In-orbit Radiometric calibration progress of FY-4B GHI's solar reflective bands

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Outline

1. **Introduction of Fengyun-4B Geosynchronous High-speed Imager**
2. **A possible scan mode for operation**
3. **VNIR radiometric calibration progress**
4. **Introduction of Fengyun-4B GHI's L1 data product**
5. **Conclusions & Discussions**

1 Introduction

- **Geosynchronous High-speed Imager (GHI) is an experimental multi-spectral flexible imaging radiometer on** Fengyun-4B satellite， which was launched on June 3, 2021.
- It was deployed at 123.5° E on June 10,2021 and recently deployed at 133° E on April 10, 2022.

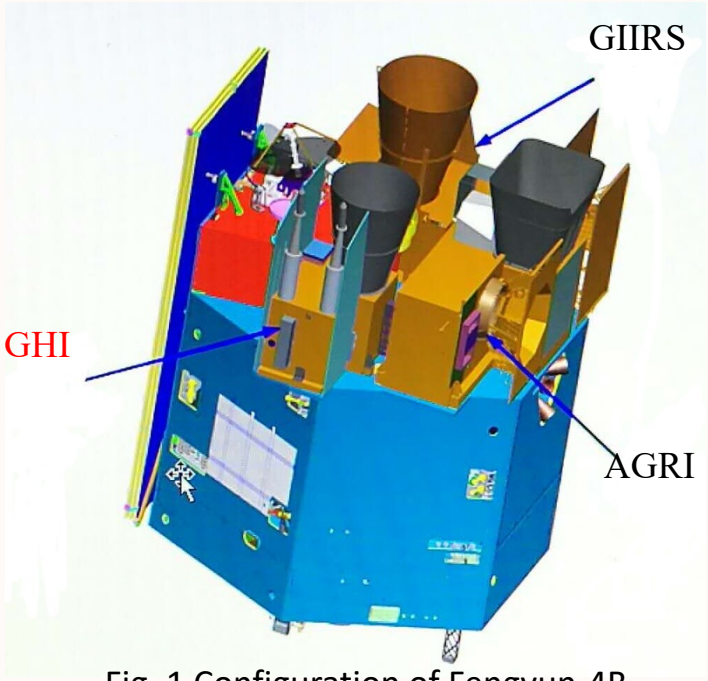
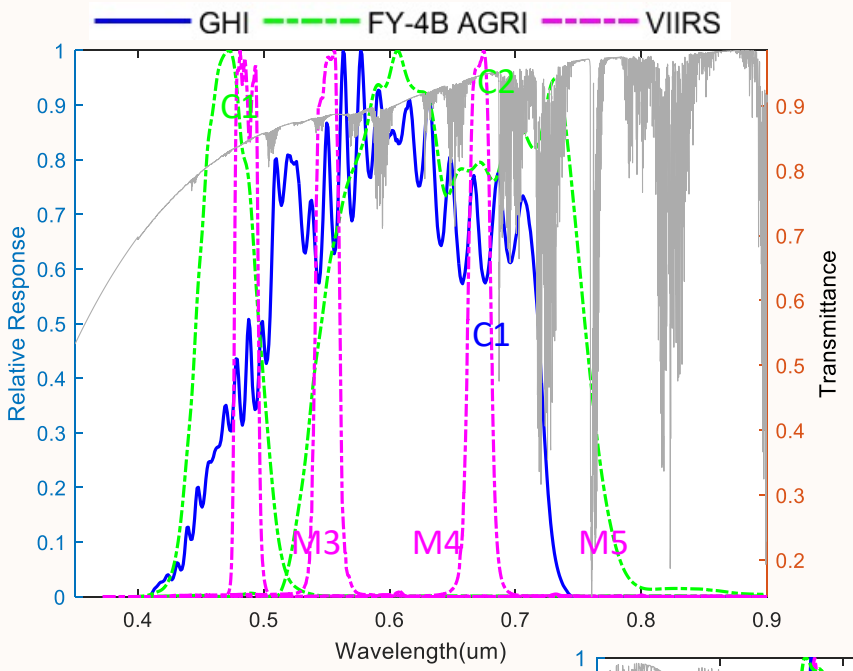
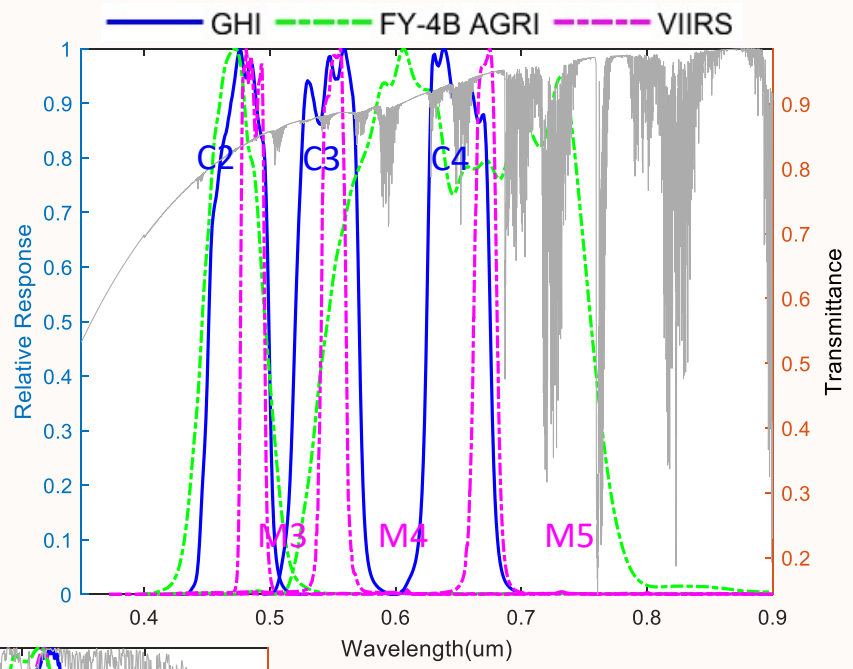


