CGMS-43 JMA-WP-02
Prepared by JMA
Agenda Item: E.1
Discussed in Plenary

JMA report on the status of current and future satellite systems

MTSAT-2 (145°E) is currently operational in imaging over the East Asia and Western Pacific regions with backup from MTSAT-1R (140°E), which has continued to perform imagery dissemination and data collection services even after its imaging function was switched over to MTSAT-2 on 1 July 2010. Its DCS (Data Collection System) has functioned properly since the satellite began operation.

JMA successfully launched the next-generation Himawari-8 satellite on 7 October 2014, and plans to start its operation in July 2015 as a replacement for MTSAT-2.

Himawari-8 is the world's first next-generation geostationary meteorological satellite, and features a new imager with 16 bands (as opposed to the 5 bands of the current MTSAT series). Full-disk imagery will be obtained every 10 minutes, and rapid scanning at 2.5-minute intervals will be conducted over several regions. The unit's horizontal resolution will also be double that of the MTSAT series. These significant improvements will bring unprecedented levels of performance in monitoring for tropical cyclones, rapidly developing cumulonimbus clouds and volcanic ash clouds.

JMA report on the status of current and future satellite systems

1 INTRODUCTION

The Japan Meteorological Agency (JMA) operates two geostationary satellites called Multi-functional Transport Satellie-1R and Multi-functional Transport Satellite-2 (MTSAT-1R and MTSAT-2). The operational use of MTSAT-1R's imaging function was switched over to MTSAT-2 on 1 July 2010, as MTSAT-1R's earth imaging sensor had reached the end of its five-year design lifetime.

JMA successfully launched the next-generation Himawari-8 satellite on 7 October 2014 and plans to start its operation in July 2015 as a replacement for MTSAT-2. Himawari-9 will also be launched in 2016 as a backup and successor satellite. Both units will observe the East Asia and Western Pacific regions for a period of 15 years.

2 CURRENT SATELLITE SYSTEMS

2.1 MTSAT-2

MTSAT-2 was launched on 18 February 2006 and placed in geostationary orbit at 145 degrees east. It was the backup satellite for MTSAT-1R from September 2006, and now acts as an operational satellite for observation over the East Asia and Western Pacific regions.

No significant anomalies on board MTSAT-2 have occurred since CGMS-42. The satellite provides 24 full-disk images, 24 Northern Hemisphere images and 8 Southern Hemisphere images a day. Operational information can be accessed on JMA's Meteorological Satellite Center (MSC) website at

http://www.data.jma.go.jp/mscweb/en/operation/.

2.2 MTSAT-1R

MTSAT-1R was launched on 26 February 2005 and placed in geostationary orbit at 140 degrees east. It has acted as a backup satellite for the imaging function of MTSAT-2 since 1 July 2010. During annual antenna or ground system maintenance, or in the event of problems with MTSAT-2, MTSAT-1R takes over its observation duties until recovery is secured. MTSAT-1R has continued to perform image dissemination and data collection services since the switchover of its imaging function to MTSAT-2.

2.2.1 Rapid scanning for monitoring of severe weather around airports

Since 2011, JMA has implemented MTSAT-1R small-sector observation around Japan at five-minute intervals during the daytime (from 00 to 09 UTC). The collected data are provided to aeronautical operators to support the monitoring of severe weather conditions around airports and in airspace. As the MTSAT-1R imager is now being used beyond its design lifetime of five years, operation is limited to the period from June to September.

2.2.2 Rapid scanning in preparation for Himawari-8 high-frequency observation

As part of preparations for Himawari-8 high-frequency observation, JMA implemented MTSAT-1R regional-sector observation around Japan at 10-minute intervals throughout the day in October 2014.

2.2.3 Rapid scanning for disaster risk reduction based on tracking of Typhoon Hagupit

Typhoon Hagupit (T1422) formed as a tropical depression (TD) at 12 UTC on 30 November 2014 and was upgraded to typhoon (TY) intensity at 18 UTC on 2 December 2014. It maintained a westward track and was expected to hit and seriously affect the Philippines. To support the response of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA), JMA conducted 10-minute-interval special observations using MTSAT-1R as an activity of the Regional Specialized Meteorological Center (RSMC) Tokyo – Typhoon Center.

RGB composite images from these observations were provided in real time via a JMA/MSC web page made accessible to PAGASA, SWFDP-Southeast Asia contacts and focal points of the Typhoon Committee's Working Group on Meteorology. JMA also provided NetCDF data and HRIT file data via the JMA Data Dissemination System (JDDS).

