



# Satellite activities at JAXA

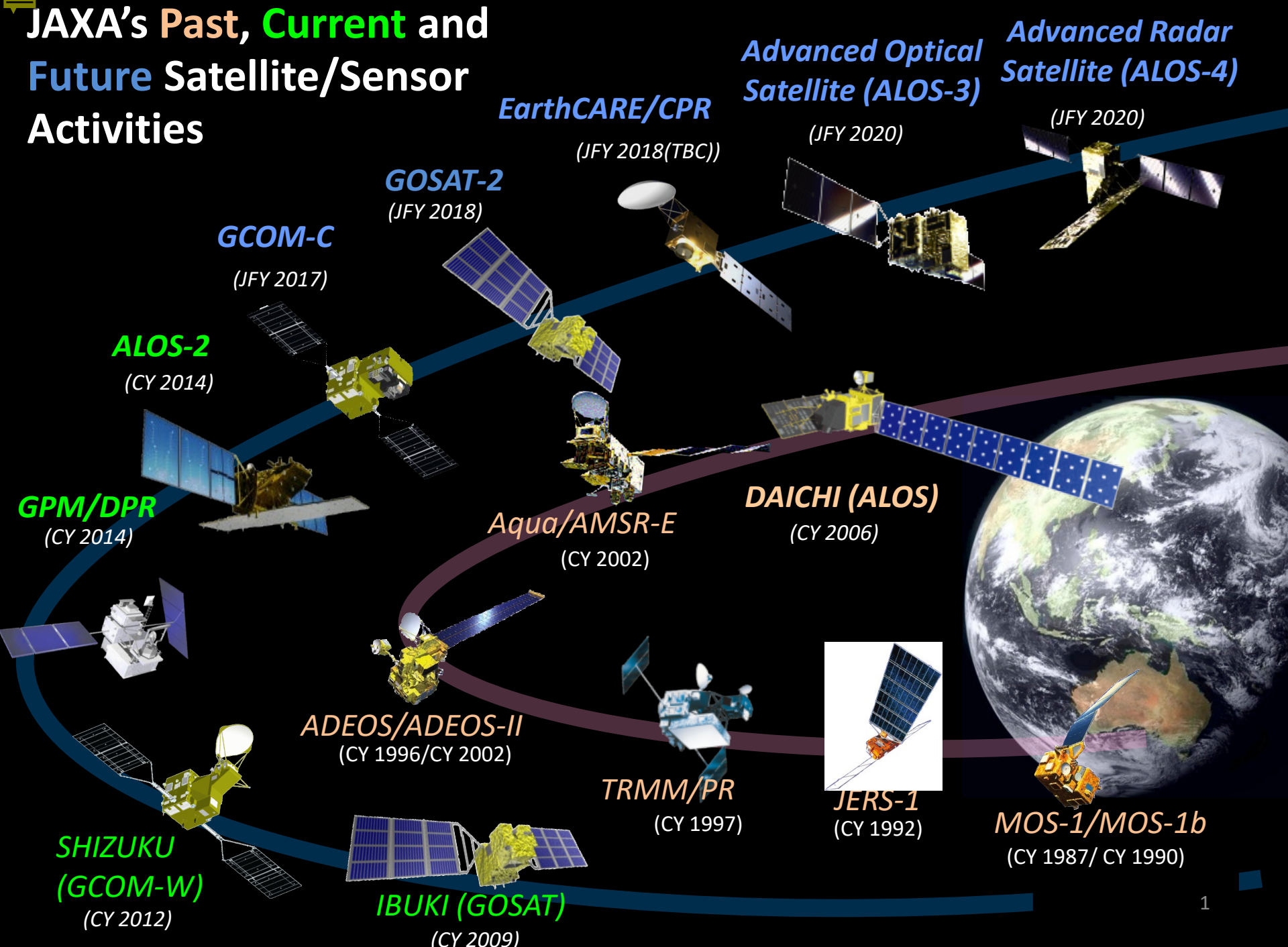
**Misako Kachi**

EORC, Space Technology Directorate I  
Japan Aerospace Exploration Agency (JAXA)

May 16, 2017

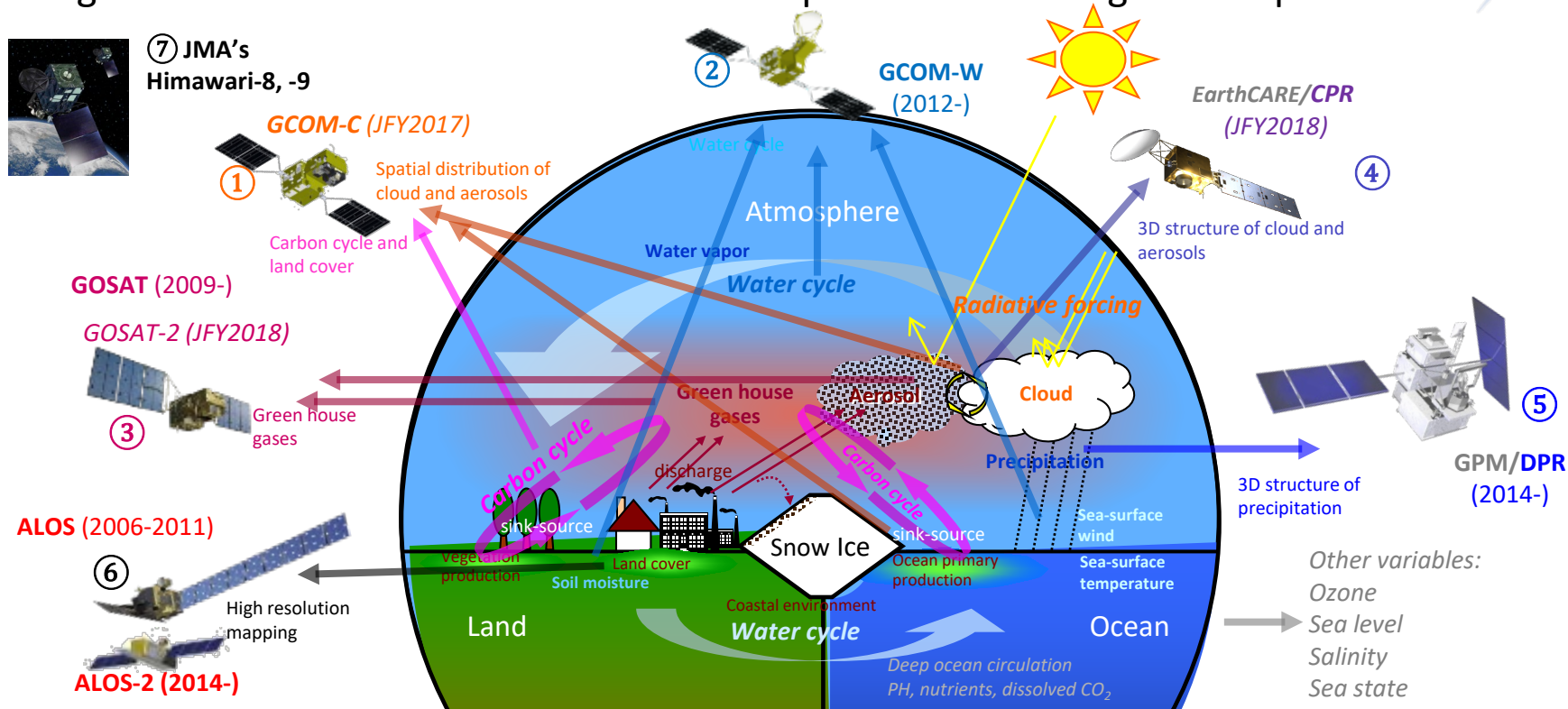
1st GODEX Meeting@Lannion, France

# JAXA's Past, Current and Future Satellite/Sensor Activities



# JAXA Earth Observation Program

There are no sensors that observe EVERYTHING on the earth. Each sensor has its own strength → observe “parts” of earth’s phenomenon taking the advantage of each sensor → the goal is to combine the sensors’ data to capture the full image of the phenomenon



⑦ JMA's Himawari-8, -9

① GCOM-C (JFY2017)  
Spatial distribution of cloud and aerosols  
Carbon cycle and land cover

GOSAT (2009-)  
GOSAT-2 (JFY2018)  
Green house gases

⑥ ALOS (2006-2011)  
High resolution mapping  
ALOS-2 (2014-)

② GCOM-W (2012-)

EarthCARE/CPR (JFY2018)

④

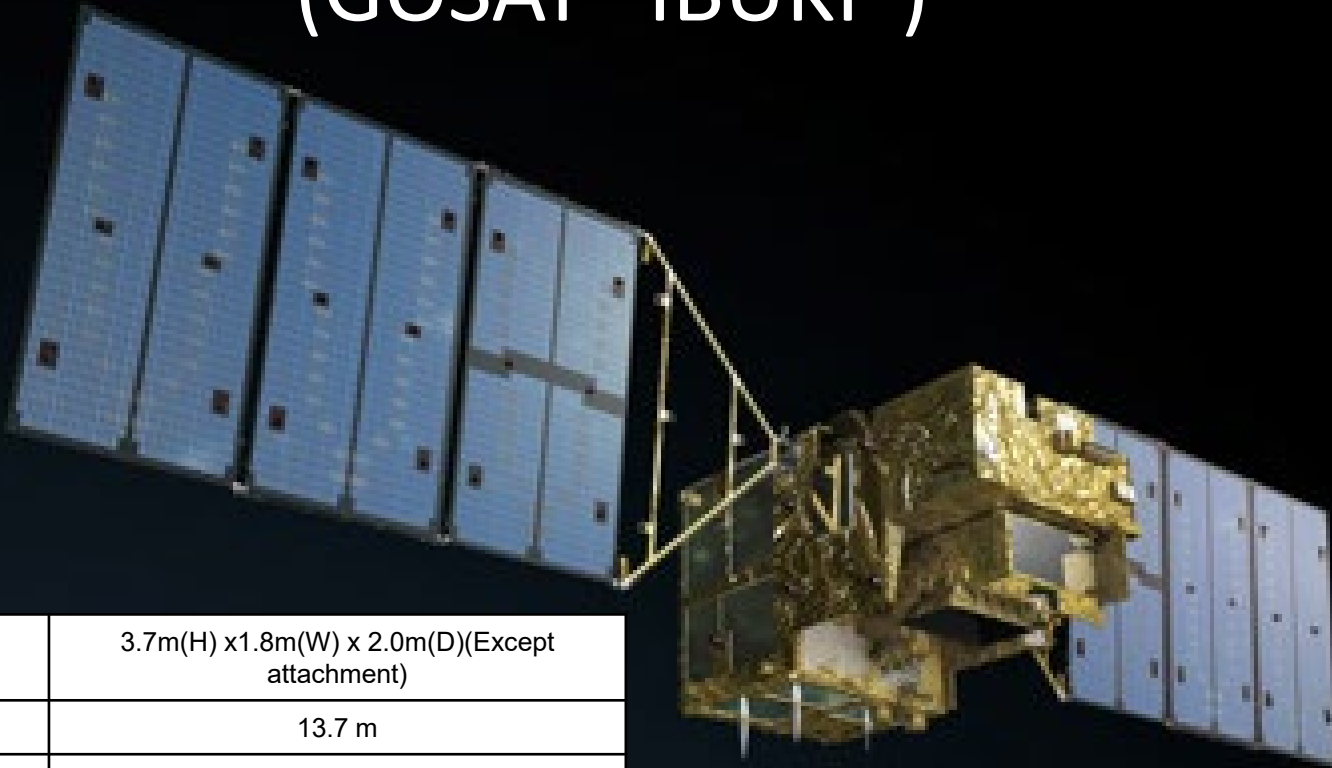
⑤ GPM/DPR (2014-)

