Introduction of Fengyun-4B Geosynchronous High-speed Imager

Presented to CGMS-50 Working Group II, agenda item 6

Executive summary of the WP

☐ The Geosynchronous High-speed Imager(GHI) is the experimental instrument imaging the Earth with 7 different spectral bands covering 6 visible/near-infrared (VNIR) bands and 1 infrared (IR) bands.

☐ Although the Fengyun-4B GHI data are currently experimental and undergoing testing, in this study we focus on reporting some preliminary assessment results of the GHI radiometric calibration performance during the post-launch test (PLT) and post-launch product tests (PLPT) period.

✓ Our results show that the GHI IR images mean brightness temperature (Tb) bias with respect to Metop-B/IASI of less than 0.7K.

✓ The GHI VNIR radiometric calibration has a mean reflectance difference to SNPP/VIIRS of less than 5% for all the 6 VNIR bands except for B01 (the panchromatic band), which has large spectral mismatch with respect to all VNIR bands of VIIRS.

✓ Also, the GHI VNIR radiometric calibration has a mean reflectance difference to FY-4B/AGRI of less than 5% for all the 6 VNIR bands.

☐ Validations and investigations are still ongoing to improve the GHI imagery and data quality.

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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.

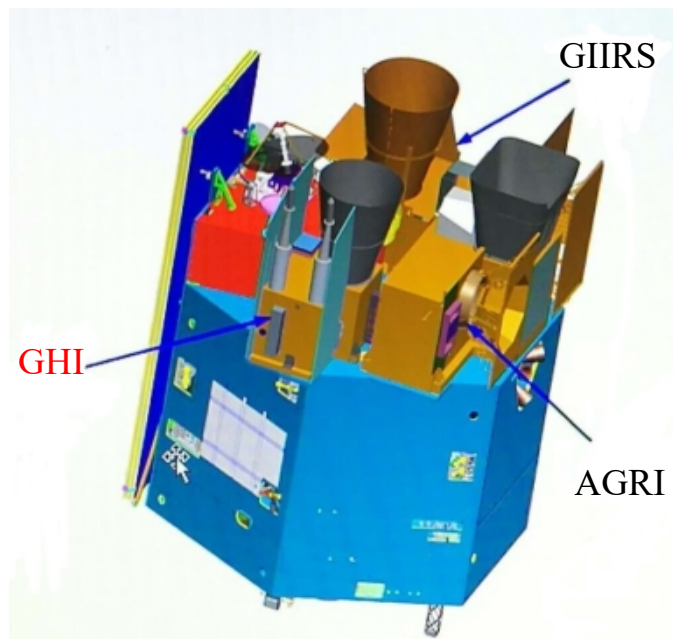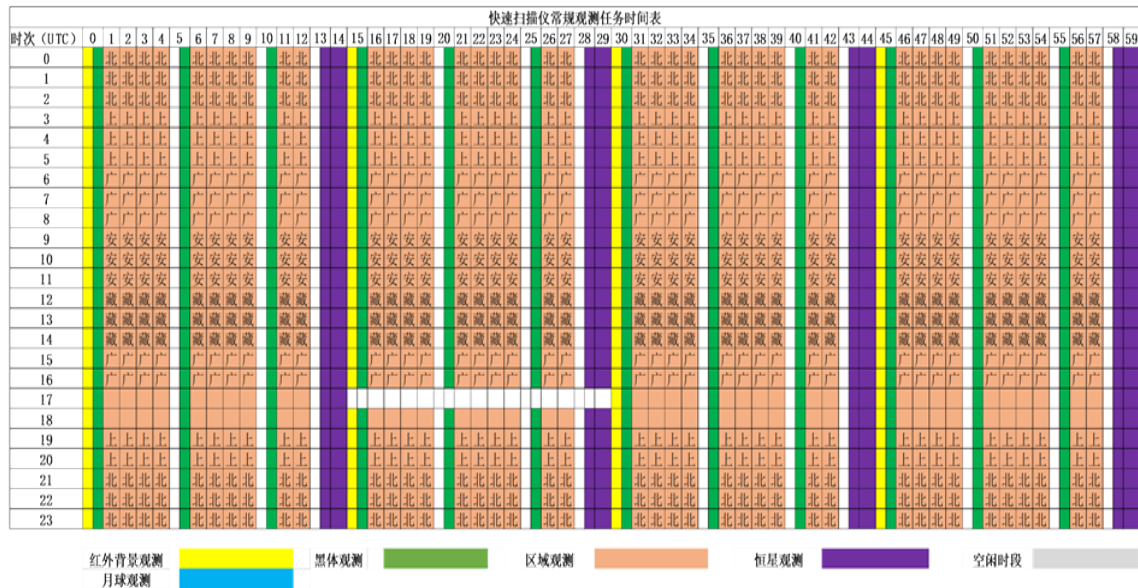◆ It was deployed at 123.5°E on June 10,2021 and recently deployed at 133°E on April 10, 2022.

