Oral Presentation-4-7-9

XVIII World Water Congress
International Water Resources Association (IWRA)

Characterizing groundwater table changes in the over-exploited area of North China Plain(NCP) in the last 30 years

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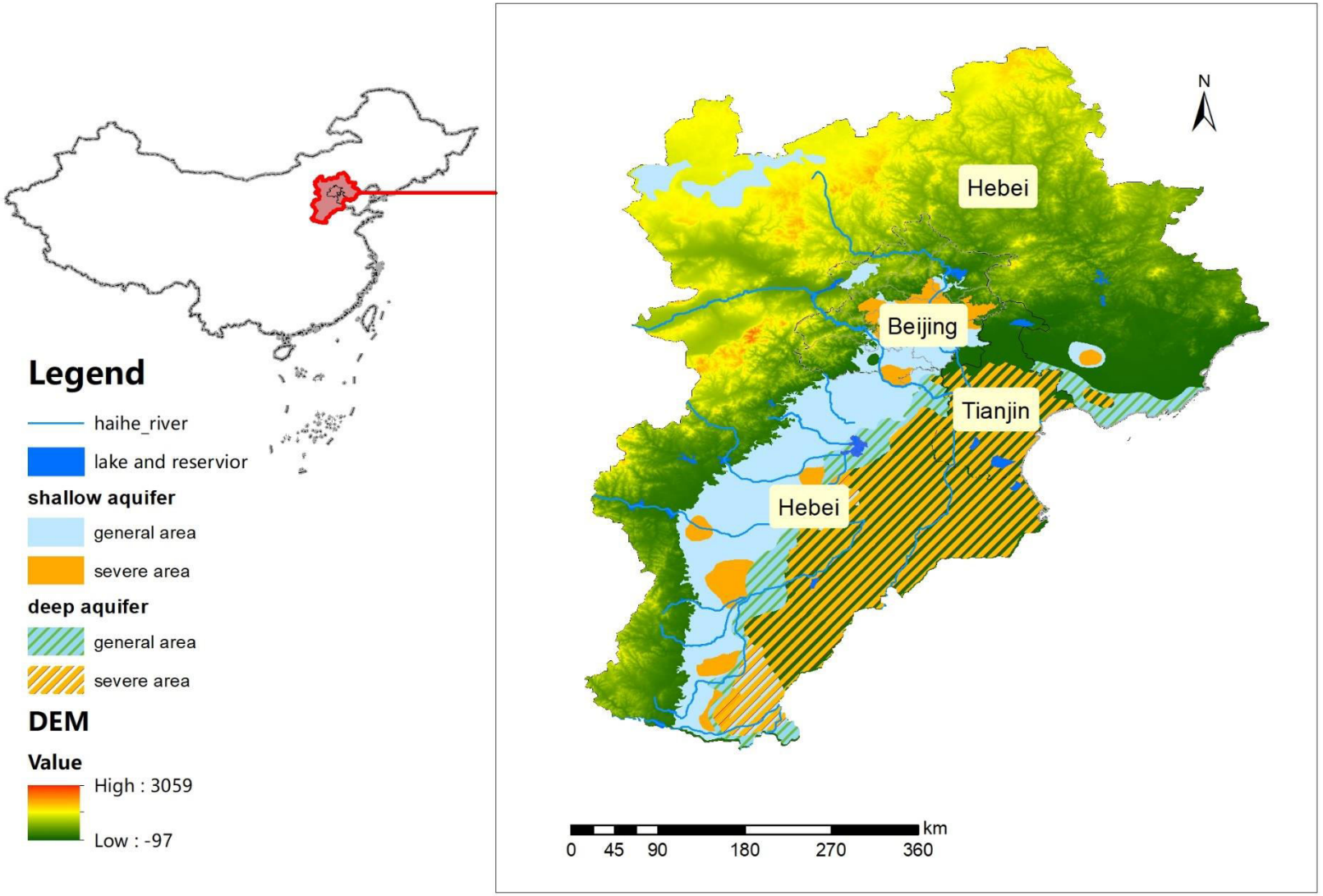
- Materials and Methods
- Results and discussion
- Conclusion

