Initial Radiometric Performance Assessment of FY-3H MERSI-III from In-Orbit Testing

NSMC: Wang Ling, Hu Xiuqing, Xu Hanlie, Zhang Bei

SITP: Niu Xinghua, Chen Shuaishuai, , Zhu Zengliang, Wang Yang

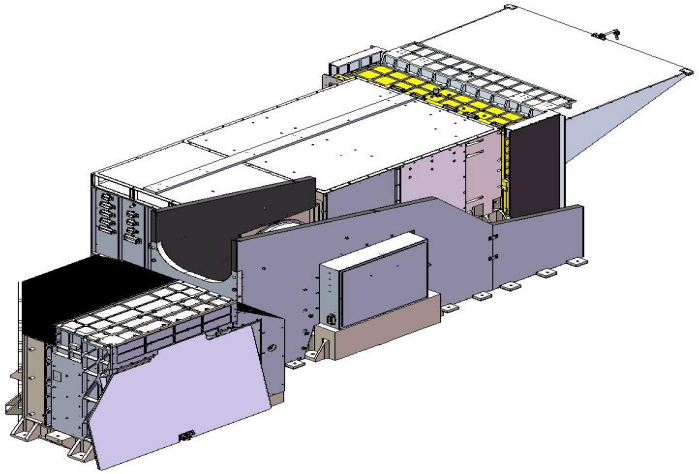
2026.03

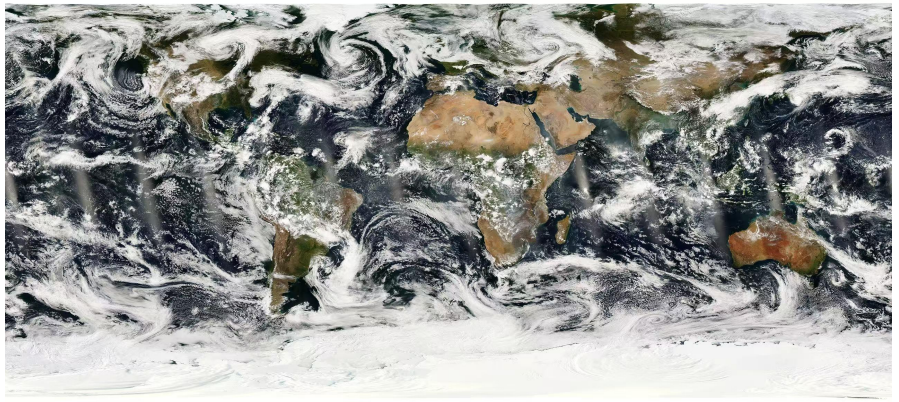
Outline

1. Overview of MERSI-III Instrument
2. Post-launch Activities
3. FY-3H MERSI-III Radiometric Performance
4. Summary

1. Overview of MERSI-III Instrument

- The **M**edium **R**esolution **S**pectral **I**mager (MERSI) is a key optical imager on China's Feng Yun 3 (FY-3) polar orbiting satellite series. MERSI-III represents the third generation of this instrument family.
- Flying on two platforms: FY-3F (EOS-AM) launched in August 2023; FY-3H (EOS-PM) launched in last September.
- MERSI-III features:
  - **25 spectral bands:** Bands 1-19 are RSBs (0.4 to 2.15 μm) and 8-15 for OC applications; Bands 20 -25 are TEBs (3.7 to 12.5 μm).
  - **2 nadir spatial resolution:** 250 m (1-4, 24-25); 1000 m (5-23)
  - **Swath Width**: 2900 km, enabling daily global coverage
  - **On-Board Calibrators**:
    - ✓ SD+SD degradation monitor for RSBs;
    - ✓ BB+SV for TEBs;
    - ✓ Lunar view through instrument maneuver





Global RGB Composite Image from FY-3H MERSI-III (2025.10.13)

1. Overview of MERSI-III Instrument

Technical Specifications of different MERSI Instruments

	MERSI	MERSI-II	MERSI-III
Platform	FY-3A/B/C	FY-3D	FY-3F/**H**
Orbit	M/A/M	Afternoon	M/A
Launch	2008/2010/ 2013	2017.11	2023.08/ **2026.10**
Channels	20 (1 TEB)	25 (6 TEBs)	25 (6 TEBs)
Wavelength	0.4-12.5 μm	0.4-12.5 μm	0.4-12.5 μm
Spatial Res.	250, 1000 m	250, 1000 m	250, 1000 m
Calibration Acurracy	RSB: 7% TEB: 1K	RSB: 5% TEB: 0.5K	**RSB: 5%/3% TEB: 0.4K/0.2K**
TEB NEdT	0.54K	0.25-0.4K	**0.25-0.3K**
RSB SNR①	0.07-0.45, 0.05-0.1 (Ocean Color)	100-200, 300-500 (Ocean Color)	**110-300, 450-600** (Ocean Color)
Mission Life	3/3/5 years	5 years	**8 years**

- Continuous Improvement include:
  - ✓ **Detection Capability and Performance**:
  - ① **Increased TEB channels**: the number of increased from 1 to 6.
  - ② **Improved detection sensitivity**: for the ocean color channels improved by 50%+, and the longwave IR: 0.54 K -> 0.4 K->0.3 K.
  - ✓ **Improved Radiometric accuracy and Stability**
  - ✓ **Longer Mission Lifetime**: from 3 to 8 years

① For MERSI, SNR is measured as NEdρ

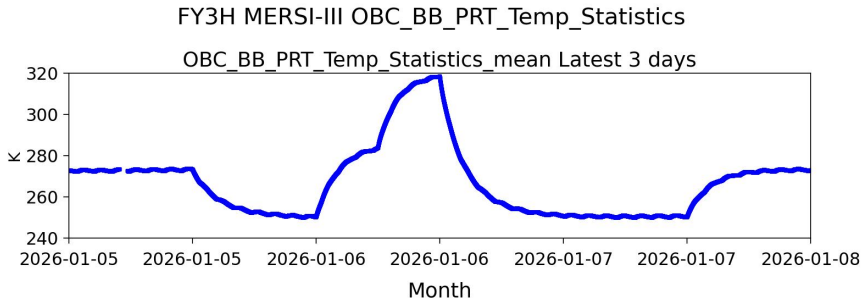
2. Post-launch Activities

key operation and calibration events

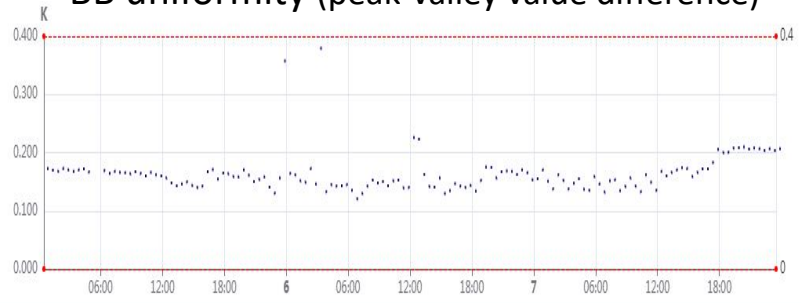
NO.	Date	Event
1	2025.09.27	FY-3H lanunched
2	2025.10.09	VNIR turned on
3	2025.10.11	Cryo-radiator Door Open
4	2025.10.12	1st SD calibration (Every two days)
5	2025.10.31	SD calibration frequency changes to 1 per week
6	2025.11.02	1st Lunar maneuver view
7	2025.12.04	Cryo-radiator heating turn off
8	2025.12.08	SWIR and TEB activated
9	2025.12.09	adjust BB temperature from the lowest to the working temperature of 274K
10	2025.12.22	the platform adjust temperature, dropped by ~3K
11	2025.12.24	control Cryo-radiator temperature to the working temperature of 90.8 K
12	2025.12.29	2nd Lunar maneuver view
13	2025.12.31	1st BB Warm-Up Cool-Down (Full: 250~320K)
14	26.01, 26.02	3rd and 4th Lunar maneuver view

On-orbit Calibration Events:

- SD calibration: 32 times
- Lunar manever view: 4 times
- BB Warm-Up Cool-Down: 1, last for 3 days

