
Utilization of Data Acquired by “DAICHI” (Advanced Land Observing Satellite) for Maps

January 16, 2008

Kazuo Inaba, Director of Topographic Department
Geographical Survey Institute/Ministry of Land Infrastructure,
Transport and Tourism

Yasushi Horikawa, Executive Director
Japan Aerospace Exploration Agency

Operation Status of “DAICHI”

➤ Observation Achievements

✓ Three sensors*¹ have been successfully acquiring data for all land areas around the globe, and, as of December 2007, about 1.8 million scenes of images*² were taken in total (PRISM: 810,000 scenes, AVNIR-2: 360,000 scenes, PALSAR: 600,000 scenes.) (There were about 800,000 scenes in March 2007.) Data acquisition by the PRISM, which is mainly utilized for topographic maps, is operating smoothly.

*1 Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM,) Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2,) and Phased Array type L-band Synthetic Aperture Radar (PALSAR)

*2 The PRISM takes an image of a 35 km x 35 km square area as one scene. Some 810,000 scenes taken by the PRISM consist of only images taken toward the nadir direction. The AVNIR-2 and PALSAR takes a 70 km x 70 km square area as one scene

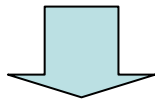
➤ Satellite System

- ✓ The bus and sensor system of the DAICHI functions and performs normally to continue stable observations.
- ✓ The DAICHI also perfectly controls its attitude to maintain its global-leading attitude control accuracy and stability as an earth observation satellite.

Update Process of a 1/25,000 Map

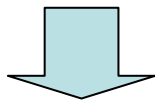
Collecting information of changes

Information on changes is not only provided by local public offices/organizations, but is also collected from satellite images, official gazettes, and other documents.



Updating a topographic map

While referring to maps and drawings, on-site surveys and measurements, and measurements using photos (aerial and satellite photos) are carried out to update a topographic map. (Recently, updating only major geographical features on a topographic map is the main method of updating rather than the conventional method of correcting an overall map, because the former is less time consuming.)



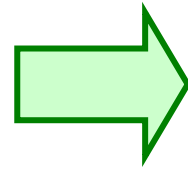
Providing a topographic map

- Publication of Maps
- Publication of Digital Map
- Through the Internet

Example of Extraction of Changes



Aerial photo (in 2001)

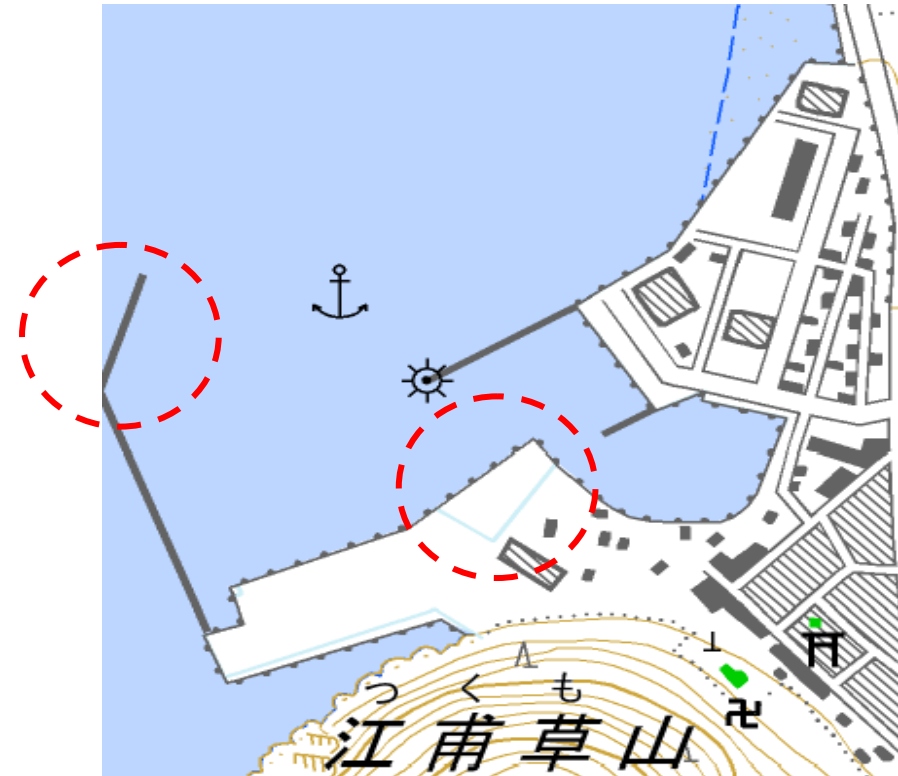


DAICHI image (in 2006)

