SST retrieval from Himawari-8

GHRSST XVI, 24 July 2015

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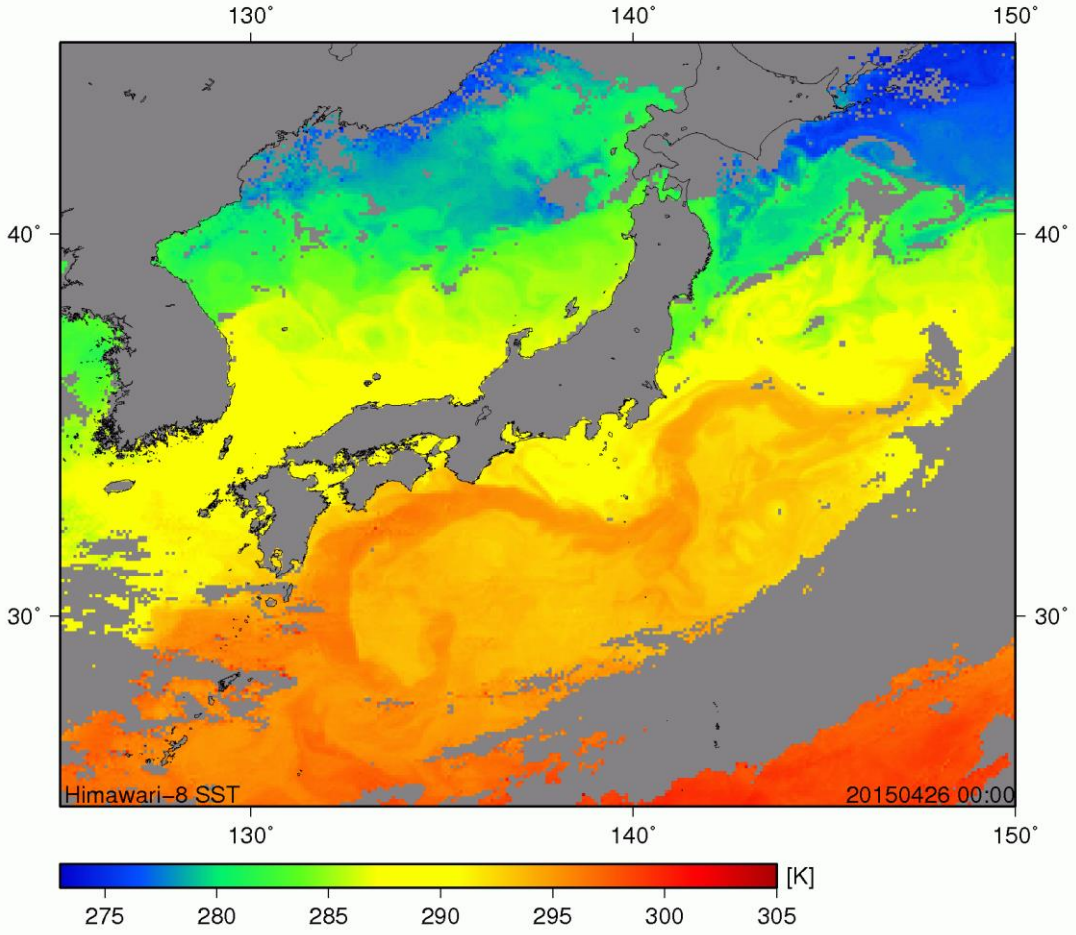
(1) JAXA EORC, (2) RESTEC, (3) JMA

Topics

- Summary
- Himawari-8
- Algorithm
- Validation results
- Future Plan



Summary

- Himawari-8 has been operational since 7 July 2015.
- We developed an SST algorithm for Himawari-8. Skin SST is calculated from two or more than two IR data.
- Bayesian method was introduced to detect cloud.
- We experimentally retrieved SSTs from Himawari-8 data and compared them with BUOY data. Validation result shows bias between -0.3 and 0.1 K and STD between 0.4 and 0.7 K.
- Himawari-8 SST will be available at JAXA's FTP server, and it will be monitored and validated at SQUAM by NOAA/NESDIS.
- GCOM-C SST will be retrieved using the same algorithm with the Himawari-8 algorithm for synergy.

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Himawari-8

- Himawari-8, JMA's new geostationaly meteorological satellite, was launched via H-IIA by JAXA on 7 October 2014 and it replaced MTSAT-2 on 7 July 2015.
- Himawari-8 stays at ~36,000 km above 140E and observes east to south-east Asia, western Pacific and around Australia every 10 minutes.
- Advanced Himawari Imager (AHI) is a visible-infrared radiometer on board Himawari-8. Function of observation has been improved with AHI.

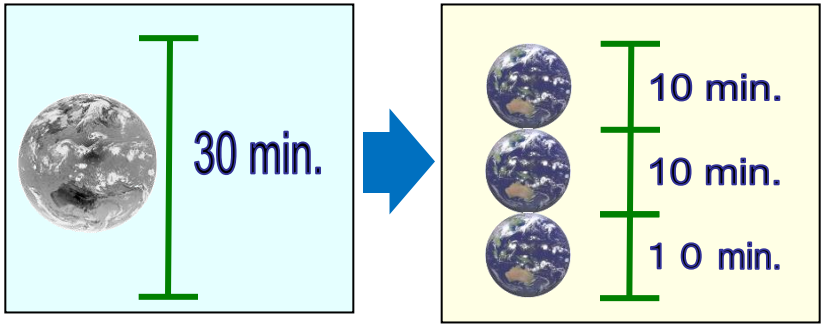
Enhancement of the observation function of Himawari-8/9 as compared to that of MTSAT-1R/2

