ABSOLUTE RADIOMETRIC CALIBRATION OF 1M SATELLITE IMAGERY

Sun-Gu Lee, Dong-han Lee, Doo-chun Seo, Jeong Heon Song, Yongseung Kim, Hongyul Paik

Space Application Center, Korea Aerospace Research Institute
P.O. Box 113, Yusung, Daejeon 305-600, Korea
Tel) 82-42-860-2854, Fax) 82-42-860-2605
leesg@kari.re.kr, dhlee@kari.re.kr, dcivil@kair.re.kr, newssong@kari.re.kr, yskim@kari.re.kr, phy@kari.re.kr

ABSTRACT:

CAL/VAL team of Korea Aerospace Research Institute(KARI) performed field campaigns for absolute radiometric calibration of 1m satellite image on Daejeon and the cal/val site of Goheung. The satellite image have spatial resolution of 1m in panchromatic spectral band of 450-900nm. The performed cal/val method is the reflectance-based of vicarious calibration methods. We collected ground-based and meteology data such as temperature, surface pressure and reflectance of targets, and radiosonde data used only to test in Goheung. Data collected on each field served as input to radiative transfer codes to generate a top-of-atmosphere(TOA) radiance estimate. Derived TOA is compared with DN of overpass satellite to calculate calibration coefficient of gain and offset.

KEY WORDS: absolute radiometric calibration, TOA, panchromatic, gain, offset

1. INTRODUCTION

Two techniques for postlaunch calibrations are usually used independently. These are onboard and vicarious techniques. Vicarious calibration provides a method for the absolute calibration of satellite sensor. And absolute calibration of satellite sensors need to determination relation of top-of-atmosphere (TOA) and DN of image data because should change calibration in experiment after launch and temporal changes could be masked by sensors degradation and in-flight. These in-flight methods have relied on both onboard systems and vicarious methods. Typical onboard systems include direct solar illumination and onboard lamps. These systems provide calibration at high temporal frequency to determine instrument response trends. The problem with onboard calibration system is that they can degrade over time, or may themselves have bias which affect the calibration (Teillet et al., 2001). Vicarious methods have an advantage in that they provide an independent means of absolute calibration using a full-system, full-aperture calibration.

To prepare absolute radiometric calibration of KOMPSAT-2, CAL/VAL team of KARI used vicarious methods to test absolute radiometric calibration of 1m satellite imagery. Twice field campaign had in KARI on 7 March 2005 and in Goheung on 4 November 2004. Following introduces field campaign method and test results.

2. OBJECTIVES

The main objective of the absolute radiometric calibration derives offset and gain by correlation between top-of-atmosphere(TOA) radiance and DNs of 1m satellite imagery. And secondary is to check sensors degradation of after launching and by temporal changes

3. METHOD

3.1 Absolute radiometric calibration - Reflectance-based method

The reflectance-based approach relies on ground-based surface reflectance measurements of selected target at the time of sensor overpass. Reflectance measured of spectroradiometer GER-3700. The atmosphere over the target is characterized using measurements from solar radiometers to determine columnar amounts of absorbing gases and the scattering properties of the aerosols. The results of the surface and atmospheric characterization are used as input to a radiative transfer code to predict the top-of-atmosphere radiance. The digital numbers reported by the sensor are compared to these predicted radiances to give a radiometric calibration. Each portion of this technique is now described in more detail

3.2 Test site description

We had two field campaigns, first had in Goheung on 4 November 2004 and second had in KARI on 7 March 2005. KARI locates at 127.21longitude and 36.22latitude. Reflectance of uniformed surrounding targets was observed as like asphalt, grass, concrete, soil and

observed portable tarps of reflectance 3.5%, 23%, 35%, 53%. Goheung locates at 127.07longitude and 38.18latitude near the south coast. The weather is clear sky two day all comparatively.

3.3 Surface reflectance measurement

Accurate determination of the surface reflectance of the test site is critical for the reflectance method. We find the surface reflectance of the site by ratioing radiometer measurements of the site to those from a panel. We collect reflectance of about three time per each target. The reflectance of this panel is assumed to be known from calibrations made in the facilities of the SVC, the reflectance of panel is almost 100% on 350 - 2500 nm. The method is to measure the upwelling radiance from the reference panel at several points in time during the data collection. This reflectance is determined by ratioing a measurement of the test site to a predicted signal expected from the reference panel at the time of the site measurement. We measure the site reflectance using an GER-3700. This system collects data over the spectral range from 350-2500nm: 1.5nm interval in 350-1050nm, 6.5nm interval in 1050-1900nm and 9.5nm interval interval in 1900-2500nm.