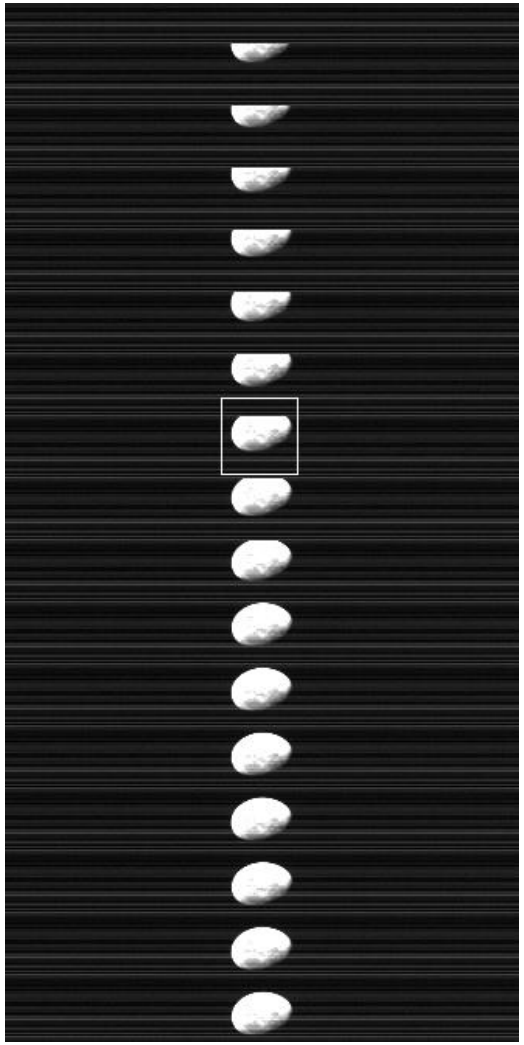


BB uniformity (peak-valley value difference)



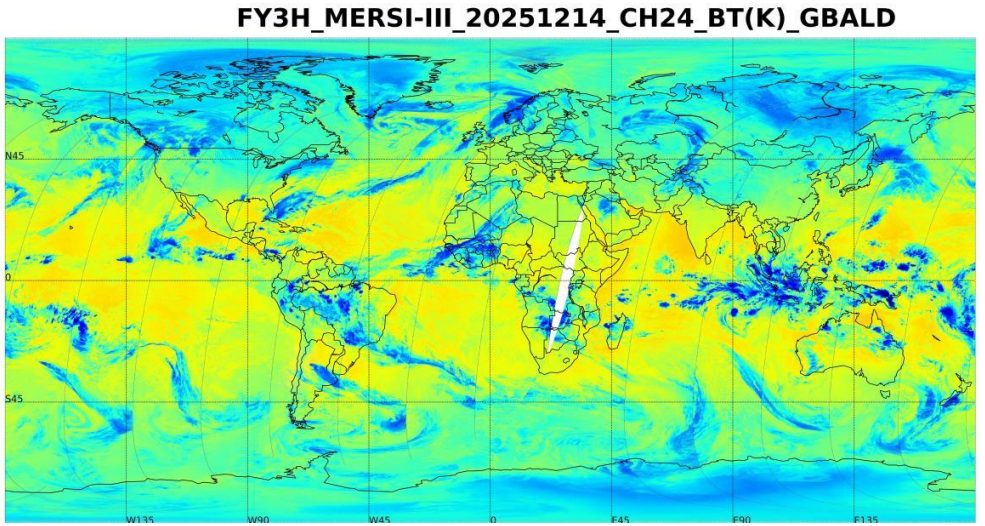
FY-3H MERSI-III Images

Lunar View (B1, 2025.11.2)



True-color image of the Bahamas (B3B2B1, 2025.10.19)

巴哈马海域MERISI真彩图（2025年10月19日）



波段24全球亮温图(2025年12月14日)

In-orbit Test (IOT) Tasks

- Last for 6 months after instrument truned on
- IOT Tasks
  - 6 categories, 23 items
  - 3 items from prelaunch test others from IOT
- Test Progress Status
  - 20 items completed
  - 3 items in progress

Category	NO.	Items	Stauts	Compliant ?
Functional performance and geometric evaluation	1	Inter-Band Registration	Complete	Yes
	2	Nadir Spatial Resolution	Complete	Yes
	3	MTF	In Progress	--
	4	Scan Cycle Stability	Complete	Yes
	5*	Scan Mirror Pointing Accuracy	prelaunch	Yes
	6	Scan Range	Complete	Yes
	7	Lunar Maneuver View	Complete	Yes
	8	SD calibration	Complete	Yes
	9	BB Warm-Up Cool-Down	Complete	Yes
Image quality	10	Detector Uniformity	Complete	Yes
Spectral Characterization	11*	Spectral Parameters: CW, WD, detector SRF uniformity	prelaunch	Yes
Radiometric evaluation	12	Dynamic Range	Complete	Yes
	13	SNR or NEdT	Complete	Yes
	14	SD parameter performance	Complete	Yes
	15	Radiometric accuracy	Complete	Yes
	16	Radiometric stability	In Progress	--
	17	Response Nonlinearity	Complete	As Expected
	18*	Polarization Sensitivity	prelaunch	B8 2 Det. fail
	19	Crosstalk	Complete	B20, 21: 0.7%
OBC performance	20	SD calibration validation	Complete	Yes
	21	Nonlinearity Coeff. Derivation from Onboard BB & validation	In Progress	--
Long-term Stability	22	Telemetry Trending	Complete	As Expected
	23	Performance Trending	Complete	As Expected