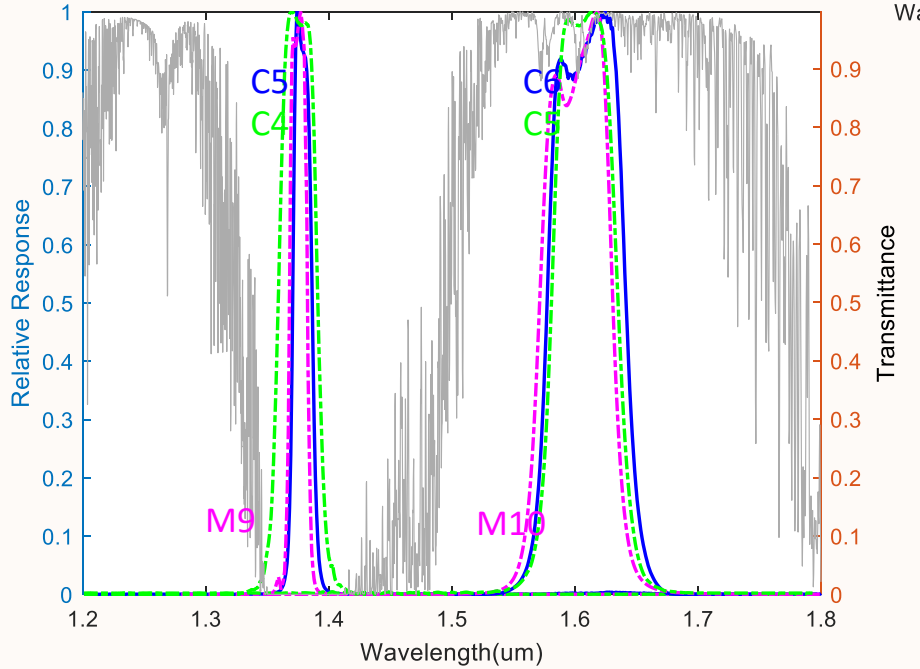
Fig. 1 Configuration of Fengyun-4B

Table 1 Characteristics of GHI

Channel/Band		Range(μm)	GSD(km)	Focal Plane Array	Primary purpose
VNIR	1	0.45~0.75	0.25	2048×1	Full color, Daytime vegetation, stars
	2	0.445~0.495	0.5	1024×1	"blue" for true color, Daytime aerosol
	3	0.52~0.57	0.5	1024×2	"green" for true color, Daytime aerosol
	4	0.62~0.67	0.5	1024×1	"red" for true color, Daytime aerosol
	5	1.371~1.386	0.5	1024×1	Daytime thin cirrus
	6	1.58~1.64	0.5	1024×1	Daytime cloud/snow, water/ice cloud
LWIR	**7**	**10.3~12.5**	**2**	**256×4**	**Nighttime imaging**



