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National Applied Research Laboratories

Data Provider Node (DPN) Report
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November 2, 2018

Awaji Island, Japan

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Outline

1. Formosat-5 Image Introduction
2. Formosat-5 observation support to Sentinel Asia
3. Formosat-5 Image Application

FORMOSAT-5 Program

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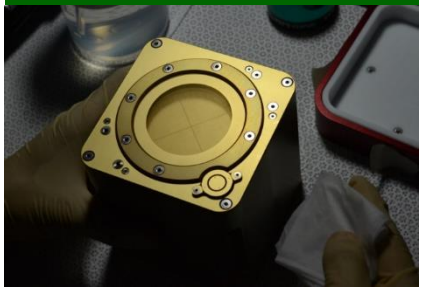
- To build up and demonstrate Taiwan's indigenous space technology on the remote sensing satellite
- To continuously serve the global imagery user's community of FORMOSAT-2
- Utilizing the linear CMOS image sensor for high-resolution (GSD =2m) EO satellite
- FORMOSAT-5 (FS-5) satellite had launched on August 25, 2017, at 2:50 a.m. Taiwan time by SpaceX's Falcon-9 rocket.
- FS-5 has begun formal operation in October 2018.

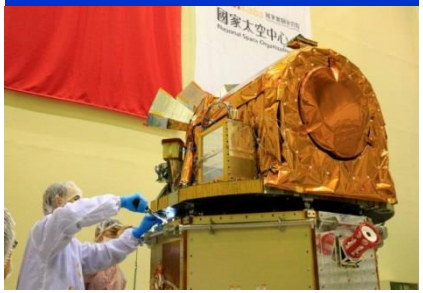
Space Segment

Spacecraft Bus

AIP (Science P/L)



RSI (Mission P/L)



Satellite I&T

Ground Segment

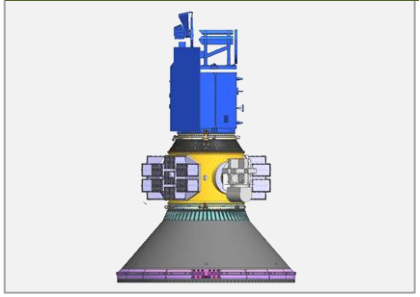
Mission Ops

Image Processing

Launch Segment

Falcon 9

Launch Configuration



FORMOSAT-5 Key Parameters

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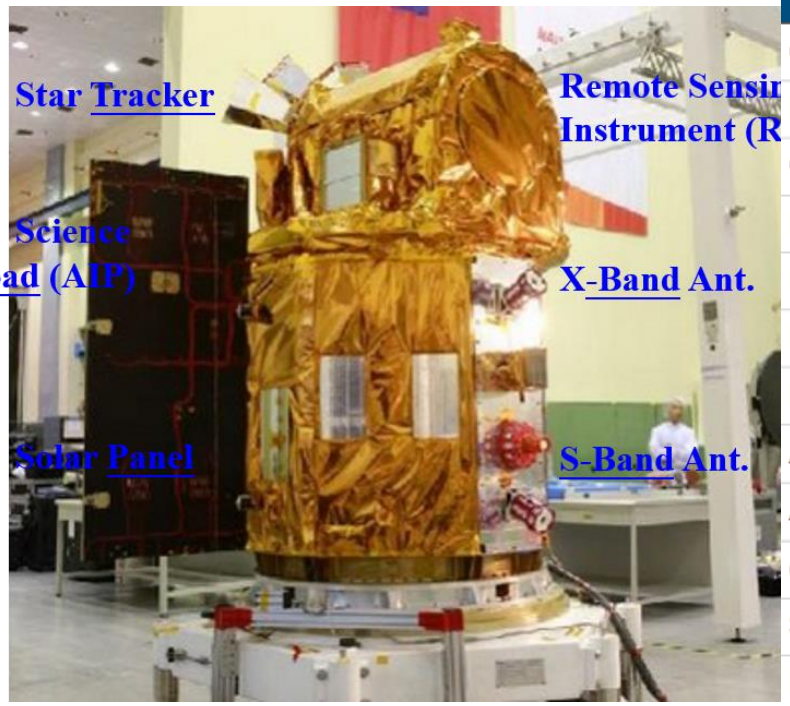

Characteristics	Description
Category	Remote sensing satellite
RSI Image Sensor	CMOS Image Sensor
Orbit	Sun-synchronous orbit @ 720 km / 98.2°
Repeatability	Every two days
Field of Regard	45° in pitch and roll axis
Period	about 99 minutes
Mission Life	5 years
Attitude Pointing Accuracy	≦2 km in nadir direction for RSI imaging
Attitude Pointing Knowledge	≦ 390 m without GCP
Ground Sampling Distance (GSD)	2m @ nadir (PAN), 4m @ nadir (Blue, Green, Red, Infrared)
Swath Width	24 km @ nadir
Radiometric Resolution	12 bits
Contrast Transfer Function (CTF)	≧ 0.1(PAN) ≧ 0.2 (Blue, Green, Red) ≧ 0.16 (Infrared)
Signal-to-Noise Ratio (SNR)	≧83 (PAN); ≧95 (Red); ≧95 (Green); ≧100 (Blue); ≧100 (Infrared)

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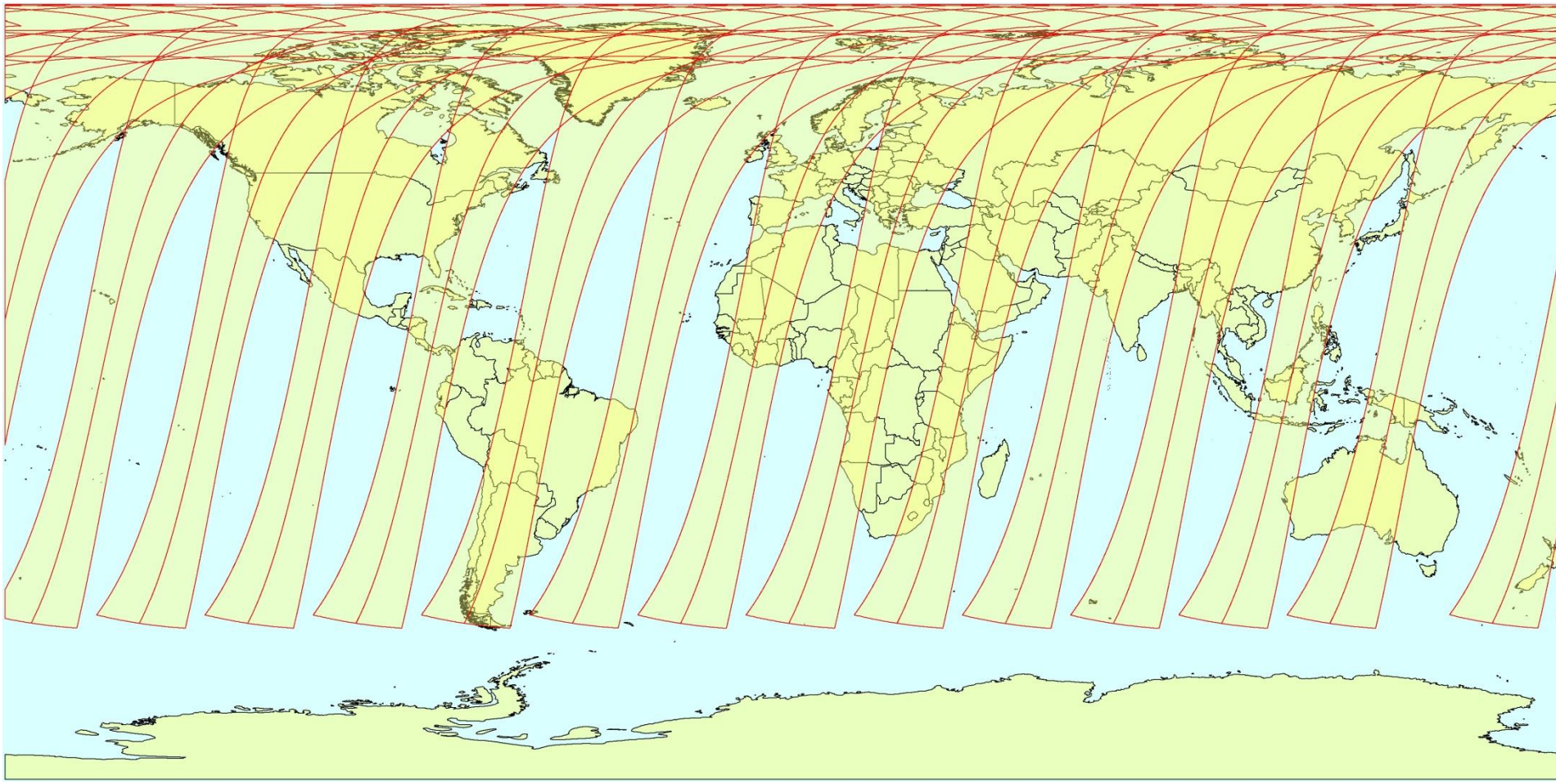
FORMOSAT-5 Coverage Day1



