



Data Provider Node (DPN) Report

NAR Labs

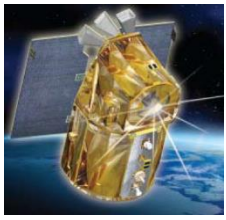
NARL

November 2, 2018

Awaji Island, Japan

Outline

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

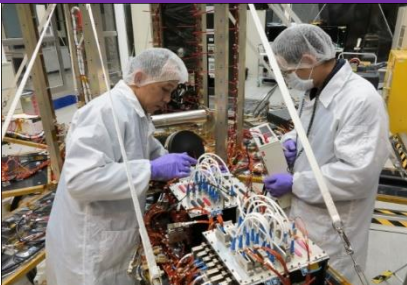


FORMOSAT-5 Program

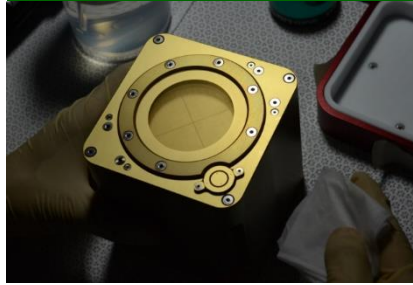
- To build up and demonstrate Taiwan's indigenous space technology on the remote sensing satellite
- To continuously serve the global imagery user's community of FORMOSAT-2
- Utilizing the linear CMOS image sensor for high-resolution (GSD =2m) EO satellite
- FORMOSAT-5 (FS-5) satellite had launched on 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



