JAXA Earth Observation Overview

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AOMSUC-12@Online, Nov. 15, 2022

Technological Development and Future Prospects in EO: JAXA's EO Achievements and Future Prospects

①Challenging R&D and Demonstration

- Promote risk-taking and cutting-edge R&D.
- Work on R&D and demonstration for challenging technologies that would open possibilities for acquiring new satellite technologies.
- For Future Earth Observation, it is important to strengthen 4D information in order to predict disasters and climate changes which are becoming more frequent and severe, thereby leading to practical countermeasures.

②Co-creation with Private Sector in addition to existing collaboration between academia and government

- Establish a new system of satellite development and utilization with future needs and the utilization (exit) of such achievements.
- Effective use of small/micro satellites as well as large ones is important. We will put more effort into co-creation with private companies in cooperation with Co-Creation program and Innovation programs.

③Building and maintaining Earth Observation satellite systems as a social infrastructure

- Organically link individual missions of Earth Observation, as a comprehensive system (System of systems), aiming to contribute to important issues that Japan should address, such as social infrastructure, monitoring climate changes, disaster prevention/reduction, national security, industrial development, and science.

Japanese Earth Observation Satellites/Sensors

Targets (JFY: Apr-Mar)

2014 2015 2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

Disasters Management & Land Monitoring

JERS1/OPS, SAR (1992-1998)
ADEOS-I/AVNIR
ALOS/AVNIR2, PALSAR (2006-2011)

[Land and disaster monitoring]
ALOS-2 / PALSAR-2
[Land and disaster monitoring]
ALOS-4/Advanced SAR
[Land and disaster monitoring]
ALOS-3/Advanced Optical

Climate System

•Climate change

ADEOS-I/OCTS (1996-1997)
ADEOS-II/GLI (2003)

[Vegetation, aerosol, cloud, SST, ocean color]
GCOM-C / SGLI
[Cloud and aerosol 3D structure]
EarthCARE / CPR
with ESA

•Water Cycle

ADEOS-II/AMSR (2003)
Aqua/AMSR-E (2002-2011)

TRMM / PR
[Precipitation 3D structure]
ACCP Pre-phase A
PMM(TBD) Phase A
with NASA
GPM / DPR
with NASA
[Wind, SST , water vapor, rainfall]
GCOM-W / AMSR2
[Wind, SST , water vapor, precipitation]
GOSAT-GW/AMSR3
GOSAT-GW/TANSO-3
[CO_2, CH_4, NO_2] *MOE*

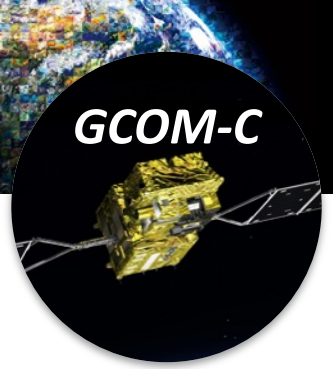
•Greenhouse gases

[CO_2, CH_4]
GOSAT / FTS, CAI
with MOE
[CO_2, CH_4, CO]
with MOE
GOSAT-2

JMA geostationary meteorological satellites

MTSAT-1R
(Himawari-6)
Himawari-10/11 planning
MTSAT-2 (Himawari-7)
[Cloud, aerosol, SST]
Himawari-8
Himawari-8 (standby)
Himawari-9 (standby)
Himawari-9

Mission status: Completed | On orbit | Development | Pre-phase-A | Phase-A



Climate Monitoring by GCOM-C

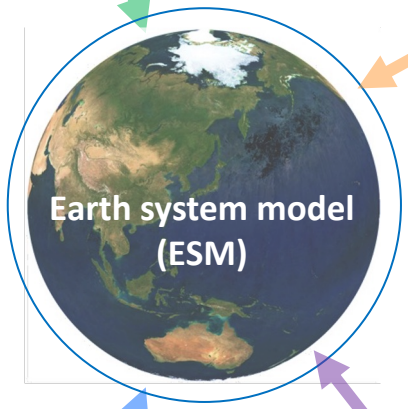
Global Change Observation Mission - Climate (GCOM-C)

- ✓ **250-m resolution**, 19 channels in **NUV**-TIR including 2-ch **polarization** with 1150-1400km swath
- ✓ **Version 3 products released Nov. 2021: https://gportal.jaxa.jp/gpr/**
- ✓ Research products (land cover, albedo, primary production, evapotranspiration, shortwave and longwave radiation, etc.) are under development
- ✓ GCOM-C has been operated about 5 years since Jan. 1, 2018, and expected to continue for more long-term observation

Global ecosystem change

Land vegetation ,Leaf area index
Land surface temperature,
BRDF reflectance, Land cover, …

Atmosphere
aerosol and clouds,
shortwave and longwave radiation…

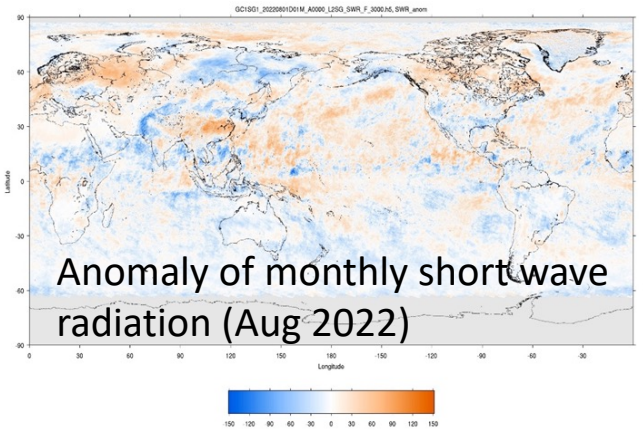


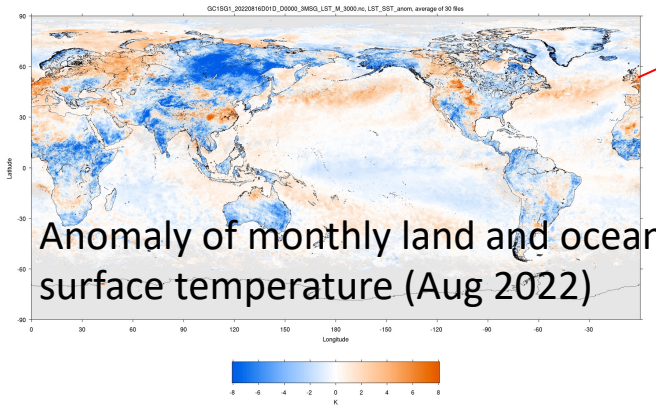
Model-observation comparison
→ Improvement of the ESM
→ Improvement of future prediction

Collaboration with
JAMSTEC, Tokyo Univ.

