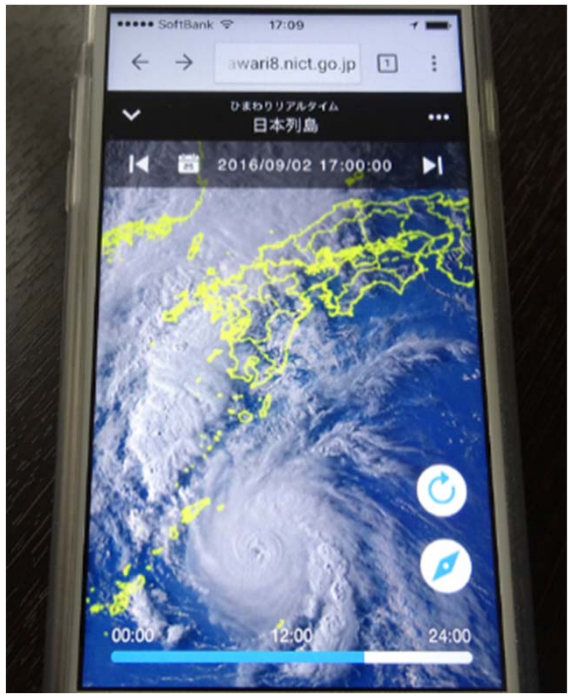
Himawari-8 satellite and its contribution to Asia and Oceania countries

- How to make us of international networks -



Himawari NICT

Ken T. Murata and Praphan Pavarangkoon

National Institute of Information and Communications Technology, Japan

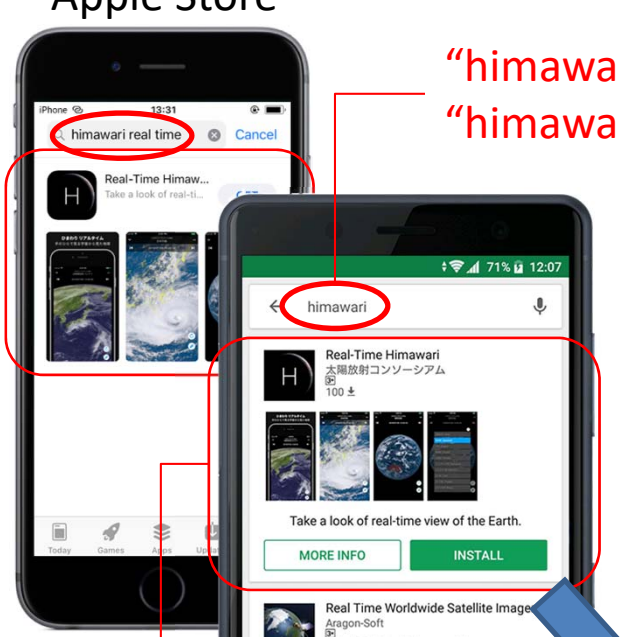
NICT ScienceCloud

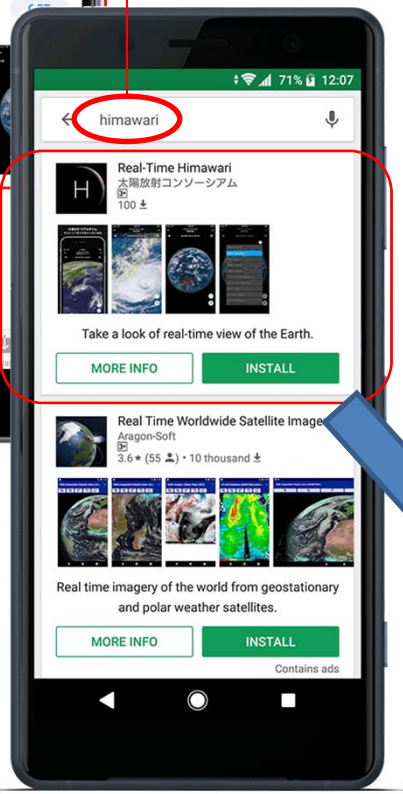
Smart Phone application (for citizens)

Free Download on Apple Store & Google Play

Apple Store

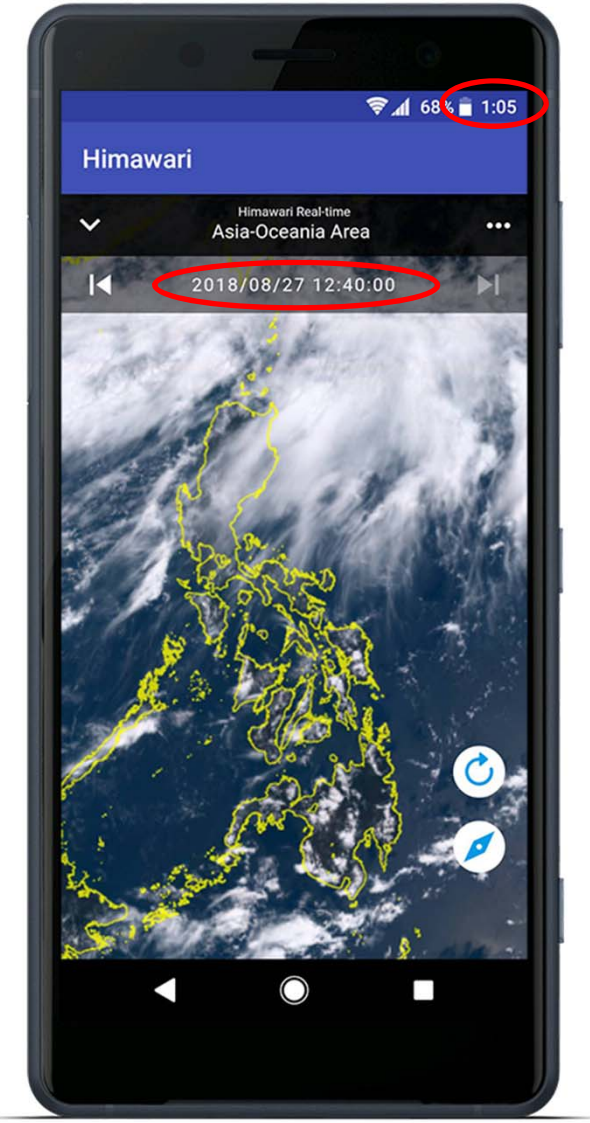
“himawari” or
“himawari real time”





Google Play

Smart Phone (Android8)



Real-Time Himawari
Solar Radiation Consortium

NICT ScienceCloud

Outline

- Introduction and experience of “Himawari real-time”
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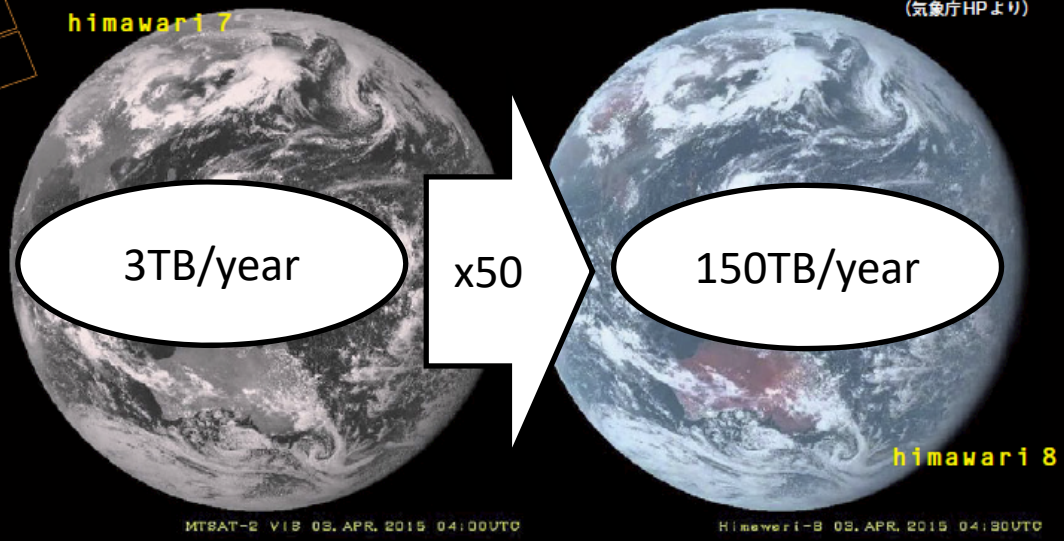
From Himawari-7 to Himawari-8

Second generation

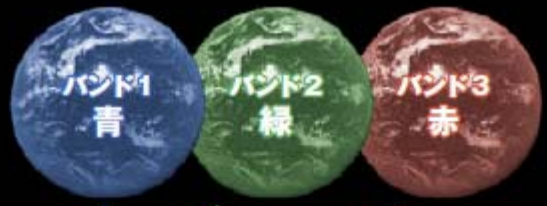
Third generation



2015年4月3日のほぼ同時刻に撮影された、ひまわり7号（左）とひまわり8号の全球画像。これまでの白黒画像がカラー化されたことがよくわかる。

H-7 data size is 3TB/year.

Band1 Band2 Band3



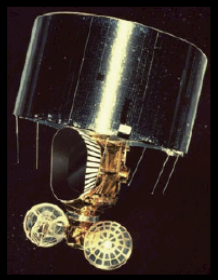
Himawari-8

運輸多目的衛星新2号（MTSAT-2） ひまわり7号

静止気象衛星（GMS） ひまわり

Himawari-7

(気象庁HPより)



(気象庁HPより)

ひまわり8号は、バンド1～3の画像を合成してカラー画像をつくりだしている。

Color image

NICT ScienceCloud

Specification of Himawari-8

Band　　Wave length　　Himawari-6/7 Spatial resolution Gradation

	バンド		中心波長 (μm)	ひまわり6号、7号相当	解像度衛星直下点 (km)	階調数	用途
1	可視	青	0.47		1	2048	植生、エアロゾル
2		緑	0.51				植生、エアロゾル
3		赤	0.64	VIS	0.5		下層雲・霧、植生
4	近赤外		0.86		1	2048	植生、エアロゾル
5			1.6		2		雲相判別
6			2.3				雲粒有効半径
7	赤外		3.9	IR4	2	16384	下層雲・霧、自然火災
8			6.2	WV		2048	上層水蒸気量
9			6.9				上・中層水蒸気量
10			7.3			4096	中層水蒸気量
11			8.6			4096	雲相判別、SO2検出
12			9.6			4096	オゾン全量
13			10.4	IR1		4096	雲画像、雲頂情報
14			11.2				雲画像、海面水温
15			12.4	IR2			雲画像、海面水温
16			13.3			2048	雲頂高度

Visible

Near-infrared

Infrared

Time and spatial resolutions of Himawari-8

target	Time resolution (min.)	Spatial resolution (pixel)
full disk	10	11000 × 11000
Japan area	2.5	3301 × 2701
Target area	2.5	1501 × 1501

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Data size of Himawari-8

Time and spatial resolutions of Himawari-8

target	Time resolution (min.)	Spatial resolution (pixel)
full disk	10	11000 × 11000
Japan area	2.5	3301 × 2701
Target area	2.5	1501 × 1501

in detail

Table 3 Time interval of Himawari-8 observations and data files provided by JMA: observation area, time interval, data format, data size, and segment

Area	Time interval (min)	Spatial resolution (pixels)	Format	Data size (MB)	Total data size (GB/day)	Number of files (files/day)	Segments
full disk	10	11000 × 11000	HSF*	590	83	22,560	10
			PNG	60	8.4	142	-
Japan Area	2.5	3301 × 2701	HSF*	25	14	9,216	No division
			NetCDF	34	19	9,216	
			PNG	4	2.1	576	-
Target Area	2.5	1501 × 1501	HSF*	5	2.8	9,216	No division
			NetCDF	7.8	4.4	9,216	
			PNG	1	0.6	576	-

* Himawari standard format

91.4GB/day (635MB/step)

Himawari Real-time

Views on PC and SP (Smart Phone)

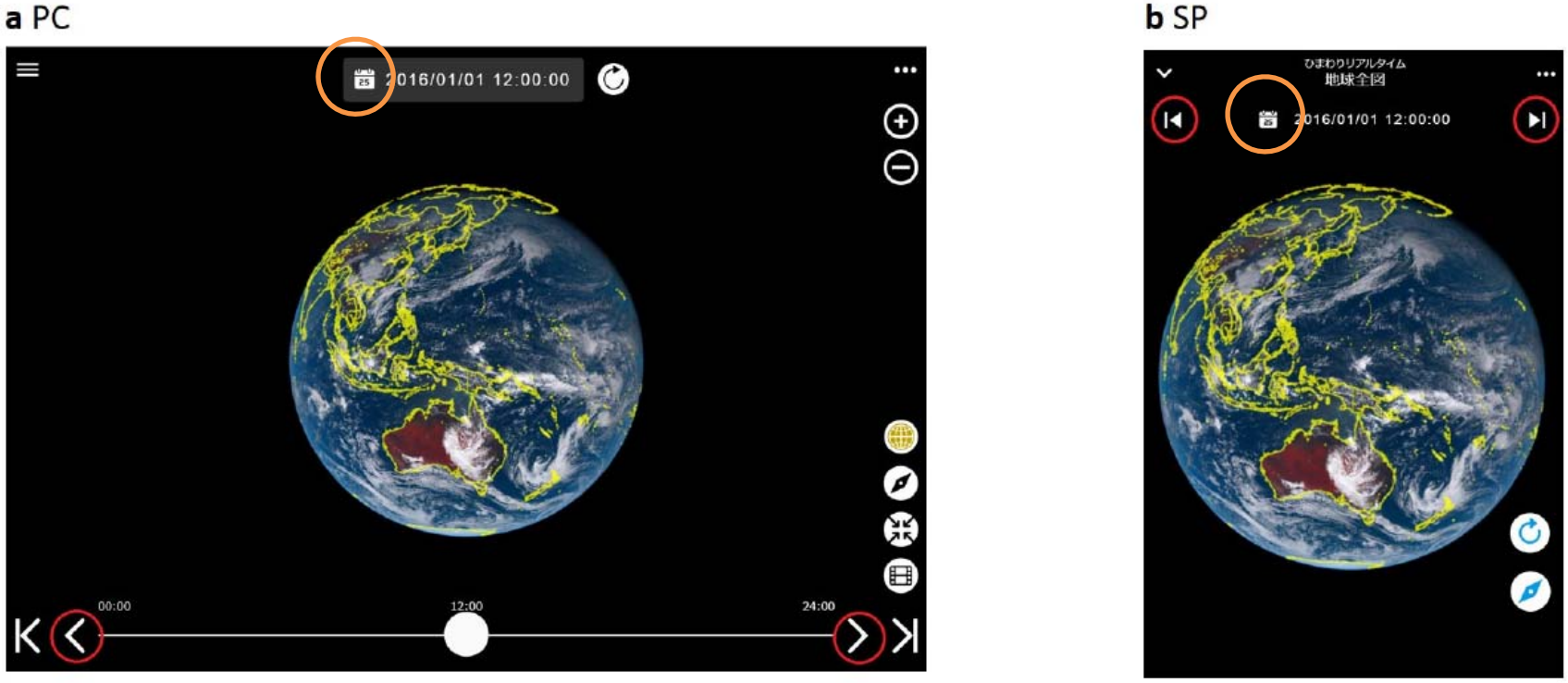
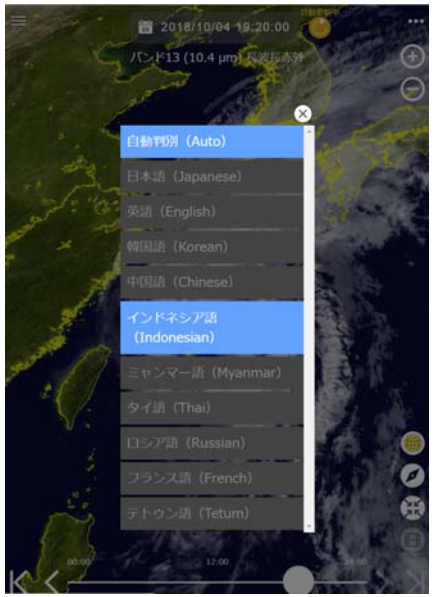


Fig. 7 Screen-captured images of full disk view in zoom level 1 on **a** PC and **b** SP where step forward/backward buttons are represented by red circle. Note that one of the Himawari-8 real-time web functions is to draw coast lines, which do not show up in Fig. 5.

https://himawari.asia

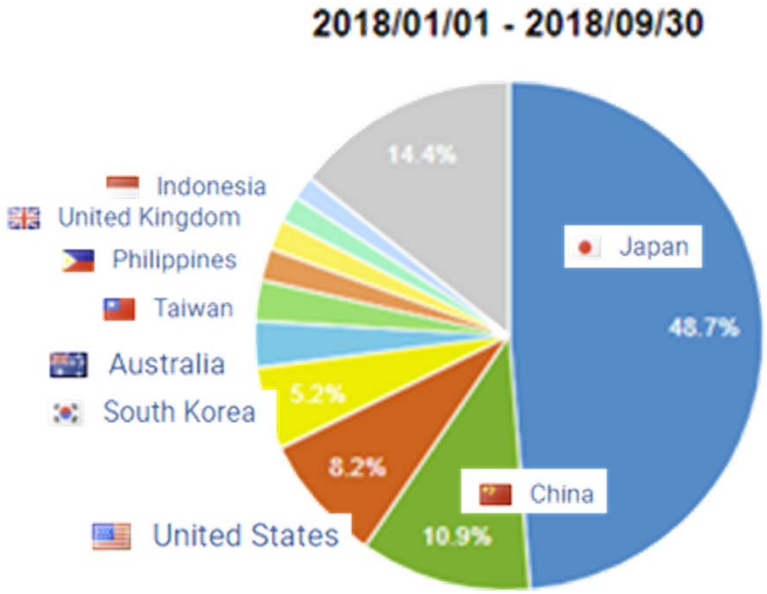
NICT ScienceCloud

Himawari real-time web

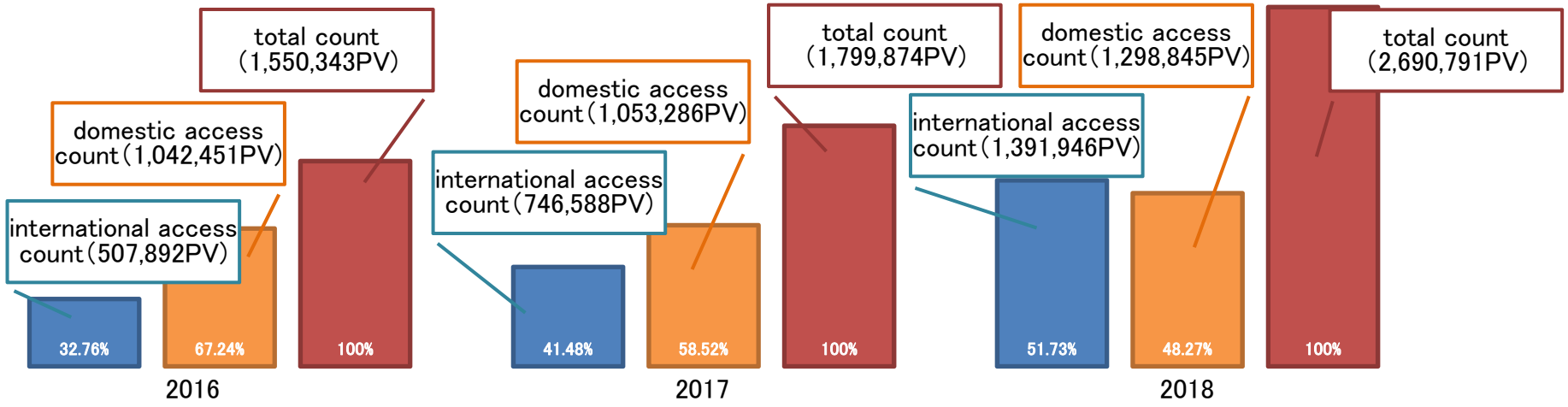


11 languages

- Japanese
- English
- Korean
- Chinese
- Indonesia
- Myanmar
- Thai
- Russian
- French
- Tetum
- Malay



■ Access count (page view)



NICT ScienceCloud

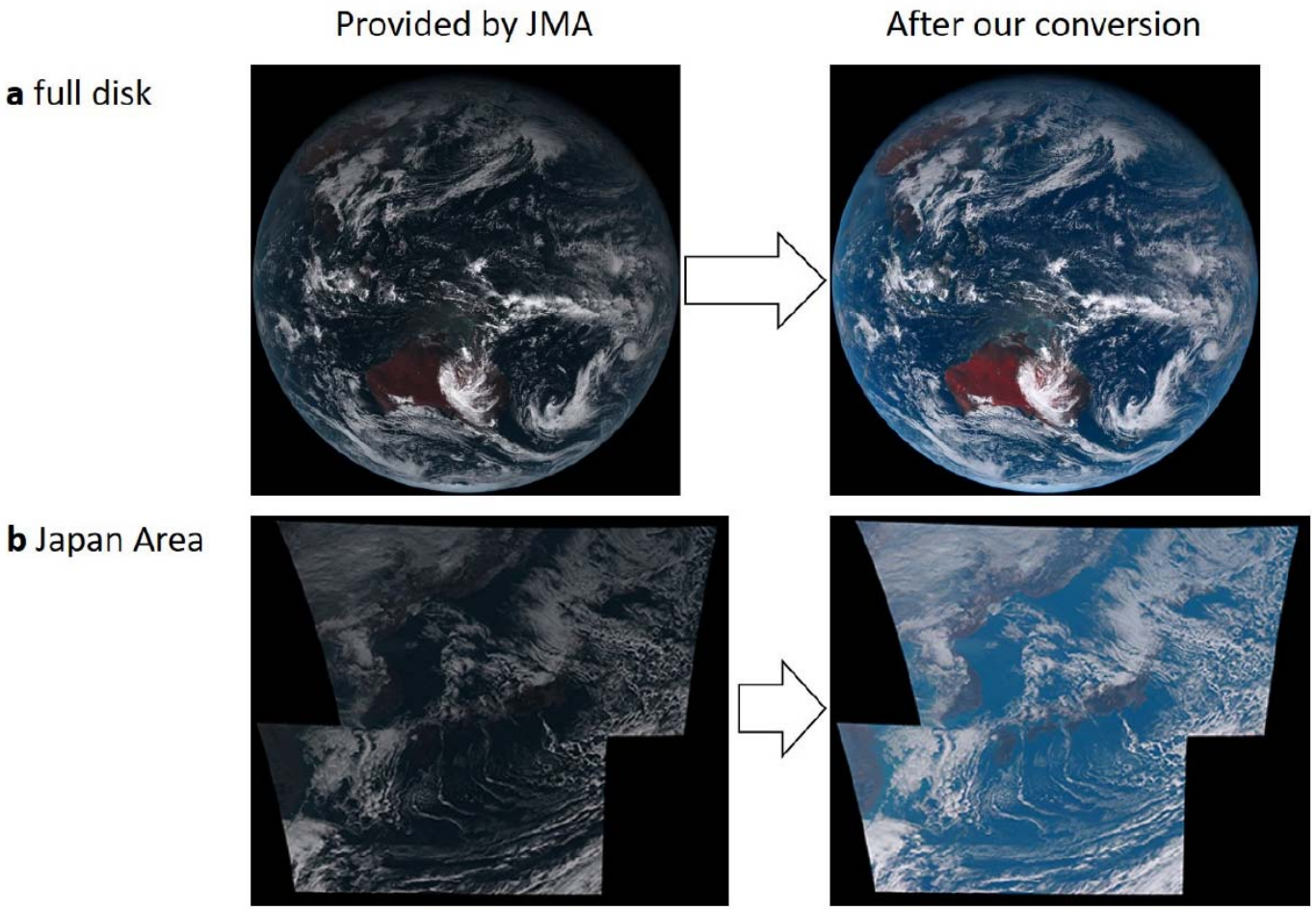
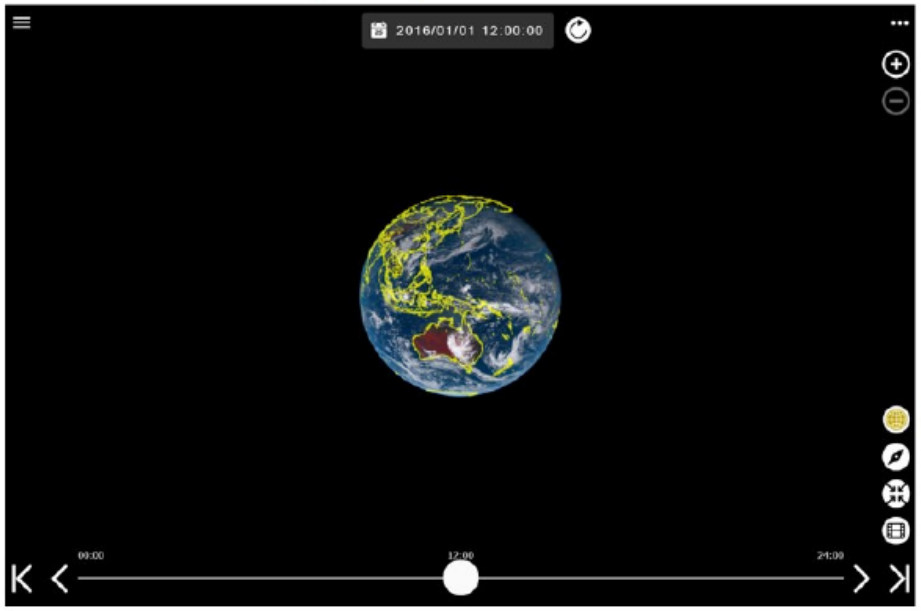
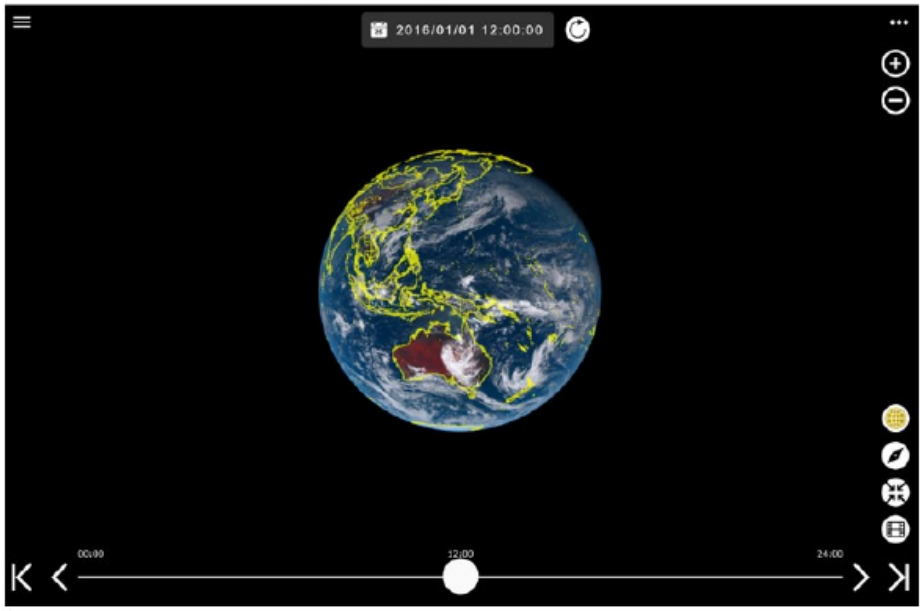


Fig. 5 PNG files provided by JMA and after our conversion of **a** full disk and **b** Japan Area at 12:00 JST on January 1, 2016.