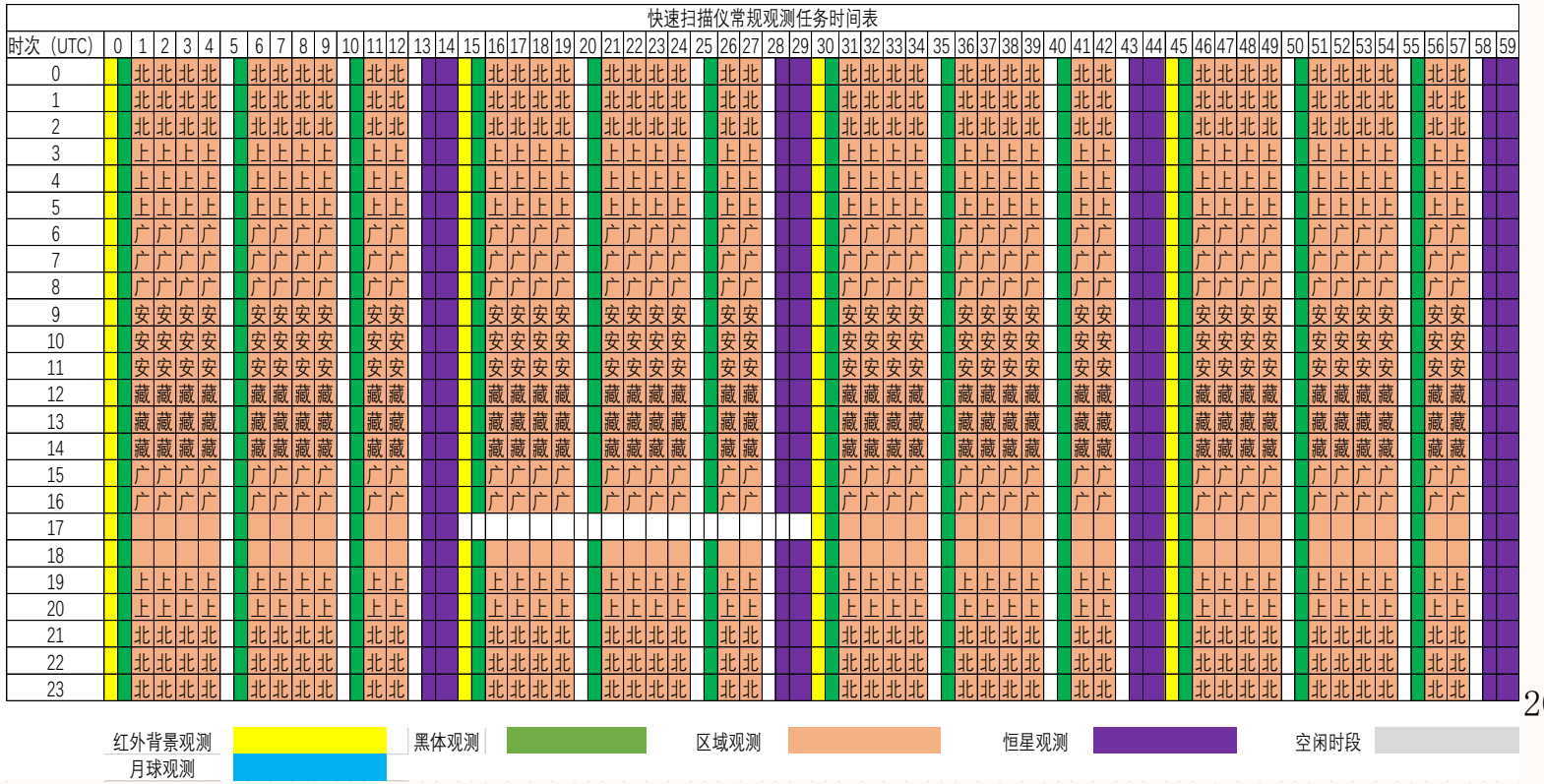




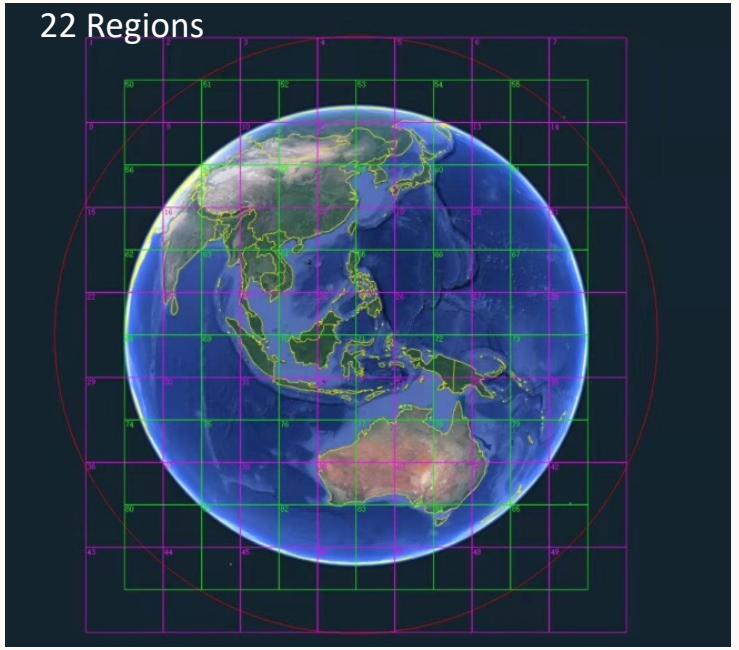
NPP-VIIRS-NG version of SRFs was adopted.

2 A possible scan mode for operation

- The basic unit in the observation schedule might be 15 mins. The basic unit is repeated every 15 minutes except the period for orbit maintenance and flywheel unloading.
- In normal scan mode, space and blackbody looks are needed to meet radiometric requirements. A stellar observation is used to meet INR requirements. Lunar scan data are collected in support of calibration activities when the moon is in the GHI's FOR.



2000km*1800km Regions Divided For China



2000km*1800km Regions Divided For Full Disk

3 VNIR Calibration Progress

- **There is no on-board Solar Diffuser (SD) .**
- Once launched, the raw digital counts are converted to reflectance using the pre-launch calibration coefficients for the reflective channels.
- Several methods are developed and applied to validate and monitor the radiometric calibration accuracy.
  - ✓ the inter-calibration with the VIIRS on-board SNPP satellite;
  - ✓ the inter-calibration with the AGRI on-board Fengyun-4B satellite;
  - ✓ 19 sites selected for reflectance monitoring;
- Lunar calibration is being developed to trend sensor's degradation.

Table 2 List of selected sites for calibration

No.	Sites	Lat	Long	SatZenithAngle	Region No.
1	Amburla	-23.39	133.12	42.11	
