

GLOBAL CHANGE OBSERVATION MISSION (GCOM)

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ABSTRACT: ADEOS II was launched on Dec., 2002. However, after about 10 months operation, it has lost most of its power due to the solar paddle failure. As a follow on of ADEOS II mission, JAXA is now planning GCOM mission which is composed of a series of satellites. They are now called GCOM-W and GCOM-C satellites. Both satellites are composed of 3 satellites with 5 year lifetime. Hence, 13 years of continuous observation can be assured with 1 year overlaps. The first satellite of GCOM-W, i.e. GCOM-W1 was launched on 18. May, 2012, and now is operating in the A-Train orbit. The first one of GCOM-C, i.e. GCOM-C1 will be launched in fiscal 2016. GCOM-W1 carries AMSR-2 (AMSR F/O). AMSR-2 is very similar to AMSR on ADEOS II and AMSR-E on EOS-Aqua with some modifications. GCOM-C1 will carry SGLI (GLI F/O). The SGLI will be rather different from GLI. The main targets of SGLI are atmospheric aerosols, coastal zone and land. In order to measure aerosols over both ocean and land, it will have a near ultra violet channel, as well as polarization and bi-directional observation capability. For, coastal zone and land observation, the IFOV of SGLI for these targets will be around 250m. The instrument will be composed of several components. The shorter wavelength region will adopt push broom scanners, while long wave region will use a conventional whisk broom scanner. The orbit of GCOM-W will be A-train, while the orbit of GCOM-C will be similar to ADEOS II.

1. Introduction

In the late 20th century, it has been pointed out that changes of the global environment could alter the living environment for human being. Such global environmental changes include, but not limited to, climate warming, the sea level rise, decrease of tropical forests, desertification, destruction of the ozone layer, acid rain and the decrease of bio-diversity. What makes global changes different from conventional natural fluctuations is that many of them have been taking place due to anthropogenic causes. Although these changes have not yet reached the stage of directly affecting the life of humankind, there is a possibility that they will have major impacts in the latter half of 21st century.

For the protection and survival of humankind's future generations, it is essential to predict the future courses of these global changes so that efforts can be made to mitigate the adverse impacts of these changes. It must be said, however, that the prediction of global changes is extremely difficult. In the case of the notion of global warming caused by an increase of the atmospheric greenhouse gases like CO₂, while most scientists agree with the general concept, there is no commonly agreed quantitative prediction of how and when this phenomenon will manifest itself.

The reasons for this lack of a common prediction lie with the extreme diversity of the factors determining the global climate and the complicated interaction of these factors on which little scientific knowledge has yet been established. Any adequate understanding of global changes must be based on an approach which regards the earth as a single system within which various global geophysical parameters, processes affecting each parameter and the interaction between parameters are understood.

The establishment of various global geophysical parameters using conventional observation and measurement methods primarily based on field campaigns, however, has been found to be extremely difficult if not impossible. Satellite observation is essential for any attempt to solve global environmental problems.

2. GCOM MISSION CONCEPT

2.1 Subjects of GCOM

The GCOM aims at continuing and improving the observation conducted by the ADEOS and ADEOS II with a view to accumulating the scientific knowledge necessary to elucidate global environmental problems.

In regard to global warming, the GCOM intends the measurement of most factors involved in the energy and water cycle and material cycle, which are the main mechanisms determining climate change, and also analysis of the relevant processes. While the measurable geophysical parameters are detailed in 2.3, the parameters directly related to the energy and water cycle are temperature, water vapor, precipitation, clouds, aerosols, albedo, heat radiation from the atmosphere and estimated air-sea energy flux, etc.

Within the material cycle, measurement of the carbon cycle is a key subject. In this particular field, the GCOM aims at estimating the primary production as well as carbon flux based on measurement data on land vegetation and phytoplankton.

