JAXA Earth Observation Satellites Program for water applications
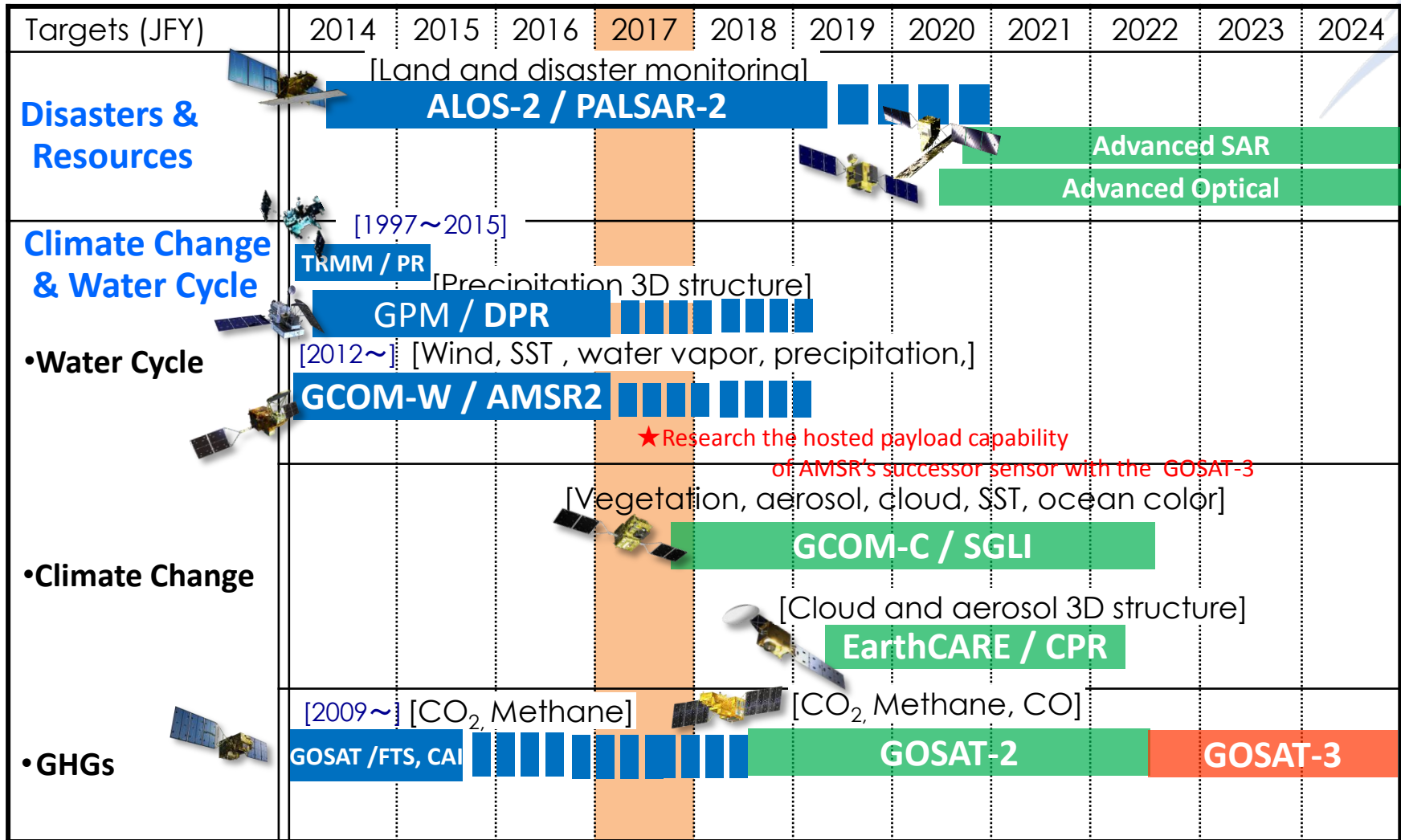
ALOS-2 Project Manager

Shin-ichi Sobue

JAXA Earth Observation Satellites

Targets (JFY)	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024

Disasters & Resources

[Land and disaster monitoring]
ALOS-2 / PALSAR-2

Advanced SAR

Advanced Optical

Climate Change & Water Cycle

[1997～2015]
TRMM / PR

[Precipitation 3D structure]
GPM / DPR

- **Water Cycle**

[2012～] [Wind, SST , water vapor, precipitation,]
GCOM-W / AMSR2

★Research the hosted payload capability
of AMSR's successor sensor with the GOSAT-3

[Vegetation, aerosol, cloud, SST, ocean color]
GCOM-C / SGLI

- **Climate Change**

[Cloud and aerosol 3D structure]
EarthCARE / CPR

[2009～] [CO_2, Methane]

[CO_2, Methane, CO]

- **GHGs**

GOSAT /FTS, CAI

GOSAT-2

GOSAT-3

Mission status: ■ On orbit ■ Development ■ Study

JAXA

1

JAXA's Earth Observation Programs

JAXA's EO scenario

1. Disaster Risk Management

| Crustal Deformation Monitoring | Flood Early Warning | Landslide Monitoring |

2. Climate Change (Mitigation/Adaptation)

| **Mitigation** GHG Monitoring | **Mitigation** Forest Monitoring | **Adaptation** Prediction of extreme weather event |

3. New Applications

| Ocean | DSM | Infrastructure Monitoring |
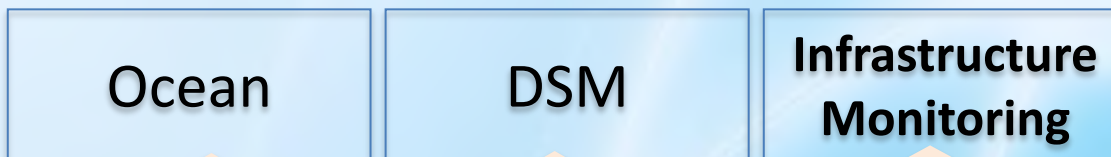
Geospatial Information By Satellite Remote Sensing

Advanced Land Observing Satellite-2 (ALOS-2)

Mission objectives

- Disaster monitoring (Earthquake, Volcano, Landslide, Flooding, …)
- Environmental monitoring (Forest, Ice sheet, …)
- Agriculture, natural resources, and ocean
- Technology development

Solar Arrays

PALSAR-2 antenna

X-band downlink antenna
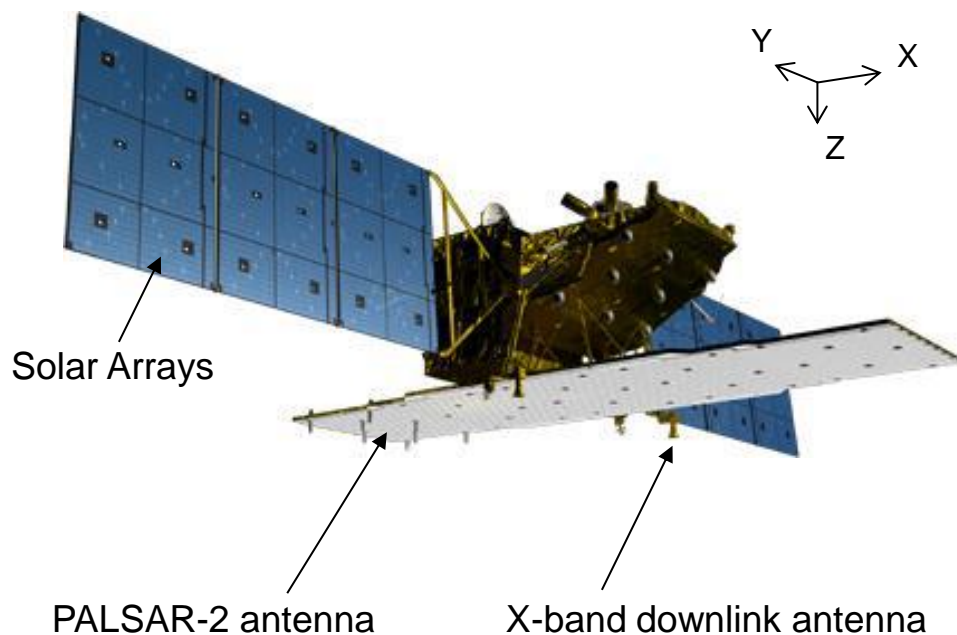
|	
Mission sensor	**PALSAR-2 (Phased Array type L-band Synthetic Aperture Radar 2)**
Launch	**May 24, 2014** H-IIA launch vehicle
Mass	2.1 tons
Lifetime	**5 years (target: 7 years)**
Orbit	Sun-synchronous, 628 km altitude, 14 days revisit, Orbit control: $\leqq$ +/- 500 m
Local sun time	12:00±15 min (descending)
	24:00±15 min (ascending)
Mission data transmission	X-band: 800 Mbps (16 QAM), 200/400 Mbps (QPSK)

