NH1.3 2020 EGU GA, May 5, 2020

Ground-based lightning and AWS network system for alert of torrential rainfall and typhoon combined with micro-satellite constellation

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SATREPS: Japan-Philippines joint project (JST-JICA, DOST)

e-ASIA: "Monitoring and prediction of extreme weather using lightning detection network and micro-satellites" (JST, BPPT, DOST)

Related programs

This work is financially supported by these programs

PHL-MICROSAT and STAMINA4 (2015-2018/2018-2020)

supported by DOST-PCIEERED

LAPAN A-4 satellite project (launch in 2020)

supported by LAPAN and BPPT

Core-to-core program (2016-2019. Mar) supported by JSPS

"Establishment of observing means for dynamics of the Earth environment in Asia with micro-satellites"

SATREPS/ULAT (2017-2022) supported by JST-JICA

"Development of extreme weather monitoring and information sharing system in the Philippines"

AVON: Asia VLF observation network

GEON: global ELF observation network

Asian Micro-satellite Consortium: 9 countries in Asia

Background

background

Monitoring and understanding thunderstorm

is the key for disaster prevention of torrential rainfall and typhoon

Thunderstorm and torrential rainfall

flood, inundation
downburst
tornado

Typhoon

flood, inundation
violent wind
high tide

Lightning

one of the main causes of internet trouble
electrical blackout
human life

background

Thunderstorm is difficult object to observe

--- very strong but its scale is too small ...

Geostationary Meteorological satellite: 0.5-1.0 km
C band radar: resolution ~1-2 km

Sample of **X-band radar** (250m resolution) observation

we cannot get information behind heavy rain area...

Typhoon

>24 hours prediction has been improved

for the location of typhoon center

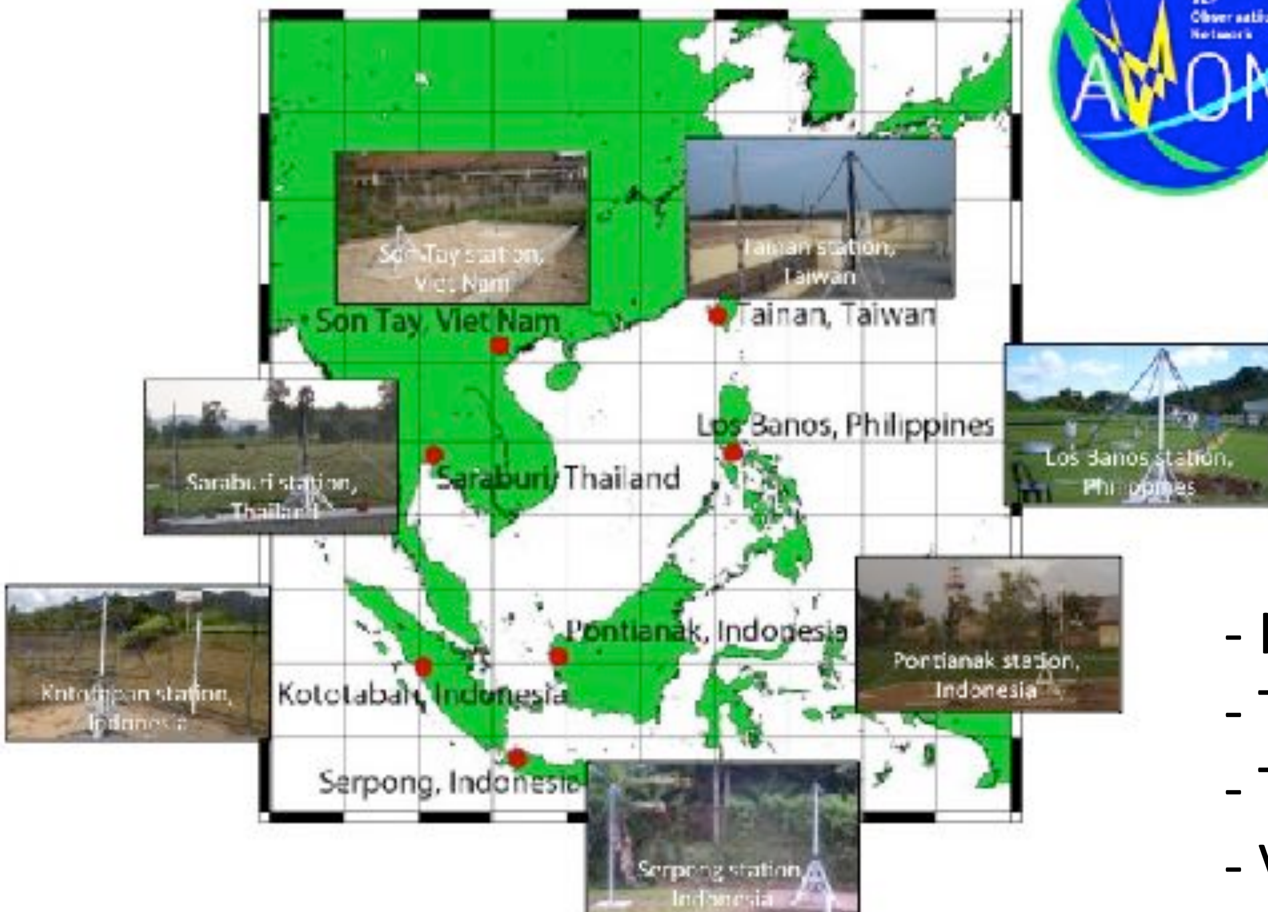
But intensity prediction has not been improved...

Our purpose

To establish the new methodology of real-time monitoring and short term prediction for thunderstorm (0.5-1 hour) and typhoon (1-2 days).

1. LIGHTNING

Our **AVON** (Asian VLF Observation Network) for scientific research



- Indonesia
- Thailand
- Taiwan
- Vietnam
- Philippines

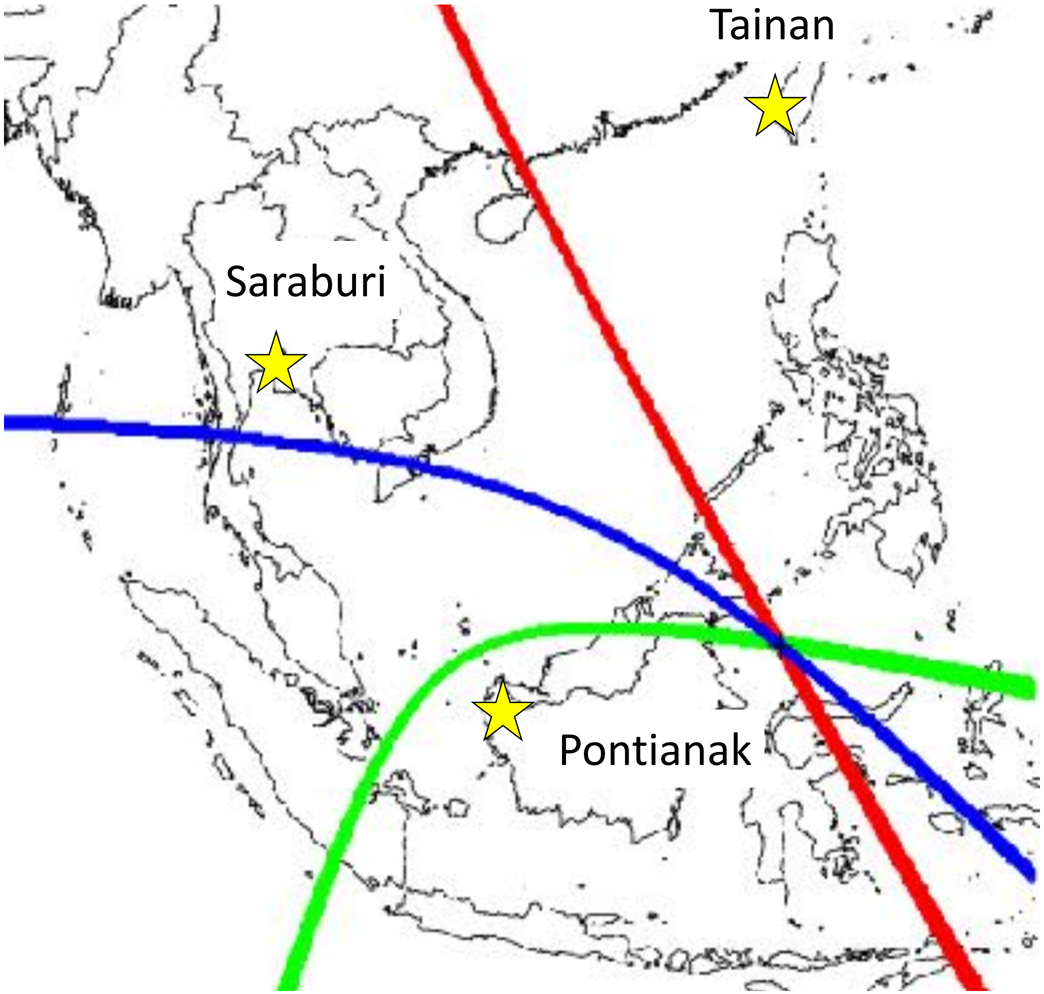
Dipole antenna:
To measure electric field

Loop antenna:
To measure magnetic field

Figure. Dipole antenna (left panel) and loop antenna (right one) installed at Los Banos, Philippines.

Geolocation of lightning by Time-of-Arrival method

background



Example of geolocation based on 3 stations observation.

