JAXA Earth Observation Satellites Program for water applications

ALOS-2 Project Manager

Shin-ichi Sobue

GSMaP

GLOBAL SATELLITE MAPPING OF PRECIPITATION

Recent progress of the GSMaP Products

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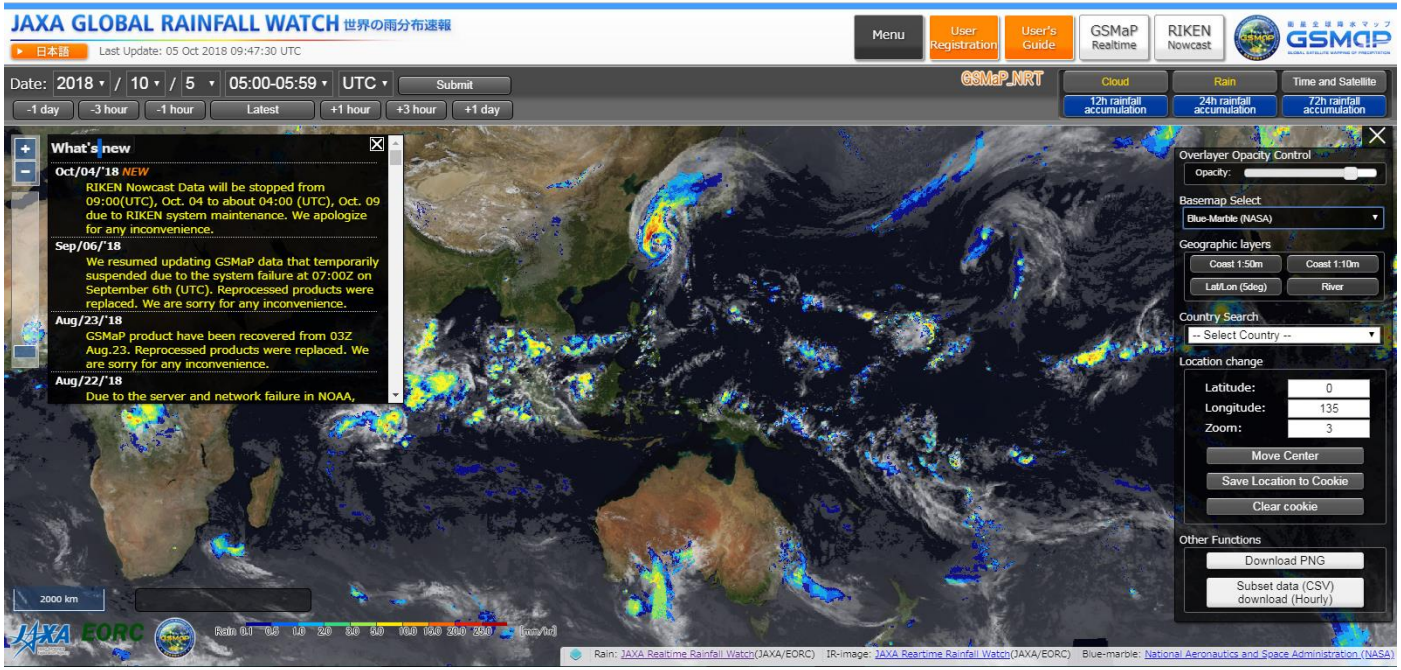
Earth Observation Research Center (EORC)

Japan Aerospace Exploration Agency (JAXA)

JAXA

Global Satellite Mapping of Precipitation (GSMaP)

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



We renewed our website!

Registered users:
4185 users
114 counties
(Sep. 2018)

- GSMaP is a blended Microwave-IR product and has been developed in Japan toward the GPM mission.
  - GSMaP (v6) data was reprocessed as reanalysis version (GSMaP_RNL) since Mar. 2000 period , and was open to the public in Apr. 2016, and new version, GSMaP (v7) was released in 17 Jan. 2017.
  - We submitted a book chapter (Kubota et al. 2018) to review the GPM-era GSMaP products (in the Springer Book on Satellite Precipitation).

Overview of GSMaP Algorithm

PMW (Imagers & Sounders)

GPM-Core GMI

GCOM-W AMSR2

DMSP SSM/I, SSMIS

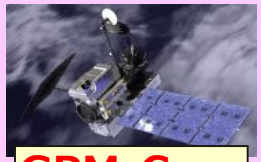
NOAA/MetOp AMSU

Good: high-frequent (wide swath, multi-satellites)
Bad: cannot measure vertical structure (need info. from radar)

GSMaP Microwave Radiometer (GSMaP_MWR) Retrieval Algorithm

Precipitation Radars

TRMM PR



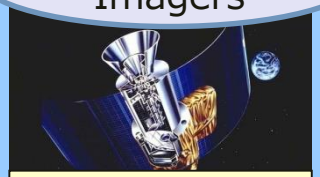
GPM-Core DPR

Data Base

Rainfall Data from each Microwave Radiometer

Merged Microwave Rainfall Data

infrared (IR Imagers



Geostationary Satellites

Microwave-IR Merged Algorithm (CMV, K/F)

Global Rainfall Map
+ Gauge-calibrated Rainfall Map
(0.1 degree grid, Hourly)

(Okamoto et al. 2005, Kubota et al, 2007, Aonashi et al. 2009, Ushio et al. 2009, Shige et al. 2009, Kachi et al. 2011)

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

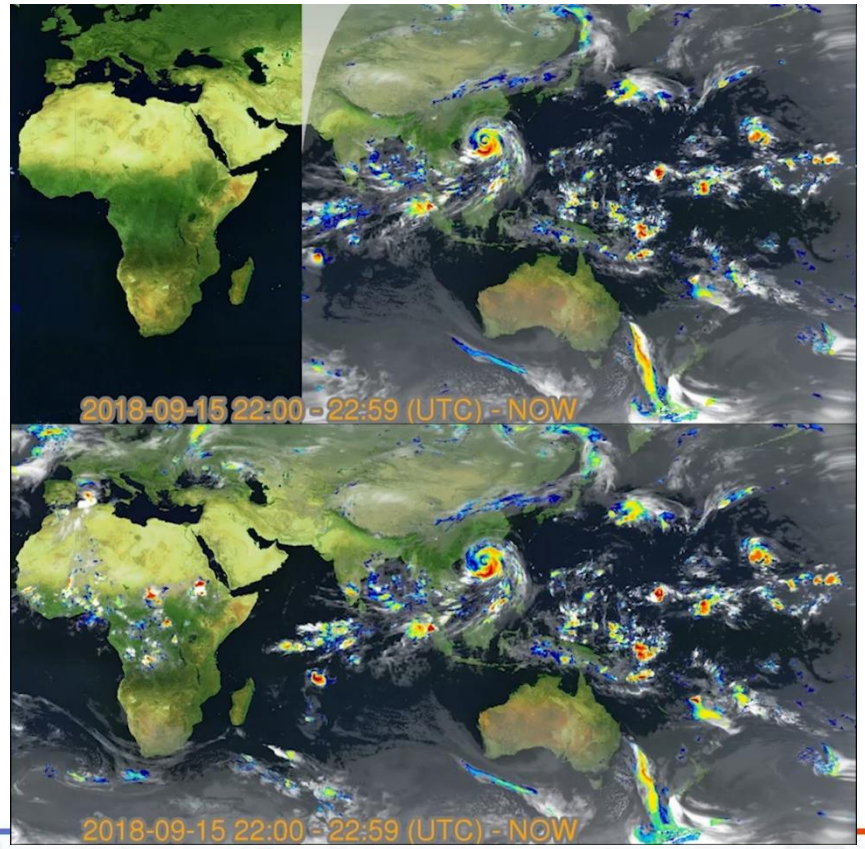
Extension of GSMaP_NOW

- JAXA has provided the GSMaP realtime product (GSMaP_NOW) in the domain of JMA GEO-Himawari since Nov. 2015.
  - The rainfall estimates are provided just now (0hr-latency)
- The GSMaP_NOW domain will be extended to the EUMETSAT GEO region (Meteosat/MSG) in this October.

Current GSMaP_NOW
(JMA GEO-Hiimawari region)

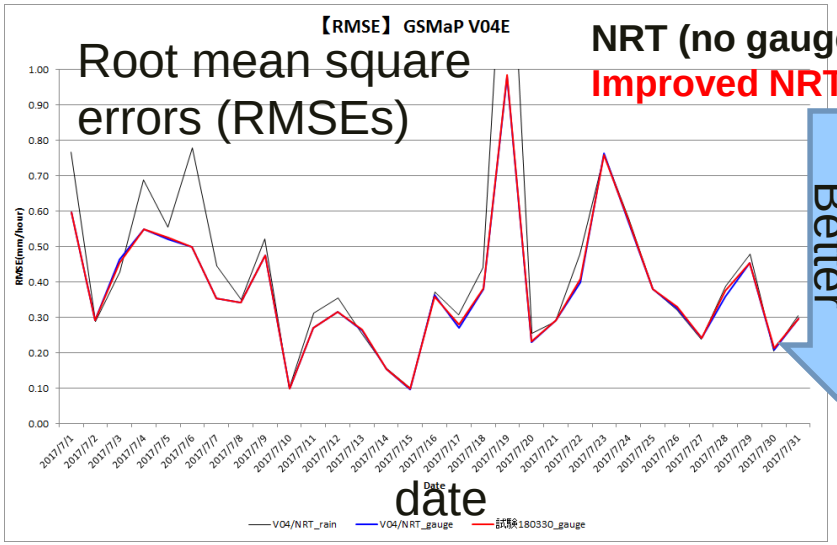
Updated GSMaP_NOW
(JMA GEO-Hiimawari region + EUMETSAT Meteosat/MSG)

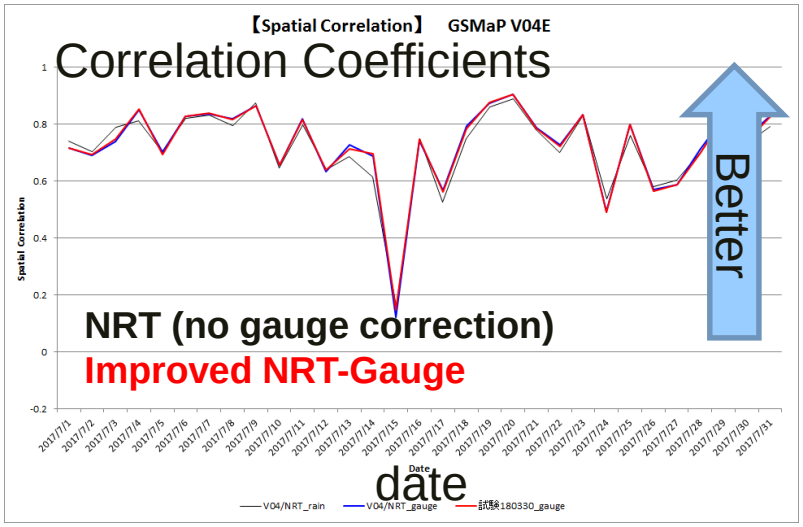
Extension of the NOAA GOES regions is on-going.



