Comparison and Validation of Different DEM Data Derived from InSAR

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Abstract

High accuracy DEM (Digital Elevation Model) can be derived from SAR (Synthetic Aperture Radar) acquisitions by InSAR (Interferometric synthetic aperture radar) technique. The principle of InSAR is briefly introduced in this paper. DEM measurements are compared with the 1:50,000 China DEM to validate the method. The good coherence between these two DEMs indicates that InSAR is potential in DEM measuring with low cost and high accuracy.

In the second part of this paper, DEM derived with an external low-accuracy DEM (SRTM: Shuttle Radar Topographic Mapping) is compared with the one without an external DEM. The results show that the latter is more unstable than the former, besides it has an overall offset. DEM is significant topography information. With the launch of high accuracy SAR satellite, InSAR will provide a cost-effective way to produce DEM.

Keywords: InSAR; DEM; Damxung; statistical histogram

1. Introduction

Interferometric synthetic aperture radar (InSAR) is a technique to extract three-dimensional information of the topography from the phase data of the SAR signal which has been widely applied in generation of digital elevation model (DEM) and topographic map. If the microwaves launched by the radar fluctuate continuously during the imaging period, with the same frequencies and the similar track, their libration directions are almost along the same line, therefore interference phenomenon will occur and the spatial distribution of phase difference reflected by the fringes. Based on this interference phenomenon of radar waves, Synthetic aperture radar interferometry technology emerged, the radar images twice at least for each slightly different viewpoint in the identical observation area, and the relative height of the ground...
objects can be obtained by the phase difference information of the corresponding pixels from two radar images. Therefore, the essence of DEM generation by the InSAR technology is the phase measurement and conversion of phase to height.

The study was based on two images derived from European Remote Sensing (ERS) tandem data: ERS-1 for 1996-04-06, ERS-2 for 1996-04-07, and the external DEM derived from the topographic map (SRTM: Shuttle Radar Topographic Mapping). The parameters of SAR are as follows in Table I. The selected test site is the Damxung area (centered in E: 90.3, N: 29.8), which located in Tibet of China. With the complex geomorphic and topographic type, the famous Nyainqentanglha mountain pass across the Damxung country along the north-west, and its elevation is more than 4 kilometers. Damxung fault is an important active tectonic in the hinterland of Qinghai-Tibet Plateau, stretching from north to south along Damxung graben system. It is composed of several NNE or NE striking active faults, which are transpressional structures. Under the regional compression, two typical geomorphologies were developed, namely, peak and basin. Thus the Damxung study area is deserving of research.

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<th>Slave image</th>
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production of electronic products, and (3) conformity of style throughout a conference proceedings. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

2. Interferometric Metric Sar procedure

A. The data processing procedure

First, in order to obtain the expected effect, the software EarthView InSAR 4.0 is selected to process the tandem images. EarthView is mainstream commercial software developed by company EarthView in Canada which products include DEM, Interferogram, Differential interferogram, Coherence image, Unwrapping phase etc. Firstly, the DEM processing mode is chosen, in which step DEM is generated only by the tandem pairs. Secondly, picked the DEM with External DEM processing mode, so except the tandem image pairs, SRTM is used as the external DEM for InSAR DEM generation to reduce the errors and get more accurate DEM. The baseline length was 108.3 m, which is about optimal for DEM generation. From the original images, two sub-images of 1741 pixels in range by 1732 pixels in azimuth were extracted and processed with the software.

The procedure we employed to generate a DEM includes the following stages: namely, image registration, interferogram calculation and filtering, phase unwrapping, elevation computation, and geocoding (Fig.1).

Especially, in the process of the registration between the master image and the external DEM, in order to get enough accuracy the GCPs (Ground control points) are selected manually. Furthermore, the RMS (Root Mean Square) is less than 2.5m

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B. Digital elevation models

The 1:50,000 China DEM is showed in Fig. 2 a, b and c demonstrates DEM derived with external DEM and DEM generated without external DEM alternatively. Regard the 1:50,000 China DEM as the base image, registration of the other DEMs are completed respectively. In the process of registration, the RMS of GCPs abides by less than 2.5m severely with the purpose of high registration accuracy. By visual interpretation we can deduced that the effect of the phase unwrapping is not so robust in the generation of DEM without external DEM. This is verified by Fig. 2 c, note that lots of holes and blanks remain in the image, so the quality of DEM is not so smooth. Apparently, the accuracy of DEM derived with external DEM is much higher than the DEM generated without the external DEM.

