CGMS

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JAXA REPORT ON THE STATUS OF CURRENT AND FUTURE SATELLITE SYSTEMS

GPM/DPR was successfully launched from Tanegashima Space Center on Feb. 27, and Initial calibration and check out of the DPR is ongoing.

TRMM/PR is still working well. 15th anniversary symposium was held in Tokyo in November, 2012.

JAXA currently operates GOSAT, Ibuki and GCOM-W1, Shizuku.

The GOSAT data products are distributed through the GOSAT User Interface Gateway (GUIG), a website for GOSAT data distribution.

The AMSR2 products are available at the GCOM-W1 Data Providing Service website.

The developments of ALOS-2, EarthCARE/CPR and GCOM-C are under way.

ALOS-2 will be launched in May 2014. While EarthCARE and GCOM-C will be launched in JFY2016.

GOSAT-2 project was officially initiated in this April as a GOSAT, Ibuki follow-on. The target launch date is in JFY2017.

The specifications of current and planned data products are described in this Working Paper.

JAXA Report on the status of current and future satellite systems

1. Status of Current R&D Satellite Systems

Satellites	Space Agency	Equator Crossing Time + Altitude	Launch date	Access to data or products (Links)	Instruments	Status, applications and other information
TRMM	NASA/ JAXA	non-sun-synchronous (35° incl) 402 km	28/11/1997	NASA PMM data access page JAXA G-Portall	- PR (Precipitation Radar) - TMI (TRMM MW Imager) - CERES - VIRS - LIS (Lightning Imaging Sensor)	Measures tropical rainfall/precipitation and radiation energy Precipitation Radar (PR) provided by JAXA Satellite bus and other instruments provided by NASA CERES no longer functional
GOSAT (IBUKI)	JAXA & Japan's Ministry of Environment	13:00 (D) 666km	23/01/2009		TANSO-FTS, TANSO-CAI	Greenhouse Gases Observing Satellite monitoring the distribution of the density of carbon dioxide
GCOM-W1 (SHIZUKU)	JAXA	13:30 (A) 700 km	18/05/2012	DPSS	AMSR-2	Global water and energy circulation. Joining the A-train.
GPM Core Observatory	NASA/JAXA	non-sun-synchronous (65° incl) 407 km	2/27/2014	NASA PMM data access page JAXA G-Portal	- DPR (Dual-frequency Precipitation Radar) - GMI (GPM MW Imager)	Measures global rainfall/precipitation DPR provided by JAXA Satellite bus and GMI provided by NASA

1.1 GOSAT (Ibuki)

The Greenhouse Gases Observing Satellite "IBUKI" (GOSAT) is the world's first spacecraft specialized to measure the concentrations of carbon dioxide and methane, the two major greenhouse gases, from space. The spacecraft was launched successfully on January 23, 2009, and has been operating properly since then.

GOSAT observes infrared light reflected and emitted from the earth's surface and the atmosphere. Column abundances of CO_2 and CH_4 are retrieved from the observed spectra. The mixing ratio of the target gas species is expressed as column-averaged dry air mole fraction above an observed unit surface area of 10.5 km.

GOSAT flies at an altitude of approximately 666 km and completes one revolution in about 100 minutes. The satellite returns to the same point in space in three days. The observation instrument on-board the satellite is the Thermal and Near-infrared Sensor for carbon Observation (TANSO). TANSO is composed of two subunits: the Fourier Transform Spectrometer (FTS) and the Cloud and Aerosol Imager (CAI).

Specifications of FTS

	Band 1	Band 2	Band 3	Band 4
Spectral coverage (μm)	0.758-0.775	1.56-1.72	1.92-2.08	5.56-14.3
Spectral resolution (cm^{-1})	0.2	0.2	0.2	0.2
Polarized light observation	Performed	Performed	Performed	Not Performed
Targeted gases	O_2	CO_2 · CH_4	CO_2 · H_2O	CO_2 · CH_4
Angle of instantaneous field of view	15.8 mrad.(corresponds to 10.5 km when projected on the earth's surface)			
Time necessary for a single scanning (sec.)	4.0 , 2.0 , or 1.1 (depending on the scanning mode being used)			

Specifications of CAI

	Band 1	Band 2	Band 3	Band 4
Spectral coverage (μm)	0.370-0.390 (0.380)	0.664-0.684 (0.674)	0.860-0.880 (0.870)	1.56-1.65 (1.60)
Targeted substances	Cloud and aerosol			
Swath (km)	1000	1000	1000	750
Spatial resolution at nadir (km)	0.5	0.5	0.5	1.5

All types of the GOSAT data products are provided for general users. Data users can search and order the Level 1 data (FTS Level 1B, CAI Level 1B, and CAI Level 1B+ data) and the higher level data products (FTS Level 2, CAI Level 2, FTS Level 3, CAI

Level 3, Level 4A, and Level 4B data products). The Level 1 data and the Level 2 data products whose uncertainties have been evaluated in the instrument calibration and data validation activities are open to the general users. Carbon dioxide flux estimates based on the observational data by GOSAT are released to general users as the Level 4 data products.

The GOSAT data products are distributed through the GOSAT User Interface Gateway (GUIG*), a website for GOSAT data distribution. Prior user registration is required for accessing the data products and can be done on "user authentication" page reached from "product & service" page on GUIG.