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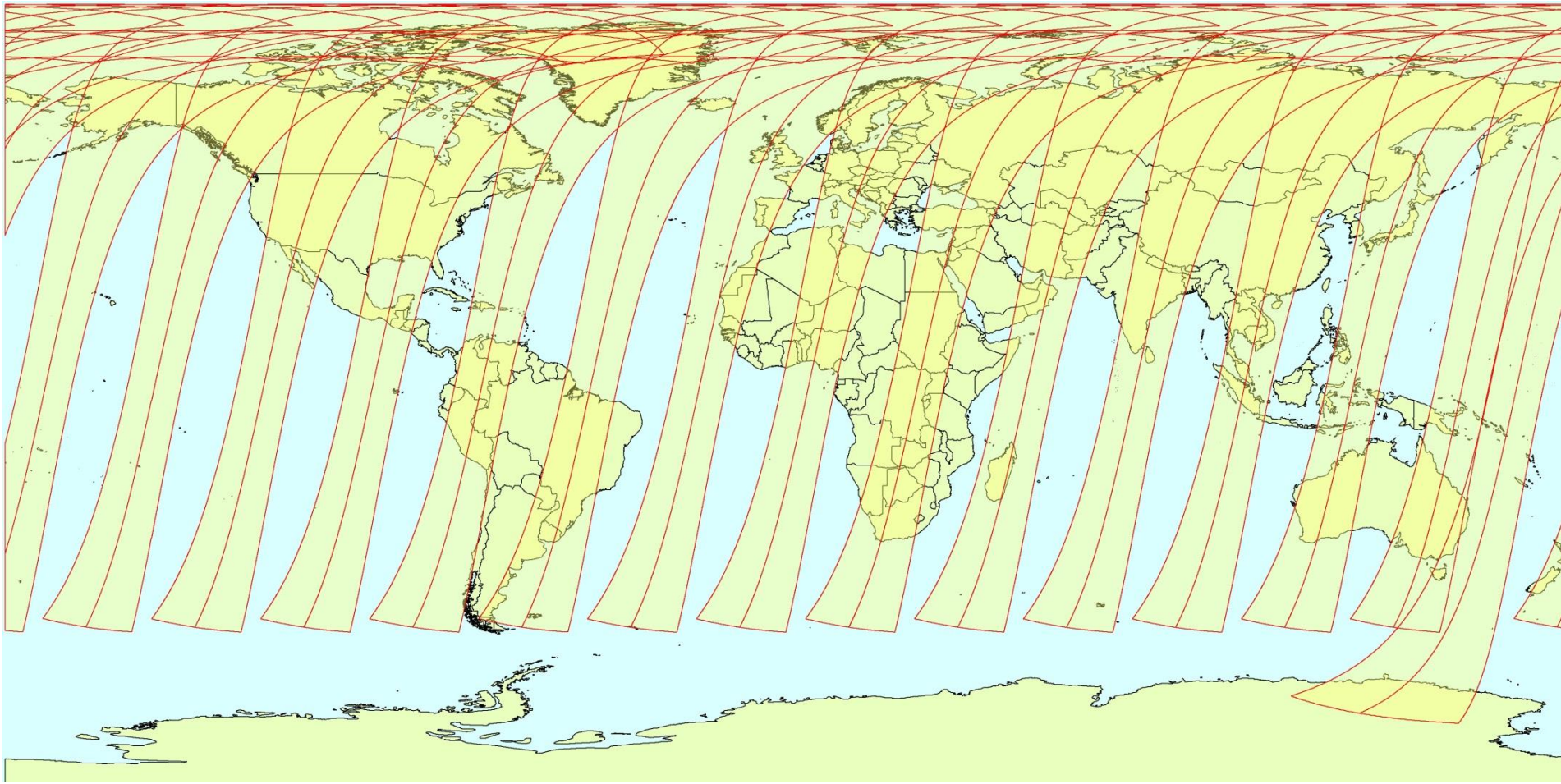
FORMOSAT-5 Coverage Day2



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FORMOSAT satellite support sentinel Asia

- **FORMOSAT -2 has been contributing Sentinel Asia since 2011 and decommissioned on June 20, 2016.**
- **FORMOSAT-2 archived data is available up to 55% percentage of land coverage of Earth for humanitarian supports.**
- **FORMOSAT-5 launched in August 25th 2017. Its observation start to support Sentinel Asia on July 2018.**

Disaster Type	2010	2011	2012	2013	2014	2015	2016	2018
Earthquake	0	5	3	0	0	2	2	2
Landslide	2	0	1	3	3	0	0	0
Tsunami	1	0	0	0	0	0	0	0
Volcano erption	2	1	0	1	3	0	0	0
Flood	5	16	4	5	3	4	4	1
Others	1	0	7	2	2	3	2	1
Total	11	22	15	11	11	9	8	4

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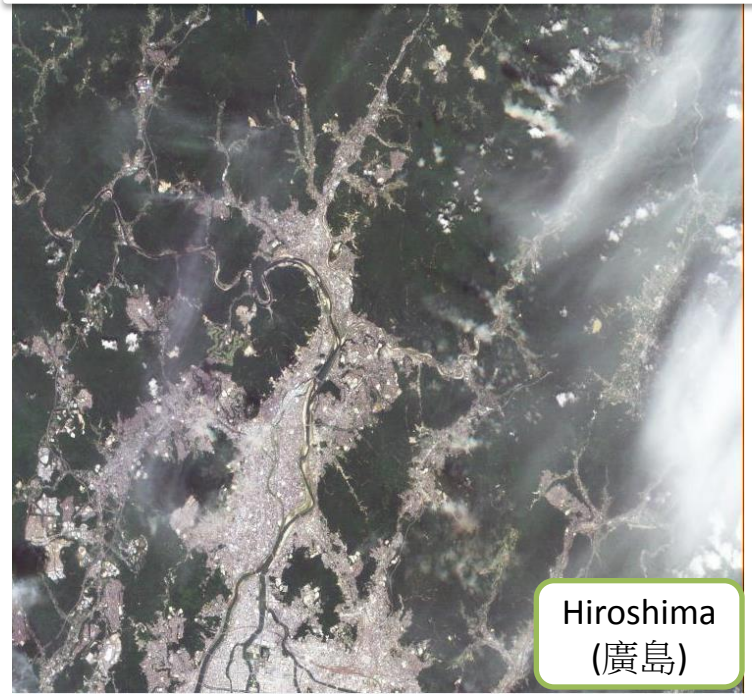
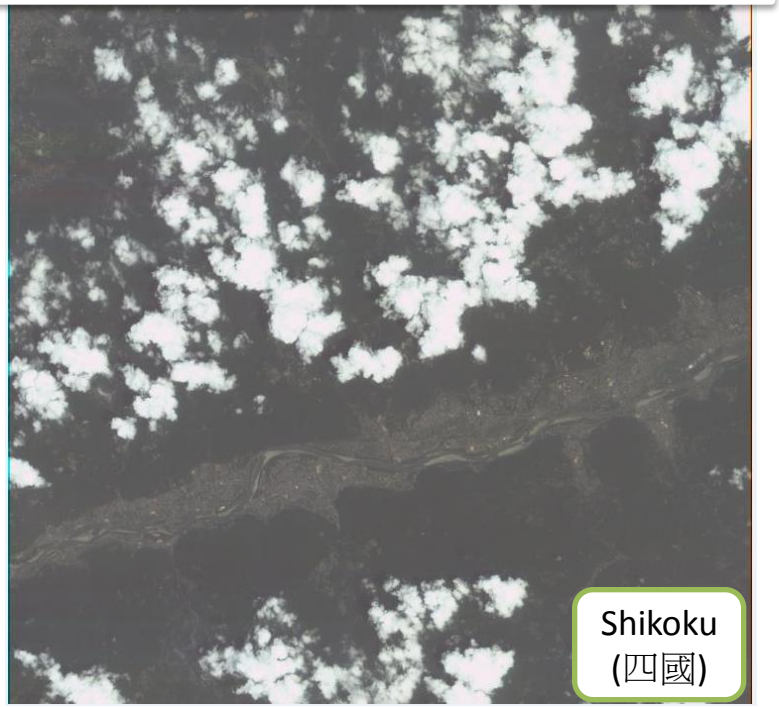
Disaster Support

