JAXA SST Products and Validation Activities - GCOM-W, GCOM-C and Himawari-8

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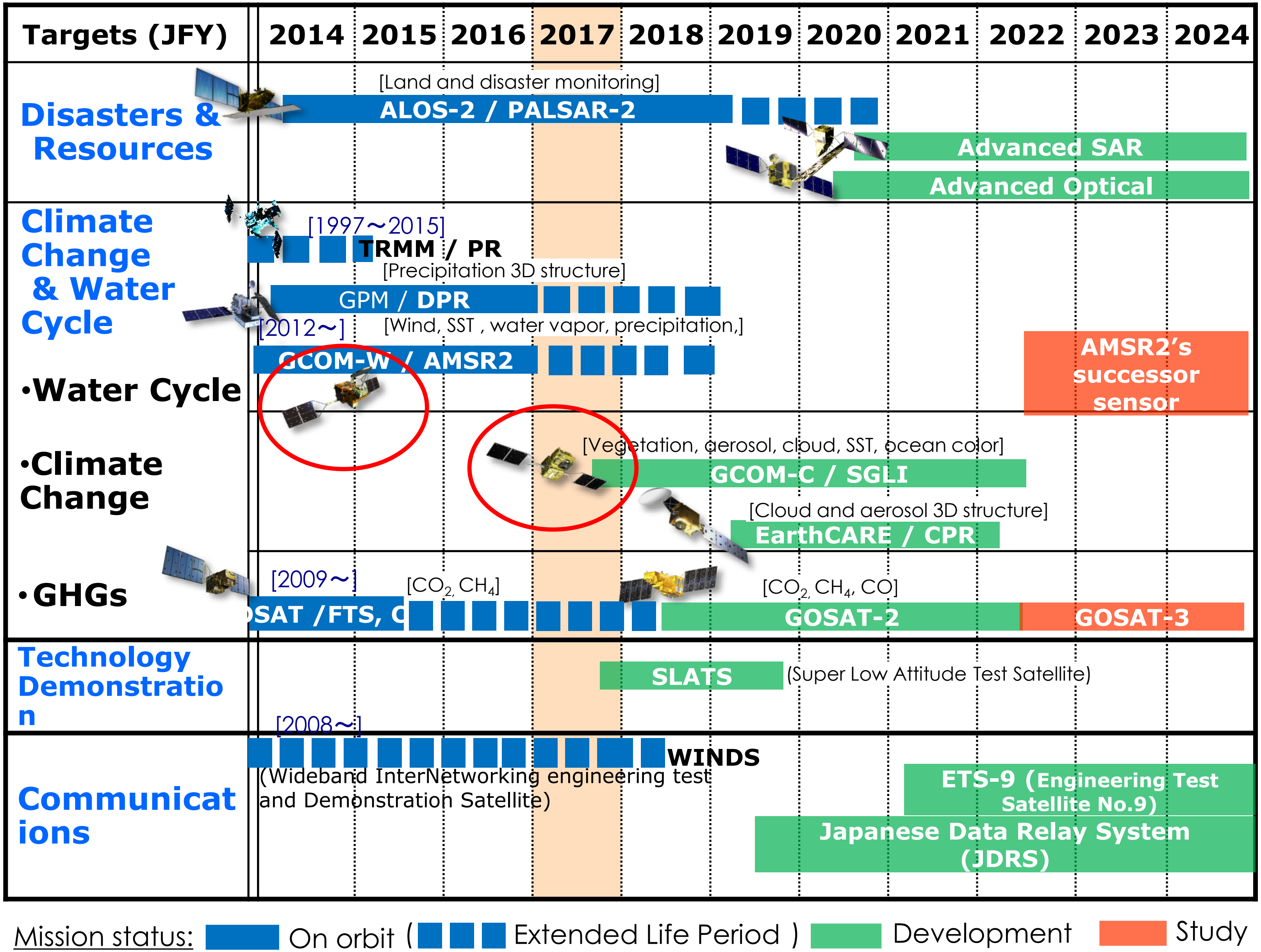
1) JAXA/EORC

2) JMA

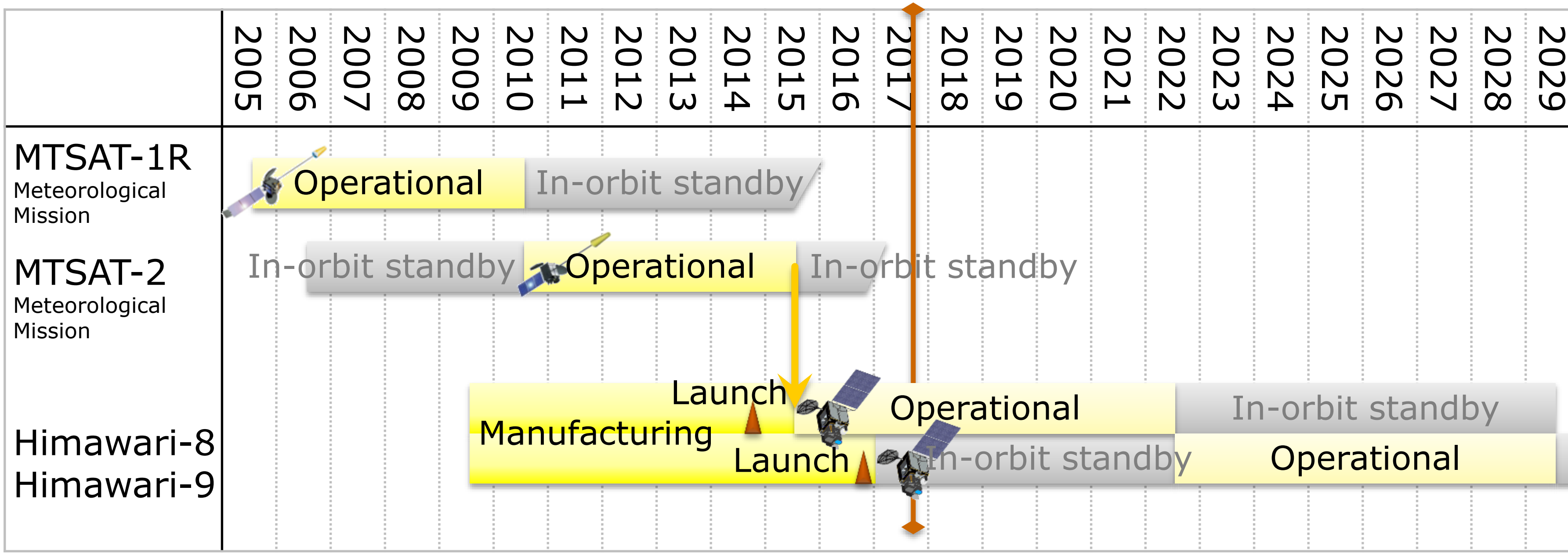
FRM4STS International Workshop
@Teddington, UK, 16-18 Oct., 2017