Study Area



- **Location:**

  North of China

- **Area:**

  14.7 million km^2

- **Population:**

  110 million

- **Groundwater exploitation**

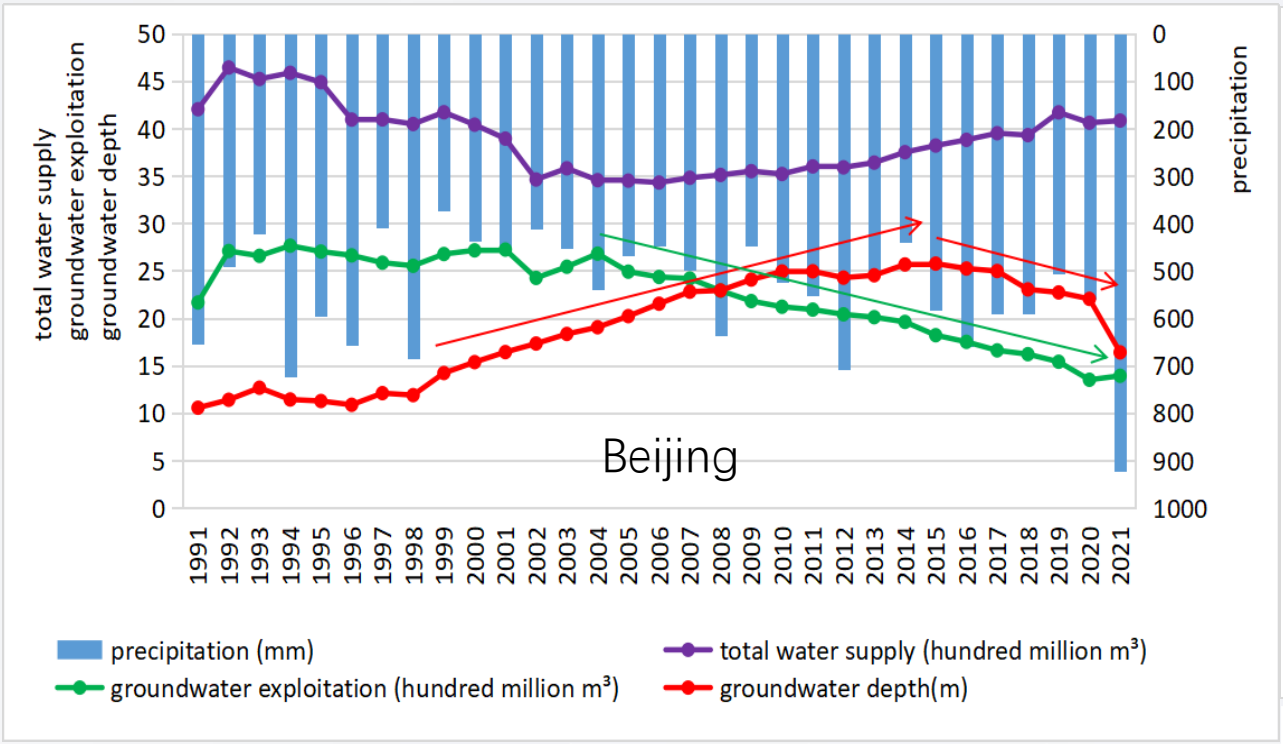
  18.8 billion m^3/a

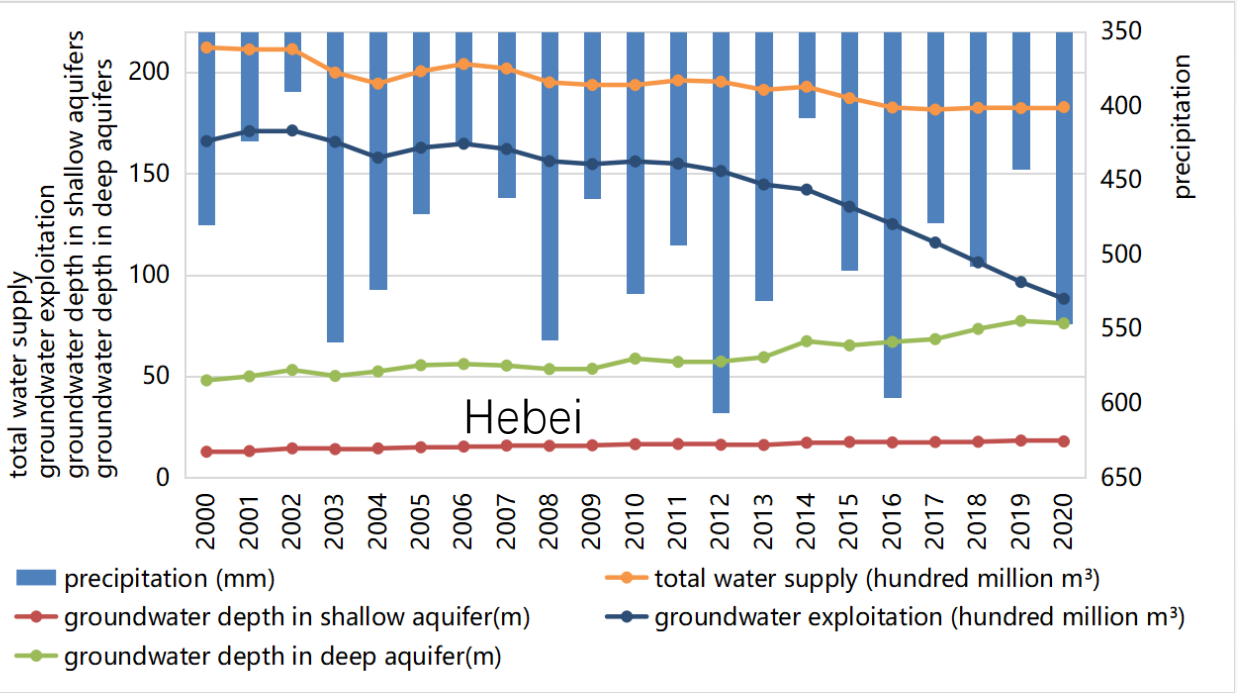
- **Over exploited aquifers**

  shallow: Beijing, regions near the mountains

  deep: Tianjin, south-east of Hebei

Water Resources and Groundwater Exploitation





	GWE	OE
1991-2000	2.62	0.39
2001-2010	2.43	0.79
2011-2020	1.78	-0.01

	groundwater table decline rate (m/a)	over-exploitation quantity ($10^8 m^3/a$)
Beijing (shallow)	0.38 (1991-2020)	3.89
Hebei (shallow)	0.24 (2001-2020)	25.3
Hebei (deep)	1.34 (2001-2020)	

Data source:
Beijing Water resources Bulletin
Hebei Water resources Bulletin

Materials and Methods

- **Data collection**

  Precipitation (3 meteorological stations, 1991~2020 monthly)

  Groundwater table depth(10 wells, 1991~2016(Beijing)

  1998 or 2000 ~2016(Hebei),1991~2010(Tianjin)

  Groundwater quality (only wells in Beijing)

- **Methods**

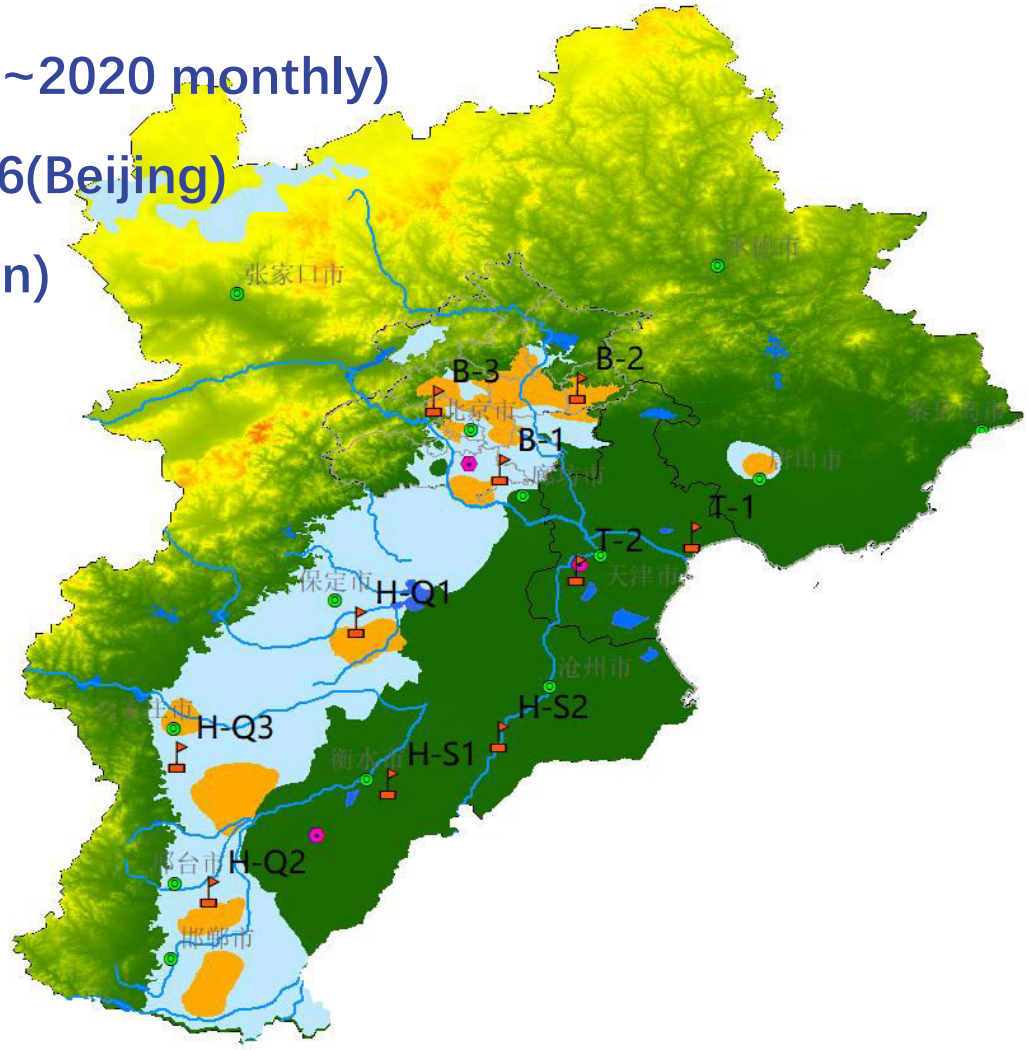
  Mann-kendall trend test

  Mutation analysis

  Continuous wavelet transform (CWT)

