12.02

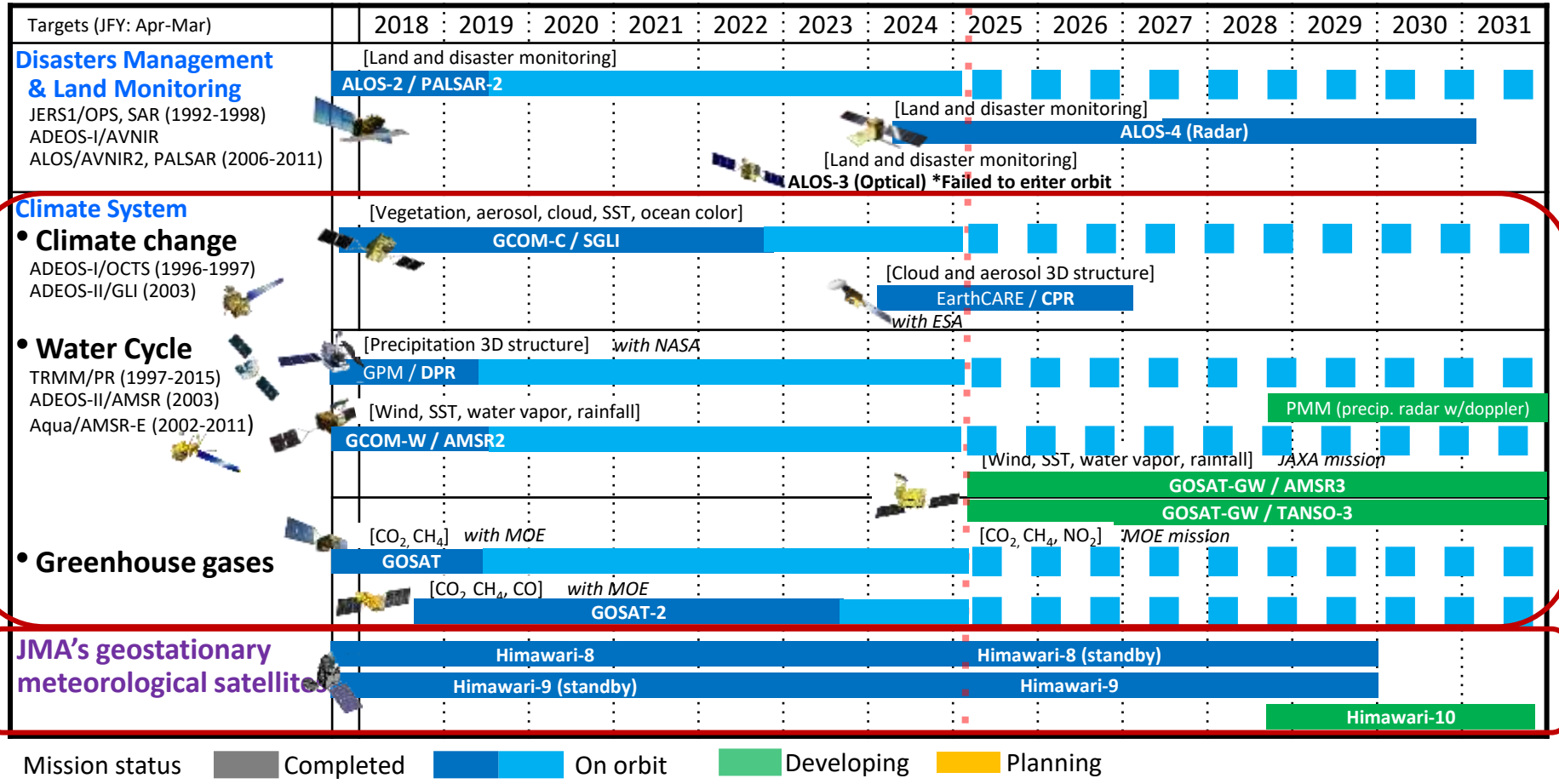
JMA and JAXA

Kozo Okamoto[*1], Misako Kachi[*2], Kotaro Bessho[*1]

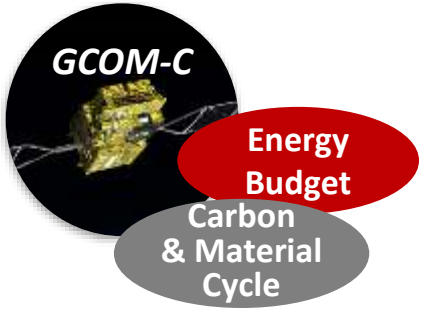
Japan Meteorological Agency (JMA),
Japan Aerospace eXploration Agency（JAXA)

ITSC-25, 8-14 May 2025, Goa, India

Japanese Earth Observation Satellites/Sensors

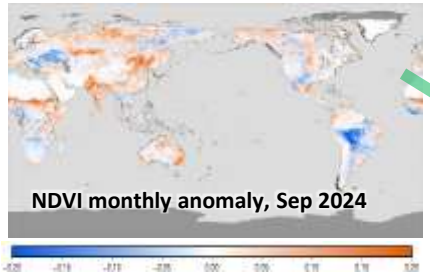


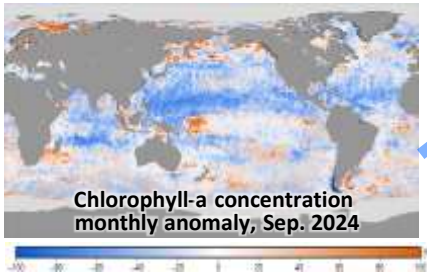
Climate Monitoring by GCOM-C
(Global Change Observation Mission – Climate)



- Observation since 1 Jan 2018 → Continued more than 7 years
- SGLI (Second-generation Global Imager)
  - ✓**250-m spatial resolution**
  - ✓**Near-UV wavelength**
  - ✓**Polarimetry**

✓**Global ecosystem change**


NDVI monthly anomaly, Sep 2024


Chlorophyll-a concentration monthly anomaly, Sep. 2024

GCOM-C targets:

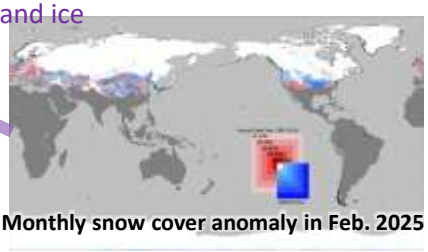
✓Aerosol and cloud processes and radiative forcing

✓Distribution and properties of snow and ice

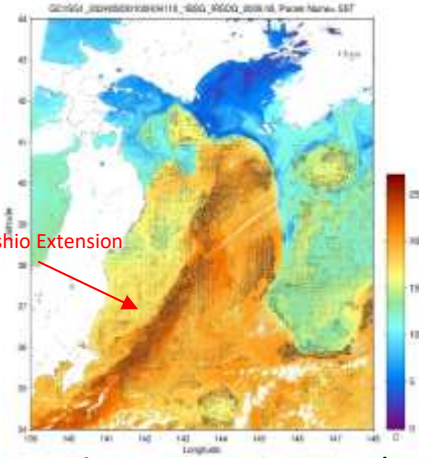
Collaboration with JAMSTEC, Tokyo Univ.

