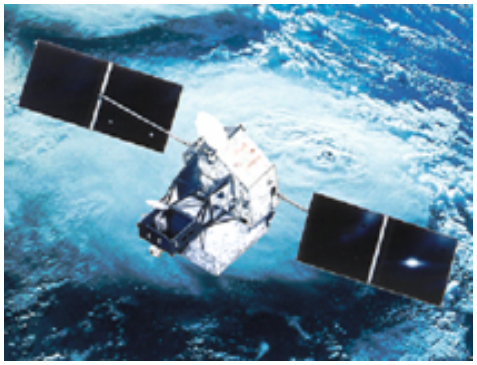
JAXA TRMM/GPM Program Status

Riko OKI (JAXA/EORC)

The 8th U.S. PMM meeting, 18-22 Mar. 2013, Annapolis, U.S.

Tropical Rainfall Measuring Mission (TRMM)

- Achieve 15 YEARS on 28 Nov. 2012 !!
- Major characteristics
  - Focused on rainfall observation. First instantaneous rainfall observation by three different sensors (PR, TMI, VIRS). PR, active sensor, can observe 3D structure of rainfall.
  - Targeting tropical and subtropical region, and chose non-sun-synchronous orbit (inc. angle 35 degree) to observe diurnal variation.
- Major achievement in Japan
  - Demonstration of high quality and high reliability of a satellite onboard precipitation radar
  - Improvement of MWR precipitation retrieval by PR 3D observation
  - Pioneering precipitation system climatology by PR observation
  - Operational use in NWP etc.
  - New products including all-weather SST, global soil moisture



US-Japan joint mission

Japan: PR, launch

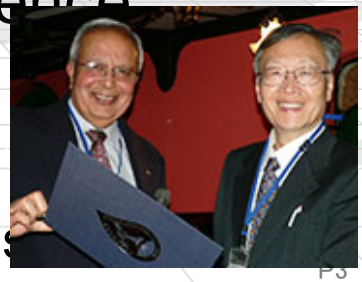
US: satellite, TMI, VIRS, CERES, LIS, operation

Launch	28 Nov. 1997 (JST)
Altitude	About 350km (since 2001, boosted to 402km to extend mission operation)
Inc. angle	About 35 degree, non-sun-synchronous orbit
Design life	3-year and 2month (still operating)
Instruments	Precipitation Radar (PR) TRMM Microwave Imager (TMI) Visible Infrared Scanner (VIRS) Lightning Imaging Sensor (LIS) CERES (not in operation)

TRMM Achieved 15 YEARS on 28 Nov. 2012 !!

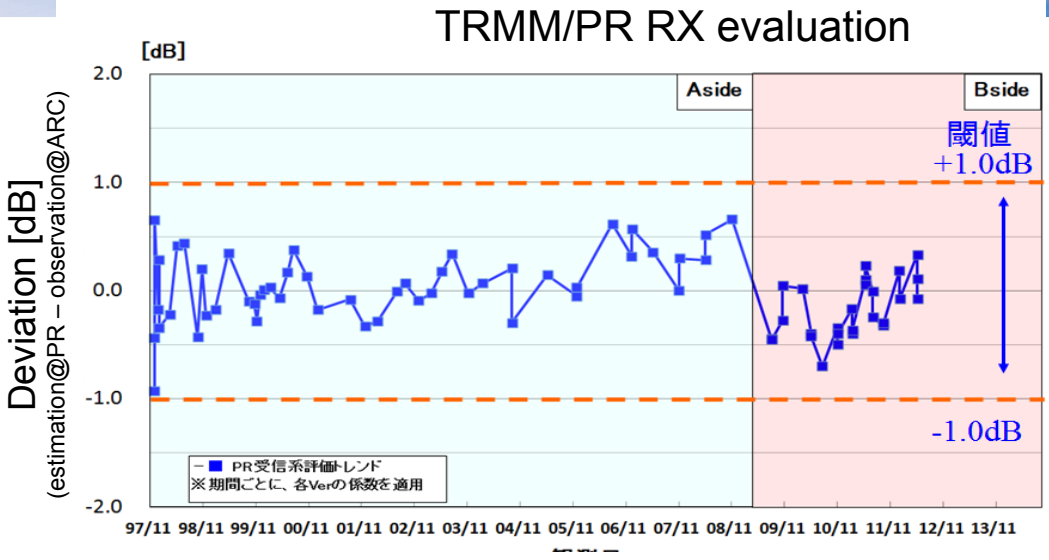
- Water for Life: Symposium on the role of space data - the 15th anniversary of the Tropical Rainfall Measuring Mission (TRMM) –
  - Date: November 12, 2012 (Monday), 10:00-17:00
  - Venue: Otemachi Sankei Plaza, Hall, Tokyo, Japan
  - 232 participants

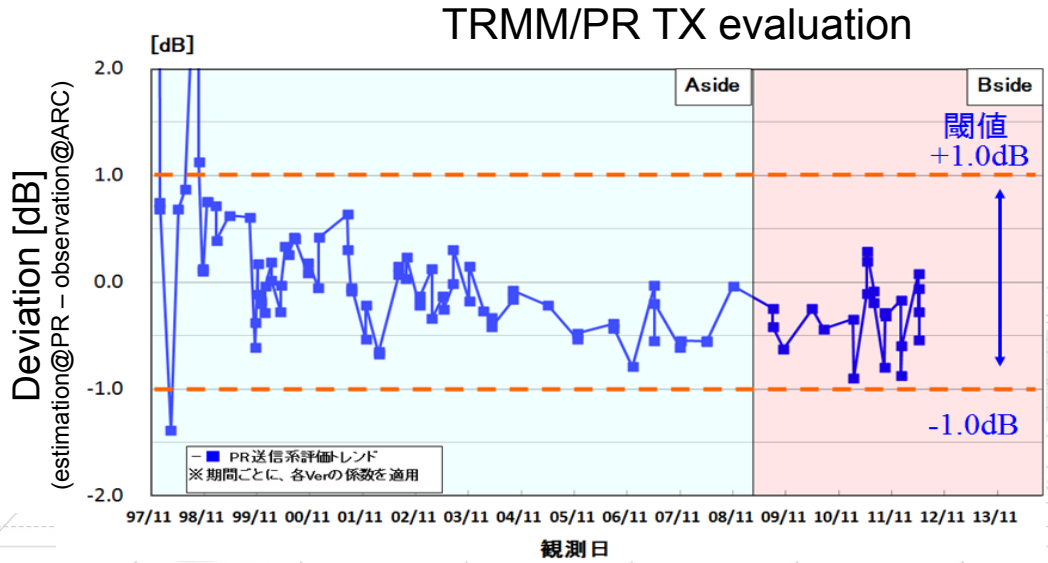
- Certificate of appreciation to Japan and US TRMM scientists from JAXA and NASA
  - was given to eight Japan and US TRMM scientists for their outstanding contribution to the scientific activities, applications and accomplishments of 15 successful years of the TRMM from Dr. Masanori Homma, Executive Director, JAXA, and Dr. Michael Freilich, Director, Earth Science Division, NASA.
- The 4th TRMM&GPM International Science Conference
  - Date: Nov. 13th (Tue) - 16th (Fri), 2012
  - Venue: Akihabara UDX Gallery NEXT Tokyo, Japan
  - 152 participants from the U.S., Europe and Asian countries



