Radiometric Performances of COMS MI for the First One Year

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1. Introduction of COMS and MI

▣ COMS: Communication, Ocean, and Meteorological Satellite

- First Korean Meteorological Geostationary Satellite
- Preparation: 2003~2010
- Launch date: June 27th, 2010.
- Operation Orbit: 128.2E / 35,800 km above Equator
- Life time: 7 years after In-Orbit Test (IOT) period
- Dimensions and Launch Weight: 2.2×2.7×3.2 ㎥ and 2,500 kg
- S/C Stabilization: 3-axis
- Multiple Payloads: MI, GOCI, Ka-band Transponders

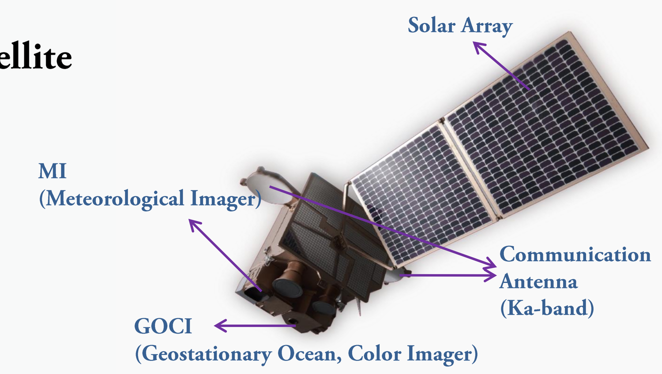


Figure 1. Structure and name of the parts of the COMS

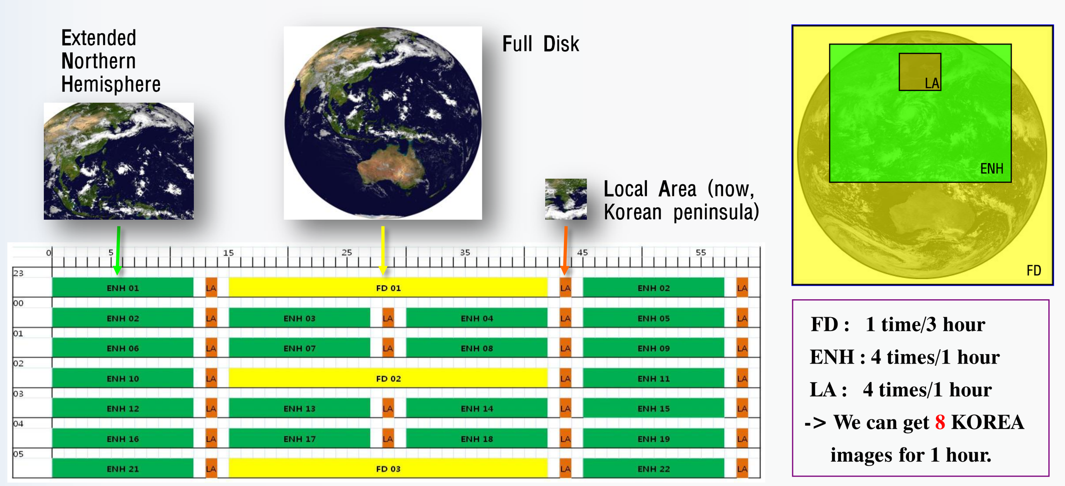
▣ MI: Meteorological Imager

- Multispectral imaging radiometer
- 1 visible and 4 infrared channels
- Mission:
  - ① Continuous monitoring of imagery and extracting of meteorological products
  - ② Early detection of severe weather phenomena
  - ③ Monitoring of climate change and atmospheric environment

Table 1. Specification of the COMS MI channels

Channel Number	Channel Full Width at Half Maximum (μm)		Spatial Resolution Half-Amplitude (IFOV in μrad) (km)	Required Range of Measurement	End Use
	Lower	Upper			
VIS	0.55	0.80	28 (1km)	0-115%(Albedo)	Cloud Cover
SWIR	3.5	4.0	112 (4km)	4-350K	Night Cloud
WV	6.5	7.0	112 (4km)	4-330K	Water Vapor
IR1	10.3	11.3	112 (4km)	4-330K	Cloud and Surface Temperature
IR2	11.5	12.5	112 (4km)	4-330K	Cloud and Surface Temperature

▣ COMS MI Observation Area and Schedule



FD : 1 time/3 hour
ENH : 4 times/1 hour
LA : 4 times/1 hour
-> We can get 8 KOREA images for 1 hour.

