Preliminary validation of Himawari-8/AHI navigation and calibration

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Introduction

History of AHI data quality

- Ground software had been updated frequently before operation start.

- Image Navigation Registration (INR)
  - 16 and 23 January
    - Landmark analysis is applied to attitude information
  - 3 February
    - Band-to-band coregistration process is activated for Band 1 to 6
  - 26 March
    - Band-to-band coregistration process is activated for Band 7 to 16
- Calibration
  - 2 and 9 March
    - Software for image processing is updated
  - 10 and 13 March
    - Software for image processing is updated
  - 18 May
    - Angular sampling distance is changed (EW direction) e.g. 14µrad to 13µrad for Band 3
  - 8 June
    - Calibration coefficients is updated

- Operation start: 7 July 2015

Band	Himawari-8/AHI			GOES-R/ABI	
	Wave length	Spatial resolution	Bit depth	Wave length	Spatial resolution
1	0.47 µm	1 km	11	0.47 µm	1 km
2	0.51 µm	1 km	11		
3	0.64 µm	0.5 km	11	0.64 µm	0.5 km
4	0.86 µm	1 km	11	0.86 µm	1 km
				1.38 µm	2 km
5	1.6 µm	2 km	11	1.61 µm	1 km
6	2.3 µm	2 km	11	2.26 µm	2 km
7	3.9 µm	2 km	14	3.90 µm	2 km
8	6.2 µm	2 km	11	6.15 µm	2 km
9	6.9 µm	2 km	11	7.00 µm	2 km
10	7.3 µm	2 km	12	7.40 µm	2 km
11	8.6 µm	2 km	12	8.50 µm	2 km
12	9.6 µm	2 km	12	9.70 µm	2 km
13	10.4 µm	2 km	12	10.3 µm	2 km
14	11.2 µm	2 km	12	11.2 µm	2 km
15	12.4 µm	2 km	12	12.3 µm	2 km
16	13.3 µm	2 km	11	13.3 µm	2 km

Information of the GOES-R/ABI is based on WMO OSCAR Web page.
http://www.wmo-sat.info/oscar/instruments/view/3

Raw data to HSD (Himawari Std. Data)

INR

- Satellite orbit: Ranging data
- Satellite attitude: Star tracker, gyro, ...
- AHI's attitude is adjusted using landmark analysis
- Band-to-band co-registration is performed by pattern matching between bands for each full-disk swath.

calibration

VNIR:

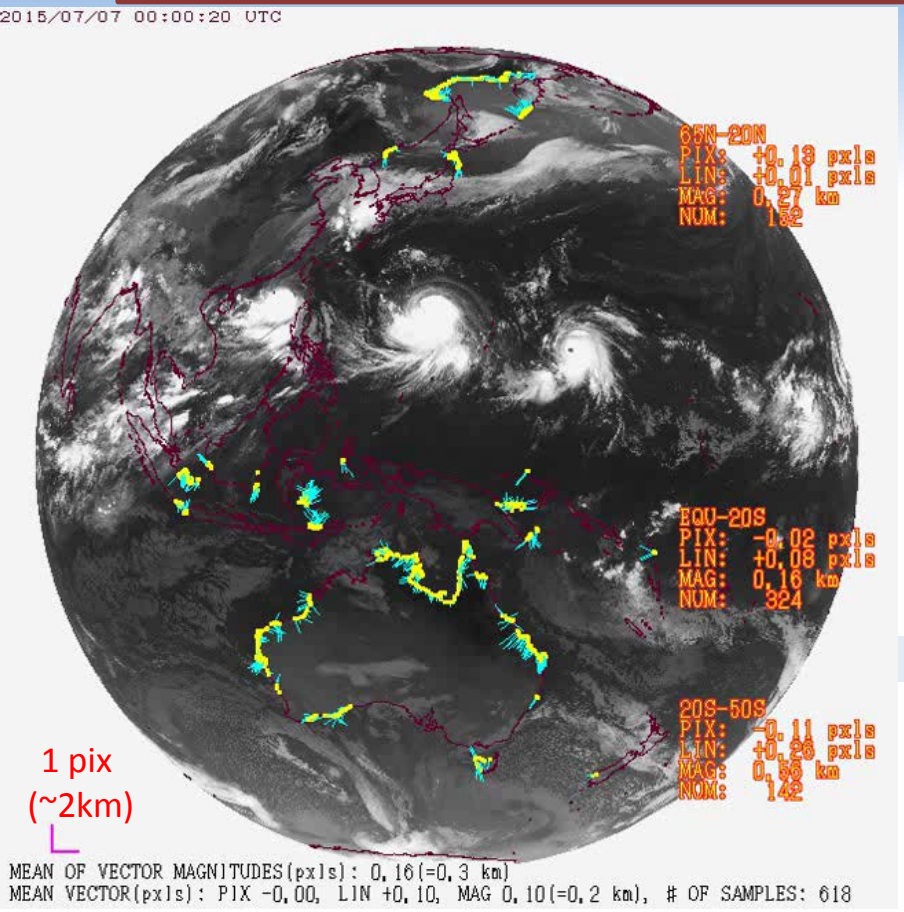
- $L = q(C\text{-}C_{sp})^2 + m(C\text{-}C_{sp})$
- C_{sp}: based on deep space view every swath.
- m : based on offline analysis of solar diffuser observation.
- q: a pre-launch value.

