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Simulation of future climate change effects on rice water requirement and water use efficiency through multi-model ensemble

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Abstract: Considering the uncertainties of climate models and downscaling methods in the assessment of climate change impact will help us obtain more credible results in the simulation of rice water utilization response to future climate change. In this paper, two Global Climate Models named HadCM3 and CGCM3 under three climate scenarios (A1B, A2 and B2) were downscaled by Statistical Downscaling Model (SDSM) and Back-Propagation (BP) artificial neural network respectively, then the four downscaled results were merged by Bayesian model averaging (BMA) method. Rice growth duration, yield, water demand and water use efficiency in two future stages (2050s and 2080s) were simulated by ORYZA2000 rice model based on BMA merging results. The results show that (1) the BMA method is more competent to produce low bias in comparison with simple model averaging (SA) method; (2) in the two future stages, rice yield and growth duration would decline remarkably as the increasing of temperature and decreasing of solar radiation; and (3) water demand falls as the solar radiation, while in 2080s, the quickly increasing of temperature will bring the increase of water demand, but the value still higher than the historical reference stage, and the decrease of water demand cannot offset the negative effects on water use efficiency brings from yield decline.

Key words: climate change; Bayesian model averaging(BMA); uncertainty; water use efficiency; ORYZA2000 rice model

Assessment method of water resources carrying capacity based on dynamic trial calculation and feedback: a case study on the Yihe River (Linyi section)

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Abstract: Development of human society makes water resources and environment become increasingly prominent, and the conventional water resources carrying capacity cannot meet the needs of water resources planning and management. By constructing balance equation of the quantity-quality and available surface water resources calculation method of water function regionalization for water quality objectives, this paper puts forward water resources carrying capacity model, which based on population size and GDP index. This model uses a method of population spatial distribution so that socio-economic indicators can be divided into water resources partitions, and utilizes the balance of domestic water under carrying level and class Ⅰ - Ⅲ amount of water resources to text the results. It considers the dual constraints of water quality and quantity on water resources carrying capacity, and also reflects the dynamic nature of available surface water resources. Case in Yi River basin, selecting COD_{cr} as pollution control indicators, this paper analyses and calculates its water resources carrying capacity in different years, which validates the rationality and science of the model. The results of the calculation can assess and forecast its carrying level in the future, as well as providing for the basis of the sustainable development of basin/region.

Key words: water resources carrying capacity; assessment method; dynamic trial calculation; joint water quality and quantity; Yihe River

An efficient risk assessment method for landslide dam breach: Taking the Hongshiyan Landslide Dam formed by the 2014 Ludian Earthquake as an example

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Abstract: A landslide dam was triggered by the Ms 6.5 Ludian earthquake on 3 August 2014 in Yunnan Province, China. The Hongshiyan landslide dam, with a height of 83 m and a lake capacity of 260×10^6 m^3, threatened the people both upstream and downstream. The existing methods are very difficult to carry out effective and quantitative risk assessment to landslide dams before dam failure, because of the dangerous geologic environment, road blockage, and short longevity of landslide dams after the earthquake. This paper presents an efficient risk assessment method for landslide dam breach with limited geometric information of landslide dam and lake and resident population: firstly, three-dimensional digital models for the lake, dam and river are built with geographic information tools; secondly, a statistical dam breach model and a hydraulic software, HEC-RAS, are applied to simulate the dam breaching and flood routing process; finally, human risks are assessed using a human risk assessment model, HURAM. It is found from risk assessment of the Hongshiyan landslide dam with the presented method that the breaching flood and human risk will be obviously reduced by constructing the spillway, but dam breaching could not be avoided. The dam safety and corresponding human risk can be temporarily controlled by excavating the drainage branch tunnel, however, the dam would be breached and cause high human risks under some extreme flood conditions (e.g., a 100-year flood). Therefore, reinforcement measures, monitoring and contingent plans are needed. The present method can be used for efficient and quantitative risk assessment of sudden unexpected landslide dams, providing the basis for the emergency management and decision.

