IPWG-11: No. 1.5

Recent status of the Global Precipitation Measurement (GPM) Mission in Japan and future Japanese Precipitation Measuring Mission (PMM)

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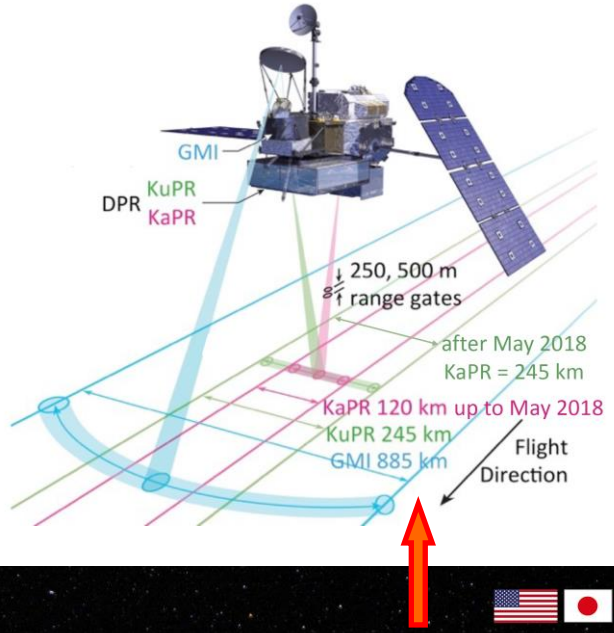
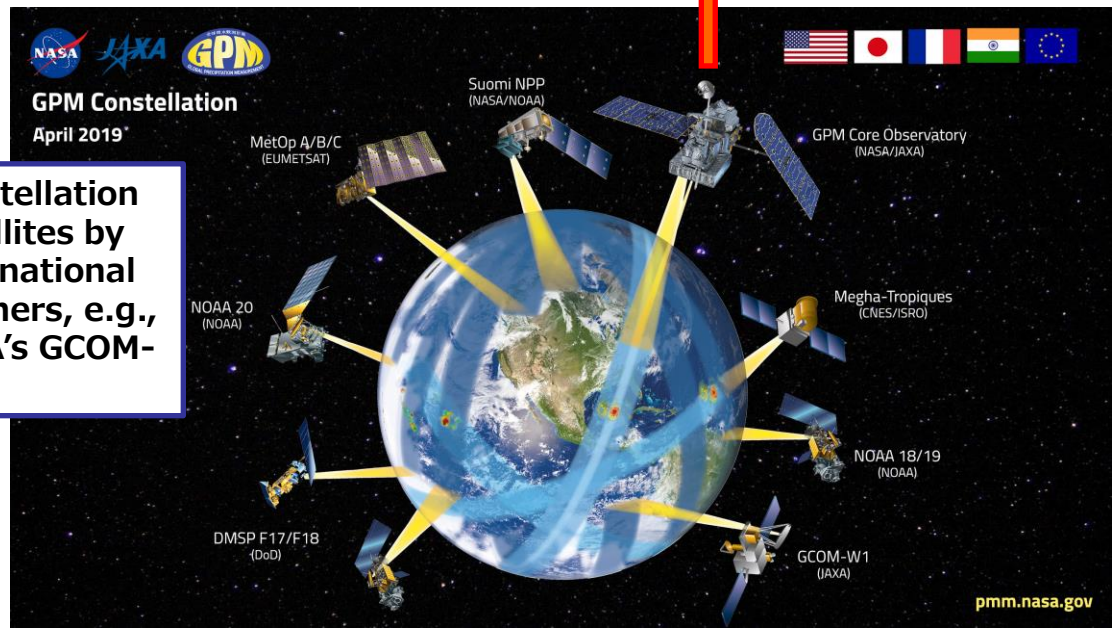
15th July 2024

Global Precipitation Measurement (GPM)

GPM Core Observatory by NASA-JAXA



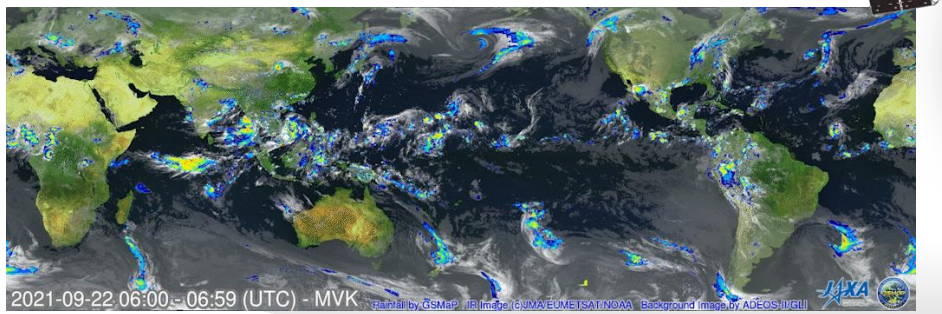


Constellation Satellites by international partners, e.g., JAXA's GCOM-W, ..