2	Warrabin	-26.28	143.65	52.92	
3	Australia	-30.85	139.75	52.37	
4	TingaTingana	-29	139.86	51.29	1
5	Dunrobin	-22.67	146.13	53.46	
6	Winton	-22.52	142.94	50.41	
7	LakeFrome	-30.85	139.67	52.28	
8	DaZaohuo_East	36.42	94.22	43.38	
9	DaZaohuo_West	36.55	93.8	43.60	
10	YangChangZiGou	37.28	96.08	43.80	
11	WuTuMeiRenNan	36.83	93.33	44.02	
12	XiaoChaiDaMuHu_W	37.36	95.07	44.12	
13	ShiDaoBan	38.66	94.53	45.66	2
14	AoBaoliang3	38.49	93.19	45.81	
15	LengHu_East	38.656	93.43	45.90	
16	CuanSiKuLeHu	37.91	90.85	45.94	
17	Dunhuang	40.138	94.321	47.25	
18	TaklamakanDesert	39.83	80.17	52.29	
19	TharDesert	27.63	71.86	48.38	3

◆ Vicarious calibration

- ☐ **Lacking onboard calibration devices, GHI's visible and near infrared channels have to be vicariously calibrated.**
- ☐ **Therefore, some invariant sites and nadir images are chosen to be periodically added in normal scan modes.**
  - ✓ GHI obtained the measurements from three designated sites once a hour.
  - ✓ Nadir region images were obtained to collocate with SNPP/VIIRS observations.
- ☐ **On Jan 18, 2022, a correction for Channels 1 to 6 was updated in the ground system.**

Table 3 SBAFs* accounting for the spectral mismatch

GHI Band No.	VIIRS Band No.	SBAF_offset	SBAF_slope
C1	/*	/	/
C2	M3	0.005915	1.002
C3	M4	0.0002603	1.007
C4	M5	-0.01284	0.9853
C5	M9	0.01232	0.9644
C6	M10	0.01139	0.9973

*SBAFs are computed using SCIAMACHY observations by Hong Qiu.

