SAKURA SCIENCE Exchange Program in Science

日本・アジア青少年サイエンス交流事業
さくらサイエンスプラン
Japan-Asia Youth Exchange Program in Science

Introduction of Remote Sensing -Basic Principle & Application-

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Remote Sensing Technology Center of Japan

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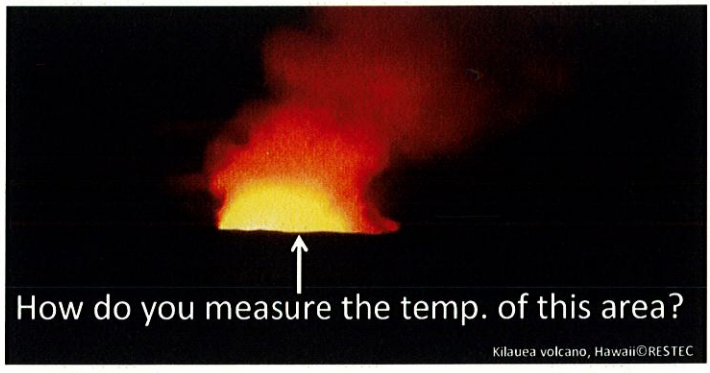
カモンバン（TH）

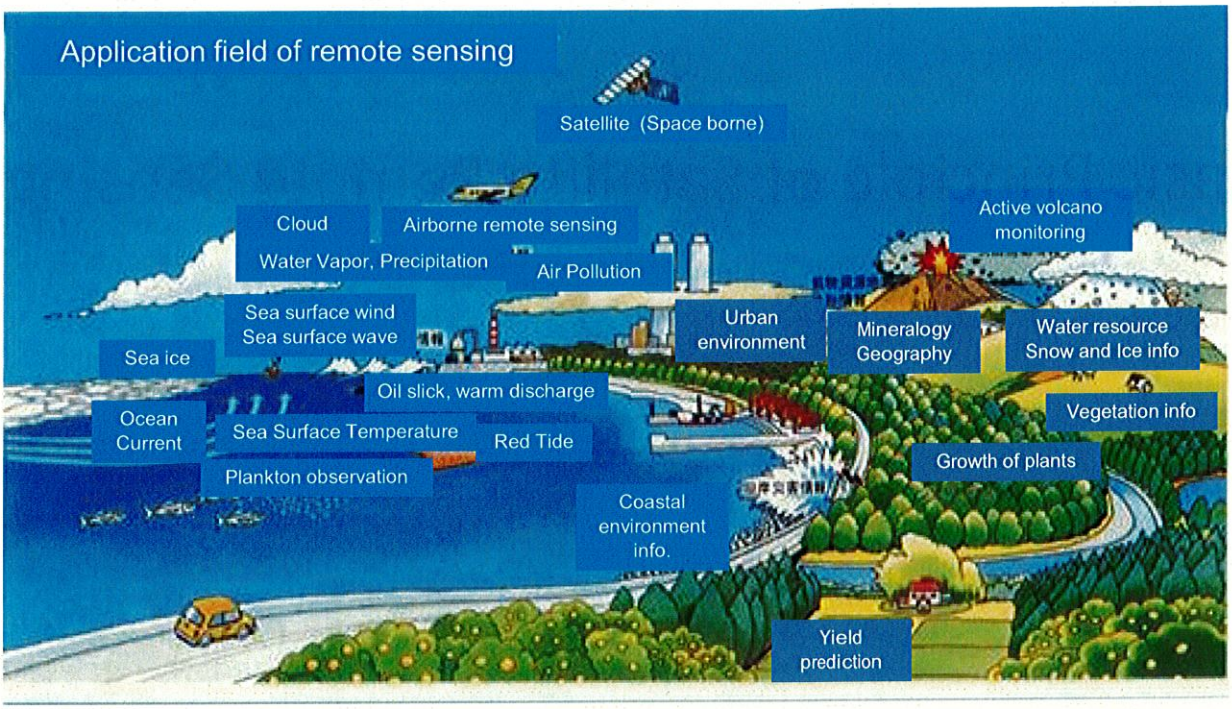
What is “remote sensing”?

Remote Sensing is …

- Technology for sensing (measuring) physical information of target from remote place.
- Recently there are lots of platform for remote sensing, satellite, airplane, UAV, Drone… But, hereafter we treat only Satellite Remote Sensing as “remote sensing”.
- When disaster occurs, it is difficult to go to damaged area, because mainly those area are still dangerous or difficult to access.
- In such cases, remote sensing is the only technique for this.



Remote Sensing is for everything

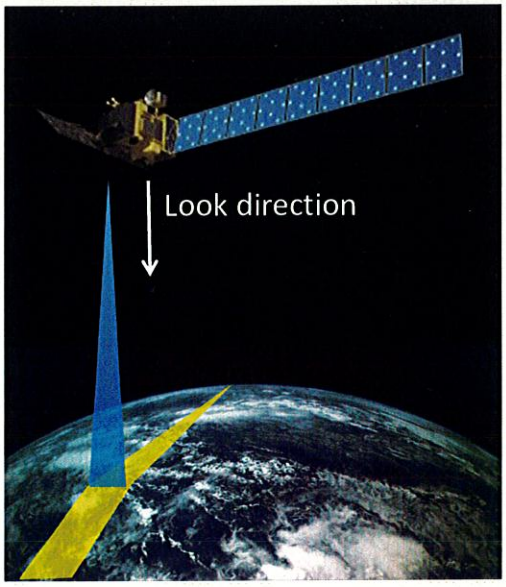


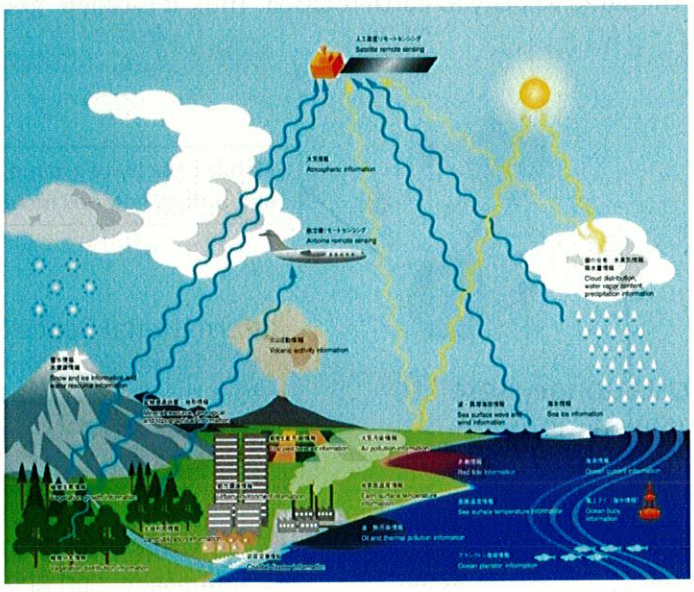
How to observe earth surface by satellites (1)

Observation instruments are directed to earth surface.

Included radar

Observation instruments that consider the direction to the earth grasp/capture information (i.e. reflection, emission, displacement, etc.) from earth surface.





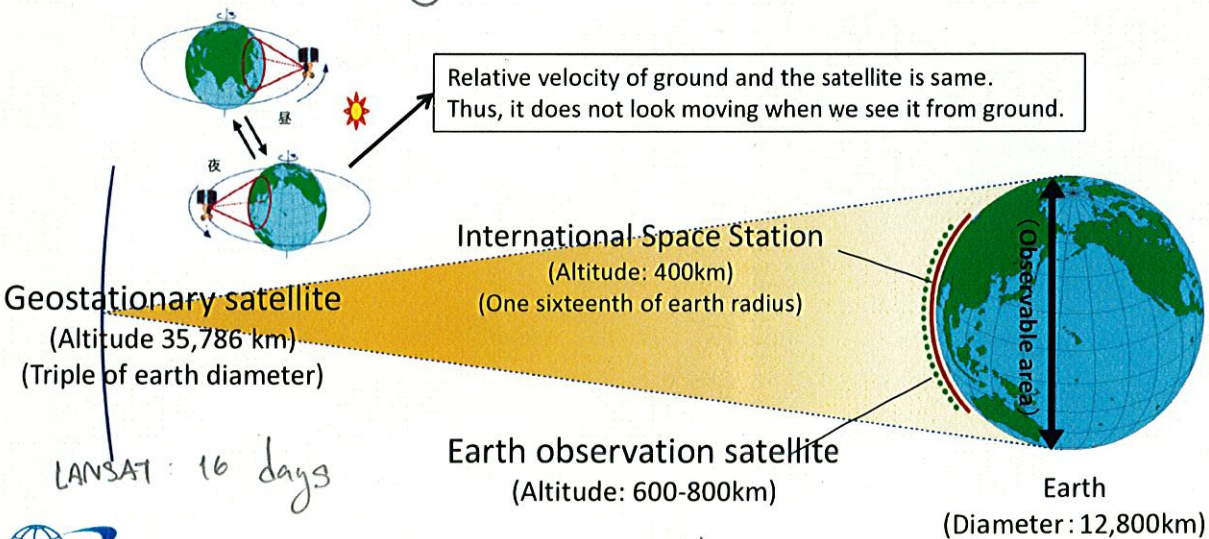
Basic Principle of Satellite Remote Sensing

How to observe earth surface by satellites (2)

Sun synchronized satellites & Geostationary satellites

Both orbiting satellites and geostationary satellites are orbiting earth. However, geostationary satellites do not look moving move when we see then from earth surface, because they are orbiting at the same velocity as earth rotation. Thus, it is called "geostationary".

→ [illegible] : for only specific area.



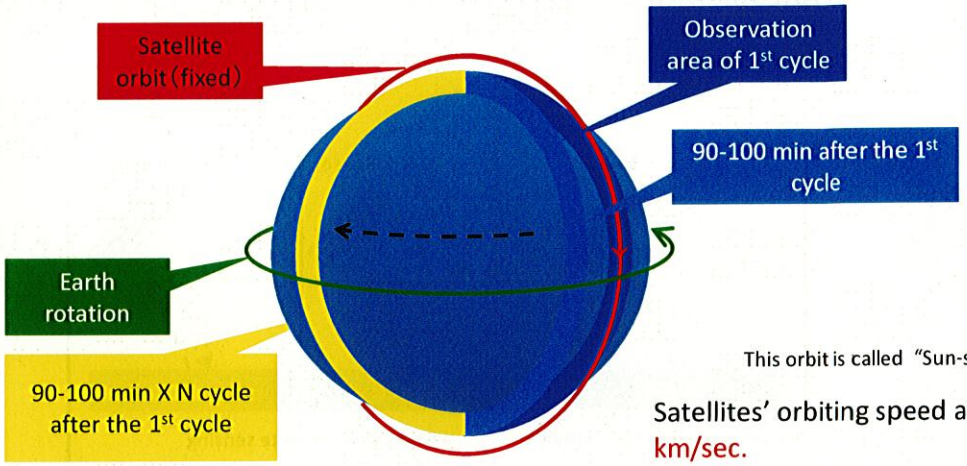
LANSAT : 16 days

: swath

How to observe earth surface by satellites (3)

Satellites are orbiting the earth for almost north-south direction.

