Himawari-8 SST by JAXA

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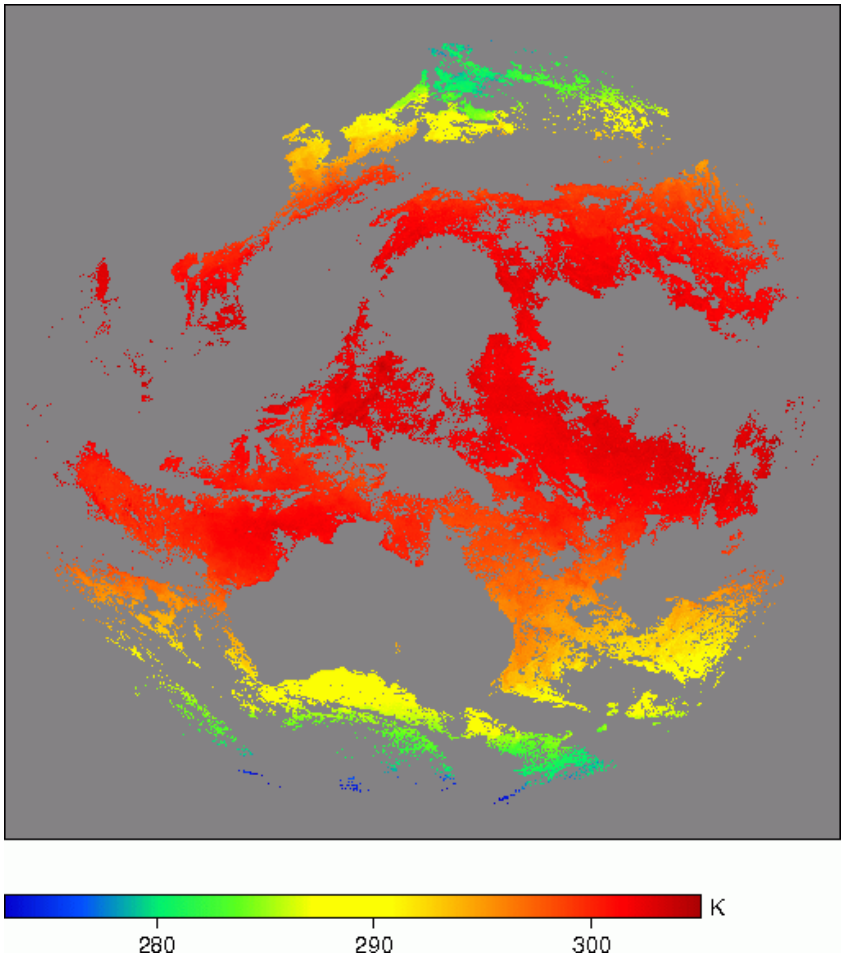
Satellite Oceanography Users Workshop, Melbourne Australia 9-11 November 2015

Topics

- Himawari-8
- SST from Himawari-8
- Himawari SST product by JAXA
- Summary



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Himawari-8

- Operator : Japan Meteorological Agency (JMA)
- Launch : 7th October 2014
- Operation : 7th July 2015 ~
- Orbit : Geostationary (140.7 °E)
- Instrument : Advanced Himawari Imager (AHI)

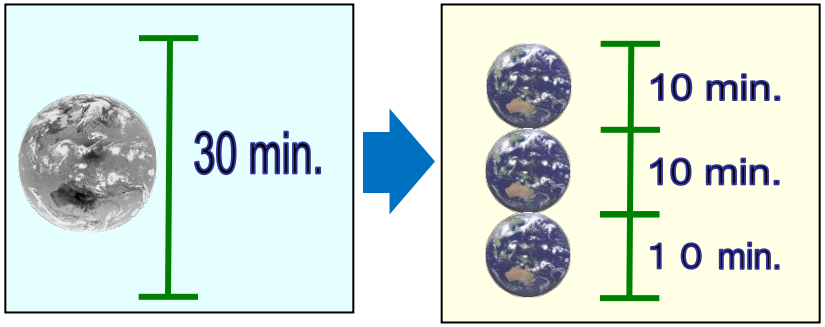
Enhancement of the observation function of Himawari-8/9 as compared to that of MTSAT-1R/2

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



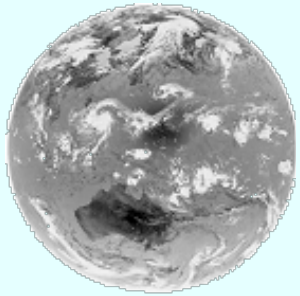
Small-sector observation

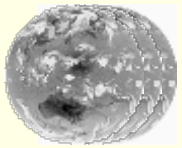
New

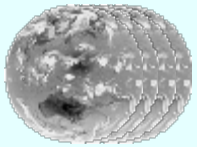
Every **2.5** minute around Japan

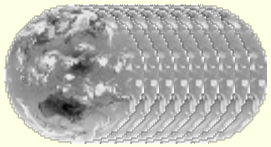
More spectral bands

	MTSAT-1R/2	Himawari-8/9
VIS	1 band (black/white image)	3 bands (color image)
NIR	N/A	3 bands
IR	4 bands	10 bands
	5 bands	**16** bands









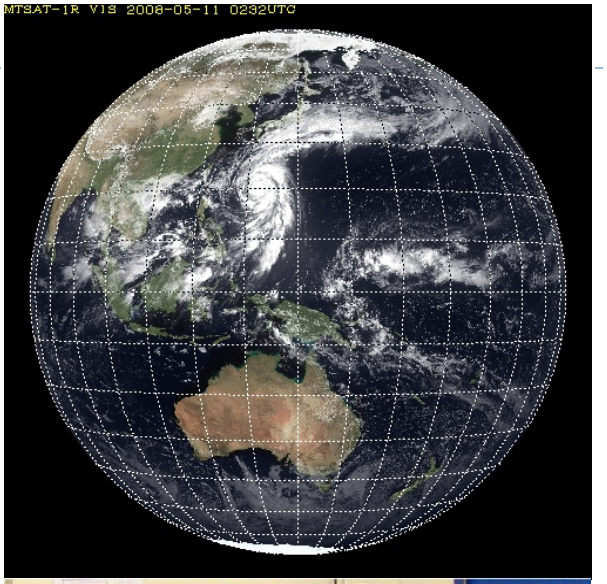
(by Meteorological Satellite Center)

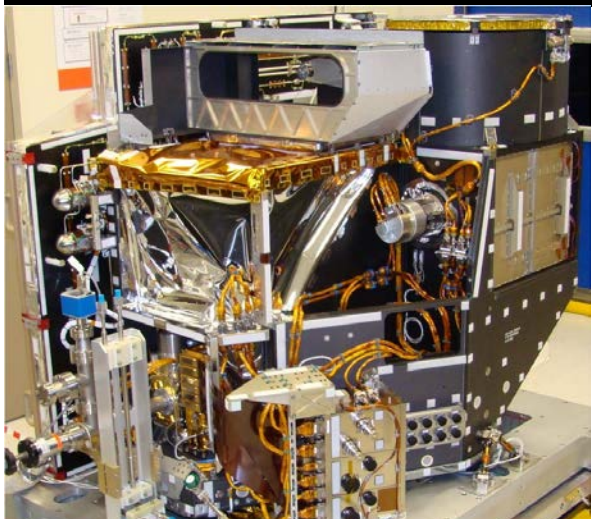
Specification of "Himawari-8/9" Imager (AHI)

*Himawari-9 will be launched in 2016

HIMAWARI-8/9

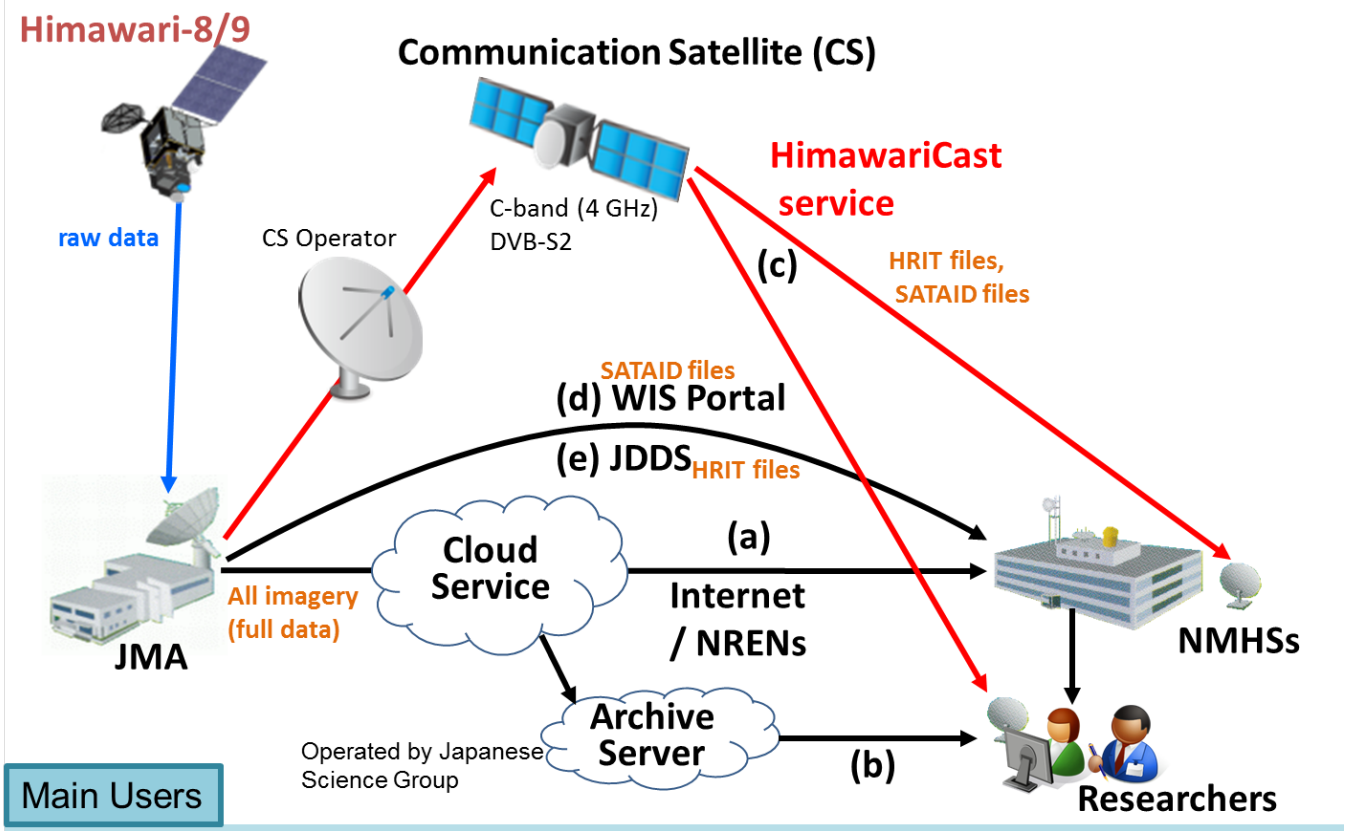
	Band	Central Wavelength [μm]	Spatial Resolution	
VIS	1	0.43 - 0.48	1Km	RGB Composited Full Color Image
VIS	2	0.50 - 0.52	1Km	
VIS	3	0.63 - 0.66	0.5Km	
NIR	4	0.85 - 0.87	1Km	Aerosol
NIR	5	1.60 - 1.62	2Km	
NIR	6	2.25 - 2.27	2Km	
IR	7	3.74 - 3.96	2Km	
IR	8	6.06 - 6.43	2Km	Water Vapour
IR	9	6.89 - 7.01	2Km	
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/

