MERGING MULTI-TRACK PSI RESULT FOR LAND SUBSIDENCE MAPPING OVER VERY EXTENDED AREA

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INTRODUCTION

Land subsidence is a common geohazard in many countries of the world. It has become the major issues of the research of urban geology in recent years. Since it characterized with slowly velocity and wide coverage, it cause damages to many urban areas and civil infrastructures. In China, the Northern China Plain, the Yangtze Delta region and the Fen-Wei graben are the three main regions have been suffering a heavy land subsidence in the past several decades[1]. For well understanding the development of land subsidence, many kinds of techniques, such as spirit leveling, bedrock marking, layered marking and GPS, has been exploited to measure the detailed displacement. However, the large amount of man-power required during such measurement campaigns make them relatively expensive and time consuming. Moreover, displacement observations only can be made at a relatively small number of observation points with a low temporal frequency. All these disadvantages limited the point-wise based surveying technology applied for terrain displacement with wide space coverage and frequent variations. The developed Differential SAR interferometry (DInSAR), which is a radar remote sensing technology capable of measuring possible displacement of radar targets along the line of sight (LOS) by calculating the difference of the phase values of two SAR images acquired at different times over the same area of interest[2], provides an efficient tool for large spatial scale surface subsidence monitoring with high accuracy and precision. In this work we present the first experiment results obtained on the North China Plain (NCP) for land subsidence monitoring by merging multi-track PSI over very extended areas with reduced set of SAR images.

PSI TECHNIQUE

The major limitations of DInSAR are related to temporal and geometric decorrelation as well as atmosphere artifacts[2,3]. The recently developed multi-temporal interferometric analysis techniques, i.e. PSI (Permanent Scatterer InSAR)[4], IPTA(Interferometric Point Target Analysis)[5], SBAS (Small BAseline subset)[6], push DInSAR technique a further step since they take advantages of long term series of SAR images, acquired over the area of interest along the same satellite track, by exploiting interferometric phase of those pixels almost unaffected by temporal and geometric decorrealtion and filtering out the atmospheric artifacts. Hence it's particularly suited to analyze surface displacement over wide regions associated to a relatively weak velocity in long time interval. In this work, we improved the current PSI algorithm by adopting the advantage of SBAS InSAR in the PSI processing chain. Comparison with the standard PSI technique which uses large number of images to generate the differential interferograms with respect to a common master image for each available acquisition, we introduce a small baseline method for interferogram formation and to estimate the average deformation rate and DEM error by exploiting the differential phase series of each coherent point target. Images with a small spatial baseline and temporal span are combined for interferogram stack generation and also to increase the observation sampling and minimize the effects of the DEM inaccuracies and decorrelation. In particular, the proposed algorithm extends the capability of SBAS for PS candidate identification from single look SAR data rather than the multi-looked image used in SBAS technique. The sub-look correlation [5,7]and amplitude stability[4] method are jointly developed for small number of SAR images, which enable the deformation map with the full spatial resolution.

MULTI-TRACK PSI RESULT MERGING

Since the coverage of the subsidence zone is usually beyond the standard scenes coverage of the ongoing radar satellite, i.e. ENVISAT and RADARSAT SAR images which have a ground coverage of 100×100 km, the interferometric analysis based on SBAS technique has been developed for regional subsidence mapping[8,9]. Even if it is capable of large coverage in the direction of the radar track by processing the long strip SAR data, an adjacent tracks merging technique for very extended area, which requires InSAR processing of multi-track (in the flight direction) and long strip (in the across direction) data, has not been archived yet. We have developed techniques in this work for subsidence mapping over very extended area by merging multi-track PSI obtained by processing of long strip SAR data. Since the deformation parameters (subsidence velocity and time series) of each track could be estimated by PSI, the following task is the integration of multi-track deformation maps. The PSI estimates of each track have their own coordinate system (datum) that is defined by the acquisition geometry of the master strip. Hence, the multi-track PSI estimates need to be referenced to a common datum before they can be integrated[10]. Thus, the datum connection procedures consists of the conversion of a common coordinate system and the connection of the PSI parameter estimates in the adjacent track.

