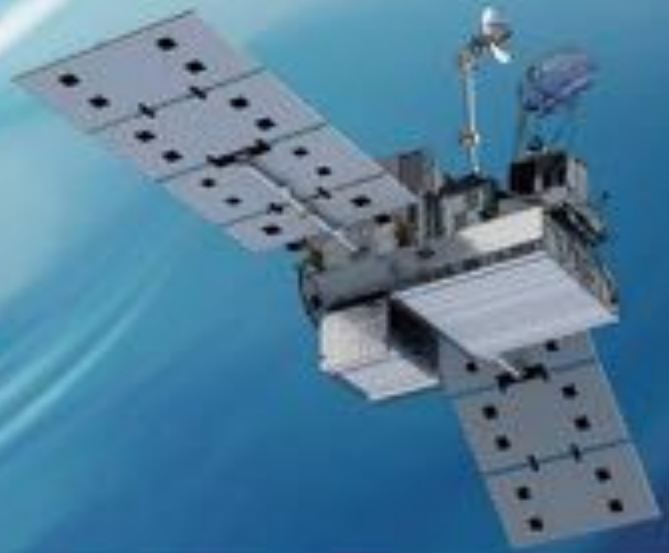
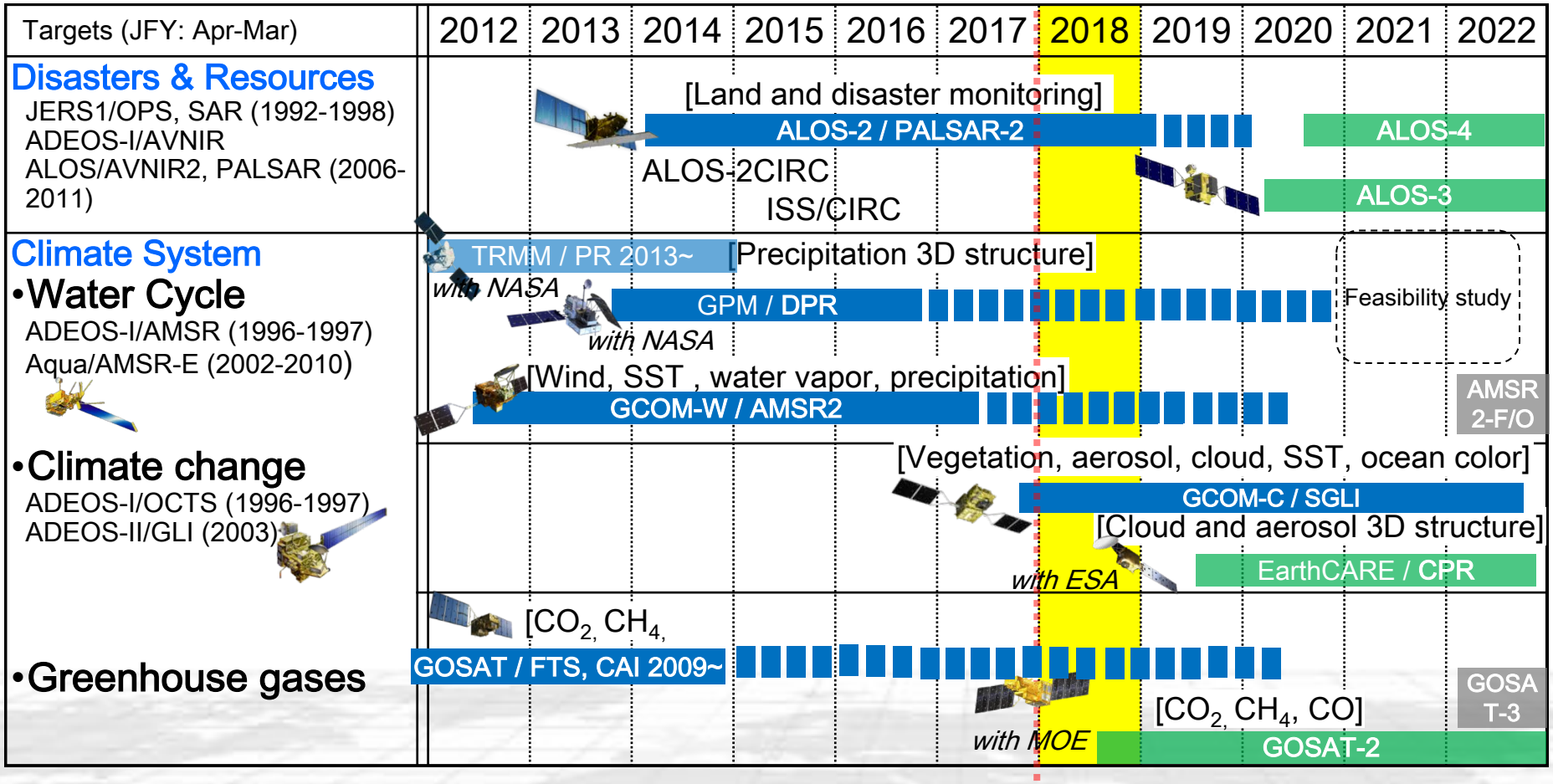
JAXA EO Program and Opportunities for GEWEX



Riko OKI (JAXA/EORC)

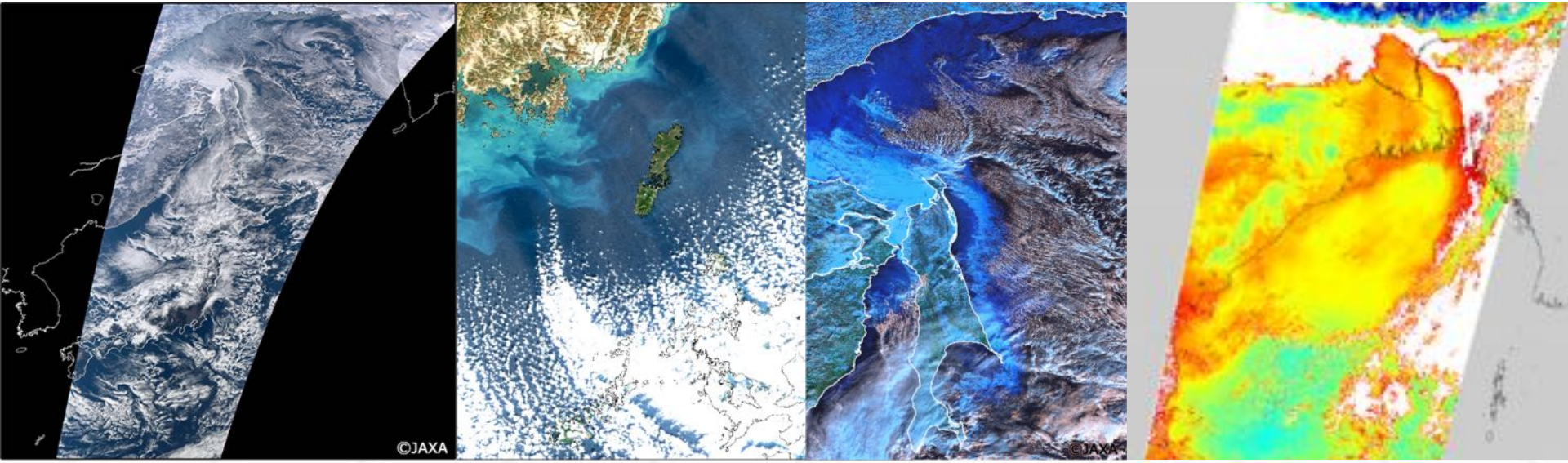
8th GEWEX Open Science Conference:
Extremes and Water on the Edge
May 6 - 11, 2018
CANMORE, ALBERTA, CANADA

JAXA Earth Observation Satellite Lineup



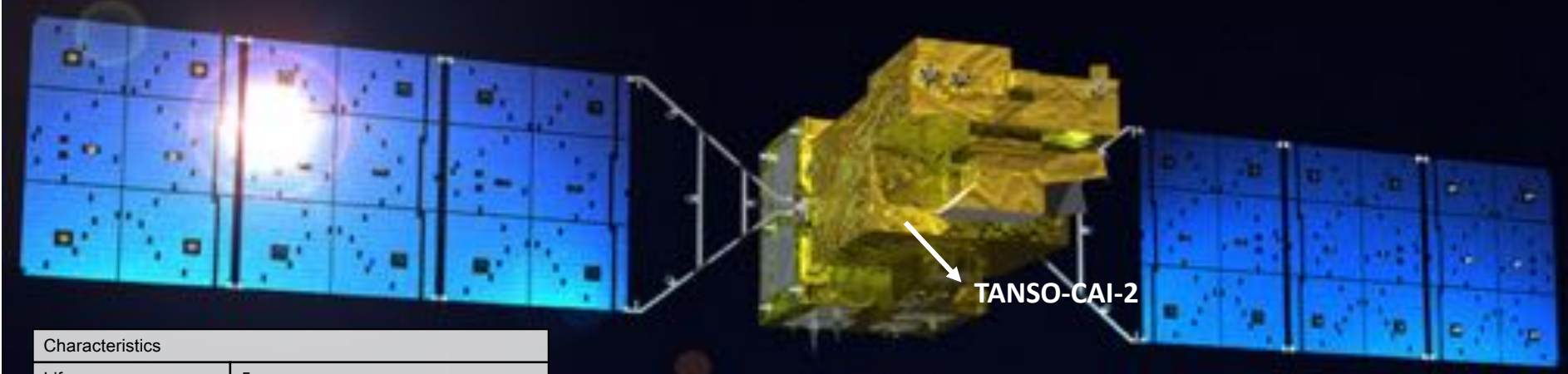
Global Change Observation Mission - Climate "SHIKISAI" (GCOM-C)

- JAXA launched GCOM-C on December 23, 2017.
- We confirmed that VNR and IRS(SWI) channels functioned properly. JAXA opened the first light image to public on January 12, 2018 from the following web site. http://suzaku.eorc.jaxa.jp/GCOM_C/index.html
- On orbit checkout phase finished at the end of March.
- After then, we will start the operation phase and conduct the initial CAL/VAL activity until December.
- We will release the SGLI products to the public at the end of this year via G-Portal.



