Examining the Calibration Performance of Communication, Ocean and Meteorological Satellite (COMS) Visible Channel Using Cloud Targets

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ABSTRACT

Solar-channel calibration of Korean geostationary satellite, Communication, Ocean and Meteorological Satellite (COMS), is assessed from three vicarious methods using cloud targets. Firstly, a ray-matching technique is used for collocated targets having the same solar and viewing geometries, while Moderate Resolution Imaging Spectroradiometer (MODIS) 0.6-μm channel serves as a reference. Secondly, collocated MODIS cloud products are used as inputs to a radiative transfer model (RTM) to produce COMS visible channel reflectances for moderately thick cloud targets. Lastly, deep convective cloud (DCC) targets are chosen based on COMS infrared brightness temperatures, and representative optical properties are used as RTM inputs for the TOA reflectance simulation. All three methods suggest a similar degree of biases around 9–10% in COMS visible reflectances.

Characteristics of COMS Meteorological Imager (MI)

COMS Meteorological Imager (MI) observes the Earth with several types of observation mode, i.e. full disk (FD), extended northern hemisphere (ENH), limited southern hemisphere (LSH), Asia-Pacific northern hemisphere (APNH), and local area (LA) modes. Among these observation modes, images from FD, ENH, and LA modes are used for the solar-channel calibration. COMS MI has one solar channel and four emissive channels, as listed in Table 1. Spectral response functions (SRFs) of COMS VIS (0.68 μm) and WIN1 (11 μm) channels are given in Fig. 2.

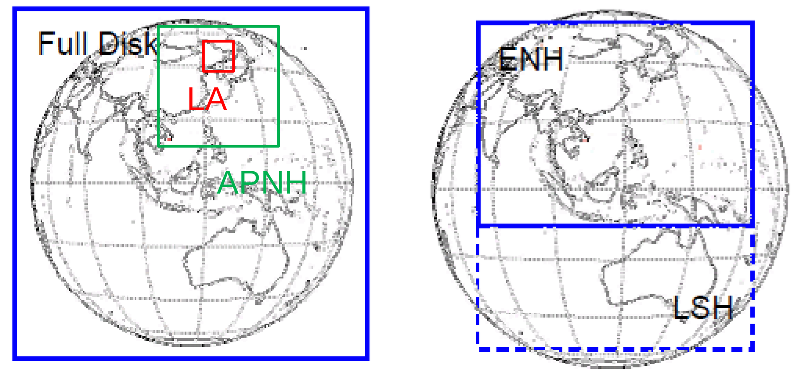

Fig. 1. COMS Observation Modes

Table 1. Spectral Characteristics of COMS MI

Channel	Center (μm)	Bandwidth (μm)	FOV (km)
VIS	0.68	0.205	1
SWIR	3.8	0.429	4
WV	6.7	0.443	4
WIN1	10.8	0.894	4
WIN2	12.0	0.845	4

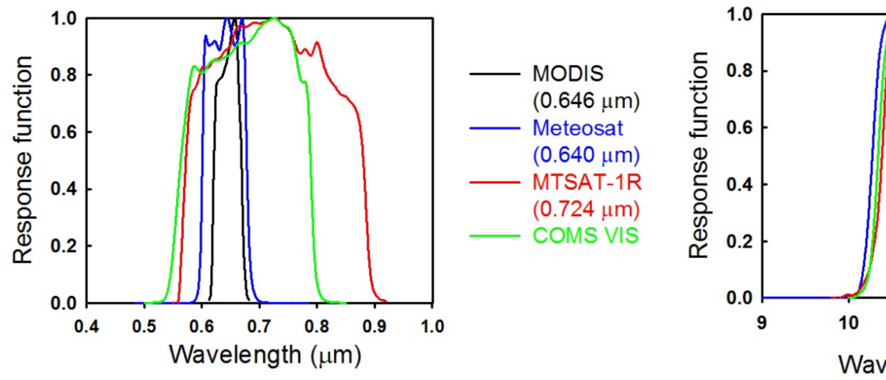

Fig. 2. SRFs of COMS VIS and WIN1 channels. Those are compared with similar channels of Meteosat-8/9 and MTSAT-1R.

