Early on-board calibration and cross-calibration results of GOSAT-GW/AMSR3

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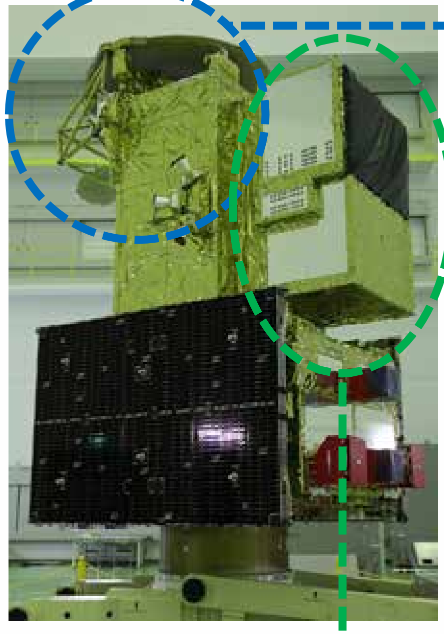
GSICS MWSG meeting @ Mar. 25, 2026

GOSAT-GW: Global Observation SATellite for Greenhouse gases and Water cycle

AMSR3
(Advanced Microwave Scanning Radiometer 3)

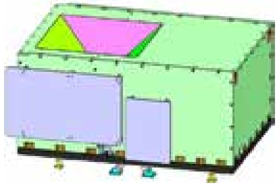


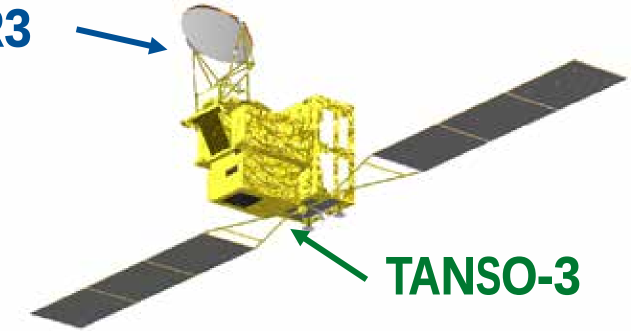
AMSR3, led by JAXA, will succeed AMSR series observations adding new high frequency channels for solid precipitation retrievals and water vapor analysis in NWP

GOSAT-GW at Tanegashima Space Center on 20 May 2025

TANSO-3
(Total Anthropogenic and Natural emissions mapping SpectrOmeter-3)

TANSO-3, led by Japanese Ministry of the Environment (MOE) and National Institute of Environment Studies (NIES), will improve observation capability of greenhouse gases from GOSAT-2/TANSO-2





GOSAT-GW Satellite Specifications

Mission Instruments		AMSR3 (JAXA) TANSO-3 (MOE/NIES)
Orbit	**Type**	Sun-synchronous, Sub-recurrent orbit
	Altitude	666km, recurrent cycle 3days (same as GOSAT)
	Local sun time at ascending	13:30+/-15min (same as GCOM-W)
	Revisit time	3 days
Satellite Mass		2.6 tons (including propellant)
Designed lifetime		> 7 years
Launch		**29 June 2025 (JST)** by H-IIA #50

Mission Schedule after the Launch

We are HERE

Jun. 29, 2025 (JST)
Launch

Jul. 1, 2025

Aug. 11
Ver.0.0/00A

Oct. 8, 2025

Nov. 27
Ver.0.1/00B

Mar. 5
Ver.0.2/00C

End Jun./Early Jul., 2026
Ver.1.0/01A

Critical Operations Phase	Initial Functional Verification Operations Phase	Initial Calibration and Validation Operations Phase	Nominal Mission Operations Phase
After the satellite separation, Deployment of the solar array paddles, antenna deployment & initial run-up of AMSR3, release of the pointing mirror lock for TANSO-3	Verify the functions of satellite and onboard instruments	Calibration and validation of AMSR3 and TANSO-3 Release of **Early AMSR3 data (Ver.0.1/0.2)** to partner agencies and selected principal investigators is planned during this period.	Release of **AMSR3 standard product (Ver.1.0)** to public *TANSO-3 products will be released by MOE/NIES.