Other variables:  
Ozone  
Sea level  
Salinity  
Sea state

- ① **GCOM-C:** Long-term observation of the horizontal distribution of aerosol, cloud, and ecosystem CO<sub>2</sub> absorption and discharge
- ② **GCOM-W:** Long-term observation of water-cycle such as the snow/ice coverage, water vapor, and SST
- ③ **GOSAT:** Observation of distribution and flux of the atmospheric greenhouse gases, CO<sub>2</sub> and CH<sub>4</sub>
- ④ **EarthCARE/CPR:** Observation of vertical structure of clouds and aerosols
- ⑤ **GPM/DPR:** Accurate and frequent observation of precipitation with active and passive sensors
- ⑥ **ALOS, -2** Fine resolution mapping by SAR instruments
- ⑦ **Himawari-8:** Synergies to enhance values of JAXA EO Satellites

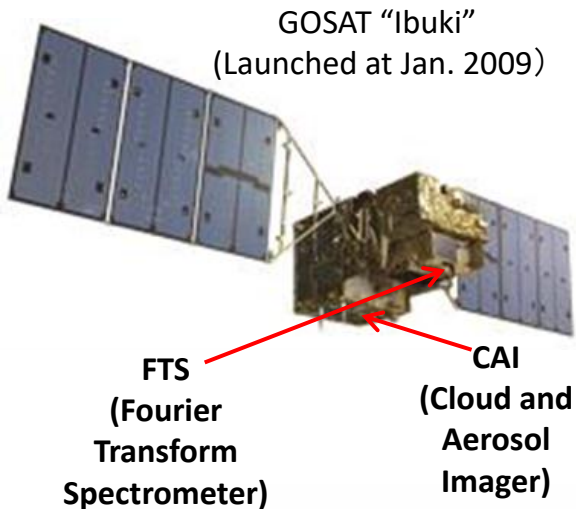
# *Satellites in Orbit*

# Greenhouse gases Observing SATellite (GOSAT “IBUKI”)



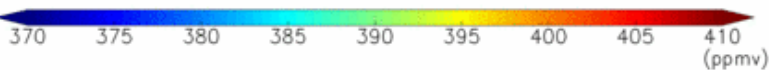
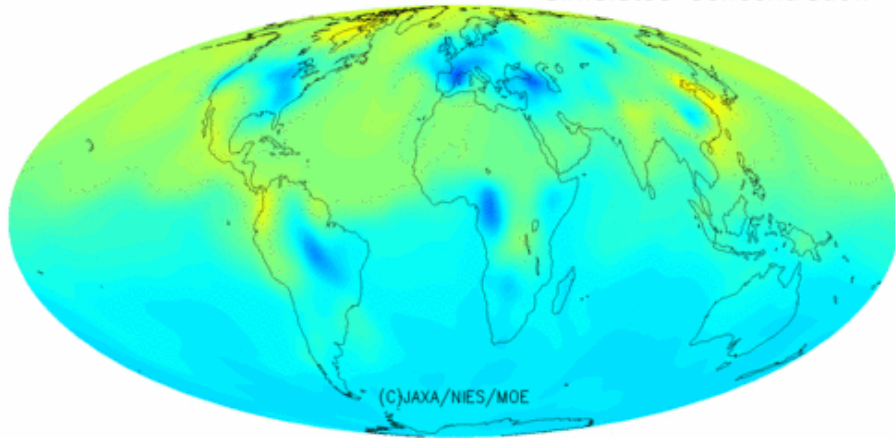
Size	Main body	3.7m(H) x1.8m(W) x 2.0m(D)(Except attachment)
	Wing Span	13.7 m
Mass	Total	1,750 kg
Power	Total	3.8KW(EOL)
Design Life	5 years	
Orbit	Sun Synchronous Orbit	
	Local time	13:00±0:15 (February 2015 - January 2016) 12:46-12:52
	Altitude, inclination, period, revisit	666±0.6 km, 98.0±0.1 deg, 98.1 min, 3 days (44 rotations)
Launch	Vehicle, date	H-IIA, Jan. 23, 2009

# CO2 and CH4 Observation by GOSAT

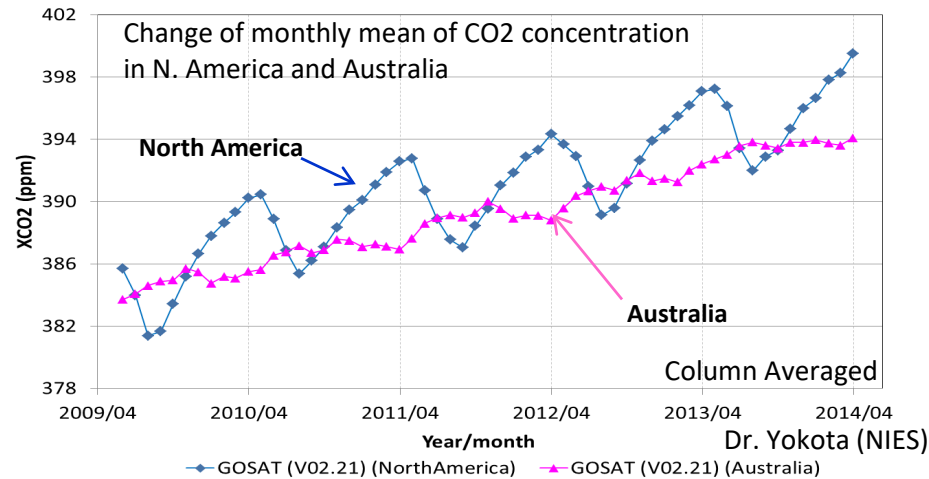


- Measure global distribution of GHGs, and understand how their emission is reduced.
- The only operation satellite for monitoring CO<sub>2</sub> and methane from space

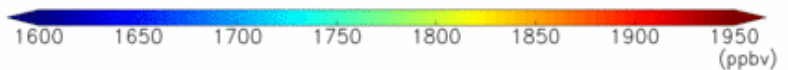
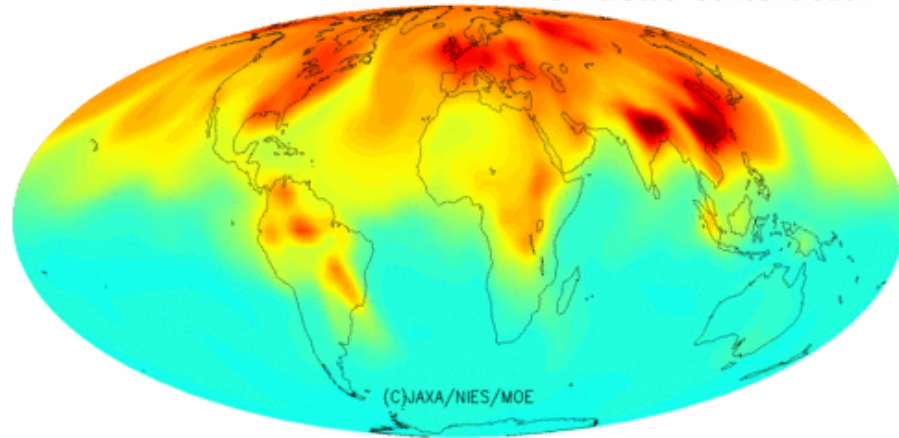
GOSAT L4B V02.02 CO<sub>2</sub> (2009/06/01) ETA:925  
Simulated Concentration



Animation of daily mean of CO<sub>2</sub> concentration  
(June 2009 - May 2011, at 800 m altitude)



