SUBJECT DEVELOPMENT FOR THE REMOTE SENSING EDUCATION BY ALOS DATA

PI No.416

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1. INTRODUCTION

The education is important for spreading remote sensing technology. Therefore the subjects which can be used in an educational front and the basic exercises which can be applied easily in a class are necessary. In the scientific research working group "Remote Sensing Data Analysis by Personal Computer" of the Remote Sensing Society of Japan (RSSJ), we continue this activities to spread remote sensing technology since held of "The training course of remote sensing data analysis using personal computer system" in 1987 [1][2]. Taking advantages of ALOS, have been launched in 2006, we started to maintain and develop subjects for the education using ALOS data.

2. GENERAL

The working group is composed of the various research fields, such as urbane, environment, oceanography, forestry, data processing, etc. A member can prepare an educational subject from the beginning class to the advanced class in each research field [3][4]. Now, we are incorporating the examples which are processed using the ALOS data. They are,
(1) Urban environmental analysis
(2) Forestry condition analysis
(3) Glacier lake monitoring

3. SOFTWARE

Free software developed for the RSSJ training course "Remote-10 [5]" was modified for the ALOS data processing. Some basic processing functions are necessary for the exercises. The functions of Remote-10 for this purpose are as follows,

(1) Data Input/output
Input satellite data of the various format, i.e., CEOS format, RESTEC format, Landsat/TM fast format, TIFF format and any other binary files, and output by the format of RESTEC format and TIFF format.
(2) Displaying
Display images by several ways, i.e., color composite image, gray scale image and level sliced image.
(3) Measurement
Measure the histogram, digital number and coordinates of selected pixel and single-cell signature.
(4) Processing
Process classification, orientation, resampling, filtering and HSI conversion.
(5) Others
The other functions, developed specially for ALOS data processing, are orientation by leader file, data fusion processing and DEM generation.

4. NEWLY DEVELOPED FUNCTIONS

The authors have already developed the basic software, Remote-10/win, to analyze and process satellite images. In this study, we improved the following functions and added it to make use of the special feature of ALOS data.

<u>(1) Registration based on the information of Leader file.</u>
Recently, the information of position becomes high accuracy because they are calculated by the information from GPS system. We improved that the registration function has been estimated using latitude and longitude of four corners recorded in the leader file.
The central coordinate of the bridge calculated by the orientation result was N35-40-37.7 and E139-45-6.2. On the other hand, it was N35-40-26.3 and E139-45-33.7 in the digital map. This difference should be occurred that each coordinates depend on the different coordinate systems, Japan standard system and world standard

system. Converting it from Japan standard to world standard system, the coordinates becomes N35-40-38.0 and E139-45-22.1, very good accuracy.

