

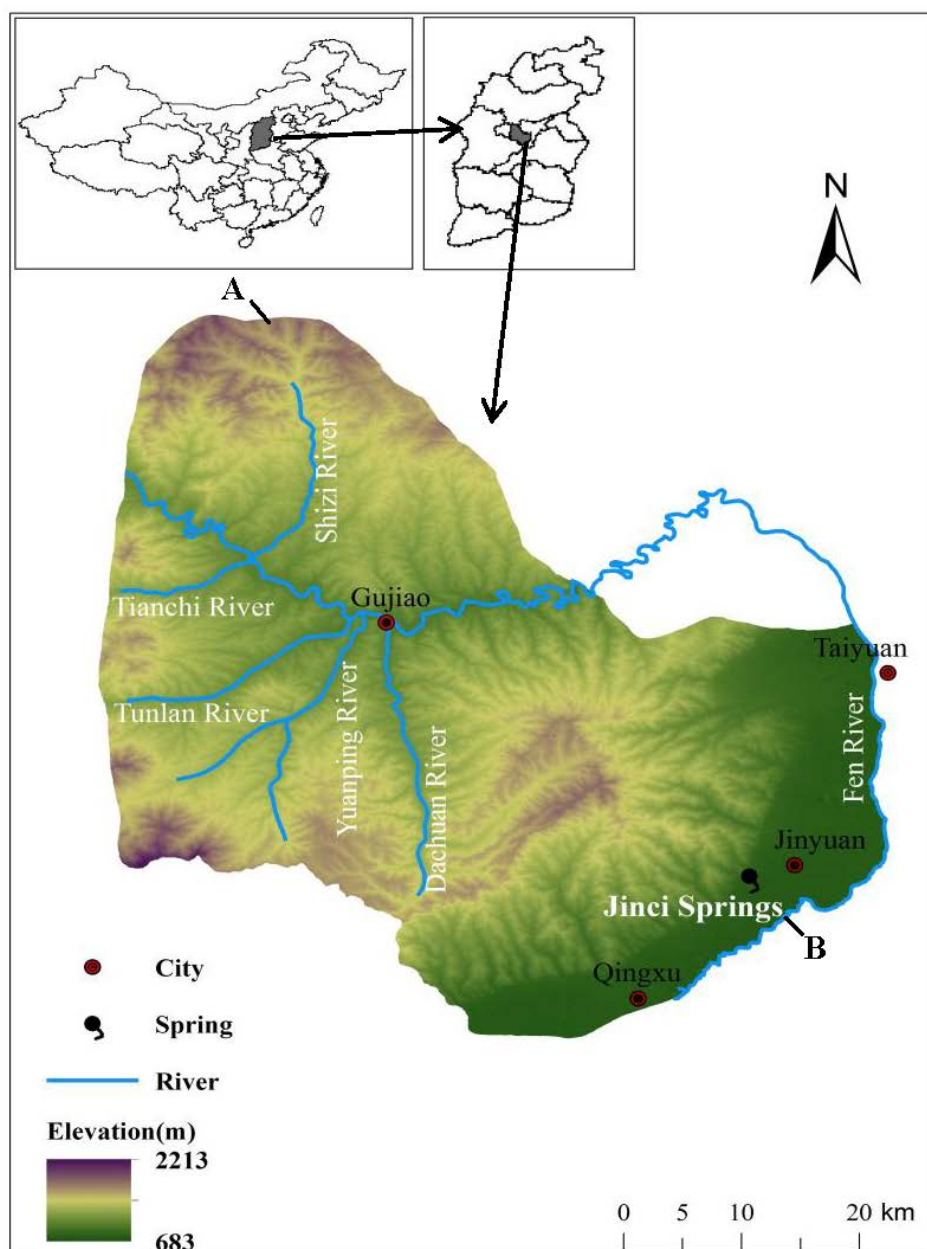
# The role of anthropogenic activities in spring discharge cessation: Jinci Springs China

Yaru Guo<sup>1</sup>, \*Yonghong Hao<sup>1</sup>, Chun Zhao<sup>1</sup>, Huan Lian<sup>1</sup>

1. Tianjin Normal University

Most of the karst spring discharge in northern China has been declining since 1950s. Jinci Springs, as one of the typical karst springs in northern China, has dried up in May 1994. In this study, we proposed grey relational analysis with time lag to calculate the delay between spring discharge and precipitation, and set up GM (1, N) model to simulate the spring discharge. The methods were applied to investigate the drying-up of Jinci Springs. Based on its characteristics of the Jinci Springs discharge, we divided the spring discharge into two stages: in the first stage (1954-1960), the spring discharge only affected by climate variations, and in the second stage (1961-1994), the spring discharge impacted by both climate variations and anthropogenic activities. In the first stage, the Jinci Springs discharge had large grey relational degrees with precipitation ahead of one year and three years. Then the GM (1, 3) model with time lag of one year and three years was set up to simulate the spring discharge of the second stage under sole effect of climate variations. Subtracted the observed spring discharge from the simulated spring discharge, we obtained the contribution of human activities to Jinci Springs cessation. Results showed that the contribution of human activities to the cessation of Jinci Springs was  $1.456\text{m}^3/\text{s}$ , accounting for 70%. The contribution of climate variations was  $0.624\text{m}^3/\text{s}$ , accounting for 30%. The impact of human activities on the spring cessation surpassed climate variations and became the major factor. The contribution of the groundwater exploitation increment was  $0.97\text{m}^3/\text{s}$ , the dewatering from coal mining increment was  $0.60\text{m}^3/\text{s}$ , and the leakage reduction of Fenhe River was  $0.19\text{m}^3/\text{s}$ . The total amount was  $1.76\text{m}^3/\text{s}$ . After the Jinci Springs dried up, human further overexploited groundwater about  $0.304\text{m}^3/\text{s}$ .

Keywords: spring discharge, anthropogenic activities , drying-up, Jinci Springs



**Figure 1** Location and digital elevation model (DEM) of Jinci Springs catchmen