A study on global environmental monitoring by using ADEOS-II GLI data

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ABSTRACT: GLI on boarded ADEOS-II satellite allows us to observe vegetation status in the two different resolutions simultaneously, because of thirty 1km resolution channels and six 250m resolution channels. There are four GLI land higher level products from these channels ; those are PGCP (Precise Geometric Correction Parameter), L2A_LC (TOA reflectance), ACLC (atmospheric corrected reflectance), and VGI (NDVI and EVI). This paper shows ADEOS-II GLI land data processing, and some of the latest results.

KEYWORDS: ADEOS-II GLI, GLI land higher level products

1 Introduction

The Global Imager (GLI) is on boarded the ADEOS-II satellite, which was launched successfully on December 14, 2002. GLI is an optical sensor for the purpose of global and frequent observations of radiation reflected by land, ocean, ice/snow, and cloud. The specification of all channels are shown in Table 1, and Fig.1 depicts relative spectral response of GLI land channel with typical spectral reflectance. Total of 21 channels are dedicated for land observations in the two spatial resolutions; channels 1, 5, 8, 13, 15, 17, 19, 24, 26, 27, 30, 31, 34, 35, and 36 are for 1 km resolution, and channels 20, 21, 22, 23, 28, and 29 are for 250 m resolution. Thus, GLI allows us to observe vegetation status in the two different resolutions simultaneously. The band positions and widths of these channels were decided based on reflectance spectra from various land objects. The observation region by mechanically scanning is 12 picture elements (12 km) to the forward direction and 1600 km in the cross-track direction.

2 Objective

The objective of this paper is to show the algorithm of GLI higher level processing after level 1 and preliminary results.

3 GLI Land Higher Level Products

At first, the precise geometric correction is conducted for GLI L1B data. This algorithm enables to determine the precise satellite position and attitude using ground control points (GCPs). In this work, the GCP collection is realized by the template matching. Two image patches contain coastal lines. One is a template from the GSHHS fine coastal data, and another is a reference image made by the binarization of the original image. The template is selected as a GCP candidate from the prepared GCP library. GTOPO30 is used due to correction of terrain elevation effect. Output pixel value is radiance [W/m^2/str/μm] derived from L1B data. The product name is PGCP.

After precise geometric correction processing, GLI composite algorithm is applied. This algorithm produces geometrically corrected 16-day surface composites, which may select the best value pixel based on cloudiness and atmospheric contamination over a composite period. The constraint view angle maximum value composite (CVMVC) technique is used to generate these composites for GLI land algorithm. This product name is L2A_LC. Output value of this algorithm is TOA reflectance $\rho_{obs} = \pi L_{sat}/F_0 \cos(\theta_s)$ in VNIR and SWIR wavelength region. F_0[W/m^2/μm] shows irradiance based on Thuiller 2002, L_{sat}[W/m^2/str/μm] is GLI observed radiance, and θ_s[rad] is solor zenith angle. In case of MTIR, the output value is radiance [W/m^2/str/μm].

GLI atmospheric correction over land will be conducted for Rayleigh scattering and Ozone absorption after CAL/VAL phase (December, 2003). They are corrected with the NOAA/TOVS data set and GTOPO30. GLI observed TOA reflectance is described as $\rho_{obs}(\tau_{O_3}, \tau_R, \theta_s, \theta_\nu, \varphi_{s-\nu}) = T_{O_3}(\tau_{O_3}, \theta_s, \theta_\nu) \times (\rho_R(\tau_R, \theta_s, \theta_\nu, \varphi_{s-\nu}) + (T_{R\downarrow}(\tau_R, \theta_s)\rho_s T_{R\uparrow}(\tau_r, \theta_\nu))/(1 - S_R(\tau_R)\rho_s)$. T_{O_3} shows ozone transmittance, ρ_R is path radiance, $T_{R\downarrow}$ is downward transmittance, $T_{R\uparrow}$ is upward transmittance, S_R is Spherical Albedo, and ρ_s is Rayliegh/Ozone Corrected Reflectance. τ_R shows optical thickness of Rayleigh scattering. In the angle parameter, θ_ν is satellite zenith angle, and $\varphi_{s-\nu}$ means relative azimuth angle between sun and satellite sensor direction. This product name is ACLC.