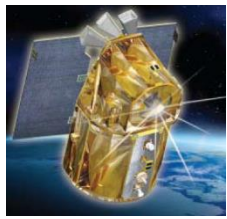
Launch Segment

Falcon 9

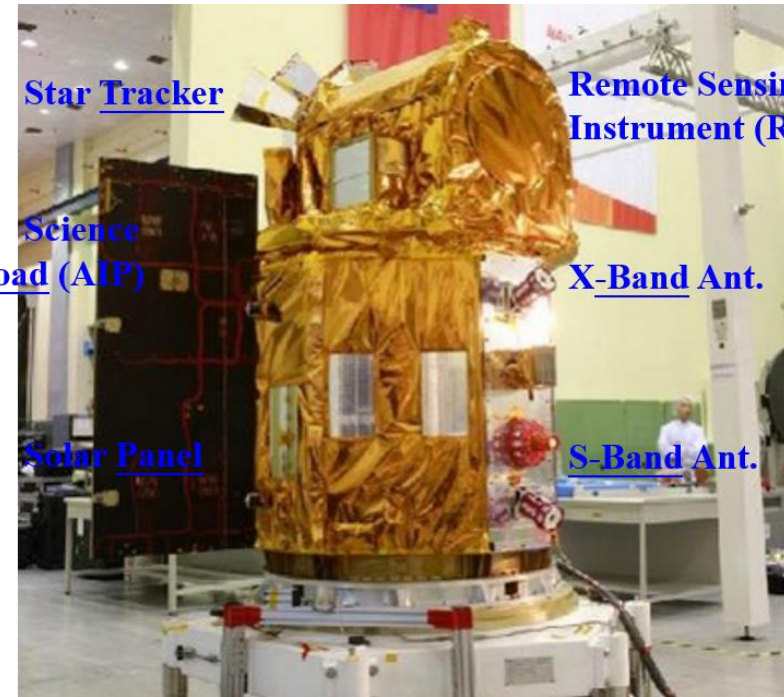


Launch Configuration

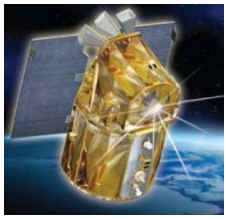




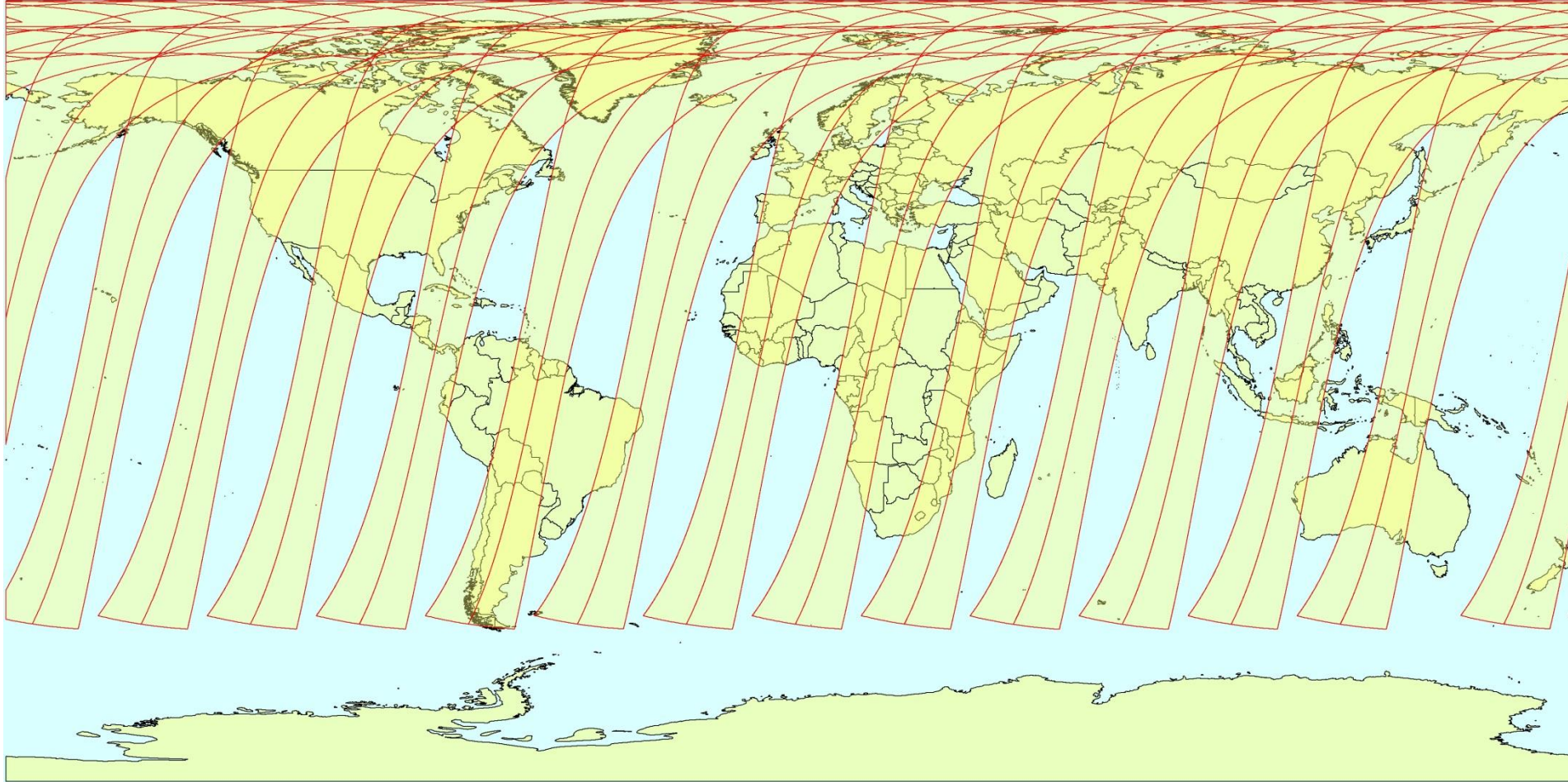
FORMOSAT-5 Key Parameters

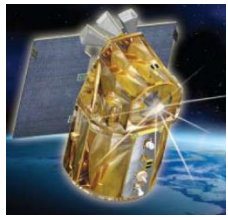


| Characteristics | Description |
|----------------------------------|---|
| Category | Remote sensing satellite |
| RSI Image Sensor | CMOS Image Sensor |
| Orbit | Sun-synchronous orbit @ 720 km / 98.2° |
| Repeatability | Every two days |
| Field of Regard | 45° in pitch and roll axis |
| Period | 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) |

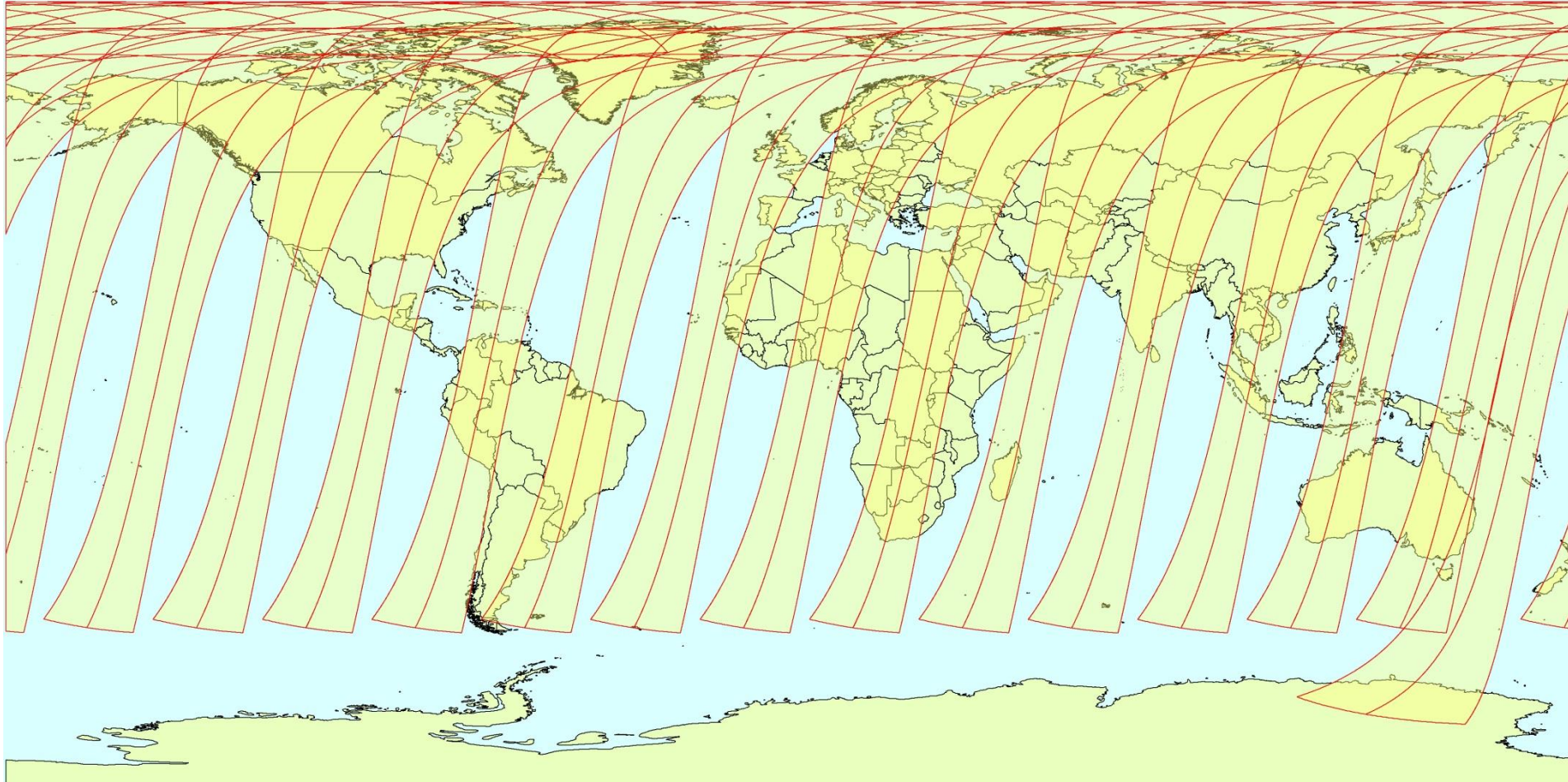


FORMOSAT-5 Coverage Day1





FORMOSAT-5 Coverage Day2

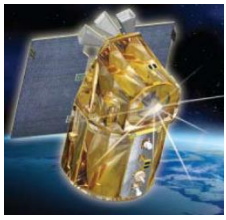




FORMOSAT satellite support sentinel Asia

- 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.

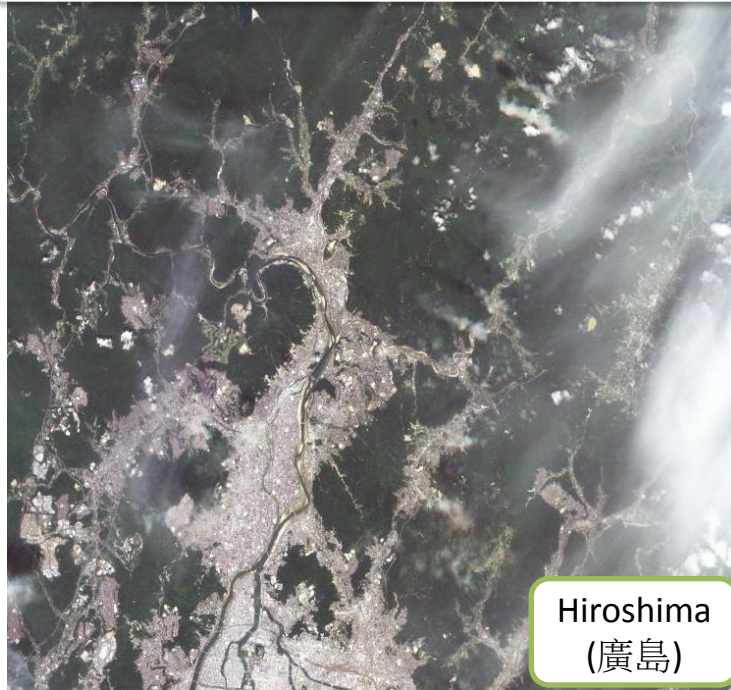
| Disaster Type | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2018 |
|-----------------|------|------|------|------|------|------|------|------|
| Earthquake | 0 | 5 | 3 | 0 | 0 | 2 | 2 | 2 |
| Landslide | 2 | 0 | 1 | 3 | 3 | 0 | 0 | 0 |
| Tsunami | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Volcano erption | 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 |