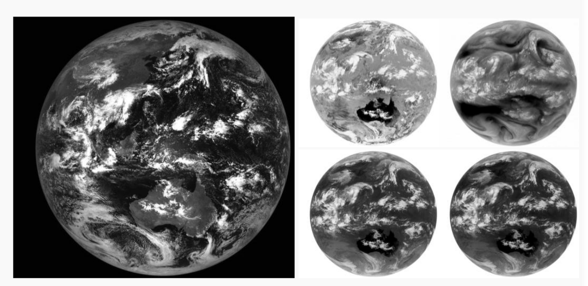


Figure 3. The FD images of the COMS MI data. Visible (left) and 4 IR (right, clockwise from upper left, SWIR, WV, IR2 and IR1) images.

Figure 2. Observation mode and its area on the earth with mission schedule of the COMS MI

☞ National Meteorological Satellite Center (NMSC) of Korea Meteorological Administration (KMA) has begun official service of COMS MI data since April 1st, 2011.

- NMSC has tuned radiometric parameters during the IOT period

2. COMS MI Data Processing System

COMS MI data processed go through the usual procedures with many modules, especially radiometric correction process which get accomplished in Image Radiometric Correction Module (IRCM) to generate LV1A data from LV0 data.

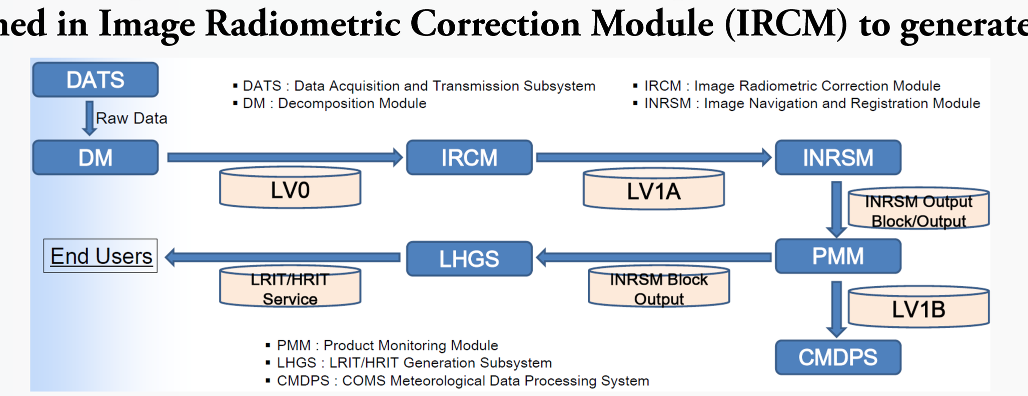


Figure 4. The COMS MI data processing modules and data products in NMSC satellite ground system

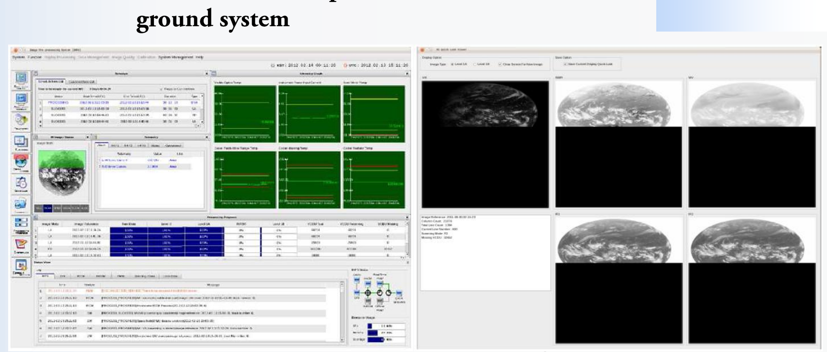


Figure 5. The COMS MI data Image Preprocessing System (IMPS) monitor display in NMSC satellite operation room

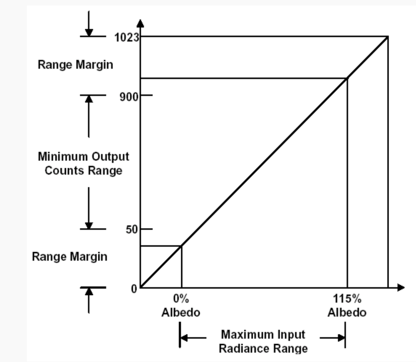
3. COMS MI Radiometric Calibration Algorithm

COMS MI radiometric correction is concerned with improving the measurement accuracy of surface spectral reflectance, emission, or back-scattering obtained from MI observations.