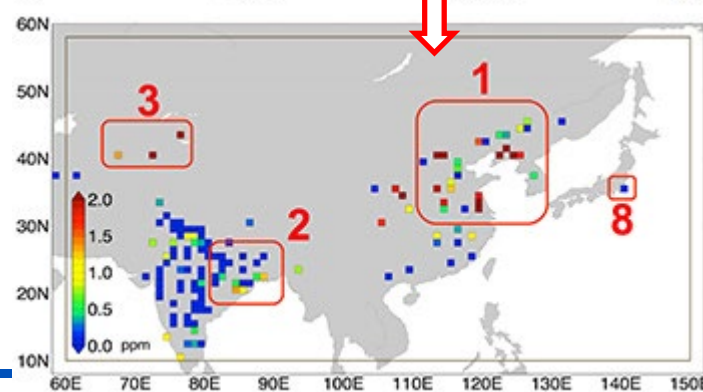
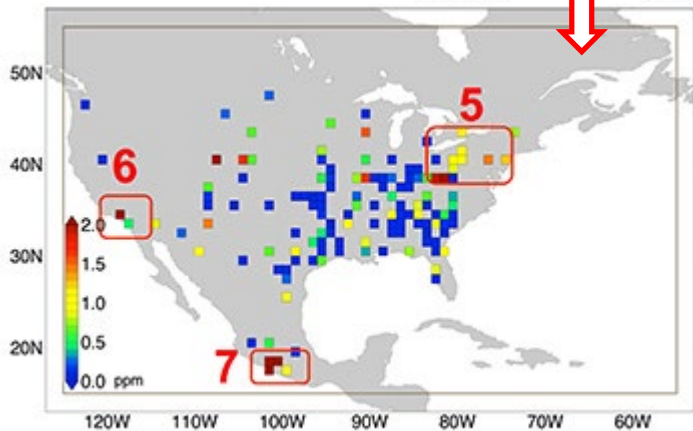
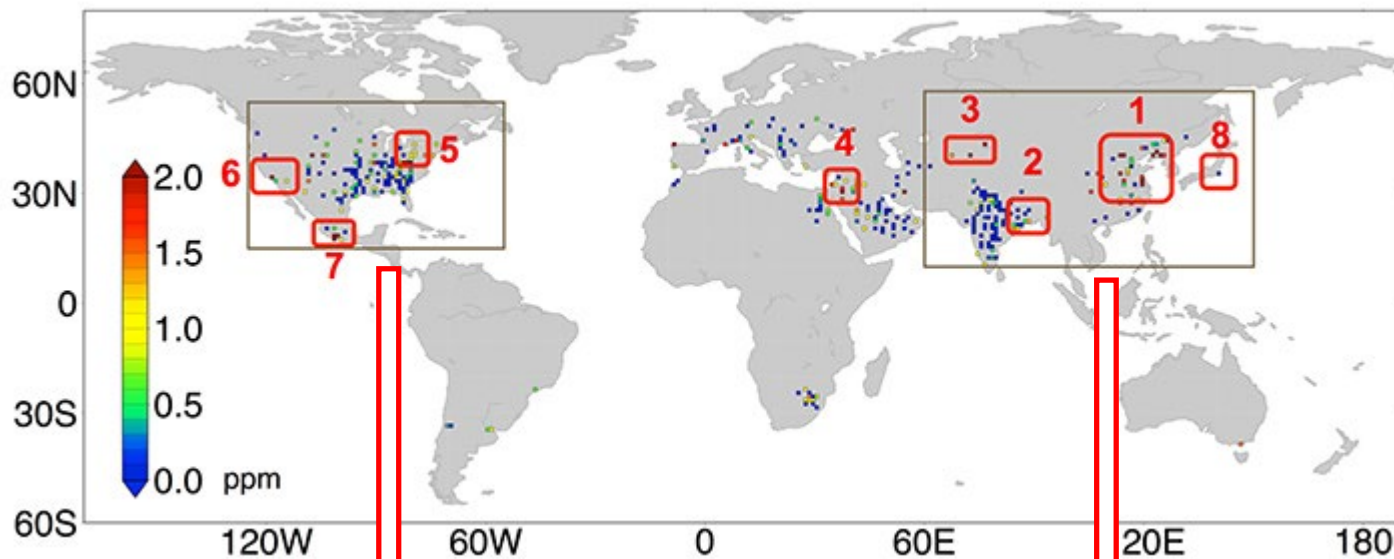
GOSAT L4B V01.01 CH<sub>4</sub> (2009/06/01) ETA:925  
Simulated Concentration



Animation of daily mean of CH<sub>4</sub> concentration  
(June 2009 - May 2011, at 800 m altitude)

# Estimation of Anthropogenic CO<sub>2</sub>

- Areas where anthropogenic CO<sub>2</sub> was observed at high concentration (average from June 2009 to December 2014) by observed GOSAT. The color indicates the anthropogenic CO<sub>2</sub>.
- The concentration of anthropogenic CO<sub>2</sub> is high in areas such as North America, Europe, Middle East, India, China where population is dense or industrial activities are promoted including thermal electric power generation and oil and gas field development.



Collaboration  
with MOE, NIES  
and JAXA

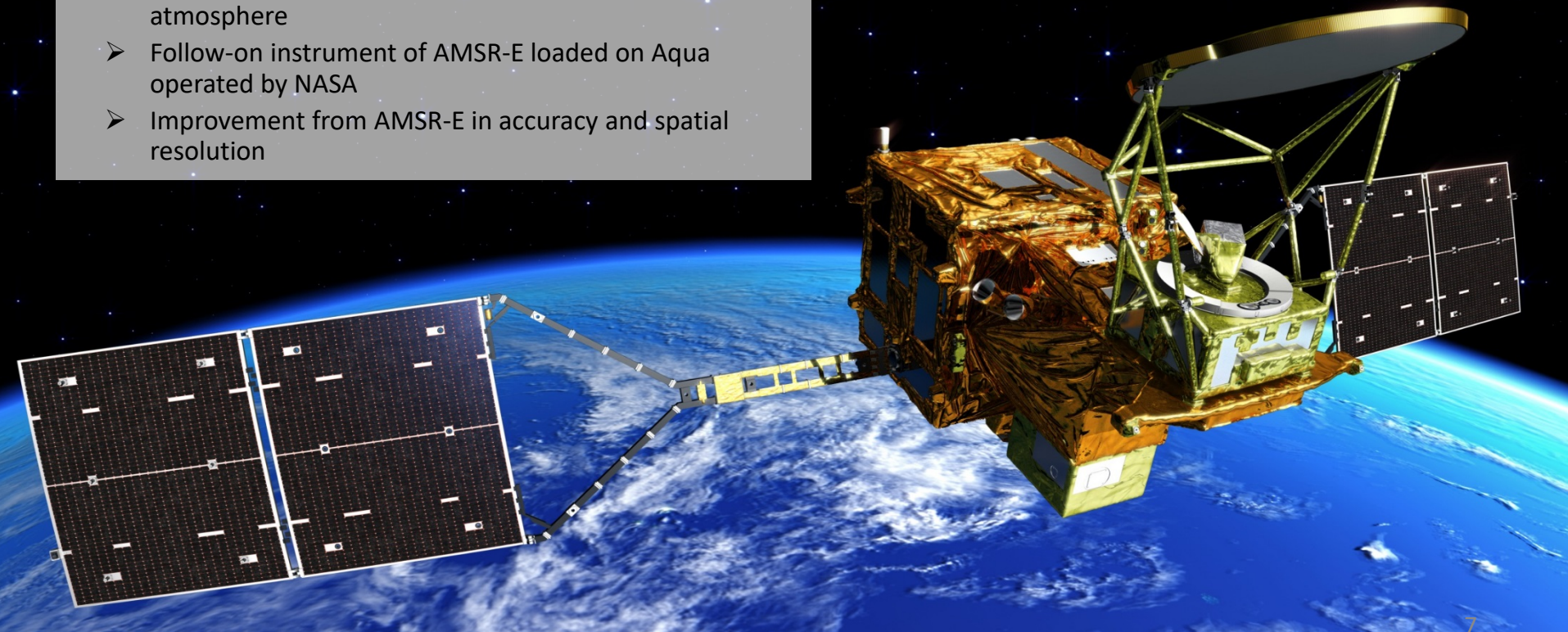
# Global Change Observation Mission – Water (GCOM-W “SHIZUKU”)

## ■ GCOM-W “SHIZUKU”: Medium size satellite

- Weight: Approx. 2 tons
- Size: 5.1m(L) × 17.5m(W) × 3.4m(H)
- Power generation: Approx. 4000W

## ■ Mission instrument: AMSR2

- Advanced Microwave Scanning Radiometer 2 (AMSR2)
- Observe weak microwave from the ground, sea surface, atmosphere
- Follow-on instrument of AMSR-E loaded on Aqua operated by NASA
- Improvement from AMSR-E in accuracy and spatial resolution





# AMSR2 Standard/Research Products

## Standard Products

Product	Resolution	Accuracy
Brightness Temperature	5-50 km	< 1.4 K
GEO	Total Precipitable Water	15 km GPS:1.5 kg/m <sup>2</sup>
	Cloud Liquid Water	15 km 0.04 kg/m <sup>2</sup>
	Precipitation	15 km Ocean 48% Land 86%
	Sea Surface Temperature	50 km 0.5 °C Zonal RMSE 0.2 °C
	Sea Surface Wind Speed	15 km 1.0 m/s
	Sea Ice Concentration	15 km 9 %
	Snow Depth	30 km 18 cm
	Soil Moisture Content	50 km 4 %

## Research Products

Products	Resolution	Accuracy
All-weather sea surface wind speed	60 km	4 m/s
High-resolution (10-GHz) SST	30 km	0.6 °C
Soil moisture and vegetation water content based on the land data assimilation	25 km	Not evaluated yet
Land surface temperature	15 km	4°C (mixed vegetation)
Vegetation water content	10 km	± 1 kg/m <sup>2</sup> (obs. site at Australia)
High resolution sea ice concentration	5 km	± 17 %
Thin ice detection	15 km	Not evaluated yet
Sea ice moving vector	50 km	Not evaluated yet

Released to public

# All-weather Sea Surface Wind Speed

- Use 6-GHz/10-GHz channels to avoid influence of rainfall (Shibata, 2006), corresponding to wind speed at best track released by JMA and NHC.
  - RMSE: 5.87 m/s for all wind range
  - RMSE: 4.18 m/s for strong (> 17 m/s) wind range
- AMSR2 all-weather SSW Released to public in October 2015 at [http://suzaku.eorc.jaxa.jp/GCOM\\_W/research/terms.html](http://suzaku.eorc.jaxa.jp/GCOM_W/research/terms.html)
- Used in JMA's operational typhoon analysis, and images are distributed to Asian meteorological agencies from JMA.

