JMA updates since CGMS-53 and report on the medium to long-term future plans on Earth observation

Presented to CGMS-54 plenary session, agenda item 3

Coordination Group for Meteorological Satellites

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Executive summary

The Japan Meteorological Agency (JMA) operates two geostationary meteorological satellites, Himawari-8 and -9, equipped with Advanced Himawari Imager (AHI). JMA conducted the operational satellite switchover from Himawari-8 (in operation since July 2015) to Himawari-9 in December 2022 for scheduled operation until FY 2030.

JMA contracted manufacturing of the follow-on satellite Himawari-10 in March 2023, with initiation of operation scheduled for FY 2030. Himawari-10 is scheduled to carry a visible/infrared imager as well as an infrared sounder and a high energy electron sensor, and high and very high energy proton sensor. JMA is considering Himawari-10 imager and sounder data formats and a plan for transition from Himawari-9 to Himawari-10.

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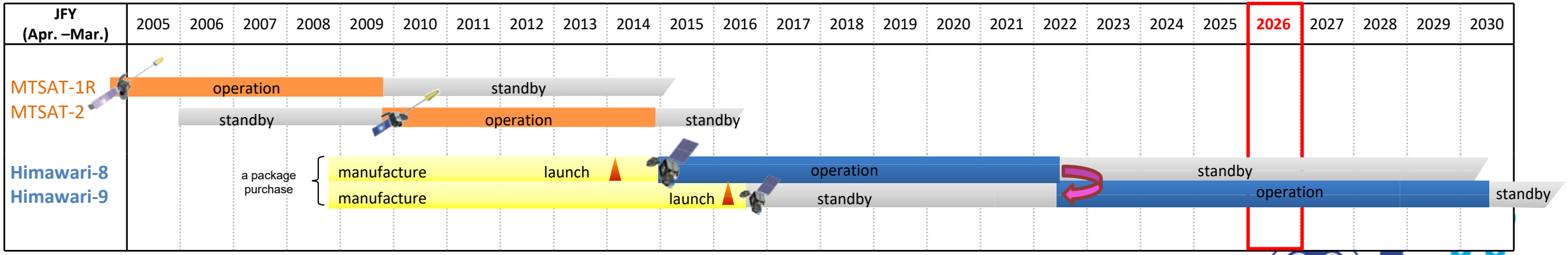
Himawari-8/9

Himawari-8 began operation on 7 July 2015, switching over to Himawari-9 on 13 December 2022

Geostationary position	Around 140.7°E
Attitude control	3-axis stabilization
Communication	1) Raw observation data transmission Ka-band, 18.1 - 18.4 GHz (downlink)
	2) DCS (Data collection System) 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, 12.2 - 12.75 GHz (downlink) 13.75 - 14.5 GHz (uplink)



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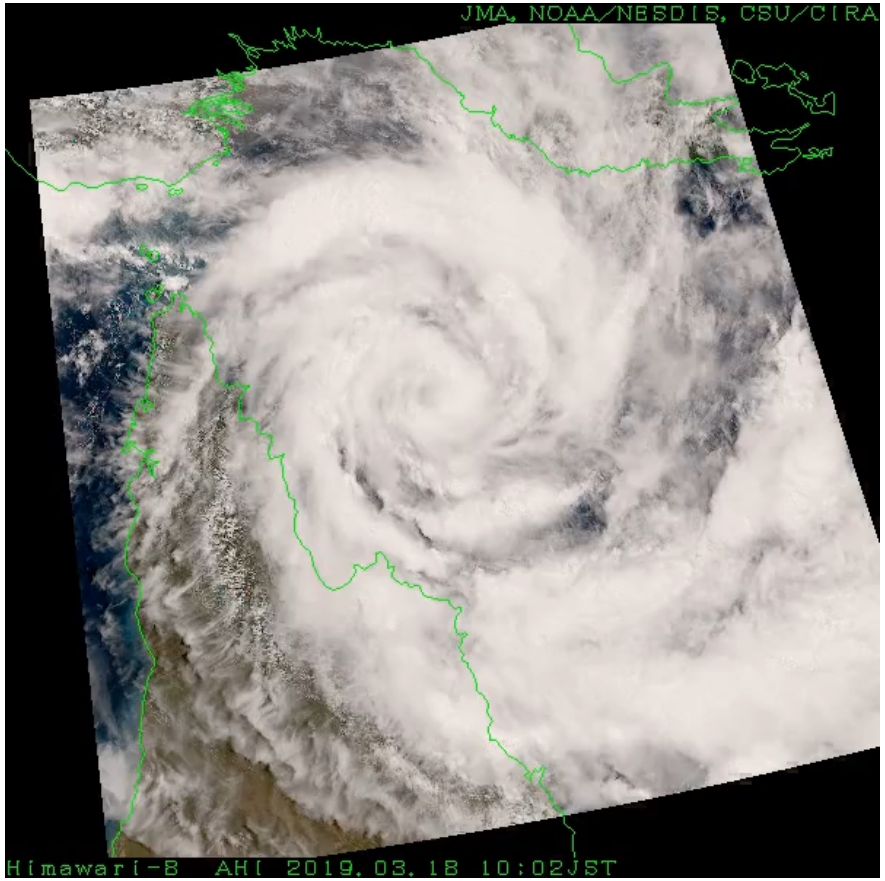
HimawariRequest

