CHALLENGE OF ASTER DIGITAL ELEVATION MODEL

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1. INTRODUCTION

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) has acquired more than two million data scenes with along-track stereovision. These data are processed to make digital elevation model (DEM) with orthorectified images. Although comparison of DEMs obtained at different times shows the crustal deformation, the difference map of DEMs suffers from the satellite attitude jitter. In this work, the methodology to overcome the problem is discussed.

2. ASTER DEM PROCESSING

ASTER DEM is produced from Level-1A data products using the homemade software with the similar method in the reference [1][2]. The corresponding point in nadir and backward observations is determined using the normalized correlation and other similarity measures. The size of the correlation window and the search area are automatically adjusted in correspondence with the texture pattern in the template. Using the bundle adjustment, the three-dimensional position of the nadir pixel is obtained. The adjustment error is statistically analyzed and the time-dependent fluctuation due to the satellite attitude jitter is evaluated. The other parameters, such as pixel and line numbers during data acquistion, are also prepared to estimate the attitude jitter.

3. SATELLITE ATTITUDE JITTER

The ASTER sensor suffers from the satellite attitude jitter that has a higher frequency than that of attitude data sampling of the star-tracker on board the Terra spacecraft. The cause of the jitter is not clarified yet; the amplitude of the jitter is as large as six meters on the ground footprint [3]. Several methods to correct the jitter are conceived using the constraint of pushbroom sensor. Since the line of sight vectors starts from the satellite at the sampling, discrepancy of the geometric position has information of the attitude jitter. First, the short wavelength infrared radiometer (SWIR) that has six line-sensors arranged in parallel is used to correct the roll jitter [4]. Since the interval of observation with two neighboring bands is 360 milliseconds, the roll component is corrected to reduce the registration error between two bands. Since this method is vulnerable to noise due to the subpixel estimation, regularization term to smooth the attitude rate is introduced in the correction. In this work, this method is further extended to other attitude components, mainly to the pitch component that is tightly related to the stability of the along-track stereovision.

4. DEM DIFFERENCE

To evaluate the DEM accuracy obtained by the ASTER, the difference at two times is analyzed. Although this method is relative comparison, the stability of the DEM accuracy is estimated. The difference is as small as 10 meters, however, the periodic oscillation in the difference map is observed, which is along the scan lines of the pushbroom sensor. The attitude jitter described above is the main cause. Assuming that the ground target is not deformed between two times, the influences of the satellite attitude jitter is evaluated. We found that the standard deviation in the difference map is decreased significantly by this procedure.

5. DEM STACKING

Another method to correct the influence of the satellite attitude jitter is stacking and mosaic of the DEM. By selecting the DEM data with a good correlation flag, the stacked DEM is produced using the method of ASTER Global DEM (GDEM) [5]. Tile of N35E138 is used for the comparison, which includes Mt.Fuji as well as the Minami Alps of Japan. Although the difference with the DEM produced by the GSI (Geographical Survey Institute) shows good agreement within 10 meters in standard deviation, the systematic error still remained in the difference map. Comparison with the ASTER GDEM is also discussed.

11. REFERENCES

[1] H. Fujisada, G. B. Bailey, G. G. Kelly, S. Hara and M. J. Abrams, “ASTER DEM Performance”, IEEE, Trans. Geosci. Remote Sens., vol. 43, pp.2707-2714,2005

[2] T. Toutin, “Three-Dimensional Topographic Mapping With ASTER Stereo Data in Rugged Topography”, IEEE, Trans. Geosci. Remote Sens., vol. 40, pp.2241-2247, 2002.

[3] A. Iwasaki, and A. Fujisada ”ASTER Geometric Performance”, IEEE, Trans. Geosci.Remote Sens., vol. 43, pp.2700-2706, 2005.

[4] Y. Teshima, and A. Iwasaki, “Correction of Attitude Fluctuation of Terra Spacecraft Using ASTER/SWIR Imagery With Parallax Observation”, IEEE, Trans. Geosci. Remote Sens., vol. 46, pp.222-227, 2007.

[5] ASTER Global DEM, . http://www.ersdac.or.jp/GDEM/E/index.html.