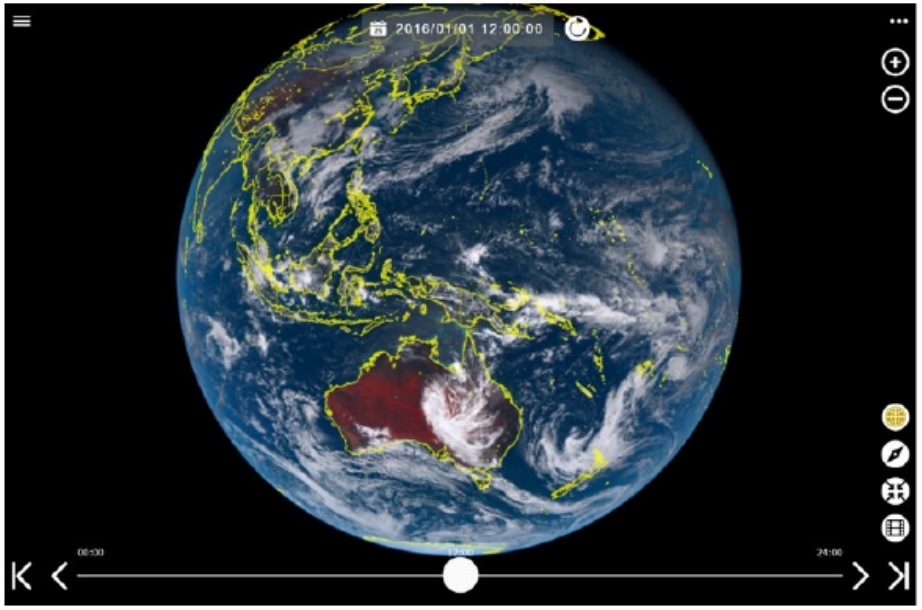
a Zoom level 1 (1 file)



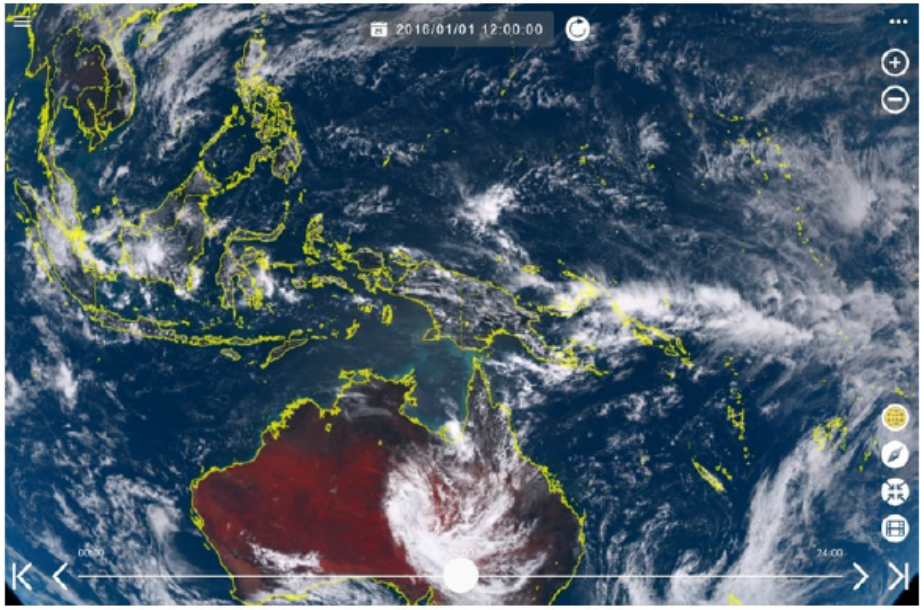
b Zoom level 2 (1 files)



c Zoom level 4 (1 files)



d Zoom level 6 (6 files)



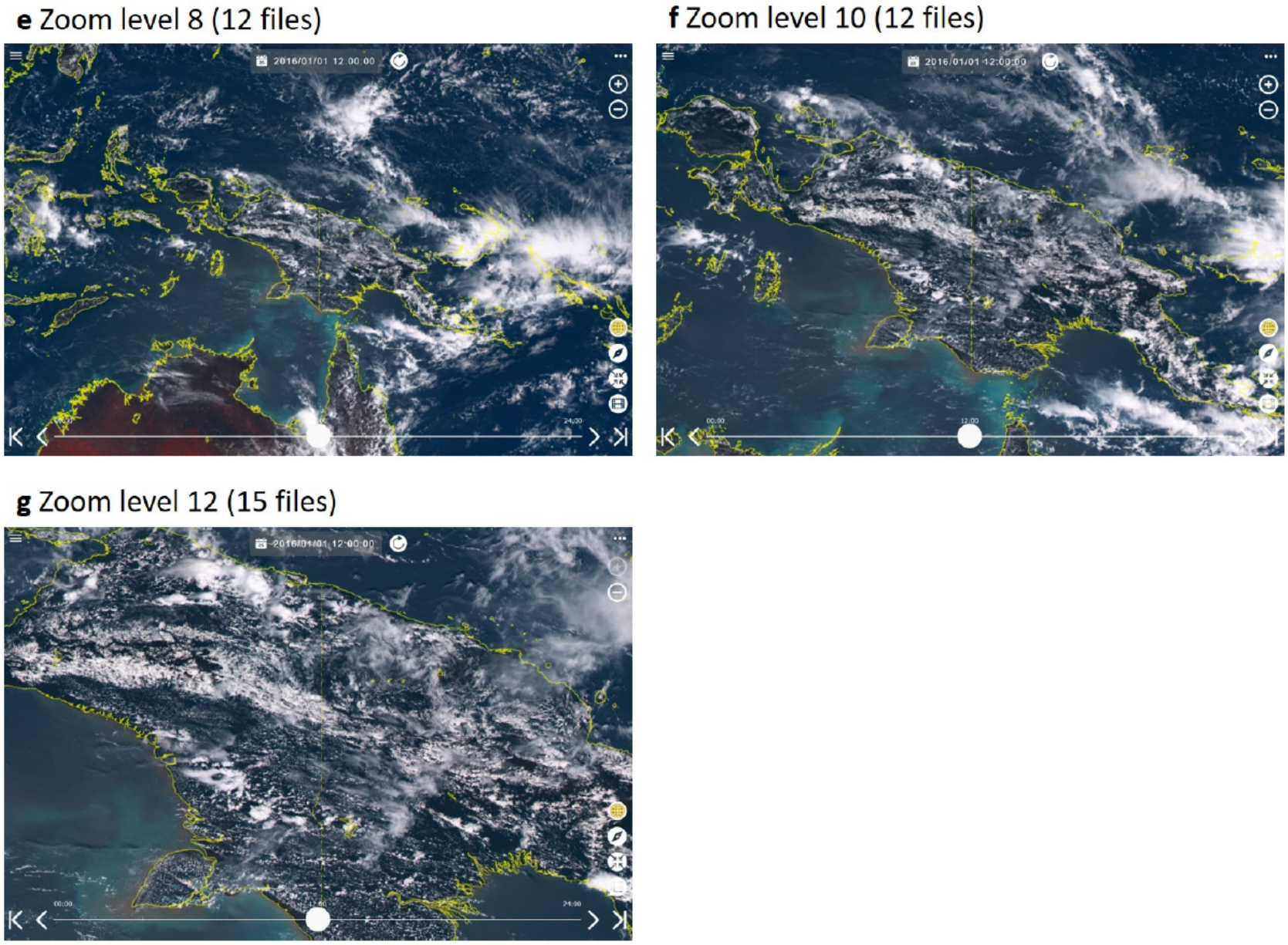
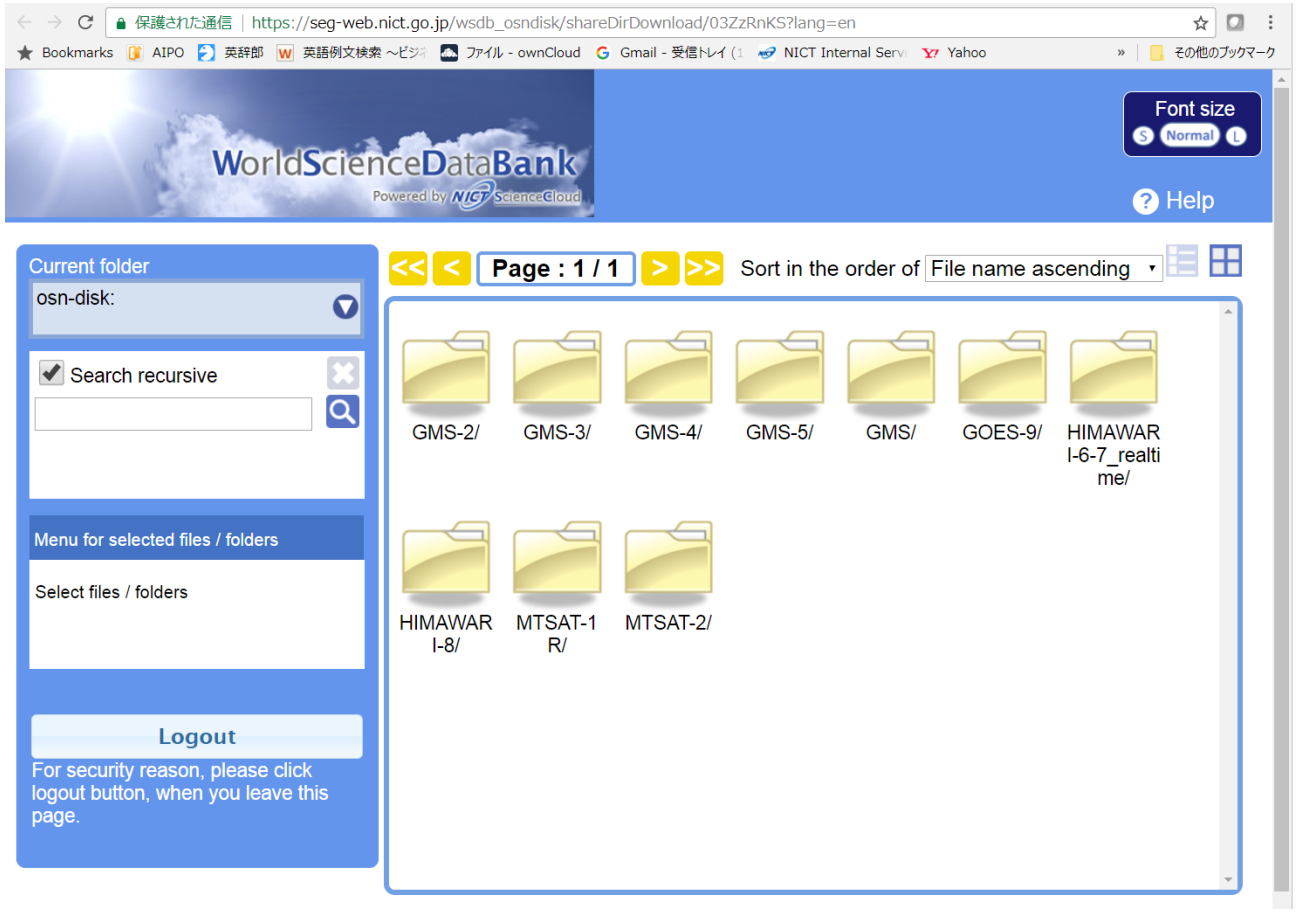


Fig. 8 Expansion of zoom level of Himawari-8 real-time web on PC: **a** 1, **b** 2, **c** 4, **d** 6, **e** 8, **f** 10, and **g** 12. The number of previewed pyramid tile image files are **a** 1, **b** 1, **c** 1, **d** 6, **e** 12, **f** 12, and **g** 15, respectively.

World Science Data Bank: WSDB(1)



https://seg-web.nict.go.jp/wsdb_osndisk/shareDirDownload/03ZzRnKS?lang=en

1byte = 8bit

NICT ScienceCloud

World Science Data Bank: WSDB(2)

Figure 4: Himawari data download web (WSDB): data file search between 0:00 and 0:15 on Jan 1 2016

1byte = 8bit

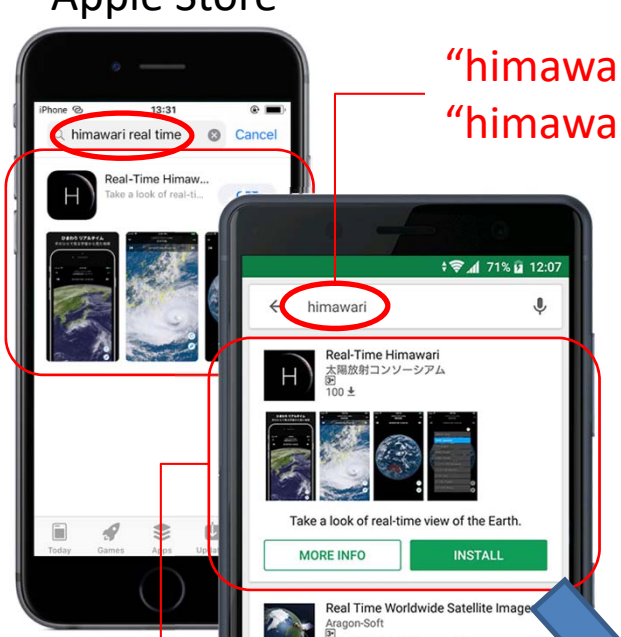
NICT ScienceCloud

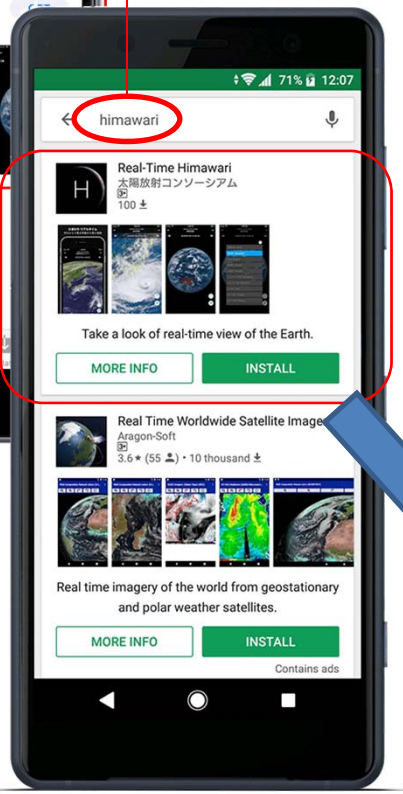
Smart Phone application (for citizens)

Free Download on Apple Store & Google Play

Apple Store

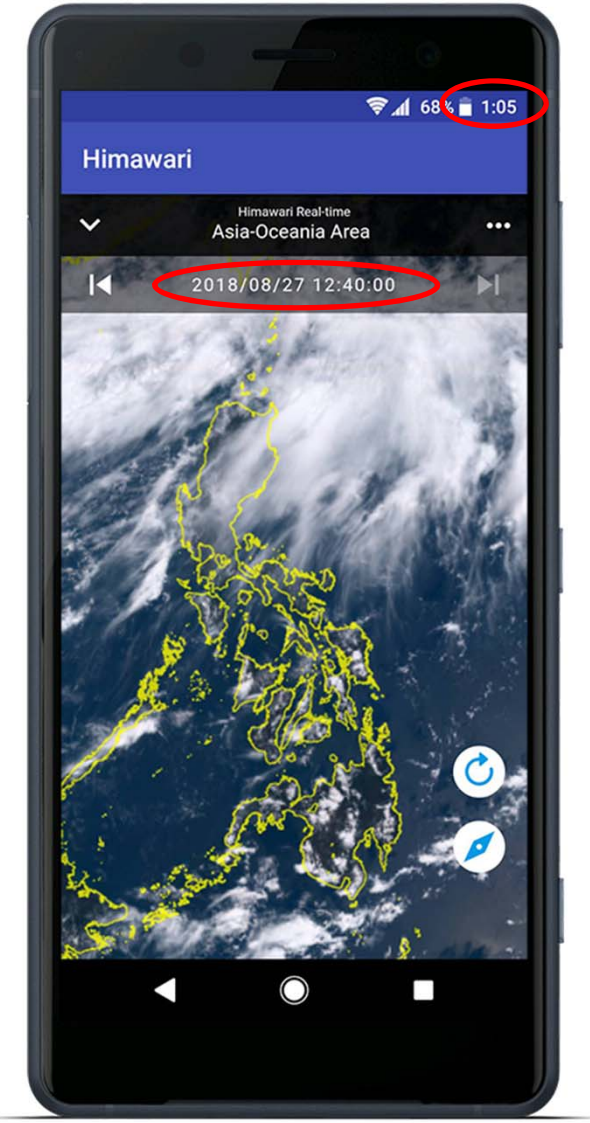
“himawari” or
“himawari real time”





Google Play

Smart Phone (Android8)



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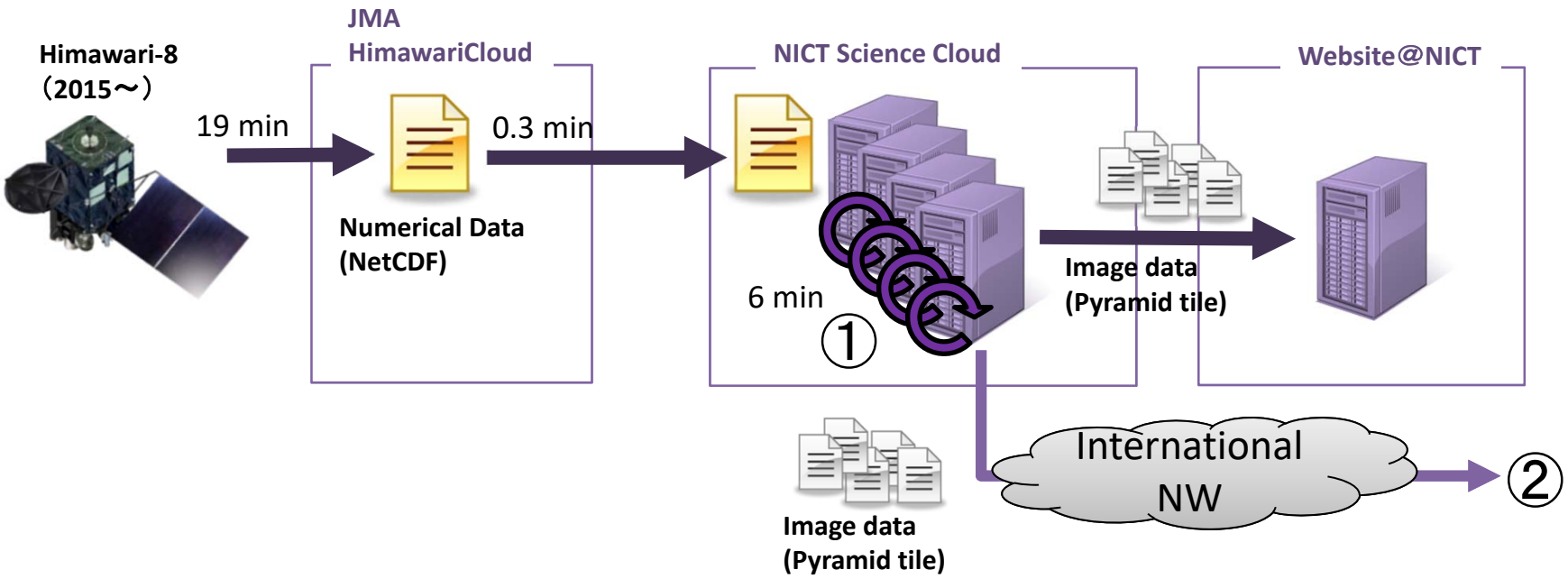
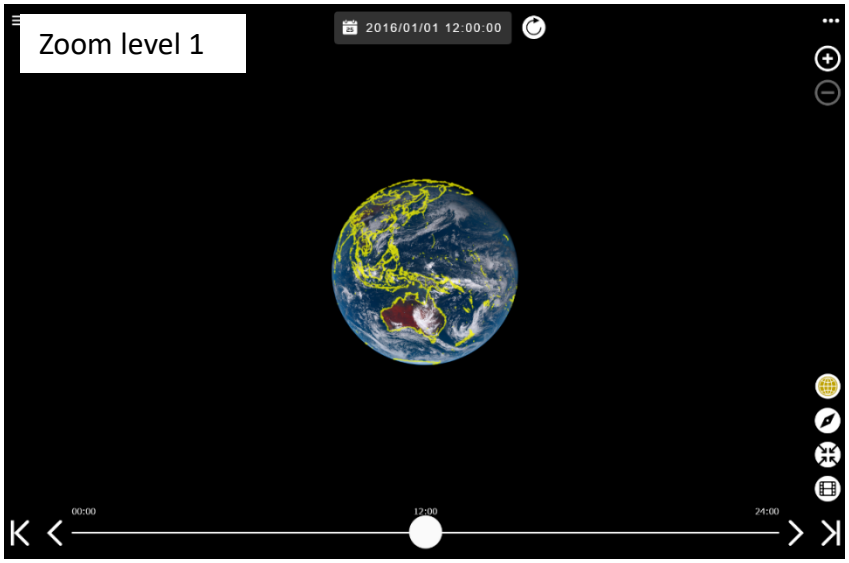
Major two techniques in Himawari-8 real-time web

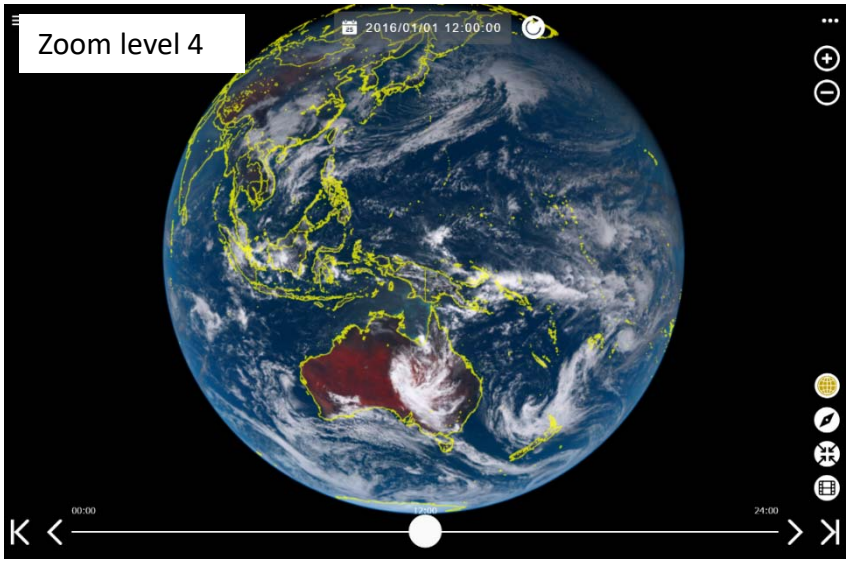


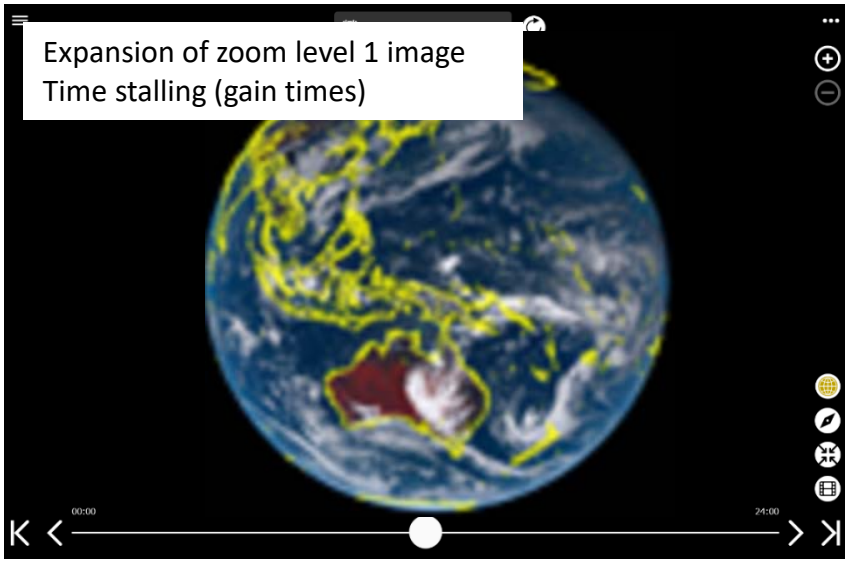
① Real-time pyramid tile image creation using parallel processing
- Gfarm/Pwrake (by Tsukbua Univ.) & concurrent processing
- Murata et al., Earth Science Informatics (2018)

② High-speed data transfer using HpFP protocol
- High-performance and Flexible protocol for Long-fat Network (LFN)
- Murata et al., IEEE international conference papers, 2016.