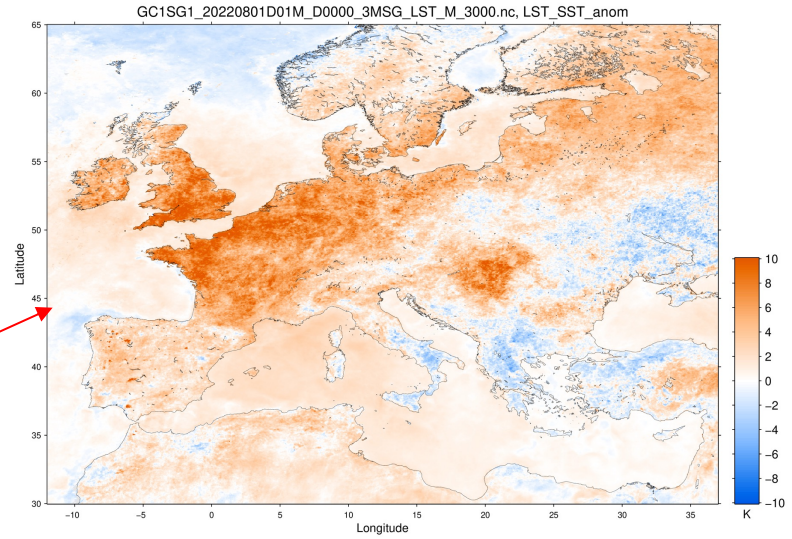
Ocean Chlorophyll-a
Total suspended matter
Sea surface temperature,
…

Snow Ice distribution
Snow properties,
albedo, …



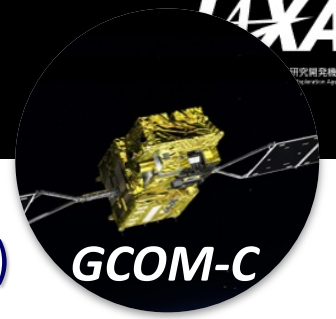


- ✓ Anomaly map is produced by GCOM-C/SGLI by merging with other sensors (examples with MODIS are below

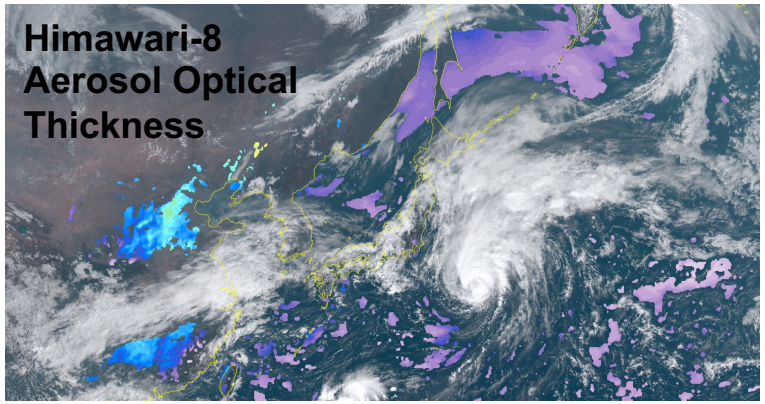


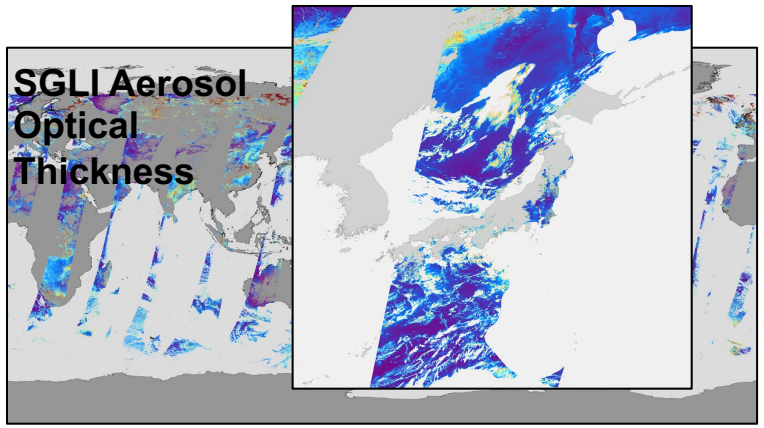
Large land surface temperature anomaly in Europe in Aug 2022

Synergy between GEO and LEO Satellites



- JAXA distributes Himawari Level 1 data and JAXA-produced geophysical products (SST, ocean color, aerosol, etc.) in near-real-time (http://www.eorc.jaxa.jp/ptree/) by applying algorithms developed for GCOM-C/SGLI to Himawari data.
- The algorithm codes (SST and aerosol) are provided to JMA for their operational utilization.

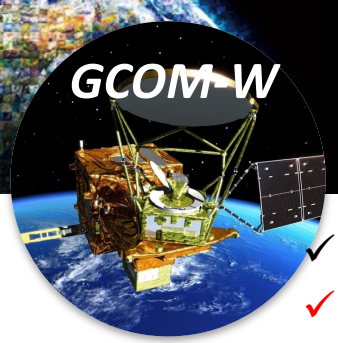




2022/9/28 10:00JST around Japan

Products distributed from the JAXA Himawari Monitor

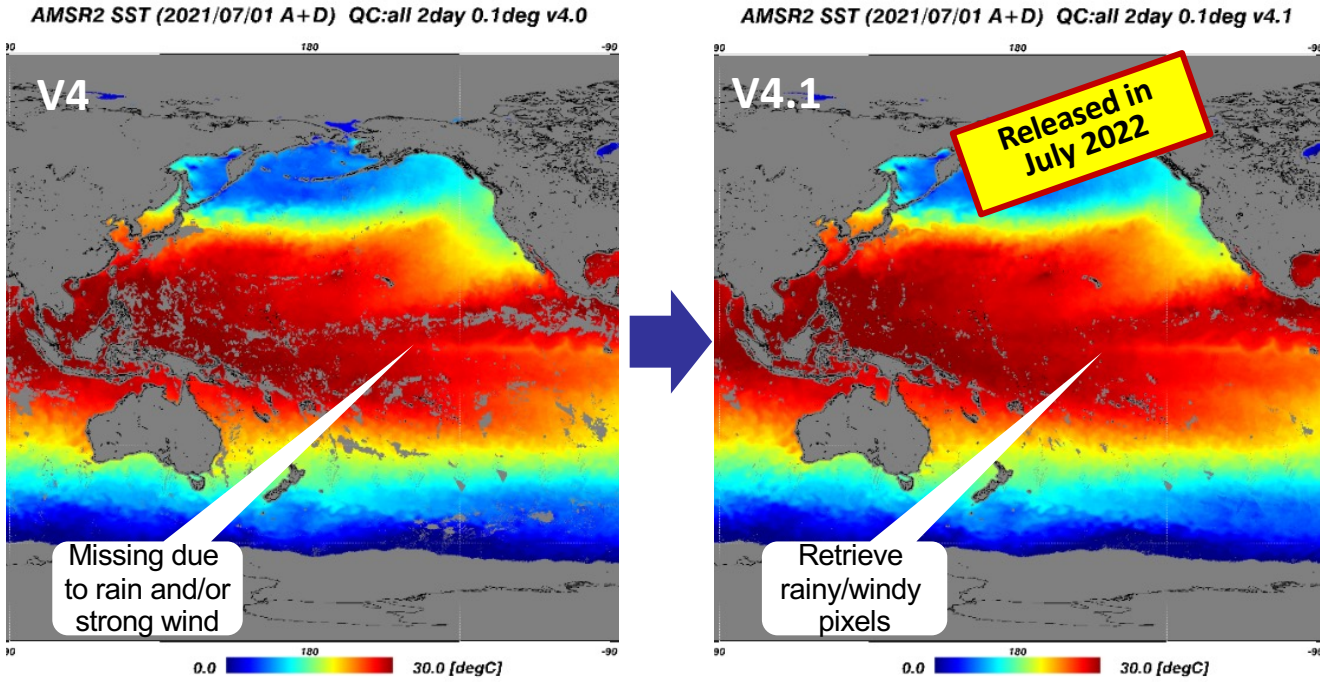
Satellite Product	Notes
Himawari HSD (L1)	Original format data provided by JMA
Himawari L1 grid data	L1 re-gridded by JAXA and provided as NetCDF format
Aerosol property	Applying algorithm for GCOM-C/SGLI and providing code to JMA
Cloud property	Applying algorithm for GCOM-C/SGLI
SST	Applying algorithm for GCOM-C/SGLI and providing code to JMA
Chrolopyll-a concentration	Applying algorithm for GCOM-C/SGLI
Solar radiation/PAR	Applying algorithm for GCOM-C/SGLI
Wild fire	Applying algorithm for GCOM-C/SGLI
Model Product	**Notes**
Aerosol property	Assimilating satellite-based aerosol data (GEO and LEO) to aerosol model under collaboration with JMA-MRI and Kyushu Univ.
SST	Assimilating satellite-based SST data (GEO and LEO) to ocean model under collaboration with JAMSTEC