Improved NRT-basis Gauge-adjusted GSMaP product (v6)

- Improved NRT-basis Gauge-adjusted GSMaP product (v6) will be open to the public soon.
  - Correction coefficients are calculated using past 30 days, based upon Mega et al. (2018).
  - We're now reprocessing past 18yr data record (since Mar. 2000)
- Validations with reference to the JMA radar around Japan show smaller RMSEs in this new product than the current NRT (no gauge-correction).





GSMaP Reliability flag is now available

- GSMaP Reliability flag was open to the public in Apr. 2017.
- Evaluation results using the JMA ground radar show a good relationship between the flag and skills of the GSMaP.

Evaluation results of the GSMaP reliability flag with reference to the JMA radar validation.

Basically, when the reliability flag is higher, validation results with the JMA radar better.
This was not applicable over the cold ocean. Need to improve the flag.

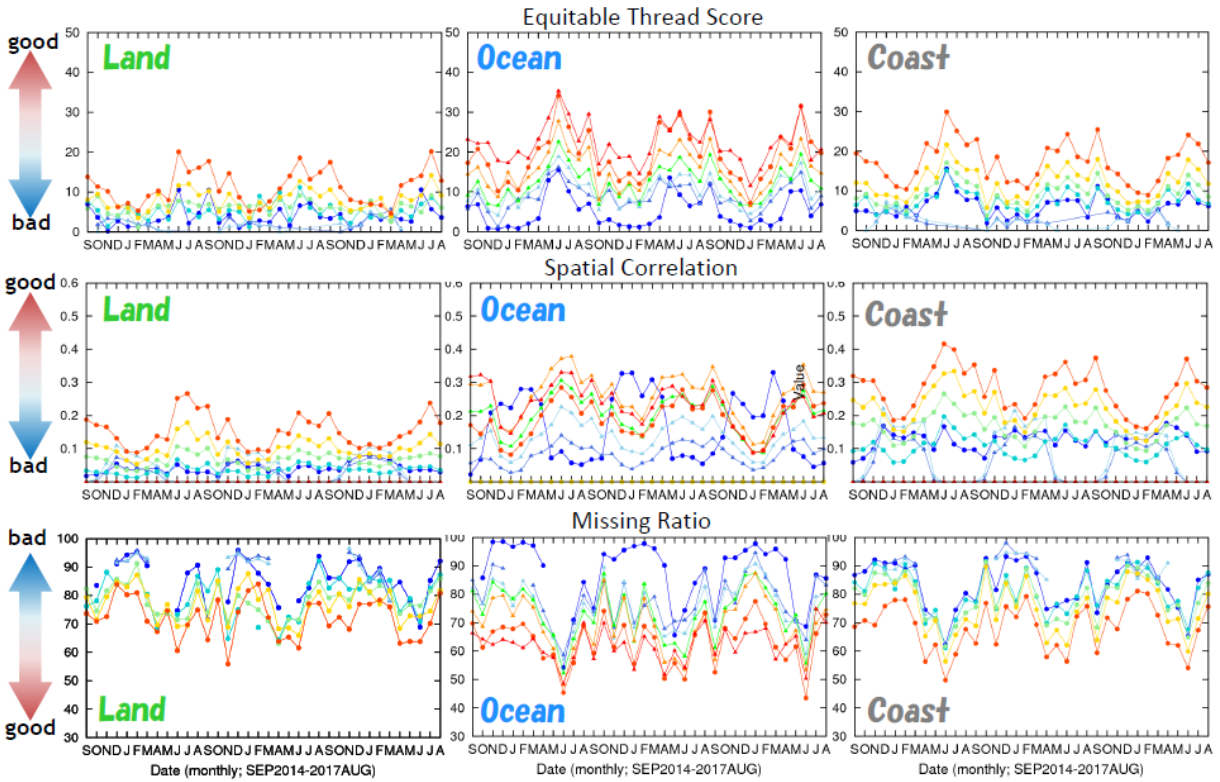
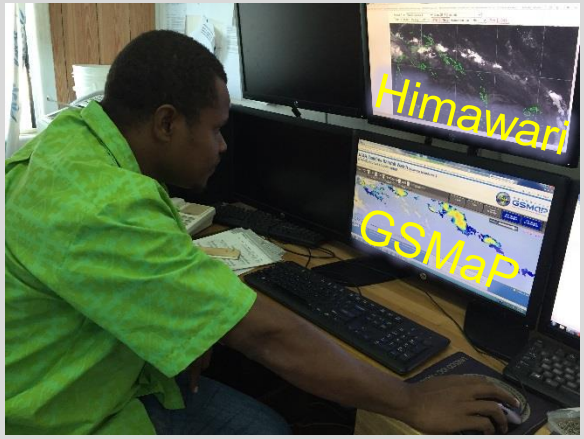


Fig.10. Timeseries of ETS (top), SC (middle), and MR (bottom) for each surface type.

Contributing to rainfall monitoring in Asia-Pacific regions

Met. agencies in the Pacific Islands utilize GSMaP for rainfall monitoring.

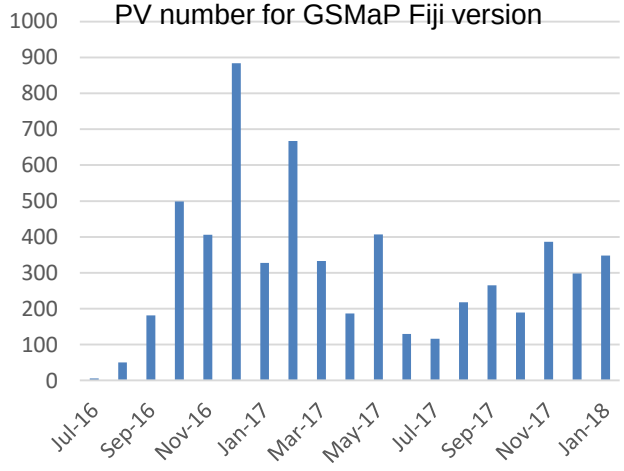
Forecaster monitoring weather by using Himawari and GSMaP



Himawari cast by JMA has been installed and used over many Asia-Pacific countries. Combination utilization of cloud information by Himawari and rainfall information by GSMaP is effective for monitoring weather.

- GSMaP is useful for monitoring the rainfall around their Islands and over the remote small islands.

Fiji Met Service Website
http://www.met.gov.fj/



GSMaP Fiji ver. website has much access every month. During cyclone season (Dec.2016), the PV number is 824, and local continuous utilization has been confirmed.

(Photos were taked in each met service)

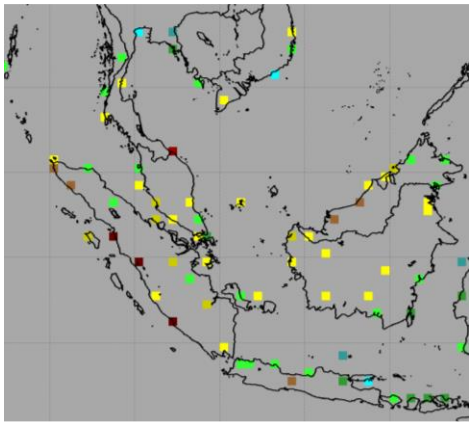
Examples of Satellite-based Climate Extremes Monitoring

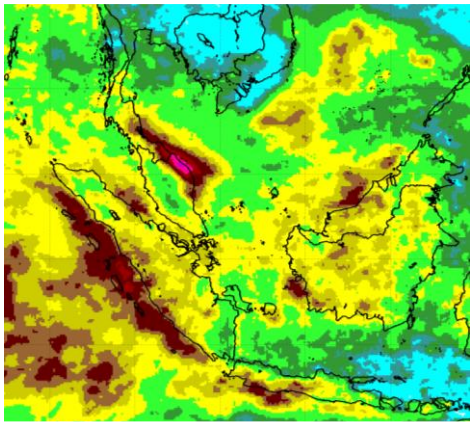
Reporting gauges (0.5 deg)

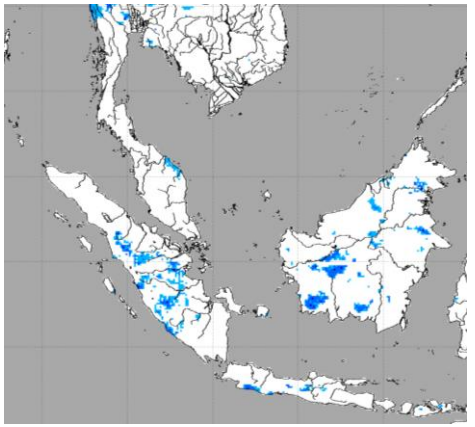
GSMaP (v6) Gauge-NRT (0.1 deg)

Satellite Detected Region of Extreme Heavy Rainfall based upon percentiles from past 18-yr data