Himawari real-time Web
Process in zoom-in

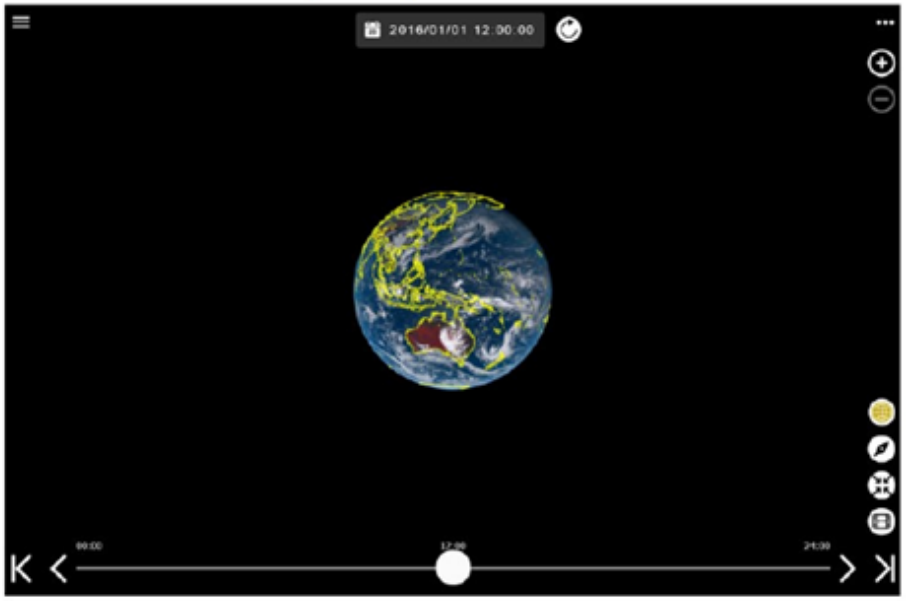




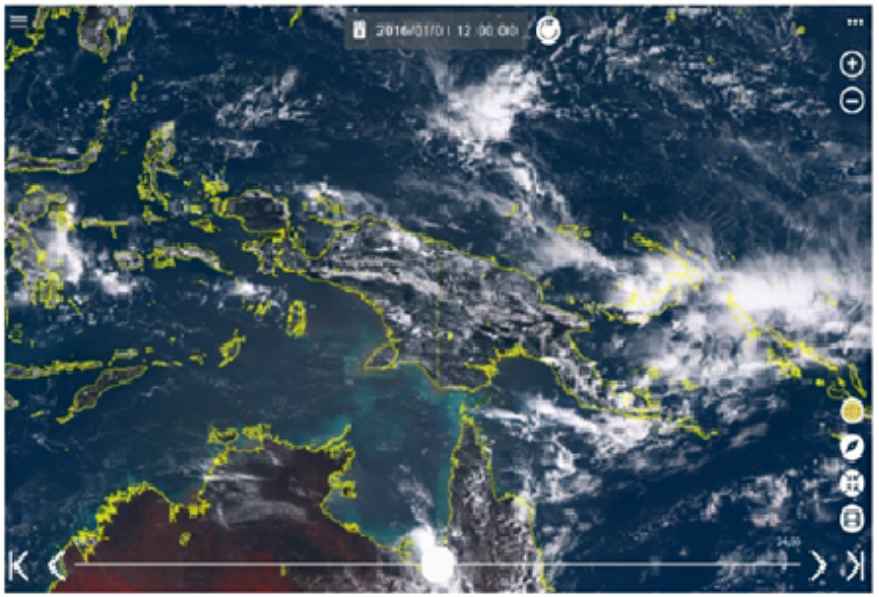


NICT ScienceCloud

a Zoom level 1 (1 file)

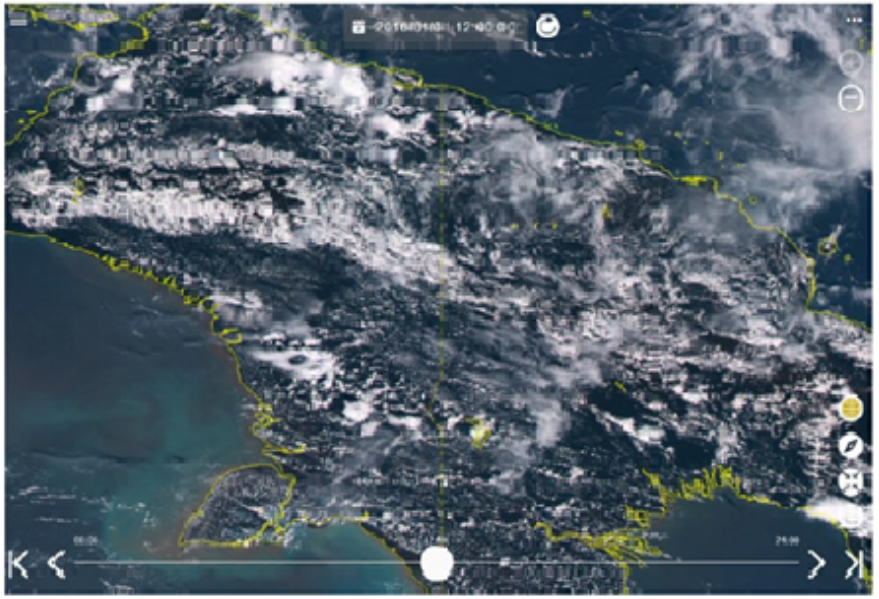


e Zoom level 8 (12 files)



c Zoom level 4 (1 files)

g Zoom level 12 (15 files)



Pyramid tile technique on Himawari-8 real-time web

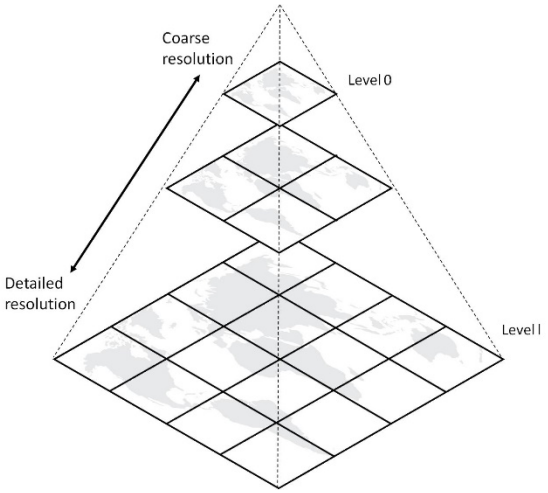
Table 7 Number of pyramid tile image files depending on zoom level for full disk (550 × 550 pixels)

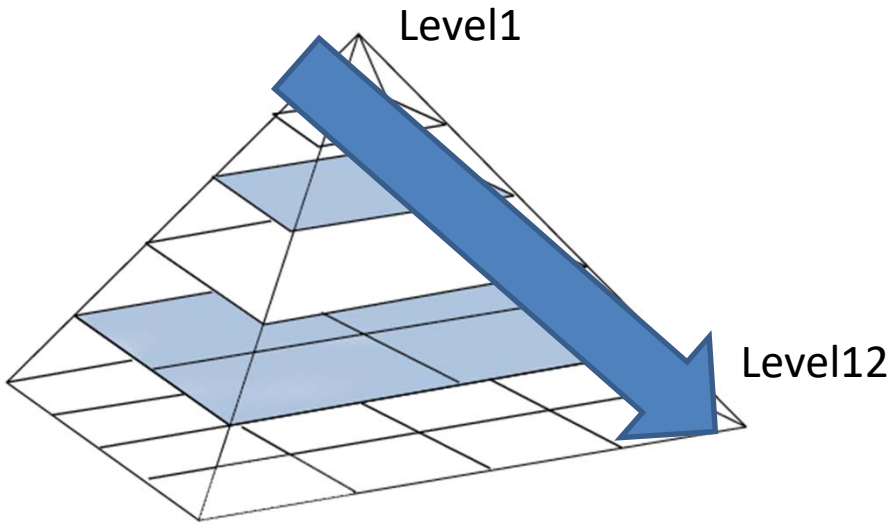
741 image files

Zoom level	1	2	3	4	5	6	7	8	9	10	11	12
Zoom ratio	0.5	0.7	1.0	1.4	1.0	1.4	1.0	1.4	1.0	1.4	1	1
Number of tile image files	1				4		16		64		256	400
Source image resolution (single tile image size)	550 × 550 pixels				1100 × 1100 pixels		2200 × 2200 pixels		4400 × 4400 pixels		8800 × 8800 pixels	11000 × 11000 pixels
File size (averaged over a day)	0.5 MB				1.8 MB		6.8 MB		24 MB		90 MB	150 MB

Table 8 Number of pyramid tile image files depending on zoom level for Japan Area (600 × 480 pixels)

Zoom level	1	2	3	4	5	6	7	8	9	10	11
Zoom ratio	0.5	0.7	1.0	1.4	1.0	1.4	1.0	1.2	2.0	2.8	4.0
Number of tile image files	1				4		16	25			
Source image resolution (single tile image size)	600 × 480 pixels				1200 × 960 pixels		2400 × 1920 pixels	3000 × 2400 pixels			
File size (averaged over a day)	0.5 MB				1.7 MB		6.2 MB	9.6 MB			





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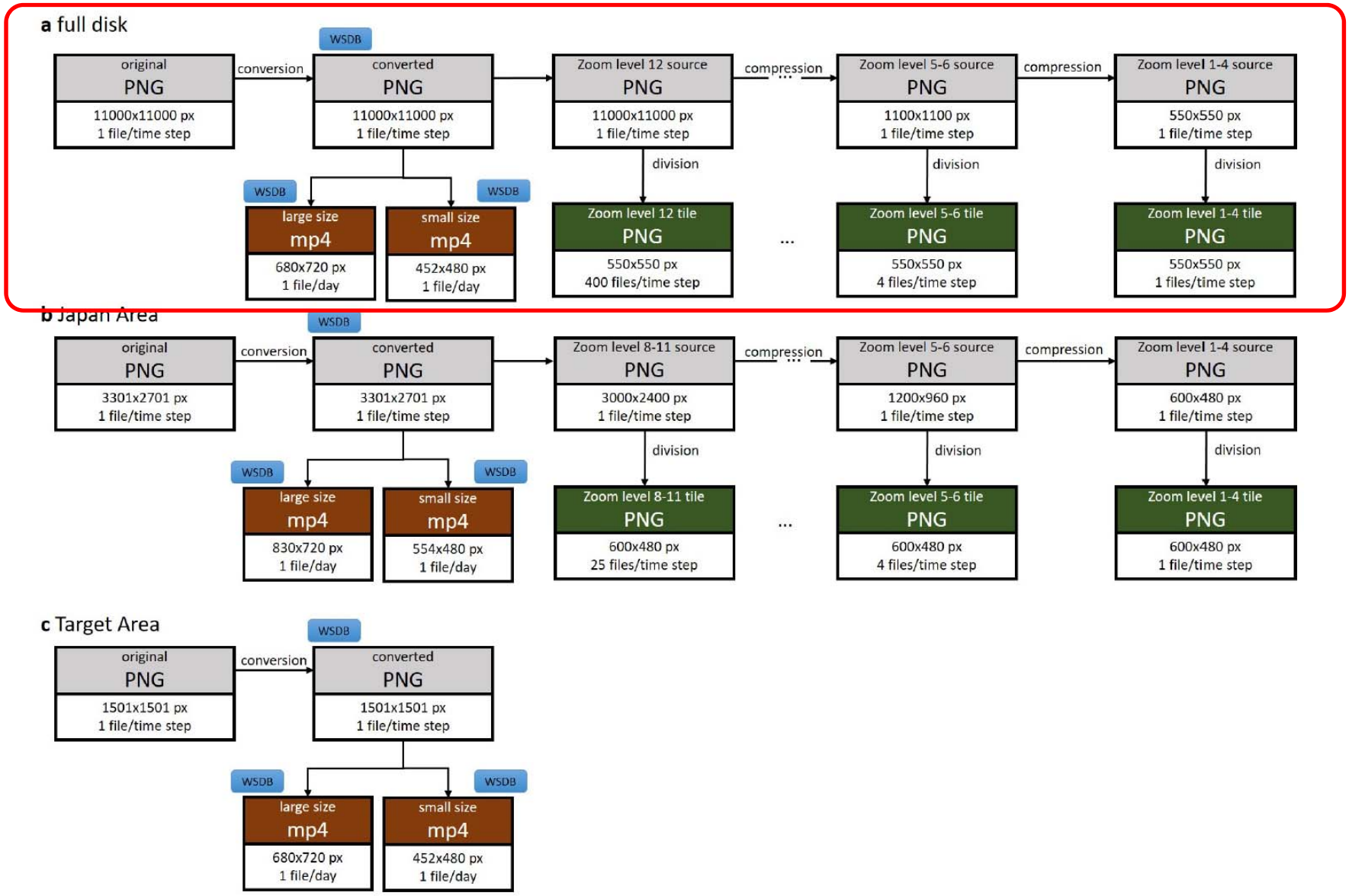
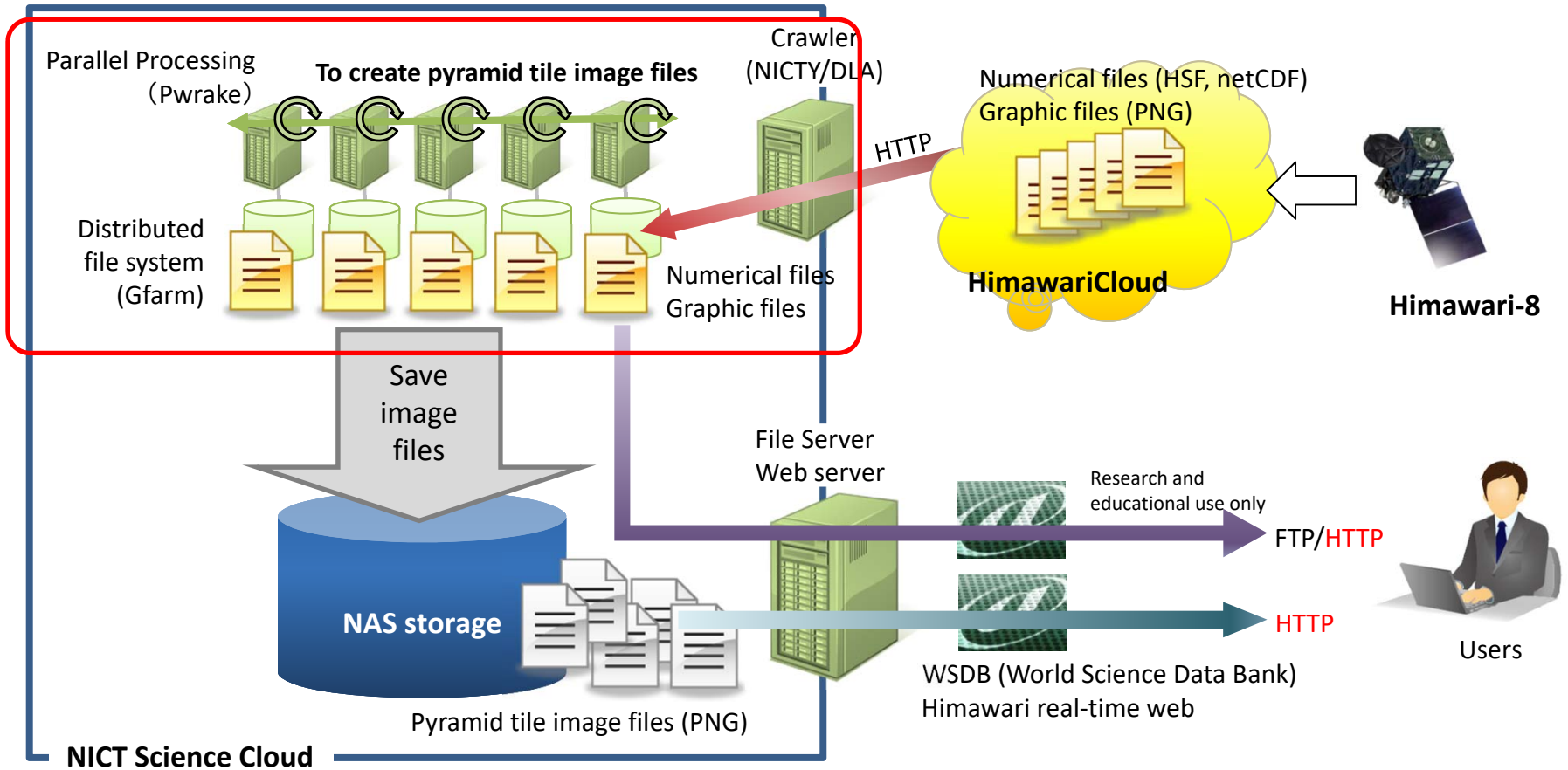
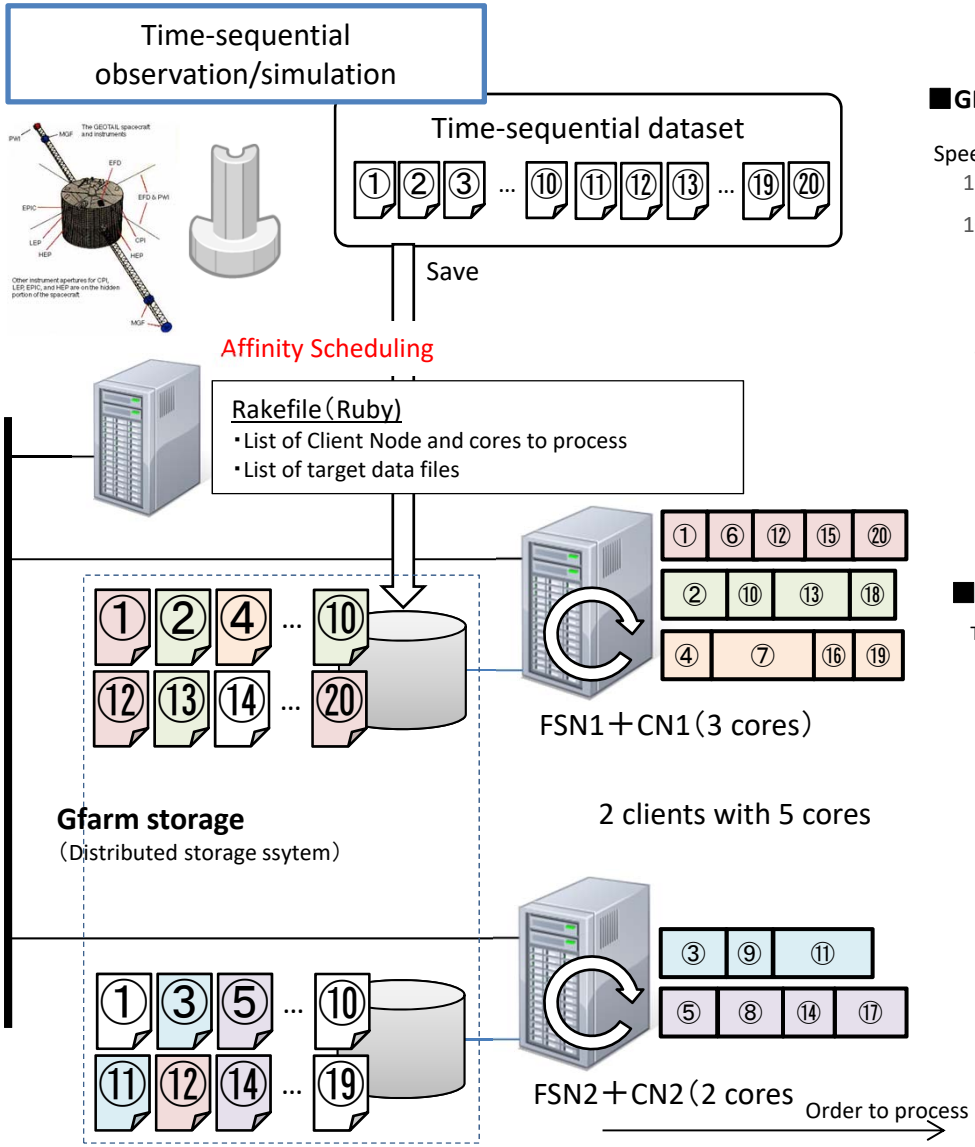


Fig. 6 Flow diagram of creation of pyramid tile image files and movie files. WSDB represents the files are downloadable on the WSDBank.

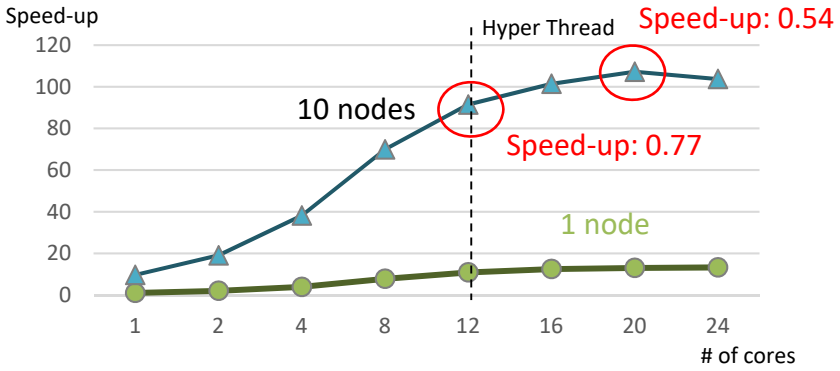
Data flow from JMA and processing on NICT Science Cloud



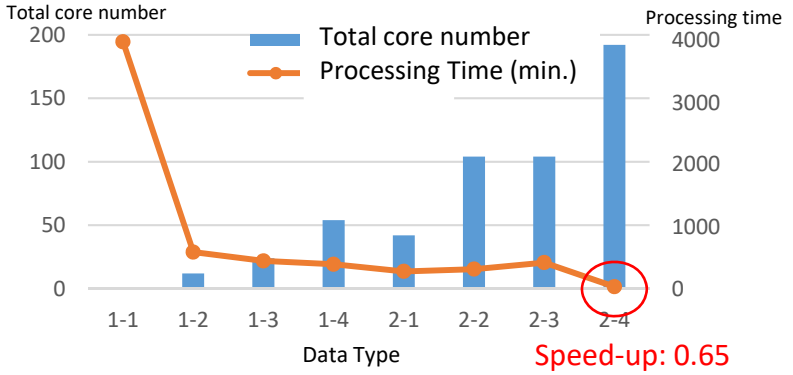
Parallel Processing via Gfarm/Pwrake



■GEOTAIL satellite data (190GB、file number27576）



■Global MHD simulation（2.3TB、file number 1000）



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Data formats of Himawari-8

Table 5 Number of bands and spatial resolution of each data format

Format	Number of bands	Spatial resolution (nadir point)
HSF*	16 bands (visible Band 1-3, near infrared Band 4-6, infrared Band 11-16)	Band 3 : 0.5 km; Band 1, 2, 4 : 1 km; Band 5-16 : 2 km
NetCDF		
PNG	1 (color graphic file made from 3 visible bands)	1 km

* Himawari standard format

Three types

Table 6 Data file size and number provided by Himawari-8 real-time web: HR and LR represent high resolution and low resolution, respectively

File	Area	Source	Time interval to update (min)	Total size/time step (MB)#	Size/day (MB)	Number of files (files/day)
Pyramid tile image file	full disk	Graphic file (PNG)	10	370	53,352	106,704
	Japan Area		2.5	27	15,840	31,680
	Target Area		-	-	-	-
	16 bands (full disk)	Numerical file (HSF)*	10	59	8,524	426,240
Movie file	full disk	Graphic file (PNG)	10	-	4 (HR)/2 (LR)	2 (with and without coast lines)
	Japan Area		2.5	-	17 (HR)/8.5 (LR)	2 (with and without coast lines)
	Target Area		10	-	7 (HR)/3.5 (LR)	1

* Himawari standard format
\# Estimated around the noon (maximum size in a day)

53.4GB/day
(370MB/step)

NICT ScienceCloud

Concurrent processing

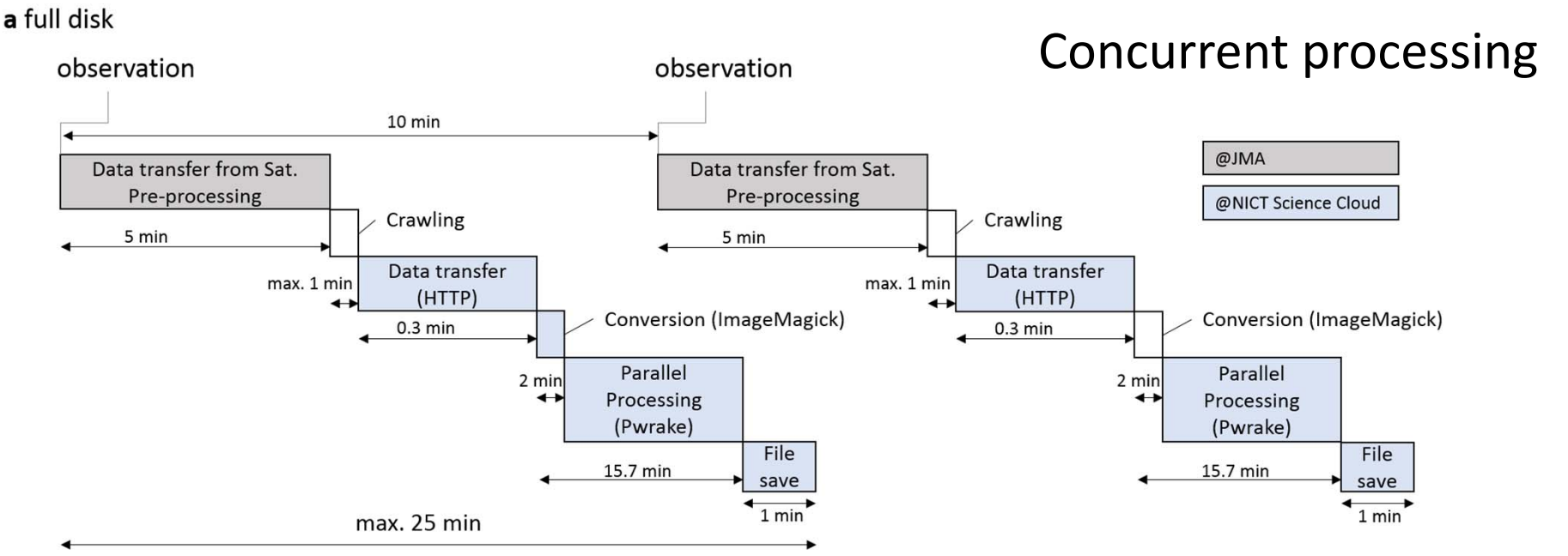
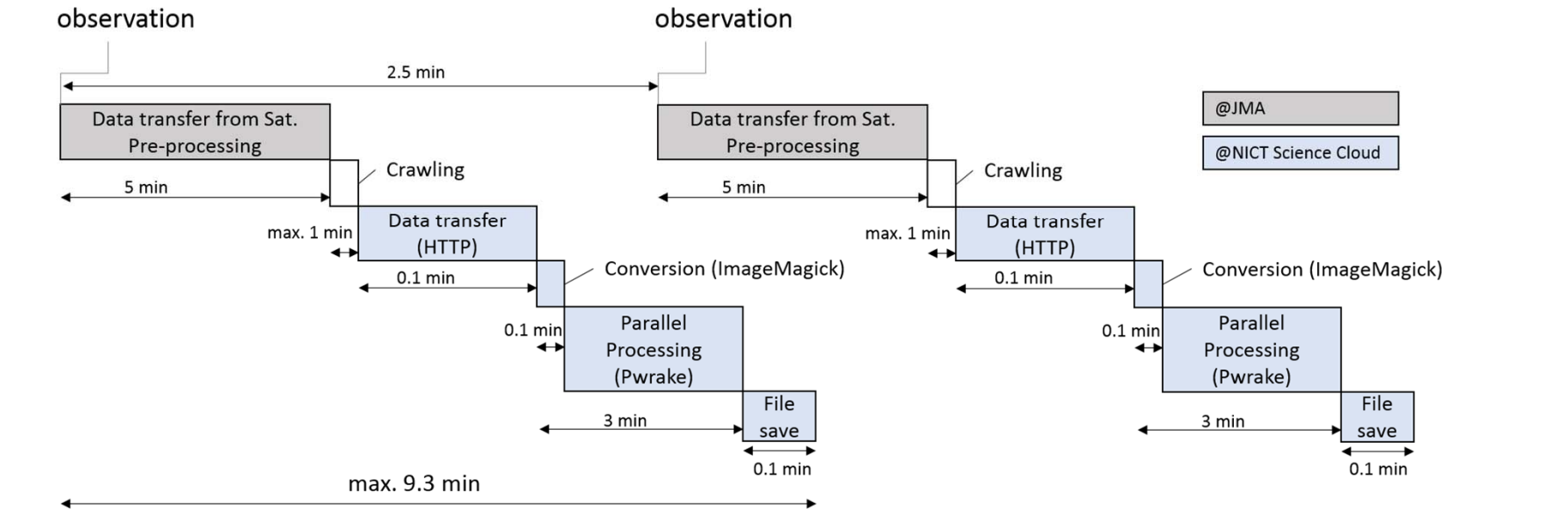


Fig. 10 Concurrent processes of Himawari-8 satellite image data and time interval of data flow of **a** full disk and **b** Japan Area.



