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Ground subsidence and relative sea level rise in coastal areas of China

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The global mean sea level rise (SLR) is accelerating and has reached 3.2 mm/yr over the last decades. Combining with local ground subsidence, relative sea level rise (RSLR) rate will be dozens of times the global mean sea level rise in some areas with serious subsidence. The RSLR will lead to an increase in the frequency of floods and storm surges, salinization of surface and ground waters, coastal erosion, and degradation of coastal habitats, which will have a serious impact on coastal cities and low-lying areas.

In this study, we combine satellite altimetry data with time series interferometric synthetic aperture radar (InSAR) to capture the distribution of RSLR rates along China's coastline. The Sentinel-1 SAR data from nine ascending tracks covering China’s coastal areas from 2016 to 2020 are used for SBAS analysis to obtain ground subsidence within the 100 km buffer zone of China’s coastline. The line of sight (LOS) deformation is projected to the vertical direction based on the incidence angle. Then 33 GNSS stations from Crustal Movement Observation Network of China whose three-dimensional velocities are known within the inertial terrestrial reference frame (ITRF) are used to calibrate and validate the obtained InSAR ground deformation rates. We use satellite altimetry products from Copernicus Marine Environment Monitoring Service (CMEMS) to calculate the sea level change, and four tide gauges from the national marine data center are used for validation purposes. The ground deformation rates are combined with SLR rates to calculate RSLR rates.

The results show that significant ground subsidence has occurred in some coastal areas of China, including Dalian and Jinzhou in Liaoning Province, Lianyungang, Huai 'an and Yancheng in Jiangsu Province, Ningbo, Zhoushan and Wenzhou in Zhejiang Province, Guangzhou, Shenzhen and Zhuhai in Guangdong Province and so on. The subsidence in Tianjin, Tangshan, and Dongying are the most serious, with the maximum subsidence rate exceeding 200 mm/yr. Overexploitation of underground liquid resources such as water and oil is the main cause of ground subsidence in China's coastal areas. While in Shanghai, the ground subsidence has been effectively controlled with the decrease of groundwater exploitation and artificial recharge of aquifer systems.

The SLR rates in China's coastal areas are slightly higher than the global average, but the maximum is less than 6 mm/yr, which makes ground subsidence dominant in the analysis of RSLR

and the distribution of RSLR is consistent with that of ground subsidence. Based on the profile analysis of RSLR along the coast, there are many places that have high RSLR rates due to ground subsidence, such as Tangshan, Tianjin, Dongying, Weifang, Lianyungang, Yancheng, Ningbo, Wenzhou, Zhuhai and so on, among which the RSLR rate in Dongying is close to 200 mm/yr. Understanding the distribution of RSLR can provide decision-making suggestions for the government's urban planning of coastal cities.