Key words: Ludian earthquake; Hongshiyan landslide lake; dam breach; peak outflow rate; flood routing; risk assessment

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Numerical study on flow of newly vortex drop shaft spillway

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Abstract: To overcome the limitations such as commonly vortices in inlet and complicated cavitation control measures of vortex drop shaft spillway, a novel shaft spillway which consists of submersible and spiral-flow-generated piers and morning glory weir was developed. Compared with the traditional morning glory shaft spillways, such newly interior energy dissipater has much difference in the hydraulic characteristics such as vortex flow and corrosion resistance mechanism. Based on the spillway project of the Qingyuan pumped storage power station, the behavior of the newly type of inlet and the performance of the vortex drop structure was investigated and simulated by using commercial computation hydromechanics software. The hydraulic characters such as the flow pattern, air core distribution, position of the annular hydraulic jump, pressure and water profiles of the outlet tunnel were obtained. It shows that such distributions of the above hydraulic elements agree well with the measured data. Besides, the simulated results help to reveal the self-adjusting mechanism and energy dissipation principle of the newly vortex drop shaft spillway.

Key words: vortex drop shaft; shaft spillway; submersible blocks of spiral flow generator; hydraulic characteristic; numerical simulation.

An analytical model for nonlinear flow parameters of fractured rock masses based on high pressure packer tests

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Abstract: The permeability of fractured rocks is an important hydraulic property for seepage analysis and design of seepage control system in the surrounding rocks around an underground tunnel subjected to high water pressure. High pressure pack test (HPPT) is an effective technique for characterizing the permeability in the fractured rocks under high water pressure. Based on the nonlinear characteristics of the P–Q curves, a Forchheimer's law–based analytical model was established to estimate the nonlinear flow parameters of the tested rocks(hydraulic conductivity k and nonlinear parameter b). Given that the expression of k is consistent with the Hvorslev equation recommended in the currently–applied codes of borehole water pressure tests, the proposed model is hence an extension of the recommended formula from Darcy's to non–Darcy's flow condition. With its simple form and clear physical meaning, the proposed model could be treated as an important basis for revision of the codes of borehole water pressure tests under high injection pressures. The proposed model was validated against the in–situ measurement data obtained in the HPPTs conducted in the surrounding rocks of a branched tunnel section at a pumped storage power station located in Qiongzhong County, Hainan Province. It is demonstrated that the nonlinear characteristics of the P–Q curves obtained in the HPPTs could be well interpreted by Forchheimer's law, and the proposed analytical model provides an effective approach for reasonably evaluating the nonlinear flow parameters of fractured rock masses and reducing the risks in the design of a tunnel system under high water pressure condition.

Key words: fractured rock masses; permeability; high pressure packer test; analytical model; nonlinear flow; hydraulic fracturing

Numerical simulation of reinforced concrete lining considering the interaction with thesurrounding rock

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Abstract: The way simulating the lining structure accurately considering the interaction with the surrounding rock is one of the focuses of geotechnical engineering. This paper brought a method ("entity elements combine with structural elements") to simulate the reinforced concrete lining, and realized the method in a numerical simulating software. The proper values of the parameters concerned were searched afterward. Conclusions are following: ① the recommended formula of the interface stiffness between the steel bars and the concrete in the FLAC USER`S MANUAL is more suitable; ② strong consistency with the practical stress of the reinforcing bars was showed when 0.55*radius of the bars was substituted in the thickness of the interface. The reasonableness of the conclusions has been verified by comparison between numerical and analytical solutions in compression and bending tests. The applicability of the conclusions was verified by comparison with the measured stress of the reinforcement bars of the NO.4 flow tunnel in Jinping II Hydropower Station. The conclusions of this paper will show its value on the determination of simulation parameters in the further engineering.

Key words: reinforced concrete lining; numerical simulation; interface parameters; FLAC

Reconstructing the release history of groundwater contamination sources based on the Bayesian inference and improved MCMC method

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Abstract: Reconstructing the information of groundwater contamination sources effectively, is not only the foundation of designing a reasonable remediation project, but also the basis of governing pollution in accordance with the law and dividing the responsibility. In this paper, a promising approach was presented, according to which the recovering approach was considered as a Bayesian approach and combined with Kriging surrogate model. In addition, an improvement plan was proposed based on the Metropolis sampling algorithm. According to the results: (1)the new method can recover the release history of groundwater contaminant sources efficiently, whose results' average relative error is 3.45 %; (2)the improved Metropolis algorithm enhances the efficiency and accuracy of the inversion results obviously, which can decrease the average relative error from 57.41 % to 3.45 %, with the condition of 500 iterations; (3)the final results are stable, while the disturbance and difference between magnitude during different periods exist.