Schedule of JAXA Satellites (lower orbit)



Schedule of JMA satellites (geostationary orbit)

気象庁
Japan Meteorological Agency



Source: http://www.data.jma.go.jp/mscweb/en/himawari89/himawari89plan.html

- Band**: x3 increased** (5-band -> 16-band)
- Resolution: **x4 improved** (VIS: 1km -> 0.5 km)
- Interval: **x3 increased** (30-min -> 10-min for full-disk, 2.5-min for local area)

(provided by JMA)

Center Wavelength of Himawari-8/AHI

Band	Wavelength (μm)	Resolution (km)	Band	Wavelength (μm)	Resolution (km)
1	0.47	1	9	6.9	2
2	0.51		10	7.3	
3	0.64	0.5	11	8.6	
4	0.86	1	12	9.6	
5	1.6	2	13	10.4	
6	2.3		14	11.2	
7	3.9		15	12.4	
8	6.2		16	13.3	

Global Change Observation Mission – Climate (GCOM-C) "SHIKISAI" (JFY2017)

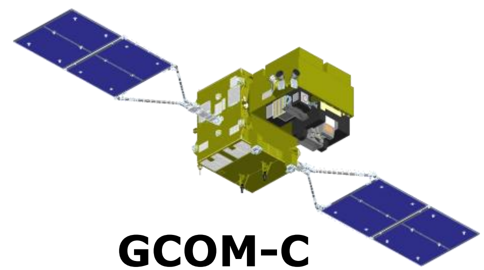
Characteristics of GCOM-C

- **Cover global area in ~2 days with wide swath more than 1150km**
- **Obsevre atmosphere, land & ocean by 19 channels**
- **250m horizontal resolution**

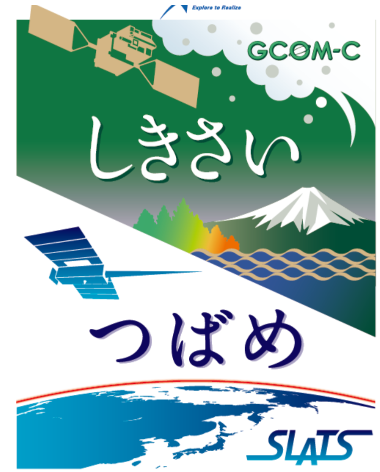
Characteristics of SGLI spectral bands

CH	λ	Δλ	L_{std}	L_{max}	SNR@L_{std}	IFOV
	nm		W/m²/sr/μm K: Kelvin		- K: NEΔT	m
VN1	380	10	60	210	250	**250** /1000
VN2	412	10	75	250	400	**250** /1000
VN3	443	10	64	400	300	**250** /1000
VN4	490	10	53	120	400	**250** /1000
VN5	530	20	41	350	250	**250** /1000
VN6	565	20	33	90	400	**250** /1000
VN7	673.5	20	23	62	400	**250** /1000
VN8	673.5	20	25	210	250	**250** /1000
VN9	763	12	40	350	1200*	250 /**1000***
VN10	868.5	20	8	30	400	**250** /1000
VN11	868.5	20	30	300	200	**250** /1000
POL1	673.5	20	25	250	250	**1000**
POL2	868.5	20	30	300	250	**1000**
SW1	1050	20	57	248	500	**1000**
SW2	1380	20	8	103	150	**1000**
SW3	1630	200	3	50	57	**250** /1000
SW4	2210	50	1.9	20	211	**1000**
TIR1	10800	700	300K	340K	0.2K	250/**500**/1000
TIR2	12000	700	300K	340K	0.2K	250/**500**/1000

Multi-angle obs. for 674nm and 869nm



GCOM-C



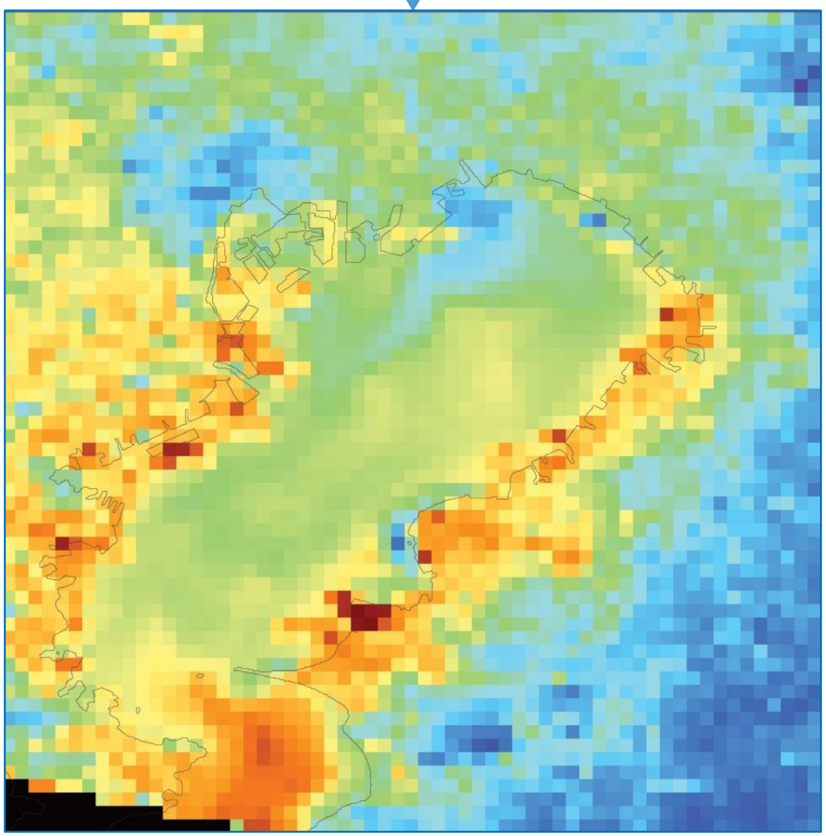
Instrument	**Second-generation Global Imager (SGLI)**
Channels	19 channels (from UV to TIR)
Orbit	Sun-synchronous orbit Altitude: ~800km Descending Local Time: 10:30
Swath width, Resolution	Swath width: 1,150km (except TIR) 1,400km (TIR) Resolution:250m -1km
Launch	Latter half of JFY2017
Designed life	5 years

SGLI Land & Sea Surface Temperature in 250m res.