Most Earth Observation Satellites are orbiting the earth within approximately 90 to 100 min per 1 cycle. Due to the earth rotation, observation area varies every cycle.



This orbit is called "Sun-synchronous sub-recurrent orbit".

Number of cycle of day (In case of 90min per cycle)
24 hours (1440 min) ÷ 90 min = 16 cycle

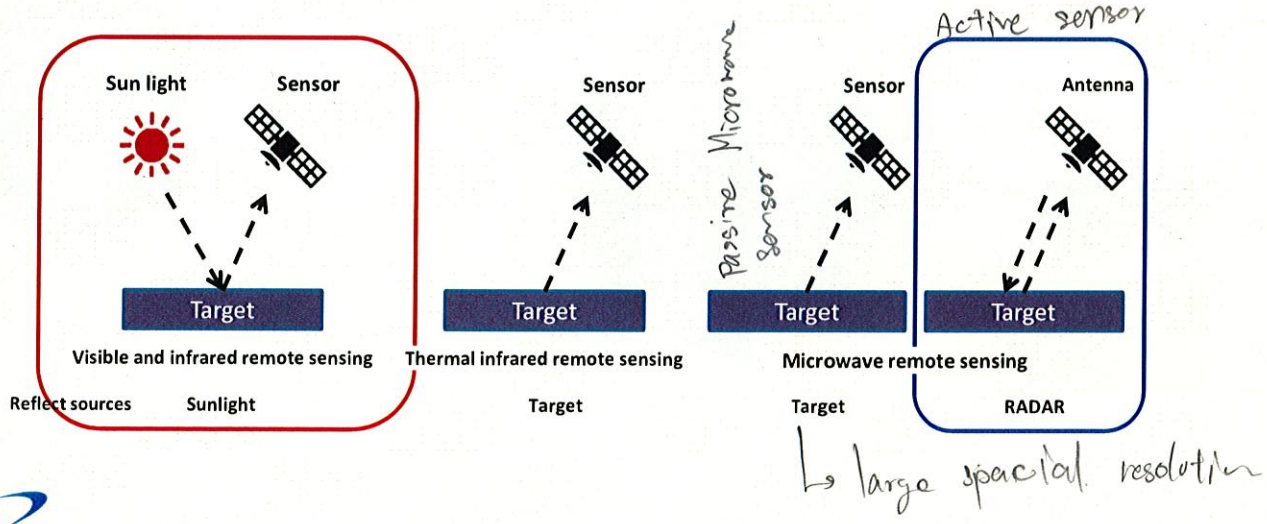
Satellites' orbiting speed at 700km altitude is 7.5 km/sec.

If we travel from RESTEC to Narita Int'l Airport (71km) at this speed, we can arrive within 10 seconds!!

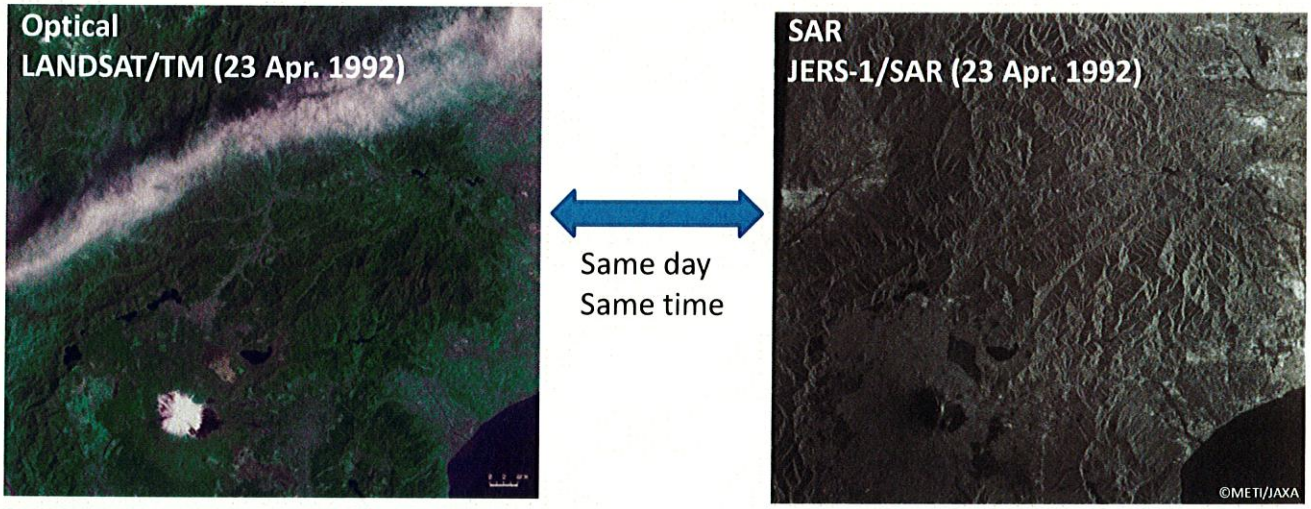
Sensor

How to observe earth surface by satellites (4)

- Optical & RADAR (Microwave) are 2 main categories.
- Optical sensor needs sun light (passive sensor) , however RADAR sensor does not need sunlight (active sensor).
- On board RADAR remote sensing, SAR (Synthetic Aperture Radar) technique is used by the theory of RADAR.



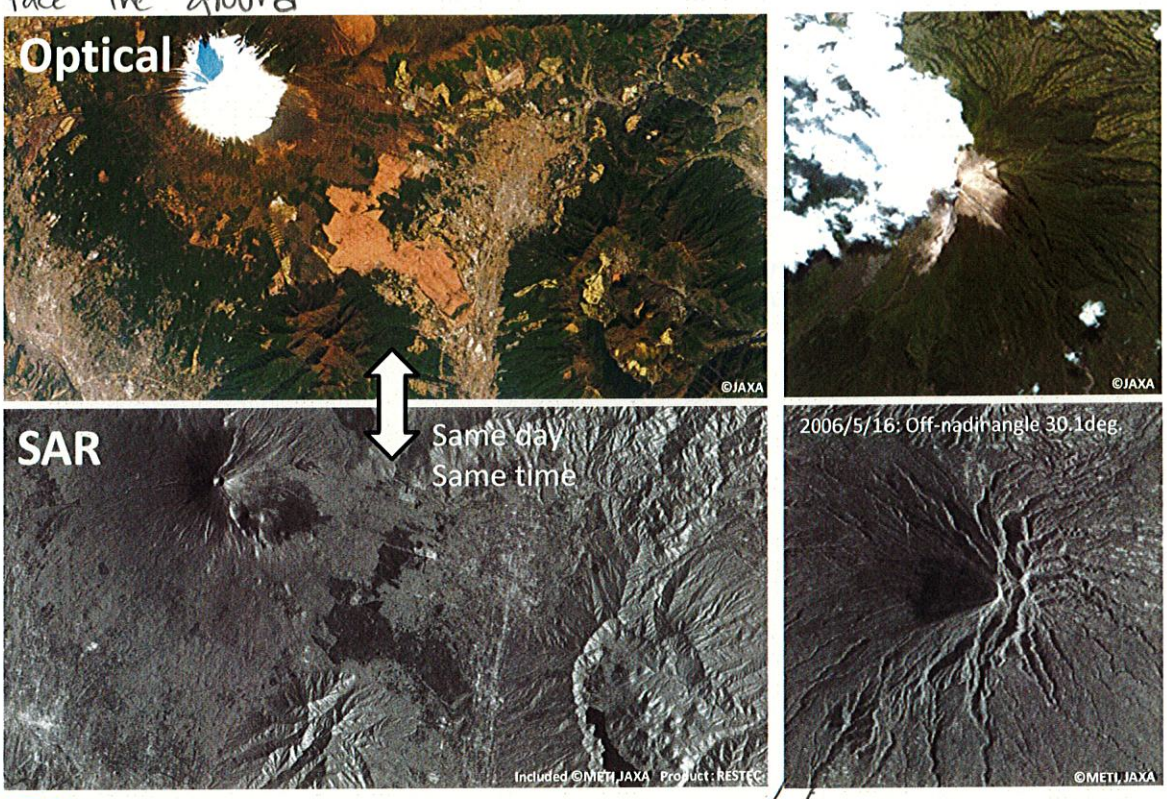
Pros / Cons of Optical and SAR Sensor



Sensor	Pros	Cons
Optical	• Similar to the Image by Digital Camera • Acquired imagery like view from sky • Easy to interpret the imagery	Cannot observe under the bad weather condition / night time
SAR	Can observe even under the bad weather condition or night time	• Difficult to interpret the imagery • Geometric Distortion

Comparison of Optical and SAR imagery

Face the ground



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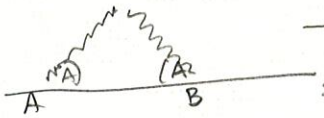
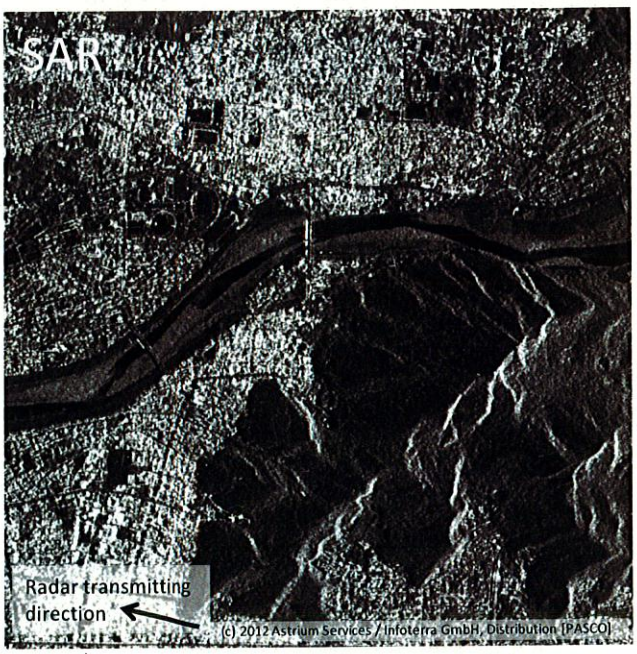
THUS



same level → cannot tell the difference between A and B

Comparison of Optical and SAR imagery



- Urban area: Buildings can be interpreted by optical sensor more easily than by radar sensor.
- Mountainous area: Specific distortion (foreshortening, layover, radar shadow) of SAR imagery can be identified by optical sensor.

