CGMS-39, CMA-WP-10
Prepared by CMA
Agenda Item: II/3
Discussed in WG II

CMA UPDATE ON GSICS ACTIVITIES

Summary of the Working Paper:

This working paper describes the actions taken by the GPRC in CMA recently. The progress of CMA GPRC includes the geostationary imager calibration monitoring based on the operational GEO-LEO IR inter-calibration for FY-2D/2E satellites, LEO-LEO inter-calibration experiment for FY-3A/3B using AIRS, IASI and MODIS. GSICS GEO-LEO IR inter-calibration for FY-2 has been running operationally at CMA since the end of 2009. FY-2C GSICS recalibration processing has already finished in whole life time since 2005. The inter-calibration results for FY-2D/2E show that the FY-2E has significant improvement in stray light elimination. Therefore, the more stable calibration results have been achieved than its predecessors FY-2C/2D. Effort is spent on real-time monitoring of the performance of FY satellites sensors, and operational development for LEO-LEO inter-calibration for FY-3A optical sensors such as MERSI, VIRR, and IRAS based on AIRS, IASI, MODIS and GOME-2.

CMA Update on GISCS Activities

1 Introduction

The CMA GSICS Processing and Research Center (GPRC) in NSMC is constructed since June, 2008. Actions have been taken in response to some recommendations of CGMS such as establishing the near real-time monitoring of instrument performance, providing explain significant discrepancies in satellite inter-calibration and encouraging continuation of the generation of long term satellite-based climatology.

Several progresses have been obtained relevant to the calibration of Fengyun satellite sensors and implementation of GSICS actions. The geostationary imager calibration monitoring based on the operational GEO-LEO IR inter-calibration for FY-2D/2E satellites give us valuable finding which the FY-2E has significant improvement in stray light elimination and more stable calibration results have been achieved than its predecessors FY-2C/2D. In addition, LEO-LEO intercalibration experiment for FY-3A/3B using AIRS, IASI , MODIS and GOME-2 has some primary results.

2 CMA Progress on GSICS

2.1 CMA GSICS GPRC

In the past two years, NSMC sped up improvement the CMA GPRC operational system in several aspects, including:

- Establishment of GSICS processing computer system
- Operational GEO-LEO inter-calibration for FY-2C/2D/2E
- Establishing the GSICS CMA website (the English version)
- LEO-LEO IR inter-calibration for FY-3 instruments based on AIRS/IASI
- LEO-LEO visible inter-calibration for FY-3 instruments based on MODIS and GOME-2
- Recalibration for the FY-1C/1D retrospectively

The computer hardware system was established for GSICS Processing at the end of 2009. GEO-LEO inter-calibration for FY-2X has operationally run since Oct., 2009. Developing the English version of CMA GPRC website started in April, 2009 and finished. It was opened at the beginning of 2010..