Completed on July 1

3-month after the launch
Completed on October 8

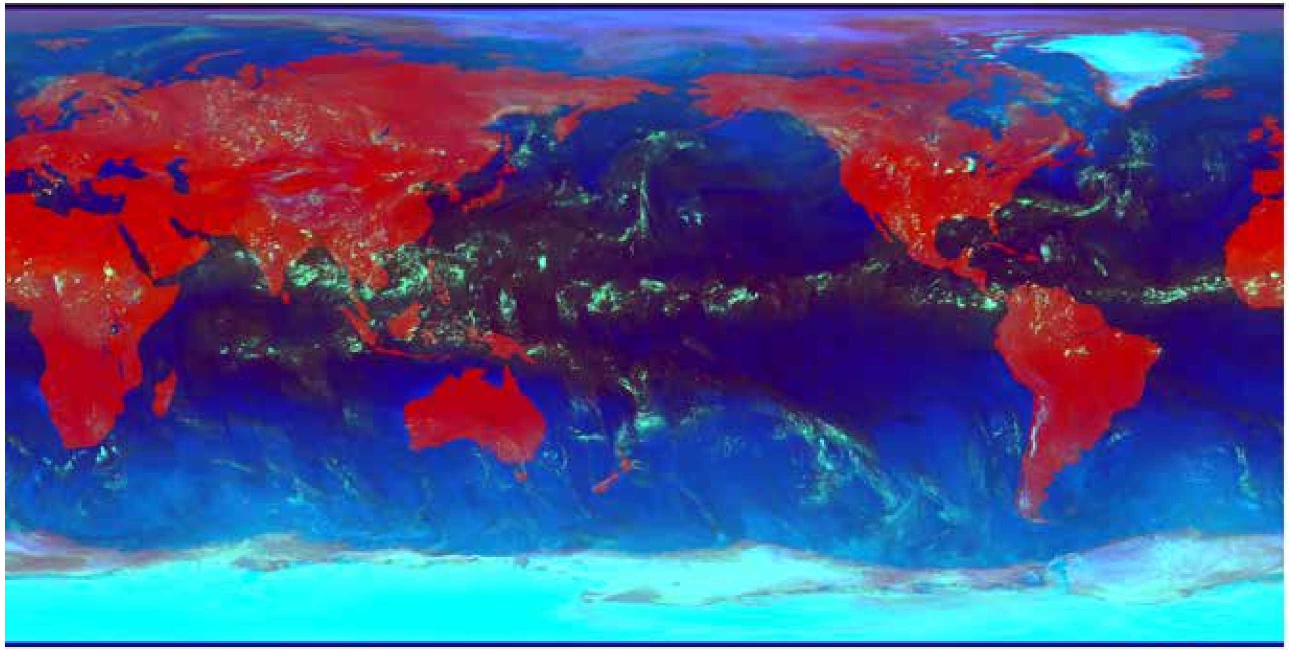
12-month after the launch

7-year after the launch

AMSR3 Early Images

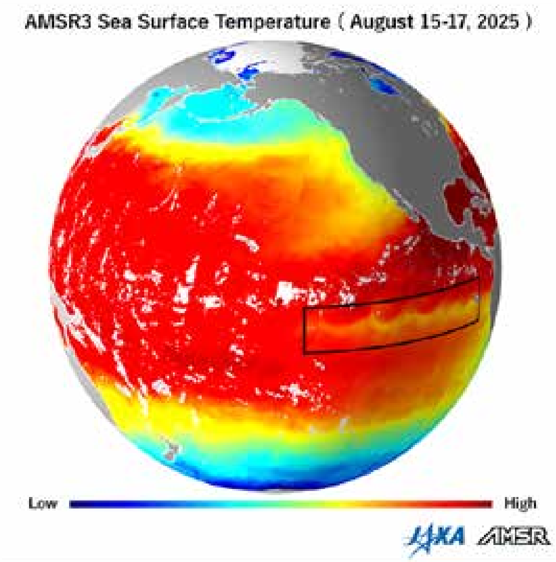
AMSR3 started scientific observation from 11 Aug. 2025 and released first images on 5 Sep. 2025.

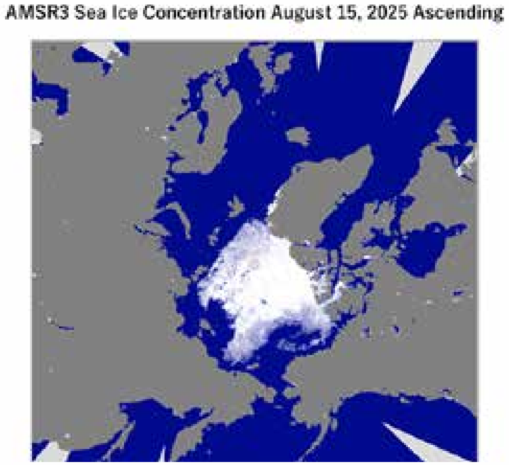
It is currently in calibration/validation phase for public data release (Ver.1.0) in the end of June/early Jul. 2026. Early data (Ver.0.1) has been provided to partner agencies since Nov. 2025.

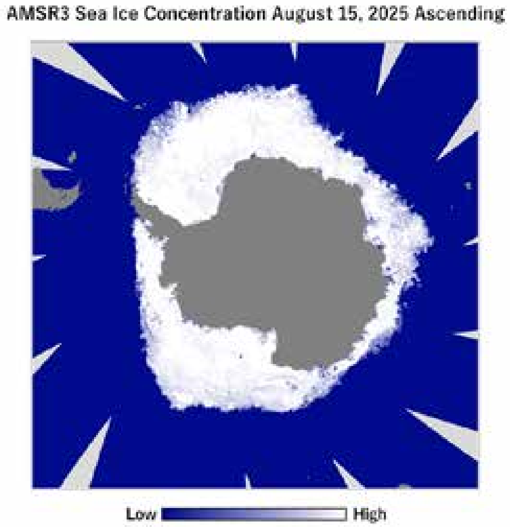


AMSR3 RGB composite image using 18.7, 89.0, and 165.5 GHz V-Pol. TB to highlight cloud/precipitation area in light green (15-17 Aug. 2025, Ascending)

https://global.jaxa.jp/press/2025/09/20250905-1_e.html



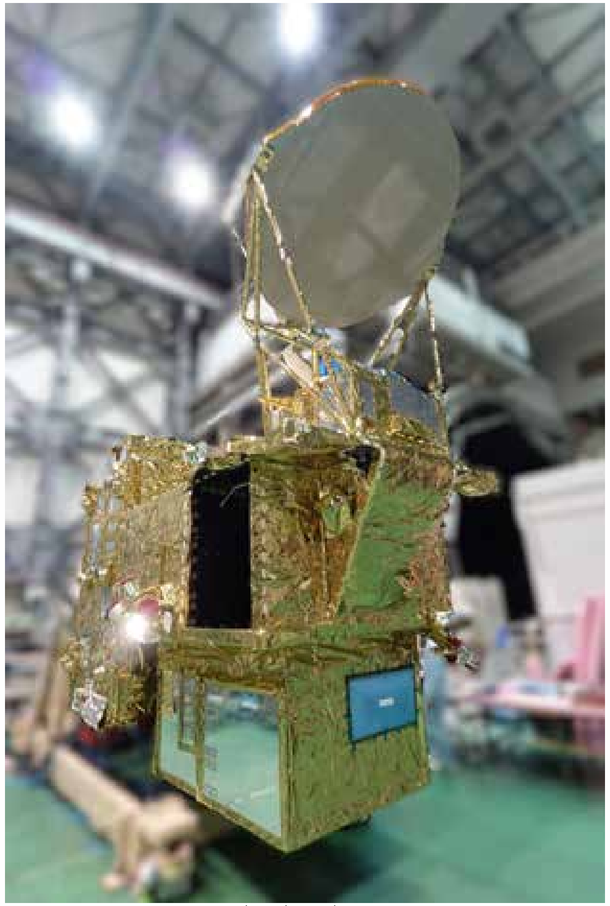




Initial cal/val phase until Jun. 2026

AMSR3 Sensor Specifications

- On-board evaluation shows that all channels satisfy NEDT specifications



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Feature of the GOSAT-GW satellite with AMSR3 Main Reflector deployed

AMSR3 Channel Sets

Center frequency [GHz]	Polari-zation	Band width ［MHz］	NEDT (1σ)	Beam width (spatial resolution)
6.925	H/V	350	< 0.34 K	1.8°(33km x 57km)
7.3			< 0.43 K	
10.25	**H/V**	**500**	**< 0.33 K**	**1.2°(22km x 38km)**
10.65	H/V	100	< 0.70 K	1.2°(22km x 38km)
18.7	H/V	200	< 0.70 K	0.65°(12km x 21km)
23.8	H/V	400	< 0.60 K	0.75°(14km x 24km)
36.42	H/V	**840**	< 0.70 K	0.35°(6km x 11km)
89.0 A/B	H/V	3000	< 1.20 K	0.15° (3km x 5km)
165.5	**V**	**3200***	**< 1.50 K**	**AZ=0.23° / EL=0.30° (4km x 9km)**
183.31±7	**V**	**1700×2**	**< 1.50 K**	**AZ=0.23° / EL=0.27° (4km x 8km)**
183.31±3	**V**	**1470×2**	**< 1.50 K**	**AZ=0.23° / EL=0.27° (4km x 8km)**

*Except 165.5GHz±300MHz because of DSB (Double Sideband) receiving system.

