaluation and synthetic evaluation. The most important procedure is the second one. In this procedure, the weights of each index and the membership degree must be calculated on the basis of AHP and fuzzy sets theory. This approach is very easy to understand and its conclusion is more accurate. Through the conclusion, problems should be found out in the water resources management. So we can take some measures to improve it.

Comprehensive Evaluation Method for Groundwater Resources Carrying Capacity

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Abstract: Due to the shortcomings of dependent function used in matter element method, it cannot be applied to engineering fields. In this paper, variable fuzzy method is proposed. Its theoretical basis is definition of relative difference function, which can identify the degree that object magnetizes and repels features according to feature value, so variable fuzzy method is a new method for recognition. Since carrying capacity of groundwater resources and its evaluation are of fuzziness, the variable fuzzy recognition method can be done as a newly proposed method for comprehensive evaluation on regional groundwater resources carrying capacity, which is based on the theory of engineering variable fuzzy set. Using the proposed method, the authors analyzed groundwater resources carrying capacity in Guanzhong plain in Shanxi province. According to the rank feature value, a reliable groundwater resources carrying capacity evaluation of Guanzhong plain can be done. The conclusions are that evaluation grade of groundwater resources carrying capacity of Xi'an is between 2 grade and 3 grade that is close to bad level; that of Xianyang, weinan and Guanzhong plain are 2 grade that is general level; that of Baoji is between 1 grade and 2 grade that is of some character of preferable level. The case study proves that the model is reliable and the method is simple, and that results are reasonable and feasible. They are good model and method for comprehensive evaluation on various problems in water resources system.

Keywords: groundwater resources; carrying capacity; Comprehensive Evaluation; variable fuzzy recognition

Water Heterogeneity Monitoring using Remotely Sensed Imagery in Hunan Province, China

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Abstract: Remote sensing technique has been widely applied in water quality monitoring, since it can provide both spatial and temporal information. In this paper, we propose a new concept—Water Heterogeneity as one of water quality index and multi-temporal Moderate Resolution Imaging Spectroradiometer (MODIS) and Landsat ETM were used to estimate Water Heterogeneity by in Hunan province, China. First, we segment remote sensing image into many objects by a robust segmentation algorithm; and then inner- and inter-object's heterogeneity is estimated. The results of this study indicated that MODIS-based water heterogeneity estimation method could potentially be applied at large spatial scales to monitor water quality on a timely and frequent basis.

Keywords: Water heterogeneity, MODIS, Landsat ETM, Segmentation, Hunan province

Change on Water Circulation Mode Affected by Water Resource Development in Shiyang River Basin

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Abstract: Shiyang River Basin, 41600 km² in area, located in inland arid region of Hexi corridor and the plain in the Basin is important agricultural irrigation region of Gansu with low precipitation and high evaporation, the water resources are seriously shortage. The total water resources in the Basin is 1.66 billion m³, mainly used for irrigation, which occupied 90% of total water resources. Because of overuse of water resources, in particular over-exploitation of groundwater, the exploration volume of groundwater was up to 1.48 billion in 2000, resulting in continual descending in groundwater table and dried up of springs in the Basin, the water circulation modes in the Basin have changed greatly from the complicated mode of surface water to groundwater to surface water to a single mode of surface water to groundwater. The variety of mode have changed the spatial distribution of water resource in the Basin which leading the flow entering the lower Minqin Basin decreasing, the inflow was 542 million m³ per year in 1950s, but only 99 million m³ per year from 2000 to 2003, and groundwater had to be over-exploited, the volume of exploitation of groundwater was 700 million m³ in Minqin Basin, far than the inflow, and resulting in continuous descending of the groundwater table of Minqin basin. The change of water circulation mode already causes a serious of severe problems, the water-use contradiction between middle and lower basin became increasingly acute. Degeneration of vegetation, desertification, and drying up of springs and lakes as well as degradation of ecology occurs in the basins, especially in Minqin basin. Water shortage and the severe environmental problems have affected greatly the sustainable development of economy and society in the basin. To settle the problems caused by unreasonable utilization of water resource in Shiyang River, some effective measures must be taken. We must strengthen comprehensive management of water resources by scientific planning, to work out water division scheme between middle and lower basin, rational allocate and use the limited water resources, to develop high efficiency and water-saving irrigation agriculture and so on. Through these measures, to improve the water resources management for sustainable economy and ecology environment in the Basin.

