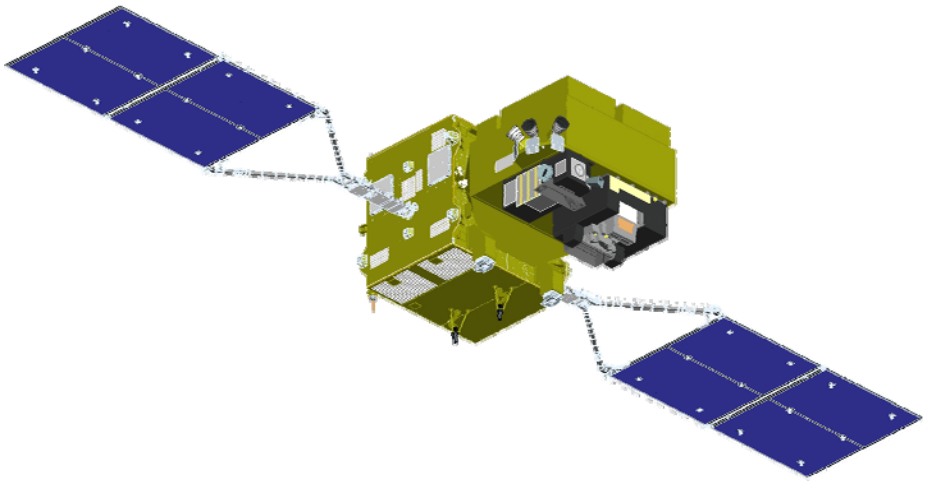
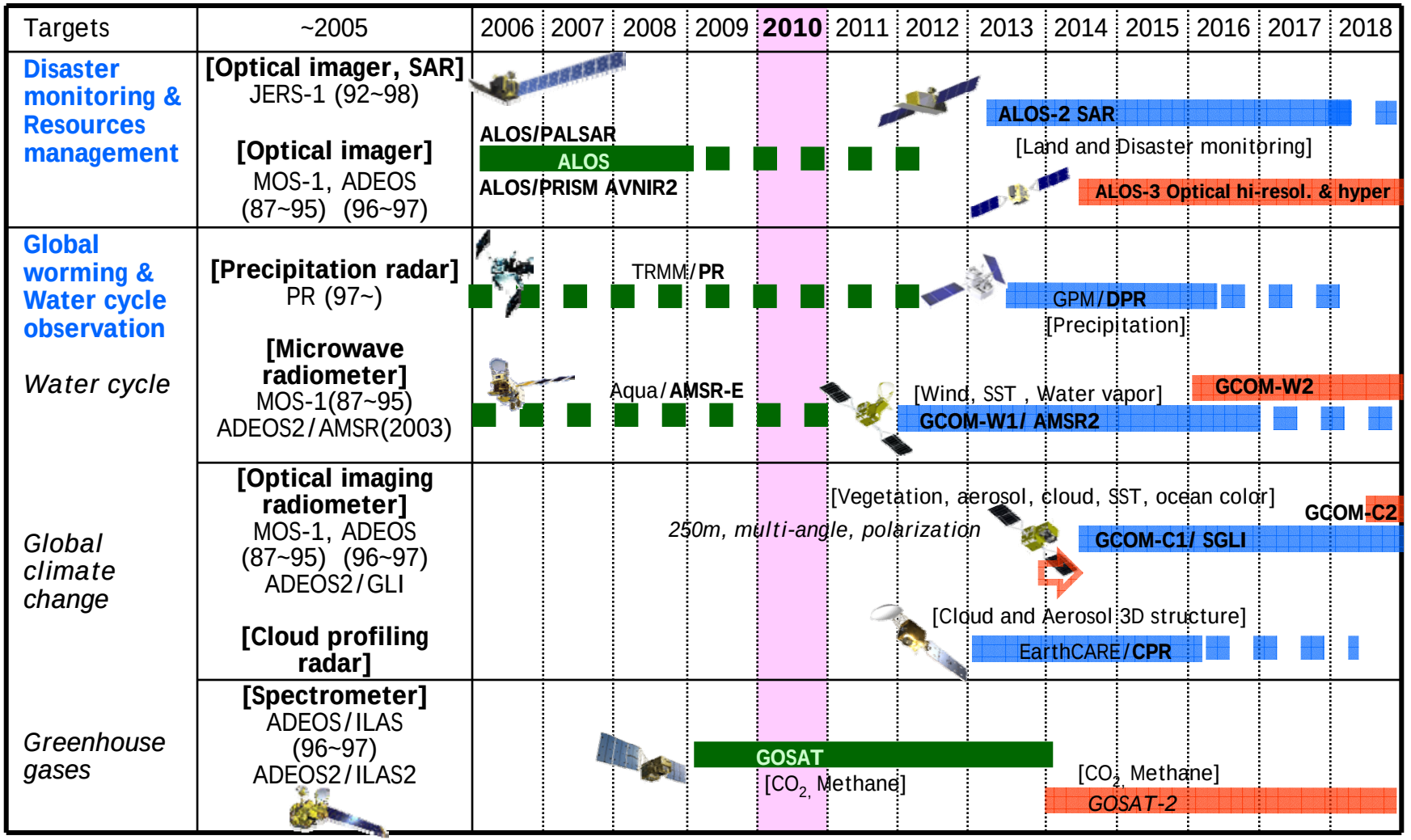
4.13-a
GCOM-C/SGLI progress