Red: Changes from AMSR2 including additional CHs

Add to improve temperature resolution (NEDT) in high-resolution SST

Modify to reduce possible risks of RF interferences from the 5G communication systems

Add to get snowfall and water vapor in higher levels

① Additional **166 & 183 GHz** channels to enable monitoring of global precipitation (rain & snow) and contribute to water vapor analysis in NWP

② Additional **10.25 GHz channels with improved NEDT** to enable robust SST retrievals in higher spatial resolution

Geometric Calibration Performance (Ver.0.2/00C)

- Geometric Calibration Method
  - Geolocation errors evaluated using coastline matching
  - Observed brightness temperature maps ⇔ land-sea fraction patterns (GCP)
- Calibration Parameter for Geometric correction
  - Rotation offset
  - Observation start timing
  - Line-of-sight vectors
  - (Fixed) Antenna geometry (MREF, SU alignment)
- Results
  - <u>Post-calibration geometric errors are well within IFOV for all channels</u> (See right table)

Geometric error for each AMSR3 frequency after geometric correction

Frequency [GHz]	Geometric Error（Average）			
	V-pol Azimuth Direction	V-pol Along-track Direction	H-pol Azimuth Direction	H-pol Along-track Direction
6.925	-0.03 km	-0.07 km	-0.06 km	0.64 km
7.3	-0.21 km	0.13 km	0.04 km	0.60 km
10.25	-0.03 km	-0.05 km	0.01 km	0.38 km
10.65	0.01 km	0.09 km	-0.01 km	0.28 km
18.7	0.02 km	0.07 km	0.05 km	0.17 km
23.8	0.01 km	0.15 km	0.00 km	0.20 km
36.42	-0.01 km	0.13 km	-0.03 km	0.15 km
89.0(A)	-0.03 km	-0.02 km	-0.02 km	-0.02 km
89.0(B)	-0.04 km	-0.06 km	-0.04 km	-0.05 km
165.5*	-0.10 km	-0.17 km	—	—

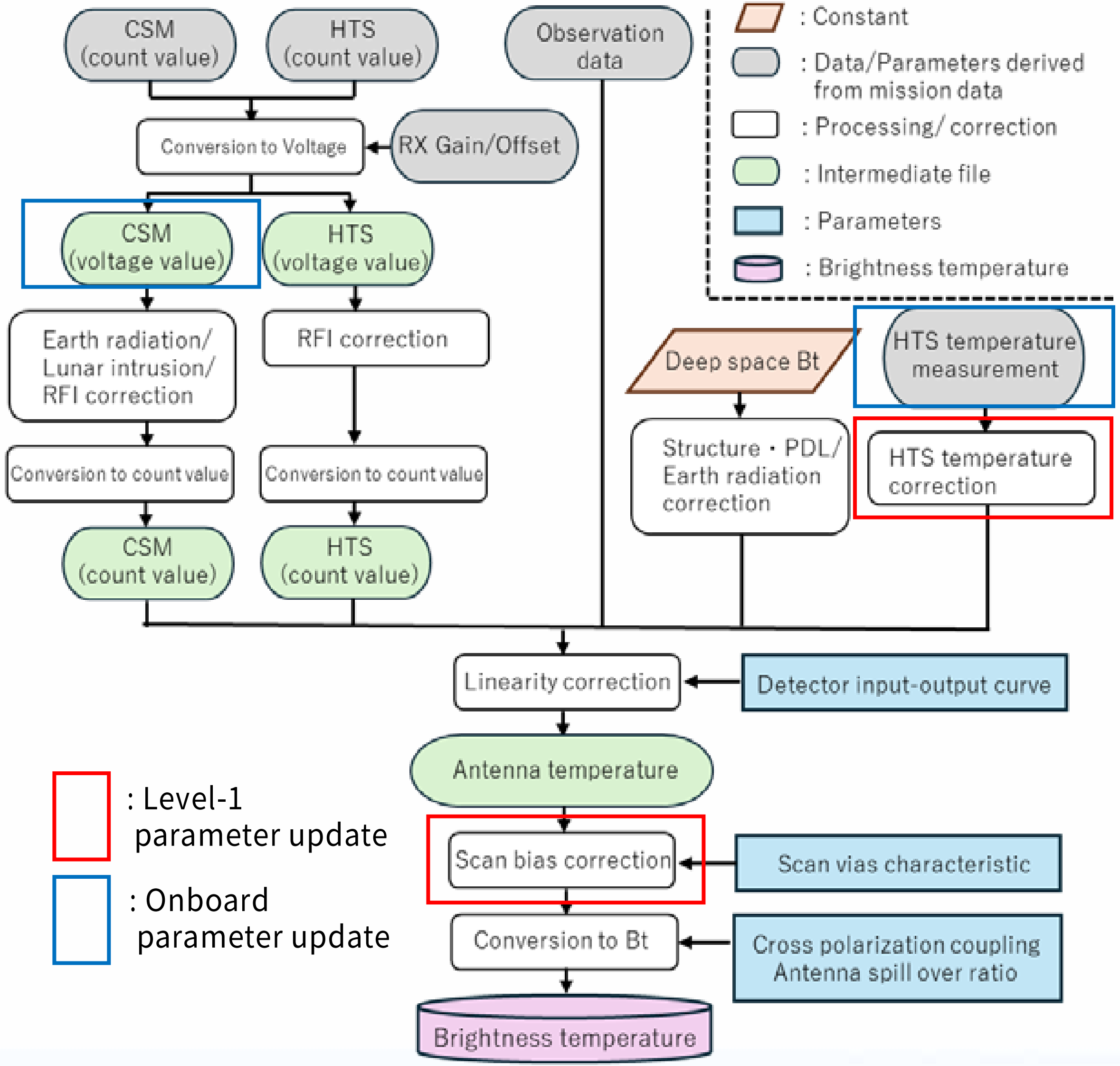
*Comparable accuracy confirmed for 183.31GHz via 165.5GHz comparison.

