Utilization of the Global Satellite Mapping of Precipitation (GSMaP) dataset

29th, Feb. 2024

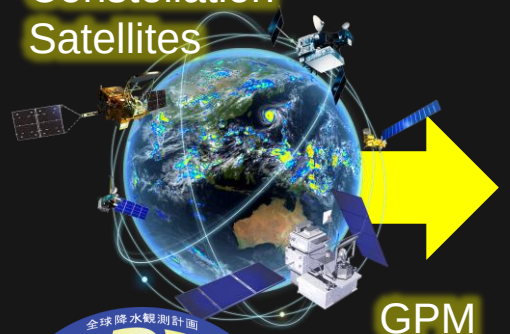
Regional Focus Group meeting

Nao Yoshida

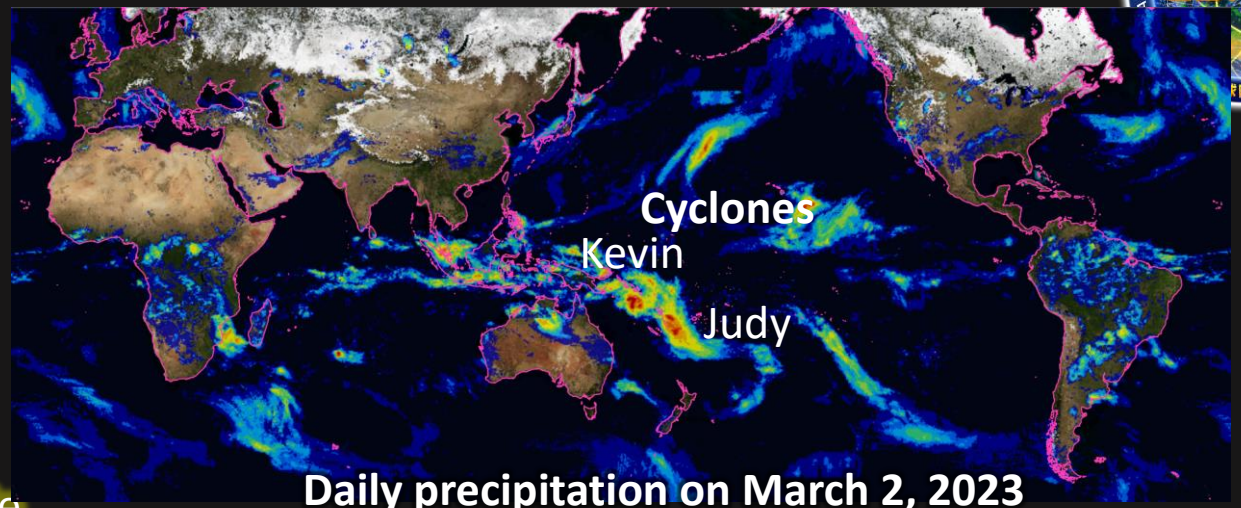
Earth Observation Research Center / Japan Aerospace Exploration Agency

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

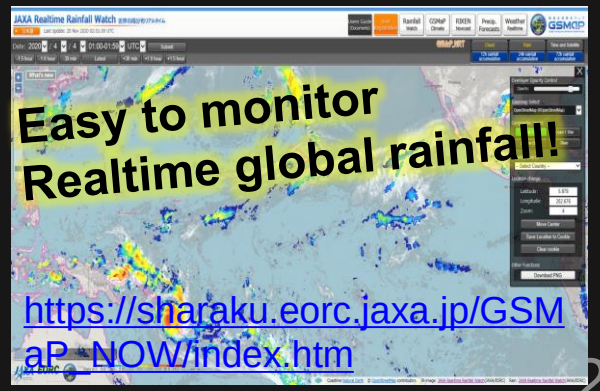
GLOBAL SATELLITE MAPPING OF PRECIPITATION

- **Hourly global** rainfall data
- Spatial resolution: about **0.1°x0.1°**
- Various version such as **real-time for monitoring** or **long-term gauge-adjusted for climatological purposes**

12,746
registered users
from 150
countries/regions
(as of Jan. 2024)
+ 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. GEE)
- Long-term archive data for more than 25 years (since 1998)



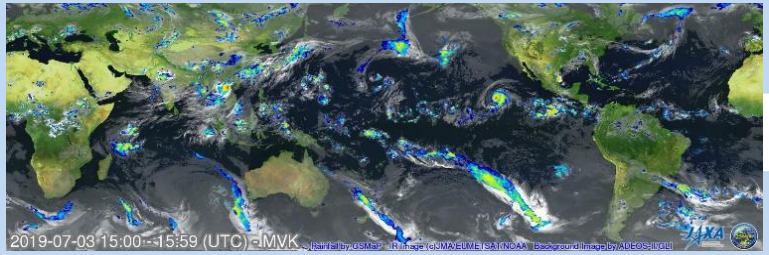
https://sharaku.eorc.jaxa.jp/GSMaP_NOW/index.htm

Multi Satellite Rainfall Product＝GSMaP

Long-term!

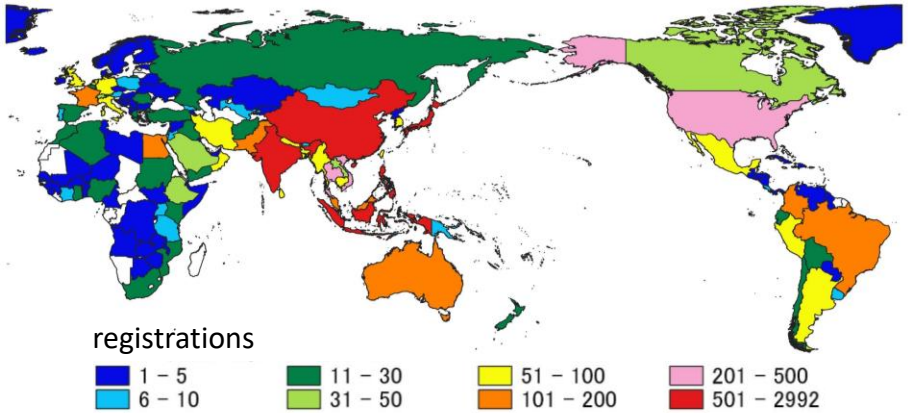
Statistics!

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.

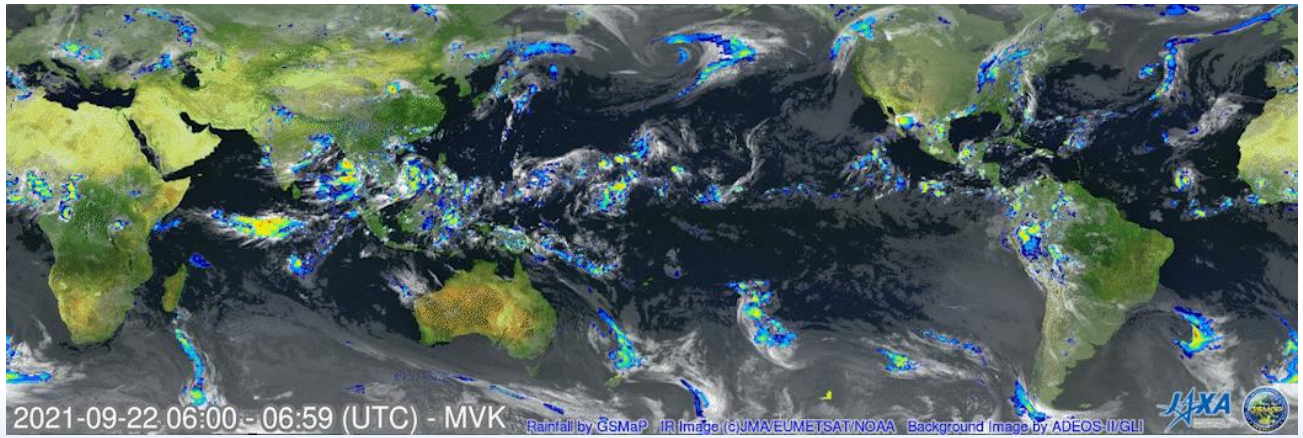


Japan	Indonesia	Philippines	China	India
3094 Users	2329 Users	954 Users	775 Users	513 users

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

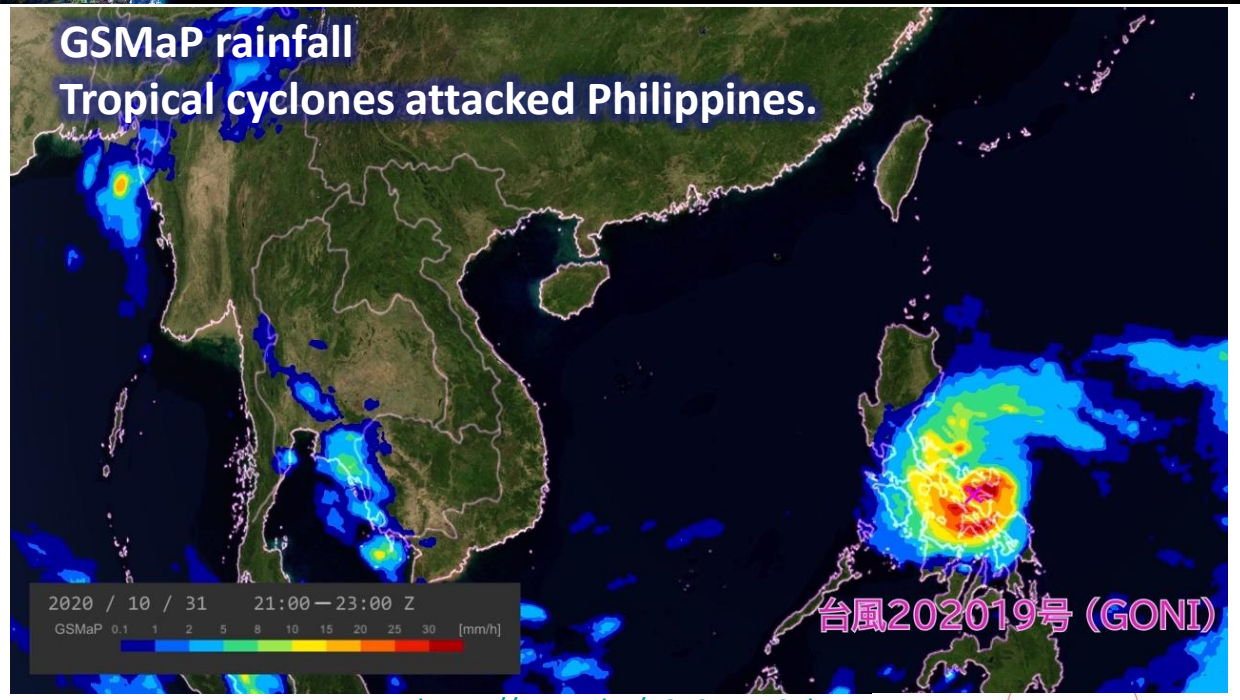


Climate monitoring	Weather Monitoring/ forecasts	Water-related disasters	Agriculture	Energy	Public health	Educations
						
WMO extremes monitoring	Asia-oceania met services	Flood analysis and predictions by disaster management offices	Flood security and insurance for farmers	Hydropower development planning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

