Inter-calibration of Himawari-8/AHI using CrIS as a reference

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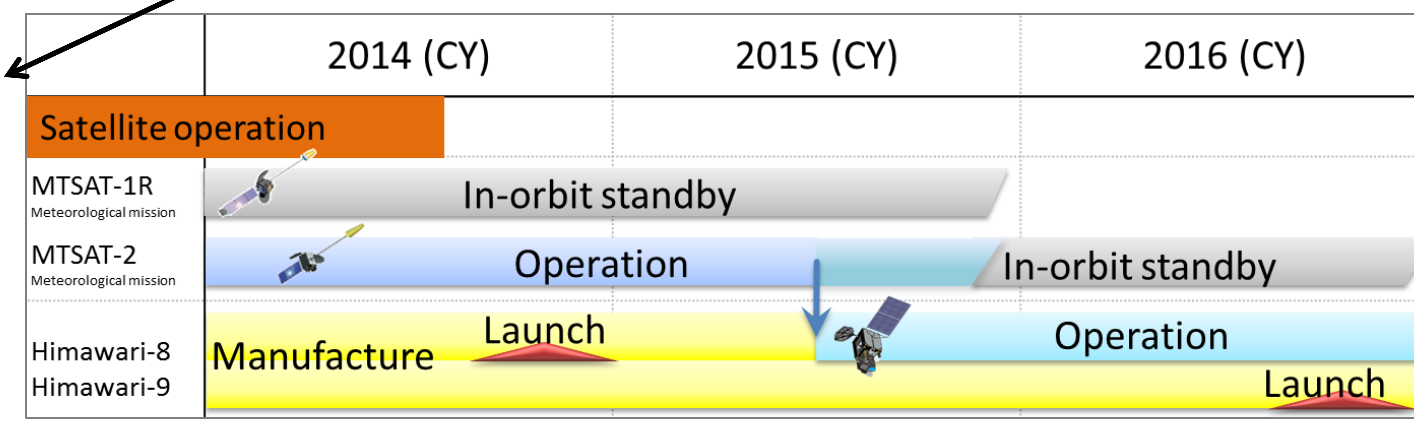
Acknowledgement

JMA is grateful to NOAA for our collaboration on AHI/ABI Cal/Val activities

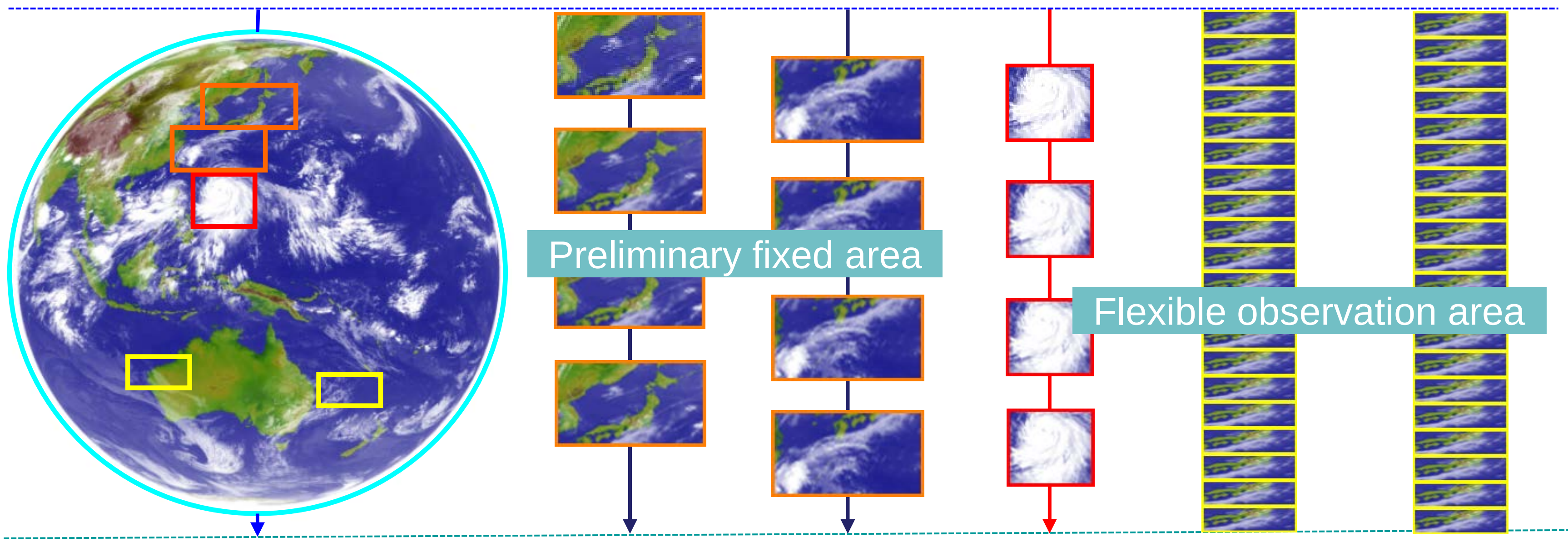
Advanced Himawari Imager (AHI) on Himawari-8

Band	Central Wavelength [µm]	Spatial Resolution [km]	# of Detectors*	Levels of digital count [bit]
1	0.47	1	676 (3)	11
2	0.51	1	676 (3)	11
3	0.64	0.5	1460 (3)	11
4	0.86	1	676 (6)	11
5	1.6	2	372 (6)	11
6	2.3	2	372 (6)	11
7	3.9	2	332 (6)	14
8	6.2	2	332 (6)	11
9	6.9	2	332 (6)	11
10	7.3	2	332 (6)	12
11	8.6	2	332 (6)	12
12	9.6	2	332 (6)	12
13	10.4	2	408 (6)	12
14	11.2	2	408 (6)	12
15	12.4	2	408 (6)	12
16	13.3	2	408 (6)	11

\# of redundant detector columns per side



Full Disk / Regional Observation in 10 minutes Repeat Cycle



Full Disk Observation every 10 min.