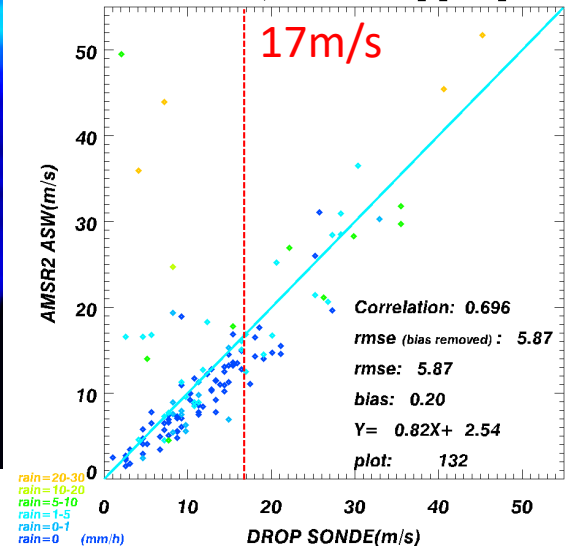
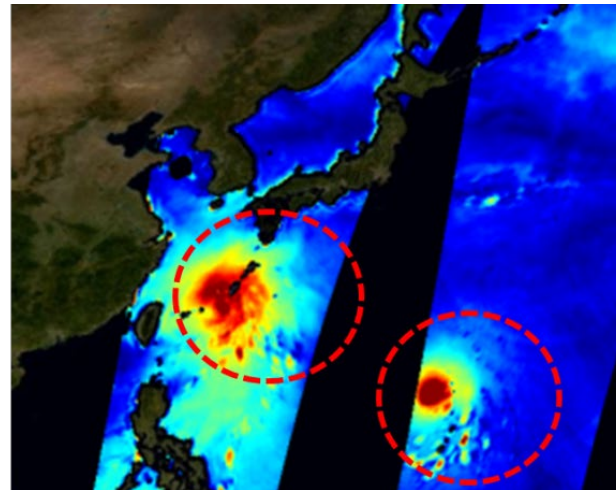
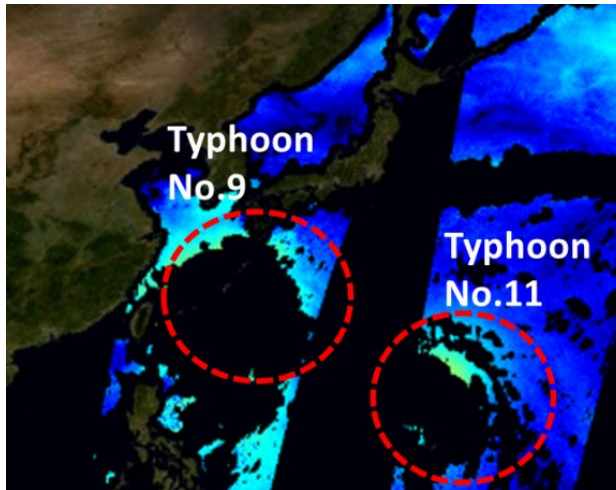
AMSR2 Standard SSW

AMSR2 All-weather SSW

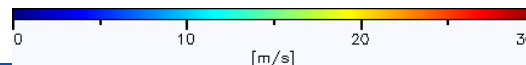
Period: Jul. 2012 – Oct. 2014

limitdist sonde\_am2: 10km  
ver: L2ASWS0120120.mu

AMSR2 ASW DROPSONDE (20120823-20141017, M\_EYE=1, MINDIST=50)



1 July, 2015 (Desc)

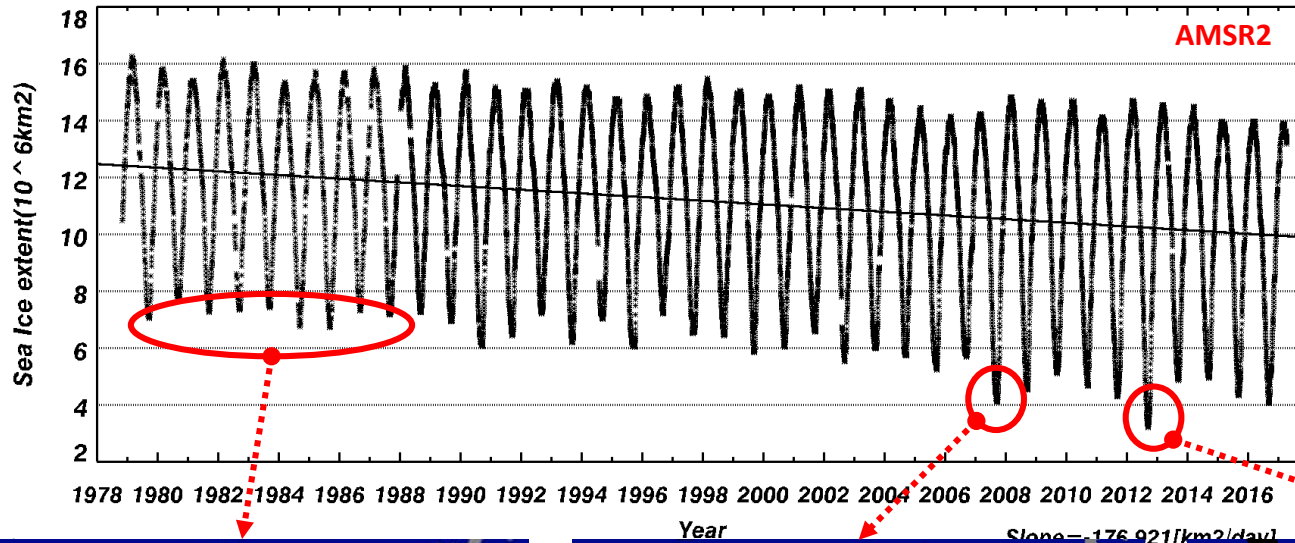


# Long-term Monitoring of Sea Ice

<http://kuroshio.eorc.jaxa.jp/JASMES/climate/index.html>

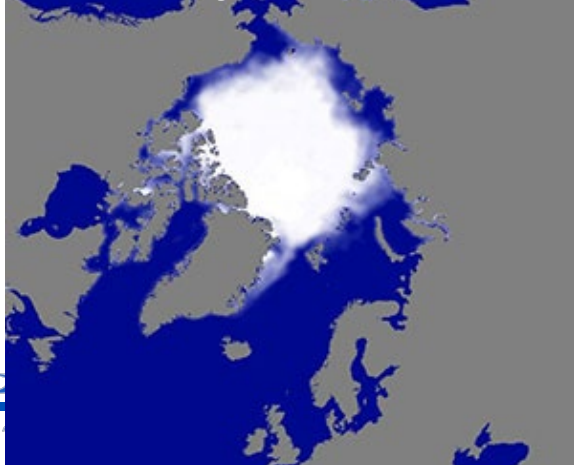
Daily sea ice concentration dataset by SMMR, SSM/I, AMSR-E, Windsat and AMSR2.

Daily Sea Ice Extent Trends (Northern Hemisphere) (1978/11/01-2017/04/14)



AMSR2 captured the smallest sea ice extent in the record in 2012, and AMSR-E captured the 2nd smallest in 2007.

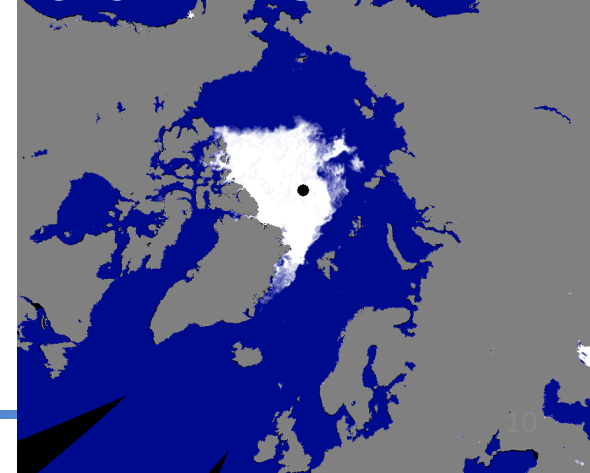
Average distribution of Sep. in 1980s by DMSP/SSM/I



Sep. 24, 2007 by Aqua/AMSR-E

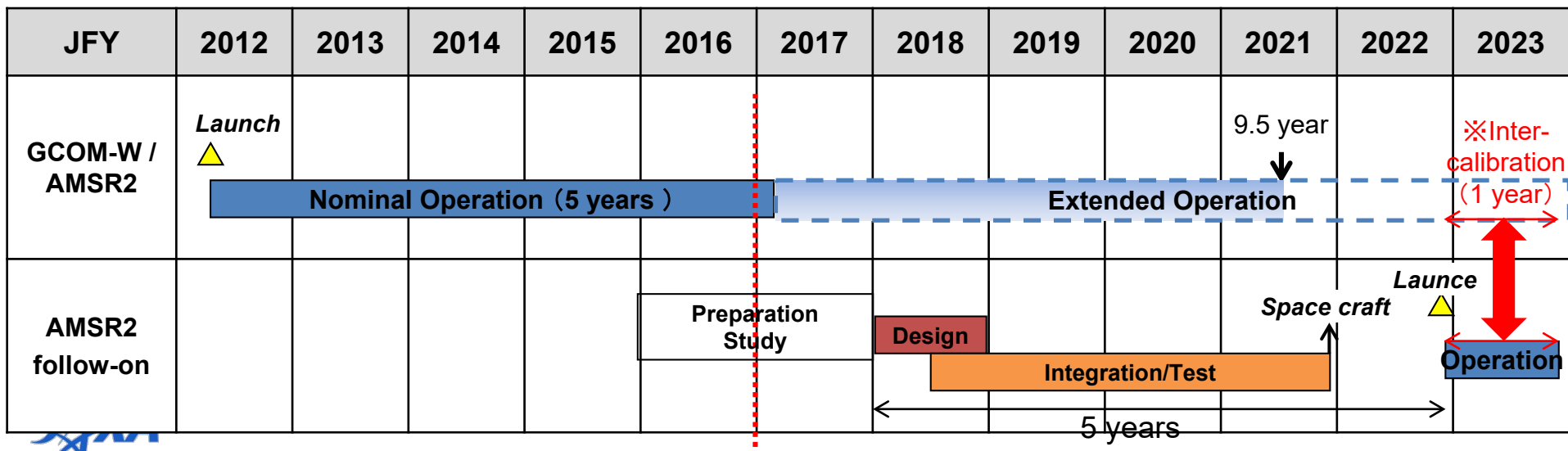


Sep. 16, 2012 by GCOM-W/AMSR2



# AMSR2 follow-on mission

- Continuity of AMSR series record is the highest priority of users
  - ✓ In the next May, AMSR2 will reach design life of 5 years. Observation operation will be continued as long as it can survive.
  - ✓ There is a high risk of gap between AMSR2 and the follow-on, even if development of AMSR2 follow-on starts from JFY2018.
  - ✓ Small budget is accepted to conduct **research on hosted payload capability of AMSR2 follow-on onto GOSAT-3 in JFY2017** in corresponding to revision of the roadmap for the Basic Plan on Space Policy. JAXA discussed with scientists on scientific synergies between two missions.



# Global Precipitation Measurement Mission (GPM)

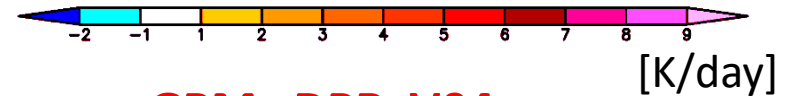
GPM is US-Japan space cooperation for monitoring global precipitation.

GPM core satellite was launched on February 28, 2014.