Cyclone Monitoring

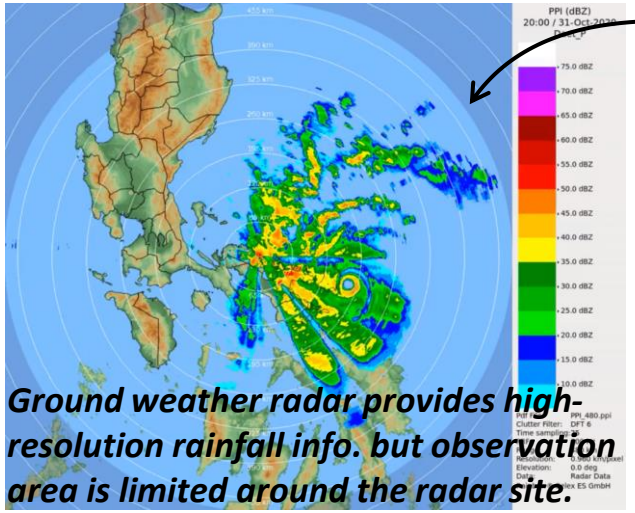


https://youtu.be/K9T2N5sa9Zk

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*

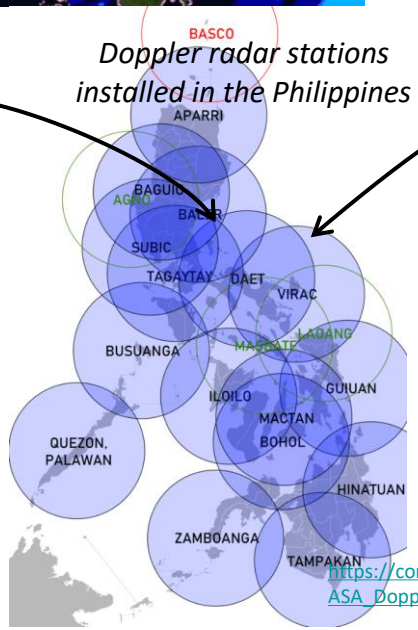
Radar image at Daet station by PAGASA



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

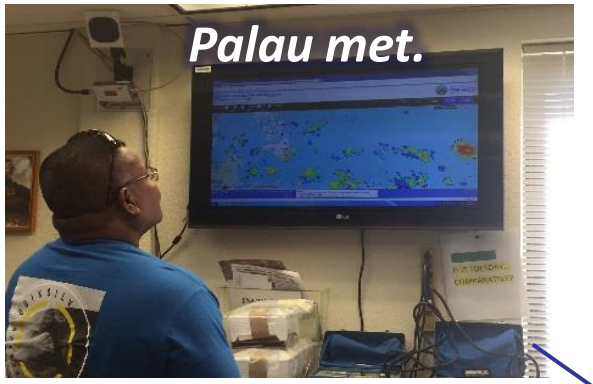


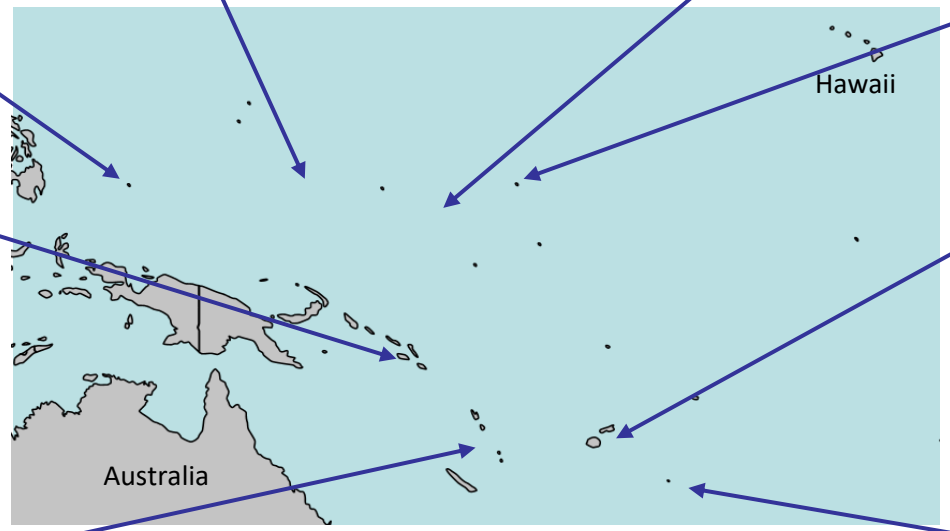
https://commons.wikimedia.org/wiki/File:PAGASA_Doppler_Radar_Network.png

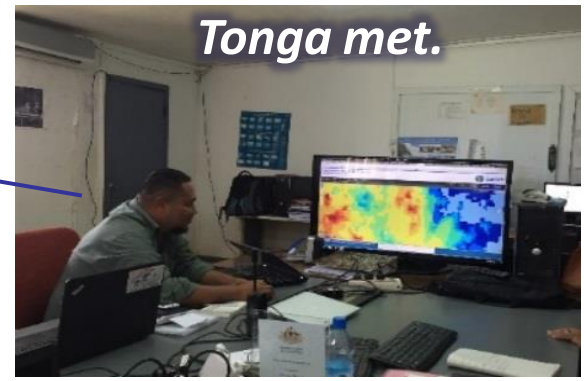
Typhoons are usually approaching from the eastern ocean.
-> Virac radar can play an important role for rainfall monitoring.

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

Utilization in Pacific Islands







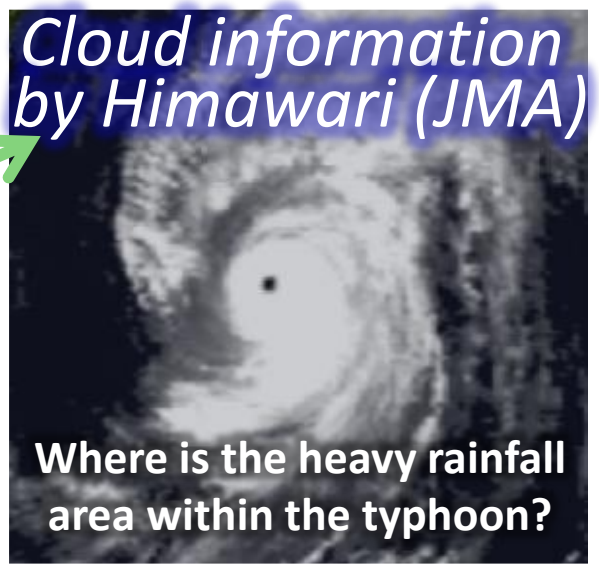
GSMaP has been used for "realtime" rainfall monitoring by meteorological services in Pacific Islands.

Combination of Himawari and GSMaP

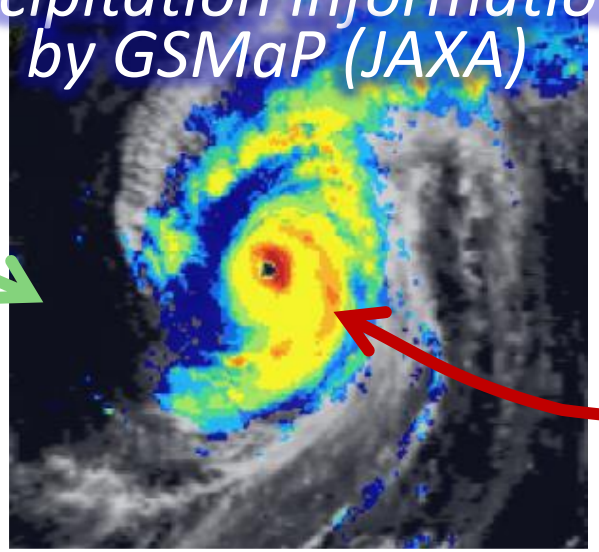
High-resolution (both spatial and temporal) Cloud information

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

Cloud information by Himawari (JMA)



Precipitation information by GSMaP (JAXA)

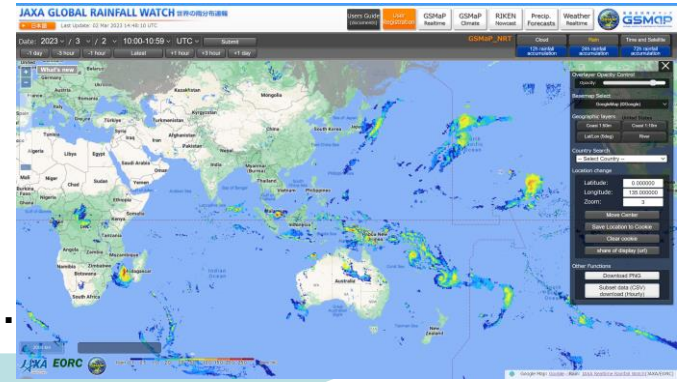


- Cloud information by Himawari provides essential information to monitor the locations of precipitation systems moving by minutes.
- In addition to the fine resolution cloud information, GSMaP can provide the rainfall information which is important for the “quantitative” rainfall monitoring.

Tropical cyclones do not always have a symmetrical precipitation structure.

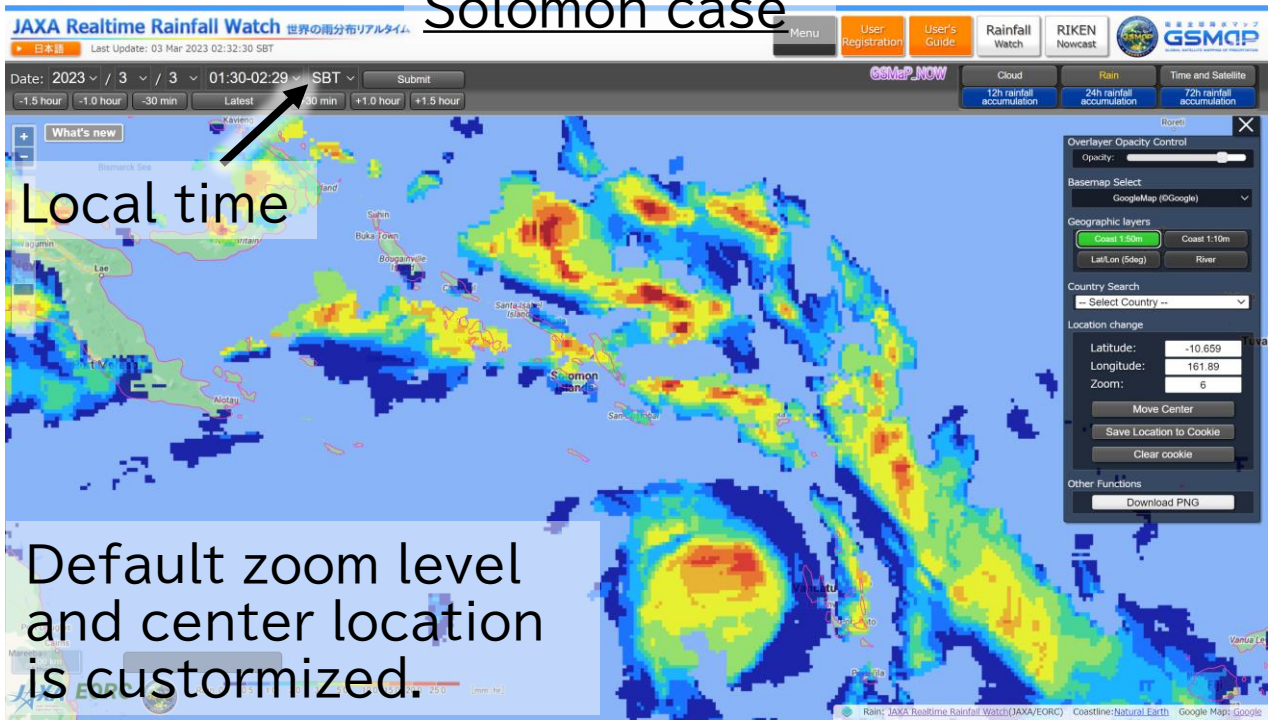
Monitoring Rainfall over islands

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
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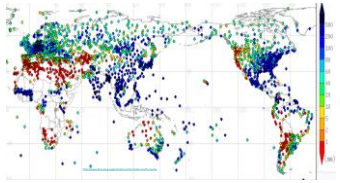
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/wallis_and_futuna.htm
- https://sharaku.eorc.jaxa.jp/GSMaP_NOW/yap.htm

Flood Analysis and Forecasting

Rainfall-Runoff-Inundation model

Ground observations



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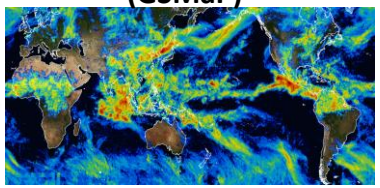
Satellite precipitation (GSMaP)



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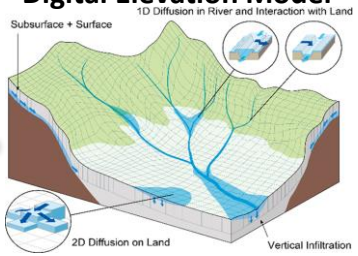
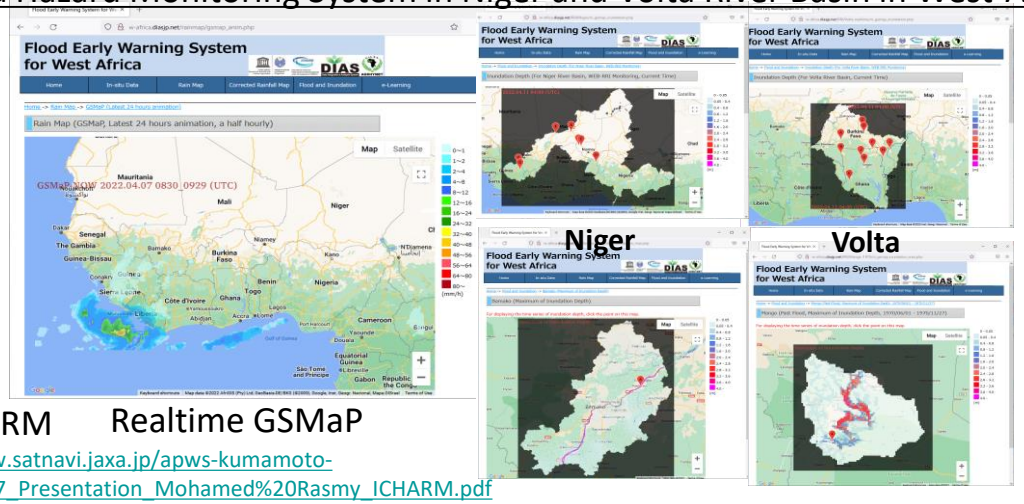
Digital Elevation Model



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

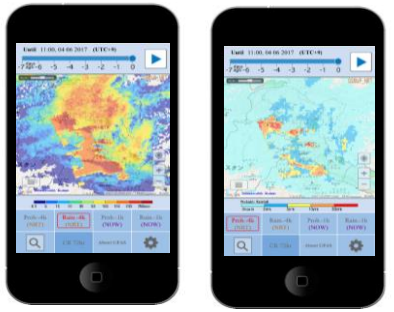
https://www.satnavi.jaxa.jp/apws-kumamoto-2022/doc/07_Presentation_Mohamed%20Rasmy_ICHARM.pdf

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.