Radiometric calibration Framework

- Framework Overviews
  - Overall radiometric calibration flow (see right figure)
  - Onboard and Level-1 parameters updated based on on-orbit characterization

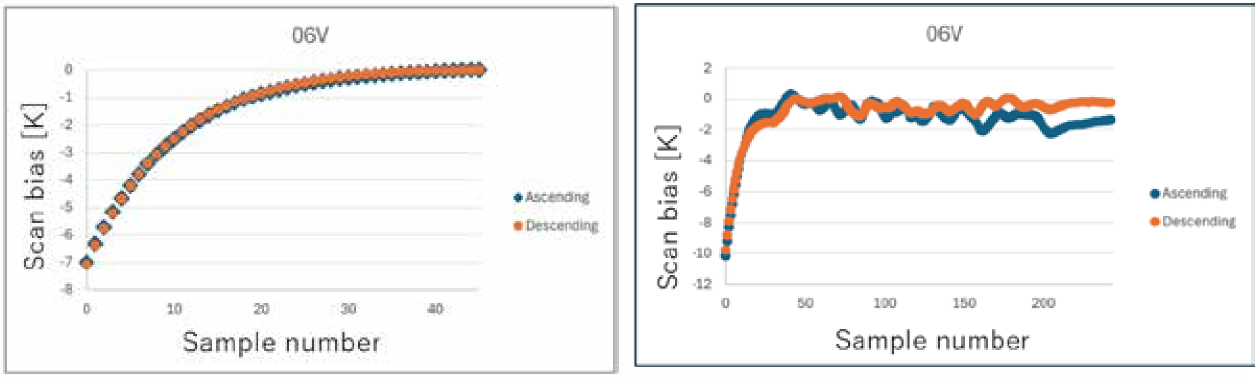
- Parameter Updates from Initial Calibration
  - Onboard updates:
    - CSM timing
    - HTS thermal control
  - Level-1 updates:
    - Scan-bias
    - HTS temperature correction

      (HTS temperature-step handling)

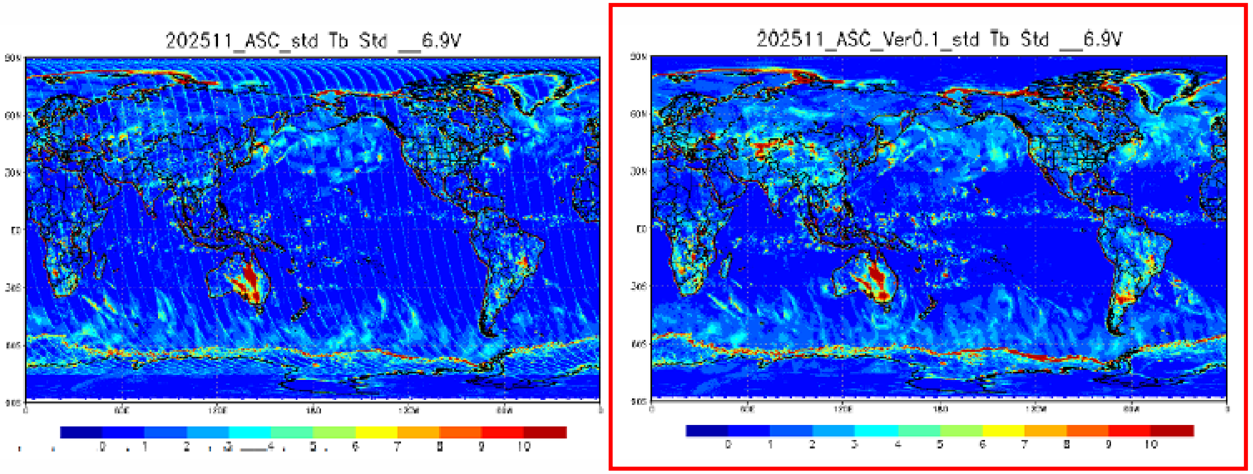


Scan Bias Correction (Ver.0.2/00C)

- **Issue**: Scan-dependent BT Bias arise （e.g., partial blockage by onboard calibration sources)
- **Action**:
  - AMSR3 scan bias evaluated and corrected following the AMSR2 methodology
  - Separate analyses over ocean and land (low-variability Siberia)
  - Bias approximated using second-order polynomial functions
- **Result**:
  - Scan bias characteristics identified at 6.9-10.65GHz (lower-left: 6.9 GHz V-pol example)
  - Edges biases effectively reduced after correction （lower-right: 6.9 GHz V-pol example）
  - Improved spatial uniformity across the entire scan



6.9GHz V-pol scan-bias characteristics at 6.9GHz (V-pol)
(Left) Ocean; (Right) land (low-variability Siberia)



Brightness temperature distribution at 6.9GHz V-pol
(Left)Pre-correction; (Right) Post-correction