2.3 DCS (Data Collection System)

MTSAT-1R's Data Collection System (DCS) has functioned properly since the satellite started operation. Although harmful interference was frequently observed on DCS channel 33, there was no negative effect on operation because no Data Collection Platform (DCP) is registered on this channel. Further information on MTSAT-DCS is available in the Monthly Operations Report section of JMA/MSC website at

http://www.data.jma.go.jp/mscweb/en/operation/opr_report.html

Since the 2004 Indian Ocean Tsunami, the number of DCPs reporting tidal data has increased in MTSAT-1R's DCS. As of 31 March 2015, MTSAT-1R collected tidal reports from 49 DCPs; 10 of these are Indonesian platforms that started to report tidal data at this time.

JMA is also preparing to improve the collection of tidal data at six-minute intervals from 8 Southeast Asian DCPs installed by the University of Hawaii in order to contribute to the enhancement of tsunami monitoring over the Pacific Ocean with greater frequency. The Agency also plans to assist with the establishment of DCPs in Vanuatu and New Caledonia.

See JMA-WP-06 for more information on MTSAT-DCS.

2.4 LRIT data dissemination from GOES-West

In collaboration with NOAA/NESDIS, provision of MTSAT LRIT full-disk images re-formatted into NOAA GOES LRIT data to Central Pacific island nations was commenced in 2012 using the GOES-West satellite. This service will continue to be provided after the start of Himawari-8's operation.

2.5 MDUS/SDUS user numbers

Table 1 shows numbers of currently registered MTSAT-1R Medium-scale Data Utilization Station (MDUS) and Small-scale Data Utilization Station (SDUS) users.

Table 1: MDUS/SDUS user numbers

Station	Number
MDUS	59
SDUS	721

2.6 List of frequencies used by MTSAT meteorological missions

Tables 2 and 3 provide basic information on the frequencies used for current MTSAT meteorological missions.

Table 2: Frequencies from earth to space used by the MTSAT system

Satellite	Frequency (MHz)	Direction	Emission	Application	Status
MTSAT-1R	402.0 – 402.4	E-S	2K00G1D 4K00G1D 6K00G1D	DCP reports	In orbit
MTSAT-1R	2029.1	E-S	6M00G1D	HRIT	In orbit
MTSAT-1R	2033.0	E-S	250KG1D	LRIT	In orbit
MTSAT-1R	2034.2	E-S	300KGXX	TC	In orbit
MTSAT-1R	2034.925 2034.933 2034.974	E-S	6K00G1D	DCP interrogation	In orbit
MTSAT-1R	2100.164	E-S	550KGXX	TC, ranging	In orbit
MTSAT-2	402.0 – 402.4	E-S	2K00G1D 4K00G1D	DCP reports	In orbit

Satellite	Frequency (MHz)	Direction	Emission	Application	Status
			6K00G1D		
MTSAT-2	2029.1	E-S	6M00G1D	HRIT	In orbit
MTSAT-2	2033.0	E-S	250KG1D	LRIT	In orbit
MTSAT-2	2034.2	E-S	300KGXX	TC	In orbit
MTSAT-2	2034.925 2034.933 2034.974	E-S	6K00G1D	DCP interrogation	In orbit
MTSAT-2	2100.164	E-S	550KGXX	TC, ranging	In orbit

Table 3: Frequencies from space to earth used by the MTSAT system

Satellite	Frequency (MHz)	Direction	Emission	Application	Status
MTSAT-1R	1677.0	S-E	10M0G1D	Raw data	In orbit
MTSAT-1R	1687.1	S-E	6M00G1D	HRIT	In orbit
MTSAT-1R	1691.0	S-E	250KG1D	LRIT	In orbit
MTSAT-1R	1694.0	S-E	400KGXX	TM	In orbit
MTSAT-1R	1694.3 – 1694.7	S-E	2K00G1D 4K00G1D 6K00G1D	DCP reports	In orbit
MTSAT-1R	2280.721	S-E	1M10GXX	TM, ranging	In orbit
MTSAT-2	1677.0	S-E	10M0G1D	Raw data	In orbit
MTSAT-2	1687.1	S-E	6M00G1D	HRIT	In orbit
MTSAT-2	1691.0	S-E	250KG1D	LRIT	In orbit
MTSAT-2	1694.0	S-E	400KGXX	TM	In orbit
MTSAT-2	1694.3 – 1694.7	S-E	2K00G1D 4K00G1D 6K00G1D	DCP reports	In orbit
MTSAT-2	2280.721	S-E	1M10GXX	TM, ranging	In orbit