Hiroshi Murakami
Earth Observation Research Center,
Japan Aerospace Exploration Agency
IOCCG#15 Jan. 19 2009

1. Status of JAXA satellite missions



2. GCOM-C/SGLI development status

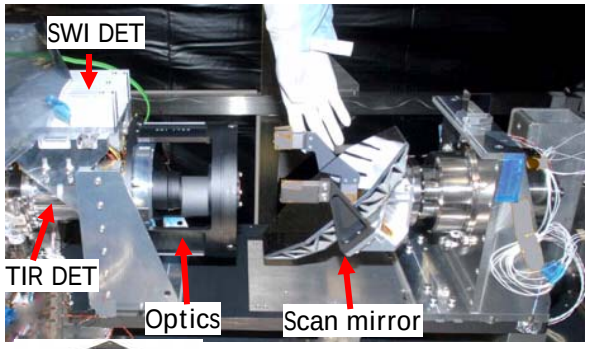
2.1 Milestones of hardware development

Japanese Fiscal Year starts in April and ends in March.

Japanese Fiscal Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
Milestone			GCOM-C1 Project start						GCOM-C1 Launch
			System Definition Review	Preliminary Design Review		Critical Design Review			
GCOM-C1 (SGLI)		Pre-Phase-A	Phase-A	Phase-B	Phase-C		Phase-D		
			SGLI BBM		EM	PFM manufacturing &tests		I&T	Launch preparation

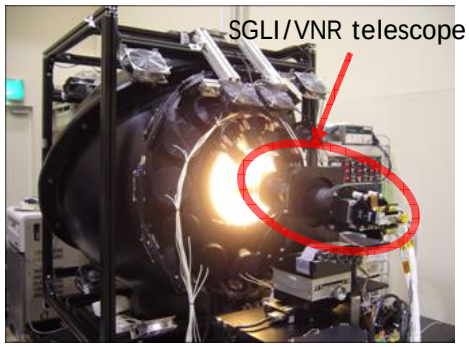
Present

IRS BBM

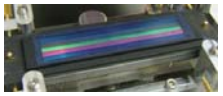


Black body

VNR BBM

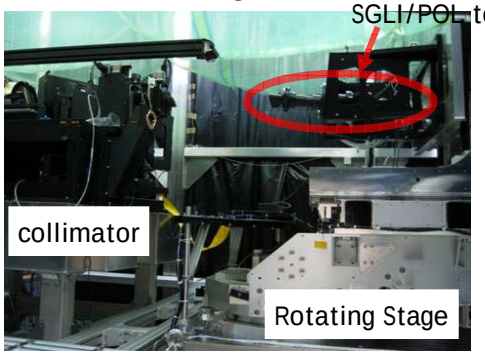


Under evaluation of SNR, Linearity, Gain stability, Spectral response, Stray light..



Detector & Spectral filter assembly

VNR-POL BBM

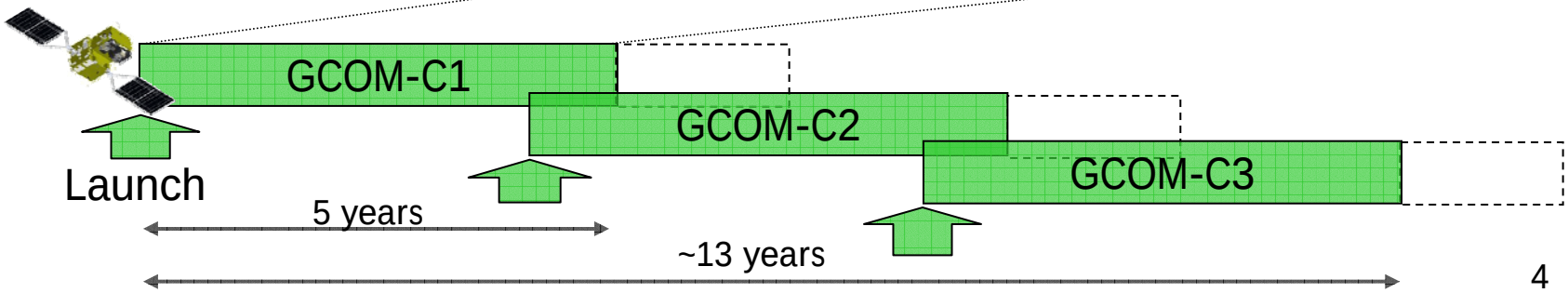


Polarization observation sensitivity..