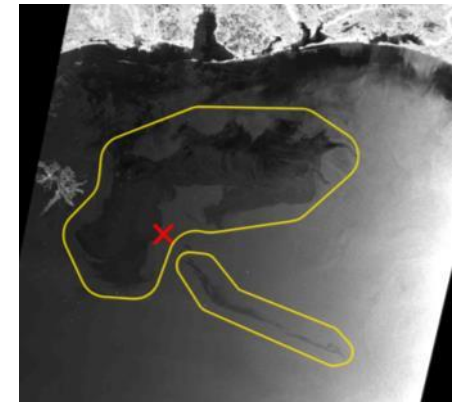## Mission Objectives:
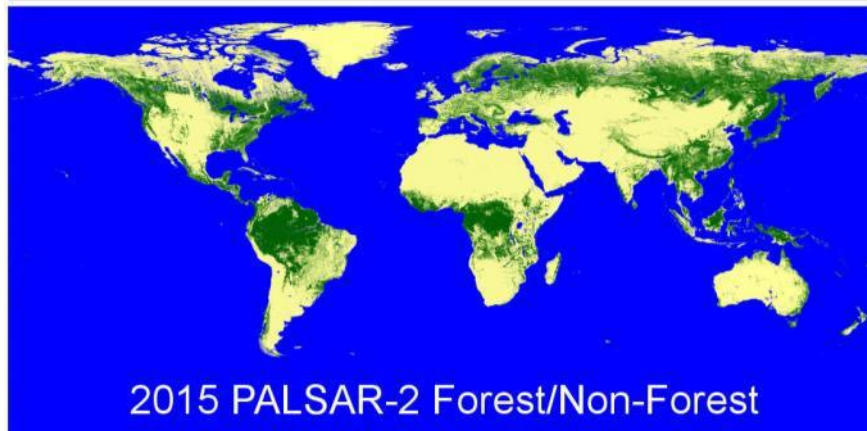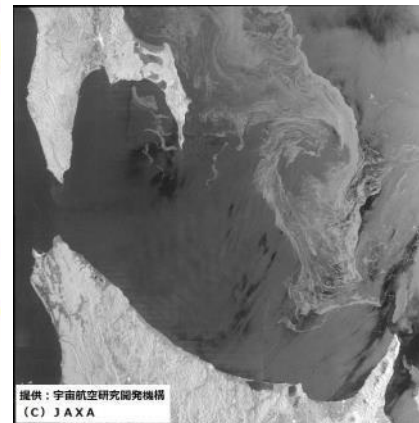
Disaster monitoring

Earthquake
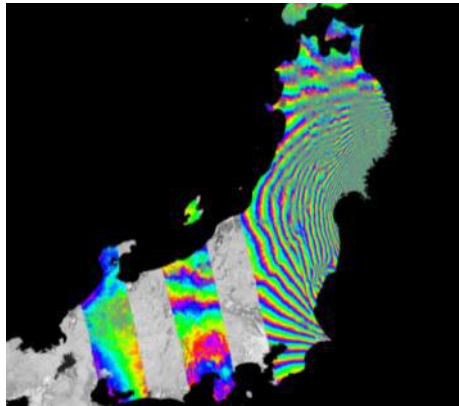
Volcano
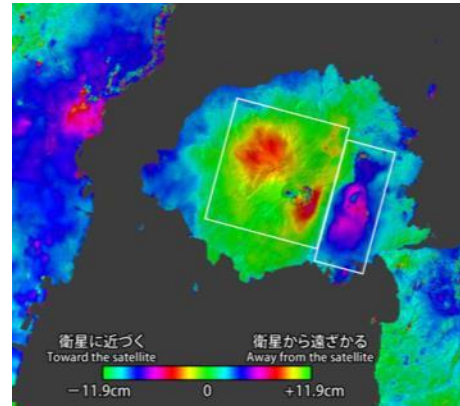
Flooding
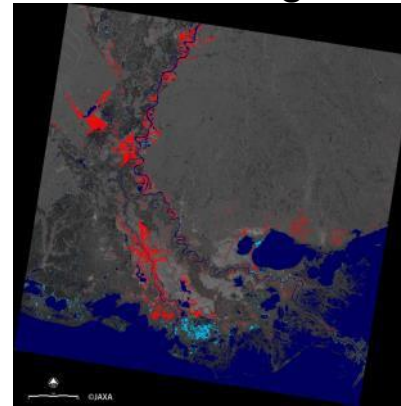
Ocean

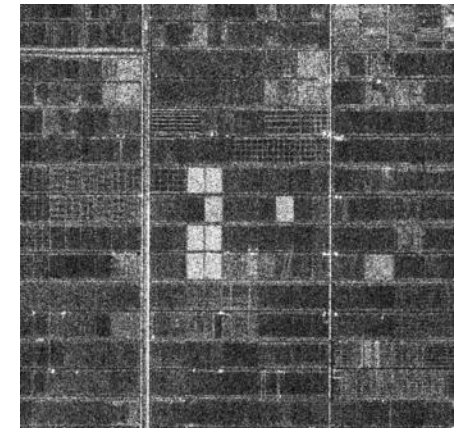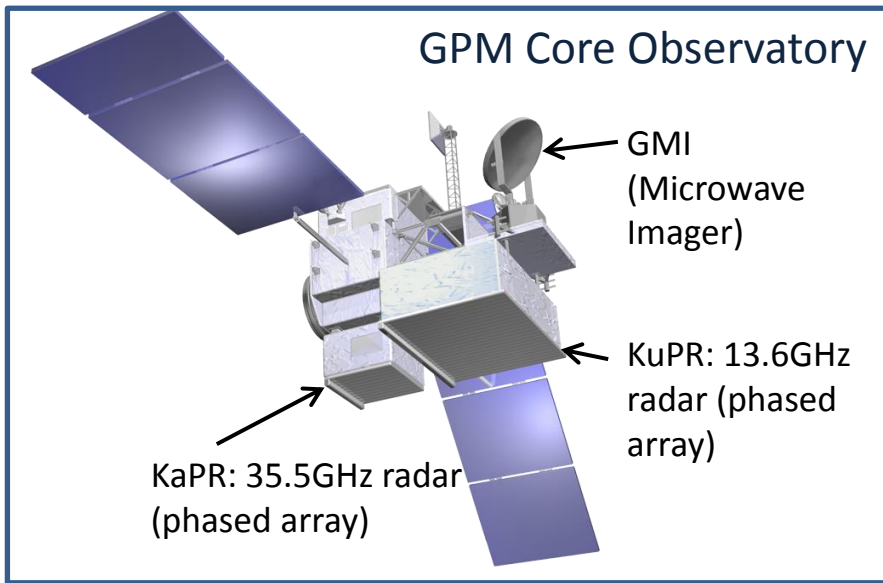### Environment and land management

Forest and wetland

2015 PALSAR-2 Forest/Non-Forest

Ice

Agriculture & natural resources

Global Precipitation Measurement (GPM)

GPM Core Observatory

- GMI (Microwave Imager)
- KuPR: 13.6GHz radar (phased array)
- KaPR: 35.5GHz radar (phased array)

Constellation Satellites by international partners

Core Observatory by NASA-JAXA

- ■ GPM is an international mission consisting of the GPM Core Observatory and Constellation Satellites for high accurate and frequent global precipitation observation.
  - ■ Core Observatory: developed under NASA and JAXA equal partnership.
  - ■ Constellation satellites: provided by international partners (includes GCOM-W1).
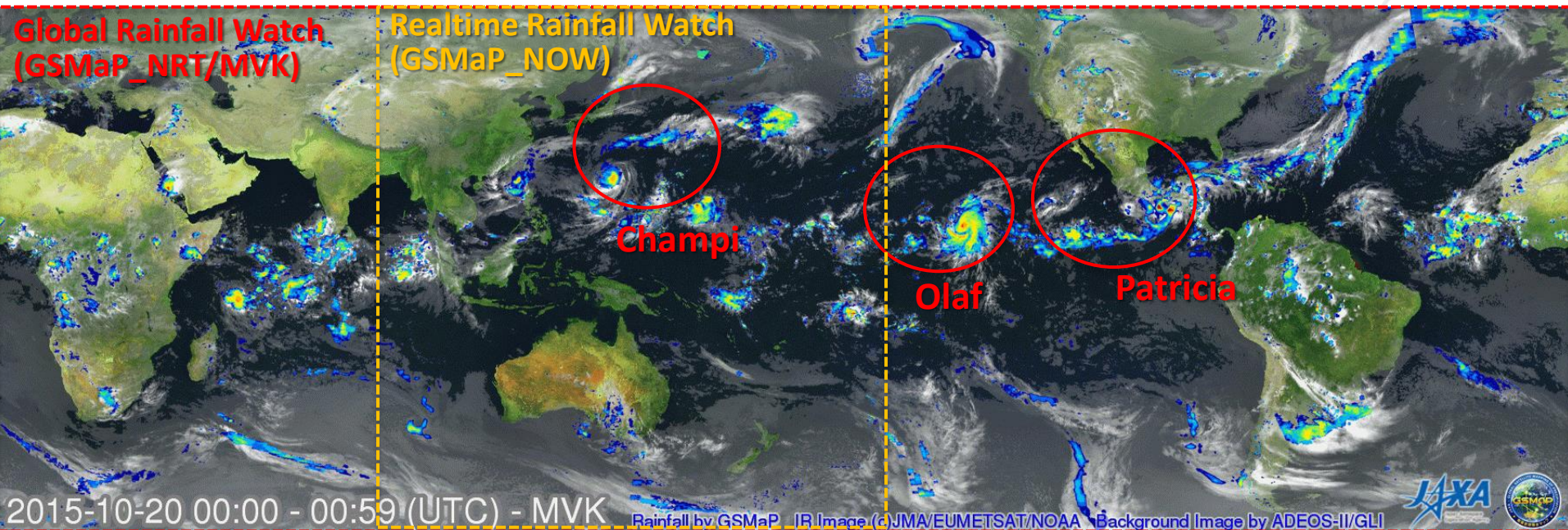- ■ Dual-frequency Precipitation Radar (DPR)
  - ■ developed by JAXA and NICT
  - ■ DPR is composed of two radars: KuPR & KaPR
- ■ GPM Core Observatory was successfully launched **on 28 Feb. 2014 (JST).**
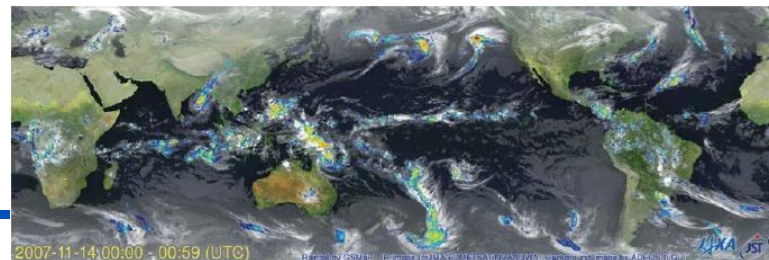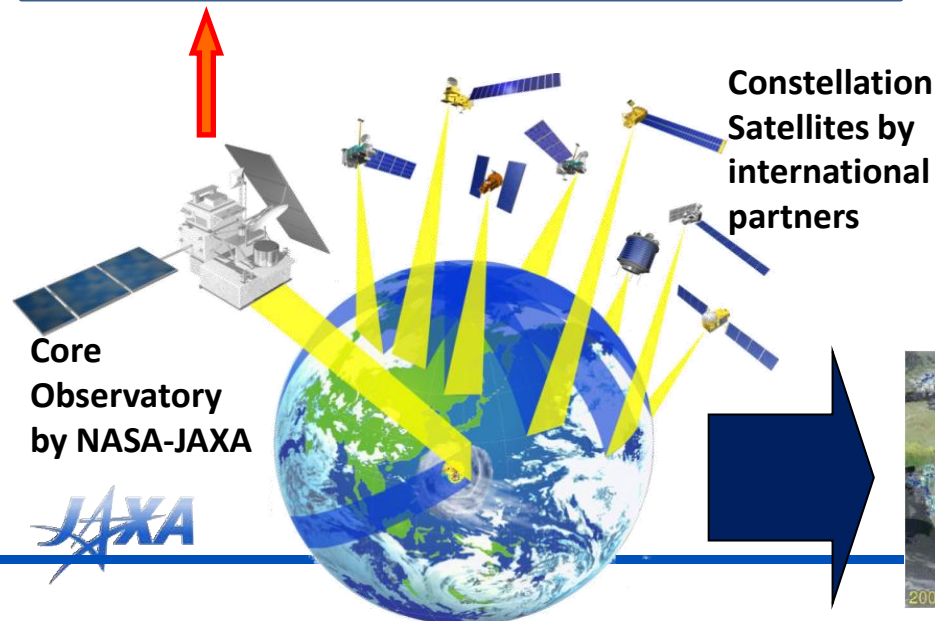
JAXA's Contribution to Forecasting