Higher spatial resolutions

MTSAT-1R/2	Himawari-8/9
VIS 1km	VIS **0.5 - 1**km
IR 4km	IR **2**km

More frequent observations

Full disk observation with 10-minute intervals

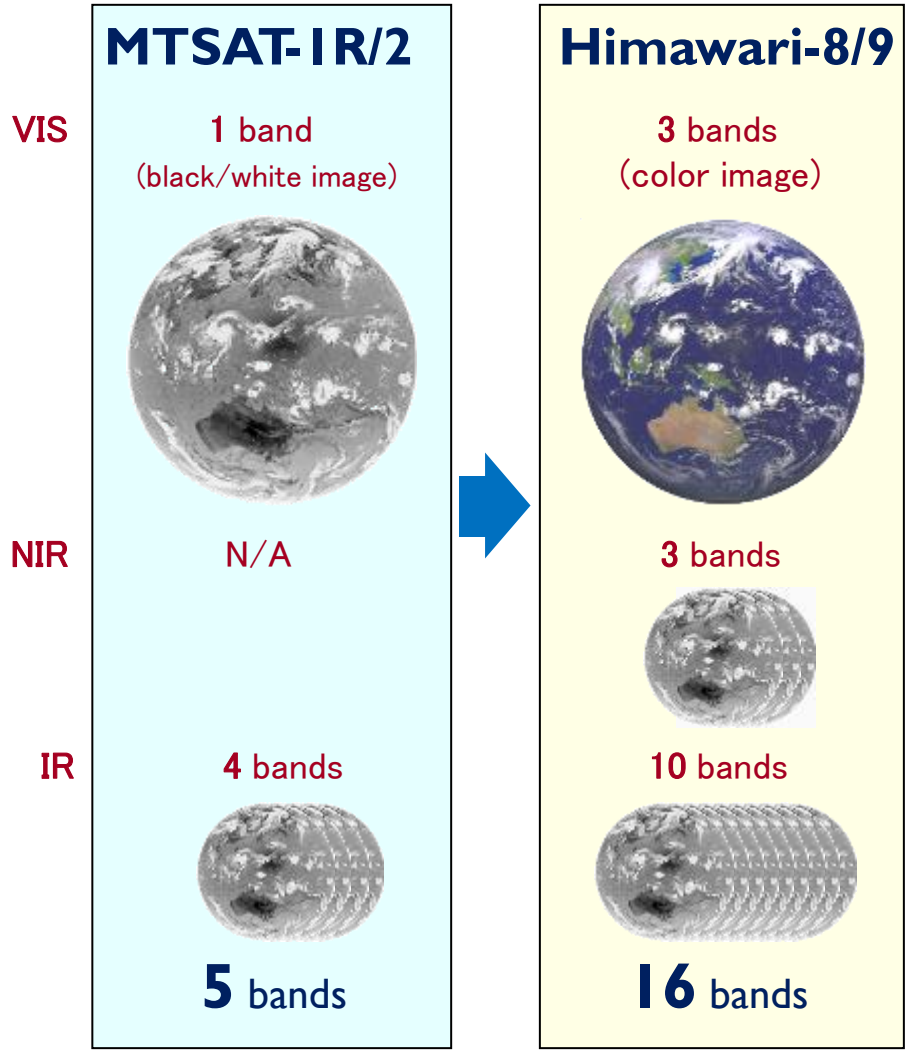


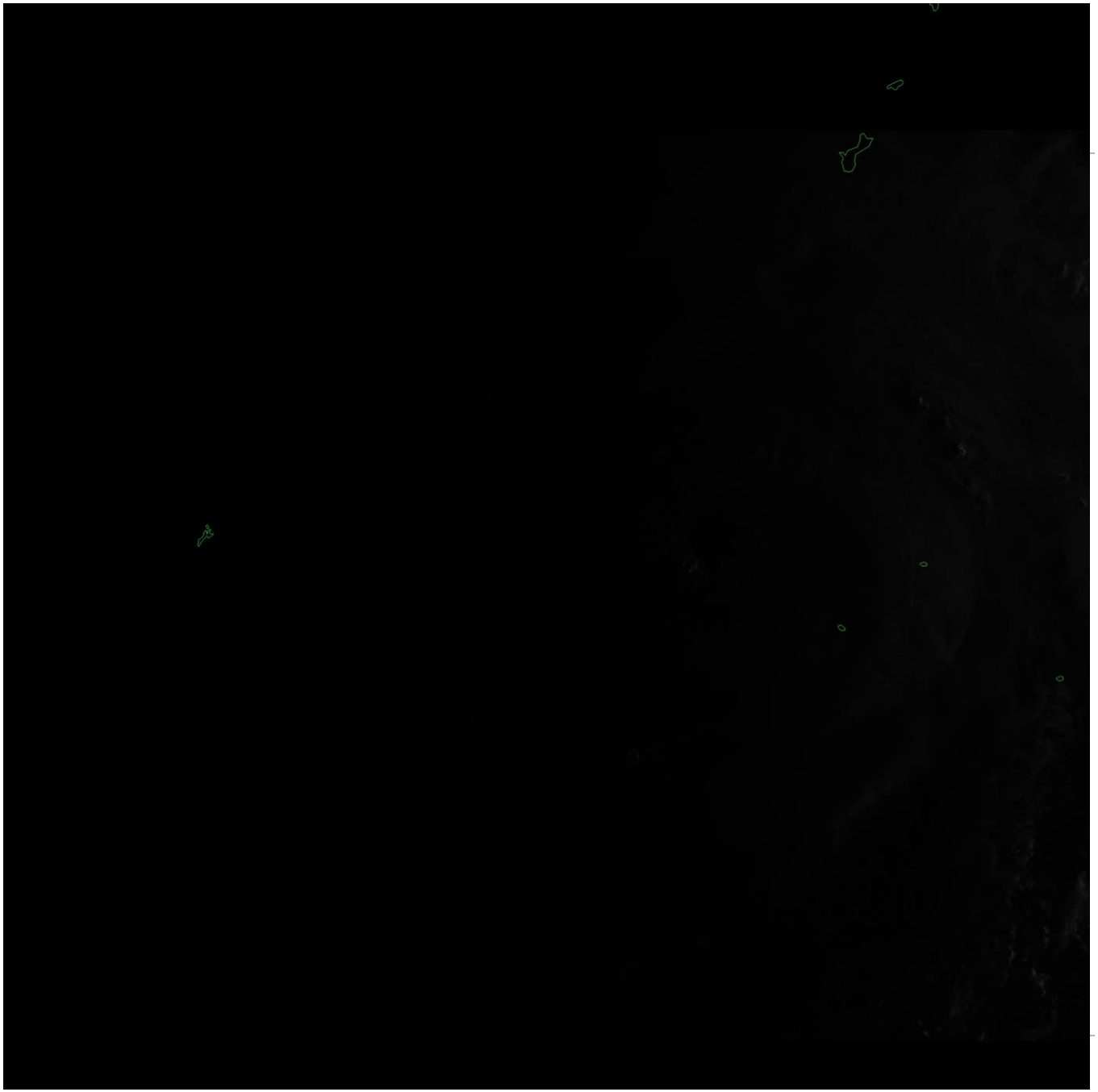
Small-sector observation

New

Every **2.5** minute around Japan

More spectral bands



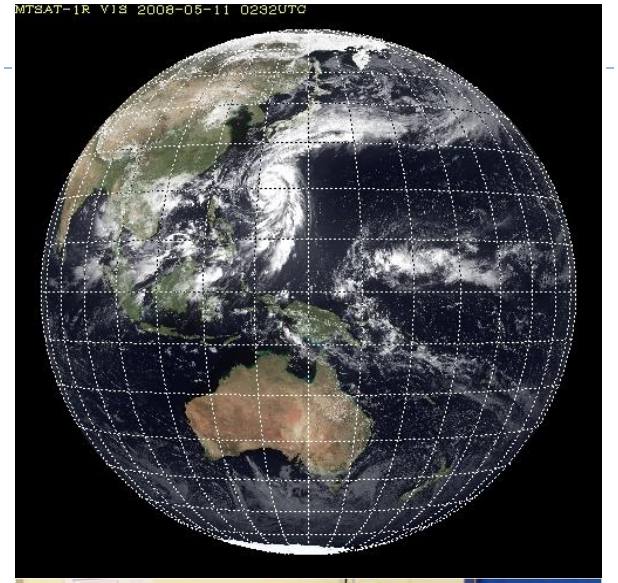


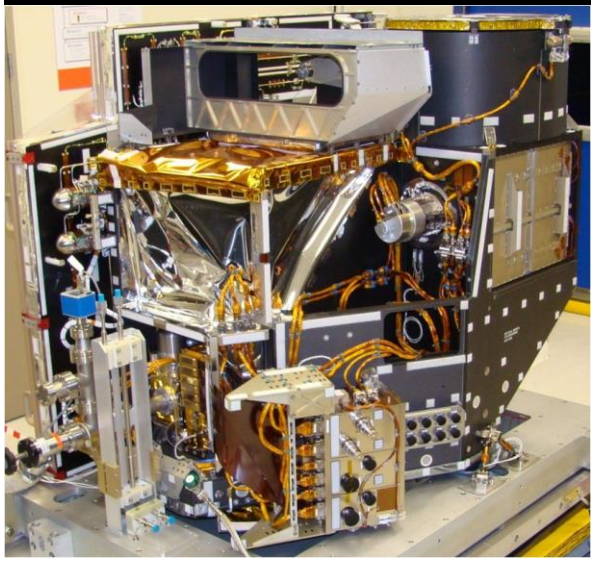
Specification of "Himawari-8/9" Imager (AHI)