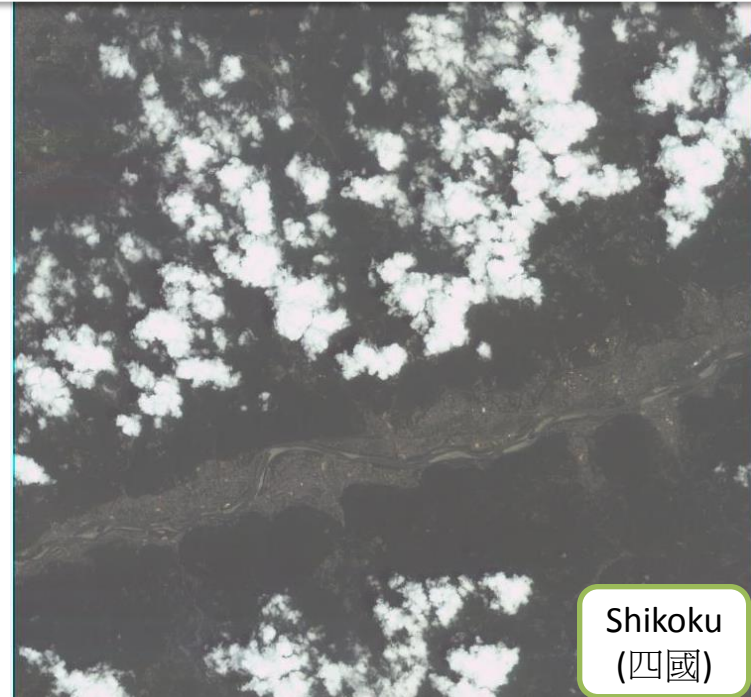
Disaster Support

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

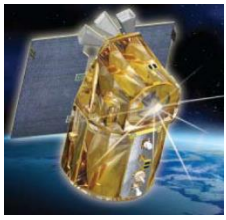
Record heavy rainfall continued to pound western and central parts of Japan



2018/07/11



2018/07/17



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



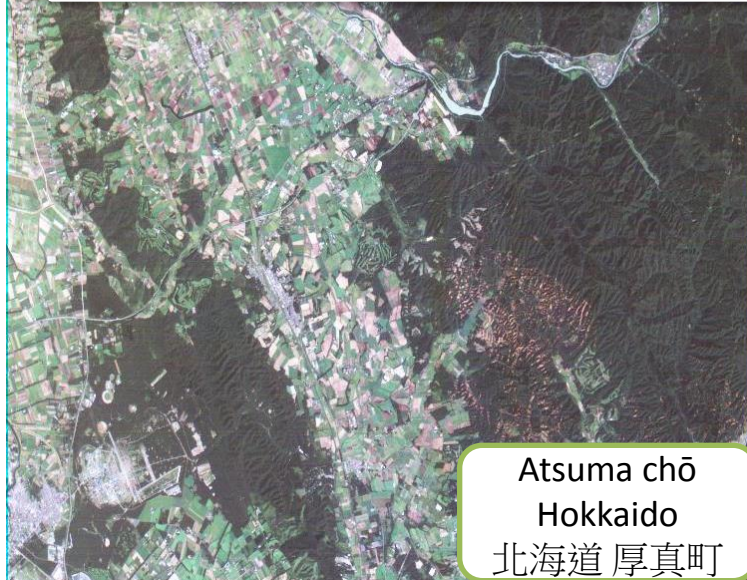
2018/07/27



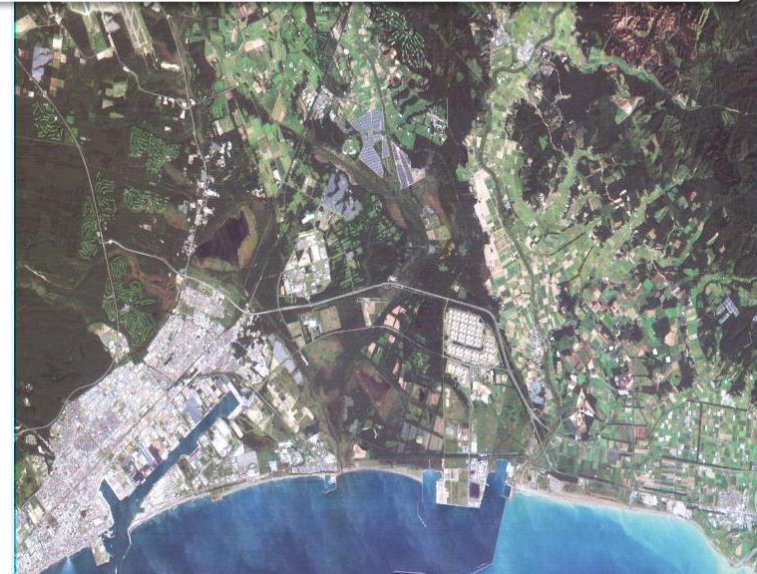
Disaster Support

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

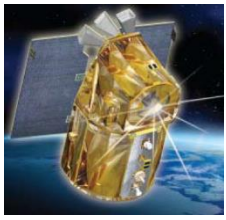
A powerful 6.7 magnitude earthquake struck the northern Japanese island of Hokkaido causing landslides