3.FY-3H MERSI-III Radiometric Performance

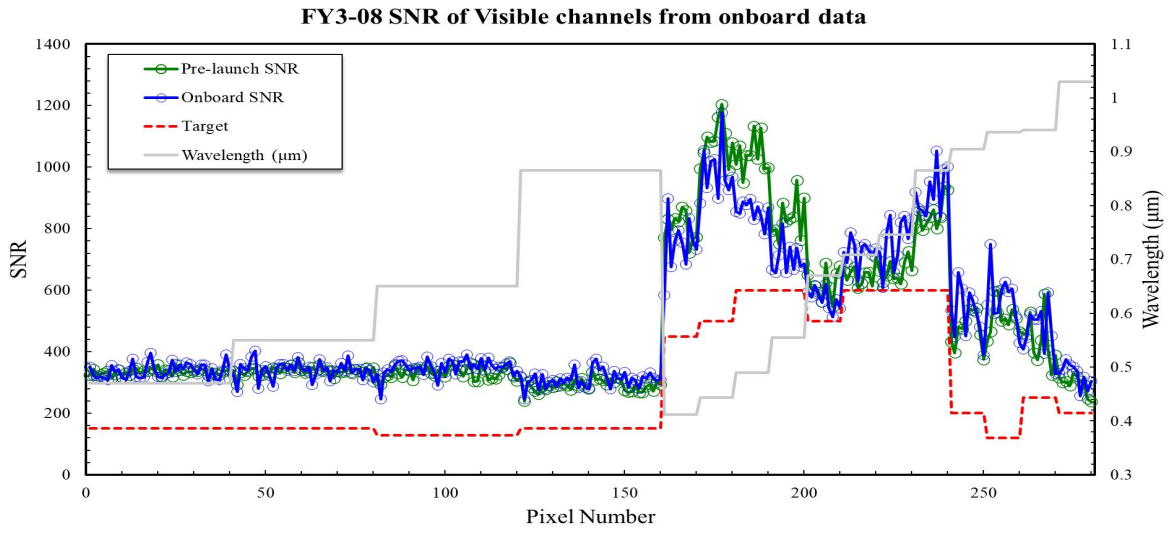
① Instrument Noise Characterization

② Radiometric Accuracy

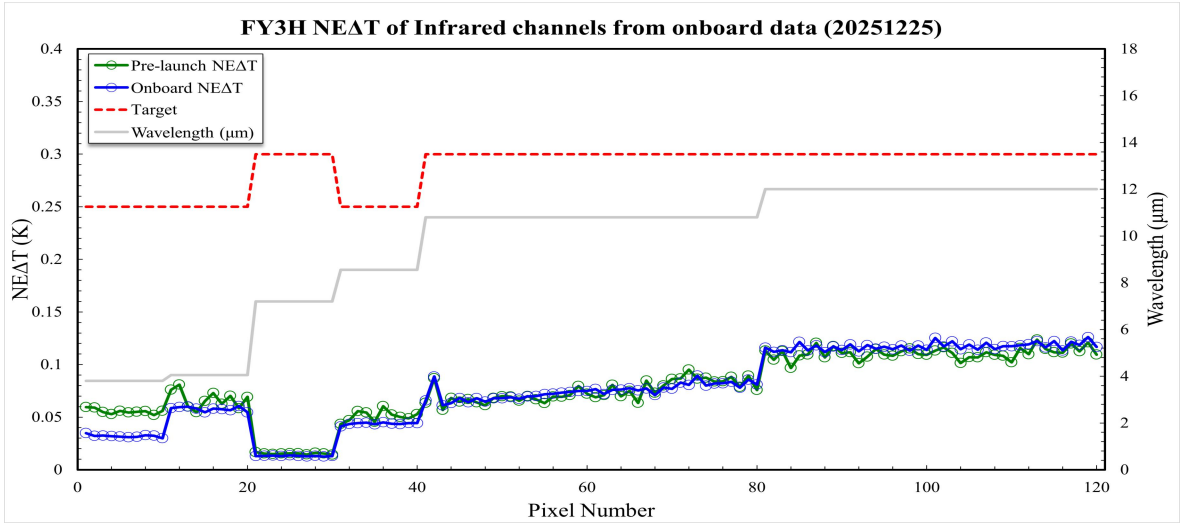
③ Stability

3.1 Instrument Noise Characterization

- RSB SNR of all detectors



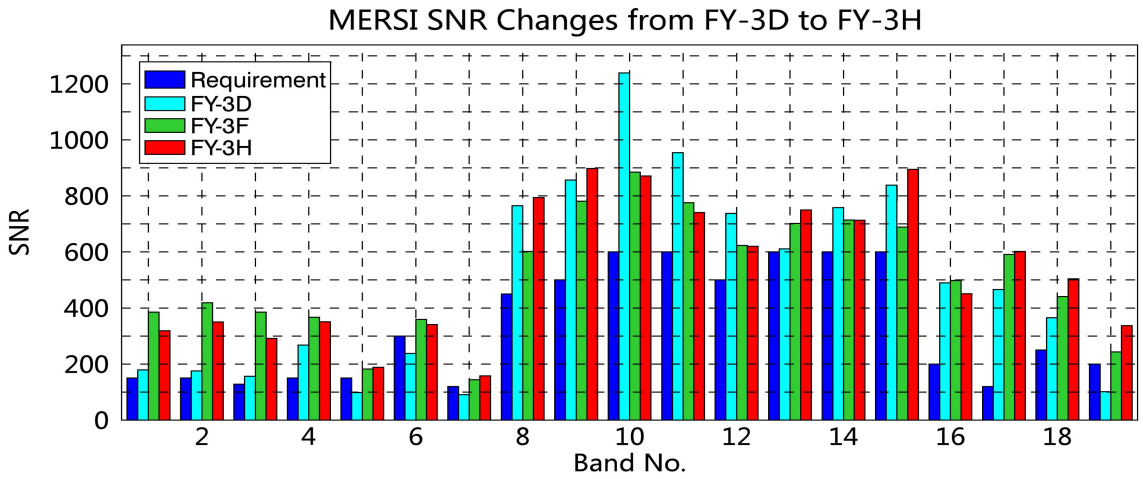
- TEB NEdT of all detectors



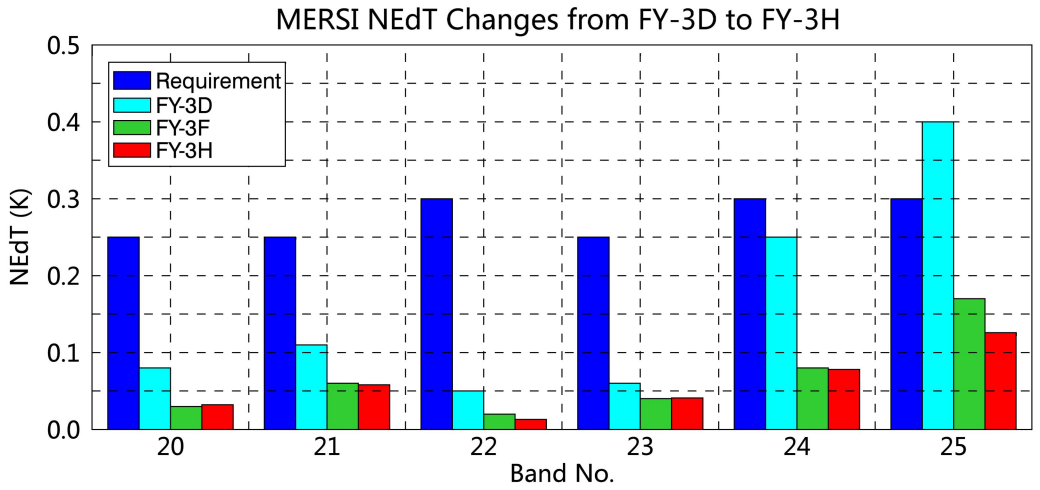
- ✓ On-orbit noise (blue symbols) performances agree well with the pre-launch ones (green symbols).
- ✓ All detectors of all bands satisfy the SNR or NEdT requirements.
- ✓ The NEDT of the TEBs is well below the required limits, with Channels 20–24 measuring < 0.1 K and MWIR/SWIR channels achieving < 50 mK.

Multi-Satellite Performance Comparison

RSB SNR of all detectors



TEB NEdT



- ✓ **Significant improvement in SNR (most channels) or NEdT from MERSI-II (on FY-3D) to MERSI-III (on FY-3F/3H)**
  - **RSB SNR： 10 channels improved >30%： four 250 m channels as well as SWIR, water vapor, and 1030 nm channels**
  - **TEB NEdT: CH20, 22, and LWIR channels reduced >50%**
- ✓ **Two MERSI-III exhibit comparable performance, while FY-3H MERSI-III shows further improvement in specific bands.**
  - **SNR: CH8, 15, and 19 .**
  - **NEdT: CH25 reduced from 0.17 K to 0.12 K.**

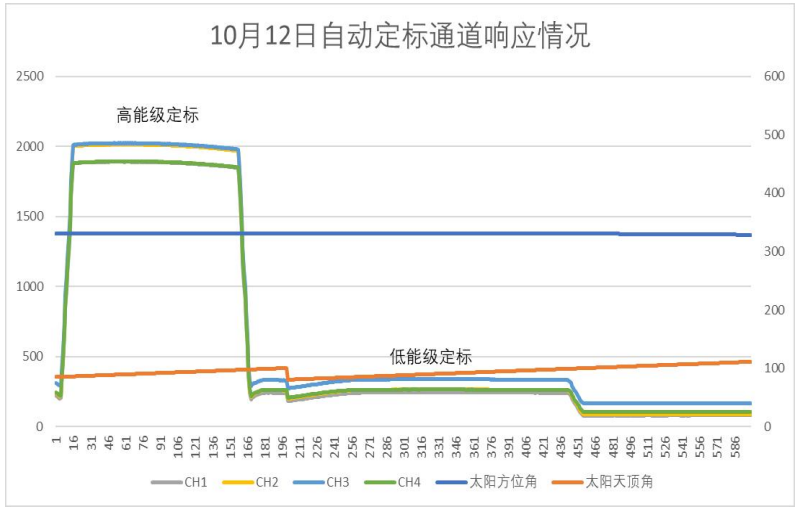
3.2 Radiometric Accuracy of RSBs

Sources of Calibration Coefficients

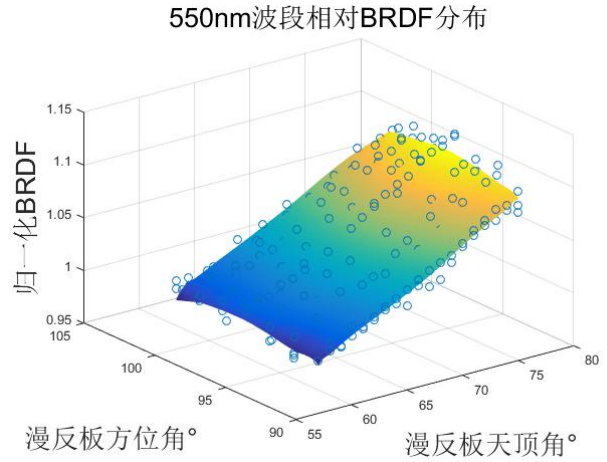
① Pre-launch laboratory integrating sphere calibration ← **Used during initial in-orbit**