Method 1: Ray-matching Method

Threshold conditions of coincident & collocated pixels between reference sensor and COMS

- ✓ MODIS 0.6 μm channel as a reference
- ✓ 0.5° grid format
- ✓ ΔViewing zenith angle (VZA) ≤ 5°
- ✓ ΔViewing azimuth angle (VAA) ≤ 15°
- ✓ ΔTime ≤ 5 min
- ✓ Over ocean

Spectral relations between two channels

Radiative simulation is performed to obtain relation between two channels, under various conditions of solar and viewing geometries and cloud properties.

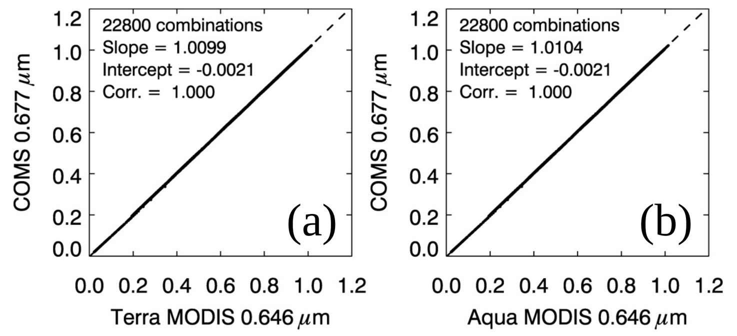

Fig. 3. Spectral relations between (a) MODIS Terra 0.646-μm and COMS 0.677-μm, and (b) MODIS Aqua 0.646-μm and COMS 0.677-μm channels.

Prediction of COMS VIS reflectances from MODIS observation

Reference values of COMS VIS reflectance are produced using theoretical relations obtained in Fig. 3. Finally, COMS Level 1B reflectances are compared with the predicted reflectances.

Calibration results from Method 1

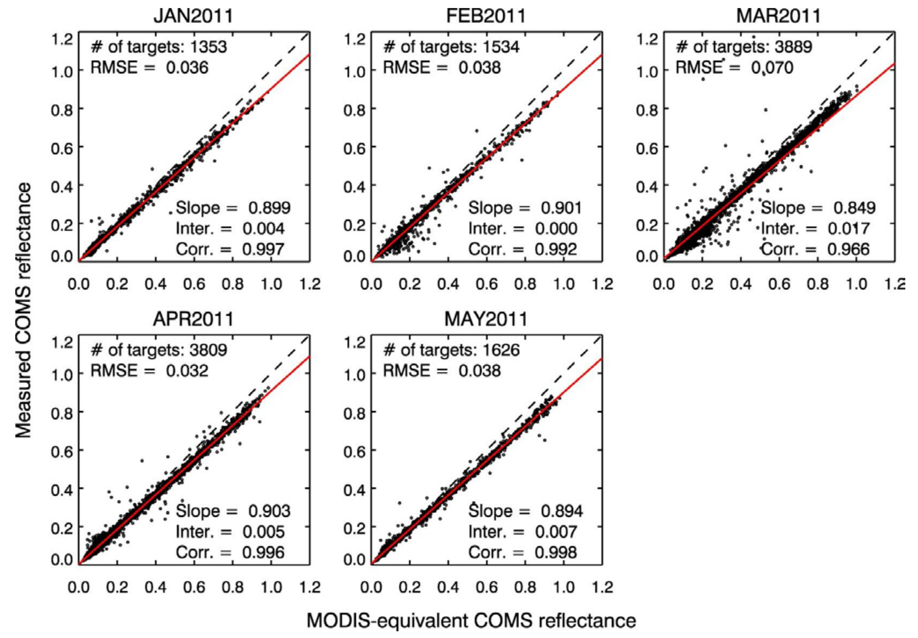

Fig. 4. Comparison between predicted COMS reflectances and observed COMS Level 1B reflectances.