✓**Radiative forcing**

Monthly anomaly of aerosol optical thickness at 500nm in Sep 2024


Monthly snow cover anomaly in Feb. 2025

✓**Environmental monitoring by 250m spatial resolution**



Sea surface temperature by GCOM-C/SGLI 250-m thermal infrared on 3 May 2024

Northern extension of Kuroshio warm current was observed in the east of Japan.

Model-Observation comparison:
✓Spatial/temporal changes
✓Correlation among the observed variables

→ Improvement of the ESM
→ Improvement of prediction of the future global environment

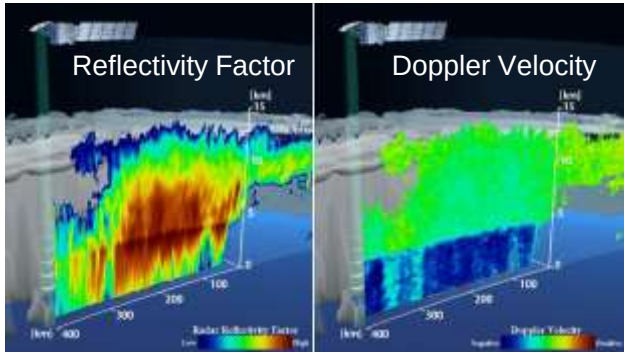
EarthCARE
(Earth Cloud Aerosol and Radiation Explorer)

- EarthCARE: Europe-Japan joint mission, launched in May 2024
- 3-D global distributions of cloud and aerosol to understand climate change
- JAXA and NICT provides world's first satellite-based cloud vertical motion by the Cloud Profiling Radar (CPR) with 94 GHz with Doppler Capability at 0.8 km spatial resolution.

* NICT (National Institute of Information and Communications Technology)

CPR first images (27th June 2024)

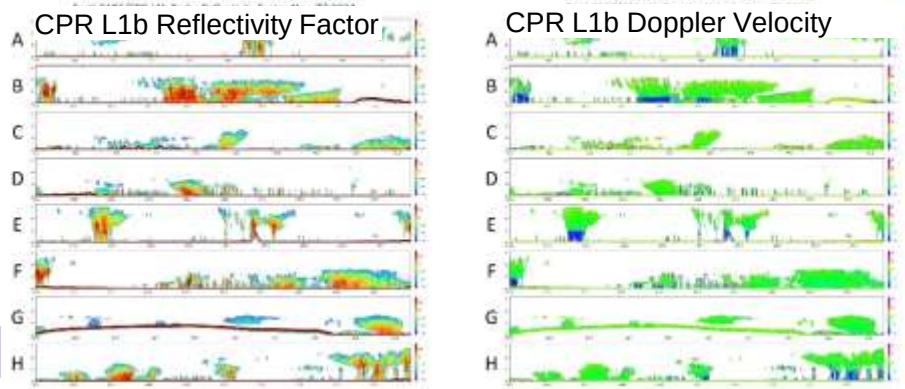
The CPR onboard the EarthCARE satellite is the world's first spaceborne Doppler radar in the W-band (94 GHz



https://global.jaxa.jp/press/2024/06/20240627-1_e.html

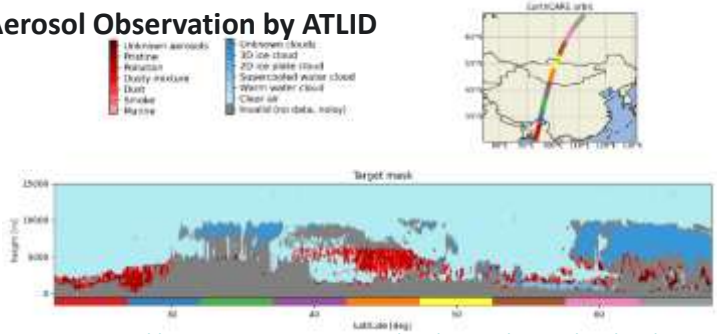
Release of Level-1 products (14th January 2025)

https://global.jaxa.jp/press/2025/01/20250114-1_e.html



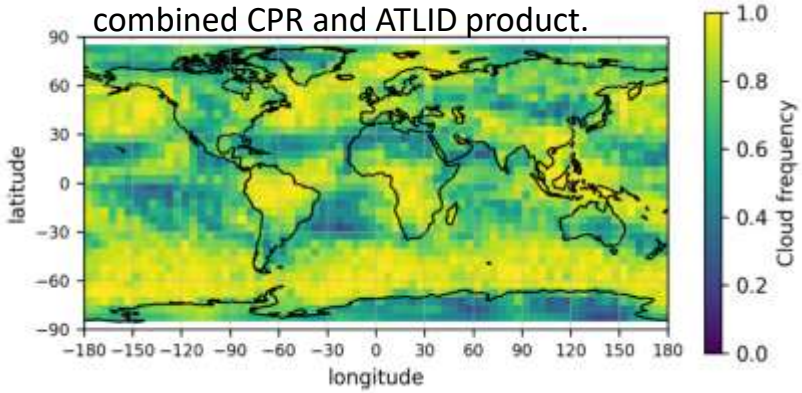
Release of Level-2 products (17th March 2025)