Greenhouse gases Observing SATellite-2 "IBUKI-2" (GOSAT-2)

GOSAT-2 to be launched in 2018



Characteristics	
Life	5 years
Orbit	Sun-Synchronous (628km)
Mass	About 2 t
Launch	FY 2018
Observation	CO_2, CH_4 and CO

1. Simultaneous CO (carbon monoxide) measurement
2. All target mode capability
3. Cloud-avoiding pointing with onboard camera

TANSO-FTS-2

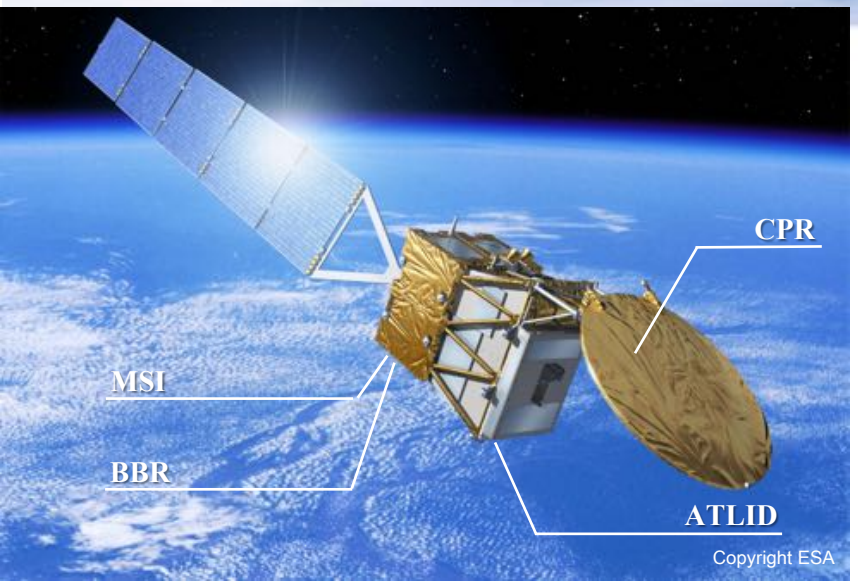
	Band 1	Band 2	Band 3	Band 4	Band 5
Target Gases	O_2	CO_2, H_2O	CO_2, CH_4, CO, H_2O		
Spectral Coverage (μm)	0.75-0.77	1.56-1.69	1.92-2.33	5.5-8.4	8.4-14.3
Spectral Coverage (cm-1)	12,950 - 13,250	5,900 - 6,400	4,200 - 5,200	1,188 - 1,800	700 - 1,188
Spectral Resolution	0.2 cm^{-1}				
Exposure	4 sec				
IFOV	9.7 km				
Pointing	±40 deg. (Along track), ±35 deg. (Cross track)				
Polarimetry	Yes (P and S channels)			No	

TANSO-CAI-2 (radiometer)

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10
Spectral Band (nm)	333 - 353	433 - 453	664 - 684	859 - 879	1585 - 1675	370 - 390	540 - 560	664 - 684	859 - 879	1585 - 1675
Tilt	+20 deg. (Forward viewing)					-20 deg. (Backward viewing)				
Spatial Resolution	460 m				920m	460 m				920m
Swath	920 km									

Earth Cloud, Aerosol and Radiation Explorer (EarthCARE)

Synergetic Observation by Four Instruments

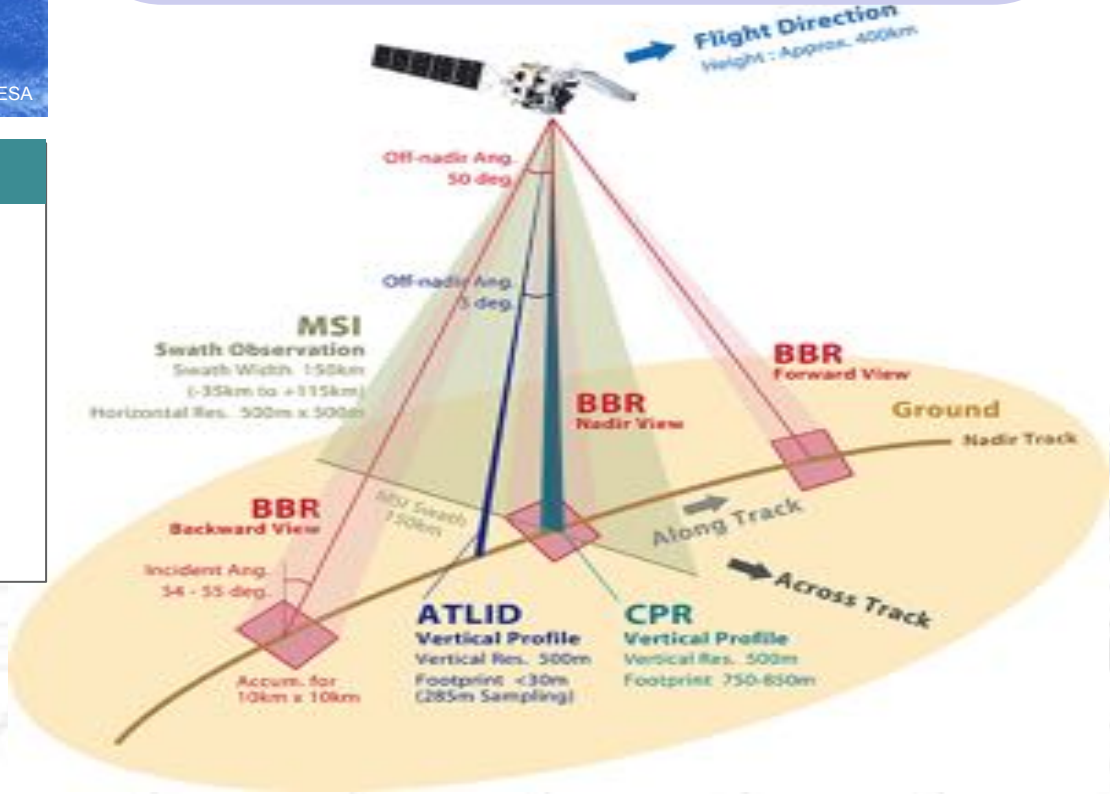


Synergetic Observation by Four Instruments on Global Scale

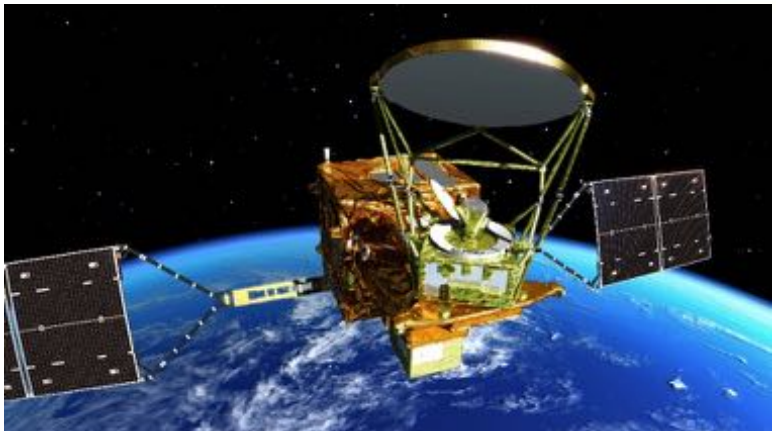
- Three-dimensional structure of aerosol and cloud including vertical motion
- Radiation flux at top of atmosphere
- Aerosol – cloud – radiation interactions

Observation Instruments on EarthCARE

CPR	Cloud Profiling Radar	NICT JAXA
ATLID	Atmospheric Lidar	esa
MSI	Multi-Spectral Imager	esa
BBR	Broadband Radiometer	esa



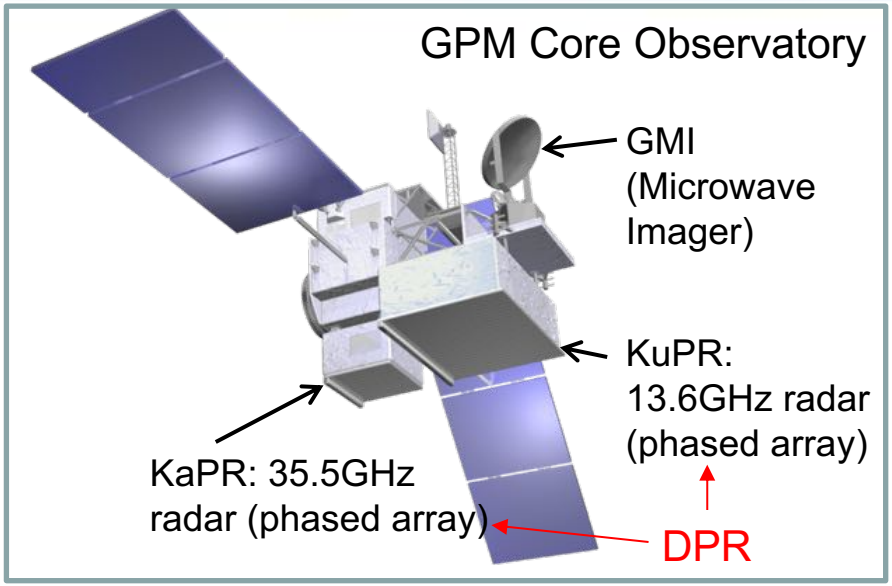
Global Change Observation Mission - Water "SHIZUKU" (GCOM-W)

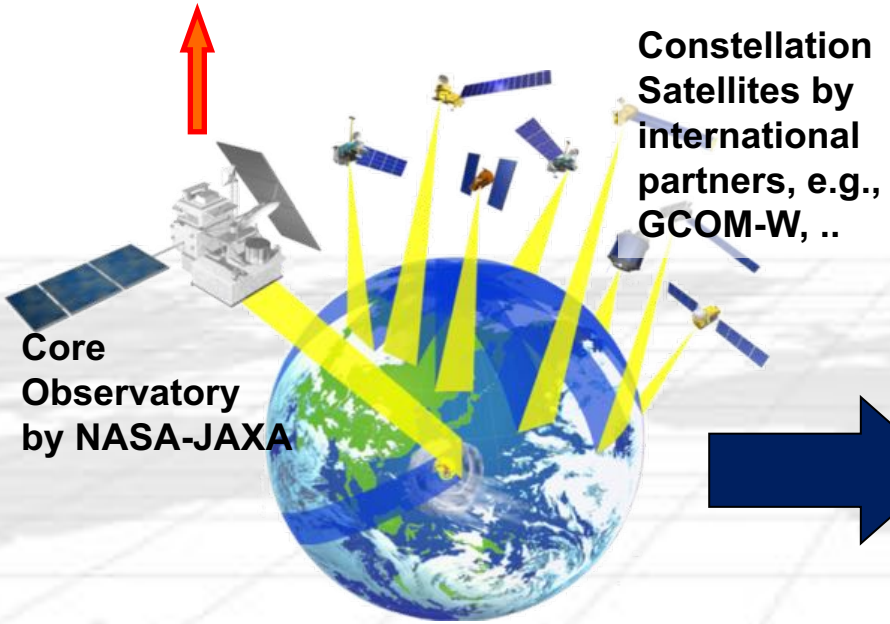


AMSR2 Products	
STD	Brightness Temperature
	Total Precipitable Water
	Total Cloud Liquid Water Content
	Precipitation
	Sea Surface Temperature
	Sea Surface Wind Speed
	Sea Ice Concentration
	Snow Depth
	Soil Moisture Content
RES	All-weather Sea Surface Wind Speed
	10-GHz Sea Surface Temperature
	Land Surface Temperature

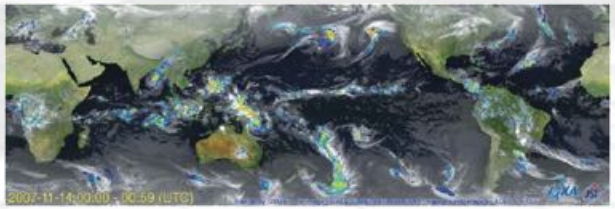
- ✓Successor of Aqua/AMSR-E (launched in May 2002), providing continuous data for climate studies and operational applications
- ✓Joining A-train constellation and also GPM constellation
- ✓Carrying AMSR2, a multi-polarization and multi-frequency microwave imager
- ✓Observing various water-related ECVs over atmosphere, land, ocean and cryosphere in high spatial resolution
- ✓Improving on-board calibration target has resulted reduction of annual TB variation due to calibration and improvement of TB stability
- ✓Achieved designed mission life (5-year) on May 18, 2017, and continues observation
- ✓Mission Definition Review of AMSR2 follow-on sensor (AMSR3) is currently on going

