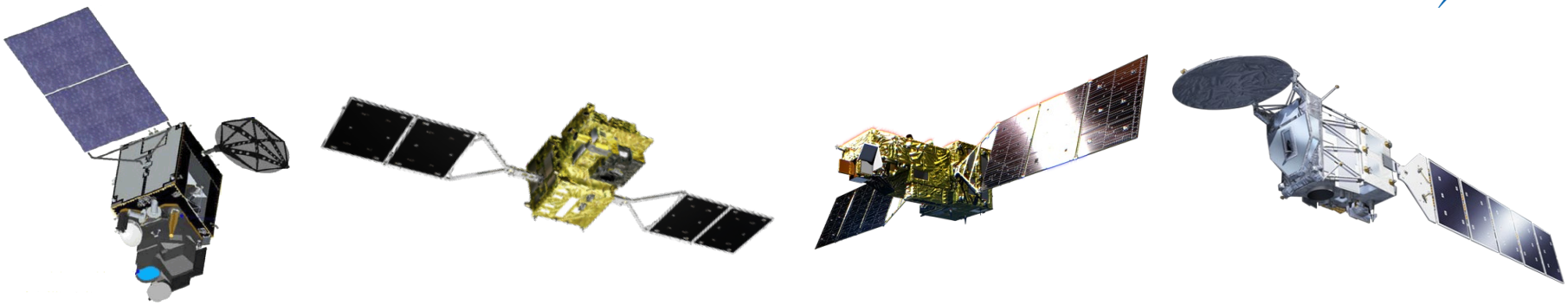


JAXA aerosol observation missions

Kazuhisa Tanada

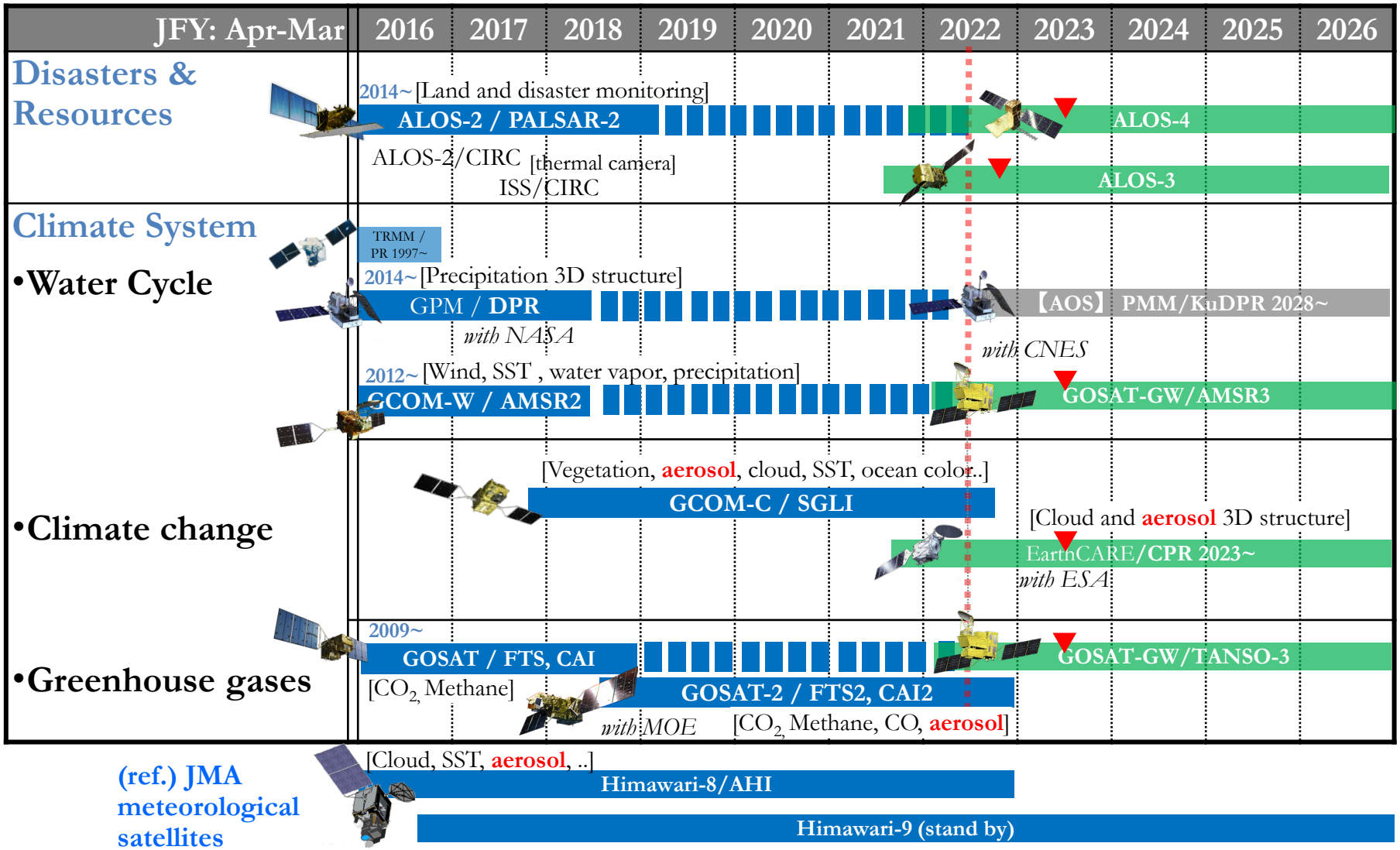
JAXA/EORC

ICAP 2022 Monterey, California

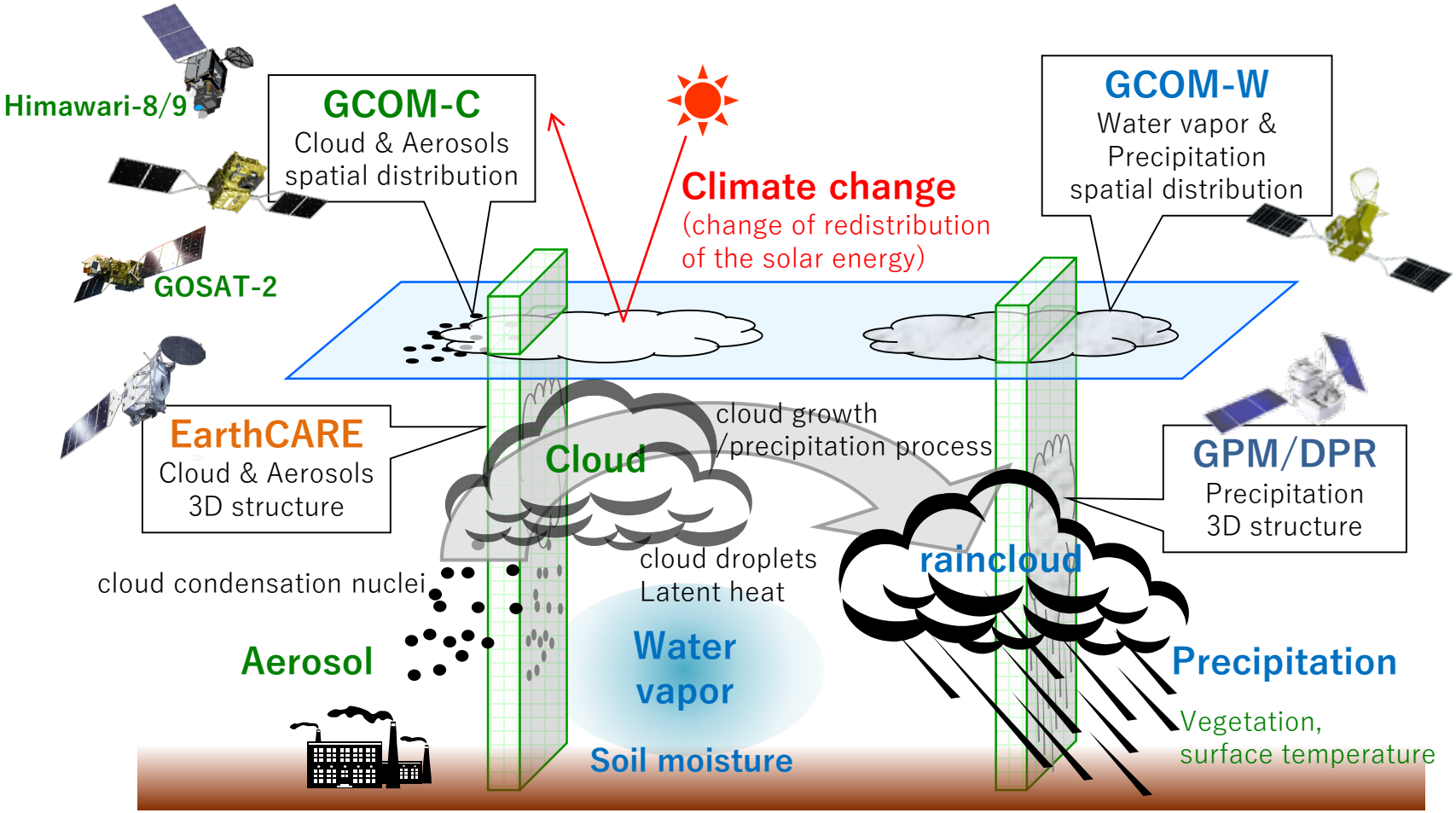
18-20. 2022

1. JAXA Aerosol Missions

1.1 JAXA Earth observation satellite missions



1.2 JAXA science targets relating with aerosols: "aerosol-cloud-precipitation system"



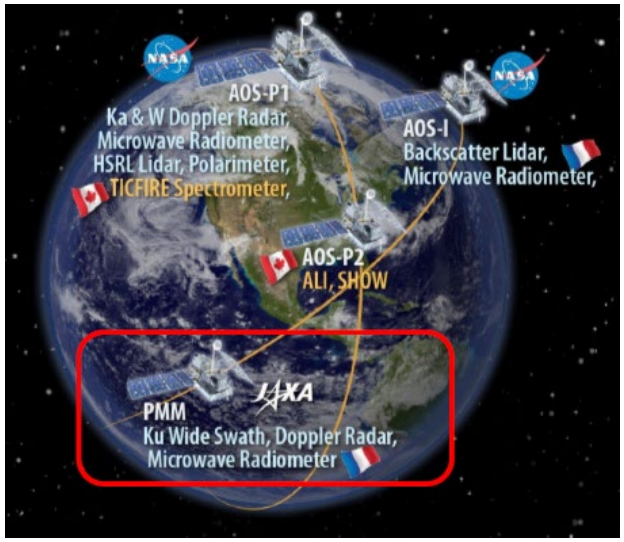
For the Earth system prediction and supporting the policy making through

- ✓ **Precise diagnosis of the current state** which is changing with the global warming
- ✓ **Understanding of the aerosol-cloud-precipitation system** → AOS

1.2 JAXA science targets: AOS Collaboration

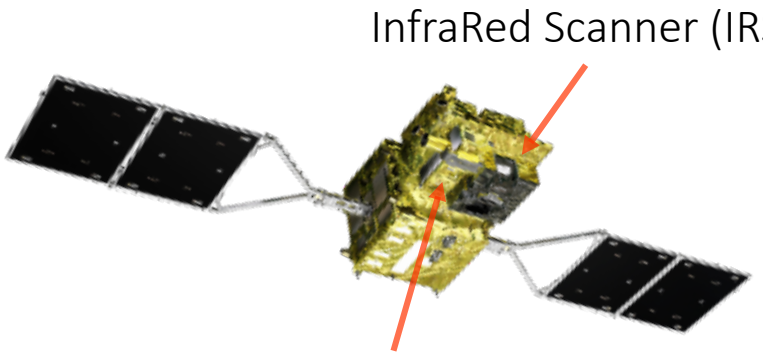
- ✓ **"Aerosol" and "Clouds, Convection and Precipitation" (A-CCP)** were selected as the Designated Observables by the US Decadal Survey issued in 2017
