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ASTER STATUS AND DATA APPLICATION USE

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ABSTRACT

ASTER Sensor was launched on December,1999, Initial Check Out term went successfully and data acquisition started regularly on September, 2000. Approximately 600 scenes are acquired each day and there have been about 254 thousand scenes by the end of July 2001. ASTER Data Distribution service was also started on December, 2000. ERSDAC accepts proposals for verification and utilization of ASTER data use in related various fields, in order to contribute to research of data availability techniques. Proposal can be submitted through: http://astweb.ersdac.or.jp/ao/ ERSDAC carries out not only ASTER mission operation, data processing and distribution but also with the research and development about data use technology. The example of ASTER data use is introduced this time. Since Miyake Island (Mt. Oyama volcano, Japan) erupted in June 2000, a lot of sulfur dioxide (SO2) gas is emitted continuously as all residents refuges are carried out and it has become the big social problem now. SO2 has grasped the qualitative action of SO2 gas from data by the Miyake Island and Etna volcano (Italy) to ASTER TIR region using having the absorption characteristic. Six bands of ASTER SWIR region can detect alteration zone according to the Ore deposit type. Making of Rock and Mineral Distribution Mapping from ASTER SWIR data, for instance, Mt. Fitton area (Australia) is presented. Making of coral reef basic classification map and sea bottom features from ASTER VNIR and SWIR to contribute understanding of roles the coral reefs play in the carbon cycle through the classification and global distribution mapping of corals, for instance, Great Barrier Reef (Australia), Iriomote-Island (Japan) are presented.

KEY WORDS: ASTER, Terra,

1. INTRODUCTION

The Advanced Spaceborne Termal Emission and Reflection Radiometer (ASTER) is a high spatial resolution multi-spectral imaging radiometer, and is onboard the NASA's Terra spacecraft launched on December 18, 1999.
The Ministry of Economy Trading and Industry (METI) developed ASTER responding to obtain detailed geological data and to understand phenomena such as volcanic activities which would significantly impact the global environment. ASTER covers the visible and near-infrared, short-wave-infrared, and thermal infrared regions with 14 spectral bands, and creates high-spatial-resolution (15-90 m) multispectral images of the Earth's surface. The ASTER data can be used to help establish a baseline for long-term monitoring of local and regional changes on the Earth's surface, which either lead to, or are in response to, global climate change. Recent general ASTER data status are reported (Yamaguchi et al., 2001).
The ASTER data release to public was started in November 2000 from both the ASTER Ground Data System (GDS) of Earth Remote Sensing Data Analysis Center (ERSDAC) in Japan and EROS Data Center (EDC) of the U.S. Geological Survey. Both distributor are keeping ASTER data observed since March 1, 2000. For more details, please visit the following web site;

http://www.ersdac.or.jp/Projects/ASTER/ASTERPro_E.html

The procedure that accepting proposals of ASTER data use in ERSDAC called ASTER Announcement of Research Opportunity on ASTER data use (ASTER ARO). The Principal Investigator selected as ASTER ARO researcher can obtain ASTER data and submit the new acquisition request by ASTER according to ASTER ARO regulations. Proposal can be submitted through the above web site or E-mail to ASTER ARO Office:

http://astweb.aster.ersdac.or.jp/ao/ or aodesk@ersdac.or.jp

The research and development are being carried out in ERSDAC for the purpose of studying earth resources and environment. The three examples of ASTER data use are introduced in this report.
Firstly, the sulfur dioxide (SO2) gas discharged from an active volcano was identified by us e for ASTER band 10, 11, 12. At Mt. Oyama volcano in Miyake-jima island (Japan), sulfur dioxide gas spread around the island to downwind, and a qualitative change of sulfur-dioxide gas is caught using ASTER TIR data for the absorption of

