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ASTER Data Utilization for Wetland Mapping and Forest Mapping

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ABSTRACT ERSDAC is doing research and development in ASTER data use technology to apply the resources exploration, environmental monitoring and disaster management with a global scale besides ASTER mission operation, data processing, and distribution. We hereby introduce Wetland Mapping and Forest Mapping made from ASTER data as the two examples of earth-environmental monitoring.

1. INTRODUCTION

1.1 Wetland Mapping

Wetland, where habitat of wild animals, has affected the circulation system of carbon dioxide or methane of greenhouse gases. Therefore, comprehensive research of Wetland mapping in all earth scales is pressing need. We made wetland map of Kushiro Mire and Iriomote Island of Japan by using VSW(Vegetation-Soil-Water) index made from ASTER data. Among the ASTER data band 3&9 and 3&4 were applicable band combinations for Kushiro Mire and Iriomote Island respectively. Maximum likelihood method was applied to VSW index and Wetland area was extracted. The accuracy of extraction method was both certified approximately 90% by ground truth.

1.2 Forest Mapping

Forest is one of the principal elements in the global environment as a sink of CO2 gas and circulation of CO2 and its effect on the global warming is yet clarified quantitatively. Therefore, it is important to monitor forest type and its bio-physical parameters in order to solve effect of CO2 on global warming immediately. For the purpose of the verification of algorithms investigation and analysis were performed in two areas of Tomakomai in Hokkaido and Kitakami in Iwate Pref. Validation for algorithms were verified by truth data, and the forest map, and Biomass, LAI(Leaf Area Index) and tree maps were created.

2. METHOD AND RESULTS OF WETLAND MAPPING

2.1 Study Area

The study areas are Kushiro Mire and Iriomote Island .
Kushiro Mire, which is organized by fen, bog, and alder, is located in lower Kushiro River basin of southeast Hokkaido, and is the biggest wetland of Japan. Among organizations fen with Sedge and Reed is predominant because of eutrophication caused by being flooded all the time.
Iriomote Island, in where Mangrove forests grow all around a river mouse, is located in 400km southwest from Okinawa Island.

2.2 Mapping Method and Result

Data set was made from two ASTER Data that each growth stage was different. But in case of Kusiro Mire there is only one scene of ASTER Data, another scene was substituted by LANDSAT-7/ETM+ data(Table1). Table 2 shows the spectral range of ASTER and ETM+.

Table 1. List of satellite data.

Test Site	Sattelite/Sensor	Path-Row	Acquisition Date
Kushiro	TERRA/ASTER	-	2000/06/19
	LANDSAT/ETM+	107-30	2000/10/16
Iriomote	TERRA/ASTER	-	2000/05/08,2001/01/03

Table 2. Spectral range of ASTER and ETM+.

ASTER band	Spectral range(μ m)	ETM+ band	Spectral range(μ m)
1 (VNIR)	0.520-0.600	1	0.450-0.520
2 (VNIR)	0.630-0.690	2	0.520-0.600
3 (VNIR)	0.760-0.860	3	0.630-0.690
4 (SWIR)	1.600-1.700	4	0.760-0.900
5 (SWIR)	2.145-2.185	5	1.550-1.750
6 (SWIR)	2.185-2.225	6	10.400-12.500
7 (SWIR)	2.235-2.285	7	2.080-2.350
8 (SWIR)	2.295-2.365		
9 (SWIR)	2.360-2.430		

2.2.1 Ground Truth

Ground truth carried out for the purpose of measurement in order to transfer ASTER data to reflectance and confirmation of the wetland distribution.

2.2.2 Drawing up Data Set

After a geometric correction using of a topographical map (1:50,000), ASTER Data was transferred to the value of reflectance. Table 3,4,5 and6 show transformation coefficient of DN value for each Band according to following formula. This value was calculated from 0 to 255 in proportion to the reflectance value from 0 to 1.

$$DN=K*N'+C \qquad (1)$$

DN' : DN value after tranformation

DN : DN value

K, C : transformation coefficient

Table 3. Transformation coefficient of DN value (Kushiro:2000/06/19)

ASTER Band	K	C
1	0.421	-18.347
2	0.551	-17.501
3	1.020	-22.035
4	1.196	-26.612
5	1.558	-37.059
6	1.206	-25.194
7	1.308	-26.000
8	1.247	-22.432
9	1.795	-41.828