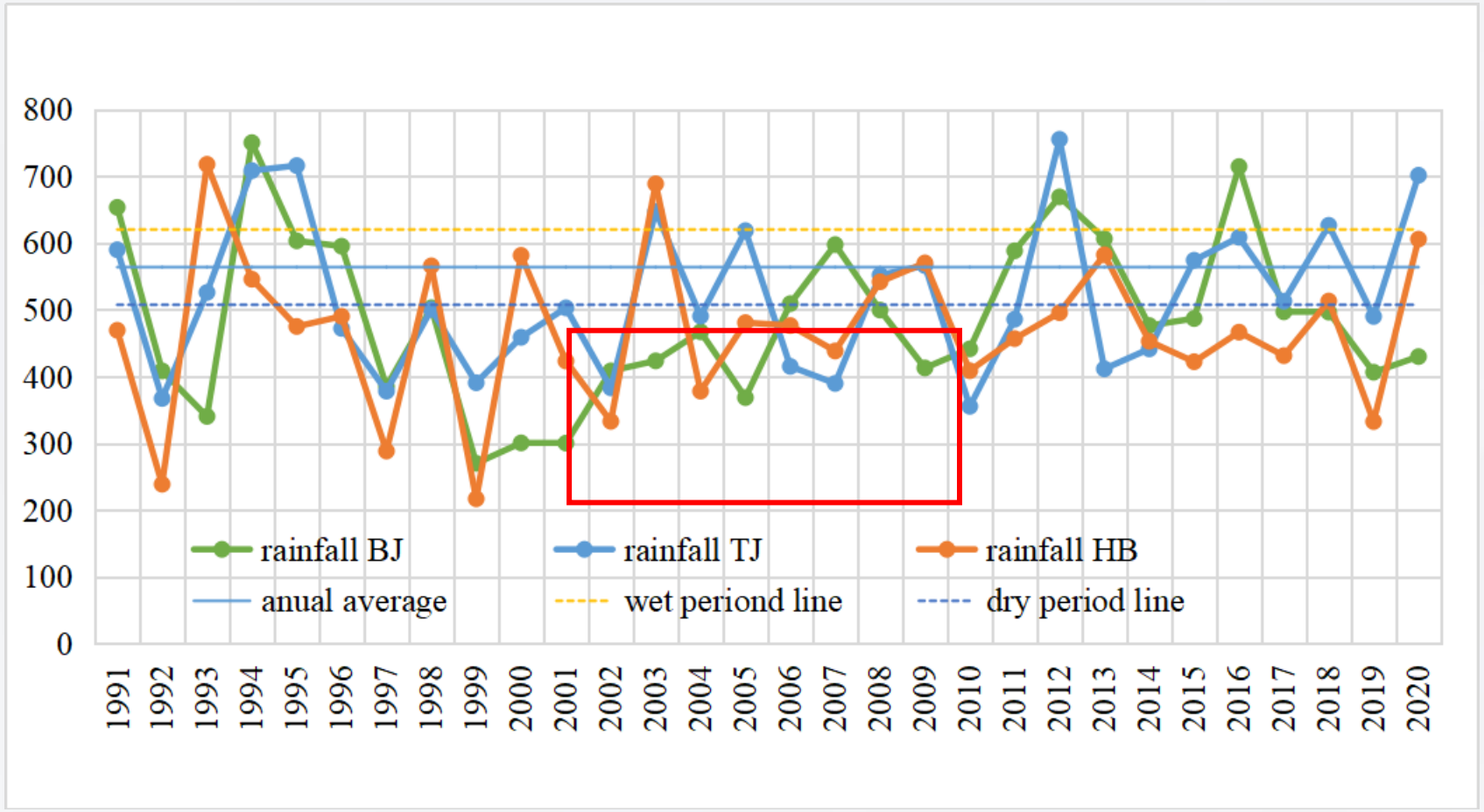
  Wavelet coherence (WTC)

  Cross wavelet transform (XWT)



Materials and Methods

Precipitation



Average annual: 492mm
12% lower than the long term average annual precipitation (559mm)