TRMM/PR L1 Calibration by ARC

Trend monitoring of PR TX/RX

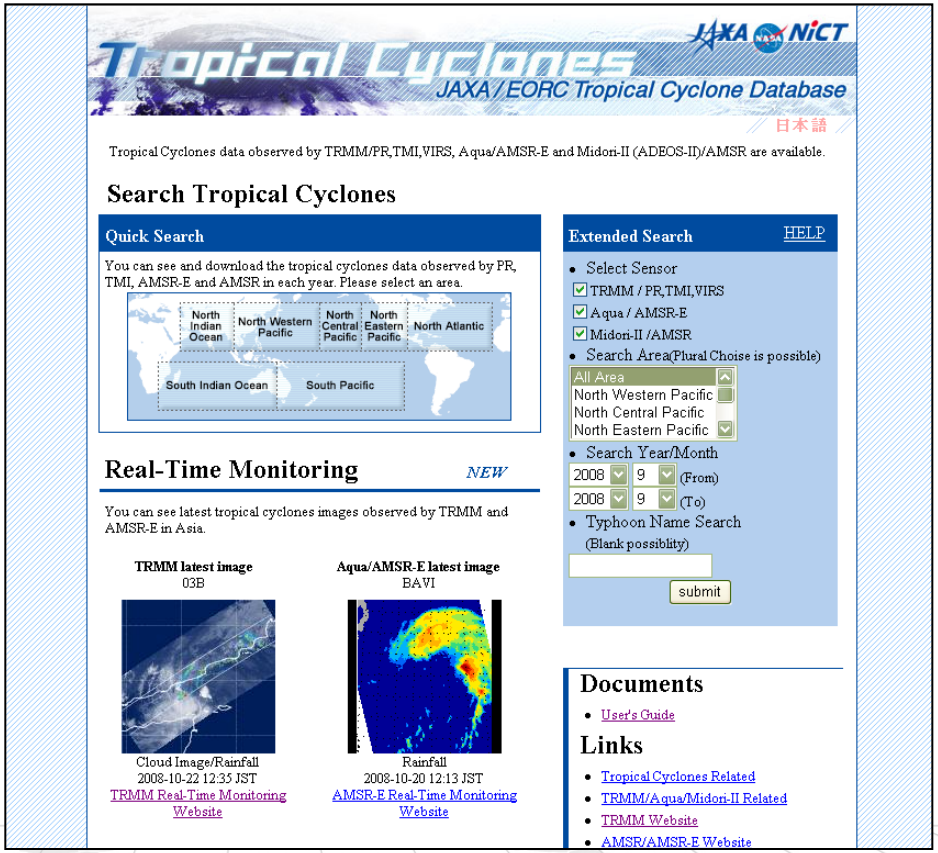


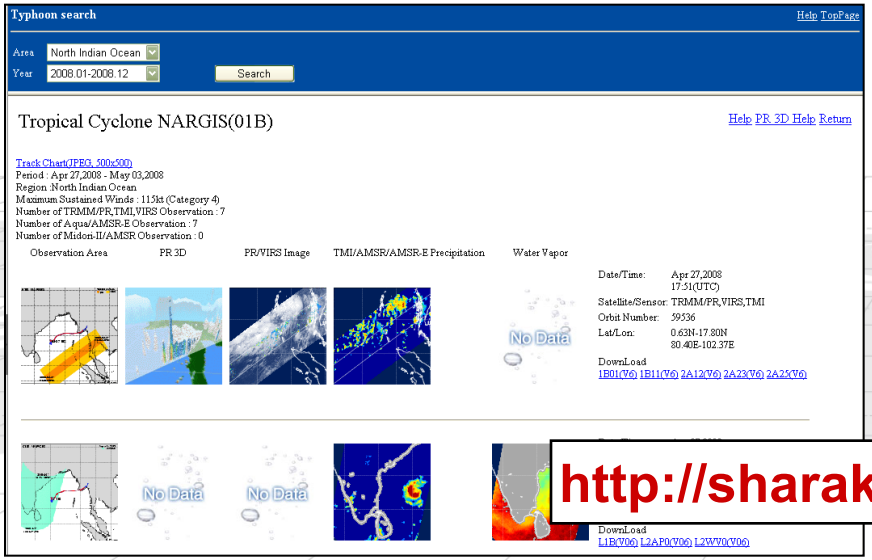


TRMM/PR TX/RX seems stable within +- 1dB

JAXA/EORC Tropical Cyclone Database and Tropical Cyclone Real-Time Monitoring

- DB
- Browse images, 3D movies and data of tropical cyclones observed by TRMM, AMSR-E, AMSR are available. Updated 1-1.5 months after observation.
- NRT monitoring
- Global regions (Asia, Americas, Oceania)
- Operating in near-real time (3-6 hours after observation)
- Browse images of PR, TMI, and storm tracks are available





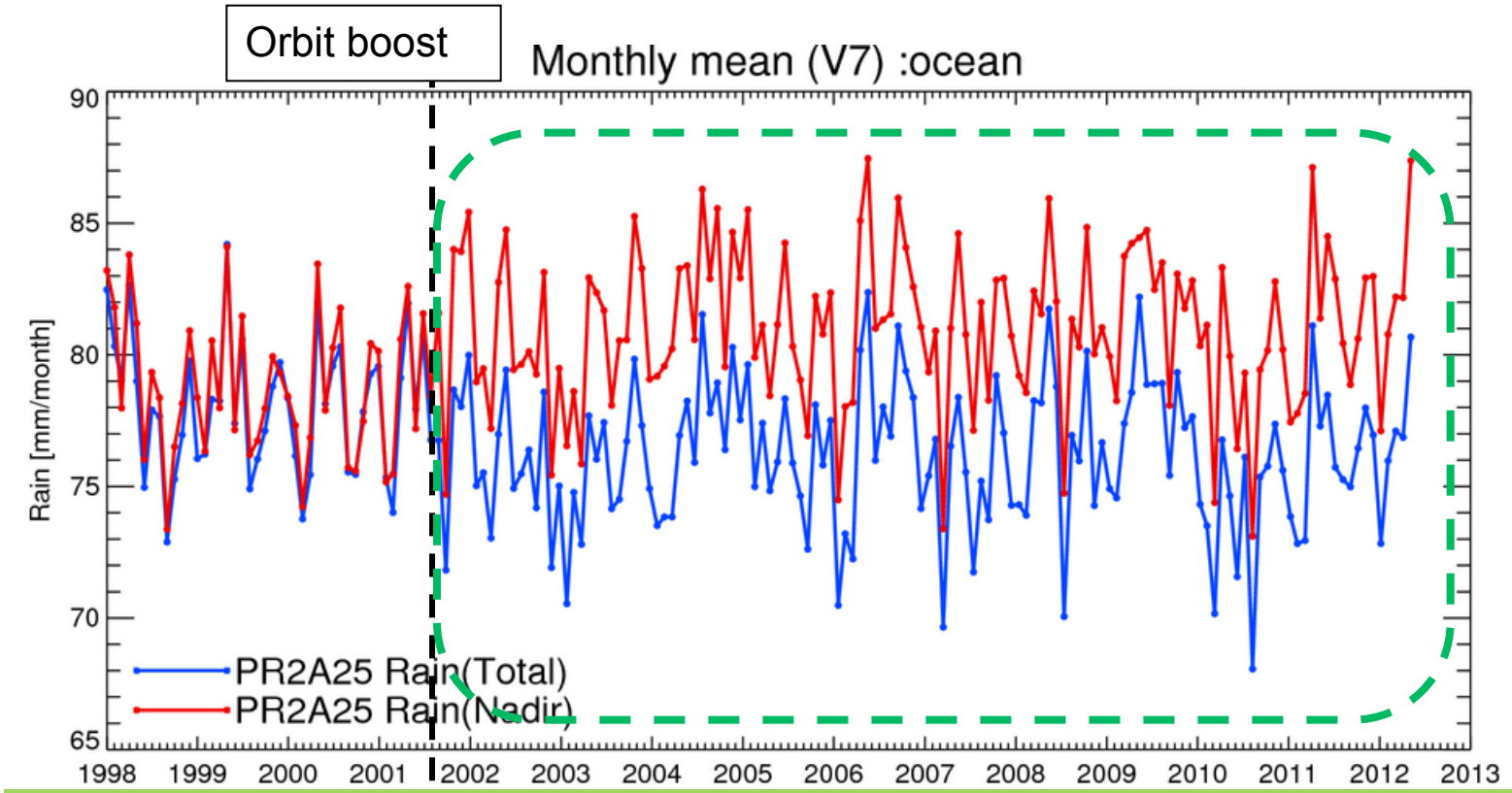
http://sharaku.eorc.jaxa.jp/TYP_DB/index_e.shtml