# The first GPM latent heating product

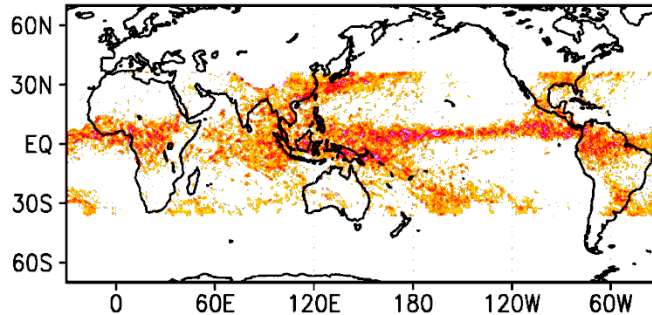
Comparison of latent heating products between TRMM/PR and GPM/DPR by the SLH algorithm (Shige et al. 2004) during Apr., May, Jun. 2014.



## TRMM PR V7A

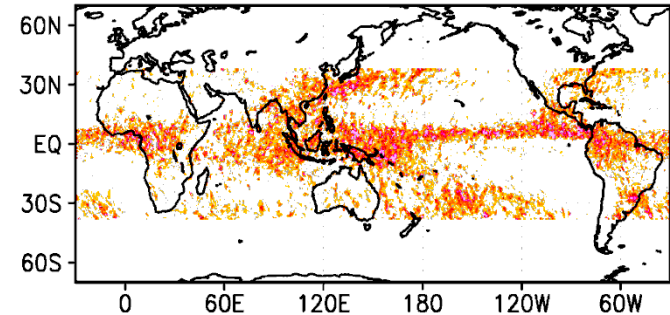
Q1R@7km Total(V7A) AMJ14

7km



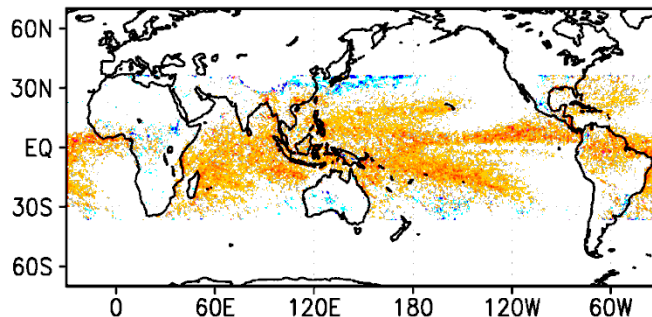
## GPM DPR V04

Q1R@7km Total(ITE057) AMJ14

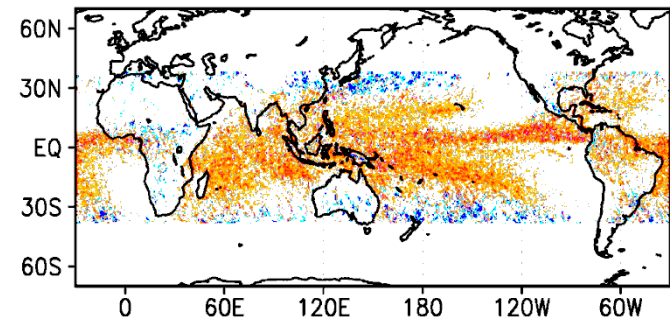


Q1R@2km Total(V7A) AMJ14

2km



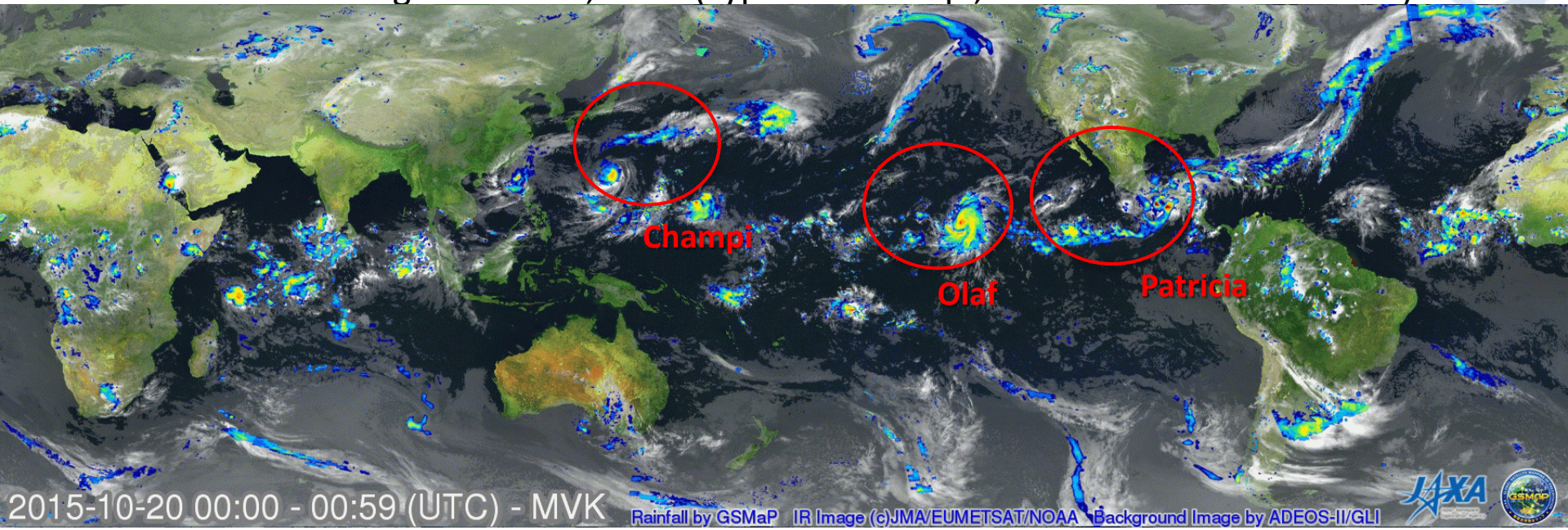
Q1R@2km Total(ITE057) AMJ14



→ Long-term latent heating observations using TRMM and GPM

# Global Satellite Mapping of Precipitation (GSMaP)

1-hr Animation during Oct. 20-24, 2015 (Typhoon Champi, Hurricanes Olaf & Patricia)



- GSMaP is a blended Microwave-IR product and has been developed in Japan for the GPM mission (Core and Constellations).
  - Processing and distributing global rainfall in near real time basis (4-h latency) by merging multi-satellite data.
  - Hourly product in 0.1x0.1deg. lat/lon grid.
- GSMaP Realtime version (GSMaP\_NOW) over Himawari area (0-h latency)
  - Extension to EUMETSAT/Meteosat area is in preparation.

<http://sharaku.eorc.jaxa.jp/GSMaP>

[http://sharaku.eorc.jaxa.jp/GSMaP\\_NOW](http://sharaku.eorc.jaxa.jp/GSMaP_NOW)

# Advanced Land Observing Satellite-2 (ALOS-2 or "DAICHI")

The logo for ALOS-2, featuring the text "ALOS-2" in a bold, green, sans-serif font. The letter "O" is replaced by a stylized satellite dish or antenna symbol.

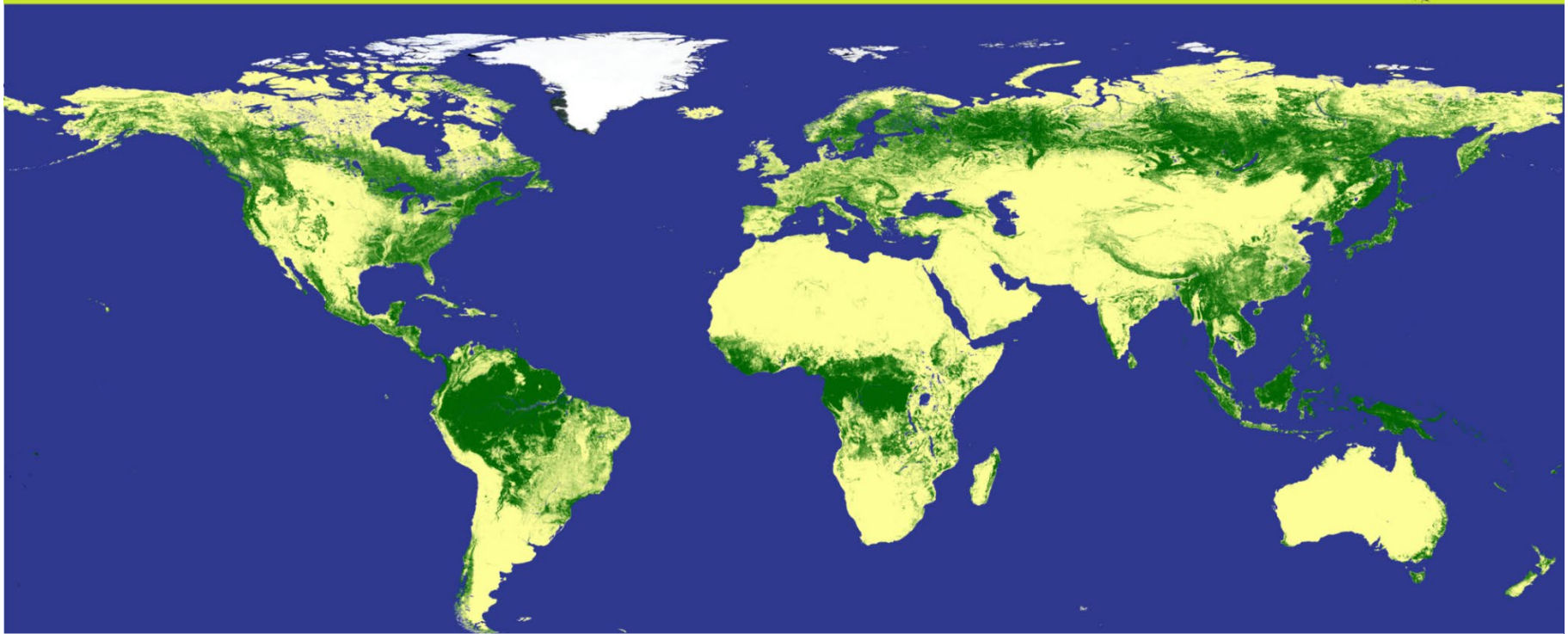
Carries L-band Synthetic Aperture Radar (PALSAR-2)

Application	Disaster, Land, Agriculture, Natural Resources, Sea Ice & Maritime Safety
L-band SAR (PALSAR-2)	Stripmap: 3 to 10m res., 50 to 70 km swath ScanSAR: 100m res., 350km/490km swath Spotlight: 1 × 3m res., 25km swath
Orbit	Sun-synchronous orbit Altitude: 628km Local sun time : 12:00 +/- 15min Revisit: 14days Orbit control: ≤ +/- 500m
Life time	5 years (target: 7 years)
Launch	JFY2013, H-IIA launch vehicle
Downlink	X-band: 800Mbps(16QAM) 400/200Mbps(QPSK) Ka-band: 278Mbps (Data Relay)
Experimental Instrument	Compact InfraRed Camera (CIRC) Space-based Automatic Identification System Experiment 2 (SPAISE2)



# 10m Global Forest/Non-Forest Map by ALOS/PALSAR

PALSAR 10m Global Forest/Non-Forest Map 2009



Forest/non-forest map is the important geophysical information on investigating the temporal forest land change, terrestrial causes on global warming, and proceeding the activity on Reducing the Emission from Deforestation and forest Degradation plus (REDD+).