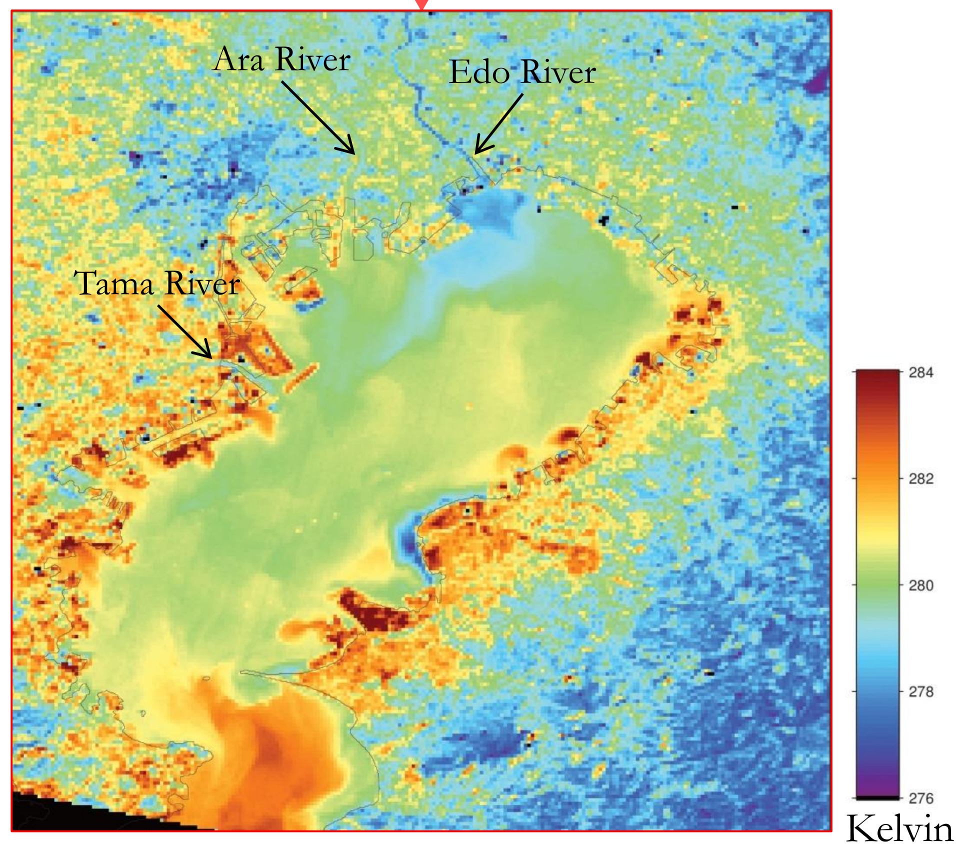
SGLI Thermal-Infrared channels have 250m res. and 1400km swath by which SGLI can observe land and surface temperature high-frequently and in finer resolution.