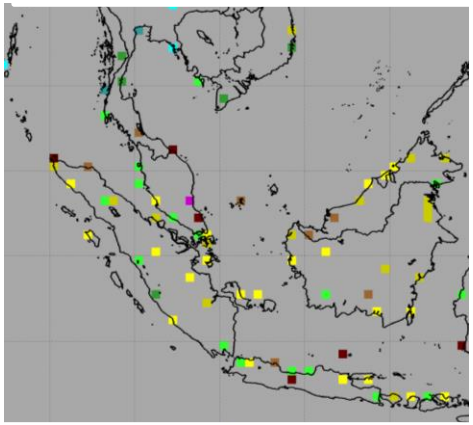
Nov 2014

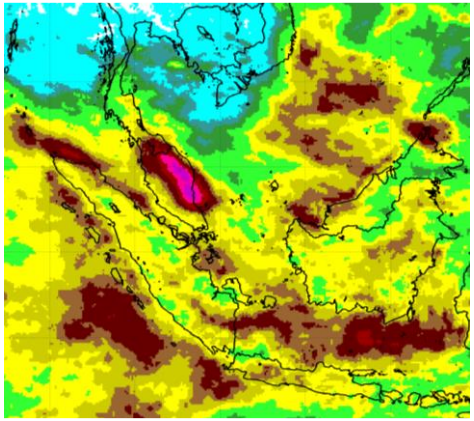


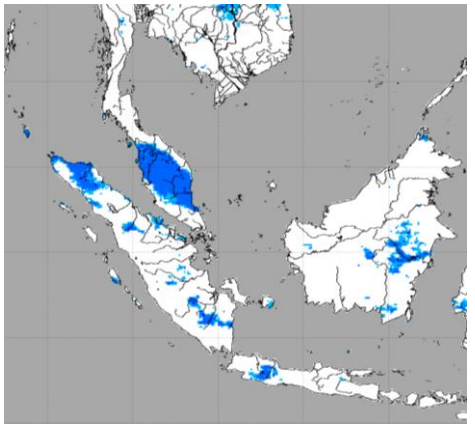


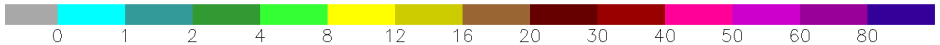


Dec 2014









(mm/day)

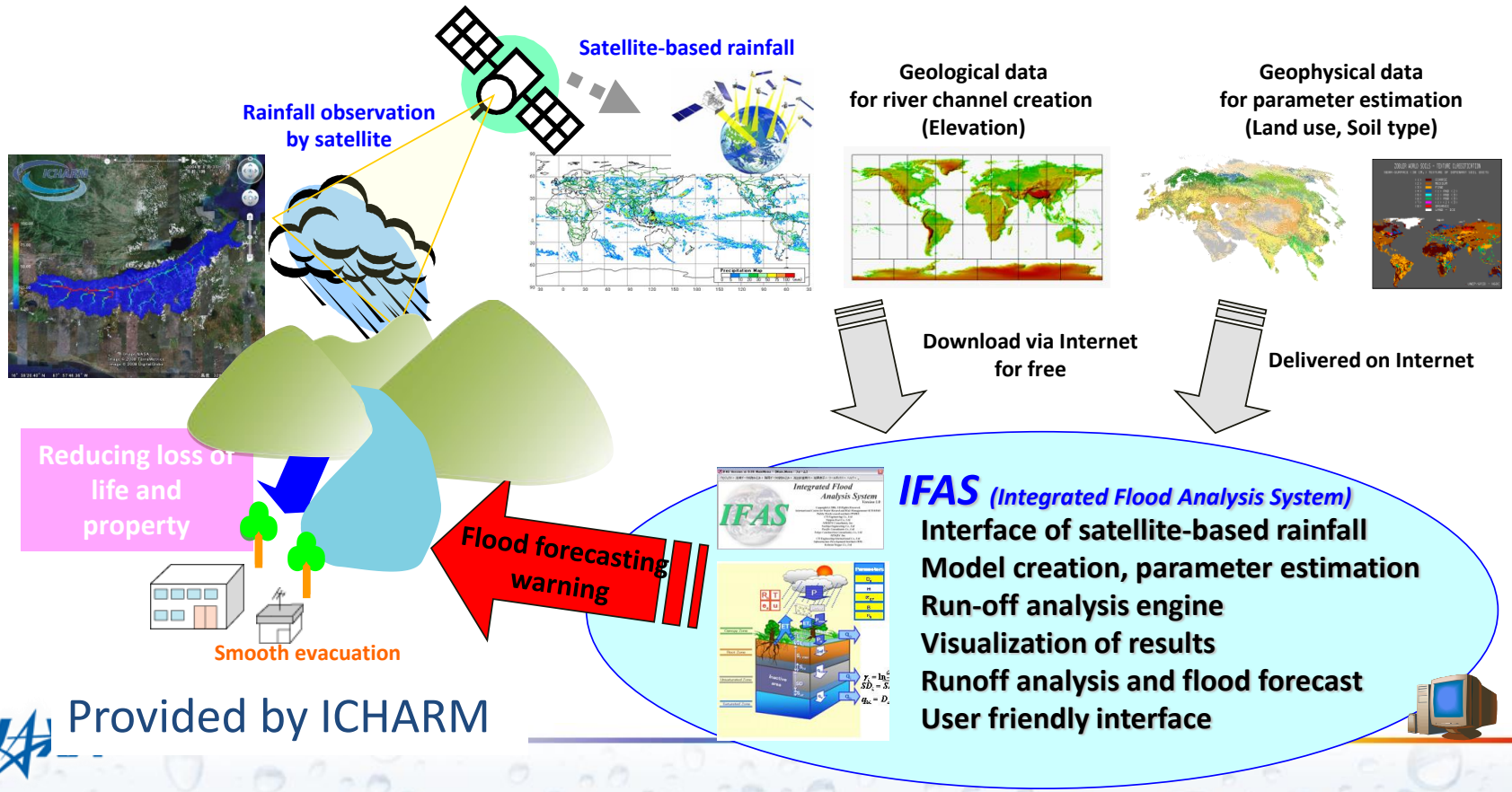
> 90th percentile
> 95th percentile
> 99th percentile

JAXA

Data utilization in flood warning

- Collaboration with JAXA and International Centre for Water Hazard and Risk Management (ICHARM) since 2005.
  - Utilization of hourly GSMaP near-real-time data in their flood forecasting system**, Integrated Flood Analysis System (IFAS)**.

Flood Forecasting System Using Satellite-based Rainfall Information as a tool of GFAS-streamflow version

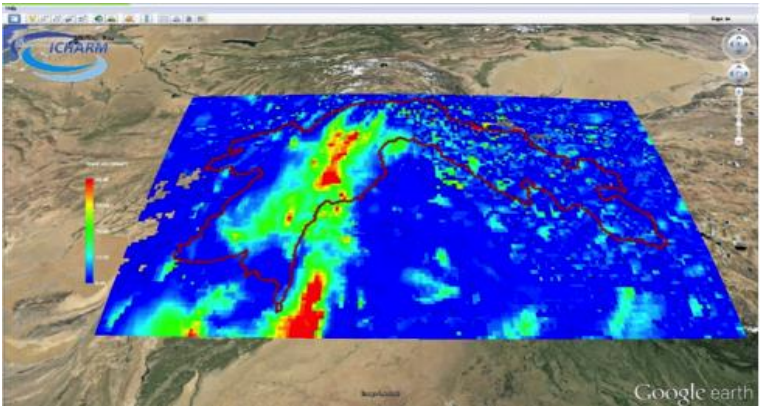


Provided by ICHARM

UNESCO Pakistan Project for Predicting Floods

- **Under UNESCO-IHP** project, **JAXA**, **ICHARM** and **Pakistan Meteorological Department (PMD)** to develop operational flood analysis system.
- After calibration of **GSMaP product** with **ground-based stations** in Pakistan, correlation coefficients are increased from 0.5 to 0.7, and can be used in the Indus Integrated Flood Analysis System (Indus-IFAS) developed by ICHARM.

Rainfall by GSMaP

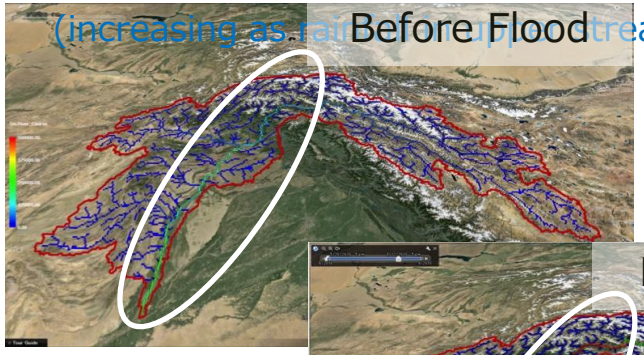


(Area within red line is Indus river basin)

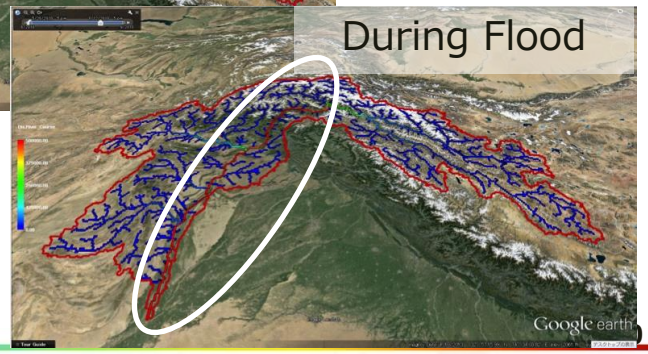
INPUT

Indus_IFAS:River discharge output using GSMaP

(increasing as rainfall in upstream increased)