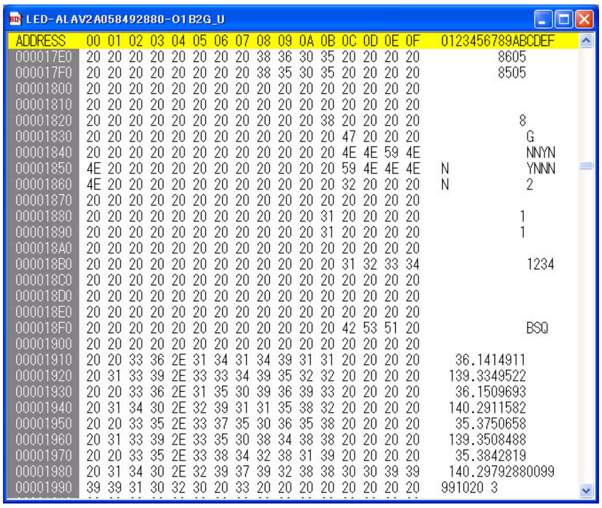


Fig.1 Latitude and longitude of four corners recorded in the leader file

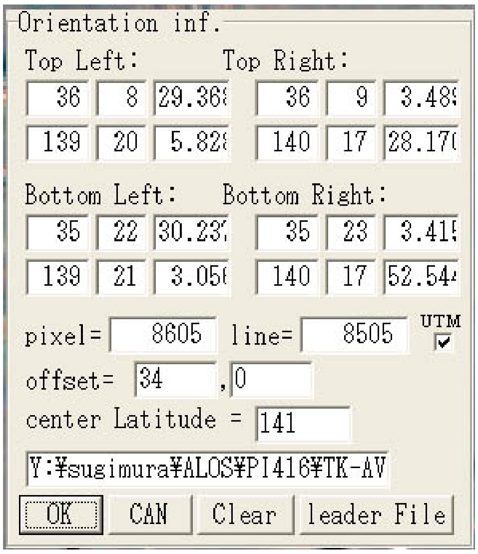


Fig.2 Obtained coordinates information

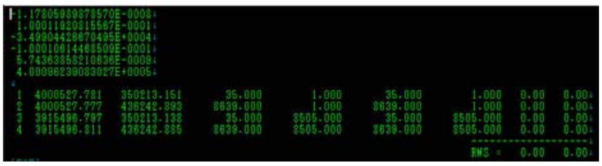


Fig.3 Orientation result

<u>(2) Data fusion</u>

ALOS observes a pair of image, high resolution but single-band (PRISM) and low resolution but multi-band (AVNIR-2) images. Here introduce a tool for the data fusion using these images.

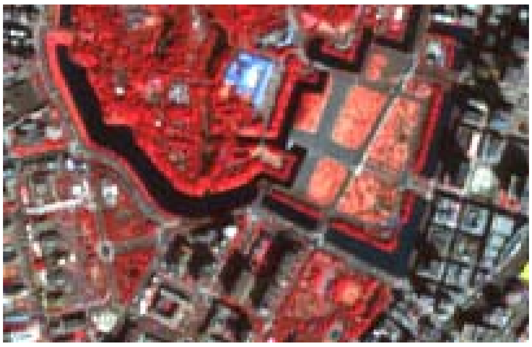


Fig.4 GCP in ALOS/AVNIR-2 image

Fig.5 GCP in Digital Map

The most popular method is the HSI conversion. This cannot process all of image band because HSI method process only RGB color image. Other than the HSI method, several methods which can process multi spectral data prepared in the software. They are Multiplicative method, Brovey transform method, Differential adding method, Spatial weight ratio method[6], Wavelet and Principle component.

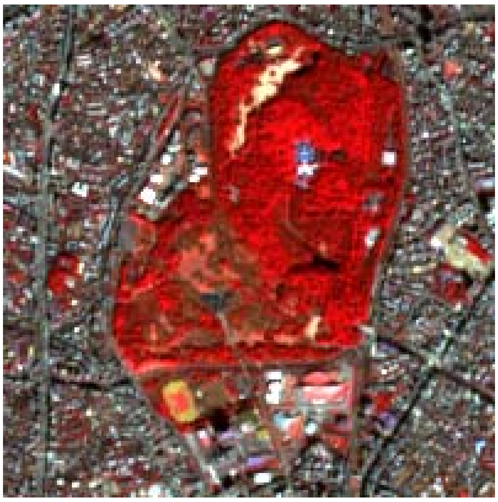
Fig.6 to 8 shows the difference of effect between these methods at Meiji shrine and its vicinity. Firstly we show the results processed by the simulation pair data generated from the ALOS/AVNIR-2 and secondly the results processed by the pair of ALOS/AVNIR-2 and PRISM data. This results concerning with the NDVI in each methods contribute to give a deep significance.

Table 1 shows the correlation between AVNIR-2 original data and fusion results generated by simulation data. In this comparison, Spatial weight ratio method is the best correlation in these data fusion methods.

These products become better contents if they can apply analysis of NDVI evaluation.