Table 4 Relative differences using prelaunch calibration coefficients

Channel	Req.	Prelaunch results	Selected Sites (Nov 12 to Dec 31)		Inter-calibration with VIIRS (Nov 12 to Dec 31)	
			PDif	std	PDif	std
C1	5%	3.889%	-7.39%	2.982%	/	/
C2	5%	3.398%	2.8637%	3.8067%	-0.2784%	1.643%
C3	5%	3.332%	-5.1307%	2.82%	-4.923%	2.392%
C4	5%	3.582%	-3.41185%	3.4727%	-7.331%	2.368%
C5*	5%	3.675%	/	/	-31.8%	3.382%
C6	5%	3.984%	-8.0237%	2.5862%	-4.529%	2.298%

*Channel used for daytime thin cirrus.

◆ Inter-calibration with FY-4B/AGRI

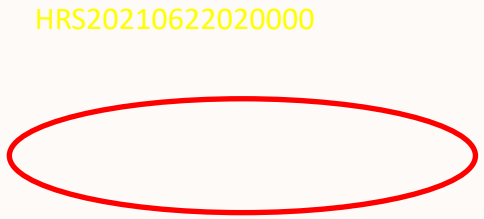
- ☐ **FY-4B AGRI and FY-4B GHI are on-board the same spacecraft.**
- ☐ **For FY-4B AGRI, a solar diffuser and the cold space observations are used for calibration of the VNIR bands.**
- ✓ Up to Feb 17, 2022, the radiometric calibration accuracy for all the VNIR bands except Channel 1 has reached within 3.3%;
- ✓ On Mar 18, 2022, an update for Channel 1 was adopted in the ground system.
- ☐ **Inter-calibration with FY-4B/AGRI provides us a good way to monitor the GHI's degradation.**
- ☐ **Initial inter-comparison between GHI and FY-4B/AGRI was conducted.**

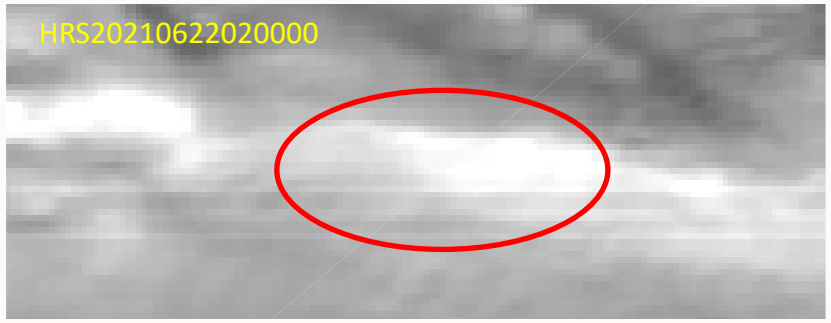
Table 5 inter-comparison between GHI and FY-4B/AGRI

GHI	C1	C2	C3	C4	C5	C6
FY-4B AGRI	C2	C1	C2	C2	C4	C5
20220228~20220318						
Without SBAF	6.18%	8.84%*	-0.9%	4.19%	1.59%	-1.96%
20220319~20220321						
Without SBAF	5.41%	2.7%	-0.6%	4.06%	4.25%	0.8%

◆ Striping

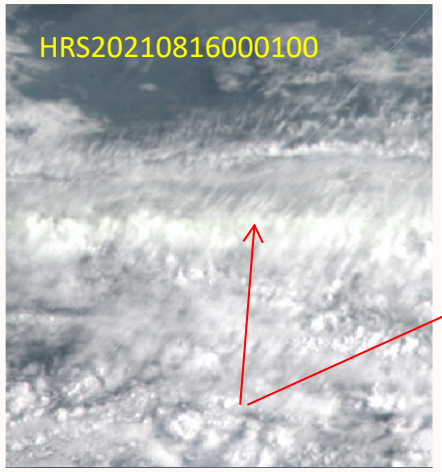
- ☐ Noticeable swath boundaries in channel 2's calibrated data and strips in channel 4's calibrated data.
- ☐ A correction, scaling the detectors' calibration coefficients was implemented in the ground system.