ΔT_1

Difference of arrival timing between Tainan and Saraburi

ΔT_2

Difference of arrival timing between Saraburi and Pontianak

ΔT_3

Difference of arrival timing between Pontianak and Tainan

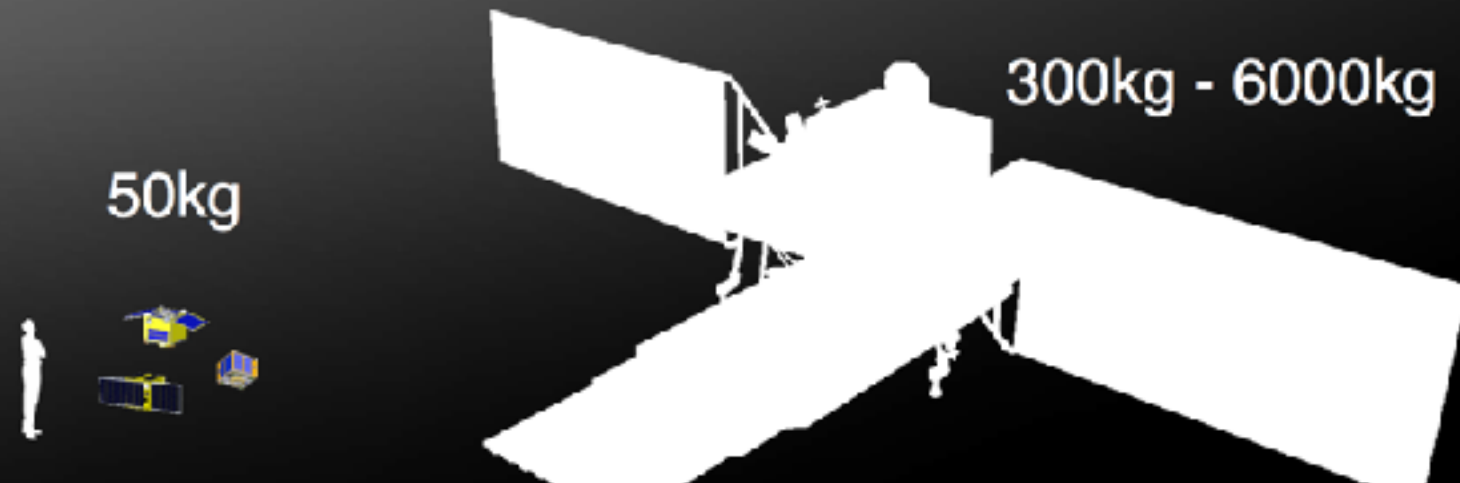
accuracy ~30km

2. MICRO-SATELLITE

background

Personal computer ⟷ Super computer

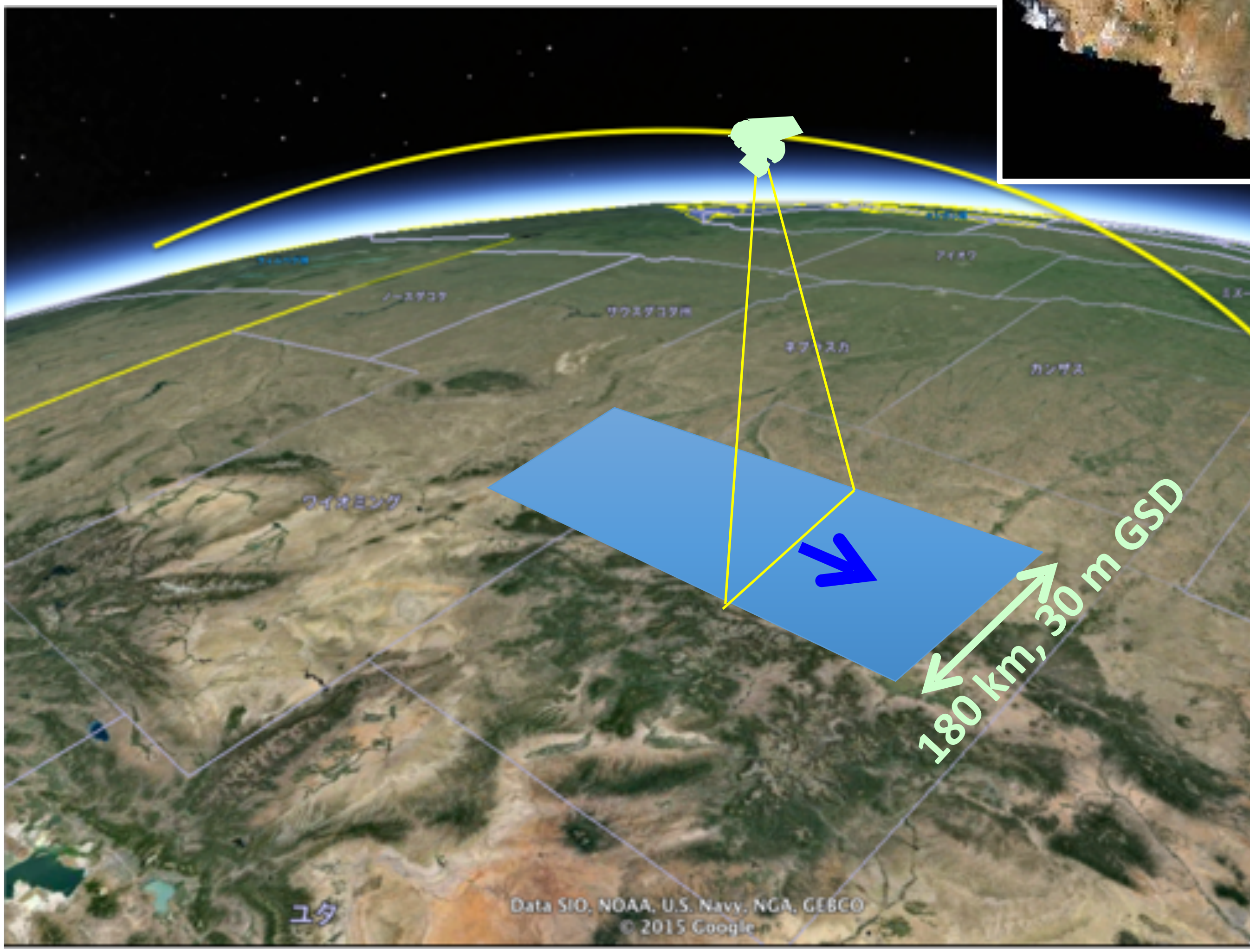
Micro-satellite ⟷ Larger-satellite



Micro-satellite	Larger-satellite
3-5M USD	> A few 100M USD
Quick fabrication (One year)	Long period (>10years)
On-demand operation based on User's purposes	To carry heavy equipments