▣ Visible Channel

- Pre-Launch calibration: Using Integrating Sphere Device (ISD)
- Observation error: SNR, less than RMS 5% at 100% Albedo
- Quantization: 10 bits for all the spectral bands
  Dynamic range is 0~115% Albedo using ISD
- In-Orbit calibration: Albedo monitoring / Moon / Vicarious calibration with ground target
- Nominal Calibration Equation

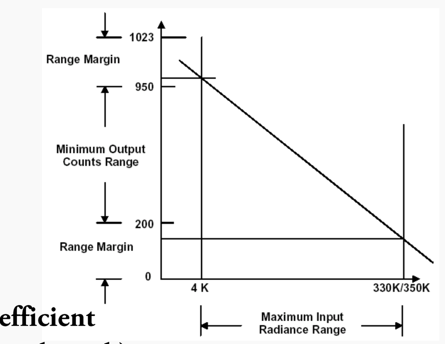
$$R = mX + b\,,$$ where R = radiance $[W/(m^2\ sr\ \mu m)]$
X = digital count
m = slope (pre-launch determined)
b = intercept (measured at each space clamp)



▣ Infrared Channels

- Pre-Launch calibration: Using accurate blackbodies in a thermal vacuum chamber
- Observation error: Noise Equivalent differential Temperature (NEdT)
- Quantization: 100 bits for all the spectral bands
  Electrical calibration target of 210K ~ 330K
- In-Orbit calibration: Blackbody / Electronic calibration / Space look
- Nominal Calibration Equation

$$R = qX^2 + mX + b\,,$$ where q = quadratic calibration coefficient (determined by ITT before launch)



☞ The radiance R is converted to counts X in the level 1B product which is performed using a simple linear rule as follows;

$$X = PixScale \times R + PixOffset\,,$$ where PixScale and PixOffset are dependent on channels and they are to be provided in the product auxiliary data.

4. COMS MI Radiometric Performances

In order to verify the radiometric quality of the COMS MI images, it is necessary to check the degradation ratio of detectors of level 1A products. And Pixel-to-pixel Response Non-Uniformity (PRNU) which is derived from SNR at 5% albedo is a principal index for verifying radiometric quality as compared with specification.

▣ Visible Channel

- PRNU : To identify the reference samples and compute the difference between the detectors at 5% albedo.
  ☞ The PRNU values for the first one year of official service are within the requirement which is 1/3 of NEdT derived from SNR at 5% albedo ($R_{5\%}$), i.e. 0.8 W m² sr⁻¹ μm⁻¹, except around local midnight.

$$\frac{1}{N_{5\%}}\sum_{N_{5\%}}(R_{Det1} - R_{Det2}) \le \frac{R_{5\%}}{3 \times SNR}$$

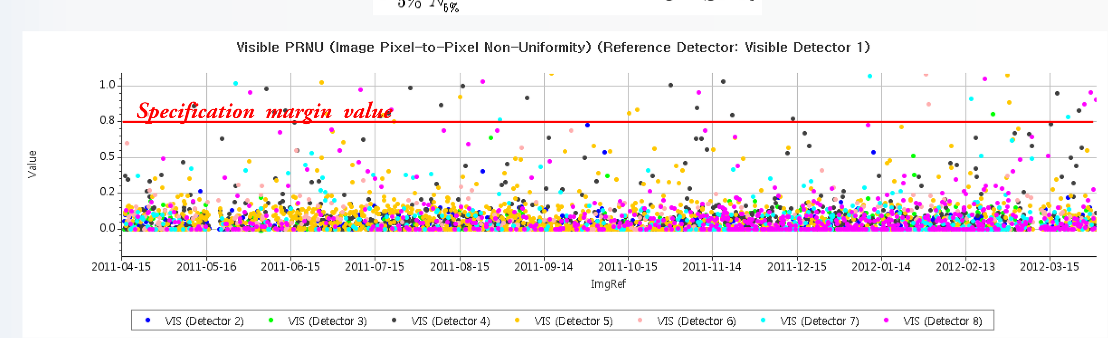


Figure 6. PRNU value distribution of the COMS MI visible channel for one year

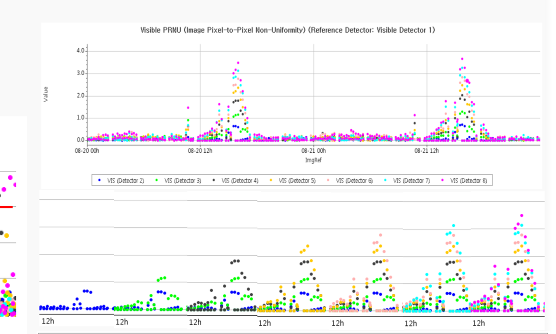


Figure 7. PRNU over value with respect to requirement around local midnight (upper). The difference extent by detector against detector 1 (below).