Region 1	Region 2	Region 3	Region 4	Region 5
2000 x 1000km	2000 x 1000km	1000 x 1000 km	1000 x 500 km	1000 x 500 km
(NE Japan)	(SW Japan)	(Target Area)	(Landmark Area)	(Landmark Area)
Every **2.5 min.**	Every **2.5 min.**	Every **2.5 min.**	Every **30 sec.**	Every **30 sec.**

Lunar observation: performed using Landmark Area (Region 5)

Himawari-8/AHI Radiometric Calibration Methods

Band [µm]	Solar Diffuser	Black Body	GSICS (IR)	GSICS (DCC)	GSICS (Moon)	RT simulation	Ray matching	GEO-GEO
Band1 [0.47]	Y			(Y)	(Y)	Y	Y	Y
Band2 [0.51]	Y			(Y)	(Y)	Y	Y	Y
Band3 [0.64]	Y			(Y)	(Y)	Y	Y	Y
Band4 [0.86]	Y			(Y)	(Y)	Y	Y	Y
Band5 [1.6]	Y			(Y)	(Y)	Y	Y	Y
Band6 [2.3]	Y			(Y)	(Y)	Y	Y	Y
Band7 [3.9]		Y	Y					Y
Band8 [6.2]		Y	Y					Y
Band9 [6.9]		Y	Y					Y
Band10 [7.3]		Y	Y					Y
Band11 [8.6]		Y	Y					Y
Band12 [9.6]		Y	Y					Y
Band13 [10.4]		Y	Y					Y
Band14 [11.2]		Y	Y					Y
Band15 [12.4]		Y	Y					Y
Band16 [13.3]		Y	Y					Y

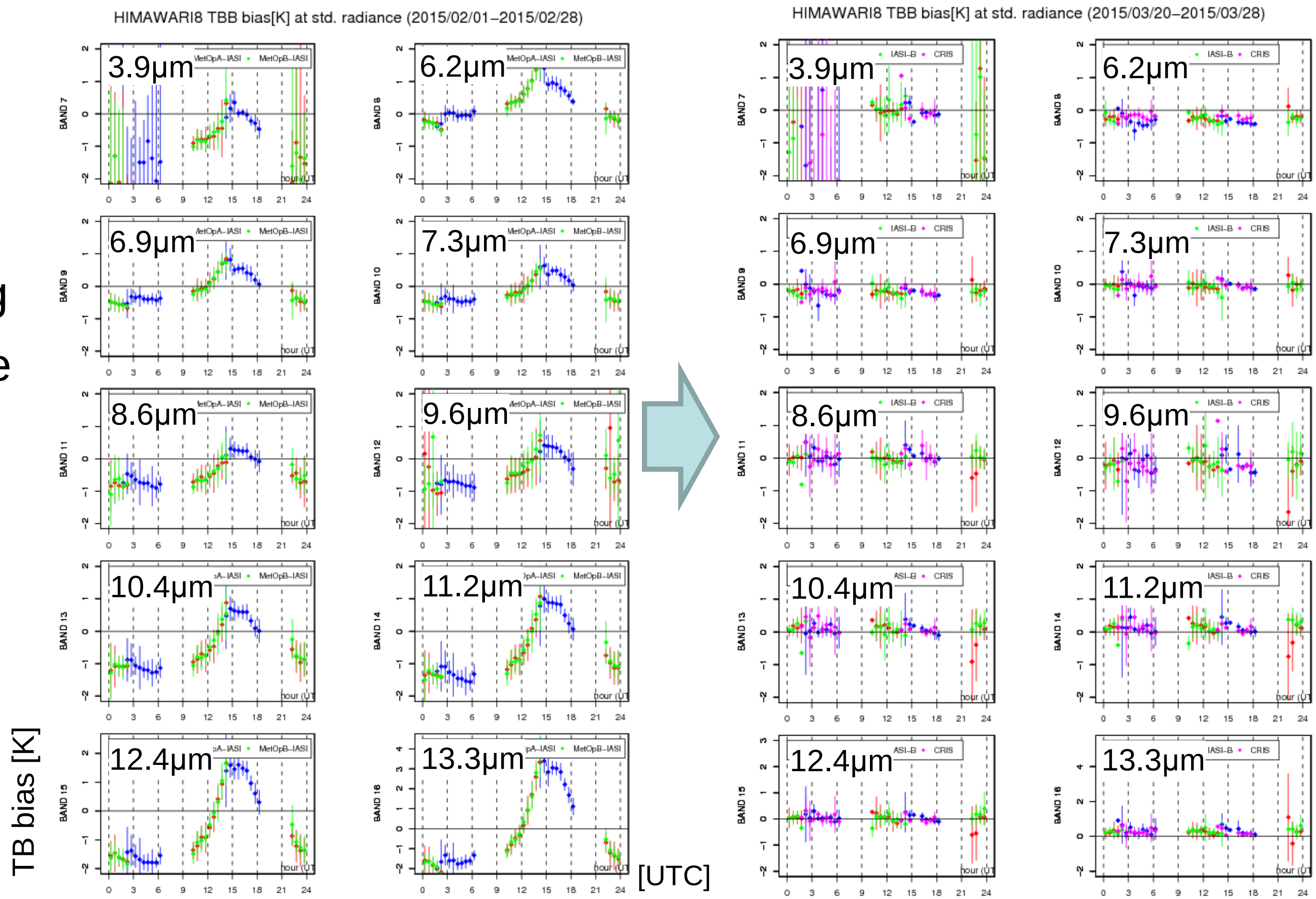
Inter-calibration of VIS/NIR bands using VIIRS
-> Poster presentation