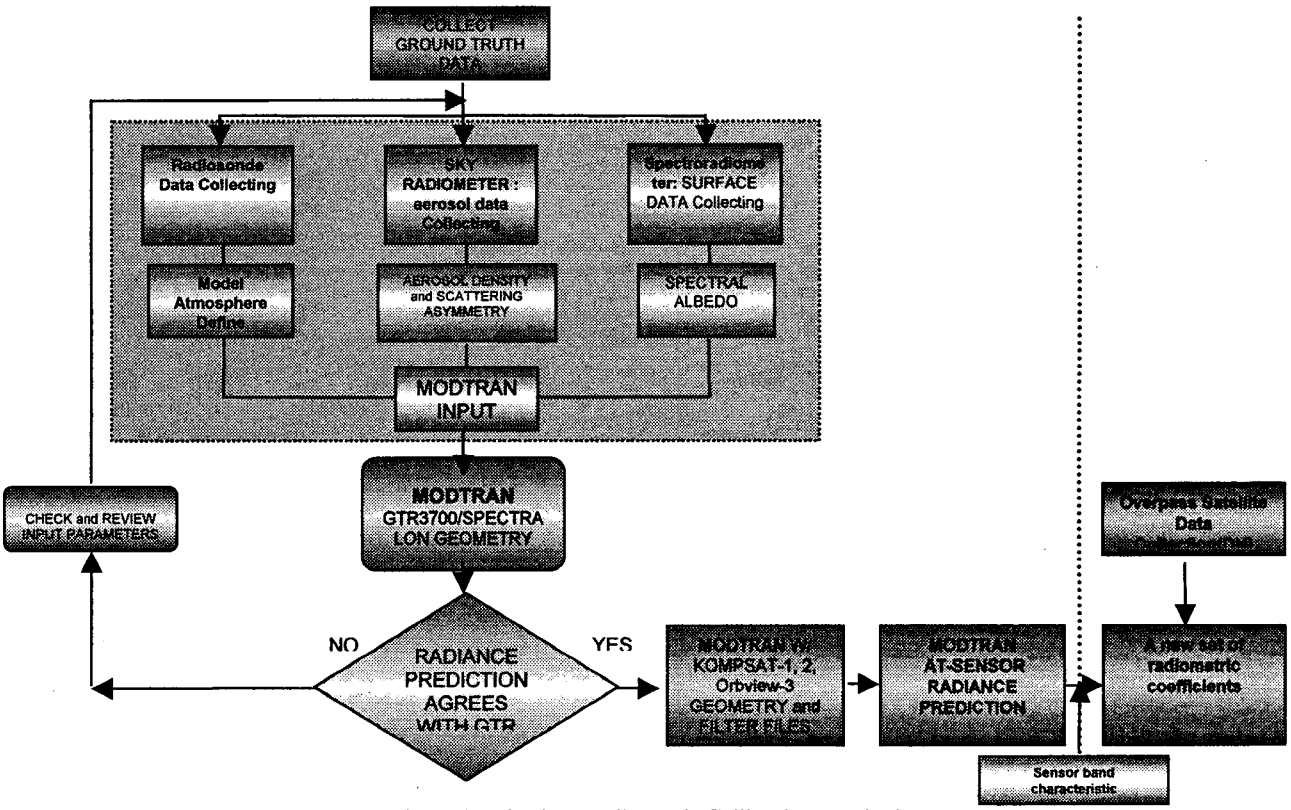


Figure 1. Absolute Radiometric Calibration Method

3.4 Radiative Transfer Code

The results from the atmospheric and surface characterizations are used in a PcModWin 4.0 v3r1 Version 1.2, radiative transfer code to compute top-of-the-atmosphere radiances. This code is discriminated of geometry and spectral band. And data input parts are spectroradiometer measurement for surface albedo, sunphotometer measurement for aerosol, and radiosonde measurement for defining of model atmosphere. In this study, model atmosphere used 1976 US data and used aerosol model of Rural-VIS=23km standard because couldn't use sunphotometer.