2. GCOM-C/SGLI development status

2.2 Milestones of Product development

Japanese Fiscal Year Apr~	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Sensor development & calibration	1. Design and trial manufacturing		2. Sensor manufacturing & tests				3. Initial calibration	4. Operation phase				
	BBM		EM		PFM						C2 Launch♦	
	Phase-A	Phase-B	Phase-C		Phase-D							
	♦Project start		♦System PDR	♦System CDR			GCOM-C1 launch♦	♦Data Release			♦Mission result evaluation	
Research Announcement	RA#1♦					♦RA#2			♦RA#3			
Product version ups & Software implementation					Selection	Ver.0♦		Ver.1♦		Ver.2♦	Ver.2.5♦	Ver.3♦ for C-1&2
	Analysis using existing satellite data				Inplementation-1 Performance test	Imple. -2 Operation test		Intensive Cal/Val phase		Improvement with product version up	Implement for C2	Version-ups & improvement
Algorithm development & improvement	1. Initial development		2.Performance development		3. Operational algorithm		4. Post-launch development and improvement phase					
	Development of algorithm performance and operational code											
	•Preparation study •Investigation of candidates		•Theoretical performance and applicability		•Selection & development of operational algorithm		•Product validation and improvement •Achievement of GCOM-C science targets •New algorithm and usage •Succession to the GCOM-C2					



2. GCOM-C/SGLI development status

2.3 GCOM-C Principal Investigators

- *The first research opportunity for GCOM-C was announced in January 2009*
- *The science team, including international participation, has been organized in July 2009 (35 Principal Investigators including 6 foreign PIs from US, France, and UK).*
- *Algorithm development, in-situ data acquisition, and application research using other satellite data are conducted by collaboration among JAXA/EORC and the PI members*

Area	*PI name*	*Organization*
Land	Y. Honda (land reflectance val)	Chiba Univ.
	K. Nasahara (NPP, LAI, Flux..)	Tsukuba Univ.
	K. Kajiwara (biomass by BRF)	Chiba Univ.
	Q-X. Wang (evapotranspiration)	NIES
	A. Ono (water stress, shadow index)	JAXA/EORC
	S. Furuumi (UPDM index)	Narasaho college
	K. Fukue (land cover)	Tokai Univ.
	N. Soyama (land cover)	Tenri Univ.
	M. Moriyama (LST, fire detection)	Nagasaki Univ.
	M. Tasumi (Crop Coefficient)	Miyazaki Univ.
	K. Ichii (model)	Fukushima Univ.
	T. Kaneko (volcano)	Tokyo Univ. ERI
	R. Suzuki (LAI, time series)	JAMSTEC
	A. Huete (Vegetation index)	The University of Arizona
	T. Miura (Vegetation time series)	University of Hawaii at Manoa
	M. Takagi (local land cover, GCP)	Kochi Univ. of Technology
	K. Mabuchi (model)	Meteorological Research Institute
	K. Nakau (fire detect., burned area)	JAXA/EORC

Area	*PI name*	*Organization*
Atmosphere	Takashi Nakajima (cloud)	Tokai Univ.
	M. Kuji (Cloud thickness)	Nara Women's Univ.
	N. Schutgens (aerosol, SKYNET)	Tokyo Univ.
	I. Sano (Pol aerosol, Atm Corr.)	Kinki Univ
	Y. Mano (non spherical)	Meteorological Research Institute
	J. Riedi (Pol cloud)	LOV, Lille Univ
Ocean	M. Toratani (Atmos. Corr)	Tokai Univ.
	R. Frouin (Atmos. Corr. function)	Scripps Institution of Oceanography
	T. Hirawake (NPP/PFT)	Hokkaido Univ.
	T. Hirata (IOP, PFT, model)	Plymouth Marine Laboratory
	J. Ishizaka (redtide)	Nagoya Univ.
	F. Sakaida (SST)	Tohoku Univ.
	S. Saitoh (fishery)	Hokkaido Univ.
	H. Kawamura (coastal monitoring)	Tohoku Univ.
	T. Iida (polar area biology)	National Institute of Polar Research
Cryosphere	T. Aoki (snow size impurity)	Meteorological Research Institute
	K. Stamnes (snow size temperature)	Stevens Institute of Technology

Red: PI team leader
Blue: Group leaders

2. GCOM-C/SGLI development status

2.4 Sensor operation and data distribution policy

- **Sensor operation**
  - ✓ Regular yearly pattern will be prepared considering intensive areas and seasonality before launch
  - ✓ Irregular tilt angles of polarimetry, 1km/250m resolution, and calibration modes will be planned more than three months before the operation
  - ✓ All data will be received at the Svalbard station; near-real time data at a station in Japan
- **Free of charge for internet acquisition**
  - ✓ The standard products (including Levels 1, 2 and 3) will be distributed with free of charge from EORC information system which is a common system for several other missions (Search & download, and FTP directory: TBD)
  - ✓ Re-distribution by users is limited to pre-defined users (to identify users by JAXA)