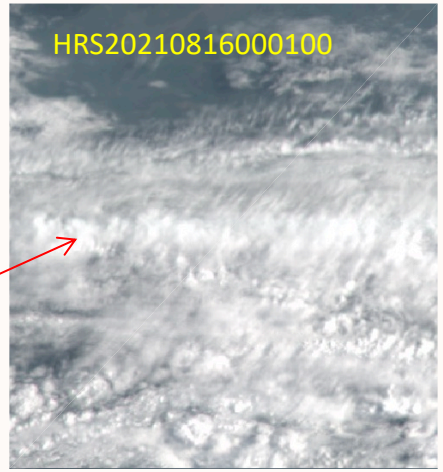


Channel 2

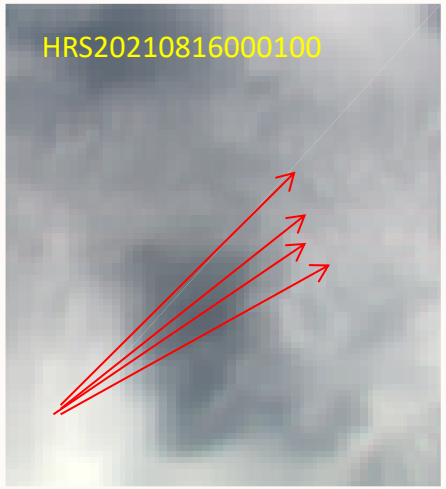
Channel 4



Before update



After update



Before update

After update

4 Introduction of GHI's L1 data product

- Four L1 data products are generated for every task.
  - ✓ FY4B-_GHI---_N_REGX_1235E_L1-_FDI_MULT_NOM_YYYYMMDDHHMMSS_YYYYMMDDHHMMSS_0250M_V0001.HDF
  - ✓ FY4B-_GHI---_N_REGX_1235E_L1-_FDI-_MULT_NOM_YYYYMMDDHHMMSS_YYYYMMDDHHMMSS_0500M_V0001.HDF
  - ✓ FY4B-_GHI---_N_REGX_1235E_L1-_FDI-_MULT_NOM_YYYYMMDDHHMMSS_YYYYMMDDHHMMSS_2000M_V0001.HDF
  - ✓ FY4B-_GHI---_N_REGX_1235E_L1-_GEO_MULT_NOM_YYYYMMDDHHMMSS_YYYYMMDDHHMMSS_2000M_V0001.HDF
- In L1 data product, the datasets are saved as four groups, namely Calibration, Data, Data_Info and QA.

Table 3 Description of GHI's L1 data products(250m)

Global Attributes			
Private Attributes			
SDS			
Group name	SDS		Description
Data Fields	SDS1	NOMChannel01	Full color channel 250M image data layer
Calibration Fields	SDS2	CALChannel01	Calibration table of Full color Channel
	SDS3	CALIBRATION_COEF(SCALE+OFFSET)	Slope and intercept of each channel
	SDS4	ESUN	bandpass-weighted solar irradiance at the mean Earth-Sun distance
Data_Info Fields	SDS5	NOMObsTime	Observation Time per Line (after resampling)
	SDS6	NOMObsColumn	Observation begin and end position per Nominal Line (after resampling)
	SDS7	VerSoftNR	Navigation software registration process version
	SDS8	VerSoftStrayLight	Stray light processing version
	SDS9	VerSoftMTF	MTF processing version
	SDS10	VerSoftVis	Vis channel calibration processing version
	SDS11	VerSoftIR	IR channel calibration processing version
QA Fields	SDS12	L0QualityFlag	L0 Quality Flag
	SDS13	NavQualityFlag	Navigation Quality Flag
	SDS14	CalQualityFlag	Calibration Quality Flag

- XX is from 01 to 06，NOMChannelXX is the scaled reflectance;
- XX is 07，NOMChannelXX is the scaled radiance

