Training session –GSMaP –

Moeka YAMAJI
Earth Observation Research Center
Japan Aerospace Exploration Agency

Tackling Extreme Precipitation Events Workshop -Indo-Pacific region
Training Session, March 3, 2023, online

Training session –GSMaP –

- *Overview of GSMaP*
- *Introduction of use cases*
- *Algorithm of GSMaP*

} 40 mins

～Q&A～

☕ *Break* ☕

- *Demonstration of the GSMaP website*
- *Data access and tools*

} 25 mins

～Q&A～

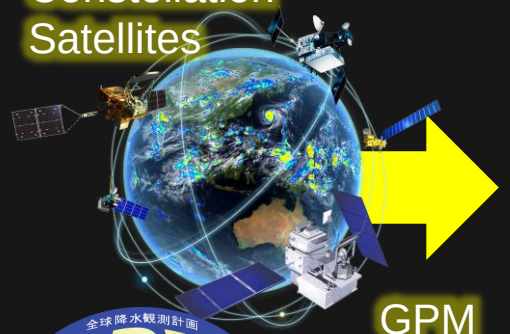
GSMaP

GLOBAL SATELLITE MAPPING OF PRECIPITATION

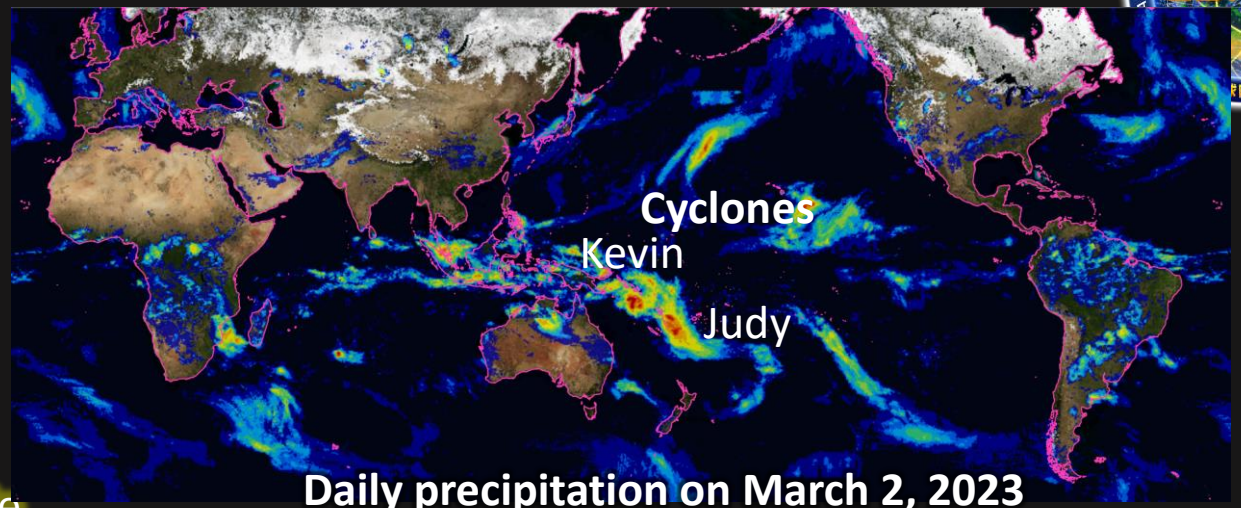
Overview of Global Satellite Mapping of Precipitation (GSMaP)

Satellite-based global rainfall map:

GPM Constellation Satellites



GPM Core Satellite



Daily precipitation on March 2, 2023

衛星全球降水マップ

GSMaP

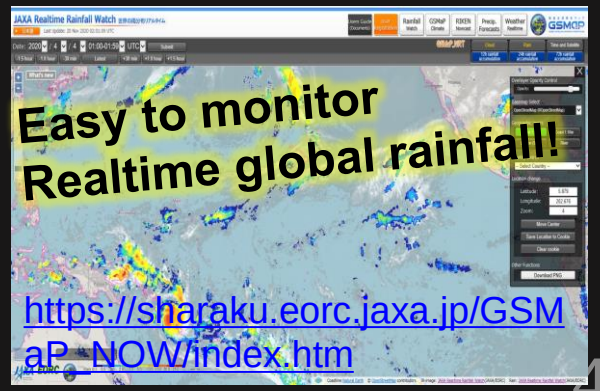
GLOBAL SATELLITE MAPPING OF PRECIPITATION

- **Hourly global** rainfall data
- Spatial resolution: about **11x11km**
- Various version such as **real-time for monitoring** or **long-term gauge-adjusted for climatological purposes**

10,839
registered users
from 148
countries/regions
(as of February 2023)
+ website users
(not registered)

The unique advantage of GSMaP

- Space-based rainfall observations allow us to capture the rainfall even in the area lack of ground-based observations.
- Rainfall can be measured globally, continuous and same interval, and consistent accuracy.
- Open and freely available via web-based GUI, FTP site and data analysis cloud platforms (ex. Tellus, GEE)
- Long-term archive data for more than 20 years (since 2000)



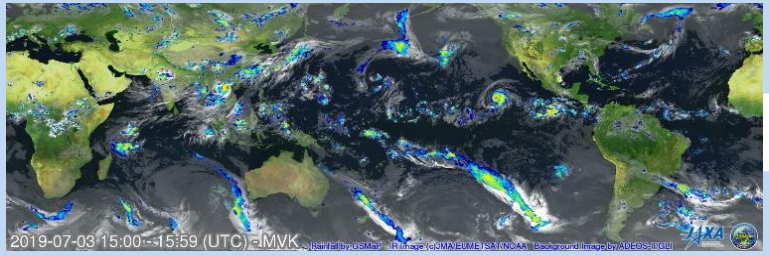
https://sharaku.eorc.jaxa.jp/GSMaP_NOW/index.htm

Multi Satellite Rainfall Product＝GSMaP

Long-term!

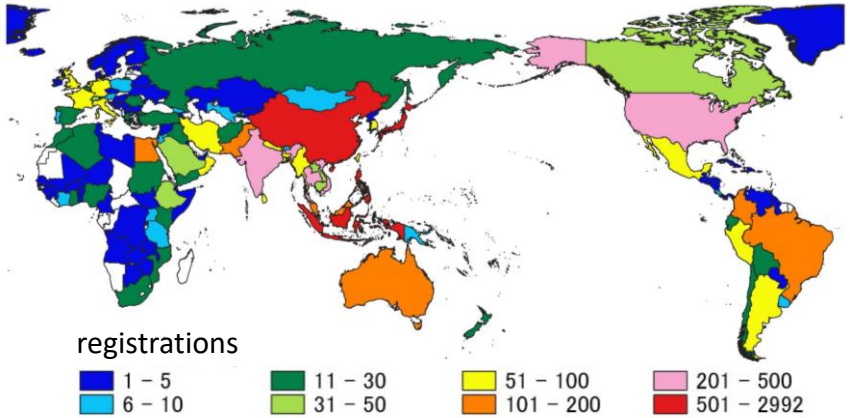
Statistics!

Realtime!



There are many Asian and Oceania users

For downloading data, quick registration is required for users. Many Asian users analyze the GSMaP dataset for various purposes.

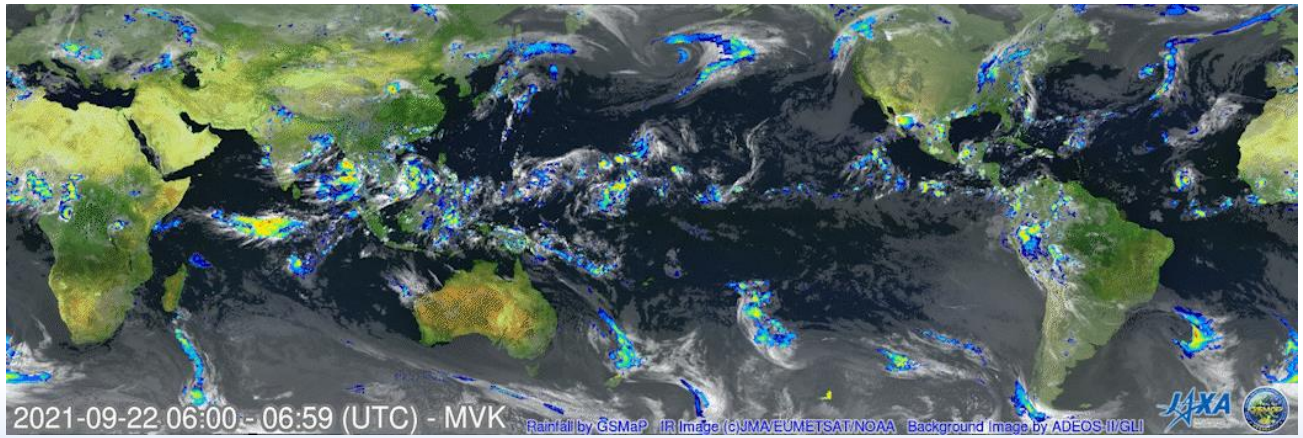


Japan	Indonesia	China	India	Vietnam	Thailand	Philippines
2992 Users	2096 Users	719 Users	488 Users	256 users	320 users	789 users

For monitoring real-time rainfall, website is a useful tool. Users can use the website without registration, so that many users from pacific islands use it for realtime rainfall monitoring.

https://sharaku.eorc.jaxa.jp/GSMaP_NOW/index.htm

Various application fields



Climate monitoring	Weather Monitoring/ forecasts	Water-related disasters	Agriculture	Energy	Public health	Educations
						
WMO extremes monitoring	Asia-oceania met services	Flood analysis and predictions by disaster management offices	Flood security and insurance for farmers	Hydropower development planning	Researches on infectious diseases	Educational tools

Use cases are collected in the book “Case studies demonstrated by TRMM/GPM/GSMaP”

https://www.eorc.jaxa.jp/GPM/doc/data_utilization/latest_jireishu_e.pdf

GSMaP Family

We provide various kind of GSMaP for various utilization purposes

Based on multi-satellites

GSMaP MVK (standard)	GSMaP NRT (near-realtime)	GSMaP NOW (realtime)
* 3-day latency * past duration available since Mar2000	* 4-hour latency * past duration available since Mar2000	* On quasi-realtime (a few minutes latency)

Gauge-adjusted using NOAA/CPC daily precipitation (Chen et al. 2008)

GSMaP Gauge (standard)	GSMaP Gauge NRT (near-realtime)	GSMaP Gauge NOW (realtime)
* 3-day latency * past duration available since Mar2000	* 4-hour latency * past duration available since Mar2000	* On quasi-realtime (a few minutes latency)

Expected Purposes

Long-term Analysis for climate, Agricultural monitor	Flood Analysis and/or prediction	Weather Realtime Monitoring

GSMaP

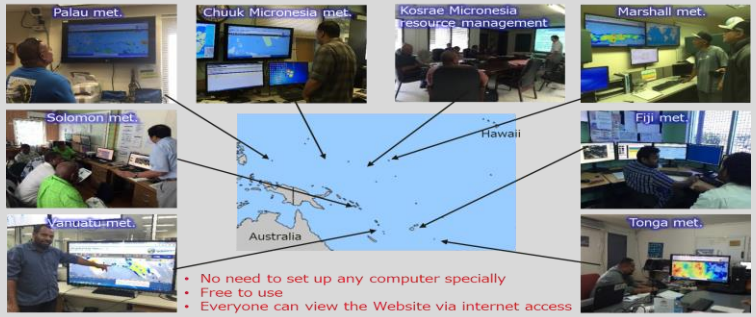
GLOBAL SATELLITE MAPPING OF PRECIPITATION

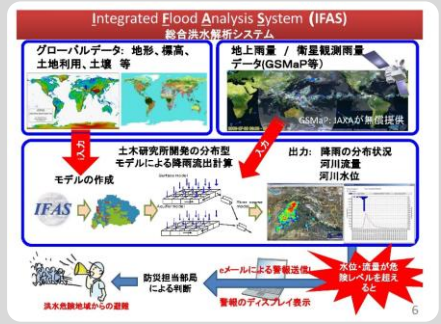
Introduction of use cases

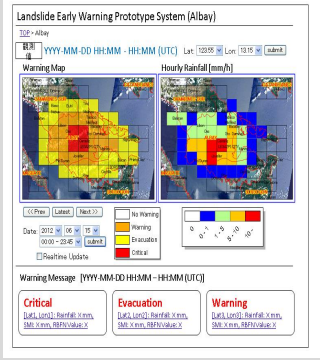
Overview of the GSMaP applications

Weather monitoring, Disaster Risk Reduction and Management

- Cyclone/Heavy rainfall monitoring
- Flood forecasting (with ground rain gauge) for areas with limited/lack of ground-based observations system
- Real time landslide warning with spatial risk information

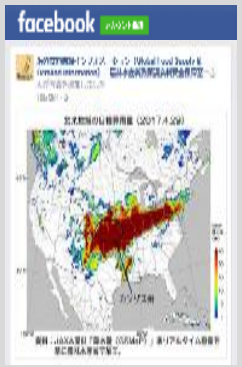


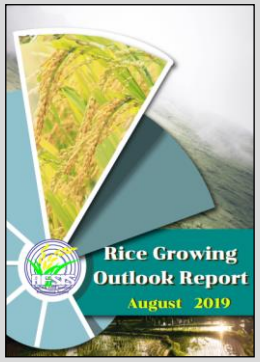


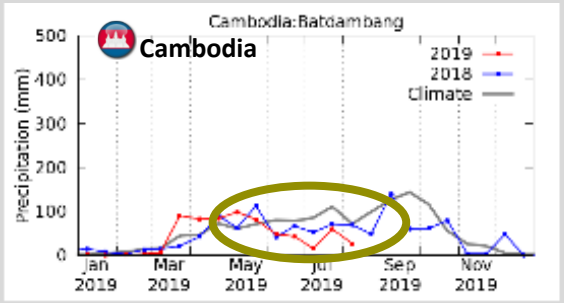


Agriculture and Food Security

- Global and near real time drought and heavy rain monitoring for national/regional food security
- Weather index based insurance for agriculture

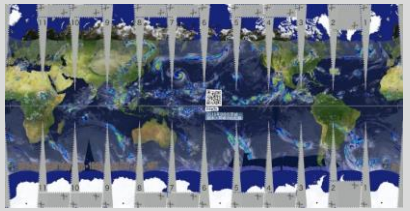






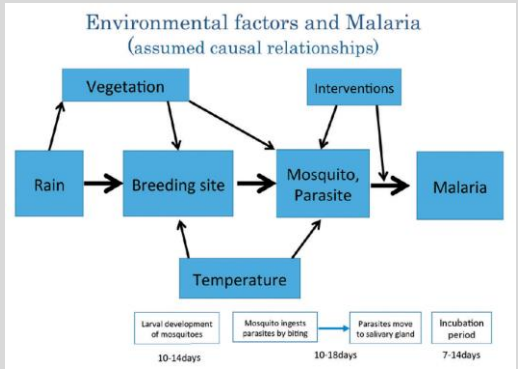
http://www.aptfsis.org/publication

Educations



Dagick Team
https://www.dagik.net/

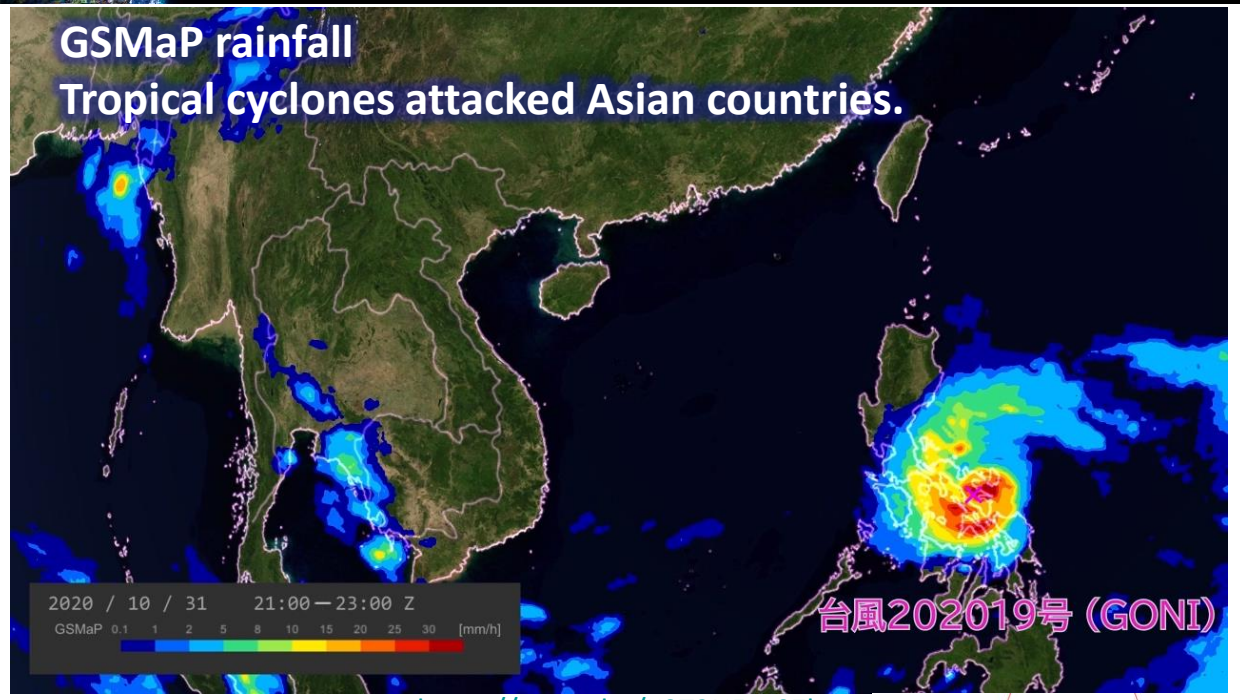
Public Health



https://www.eorc.jaxa.jp/GPM/doc/data_utilization/2019_jireishu_j.pdf

Others
Climate monitoring etc.

Cyclone Monitoring



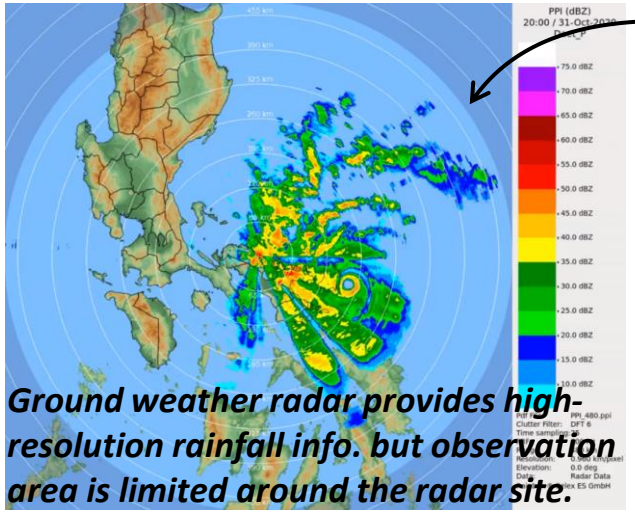
https://youtu.be/K9T2N5sa9Zk

We would like to express our sincere condolences to all who were affected by Typhoon Rolly/Goni.

Space-based information like GSMaP can help;

- *capturing the amount and distributions of rainfall even over the oceans and the area lack of ground-based observations*
- *as a complementary tool of ground-based radars in case of trouble and unavailability*

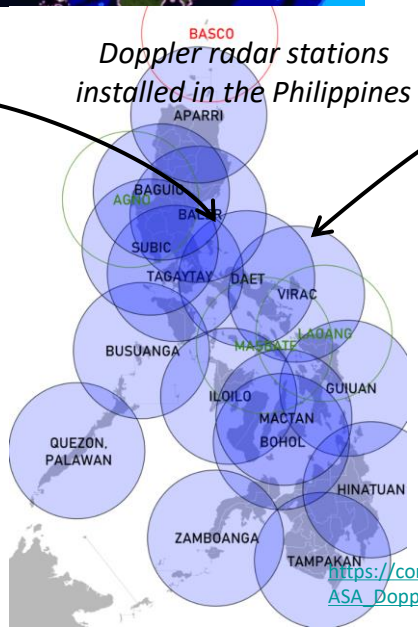
Radar image at Daet station by PAGASA



Ground weather radar provides high-resolution rainfall info. but observation area is limited around the radar site.

https://twitter.com/dost_pagasa/status/1322645728213176320

Doppler radar stations installed in the Philippines



https://commons.wikimedia.org/wiki/File:PAGASA_Doppler_Radar_Network.png

Typhoons are usually approaching from the eastern ocean.
-> Virac radar can play an important role for rainfall monitoring.