Latent Heat Research Product

- Latent heating profile estimated by PR 3-D observation
- All data are available during PR observation period (updating every 1-month)
- Base on Spectral Latent Heating (SLH) algorithm (Shige et al., 2004, 2007, 2008)
- Orbital (non-grid, grid) and monthly data in 0.5-deree lat/ lon grid are available
- Became standard product in TRMM Ver.7

http://www.eorc.jaxa.jp/TRMM/lh/index.html

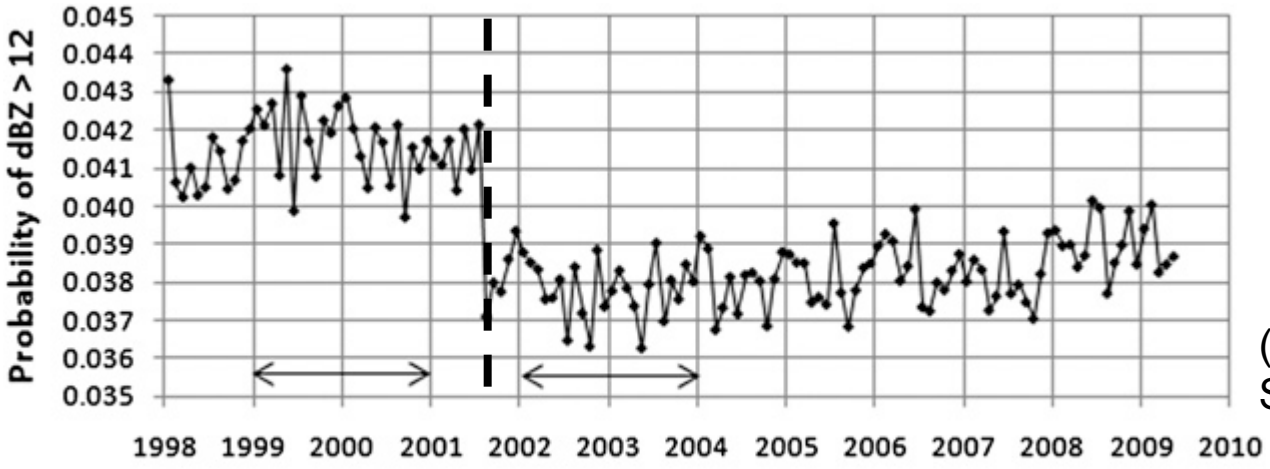
A reduction of discontinuity



The effects by an increase in the range of surface clutter and a beam mismatch mitigated by use of the data at the inner swath but the effects of the sensitivity degradation remain.

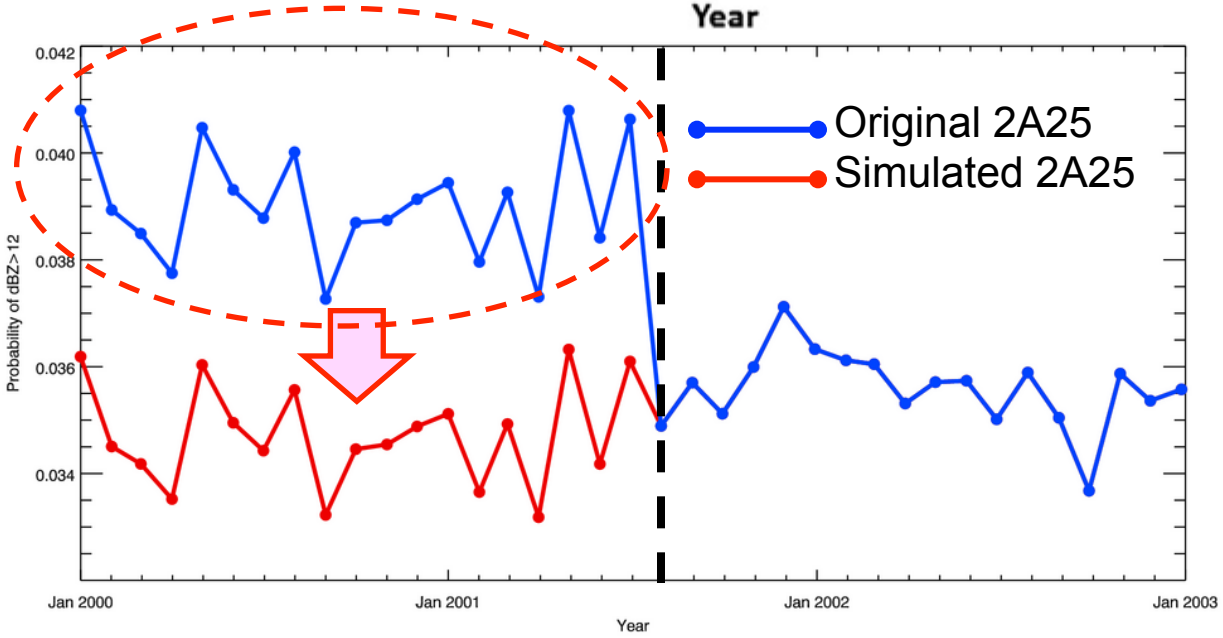
It is necessary to estimate the effects of the sensitivity degradation.

Area-weighted probability of path-averaged dBZ>12



Monthly time series of the probability of path-averaged reflectivity greater than 12 dBZ from 3A25.

(as shown in Short and Nakamura, 2010)



The time series of the simulated 2A25 reduce discontinuity before and after the orbit boost.

End-of-Mission Proposal for TRMM/PR (summary)

- **Keep the PR ON** during the end of mission period (402.5 km to 335 km altitude). **<Baseline>**
  - Between 3rd quarter of 2014 and mid 2017.
- During that period, nominal observation and several experimental operations are implemented.
  - (1) Nominal observation for the comparison with the GPM/DPR data, long term precip. record, and the GSMaP improvement with multiple radar data.
    - Minimum observation height requirement: surface to 5 km.
  - (2) Experimental observations for DPR algorithm improvement (I)
    - **No need to change the satellite operation**

    (2a) Radiometer mode (including PR Tx off)

    (2b) External calibration mode

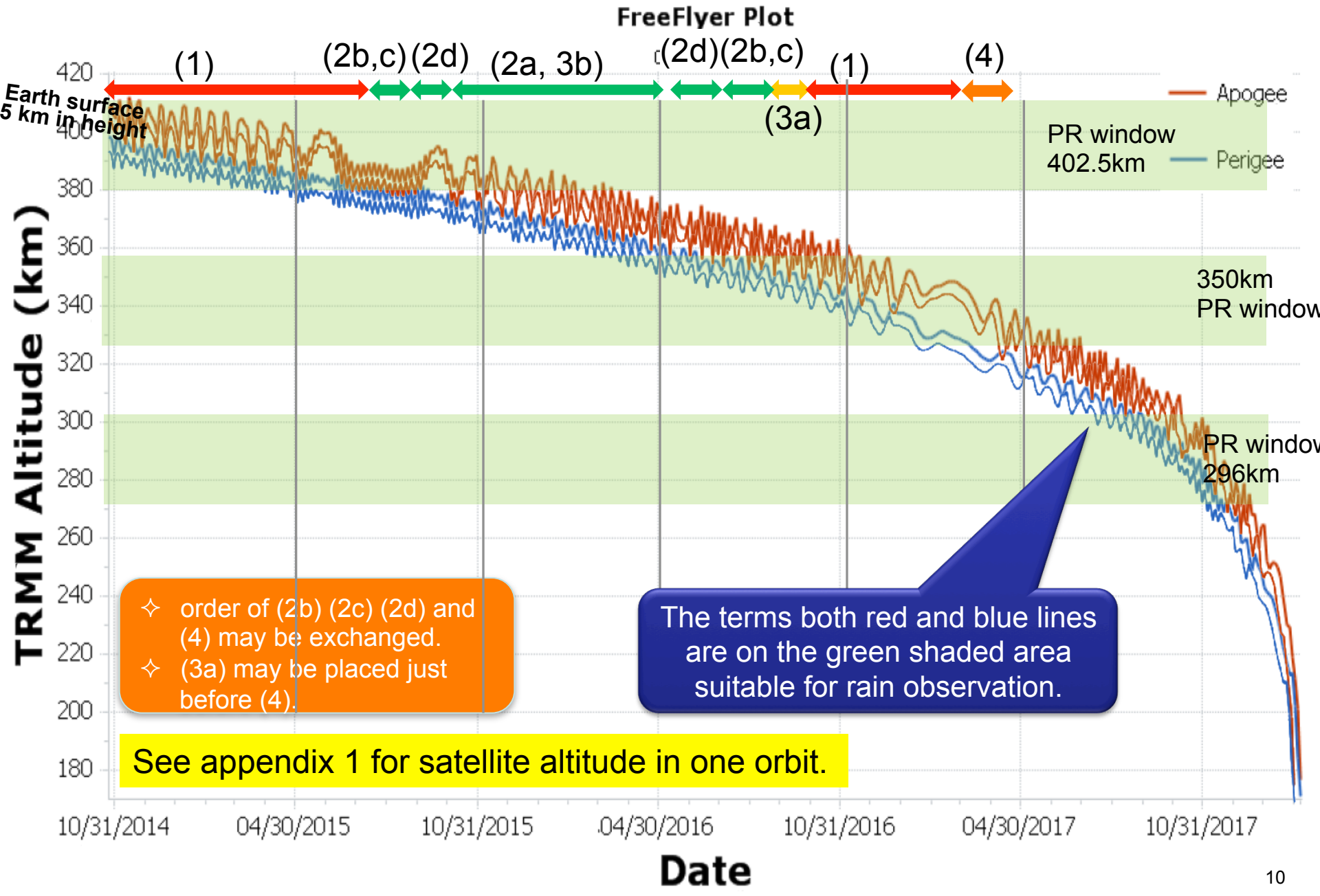
    (2c) GPM KaPR-like scanning experiment

