

Development of the Advanced Microwave Scanning Radiometer (AMSR) Series and its Utilization

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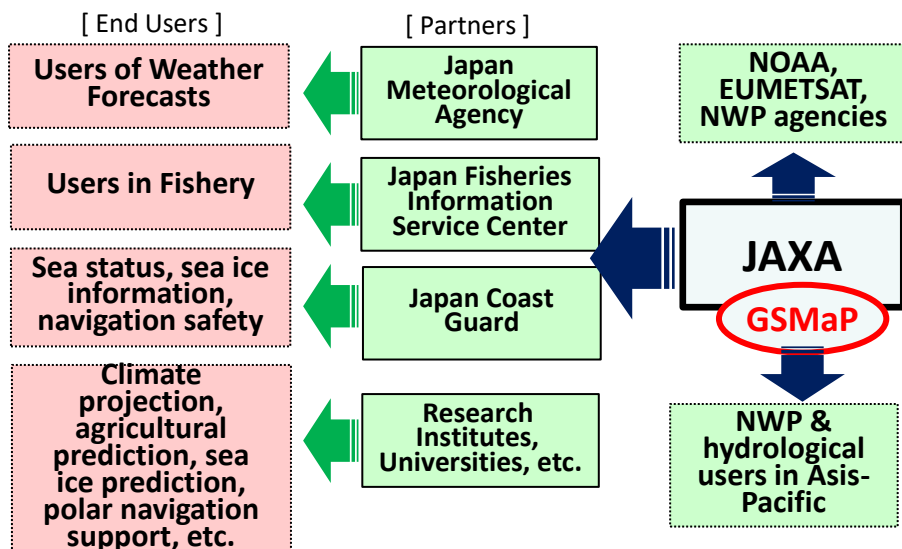
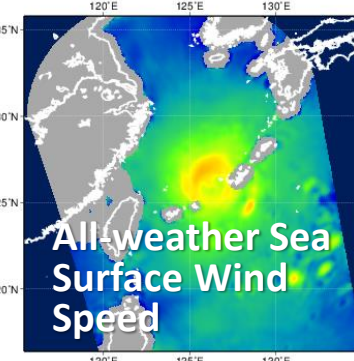
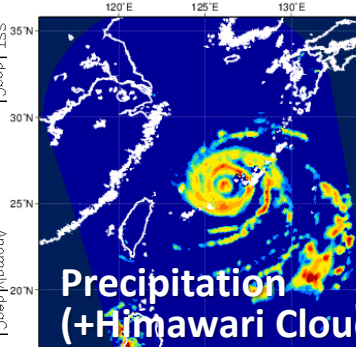
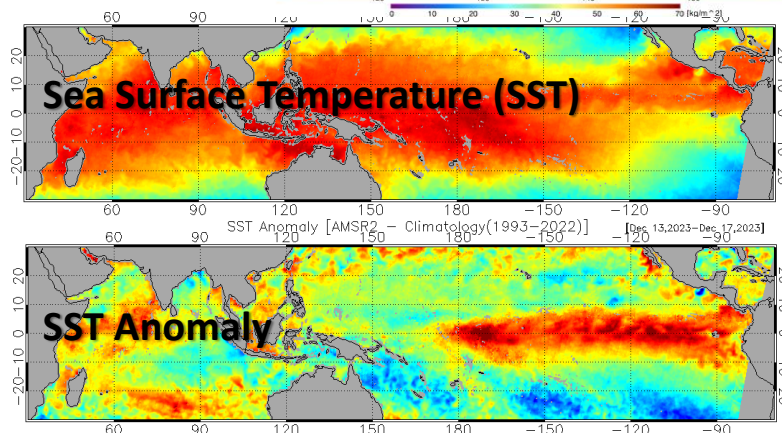
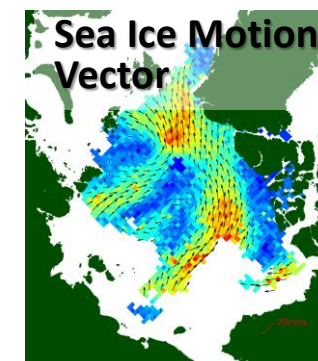
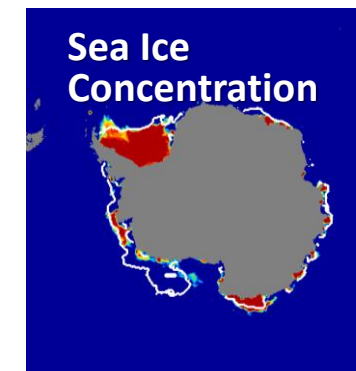
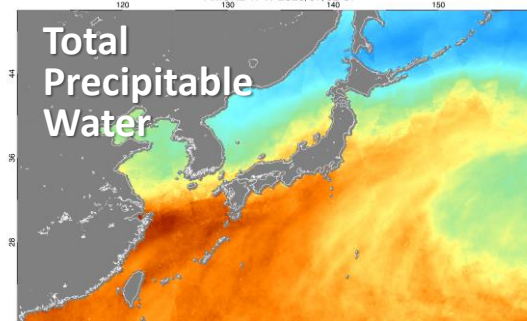
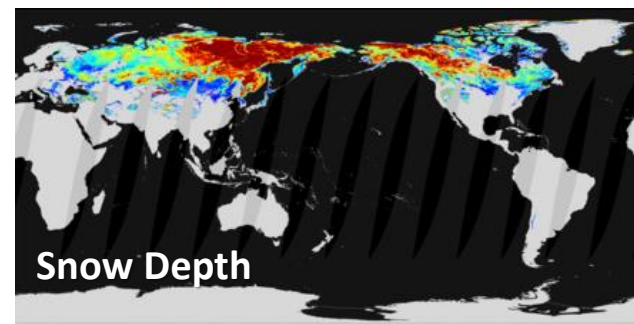
⁴⁾ Institute of Low Temperature Science, Hokkaido University



