A Problem and Its Solution About Using Sentinel-1A Data Monitoring the Surface Deformation

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Keywords: Sentinel-1A data, volume scattering decorrelation, InSAR.

Abstract: WITH the continuous maturity of InSAR(Interferometric Synthetic Aperture Radar) technology, Sentinel-1A data as a free C-band data source has been more and more popular, but there are still some problems in the application of sentinel data in surface deformation monitoring. In this paper, through the interference processing of sentinel data which are from the same time interval and different season（summer and winter）in northern China, we found that there is a serious problem of volume scattering decorrelation in the summer data, which caused a large error in the results. However, the effect of long-term interval is less than the volume scattering decorrelation, it can provide guidance for the use of time series InSAR technology such as SBAS-InSAR and so on.

1. Introduction

The stability of the surface is of great significance to the construction of some major projects such as power lines, roads and railways construction. Traditional survey methods can only be done manually, this not only consumes a lot of human resources, but also the historical deformation of the surface cannot be well mastered, resulting in the possibility of geological instability after the completion of the line. With the continuous development of surface deformation monitoring technology, such as level monitoring, GPS monitoring and InSAR monitoring, we have been able to have a good understanding of the historical deformation of the surface, and can have a good judgment on the stability of a certain area. InSAR technology is a method of interfering two or more radar images and obtaining the surface elevation or elevation variation by the phase differences of different interferograms[1].The technology mainly includes D-InSAR SBAS-InSAR PS-InSAR, etc. SBAS-InSAR, PS-InSAR technologies are developed on the basis of D-InSAR. These two methods have greatly improved in the overcoming the influence of some factors such as atmosphere and decorrelation[2]. In recent years, with the continuous development of this technology, InSAR has been successfully applied in various fields, such as landslide monitoring[3, 4], surface deformation monitoring in mining areas[5-7], seismic research[8-10] and road monitoring[11, 12] and so on. Although InSAR technology is constantly evolving, low coherence has not been well overcome as a major factor limiting the technology. Xin Tian studied the influence of different interference conditions on the coherence of interferograms, and pointed out the specific laws between wavelength, surface vegetation and interference process[13]. sentinel as the C-band datasource, although it has a high sensitivity to the surface micro-deformation, due to the short wavelength, the penetration of trees and other ground objects is poor, thus some errors caused by the correlation are often generated in the application process, affecting the application of sentry data in some areas.

For surface stability monitoring, surface deformations need to be observed at a longer time baseline. For some large geological disasters such as landslides and collapses, there will be some continuity in time and space[14, 15]. In the monitoring of surface stability, if the surface shape variable was small within a long period of time, it can be predicted that the surface will be in a relatively stable state within a certain period of time. In the process of studying this method, we selected four images with similar atmospheric conditions, two of them came from the winter and the two from summer, and they have the same timebaseline. We performed two dinsar processing separately, and we found that the sentinel data may have large errors in the lush areas in summer. Through analysis, we found out the cause of the problem and proposed a corresponding solution.

2. Study Area

The study area selected the representative area of Laiyuan to Quanyu in Hebei Province with a range of 114.44°-115.00° east longitude and 38.73°-39.41° north latitude as shown in Figure 1. After field investigations and optical satellite image surveys, the surface of the area has been in a relatively stable state for a long time. The trees are flourishing in summer. Since it is located in the north of China, most trees in winter will fall, which provides better conditions for our experiments.

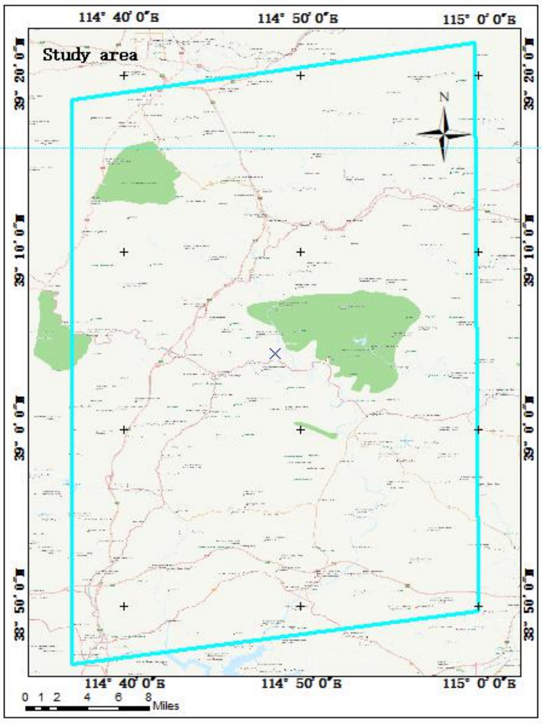

Figure 1: Study area.