NICT ScienceCloud

Concurrent processing

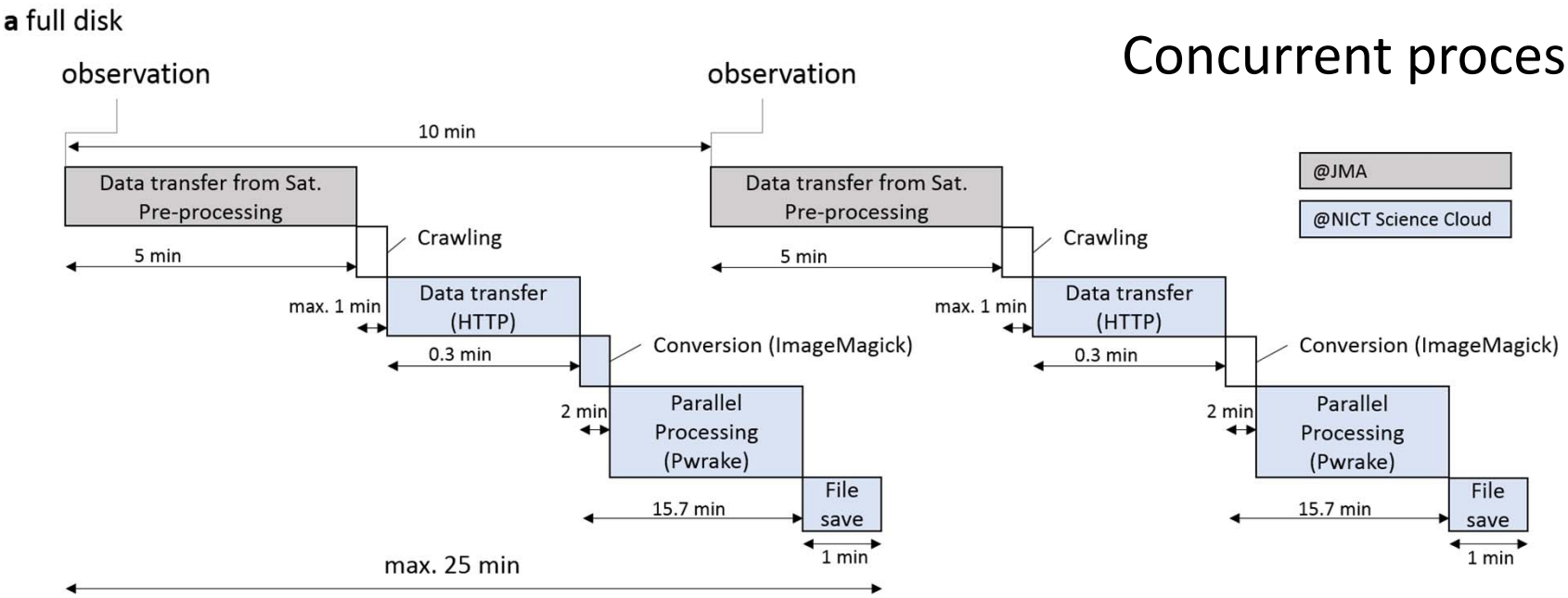


Fig. 10 Concurrent processes of Himawari-8 satellite image data and time interval of data flow of **a** full disk and **b** Japan Area.

Table 9 Required specification for real-time concurrent operation via Pwrake

	Japan Area	full disk
Latency (after observation)	$\leq$ 9.3 min	$\leq$ 25 min
Number of servers	4	4
Number of total cores	13	13
Parallel processing time	2.9 min	13.7 min
Number of original (input) data files/time step	1 file	1 file
Number of created (output) image files/time step	55 files	741 files
Required I/O speed	0.2 file/s (0.1 MB/s)	0.6 file/s (0.3 MB/s)

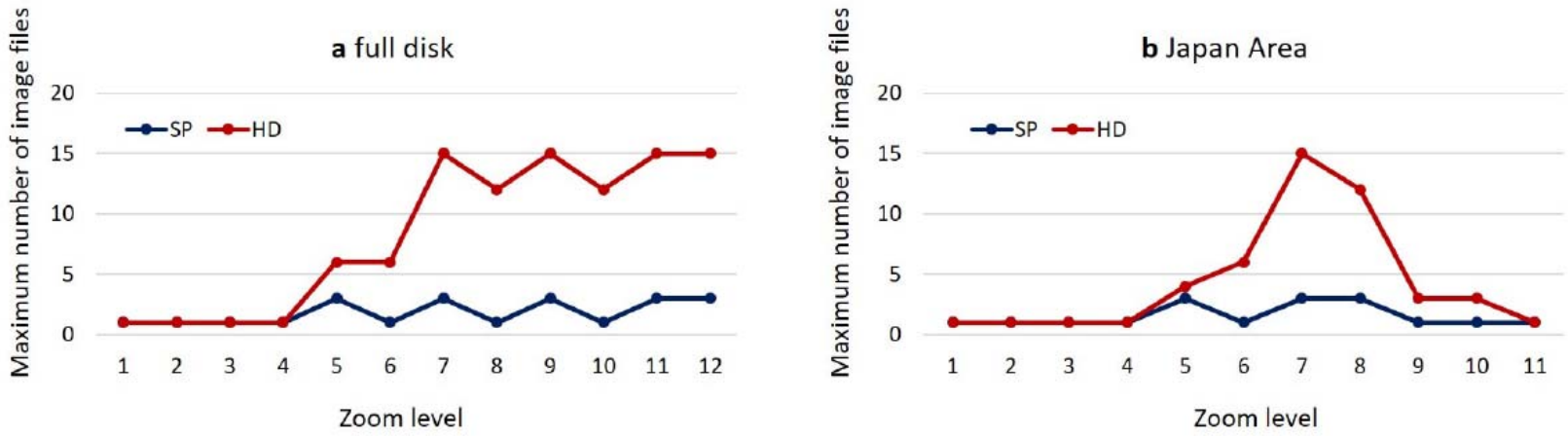


Fig. 9 Maximum numbers of previewed full disk and Japan Area image files: SP and HD are for smartphone and high-definition display, respectively. The resolution of SP is 375 × 667 pixels that is currently most popular size.

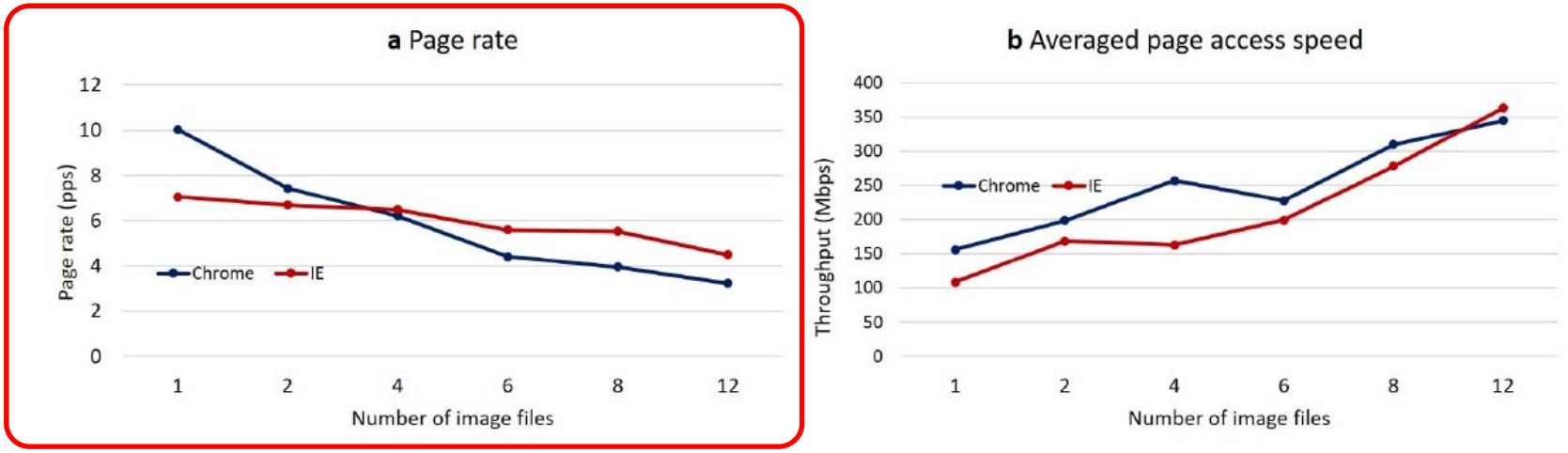


Fig. 15 Dependence of image preview speeds on the number of image files to preview full disk images on Himawari-8 real-time web in laboratory experiments: **a** page rate and **b** throughput or averaged page access speed.

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- Introduction and experience of “Himawari real-time”
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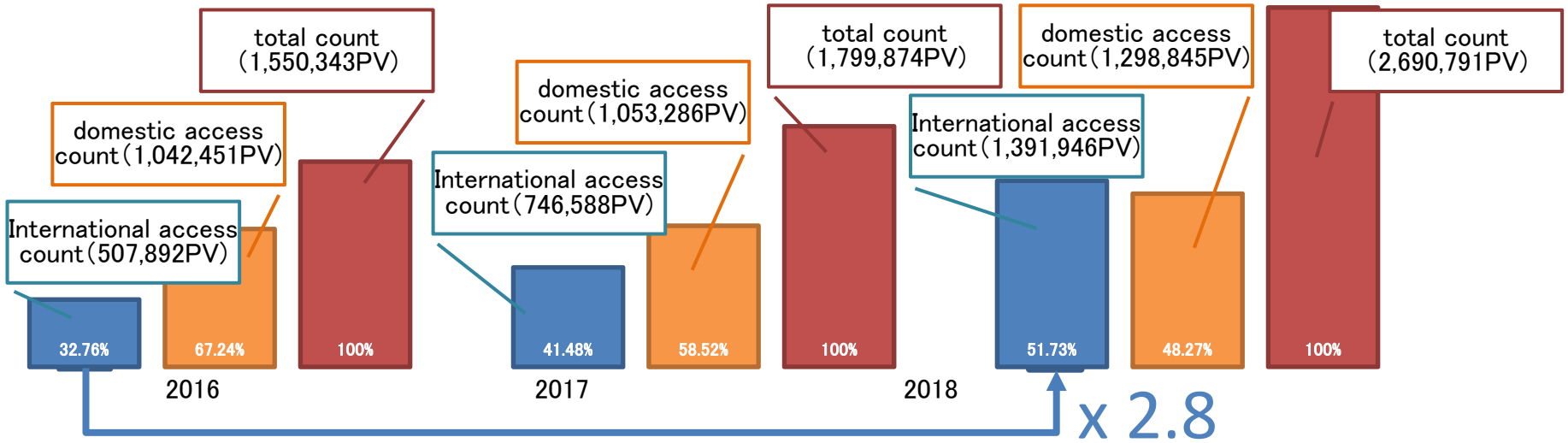
Himawari real-time web

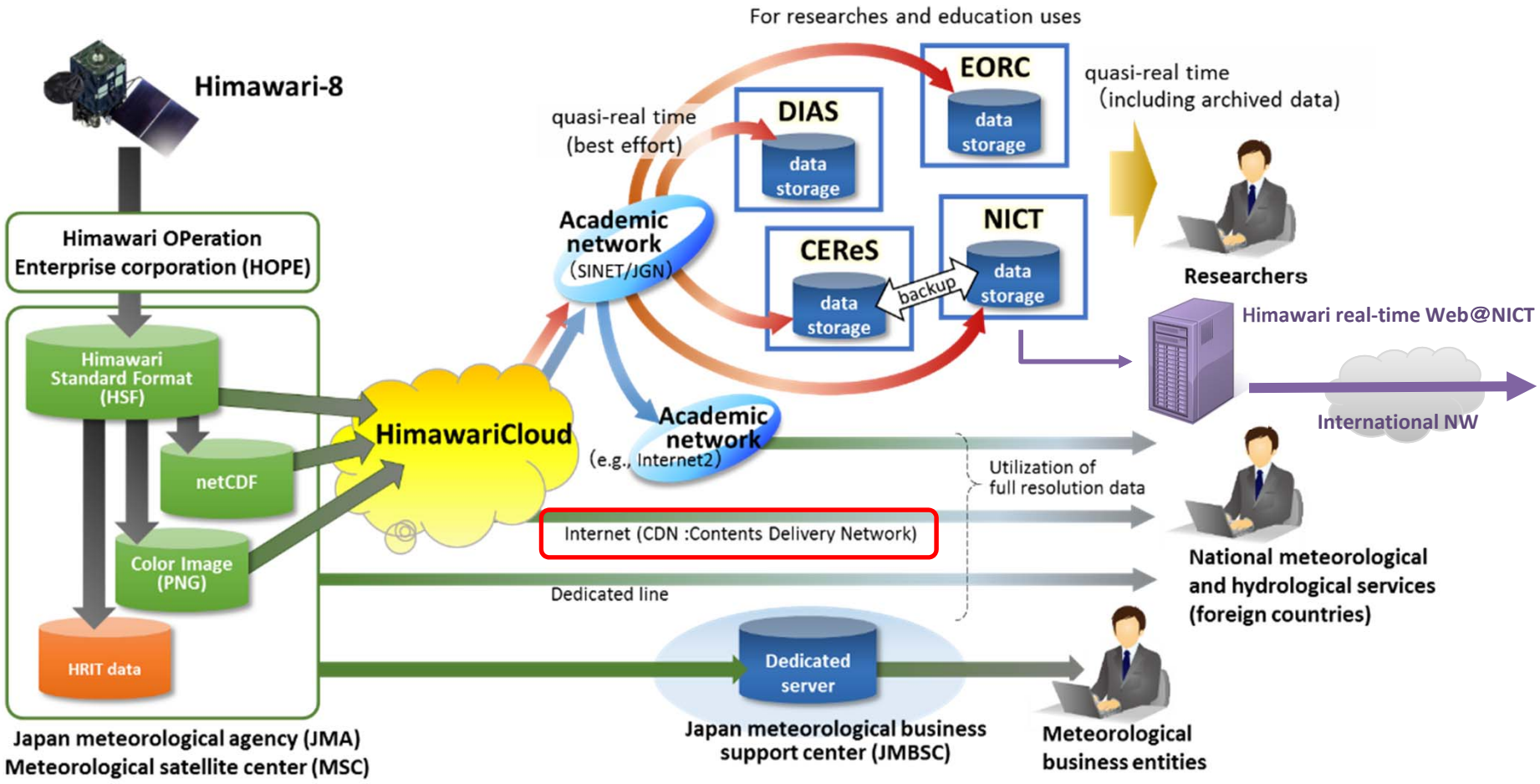
■ Access count (page view)



Total Page View (PV): from Jan to Sep in 2017 (1.3 millions) and 2018 (2.1 millions)

NICT ScienceCloud

Himawari data flow from JMA

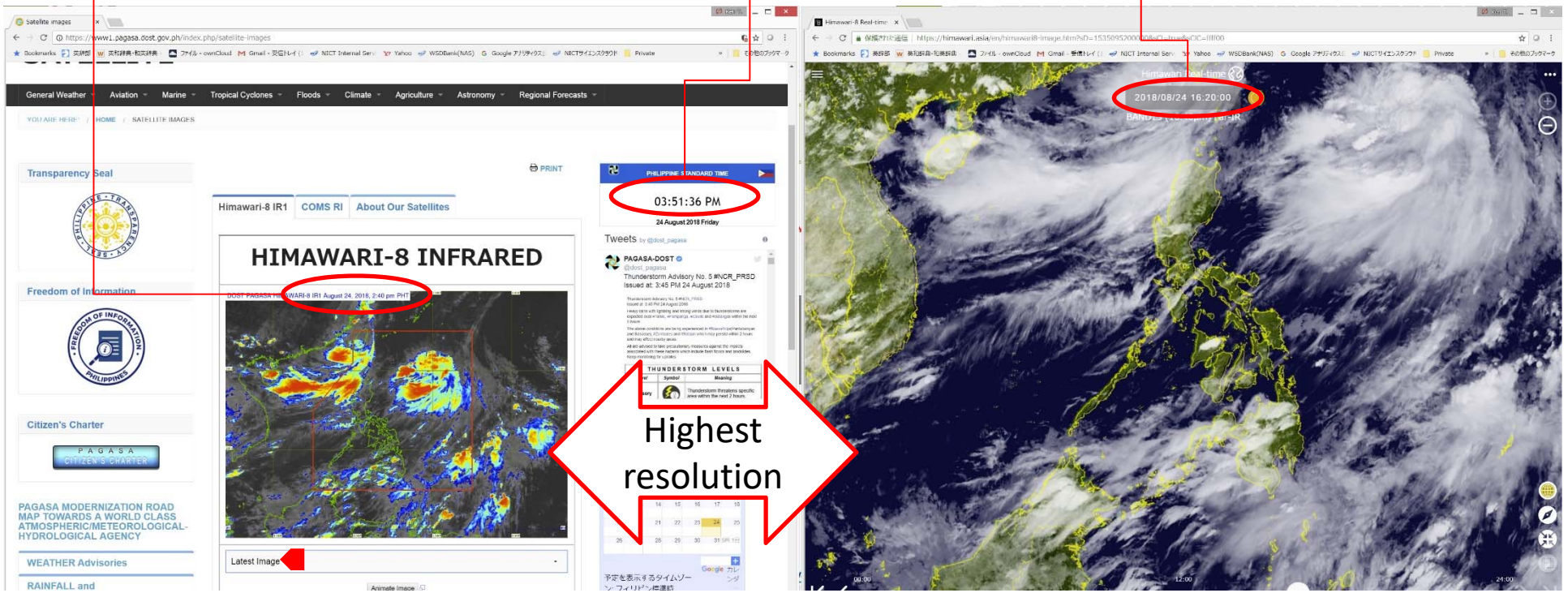


Comparison: PAGASA (meteorology agency) and NICT (Himawari real-time web)

02:40 PM in PST
(-71 minutes)

@03:51 PM in PST

03:20 PM in PST
(-31 minutes)



PAGASA (Philippines)
https://www1.pagasa.dost.gov.ph/index.php/satellite-images

NICT (Japan)
http://himawari.asia (http://himawari8.nict.go.jp)

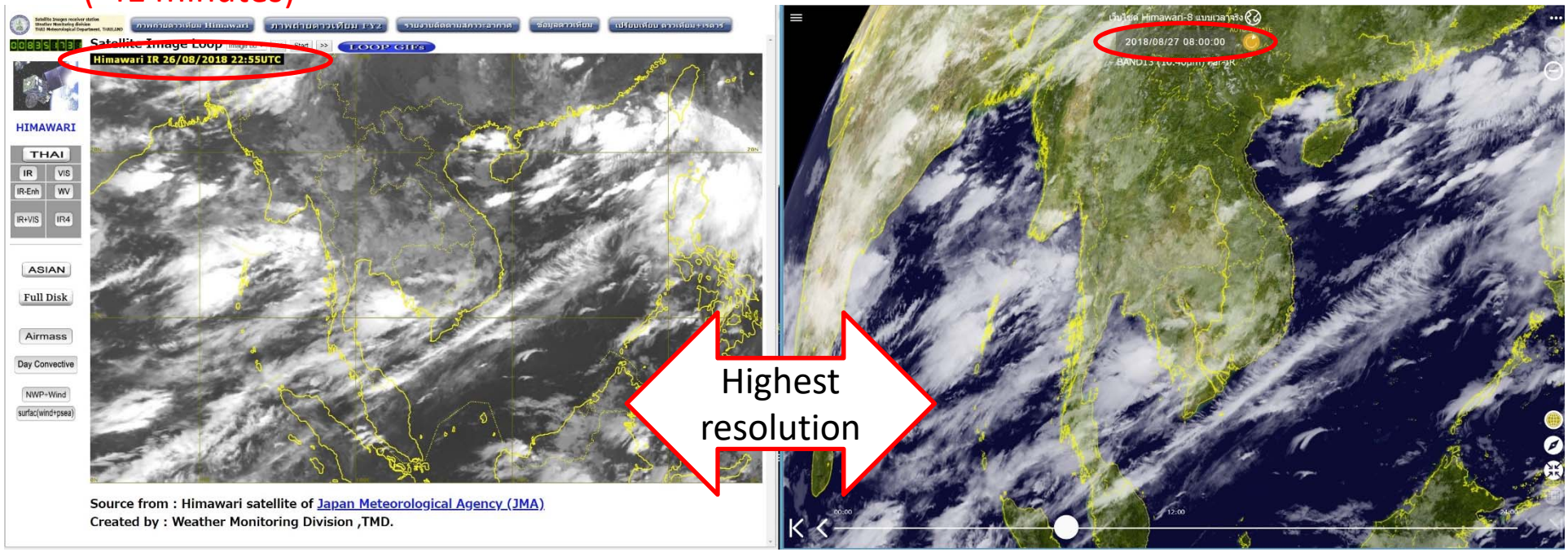
NICT ScienceCloud

Comparison: TMD and mirroring@NECTEC

22:55 in UTC
(-41 minutes)

@23:36 in UTC

23:00 in UTC
(-36 minutes)



Thai Meteorological Department (Thailand)
http://www.sattmet.tmd.go.th/satmet/mergesat.html

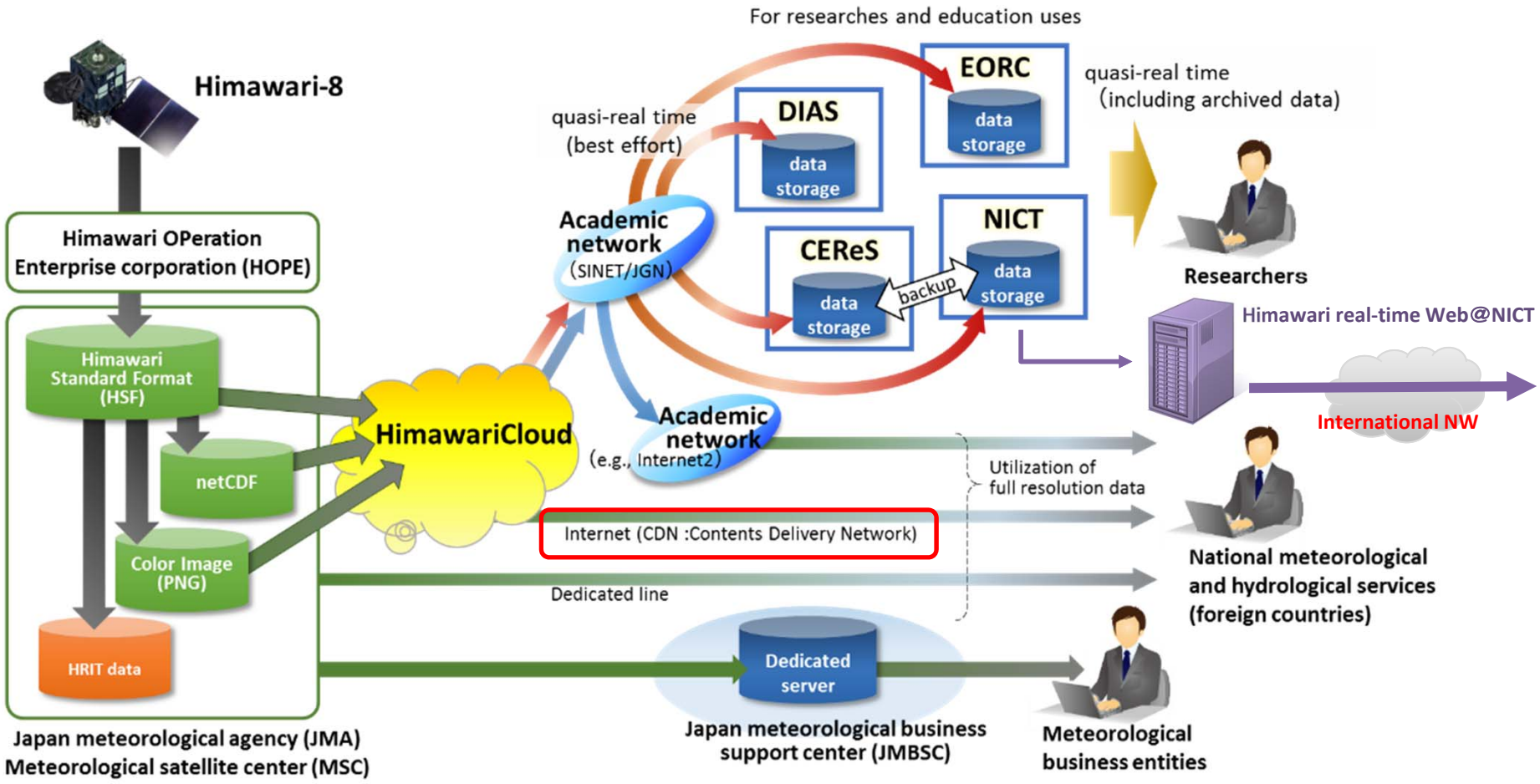
This area only

NECTEC mirror site (Thailand)
http://himawari.ino.nectec.or.th/th/himawari8-image.htm

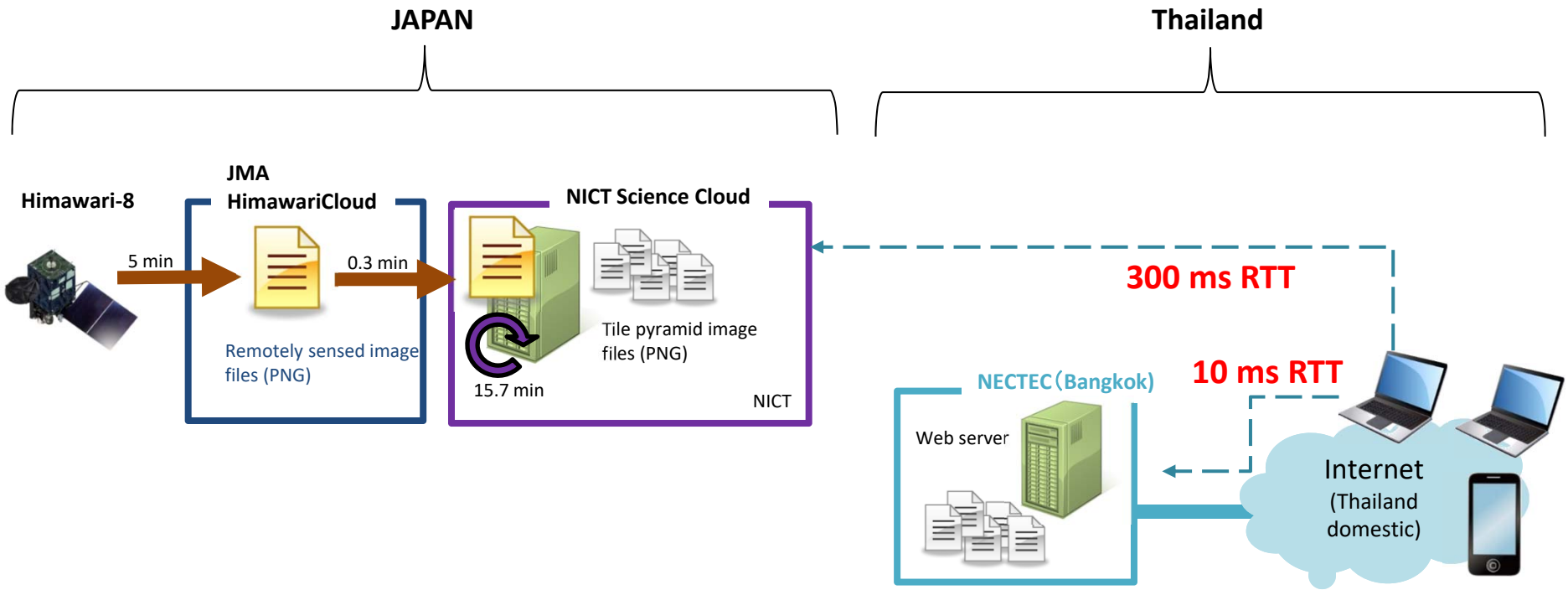
Expandable to full disk (global)