- HimawariRequest was started from January 2018 in cooperation with Bureau of Meteorology (BoM), Australia.
- International service for NMHSs in Himawari-8/9 coverage area to request Target Area observation(1,000 x 1,000 km area every 2.5 minutes).
- JMA expects this service to support disaster risk reduction activities in the Asia Oceania region.
- Status as of 1 May 2026
  - Registration: 22 NMHSs
  - 374 requests for TC, volcanic eruption, wildfires, etc.



HimawariRequest from BoM on 13-19 Mar. 2019

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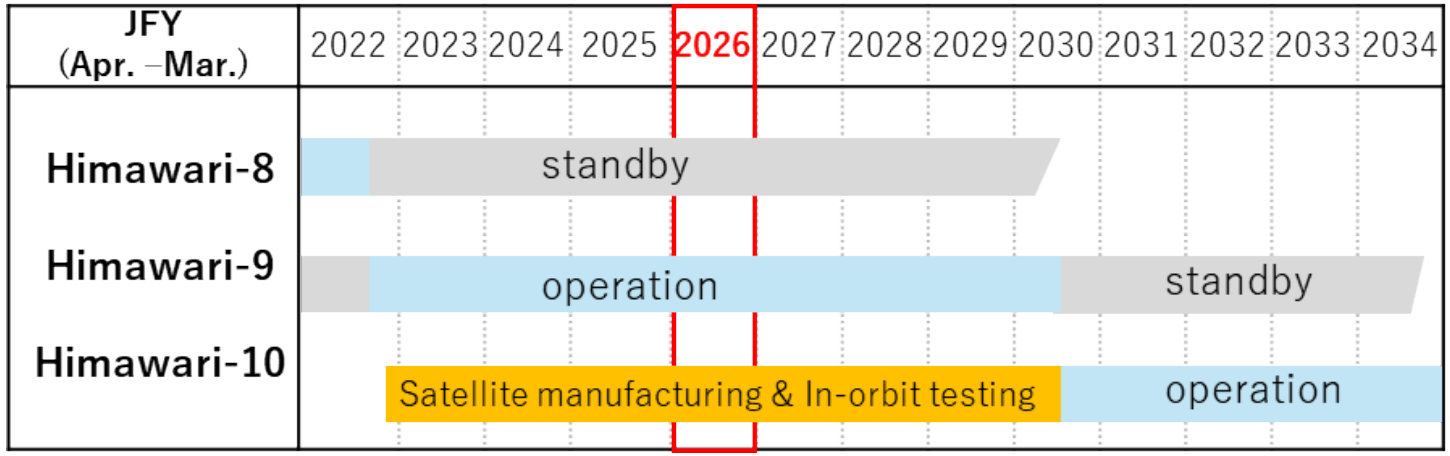
Himawari Follow-on Program

- JFY2018: JMA has started to consider the next GEO satellite (Himawari-10) program.
  - JMA will pursue seamless GEO satellite system by considering CGMS baseline and WMO Vision for WIGOS in 2040 to contribute the establishment of Geo-Ring observation.
- JFY2022: Start of manufacturing of Himawari-10 using supplemental budget
- JFY2024: PDR (Preliminary Design Review) for Himawari-10
- JFY2025: Contract for Ground Segment of Himawari-10
  CDR (Critical Design Review) for Himawari-10 was completed
- JFY2030: Launch and start of operation of Himawari-10
- JMA has started to consider the successor to Himawari-10.