Conventional satellites

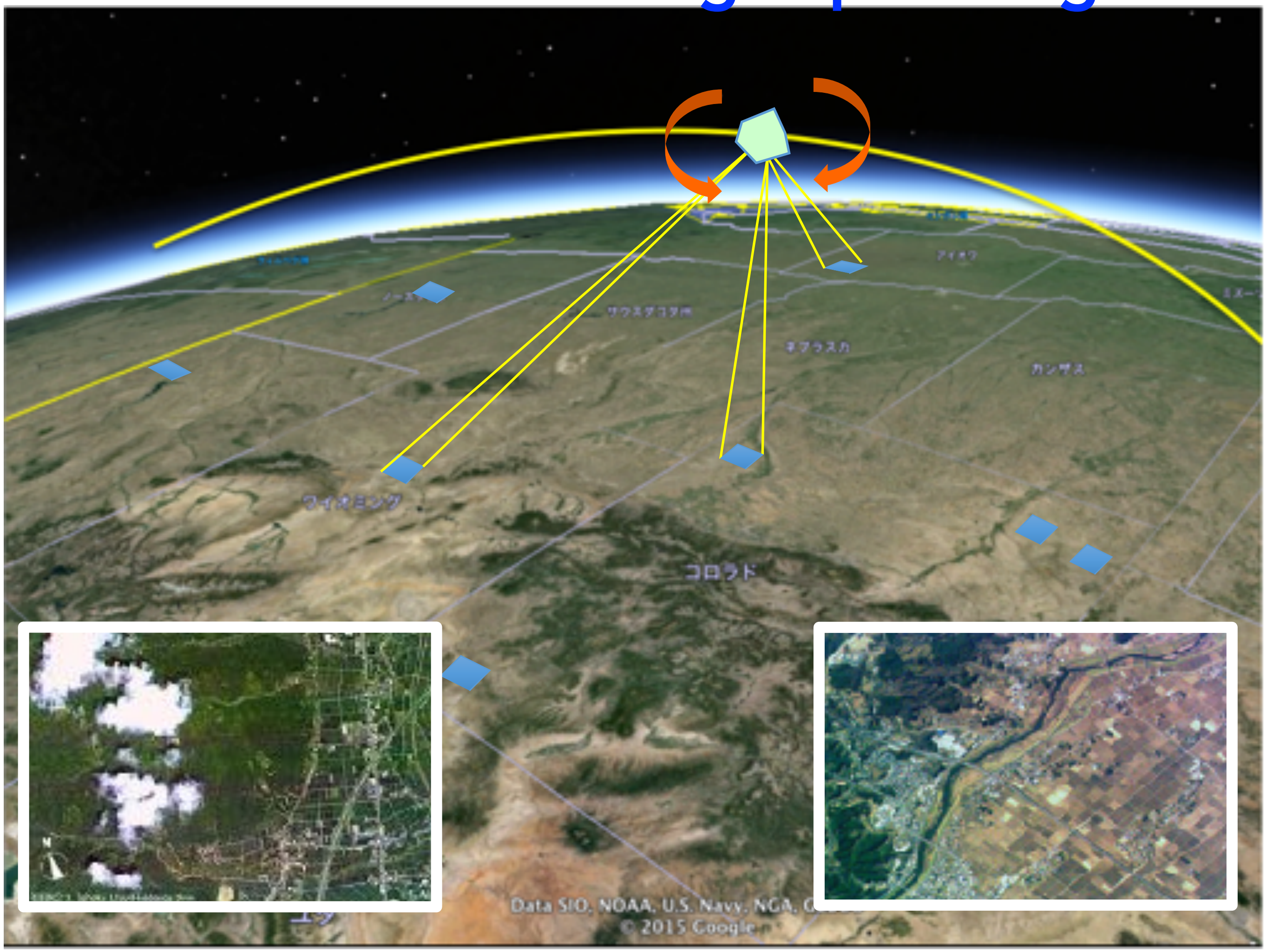
LANDSAT-8: pushbroom imaging



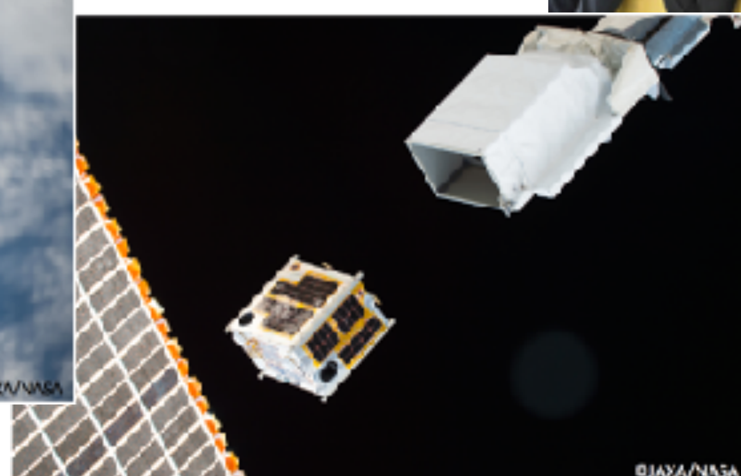
revisiting period: 16 days

Our micro-satellites: DIWATA, RISING-2, LAPAN A series, etc.

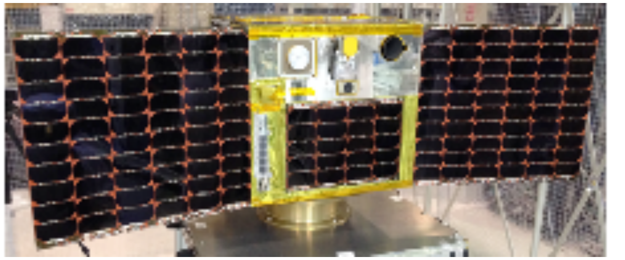
On-demand target pointing

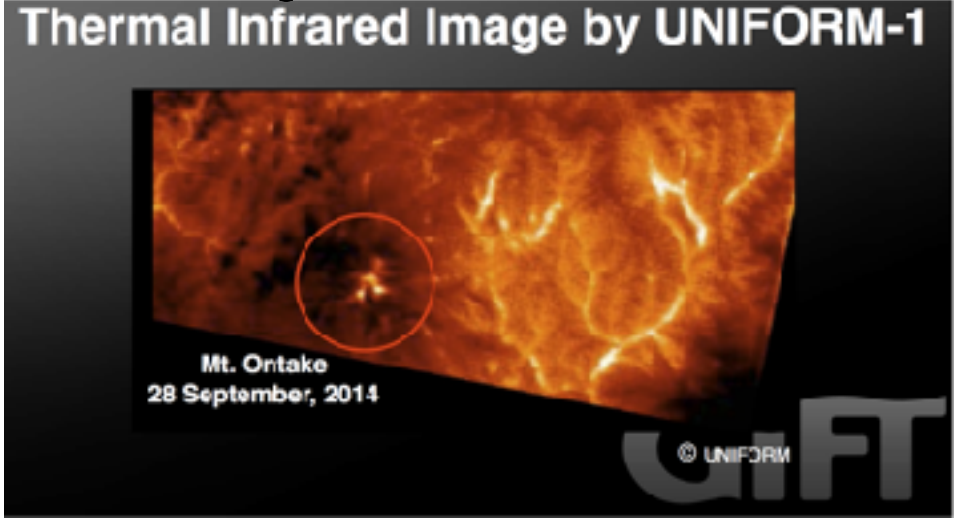


DIWATA-1, the first Philippine micro-satellite and released from International Space Station (2016.4)

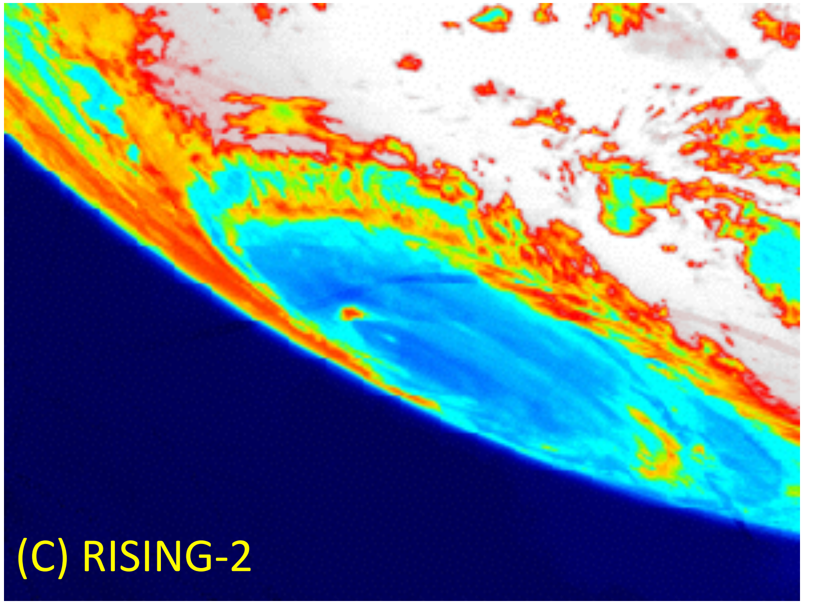


UNIFORM-1 satellite with Thermal Infrared sensor developed by Hokkaido University