NICT ScienceCloud

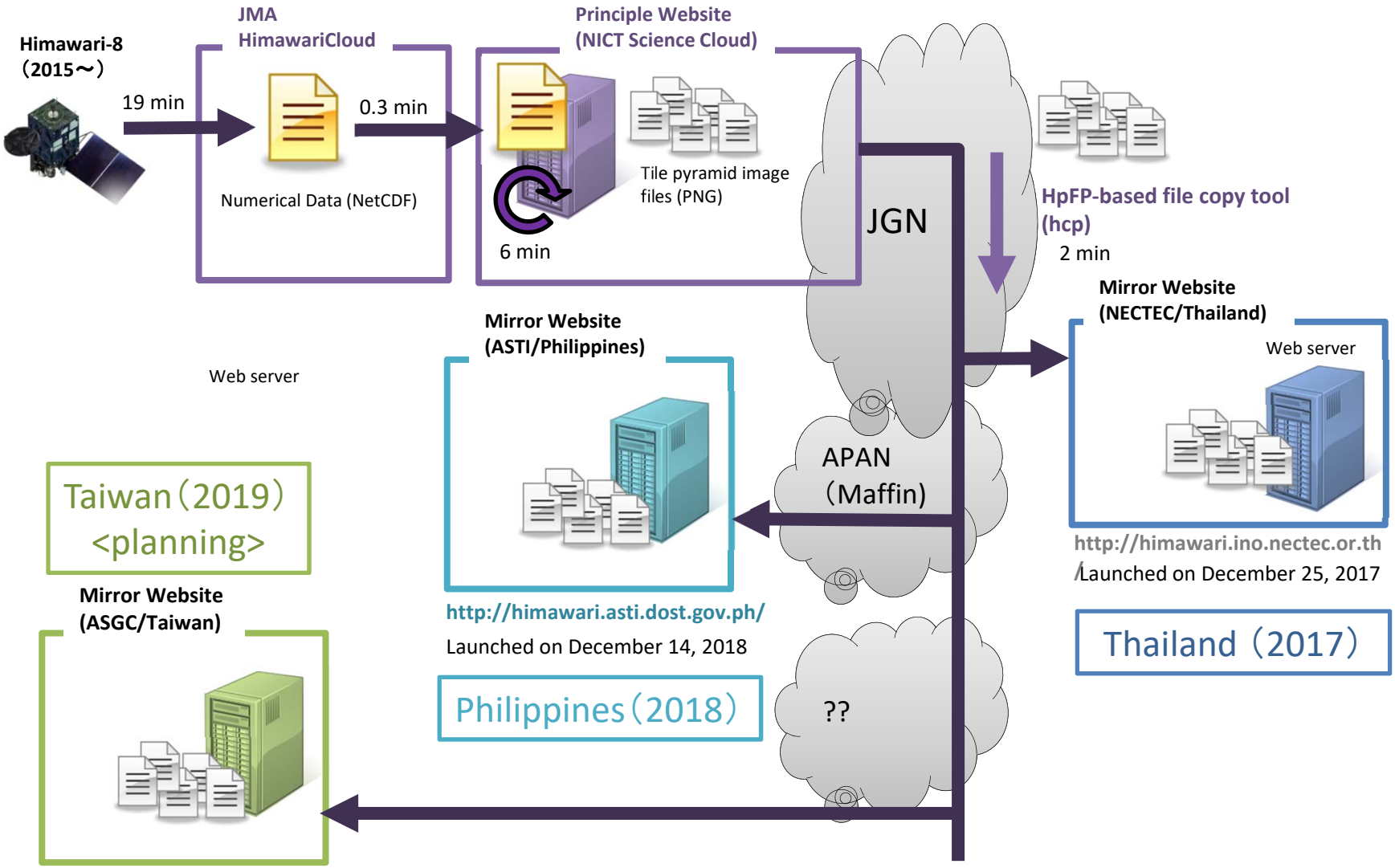
Himawari data flow from JMA



Remote (international) access and local (domestic) access to Himawari web in Thiland



Mirroring of “Himawari” images to Asian countries

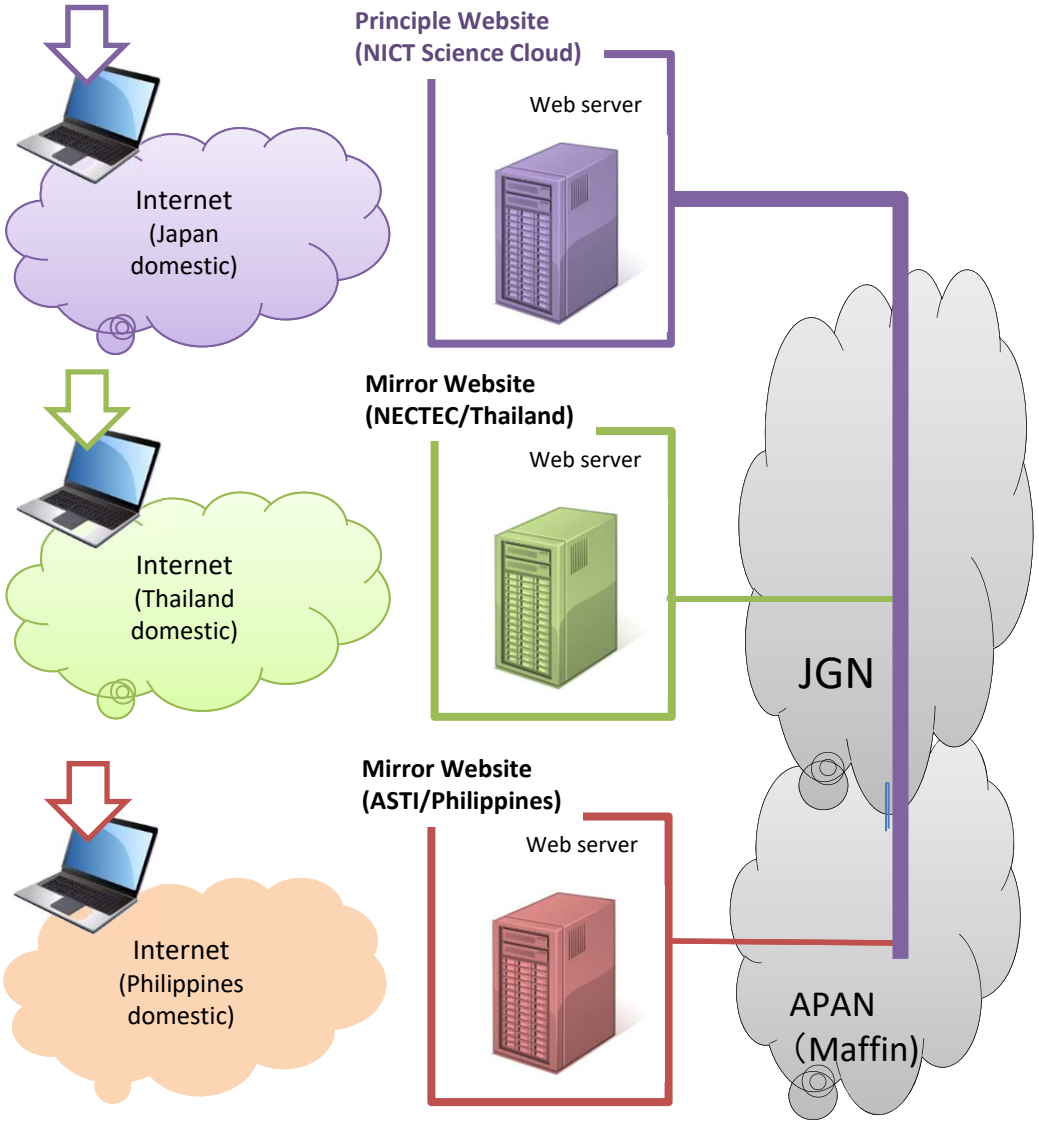


Access Speed

Web server	Access speed(s)
NICT	1.45
NECTEC	7.51
ASTI	2.77

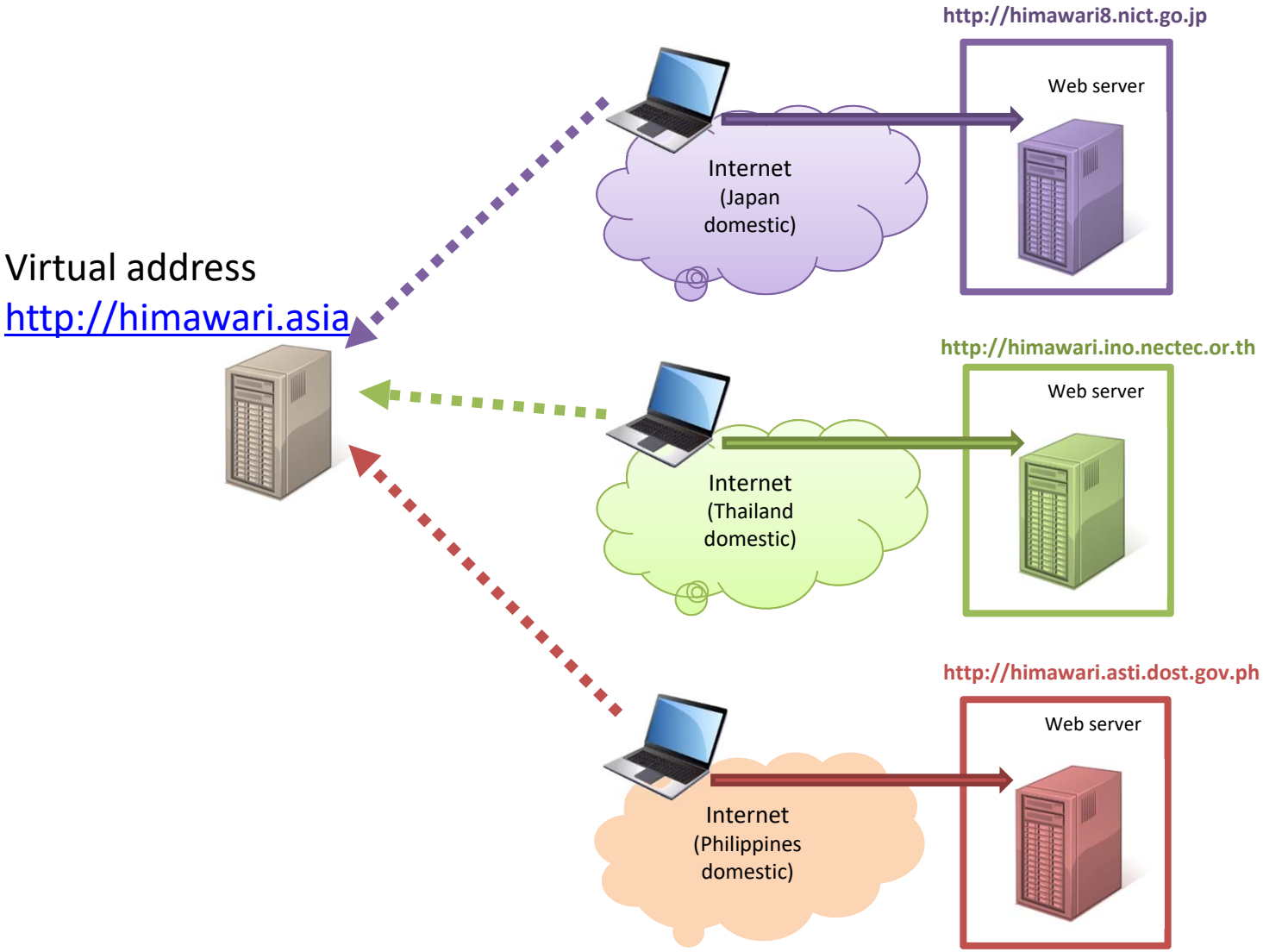
Web server	Access speed(s)
NICT	6.37
NECTEC	2.05
ASTI	4.68

Web server	Access speed(s)
NICT	3.53
NECTEC	5.54
ASTI	1.79



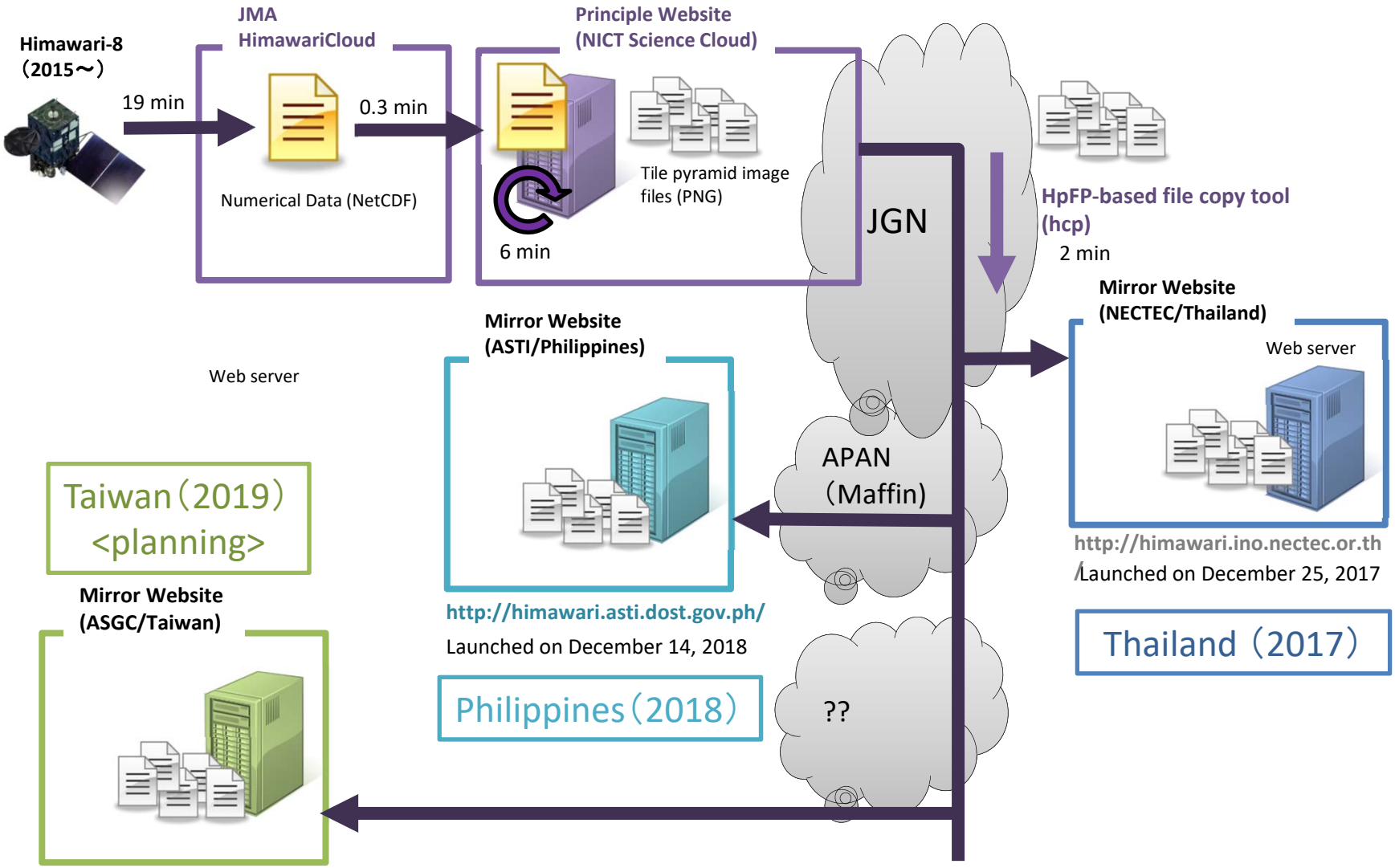
NICT ScienceCloud

Virtual address (https://Himawari.asia)

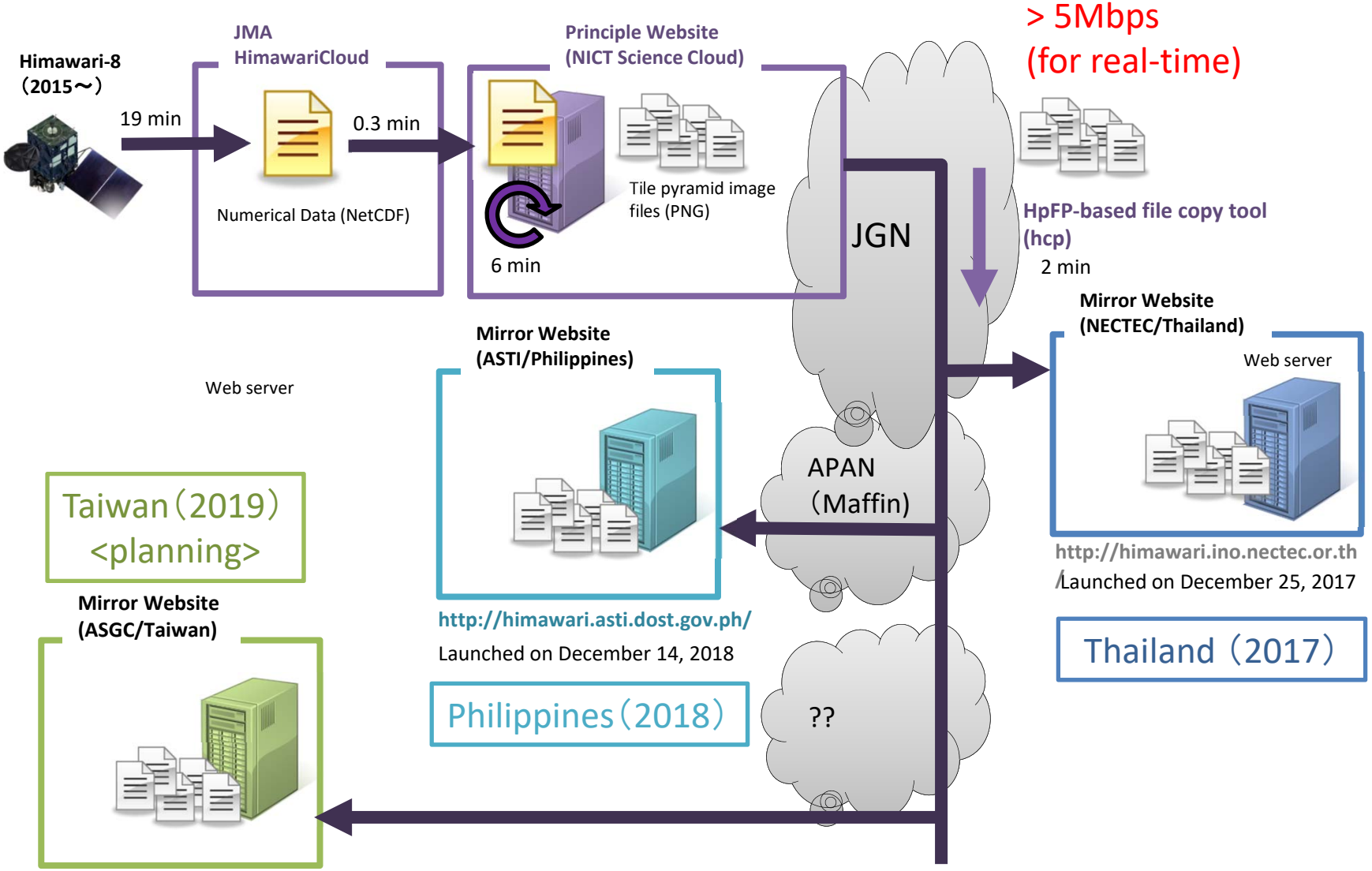


NICT ScienceCloud

Mirroring of “Himawari” images to Asian countries

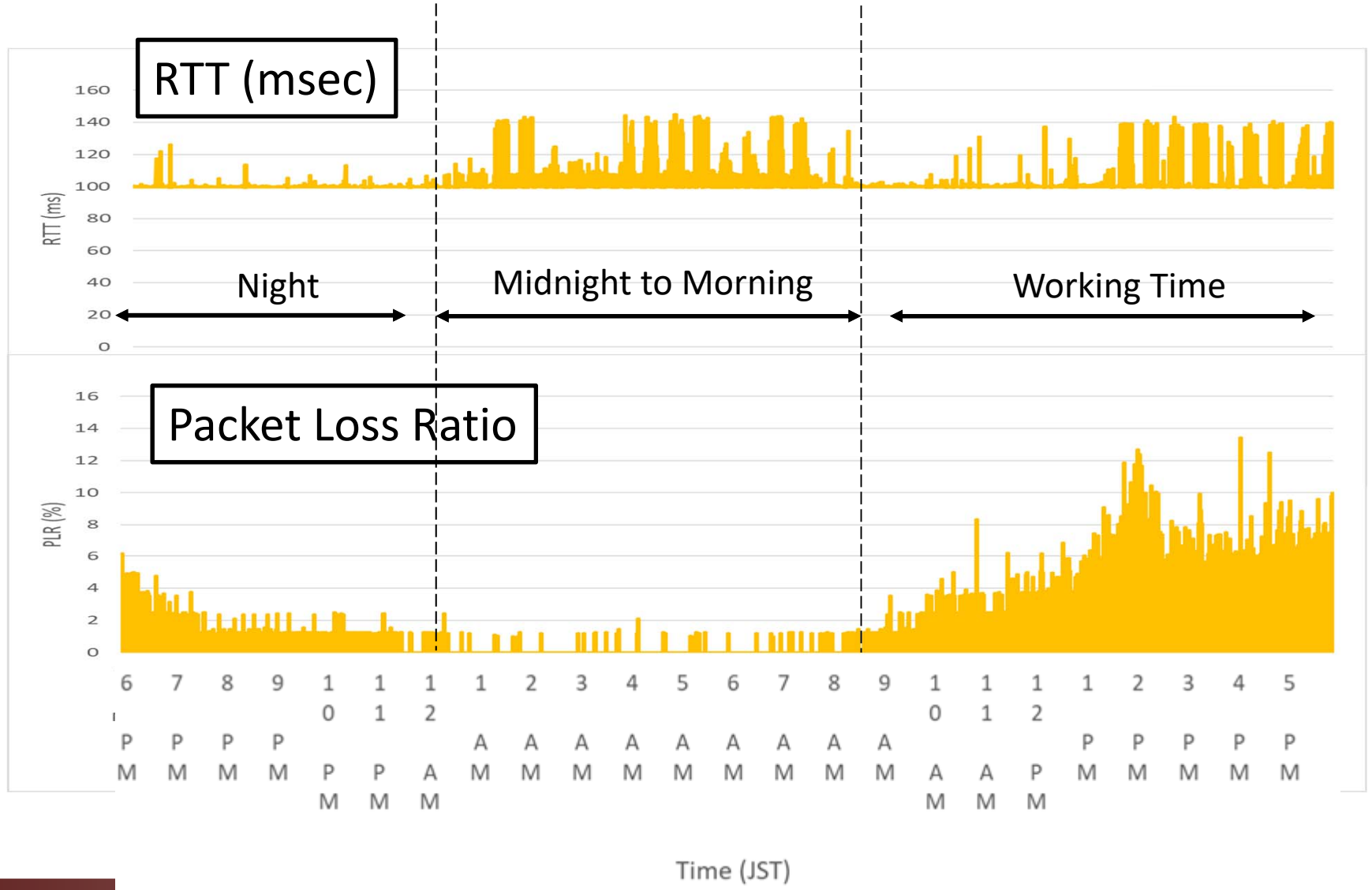


Mirroring of “Himawari” images to Asian countries



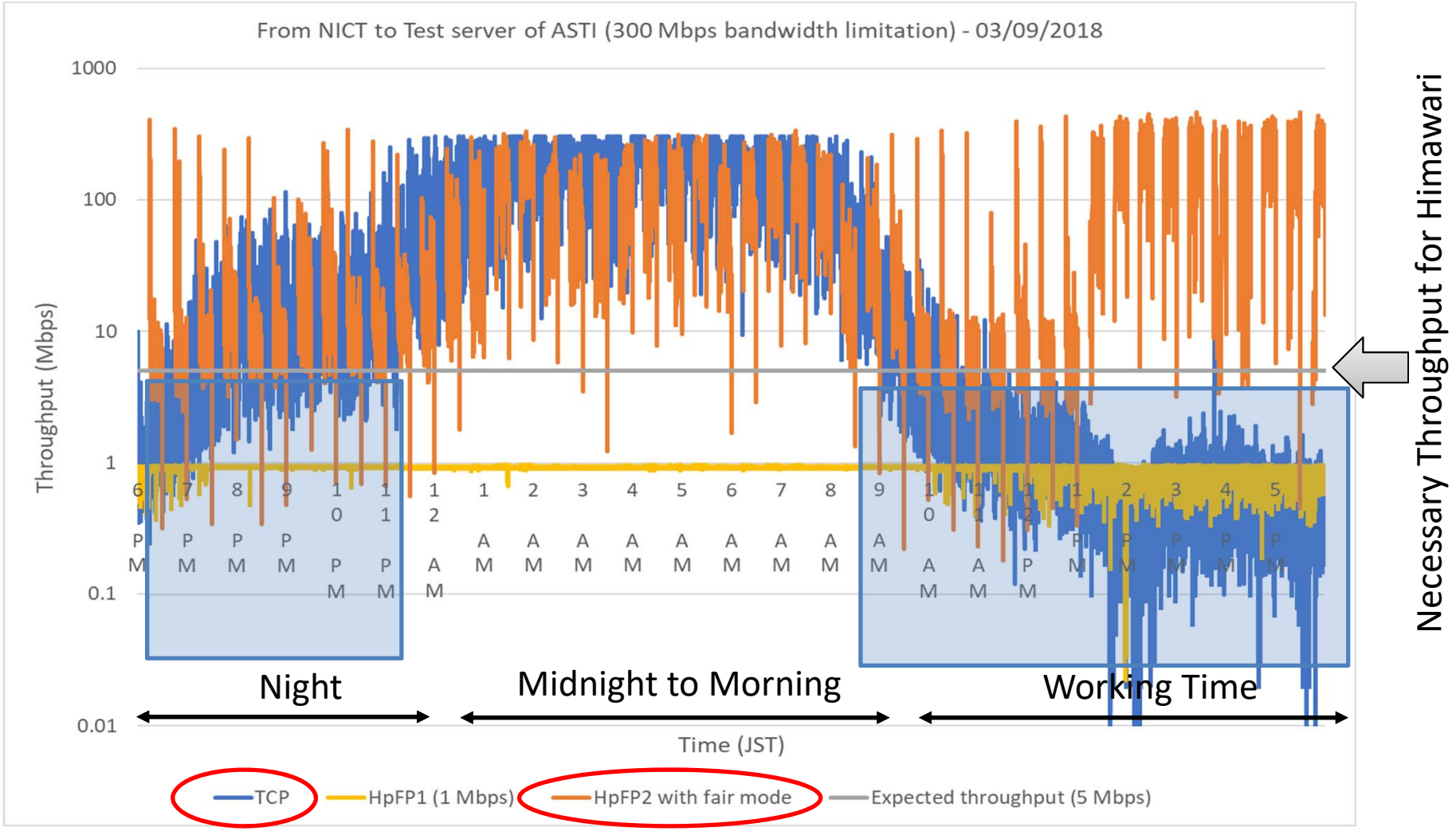
RTT (latency) and Packet Loss Ration

NICT (Japan) to ASTI (Philippines)