Example of Updating Using DAICHI Data ①



Before



After

* The shape of the seaport was modified based on images acquired by the DAICHI and the confirmation/verification through on-site survey (Map name: "Kannonji")

Example of Updating Using DAICHI Data ②



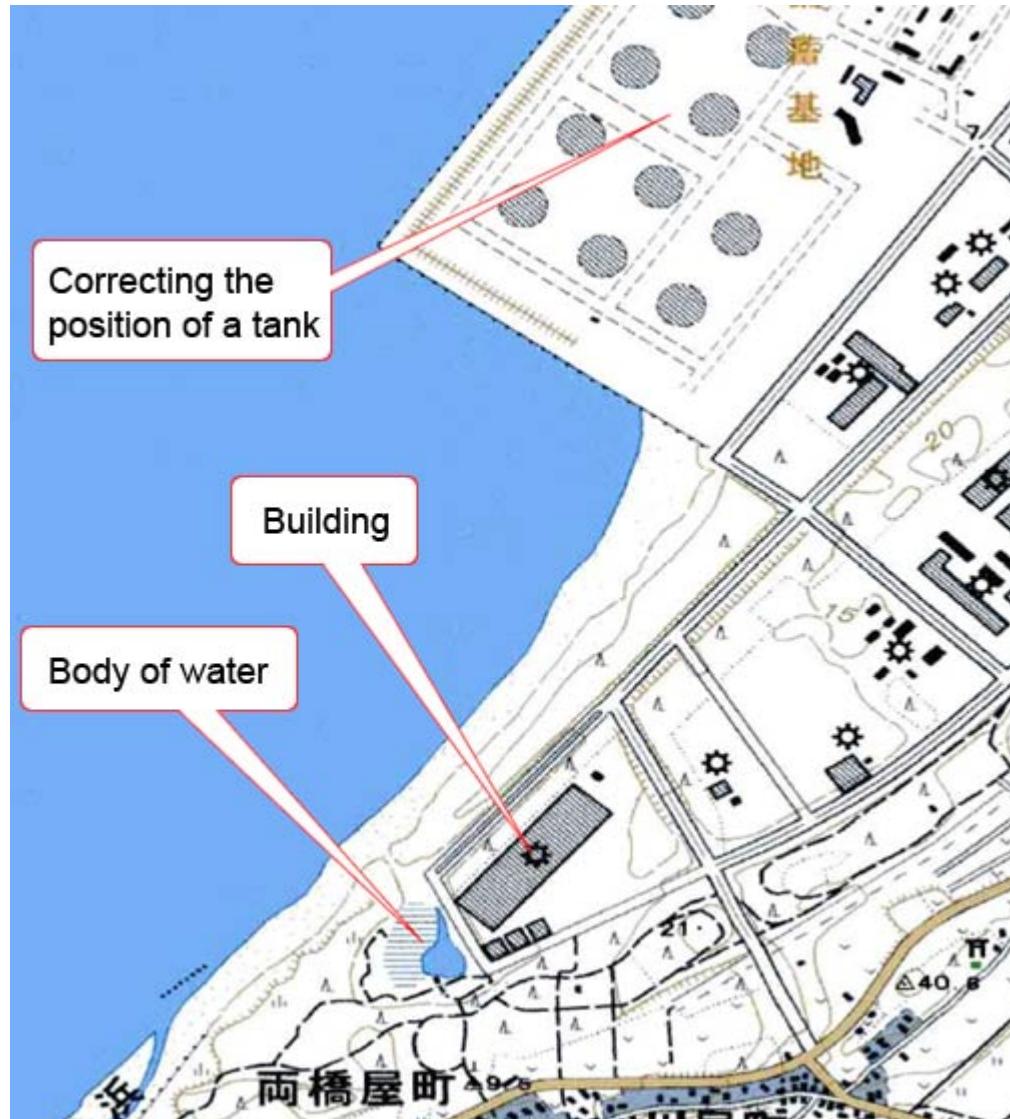
Before



After

* Major buildings and other features were corrected based on images acquired by the DAICHI and the confirmation/verification through on-site survey (Map name: “Takamatsu-Hokubu”)

