Global Change Observation Mission (GCOM)

Ocean Vector Winds Science Team Meeting

Boulder, CO

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EORC, JAXA

GEOSS 10 year implementation plan

Earth System Model
- Ocean
- Cryosphere
- Land
- Atmosphere
- Solid Earth
- Biosphere

Prediction & Analysis
High speed computing & communication
Visualization

Assimilation

Other data
Socio-economic data

Earth observation system
- In-situ observation
- Airborne observation
- Satellite observation

Interoperability
Criterion

Observation

Policy decision support
- Evaluation
- Decision support system

Policy decision

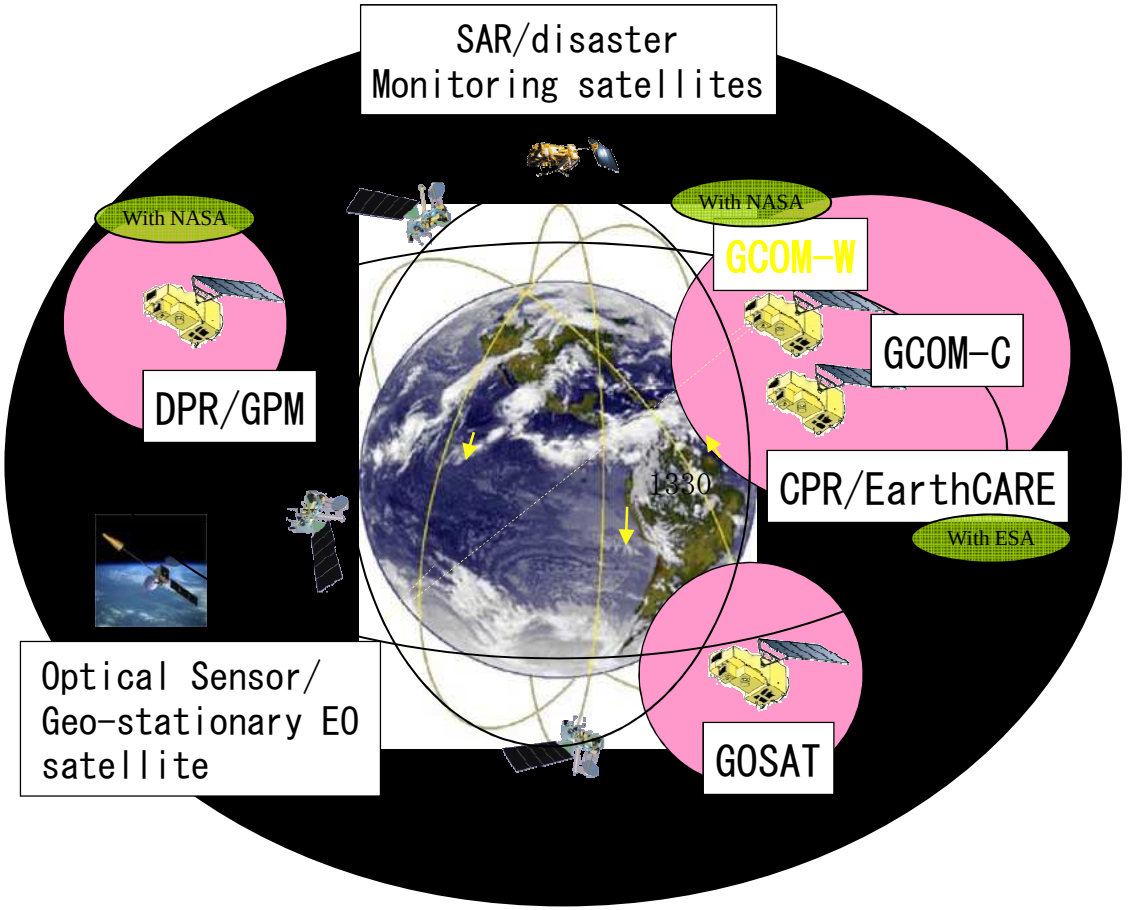
Value optimization, Elimination of gap areas,
Continuous feedback for human activity understanding

GCOS
Essential Climate Variables (ECV)
Require continuous satellite products

9 Societal benefit areas

To develop and operate an Earth Observation Network for GEOSS

To develop advanced satellites
→to aim cutting edge system and mutual complementary system to the operational system such as WWW, NPOESS



A plan of advanced satellites

Sea surface wind vector	AMSR 2, Scatterometer (GCOM-W)
SST	AMSR 2 (GCOM-W) SGLI (GCOM-C)
Cloud structure	Cloud Profiling Radar (EarthCARE)
Aerosol	SGLI (GCOM-C)
CO_2 concentration	TANSOr (GOSAT)
Precipitation	Dual-frequency Precipitation Radar (GPM)
Disaster monitoring	SAR/disaster monitoring satellites, Optical Sensor/ Geo-stationary EO satellite

GCOM Mission

- **Continuation of ADEOS Ⅱ**
- **Contribution to GEOSS**
- **Climate, Weather, Water, Ecosystem, Agriculture, etc. in GEOSS 9 areas**
- **Focus on Climate change / Global warming and Water cycle committed in Summit**
- **Contribution to operational fields like weather forecast, fisheries, etc.**
- **Long term continuous measurements**

Scientific Targets

- **Accurate estimation of aerosol radiative forcing**
- **Validation of climate models**
- **Accurate estimation of primary production**
- **Better understanding of coastal phenomena**
- **Better understanding of sea ice trend**

Operational Applications

- **Input to NWP**
- **Extreme weather forecasting**
- **Fisheries**
- **Navigation**
- **Coastal management**
- **Crop yield estimation**
- **Monitoring forest decrease**
- **Monitoring volcano eruptions**
- **Monitoring forest fire**

GCOM satellites

- **GCOM-W1**
  - **AMSR2 (Advanced Microwave Scanning Radiometer 2)**
  - **Planned to be launched in fiscal, 2011**
- **GCOM-C1**
  - **SGLI (Second generation Global Imager)**
  - **Planned to be launched in fiscal 2013**
- **Plan for the 2nd and 3rd generations**
  - **GCOM-W2 (in 2015), GCOM-W3 (in 2019)**
  - **GCOM-C1 (in 2017), GCOM-C3 (in 2021)**