- Intercept : Determined at each space clamp (from averaged count value of two space looks) for the calibration equation.

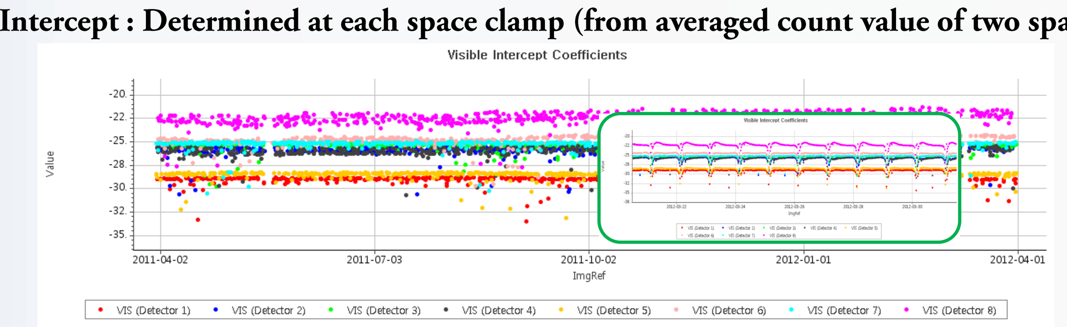


Figure 8. Intercept ('b' of the calibration equation) value trend of the COMS MI data for one year and daily trend (in the green box)

Table 2. Visible channel Slope (m) values

Detectors	Slope (m) value W /(m² sr μm count)
Detector 1	0.62518
Detector 2	0.62781
Detector 3	0.62590
Detector 4	0.61910
Detector 5	0.62399
Detector 6	0.62930
Detector 7	0.63093
Detector 8	0.62456

▣ Visible Channel (Continued from previous column)

- Moon : In order to monitor the degradation of the MI visible channel, we use a method based on the comparison between the global signal produced by the Moon measured by the instrument and the model provided by Robotic Lunar Observatory (ROLO) as a function of phase angle of Sun-Moon-Earth.
  ☞ The degradation trend of MI visible channel is 4.62% (for 1year total ratio is about 5.04%) based on trend line of moon response slope factor from June 2011 to May 2012.

$$P = \frac{I_{inst}}{I_{ref}}\,,$$ where I_{inst} is the Moon irradiance as measured by the MI
I_{ref} is the Moon irradiance computed by ROLO model

The ratio, $k = \frac{P(t)}{P(t_0)}$ expressed in percentage,

but we can directly use slope factor, $\frac{Response_{Img}}{Response_{ref}} \cong P(t)$ instead of k.

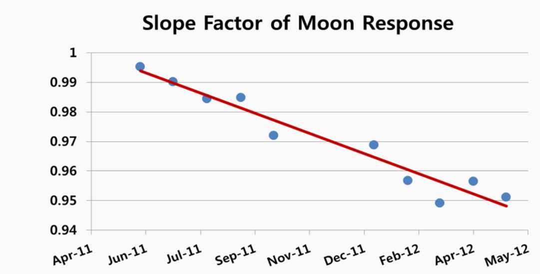


Figure 9. Slope factor and trend line of Moon response for 1 year

▣ Infrared Channel

- PRNU : To identify the reference samples and compute the difference between the detectors at 220 and 300K.
  ☞ The PRNU values for IR channels for the first one year of official service are mostly within the specification.