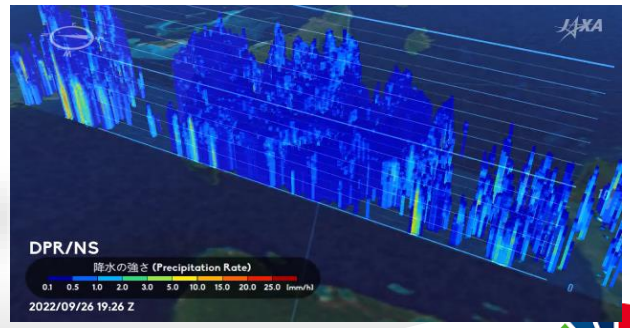
- The GPM is an international mission consisting of the GPM Core Observatory by NASA-JAXA and constellation satellites by international partners for high-precision and high-frequency global precipitation observation.
- The GPM Core Observatory is equipped with the **Dual-frequency Precipitation Radar DPR developed by JAXA and NICT and the GPM Microwave Imager (GMI) developed by NASA**.
- The GPM Core Observatory was launched by the H-IIA rocket from the Tanegashima Space Center in February 2014, and has been **in operation for 10 years since February 2024**.
- We have provided global merged precipitation products, such as JAXA's GSMaP and NASA's IMERG that integrate the GPM Core Observatory and constellation satellites.

JAXA GPM (Global Precipitation Measurement)

Global Satellite Mapping of Precipitation (GSMaP)



Dual-frequency Precipitation Radar (DPR)



Climate monitoring

WMO extremes monitoring

Weather Monitoring/ forecasts

Asia–oceania met services

Water-related disasters

Flood analysis and predictions by disaster management offices

Agriculture

Flood security and insurance for farmers

Energy

Hydropower development planning

Public health

Researches on infectious diseases

Educations

Educational tools

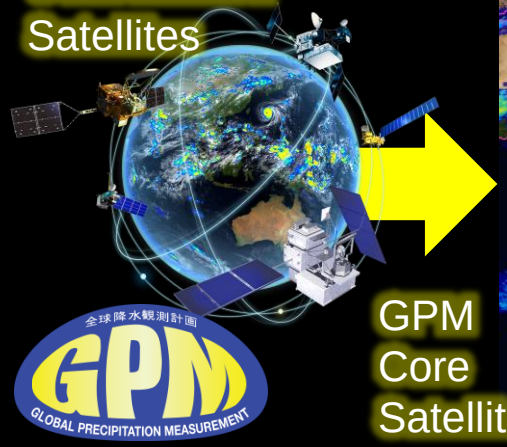
Use cases are collected in the book “Case studies demonstrated by TRMM/GPM/GSMaP”

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

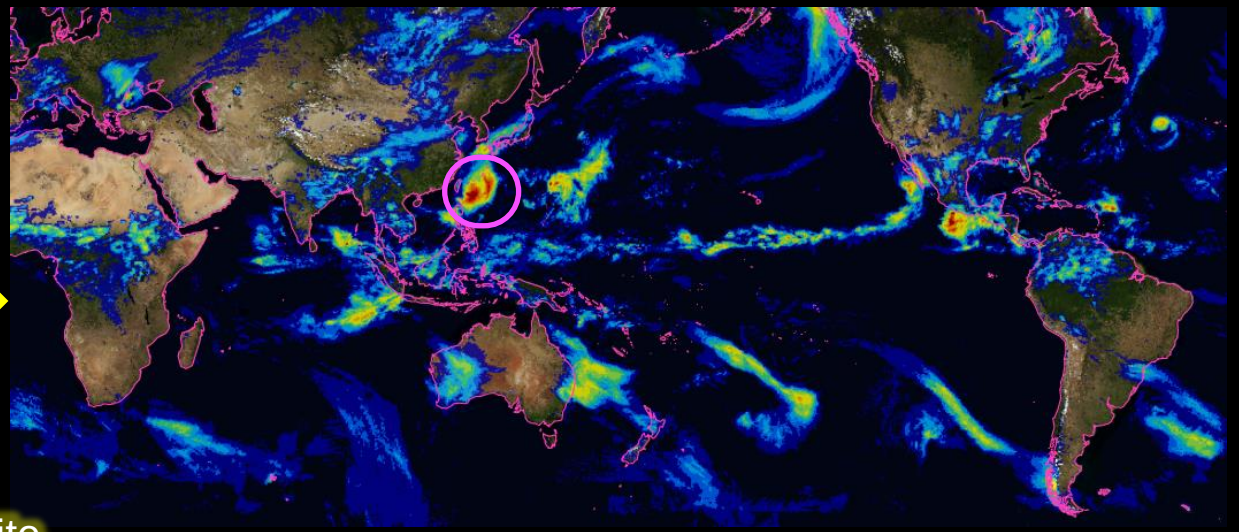
Japanese GPM Product:
Global Satellite Mapping of Precipitation

GSMaP
衛星全球降水マップ
GLOBAL SATELLITE MAPPING OF PRECIPITATION

GPM Constellation Satellites



GPM Core Satellite

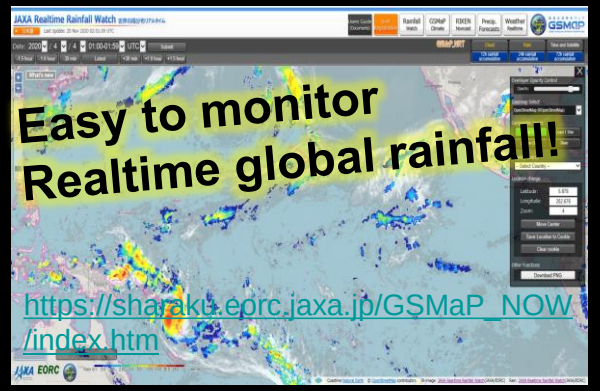


- **Hourly global** rainfall data
- Spatial resolution: about **11x11km**
- Various version such as **real-time for monitoring** or **long-term gauge-adjusted for climatological purposes**

13,481
registered users
from 151
countries/regions
(as of the end of June 2024)
+ website users
(not registered)

GSMaP is a blended Microwave-IR product and has been developed in Japan for the GPM mission.