3. Data Processing and Discussion

3.1.Data Processing

We used two scenes of winter Sentinel-1A data from March 2, 2016 to March 26, 2016 and two scenes of summer Sentinel-1A data from 2016.5.30 to 2016.7.24. Winter data and summer data have the same time interval. Since the interval is only 24 days, the shape variable is very small. Then the SRTM DEM with 30m resolution was used to remove the terrain phase. After filtering, unwrapping, refinement and re-flattening, we got the coherence coefficient graph and deformation result graph. We have calculated the coherence coefficient graph. The average summer coherence coefficient is 0.628, while in summer is only 0.420. The specific line chart is shown in Figure 2 and Figure 3. The deformation results are shown in Figure 4 and Figure 5. The deformation results show that the average shape variable in winter is -4.3mm, and the summer data shape variable of the same time interval reaches 15mm.

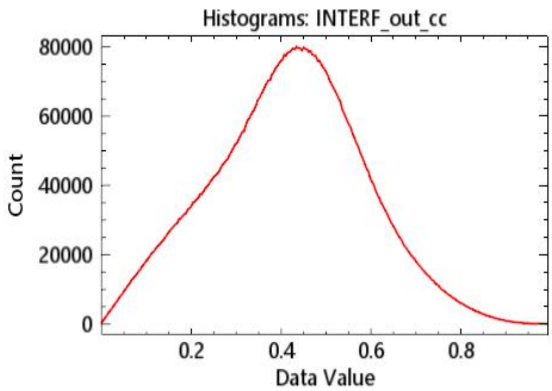

Figure 2: Winter coherence coefficient graph.

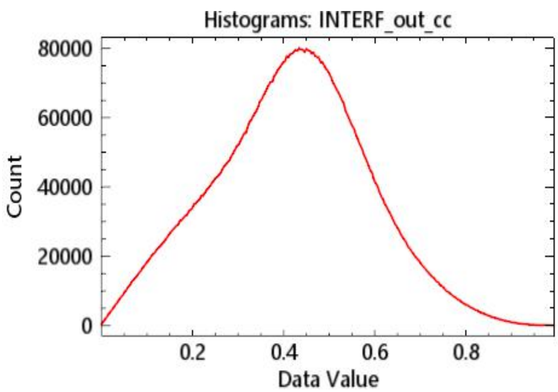

Figure 3: Summer coherence coefficient graph.

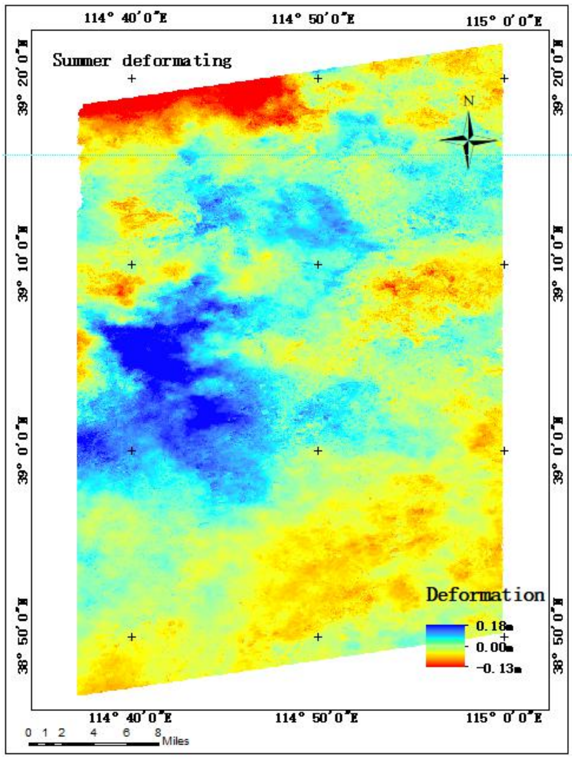

Figure 4: Winter deformation.