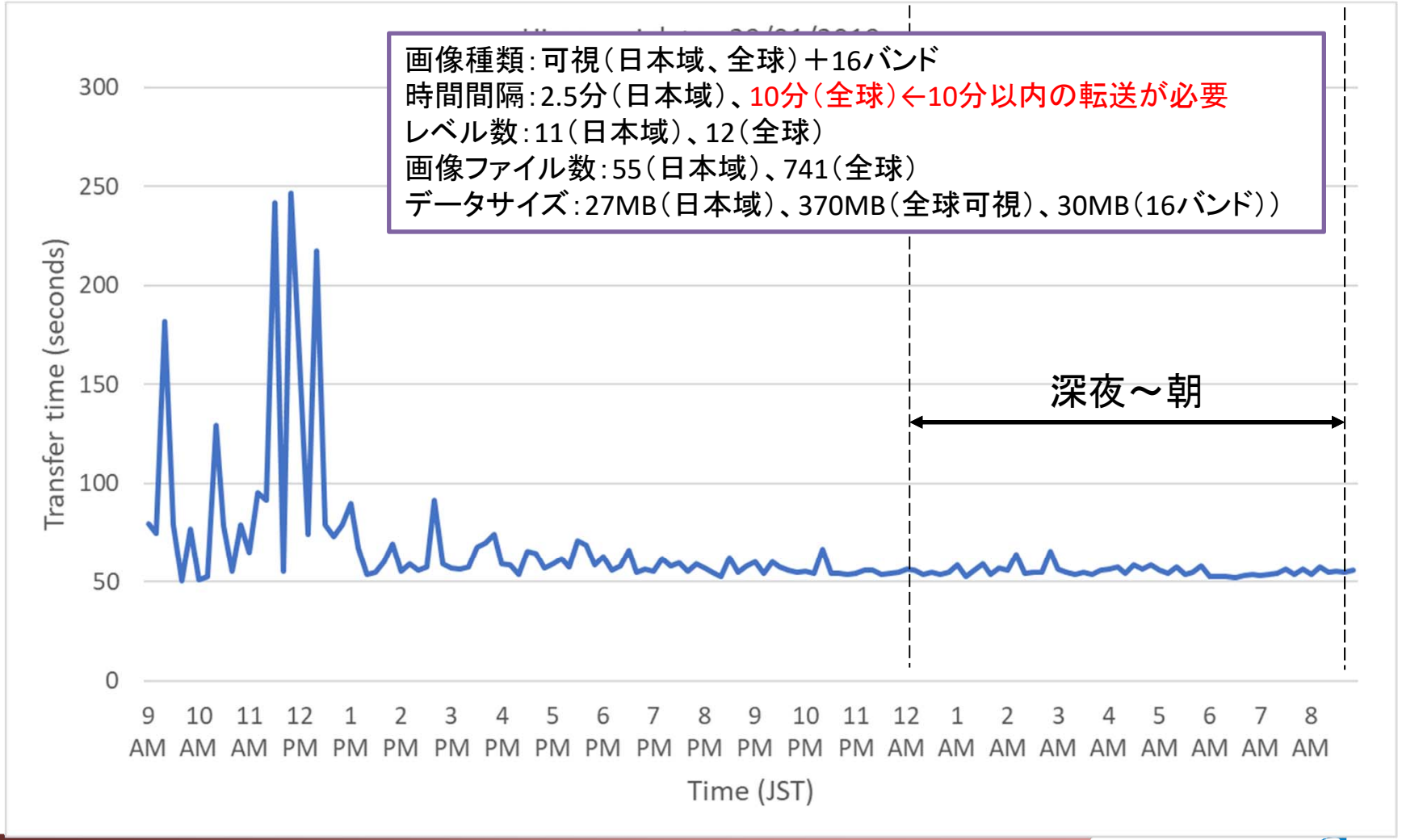


Throughputs measured by TCP(CUBIC) and HpFP2

NICT (Japan) to ASTI (Philippines)



HpFP2によるひまわりデータ転送性能
NICT（日本）→ASTI（フィリピン）



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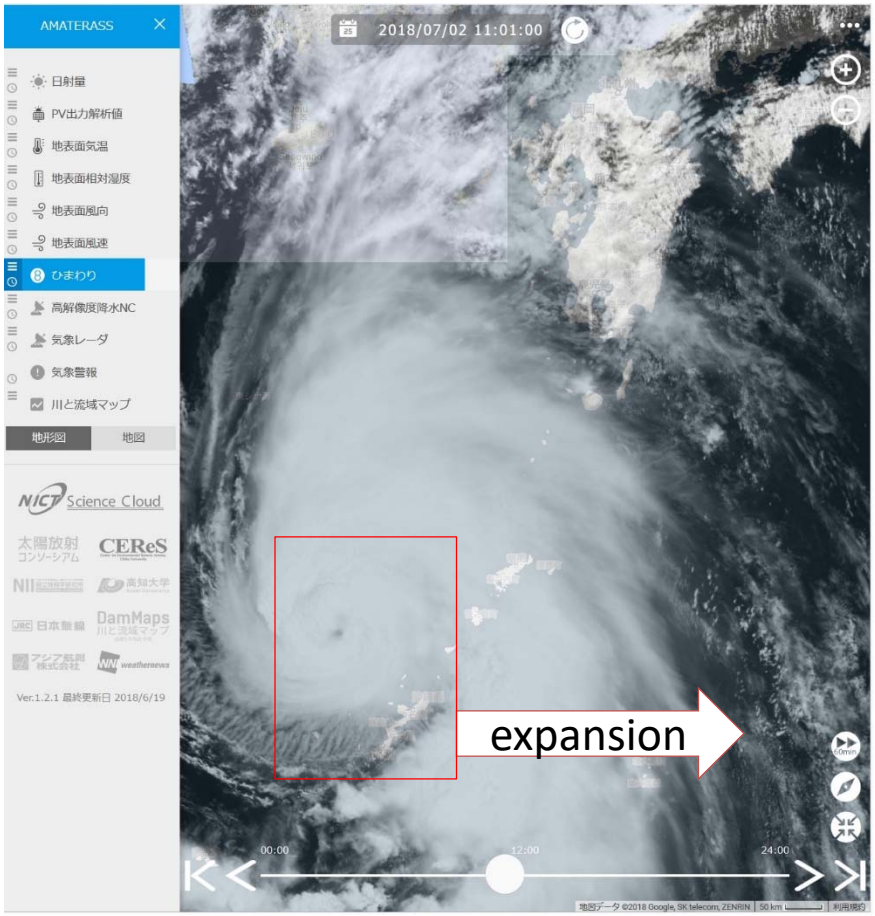
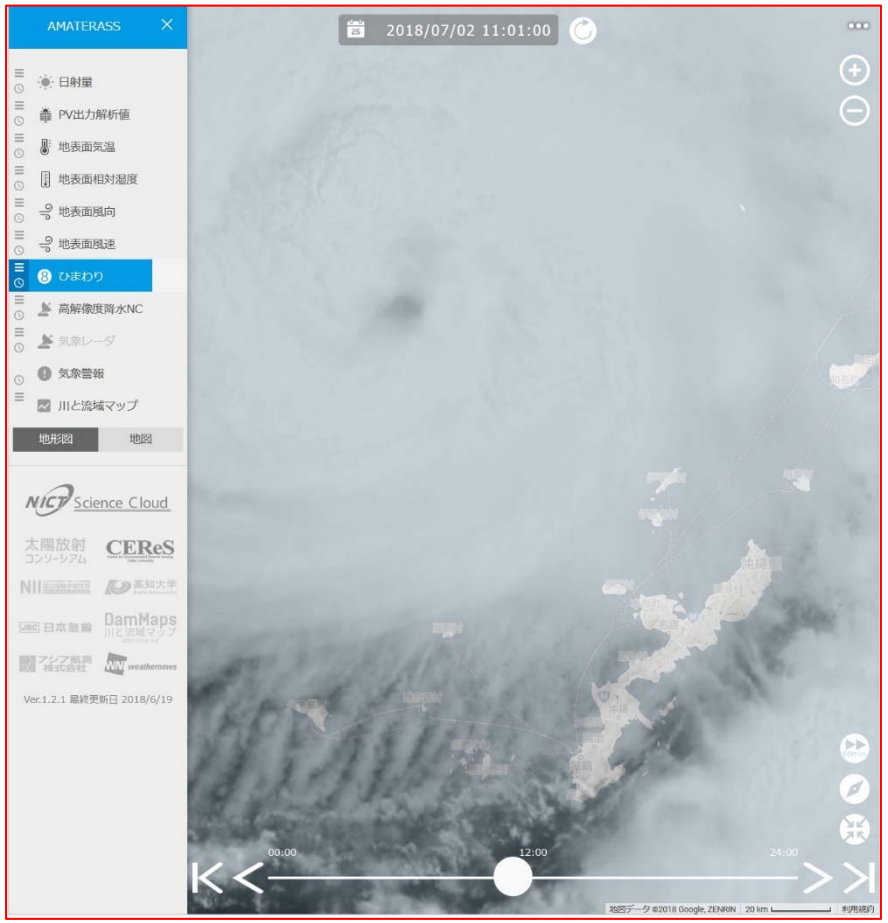
Amaterass Web

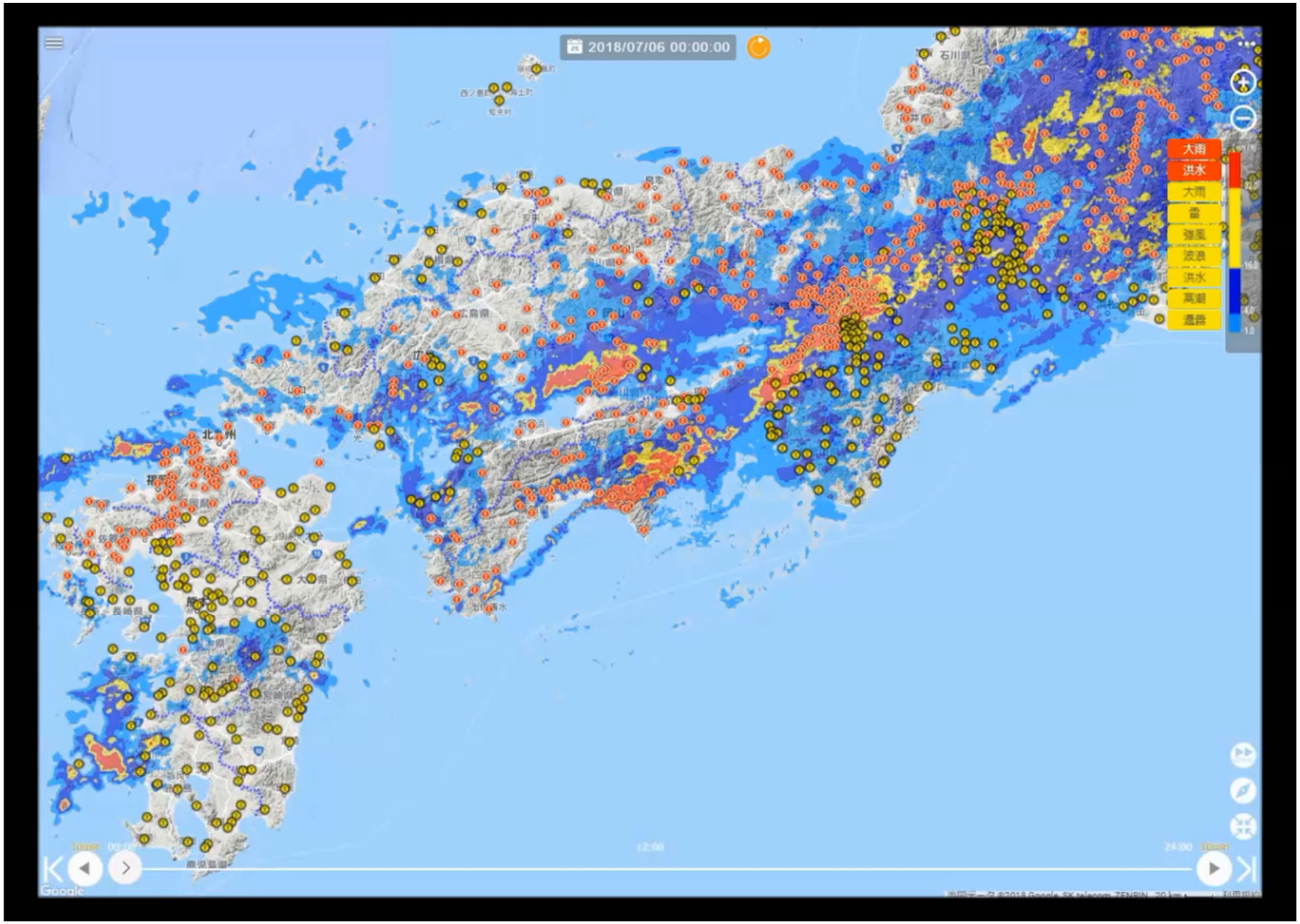
An awful "eye" of typhoon looking in high resolution at “Okinawa” island on 2018/07/02





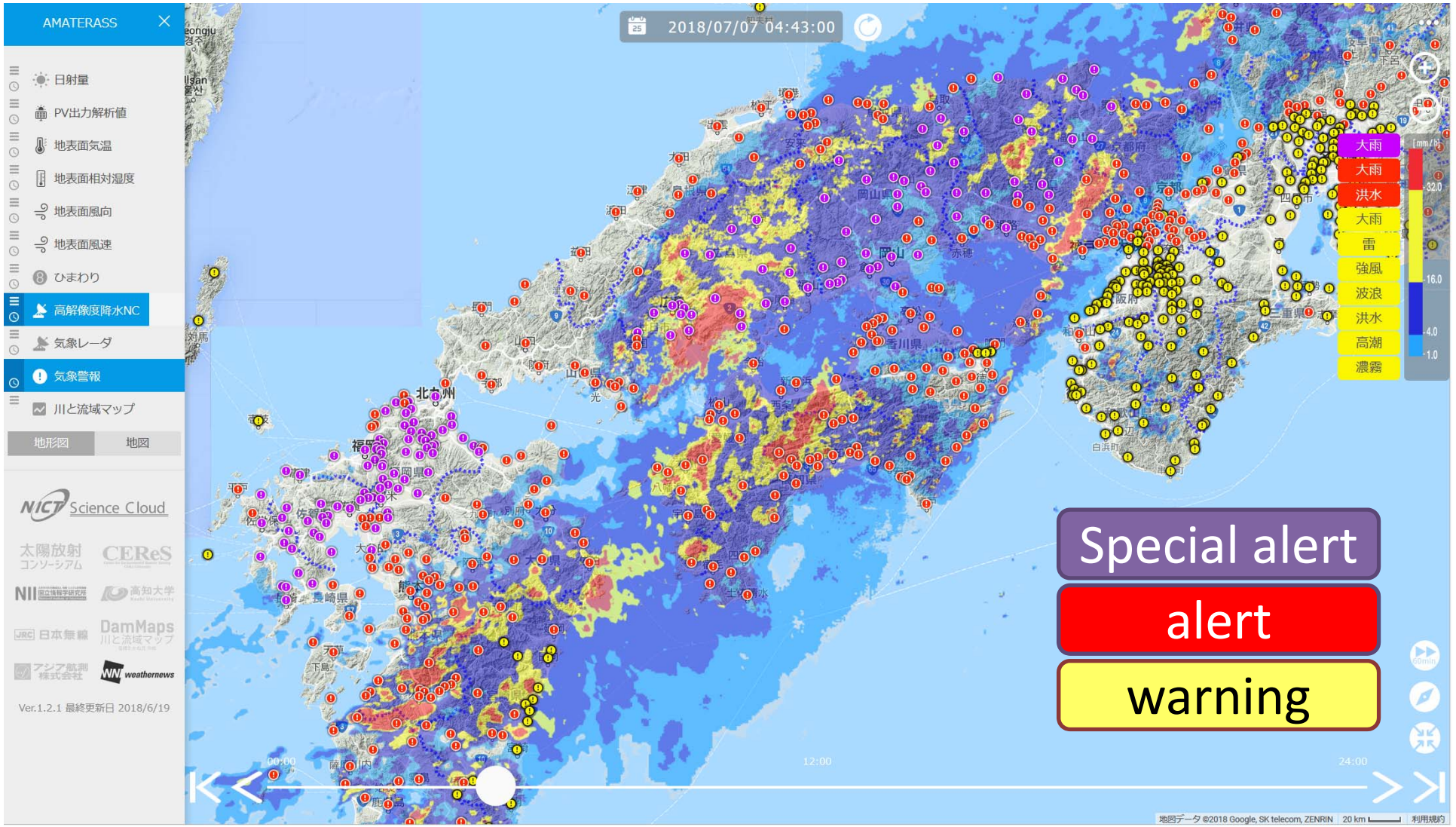
Data is provided by Dr. Atsushi HIGUCHI (CEReS/Chiba-U)

Himawari real-time Web (regional version)



NICT ScienceCloud

Himawari real-time Web (regional version)



NICT ScienceCloud

Himawari real-time Web (regional version)

NICT ScienceCloud

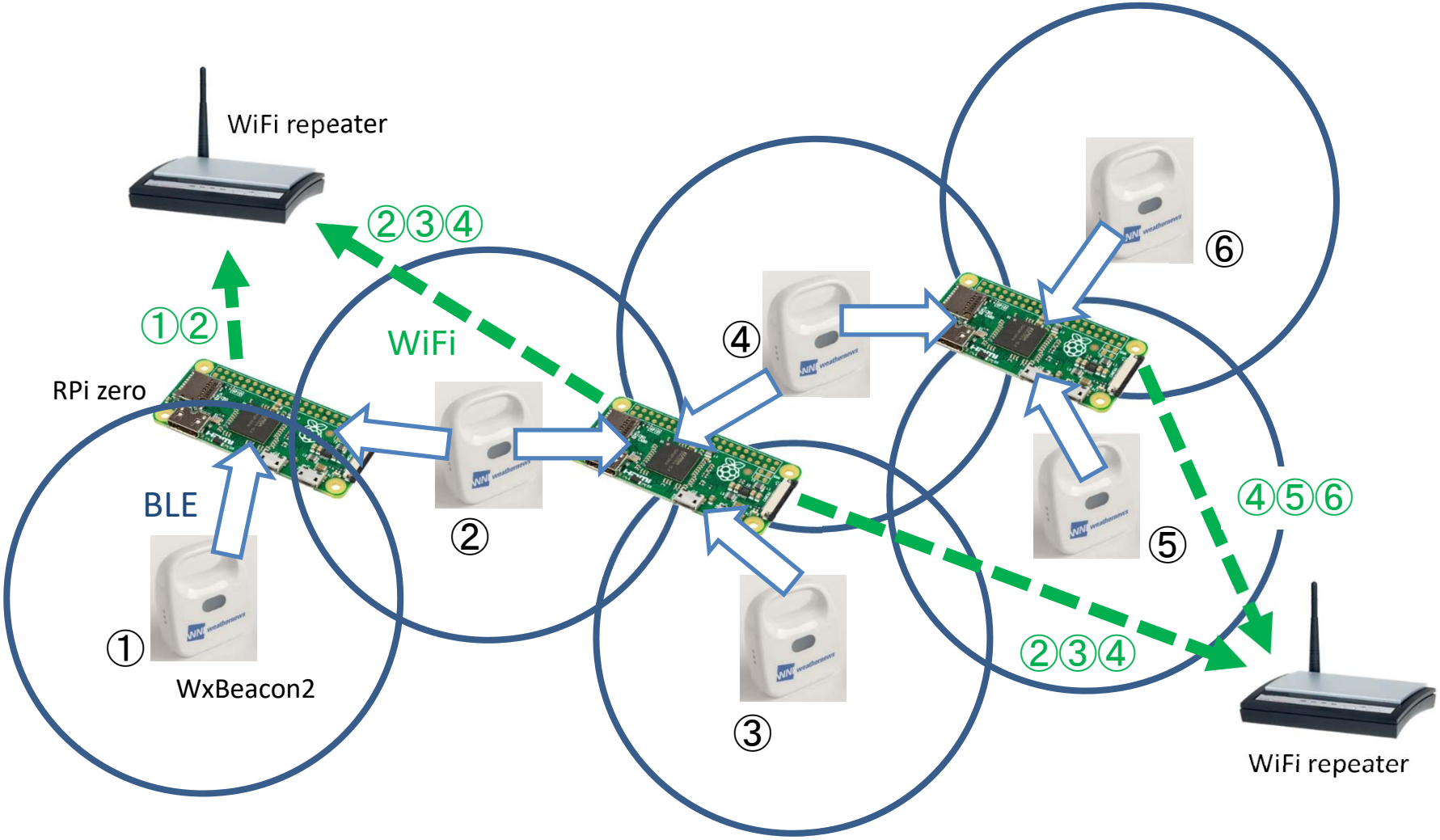
WxBeacon2

- Temperature
- Humidity
- Pressure
- Noise
- Light
- UV

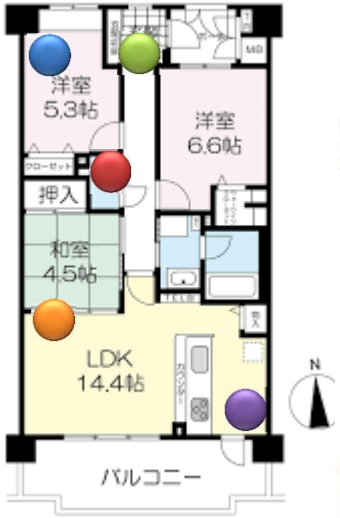
(50US$)

NICT ScienceCloud

Tiny sensor: WxBeacon2 （50US$)