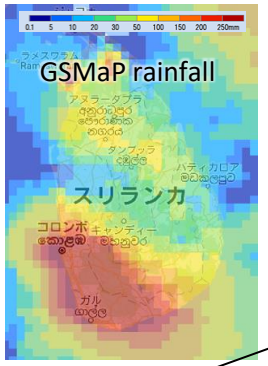
GSMaP rainfall

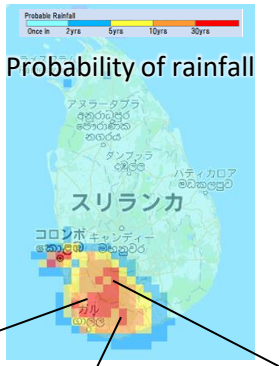
Probability of rainfall



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

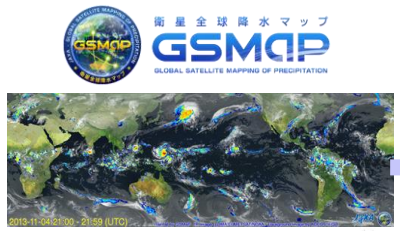
GSMaP based Landslide Warning System (GLWS)

- 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

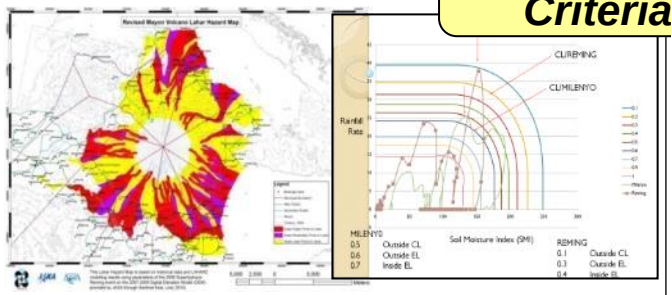


Calibrated rainfall data via GSMaP IF

Ground-based Rainfall data

Model preparation

Hazard maps, Criteria

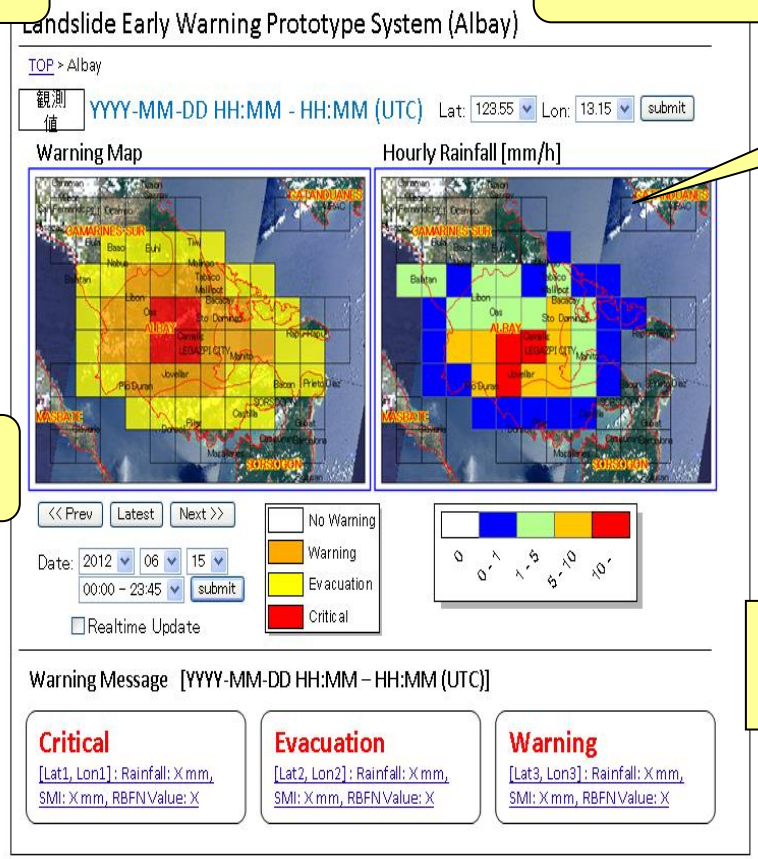


Maps

Warning criteria

Automatic prediction

System



GLWS can provide spatial distribution of landslide risk

Application

Analysis /warning

Agency/Local gov.

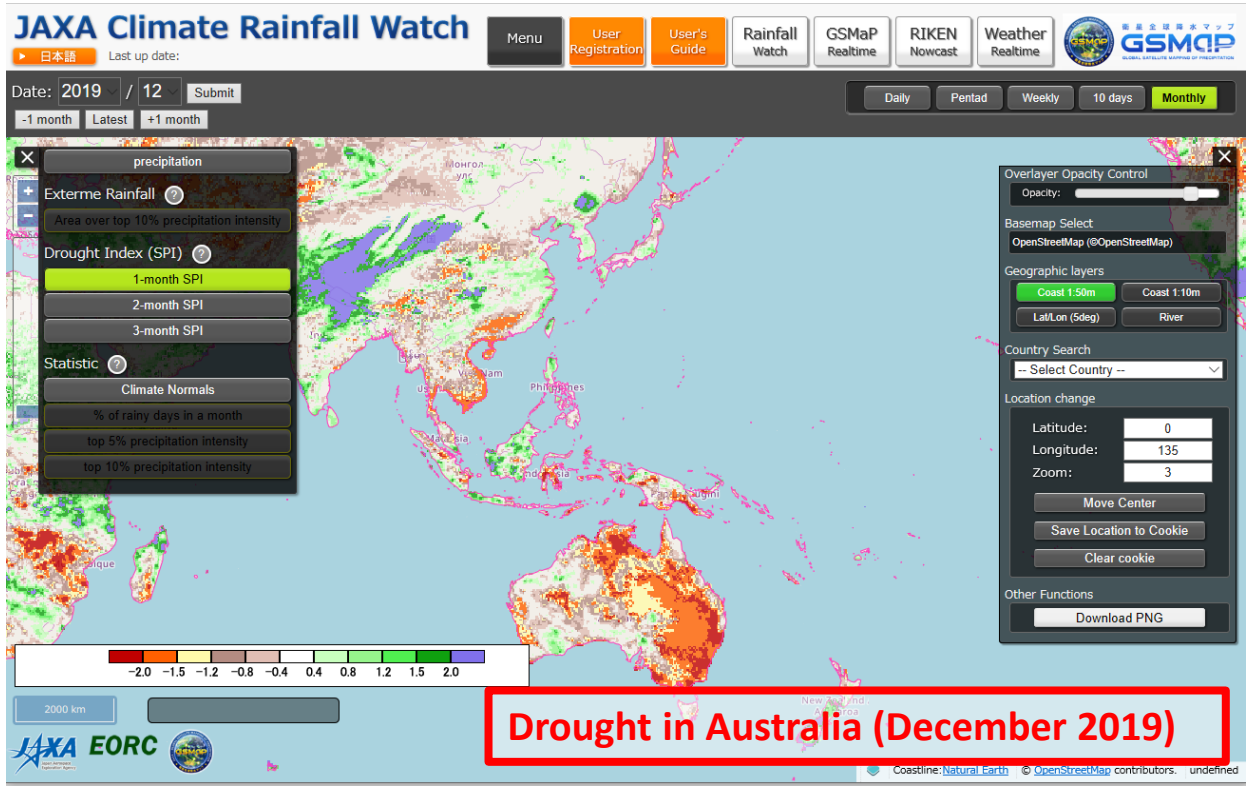
The warning criteria method applied in this system is also used in the Japan Meteorological Agency (rainfall by ground-based radar is used instead).

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

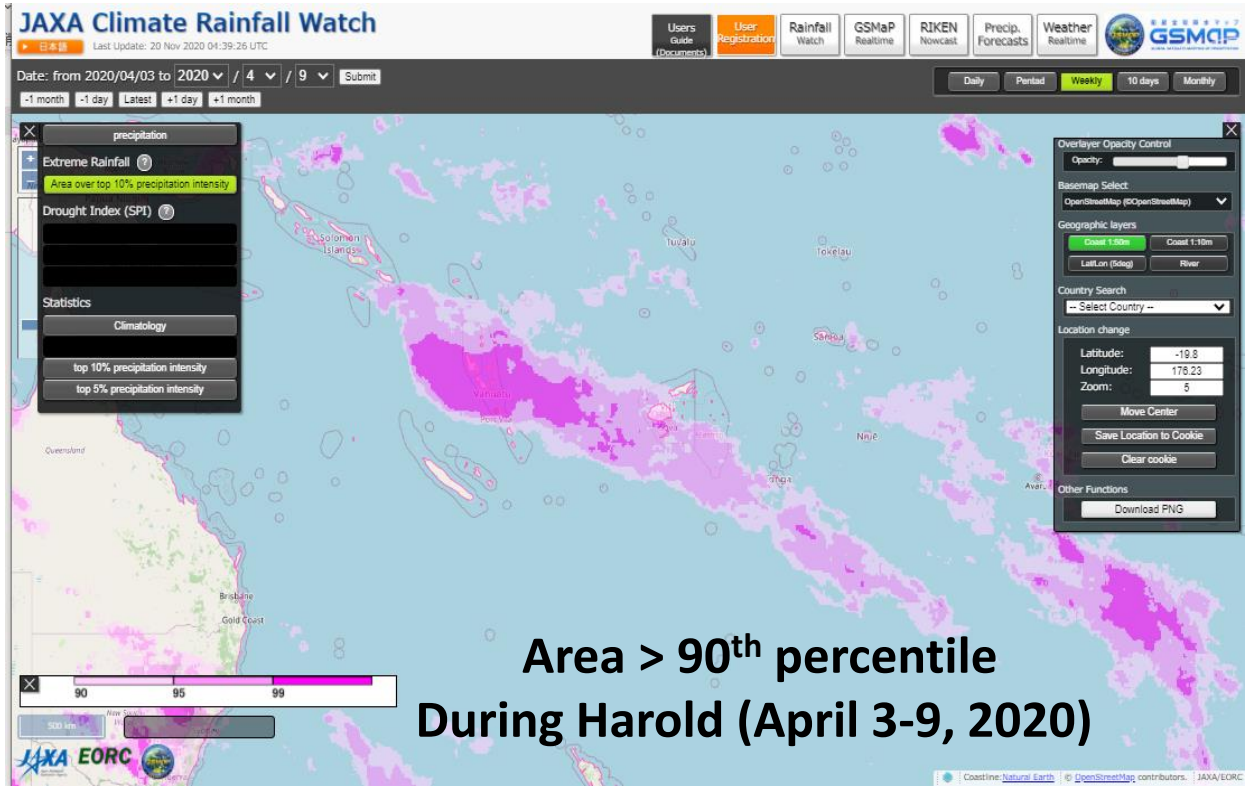
Drought and Heavy Rainfall Monitoring

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.

Displaying accumulated rainfall in some temporal scale (daily, pentad, weekly, 10-days and monthly) and 20-year climate normal.