rough → image bright

smooth → dark

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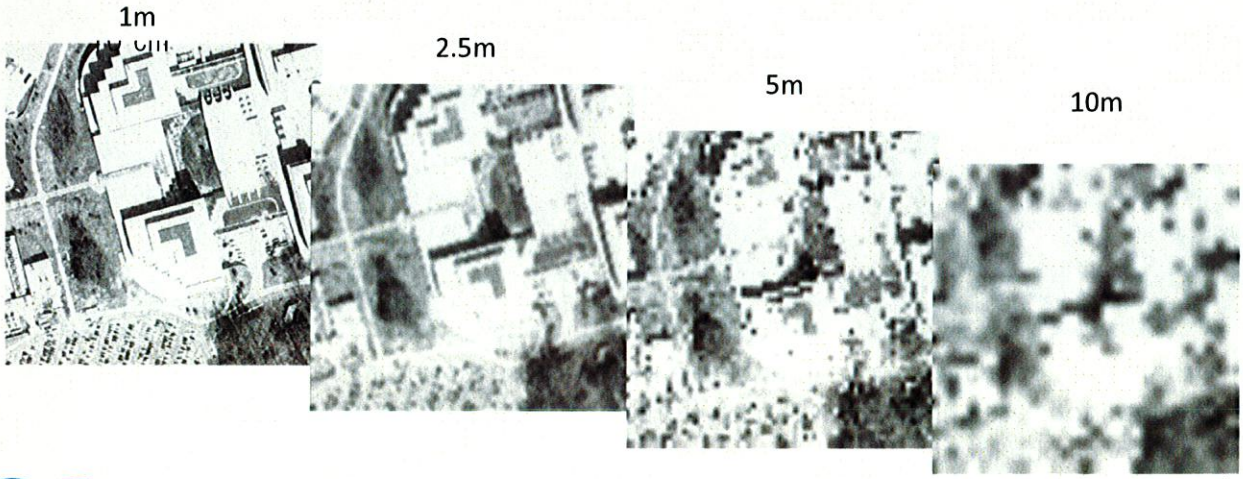
Spatial Resolution
-Optical Sensor-

Spatial resolution and recognizable target

Spatial Resolution	Recognizable objects
1m	Type of buildings / existence of cars
2.5m	Type of buildings
5m	Existence of buildings.
10m	Existence of large buildings.

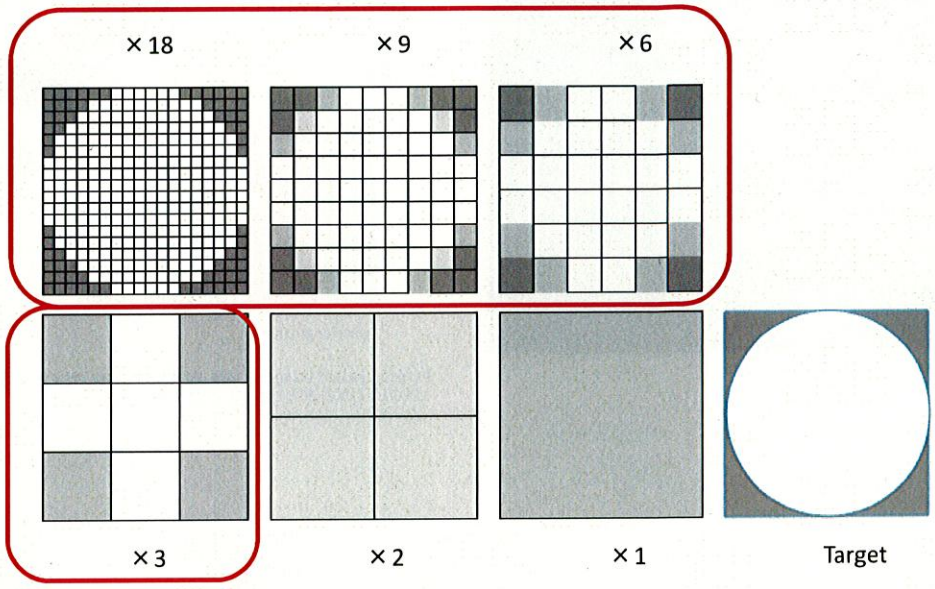


(source:FAS IMINT 101-Introduction to Image Intelligence home page)
Aerial photo simulation images (source:FAS IMINT 101-Introduction to Image Intelligence home page)

Spatial resolution and recognizable target

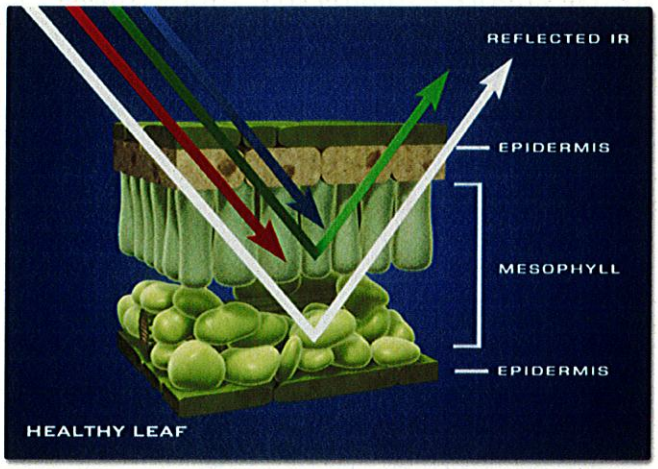
Recognizable target in pixels of imagery

Relationship of target and spatial resolution: This figure explains that more than 2 times larger spatial resolution of the target might be necessary to recognize it.

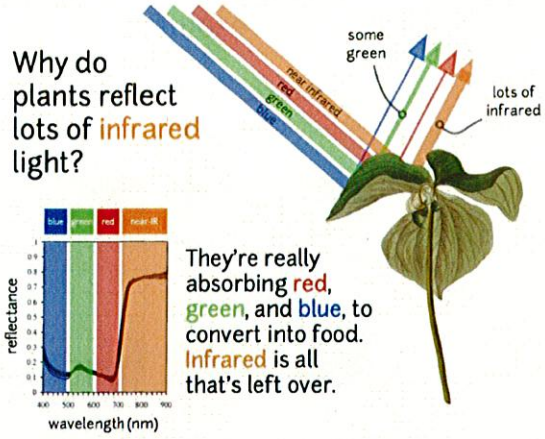


Spectral Bands
-Optical Sensor-

Why leaves are green?



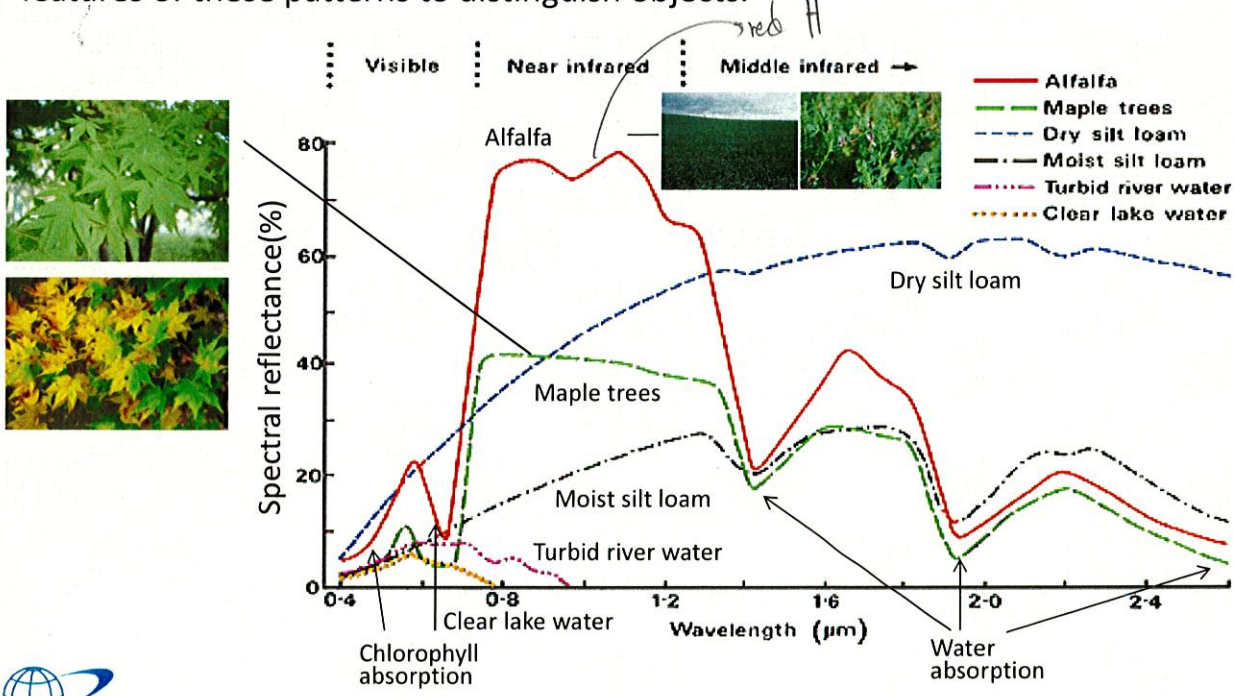
https://science.nasa.gov/ems/08_nearinfraredwaves



https://kaiserscience.files.wordpress.com/2015/01/plants-absorb-visible-light-and-reflect-infrared.jpg

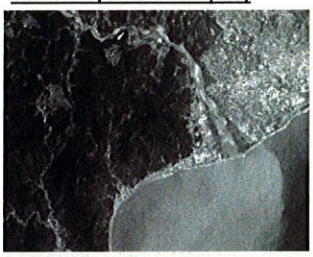
Reflectance and emittance spectra

All objects have different spectral reflectance pattern. Remote sensing uses the features of these patterns to distinguish objects.



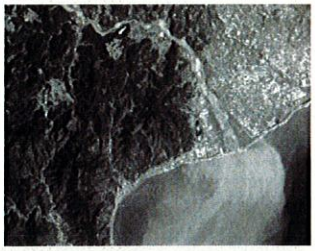
Spectral bands of Landsat-5/TM

Band 1 (0.45~0.52μm)



Blue band
absorption by Chlorophyll in the mountain
reflection by turbid sea water.

