A STUDY ON DIFFERENT PS-LIKE METHODS FOR SUBSIDENCE IN TIANJIN, CHINA

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By analyzing the evolution of phase signals among different SAR acquisitions and subtracting the topographical relief, ground deformation information can be extracted. That is the principle of DInSAR (differential synthetic aperture radar interferometry). But geometrical decorrelation, temporal decorrelation and the atmospheric phase screen (APS) degrade the accuracy of DInSAR, and sometimes even make deformation monitoring impossible [1-11].

PS (Permanent Scatter) [2] technique is possible to avoid many of the limitations of conventional DInSAR by analyzing just certain pixels which behave like point scatters and retain good correlations. Several PS-like methods have been developed and practiced by many researchers [3][5][6][7][9][10][11].

In this paper, the method developed by [9], named as primary PS-like method, and Stanford Method for PS (StaMPS) are both studied and used for monitoring the subsidence in Tianjin area. And the results of the two methods are compared.

17 ENVISAT SLC data for Tianjin area are used, covering from April 2003 to March 2006. The SLC senses acquired on Nov-05-2004 is chose as the master images and the parameters of the interferometric pairs are shown in Tab.1. For the generation of differential interferograms, SRTM DEM and DEOS precise orbits are processed and Doris software (Delft Object oriented Radar Interferometric Software) is used.

Tab.1 The parameters of the interferometirc pairs

ID	**Acquisition time of master**	**Acquisition time of slave**	**Perpendicular baseline(meters)**	**Time baseline(days)**
1	Nov-05-2004	Apr-25-2003	1318.5449	-560
2		Oct-17-2003	694.1080	-385
3		Dec-26-2003	524.7061	-315
4		Jan-30-2004	588.3871	-280
5		Mar-05-2004	-193.3647	-245

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6		Apr-09-2004	751.8968	-210
7		May-14-2004	-474.8380	-175
8		Jun-18-2004	-32.9524	-140
9		Jul-23-2004	228.9768	-105
10		Aug-27-2004	-17.8307	-70
11		Nov-05-2004	0.0000	0
12		Dec-10-2004	-125.9155	35
13		Mar-25-2005	-792.6458	140
14		Jun-03-2005	-340.3566	210
15		Sep-16-2005	-56.4920	315
16		Dec-30-2005	35.5001	420
17		Mar-10-2006	-80.9171	490

Compared with traditional DInSAR process, the primary PS-like method's special steps mainly include: (1) Calibration of the SLC images; (2) Persistent Scatterers Candidates (PSC) selection; (3) Triangulation of PSC and calculation of the phase difference of each PSC couple; (4) Estimation of the differential linear deformation velocity and DEM error between each PSC couple; (5) Integration the linear deformation velocity based on one reference PSC; (6) Dealing with the atmospheric phase screen (APS); (7) detection of all PS and re-estimation of the linear deformation velocity.

While using the primary PS-like method to select PSC, we calibrate the ASAR images and use calibrated backscattering coefficient threshold. Thus, we can properly select PSC and discard the pixels whose amplitudes are relatively stable while whose backscattered signals are weak and incoherent. Fig.1 shows the distribution and the relative deformation velocity of the displacement field.

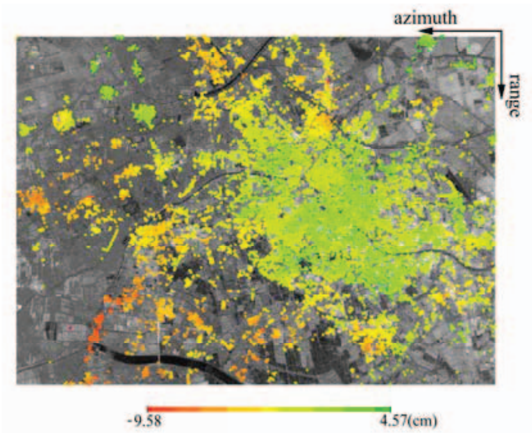

Fig.1 The linear velocity map of Tianjin area from the primary PS-like method

StaMPS is a relatively new PS-like method, which uses spatial correlation of interferogram phase to find a network of stable pixels in almost all terrain without prior knowledge of temporal variations in the deformation[1].

Based on Doris software and obeying some special rules, StaMPS tries to choose a master image to maximize the sum correlation of all interferograms. As to PS identification, PS selection and displacement estimation, StamPS differs from many other PS-like methods. An optional initial set of PS candidates is firstly selected, whose amplitude dispersion are lower than an input threshold. Then the PS pixels are refined in an iterative process by estimating their phase variation measure. After that, bad PS pixels, which appear to be persistent only in certain interferograms and seemed to be dominated by scatters in adjacent pixels or deemed too noisy, are rejected based on their PS probability, which is calculated by both the amplitude dispersion and phase variation measure. After the selection of PS, the wrapped phase of PS pixels is corrected for spatially uncorrelated look angle error and unwrapped by a pseudo-3D method. Then spatially-correlated look angle (SCLA) error and master atmosphere and orbit error (AOE) phase is estimated, and the other spatially correlated noise is estimated and removed by low-pass filtering in time and space. The unwrapping accuracy can be further improved by redo phase unwrapping after subtracting SCLA, AOE phase in an interactive way until the unwrapped result becomes stable and reliable.