*Himawari-9 will be launched in 2016

HIMAWARI-8/9

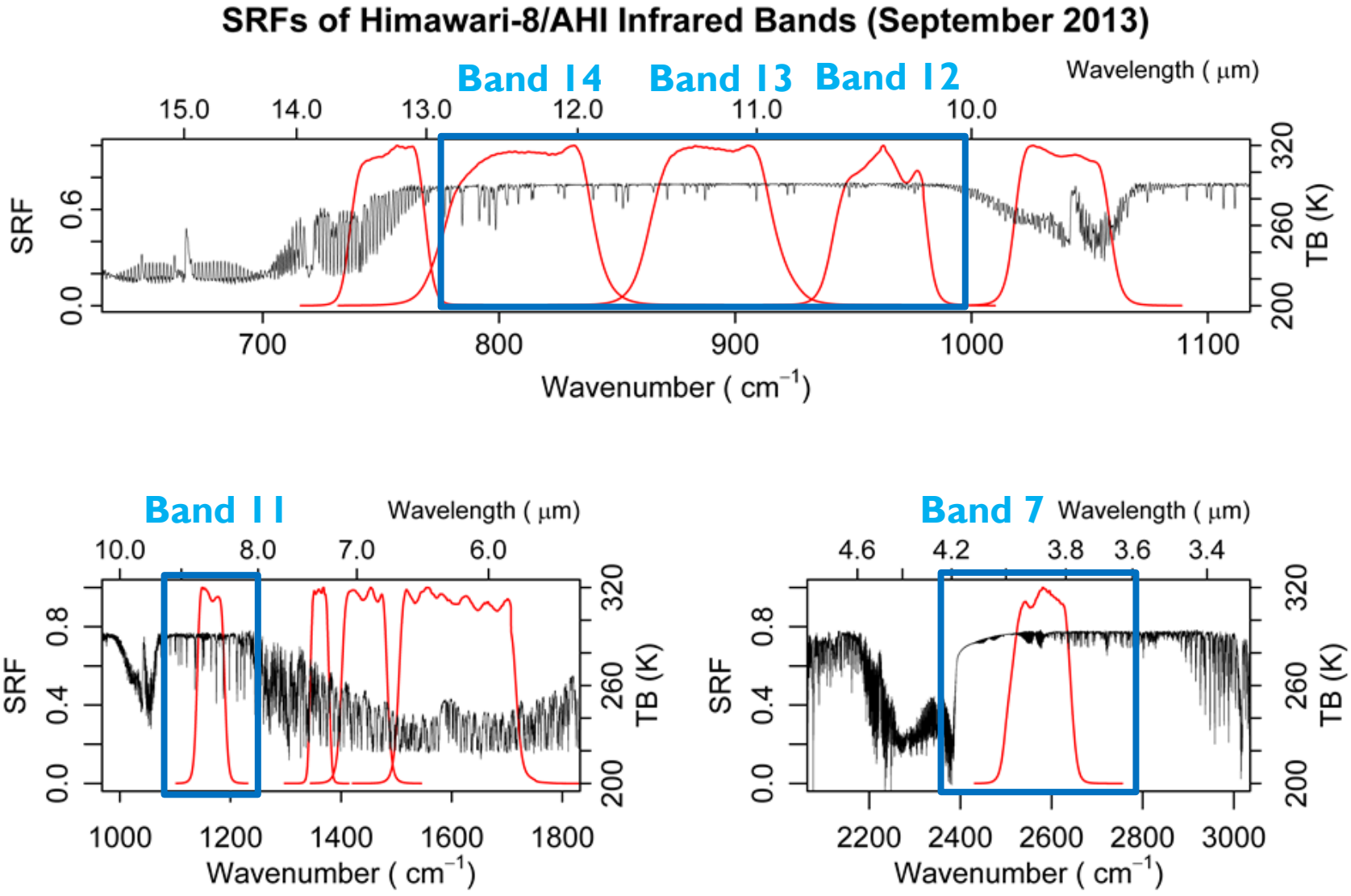
	Band	Central Wavelength [μm]	Spatial Resolution	
VIS	1	0.43 - 0.48	1Km	RGB Composited Full Color Image
VIS	2	0.50 - 0.52	1Km	
VIS	3	0.63 - 0.66	0.5Km	
NIR	4	0.85 - 0.87	1Km	Aerosol
NIR	5	1.60 - 1.62	2Km	
NIR	6	2.25 - 2.27	2Km	
IR	7	3.74 - 3.96	2Km	
IR	8	6.06 - 6.43	2Km	Water Vapour
IR	9	6.89 - 7.01	2Km	
IR	10	7.26 - 7.43	2Km	
IR	11	8.44 - 8.76	2Km	SO_2
IR	12	9.54 - 9.72	2Km	O_3
IR	13	10.3 - 10.6	2Km	Atmospheric Windows
IR	14	11.1- 11.3	2Km	
IR	15	12.2 - 12.5	2Km	
IR	16	13.2 - 13.4	2Km	CO_2





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

Spectral Response Functions of IR bands



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SST Algorithm

- It calculates Skin SST from a combination of two or more than two IR data.
- We currently uses 10.4 and 11.2 micron bands as the key bands, and 12.4, 8.6 and 3.9 micron bands as optional bands.
- Coefficients and parameters used in retrieval were calculated from NWP data with RTTOV in advance.

SST calculation

$$I_\lambda = \varepsilon I_\lambda{}^s t_\lambda + (1-\varepsilon_\lambda) I_\lambda{}^\downarrow t_\lambda + I_\lambda{}^\uparrow$$

$$\begin{aligned} I^s_\lambda &= \overline{I^s_\lambda} + I^{s\prime}_\lambda \\ I^\uparrow_\lambda &= \overline{I^\uparrow_\lambda} + I^{\uparrow\prime}_\lambda \\ I^\downarrow_\lambda &= \overline{I^\downarrow_\lambda} + I^{\downarrow\prime}_\lambda \\ t_\lambda &= \overline{t_\lambda} + t_\lambda{}' \end{aligned}$$

$$\begin{aligned} I^{s\prime}_\lambda &= I^{s\prime}_\lambda|_{I'_\lambda} + I^{s\prime\prime}_\lambda \\ I^{\uparrow\prime}_\lambda &= I^{\uparrow\prime}_\lambda|_{I'_\lambda} + I^{\uparrow\prime\prime}_\lambda \\ I^{\downarrow\prime}_\lambda &= I^{\downarrow\prime}_\lambda|_{I'_\lambda} + I^{\downarrow\prime\prime}_\lambda \end{aligned}$$

$$I_\lambda = \overline{I_\lambda} + I_\lambda{}'$$

$\phi_\lambda(I'_\lambda)$

Introduced two empirical functions:

$$\phi_\lambda(I'_\lambda) : I_\lambda{}' \longrightarrow I^{s\prime}_\lambda|_{I'_\lambda}$$

$$\psi_{\lambda_0,\lambda}(I^{s\prime\prime}_{\lambda_0}, t'_{\lambda_0}) : (I^{s\prime\prime}_{\lambda_0}, t'_{\lambda_0}) \xrightarrow{\approx} I^{s\prime\prime}_\lambda$$

SST calculation

$$I_\lambda = \varepsilon I_\lambda{}^s t_\lambda + (1-\varepsilon_\lambda) I_\lambda{}^\downarrow t_\lambda + I_\lambda{}^\uparrow$$

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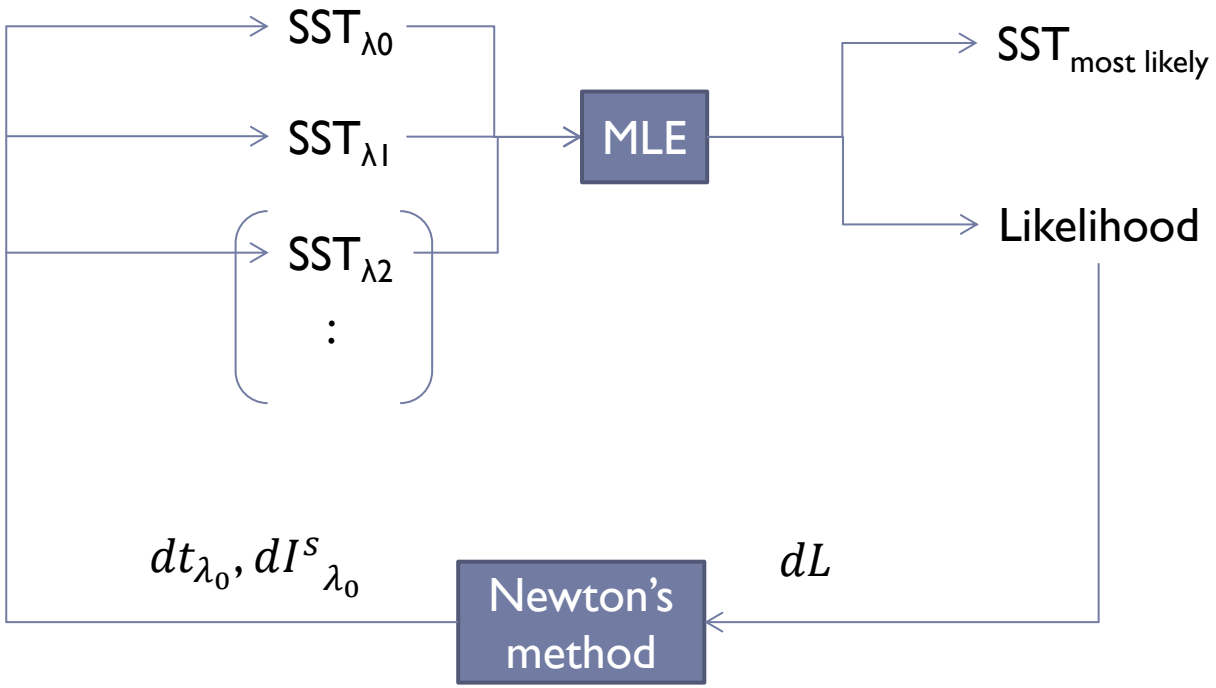
SSTs can be calculated at each IR bands from $I^{s\prime\prime}_{\lambda_0}$ and t'_{λ_0} .

$SST_{\lambda 0}$, $SST_{\lambda 1}$ (, $SST_{\lambda 2}$, ...)