SGLI basic operation modes*

Basic modes	VN1-8,10-11	VN9, SW1-2	SW3	SW4	T1-2	P1-2	
Day-land/coast	250m	1km	250m	1km	500m 250m**	1km	+45° −45°
Day-offshore/polar	1km	1km	1km	1km	1km	1km	+45° −45°
Night-land	OFF	OFF	250m	1km	500m 250m**	OFF	
Night-coast	OFF	OFF	OFF	OFF	500m 250m**	OFF	
Night-offshore/polar	OFF	OFF	OFF	OFF	1km	OFF	

*: Other modes for cal/val and special requests will be planned more than three months before the operation

**: 250m mode is limited by downlink data volume per a path

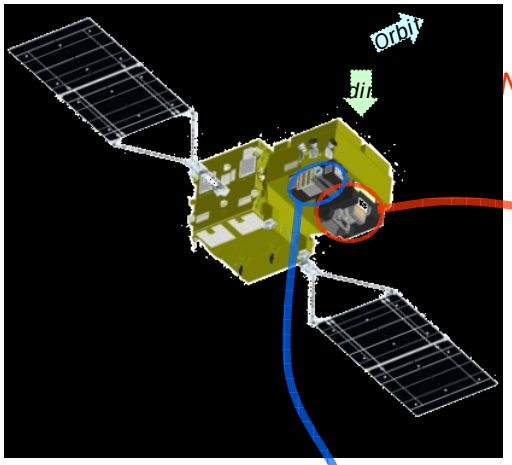
Band	λc
VN1	380nm
VN2	412nm
VN3	443nm
VN4	490nm
VN5	530nm
VN6	565nm
VN7	673.5nm
VN8	673.5nm
VN9	763nm
VN10	868.5nm
VN11	868.5nm
P1	673.5nm
P2	868.5nm
SW1	1050nm
SW2	1380nm
SW3	1630nm
SW4	2210nm
T1	10.8um
T2	12.0um

3. Summary

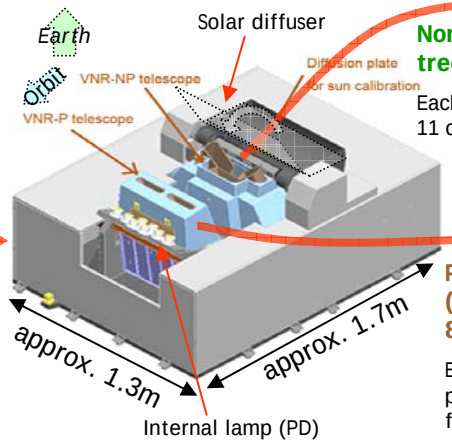
- *GCOM-C targets*
  - Improvement of knowledge and future prediction of the climate system through long-term observations regarding radiation budget and carbon cycle
- *GCOM-C/SGLI characteristics*
  - 250-m resolution and 1150-km swath for the land and coast observations
  - Near-UV and polarization observation for the land aerosol estimation
  - Multi-angle observation for the biomass and land cover classification
- *Schedule*
  - Satellite, sensor (finished the first component studies), and algorithm are developing for the launch in 2014
  - Governmental mission evaluation has been done (Nov.-Dec. 2009), but..
  - GCOM-C PI team (2009-2012) has organized in summer 2009 through the first research announcement
  - The first PI workshop was held in Tokyo Jan. 12-14 2010
- *Science challenges*
  - Integrated use of GCOM-C and other data (in-situ and other satellites) for the global estimation and model improvement
  - Optical connection between satellite and (bio/)physical parameters for the optimum use of the multi-spectral, multi-angle, and polarization observations
- *Others*
  - International collaboration (JAXA-CNES, GCOM-NOAA..) are discussed

Backup

SGLI design

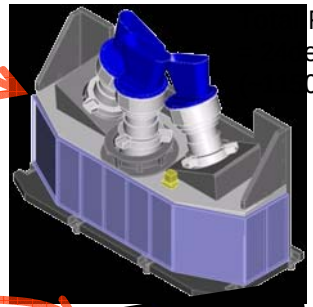


Visible and Near-infrared Radiometer (SGLI-VNR)



