OVERVIEW OF DEM PRODUCT GENERATED BY USING ASTER DATA

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ABSTRACT

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is one of the instrument boarded on EOS-AM1, will be launched by NASA, USA on June, 1998. The ASTER instrument has developed by Ministry of International Trade and Industry of Japan, based on the requirement of ASTER team constituted with Japanese and American scientists.
DEM working group of Japan's ASTER science team defined the general specification of DEM products, and has been developing the algorithm of DEM generation. The DEM products generated by the algorithm will be distributed through ASTER ground data system (ASTER GDS) that has been developing by Earth Remote Sensing Data Analysis Center (ERSDAC) of Japan. In this paper, We disclose the specification, contents, accuracy of the DEM products.
ASTER DEM products will be provided to 2 type products called XYZ set and Z set. XYZ set is consisted of header, relative DEM, Quality flags (correlation value, abnormal value, water and cloud area). Z set is consisted of the 30m grided DEM made from XYZ set. Relative DEM means elevation data generated by not using GCP, and derived from ASTER stereo pair image using stereo matching method.
We made ASTER simulation image data from JERS1/OPS data and calculated relative DEM using simulation data. As a result, the relative DEM was generated as the accuracy of 12.5m R.M.S.

1. ASTER INSTRUMENT

1.1 Spacecraft Parameters

The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is one of the instrument boarded on EOS-AM1 platform, will be launched by NASA, USA on June, 1998.
he spececraft parameters shows in table 1.

Table 1 Orbit Parameters

Orbit	Sun Synchronous
Cycle	16 days
Period a orbit	98.9 min.
Altitude	705Km (at equator)
Inclination	98.2 degree
Orbit Position Knowledge	150m (3s)

1.2 ASTER Instrument

The ASTER instrument was developed by Ministry of International Trade and Industry of Japan based on the requirement of ASTER team constituted with Japanese and American scientists.

The ASTER is consisted of The Visible and Near Infrared Radiometer (VNIR), The Short Wavelength Infrared Radiometer (SWIR) and The Thermal Infrared Radiometer (TIR). Especially, VNIR has the following features for DEM generation.
(1)the stereoscopic capability in the along track direction
(2)the stereoscopic viewers are observed by nadir and backward
(3)Base to Height Ratio (B/H) is fixed 0.6.
(4)Ground resolution is 15m.
(5)the backward viewing detector has tilt angle on 1.33 degree from along track direction. So the corresponding area with nadir image and backward image is made sure of

maximum by compensation for the earth rotation.

2. POLICY OF DEM GENERATION

We have had the following policies on DEM generation.
(1)DEM are generated operationally, if it is possible.
(2)GCP aren't utilized with a basis.
(3)Coarse DEM are utilized with a basis.
(4)DEM of 30 m grid are generated.
(5)DEM generation of Southeast Asia area is given high priority.
By these policies, many relative DEM products will be possibly generated. But some problems are caused.
(a)As ASTER is optical sensor, it is impossible to generate DEM in cloud area, water area, etc. Therefore, these area has to be detected automatically.
(b)For assure to quality of product, abnormal DEM data that caused by mismatching have to be detected automatically.
(c)The accuracy of elevation data depends on pointing knowledge of spacecraft because GCP isn't utilized. Therefore, the performance of pointing knowledge had be clear.
(d)Coarse DEM is desired one of high accuracy. As the best DEM product is DTED made by Defense Mapping Agency of USA, it isn't available. So, next better product is GLOBE product or DCW product. As the GLOBE product is 1Km Grid data. GLOBE will be selected as coarse DEM.

3. The ALGORITHM

The general flow chart shows in figure 1 and figure 2.
This algorithm will be implement in ASTER Ground Data System.

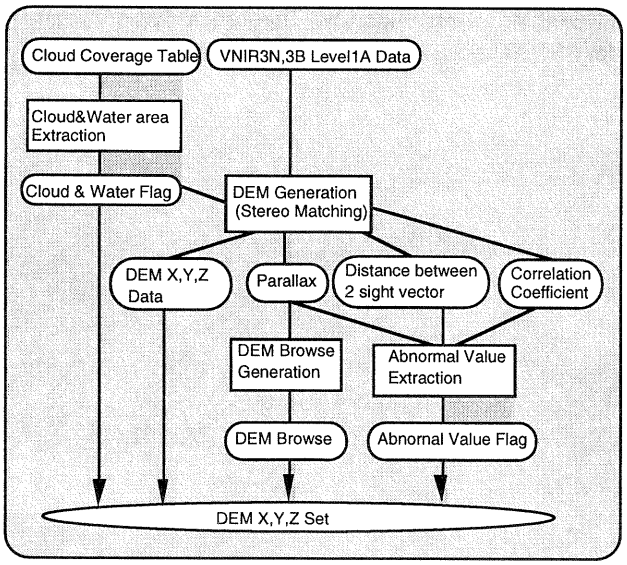

Figure 1 General Flow Chart (1)