Discharge of main river is normal (green) before flood

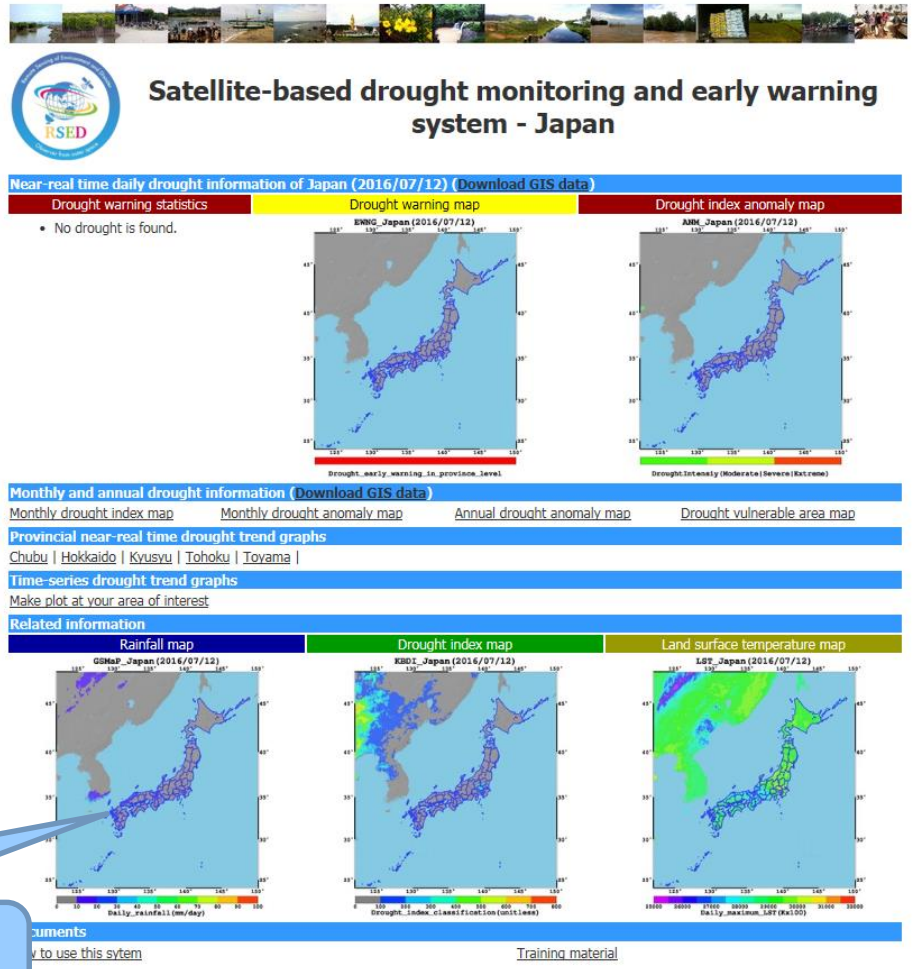


Discharge of main river is largely increased (red) during flood

Example of Indus-IFAS in Pakistan (Image provided by ICHARM)

Satellite-based drought monitoring

- Prof. Takeuchi (Univ. of Tokyo) developed drought monitoring system using the GSMaP rainfall and land surface temperature from the Meteorological satellite and operates the website (http://wtlab.iis.u-tokyo.ac.jp/DMEWS).

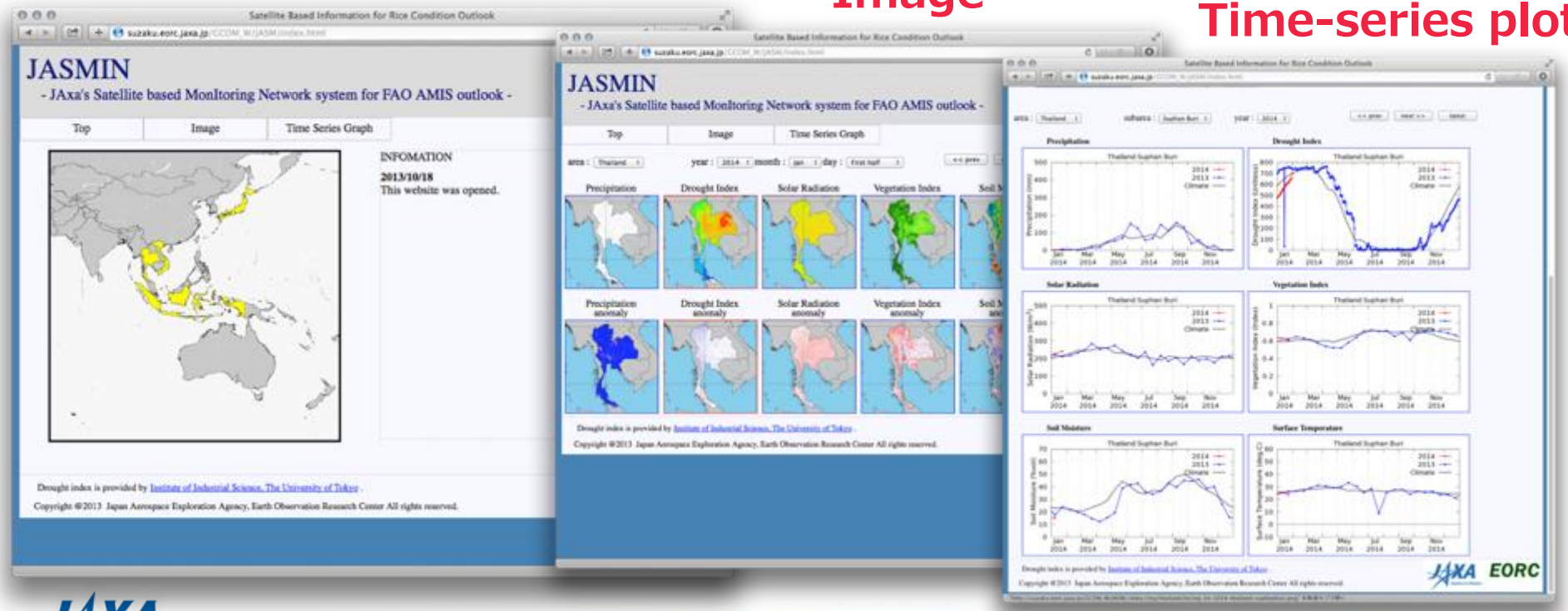


Display drought index in addition to the rainfall amount

Agromet Information Database System: JASMIN

- **JASMIN (JAxa's Satellite-based Monitoring Network system)** provides GSMaP and satellite-based drought index, solar radiation, land surface temperature, soil moisture, and vegetation index (update twice a month).
- These information are used to generate monthly rice growing outlook which is reported to FAO(Food and Agriculture Organization of the United Nations) through GEOGLAM(GEO Global Agricultural Monitoring Initiative).

Top Page **Image** **Time-series plot**



http://suzaku.eorc.jaxa.jp/JASM/index.html

[Oyoshi et al., JSPRS., 2016]

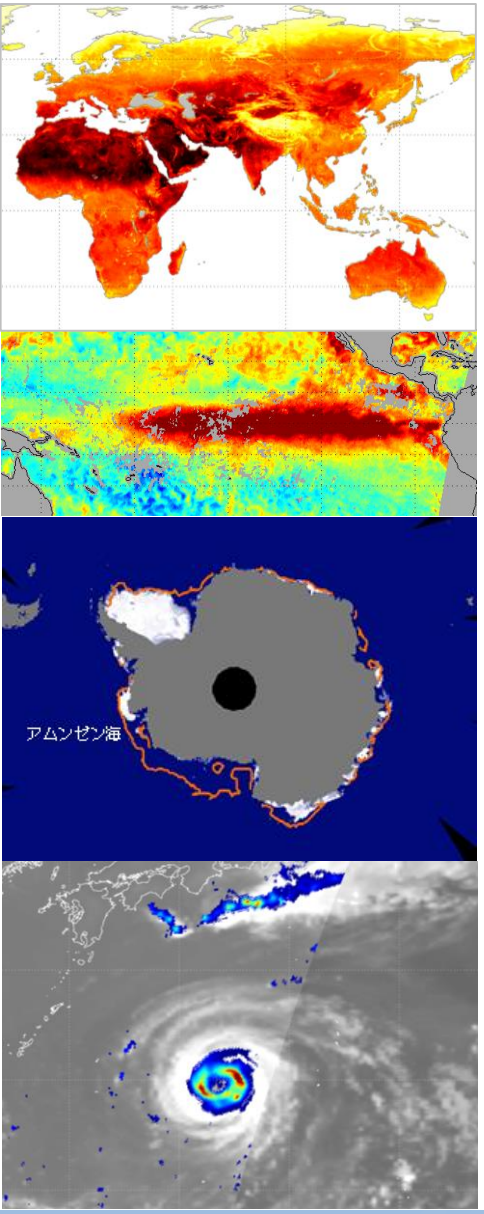
GSMaP Product list

Product name	Variables	Resolution	Latency	Update interval
Standard product	Hourly Precip Rate (**GSMaP_MVK**)	Horizontal: 0.1×0.1 deg.lat/lon Temporal: 1 hour	3 days	1 hour
	Gauge-adjusted Hourly Precip Rate (**GSMaP_Gauge**)			
Near-real-time product	Hourly Precip Rate (**GSMaP_NRT**)		4 hours	
	Gauge-adjusted Hourly Precip Rate (GSMaP_Gauge_NRT)			
Real-time product	Hourly Precip Rate (**GSMaP_NOW**)		0 hours	0.5 hour

GSMaP uses NOAA/CPC unified rain gauge (2-3 day latency, daily)
TRMM 3B42 and NASA IMERG final products use GPCC rain gauge(2-3 month latency, monthly). Note latency, downscaling issues

In addition, there are reanalysis products (GSMaP_RNL, GSMaP_RNL_Gauge), calculated with Japanese 55-year reanalysis (JRA55), and GSMaP Riken NowCast (GSMaP_RNC, Otsuka et al. 2016) by AICS/RIKEN.