- U.S. counterpart is “IMERG”
- A review paper of GPM-GSMaP V03 & V04 was published: Kubota et al. 2020
- GPM-GSMaP V05 (algorithm version 8) was released in Dec 2021, and the reprocessing the data since 1998 was completed in July 2023.
  - A review paper of V05 (algorithm version 8) was submitted as Kubota et al. (2024)



GSMaP adjusted by gauge data over the India

- Under the JAXA and the ISRO cooperation, we have developed the merge rainfall product with rain gauges over the India and been available from ISRO MOSDAC.

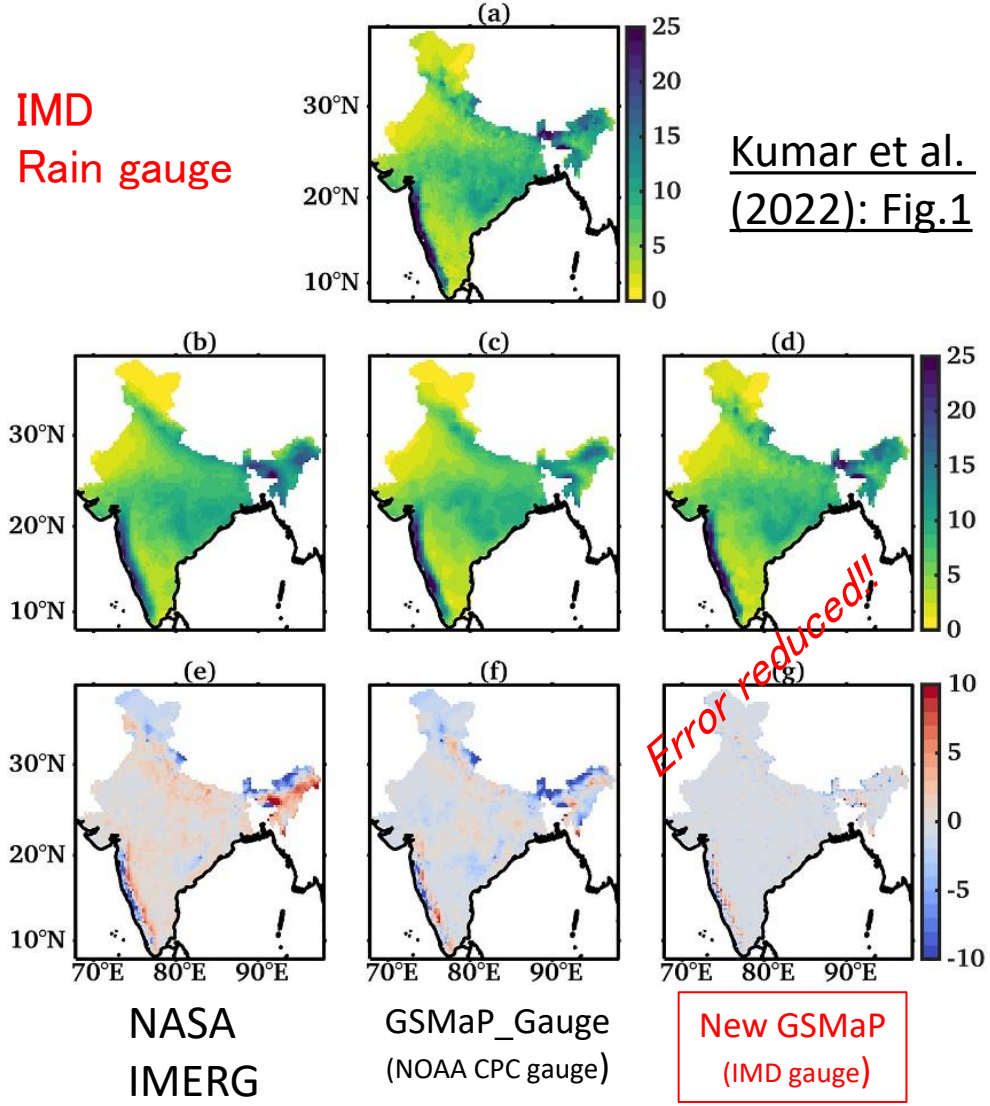
https://www.mosdac.gov.in/gsmap-isro-rain

- Create more than 20-year GSMaP rainfall product adjusted by rain gauge measurements over the India, with Indian Meteorological Department (IMD) daily gridded rainfall product
- Improvements are significant in orographic regions with high rainfall amounts, such as the western Ghats and northeastern parts of India.