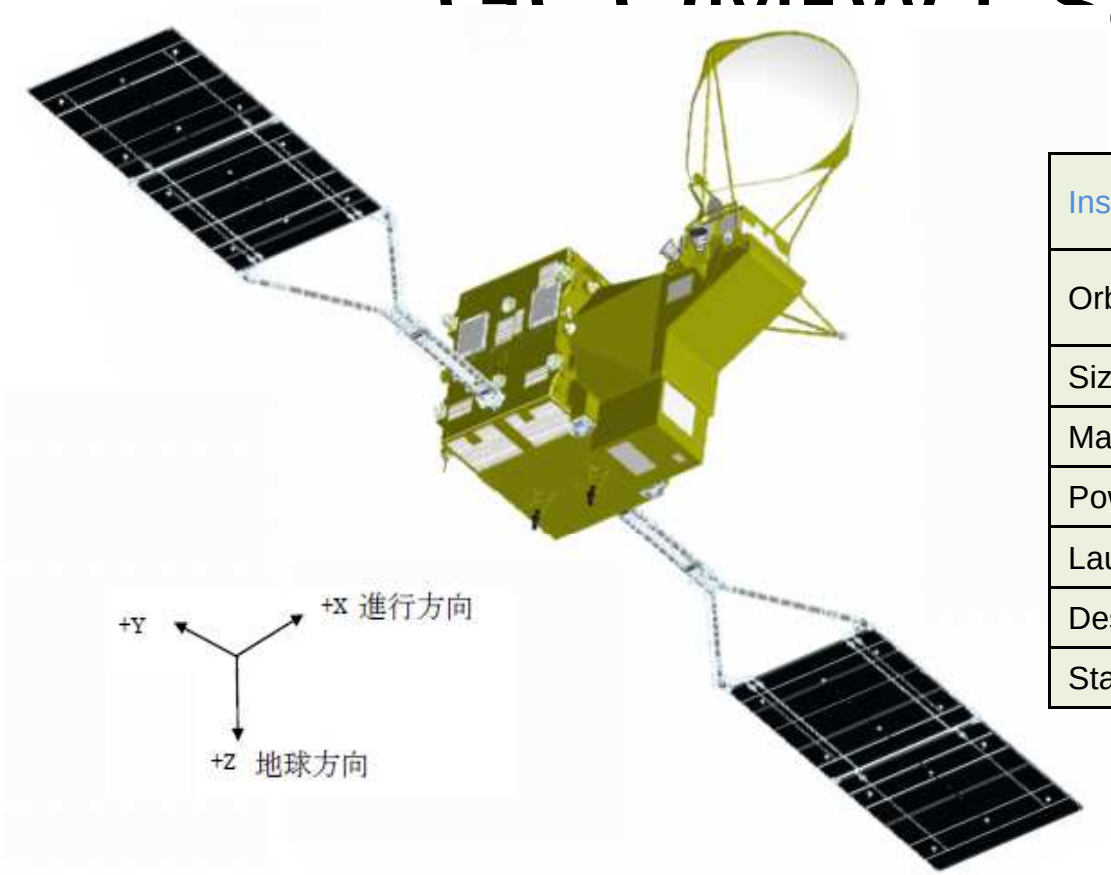
GCOM-W1

- Orbit
  - Sun synchronous orbit
  - Height: about 700km
  - Local time of ascending node: 13:30
- Weight: about 1.9t
- Power Consumption: about 4kW
- Lifetime: 5 years
- Data transmission
  - Global observation data are stored and transmitted every orbit period
  - Observed data are transmitted to ground stations in real time

Downlink

- Freq : 8245MHz
- Polarization : RHCP
- Modulation : OQPSK
- Data Rate : 10Mbps (20Msps)
- Coding : CCSDS, Reed-Solomon, convolution

GCOM-W1 satellite



GCOM-W (Water)

Instrument	Advanced Microwave Scanning Radiometer-2
Orbit	Sun Synchronous orbit Altitude：699.6km (over the equator)
Size	5.1m (X) * 17.5m (Y) * 3.4m (Z)
Mass	1880kg
Power	Over 4050W
Launch	JFY2011 (CY2012 Winter)
Design Life	5-years
Status	Preliminary Design started in JFY2007

- *GCOM-W1/AMSR2 will contribute to long-term observation of global water and energy cycle.*
- *Continue AMSR-E observation (high spatial resolution, low-frequency channels,etc.).*
- *Construct reliable long-term dataset to contribute for understanding and monitoring of climate change.*
- *Contribute to operational use by providing continuous cloud-through SST, frequent and quantitative storm observation to maintain precipitation forecast accuracy.*

Basic requirements for AMSR 2

- Minimum modifications from AMSR on ADEOS-II to reduce risks/cost and keep the earliest launch date.
- Several essential improvements.
  - Improvement of calibration system including warm load calibration target.
  - Consideration to C-band radio frequency interference (RFI).
- Combination with SeaWinds-type scatterometer is highly desired.

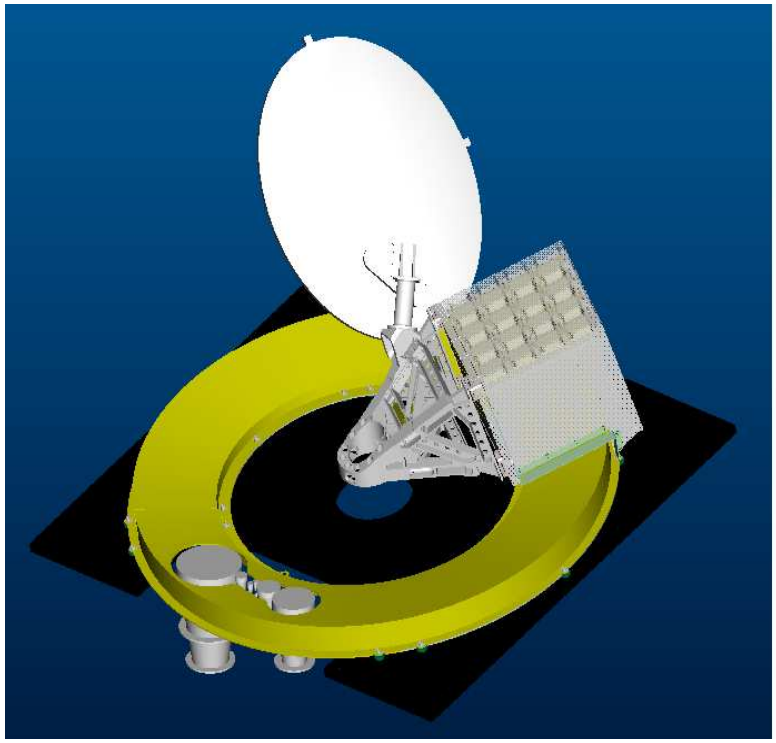
Basic requirements for AMSR 2

- Antenna : 2.0m, offset parabolic antenna
- Channel sets
  - Identical to AMSR-E (no O_2 band channels)
  - 6.925,7.3, 10.65, 18.7, 23.8, 36.5, 89.0GHz
  - Dual polarization
- Calibration
  - Improvements of hot load etc.
  - Enhance pre-launch calibration testing
- Orbit
  - Afternoon orbit with 700~800km altitude
- Mission life
  - 5 years

Improvement of hot load

- Adoption of temperature controlled reflector over hot load
- Minimize the effect of thermal interference
- Design results shows the maximum temperature difference less than 2K
- Brightness temperature accuracy will be around 0.1K

Prototyping and testing



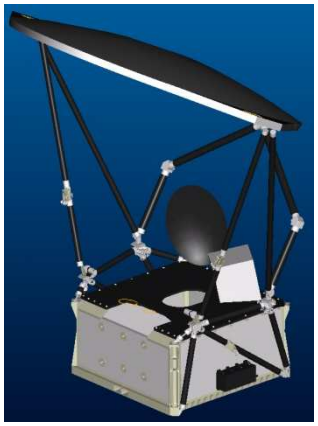
Calibration Assembly

MPU testing board

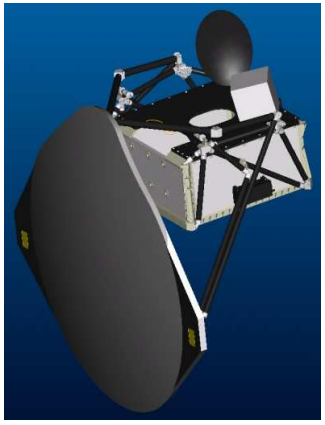
Temperature Resolution

Frequency	Resolution(target)
6.925	<0.34(0.3)
7.3	<0.43
10.65	< 0.7(0.6)
18.7	< 0.7(0.6)
23.8	< 0.6(0.55)
36.5	< 0.7(0.65)
89.0	< 1.2(1.1)

Overview of AMSR2 instrument



Deployed



Stowed

- Deployable main reflector system with 2.0m diameter.
- Frequency channel set is identical to that of AMSR-E except 7.3GHz channel for RFI mitigation.
- Two-point external calibration with the improved HTS (hot-load).
- Deep-space maneuver will be considered to check the consistency between main reflector and CSM.