水循環変動観測衛星「しずく」
Global Change Observation Mission -Water "SHIZUKU"



JAXA Global Change Observation Mission (GCOM): Status of GCOM-Water (GCOM-W)

M. Kachi[1)], H. Fujii[1)], T. Maeda[1)], N. Ono[1)], M. Kasahara[1)], and N. Ebuchi[1),2)]

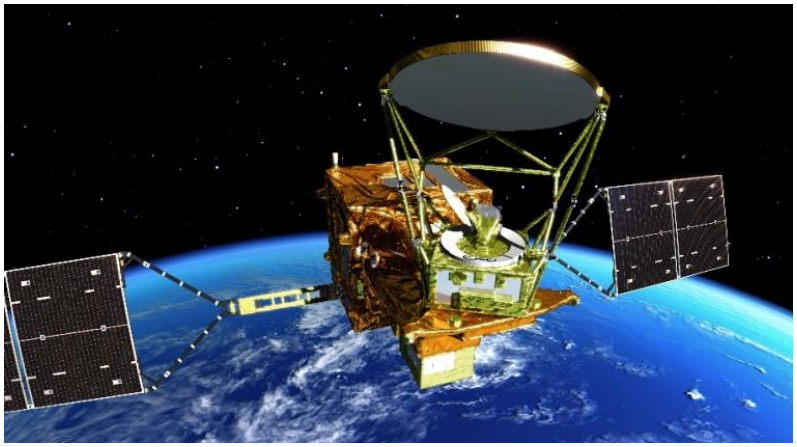
[1)] Japan Aerospace Exploration Agency

[2)] Hokkaido University

19 September, 2018 @ @ Tallinn, Estonia
EUMETSAT Meteorological Satellite Users Conference 2018

GCOM Global Change Observation Mission
JAXA

Overview of GCOM-W and AMSR2



Instrument	**Advanced Microwave Scanning Radiometer 2 (AMSR2)**
Altitude	**705 km**
Orbital inclination	**98.2 deg**
Local sun time at Ascending node	**13 :30**
Launch vehicle	**H-IIA**
Launch	**May 18, 2012**
Designed lifetime	**5 years**

- ✓Successor of Aqua/AMSR-E (launched in May 2002), providing continuous data for climate studies and operational applications
- ✓Joining A-train constellation (same as Aqua) and also GPM constellation
- ✓Carrying AMSR2, a multi-polarization and multi-frequency microwave imager
- ✓Observing various water-related ECVs at high spatial resolution
- ✓Improving on-board calibration target has resulted reduction of annual TB variation due to calibration and improvement of TB stability
- ✓Achieved designed mission life (5-year) on May 18, 2017, and continues observation
- ✓Enough fuels to keep current orbit for more than 15 years

https://www.gportal.jaxa.jp/gp/

AMSR2 Standard Products

Product		Coverage	Resolution	Release Accuracy	Standard Accuracy	Target Accuracy	Validation Result	Latest version
Brightness Temperature		Global	5-50km	±1.5K	±1.5K	±1.0K (bias) ±0.3K(random)	< 1.4 K	Ver.2.2
GEO	Total Precipitable Water	Global Ocean	15km	±3.5 kg/m^2	±3.5 kg/m^2	±2.0 kg/m^2	1.5 kg/m^2	Ver.2.1
	Cloud Liquid Water	Global Ocean	15km	±0.10 kg/m^2	±0.05 kg/m^2	±0.02 kg/m^2	0.04 kg/m^2	Ver.2.1
	Precipitation	Global (except high latitude)	15km	Ocean ±50 % Land ±120 %	Ocean ±50 % Land ±120 %	Ocean ±20 % Land ±80 %	Ocean 48% Land 86%	Ver.2.1
	Sea Surface Temperature	Global Ocean	50km	±0.8 ºC	±0.5 ºC	±0.2 ºC (zonal mean)	0.5 ºC < 0.2 ºC (zonal)	Ver.3.0
	Sea Surface Wind Speed	Global Ocean	15km	±1.5 m/s	±1.0 m/s	±1.0 m/s	1.0 m/s	Ver.3.0
	Sea Ice Concentration	Ocean in high latitude	15km	±10 %	±10 %	±5%	9 %	Ver.3.0
	Snow Depth	Land	30km	±20 cm	±20 cm	±10 cm	18 cm	Ver.2.1
	Soil Moisture	Land	50km	±10 %	±10 %	±5 %	4 %	Ver.3.0

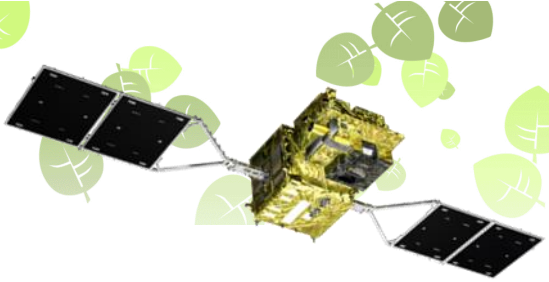
http://suzaku.eorc.jaxa.jp/GCOM_W/research/resdist_j.html

AMSR2 Research Products and Accuracy

Products	Area	Resolution	Target accuracy	Status
All-weather sea surface wind speed	Ocean	60 km	± 7 m/s for strong wind (>17m/s)	**Ver.3.0 released 4.07 m/s**
High-resolution (10-GHz) SST	Ocean	30 km	± 0.8 ºC	**Ver.3.0 released 0.55 ºC**
Soil moisture and vegetation water content based on the land data assimilation	Africa, Australia (at first stage)	25 km	soil moisture: ± 8% vegetation water: ± 1 kg/m^2	**Under development**
Land surface temperature	Land	15 km	forest area: ± 3 ºC nondense vegetation: ± 4 ºC	**Ver.1.0 released 3 ºC (forest) 4 ºC (nondense vegetation)**
Vegetation water content	Land	10 km	± 1 kg/m^2	**Under evaluation**
High resolution sea ice concentration	Ocean in high latitude	5 km	± 15 %	**Under evaluation**
Thin ice detection	*Global*	15 km	± 80 % (answered correctly)	**Consideration to release 92.4 % for Okhotsk sea**
Sea ice moving vector	Ocean in high latitude	50 km	2 components: 3 cm/s	**Under evaluation**
Total Precipitable Water over Land	*Land (except ice and vegetation)*	*15 km*	*± 6.5 kg/m^2*	***Newly Proposed 2.59 kg/m^2 vs. GPS***

Released to public | **To be released** | **Newly proposed**

GCOM-C
Global Change Observation Mission-Climate



JAXA Global Change Observation Mission (GCOM): Status of GCOM-Climate (GCOM-C)

Murakami H , Kachi M* , Nakajima T

JAXA EORC

EUMETSAT 2018

- Meteorological Satellite Conference

17 to 21 September 2018, Tallin, Estonia

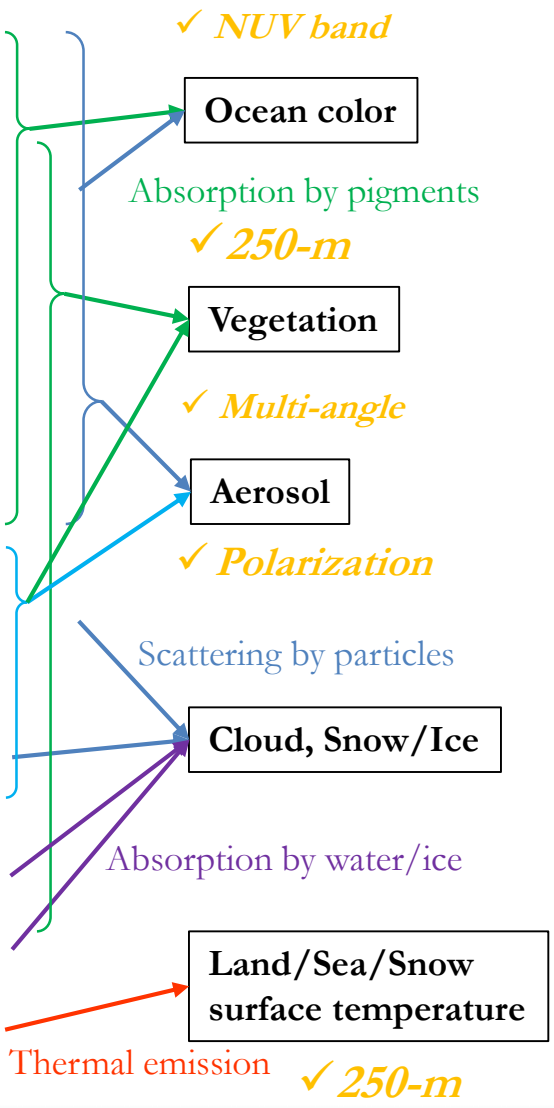
GCOM-C launch on 23 Dec. 2017

GCOM Global Change Observation Mission

JAXA

1. GCOM-C/SGLI: observation channels

Sub-system	channel	Center wavelength	width	Standard radiance	Saturation radiance	SNR	Pixel size
		nm		W/m²/sr/μm or Kelvin		TI: NEΔT	m
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	
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

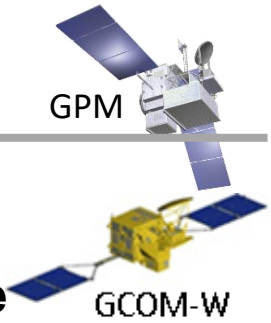


Cited from Okamura et al., 2018. SNR is defined at the standard radiance and IFOV shown by bold characters