Simulated by LANDSAT-8/TIRS
11μm 100m data on 23 Jan. 2014

1-km resolution



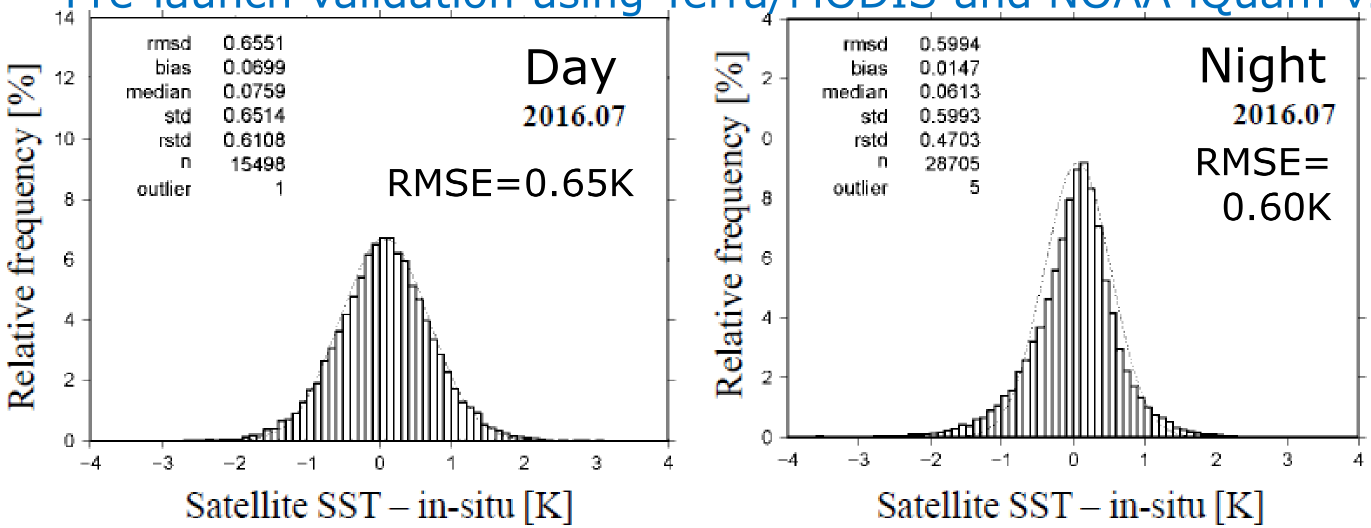
250-m resolution



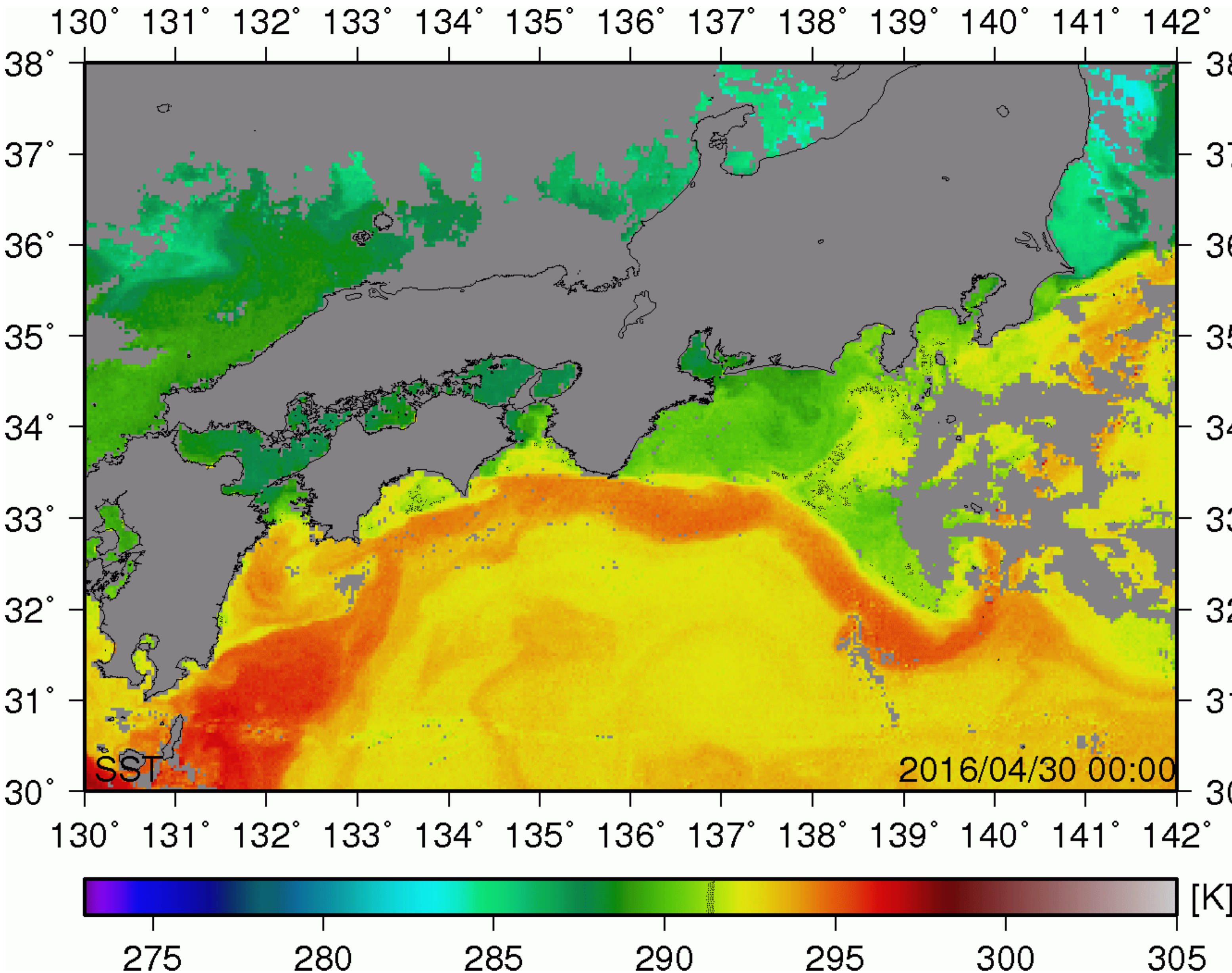
SST algorithm for SGLI

- SST calculation: Bulk-SST using Quasi-physical method with parameterized infrared radiative transfer equation. Using IR & NR (normal-mode: day & night) and IR & VIS (night-mode: nighttime only) channels.
- Cloud screening: Bayesian to estimate cloud probability by using for IR & VIS channels in day-time and IR only in night-time.
- Introduction of Q-method to mitigate systematic errors depending on seasons and area.
- SST algorithm was also applied to Himawari-8/AHI and Terra & Aqua/MODIS considering synergies and consistencies. To increase consistency, inter-calibration method focused on SST is also developed.

Pre-launch validation using Terra/MODIS and NOAA iQuam v2



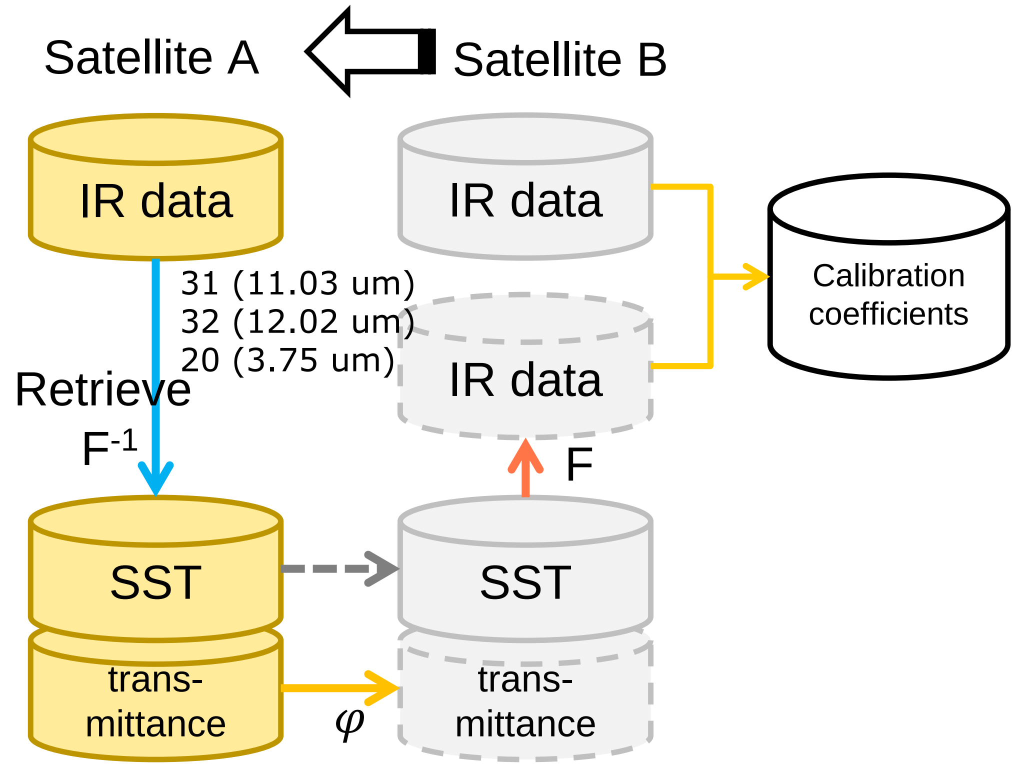
Himawari-8/AHI SST in 10-minutes



New cross-calibration method for IR channels

- In order to produce consistent SST datasets from various IR imagers (AHI, MODIS, VIIRS, SGLI), we have introduced a new physical SST algorithm applying to all IR imagers. Inconsistencies around about 0.3~0.4 K are still found due to calibration of each instrument.

