Rapid Land Subsidence in Tianjin, China Derived from GPS and InSAR Data (2010-2022)

R. Zhao[1], G. Wang[2], X. Yu[2], X. Sun[3], Y. Bao[4], G. Xiao[5], W. Gan[6], S. Shen[7]

1 School of Geology and Geomatics, Tianjin Chengjian University, Tianjin 300384, China
2 Department of Earth and Atmospheric Sciences, University of Houston, Houston 77204, USA
3 School of Civil Engineering, Tianjin Chengjian University, Tianjin 300384, China
4 Key Laboratory of Urban Security and Disaster Engineering of Ministry of Education, Beijing University of Technology, Beijing 100124, China
5 Key Laboratory for Digital Land and Resources of Jiangxi Province, East China University of Technology, Nanchang 330013, China
6 State Key Laboratory of Earthquake Dynamics, Institute of Geology, China Earthquake Administration, Beijing 100029, China.
7 Key Laboratory of Intelligent Manufacturing Technology of Ministry of Education, Shantou University, Shantou, Guangdong 515063, China

Correspondence to: Guoquan Wang (gwang@uh.edu)

Abstract

This is an update of the study that we submitted to the TISOLS 2020: Rapid Land Subsidence in Tianjin, China Derived from Continuous GPS Observations (2010–2019) (https://piahs.copernicus.org/articles/382/241/2020/) (Zhao et al. 2020). Recently, we reprocessed the GPS observations (2010-2021) at five continuous GPS stations (JIXN, YJBD, TJBH, HECX, TJWQ) in Tianjin. The new data indicate that the overall subsidence has slowed down since around 2019, and a slight land rebound has been observed in the Wuqing District (Fig. 1). Our recent subsidence studies using InSAR (Sentinel-1A/B, 2014-2021) also indicate that the subsidence rates across the entire previously subsiding areas in Tianjin have reduced remarkably since 2019 (Yu et al. 2023). Further investigations suggest that the reduction of subsidence rates is resulted by the South–to-North Water Diversion Project (SNWDP), which has brought over 7 billion m^3 of water from the Yangtze River system to Tianjin from 2015 to 2021. The South-to-North Water Diversion Project was designed to channel water from the Yangtze River in southern China to the more arid and industrialized north, comprising three canal systems: the Eastern Route, the Central Route, and the Western Route. The Western Route is still at the planning phase as of 2022. The Central Route and the Eastern Route began to bring water to Tianjin in 2014 (December) and 2021, respectively. The Yangtze water diverted to Tianjin was about 1.1 billion m^3 in 2021, accounting for about 35% of the annual total water use (~3.2 billion m^3). Groundwater was about 25% of the total water use in Tianjin for the public, industrial, and agriculture before 2015, and has been reduced to 0.8% of the total water use in 2021 (Tianjin Water Resources Bulletin).

The ongoing subsidence in Tianjin is primarily caused by the groundwater withdrawals from the deep aquifers, approximately 150 m to 400 m below the land surface. The amount of the deep-groundwater withdrawal was 0.23 billion m^3 in 2014 and had been reduced to 0.06 billion m^3 in 2021. Currently (as of 2021), there are still about 0.25 billion m^3 groundwater withdrawals in the shallow aquifers (within 150 m) (Tianjin Water Resources Bulletin). However, the withdrawals in the shallow aquifers are balanced by natural and human recharge, thus, do not considerably contribute to ongoing land

subsidence. Groundwater-levels in deep aquifers have elevated across the Tianjin area since around 2017. In turn, the rates of land subsidence have reduced gradually, and a slight land rebound (a few millimeters per year) has been observed in several areas since 2019. We will present detailed information about the change in subsidence rates before and after the available of the Yangtze water in Tianjin.

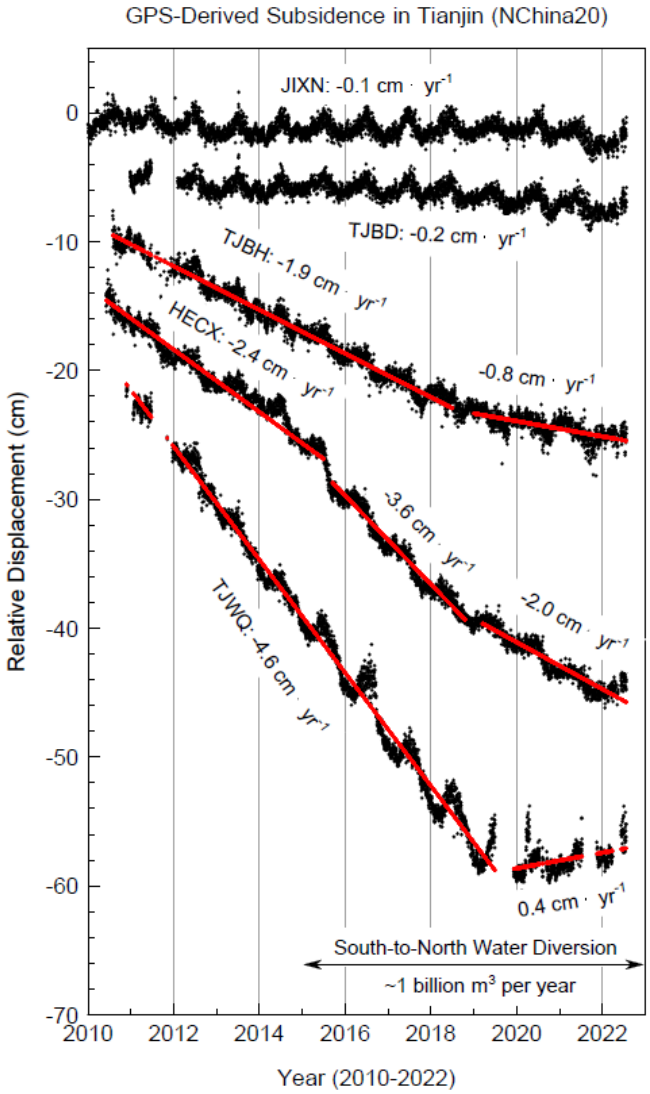

Figure 1 GPS-derived subsidence time series recorded at four GPS stations (JIXN, TJBD, TJBH, TJWQ) within and one (HECX) adjacent to the municipality of Tianjin. The subsidence time series are aligned to the stable North China Reference Frame 2020 (NChina20) (Bao et al. 2021).

References

Bao, Y., Wang, G., Yu, X., Xiao, G., Zhao, R., and Gan, W.: Establishment and applications of Stable North China Reference Frame: NChina20. Earthquake Research in China, 36(4): 788-805, 2020.

Yu, X., Wang, G., Hu, X., Liu, Y., and Bao, Y.: Land Subsidence in Tianjin, China: Before and after the South-to-North Water Diversion. Remote Sensing, 15(6): 1647, 2023. https://doi.org/10.3390/rs15061647

Zhao, R., Wang, G., Yu, X., Sun, X., Bao, Y., Xiao, G., Gan, W., and Shen, S.: Rapid Land Subsidence in Tianjin, China Derived from Continuous GPS Observations (2010–2019), Proc. IAHS, 382, 241–247, https://doi.org/10.5194/piahs-382-241-2020, 2020.

Tianjin Water Resources Bulletin: http://swj.tj.gov.cn/zwgk_17147/xzfxxgk/fdzdgknr1/tjxx/