"GSMaP_NOW" over "Himawari-8" area start just now!
## Global Satellite Mapping of Precipitation (GSMaP)

GSMaP (Global) observed Hurricane Patricia and Olaf, and Typhoon Champi: 20-24 Oct. 2015, hourly animation

- **Rapidly changing precipitation phenomena need frequent observations.**
- **Global rainfall map merging GPM Core Observatory, polar orbiting microwave radiometer/sounders, and geostationary infrared radiometers.**

JAXA Global Rainfall Watch (4-hr delay) : http://sharaku.eorc.jaxa.jp/GSMaP
JAXA Realtime Rainfall Watch (Himawari-area): http://sharaku.eorc.jaxa.jp/GSMaP_NOW
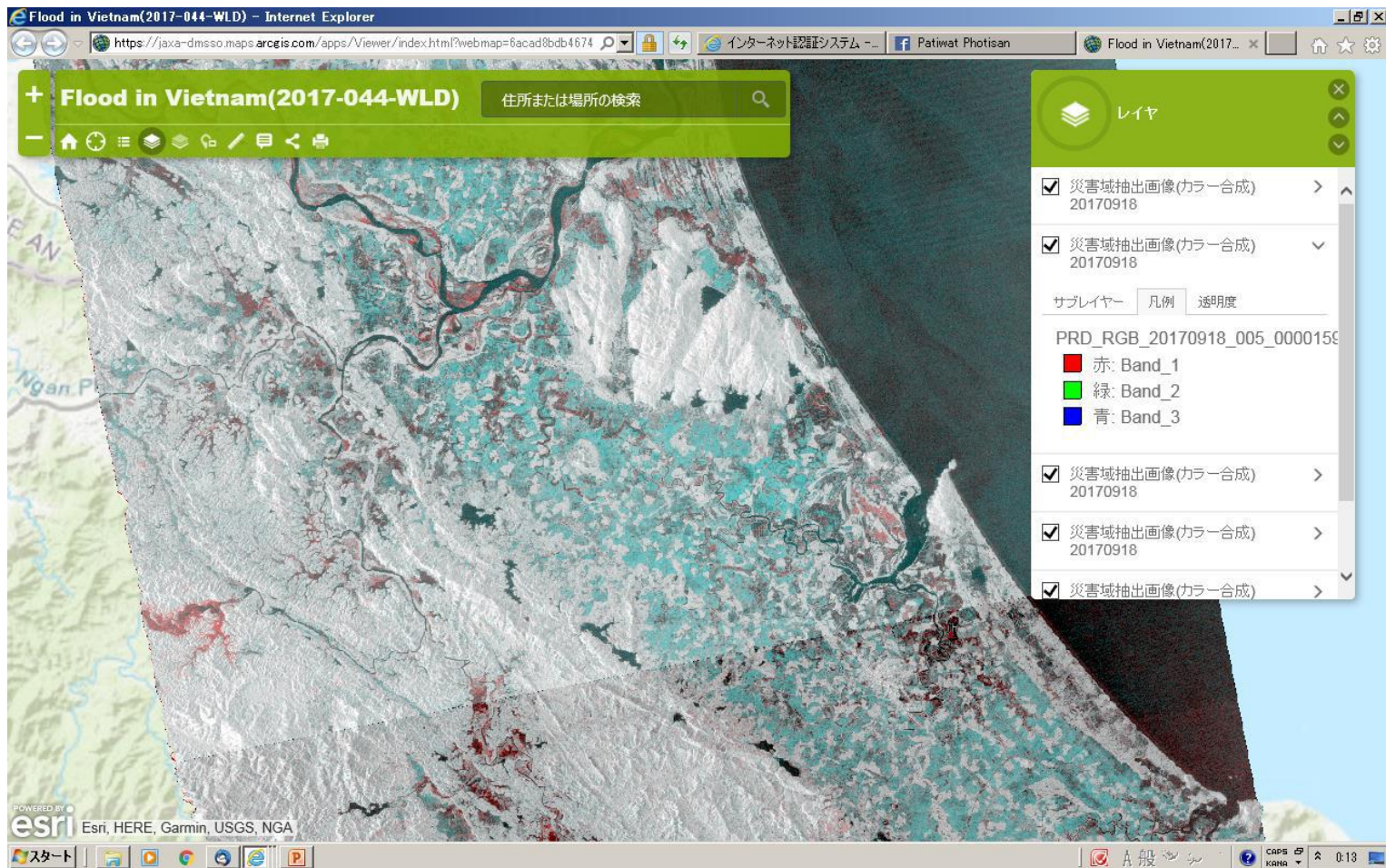
Typhoon 19 by GSMaP
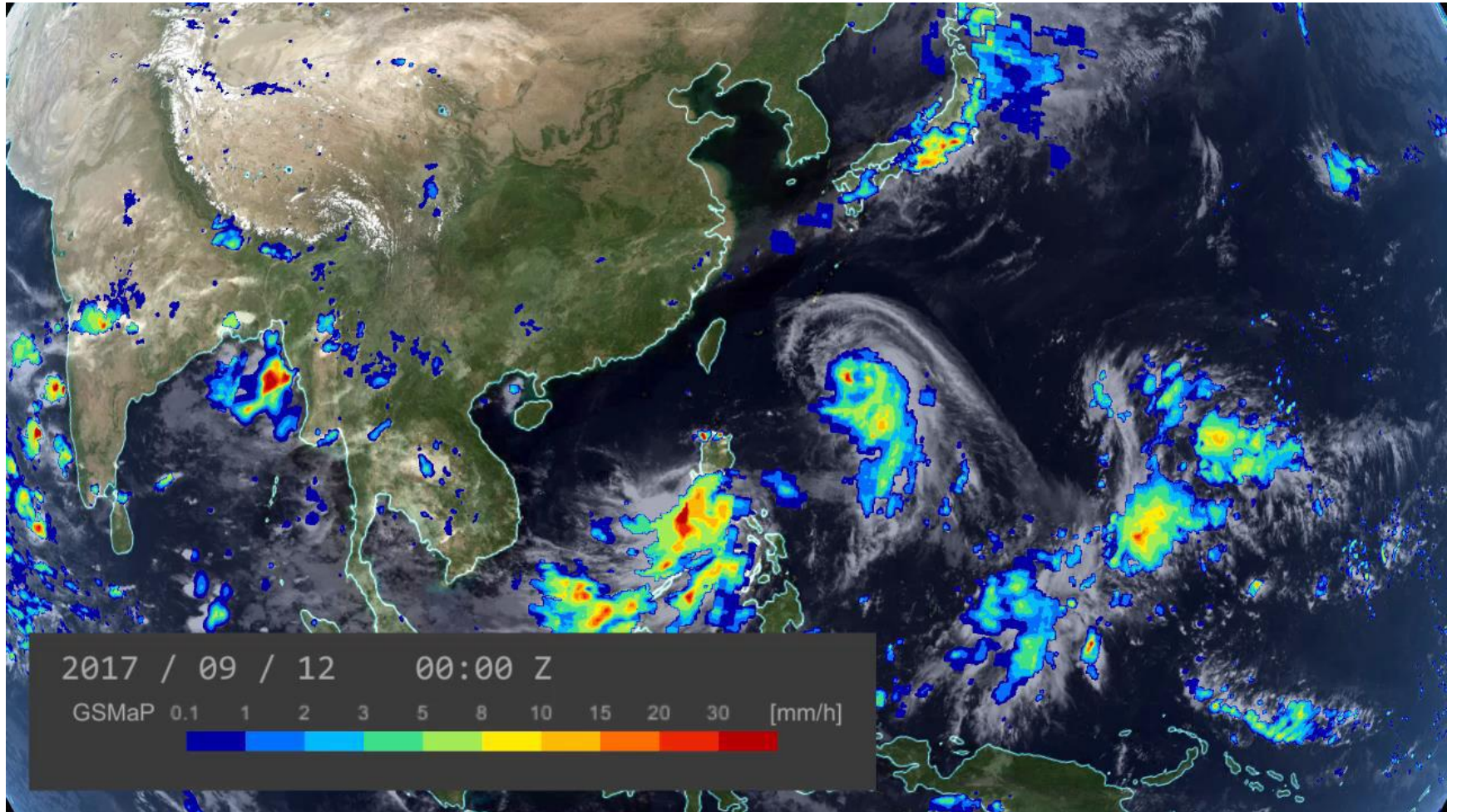
Typhoon 19 by HDTV camera on JEM/ISS