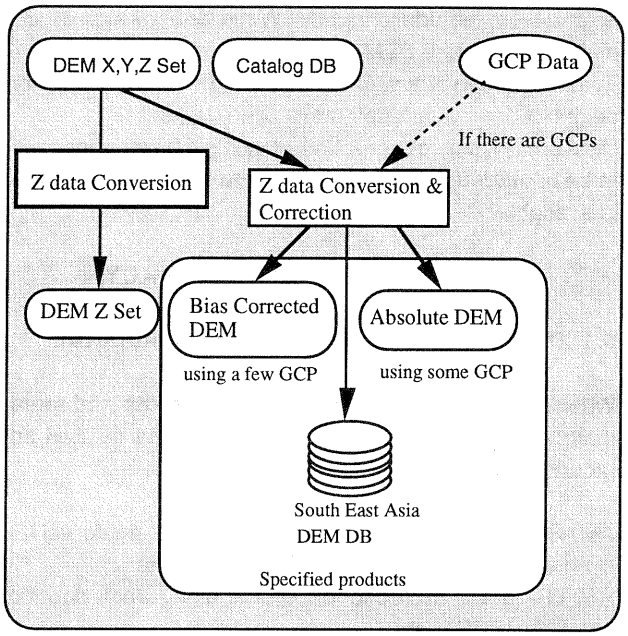

Figure 2 General Flow Chart (2)

We adopted the stereo matching method using area correlation technique. In a search of correspondence point, We utilized stereo matching method on three stages. Because it was a purpose that process time is saved and mismatching is reduced. So, First correspondence of tie point is examined using SSDA method. Second and Third correspondence is examined using correlation method.

If GCP are available, Bias corrected DEM and absolute DEM are able to be generated. But GCP had to be prepared by not system administrator but user. Their DEM are treated as specific product.

4. ASTER DEM PRODUCT

Two kinds of DEM products will be distributed.
(1)XYZ set product
(2)Z set product

XYZ set product is the Data Set that consisted of relative elevation data, correlation value and quality flags.
The elevation is calculated by stereo matching, and the coordinate system is thing of earth fixation coordinate system. Therefore, it isn't grid data but random data.
The quality flags are the index data which are indicated the area where elevation was abnormal, matching impossibility area.
The correlation value is also one of quality index. If correlation value is low, probability that mismatching is occurred is high.
XYZ set DEM will be generated 30sets per day.

Z set product consists of only elevation data made from XYZ set DEM.
It is grid data converted into map projection such as UTM,

polarstereo, latitude longitude. When GCP exists, we can make the absolute DEM.
By using quality flags, DEM is able to be interpolated from neighbor data, converted into a fixed value.
DEM provided by observation of multiple times is possible to be upgraded to high accuracy data. Also DEM mosicing is available.

5. ESTIMATION OF ACCURACY

5.1 DEM accuracy using ASTER simulation

When there is no error at orientation elements and stereo matching, the precision of DEM is decided by B/H and ground resolution.

As ASTER data weren't available yet, we made ASTER simulation data made from JERS-1 OPS data.
ASTER data is stereoscopic on the along track direction same as JERS1data.
We estimated the accuracy of ASTER DEM data through ASTER simulation data were processed.
The condition of process is follows.
(1) Original DEM is used to elevation data to be generated from 1:25000 topographic map by Geographical Survey Institute of Japan.
(2)Image data is resampled from JERS1 data.
(3)Orientation image data is calculated from JERS1 data.
(4)ASTER backword image data is calculated from original DEM and orientaion image data.

The result of estimation shows table 2. Also figure 3 shows generated ASTER simulation data and figure 4 shows original DEM and generated DEM.
Figure 5 shows the result of extraction of water area as impossible matching area.