Band 2 (0.52~0.60μm)

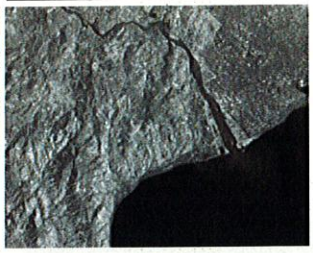


Green band
Distinguish from water and land

Band 3 (0.63~0.69μm)

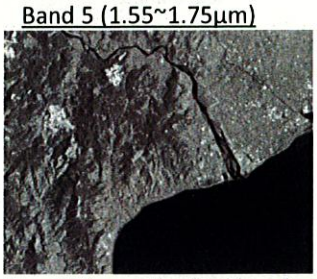
Red band
Distinguish from water and land
Vegetation area is clear

Band 4 (0.76~0.90μm)



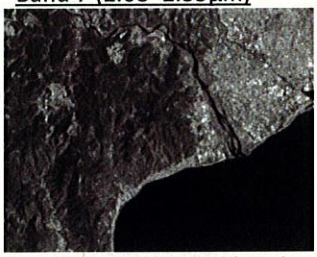
Near Infra-Red band
Strong reflection from vegetation
Black in river and sea due to the lack of reflection.

Band 5 (1.55~1.75μm)



Short Wave Infra-Red band
Strong reflection from vegetation and soil.
Soil has moisture, darker.

Band 7 (2.08~2.35μm)



Short Wave Infra-Red band
Weaker reflection from vegetation than soil.
Mountain is darker than Band 5.

Band 6 (10.4~12.5μm)

Thermal Infra-Red band
Detect the temperature of water.

Around the Fuji River and Suruga Bay
Aqisition date: April 23, 1992

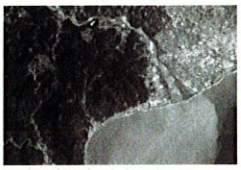
-each band should have spatial character characteristics

Color Composite

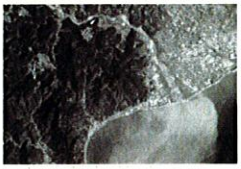
Single Band Image

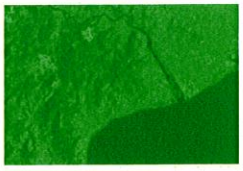
Color Filter

Band 1 (Blue)

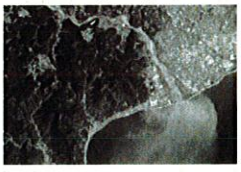


Band 2 (Green)





Band 3 (Red)



- If different three bands image are assigned to three primary colors, we can get color composite images
- Three color composite types are called "true color", "false color" and "natural color".

True color composite

Commonly used Color Composite

Natural Color Composite

Vegetation is emphasized by green.

Red: Band 3
Green: Band 4
Blue: Band 2

False Color Composite

Vegetation is emphasized by red.

Red: Band 4
Green: Band 3
Blue: Band 2

Short Wavelength Color Composite

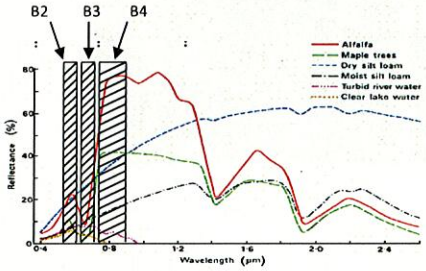
The urban region and vegetation is more clearly classified.

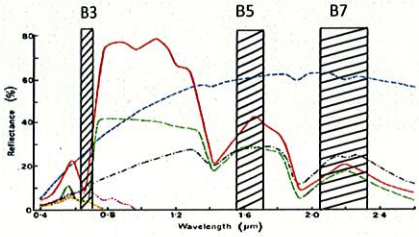
Red: Band 7
Green: Band 5
Blue: Band 3

Thermal IR Color Composite

Hotter area is emphasized by red.