Inundation area estimation by Sentinel-Asia using ALOS-2
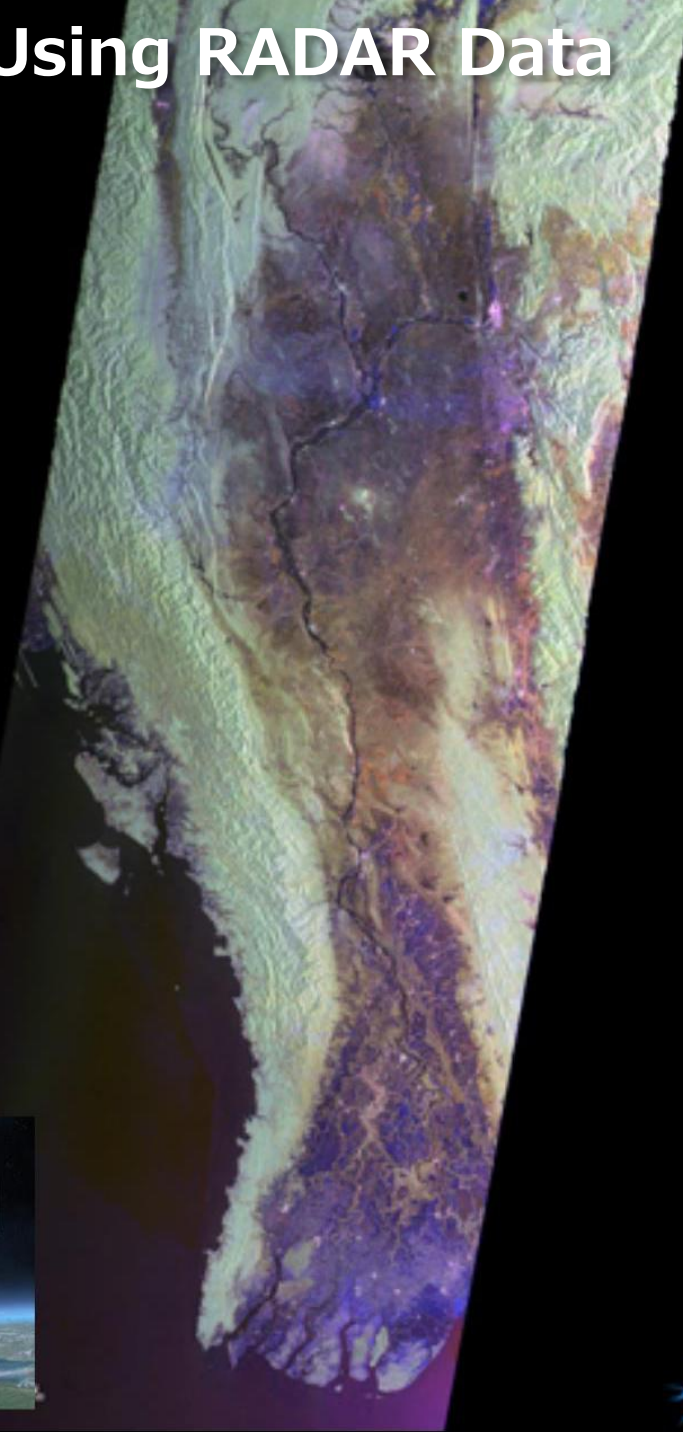

http://arcg.is/2h8rS7f

Inundated Area Detection Using RADAR Data

Rainfall Anomaly by GSMaP


2015/07/16 – 2015/07/31
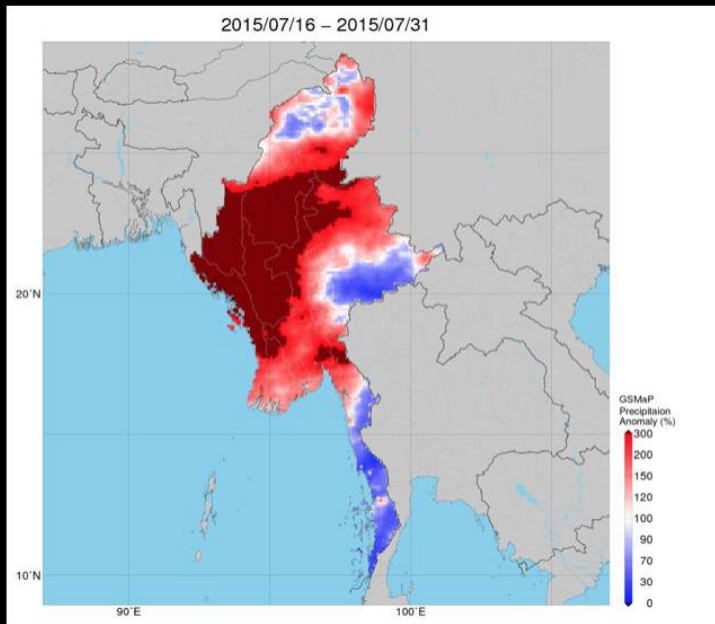
**ALOS-2 ScanSAR Mode
(R:G:B = HH:HV:HH/HV)
28th July 2015**
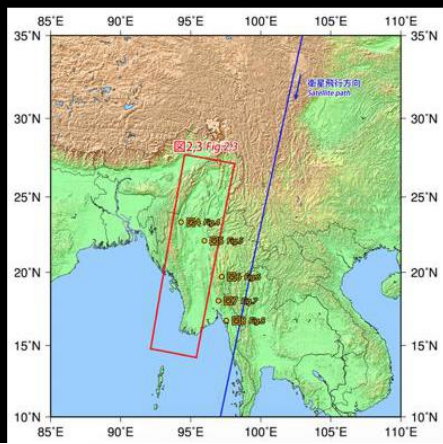
Disaster Risk Management
Flood Early Warning

GPM

- ✓ **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.**

GCOM-W

Global Satellite Mapping of Precipitation (GSMaP)

In-situ Data

Model

+

Warning Message
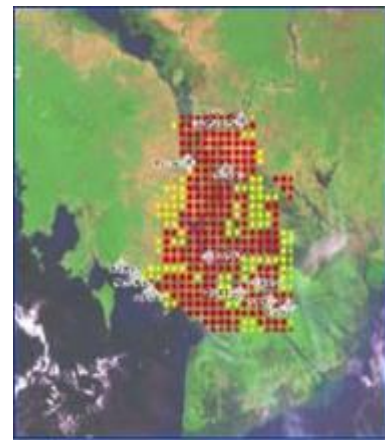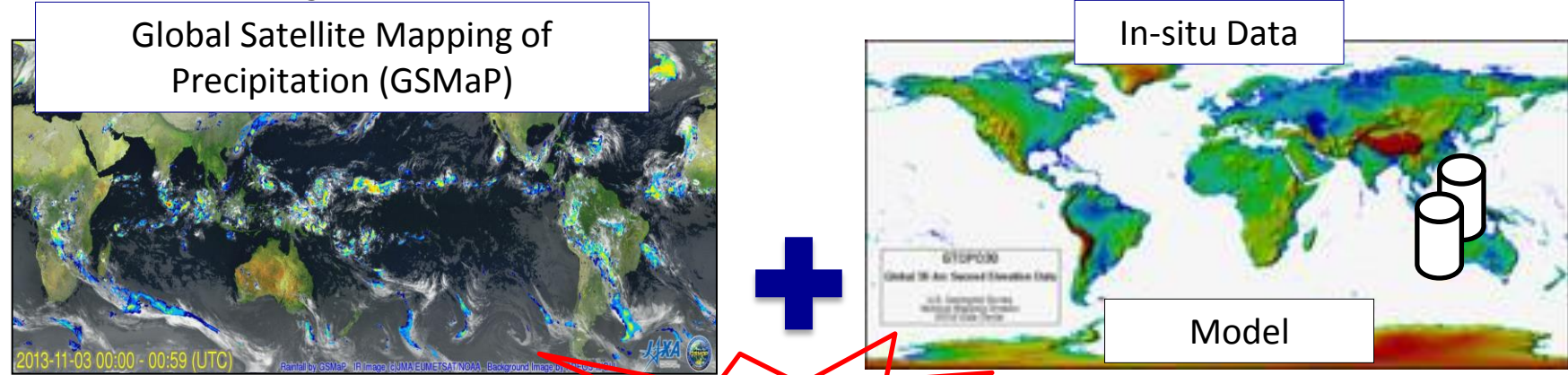
Global satellite data is effective to grasp the situation on water rising of International cross-border rivers.

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）

GSMaP based Landslide Warning System (GLWS)
- Pilot Study in the Philippines -

GSMaP rainfall archives are analyzed by a machine learning method (RBFN), and critical lines (CLs) of hourly rainfall and soil moisture index (SMI) are selected.