Emergency Obs. ID	Date	Disaster	Country	Formosat5
ERJPJX000085	2018/7/6	Flood	Japan	2018/07/11 2018/07/17

Record heavy rainfall continued to pound western and central parts of Japan



2018/07/11



2018/07/17

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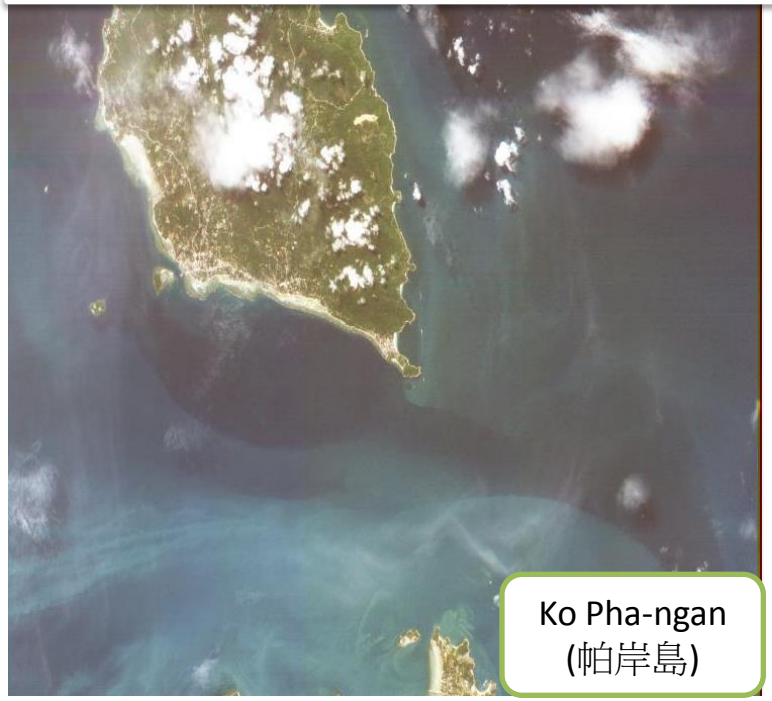
Disaster Support

Emergency Obs. ID	Date	Disaster	Country	Formosat5
ERTHGS000017	2018/7/9	Other	Thailand	2018/07/27

Oil spill occurred in southern of Thailand



2018/07/27

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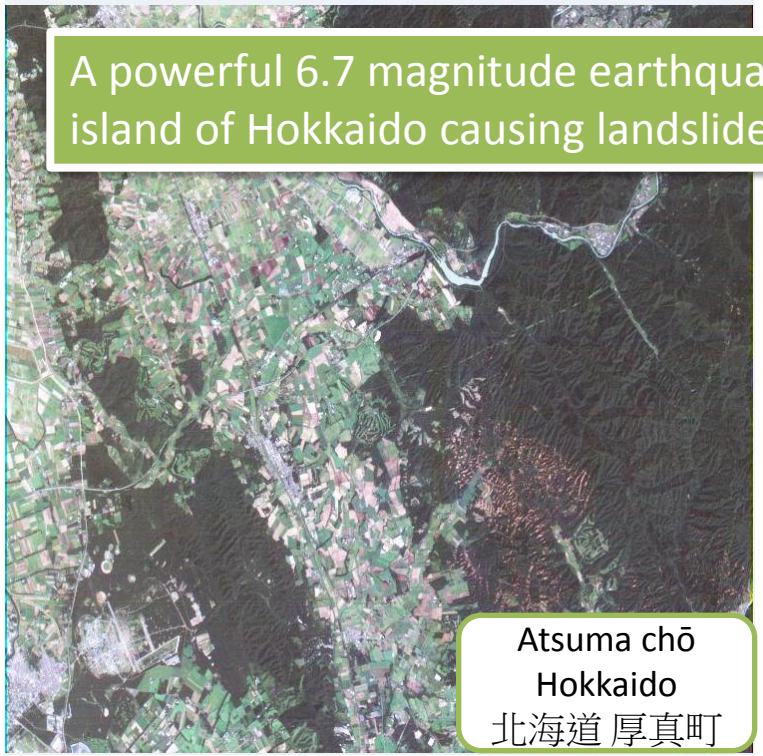
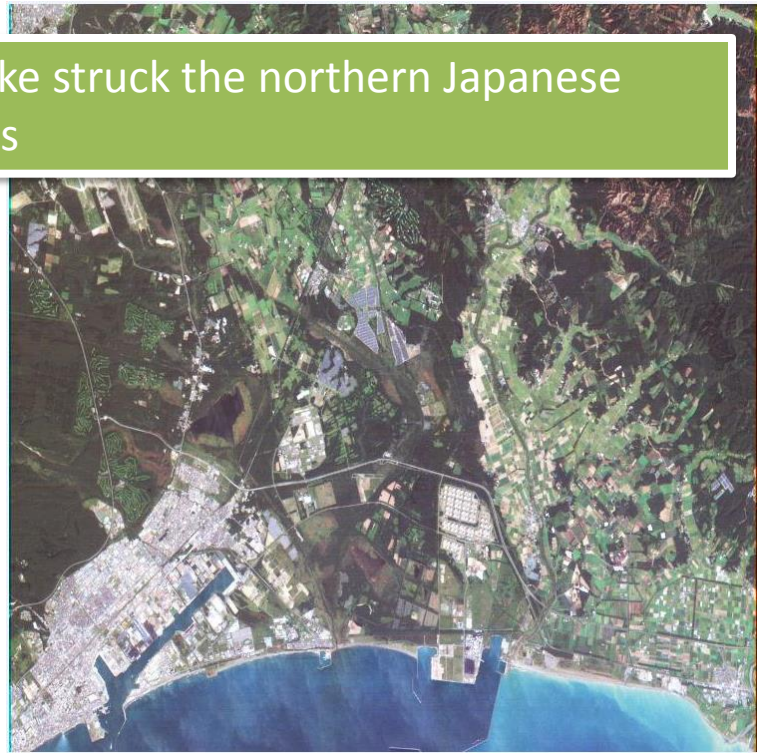
Disaster Support

Emergency Obs. ID	Date	Disaster	Country	Formosat5
ERJPJX000087	2018/9/5	Earthquake	Japan	2018/09/11

A powerful 6.7 magnitude earthquake struck the northern Japanese island of Hokkaido causing landslides