GUIG:https://data.gosat.nies.go.jp/GosatUserInterfaceGateway/guig/GuigPage/open.do;jsessionid=0F6497855D3B130F97D71E3D2BEC9323?lang=en*

GOSAT Data Products

Product Level	Sensor / Band	Product Designation	Description	Product Provision Unit	Data Format
L1B	FTS	FTS L1B data	Radiance spectral data obtained by performing Fourier transform on interferogram data	FTS scene	HDF5
	CAI	CAI L1B data	Radiance data (band-to-band and geometric corrections applied / data mapping not performed)	CAI frame	
L1B+	CAI	CAI L1B+ data	Radiance data (band-to-band and geometric corrections applied / data mapping performed)		
L2	FTS SWIR	L2 CO_2 column amount (SWIR)	CO_2 column abundance data retrieved from SWIR radiance spectral data	FTS scan	HDF5
		L2 CH_4 column amount (SWIR)	CH_4 column abundance data retrieved from SWIR radiance spectral data		
	FTS TIR	L2 CO_2 profile (TIR)	CO_2 vertical profile data retrieved from TIR radiance spectral data		
		L2 CH_4 profie (TIR)	CH_4 vertical profile data retrieved from TIR radiance spectral data		
	CAI	L2 cloud flag	Cloud coverage data	CAI frame	
L3	FTS SWIR	L3 global CO_2 distribution (SWIR)	CO_2 column-averaged mixing ratio data projected on a global map	month (global)	
		L3 global CH_4 distribution (SWIR)	CH_4 column-averaged mixing ratio data projected on a global map		
	FTS TIR	L3 global CO_2 distribution (TIR)	CO_2 concentrations at each vertical level projected on a global map		
		L3 global CH_4 distribution (TIR)	CH_4 concentrations at each vertical level projected on a global map		
	CAI	L3 global radiance distribution	Global radiance distribution data (3 days' worth, including data for cloudy segments)	3 days (global)	
		L3 global reflectance distribution	Clear-sky reflectance data (composed only of clear-sky segments selected from a month's worth of data)		
		L3 NDVI	Vegetation index global distribution data (with cloudy meshes flagged)	3 days - Rectangle (30°×60° (lat.× lon.))	
L4A	-	L4A global CO_2 flux	CO_2 flux per each of 64 global regions (monthly average)	year (global)	Text/NetCDF
L4B	-	L4B global CO_2 distribution	Three-dimentional global distribution of CO_2 concentration	month (global) 2.5°×2.5°grid (lat.× lon.)	NetCDF

In addition to the GOSAT data products, global distributions of total and tropospheric ozone can be retrieved from FTS TIR band [Ohyama et al., 2012]. Global and seasonal distributions of terrestrial chlorophyll fluorescence are measured from space by using FTS O_2 band [Joiner et al., 2011, Frankenberg et al., 2011, Guanter et al., 2012].

References

http://www.gosat.nies.go.jp/index_e.html
http://www.jaxa.jp/projects/sat/gosat/index_e.html
http://www.eorc.jaxa.jp/GOSAT/index_j.html

Ohyama, H., S. Kawakami, K. Shiomi, and K. Miyagawa, Retrievals of total and tropospheric ozone from GOSAT thermal infrared spectral radiances, IEEE Transactions on Geoscience and Remote Sensing, vol. 50, issue 5, pp. 1770-1784, 2012.

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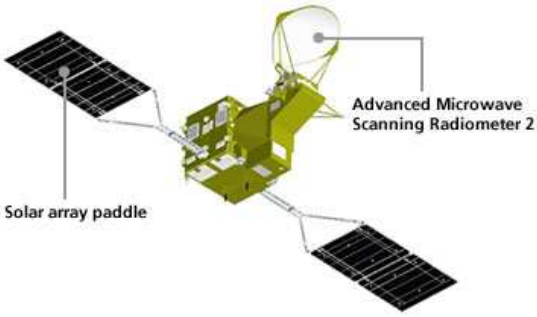
1.2 GCOM-W1 (Shizuku)

The Global Change Observation Mission 1st - Water "SHIZUKU" (GCOM-W1) mission aims to establish the global and long-term observation system to collect data which is needed to understand mechanisms of climate and water cycle variations, and demonstrate its utilization. Advanced Microwave Scanning Radiometer 2 (AMSR2) on-board the GCOM-W1 satellite has taken over Aqua/AMSR-E observations of water vapor, cloud liquid water, precipitation, SST, sea surface wind speed sea ice concentration, snow depth, and soil moisture.



GCOM-W1 was launched from the Tanegashima Space Center at 1:39 am on May 18, 2012 (Japan Standard Time) and entered into the A-train orbit on June 29. The A-Train satellite constellation cross the equator within a few minutes of one another at around 1:30 pm local time, and GCOM-W1 is flying in front of the Aqua satellite, thus it takes the most front position in the A-Train until another NASA satellite, OCO-2 joins the constellation. GCOM-W1 has started the initial observations since July 3, after increasing the antenna rotation of the on-board AMSR2 to 40 rpm, then has moved to the regular observation operation on August 10 as scheduled after completion of the initial functional verification

AMSR2 on-board the GCOM-W1 satellite is a remote sensing instrument for measuring weak microwave emission from the surface and the atmosphere of the Earth. From about 700 km above the Earth, AMSR2 has provided us highly accurate measurements of the intensity of microwave emission and scattering since July, 2012. The antenna of AMSR2 rotates once per 1.5 seconds and obtains data over a 1450 km swath. This conical scan mechanism enables AMSR2 to acquire a set of daytime and night-time data with more than 99% coverage of the Earth every 2 days.

The AMSR2 products are available at the GCOM-W1 Data Providing Service website (https://gcom-w1.jaxa.jp/auth.html).

