JMA updates since CGMS-52 and report on the medium to long-term future plans on Earth observation

Presented to CGMS-53 plenary session, agenda item 3

Coordination Group for Meteorological Satellites

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 2029.

JMA contracted manufacturing of the follow-on satellite Himawari-10 in March 2023, with initiation of operation scheduled for FY 2029. 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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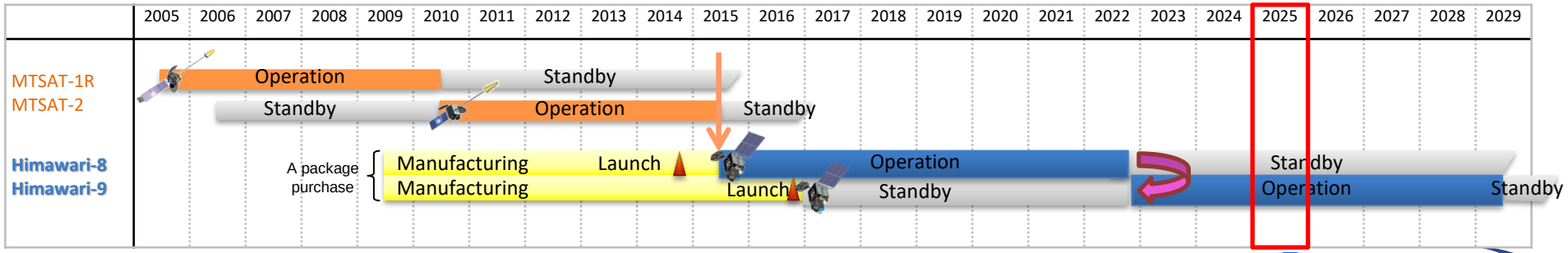
Himawari-8/9

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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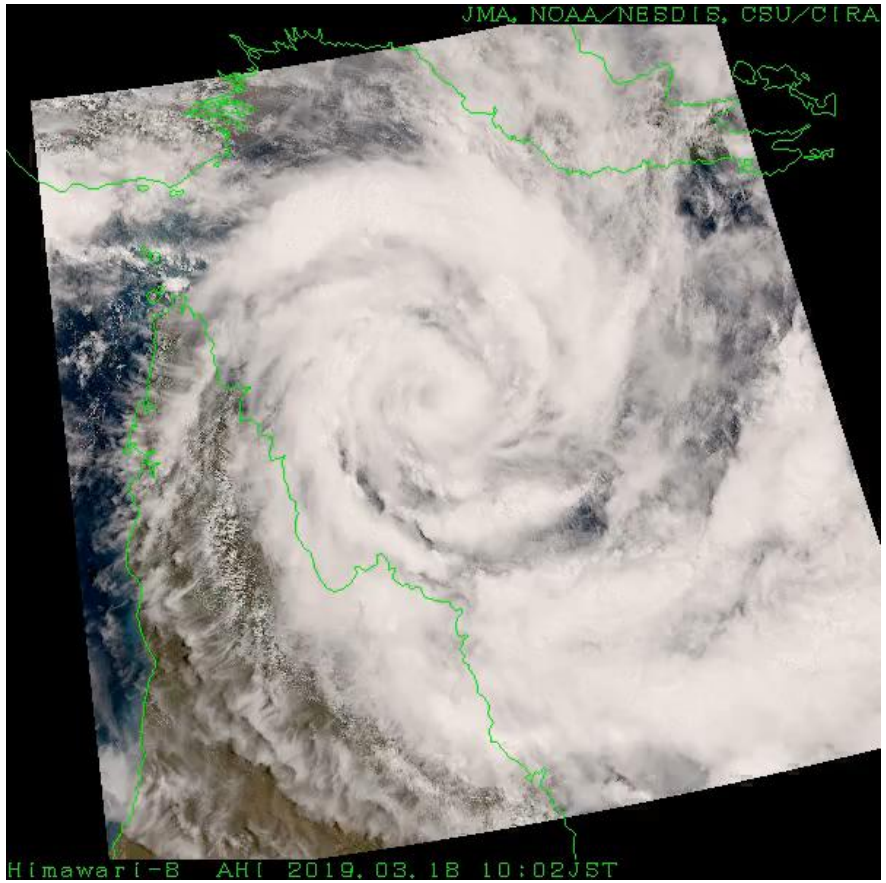
HimawariRequest

- 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 2025
  - Registration: 22 NMHSs
  - 290 requests for TC, volcanic eruption, wildfires, etc.