In regard to changes of the land environment, the measuring subjects are tropical forests and the global distribution of vegetation and its changes. In regard to the cryosphere, the sea ice concentration and snow coverage are measured and their interaction with the climate is analyzed.

2.2 Expected Achievements of GCOM

As a succeeding satellite in the ADEOS series beginning with the launch of the first ADEOS in 1996, the GCOM is expected to make the following achievements by the end of its mission (around 2020).

1) Global Warming

- Understanding of the global warming by global and long-term measurement data on various parameters.
- Separation between natural variability and trends using the data set covering the 20 year period from the launch of the ADEOS or the 15 year period from the launch of the ADEOS II.

2) Change of Land Environment

- Understanding of global forest dynamics
- Understanding of snow and ice changes

3) Clarification of sink and source of greenhouse gases.

2.3 Geophysical Parameters which will be Continuously Measured by GCOM

GCOM is a mission which continuously measures the following geophysical parameters more than 13 years.

1) Atmosphere

PAR, cloud amount, cloud type, cloud top height, optical thickness of cloud, cloud water equivalent, horizontal distribution of column water vapor, horizontal distribution of precipitation, optical thickness of aerosol, size distribution of aerosol, aerosol type

2) Ocean

chlorophyll-a, extinction coefficients, suspended solids (SS), colored dissolved organic matter (C-DOM), sea surface winds, sea surface temperature

3) Land

vegetation distribution, APAR (absorbed photosynthetic active radiation), LAI (leaf area index), Biomass, land cover, land surface reflectance, land surface temperature and emissivity, surface soil moisture over non vegetated area

4) Cryosphere

sea ice concentration, snow cover, discrimination of wet and dry snow over non vegetated area, dry snow water equivalence over non vegetated area, ice cover

2.4 Possible Contribution to Understanding of Global Changes

1) Global Warming

(a) Understanding of the reality of the phenomenon : global and long-term measurement data on various parameters which significantly affect global warming except for some parameters (evapotranspiration, etc.) related to the water cycle, can be retrieved.

(b) Separation between natural fluctuations and trends: using the data set covering the 15 year period from the launch of the ADEOS or the 10 year period from the launch of the ADEOS II covering one sun spot cycle and two or three ENSO cycles, it will be possible to separate the natural fluctuation components of the climate and trends.

(c) Understanding of the sinks/sources of GHGs

2) Change of Land Environment

(a) Understanding of global forest dynamism

(b) Understanding of snow and ice changes

2.5 Contribution to Operational Applications

GCOM satellites contribute not only to global change researches, but also several operational applications. Typical applications are listed below.

1) Accuracy improvements of numerical weather prediction

2) Accuracy improvements of extreme weather prediction

3) Ship navigation

4) Fisheries

5) Coastal management

6) Crop yield estimation

7) Volcanic eruptions

8) Air quality assessment including dust aerosols

9) Wild fires

3. GCOM FIRST GENERATION SATELLITES

3.1 GCOM Satellites

After the failure of ADEOS II, JAXA is now planning to launch small satellites rather than large ones. According to this strategy, ADEOS II follow on is now divided into two missions, i.e., GCOM-W and GCOM-C. The continuous observation required to GCOM mission poses these two missions to be composed of series of satellites, i.e., 3 satellites with 5 year life time for each mission, hence provides at least 13 years of continuous data.

GCOM-W and GCOM-C will have sun-synchronous orbit, but their local times are different. Equator crossing local time of GCOM-W will be around 13:30 at ascending node, while that of GCOM-C will be around 10:30 at descending node. These satellites will focus on water cycle, energy cycle and carbon cycle. The tentative specifications of the satellites are as follows. Now, the GCOM-W1 was put into the A-train.

GCOM-W

orbit : altitude : 700km

mass : 1.9 ton

power : 4kW

GCOM-C

orbit : altitude : 800km

mass : 2.1 ton

power : 4kW

3.2 Planned launch dates

GCOM-W1 was launched in 18, May, 2012 and GCOM-C1 will be launched in fiscal 2015. The launch of successive satellites is planned as follows.