Beijing: 487mm
Tianjin: 521mm
Hebei: 469mm

Continuous dry period: Beijing，1997～2006; Tianjin，1996~2002

Wet year: occasionally occurred in some year, for example in 2012, 1994

Materials and Methods

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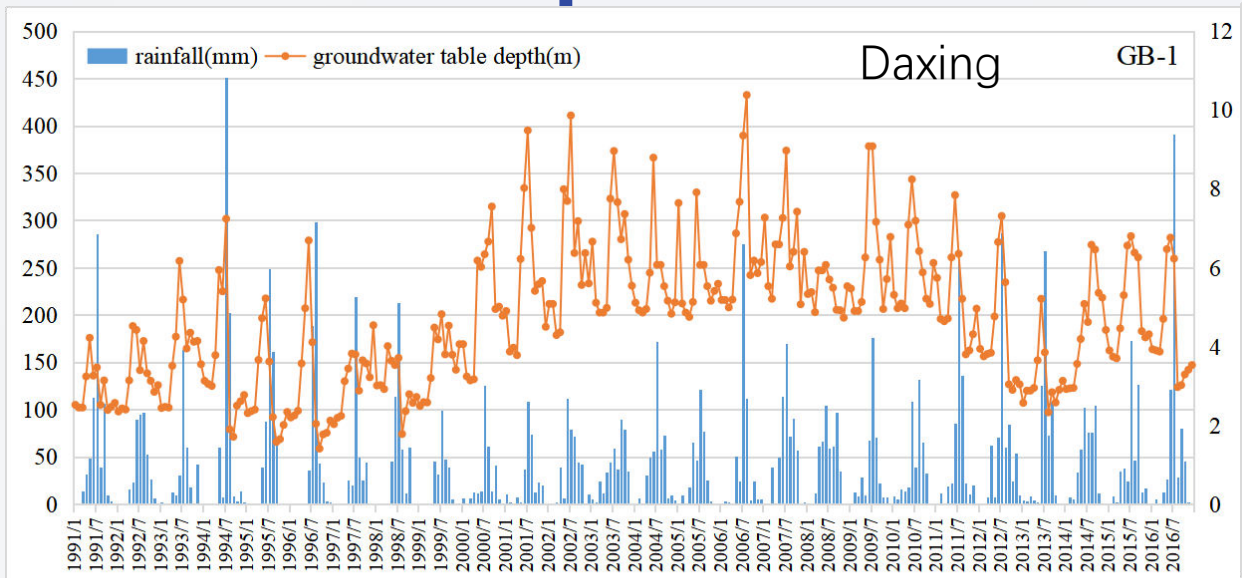
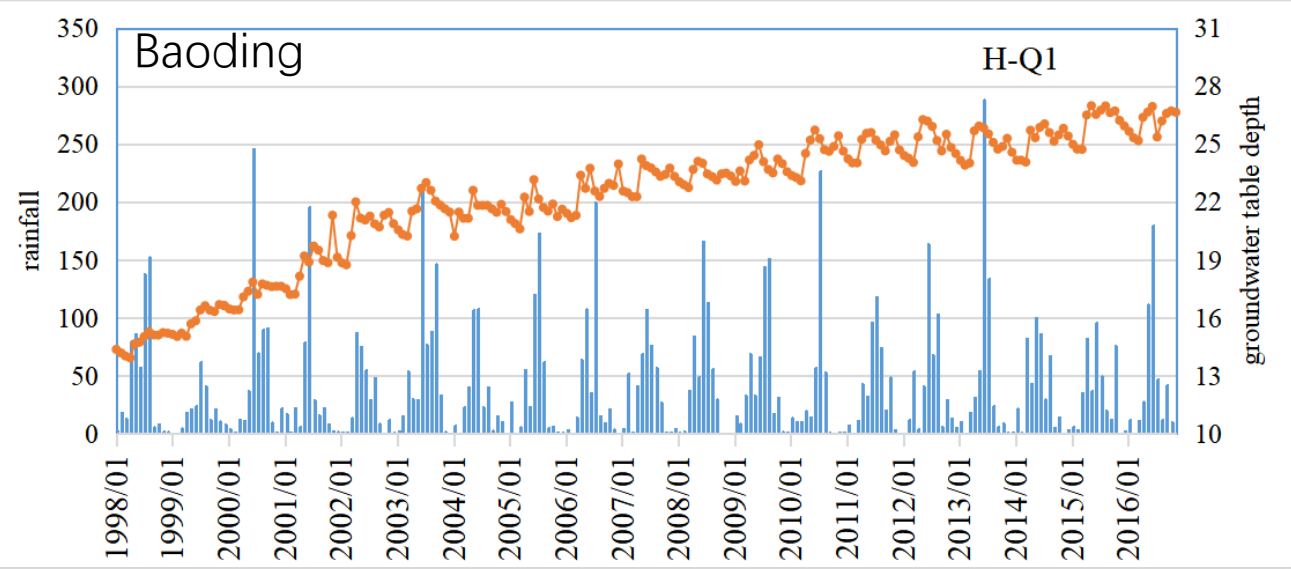
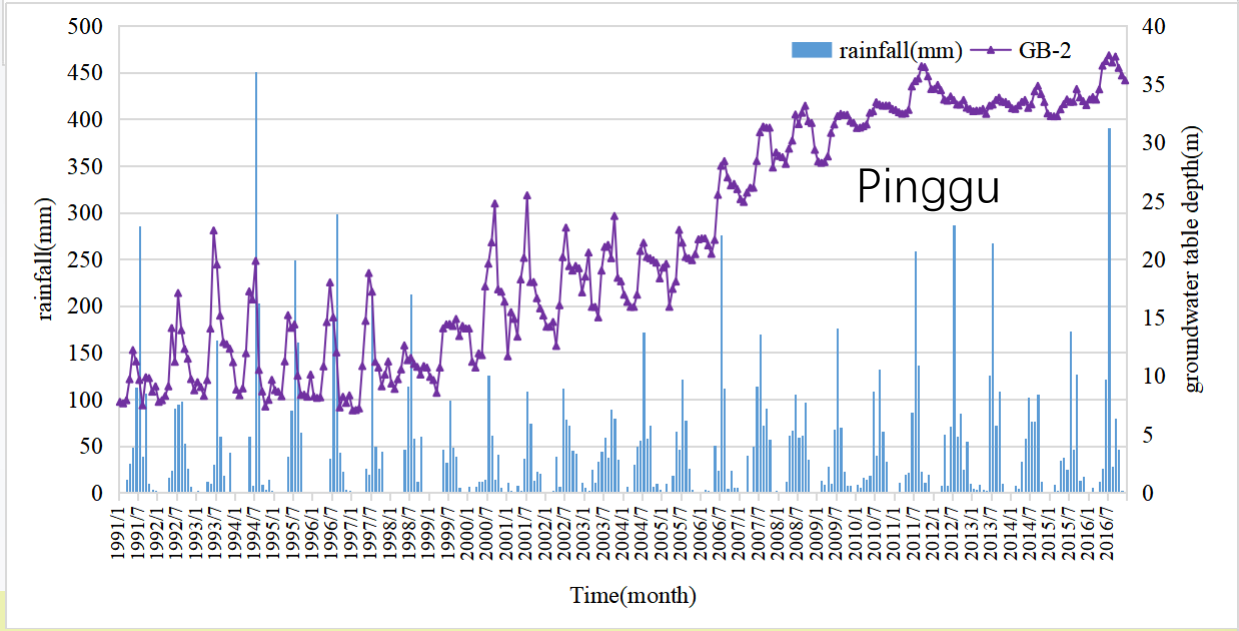
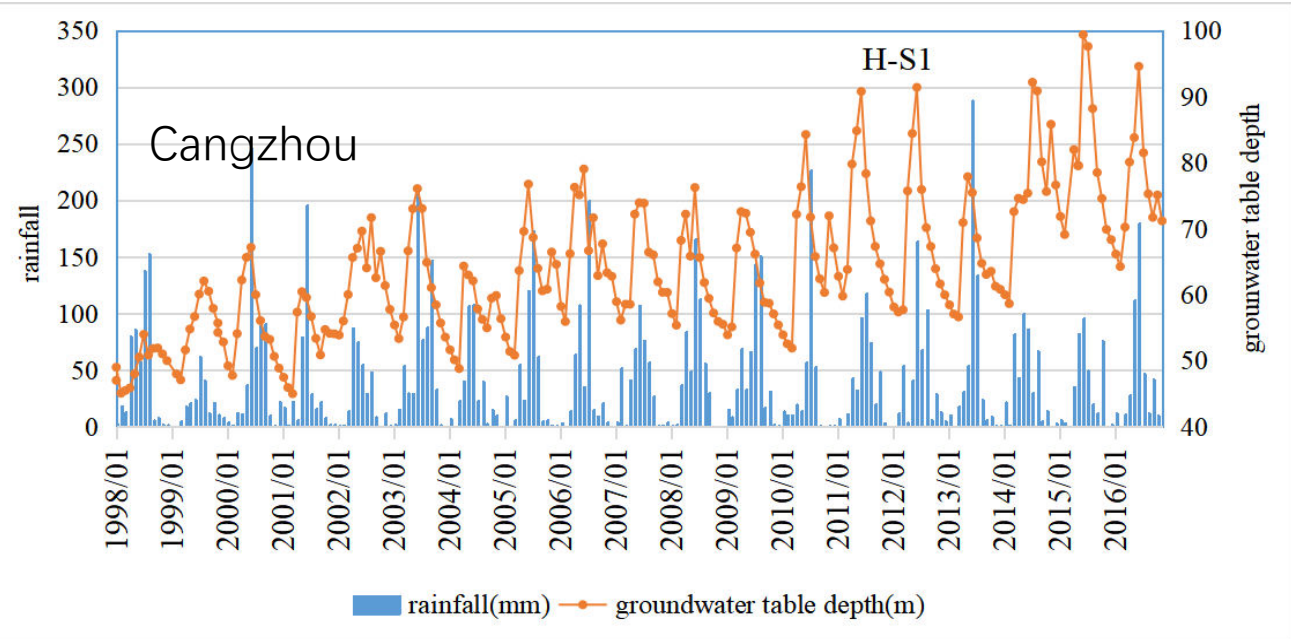
Precipitation vs. Groundwater Table Depth (monthly)









