

DEM GENERATION USING JERS-1 SAR INTERFEROMETRY

Mitsuharu TOKUNAGA

Institute of Industrial Science, University of Tokyo
 7-22-1, Roppongi, Minatoku, Tokyo 106, Japan
 TEL: +81-3-3402-6231 ext.2564
 FAX: +81-3-3402-6231
 Email: toku@shunji.iis.u-tokyo.ac.jp

ABSTRACT

This paper presents the DTM accuracy derived from JERS-1 SAR Interferometry based on the branch cut method. The target area were selected FUJI and FUGEN mountain in the volcanic mountaions. The accuracy of the calculated DTM is that maximum error and R.M.S.E were 217m, and 27.7m respectively. The accuracy weren't better than theoretical values, but it is regarded as the next factor.

(1) satellite position and orientations (2) precision of geometric correction (3) phase unwrapping algorithm
 In this paper, the one of DTM accuracy derived from JERS-1 SAR Interferometry made clear.

1 INTRODUCTION

The high accuracy Digital Terrain Model (DTM) has been required for the wide field of geoinformatics, monitoring for environment and GIS. The trend will become strong because the high resolution satellite data will be available right away. Now, some method of approach for DTM generation are proposed. For example, the stereo matching using optical data or synthetic aperture radar (SAR) data, SAR interferometry, laser profile and so on are there.

Recently, many articles about Interferometry SAR (InSAR) has been published. Because the potentials of InSAR has been proved in many fields, as DTM generation, glacier analysis, the earth crust change.

Especially, InSAR is provided the high accuracy DTM that couldn't derived from the others remote sensing data.

However, the majority report is to develop the algorithm and to be calculated the fringe data. Few report is evaluated the DTM.

In this study, the comparison DTM derived from interferometry SAR with DTM made from topographic map was carried out in order to clear the accuracy.

2 FUNDAMENTAL OF DTM GENERATION BY INTERFEROMETRY SAR

The Figure 1 shows the geometry of Interferometry SAR.

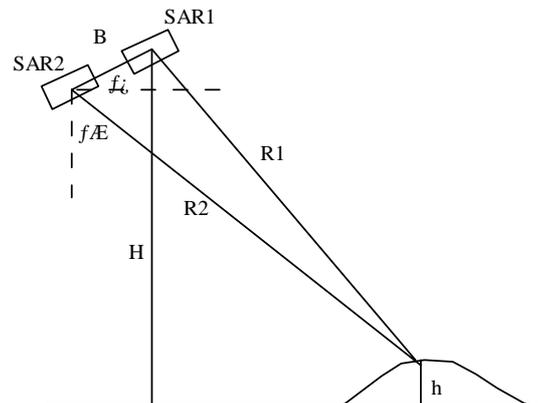


Fig. 1 Geometry of Interferometry SAR

where:

- B : Baseline between two SAR antenna.
- α : inclination angle of baseline
- θ : incident angle of radar
- R1,R2 : the length of slant range
- H : the height of Satellite 1 from surface of the earth
- h : the elevation value of target point

The difference of the slant length of SAR 1 and SAR 2 is approximated the next equation.

$$R2 - R1 = B \sin(\theta - \alpha) \quad (1)$$

Also, the relation of difference of phase and elevation value shows the nest equation.

$$\phi = 4\pi B \sin(\theta - \alpha) / \lambda \quad (2)$$

where:

- λ : the wave length of radar

Then, the elevation values are calculated by the following equation according to the geometry of interferometry.

$$h = H - R1 \cos \theta \quad (3)$$

If phase difference ϕ is already known, θ can be calculated by the equation 2.

So, the elevation values are calculated according to the equation 3.

But, it is difficult that the height of the satellite is determined precisely.