Distribution/dissemination of Himawari-8 data



(by Meteorological Satellite Center : http://www.jma-net.go.jp/msc/en/index.html)

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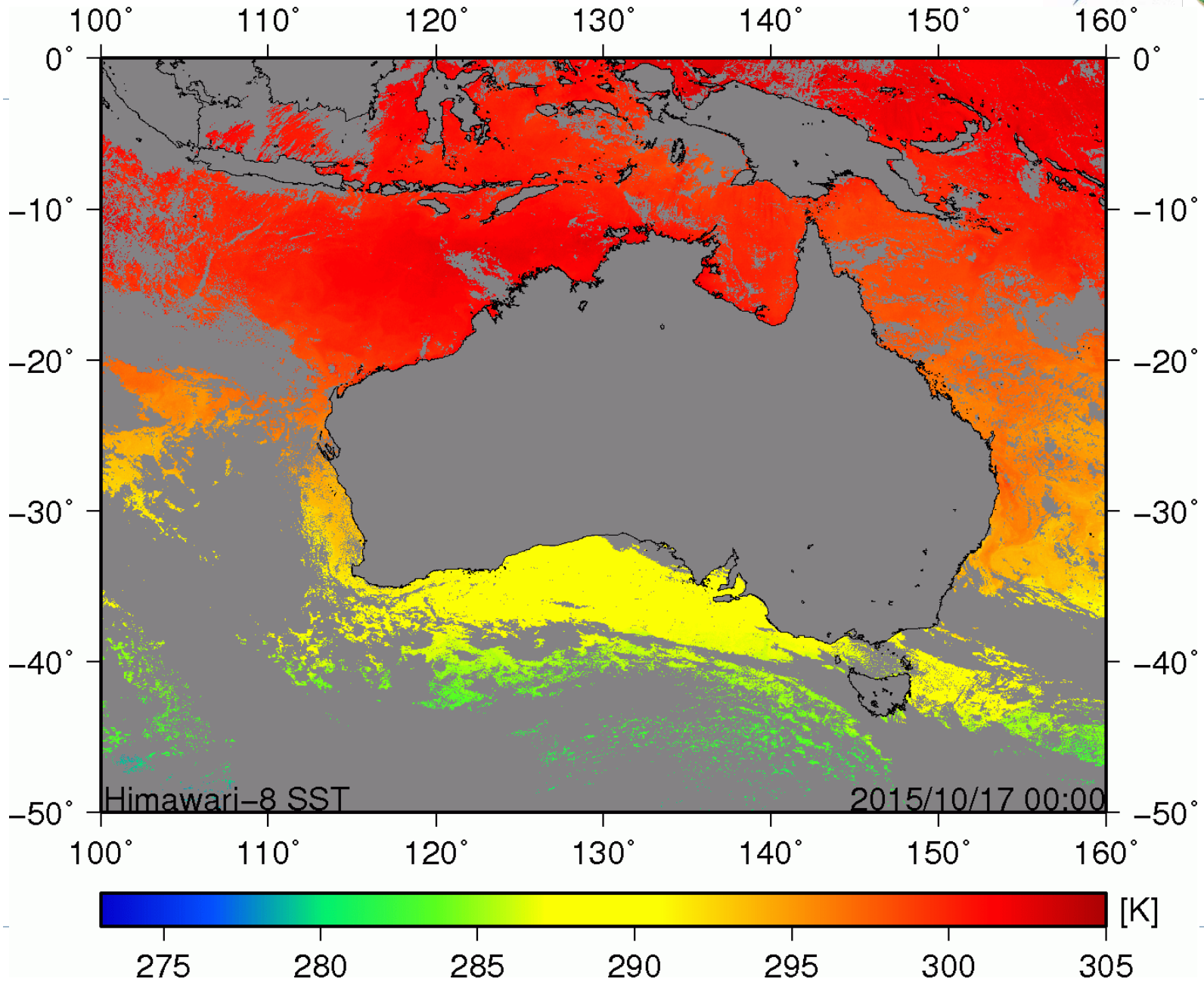

100°
110°
120°
130°
140°
150°
160°
0°
−10°
−20°
−30°
−40°
−50°
Himawari−8 SST
2015/10/17 00:00
[K]
275
280
285
290
295
300
305

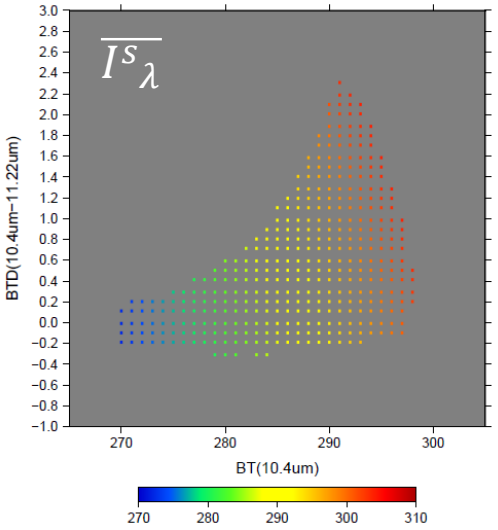
Himawari-8 SST by JAXA

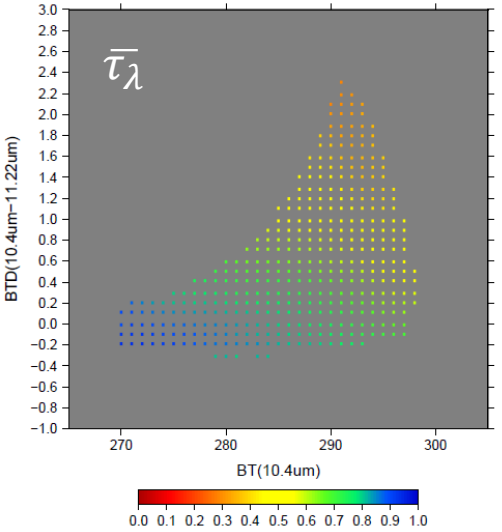
- SST : skin temperature
- Algorithm
  - SST algorithm : Original (quasi-physical algorithm)
  - Cloud screening : Mask based on Bayesian
- Quality (statistics against buoy) :
  - RMS : 0.58 K
  - Bias : -0.15 K
- Issues :
  - cloud screening, etc.

SST Algorithm

- Quasi-physical algorithm
  - SSTs are calculated by solving approximate equation for radiative transfer.
  - Forward model
    - a parameterized approximate equation for radiative transfer
  - Optimization algorithm
    - Newton method (Merchant et al. 2008, Rodgers 1990)
- Skin SST is calculated from two or more than two IR data
  - IR data for JAXA's SST
    - Standard mode SST: 10.4 + 11.2 + 8.6 micron band
    - Night mode SST : 10.4 + 11.2 + 3.9 micron band
  - No NWP
  - No SST analysis
- Algorithm is calibrated by using NWP data and RTTOV
  - NWP data : provided by JMA
  - RTTOV : radiative transfer model by NWPSAF of EUMETSAT