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WMO Vision for WIGOS in 2040 for GEO

	Application	Satellite/Instrument
VIS/IR Imager w/ rapid repeat cycles	Cloud amount/type/top height/temperature, wind, sea/land surface temperature, precipitation, aerosols, snow cover, vegetation cover, albedo, atmospheric stability, fires, volcanic ash, sand/dust storm, convective initiation	• NOAA: GOES-16,17,18.19/ABI • JMA: Himawari-8,9/AHI • KMA: GK-2A/AMI • CMA: FY-4A,4B/AGRI • EUMETSAT: MTG-I1/FCI
Hyperspectral IR Sounder	Atmospheric temperature/humidity, wind, rapidly evolving mesoscale features, sea/land surface temperature, cloud amount/top height/temperature, atmospheric composition	• NOAA: GeoXO/GXS (2032) • JMA: Himawari-10/GHMS (2030) • KMA: N/A • CMA: FY-4A,4B/GIIRS • EUMETSAT: MTG-S1/IRS (2025)
Lightning Mapper	Lightning, location of intense convection, life cycle of convective systems	• NOAA: GOES-16,17,18,19/GLM • JMA: N/A • KMA: N/A • CMA: FY-4A/LMI • EUMETSAT: MTG-I1/LI
UV/VNIR Sounder	Ozone, trace gases, aerosol, humidity, cloud top height	• NASA: TEMPO • JMA: N/A • KMA: GK-2B/GEMS • CMA: N/A • EUMETSAT: MTG-S1/UVN (2025)

JMA's 10-Year Strategy Toward 2030

1. Technology Developments

- Application of latest sci & tech;
  - ✓ Advanced ***satellites***, remote sensing, big data
  - ✓ NWP and other prediction tech.
  - ✓ Collaboration etc.
- Improvement of forecasts
  - ✓ Nowcast up to 1 hour
  - ✓ ***12-hour forecast of localized heavy rain (stationary linear mesoscale convective systems)***
  - ✓ ***3-day typhoon forecast*** etc.

Synergies

Met. Services for Better Society

2. Promotion of Effective Utilization of Info./Data

- Build environment for better usage
  - ✓ Larger data flow
  - ✓ Easier access
- Raise capacity for the utilization
  - ✓ Literacy about disaster, safety, etc.
  - ✓ Application technology/skill

3. Contribution to Disaster Resiliency

- JMA to contribute to "Disaster Awareness Society" and to play the leading role in met. services
  - ✓ Improved impact-based warnings on the basis of advanced sci & tech
  - ✓ Collaborate with stake-holders to build local decision making capacity
  - ✓ Raise individual disaster awareness and response capacity

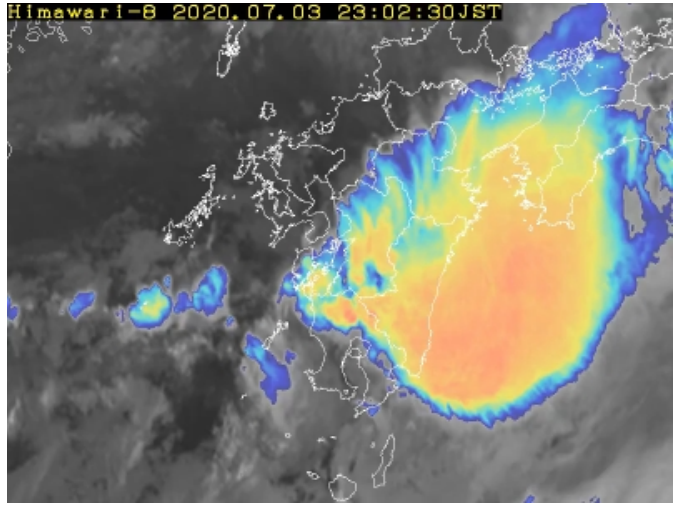
We need to observe 3-D humidity information to improve these forecasts

Toward Better Prediction for Stationary Linear Mesoscale Convective Systems

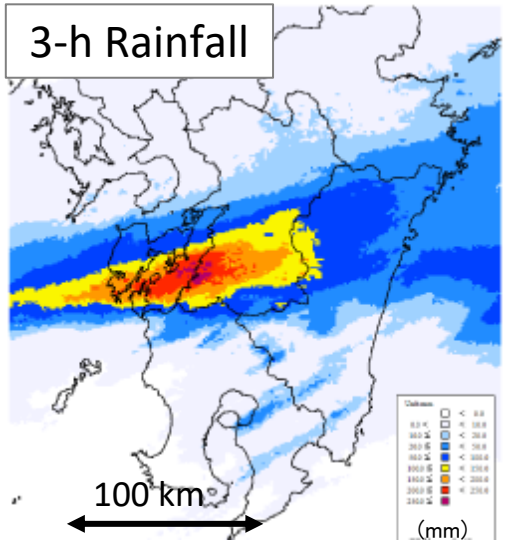
- Recent extreme high-impact weather events creating demand for enhanced JMA weather forecasts/warnings
- Enhancement of such demand caused by torrential rain during the East Asian rainy season since 2020
  - ✓ Mainly caused by **Stationary Linear Mesoscale Convective Systems (SLMCS)**
- Essential understanding of the mechanics of atmospheric water vapor causing severe disasters
  - ✓ e.g., sustained inflow of large amount of water vapor