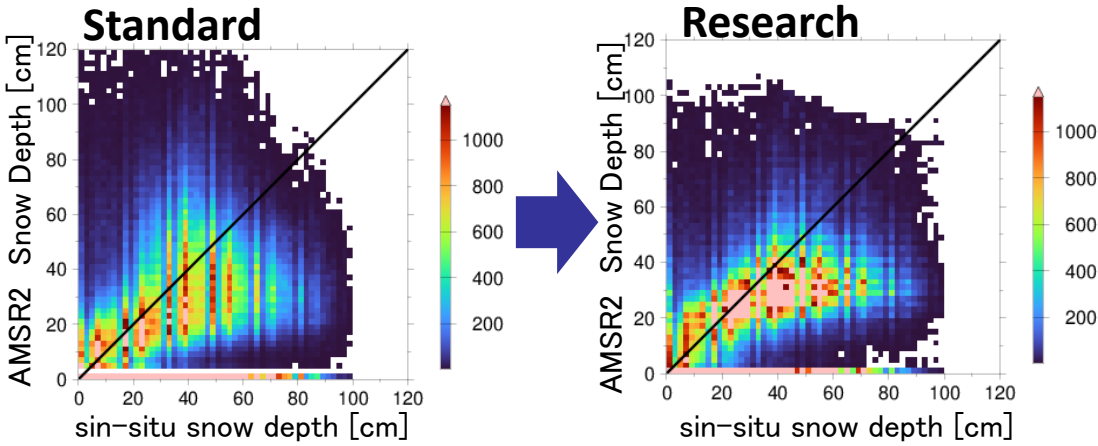
New GCOM-W/AMSR2 Products
Global Change Observation Mission - Water (GCOM-W)

- ✓ Start observation since Jul. 3, 2012
- ✓ **Sea Ice Motion Vector V1 in Mar. 2022**
- ✓ **SST V4.1 in Jul. 2022**
- ✓ **Improved Snow depth V3 & Soil Moisture Content as research product in Sep. 2022**
- ✓ **Precipitation V3 in Oct. 2022**
- ✓ **Standard product:** https://gportal.jaxa.jp/gpr/
- ✓ **Research product:** https://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist.html

AMSR2 SST Ver.4.1



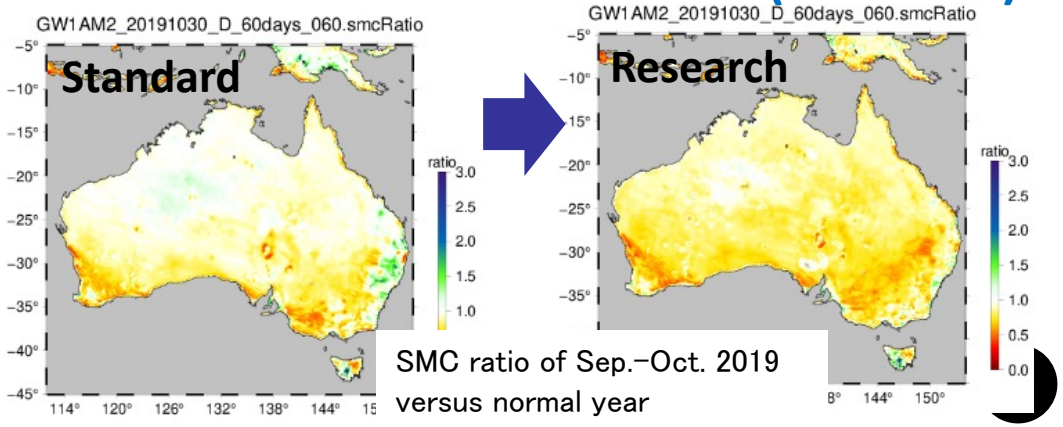
AMSR2 Snow Depth Ver.3 (Research)



Improved version of Snow Depth (SND) and Soil Moisture Content (SMC) products, which are developed for AMSR3 will be released to public as **research product.**

Released in September 2022

AMSR2 Soil Moisture Content (Research)



SMC ratio of Sep.–Oct. 2019 versus normal year

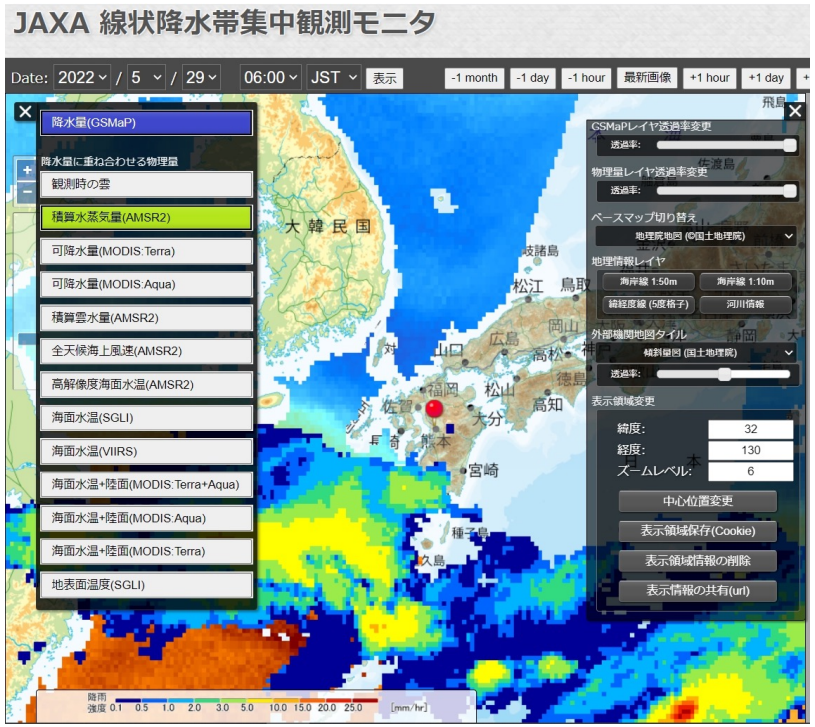
JAXA's Contribution to JMA's "senjo-kousuitai" database

- Meteorological Research Institute (MRI) in JMA conducted a joint field campaign during Jun.-Oct. 2022 for localized heavy rainfall in Japan, named as "senjo-kousuitai", with 14 research agencies & universities.
- JAXA has participated in this campaign and conducted ground-observations in Kumamoto and Nagasaki, and provided the JAXA satellite data and & the field campaign observation data to the JMA/MRI's "senjo-kousuitai" database.