2018/09/11



2018/09/11

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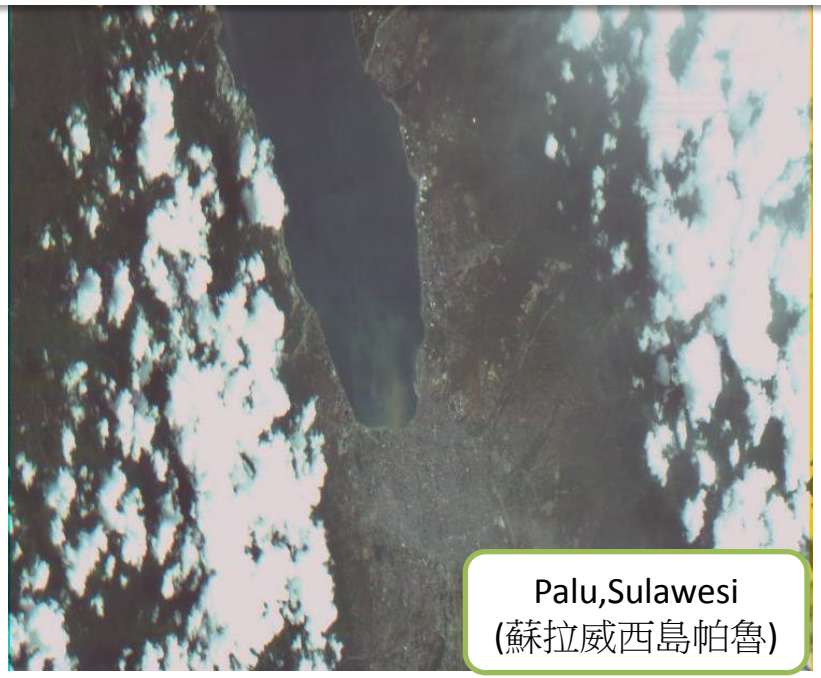
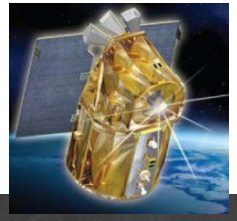
Disaster Support

Emergency Obs. ID	Date	Disaster	Country	Formosat5
ERAHAC000006	2018/9/28	Earthquake	Indonesia	2018/10/02

A powerful 7.5 magnitude earthquake struck the Indonesian province of Central Sulawesi. The earthquake caused a deadly tsunami in coastal areas.



2018/10/02



Panchromatic Image, Taoyuan Airport

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Image Date:2018/8/7
Cloud Coverage: ~18%

Multi-Spectral Image, Taoyuan Airport

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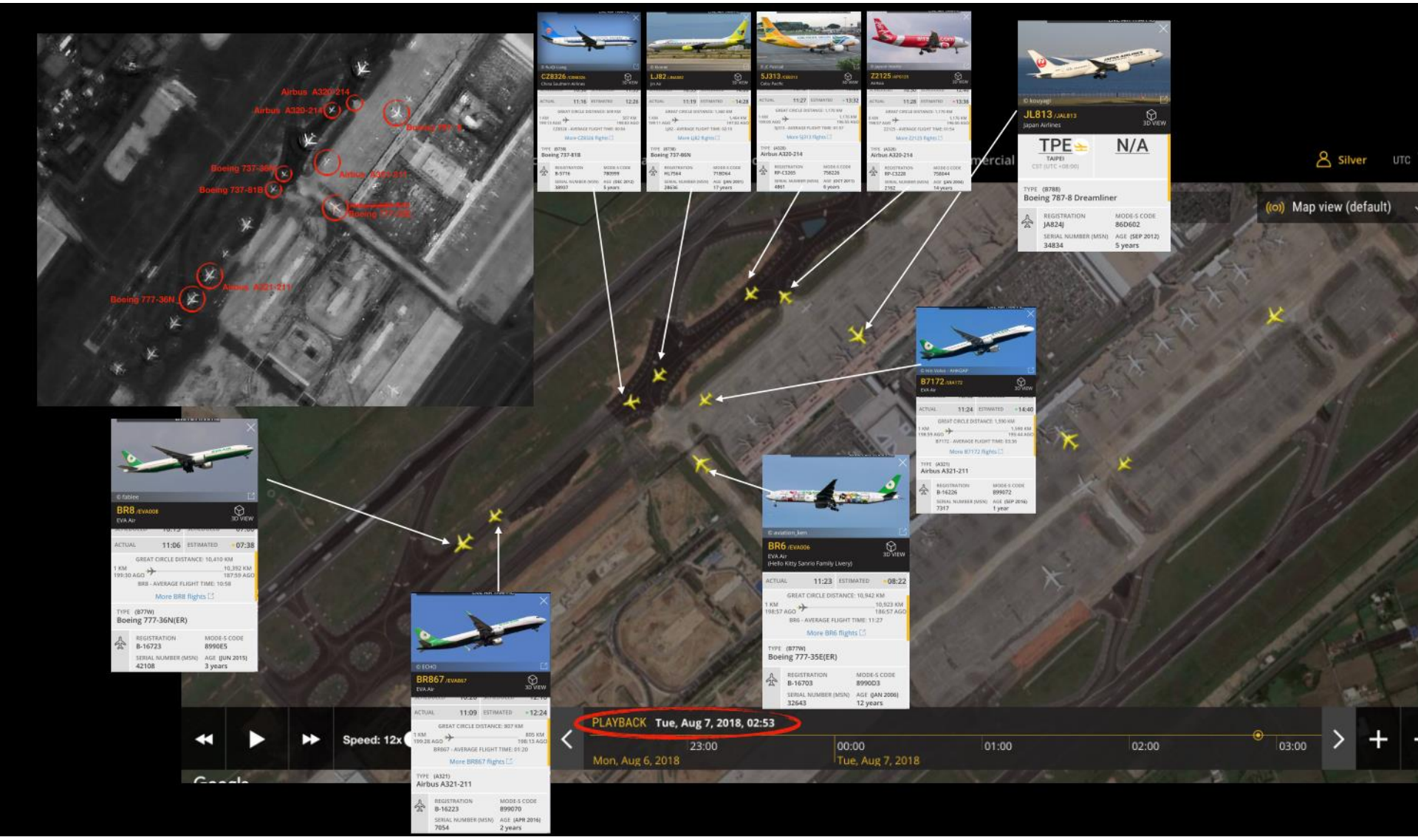
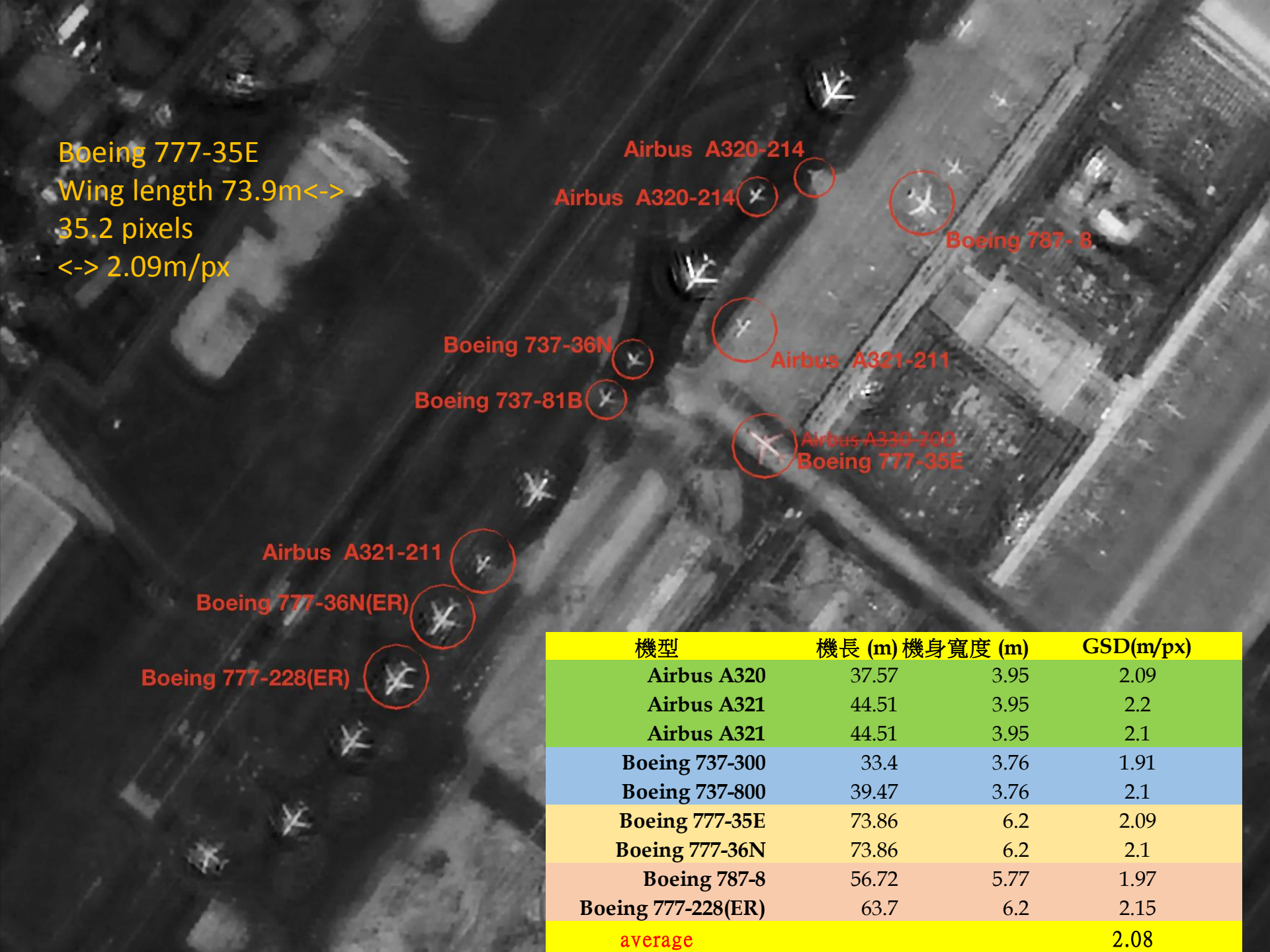
Airplane Info. (from flightradar24)