sulfur dioxide in thermal infrared region. Actual concentration of sulfur dioxide gas is measured by Japan meteorological agency, Urai, 2001 reported the relation between ASTER band 11 temperature and calculated atmospheric column using real sulfur dioxide concentration. At Mt. Etna the straight current of sulfur dioxide gas is identified.
Secondly, the distribution map of rocks and minerals is extracted by pattern recognition using Fuzzy logic at Mt. Fitton area in central Australia. In this case the six minerals selected as end member of this classification method.
Thirdly, the bottom materials of coral reef are classified for ASTER VNIR data. The high spatial resolution (15m) image is created from ASTER VNIR data. Using bottom Index for ASTER Band 1 and 2 at coral reef in Great Barrier Reef and Iriomote island (Japan), the bottom materials are classified.
For these color images, please visit the following web site;

http://www.science.aster.ersdac.or.jp/

2. ASTER PRESENT STATUS

2.1 Characteristics of ASTER Product

The ASTER instrument has three separate optical subsystems; the visible and near- infrared radiometer (VNIR), short-wave-infrared radiometer (SWIR), and thermal infrared radiometer (TIR). Observational performance of the ASTER instrument was examined by using the actual ASTER images. List of ASTER products is shown in Figure 1. The quality of standard and semi-standard products are confirmed by ASTER Science Team.
The ASTER instrument consists of three subsystems in order to realize the optimum optical design for each wavelength region. Therefore, band-to-band registration of the 14 spectral bands not only within each telescope but also among three telescopes was one of the biggest challenges. However, we have confirmed that the ASTER Level-1 data processing can successfully achieve the required band-to-band registration accuracies, 0.2 pixel within each telescope and 0.3 pixels among different telescopes respectively. The geometric performance of Level-1 data product is summarized in Table 2. Note that all quality values are tentative and rough evaluated by limited image data. ASTER Science team are carrying out much data analyses for a final quality confirmation.

Table 1 List of ASTER data Products

Product processed in Japan	Products No.	Description	Data set ID
Standard Data Products	1A	Radiance at sensor	ASTL1A
	1B	Registered radiance at sensor	ASTL1B
	2A02	Relative spectral emissivity (Decorrelation Stretch)	AST2A02
	2A03	Relative spectral reflectance (Decorrelation Stretch)	AST2A03V
			AST2A03S
	2B01	Surface radiance	AST2B01V
			AST2B01S
			AST2B01T
	2B03	Surface temperature	AST2B03
	2B04	Surface emissivity	AST2B04
	2B05	Surface reflectance	AST2B05V
			AST2B05S
Semi - Standard Data Products	3A01	Radiance registered at Sensor with Orthophoto Correction	AST3A01
	4A01	Relative digital elevation model (XYZ)	AST4A01X
			AST4A01Z
Special Data Products (Higher Level)	4A04	Volcanic Map	not decided
	4A08	Mineral and Rock Map	
	4A09	Geological Structure Map	
	4A15	Coral reef Map	
	4A16	Turbidity	
	4A17	Water Surface Temperature	
	4A19	Aquatic Plants	
	4xxx	Agricultural-land Map	
	4xxx	Arid-land Map	
	4xxx	Wetland Map	
	4xxx	Forest Map	

Table 2 The geometric performance of Level-1 data product

Item		Level 1 data Product accurate
Intra-telescope Registration	VNIR	< 0.1 pixels
	SWIR	< 0.1 pixels
	TIR	< 0.1 pixels
Inter-telescope Registration	SWIR/VNIR	< 0.2 pixels
	TIR/VNIR	< 0.2 pixels
Stereo Pair System Error	3B/3N	< 10 m
Pixel Geolocation Knowledge	Relative	< 15 m
	Absolute	< 50 m