Cross-calibration Method

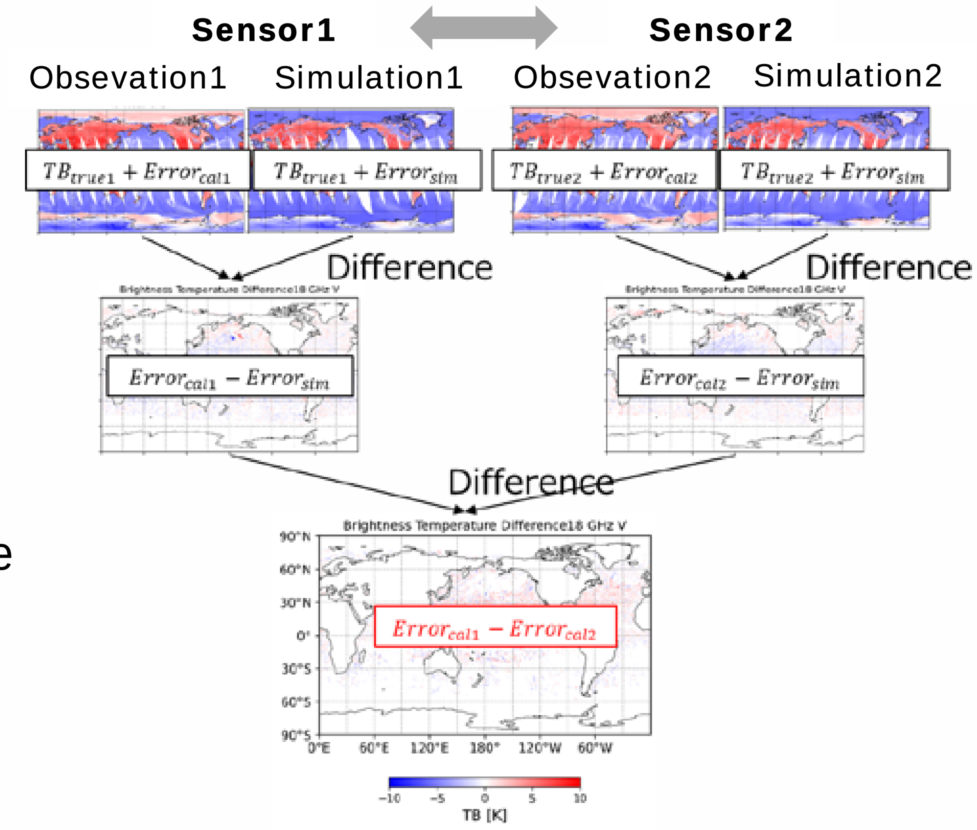
- Cross-calibration method: Double Difference (DD)
  - Comparison of observed and simulated TB to minimize TB differences caused by observation condition (frequency, incident angle, etc.) and evaluate biases arise from calibration error

$$DD_{AMSR3\ vs\ AMSR2} = (TB_{AM3obs} - TB_{AM3sim}) - (TB_{AMSR2obs} - TB_{AMSR2sim})$$

$$DD_{AMSR3\ vs\ GMI} = (TB_{AM3obs} - TB_{AM3sim}) - (TB_{GMIobs} - TB_{GMIsim})$$

- Match-up condition
  - Ocean: Time difference within ±30-min.
  - Land: Time difference ±15-min but limited to Congo and Amazon forests, whose TB natures are homogeneous.
  - Converted to 0.5-degree grids when there are more than 10 effective pixels within a grid
- Screening condition
  - Exclude data where simulations have large error (cloudy, sea ice, sun glint, strong wind)
  - Exclude data if they may be affected by RFIs
  - Exclude data if homogeneity within a 0.5-degree grid is low due to influence by land surface or clouds

Double Difference (DD) Method



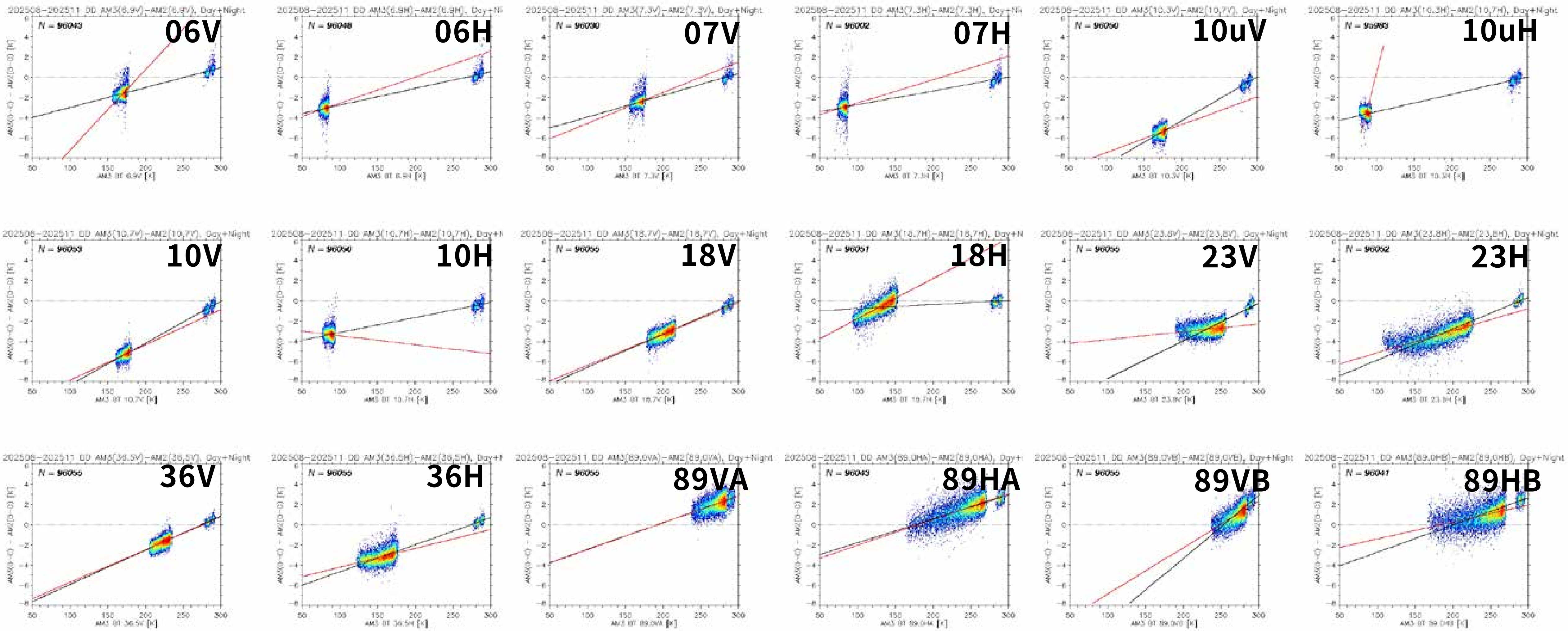
Data and Model

- Period
  - From August 11, 2025, to November 30, 2025
- Brightness temperature (Tb) products for intercalibration
  - AMSR3: Level-1B (Version 0.1/00B)
  - AMSR2: Level-1B (Version 220) ← **For 6-89 GHz channels**
  - GMI: Level-1B (Version 07B) ← **For 10-183 GHz channels**
- Radiative transfer model (RTM)
  - RTTOV 13.2 distributed by NWP SAF
  - Used surface emissivity model/atlas built-in RTTOV 13.2: FASTEM6 for ocean and TELSEM2 for land surface emissivity.
- Ancillary data (Global analysis data)
  - Japan Meteorological Agency (JMA)'s global analysis data (GANAL) as atmospheric profile
  - Merged satellite SST (MGDSST) as SST

Intercomparison Results AMSR3 vs AMSR2

For Ascending and Descending data

Linear Fit —: Ocean and Land, —: Ocean only



Interconversion Coefficients AMSR3 vs AMSR2

Correction coefficients to calibration bias from AMSR3 TB to AMSR2 TB

$$Tb_{AMSR3toAMSR2}[K] = Tb_{AMSR3}[K] - \Delta Cal\ [K]$$

$$\Delta Cal\ [K] = Tb_{AMSR3}[K] \times slope + intercept$$

* $Tb_{AMSR3toAMSR2}$: Tb_{AMSR3} *Calibrated to* Tb_{AMSR2}

AMSR3 calibration biases have negative tendency (max. ~-5K) except 89-GHz compared with AMSR2.