Iteration of retrieval



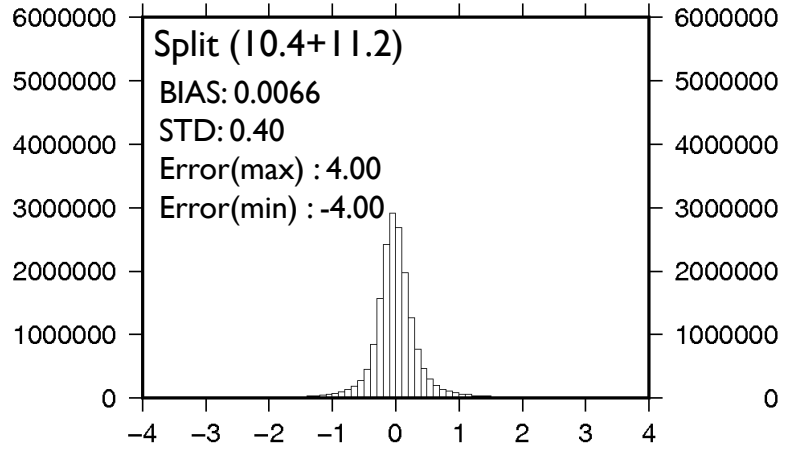
$$\mathbf{x}_{n+1} = \mathbf{x}_n + (\mathbf{S}_x^{-1} + \mathbf{K}^T\mathbf{S}_r^{-1}\mathbf{K})^{-1}\mathbf{K}^T\mathbf{S}_r^{-1}\mathbf{r}(\mathbf{x}_n)$$
$$\mathbf{r}(\mathbf{x}) \equiv (T_{s,\lambda_i} - T_s(\mathbf{x}))$$
$$J(\mathbf{x}) \equiv \mathbf{r}(\mathbf{x})^T\mathbf{S}_r^{-1}\mathbf{r}(\mathbf{x})$$

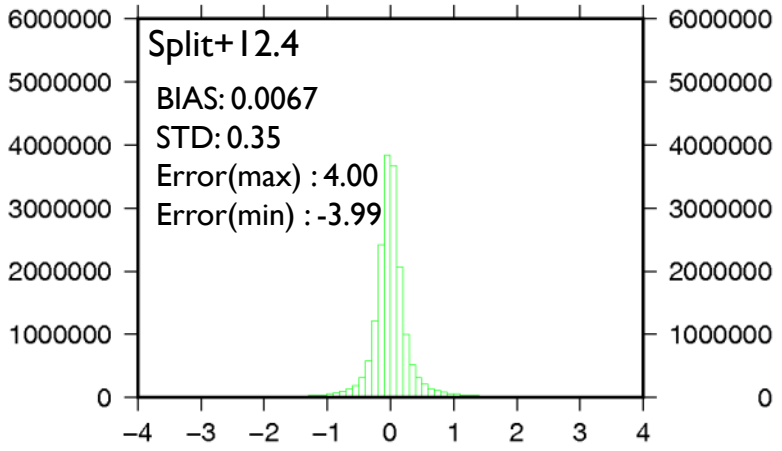
Algorithm Validation

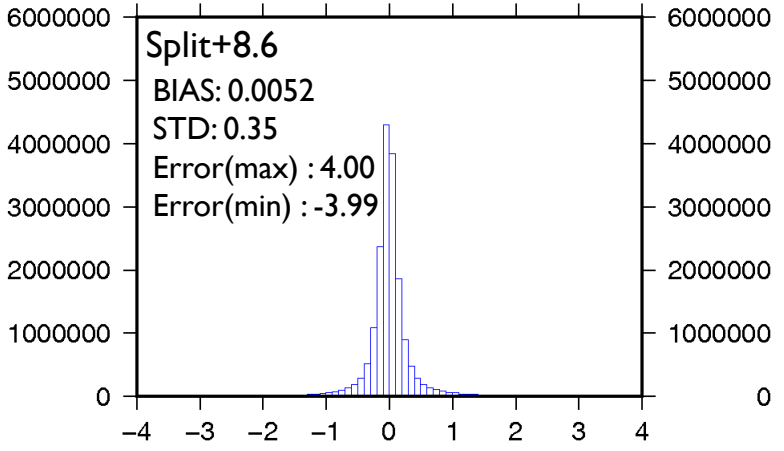
- Data
  - SST analysis
  - NWP data

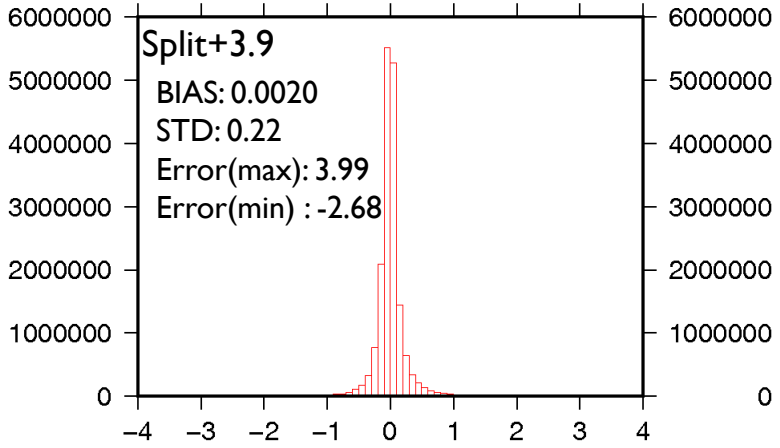
- Validation procedure
  - 1) Calculate TOA radiances from SST analysis and NWP data with RTTOV 10.2
  - 2) Estimate SSTs from the TOA radiances
  - 3) Compare estimated SSTs with SST analysis

Algorithm Capability

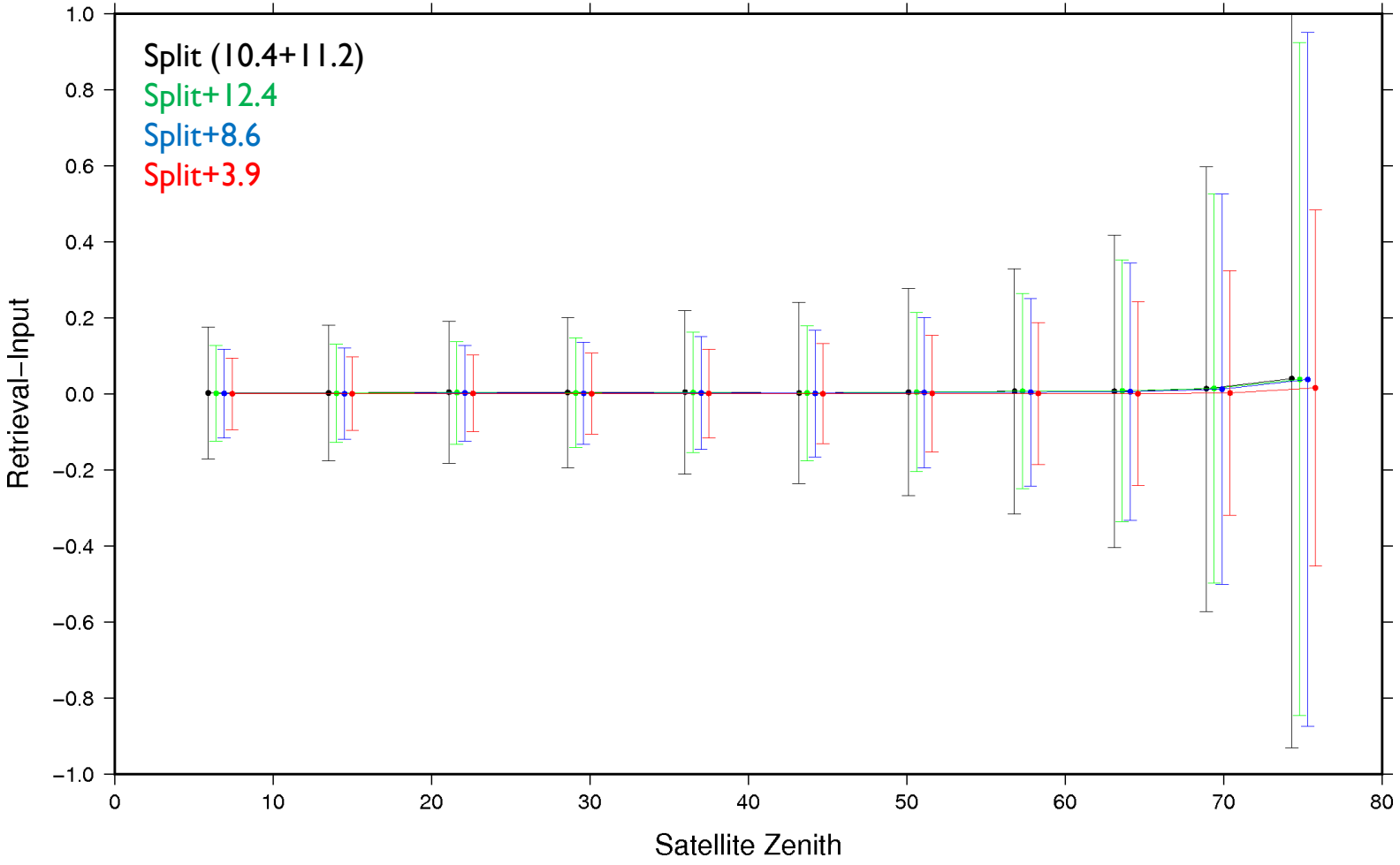








Algorithm Capability (2)