1. GCOM-C/SGLI: standard products

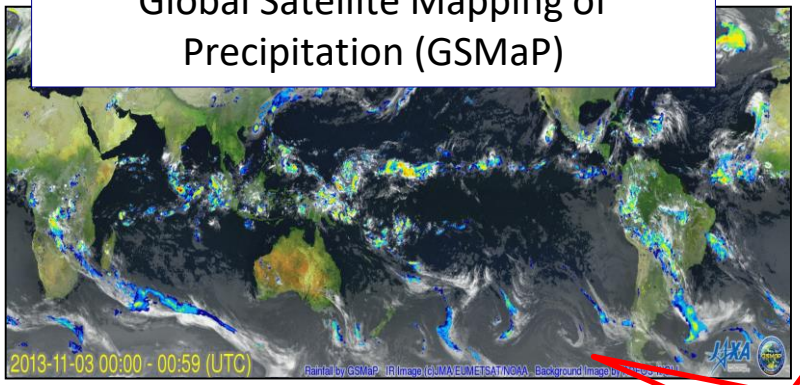
Area	Group	Standard Product	Grid Size
Common	Radiance	Top-of-atmosphere radiance (including system geometric correction)	VNR, SWI: Land/coast: 250 m, offshore: 1 km, polarimetry: 1 km TIR: Land/coast: 500 m, offshore: 1 km
Land	Surface reflectance	Precise geometric correction	250 m (equal-area grid (EQA) tile)
		Atmospheric corrected reflectance	250 m (EQA tile)
	Vegetation and carbon cycle	Vegetation index	250 m (EQA tile)
		Shadow index	
		Above-ground biomass	1 km (EQA tile)
		Vegetation roughness index	
		Fraction of absorbed photosynthetically active radiation	250 m (EQA tile)
		Leaf area index	
	Temperature	Surface temperature	250 m (EQA tile)
Atmosphere	Cloud	Cloud flag/Classification	1 km (EQA tile)
		Classified cloud fraction	1 km (EQA tile), 1/12 deg (global)
		Cloud top temp/height	
		Water cloud optical thickness/effective radius	
		Ice cloud optical thickness	
	Aerosol	Aerosol by non-polarization	1 km (EQA tile), 1/12 deg (global)
		Aerosol over the land by polarization	
Ocean	Ocean color	Normalized water leaving radiance	250 m (coast), 1 km (offshore), 1/24 deg (global)
		Atmospheric correction parameters	
		Photosynthetically available radiation	
	In-water	Chlorophyll-a concentration	250 m (coast), 1 km (offshore), 1/24 deg (global)
		Suspended solid concentration	
		Colored dissolved organic matter	
	Temperature	Sea surface temperature	500 m (coast), 1 km (offshore), 1/24 deg (global)
Cryosphere	Area/distribution	Snow and Ice covered area	250 m (EQA tile), 1 km (EQA tile)
		Okhotsk sea-ice distribution	250 m (scene)
	Surface properties	Snow and ice surface temperature	250 m (EQA tile), 1 km (EQA tile)
		Snow grain size of shallow layer	

Disaster Risk Management
Flood Early Warning

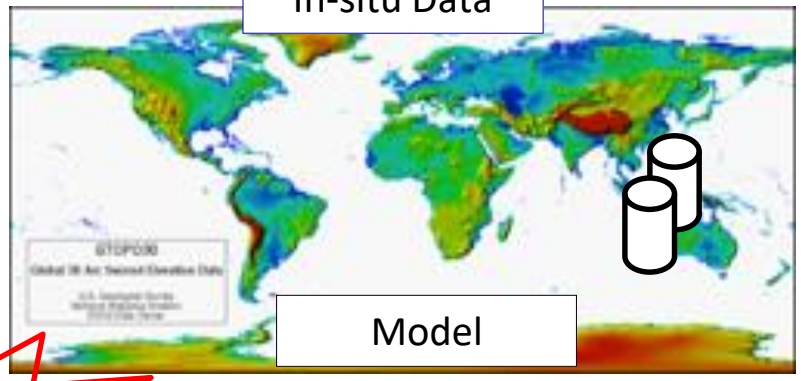


- ✓ **Satellite data and in-situ data are merged to predict flood of lower river region several days before.**
- ✓ **Based on this information, the warning and evacuation call are sent directly to residents.**

Global Satellite Mapping of Precipitation (GSMaP)

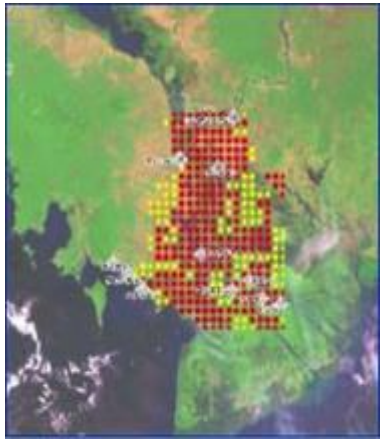


In-situ Data



Model

Warning Message



Global satellite data is effective to grasp the situation on water rising of International cross-border rivers.
In Bangladesh, flood forecasting made it possible to take measures for crops in advance of damages. The farmers have a few days for harvest until flood at upper river flows down to lower areas and causes damage to the crops.

Partners ICHARM UNESCO ADB (System will be organized)

Sentinel Asia

(As of April 1, 2017)

Space Community

APRSAF

- Satellite Image
- Promotion of Utilization
- Capacity Building

Disaster Reduction Community

ADRC
Member Countries
(30 member countries)

- Disaster Information
- Utilization (User)

Sentinel Asia

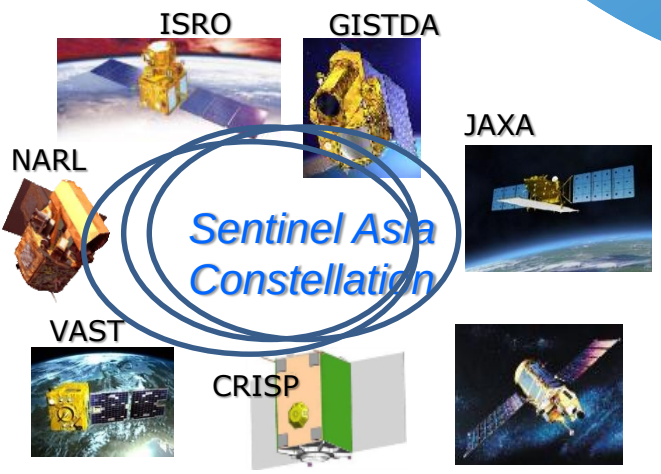
87 organizations from 17 countries & regions and 15 international organizations
In total: 104* organizations

Joint Project Team (JPT)

International Community

UNESCAP, UNOOSA
ASEAN, AIT and
International Disaster Charter
etc.

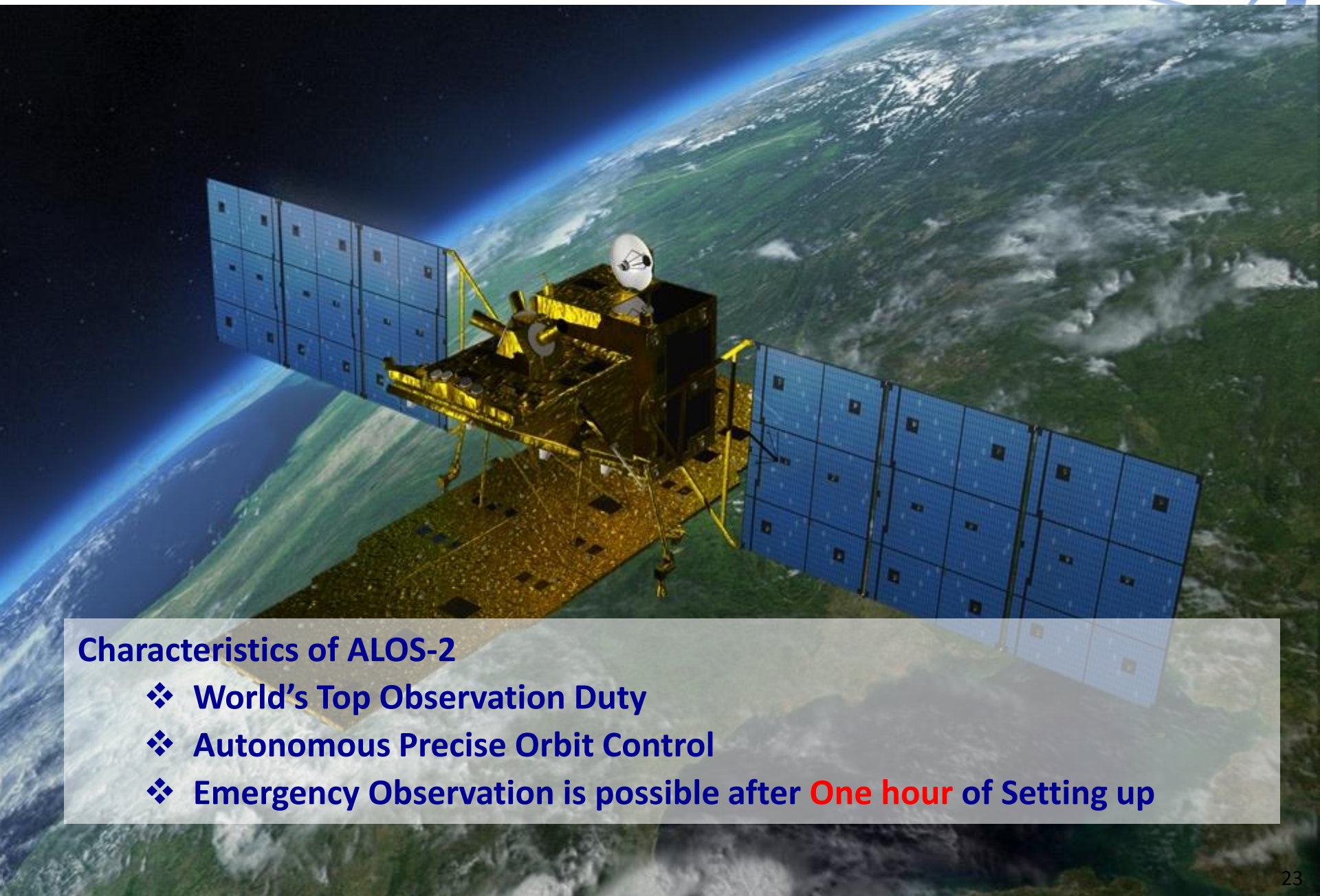
International Cooperation



*) JPT includes 7 Data Provider Nodes (DPN)
CRISP, GISTDA, ISRO, JAXA, KARI, NARL and VAST

*) JPT includes 42 Data Analysis Nodes (DAN)