The deformation maps in time series from StaMPS are shown in Fig.2 and the subsidence history of the area is directly described. In Fig. 2, we show not all the 17 images' deformation but 14 images' from Oct, 2003 to Dec, 2005.

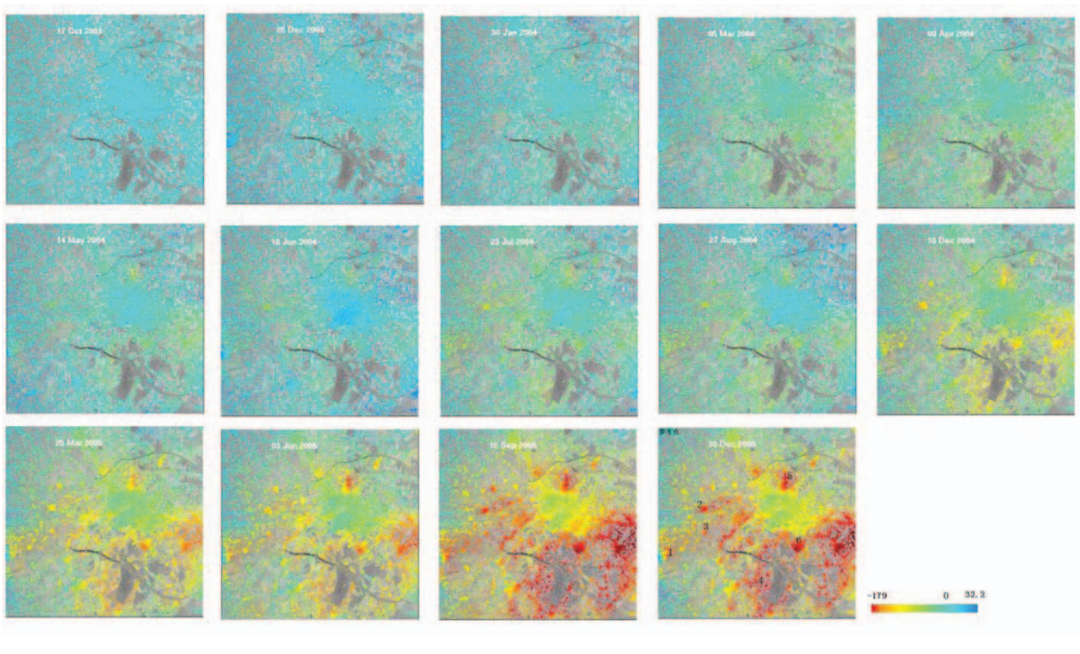

Fig.2 The deformation maps in time series from StaMPS

Comparing the linear velocity map in Fig.1 and the last sub-map in Fig.2, a similar deformation trend could be identified in spite of the area shown in Fig.1 is smaller. It can be safely inferred that the subsidence cones exposed by DInSAR technique are believable.

Because StaMPS doesn't use a certain model to estimate the deformation value, the non-linear deformation history of PS pixels can be calculated. In the last sub-map in Fig.2, we label seven small areas by number form 1 to 7 and select some PS pixels near each small area to plot their deformation time series. Fig.3 illustrates the subsidence curves for 37 PS pixels near the small area labeled by number 2 and the non-linear characteristic of the deformation history in this small area is obvious.

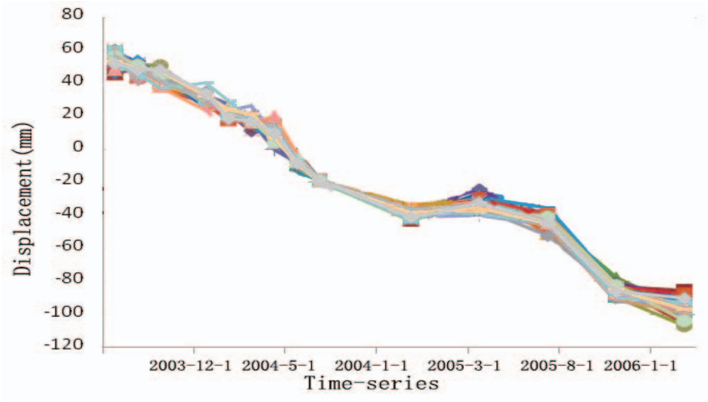

Fig.3 The subsidence history curves for 37 PS pixels near the small area labeled as 2

By using the primary PS-like method and StaMPS, the subsidence field in Tianjin area has been mapped. As to PS selection, the primary PS-like method needs less input parameters and easier to understand than StaMPS. For deformation value calculation, StaMPS is good at evaluating non-linear subsidence history.

In the future work we will try to enhance the primary PS-like method and try to use StaMPS to monitor the deformation of landslide in Three gorge area, China.

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