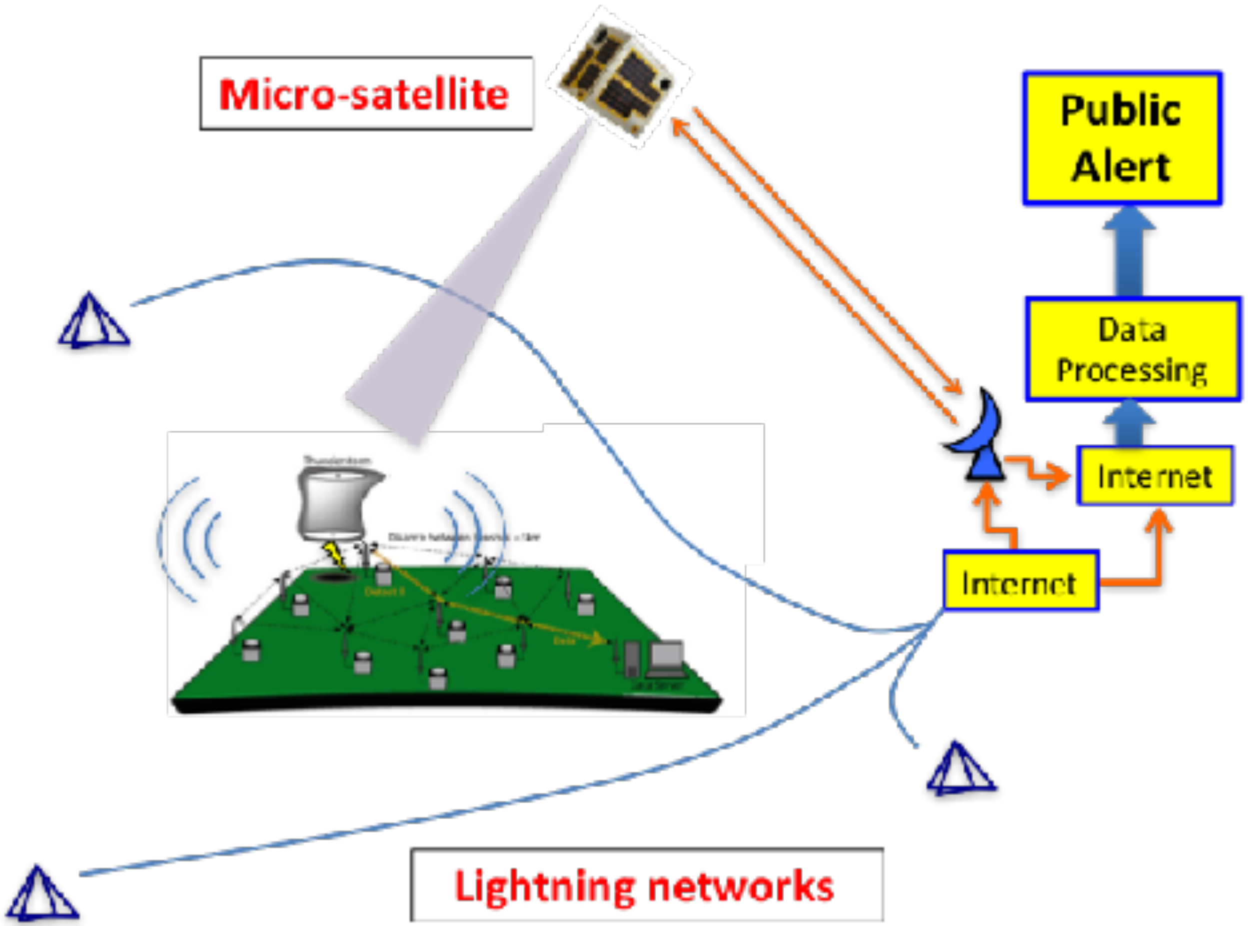
Volcano eruption



Typhoon observation with RISING-2 satellite

Final goal:
next generation disaster monitoring system

Quasi real-time report of thunderstorm development



Lightning observation

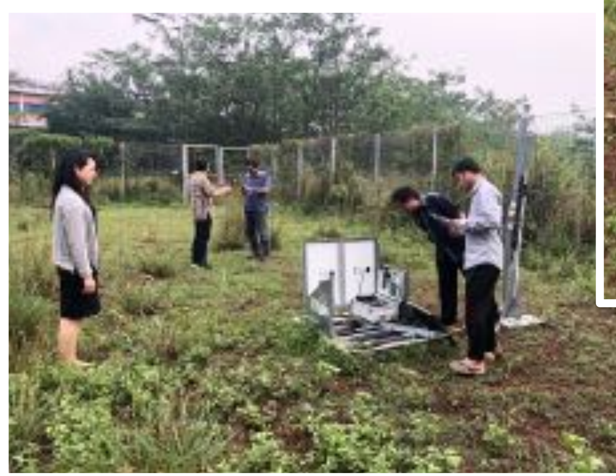
system installation and analysis

e-ASIA/SATREPS activities

Lightning sensor (POTEKA) installation

POTEKA system with lightning sensor (Sapporo station)