Aerosol Observation by ATLID



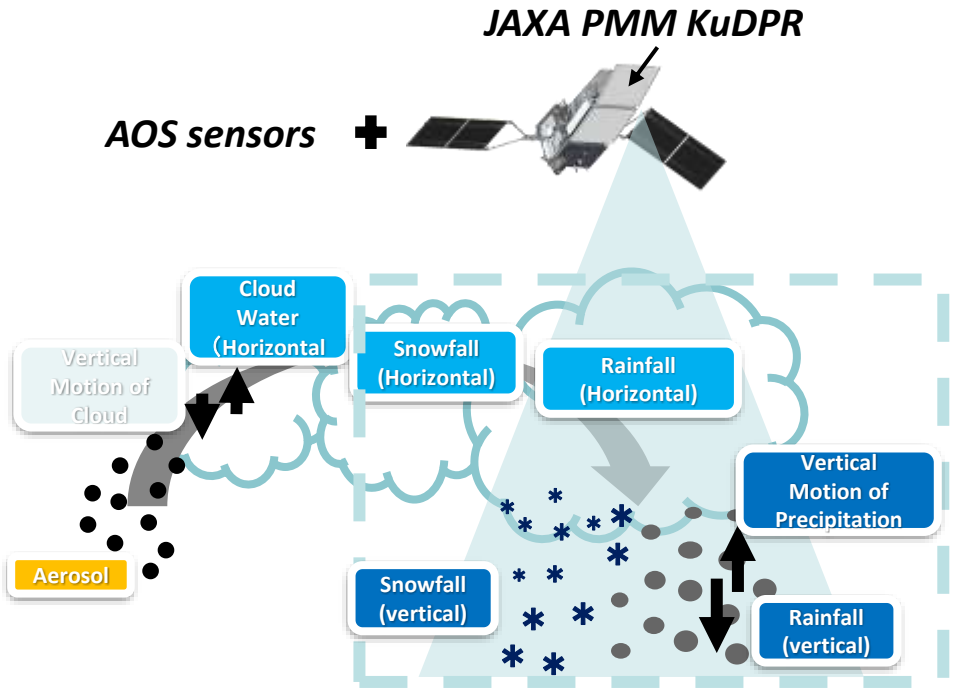
https://www.satnavi.jaxa.jp/en/news/2025/03/17/10746/index.html

Global distribution of cloud cover based on combined CPR and ATLID product.



Next Generation Precipitation Radar planned in JAXA: Precipitation Measuring Mission (PMM)

- JAXA has a long heritage of development and operation of space-borne precipitation radar
  - TRMM (Nov. 1997 ~ Apr. 2015) and GPM (Feb. 2014~)
- In June 2023, JAXA's Precipitation Measuring Mission (PMM) Project Team was established on for the Spacecraft carrying the Ku-band Doppler Precipitation Radar (KuDPR)
  - Participation in NASA Atmosphere Observing System (AOS) mission.
  - Targeting launch is JFY2028. Preliminary Design Review (PDR) is scheduled in JFY2025.



- JAXA's KuDPR will focus on advanced observation of precipitation.
  Doppler velocity observation & High sensitivity observation
- International collaboration with NASA AOS mission will bring us integrated understanding of Aerosol, Cloud and Precipitation processes.

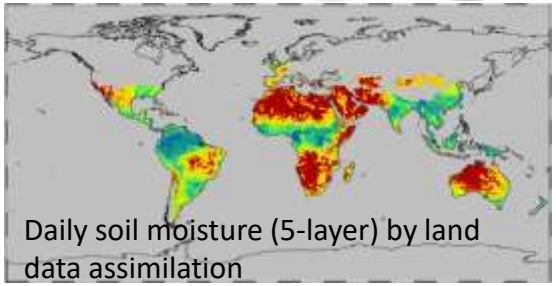
KuDPR major characteristics

Frequency	13.6 GHz
Observation modes	・Doppler obs. mode ・Dense sampling obs. mode ・Normal scan obs. mode

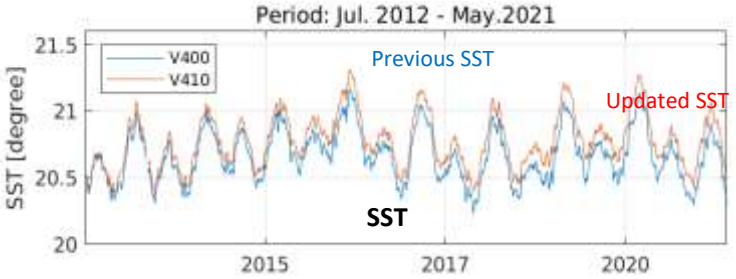
KuDPR will be two-antenna system that adopts Displaced Phase Center Antenna (DPCA) approach (Durden et al. 2007, Tanelli et al. 2016) → **More accurate Doppler measurement**

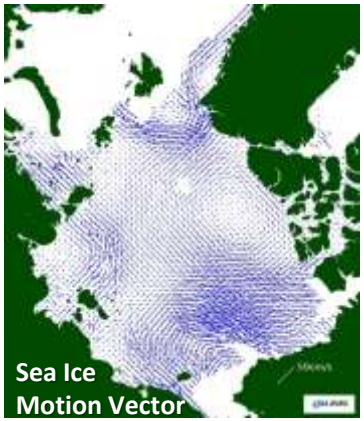
The Advanced Microwave Scanning Radiometer (AMSR) series

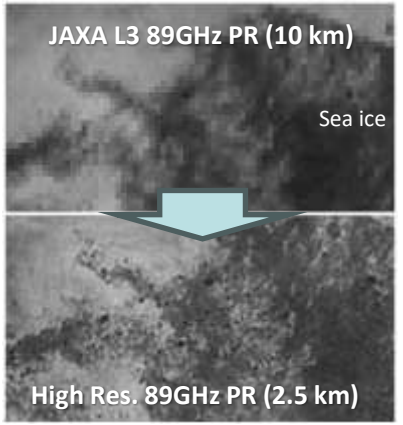
- The Advanced Microwave Scanning Radiometer series (AMSR-E, AMSR2, and future AMSR3)
  - Same local observation time and similar specification to achieve continuous observation +23 years
    - Launch: Aqua/AMSR-E May 2002, GCOM-W/AMR2: May 2012
  - Microwave channels of 6.9-89GHz enable to observe "water-related" geophysical parameters in all-weather
  - Observing SST and soil moisture in 30-50km spatial resolution by large (~2-m) diameter antenna



- New research products has been released in 2024~2025
  - Recalculation of updated SST (V4.11)
  - Sea Ice Motion Vector for Arctic (released) & Antarctic (coming soon)
  - High-resolution TB for Cryosphere studies