2.2 Operation status of ASTER

The primary limitation on ASTER data collection is the data volume allocated to the instrument on Terra, due to limits in onboard memory and in the communications link with TDRSS and ground stations. Fundamentally ASTER obtains data by target observation based upon data acquisition requests. The ASTER scheduler automatically generates a One-Day-Schedule (ODS) for ASTER observation every day using the prioritization function in order to maximize the science return. Currently ASTER is acquiring approximately 600 scenes (one scene covers an area of approximately 60 km by 60 km) per day as an average that is slightly lower than the maximum data rate capacity, but is still on a satisfactory level. About 254,000 scenes have observed and we have already obtained more than 200,000 ASTER scenes by the end of July 2001 (Figure 1). The ASTER Level-1A (L1A) data product consists of unprocessed raw image data and coefficients for radiometric and geometric correction. The Level-1B (L1B) data product is re-sampled image data by applying the correction coefficients to L1A data. The ASTER Ground Data System (GDS) has a capacity to routinely process up to 760 L1A scenes and 180 L1B scenes per day, as original planned, and now has more capacity including reprocessing of the data obtained during the initial check-out phase. The total numbers of L1A and L1B scenes available are 180,399 and 28,034 respectively as of July 12, 2001.

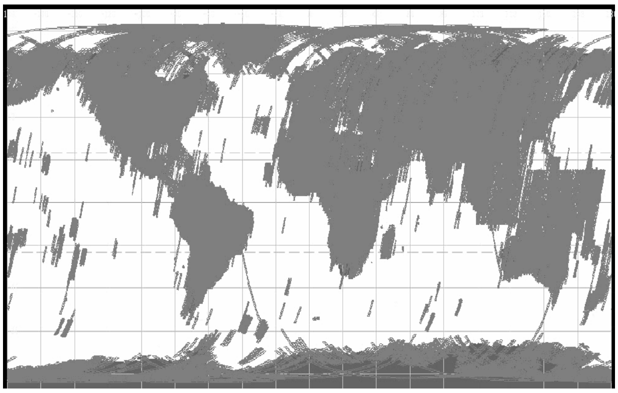


Figure 1 ASTER All observed Scenes
(253,654 scenes, at August 1 2001)

3. ANNOUNCEMENT OF RESEARCH OPPORTUNITY ON ASTER DATA USE

3.1 Outline of ASTER ARO

Announcement of Research Opportunity on ASTER data use, in order to contribute to research of data availability techniques implemented by Earth Remote Sensing Data Analysis Center (ERSDAC), is announced by ERSDAC to begin accepting proposals for verification and utilization of ASTER data use in related various fields, as part of research and development of remote sensing technology for non-renewable resources. ASTER ARO is open to all investigators and organizations both the domestic and overseas desiring to use ASTER data for peaceful and non-commercial purposes.

ERSDAC accept about 140 research proposals and have approved more than 120 research programs. Most research categories are Geology, Ecology & Vegetation and Agriculture. List of all research categories for ASTER ARO is shown in Table 3.

ASTER products are delivered into three items; standard products, semi-standard products and specialized products. The standard products and semi-standard products are available for ARO researchers.

Table 3 All research categories for ASTER ARO

1) Radiometric calibration	13) Glaciers & Icesheets	25) Fisheries
2) Geometric calibration	14) Natural hazards	26) Human activities
3) Validation	15) Agriculture	27) Other ocean observation
4) Other calibration	16) Hydrology	28) Clouds
5) Geology	17) Water	29) Aerosols
6) Soils	18) Use & Plan	30) Air-Land
7) Paleoclimatology	19) Archaeology	31) Air-Sea
8) Topography & Cartography	20) Other land observation	32) Atmospheric chemistry
9) Volcanology	21) Oceanography	33) Other atmospheric observation
10) Ecology & Vegetation	22) Marine ecosystem	34) Public
11) Lakes & Rivers	23) Coastal processes	35) Education
12) Snow / Ice cover	24) Sea Ice	36) Others ( )