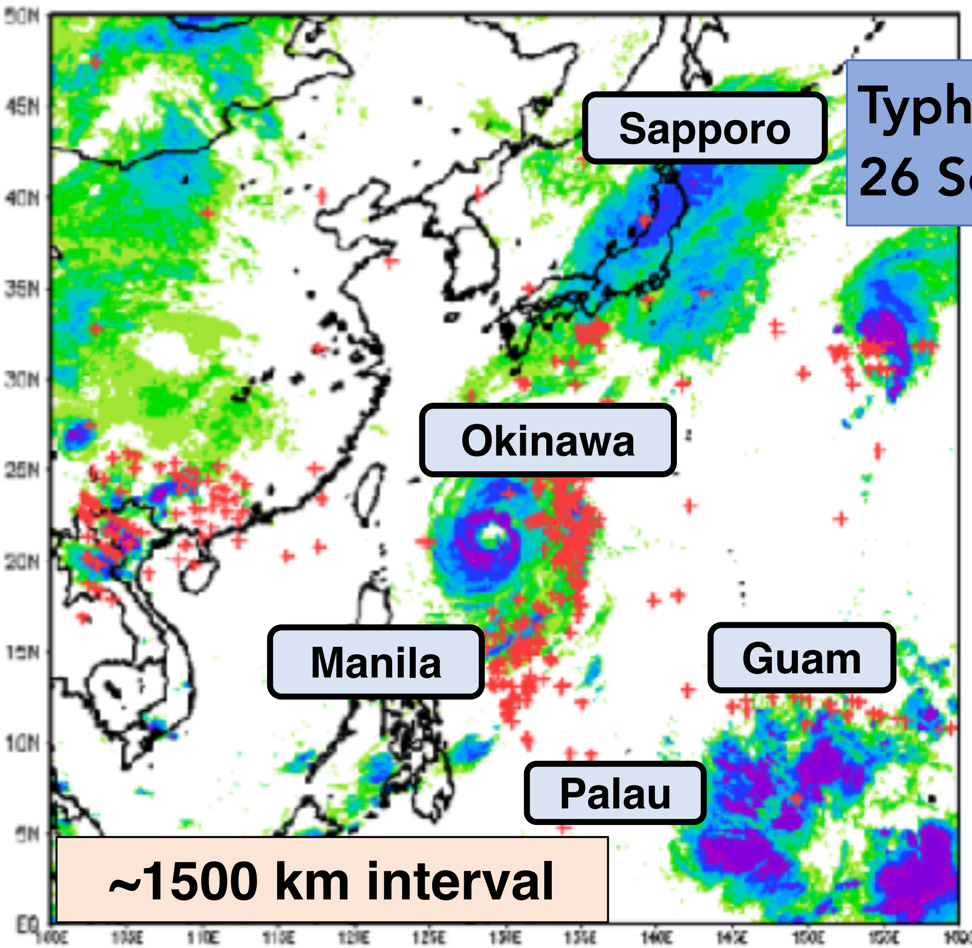
Training in Japan



Serpong station

Typhoon network

Typhoon 24, Trami/Paeng
26 Sep 2018



+: geolocated lightning

VLF receiver

30 km accuracy for geolocation
6 sites completed

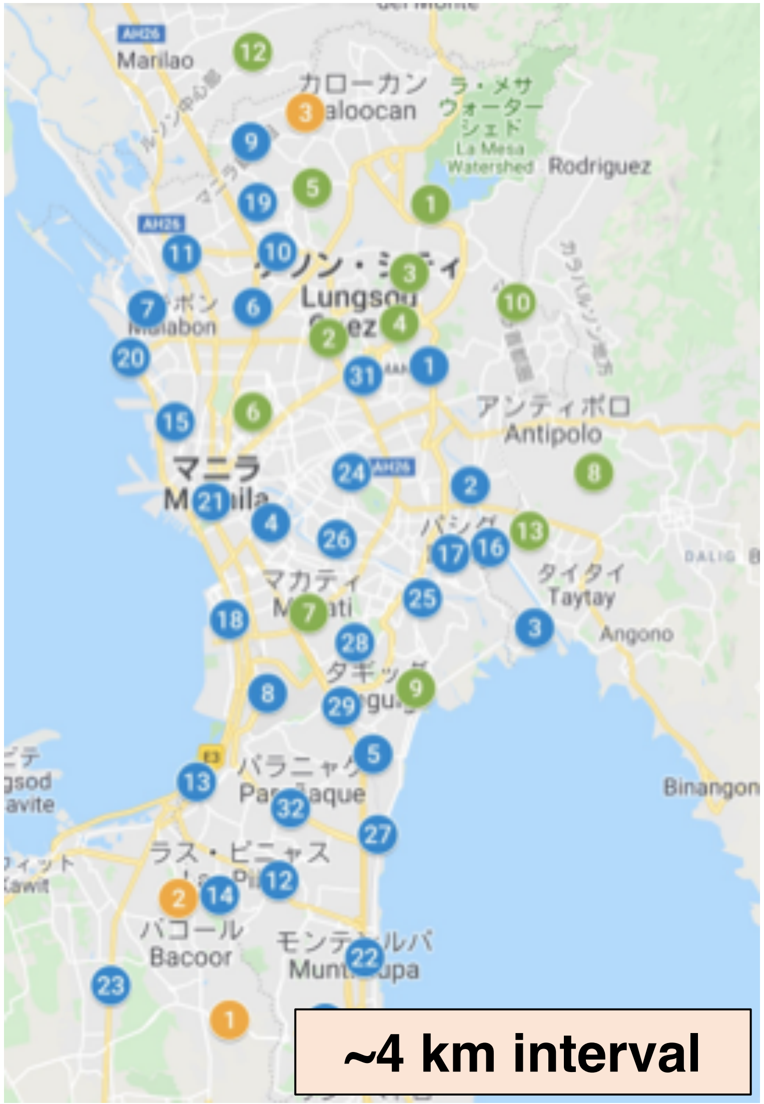
Nation-wide network

~300 km interval

VLF receiver
Infrasound (>0.01 Hz)
+ AWS

3 km accuracy for geolocation
>5 sites/10 sites completed

Metro Manila network



~4 km interval

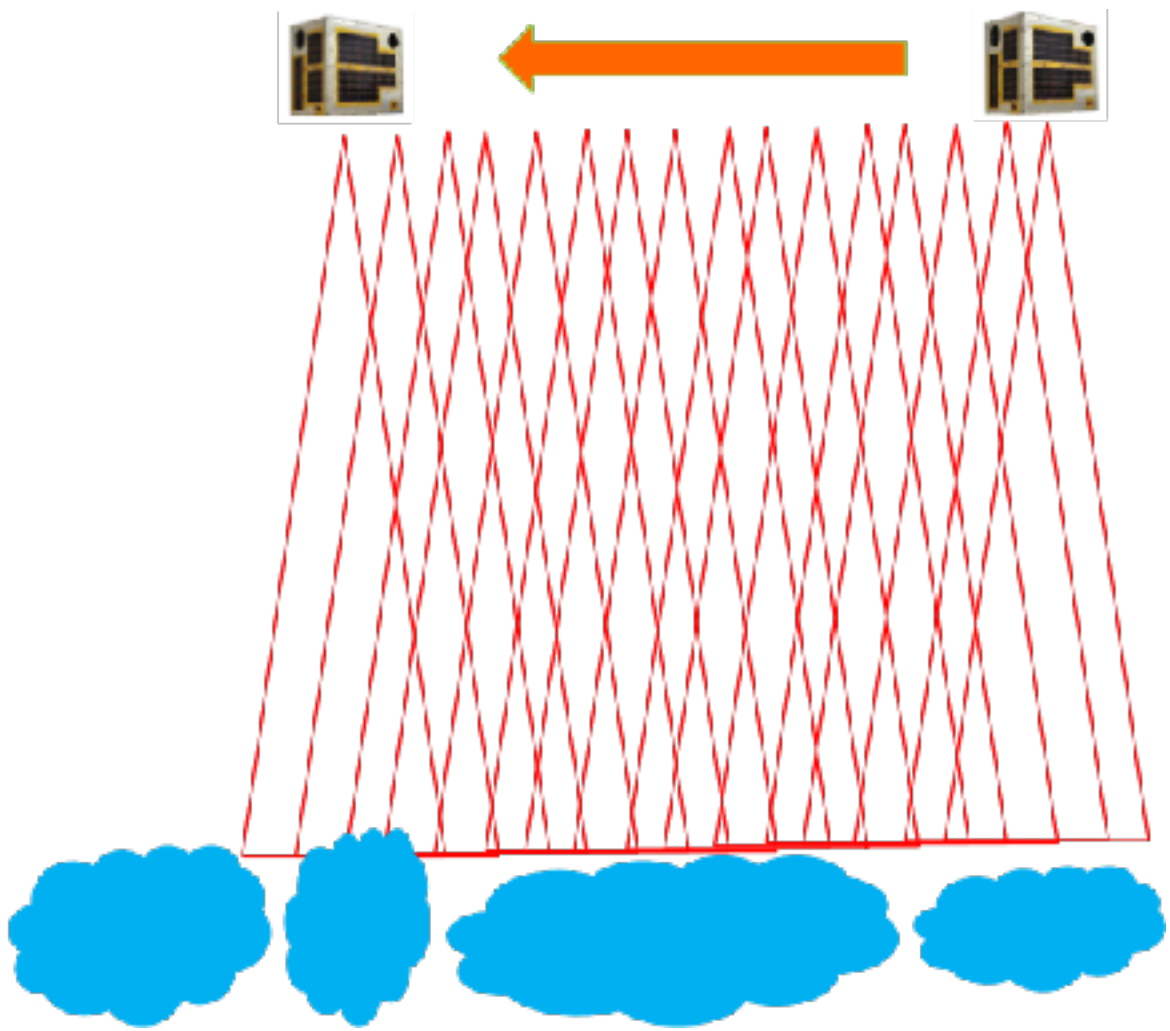
Slow antenna (quasi static E field)
Field mil (static field)
Infrasound (>0.1 Hz)
+ AWS

100 m accuracy for geolocation
>32 sites/50 sites completed

Micro-satellite

- On-demand operation and 3-D imaging
- development of thermal infrared

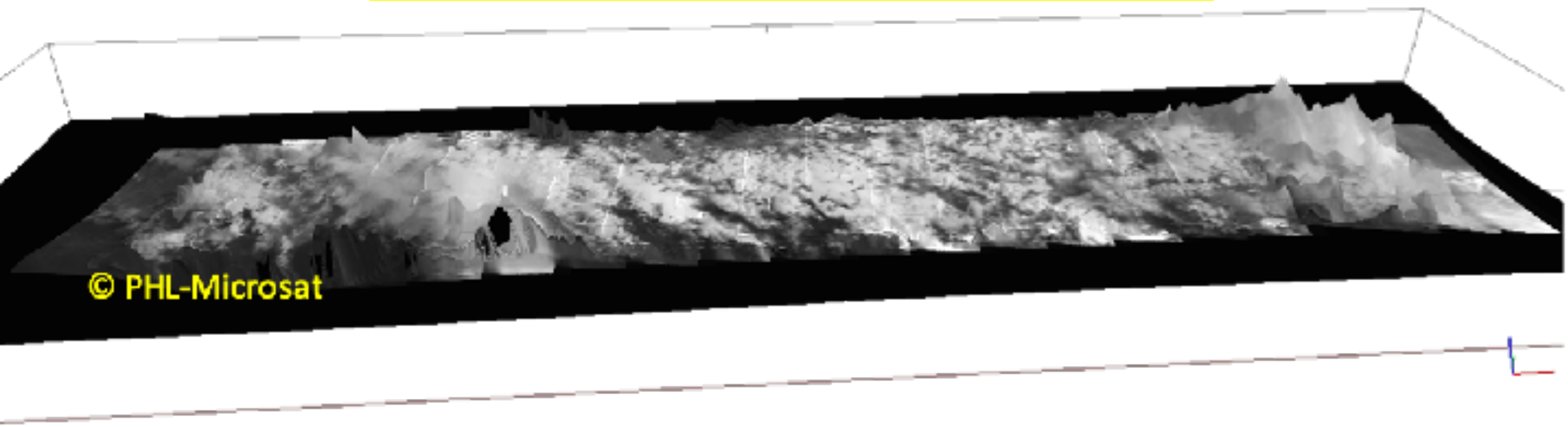
Stereo imaging by consecutive exposures



e-ASIA/SATREPS activities

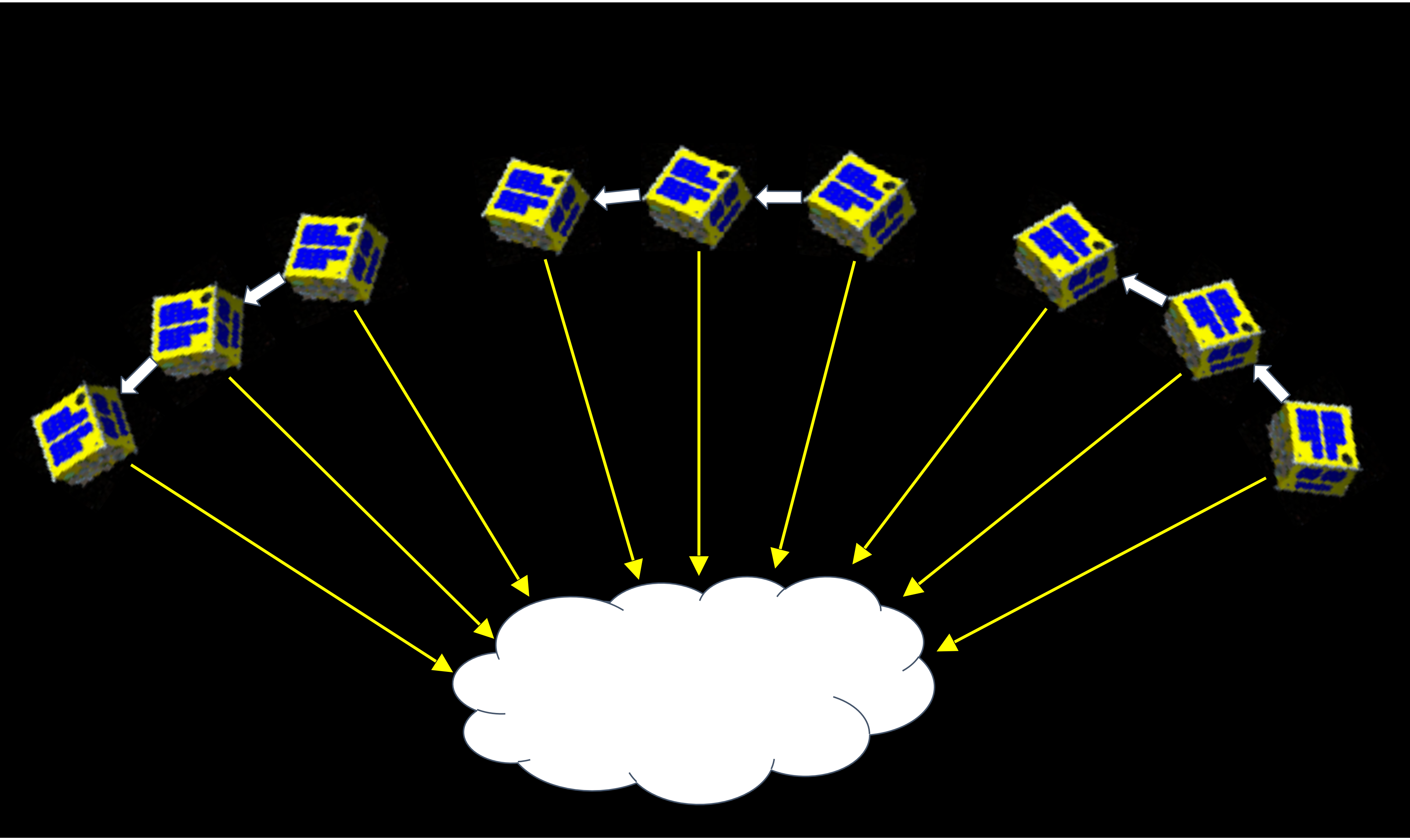
STEREO imaging by DIWATA-1

Catro master (2018) work (Hokkaido Univ)