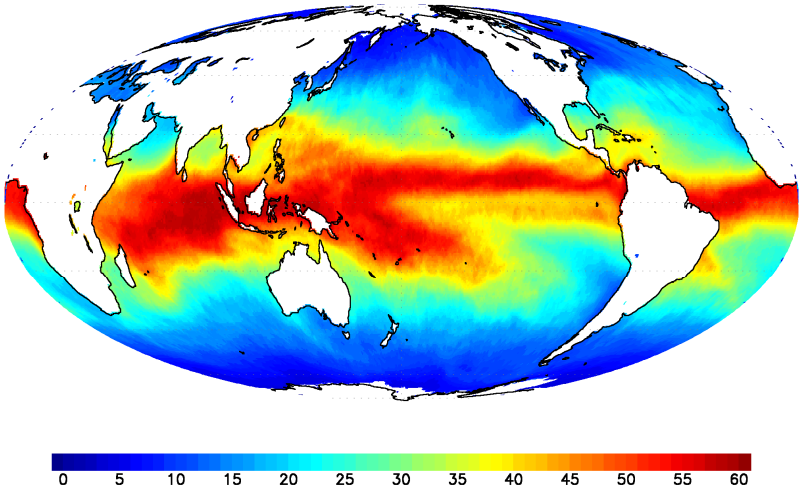
GCOM-W1/AMSR2 characteristics	
Orbit	Sun Synchronous with 699.6km altitude (over the equator)
Launch	JFY2011
Design-Life	5-years
Local time	13:30 LTAN
Swath width	1450km
Antenna	2.0m offset parabola
Incidence angle	Nominal 55 degree

AMSR2 Channel Set				
Center Freq. [GHz]	Band width [MHz]	Polarization	Beam width [deg] (Ground res. [km])	Sampling interval [km]
6.925 / 7.3	350	V and H	1.8 (35 x 62)	10
			1.7 (34 x 58)	
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