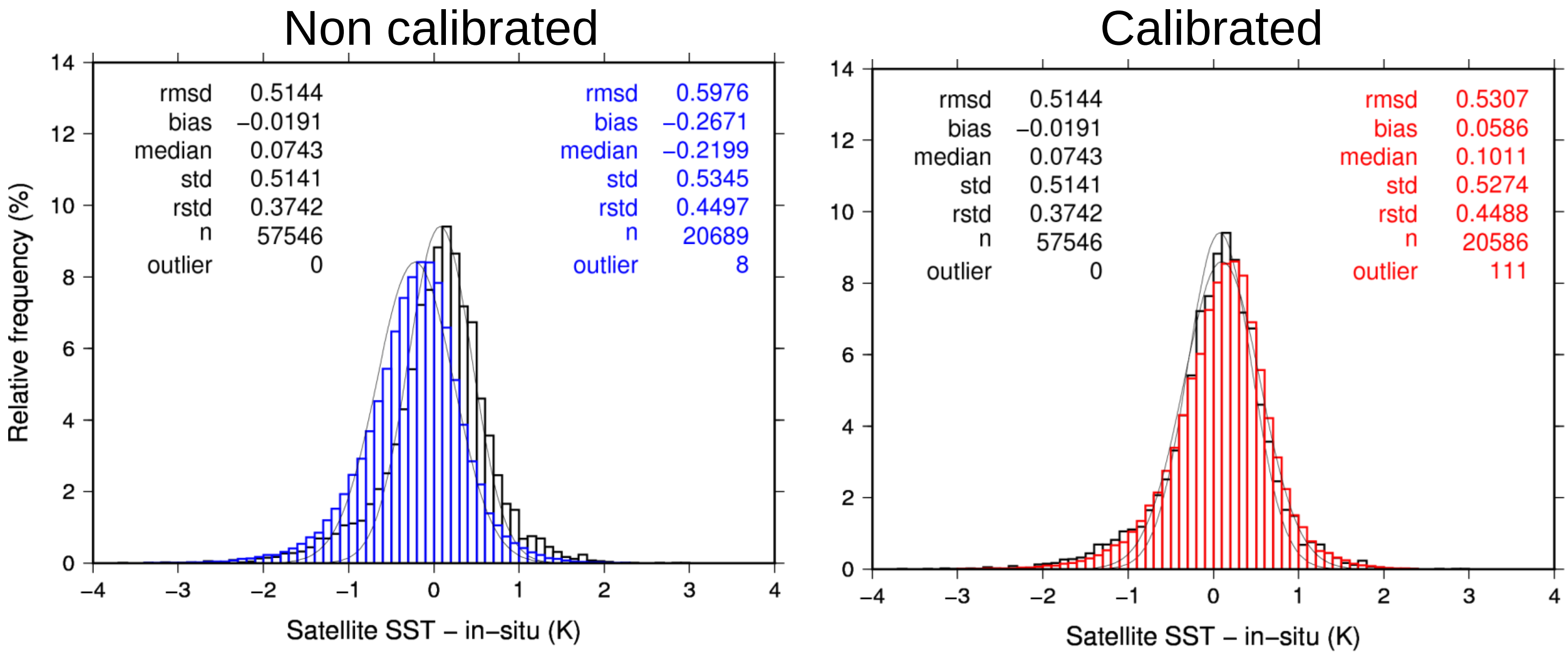
  - GSICS correction was applied to Himawari-8/AHI, but improvement in SST retrieval was very small.
  - Currently, we are developing a new cross-calibration method focused on SST, by using SST and transmittance data which are physically retrieved from satellite IR data.
  - The method is expected to improve consistency in satellite SSTs effectively.



F denotes a parameterized radiative transfer equation which was derived by the simplification the IR radiative transfer equation.

Calibration Results Applied to MODIS and AHI

Differences between buoy data and satellite SSTs for May 2016.



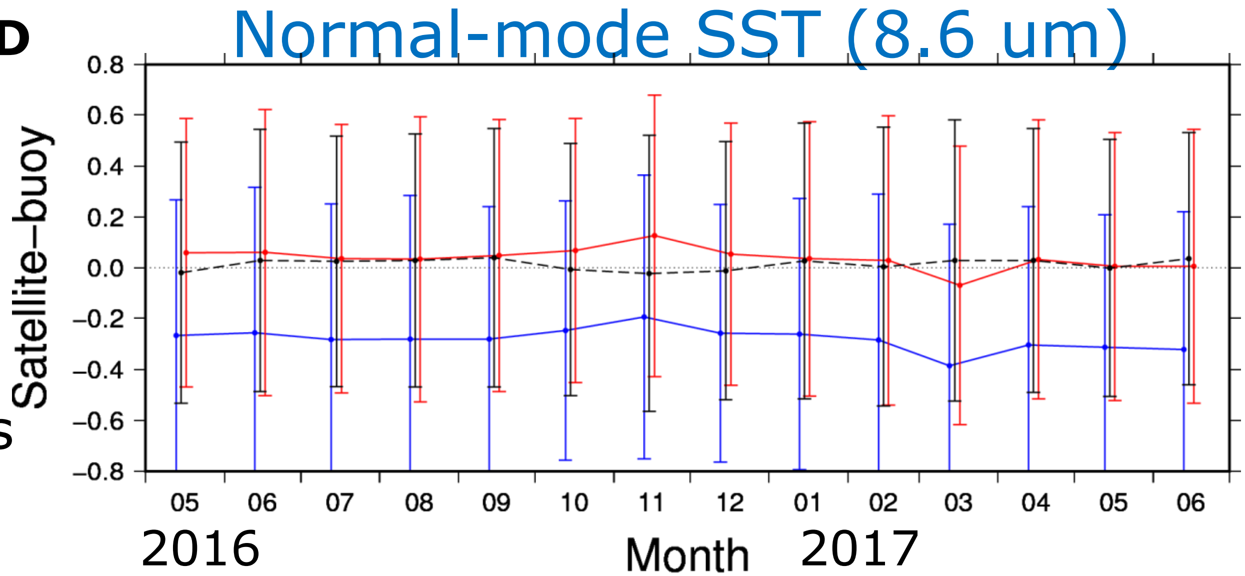
Blue: original Himawari-8 SST, **red: corrected Himawari-8 SST**, and **black: Terra/MODIS SST**. Correction coefficients calculated by the comparison between simulated and observed Himawari-8 data were used. Himawari-8 SSTs were determined from 10.4, 11.2, and 8.6 um band data.