Global Precipitation Measurement (GPM)





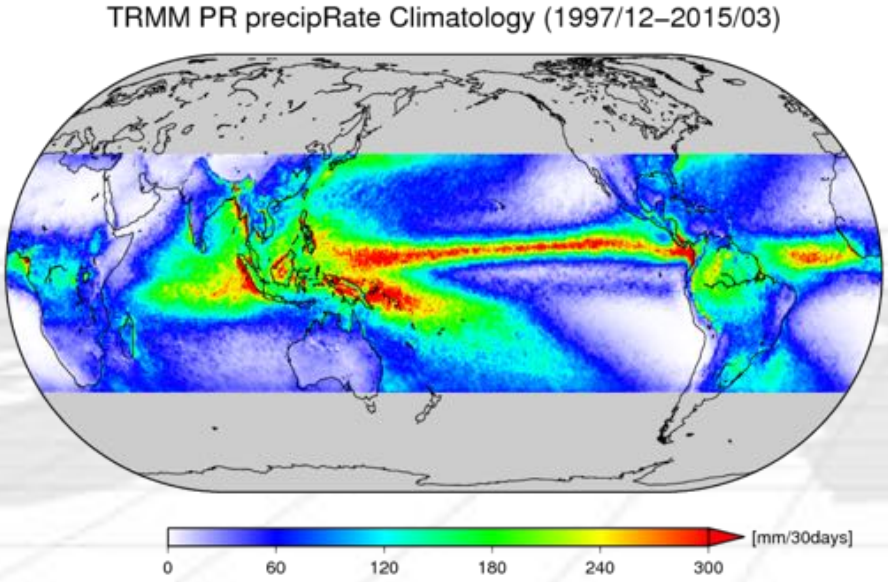
- GPM is an international mission consisting of the GPM Core Observatory and Constellation Satellites for high accurate and frequent global precipitation observation.
  - Core Observatory: developed under NASA and JAXA equal partnership.
  - Constellation satellites: provided by international partners (includes GCOM-W1).
- Dual-frequency Precipitation Radar (DPR)
  - developed by JAXA and NICT
  - DPR is composed of two radars: KuPR & KaPR
- GPM Core Observatory was successfully launched at Tanegashima, Japan on **Feb. 2014.**
- GPM/DPR completed the Prime mission phase and moved to the extended mission phase on Dec. 2017.



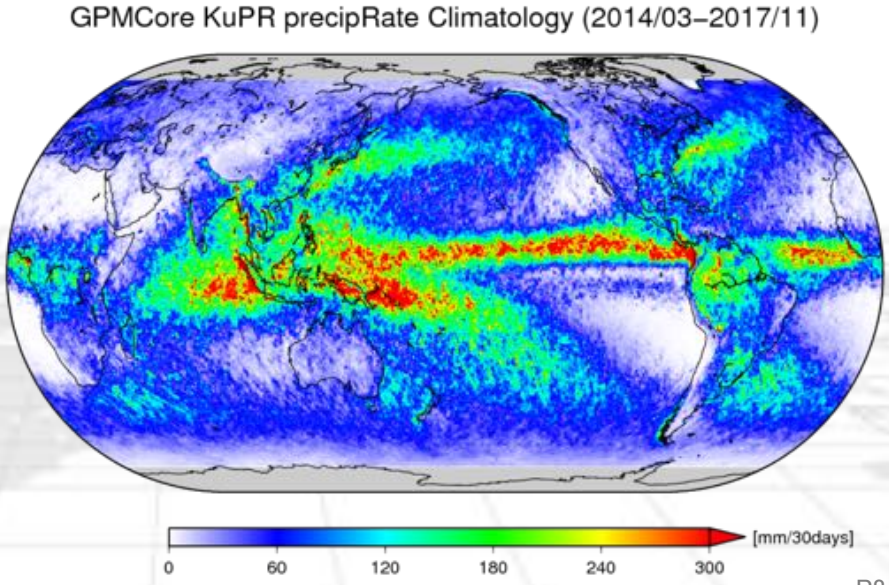
Wider coverages by GPM/DPR observations

- Climatological distribution of surface precipitation amount for TRMM/PR vs. GPM/DPR
- **→Wider coverages by GPM/DPR observations**

Surface precipitation distribution byTRMM/PR (Dec. 1997-Mar.2015)



Surface precipitation distribution byGPM/DPR (Mar.2014-Nov.2017)



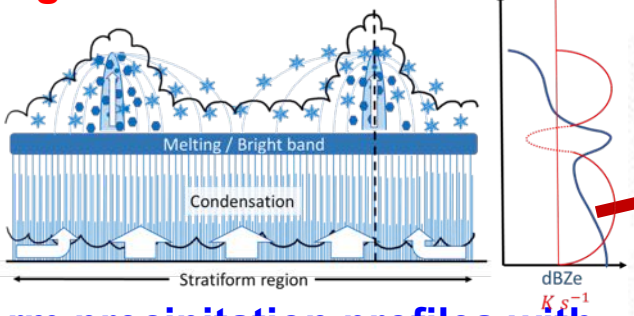
Differences of precipitation features between the tropics and extratropic revealed by the GPM/DPR

- 3-D observation of the GPM/DPR enables us to analyze precipitation feature not only in the Tropics, but also in the mid-latitudes!

Kobayashi et al. (2018, *QJRMS*)

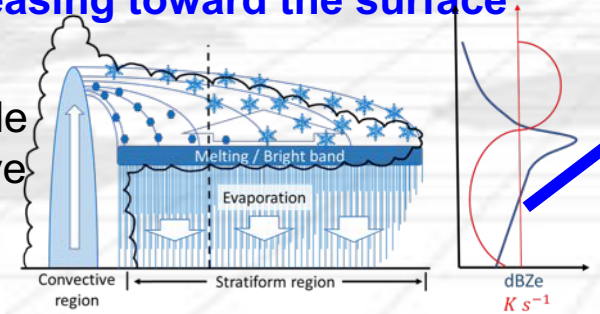
Stratiform precipitation profiles with increasing toward the surface

Mid-latitude frontal system

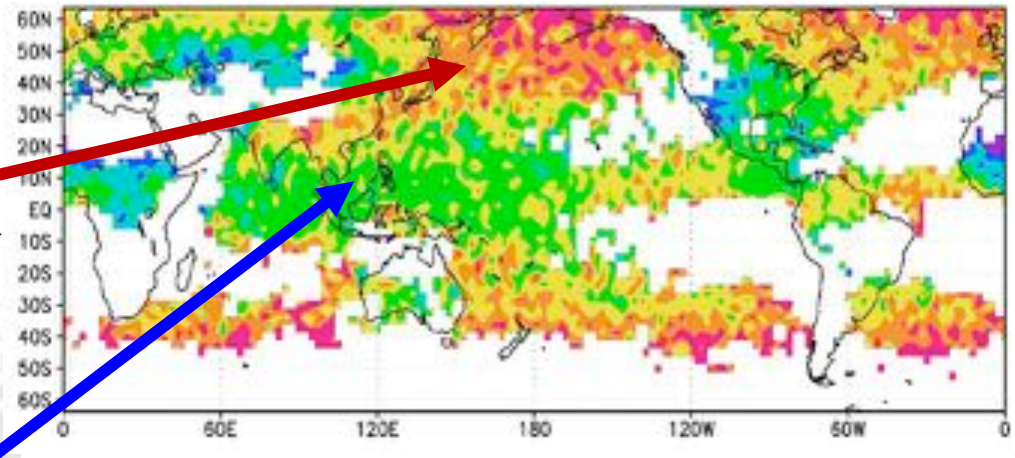


Stratiform precipitation profiles with decreasing toward the surface

Tropical Mesoscale convective system (MCS)



Analzyed results using GPM/DPR data during N.H. Summer

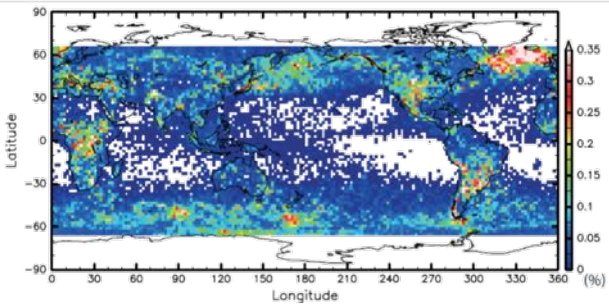


Kobayashi, K., S. Shige, and M. K. Yamamoto, 2018: Variable nature of stratiform precipitation from the tropics to extratropical latitudes seen by GPM. Part I: Vertical structure of radar reflectivity below the bright band. *Q. J. R. Meteorol. Soc.*, in press

Distribution of intense solid precipitation （hail and graupel etc.）retrieved by DPR

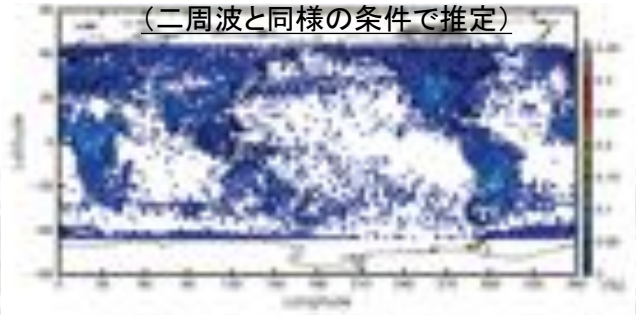
Iguchi et al. (2018, *JTECH*)

Percentage of intense solid precipitation retrieved from dual frequency information



Percentage of intense solid precipitation, but from single（KuPR) frequency

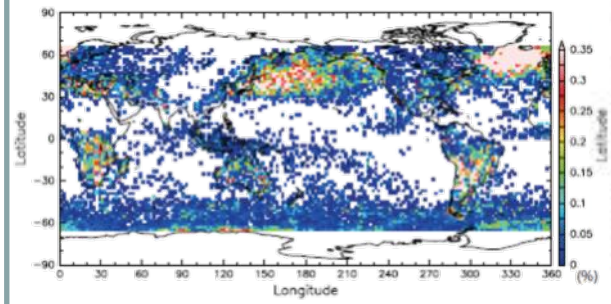
（二周波と同様の条件で推定）



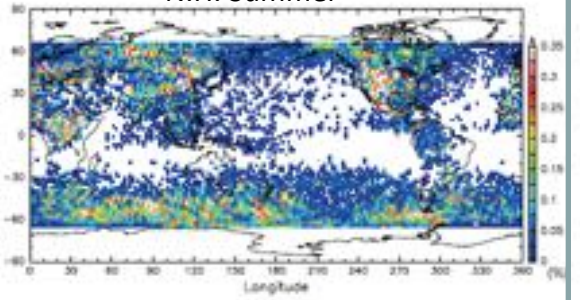
could get new information by using dual frequcies

