Optimization of the Combined C-/X- Band Time-Overlapped Ground Deformation Time-Series Derived by SBAS-DInSAR and SVD method

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Abstract

Spaceborne Multi-temporal Synthetic Aperture Radar Interferometry (MT-InSAR) is an advanced technology which is capable of obtaining line of sight (LOS) ground deformation measurements. Moreover, singular value decomposition (SVD) method has been efficiently used for combing two time-overlapped ground deformation time-series. In this work, we used two time-overlapped SAR datasets separately collected by COSMO-SkyMed (CSK) and Sentinel-1A(S1A) sensor to investigate the optimal number of SAR observations during the time-overlapped period for combing two deformation time-series with SVD. Thirty-four combined CSK+S1A deformation time-series were carried out, showing that when SVD is used for combing two time-overlapped deformation time-series, the optimal number of SAR observations during the time-overlapped period is approximately 5.

Keywords: MT-InSAR; SVD; Optimization; time-overlapped; Small Baseline Subset

1. Introduction

Due to the short-term distribution of single SAR dataset, the merge of the multi-platform MT-InSAR was carried out to obtain the long-term vertical ground deformation time-series. SVD method, a generalization of the eigen-decomposition, was used to combine the time-overlapped deformation time-series. This method takes into account the physical process of ground deformation, and can obtain high-precision combined deformation time-series. However, there is a lack of knowledge of how to affect the accuracy of the combined deformation time-series by changing the number of SAR observations in the time-overlapped period. In this study, we used two time-overlapped SAR datasets (CSK and S1A SAR datasets) covering Shanghai to investigate the optimal number of SAR observations during the time-overlapped period for combining two time-overlapped deformation time-series with SVD.

2. Data and Methods

2.1 SAR data

The two SAR datasets used in this study are CSK and S1A. And the detailed parameters of the two datasets are shown in Table 1. There are 23 CSK images and 13 S1A images in the time-overlapped period from February 26, 2015 to March 18, 2016.

Table 1. Detailed information of 2 SAR datasets.

Sensor	Band	Polarization	Orbit type	Heading (deg)	Incidence (deg)	No.of images	Time frame
CSK	X	HH	Descending	8	29	61	Dec 7, 2013 to Mar 18, 2016
S1A	C	VV	Ascending	-12	39	47	Feb 26, 2015 to Jan 12, 2019

2.2 Methods

MT-InSAR techniques, which can be divided into two main classes: the permanent scatterers (PS) InSAR and the small baseline subset (SBAS) InSAR, were the powerful tool for the monitoring of deformation with high spatio-temporal resolution [1]. Due to the lower requirement of the SBAS technique for the number of SAR images, we used the SBAS technique to obtain the deformation time-series.

SVD method is a generalization of the eigen-decomposition which can be used to analyze rectangular matrices [2]. SVD is not only used to calculate the deformation velocity in the SBAS technique, but also used to merge the two MT-InSAR deformation time-series which have an overlapped period [3]. Specifically, if matrix **A** is irreversible, it can be eigen-decomposed to compute the generalized inverse matrix of **A**, as follow:

$$A=U\Lambda V^{T}$$

3. Results

By applying the SBAS technique, the relevant CSK and S1A line-of-sight (LOS)-projected deformation time-series were obtained. Further, the CSK and S1A LOS deformation time-series were converted to vertical direction with the satellite incidence angles [4]. Then, we removed the components of the CSK vertical deformation time-series in N1 (1,2…,22) times during the time-overlapped period. Correspondingly, we removed the last N1 components in the N1-th removal operation. Thus, we acquired 22 groups of new CSK deformation time-series. Furthermore, the 22 groups of new CSK time-series were combined with the initial S1A time-series by using SVD method respectively. we obtained 22 groups of CSK+S1A deformation time-series. We divided the new combined CSK+S1A deformation time-series into four classes, on the basis of N1=1, N=2-4, N=5, N=6-22. At five benchmarks labeled as A, B, C, D, and E, we plotted the classified deformation time-series to demonstrate the combined results, as shown in Figure 1. Generally, at the five benchmarks, the new CSK+S1A time-series combined by keeping 5 components and keeping 6-22 components both show a good agreement with the original CSK+S1A time-series and ground leveling data. Moreover, at the benchmarks B, C, and E, the new CSK+S1A time-series combined by keeping less than 5 components show a good agreement with the original CSK+S1A time-series and ground leveling data. However, at the benchmarks A and D, the cumulative bias could reach more than 10 mm between the original CSK+S1A time-series and the new CSK+S1A time-series combined by keeping less than 5 components.

