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JAXA Earth Observation Program and Data Product

JAXA operates various kind of satellite sensors and opens the products to the public. We keep developing and improving the products to address the climate issues.

The major updates since CGMS-49 is that the pre-project team of Precipitation Measuring Mission, following to the Global Precipitation Measurement (GPM) mission, was organized in JAXA in January 2022. JAXA would appreciate the supports by CGMS and IPWG.

In terms of the WMO project for monitoring extremes, JAXA contributes to the WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) Project by providing GSMaP rainfall product with climate normal. JAXA improved the algorithm in December 2021 (algorithm version 8), and currently reprocesses the past GSMaP dataset since 1998, and will re-calculate the climate normal again.

JAXA Earth Observation Program and Data Product

1 INTRODUCTION

Purpose of the paper is as follows;

1) to update the status of JAXA's Earth Observation satellite program and data product in operation and to be launched shown in Table 1 (Sections 2 and 3),
2) to introduce the contribution to WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) Project (Section 4), and
3) to report the status of the next generation Precipitation Radar discussed in JAXA, following to the TRMM/PR and the GPM/DPR (Section 5).

Table 1. Line-up of the JAXA Earth Observation Satellites and Sensors

Satellites and/or Sensors		Launch (UTC)
In operation		
GOSAT***	Greenhouse gases Observing SATellite	23 Jan. 2009
GCOM-W	Global Change Observation Mission -Water	17 May 2012
GPM/DPR*	Dual-Frequency Precipitation Radar onboard the Global Precipitation Measurement Mission Core Observatory	27 Feb. 2014
ALOS-2	Advanced Land Observing Satellite-2	24 May 2014
GCOM-C	Global Change Observation Mission - Climate	23 Dec. 2017
GOSAT-2***	Greenhouse gases Observing SATellite-2	29 Oct. 2018
To be launched		
ALOS-3	Advanced Land Observing Satellite-3	TBD
ALOS-4	Advanced Land Observing Satellite-4	TBD
EarthCARE/CPR**	Cloud Profiling Radar onboard the Earth Cloud, Aerosol and Radiation Explorer	JFY 2023 (Planned)
GOSAT-GW***	Global Observing SATellite for Greenhouse gases and Water cycle	JFY2023 (Planned)
ISS/MOLI	Multi-footprint Observation Lidar and Imager (MOLI) installed in the Exposed Facility of the Japanese Experiment Module (JEM) of the International Space Station (ISS)	JFY2024 (As target)

* Joint mission with NASA
** Joint mission with ESA
*** Joint with the Ministry of the Environment (MOE) in Japan and National Institute of Environment Study (NIES).

2 CURRENT SATELLITE MISSIONS AND PRODUCTS

The GOSAT data since 2009 has been distributed through the GOSAT Data Archive Service (GDAS; https://data2.gosat.nies.go.jp/index_en.html). GOSAT-2 was launched in October 2018 and has been in normal operation since February 2019. Simultaneously-observed GOSAT and GOSAT-2 data have been inter-compared. The level-1B product of calibrated radiance spectra have been released since July 2019. Their research products are available at the JAXA GOSAT EORC site (https://www.eorc.jaxa.jp/GOSAT/index.html).

GCOM-W is operating normally, and all Advanced Microwave Scanning Radiometer 2 (AMSR2) standard products, including near-real-time products, are freely available via the JAXA G-Portal system (https://gportal.jaxa.jp/gpr/). In addition, some research products, including high-resolution sea ice concentration and sea ice motion vector over Northern Hemisphere, have been distributed through the GCOM-W Research Product Distribution Service (https://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist.html). AMSR2 Sea Surface Temperature (SST) Ver.4.1 and Precipitation Ver.3 standard products will be released to public in early summer 2022. For better continuity between AMSR2 and AMSR-E on EOS Aqua satellite, JAXA also provides the reprocessed AMSR-E products applying the latest AMSR2 algorithms at the G-Portal system. A new web site, which integrates information regarding all AMSR series, AMSR, AMSR-E, AMSR2 and future AMSR3, has been launched in November 2021 ().

GCOM-C carrying Second-generation Global Imager (SGLI) is operating since December 2017. SGLI has 250-m resolution channels from near-UV (380 nm) to thermal infrared (12 um) wavelengths, and 1-km polarization channels in red and near infrared wavelengths. The standard products about cloud, aerosol, snow/ice, surface temperature, vegetation, and ocean colour from SGLI has been open to the public (the first version products since December 2018, and revised as Ver.3 since November 2021.) via JAXA G-Portal system and JAXA JASMES web page (https://www.eorc.jaxa.jp/JASMES/SGLI_STD).