Advanced Microwave Scanning Radiometer (AMSR) Series

<https://www.eorc.jaxa.jp/AMSR/>

- A series of Japanese passive microwave radiometers with the world best capability
 - Microwave channels of 6.9-89GHz (additional 166-183GHz channels in AMSR3) enable to observe “water-related” geophysical parameters in all-weather without sun-light
- Widely used in **operational applications** (c.f., numerical weather prediction, tropical cyclone analysis, SST analysis, sea ice analysis and fisheries) as well as **water cycle variation & climate change studies**





Sensor Comparison of the AMSR Series

- ✓ Multi-frequency in 6.9-89 GHz
- ✓ Fine resolution with large size antenna
- ✓ Global observation

Demonstration of operational utilization

Establish operational utilization & long-term archive

Continue & expand past AMSR series



A-train Constellation

GPM Constellation

Sensor	AMSR	AMSR-E	AMSR2	AMSR3
Mission Period	2002.12-2003.9	2002.5-2011.10	2012.5-present	JFY2024
Altitude	803 km	705 km	700 km	666 km
Swath Width	1600 km	1450 km	1617 km	> 1530 km
Frequency (GHz)	6.9,10,18,23,36,50,52,89	6.9,10,18,23,36,89	6.9/7.3,10.65,18,23,36,89	6.9/7.3,10.25/10.65,18,23,36,89,166,183
Antenna Size	2.0 m	1.6 m	2.0 m	2.0 m
Spatial Resolution	40x70 km@6.9GHz 8x14 km@36GHz	43x75 km@6.9GHz 8x14 km@36GHz	35x62 km@6.9GHz 7x12 km@36GHz	34x58 km@6.9GHz 7x11 km@36GHz
LTAN	10:30	13:30	13:30	13:30

Mission Targets of the AMSR Series

2002-2011

AMSR

AMSR-E

Demonstration for operational utilization (NWP, Fisheries)

- 8 geophysical products
- Spatial resolution less than 50km

2012-

Succeed AMSR-E Observation

AMSR2

Establish operational utilization by improved data latency

- Disseminate global < 2.5H & Japan area < ~16min
- Climate change monitoring by long-term observation
- Consistency with AMSR-E
- Improved calibration accuracy

JFY2024-

Jointly with the TANSO-3 Mission

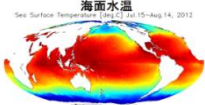
AMSR3

Continue achievements of past AMSRs, and respond to new user needs by:

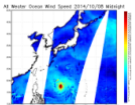
- New high-frequency channel; and
- Improve spatial resolution of products

AMSR Products

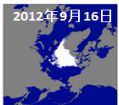
SST



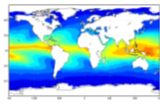
Wind Speed



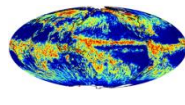
Sea Ice



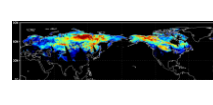
Water Vapor



Rainfall



Snow Depth

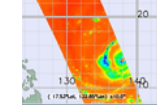


Soil Moisture

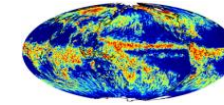


New Products in AMSR3

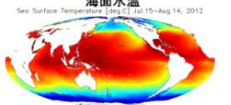
High-Freq. CH



Snowfall



High-res. SST



~ AMSR2

AMSR3

Water Cycle Variation

- Sea ice change in polar regions
- El Nino & La Nina

Operational Utilization

- NWP, typhoon analysis
- Detect fishery fields in offshore

Water Cycle Variation

- Improve model prediction
- Improve extreme weather

Operational Utilization

- Improve forecast of typhoon track, intensity, etc.
- Use in fishery in near coast
- Support navigation in polar oceans

Establish operational utilization by continuous observations

- Used in NWP in more than 40 countries & provided data to users in more than 90 countries