(Y) : under implementation

GSICS Approach Helped AHI Commissioning Phase Activity

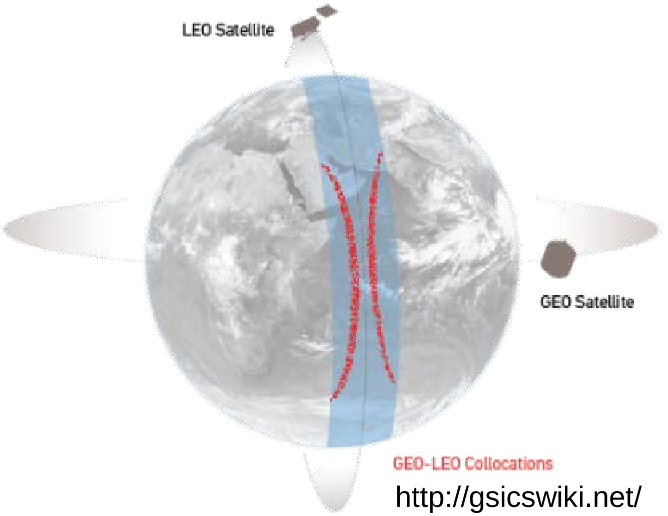
- GSICS approach revealed diurnal variation of IR calibration performance due to a bug of ground processing software

Diurnal variation in commissioning phase data at the earliest stage



Inter-calibration using LEO Hyper-spectral Sounders as References

- Reference instruments
  - Metop-[A,B]/IASI, Aqua/AIRS, **S-NPP/CrIS**
- GEO/LEO collocation based on SNO approach
  - Temporal/Spatial/Geometric thresholds
  - Averaging GEO pixels to be equivalent to LEO FoV size (~12km)
- Generation of GEO imager "*super-channel*"
  - Convolution of LEO spectra with GEO spectral response
  - Spectral gap (e.g. AHI 3.9 μm and CrIS): compensated using "*gap-filling*" optimization method
- Regression of GEO and LEO in radiance
  - Derivation of radiance correction (i.e. *GSICS Correction*)
  - Converted to TB for easy understanding



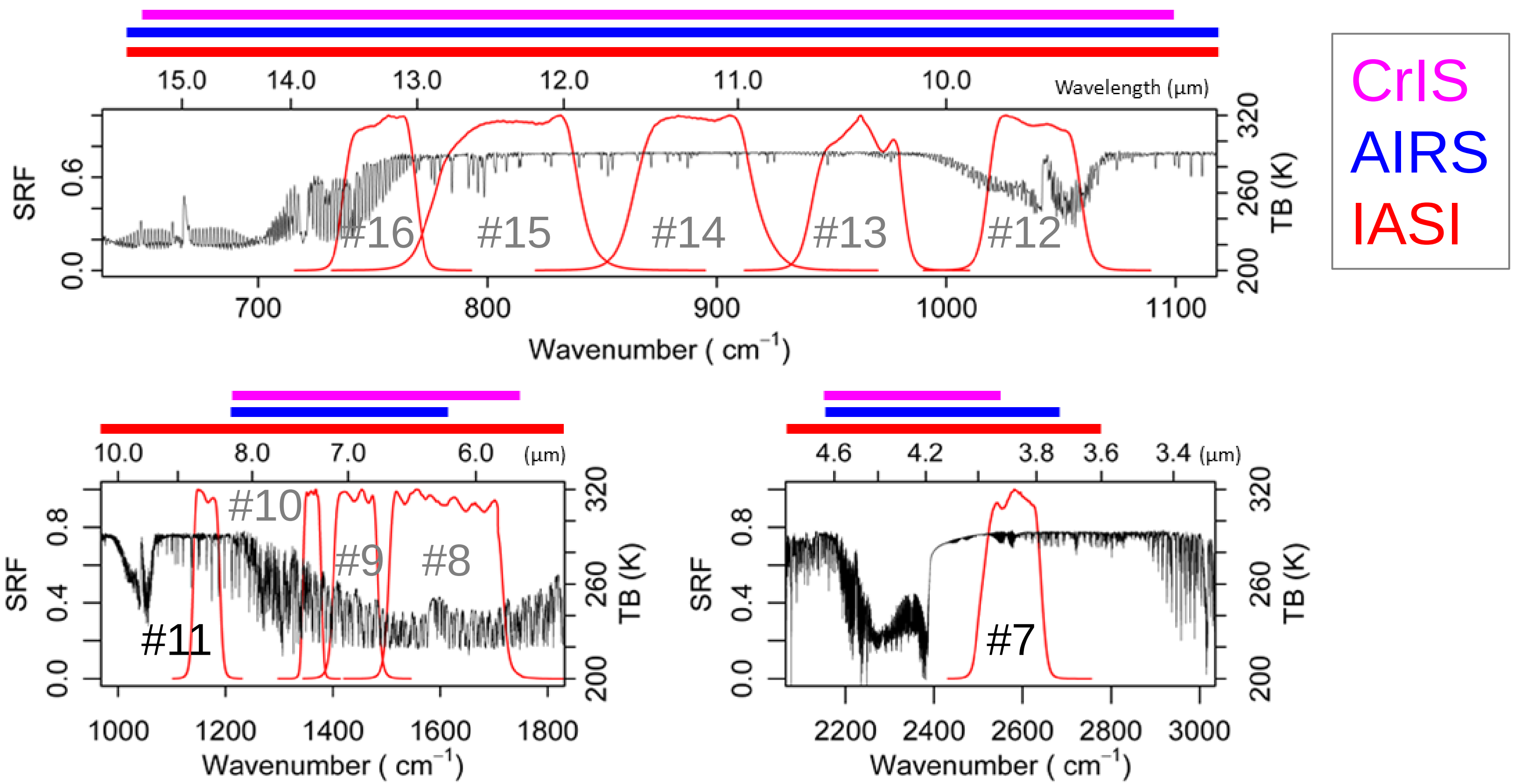
http://gsicswiki.net/

AHI-CrIS Collocation conditions

Time difference	5 minutes
Viewing angle diff.	$\lvert\cos(VZA_{CrIS})/\cos(VZA_{AHI}) - 1\rvert < 1$ or 3%
Environment uniformity	Stdv. of AHI (18x18 pixels) < thresholds (band/scene dependent)