② Onboard SD calibration ← **Updated coefficients after performance checking**

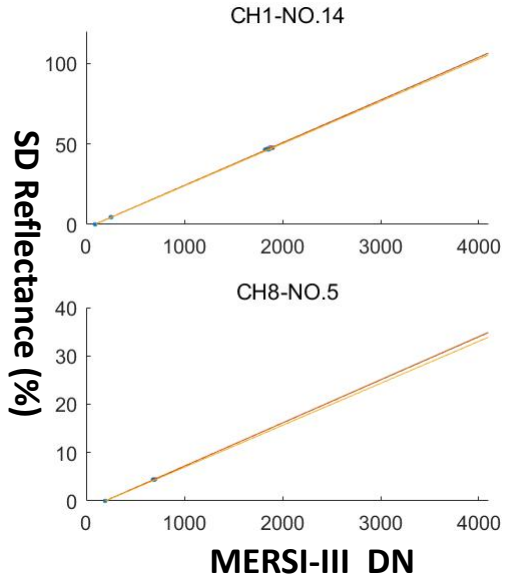
MERSI-III DN for SD View



Calibration Reference: SD BRDF + SAP transmittance（characterized pre-launch）



On-orbit calibration coefficient derivation

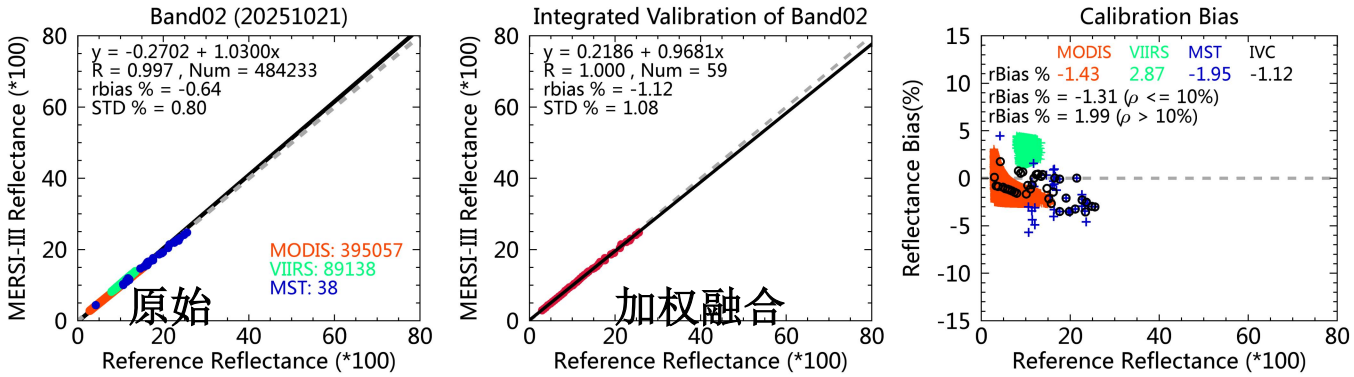


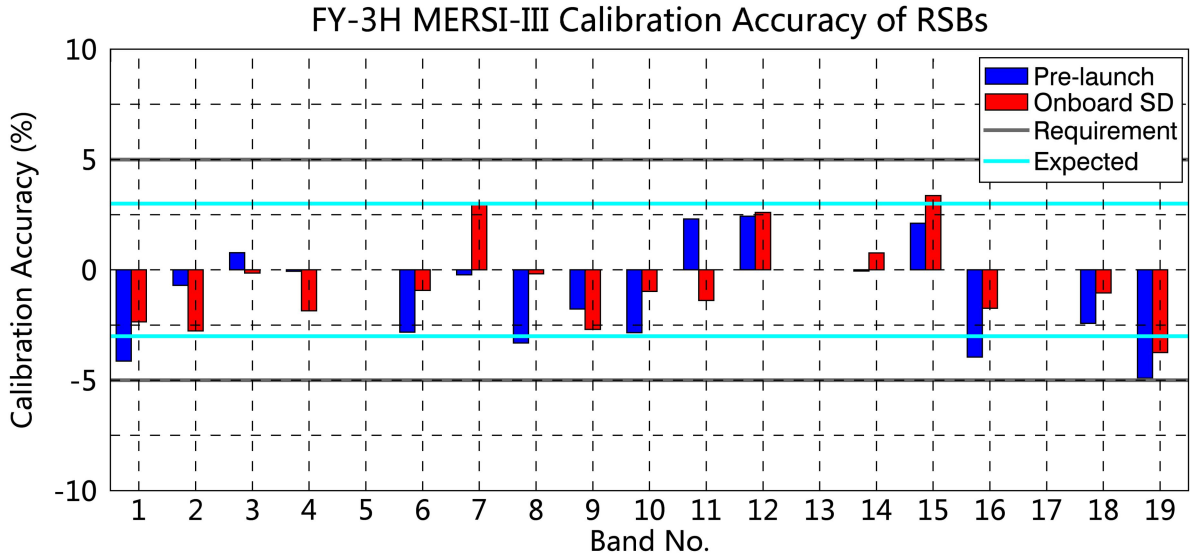
- A Solar Attenuation Plate (SAP) is positioned before the SD, enabling:
  - 2 illumination levels for Land/Atmosphere bands.
  - 1 illumination level for Ocean Color bands.

Calibration Accuracy Validation

- **Validation Method: Integrated Use of Multiple Vicarious Calibration Methods (IVC)**
  - SNO with Aqua MODIS, J1/J2 VIIRS
  - RTM simulations over global PICS
- **Verifiable Bands: 16 (except B5, 13, 17)**
  - B5, 17： Cirrus clouds and strong water vapor absorption, large uncertainty in validation results
  - B13： Saturated
- **Validation Time: Initial Phase of Channel Activation (First Month)**
  - VNIR--2025.10.21; SWIR--2025.12.20

✓ Both pre-launch and on-orbit SD calibration meet the 5% accuracy requirement.





3.3 Radiometric Accuracy of TEBs

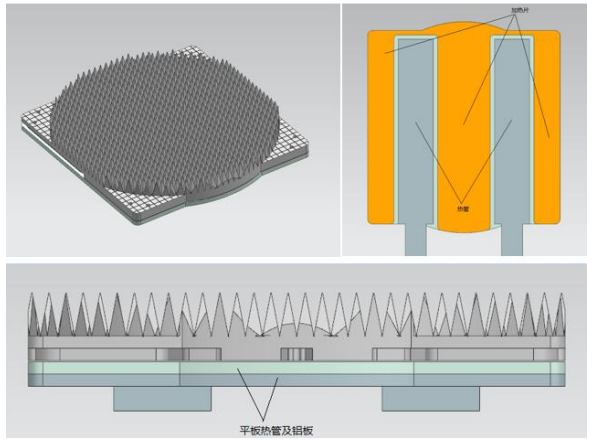
On-Orbit Calibration Methodologies for TEBs

$$L_{EV} = a_0 + b_1 \cdot (DN_{EV} - SV) + a_2 \cdot (DN_{EV} - SV)^2$$

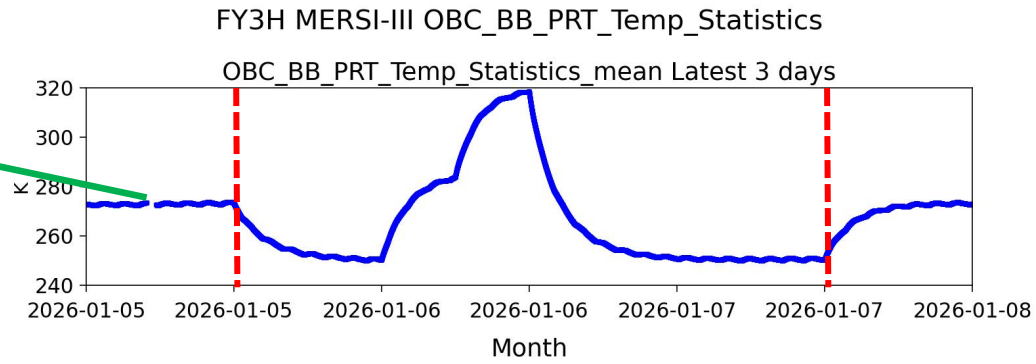
Sources of Calibration Coefficients

- **a0, a2**: Use pre-launch values at the Initial Phase after launch; Updated via on-board BB **during Warm-Up and Cool-Down (250-320 K)** or SNO method
- **b1**: Derived from on-board BB at fix temperature of 274K + SV, updated on a scan-by-scan basis

On-board BB



- Emissivity > 0.96
- Uniformity better than 0.2 K
- Temperature tuning capability from 260 to 320 K



BB Warm-Up Cool-Down

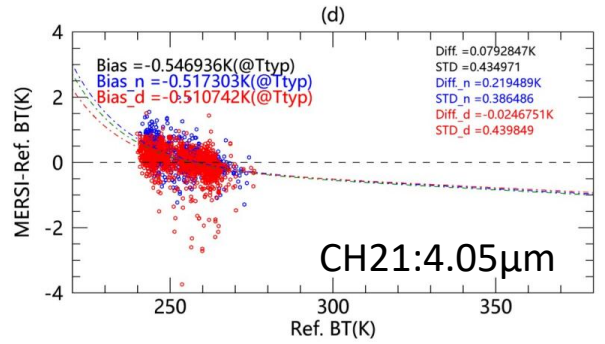
Performance of Pre-launch Nonlinear Coefficient (a_0, a_2)

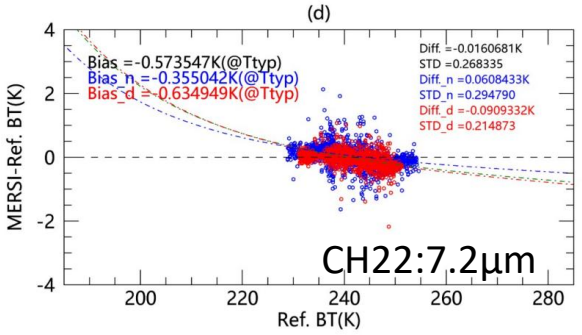
- Validation Method：SNO with Metop-C/IASI
- Data Period：2026.01.13-2026.01.16
- Condition: Nighttime comparison results were used.