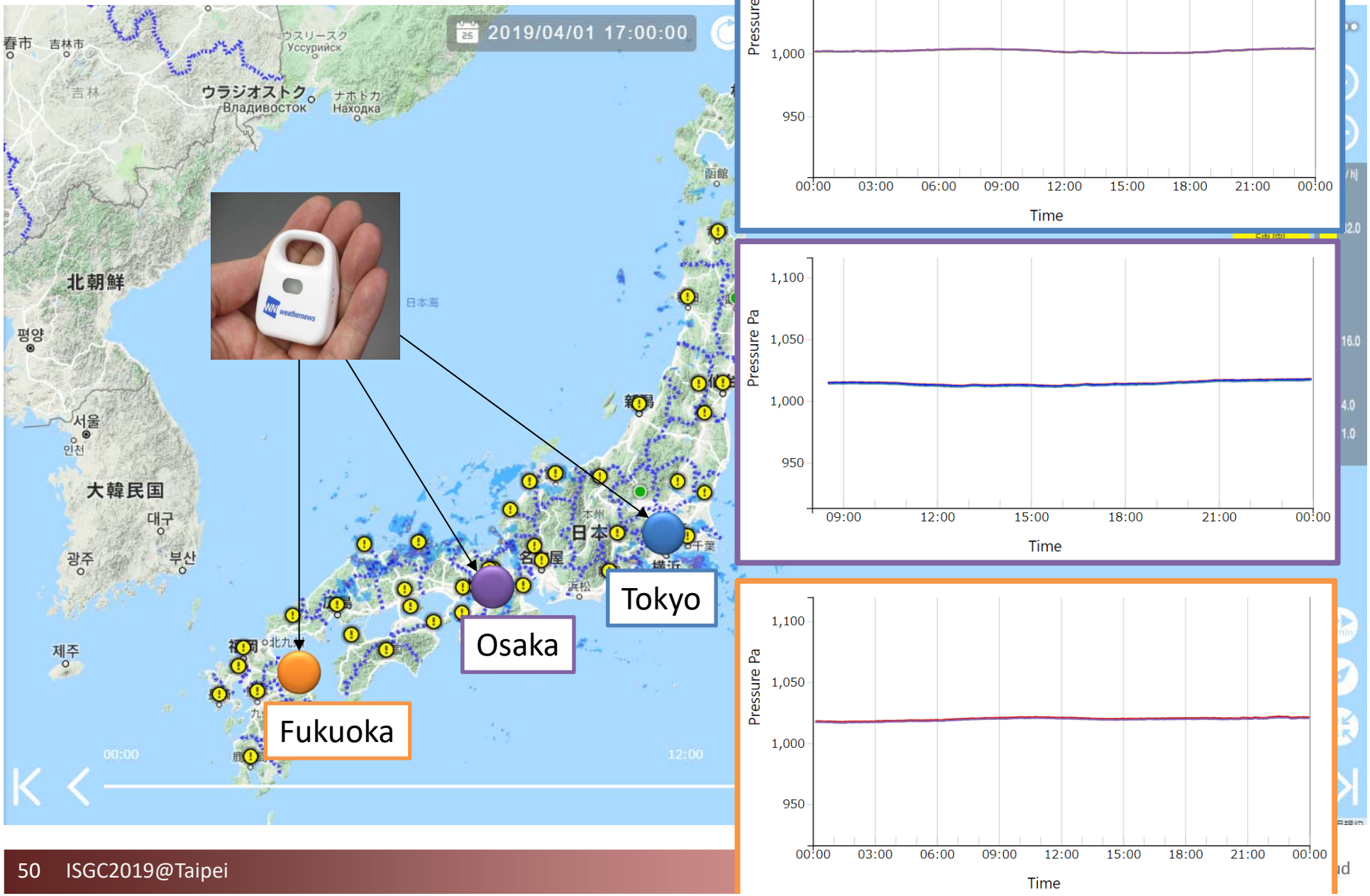


Tiny sensor:
WxBeacon2

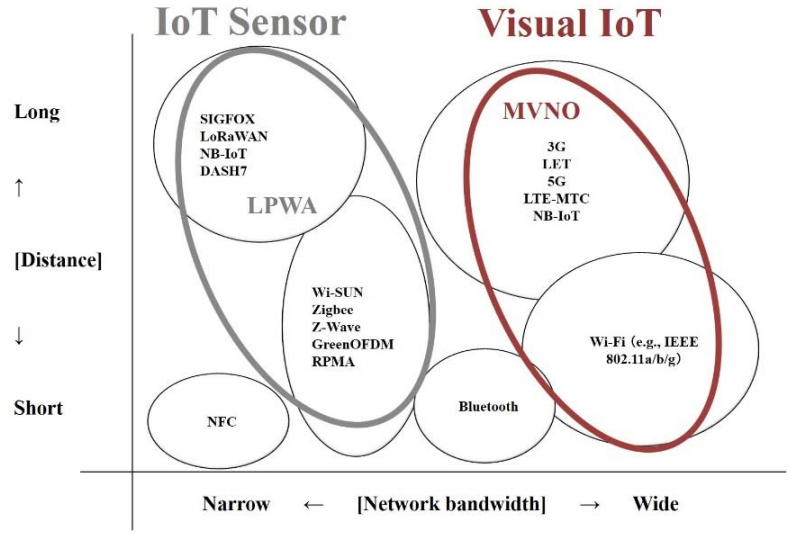


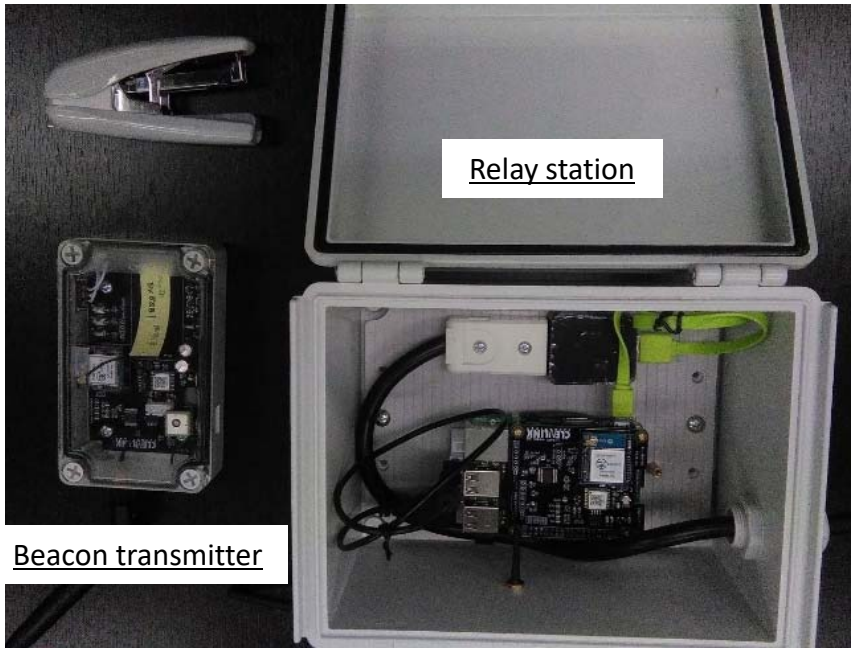
NICT ScienceCloud

Global measurement



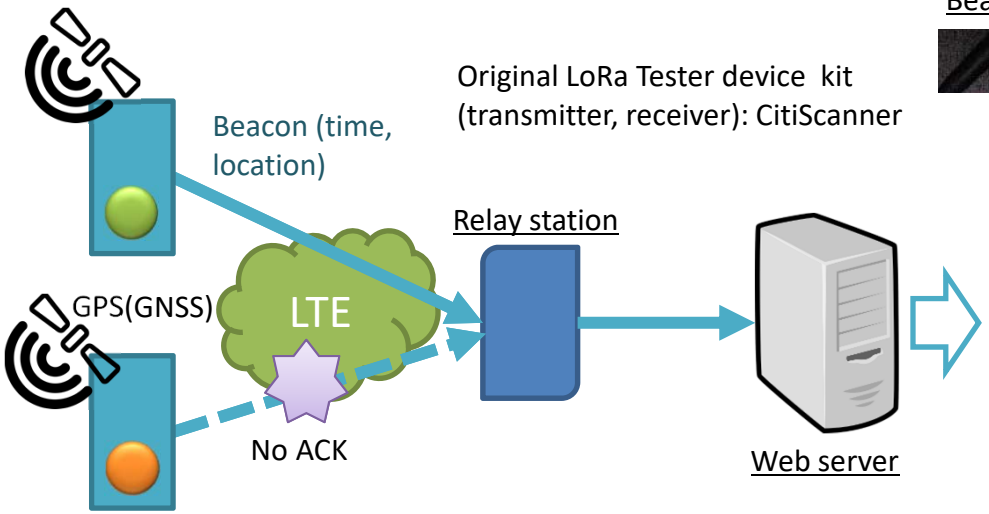
LPWA (private LoRa) communication

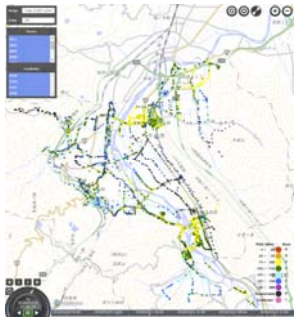




Beacon transmitter

Original LoRa Tester device kit (transmitter, receiver): CitiScanner





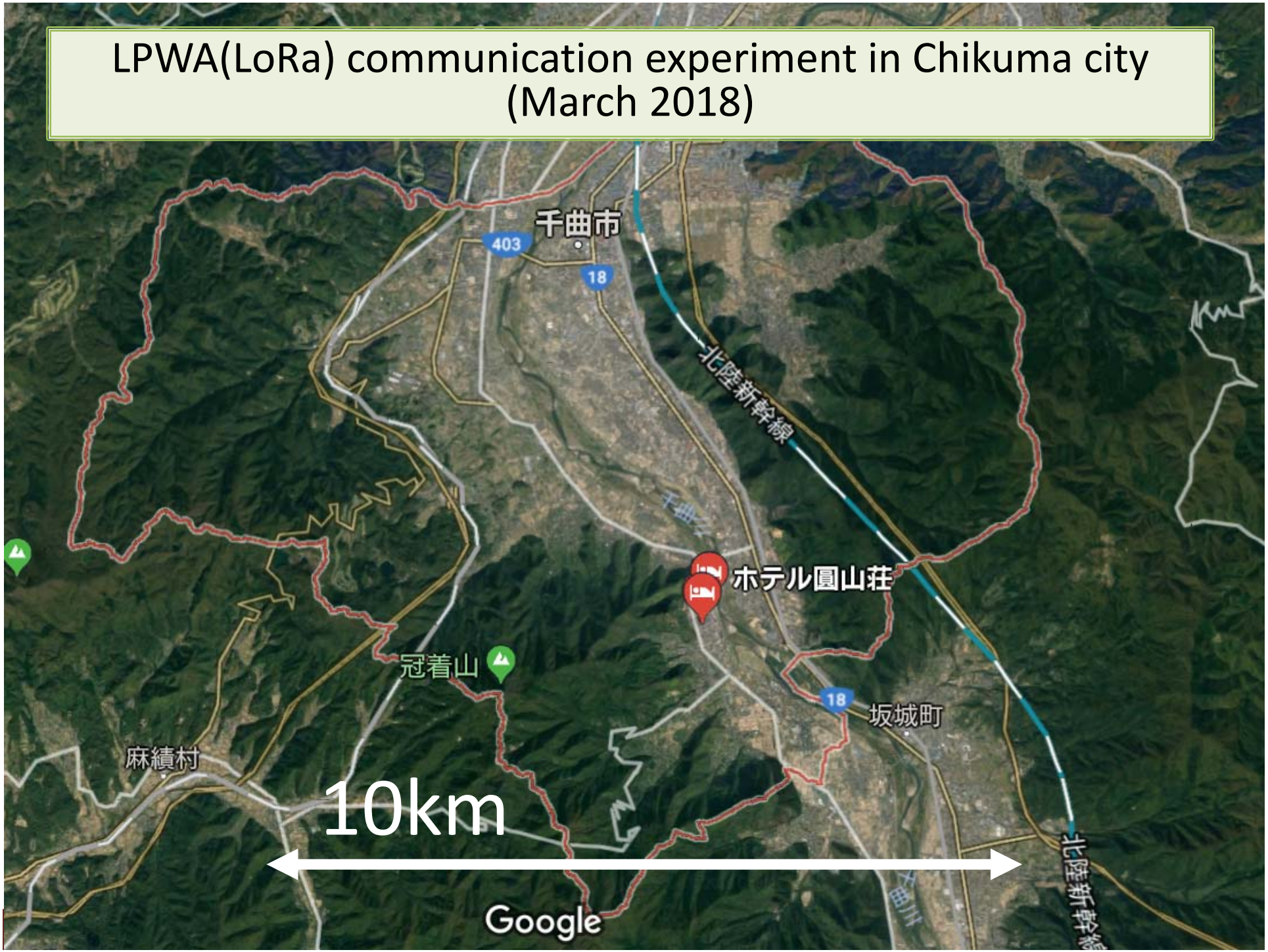
Web application

NICT ScienceCloud

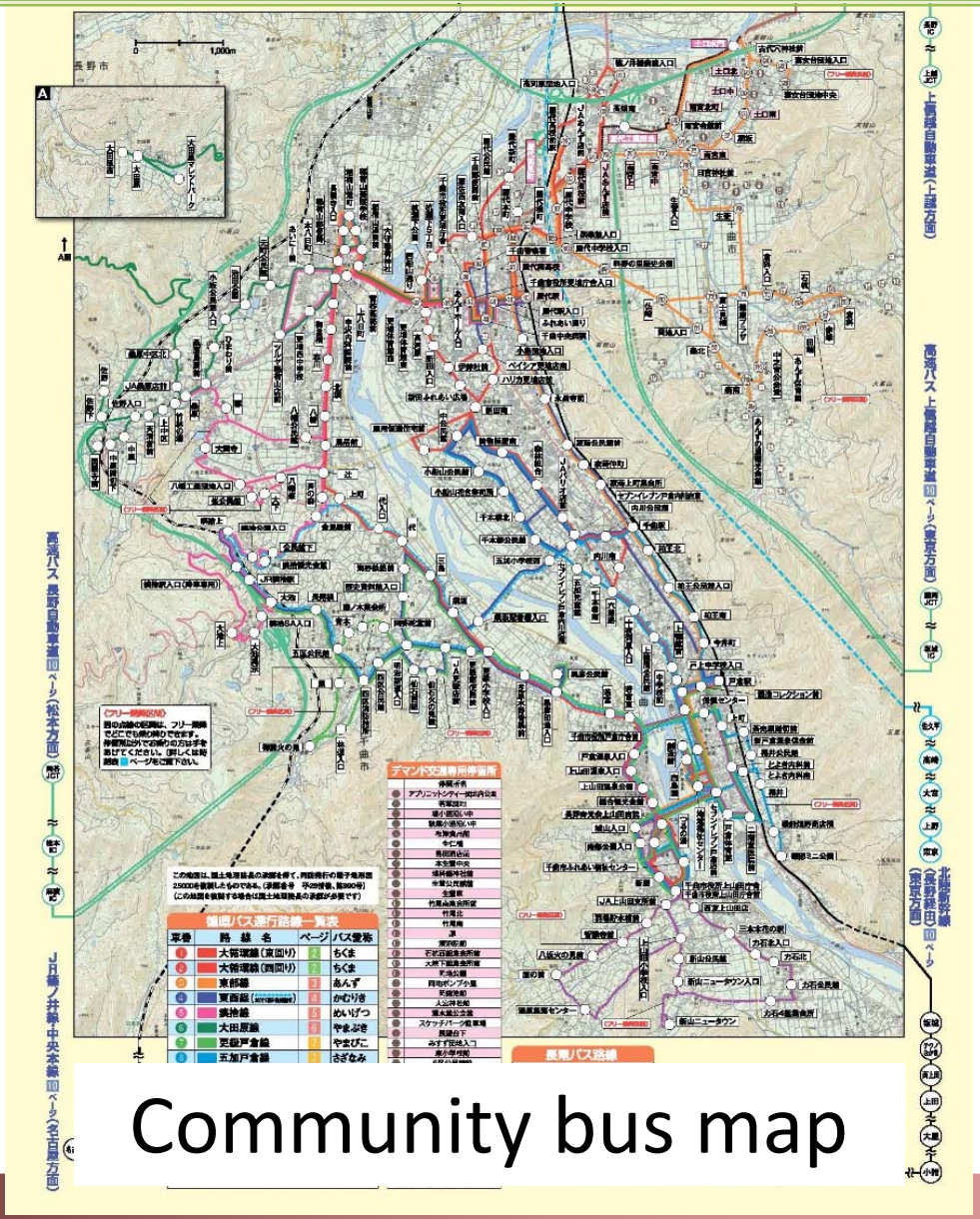
LoRa communication experiments 2018
Experiment models

NICT ScienceCloud

LPWA(LoRa) communication experiment in Chikuma city (March 2018)



Community Bus Map (Chikuma City, Japan)



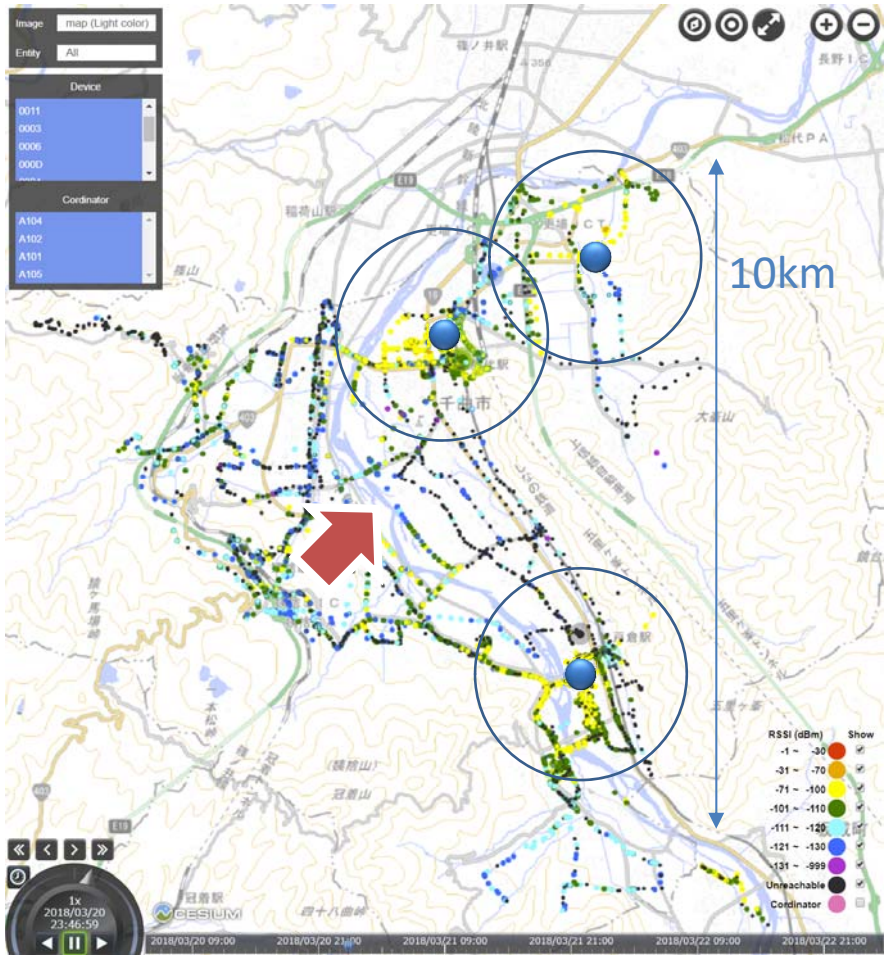
NICT ScienceCloud

LPWA(LoRa) communication experiment in Chikuma city (March 2018)

Relay stations

Beacon transmitter

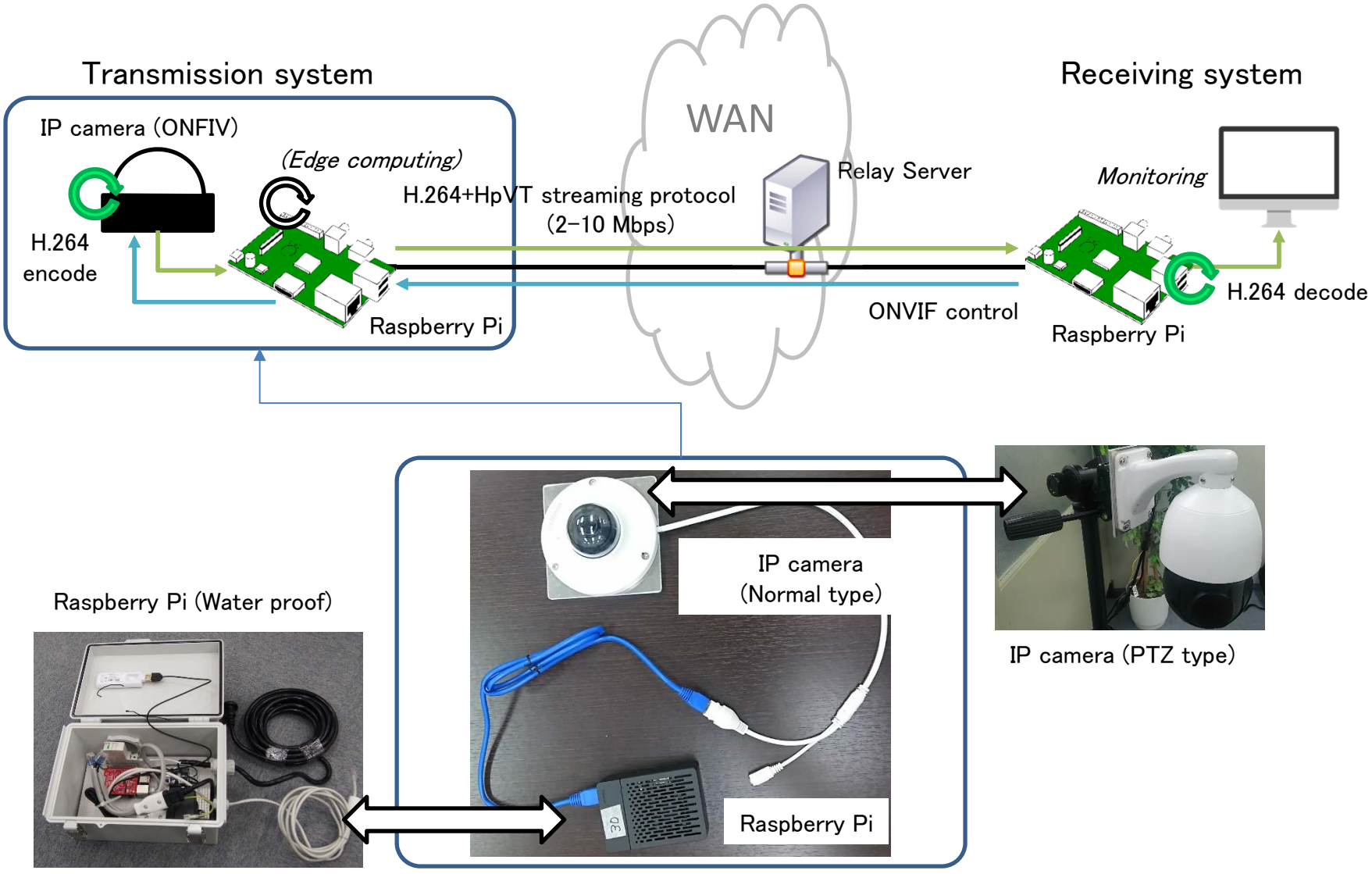
Web application of LoRa Citiscanner
(2018 March, Chikuma city, Nagano)