- ✓ NASA established **"AOS" (Atmosphere Observing System) project** which is an international scheme to observe A-CCP with a constellation.
  - AOS constellation has two projects: AOS-I (Inclined orbit) and AOS-P (polar orbit)
- ✓ JAXA GPM + EarthCARE community has agreed to join the AOS project with **PMM (Precipitation Measurement Mission) / KuDPR (Ku-band Doppler Precipitation Radar)** as AOS-I with following new/advanced functions improved from GPM/DPR

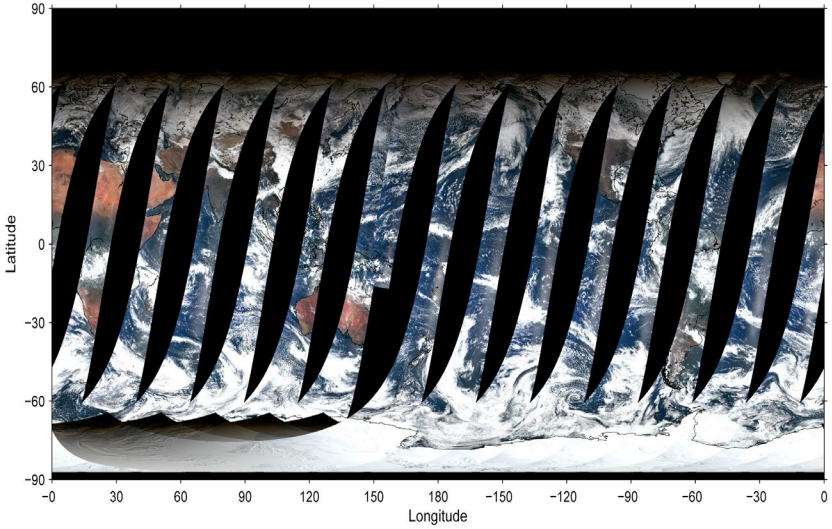
KuDPR targets	KuDPR function (requirement)
• To detect shallow & light rain/drizzle, snow • For more accurate global precipitation map	Higher Sensitivity than DPR
• To improve the model representation • World first observation of vertical motion of the precipitation	Doppler Velocity Observation



