DETECTION OF LAND SUBSIDENCE IN BEIJING, CHINA, USING INTERFEROMETRIC POINT TARGET ANALYSIS TECHNIQUE

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Land subsidence is a hazard that can pose considerable threats to local population and urban infrastructure. Although land subsidence may be caused in various ways [1], it can be divided into two kinds: natural and man-induced subsidence [2]. Natural subsidence relates to processes originated in Earth such as tectonic processes and volcanism. Man-made subsidence is caused by human activities such as fluid extraction and mining [3]. Land subsidence in Beijing is supposed to be caused by over-exploitation of ground water [4]. This over-exploitation of ground water is leading to a rapid decline of water levels, drying out clay layers that finally result in land subsidence [4].

Beijing covers an area of about 16808km^2. Although Beijing's in-situ subsidence monitoring system, composed of leveling data, GPS, boreholes and drilled ground water wells, is necessary and reliable, its sparse data grid in the area is a limitation which keeps us from understanding the whole deformation field. Spaceborne differential SAR interferometry (DInSAR) has proven a remarkable potential for mapping ground deformation phenomena over tens-of-kilometers-wide areas with centimeter-scale accuracy on the fine space grid [5].

However, temporal decorrelation and atmosphere disturbance degrade the accuracy of DInSAR for slow deformation monitoring. Temporal decorrelation of the images makes it difficult for us to utilize interferograms to retrieve the subsidence history [6,7,8]. Atmospheric inhomogeneities produce an atmospheric phase screen (APS) on every SAR image, which can contaminate the results of the deformation monitoring [9,10]. In this article, we apply the Interferometric Point Target Analysis (IPTA) method [11], which regards the atmosphere disturbance as residual phase and can greatly weaken them. As to serious decorrelation, a proper numbers of pixels with high coherence are selected to obtain accurate interferometric phase.

In order to detect and monitor vertical motion of the land surface over time, IPTA firstly identifies backscattering objects, named as coherent points or points targets, at the ground surface that persistently reflect radar radiation emitted by the SAR antenna [1]. During the interferometric point target analysis, the interferograms are only interpreted for the selected coherent points [11]. The interferometric point targets must remain stable over the time period of interest to permit analysis of the phase history. Due to the requirement that all measurement points must be coherent points, IPTA works preferably in urban environments.

The core component of the IPTA technique is the iterative estimation of phase differences for all measurement points over the sets of the SAR data using a linear model. Due to the usage of a linear model for the processing, the linear deformation rate and precise DEM correction parameters are obtained. In addition, the model can be used to weaken the disturbing effects of the atmosphere. The standard deviation from the iterative function serves as a quality measure for the regression function.

As for phase unwrapping, the minimum cost flow (MCF) algorithm is used to minimize the total cost associated with phase discontinuities in the scene. And Delaunay triangulation is used to generate an optimized irregular triangular network of the points to be unwrapped.

In this paper, IPTA technique was used to retrieval the phase history, extract the linear deformation information from interferometry phase and weaken atmosphere phase delay in Beijing. 20 ENVISAT ASAR images acquired between June, 2003 and March, 2007 have been selected. During the course of the process, multi-master interferometric pairs are used to retrieve the deformation information, similar to the SBAS [12] method.

Classification and visualization of the ground subsidence data illustrate the subsidence trend and the boundary between the center and the eastern area of Beijing, which are respectively corresponding to mainly stable ground and increasingly land subsidence-affected ground. The results of deformation velocity are shown in Fig.1. In order to analyze the land subsidence, two points were selected in the subsidence center. Sequence of land subsidence in Beijing was shown in Fig.2. This overall view shows that land subsidence is severe in eastern Beijing, which coincides with previous ground work derived form ground data [4].