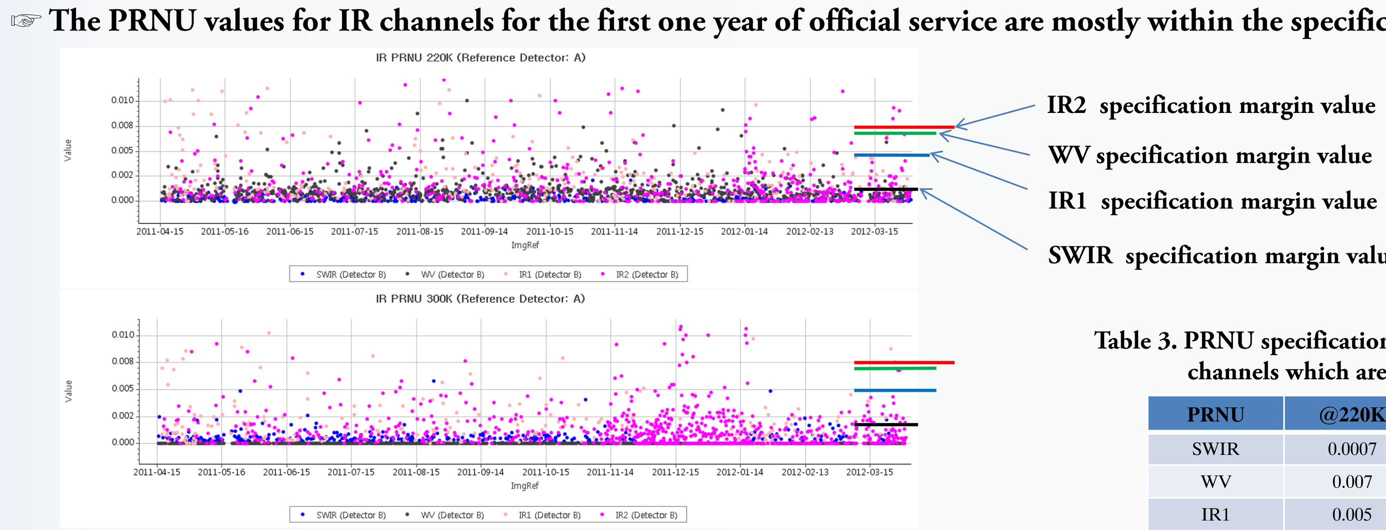


Figure 10. PRNU value distribution of the COMS MI infrared channels for one year

Table 3. PRNU specification margin values for IR channels which are derived from NEdT

PRNU	@220K	@300K
SWIR	0.0007	0.0007
WV	0.007	0.007
IR1	0.005	0.005
IR2	0.008	0.008

- Slope : Determined from each blackbody calibration sequence data for the IR channel calibration equation.
  ☞ The Slope coefficient values at calibration equation are tend to oscillate diurnally and annually.

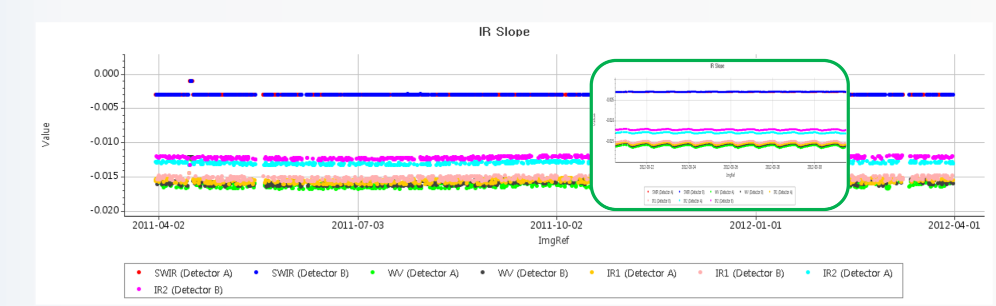


Figure 11. Slope ('m' of the calibration equation) value trend of the MI data for one year and daily trend (in the green box)

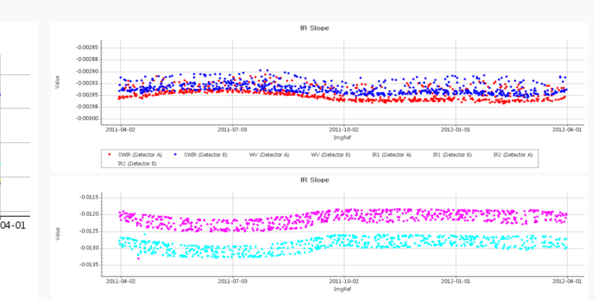


Figure 12. Slope value trend by season each band (upper is SWIR and below is IR2)

5. Remarkable Conclusion

▣ Until now COMS and MI are working well.

- NMSC of KMA has begun official service of the COMS MI data more than one year successfully since April 1st, 2011.
- The service success rate for the COMS MI data for the first one year is 95.2% (NMSC service only).
  (Including the back-up station support, success rate rises to 99.46%.)

▣ COMS MI data radiometric performance meets user requirement.

- All the radiometric parameters are within the specification for visible and infrared channels.
- The visible channel detectors' degradation trend which is Moon slope factor, computed by comparing with ROLO model is about 5.04% for the first one year and it is reliable as compared with heritage instruments', 5~6% trend.

▣ Further work for COMS MI radiometric performance and issue

- Monitoring and studying out the method to reduce the MI image quality deterioration caused by stray light and other sources during eclipse seasons.
- A new algorithm for removing stripes on the WV channel images will be developed.