解析度判讀(飛機長度, MS桃機影像)



機型	機長 (m)	機身寬度 (m)	GSD(m/px)
Airbus A320	37.57	3.95	2.09
Airbus A321	44.51	3.95	2.2
Airbus A321	44.51	3.95	2.1
Boeing 737-300	33.4	3.76	1.91
Boeing 737-800	39.47	3.76	2.1
Boeing 777-35E	73.86	6.2	2.09
Boeing 777-36N	73.86	6.2	2.1
Boeing 787-8	56.72	5.77	1.97
Boeing 777-228(ER)	63.7	6.2	2.15
average			2.08

What can be done

- With single image

Index calculation		
NDVI (Normalized difference vegetation index)	○	$NDVI = \frac{NIR - RED}{NIR + RED}$
EVI(Enhanced vegetation index)	○	$\text{EVI} = 2.5 \times \frac{NIR - RED}{NIR + 6 \times RED - 7.5 \times BLUE + 1}$
NDWI (Normalized difference water index)	○	$NDWI = \frac{GREEN - NIR}{GREEN + NIR}$
NDSI (Normalized difference soil index)	×	$NDSI = \frac{SWIR - NIR}{SWIR + NIR}$
GRVI (Green-Red vegetation index)	○	$\text{GRVI} = \frac{GREEN - RED}{GREEN + RED}$

Good	○
Fair	△
Poor	×

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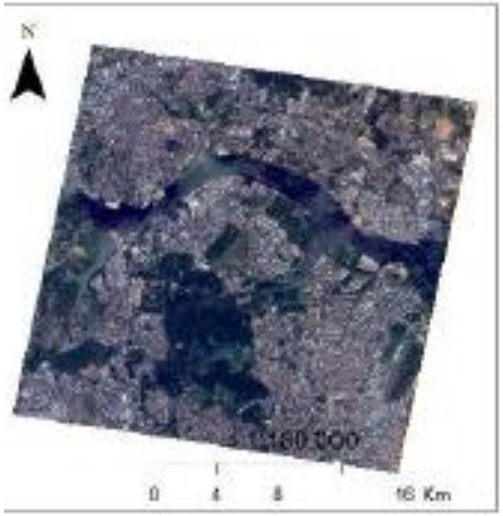
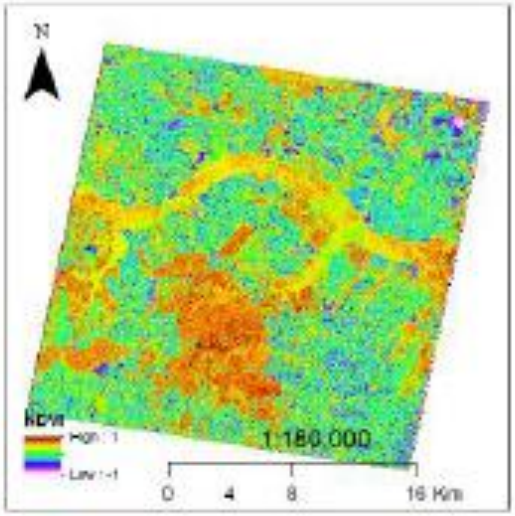
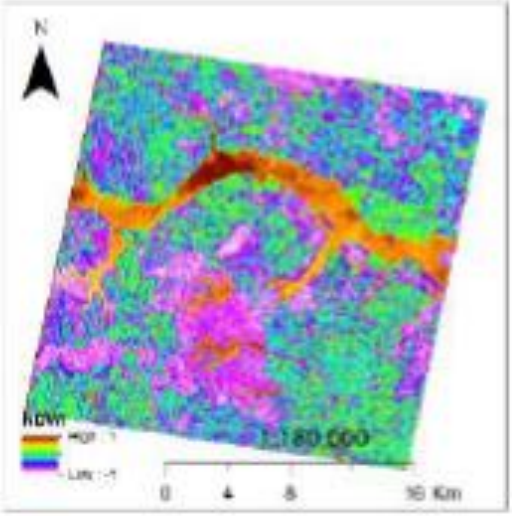
Result of index calculation



RGB image



GRVI: Can be used for a phonological indicator such as leaf green-up and autumn coloring



NDWI: Monitor changes in water content, water level (flooding impacts)

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What Can be Done

- With single image

Classification		
Urban, agriculture, forest, wetland, water bodies	○	Some difficulties in mountainous area
Broadleaf and conifer	△	Possible in winter
Dense and sparse	×	May be possible by reflectance properties
Forest type (Species)	×	May be possible in some forest type
Identification		
Building	○	Better using Pancromatic band
Car and boat	△	Not very clear
Tree stem	×	Cannot identify
Person	×	Invisible
Wildlife	×	Invisible

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What Can be Done

- With time-series images

Forest loss detection (from 0.0016 ha)	○	Only possible if there is no misregistration
Forest degradation	△	Only possible for some type of degradation (ex. Windthrow damage)
Land use change analysis	○	Only possible if there are no misregistration
Carbons stock calculation	○	Possible with carbon factor for each landuse type
AGP (Annual greenest pixel)	○	Only possible if there are no misregistration

Phenological Change Detection

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Multi-resources, multi-period high-resolution satellite imagery to analyze phenological changes for detection purpose.