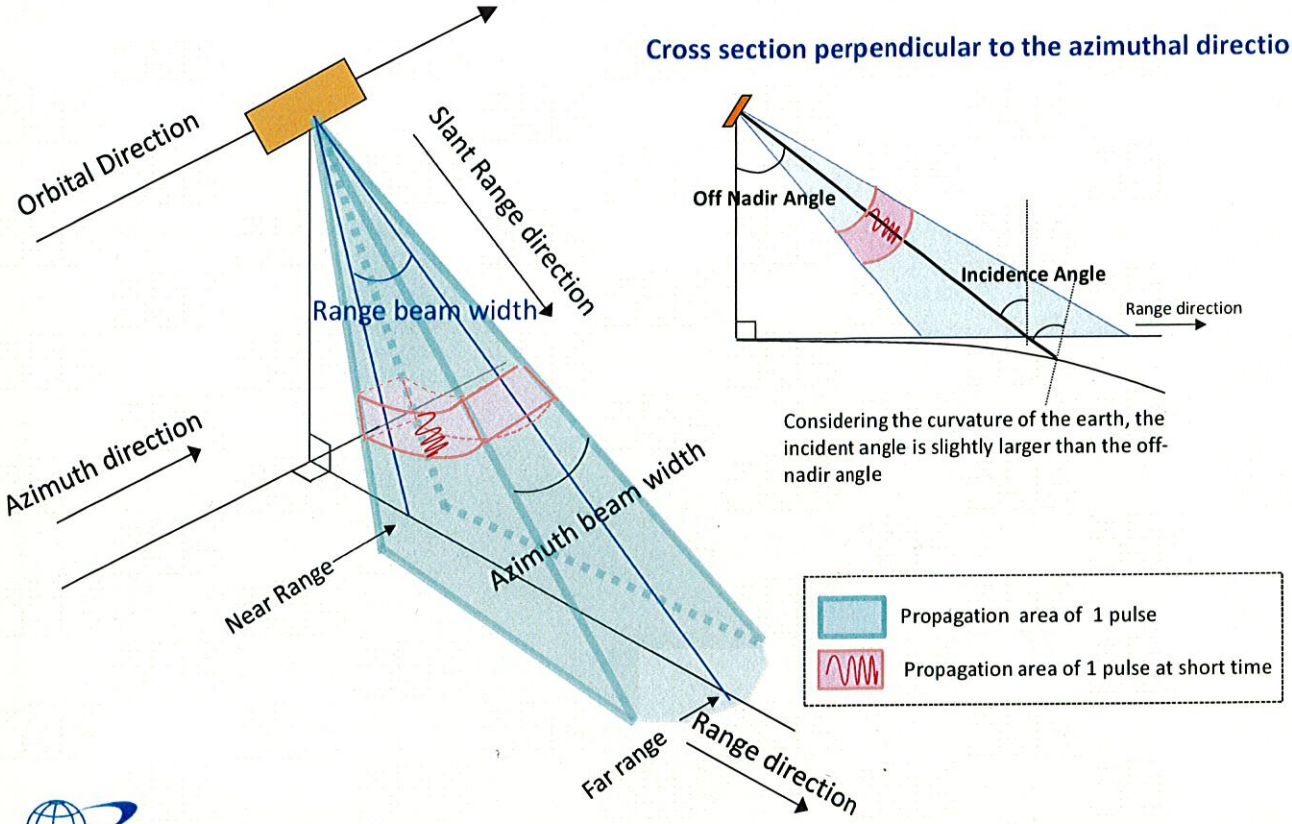
Red: Band 6
Green: Band 4
Blue: Band 2



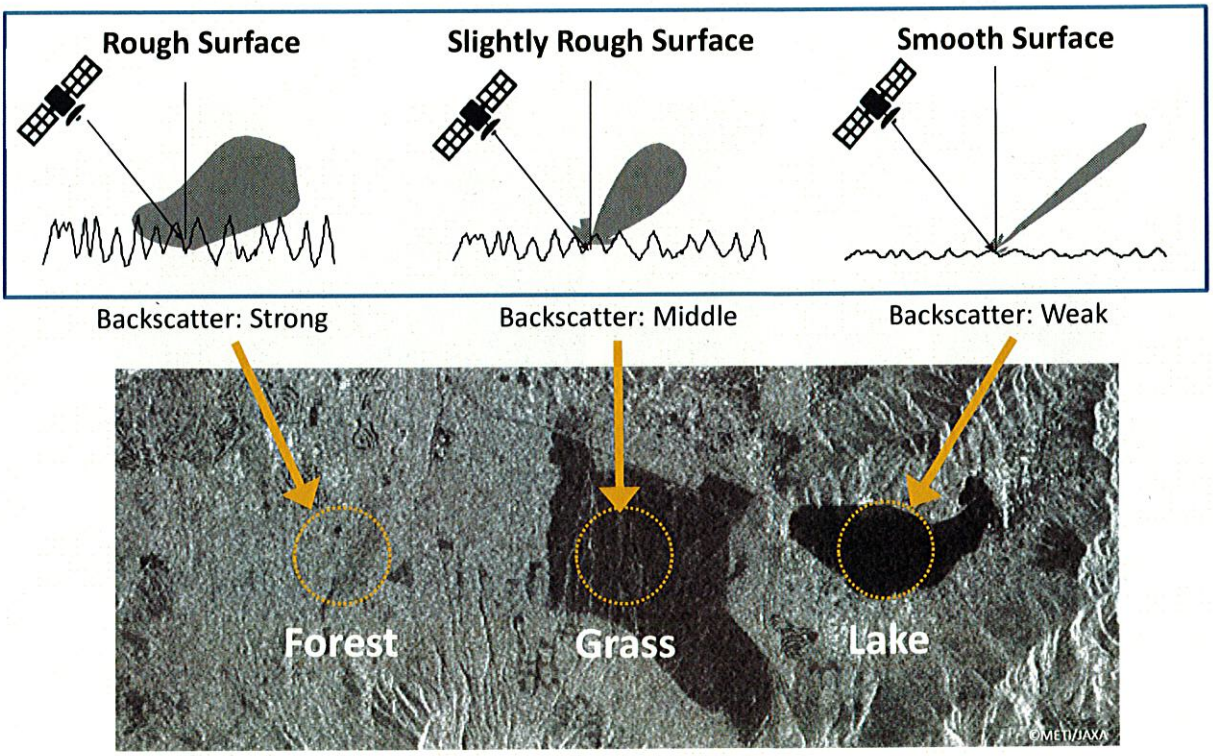


SAR

Observation geometry of SAR



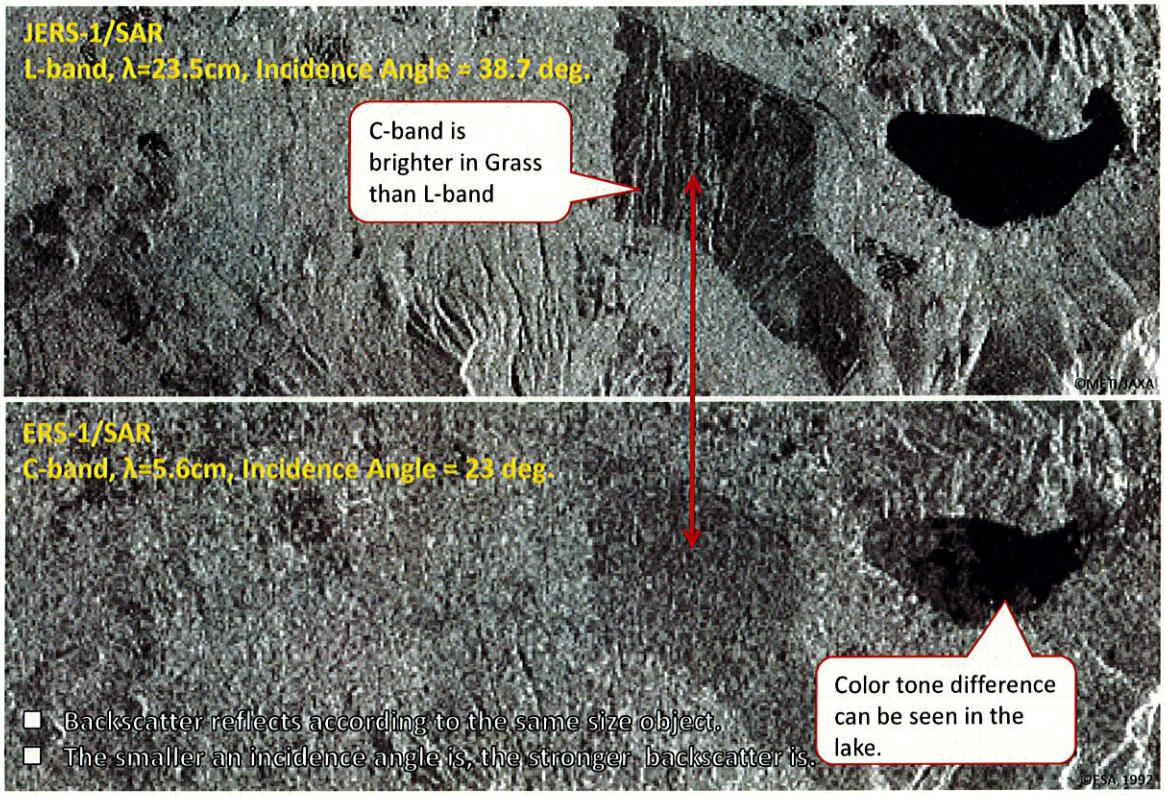
Surface roughness in SAR Image



Roughness depends on the wavelength of microwave

SAR image includes some " sprayed sand " pattern, this is called a "speckle noise"

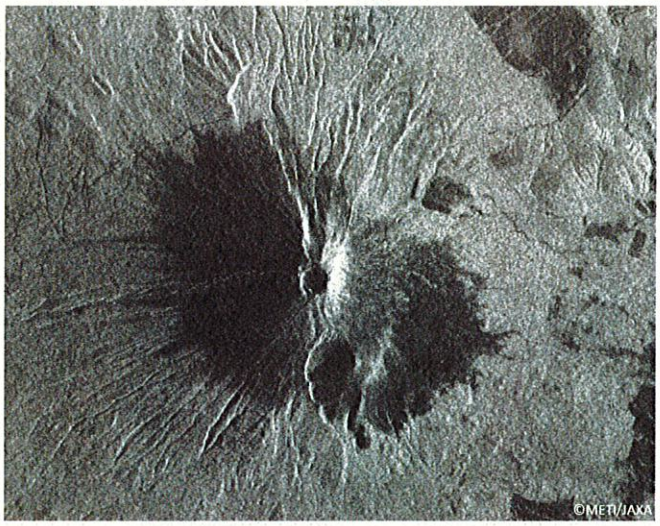
Wavelength & Incidence angle



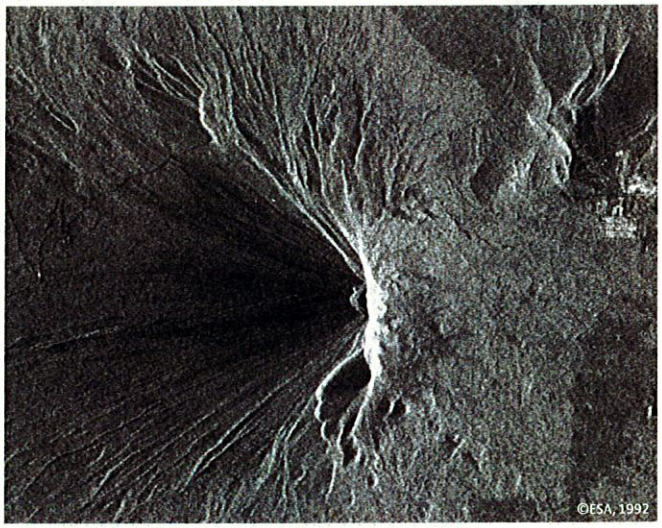
- Backscatter reflects according to the same size object.
- The smaller an incidence angle is, the stronger backscatter is.

PFXC

Geometric Distortion

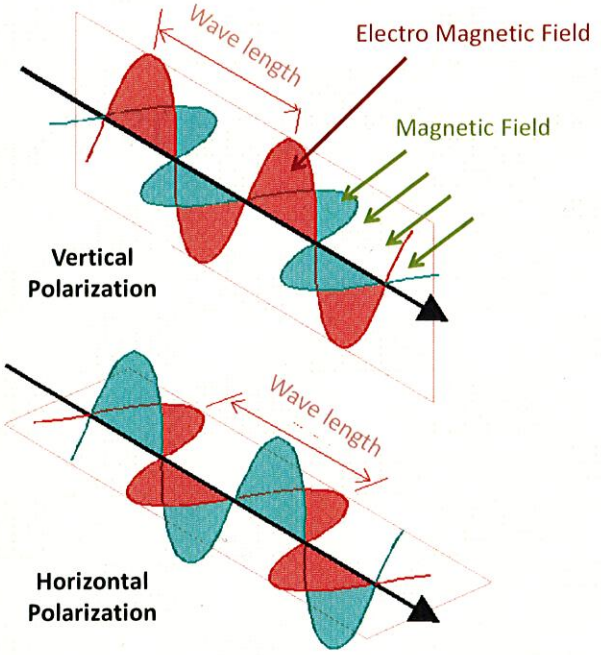


JERS-1/SAR, Incident angle 38.7 deg.



ERS-1/SAR, Incident angle 23 deg.

Polarization



perpendicular polarization consists of **Vertical polarization** and **horizontal polarization**.

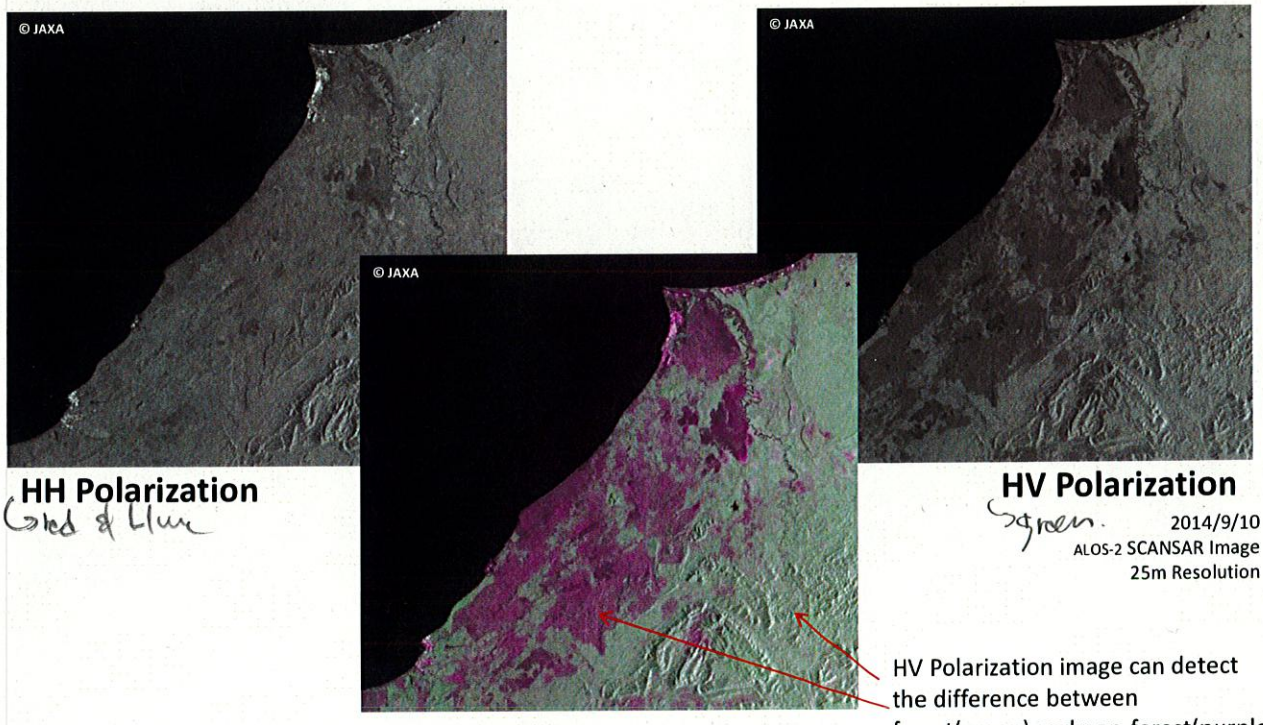
Polarization direction is **fixed by the direction of electromagnetic field**.

In SAR system, emitting and receiving polarization should be considered.

Observation using several polarization called **multi-polarimetry**.

Observation using all combination of polarization called **full-polarimetry**.

