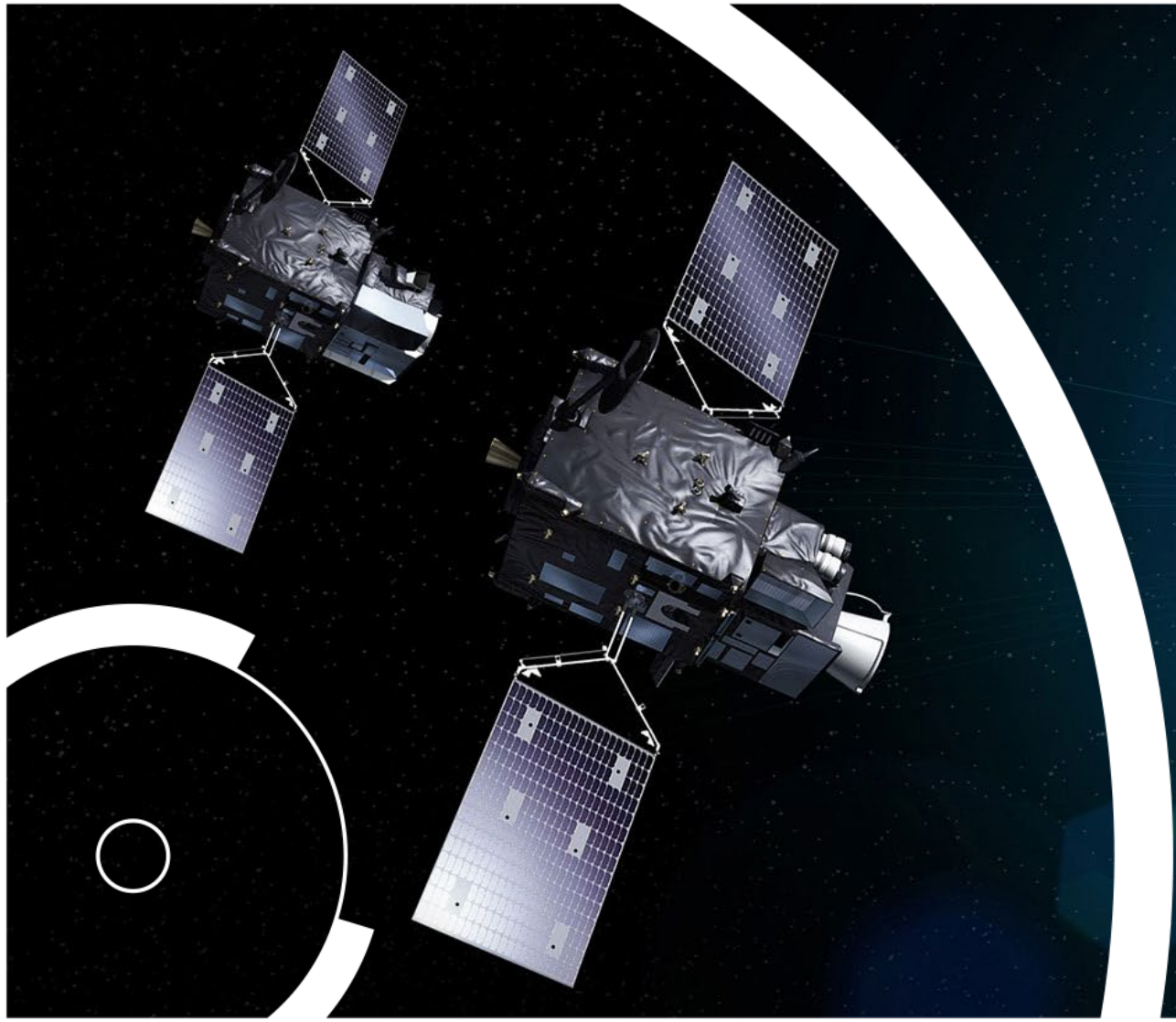


How well the new generation of Chinese IR hyperspectral sounders compare with IASI?

B. Theodore, P. Dussarrat, G. Deschamps, D. Coppens

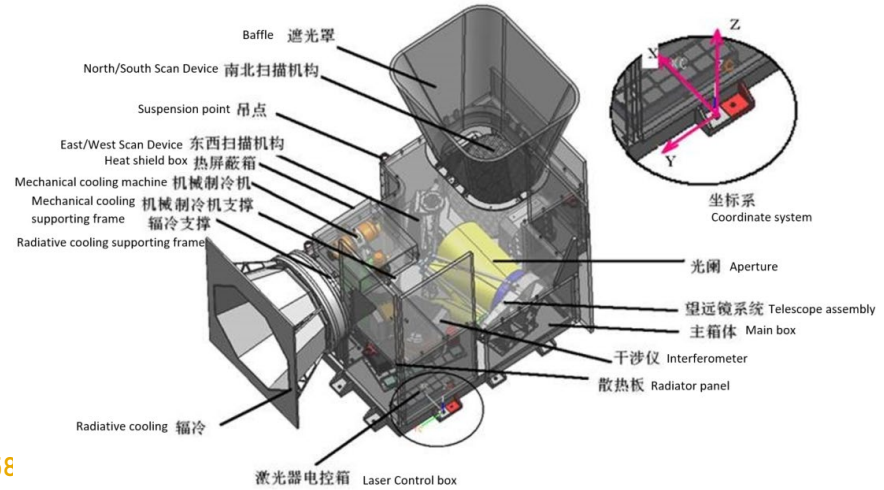
ITSC-24, Tromsoe, 16 March 2023

FY4A/B-GIIRS Properties

http://fy4.nsmc.org.cn/nsmc/en/instrument/GIIRS.html

	FY-4A (R&D)				FY-4B (Operational)			
Spectral parameters (normal mode)		Range (cm^{-1})	Resolution	No. channels		Range (cm^{-1})	Resolution	No. channels
	LWIR	700~1130	0.8	538	LWIR	700~1130	0.625	688
	S/MIR	1650~2250	1.6	375	S/MIR	1650~2250	1.2	500
	VIS	0.55-0.75μm		1	VIS	0.55-0.75μm		1
Spatial Resolution	L/S/MWIR		16km		L/S/MWIR		8km	
	VIS		2km					
Area	China		5000 × 5000 km^2		China		5000 × 5000 km^2	
	Mesoscale		1000 × 1000 km^2		Mesoscale		1000 × 1000 km^2	
Temporal resolution	China		<1 hour		China		<1 hour	
	Mesoscale		<½ hour		Mesoscale		<½ hour	
Sensitivity ($mW/m^2sr \cdot cm^{-1}$)	LWIR		0.5~1.1		LWIR		0.3	
	S/MIR		0.1~0.14		S/MIR		0.06	
	VIS		S/N>200(ρ=100%)		VIS		S/N>200 (ρ=100%)	
Calibration accuracy (radiation)	1.5k (3σ)				1.0k (3σ)			
Calibration accuracy (spectrum)	10 ppm (3σ)				5 ppm (3σ)			
Quantization (bits)	13				13			

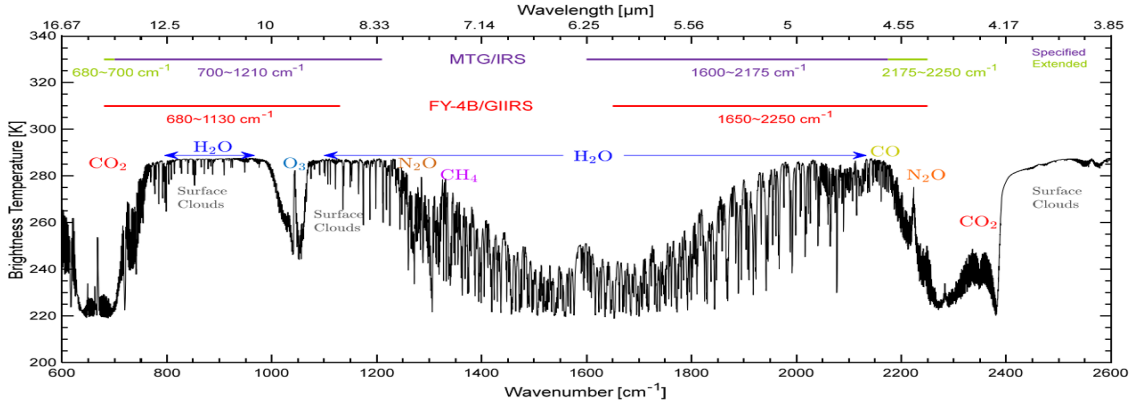
http://gsics.atmos.umd.edu/pub/Development/Annualmeeting2022/2022.03.12%20Performance%20Status%20of%20FY-3E%EF%BC%8FHIRAS%20and%20FY-4B%EF%BC%8FGIIRS.pdf



www.eumetsat.int

https://img.nsmc.org.cn/PORTAL/NSMC/DOC/CONFERENCE/AOMSUC/AOMSUC11/POSTER/2-3-NI.pdf

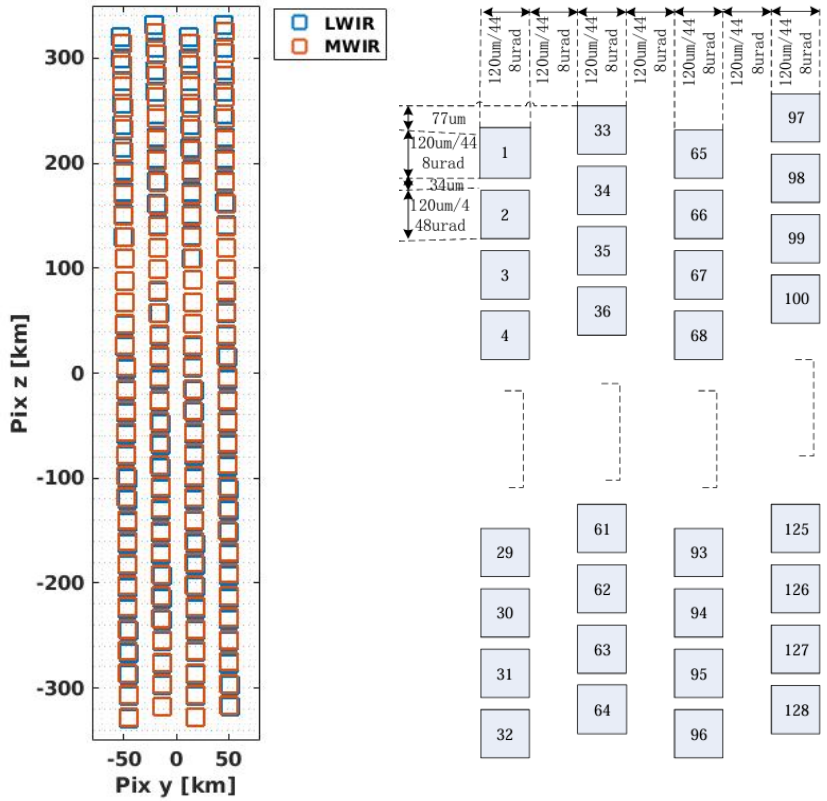
	FY-4A/GIIRS	FY-4B/GIIRS
Spectral Range	LWIR:700cm^{-1}-1130cm^{-1} S/MIR:1650cm^{-1}-2250cm^{-1}	LWIR:680cm^{-1}-1130cm^{-1} S/MIR:1650cm^{-1}-2250cm^{-1}
Spectral resolution	0.625cm^{-1}	0.625cm^{-1}
Temporal Resolution	35min（1000*1000） 67min（5000*5000）	45min（5000*5000）
Sensitivity(mW/m^2sr cm^{-1})	LWIR:0.5-1.1 S/MIR:0.1-0.14 S/N≥200 (ρ=100%)	LWIR:≤0.5 S/MIR:≤0.1 S/N≥200 (ρ=100%)
Calibration accuracy (radiation)	1.5K	0.7K
Calibration accuracy (spectrum)	10ppm	<10ppm
Spatial Resolution	L/S/MIR:16km VIS:2km	L/S/MIR:12km VIS:1km