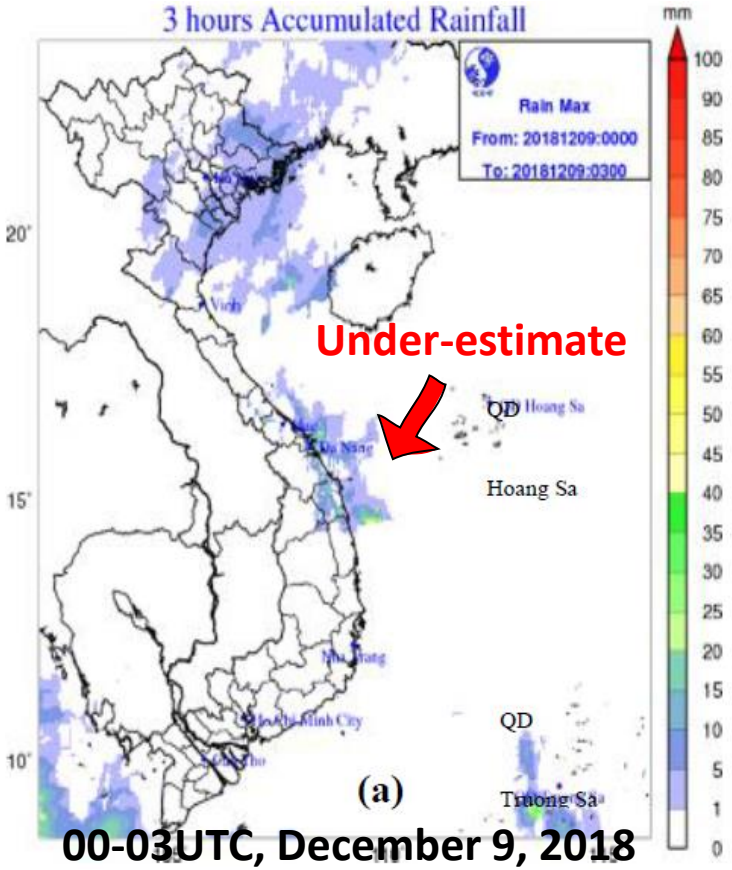
Photo from PAGASA / MANILA BULLETIN
https://mb.com.ph/2020/11/03/pagasa-weather-radar-among-rolly-casualties-in-catanduanes/

GSMaP for Quantitative Precipitation Estimation (QPE)

Saito et al. 2020, VNJHM

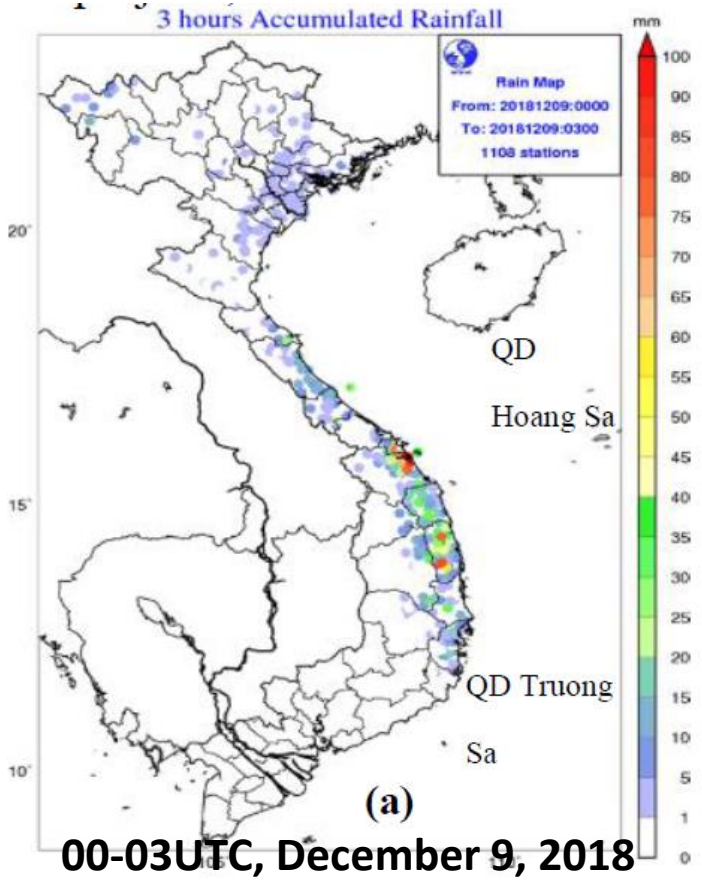
VietNam Meteorological and Hydrological Administration (VNMHA) uses GSMaP data for QPE, leading to improve the under-estimation.

Precipitation analysis by VNMHA



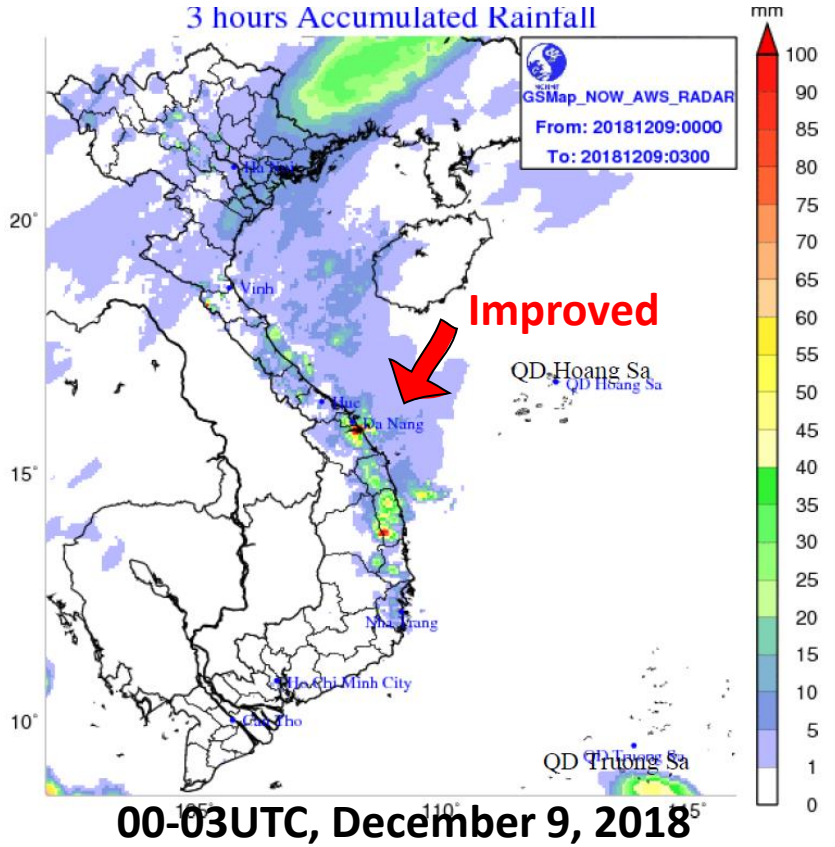
00-03UTC, December 9, 2018

RainGauge precipitation
by automated weather stations



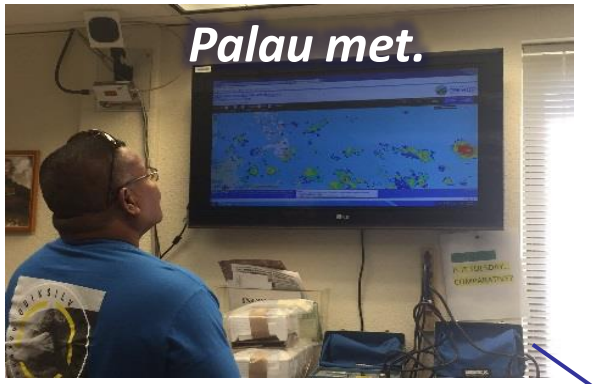
00-03UTC, December 9, 2018

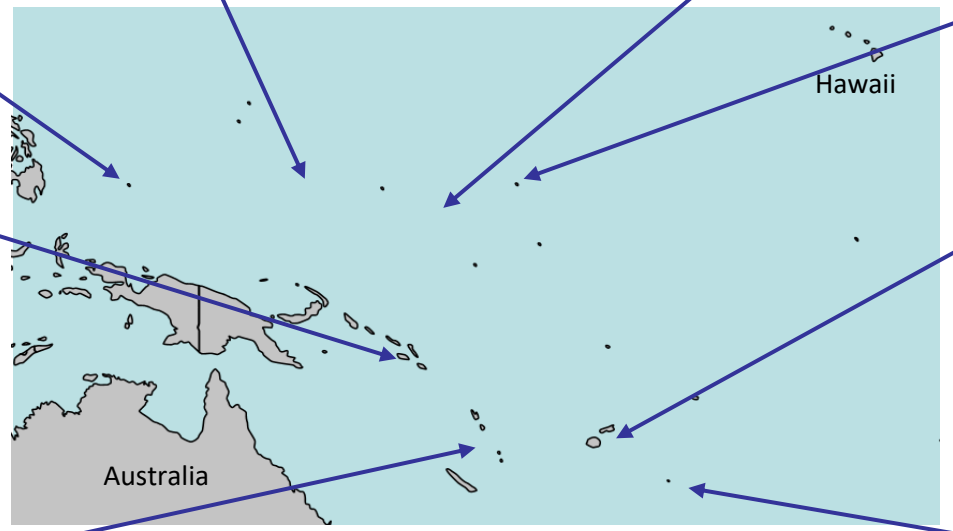
Modified precipitation analysis using
AWS and radars with GSMaP data

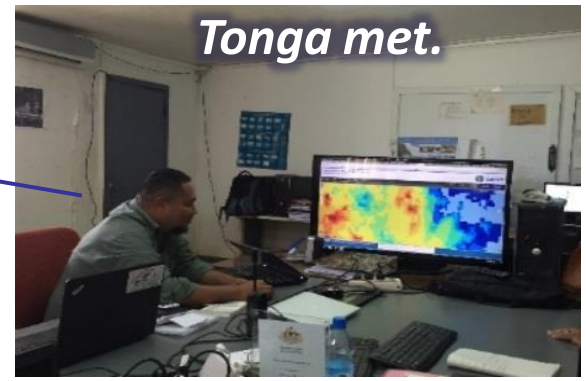


00-03UTC, December 9, 2018

Utilization in Pacific Islands







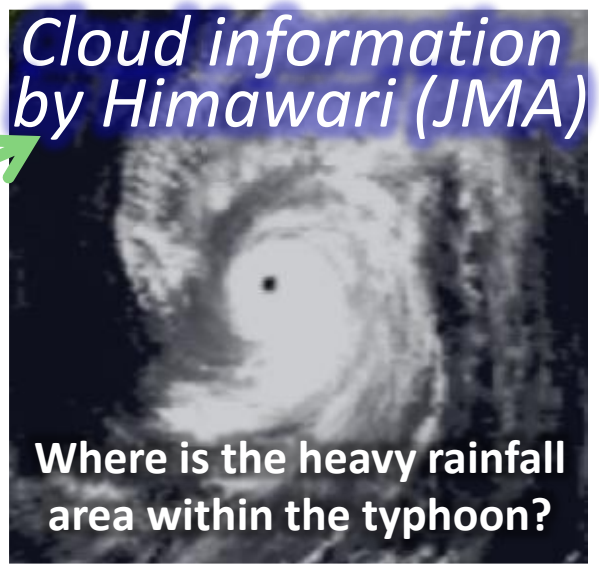
GSMaP has been used for "realtime" rainfall monitoring by meteorological services in Pacific Islands.

Combination of Himawari and GSMaP

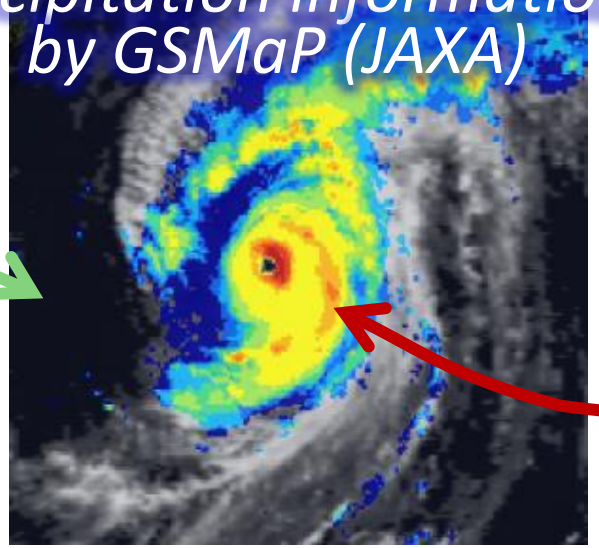
High-resolution (both spatial and temporal) Cloud information

Hourly-0.1deg resolution but based on directory observed precipitation information

Cloud information by Himawari (JMA)



Precipitation information by GSMaP (JAXA)

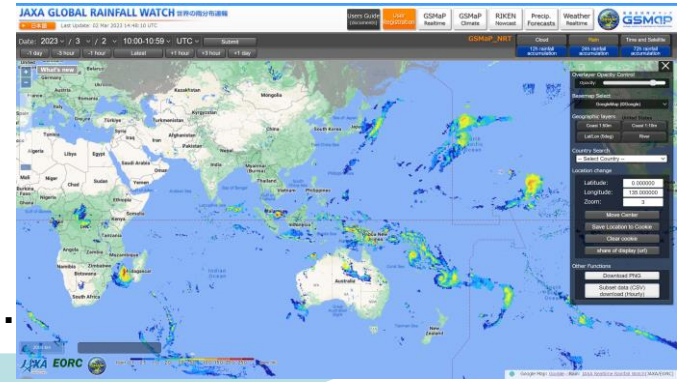


- Cloud information by Himawari provides essential information to monitor the locations of precipitation systems moving by minutes.
- In addition to the fine resolution cloud information, GSMaP can provide the rainfall information which is important for the “quantitative” rainfall monitoring.

Tropical cyclones do not always have a symmetrical precipitation structure.

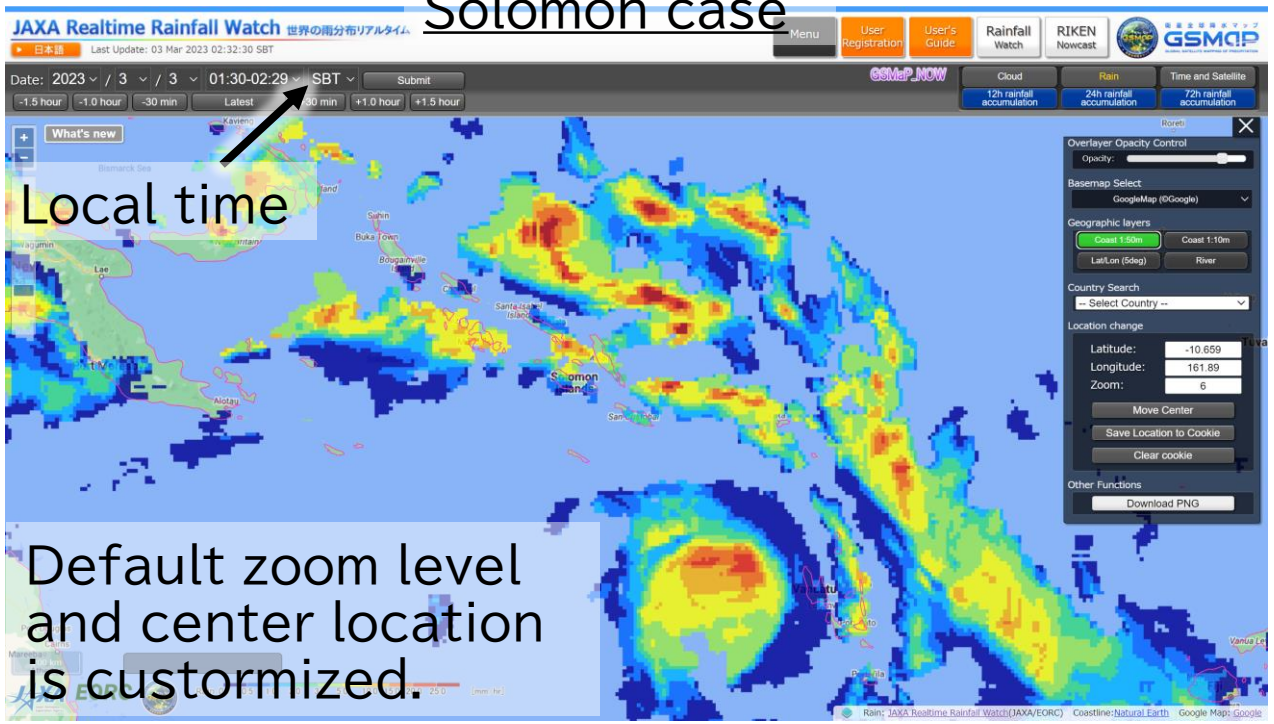
Monitoring Rainfall over islands

The default zoom level of GSMaP website too large to monitor rainfall over small islands…



We prepare some GSMaP websites to support small islands to monitor the realtime rainfall.

Solomon case



- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/mauritius.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/chuuk.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/cook.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/fiji.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/french_polynesia.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/guam.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/kiribati.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/kosrae.htm
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- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/solomon.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/tokelau.htm
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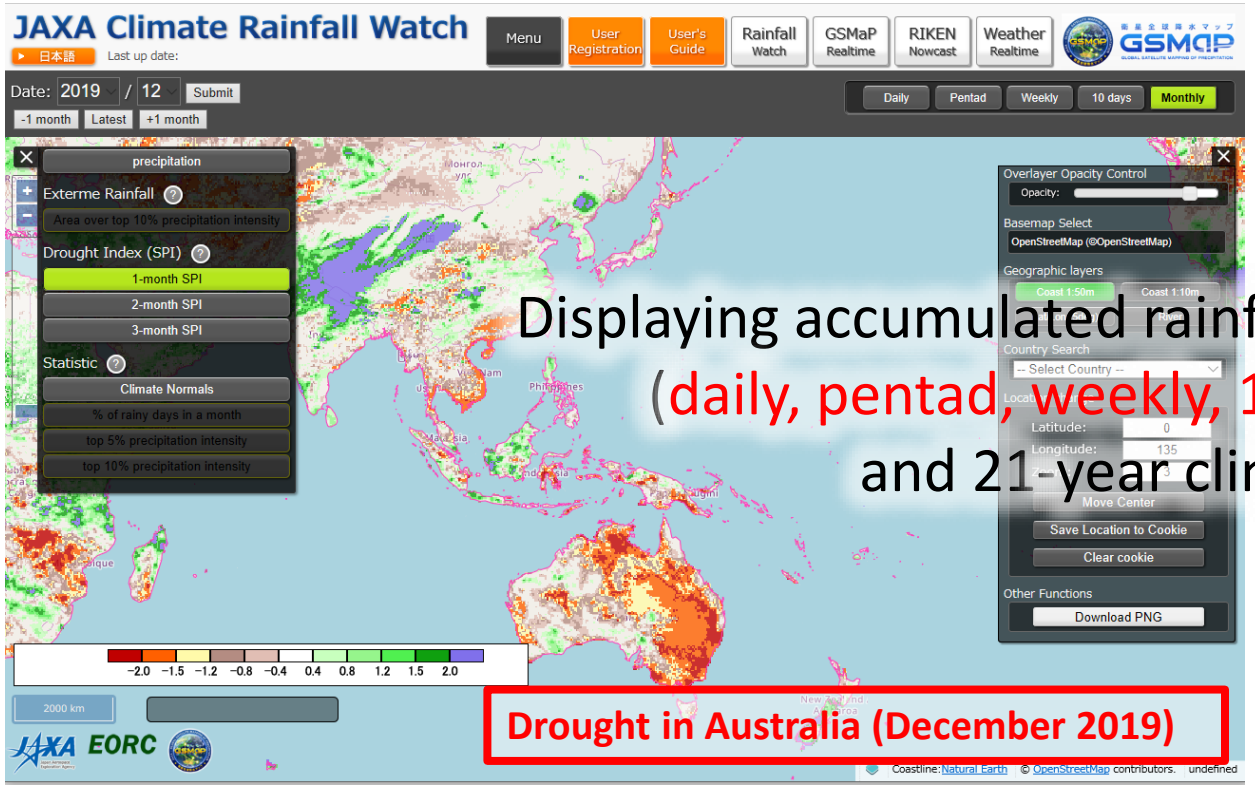
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/vanuatu.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/wallis_and_futuna.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/yap.htm

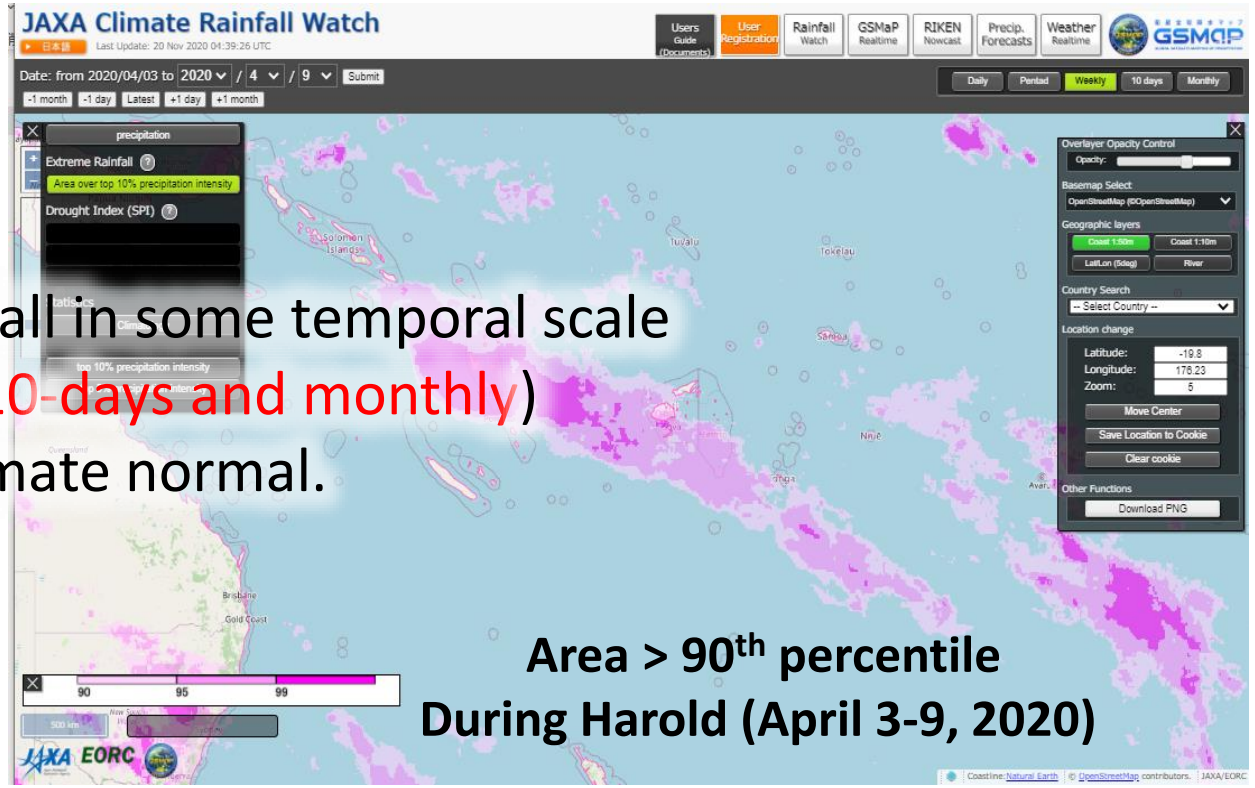
Drought and Heavy Rainfall Monitoring

We started to operate a website "**JAXA Climate Rainfall Watch**", which provides information about **extreme drought and heavy rainfall** over the world based on the GSMaP statistics.



Drought in Australia (December 2019)

Displaying accumulated rainfall in some temporal scale
(daily, pentad, weekly, 10-days and monthly)
and 21-year climate normal.



Area > 90th percentile During Harold (April 3-9, 2020)

Graphical User Interface of the "JAXA Climate Rainfall Watch" website (https://sharaku.eorc.jaxa.jp/GSMaP_CLM/)

We are collaborating with World Meteorological Organization on this topic and providing the region-subset data to Asia-Pacific regions. Recently, we are discussing with WMO, African countries, and EUMETSAT to provide of GSMaP data to agencies in African regions for contributing to Climate Risk and Early Warning Systems.

Utilization of GSMaP Climate product in Indonesia

BMKG

THE FLOOD AND STRONG WIND EVENT IN THE SOUTH SULAWESI ON FEBRUARY 13TH, 2023.

