FUTURE PLAN AND RECENT ACTIVITIES FOR THE JAPANESE FOLLOW-ON GEOSTATIONARY METEOROLOGICAL SATELLITE HIMAWARI-8/9

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Abstract

JMA plans to launch Himawari-8 in summer 2014 and commence its operation in 2015, when MTSAT-2 is scheduled to complete its period of operation. The Agency also plans to launch Himawari-9 in 2016. In July 2009, JMA completed contract arrangements for the manufacture of Himawari-8 and -9, which have identical specifications. Currently, their production is in the design phase. Himawari-8 and -9 carry Advanced Himawari Imager (AHI) units comparable to the Advanced Baseline Imager (ABI) on board GOES-R to enable enhanced nowcasting, NWP and environment monitoring. JMA plans to use two ground stations to establish site diversity in the interests of mitigating the rain attenuation effect on the Ka-band to be used for the imagery data downlink. Downlinked data will be delivered to the Meteorological Satellite Center, which generates satellite products and delivers them to users. The AHI imagers on board Himawari-8/9 will have a higher level of observing capability than the MTSAT-2 imager. In association with this enhancement, JMA is improving its current satellite products (particularly those based on atmospheric motion vector data) as well as developing new products related to instability indices and volcanic ash. To support these developments, Himawari-8/9 simulated images are generated in two ways – one involving the accumulation of high-spectral-channel observations from hyper sounders such as AIRS and IASI, and the other using radiative transfer computation based on the provisional response functions of Himawari-8/9.

INTRODUCTION

The Japan Meteorological Agency (JMA) has operated the GMS and MTSAT series of satellites at around 140 degrees east to cover the East Asia and Western Pacific regions since 1977, and makes related contributions to the WMO's World Weather Watch (WWW) Programme. As a follow-on to the MTSAT series, the Agency plans to operate next-generation satellites called Himawari-8 and Himawari-9 (*himawari* means "sunflower" in Japanese).

SCHEDULE

Currently, MTSAT-2 (also called Himawari-7) is operational, while MTSAT-1R (also called Himawari-6) is on standby in orbit. MTSAT-2, which took over the earth observation mission of MTSAT-1R on July 1, 2010, is scheduled to complete its observation operation in around 2015. In order to provide continuous observation, JMA plans to launch Himawari-8 in 2014 and begin its operation in 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 at around 140 degrees east covering the East Asia and Western Pacific regions, as with the GMS and MTSAT series.

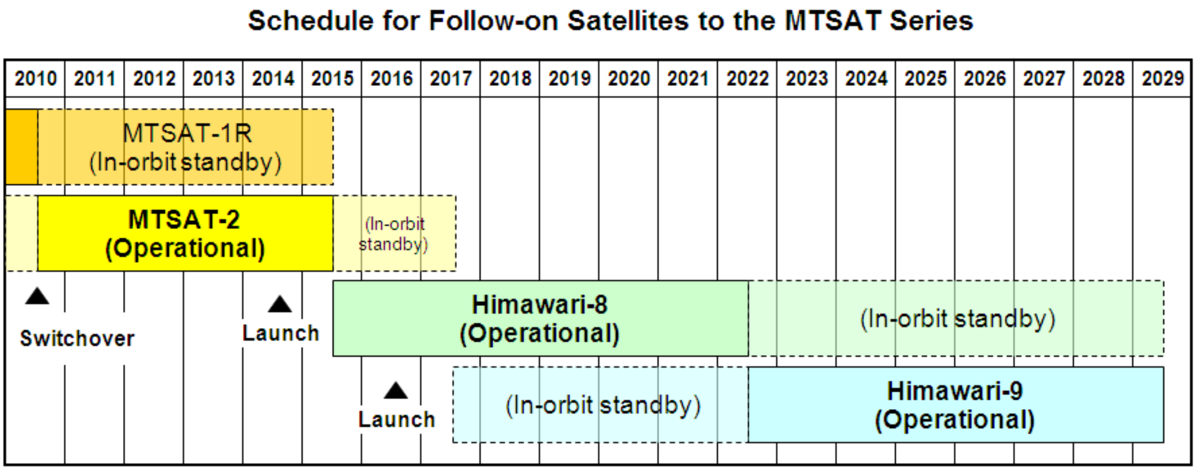

Figure 1: **Schedule for the follow-on satellites to the MTSAT series**.