AMSR2 Precipitation Product Ver.3

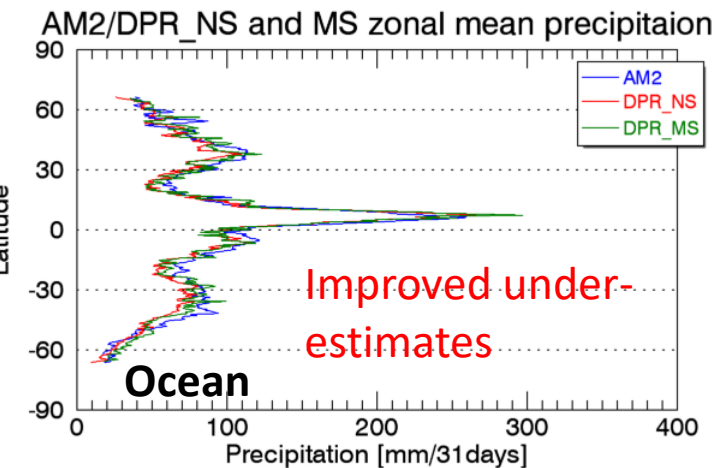
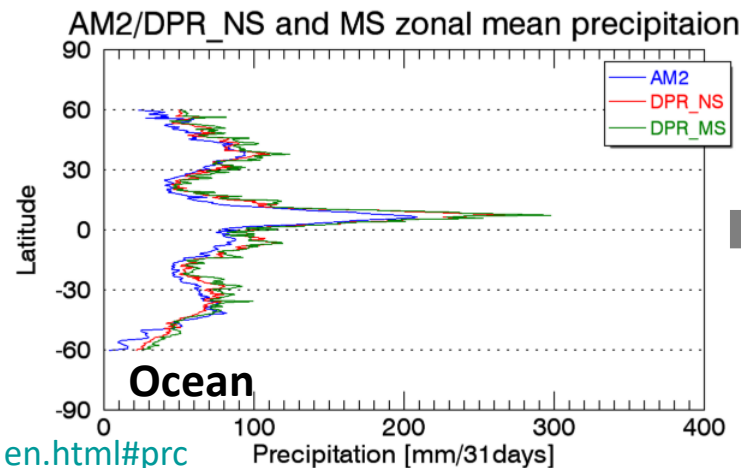
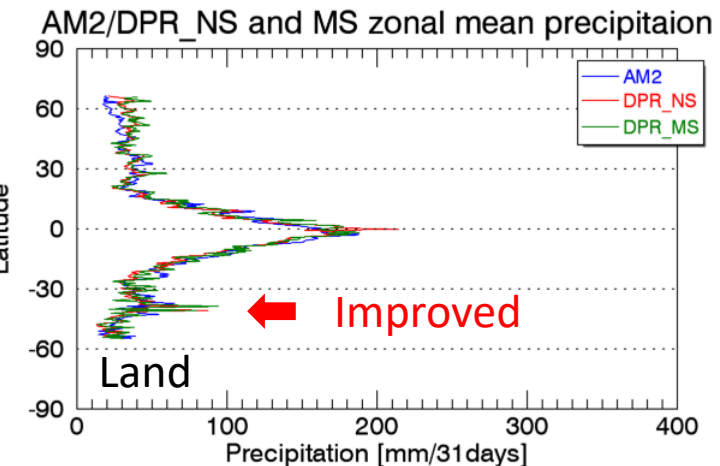
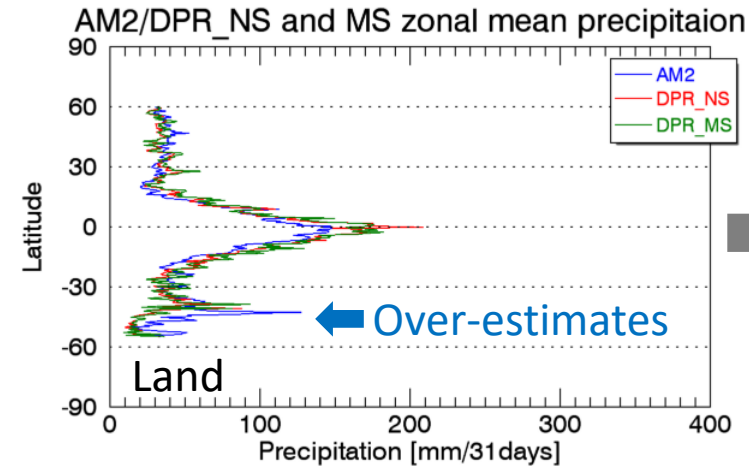
- Ver.3.0 released in Oct. 2022
 - Ver.3.1 released corresponding to format change of NOAA Autosnow in Jul. 2023.
 - Ver.3.11 will be released soon to fix bug in the start of calendar year
- Major improvements in Ver.3.0
 - NOAA Autosnow data (sea ice and snow cover information) was added to the reference data. The range limitation of the estimated area (less than 60 degrees latitude) has been removed.
 - * Already introduced in GSMaP V04
 - Based on the relationship between the scattering bias of the conventional GSMaP algorithm and the precipitation characteristics observed by the DPR, the following improvements were implemented.
 - * Partly introduced in GSMaP V05
 - See more details in updated AMSR2 precipitation ATBD on the web site

