COMS MI Radiometric Performances over Two Years

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NMSC of KMA

Ⅰ. Introduction of COMS and MI

The first Korean meteorological geostationary satellite was launched on June 27th, 2010.

◈ **COMS: Communication, Ocean, and Meteorological Satellite**
- Operation Orbit: 128.2E / 35,800 km above the 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

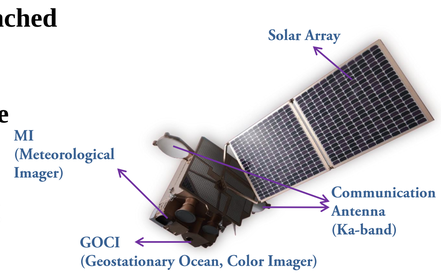


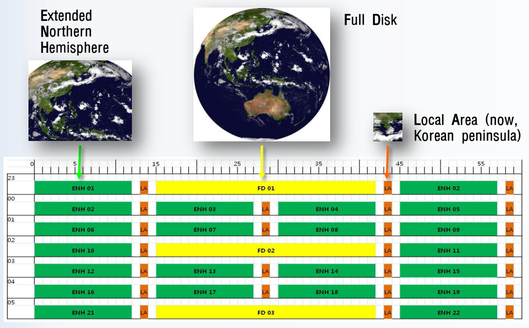
Figure 1. Structure and name of each parts of the COMS

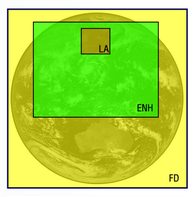
◈ **MI: Meteorological Imager**
- Multispectral imaging radiometer
- 1 visible and 4 infrared channels
- Mission
  - ⅰ. Continuous monitoring of imagery and extracting of meteorological products
  - ⅱ. Early detection of severe weather phenomena
  - ⅲ. Monitoring of climate change and atmospheric environment

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

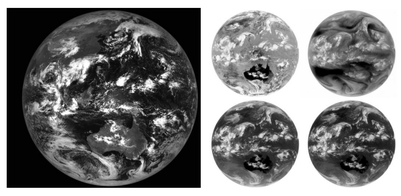


Figure 3. The FD images of the COMS MI data. Visible (left) and 4 IR (right, clockwise from upper left, SWIR, WV, IR2 and IR1) images.

National Meteorological Satellite Center (NMSC) of Korea Meteorological Administration (KMA) has begun official service of the COMS MI data since April 1st, 2011. Since then, NMSC has been under the normal operation for 24 hours a day.

Ⅱ. 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: Signal to Noise Ratio (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

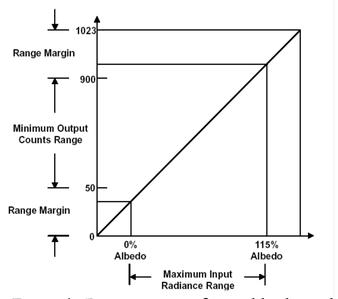


Figure 4. Dynamic range for visible channel

$$R = mX + b\,,$$ where R = radiance (W m^{-2} sr^{-1} μm^{-1})
X = digital count
m = slope (pre-launch determined)
b = intercept (measured at each space clamp)

◈ **Infrared Channel**
- Pre-Launch calibration: Using accurate blackbodies in a thermal vacuum chamber
- Observation error: Noise Equivalent Differential Temperature (NEDT)
- Quantization: 10 bits for all the spectral bands, Electric calibration target of 210K ~ 330K
- In-Orbit calibration: Blackbody / Electronic calibration / Space look
- Nominal Calibration Equation

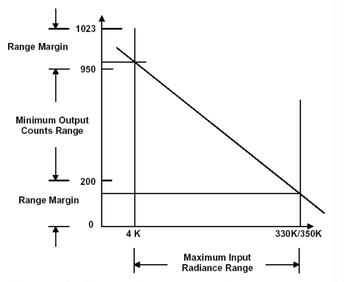


Figure 5. Dynamic range for infrared channel

$$R = qX^2 + mX + b\,,$$ 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.