Damxung area, with unique topography and geomorphology, includes many portions affected by foreshortening, layover deriving from InSAR and even shadow that make the phase unwrapping difficult. The most apparent improvement with the external DEM is that the steep slopes in topography are much closer to the ground surface. These issues will also be demonstrated below in the quantitative analysis.
3. Experimental Results and Analysis

Based on the various DEMs, we adopted the method of statistical histograms to compare the different DEMs firstly. In the one hand, compared the China (1:50,000) DEM with the DEM generated by tandem pairs without external DEM, the result is demonstrated in Fig.3.a.

Band 1(white): 1:50,000 DEM;
Band 2(red): The DEM generated by Tandem pairs without external DEM;
Band 3(green): The absolute height difference between Band 1 and Band 2;
In the other hand, the statistical histogram of DEM created by tandem pairs with external DEM and China (1:50,000) DEM is showed in Fig.3 b.

Band 1(white): 1:50,000 DEM;
Band 2(red): The DEM generated by Tandem pairs with external DEM;
Band 3(green): The absolute height difference between Band 1 and Band 2;

From the Fig.3 a, the statistical histogram tells us that the trend of the 1:50,000 China DEM (white) and the DEM derived without external DEM (red) are consistent in the mass but there is still obvious fluctuation around the elevation 5 kilometers. The histogram of the absolute height difference between these two DEMs manifest that deviation is still convergent, thereby this result validate the method of DEM generation by tandem pairs. The good coherence between these two DEMs indicates that InSAR is potential in DEM measuring. Its StDev (Standard deviation) is 374.47. Compared with the Figure 3.a, the effect of the Fig.3 b is much more stable. Except small perturbation in the elevation 4.25 km to 4.5 km, other sections are accordant pretty good. Furthermore, StDev of the DEM absolute height difference is 92.65. The former StDev is 4 times more than the latter.

From what has been discussed of the two statistical histograms above, we may safely draw a conclusion that the DEM created by tandem pairs with external DEM get higher accuracy than the DEM obtained only by tandem pairs without external DEM. According the principle of data processing, we can also conclude that with the external DEM the phase unwrapping quality must be improved by subtracting the phase which computed by external DEM.

We employed the China 1:50,000 DEM to make the slope, and then the slope divided into 10 segmentations, namely 0-10, 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 80-90. Finally we applied the segmentations to mask the absolute difference of the DEM we talked above respectively, and calculated statistically. The results are listed in Table II and TABLE III.
According to Table I and Table II, RMSE (Root Mean Square Error) value of DEM generation with external DEM is smaller than RMSE of DEM generation without external DEM. The former has the advantage in registration between master image and external DEM, in this paper we selected GCPs manually, therefore these GCPs were applied to correct the offset and trend.
4. Conclusion and Discussion

This paper presented a fundamental procedure for DEM generation using ERS-1/ERS-2 tandem data. The method was applied to a test area located in Damxung, Tibet of China, where two tandem pairs were available. The principle of InSAR was briefly presented. Furthermore, different DEMs were obtained by different processing methods, and then comparison and validation between three kinds of DEMs were conducted. From the first part of this experiment, we can realize that the generation of DEM derived by InSAR is feasible and effective. Then it is affirmative that the accuracy of the DEM generated by InSAR is improved by using external DEM, the second part testifies that the external DEM plays an important role in the improvement of accuracy of DEM.

And then, the next step that we will launch is taking JERS and ERS DEM as an example, L band SAR and C band SAR are compared to estimate the effect of working band of SAR sensors. ERS pair shows good coherence because of the tandem mode of satellites. And JERS images have good coherence because the L band is less affected by time interval. Small wavelength leads to good accuracy, so that the C-band ERS gets the better DEM. These results will be verified in future work.

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References