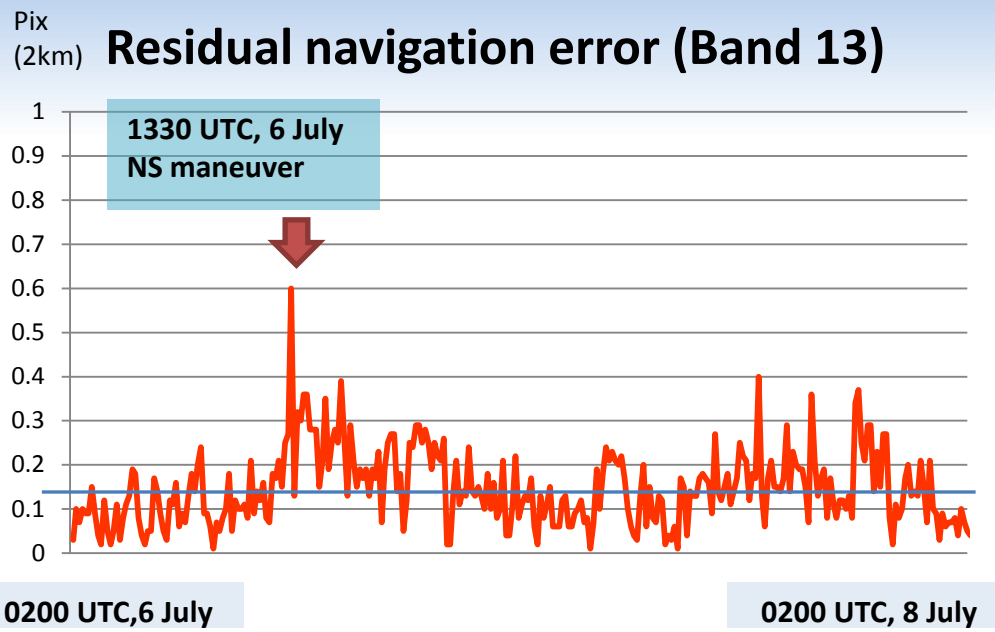
IR:

- $L = qC^2 + mC + b$
- b: based on deep space view every swath.
- m : based on BB and deep space view every 10 minutes.
- q : a pre-launch value.