- Satellite product from JAXA which may be potential used in operational rainfall analysis related to climate perspective for extreme weather events (extreme rain events) is **GSMAP Climate products**
- https://sharaku.eorc.jaxa.jp/GSMaP_CLM/index.htm

Extreme Rainfall

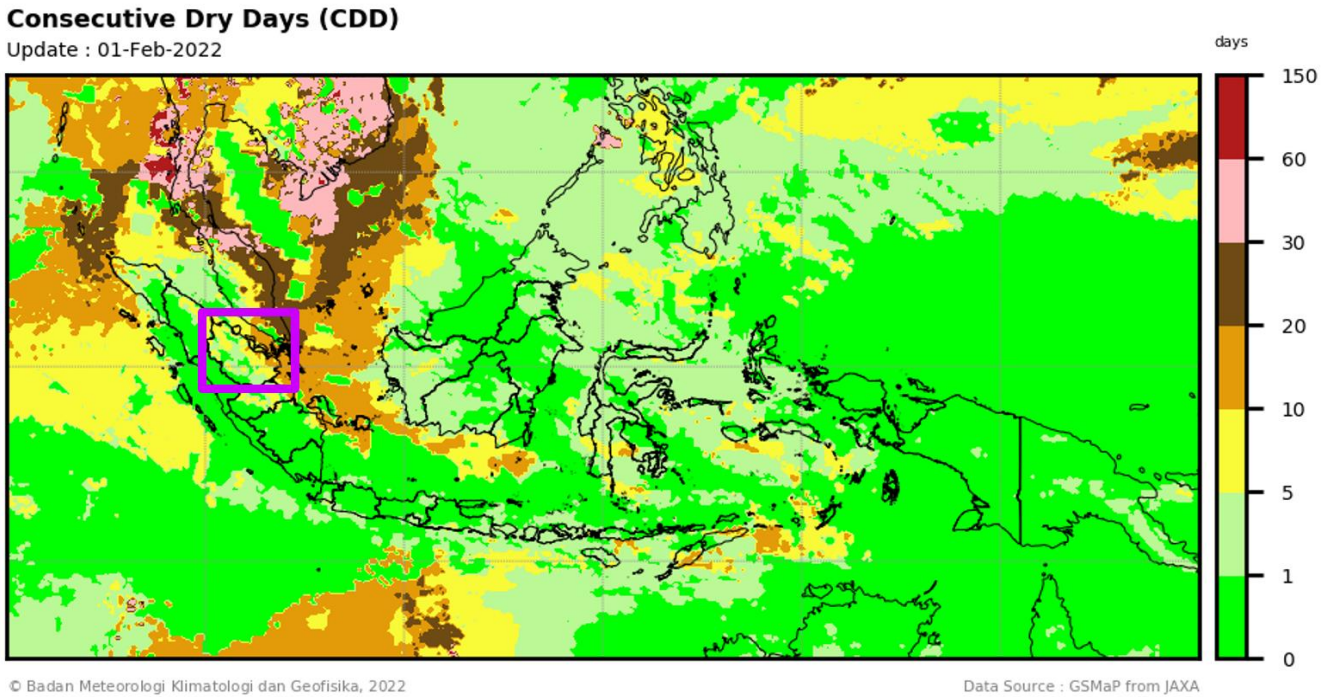
- Heavy Rainfall Criterion
  The heavy rainfall criterion is the top 10% precipitation intensity (90th percentile) over the 22 years (April 2000 to March 2022).
- Extreme Rainfall
  An area where "mean rainfall amount exceeds the criterion" and "the heavy rainfall criterion is 1 mm/day or more" is colored as an area of extreme rainfall. The value is the corresponding from 90th to 99th percentile values.

Presentation by BMKG

Utilization of GSMaP Climate product in Indonesia

BMKG

FOREST FIRE EVENTS ON FEBRUARY 2022 IN PROVINCE OF RIAU



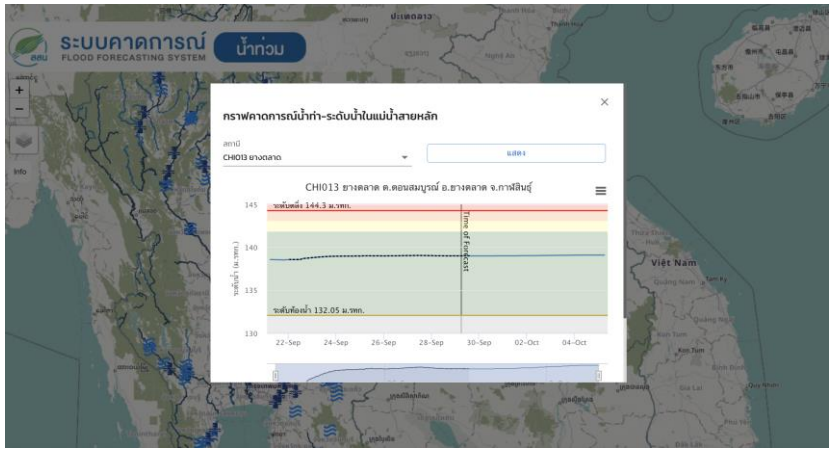
Presentation by BMKG

Hydrological applications in Thailand

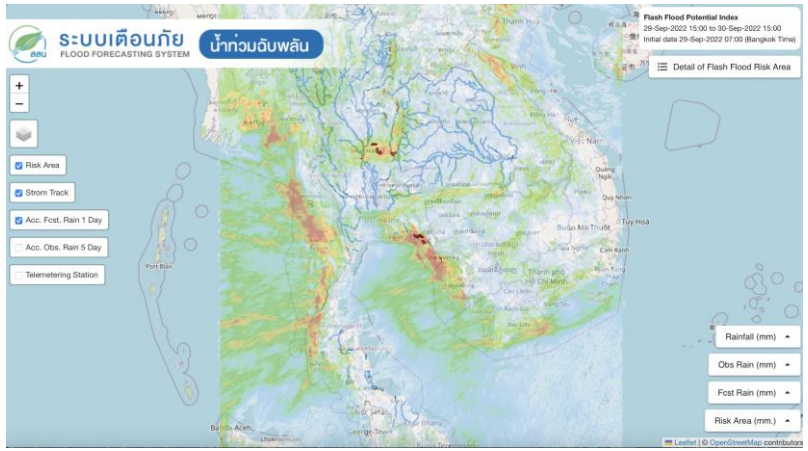
- Since January 2017, **Hydro-Informatics Institute (HII), Thailand** has developed methods to use GSMaP products as input in their flood forecasting system (Chi and Mun river basins) to simulate more realistic runoff and generate areal rainfall for early warning monitoring system.
- In 2019, GSMaP-NOW data are used as input for flash flood potential index calculation and rainfall monitoring system. HII's applications from GSMaP products are used by stakeholders and water related agencies to support water resource management and flood early warning in Thailand.

https://www.thaiwater.net/weather/rainfall
https://www.thaiwater.net/floodforecast
https://www.thaiwater.net/FlashFlood
http://live1.hii.or.th/product/latest/rain/gsmap_now/gsmap.html

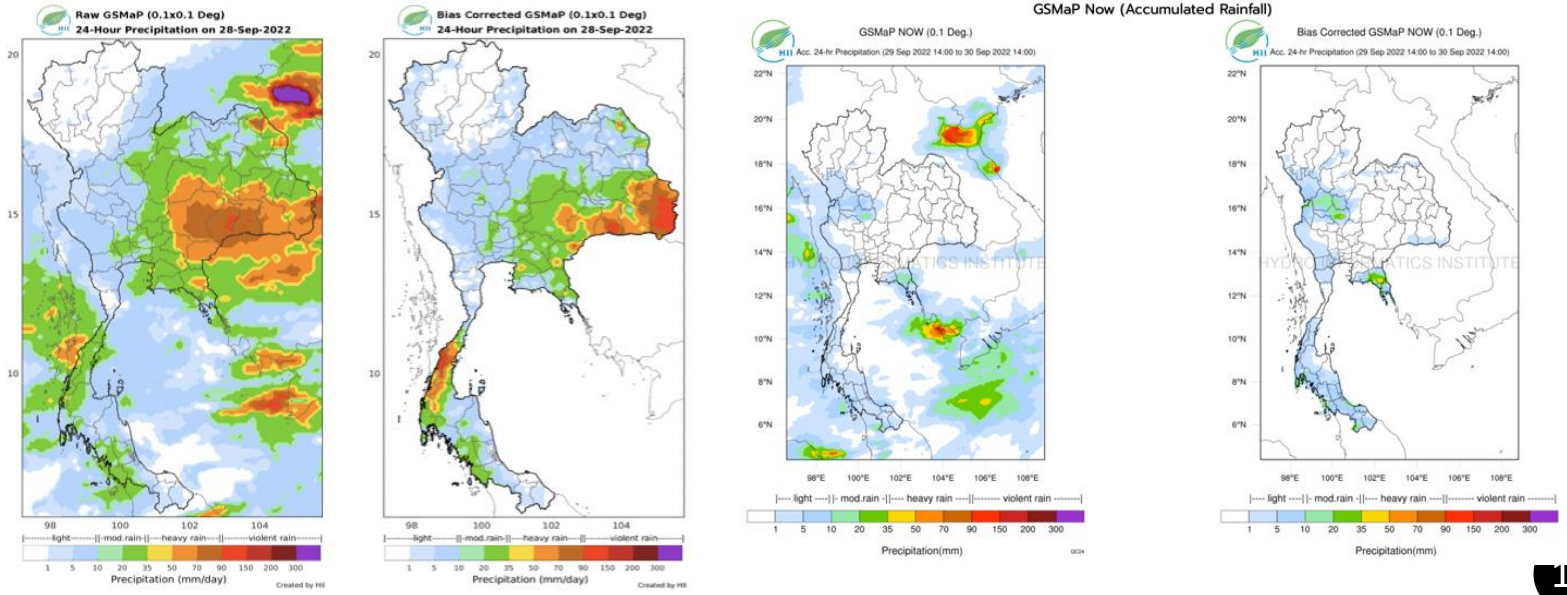
Satellite Rainfall for Flood Forecasting System



GSMaP-NOW for Flash Flood Potential Index

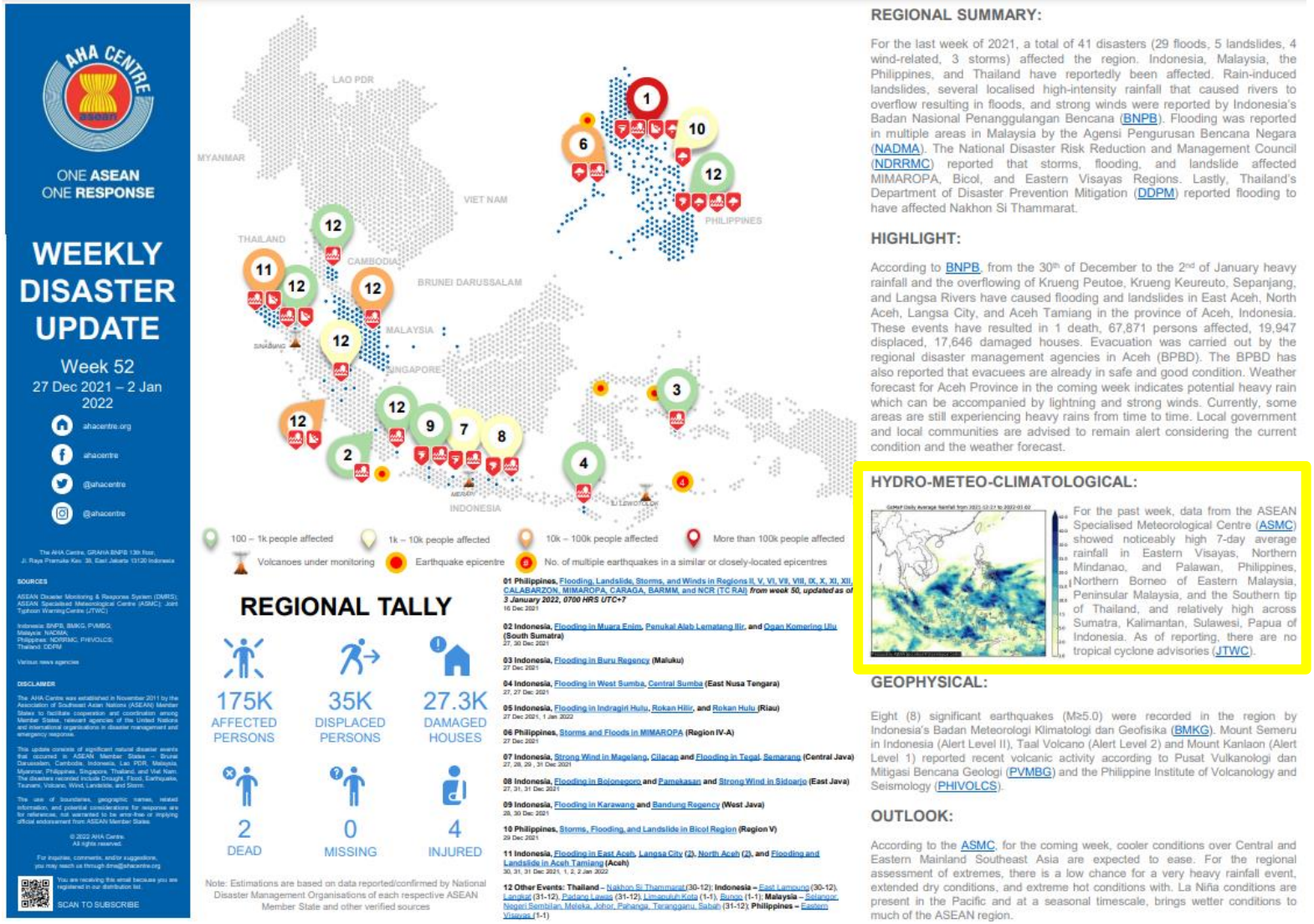


Rainfall Monitoring System



Disaster report at AHA Centre

GSMaP is used in regularly published reports by the ASEAN Coordinating Centre for Humanitarian Assistance on disaster management (AHA Centre).
https://reliefweb.int/report/indonesia/asean-weekly-disaster-update-week-52-27-dec-2021-2-jan-2022



AHA CENTRE

ONE ASEAN
ONE RESPONSE

WEEKLY DISASTER UPDATE

Week 52
27 Dec 2021 – 2 Jan 2022

ahacentre.org
ahacentre
@ahacentre
@ahacentre

The AHA Centre, GRAHA BNPB 13th floor,
Jl. Raya Pramuka Kav. 38, East Jakarta 13120 Indonesia

SOURCES

ASEAN Disaster Monitoring & Response System (DMRS);
ASEAN Specialised Meteorological Centre (ASMC); Joint Typhoon Warning Centre (JTWC)

Indonesia: BNPB, BMKG, PVMBG;
Malaysia: NADMA;
Philippines: NDRRMC, PHIVOLCS;
Thailand: DDPM

Various news agencies

DISCLAIMER

The AHA Centre was established in November 2011 by the Association of Southeast Asian Nations (ASEAN) Member States to facilitate cooperation and coordination among Member States, relevant agencies of the United Nations and international organisations in disaster management and emergency response.

This update consists of significant natural disaster events that occurred in ASEAN Member States – Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam. The disasters recorded include Drought, Flood, Earthquake, Tsunami, Volcano, Wind, Landslide, and Storm.

The use of boundaries, geographic names, related information, and potential considerations for response are for reference, not warranted to be error-free or implying official endorsement from ASEAN Member States.

For inquiries, comments, and/or suggestions, you may reach us through bnsp@ahacentre.org

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SCAN TO SUBSCRIBE

LAO PDR
MYANMAR
VIET NAM
THAILAND
CAMBODIA
BRUNEI DARUSSALAM
MALAYSIA
SINGAPORE
PHILIPPINES
INDONESIA

100 – 1k people affected
1k – 10k people affected
10k – 100k people affected
More than 100k people affected
Volcanoes under monitoring
Earthquake epicentre
No. of multiple earthquakes in a similar or closely-located epicentres

REGIONAL TALLY

175K AFFECTED PERSONS
35K DISPLACED PERSONS
27.3K DAMAGED HOUSES
2 DEAD
0 MISSING
4 INJURED

Note: Estimations are based on data reported/confirmed by National Disaster Management Organisations of each respective ASEAN Member State and other verified sources

01 Philippines, Flooding, Landslide, Storms, and Winds in Regions II, V, VI, VII, VIII, IX, X, XI, XII, CALABARZON, MIMAROPA, CARAGA, BARMM, and NCR (TC RAI) *from week 50, updated as of 3 January 2022, 0700 HRS UTC+7*
16 Dec 2021

02 Indonesia, Flooding in Muara Enim, Penukal Abab Lematang Ilir, and Ogan Komering Ulu (South Sumatra)
27, 30 Dec 2021

03 Indonesia, Flooding in Buru Regency (Maluku)
27 Dec 2021

04 Indonesia, Flooding in West Sumba, Central Sumba (East Nusa Tengara)
27, 27 Dec 2021

05 Indonesia, Flooding in Indragiri Hulu, Rokan Hilir, and Rokan Hulu (Riau)
27 Dec 2021, 1 Jan 2022

06 Philippines, Storms and Floods in MIMAROPA (Region IV-A)
27 Dec 2021

07 Indonesia, Strong Wind in Magelang, Cilacap and Flooding in Tegal, Semarang (Central Java)
27, 28, 29 , 31 Dec 2021

08 Indonesia, Flooding in Bojonegoro and Pamekasan and Strong Wind in Sidoarjo (East Java)
27, 31, 31 Dec 2021

09 Indonesia, Flooding in Karawang and Bandung Regency (West Java)
28, 30 Dec 2021

10 Philippines, Storms, Flooding, and Landslide in Bicol Region (Region V)
29 Dec 2021

11 Indonesia, Flooding in East Aceh, Langsa City (2), North Aceh (2), and Flooding and Landslide in Aceh Tamiang (Aceh)
30, 31, 31 Dec 2021, 1, 2, 2 Jan 2022

12 Other Events: Thailand – Nakhon Si Thammarat (30-12); **Indonesia** – East Lampung (30-12), Langkat (31-12), Padang Lawas (31-12), Limapuluh Kota (1-1), Bungo (1-1); **Malaysia** – Selangor, Negeri Sembilan, Melaka, Johor, Pahang, Terangganu, Sabah (31-12); **Philippines** – Eastern Visayas (1-1)

REGIONAL SUMMARY:

For the last week of 2021, a total of 41 disasters (29 floods, 5 landslides, 4 wind-related, 3 storms) affected the region. Indonesia, Malaysia, the Philippines, and Thailand have reportedly been affected. Rain-induced landslides, several localised high-intensity rainfall that caused rivers to overflow resulting in floods, and strong winds were reported by Indonesia's Badan Nasional Penanggulangan Bencana (BNPB). Flooding was reported in multiple areas in Malaysia by the Agensi Pengurusan Bencana Negara (NADMA). The National Disaster Risk Reduction and Management Council (NDRRMC) reported that storms, flooding, and landslide affected MIMAROPA, Bicol, and Eastern Visayas Regions. Lastly, Thailand's Department of Disaster Prevention Mitigation (DDPM) reported flooding to have affected Nakhon Si Thammarat.

HIGHLIGHT:

According to BNPB, from the 30th of December to the 2nd of January heavy rainfall and the overflowing of Krueng Peutoe, Krueng Keureuto, Sepanjang, and Langsa Rivers have caused flooding and landslides in East Aceh, North Aceh, Langsa City, and Aceh Tamiang in the province of Aceh, Indonesia. These events have resulted in 1 death, 67,871 persons affected, 19,947 displaced, 17,646 damaged houses. Evacuation was carried out by the regional disaster management agencies in Aceh (BPBD). The BPBD has also reported that evacuees are already in safe and good condition. Weather forecast for Aceh Province in the coming week indicates potential heavy rain which can be accompanied by lightning and strong winds. Currently, some areas are still experiencing heavy rains from time to time. Local government and local communities are advised to remain alert considering the current condition and the weather forecast.

HYDRO-METEO-CLIMATOLOGICAL:

For the past week, data from the ASEAN Specialised Meteorological Centre (ASMC) showed noticeably high 7-day average rainfall in Eastern Visayas, Northern Mindanao, and Palawan, Philippines, Northern Borneo of Eastern Malaysia, Peninsular Malaysia, and the Southern tip of Thailand, and relatively high across Sumatra, Kalimantan, Sulawesi, Papua of Indonesia. As of reporting, there are no tropical cyclone advisories (JTWC).

GEOPHYSICAL:

Eight (8) significant earthquakes (M≥5.0) were recorded in the region by Indonesia's Badan Meteorologi Klimatologi dan Geofisika (BMKG). Mount Semeru in Indonesia (Alert Level II), Taal Volcano (Alert Level 2) and Mount Kanlaon (Alert Level 1) reported recent volcanic activity according to Pusat Vulkanologi dan Mitigasi Bencana Geologi (PVMBG) and the Philippine Institute of Volcanology and Seismology (PHIVOLCS).

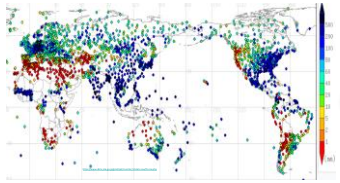
OUTLOOK:

According to the ASMC, for the coming week, cooler conditions over Central and Eastern Mainland Southeast Asia are expected to ease. For the regional assessment of extremes, there is a low chance for a very heavy rainfall event, extended dry conditions, and extreme hot conditions with. La Niña conditions are present in the Pacific and at a seasonal timescale, brings wetter conditions to much of the ASEAN region.

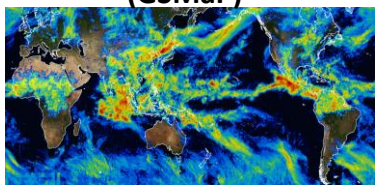
Flood Analysis and Forecasting

Rainfall-Runoff-Inundation model

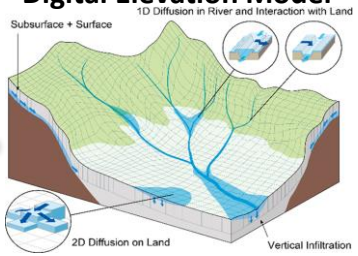
Ground observations



Satellite precipitation (GSMaP)

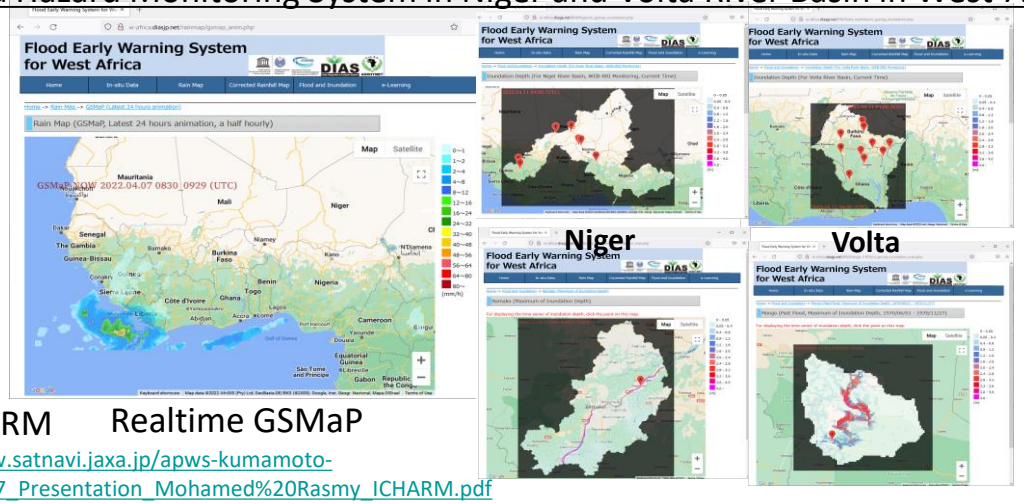


Digital Elevation Model



International Centre for Water Hazard and Risk Management under the auspices of UNESCO (ICHARM) has developed the RRI model that can estimate large-scale floods worldwide in quasi-real time, by using GSMaP. The model is being used for water-related disaster management in some countries, such as Thailand, Philippines, Cambodia, Indonesia, Malaysia, Pakistan etc.

