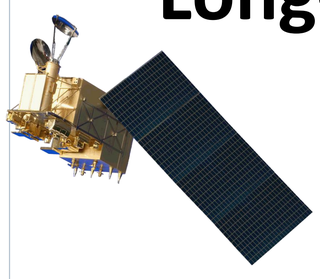
Long-term assessment and recalibration of FY-1/3 VIRR and MERSI reflective solar bands



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INTRODUCTION

The Medium Resolution Spectral Imager (MERSI) and Visible Infrared Radiometer (VIRR) are two major multi-spectral imaging instruments onboard the second generation polar orbiting meteorological satellite Fengyun-3 (FY-3) in China. The VIRR is inherited from Multispectral Visible Infrared Scanning Radiometer (MVISR) of the first generation polar orbiting meteorological satellite (FY-1). The Fengyun satellite historical dataset reprocessing project carried out the task of FY-1/3 VIRR and MERSI reprocessing to generate the long time series data record. The on-orbit radiometric response changes of FY-1C/D VIRR, FY-3A/B/C VIRR and FY-3A/B MERSI reflective solar bands are derived using stable target tracking such as desert, ocean and cloud. The long-term radiometric quality is evaluated using multisite calibration tracking (MST), deep convective cloud (DCC) and simultaneous nadir overpass (SNO) methods. The dataset is re-calibrated mainly using the daily coefficients derived by MST. It shows that the long-term varying of sensor radiometric response is corrected and the radiometric stability is improved.

METHOD

- ***Evaluation:***

1. Comparison with radiometric references: radiometric references : PICs (desert/ocean/DCC), reference instrument(SNO).

$$PDif = R^{Mea} / R^{Ref} - 1$$

2. Find instrumental characteristics.

- ***Re-calibration:***

1. Correction for the response time variation: MST trending model.
2. Correction for other potential issues: stray light, nonlinearity, temperature dependence.
3. Correction for the radiometric bias : MODIS→FY-3→FY-1.

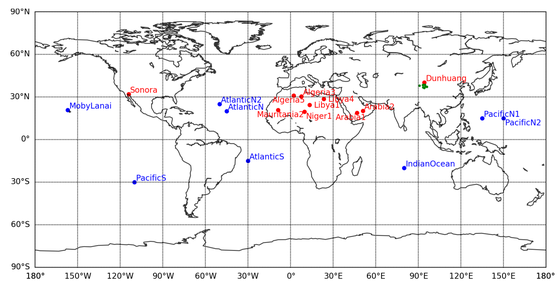

Figure 1 Fixed site positions of PICs.

DATA

VIRR and MERSI are both cross-track scanning radiometer. FY-1A/B/C/D were launched on Sept. 7, 1988, Sept. 3, 1990, May 10, 1999, and May 15, 2002, respectively. FY-3A/B/C were launched on May 27, 2008, Nov. 5, 2010, and Sept. 23, 2013,respectively.

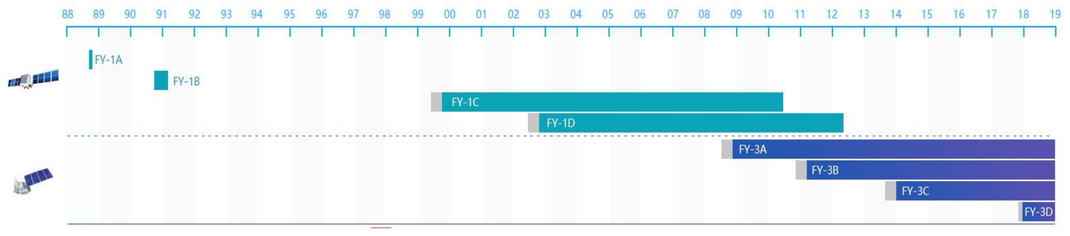

Figure 2 Time range of FY-1/3 dataset.

Table 1 FY-1/3 VIRR spectral specification.