For the common coordinate conversion, the first step is geocoding of each single track. This is carried out by using the external DEM to transform the SAR images from radar coordinate to map coordinate. Moreover, a polynomial transformation is performed between the geocoded single track by using the tie points in the overlapped areas to transform the adjacent track to the master track we selected in advance.

PSI parameter estimates connection is the merging of the estimated deformation velocity in different track into a same datum. In the previous step the coordinate conversion is completed the major task in this step is to calculate the difference between the master track and the adjacent track and then compensate the difference by using a transform function. Since in the overlapped areas in multi-track map the deformation refers to the same regimes, the PSI estimated velocity should theoretically only differ a translation because each of the track has the different reference in the procedure of deformation map generation. Considering this fact in the PSI processing the same reference PS in the overlapped area have been identified for the calculation of deformation map of the adjacent tracks. For the deformation parameters computation over the same area, PS within resolution cell distance are weighted averaged to form the deformation to represent the same deformation regime.

RESULTS AND CONCLUSIONS

To verify the presented technique we have studied the large subsidence mapping by integrating multi-track PSI over very extended area in the North China Plain. We applied the ENVISAT ASAR data acquired from Jan, 2007 to Mar, 2009 in three neighboring tracks (Track-218, Track-447 and track-218, Frame from 2799 to 2817) to perform the PSI analysis. The PSI estimated subsidence velocity map in adjacent track have been integrated to generate the large coverage subsidence velocity map; these result are relevant to an area extends about 200×500 km. The estimated subsidence rate has been validated with the precise leveling measurement and the stand deviation between the two groups of data is $\pm 4.6mm$.

The presented results demonstrate the capability of the exploited solutions for land subsidence mapping over very extended areas with space-time information. The merged multi-track PSI subsidence velocity map allows to well investigate the development of regional subsidence as well as localized deformation. Meanwhile, the time series of PS provides the subsidence history of area of interest.

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REFERENCES

[1] Q. C, He, Land Subsidence in the North China Plain(NCP). in Proc. the 7th International Symposium on Land Subsidence, 2005, pp:18-29.

[2] R. F. Hanssen “Radar Interferometry-Data Interpretation and Error Analysis "[M]. New York, Kluwer Academic Publishers, 2002.

[3] H. A. Zebker, P A. Rosen, S. Hensley. “Atmospheric Effects in Interferometric Synthetic Aperture Radar Surface Deformation and Topographic Maps”. Geophysical Research Letter, vol. 102,pp. 7547-7563. 1997.

[4] A. Ferretti, C. Prati, F. Rocca, “Nonlinear Subsidence Rate Estimation Using Permanent Scatterers in Differential SAR Interferometry”. IEEE Trans. Geosci. Remote Sensing , vol.38(5), pp. 2202-2212, 2001.

[5] W.Charles, W.Urs, W.Andreas. “Interferometric Point Target Analysis with JERS-1 L-band SAR Data”. *IGARSS'03*, Toulouse, France, 21-25, July, 2003.

[6]O.Mora, J.Mallorqui, A.Broquetas. “Linear and Nonlinear Terrain Deformation Maps from A Reduced Set of Interferometric SAR Images”. IEEE Trans. Geosci. Remote Sensing, vol.41(10), pp.2243-2253, 2003.

[7] Z. S. Rafael, P. Kostas, H. Irena, et al, “Analysis of Coherent Scatterers over Urban Areas”. http://earth.esa.int/workshops/ polinsar2005/particiants/124/paper_Paper_PolinSAR_2005_Schn-eider.pdf.

[8] C. Francesco, M. Mariarosaria, Antonio P, et al. SBAS-DInSAR Analysis of Very Extended Areas: First Results on a 60,000-km^2 Test Site. IEEE Geosci. Remote Sensing Letters, vol. 5, No. 3, July 2008.

[9] G, Daqing, W. Yan, H. Qiong, et al, Large Scale Land Subsidence Monitoring with a Reduced Set of SAR Images. in Proc. *IGARSS, 2008*, pp: 1205-1208.

[10] G. Ketelaar, F.van Leijen, P. Marinkovic, et al, Multi-track PS-InSAR datum connection, in Proc. *IGARSS, 2007*, pp: 1205-1208.