Flood Hazard Monitoring System in Niger and Volta River Basin in West-Africa



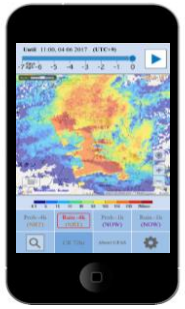
(c) ICHARM Realtime GSMaP

https://www.satnavi.jaxa.jp/apws-kumamoto-2022/doc/07_Presentation_Mohamed%20Rasmy_ICHARM.pdf

Global Flood Alert System-II

Infrastructure Development Institute (IDI) has developed and operated the Global Flood Alert System-II, a system that statistically utilizes long-term GSMaP data and displays on a map the levels of danger in terms of the annual exceedance probability of rainfall (return period), and makes it available on its website.

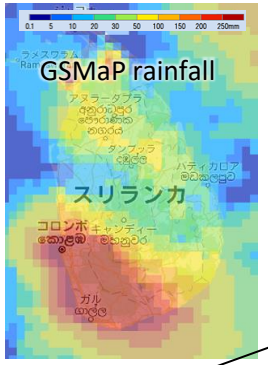
GSMaP rainfall

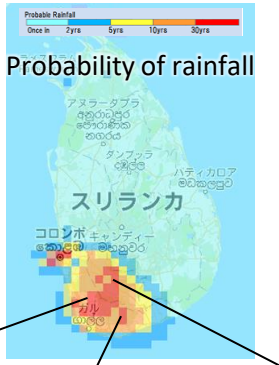


Probability of rainfall

Six languages supports:
English, Japanese, Spanish, German, Vietnamese, and Myanmar.

Case of Sri Lanka on May 24, 2017





(c) EU（ECHO）

(c) Sri Lanka Red Cross

(c) AFP

(c) Sri Lanka Red Cross

Landslide Warning System

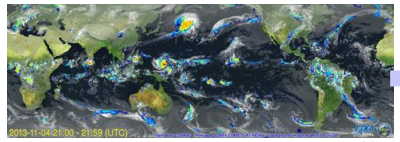
GSMaP based Landslide Warning System (GLWS)

- 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

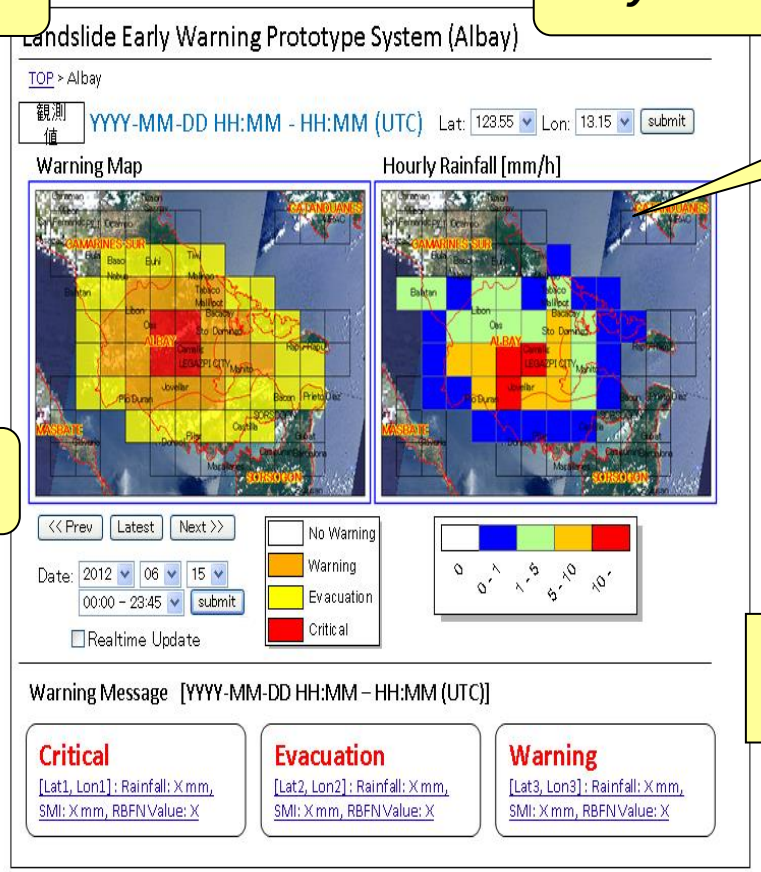


Calibrated rainfall data via GSMaP IF

Ground-based Rainfall data

Automatic prediction

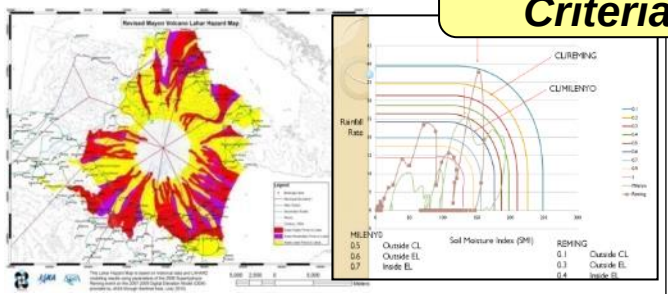
System



GLWS can provide spatial distribution of landslide risk

Model preparation

Hazard maps, Criteria



Maps

Warning criteria

Application

Analysis /warning

Agency/Local gov.

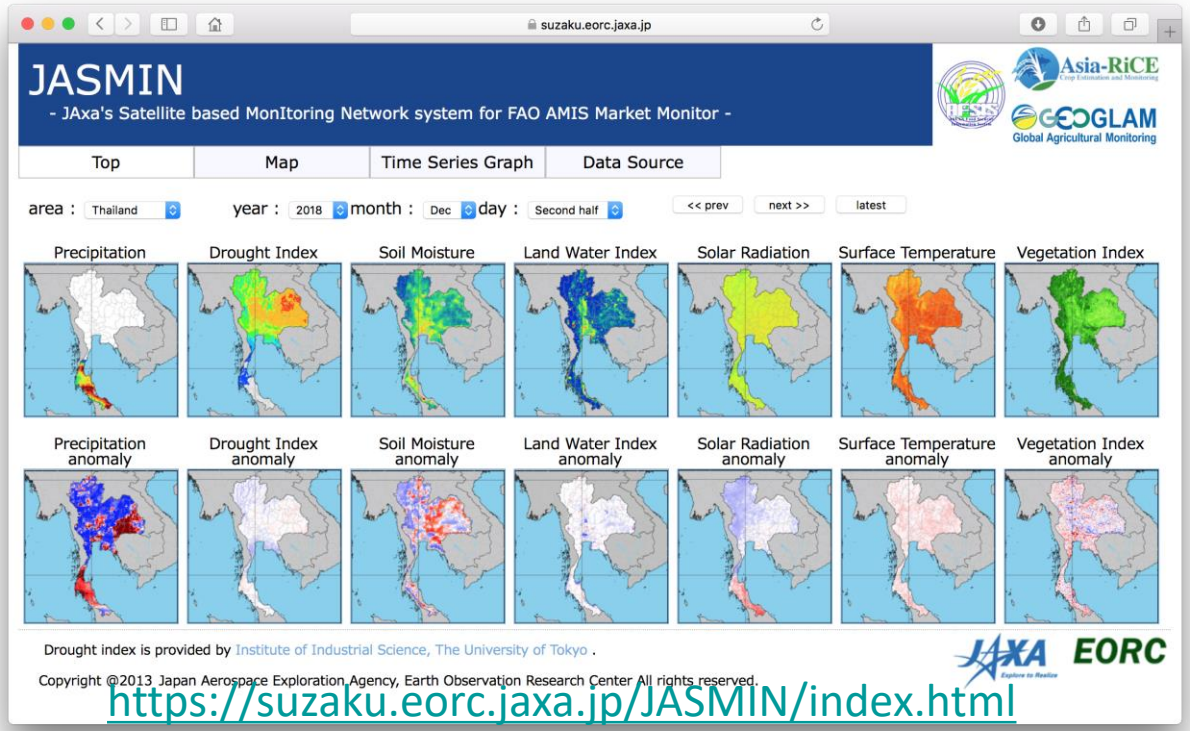
The warning criteria method applied in this system is also used in the Japan Meteorological Agency (rainfall by ground-based radar is used instead).

This system using GSMaP can be applied for regions lack of ground-based rainfall observations.

Agro-meteorology Information Provision System (JASMIN)

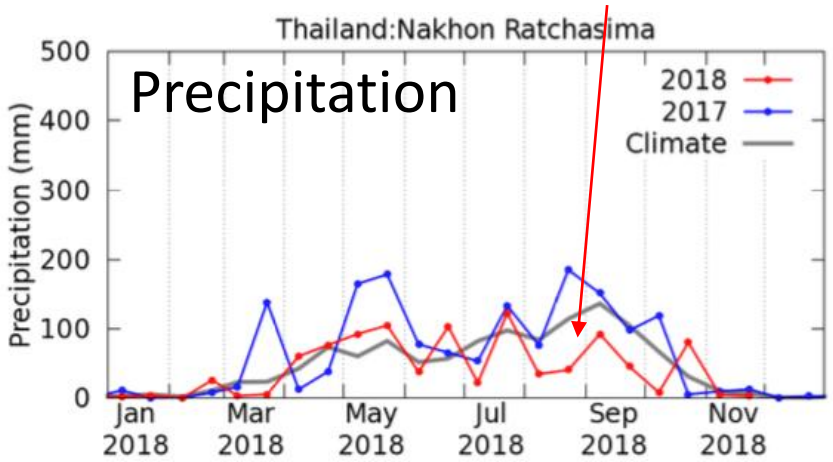
JASMIN developed by JAXA provides satellite-based various agro-met data for monitor.

- GEOGLAM was endorsed by the G20 Summit, aims to enhance regional and global agricultural production estimates through the use of Earth observations [Meeting of G20 Agriculture Ministers, G20 France 2011 Summit final declaration, 2011]
- Asian agencies are implementing **Asia-RiCE (Asia Rice Crop Estimation & Monitoring)** to strengthen **rice crop** monitoring ability **by using remote sensing**, which is a component for GEOGLAM.



https://suzaku.eorc.jaxa.jp/JASMIN/index.html

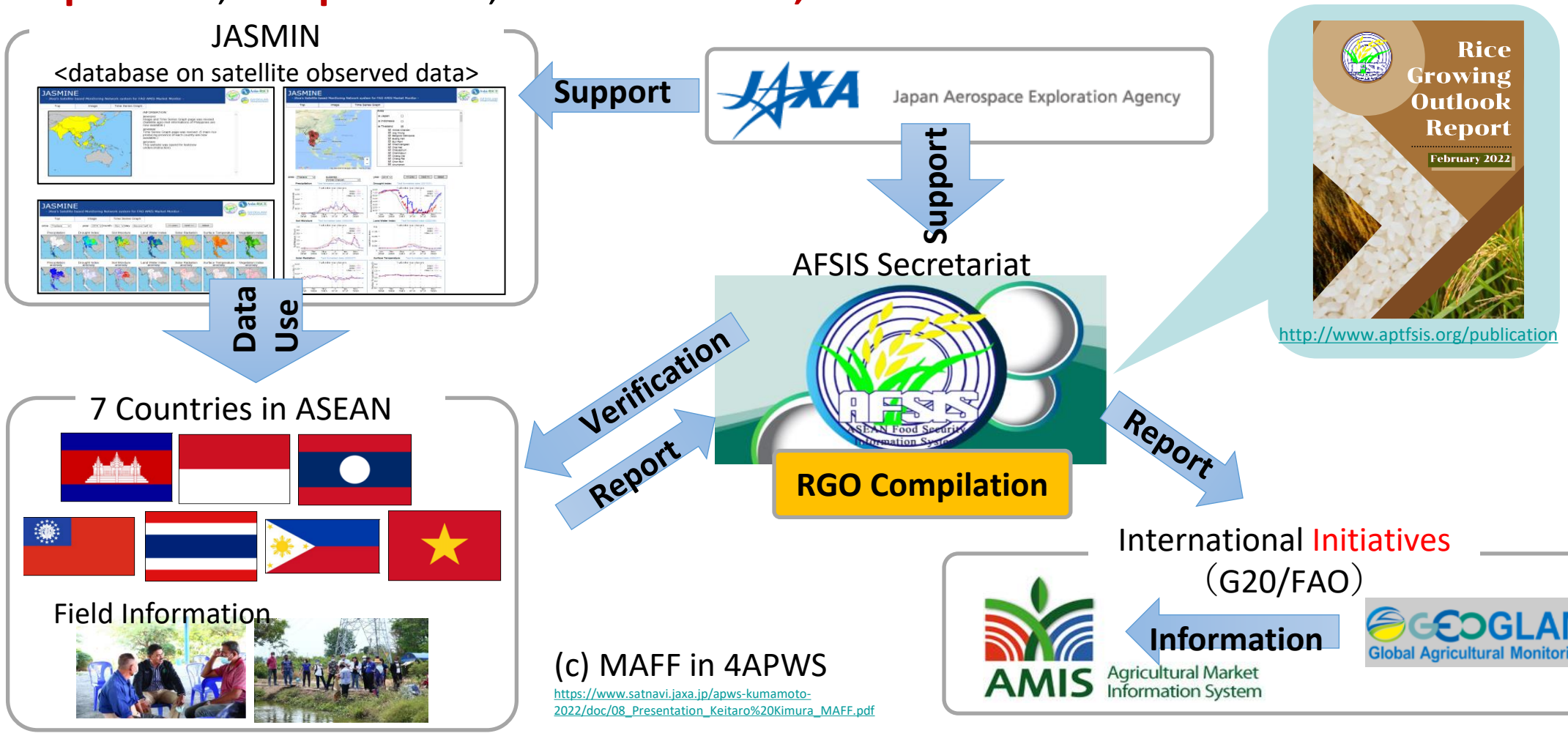
Assessment Example : Expected to poor yield of Northeastern region due to the shortage of rainfall in grain filling stage (Thailand, Dec 2018)



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

Rice Growing monitoring system

- Work with **agricultural statisticians in ASEAN countries and the ASEAN Food Security Information System (AFSIS)** to publish monthly **Rice Growing Outlook (RGO) report**
- Utilize local information with satellite derived agrometeorological information such as **precipitation**, **temperature**, **solar radiation, and soil moisture etc.**

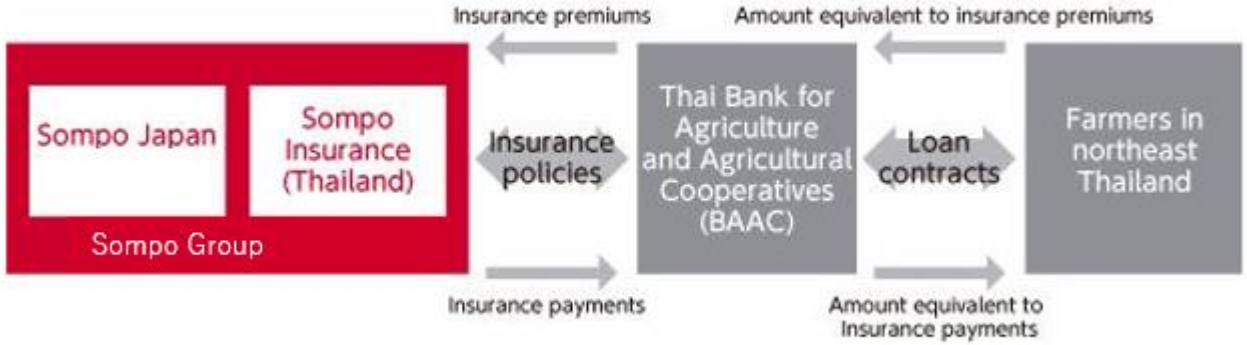


(c) MAFF in 4APWS
https://www.satnavi.jaxa.jp/apws-kumamoto-2022/doc/08_Presentation_Keitaro%20Kimura_MAFF.pdf

Weather Index Insurance for famers

Insurance for farmers in Asian region

- Weather index insurance is available for farmers of "longan" (tropical fruit) and "sugarcane" in Thailand.



Drought makes it difficult to continue operations when crops are damaged by drought.

Insurance payments are made when it is determined to be a drought, so that even if crops are damaged, the farmers can continue the agricultural business.

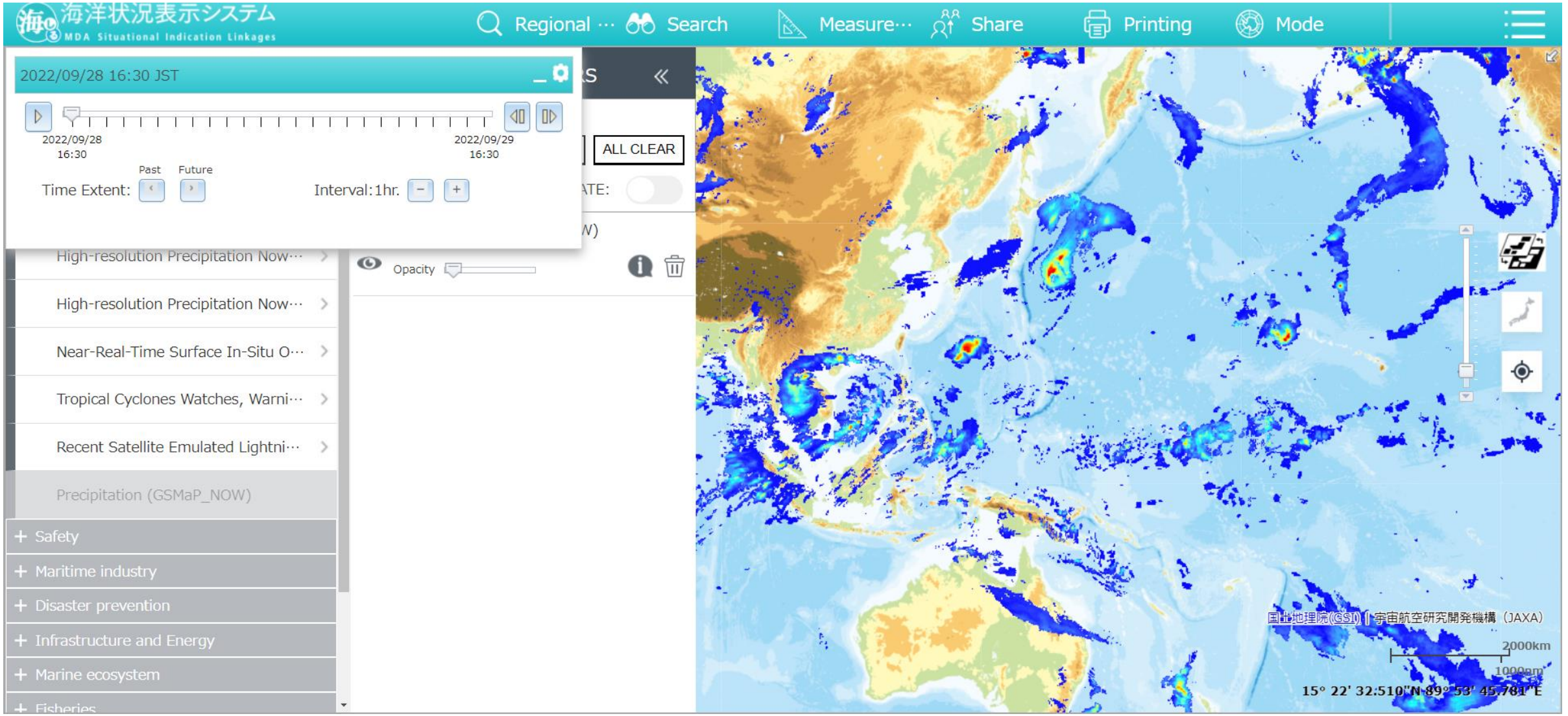
Even if income is insufficient due to lack of harvest, the insurance proceeds can be used to purchase seeds for the next season.

GSMaP is used to determine “drought”, which is important information for the insurance in the region lack of ground-based rainfall information.

https://www.sompo-hd.com/en/csr/action/community/content4/

Maritime Domain Awareness (MDA) by Japan Coast Guard

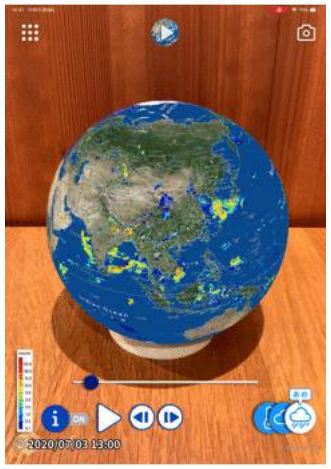
GSMaP is used in the MDA Situational Indication Linkages (MSIL) by Japan Coast Guard, which is an information service that aggregates various marine data held by relevant ministries and government agencies and shows the data on maps.