Spectral "Gap-filling" of CrIS to Generate AHI Super-channel

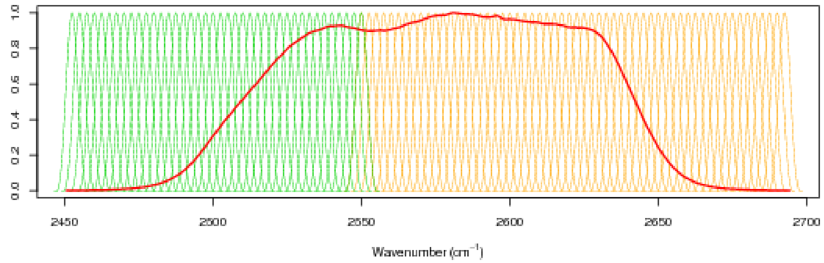
- CrIS covers about 40% of AHI Band 7 (3.9μm)
- Most spectral range of AHI Band 11 (9.6 μm): not covered by CrIS



Spectral "Gap-filling" method

(Tahara and Kato, 2009)

Himawari-8/AHI Band 7 (3.9µm)
S-NPP/CrIS (Valid, Missing channels)



Formulation

$$\log I_i^{\mathrm{calc}} = c_0 + \sum_k c_k \log I_{i,k}^{\mathrm{sim}}$$

Estimated radiance of missing channel i

Simulated radiance of channel i for model profile k

- For each GEO channel and each hyper sounder observing point
- Log radiance estimated to prevent radiance from being negative

Simulated radiances for 8 model profiles

- Tropic, US standard, Mid-latitude winter and summer profiles
- Thick cloud at 500 hPa and 200 hPa for Tropics and US std.

Coefficients (c_0, c_k) computation

- Solving least square problem by applying valid hyper sounder observations and corresponding simulated radiances

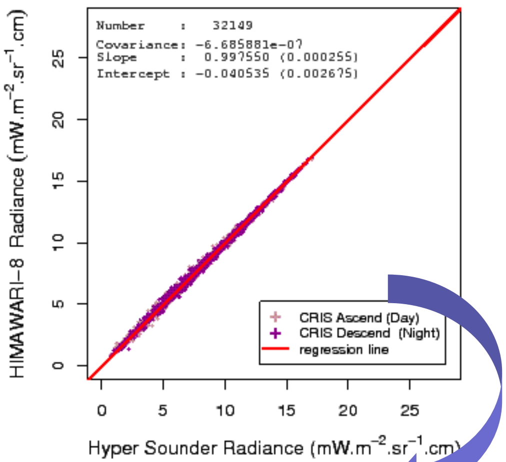
No NWP fields, no RT computation in operation

Computation of GEO super-channel

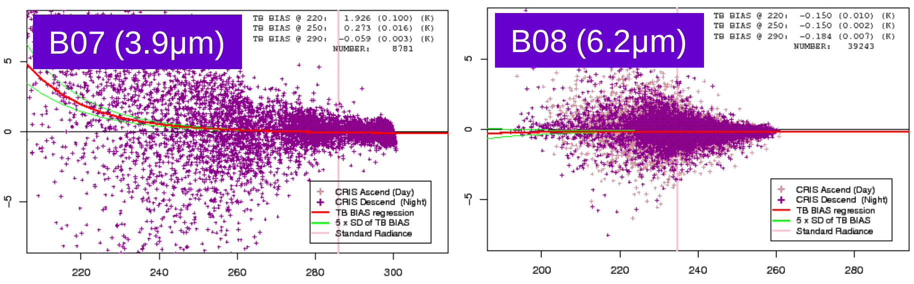
$$I_s = \frac{\sum_i w_i I_i}{\sum_i w_i}$$

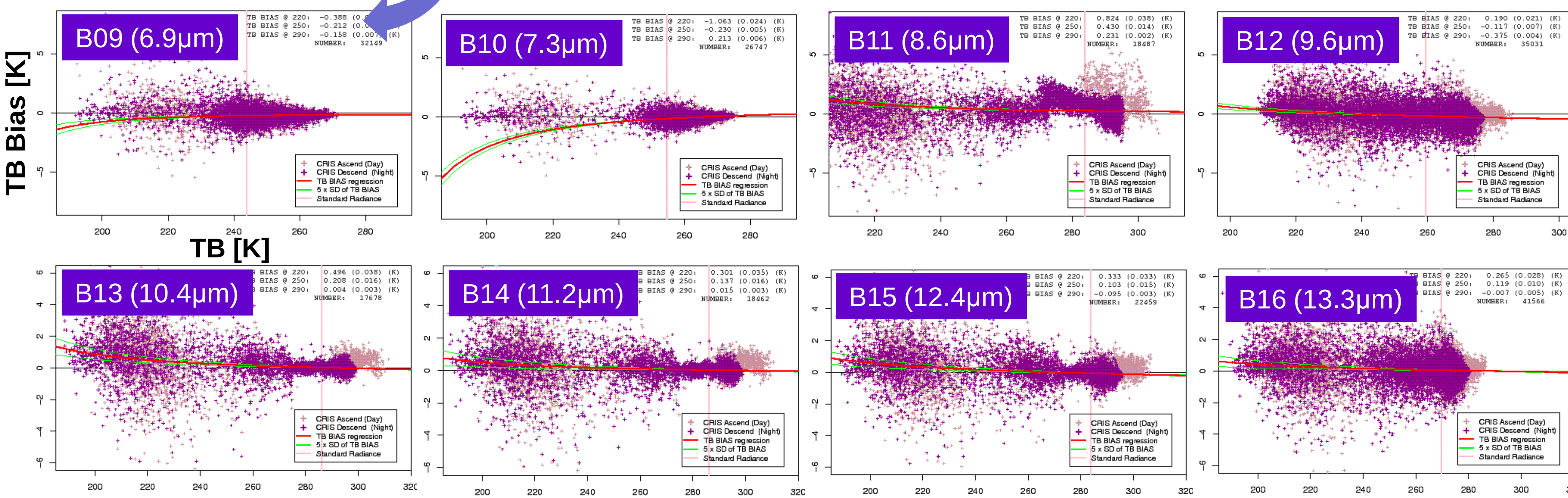
I_s: GEO super channel
wi: weight for LEO channel i