Polarimetric SAR Imagery



HH Polarization

HV Polarization

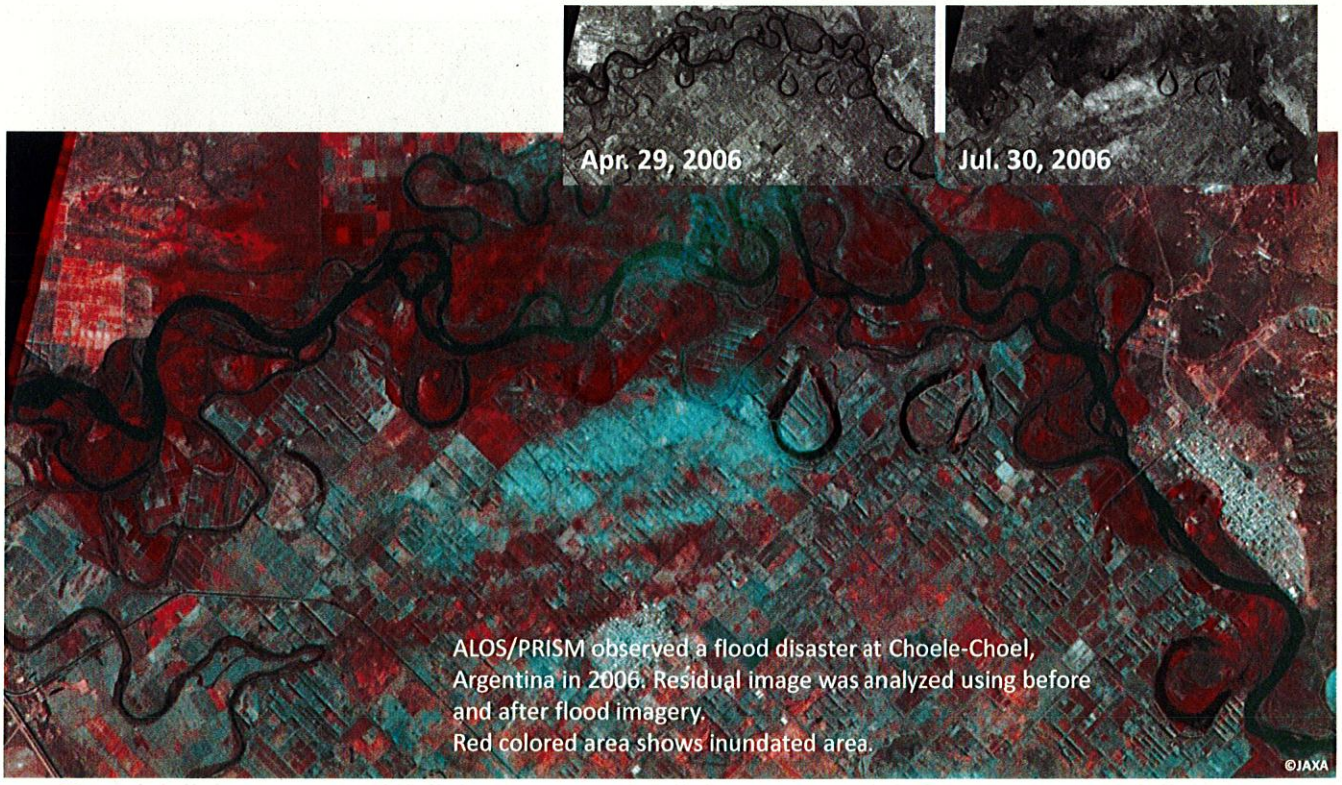
2014/9/10
ALOS-2 SCANSAR Image
25m Resolution

R:G:B=HH:HV:HH

HV Polarization image can detect the difference between forest(green) and non-forest(purple) area.

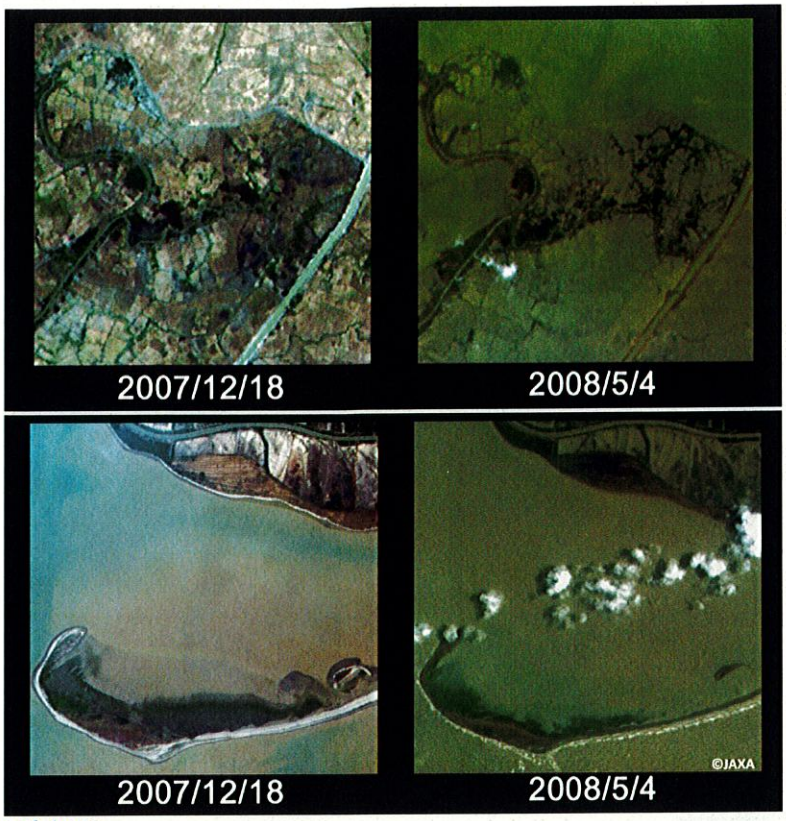
Application of Satellite Remote Sensing for disaster

Flood in Argentina



Flood in Delta Region in Myanmar

Image of before and after flood area in delta region of Myanmar by "Cyclone Nargis" (May 2, 2008) taken by ALOS/AVNIR-2.



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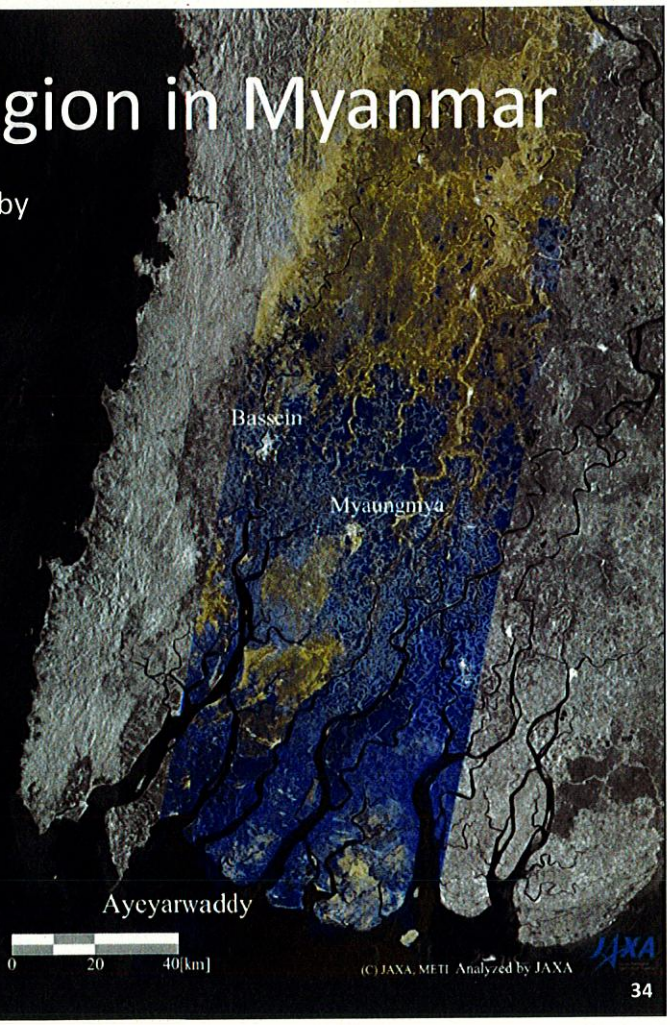
Flood in Delta Region in Myanmar

Image of flood area in delta region of Myanmar by "Cyclone Nargis" (May 2, 2008) taken by ALOS/PALSAR.



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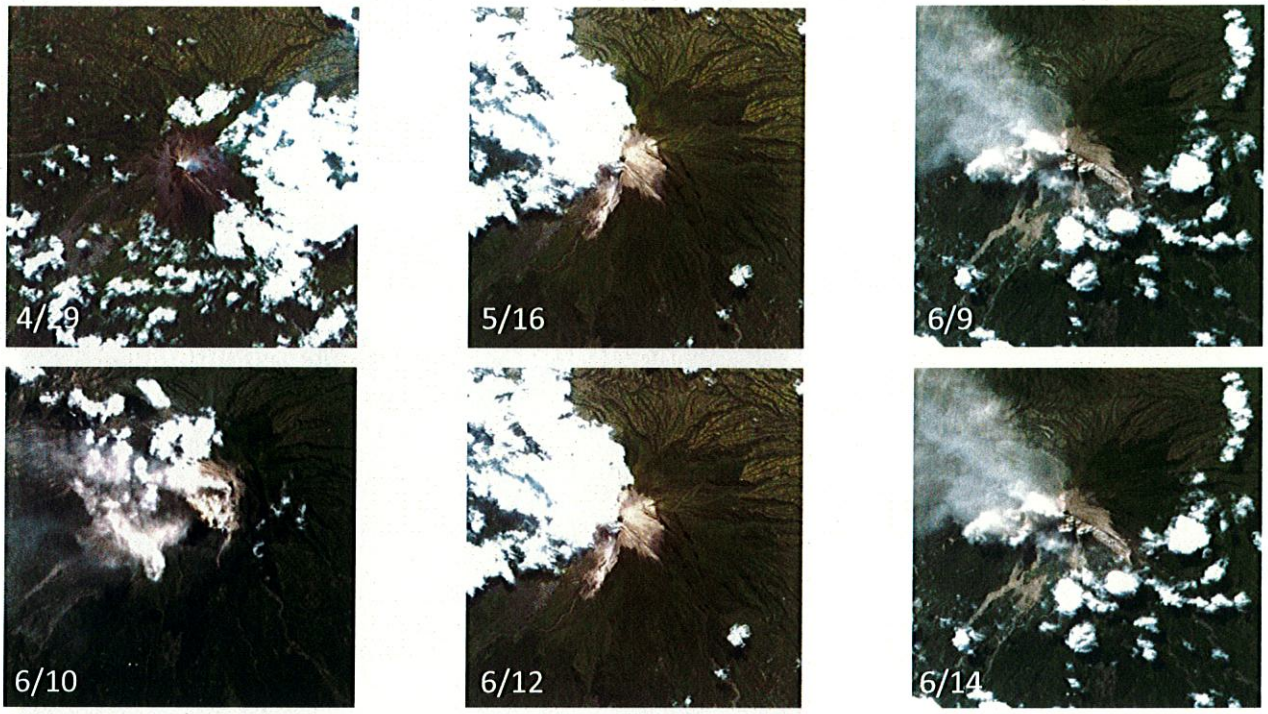
Eruption at Mt. Murapi, Indonesia in 2006



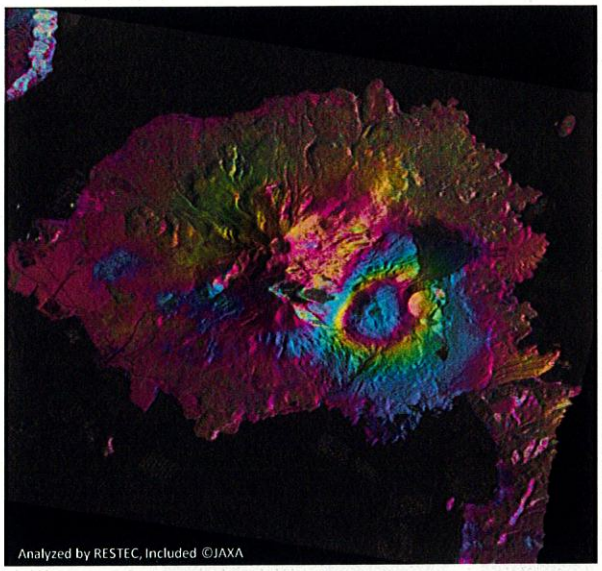
Expansion of pyroclastic flow and deforestation were understood from the continuous observation imageries.