HimawariRequest from BoM on 13-19 Mar. 2019

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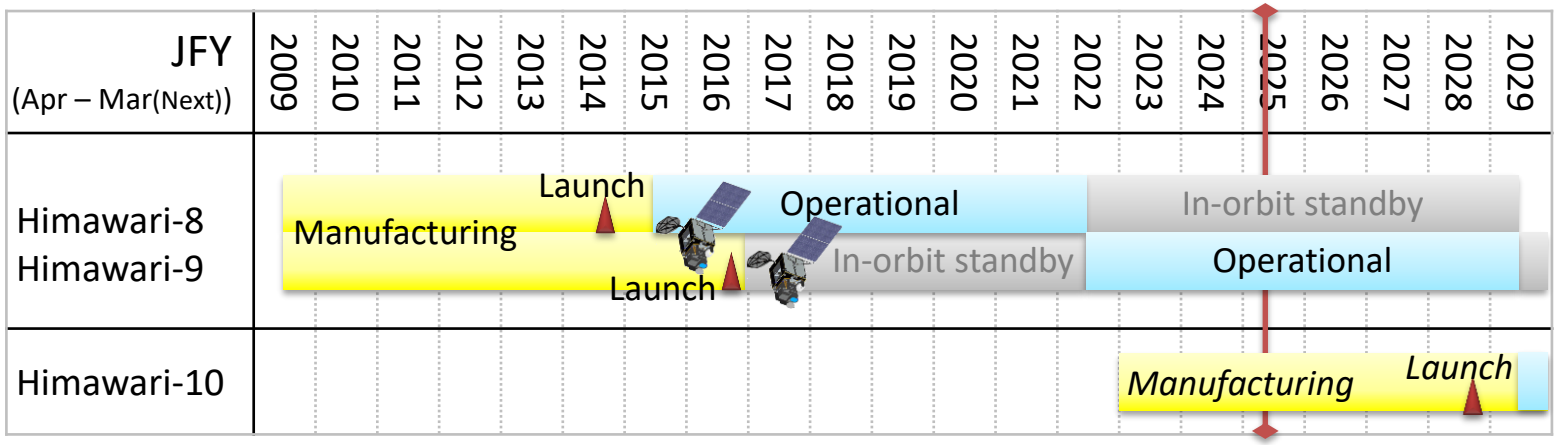
Himawari Follow-on Program

- JFY2018: JMA has started to consider the next GEO satellite (Himawari-10) program.
  - "Japan will continue manufacturing Himawari-10, with operational commencement provisionally scheduled for around FY 2029."
    <Japan's "Basic Plan on Space Policy" (June 2023)>
  - 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 H-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
- JFY2028: Launch of Himawari-10
- JFY2029: Start of operation of Himawari-10

- JMA has just 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-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: N/A • JMA: N/A • 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-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)

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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

