Groundwater Controlling Level in Luliang County

Fu Dongshuai[1,2], Zhang Daiqing[2], Tao Chaoyu[2], Yang Qiuping[2]
(1. Kunming University of Science and Technology, 650500, China ; 2.Qujing Branch of Yunnan Hydrology and Water Resources Bureau, 655000, China)

Objectives

Groundwater resource is an important part of water resources. Chinese relevant departments have organized the work to establish the control index of groundwater. At present, the groundwater controlling level in non-overexploited areas is mainly determined by the mean value of groundwater level for many years.

Local authorities have been monitoring groundwater levels in Luliang County since 2018 in Xiqiao and Zhongshu, and obtained a series of short observations. To address the data is shout, we try to build a model with hydrological data on precipitation, evaporation, and runoff from the Nanpan River to calculate groundwater levels in this area from 1979 to 2022 and define more scientifically groundwater controlling levels.

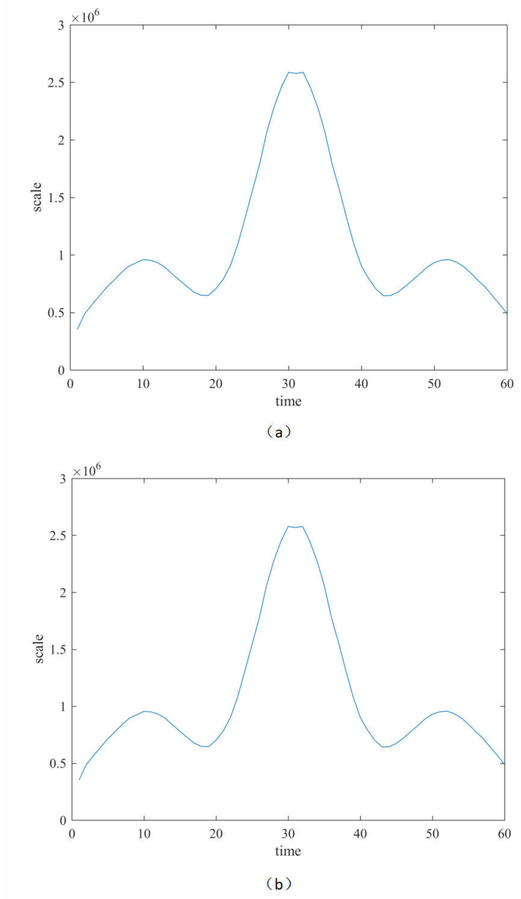

Fig 1 Wavelet square difference of Xiqiao(a), Zhongshu(b).