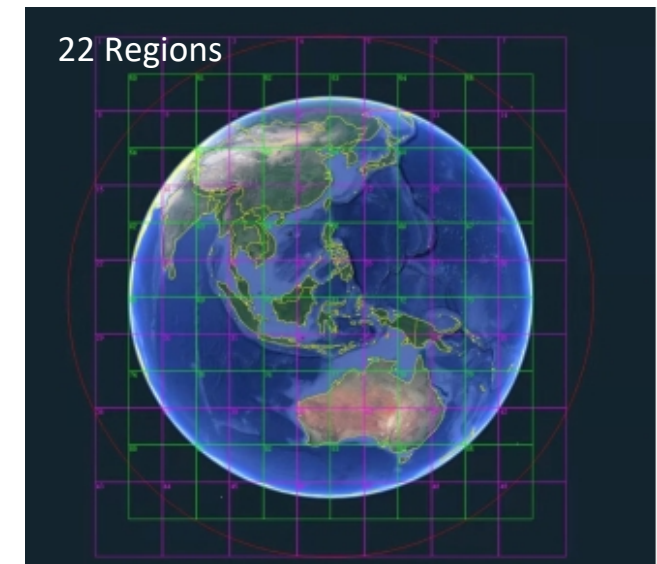Fig. 1 Configuration of Fengyun-4B

Table 1 Characteristics of GHI

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

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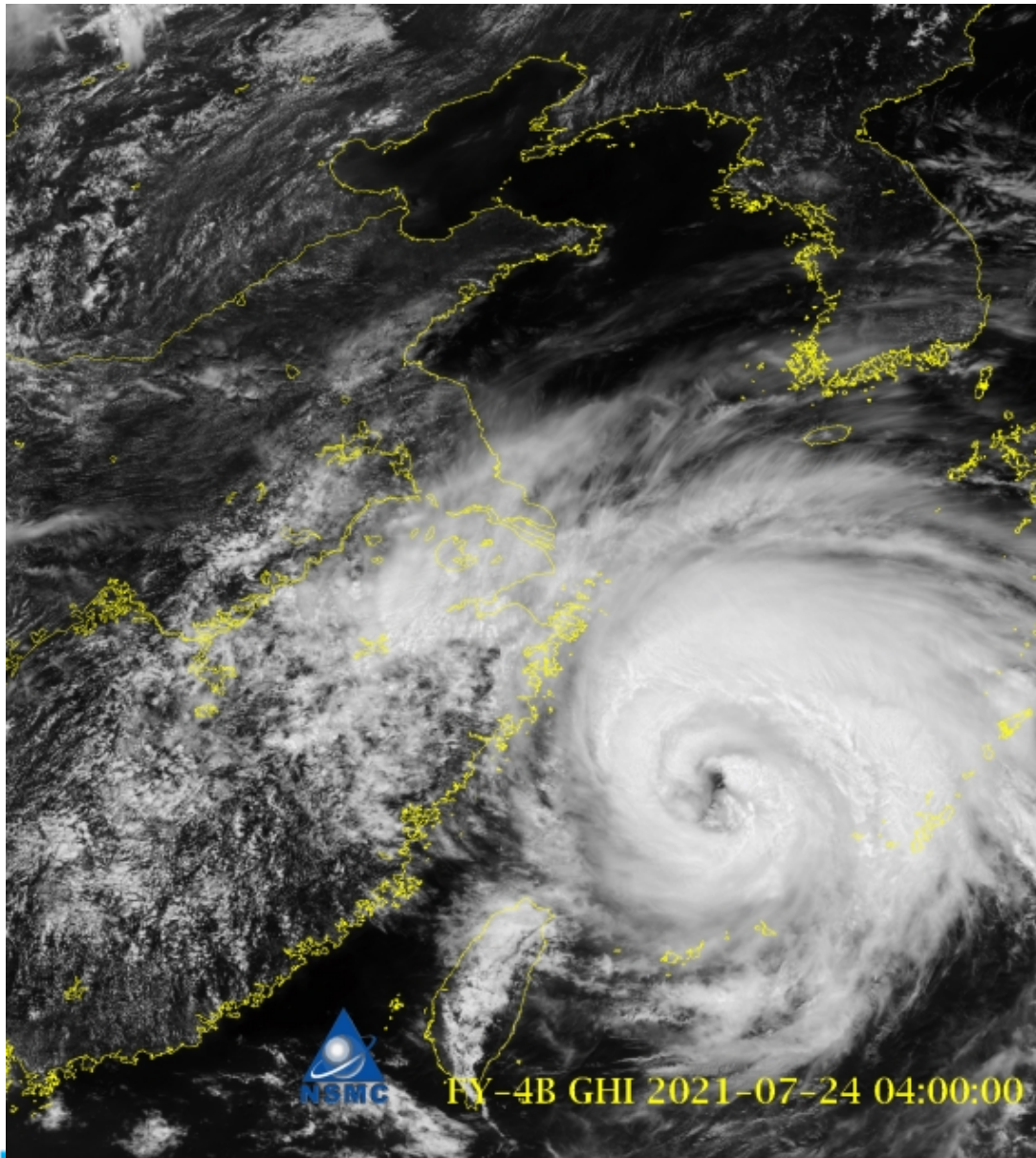
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A possible scan mode for operation