Non-polarization tree telescopes

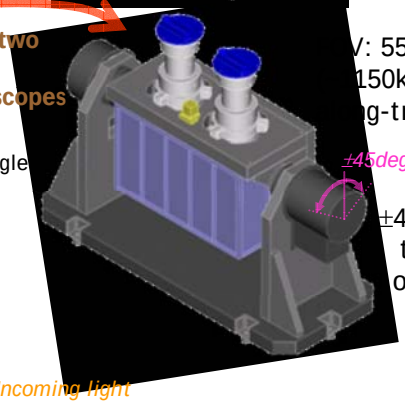
Each has the same 11 channels



FOV: 70deg
eg × 3 telescopes
0km@nadir)

Polarization two (670nm and 865nm) telescopes

Each has tree polarization-angle filters

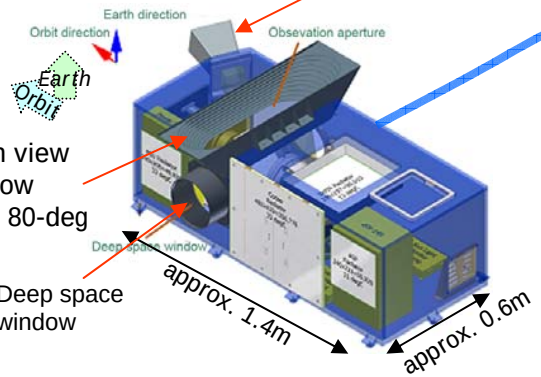


V: 55deg
150km@±45deg
g-track slant)

±45deg along-track slant observation

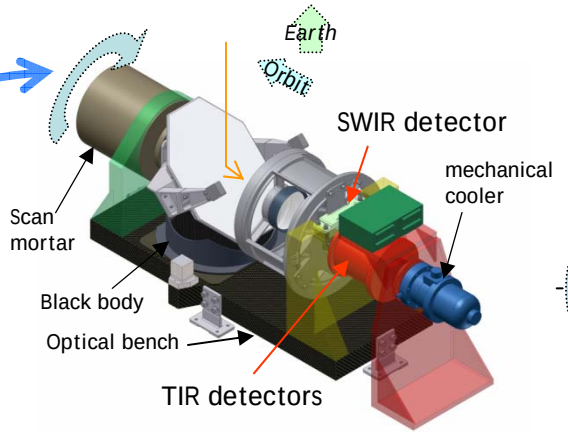
InfraRed Scanner (SGLI-IRS)