4. APPLICATION USE OF ASTER DATA

4.1 Sulfur Dioxide gas at Miyake Island volcano and Etna volcano

4.1.1 Outline

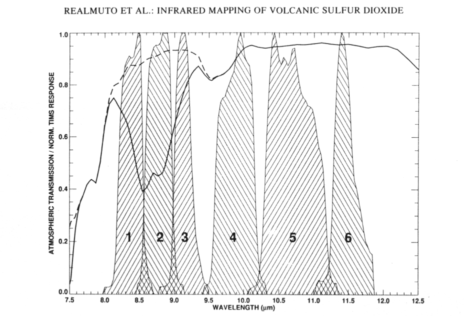
Mt. Oyama in Miyake Island has erupted on June, 2000, and repeatedly emission sulfur dioxide gas was confirmed since August. According to the Miyake Island observation team of geological survey has reported the possibility that the amount of sulfur dioxide gas has estimated 10 times as much as ever observed. Following the urgent observation request by ASTER science team, the Miyake Island is observed and monitored intensively. The extraction algorithm of the sulfur dioxide gas and result of sulfur dioxide gas mapping of Mt. Oyama in Miyake Island and Etna Volcano in Sicily Italy by using ASTER data are stated.

4.1.2 Method

Realmuto et al.(1994) applied the absorption of sulfur dioxide due to thermal infrared range and variations of TIMS channels 1-3 observation brightness which was indicated the concentration of sulfur dioxide gas (Figure 2).

Wave range of TIMS channel 1-3 is similar to the ASTER TIR band 10-12 so that ASTER observation data sufficiently considered to be presumed the concentration of sulfur dioxide gas. The orbit of Terra/ASTER is 705km in altitude, therefore, it receives bigger atmospheric influence than that of TIMS. Consequently, their original method could not apply to ASTER data directly.

For sulfur dioxide distribution discharged from a volcano with using actual ASTER data was applied to qualitative distribution image shows next equation.



Spectral transmission through two model atmospheric columns, as calculated with the LÖWTRAN 7 radiative transfer code. The solid and dashed lines represent the transmission through columns containing 23 and 0 g m^{-2} of SO_2, respectively. Also shown are the spectral response functions of the six TIMS channels.

E[T11]/Average(E[T10] and E[T12]) = f(concentration of SO2 , factor of volcanic smoke, factor of atmosphere, ground surface) [equation 1]

E[T**] explains ASTER TIR band**of measured radiance , Average( ) of average value

Left part explains absorption degree of ASTER TIR band 11. When factor of atmosphere and volcanic smoke, and ground surface assumed nearly constant and the band ratio of the left part as the function of only sulfur-dioxide gas concentration. Therefore, the value can be calculated from ASTER TIR data, and a qualitative sulfur-dioxide gas map can be obtained.

The result of which applied this method to ASTER data is shown in Fig. 3 and 4, and explains distribution of sulfur dioxide gas discharged from Miyake Island and Etna volcano. The band ratio shows only <0.494 pixel. Moreover, the TIR band 14 is indicated by gray scale at a background for the distribution physical relationship of high concentration sulfur dioxide gas. Threshold 0.494 is adopted as to clear the speckle noise in the ocean without volcanic smoke by using rationing.