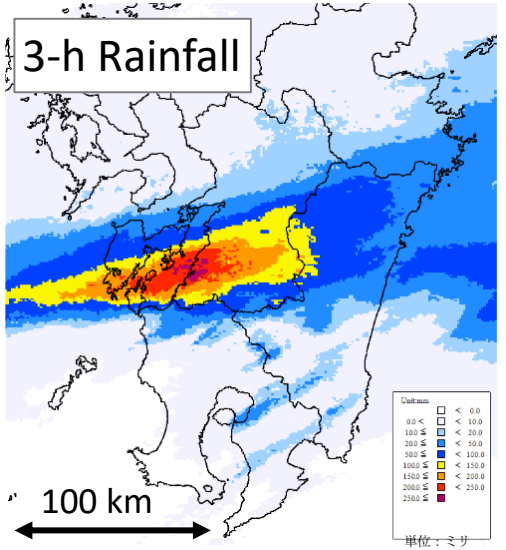
3. Contribution to Disaster Resiliency

- 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

- High-impact weather events in recent years have resulted in a demand for improving JMA's weather forecasts/warnings
- Torrential rain events during East Asian rainy season in 2020 and 2021 further enhanced this demand
  - ✓ Mainly caused by stationary linear mesoscale convective systems
- JMA established WG with external experts and internal TF to improve the prediction system to issue warnings with extended lead time by
  - ✓ Introducing advanced observation technologies such as GNSS receivers on vessels (short-term subject) and geostationary IR sounders (long-term subject)
  - ✓ Improving NWP models
- Enhanced collaboration with academia.



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)

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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.

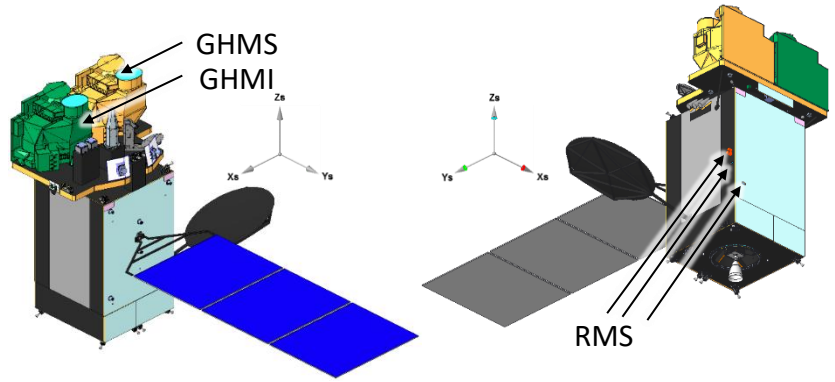
- **Data Collection System**
  Relays surface-based Data Collection Platforms (DCPs) data.

- **Radiation Monitors for Space weather (RMS)**
  Measures proton & electron flux in geostationary orbit, as a government furnished equipment by NICT.

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)

- Observing sequence & band configuration changed for Himawari-10.
- Values in the tables show JMA requirements.

Improvement from Himawari-8/9

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

GHMI Spectral band characteristics

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

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Geostationary HiMawari Sounder (GHMS)

- L3Harris's new infrared FTS sounder based on the same concept with its GeoXO Sounder (GXS).
- Values in the tables show JMA requirements.

GHMS Observing Area & Interval

Observing Area (minimum coverage)	Interval
Sounding Disk (LZA ≤ 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

※ 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 characteristics

Spatial (horizontal) resolution		≤ 4.2 km
Spectral Coverage	LWIR	680 - 1095 cm^{-1} (14.7 - 9.13 µm)
	MWIR	1689 - 2250 cm^{-1} (5.92 - 4.44 µm)
Spectral Resolution (FWHM)		≤ 0.754 cm^{-1}
Spectral Sampling Distance		≤ 0.625 cm^{-1}

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Future plan: Data Format for GHMI (Draft)

This is only a preliminary plan at this time and could change significantly in the future.

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.