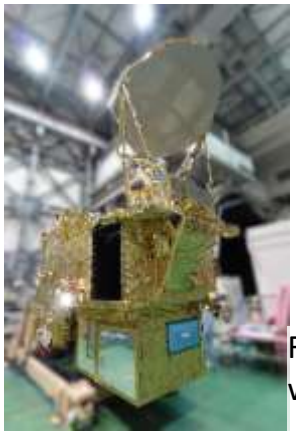






GOSAT-GW: Global Observation SATellite for Greenhouse gases and Water cycle

AMSR3
(Advanced Microwave Scanning Radiometer 3)

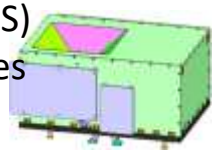


- Led by JAXA
- Succeed AMSR series observations
- Add new high-frequency ch for solid precipitation retrievals and water vapor analysis in NWP

Feature of the GOSAT-GW satellite with AMSR3 main reflector deployed

TANSO-3
(Total Anthropogenic and Natural emissions mapping SpectrOmeter-3)

- Led by Japanese Ministry of the Environment (MOE) and National Institute of Environment Studies (NIES)
- Improve observation capability of greenhouse gases from GOSAT-2/TANSO-2
  - 2 imaging modes: wide mode (footprint 10 km, swath 911 km) and focus mode (3 km, 90km)
  - NO2 observation (0.4 μm), in addition to O2 (0.76 μm) and CO2 and CH4 (1.6μm)



GOSAT-GW Satellite Specifications

Mission Instruments		AMSR3 (JAXA) TANSO-3 (MOE/NIES)
Orbit	**Type**	Sun-synchronous, Sub-recurrent orbit
	Altitude	666km, recurrent cycle 3days (same as GOSAT)
	Local sun time at ascending	13:30±15min (same as GCOM-W)
	Revisit time	3 days
Satellite Mass		2.6 tons (including propellant)
Designed lifetime		> 7 years
Launch		To be launched on 24 June 2025 by H-IIA rocket

GOSAT(2009~): The world's first spacecraft to measure CO2 and CH4
GOSAT-2 (2018~)

GOSAT-GW: AMSR3 and AMSR series

Aims of AMSR3
- Succeed AMSR series' observation of water-related parameters
- Respond to new user needs by hardware/software improvements

AMSR3 Major Improvements

1. Additional **166 & 183 GHz** channels for snowfall/water vapor
2. Additional **10.25 GHz channels with better NEDT** for robust SST

AMSR — 2002-2011 — AMSR-E

2012-present — AMSR2

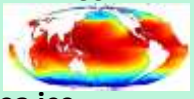
2025.6 - AMSR3

New stakeholder's needs

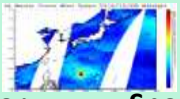
AMSR3 products

AMSR Products

SST

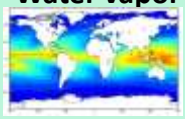


Surface wind speed



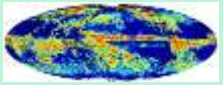
Sea ice

Water vapor

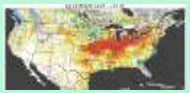


Snow depth

Rainfall



Soil Moisture

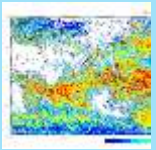


Understanding and anticipation of Water cycle

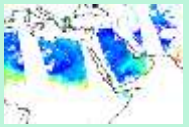
Operational utilization

New AMSR3 Products

Snowfall

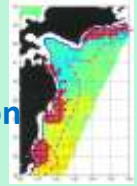


Water Vapor



High-res. Sea ice concentration

High-res. SST

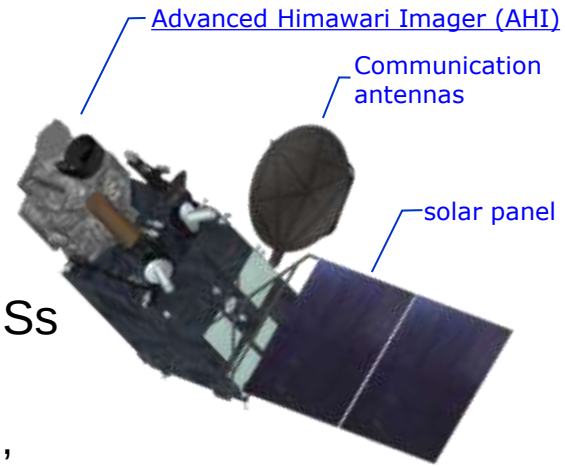


Understanding and anticipation of Water cycle

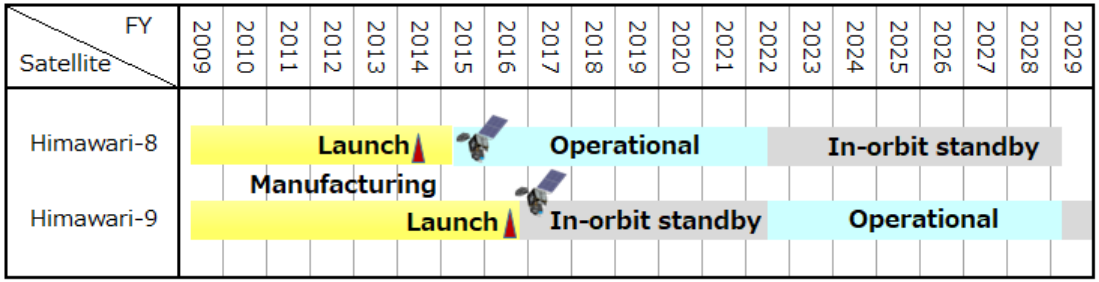
Operational utilization

Himawari-8/9 overview

- Launch in 2014 and 2016
- Switchover operational satellite from Himawari-8 to Himawari-9 on 13 Dec. 2022
- AHI: Advanced Himawari Imager
  - 16 band: 3 VIS, 3 NIR, 10 IR
  - 10-min full-disk, 2.5-min Japan area, 2.5-min target area
- HimawariRequest: Target area obs on request from NMHSs
  - 1,000 km x1,000 km, every 2.5 min
  - 22 NMHSs registration, 290 requests for TC, volcanic eruption, wildfire (as of 1 May 2025)
- Operational products: AMV, CSR, HCAI, AOT, Aswind
- User support:
  - https://www.data.jma.go.jp/mscweb/en/support/support.html