Kumar et al. 2022, *ESS*
https://doi.org/10.1029/2022EA002595

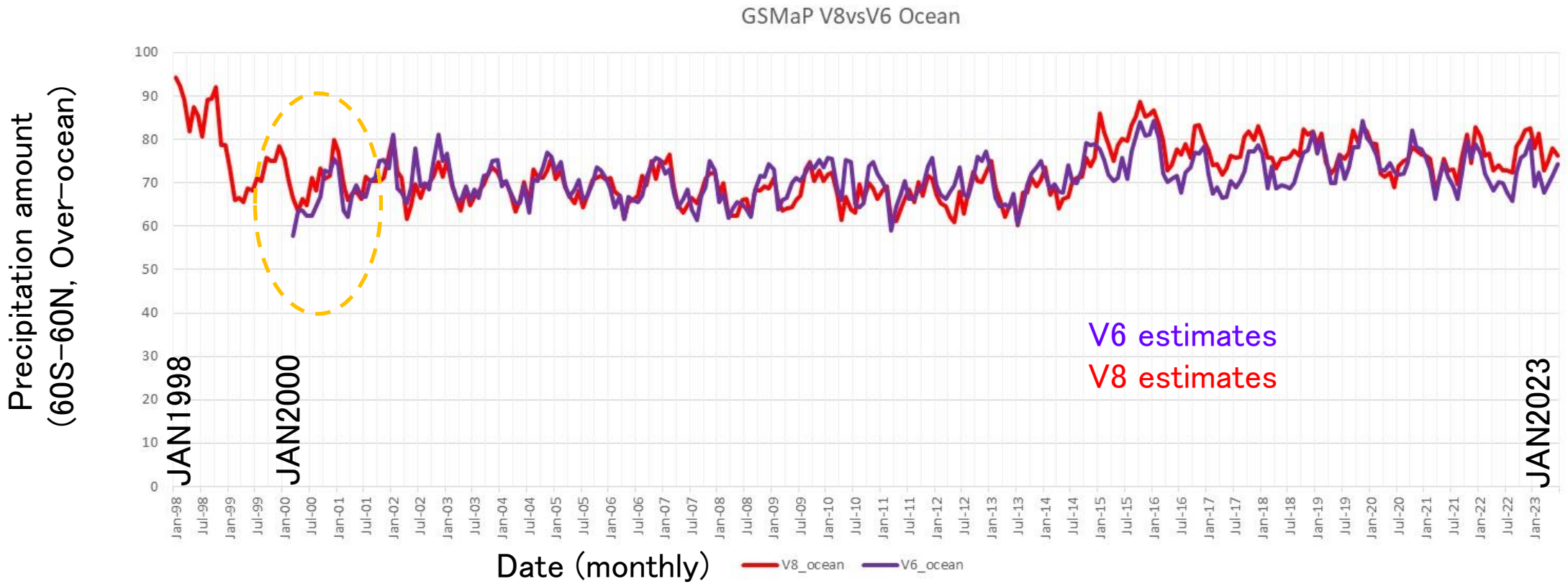
IMD
Rain gauge

Kumar et al. (2022): Fig.1



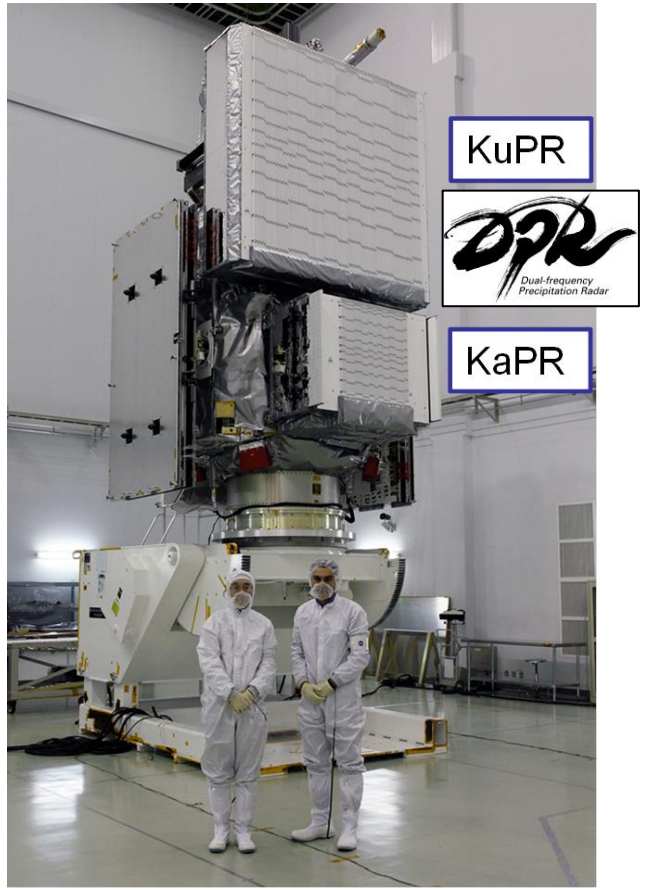
Reprocessing for construction of longer-term GSMaP dataset

- The new version (algorithm version 8, Kubota et al. 2024) of the GSMaP is available during a period during the past 25 years since Jan. 1998.
  - Precipitation estimates for the period during 1998-2000 are available only in the V8 (Red line).
- We're now developing improvements of GSMaP toward a future version upgrade (target schedule: April 2026).