Heavy rain event in western Japan on 4th July 2020

Himawari-8 imagery



3-h Rainfall



3-h accumulated radar/rain-gauge obs. (mm) at 0500 on 4th July 2020

Houses submerged by the Kuma River on 4 July 2020 (MLIT)

Himawari-10 Overview

Missions

- **Geostationary HiMawari Imager (GHMI)**
  Measures visible & infrared radiance for weather monitoring/nowcasting & other applications.
  Extended version of AHI (Advanced Himawari Imager).

- **Geostationary HiMawari Sounder (GHMS)**
  Measures high-spectral-resolution infrared radiance to collect vertical information of atmospheric temperature & water vapor, which improve weather forecasting by assimilating to numerical weather prediction models.

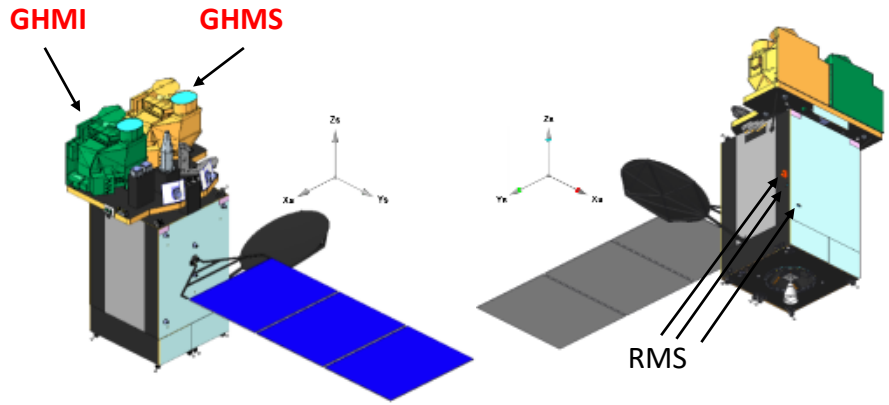
- **Data Collection System**
  Relays surface-based Data Collection Platforms (DCPs) data.

- **Radiation Monitors for Space weather (RMS)**
  Measures proton & electron flux in geostationary orbit, as a government furnished equipment by NICT.
  NICT: National Institute of Information and Communications Technology, Japan

Location

- Geostationary orbit at around 140.7 deg. E

Satellite Outline



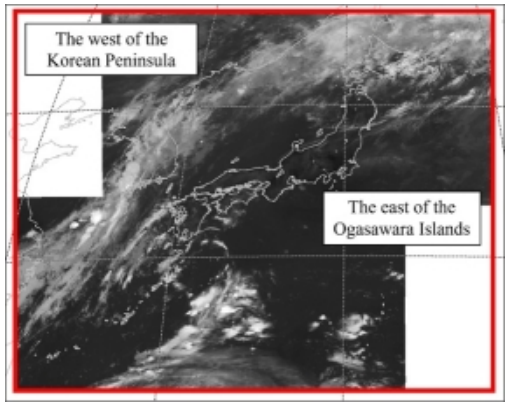
Satellite Design	
Spacecraft	MELCO standard DS2000 bus
Mass (approx.)	2.4 t (dry), 6.1 t (with propellant)
Size (approx.)	4 m x 3 m x 6 m (folded), 11 m (deployed)
Design life	≥ 15 years (mission period ≥ 10 years)
Communications	Ka-band: Mission data downlink Ku-band: TT/C uplink & downlink UHF-band: DCP uplink

Geostationary HiMawari Imager (GHMI)

- L3Harris's 18-band imager based on the same concept with its GeoXO Imager (GXI) selected by NASA
- Observing sequence & band configuration changed for Himawari-10

GHMI Observing Area & Interval

Observing Area (minimum coverage)	Interval
Full Disk	10 min
Japan (EW 2500 km x NS 2000 km)	2.5 min
Target Area1 (EW 1000 km x NS 1000 km)	2.5 min
Target Area2 (EW 1000 km x NS 1000 km)	2.5 min
Target Area3 (EW 1000 km x NS 1000 km	2.5 min
Target Area4 (EW 1000 km x NS 1000 km)	2.5 min
Target Area5 (*) (EW 1000 km x NS 500 km)	30 sec