Method 2: Cloud simulation using MODIS cloud products

Threshold conditions of cloud targets

- ✓ 0.5° grid format, ΔTime ≤ 5 min
- ✓ Overcast grid over ocean
- ✓ 5 ≤ Cloud optical thickness (COT) ≤ 99
- ✓ Cloud top temperature (CTT) ≤ 227 K or CTT ≥ 273 K

RTM inputs

Ocean BRDF, Tropical profiles, and MODIS cloud properties such as COT, cloud top pressure, and effective size.

Lognormal-independent column approximation (LN-ICA) (Oreopoulos and Davis, 1998)

To avoid one-dimensional simulation errors, LN-ICA is adopted to resolve subgrid variation of COT. This method finds the closest LN function to the actual distribution of COT, and then integration is performed to get grid-averaged reflectance (Ham and Sohn, 2010).

Calibration results from Method 2

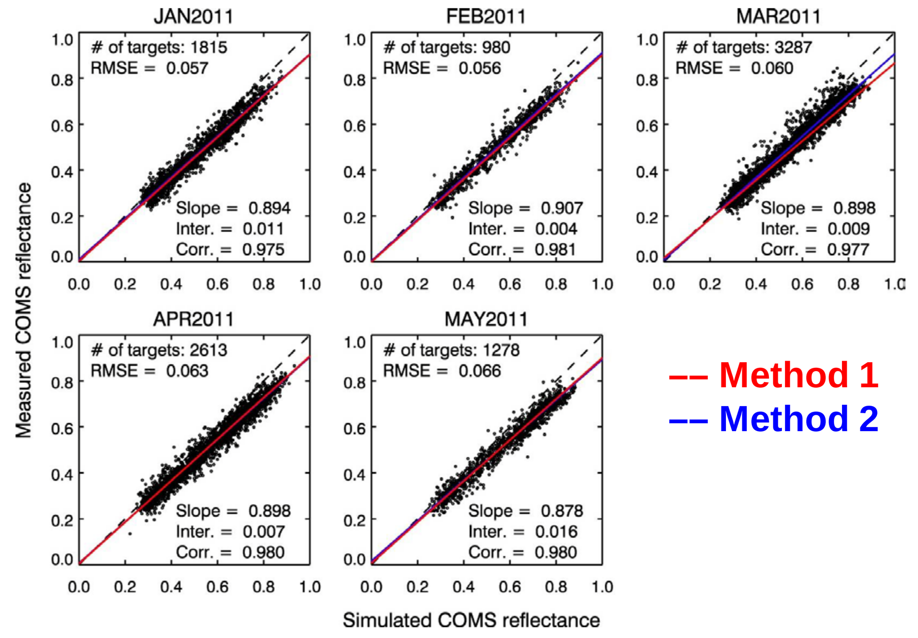

Fig. 5. Comparison between simulated COMS reflectances and observed COMS Level 1B reflectances. Regression lines from Methods 1 & 2 are given with red and blue lines, respectively.

Method3: DCC simulation method

Threshold conditions of DCC targets

- ✓ $TB_{11} \le 190$ K, TB_{11}: brightness temperature at 11-μm channel
- ✓ $STD(TB_{11}) \le 1$ K, $STD(TB_{11})$: standard deviation (STD) of TB_{11} over surrounding 10 km x10 km area
- ✓ $STD(R_{0.6})/E(R_{0.6}) \le 0.03$, $STD(R_{0.6})$ and $E(R_{0.6})$: STD and mean of visible reflectance ($R_{0.6}$) over surrounding 10 km x10 km area