Dual-frequency Precipitation Radar (DPR) status

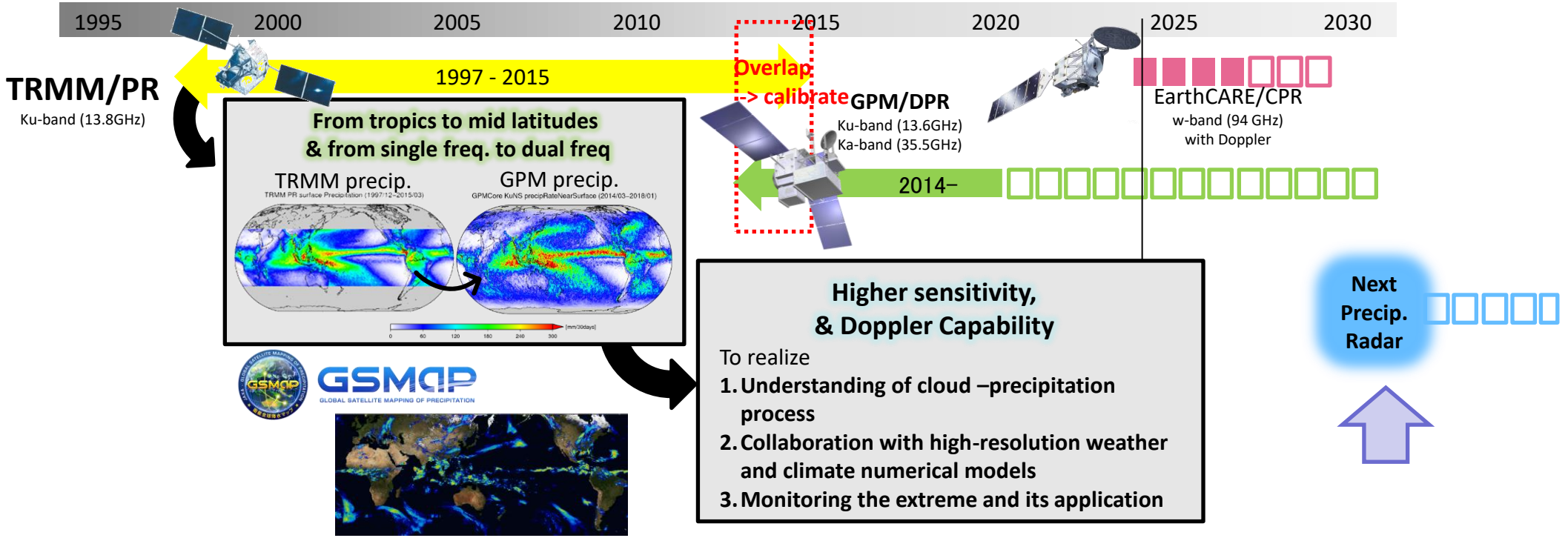
All data collection is nominal and instruments are in good condition.



- The GPM Core Observatory (GPM-CO) satellite performed two orbit boost maneuvers on Nov. 7 and 8, 2023 that raised its altitude from 407km to 442km.
  - This is because the recent lifetime estimates had been getting shorter due to unexpectedly high solar activity, which caused additional atmospheric drag on the spacecraft. It was predicted that the mission could end in mid-2027.
  - The primary goal of restoring GPM-CO's lifetime is to allow the GPM mission to overlap with the satellites associated with the future Atmosphere Observing System (AOS) mission planned by NASA, JAXA, and other agencies, allowing for inter-calibration of instruments between the GPM and the AOS missions.
- By this orbit boost, the lifespan of the GPM-CO became closer to the original estimates of ending in the early 2030's.
- On March 5, 2024, JAXA and NASA resumed the GPM/DPR Standard products(L1B are V07B, other products are V07C), which corresponded to the GPM orbit boost.
  - Evaluations for impacts of the GPM orbit boost to the DPR observations were described in Kubota et al. (2024, Proc. IGARSS).
    - Instrument footprints and swath widths increased proportionately with the altitude change.
    - Radar sensitivity was reduced slightly.

JAXA's Next-generation Precipitation Radar Project

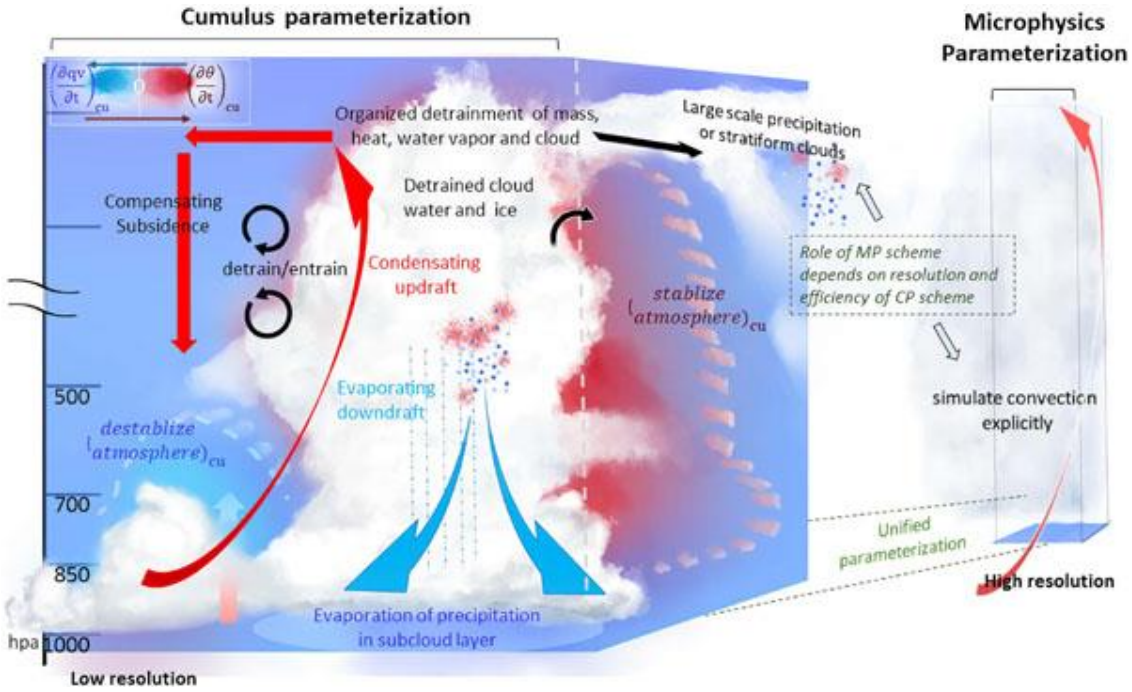
- The JAXA has studied a feasibility of a **next generation precipitation radar** with Japanese science team and user community.
  - ➢ The EarthCARE satellite carries the first Cloud Profiling Radar (CPR) with a **Doppler capability in space**. The CPR has been developed by the JAXA and the NICT.
    - ✓ CPR can contribute to IPWG community by measuring light precipitation.
- Our targets for the next generation precipitation radar in the **Precipitation Measuring Mission (PMM) Observatory** will be **Doppler Observations, Higher sensitivity measurements with scanning capability.**
  - ✓ JAXA has participated **in NASA's Atmosphere Observing System (AOS)** mission.