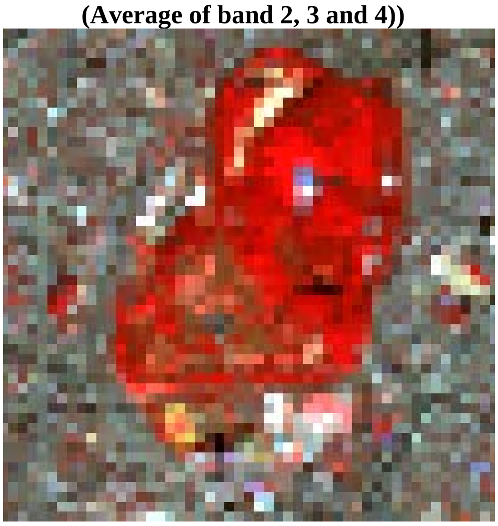
Table 1 Correlation of fusion images

	Multiple	Brovey	difference	Ratio	Wavelet	PCA
Band 1	0.91115	0.93468	0.95945	0.91007	0.94160	0.95191
Band 2	0.92599	0.97825	0.97780	0.98048	0.97443	0.97678
Band 3	0.92862	0.98175	0.98278	0.98915	0.98209	0.98414
Band 4	0.90194	0.96151	0.95886	0.96503	0.93175	0.90585
average	0.91693	0.96405	0.96972	0.96118	0.95747	0.95467
NDVI	0.88083	0.88357	0.86231	0.88380	0.80038	0.86942



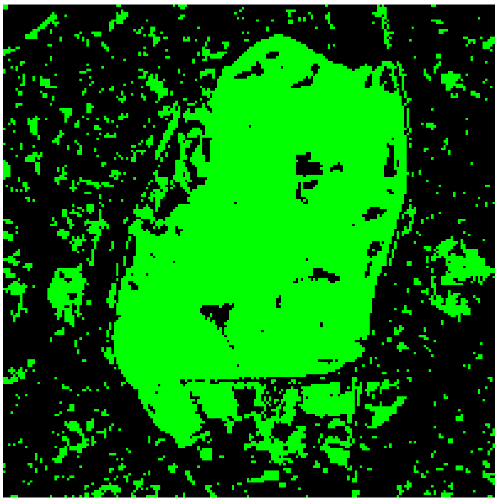
(a) AVNIR-2 original data (resolution=10m)

(b) Pan image generated from AVNIR-2 (Average of band 2, 3 and 4))

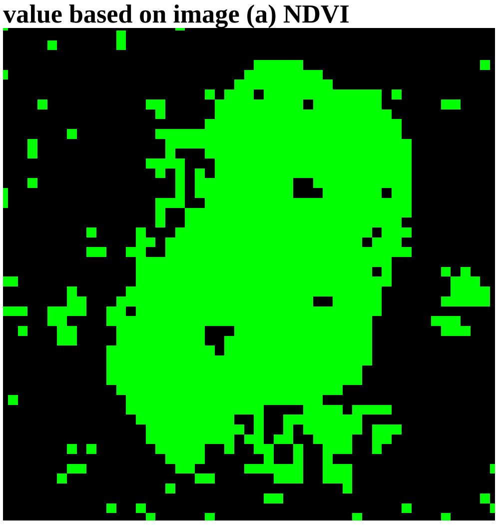


(c) Multi image generated from AVNIR-2 (Average of 4x4 pixels)

(d) NDVI of image (a)



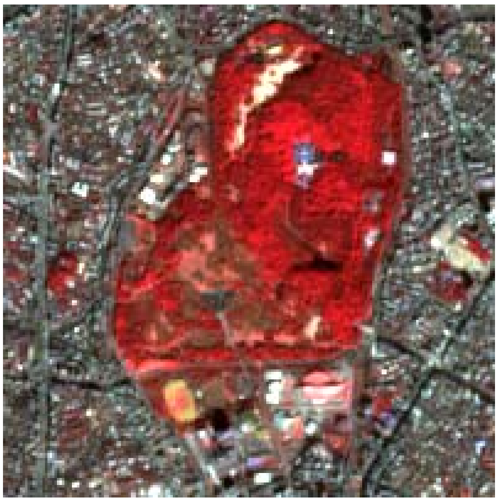
(e) Extraction of the vegetation area by the threshold value based on image (a) NDVI