Drought in Australia (December 2019)



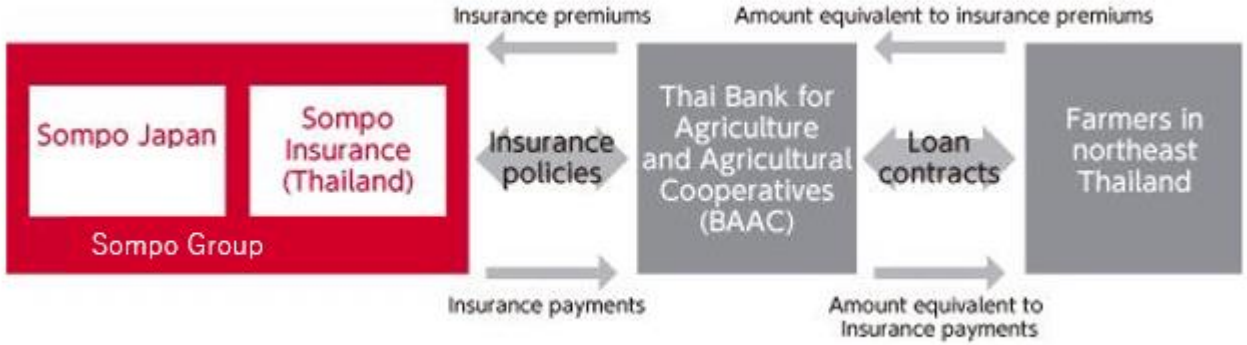
Area > 90th percentile
During Harold (April 3-9, 2020)

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

Weather Index Insurance for farmers

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/

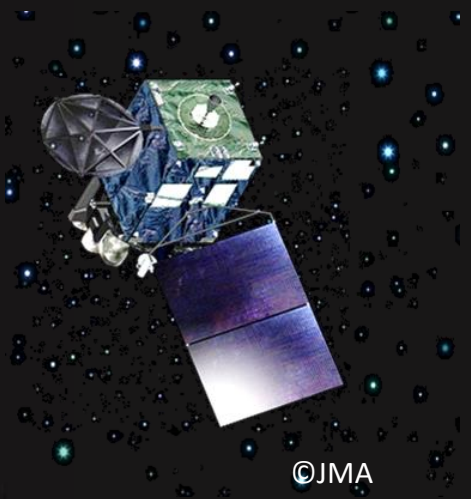
GSMaP Global Satellite Mapping of Precipitation

Dual-frequency Precipitation Radar

DPR

DPR provides "reference standard"

GPM Microwave Imager



GPM Core Observatory

GPM constellation satellites

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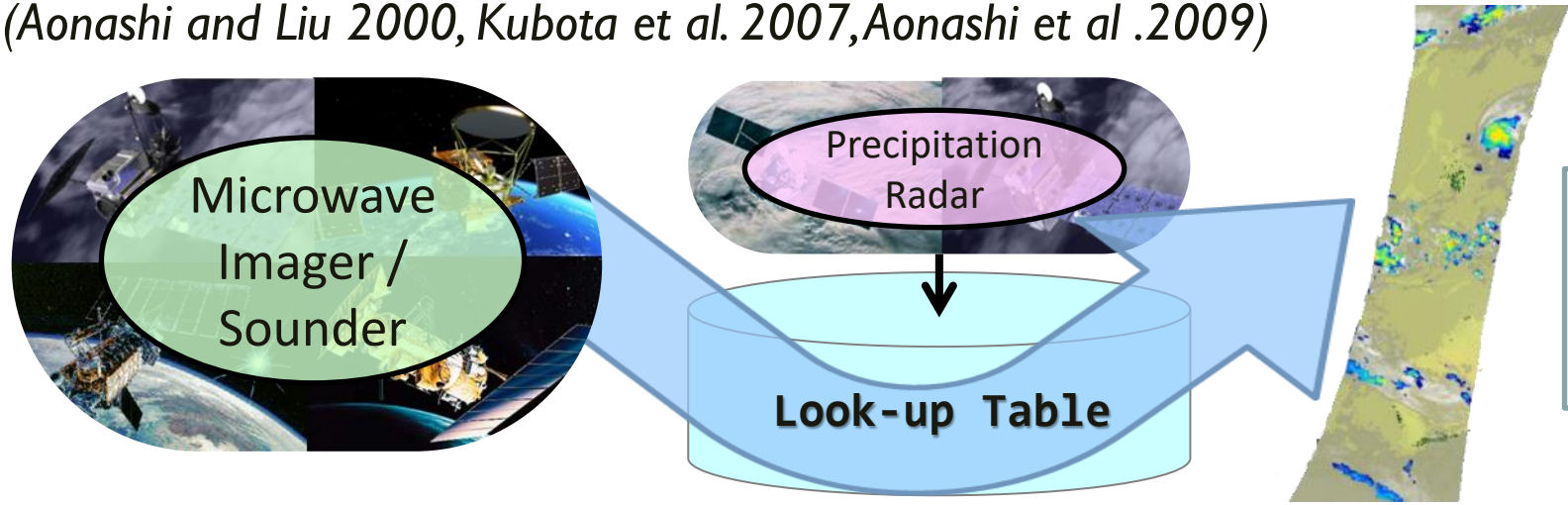
Geostationary Satellites

Precipitation Radar	Microwave Radiometer	Infrared Imager

How can these different sensors be used in the algorithm?

Rainfall Data from each Microwave Radiometer

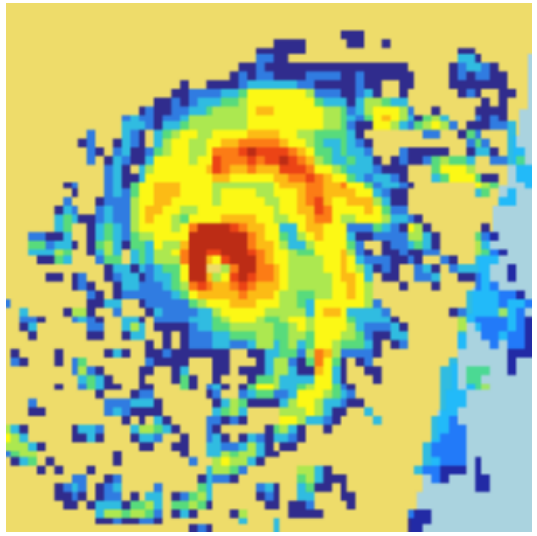
(Aonashi and Liu 2000, Kubota et al. 2007, Aonashi et al .2009)



Rainfall Data from each Microwave Radiometer

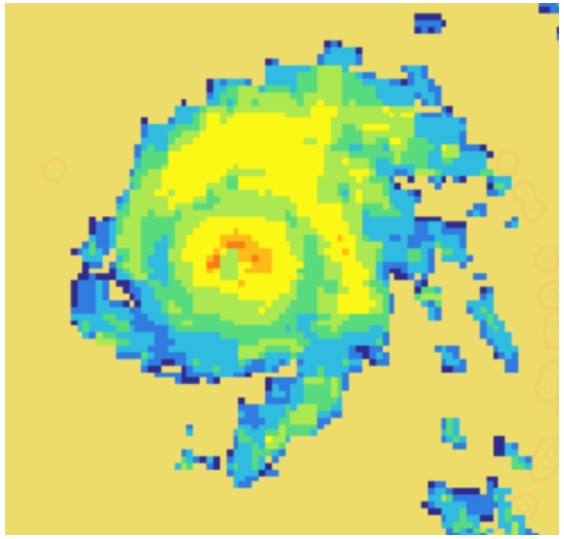
(Microwave Imager)

GCOM-W/AMSR-2

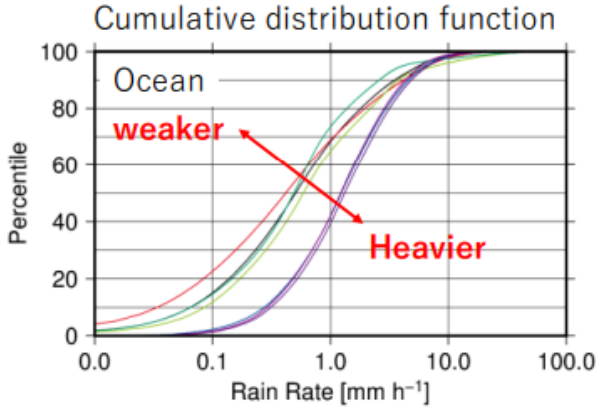


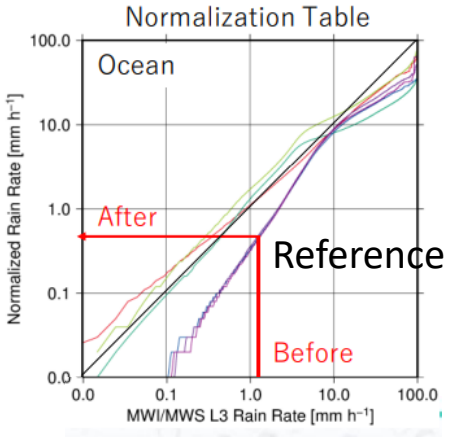
(Microwave Sounder)

NOAA-19/AMSU-A/MHS



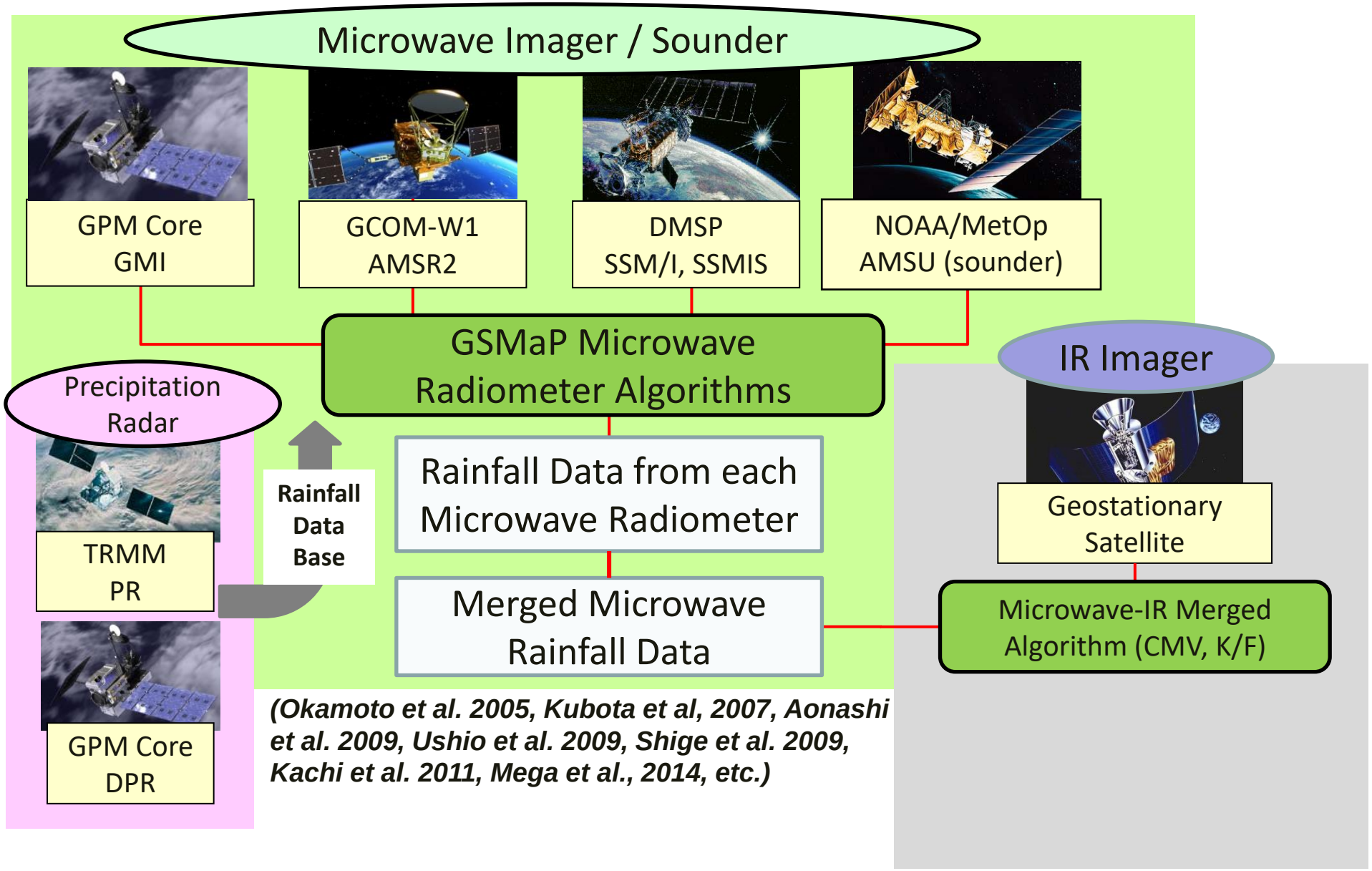
Depending on the type of Microwave Radiometer, precipitation intensity and resolution slightly differ. Normalization method [Yamamoto et al.,2022] is included for precipitation intensity.