Oceanic geophysical parameters by AMSR

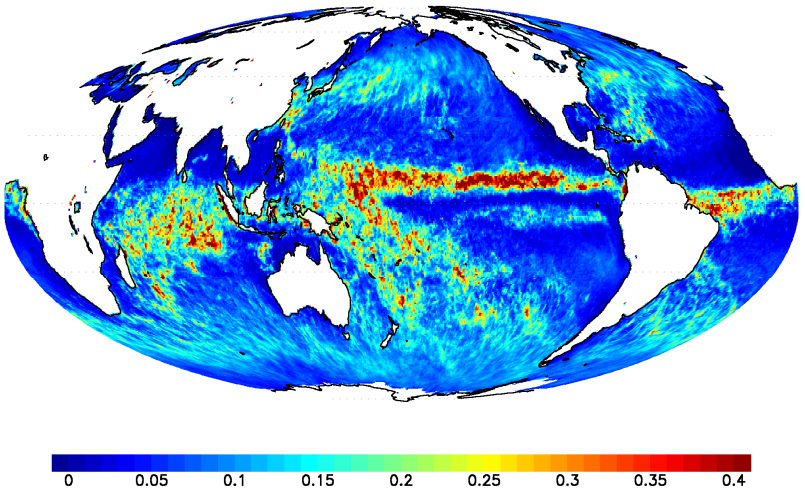
Global Monthly Mean in April 2003

AMSR 200304 Monthly TPW (kg/m2) Takeuchi Algorithm



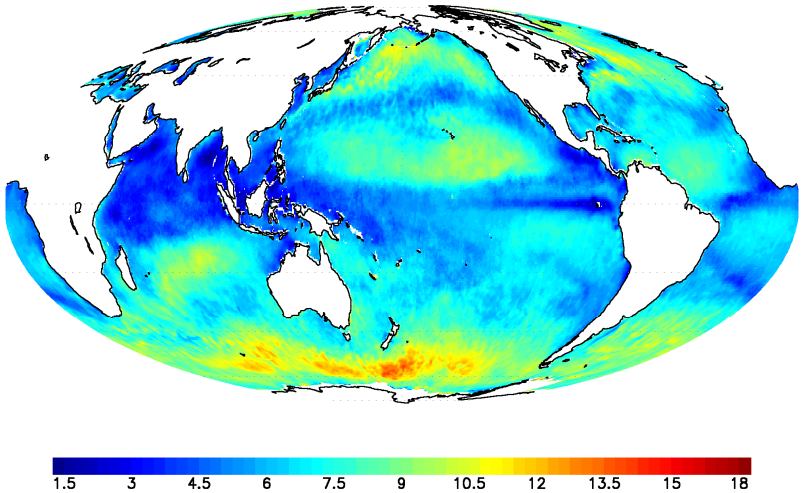
Total precipitable water

AMSR 200304 Monthly CLW (kg/m2) Wentz Algorithm



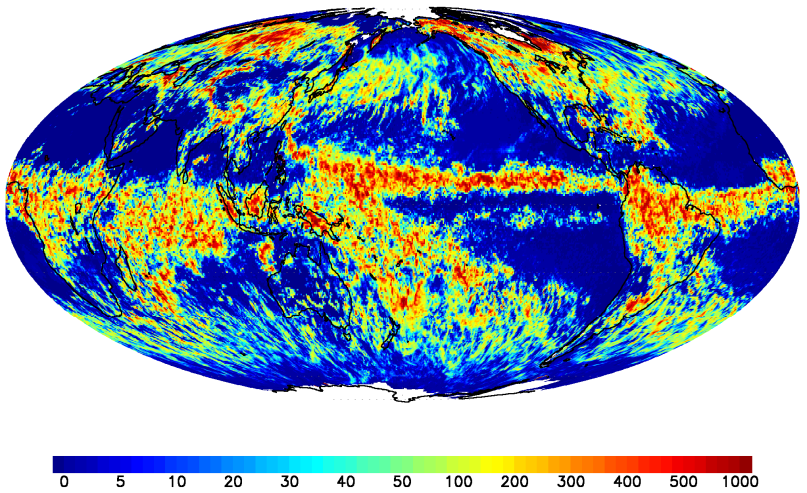
Cloud liquid water

AMSR 200304 Monthly SSW (m/s) Shibata Algorithm



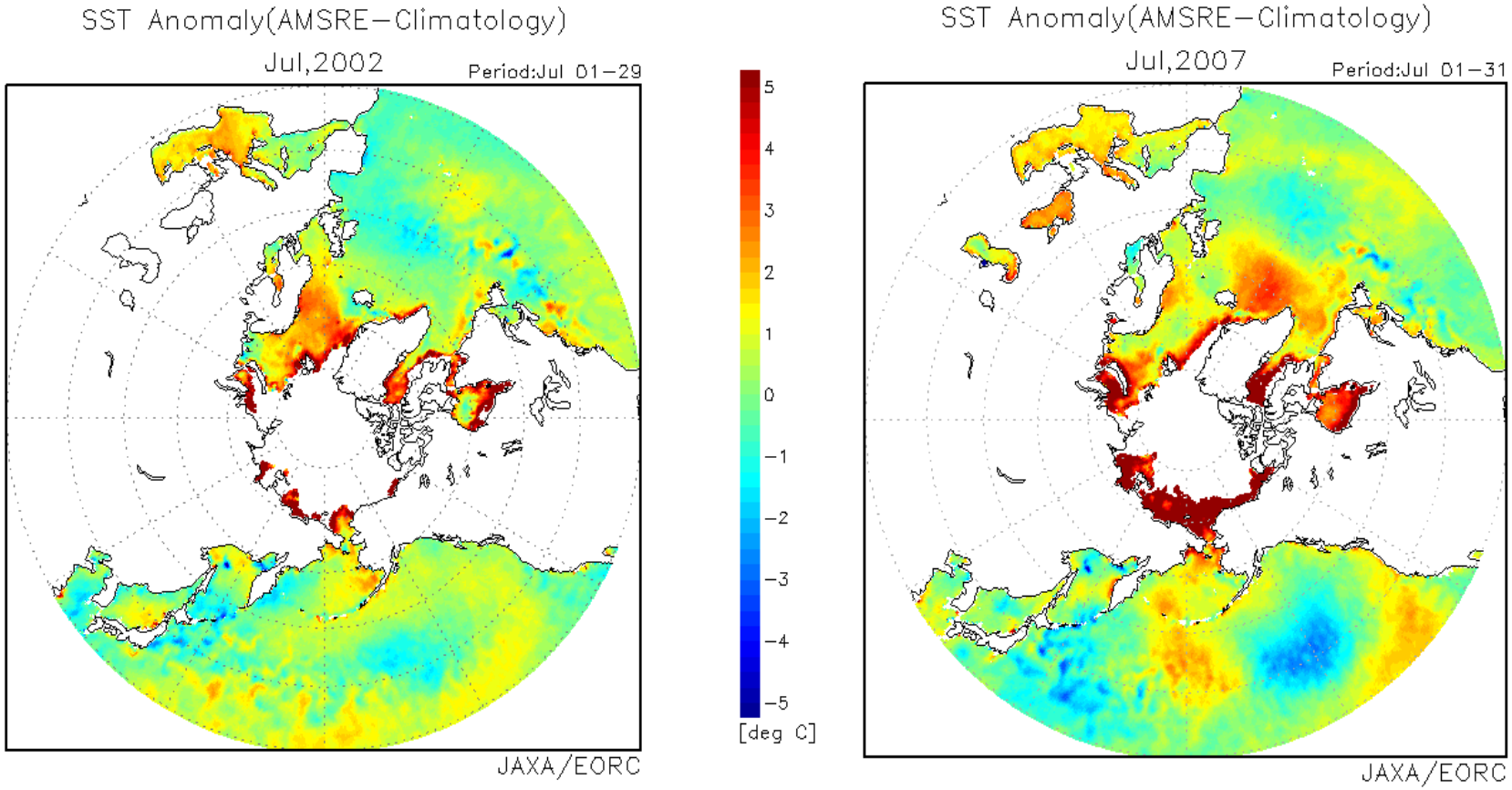
Sea surface wind speed

AMSR 200304 Monthly Precip. (mm) Liu Algorithm



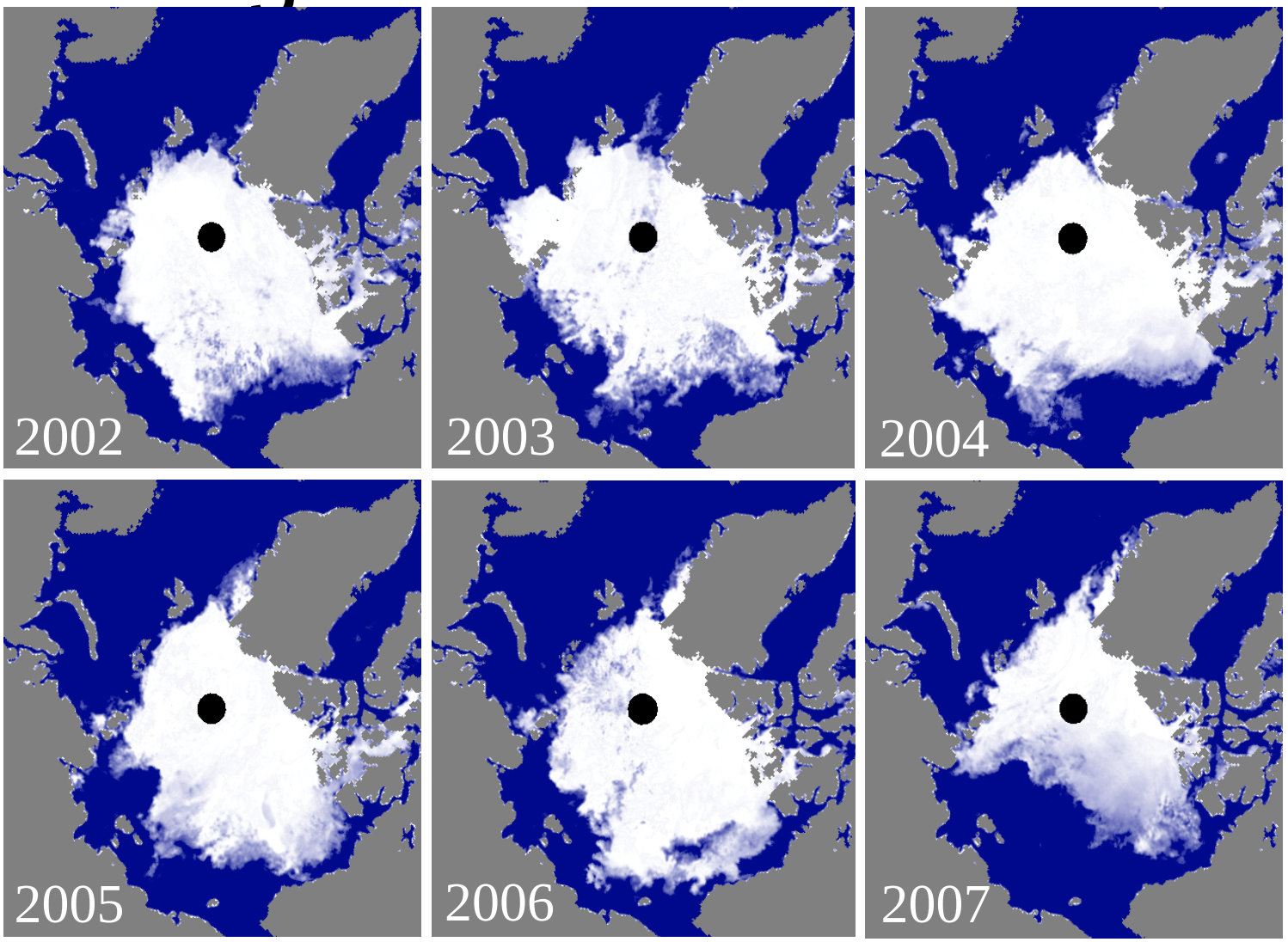
Precipitation

SST anomaly in northern high latitudes



Monthly SST anomaly in northern high latitude oceans for July 2002 (left) and July 2007 (right).