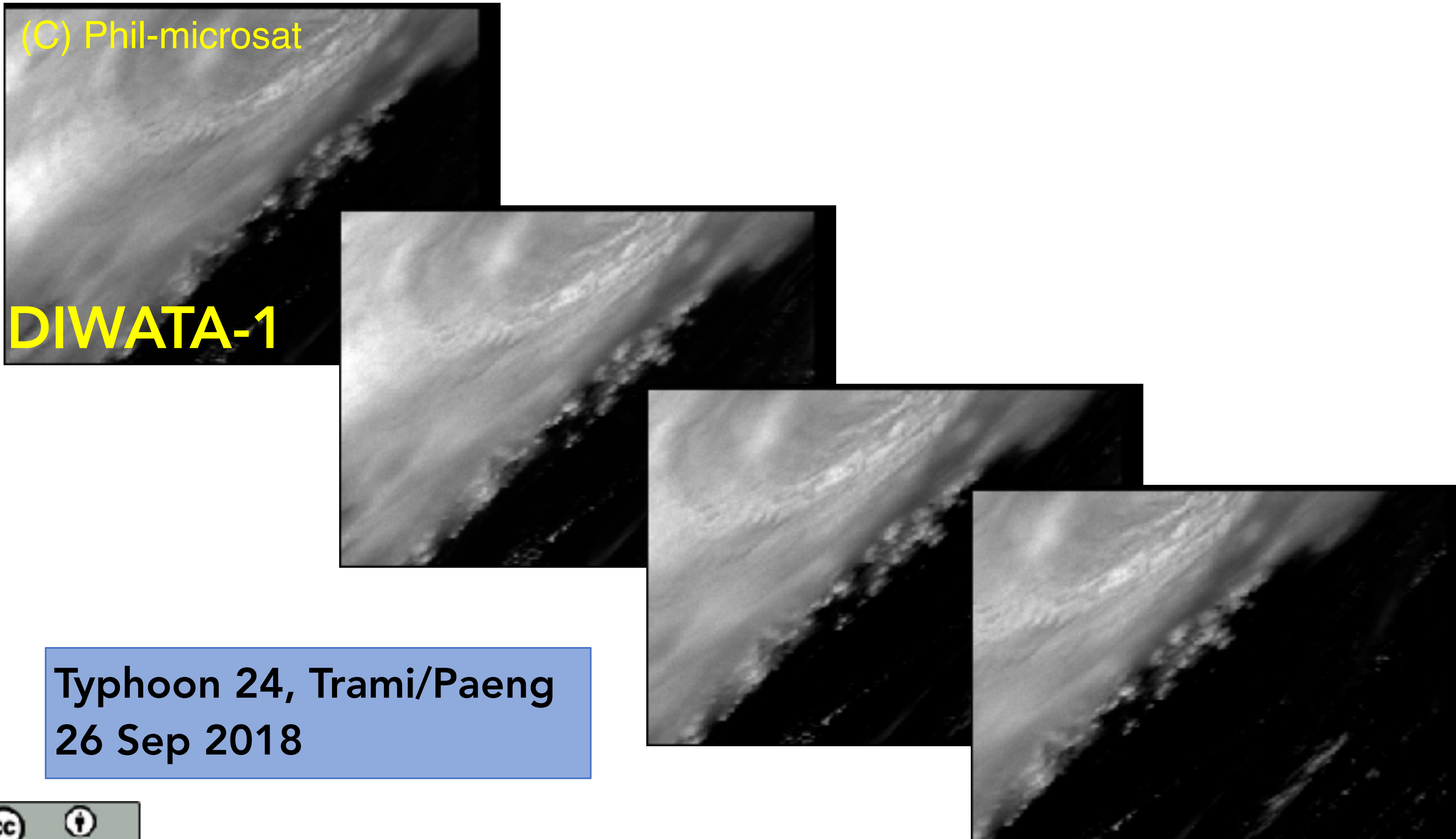
The world's first detailed 3-D cloud top structures observed by satellite

On-demand target pointing



e-ASIA/SATREPS activities

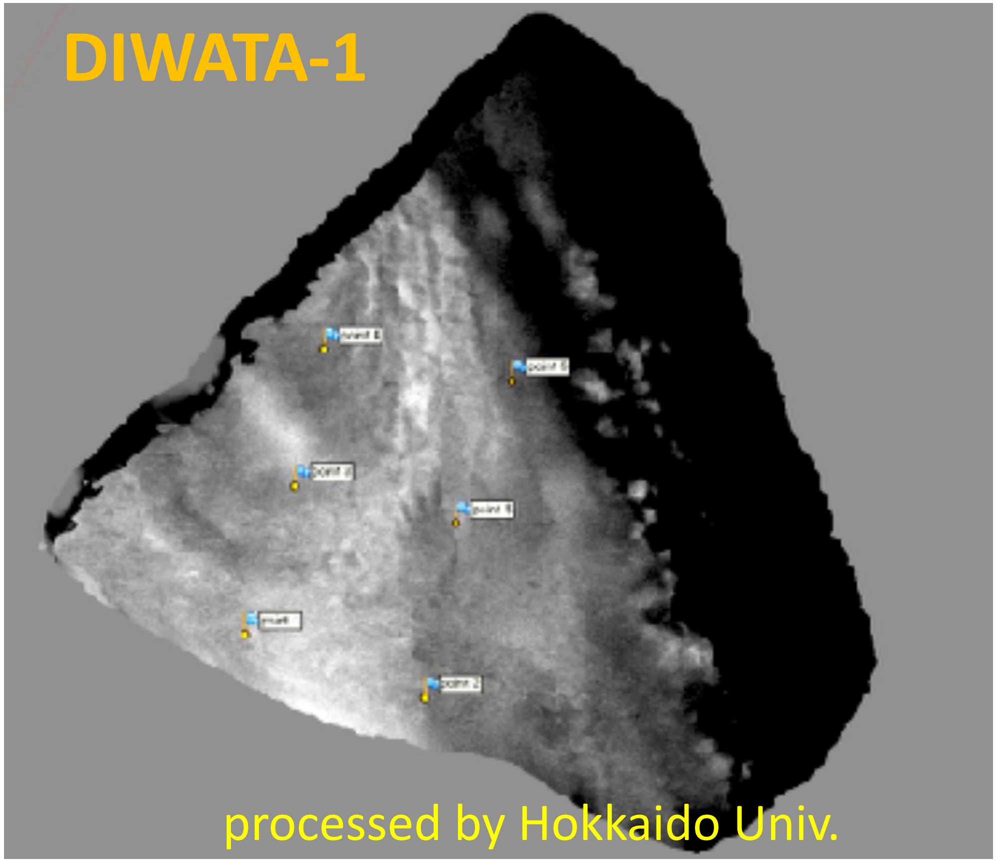
Target pointing of typhoon eye



Typhoon 24, Trami/Paeng
26 Sep 2018

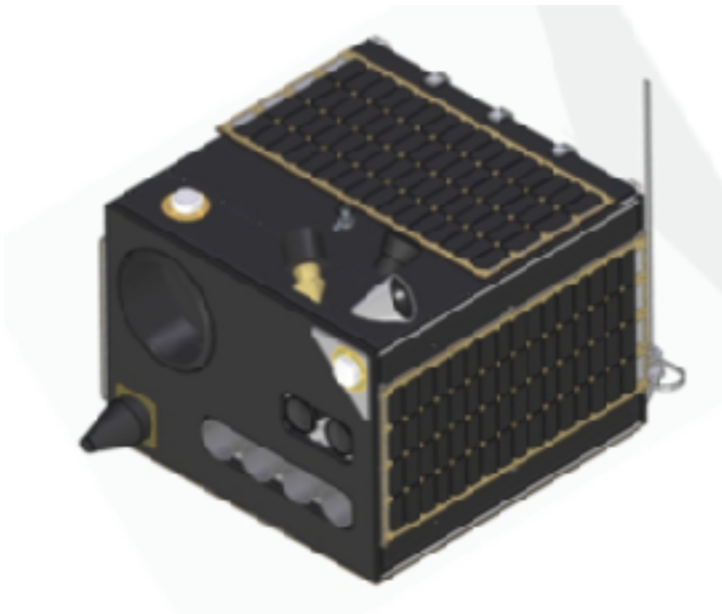
e-ASIA/SATREPS activities

The world's first precise 3-D image of typhoon eye

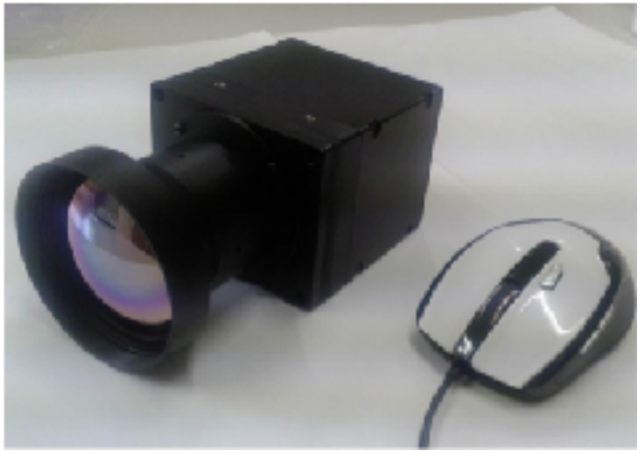


LAPAN A-4

will be launched 3th Quarter of 2020



Thermal Infrared Camera (TIS)

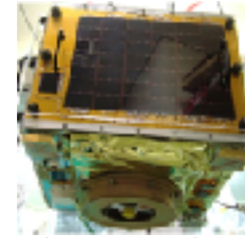


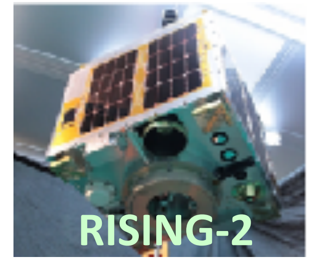
In order to estimate the cloud top temperature of thunderstorm

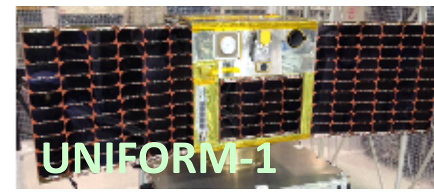
Heritages and on-going projects with 50-kg satellite

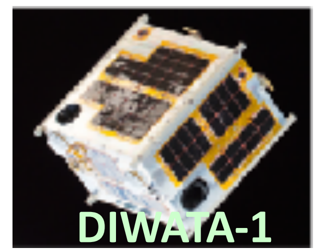
50-kg satellites (launching year)