Review on Numerical Models of the movement of unsaturated soil-water

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Abstract. Soil-water is the tache between the surface water and ground water, it is of great significance in water cycle, which closely relates to the agriculture, hydrology, environment etc. Soil-water research attracts more and more people's attention, and it has made remarkable strides. In fact, the movement of unsaturated soil-water is a hotspot of soil-water research, there also have been many numerical simulation methods in research. In the result of the development of computer technology, the numerical simulation of the movement of unsaturated soil-water could process successfully. In this paper, numerical simulation methods are discussed depending on the domestic and foreign studies, which include finite element mass-lumped model and finite volume model. We consider that the numerical simulation of the movement of unsaturated soil-water has made a mighty advance, but there is much work should to do. The research of this field is only in its prime.

Key words: soil water; numerical simulation; research review

Study on the Model of Irrigation and Water consuming of soil water Reservoir in Point Source infiltration under Film Hole irrigation

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Abstract: Based on the principle of soil water dynamics, a mathematical model of soil-water movement is presented for Point Source infiltration under Film Hole irrigation(PSIUSHI).Alternative direction implicit technique(ADI)is used to solve specific PSIUSHI model developed by the author. Through systemic contrast and analysis, the model of consuming of soil water reservoir in PSIUSHI shows that the model has good relativity. The error between laboratory test and forecast is satisfied. So this model can provide a practical and convenient way for forecasting irrigation quantity and date.

Study on Numerical Simulation of Jet in Coflowing Ambient

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Abstract: The mixing features when a sewage jet enters a finite depth coflow ambient are studied by numerical simulation. The standard k- ϵ turbulence model is employed to simulate the 3-D pure jets. The SIMPLE arithmetic and the Hybrid Finite Analytic Method (HFAM) are used to solve the simulation equations. The mathematical model and numerical method are verified by the experimentation data and the analytical values and can be applicable to the numerical studies on horizontal pure jet discharged in coflow. Based on a series of numerical calculation, the behavior of flow field that a jet enters a coflow is analyzed. The main influences of flow field and concentration distribution on the jet path are the value of velocity ratio (R) , the concentration distribute principles of change at different velocity rate is that bigger the ratio of jet initial velocity to environmental flow velocity is, more concentrative the concentration is comparing at the same place, the concentration trajectories on different cross sections are obtained subsequently.

Keywords: coflow; jet; turbulence model; numerical simulation

Non-point Sourced Water Pollution and the Protection **—— A Case Study in Guangdong Province**

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Abstract: The total length of the rivers in Guangdong Province is about 11,270 kilometers, of which 19% exceeds the national environmental standards in terms of water pollution. For the 132 reservoirs evaluated in 2003, 13% of them have been eutrophicated, while 87% are in middle level of eutrophication. The calculation outcomes show that rural sewage and solid waste, fertilizers and pesticides, dispersed livestock grazing, soil erosion and urban storm runoff are the five major non-point sources contributing about half of the pollution in the water system. And in this paper, some suggestions have been put out on how to control these non-point pollutions to make the water body cleaner.