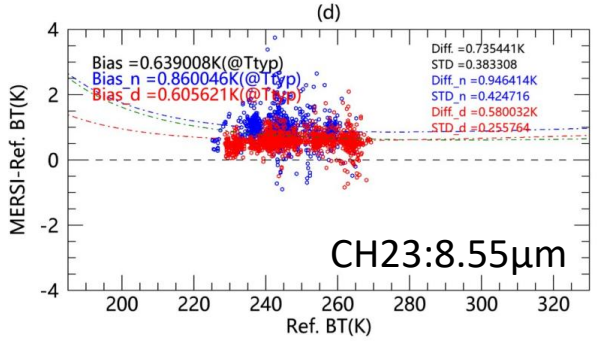
Calibration Bias (k)

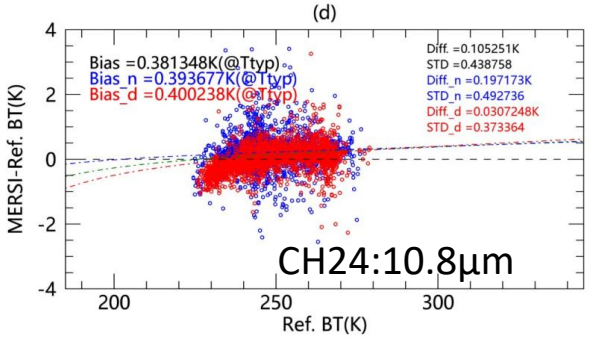
Band	21	22	23	24	25
T_{typ}	-0.52	-0.36	0.86	0.39	-0.17
Mean	0.22	0.06	0.95	0.20	-0.14

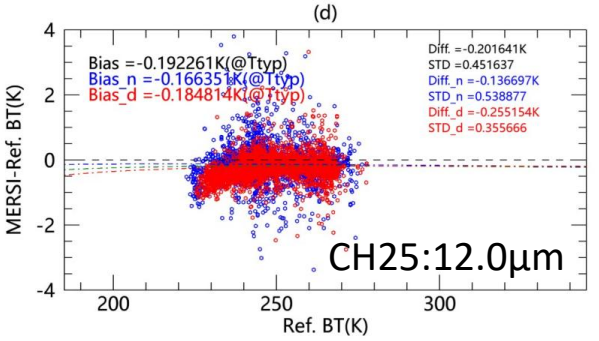
Note: Validation results for CH20 are omitted due to incomplete spectral coverage by IASI











- ✓ Three channels met specifications (<0.4K); CH21 and 23 failed.
- ✓ The bias of CH21 and 22 exhibits signicant temperature dependence, indicating that the pre-launch nonlinearity coefficients are no longer valid on orbit.

On-orbit update

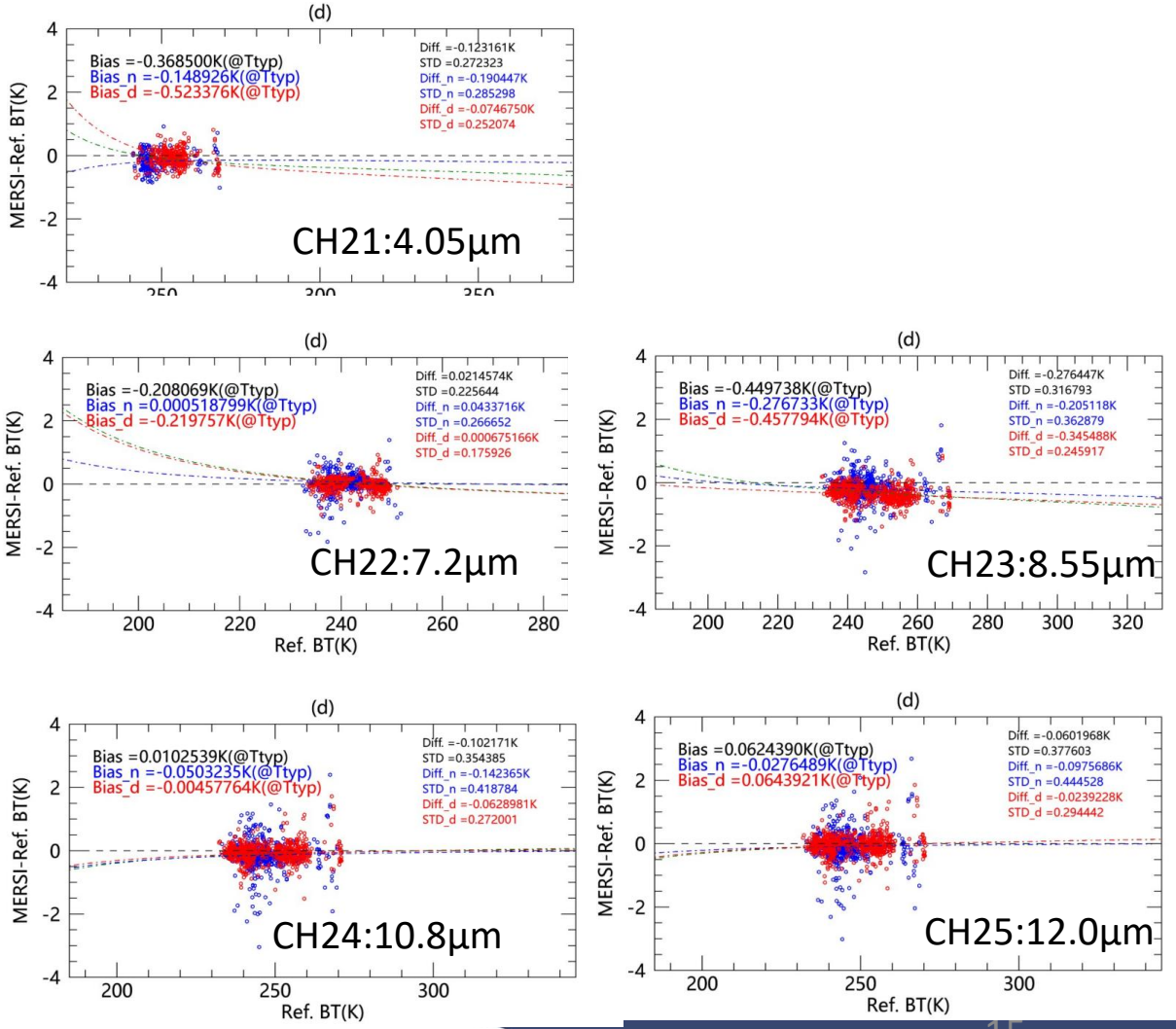
- **Update method:** based on SNO with IASI as reference; Corrected BB radiance baseline and updated nonlinear coefficients for CH21, 22, 24
- **Validation Approach:** Independent validation performed using February data, cross-compared with IASI.

Calibration Bias After Update (K)

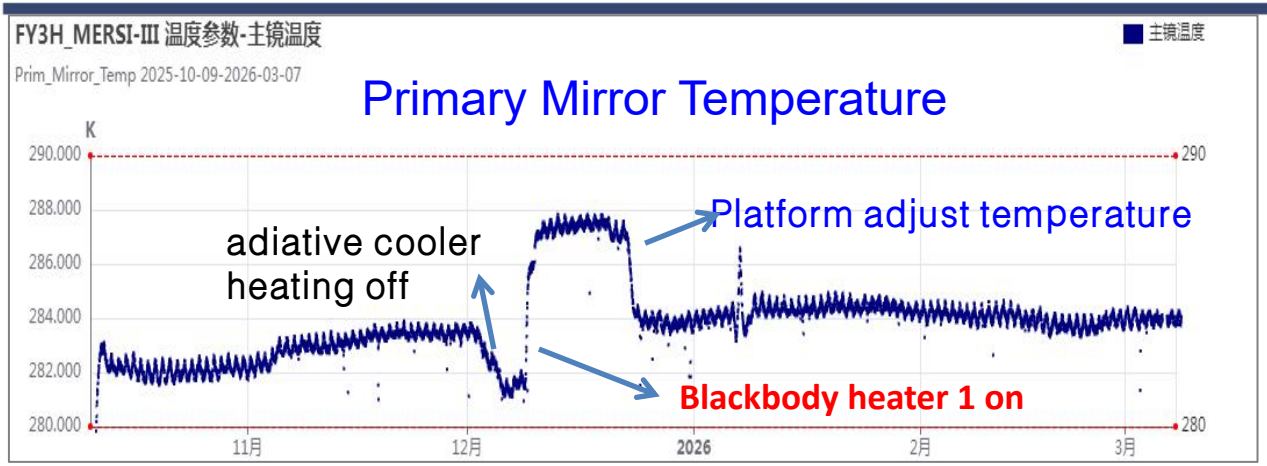
Band	21	22	23	24	25
T_{typ}	-0.149	0.001	-0.276	-0.050	-0.028
Mean	-0.190	0.043	-0.205	-0.142	-0.098

