HIGH RESOLUTION D-INSAR MEASUREMENT FOR LAND SUBSIDENCE

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Abstract

TerraSAR-X is Germany's first national remote sensing satellite. Compared to other European satellites, ERS-1/-2 and Envisat, TerraSAR-X data are more suitable for land subsidence monitoring due to its high resolution (strip-mode, 3 m) and short repeat acquisition cycle (11 days). It is well known, the major cause of the surface subsidence phenomenon is over-exploitation of groundwater, while the contribution of tectonic settlement was found to be very small. The traditional measurement method, differential leveling, can draw the spatial-temporal relationship between the real distribution of land subsidence and groundwater drawdown, their time series curves are similar, but the survey results shown the land subsidence centers don't overall match the groundwater depression cones, namely local deviations, and land subsidence always lags behind groundwater level decline, with different lag time at different sites. Some documents think that land subsidence centers shift from the corresponding groundwater depression cones to the sides with thicker accumulated clay layers and the shift strongly depends on the different physical properties of clay soils. In this paper, a study area of subsidence in the city of Taiyuan has been investigated using TerraSAR-X high resolution data and D-INSAR technique. In order to determine the accurate location and shape of each subsidence center, a time series of differential interferograms has been first generated and applied to preliminary location determination and rough subsidence rate estimation for each subsidence center, then the time series analysis of persistent scatterers including single point objects and highly coherent surface pieces for each subsidence center has been used for accurate positioning of subsidence center and precise subsidence rate estimation. In fact, the second step is a problem of parameter estimation based on a subsidence modeling. An important parameter, e.g. parameter limit estimation for phase or displacement rate must be preset in advance, this is done usually based on experience. In this paper, this parameter limit has been estimated through stacking a series of phase-unwrapped interferograms with corresponding time-weighted average. The results of the study using

TerraSAR-X data for land subsidence measurement in Taiyuan represent that the high resolution TerraSAR-X interferometry may provide more details of the subsidence phenomenon, and help to determine the accurate location and shape of each subsidence center. In addition, the results of the study indicate that the misfit and shift of the subsidence center from groundwater drawdown measured by traditional leveling should be caused by inaccurate positioning of subsidence center, not by different thickness of the accumulated clay layers.

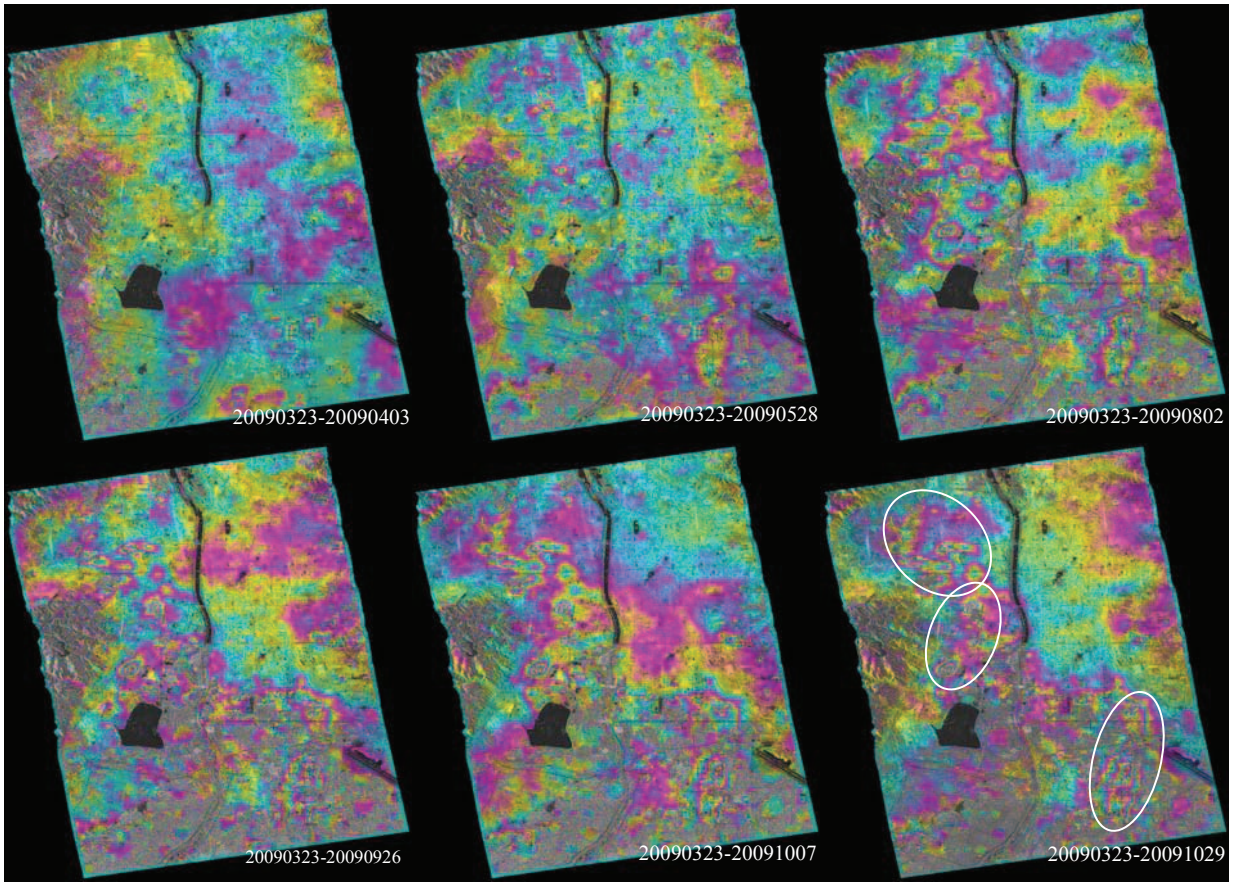

Fig.1. Differential interferogram series shows the process of the developing and growing of the subsidence centers. The random property of he atmospheric effects on interferometric phase are clearly to seen, and the real subsidence funnels are growing with the time, see the areas marked with white ellipses in the last interferogram.