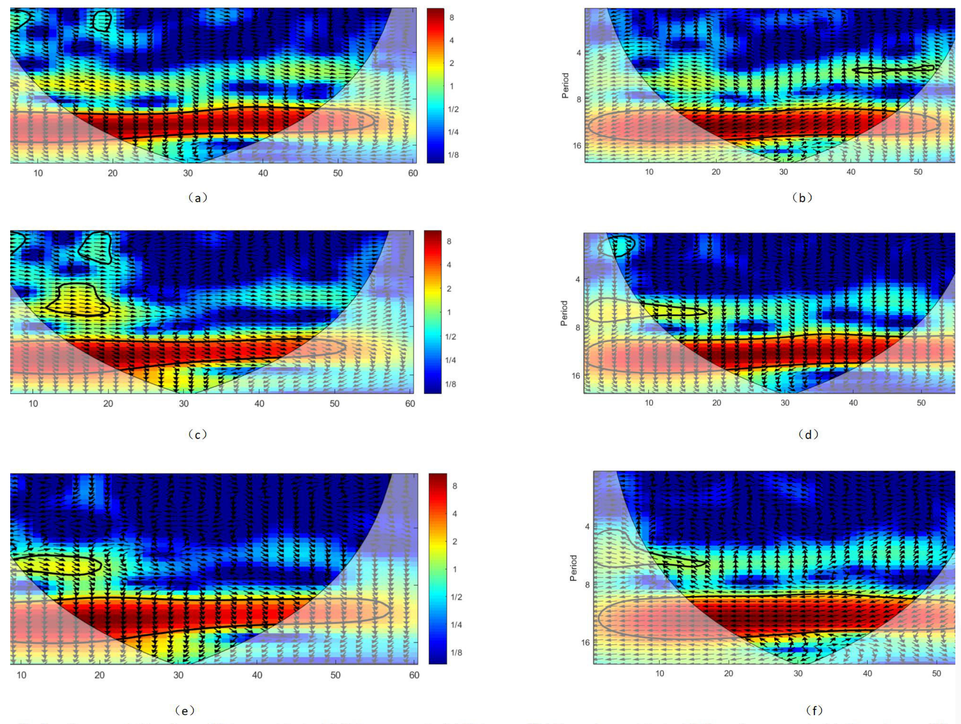

Fig.2 Cross wavelet transform of Xiqiao-precipitation(a), Xiqiao-evaporation(b), Xiqiao-runoff(c), Zhongshu-precipitation(d), Zhongshu-evaporation(e), Zhongshu-runoff(f).

Methods

Using the wavelet analysis method, we performed a monthly scale analysis of the groundwater levels from 2018 to 2022(Fig. 1). Cross-wavelet analysis was used to analyze the lags of precipitation, evaporation, and mean flow of the Nanpan River on the groundwater table (Fig. 2).

According to the lag calculation, the corresponding hydrological elements are delayed and a different data sequence is established by BP neural network. The data of precipitation, evaporation, and runoff of Nanpan River from 2018 to 2021 are used as the training set and the data from 2022 are used as the test set.

First, we separate model-calculated groundwater levels from 1979 to 2022 based on wet, median, and dry precipitation conditions. We then calculate the average water level and the difference between the highest and lowest water levels for each quarter of wet, intermediate and dry years. Finally, we add the MAE of the BP neural network model to the difference between the highest and lowest water level to obtain the adjustment range, and combine the average water level with the adjustment range to obtain the groundwater control level.

Results

We used MAE, MAPE, and MSE to evaluate the prediction accuracy of the proposed model (Table1). The overall prediction bias is minor, and it has a certain reference value. We have got the groundwater levels from 1979 to 2022 by this model，and established the groundwater controlling levels in Luliang county (Table2).

Conclusions

The main aquifers in Luliang County are carboniferous limestone and quaternary and Neogene clays, and groundwater levels in this area have a distinct period of about 10 - 12 months. Groundwater levels have some hysteresis compared to the dynamic changes of other hydrological elements.

We use a BP neural model to reconstruct historical groundwater levels using precipitation, evaporation, and runoff from the Nanpan River as input. The results show that the accuracy of the model was improved after the delay time is removed, and it is able to mostly reflect the changes in local groundwater levels.

Based on the above results, the establishment of the groundwater controlling level has been completed.

Table 1
Accuracy of model

	Data name	MAE	MAPE	MSE
Xiqiao	Eliminate lag	0.585	3.2%	0.473
	Lag is not eliminated	0.619	3.4%	0.481
Zhongshu	Eliminate lag	0.392	2.1%	0.222
	Lag is not eliminated	0.472	2.6%	0.327

Table 2
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		First quarter	Second quarter	Third quarter	Fouth quarter
Wet	Xiqiao	1828.65±0.96	1828.60±0.73	1830.44±1.82	1829.76±1.40
	Zhongshu	1832.01±1.04	1831.53±0.83	1832.23±0.98	1833.66±1.88
Median	Xiqiao	1828.72±0.79	1828.57±0.90	1830.08±1.09	1829.47±1.15
	Zhongshu	1832.07±1.06	1831.55±0.86	1832.31±1.15	1832.86±1.30
Dry	Xiqiao	1828.75±1.21	1828.47±0.95	1829.54±1.20	1829.35±1.22
	Zhongshu	1832.15±1.18	1831.51±1.00	1831.96±0.94	1832.86±1.17