Percentage of intense solid precipitation in column

N.H. winter

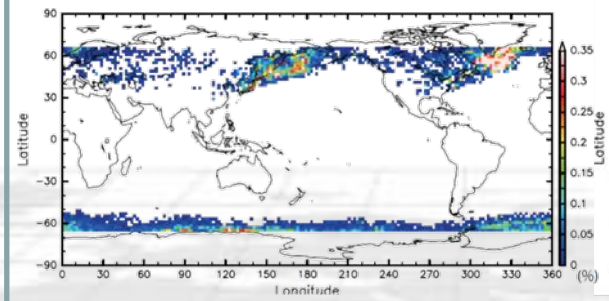


N.H. Summer

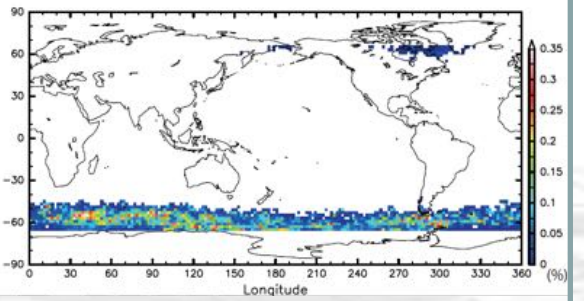


Percentatge of intense solid precipitation that reaches the ground surface

N.H. winter



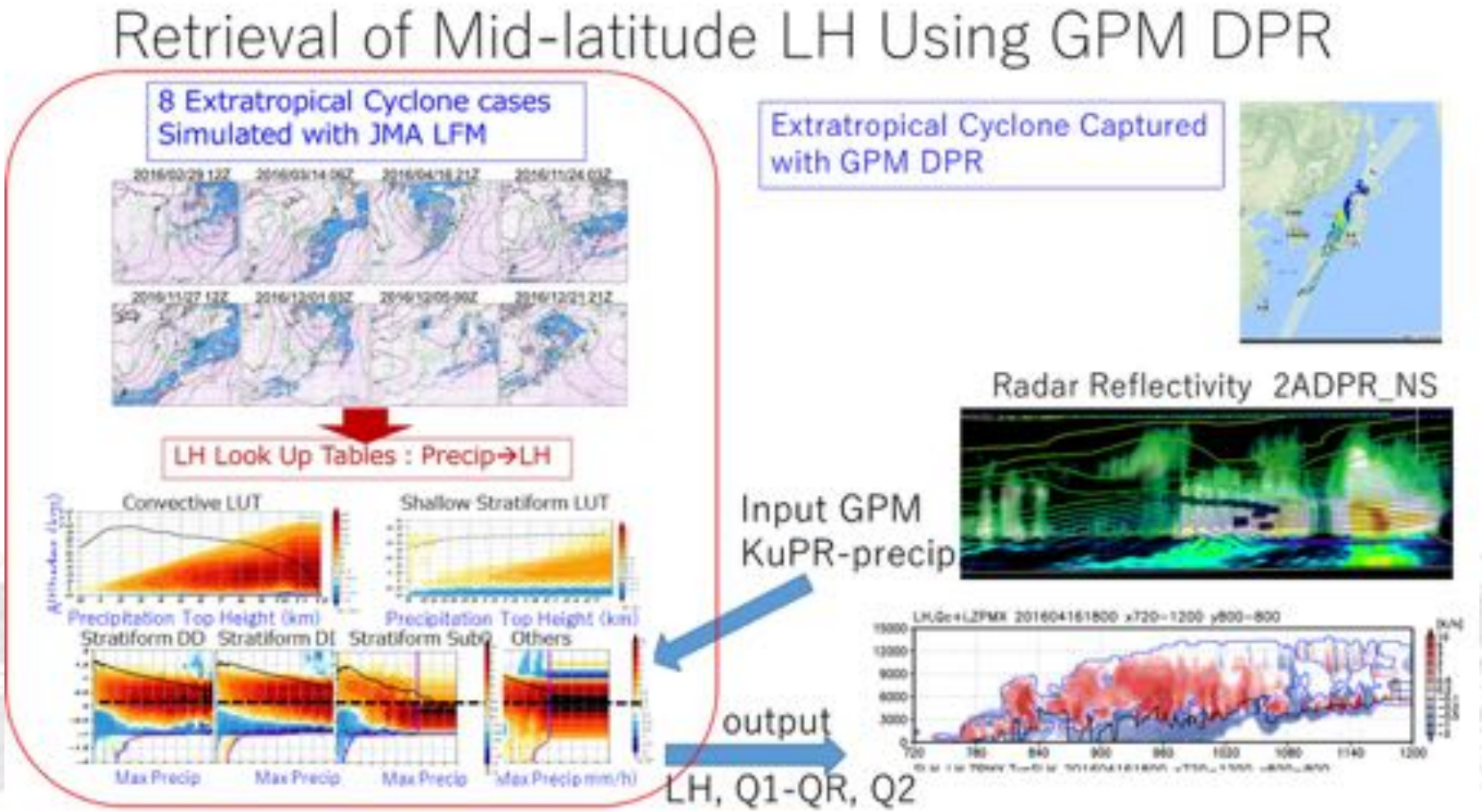
N.H. summer



Solid precipitation that reaches the surface can be seen over ocean than land in the winter of Northern Hemisphere. Especially over north western Pacific and north western Atlantic

DPR SLH V05 product

- GPM latent heating V05 product released in Jul. (SLH) and Aug. (CSH) 2017 included LH retrievals over mid-latitudes.

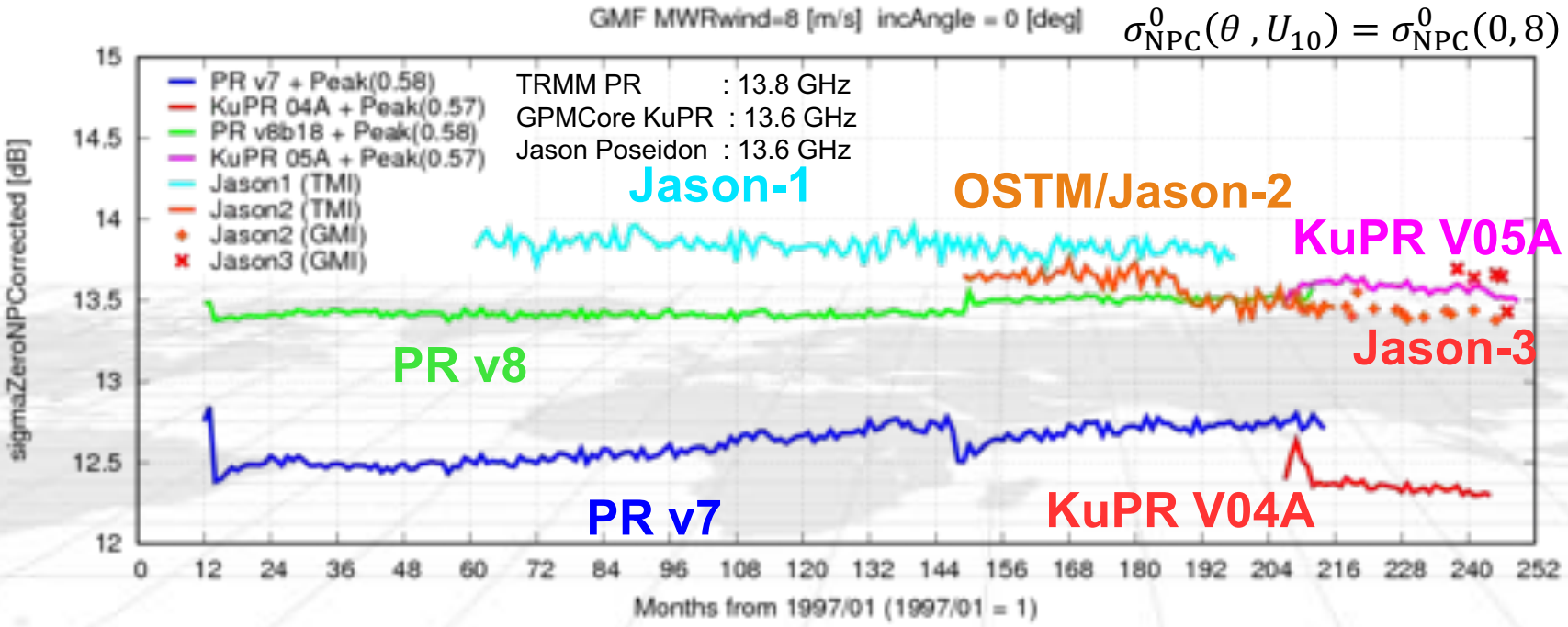


(provided by Prof. Takayabu, Univ. Tokyo)

Better continuity of the TRMM/PR V8 and the GPM/KuPR V05

- GPM/DPR's calibration factors was changed in V05 released in May 2017, and TRMM/PR's calibration factors was also changed in TRMM V8 released in Oct. 2017.
- Better continuity was realized in the GPM/KuPR V05 and the TRMM/PR V8.

Comparisons of the NRCS (σ^0) with various sensors



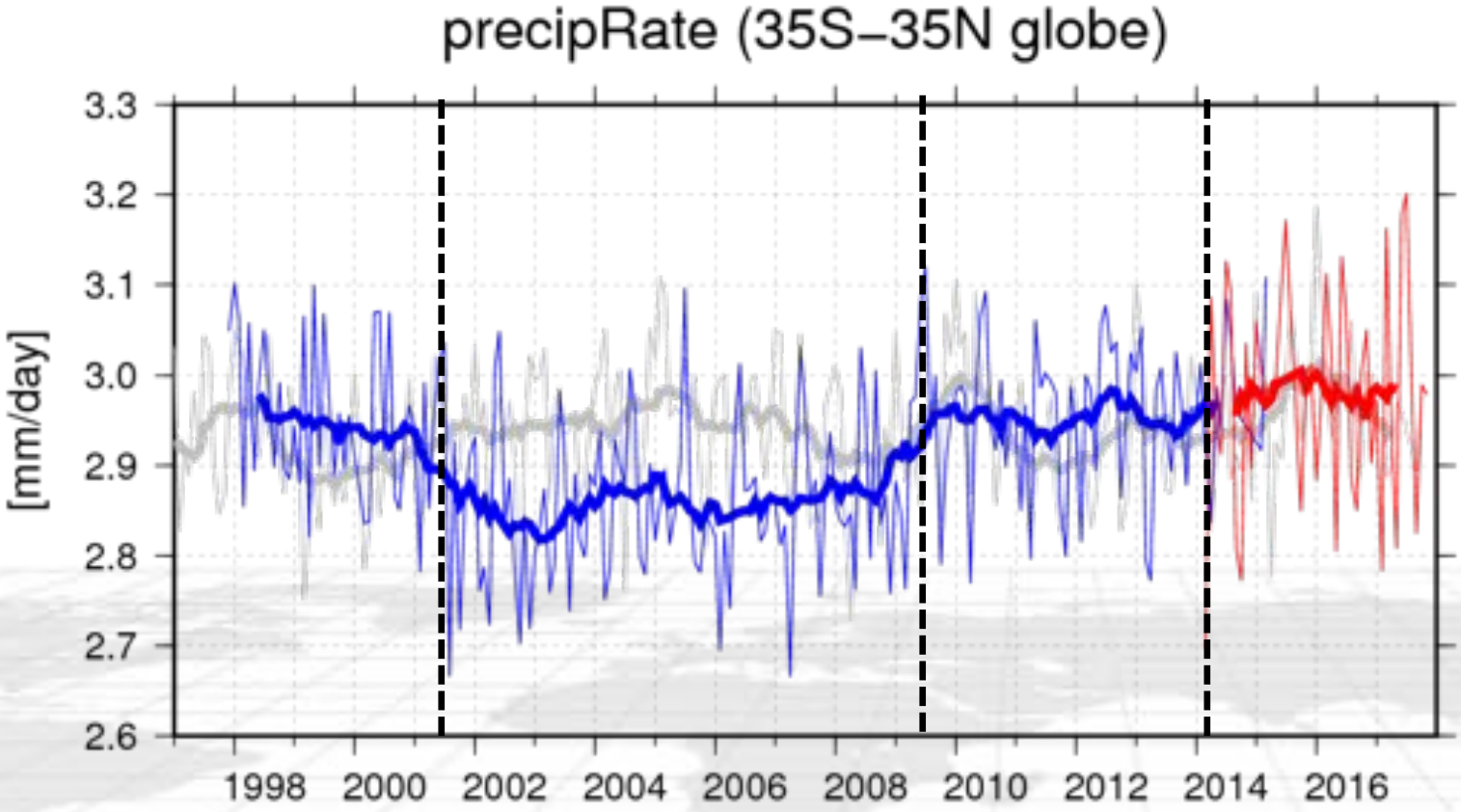
20-year Precipitation time series by TRMM/GPM spaceborne radars