https://www.eorc.jaxa.jp/AMSR/datacatalog/atmosphere/index_en.html#prc

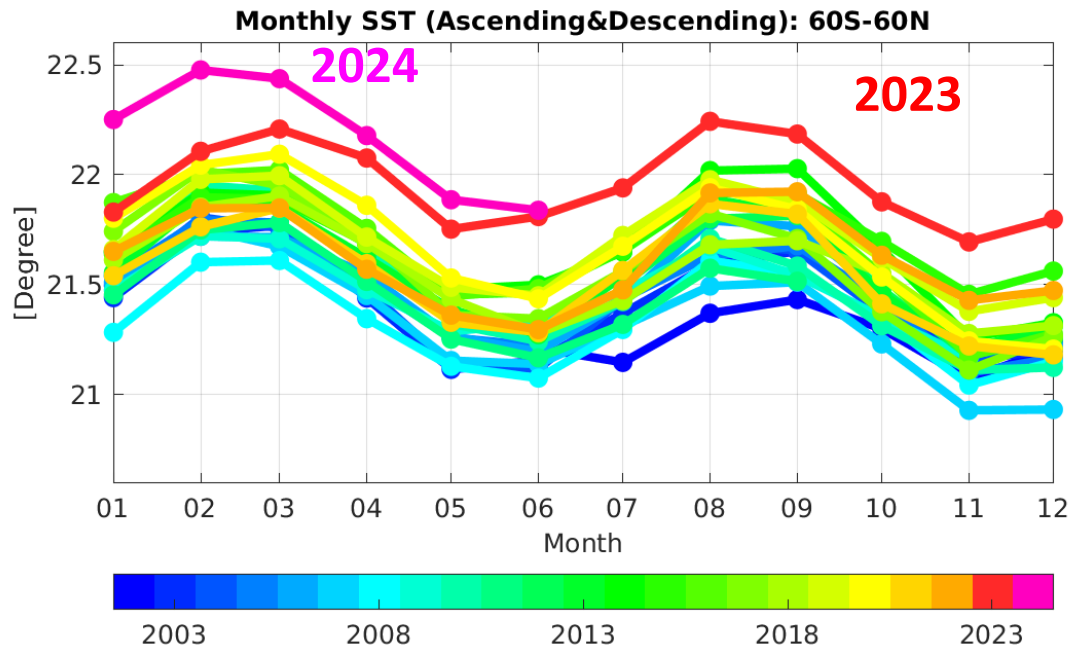
Comparison of zonal mean with GPM/DPR
Jun. 2014 - May 2015, Dec. 2018 - Nov. 2021