Table 4. Transformation coefficient of DN value (Kushiro:2000/10/16)

ETM+ Band	K	C
1	0.329	4.470
2	0.839	-14.216
3	0.811	-8.790
4	0.992	-16.866
5	0.956	-13.421
7	1.132	-13.931

Table 5. Transformation coefficient of DN value (Iriomote:2000/05/08)

ASTER Band	K	C
1	0.862	-63.240
2	1.084	-52.148
3	1.589	-13.171
4	1.586	-5.919
5	1.581	0.431
6	1.293	3.618
7	1.288	7.398
8	1.160	10.394
9	1.813	-1.155

Table 6. Transformation coefficient of DN value (Iriomote： 2001/01/03)

ASTER Band	K	C
1	0.987	-19.258
2	1.306	-13.543
3	1.862	-14.066
4	2.053	33.515
5	2.726	17.937
6	2.114	25.355
7	2.532	15.994
8	2.382	15.836
9	4.317	2.076

2.2.3 Application of Wetland Map

After all band commbinations transformed to VSW (Vegetation-Soil-Water) index imagery, adequate band combination was investigated. VSW index is for monitoring to wetland which vegetable, soil, and water are piled up each other (Yamagata et.al,1991).

Maximum likelihood method was applied to VSW index imagery, and wetland area was extracted. And after removing tiny noise on extracted imagery by majority filtering and extracted element on steep slope area which wetland never exist by slope image made from DEM data, wetland map was completed.

By compared wetland map with vegetation map of Kushiro Mire, the accuracy of extraction of wetland area was certified 87.2%.

In case of Iriomote Island, the accuracy of extraction of wetland area was certified 100% by compared with wetland mark of a topographical map (1:25,000). However there were some errors that extracted as wetland besides Mangrove forests. So it is necessary to investigate a method of removing the error.

3. METHOD AND RESULTS OF FOREST MAPPING

3.1 Study Area

The study areas are Tomakomai in Hokkaido and Kitakami in Iwate Pref.

Kitakami has more complicated geographical feature to Tomakomai being comparatively gentle geographical feature. Therefore, these two areas where different geographical features made into the experiment site.

3.2 Mapping Method and Result

This algorithm necessary to obtain satellite data of both Summer season(thickness) and Autumn season(defoliation) since Tomakomai and Kitakami acquired from only one season's of ASTER data, therefore, LANDSAT/TM data was substituted for required season. Satellite data is listed in Table 7.

Table 7. List of sattelite data.

Test Site	Sattelite/Sensor	Path-Row	Acquisition Date
Tomakomai	TERRA/ASTER		2000/06/17,2000/06/24
	LANDSAT/TM	107-30	1999/11/14
Kitakami	LANDSAT/TM	107-32	2000/07/11
	TERRA/ASTER		2000/10/16

3.2.1 Ground Truth

The following contents of field survey was performed in the Tomakomai area.

1) Comapare and confirm between actual vegetation map and the local situation.
2) Canopy closure or understory vegetation
3) Spectral reflectance measure ment of Dark Target and Bright Target

3.2.2 Application of Forest Mapping

DN value of satellite data was modified.

After atomospheric correction, the value of coefficients a and b is shown for transformation of ASTER and TM (Table 8 and 9). In the Tomako mai area used spectral reflectance data, and atmospheric correction and sun elevation were rectified. On the other hand, Kitakami area was not use spectral reflectance data, therefore, it rectified relatively between scenes on the basis of TM data in July.

$$Y=a*X+b \qquad \ldots\ldots.. \qquad (2)$$

Y : spectral reflectance
X : DN value
a,b : coefficient

Table 8. Coefficients of Reflectance Transformation (Tomakomai).

ASTER (2000/06/17)			TM (1999/11/14)		
Band Number	a	b	Band Number	a	b
1 (VNIR)	0.0010	-0.0146	2	0.0043	-0.0259
2 (VNIR)	0.0017	-0.0280	3	0.0042	-0.0349
3 (VNIR)	0.0022	-0.0620	4	0.0056	-0.0435
4 (SWIR)	0.0028	-0.0228	5	0.0040	-0.0216
5 (SWIR)	0.0039	-0.0376	7	0.0071	-0.0173
6 (SWIR)	0.0036	-0.0331			
7 (SWIR)	0.0040	-0.0427			
8 (SWIR)	0.0042	-0.0418			
9 (SWIR)	0.0066	-0.0948			

Table 9. Coefficients of DN Transformation (Kitakami, ASTER).