*Mainly used for CAL/VAL activities

Improvement from Himawari-8/9

GHMI Spectral band characteristics

	Center Wavelength [μm]	Band width [μm]	Spatial resolution at nadir [km]		
			H-10	H-8/9	
VIS	0.46 - 0.48	≤ 0.07	0.5	1	
	0.54 - 0.56	≤ 0.05	0.5	1	Change in center wavelength
	0.63 - 0.65	≤ 0.12	0.25	0.5	
NIR	0.85 - 0.87	≤ 0.06	1	1	
	1.375 - 1.385	≤ 0.04	2	-	New band
	1.60 - 1.62	≤ 0.08	1	2	
	2.24 - 2.27	≤ 0.06	1	2	
IR	3.75 - 3.95	≤ 0.50	1	2	
	5.10 - 5.20	≤ 0.20	1	-	New band
	6.05 - 6.45	≤ 1.20	2	2	
	6.90 - 7.00	≤ 0.50	1	2	
	7.27 - 7.43	≤ 0.60	2	2	
	8.44 - 8.76	≤ 0.50	2	2	
	9.55 - 9.70	≤ 0.50	2	2	
	10.3 - 10.5	≤ 0.90	1	2	
	11.1 - 11.3	≤ 1.00	2	2	
	12.25 - 12.55	≤ 1.20	2	2	
	13.2 - 13.4	≤ 0.70	2	2	

Future plan: Data Format for GHMI (Draft)

This plan is subject to change.

Himawari-8/9 data format

Many types of data format
depending on the resolution etc.

Himawari Standard data (HSD)

- JMA original format for Himawari-8/9 full data (High resolution)
  - ➢ Users need to create a program to read the original format.
    - ✓ A large burden on the users.

HRIT/LRIT

- The data format distributed for HimawariCast service. (Low resolution)

NetCDF

- The data format for Japan area and Target area observations of Himawari-8/9

Himawari-10 data format

Unified data format (NetCDF-compliant)

NetCDF*

- Standard data format
  - ➢ Used for GOES-16/17/18 (ABI) and MTG (FCI, IRS).
  - ➢ Users can use existing program supporting NetCDF.
    - ✓ Relatively low burden on the users.

*Note: The data components of NetCDF format are different between Himawari-8/9 and Himawari-10.

"**Himawari-8/9 data**" and "**Himawari-10 data**" have different data format.

✓ All Himawari data users need to move to new data format.

Future plan: Transition Plan for GHMI (Draft)

This plan is subject to change.

Preliminary our transition plan

* The “H-10 data format” in this slide refers to “NetCDF for Himawari-10”.

① Himawari-9 operation phase

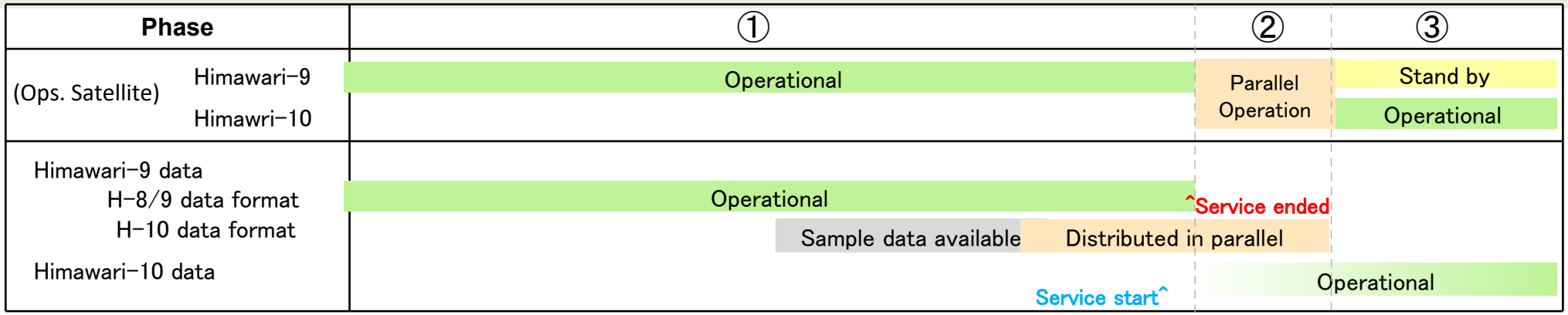
- H-9 data in H-10 data format will be provided in advance.
  - Sample data in H-10 data format created from H-9 data will be available for download.
  - H-9 data in H-8/9 data format and H-10 data format will be distributed in parallel.