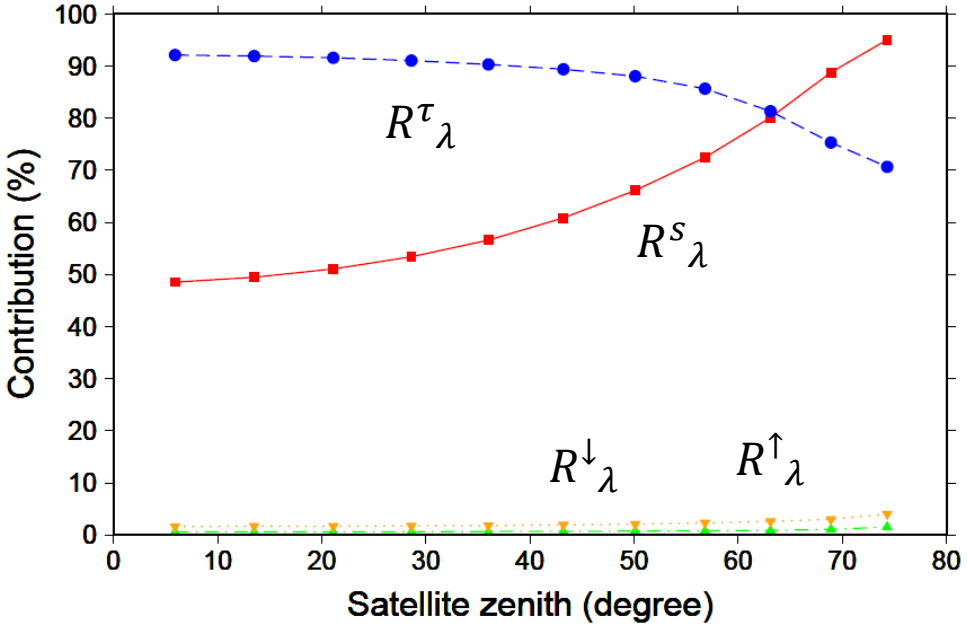
Parameterization of Radiative Transfer



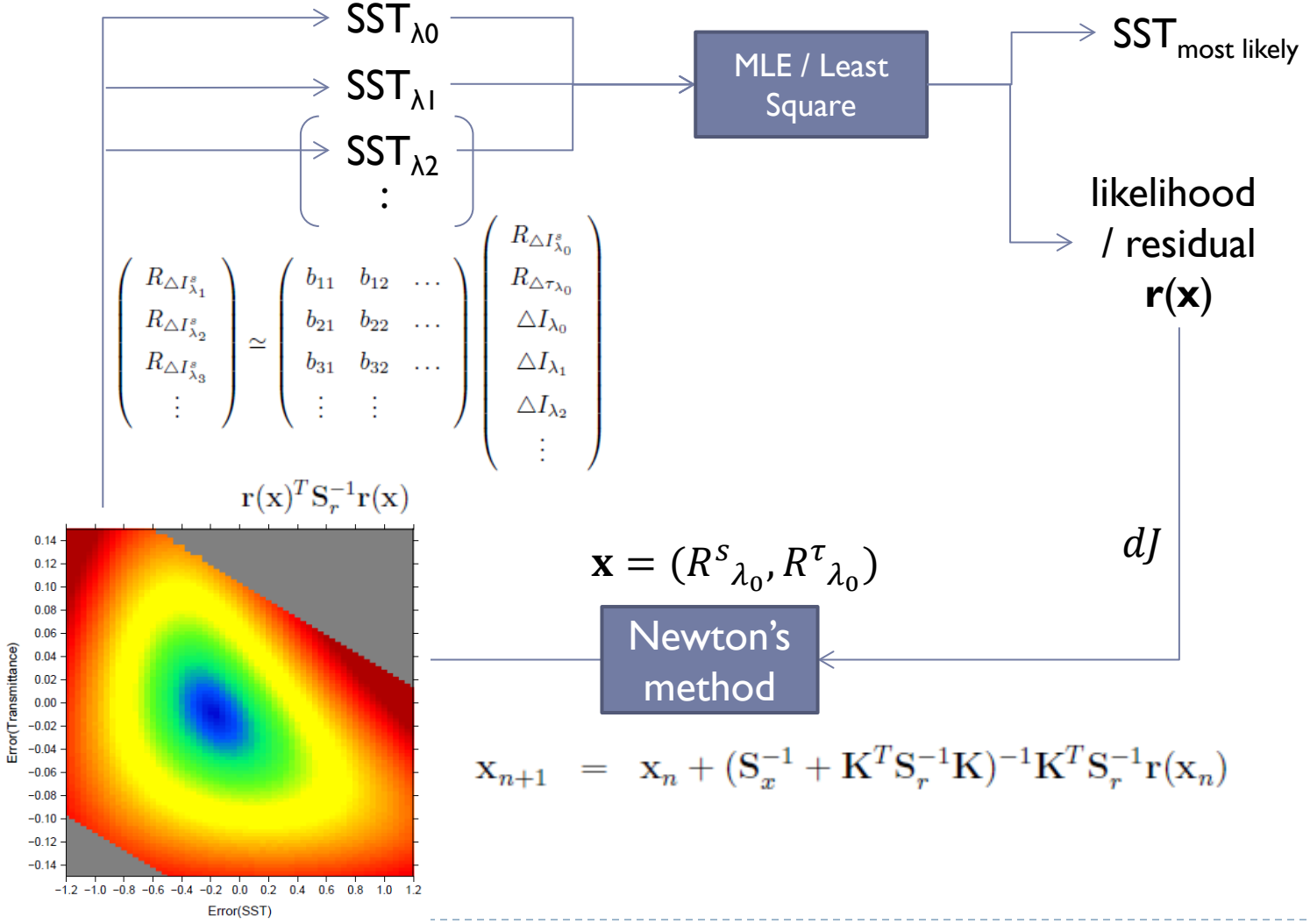


$$\overline{I}_\lambda + \triangle I_\lambda = \varepsilon_\lambda(\overline{I}^s_\lambda + \triangle I^s_\lambda)(\overline{\tau}_\lambda + \triangle\tau_\lambda) + (1-\varepsilon_\lambda)(\overline{I}^{\downarrow}_\lambda + \triangle I^{\downarrow}_\lambda)(\overline{\tau}_\lambda + \triangle\tau_\lambda) + (\overline{I}^{\uparrow}_\lambda + \triangle I^{\uparrow}_\lambda).$$

$$\begin{pmatrix} \triangle I_{\lambda_0} \\ \triangle I^s_{\lambda_0} \\ \triangle\tau_{\lambda_0} \\ \triangle I^{\uparrow}_{\lambda_0} \\ \triangle I^{\downarrow}_{\lambda_0} \end{pmatrix} = \begin{pmatrix} 1 & & & & \\ a_{21} & 1 & & & \\ a_{31} & a_{32} & 1 & & \\ a_{41} & a_{42} & a_{43} & 1 & \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{pmatrix} \begin{pmatrix} \triangle I_{\lambda_0} \\ R^s_{\lambda_0} \\ R^{\tau}_{\lambda_0} \\ R^{\uparrow}_{\lambda_0} \\ R^{\downarrow}_{\lambda_0} \end{pmatrix}$$

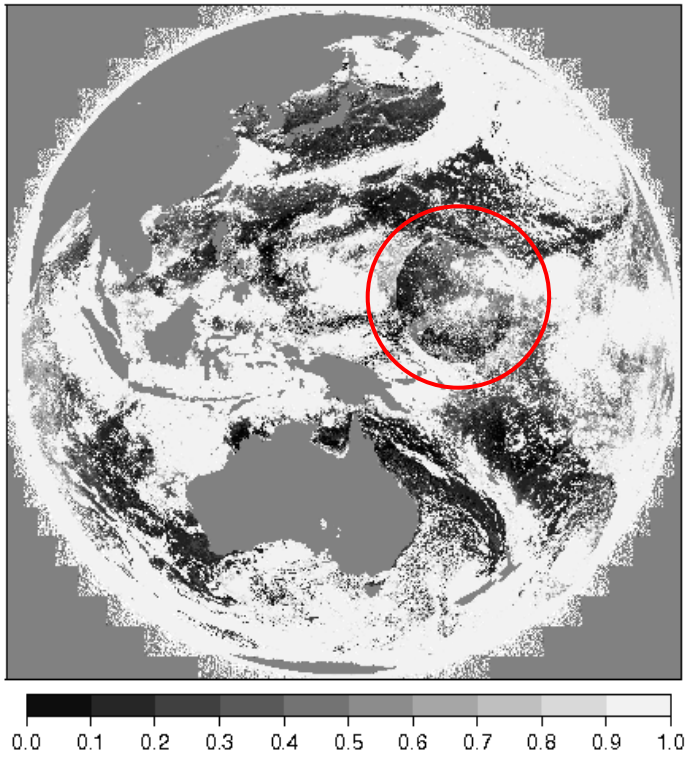


Optimization algorithm

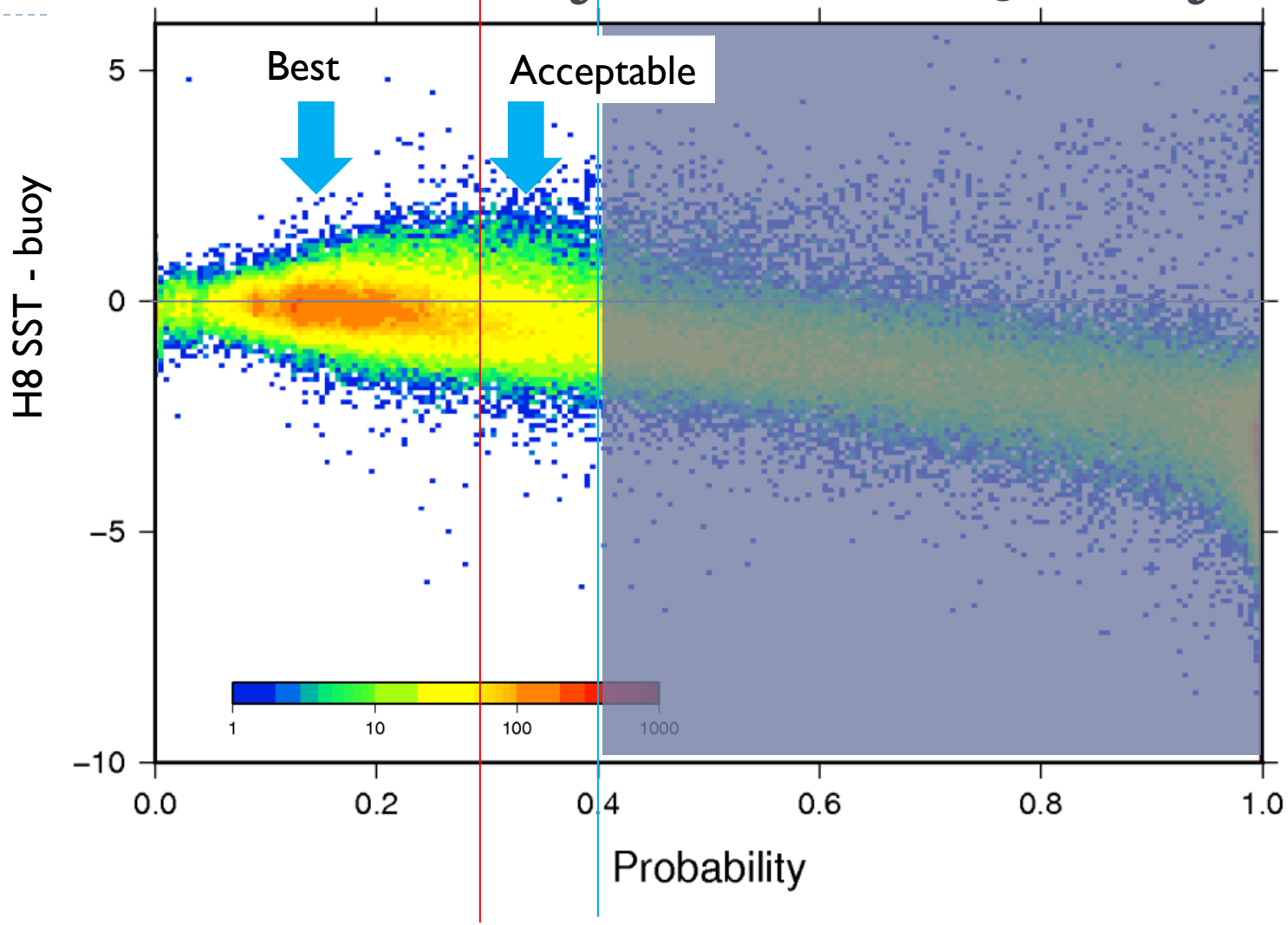


Cloud Screening

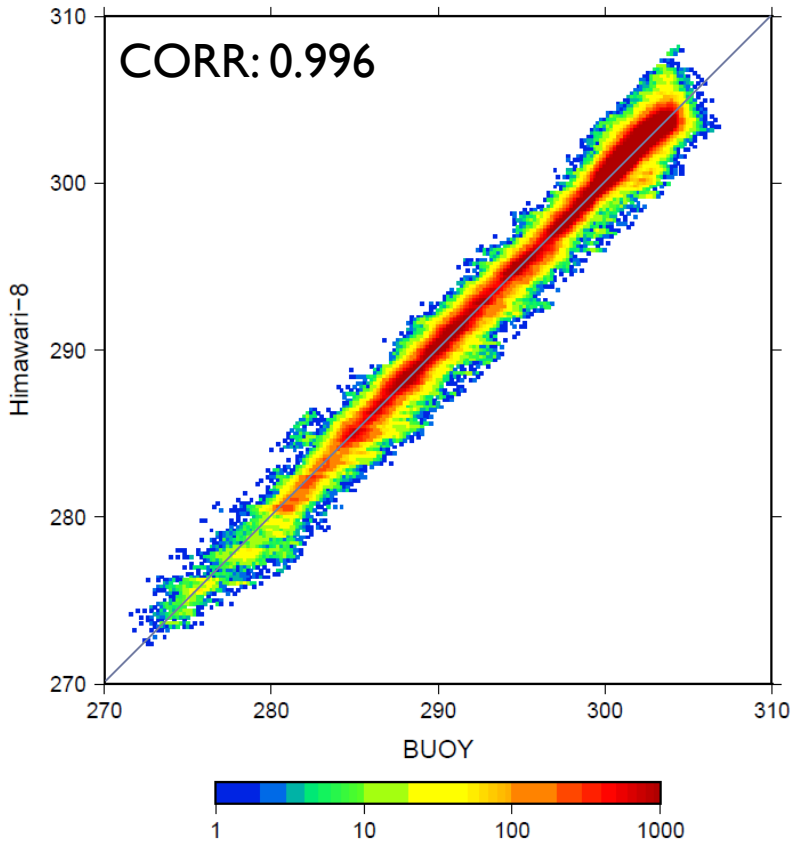
- Bayesian inference
  - $P(C^{loud}|O^{bs+anci})=P(O^{bs+anci}|C^{loud})\ P(C^{loud})\ /\ P(O^{bs+anci})$
- Data and ancillary
  - 10.4, 12.4, 3.9 um
    - (3.9 um : alternative to visible data)
  - daily SST analysis (MGDSST by JMA)
- PDFs : $P(O^{bs+anci}|C^{loud})$, $P(C^{loud})$, $P(O^{bs+anci})$
  - Generated using Himawari-8 data
  - Data period : 2 month
    (May ~ June 2015)
- Reference
  - C.J. Merchant et al. 2005
  - O.Embury, C.J. Merchant 2014, GHRSST-XV