Example of Updating Using DAICHI Data ③



* Major buildings and other features were corrected based on images acquired by the DAICHI and the confirmation/verification through on-site survey (Map name: "Ayukawa")

Achievements to Date

- Extracting changes due to a time lapse
 - ✓ 168 scenes of images acquired by the DAICHI (between Aug. and Dec. 2007)
- Updating of maps
 - ✓ 52 sheets of topographic maps have been updated (in Japan Fiscal Year 2006 and 2007)
 - ✓ Among them, three sheets for “Io To”, “Nakoso” and “Yutsubo” were published.

Issues Found during the Verification Phase

- Lack of height accuracy
 - ✓ The accuracy required for maintaining the high quality for a map with a scale of one to 25,000 is five meters (half of the contour line interval). However, the height accuracy of the images acquired by the DAICHI was six meters until mid Dec. 2007, according to the JAXA's evaluation.

- Image compression block noise^{*1} and not enough gradation^{*2} which contribute to difficulties in more accurate understanding
 - ✓ To update a 1/25,000 map, an image is enlarged to a size that even the naked eye could see. In the process of enlargement, some block noises appeared, and gradation became unclear in some parts, thus demarcations of roads and buildings became unclear. It caused difficulty in updating the topographic map.

*1 Block noise: In the case of JPEG compression, one block is 8 pixels x 8 pixels. When the demarcation lines of the block are too clear to be visible, it is called "block noise."

*2 Gradation: Stages of color tones. PRISM shoots images with 256 tones of gradation (8 bits.)

Geographical Survey Institute's Response to the Issues

1. For the lack of height accuracy

- ✓ Introducing software corresponding to the RPC model* (improving height accuracy)

* The RPC (Rational Polynomial Camera) model matches positions of ground coordinates and satellite images on software. The model makes the three-dimensional measurement easier. JAXA provided the model to the Geographical Survey Institute.

- ✓ Technical verification was performed until the end of Dec. 2007, and it was confirmed that accuracy up to five meters could be achieved by using ground control points.
- ✓ We plan to start using the above explained method in Jan. 2008, and we expect that the problem with height accuracy will be solved then.

2. For block noise, the Geographical Survey Institute provided JAXA with a method to reduce block noise using one of the R&D achievements of the Institute. Its effectiveness has been confirmed by the two organizations.

3. For gradation, JAXA will change the operational setting of the PRISM sensitivity, and evaluate the effectiveness.

- With the above mentioned improvements, we plan to further expand the use of satellite data to quickly update of topographic maps.

JAXA's Response to the Issues ①

➤ Height accuracy

✓ Background and Cause

- The necessary height accuracy for a 1/25,000 topographic map is half the 10-meter contour line interval, making it five meters. However, that accuracy is hard to achieve with the specifications of the satellite due to technical hurdles including design analysis and verification on extremely small thermal distortion of the satellite. Such height accuracy, therefore, was set as our technical goal.
- The major cause of the height accuracy error was a minute change caused by e.g. thermal distortion of the satellite. The change fluctuates season by season, thus we have acquired long-term data in order to improve the accuracy.
- The height accuracy using the ground control points had still been six meters until mid Dec. 2007, and the major reason for that was not attitude control, but because we were still in the midst of accumulating necessary data for improving the height accuracy.

✓ Response

- As the data has been accumulated, we now can satisfy our goal of five meters by using ground control points.

➤ Block noise

✓ Background and Cause

- Block noise occurs when data acquired by the PRISM is compressed by JPEG*1.

*1 JPEG (Joint Photographic Experts Group) is a standard of the International Organization for Standardization (ISO) for data compression, and is widely used all over the world.