Web server

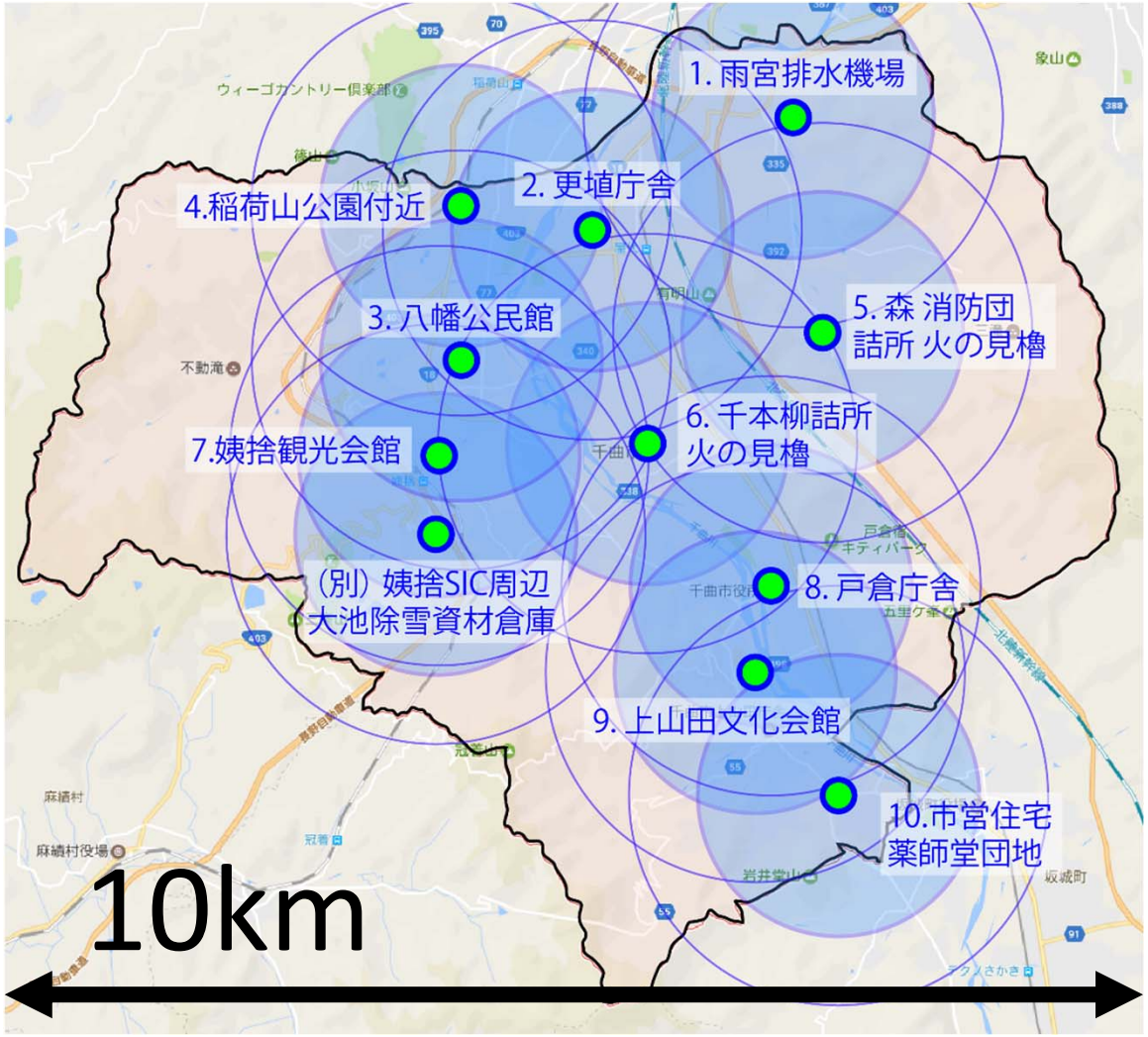
NICT ScienceCloud

Visual IoT System Configuration



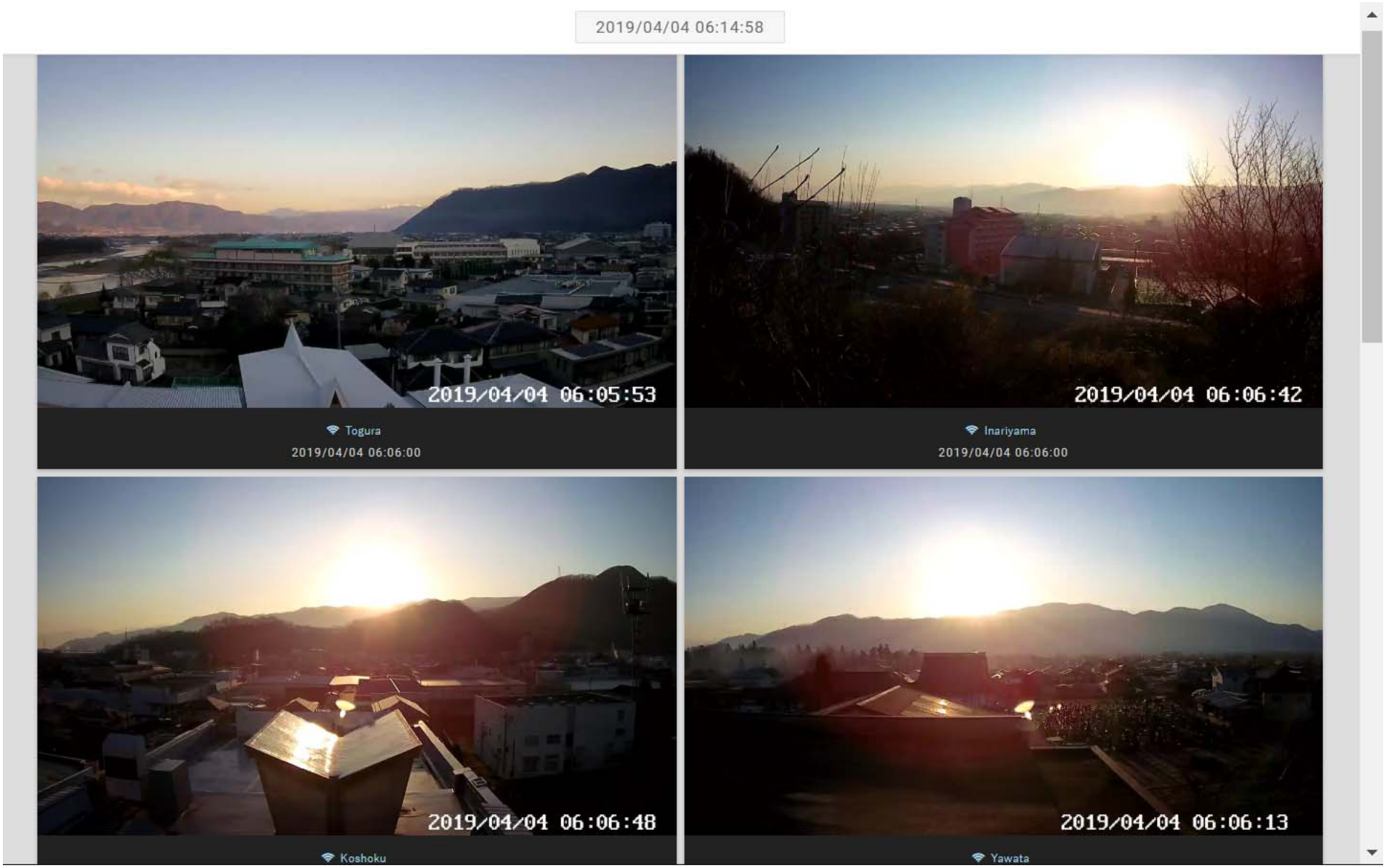
Weather
Station
IP camera

PLAN 2019



NICT ScienceCloud

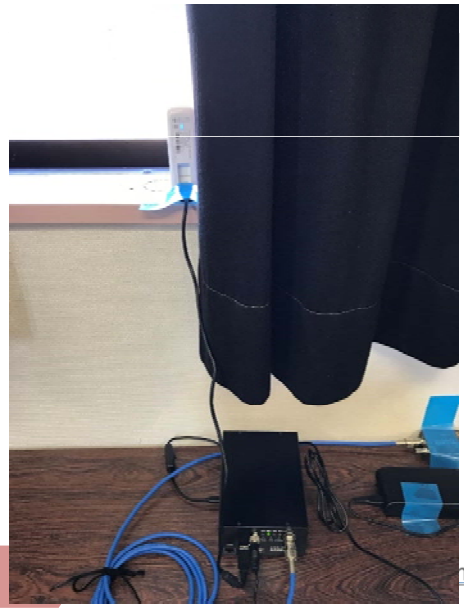
Multi-camera covering a whole city



NICT ScienceCloud

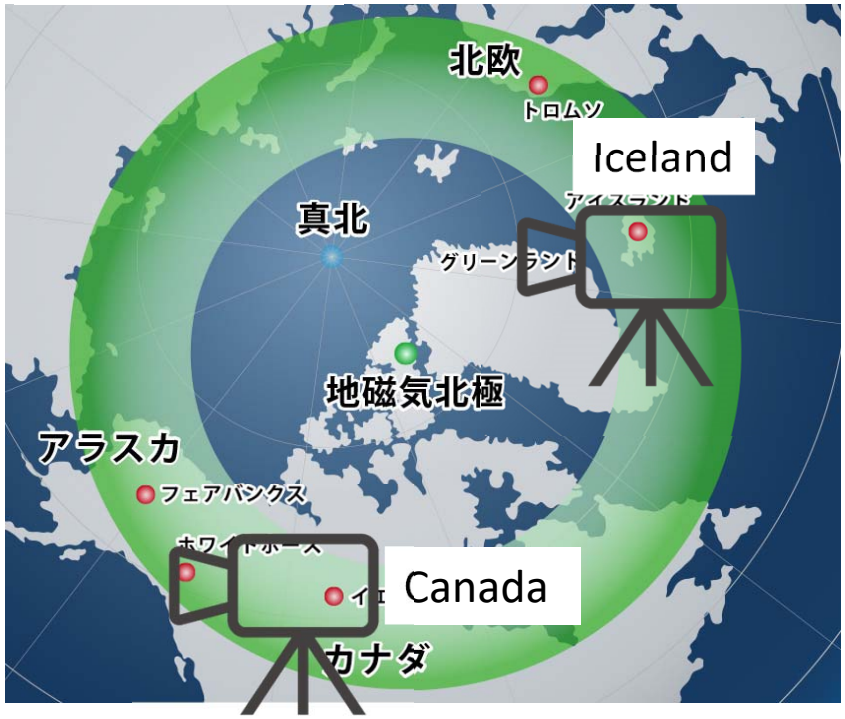
Smart Tourism
aurora real-time movie

Aurora camera

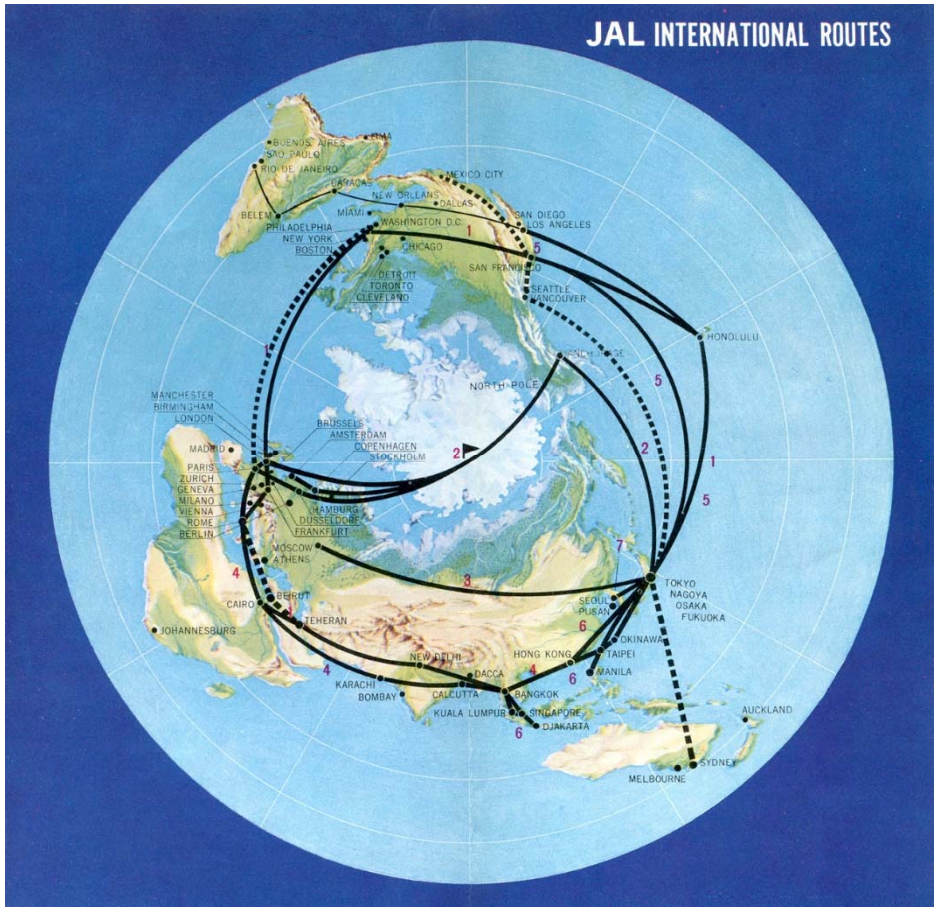


Smart Tourism
New aviation service (aurora information)

Aurora camera



Polar route



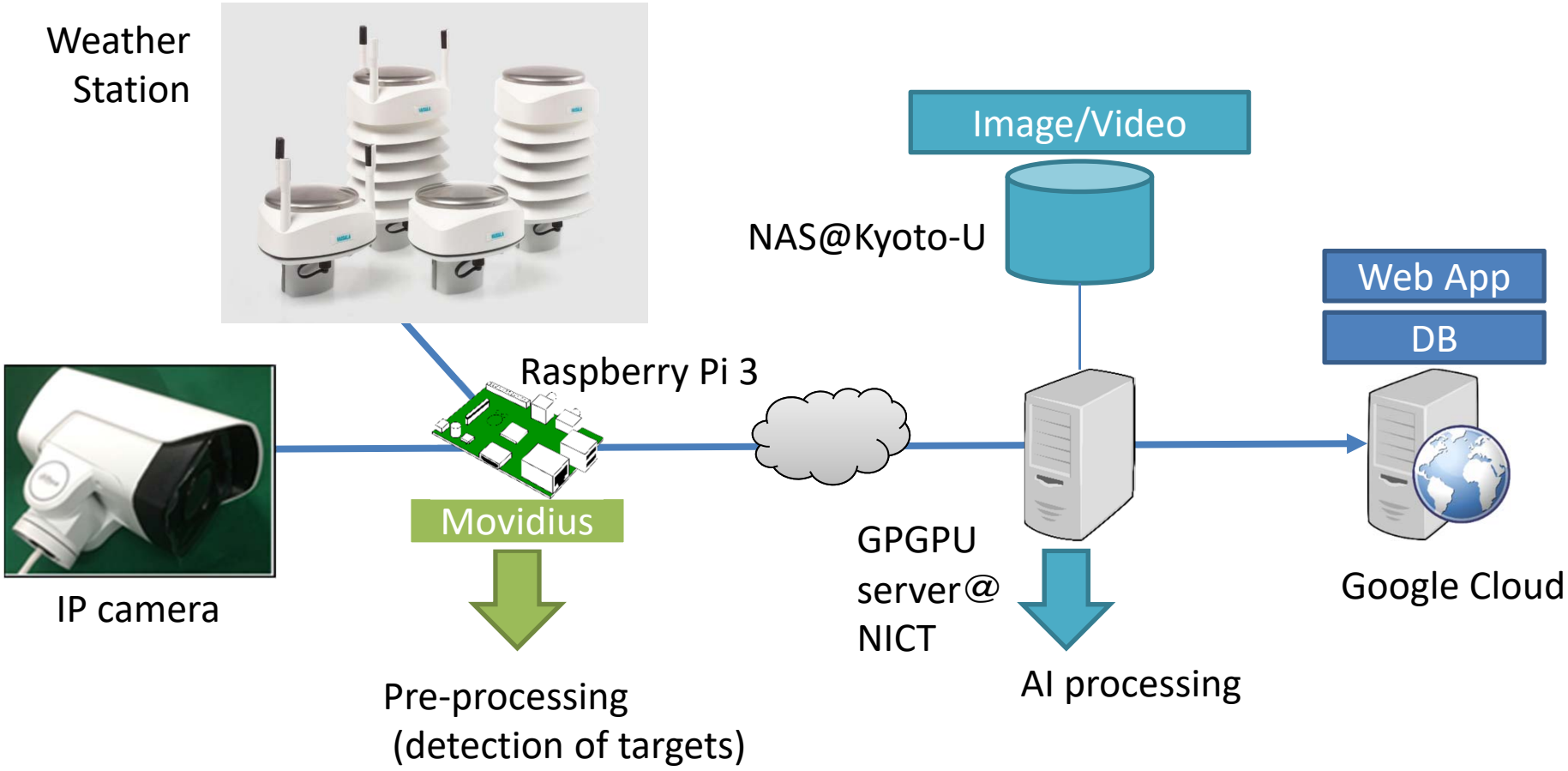
NICT ScienceCloud

Multi- and Large-scale movies and images

Tiled Display Wall powered by “ChOWDER”

(in collaboration with Dr. Kawanabe, RIKEN/Japan)

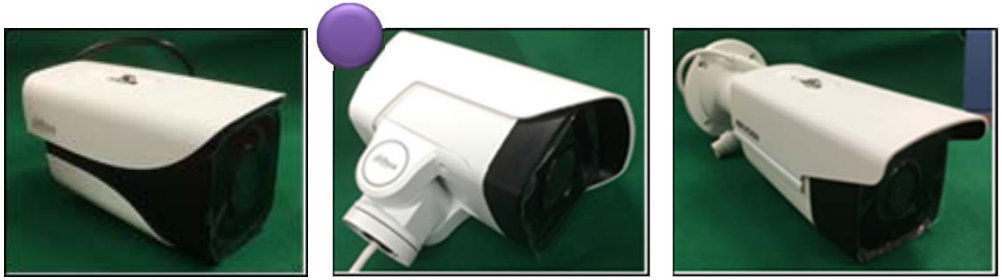
Integrated Environment Monitoring System



Commercial IP camera
ONVIF (profile S) required

300 – 1,500 USD

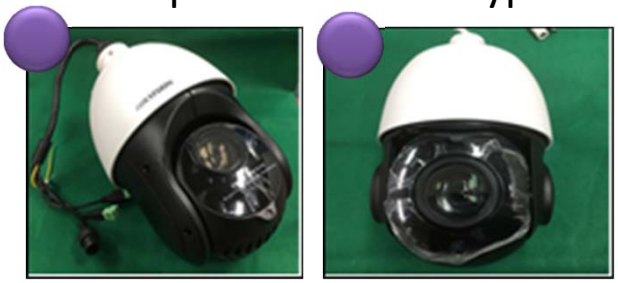
Desk-top type



Barrett type

Dome type

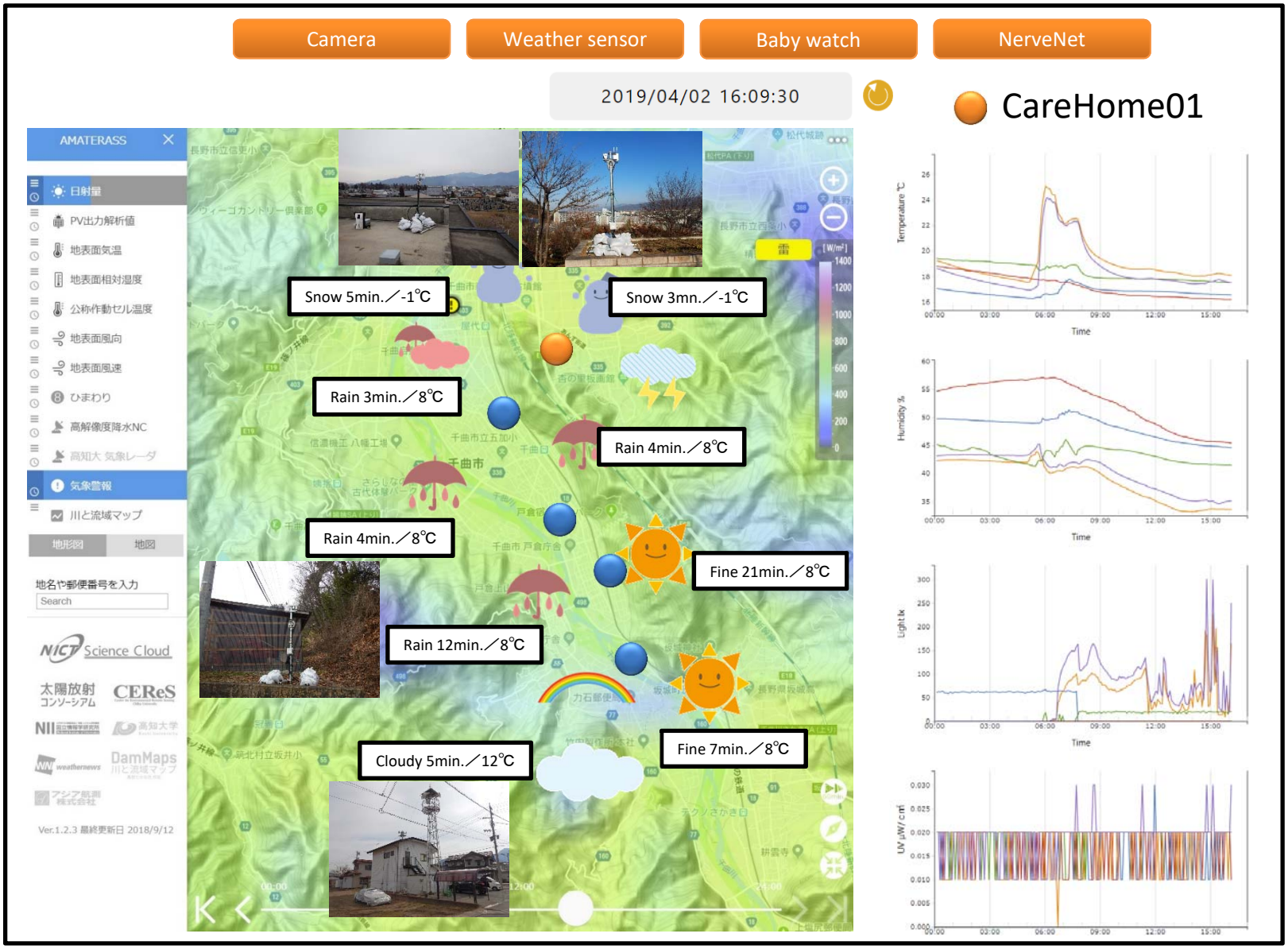
Japanese lantern type



PTZ (Pan-Tilt-Zoom)

NICT ScienceCloud

Final Image of “Local” Himawari



NICT ScienceCloud

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  - Plan & Idea

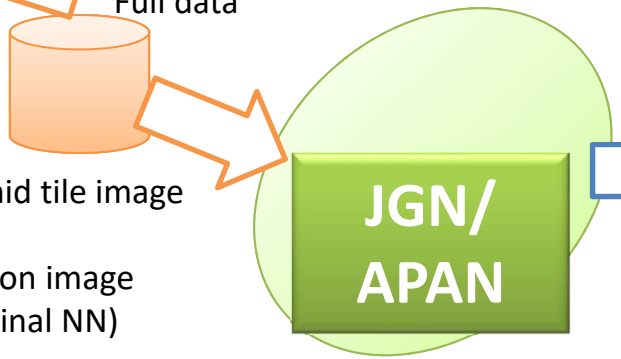
AI for “eye” and “trajectory” of Typhoon

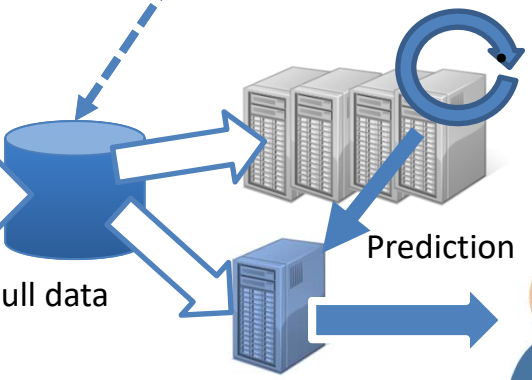
HIMAWARI satellite

Total file number and size per year

	Total file number	Total file size
Full scale image for AI	900,000	90TB
Pyramid tile image	150,000,000	20TB

Full data





Typhoon prediction based on AI

Prediction

Full data

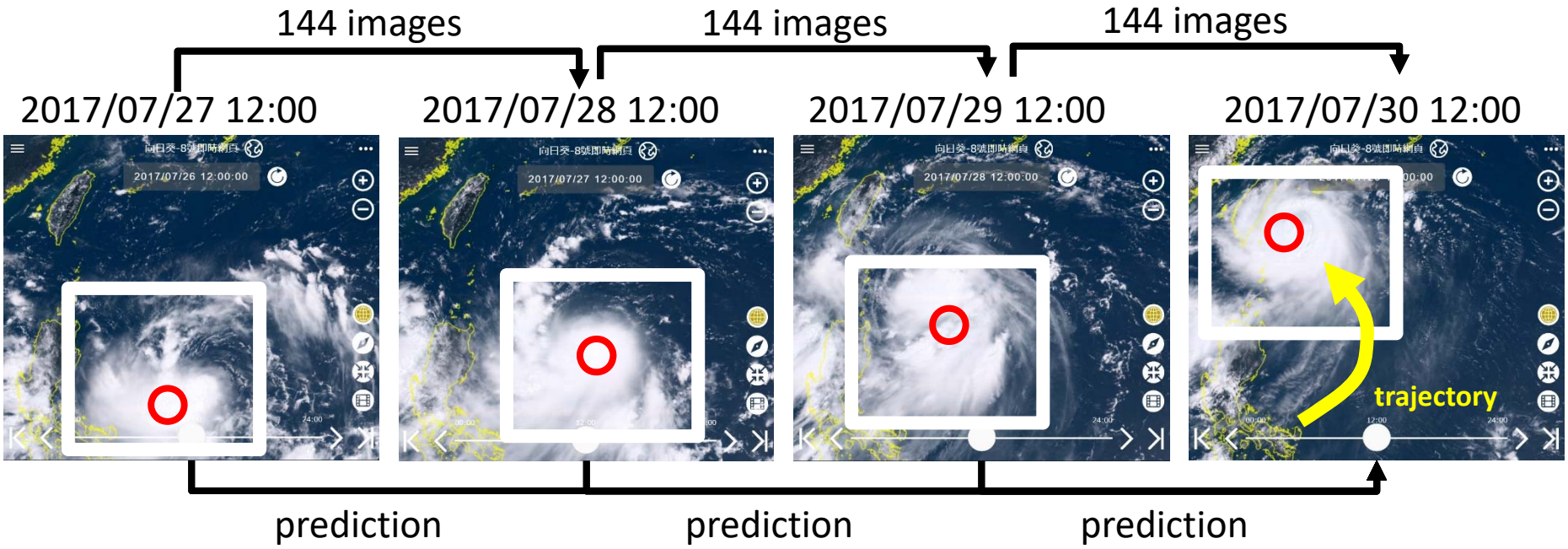
Web application
(Himawari real-time)

- High resolution pyramid tile image generation
- Real time solar radiation image creation using AI (original NN)

Japan

Taiwan

AI for “eye” and “trajectory” of Typhoon



AI for “eye” and “trajectory” of Typhoon

Learning data set of “eye”s of typhoon

Learning data set of environmental data (input) and typhoon trajectory (output)

Japanese meteorological researchers

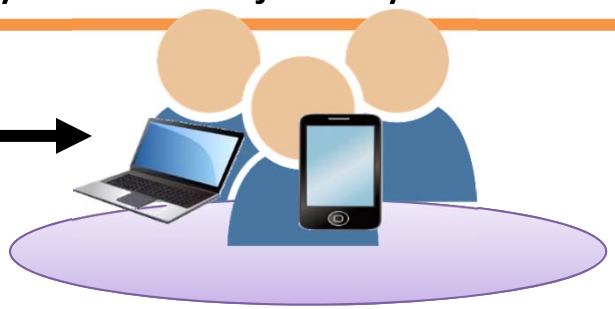
Automatic detection of “eye” of typhoon using DL (e.g., CNN)

Prediction of typhoon trajectory from environmental data using DL (e.g., RNN)

AI researchers and engineers at ASGC

Indication of “eye” and “trajectory” on Himawari-8 real-time web

Web application engineer at NICT

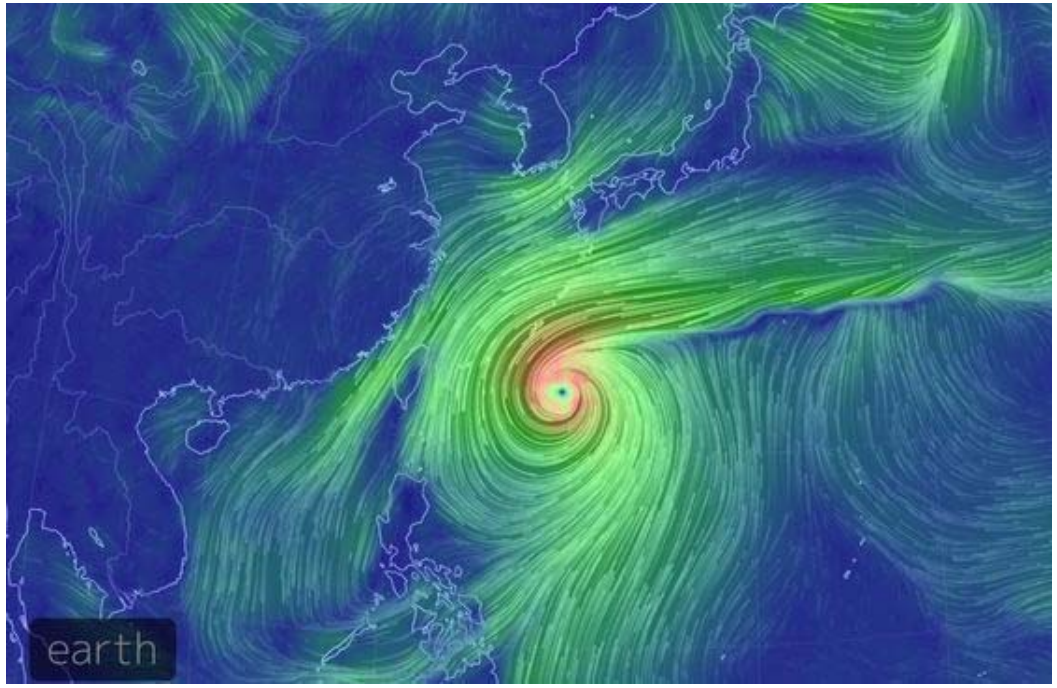


Taiwan citizens
Meteorological and research organizations

Real-time visualization of Himawari and Simulation

Himawari real-time

Numerical Simulation in real-time



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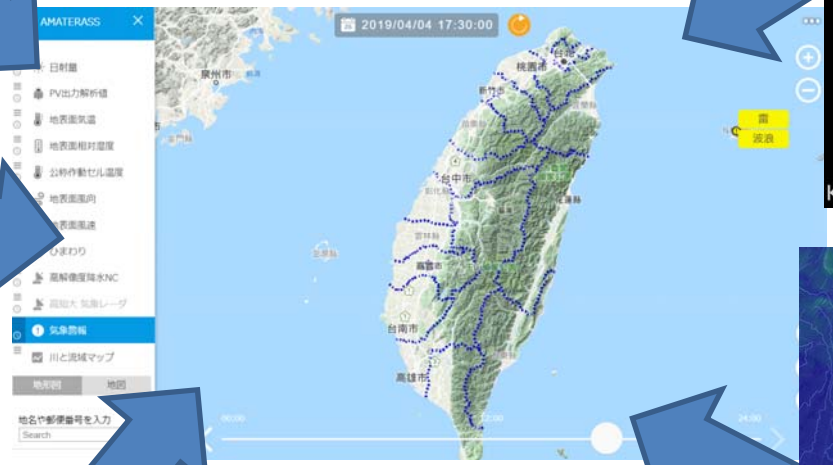
Taiwan Regional Himawari (real-time)

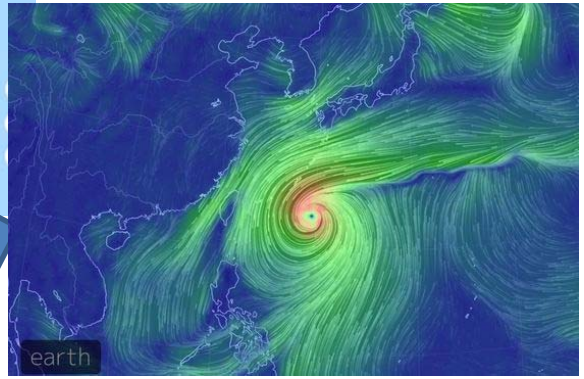
Small sensors

Smart IP cameras

Weather stations



Himawari satellite



Computer simulation

NICT ScienceCloud

ひまわり・Amaterass 出力ファイル・必要リソース一覧

	Pyramid tile image level	Data interval	Total file size [TB/year]	Total file number [billion/year]	CPU core
Himawari 16 bands	Level 10	10 min.	2.8	150	32

	Pyramid tile image level	Data interval	Total file size [TB/year]	Total file number [billion/year]	CPU core
Himawari 16 bands	Level 10	10 min.	2.8	150	32

Summary

- Introduction and experience of “Himawari real-time”
- Techniques in “Himawari real-time”
- Project to expand “Himawari real-time” to Asian countries
- From “Global” to “Local”, from “satellite” to “IoT”
- Collaboration plan with ASGC/Taiwan

Thanks!