2018/09/11



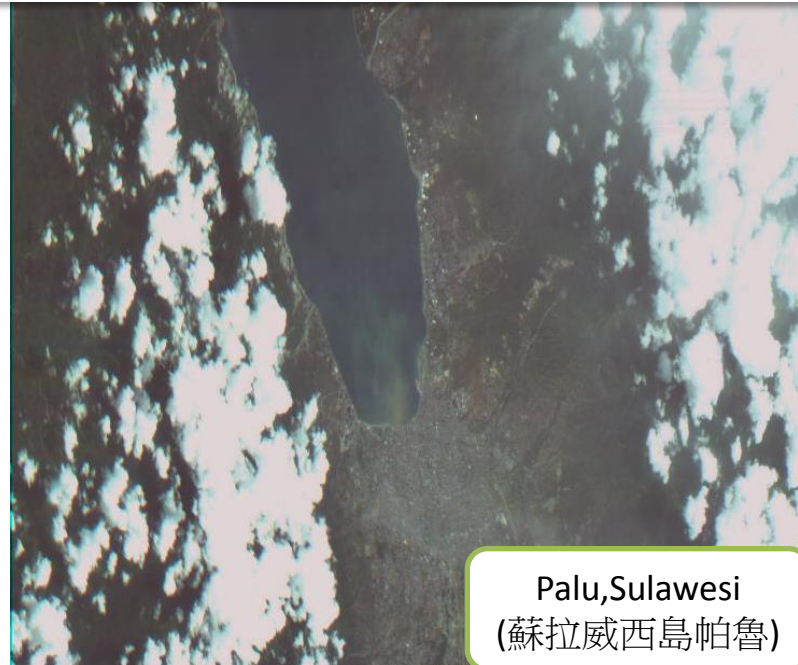
2018/09/11



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.



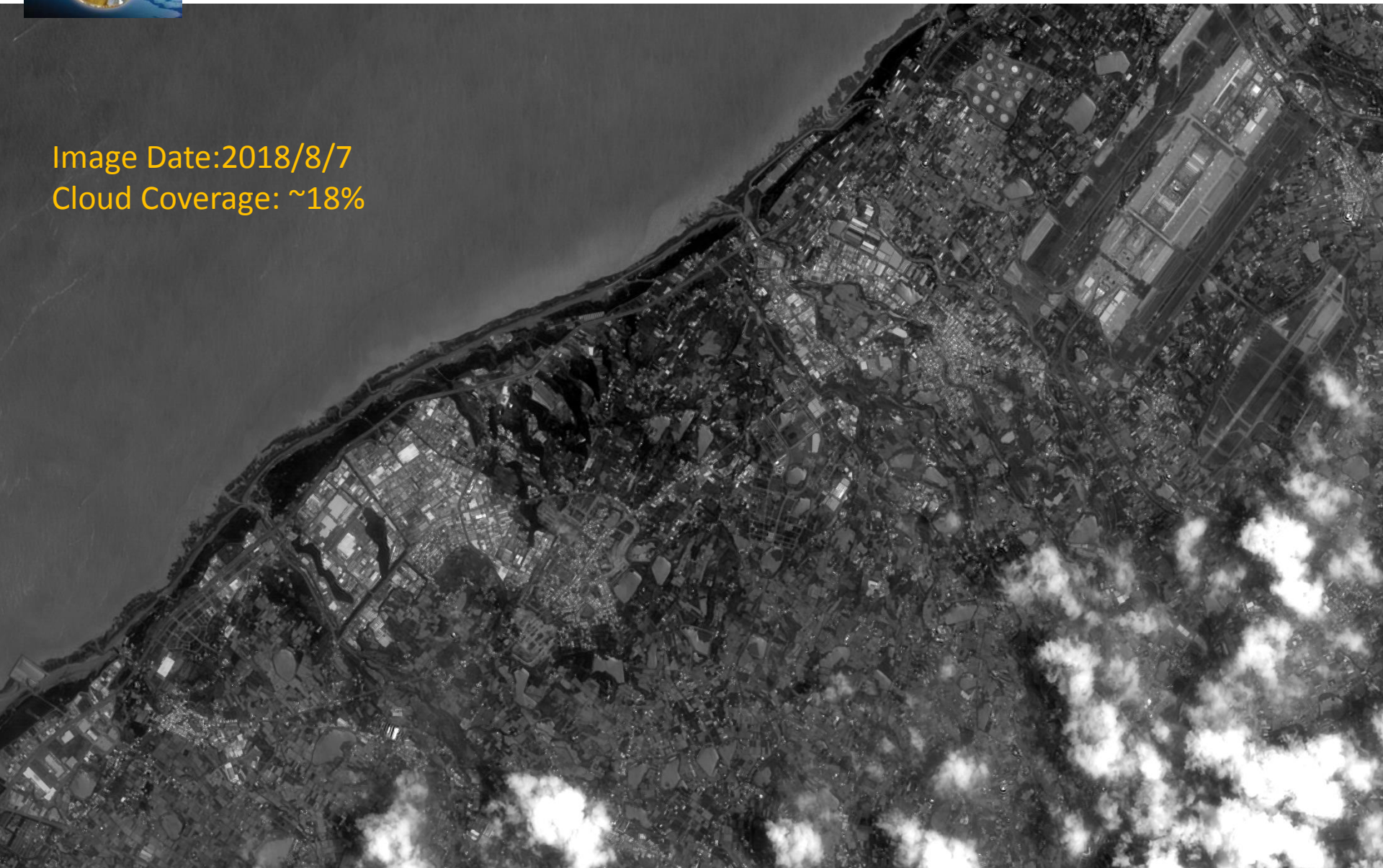
Palu, Sulawesi
(蘇拉威西島帕魯)

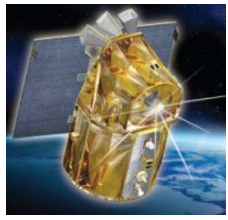
2018/10/02



Panchromatic Image, Taoyuan Airport **NAR Labs**

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

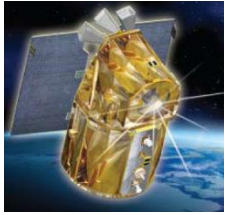




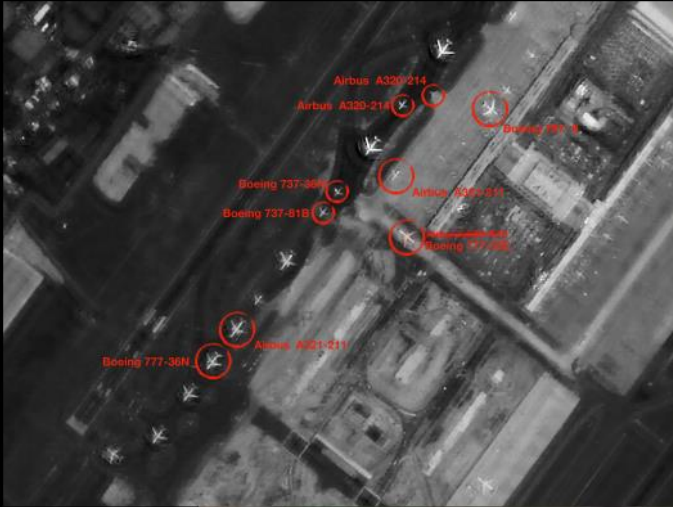
Multi-Spectral Image, Taoyuan Airport

NARLabs





Airplane Info. (from flightradar24)



| | | | |
|---------------------------------------|----------------------|---------------------------|---------------------|
| CZ8326 China Southern Airlines | LJ82 Alitalia | 5J313 Cebu Pacific | Z2125 Airbus |
|---------------------------------------|----------------------|---------------------------|---------------------|