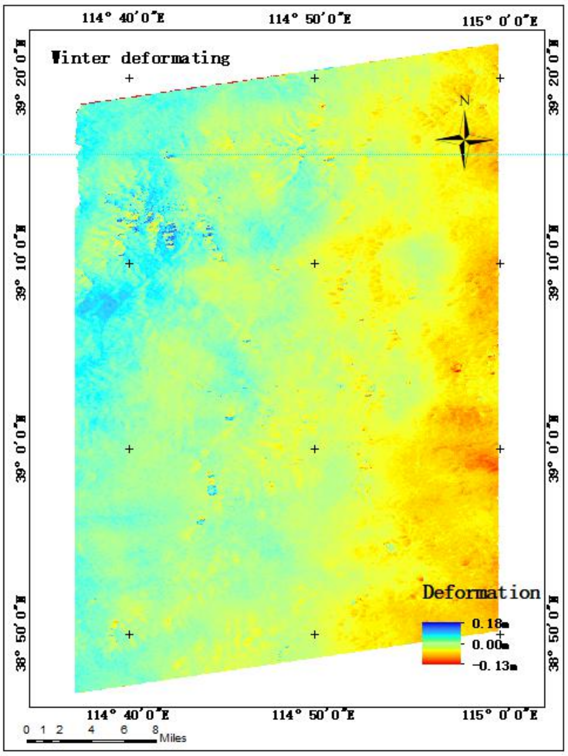

Figure 5: Summer deformation.

3.2. Discussion

It can be seen from Figure 2 and Figure 3 that the sentinel data has obvious difference between winter and summer. While the coherence of winter data is above 0.3, the peak value is about 0.65, the summer data coherence is lower overall and the peak value is around 0.45, which will play a key role in the phase unwrapping result. In the case of using the same unwrapping method, the large deformation variable is obtained in the place with more vegetation in summer, reaching 170mm. There is a clear error, and the winter data results are more normal. The main reasons for analysis are as follows.

The coherence of two echo signals is the basic condition of InSAR interference [16]. The loss of coherence means the loss of correlation, the InSAR technology will not be able to get the actual characteristics and changes of the surface [17]. There are many factors affecting coherence, including changes in the physical distribution of scatters during two imaging periods (time decorrelation), the change of two observation positions (spatial decorrelation), and imaging area geomorphological features, geophysical activities, data processing, etc. In this experiment, time and space decorrelation are used as independent variables, and the rest of the coherent factors are fixed. where the spatial de-correlation mathematical expression is as follows.

$$\gamma_{spatial} = \gamma_{surface} + \gamma_{volume} \tag{1}$$

The total spatial decorrelation consists of volume scattering decorrelation and surface scattering decorrelation. The surface scattering decorrelation is mainly due to the offset of the pop wave in the two echo signals, which causes the echo signal to be out of correlation. The volume scattering decorrelation is mainly caused by the penetration of the electromagnetic wave signal. It has a strong relationship with the radar wavelength and the size of the scatter. In some areas where vegetation covers more, the volume scattering decorrelation is more dominant than the surface scattering decorrelation [18-19]. Based on this point of view, the vegetation in the experimental area is dense, and the correlation of body scattering is extremely obvious. Although the time interval is short, there is still a large error.

4. Conclusion

With the increasing demand of InSAR data, Sentinel-1A as free c-band data is used more and more. In this paper, we processed Sentinel-1A data at the same time interval and same area (in the north of China) with different season, and found that severe volume scattering decorrelation in summer data can cause large errors in the results. For the use of Sentinel-1A data with long-term baseline in a region with more trees, the impact of other factors is much less than the volume scattering decorrelation. Therefore, for the use of Sentinel-1A data, according to the actual situation of the region, selecting the appropriate data quantity and data interval will fundamentally improve the accuracy of the results.

Acknowledgments

We are very grateful to ESA for being able to provide Sentinel-1A data.

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