3 FUTURE SATELLITE SYSTEMS

3.1 Schedule

MTSAT-2 (also known as Himawari-7) is currently operational and scheduled to complete its observation operation in 2015. JMA successfully launched its successor, Himawari-8, on 7 October 2014 and plans to begin its operation in July 2015. To ensure the robustness of the satellite observation system, the launch of a second follow-on satellite, Himawari-9, into in-orbit standby is also scheduled for 2016. JMA will continue to operate Himawari-8 and -9 covering the East Asia and Western Pacific regions, as with the GMS and MTSAT series.

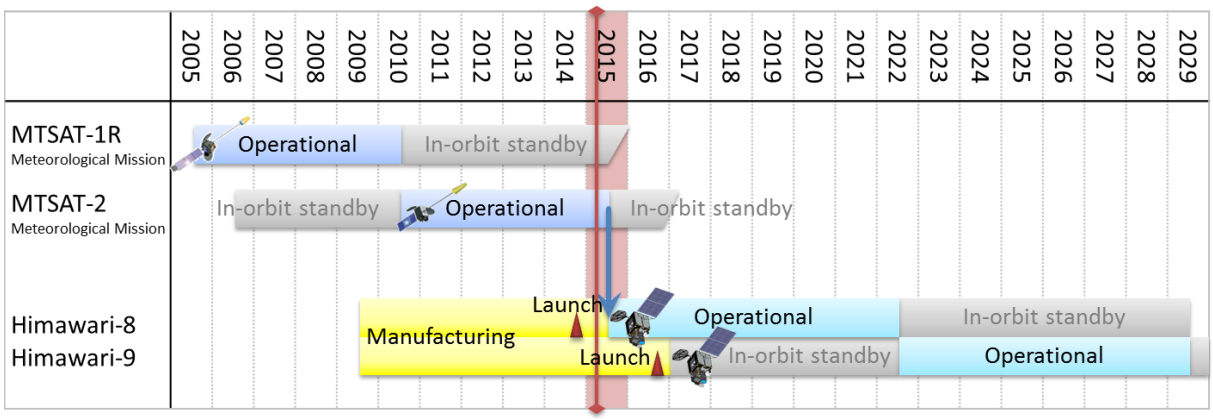

Figure 1: Schedule for Himawari-8 and -9

3.2 Space segment

Table 4 lists the major specifications of Himawari-8 and -9. These are identical for each unit, and operation will also be in the same geostationary orbit at 140.7°E.

Himawari-8 and -9 will have a dedicated meteorological mission, whereas the MTSAT satellites perform both meteorological and aeronautical functions. They will each carry a new unit called the Advanced Himawari Imager (AHI). Table 5 shows the specifications of the AHI, which has capabilities comparable to those of the ABI imager on board GOES-R. The functions and specifications are notably improved from those of the imager on board the MTSAT units, and enable better nowcasting, improved numerical weather prediction accuracy and enhanced environmental monitoring.

Figure 2 shows the first true-color composite image created from Himawari-8's three visible bands corresponding to red, green and blue. The picture shows the beautiful earth with white clouds, the blue ocean and variously colored continents. Figure 3 shows the spatial resolution difference between the visible bands of MTSAT-2 and Himawari-8. It can be seen that the clouds and landforms in the imagery of Himawari-8 are sharper.

New frequency bands will be introduced for communication between the satellites and ground stations. The Ka-band will be used for downlinking of meteorological data, and the Ku-band will be used for telemetry and command operations.

The satellites will each carry a transponder to relay meteorological/tsunami data from data collection platforms (DCPs) in order to sustain the data collection system (DCS) currently operated using the MTSAT units. See JMA-WP-06 for more information on Himawari-DCS.