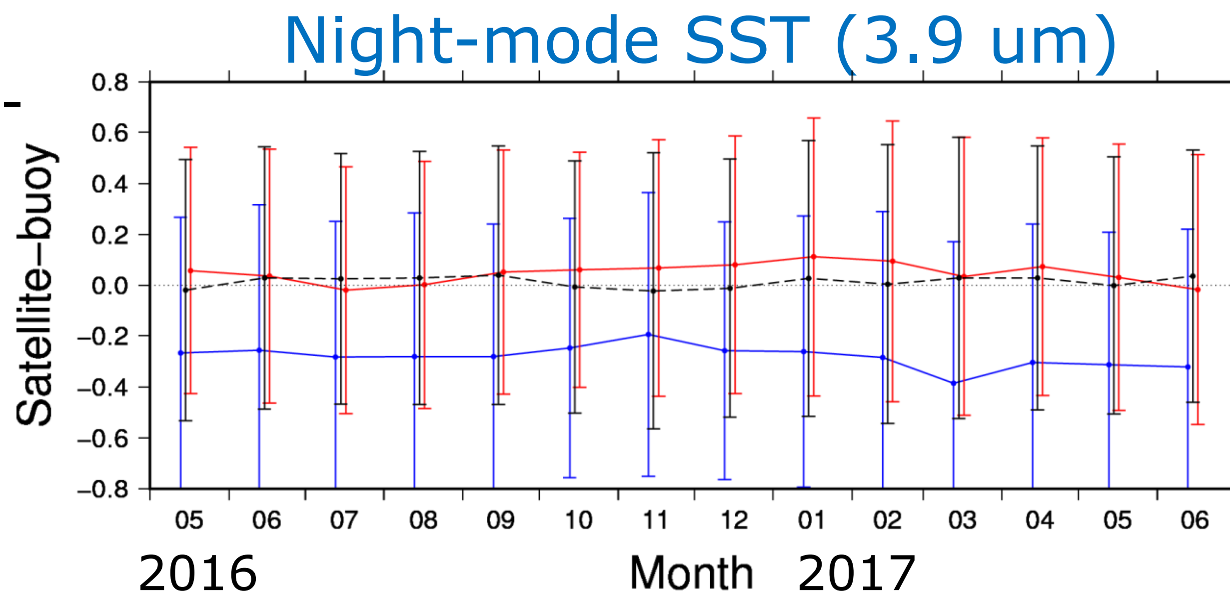
The result shows a good capability of the method that **reduced the mean difference of ~0.2 K** between Himawari-8 and Terra/MODIS SSTs to **nearly zero**.

SST Long-term validation by iQuam

Monthly bias and STD with iQuam v2
Solid: Himawari-8/AHI
Dash: Terra/MODIS
Blue: original SST
Red: corrected SST

- iQuam buoy data is really useful to check long-term variation of SSTs.
- Recent AHI normal-mode SST shows slightly enhanced negative bias trends. We are checking if this came from sensor trend.





AHI SST comparison with ISAR

- AHI SSTs with the cloud probability less than 0.3 were chosen for the comparison.
- ISAR data (provided by Prof. P. Minnet) within 1.5 km and 10 min from each AHI SST were chosen without any QC.
  - Number of the match-ups are 3,933 from the cruises of AL38 to AL42 and Kaimei for July 2015 to February 2016.
- Since ISAR data number and period is limited, we will use the data as temporally product or evaluation for algorithm.
- We have also received ISAR data provided by Australian Bureau of Meteorology (ABoM), but not analyzed yet.

ISAR Validation results (normal-mode)

daytime

cruise	bias	median	STD	rSTD	N
AL38	-0.46	-0.56	0.76	0.30	37
AL39	0.42	0.45	0.62	0.46	349
AL40	**0.67**	**0.83**	0.66	0.39	81
AL40x	**1.28**	**1.35**	0.68	0.46	81
AL41	**2.35**	**2.43**	0.61	0.50	429
AL42	0.16	0.17	0.63	0.68	742
Kaimei	-0.07	-0.01	0.44	0.38	65

nighttime

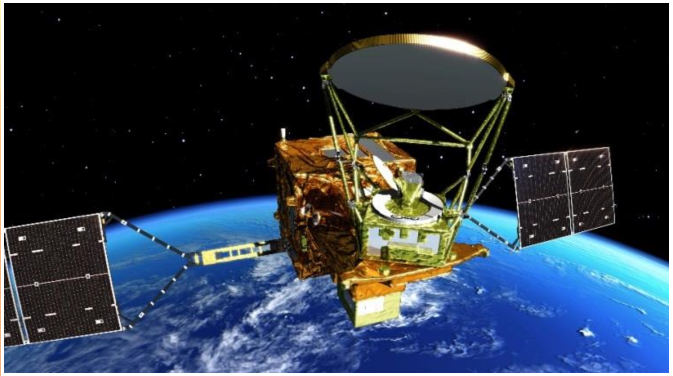
cruise	bias	median	STD	rSTD	N
AL38	-0.40	-0.39	0.38	0.38	47
AL39	0.33	0.36	0.53	0.39	597
AL40	-0.08	0.24	**0.96**	**1.03**	69
AL40x	0.40	**0.73**	**0.97**	1.06	69
AL41	**1.33**	**1.45**	**0.92**	**0.92**	649
AL42	0.25	0.26	0.51	0.53	836
Kaimei	-0.17	-0.18	0.40	0.29	31

ISAR Validation results (night-mode)

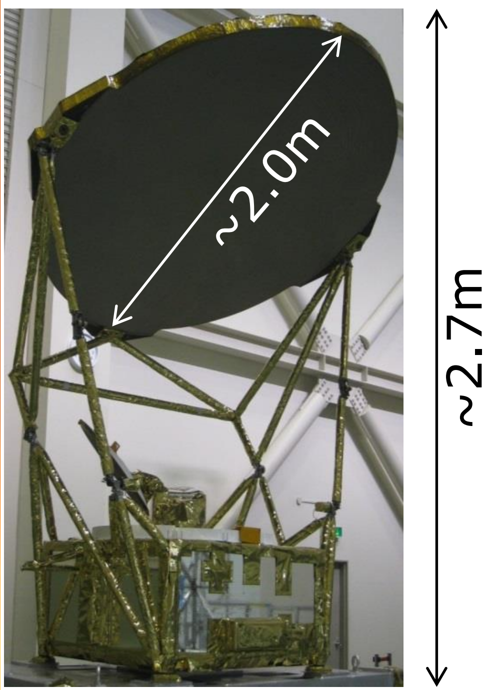
	cruise	bias	median	STD	rSTD	N
	AL38	-0.34	-0.33	0.30	0.28	46
	AL39	0.11	0.15	0.44	0.26	494
night-time	**AL40**	0.24	0.50	**0.76**	**0.65**	55
	AL40x	**0.72**	**0.99**	**0.76**	**0.68**	55
	AL41	**1.12**	**1.34**	**0.87**	**0.85**	624
	AL42	0.23	0.28	0.46	0.47	812
	Kaimei	-0.06	-0.01	0.26	0.24	28

- Except for AL40 and AL41, expected results were derived (-0.4 ~ 0.4 K of bias, 0.5-0.7 K of STD during daytime, and 0.4 ~ 0.5 K of STD during nighttime).
  - AL40 seems to be more affected by clouds than others.
- Better performances of 3.9 um SST (night-mode) are also as expected.
- High biases of 1 ~ 2 K and large STDs of ~ 0.9 K against AL40, AL40x, and AL41 data need examinations.
  - Positive biases of AL39 & AL40 can be explained by AHI SST's issue of seasonal positive biases in northern high-latitude.
  - Positive biases of AL41 cannot be explained by above issue.