Changes in AMSR-E sea ice



AMSR-E sea ice extent over northern polar region on August 20 of recent 6 years (2002-2007). Images were obtained from the Arctic Sea-Ice Monitor site maintained by the International Arctic Research Center (http://www.ijis.iarc.uaf.edu/en/index.htm).

products	IFOV	std. accr.	dynamic range
brightness temp.	5-50km	±1.5K	2.7-340K
total prec. water	15km	±3.5kg/m^3	0-70kg/m^3
cloud liq. water	15km	±0.05kg/m^2	0-1.0kg/m^2
precipitation	15km	Ocean: 50% Land:±120%	0-20mm/h
SST	50km	±5 ℃	-2-35℃
sea surf. winds	15km	±1m/s	0-30m/s
sea ice conc.	15km	±10%	0-100%
snow depth	30km	±20cm	0-100cm
soil moisture	50km	±10%	0-40%

CGOM-C1

- Orbit
  - Sun synchronous orbit
  - Height: about 800km
  - Local time of descending node: 10:30
- Weight: about 2.0t
- Power Consumption: about 4kW
- Lifetime: 5 years
- Data transmission
  - Global observation data are stored and transmitted every orbit period
  - Observed data over Japanese islands are transmitted to JAXA ground station in real time

SGLI

- Wide spectrum coverage
- Near UV, VIS, NIR, SWIR, TIR
- Polarization measurements
- Multiple angle observation
- Multiple telescopes

VNR

- Composed of 3 telescopes to cover the total swath
- Each telescope covers 24 degree achieving 70 degree in total

Polarization

- Composed of 1 telescope for each channel
- IFOV is 55 degree
- Looking fore, nadir & aft
- One camera with tilt or two cameras?

VNIR

Ch.	central wavelength [nm]	IFOV [m]	⊿λ [nm]	Lλ [W/m^2/str/μm]	L_{max}. [W/m^2/str/μm]	S/N
VN1	380	250	10	60	210	250
VN2	412	250	10	75	250	400
VN3	443	250	10	64	400	300
VN4	490	250	10	53	120	400
VN5	530	250	20	41	350	250
VN6	565	250	20	33	90	400
VN7	670	250	10	23	62	400
VN8	670	250	20	25	210	250
VN9	763	1000	8	40	350	400
VN10	865	250	20	8	30	400
VN11	865	250	20	30	270	200

Polarization channels (3 directions)

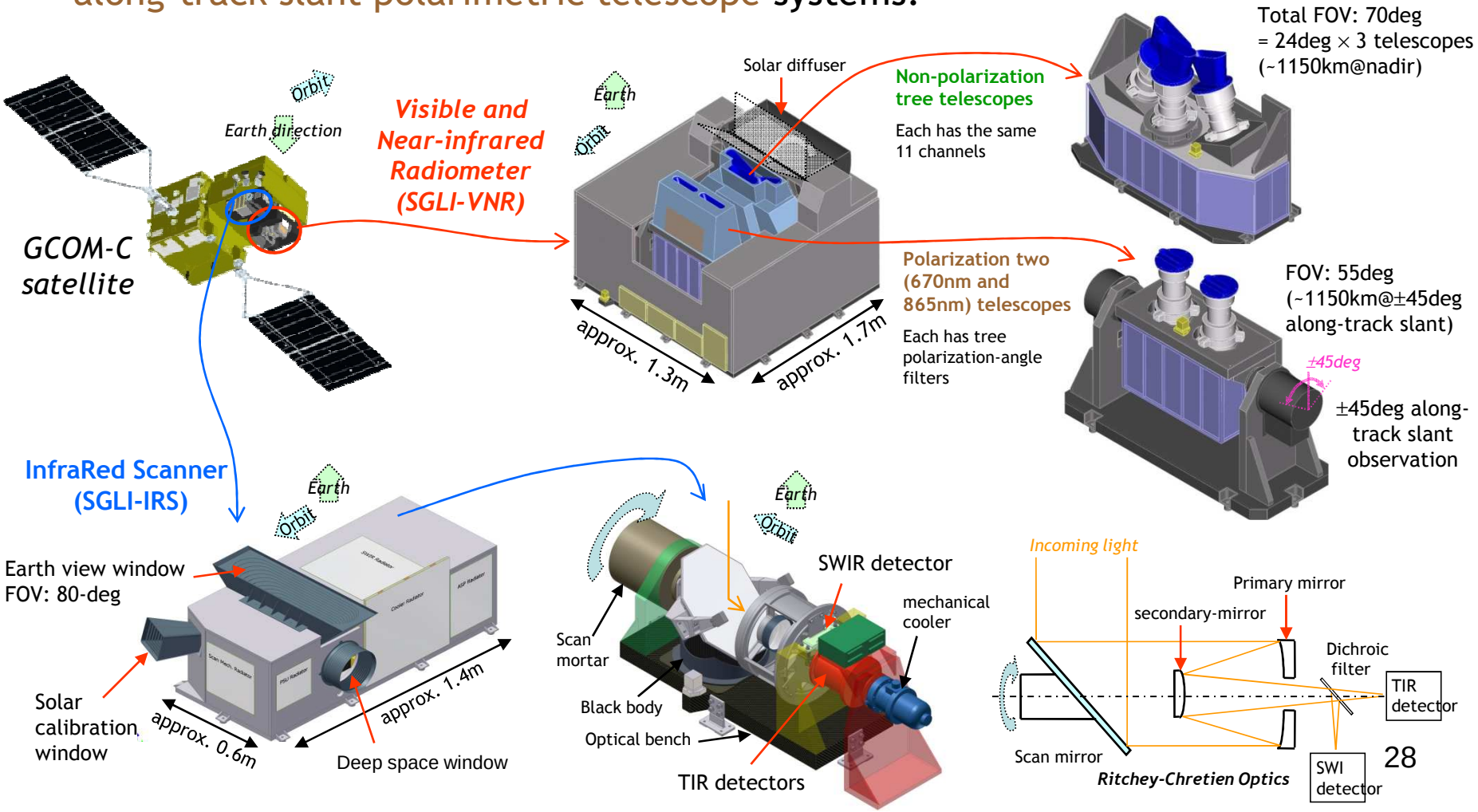
Ch.	central wavelength [nm]	IFOV [m]	$\Delta\lambda$ [nm]	$L\lambda$ [$W/m^2/str/\mu m$]	L_{max}. [$W/m^2/str/\mu m$]	S/N
P1-1	670	1000	20	25	250	250
P1-2	670	1000	20	25	250	250
P1-3	670	1000	20	25	250	250
P2-1	865	1000	20	30	300	250
P2-2	865	1000	20	30	300	250
P2-3	865	1000	20	30	300	250

IRS						
Ch.	central wavelength [μm]	IFOV[m]	⊿λ[μm]	L_λ[W/m^2/str/μm] or Tstd[K]	L_{max}[W/m^2/str/μm] or T_{max}[K]	S/Nor NEdT@300[K]
SW1	1.05	1000	0.02	57	248	500
SW2	1.38	1000	0.02	8	103	150
SW3	1.63	250	0.2	3	50	57
SW4	2.21	1000	0.05	1.9	20	211
T1	10.8	500	0.7	300	340	0.2
T2	12.0	500	0.7	300	340	0.2