- Data acquired by the PRISM is large in volume; therefore, to transmit data to the data relay satellite "KODAMA," the "lossy" data compression method was adopted to the DAICHI as the first Japanese earth observation satellite (for more details, please refer to Attachment 1.) The compression rate was about 25 % (1/4) as it did not affect image quality, yet data transmission is possible.
- We had recognized that the JPEG data compression method causes some errors such as block noise, thus we evaluated the height accuracy error and effect on images due to the compression by simulation using aerial photos (Japan Fiscal Year 1995.) As a result of our evaluation, we found that the effect on the height accuracy was small, and no block noise was detected.

JAXA's Response ②

2. Block noise (Continued)

✓ Background and Cause (Continued)

- We assumed that the block noise occurred in small portion of images acquired by the PRISM due to the effect of the atmosphere and the difference of photo-shooting characteristics between aerial photos used for the simulation and PRISM image acquisition (films vs. CCD*2.)

*2 CCD (Charge Coupled Device): a device to convert light into electric signals

✓ Response

- In Dec. 2007, JAXA confirmed that we could make improvements to the block noise issue by using block noise reduction software (newly developed software) based on a method researched by the Geographical Survey Institute.
- We will apply the software to the JAXA ground system by March 2008, then start providing the data.

3. Gradation

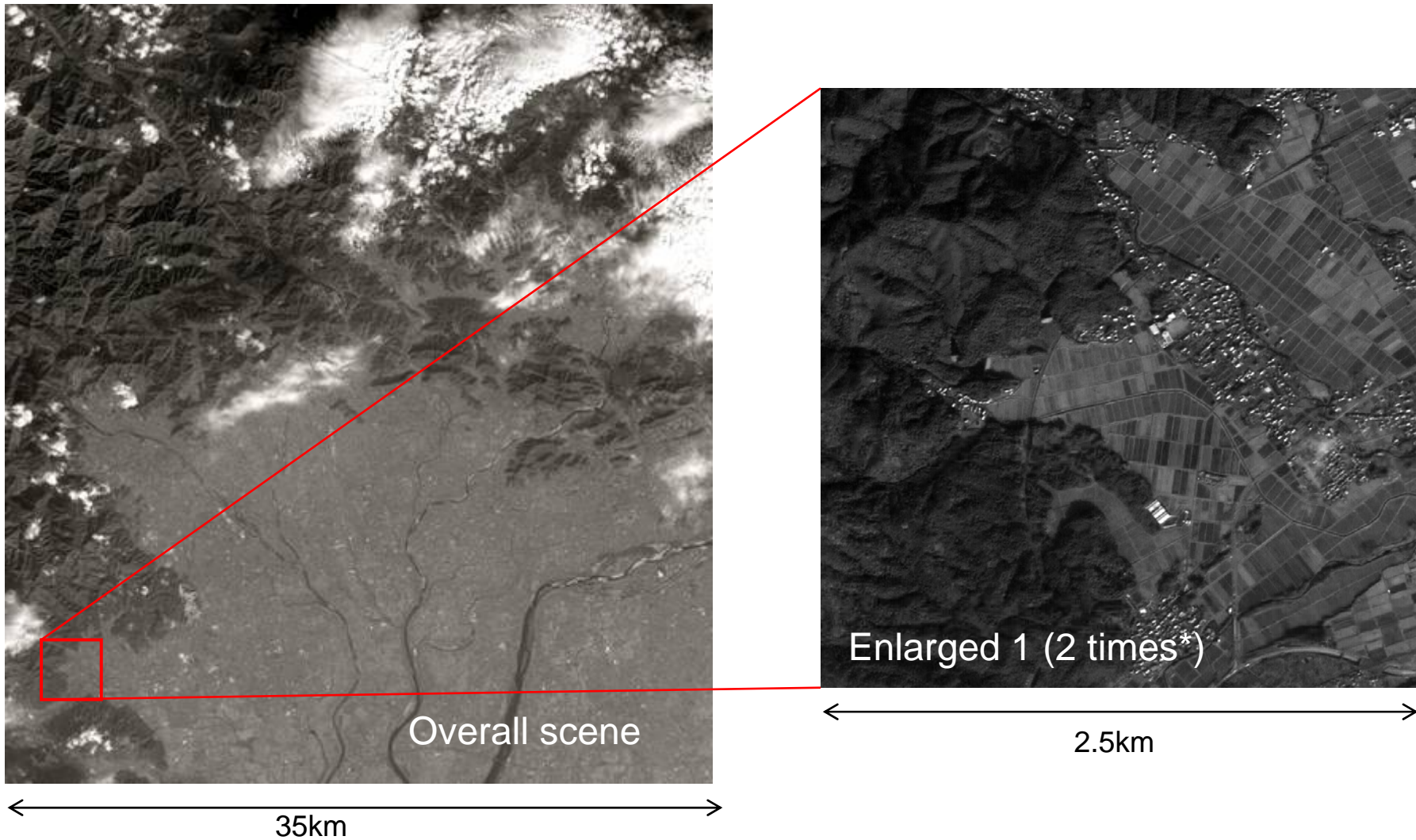
✓ Background and Cause

- The PRISM converts sunlight reflection and diffusion on the ground surface, atmosphere, and clouds into electric signals, then transmits them with 256 gradations (8 bits.)
- The PRISM can be set for four different sensitivities in order to cope with various observation targets, and the current sensitivity is the second highest as a result of the post-launch evaluation.

✓ Response

- To improve the clarity of the images, we will set the sensitivity to the highest level and carry out a few observations in Japan to evaluate the image quality including clarity by March 2008.