Keywords: non-point sourced pollutants, water pollution, prevention and control measures

Countermeasures of Agricultural Non Point Source Pollution in Taihu Lake Basin

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Abstract: In recent years, the eutrophication of Taihu Lake has become much more serious. Water quality in Taihu Lake was partially improved with the point source pollution control, but the eutrophication of Taihu Lake hadn't been controlled because of the agricultural non point source, which has become the main pollution source of the eutrophication of Taihu Lake nowadays. This paper outlines the water pollution of Taihu Lake and the status of agricultural non point source pollution in Taihu Lake Basin, analyzes the components of agricultural non point source pollution. Finally, comparing to the experiences of Best Management Practices of controlling agricultural non point source pollution in North America and Western Europe, this paper discusses principles on agricultural non point source pollution control and puts forward the measures in order to control the agricultural non point source pollution from the aspects of laws and regulations, pollution sources, monitoring system, ecotechnological methods, economic measures, educating farmers and attracting stakeholders involvement.

Keywords: Agricultural Non Point Source(ANPS); Eutrophication; Taihu Lake Basin; Sustainable Agriculture; Best Management Practices(BMPs)

Evaluation of the uncertainties resulted from using six hydrological models in assessing hydrological impact of climate change in the Dongjiang Basin, South China

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Abstract: Uncertainties in future climatic scenarios resulted from using different global circulation models (GCMs) are a well-known fact in the scientific community. However, quantitative uncertainties in hydrological responses to the climatic scenarios resulted from using different hydrological models received a much less attention. Therefore, comparing and quantifying such uncertainties are of particular importance for water resources management of a catchment, a region and globe. In this study, potential impacts of human-induced climate change on water availability in the Dongjiang basin, south China are investigated using six monthly water balance models, namely Thornthwaite-Mather (TM), vrije Universitet Brussel model (VUB), Xinanjiang model (XAJ), Guo model (GM), WatBal model (WM) and Schaake model (SM). The study use 29-year records of monthly streamflow and climatic records in the Dongjiang basin. The ability of the six models in simulating present climate water balance components is first evaluated and the results of the models in simulating the impact of the postulated climate changes are analyzed and compared. The major results and contributions of the present study reveal that (1) all the six conceptual models have similar skills in reproducing historical water balance components, however (2) greater diversifies in the results exist when the models are used to simulate the hydrological impact of the postulated climate changes. The study provides an insight into the plausible changes in basin hydrology due to climate change, that is, to provide significant implications for the study of response strategies of water supply and flood control to climate change, uncertainties caused by hydrological modeling approaches must be a great concern.

Keywords: climate change; water balance models; uncertainties; hydrological impact

Flood Frequencies Analysis Transformed Model for Small Sample

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Abstract: This thesis is aimed to integrate the theory of nonparametric statistics and that of transference, establish nonparametric statistical transference models, explore their applicability in analyzing floods frequency, the present model improves the precision in small sample estimation, and provide an alternate method to floods frequency analysis. Firstly , the thesis reviews the condition of the application of nonparametric statistics in hydrology and water resources and points out the difference of nonparametric statistics and parameter statistics in calculation method as well as their advantages and disadvantages. Secondly, it suggests integrating the theory of transference and that of nonparametric statistics as its research focus. Thirdly, it establishes nonparametric density transference model, transference regression model, and floods frequency-analyzing model, which are all applicable to floods frequency analysis. Theoretically, it discusses the consistency and asymptotic behavior of nonparametric transference model, introduces the idea and methods of model building in detail and testifies the stability of the models by means of statistical experimentation. The main factor influencing nonparametric kernel estimation accuracy lies in the choice of kernel function and bandwidth especially bandwidth has an enormous influence on the result of kernel estimation. Adopting the method of transformed kernel estimate helps overcome the contradiction of non bias and minimum mean square error requirement and avoid the difficulty in choosing bandwidth. With the help of transference method, a new sample can be made available. For its corresponding function curve is smoother and the gap of the true value of the statistical points is smaller, using more smooth points can avoid making big errors/deviations. And what's more, optimal function is more even and bias is small, as a result, mean square error diminishes by choosing bigger bandwidth Finally, based on curve-fitting method and non-parameter model, analyses and calculations are conducted on the floods frequency of yearly maximum floods peak flow in Yichang Station, Xiaolangdi Station and Qinhe-based Wulongkou Hydrometric Station, the results of which proves the feasibility of the method. In particular, non-parameter transference model has better stability in contrast to the less ideal hydrological data of curve-fitting method.