TB Biases Converted from Radiance Regression

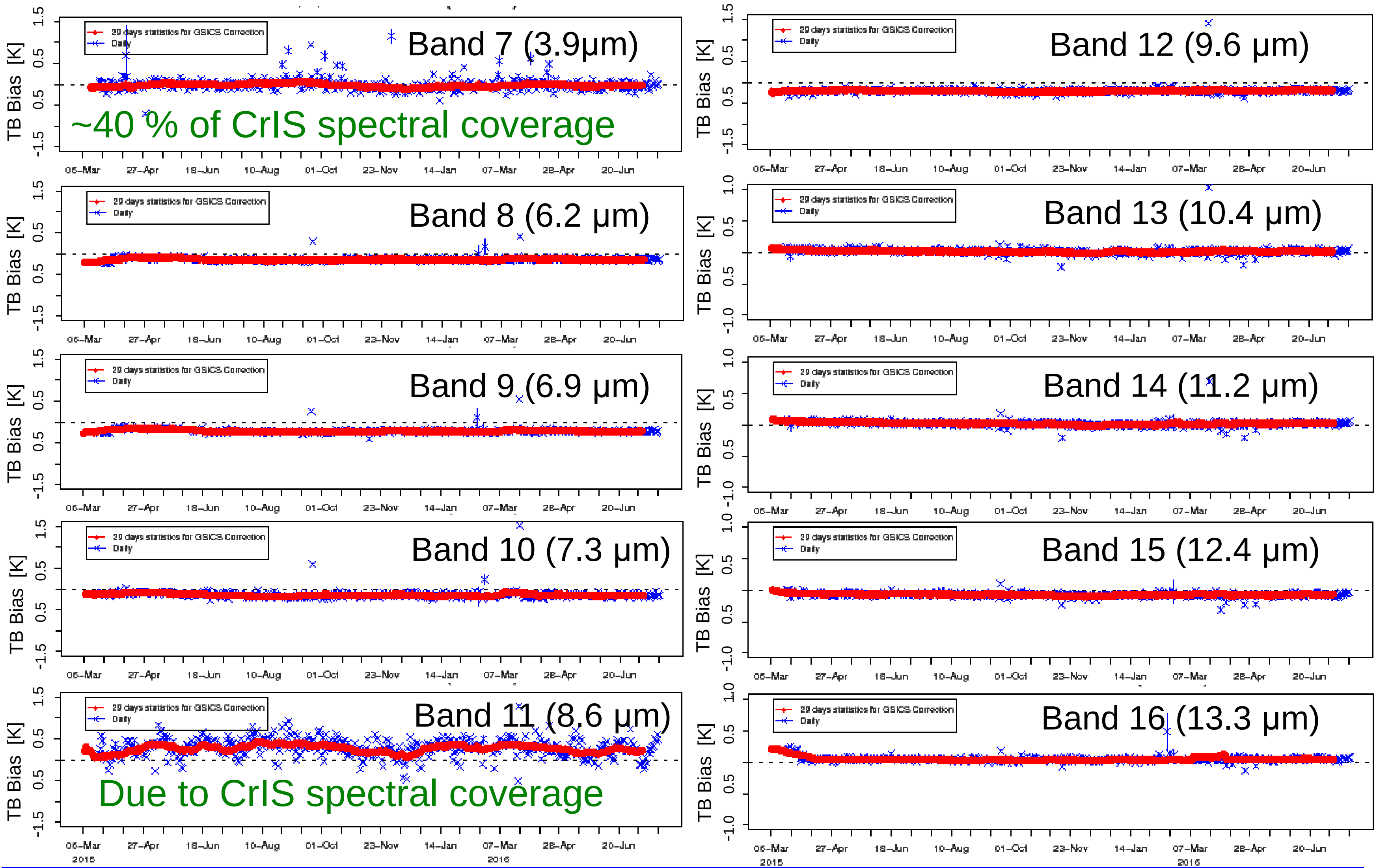


TB biases w.r.t.
S-NPP/CrIS
(Data from 1-29 June 2016 are used)





Time series of AHI TB biases w.r.t S-NPP/CrIS at standard scene



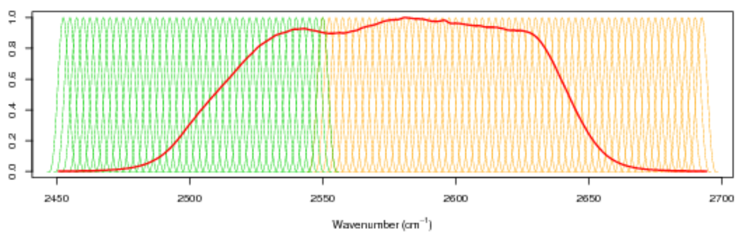
Standard scene: typical scene defined as 1976 US Standard Atmosphere at nadir, at night, in clear sky, over the sea with SST=288.15K and a wind speed= 7m/s

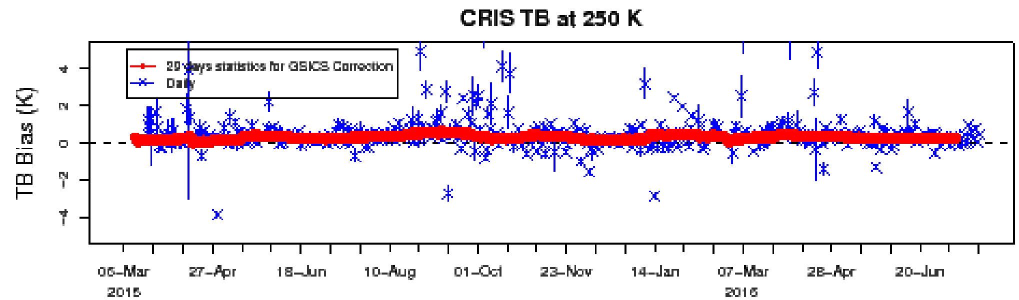
GSICS Global Space-based Inter-Calibration System