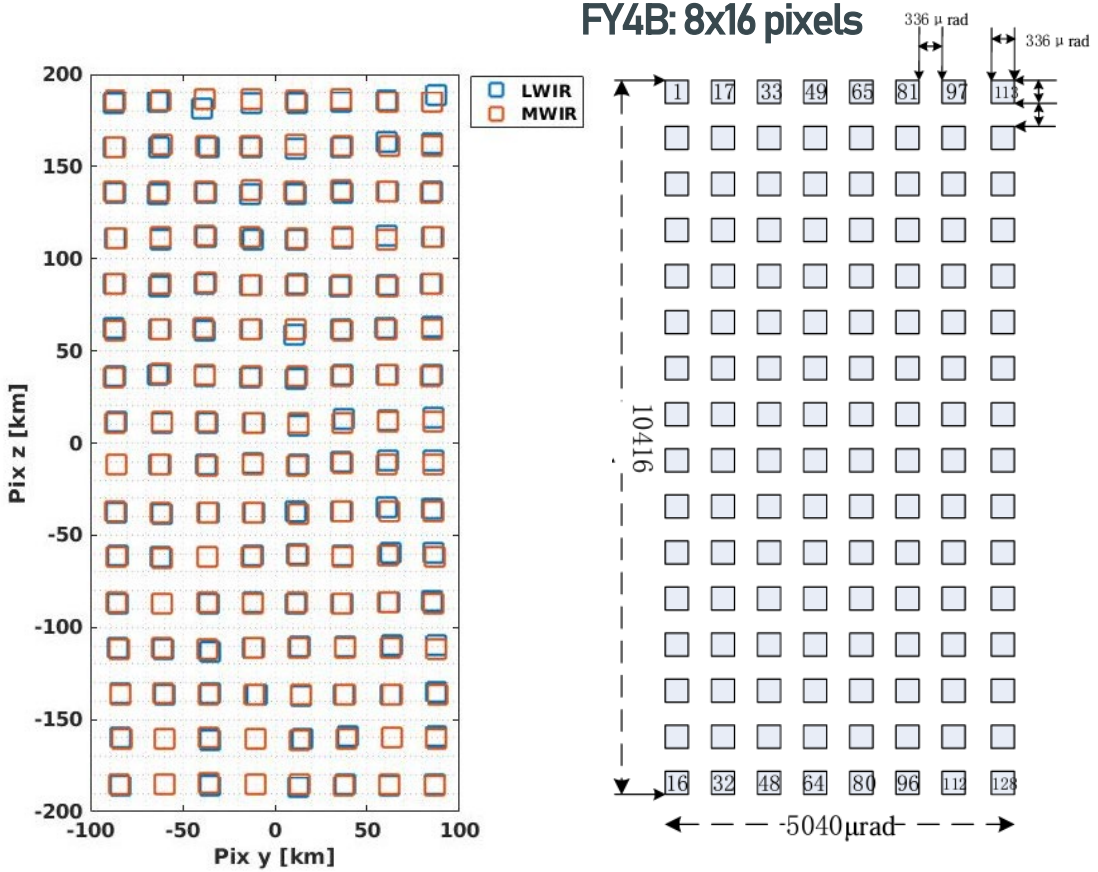
Detector Matrix

- Pixel matrix and co-registration (using NADIR dwell and product lat/long):

FY4A: 4x32 pixels



FY4B: 8x16 pixels



https://img.nsmc.org.cn/PORTAL/NSMC/DOC/CONFERENCE/AOMSUC/AOMSUC11/POSTER/2-3-NI.pdf

- GIIRS-B detector array more regular, pixels gap on purpose ?

GIIRS scan

Platform SSP:

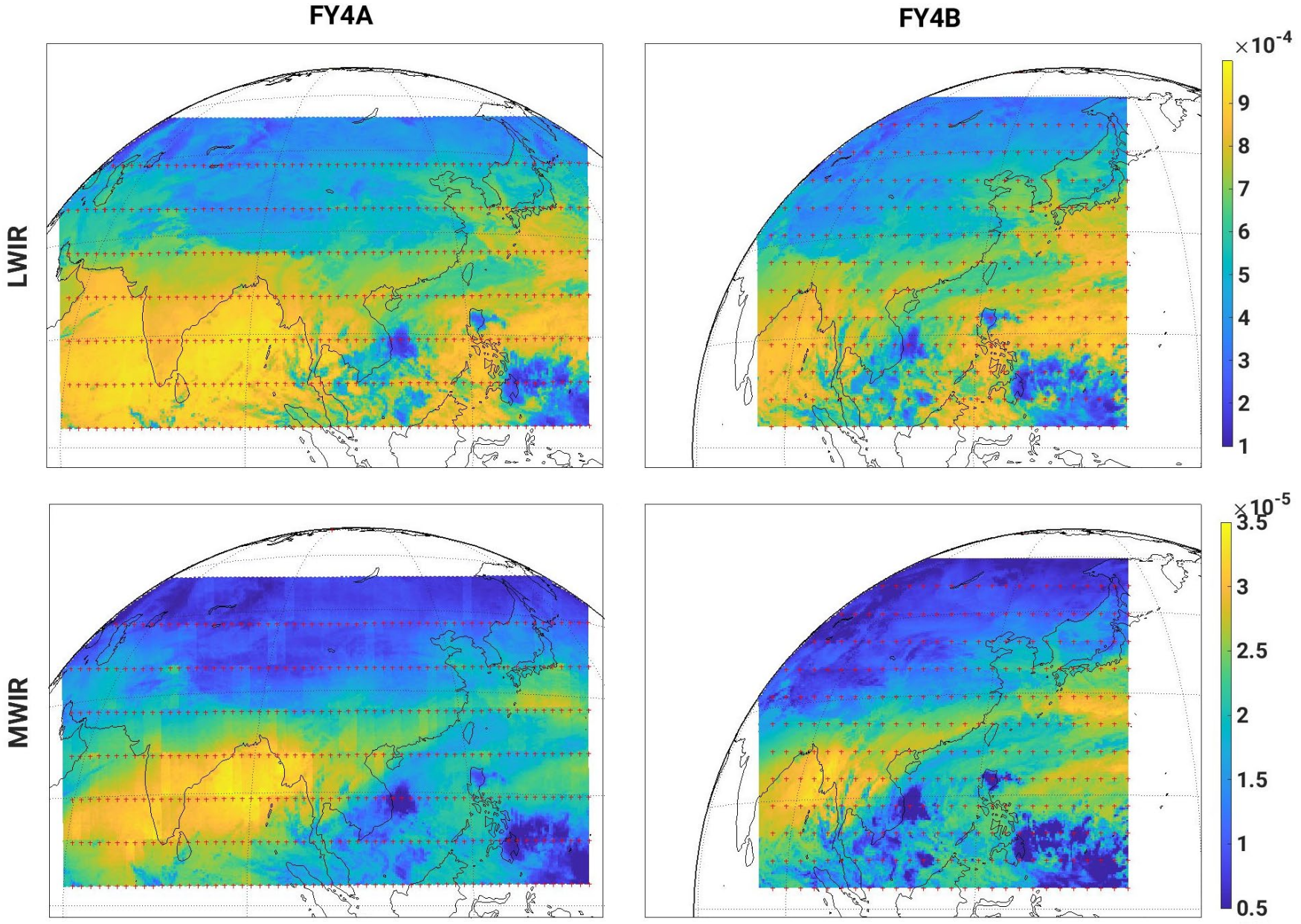
GIIRS-A : 104.7E

GIIRS-B : 133E

12 full scans of north Asia per day made of:

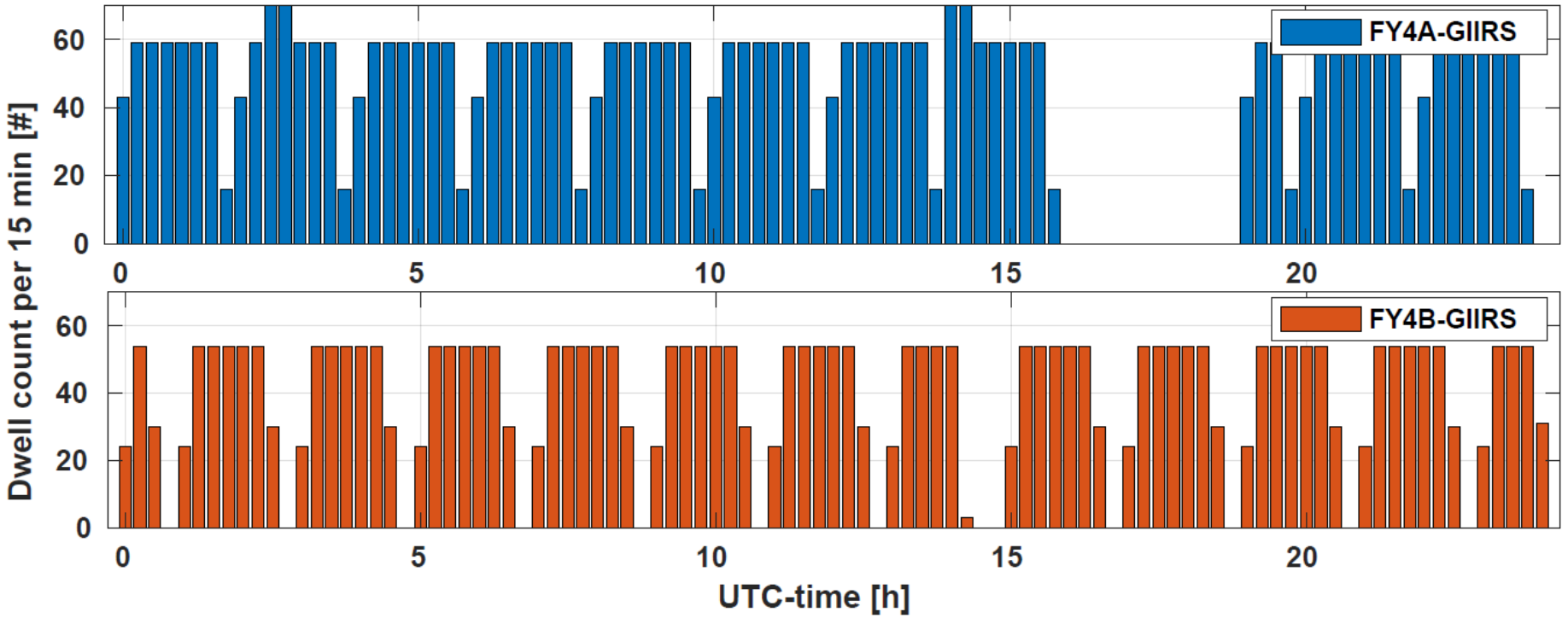
GIIRS-A : 7x59 stares

GIIRS-B : 12x27 stares



GIIRS scan

- Number of dwells per 15min (“Observing Beginning Time” product):
  - Dips in data because of calibration views every two hours ?
  - Star detection for navigation: https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=8629974

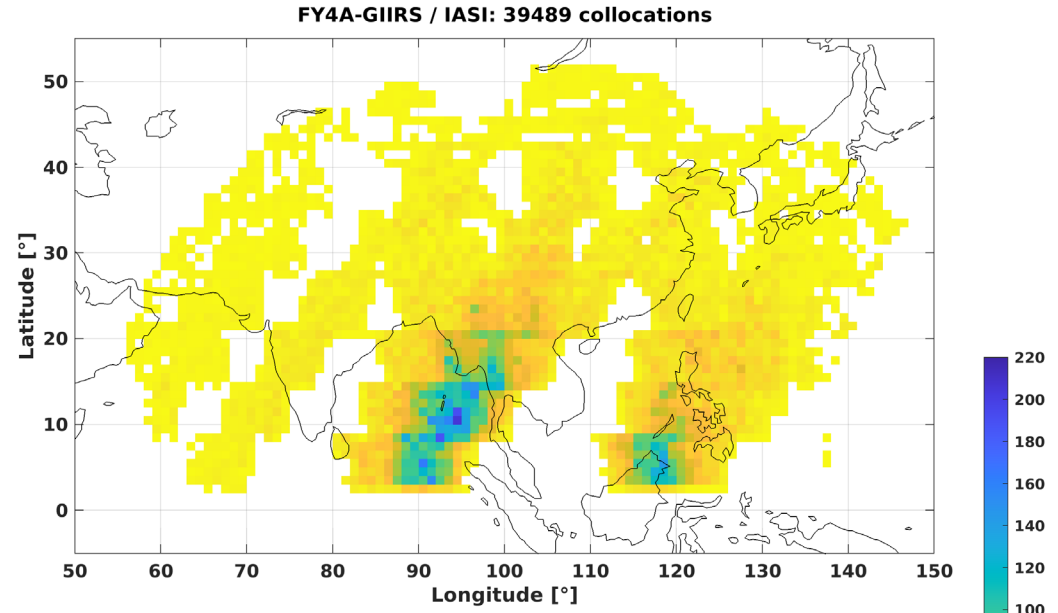


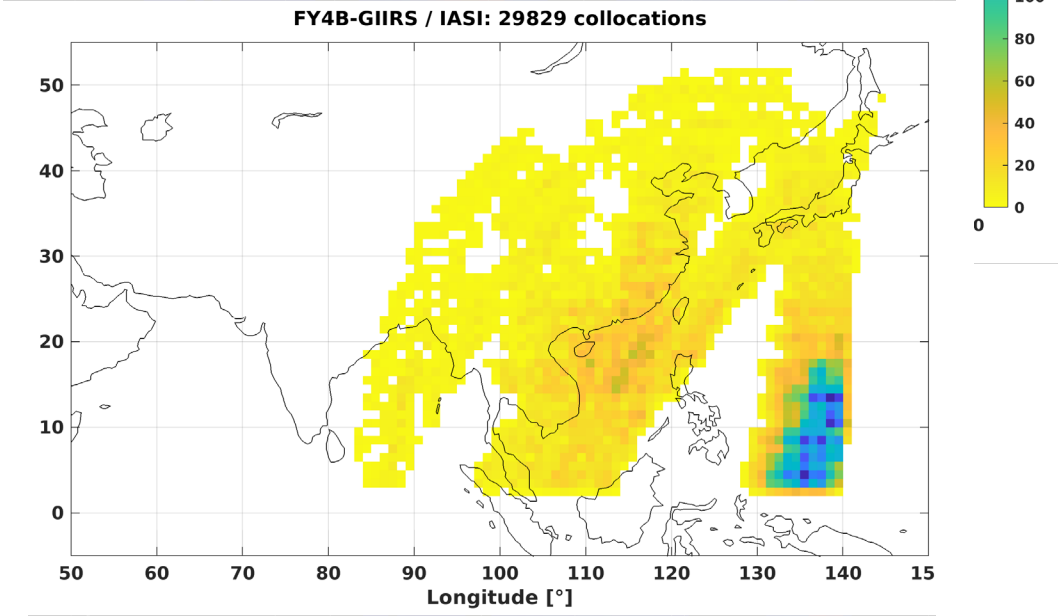
  - No measurements at around 17:00 UTC for FY4A and at 14:30 UTC for FY4B, exactly when the platforms face the sun ! Probably to avoid sun-straylight...

FY4A/B-GIIRS vs. IASI collocations

Colocation parameters:

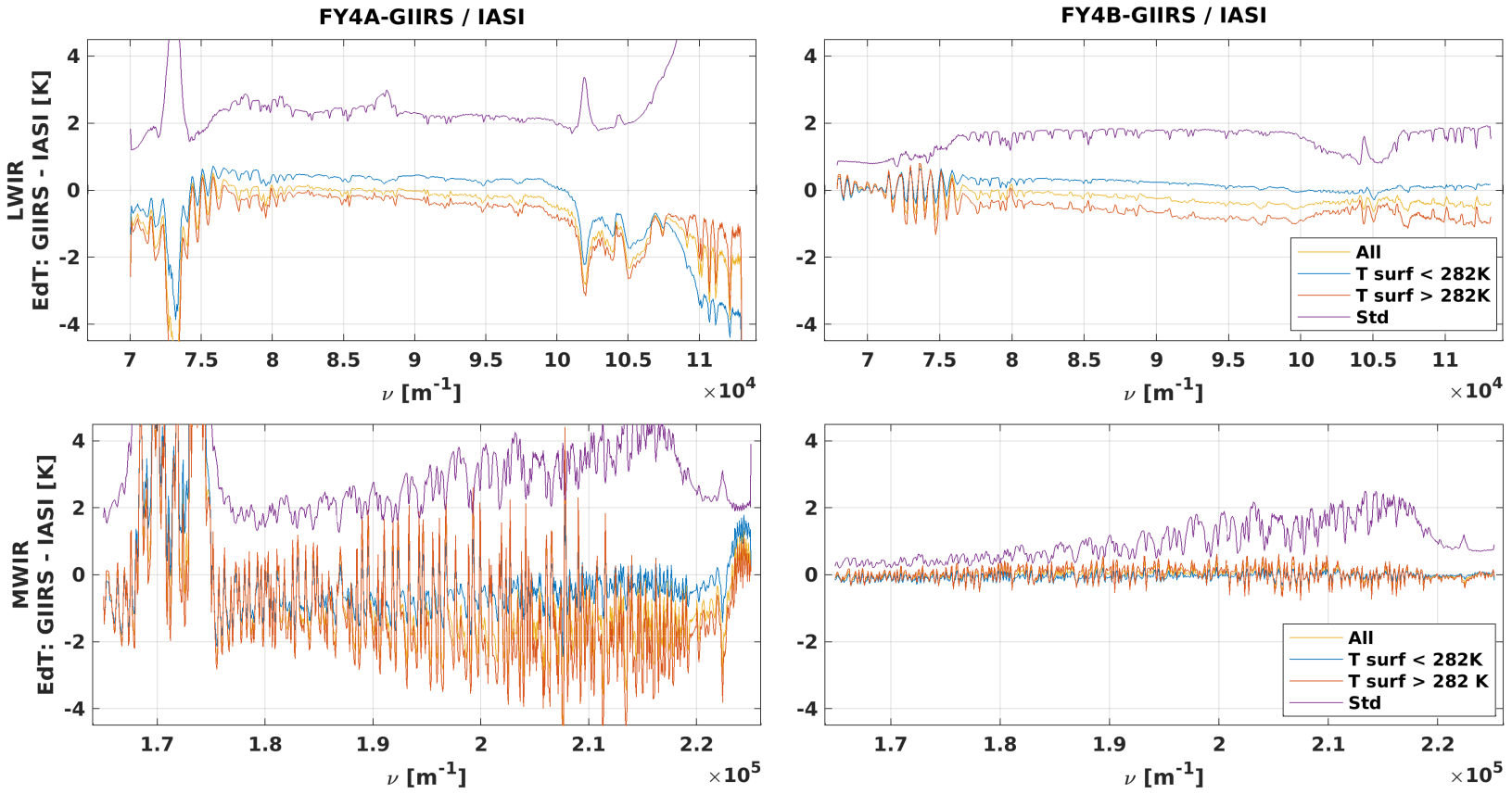
- 12/12-15/1: ~1 month
- Colocations criteria:
  - Δt = 1000s
  - Δd = 10km (GIIRS-A/B pixel = 16/12km)
  - $\Delta \theta$ = 10degrees (zenith)
- GIIRS-A vs. IASI = 39489 colocations
- GIIRS-B vs. IASI = 29829 colocations