Frequency Channels and Resolutions of AMSR2
(Orbit altitude of 700 km and main-reflector size of 2.0m are assumed)

Center frequency [GHz]	Band width [MHz]	Polarization	Beam width [deg.] (Ground resolution [km])	Sampling interval [km]
6.925 / 7.3	350	V and H	1.8 (35 x 62)	10
10.65	100		1.2 (24 x 42)	
18.7	200		0.65 (14 x 22)	
23.8	400		0.75 (15 x 26)	
36.5	1000		0.35 (7 x 12)	
89.0	3000		0.15 (3 x 5)	5

GCOM-W1 Standard Products

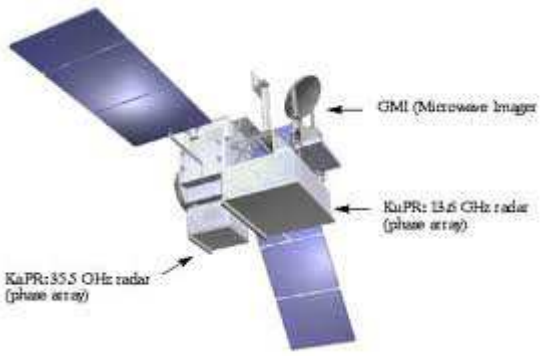
Product	Range	Comments
Brightness temperatures		
Brightness temperatures	2.7-340K	Global, 6 frequency with dual polarizations
Geophysical parameters		
Integrated water vapour	0 - 70kg/m^2	Over global ocean*, columnar integrated value
Integrated cloud liquid water	0 - 1.0kg/m^2	Over global ocean*, columnar integrated value
Precipitation	0 - 20mm/h	Global (except over ice and snow), surface rain rate
Sea surface temperature	-2 - 35℃	Global ocean*
Sea surface wind speed	0 - 30m/s	Global ocean*
Sea ice concentration	0 - 100%	High latitude ocean areas
Snow depth	0 - 100cm	Land surface (except dense forest regions)
Soil moisture	0 - 40%	Land surface (except ice sheet and dense forest regions)

* *Except sea ice and precipitating areas*

References

http://www.jaxa.jp/projects/sat/gcom/index_e.html
http://suzaku.eorc.jaxa.jp/GCOM/index.html

1.3 GPM and DPR



The Global Precipitation Mission (GPM) is a satellite program to measure the global distribution of precipitation accurately in a sufficient frequency so that the information provided by this program can drastically improve weather predictions, climate modelling, and understanding of water cycles. The accurate measurement of precipitation will be achieved by the Dual-frequency Precipitation Radar (DPR) installed on the GPM core satellite. The DPR on the GPM core satellite is developed by JAXA and National Institute of Information and Communications Technology (NICT).

GPM Core Observatory was successfully launched from Tanegashima Space Center on Feb. 27. The GPM Core Observatory is carrying DPR (KuPR and KaPR) and GPM Microwave Imager (GMI) and its orbit is non-sun-synchronous with 407km altitude and 65 degrees inclination. Initial calibration and check out of DPR is ongoing. Both NASA/GSFC and JAXA has developed ground system to process GPM standard products. At JAXA‘s GPM Mission Operation System in Tsukuba.

Major characteristics of DPR

Name	KuPR	KaPR
radar type	active phased array radar	
Antenna	slotted waveguide antenna	
Frequency	Ku-band 13.60 GHz	Ka-band 35.55 GHz
peak transmit power	> 1000 W	> 140 W
Swath	245 km	125 km
horizontal resolution	5 km	
range resolution	250 m	250m/500m
observation altitude	surface ~ 19 km	
observation rain rate	0.5 mm/h ~	0.2 mm/h ~
Size	2.4 m x 2.4 m x 0.6 m	1.44 m x 1.07 m x 0.7 m
	< 470 kg	< 336 kg

JAXA GPM Data Products

There are three kinds of products that are Standard product, Research product and Near-real time product. Research products are the ones in research phases; however, those have possibilities to be Standard products. Several candidates for research product are considered at JAXA GPM project, and will be defined later. Near-real time products will be generated using estimated orbital information for

prompt data release and distributed to users who need GPM data as soon as possible for their operational purposes.

Following tables are list of JAXA GPM products. Other than JAXA GPM products, some of the GPM standard products processed at NASA will be distributed from JAXA. GPM standard products will be authorized between the U.S. and Japan Joint Precipitation Measuring Mission (PMM) Science Team.

JAXA is responsible for the GPM/DPR algorithm development for engineering values (Level 1) and physical products (e.g. precipitation estimation) (Level 2 and 3) and the quality control of the products as the sensor provider. Furthermore, JAXA is planning to generate the DPR/GMI combined algorithms, which will be based on DPR maximizing the use of DPR information, and Global Precipitation Map product, which will merge multiple satellite information and mapped data with high temporal resolution, considering data needs in some operational areas such as weather forecasts and flood warning. DPR and DPR/GMI combined Level 2 and 3 algorithms are jointly developed by Japan and US joint algorithm team.

To meet the GPM objectives, retrieval algorithms will require global applicability, robustness, and long-term stability. Algorithms that can be extended and applied for similar instruments (e.g., PR, and microwave radiometers on board the other satellites) and historical data records are preferable for integrated retrieval. Computationally efficient, fast-processing algorithms are important for the operational applications of the products. Level 2 of the Dual-frequency Precipitation product and the DPR/GMI combined product and Level 3 Global Precipitation Map product, which are denoted in light grey in the table below, are also required to process in near real time. Each near-real-time algorithm will be developed based on the standard algorithm. All near-real-time products have to be produced and distributed within 60 minutes after acquisition of observation data.