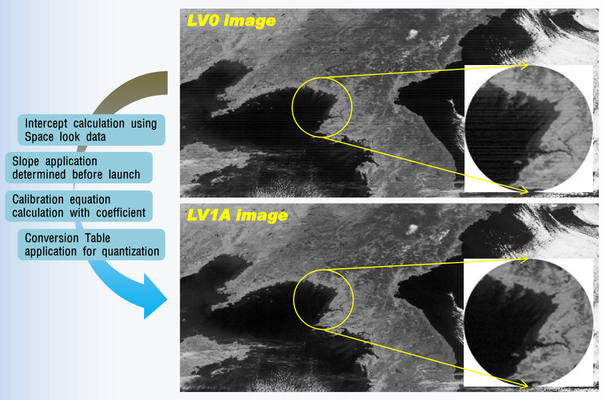


Figure 6. The step of radiometric calibration for visible channel's image

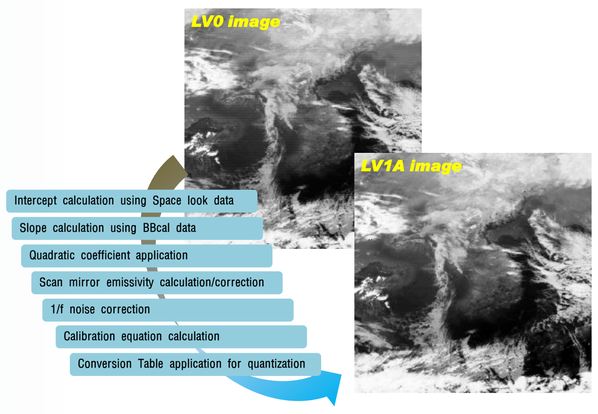


Figure 7. The step of radiometric calibration for infrared channels' image

Ⅲ. COMS MI Radiometric Performances

It is necessary to check the radiometric indices with respect to the specification, because it is measures of verifying the radiometric quality of the COMS MI images. Signal to Noise Ratio (SNR), Noise Equivalent Differential Radiation (NEDR), and Pixel-to-pixel Response Non-Uniformity (PRNU) are principal indices for verifying radiometric quality. We also check the degradation rate of visible channel detectors.

◈ **Visible (VIS) Channel**

◎ SNR
- We compute the SNR from the Space look (Dark) data, to check the radiometric performance.

☞ SNR performance over two years is better than the specification, i.e. 10 at 5% albedo.

$$SNR_{5\%} = \frac{R_{5\%}}{\sqrt{A_{in\_orbit} + B_{on\_ground} \times R_{5\%}}}$$

where, $R_{5\%} = Albedo(0.05)/\zeta$

$A_{in\_orbit} = (m \times \sigma_c)^2$

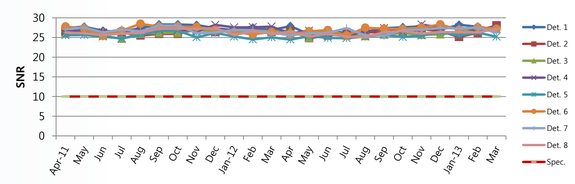


Figure 8. SNR value trend of the COMS MI visible channel over two years

◎ PRNU
- It is to check the radiometric difference between a reference detector and other detectors.

☞ PRNU values are within the requirement over two years which is derived from SNR at 5% albedo ($R_{5\%}$), i.e. 0.8 W·m^{-2}·sr^{-1}·μm^{-1}, except around local midnight.