At last, vegetation indices are calculated by GLI VGI algorithm. Normalised Difference Vegetation Index (NDVI) is most used for land from before, and many studies have shown a qualitative and quantitative analysis of NDVI in vegetation growth. Therefore, NDVI should be land product for global land monitoring, because of continuity. The NDVI is described as $NDVI = (\rho_n - \rho_r)/(\rho_n + \rho_r)$. ρ_n shows reflectance in near infrared region, and ρ_r is reflectance in visible red region (ρ_{obs} or ρ_s). GLI land team adopt another index, 'Enhanced Vegetation Index' (EVI) for increased sensitivity over a wider range of vegetation conditions, removal of soil background influences, and removal of residual atmospheric contamination effects present in the NDVI. The EVI is described as $EVI = G \times (\rho_n - \rho_r)/(L + \rho_n + C1 \times \rho_r - C2 \times \rho_b)$. L is the canopy background factor, and C1 and C2 are the coefficients of the aerosol 'resistance' term, which uses the reflectance in blue channel (ρ_b;ρ_{obs} or ρ_s). It is indicated that the currently used coefficients, G = 2.5; L = 1; C1 = 6; and C2 = 7.5, are fairly robust.

4 Preliminary Results

In initial checkout phase, the geometric accuracy by system correction (250m) is estimated about 4pixels(static) in the scan direction and 5-10 pixels (change linearly) in the track direction. However, the accuracy by precise geometric correction with GCPs is less than 1pixel. Band-to-band registration errors are recognised in proportional to arrangement of detectors on the focal plane. Geolocation can sometimes displace along track direction by approx. 7km at max. when GPSR stopped. However, NASDA has developed the algorithm to calculate accurately scanning time without GPSR data, which will be applied from next L1 software version. GLI geometric calibration team will continue to check error pattern.

The saturation level for land is almost satisfied with maximum radiance of specification. In case of GLI land channels, Ch. 5,8,13,15,19,22,23, may be sometimes saturated in extreme high bright target. And Ch.13,19,22,23 turn down partly in the range exceeding the saturation level (over saturation). They will not be critical problems in unsaturated areas. Stripe noise originated from detectors and mirror and electric system noise of MTIR are sometimes appeared. The L1B DN of Ch.30 (3.7 μ m) frequently becomes zero in low-temperature (<240K) areas, however this will be occurred at the top of high-altitude clouds and in polar regions in the nighttime.

Left image of Fig.3 shows the example of precise geometric corrected GLI 1km L1B image, and right image shows 250m. These images are captured on Febrary 7, 2003. It is clear that 1km data is useful for global monitoring, and 250m data is useful for more detailed monitoring. Fig.4 shows the example of the GLI expected results of NDVI processed by GLI 1km NDVI algorithm by using Terra/MODIS data without atmospheric correction.

Above these algorithms are only for GLI 1km data, and 250m product is until only L1B. Therefore, 250m higher level algorithm has to be developed as soon as possible, and this is ongoing now.

Ground based validation activity is very important for the above GLI land higher level product. Fig.4 depicts GLI land validation sites, and there is 2 kinds of land type. One is grassland type, and the other is forest type. GLI land validation group will obtain the representative spectral reflectance at satellite footprint scale and the atmospheric parameter will be also acquired on the sites. GLI land validation group also plan to evaluate sensitivity of biophysical parameter for vegetation indices. ADEOS-II GLI activity is CAL/VAL phase from April 15 to December 14 of 2003 (delivery to PIs). The above higher processed data will be provided for public users after that.

References

[1] Yamamoto, H., Hashimoto, T., Mitomi, Y., Yoshioka, H., and Igarashi, T., 2003, "Global Land Monitoring by ADEOS-II GLI", Proceedings(CD-ROM), Global Mapping Forum, Okinawa Convention Center, Okinawa, Japan, July 12-15.