    (2d) Wider swath experiment with phase-shifter code change
  - (3) Experimental observations for DPR algorithm improvement (II)
    - **Need to change the satellite operation**

    (3a) 90-deg. yaw maneuver with nominal observation mode

    (3b) Pitch maneuver (fixed pitch offset from nominal attitude)
  - (4) Engineering checkout
    - similar to the initial checkout after the launch.

Satellite altitude and experiment schedule



Concept of GPM

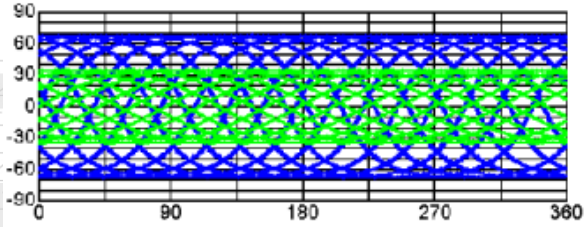
3-hourly global rainfall map

Core Observatory

- Dual-frequency Precipitation Radar (DPR)
- Microwave Imager (GMI)

✧Highly sensitive precipitation measurement
✧Calibration for constellation radiometers

JAXA and NICT: DPR
NASA : Spacecraft bus and GMI
JAXA: H2A Launcher



Blue: Inclination ~65º (GPM core)
Green: Inclination ~35º (TRMM)

Constellation Satellites

- Microwave Radio-meters installed on each satellite

✧Frequent precipitation measurement

Expected Partners:
NASA, NOAA, CNES-ISRO, China, others

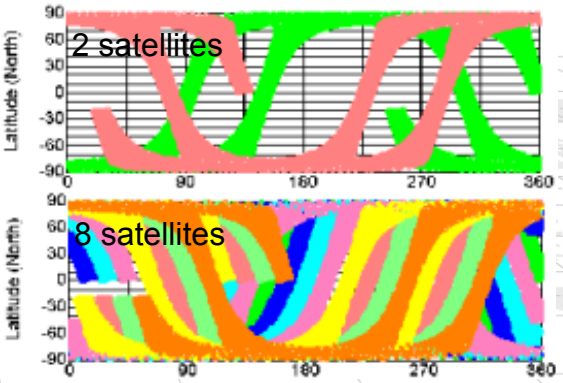
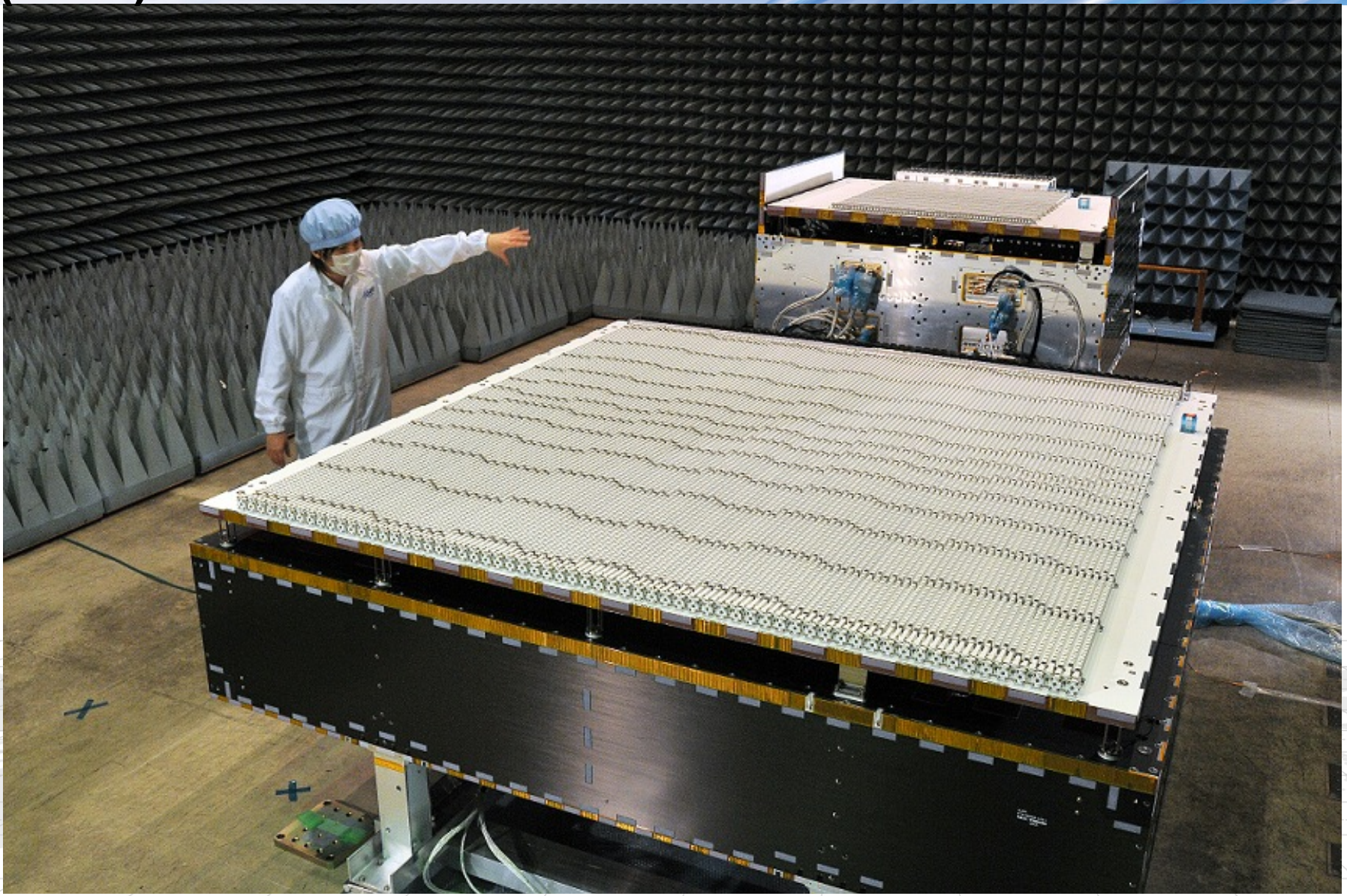