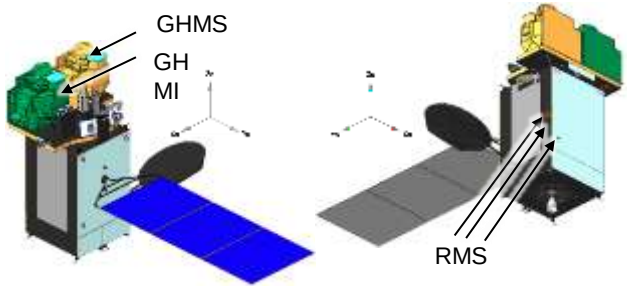


CSR: clear sky radiance
HCAI: high-resolution cloud analysis information
AOT: Aerosol Optical thickness
Aswind: AMV-based sea-surface wind



Himawari-10 overview

- Schedule
  - JFY2024: PDR (Preliminary Design Review)
  - JFY2025: Contract for Ground Segment, Critical Design Review (CDR)
  - JFY2028: Launch
  - JFY2029: Start operation
- Payloads
  - Geostationary HiMawari Imager (GHMI)
  - Geostationary HiMawari Sounder (GHMS)
  - Data Collection System
    - Relays surface-based Data Collection Platforms (DCPs) data.
  - Radiation Monitors for Space weather (RMS)
    - Measure proton & electron flux in geostationary orbit, as a government furnished equipment by NICT (National Institute of Information and Communications Technology).
- Location
  - Geostationary orbit at around 140.7 deg. E



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 new 18-band imager based on the same concept with its GeoXO Imager (GXI)
  - Observing sequence & band configuration changed from Himawari-8/9
    - Values in the tables show JMA requirements

GHMI Observing Area & Interval

Improvement from Himawari-8/9

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) * Mainly used for CAL/VAL activity	30 sec

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

Geostationary HiMawari Sounder (GHMS)

- L3Harris's new infrared FTS sounder
  - 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}

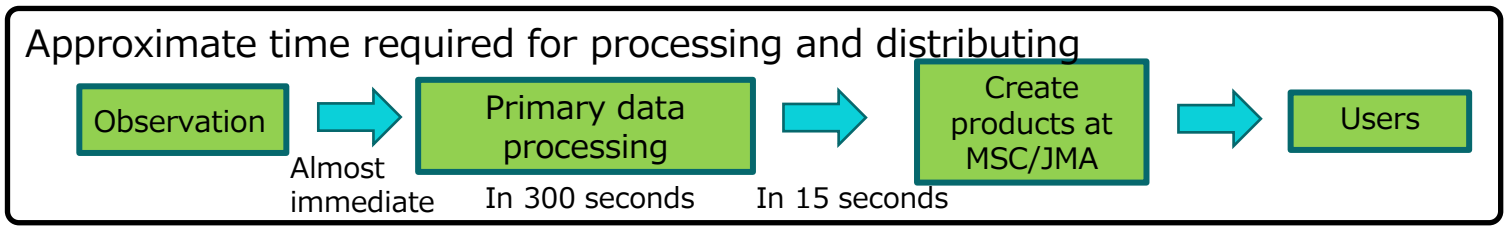
Future data plan of GHMI and GHMS

- GHMI
  - Unified data format of NetCDF
    - ← HSD (Himawari Standard data), HRIT/LRIT, NetCDF for Him-8/9
  - Transition plan of data distribution

During the parallel operation period, H-9 and H-10 data will be distributed in H-10 data format

Japanese Fiscal Year (JFY)	2026	2027	2028	2029	2030
(Ops. Satellite) Himawari-9	Operational			Parallel Operation	Stand by
(Ops. Satellite) Himawri-10					Operational
Himawari-9 data H-8/9 data format	Operational			^Service ended	
Himawari-9 data H-10 data format		Sample data available		Distributed in parallel	
Himawari-10 data				Service start^	Operational

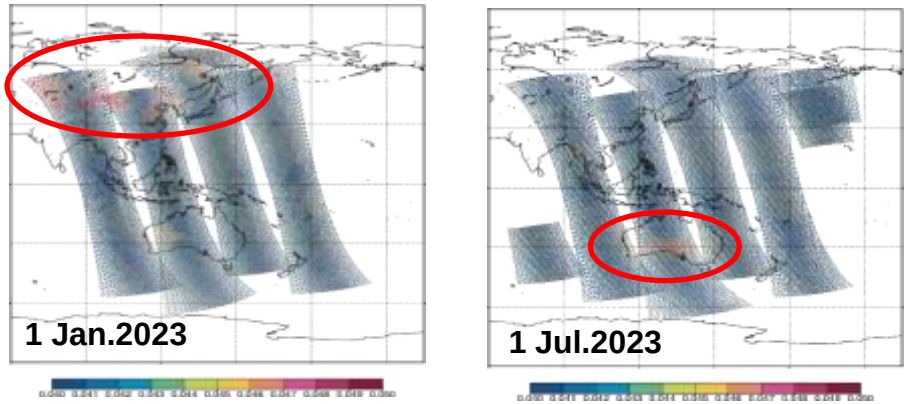
- GHMS
  - Disseminate Principal Component Analysis (PCA) data to NMHSs.
  - No spatial resampling
  - Details of stored data under consideration



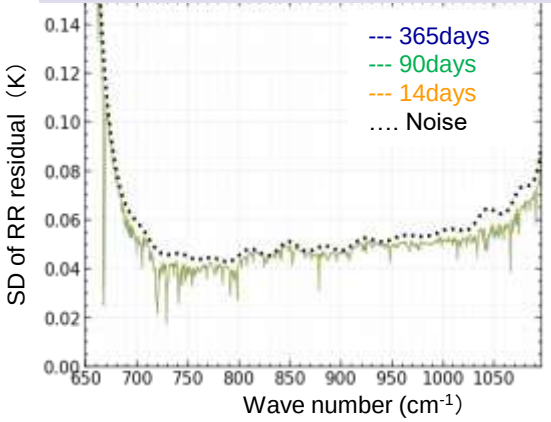
Fundamental study on Principal Component Analysis (PCA)

- Investigate feasibility of GHMS PCA using NOAA-20/CrIS
- Reconstructed radiances (RRs) using 150 PC have as small residuals as instrumental noise
  - But relatively large residual in hot areas in the summer
- The majority of spectrum was reconstructed by two weeks of training data, regardless of the season