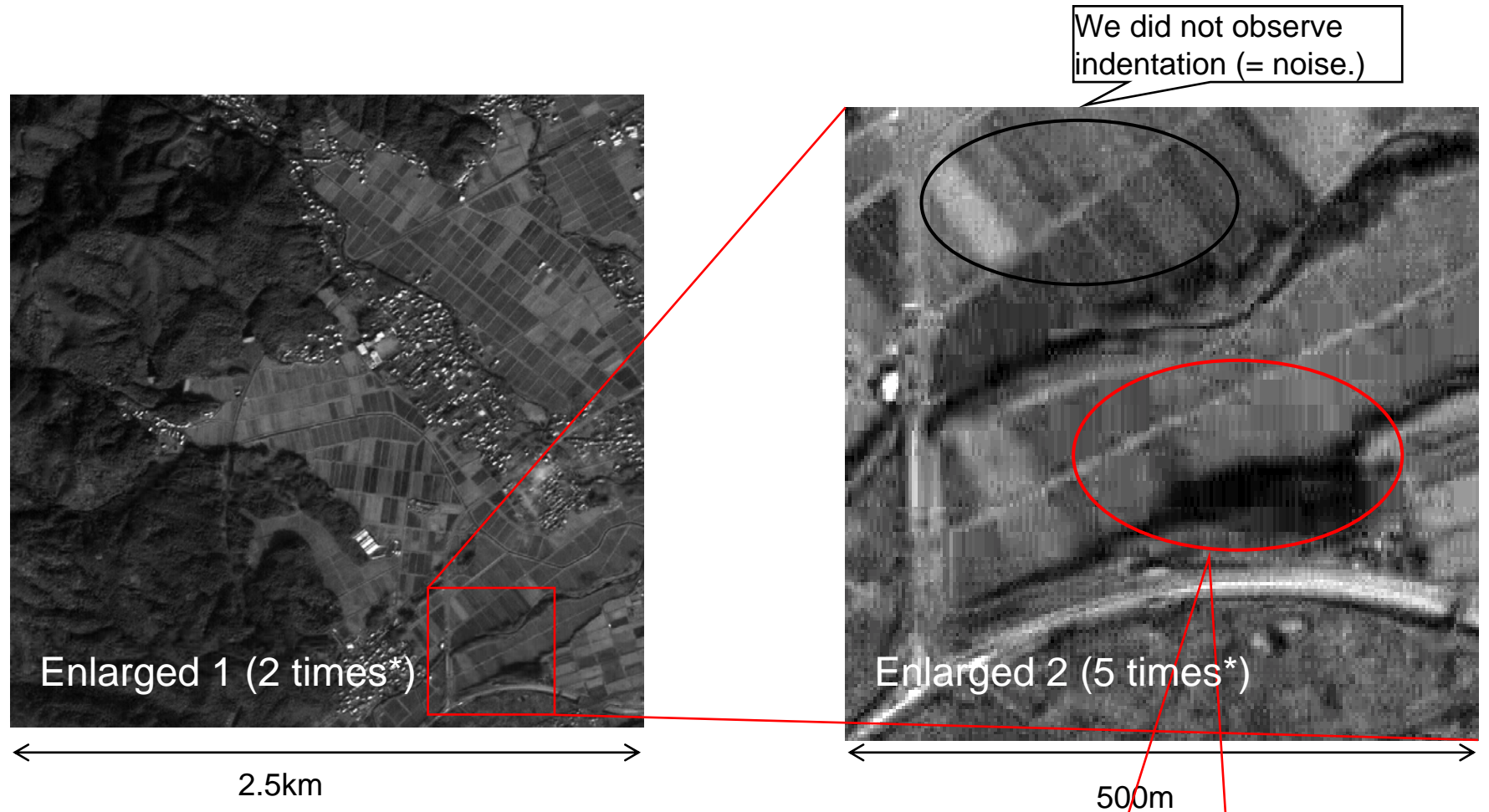
PRISM Image and Block Noise Example



* Enlarged ratio is two times against a 1/25,000 topographic map.

Figure 1: PRISM Image Example (North-western Nagoya City, image taken on Dec. 12, 2007)

PRISM Image and Block Noise Example



* Enlargement ratios are against a 1/25,000 topographic map.

