CGMS

CGMS-37, JAXA-WP-02
Prepared by JAXA
Agenda Item: C.3
Discussed in Plenary

Update on JAXA's Future Satellite Systems

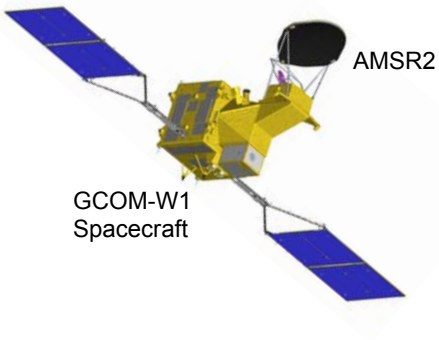
Updated status of JAXA's Future Satellite Systems are reported, which include Global Change Observation Mission (GCOM), Global Precipitation Measurement (GPM)/ Dual-frequency Precipitation Radar (DPR), and Earth Clouds, Aerosols and Radiation Explorer (EarthCARE)/Cloud Profiling Radar (CPR). A Long-Term Plan of JAXA Earth Observation is also referred.

GCOM(Global Change Observation Mission)

The "Global Change Observation Mission"(GCOM) aims to construct, use, and verify systems that enable continuous global-scale observations of effective geophysical parameters for elucidating global climate change and water circulation mechanisms, GCOM will consist of two satellite series (GCOM-W and C) spanning three generations with one year overlap in orbit enables over 13 years observation in total.

GCOM-W1

Water cycle variation will be observed by the Advanced Microwave Scanning Radiometer-2 (AMSR2) onboard the GCOM-W (Water) satellite. GCOM-W will observe precipitation, water, sea surface wind speed, sea water temperature, soil moisture, snow depth and etc..



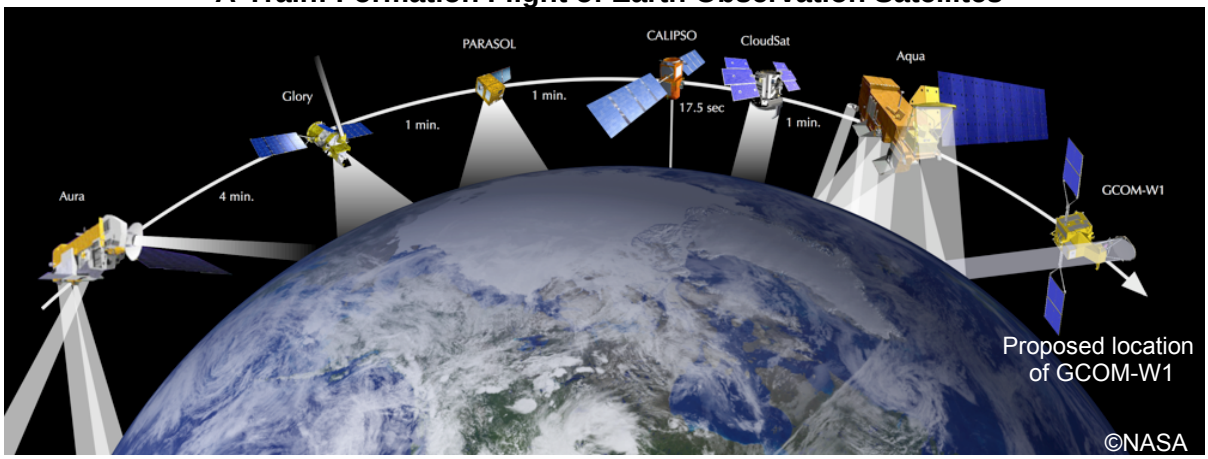
The first generation of GCOM-W (called GCOM-W1) is scheduled to be launched in January 2012. Its orbit will be sun-synchronous with 699.6km altitude (over the equator), 98.186 degrees inclination and 13:30 local time of descending node. Dual launch with Korean KOMPAT-3 by H-IIA vehicle is planned.

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

In February 2009, JAXA decided GCOM-W1 to join into the afternoon “A-Train” satellite constellation which cross the equator within a few minutes of one another at around 1:30 p.m. local time. The proposed location of GCOM-W1 in the A-Train is 259.5 seconds ahead of Aqua.

A-Train: Formation Flight of Earth Observation Satellites

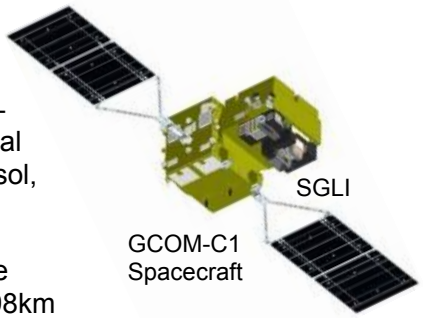


GCOM-W1 Standard Products

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*

GCOM-C1



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

The first generation of GCOM-C (called GCOM-C1) is scheduled to be launched in summer of 2014. 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/μm 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	400	1000
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(TBD)	1000
T1	10.8	0.74	300	340	0.2	500
T2	12.0	0.74	300	340	0.2	500

*[*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.*

GCOM-C1 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		4~9km (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)
				4~9km (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

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.

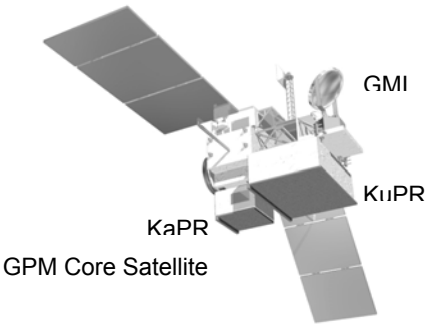
For commercial purpose, JAXA makes license agreements with commercial purpose users and imposes royalties on them.