Photo of Dual-frequency Precipitation Radar (DPR) instruments



Status of AMSR2 and GCOM-W1

- **2012.5.18** GCOM-W1 (SHIZUKU) was launched
- **2012.6.29** Join A-Train orbit
- **2012.7.03** Start AMSR2 observation from A-Train orbit
- **2012.7.04** Release of AMSR2 observation images
- **2012.8.10** Initial functional verification completed
- **2012.8.31** Preliminary L1 delivery to PI and related agencies
- **2012.10.19** Preliminary L2 delivery to PI and related agencies
- **2013.1.24** L1 (and L3TB) public release from **https://gcom-w1.jaxa.jp/**
- *2013.5* *L2 (and L3GEO) public release*

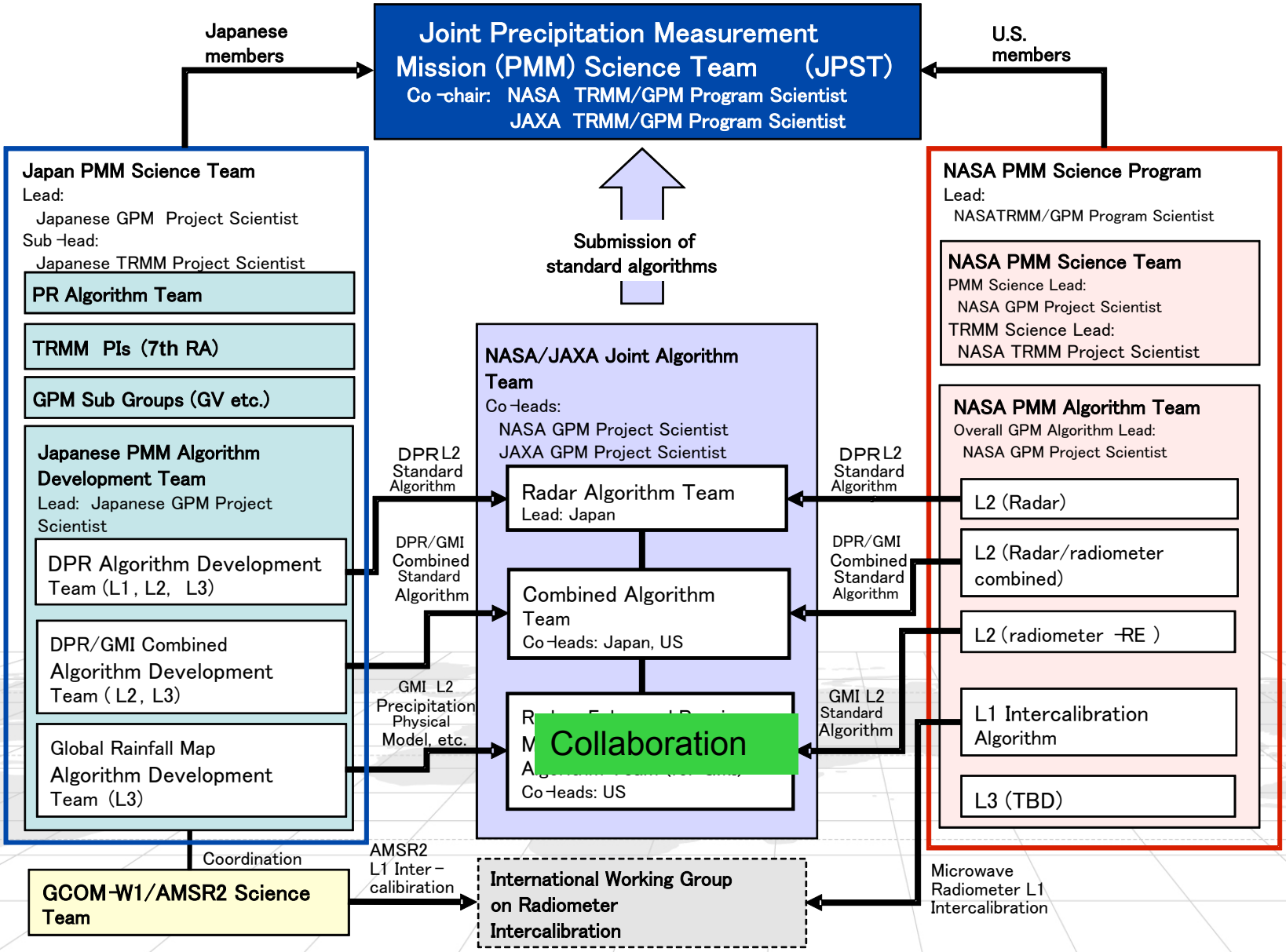
See poster #129 for more details

Japanese PMM Science Team

- The current Japanese PMM Science Team was organized in Apr. 2010 for three-year period (JFY2010-2012).
  - It is the 6th RA since the first TRMM RA, but the 2nd as PMM
- The next new Japanese PMM Science Team will start in Apr. 2013 for three-year period.
  - 28 proposals for the 7th RA (JFY2013-2015) were selected by Feb. 2013 after review process.
    - 23 with research cost proposals
    - 5 no cost transfer proposals including 3 from abroad
- The science team includes both TRMM and GPM activities.
  - Continue to focus on GPM algorithm development and related GV activities.
  - New science team will include more Application studies related to new research products, **data assimilations, and model utilizations**.

Japan and U.S. PMM Science Framework

-- two joint algorithm development teams --



GPM Algorithm Development Status (Summary)

- DPR Level 1 algorithm (JAXA)
  - At-launch code (initial version) was submitted to JAXA MOSS in Nov. 2012
- DPR Level 2 and 3 algorithm (Joint Japan-U.S.)
  - “At-launch code (Version 1) ” was submitted to JAXA MOSS and NASA PPS in Dec. 2012.
  - “At-launch code (Version 2) ” will be submitted to in JAXA MOSS and NASA PPS Mar. 2013.
- DPR/GMI combined Level 2 algorithm (Joint Japan-U.S.)
  - “At-launch code (Version 1)” will be submitted to NASA PPS by the end of Mar. 2013.
- Global Rainfall Map algorithm (Japan)
  - “At-launch code (Version 1)” was submitted to JAXA MOSS in Jan. 2013.

DPR L1 algorithm development（～FY25）(1/2)

Version 1 *（～Oct. 2010）*

- Basic algorithm flow
- Partly development of basic functions
- Corresponding to HDF4 format

50 %

Version 2 *（～Mar. 2012）*

- Completion of basics functions
- Introduction of tentative data base（calibration coefficient、ground testing data etc.,）
- Introduction of PPS toolkit（I/O, Geo, Time）
- HDF5 format
- Basic error processing
- Near-real-time processing

90 %

FY24

Version 3（At-Launch code）*（～Oct. 2012）*

- Adjustment basis on results of ground testing
  - bias correction of RX echo offset
  - decision of data base
- Checking robustness
- Adding function of SRT
- Corresponding to NASA toolkit

100 %

Completion of 100% function as DPR L1B

FY25 **Version 4（Improved At-Launch code）** *（～July. 2013）*

Algorithm development framework of DPR-L2

lead：Toshio Iguchi（NICT）
R. Meneghini (GSFC)