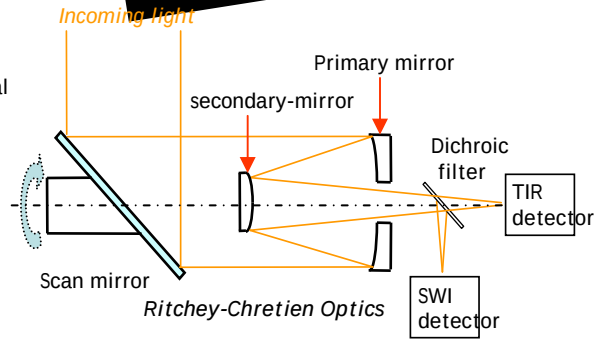
Solar calibration window



Earth view window FOV: 80-deg

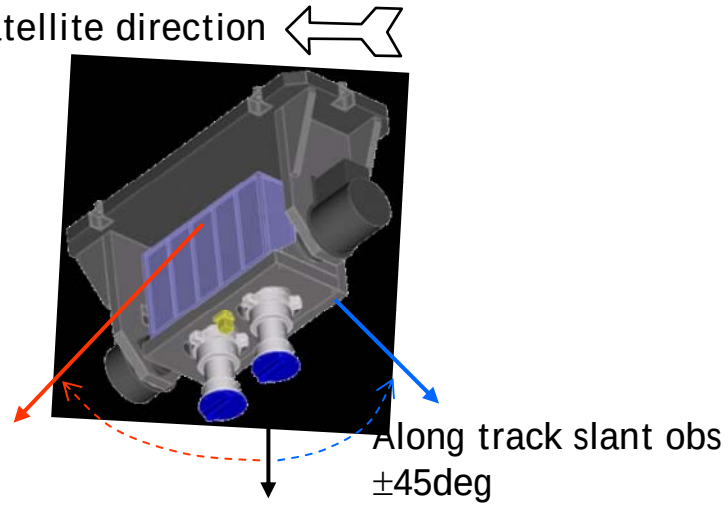
Deep space window

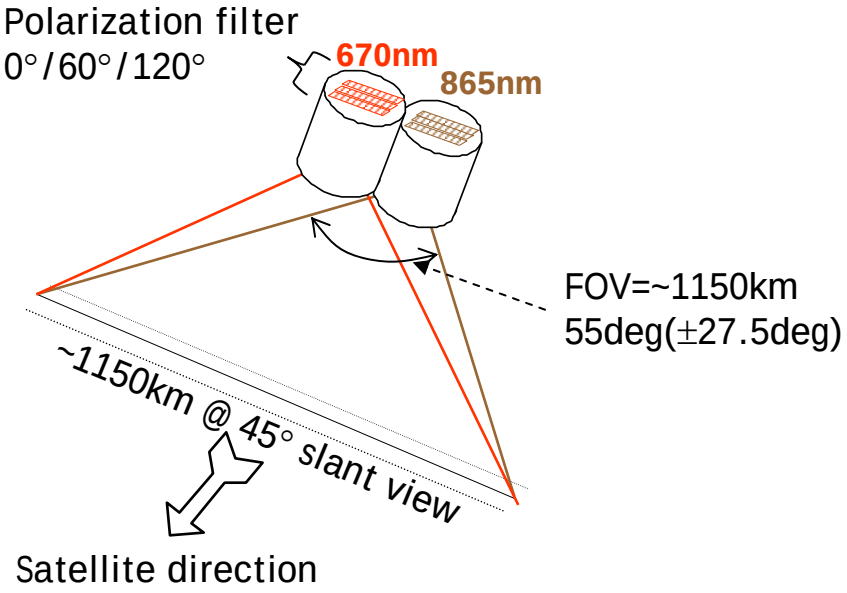


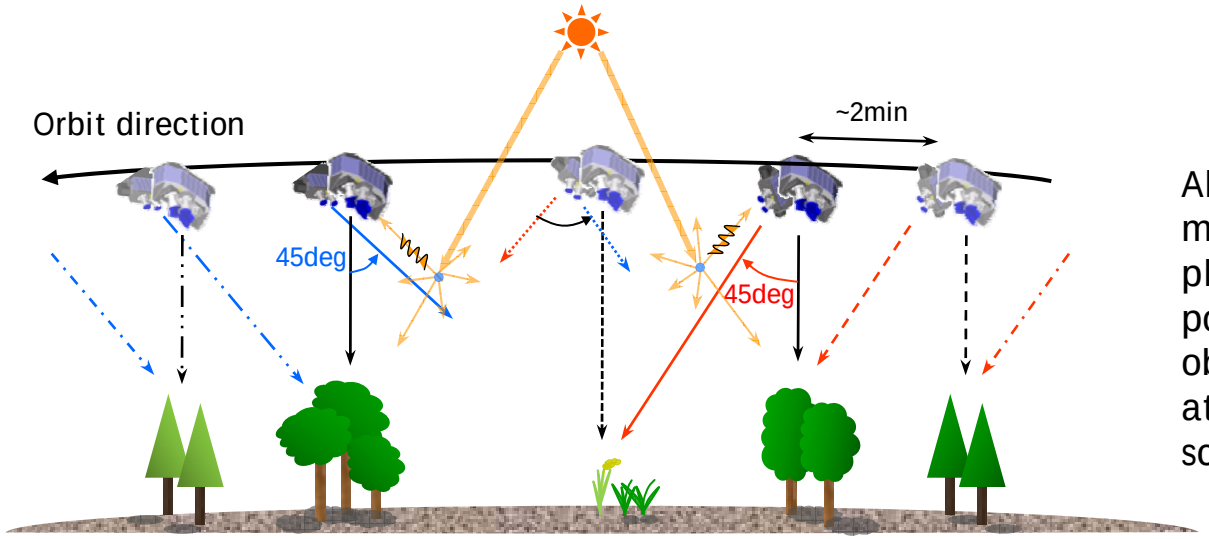


- SGLI initial design and trial manufacturing (breadboard model: BBM) has been done in 2009.
- The BBM includes non-polarized and polarized telescopes, spectral filter assembly, mirror scanning system, detector cooling system, and onboard calibration systems.
- Their results will be reflected to the next engineering model (EM) development.

SGLI Polarimetry







Along-track ±45deg modes will be planned for polarization observation of the atmospheric scattering

GCOM-C development status

Satellite orbit and SGLI specification

- The SGLI features are finer spatial resolution (250m (VNI) and 500m (T)) and polarization/along-track slant view channels (P), which will improve land, coastal, and aerosol observations.

GCOM-C SGLI characteristics (Current baseline)	
Orbit	Sun-synchronous (descending local time: 10:30) Altitude: 798km, Inclination: 98.6deg
Launch Date	Jan. 2014 (HII-A)
Mission Life	5 years (3 satellites; total 13 years)
Scan	Push-broom electric scan (VNR: VN & P) Wisk-broom mechanical scan (IRS: SW & T)
Scan width	1150km cross track (VNR: VN & P) 1400km cross track (IRS: SW & T)
Digitalization	12bit
Polarization	3 polarization angles for P
Along track direction	Nadir for VN, SW and T, +45 deg and -45 deg for P
On-board calibration	VN: Solar diffuser, Internal lamp (PD), Lunar by pitch maneuvers, and dark current by masked pixels and nighttime obs. SW: Solar diffuser, Internal lamp, Lunar, and dark current by deep space window T: Black body and dark current by deep space window All: Electric calibration