- Geometry(in Goheung)

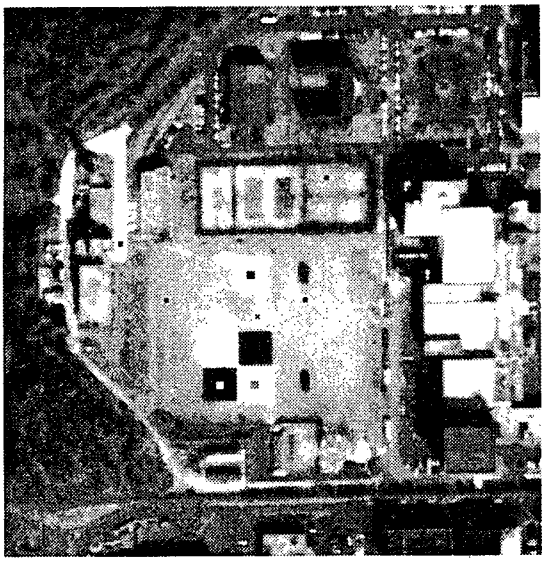
observer height: 100km, Final height: 0.1km, Azimuth angle at observer LOS to sun: 162.5degree, sun zenith angle: 51.8degree, spectral range: 400-950nm

- Geometry(in KARI)

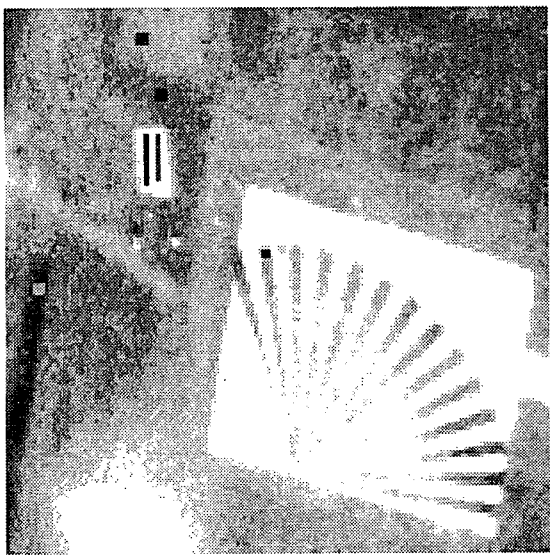
observer height: 100km, Final height: 0.1km, observer zenith angle: 177.9degree, Azimuth angle at observer LOS to sun: -84.4degree, sun zenith angle: 45.3degree, spectral range: 400-950nm

3.5 Determination of Image DNs

To determine the sensor gain and offset (in units of DN/unit radiance), we average the DNs for the pixels of interest in the image(satellite) data for each targets of the Figure 2: (a)KARI site, (b) CAL/VAL site in Goheung.



(a) KARI site



(b) CAL/VAL site in Goheung

Figure 2. Test site of radiometric calibration in KARI(a) and in Goheung(b)

4. RESULTS

Table1 and Table2 show results of calibration in KARI and Goheong DN of satellite data and radiance value on 4 November 2004 in Goheung. First columns are targets observed in KARI and Goheong and second columns are reflectance calculated of targets in situ and third columns are average DNs reported from satellite data and last columns are TOA values calculated from radiative transfer code. Target data of Goheung excepted by cloud.

Figure3 shows slope by various targets in Goheung and in KARI. We derived gain and offset of satellite sensor by the slope. Following is the result

- The result of Goheung field campaign is L=0.00007*DN-0.0029, correlation coefficient: 0.937
- The result of Daejeon field campaign is L=0.00008*DN-0.0026, correlation coefficient: 0.967

Table1. DN of satellite data and radiance value on 4 November 2004 in Goheung

Targets	Reflectance	Digital Number	Radiance
Tarp(23%)	0.25	69.28	0.0033
Tarp(35%)	0.34	82.41	0.00422
Asphalt	0.039	38.44	0.0012
Gravel	0.32	48.77	0.00229
Soil	0.35	55.44	0.0019
Target(white)	0.55	85	0.00639
Target (Black p)	0.037	56.75	0.0012

