South-to-North Water Diversion's influence on the restoration of groundwater resources in Beijing

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Abstract

Groundwater plays an important role on water supply and safety in Beijing. Since the south-to-north water diversion (SNWD), the Beijing's groundwater table has rebounded significantly. Scientifically studying the key influencing factors of groundwater level fluctuation is crucial for guaranteeing the regional water supply and water source allocation. Based on the in-depth analysis of groundwater and water resource structure evolution, combined with (Gravity Recovery and Climate Experiment) GRACE gravity satellite, this study aimed to quantify the contribution rate of the SNWD in Beijing. The results showed that the SNWD has a strong impact on the restoration and conservation of groundwater. These can provides scientific and technological support for the continuous improvement of the comprehensive measurements of groundwater overdraft in Beijing.

Introduction

Groundwater plays an important role on water supply and safety in water-scarce city. Cross-basin water transfer projects were emerged for adjusting the balance of water resources in different regions, such as South-to-North Water Diversion (SNWD) in China. Since the SNWD , the Beijing's groundwater table has rebounded significantly. Beijing is the political, cultural, international exchange, a scientific, and technological innovation center in China, with a population of more than 21 million in 2020. The per capita freshwater resource was about 118 cubic meters per year in 2020, i.e. one-20th of the world's average, which is far lower than the international lower limit of per capita water consumption. Scientifically studying the influence of SNWD is crucial for guaranteeing the regional water supply and water source allocation.

Method

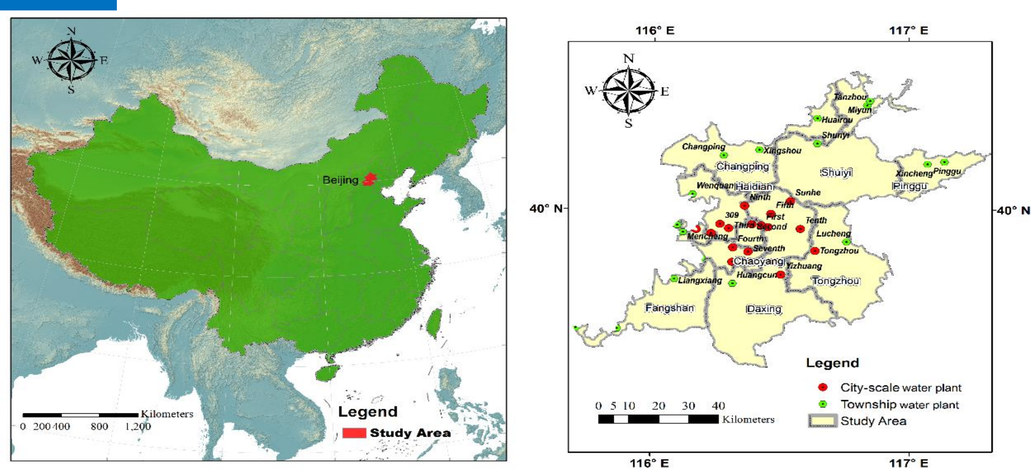


Fig.1 The locations of the water plants over the study area.

Data availability: The data used in this study include ground-based monitoring, statistical data, and reanalysis data. Monthly groundwater (GW) depth measurements for Beijing during 2005–2020 were derived from Beijing Groundwater Dynamics Bulletins.Annual water use data in terms of various water sources and sectors were derived from Beijing Water Resource Statistics Year Books.The global time-varying gravity field models was collected from the Center for Space Research (CSR), GeoForschungsZentrum Potsdam (GFZ), Jet Propulsion Laboratory (JPL)'s Gravity Recovery and Climate Experience (GRACE) and its successor task GRACE Follow on (GFO) since April 2002, as well as the latest global Mascon products from CSR, JPL, Goddard Space Flight Center Mascons (GSFC).