② Himawari-9 and Himawari-10 parallel operation phase

- H-10 data in H-10 data format and H-9 data in H-10 data format will be distributed in parallel.
- H-9 data in H-8/9 data format will be discontinued at the start of observation of H-10.

③ Himawari-10 operation phase

- H-10 data in H-10 data format
  - ✓ No H-10 data in H-8/9 data format
- H-9 data for back up will be distributed in H-10 data format if some troubles happen in H-10.

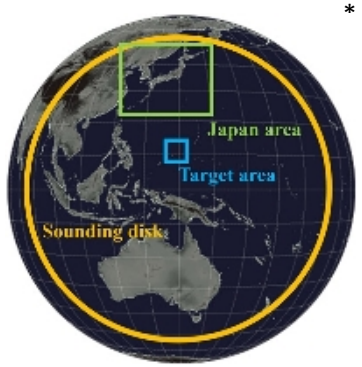


Geostationary HiMawari Sounder (GHMS)

- L3Harris's new infrared FTS sounder based on the same concept with its GeoXO Sounder (GXS)

GHMS Observation Areas & Time Interval

Observation Areas (minimum coverage)	Interval
Sounding Disk (zenith angle ≤ 60 deg)	60 min
Japan (EW 2500 km x NS 2000 km)	15 min*
Target Area (EW 1000 km x NS 1000 km)	15 min



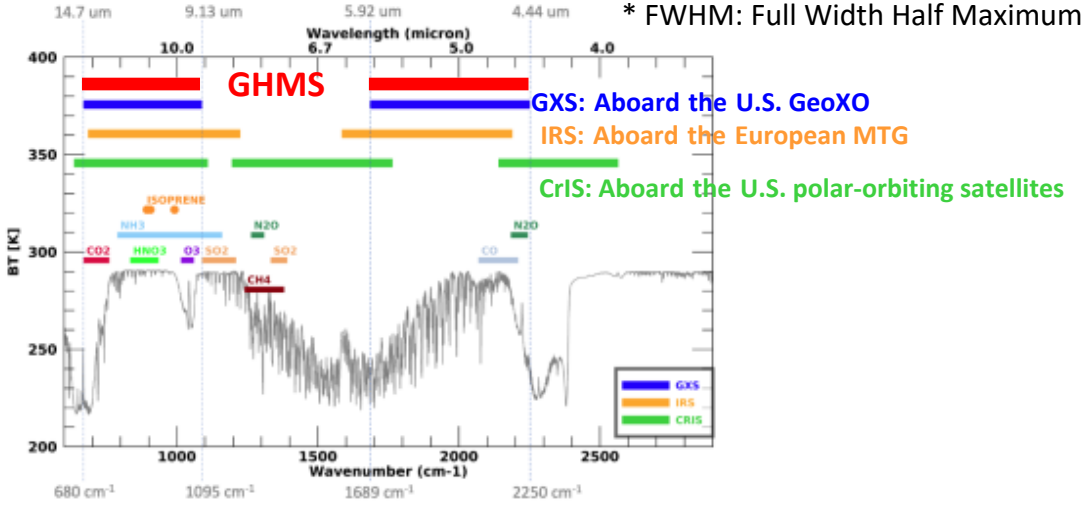
The assumed GHMS observation coverage

* Sounding Disk observation over Japan area is regarded as one of the "Japan" observations in the 60-min repeat cycle (i.e., three "Japan" observations to be conducted in 60 minutes).

GHMS Spatial & Spectral specifications

Spatial (horizontal) resolution		4.1 km
Spectral Coverage	LWIR	680 - 1095 cm^{-1} (14.7 - 9.13 µm) About 650 channels
	MWIR	1689 - 2250 cm^{-1} (5.92 - 4.44 µm) About 900 channels
Spectral Resolution (FWHM*)		≤ 0.754 cm^{-1}
Spectral Sampling Distance		≤ 0.625 cm^{-1}

* FWHM: Full Width Half Maximum



Data File for GHMS (Draft)