Figure 2: Block Noise Example

Comparison: Before and After Block Noise Reduction

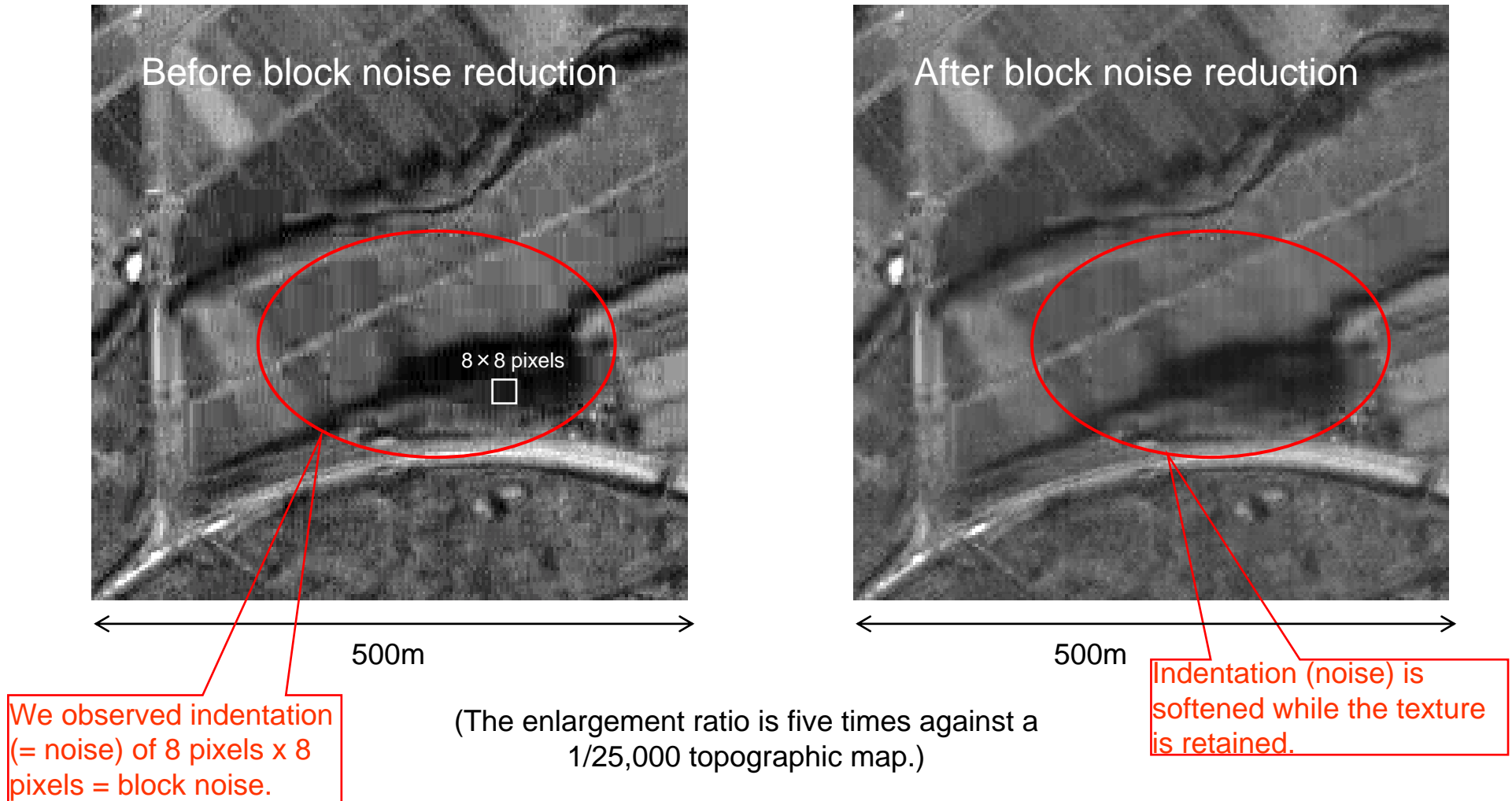


Figure 3: Example of Before (left) and After (right) Applying the Block Noise Reduction Software

Conclusion

- JAXA and the Geographical Survey Institute are positive about solving the issues we have faced when using DAICHI data for maps by cooperatively dealing with them.
- The two organizations will work together to expand the use of satellite data for topographic map updating.

Attachment 1: DAICHI Data Compression Method

- The PRISM is an optical sensor with high resolution and broad coverage that can carry out observations in three directions.
- Its data volume prior to compression is quite large, about 960 Mega bits per second (equivalent to about 10 optical fibers for houses), thus data is compressed to about a fourth for transmission to the data relay satellite “KODAMA,” whose communication line volume is about 240 M bits per second.
- In the compression method in which compressed data can be perfectly restored to its original state, the compression rate is about 75 % (three fourths). In order to compress the data to one fourth, we need to adopt an “irreversible (lossy)” compression method in which data can not be perfectly restored later.
- When JAXA (then NASDA) started designing the DAICHI in Japan Fiscal Year 1996, we studied various data compression methods for space use, and selected the JPEG method, which can deal with a large volume image data.
- As we knew that block noise and other errors could be generated by JPEG compression, we verified its impact on the height accuracy and image quality. In our simulation using aerial photographs, the impact on height accuracy was minimal and no block noise was detected when the compression rate was about a fourth. For a JPEG compression, a one-fourth compression image is said to be a high-quality image.