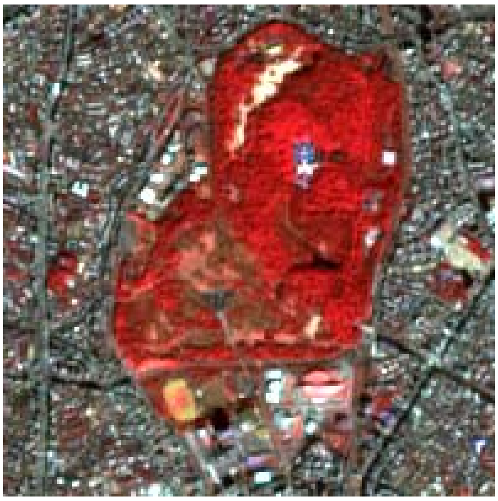
(f) Extraction of the vegetation area by the threshold value based on image (c) NDVI

Fig.6 Data reduction of ALOS/AVNIR-2 from 10m to 40m for their pixel spacing

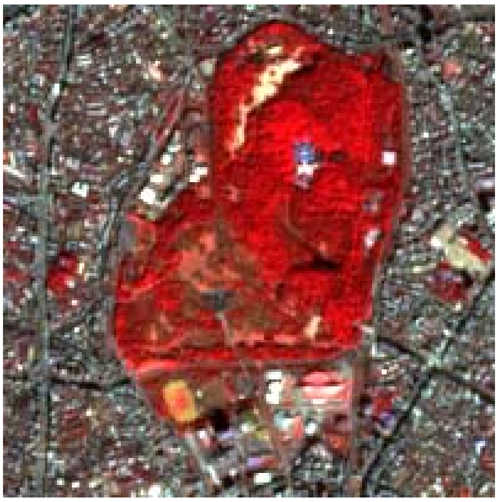
(a) Multiplicative method



(b) Brovey transform method

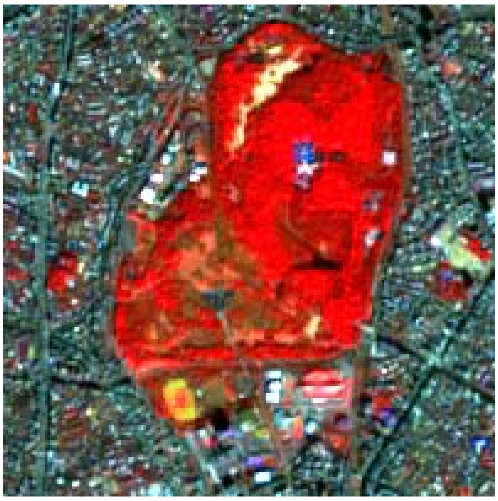


(c) Differential adding method



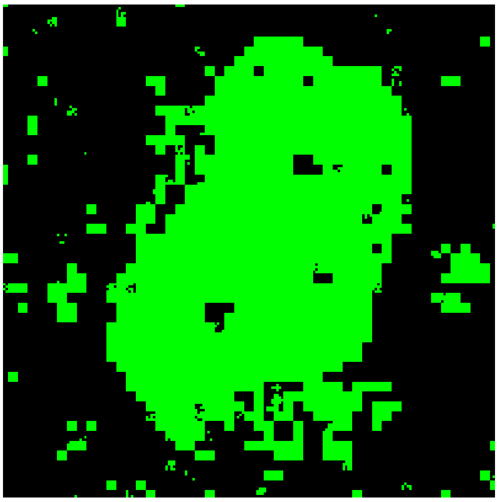
(d) Spatial weight ratio method

(e) Wavelet

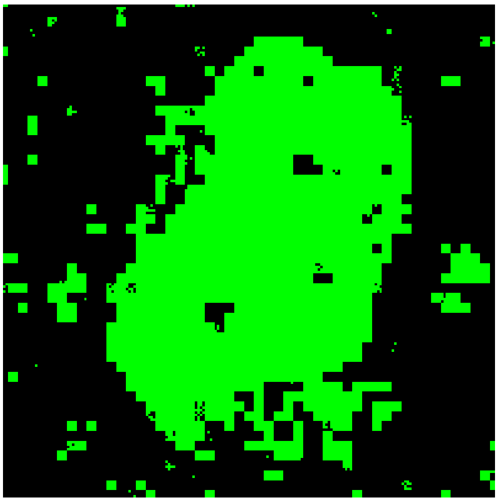


(f) Principle component

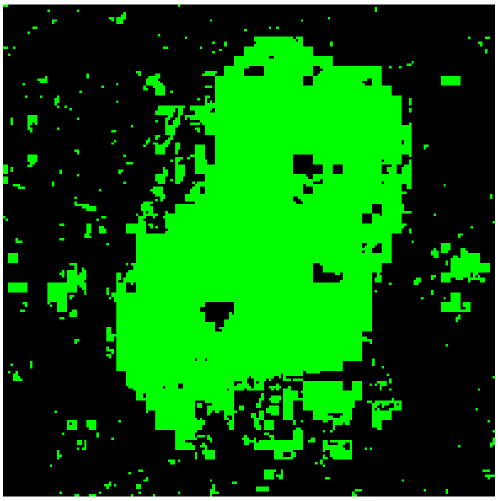
Fig.7 Data fusion results by deferent methods



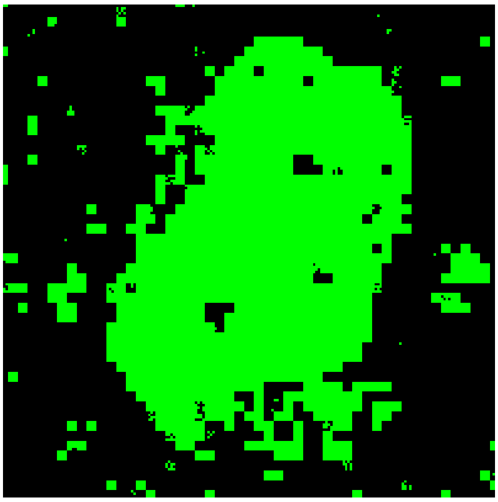
(a) Multiplicative method