The system monitors rainfall in real-time and determines the landslide warning level.
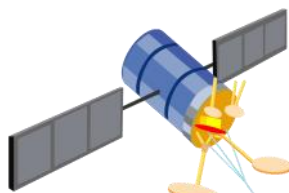

Rainfall monitoring

Sensor network

Automatic prediction

System

AWS

GSMaP-Now Satellite

Application

Analysis / warning

Model preparation

Hazard maps, Criteria

Maps   Warning criteria
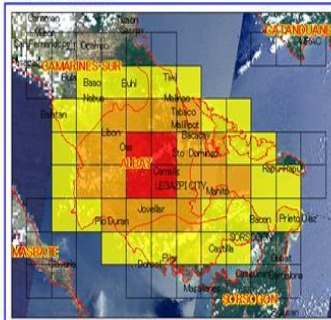
Landslide Early Warning Prototype System (Albay)
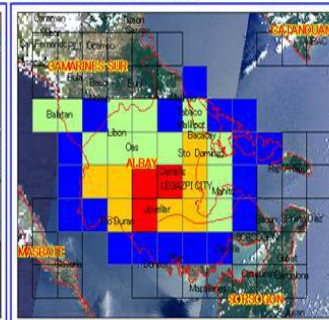
TOP > Albay

観測値 YYYY-MM-DD HH:MM - HH:MM (UTC) Lat: 123.55 Lon: 13.15 submit
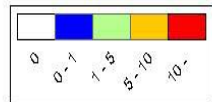
Warning Map   Hourly Rainfall [mm/h]

<< Prev | Latest | Next >>

Date: 2012 06 15
00:00 - 23:45 submit
☐ Realtime Update

No Warning
Warning
Evacuation
Critical

0   0 - 1   1 - 5   5 - 10   10 -
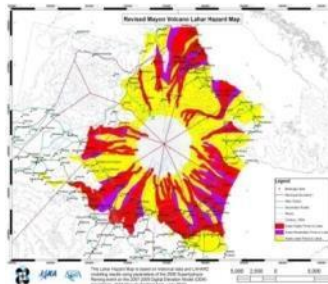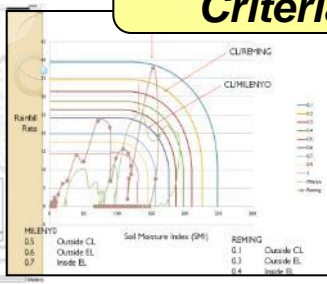
Warning Message [YYYY-MM-DD HH:MM – HH:MM (UTC)]

Critical
[Lat1, Lon1] : Rainfall: ✕mm, SMI: ✕mm, RBFN Value: ✕

Evacuation
[Lat2, Lon2] : Rainfall: ✕mm, SMI: ✕mm, RBFN Value: ✕

Warning
[Lat3, Lon3] : Rainfall: ✕mm, SMI: ✕mm, RBFN Value: ✕

Agency／Local gov.

Overview of the prototype-system

The Landslide and Flood disaster Early Warning System with GSMaP

Input

GSMaP   AWS

↓   ↓

GSMaP Correction

↓

Corrected GSMaP

↓
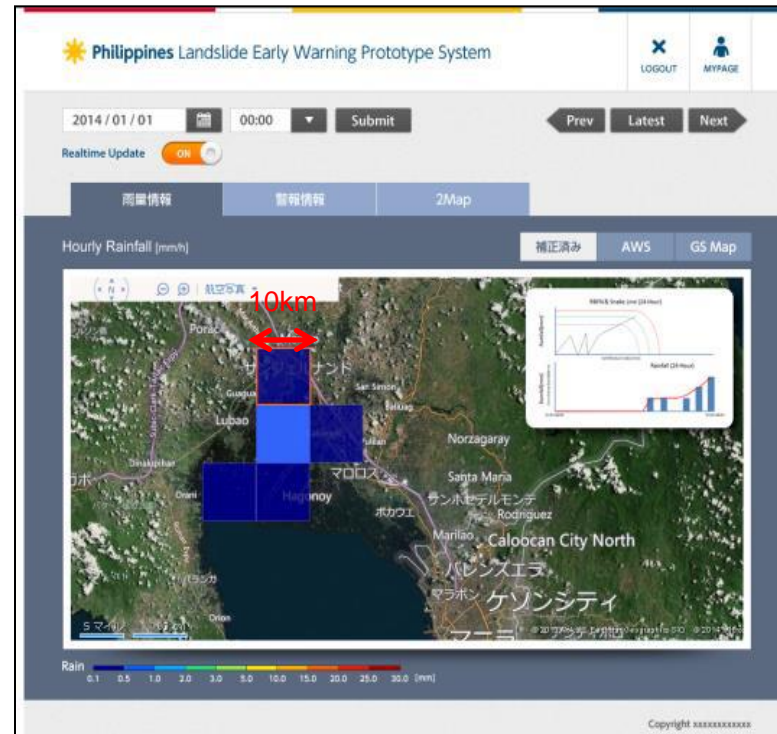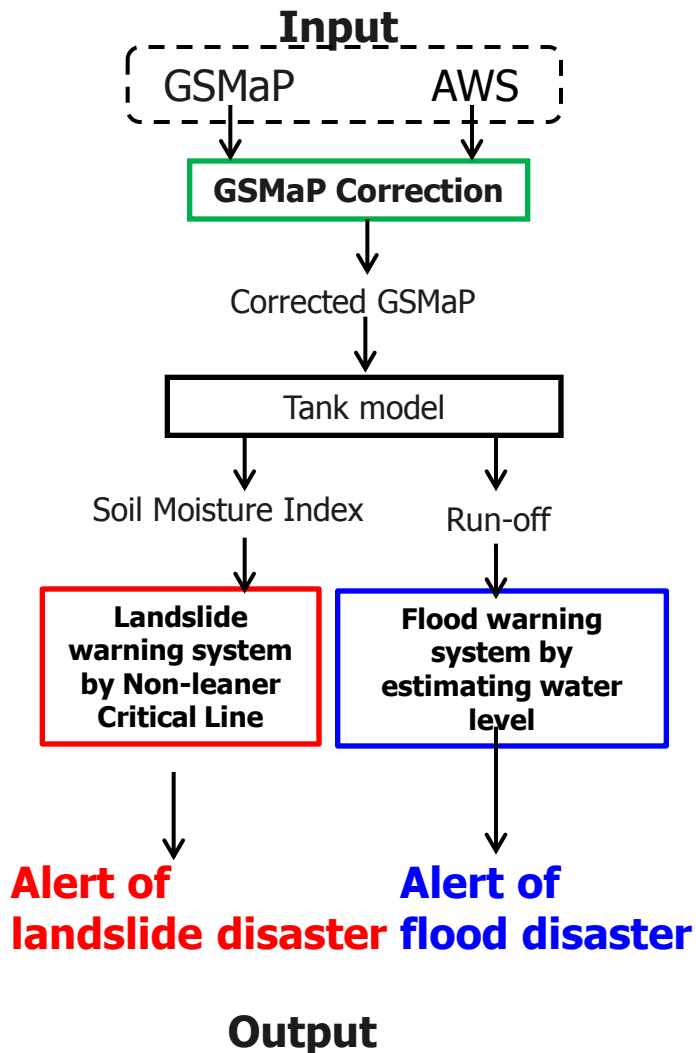
Tank model

↓   ↓

Soil Moisture Index   Run-off

↓   ↓

Landslide warning system by Non-leaner Critical Line   **Flood warning system by estimating water level**

↓   ↓

Alert of landslide disaster   **Alert of flood disaster**

Output

Web Browser

First user list is necessary (User's Name and Email address)

Login:
User ID
Password

GFAS-II （Global Flood Alert System ver.2）

● GFAS developed by IDI is a system to apply global satellite precipitation estimates to flood forecasting. GFAS utilizes GSMaP as a means of estimation to provide "**global flood risk map**" that is display on the Internet. GFAS-II, upgraded in 2017, is **PC & Smartphone-friendly version**, and available to everyone around the world.

GFAS-II currently has the displays for 5 languages (English, Japanese, Spanish, German and Vietnamese).
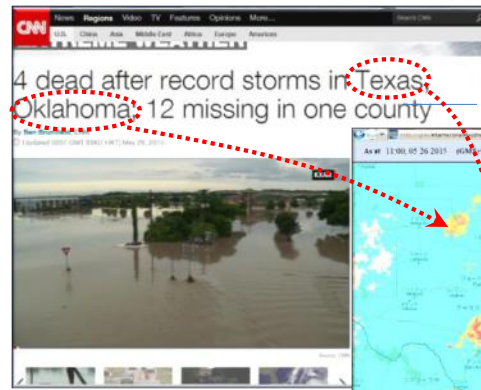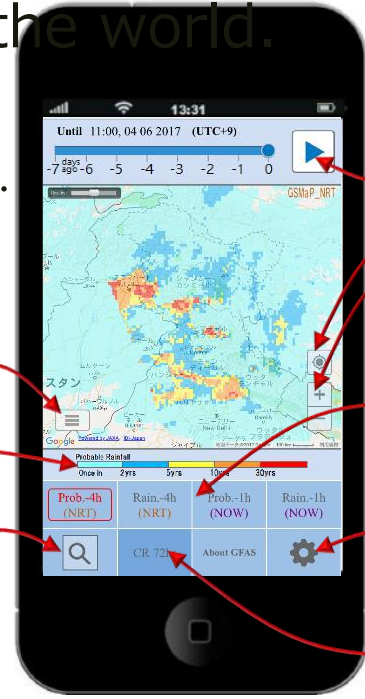

Captured Image of GFAS-II web site
72 Cumulative precipitation
of 11:00, May 23~26, 2015

4 dead after record storms in Texas, Oklahoma; 12 missing in one county
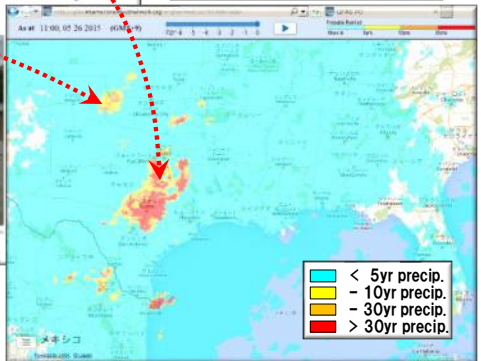
Display / Hide of the menu

Legend

Search Location by place name

< 5yr precip.
– 10yr precip.
– 30yr precip.
> 30yr precip.