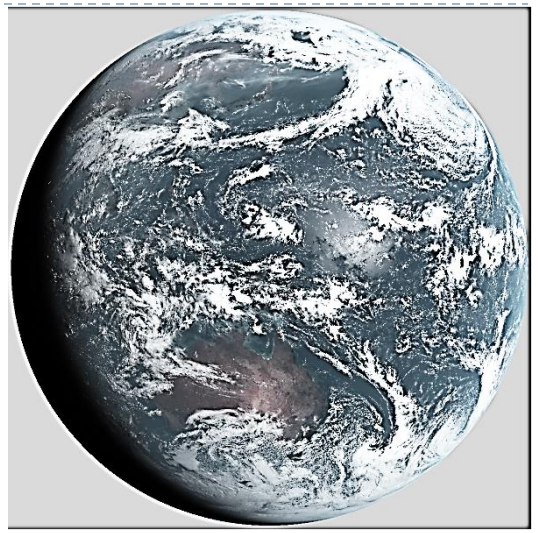


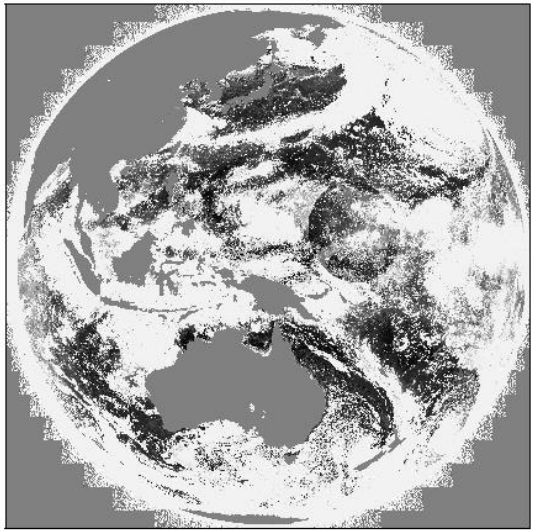
Cloud Screening

- Bayesian

- Data and ancillary
  - 10.4, 12.4, 3.9 um
  - Satellite zenith, Solar zenith, Sun glint
  - daily SST analysis (MGDSST by JMA)

- Reference
  - C. J. Merchant et al. 2005
  - O. Embury, C. J. Merchant 2014, GHRSST-XV





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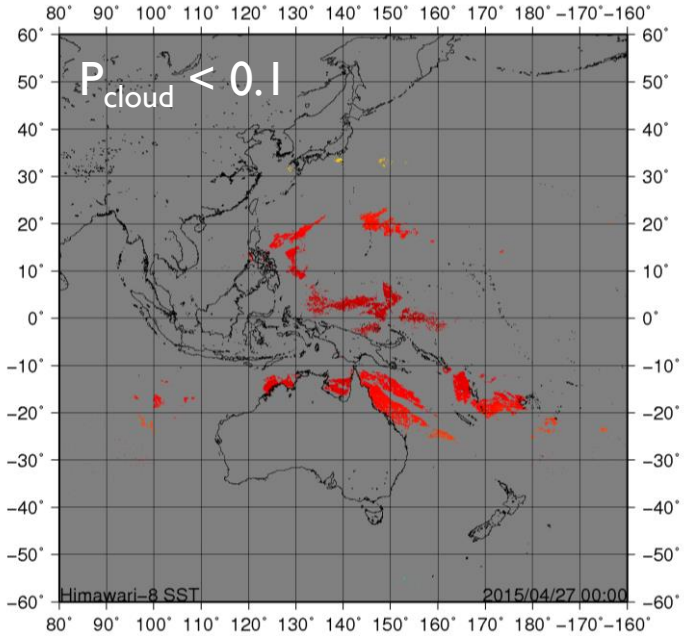
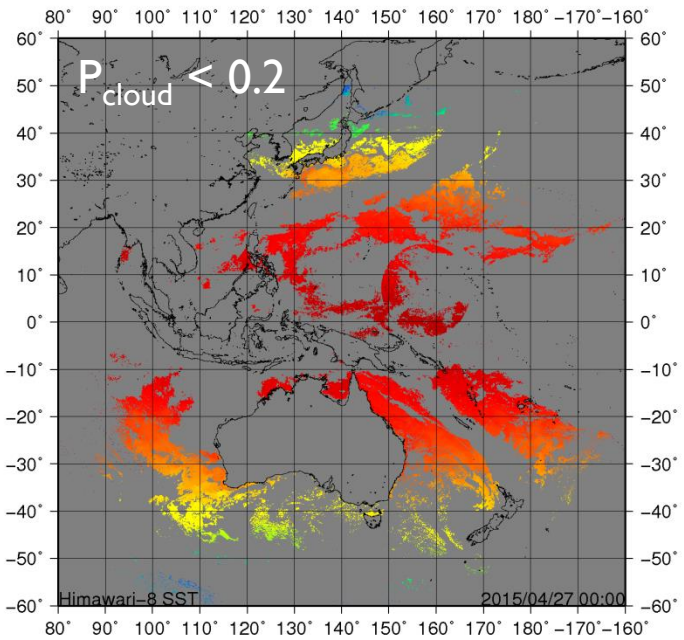
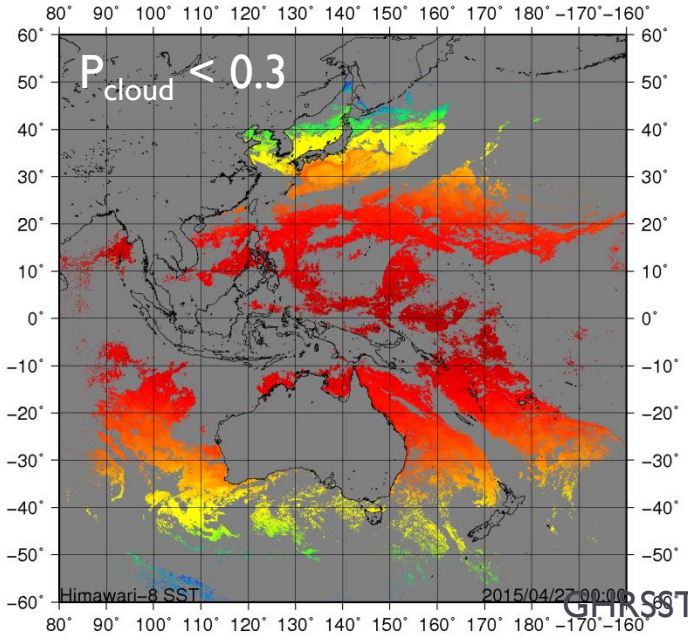
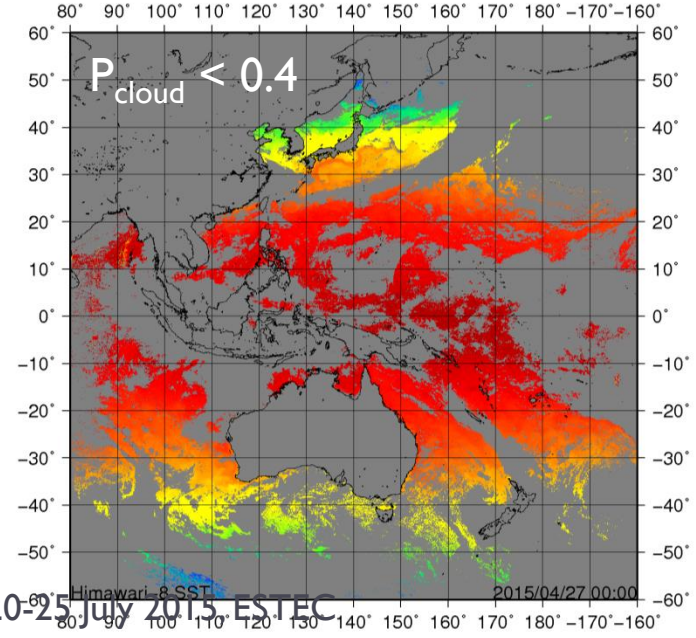
Validation