ALOS-2 was launched on May 24, 2014, and it is currently operating very well even more than its designed mission life of five years and the target of seven years since launching the satellite. The mission objectives are as follows;

1) Disaster monitoring of damage areas, both in considerable detail, and when these areas may be large,
2) continuous updating of data archives related to national land and infrastructure information,
3) effective monitoring of cultivated areas, and
4) global forest monitoring in support of carbon cycle science.

To achieve its missions, ALOS-2 carries the Phased Array type L-band Synthetic Aperture Radar-2 (PALSAR-2), which is an active microwave SAR instrument using the 1.2 GHz frequency known as L-band. Compared to the PALSAR instrument onboard its predecessor ALOS satellite, the PALSAR-2 instrument has enhanced features (e.g. finer spatial resolution, spotlight mode, dual-polarisation ScanSAR).
The standard product of ALOS-2 is delivered in commercial bases, but the high-level product and the research dataset i.e., annual global mosaics and the forest/non-forest

classification maps are distributed from JAXA EORC website free of charge (https://www.eorc.jaxa.jp/ALOS/en/index_e.htm).

GPM/DPR product is available from JAXA G-Portal system (https://gportal.jaxa.jp/gpr/). For better continuity between GPM and the Tropical rainfall Measurement Mission (TRMM) whose operation had been terminated after its 17 years long service, level 1 calibration factors for both Precipitation Radar (PR) onboard TRMM and GPM/DPR have been communized since 2017.

After the nominal mission operation phase of GPM mission, the scan pattern of the DPR has been changed since 21 May 2018. The new standard product applied to the new scan pattern was released as Version 07 in December 2021. The long-term TRMM/GPM level-2/3 product with common algorithm (Version 07) and data format is currently being reprocessed, and will be distributed via G-Portal system.

As the applications of the GPM/DPR, the Japan Meteorological Agency (JMA) has assimilated the DPR data in the meso-NWP system since March 2016.

In addition to the above product, some multi-satellite products are open to the public. Under the GPM mission, Global Satellite Mapping of Precipitation (GSMaP) has been developed and provided via JAXA G-Portal and JAXA/EORC website (https://sharaku.eorc.jaxa.jp/GSMaP/index.htm). The GSMaP is basically generated by using GPM constellation satellites, including GCOM-W/AMSR2, and is available since March 2000. It has some types for user purposes including real-time version, gauge-adjusted version, and so on. The GSMaP products are validated by in-situ observation in worldwide under collaboration with the WMO-CGMS International Precipitation Working Group (IPWG).

JAXA improved the algorithm in December 2021 (algorithm version 8). Currently, we are reprocessing the past GSMaP dataset since 1998, and will distribute the dataset to the public.

The GSMaP near-real-time gauge-adjusted version 6 has been used in the WMO SWCEM project; details are described in Section 4.

JAXA has also developed the geophysical retrieval algorithms for the geostationary satellite “Himawari-8”, which is operated by the JMA, in an attempt to seek synergies between Himawari and JAXA’s Earth observation satellites, especially with GCOM-C. We have distributed browse images, geophysical data products (SST, cloud, aerosol properties, wildfire, chlorophyll-a concentration, and surface shortwave radiation), and model assimilated data (aerosol properties and SST) from the Himawari and other satellite data through the JAXA Himawari Monitor and P-Tree system (https://www.eorc.jaxa.jp/ptree). Several algorithms developed for GCOM-C was applied to Himawari data to produce consistent dataset, taking the opportunity of both satellites loading a multispectral imaging sensor.

3 MISSIONS AND PRODUCTS IN NEAR FUTURE

ALOS-3 was originally planned to be launched in JFY2021, however, it is currently waiting for the development of the launch vehicle called H3, which is newly developing

as the main transportation by JAXA. ALOS-3 is the next high-resolution optical mission as a successor to the optical mission of ALOS and is now under testing the flight model. The missions of ALOS-3 are (a) to contribute safe and secure society including provisions for natural disasters, and (b) to create and update geospatial information. The wide-swath and high-resolution optical imager (WISH) is designed to achieve the mission objectives, which consist of the panchromatic band and multispectral bands by six channels. The panchromatic band has 0.8 m of the Ground Sampling Distance (GSD) and the multispectral band 3.2 m (GSD), and the observation swath width is 70 km at nadir.

ALOS-4 is also waiting the H3 launcher, and it is a follow-on mission of ALOS-2, and will observe the Earth's surface using its onboard the Phased Array type L-band Synthetic Aperture Radar-3 (PALSAR-3). The data will be utilized for monitoring disaster, forest, sea ice, infrastructure, and many other applications with the advantages of Synthetic Aperture Radar (SAR) such as all-weather and day-and-night observation capability. With further improved observation performance compared to the predecessor PALSAR-2 aboard ALOS-2, the satellite aims at achieving both high resolution and a wider observation swath.