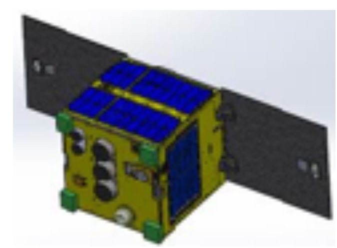
SPRITE-SAT (2009)
RISING-2 (2014)
UNIFORM-1 (2014)
DIWATA-1 (2016): Philippines
DIWATA-2 (2018) : Philippines
RISESAT (2019)
MicroDragon (2019): Vietnam
LAPAN A-4 (2020) Indonesia
Myanmar (2020-) x2 Myanmar
MMSAT (2021-) x 2 Malaysia

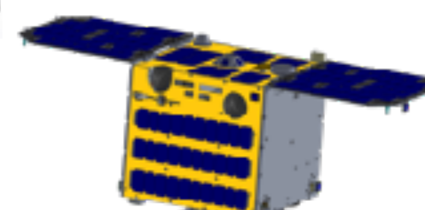

SPRITE-SAT





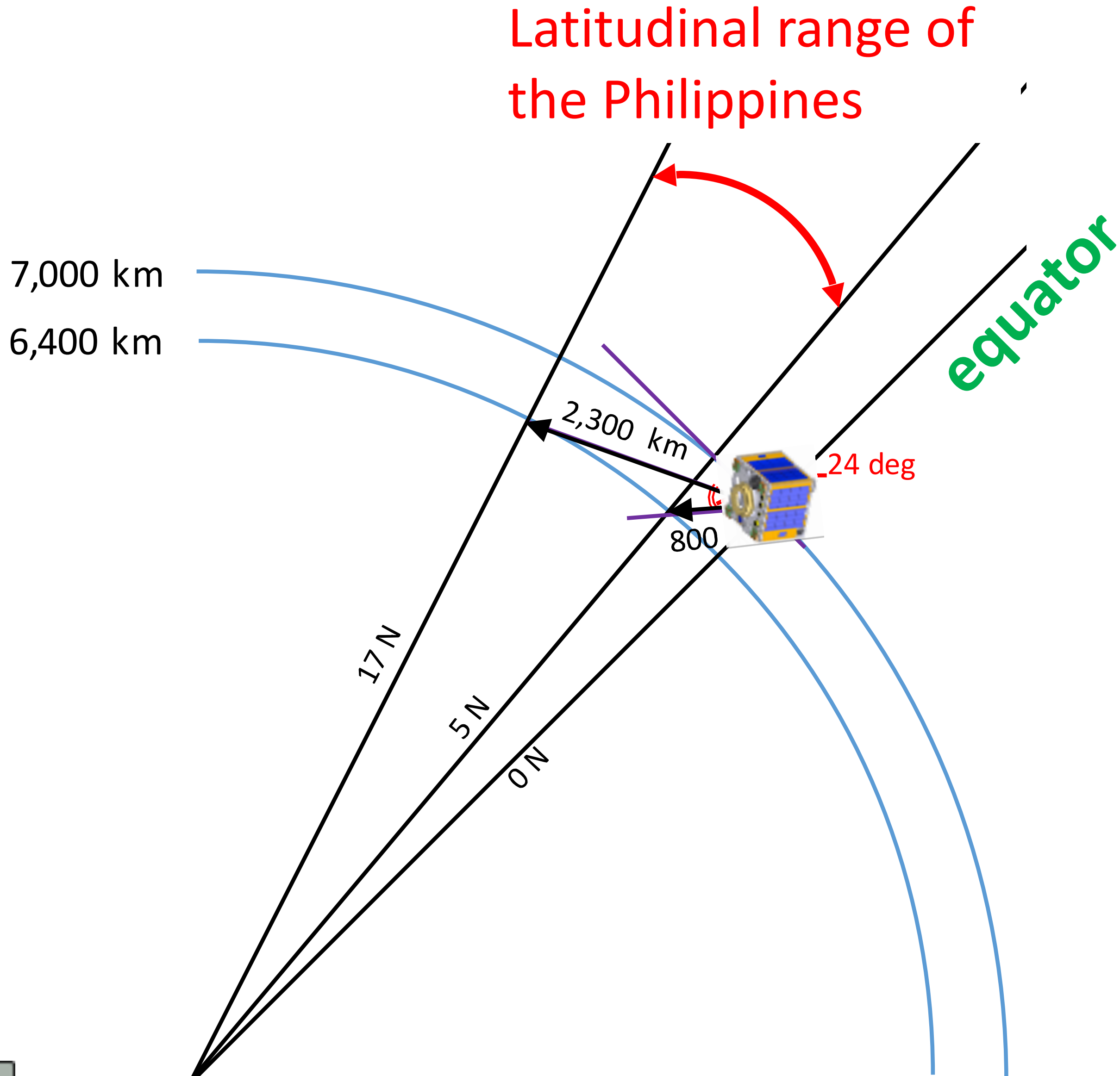



MicroDragon


DIWATA-2

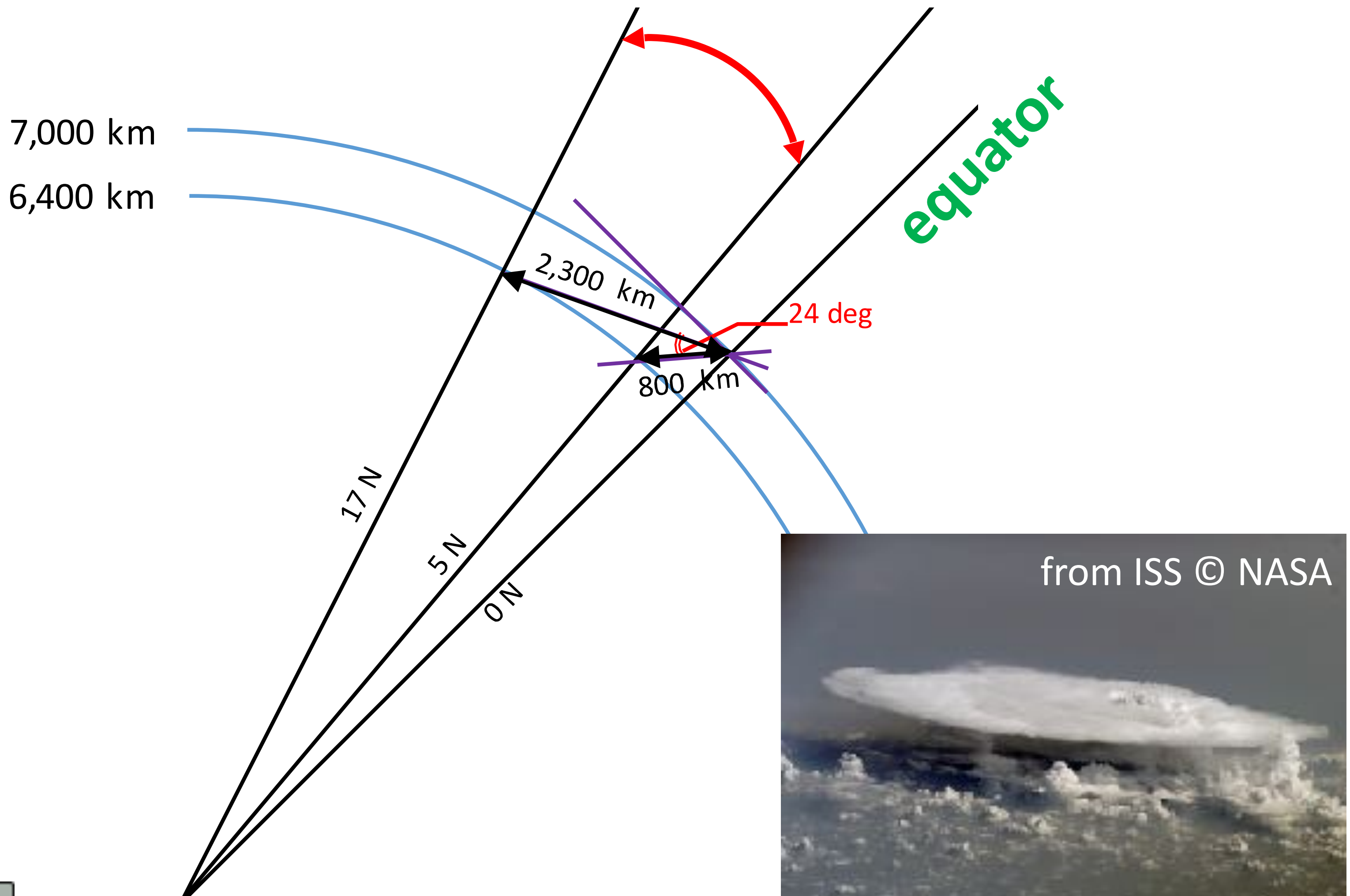
Future scopes

Future scope

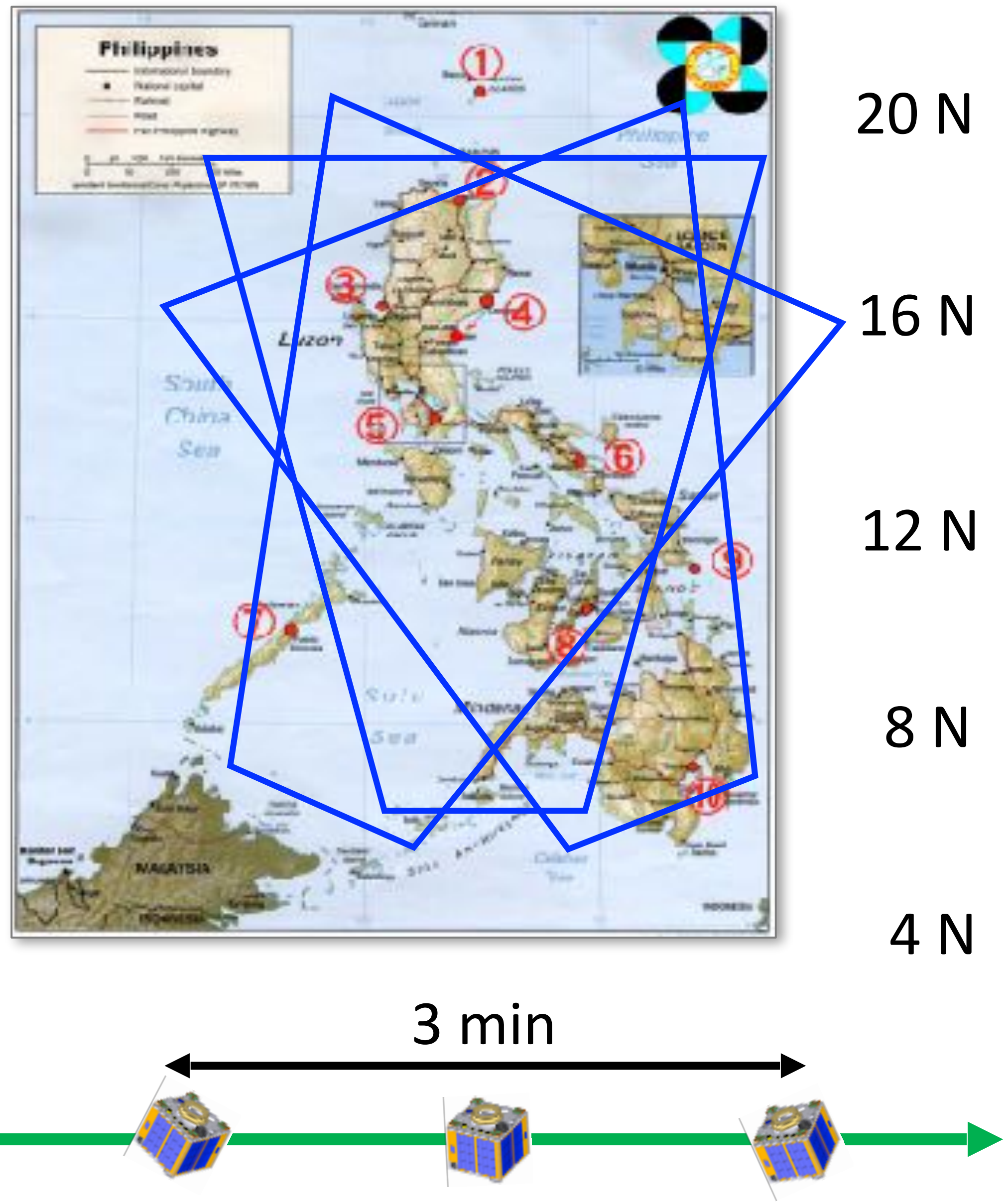


Future scope

Latitudinal range of the Philippines



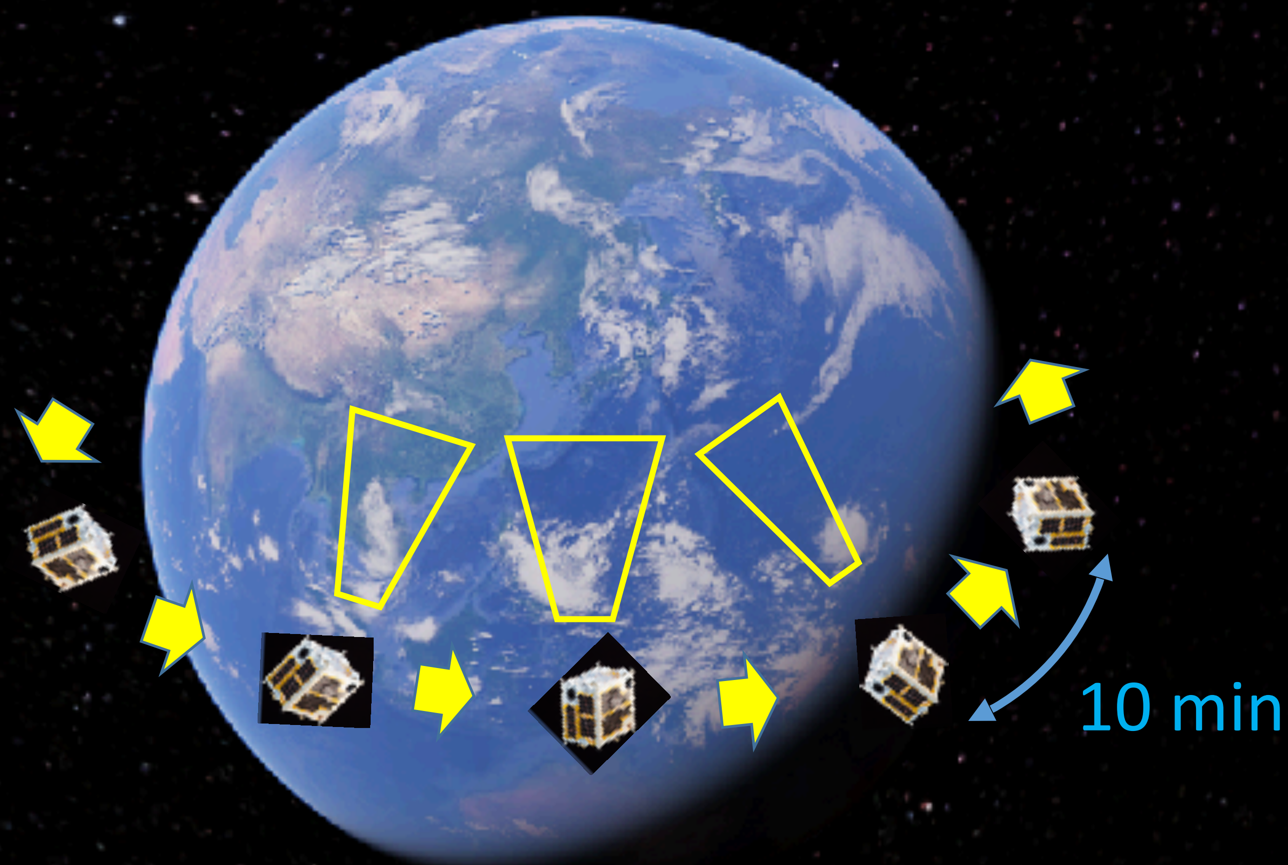
Future scope



equator

Future scope