JAXA GPM near-real-time products

Level	Algorithm	Product	Major Physical Parameters	Unit	Coverage
1R	Depends on each sensor	Microwave radiometer product	Brightness temperature	arbitrarily	Depends on each sensor
2R	DPR algorithm (Japan-US joint)	Dual-frequency precipitation product	Rain rate profile, drop size distribution, precipitation status (rain/snow), attenuation profile	arbitrarily	245km
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	rain rate profile, surface rain rate	Orbit	125km
3R	Global precipitation map algorithm	Global precipitation map product	Mean rainfall, observation number, rain pixel number	Hourly	Global

JAXA GPM Standard Products

Level	Algorithm	Product	Major physical parameter	Unit	Coverage
1	KuPR algorithm	KuPR product	Received power profile	Orbit	245km (swath)
	KaPR algorithm	KaPR product	Received power profile	Orbit	125km (swath)
2	DPR algorithm (Japan-US joint)	KuPR product	Radar reflectivity profile, normalized radar surface cross section (σ^0), rain type, bright-band height, attenuation corrected radar reflectivity profile, rain rate profile	Orbit	245km (swath)
		KaPR product	Radar reflectivity profile, normalized radar surface cross section (σ^0), rain type, bright-band height, attenuation corrected radar reflectivity profile, rain rate profile	Orbit	125km (swath)
		Dual-frequency precipitation product	Rain rate profile, drop size distribution, precipitation status (rain/snow), attenuation profile	Orbit	245km (swath)
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	rain rate profile, surface rain rate	Orbit	245km (swath)
	DPR latent heating algorithm	DPR latent heating product	Latent heating profile, rain type	Orbit	245km (swath)

JAXA GPM Standard Products (Cont'd)

Level	Algorithm	Product	Major physical parameter	Unit	Coverage
3	DPR algorithm (Japan-US joint)	Dual-frequency precipitation product	Mean surface rainfall, time information, Ascending/Descending flag	Daily	Global
			Mean rainfall (dual), observation number, rain pixel number, mean bright-band height, storm height, rain/snow determination, time information	Daily (Asc/Dsc)	Global
			Mean rainfall (single, dual), observation number, rain pixel number, mean bright-band height, storm height, mean attenuation corrected radar reflectivity profile, mean DSD parameters, histogram	Monthly	Global
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	Mean rainfall, observation number, rain pixel number,	Monthly	Global
	DPR latent heating algorithm	DPR latent heating product	Latent heating profile, number of latent heating pixel	Orbit	Global
				Monthly	Global
	Global precipitation map algorithm	Global precipitation map product	Mean rainfall, observation number, rain pixel number	Hourly	Global
				Monthly	Global

NOTE: Other than these products listed up in this table, some of the GPM standard products processed at NASA will be distributed from JAXA. GPM standard products will be authorized between the U.S. and Japan Joint PMM Science Team.

CEOS Precipitation Constellation

CEOS Precipitation Constellation (PC) is proposed as one of first four virtual constellations, and JAXA and NASA is co-leading CEOS PC activities with other participating agencies.

CEOS PC holds annual meeting (International workshop) to exchange information of the individual satellite projects and specifications of instruments, and to establish annual or biennial Work Plan to implement the broad goals and specific phase objectives outlined in the PC Implementation Plan. The fourth CEOS PC International Workshop was held in 10 November 2011 in Denver, U.S., which was originally scheduled in April 2011 in Brazil, but postponed because of the March Earthquake in Japan. At the forth workshop, CEOS PC 2011-2012 Work Plan and 2009-2011 Accomplishment were developed. In addition, the relationship of proposed CEOS PC Portal to the proposed CEOS Water Portal were discussed.

Results of the workshops were uploaded to the CEOS PC web site (http://ceospc.gsfc.nasa.gov) operated by NASA. The fifth CEOS PC workshop is planning to be held in late 2014 in Japan.

As a follow up to discussion at the 4th workshop, the subsequent 2012 CEOS-GEO Actions Workshop, and the CEOS SIT-27 Meeting, JAXA and NASA, co-chairs of the CEOS PC, are proceeding with the PC Data Portal Development. White Paper describing the concept and the implementation approach was distributed to PC members in September 2012. Update of the White Paper in order to raise issues regarding concern about decrease of future passive microwave imager instruments was completed in March 2014. The PC Data Portal with interface to the CEOS Water Portal is a contribution to the GEO Water Strategy and 2012 CEOS-GEO Action WA-01-C1_3. PC Portal (first phase) initial operational capability is available in 2013, and the PC Portal second phase is under preparation.

References

http://www.jaxa.jp/projects/sat/gpm/index_e.html
http://www.eorc.jaxa.jp/GPM/index_e.htm
http://pmm.gsfc.nasa.gov/
http://ceospc.gsfc.nasa.gov/

2. Status of Future R&D Satellite Systems

Satellites	Space Agency	Equator Crossing Time + Altitude	Planned Launch Date	Planned access to data or products (Links)	Planned Instruments	Status, applications and other information
ALOS-2	JAXA	12:00 628km	Japan Fiscal Year 2013			PALSAR-2
EarthCARE	ESA-JAXA	10:30 (D) 450 km	11/2016			ATLID, BBR, CPR, MSI, Cloud, radiation and aerosol interaction processes
GCOM-C	JAXA	10:30 (D) 798 km	Japan Fiscal Year 2016			Carbon cycle and radiation budget (Atmosphere, Ocean, Land and Cryosphere)
GOSAT-2	JAXA	13:00 666km(TBD)	Japan Fiscal Year 2017			Next generation of GHG observing satellite

2.1 ALOS-2

The Advanced Land Observing Satellite-2 (ALOS-2) is a follow-on mission from the ALOS “Daichi”. ALOS had contributed to cartography, regional observation, disaster monitoring, and resource surveys, until May 2011. ALOS-2 will succeed to this mission with enhanced capabilities. Specifically, JAXA is conducting research and development activities to improve wide and high-resolution observation technologies developed for ALOS in order to further fulfil social needs.