1.3 JAXA aerosol missions: GCOM-C/SGLI

Global Change Observation Mission – Climate (GCOM-C), Second-generation Global Imager (SGLI)



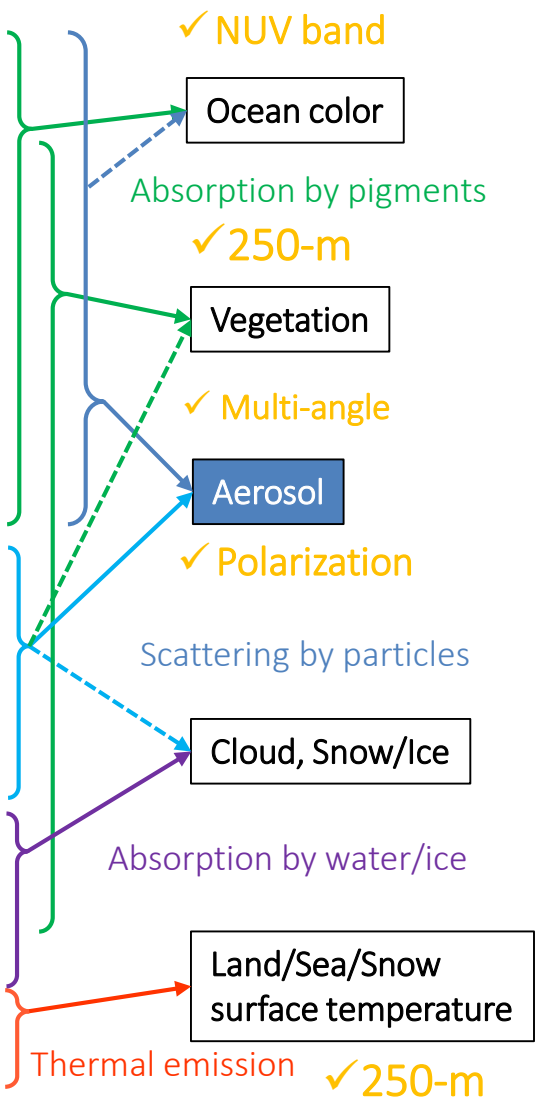


An example of SGLI/VNR daily coverage (5 Jan2018)

GCOM-C SGLI characteristics	
Launch Date	23 Dec. 2017
Weight	2,000kg
Orbit	Sun-synchronous (descending local time: 10:30), Altitude: 798km, Inclination: 98.6deg
Mission Life	5 years (3 satellites; total 13 years)
Scan	Push-broom electric scan (VNR) Wisk-broom mechanical scan (IRS)
Scan width	1150km cross track (VNR: NP & POL) 1400km cross track (IRS: SWIR & TIR)
Spatial resolution	250m (land and coast), 500m (TIR), 1km
Polarization	3 polarization angles for POL
Along track tilt	Nadir for VN, SW and TIR, & +/-45 deg for POL

1.3 JAXA aerosol missions: SGLI observation channels

Sub-system	channel	Center wavelength	width	Standard radiance	Saturation radiance	SNR	Pixel size
		nm		W/m^2/sr/μm or Kelvin		TI: NEΔT	m
Visible and Near Infrared Radiometer (VNR)	VN01	379.9	10.6	60	240-241	624-675	250/1000
	VN02	412.3	10.3	75	305-318	786-826	250/1000
	VN03	443.3	10.1	64	457-467	487-531	250/1000
	VN04	490.0	10.3	53	147-150	858-870	250/1000
	VN05	529.7	19.1	41	361-364	457-522	250/1000
	VN06	566.1	19.8	33	95-96	1027-1064	250/1000
	VN07	672.3	22.0	23	69-70	988-1088	250/1000
	VN08	672.4	21.9	25	213-217	537-564	250/1000
	VN09	763.1	11.4	40	351-359	1592-1746	250/**1000**
	VN10	867.1	20.9	8	37-38	470-510	250/1000
	VN11	867.4	20.8	30	305-306	471-511	250/1000
	PL01 +60	672 .2	20.6	25	295	609	**1000**
	PL01 +0				315	707	
	PL01 –60				293	614	
	PL02 +60	866.3	20.3	30	396	646	**1000**
	PL02 +0				424	763	
	PL02 –60				400	752	
Infrared Scanner (IRS)	SW01	1050	21.1	57	289.2	951.8	**1000**
	SW02	1390	20.1	8	118.9	347.3	**1000**
	SW03	1630	195.0	3	50.6	100.5	250/1000
	SW04	2210	50.4	1.9	21.7	378.7	**1000**
	TI01	10785	756	300K	340K	0.08K	250/500/**1000**
	TI02	11975	759	300K	340K	0.13K	250/500/**1000**