PreparationModule
（EORC久保田・RESTEC吉田）

Vertical Profile Module
（EORC久保田）

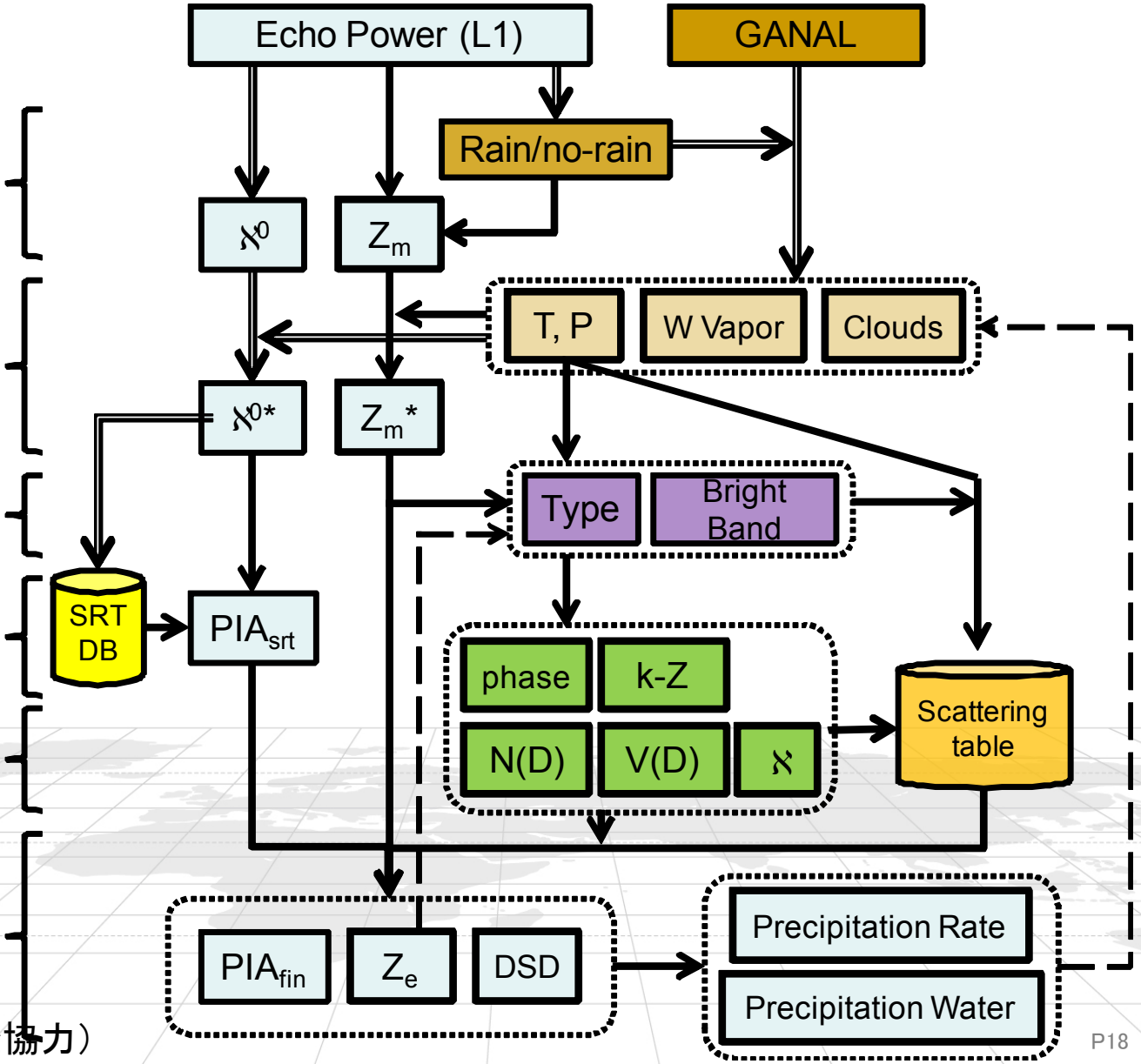
Classification Module
（東海大学　阿波加教授）

SRT Module
(Dr. Meneghini(NASA/GSFC)

DSD Module
（長崎大学　瀬戸准教授）

Solver Module
（長崎大学　瀬戸准教授）

コード統合＆提出：EORC
テスト：EORC（NASA/GSFCと協力）



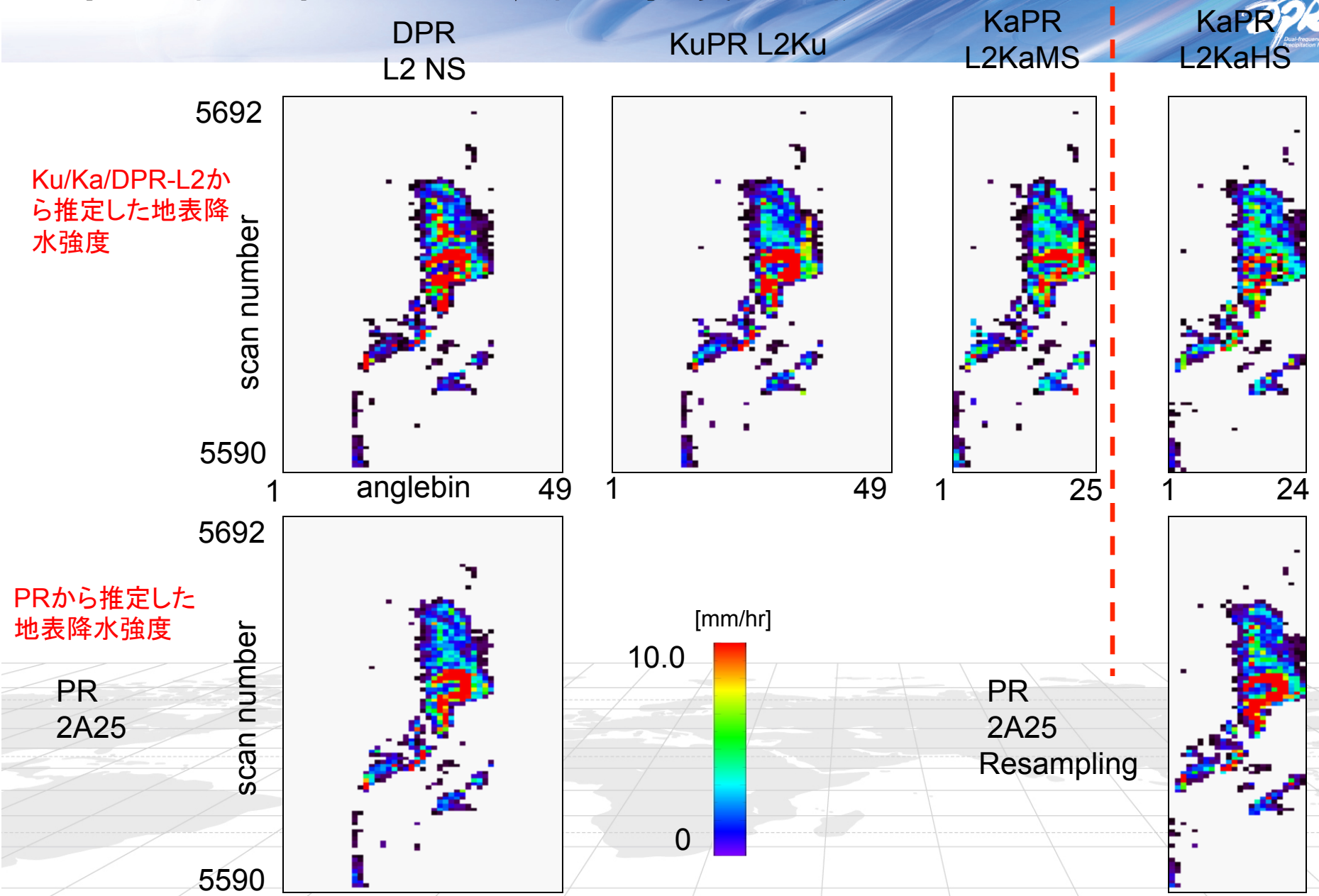
DPR L2 Algorithm Development activities

- DPR Level 2 algorithm (Joint Japan-U.S.)
  - “At-launch code (initial version)“ (Version 3) was submitted to JAXA MOSS and NASA PPS in Dec. 2012.
  - “At-launch code (version 2)“ (Version 4) will be submitted to JAXA MOSS and NASA PPS in Mar. 2013.
  - “At-launch code (final)“ (Version 4) will be submitted to JAXA MOSS and NASA PPS in Sep. 2013.

- DPR-L2 development meetings
  - DPR-L2 domestic meeting, one per a month.
  - DPR-L2 joint international meeting（teleconference）, once per two months.
    - Apr. 2012, Jun. 2012, Aug. 2012, Oct. 2012, Nov. 2012, Jan. 2013
- EORC takes roles of integration, version control, generating DPR-L1 simulated data, testing and evaluation of Ku/Ka/DPR-L2 algorithm, collaborating with NASA PPS.