Now, the next equation shows the partial differential equation of different phase against slant range and elevation.

$$\partial\phi / \partial R1 = 4\pi B \cos(\theta - \alpha) / \lambda R1 \tan \theta \quad (4)$$

$$\partial\phi / \partial h = 4\pi B \cos(\theta - \alpha) / \lambda R1 \sin \theta \quad (5)$$

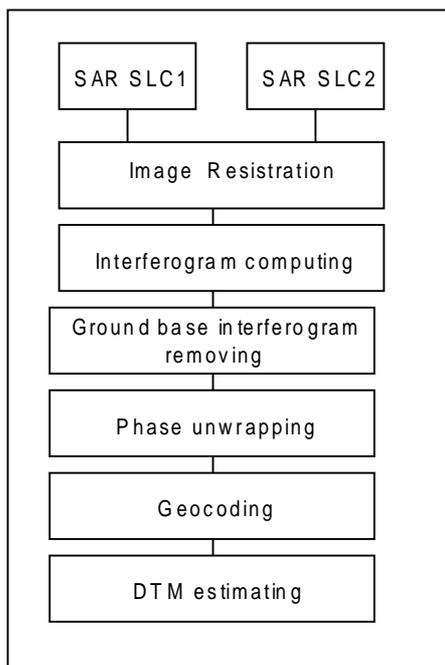
The equation 4 shows the proportion of different phase against the change of the slant range. So, it is shown the fringe when the surface of the earth is flat. That is why it is called the orbital fringe.

The equation 5 shows the relation of phase difference and elevation. The elevation value is calculated from the difference of phase difference from the orbital fringe.

3 PROCESS

The DTM were provided according to the next flow.

Fig. 2 The Flow of the Process



(1) Geometric Corresponding

Geometric correction processing were carried out for corresponding to two SAR images. In this paper, corresponding points were selected better points into some candidate corresponding point by manual.

(2) Calculation of the phase difference

Subtracted the phase of SAR 1 from one of SAR 2.

(3) Calculation of the orbital fringe

The orbital fringe created according the equation 4.

(4) Extraction the orbital fringe

Subtracted the phase difference generated in (2) from the orbital fringe. If the elevation fringe is not appeared, regenerated the orbital fringe by changing the orbital position parameters. Because the orbital position data aren't precise for interferometry processing.

(5) Phase unwrapping

The phase is distributed 0 to 2π . Therefore, the phase must be integrated. However, it is difficult to process by influence of the noise. Some methods were proposed, but the best one is unknown.

(6) Conversion phase to DTM

Convert from the integrated phase to elevation value according to the equation 5.

4 RESULTS

The following images are processed as input data.

(1) JERS1 Level 0 , 1993/07/07

(2) JERS1 Level 0 , 1993/08/20

The length of baseline is shown 818m by NASDA.

The reference DTM data is used the 50m grid digital map data made by Geographical Survey Institute of Japan.

Fig. 3 shows the estimated line. Fig.6 and Fig.7 shows the profile of the DTM on the estimated line.

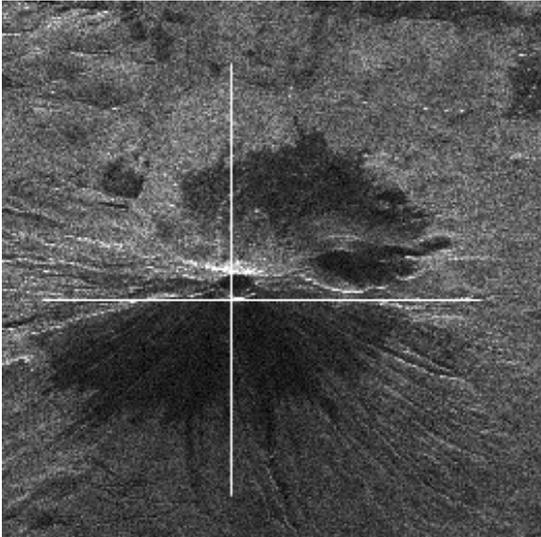


Fig. 3 Plot line for DTM estimation



Fig. 4 Fringe (FUJI)