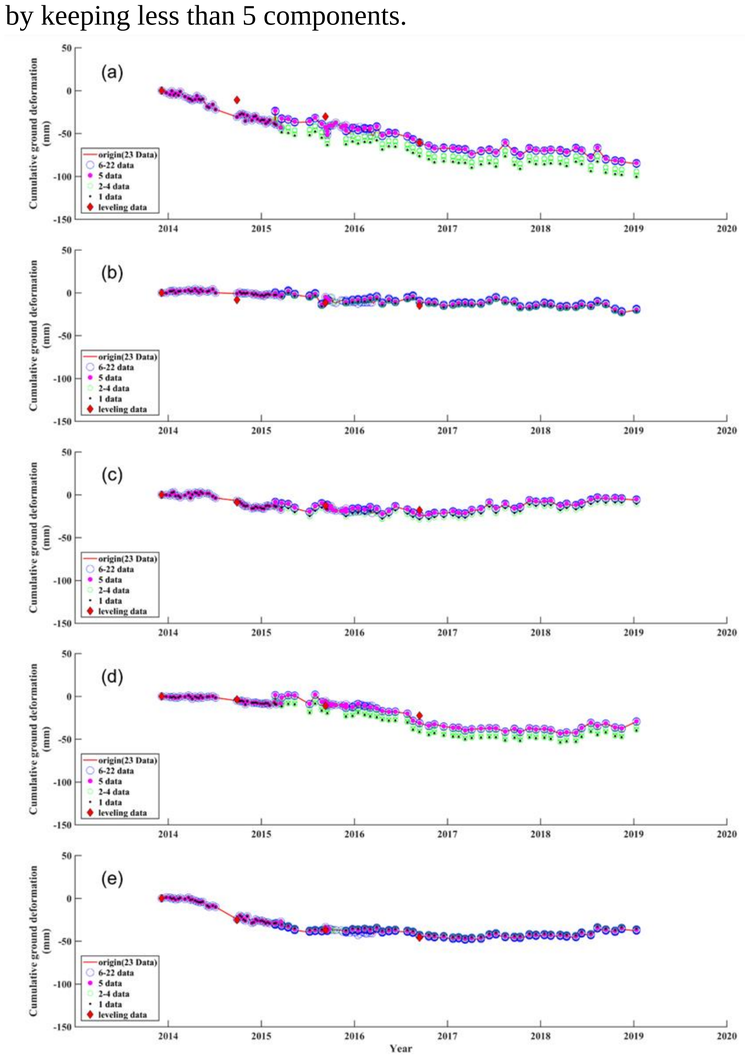

Figure 1. The plot of four classified new CSK+S1A time-series combined by keeping 1, 2-4, 5, 6-22 components of CSK time-series between overlapped period at the five leveling benchmarks labeled as A, B, C, D, and E.

Similarly, we removed the components of the S1A time-series by N2 (1,2…,12) times, and removed the first N2 components in the N2-th removal operation. We obtained 12 groups of new S1A time-series. After the combination with initial CSK time-series, we obtained another 12 groups of CSK+S1A deformation time-series.

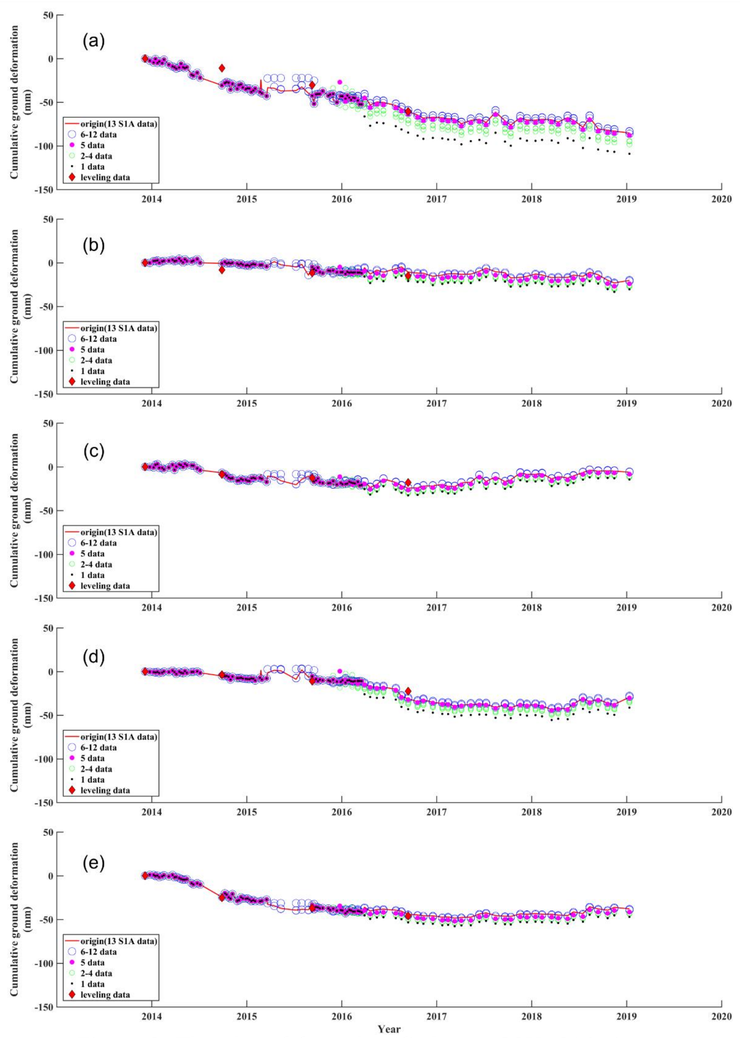

Figure 2. The plot of four classified new CSK+S1A time-series combined by keeping 1, 2-4, 5, 6-12 components of S1A time-series between overlapped period at the five leveling benchmarks.

We plotted the combined results by similar classification at five benchmarks labeled as A, B, C, D, and E, as shown in Figure 2. Analogously, the new combined CSK+S1A deformation time-series obtained by keeping more than 5 components of S1A deformation time-series are in good agreement with the original combined CSK+S1A deformation time-series.

4. Conclusion

We compared the accuracy of the 34 groups of combined CSK+S1A ground deformation time-series to investigate the optimal number of SAR observations during the overlapped period. The results indicate that the accuracy of time-series combined with more than 5 SAR observations in the time-overlapped period is similar with the one obtained with only 5 SAR observations. It suggests that when SVD is used for combing two time-overlapped deformation time-series, the optimal number of SAR observations during the time-overlapped period is approximately 5.

5. Reference

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