FY4A/B-GIIRS vs. IASI Radiometric Calibration

- Re-apodisation of IASI and GIIRS-A (not apodised) to match GIIRS-B Hamming apodisation and sampling (= $62.5\mathrm{m}^{-1}$)
- Radiometric calibration evaluation as function of the scene temperature

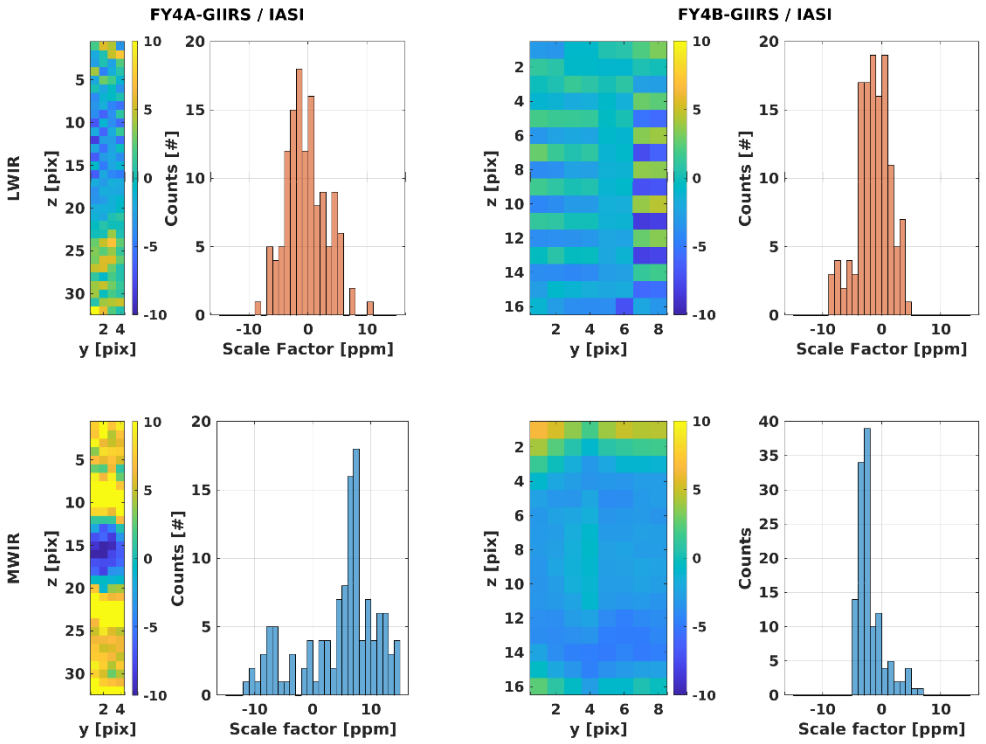


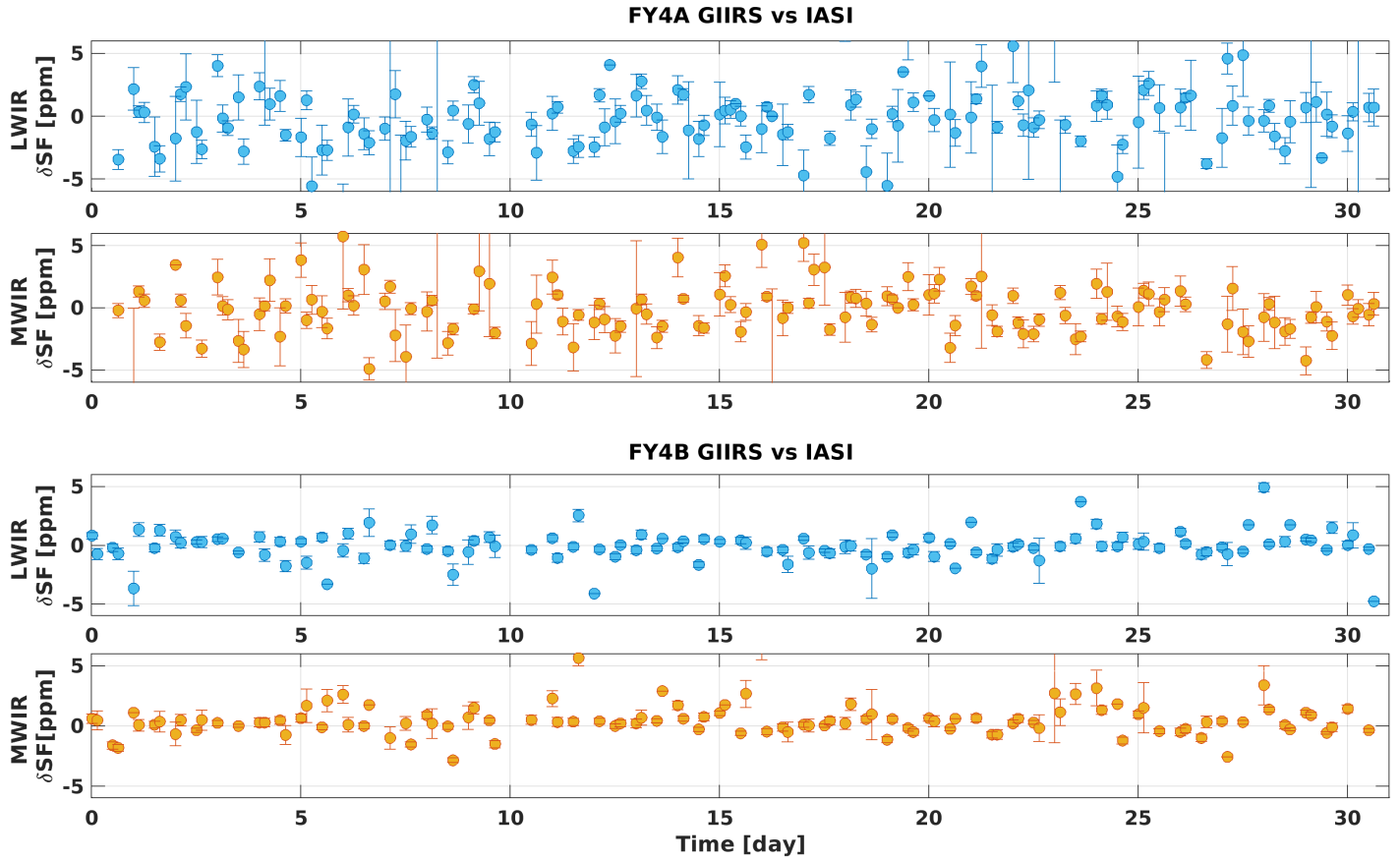
Warm scenes are measured too cold and cold scenes too warm➔ probably an indication of infield straylight

- GIIRS-B is significantly better: no more contaminations, less scene-dependency !

FY4A/B-GIIRS vs. IASI Spectral Calibration

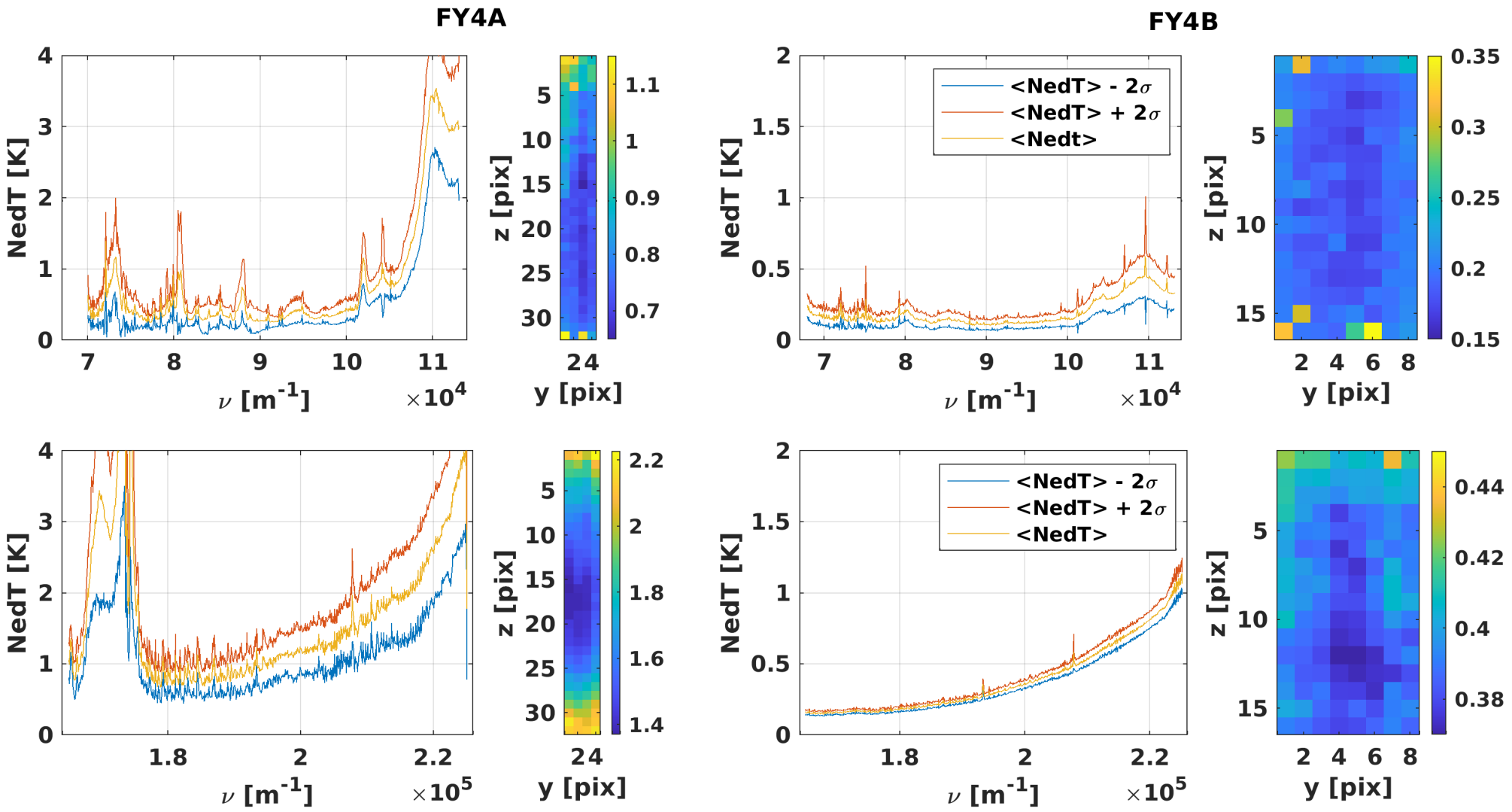
- Spectral scale factors are computed using IASI as reference