Himawari Standard Data → Validation

Residual navigation error



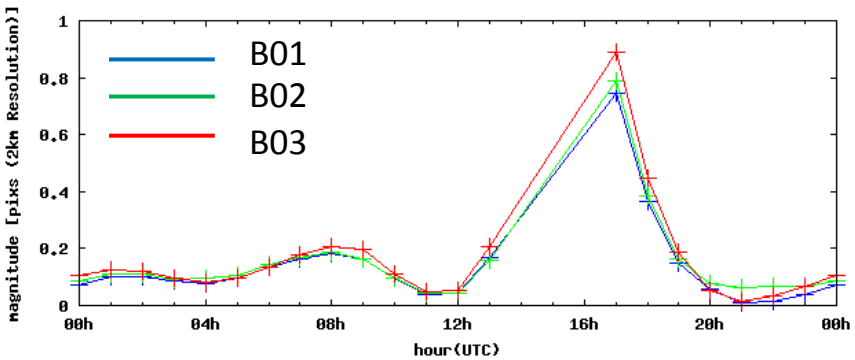


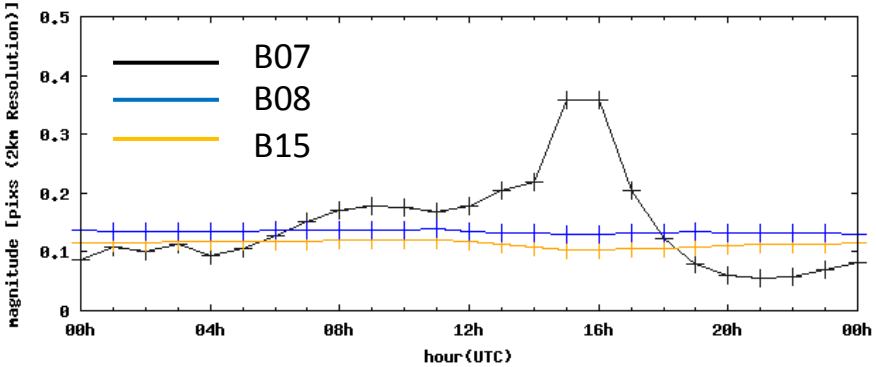
* Wmv movie

- Residual navigation error is less than around 0.5 pixels (1 pixel = 2 km).
- Occasionally and provisionally, there are “spike” in the next observation of orbit determination and the timing of satellite going into and going out from shadow of the earth.

Co-registration Error (relative to Band 13, 10.4μm)

- The residual co-registration error: ~0.1-0.2 pixels (1 pixel = 2 km) for most bands.
  - VIS/NIR & B07 relatively large co-registration error from midnight to dawn
  - Root cause could be an estimation error of co-registration correction using the sensor temperature





Band [μm]	Typical error magnitude	Error (EW)	Error (NS)
B01 (0.47)	0.15	-0.15	0.05
B02 (0.51)	0.15	-0.15	0.00
B03 (0.64)	0.15	-0.15	0.02
B04 (0.86)	0.15	-0.15	0.00
B05 (1.6)	0.20	-0.05	-0.20
B06 (2.3)	0.05	0.0	0.05

Band [μm]	Typical error magnitude	Error (EW)	Error (NS)
B07 (3.9)	**0.150**	0.15	0.050
B08 (6.2)	**0.132**	0.08	0.105
B09 (6.9)	**0.217**	0.06	0.209
B10 (7.3)	**0.225**	0.125	-0.185
B11 (8.6)	**0.270**	0.12	-0.240

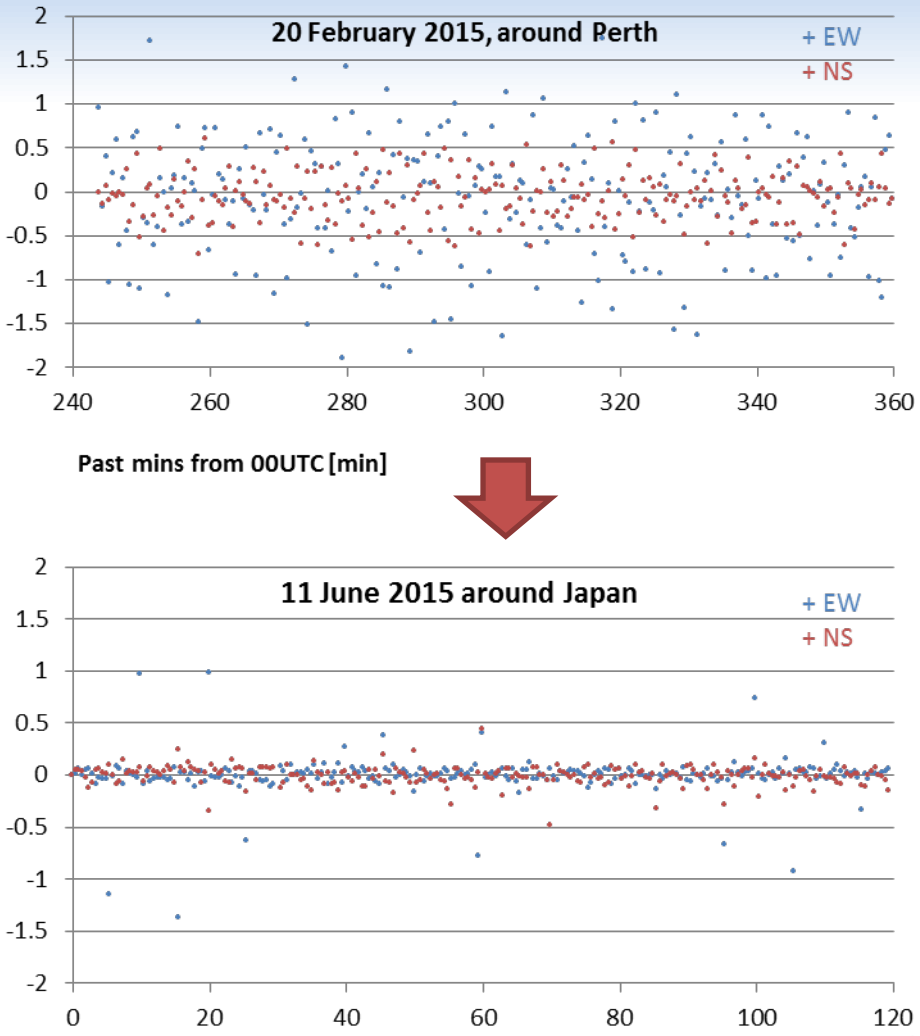
Band [μm]	Typical error magnitude	Error (EW)	Error (NS)
B12 (9.6)	**0.190**	0.184	0.050
B14 (11.2)	**0.118**	-0.063	-0.100
B15 (12.4)	**0.115**	-0.03	0.114
B16 (13.3)	**0.015**	-0.01	-0.010