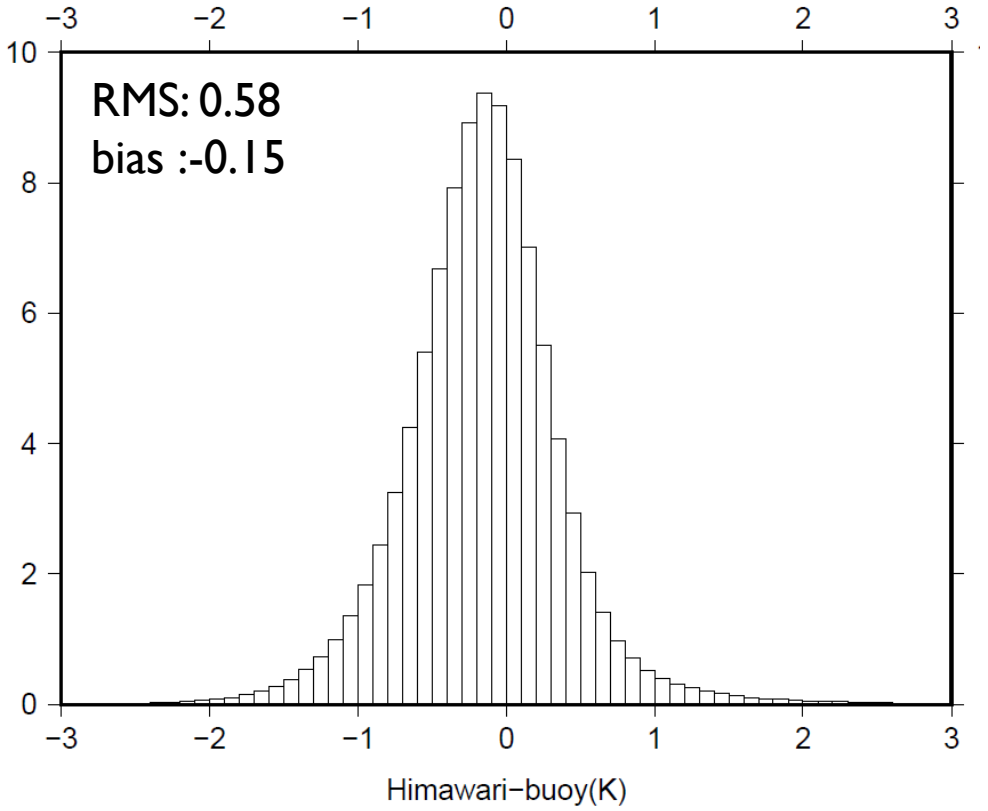


Cloud Probability and SST Quality



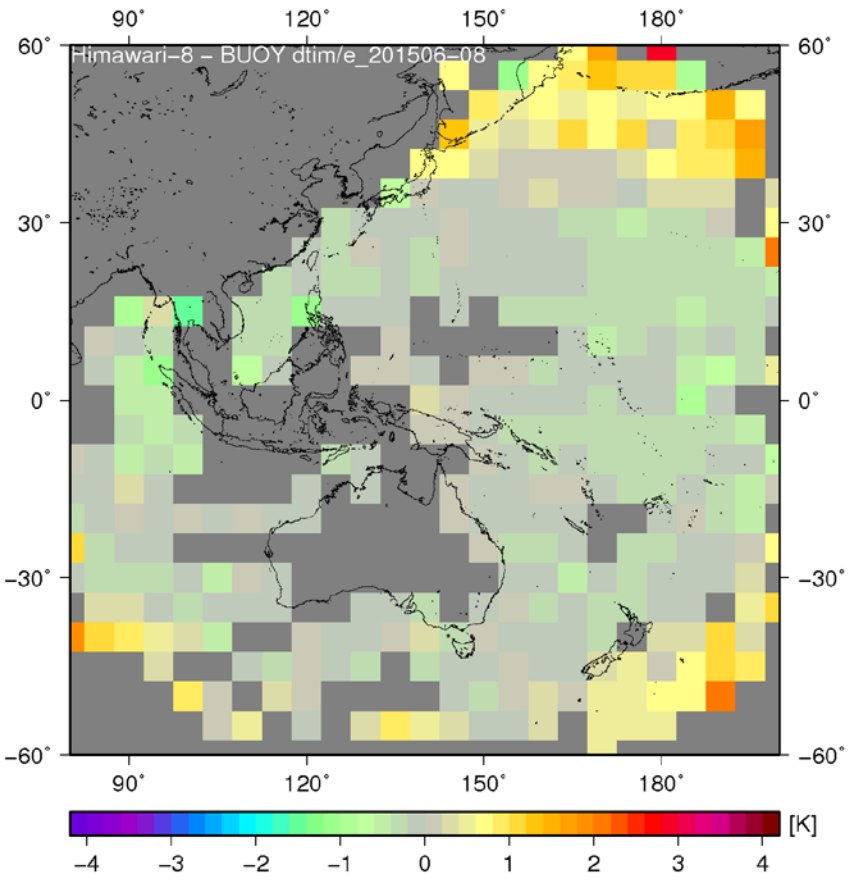
Himawari-8 SST vs. buoy data



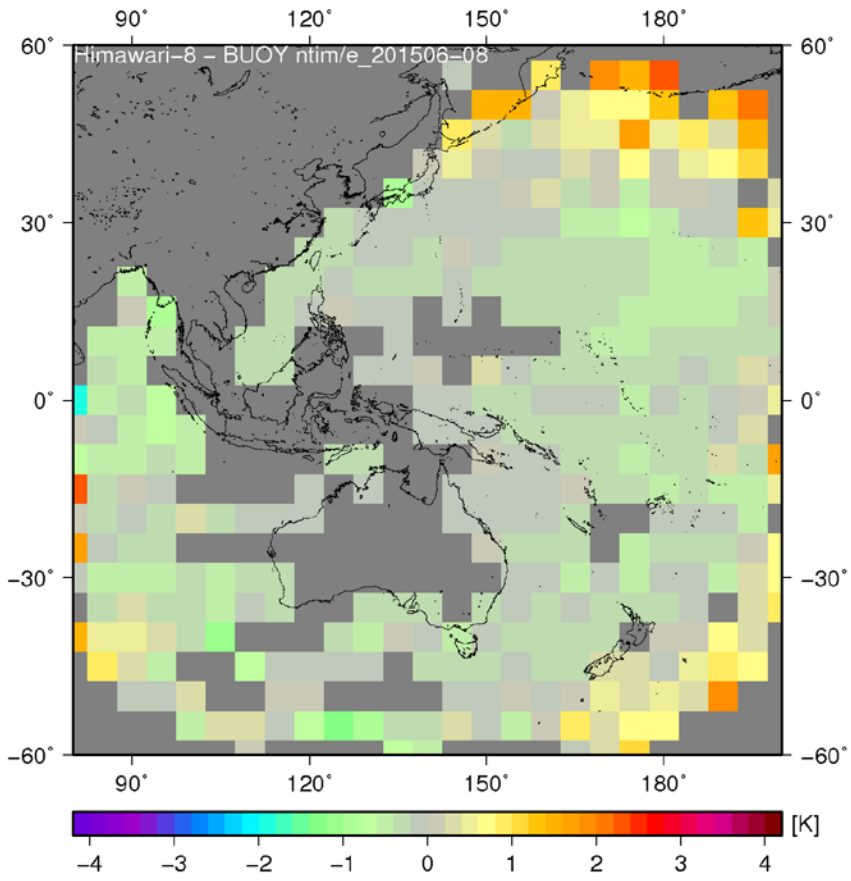


- H8 SST : 10.4 + 11.2 + 8.6, Pcloud < 0.3 (best)
- buoy data : iQuam of NOAA
- Period : June ~ September 2015