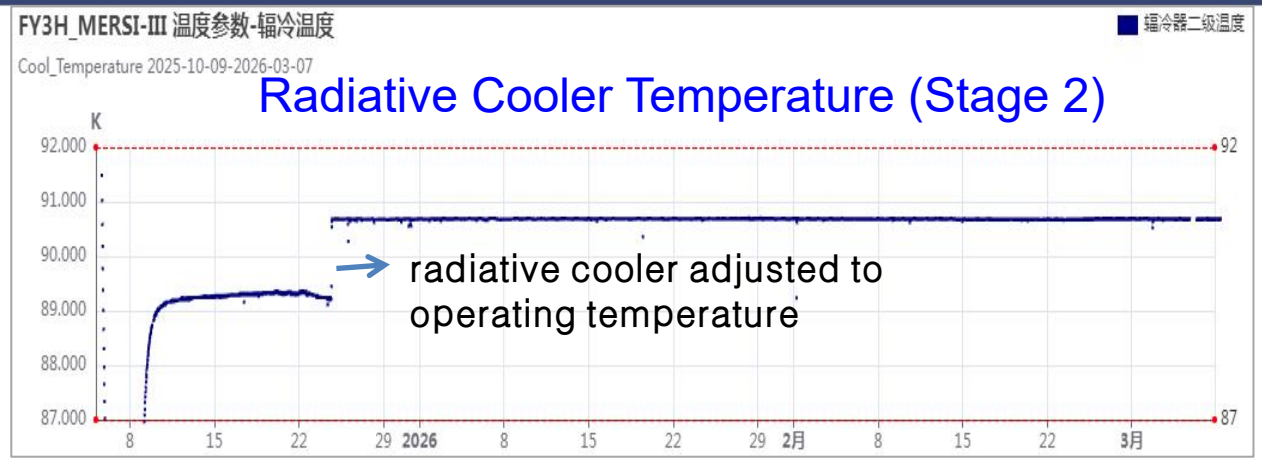
- **Update Results are excellent:**
  ① All channels meet specifications. 4 out of 5 bands (except CH23) meet expected targets of 0.2K.
  ② Nonlinearity has been effectively corrected: Temp-dependence ↓ vs. pre-launch

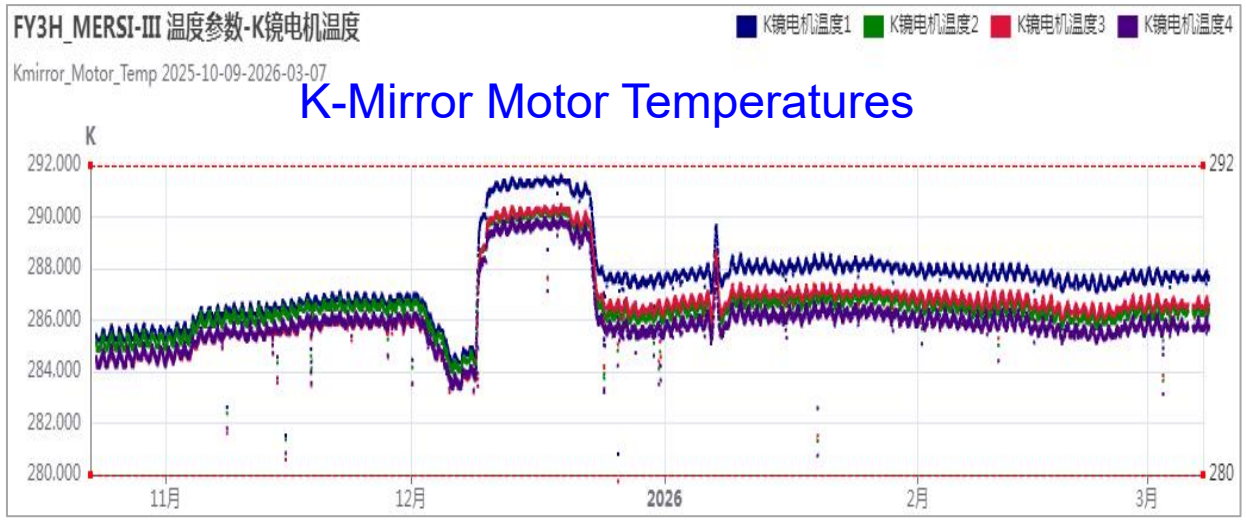
validation of the updated calibration coefficient