Reference is GMI.

Overview of GSMaP Algorithm



Flowchart of MWR-IR Merged algorithm

(Ushio et al. 2009)

TIME

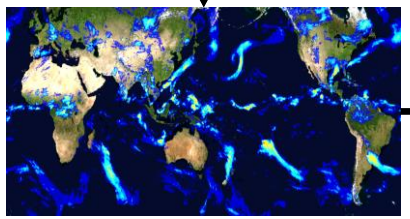
Infrared (IR) Data

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

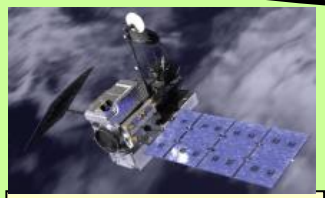
GSMaP present

MWR data Present (Within the last hour)

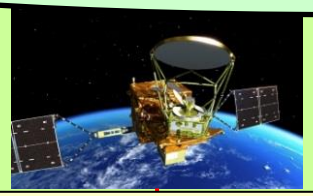
Microwave Radiometer (MWR) Data

Overview of GSMaP Algorithm

Microwave Imager / Sounder



GPM Core
GMI



GCOM-W1
AMSR2

DMSP
SSM/I, SSMIS

NOAA/MetOp
AMSU (sounder)

GSMaP Microwave
Radiometer Algorithms

Precipitation
Radar

TRMM
PR

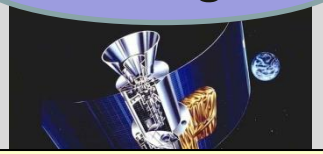
GPM Core
DPR

Rainfall
Data
Base

Rainfall Data from each
Microwave Radiometer

Merged Microwave
Rainfall Data

IR Imager



Geostationary
Satellite

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

Global Rainfall Map
+Gauge-calibrated Rainfall
(0.1x0.1 deg. box, 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, Mega et al., 2014, etc.)

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)

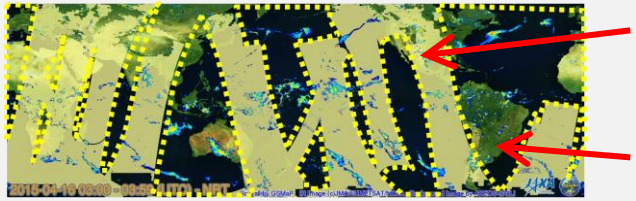
Expected Purposes

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

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

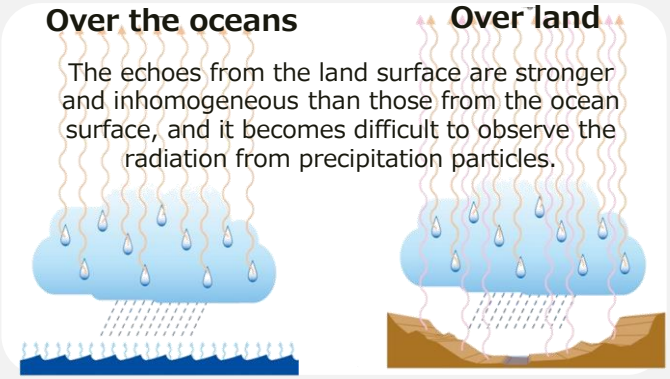
Retrieved by using PMW algorithm -> Better accuracy

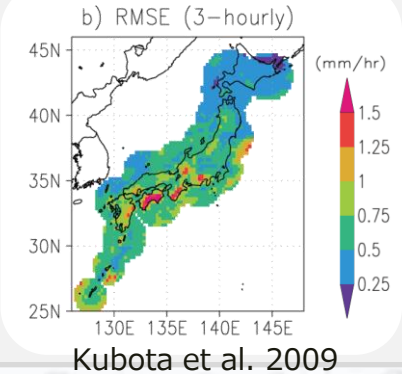
Outside of the yellow-shaded areas

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.