Impacts of "Gap-filling" method on inter-calibration results (AHI 3.9μm)

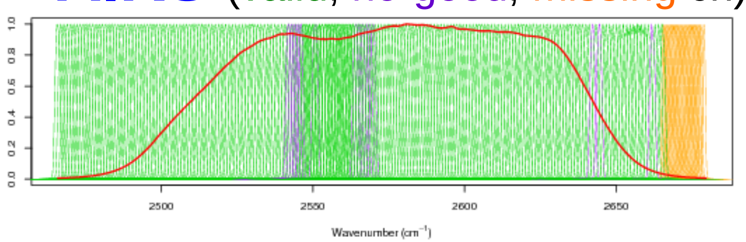
- Gap-filling method efficiently reduces the inter-calibration uncertainty

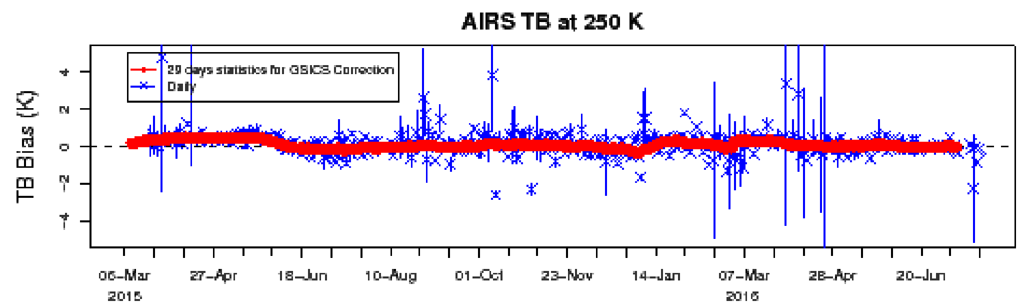
CrIS (valid, missing ch)



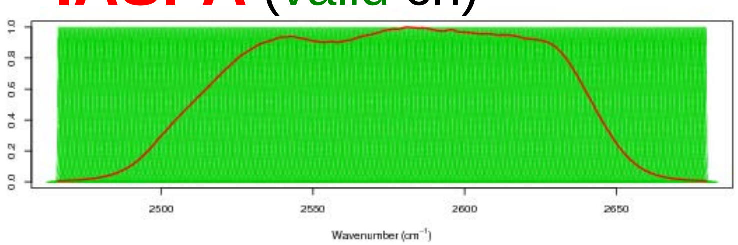


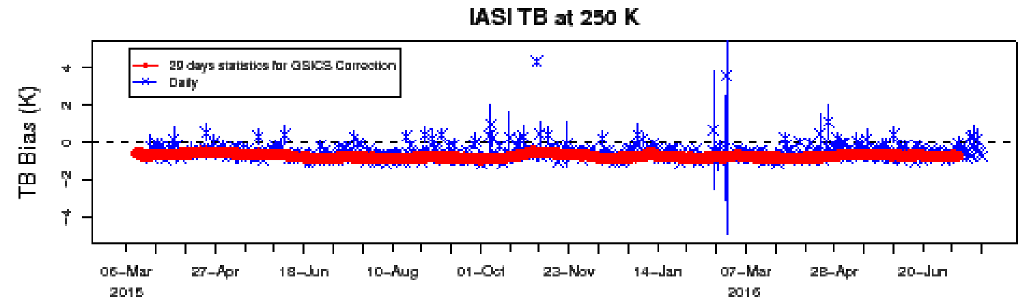
AIRS (valid, no-good, missing ch)





IASI-A (valid ch)

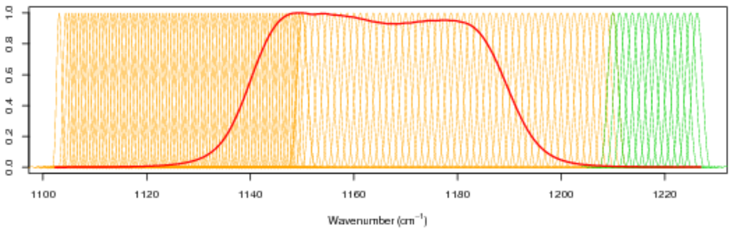


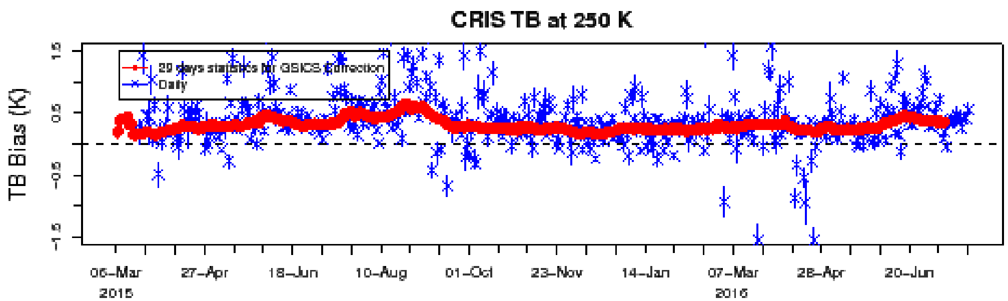


Impacts of "Gap-filling" method on inter-calibration results (AHI 8.6μm)