4 Introduction of GHI's L1 data product

◆ Reflective Channels（Scaled Reflectance，SR）

Scaled reflectance can be converted to reflectance by two ways:

① CALChannelXX is the LUT，which can be used to convert SR to reflectance；

② CALIBRATION_COEF（SCALE+OFFSET）provides every reflective channel's slope and offset that are needed to convert SR to reflectance.

$$Ref = SR * SCALE + OFFSET$$

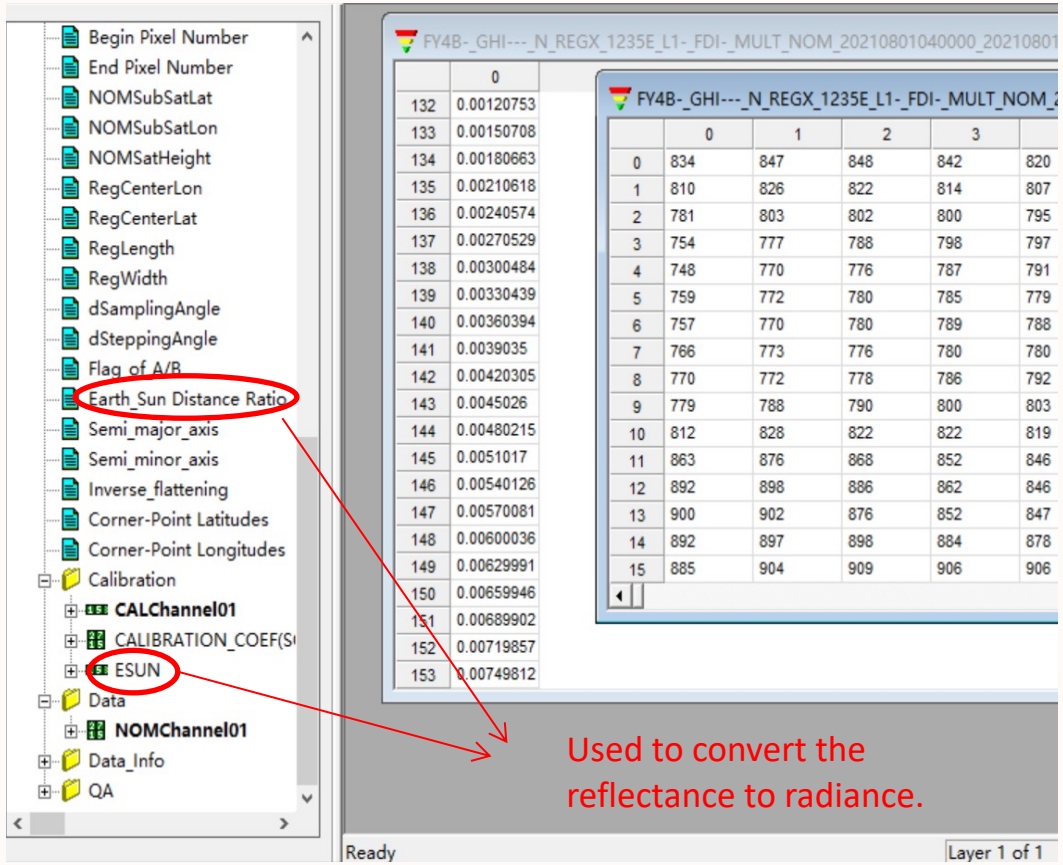
◆ Emissive Channel（Scaled Radiance，SR）

Scaled radiance can be converted to radiance and brightness temperature through the following steps：

① CALChannelXX is the LUT，which can be used to convert SR to brightness temperature；

② CALIBRATION_COEF（SCALE+OFFSET）provides channel 7's slope and offset, which are used to convert SR to radiance（W/（m^2 sr um））

$$Rad = SR * SCALE + OFFSET$$



5 Conclusions & Discussions

- GHI provides us near-1min continuous images of 2000km ×1800km;
- Its flexible scan mode offers us a chance to track and monitor the rapid-developping event.
- This flexibility also brings us some difficulties for the inter-calibration.
- GHI data analysis will continue:
  - Absolute calibration accuracy will be kept on analyzing;
  - The method using lunar observations monitor the GHI's degradation is being explored;
  - ……

Thanks for Listening!

National Satellite Meteorological Center