GPCP V2.3 (Adler et al., 2017)

PR v8b18 nadir (test version) → *open to the public in June 2018*

KuPR V05A nadir

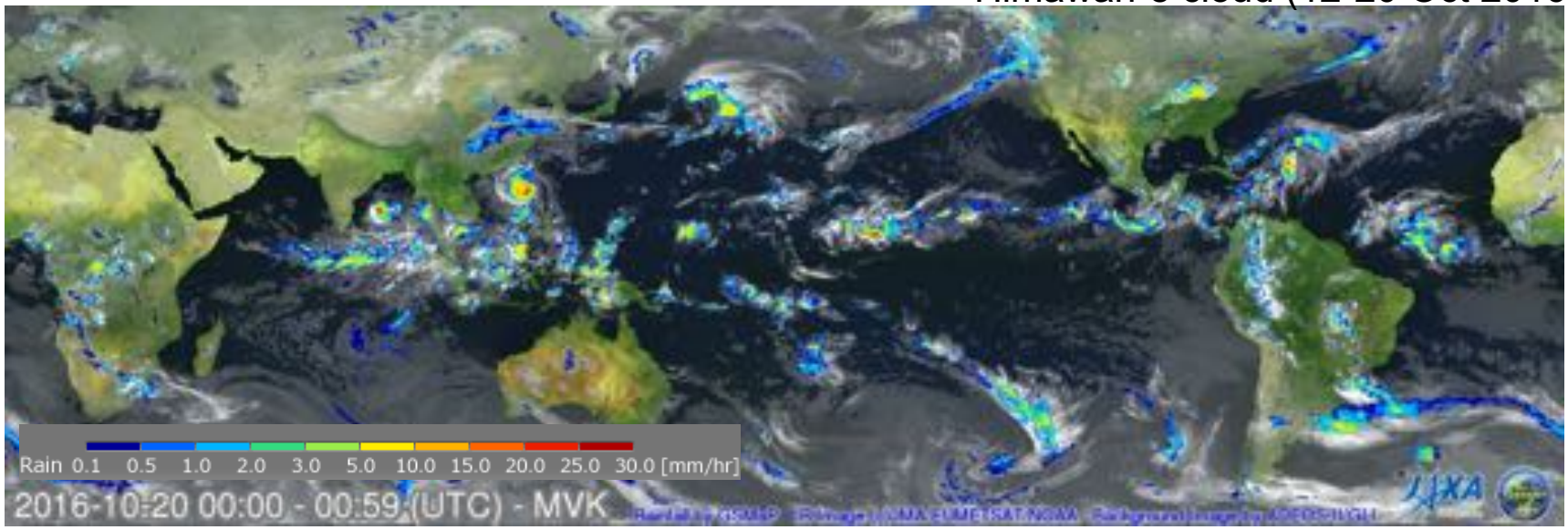
Heavy lines denote 13-month running mean



Global Satellite Mapping of Precipitation (GSMaP)

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

GSMaP_NRT hourly rain with Himawari-8 cloud (12-20 Oct 2016)



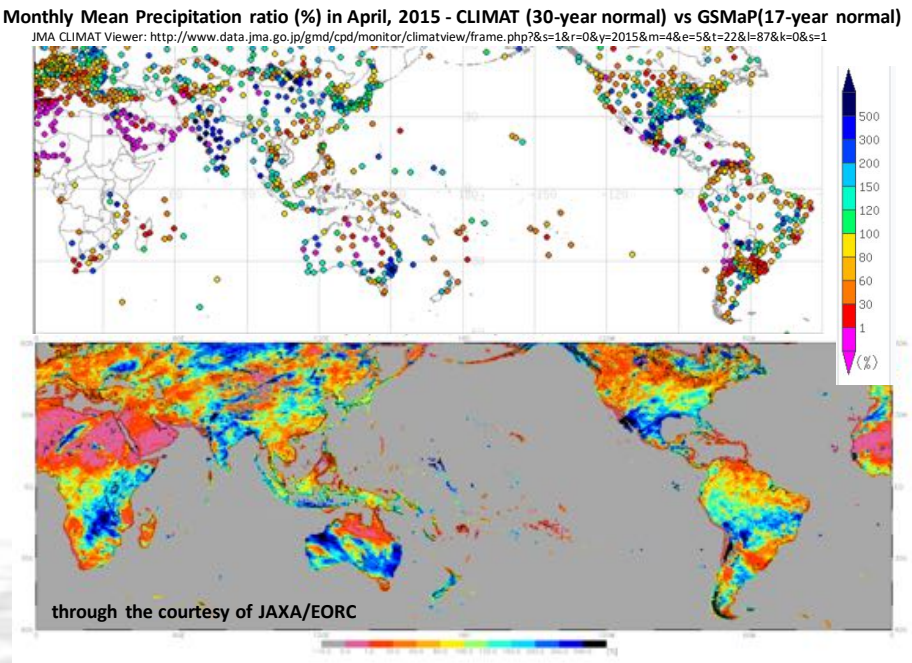
- GSMaP is a blended Microwave-IR product and has been developed in Japan toward the GPM mission.
  - U.S. counterpart is “IMERG”
  - GSMaP (v6) data was reprocessed as reanalysis version (GSMaP_RNL) since Mar. 2000 period , and was open to the public in Apr. 2016, and new version, GSMaP (v7) was released in 17 Jan. 2017.
  - GSMaP realtime product (GSMaP_NOW) in the domain of GEO-Himawari, GSMaP Riken Nowcast (GSMaP_RNC) data developed by RIKEN/AICS (Otsuka et al. 2016) are now available from JAXA/EORC ftp site.

WMO SEMDP

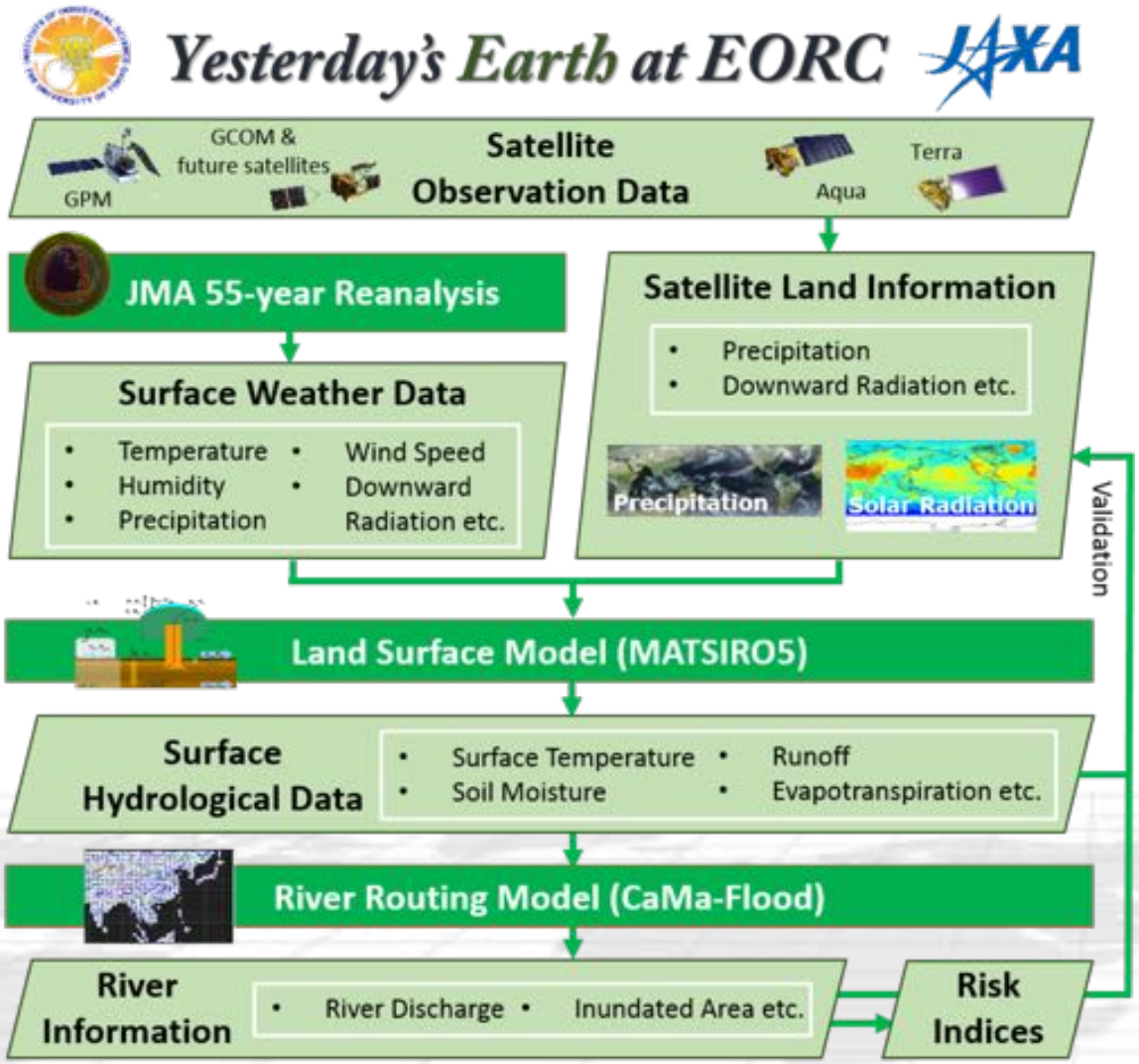
- WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) Demonstration Project (SEMDP)
  planned by Mr. Kurino (WMO)

(i) monitoring **persistent heavy precipitation** and **droughts**;
(ii) making best use of existing and newly developed satellite derived products and time series of measurements;
(iii) making best use of products that combine satellite information with in-situ and/or model reanalysis data;
(iv) recommendations as to which products should be transitioned from research to operations, including an assessment of those products.