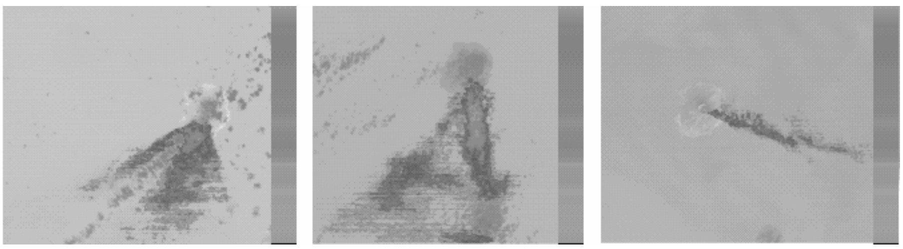


Figure 3 Sulfur dioxide distribution around Miyake island

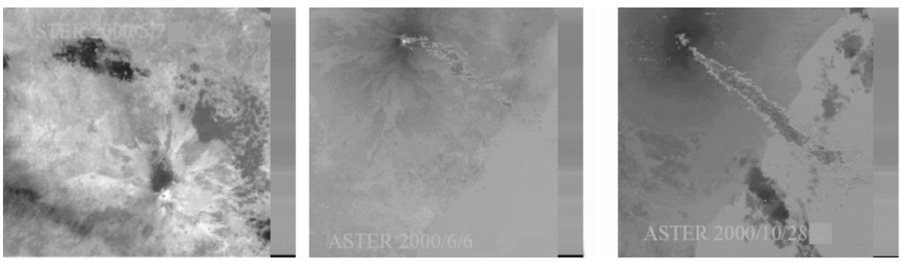


Figure 4 Sulfur dioxide distribution around Etna volcano

4.2 Rock and Mineral distribution at Mt. Fitton area

One of purpose of ERSDAC is to develop the new classification algorithm that estimates substances in each pixel by pattern recognition using Fuzzy logic. This algorithm was named IFP(Integrated Fuzzy Pattern Recognition) algorithm. IFP stands for Integrated Fuzzy Pattern recognition. IFP algorithm uses spectral database as supervisors and is also able to use spectra from image data. Especially detailed processing version is called D-IFP. For mineral mapping six end-members were selected according to the geological information. These six minerals and rocks are muscovite, calcite, talc, quartz, siltstone and granite.

Distributions of end-members showed a good correspondence with alteration zoning. Quartz and clay minerals are identified in siliceous alteration zone and argellic alteration zone. Most case average coincidence between analysis results of ground survey and processed results was 0.85

4.3 Coral mapping at Great Barrier Reef

4.3.1 Outline

ASTER Global Mapping mission include Coral Reef observation which makes a coral reef distribution map and the monitoring in the northwest pacific ocean and east coast of Australia two times of within an ASTER operational period. ERSDAC build coral reef database which were collected from past satellite data in order to consider as the basic data in the case of coral reef mapping. Examination of the coral reef distribution map using ASTER data and the classification mapping simultaneously. Coral reef observation data by using optical sensor characterized the bottom materials. These are consists of biocoenose (Coral, Seaweed, Sea glass), sand, rock. Satellite observation is hard to classify the bottom material of using spectral characteristic data due to the scale below several meters and the effect of seawater extinction. Therefore, this study applied distribution map focused on the characteristics of bottom materials and the coral reef classification.

Great Barrier Reef is the world's largest coral reef which stretches width of 20-240 km and the length of 2,000 km in the Queensland state offshore of the Australia northeast shore. It is made up of over 2,900 individual reefs (range from 0.1km-100km2) divided by many channels between reef and shore. Some part of the reefs appears when low water and others in the sea.

The Iriomote island is an island of about 130km of the circumferences in the southwest of the Japan, and the western part of the Ishigaki Island. Sekisai coral-reef lagoon, largest lagoon in Japan, is located between the Iriomote Island and the Ishigaki Island, and where the Japan's largest coral reef area. The Fringing reef parallel to the land. (Environment Agency 1996)

4.3.2 Method

The spectrum of bottom material for which it does not depend on depth of water in order to classify bottom material-- it is necessary to compute a reflective characteristic index value and to perform the classification by this index value. In the main subject, the bottom material classification was tried using the following techniques. As a basic classification, land and ocean space were classified by ASTER band 9. Next, Bottom Index value was used as detailed classification of which the reflective brightness value of Ri and Rj(band i and j) logarithms ratio are stable regardless of the depth of water (Lyzenga,1978).

$$BI_{ij} = -A \times \ln(R_i - R_{ideep}) + \ln(R_j - R_{jdeep})$$

BIij : Bottom Index used band i and band j
Ri : radiance of band i
Rideep : radiance of band i at deep sea (= path radiance of atmosphere)
A : =(Kj/Ki) Ki mean the sea water's extinction coefficient of band i

Using ASTER data from Great Barrier Reef, Maldive Islands, Red Sea, and Iriomote Island were presumed for an extinction coefficient ratio of band 1 and 2 . The presumption ratio became 0.42 and 0.60-0.62, respectively. The extinction coefficient value distribution about 25 pixels considered to be sand bottom material is shown in Figure 4-3-1. Bottom material index value was calculated from ASTER data of each area using these extinction coefficients.