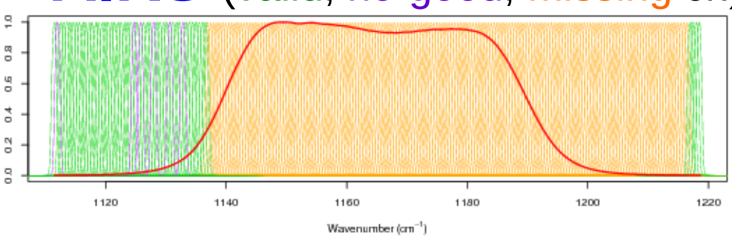
- Gap-filling does not work in case of too big gap

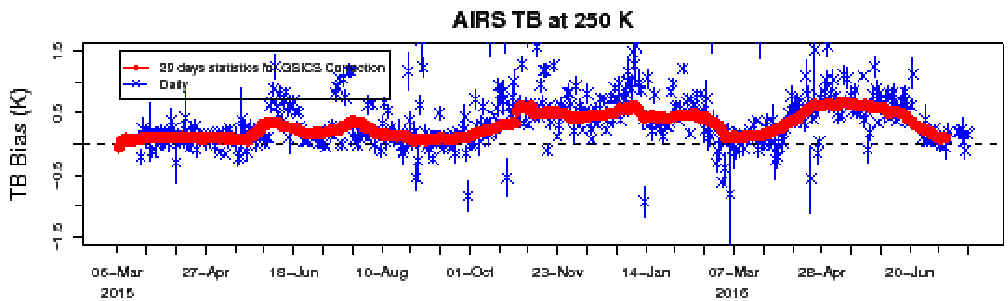
CrIS (valid, missing ch)



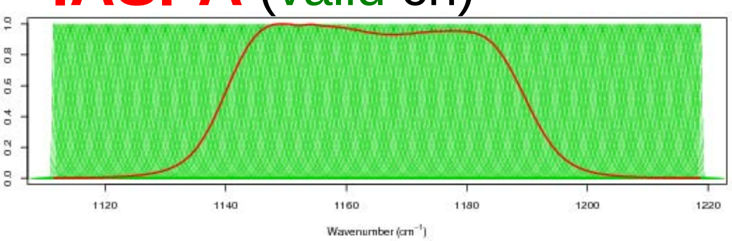


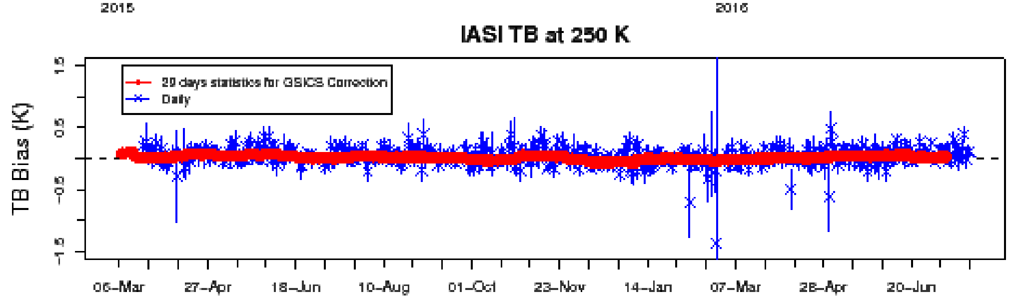
AIRS (valid, no-good, missing ch)





IASI-A (valid ch)



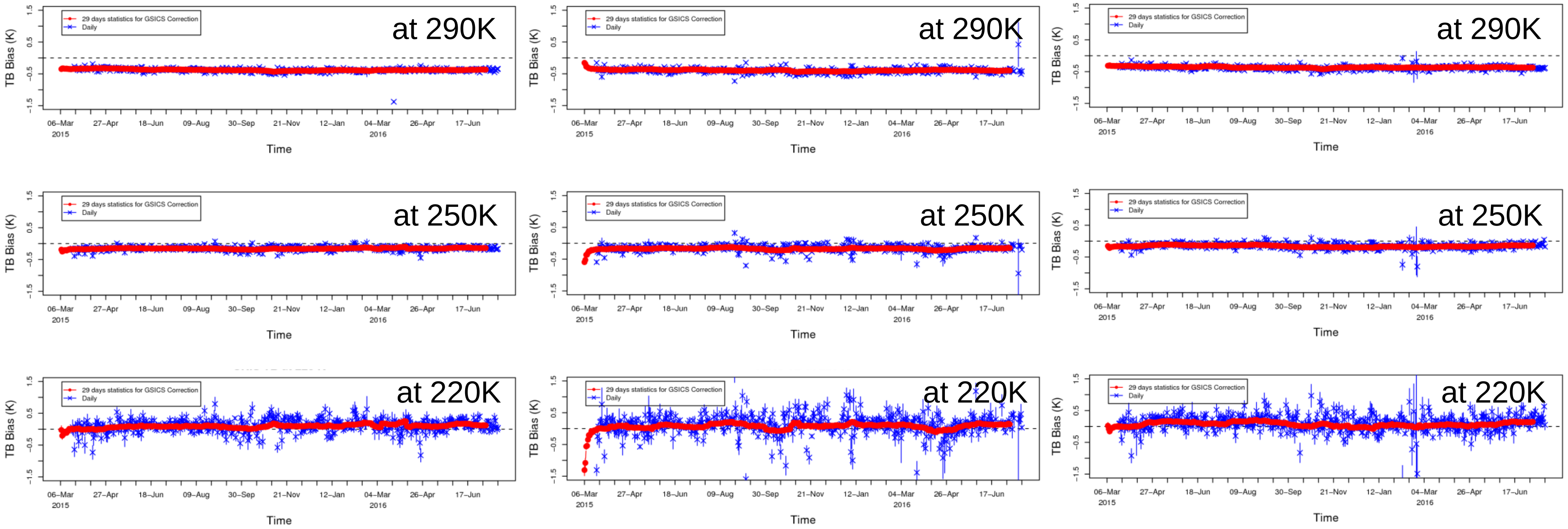


TB Bias Stability at different scenes

- Similar results in all hyper sounders
- AHI Tb biases: stable w.r.t. CrIS at cold scenes compared with others