JL813 /JAL813
Japan Airlines
TPE
TAIPEI
N/A
Boeing 787-8 Dreamliner
REGISTRATION: JAR24
MODE-S CODE: 86D602
SERIAL NUMBER (MSN): 34834
AGE (SEP 2012): 5 years

B7172
EVA Air
ACTUAL: 11:24 ESTIMATED: 11:40
GREAT CIRCLE DISTANCE: 1,590 KM
REGISTRATION: B-16723
MODE-S CODE: 899072
SERIAL NUMBER (MSN): 42108
AGE (JUN 2015): 3 years

BR6
EVA Air
ACTUAL: 11:23 ESTIMATED: 08:22
GREAT CIRCLE DISTANCE: 10,942 KM
REGISTRATION: B-16703
MODE-S CODE: 899003
SERIAL NUMBER (MSN): 32643
AGE (JAN 2006): 12 years

BR867
EVA Air
ACTUAL: 11:09 ESTIMATED: 12:24
GREAT CIRCLE DISTANCE: 907 KM
REGISTRATION: B-16223
MODE-S CODE: 899070
SERIAL NUMBER (MSN): 7054
AGE (APR 2014): 2 years


BR8
EVA Air
ACTUAL: 11:06 ESTIMATED: 07:38
GREAT CIRCLE DISTANCE: 10,410 KM
REGISTRATION: B-16723
MODE-S CODE: 899085
SERIAL NUMBER (MSN): 42108
AGE (JUN 2015): 3 years

PLAYBACK Tue, Aug 7, 2018, 02:53

Speed: 12x
Mon, Aug 6, 2018 23:00 Tue, Aug 7, 2018 00:00 01:00 02:00 03:00

解析度判讀(飛機長度, MS桃機影像)

NAR Labs



Boeing 777-36N
Wing length 63,7m<->
17.4 pixels
<-> 4.2 m/pxs

Boeing 777-36N

Airbus A321-211

Airbus A321-211
機長44.51m<-> 10.73pixels
<-> 4.15 m/pxs

Boeing 777-35E
 Wing length 73.9m<->
 35.2 pixels
 <-> 2.09m/px



| 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 |

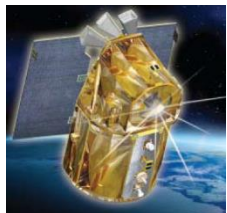


What can be done

■ With single image

| Index calculation | | |
|---|---|---|
| NDVI (Normalized difference vegetation index) | ○ | $NDVI = \frac{NIR - RED}{NIR + RED}$ |
| EVI(Enhanced vegetation index) | ○ | $EVI = 2.5 \times \frac{NIR - RED}{NIR + 6 \times RED - 7.5 \times BLUE + 1}$ |
| 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) | ○ | $GRVI = \frac{GREEN - RED}{GREEN + RED}$ |

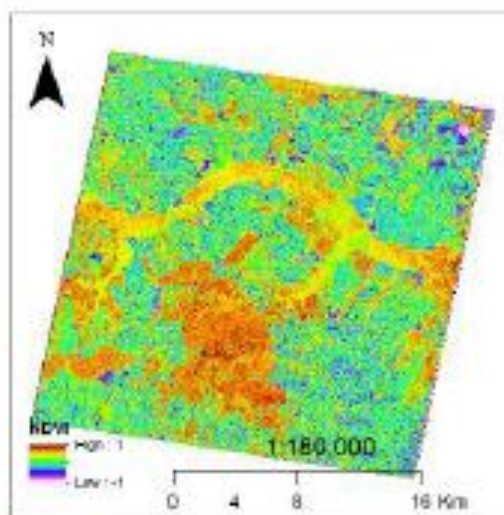
| | |
|------|---|
| Good | ○ |
| Fair | △ |
| Poor | × |



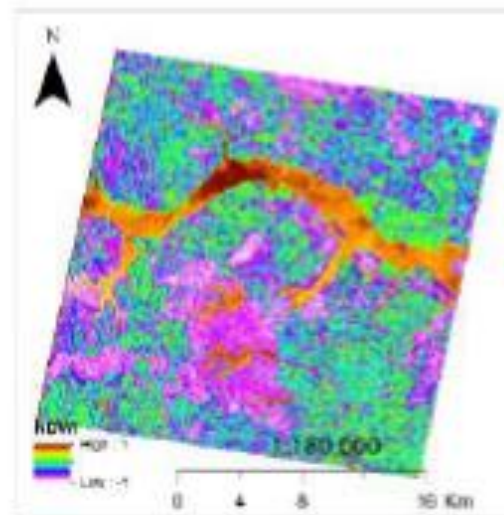
Result of index calculation



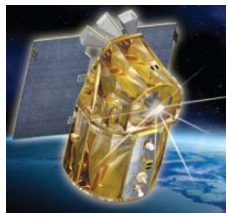
RGB image



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



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



What Can be Done

■ With single image

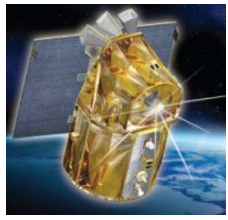
| Classification | | |
|---|---|---|
| Urban, agriculture, forest, wetland, water bodies | ○ | Some difficulties in mountainous area |
| Broadleaf and conifer | △ | Possible in winter |
| Dense and sparse | × | May be possible by reflectance properties |
| Forest type (Species) | × | May be possible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