2. GCOM-C products and SGLI design

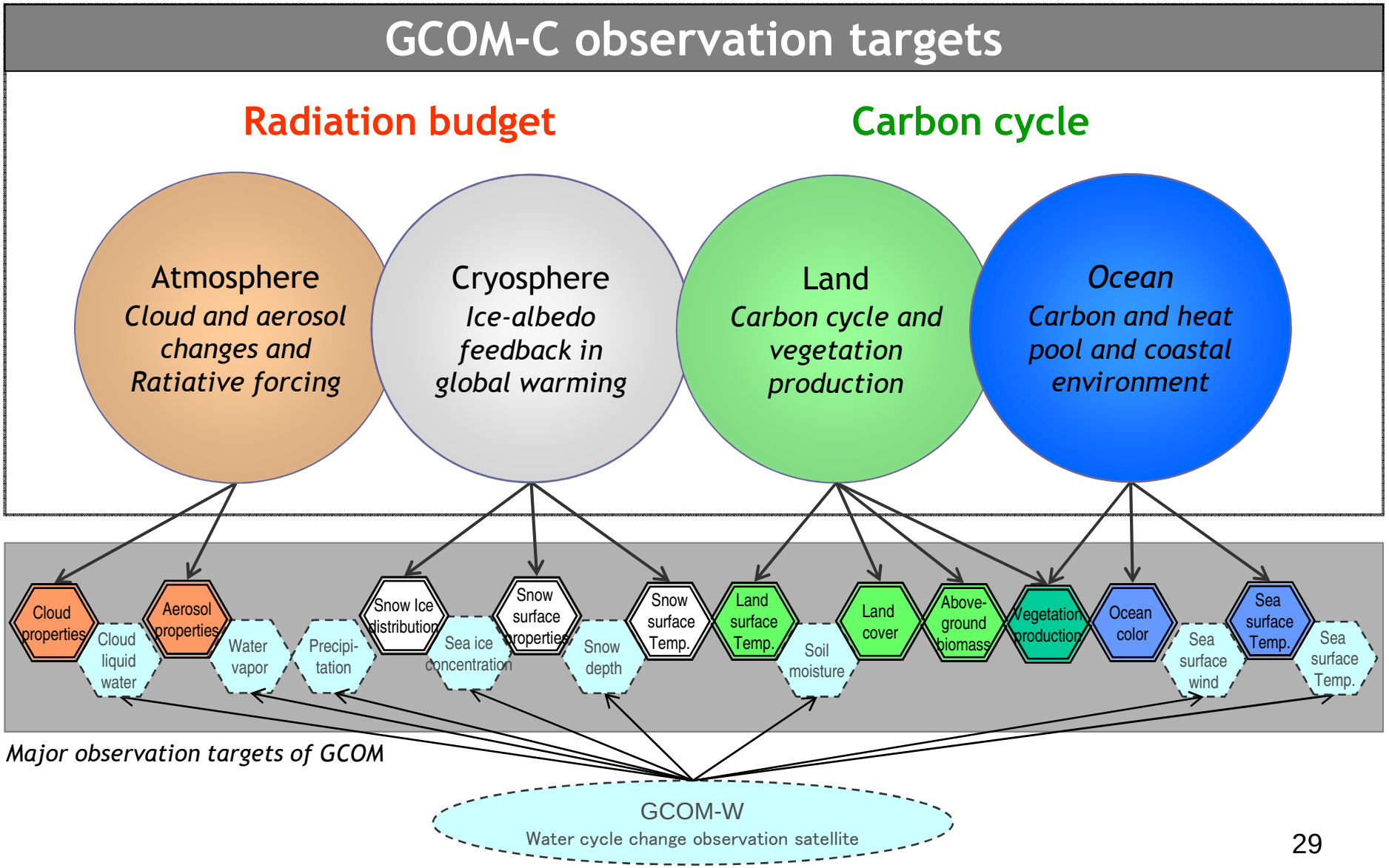
- 2.8 SGLI design (VNR and IRS)

- SGLI system consists of two components: SGLI-VNR and SGLI-IRS to optimize optics for each wavelength range
- SGLI-VNR consists of 11-channel non-polarimetric telescope and 2-channel along-track slant polarimetric telescope systems.



2. GCOM-C products and SGLI design

- 2.1 mission target and product groups



Major observation targets of GCOM

Standard products (land)

products	GSD	accuracy
radiance	250/1000m	5%, 0.5K
geom. corr. rad.	250m	0.5pixel
land surface refl.	250m	5%/10%*1
veg. index	250m	20%/15%*2
veg. roughness. index	1km	20%/15%*2
shadow index	1km	20%/15%*2
land surf. temp	500m	2.5K
fAPAR	250m	30%/20%*2
LAI	250m	30%
above ground biomass	1km	30%

*1 : >443nm / ≦443nm
*2 : grass land / forest

Research products (land)

products	GSD	accuracy
net primary prod.	1km	TBD
veg. water stress index	500m	TBD
fire	500m	TBD
land cover class.	250m	TBD
land surface albedo	1km	TBD

Standard products (atmosphere)

products	GSD	accuracy
cloud flag/type	1km	
cloud type & amount	1km/0.1°	15%
cloud top temp/altitude	1km/0.1°	3k/2km
opt. thick. of water cloud	1km/0.1°	100%
opt. thick. of cirrus	1km/0.1°	70%
aerosol over ocean	1km/0.1°	0.1
aerosol over land UV	1km/0.1°	0.15
aerosol over land pol.	1km/0.1°	0.15

Research products (atmosphere)

products	GSD	accuracy
geom. thickness of water clouds	1km/0.1°	N/A
land surface long wave radiant flux	1km/0.1°	N/A
land surface short wave radiant flux	1km/0.1°	N/A

Standard products (ocean)

products	GSD	accuracy
normalized water leav. rad.	250m/1km/4-9km *1	50%
atm. corr. parameter	250m/1km/4-9km	50%
PAR	250m/1km/4-9km	15%
chlorophyll-a	250m/1km/4-9km	-60-+150%
SS	250m/1km/4-9km	-60-+150%
CDOM	250m/1km/4-9km	-60-+150%
SST	500m/1km/4-9km	0.8K

***1 : 250m:coastal, 1km : open ocean, 4-9km : global**

Research products (ocean)

products	GSD	accuracy
euphotic zone depth	250m/1km/4-9km	N/A
intrinsic opt. char. of seawater	250m/1km/4-9km	N/A
primary production	500m/1km/4-9km	N/A
phytoplankton type	250m/1km/4-9km	N/A
red tide	250m/1km/4-9km	N/A
sensor fusion ocean color	250m/1km	N/A
sensor fusion SST	500m/1km	N/A

Standard products (cryosphere)