GSMaP climate analysis

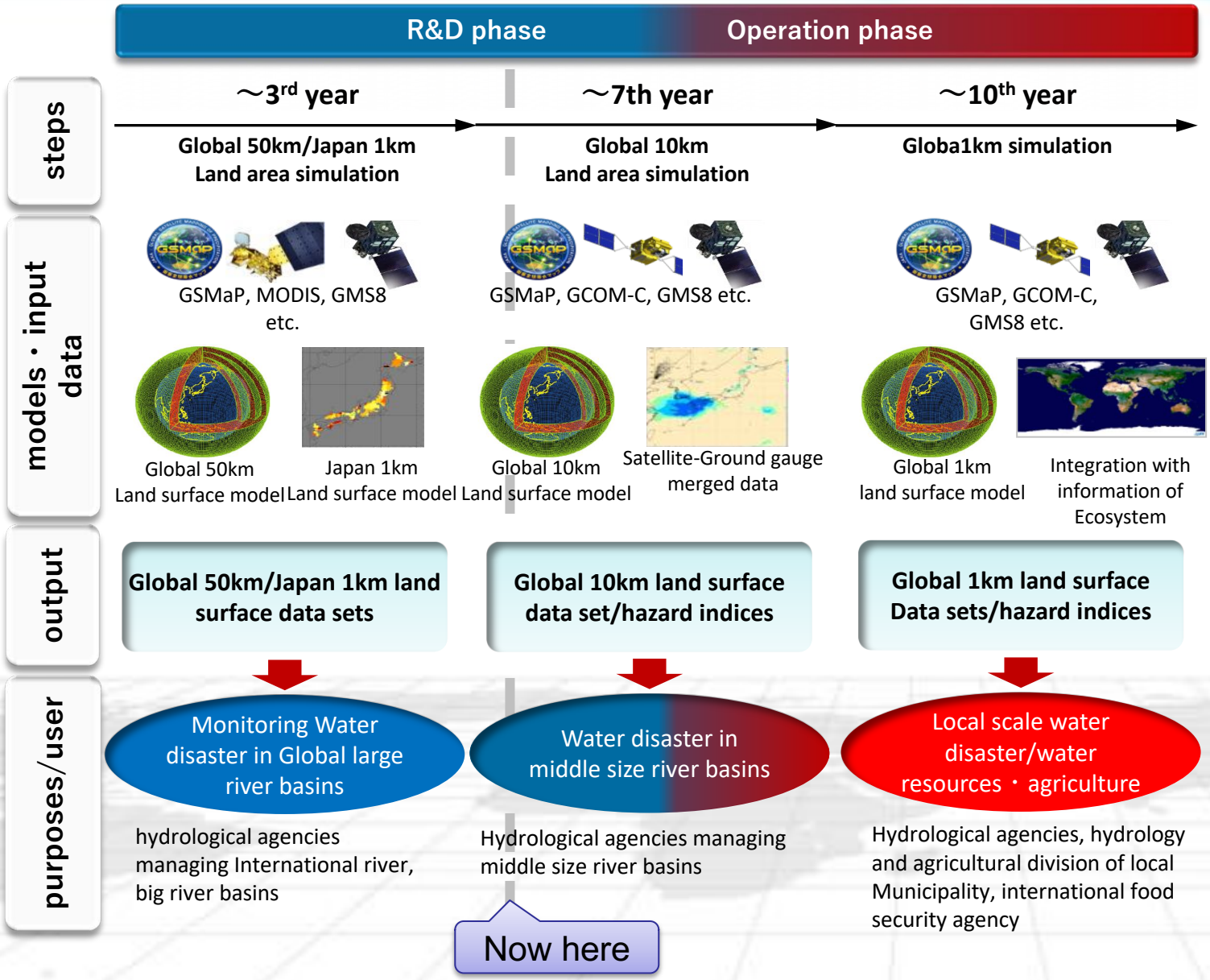


JAXA Yesterday's Earth at EORC (YEE)



- JAXA has developed global hydrological simulation model "Yesterday's Earth at EORC" so called "YEE"
- YEE utilizes both global reanalysis data and satellite observation data aiming to produce more reliable hydrological dataset and risk indices.
- Japan(local) 1-km model is also about to release.

Water Cycle research task at EORC

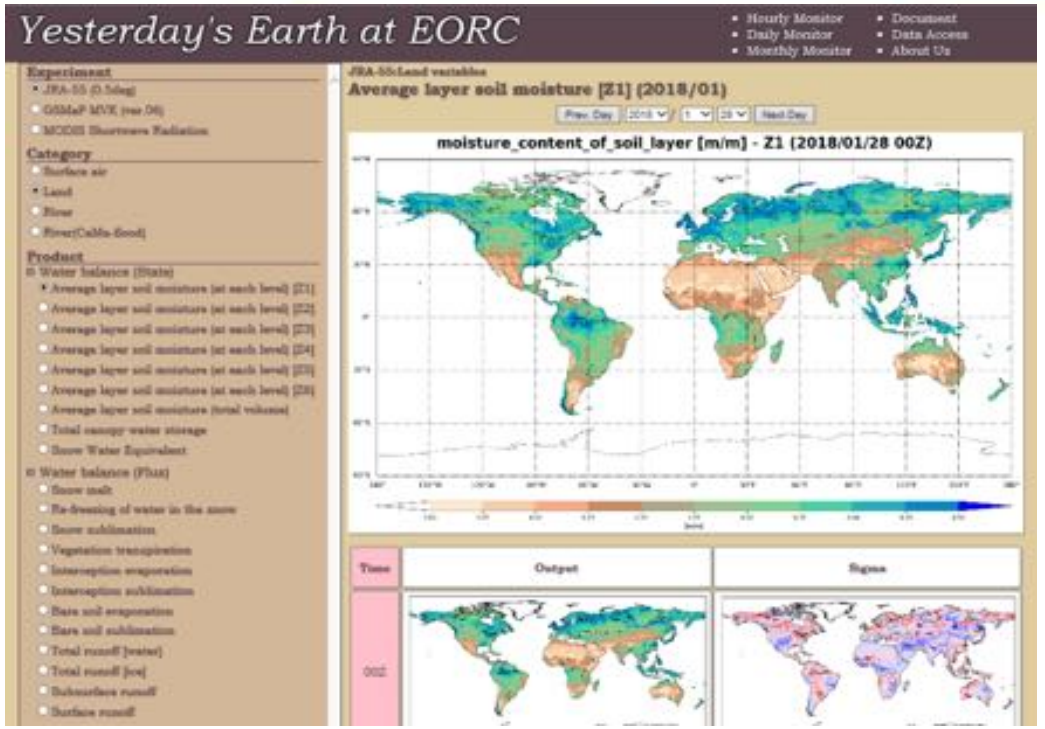


Aiming to develop hyper-resolutional (global 1km) model

YEE website

- Monitor output data from YEE system.
- Not only the images of various outputs and its sigma, raw data in netCDF format are also available through website.

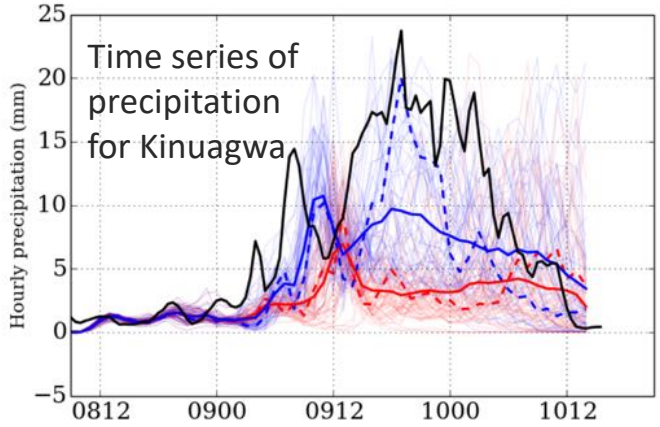
http://www.eorc.jaxa.jp/theme/water/

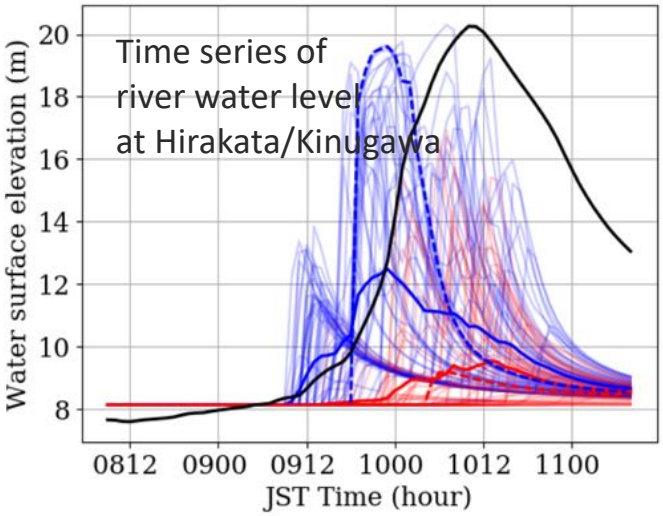


Experiment	Spatial Resol.	Temporal Resol.	Period	Latency	Forcing
JRA55 ver.	0.5-deg(Land) 0.25-deg(River)	3hourly, daily, monthly	1958-present	About 3.5days	Surface meteorological parameters by JRA55
MODIS ver.	〃	〃	2002-present	About 5days	Same as JRA55 ver. except solar radiation from MODIS
GSMaP ver.	〃	〃	2000-present	About 20days	Same as JRA55 ver. except rainfall from GSMaP

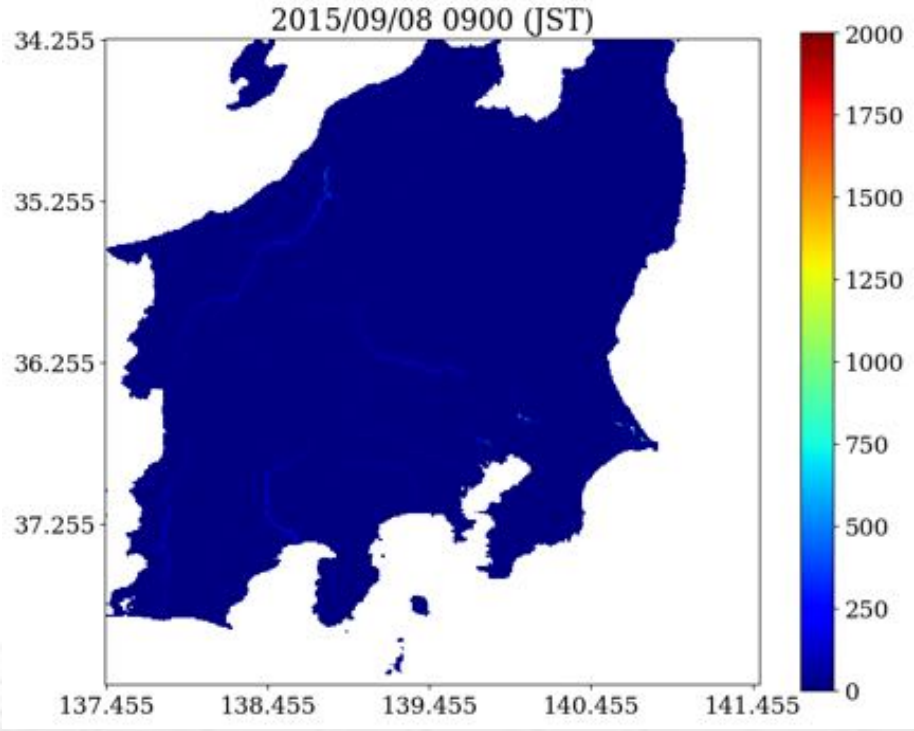
Hind cast experiment of Kinugawa Flooding case in Sep. 9, 2015

High-resolution (1km) ensemble simulation using satellite assimilated meteorological data





Blue/Red: with/without data assimilation
Black: observation



- Satellite data assimilation improved the precipitation and water level results.
- More improvements (ex. peak time of water level) are needed.