Multi-angle obs. for 674nm and 869nm

250m over the Land or coastal area, and 1km over offshore

SGLI channels						
CH	λ	Δλ	L_{std}	L_{max}	SNR at Lstd	IFOV
	VN, P, SW: nm T: μm		VN, P: W/m²/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	*1200*	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	1000
T1	10.8	0.7	300	340	0.2	500
T2	12.0	0.7	300	340	0.2	500

250m-mode possibility ~15min /path (TBC)

GCOM-C products (1/3)

GCOM-C products accuracy targets (Standard-1)

Area	group	Product	Day/night	Grid size	Release threshold[*1]	Standard accuracy[*1]	Target accuracy[*1]
Common	radiance	TOA radiance (including system geometric correction)	TIR and land 2.2μm: both Other VNR,SWI: daytime (+special operation)	VNR,SWI Land/coast: 250m, offshore: 1km, polarimetory:1km TIR Land/coast: 500m, offshore: 1km	Radiometric 5% (absolute[*3])[*5] Geometric<1pixel	VNR,SWI: 5% (absolute[*3]), 1% (relative[*4]) TIR: 0.5K (@300K) Geometric<0.5pixel	VNR,SWI: 3% (absolute[*3]), 0.5% (relative[*4]) TIR: 0.5K (@300K) Geometric<0.3pixel
Land	Surface reflectance	Precise geometric correction	both	250m	<1pixel[*6]	<0.5pixel[*6]	<0.25pixel[*6]
		Atmospheric corrected reflectance (incl. cloud detection)	Daytime	250m	0.3 (<=443nm), 0.2 (>443nm) (scene) [*7]	0.1 (<=443nm), 0.05 (>443nm) (scene) [*7]	0.05 (<=443nm), 0.025 (>443nm) (scene)[*7]
	Vegetation and carbon cycle	Vegetation index		250m	Grass:25%(scene), forest:20%(scene)	Grass:20%(scene), forest:15%(scene)	Grass:10%(scene), forest:10%(scene)
		Above-ground biomass		1km	Grass:50%, forest: 100%	Grass:30%, forest:50%	Grass:10%, forest:20%
		Vegetation roughness index		1km	Grass&forest: 40% (scene)	Grass& forest:20% (scene)	Grass&forest:10% (scene)
		Shadow index		250m, 1km	Grass&forest: 30% (scene)	Grass& forest:20% (scene)	Grass&forest:10% (scene)
		fAPAR		250m	Grass:50%, forest: 50%	Grass:30%, forest:20%	Grass:20%, forest:10%
		Leaf area index		250m	Grass:50%, forest: 50%	Grass:30%, forest:30%	Grass:20%, forest:20%
	temperature	Surface temperature	Both	500m	<3.0K (scene)	<2.5K (scene)	<1.5K (scene)

Common note:

*1: The “release threshold” is minimum levels for the first data release at one year from launch. The "standard" and "research" accuracies correspond to full- and extra success criteria of the mission respectively. Accuracies are shown by RMSE basically.

Radiance data note:

*2: TOA radiance is derived from sensor output with the sensor characteristics, and other products are physical parameters estimated using algorithms including knowledge of physical, biological and optical processes

*3: absolute error is defined as offset + noise

*4: relative error is defined as relative errors among channels, FOV, and so on.

*5: Release threshold of radiance is defined as estimated errors from vicarious, onboard solar diffuser, and onboard blackbody calibration because of lack of long-term moon samples

Land data note:

*6: Defined as RMSD from GCP

*7: Defined with land reflectance~0.2, solar zenith<30deg, and flat surface. Release threshold is defined with AOT@500nm<0.25

GCOM-C products (2/3)

GCOM-C products accuracy targets (Standard-2)