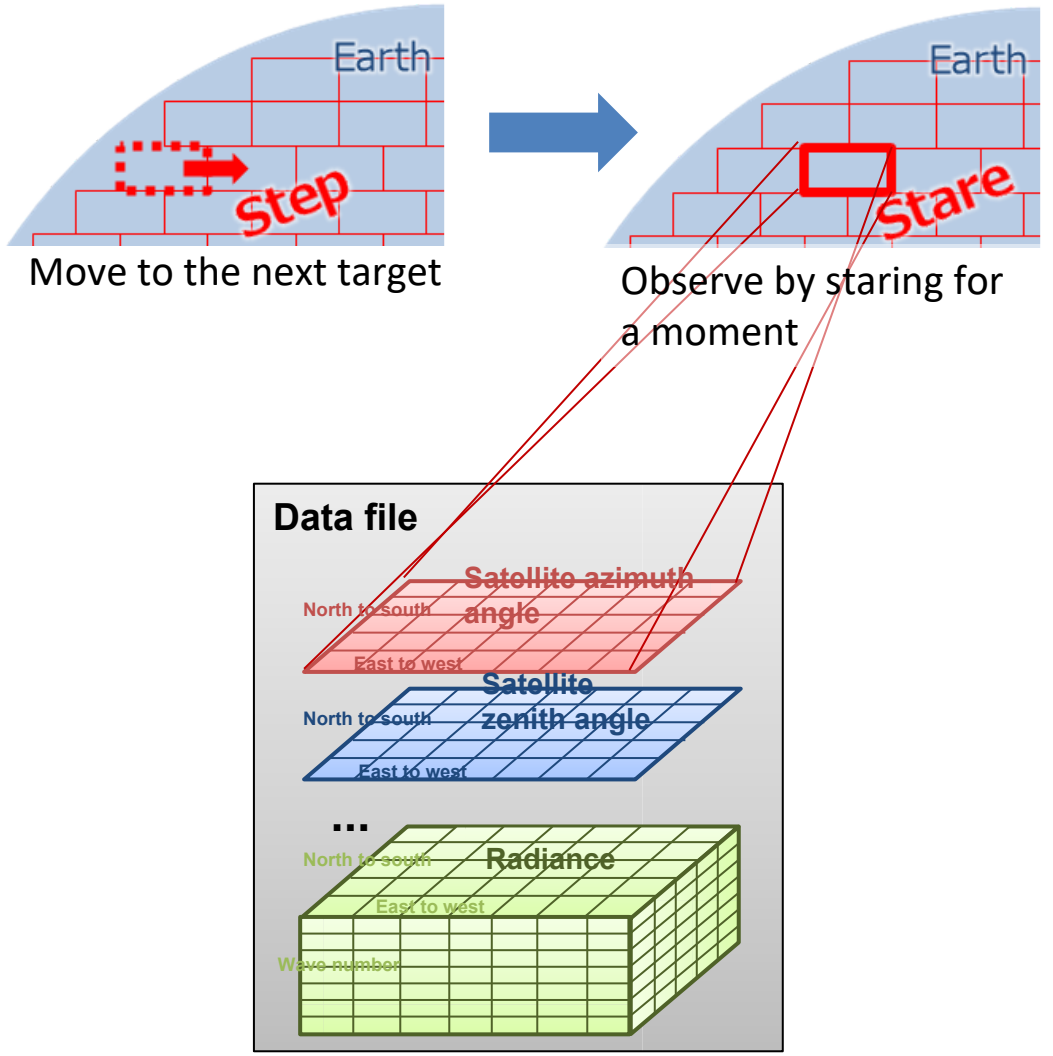
This plan is subject to change.

Overview of GHMS observation

- **"Step and Stare observation"** with an area sensor.
  - One stare can observe a range of about 1,000 km from east to west and about 500 km from north to south at nadir.
- The number of stares required for each observation area every one hour is 154 for sounding disc, 12 (4 rows x 3 cols) x 3 for Japan area and 2 (2 rows x 1 cols) x 4 for target area.

L1 Data File Format

- Unified data format (NetCDF)
- Smallest unit of data is a single file for each stare.
- **Principal component analysis (PCA) data** will be distributed to NMHSs.
  - JMA will consider to provide the source data of GHMS, while assessing the cost of providing the service and the needs of the users.
- No spatial resampling unlike imager
- Details of stored data are under consideration.
  - Radiance, data quality, latitude, longitude, satellite zenith angle and azimuth angle, solar zenith angle and azimuth angle etc. will be stored in two or three-dimensional array



Schematic image of observation and stored data

Estimation of data volume

Based on the results of the critical design review, the estimation of data volume for GHMI and GHMS of Himawari-10 is the following:

※ Leval1 data with the finest resolution (equivalent to the “Himawari Standard Data” of Himawari-9)

＜GHMI＞ Data volume par day [GiB = 2^{30}byte]

Observing Area	Himawari-9	Himawari-10	ratio
Full disk	81 GiB	471 GiB	5.8
Japan area	13 GiB	102 GiB	7.8
ALL (including Target area)	110 GiB	788 GiB	7.2