Eruption at Mt. Miyakejima, Japan

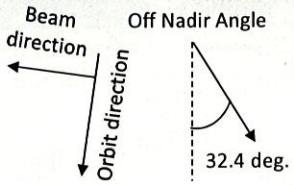
Pre Eruption | Post Eruption (Aug. 2) | Post Eruption (Aug. 30)

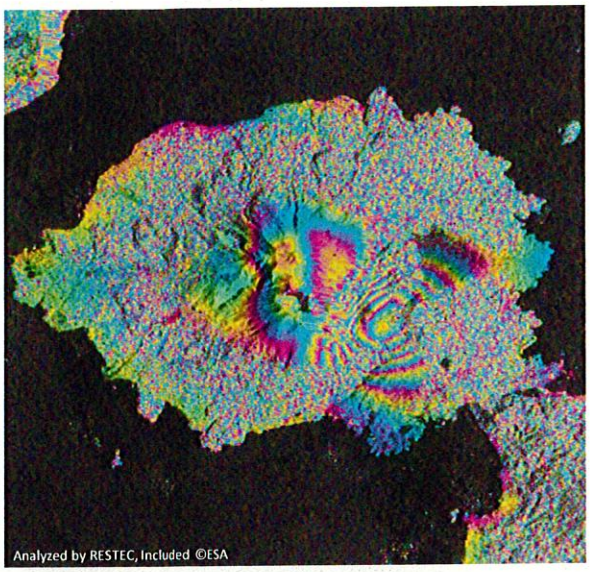
Jul. 8, 2000 Phreatic eruption
Aug. 10, 18,and29, 2000 Eruptions

Deformation at Mt. Sakurajima, Japan

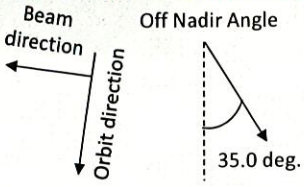


ALOS-2/PALSAR-2
(L-band)
Master: 2015/08/10
Slave: 2015/08/24

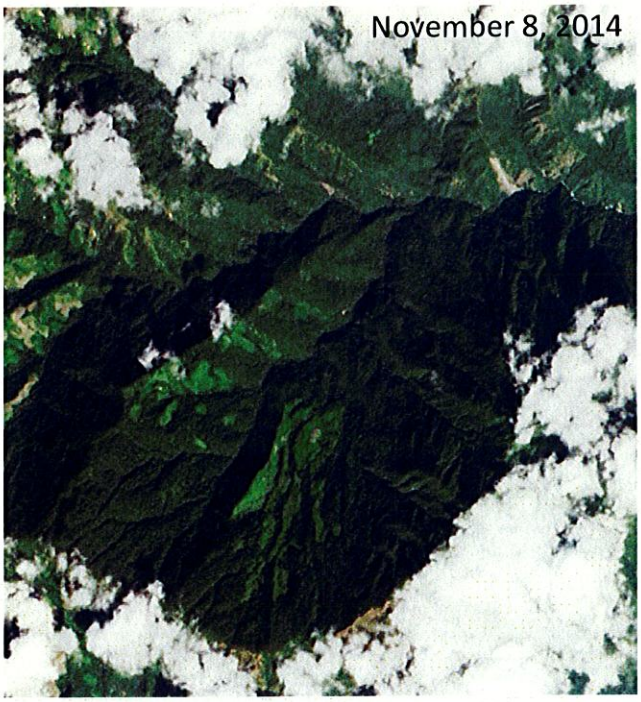


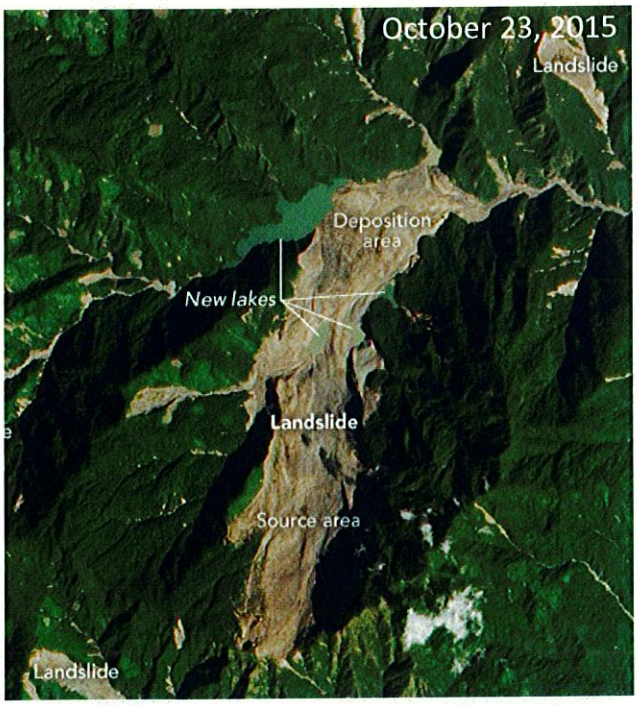


Sentinel-1A
(C-band)
Master: 2015/07/31
Slave: 2015/08/24



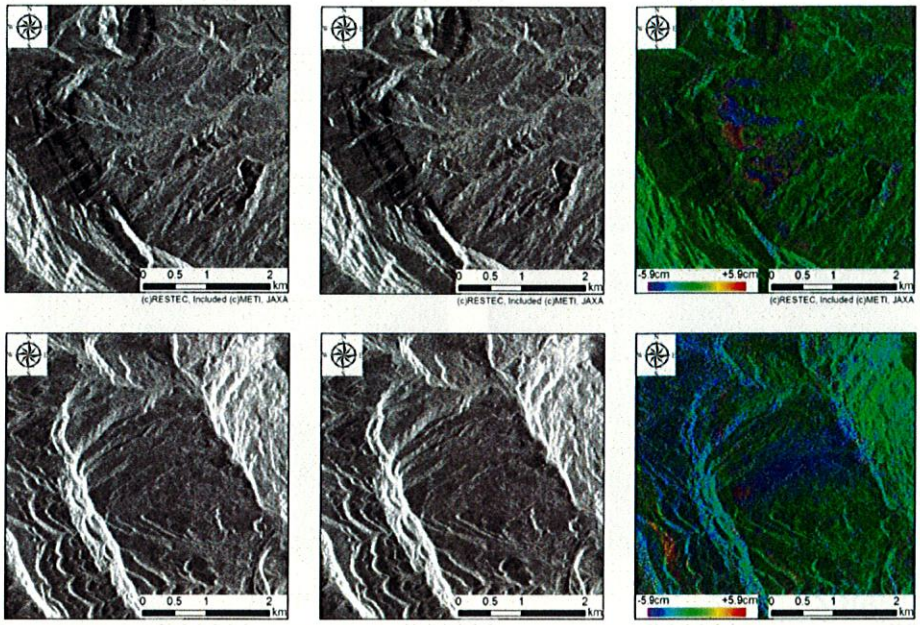
Landslide at Chin, Myanmar





Landslide occurred in July, 2015
Observed by NASA EO-1 (US satellite), 30m spatial resolution