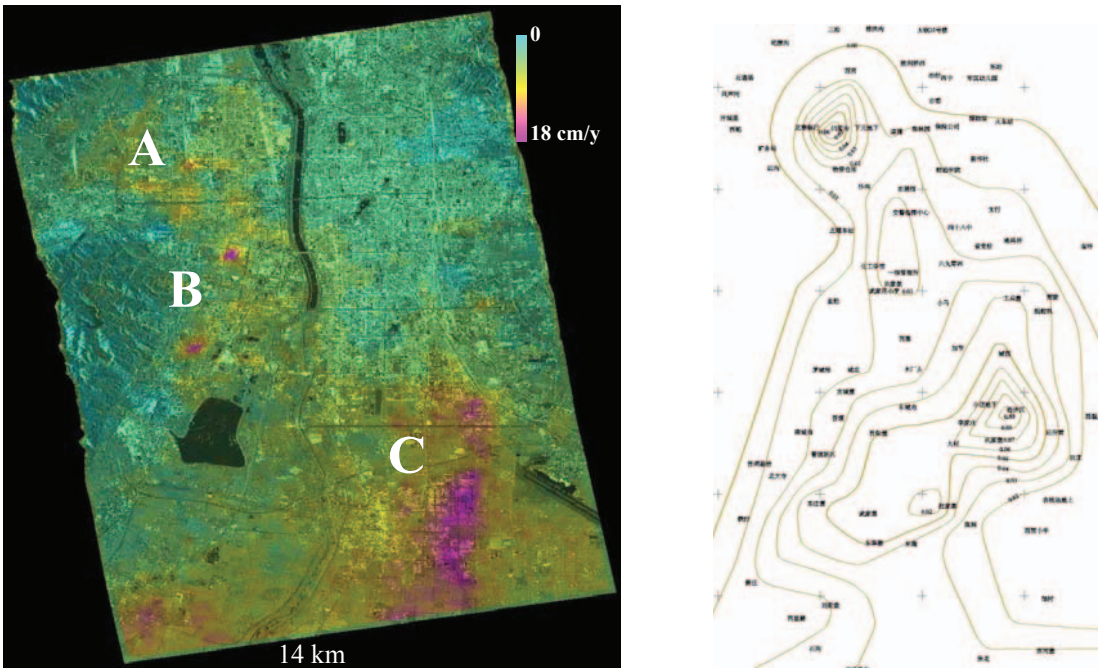

Fig. 2. Left: phase-unwrapped interferogram after stacking indicates that there are mainly three subsidence areas in the study region, each region consists of severer small subsidence funnels. Right: Subsidence Contour Map derived from leveling survey in the same area shown almost same three subsidence areas, but all real settlement centers are not measured out. The traditional leveling measurement can only give a rough outline of the ground subsidence phenomena.

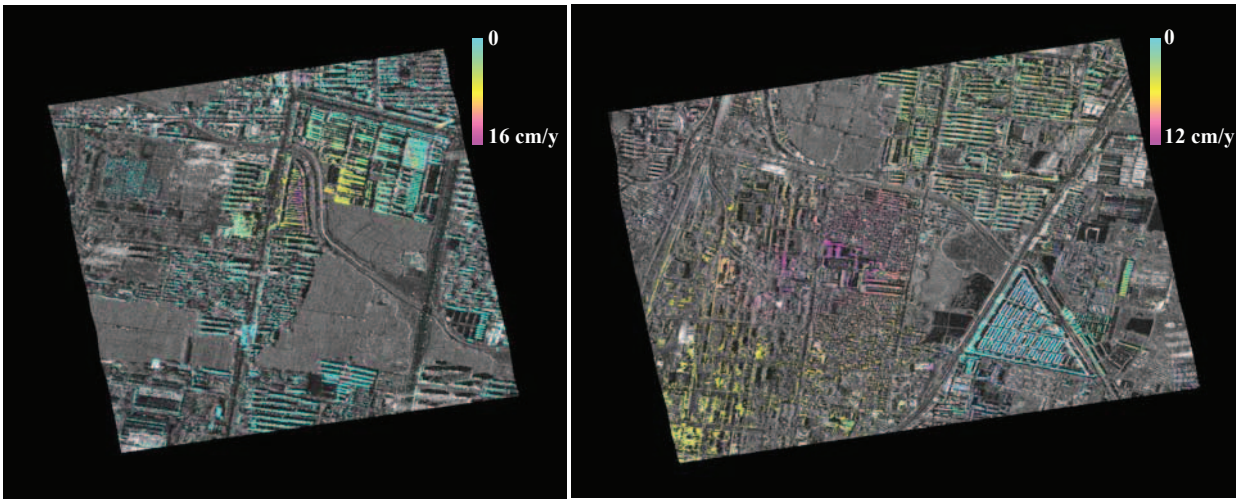

Fig. 3. Examples of the time series analysis results. In subsidence area B there are two subsidence centers showing which buildings have large subsidence rate, e. g. where are the true subsidence centers. The traditional leveling measurement can not reach such a level of accuracy.

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