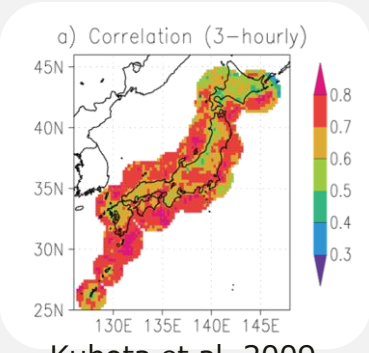




Kubota et al. 2009

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



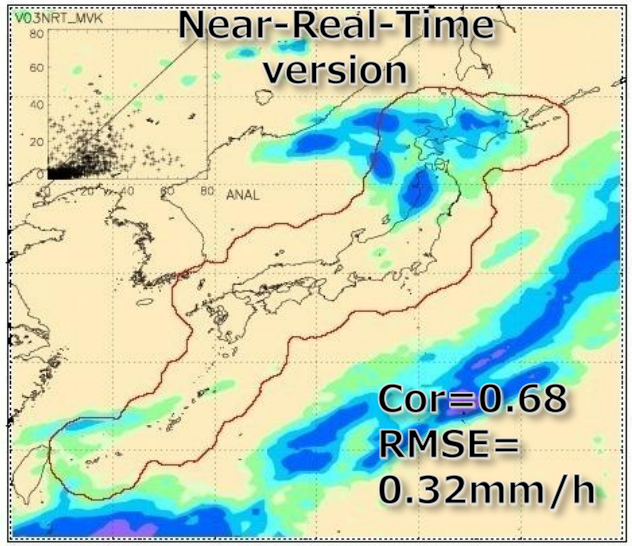
Kubota et al. 2009

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

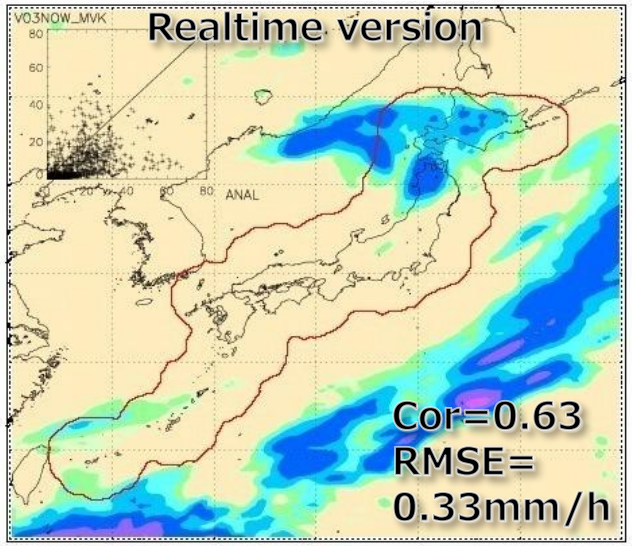
Snapshots of Daily Validation

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

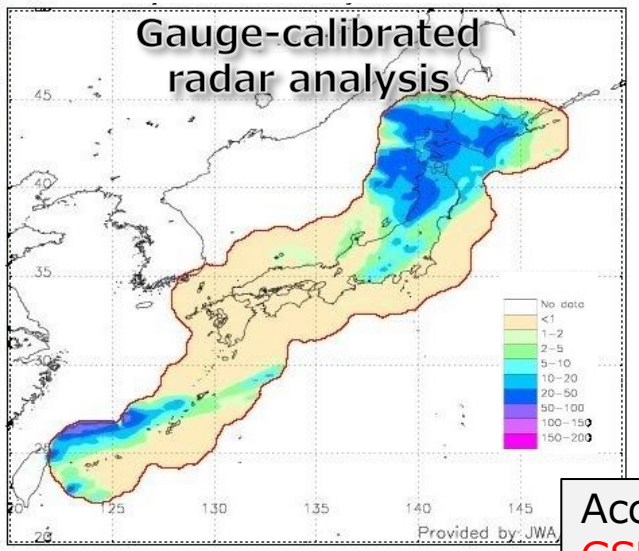
GSMaP_NRT



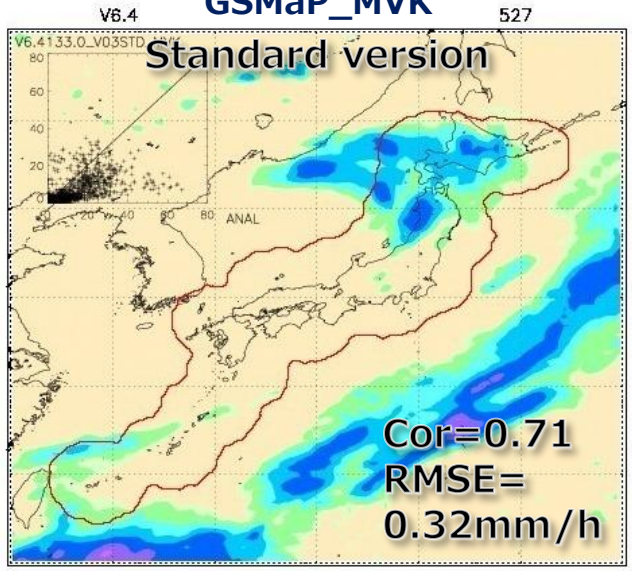
GSMaP_NOW



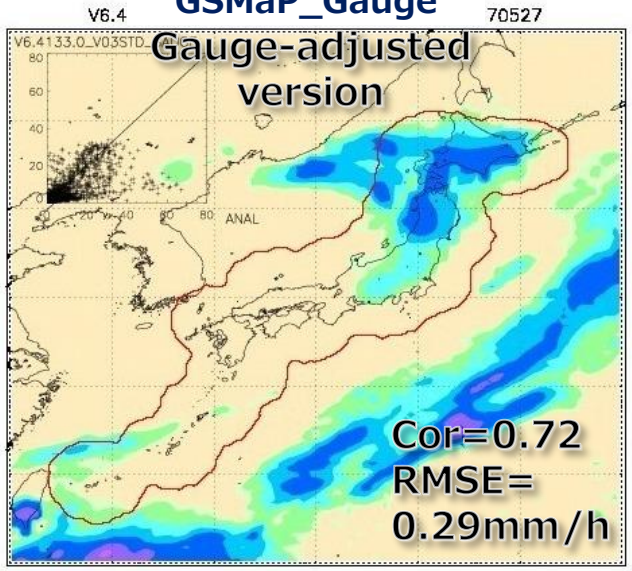
JMA's Radar-AMeDAS



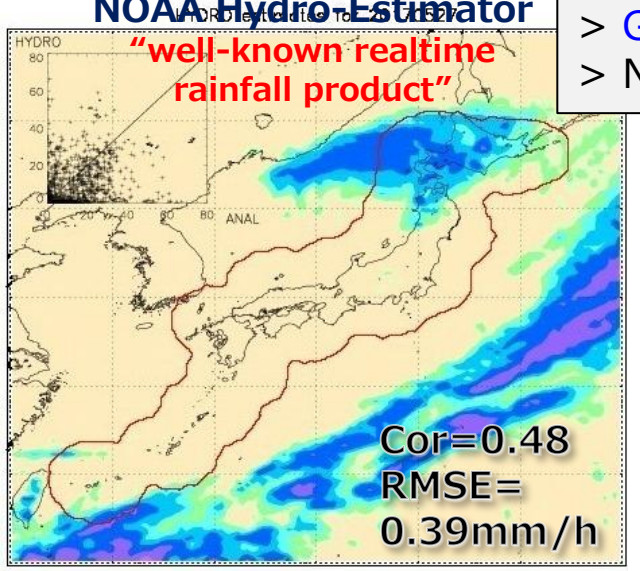
GSMaP_MVK



GSMaP_Gauge

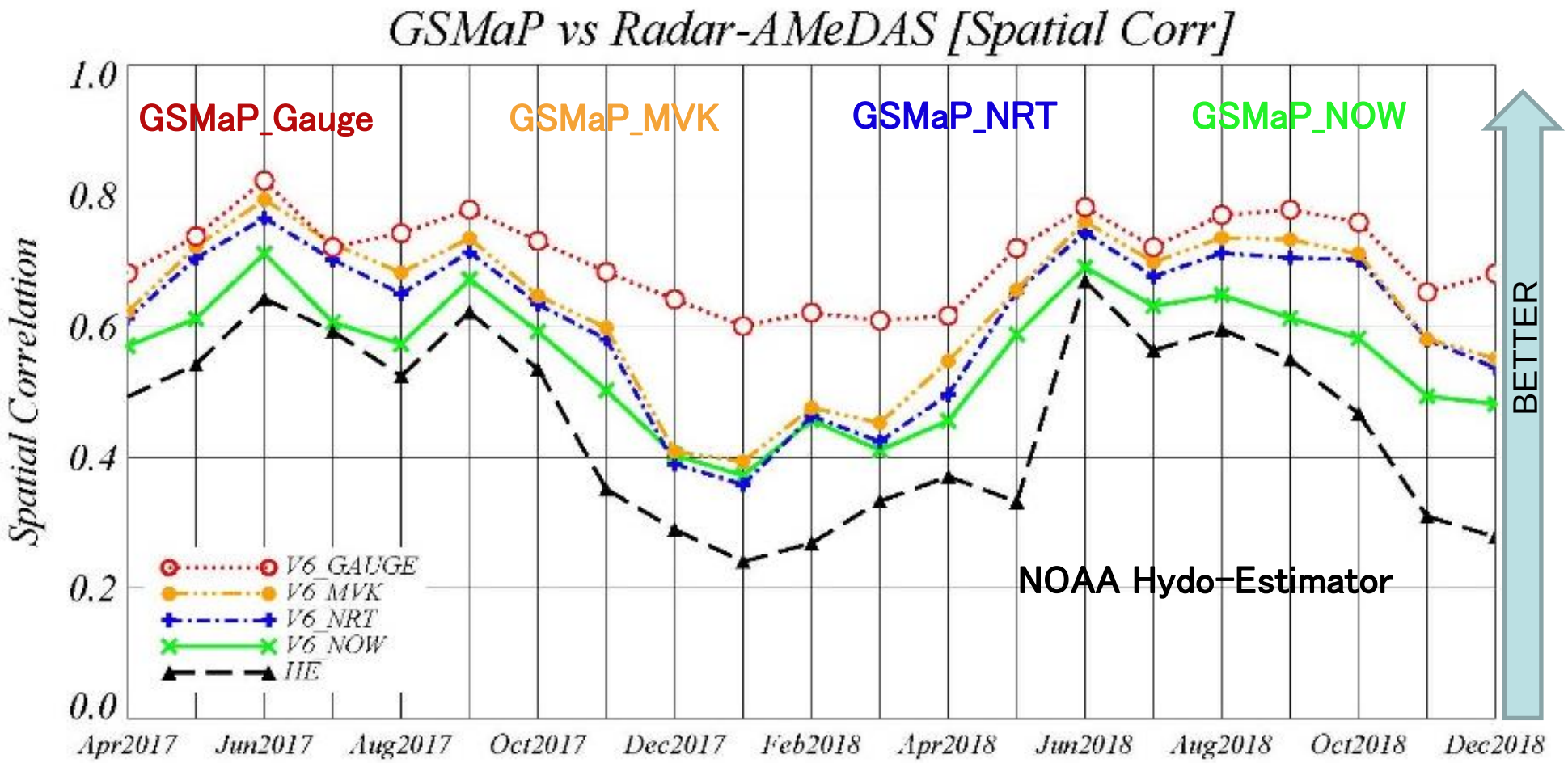


NOAA Hydro-Estimator



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 websites

- For users who would like to **monitor precipitation in realtime**
  ...JAXA REALTIME RAINFALL WATCH
  You can see global precipitation map, updated **every 30 minutes**.

- For users who would like to see **precipitation in the past specific date**
  ...JAXA GLOBAL RAINFALL WATCH
  You can see hourly global precipitation map **since March 2000**.

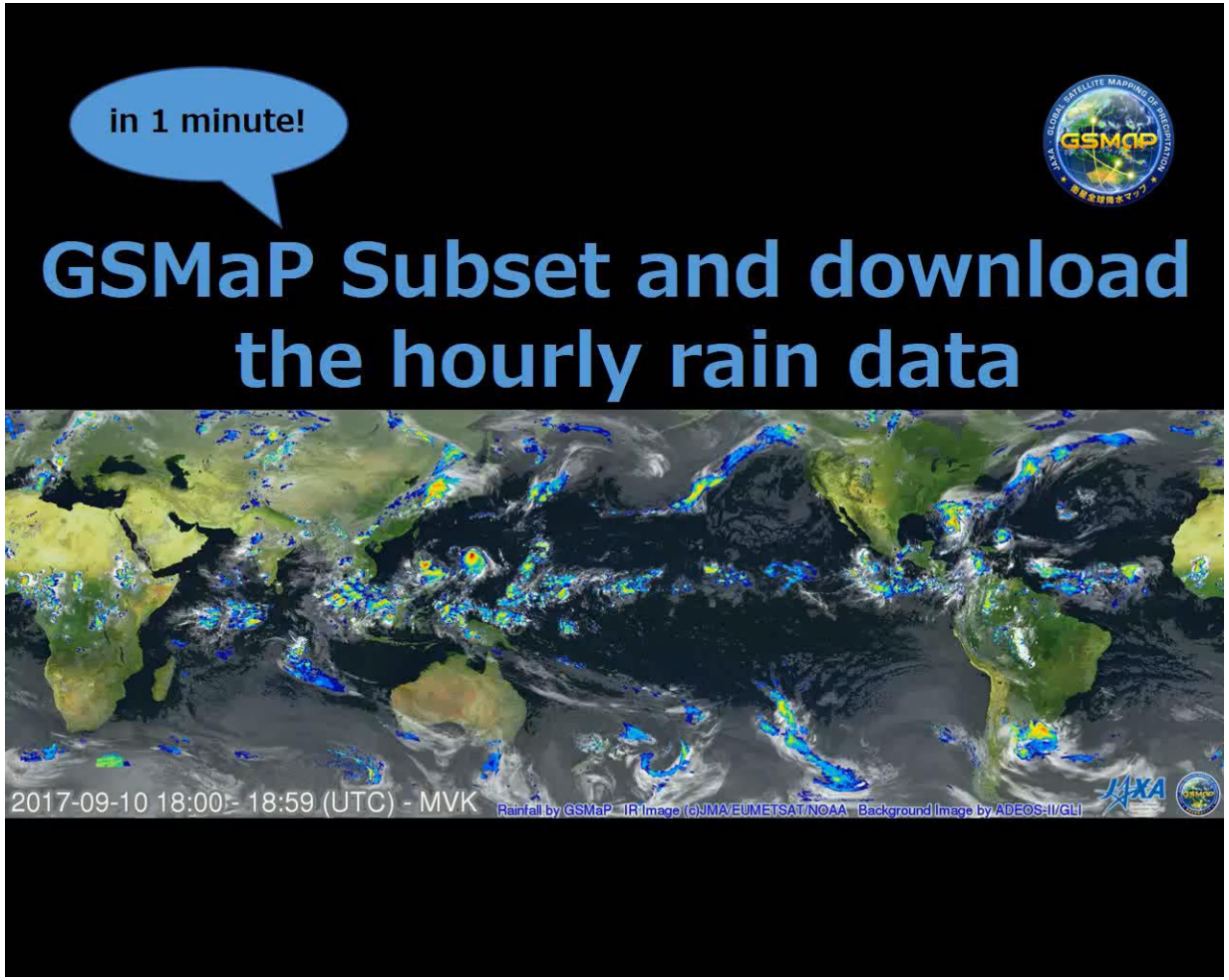
- For users who would like to see **daily or monthly precipitation**
  ...JAXA CLIMATE RAINFALL WATCH
  You can see indices related to **extreme heavy rainfall and drought** as well as accumulated precipitation.

GSMaP websites

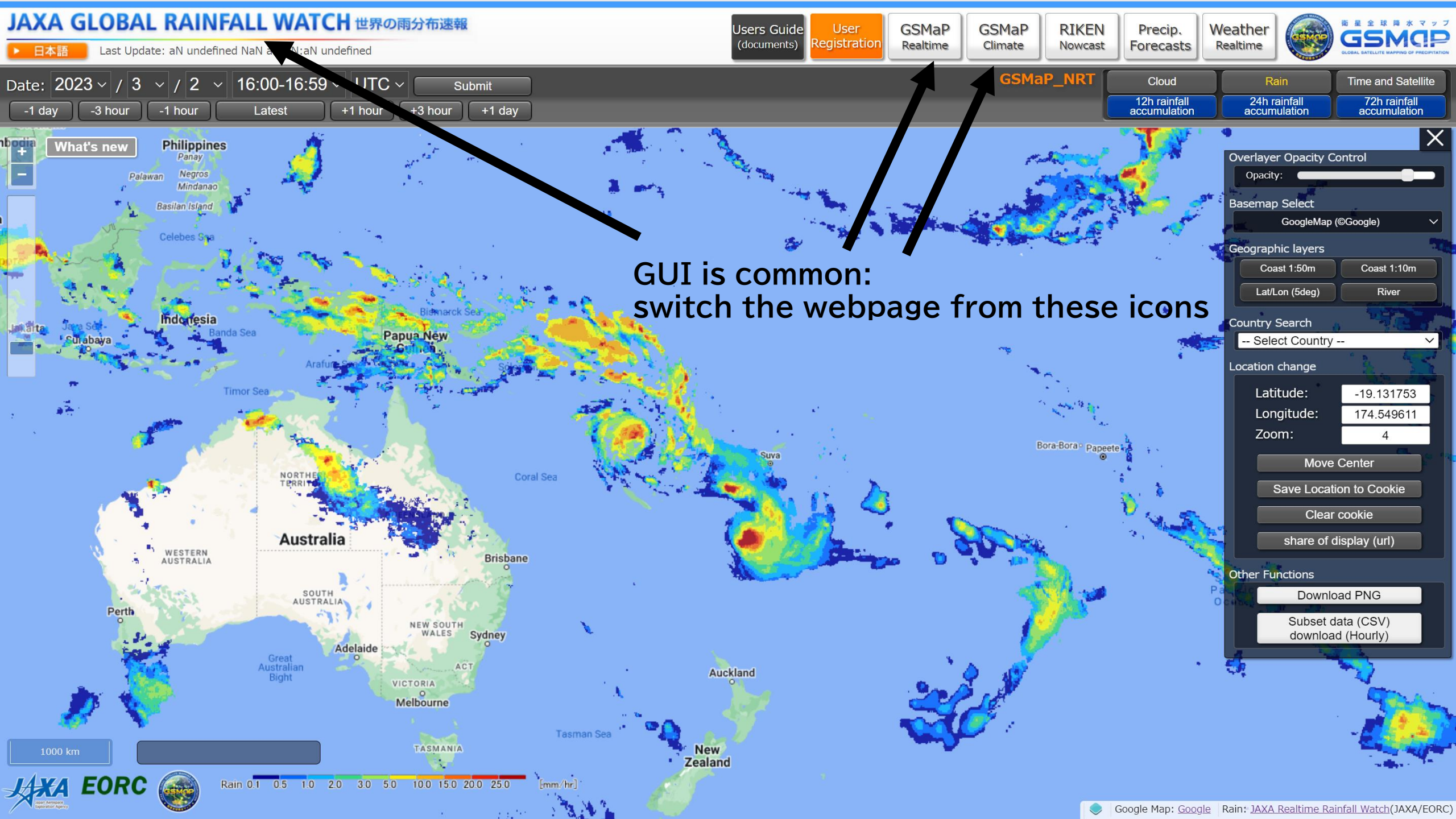
How to use GSMaP website in 1 minute!

https://youtu.be/0JanK-fZMt4

GSMaP subset and
download hourly rain data in 1 minute!