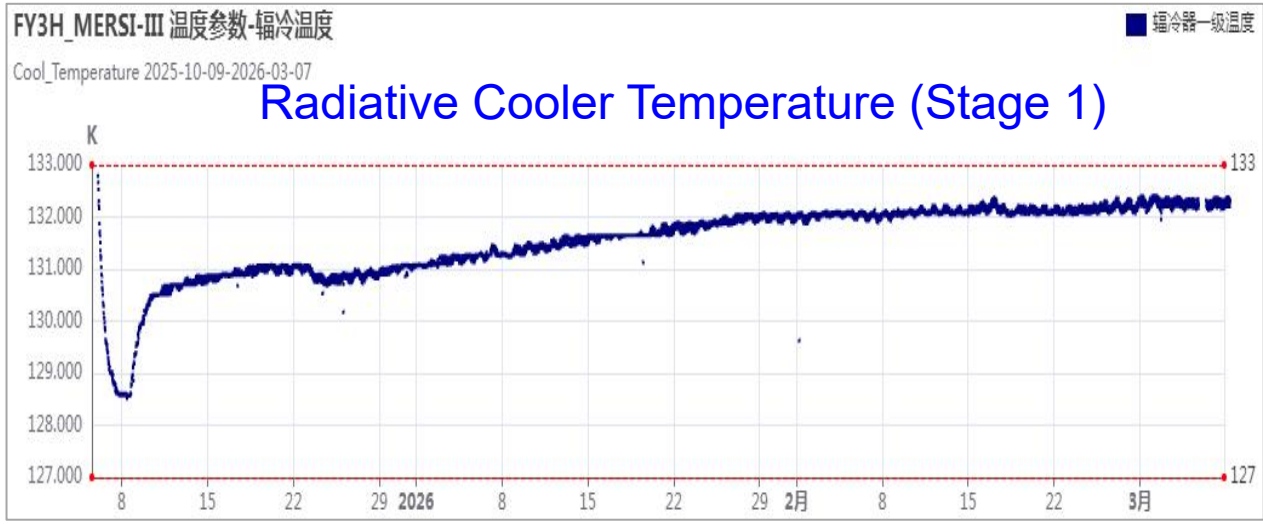


3.4 Stability--(1) Telemetry Parameters





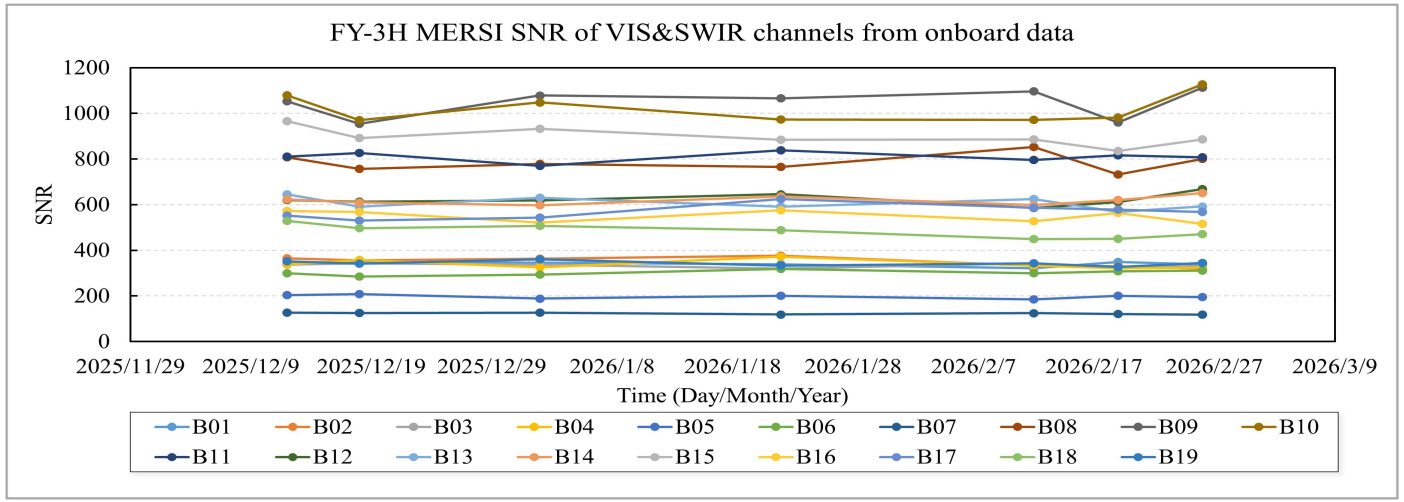




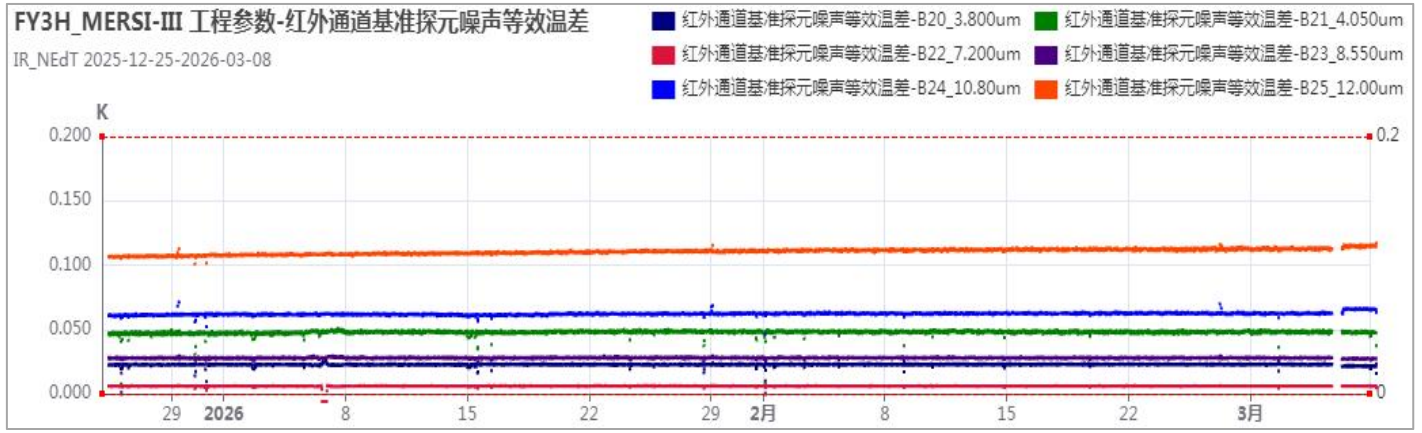
- Primary Mirror & K-Mirror Temperatures: Long-term stable during non-stellar operations; daily fluctuation<0.4K
- Radiative Cooler: Stage 2 stable; Stage 1: Slight increase (~1 K) due to external thermal load — still acceptable
- The instrument is operating reliably under steady-state conditions.

3.4 Stability--(2) Instrument Noise

- RSB SNR



- TEB NEdT

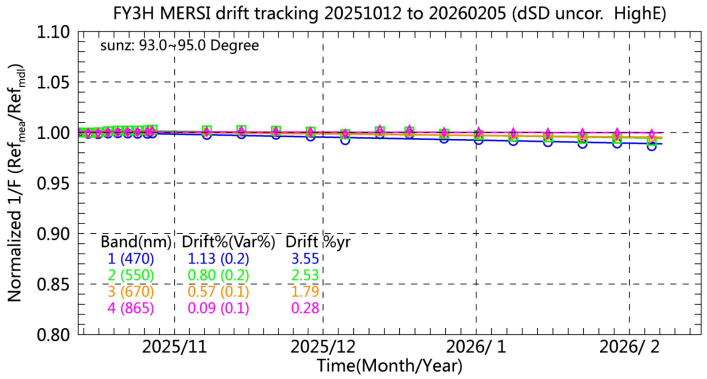


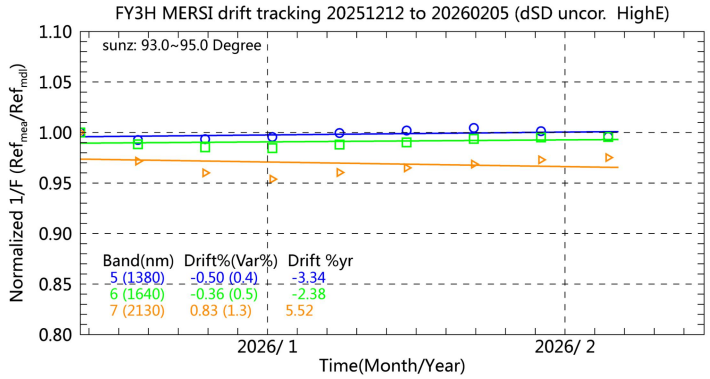
✓ Both SNR and the NEdT were stable during the In-Orbit Test phase.

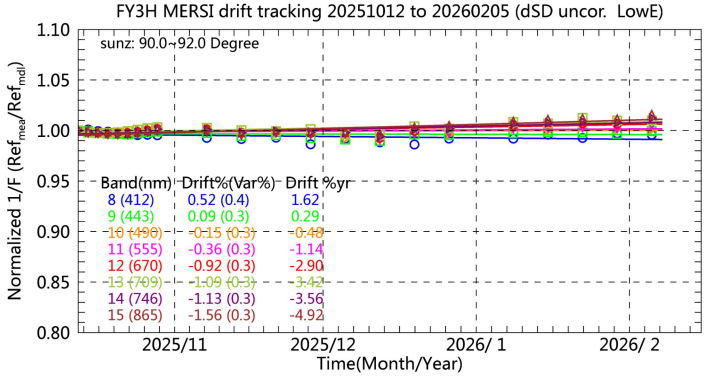
(3) Instrument Radiometric Response

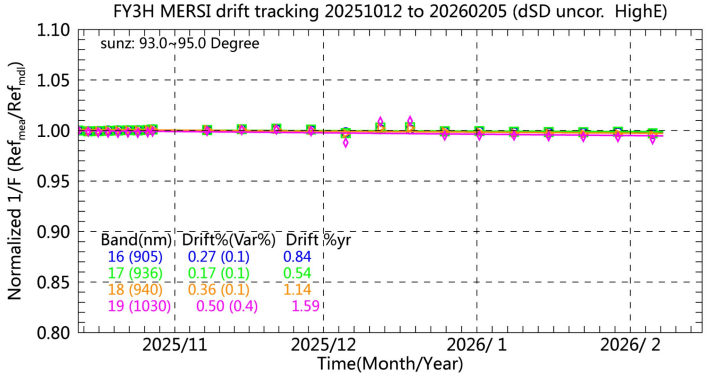
- Method：tracking using on-board SD

Time Series of Normalized SD Reflectance for RSBs



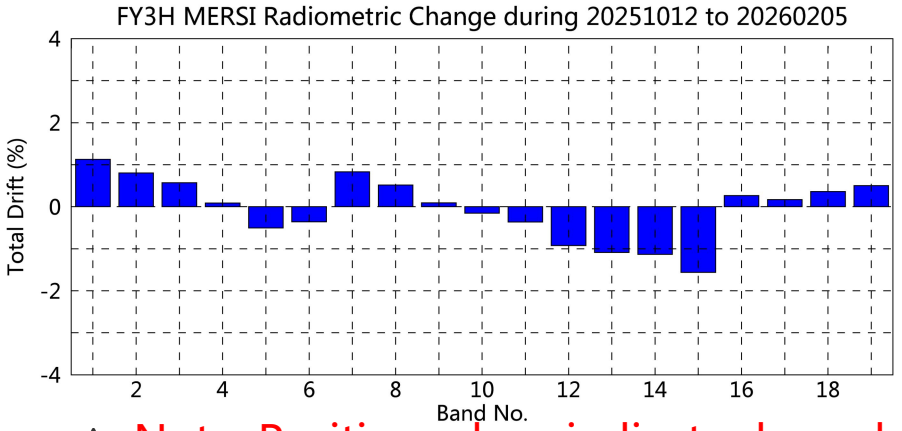






Time period: VNIR--20251012 to 20260205; SWIR--20251212-20260205

In-orbit Radiometric Response Change



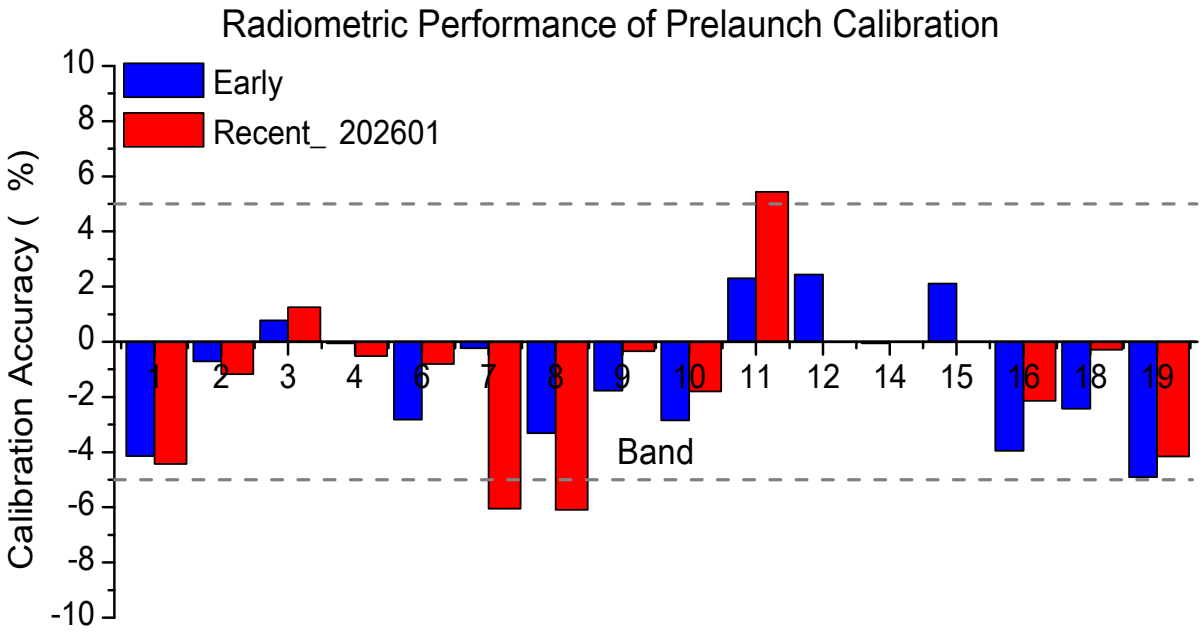
★ Note: Positive values indicate degradation; negative values indicate enhancement.