Results and discussion

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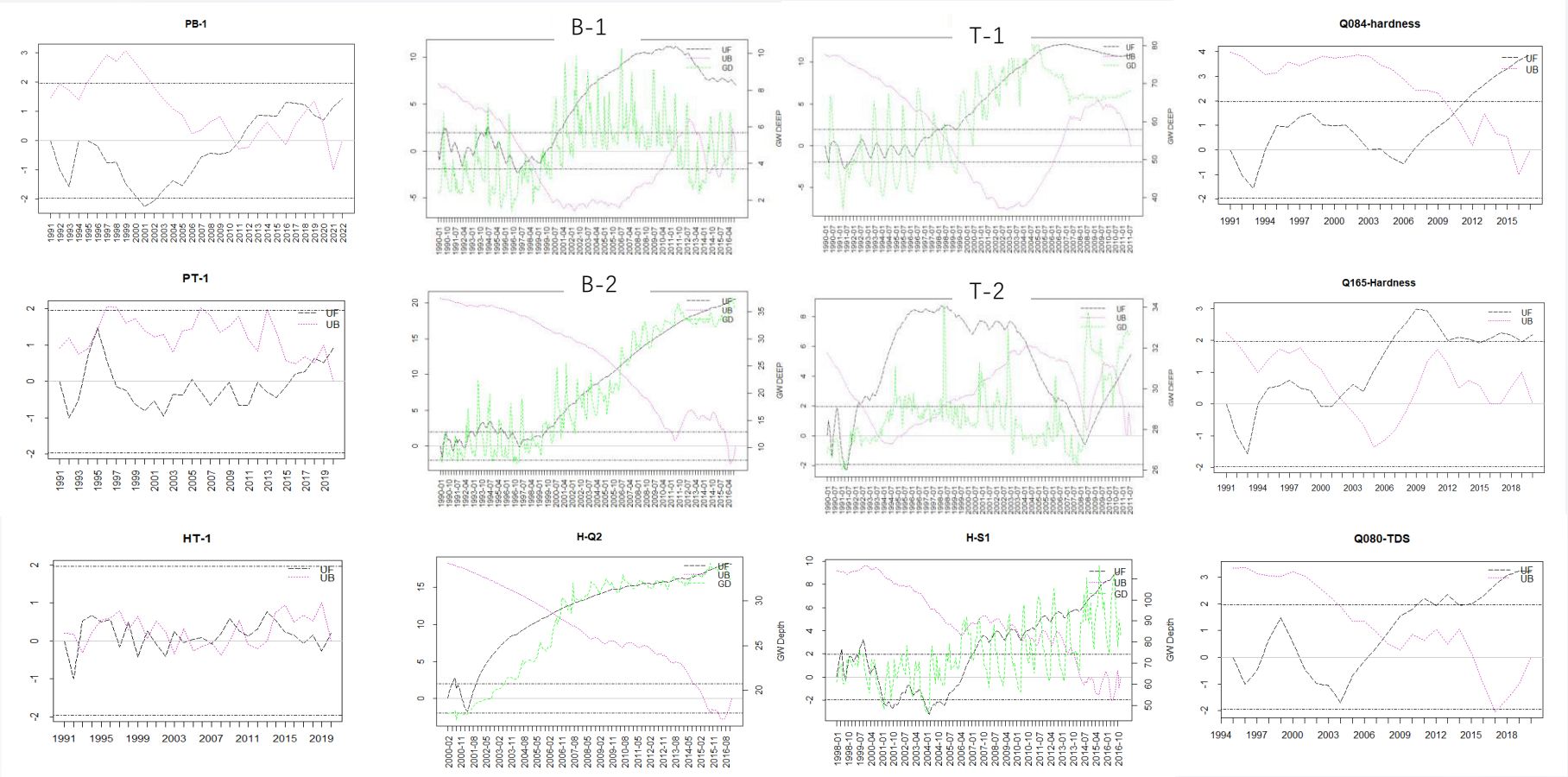
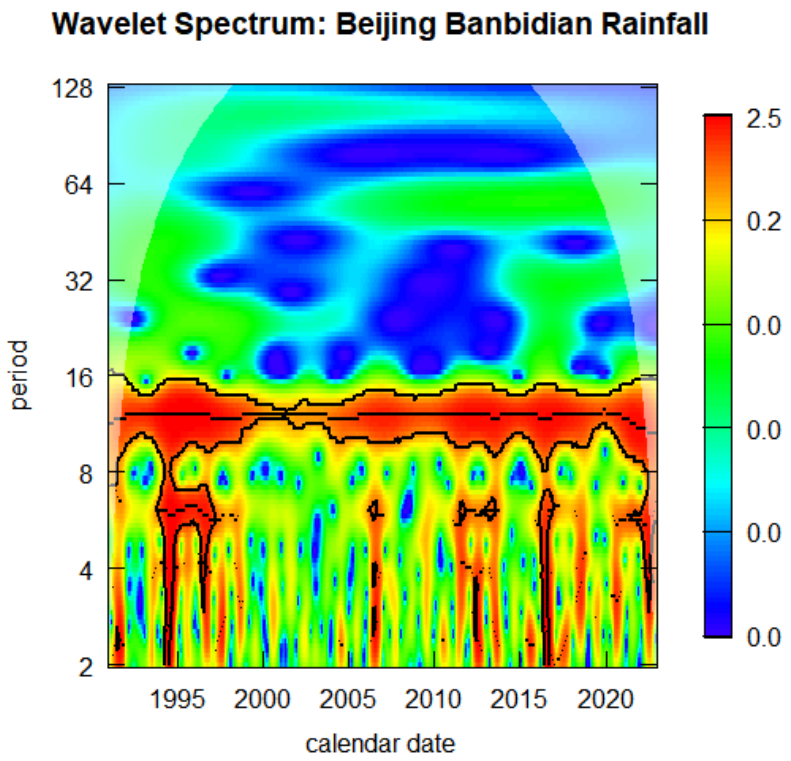
1.Trend of annual precipitation , groundwater table and water quality