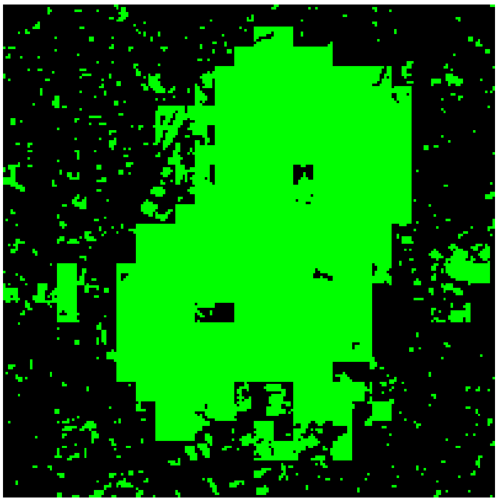
(b) Brovey transform method



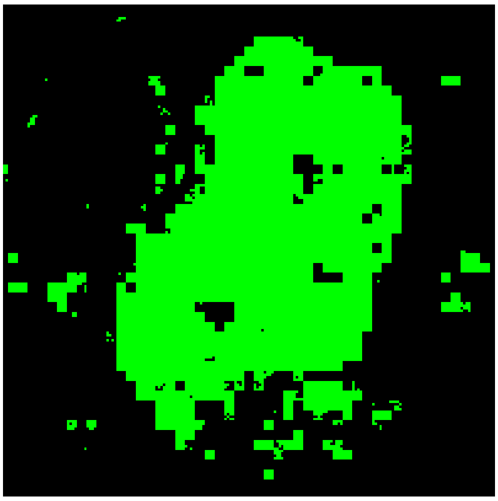
(c) Differential adding method



(d) Spatial weight ratio method



(e) Wavelet



(f) Principle component

Fig.8 Extraction of the vegetation area by the threshold value based on Fig.7 (a) - (f) NDVI

The comparison of vegetation area extracted by threshold is shown in Table 2. The test site covers 14km×12km area at Meiji Shrine and its vicinity. Fig.7 and 8 show a part (2km×2km) of test site. Because of the averaging process (4×4 area), the small scale vegetation area was not extracted. So the number of pixels extracted as vegetation is smaller than the one by the original image analysis.