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

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

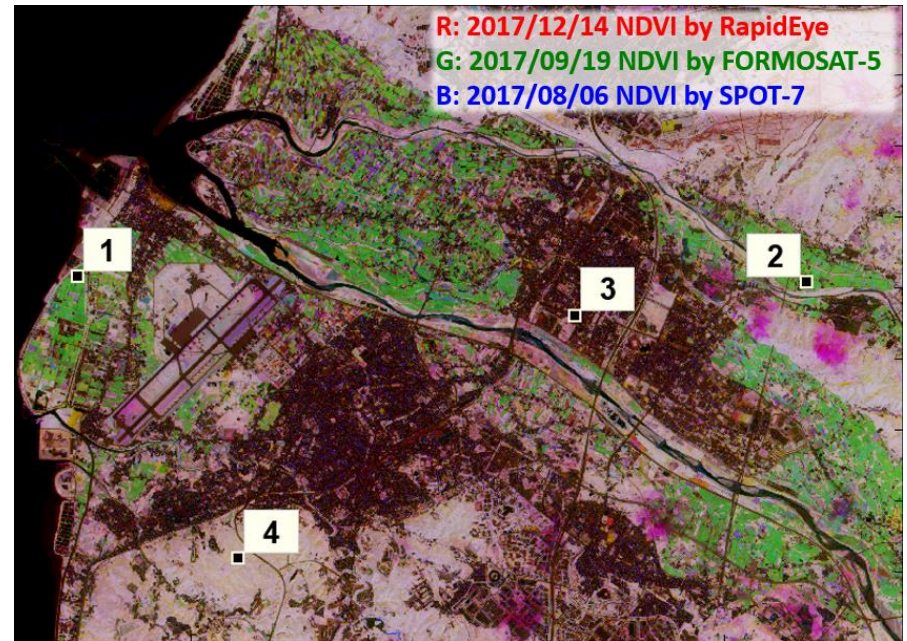
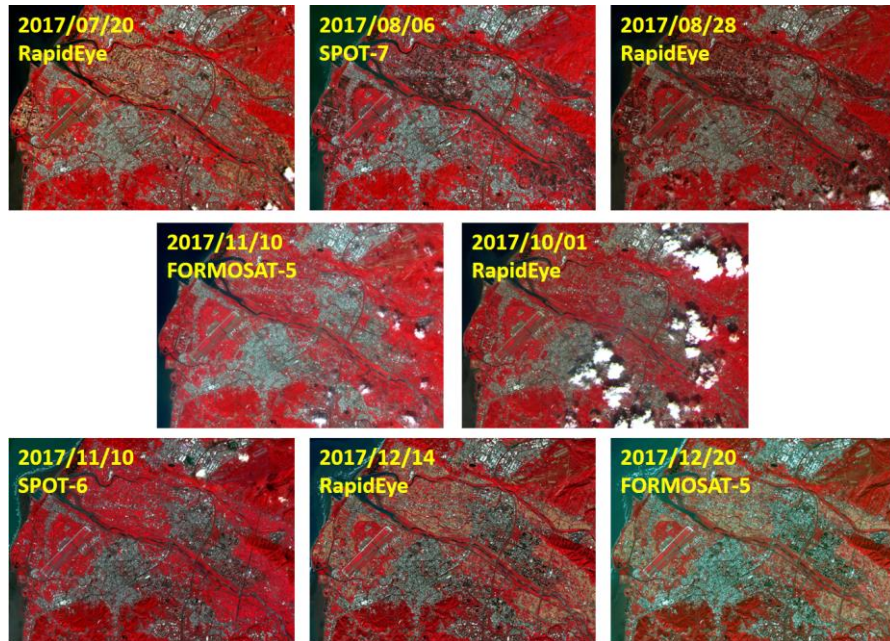
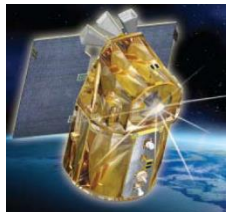
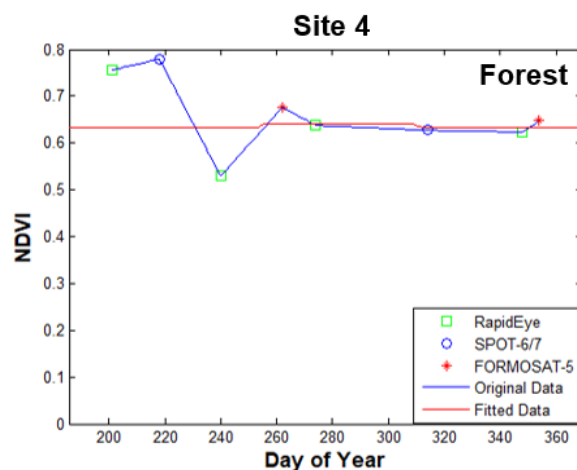
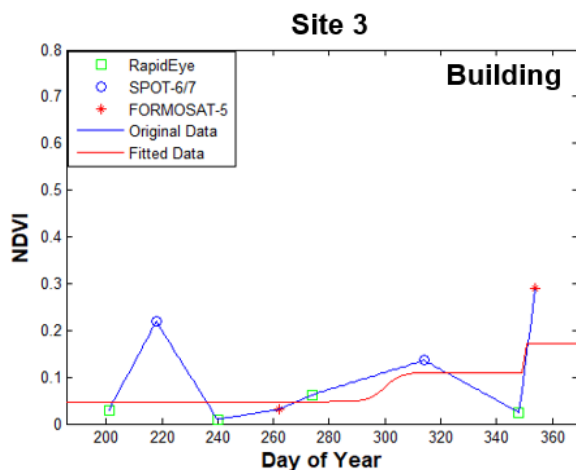
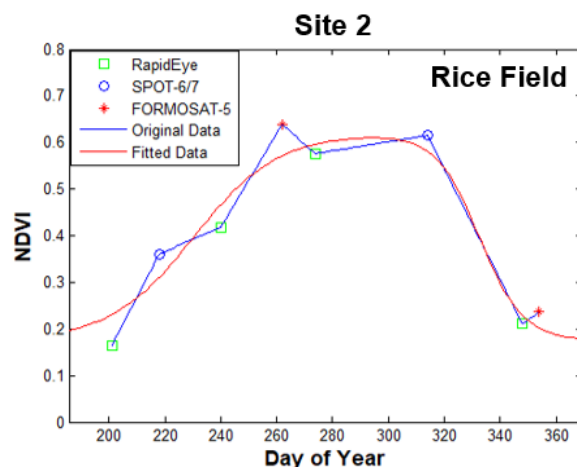
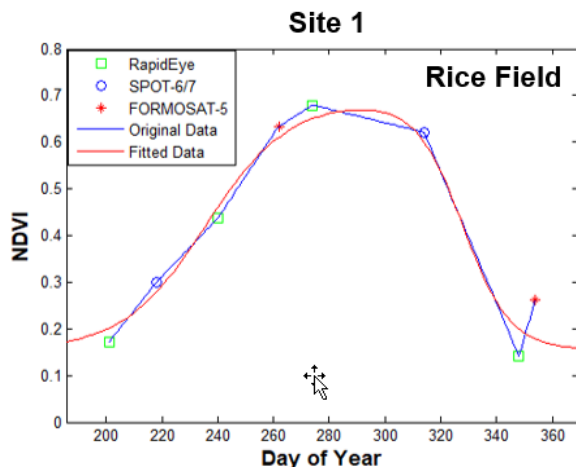


圖 4. 針對新竹縣市 106 年度二期稻作範圍，本研究所使用之測試範圍與對應之衛星影像

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



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



Land Change Analysis

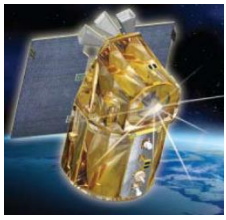
Formosat 5 Images–Zengwen Reservoir High water period and dry season