Key words: contaminant source identification; Bayesian inference; surrogate model; improved Metropolis algorithm; release history

Study on the characteristics of rainfall infiltration runoff using artificial simulation experiment in Wenchuan Earthquake Area

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Abstract: The Wenchuan earthquake led to a lot of landslide deposits, which triggered mountain collapse and secondary geological disasters under the condition of rain washing out. In this article, the landslide deposit was chosen as the research object in the Wenchuan Earthquake area, and the slope runoff and infiltration principle of the landslide deposit was researched by using indoor artificial rainfall simulation method under the conditions of different rainfall intensities and earth rock ratios. The results show that: (1) There was no runoff under the conditions of the earth-rock ratio of 1∶4 and the earth-rock ratio of 1∶2 at the rainfall intensity of 1.0 mm/min, the runoff time of deposit decreased with the increasing rainfall intensity, but the runoff rate was opposite and the average flow rate of earth-rock ratio of 1∶1 was greater than that of 1∶2. (2) The infiltration showed significantly different laws under the three kinds of earth-rock deposit and rainfall intensity, and the Horton model was the most suitable model to describe the infiltration on Wenchuan Earthquake landslide deposit. (3) The cumulative runoff of earth-rock ratio of 1∶1 was greater than that of 1∶2 under the conditions of 1.5mm/min rainfall intensity while the cumulative runoff of earth-rock ratio of 1∶1 was equal to the earth-rock ratio of 1∶2 under the conditions of 2.0mm/min rainfall intensity. This study provides strong experimental basis for managing the Wenchuan earthquake landslide deposit.

Key words: Wenchuan earthquake area; landslide deposit; runoff; artificial rainfall

PA-DDS algorithm for multi-objective reservoir operation

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Abstract: PA-DDS (Pareto-Archived Dynamically Dimensioned Search) is one of the multi-objective evolutionary algorithms designed to obtain multiple solutions, which offer different trade-off of the problem objectives. The algorithm was introduced into reservoir operating rule curves optimization for the targets of water supply and power generation, and compared with NSGA-Ⅱ (Non-dominated Sorting Genetic Algorithm Ⅱ) and MOPSO (Multi-Objective Particle Swarm Optimization) in convergence. Furthermore, the performance of PA-DDS and NSGA-Ⅱ are also analyzed in distribution and approximation between whole Pareto fronts of non-dominated solutions. The capacity of PA-DDS solving multi-objective reservoir operating problems and optimal rule curves were analyzed. It is shown that PA-DDS algorithm performs better than NSGA-Ⅱ algorithm in getting the non-dominated solutions. The optimized rule curves can effectively mitigate the conflict between water supply and power generation by dramatically increasing (8.07 %) the water supply yield with slight decrease (0.96 %) in power generation, and can improve the economic benefit by 55 million yuan annually.

Key words: operating rule curves; multi-objective optimization; PA-DDS algorithm; Danjiangkou reservoir

Study on a new method for flood frequency analysis

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Abstract: In order to solve the problem of linear limitation for flood frequency analysis in parametric method and avoid the complex process for choosing the kernel function in nonparametric method, a new flood frequency analysis method based on probability density evolution method is proposed for calculating the flood frequency value. Firstly, a joint probability density function model of annual maximum peak discharge is established based on the introduction of probability density evolution method. Secondly, the one-sided difference scheme which has the characteristic of direction adaptive is adopted to solve the model, and then, the numerical results of the model are integrated to get the probability density function of peak discharge. Finally, the probability density function of peak discharge is used to deduce the frequency value of peak discharge via the cubic spline interpolation and trapezoid method. Taking the Shimen Dam in Taiwan and the Dalai hydrologic station located at the downstream of Nen River in Heilongjiang Province as examples, the flood frequency of them are analyzed. The results show that, the flood frequency curve agrees better with the empirical frequency plots by using the probability density evolution method than the curve fitting method that is widely used. And the method based on probability density evolution method is an effective way for hydrologic frequency analysis.