海上の降水事例での地表降水強度の比較

v13b



Global Rainfall Map Development Status

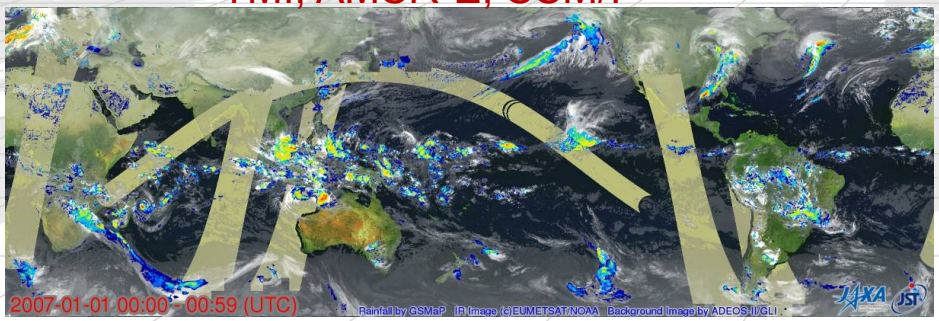
- GPM GSMaP Ver.0（At-launch code）
  - The initial version was submitted in Feb. 2013. The final version will be submitted in Apr. 2013.
    - Microwave imager algorithm is based on AMSR2 precipitation algorithm
    - New overland algorithm for microwave imagers
    - Introduction of land algorithm for microwave sounders
    - Updates of databases
    - Introduction of gauge-calibrated rainfall in microwave-IR merged algorithm
- Plan of 2013
  - Introducing GPM at-launch code to the GSMaP_NRT system.
  - Introducing AMSR2 data to the GSMaP_NRT system.
  - Introducing some sensor data those have not been used in the NRT system.（DMSP-F18 SSMIS, NOAA-15/16/18 AMSU-A/AMSU-B/MHS）
  - Introducing Megha-Tropiques data
- GPM GSMaP Ver.0（At-launch code, final）will be submitted to JAXA MOS
- Promoting joint research activities and new applications using GSMaP.

Updates of Near Real Time GSMaP system

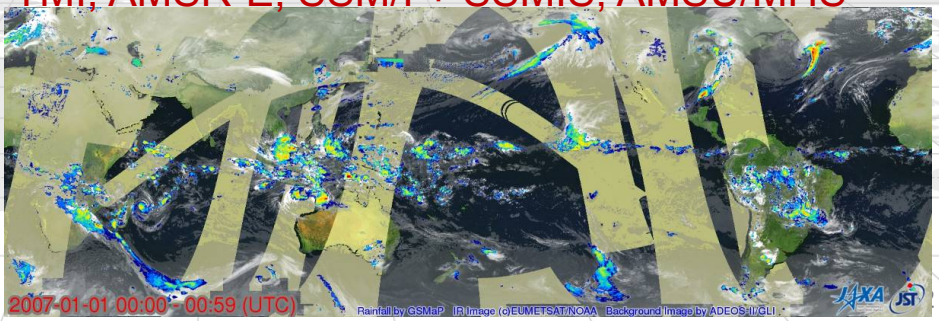
http://sharaku.eorc.jaxa.jp/GSMaP/index.htm

- Can access from the EORC web page
- Changed the registration form (Apr. 2012).
  - **The number for registration per month has increased 5 times since last year.**
  - 210 registrants at the end of Feb. 2012, 2 possible business users
  - 450 registrants at the end of Feb. 2013, 3 possible business users
- Released text version of re-analysis data in GIS format (Oct. 2012) due to many requests from flood community.
  - Now daily product only on the web. Hourly data will be available soon.
- Test version of GSMaP gauage-calibrated GPM product was released for limited users for evaluation. (Nov. 2012)
- Web site renewal (Mar. 2013), New GSMaP logo
- Introduction of GCOM-W1/AMSR2 (May 2013).

TMI, AMSR-E, SSM/I

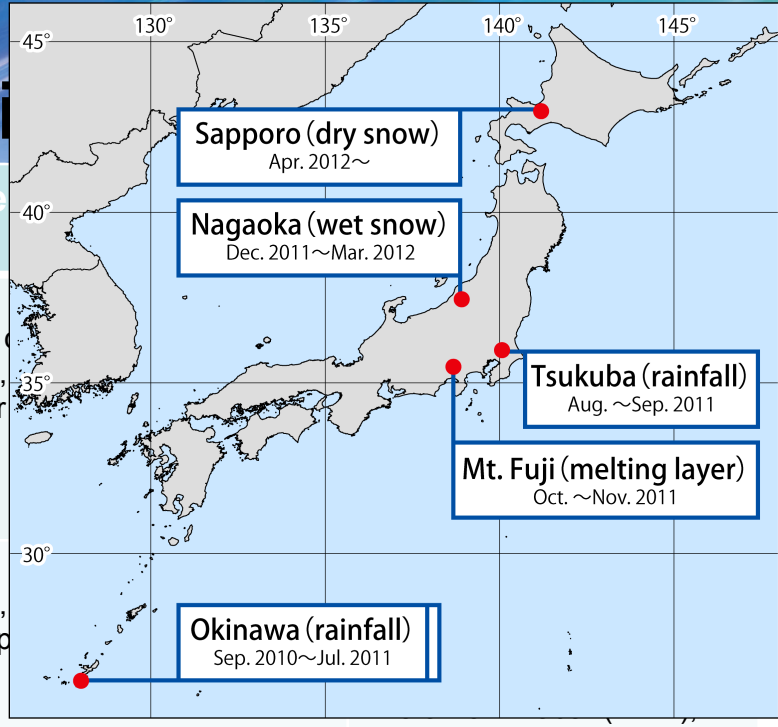


TMI, AMSR-E, SSM/I + SSMIS, AMSU/MHS



Japanese GPM GV for DPR vali

Site	Targets	Period	PI	Paramete	
Okinawa	Rain(Subtr opics)	-- July 2011	NICT/Nagoya Univ.	Rain Rate, Attenuation (DSD (profile, Melting layer 雨滴変形度	
Tsukuba	Rain(the Temperate Zone)/ Melting layer	Summer 2011	NIED	Rain Rate, DSD (profile, Attenuation p layer	ORG
Mt. Fuji	Melting layer	Autumn 2011	NICT/Nagoya Univ.	Attenuation profile through melting layer, DSD (profile, ground)	Ka-band GV radar x2, 2DVD, Disdrometer, Micro Rain Radar (MRR), ORG
Nagaoka	Wet snow	Winter 2012	NIED	DSD (profile), Rain rate (snow), Attenuation characteristics, (Ka) Snow particle parameters (density, particle size, falling speed etc.,)	Ka-band GV radar x2, X-band Radar, Lidar, 2DVD, Snow Particle Obs. system
Sapporo	Snow(dry/ wet) Rain	Sprinter 2012 –winter 2013	Hokkaido Univ.	Rain profile, Rain rate (rain, snow), Attenuation characteristics, Snow particle parameters (density, particle size, falling speed etc.,)	Ka-band GV radar x2, X-band radar, 2DVD, Lidar, Micro Rain Radar (MRR), Snow Particle Obs. system
Zao	Melting layer	Autumn 2013		Attenuation profile through melting layer	Ka-band GV radar x2, 2DVD, ORG, Disdrometer