1 pixel = 2 km for all bands

Jitter

- Fluctuation magnitude: validated using successive two images
- The variation is reduced to less than 0.5 pixels in EW/NS (1 pixel = 2 km).

	2015-06-11		2015-02-20	
	Mean	Stdv	Mean	Stdv
EW	-0.04	0.16	-0.09	0.68
NS	-0.02	0.12	-0.07	0.27
magnitude	0.12	0.17	0.62	0.40



Calibration/Validation approaches

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

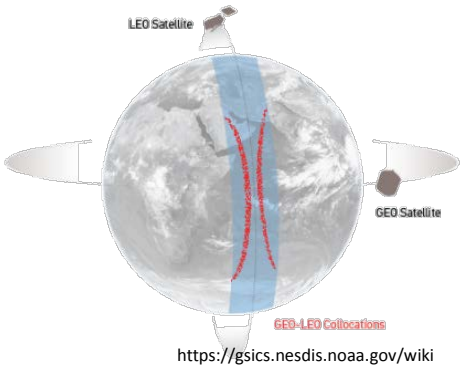
GSICS (Global Space-based Inter-Calibration System GSICS):

- An international collaborative effort for inter-calibration initiated by WMO and the CGMS .

IR validation approach:

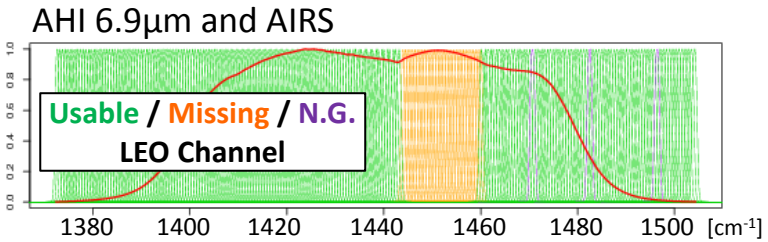
Inter-calibration with LEO hyper-spectral sounder

Collocate

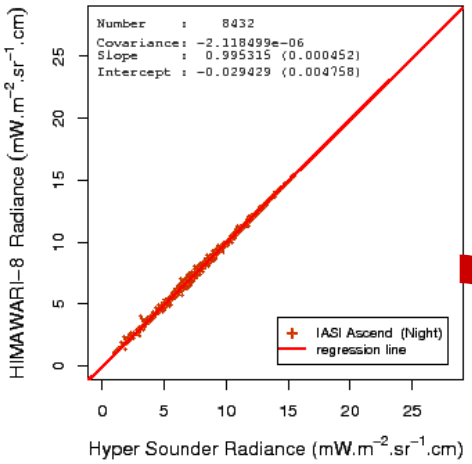


https://gsics.nesdis.noaa.gov/wiki

Generate "Super-channel"

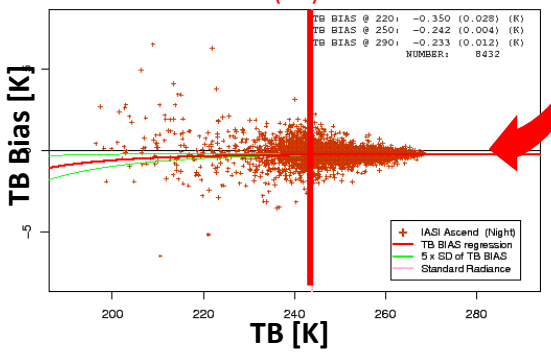


Regression analysis



- The validation approach is developed under the GSICS collaboration framework.
- Reference instruments
  - **Metop-A/IASI**, Metop-B/IASI, Aqua/AIRS and S-NPP/CrIS
- Collocation of GEO and LEO based on SNO approach
- Generation of GEO imager "*super-channel*"
  - Convolution of LEO spectra with GEO spectral response
- Regression of GEO and LEO in radiance