GCOM-W and Advanced Scanning Microwave Radiometer 2 (AMSR2)



- ✓Launched on May 18, 2012
- ✓Successor of Aqua/AMSR-E (2002-2011 (2rpm mode: 2012-2015)), providing continuous data for climate studies and operational applications
- ✓AMSR2 is a multi-polarization and multi-frequency microwave imager with conical scanning at 40 rpm
- ✓Swath width is ~1600km@700km altitude
- ✓Observes water-related geophysical parameters
- ✓High spatial resolution with 2m diameter antenna
- ✓Improvement of on-board calibration target has resulted reduction of annual TB variation due to calibration and improvement of TB stability



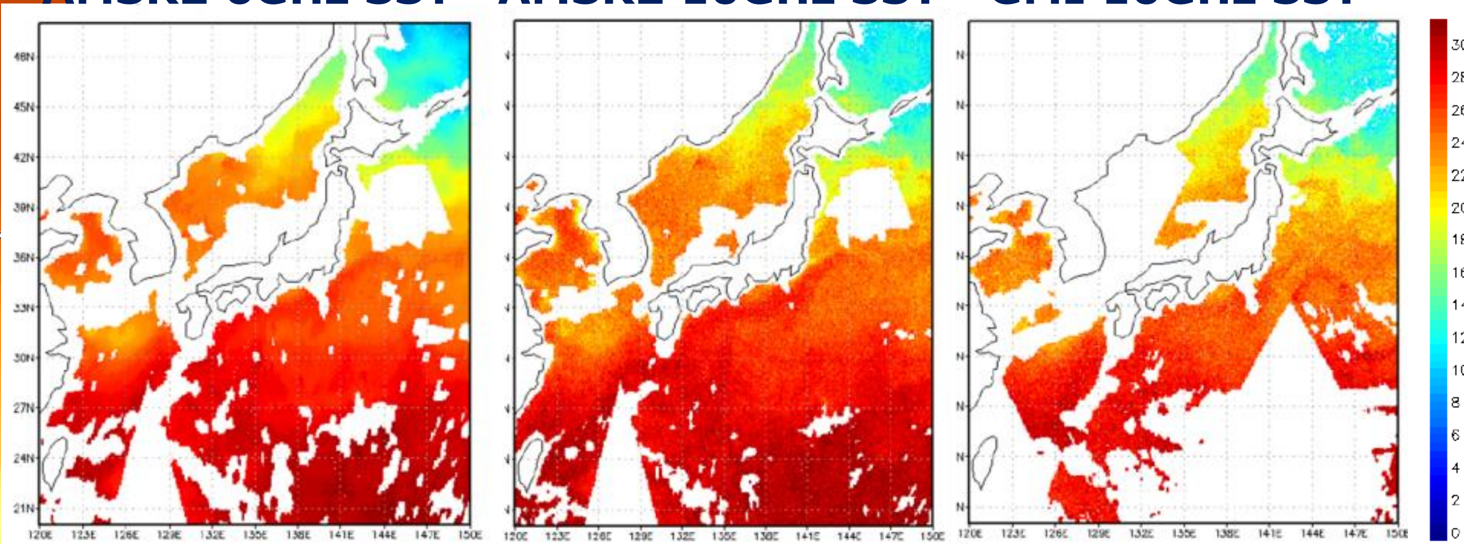
AMSR2 Sensor Unit

Freq. [GHz]	Temp. res.	Beam width (-3dB) (res. at surface)
6.925/7.3	< 0.34 K	1.8° (35km x 62km)
10.65	< 0.70 K	1.2° (24km x 42km)
18.7	< 0.70 K	0.65° (14km x 22km)
23.8	< 0.60 K	0.75° (15km x 26km)
36.5	< 0.70 K	0.35° (7km x 12km)
89.0 A/B	< 1.20 K	0.15° (3km x 5km)

AMSR2 6GHz and 10GHz SSTs

- Standard SST mainly uses 7GHz channels, and 10GHz research SST included in standard SST products uses 10GHz channels.
- 10GHz channels have advantage in finer (30km) resolution compared to that of 6GHz (50km).
- Disadvantage of 10GHz is poor sensitivity to low temperature range, less than 10 degC. Currently SST less than 9 degC is set as missing.
- Same algorithm was applied to GPM-Core/GMI and product was released to public in April 2015.

AMSR2 6GHz SST **AMSR2 10GHz SST** **GMI 10GHz SST**



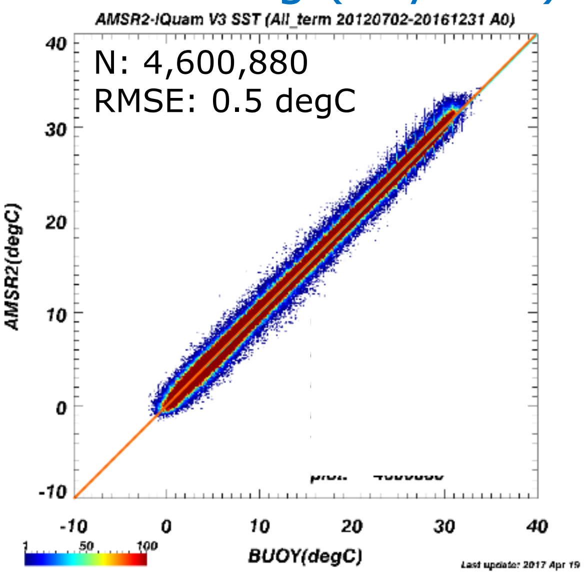
Validation with iQuam buoy

Product	RMSE
AMSR2 6GHz SST	0.50℃
AMSR2 10GHz SST	0.55℃
GMI 10GHz SST	0.60℃

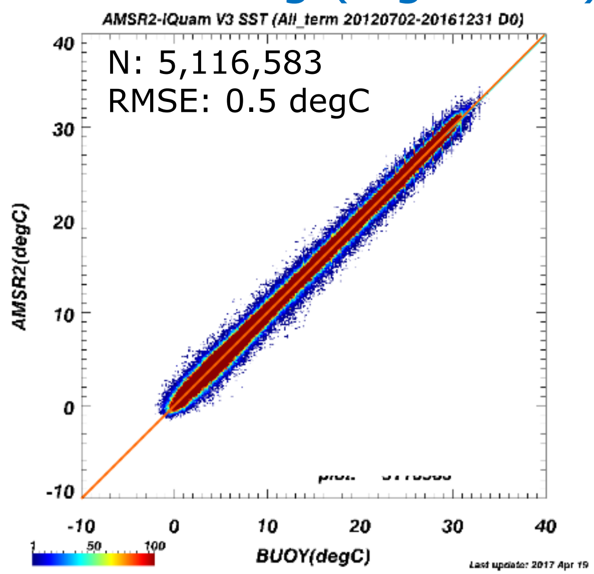
AMSR2 SST Ver.3 Validation (released on 1 Mar. 2017)