Band.	FY-1A/B VIRR-1	FY-1C/D VIRR-2	Dynamic	FY-3A/B/C VIRR-3	Dynamic
1	0.58-0.68	0.58-0.68	90%	0.58-0.68	100%
2	0.725-1.10	0.84-0.89	90%	0.84-0.89	100%
3	0.43-0.53	3.55-3.95		3.55-3.95	
4	0.53-0.58	10.3-11.3		10.3-11.3	
5	10.5-12.5	11.5-12.5		11.5-12.5	
6		1.56-1.64	80%	1.56-1.64	90%
7		0.43-0.48	50%	0.43-0.48	50%
8		0.48-0.53	50%	0.48-0.53	50%
9		0.53-0.58	50%	0.53-0.58	50%
10		0.900-0.960	90%	1.325-1.395	90%

Table 2 FY-3A/B/C MERSI spectral specification.

Band	CW (μm)	BW (μm)	IFOV (m)	NEΔρor NEΔT	Dynamic Range (ρ or T)
1	0.470	0.05	250	0.3%	100%
2	0.550	0.05	250	0.3%	100%
3	0.650	0.05	250	0.3%	100%
4	0.865	0.05	250	0.3%	100%
5	11.25	2.5	250	0.54K	330K
6	1.640	0.05	1000	0.08%	90%
7	2.130	0.05	1000	0.07%	90%
8	0.412	0.02	1000	0.1%	80%
9	0.443	0.02	1000	0.1%	80%
10	0.490	0.02	1000	0.05%	80%
11	0.520	0.02	1000	0.05%	80%
12	0.565	0.02	1000	0.05%	80%
13	0.650	0.02	1000	0.05%	80%
14	0.685	0.02	1000	0.05%	80%
15	0.765	0.02	1000	0.05%	80%
16	0.865	0.02	1000	0.05%	80%
17	0.905	0.02	1000	0.10%	90%
18	0.940	0.02	1000	0.10%	90%
19	0.980	0.02	1000	0.10%	90%
20	1.030	0.02	1000	0.10%	90%

CW: Central wavelengths;
BW: Bandwidths;
IFOV: Instantaneous field of view (nadir).

RESULTS

- ***Sensor Normalized Response***

Sensor response was derived using MST and DCC methods. For VIRR, it showed faster attenuation at smaller wavelength and obvious seasonal variation at 865nm. For MERSI, it showed large degradation at short wavelength and 1030nm. For both VIRR and MERSI, there was larger seasonal change for FY-3B.