Table 4: Major specifications of Himawari-8 and -9

Geostationary position	140.7 °E
Attitude control	3-axis stabilization
Imaging sensor	Advanced Himawari Imager (AHI)
Communications	1) Raw observation data transmission Ka-band, 18.1 – 18.4 GHz (downlink)
	2) DCS Uplink from DCP stations 402.0 – 402.4 MHz (uplink) Transmission to ground segments Ka-band, 18.1 – 18.4 GHz (downlink)
	3) Telemetry and command Ku-band, 13.75 – 14.5 GHz (uplink) 12.2 – 12.75 GHz (downlink)
Contractor	Mitsubishi Electric Corporation
Launch vehicle	H-IIA rocket

Table 5: AHI specifications

Imaging channels			
	Band	Central wavelength (μm)	Spatial resolution (km)
	Visible	0.47	1
		0.51	
		0.64	0.5
	Near-infrared	0.86	1
		1.6	2
		2.3	
	Infrared	3.9	
		6.2	
		6.9	
		7.3	
		8.6	
		9.6	
		10.4	
		11.2	
		12.4	
		13.3	
Observation			
	Full Disk	Every 10 minutes	
	Target area	Every 2.5 minutes	
	Japan area	Every 2.5 minutes	
Lifetime of meteorological mission			
	8 years of in-orbit operation out of a 15-year in-orbit period		

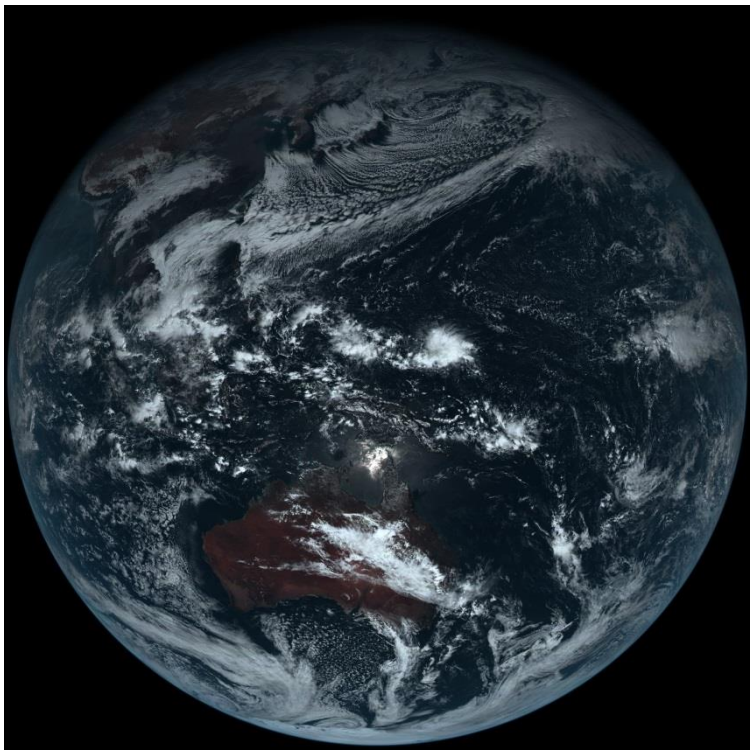

Figure 2: First true-color composite image from Himawari-8 (taken at 02:40 UTC on 18 December 2014)