©JAXA, METI Analyzed by JAXA

● : Forest   ● : Non-Forest   ● : Water

# *Upcoming Satellites*

# Global Change Observation Mission – Climate (GCOM-C) in JFY 2017



Coming Soon!

GCOM-C SGLI characteristics	
Orbit	Sun-synchronous (descending local time: 10:30), Altitude: 798km, Inclination: 98.6deg
Launch Date	<b>JFY 2017</b>
Mission Life	5 years
Scan	Push-broom electric scan (VNR: VN & P) Wisk-broom mechanical scan (IRS: SW & T)
Scan width	<b>1150km</b> cross track (VNR: VN & P) <b>1400km</b> cross track (IRS: SW & T)
Spatial resolution	<b>250m, 500m, 1km</b>
Polarization	<b>3 polarization angles for POL</b>
Along track tilt	Nadir for VN, SW and TIR, & +/-45 deg for P

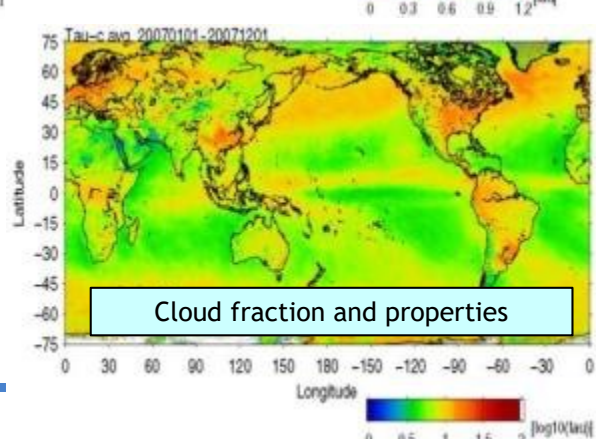
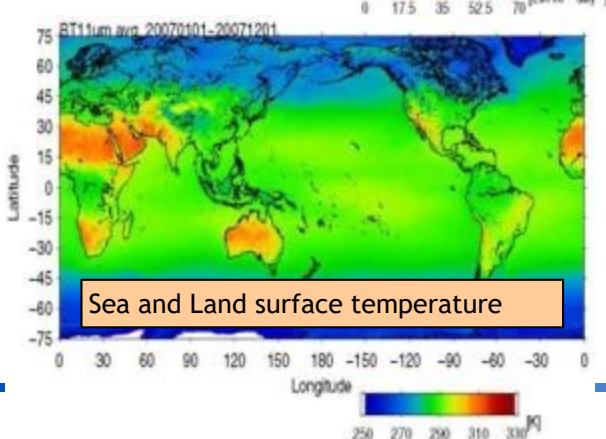
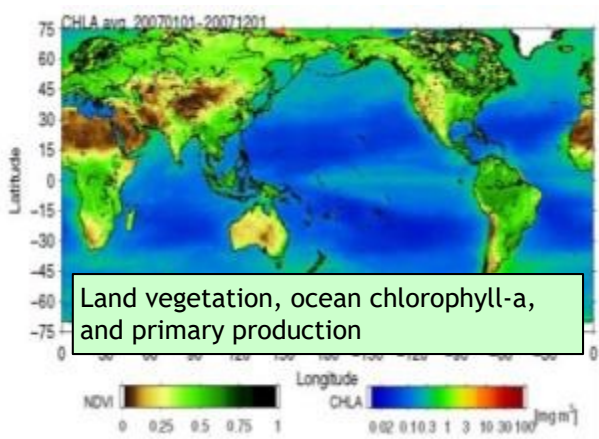
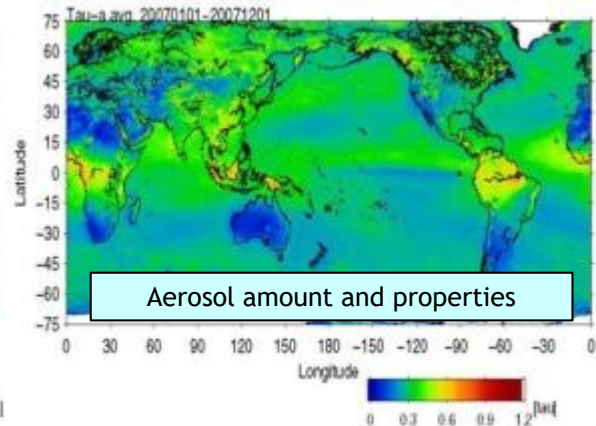
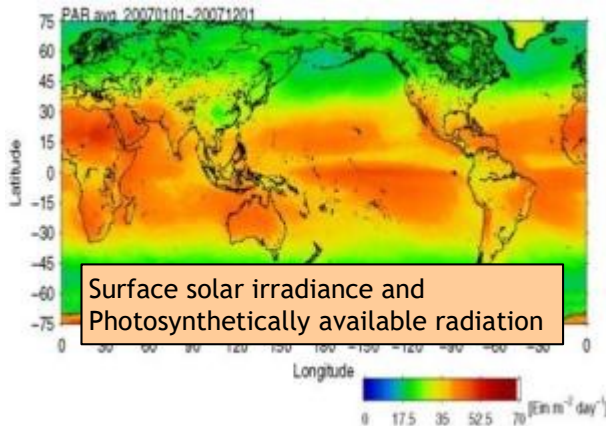
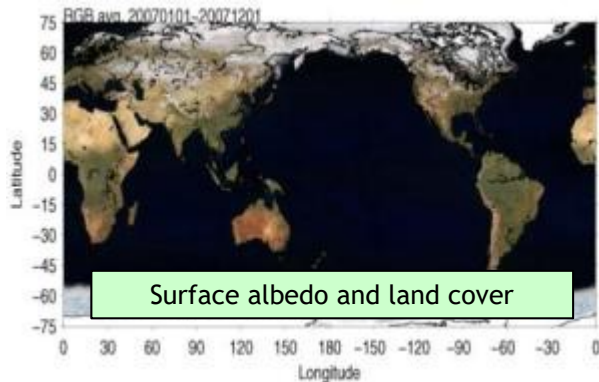
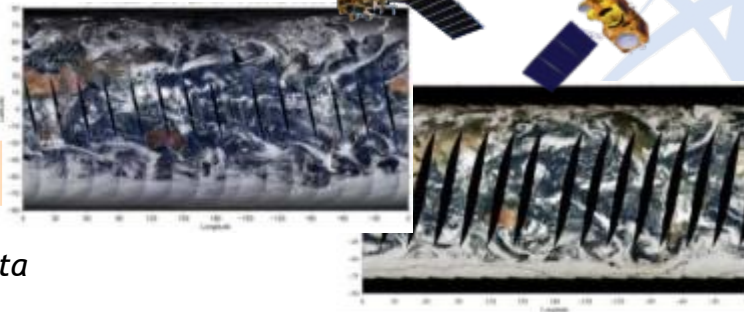
- Multi-band Imaging Radiometer (Near UV ~ TIR)
- Polarimeter
- Tilt Observation
- 250m Global at minimum

# Examples of GCOM-C SGLI Products

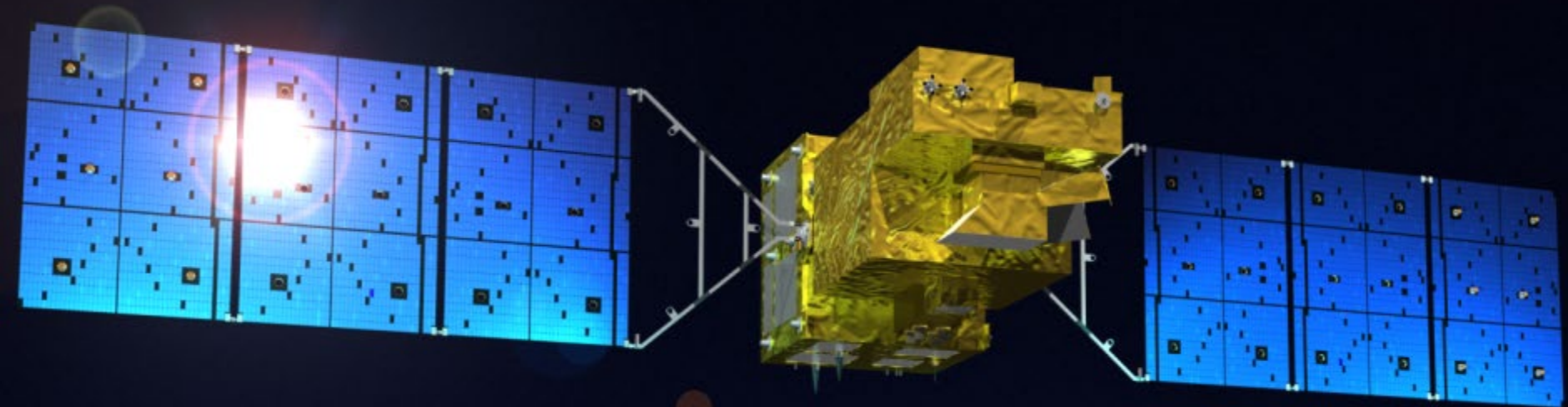


GCOM-C  
observation

Global data accumulation and  
synthesis with other satellite data



# GOSAT-2 on orbit in early 2018



## Upgrade in GOSAT-2 mission

## GOSAT achievement

## GOSAT target

Measurement precision	0.5 ppm for CO <sub>2</sub> 5 ppb for CH <sub>4</sub>	←2ppm for CO <sub>2</sub> ←12ppb for CH <sub>4</sub>	←4 ppm for CO <sub>2</sub> ←32 ppb for CH <sub>4</sub>
Flux estimation	1000km for land	←2000km in sub-continental scale	
Anthropogenic emission	CO to distinguish emission source		
Ecosystem carbon exchange	Chlorophyll fluorescence to place constrains on GPP		
Aerosol monitoring	Aerosol size distribution and its property		

# Earth Cloud, Aerosol and Radiation Explorer (EarthCARE)

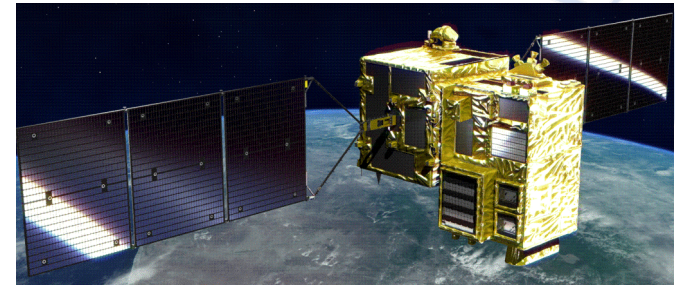
JAXA provides Cloud Profiling Radar (CPR) , the world's first W-band Doppler radar (94GHz) to observe vertical structure and dynamics of clouds,.