Results & Discussion

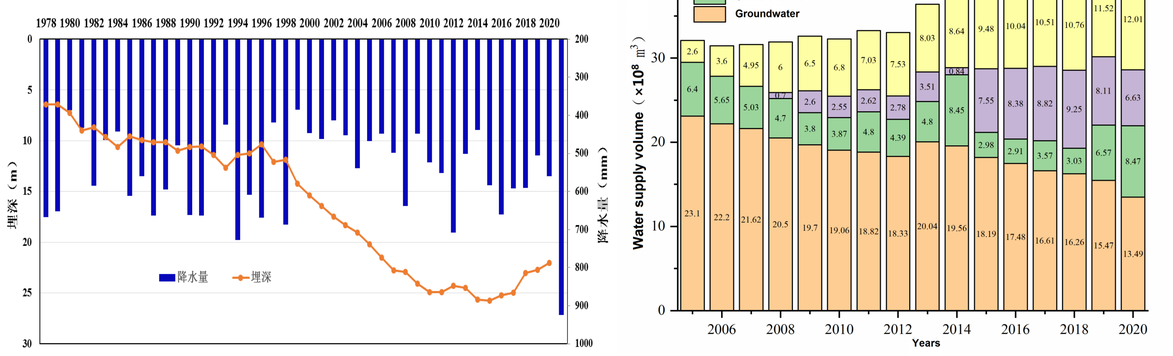


Fig.2 Groundwater level and precipitation fluctuation in 1978 to 2020;Evolution of water resource structure from 2005 to 2020.

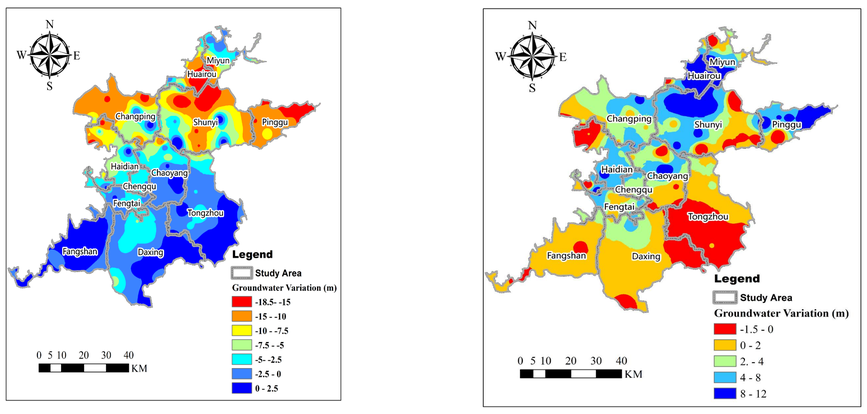
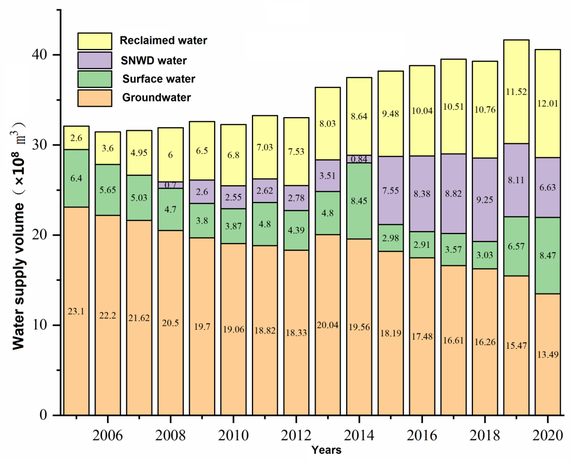


Fig.3 Fluctuation range of groundwater level change in plain area of Beijing during 2005–2015 (Left) and 2015-2020(Right)