Animation display of rain area

- Jump to the Current Location
- Zooming

Selection of Information
NRT or NOW
 - Prob :Probable Rainfall (Risk map)
 - Rain :GSMaP (Observed Rainfall)

Other Functions
 -Selection of language
  EN, ES, DE, VN
 -Selection of layer
  Map, Aerial Photo
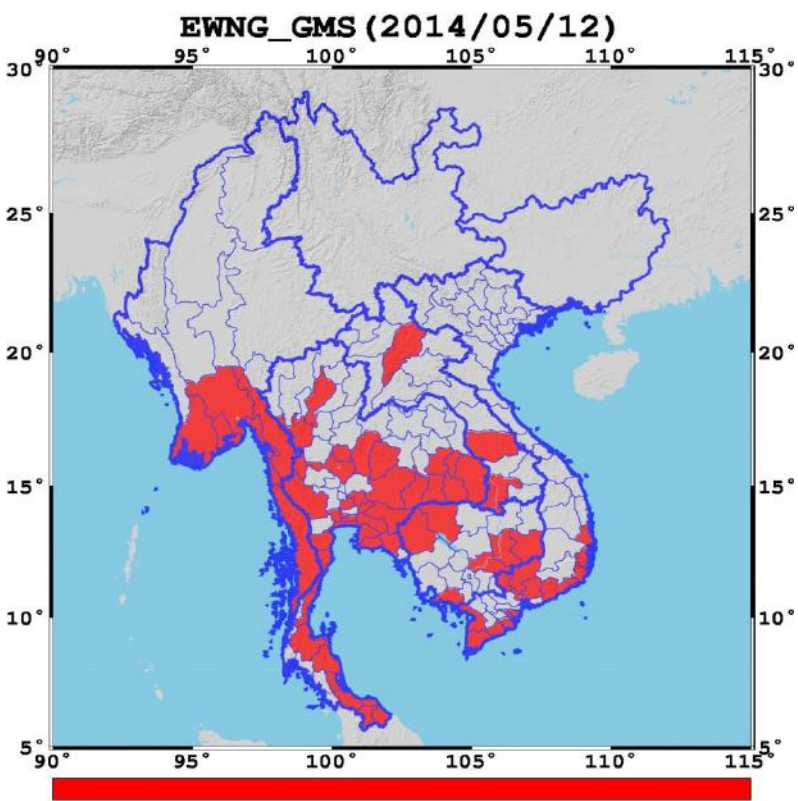
Selection Cumulative rainfall
1h, 3h, 12h, 24h, 72h

[Smart Phone]   **http://gfas.internationalfloodnetwork.org/n-gfas-web/sp/frmMain.aspx**
[PC]   **http://gfas.internationalfloodnetwork.org/n-gfas-web/pc/frmMain.aspx**

ADB Joint Project on Drought Monitoring

Target: Greater Mekong Subregion (GMS)

- Add free satellite-based drought information to GMS-AIN

Drought_early_warning_in_province_level

GMS-AIN (Great Mekong Subregion
Agricultural Information Network)

Free data and automatically updated

-> No operational cost

Drought Indices and alerts
-KBDI (Keetch-Byram Drought Index); daily, 10km

Example: Rice Growth Outlook in Vietnam

Rice Growth Outlook (September 2016)
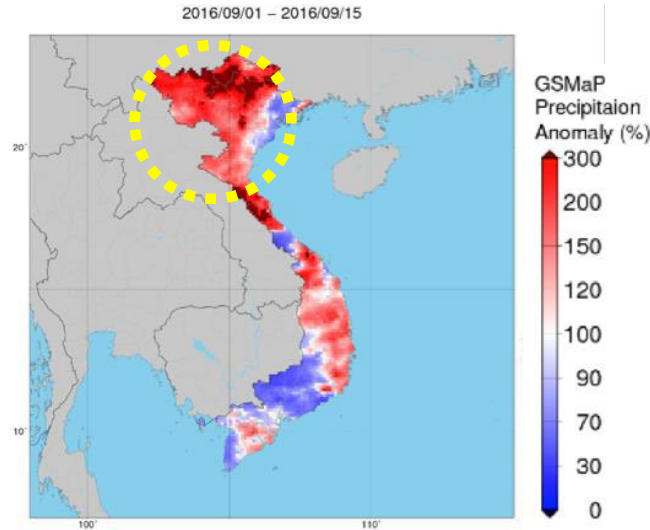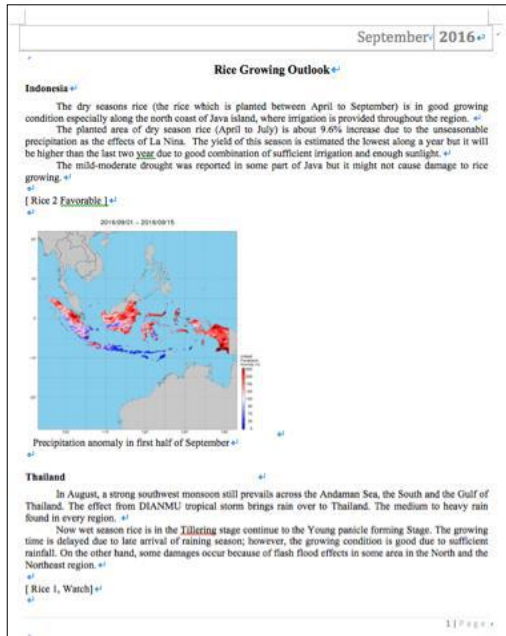
Precipitation anomaly in first half of September

Precipitation (Hanoi Province)

Vietnam

In the North, the seeding of autumn-winter rice (wet season rice) is completed. The sown area is around 1.1 million ha, accounting for 99.2% of the last year area. **The weather in the North is not good for paddy due to storm and flood.**
In the South, the summer-autumn rice enters a harvesting time. The harvested area is around 1.0 million ha ·····..

Satellite derived agro-met information can support to judge rice growth.

Vietnam Data Cube - SAR based rice crop monitoring scheme

Rice Crop Mapping in Southeast Asia

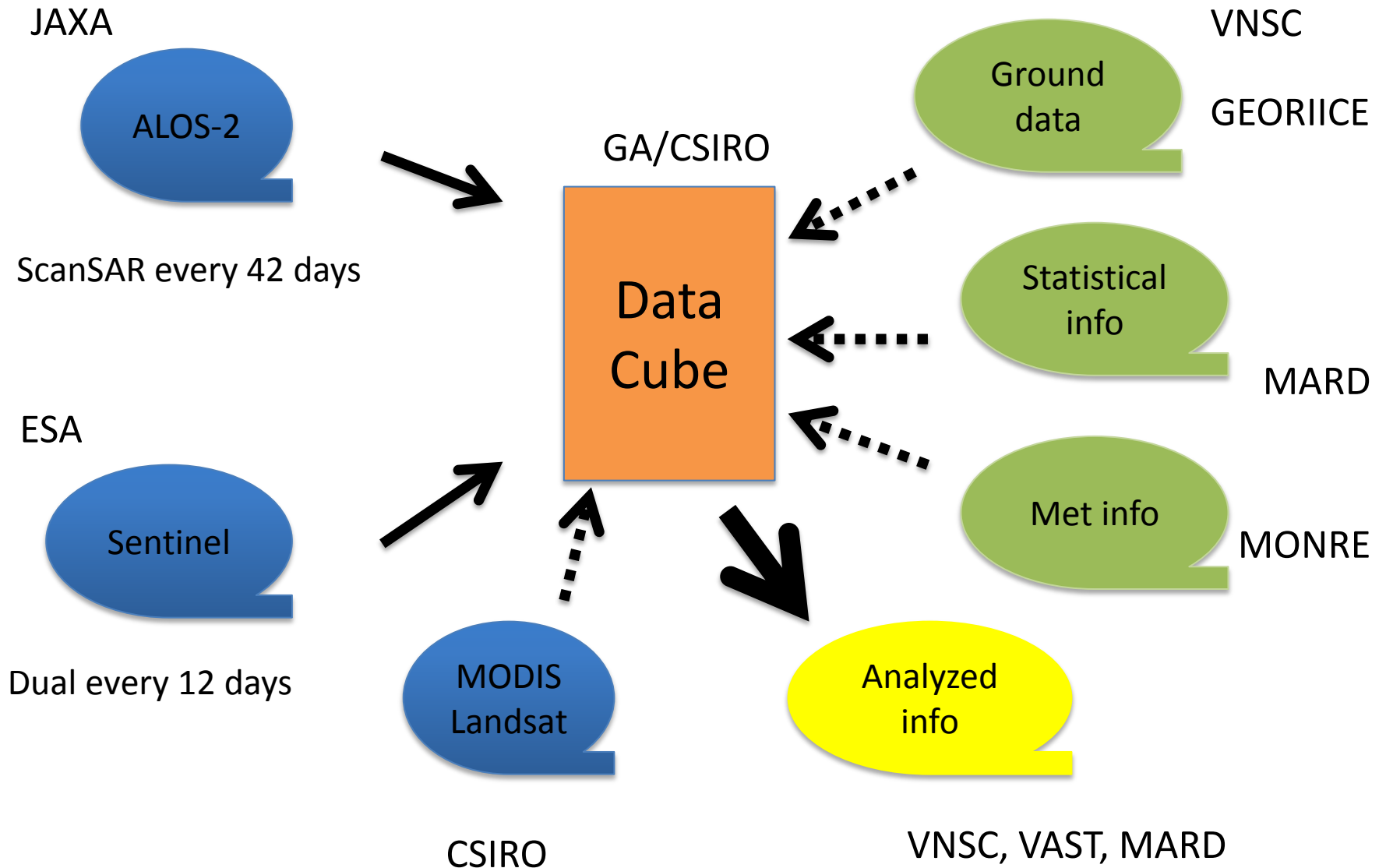- ADB Technical Assistance project and SAFE project under the APRSAF have successfully demonstrated INAHOR using ALOS-2 with the mapping accuracy of 80-90% for the target provinces.
- Scaling-up for major rice producing areas is currently demonstrated in Vietnam and Indonesia.
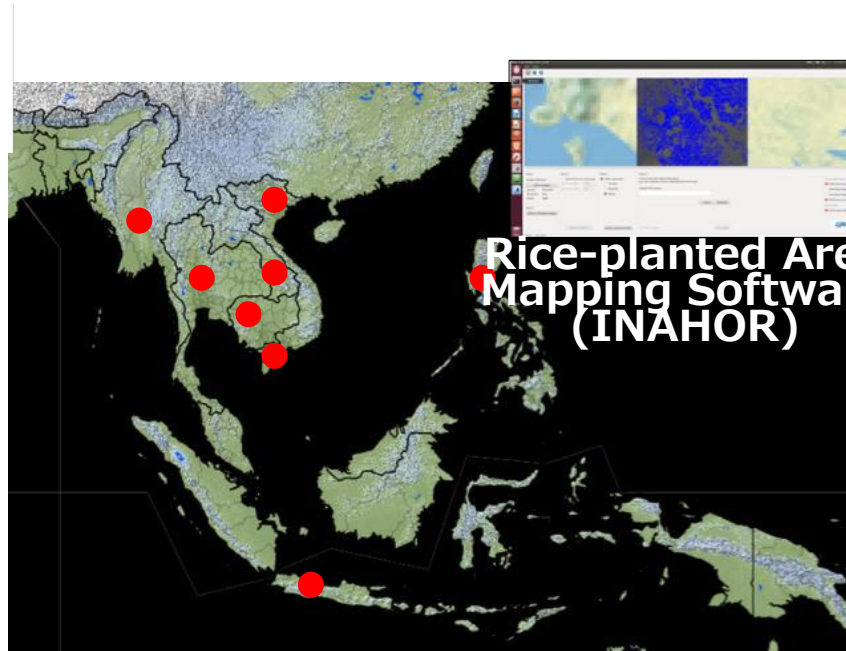