Keywords: non-parameter statistics, kernel estimation, density estimation, bandwidth, kernel function transference, nonparametric regression, historical floods, frequency analysis.

Flood Utilization Integrated Risk Evaluation Model Based On D-S Evidence Theory

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Abstract: According to the serious problem of water resources shortage and deterioration of water environmental utilization becomes an important content in flood management and also a solution for above problems. However, flood utilization is a risk decision. In traditional risk evaluation theory, the uncertainty of event is concerned enough, but has few studies on the incompleteness of event and uncertainty of human's subjective decision. An integrated risk evaluation model of flood utilization is provided based on D-S evidence theory which can solve these problems successfully. With the case study, we get some benefit conclusions.

Keywords: Flood utilization D-S evidence theory Risk evaluation model

The study of Nokandeh dam in Golestan state in flood control using HEC-HMS model

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Abstract: However the flood is phenomenon that every one look at it as a destructive factor, but by using flood control methods, we can control destructive event and use it for expanding level. Hydrologic model such as HEC-HMS, is designed for simulation of rainfall-runoff process in watershed. By setting data that related to reservoir element, we can observe simulation flood hydrograph when reservoirs are built and recognize the effect of reservoir in flood control. Floods that happened in Nokandeh represent a real requirement of designing a plan for flood control. The purpose of this paper is the study of the function of Nokandeh dam in flood control. So the necessary parameters for running HEC-HMS model in after and before building of reservoir that related to design rainfall was introduced to the model. The results of running model show that the effect of this reservoir in flood discharge reduction is a few and we must notice the other ways for flood control and flood peak reduction in watershed.

Keyword: flood control, HEC-HMS model, reservoir, Nokandeh watershed, rainfall runoff process.

A new empirical model for monthly reference crop evapotranspiration estimating in zhalong wetland

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Abstract: The main purpose of this research is to establish an easy applied expression for monthly reference crop evapotranspiration (ET₀) estimating in Zhalong wetland region, and it should approach the P_M model than other commonly used models in local ET₀ calculating. By fitting the Penman-Monteith (P_M) model, a new empirical model coupled with four meteorological variables was established; the meteorological data needed in this study comes from eight weather stations around Zhalong wetland from 1966 to 2000. The study site lies in the down river region (typical reed swamps growing) of Wuyuer River, a branch of Nenjiang River, and Shuangyang River.

Statistical relationships between variables and ET₀ were analyzed to select basal independent variables of model; multicollinearity was detected to avoid bringing high related variables. Consequently, several combinations of meteorological variables were selected, which influence ET₀ in this region obviously. In order to choose the most fitting expressions, three main fitting models linear, exponential and polynomial of degree n were compared. According to the most 2 fitting correlation coefficient (R) and the least root mean square error (RMSE), the nonlinear exponential model with the combination viz. the maximal temperature and the minimal temperature plus precipitate on plus wind speed was selected. Referring to the classical P_M model, three commonly used empirical models, Blaney-Criddle (B_C), Priestley-Taylor (P_T) and Hargreaves (HG) were compared to the new model, and the comparison was first made using the original constant values involved in each model and then made using the recalibrated constant values. The result shows that the new model improves the R² to P_M model and reduces the RMSE for both stations markedly. So it can serve as a useful tool, for monthly ET₀ calculations and farther study of climatic change on hydrological response in Zhalong wetland region.