Table 2 Extracted number of pixels in each method

data	NDVI>80
original	518497
simulation	303648
NDVI(multiple)	314308
NDVI(Brov)	258827
NDVI(diff)	270061
NDVI(Ratio)	253481
NDVI(wavelet)	261373
NDVI(PCA)	191245

(a) ALOS/AVNIR-2 data (2007.3.1)

(b) ALOS/PRISM data (2007.3.1)

Fig.9 Original ALOS/AVNIR-2 and PRISM data

On the basis of this result, data fusion was processed using actual ALOS/AVNIR-2 and PRISM data. Fig.9 is ALOS/AVNIR-2 and the PRISM data which used in this study. Fig.10 is enlarged image of Ueno Park (500m×500m) where covered with forest.
The comparison of vegetation area extracted by threshold is shown in Table 3.

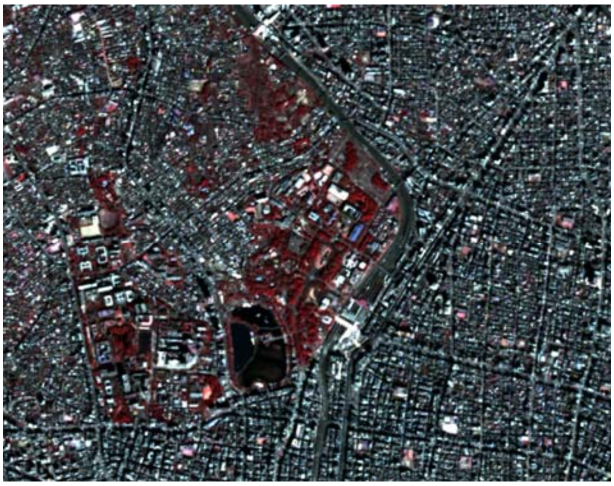
Table 3 Extracted number of pixels in each method

Data	NDVI>80
NDVI(AVNIR-2)	503371
NDVI(multiple)	389343
NDVI(Brov)	384366
NDVI(diff)	924596
NDVI(Ratio)	479176
NDVI(wavelet)	547792
NDVI(PCA)	409030