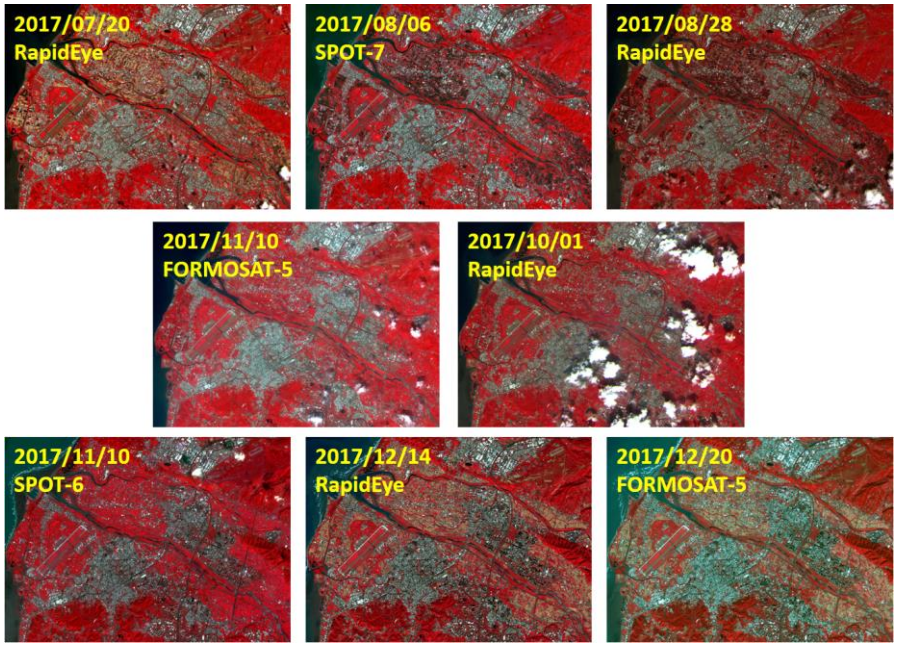

圖 4. 針對新竹縣市 106 年度二期稻作範圍，本研究所使用之測試範圍與對應之衛星影像

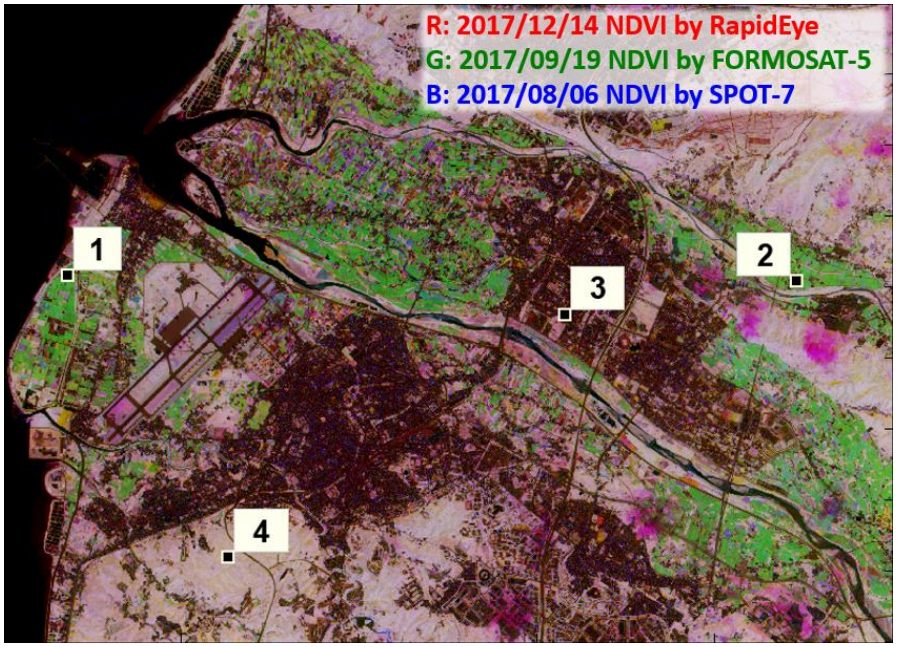

圖 5. 使用對應稻作播種期、抽穗期以及收割期之 NDVI 影像組成對應之 RGB 影像顯示時，在視覺上應可看出稻作分布的範圍

NDVI for Rice Field, Building, & Forest

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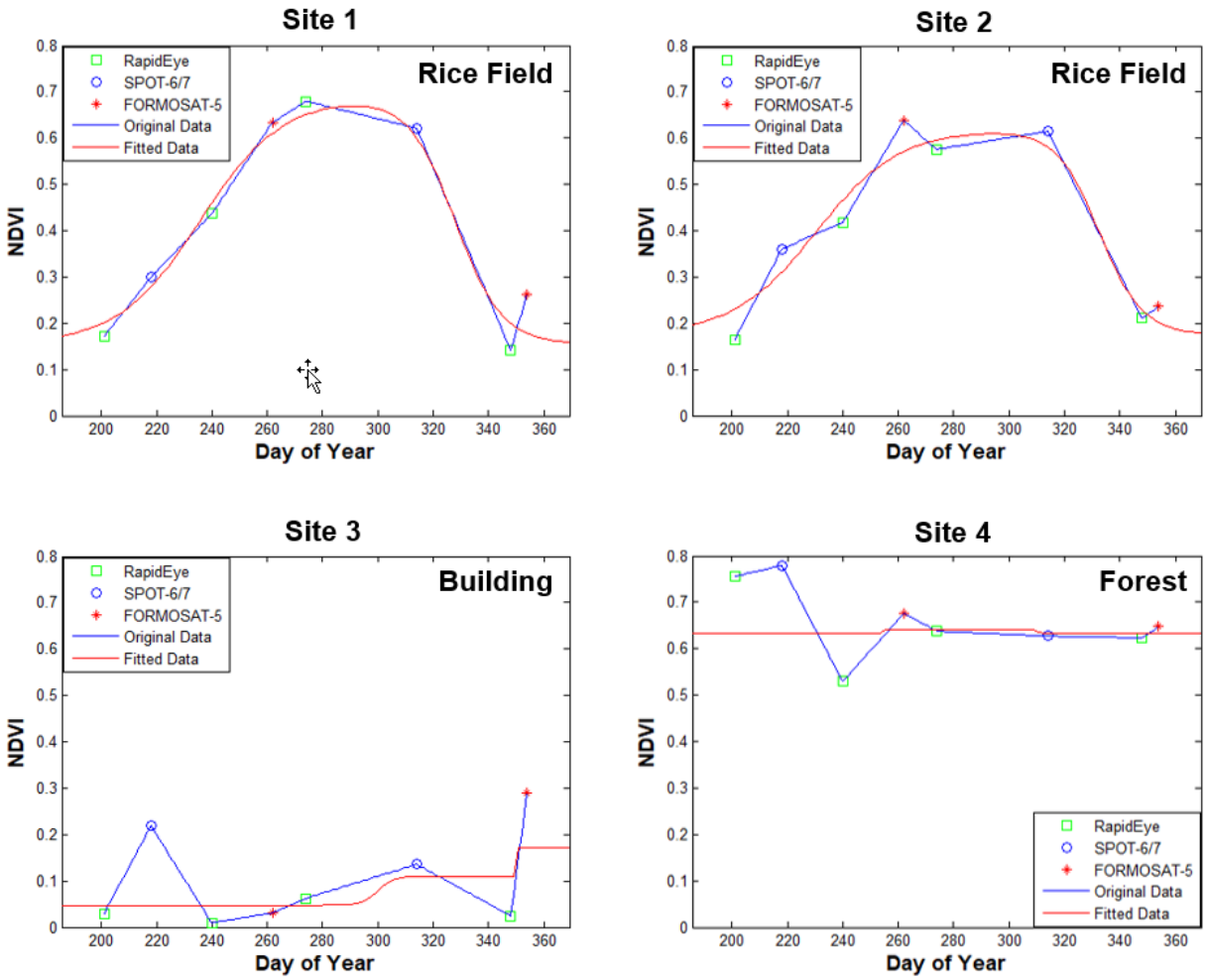

Double logic function for NDVI description is more apparent in Rice Field than in Buildind and Forest Area

Land Change Analysis

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Formosat 5 Images–Zengwen Reservoir High water period and dry season