Bias for each 5x5 degrees



Day-time

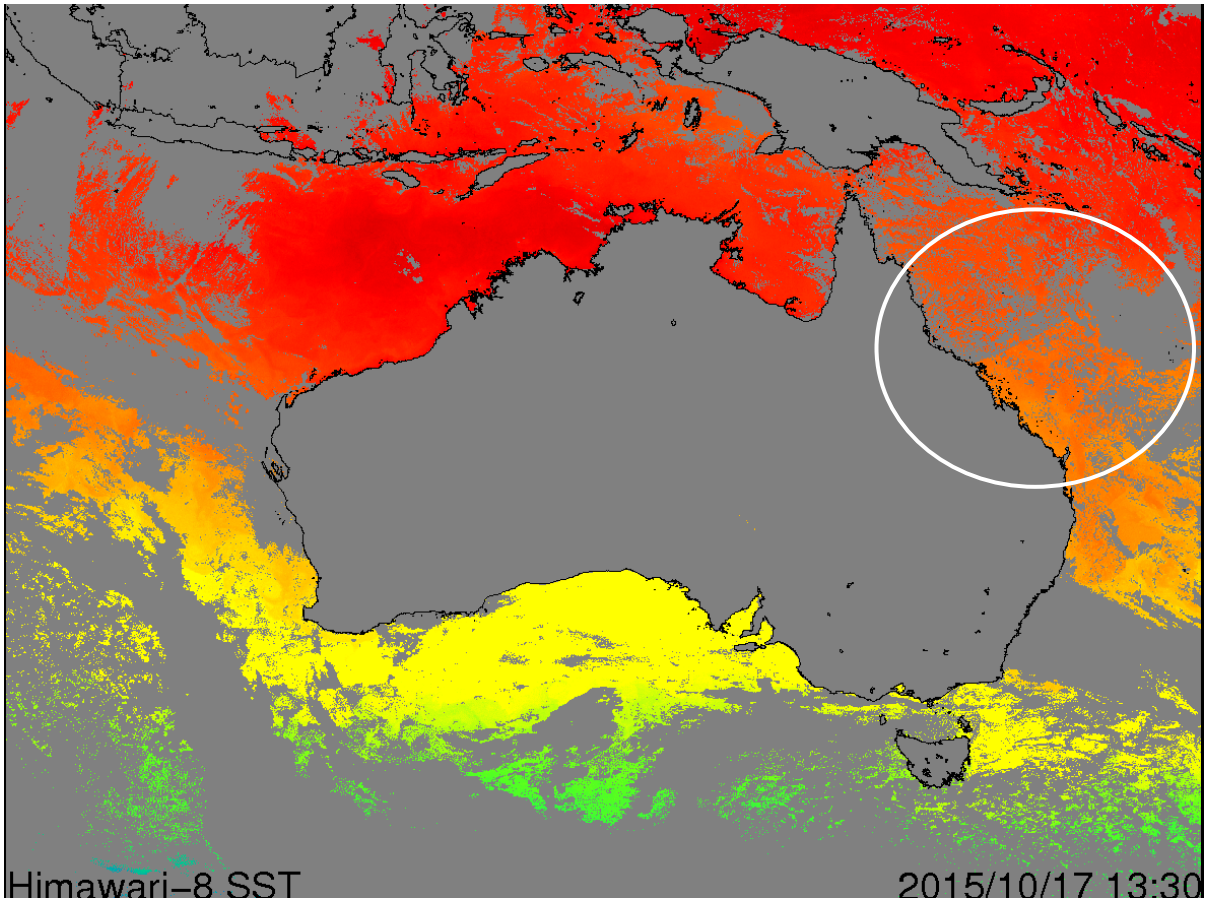


Night-time

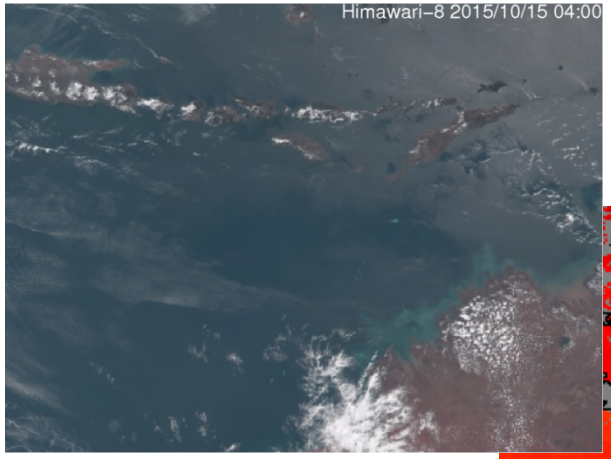
Other known issues

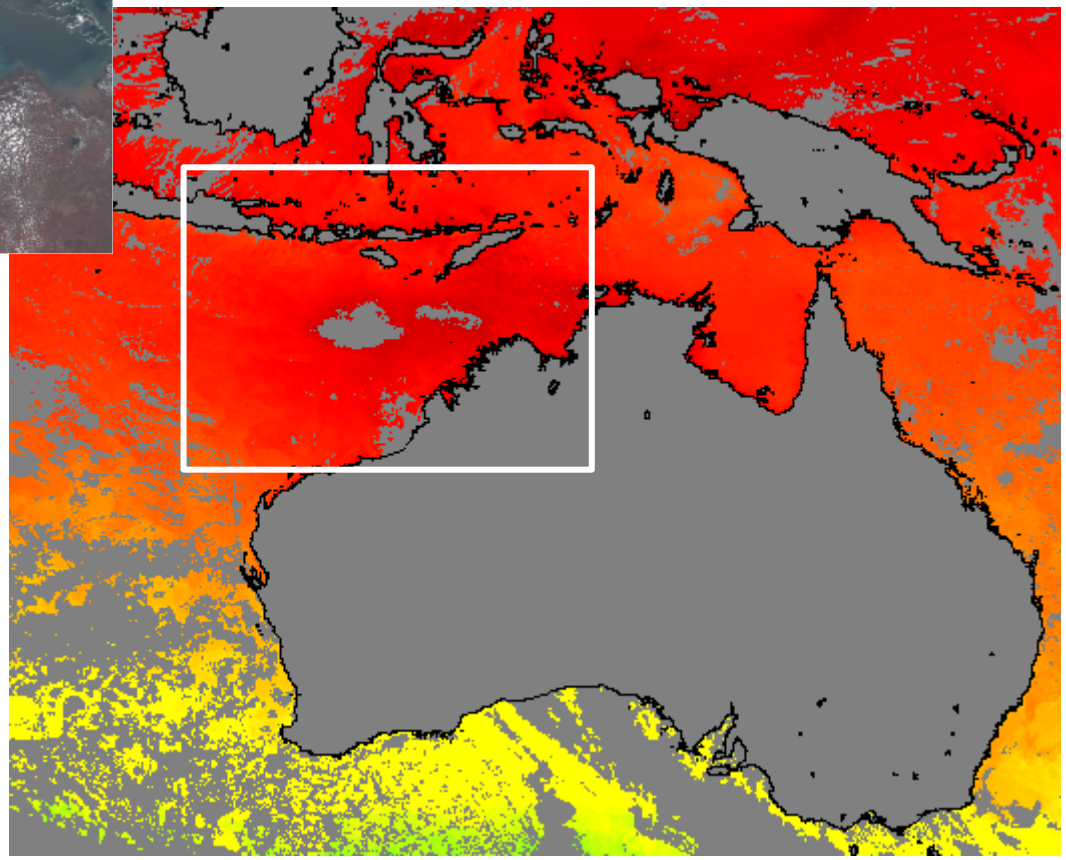
- Unnatural cloud mask
- False detection of cloud
- Line-shaped noise along the swath boundary (?)