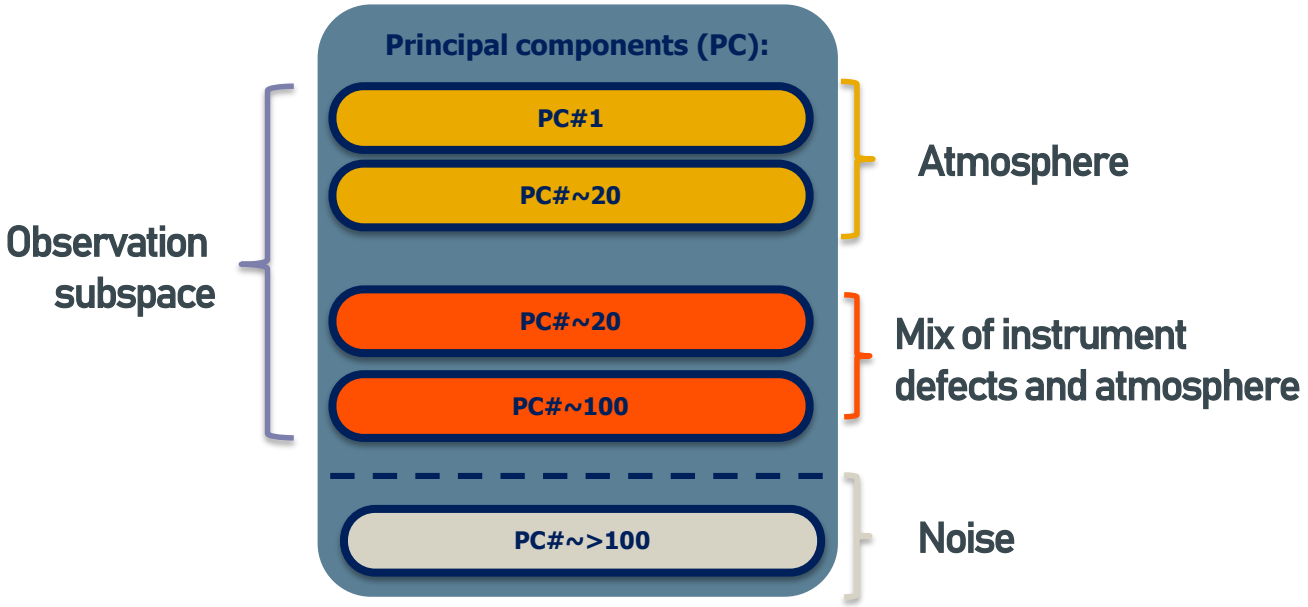
- Spectral calibration satisfies the requirement of 10 ppm for both GIIRS. It is however better for GIIRS-B with much less dispersion and a better time-stability

Noise estimation

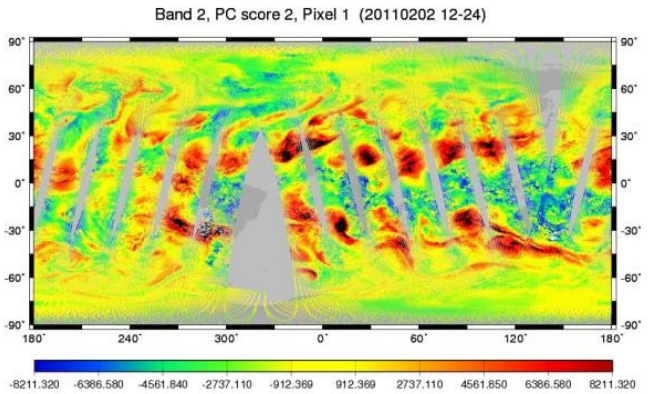


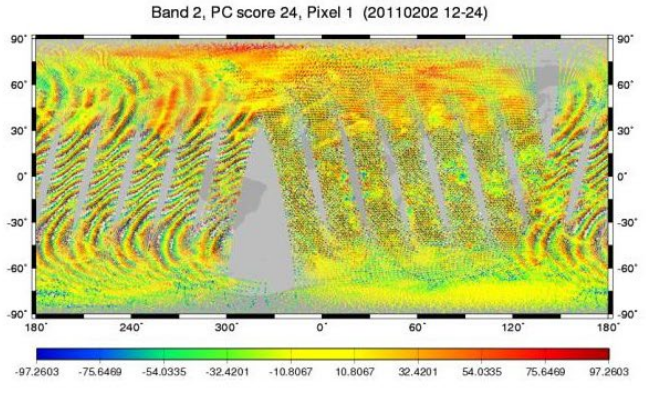
PC Decomposition

- Principal Component Analysis (PCA) can help highlighting some instrumental defects/characteristics



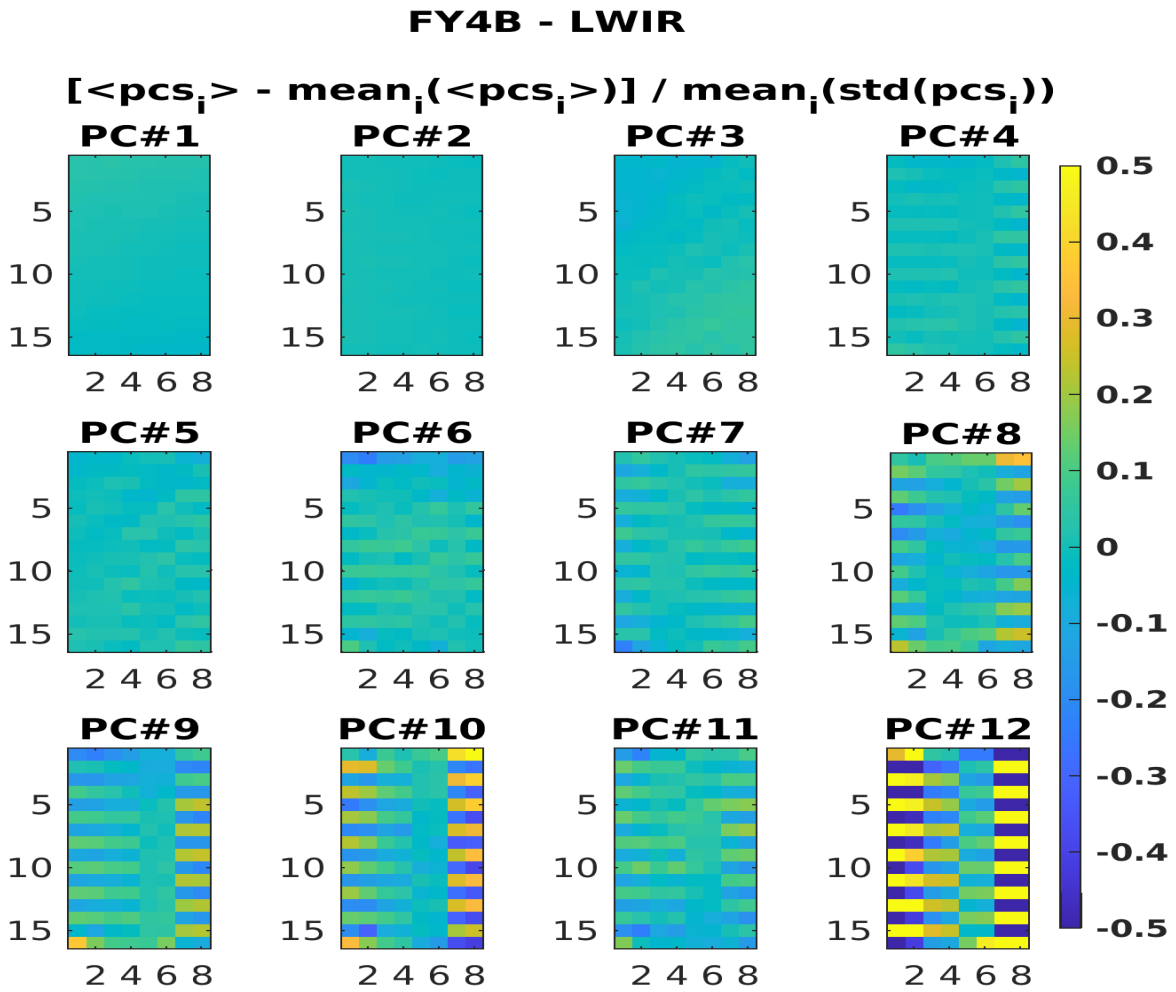
- IASI:
  - Band 2: PC#24 = snake skin:
  - Associated to vibrations.