Standard radiance* (TB)



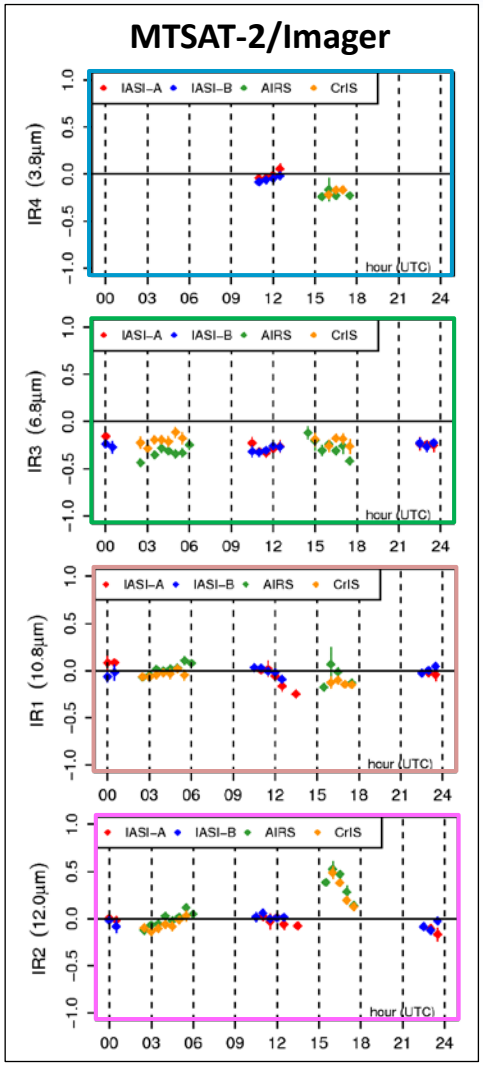
* simulated radiance under the standard atmosphere, SST=288.15, night time, clear sky and nadir.