Ver.2

Ver.3

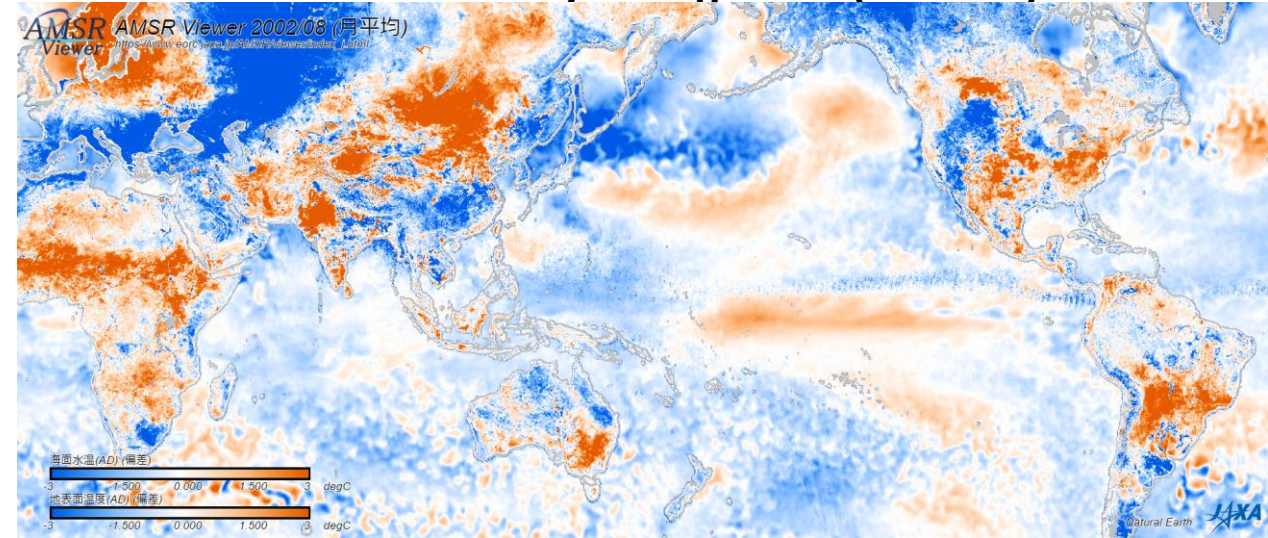


SST Variation during 2002-2024 by the AMSR Series

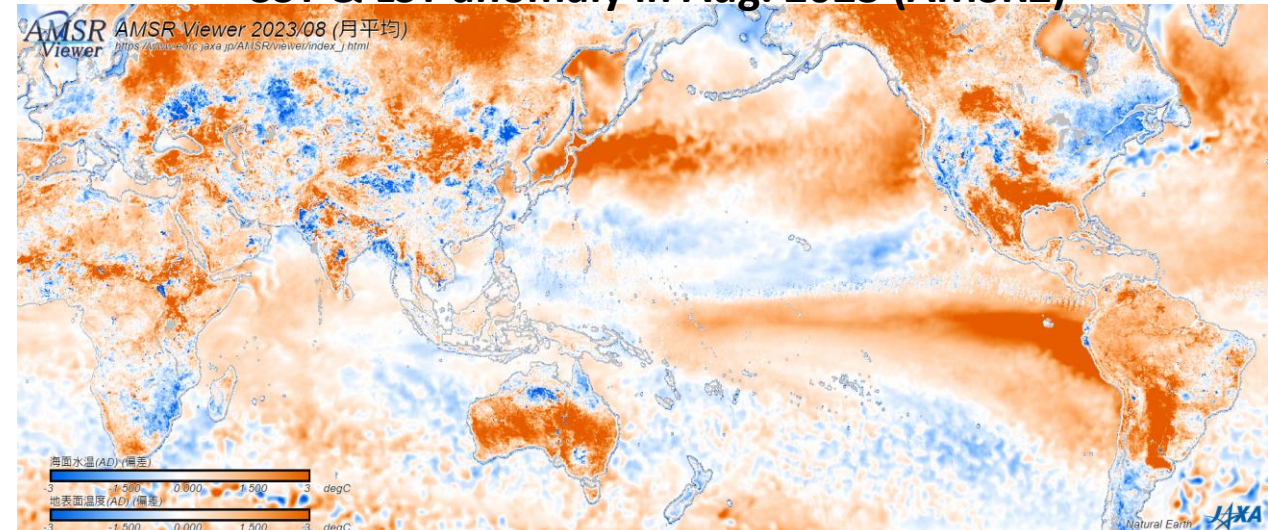


- Since Mar. 2023, monthly global (60S-60N) SST by AMSR2 recorded the highest values during AMSR observations since 2002.
- Higher SST tendency continues in 2024 but slightly moderates due to ending of El Nino in tropics.
- Comparison of monthly anomaly of SST & LST in Aug. between 2002 and 2023 shows contrast in wide area around the world.

SST & LST anomaly in Aug. 2002 (AMSR-E)



SST & LST anomaly in Aug. 2023 (AMSR2)



Monthly SST Climatology is calculated during AMSR data from 2002 to 2023

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

- GOSAT-GW will carry two instruments, **AMSR3** & TANSO-3
 - **AMSR3**, developed by JAXA, will succeed AMSR series observations adding new high-frequency channels for solid precipitation retrievals and water vapor analysis in NWP.
 - TANSO-3, led by Japanese Ministry of the Environment (MOE), will improve observation capability of greenhouse gases from GOSAT-2/TANSO-2. (Choose grating spectrometer to enable spatially detailed observation)
 - Target launch is **JFY2024 (until Mar. 2025)**
- Status of development
 - Jun. 2018: Mission Definition Review (MDR)
 - Jul. 2018: Project Preparation Review
 - Nov. 2019: Project Readiness Review
 - Dec. 2019: Established GOSAT-GW Project
 - Aug. 2020: Preliminary Design Review (PDR) of AMSR3 system
 - Dec. 2020: PDR of TANSO-3 system
 - Mar. 2021: PDR of GOSAT-GW satellite system
 - Oct. 2021: Critical Design Review (CDR) of AMSR3 system
 - Jun. 2023: CDR of GOSAT-GW satellite system
 - Spacecraft & AMSR3 flight models are in manufacturing and testing phase



Satellite specification

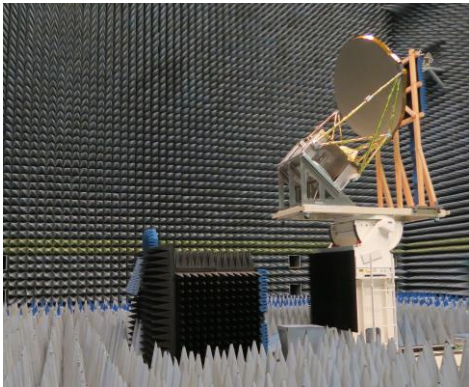
Orbit	Type	Sun-synchronous, Sub-recurrent orbit
	Altitude	666km, recurrent cycle 3days (same as GOSAT)
	MLTAN	13:30±15min (same as GCOM-W)
Mass		2.6 ton (Including propellant)
Power		> 5.3 kW
Design life		> 7 years
Launch vehicle		H-IIA rocket
Mission data downlink rate		Direct transmission with X-band: 400 Mbps Direct transmission with S-band: 1 Mbps (Only for AMSR3)
Instrument		TANSO-3 (GHGs), AMSR3 (water cycle variables)



GOSAT-GW/AMSR3 Sensor Specification



AMSR3 sensor in production.
Photo: AMSR3 Main Reflector at Tsukuba Space Center



Antenna pattern measurement with MREF and Feed. Radiation characteristics for channels below 89 GHz were verified.

Center frequency [GHz]	Polarization	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	4000	< 1.50 K	AZ=0.23° / EL=0.30° (4km x 9km)
183.31±7	V	2000×2	< 1.50 K	AZ=0.23° / EL=0.27° (4km x 8km)
183.31±3	V	2000×2	< 1.50 K	AZ=0.23° / EL=0.27° (4km x 8km)

Red: Changes from AMSR2 including additional CHs

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

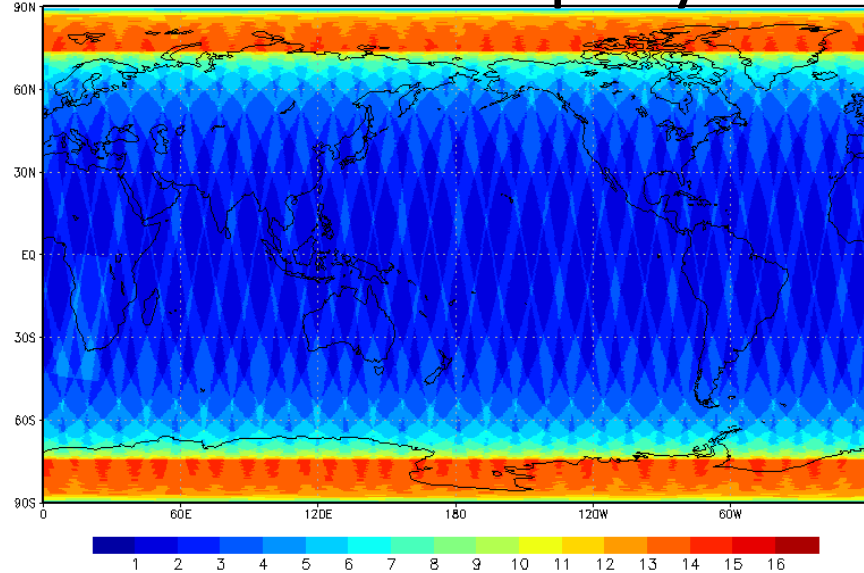
Modify to reduce possible risks of RF interferences from the 5G communication systems