These social needs include: 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 4) Global monitoring of tropical rain forests to identify carbon sinks.

The state-of-the-art L-band Synthetic Aperture Radar (PALSAR-2) aboard ALOS-2, which is an active microwave radar using the 1.2GHz frequency range, will, in responding to society’s needs, have enhanced performance compared to ALOS/PALSAR. PALSAR-2 is capable of observing day and night, and in all weather conditions.

ALOS-2 will be launched on May 24, 2014 by the H-IIA Launch Vehicle.

Major characteristics of ALOS-2

Observation mode	Spotlight: 1m~3m resolution, 25km swath Stripmap: 3m~10m resolution, 50km~70km swath ScanSAR: 100m resolution, 350km/490km swath
Orbit	Type: Sun-synchronous sub-recurrent orbit Altitude: 628km Local sun time at Descending Node: 12:00 +/-15min Revisit time: 14 days
Design life	5 years (target: 7 years)
Mass	Approx. 2 ton

References

http://www.jaxa.jp/projects/sat/alos2/index_e.html

2.2 EarthCARE and CPR

EarthCARE Spacecraft © ESA

The Earth Clouds, Aerosols and Radiation Explorer (EarthCARE) is a joint European-Japanese mission addressing the need for a better understanding of the interactions between cloud and aerosol, and their radiative processes that play a role in climate regulation. Japan (JAXA and NiCT) will provide Cloud Profiling Radar (CPR) to the spacecraft.

CPR is a 94 GHz Doppler Radar which has several characteristics. First point is the high sensitivity. This requirement is divided into large antenna size requirement, low noise figure of receiver requirement and high power of transmitter requirement. Second point is the Doppler capability. To materialize this function with satisfactory accuracy, large diameter of antenna with precise surface figure and high pulse repetition frequency (PRF) are required. To keep accuracy especially at boundary layer region, several other fine characteristics, such as side lobe characteristics of antenna, cross polarization characteristics and so on, are also required for CPR design.

CPR Major Specifications (Draft)

Radar type	94 GHz Doppler Radar
Center frequency	94.05 GHz
Pulse width	3.3 micro second (equivalent to 500m vertical resolution)
Beam width	0.095 deg
Polarization	Circular; Tx: LHCP, Rx: RHCP
Transmit power	> 1.5 kW (Klystron spec.)
Height range	-1 ~ 20 km
Resolution	500 m (100 m sample); Vertical, 500m integration; Horizontal
Sensitivity*	-35 ~ +23 dBZ
Radiometric accuracy*	< 2.7 dB
Doppler range*	-10 ~ +10 m/s
Doppler accuracy*	< 1 m/s
Pulse repetition frequency	Variable; 6100~7500 Hz
Pointing accuracy	< 0.015 degree

**; at 10 km integration and 387 km orbit height*

JAXA will produce not only CPR products but also other products from the each sensor and the synergetic use of other sensors.

EarthCARE JAXA Products

Standard Products

Sensor	Process. Level	Product	Priimary Parameter	Grid Spacing		Spatial Resolution		Release Accuracy	Standard Accuracy	Target Accuracy
				Horizontal	Vertical	Horizontal	Vertical			
CPR	L1b	CPR one-sensor Received Echo Power Products and Doppler Product	Received Echo Power	0.5km	0.1km	0.765km*3 (Cross-track) 0.840km*3 (Along-track)	0.5km	< 4.7dB	< 2.7dB	–
			Radar Reflective Factor					< 4.7dB	< 2.7dB	< 2.7dB
			Surface Radar Cross Section		–		–	–	–	–
			Doppler Velocity/Covariance of Pulsepair/Spectrum Width		0.1km		0.5km	–	≦ 1.3m/s (Doppl. Vel)	< 0.2m/s (Doppl. Vel)
CPR	L2a	CPR one-sensor Echo Product	Integrated Radar Reflective Factor/Integrated Doppler Velocity/Gas Correction Factor	1km	0.1km	1km/ *10km*	*0.5km*	–	≦ 1.3m/s (Int. Doppl. Vel.)	< 0.2m/s (Int. Doppl. Vel.)
CPR	L2a	CPR one-sensor Cloud Products	Cloud Mask	1km	0.1km	1km/ *10km*	*0.5km*	±30%	±10%	±5%
			Cloud Particle Type					±100%	±50%	±20%
			Reff./LWC/IWC					–	±100% (LWC)	±50% (LWC)
			Optical Thickness				–	–	±100%	±50%
ATLID	L2a	ATLID one-sensor Cloud Aerosol Poducts	Feature Mask	L1b min. unit/1km	0.1km	L1b min. unit/1km/ *10km*	*0.1km*	±100%	±40%	±10%
			Target Mask	1km		1km/ *10km*		±100%	±40%	±10%
			Aerosol Extinction Coeff./Backscat. Coeff./Lidar Ratio/Dep. Ratio			*10km*		±60% /±90%, ±150%/±150%	±40% /±70%, ±110%/±130%	±20% /±50%, ±70%/±100%
			Cloud Extinction Coeff./Backscat. Coeff./Lidar Ratio/Dep. Ratio			1km/ *10km*		±50% /±90%, ±140%/±150%	±30% /±70%, ±100%/±130%	±15% /±50%, ±65%/±100%
			Planetary Boundary Layer Height		–		–	±500m	±300m	±100m
MSI	L2a	MSI one-sensor Cloud Poducts	Cloud Flag/Cloud Phase	0.5km	–	*0.5km*	–	±15% Ocean ±20% Land	±15%	±10%
			Optical Thickness of Liquid Cloud					±10%	±100% (Converting to LWP)	±50% (Converting to LWP)
			Reff. of Liquid Cloud					±30%		
			Cloud Top Temp./Pressure/Altitude					±1K (CTT)	±3K (CTT)	±1.5K (CTT)
CPR + ATLID	L2b	CPR-ATLID synergy Cloud Poducts	Cloud Mask/Cloud Particle Type	1km	0.1km	1km/ *10km*	*0.5km*	–	root mean square of errors of one-sensor products	–
			Reff./LWC/IWC					–		±2μm (water)/ ±20%/±30%
			Optical Thickness		–		–	–		–
CPR + ATLID + MSI	L2b	CPR-ATLID-MSI synergy Cloud Poducts	Cloud Mask/Cloud Particle Type	1km	0.1km	1km/ *10km*	*0.5km*	–	root mean square of errors of one-sensor products	–
			Reff./LWC/IWC					–		±2μm (water)/ ±20%/±30%
			Optical Thickness		–		–	–		–
CPR+ ATLID+ MSI+BBR	L2b	Four-sensors Synergy Radiative Products	SW/LW Radiative Flux	10km*2	–	*10km*	–	–	±25W/m2	±10W/m2
			SW/LW Radiative Heating Rate		0.5km*2		0.5km	–	–	–