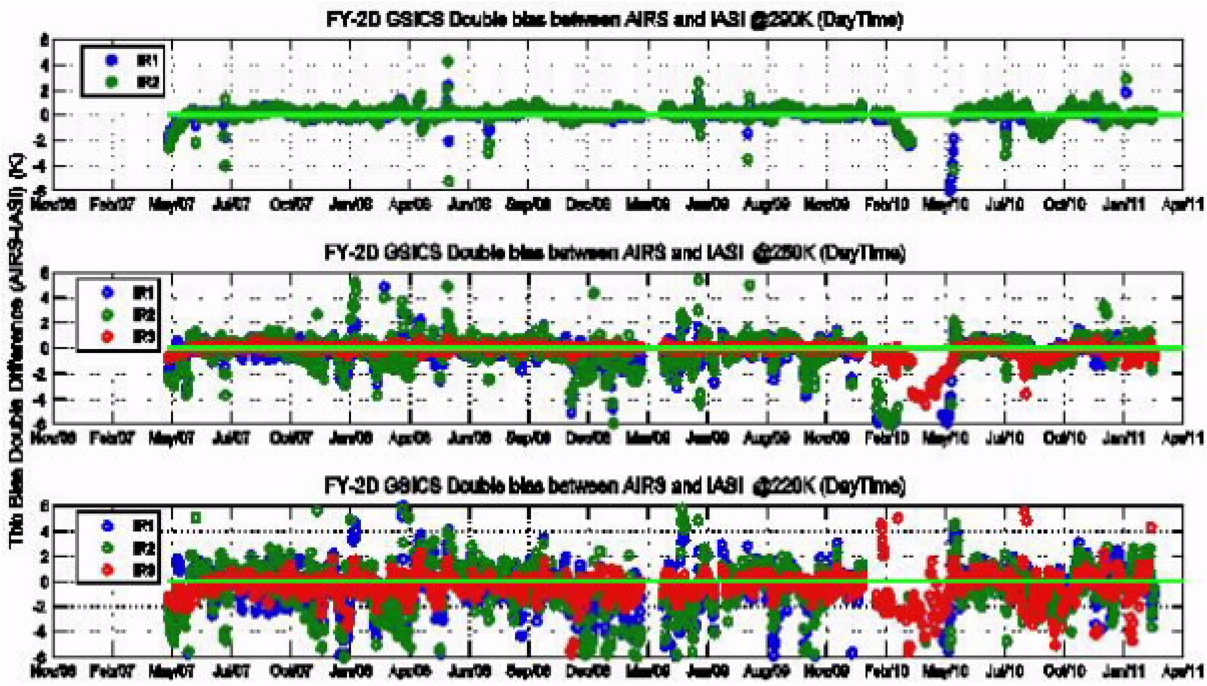
2.2 FY-2 GSICS Calibration

FY-2C/2D/2E are the operational satellites of Chinese first generation geostationary satellite. The main sensor VISSR on them has five bands including two split windows IRs, water vapor, Mid-IR and visible channels. FY-2C was launched on Oct. 19, 2004 and located at 105E. FY-2D was launched on Dec 8, 2006, located at 86.5E and is still operating on orbit by now. FY-2E was launched on Dec 23, 2008, located at same location as FY-2C. FY-2C finished its operational mission on Nov. 25, 2009, replaced by FY-2E immediately.

CMA GSICS Processing and Research Center (GPRC) established GSICS GEO-LEO IR operational routine which adjusted JMA GSICS codes to the interface of the normal FY-2C/2D L1 data and their spectral response function (SRF) files. This operational processing begun in September, 2009 and provides the real-time result on web(http://fengyunuds.cma.gov.cn/gsics). JMA spectral compensation method is also used for spectral gap filling of hyper sounders AIRS and IASI (Tahara, 2008; Tahara, 2009). The baseline collocation algorithms used in this inter-calibration are determined by the GSICS research working group (Wu, 2008).

All in-flight operational data of FY-2C/2D are collected for GSCIS calibration reprocessing. FY-2C GSICS recalibration processing in whole life time since 2005 has already finished. FY-2D/2E GSICS monitoring is ongoing. The following is the GSICS calibration latest result analysis of FY-2D/2E based on AIRS and IASI.

The bias results comparison for three satellites FY-2C/2D/2E show that the bias of FY-2E is more stable and smaller than FY-2C/D. Figure 2 shows that the double differences (Tbbairs- Tbbiasi) of Tbb bias of FY-2D/2E with AIRS and IASI. FY-2E has perfect consistence and stability of double difference between AIRS and IASI even if at colder reference target (220K). This kind of low double differences in cold reference target is a good signal for the calibration correction. But the bigger double differences still appear in eclipse phase. This give us important indication of significant improvement of stray light in FY-2E than in FY-2C and FY-2D.
We think the sensors are being improved step by step on the stray-light contamination decrease from FY-2C to FY-2E.