Table 2 Accuracy of Elevation

Positive Maximum Error (m)	Negative Maximum Error (m)	Average Error (m)	R.E.M.S(m)
175	-199	0.87	12.31

As this case has no error in orientation data, the cause of error seems to be mismatching.
The orientation elements are decided by system configuration. The position knowledge of EOS-AM1 spacecraft becomes high to utilize data of TONES satellite compared with others spacecraft. Therefore orientation error isn't mainly cause in elevation error.

And, It is easy to be matching on stereoscopic image in along track direction, compared with one on cross track direction. Therefore, the accuracy of DEM using real ASTER data will be not change one of simulation data.

5.2 The caurse of Mismatching

The area where mismatching are occurred are estimated that JERS-1 data were processed about 30 scenes include desert zone, tropical rain forest zone, a grassy plain, steep mountain zone. As a result, the area where mismatching are occurred had the next characteristic.

(1) when the same intensity level
(2) when resemblance pattern continues
(3) when saturation data exist
(4) when area of the sea, cloud level exists
(5) shadow department of clouds

JERS-1 data has the capability that are B/H=0.3, ground resolution=18m and 24m. In case of JERS1 data, the accuracy of DEM is settled 60m-80m. It's average is estimated with 30m-40m.
The results of experiment were able to get several characters near by a theory value, showed in the table.

On the other hand, ASTER data has the capability that are B/H=0.6, the ground resolution=15 m. In case of ASTER data, the accuracy of DEM is settled 12.31m. It's near a theory value.

6. FUTURE

ASTER DEM product's accuracy will be 12.5m that has the potentiality of drawing 1:100,000 scale topographic map.
The Algorithm will be upgrading, especially searching method of stereo tie point, extraction method of mismatching area.

7. REFERNCE

(1)ERSDAC, 1995. Algorithm Theoretical Basis Document for ASTER Level-1 Data Processing.