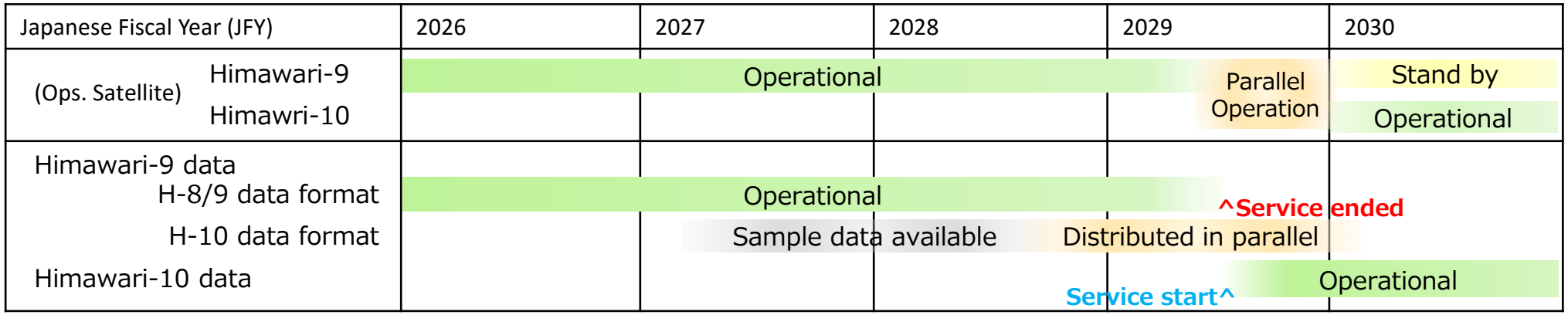
"**Himawari-8/9 data**" and "**Himawari-10 data**" have different data format.

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

Future plan: Transition Plan for GHMI (Draft)

This is only a preliminary plan at this time and could change significantly in the future.

Transition Plan for GHMI (Draft)	
During H-9 operation (Back up: H-8)	• H-9 data in H-10 data format will be provided in advance. 【From around JFY 2027】 ➢ Sample data in H-10 data format created from H-9 data will be available for download. 【From around JFY 2028】 ➢ H-9 data in H-8/9 data format and H-10 data format will be distributed in parallel.
H-9 and H-10 parallel operation	• **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.
After starting H-10 operation (Back up: H-9)	• 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 ✓ Users will not need to change their operation because of same data format



Future plan: Smallest unit of data for GHMI (Draft)

This is only a preliminary plan at this time and could change significantly in the future.

Smallest unit of data for GHMI (Draft)

- Himawari-10 data will be provided as a single file for each swath.
  - In order to reduce the time to delivery, the swath data will be provided in order of completion.
  - Users need to combine the swath data. (JMA is considering to provide a program to combine the swath data.)

Approximate time required for processing and distributing

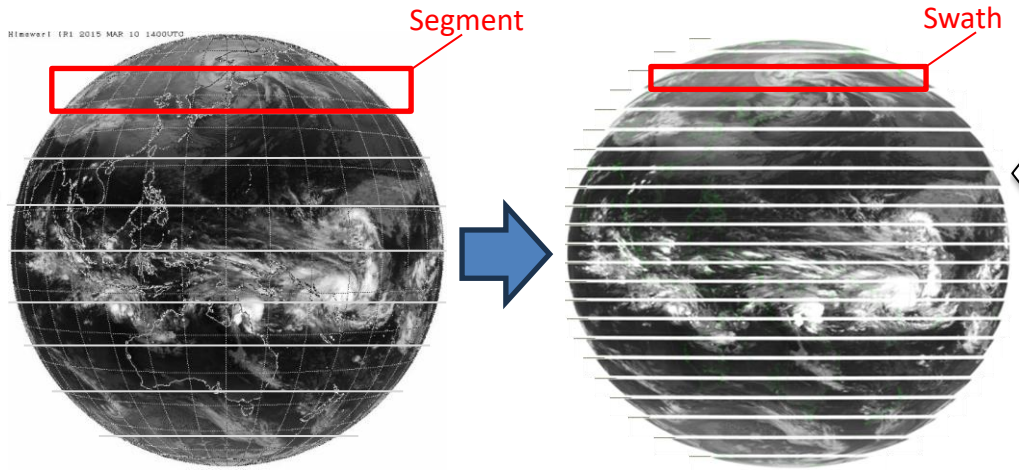
Observation → Primary data processing → Create products at MSC/JMA → Users

Almost immediate | In 60 seconds | In 15 seconds | The method of provision is not yet determined.