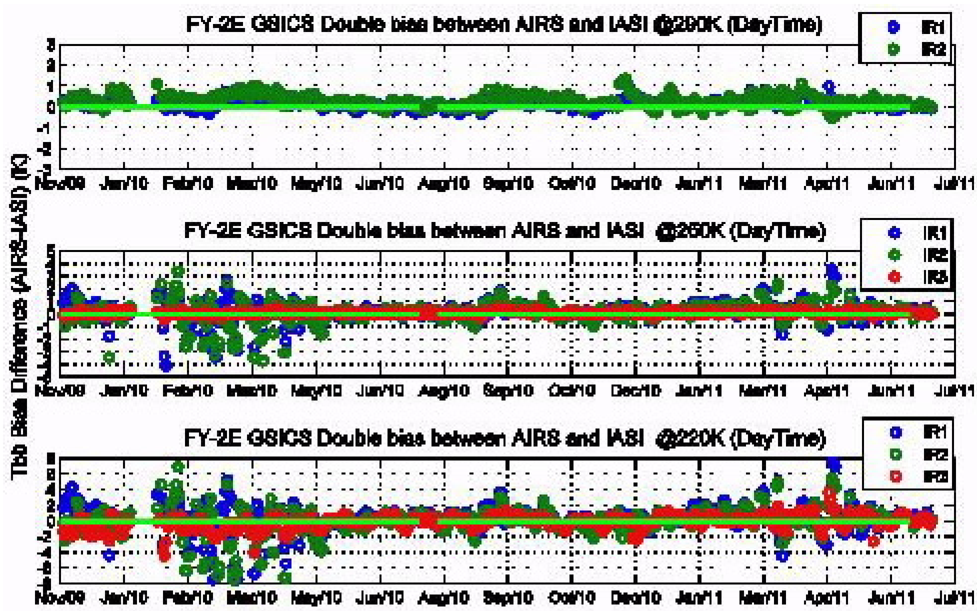


Figure 2 Double difference (Tbbairs- Tbbiasi) of Tbb bias of FY-2D and FY-2E with AIRS and IASI. The top is the double difference for IR1, IR2 and IR3 of FY-2D at three reference scenes 290k, 250K and 220K. The bottom is for FY-2E at the same situation.

Current operational calibration at NSMC for the FY-2 is based on weekly inter-calibration with AVHRR and HIRS. Plan is made to replace the current operational calibration with the inter-calibration based on IASI, and validation of it using the result from inter-calibration with AIRS.This is our GSICS correction policy and this policy is different from other members in GSICS community.

2.3 FY-3 instruments' Inter-calibration

Similar GEO-LEO IR algorithm is also tested for LEO-LEO infrared bands on FY-3A's MERSI, VIRR and IRAS with the AIRS and IASI based on simultaneous nadir observation (SNO). We collected some L1 data of AIRS, IASI, and the FY-3A MERSI and VIRR simultaneous nadir observation (see Figure 3).

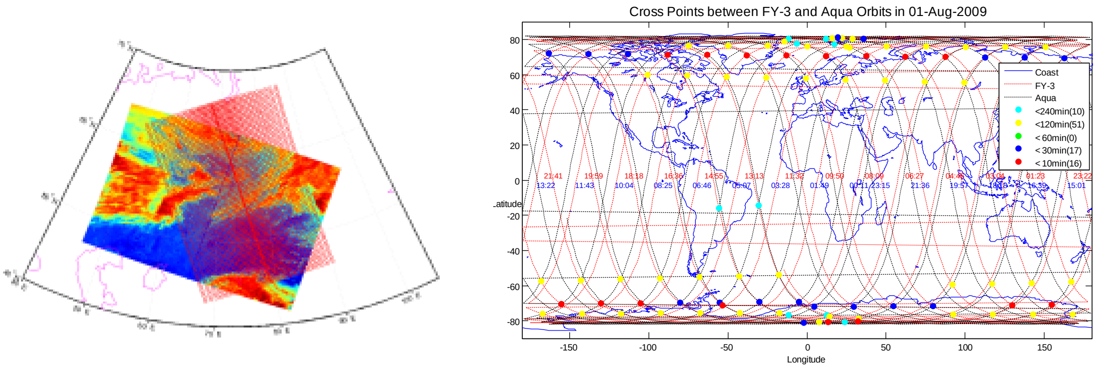


Figure 3 Collocation map of VIRR (bottom) and AIRS (overlay Grid) and SNO Cross Point between FY-3A and Aqua orbit in Aug. 01, 2009

The results from intercalibration show that the radiance of band 5 of MERSI is larger than collocated radiance of AIRS, and than IASI. The result of VIRR IR bands shown that band 4 was perfectly consistent with AIRS, and with IASI, but band 5 radiance was a little lower in comparison. This comparison will be done operationally after it is tested successfully.