Validation with NOAA iQuam v2 buoys from 2 Jul. 2012 to 31 Dec. 2016.
Match-up with differences within 2-hour in time and 30km in distance.

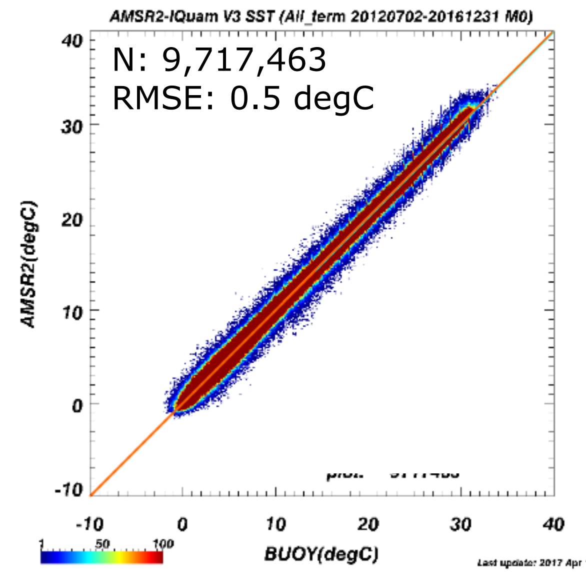
Ascending (daytime)



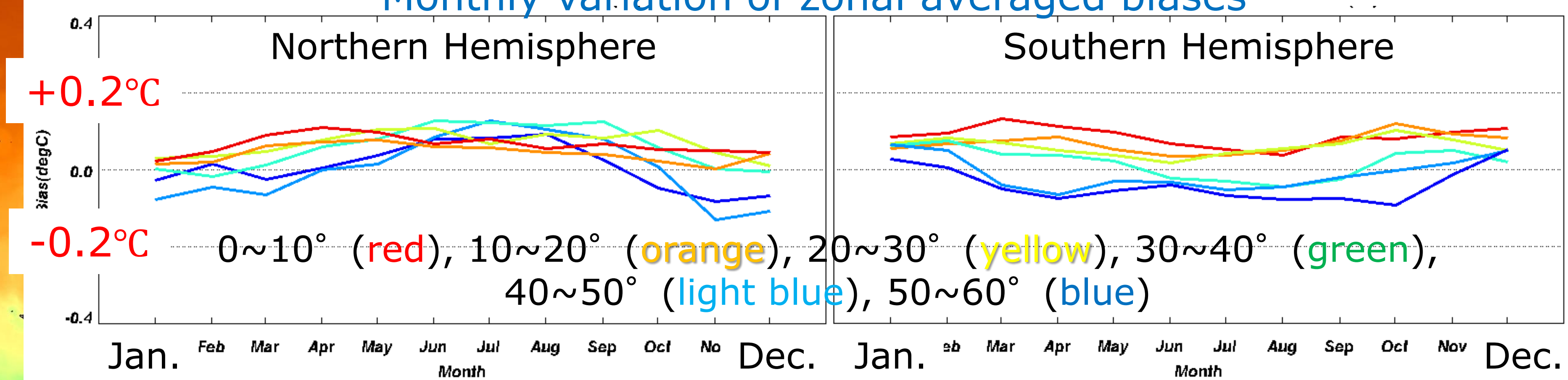
Descending (nighttime)



Ascending/Descending



Monthly variation of zonal averaged biases



Other surface information we are working on …

- GCOM-C/SGLI
  - Land surface temperature product
  - Snow and ice covered area product
  - Snow and ice surface temperature product
- Himawari-8
  - Thin ice detection product: in preparation
- GCOM-W/AMSR2
  - Sea ice concentration/sea ice extent product: availale
  - Land surface temperature research product: now validating for release
  - Thin ice detection research product: now validating for release
  - Sea ice thickness product: new candidate for research product, under development
  - Ice sheet monitoring over Greenland: in preparation

Summary

- Optical SST products are developed based on GCOM-C/SGLI algorithm
  - GCOM-C/SGLI SST algorithm is ready for launch in JFY2017
  - Himawari-8/AHI SST is distributed in GDS2.0 format (**http://www.eorc.jaxa.jp/ptree**)
  - Aqua/Terra MODIS & NPP/VIIRS SSTs are in preparation
  - New cross-calibration method is developed and introduced between AHI and MODIS.
  - Operational validation monitoring with iQuam buoys are in preparation to check long-term trend.
  - Validation using ISAR data is underway.
- PMW SST products are developed distributed based on GCOM-W/AMSR2 algorithm
  - GCOM-W/AMSR2 6 & 10-GHz SST, GPM/GMI 10-GHz SST, Windsat 6-GHz SST are distributed in GDS2.0 format (**http://suzaku.eorc.jaxa.jp/GHRSST**)
  - Validation using iQuam buoys shows 0.5 degC in RMSE.
  - Operational validation monitoring web page is available (**http://www.eorc.jaxa.jp/GCOM_W**)
- Other surface information from GCOM-C, Himawari-8 and GCOM-W is/will be available.

backup

Matched ISAR data to AHI SST

Crouse	Period	Satellite zenith angle coverage	N (daytime)	N (nighttime)
AL38	23 Jun – 9 Jul, 2015	39.6 – 74.4	37 (0)	47 (0)
AL39	27 Jul – 31 Aug	39.5 – 74.3	349 (0)	597 (0)
AL40	27 Aug – 2 Sep	47.1 – 74.3	81 (0)	69 (0)
AL41	29 Nov – 17 Dec	35.4 – 72.3	430 (1)	649 (0)
AL42	26 Jan, 2016 – 18 Feb	36.0 – 70.9	742 (0)	836 (0)
Kaimei	19 Oct – 21 Oct 2015	40.8 - 41.3	65 (0)	31 (0)

() : total number of outliers