Himawari-8/9 data is provided as a single file for each segment into which the full-disc data is divided.

Segment data are created by multiple swaths, and then the segments data are distributed.

Each segment has no overlap.



Himawari-8/9 data　　Himawari-10 data

Himawari-10 data will be provided as a single file for each swath.

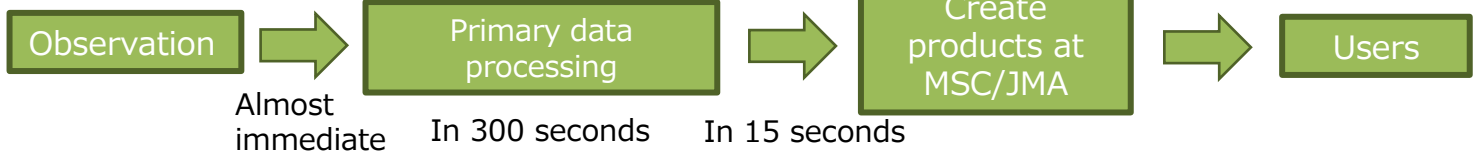
It depends on how to provide the data from MSC/JMA, but the data will be available in 2 or 3 minutes from end of observation of one swath.
(Himawari-8/9 data are provided in about 8 minutes.)

Future plan: Smallest unit of data for GHMS (Draft)

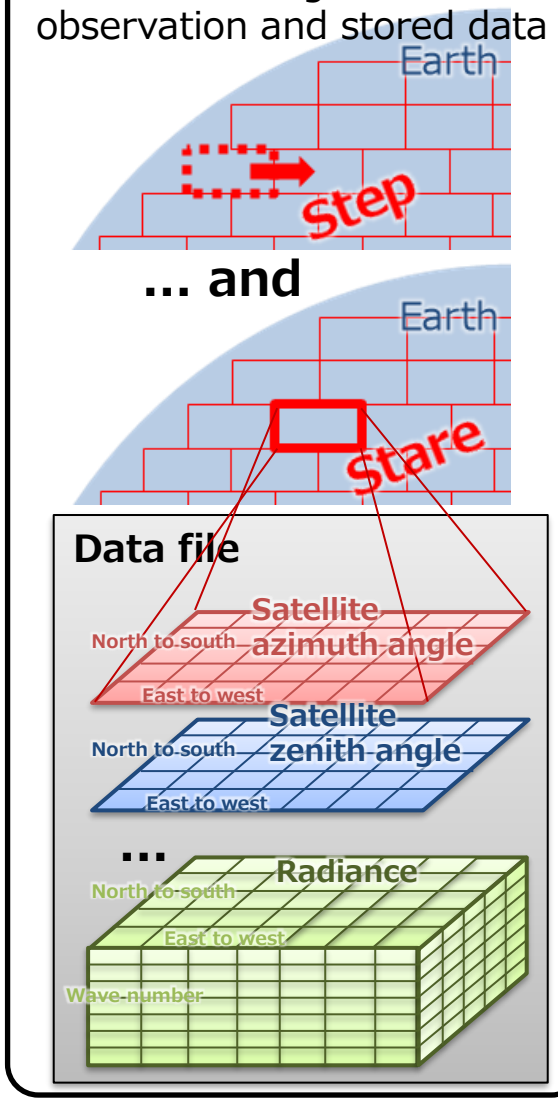
This is only a preliminary plan at this time and could change significantly in the future.