ADB TA Project

- Laos
- Thailand
- Vietnam (North)
- Philippines

[2014-2016]

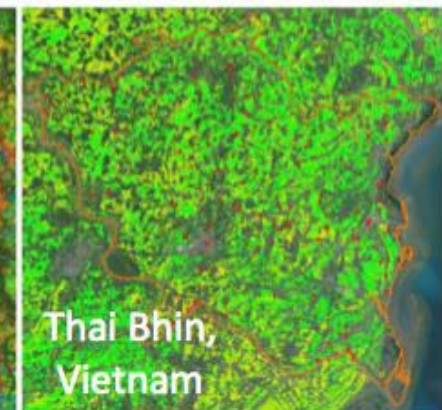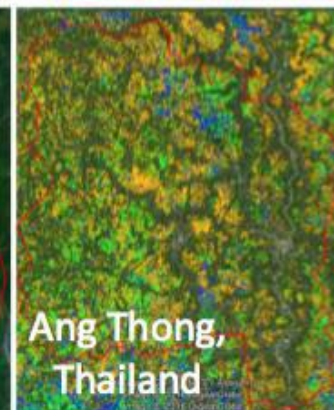**Rice-planted Area Mapping Software (INAHOR)**

SAFE Project (Test site)

- Myanmar
- Cambodia   [2016-]

SAFE Project (Scaling-up)

- Vietnam (Mekong Delta)
- Indonesia

[2014-]

Savannakhet, LAO PDR

Neuva Ecija, the Philippines

Ang Thong, Thailand

Thai Bhin, Vietnam

Water Detection with Radar
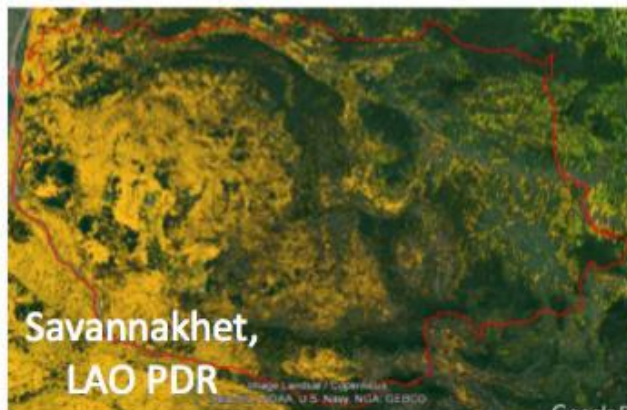
- **WASARD** (Water Across Synthetic Aperture Radar Data) is a new machine learning algorithm for water detection using radar datasets.
- The algorithm is trained using Landsat data and the Australian WOFS water detection algorithm, which has >97% accuracy.
- WASARD has shown >96% correlation with WOFS results using Sentinel-1 and ALOS datasets over Vietnam.
- WASARD produces a simple linear water classifier algorithm with the format: (Coefficient-1)*(Band-1) + (Coefficient-2)*(Band-2) + Bias

Sample water detection results for Lake Buon Tua Sarh in Vietnam. The correlation between WOFS and WASARD was 97%.
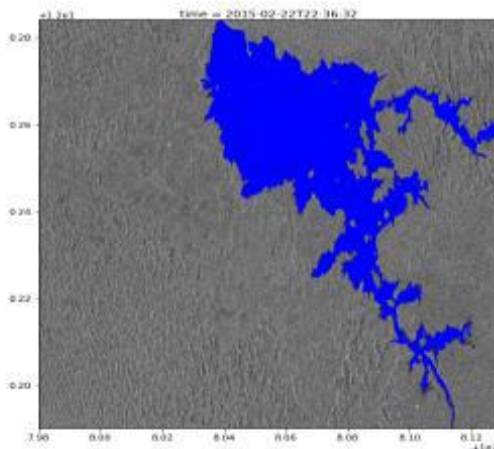
Sentinel-1 WASARD

Landsat WOFS

19
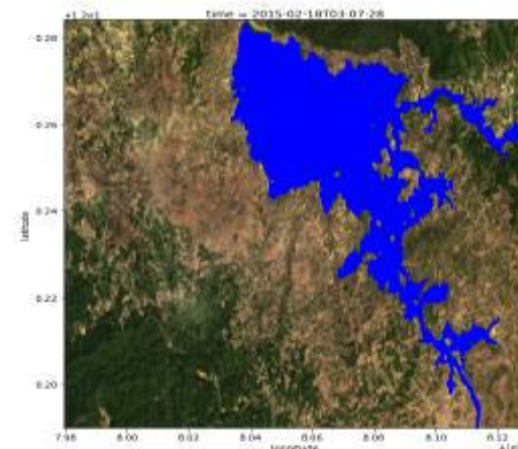
ALOS-2 ScanSAR data provision

- For GEOGLAM and CEOS
  - Under GEOGLAM/Asia Rice and ALOS K&C project, JAXA provides ScanSAR data at technical demonstration sites (100km x 100km – one province) in Cambodia, Myanmar, Malaysia, Lao, India, China, Thailand and Taiwan to Asia Rice crop team members with ALOS-2 download system now.
  - Under Asia Pacific regionsal space agency forum (APRSAF) framework with GEOGLAM/Asia Rice, JAXA provides scale up activity for Indonesia (Top 10 rice crop production provinces) and Vietnam (Mekong)
- Proposal from JAXA
  - Under cooperation with JICA and commerical data providers, JAXA starts to prepare to provide on-line access to intermidate JJ-FAST products = ScanSar ortho-slop corrected DN data and/or ALOS-2 25m path ortho-slop correct data (gamma naught) from ALOS-2 path mosaic to selected countries for each target country data where JAXA, ADB and APRSAF countries have cooperative aggeement (Indonesia, LaoPDR, Thailand, Philippine, Low Mekong (Vietnam + Cambodia)) for governmental use in respecting countries.
  - JAXA starts to prepare sample data of ScanSAR data to ingest Vietnam data cube and propose CEOS ARD of SAR (1-5 degree mesh tiled data or path orth-slop corrected data) in cooperation with CEOS SEO (NASA)
  - Other than ASEAN area, JAXA will discuss with commercial data distributor to have same framework of ALOS-2 ScanSAR intermidate product to target countrys' governmetal use if CEOS and GEO community are interested in.

Coordination status with respecting countries

1. Vietnam

- VNSC and CSIRO/GA already prepare to implement CEOS Mekong data cube by the end of this year
- VNSC and JAXA agreed to coordinate ALOS-2 ScanSAR data ingestion with rice crop area estimation software (INAHOR) to CEOS Mekong data cube
- JAXA and VNSC will finalize MOU for Vietnam data cube with ALOS-2 ScanSAR data and will have Data cube workshop as a pre-workshop of GEOSS-AP agriculture working group (WG5)

2. Indonesia

- LAPAN, MOA and JAXA agreed to coordinate coordinate ALOS-2 ScanSAR data ingestion to LAPAN data archive
- JAXA and LAPAN start to coordinate MOU to archive and use ALOS-2 ScanSAR data in Indonesia

3. Thailand

- JAXA and GISTDA start to discuss ALOS-2 ScanSAR data of Thailand and Lao provision to GISTDA

JAXA's EO Data Portals

	Portal Name and URL
	G-Portal **(GPM, TRMM, JERS-1, AQUA/AMSR-E....etc.)** https://www.gportal.jaxa.jp/gp/top.html *Free andn Open Data
	GCOM-W: Global Change Observation Mission-Water http://suzaku.eorc.jaxa.jp/GCOM_W/data/data_w_index.html *Free and Open Data
	GSMaP: Global Satellite Mapping of Precipitation http://sharaku.eorc.jaxa.jp/GSMaP_crest/index.html *Free and Open Data
	Precise Global Digital 3D Map "ALOS World 3D" Homepage (30m resolution) http://www.eorc.jaxa.jp/ALOS/en/aw3d/index_e.htm *Free and Open Data

High resolution data is available through commercial distributors.
  ALOS-2: PASCO (http://en.alos-pasco.com/)
  ALOS World 3D (5m resolution): NTT DATA and RESTEC (http://aw3d.jp/en/index.html)