SPACE SEGMENT

Table 1 lists the major specifications of Himawari-8 and -9. JMA completed contract arrangements for the manufacture of these satellites in July 2009. The PDR (Preliminary Design Review) stage is now finished, and production is in the detailed design phase. The two units have identical specifications, and will be operated in the same geostationary orbiting position at around 140 degrees east. Himawari-8 and -9 will have a dedicated meteorological mission, whereas MTSAT performs both meteorological and aeronautical functions. They will carry a new unit called the Advanced Himawari Imager (AHI).

Geostationary position	Around 140°E
Attitude control	3-axis attitude-controlled geostationary satellite
Imaging sensor	Advanced Himawari Imager (AHI)
Communications	1) Raw observation data transmission Ka-band, 18.1 – 18.4 GHz (downlink)
	2) DCS International channel 402.0 – 402.1 MHz (uplink) Domestic channel 402.1 – 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 (planned)

Table 1: **Major specifications of Himawari-8 and -9**

Table 2 shows JMA's requirements for the imager, 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 MTSAT, and enable better nowcasting, improved numerical weather prediction accuracy and enhanced environmental monitoring. 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 environmental data from data collection platforms (DCPs) to sustain the data collection system (DCS) currently operated by MTSAT. JMA plans to provide all imagery data from Himawari-8 and -9 using the Internet as the primary dissemination method. It is also researching the feasibility of other dissemination methods and technologies.

Imaging channels			
	Band	Central wavelength (μm)	Spatial resolution (km)
	Visible	0.46	1
		0.51	
		0.64	0.5
	Near-infrared	0.86	1
		1.6	2
		2.3	
	Infrared	3.9	
		6.2	
		7.0	
		7.3	
		8.6	
		9.6	
		10.4	
		11.2	
		12.3	
		13.3	
Observation			
	Scan capability	Full disk: normal operation Area: definable schedule and location	
	Imaging rate	< 10 min (full disk)	
Lifetime of meteorological mission			
	8 years of in-orbit operation out of a 15-year in-orbit period		

***Table 2:* JMA's requirements for the Himawari-8 and -9 imager**

GROUND SEGMENT

JMA plans to use two ground stations to establish site diversity in the interests of mitigating the rain attenuation effect on the Ka-band to be used for the imagery data downlink. The primary ground station will be located in the Kanto region (in the middle of Japan), and the secondary one will be placed in the Hokkaido region (in the north of Japan). The imagery and DCP data collected at the ground stations will be sent to the Meteorological Satellite Center in Tokyo via dedicated lines for processing to generate satellite products for users.

PREPARATION FOR NEW PRODUCTS

The follow-on satellites will offer high observation potential, which will enable users to analyze cloud properties and cloud physics. To make the most of these functions as well as to provide users with effective information from the start of Himawari-8's operation, JMA has set up an environment for the development of new products from the follow-on satellites in collaboration with its Meteorological Satellite Center (MSC) and other internal related divisions according to the policies outlined here. In the future, the Agency plans to start the development of related products, and is interested in pursuing scientific and prototyping activities in collaboration with CGMS members. This is particularly the case with EUMETSAT and NOAA/NESDIS, which already operate or are preparing to use a new generation of multi-channel imaging instruments (MSG and GOES-R).

IMPROVEMENT OF CURRENT SATELLITE PRODUCTS

Enhancement of current satellite products is planned based on the use of fresh observation information from the new imagers on board the follow-on satellites. The products earmarked for improvement are; Atmospheric Motion Vector (AMV), Clear Sky Radiance (CSR), Cloud Grid Information (CGI) and Sea Surface Temperature (SST).

In particular, significant improvement of the AMV product is foreseen. Higher image resolutions and more frequent observations are expected to provide better target tracking accuracy, and the increased number of imaging bands will enhance AMV height assignment.

DEVELOPMENT OF NEW PRODUCTS

The enhancement of the observation function of Himawari-8/9 as compared to that of MTSAT-2 is expected to provide a variety of new parameters. To build up new products efficiently against a background of limited research resources, JMA is focusing on the development of two outputs relating to instability indices and volcanic ash.

INSTABILITY INDICES

JMA plans to introduce a derivation technique for instability indices, which are operationally used at EUMETSAT and NOAA, and to implement localization for the area around Japan. These indices are expected to support weather forecasters in the early detection of severe meteorological phenomena such as heavy rain and thunderstorms. Instability indices are calculated from atmospheric profiles of temperature and humidity as retrieved using a one-dimensional variational (1D-Var) method based on Himawari-8/9 multi-band observations. The 1D-Var system was developed by JMA's Numerical Prediction Division. Investigation on the formulation of the indices is currently under way.