References

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

GPM (Global Precipitation Mission)
and DPR (Dual Frequency Precipitation Radar)

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. Its feasibility has been studied at Goddard Space Flight Center of National Aeronautics and Space Administration (NASA) and JAXA. The accurate measurement of precipitation will be achieved by the Dual-frequency Precipitation Radar (DPR) installed on the GPM core satellite. DPR on the GPM core satellite is being developed by JAXA and National Institute of Information and Communications Technology (NICT).



GPM Core Satellite

NASA and JAXA signed implementation phase MOU in July 2009. DPR Critical Design Review (CDR) completed in October 2009. While, NASA Mission CDR is scheduled in December 2009.

The GPM Core Satellite carrying DPR (KuPR and KaPR) and GPM Microwave Imager (GMI) is scheduled to be launched in July 2013. Its orbit will be non-sun-synchronous with 407km altitude and 65 degrees inclination.

Major characteristics of DPR

Name	KuPR	KaPR
radar type	active phased array radar	
antenna	slotted waveguide antenna	
frequency	Ku-band 13.6 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 rainrate	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

Data Products Updates

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. At present, no Research Product is decided at JAXA GPM project, but 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.

Current plan of JAXA GPM products is updated. Other than JAXA products listed up in the following 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 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,.

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. Products denoted in light grey in Table 3, which are Level 2 the Dual-frequency Precipitation product and the DPR/GMI combined product, and Level 3 Global Precipitation Map product, 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.

Updated Plan of JAXA GPM 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/800km (swath)
3	DPR algorithm (Japan-US joint)	Dual-frequency precipitation product	Mean rainfall, observation number, rain pixel number, mean bright-band height, storm height	Monthly	Global (Horizontal: 0.5º grid box, Vertical: 250m)
	DPR/GMI combined algorithm (Japan-US joint)	DPR/GMI combined product	Mean rainfall, observation number, rain pixel number,	Monthly	Global (Horizontal: 0.5º grid box)
	Global precipitation map algorithm	Global precipitation map product	Mean rainfall, observation number, rain pixel number	3-hr/ monthly	Global (Horizontal: 0.1º grid box)

NOTE: Products denoted in light grey will also be processed and provided in near real time. Each near-real-time algorithm will be developed based on the standard algorithm. 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 Updates

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 third CEOS PC International Workshop is scheduled in 29-30 October 2009 in Salt Lake City, U.S., and CEO PC 2009-2010 Work Plan will be released after the workshop.

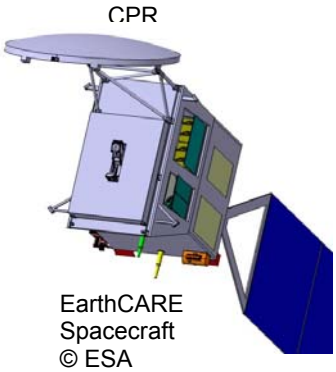
References

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

EarthCARE (Earth Clouds, Aerosols and Radiation Explorer) **and**
CPR (Cloud Profiling Radar)

EarthCARE is a joint European-Japanese mission addressing the need for a better understanding of the interactions between cloud, radiative and aerosol processes that play a role in climate regulation. Japan (JAXA and NiCT) will provide 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.



EarthCARE Spacecraft
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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
Transmit power	> 1.5 kW (Klystron spec.)
Height range	-0.5 ~ 20 km
Resolution	500 m (100 m sample); Vertical, 500m integration; Horizontal
Sensitivity*	-35 ~ +21 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

CPR Standard Products (DRAFT)

Level	Product		Parameter	accuracy			Scene unit	Swath	Spatial resolution	
				Release	Standard	Target			Horizontal	Vertical
1	Cloud product		Received power	<11.2 dB	<9.2 dB		1orb.	0.8km	0.8x0.5km	500m
			Radar reflection factor	<4.7 dB	<2.7 dB	<2.7 dB	1orb.	0.8km	0.8x0.5km	500m
			Normalized scattering cross section of ground	<4.7 dB	<2.7 dB	<2.7 dB	1orb.	0.8km	0.8x0.5km	500m
	Doppler product		Doppler velocity	–	<4.5 m/s		1orb.	0.8km	0.8x0.5km	500m
			Spectral bandwidth	–	–	–	1orb.	0.8km	0.8x0.5km	500m
2	Standalone product	Cloud product	Cloud mask				1orb.	0.8km	0.8x0.5km	500m
			Radar reflection factor with atmospheric correction	<7.7 dB	<5.7 dB	<4.5 dB	1orb.	0.8km	0.8x0.5km	500m
			Profile of Ice water and lquid water contents				1orb.	0.8km	0.8x0.5km	500m
			Profile of optical thickness	<7.7 dB	<5.7 dB	<4.5 dB	1orb.	0.8km	0.8x0.5km	500m
		Doppler product	Doppler velocity		<1m/s	0.2m/s	1orb.	0.8km	0.8x0.5km	500m
			Spectral bandwidth	–	–	–	1orb.	0.8km	0.8x0.5km	500m
	Synergy product		Profile of effective radius with radar and lidar				1orb.	0.8km	0.8x0.5km	500m
			Profile of Ice water and lquid water contents with radar and lidar				1orb.	0.8km	0.8x0.5km	500m
			Profile of optical thickness with radar and lidar				1orb.	0.8km	0.8x0.5km	500m
			Profile of radiative flux			10W/m2	1orb.	0.8km	0.8x0.5km	500m

Data Products and its accuracy are currently under discussion 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

Long-Term Plan of JAXA Earth Observation