Add to get snowfall and water vapor in higher levels

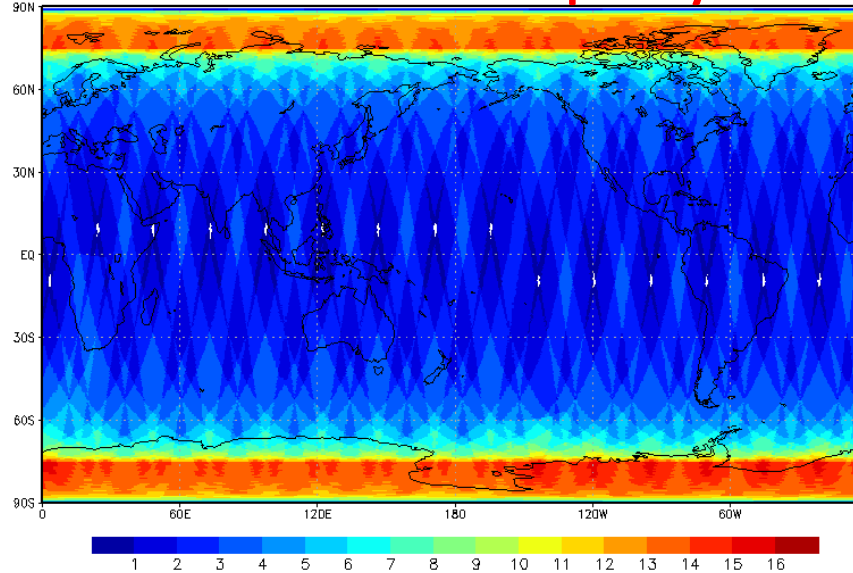
- ① Additional **166 & 183 GHz** channels to enable monitoring of global precipitation (rain & snow) and contribute to water vapor analysis in NWP
- ② Additional **10.25 GHz channels with improved NEDT** to enable robust SST retrievals in higher spatial resolution

AMSR3 Observation Frequency

AMSR2: Observation frequency in 2-day

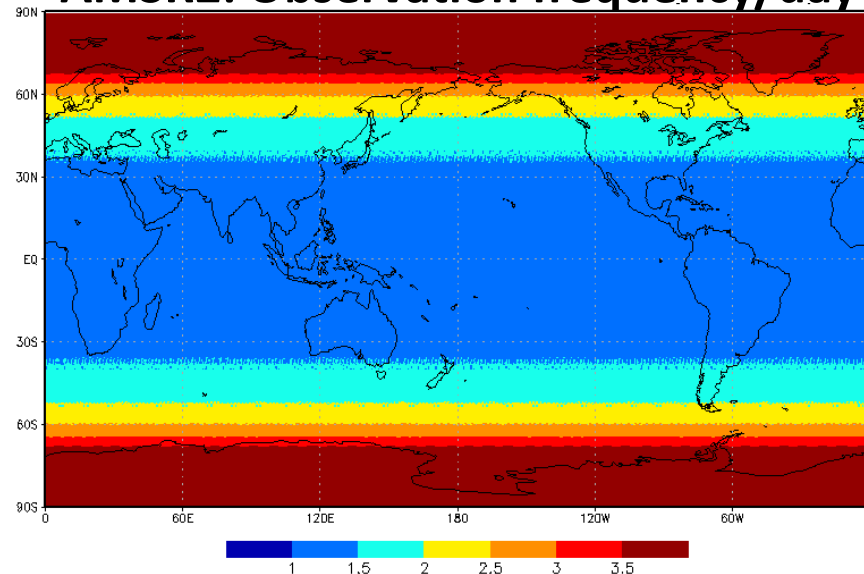


AMSR3: Observation frequency in 2-day

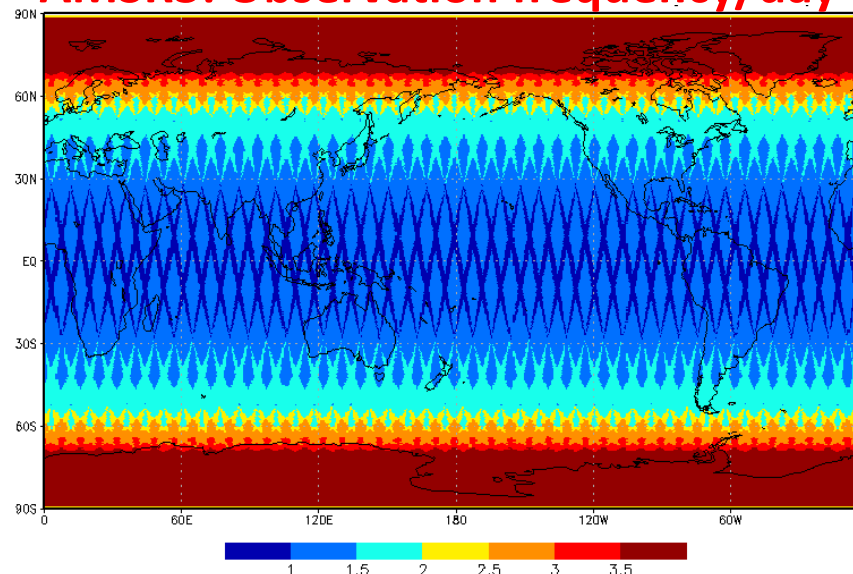


Unlike AMSR2, **AMSR3 cannot cover global area within 2-day** and small missing areas (white) are remained.