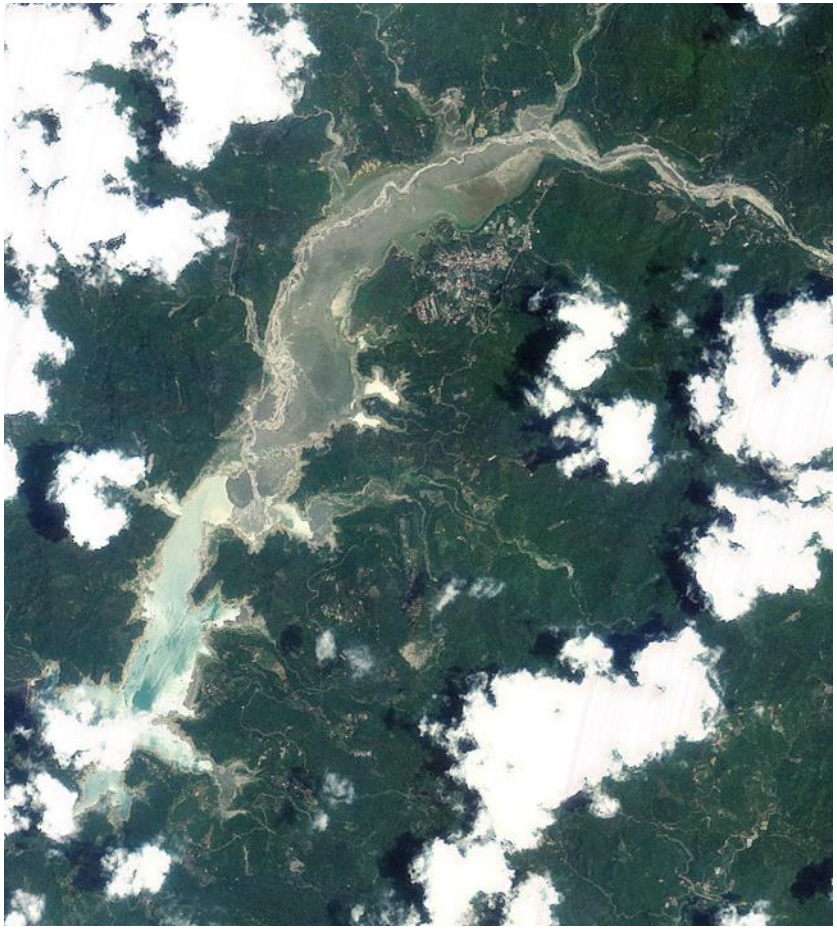

Image Date: 2018/1/1

Image Date: 20180519

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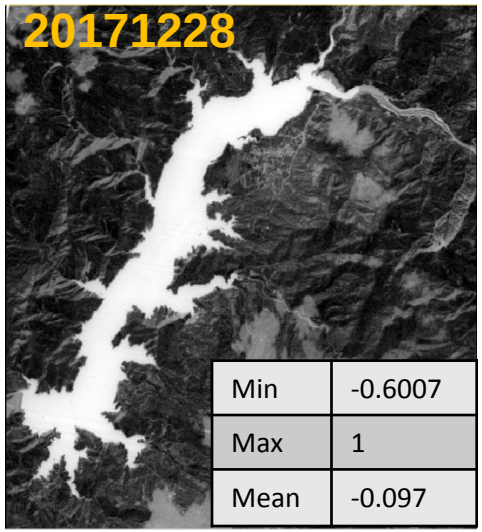
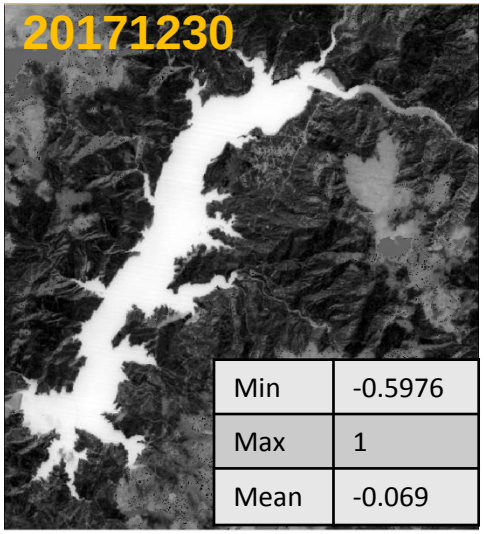
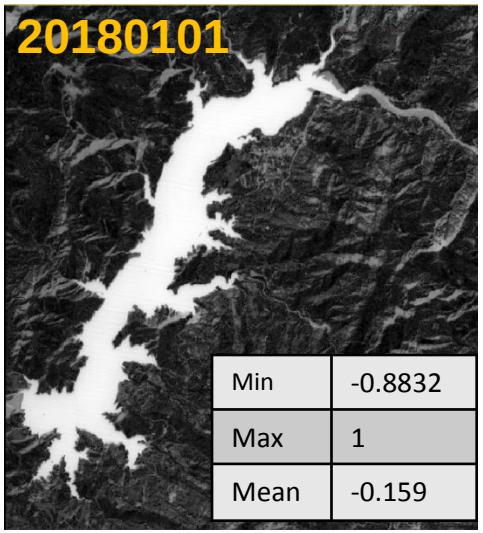
High water period and dry season — NDWI

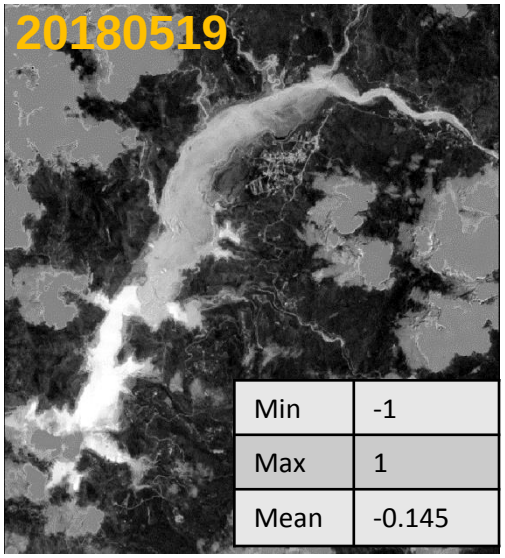


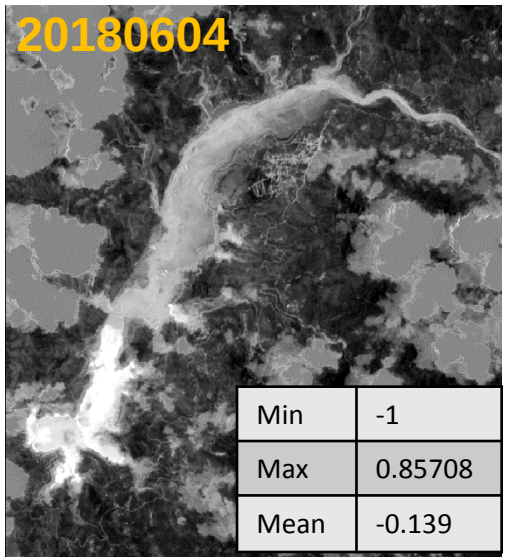




Normalized Difference Water Index (NDWI)
is used to monitor changes related to water content in water bodies, using green and NIR wavelengths

$$NDWI = \frac{(GREEN - NIR)}{(GREEN + NIR)}$$





Ref:WIKI

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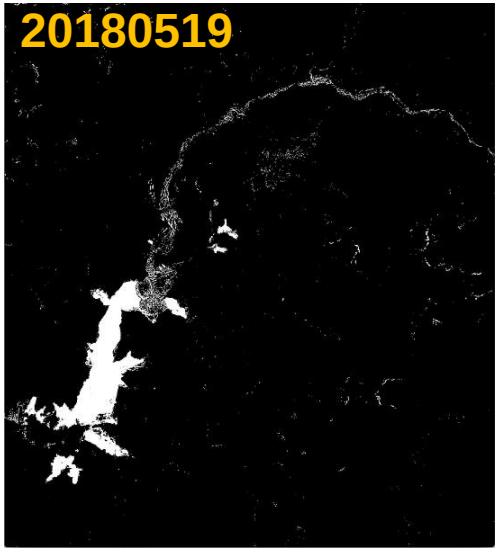
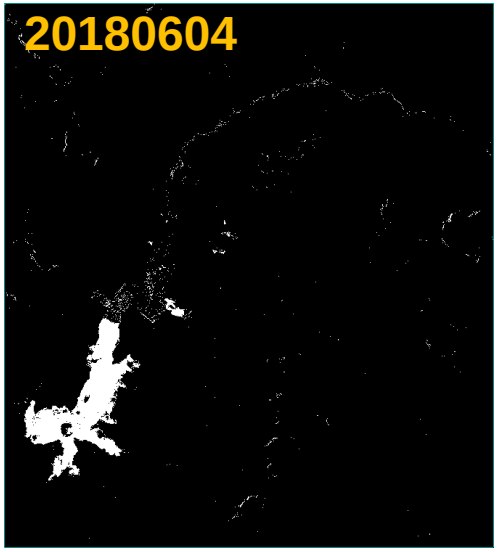
Binary processing — OTSU

Otsu's method
is used to automatically perform clustering-based image thresholding or, the reduction of a graylevel image to a binary image.





