Calibration for the solar channel of COMS/MI using MODIS-derived BRDF parameters over desert targets

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Abstract

Vicarious calibration method using MODIS-derived surface reflectivity data as inputs to a radiative transfer model have been developed for the planned COMS solar channel. Pilot test was conduced over the Simpson Desert targets in Australia. Results suggested that calibration can be achieved within 5% error range.

1. Introduction

Communication, Ocean, and Meteorological Satellite (COMS) planned to be launched in year 2008 will be the first Korean geostationary satellite. The Meteorological Imager (MI) aboard the COMS will measure the reflected solar radiation within a spectral band (550 ~ 800 nm) as well as emitted infrared radiation at 4 spectral bands. As no in-flight calibration device will be available for solar channel, a development of vicarious calibration is required for producing level 1.5 data.

Vicarious absolute calibration methods rely on an independent estimation of the radiances observed by the radiometer. Three different techniques have essentially been used for the estimation of the incoming radiance in the visible spectral region: (i) instrument cross-calibration, (ii) airborne calibration campaign, and (iii) radiative transfer modeling (Govaerts, 2001). We consider first and third methods for COMS calibration, because the second method is too expensive to be used on a regular basis for monitoring the sensor drift. The first method adapted for COMS calibration by using Terra/MODIS which has an accurate on-board calibration device. The third method relies on radiative transfer modeling over bright desert, sea, and optically thick cloud targets.

In this study, we show some pilot test results based on the third method using radiative transfer model and MODIS data over a bright desert target in Australia.

2. RTM input data

Spectral radiances are calculated using a radiative transfer model (RTM) 6S (Vermote et al. 1997) for all successfully identified targets accounting for geometry, atmosphere, target, and sensor properties. Table 1 shows necessary input data to the RTM/

Table 1: Inputs to 6S radiative transfer model

Group	Properties
Geometry	Solar/Sensor geometry angles
	Date
Atmosphere	Vertical profile of (T, p, q)
	Total precipitable water
	Total ozone
	Aerosol characteristics
Target	Surface reflectance
	Height
Sensor	Spectral band width
	Response function

It is difficult to obtain accurate aerosol properties and surface reflectance over the desert land. From various sensitivity tests, it is noted that even the same aerosol optical thickness (AOT) would result in different TOA radiance because of different aerosol types. However, in the case of AOT less than 0.2, these variances appear small enough to simulate radiances less than 1% error over the bright desert target because of the dominance of larger surface contribution. Therefore we select only very clear sky target to minimize the aerosol influences. In contrast because of the high reflectivity of desert surface the major source of error arises from the parameterization of surface reflectance.

3. Bidirectional Reflectance Distribution Function

The earth's surface scatters radiation anisotropically with respect to different wavelength spectrum. The Bidirectional Reflectance Distribution Function (BRDF) specifies the behavior of surface scattering as a function of illumination and view angles at a particular wavelength. In this study, we used MODIS-derived BRDF model (called Ross_Li Model), which is an empirical kernel-drivel model with simple trigonometric expressions as kernels. This model consists of a weighted linear sum of an isotropic term (f_{iso}), a volume-scattering term (f_{vol}), and a geometric-optical term (f_{geo}) (Strahler et al. 1999).

$$BRDF = f_{iso} + f_{vol}K_{vol} + f_{geo}K_{geo} \qquad (1)$$

The volume-scattering term expresses effects caused by the small (interleaf) gaps in a canopy whereas the geometric-optical term expresses effects caused by the larger (intercrown) gaps (Roujean et al. 1992, Wanner W. et al. 1995). In eq. (1), K terms are simple trigonometric kernels dependent on angles and wavelength, f terms are empirically calculated parameters depending on wavelength. These parameters are provided by MODIS (MOD43C2) in seven spectral bands at a 0.05 degree spatial resolution on a 16-day cycle. The retrieved parameters will then be spectrally and linearly interpolated to the COMS/MI bands, because the reflectance of dry sand tends to have a linear relationship with wavelength (Staetter, 1978)

4. Target selection

We selected bright desert targets over the Simpson Desert of Austalia that are assumed to be less influenced by atmospheric conditions because of larger surface reflection. Spatial and temporal variations of MODIS-derived BRDF were examined and then targets showing smallest variations were selected as test targets. The test targets are located in the region of -20.05 S ~ -20.00 S and 137.00 E ~ 137.05 E.