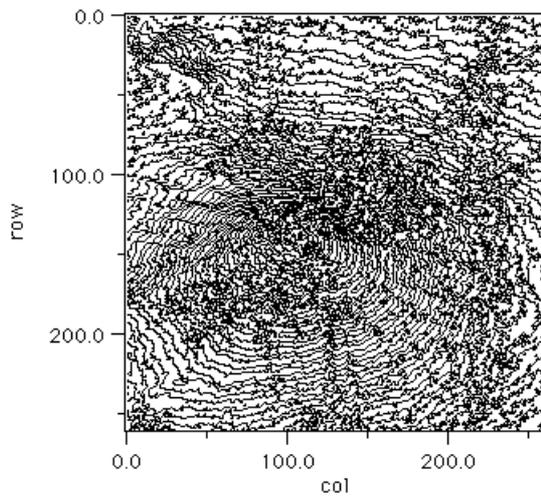


Fig. 5 Contour Line of Generated DTM

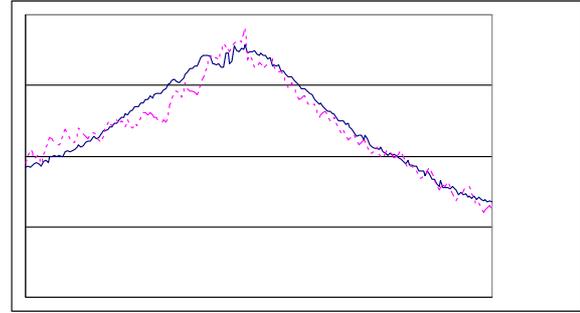


Fig. 6 DTM Profile for Azimuth direction
(Real Line: Topograph, Break Line: generated DTM)

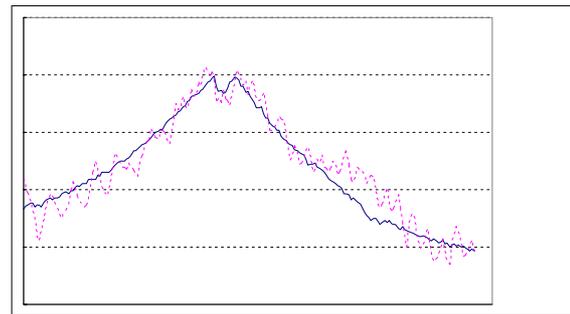


Fig. 7 DTM Profile for Range direction
(Real Line: Topograph, Break Line: generated DTM)

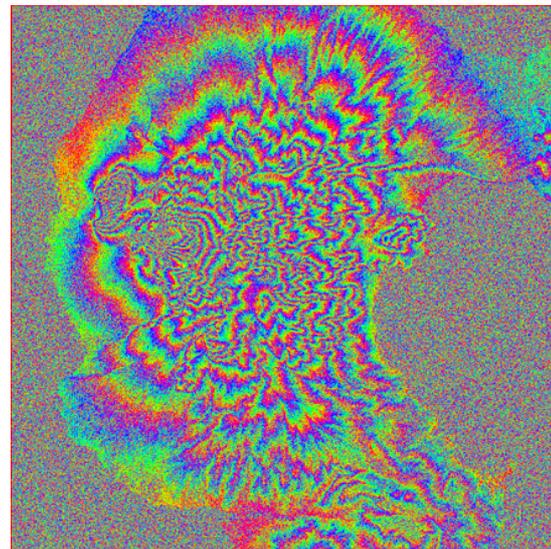


Fig. 8 Fringe (FUGEN)