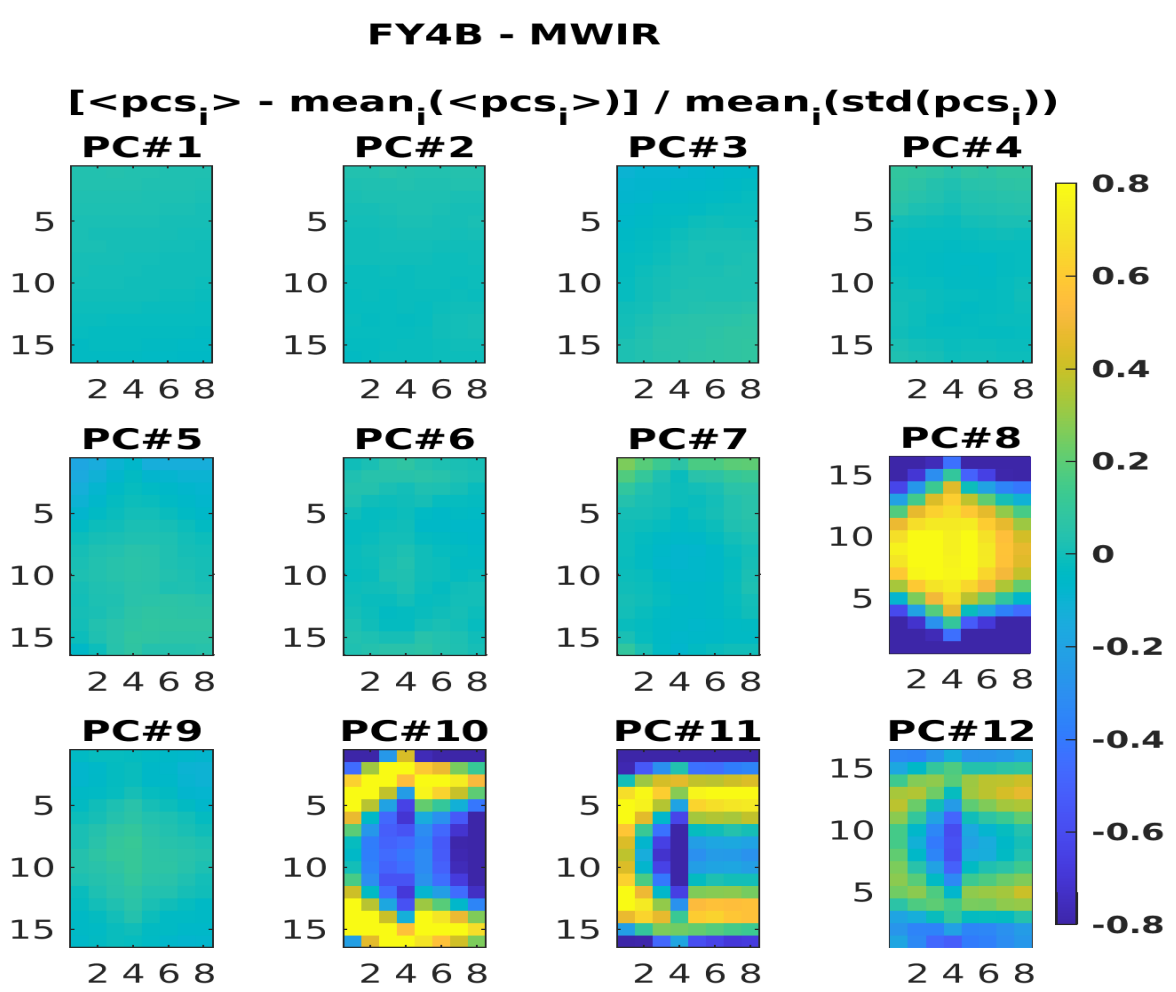




FY4B GIIRS PCA

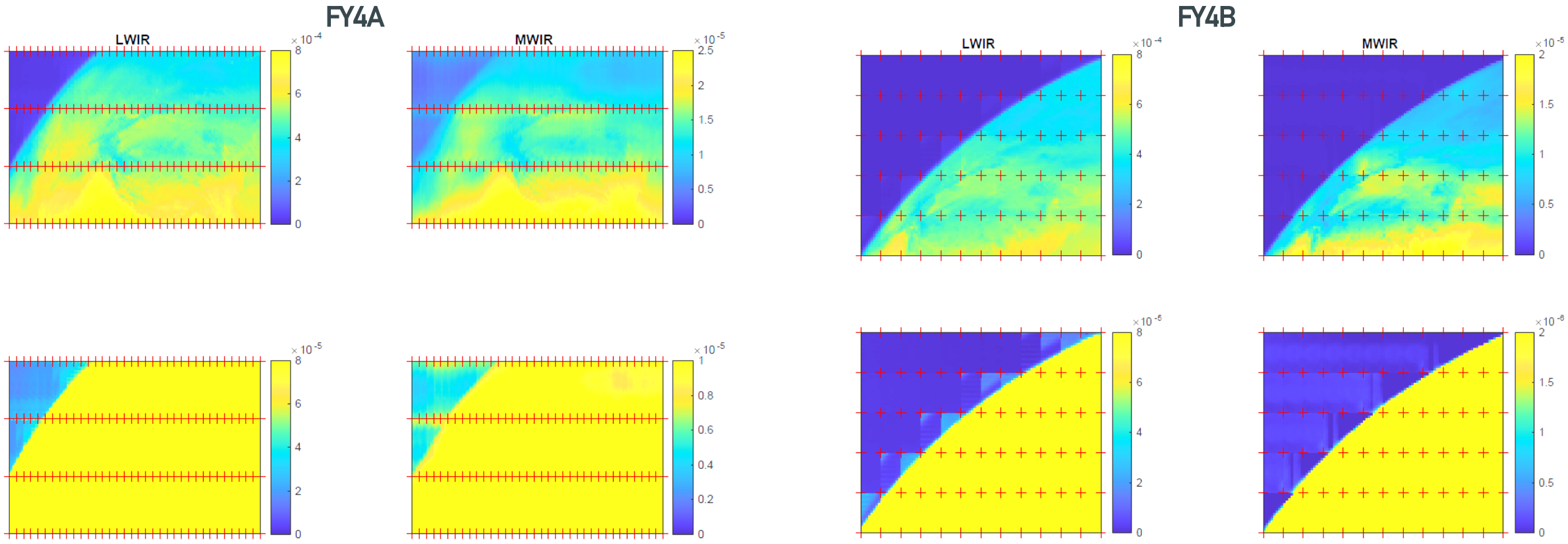
- FY4B-GIIRS:
  - LWIR: PC#12 = checkerboard:
  - MWIR: PC#8 = diamond:
  - Both associated with spectral calibration issues.





FY4A/B-GIIRS Limb views

- Analysis of Earth limb (averaged on ~3 days) data looking for straylight
- Enhanced contrast to trace residual signal in space:

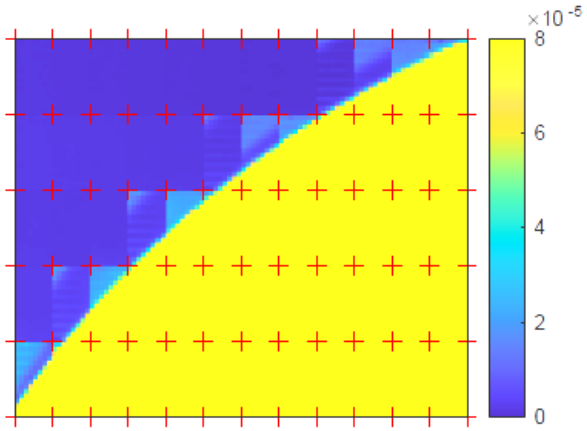


- Definitive improvement ! But GIIRS-B residual straylight is still clearly visible ~1% !
  - LWIR: In-field symmetric ghosts ! / MWIR: Out-of-field Earth straylight !

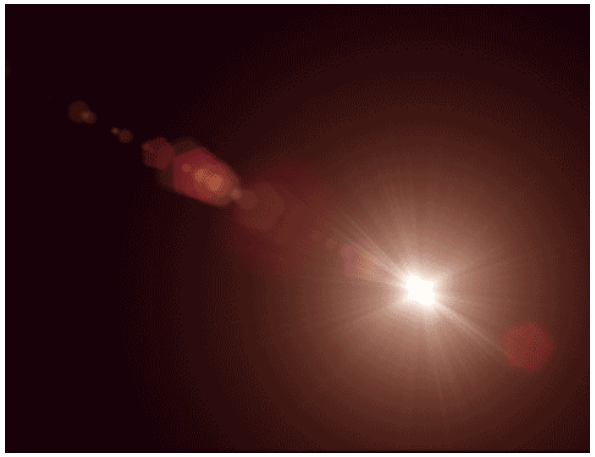
FY4B-GIIRS LWIR straylight

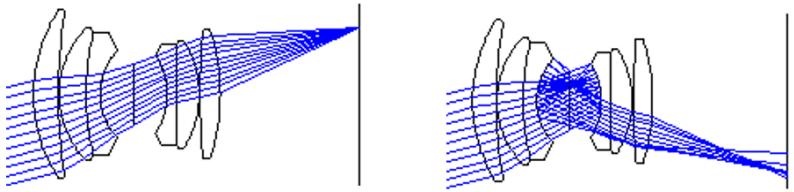
- Simulation of GIIRS LWIR in-field straylight: slightly un-focused symmetrical ghosts = camera flares ?
  - Hypothesis of ~3.5% ghosts

FY4B LWIR Measurements:

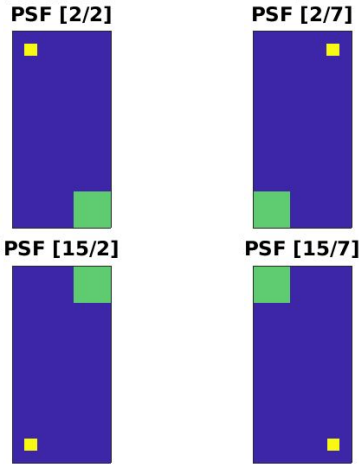


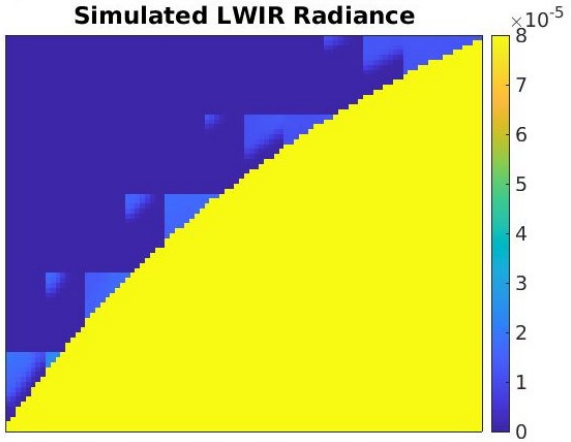
Flare examples:





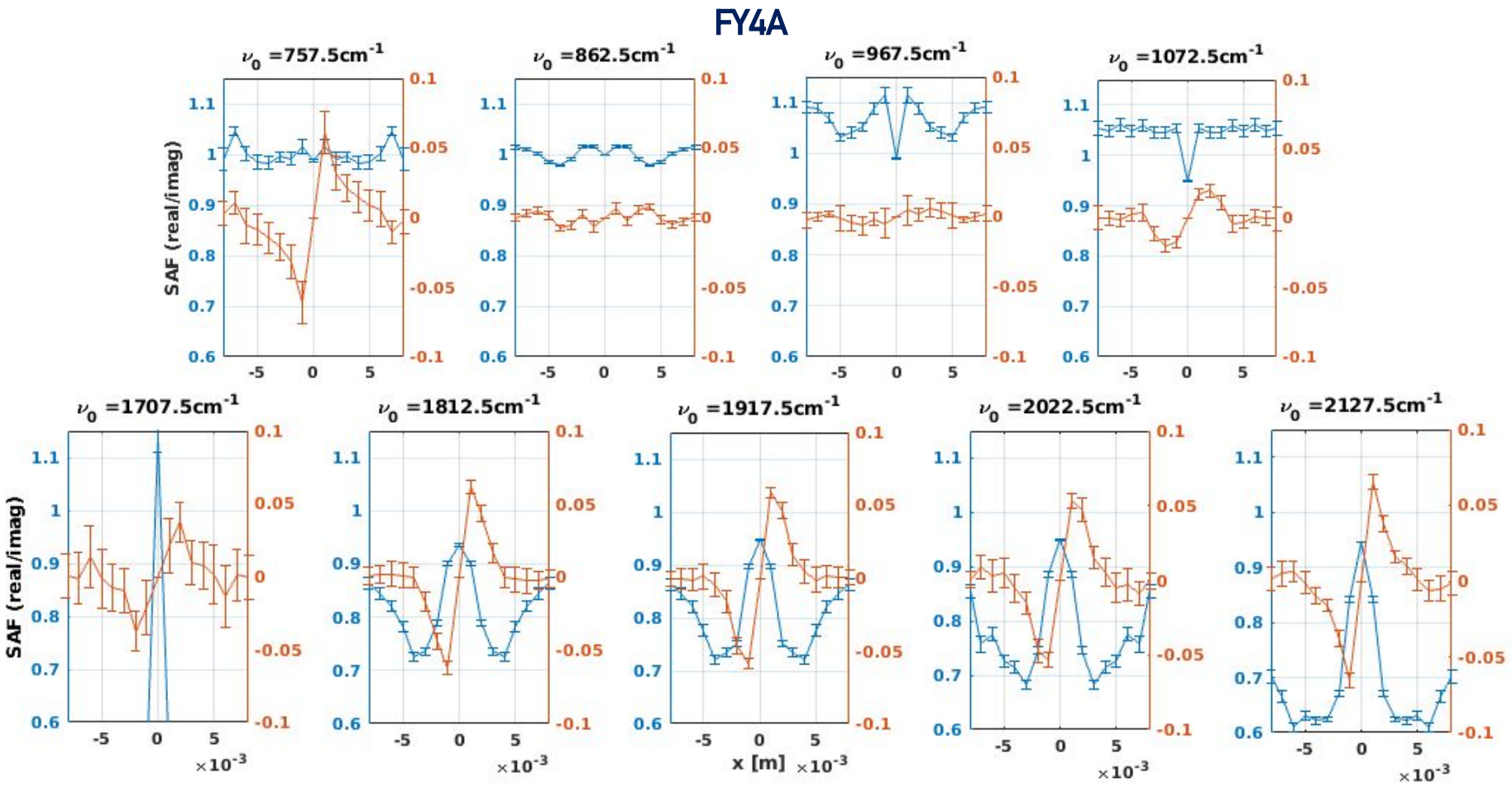
Flare simulations





SAF retrieval

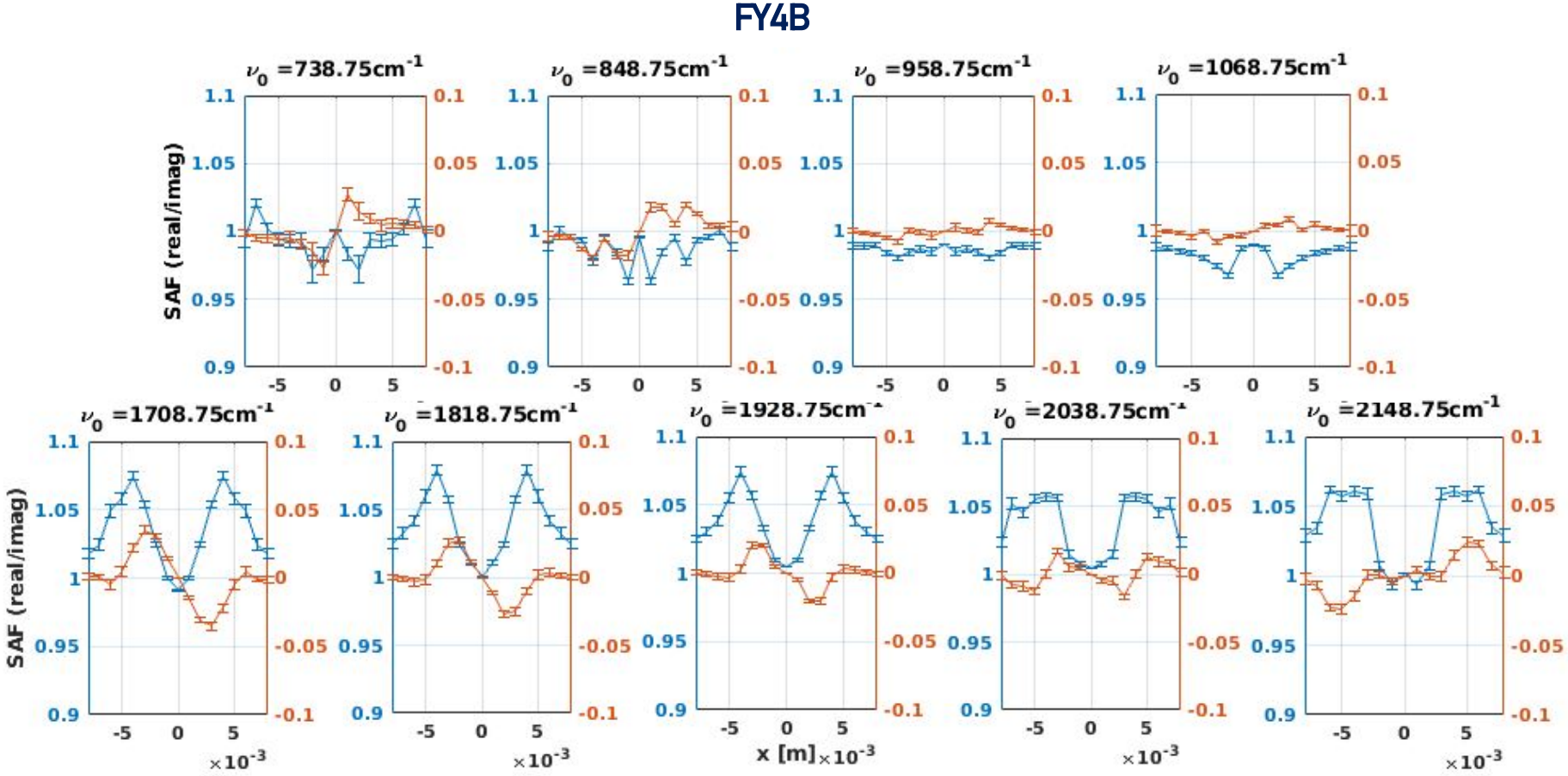
- FY4A-GIIRS SAF retrieval (all detector included):



- Straylight effects…. ?

SAF retrieval

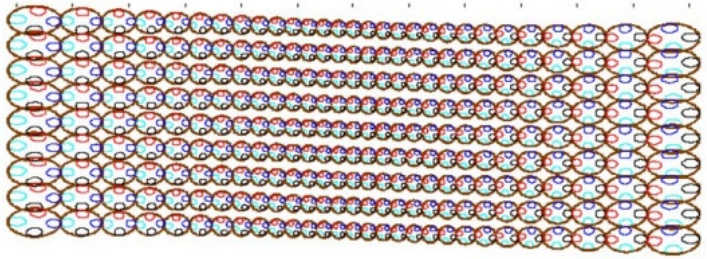
- FY4B-GIIRS SAF retrieval (all detector included):

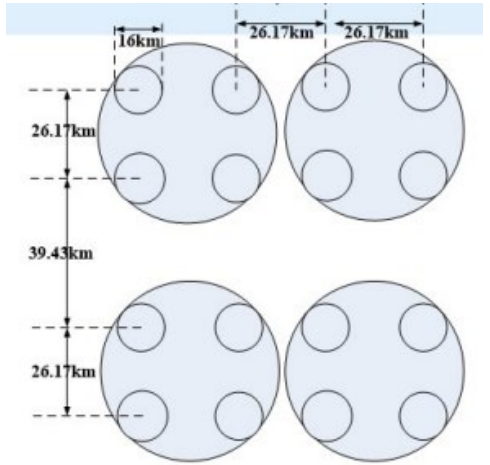


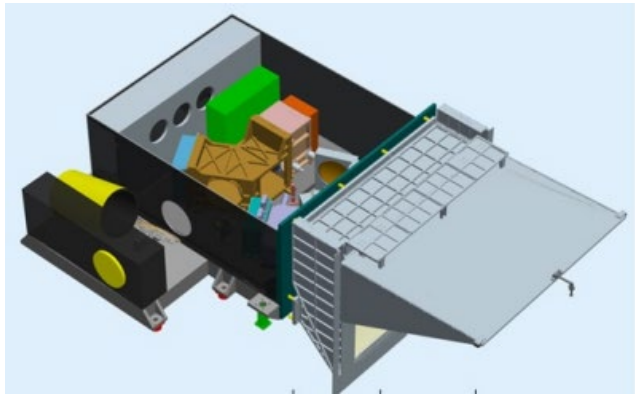
- MWIR wrong apodisation ? Straylight effects…. Over-correction TBC

A word about HIRAS

- FY3-D/E : LEO
- 4 Pixels x 29 scan angles ≅ IASI







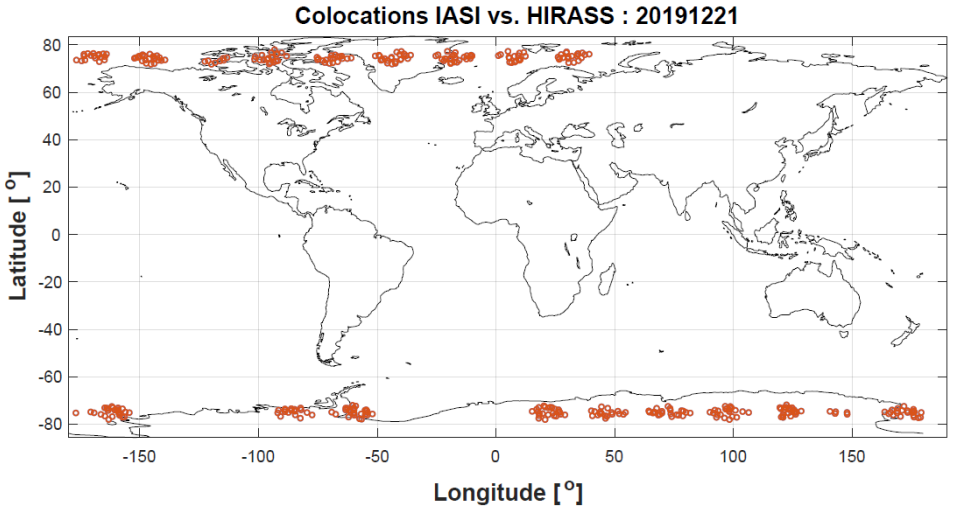
- Specifications :