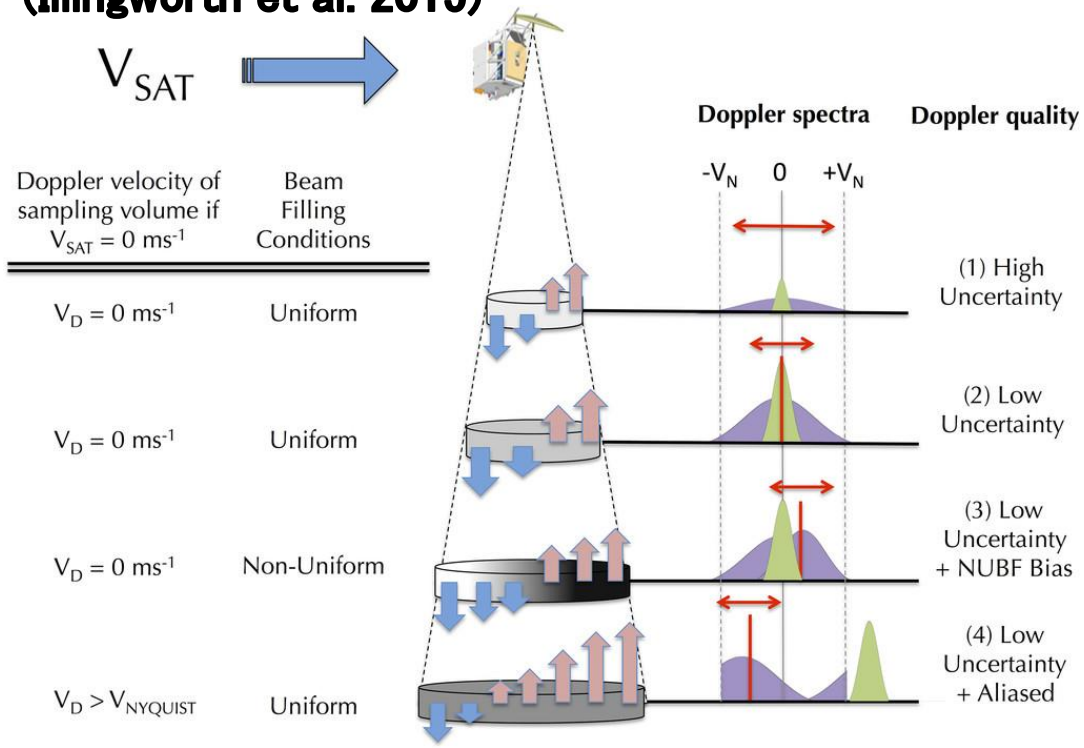
Challenges in measuring Doppler velocities from Space

- Measurements of Convection (vertical atmospheric motion) by Doppler velocities from space is desirable for understanding of cloud-precipitation process.
- On the other hand, estimating Doppler velocities from space is very challenging because of satellite motion, velocity folding, and nonuniform beam filling.

Process of cloud microphysics considered in a model (Sui, Satoh, and Suzuki 2020)