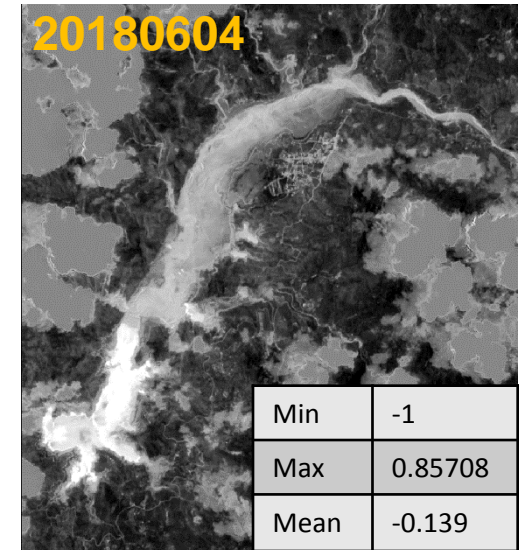
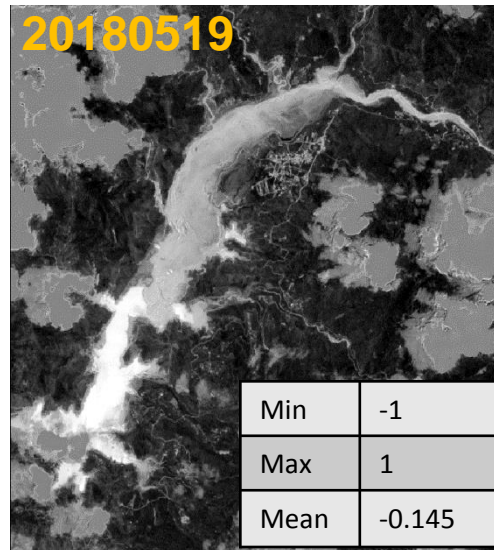
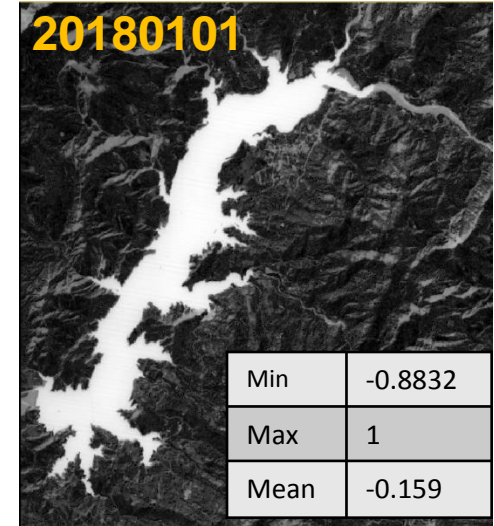
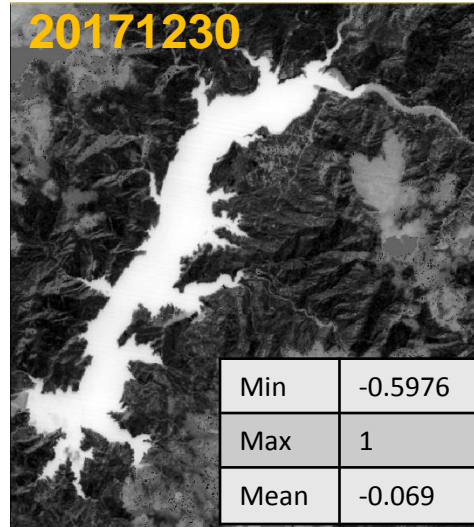
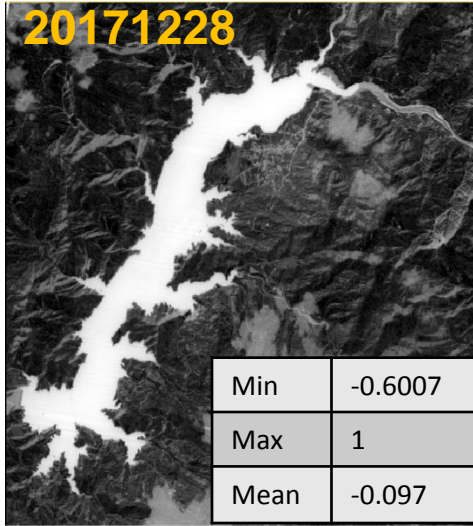
Image Date: 2018/1/1



Image Date: 20180519



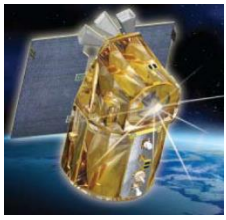
High water period and dry season — NDWI



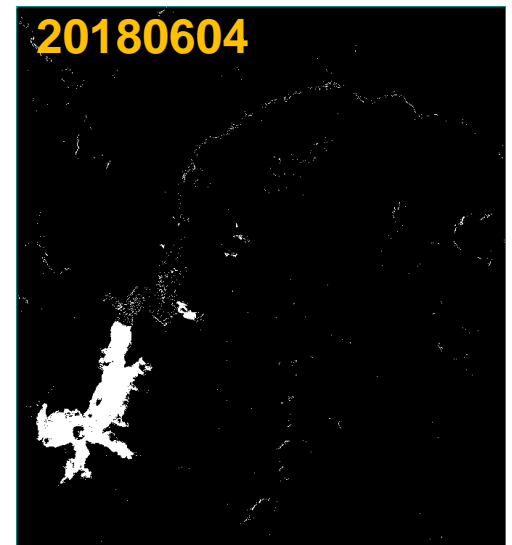
Normalized Difference Water Index (NDWI)

is used to monitor changes related to water content in water bodies, using green and NIR wavelengths