- No significant degradation observed across all bands.
- Bands 1 and 7 exhibit relative larger degradation, with total degradation ranging from 0.8% to 1.1%。

(4) Radiometric Accuracy of RSBs

- Validation Timeline:
  - ✓ Early (initial phase): VNIR--20251021; SWIR--20251220
  - ✓ Recent (latest validation): 20260121

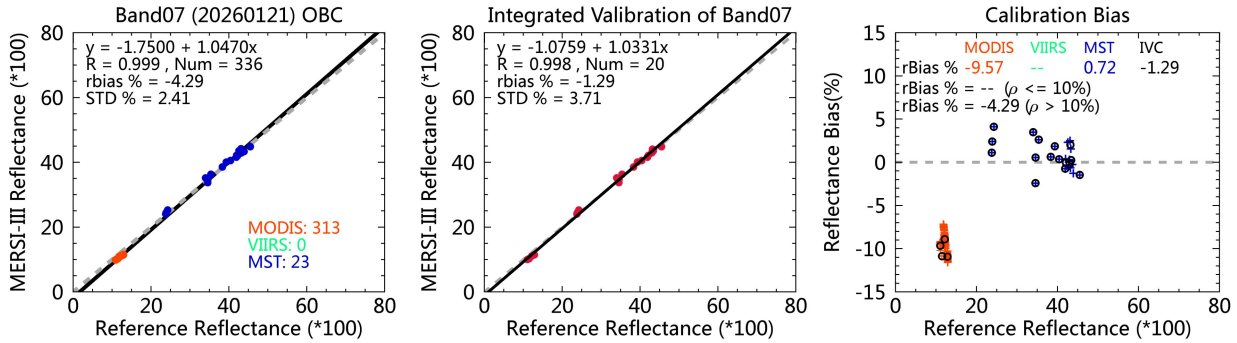
Radiometric Stability using Pre-launch Calibration Coefficient

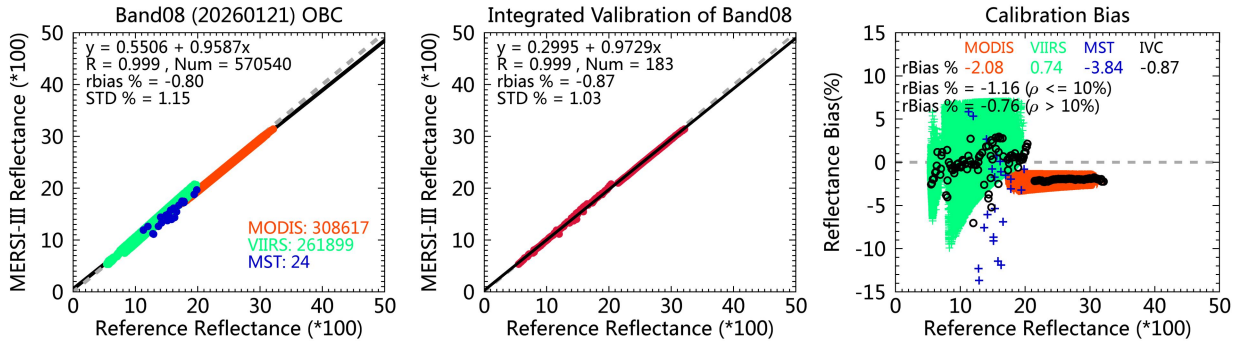


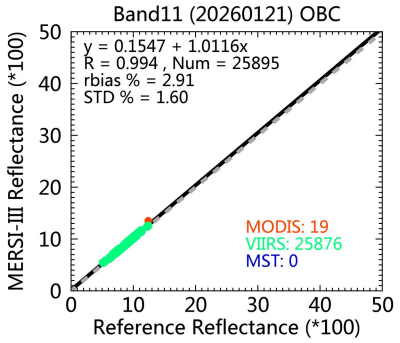
- **Key Findings on Calibration Stability**
  - ✔ Early On-orbit: All bands maintained calibration accuracy of <5%.
  - ✔ Recent Validation: Most bands still within ±5%, while Bands 7, 8, and 11 exceeded 5%.
  - ⚠ Bands Requiring Update: 7, 8, 11

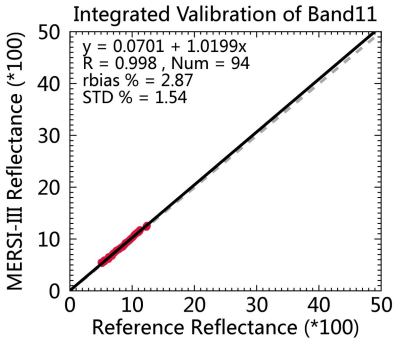
(4) Radiometric Accuracy of RSBs

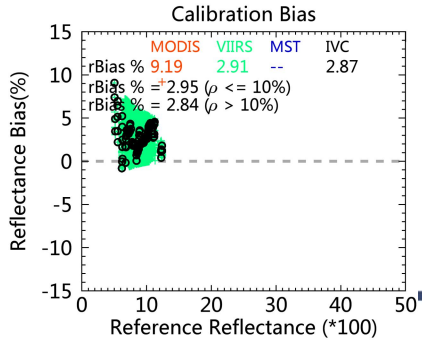
Onboard Calibration Accuracy for Bands 7, 8, 11 — January 2026



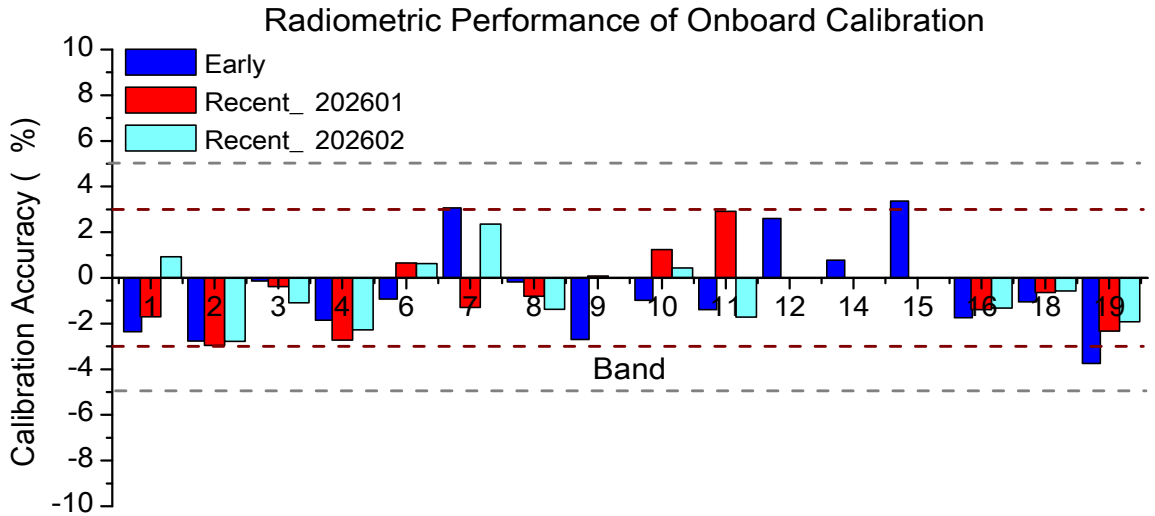








Radiometric Performance of Onboard Calibration (Early vs. Recent)



- ✓ **Jan 28, 2026:** first update of RSB coefficients completed using onboard SD reference .
- ✓ **SD calibration is stable over time:** Accuracy maintained within 5%; 14 out of 19 channels < 3%
- ✓ **Operational Value:** enables timely correction of instrument drift → ensures radiometric consistency of RSBs

4 Summary

- FY-3H MERSI-III is operating stable on-orbit. All tested functions and radiometric performance meet the specified requirements.
- The SD calibration system is effective, achieving a calibration accuracy: <5% generally; <3% for 14 channels, with long-term stability.
- After on-orbit coefficient update, the TEB calibration accuracy is better than 0.3 K, with 4 channels better than 0.2 K。

- Key Improvements Compared to FY-3 F & D MERSI
  ① Improved detector uniformity of raw data
  ② Enhanced detection sensitivity
  ③ Higher radiometric calibration accuracy

Thank you.
Looking forward to using FY-3H MERSI-III data!