GCOM-W2 : 2019

GCOM-W3 : 2024

GCOM-C2 : 2020

GCOM-C3 : 2024

3.3 Details of GCOM-W1 Sensor

GCOM-W1 carries single instruments, i.e., AMSR-2 (Advanced Microwave Scanning Radiometer 2). The AMSR-2 is the follow on of the AMSR on board the ADEOS2 and AMSR-E on Aqua and will aim at achieving the measurement of the same geophysical parameters. AMSR-2 is a total power microwave radiometer with two points calibration, i.e. deep space using cold sky mirror and on-board hot load [1]. For the absolute calibration, deep space observation by main mirror will be conducted [2]

There are several improvements from AMSR and AMSR-E. The first one is the improvement of the hot load. As well known, the hot loads on board AMSR and AMSR-E had a large temperature gradient. This gradient was mainly caused by the low thermal conductivity of the hot load material and also the reflection from the surrounds by MLI over the hot load. To avoid these phenomena, JAXA decided to add a temperature controlled reflector (TCP) over the hot load. With this TCP and several shields to avoid incident radiation from the surroundings, the temperature gradient will be less than 2K, and the accuracy of brightness temperature over hot load will be around 0.1K..

Another problem of AMSR and AMSR-E was electromagnetic interference from the ground to C band data [3]. JAXA has decided to add 7.3 GHz experimental band to AMSR-2. This frequency is rather free from interference from the preliminary study over Japan and US.

AMSR-2 is a conical scanning microwave radiometer with 2 m aperture parabolic antenna. The incidence angle is 55° and the swath width is more than 1,420 km in the case of 700km altitude orbit. Specifications of AMSR-2 are shown in Table 1.

a	b	c	d	e
6.9	50	350	0.3	12
7.3	50	350	0.3	12
10.65	50	100	0.6	12
18.7	25	200	0.6	12
23.8	25	400	0.5	12
36.5	15	1000	0.5	12
89.0	5	3000	1.0	12

a : central frequency (GHz)

b : ground resolution (km)

c : bandwidth (MHz)

d : NEdT

e : quantization bits

Table 1 Specifications of AMSR-2.

3.4 Products from GCOM-W1 [4]

Standard products from GCOM-W are listed below and were released to the public on May, 2013.

- 1) brightness temperature
- 2) total water vapor
- 3) total cloud liquid water
- 4) precipitation
- 5) sea surface temperature
- 6) sea surface wind speed
- 7) sea ice concentration
- 8) snow amount
- 9) soil moisture

3.5 Details of GCOM-C1 Sensor

GCOM-C will carry only one instrument, i.e. SGLI (Second Generation Global Imager). The SGLI sensor will be a multi-purpose visible infrared imager and an advanced version of the GLI. It will be capable of measuring ocean color, land cover and vegetation, snow and ice, clouds, aerosols and water vapor, etc. The different characteristics with GLI are as follows.

- a) The largest target of SGLI is to retrieve global aerosol distributions. In order to achieve this target, SGLI will have 2 polarization channels with 3 directions.
- b) SGLI is mainly focused to land and coastal areas. There are 11 250m IFOV channels compared to 6 250m channels in GLI.
- c) VNR component of SGLI is a push broom scanner.

The components of the SGLI are as follows.

- (a) Visible and Near-Infrared (VNR)-non-polarization : 11 channel visible and near infrared push broom scanner.
- (b) VNR-polarization : 2 visible spectral channels with 3 polarization directions push broom scanner
- (c) Shortwave and Thermal Infrared (SWI & TMI): 5 channel shortwave and thermal infrared optical mechanical scanner

The details of radiometric specifications of VNR are shown in Table 2(a).