AMSR2: Observation frequency/day



AMSR3: Observation frequency/day



Observation frequency of AMSR3 is **NOT homogeneous** for every longitude and there are fixed areas less than 1 observation/day (blue).

List of AMSR3 Standard Products (as of Jul. 2024)

Product	Area	Status in AMSR2
Brightness Temperature (L1B)	Global	Released (V2.2)
Resampled Brightness Temperature (L1R)	Global	Released (V2.2)
Integrated Water Vapor Content (ocean & land)	Global Ocean & Land (except vegetation/ice area)	Ocean: Released (V2.2) by H. Murata & M. Kazumori Land: Released (V1) as research product by H. Murata & M. Kazumori
Integrated Cloud Liquid Water Content	Global Ocean	Released (V2.2) by H. Murata & M. Kazumori
Precipitation (rainfall & snowfall) * to be consistent to GSMaP	Global	Rainfall: Released (V3.11) by K. Aonashi Snowfall: Under development for AMSR3 by G. Liu
Sea Surface Temperature (6GHz, 10GHz, multi-band)	Global Ocean	6GHz: Released (V4.11) by A. Shibata 10GHz & multi-band: Released (V4.1) as research product
Sea Surface Wind Speed	Global Ocean	Released (V4) by A. Shibata
All-weather Sea Surface Wind Speed	Global Ocean	Released (V3) as research product by A. Shibata
Sea Ice Concentration	High-lat. Ocean	Released (V3) by K. Cho & J. Comiso
High-resolution Sea Ice Concentration	High-lat. Ocean	Released (V1) as research product by G. Spreen & G. Heygster
Snow Depth	Global Land	Released (V2) by R. Kelly * New version for AMSR3 was released as research product
Soil Moisture Content	Global Land	Released (V3) by H. Fujii & T. Koike * New version for AMSR3 was released as research product

* Sea Ice Motion Vector by K. Shimada is being considered to upgrade from research to standard product in AMSR3.



Recent Outreach Activities

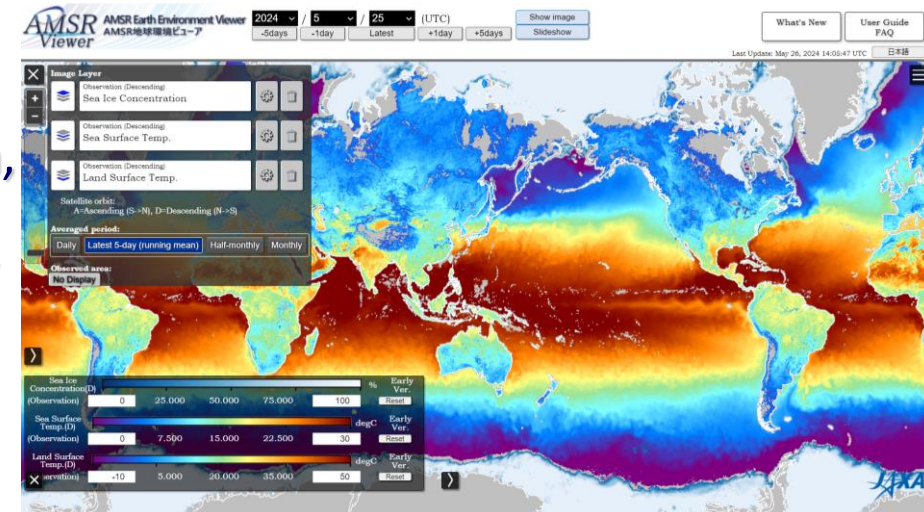
- AMSR3 Symposium (in Japanese) was held in Mar. 2024 with attendees, 91 in-person & 250 online.
- Presentations & Webinar video is available from the symposium web site (<https://clickpulsepro.com/jaxa/>)



サテきゃらソング ~しずくのうた~
JAXAサテナビチャンネル

- Song of “SHIZUKU” (GCOM-W) was released in May 2024
- Available at YouTube “JAXA SATENAVI channel” or check “#さてらいふ”