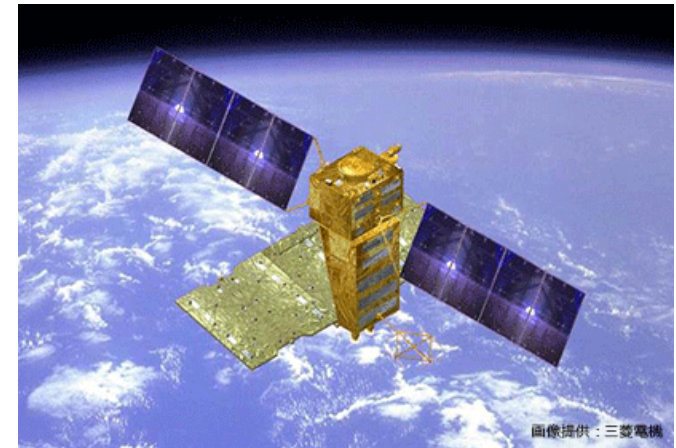
Institutions	European Space Agency (ESA), National Institute of Information and Communications Technology (NICT), Japan Aerospace Exploration Agency (JAXA)
Launch	2018 using Soyuz or Zenit (by ESA)
Mission Duration	3-years
Mass	Approx. 2200kg
Orbit	Sun-synchronous sub-recurrent orbit Altitude: approx. 400km Mean Local Solar Time (Descending): 14:00
Repeat Cycle	25 days
Orbit Period	5552.7 seconds
Semi Major Axis	6771.28 km
Eccentricity	0.001283
Inclination	97.050°

# Advanced Optical and Advanced Radar

- Advanced Optical Satellite (ALOS-3)
  - Successor of ALOS/AVNIR-2 (high-resolution optical imager)
  - Horizontal resolution: 0.8m (panchromatic band) and 3.2m (color band)
  - Swath width: 70km
  - Scheduled to be launched in JFY 2020
- Advanced Radar Satellite (ALOS-4)
  - Successor of ALOS-2/PALSAR2 (L-band SAR)
  - Horizontal resolution: 1x3m (spot-light mode), 3m (high-resolution mode), and 25m (wide swath mode)
  - Swath width: 35kmx35km (spot-light mode), 200km (high-resolution mode) and 700km (wide swath mode)
  - Scheduled to be launched in JFY 2020



**Advanced Optical Satellite**



**Advanced Radar Satellite**

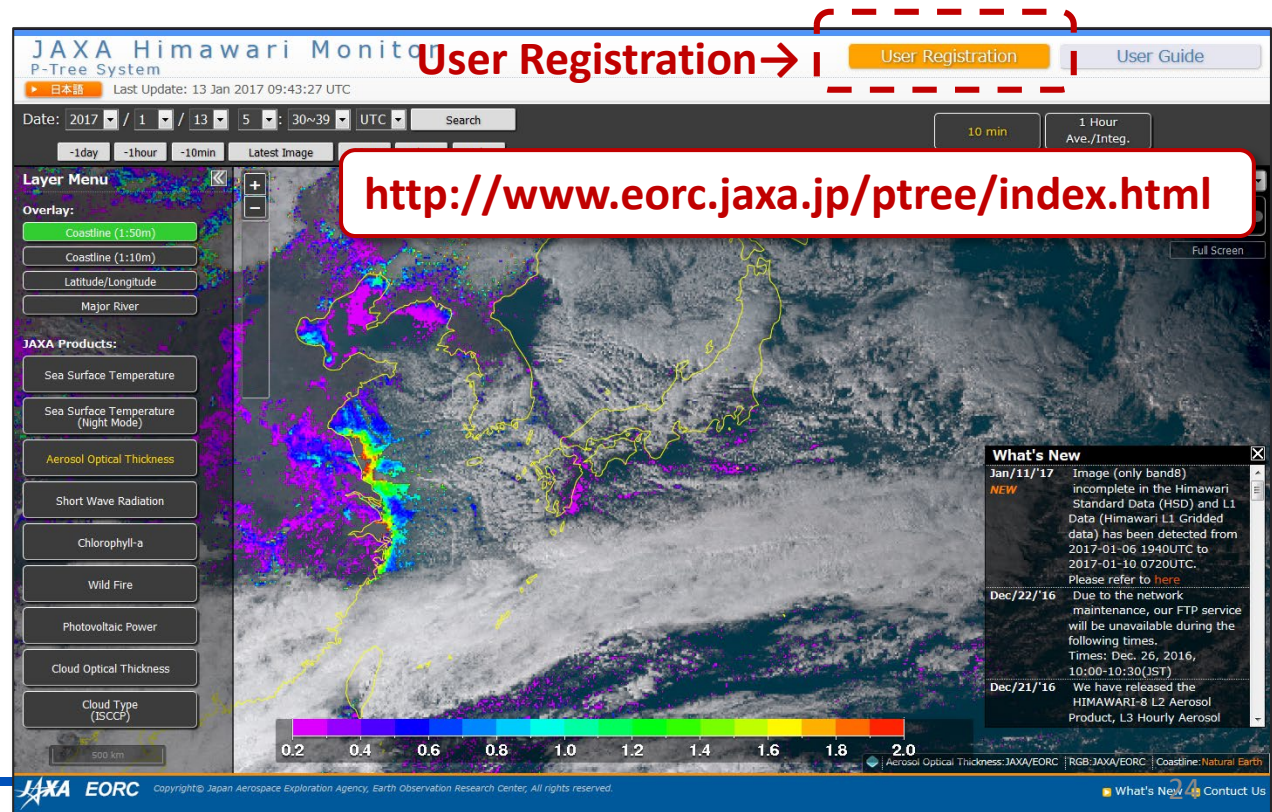
# *Synergies with Himawari*



# JAXA Himawari Monitor

- JAXA has been developing Himawari-8 products using the retrieval algorithms which will be consistent with the upcoming Japanese earth observation missions (GCOM-C, GOSAT-2 and EarthCARE), in order to seek synergies between the satellites
- JAXA Himawari Monitor website site was opened in August 2015 to distribute Himawari original (Level 1) and geophysical (Level 2) products
- Over 750 registrations from domestic and international users until today

Aerosol Optical Thickness  
(1530UTC 13 Jan 2017)



# JAXA Himawari Products

	Product name		Grid size	Interval	Format	
L1	Reflectance (6 bands)		500m/1km/2km	10min(full)	HSD	
	Brightness temperature (10 bands)			2.5min(Japan)	NetCDF	
L2	Atmosphere	Aerosol properties	5km	10min	NetCDF	
		Cloud properties	5km	10min		
	Ocean	Sea surface temperature	2km	10min/1hr/1dy		
		Ocean color (Chlorophyll-a)	5km(full) 1km(Japan)	1hr		
	Land	Wild fire	-	10min		CSV
	Flux	Photosynthetically active radiation (PAR) & Shortwave radiation (SWR)		5km(full) 1km(Japan)		1hr
Photovoltaic Power (image only)		1km/4km	10min	-		

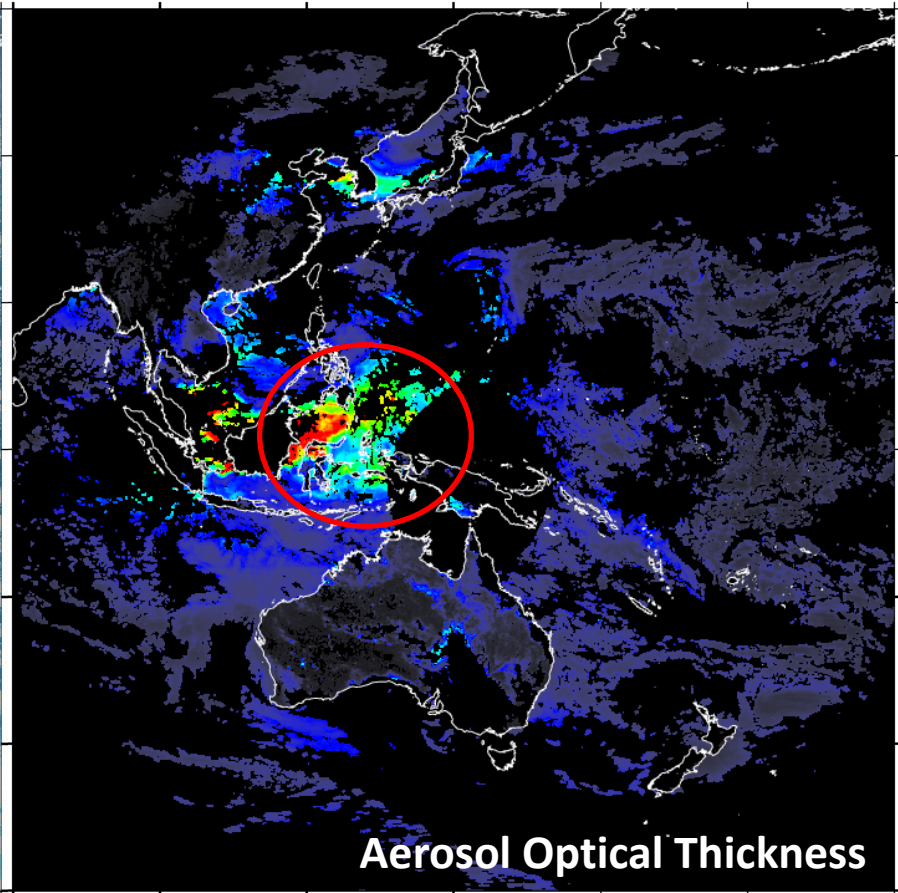
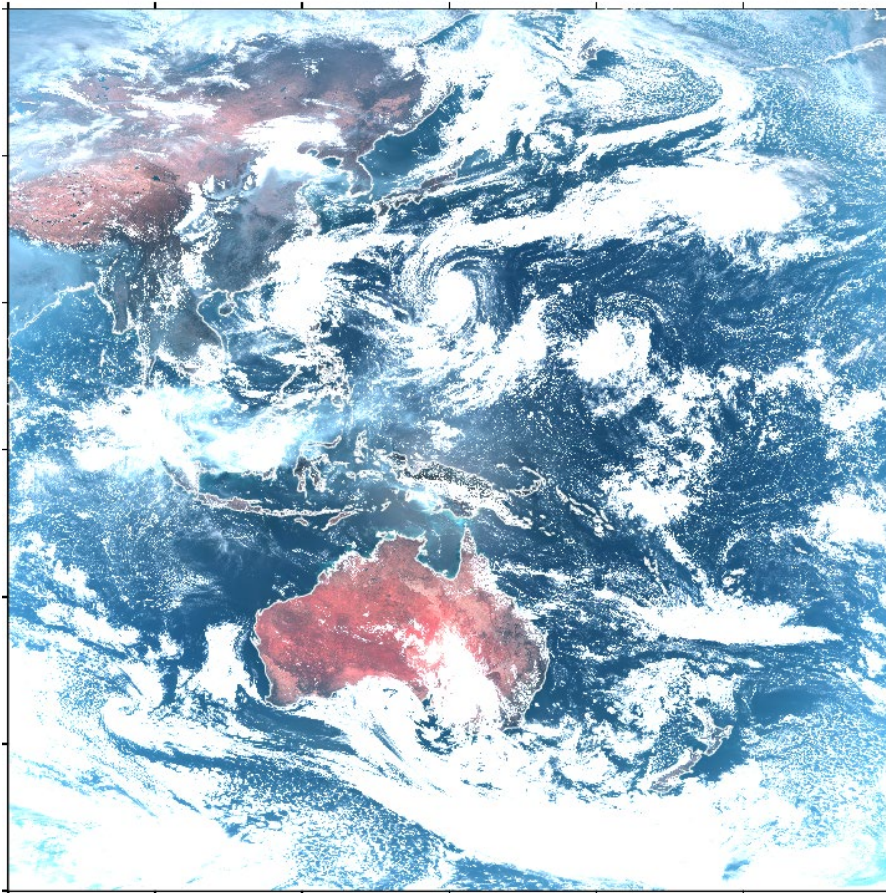
- L2 Algorithms are based on those developed for GCOM-C/SGLI. References are available at the web site.