JMA/MRI's "senjo-kousuitai" database

JAXA Satellite data & field campaign observation data

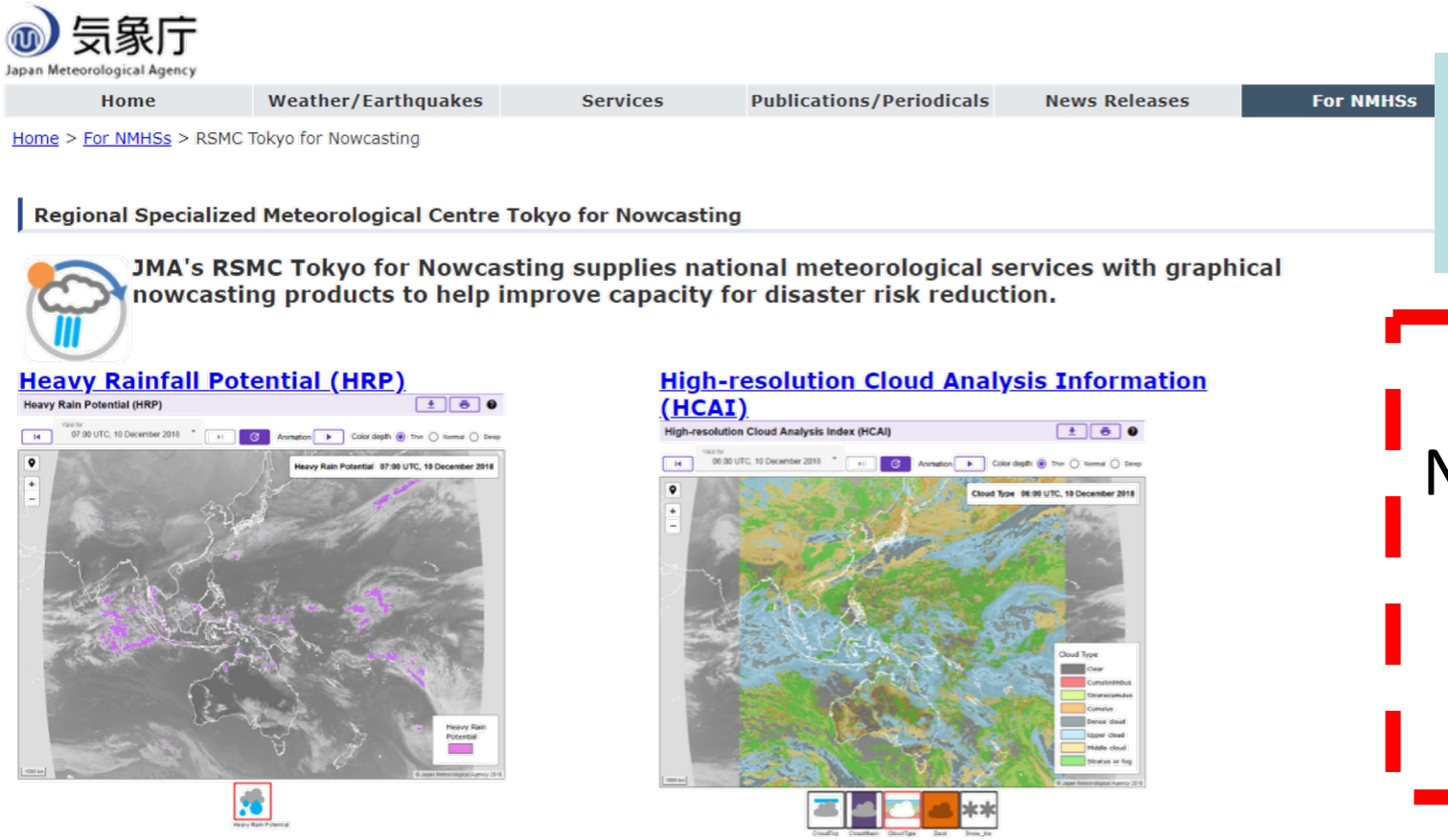
Quick-look images



Ground observations conducted by the JAXA in the Kumamoto Local Meteorological Office

Collaboration with JMA for the GSMaP utilization

- WMO's Regional Specialized Meteorological Centre Tokyo for Nowcasting (RSMC Tokyo for Nowcasting) operated by JMA supplies National Meteorological and Hydrological Services (NMHSs) with graphical nowcasting products to help improve capacity for disaster risk reduction.
- **JAXA and JMA** have been collaborating toward the utilization of **GSMaP data** in the issuance of warnings by NMHSs in Asia and Pacific region through the RSMC Tokyo for Nowcasting.

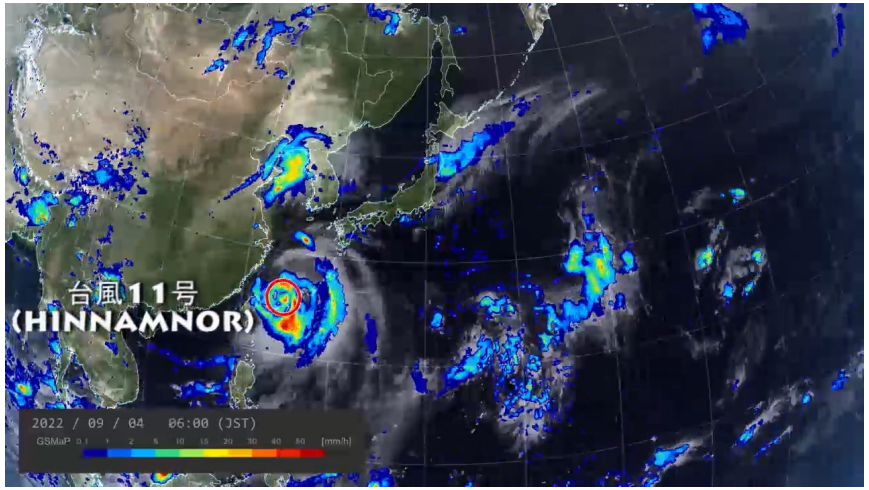


Top page of the JMA website "Regional Specialized Meteorological Centre Tokyo for Nowcasting"
https://www.jma.go.jp/jma/jma-eng/jma-center/nowcasting/

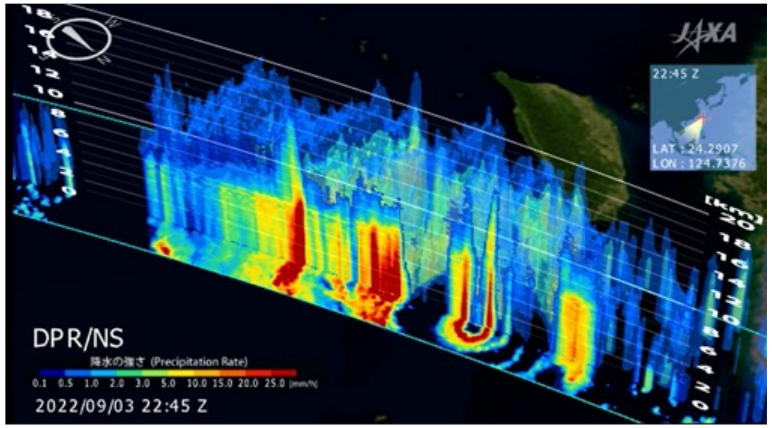
New product using JAXA GSMaP is expected!!