Unnatural cloud mask

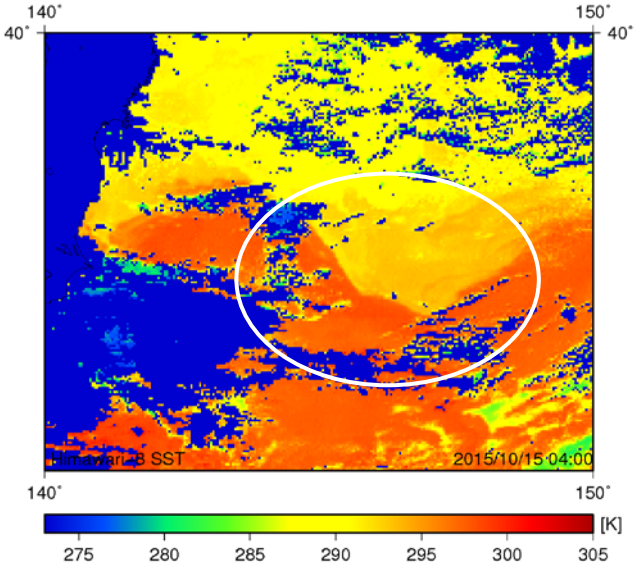


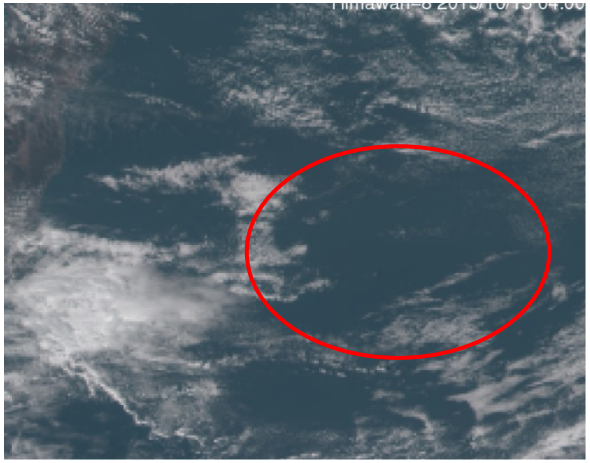
False detection of cloud

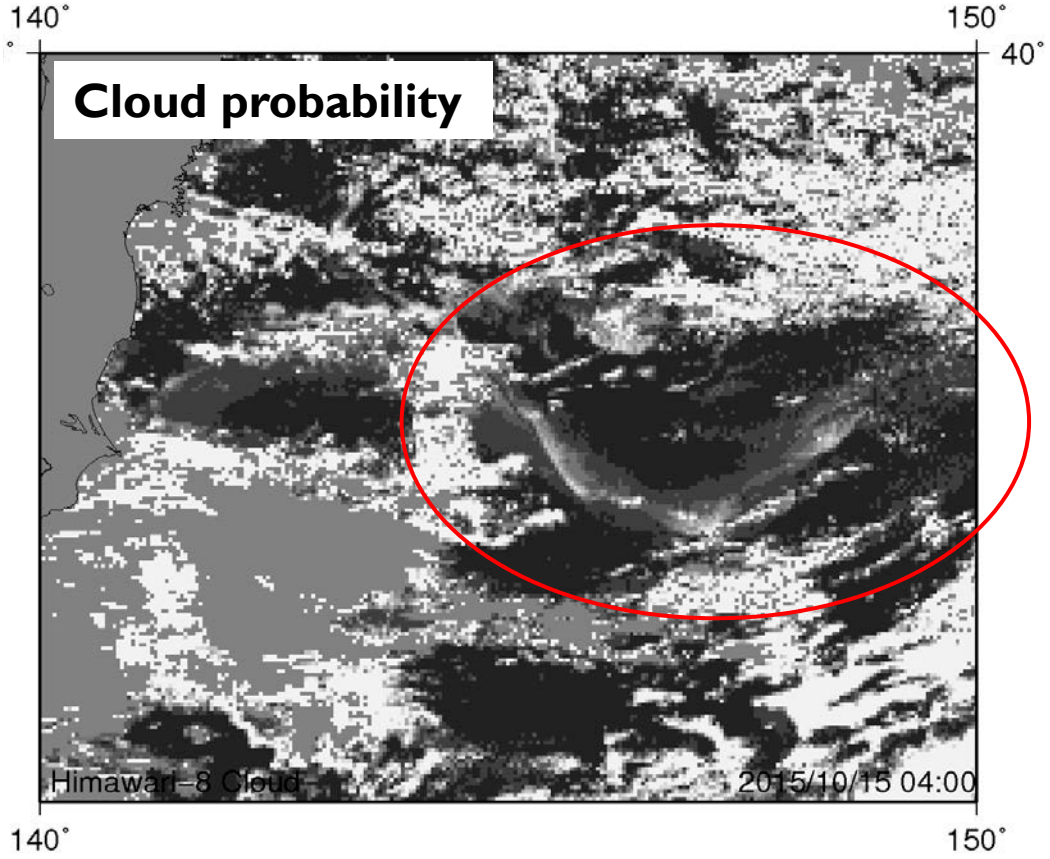




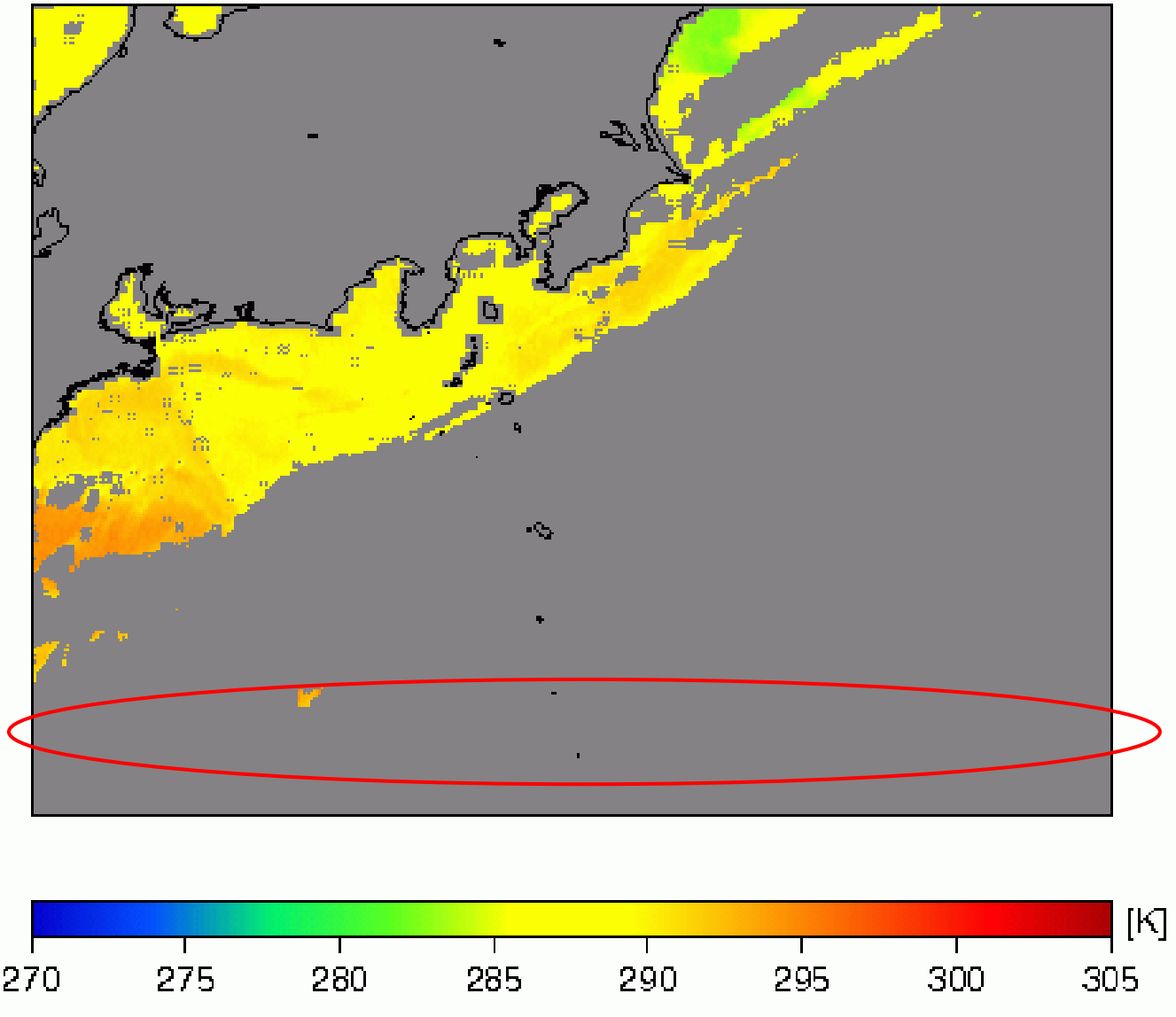
False detection of cloud (2)







Line-shaped noise along the swath boundary (?)



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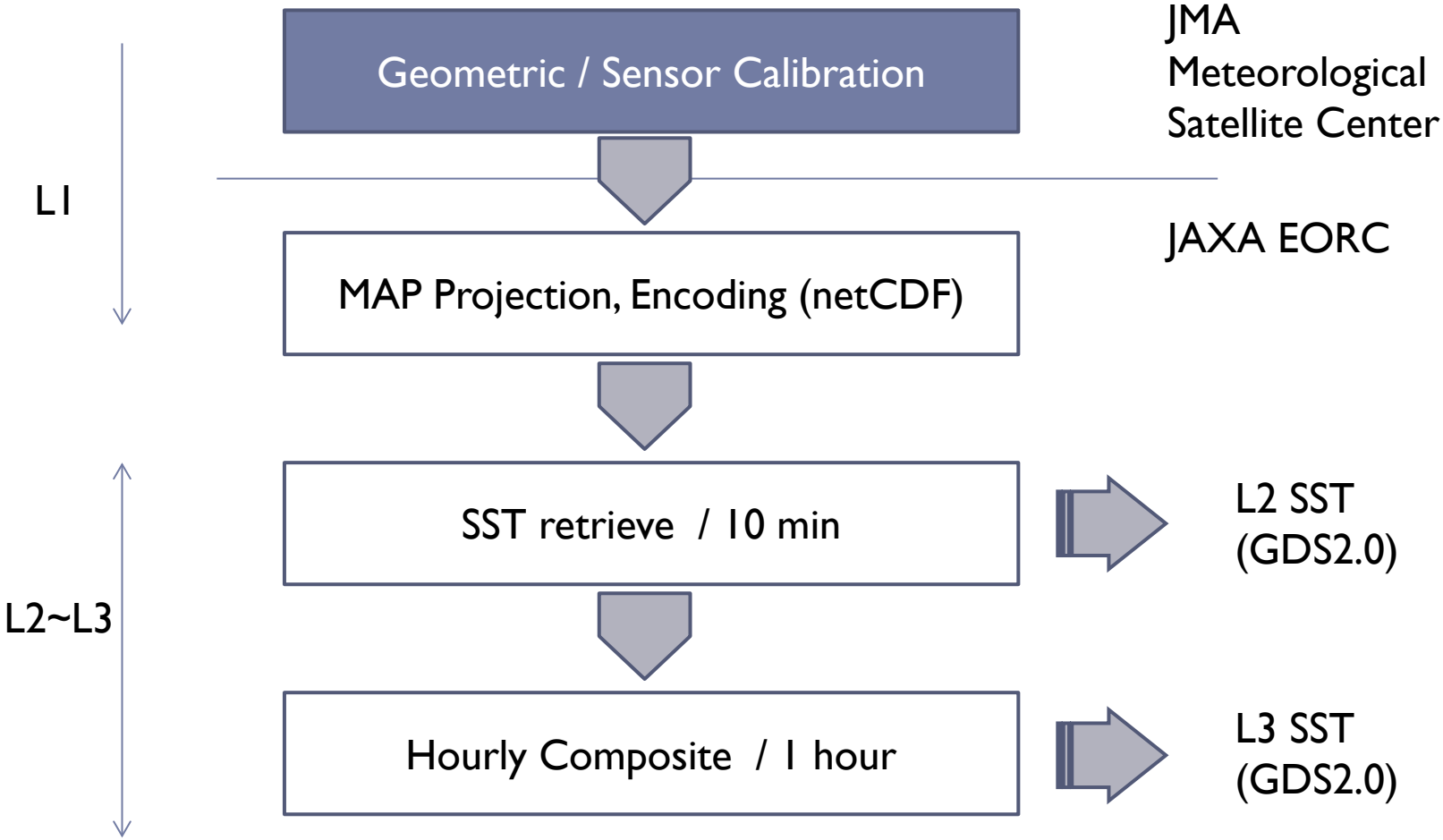
Data processing for Himawari-8 SST at JAXA



Himawari-8 SST Product by JAXA

- L2 SST
  - Skin SST from 10.4, 11.2 and 8.6 μm data
  - snap shot
  - Temporal resolution: 10-minute

- L3 SST
  - Skin SST from 10.4, 11.2 and 8.6 μm data (normal mode)
  - Skin SST from 10.4, 11.2 and 3.9 μm data (night mode)
  - hourly composite
  - Temporal resolution: 1-hour

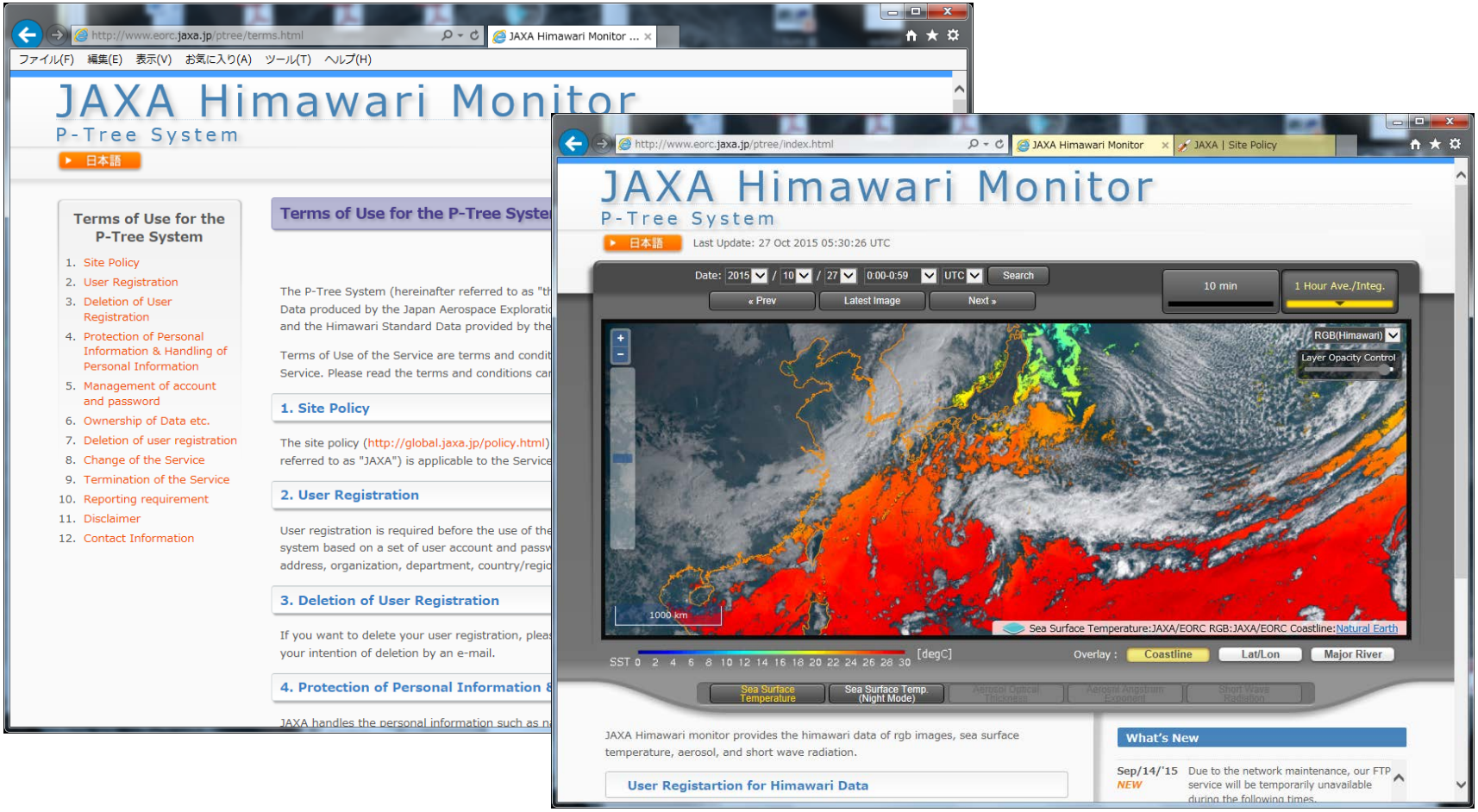
Specifications of JAXA Himawari-8 SST

- File format : NetCDF (GDS 2.0*)
- Area coverage : 80E-160W, 60N-60S
- Spatial Resolution : 0.02 x 0.02 degrees
- Array size : 6001 x 6001
- Total size : ~ 17 MB/file
- Latency : ~ 1 hour
- Web site :
  - Himawari Monitor (http://www.eorc.jaxa.jp/ptree/index.html)