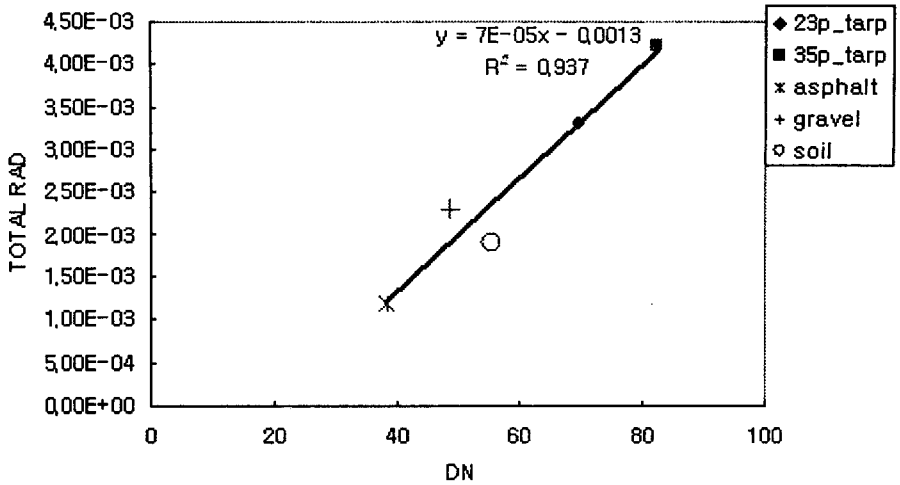
Table2. DN of satellite data and radiance value on 7 March 2005 in KARI

Targets	Reflectance	Digital Number	Radiance
Tarp(53%)	0.568	128.08	3.65E-03
Tarp(35%)	0.372	90.11	2.67E-03
Tarp(23%)	0.263	74	2.14E-03
Tarp(3.5%)	0.034	46.12	1.09E-03
Hardcourt	0.159	65.66	1.66E-03
Soil	0.223	75.22	2.29E-03
Concrete	0.332	83.33	1.90E-03
Grass	0.26	78.55	2.14E-03
Asphalt	0.124	64.88	1.47E-03

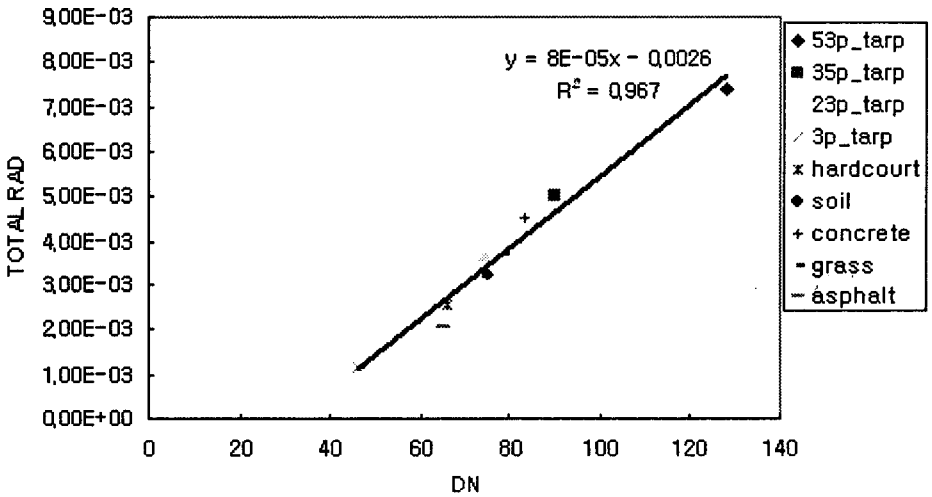
* radiance: $W/cm^2/sr/\bullet m$

5. CONCLUSIONS

KARI performed the absolute radiometric calibration of 1m satellite imagery in Deajeon on 4 December 2004 and in Goheung on 7 March 2005. The radiances predicted at the top of the atmosphere using radiative transfer code. In result, we derived offset and gain by correlation between top-of-atmosphere radiance and DNs of 1m satellite imagery. The result of our test is comparable with coefficient of itself test. In the future, we expect this absolute radiometric method that will be used to calculate radiance TOA of KOMPSAT-2 and to monitor degradation of sensor over the time.



(a) The result in Goheung (2004. 11. 4)



(b) The result in KARI (2005. 3. 7)

Figure 3. The results of gain and offset for absolute radiometric calibration in KARI(a) and in Goheung (b)

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