(a) ALOS/AVNIR-2 data of Ueno Park

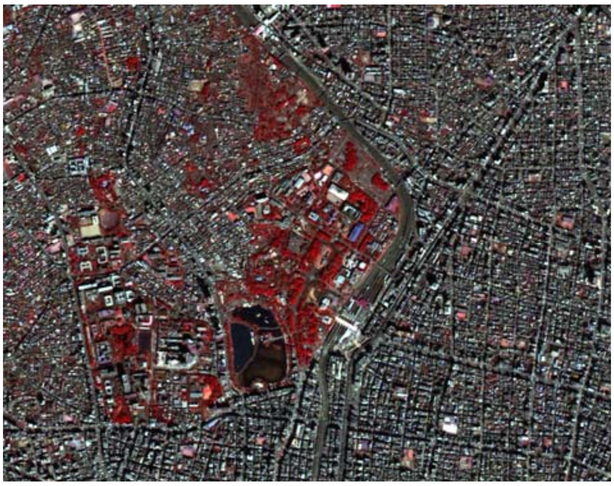
(b) ALOS/PRISM data of Ueno Park

Fig.10 expanded image of AVNIR-2 and PRISM data



(a) Multiplicative method

(b) Brovey transform method



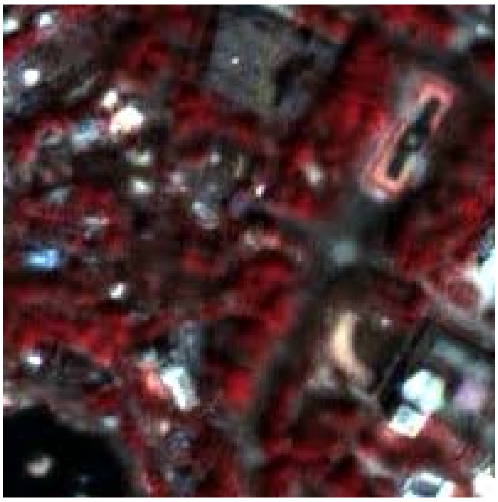
(c) Differential adding method

(d) Spatial weight ratio method

(e) Wavelet

(f) Principle component

Fig.11 Data fusion results by deferent methods


(a) Multiplicative method


(b) Brovey transform method


(c) Differential adding method


(d) Spatial weight ratio method


(e) Wavelet


(f) Principle component

Fig.12 Data fusion results by deferent methods

(3) DEM generation
PRISM has three independent optical systems to acquire images in the view of nadir, forward, and backward simultaneously. Using pair image, it is possible to generate DEM (digital elevation model).
To calculate the elevation from stereo pair image, we developed a function to measure a displacement (parallax) between the pair image. Fig.13 shows a color composite image produced by assigning red to forward viewing, green to nadir viewing and blue to backward viewing images. There are big displacements at Imperial Palace, Building around Tokyo Station, etc. To detect a corresponding point of pair image, template matching based on the correlation has been applied. As the result, we can estimate its elevation and generate digital elevation model. Fig.14 shows the detected displacement of Imperial Palace and its vicinity.

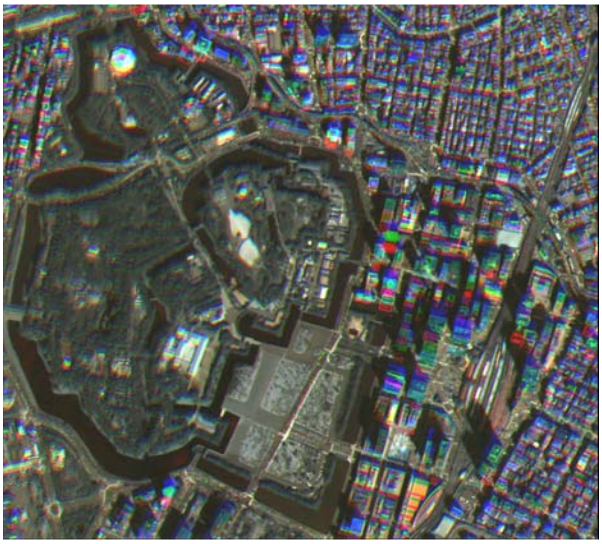


Fig.13 Color composite image of nadir, forward and bac kward viewing

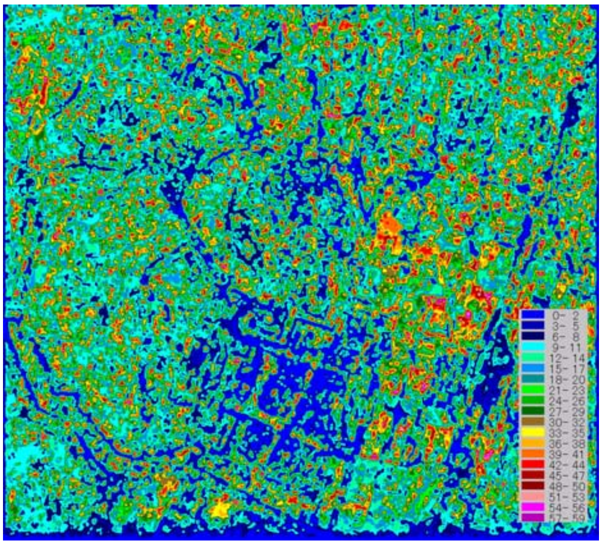


Fig.14 parallax of forward and backward viewing

5. APPLICATION

Using the functions of Remote-10, several processing were tested for the preparation of next subjects.

(1) Environmental research by vegetation
As an example of Meiji Shrine shown in Fig.6, it was confirmed that the ALOS image has good potential to evaluate the vegetation environment of city.