4.3.3 Results

Classification result of Great barrier reef and Iriomote Island indicates in Figure 5 and 6.

Bottom index value was assigned to 1-255, and level sliced at seven stages. Threshold of a level slice was set up by the manual. The result mostly adjusted with the existing geographical feature classification boundary was obtained on both Great Barrier Reaf and Iriomote Island. In the level slice of bottom material index value is planning on to investigate the biocoenose of each level.

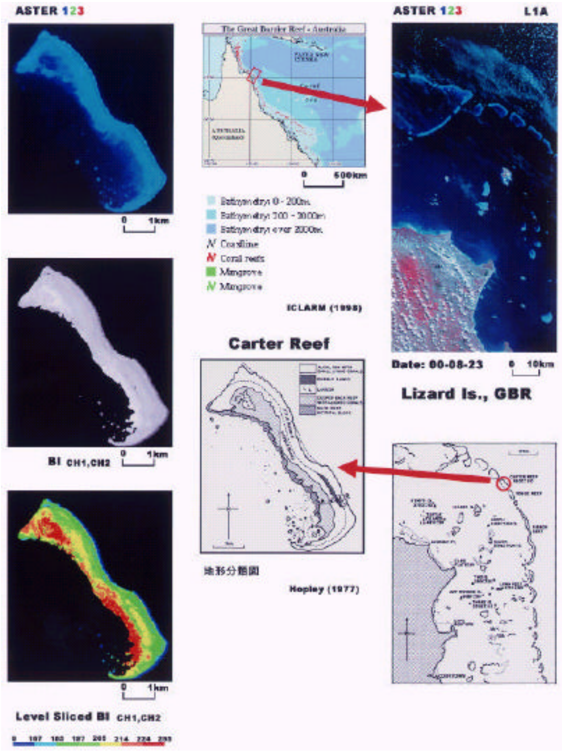


Figure 5 Coral Reef Classification Map at Great Barrier Reef

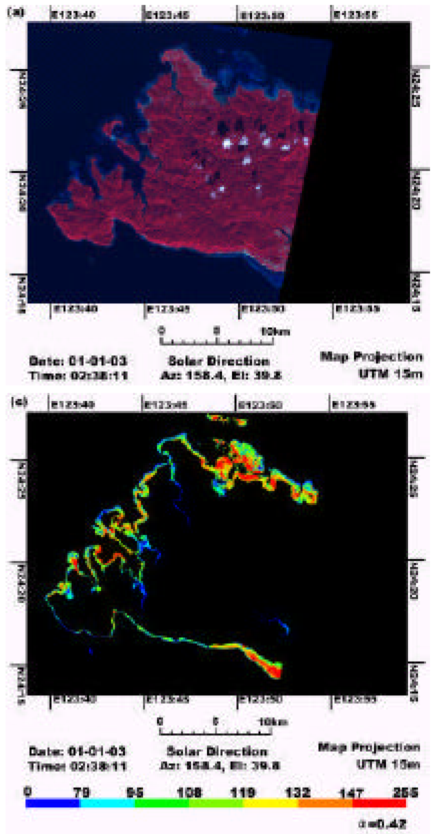


Figure 6 Coral Reef Classification Map at Iriomote Island

5. CONCLUSIONS

The ASTER data release to public was started in November 2000 from the ASTER Ground Data System (GDS) of Earth Remote Sensing Data Analysis Center (ERSDAC) in Japan. ERSDAC carries out not only ASTER mission operation, data processing and distribution but also with the research and development about data use technology. The example of three method for aster data use is introduced in this report. We wish many researchers use ASTER data for their various category. Please contact the above ASTER ARO office.

Acknowledgement;
Most information of ASTER in this report are disclosed by ASTER Science team members. We appreciate their hard work and great help.

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