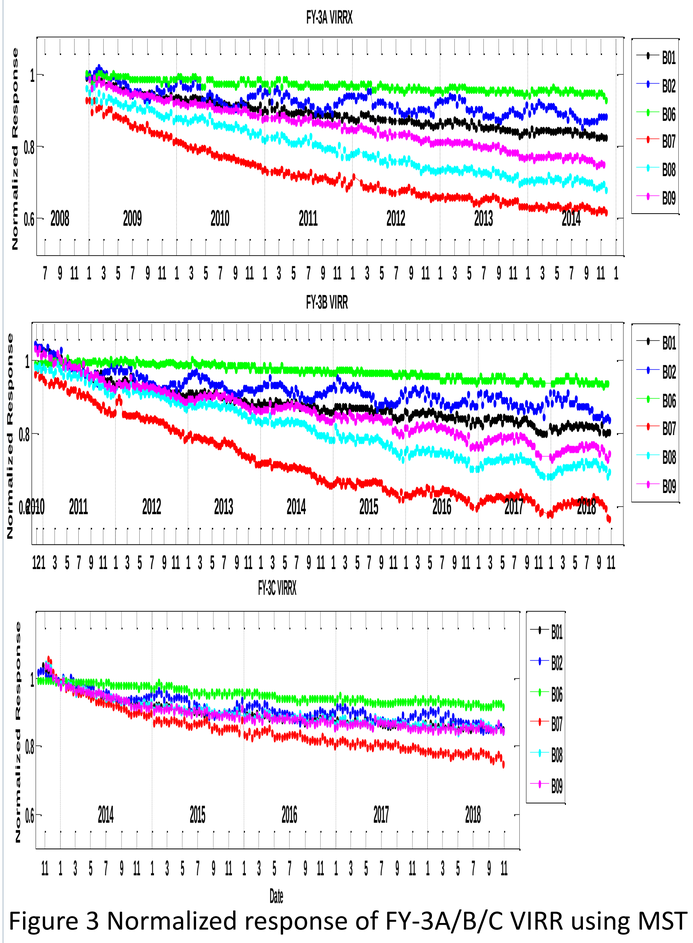

Figure 3 Normalized response of FY-3A/B/C VIRR using MST method

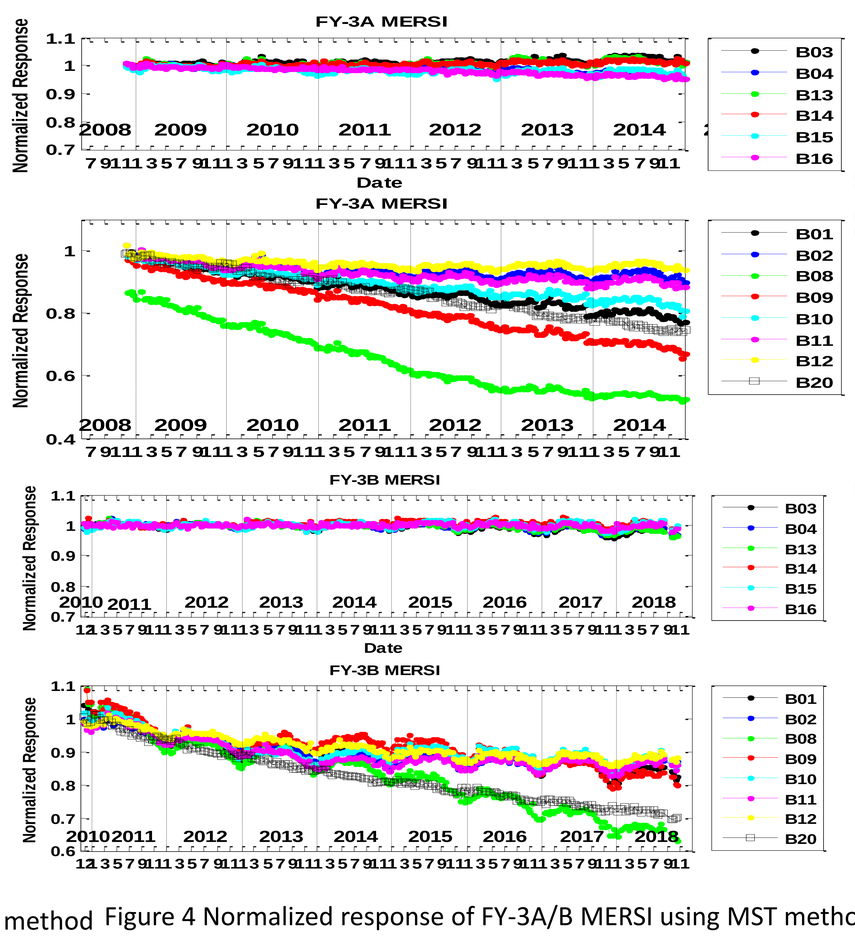

Figure 4 Normalized response of FY-3A/B MERSI using MST method

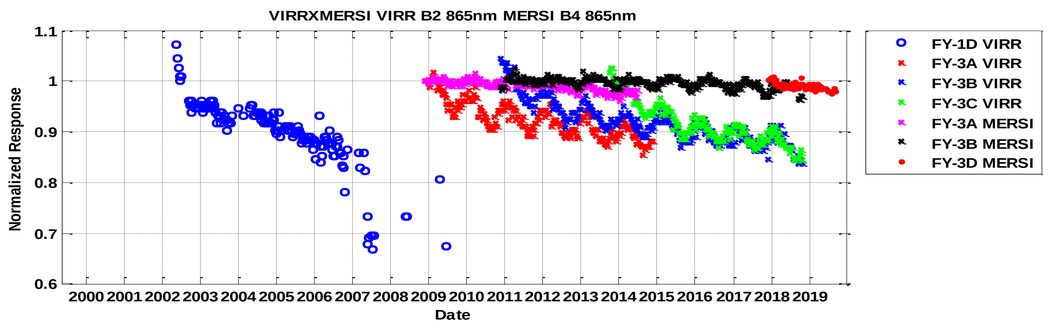

Figure 5 Normalized response of FY-1D VIRR, FY-3 VIRR & MERSI using MST method

- ***Calibration Performance***

The dataset is re-calibrated using the daily coefficients derived by MST. The re-calibrated TOA reflectance was evaluated using SNO and stable targets. The lifetime stability and inter-platform consistency were improved.