The result may be reasonable since AMSR2 calibration biases had positive tendency (max. ~5K) compared with TMI and AMSR-E (Okuyama et al., 2015).

For Ascending and Descending data

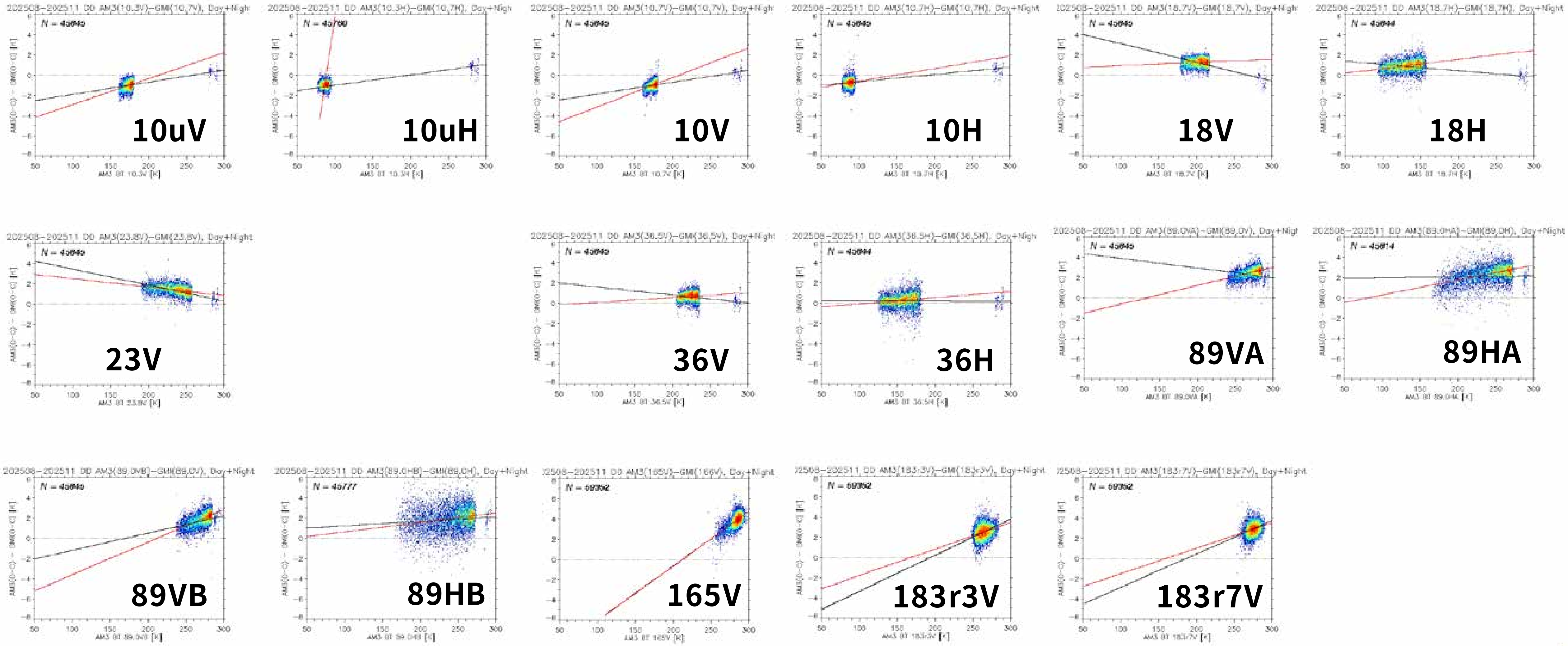
Freq.	①Ocean only		②Ocean and Land		Typical TB		①Ocean only		②Ocan and Land	
	Slope	intercept	Slope	intercept	TB@Ocean	TB@Land	ΔT@Ocean	ΔT@Land	ΔT@Ocean	ΔT@Land
6V	0.07981	-15.17952	0.01968	-4.93884	170.59	284.82	-1.57	7.55	-1.58	0.67
6H	0.02580	-5.13538	0.01649	-4.38759	80.86	282.83	-3.05	2.16	-3.05	0.28
7V	0.03035	-7.57494	0.02150	-6.07460	170.43	285.42	-2.40	1.09	-2.41	0.06
7H	0.02318	-4.85176	0.01372	-4.08097	82.07	283.39	-2.95	1.72	-2.95	-0.19
10uV	0.02766	-10.20262	0.04315	-12.89378	173.65	284.93	-5.40	-2.32	-5.40	-0.60
10uH	0.29141	-28.77682	0.01724	-5.11727	86.39	283.88	-3.60	53.95	-3.63	-0.22
10V	0.03502	-11.34727	0.04149	-12.47864	174.38	284.89	-5.24	-1.37	-5.24	-0.66
10H	-0.00894	-2.53365	0.01491	-4.62041	87.43	283.76	-3.31	-5.07	-3.32	-0.39
18V	0.03084	-9.44677	0.03287	-9.86128	202.72	285.44	-3.19	-0.64	-3.20	-0.48
18H	0.03975	-5.72626	0.00404	-1.15183	129.55	284.57	-0.58	5.59	-0.63	0.00
23V	0.00767	-4.57538	0.03735	-11.42421	235.25	287.49	-2.77	-2.37	-2.64	-0.69
23H	0.02181	-7.30319	0.03090	-8.93575	187.62	287.08	-3.21	-1.04	-3.14	-0.06
36V	0.03230	-8.91886	0.03390	-9.27655	222.67	285.07	-1.73	0.29	-1.73	0.39
36H	0.01855	-6.04692	0.02676	-7.30888	154.82	284.50	-3.17	-0.77	-3.17	0.30
89VA	0.02648	-5.09502	0.02628	-5.04320	272.29	289.63	2.11	2.57	2.11	2.57
89HA	0.02544	-4.56453	0.02339	-4.09669	242.04	289.47	1.59	2.80	1.57	2.67
89VB	0.04591	-11.44347	0.06236	-15.80728	271.66	289.69	1.03	1.86	1.13	2.26
89HB	0.01668	-3.05165	0.02687	-5.39003	241.64	289.49	0.98	1.78	1.10	2.39