Ref:WIKI

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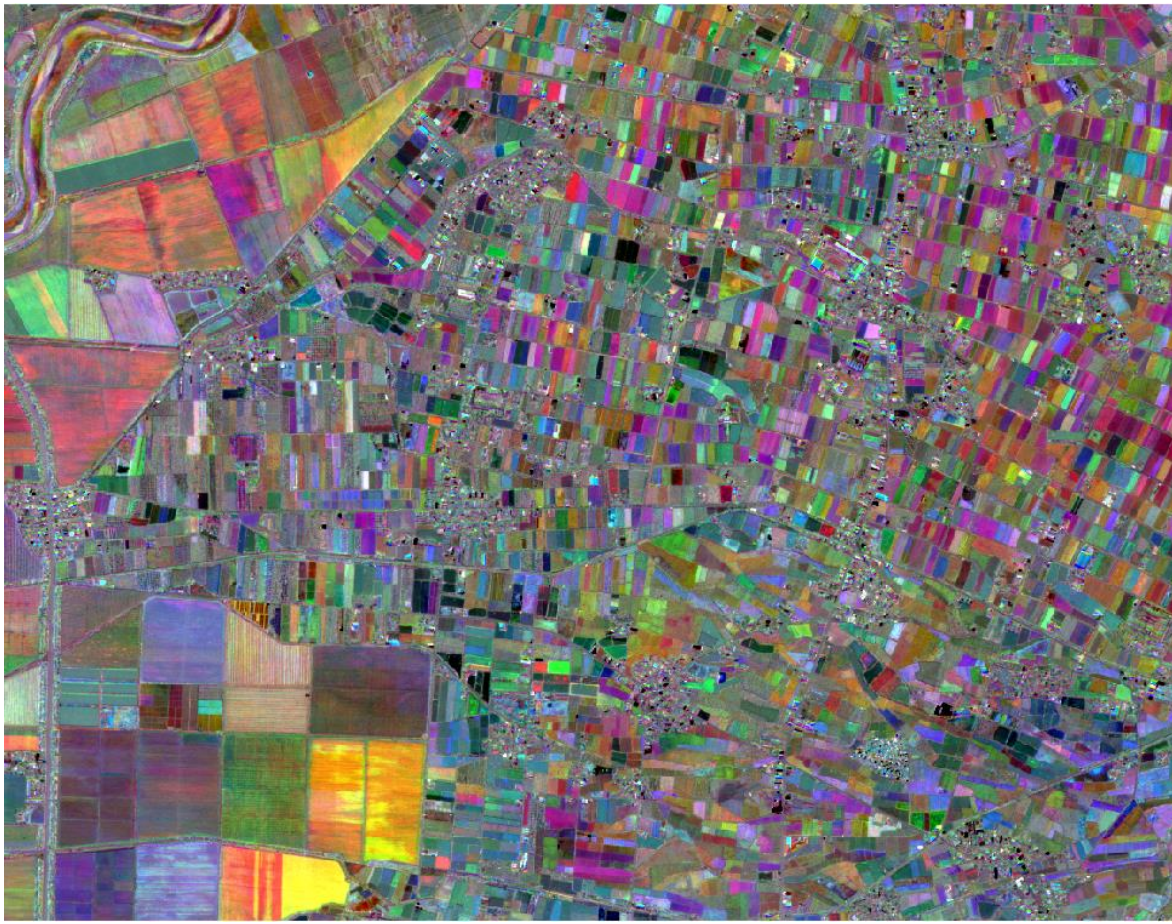
Formosat Images Data Cube Trial operation

- Geometric and Radiometric Processing
  - Precise Image Co-registration
  - Top Of Atmosphere (TOA) Reflectance
  - Multi-Temporal Cloud Detection(MTCD) for Pixel Quality Index (PQI)
- Metadata File generation
  - YAML format
- Data Cube Internal Image Generation
  - NetCDF format



Formosat-2 Time Series PCA Principal component images

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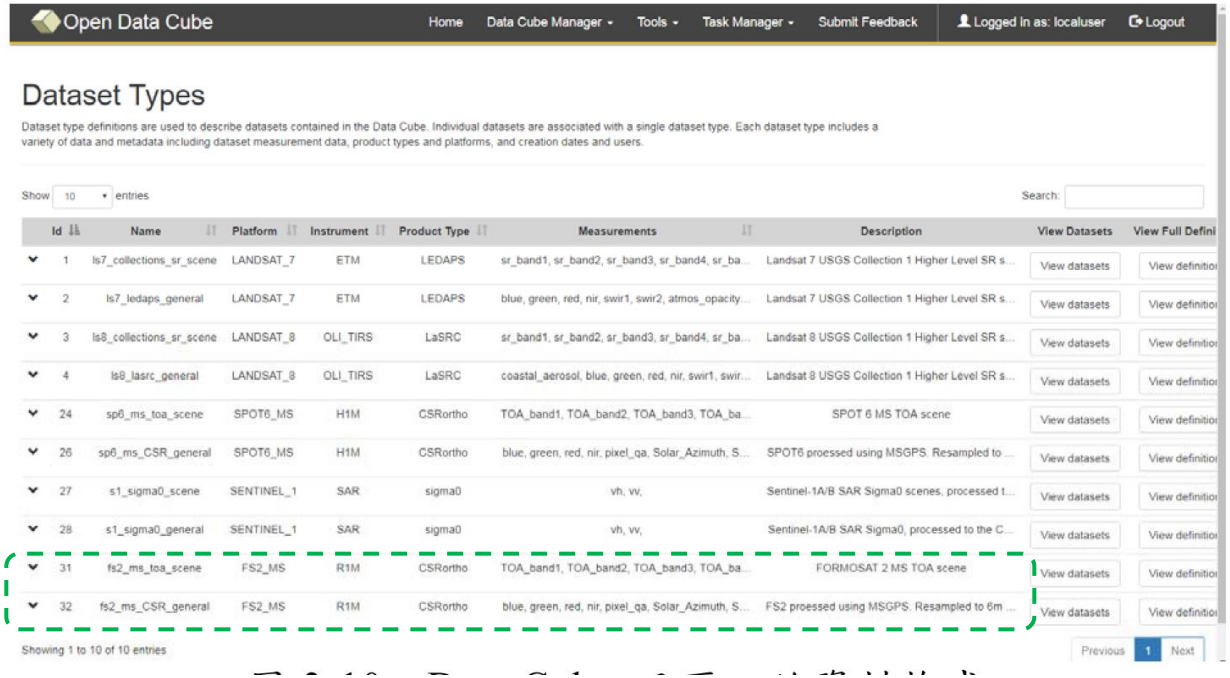
Import Formosat data to Data Cube

- NSPO have cooperated with University and CRSRS in
  - Geometric and Radiometric Pre-processing
  - ingest Formosat images into Open Data Cube (by reference to https://datacube-core.readthedocs.io/en/latest/)
- Need more support from CSIRO about how to use the APP and Service; how to use the Data Cube to make the function and benefit is what we need to learn and develop.



Thank you for your attention !