Smallest unit of data
• Himawari-10 data will be provided as a single file for each stare.
Overview of the 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 full-disc, 12 x 3 for Japan area and 2 x 4 for target area.
Overview of the data
• 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. • 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)

Approximate time required for processing and distributing

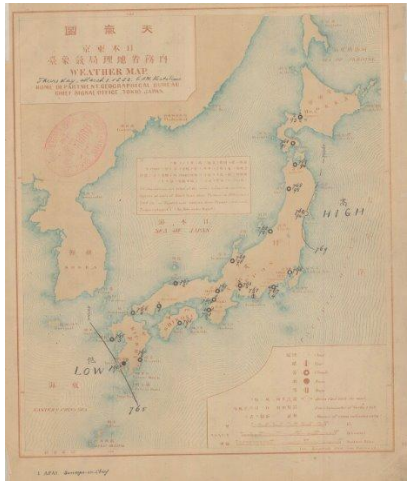


Schematic image of observation and stored data



The 150th anniversary of meteorological services in Japan

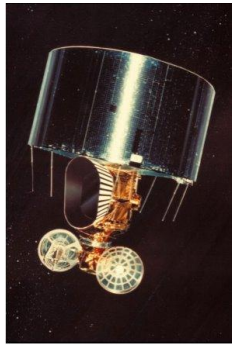
- On 1 June 1875, the Tokyo Meteorological Observatory (now JMA), began observation using meteorological instruments and seismometers.
- The 150th Anniversary Ceremony was taken place on 2 June 2025 in Tokyo to celebrate the Year of Meteorological Services and to renew our commitment to the safety and security of the public, to the performance of our duties and to improve our technology using the latest scientific knowledge.



The first weather map (1883.3.1)

The 150th Anniversary Ceremony
Source: Ministry of Land, Infrastructure, Transport and Tourism website (https://www.mlit.go.jp/page/kanbo01_hy_010284.html)

- In 2028, the 50th anniversary of Himawari is coming, because the GMS (the first Himawari) started the operation in 1978.



GMS (The first Himawari)

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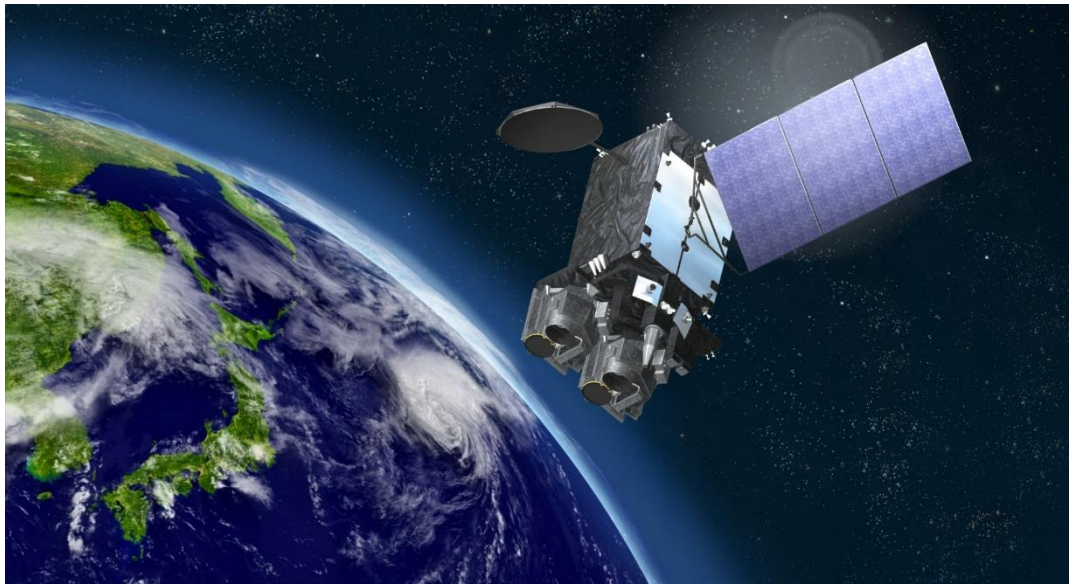
Thank you!!

A 150-year journey:
preventing disasters for a better future



Himawari-10 Perspective image

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