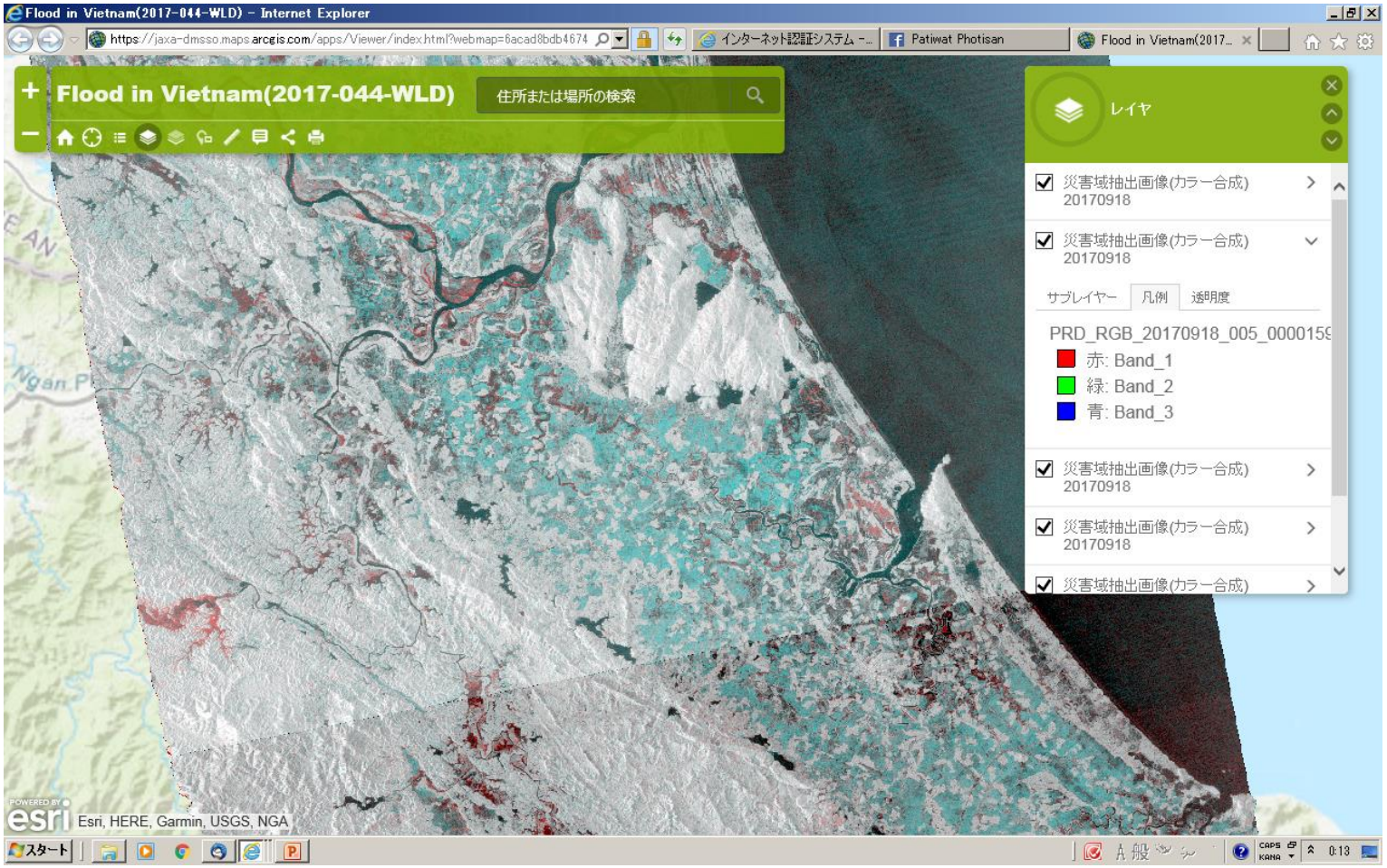
ALOS-2: Advanced Land Observing Satellite -2



Characteristics of ALOS-2

- ❖ World's Top Observation Duty
- ❖ Autonomous Precise Orbit Control
- ❖ Emergency Observation is possible after One hour of Setting up

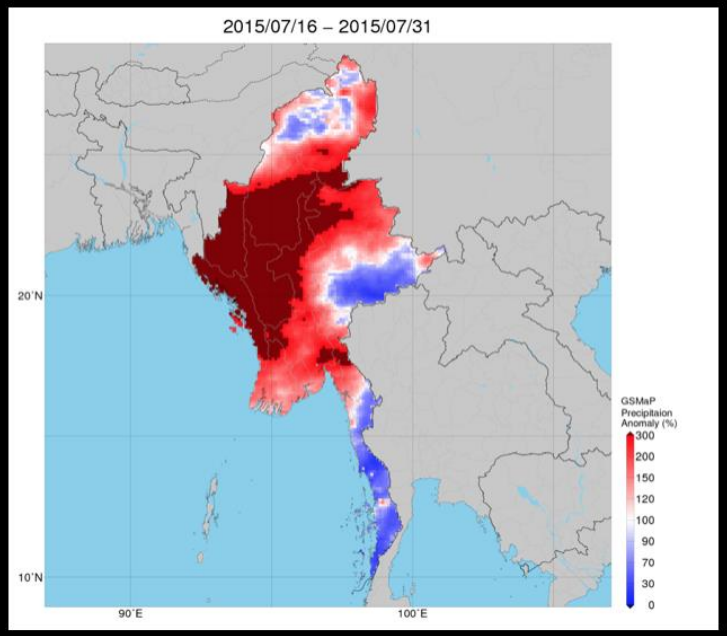
Inundation area estimation by Sentinel-Asia using ALOS-2

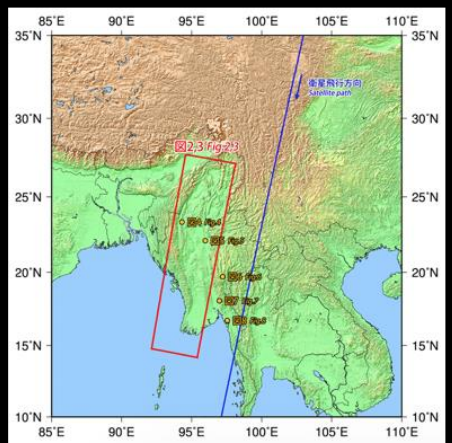


http://arcg.is/2h8rS7f

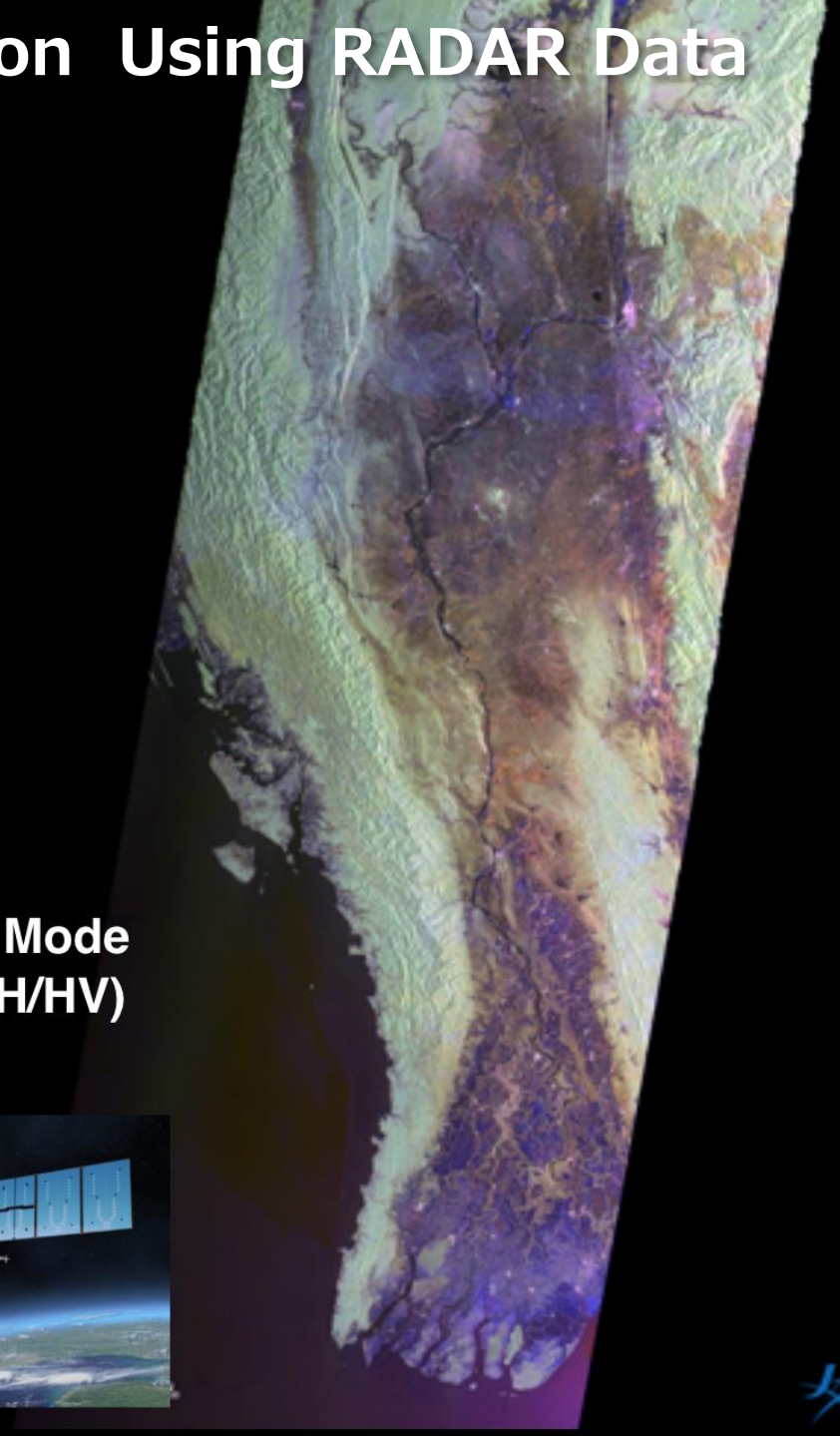
Inundated Area Detection Using RADAR Data