Calibration bias at typical TBs

Intercomparison Results AMSR3 vs GMI

For Ascending and Descending data

Linear Fit —: Ocean and Land, —: Ocean only



Interconversion Coefficients AMSR3 vs GMI

Correction coefficients to calibration bias from AMSR3 TB to GMI TB (no incident angle correction)

$$Tb_{AMSR3toGMI}[K] = Tb_{AMSR3}[K] - \Delta Cal\ [K]$$

$$\Delta Cal\ [K] = Tb_{AMSR3}[K] \times slope + intercept$$

$* \ Tb_{AMSR3toGMI}$: Tb_{AMSR3} $Calibrated\ to\ Tb_{GMI}$

AMSR3's lower frequency channels (10-89-GHz) show smaller calibration biases (-1~2K) compared with GMI, which has relatively good calibration accuracy.

AMSR3's newly-added higher frequency channels show positive biases (2.5~4K) compared with GMI.

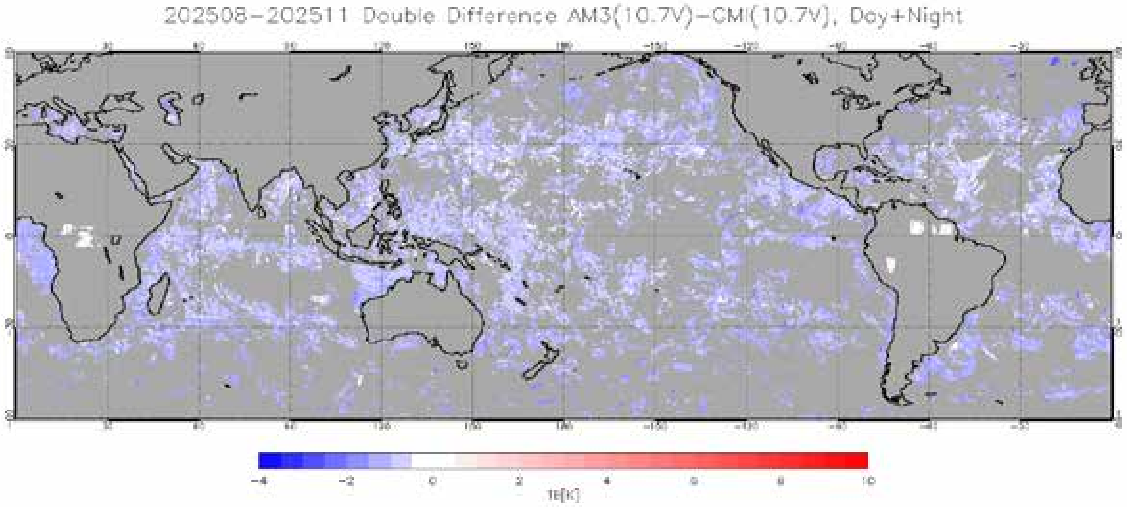
For Ascending and Descending data

Feq.	①Ocean only		②Ocean and Land		Typical TB		①Ocean only		②Ocan and Land	
	Slope	intercept	Slope	intercept	TB@Ocean	TB@Land	ΔT@Ocean	ΔT@Land	ΔT@Ocean	ΔT@Land
10uV	0.02565	-5.44212	0.01200	-3.07521	173.43	285.01	-0.99	1.87	-0.99	0.35
10uH	0.50539	-44.75473	0.01042	-2.03825	86.43	283.86	-1.07	98.71	-1.14	0.92
10V	0.02904	-6.03724	0.01169	-3.01882	174.01	285.00	-0.98	2.24	-0.98	0.31
10H	0.01236	-1.80562	0.00720	-1.35353	87.53	283.72	-0.72	1.70	-0.72	0.69
18V	0.00315	0.65475	-0.01838	4.97926	202.08	285.52	1.29	1.55	1.26	-0.27
18H	0.00908	-0.23885	-0.00622	1.71152	129.14	284.54	0.93	2.34	0.91	-0.06
23V	-0.00828	3.35669	-0.01576	5.05440	233.75	287.64	1.42	0.97	1.37	0.52
36V	0.00479	-0.38634	-0.00787	2.40555	222.48	285.09	0.68	0.98	0.65	0.16
36H	0.00624	-0.69061	-0.00009	0.27589	155.12	284.43	0.28	1.08	0.26	0.25
89VA	0.01819	-2.39454	-0.00947	4.85979	271.54	289.94	2.55	2.88	2.29	2.11
89HA	0.01478	-1.17686	0.00095	1.93748	241.12	289.75	2.39	3.11	2.17	2.21
89VB	0.03210	-6.78855	0.01703	-2.87423	270.90	289.98	1.91	2.52	1.74	2.06
89HB	0.00916	-0.25157	0.00423	0.84311	240.68	289.74	1.95	2.40	1.86	2.07
165V	0.05394	-11.42932	0.05394	-11.41600	283.85	283.66	3.88	3.87	3.90	3.89
183r3V	0.02612	-4.36516	0.03563	-6.88140	264.27	258.43	2.54	2.39	2.53	2.33
183r7V	0.02510	-3.98561	0.03296	-6.12485	275.36	271.17	2.93	2.82	2.95	2.81