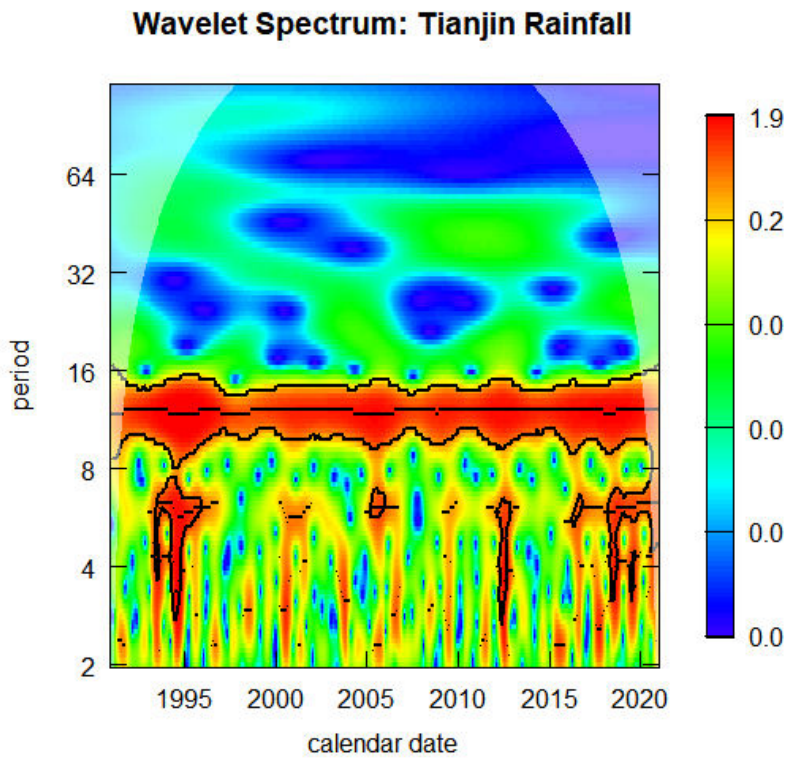


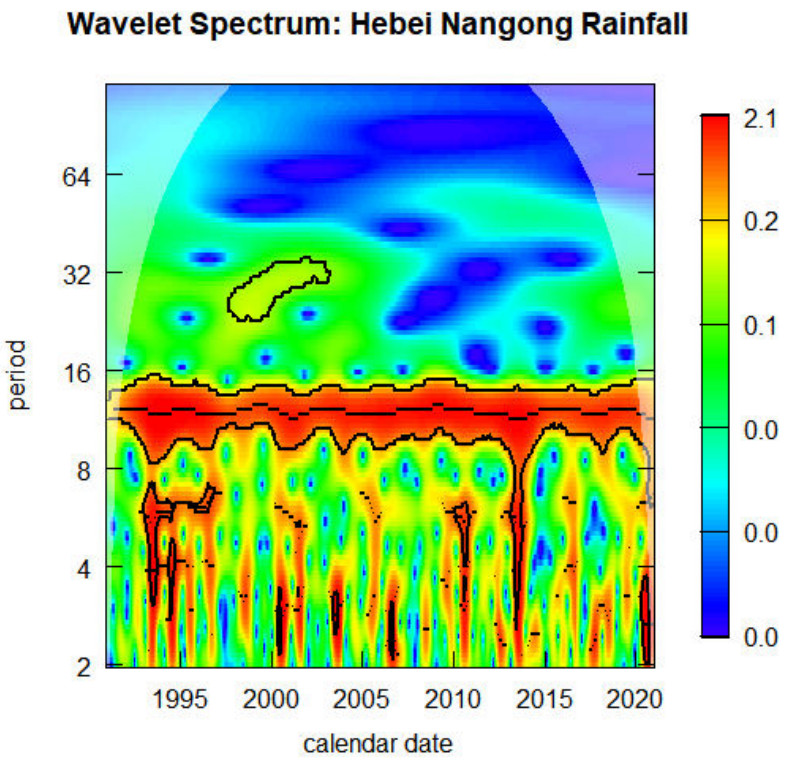
Precipitation	Groundwater table depth	Hardness and TDS

wells	*z* values	mutation point
T-1	10.89	1998/1/1
T-2	5.49	
B-1	7.12	1998/3/1
B-2	20.63	
B-3	18.11	
H-Q1	18.66	
H-Q2	18.23	
H-Q3	17.14	
H-S1	9.18	
H-S2	10.55	
PB-1	1.43	2010
PT-1	0.89	1994
PH-1	0.18	1992
BQ1	2.18	2001
BQ2	3.24	2007
BQ3	3.92	2010

2.Periodicity analysis of precipitation







Results and discussion

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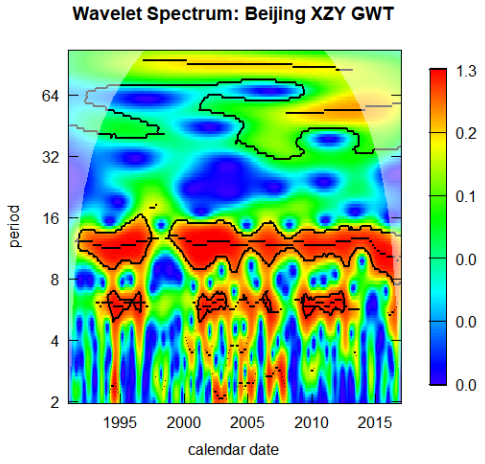
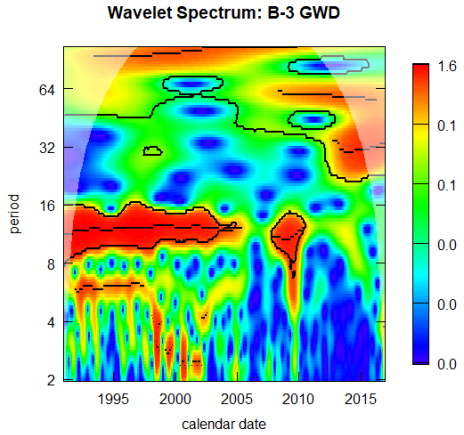
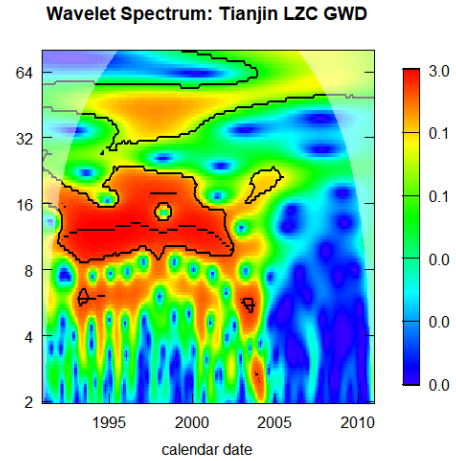
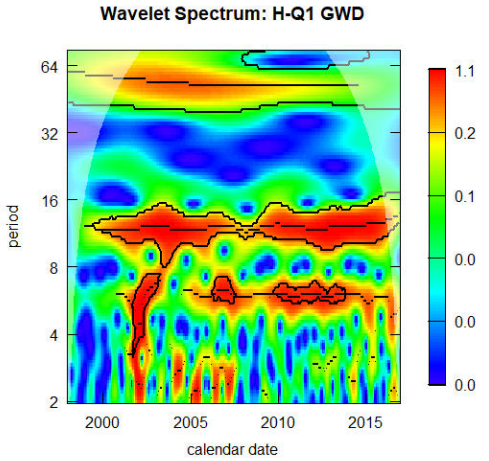
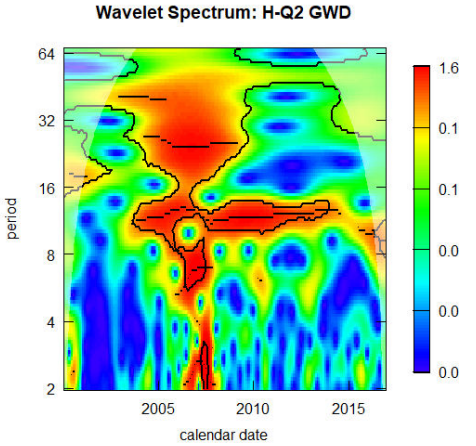
2.Periodicity analysis of groundwater table and groundwater quality