* GDS: GHRSST Data Specification

JAXA Himawari Monitor

- http://www.eorc.jaxa.jp/ptree/index.html



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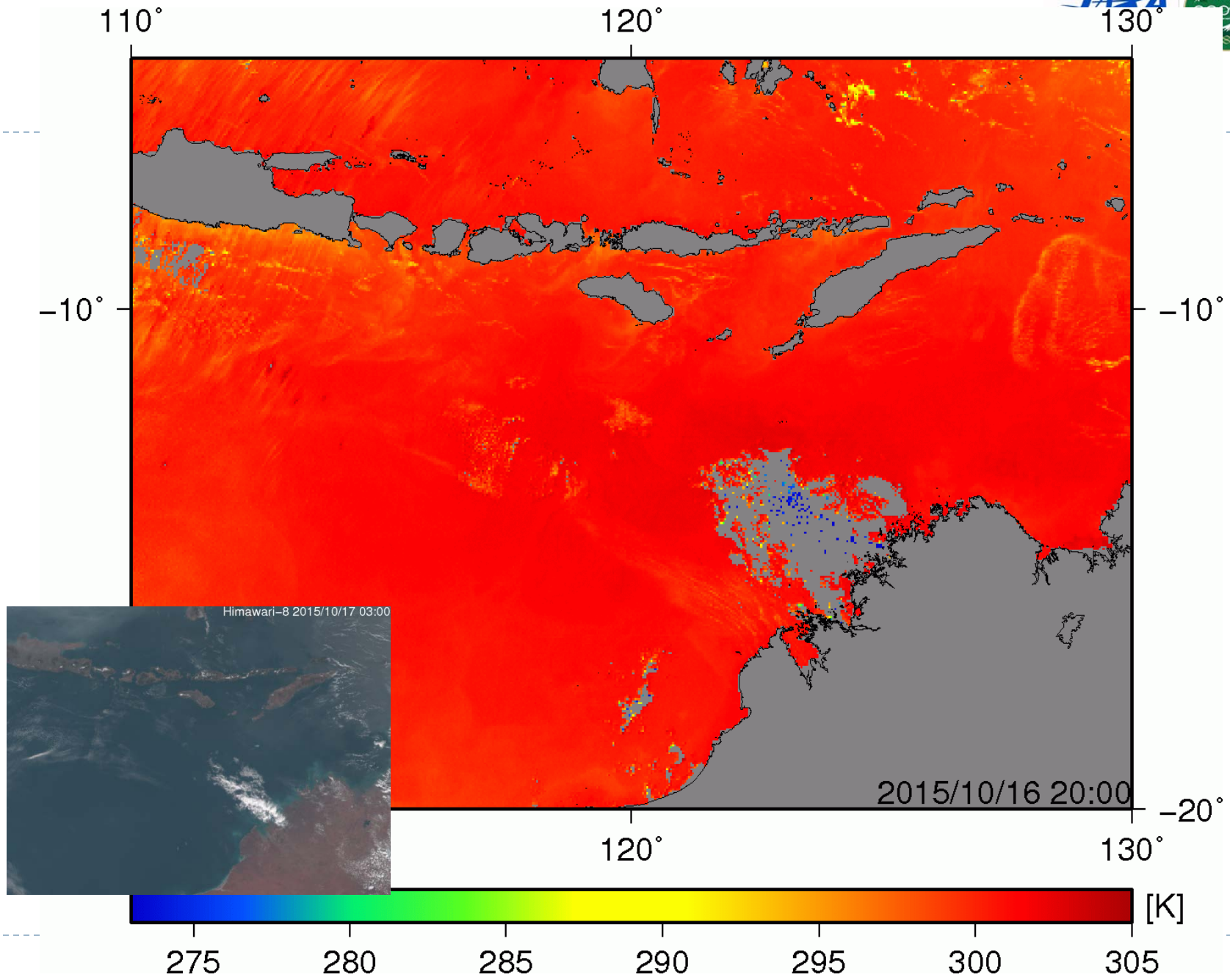
Summary

- Himawari-8 has been operational since 7th July 2015.
- JAXA started operational retrieval of Himawari-8 SST in September.
- Himawari-8 SSTs are retrieved with a new SST algorithm and cloud mask based on Bayesian.
- RMS and bias of Himawri-8 SST against buoy data are 0.58 K and -0.15 K, respectively.
- Himawari-8 SSTs in GDS2 are available at JAXA's website: "JAXA Himawari Monitor".

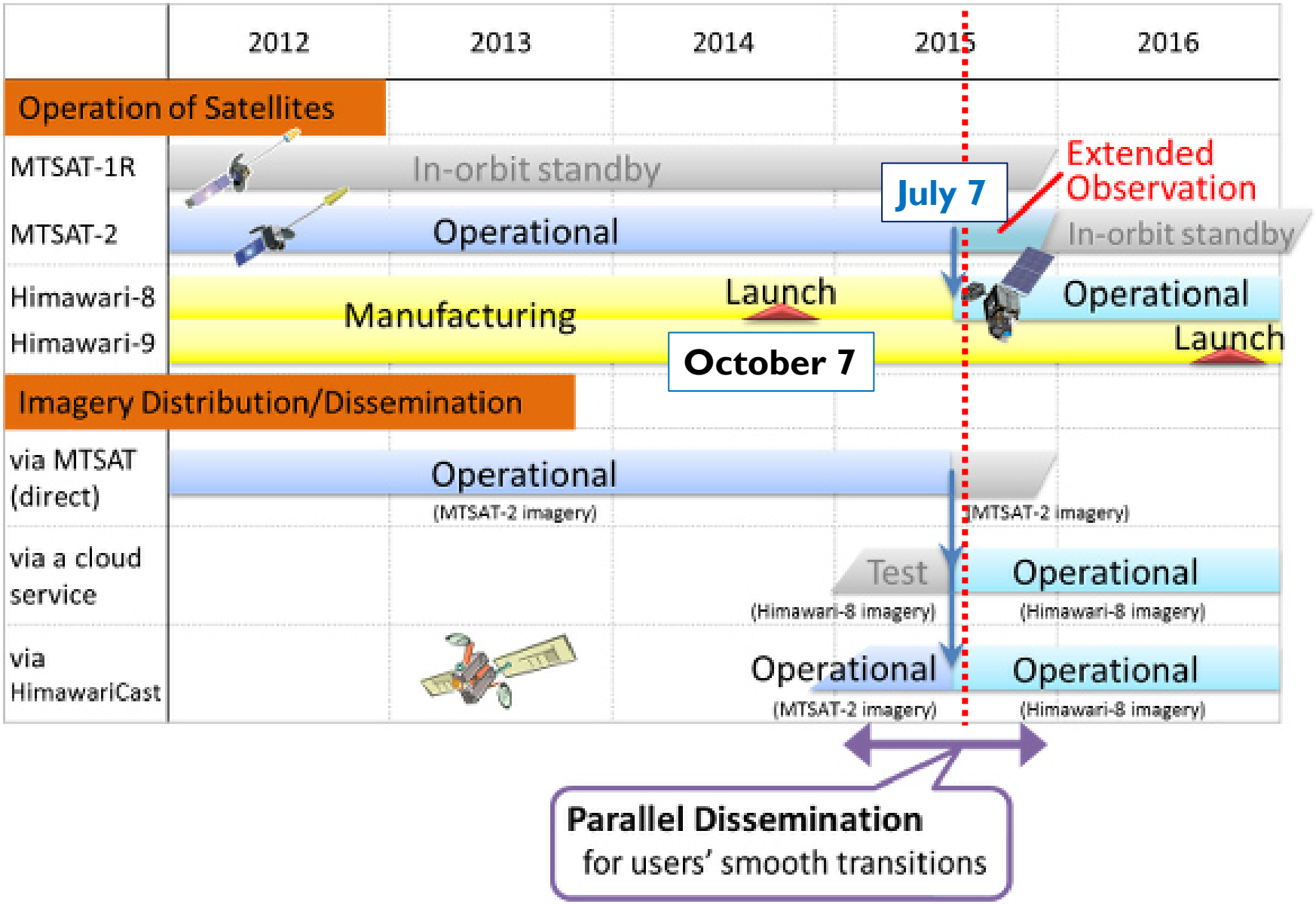

110°
120°
130°
−10°
−10°
−20°
120°
130°
Himawari−8 2015/10/17 03:00
2015/10/16 20:00
[K]
275
280
285
290
295
300
305