DCC properties obtained from MODIS cloud products

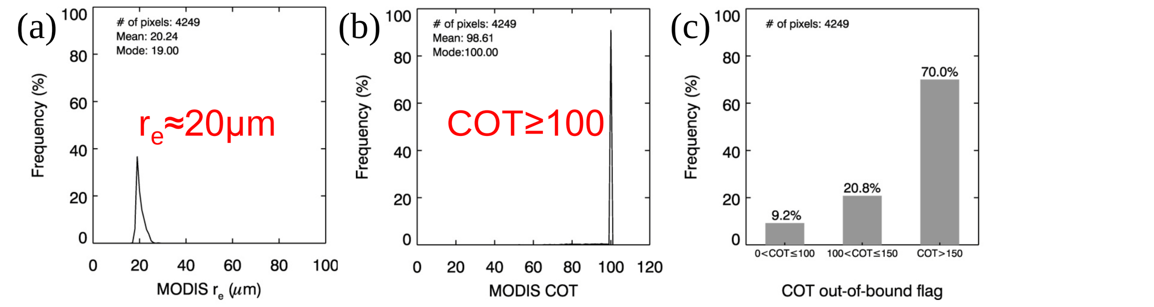

Fig. 6. Frequency distribution of (a) effective radius, (b) COT, and (c) three COT classes (COT <100, 100 ≤ COT <150, and COT ≥ 150) obtained from 1 month of Aqua MODIS data (January 2006).

DCC properties obtained from MODIS cloud products

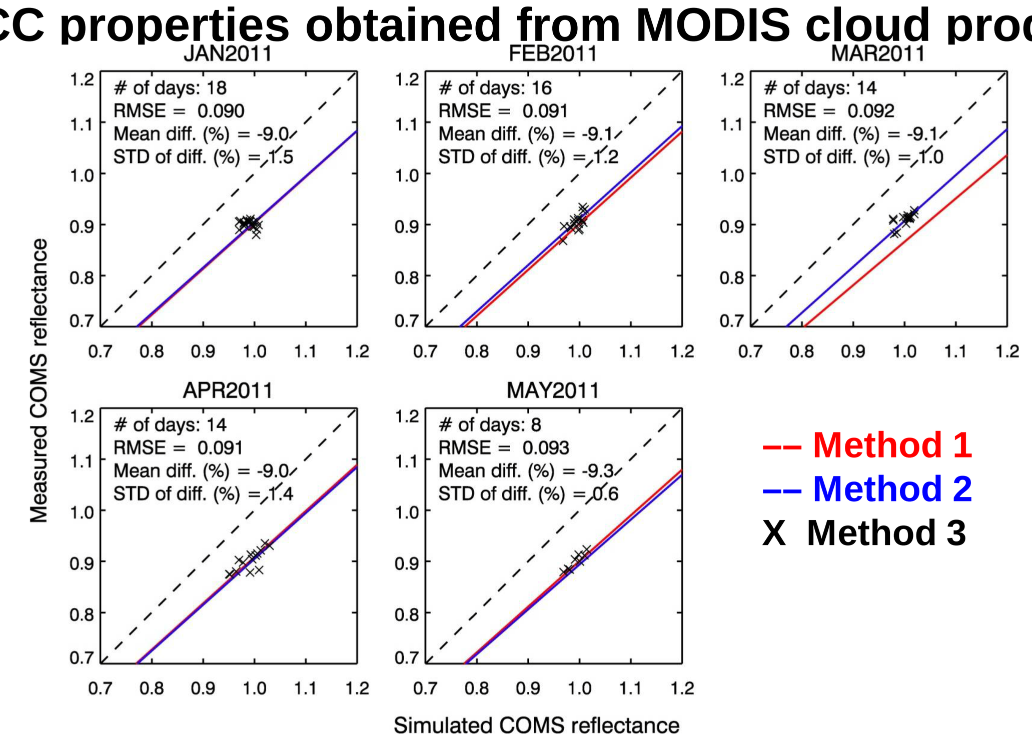

Fig. 7. Comparison of Method 3 (crosses) against Method 1 (red line) and Method 2 (blue line). For Method 3, the daily average is calculated when the number of selected DCC targets is greater than 10.

Summary

- Ray-matching method and two cloud modeling methods are developed and applied to COMS visible channel.
- In the results from three methods, it is shown that reference values of COMS reflectances are always higher than COMS Level 1B reflectances, suggesting low biases (9~10%) of COMS Level 1B visible reflectances.