Band Number	a	b
1 (VNIR)	0.7055	-1.9305
2 (VNIR)	1.1901	-0.2340
3 (VNIR)	1.4812	-4.6478
4 (SWIR)	2.7033	-9.3075
5 (SWIR)	1.9880	-10.2435
6 (SWIR)	1.9450	-9.9907
7 (SWIR)	2.0047	-11.0301
8 (SWIR)	1.9101	-7.8967
9 (SWIR)	2.1119	-13.1455

Land forms were modified using Sun incidence angle multip ly by constant coefficient (<1).
The coefficient was set up for the difference of DN value of a north-south slope to become the minimum for every band. The value of coefficient a is shown in Table 10.

$$Y = X / \cos(a * b) \quad ??????(3)$$

Y :DN value of topographic correction(after)
X :DN value of topographic correction(befoer)
b: Sun incident angle
a : Coefficient

Table 10. Coefficients of Topographic correction.

Tomakomai				Kitakami			
ASTER (2000/06/17)		TM (1999/11/14)		TM (2000/07/11)		ASTER (2000/10/16)	
Band Number	a	Band Number	a	Band Number	a	Band Number	a
1 (VNIR)	0.57	2	0.37	2	0.37	1 (VNIR)	0.50
2 (VNIR)	0.64	3	0.37	3	0.37	2 (VNIR)	0.56
3 (VNIR)	0.84	4	0.57	4	0.57	3 (VNIR)	0.84
4 (SWIR)	0.79	5	0.66	5	0.66	4 (SWIR)	0.73
5 (SWIR)	0.71	7	0.61	7	0.61	5 (SWIR)	0.67
6 (SWIR)	0.71					6 (SWIR)	0.79
7 (SWIR)	0.78					7 (SWIR)	0.82
8 (SWIR)	0.88					8 (SWIR)	0.83
9 (SWIR)	0.69					9 (SWIR)	0.73

The confusion matrix of reference data were 81% of Needle-leaf, 67% of Broad-leaf, and 89% of Karamatsu (deciduous pine tree) in Tomakomai, when each forest type of the Actual vegetation map was 100%.
In addition, 97% of Needle-leaf and 94% of Broad-leaf in Kitakami, respectively(Table 11 and Table 12).

Table 11. Confusion matrix (Tomakomai).

		Reference data				
		Needle-leaf	Broad-leaf	Karamatsu	Others	Total
Truth data	Needle-leaf	81	16	3	0	100
	Broad-leaf	13	67	17	3	100
	Karamatsu	5	6	89	0	100

Table 12. Confusion matrix (Kitakami).

		Reference data			
		Needle-leaf	Broad-leaf	Others	Total
Truth data	Needle-leaf	97	3	0	100
	Broad-leaf	3	94	3	100
	Karamatsu	77	23	0	100

3.2.3 Application of Forest Parameter Distribution Map

Forest parameter relevant to Carbon circulation is considered following 5 categories which are able to estimate and inevitable.

1)Biomass(Timber volume)
2)LAI
3)Height
4)DBH model
5)Tree age

These are increased of time lapse and are not independent variables mutually. That is, if a forest type is specified and a satellite can estimate one of parameters, other parameters in applying a transformation coefficient to it may be able to be evaluated. While the previous model was applied to actual ASTER data and the applicability was evaluated, the coefficient in a model was adjusted and the forest parameter figure was created. Since there was no planar truth data so that the evaluation was not in detail.

4. CONCLUSSION AND CONTINUING WORK

For wetland mapping, VSW index was calculated from satellite data and apply maximum likelihood method to the index image that it verified the availability. Generalizing this method applying to ASTER Data for other areas, and making wetland mapping on a global scale.
VSW index is computed from the likeness of Wetland mapping, therefore health data, and it is in this index picture.
Forest Mapping is able to evaluate adequately, however, it is necessary to improve further for the problems of such seasons of data use, accuracy of truth data, accuracy location of Satellite image. Moreover, applying to the overseas, generalizing this method, and evaluating the forest parameter map are necessary to be considered.

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