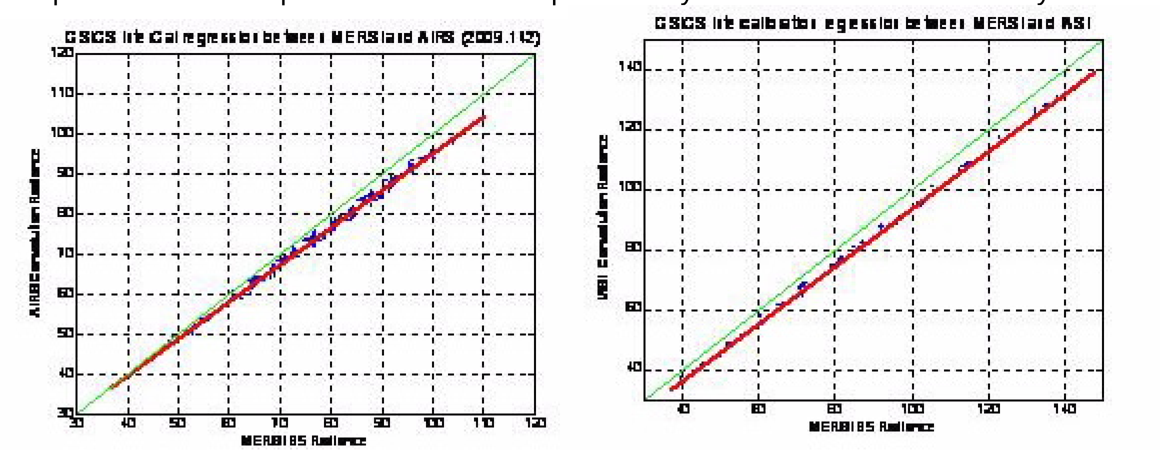


Figure 4 GSICS LEO-LEO inter-calibration for MERSI with AIRS and IASI

Except for inter-calibration for thermal emissive bands with AIRS and IASI, EOS/MODIS are used to inter-calibrate and assess the calibration of reflective solar bands of MERSI/VIRR based on the global SNO observation with them. To reach the goal, the orbit prediction of FY-3A and Terra/Aqua is the firstly job and the location and time of their SNO give the guide of data collection for SNO inter-calibration. There are 18 bands of MERSI similar to MODIS's bands(Table 1). SNO method is used to assess MERSI radiance accuracy. The spectral difference between MERSI and MODIS is a great challenge for the inter-calibration.

Table 1 Similar bands' specification between FY-3/MERSI and EOS/MODIS (nm)

FY3A/MERSI			EOS/MODIS			FY3A/MERSI			EOS/MODIS		
band	Midwl	Width	band	Midwl	Width	Band	Midwl	Width	Band	Midwl	Width
1	470	50	3	469	20	11	520	20	11	531	10
2	550	50	4	555	20	12	565	20	12	551	10
3	650	50	1	645	50	13	650	20	13	667	10
4	865	50	2	858	35	14	685	20	14	678	10
5	11250	2500	31	11030	500	15	765	20	15	748	10
6	1640	50	6	1640	24	16	865	20	16	869	15
7	2130	50	7	2130	50	17	905	20	17	905	30
8	412	20	8	412	15	18	940	20	18	936	10
9	443	20	9	443	10	19	980	20			
10	490	20	10	488	10	20	1030	20			

Recently the hyperspectral sensor Global Ozone Monitoring Experiment-2 (GOME-2) is also used to inter-calibrate the solar reflective bands of MERSI. The GOME-2 is one of the new-generation European instruments carried on MetOp-A (launched in October 2006). It continues the long-term monitoring of atmospheric trace gases started by GOME on ERS-2 and SCIAMACHY on Envisat. GOME-2 is a medium-resolution double UV-VIS spectrometer and comprises four main optical channels which focus the spectrum onto linear silicon photodiode detector arrays of 1024 pixels each, and two Polarisation Measurement Devices (PMDs) The four main channels provide continuous spectral coverage of the wavelengths between 240 and 790 nm with a spectral resolution (FWHM) between 0.25 nm and 0.5 nm. The MERSI inter-calibration based on GOME-2 has small error from spectral response adjustment. Figure 6 gives the SNO images from FY-3B/ MERSI and METOP-A/GOME-2 on Dec.15, 2010. Figure 7 gives one case of GOME-2 apparent spectral reflectance and SRF of FY-3B/MERSI. Table 2 lists the inter-calibration results (Slope) and uncertainty (%) estimation using MetopA/GOME-2. The greatest uncertainty of this method is the spatial collocation and the reference sensor 's calibration accuracy