Satellite products for Educations

“Hobonichi Globe”, an Augmented Reality (AR) globe

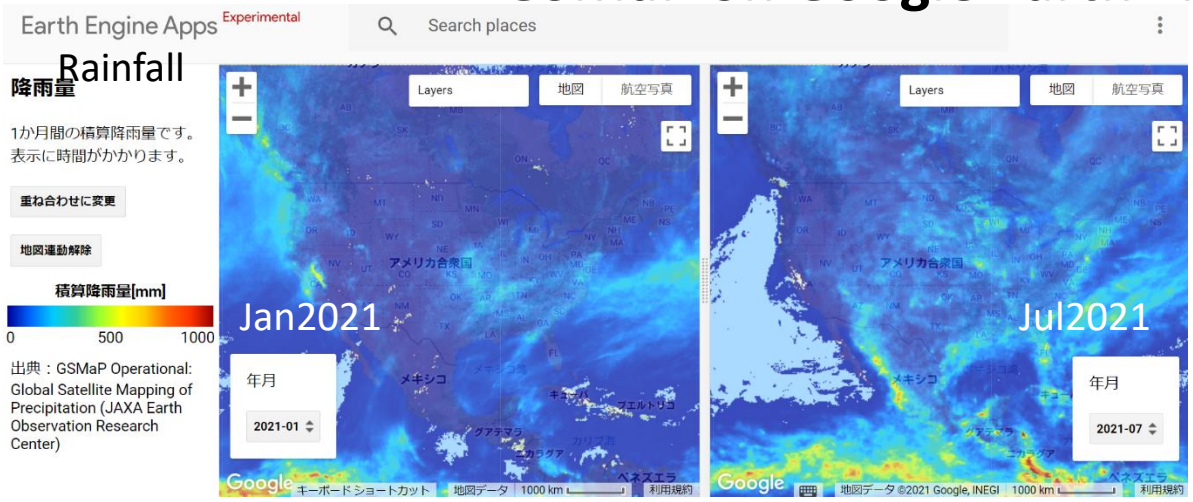
https://earthball.1101.com/en/



HOBONICHI, a Japanese private company, uses GSMaP realtime rainfall image to show the Earth's current status on the AR globe.

When you view the Hobonichi Globe with a smartphone or tablet, you can see the Earth's current status, including GSMaP rainfall.

GSMaP on Google Earth Engine for education



https://gakkoushien.users.earthengine.app/view/rainfallr2

In Japan’s GIGA School Program, each elementary school student uses each one PC to learn ICT skills.
JAXA provides GEE apps using monthly GSMaP rainfall data to support the study of global rainfall climatology.

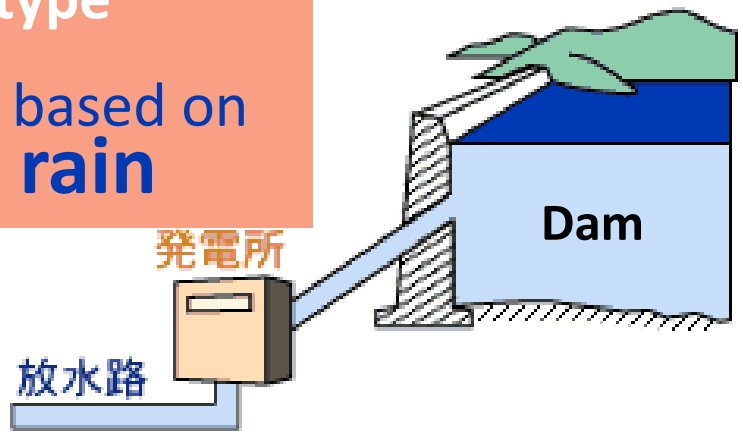
Hydro-power development planning

- Since 2018, the JAXA and the J-POWER (Electric Power Development Company in Japan) have studied the hydropower development planning using the GSMaP data.
- A joint paper by the J-Power and the JAXA was published in November 2020.
  - The paper describes the GSMaP data can be helpful in the hydropower development planning with consideration of error tendencies (sorry for the Japanese language) .

Pondage type

↓

Operations are based on **monthly rain**



Mori, T., S. Nakamura, and M. Yamaji, 2020: Potential use of Global Satellite Mapping of Precipitation (GSMaP) for River Runoff Estimation in Hydropower Development Studies. Electric Power Civil Engineering. (in Japanese)

https://www.enecho.meti.go.jp/category/electricity_and_gas/electric/hydroelectric/mechanism/use/

GSMaP

GLOBAL SATELLITE MAPPING OF PRECIPITATION

Algorithm of GSMaP

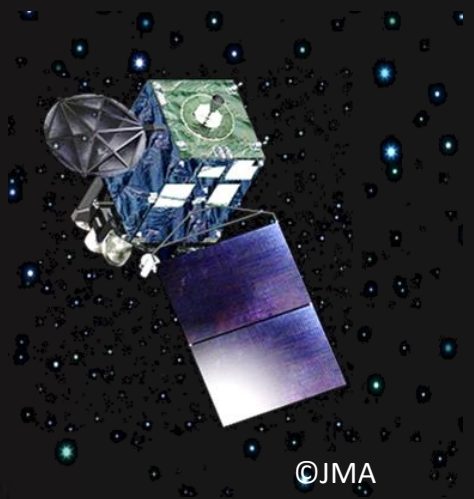
GSMaP Global Satellite Mapping of Precipitation

Dual-frequency Precipitation Radar

DPR

DPR provides "reference standard"

GPM Microwave Imager



GPM Core Observatory

GPM constellation satellites

+

Geostationary Satellites

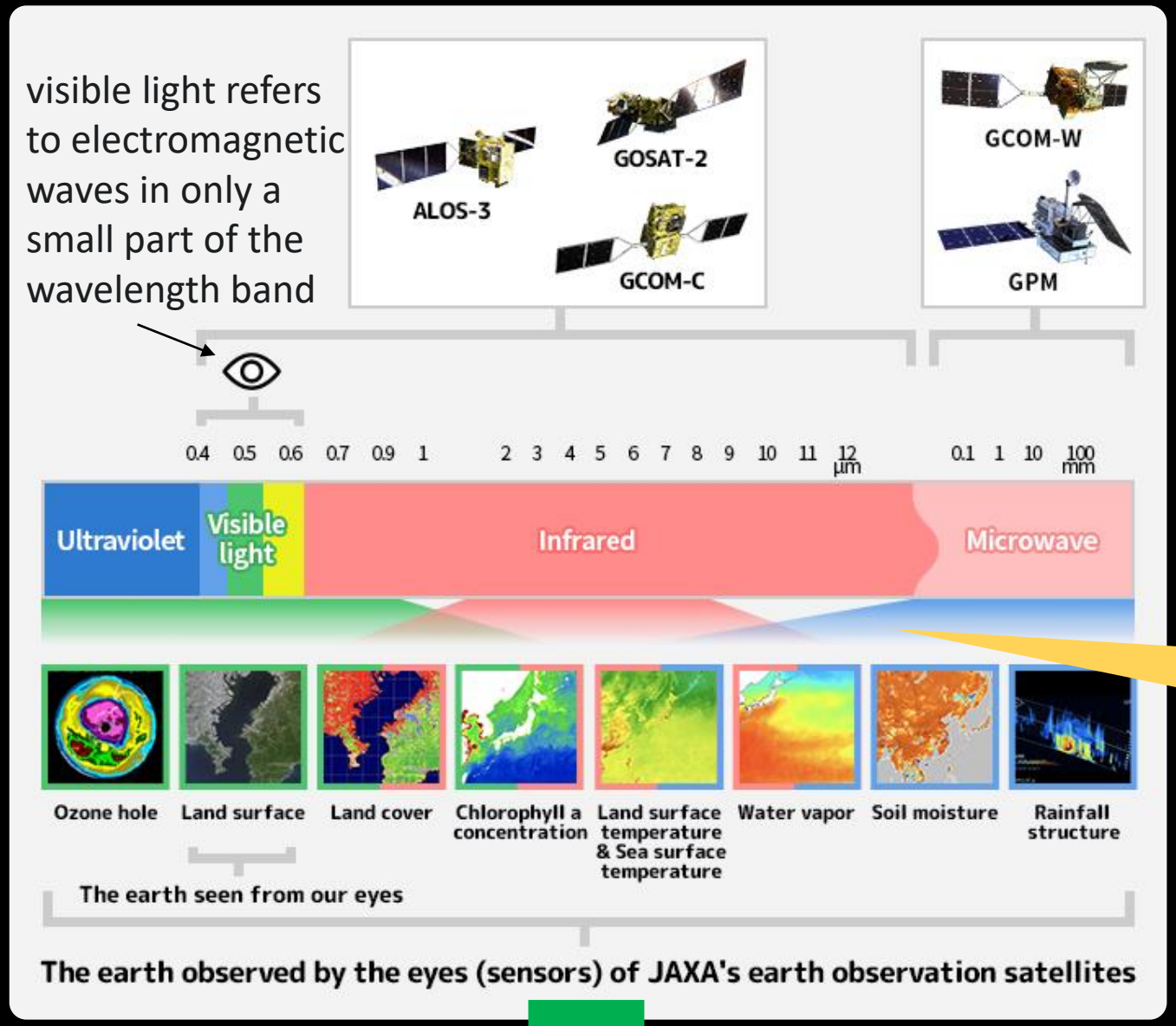
Precipitation Radar

Microwave Radiometer

Infrared Imager

How can these different sensors be used in the algorithm?

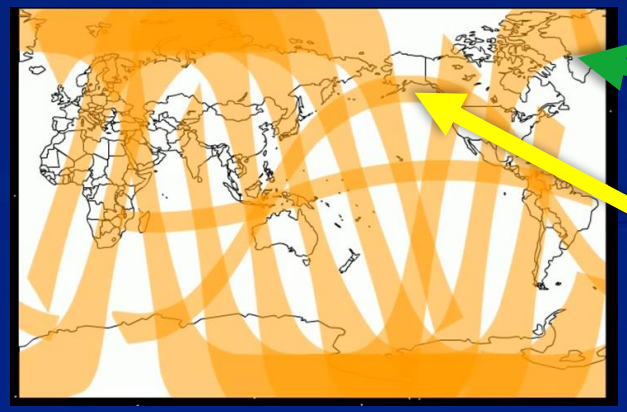
Remote sensing by Earth observation satellites



The electromagnetic waves in the visible, infrared, and microwave wavelengths are widely used in Earth observations.

Earth Observation Research Center (EORC), in JAXA develops algorithms to generate "products" or "information" from "signals" of satellite observations.

Science and Application Users all over the world!



Orbit of satellites

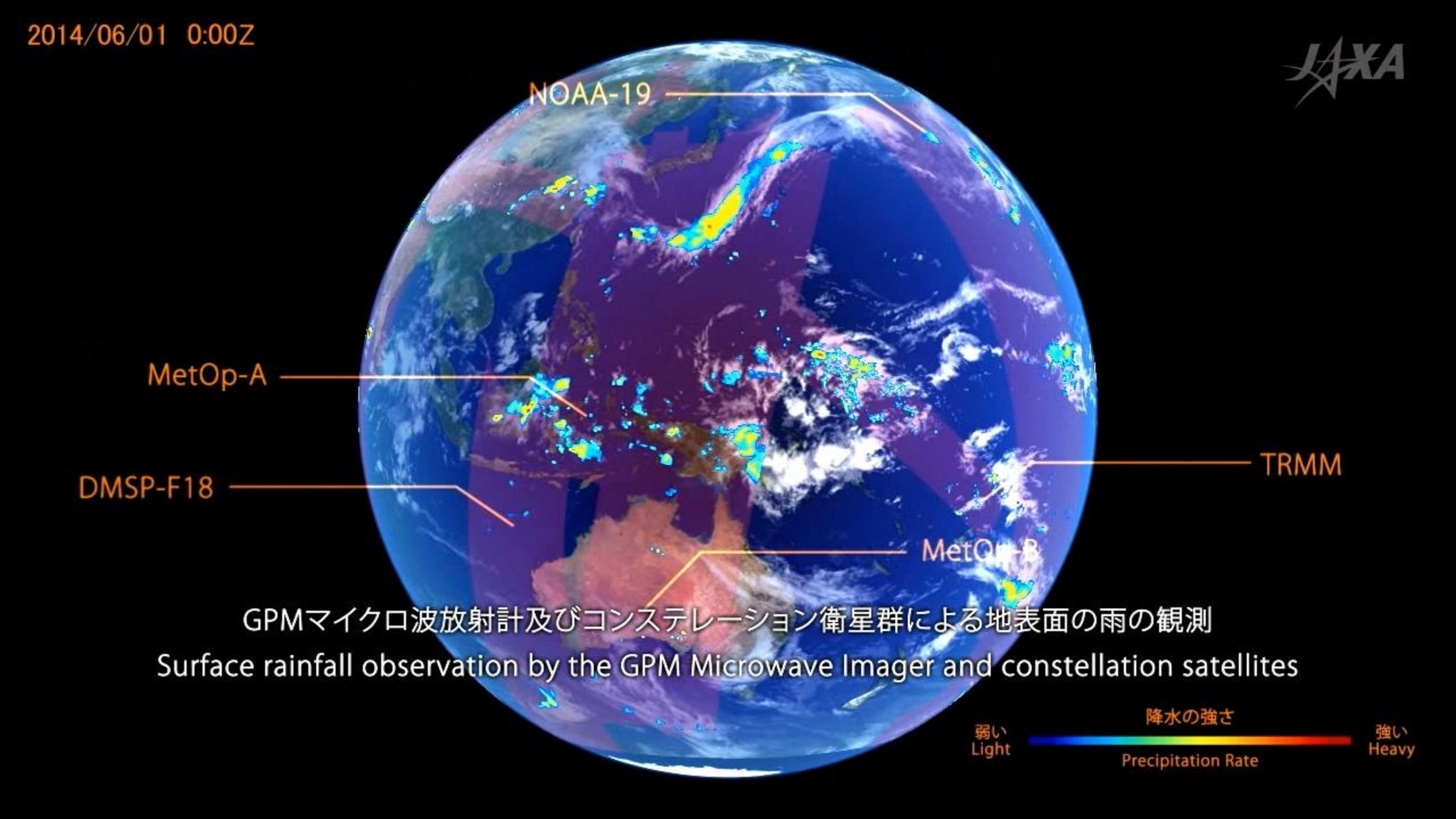
Polar LEO

Inclined LEO

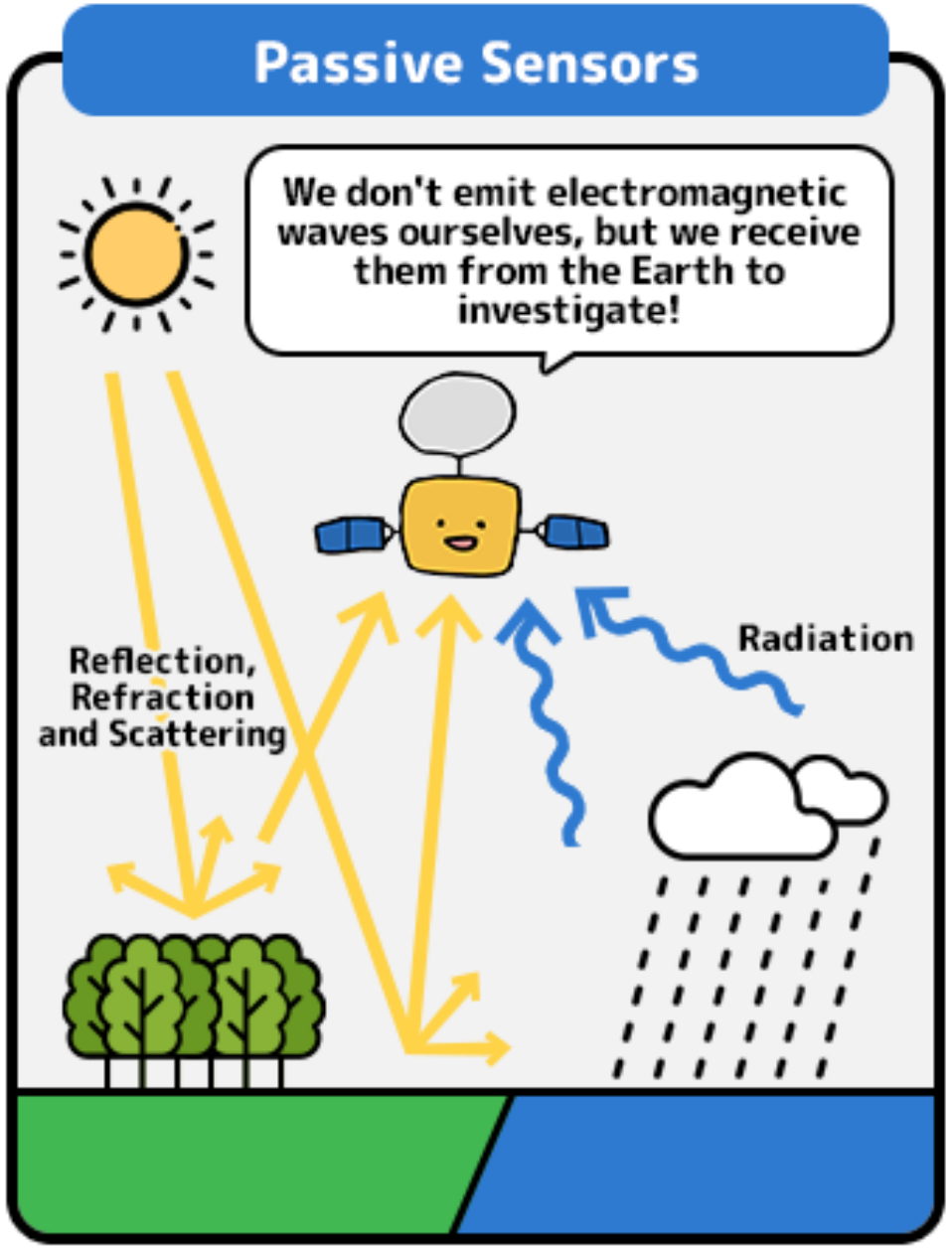
Low Earth Orbit

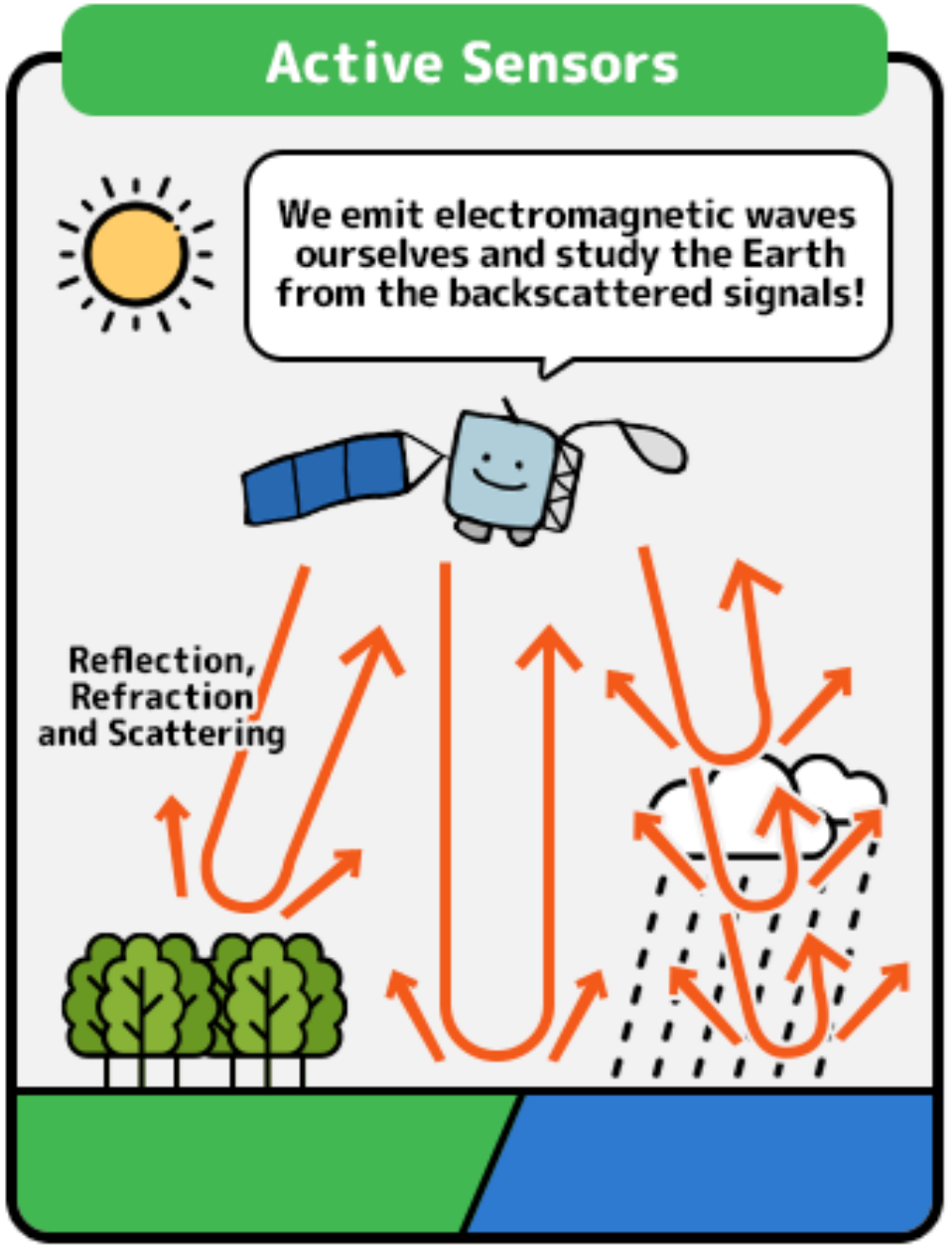
Geostationary Earth Orbit

GEO
36,000km


2014/06/01 0:00Z
JAXA
NOAA-19
MetOp-A
DMSP-F18
TRMM
MetOp-B
GPMマイクロ波放射計及びコンステレーション衛星群による地表面の雨の観測
Surface rainfall observation by the GPM Microwave Imager and constellation satellites
降水の強さ
弱い
Light
強い
Heavy
Precipitation Rate