Ch.	a	b	c	d	e	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	673.5	250	20	23	62	400
VN8	673.5	250	20	25	210	250
VN9	763	1000	12	40	350	400
VN10	868.5	250	20	8	30	400
VN11	868.5	250	20	30	300	200

- a : center wavelength
- b : IFOV
- c : channel width
- d : standard radiance to define S/N
- e : maximum radiance

Table 2 (a) specifications of VNR

The details of specifications of polarization channels are shown in Table 2(b)

Ch.	a	b	c	d	e	S/N
670-P1	673.5	1000	20	25	250	250
670-P2	673.5	1000	20	25	250	250
670-P3	673.5	1000	20	25	250	250
865-P1	868.5	1000	20	30	300	250
865-P2	868.5	1000	20	30	300	250
865-P3	868.5	1000	20	30	300	250

Table 2(b) specifications of polarization channels

The swath widths of both VNR and polarization channels are 1050km.

The details of specifications of IRS (SWI & TMI) are shown in Table 2(c). The swath width of IRS is 1400km.

Ch.	a	b	c	f	g	h
1	1.05	1000	0.02	57	248	300
2	1.38	1000	0.02	8	103	150
3	1.64	250	0.2	3	50	57
4	2.21	1000	0.05	1.9	20	211
5	10.8	500*	0.74	300	340	0.2
6	12.0	500*	0.74	300	340	0.2

f : standard radiance to define S/N or standard temperature
g : maximum radiance or maximum temperature
h : S/N or NE δ T

Table 2(c) Specifications of IRS

* : For thermal IR channels, there are 3 IFOV modes. 250m will be used experimentally for coastal zones, 500m for coastal zones, and 1000m for open ocean.

3.6 Products of GCOM-C1 [4]

Standard products from GCOM-C are listed below

Land

1) radiance, 2) surface reflectance, 3) vegetation index, 4) vegetation roughness index, 5) shadow index
6) land surface temperature, 7) FAPAR, 8) LAI, 9) above ground biomass

Atmosphere

1) cloud flag, 2) cloud amount, 3) cloud top height & temperature, 4) water cloud optical depth & size
5) cirrus droplet size, 6) aerosol over ocean, 7) aerosol over land (near UV), 8) aerosol over land (polarization)

Ocean

1) normalized water leaving radiance, 2) atmospheric correction parameter, 3) PAR, 4) Chlorophyll-a
5) suspended solids, 6) CDOM, 7) SST

Cryosphere

1) snow & sea ice distribution, 2) ice distribution over Okhotsk sea, 3) snow & ice surface temperature
4) shallow snow particle size

3.7 GCOM-W2

Now, the GCOM-W2 discussions have started. For GCOM-W1, there are no scatterometer. However, from the experience of AMSR, the synergy of a microwave radiometer and a scatterometer gave us higher accuracies to both sensor products, as well as new products. Now JAXA is negotiating with NASA, JPL and ISRO for the provision of a microwave scatterometer to GCOM-W2.

The improvement of AMSR2 is also under discussion by JAXA and users. New specification requirements includes a larger aperture as well as the addition of higher frequency channels for snow and water vapor, etc.

4. References

- [1] Colton M.C. and G.A. Poe, "Intersensor calibration of DMSP SSM/T's : F-8 to F-14, 1987-1997", IEEE Trans. Geosci. Remote Sensing, vol.37(1), pp.418-422, 1999.
- [2] Jones W.L., Park J.D., Soisuvarn S., et.al., "Deep-space calibration of the Windsat radiometer", IEEE Trans. Geosci. Remote Sensing, vol.44(3), pp.476-495, 2006.
- [3] JAXA, "Improved Advanced Microwave Radiometer (AMSR-E) on-board Aqua Stationary Operation Completion Review Report", JAXA technical document SDA-050005, 2005. (in Japanese)
- [4] JAXA, "GCOM mission requirement specifications", JAXA technical document SAP-060001, 2006. (in Japanese)