Sapporo Campaign Observation

Jun.2012-Mar.2013

Dry Snow observation is main target

Hokkaido University

Nissin Elementary School

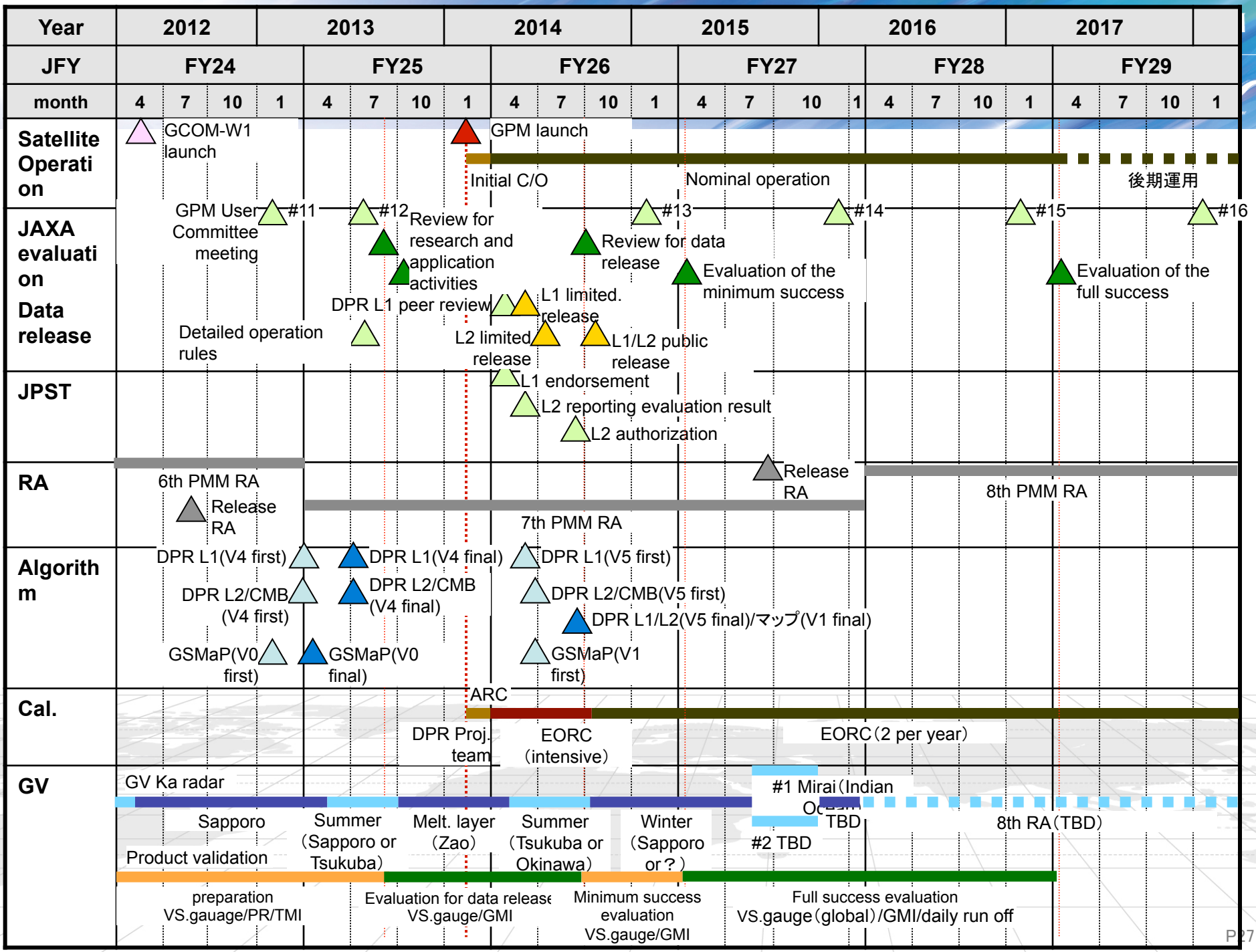
Mt.Okura Winter Sports Museum

Joint study with agencies / organizations

- with NASA
  - Joint development of DPR L2 and DPR/GMI combined algorithm
- with NICT
  - Development of DPR hardware, DPR algorithm, and implementation of calibration/validation activities
- with Japan Meteorological Agency / Meteorological Research Institute
  - Data assimilation of microwave imagers (TMI, AMSR-E, etc.) into operational NWP models since 2003.
  - Joint study with MRI for “development of data assimilation system for satellite-based cloud and precipitation observation data” has been started since Oct. 2012.
- with International Centre for Water Hazard and Risk Management (ICHARM) / International Development Institute (secretariat of International Flood Network)
  - Application of GSMaP and satellite data into flood alert and/or analysis system.
- with Japanese weather service companies
  - Introduction of GSMaP and satellite images into mobile web site.
  - Introduction of GSMaP and satellite data into forecast systems.

Schedule toward and after the launch

- Review
  - Aug. or Sep. 2013, EORC system readiness review.
  - Sep. or Oct. 2013, GPM/DPR Development Completion review.
- Data release
  - L1 peer review (JAXA internal), before L+3
  - L1 JPST endorsement, before L+3
  - L1 limited release, L+3
  - L2 reporting evaluation to JPST, L+4
  - L2 limited release, L+4
  - Review for data release, before L+6
  - L1/L2 authorization by JPST, before L+6
  - L2/L2 Un-limited release, L+6
- JAXA Mission Success Criteria
  - Minimum success, L+14
  - Full success, L+38


Year
2012
2013
2014
2015
2016
2017
JFY
FY24
FY25
FY26
FY27
FY28
FY29
month
4 7 10 1 4 7 10 1 4 7 10 1 4 7 10 1 4 7 10 1 4 7 10 1 4 7 10 1
Satellite Operation
GCOM-W1 launch
GPM launch
Initial C/O
Nominal operation
後期運用
JAXA evaluation
GPM User Committee meeting
#11
#12
#13
#14
#15
#16
Review for research and application activities
Review for data release
Evaluation of the minimum success
Evaluation of the full success
Data release
DPR L1 peer review
L1 limited. release
Detailed operation rules
L2 limited release
L1/L2 public release
JPST
L1 endorsement
L2 reporting evaluation result
L2 authorization
RA
6th PMM RA
Release RA
7th PMM RA
Release RA
8th PMM RA
Algorithm
DPR L1(V4 first)
DPR L1(V4 final)
DPR L1(V5 first)
DPR L2/CMB (V4 first)
DPR L2/CMB (V4 final)
DPR L2/CMB(V5 first)
DPR L1/L2(V5 final)/マップ(V1 final)
GSMaP(V0 first)
GSMaP(V0 final)
GSMaP(V1 first)
Cal.
ARC
DPR Proj. team
EORC（intensive）
EORC（2 per year）
GV
GV Ka radar
#1 Mirai（Indian Ocean）
TBD
8th RA（TBD）
#2 TBD
Sapporo
Summer（Sapporo or Tsukuba）
Melt. layer（Zao）
Summer（Tsukuba or Okinawa）
Winter（Sapporo or？）
Product validation
preparation VS.gauage/PR/TMI
Evaluation for data release VS.gauge/GMI
Minimum success evaluation VS.gauge/GMI
Full success evaluation VS.gauge（global）/GMI/daily run off

Meeting, workshop, conference

- April 2013, EGU GPM special session
- June 2013, AOGS GPM special session
- July 2013, IGARRS GPM special session

- After launch, GPM International Workshop, hosted by NASA

- 21-25 October 2014, 7th International Precipitation Working Group (IPWG) Workshop, Tsukuba Japan, hosted by JAXA, CGMS and IPWG

Summary (TRMM)

- The Symposium and the 4th science conference were held in November in Tokyo at the timing of TRMM's 15-year achievement.

- Providing TRMM Version 7 products through MOSS and EORC systems.
  - TRMM typhoon data base, NRT typhoon monitoring、latent heat research product etc.
  - GSMaP_NRT), re-analysis GSMaP
- Investigating to generate long term precipitation record data by PR, reducing altitude change effect.

- Proposing TRMM/PR operation during the end-of-mission period for GPM/DPR.

Summary (GPM)

- Algorithm developments for DPR and DPR/GMI combined L2 products are on going under the U.S.-Japan joint teams.
- Global Rainfall Map algorithm is being developed as one of the Japanese GPM products.
  - At launch cord (initial version) were submitted on schedule.
  - New Japanese PMM science team
- Pre-launch ground based observation by the two GV Ka-band radars has been conducted in Okinawa, Tsukuba, Mt. Fuji, and Nagaoka. Now Sapporo experiment is going on. After that, we will move them in Zao to retry melting layer observation.
- Preparing for the coming launch readiness review and data release.
  - Investigating how to confirm a certain level of data quality for the first data release after launch, etc.
- JAXA started conversation with NASA on GPM F/O mission. Inside JAXA, our proposal to study precipitation/cloud radar for next mission has been accepted as one of the internal studies.