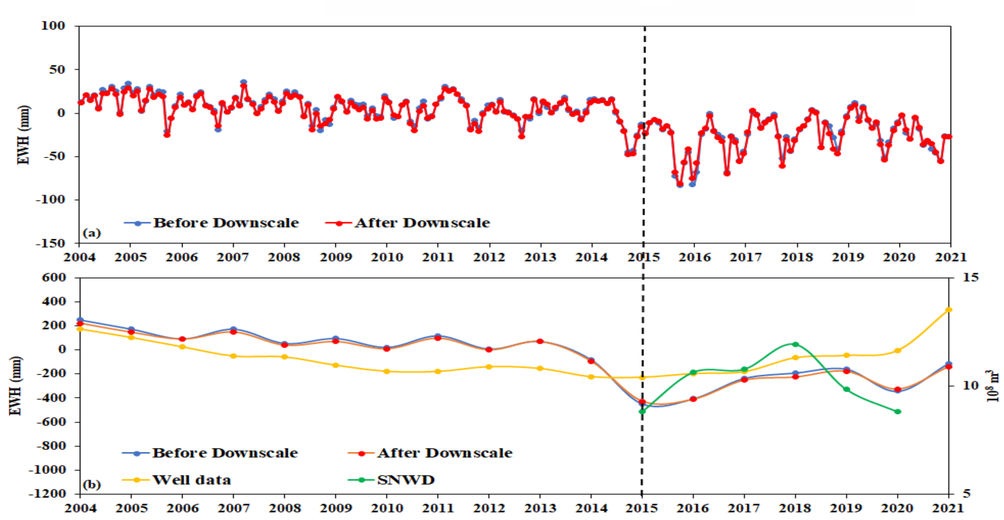


Fig.4 Groundwater level fluctuations in Beijing (Well data: data from monitoring sites; SNWD:South-to-North Water Transfer Transfer)

The results showed that the annual trend of groundwater in most areas of Beijing has increased after the SNWD, and the annual trend of the mean reserve before the SNWD (2004-2014) was -20.77 mm/a. After the SNWD (2015-2021), the average annual trend was 39.32 mm/a. After 2018, the annual change of groundwater storage increased significantly in 2019 and 2021, increasing by 248.09 mm and 285.51mm respectively compared with 2015.

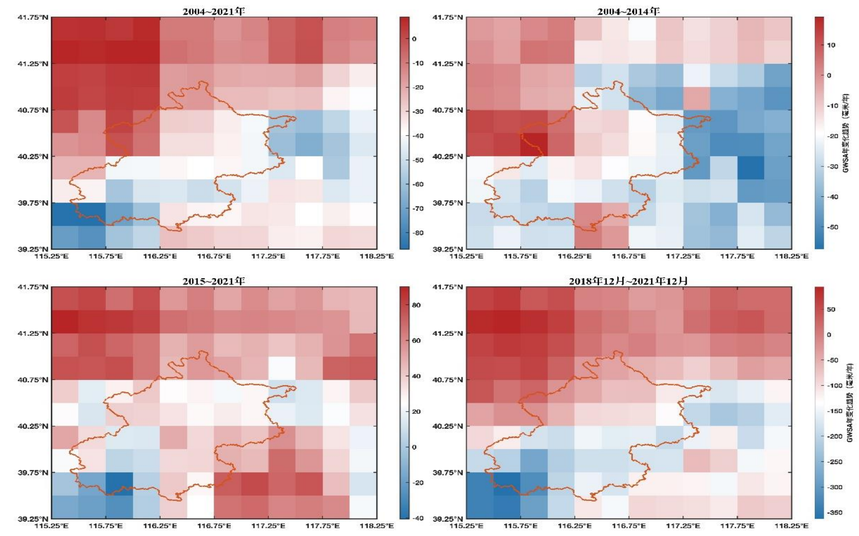


Fig.5 Annual trends of groundwater in Beijing from 2004 to 2021, 2004 to 2014, 2015 to 2021, 2018 to 2021

The results showed that the annual trend of groundwater change in most areas of Beijing increased after the south-to-north water diversion, although the overall groundwater reserve in Beijing was still decreasing from the annual average value of GWSA, but the trend of reduction was significantly reduced. After 2018, the annual GWSA change trend in the north was significantly better than that in the south, and it is necessary to focus on the difference between the north and the south.

Conclusion

- The structure of Beijing's water supply has undergone great changes.
- Groundwater in Beijing rebounded significantly .
- The annual trend of groundwater restoration resources in the north was significantly better than that in the south.
- The SNWD has a strong impact on the restoration and conservation of groundwater in Beijing.

Outlook

- The difference between the north and the south of groundwater reserver estoration should be focused on .
- Quantification the other influencing factors of groundwater level fluctuation is also crucial for guaranteeing the Beijing's regional water supply.

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