5. Satellite-level radiance simulation

The radiances at the satellite level are computed with the 6S code accounting for surface and atmospheric properties as in Table 1. The 6S RTM has been adapted to represent surface directional effects as a function of wavelength within the spectral interval of interest.

6. Cloud and sand storm detection

Since only clear sky cases are simulated, scenes contaminated by the presence of sand storms, clouds and cloud shadows need to be carefully removed from the selected target data, to avoid a calibration bias (Govaerts et al., 1998). A filtering mechanism has been used.

7. Results

Simulated radiances using MODIS-derived BRDF parameters as inputs to 6S RTM are compared with MODIS radiances in order to examine feasibility of this method as a vicarious calibration for the COMS satellite. Fig.1 shows the annual variation of calculated radiances (red) and measured radiances (blue). It indicates that MODIS measurements are contaminated by likely clouds. Nonetheless major data points are in good agreement.

Figure 2 shows the comparison results after removing the cloud-contaminated scenes from MODIS measurements for year 2004. It is noted that variances appear larger during the southern hemisphere summer and smaller during the southern hemisphere winter. Results strongly implies that calibration can be performed within 5 % error margin as shown in Fig. 3.

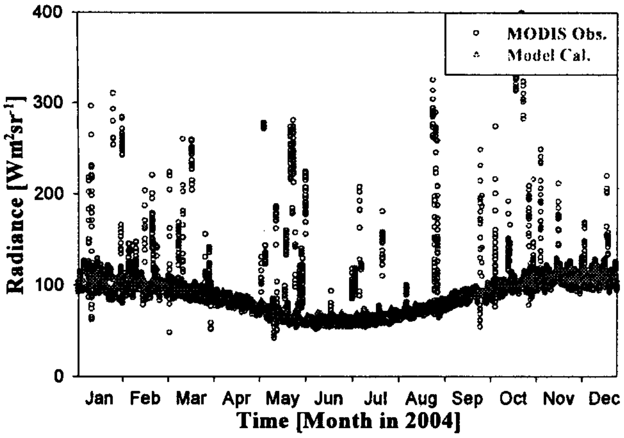

Fig. 1: MODIS band 1 (620~670nm) observation in radiance for each pixel over Australian Simpson desert (20S, 137E) in 2004 (blue circle). Red triangle represents simulated model calculation.

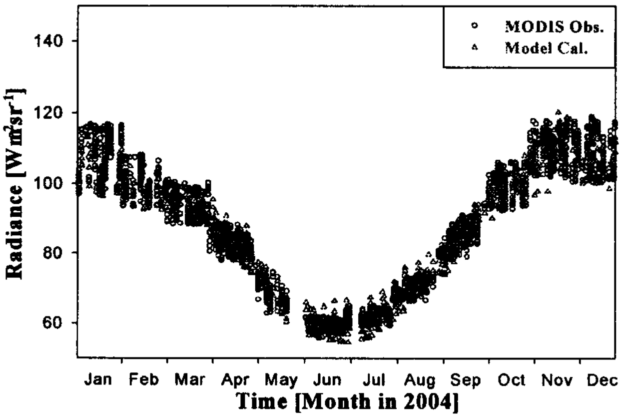

Fig. 2: The same as Fig.1 except for clear sky condition

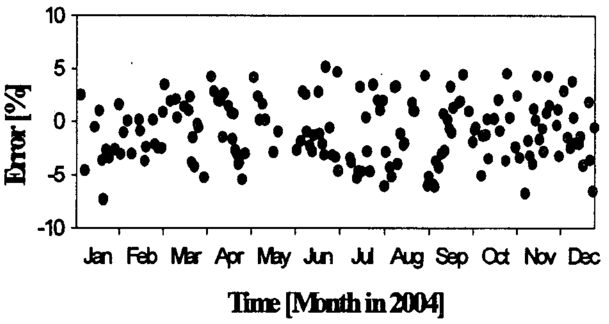

Fig. 3: The same as Fig.1 except for spatially averaged retrieval error.

8. Discussion

The results showing in this paper are promising because of errors equivalent to 5%. However, cares must be taken because comparison is circular. Simulation results are based on BRDF information from MODIS and results are compared with MODIS. We plan to compare with different data sources such as MISR.

9. Acknowledgement

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