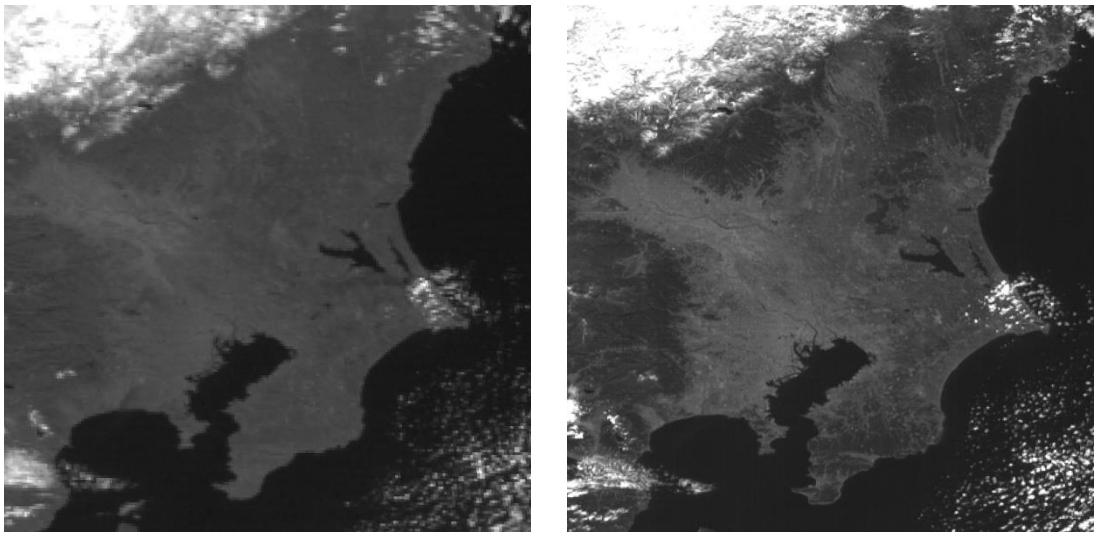

Figure 3: Sample of spatial resolution difference between the visible bands of MTSAT-2 (left) and Himawari-8 (right) at 03:00 UTC on 29 January 2015

3.3 Ground segment and operations

The Himawari-8/9 satellites and their ground stations will be operated by Himawari Operation Enterprise Corporation (HOPE) — a special-purpose company (SPC) established under JMA's Private Finance Initiative (PFI) project. Observation data from AHI and DCP data will be transmitted through HOPE to JMA, which will process the information and disseminate products to users. Figure 4 gives an overview of the Himawari-8/9 ground segment.

3.3.1 Site diversity

Himawari-8/9 will use the Ka band for AHI and DCP data downlink frequency, and will adopt the Ku band for telemetry, tracking and command (TT&C) as described in Section 3.2. To minimize the potential for negative data impacts from these bands, which both tend to be affected by rain attenuation, two antenna sites will be used in the interests of diversity. One is in the Kanto region (the primary station) and the other is in the Hokkaido region (the secondary station), meaning that their locations are around 800 km apart in areas with different weather conditions. The two centers for processing data received are also located in the Kanto and Hokkaido regions.

3.3.2 Operation by HOPE

HOPE will operate the antenna sites and data centers. The antenna sites house transmitting/receiving equipment including antennas with a diameter of 9 meters, and the data centers have equipment for satellite control and AHI/DCP data processing. AHI and DCP data received at these sites will be transmitted to data centers, where AHI data will be processed to create raw data with calibration/navigation parameters attached and DCP data will be converted for use with JMA's telecommunications system. The processed data will be transmitted to JMA's Meteorological Satellite Center (Tokyo) and its Osaka Regional Headquarters (Osaka). In the event that the primary station becomes dysfunctional, the secondary station will take over its operations.

3.3.3 Operation by JMA

The Meteorological Satellite Center (MSC) will receive data from both the primary and secondary stations for preprocessing. Himawari Standard Data, HRIT files and edited DCP data will then be produced and provided to users. The Osaka Regional Headquarters will receive data from the secondary station only. In the event that the MSC system becomes dysfunctional (e.g., due to a malfunction caused by a natural disaster), data/products will be provided from Osaka.