VOLCANIC ASH

The importance of volcanic ash monitoring was highlighted by the April 2010 eruption of Eyjafjallajokull in Iceland and the January 2011 eruption of Shinmoe-dake in western Japan. Volcanic ash directly affects airplane flight plans, and is monitored by JMA's Tokyo Volcanic Ash Advisory Center (VAAC). Currently, differences between MTSAT 10.8-micron and 12-micron images are used for monitoring the spread of ash. However, quantitative information is also required. From Himawari-8/9 observations, quantitative data such as ash density and height are expected. JMA plans to develop the product based on a EUMETSAT MSG algorithm and a NOAA/NESDIS GOES-R algorithm. The Agency has already started a review of both methods, and will continue related research.

PREPARATION OF SIMULATED SATELLITE IMAGES FOR THE DEVELOPMENT OF NEW PRODUCTS

To support the development of Himawari-8/9 products, simulated images are necessary. Himawari-8 and 9 provide 2.5-minute-interval images of the area around Japan as well as 2-km-resolution images in infrared bands. In order to develop the use of this imagery, MTSAT-1R low-level images are used. MTSAT-1R originally has a 2-km-resolution observing capability in infrared bands, and currently performs 5-minute-interval observations of the area around Japan. Simulated images are generated from the two methods and are used to develop the use of Himawari-8/9 16-band images.

IMAGES SIMULATED FROM HYPER SOUNDER DATA

Simulated images are generated by accumulating high-spectral-channel observations from MetOp/IASI and other hyper sounders. Such images are useful for the development of products related to volcanic ash/gas, yellow sand, ozone and surface variables, as they originate from actual observations including weather conditions. JMA has conducted a number of experiments (e.g., total ozone monitoring) in this area and achieved promising results (Figures 2).