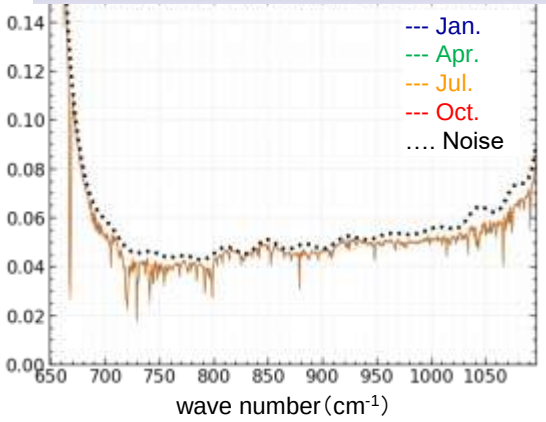
RR residual [K] (LW band)



Dependence of training period



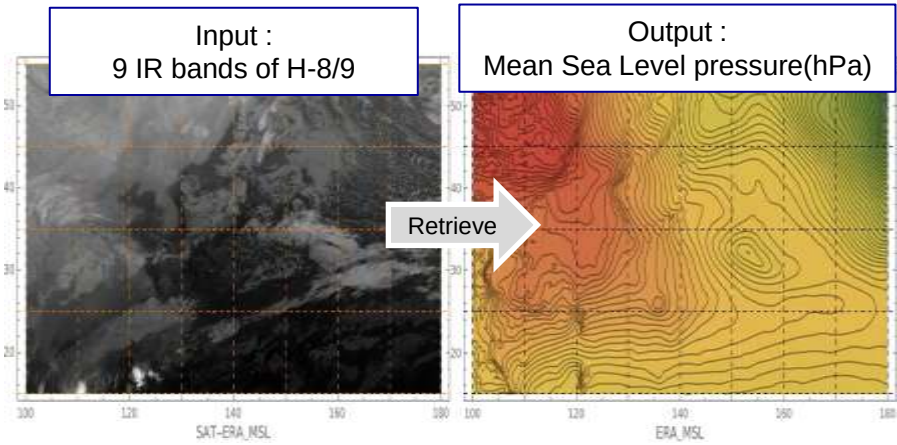
Dependence on target month

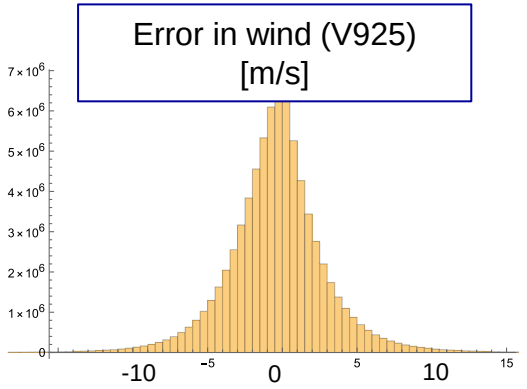


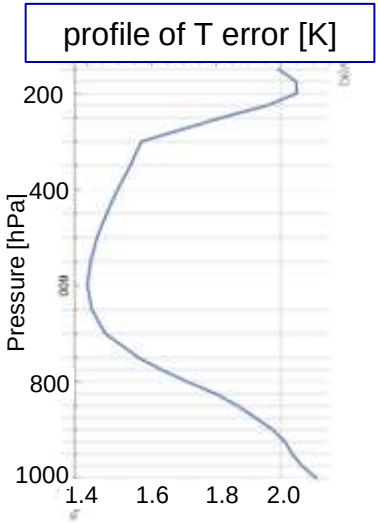
Courtesy of S. Koyamatsu

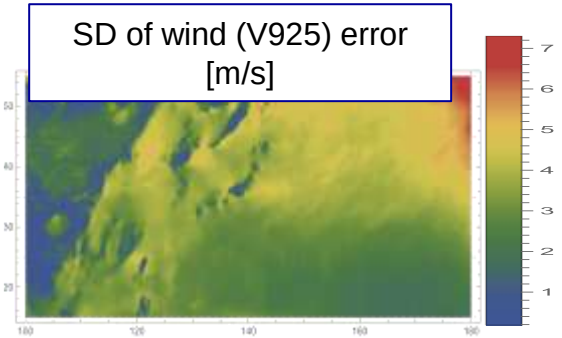
Product development for GHMS

- Development is ongoing of vertical profiles of atmospheric variables, including wind vectors.
- Expect ML approaches to improve products by exploiting spatial and temporal information at the reasonable computational time
- Promising results of estimating meteorological variables from Himawari-8/9 using U-Net
- Plan to test more cases, apply for sounders, develop explainability and short-period training





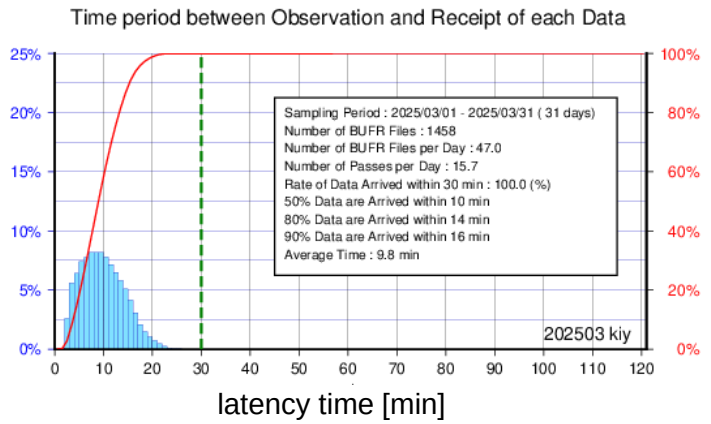




Courtesy of K. Shimoji

Direct Readout Activity at JMA

- Direct Readout (DR) from LEO satellites since 1968
- The low latency products used for NWP and environmental monitoring (sea ice, volcanic eruption, Tropical Cyclone,,,)
- JMA processes DR data from Kiyose (JMA) and Syowa (NIPR*) and provides products to DBNet.
  - Mostly within 30 min
  - ATOVS and IASI products have been provided to DBNet regularly.
  - ATMS and CrIS products are provided to DBNet via DBRTN.
  - Data from Metop-SG series will be acquired at Kiyose station.