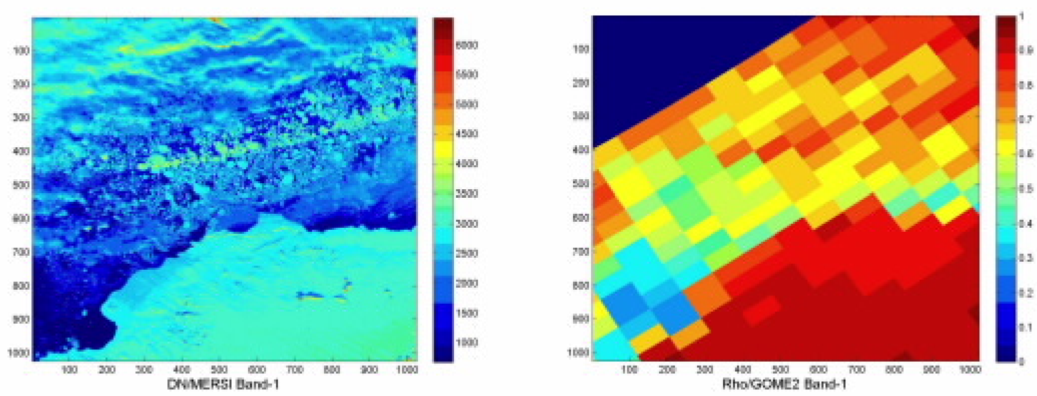


Figure 6 Simultaneous Nadir Observation image of FY-3B/MERSI and METOP-A/GOME-2 on Dec.15, 2010

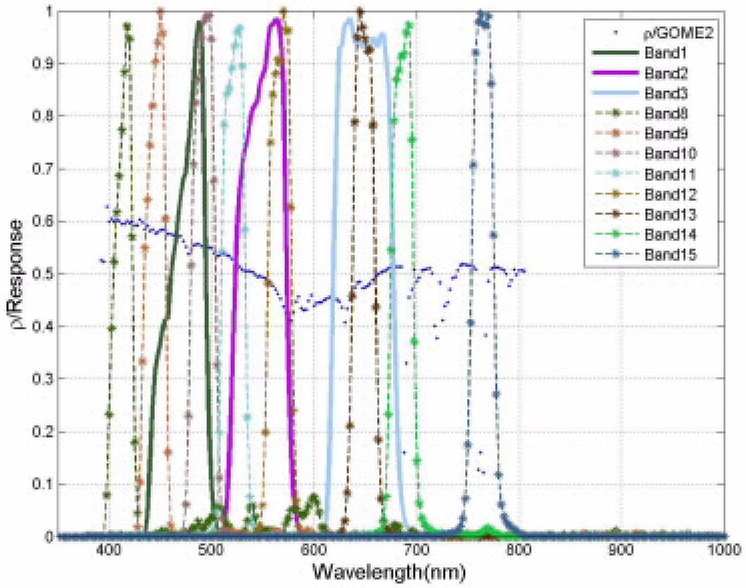


Figure 7 GOME-2 apparent spectral reflectance and SRF of FY-3B/MERSI

Table 2 FY-3B/MERSI inter-calibration results (Slope) and uncertainty (%) using MetopA/GOME-2

Band	Cal_Slope	Reflectance Uncertainty	Spatial Uncertainty	Total Uncertainty
1	0.0002669	0.16	0.72	0.74
2	0.0002677	0.15	0.89	0.91
3	0.0002508	0.14	0.98	0.99
8	0.0002384	0.18	0.68	0.70
9	0.0002232	0.23	0.69	0.73
10	0.0002065	0.21	0.78	0.81
11	0.0002102	0.21	0.86	0.88
12	0.0002016	0.21	0.91	0.93
13	0.0002063	0.21	1.03	1.05
14	0.0001806	0.21	1.06	1.09
15	0.0001871	0.21	1.14	1.16

2.5 FY-1C/1D historical Data Recalibration

To improve the data accuracy and predictive usefulness of historical satellite observations, NSMC is reprocessing the archive FY-1C/1D data. Several campaign field measurement data for the FY-1C/1D vicarious calibration (VC) in China radiometric calibration sites (CRCS) -Dunhuang were collected. These measurements are important to calibrate and validate the L1B radiance and L2 retrieval products of satellite data. Reflectance-based VC using CRCS Dunhuang site has been the baseline method of operational calibration since 1999 for the multi-spectral visible and infrared scanning radiometer (MVISR), which has no visible channel calibrator onboard the Chinese first generation polar-orbiting meteorological satellite FY-1C and FY-1D.