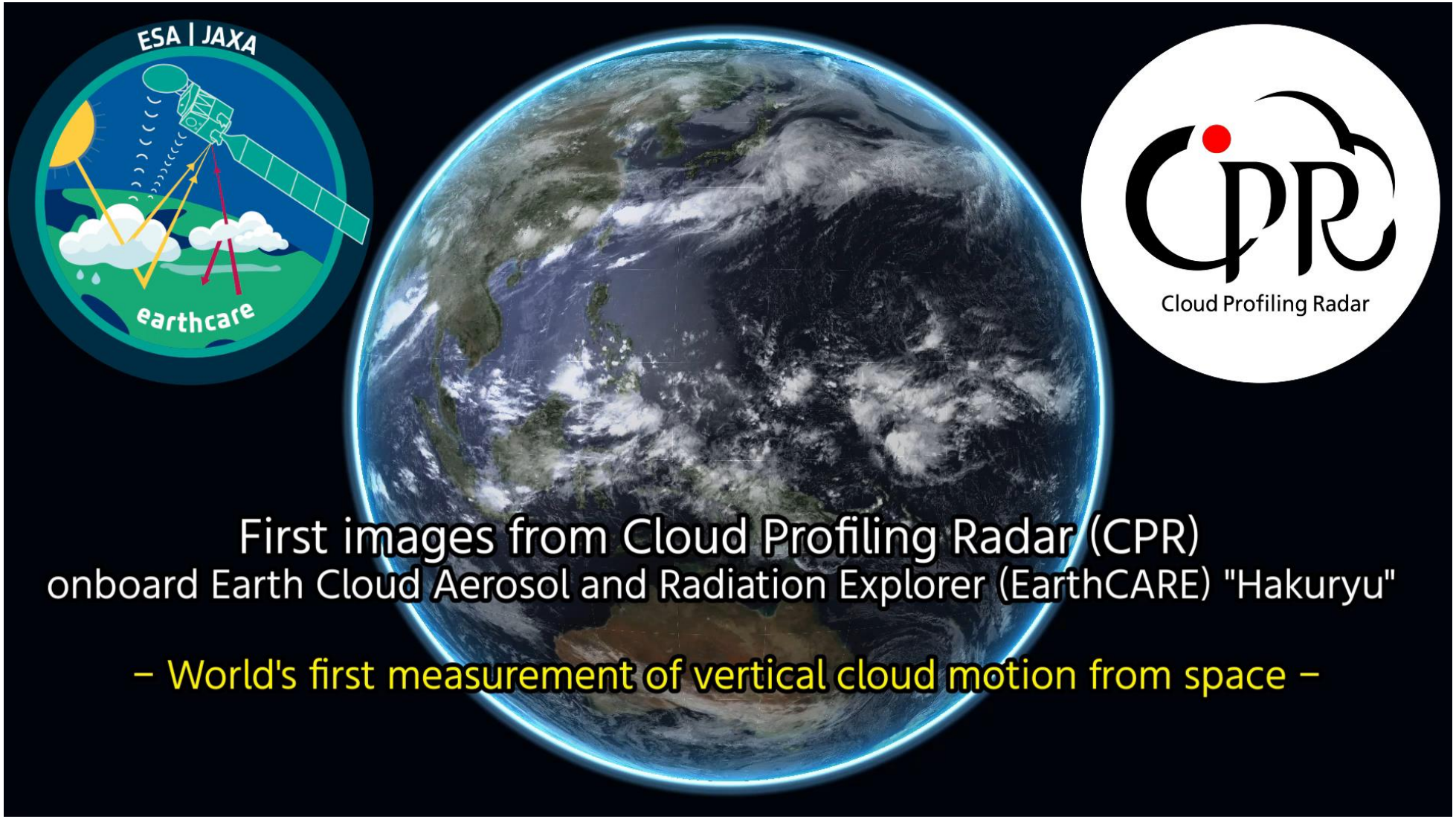


Challenges in measuring Doppler velocities from Space (Illingworth et al. 2015)



The CPR onboard the ESA-JAXA EarthCARE satellite is the world's first spaceborne Doppler radar in the W-band (94 GHz) and was jointly developed by JAXA and NICT.

JAXA/NICT/ESA released EarthCARE/CPR first images on 27 June 2024.



(c) JAXA/NICT/ESA

https://www.youtube.com/watch?v=1wIHIE6_RX8

JAXA's PMM Observatory in the AOS (Atmosphere Observing System) mission

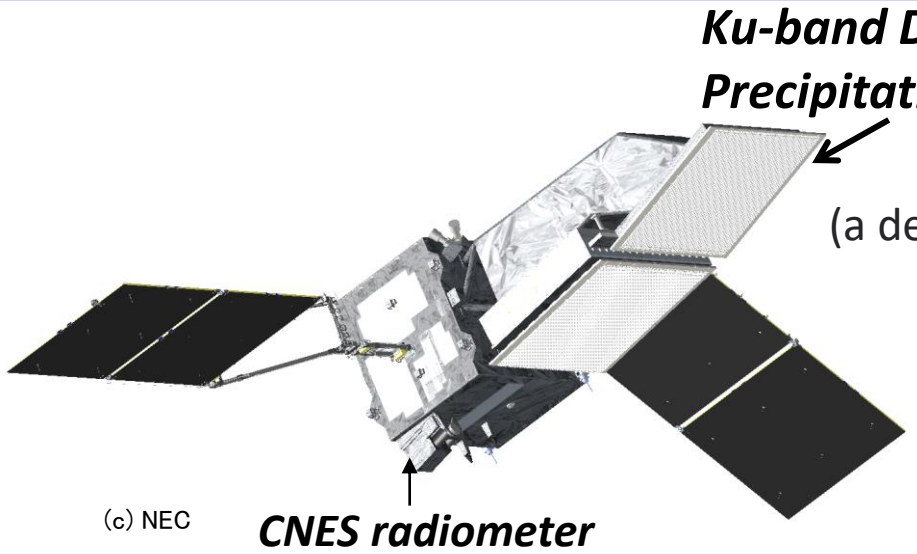
World's first satellite-based Ku-band (13GHz) doppler precipitation radar (KuDPR) is planned in the JAXA's PMM.

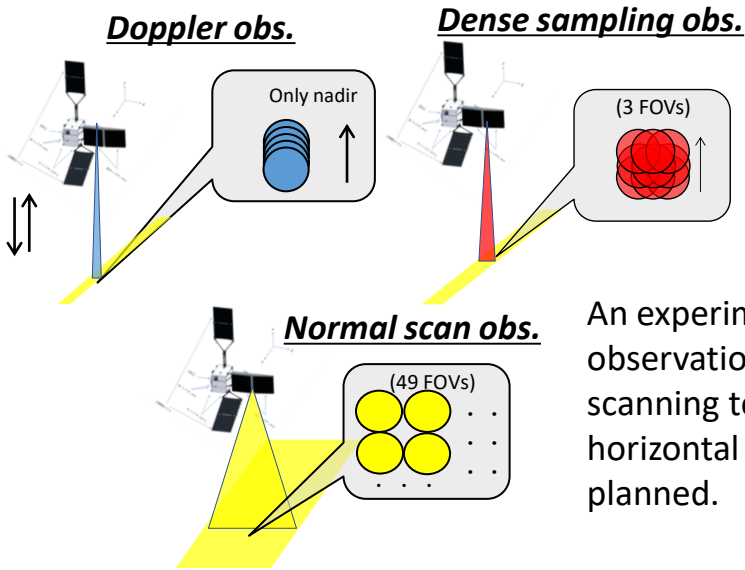
The KuDPR will be two-antenna system that adopts Displaced Phase Center Antenna (DPCA) approach (Durden et al. 2007, 2023, Tanelli et al. 2016, Nakamura and Furukawa 2023).