☐ **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.**

36 Regions

2000km*1800km Regions For China

快速扫描仪常规观测任务时间表

红外背景观测 | 黑体观测 | 区域观测 | 恒星观测 | 空闲时段
月球观测

22 Regions

2000km*1800km Regions For Full Disk

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FY-4B GHI 2021-07-24 04:00:00

Observations for Typhoon In-Fa

Radiometric 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	Lon	SatZA	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

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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.**
- ☐ **Based on the observations from December, 2021,** GHI IR mean brightness temperature (Tb) bias with respect to Metop-B/IASI of less than 0.7K.

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

Table 4 Relative differences using prelaunch calibration coefficients

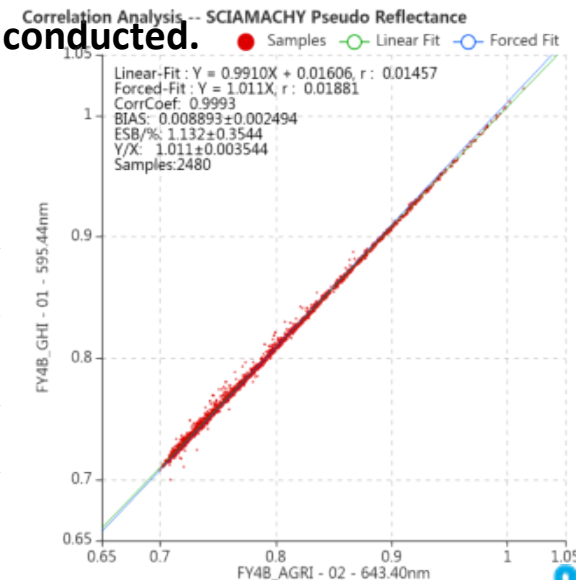| Band	Req.	Prelaunch results	Selected Sites (Nov 12 to Dec 31)		Inter-calibration	
			PDif	std	PDif	std
C1	5%	3.889%	-7.39%	2.982%	/	/
C2	5%	3.398%	2.8637%	3.8067%	-0.2784%	1.643%
C3	5%	3.332%	-5.1307%	2.82%	-4.923%	2.392%
C4	5%	3.582%	-3.41185%	3.4727%	-7.331%	2.368%
C5*	5%	3.675%	/	/	-31.8%(4.566%)	3.382%
C6	5%	3.984%	-8.0237%	2.5862%	-4.529%	2.298%
C7	0.7K	0.82K			0.5822K	

*Channel 5 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 FY-4B AGRI 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%

Correlation Analysis -- SCIAMACHY Pseudo Reflectance
- Samples — Linear Fit — Forced Fit

Linear-Fit : Y = 0.9910X + 0.01606, r : 0.01457
Forced-Fit : Y = 1.011X , r : 0.01881
CorrCoef: 0.9993
BIAS: 0.008893±0.002494
ESB/%: 1.132±0.3544
Y/X: 1.011±0.003544
Samples:2480

FY4B_GHI - 01 - 595.44nm (y-axis)
FY4B_AGRI - 02 - 643.40nm (x-axis)