10 satellites in equatorial orbit



Asian Micro-satellite Consortium

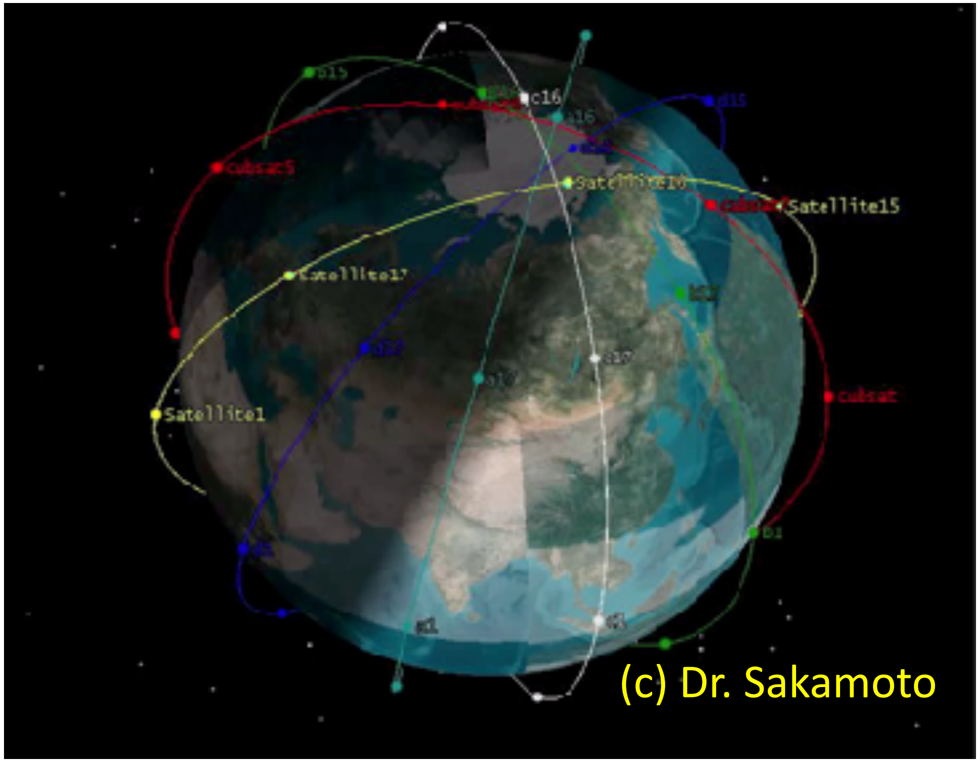
to maximize the efficiency of space use, sharing data, toward the **super-constellation** realizing real-time

- sharing data, technology, and application
- standardizing sensor and operation system
- establishing ground validation

- involving **9 countries in Asia**
- signed by representatives of 16 universities/institutes

Future scope

Super constellation under international collaboration



If we share ~50 satellites, continuous monitoring of disaster anywhere in the world will be possible.

Satellite + Ground = next generation earth monitoring