Our VC activity involves the measurements of ground-viewing radiometers/spectroradiometer ASD, sun-viewing photometer CE318, and portable meteorological instruments positioned in a ground target area, and radiosonde equipment at Dunhuang weather station. Surface reflectance measured by ASD was modified by BRDF model (Section 2.4) according to the satellite observation geometry. The measurement data are input into the radiative transfer model (RTM) 6S (Vermote, et al. ,1997)to estimate apparent radiances or apparent reflectance at the position of a satellite sensor. We compare the average of the digital numbers of the Dunhuang site observed by the sensor with these estimated radiances to give the radiometric calibration coefficients. The uncertainty estimation of VC using Dunhuang site is about 6% according to Zhang's (2004) paper. Table 3 shows the VC results of two sensors MVISR onboard FY-1C/1D.

Table 3 FY-1C/1D MVISR VC Results (slope)based on CRCS Dunhuang site during deferent date.

	B1	B2	B6	B7	B8	B9	B10*
FY-1C CRCS Calibration coefficient (Slope)							
Pre-flight Cal	0.0918	0.0923	0.0840	0.0526	0.0536	0.0537	0.0952
1999/07/07	0.0829	0.0892	0.0598	0.0483	0.0479	0.0777	0.0902
2000/09/22	0.1414	0.1072	0.0685	0.0703	0.0646	0.0913	0.1094
2002/07/10	0.0959	0.1142	0.0645	0.2199	0.2205	0.0758	0.1163
2002/07/18	0.0954	0.1129	0.0644	0.2338	0.2228	0.0757	0.1123
Total Degradation	***--***	***26.57%***	***7.69%***	***384.0%***	***365.1%***	***-2.57%***	***24.5%***
FY-1D CRCS Calibration coefficient (slope)							
Pre-flight Cal	0.0939	0.0941	0.0849	0.0524	0.0521	0.0523	0.0942
2002/07/07	0.0893	0.0998	0.0831	0.0423	0.0631	0.0817	0.0892
2005/07/13	0.1040	0.1245	0.0863	0.0621	0.0775	0.1010	0.1191
2006//08/23	0.1292	0.1568	0.0889	0.0926	0.1028	0.1220	0.1566
Total Degradation	***48.04%***	***57.11%***	***6.97%***	***118.9%***	***62.91%***	***49.32%***	***75.56%***

It can be found that there is significant difference of calibration coefficient in some bands between the preflight calibration and the first VC just after launch. The difference is more than 25% in band 6 and band 9 of FY-1C/MVISR and in band 9 of FY-1D/MVISR, more than 20% in band 1 and 2 of FY-3A/VIRR and more than 10% in some other bands. The reason for so large a difference may be the big error of preflight calibration or radiometric sensitivity effect from the launch vibration. VC also provided the calibration correction of FY-1C/MVISR in September, 2000 due to unexpected sensitivity degradation (more than 80% on August 21, 2000) at band 1 (Gu et al, 2002). On February 8, 2001 which led to switch to the backup instrument. From long term variation trend analysis of sensor's calibration coefficient, we often find appearance of great degradation of blue bands (7 and 8) of all the three sensors except for band 8 of FY-3A/VIRR. The degradation rate per year is more than 15% for the band 7 (455nm). Degradation comparison of these three sensors shows that the later one is better than the older one. Relatively, calibration coefficient of bands in longer wavelength keeps stable and has small degradation in orbit such as band 6 (1640nm). This kind of degradation characteristics is very useful for instrument calibration monitoring and machnism analysis of sensor sensitivity in space environment.