Research Products

Sensor	Process. Level	Product	Priimary Parameter	Grid Spacing	
				Horizontal	Vertical
CPR	L2a	CPR One-sensor Doppler Product	Doppler velocity correction value (considering inhomogeneity)/ Doppler velocity unfolding value	1km/10km	0.5km
		CPR One-sensor Rain and Snow Product	LWC*/IWC*/Rain Rate/Snow Rate/Attenuation Corrected Radar Reflectivity Factor		
		CPR One-sensor Vertical Velocity Product	Vertical air motion/ Sedimentation Velocity		
ATLID	L2a	ATLID One-sensor Aerosol Extinction Product	Aerosol Extinction Coefficient (Water Soluble/Dust/SS/BC)	10km	0.1km
MSI	L2a	MSI One-sensor Ice Cloud Product	Optical Thickness of Ice Cloud with Reflection method/Effetive Radius of Ice(1.6&2.2μm)/Ice Cloud Top Temperature/Pressure/Altitude	0.5km	–
		MSI One-sensor Aerosol Cloud Product	Aerosol Optical Thickness (Ocean/Land)/ Angst. Exp.		
CPR + ATLID	L2b	CPR-ATLID Synergy Particle Mass Ratio Product	Mass Ratio (2D_Ice/IWC)*	1km/10km	0.5km
		CPR-ATLID Synergy Rain and Snow Product	LWC*/IWC*/ Rain Rate/Snow Rate		
		CPR-ATLID Synergy Vertical Velocity Product	Vertical air motion/ Sedimentation Velocity		
ATLID + MSI	L2b	ATLID-MSI Synergy Aerosol Components Product	Aerosol Extinction Coefficient (Water Soluble/Dust/SS/BC) Mode Radius (Fine mode/Coarse mode)	10km	0.1km
		ATLID-MSI Synergy Aerosol Direct Radiave Forcing Product	Aerosol Direct Radiative Forcing (TOA/BOA)	10km	–
CPR + ATLID + MSI	L2b	CPR-ATLID-MSI Synergy Cloud Doppler Product	Cloud Mask/Cloud Particle Type/Cloud Effective Radius (Water・Ice)/LWC/ IWC(with Doppler)	1km/10km	0.5km
			Optical Thickness/LWP/ IWP(with Doppler)		–
		CPR-ATLID-MSI Synergy Rain and Snow Product	LWC*/IWC*/ Rain Rate/Snow Rate		0.5km
		CPR-ATLID-MSI Synergy Vertical Velocity Product	Vertical air motion/ Sedimentation Velocity		
		CPR-ATLID-MSI Synergy Ice Cloud Product	Ice Effective Radius/Optical Thickness	0.5km	–

Auxiliary Product

Sensor	Process. Level	Product	Priimary Parameter	Grid Spacing	
				Horizontal	Vertical
CPR	Aux	ECMWF CPR Grid Product	Temperature/Specific Humidity (CPR Grid)	1km	0.1km
			Pressure(CPR Grid)	–	0.1km
			Surface Pressure/2m Temperature (CPR Grid)	1km	–
ATLID	Aux	ECMWF ATLID Grid Product	Temperature/Specific Humidity/Ozone Mass Ratio (ATLID Grid)	1km	0.1km
			Pressire(ATLID Grid)	–	0.1km
			Total Column Ozone/10m U-Velocity/ 10m V-Velocity (ATLID Grid)	1km	–
MSI	Aux	ECMWF MSI Grid Product	Temperature/Specific Humidity (MSI Grid)	10km	25 layers*1
			Pressure(MSI Grid)	–	25 layers*1
			Total Column Ozone/10m U-Velocity/ 10m V-Velocity/Surface Pressure/ Skin Temperature (MSI Grid)	10km	–

NOTE: The accuracy is defined using the "Pixel Integration Length" in red italic numbers. The accuracies of CPR L1b are defined by 10km integration. Those accuracies except for CPR are assumed under the condition that sensors developed by ESA functioned as expected. The accuracies of ATLID is based on the information before the change of specifications. The length of a scene is defined as the length of an orbit divided equally. "CPR-ATLID-MSI Synergy Cloud Products and Four Sensors Synergy Radiation Budget Products are the final goal of the EarthCARE mission. Therefore, they are defined as the standard products, although they will be released one year after the start of MOP." NRT and Statistics (L2c) will be adjusted appropriately by taking user's needs into account.