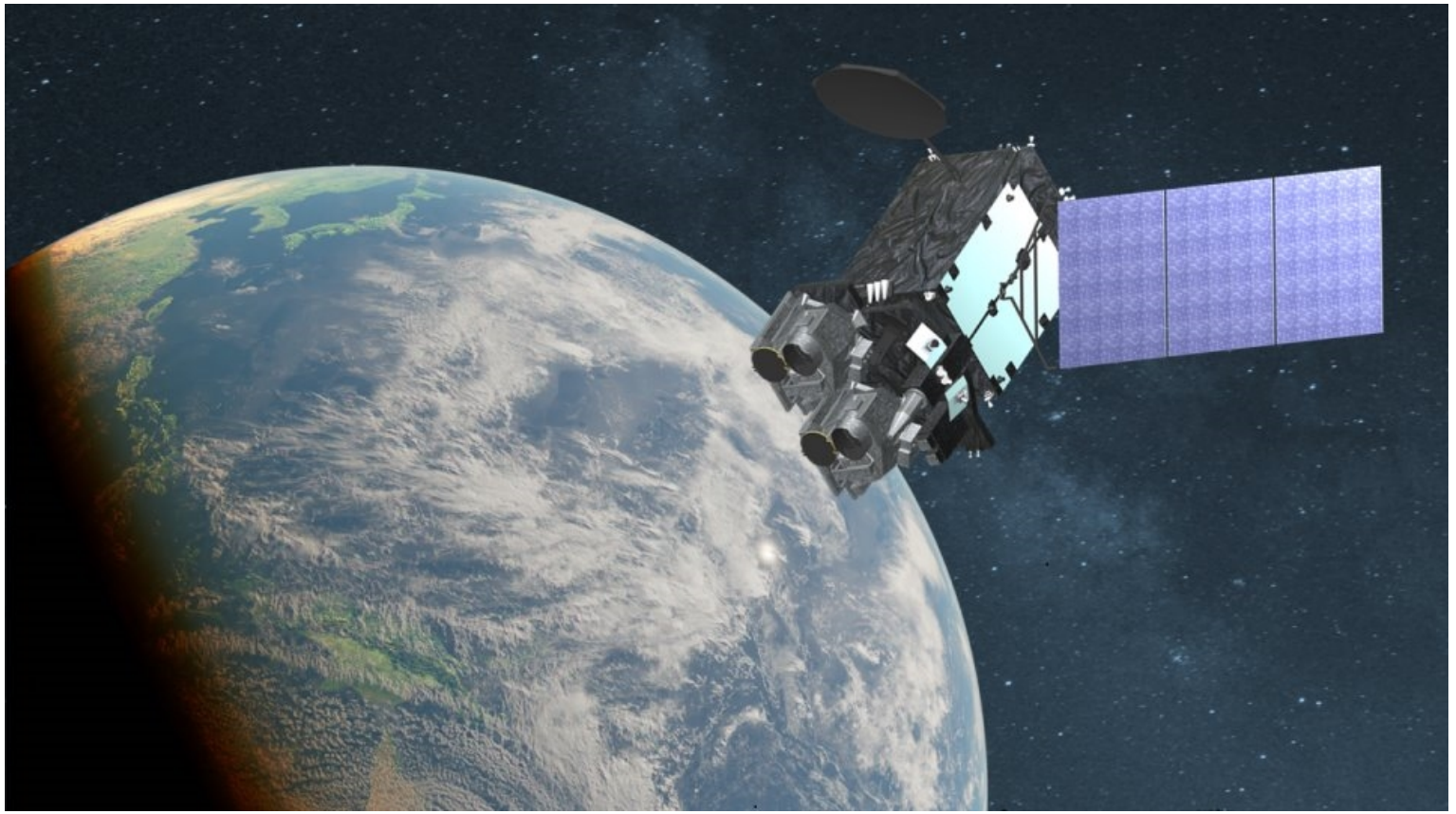
- ○ The increase in data volumes is mainly due to the following updates;
  - Doubling of resolution in some bands (resulting in a fourfold increase in data volume for those bands).
  - Expansion of the observation area at Japan area.
  - Addition of new observation bands.
  - Inclusion of quality control information.
- ○ This estimation includes 30% of calculated data volume as a margin.

＜GHMS＞ Data volume par day [GiB = 2^{30}byte]

Data	Himawari-10
Full spectral data	1535 GiB
Principal Component Analysis product for distribution	a fraction of the above

- ○ Access to the full spectral data will be considered based on user request.

Thank you!!



Himawari-10 Perspective image

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