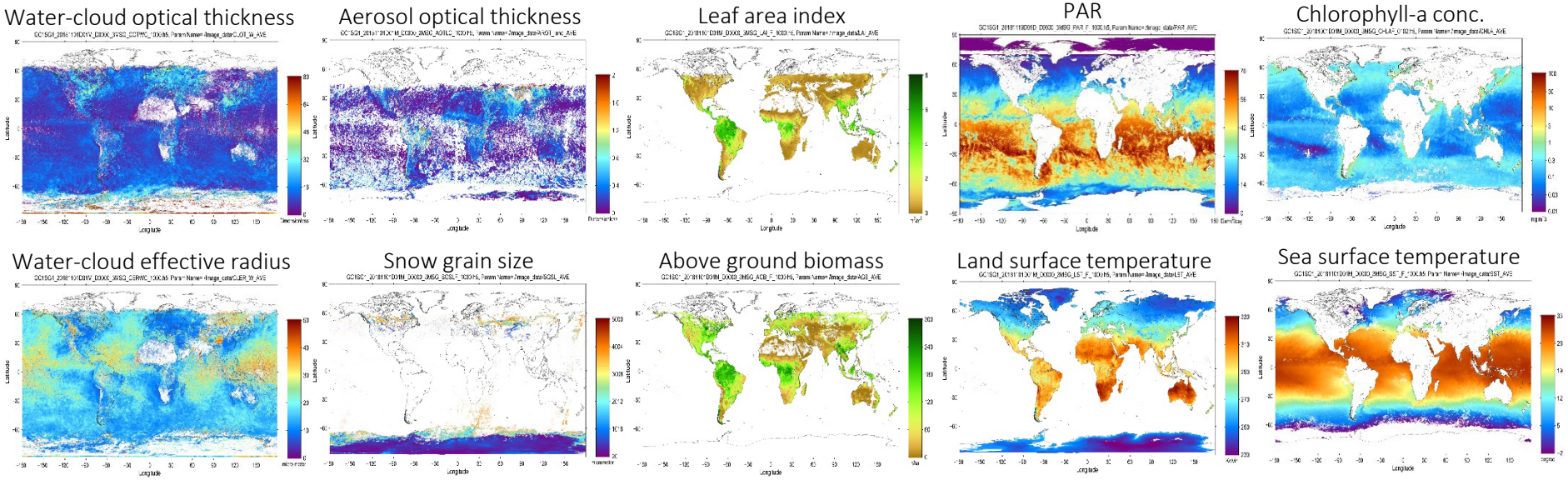
Cited from Okamura et al., 2018. SNR is defined at the standard radiance and IFOV shown by bold characters

1.3 JAXA aerosol missions: GCOM-C products

- ✓ GCOM-C products have evaluated by using in-situ observations and other satellite data

  (https://suzaku.eorc.jaxa.jp/GCOM_C/data/validation.html)

- ✓ All standard products (Level-1, 2, and 3) have been open to the public via JAXA data portal, "G-Portal" (GUI data search and direct FTP are available; https://gportal.jaxa.jp/gpr/)

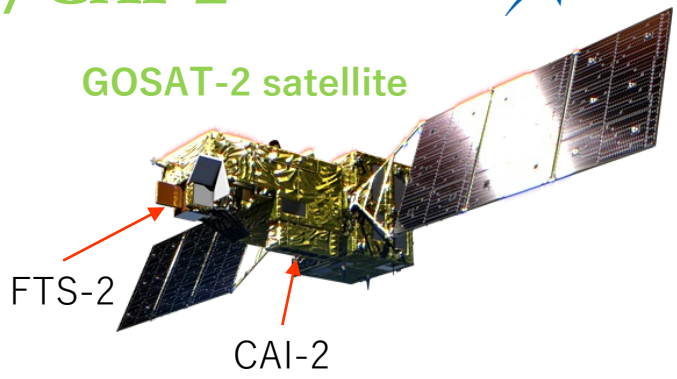


1.3 JAXA aerosol missions: GOSAT-2/CAI-2

- Greenhouse gases Observing SATellite-2 (GOSAT-2) /Thermal And Near Infrared Sensor for carbon Observation - Cloud and Aerosol Imager-2 (TANSO-CAI-2)

- The CAI-2 standard aerosol product will be produced by "**the multiwavelength and multipixel method**" (Hashimoto and Nakajima JGR 2017) which uses general characteristics of heterogeneous land surface reflectance and smoothly distributed aerosol over the surfaces.

First image of CAI-2

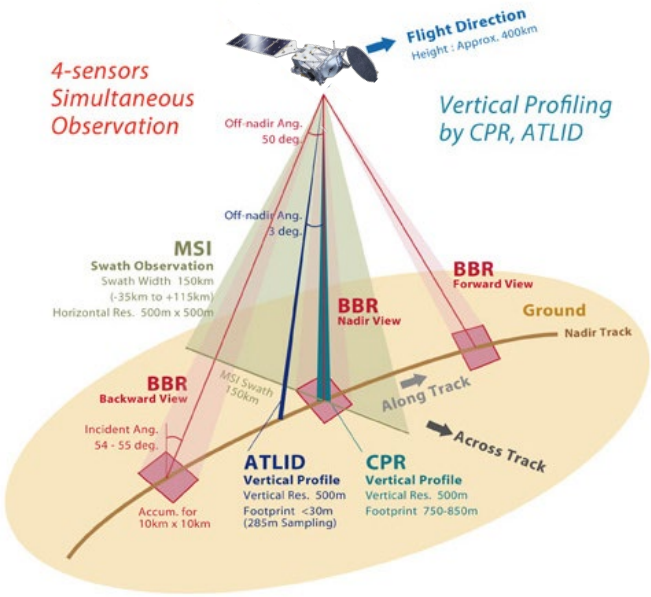


GOSAT-2	
Launch	**Oct. 29 2018**
Orbit type	Sun synchronous (dec 13:00 ± 0:15)
Altitude	613 km
Repeat cycle	6 days
Mass	< 2,000 kg
Power	5.0 KW

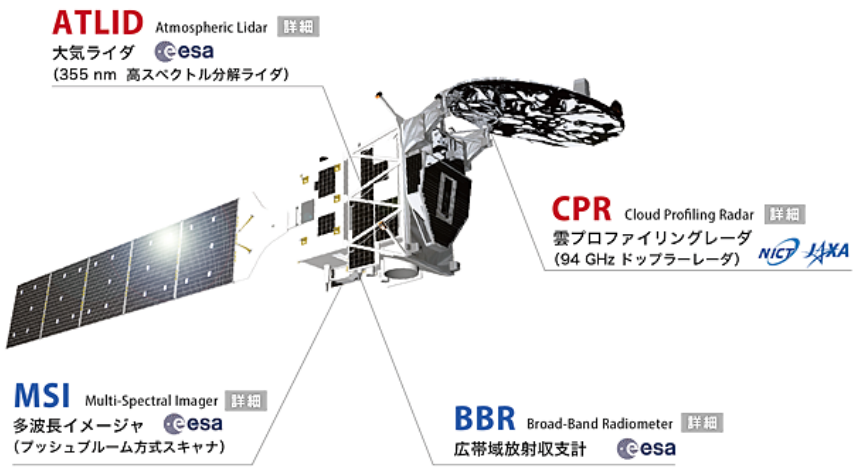
CAI-2 bands	nm	Tilt	Spatial resolution	Swath
B1	333 - 353	+20 deg. (Forward viewing)	460 m	920 km
B2	433 - 453			
B3	664 - 684			
B4	859 - 879			
B5	1585 - 1675		920m	
B6	370 - 390	-20 deg. (Backward viewing)	460 m	
B7	540 - 560			
B8	664 - 684			
B9	859 - 879			
B10	1585 - 1675		920m	

1.3 JAXA aerosol missions: EarthCARE/Cloud Profiling Radar (CPR)

- EarthCARE will observe 3D structure of clouds and aerosols, and reduce errors in climate change and weather forecast, by Japan (JAXA/NICT)-Europe (ESA) cooperation.
- CPR is the world's first W-band Doppler radar (94GHz) aboard a satellite. We can understand the vertical structure of clouds, as well as the ascending and descending movement of clouds.