HIMAWARI

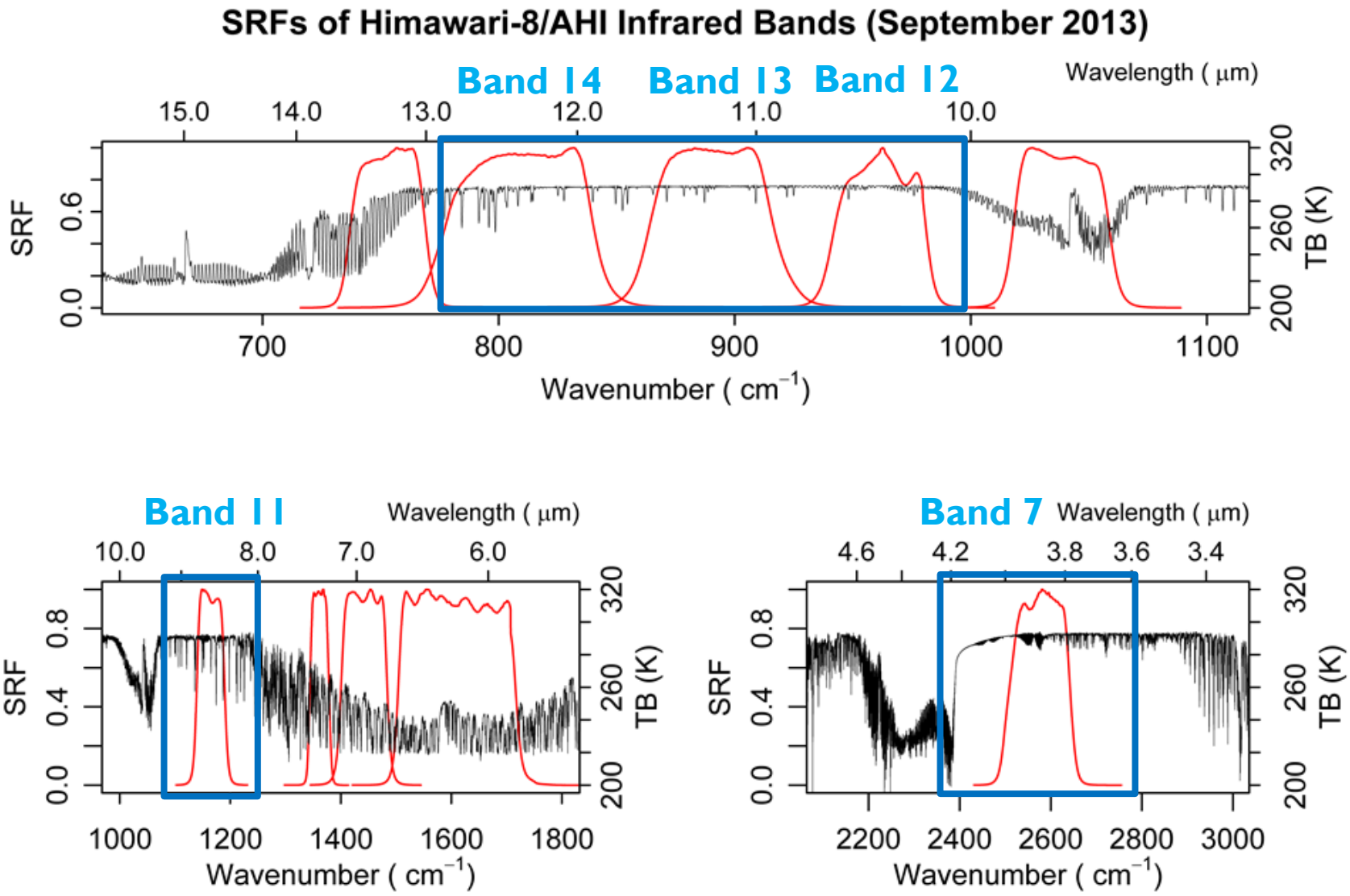
- means sunflower in Japanese

Backups

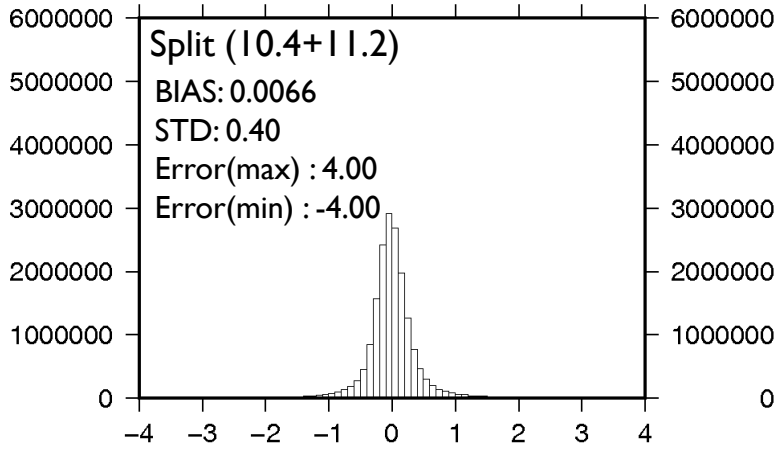
Schedule for Himawari-8/9

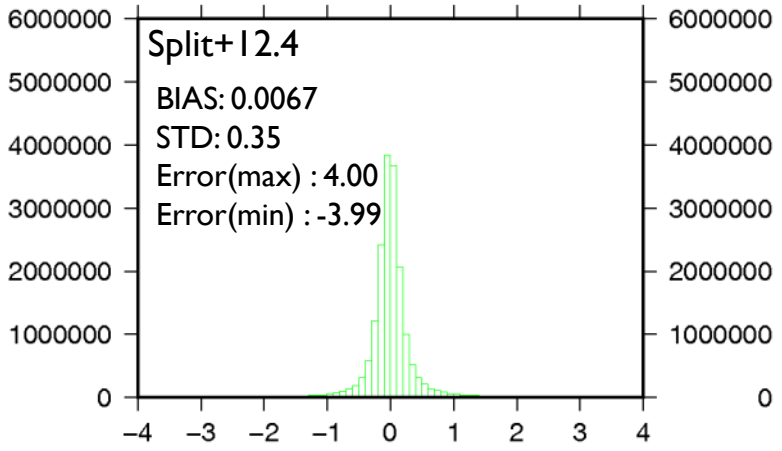


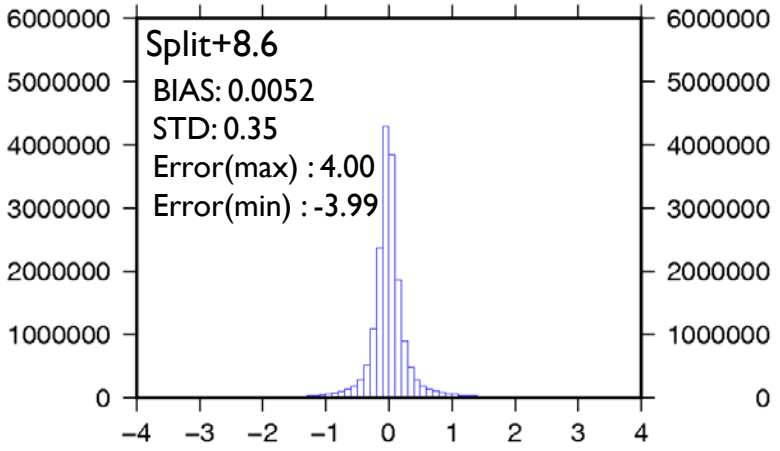
Spectral Response Functions of IR bands

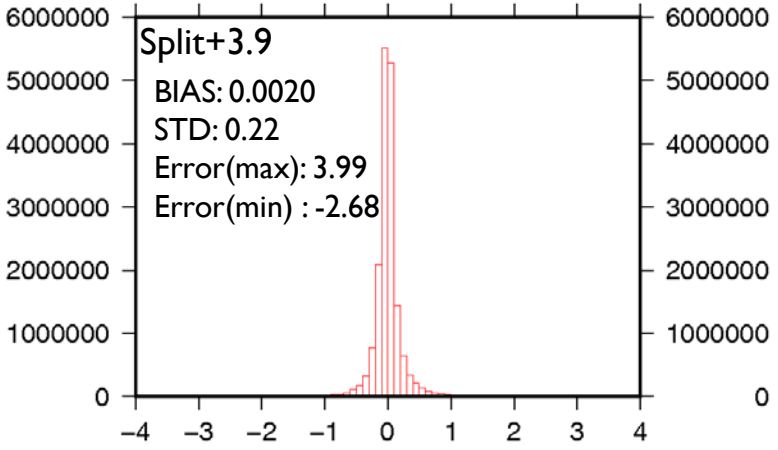


Algorithm Capability

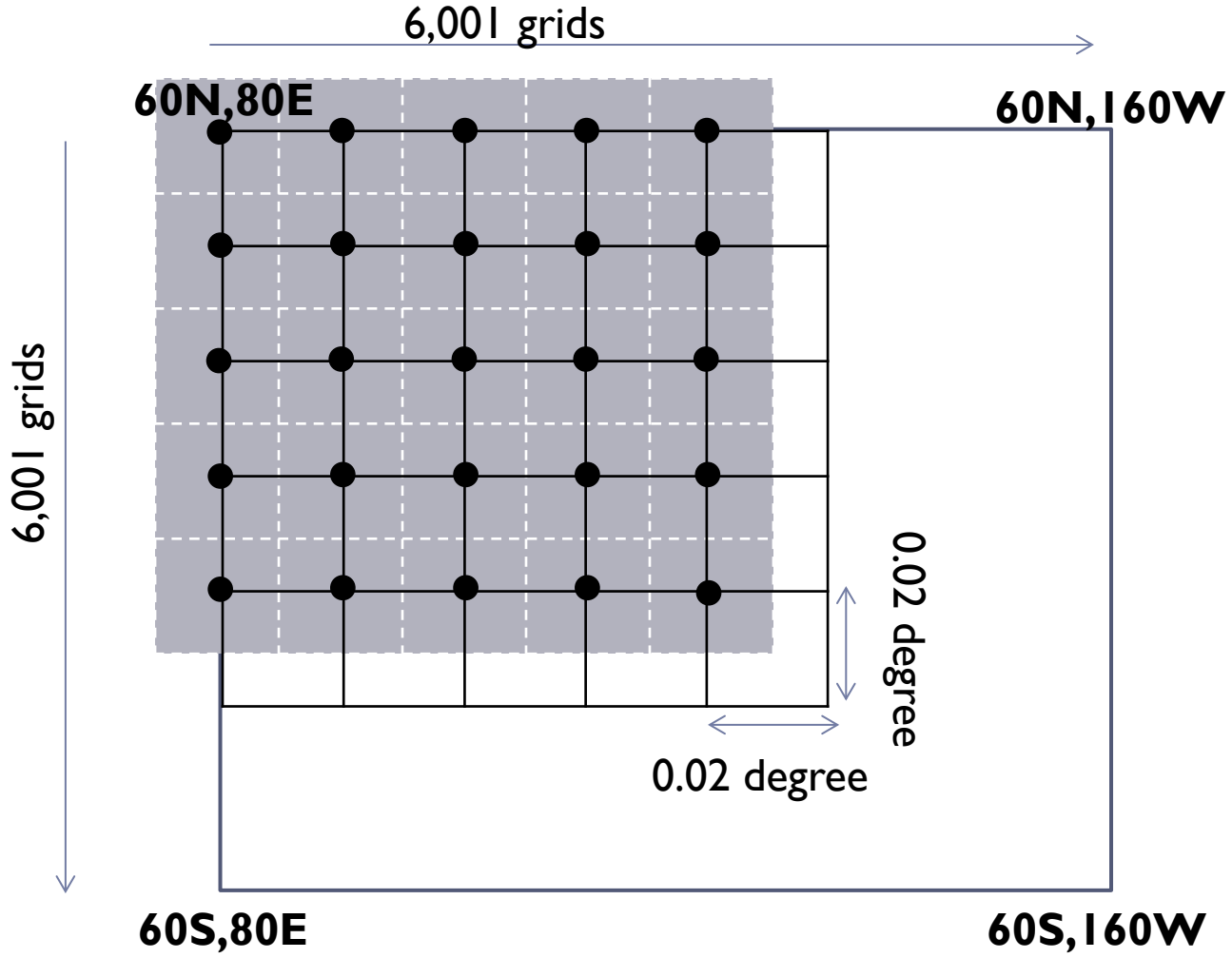








SST Grid definition



L2P flags for Himawari-8 SST (common)

bit	value	description	remarks
0	0	Passive microwave data	no use
1	0	Ocean	
	1	Land	
2	0	Ice	no use
3	0	Lake	
4	0	River	
5	0	Spare	

L2P flags for Himawari-8 SST (provider specific)

bit	value	description		remarks
6-7	00	fine	satellite zenith	
	01		satellite zenith	
	10	error	satellite zenith	
	11		satellite zenith	
8-9	00	not used		currently no meanings
	10	used (sun-glint angle)		
	11	used (sun-glint angle)		
10	0	reserved		no use
11	0	not used		Optional band used to calculate SST
	1	used		
12	0	not used		
	1	used		

Quality level for Himawari-8 SST

bit	value	description	remarks
0		no data	
1		bad data	
2		worst quality	
3		low quality	
4		acceptable quality	0.3 < Cloud Probability < 0.4
5		best quality	Cloud Probability < 0.3

SSES for Himawari-8

- Bias and standard deviation will be calculated by comparing with buoy data.
- SSES will be calculated as a function of cloud probability.
- SST will be given SSES corresponding to its cloud probability.
- SSES bias and standard deviation will be updated every week.

Calculation/Update cycle of SSES