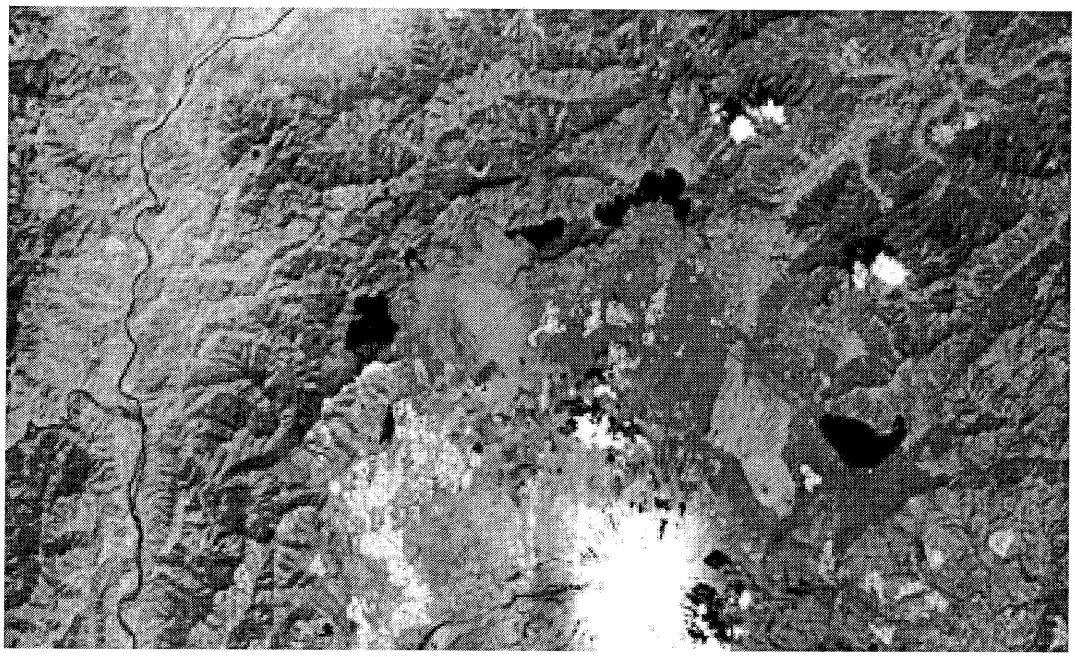

Figure 3 ASTER simulation data

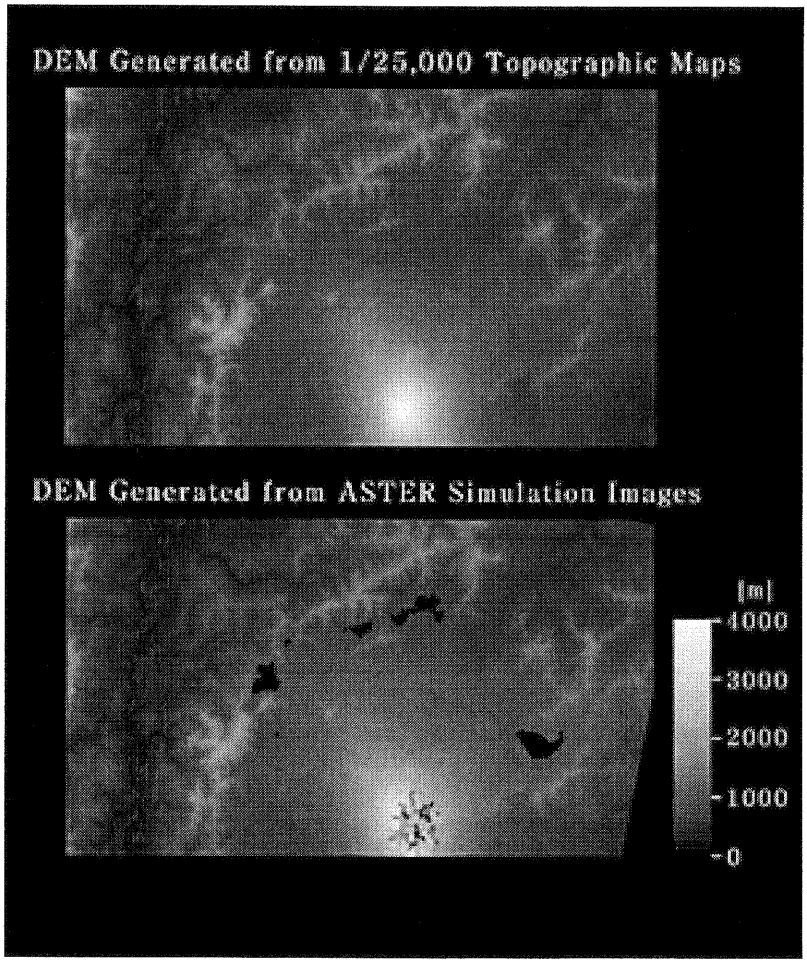

Figure 4 Comparison of DEM

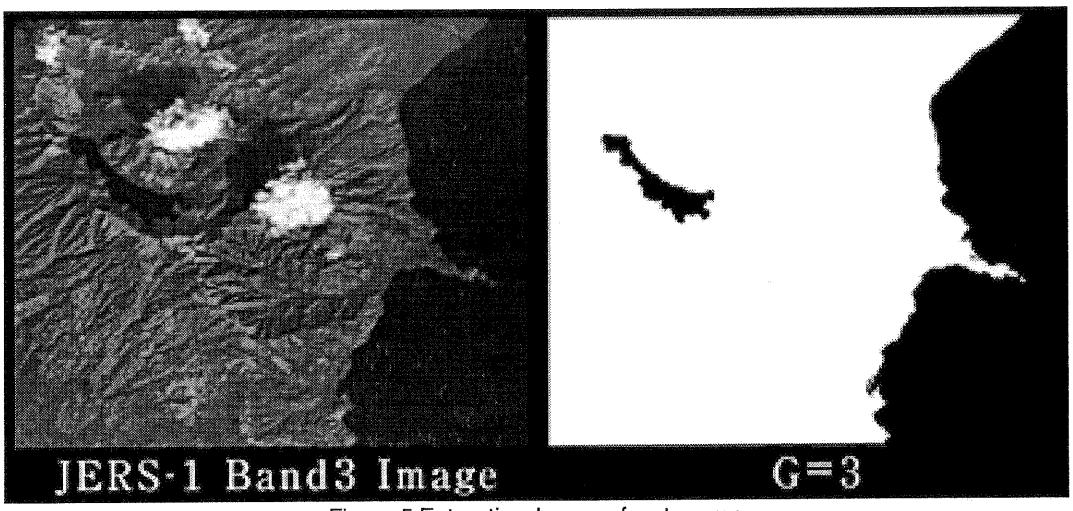

Figure 5 Extraction Image of water area