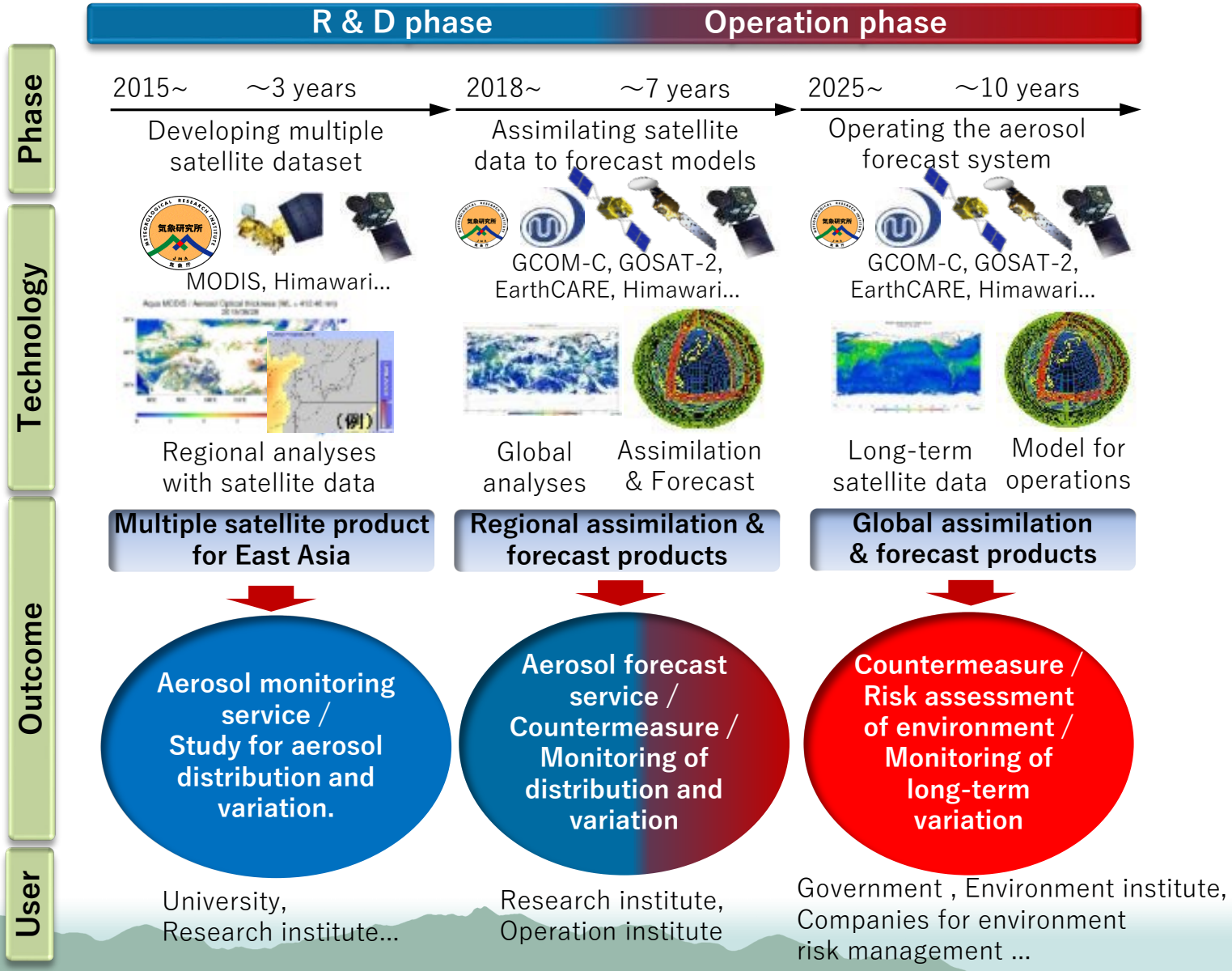
- **Mission**
  - Vertical profile of clouds, aerosol
  - Interaction between clouds and aerosol
  - Cloud stability and precipitation
- **Orbit**
  - Sun synchronous (14:00)
  - Altitude 400km
- **Task sharing**
  - JAXA/NICT (CPR)
  - ESA (ATLID, MSI, BBR, Spacecraft)
- **Launch target**
  - JFY2023



1.3 JAXA aerosol missions:

Integration of multiple satellite data through model assimilations

We aim to establish the aerosol data assimilation and forecasting system with JAXA satellites.