Station	Satellite	Sensor	Collect	Process	Provision for DBNet
Kiyose	NOAA-18/19	ATOVS	✓	✓	✓
	S-NPP, NOAA-20/21	ATMS	✓	✓	✓ (via DBRTN)
		CrIS	✓	✓	✓ (via DBRTN)
	Metop-B/C	ATOVS	✓	✓	✓
		IASI	✓	✓	✓
Syowa	NOAA-18/19	ATOVS	✓	✓	✓
	S-NPP, NOAA-20	ATMS	✓	✓	✓ (via DBRTN)
	Metop-B/C	ATOVS	✓	✓	✓

*NIPR: National Institute of Polar Research

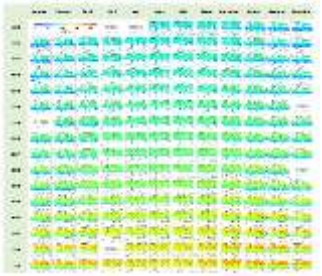
Backup slides

A-decade-long GHG observation by GOSAT series
Greenhouse gases Observing SATellite (GOSAT) & GOSAT-2

Carbon & Material Cycle

2009-Now

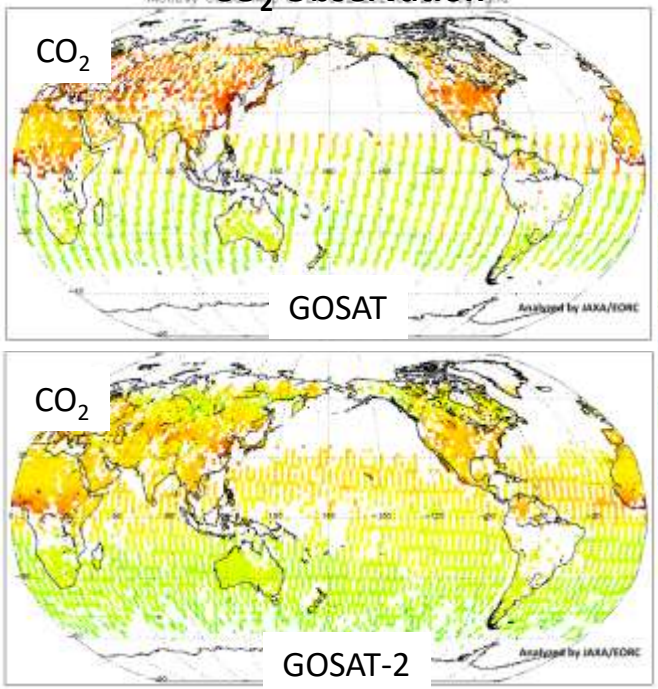
2018-Now



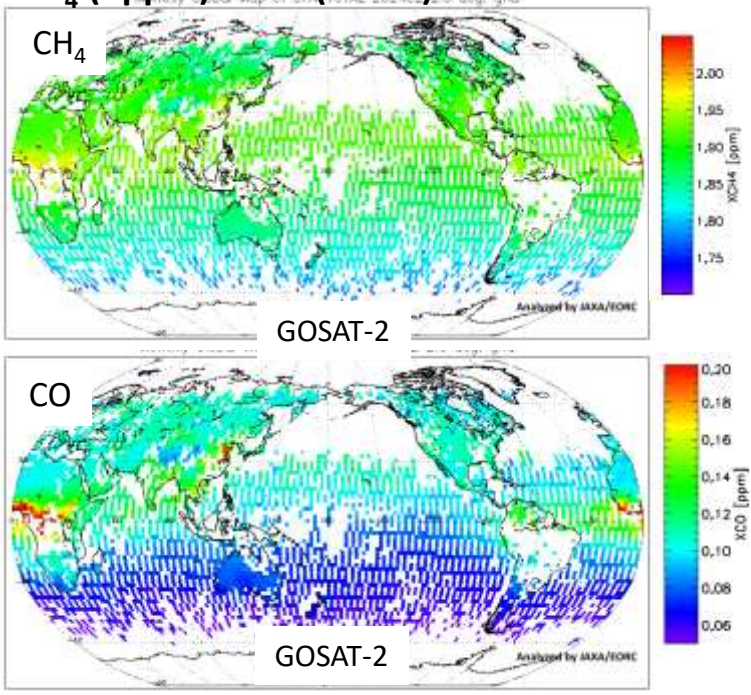
2009-2024 seasonal variation and year-to-year increase of global CO_2 observed by GOSAT.

- GOSAT (Green house gases Observing SATellite)
  - The world's first spacecraft to measure the concentrations CO2 and CH4
- GOSAT/TANSO-FTS: 0.7,1.6,2μm+TIR, spectral res. 0.2cm^{-1}
- GOSAT-2/TANSO-FTS-2: 0.7,1.6,2μm+TIR, spectral res. 0.2cm^{-1}

CO_2 Observation



CH_4 (upper) & CO (lower) Observation



Global CO_2 concentrations observed by GOSAT and GOSAT-2, CH_4 and CO (Feb. 2024)

GOSAT-GW: TANSO-3 and TANSO series

2009-present

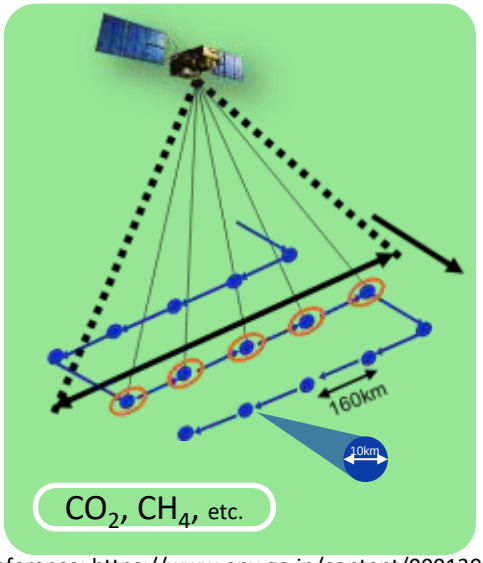
2018-present

JFY2025 -

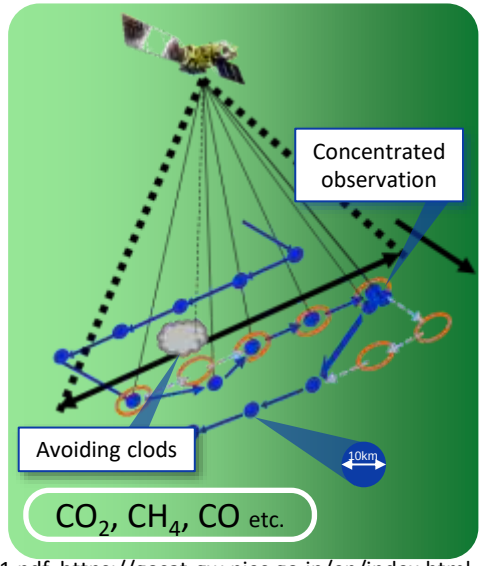
Aims of TANSO-3

- Long-term monitoring of GHGs of entire earth
- Verification of human-induced GHG emissions by country
- Detection of large-scale emission sources