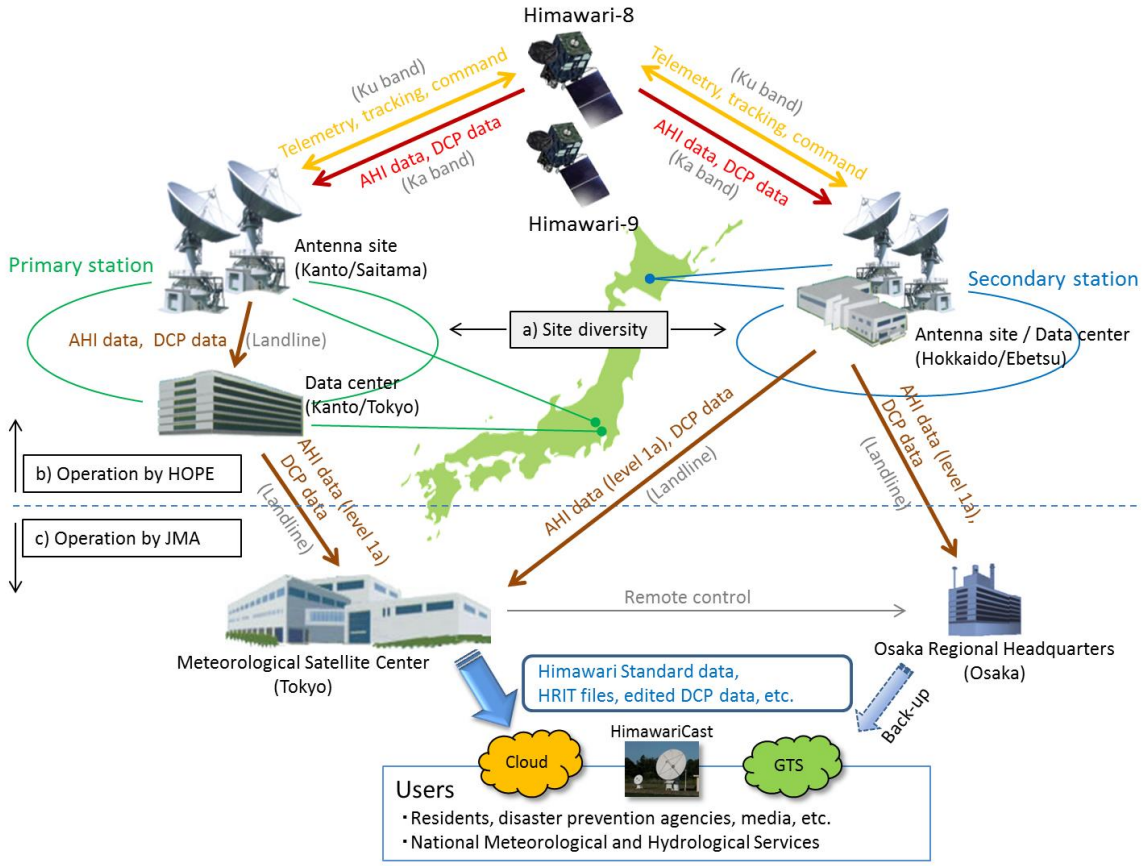

Figure 4: Overview of the Himawari-8/9 ground segment and operations

3.4 List of frequencies to be used by Himawari-8 and -9

Tables 6 and 7 show basic information on the frequencies to be used by Himawari-8/9.

Table 6: Frequencies from earth to space to be used by the Himawari-8/9 system

Satellite	Frequency (MHz)	Direction	Emission	Application	DBIU[1]
Himawari-8/9	402.0 – 402.4	E-S	2K00G1D 4K00G1D 6K00G1D	DCP reports	2014/2016
Himawari-8/9	13750 – 14500	E-S	40K0G2D 210KG3N 250KG9W 620KF3N	TC, ranging	2014/2016

Table 7: Frequencies from space to earth to be used by the Himawari-8/9 system

Satellite	Frequency (MHz)	Direction	Emission	Application	DBIU
Himawari-8/9	18100 – 18400	S-E	110MG1D 110MG7W	Raw data	2014/2016
Himawari-8/9	18100 – 18400	S-E	2K00G1D 4K00G1D	DCP reports	2014/2016

[1] DBIU: date of bringing into use

Satellite	Frequency (MHz)	Direction	Emission	Application	DBIU
			6K00G1D 400KG7D		
Himawari-8/9	12200 – 12750	S-E	1M20G2D 1M20G9W	TM, ranging	2014/2016

3.5 Data distribution/dissemination

JMA will distribute Himawari-8/9 data in two ways. One is the HimawariCast service, by which primary sets of imagery will be disseminated for operational meteorological services via a communication satellite. The other is the HimawariCloud service, by which full sets of imagery will be delivered to National Meteorological and Hydrological Services (NMHSs) via an Internet cloud service.

See JMA-WP-08 for more information on data distribution/dissemination.

3.6 Support for user readiness

To support user preparations for Himawari-8/9 data utilization, JMA provides Himawari-8/9 information at http://www.data.jma.go.jp/mscweb/en/himawari89/. The information encompasses the schedule, spacecraft/AHI specifications (including estimated spectral response functions, or SRFs), sample data in various file formats, and data distribution/dissemination methods. JMA also posts Himawari-8/9 information to the Satellite User Readiness Navigator (SATURN).

JMA will host the Sixth Asia/Oceania Meteorological Satellite Users' Conference (AOMSUC-6) from 9 to 13 November 2015 in Tokyo, Japan. In conjunction with this event, JMA also plans to hold a two-day training course for representatives from NMHSs in the Asia and Oceania regions in order to facilitate and sophisticate Himawari-8 data utilization. See JMA-WP-10 for more information on AOMSUC-6.

In its role as a VLab Centre of Excellence, the Australian Bureau of Meteorology runs the National Himawari-8 Training Campaign to assist WMO Region V countries in preparing for the effective use of Himawari-8 data. JMA appreciates the Bureau's efforts in this regard and contributes to the campaign by providing test data.