<http://www.eorc.jaxa.jp/ptree>

# Himawari Aerosol and Hot Spot

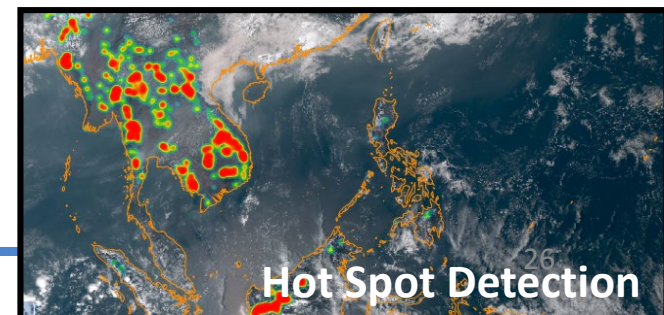
NC\_H08\_20151020\_0230\_R21\_FLDK.02401\_02401.nc

AOT1H H08\_20151020\_0230\_1H\_ARPbet\_FLDK.02401\_02401.nc



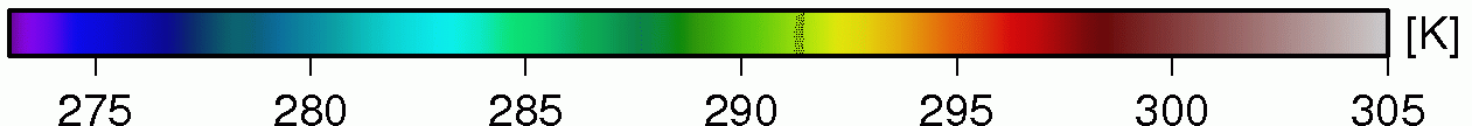
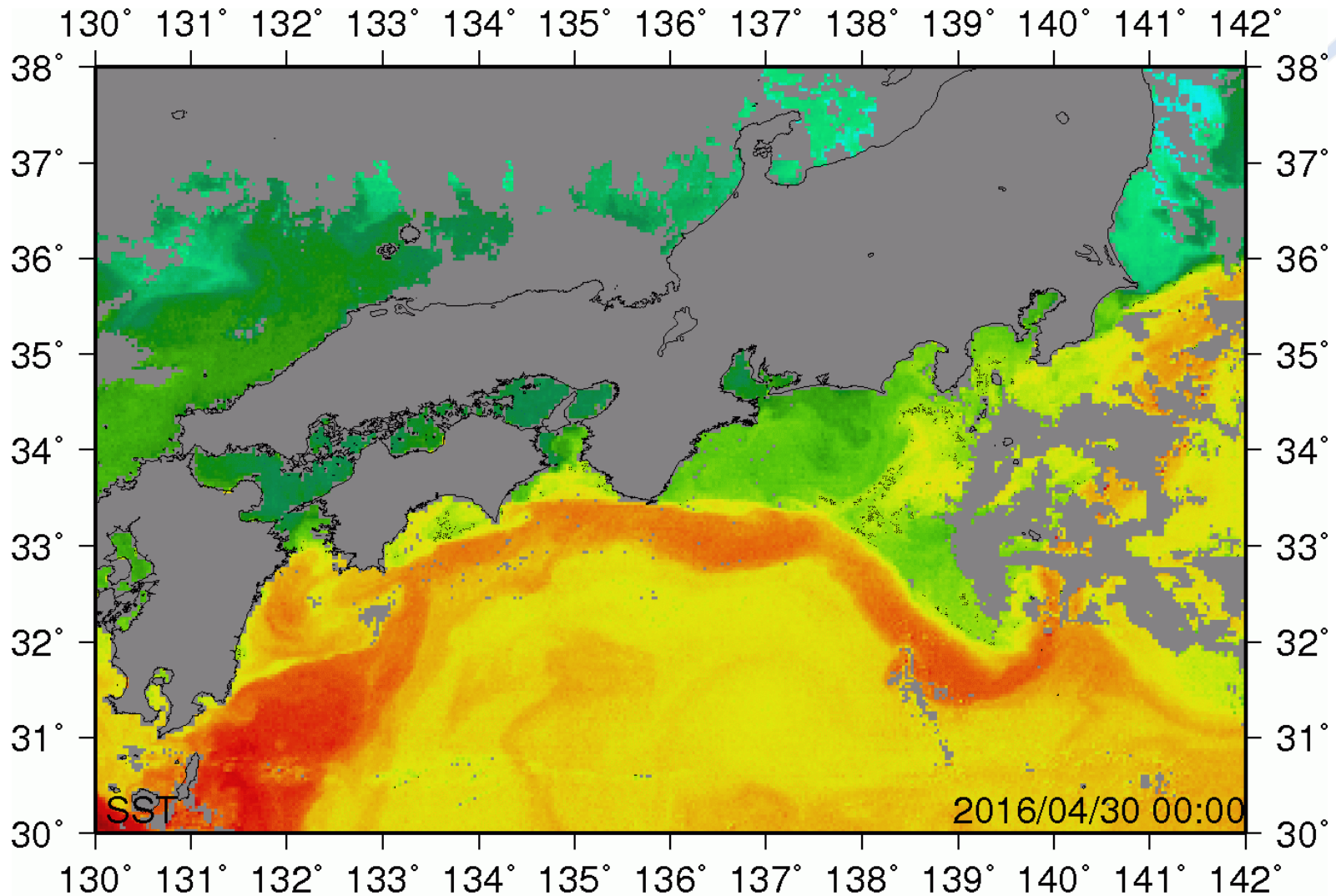
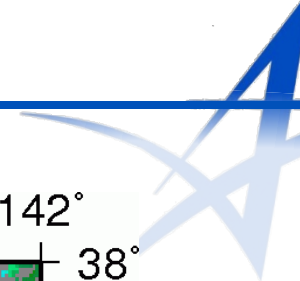
Aerosol Optical Thickness

- JAXA EORC applied the aerosol algorithm developed for JAXA LEO missions (GCOM-C, EarthCARE, GOSAT-2) to Himawari-8
- Wild fire in Borneo Island (Indonesia), atmospheric pollutant from Chinese continent and hot spot over Southeast Asia



Hot Spot Detection

# Himawari SST in 10-minutes



# Summary

- Current satellites
  - 4 satellite in orbit: GOSAT (2009-present) (w/ NIES, MOE), GCOM-W (2012-present), GPM (2014-present) (w/ NASA), ALOS-2 (2014-present)
- Upcoming satellites
  - GCOM-C in JFY 2017, GOSAT-2 in JFY 2018, and EarthCARE (w/ ESA) in JFY 2018
  - ALOS-3 (optical) and ALOS-4 (SAR) is scheduled in JFY 2020
- Himawari-8
  - Develop and distribute geophysical parameters at JAXA since August 2015
- Data distribution
  - <http://www.gportal.jaxa.jp/gp/top.html> (ADEOS, ADEOS-2, AMSR-E, TRMM, GPM, and future environmental satellites)
  - <https://gcom-w1.jaxa.jp> (AMSR, AMSR-E, GCOM-W) (transfer to G-Portal in JFY2017)
  - [https://data2.gosat.nies.go.jp/index\\_en.html](https://data2.gosat.nies.go.jp/index_en.html) (GOSAT at NIES)
  - [https://satpf.jp/spf\\_atl/?lang=en](https://satpf.jp/spf_atl/?lang=en) (ALOS, ALOS-2 at PLATFORM) (NOT FREE except PIs)
  - [http://suzaku.eorc.jaxa.jp/GCOM\\_W/research/resdist.html](http://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist.html) (GCOM-W research)
  - <https://sharaku.eorc.jaxa.jp/GSMaP> (GSMaP, GSMaP\_NOW)
  - <http://www.eorc.jaxa.jp/ptree> (Himawari data at JAXA)
  - <http://kuroshio.eorc.jaxa.jp/JASMES/index.html> (Sea Ice long-term data, etc.)
  - <http://suzaku.eorc.jaxa.jp/GHRSSST/index.html> (JAXA's SST in GDS (NetCDF) format)