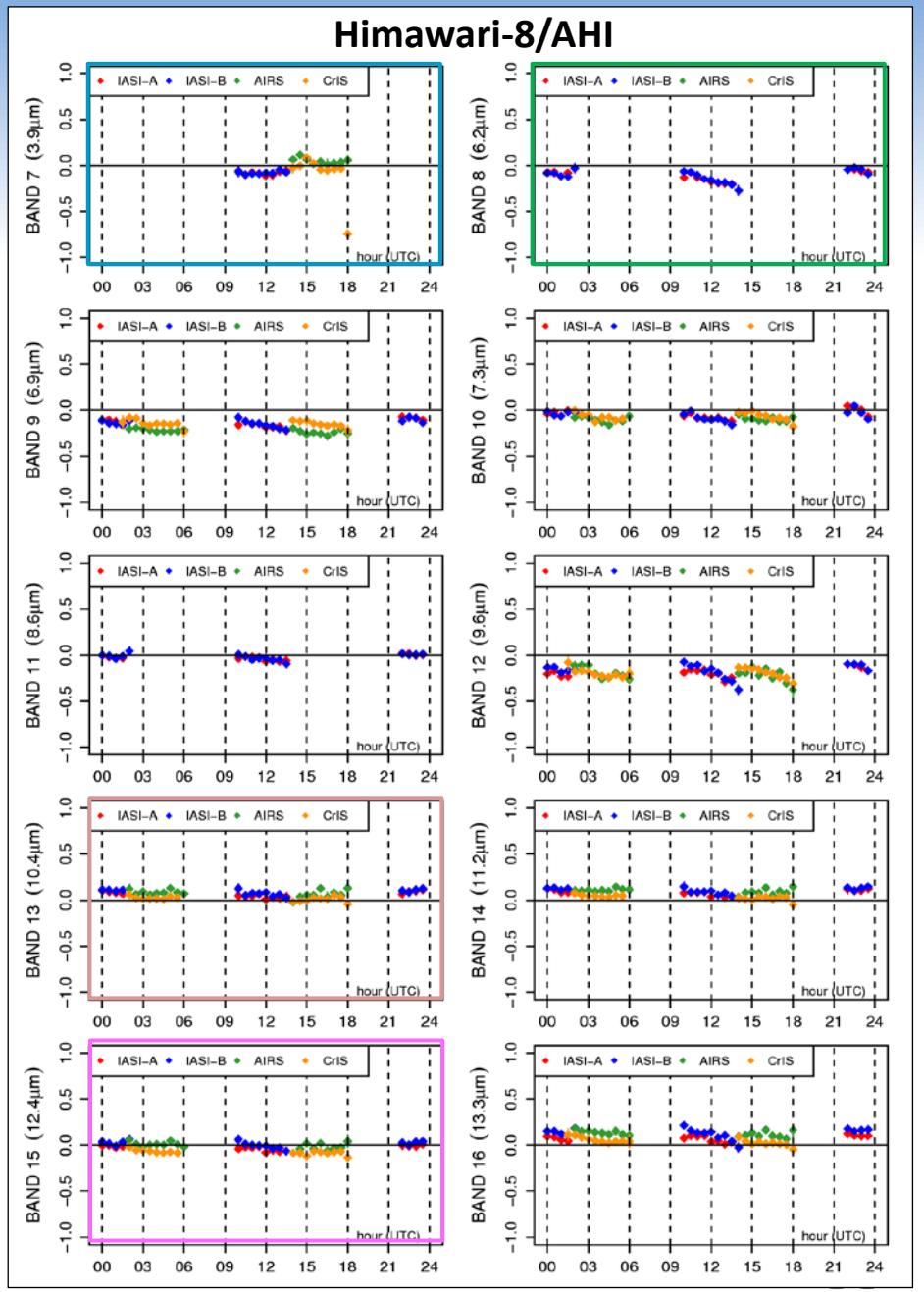
TB biases
Time Dependence

- **No significant bias, diurnal calibration variation**
- **|TB bias| < ~0.2K**
- **w/ uncertainty of ~5mK**

Reference sensor
- **Metop-A/IASI**
- **Metop-B/IASI**
- **Aqua/AIRS**
- **S-NPP/CrIS**

Monthly statistics in April 2015





VIS/NIR validation approaches

A) Vicarious cal. using RT Simulation

Reference
- simulated radiance for multiple targets such as cloud-free ocean, liquid cloud

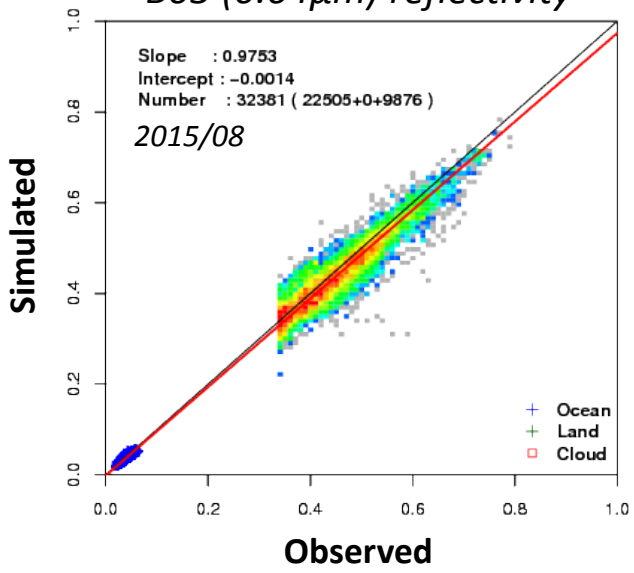
Collaboration research
- with the University of Tokyo and JAXA/EORC [Prof. Nakajima]

B) Ray-matching w/ S-NPP/VIIRS

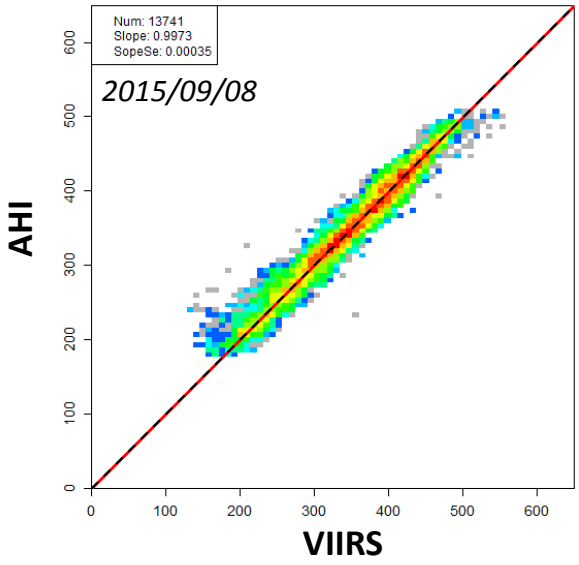
Reference
- S-NPP VIIRS data with close observation time and geometry condition
- SRF difference is corrected based on the Spectral Band Adjustment Factor※