1.3 JAXA aerosol missions:

Integration of multiple satellite data through model assimilations

Future Targets：

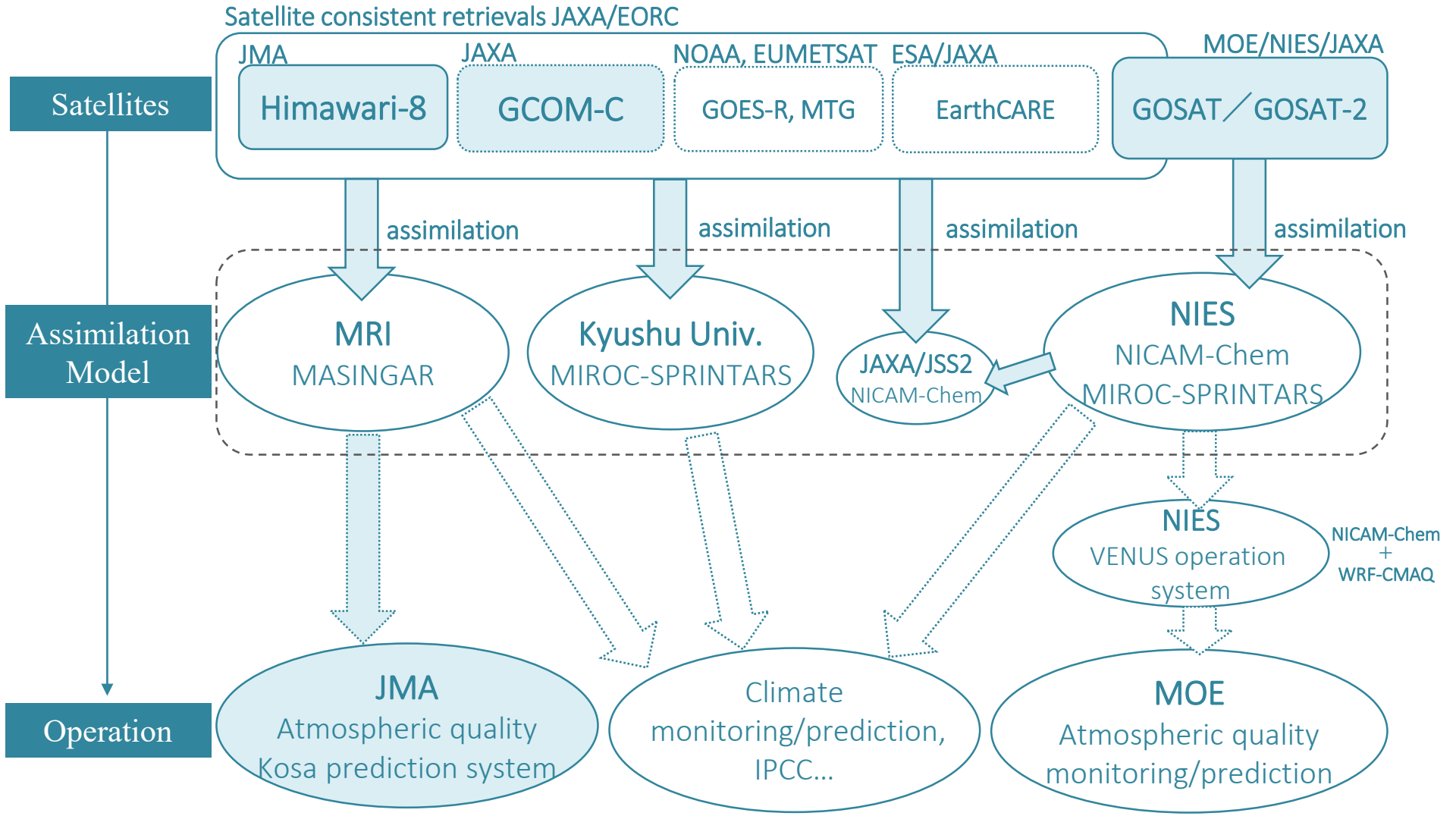
- ✓ JAXA, JMA/MRI, Kyushu University, and NIES will collaborate to develop a model assimilation system for GOSAT-2, EarthCARE in addition to Himawari and GCOM-C, and develop assimilation products (which uses not only AOT but also aerosol types and altitudes information)
- ✓ Accumulation of satellite data & assimilated aerosol data will contribute to climate change prediction research by not only monitoring the aerosol's current situations and short-term forecasts, but also by monitoring long-term variation in aerosols and improving knowledge of their generation and transport.

Schedule FY2022：

① Development of the aerosol products for assimilation and analyses with the products	• Improvement of aerosol products by assimilation studies: improved handling of errors for combining satellite data; developing combined data • Support for switchover to Himawari-9 • Case studies for analysis of global environmental changes using aerosol products: ex.) biomass burning aerosols
② Research of the data assimilation for aerosol transport model and prediction	• Study of improved assimilation using multi-satellite data such as GCOM-C • Study on improvement of prediction by effective assimilation with not only AOT • Analysis of global environmental changes using assimilation products (and reanalysis products: TBD) • Development of data providing system for practical use
③ Improving the Himawari-Monitor system	• Operation of the Himawari-Monitor processing system, etc.

1.3 JAXA aerosol missions:

Integration of multiple satellite data through model assimilations

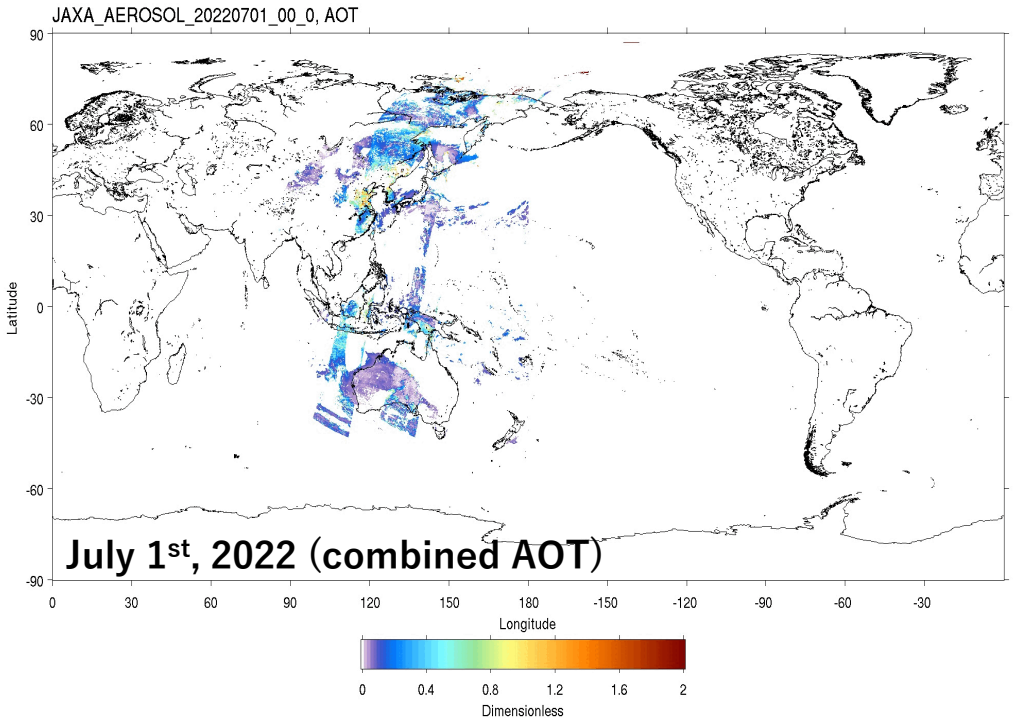


1.3 JAXA aerosol missions:

Integration of multiple satellite data through model assimilations

Development of the combined satellite dataset for assimilation input (every 3 hours)

Uncertainty is also output for data assimilation
(obtained from Himawari/AHI's AOT and SGLI Ver.3 AOT)



NetCDF product will contain:

- **AOT**
- **UNC_AOT**
- **AAE**
- **UNC_AAE**
- **SSA**
- **UNC_SSA**
- **…**

(The SGLI & Himawari combined values are bias corrected and weighted by $1/UNC^2$)

Spatial resolution: 0.05 deg.