EarthCARE will be launched in JFY2023, which observes clouds, aerosols, and radiation on a global scale to improve the accuracy of climate change predictions. JAXA is developing the CPR on the EarthCARE, which will be the world's first W-band (94GHz) Doppler radar aboard a satellite.

GOSAT-GW, joint mission of GOSAT-2 follow-on (TANSO-3) and GCOM-W/AMSR2 follow-on (AMSR3) has been in development phase (Phase-B) since December 2019. TANSO-3 will be the mission of Ministry of the Environment in Japan (MOE) and National Institute of Environment Study (NIES). Orbit of the joint satellite will be 666 km altitude (same as GOSAT) and 13:30 Local Time in Ascending node (same as GCOM-W). Sensor specification of the AMSR3 is almost equivalent to AMSR2 with some additional channels. New high frequency channels of 165.5 GHz, 183.31+-3 GHz, and 183.31+-7 GHz V-polarization are available in AMSR3 for snowfall retrievals and water vapor analysis in numerical weather prediction in meteorological agencies. Also, additional 10.25 GHz V- and H-polarization channels with wider band width and improved NEDT will be added to current 10.65 GHz channels to improve robustness of higher resolution SST retrievals especially for fisheries. To prepare future considerable impacts by 5G communication, center frequency and band width of 36.5 GHz channels are slightly modified from those of AMSR2. TANSO-3 uses imaging spectrometer technology to measure CO2, CH4 and NO2 globally with medium and locally with high spatial resolution. GOSAT-GW is scheduled to be launched in JFY2023.

The Multi-footprint Observation LiDAR and Imager (MOLI) will be installed in the Exposed Facility of the Japanese Experiment Module (JEM) "Kibo" of the International Space Station (ISS). It has two sensors: LiDAR and imager. When we estimate the forest canopy height or Above Ground Biomass (AGB) from the space-borne LiDAR waveform, a pulse broadening effect by ground slope affects the estimation accuracy significantly. However, MOLI can calculate the ground slope angle by comparing measured values of ground elevation between adjacent footprints, and it can be used

to correct the pulse broadening effect. This function can be expected to contribute to the improvement of the estimation accuracy of the canopy height and AGB. In addition, the imager makes us possible to understand forest conditions around the footprint by shooting at the same time as LiDAR observation, although it has a narrow observation swath. MOLI is currently targeted to be launched in JFY2024.

4 CONTRIBUTIONS TO WMO SPACE-BASED WEATHER AND CLIMATE EXTREMES MONITORING (SWCEM)

JAXA has participated in the WMO SWCEM by providing the GSMaP Near-real-time Gauge-adjusted Rainfall Product (GNRT6). Based upon experiences in the SWCEM, JAXA started to operate a website “JAXA Climate Rainfall Watch”, which provides information about extreme heavy rainfall and drought over the world using the GNRT6.

Recently Tashima et al. (2020*) summarized the usefulness of precipitation extremes monitoring in the East Asia and Western Pacific region using the GNRT6. In the paper, the drought in mainland Southeast Asia in March-May 2019 was examined.

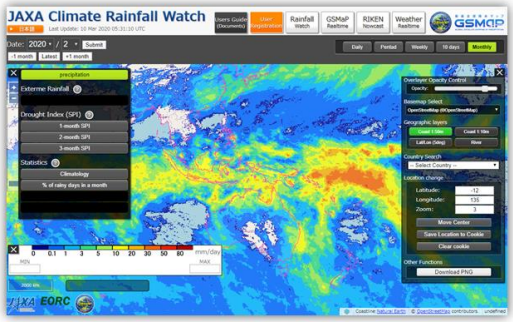

Fig. 1 Graphical User Interface of the "JAXA Climate Rainfall Watch" website (https://sharaku.eorc.jaxa.jp/GSMaP_CLM/)

According to the Analytical Report published by Global Drought Observatories (GDO), from the beginning of the wet season in mainland Southeast Asia in 2019, a short and intense dry spell hit a large area across Laos, southern China, Myanmar, and Thailand, including the upper Mekong basin. In particular, the region of Yunnan in China was heavily affected by the drought. The river Mekong is the main freshwater body in the region, but the extreme drought over upstream Chinese provinces had contributed to very low water levels on record.

Corresponding to this GDO’s report, the three-month SPI from March to May 2019 derived from GNRT6 was below -1.5 (i.e. “extreme or exceptional drought”) over Laos, southern China, Myanmar, and Thailand.