※ http://www-pm.larc.nasa.gov/cgi-bin/site/showdoc?mnemonic=SBAF

B03 (0.64μm) reflectivity



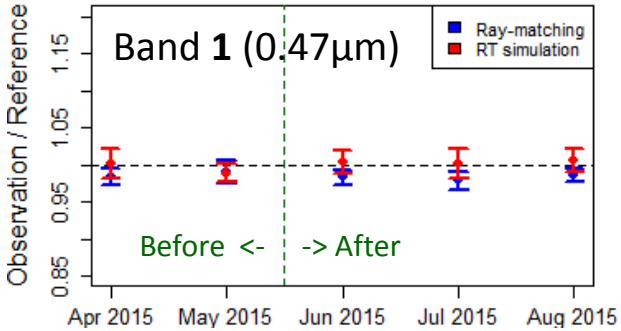
B01 (0.47μm) radiance

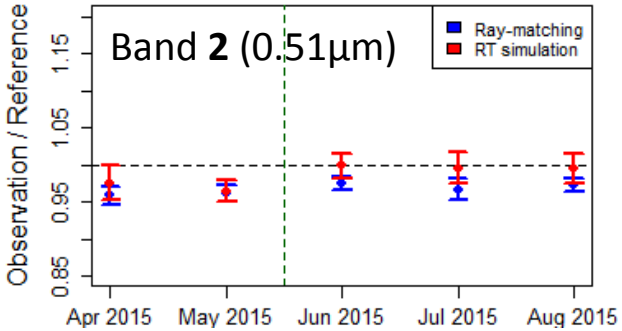


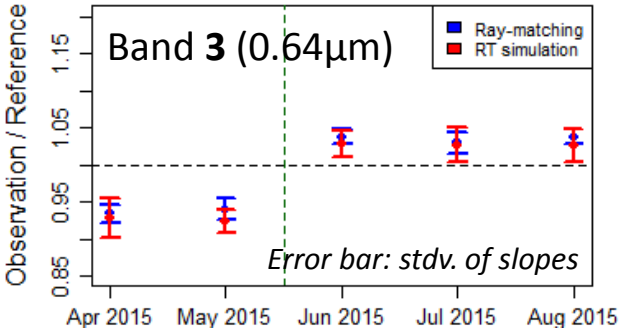
Validation of Calibration Slope Update

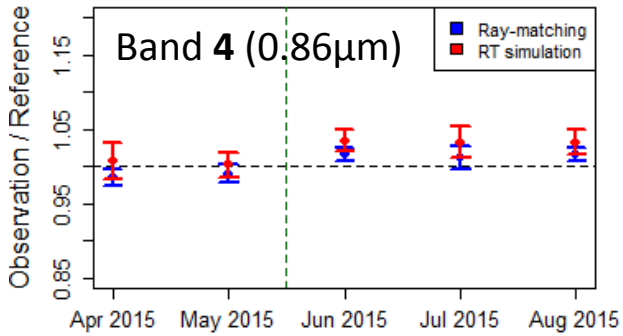
- Calibration coefficients were updated based on SD observation on 8 June.
- Bias: reduced (except for Band 5) after the update
  - Discrepancy of validation results will be investigated further
- Trend analysis of SD observation will also be performed
- Other Cal/Val approaches (e.g. lunar, deep convective cloud): under implementation

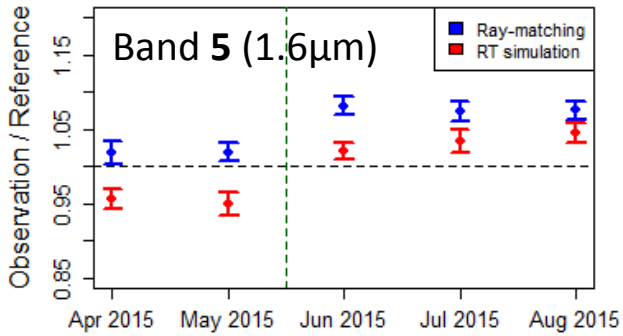
Reference:
- RT simulation
- VIIRS observation

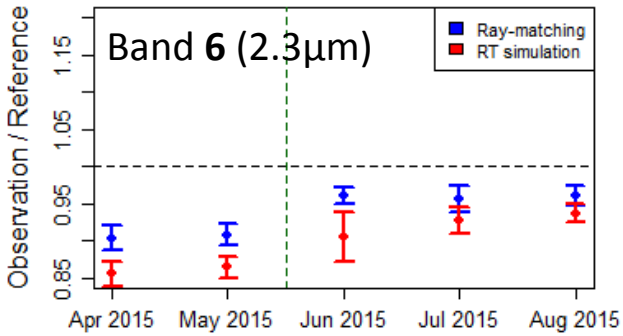












Coherent noise

- Coherent noise (all bands)
  - Vertical stripe can be seen over low radiance region such as deep space and clear sky ocean.
  - Correction module was implemented to band 7.
  - The module will be also applied to other noisy bands.