(2) Change detection of the glacier lake
Using a stereo pair of images taken by KH-9/Hexagon in 1973 and a high resolution panchromatic image taken by ALOS/PRISM in 2006, the time-sequential usage of high resolution satellite images was discussed[7]. Tsho Rolpa Glacier Lake, one of the biggest glacier lakes at Himalayan range, has been selected for the test site. It is possible to find a feature of moraine before the water level of the lake rises. (Fig.15 and 16)

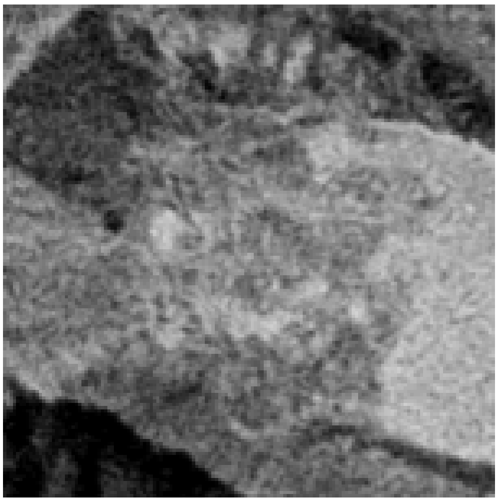


Fig.15 Moraine in Hexagon image

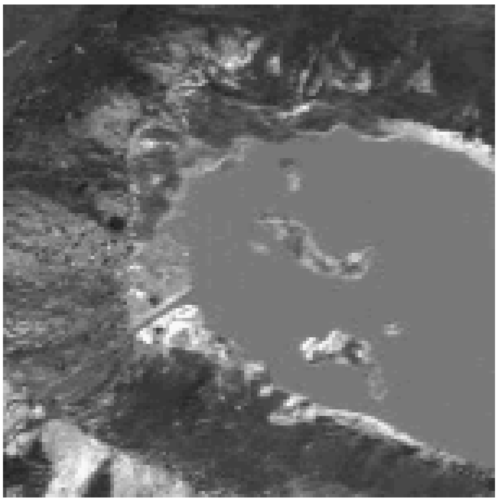


Fig.16 Moraine in PRISM image

(3) Monitoring of the industrial city

Now, an urban environment of China becomes a serious international problem in the east of Asia. We compared images observed by CORONA/KH-4 in 1965 and by ALOS in 2007. The "Steel City" Anshan, one of the biggest industrial city in China, has been selected for the test site. Development of steel and iron complex (Fig.17 and 18) and strip mining (Fig.19 and 20) caused an environmental pollution. It is important to monitor the effect of Chinese counter plan for this problem.[8]

Fig.17 Industrial area of Anshan in 1965

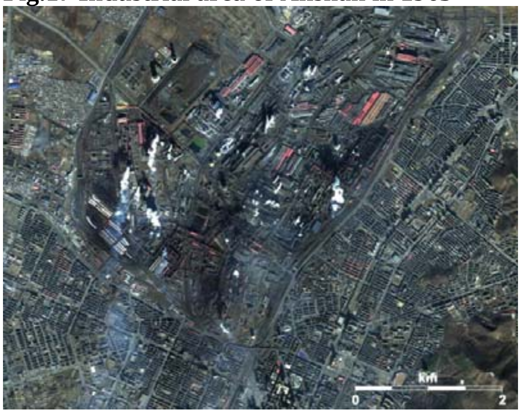


Fig.18 Industrial area of Anshan in 2007

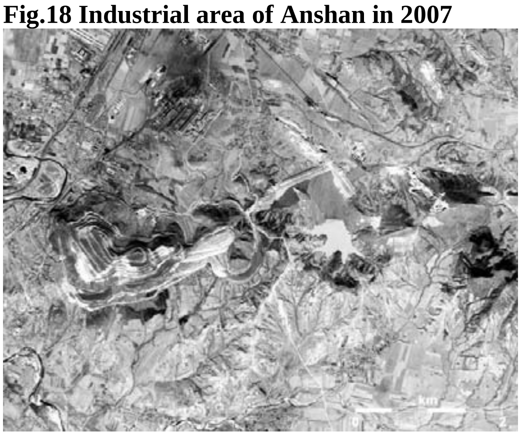


Fig.19 Southern mining of Anshan in 1965

Fig.20 Southern mining of Anshan in 2007

6. CONCLUSION

ALOS data contribute many subjects, prepared for the "Remote Sensing Training Course", to advance their quality. Maintaining subjects, we are going to hold a remote sensing training course in the near future.

The latest version of software "Remote-10" can be used from the next URL.

http://www.restec.or.jp/research/remo10w.exe

7. REFERENCES

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