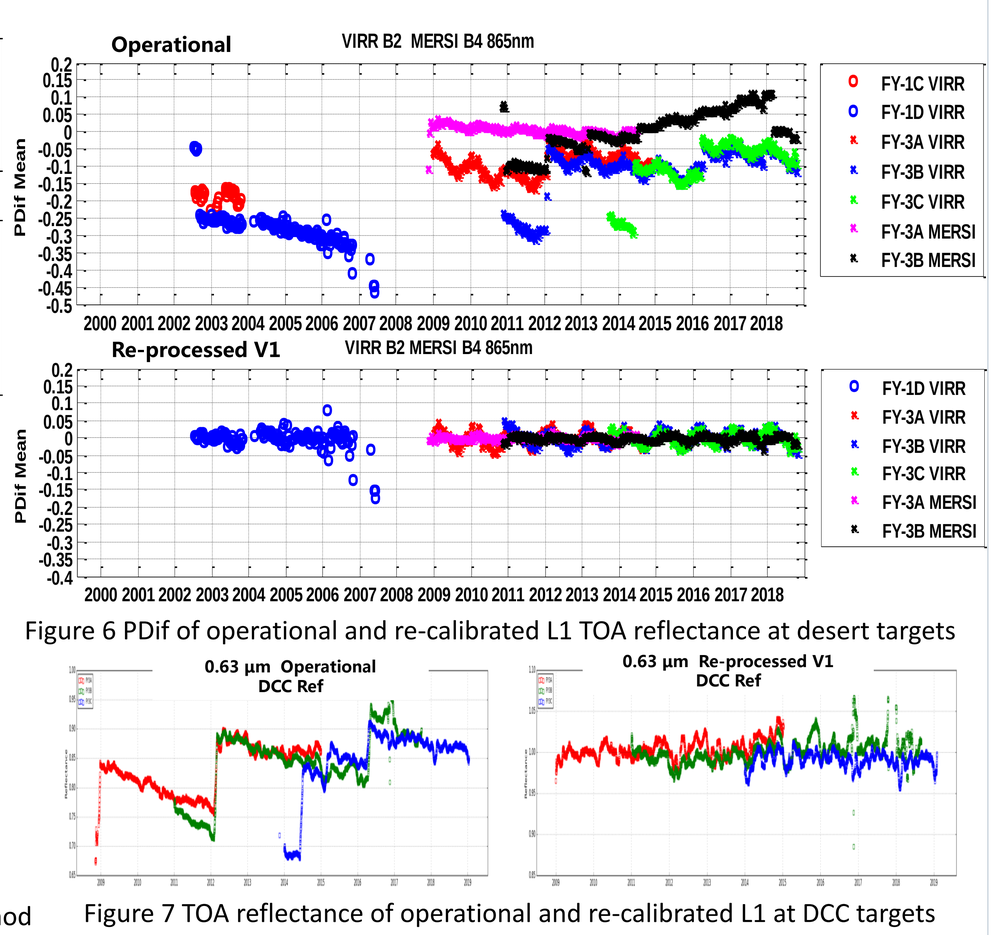

Figure 6 PDif of operational and re-calibrated L1 TOA reflectance at desert targets

Figure 7 TOA reflectance of operational and re-calibrated L1 at DCC targets

Figure 8 Lifetime TOA reflectance histogram, reflectance and PDif time series of re-calibrated L1 at SNO targets against Aqua/MODIS

SUMMARY

Vicarious methods are used to evaluate the FY-1/3 VIRR &MERSI RSB data performance and correct the time variation of instrument response.
The data performance could be improved after re-calibration simply using the MST trending result, while the absolute accuracy may be improved.
The time factor in re-calibration model needs to be adjusted , especially for the early phase in orbit and blue bands.
The seasonal features in normalized response and PDif time series reveal unresolved issues related to instrumental characteristics, such as stray light, nonlinearity, temperature dependence, etc.
Result differences between MST, DCC , SNO need be investigated to obtain consistency.

Acknowledgement: The research is supported by National Key R&D Program of China (No. 2018YFB0504900, 2018YFB0504905).