- Himawari-8 SST
  - SST(split+12.4), SST(split+8.6) and SST(split+3.9)
  - 3 hourly data in May 2015
  - Cloud Probability < 0.3
- In-situ data
  - BUOY (drifter and moored) from iQuam
- Match-up conditions
  - Within 3km and 3 hours
- Validation result includes uncertainties caused by
  - different measurement depth (skin / bulk)
  - different spatial resolution
  - match-up conditions


P cloud < 0.1
Himawari-8 SST
2015/04/27 00:00

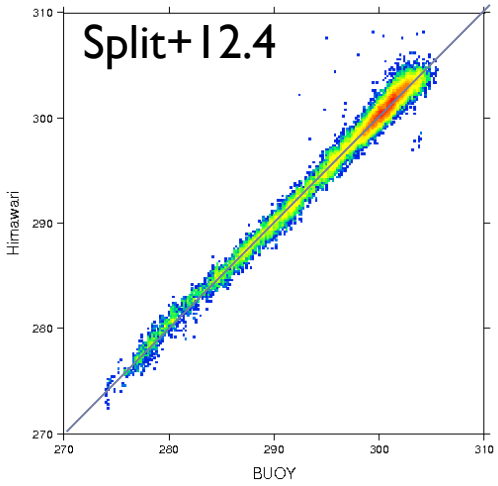

P cloud < 0.2
Himawari-8 SST
2015/04/27 00:00

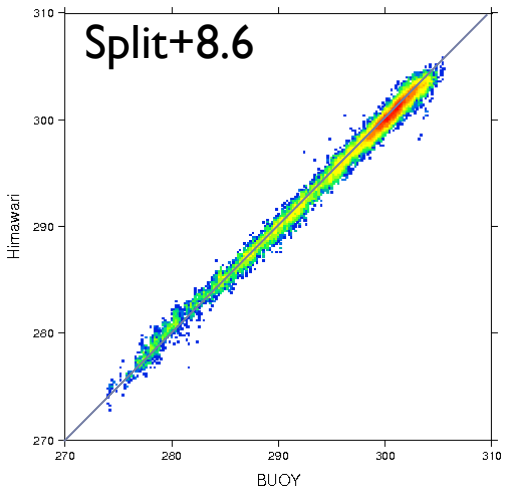

P cloud < 0.3
Himawari-8 SST