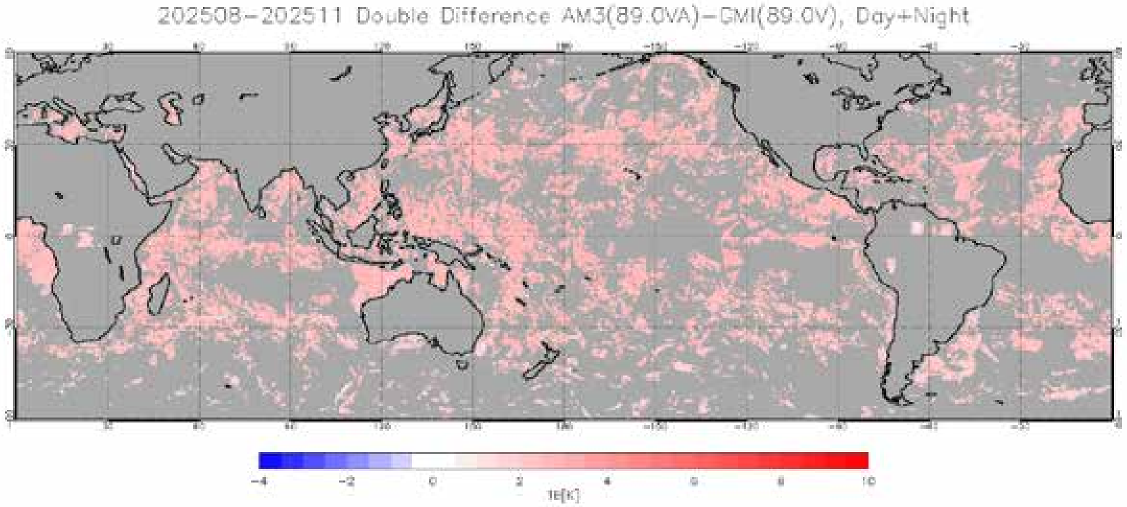
Calibration bias at typical TBs

Example Average of Double Difference between AMSR3 - GMI

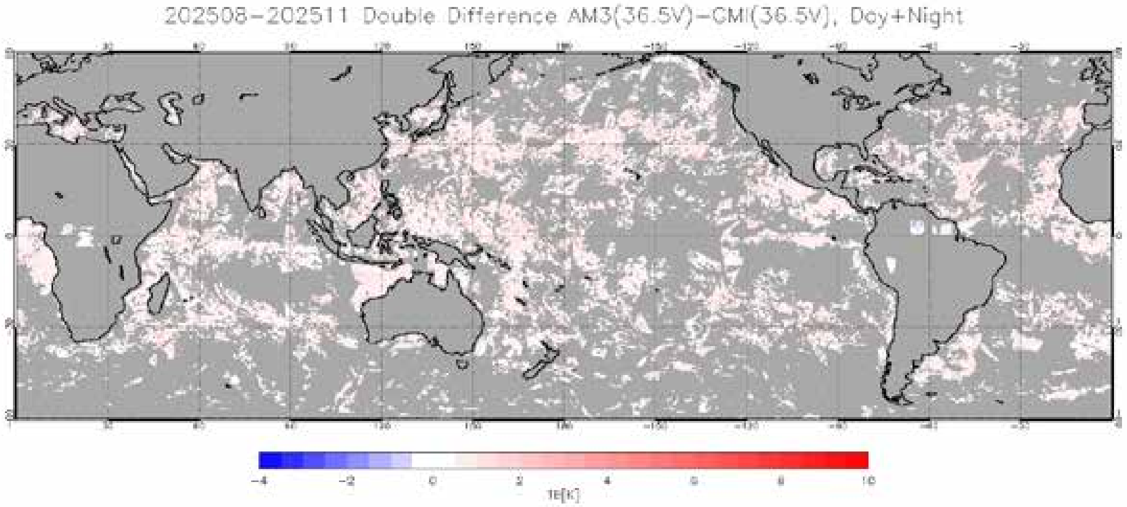
10V



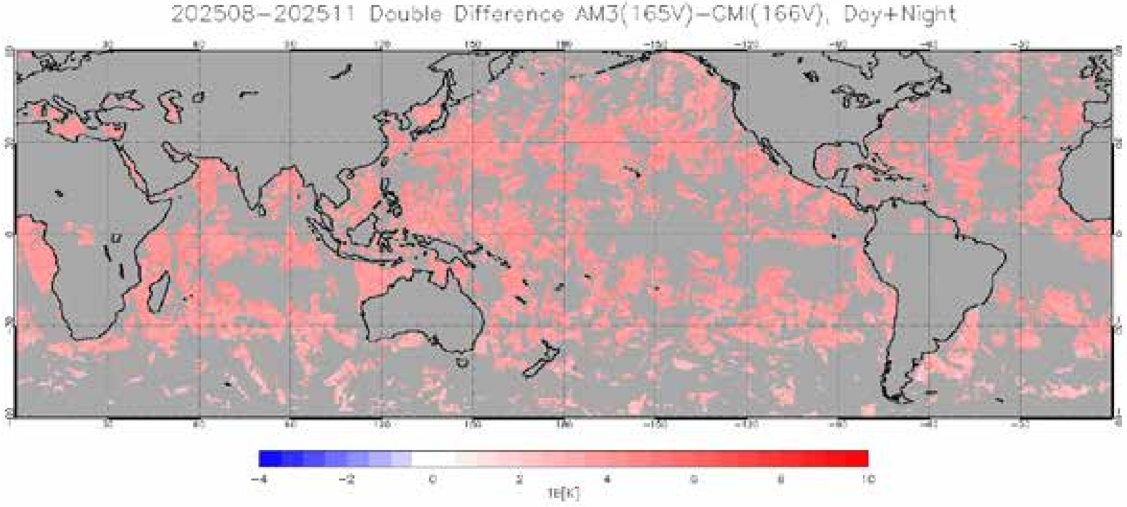
89VA



36V



165V



Summary

- GOSAT-GW satellite carrying AMSR3 was launched on June 29, 2025 (JST).
  - AMSR3 first images was released Sep. 5 including SST and sea ice concentration images.
- AMSR3 is currently in the Initial Calibration and Validation Operations Phase, and preparing public data release scheduled 1-year after the launch (end June/early July 2026).
  - Early Ver.0.1/00B data was provided to partner agencies and principal investigators from Nov. 27, 2025
  - On-board calibration results of Ver.0.2/00C are shown. Some issues remained for consideration in Ver.1.0/01A (HTS control temperature, deep space calibration, etc.)
- Cross-calibration between AMSR3 and AMSR2/GMI are also shown to evaluate calibration errors.
  - Early results by DD method using AMSR3 Level 1 Ver.0.1/00B were shown.
  - AMSR3 roughly shows negative bias (max. ~5K) against AMSR2, and smaller bias (-1~2K) for low-frequency channels and positive bias (2~4K) for high frequency channels against GMI.
  - No obvious differences in cross-calibration results between Ascending and Descending orbits
  - Cross-calibration for AMSR3 Level 1 Ver.0.2/00C is currently underway.
- In future, temporal analysis including seasonal/annual changes using Ver.1.0/01A (release version) for longer period.