Features of sensors



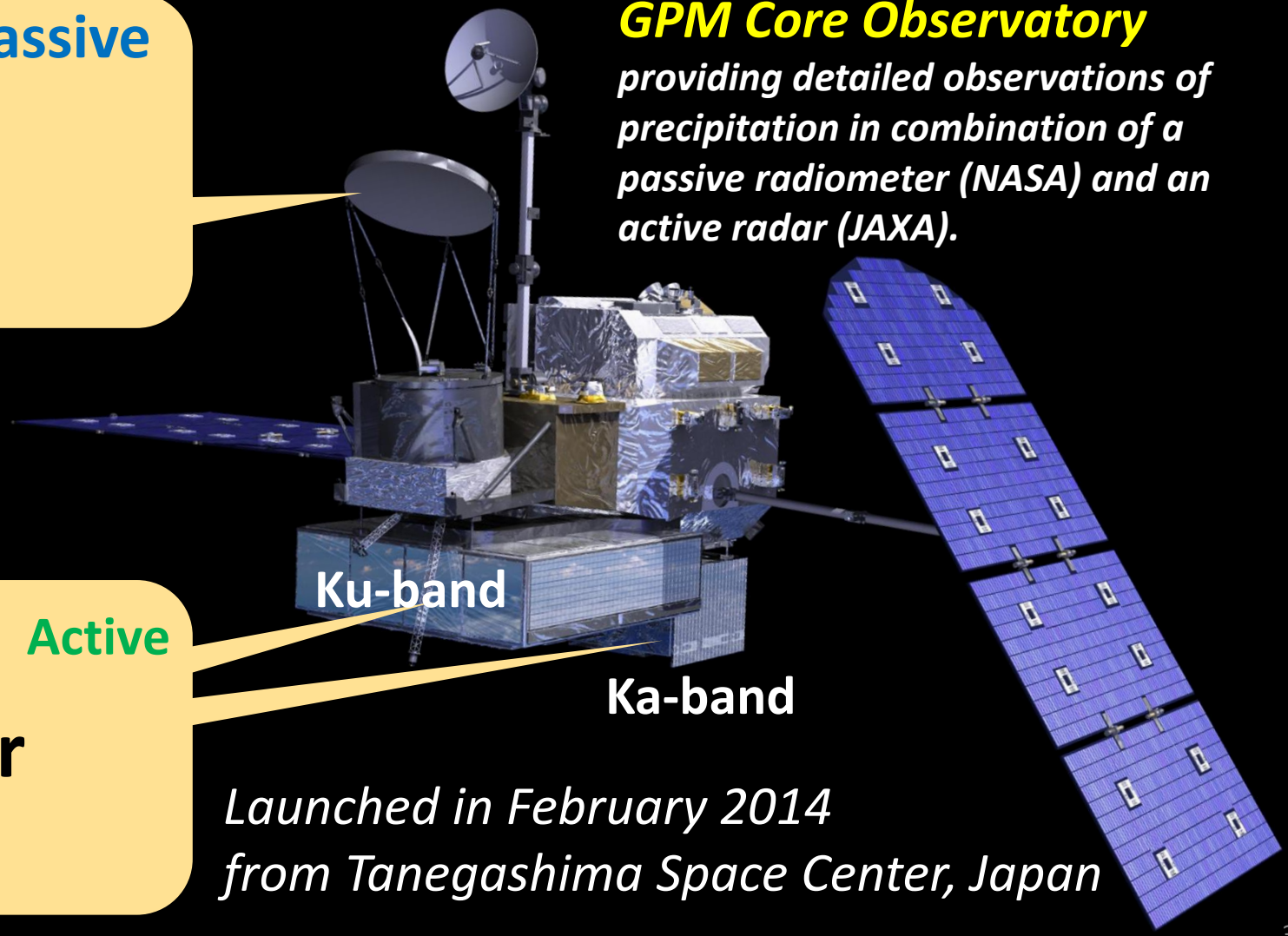


NASA-JAXA Joint Mission

"Global Precipitation Measurement (GPM) Mission"

NASA **GPM Microwave Imager (GMI)** — Passive

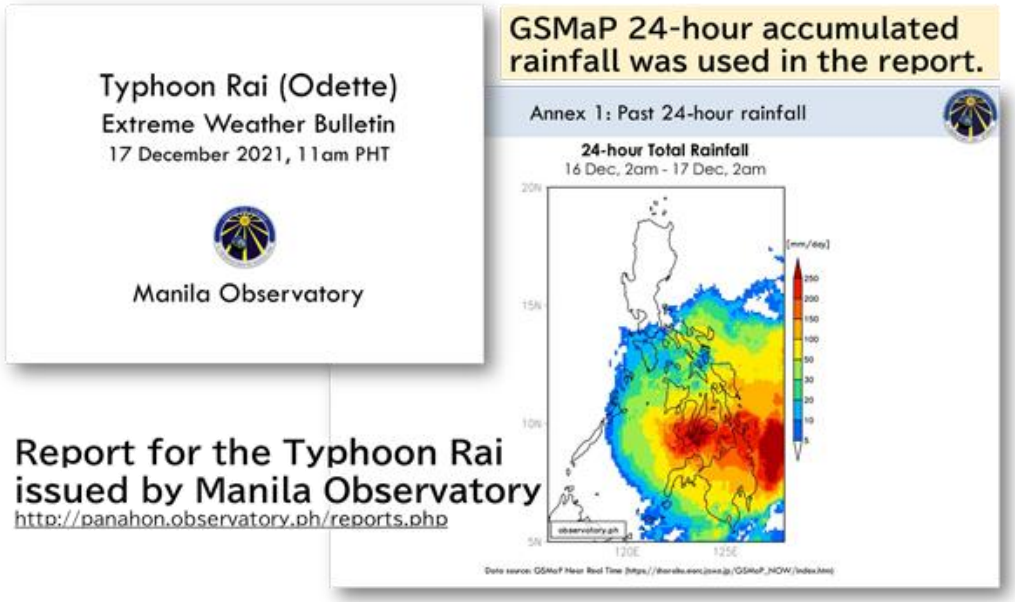
JAXA NICT **Dual-frequency Precipitation Radar (DPR)** — Active

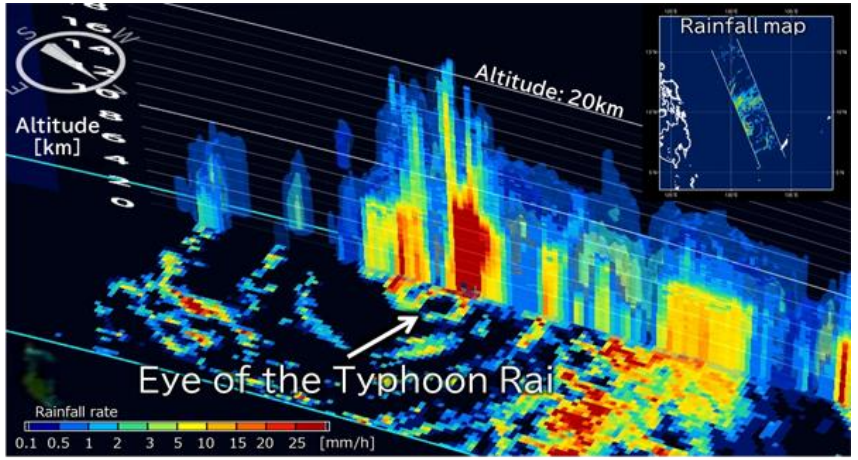


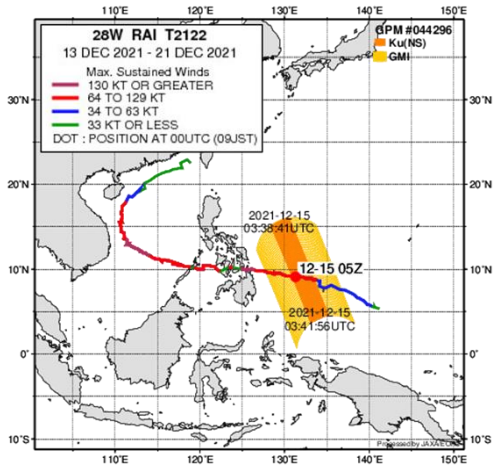
GPM Core Observatory
providing detailed observations of precipitation in combination of a passive radiometer (NASA) and an active radar (JAXA).

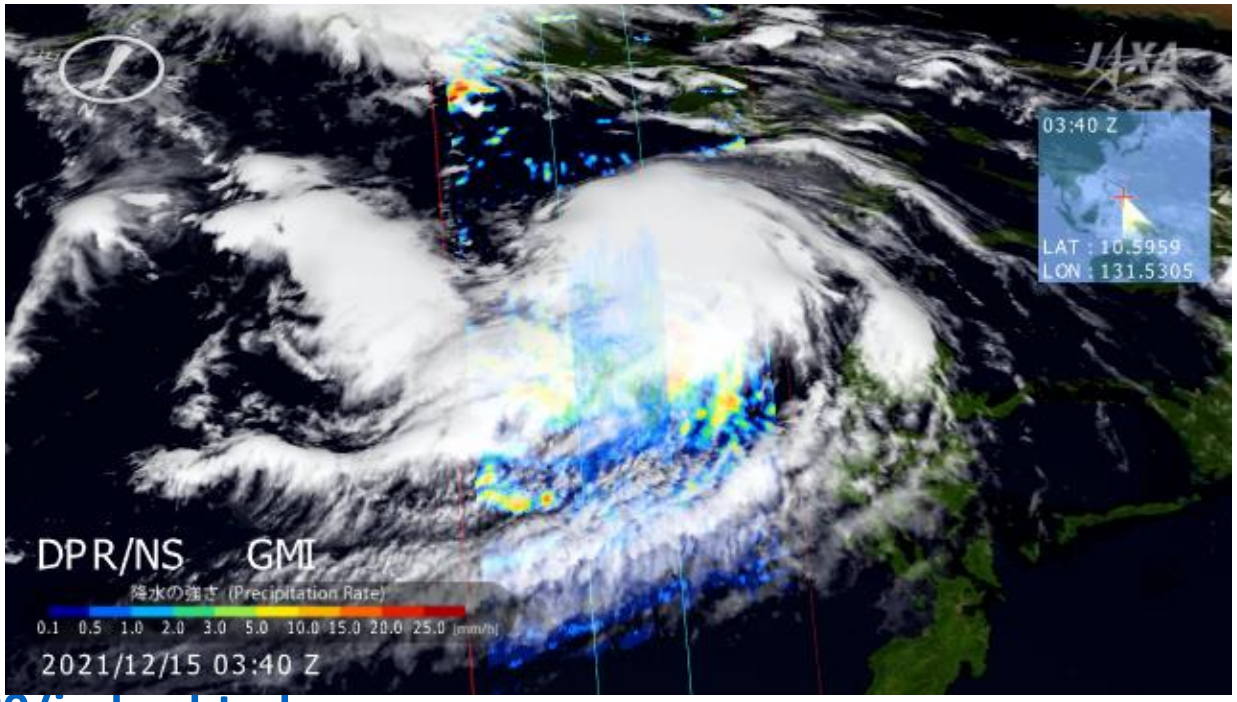
Launched in February 2014
from Tanegashima Space Center, Japan

GPM/DPR observations of Typhoon Rai which caused damage in the Philippines





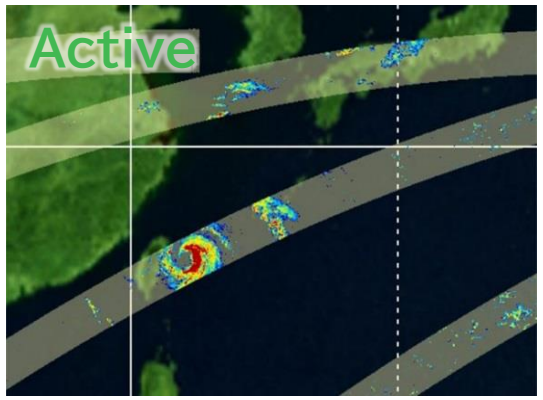


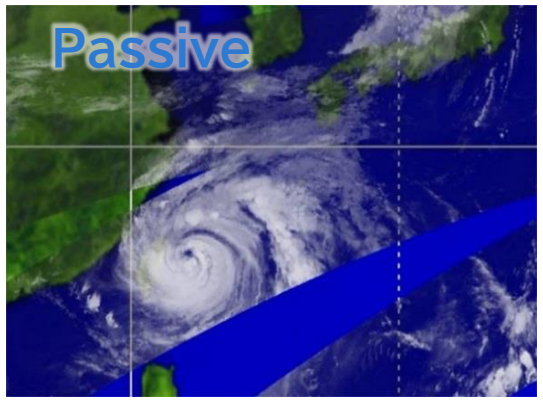


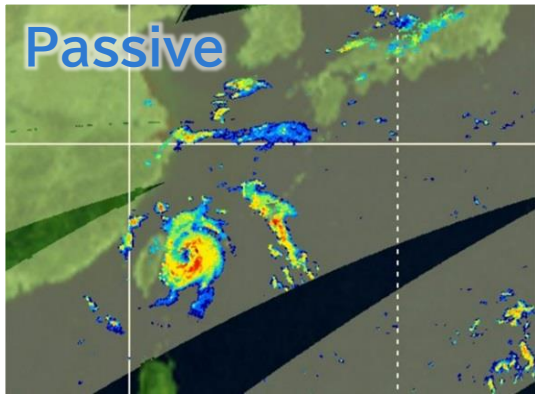
The precipitation information observed by JAXA satellites was also used as one of the information sources in the report on Typhoon Rai by the Manila Observatory in the Philippines.
The report shows the 24-hour accumulated precipitation by GSMaP obtained in real time. In regular post on SNS, the Manila Observatory utilized GSMaP data to indicate which area had heavy rainfall at the time of posting.

https://earth.jaxa.jp/en/earthview/2021/12/27/6689/index.html

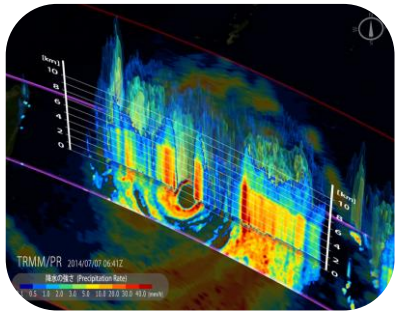
Features of sensors



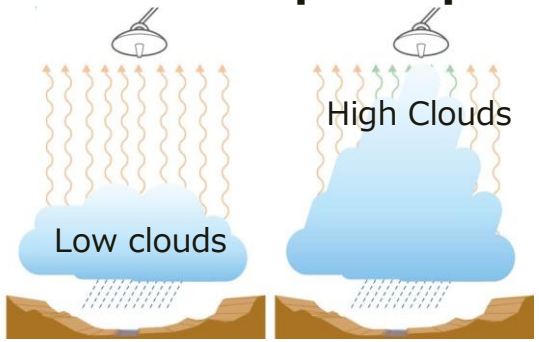




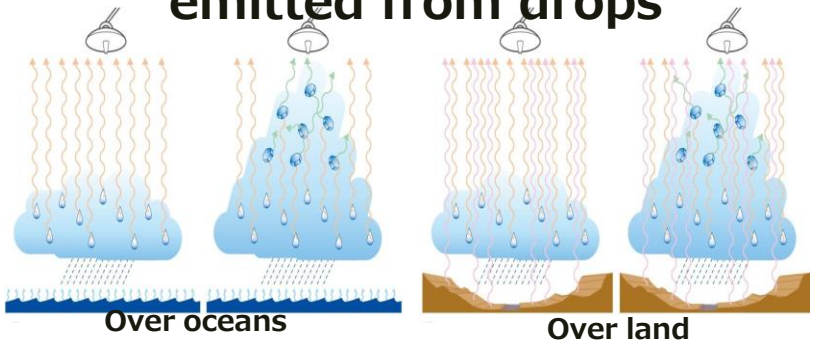
Directly observe vertical structure of precipitation



Measure cloud top temperature



Measure microwave radiation emitted from drops



Precipitation Radar

e.g., GPM/DPR

- Actively emit pulse and measure the echoes reflected back from drops.
- Can detect vertical distributions of precipitation but narrow swath.
- There is only one precipitation radar in operation over the world, developed by Japan.

Infrared Imager

e.g., Himawari/AHI

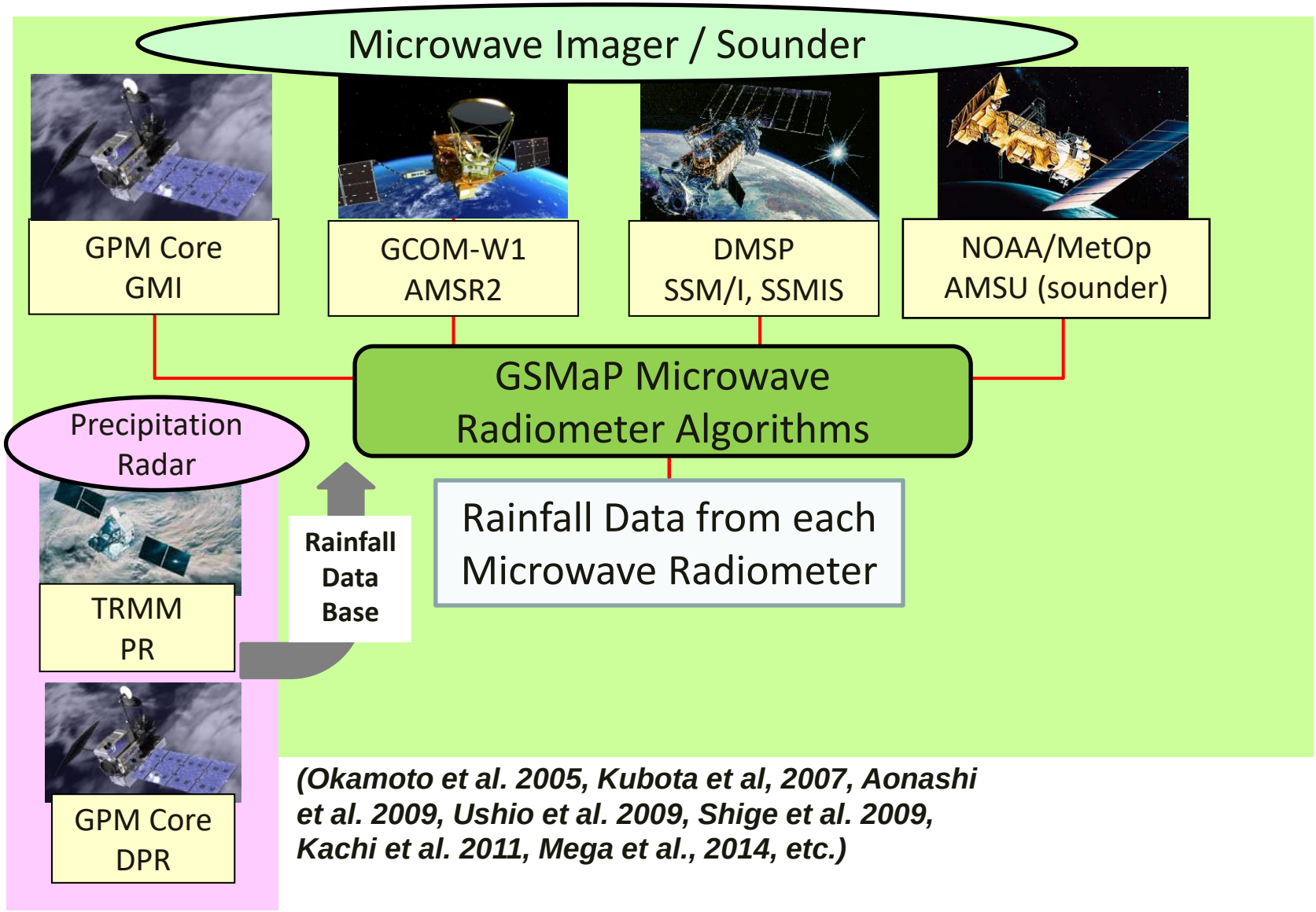
- Measure cloud top temperature.
- Cannot directory observe precipitation.

Microwave Radiometer (Imager/Sounder)

e.g., GPM/GMI

- Measure intensity of microwave radiation that is constantly emitted from raindrops.
- Can estimate spatial distributions of precipitation with wider swath
- There are many microwave radiometers in operation.

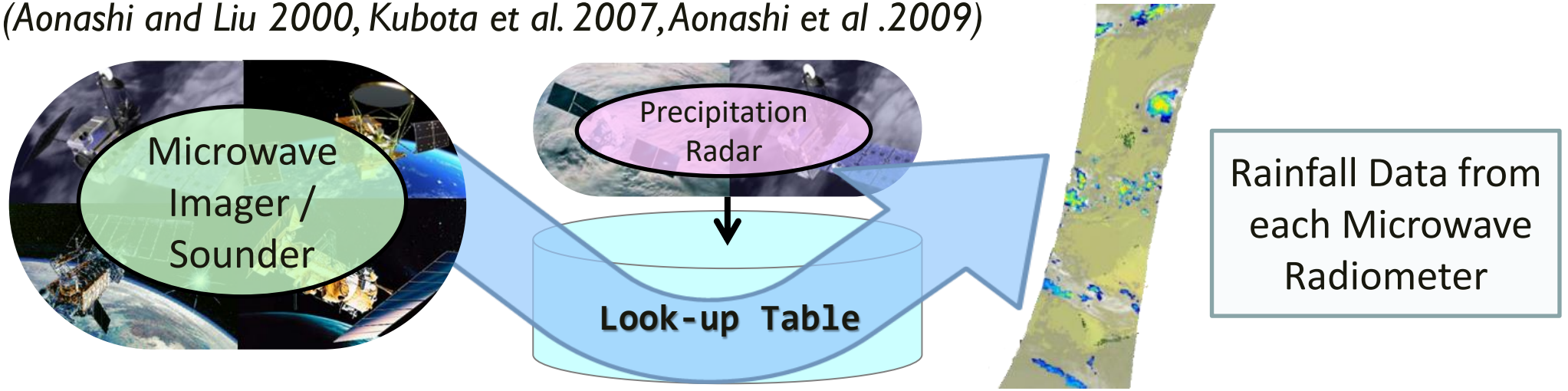
Overview of GSMaP Algorithm



(Okamoto et al. 2005, Kubota et al, 2007, Aonashi et al. 2009, Ushio et al. 2009, Shige et al. 2009, Kachi et al. 2011, Mega et al., 2014, etc.)

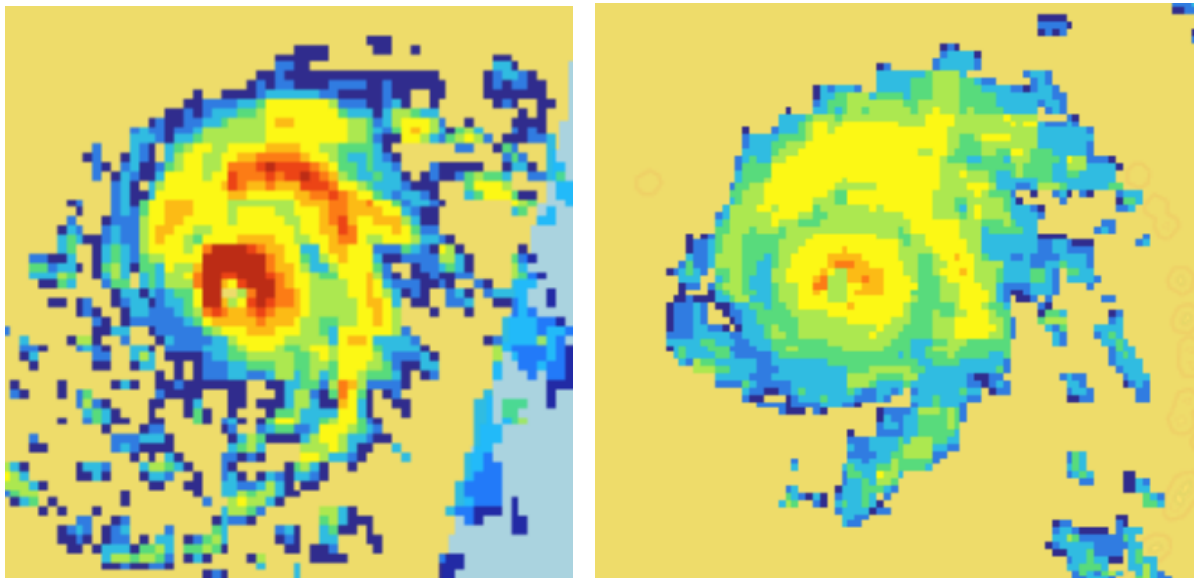
Rainfall Data from each Microwave Radiometer

(Aonashi and Liu 2000, Kubota et al. 2007, Aonashi et al .2009)



(Microwave Imager)
GCOM-W/AMSR-2

(Microwave Sounder)
NOAA-19/AMSU-A/MHS



Depending on the type of Microwave Radiometer, precipitation intensity and resolution slightly differ.