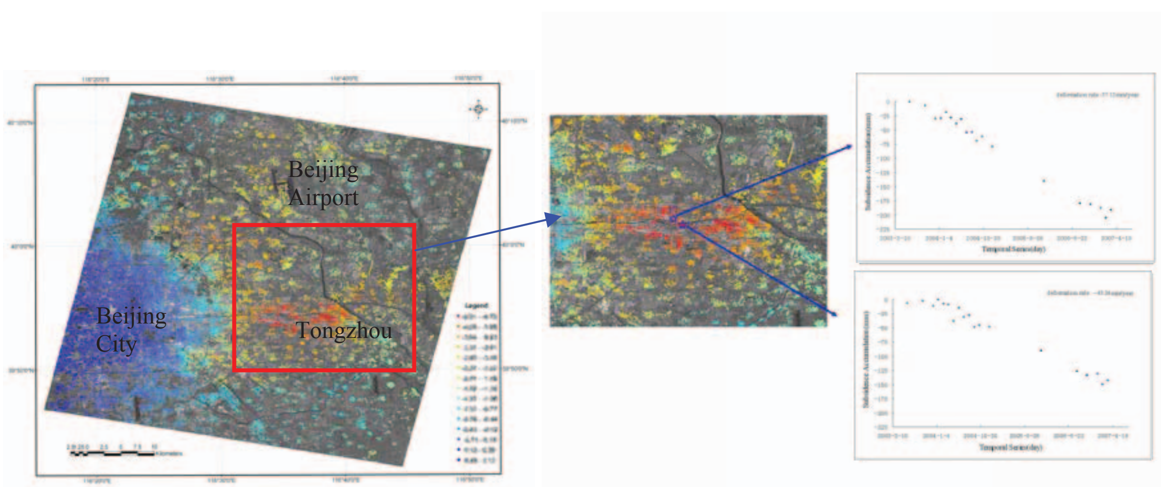

Fig.1. The land subsidence velocity map of test site and the deformation histories of two points

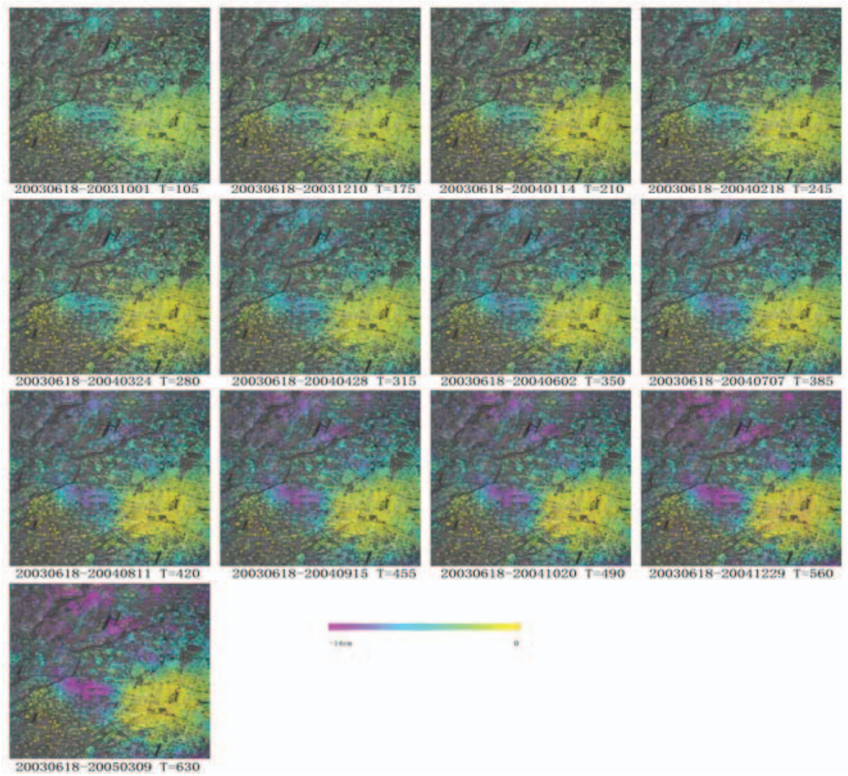

Fig.2. Sequence of land subsidence in Beijing (in radar coordination)

The intention of this article is to demonstrate how IPTA technique could be used to extract valuable information in Beijing area. Unlike conventional ground-based monitoring methods, IPTA benefits from the ability of satellite remote sensing techniques of covering large areas. Besides, the subsidence deformation field of the eastern Beijing could be sketched by our results. The deformation values given by this paper should still be validated by ground measurements.

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