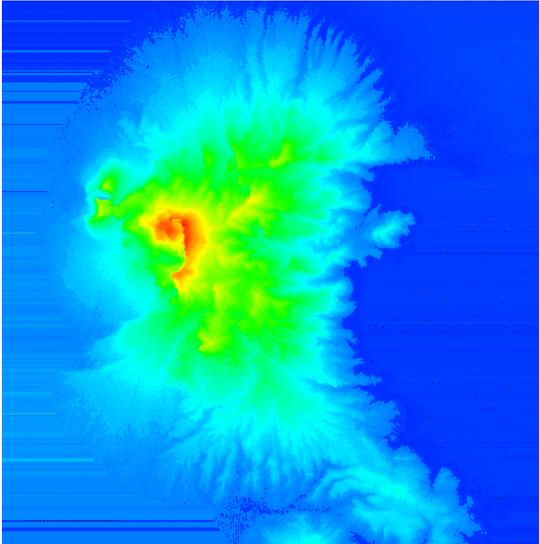


Fig. 9 Computing DTM (FUGEN)

5 CONCLUSION

The accuracy of DTM derived from SAR interferometry using JERS-1 were made clear in this study. Even if the accuracy of the satellite positions and orientations, the length of baseline, the change of surface of the earth (corresponded with correlation coefficient) and the algorithm of phase unwrapping gave influence to precision of the DTM generation, their quantitative relations couldn't make clear in this time.

In the future, some experience will be examined on the difference condition, as different length of baseline, the different observation date, and so on.

Finally, the factor obstructing promotion of studies on SAR interferometry recognized through this study are described.

The most important factor is that whether ability to generate SAR interferogram isn't understood till two SAR data are handled. The fact means it isn't understood whether process of SAR interferometry is well before having purchased SAR data.

Additionally, there is observation interval for more than 44 days at least in the case of using JERS1 data. Naturally, the surface of the earth may be changed in the meantime. So the fact is indicated that it is difficult to process the interferometry SAR data by repeat pass observation.

So, it is same situation about the length of baseline. The length of baseline could just calculate after having purchased SAR data.

Therefore the catalogue search system is required for interferometry SAR data. It is advisable to be able to display the length of baseline, incident angle and correlation coefficient at least as search items in the system.

Finally, SAR data set consisted complex type are distributed is expected in order to study SAR interferometry.

6 REFERENCE

- (1) NASDA : JERS-1 Science Program Application Data Sets, JERS-1/SAR Interferometry, CD-ROM Vol.1, 1995
- (2) Richard M. Goldstein, Howard A. Zebker, Charles L. Werner : Satellite radar interferometry : two-dimensional phase unwrapping, *Radio Science*, Vol. 23, No. 4, pp. 713-720, Jul.-Aug., 1988
- (3) J. M. Huntley, H. Saldner : Temporal phase-unwrapping algorithm for automated interferogram analysis, *APPLIED OPTICS*, Vol. 32, No. 17, Jun., 1993
- (4) Howard A. Zebker, Richard M. Goldstein : Topographic Mapping From Interferometric Synthetic Aperture Radar Observations, *Journal of GEOPHYSICAL RESEARCH*, Vol. 91, NO. B5, pp. 4993-4999, Apr., 1986
- (5) A. K. Gabriel, R. M. Goldstein, H. A. Zebker : Mapping small elevation changes over large areas: Differential radar interferometry, *J. of Geophysical Research*, Vol. 94, No. B7, pp. 9183-9191, 1989
- (6) Claudio Prati, Fabio Rocca, Andrea Monti Guarnieri, Elvio Damonti : Seismic Migration For SAR Focusing : Interferometrical Applications, *IEEE Trans. GE*, Vol. 28, No. 4, pp. 627-639, Jul., 1990
- (7) Howard A. Zebker, Soren N. Madsen, Jan Martin, Kevin B. Wheeler, Timothy Miller, Yunling Lou, Giovanni Alberti, Sergio Verella, Alessandro Cucci : The TOPSAR Interferometric Radar Topographic Mapping Instrument, *IEEE Trans. GE*, Vol. 30, No. 5, Sep., 1992