Summary 1 (satellites/sensors)

- GCOM-C was successfully launched
  - SGLI products will be released at the end of this year via G-Portal.
- GCOM-W and GPM achieved designed mission life in May 2017, and transferred to Extended Mission period.
  - Long term record of AMSR sensor series and PR-DPR series can contribute GEWEX science
  - (for GCOM-W/AMSR2 results, please check Kachi's presentation on Thursday)
- GOSAT-2 will be launched in 2018. EarthCARE will be launched in 2020.
- Mission Definition Review of AMSR2 follow-on sensor (AMSR3) is currently on going

Summary 2 (research activities)

- Results of GPM/DPR
  - Accumulating 3-dimentional precipitation data including mid latitude.
  - Differences of precipitation features between the tropics and extratropic revealed by GPM/DPR
  - Distribution of intense solid precipitation（hail and graupel etc.）
  - DPR Latent heating profile product was released
  - Continuous Precip. Radar data from TRMM to DPR will be released
- GSMaP
  - WMO Space-based Weather and Climate Extremes Monitoring (SWCEM) Demonstration Project (SEMDP)
- JAXA global hydrological simulation model “Yesterday’s Earth at EORC (YEE)”
  - YEE utilizes both global reanalysis data and satellite observation data aiming to produce more reliable hydrological dataset and risk indices.
  - Japan(local) 1-km model is also about to release.
- JAXA EO Research Opportunities will be Announce this summer

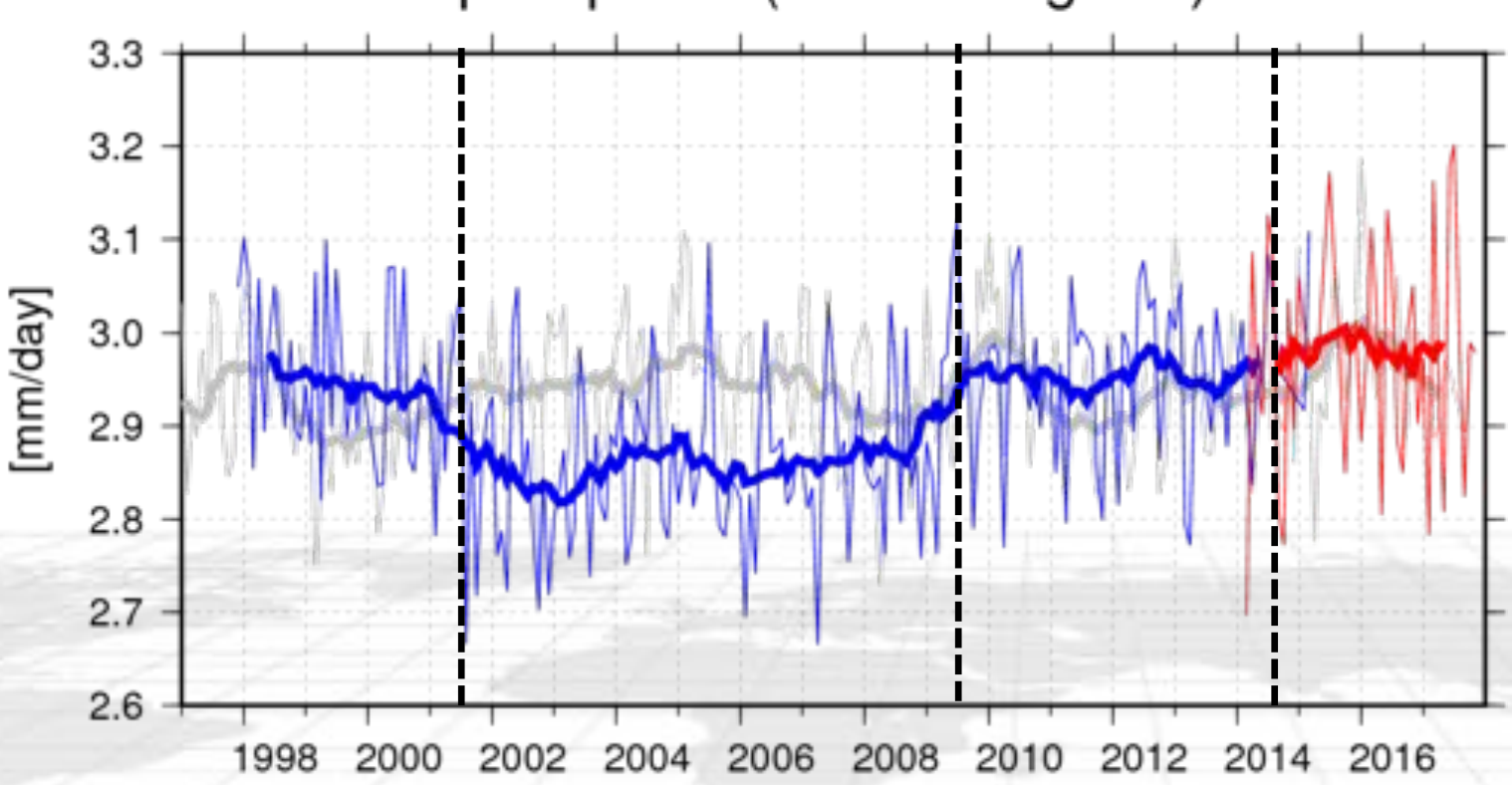
20-year Precipitation time series

GPCP V2.3 (Adler et al., 2017)

PR v8b18 nadir

KuPR V05A nadir

Heavy lines denote 13-month running mean



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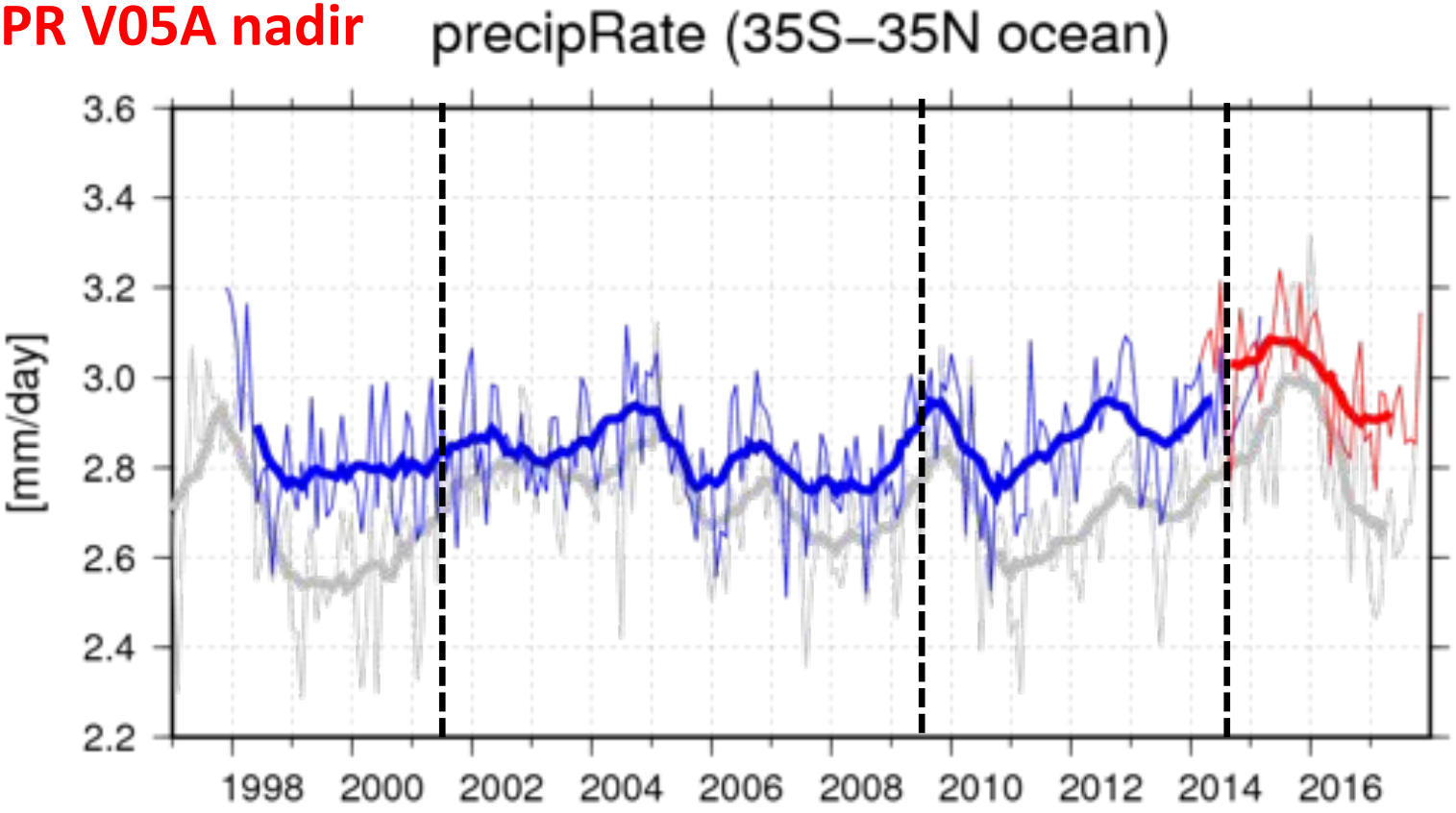