Comparison of the GNRT6 with those from Gauge-Based Analysis of Global Daily

* Tashima, T., T. Kubota, T. Mega, and T. Ushio, and Riko Oki, 2020: Precipitation extremes monitoring using the near-real-time GSMaP product, *IEEE J. Sel. Topics Appl. Earth Observ. Remote Sens.* https://doi.org/10.1109/JSTARS.2020.3014881.

Precipitation provided by the NOAA CPC (CPC GAG) was performed, and it was found that discrepancies between them were noticeable in Myanmar (which had dry conditions), with dry conditions in the GNRT6 and wet conditions in the CPC GAG. Because there were no available gauges at Myanmar in the CPC GAG, the quantitative reliability of the CPC GAG was low there. This clearly demonstrates the value of space-based rainfall estimates for drought detection and monitoring, especially for regions where rain gauge observations are limited or unavailable.

As one of cooperation activities of the SWCEM, JAXA extended the data coverage 'eastward' for covering whole region of responsibility for the WMO Pacific RCC-Network, and update climate normal for 20 years in April 2020.

Furthermore, JAXA improved the algorithm in December 2021 (algorithm version 8), and currently reprocesses the past GSMaP dataset since 1998, and will re-calculate the climate normal again.

Through these efforts, the JAXA is contributing to precipitation extremes monitoring activities using satellite data in the WMO SWCEM.

5 NEXT GENERATION SPACEBORNE PRECIPITATION RADAR MISSION

JAXA has discussed the next generation precipitation radar mission with Japanese science team and user community since 2008. JAXA has large heritage of the TRMM/PR and GPM/DPR, and the data record of spaceborne precipitation radars is more than 20 years.

Recently Japan experiences extreme rain and flood event almost every year, so that monitoring and forecasting heavy rain is crucial for our lives. Against the background, continuous precipitation observations from TRMM/PR and GPM/DPR to the next generation precipitation radar is desirable from the applicational viewpoint as well as the scientific aspect including understanding of cloud-precipitation processes.

As discussed with Japanese science team and user community, JAXA raised three mission objectives for the next generation precipitation radar as follows;

1) Elucidation of global water cycle parameters and understanding of cloud-precipitation processes,
2) Contribution to enhancement of weather and disaster management,
3) Provision of long-term information on water resources infrastructure contributing to global-scale climate and water issues

On the U.S. side, NASA's Architecture Study had been conducted in response to the observations of Aerosol, Cloud, Convection and Precipitation (ACCP), which are the “designated” targeted observables defined in the 2017-2027 Decadal Survey for Earth Science and Applications from Space (ESAS 2017) by the National Academies.

The mission objectives discussed in Japan are quite synergetic to some of the Goals of the ACCP Study. Hence, JAXA has participated in NASA’s Atmosphere Observing System (AOS) Pre-Phase-A activities since June 2021, following to the ACCP Architecture Study from 2019 to 2021 in U.S.

JAXA Mission Definition Review (MDR) for the next generation Precipitation Radar satellite was completed in August 2021. The review board confirmed that the JAXA mission with a spacecraft carrying Ku-band Doppler radar is valuable as a successor of GPM/DPR.

In December 2021, Implementation Plan of the “Basic Plan on Space Policy” noting the Precipitation Radar Satellite Phase A activity was released from Cabinet Office of the Japanese government.

In January 2022, Precipitation Measuring Mission (PMM) Pre-Project Team was established on for the JAXA Spacecraft carrying the Ku-band Doppler Precipitation Radar. Currently, JAXA is conducting conceptual study, and the System Requirements Review (SRR) is now scheduled in June 2022.

Related Actions of CGMS

In the CGMS-48 in 2020, WG II recommended the item to the IPWG (***WGII/A48.13***) to review the operational utilizations of spaceborne precipitation radar and to submit a report regarding the necessity of the precipitation radar.

After the CGMS-49, the report titled “A review of the different operational applications of spaceborne precipitation radars within the IPWG community” was endorsed by CGMS members (***Plenary/A49.02***) and published via CGMS webpage. In addition, JAXA received a letter from CGMS (***Plenary/A49.03***) expressing the strong support for the continuity of precipitation radar measurements beyond GPM/DPR, as agreed in the CGMS-49 Plenary. The IPWG report was regarded as requirements from international precipitation communities in the JAXA PMM MDR. JAXA appreciates the efforts by CGMS and IPWG to support the new mission.

In CGMS-50, the mission status in JAXA will be presented in WG III, corresponding to ***WGIII/A49.06***.

6 CONCLUSIONS

JAXA operates various kind of satellite sensors and opens the products to the public. We keep developing and improving the products to address the climate issues.

The major updates since CGMS-49 is that the pre-project team of Precipitation Measuring Mission, following to the Global Precipitation Measurement (GPM) mission, was organized in JAXA in January 2022. JAXA would appreciate the supports by CGMS and IPWG.

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