An inter-calibration method (Liu J. et al., 2004) is applied to calibrate all the historical data of FY-1C/1D MVISR. Figure 8 show the the apparent reflectance of Dunhuang site of band 1 of FY-1C/1D using the latest recalibration coefficient.

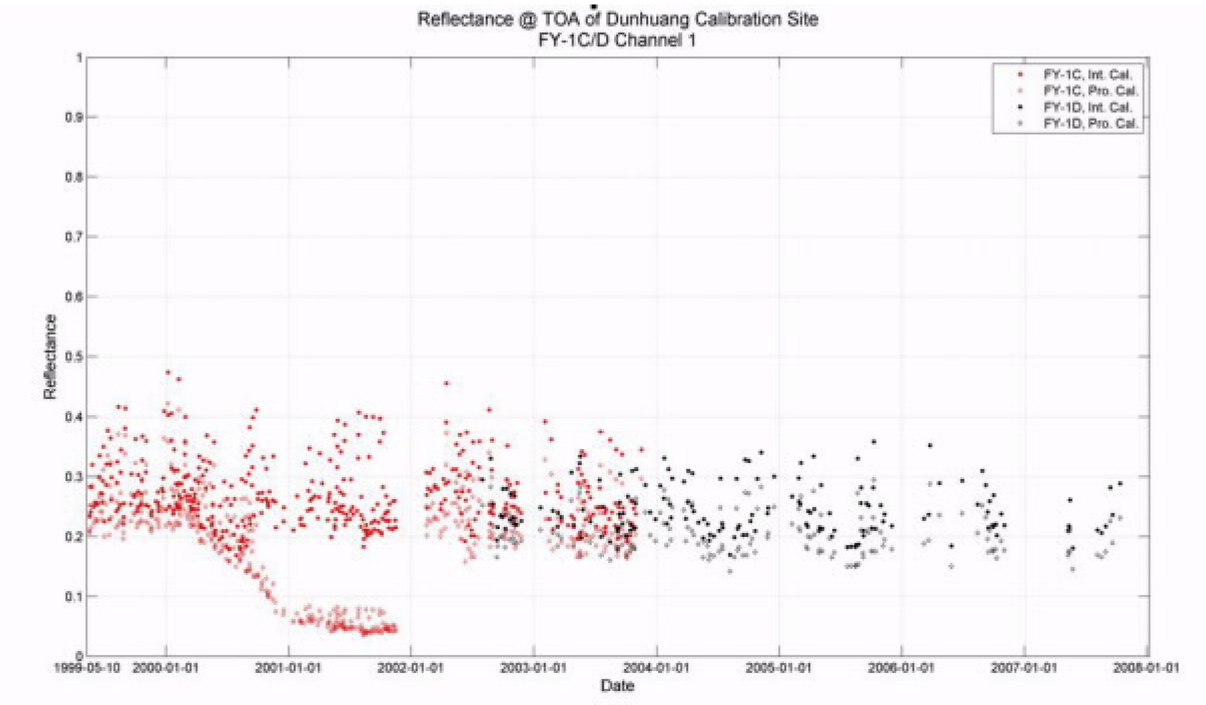


Figure 8 Apparent reflectance of Dunhuang site of band 1 of FY-1C/1D using intercalibration from 1999 to 2007 and comparison with the preflight calibration

3 Experiences from GSICS and future plan

Experiences from GSICS:

- ⇨ GSICS is monitoring the FY-2/3 instruments calirabtion trend on orbit and indicates the annual and season fluctuation of operation calibration bias.
- ⇨ GSICS gives FY-2/3 a good independent radiance reference standard and enhances Fengyun sensors' calibration tie to international SI.
- ⇨ GSICS results verify the improvement of instrument manufacture step by step and provide positive feedback to the vendor.
- ⇨ GSICS provides a tie bridge of consistent calibration between geostationary FY-2 and polar orbiting FY-3 similar bands using the same GSICS advised sensors.

Near Future plan:

- ⇨ We are moving to realize in the operational FY-3 optical instruments GSICS, and the realtime assessment of these instruments. NSMC GPRC will keep its GISICS website updating to provide more information about FY's sensors calibration.
- ⇨ A calibration data platform is planned to be established including the OBC engineering and telemetry data, reference sensors' SNO observation and global reference sites image of FY serial sensors.

Reference

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