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

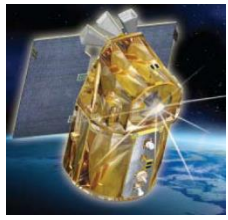


Binary processing — OTSU



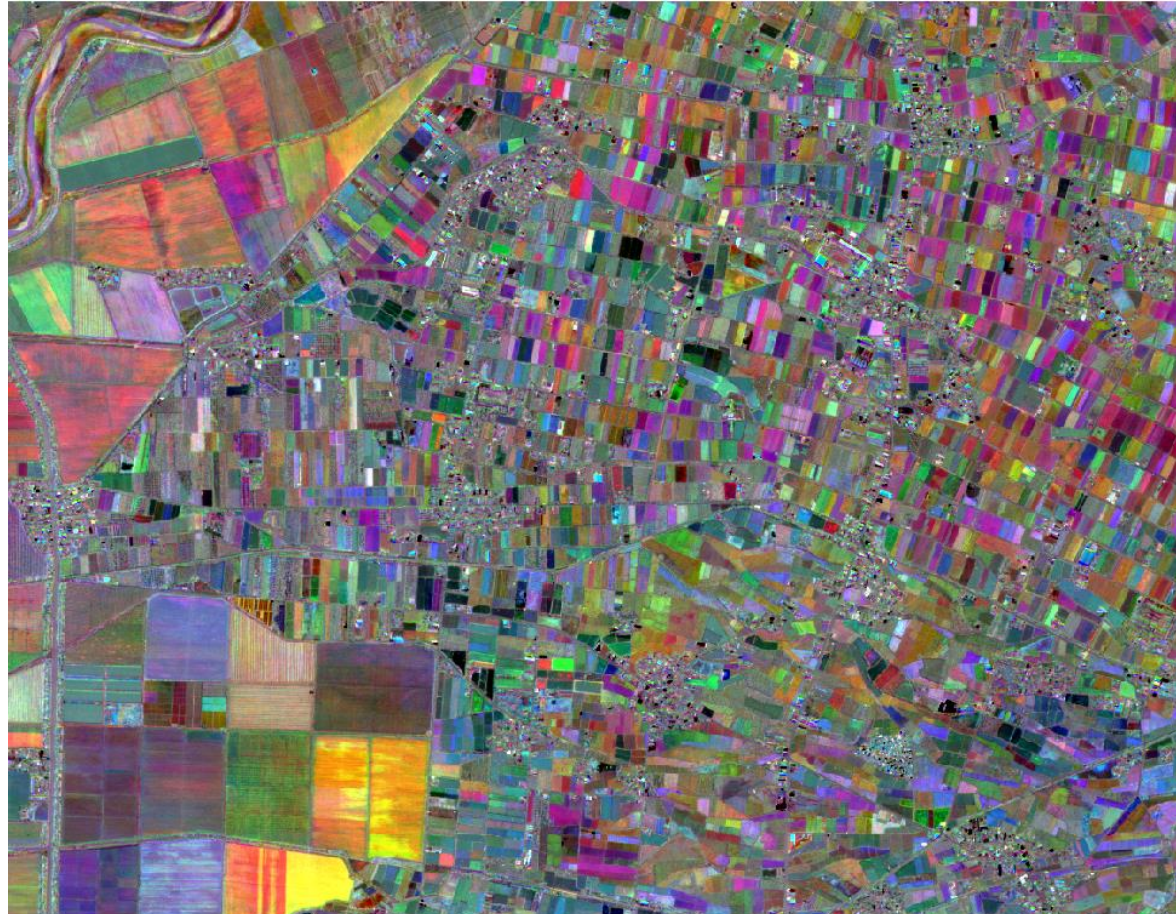
Otsu's method

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

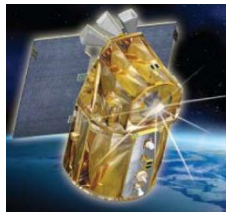


Formosat Images Data Cube Trial operation

- 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



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.

Open Data Cube

Home Data Cube Manager Tools Task Manager Submit Feedback Logged in as: localuser Logout

Dataset Types

Dataset type definitions are used to describe datasets contained in the Data Cube. Individual datasets are associated with a single dataset type. Each dataset type includes a variety of data and metadata including dataset measurement data, product types and platforms, and creation dates and users.

Show 10 entries Search:

| Id | Name | Platform | Instrument | Product Type | Measurements | Description | View Datasets | View Full Defini |
|----|--------------------------|------------|------------|--------------|--|--|---------------|------------------|
| 1 | ls7_collections_sr_scene | LANDSAT_7 | ETM | LEDAPS | sr_band1, sr_band2, sr_band3, sr_band4, sr_ba... | Landsat 7 USGS Collection 1 Higher Level SR s... | View datasets | View definition |
| 2 | ls7_ledaps_general | LANDSAT_7 | ETM | LEDAPS | blue, green, red, nir, swir1, swir2, atmos_opacity... | Landsat 7 USGS Collection 1 Higher Level SR s... | View datasets | View definition |
| 3 | ls8_collections_sr_scene | LANDSAT_8 | OLI_TIRS | LaSRC | sr_band1, sr_band2, sr_band3, sr_band4, sr_ba... | Landsat 8 USGS Collection 1 Higher Level SR s... | View datasets | View definition |
| 4 | ls8_lasrc_general | LANDSAT_8 | OLI_TIRS | LaSRC | coastal_aerosol, blue, green, red, nir, swir1, swir... | Landsat 8 USGS Collection 1 Higher Level SR s... | View datasets | View definition |
| 24 | sp6_ms_toa_scene | SPOT6_MS | H1M | CSRortho | TOA_band1, TOA_band2, TOA_band3, TOA_ba... | SPOT 6 MS TOA scene | View datasets | View definition |
| 26 | sp6_ms_CSR_general | SPOT6_MS | H1M | CSRortho | blue, green, red, nir, pixel_qa, Solar_Azimuth, S... | SPOT6 processed using MSGPS. Resampled to ... | View datasets | View definition |
| 27 | s1_sigma0_scene | SENTINEL_1 | SAR | sigma0 | vh, vv, | Sentinel-1A/B SAR Sigma0 scenes, processed t... | View datasets | View definition |
| 28 | s1_sigma0_general | SENTINEL_1 | SAR | sigma0 | vh, vv, | Sentinel-1A/B SAR Sigma0, processed to the C... | View datasets | View definition |
| 31 | fs2_ms_toa_scene | FS2_MS | R1M | CSRortho | TOA_band1, TOA_band2, TOA_band3, TOA_ba... | FORMOSAT 2 MS TOA scene | View datasets | View definition |
| 32 | fs2_ms_CSR_general | FS2_MS | R1M | CSRortho | blue, green, red, nir, pixel_qa, Solar_Azimuth, S... | FS2 processed using MSGPS. Resampled to 6m ... | View datasets | View definition |

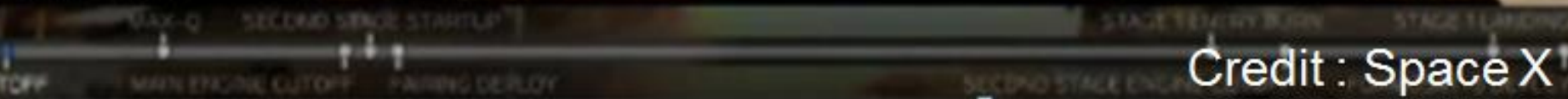
Showing 1 to 10 of 10 entries

Previous 1 Next



Thank you for your attention !

FORMOSAT-5



Credit : Space X

T+ C
STAGE
SPEED
000
LIFTOFF
THE HOLD
RELEASE
BEGUN
DIRECT