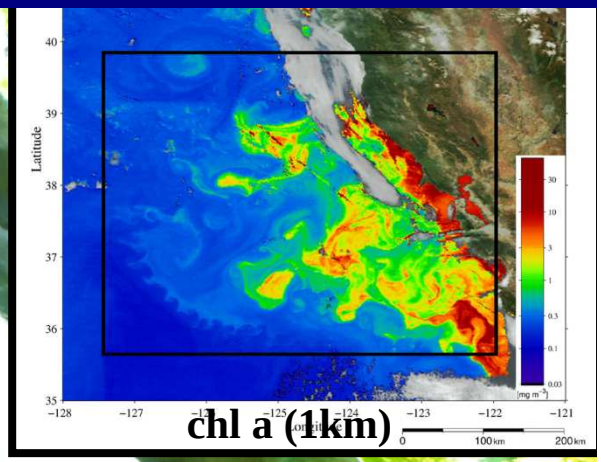
products	GSD	accuracy
snow & ice cover	250m/1km	7%
sea ice dist. in Okhotsk sea	250m	5%
snow/ice surface temp.	500m/1km	2K
snow particle size	250m/1km	50%

Research products (cryosphere)

products	GSD	accuracy
snow/sea ice class.	1km	N/A
snow cover over mountains	250m	N/A
snow particle size of semi surface	1km	N/A
surface snow particle size	250m/1km	N/A
snow/ice surface albedo	1km	N/A
snow impurity	250m/1km	N/A
ice sheet roughness	1km	N/A
ice sheet edge monitor	250m	N/A

250m ocean

GLCFS 250m RGB:22/21/20, 2003.5.26



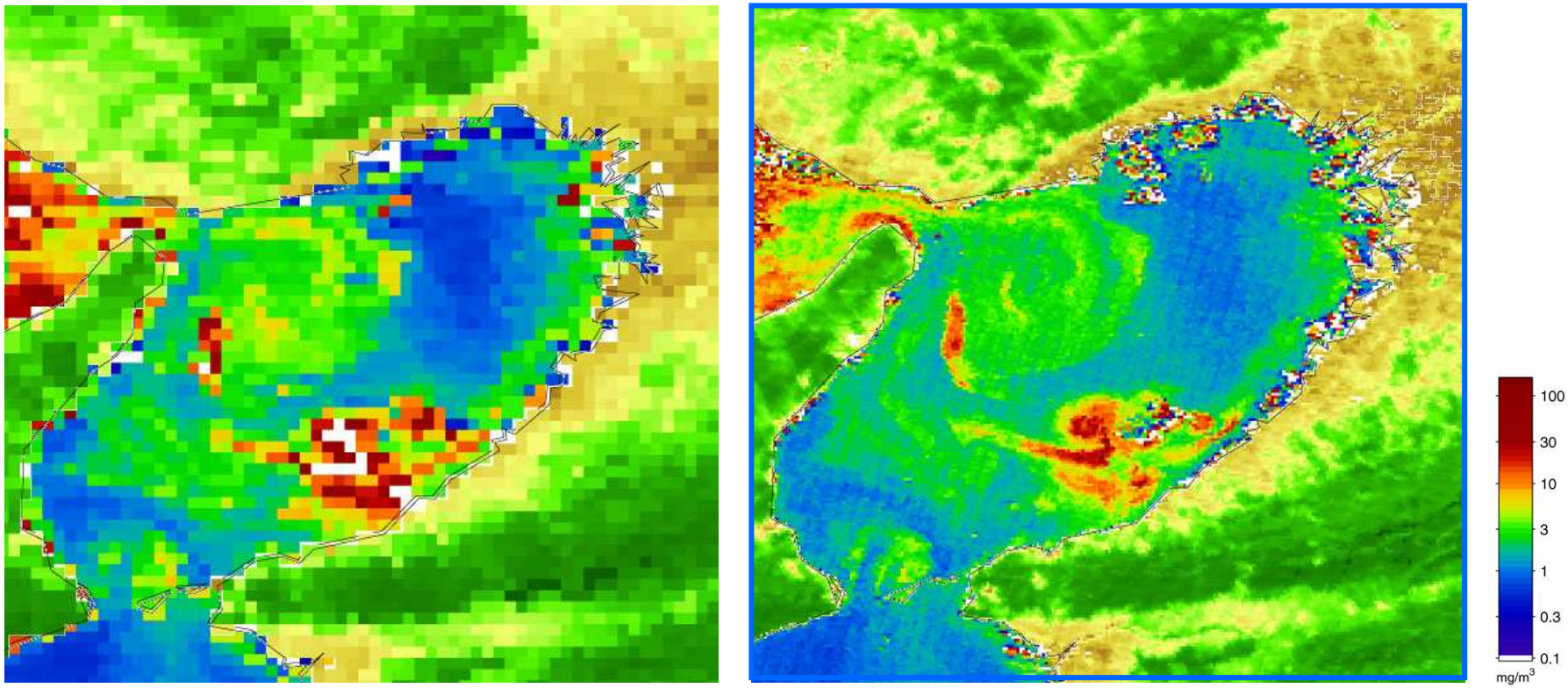
chl a (1km)

San Francisco

3. Examples of expected GCOM-C product

- 3.4 VNR 250m land and coastal observation

250m Ocean color chlorophyll-a and NDVI simulated using GLI 250m channels



(a) GLI 1km Osaka Bay
(1 Oct. 2003, CHL by LCI)

(b) GLI 250m Osaka Bay
(1 Oct. 2003, CHL by LCI)

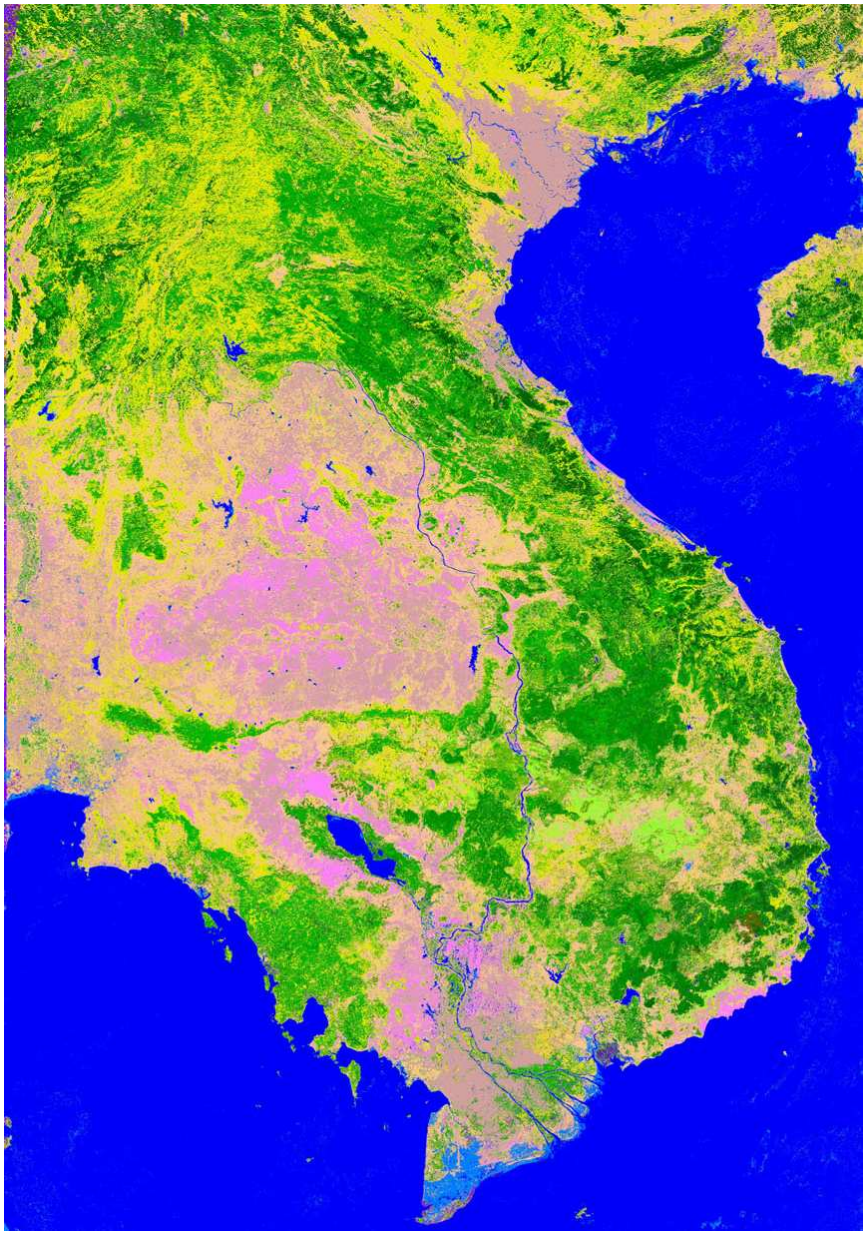
SGLI 250m resolution will enable to detect more fine structure in the coastal area such as river outflow, regional blooms, and small current.