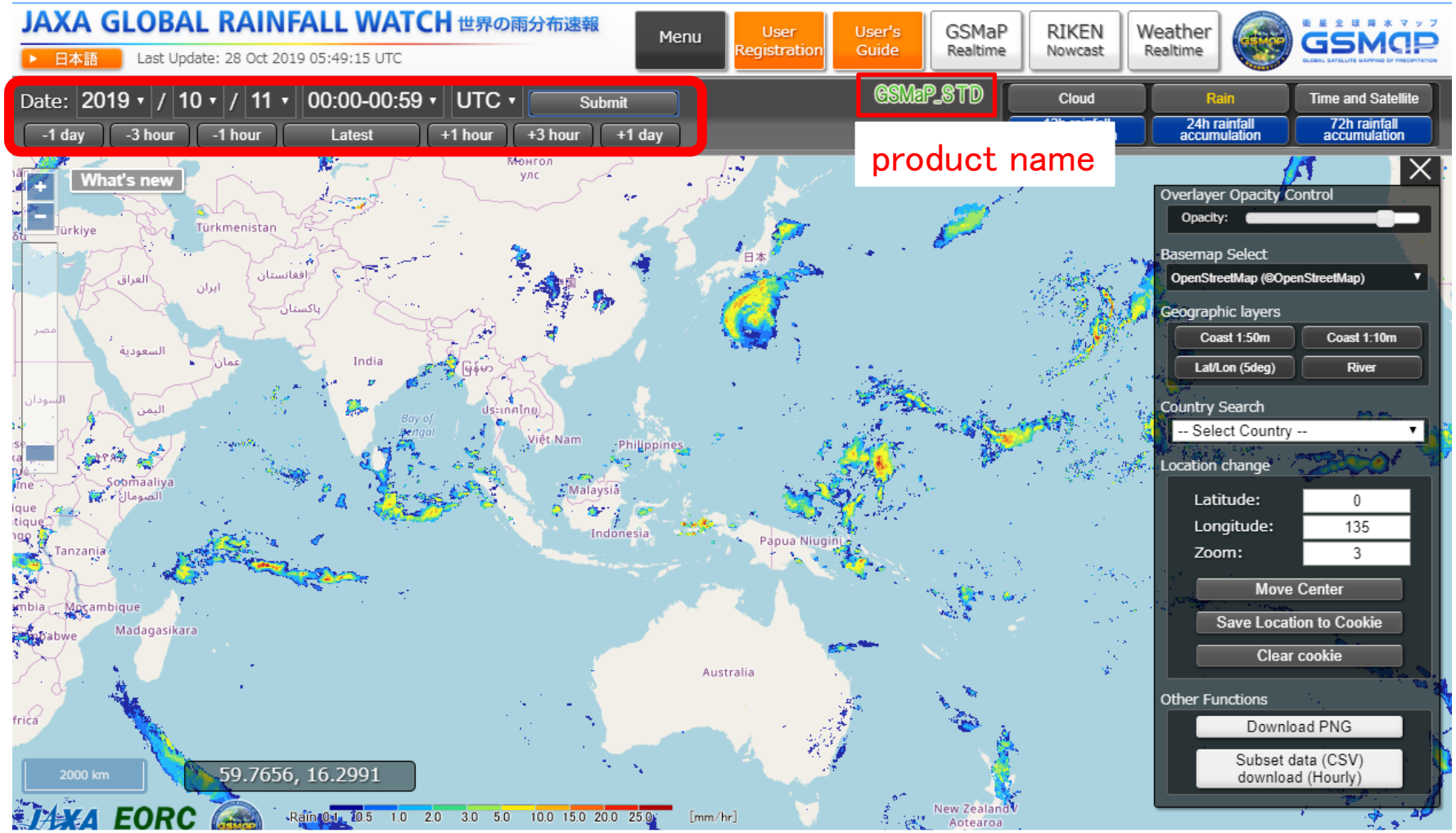


https://youtu.be/VnxH7inZh6g


JAXA GLOBAL RAINFALL WATCH 世界の雨分布速報
日本語
Last Update: aN undefined NaN aN:aN undefined
Users Guide (documents)
User Registration
GSMaP Realtime
GSMaP Climate
RIKEN Nowcast
Precip. Forecasts
Weather Realtime
GSMaP
Date: 2023 / 3 / 2 16:00-16:59 UTC Submit
-1 day
-3 hour
-1 hour
Latest
+1 hour
+3 hour
+1 day
GSMaP_NRT
Cloud
Rain
Time and Satellite
12h rainfall accumulation
24h rainfall accumulation
72h rainfall accumulation
What's new
GUI is common:
switch the webpage from these icons
Overlayer Opacity Control
Opacity:
Basemap Select
GoogleMap (©Google)
Geographic layers
Coast 1:50m
Coast 1:10m
Lat/Lon (5deg)
River
Country Search
-- Select Country --
Location change
Latitude: -19.131753
Longitude: 174.549611
Zoom: 4
Move Center
Save Location to Cookie
Clear cookie
share of display (url)
Other Functions
Download PNG
Subset data (CSV) download (Hourly)
Philippines
Indonesia
Papua New Guinea
Australia
Perth
Adelaide
Melbourne
Sydney
Brisbane
Auckland
New Zealand
Suva
Bora-Bora
Papeete
Coral Sea
Tasman Sea
Timor Sea
Great Australian Bight
TASMANIA
1000 km
JAXA EORC
Rain 0.1 0.5 1.0 2.0 3.0 5.0 10.0 15.0 20.0 25.0 [mm/hr]
Google Map: Google
Rain: JAXA Realtime Rainfall Watch(JAXA/EORC)

GSMaP website [png]

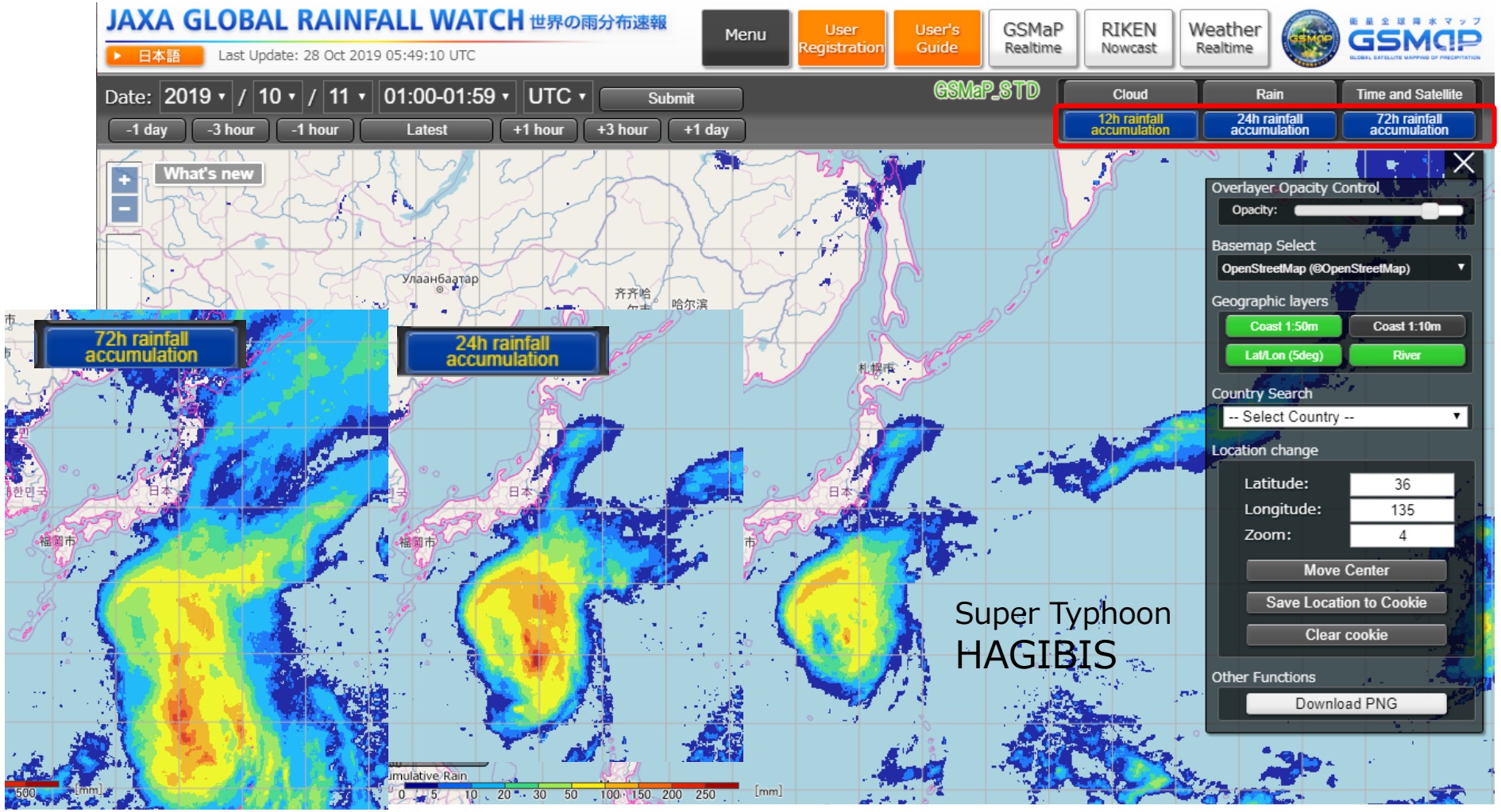
http://sharaku.eorc.jaxa.jp/GSMaP/index.htm



select date

GSMaP website [png]

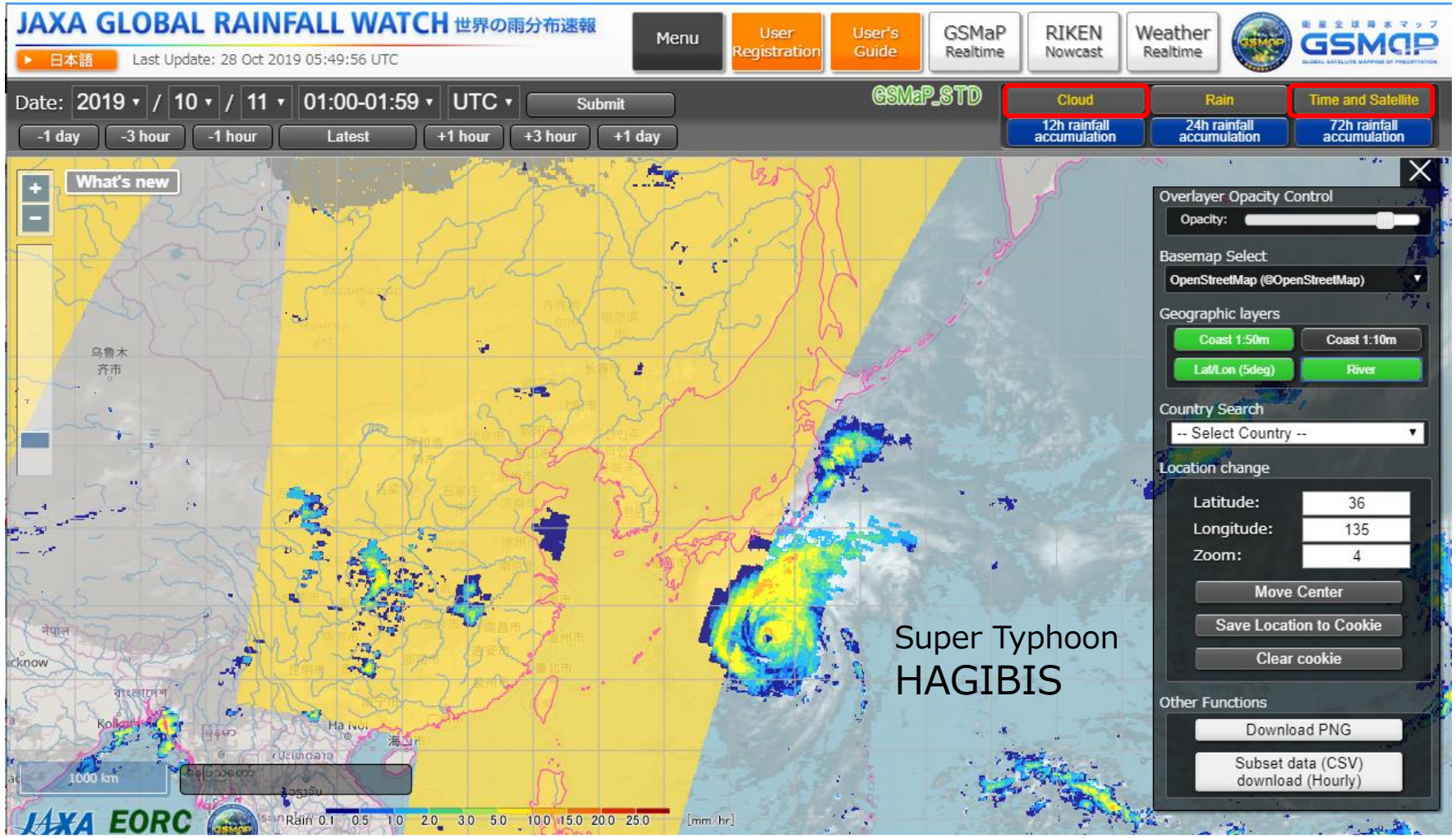
http://sharaku.eorc.jaxa.jp/GSMaP/index.htm



Check accumulated precipitation (12h/24h/72h)