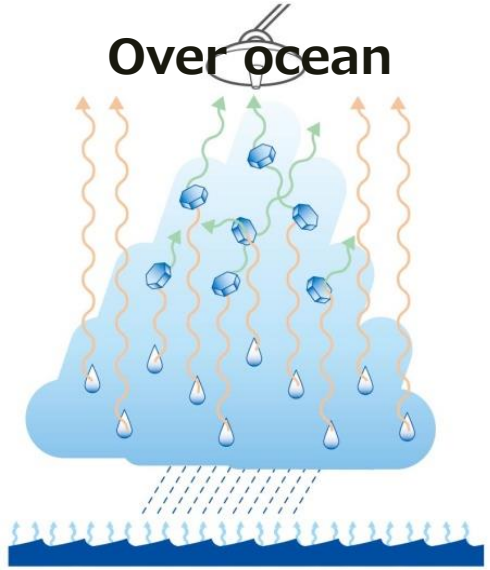
Why rainfall retrievals differ depending on Microwave sensors?

Low frequency channel observations (ex., 19GHz):

- Detect "**emission**" signals from raindrop (many raindrops → large emissivity)
- This method cannot be used over land due to its large emission from the land surface.

High frequency channel observations (ex., 85GHz):

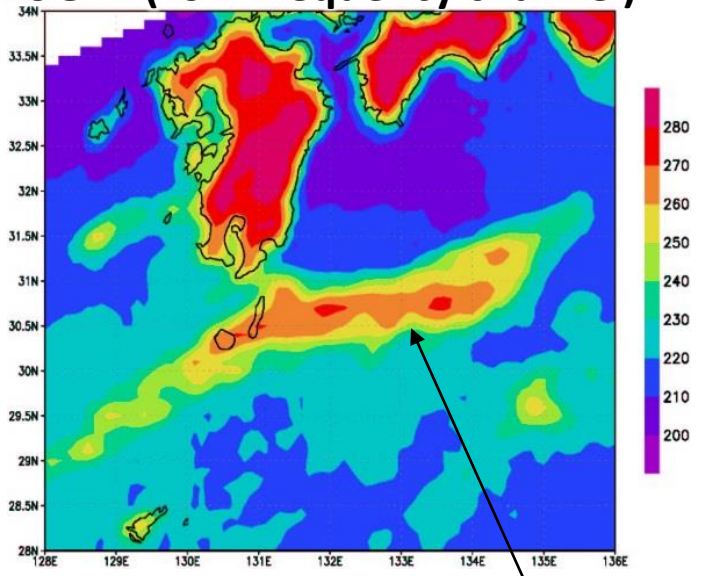
- Detect "**scattering**" signals from snow or ice particles
  (many ice particles → large scattering effect → observed microwave decreased)
- More ice in the upper level often means that rainy clouds have developed to a higher altitude. We assume this correlation and estimate heavy surface precipitation if sensors detect large scattering signals.



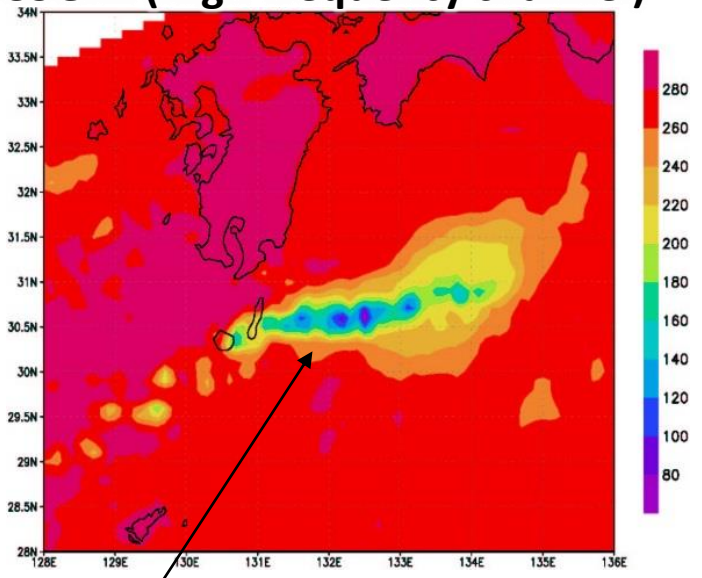
Over the oceans, precipitation is estimated from Emission signals from raindrop and Scattering signals from snow/ice

Over land, precipitation is estimated from Scattering signals from snow/ice only

Passive microwave sensor 19GHz (Low-frequency channel)

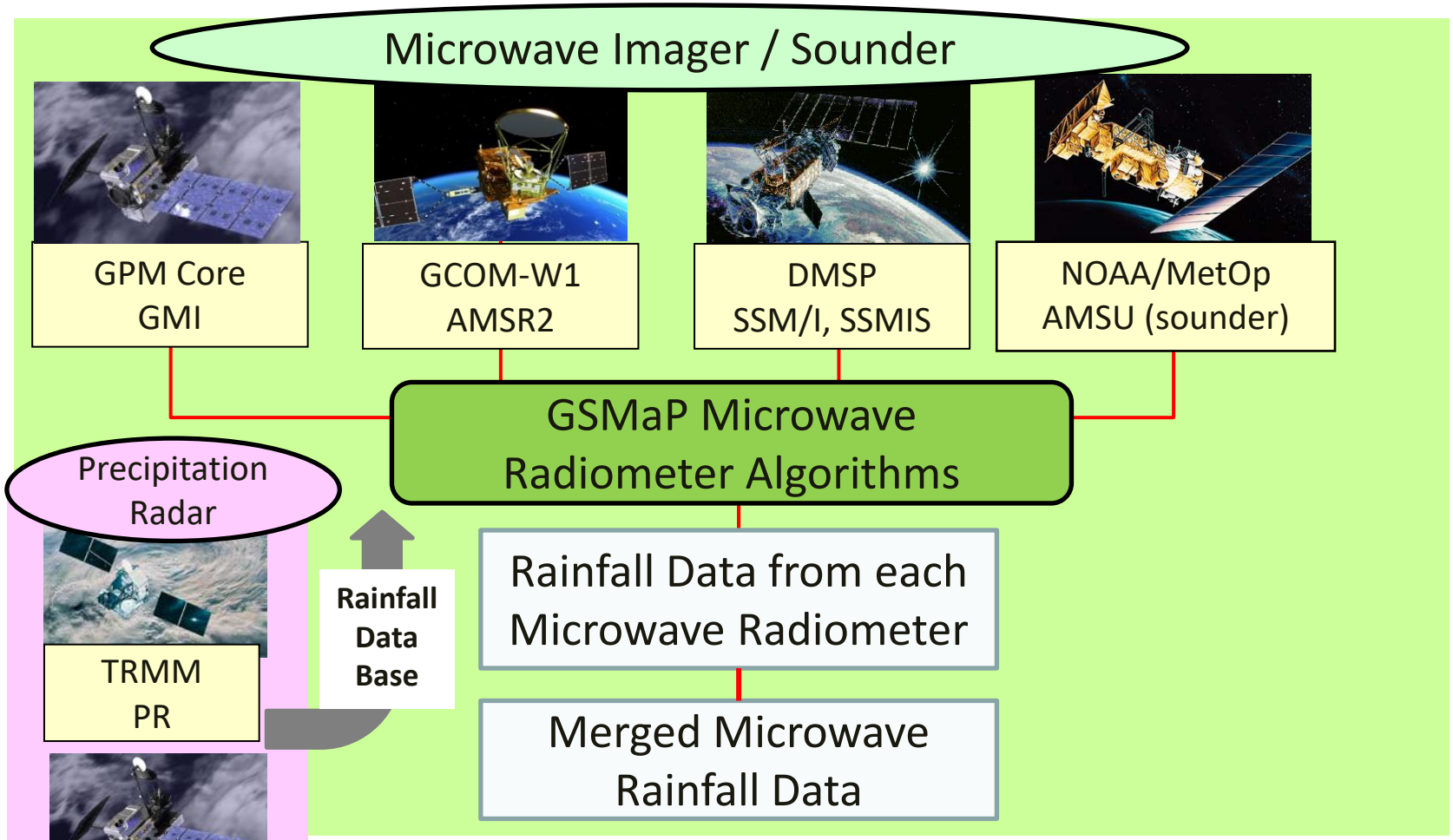


Passive microwave sensor 85GHz (High-frequency channel)



Precipitating area

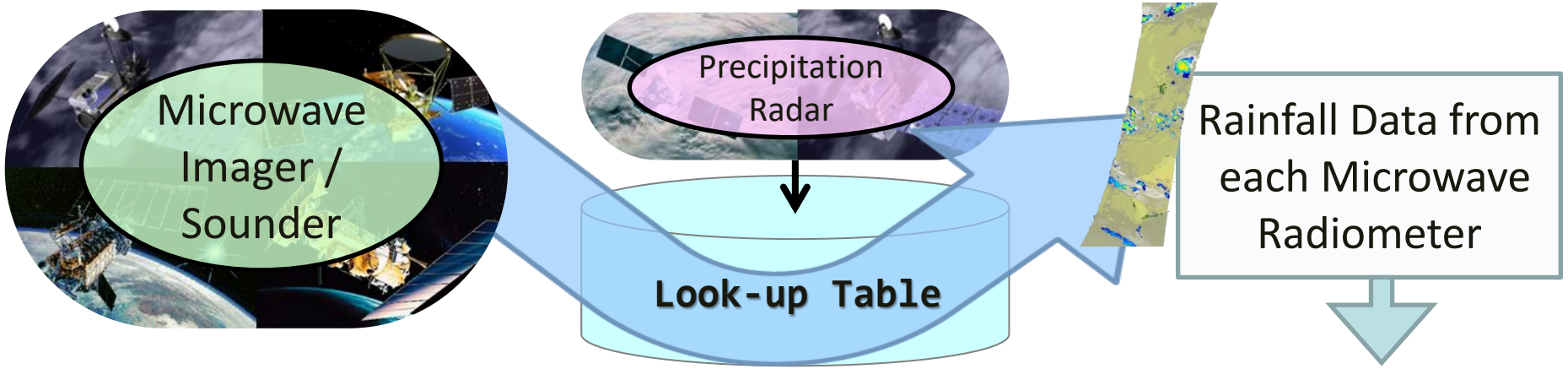
Overview of GSMaP Algorithm

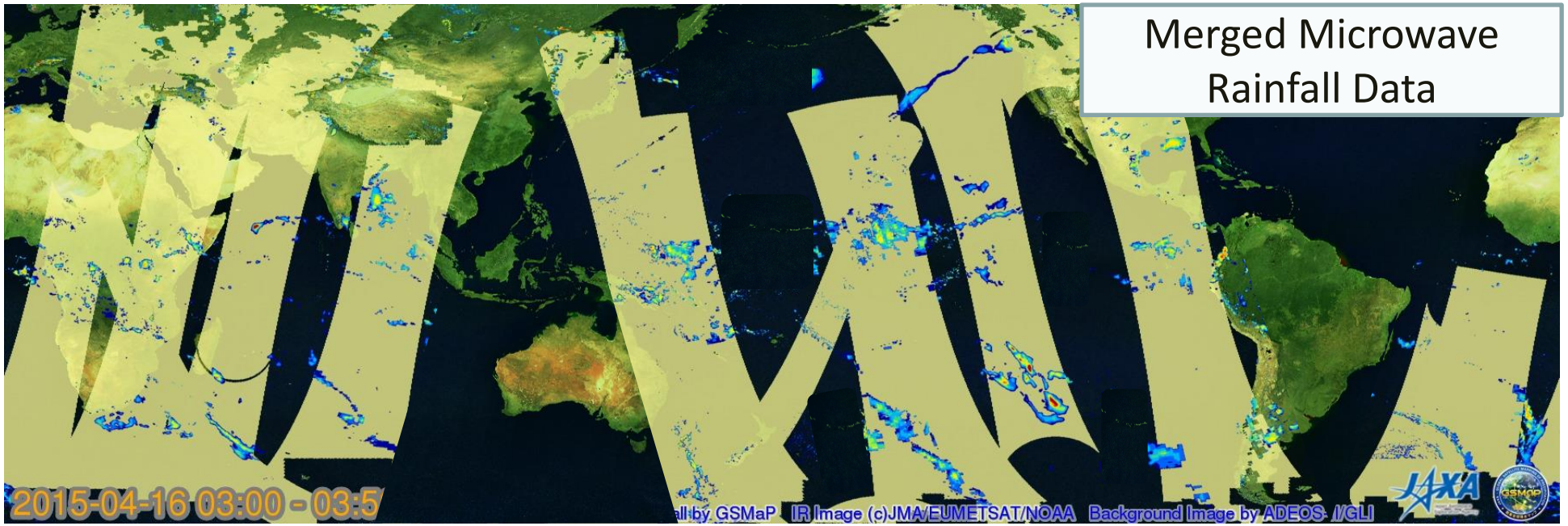


(Okamoto et al. 2005, Kubota et al, 2007, Aonashi et al. 2009, Ushio et al. 2009, Shige et al. 2009, Kachi et al. 2011, Mega et al., 2014, etc.)

Simplified explanation of Algorithm

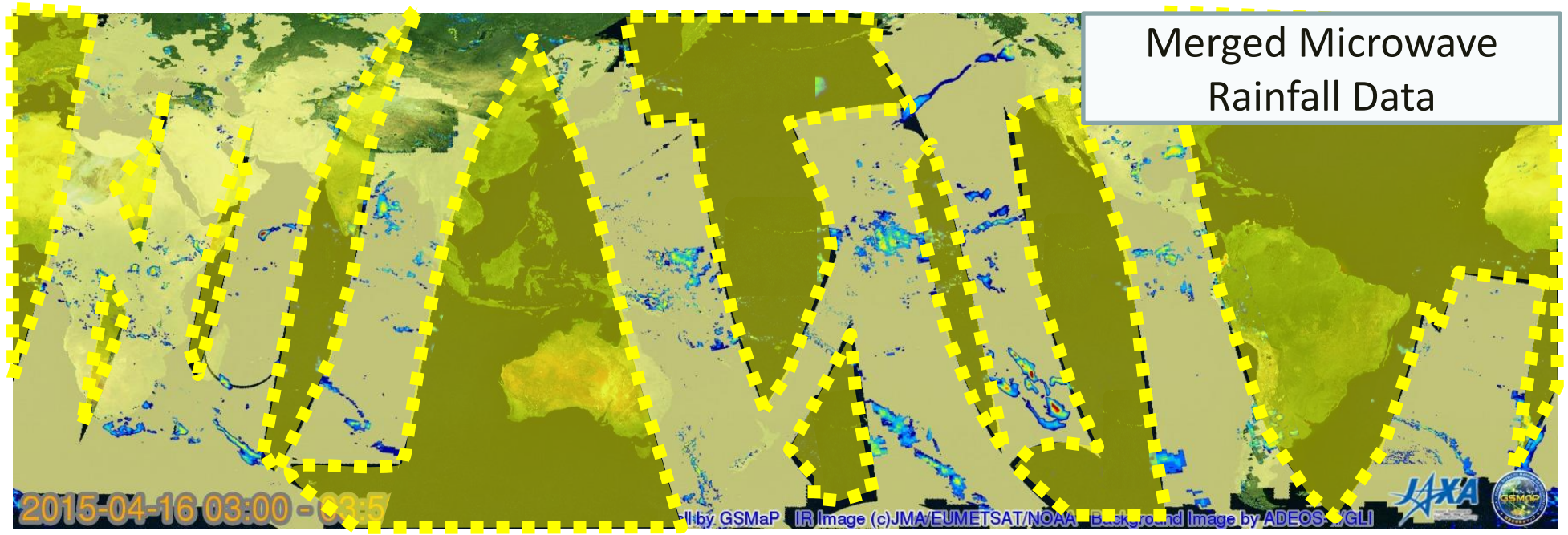
(Aonashi and Liu 2000, Kubota et al. 2007, Aonashi et al .2009)





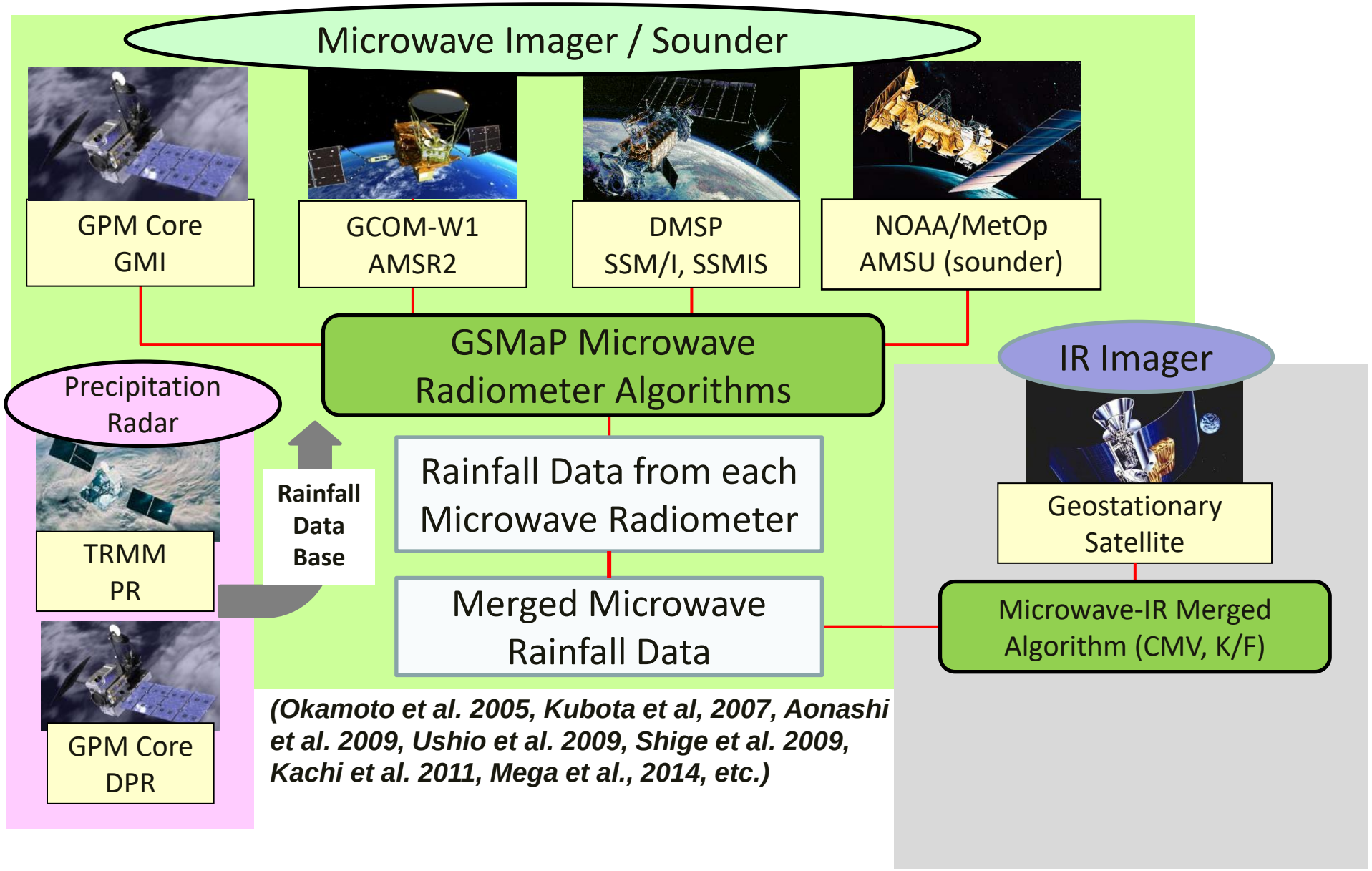
Simplified explanation of Algorithm

Some area cannot be covered with
merged microwave rainfall data in one hour...



Yellow color indicates an area observed by microwave imager and sounder.