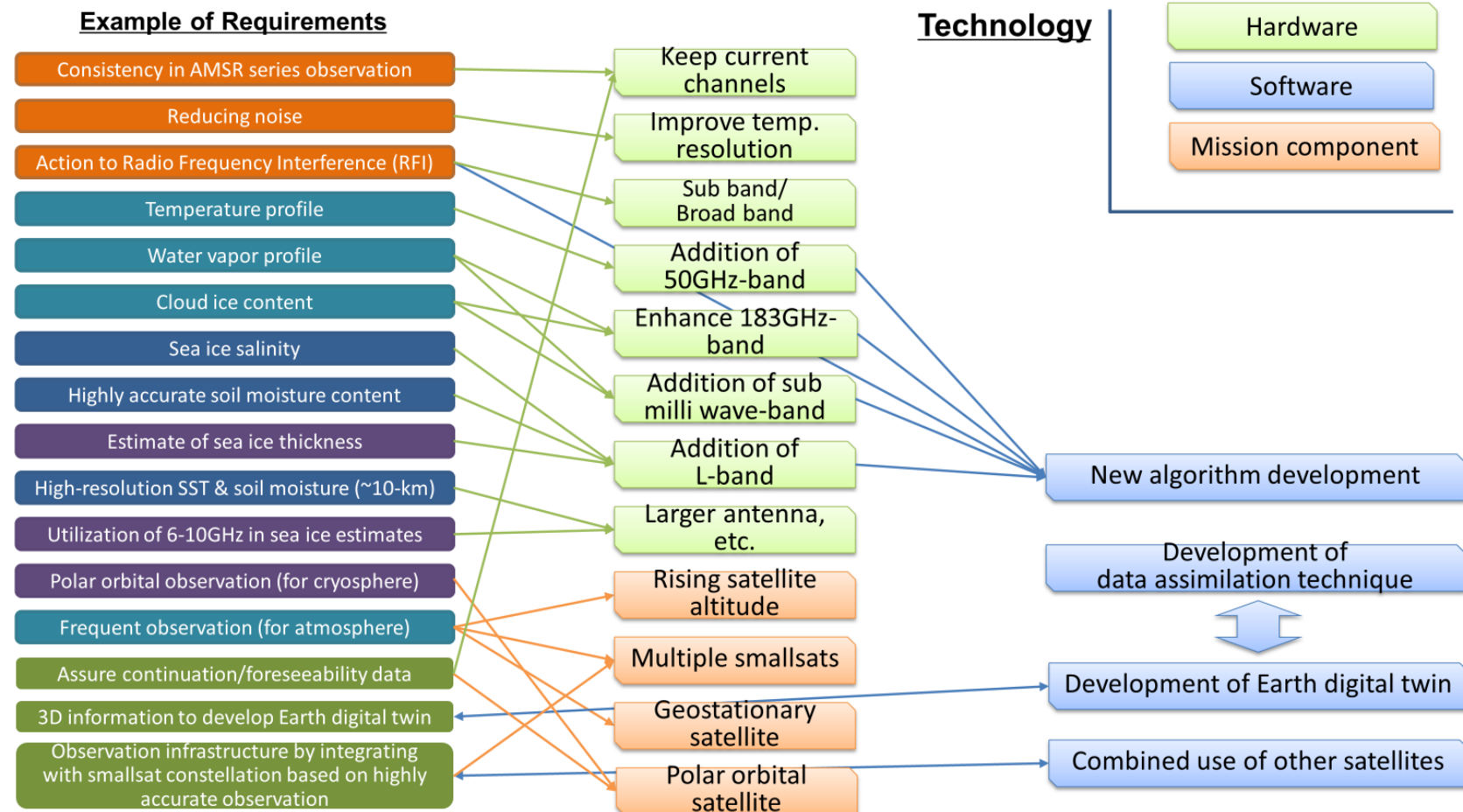
- New capability in AMSR Viewer, web visualization tool, to display 5-day mean, half-monthly & monthly (<https://www.eorc.jaxa.jp/AMSR/viewer/>)
- AMSR Viewer for polar region is in preparation





AMSR3 Follow-On Discussions Ongoing

- Discussions on AMSR3 follow-on mission started since Mar. 2021
 - AMSR user committee (domestic) & science team (international) for requirements
 - JAXA internal studies for HW feasibility
 - Iteration among science users, stakeholders, and engineers
- Current requirements
 - Continuation of AMSR3 capability
 - New requirements that need hardware upgrade and/or development of new component
 - New requirements that need software development





Summary

- AMSR series -- A series of Japanese passive microwave radiometers with the world best capability: AMSR/AMSR-E, AMSR2, and AMSR3 (<https://www.eorc.jaxa.jp/AMSR/>)
- GCOM-W/AMSR2
 - AMSR2 and GCOM-W achieved 12-year observations and are in good conditions
 - Update of standard products toward AMSR2
 - Development/release of new research products -- Soil Moisture Content & Vegetation Water Content by Land Data Assimilation, and Thin Ice Thickness (Thermal Ice Thickness) in Mar. 2024
 - Captured globally high SST conditions since Mar. 2023 and minimum sea ice extent in the Antarctic ocean in 2023
- GOSAT-GW/AMSR3
 - AMSR3 - Additional G-band (166 & 183 GHz) to enable monitoring of global precipitation (rain & snow) and contribute to water vapor analysis in NWP, and additional 10.25 GHz channels with improved NEDT for robust SST with higher spatial resolution
 - Manufacturing and testing of component flight model are ongoing. Manufacturing of AMSR3 receiver, antenna, G-band antenna subsystem, calibration units were manufactured.
 - **Launch of GOSAT-GW satellite is scheduled in JFY2024**
 - Product will be released to the public about one year after the launch. Early data access will be available to the selected PIs by the research announcement (RA) and partner agencies during CAL/VAL phase.
 - 4th JAXA Earth Observation Research Announcement (EORA4, JFY2025-2027) for JAXA's EO missions including AMSR3 & GCOM-W has been issued on Jul. 1, 2024 (deadline: 03Z on Aug. 21, 2024).
- AMSR3 F/O Discussions -- Ongoing with requirements from domestic & international users and internal studies on hardware feasibility by JAXA