Typhoon No.11 in Sep. 2022 observed satellites and simulated by NEXRA model

GSMaP precipitation
28th Aug. – 7th Sep. 2022

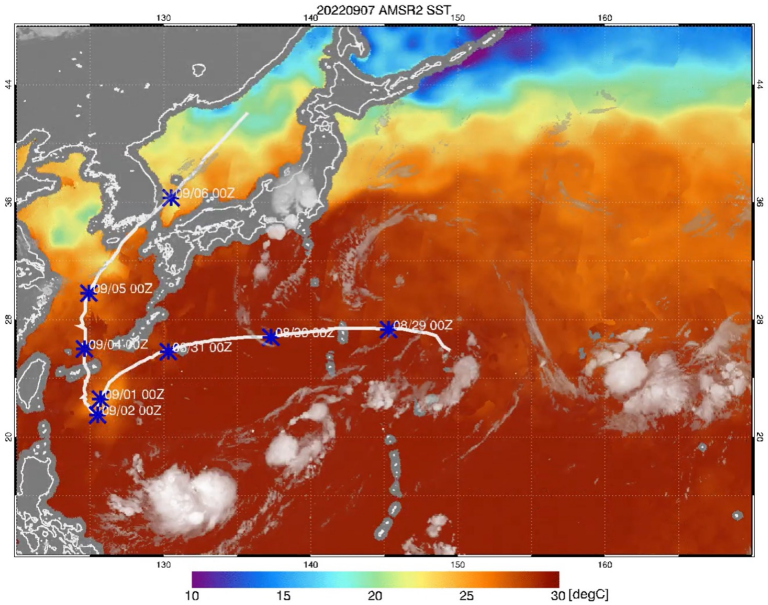


3-D precipitation of the typhoon by GPM/DPR in 3rd Sep.2022



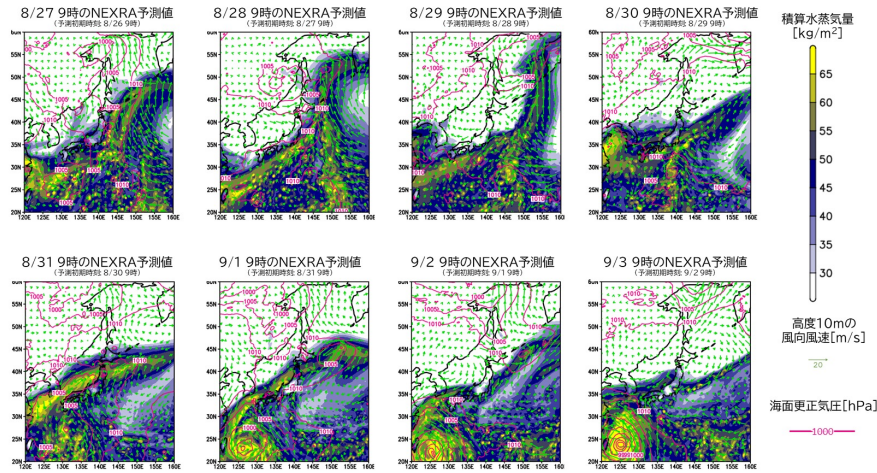
AMSR2 SST and Himawari-8 cloud in 7th Sep.2022

Ocean model with RIKEN-JAXA "LORA"



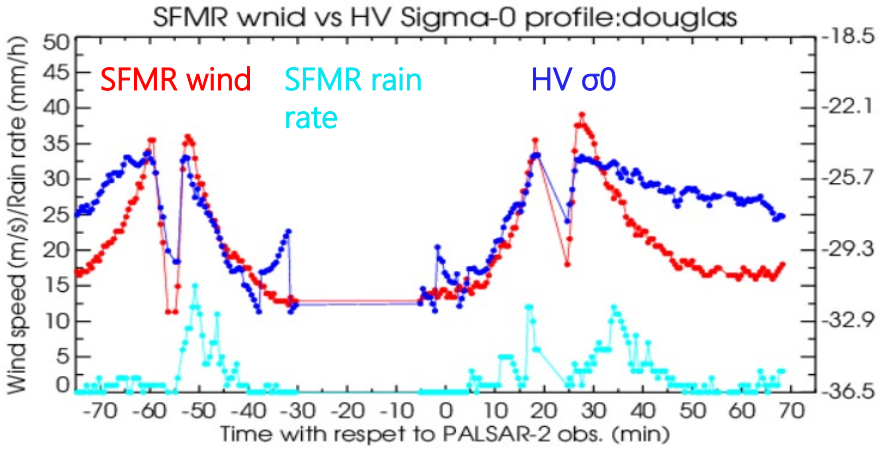
https://earth.jaxa.jp/ja/earthview/2022/10/21/7342/index.html

NEXRA: data assimilation system using the GSMaP at JAXA supercomputer system generation 3 (JSS3)

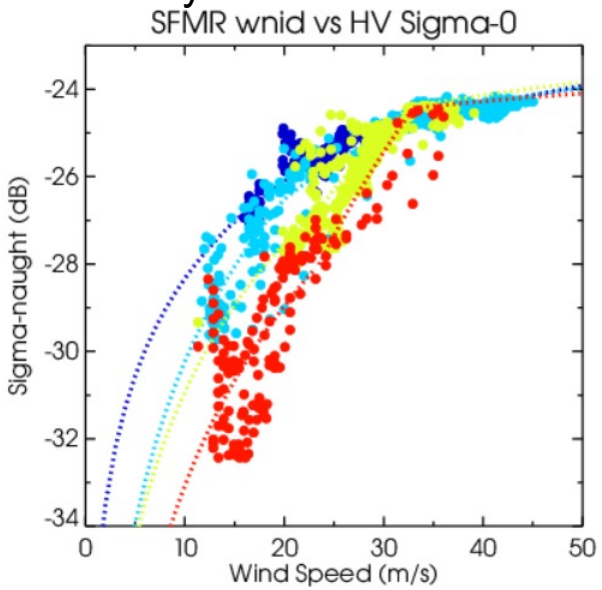


ALOS-2 Derived Surface Wind Speed of Cyclone "DOUGLAS" in July 2020

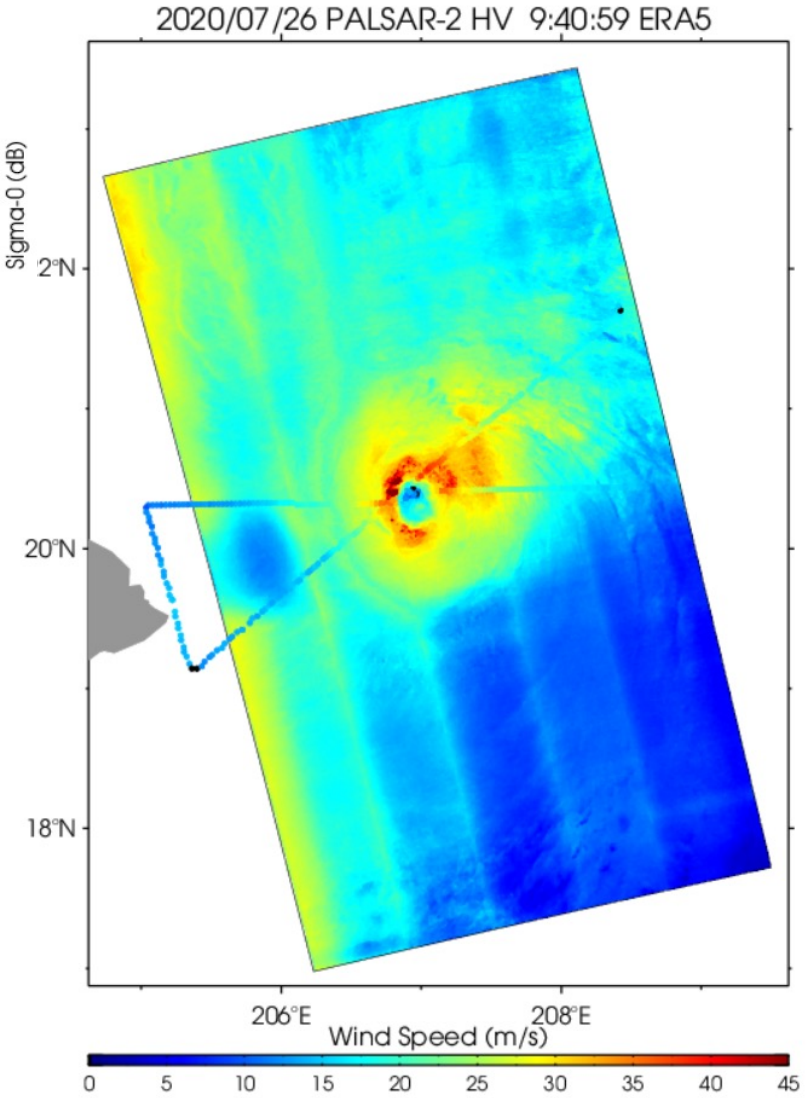
- The Sea Surface Wind (SSW) estimation under typhoon / tropical cyclone is essential to improve the forecasting.
- The emergency observations conducted several times in 2020.
- SFMR, the Airborne Passive Microwave Radiometer observations were used to develop model function collaboration with JMA-MRI.