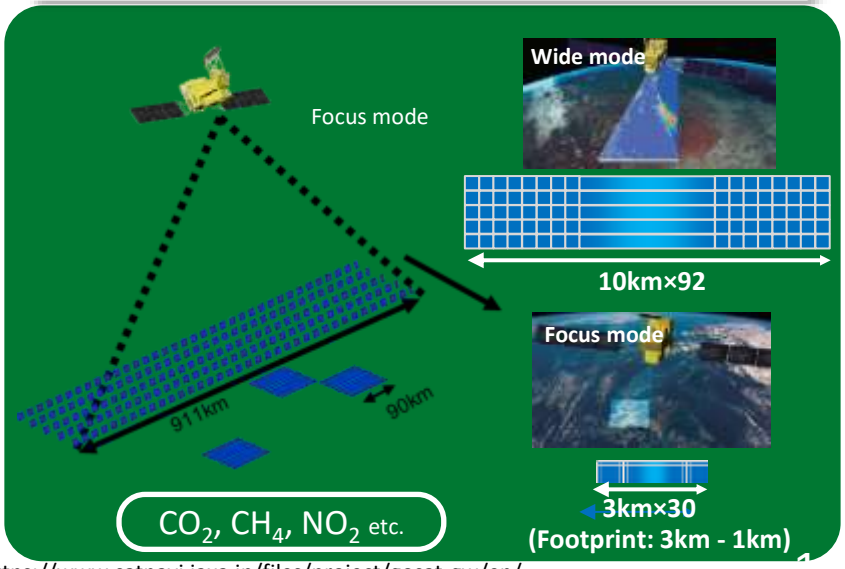
TANSO



TANSO-2



TANSO-3

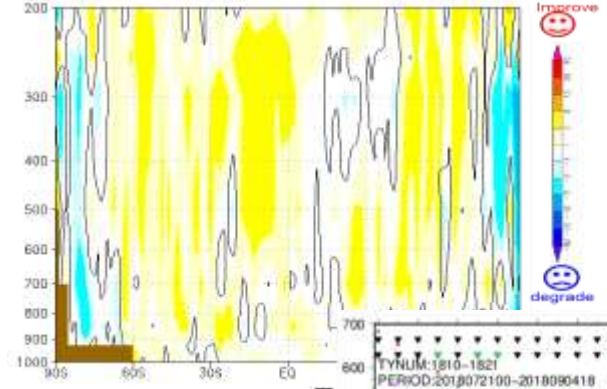


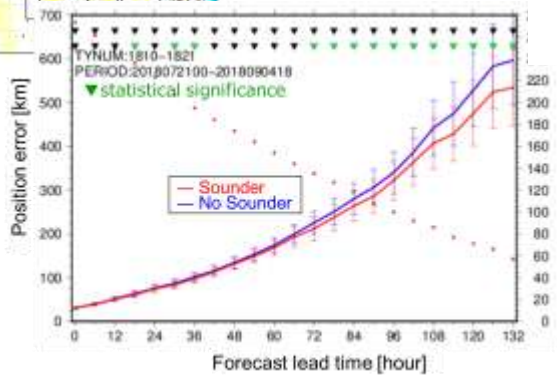
Reference: https://www.env.go.jp/content/000130091.pdf, https://gosat-gw.nies.go.jp/en/index.html, https://www.satnavi.jaxa.jp/files/project/gosat-gw/en/

OSSE for Himawari-10

- Before determination of Himawari-10/GHMS at JMA, we conducted OSSEs for Geo-based hyper-spectral infrared sounders (GeoHSS) to discuss a Himawari-10
  - Pseudo-obs (equivalent MTG/IRS) simulated from ERA5
- Results of global and regional data assimilation experiments in several cases
  - Assimilate clear-sky radiance in global system and T/H-profiles in regional system
  - Improved forecasts of large scale field and TC track
  - Improved forecasts of moisture flux over the ocean, rainfall statistics and heavy rain bands
  - Temporal frequency reduction (1h to 3h) lessened the impact but still improved especially in SH

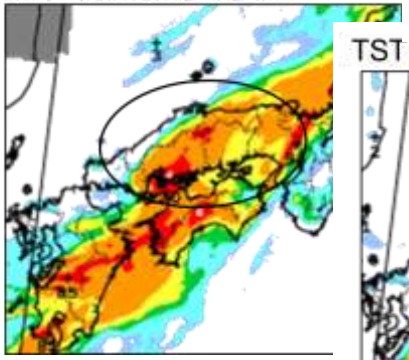
Temperature improvement ratio [%] at 48 h



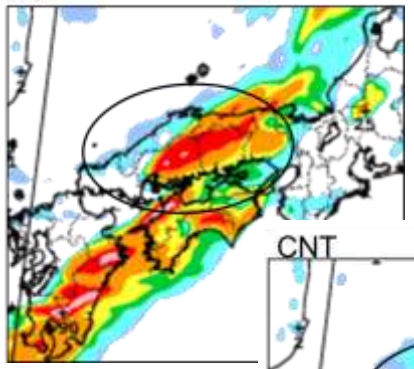


Typhoon Track forecast error [km]

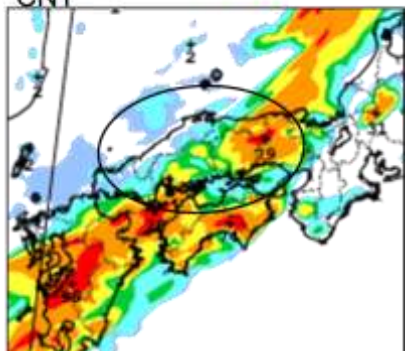
OBS (radar-raingauge)



TST



CNT



accumulated rainfall [mm/3h]

Comparison of heavy rainfall forecast valid at 2100 UTC 06 July 2021

Okamoto et al. 2020, sola
Fujita et al. 2023, jmsj