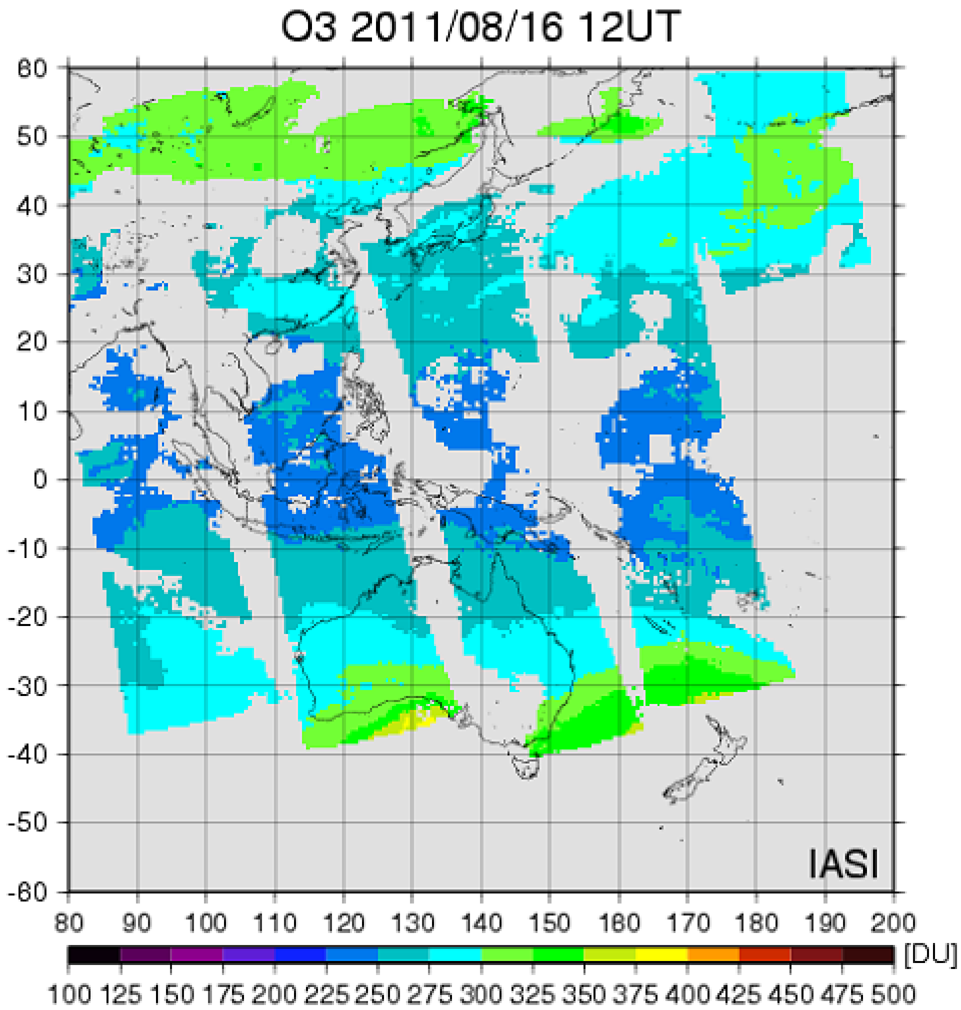

Figure 2: **Estimation of O_3 distribution at 12 UTC on 16 August, 2011, based on simulated infrared channel images of 9.6 µm and 11.2 µm. Simulated images are formed from an accumulation of MetOp/IASI high-spectral-channel observations. Dense ozone is seen in high-latitude areas.**

IMAGES OF RADIATIVE TRANSFER SIMULATION

Another type of simulated image is generated by radiative transfer computation based on the provisional response functions of the follow-on satellites. For this purpose, data from RSTAR (Nakajima, T., and M. Tanaka, 1986 and 1988) are used. For atmospheric fields, analysis and forecasts from JMA's Numerical Weather Prediction are adopted. To determine surface conditions, a MODIS product released by NASA is used. For atmospheric composition, climate conditions are currently adopted. Figure 3 shows examples of these images. JMA plans ongoing improvement of the related simulation techniques and their utilization in the development of new products.

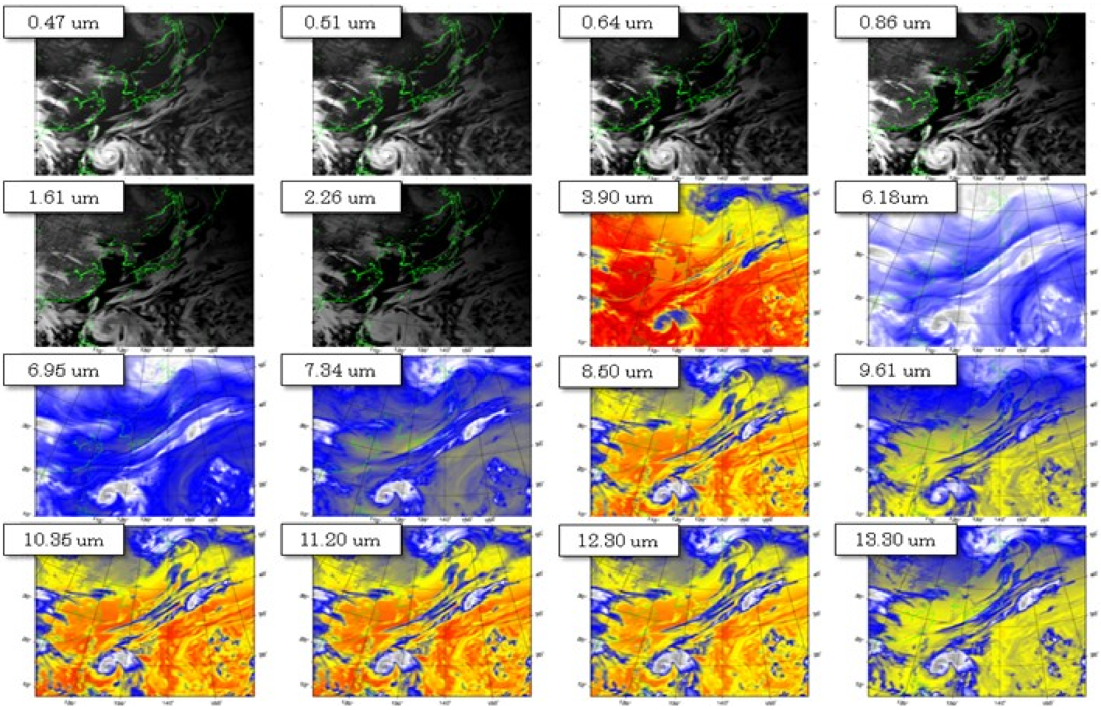

Figure 3: **Radiative transfer simulated images for Himawari-8/9's 16 AHI bands. The numbers shown in each figure indicate the central wavelength of the bands.**

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