Comparison between wind speed and rain rate derived by SFMR and PALSAR-2 σ^0.

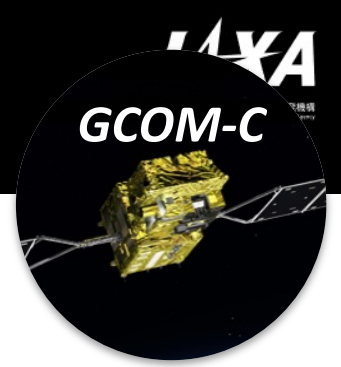


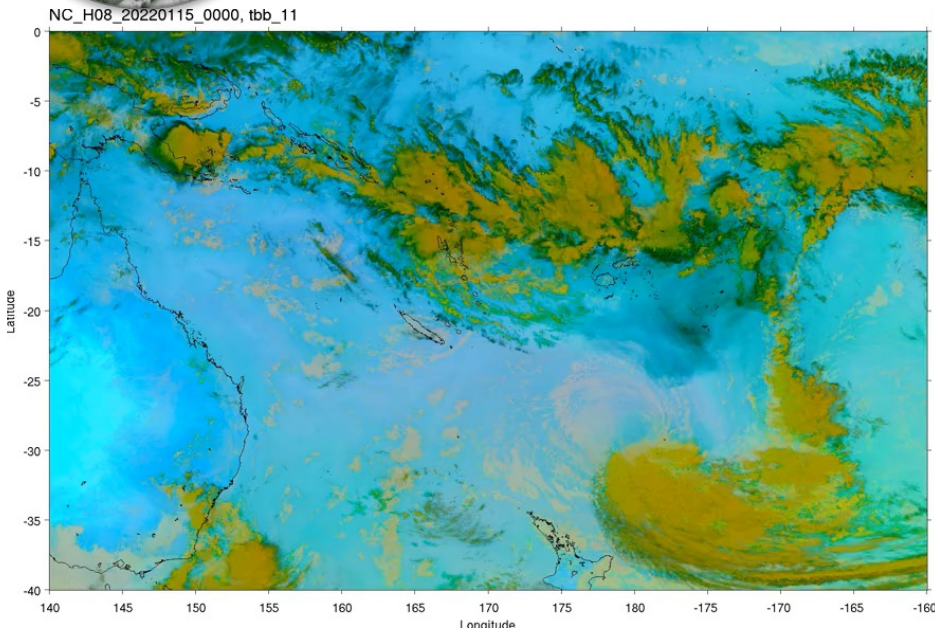
Updates of the model function (GMF).
DORIAN(2019/9/5), DOUGLAS(2020/7/26)



Estimated SSW by PALSAR-2/HV for DOUGLAS. Overlaid SFMR SSW

Eruption of submarine volcano in Tonga Jan. 2022



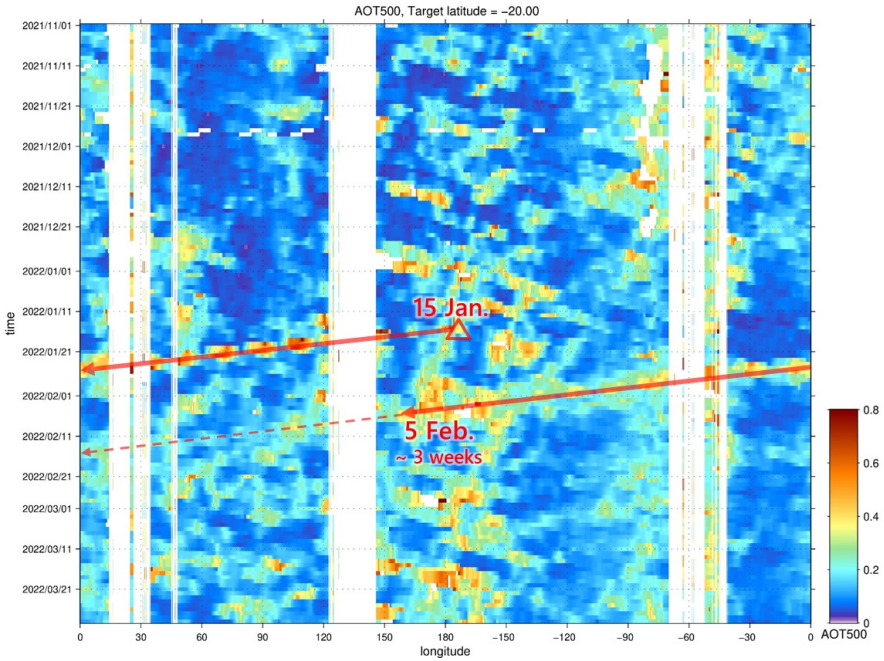


Movie of Himawari-9 AHI Ash RGB (using 8.6, 10, 11, 12μm) from Jan 15 to Jan 17.

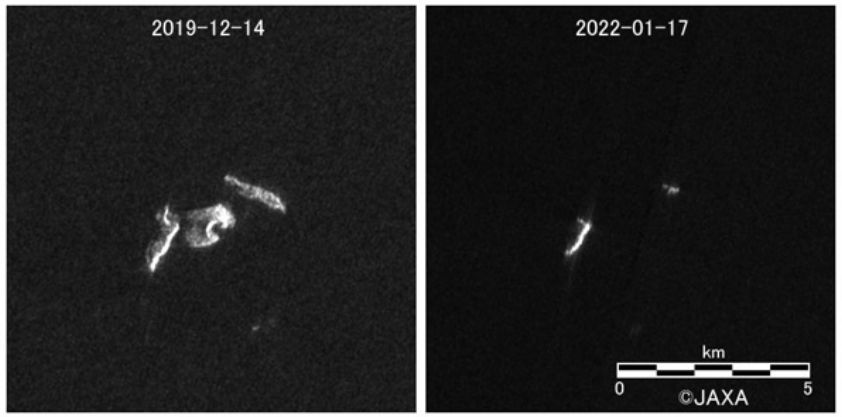
- Brown: cold, thick, high-level clouds
- Black: thin cirrus clouds
- Light green: SO_2 gas plume
- Red: volcanic ash
- Yellow: Mixed volcanic ash and SO2 gas plume

(JMA Himawari Ash RGB quick guide)

Zonal movement of the aerosol by GCOM-C/SGLI TOA reflectance at 1.38μm (water-vapor absorption band)



one around by about 3 weeks

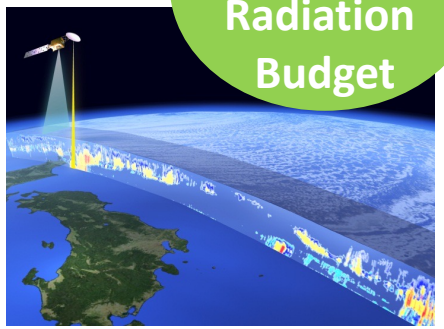


Change of the Hunga-Tonga-Hunga-Ha'apai volcano observed by ALOS-2 (Left) December 14, 2019, (Right) January 17, 2022 Most of the land, especially a volcanic vent existed nearly in the center of the image has disappeared by the eruption.