→ The DPCA approach can lead to **more accurate Doppler measurement.**

Major characteristics

Frequency	13.6 GHz
Observation modes	・Doppler obs. mode (at-nadir) ・Dense sampling obs. mode (near-nadir) ・Normal scan obs. Mode (similar to that of GPM/KuPR)





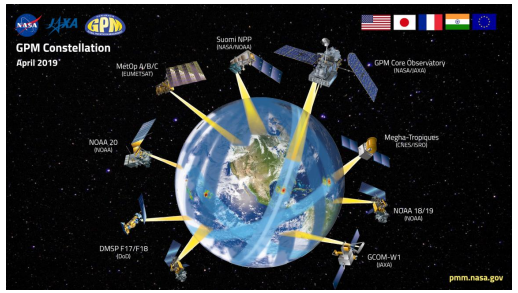
An experimental observation of doppler beam scanning to measure horizontal winds is also planned.

- In June 2023, JAXA's Precipitation Measuring Mission (PMM) Project Team was established on for the Spacecraft carrying the Ku-band Doppler Precipitation Radar, with participation in NASA AOS mission.

Synergy of GPM and PMM Observatory/KuDPR

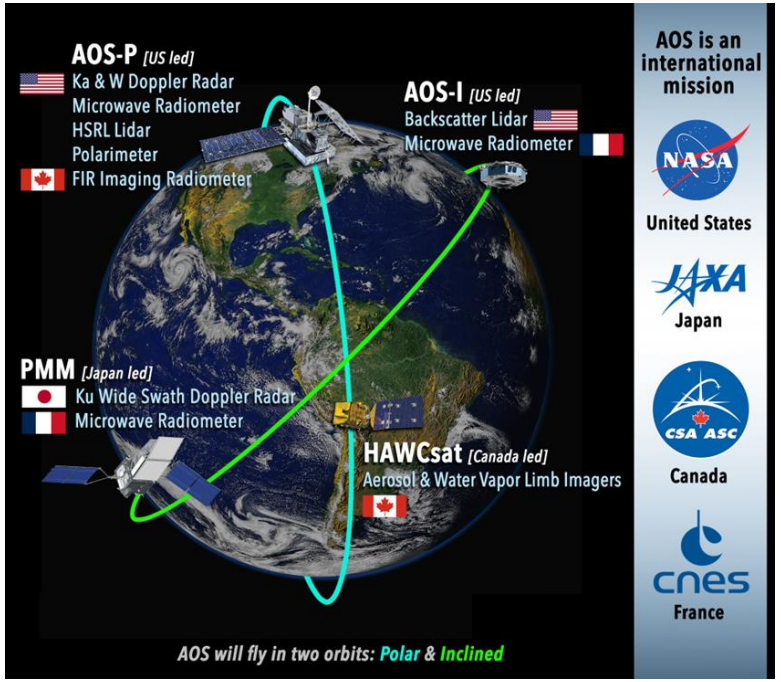
- Features of KuDPR in the AOS mission
  - JAXA's KuDPR in AOS will focus on advanced observation of precipitation.
    - Doppler velocity obs.
    - High sensitivity obs.
  - International collaboration with NASA AOS mission will bring us integrated understanding of Aerosol, Cloud and Precipitation processes.
  - International collaboration also enhances the mission value for improving weather/climate models.

GPM Constellation



(figure by NASA/GSFC)

AOS Architecture (Jan-2023 Version)



(figure by NASA)

- Synergy of GPM/DPR and PMM/KuDPR
  - The overlap between the GPM-Core and the TRMM satellite observations at the start of GPM was essential to ensure consistency between the instruments.
  - Overlap between GPM and the PMM/KuDPR will provide similar benefits for construction of longer-term precipitation dataset.

Summary

- Dual-frequency Precipitation Radar (DPR) status
  - The GPM Core Observatory (GPM-CO) satellite performed two orbit boost maneuvers on Nov. 7 and 8, 2023 that raised its altitude from 407km to 442km.
  - On March 5, 2024, JAXA and NASA resumed the GPM/DPR Standard products(L1B are V07B, other products are V07C), which corresponded to the GPM orbit boost.
- Global Satellite Mapping of Precipitation (GSMaP)
  - GSMaP adjusted by gauge data over the India (Kumar et al. 2022, https://doi.org/10.1029/2022EA002595)
  - Reprocessing for longer-term GSMaP dataset since Jan. 1998 (Kubota et al. 2024, submitted)
- AOS/PMM Observatory with KuDPR
  - JAXA's Precipitation Measuring Mission (PMM) carrying the Ku-band Doppler Precipitation Radar (KuDPR), with participation in NASA Atmosphere Observing System (AOS) mission.
    - The ESA-JAXA EarthCARE satellite carries the world's first spaceborne Doppler radar in the W-band (94 GHz) by JAXA and NICT (https://www.youtube.com/watch?v=1wIHIE6_RX8).
  - International collaboration with NASA AOS mission will bring us integrated understanding of Aerosol, Cloud and Precipitation processes, and also enhances the mission value for improving weather/climate models.