Key words: probability density evolution method; annual maximum peak discharge; flood frequency analysis

Study on ecological compensation standard of green water management based on SWAT model

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Abstract: Green water is invisible water also results from precipitation and permeates into the unsaturated soil and for plant growth. Corresponding with blue water, green water is an important part of freshwater systems that to maintain the landscape coordination and balance. Visible blue water has been mankind's concerned focus in terms of water use and management, while the management and utilization of productive green water was ignored. The Upper Du River in Water Resource Area of the Mid-route of South-to-North Water Transfer was taken as study area, and green water management and ecological compensation were combined to build the framework of ecological compensation based on green water management in water resources area. The implementation effect of green water management measures was simulated by SWAT model in order to determine the ecological compensation standard. The results show that four green water management measures such as bench terraces, stone lines, mulching and contour tillage are produced good benefits in water conservation, soil conservation and water quality protection etc. The average benefit-cost ratio is greater than 1, so four green water management measures are suitable for application and promotion in Water Resource Area of the Mid-route of South-to-North Water Transfer. The ecological compensation standard of green water management is 17.84 million RMB per year, as well as 343.5 RMB per hectare. The mechanism for green water management ecological compensation has an advantage of sustaining and stable, that could improve farmer's enthusiasm and provide a reference for other water resources area in ecological compensation.

Key words: green water management; ecological compensation; SWAT; water resources area

Research on initial formation and attenuation of landslide-generated waves

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Abstract: An experimental model system is designed to study landslide-generated waves, a high-speed camera is used to film the forming process of landslide-generated waves and a system of multi-functional monitor is applied to record the height of landslide-generated waves along the channel. The formation and the attenuation of landslide-generated waves are revealed. After the landslide body with high speed rushing into the water, waves are generated firstly from swash to forward fall and then back collapse. Introducing a landslide-generated wave pattern Froude number, the initial form of landslide-generated waves is divided into three kinds: conventional landslide-generated waves, translation landslide-generated waves and jump landslide-generated waves. Conventional landslide-generated waves presents stable waveform, translation landslide-generated waves slowly attenuate to conventional landslide-generated waves, and jump landslide-generated waves first attenuate to translation landslide-generated waves and then to conventional landslide-generated waves.

Key words: landslide-generated waves; initial form of landslide-generated waves; conventional landslide-generated waves; translation landslide-generated waves; jump landslide-generated waves; attenuation

Multi-reservoir operation using elite-gather social spider optimization

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Abstract: The novel meta-heuristic social spider optimization (SSO) provides a new effective way to solve the multi-reservoir optimal operation problem. However, SSO has some disadvantages like premature convergence and poor search ability. Thus, the elite-gather social spider optimization (ESSO) is proposed to alleviate the existing defects of the SSO. ESSO takes advantage of the elite individual to guide the evolution of the population for the globally optimal solution. Moreover, the neighborhood search mechanism is introduced into ESSO to improve the local search ability of the method. The proposed approach is applied to the optimal operation of Lancang River cascade reservoirs, and the results shows that ESSO can improve the convergence property and robustness of SSO. Thus, ESSO is a feasible method for the multi-reservoirs operation problem.

Key words: multi-reservoirs; optimal operation; social spider optimization; elite guide; neighborhood search; mutation mechanism

Research of discharge calculation model based on genetic programming applied to South-to-North Water Diversion Middle Route Project

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Abstract: South-to-North Water Diversion Middle Route Project is a linear project which has none regulating reservoirs and many water diversion gates, very difficult to dispatch. Calculation for flow rate is important to water dispatch which is used to adjust flow rate in order to achieve water plan, At present, calculating methods involves traditional hydraulics formula and manual parameter calibration which is inflexible. The paper established discharge model based on genetic programming which is used in South-to-North Water Diversion Middle Route Project to calculate flow rate automatically. The results showed the model has strong adaptability, flexibility and high fitting accuracy.

Key words: South-to-North Water Diversion Middle Route; genetic programming; flow rate