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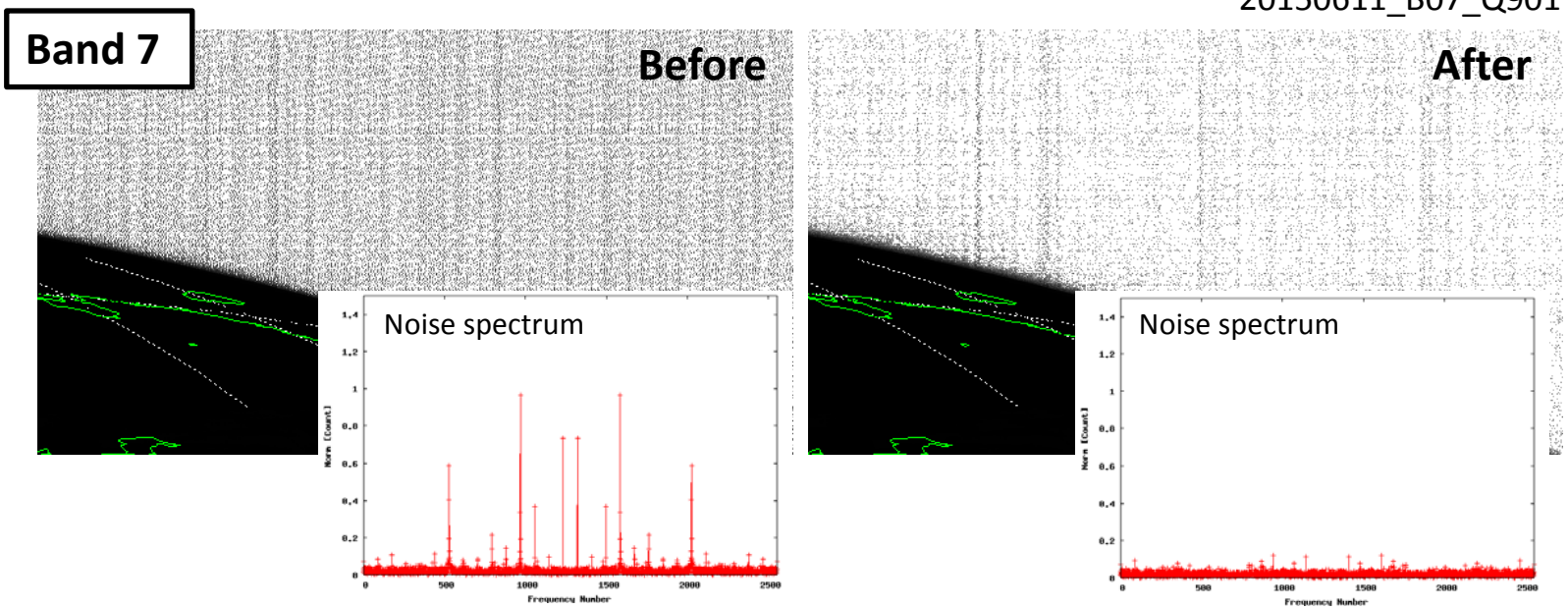

Summary

Navigation

- The residual error is less than 0.5 pixels for 2km resolution bands in many cases.
- The residual co-registration error is around 0.1-0.2 pixels for most bands.
- Jitter is less than 0.2 pixels.

VIS/NIR (Band 1-6)

- Calibration coefficients update (8 June 2015)
- Band 1 to 4: No significant bias; Band 5 and 6: ~7% discrepancy is indicated at most

IR (Band 7 to 16)

- No significant Tb bias (0.2 +/- 0.005K)

Monitoring Web page

- Calibration/Navigation status is available on *http://www.jma-net.go.jp/msc/en/*

Current issue: Validation with multi approaches

e.g. Lunar calibration

cf. Poster (P08)
"Visible channel calibration of JMA's geostationary satellites using the Moon images" by M. Takahashi and A. OKuyama