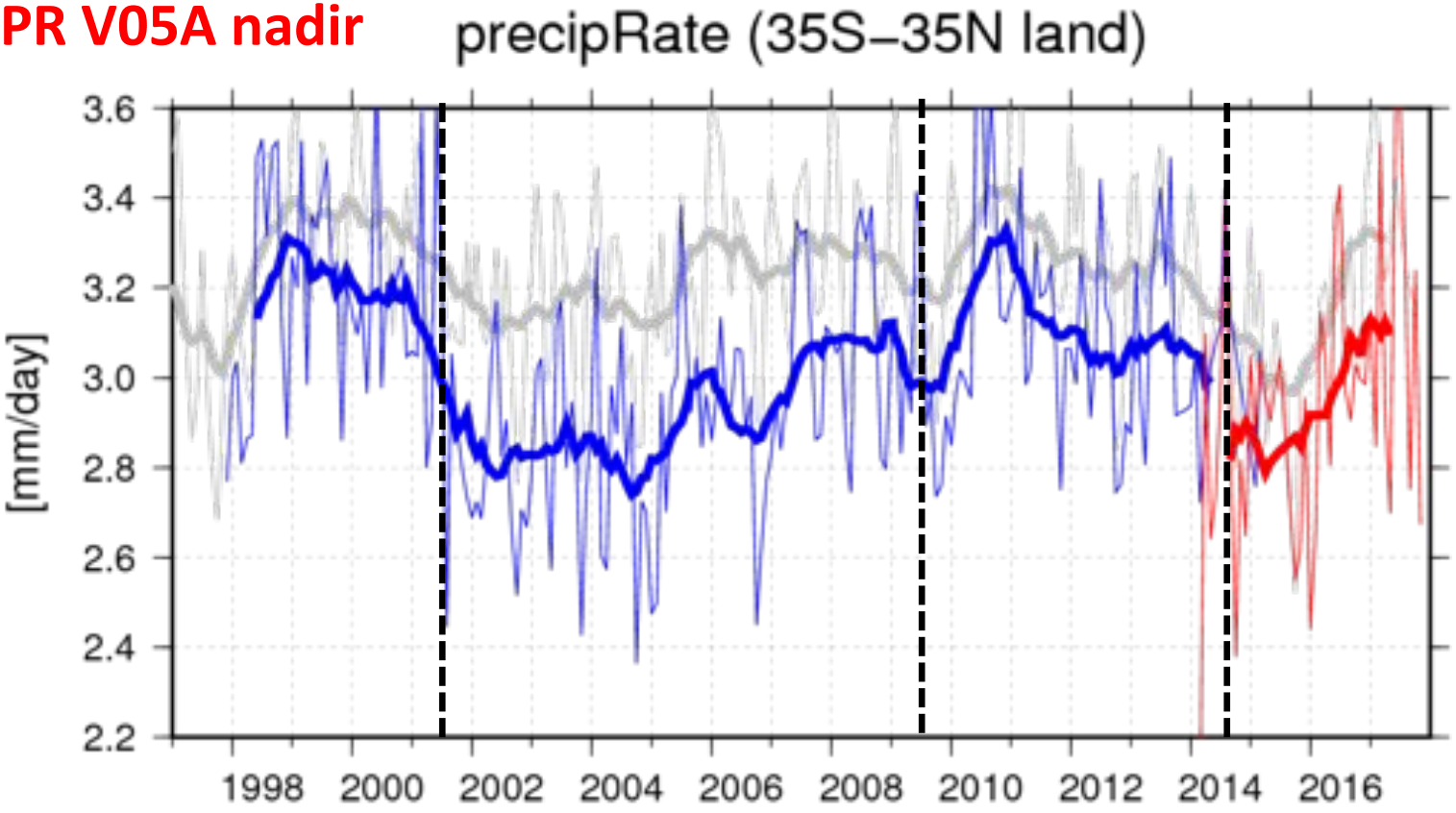
20-year Precipitation time series

GPCP V2.3 (Adler et al., 2017)

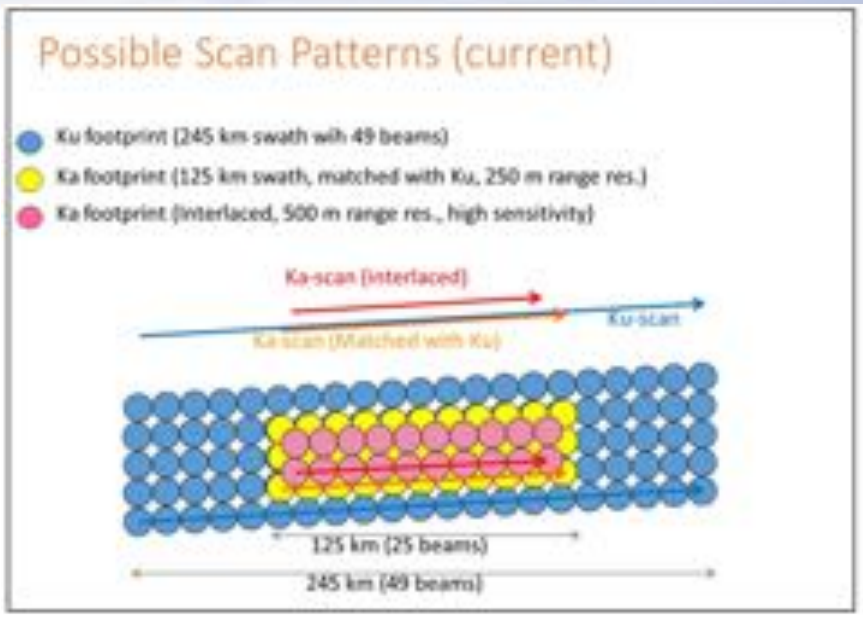
PR v8b18 nadir

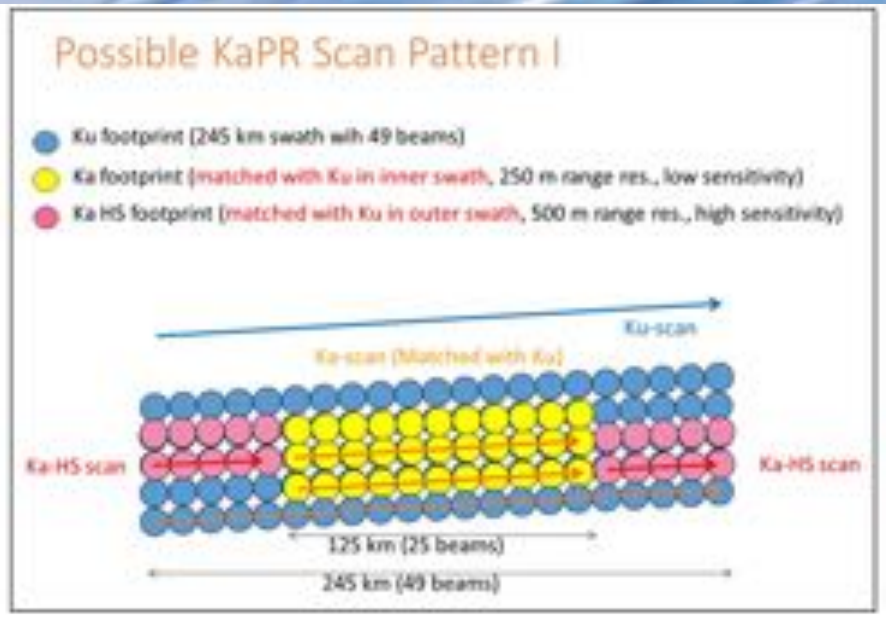
KuPR V05A nadir

Heavy lines denote 13-month running mean



KaPR's scan pattern experiment (KaPR only)





(1) Major changes:

- KaPR-HS's scan pattern was changed.
  → Dual-frequency technique will be applied in a full swath.

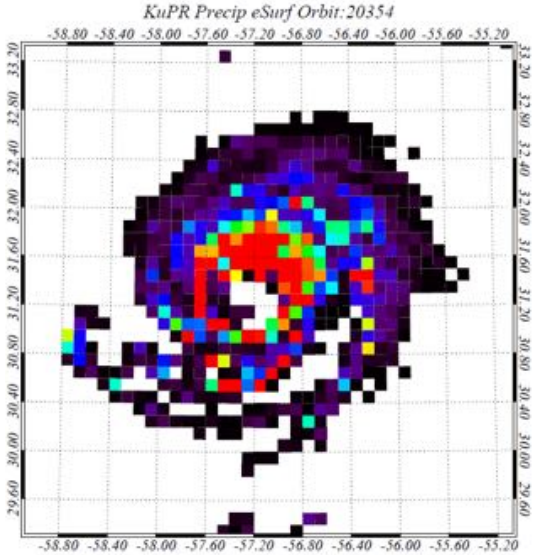
(2) Minor changes:

- Scan timing of KaPR-MS scan was slightly changed to realize improvement of beam matching between KuPR and KaPR (by a request from the DPR-L2 team).

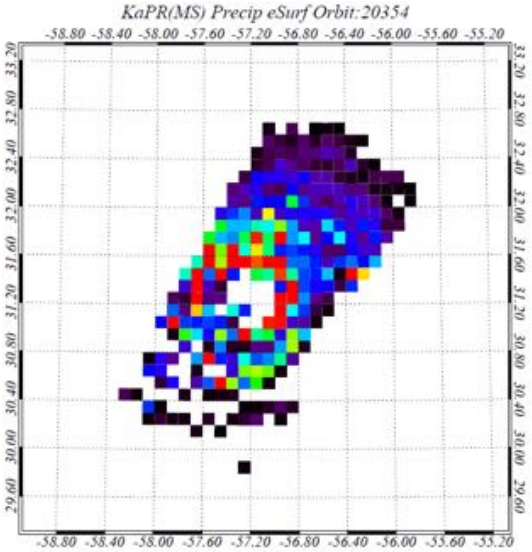
Preliminary KaPR's scan pattern experiment

Sep 27th 2017 Hurricane LEE Precipitation (eSurf)

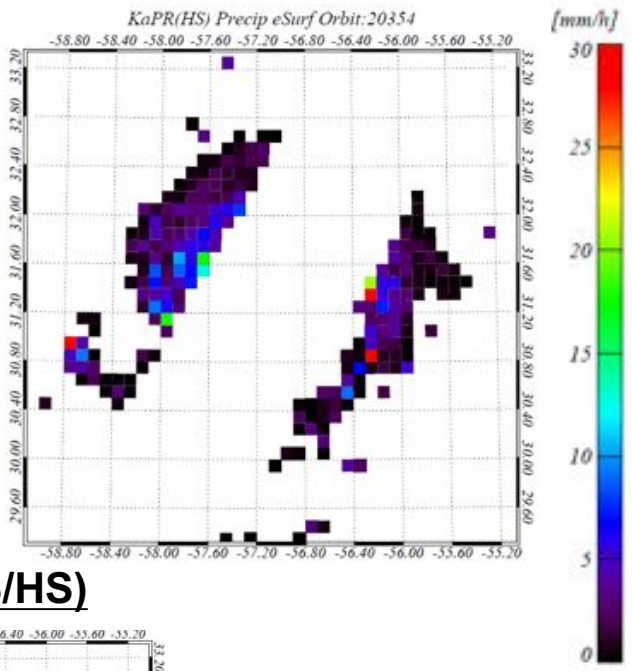
KuPR



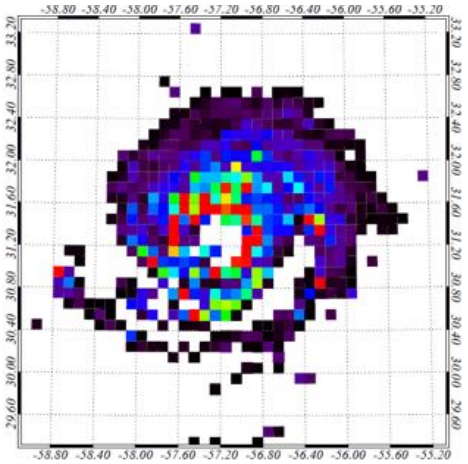
KaPR(MS)



KaPR(HS)



KaPR(MS/HS)



Dual-frequency technique will be applied in a full swath.

DPR Sensor Status

- JAXA is continuing DPR data monitoring to confirm that DPR function and performance are kept on orbit.
  - Operation Mode
  - Temperature
  - Bus Voltage and Current
  - System Noise
  - Sea Surface Radar Cross Section (σ0)
  - Internal Calibration
    - ～1 time / week
  - External Calibration
    - 2 periods / year (～5 times / period)
  - TX/RX Amplifier Status
    - 2 times / year

DPR data monitoring results show that there is no degradation of DPR function and performance from Launch till now.

JAXA GPM mission status

- After the launch on February 2014, 3-year and 2-month operation was completed at the end of April 2017.
- JAXA completed the End of Prime mission review of the GPM/DPR on June 19th 2017 to confirm achievements of the mission requirement.
- The GPM/DPR management review was held on 26th October 2017 for approval to move extended mission phase.
- On 1st December 2017, JAXA/GPM project team moved to the SAOC (Space Application Operation Center).