Time series of Tb biases between hyper sounders and **Himawari-8/AHI Band 12 (9.6µm)**

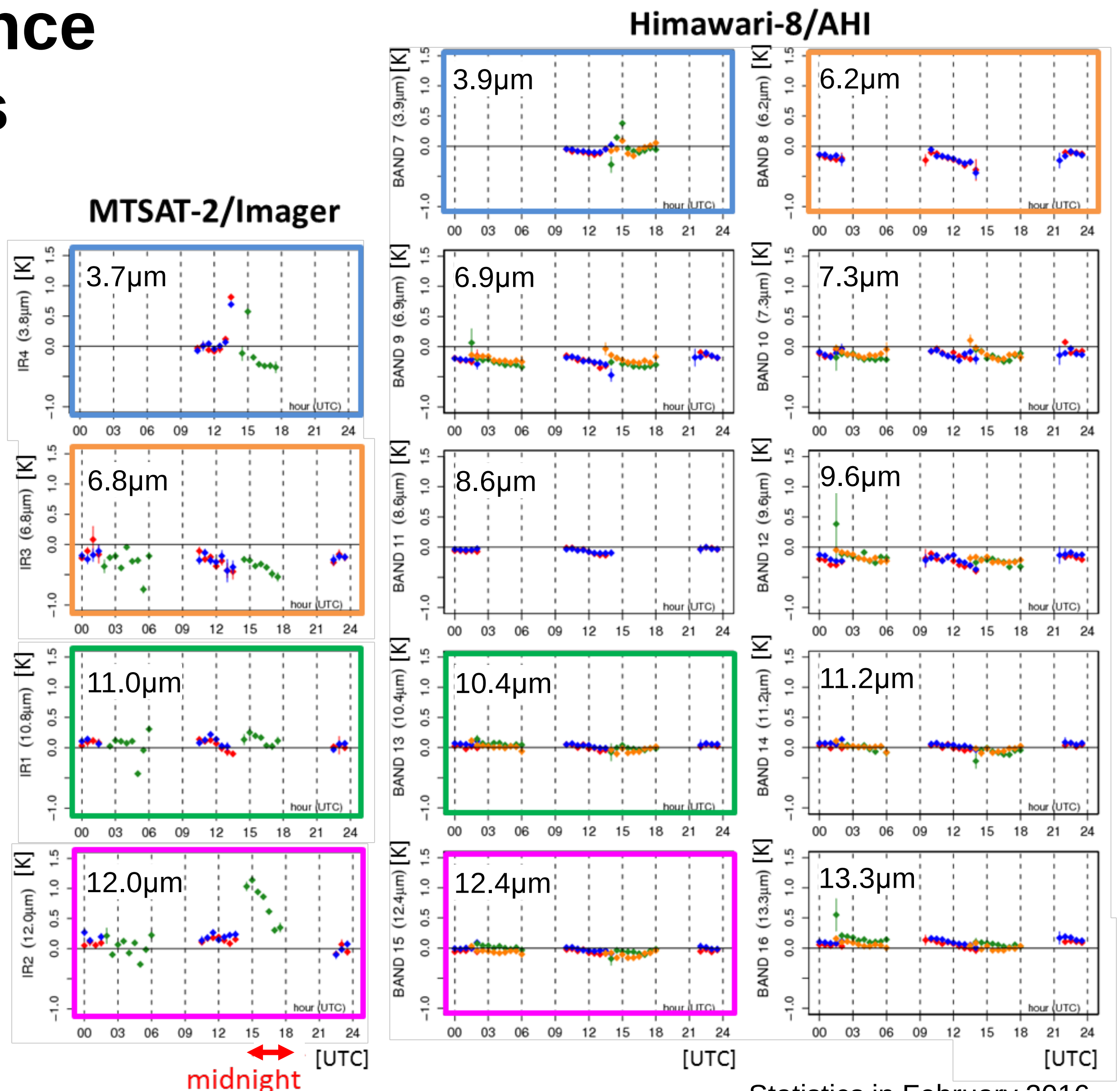
w.r.t. S-NPP/CrIS | w.r.t. Aqua/AIRS | w.r.t. Metop-A/IASI



Time Dependence of Tb Biases

- MTSAT-2:
  - Diurnal variation of Tb biases during midnight
- Himawari-8
  - No significant diurnal variation

Multiple references: very important to validate diurnal calibration biases



Statistics in February 2016

Reference sensors:
- Metop-A/IASI
- Metop-B/IASI
- Aqua/AIRS
- S-NPP/CrIS

Summary and Future Plan

Inter-calibration of Himawari-8/AHI IR bands

- Method
  - Metop-[A,B]/IASI, Aqua/AIRS and S-NPP/CrIS as references
  - Based on SNO approach
  - Spectral "gap-filling" method is applied if the reference sensor does not cover spectral range of GEO channel
- Results
  - All IR bands are very stable, Tb biases < 0.2K at standard scene
  - No significant diurnal calibration biases
    - ✓ Multiple references: important/useful to validate them
- Future Plans
  - Inter-calibration results will be included in L1B equivalent data (i.e. Himawari Standard Data) once the product gets GSICS stamp
  - Generation of "Prime GSICS Correction" (blending multiple references results)

Thanks for Your Attention

IR on-board Calibration

$$R_{obs} = F(\theta,\phi)(q_n C^2 + m_n C + b_n) - G(\theta)R_{Mns} - H(\theta,\phi)R_{Mew}$$

- q_n: pre-launch test value
- m_n: updated using blackbody observation for each full-disk observation
- b_n: updated using deep space observation for each swath

R_{obs}: Observed radiance
C: Raw digital count
q_n, m_n, b_n: Coefficients
n: Detector ID
θ, ϕ : Incidence angle to SM
$F(\theta, \phi)$, $G(\theta, \phi)$, $H(\theta, \phi)$: Parameters on scan mirror emissivity
R_{Mns}, R_{Mew}: NS/EW scan mirror radiance