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Evolution of land subsidence over Beijing, China revealed by MT-InSAR technology

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Regional land subsidence is an integrated systematic issue related to multidisciplinary and being of global focus, and has been being a serious threat to the urban infrastructure, high-speed railway and the utilization of underground space, and restricting the sustainable development of society. The study of the regional subsidence evolution in Beijing Plain is of great significance: it is necessary to reveal the regional land subsidence evolution law under the background of Integration of Beijing-Tianjin-Hebei and the South-to-North Water Diversion. Furthermore, it can help to realize the scientific regulation of regional subsidence and ensure the sustainable development of regional economy and society, which has a special significance and application prospect. Therefore the MT-InSAR method is used to obtain the regional ground subsidence time series information of the study area in three periods: Jun. 2003 $\sim$ Aug. 2010, Oct. 2010 $\sim$ Nov. 2015, and May. 2015 $\sim$ Jun. 2018. Then equations are established based on the time-overlapping information to complete the fusion of multi-platform time series, the inconsistence between different reference points is solved, simultaneously. The results show that, the maximum subsidence values in Beijing Plain are 690.6 mm, 649.2 mm and 411.7 mm during the three periods, with maximum deformation rates of 100.6 mm/a, 130.0 mm/a and 142.3 mm/a, respectively. For the spatial distribution and the evolution of the land subsidence field, the weighted spatial kernel density analysis, profile analysis, trend-surface analysis and profile-gradient analysis are used to analyze the spatial-temporal evolution characteristics of the land subsidence field. In this case, land subsidence in Beijing Plain are thoroughly analyzed overall distribution characteristics and evolution process. Nine subsidence centers are identified and the subsidence centers are connecting to form a main subsidence area in the northern part of Beijing Plain. The spatial clustering degree of the subsidence in the Beijing Plain indicates an overall heterogeneity in spatial. Moreover, the northern subsidence areas spread along the Nankou-Sunhe fault, and is cut into several subsidence centers by active faults, indicating that the regional geological structure has obvious control effect on the spatial distribution of land subsidence areas. The evolution of the subsidence field: the northern subsidence areas spread along the northwest-southeast direction, and then expands to both the east and west sides. Then through the distribution of subsidence areas and groundwater funnel, the InSAR based time series and the monitoring well based groundwater level changes, the correlations in spatial and responses between land subsidence field and groundwater flow field are analyzed. The results show that the subsidence center in the northern Beijing Plain is consistent with the groundwater drop funnel in spatial, with a similar downward trend over the whole observation time. Through the analysis of well based results located in different areas, the long term groundwater exploitation in the northern subsidence area has led to the continuous decline of the water level, resulting in the inelastic and permanent compaction; while for the monitoring wells located outside the subsidence area, the subsidence time series show obvious elastic deformation characteristics as the groundwater level changes.