(Reference 1) JAXA/ Geographical Survey Institute Coordination Process for Mapping

- JAXA (then NASDA) Project Team was established (April 1994.)
 - ✓ Asked the Institute to evaluate JPEG compressed simulation data (one-fourth compression)
- Memorandum of Understandings between NASDA and the Institute for research cooperation was signed (Sep. 1994.)
 - ✓ Theme: Study of Satellite Maps, Research for Understanding Technologies of National Geographical Information Using Satellite Data
- Liaison Meeting between NASDA and the Institute for cooperative research was established (Jan. 1995)
 - ✓ A meeting to discuss and coordinate necessary matters for promoting cooperative research (Representatives: Director General of the Institute and NASDA Vice President)
- JAXA Reviews (【 】shows the main issue(s) to be confirmed at each review.)
 - ✓ Review of the project (Dec '96) 【Rationality and appropriateness of the project】
 - ✓ Preliminary Design Review (May '98) 【Appropriateness of the development specifications】
 - ✓ Development Completion Review (May '05) 【Whether the development results met the specifications】
 - ✓ Calibration/Verification Completion Confirmation (Oct '06) 【Whether JAXA standard products can be provided】
- The two organizations have been maintaining close cooperative relations including holding more than 40 liaison meetings.
 - ✓ Preliminary Design Phase (Jan '95 to May '98) : Coordinating the ALOS specifications (9 meetings in total)
 - ✓ Basic Design to Detailed Design Phases (May '98 to Jan '01) Reporting the progress (6 in total)
 - ✓ Sustaining Design to Launch (Jan '01 to Jan '06) Planning calibration and verification (21)
 - ✓ Launch to today (Jan '06 to Jan '08): Operation arrangement meeting etc. (8)

We established the ALOS Advisory Committee (with 20 experts and relevant personnel) within the framework of the Earth Environment Observation Committee (in July 1995) to put user requirements together.