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

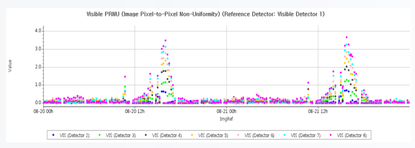


Figure 9. PRNU excess value distribution against the requirement around local midnight

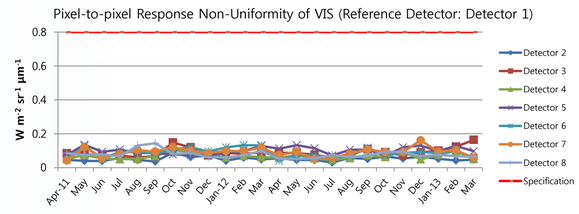
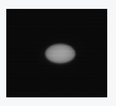


Figure 10. PRNU value trend of the COMS MI visible channel over two years

◎ Degradation
- Albedo Monitor is a measure of monitoring to check degradation of the visible channel.
- Using Sun observation from pinhole

☞ The mean degradation rate for 32 months is 0.05% and total degradation rate is about 4.26% up to Aug., 2013.



$$\Lambda = m_{ground} \times \left(\frac{1}{m_{AM}} - \frac{1}{m_{ground}}\right)$$

Figure 11. Albedo (Sun observation using pinhole) image and degradation rate equation (m is a slope)

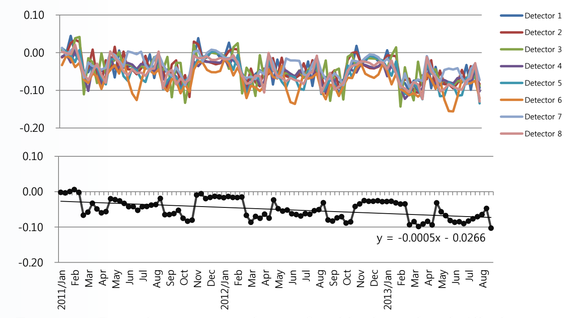


Figure 12. Degradation rate distribution of the MI visible detectors each (upper) and mean value (below)

Figure 13. Degradation rate tendency of visible channel with Albedo monitor

◈ **Infrared (IR) Channel**

◎ NEDR
- Digital count values from the Blackbody and the space look observation are processed to estimate the IR channels' radiometric performances at 300K and 220K.

☞ NEDR values of all the channels of IR are within the requirements.

Figure 14. NEDR value distribution of the COMS MI infrared channels (SWIR, WV, IR1, IR2 clockwise)

◎ PRNU
- It is to compute the difference between the detectors at 220K and 300K

☞ PRNU values for all IR channels are mostly within the specification.

Table 2. Specification for IR

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

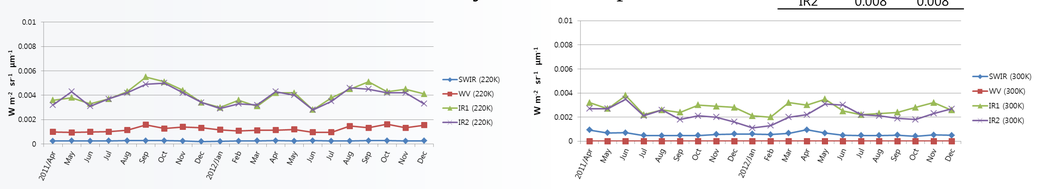


Figure 15. PRNU value distribution @220k (left) and @300K (right)

Ⅳ. Summary and Remarkable Conclusion

◈ **COMS MI data radiometric performances meet user requirement and have kept up high quality of products.**
- **All the radiometric indices are within the specification for visible and infrared channels.**
- **The visible channel detectors' degradation rate from Sun observation data (Albedo monitoring) is about 1.6% per year around 2~3 years after launch.**

◈ **Monitoring about radiometric performances and health of the sensor will be continued.**

REFERENCES

◇ COMS.TN.00116.DP.T.ASTR, 2011. *MI Radiometric Model*, EADS Astrium Report, pp.1-127.

◇ Kim et al., 2013. *Radiometric Performances of the COMS MI*, Proc. of 2013 CALCON Conference, Utah, USA, 19th -22nd, Aug..