2015/04/27 00:00


P cloud < 0.4
Himawari-8 SST
2015/04/27 00:00

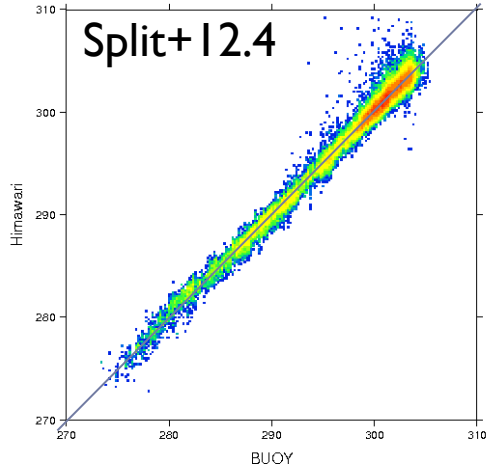
Himawari-8 vs. BUOY

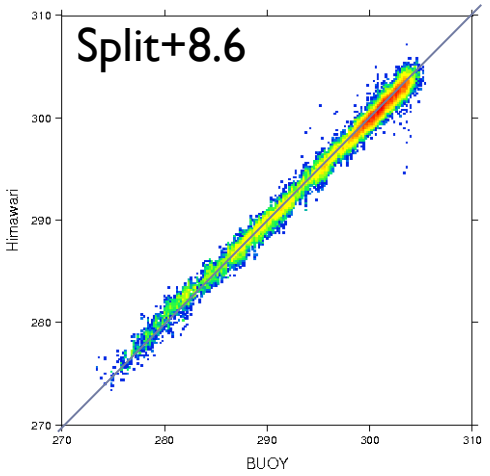
daytime

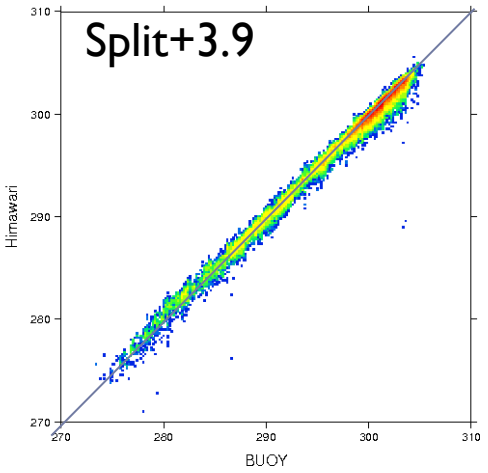




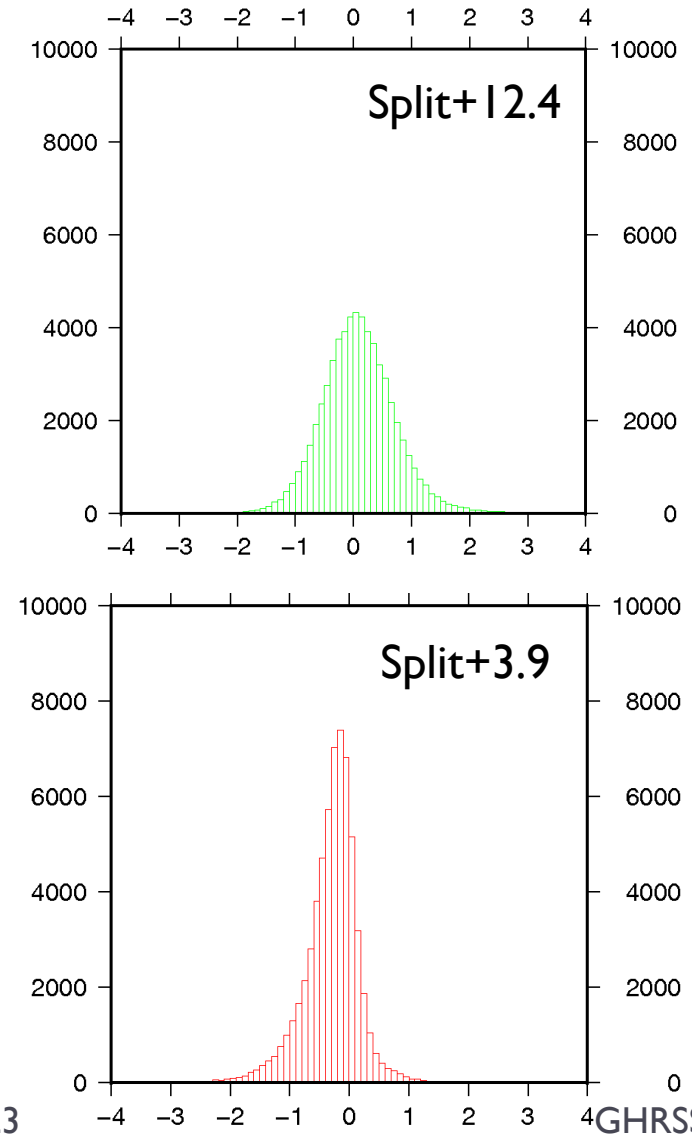
night time

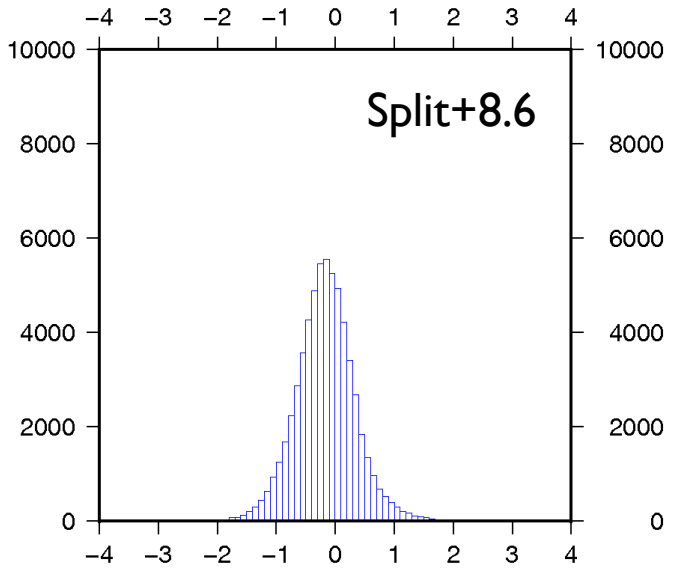






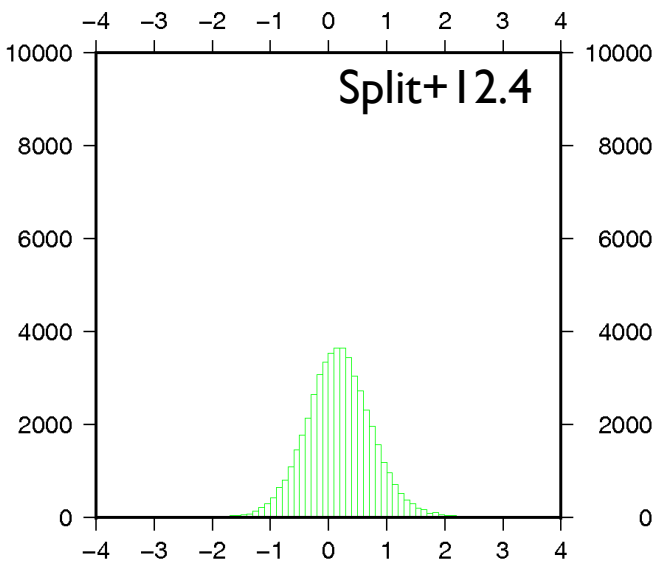
Statistics (nighttime)

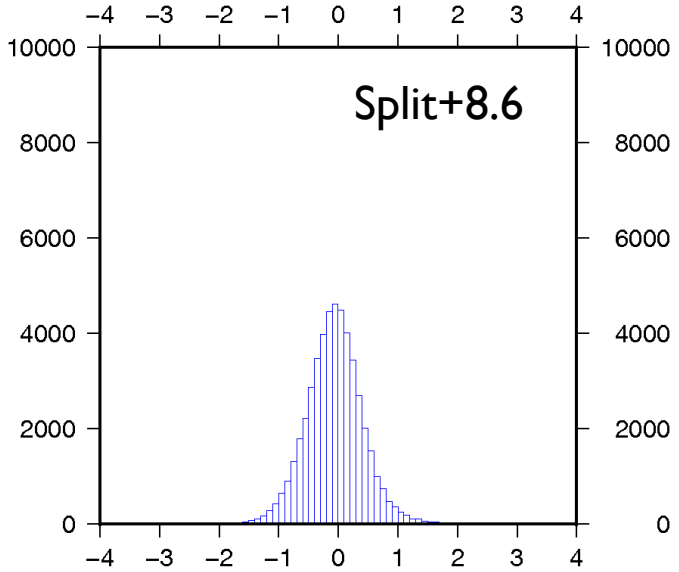




SST	BIAS	STD	N
Split+12.4	0.104	0.69	62182
Split+8.6	-0.17	0.52	62068
Split+3.9	-0.30	0.46	61116

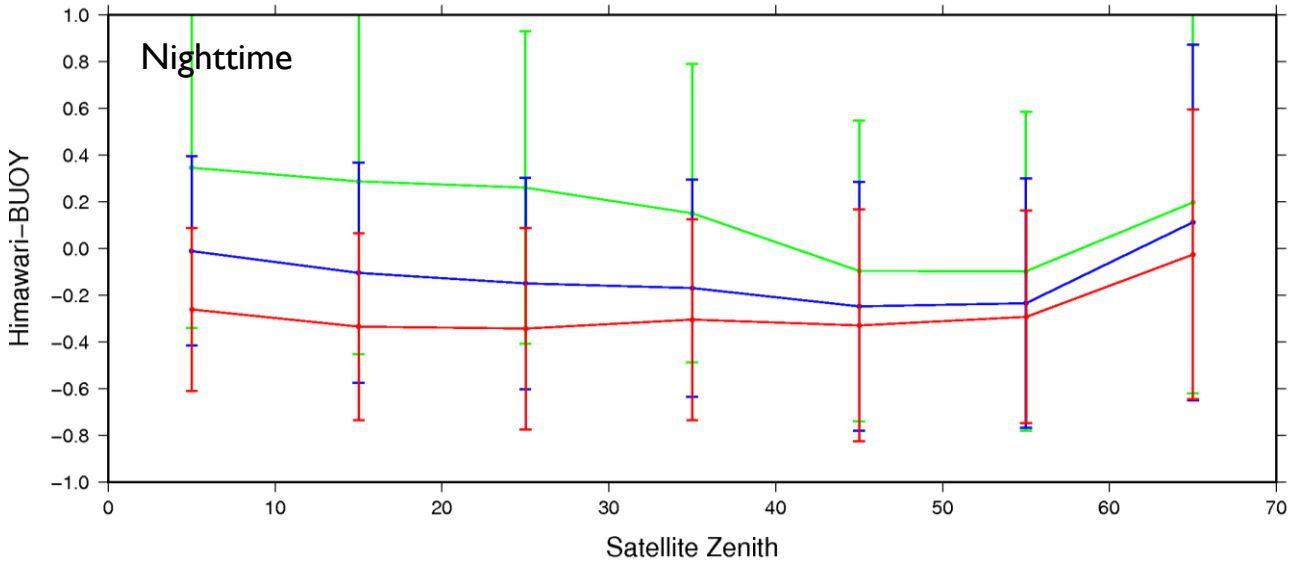
Statistics (daytime)