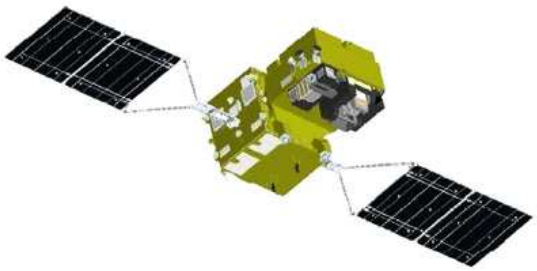
**1: Depends on the resolution of ECMWF data that JAXA will receive by the time of launch *2: The values shown are defined at the time of JAXA CDR. In future, the values may change if there are strong scientific requirements. *3: The values shown are defined when antenna beam width was 0.095 degrees and satellite altitude was 460km. *(in Research Product) including with/without Doppler*

Data Products were decided and the accuracy of them were also decided in Joint Mission Advisory Group consists of European and Japanese scientists

References

http://www.jaxa.jp/projects/sat/earthcare/index_e.html
http://www.eorc.jaxa.jp/EARTHCARE/en/index.html
http://www.esa.int/esaLP/LPearthcare.html

2.3 GCOM-C



Climate change observation will be performed by the Second-generation Global Imager (SGLI), a multi-wavelength optical radiometer, on-board the GCOM-C (Climate) satellite on clouds, aerosol, ocean color (marine ecosystem), vegetation, snow and ice.

The first generation of GCOM-C (called GCOM-C) is scheduled to be launched in JFY2016. Its orbit will be sun-synchronous with 798km altitude (over the equator), 98.6 degrees inclination and 10:30 local time of descending node.

SGLI Channel Specifications

CH	λ	Δλ	L_{std}	L_{max}	SNR at Lstd	IFOV
	VN, P, SW: nm T: μm		VN, P: $W/m^2/sr/\mu m$ T: Kelvin		VN, P, SW:- T: NEΔT	m
VN1	380	10	60	210	250	250
VN2	412	10	75	250	400	250
VN3	443	10	64	400	300	250
VN4	490	10	53	120	400	250
VN5	530	20	41	350	250	250
VN6	565	20	33	90	400	250
VN7	673.5	20	23	62	400	250
VN8	673.5	20	25	210	250	250
VN9	763	12	40	350	1200[*3]	250
VN10	868.5	20	8	30	400	250
VN11	868.5	20	30	300	200	250
P1	673.5	20	25	250	250	1000
P2	868.5	20	30	300	250	1000
SW1	1050	20	57	248	500	1000
SW2	1380	20	8	103	150	1000
SW3	1630	200	3	50	57	250
SW4	2210	50	1.9	20	211	1000
T1	10.8	0.74	300	340	0.2K	500[*2]
T2	12.0	0.74	300	340	0.2K	500[*2]

*[*1] Polarization channels (P1 and P2) should have capability to observe at three polarization direction (0, 60,120 deg.) and NADIR / Tilt view at +-45 deg.*

*[*2] They have a 250m resolution mode as a potion*

*[*3] SNR at 1km resolution*

GCOM-C Standard products

Area	Group	Product	Day/night	Grid size
Common	Radiance	Top-Of-Atmosphere radiance (including system geometric correction)	*TIR and land 2.2mm:* Both *Other VNR,SWI:* Daytime (+special operation)	VNR,SWI Land/coast: 250m, offshore: 1km, polarimetory:1km TIR Land/coast: 500m, offshore: 1km
Land	Surface reflectance	Precise geometric correction	Both	250m
		Atmospheric corrected reflectance (incl. cloud detection)	Daytime	250m
	Vegetation and carbon cycle	Vegetation index		250m
		Above-ground biomass		1km
		Vegetation roughness index		1km
		Shadow index		250m, 1km
		fAPAR		250m
		Leaf area index		250m
	Temperature	Surface temperature	Both	500m
Atmosphere	Cloud	Cloud flag/Classification	Both	1km
		Classified cloud fraction	Daytime	1km (scene),
		Cloud top temp/height	Both	0.1deg (global)
		Water cloud OT/effective radius	Daytime	
		Ice cloud optical thickness		
	Aerosol	Aerosol over the ocean		
		Land aerosol by near ultra violet		
		Aerosol by Polarization		
Ocean	Ocean color	Normalized water leaving radiance (incl. cloud detection)	Daytime	250m (coast)
				1km (offshore)
		Atmospheric correction parameter		4km (global)
		Photosynthetically available radiation		
	In-water	Chlorophyll-a concentration		
		Suspended solid concentration		
		Colored dissolved organic matter		
	Temperature	Sea surface temperature	Both	500m (coast)
				1km (offshore)
				4km (global)
Cryosphere	Area/ distribution	Snow and Ice covered area (incl. cloud detection)	Daytime	250m (scene)
				1km (global)
		Okhotsk sea-ice distribution		250m
	Surface properties	Snow and ice surface Temperature		500m (scene)
		Snow grain size of shallow layer		1km (global)

Access to GCOM data

To R&D and operational organizations, JAXA can provide GCOM data which includes standard products, processed data and related information which meets users' needs to user organizations, via the JAXA on-line system (free of charge), optionally via a dedicated communication line or media upon users' needs (minimal cost charged) under the cooperative agreements with JAXA after commissioning (launch + 3 months) for Calibration and Validation, keeping the data latency, if required (GCOM-W1 global data: observation time + 150min.).