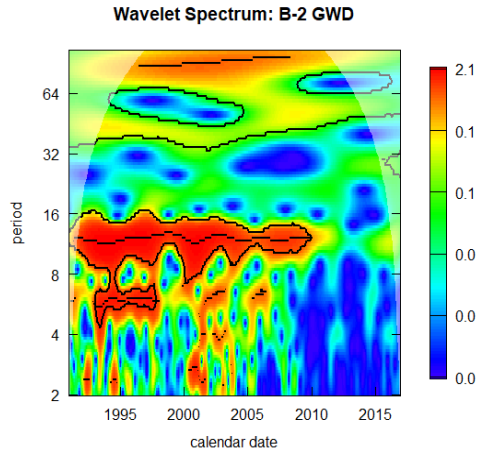


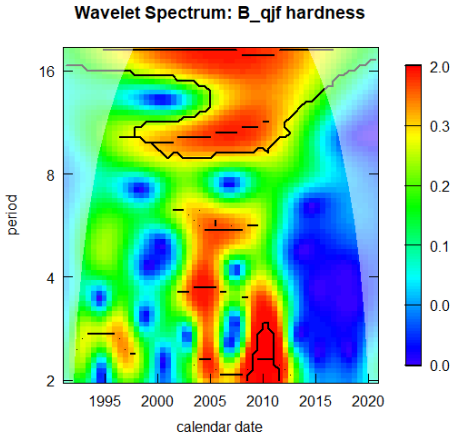


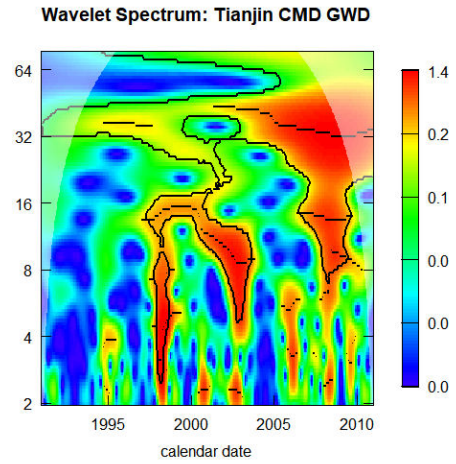


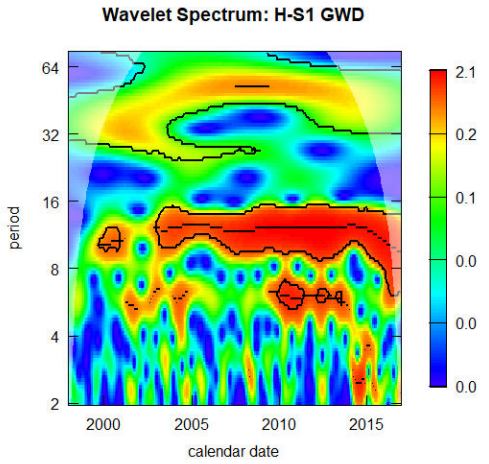


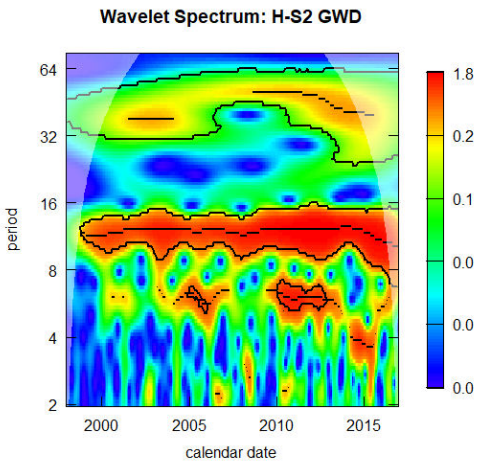






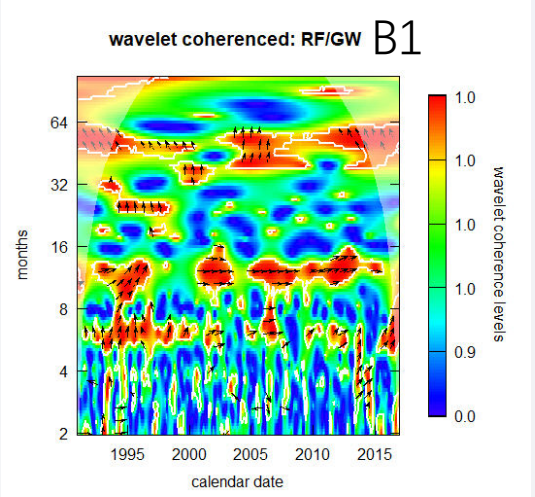




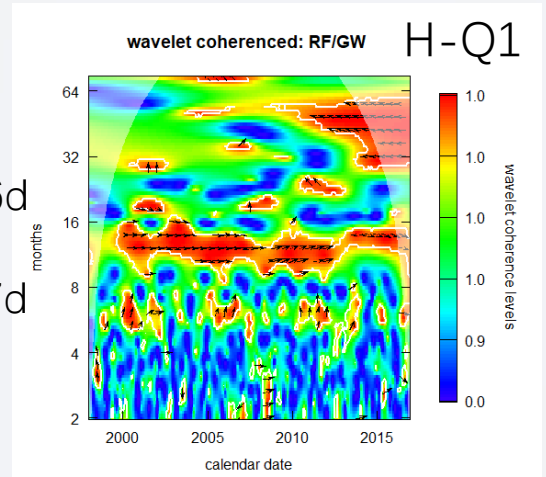


Results and discussion

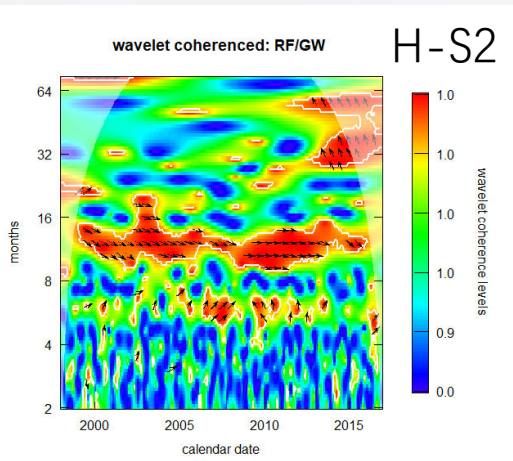
3. Quantitative response of groundwater table to precipitation