**Based on SIAMACHY reflectance, GHI's Band 1 is about 1% brighter than AGRI's Band 2.

L1&L2 data product

- ❑ Three FDI with different spatial resolutions and one GEO L1 data products are generated for every task.
- ✓ FY4B-_GHI---_N_REGX_*aaaa*E_L1-_FDI_MULT_NOM_*yyyymmddhhmmss_yyyymmddhhmmss_rrrr*M_V*bbbb*.HDF
- ✓ FY4B-_GHI---_N_REGX_*aaaa*E_L1-_GEO_MULT_NOM_*yyyymmddhhnnss_yyyymmddhhnnss_rrrr*M_V*bbbb*.HDF
- ❑ In L1 data product, the datasets are saved as four groups, namely Calibration, Data, Data_Info and QA Fields.

Table 6 the desrciption of italics in the filename

Characters	Description
aaaa	Norminal satellite longitude
yyyymmddhhnnss_yyyymmddhhnnss	Observation start time to observation end time. yyyy: year(4 digits) mm: month(01-12) dd: day(01-31) hh: hour(00-23) nn: minute(00-59) ss: second(00-59)
rrrr	Spatial resolution at sub-satellite point(0250-2000).
bbbb	The version of the processing software.

Table 7 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
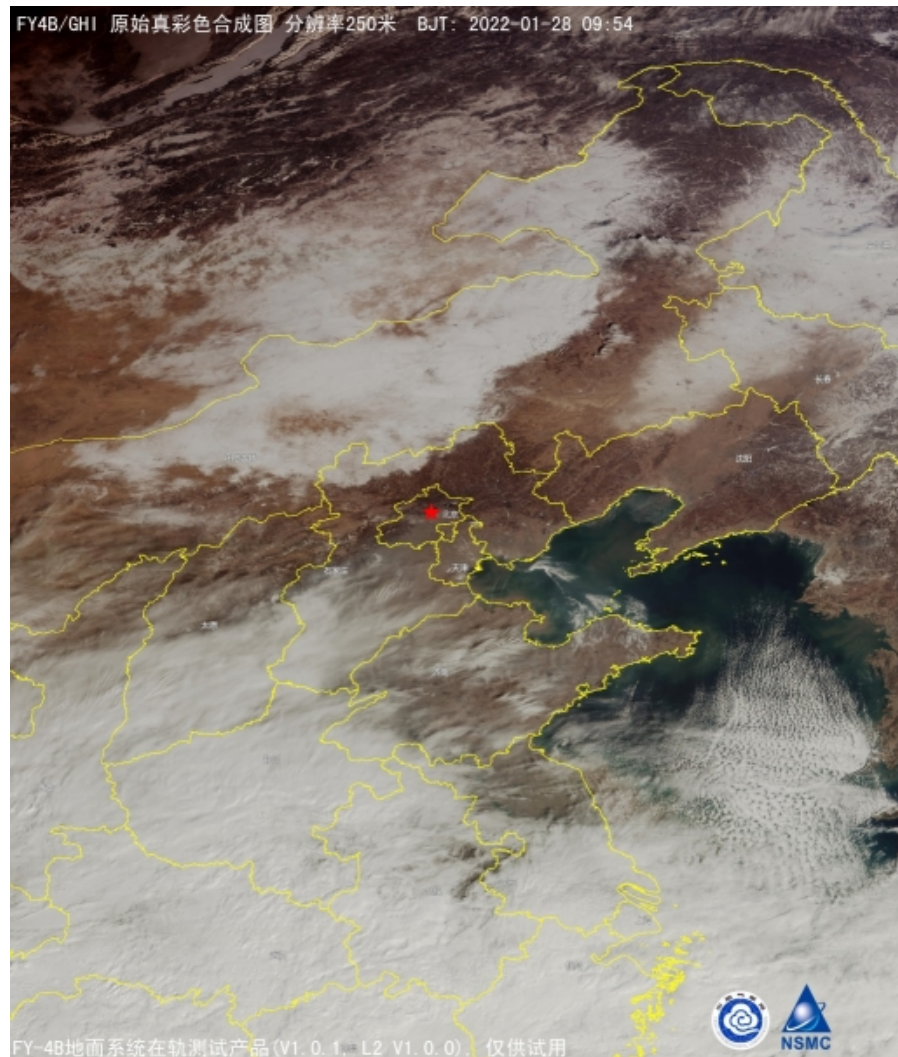
250m true-color imagery from GHI

Conclusions & Discussion

☐ 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;

- ......

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Key issues of relevance to CGMS:

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