Future Missions

GCOM-C: Global Change Observation Mission- Climate

shortwave & thermal InfraRed (T) Scanner (IRS)

Polarization (along-track slant) radiometer (P)

Visible & Near infrared push-broom Radiometer (VNR)

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

GOSAT-2 on orbit in early 2018
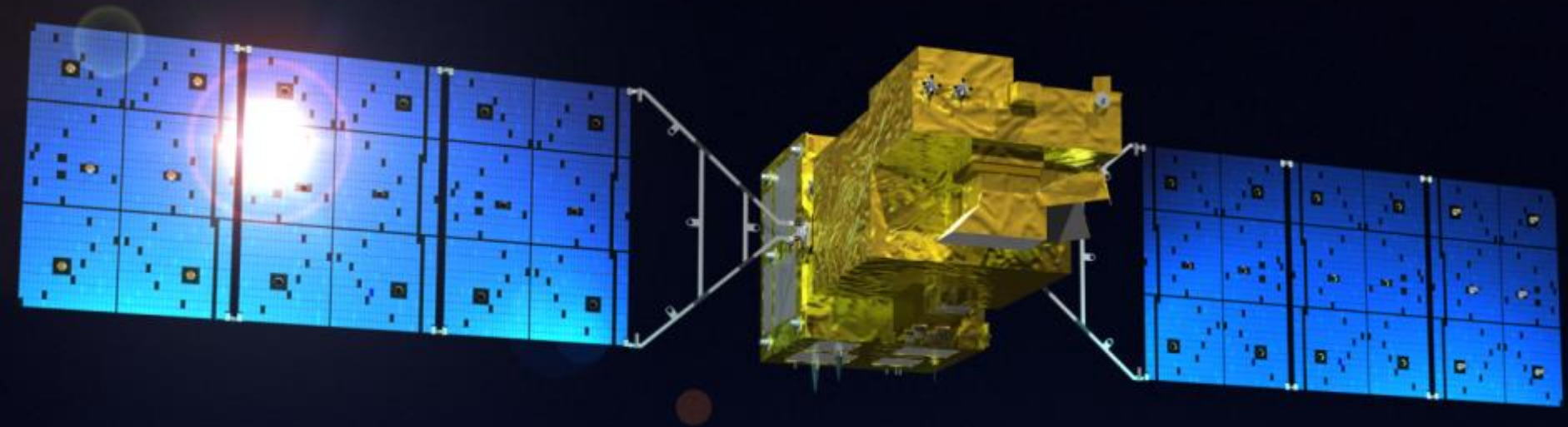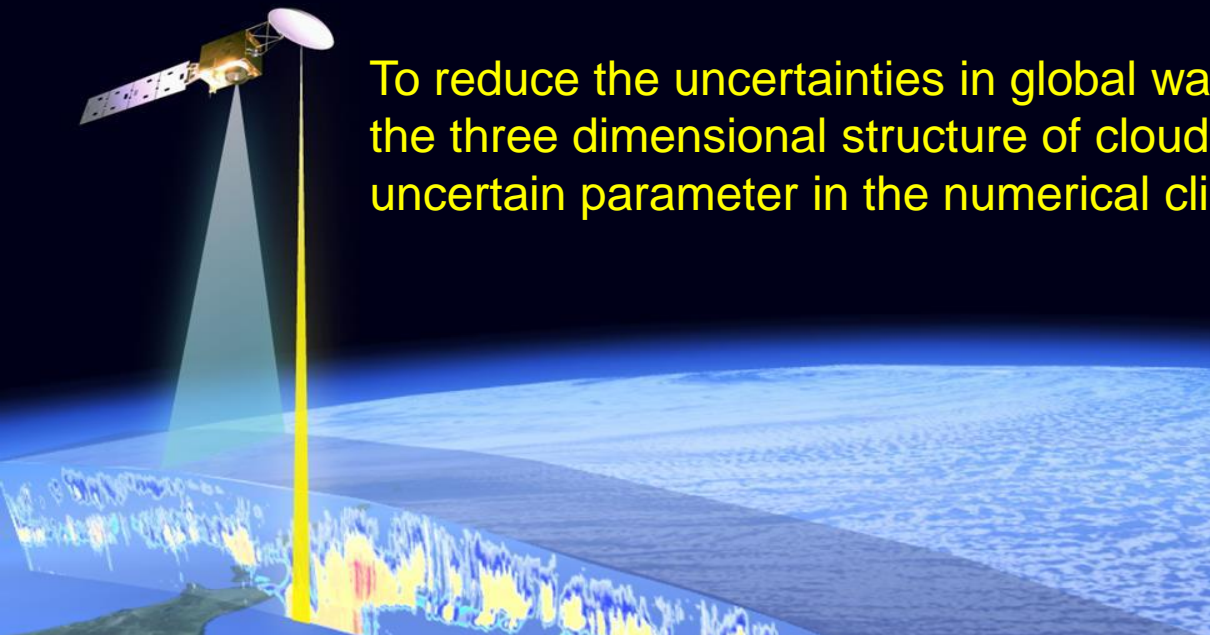
| Upgrade in GOSAT-2 mission		GOSAT achievement	GOSAT target
Measurement precision	0.5 ppm for CO_2 5 ppb for CH_4	←2ppm for CO_2 ←12ppb for CH_4	←4 ppm for CO_2 ←32 ppb for CH_4
Flux estimation	1000km for land	←2000km in sub-continental scale	
Anthropogenic emission	CO to distinguish emission source		
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)

To reduce the uncertainties in global warming prediction by measuring the three dimensional structure of clouds and aerosols, which are most uncertain parameter in the numerical climate models.

Characteristics	
Life	3 years
Orbit	Sun-Synchronous (around 400km)
Mass/Power	About 2.2 t/ about 3.4 kw
Launch	FY 2019 (TBC)
Instruments	CPR: Cloud Profiling Radar (JAXA/NICT) ATLID: Atmospheric Lidar (ESA) MSI: Multi-Spectral Imager (ESA) BBR: Broadband Radiometer (ESA) Satellite bus: Airbus DS Satellite launch: ESA
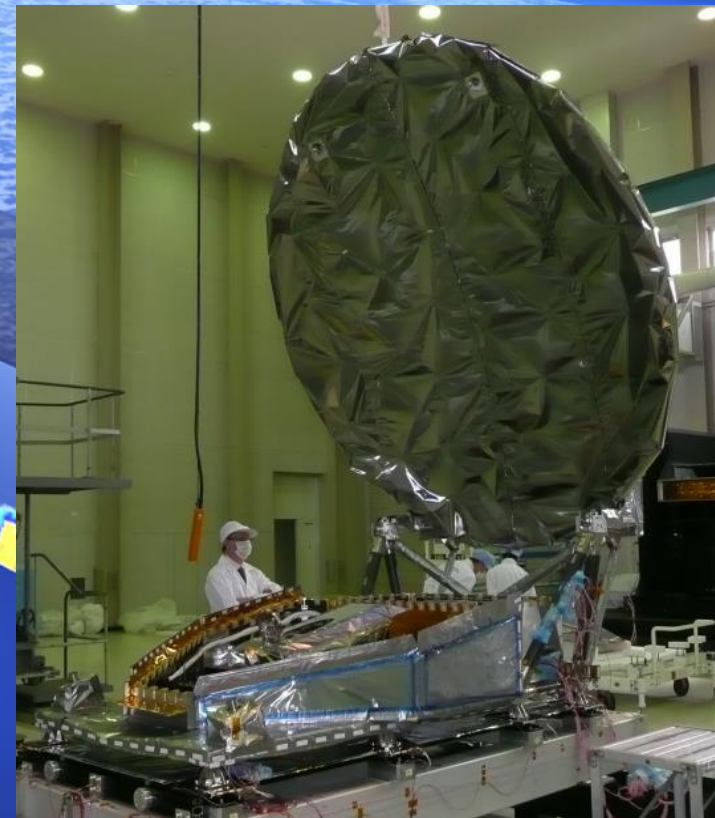
CPR (Cloud Profile Radar)

ALOS successors: Advanced Optical Satellite and Radar Satellite
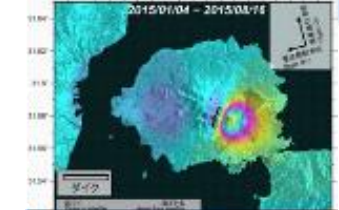
Advanced Optical Satellite (ALOS-3)

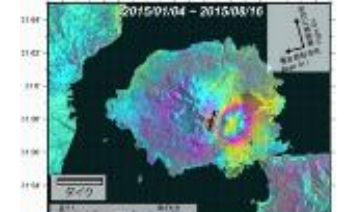### Hazard Map

High Precision 1/25,000 Map (C) GSI

Characteristics

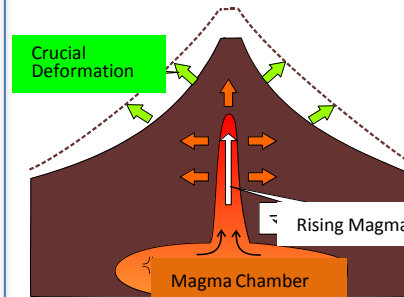| Life	7 years
Orbit	Sun-Synchronous (670km)
Mass	About 2.7 t
Launch	FY 2020
Resolution	Panchromatic : 0.8m (swath: 70km) Multi: 3.2m (swath: 70km)

Advanced Radar Satellite (ALOS-4)

Modeling

Observation

Crucial Deformation

Rising Magma

Magma Chamber

Estimate situation of magma chamber under the ground and faulting

Take a decision for evacuation

Characteristics

Life	7 years
Orbit	Sun-Synchronous (628km)
Mass	About 3 t
Launch	FY 2020
Resolution	Spotlight 1 × 3 m (swath: 35km) Strip map 3/6/10m (swath: 200km) ScanSAR 25m (swath: 700km)

Thank you very much for your attention.

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