Future Missions for Climate & Water: EarthCARE (JFY2023)

To be launched in JFY2023

Cloud/ Aerosol Radiation Budget



- Europe-Japan joint mission
- 3 dimensional global distributions of cloud and aerosol to contribute to precise understanding of climate change
- JAXA and NICT provides world's first satellite-based cloud vertical motion by the Clod Profiling Radar (CPR) with 94 GHz with Doppler Capability at 0.8 km spatial resolution.

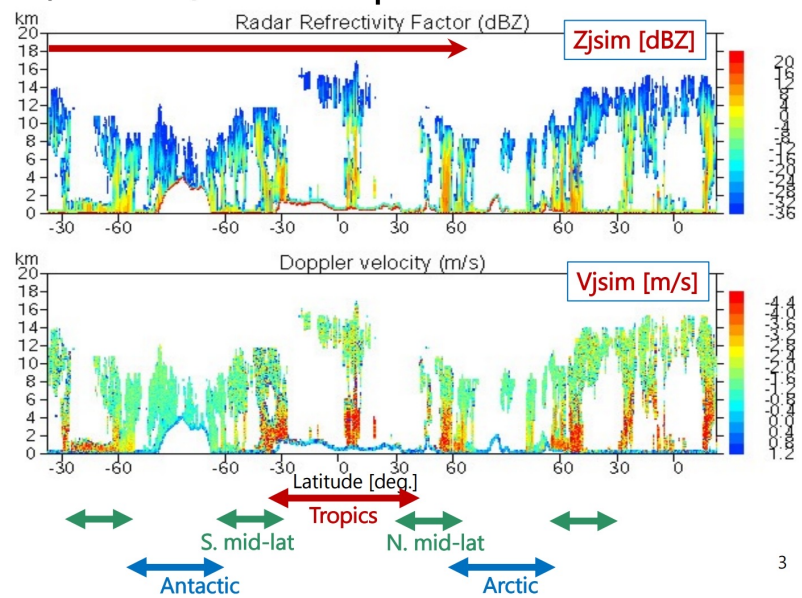
- Clouds continue to contribute the largest sources of uncertainty in current climate predictions.
- Measuring Doppler velocities from space is very challenging (Illingworth et al. 2015), but it is expected to advance climate modeling.

Orbit	Sun-synchronous sub-recurrent orbit Altitude: approx. 400km Inclination angle: 97.05° Local Sun Time at Desc.: 14:00 Revisit time: 25 days
Instruments	**- Cloud Profiling Radar (CPR)** by NICT & JAXA - Atmospheric Lidar (ATLID) by ESA - Multi-Spectral Imager (MSI) by ESA) - Broad-Band Radiometer (BBR) by ESA
Mass	Approx. 2.2 tons at launch
Designed lifetime	3 years

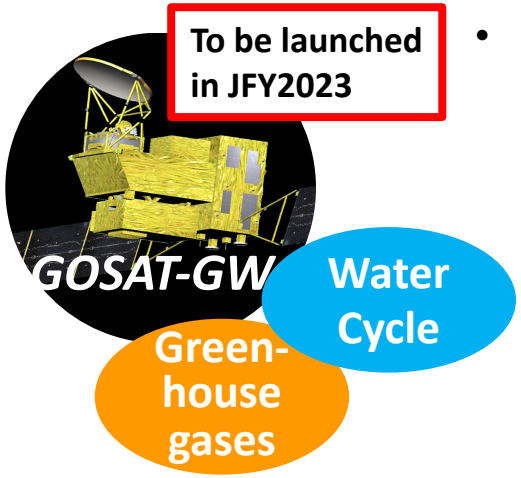
Doppler simulation of global clouds

✓ estimated the satellite-observed Doppler velocity by using a combined approach of global cloud resolving model "NICAM" and a satellite data simulator "Joint-Simulator" (Hagihara et al. 2022).

Data, NICAM/J-Sim output: 1st orbit



Future Missions for Climate & Water: GOSAT-GW (JFY2023)

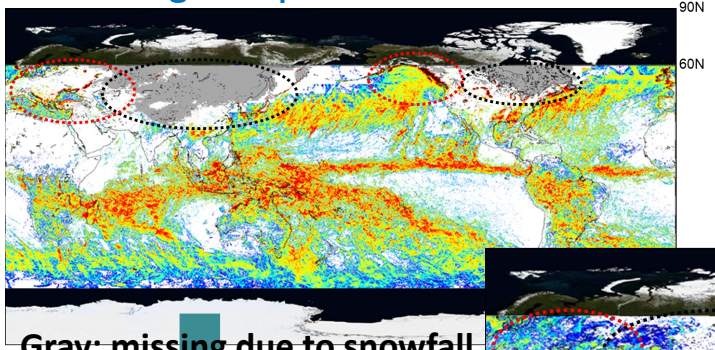


- Carrying two instruments, AMSR3 and TANSO-3.
  - AMSR3 (JAXA) will succeed AMSR series observations with adding new high frequency channels (166 & 183 GHz) for snowfall retrievals and water vapor analysis for numerical weather prediction.
  - TANSO-3 (led by Ministry of Environment in Japan) uses imaging spectrometer technology to measure CO2, CH4 and NO2 globally with medium and locally with high spatial resolution.

Orbit	Sun-synchronous sub-recurrent orbit Altitude: approx. 666km Inclination angle: 98.06° Local Sun Time at Desc.: 1:30 +/- 15 min Revisit time: 3 days
Instruments	**- Advanced Microwave Scanning Radiometer 3 (AMSR3)** **- Total Anthropogenic and Natural emissions mapping SpectrOmeter-3 (TANSO-3)** (for Ministry of Environment in Japan (MOE))
Mass	Approx. 2.6 tons at launch
Designed lifetime	**7 years**

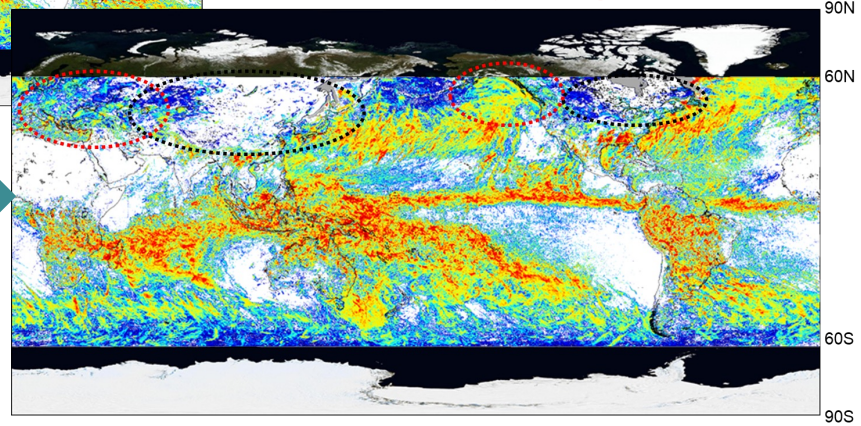
Impact of High-freq. channels to Precipitation retrievals