Overview of GSMaP Algorithm



Flowchart of MWR-IR Merged algorithm

(Ushio et al. 2009)

TIME

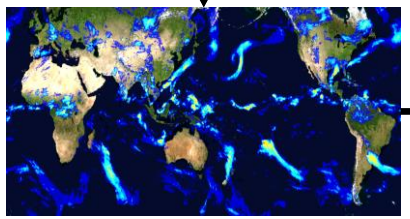
Infrared (IR) Data

Geo IR at 1-hour before present

Geo IR present

Cloud motion vectors

1-hour-before GSMaP is propagated by the motion vectors



Kalman Filter

GSMaP Data

GSMaP at 1-hour before present

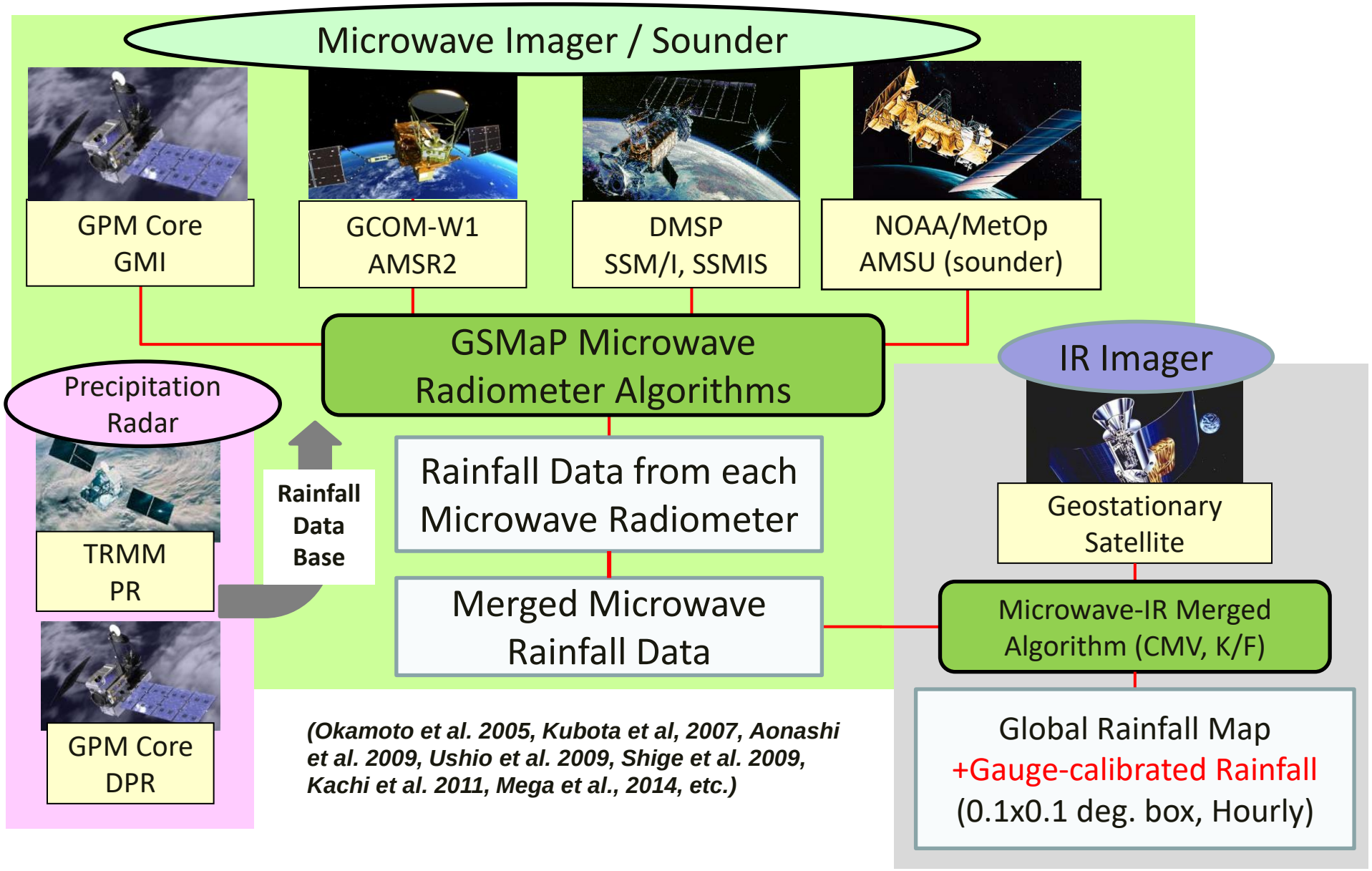
GSMaP propagated using IR motion vectors is overwritten by MWR data within the last hour

GSMaP present

MWR data Present (Within the last hour)

Microwave Radiometer (MWR) Data

Overview of GSMaP Algorithm

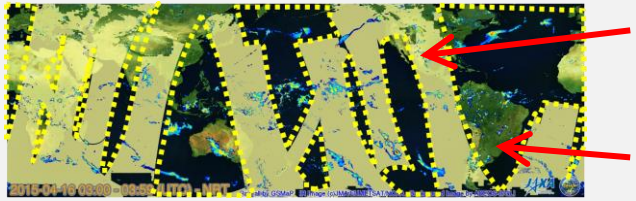


(Okamoto et al. 2005, Kubota et al, 2007, Aonashi et al. 2009, Ushio et al. 2009, Shige et al. 2009, Kachi et al. 2011, Mega et al., 2014, etc.)

Some factors affecting the accuracy of GSMaP

① PMW-retrieved? or PMW-IR estimation?

An example of the PMW overpasses within an hour



Inside of the yellow-shaded areas

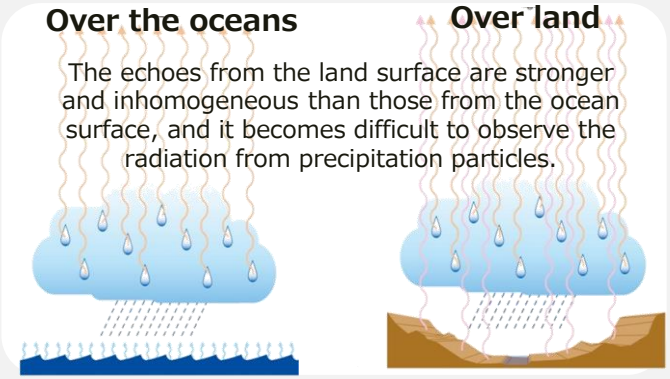
Retrieved by using PMW algorithm -> Better accuracy

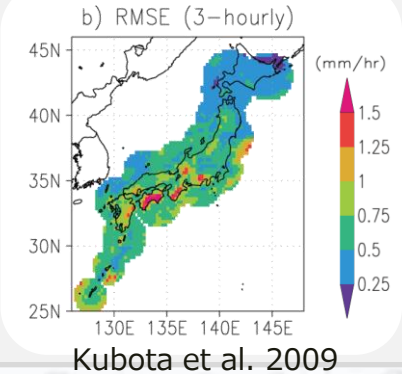
Outside of the yellow-shaded areas

Estimated by PMW-IR combined algorithm -> relatively lower accuracy

② Surface type

- Because of the PMW sensor features, accuracy is generally better over the oceans than over land.
- Over the mountainous regions, orographic rainfall is relatively difficult to be estimated.

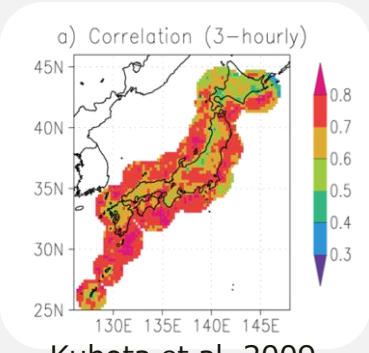




Kubota et al. 2009

③ Low temperature and snow

- Surface snow causes false signals and lowers the accuracy of GSMaP estimates.
- Snow estimation is still in the R&D stage with a large research component



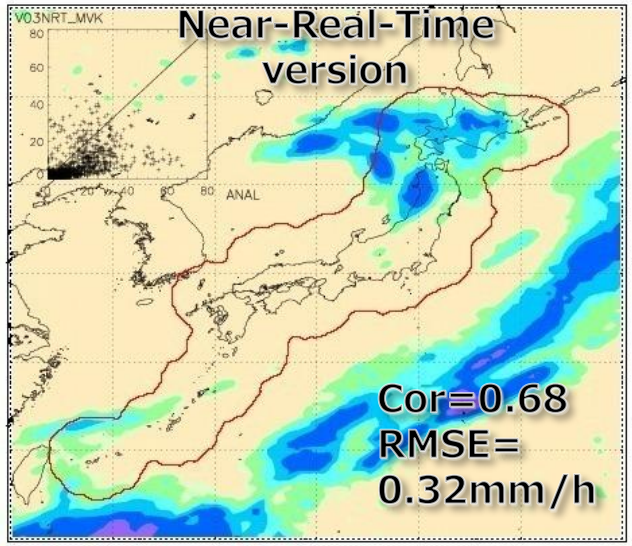
Kubota et al. 2009

From an algorithmic point of view, we know the qualitative error factors.

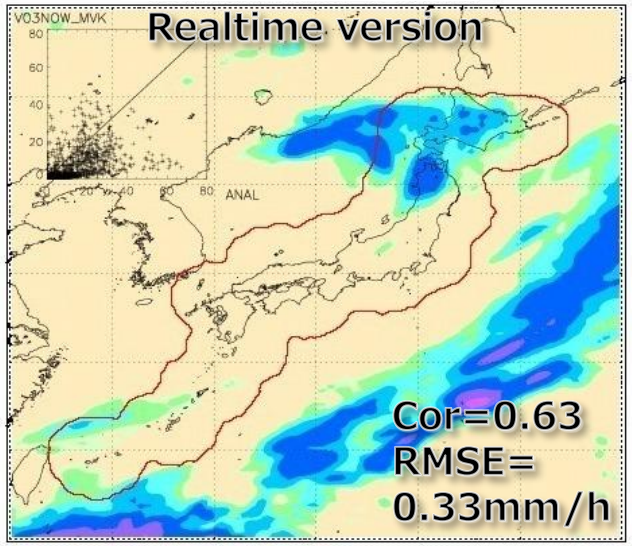
Snapshots of Daily Validation

May. 27, 2017, in 0.25 degree grid and daily accumulation

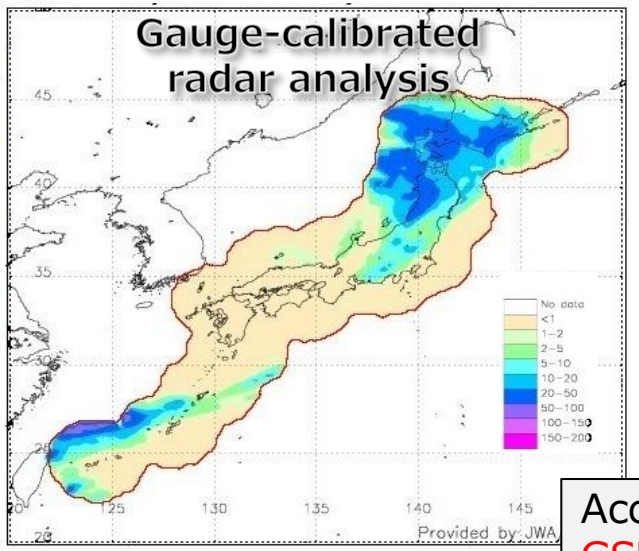
GSMaP_NRT



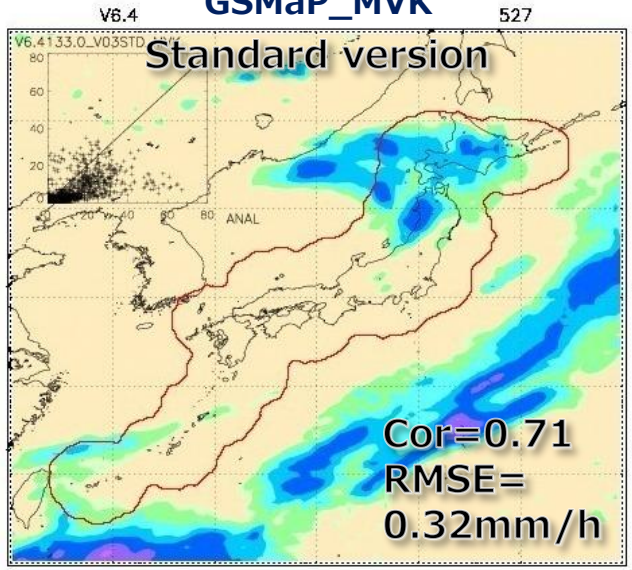
GSMaP_NOW



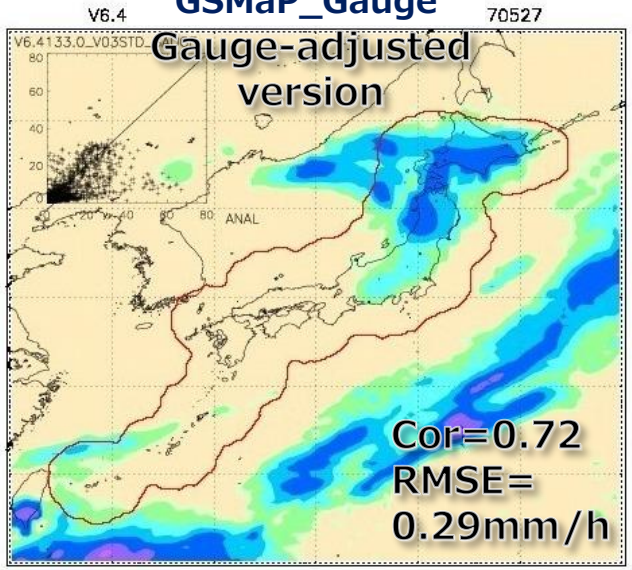
JMA's Radar-AMeDAS



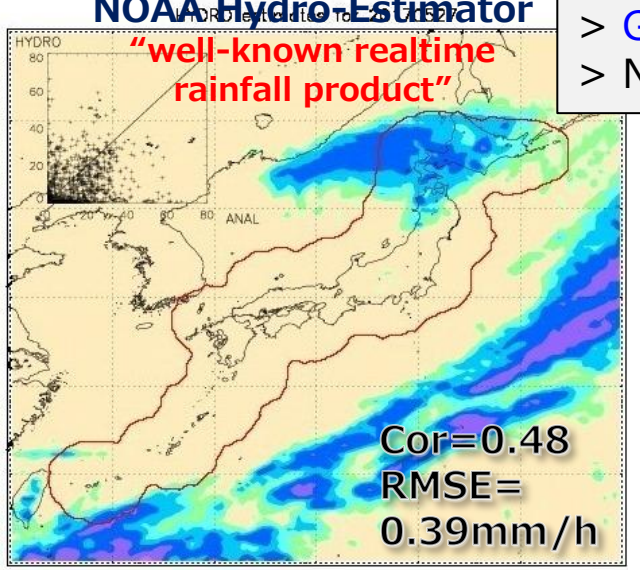
GSMaP_MVK



GSMaP_Gauge

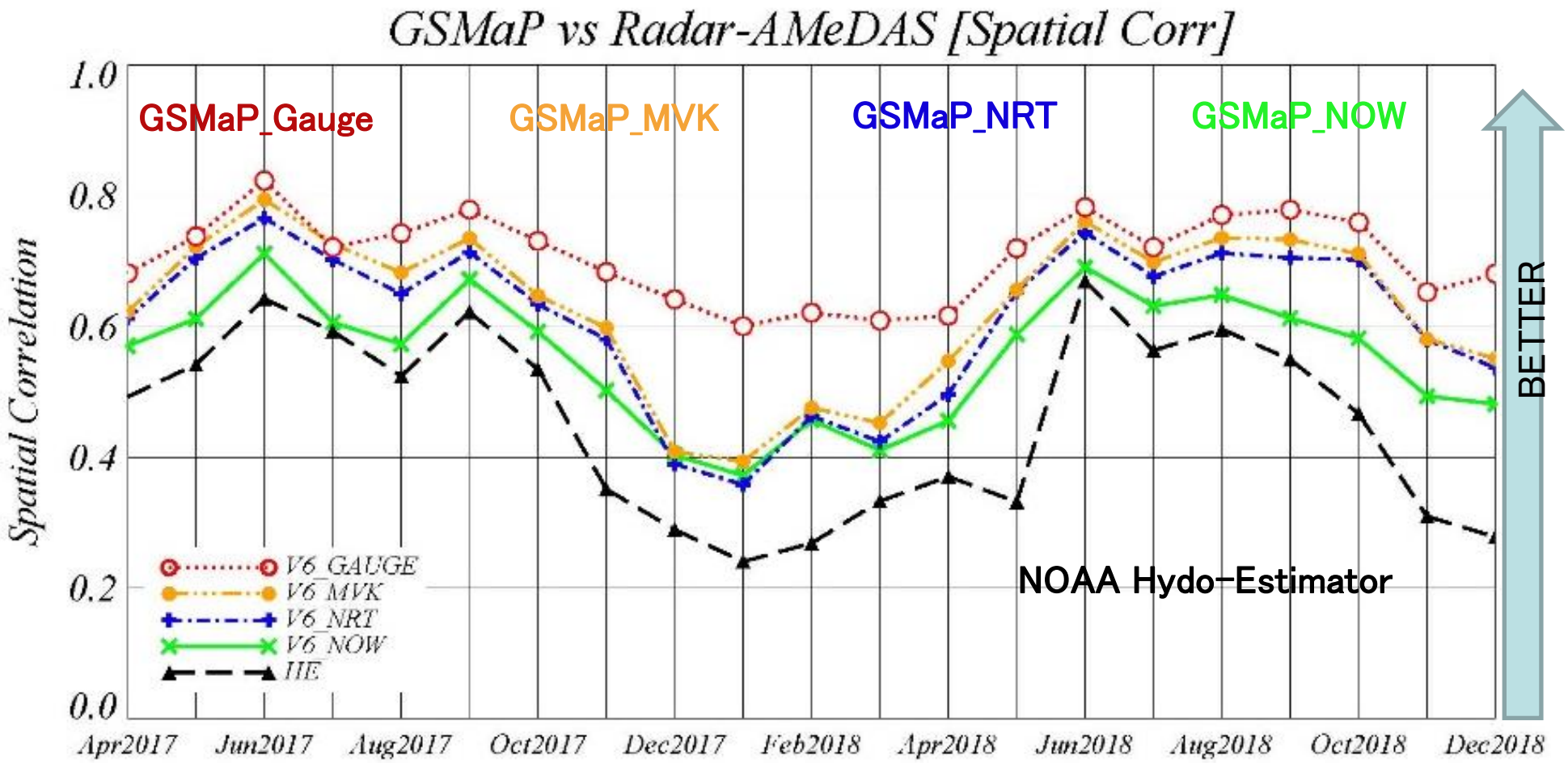


NOAA Hydro-Estimator



Accuracy over Japan is …
GSMaP_Gauge >GSMaP_MVK
> GSMaP_NRT > GSMaP_NOW
> NOAA H-E

Snapshots of Daily Validation



Accuracy over Japan is …
GSMaP_Gauge >GSMaP_MVK > GSMaP_NRT > GSMaP_NOW > NOAA H-E

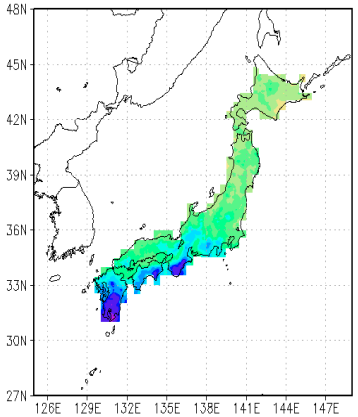
Accuracy varied seasonally around Japan, which suggested that the accuracy depends on some factors like precipitation amount and characteristics.

GSMaP validation for some spatial/temporal resolutions

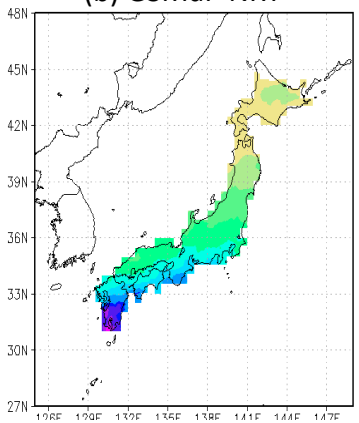
- ***Same kind of validation analysis in Japan using JMA radar/gauge analyzed data and GSMaP_NRT was conducted in some resolutions.***
- ***The accuracy got better as the spatial/temporal resolution became coarser, which is because shift of location and time is canceled.***

3-month accumulated precip(JJA 2015)

(a) JMA radar/gauge data



(b) GSMaP NRT



RMSE

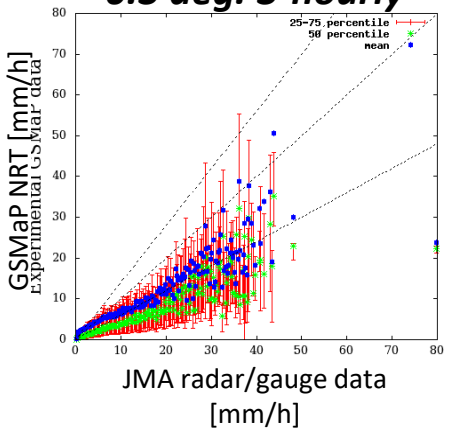
Spatial res. \ temporal res.	1	3	6	12	24
0.1	1.20	0.93	0.78	0.63	0.51
0.3	1.00	0.82	0.70	0.58	0.47
0.5	0.86	0.72	0.63	0.52	0.42
0.8	0.70	0.61	0.54	0.45	0.37
1.0	0.66	0.58	0.51	0.43	0.35

Correlation Coefficient

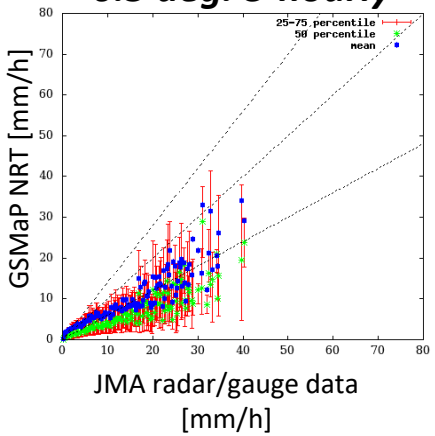
Spatial res. \ temporal res.	1	3	6	12	24
0.1	0.37	0.45	0.49	0.53	0.58
0.3	0.45	0.52	0.55	0.59	0.63
0.5	0.51	0.56	0.60	0.62	0.67
0.8	0.57	0.61	0.64	0.67	0.71
1.0	0.61	0.65	0.68	0.70	0.73

※The unit for RMSE is unified to mm/h.

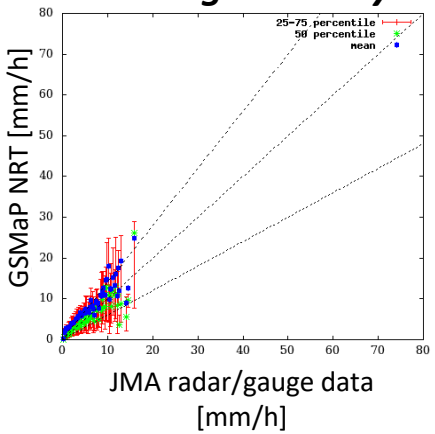
0.3 deg. 3-hourly

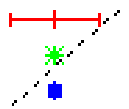


0.5 deg. 3-hourly



0.8 deg. 3-hourly





from 25 %-tile
to 75 %tile
50%tile
mean

GSMaP updates

- History of GSMaP major updates

Date	Product version	Algorithm Version
Sep. 2014	V03	v6
Jan. 2017	V04	v7
Dec. 2021	**V05**	**v8**

  - A review paper of GPM-GSMaP V03 & V04: Kubota et al. (2020), https://doi.org/10.1007/978-3-030-24568-9_20

- GPM-GSMaP V05 (algorithm version 8) is available from:
  - G-Portal https://gportal.jaxa.jp/gpr/?lang=en
    HDF, Global-scale txt, NetCDF, GeoTiff format
  - JAXA Rainfall Watch https://sharaku.eorc.jaxa.jp/GSMaP/index.htm
    Binary, region-subset txt, NetCDF format

Summary of the first half

- GSMaP is the **multi-satellite product** by combining passive microwave radiometers, IR imagers, and precipitation radars.
- GSMaP consists of some products, **realtime, near-realtime, standard and their gauge-adjusted versions**.
- Users can select the appropriate product according to their purposes, and the GSMaP products are widely used for various fields.