Area	Group	Product	Day/night	Grid size	Release threshold[*1]	Standard accuracy[*1]	Target accuracy[*1]
Atmosphere	Cloud	Cloud flag/Classification	Both	1km	10% (with whole-sky camera)	Incl. below cloud amount	Incl. below cloud amount
		Classified cloud fraction	Daytime	1km (scene), 0.1deg (global)	20% (on solar irradiance)[*8]	15%(on solar irradiance)[*8]	10%(on solar irradiance)[*8]
		Cloud top temp/height	Both		1K[*9]	3K/2km (top temp/height)[*10]	1.5K/1km (temp/height)[*10]
		Water cloud OT/effective radius	Daytime		10%/30% (CloudOT/radius) [*11]	100% (as cloud liquid water[*13])	50%[*12] / 20%[*13]
		Ice cloud optical thickness			30%[*11]	70%[*13]	20%[*13]
	aerosol	Aerosol over the ocean			0.1(Monthly τa_670,865)[*14]	0.1(scene τa_670,865)*[14]	0.05(scene τa_670,865)
		Land aerosol by near ultra violet			0.15(Monthly τa_380)[*14]	0.15(scene τa_380)[*14]	0.1(scene τa_380)
		Aerosol by Polarization			0.15(Monthlyτa_670,865)[*14]	0.15(scene τa_670,865)[*14]	0.1(scene τa_670,865)
Ocean	Ocean color	Normalized water leaving radiance (incl. cloud detection)	Daytime	250m (coast) 1km (offshore) 4~9km (global)	60% (443~565nm)	50% (<600nm) 0.5W/m^2/str/um (>600nm)	30% (<600nm) 0.25W/m^2/str/um (>600nm)
		Atmospheric correction param			80% (AOT@865nm)	50% (AOT@865nm)	30% (AOT@865nm)
		Photosynthetically available radiatioin			20% (10km/month)	15% (10km/month)	10% (10km/month)
	In-water	Chlorophyll-a concentration			–60~+150% (offshore)	–60~+150%	–35~+50% (offshore), –50~+100% (coast)
		Suspended solid concentration			–60~+150% (offshore)	–60~+150%	–50~+100%
		Colored dissolved organic matter			–60~+150% (offshore)	–60~+150%	–50~+100%
	temperature	Sea surface temperature	Both	500m (coast) 1km (offshore) 4~9km (global)	0.8K (daytime)	0.8K (day&night time)	0.6K (day&night time)
Cryosphere	Area/ distribution	Snow and Ice covered area (incl. cloud detection)	Daytime	250m (scene) 1km (global)	10% (vicarious val with other sat. data)	7%	5%
		OKhotsk sea-ice distribution		250m	10%	5%	3%
	Surface properties	Snow and ice surface Temperature		500m (scene) 1km (global)	5K (vicarious val with other sat. data and climatology)	2K	1K
		Snow grain size of shallow layer		250m (scene) 1km (global)	100%(vicarious val with climatology between temp-size)	50%	30%

Atmosphere note:

*8: Comparison with in-situ observation on monthly 0.1-degree

*9: Vicarious val. on sea surface and comparison with objective analysis data

*10: Inter comparison with airplane remote sensing on water clouds of middle optical thickness

*11: Release threshold is defined by vicarious val with other satellite data (e.g., global monthly statistics in the mid-low latitudes)

*12: Comparison with cloud liquid water by in-situ microwave radiometer

*13: Comparison with optical thickness by sky-radiometer (the difference can be large due to time-space inconsistence and large error of the ground measurements)

*14: Estimated by experience of aerosol products by GLI and POLDER

GCOM-C products (3/3)

GCOM-C products accuracy targets (Research product)

Area	Group	Product	Day/night	Grid size	Release threshold*1
Land	Application	Land net primary production	Daytime	1km	30% (yearly)
		Water stress trend	N/A	500m	10% *15 (error judgment rate)
		Fire detection index	Both	500m	20% *16 (error judgment rate)
		Land cover type	Daytime	250m	30% (error judgment rate)
		Land surface albedo		1km	10%
Atmosphere	Cloud	Water cloud geometrical thickness	Daytime	1km (scene), 0.1deg (global)	300m
	Radiation budget	Long-wave radiation flux			Downward 10W/m2, upward 15W/m2 (monthly)
		Short-wave radiation flux			Downward 13W/m2, upward 10W/m2
Ocean	Ocean color	Euphotic zone depth	Daytime	250m (coast), 1km (offshore), 4~9km (global)	30%
	In-water	Inherent optical properties			a(440): RMSE<0.25, bbp(550): RMSE<0.25
	Application	Ocean net primary productivity		500m (coast), 1km (offshore), 4~9km (global)	70% (monthly)
		Phytoplankton functional type		250m (coast), 1km (offshore), 4~9km (global)	error judgment rate of large/ small phytoplankton dominance<20%; or error judgment rate of the dominant phytoplankton functional group <40%
		Redtide			error judgment rate <20%
		multi sensor merged ocean color		250m (coast), 1km (offshore)	–35~+50% (offshore), –50~+100% (coast)
		multi sensor merged SST	Both	500m (coast), 1km (offshore)	0.8K (day&night time)
Cryosphere	Area/ distribution	Snow and ice classification	N/A	1km	10%
		Snow covered area in forest and mountain	Daytime	250m	30%
	Surface propaties	Snow grain size of subsurface layer		1km	50%
		Snow grain size of top layer		250m(scene), 1km (global)	50%
		Snow and ice albedo		1km	7%
		Snow impurity		250m(scene), 1km (global)	50%
		Ice sheet surface roughness	N/A	1km	0.05 (height/width)
	Boundary	Ice sheet boundary monitoring	N/A	250m	<500m

Research product note:

*15: Evaluate in semiarid regions (steppe climate etc.)

*16: Fires >1000K occupying >1/1000 on 1km pixel at night (using 2.2um of 1 km and thermal infrared channels)