Table.1: Specification of GLI channels

ch	Wave length [nm]	Dynamic range [W/m2/str/um]	SNR (input L)	ch	Wave length [nm]	Dynamic range [W/m2/str/um]	SNR (input L)	ch	Wave length [nm]	Dynamic range [W/m2/str/um]	SNR (input L)
VNIR (1km) (#p: *piecewise linear band*)				15	710.1	233 (369)	300 (10)	250 m bands			
1	380.7	683	467 (59)	16	749	11 (17)	991 (7)	20	462.4	691	241 (36)
2	399.6	162	1286 (70)	17	762	246 (473)	293 (6)	21	542.1	585	141 (25)
3	412.3	130	1402 (65)	18	866.1	8 (13)	1309 (5)	22	661.3	115 (156)	255 (14)
4p	442.5	110 /680	893 (54)	19	865.7	211 (339)	386 (5)	23	824.1	210 (287)	218 (21)
5p	459.3	124 /769	880 (54)	SWIR (1 km)				28	1644.9	76	298 (5)
6	489.5	64	1212 (43)	24	1048.6	227	381 (8)	29	2193.8	32	160 (1.3)
7p	519.2	92 /569	627 (31)	25	1136.6	184	412 (8)	MTIR (Kelvin, NEΔT at 300K)			
8p	544	96 /596	611 (28)	26	1241	208	303 (5.4)	30	3721.1	345 K	0.07 K
9	564.8	39	1301 (23)	27	1380.6	153	192 (1.5)	31	6737.5	307 K	0.03 @285K
10	624.7	28*1 (39*2)	1370 (17)	•Dynamic range and SNR are cited from "Tanaka, K., GLI Mission Data Evaluation Test results, NASDA ADEOS-II Project, ADEOS-II/GLI Workshop, November 14-16, 2001, Tokyo, Japan".				32	7332.6	322 K	0.03 K
11	666.7	22 (31)	1342 (13)	•Center wavelength is derived from GLI spectral response.				33	7511.4	324 K	0.02 K
12	679.9	23 (33)	1293 (12)	•S/N tests are in ambient (VN+SW) and high temp (MT) condition.				34	8626.3	350 K	0.05 K
13	678.6	342 (522)	235 (12)	•*1 Maximum radiance for **linear response (VN2)**				35	10768	354 K	0.05 K
14	710.5	16 (24)	1404 (10)	•*2 Predicted maximum radiance for **DN=4095 (12bit) or saturation.**				36	12001.3	358 K	0.06 K
									NASDA GLI CAL Group, May 1, 2002		
										(orange)	**:1km Land Channel**
										(pink)	**:250m Land Channel**

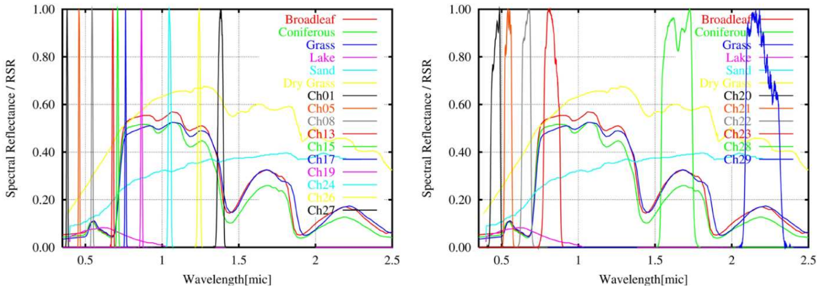

Fig.1:Relative Spectral Response (Left:1km Right:250m)

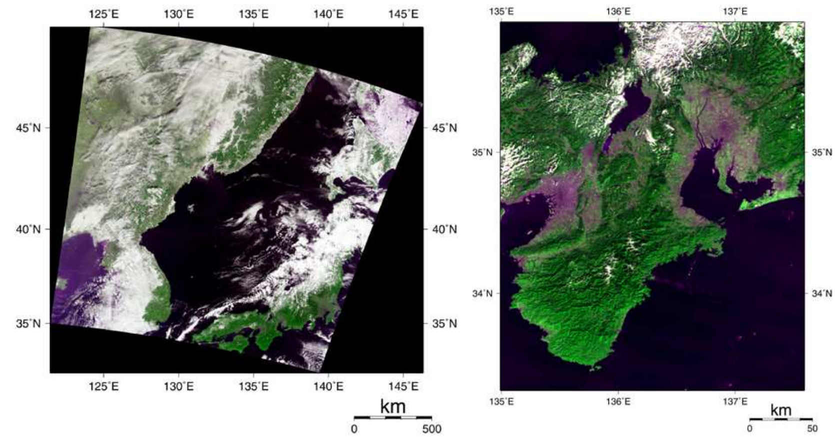

Fig.2: Example of GLI images (Left:RGB=Ch.13,19,8(1km); Right:RGB=Ch.22,23,21(250m))

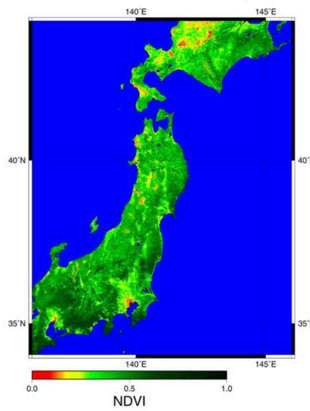

Fig.3: Expected result of GLI 1km NDVI product

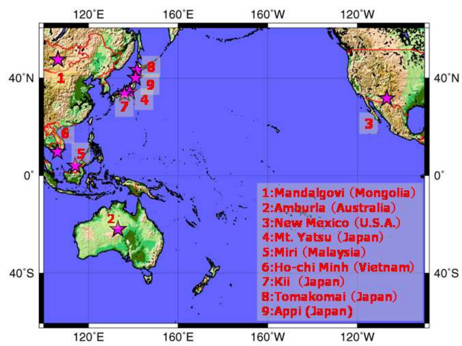

Fig.4: GLI land validation site