Hiroshi Murakami, Mitsuhiro Toratani and Hajime Fukushima, **Satellite ocean color observation with 250 m spatial resolution using ADEOS-II GLI**, Remote Sensing of the Marine Environment, Proceedings of SPIE, Volume 6406-05, Nov. 28, 2006

3. Examples of expected GCOM-C product

- 3.3 VNR 250m land cover classification

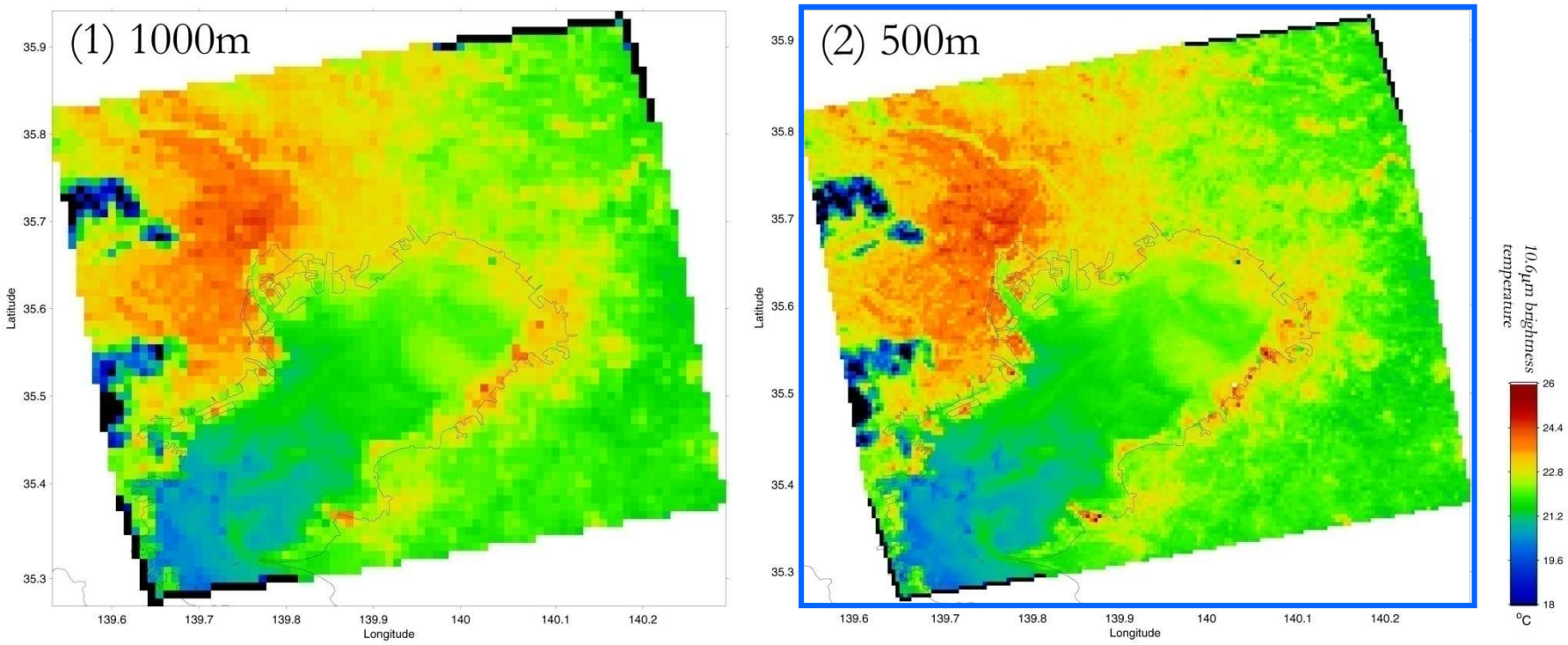
- SGLI's 250m channels (11CHs from 380nm to 1640nm) and once/2-day observation and can improve the land cover classification.



Classification to 25 class (IGBP: International Geosphere-Biosphere Program) using GLI 39 scenes (2003/04~2003/10)
(provided by Dr. Nguyen Dinh Duong, VAST(Vietnamese Academy of Science and Technology)

3. Examples of expected GCOM-C product

- 3.5 Thermal infrared 500m land and coastal observation



- The 500m and 1000m spatial resolution thermal infrared images are simulated using ASTER data (original resolution is 90m) (Tokyo Bay in the night on August 4, 2003).
- *SGLI 500m-resolution thermal infrared channels will enable detection of fine structures such as land and coastal surface temperature influenced by the city and the river flows.*

Recent status of GCOM-W1

- Project status
  - GCOM-W1 was approved to move to development phase (by SAC on August 8, 2007).
  - PDR was finished in June, 2008
  - AMSR2 CDR1 was finished in July, 2008.
  - deltaCDR was finished on November 2008.
  - Current target launch date is Fall, 2011.
  - Delay of ADM (Honeywell) : 3 months
  - Schedule margin : 3 months

Recent status of GCOM-C1

- GCOM-C1 is under phase B.
- GCOM-C1 was approved to go to a project within JAXA on July, 2008.
- Next step : phase C

International Cooperation

- Discussions on the cooperation with NPOESS is underway with NOAA
- JAXA is proposing a joint science activity with NASA
- Provision of a scatterometer on GCOM-W2 is under discussion with JPL and NOAA

Joint Science Team

- Joint Research & Operational Users Working Group (ROUWG) was established.
- First meeting was held on Apr.20,2009 in Tokyo.
- Next meeting will be held in Washington DC on August 2009.

GCOM User Groups

- GCOM Advisory Committee
- User requirements from both research & operation
- Within JAXA or outside JAXA?
- GCOM-W sub-committee (T. Oki)
- GCOM-C sub-committee (Y. Honda)
- User I/F subgroup (K. Cho)
- GCOM-W science team (+PIs)
- GCOM-C science team (+PIs)

Basic Law on Space

- Basic Law on Space has passed the Parliament last June
- Strategic Headquarters has been established (Minister level)
- All the space activities will go under the Cabinet Office
- Restructuring of JAXA
- Increased budget?