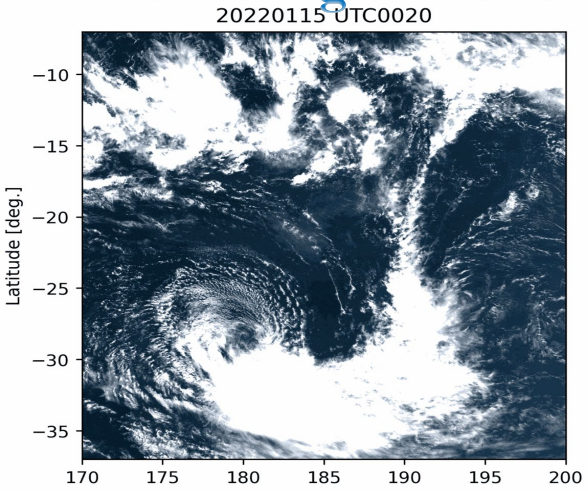
Purpose：To provide to related institutes and public, and prepare for adding other satellite products smoothly.

Next：Make error definitions consistent with other products (MODIS, AHI, etc.) so that they can be easily used in assimilation.

2. Aerosol Observation by GCOM-C/SGLI

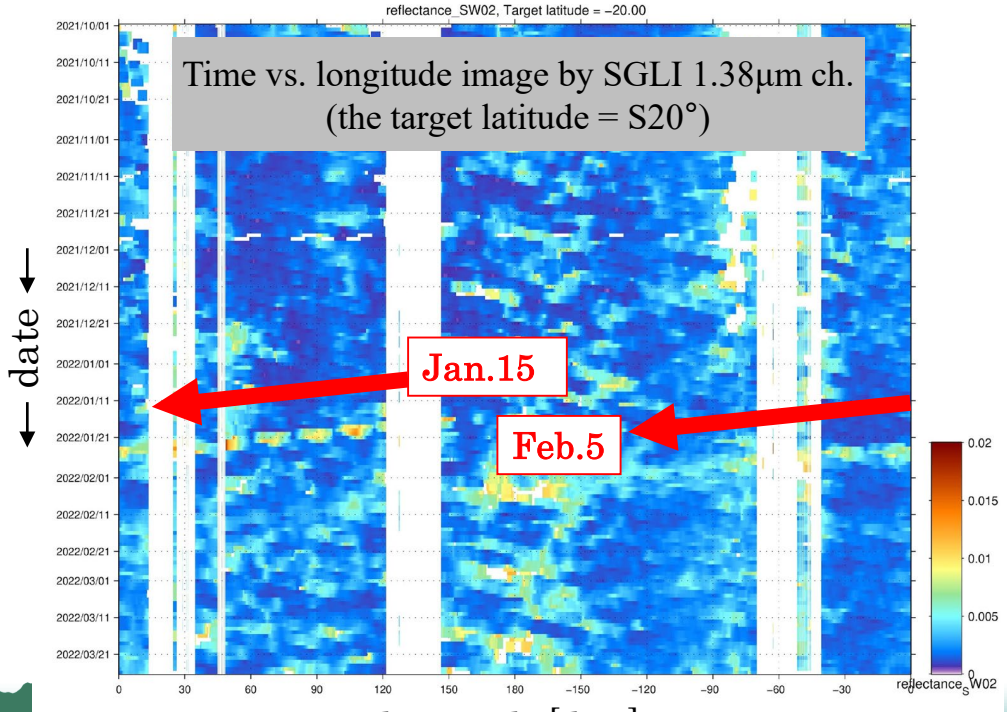
2.1 GCOM-C/SGLI aerosol observation:

Monitoring of the aerosols emitted from Tonga volcanic eruption



■Hunga-Tonga Hunga-Ha'apai volcanic eruption

Date: January 15, 2022
Place: The South Pacific island nation of Tonga



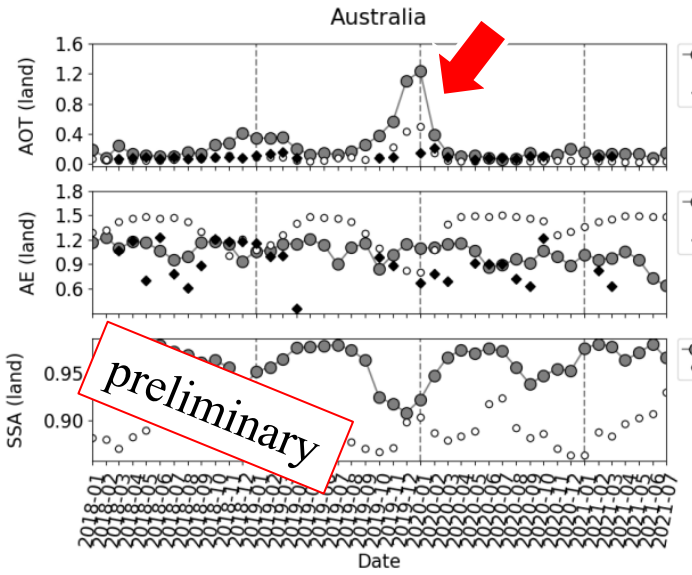
Since the 1.38 μm channel (shortwave infrared) is within the strong water vapor absorption band, light from the ground surface and the lower layer of the atmosphere cannot be seen.

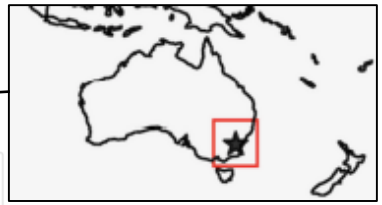
By utilizing this characteristic, it is possible to extract the scattered light from clouds and aerosols in the upper atmosphere.

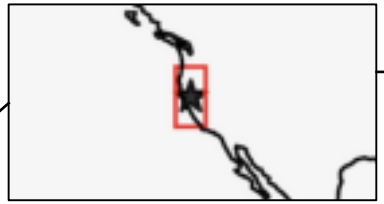
As for the aerosols emitted from the Tonga volcanic eruption, which exist in stratosphere, we confirmed that they spread westward and returned to the same region in about three weeks.

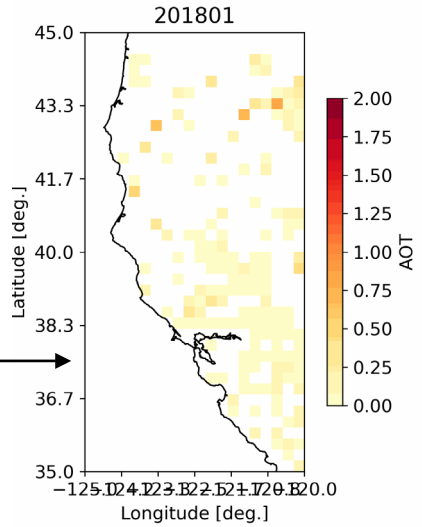
2.1 GCOM-C/SGLI aerosol observation:

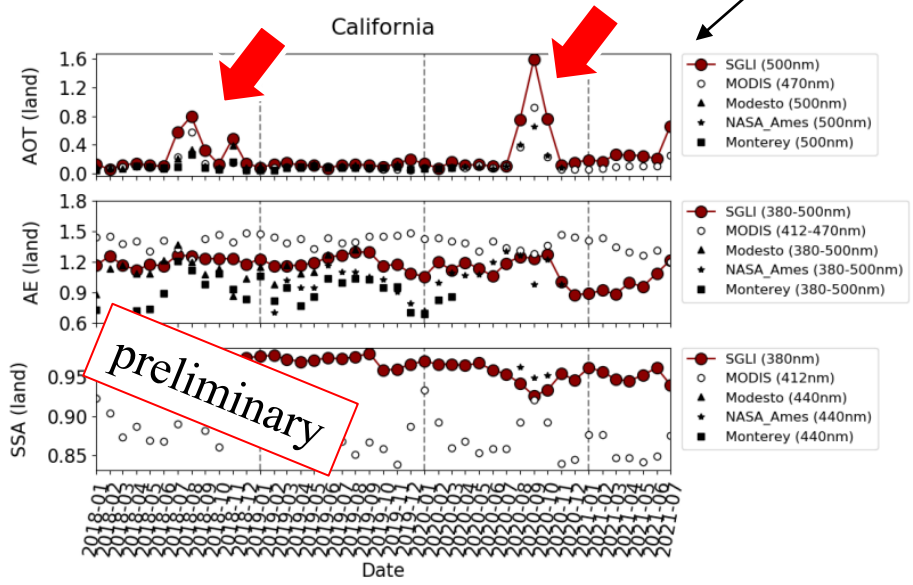
Monitoring of the aerosols emitted from wildfires









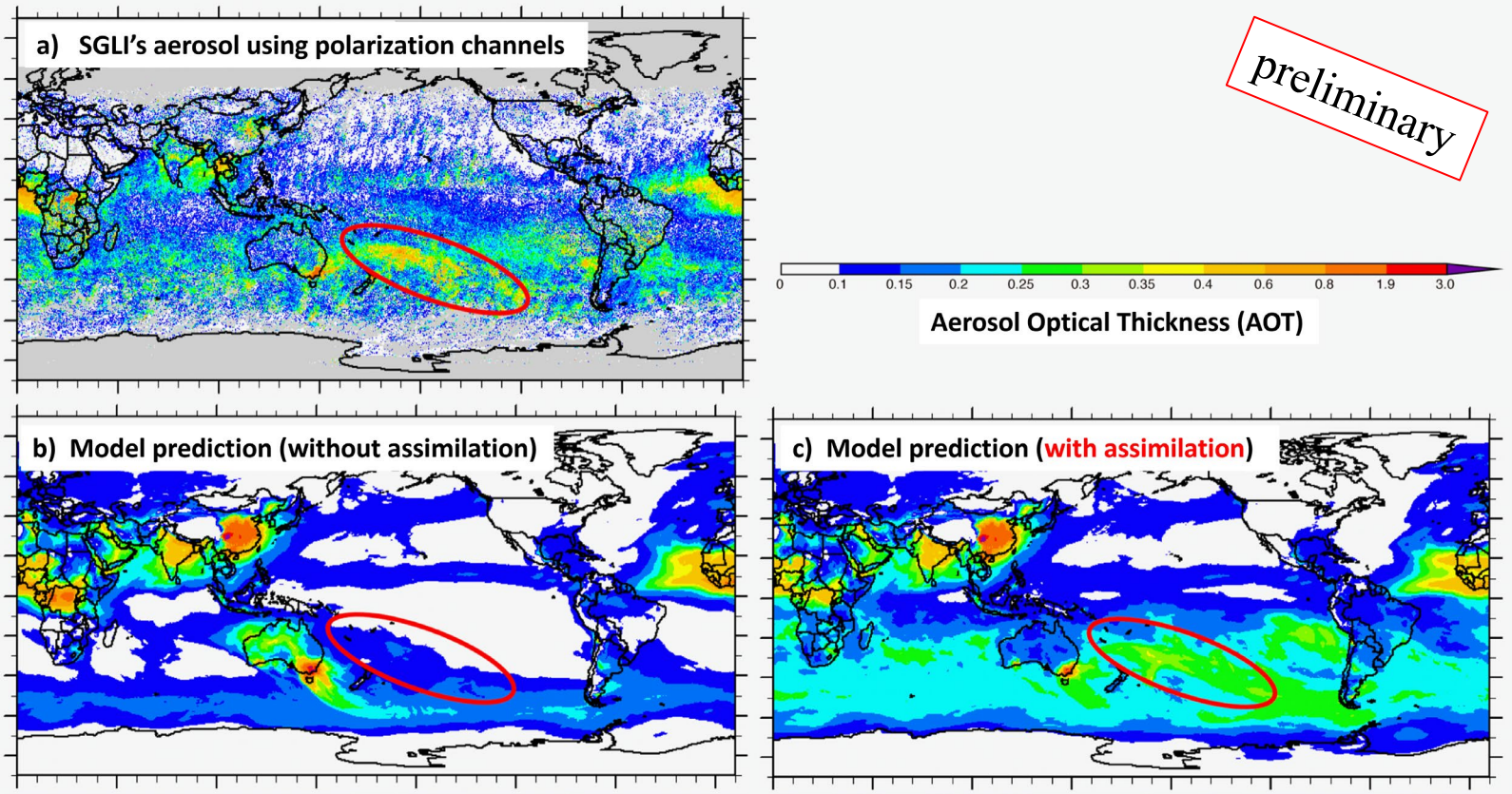


The wildfires occurred in Australia and California are captured by SGLI Aerosol Optical Thickness (AOT) product.
By analyzing the aerosol optical properties such as Ångström exponent (AE) and Single Scattering Albedo (SSA), we can understand the characteristics of aerosols from wildfire considering the local humidity and land cover, etc.

<u>These information can be used for improving the aerosol transport and emission model.</u>

2.2 GCOM-C/SGLI data assimilation:

SGLI aerosol data assimilation on Australian wildfire



An aerosol data assimilation experiment using SGLI polarization observation on Australian wildfire (provided by **K. Yumimoto, Kyushu University**):

a) Aerosol optical thickness calculated by using SGLI polarization observation,
b) Model estimation value without assimilating SGLI data,
c) Model estimation value with assimilating SGLI data

This result suggests that the satellite observation can improve the aerosol model with the data assimilation.

3. Summary

- JAXA is operating polar orbit satellite missions, GCOM-C and GOSAT2, and will have EarthCARE for the aerosol observation.
- A sensor common algorithm is developed in JAXA/EORC
- Satellite AOT assimilation is investigated with JMA/MRI, Kyusyu Univ., AORI, and NIES
- The “Aerosol and Clouds, Convection and Precipitation” is the next key science target and “AOS” project is now established.
- GCOM-C/SGLI aerosol observations show good possibilities to improve the models.

Appendix