To general researchers, JAXA will provide GCOM standard product via the JAXA on-line system (free of charge) after Calibration and Validation phase in about one year after the launch. Simple registration and consent to data use conditions are required on the system. Before providing GCOM standard products, AMSR and AMSR-E standard products have been available on the system since August, 2011 (https://gcom-w1.jaxa.jp/).

Direct reception; receiving the real-time observation data from the GCOM satellites at the users' ground station can be available, subject to conditions defined by JAXA in an individual agreement. Actual cost due to the direct reception is charged on users, in principle. (e.g. cost for provision and maintenance of processing software)

Secondary distribution is basically prohibited, but R&D user agencies can distribute GCOM data to third parties, provided that they nominate the third parties to JAXA and make them comply with the 'rights and use conditions' specified in the GCOM data policy.

For commercial purpose, JAXA makes license agreements with commercial purpose users and imposes royalties on them.

References

http://www.jaxa.jp/projects/sat/gcom/index_e.html
http://suzaku.eorc.jaxa.jp/GCOM/index.html

2.4 GOSAT-2

The Greenhouse Gases Observing Satellite -2 (GOSAT-2) is the next generation of the greenhouse gases measurement satellite. GOSAT-2 measures the concentrations of carbon dioxide, methane and carbon monoxide from space. The spacecraft will be launched in JFY2017.

GOSAT-2 observes the solar light reflected on earth surface and thermal infrared emitted from the atmosphere. Column abundances of CO_2, CH_4 and CO are retrieved from the observed spectra. The mixing ratio of the target gas species is expressed as column-averaged dry air mole fraction above an observed unit surface area of 10.5 km (TBD).

GOSAT-2 flies at an altitude of approximately 666 km (TBD) and completes one revolution in about 100 minutes. The satellite returns to the same point in space in three days (TBD). The observation instrument on-board the satellite is the Thermal and Near-infrared Sensor for carbon Observation (TANSO). TANSO is composed of two subunits: the Fourier Transform Spectrometer -2 (FTS-2) and the Cloud and Aerosol Imager -2 (CAI-2).

Specifications of FTS-2

	Band1	Band2	Band3	Band4	Band5
Spectral coverage (μ m)	0.754-0.772	1.56-1.69	1.92-2.38	5.6-8.4	8.4-14.3
Targeted gases	O_2	CO_2, CH_4	CO_2, H_2O, CO	CH_4	CO_2
Polarization observation	Yes	Yes	Yes	No	No
Sampling resolution (cm^{-1})	0.2				
IFOV (mrad)	15.8				

Specifications of CAI-2

	Forward viewing				
	Band1	Band2	Band3	Band4	Band5
Spectral coverage (nm)	333-353	433-453	664-684	859-879	1585-1675
Target	Clouds and Aerosols				
Spatial resolution (m)	500				1000
Tilt angle (deg)	+20				
Swath (km)	1000				
	Backward viewing				
	Band6	Band7	Band8	Band9	Band10
Spectral coverage (nm)	370-390	540-560	664-684	859-879	1585-1675
target	Clouds and Aerosols				
Spatial resolution (m)	500				1000
Tilt angle (deg)	-20				
Swath (km)	1000				

GOSAT-2 data products are to be provided for public users. Data users can search and order the Level 1 data (FTS Level 1B, CAI Level 1B data) and the higher level data products (FTS Level 2, CAI Level 2, FTS Level 3, CAI Level 3, Level 4 data products). The Level 1 data and the Level 2 data products whose uncertainties have been evaluated in the instrument calibration and data validation activities are open to the general users. Carbon dioxide flux estimates based on the observational data by GOSAT-2 are released to general users as the Level 4 data products.

The GOSAT-2 data products are distributed to public through the website (TBD).

GOSAT Data Products (TBD)

Product Level	Sensor/Band	Product name	Description
L1B	FTS-2	FTS L1B data	Radiance spectral data
	CAI-2	CAI L1B data	Geometric corrected radiance data
L2	FTS-2/SWIR	L2 XCO_2	CO_2 column abundance data retrieved from SWIR radiance spectral data
		L2 XCH_4	CH_4 column abundance data retrieved from SWIR radiance spectral data
		L2 XCO	CO column abundance data retrieved from SWIR radiance spectral data
	FTS-2/TIR	L2 CO_2 profile	CO_2 vertical profile data retrieved form TIR radiance spectral data
		L2 CH_4 profile	CH_4 vertical profile data retrieved form TIR radiance spectral data
	CAI-2	L2 cloud flag	Cloud coverage data
L3	FTS-2/SWIR	L3 global CO_2 distribution	CO_2 column-averaged mixing ratio data projected on a global map
		L3 global CH_4 distribution	CH_4 column-averaged mixing ratio data projected on a global map
		L3 global CO distribution	CO column-averaged mixing ratio data projected on a global map
	FTS-2/TIR	L3 global CO_2 distribution	CO_2 concentrations at each vertical level projected on a global map
		L3 global CH_4 distribution	CH_4 concentrations at each vertical level projected on a global map
	CAI-2	L3 global radiance distribution	Global radiance distribution data
		L3 global reflectance distribution	Clear-sky reflectance data
L4	-	L4 global CO_2 flux	CO_2 flux (monthly average)