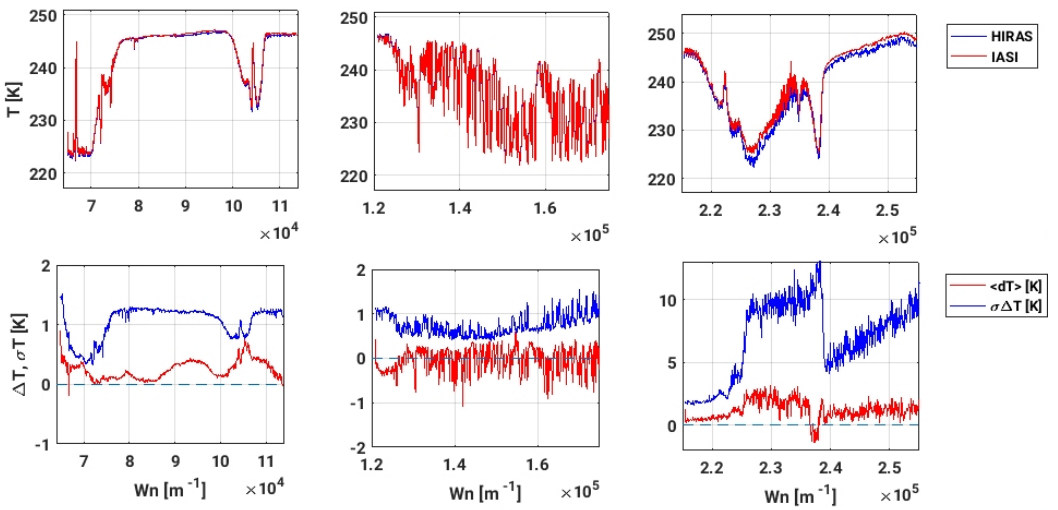
Band	Spectral range (cm-1)	Resolution (cm-1)	NEΔT @250K	chs
Longwave	650 *– 1136 (15.38 μm-8.8 μm)	0.625	0.15K	778
Midwave1	1210 – 1750 (8.26μm-5.71 μm)	1.25	0.1K	433
Midwave2	2155-2550 (4.64μm-3.92 μm)	2.5	0.3K	159

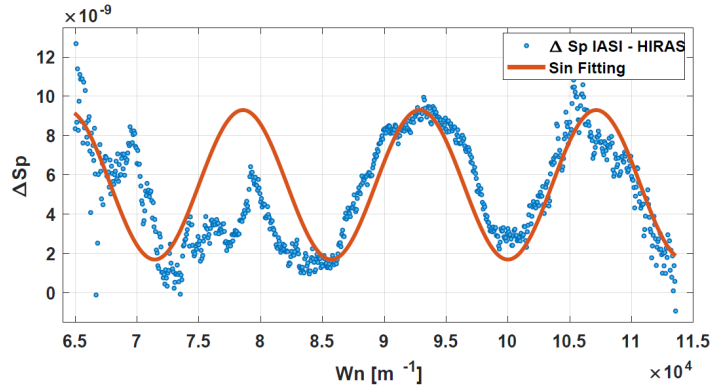
- Direct flux available @ EUMETSAT since 2020 (FY-3E) and 2023 (FY-3E)

HIRAS vs. IASI

- Colocations parameters : $< (7.5km)^2 \quad < 300s$ only at the poles with additional parameters (optional) : zenith, azimuth, scene types (cloudy, sea ..), long/lat







- Around 300 hundred colocations are found during one day every two weeks with all three IASI.
- NB : There is a geo-localisation difference between MWIR and LWIR (20-60km) !

Suspicions toward an etalon effect (stray light) occurring in LWIR band, coating issue creating a ~10μm cavity

In conclusion…

- GIIRS-B shows a definitive improvement wrt. GIIRS-A !
- Some instrumental effects could be as stake (mis-alignment, defocus, ringing, etalon, ZPD shift …), very interesting in the perspective of IRS (and IASI-NG)
- GIIRS-B is close to operational quality: assessment on going @ ECMWF, please see Chris Burrows'poster
- More work needed on HIRAS whose data seems very promising

Thank you!

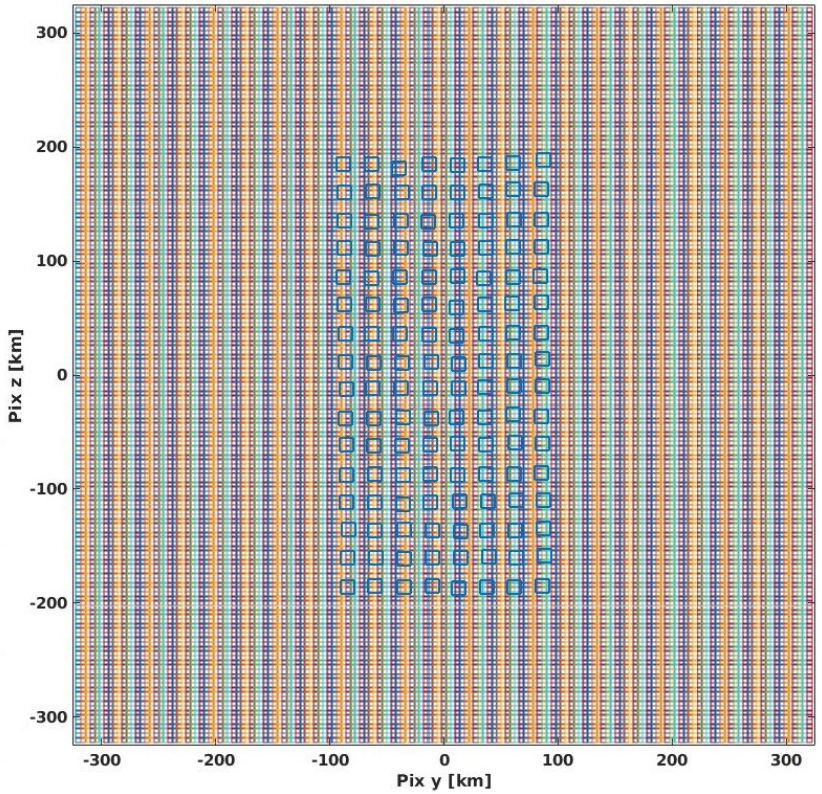
Questions are welcome.

FY4B-GIIRS scan

- ~2h full scan of GIIRS-B over Asia/China = ~320 times 16x8 soundings:

FY4B-GIIRS 2h scan
(averaged LWIR band)

FY4B-GIIRS vs. MTG-S IRS dwell

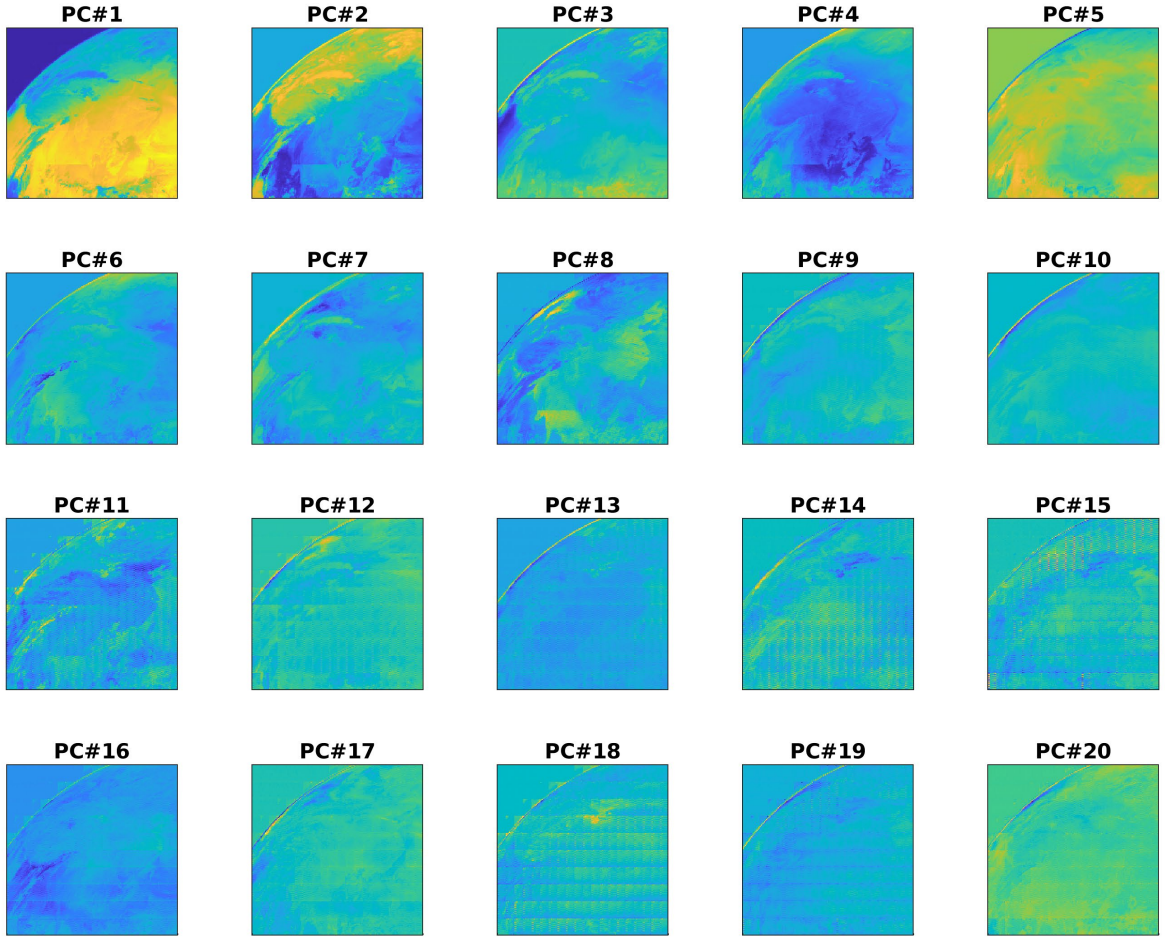


- MTG-S IRS will perform ~560 times 160x160 soundings in 2 hours, 350 times denser than FY4B-GIIRS !

FY4B GIIRS PCA

- FY4B-GIIRS:
  - LWIR: PC#12 = checkerboard:
  - MWIR: PC#8 = diamond:
  - Both associated with spectral calibration issues.

FY4B GIIRS LWIR



FY4B GIIRS MWIR