Without high-freq. channels



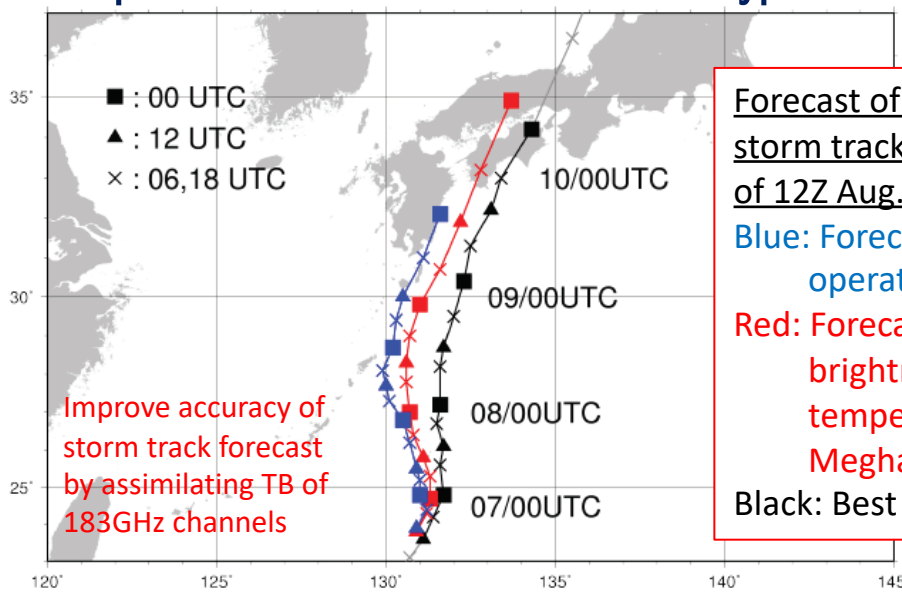
Gray: missing due to snowfall
White: No rainfall

With high-freq. channels



（Monthly GSMaP precipitation of Jan. 2015 using GMI)

Impact of 183 GHz channels to Typhoon forecast



Forecast of Typhoon #11 storm track with initial time of 12Z Aug. 6, 2014
Blue: Forecast by JMA operational system
Red: Forecast with 183 GHz brightness temperature by Megha-Tropiques
Black: Best track

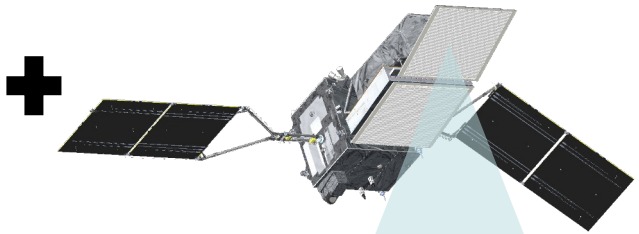
（Image provided by JMA）

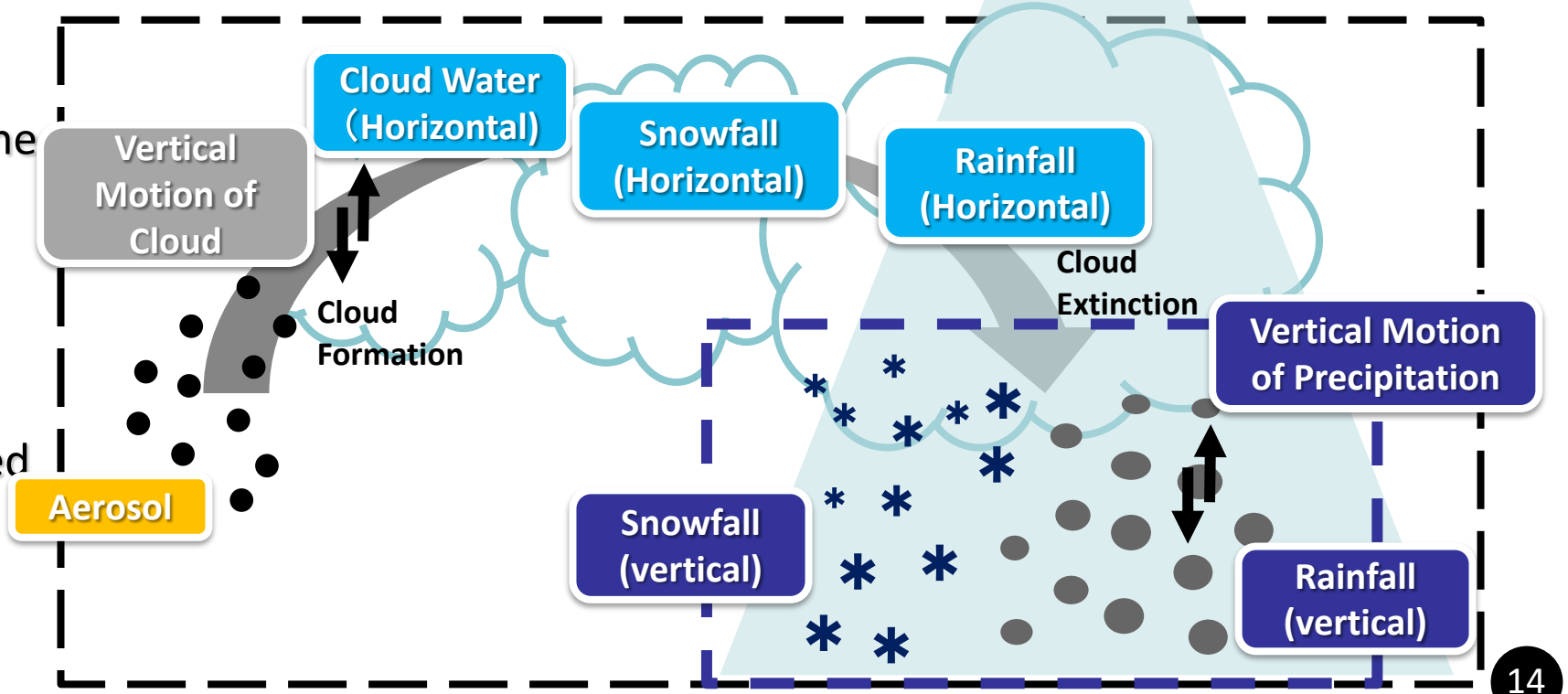
Future Missions for Climate & Water:
Precipitation Radar in Synergy with Aerosols and Cloud Science

- Japan's next precipitation radar satellite (PMM), carrying Ku-band Doppler precipitation radar (KuDPR), focuses on advanced observation of precipitation
  - Doppler velocity obs.
  - High sensitivity
- International collaboration with the NASA AOS mission will bring us integrated understanding of Aerosol~Cloud~Precipitation processes
- The mission value can be enhanced for improving weather/climate models by collaboration with the NASA AOS mission.

Atmosphere Observing System (AOS) Constellation by NASA, CSA, CNES

JAXA PMM





Summary

- JAXA Satellites/Sensors
  - Nominal Operation: GCOM-C, GOSAT-2
  - Extended Operation: GOSAT, GCOM-W, GPM/DPR, ALOS-2
  - Future: ALOS-3 (TBC), ALOS-4 (TBC), EarthCARE/CPR (JFY2023), and GOSAT-GW (JFY2023)
  - Phase A Study: Precipitation Measuring Mission (PMM) with Ku Doppler Radar
- Recent Topics
  - Typhoon No.11 in 2022
  - Eruption of submarine volcano in Tonga Jan. 2022
- Collaboration with JMA
  - JAXA to develop/operates EO satellites (R&D) and to provide outcomes (algorithm, data, scientific results, etc.) to JMA
  - Several joint research activities with JMA & JMA-MRI are underway