Rainfall Anomaly by GSMaP





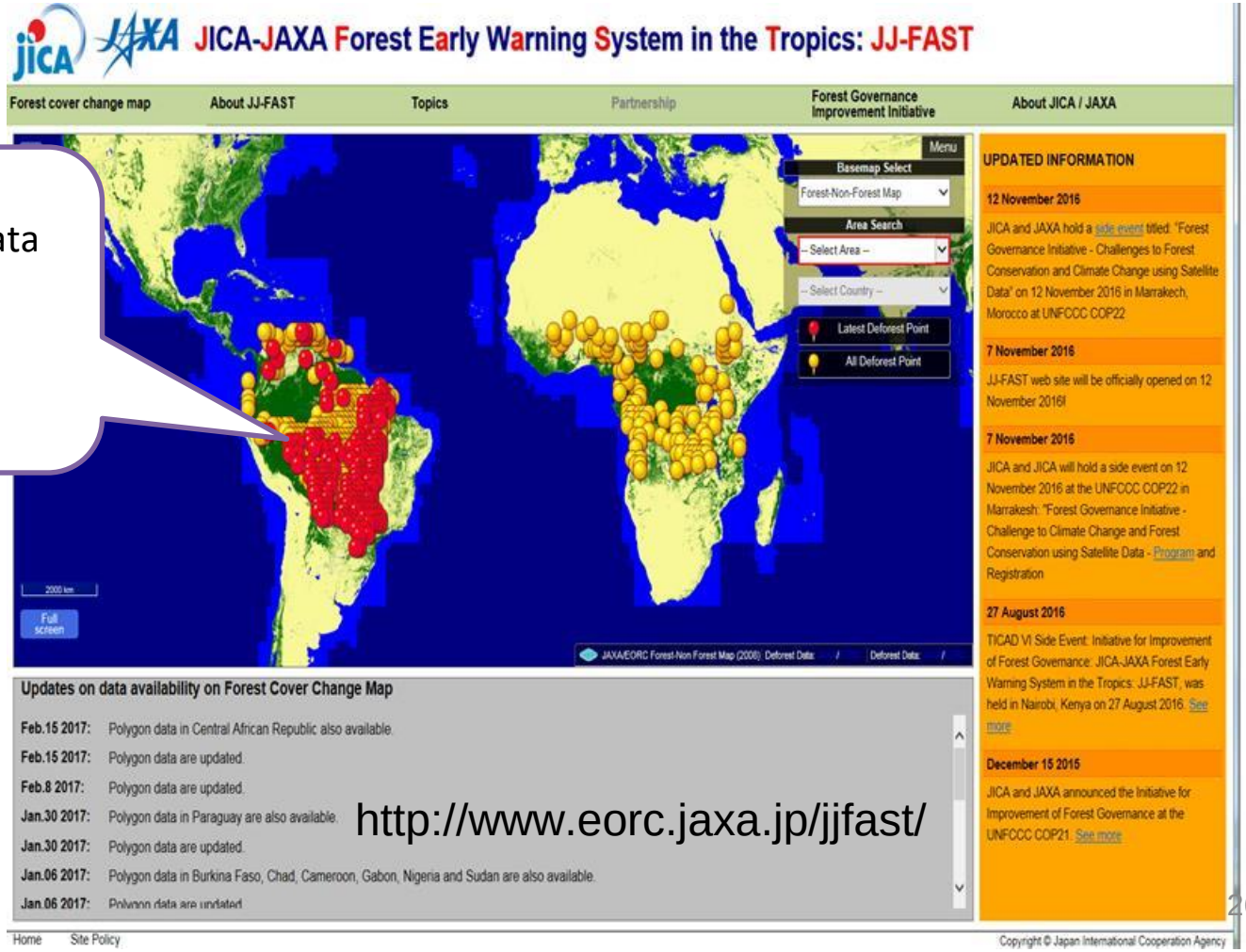
ALOS-2 ScanSAR Mode
(R:G:B = HH:HV:HH/HV)
28th July 2015



JICA-JAXA Forest Early Warning System in the Tropics (JJ-FAST)

- ScanSAR Ortho-slop corrected DN data will be processed during production of forest cover change (deforest / logging area)
- ADB INAHOR project countries and APRSAF SAFE prototyping country (Indonesia, LaoPDR, Philippine, Thailand and Vietnam) ScanSAR data will be freely accessible from JAXA archive from next year.under JJ-FAST for those countrys' own government use under a bilateral agreement

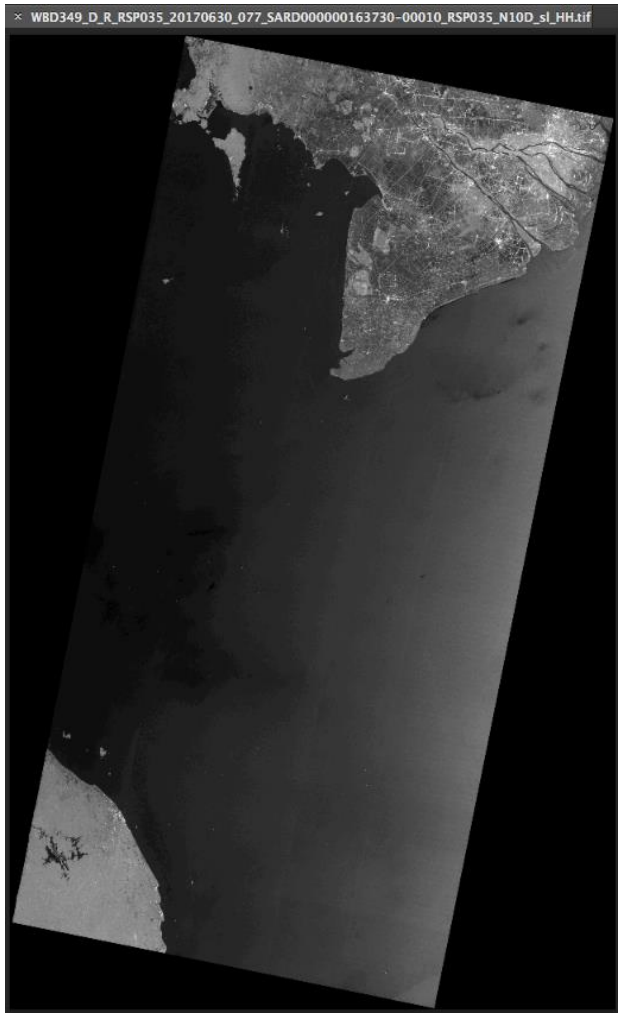
Provide deforest area data
(1 degree mesh)
Yellow: All avalable data
Red: Latest update data



ALOS-2 ScanSAR data specification for GFOI and other applications(DRAFT)

Product characteristics as ARD (under discussion)

- Path data
- Polarisation: HH + HV
- Gamma-0
- Image size: arbitrary
- Pixel spacing: 50 m
- Image segment start & end: arbitrary
- Orho & slope correction by SRTM1
- Data type: 16 bits UInt
- File format: GeoTIFF
- Temporal resolution: every 1.5 months (9 times per a year (target)
- Spatial resolution: All paths in target region



PALSAR-2 ScanSAR (HH)
30 June 2017

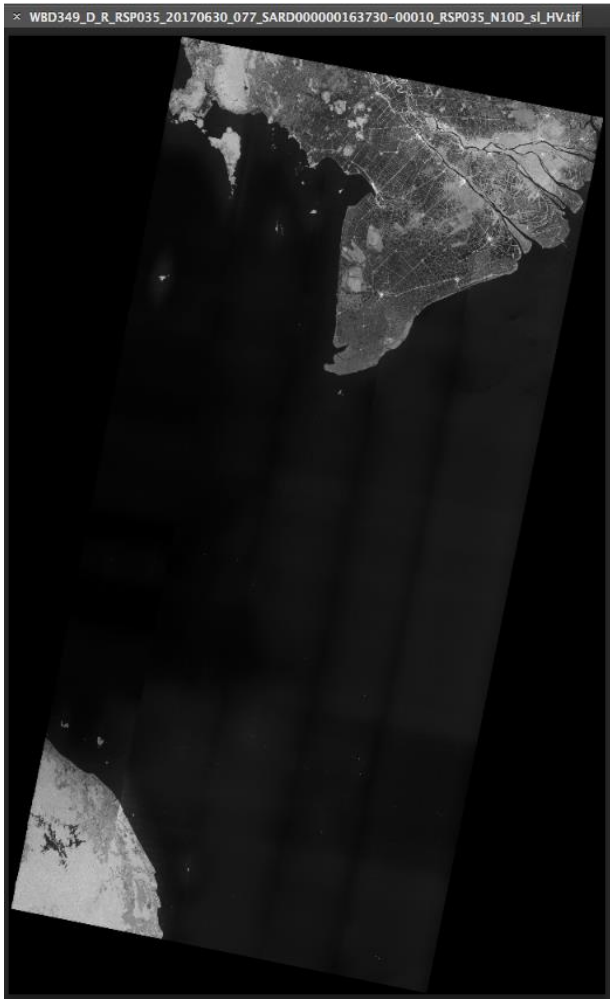
Limitations:

- Indonesia, Thailand, LaoPDR, Cambodia, Vietnam
- For non commericail users only authorized by space related agencies in target countries

ALOS-2 ScanSAR data samples

Tag	Description
origin	Image courtesy
satellite	satellite name
instrument	instrument name
file_name	File name
product	Path or Tile
obs_date	Observation date
polarization	Types of polarization
rsp	Number of Path
cycle	Observation cycle
obs_mode	Observation Mode
off-nadir_angle	Off-nadir angle [deg]
satellite_direction	Orbit Direction D:Descending A:Ascending
look_side	Observation Direction L: Left looking R: Right looking
replay_id	Downlink ID
version	Software release and revision number
DEM	Digital Elevation Model
upper_left_latitude	Upper left latitude
upper_left_longitude	Upper left longitude
pixel	Number of pixels
line	Number of lines
data_type	UInt16:Unsigned short integer 16-bit
interleave	Permutations of dimensions in binary data BSQ - Band Sequential (X[col,row,band]) BIL - Band Interleave by Line (X[col,band,row]) BIP - Band Interleave by Pixel (X[band,col,row])
calibration_equation	The equation for convering digital number to backscattering coefficient (gamma-naught, dB)
calibration_factor(CF1)	CF1 value
calibration_info_url	ALOS-2 callibration website

Data header



PALSAR-2 ScanSAR (HV)
30 June 2017


Thank you very much for your attention.
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TDS Site in Japan
JAXA
Explore to Realize