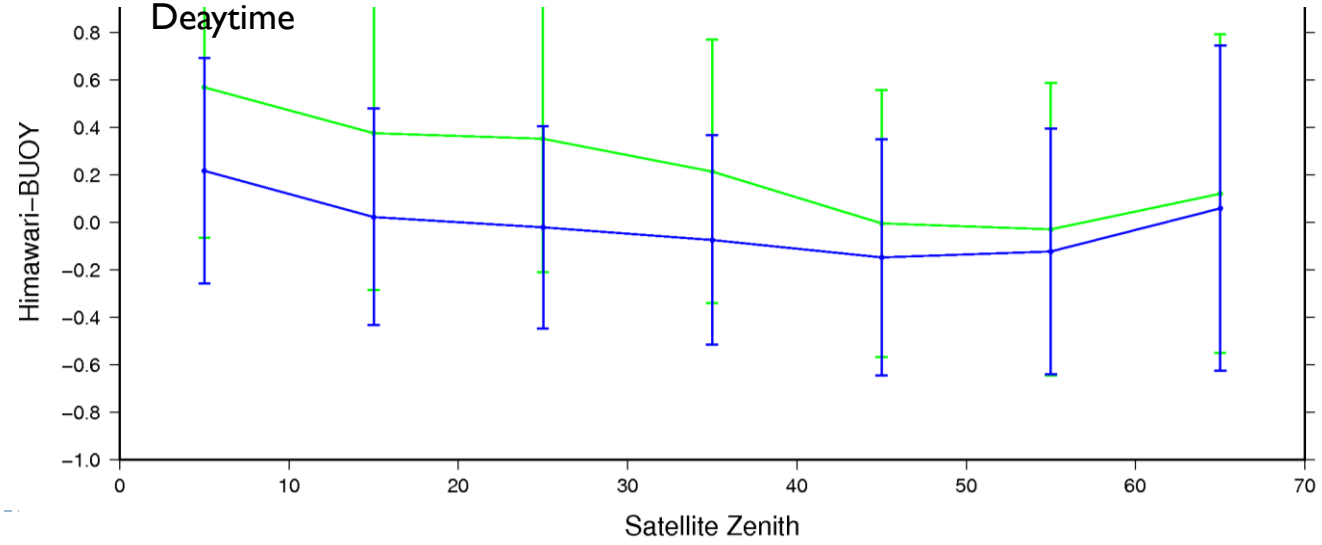




SST	BIAS	STD	N
Split+12.4	0.18	0.60	49268
Split+8.6	-0.068	0.48	49237

Dependency





Split+12.4
Split+8.6
Split+3.9

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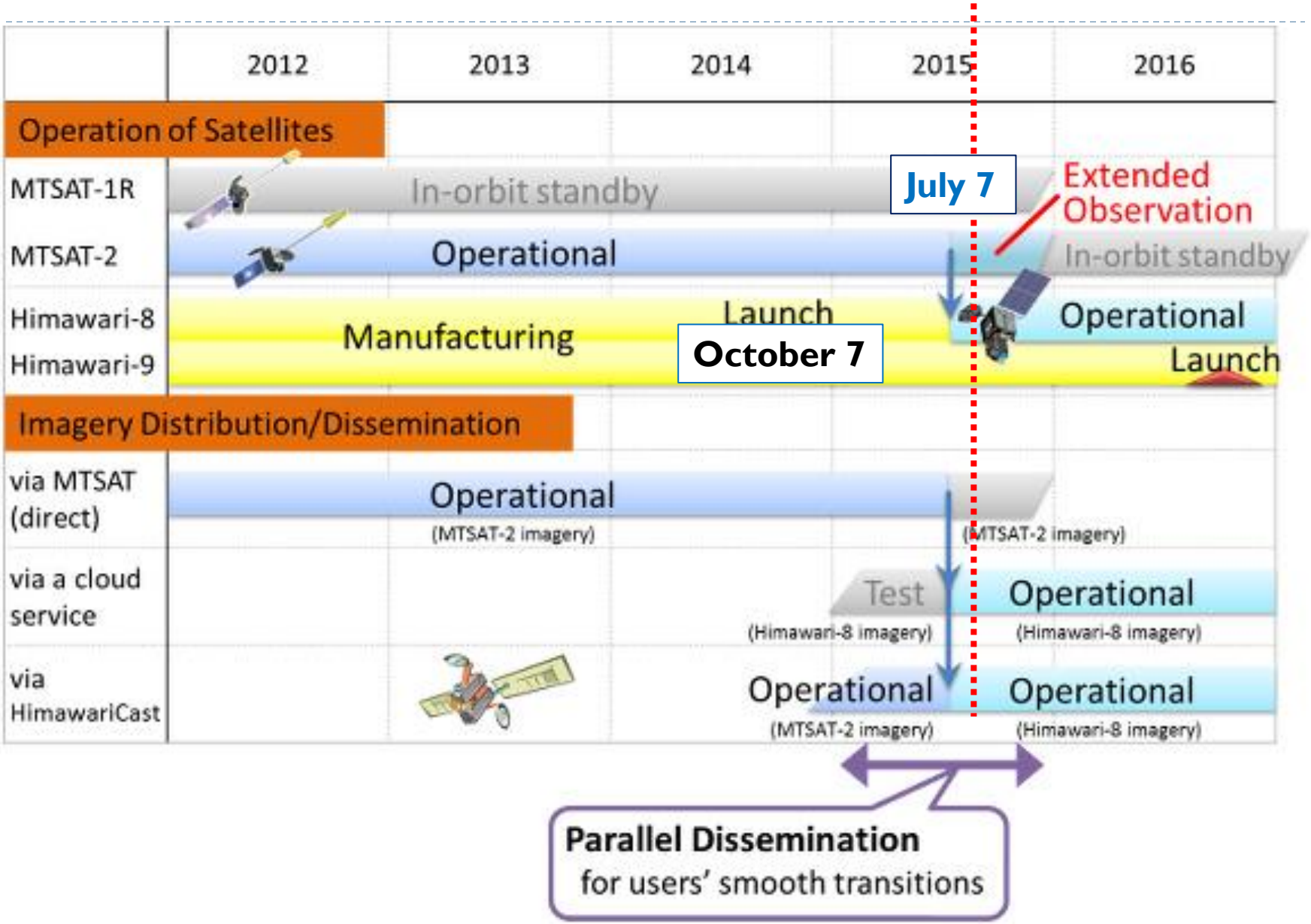
Future Plan

- H8 L2 SST by JAXA
  - H8 L2 SST Product by JAXA will soon be available at JAXA's FTP server.
- Monitoring and validation by SQUAM/NOAA
  - H8 L2 SST will be monitored and validated at SQUAM by NOAA/NESDIS.
- Synergy with GCOM-C/SGLI (2016 JFY)
  - GCOM-C SST will be retrieved using the same algorithm with Himawari-8 .

Thank you

Backups

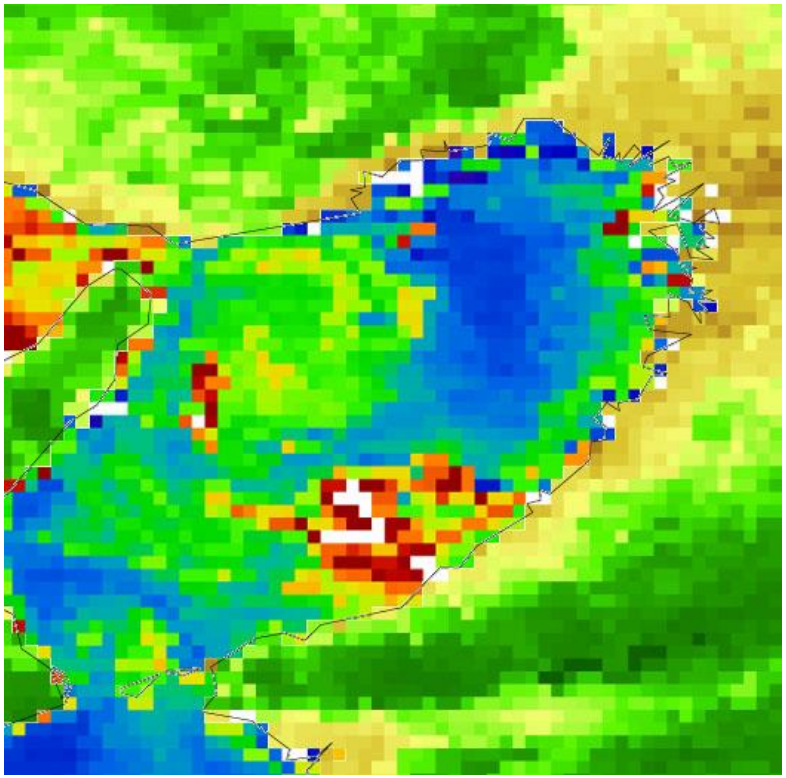
Schedule for Himawari-8/9



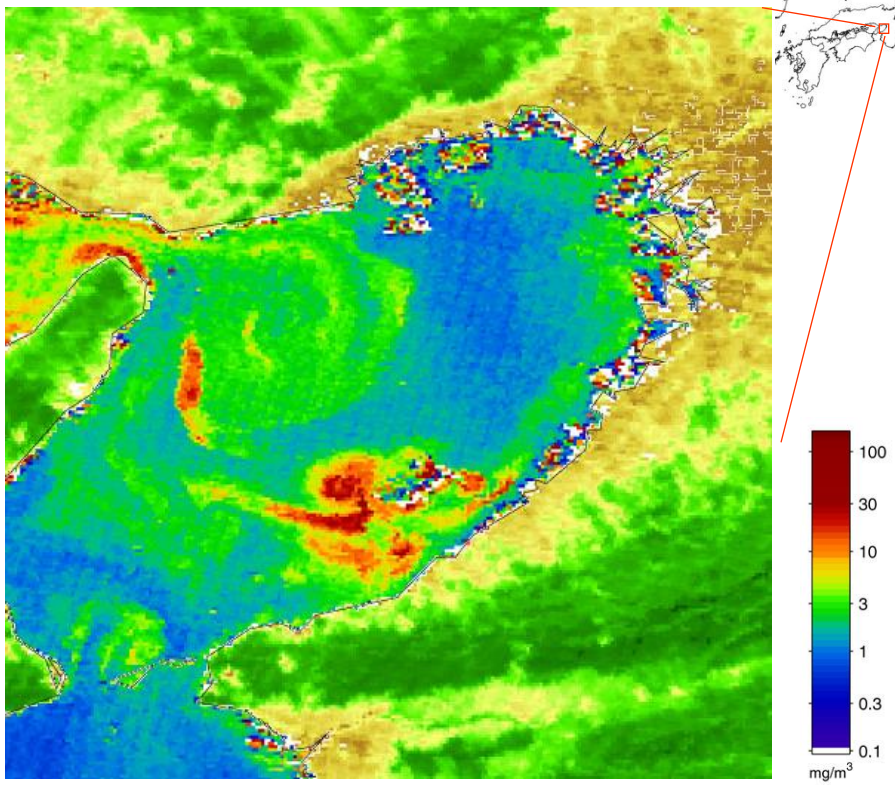
SGLI 250m Visible-SWIR observation

250m resolution to detect finer structure in the coastal area such as river outflow, regional blooms, and small current.

250m Ocean colour product simulated using GLI 250m channels



(a) GLI 1km Osaka Bay
(1 Oct. 2003, CHL by LCI)



(b) GLI 250m Osaka Bay
(1 Oct. 2003, CHL by LCI)