GSMaP website [png]

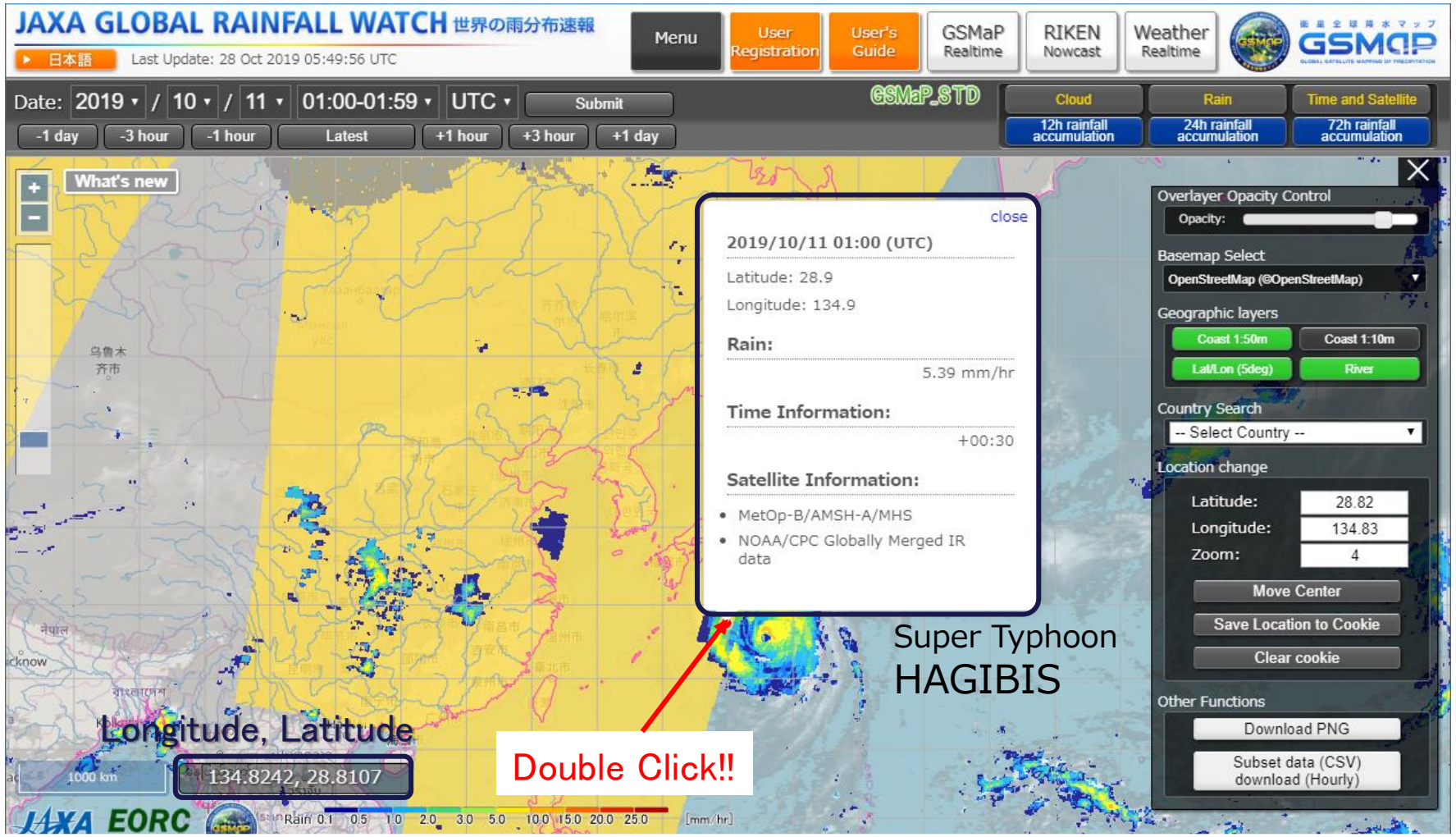
http://sharaku.eorc.jaxa.jp/GSMaP/index.htm



Overlay Cloud and/or Information flag

GSMaP website [png]

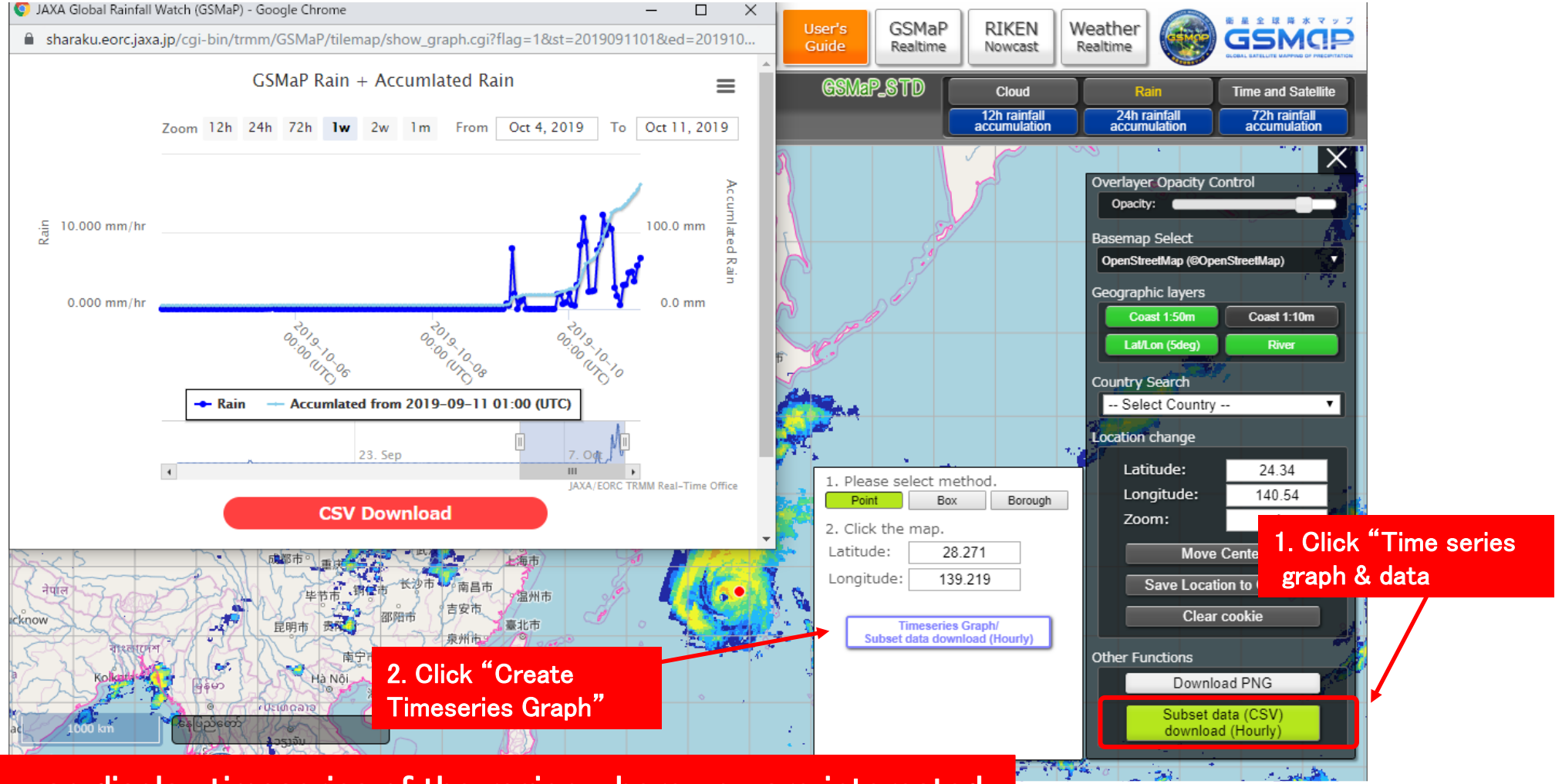
http://sharaku.eorc.jaxa.jp/GSMaP/index.htm



Display information of the point where you are interested

GSMaP website [png]

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



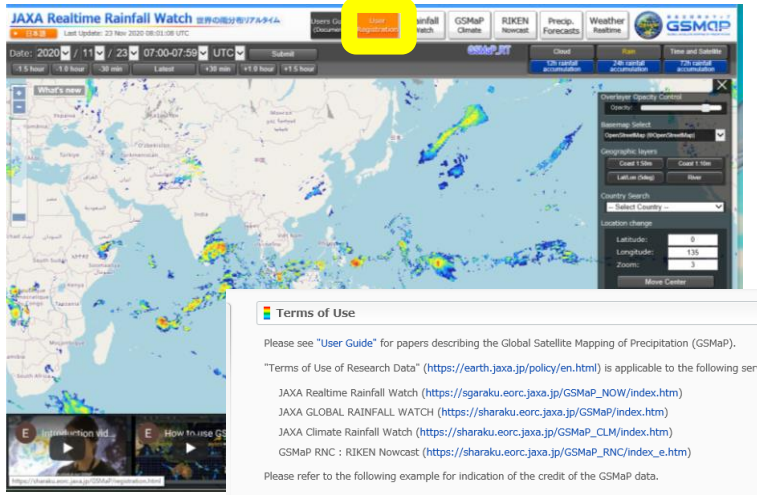
You can display timeseries of the region where you are interested.
After user registration, you can download the CSV data.

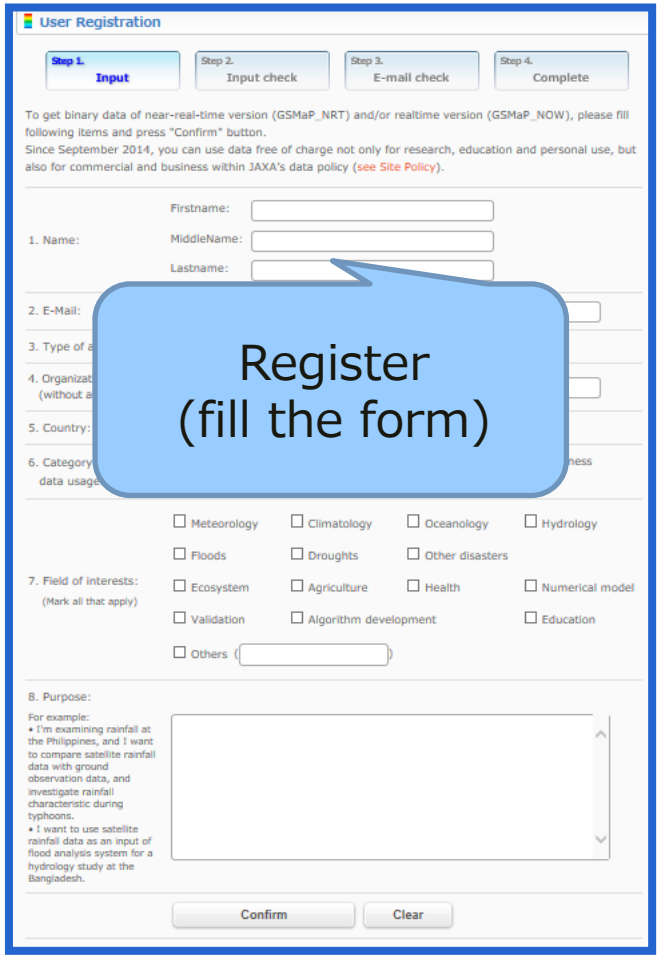
GSMaP data distribution for analysis

Click here

User Registration

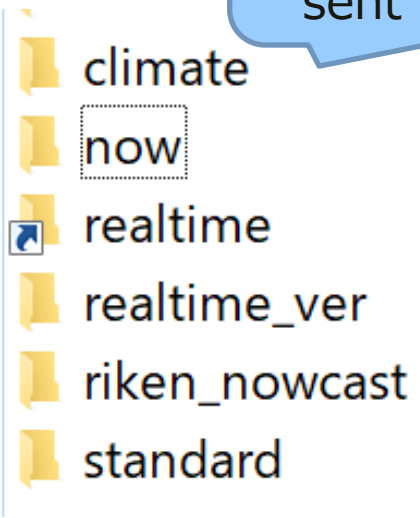
You can download the data after user registration (free of charge).
https://sharaku.eorc.jaxa.jp/GSMaP/registration.html





Register
(fill the form)

Ftp server information will be sent via email



Data specifications are explained in the documents.
https://sharaku.eorc.jaxa.jp/GSMaP/faq/GSMaP_faq18.html

Summary

- 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.
- We distribute the data or image via website and ftpsite and users can freely access to the data.