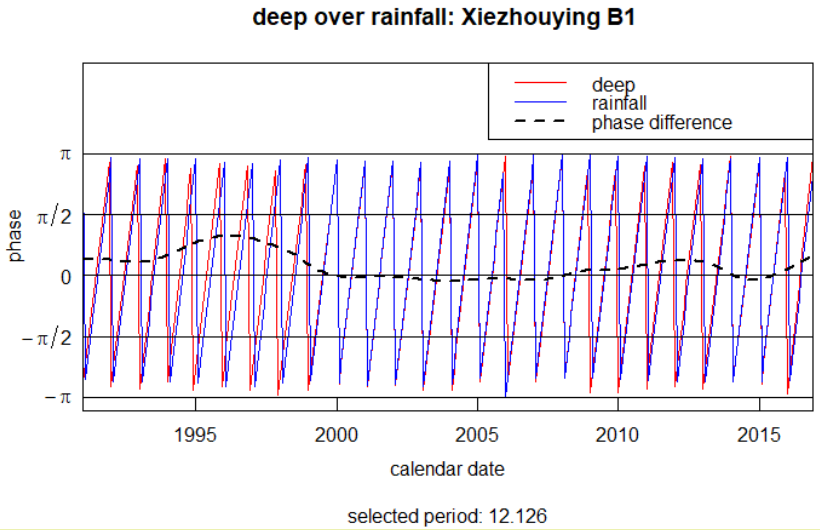
1991~2016 :13.6d
1991~1999 :35d
2000~2008 :-4.7d

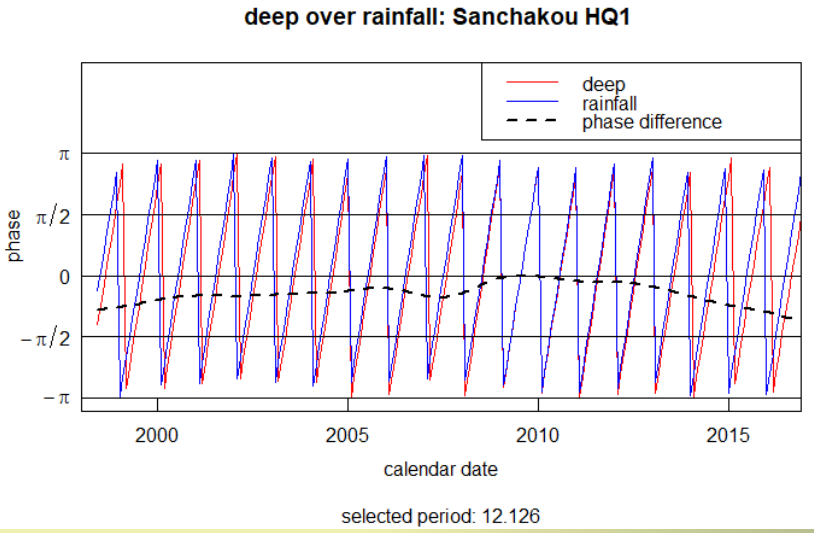


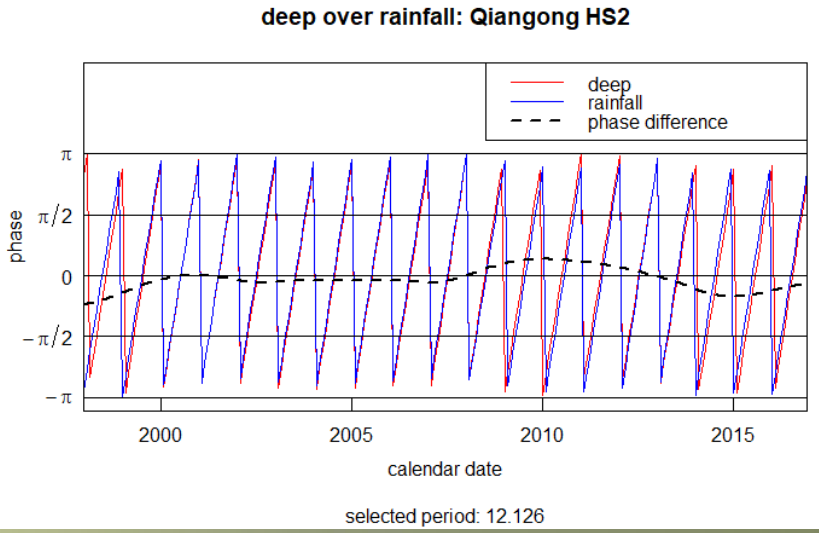
1998~2016:
-25.5d



1998~2016:
-4.2d







Conclusion

- **In this study, the combination of the Mann-Kendall test and wavelet ananlysis was used to clarify the response mechanism of groundwater table depth to precipitation. The main conclusions are summarized as follows:**

1. The average annual precipitation in the NCP from 1991 to 2020 was 493 mm, and there was no significant trend for annual precipitation fluctuation. There is a significant monotonic decreasing trend for groundwater tables and the average declining rate is 0.3m/a and 1.3m/a in shallow and deep aquifers respectively in the last 30 years. The water quality shows an increasing trend too.
2. Precipitation and groundwater table depths in the study area shown a significant oscillation period of 9–15 months, indicating that groundwater table had periodic responses to the precipitation events. The groundwater table depth has the same period with precipitation for most wells. But in exclusively B1 well, when the depth was less than 3 meter, the period has a little difference, the deep were on average 35 days ahead of precipitation from 1991 to 1999 .
3. The lag time of groundwater table to precipitation can vary with different conditions. The main factors influencing the lag time between precipitation and groundwater recharge include groundwater table depth, aquifer lithology, precipitation intensity, and groundwater exploitation intensity. Although these factors may cause some uncertainties in the assessment of the response of groundwater level to precipitation, the combination of the Mann-Kendall test and wavelet analysis are useful, particularly in areas lacking hydrogeological data. It is also helpful for assessment of exploitation reducing policy and identification of water quality monitoring period.

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Thank you very much for your attention!