Keywords: Fitting empirical model, Penman-Monteith, Priestley-Taylor, Hargreaves, Blaney-Criddle, reference crop evapotranspiration, Zhalong wetland

Study of the hierarchical strategies and management for ecological water demand in arid inland river basins in northwest China

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Abstract: Given the increasing threat of water shortages in the arid inland river basins in northwest China, Water resources are not only valuable natural resource, but also an important environmental factor due to the low precipitation and the dry climate. Ecosystem is strongly depends on water resources. Human impact on the water supply will certainly cause a chain reaction within the ecosystem. Especially in recent decades, with the increased intensity of human activities and overuse or misuse of water resources caused a series of environmental problems. The wetland area has varnished in great quantity, the natural vegetations have fully degenerated, the land salinization has become intensified, coverage percentage of land has reduced, desertification has aggravated. These problems were important factors to affected ecosystem safety and sustained development in the arid inland river basins in northwest China. Environmental degradation has become the research focus of many scholars in recent decades. Therefore, it is very necessary to understanding deeply the ecosystem system for the social economic system, reasonable make sure that the dry inland river area ecosystem uses the water, the quantity slices the solid guarantee also, is important link that resolves the northwest and dry inland river area ecosystem environment to worsen the problem. Take an example for Shi Yang River, this paper analyzed ecosystem hierarchical structure which was drove by water moisture conditions in the lower reach of the dry inland river region, and bring forward the hierarchical strategies and the management way, Based on this, the paper studied the hierarchical strategies and management problem of water demand by the eco-environment of Minqin oasis in the lower reach of Shi Yang River.

Keywords: Arid inland river basins; Hierarchical structure of ecosystem; Ecological water usage; Hierarchical strategies and management.

A nonlinear perturbation model based on Artificial Neural Network

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Abstract A nonlinear perturbation model (NLPM) based on Artificial Neural Network (ANN) is proposed and developed. The NLPM-ANN model structure is similar to that of the Linear Perturbation Model (LPM). The difference is that ANN, instead of the linear response function, was used to simulate the unknown relationship between the input perturbations and the output perturbations. Eight watersheds, across of a range of climatic conditions and watershed area magnitudes located in China, were selected for testing the daily rainfall-runoff forecasting ability of this model. The proposed model was also compared with the LPM, NLPM-API, and two different ANN models. It is shown that the model efficiency of NLPM-ANN model is significantly higher than that of the LPM. The results demonstrate that the relationship between the perturbations is high nonlinear though subtracting the seasonal means, and ANN is capable to simulate this relationship. Comparing with the NLPM-API, the NLPM-ANN also shows advantages in simulating the nonlinear relationship between the rainfall and runoff. The results also indicate that consideration of the seasonal information can improve the model efficiency of not only the linear models but also the ANN models. Subtracting the seasonal means, which is adopted in the LPM, is also a feasible way to reduce the system complexity and improve the model efficiency of ANN models.

Keywords: flood forecasting, Linear Perturbation Model, Non-linear Perturbation Model, Artificial Neural Networks

Studying and Application for Facing the Integration Method of the Flood Control Decision Subject

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Abstract: Through the analysis of application subject of the flood control, the paper is to establish the topological relationship between the flood control entities in various river basins using the thought of data structure and the method of data elements. Adopting the database technique, facing the integration method of the flood control decision subject, separation method and control technique of the user interface and application program, to establish the elicitation method of flood control information service based on the professional knowledge, facing to the subject of flood control, the model is integrated into the experiences and knowledge about the flood control, which have significant realistic meaning for the flood control.

Keywords: Decision Subject; Information Integration; Flood-control; DSS

Framework of Data Integration on Hydrology and Water Resources

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Abstract The data integration is a key problem for research on the digital hydrology and water resources. The data of hydrology and water resources were usually stored in databases for different locations and structures. These databases are not only of inconformity in forms, but also in semantics, especially, for hydrology and water resources analysis and forecast in a complicated basin. Therefore, development of a framework of data integration on hydrology and water resources based on the Service-Oriented Architecture is necessary. This framework characterizes loosely coupling, and binding and processing data in order to integrate a large-scale data share the information resources, and reduce difficulty of the information system development. Following the framework, we can improve reliability and portability of the information system for hydrology and water resources.

Key words data integration; framework; information system; hydrology and water resources