Landslides in Pakistan

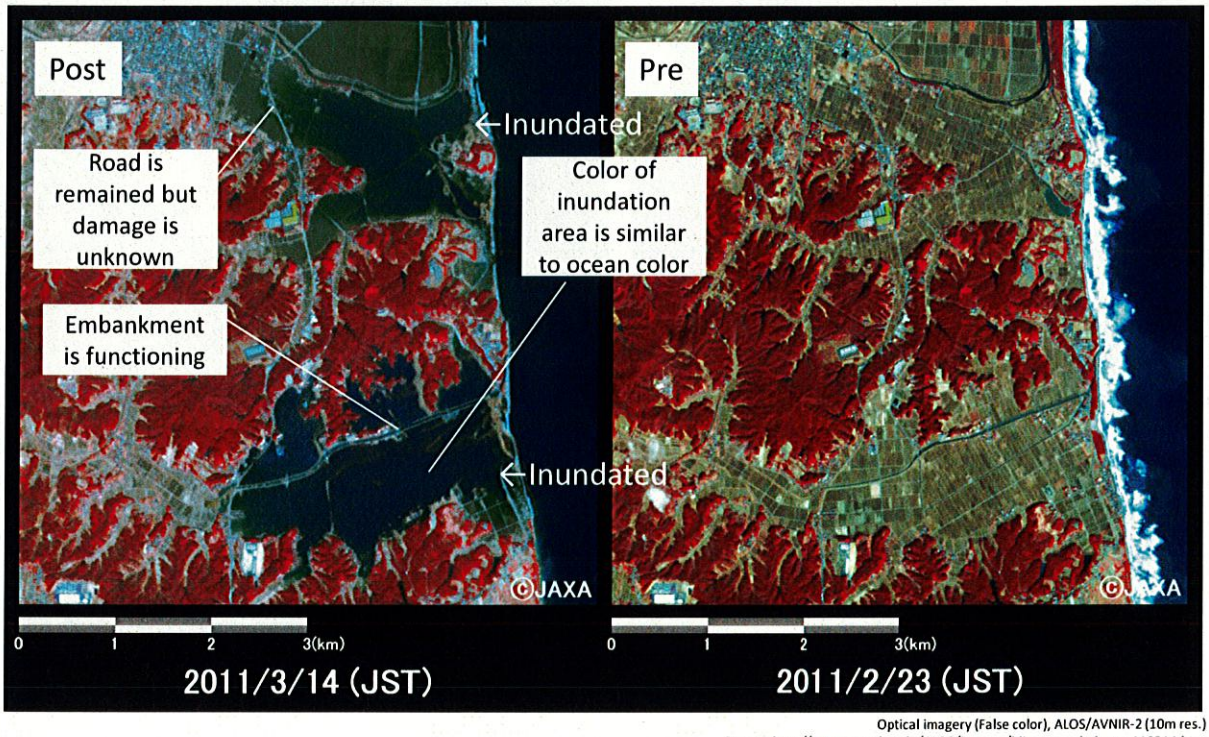


Processed by ©RESTEC, Included ©JAXA, METI

2007/01/22 2008/12/12 DInSAR

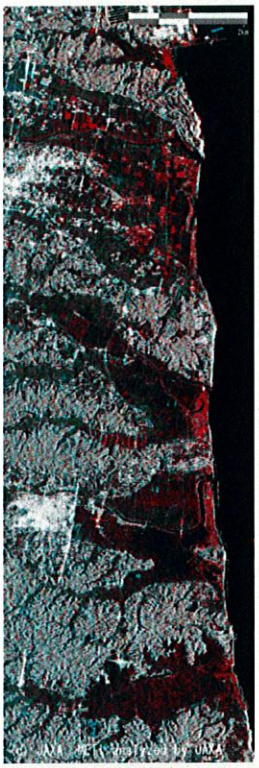
Landslides had caused by the M6.4 Earthquake in 2008. This disaster is detected by DInSAR

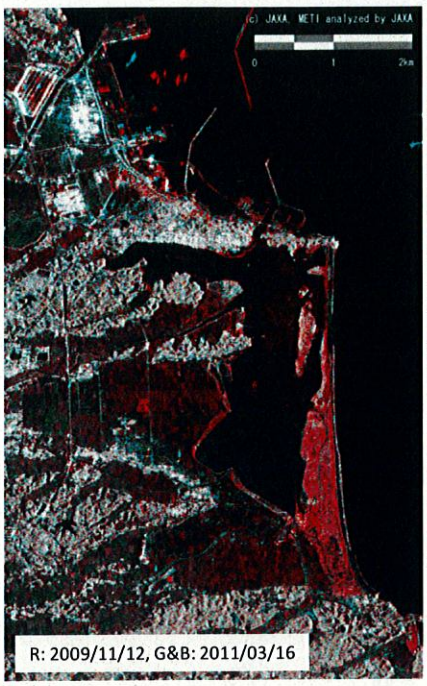
Tsunami by the 2011 Great East Japan Earthquake



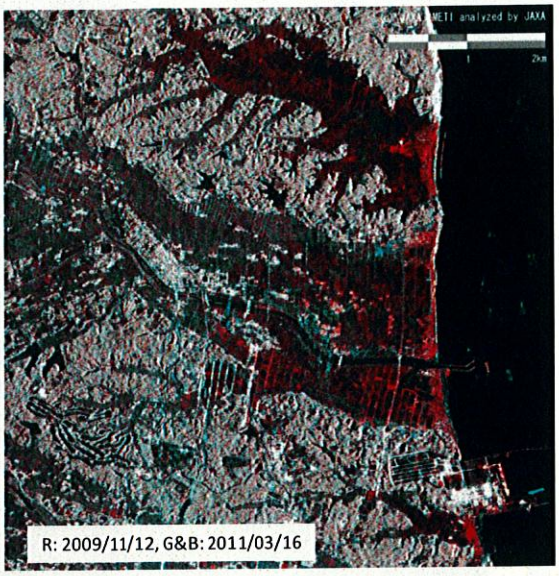
Optical imagery (False color), ALOS/AVNIR-2 (10m res.)
Source: http://www.eorc.jaxa.jp/ALOS/img_up/jdis_opt_tohokueq_110314.htm

Tsunami by the 2011 Great East Japan Earthquake





From Miyagi to Fukushima



Red and cyan color shows change of pre-post
Red: Mainly inundation
Cyan: Inundation and others

SAR imagery, ALOS/PALSAR (10m res.)
Source: http://www.eorc.jaxa.jp/ALOS/img_up/jdis_pal_tohokueq_110316.htm

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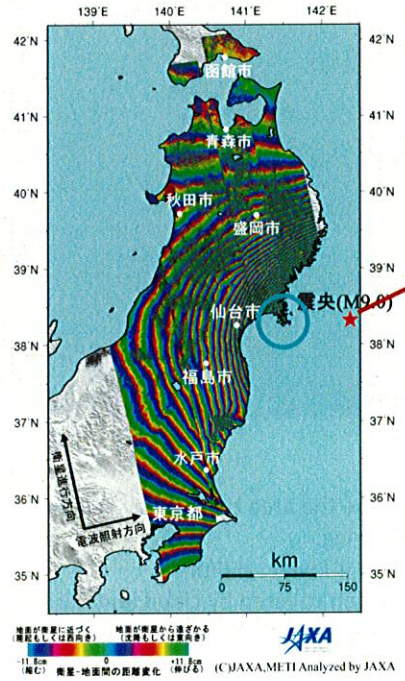
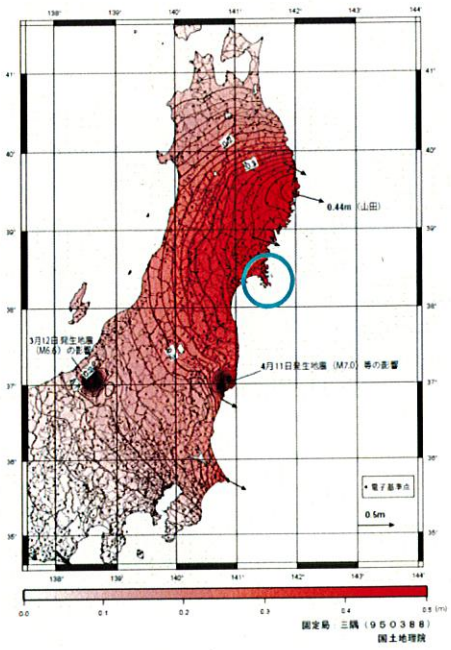
Deformation by the 2011 Great East Japan Earthquake



Hypocenter

Displacement of Ojika peninsula
DInSAR: approx. 4.0m
GPS "Ojika":
approx. 5.3m (horizontal)
approx. 1.2m (vertical)
to LOS: approx. 4.4m



DInSAR analysis image

GPS observation result

Source: http://www.gsi.go.jp/common/000060569.pdf

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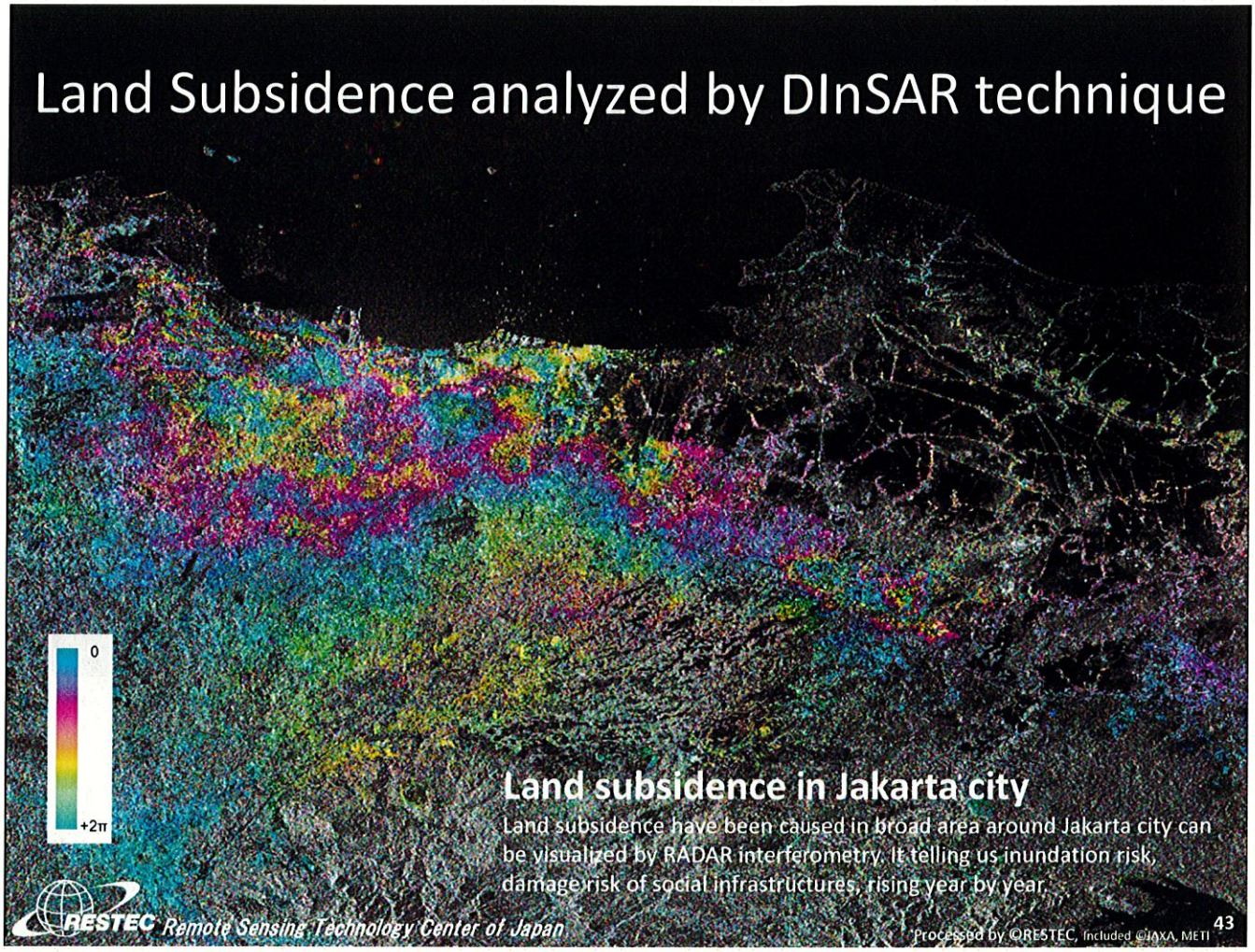
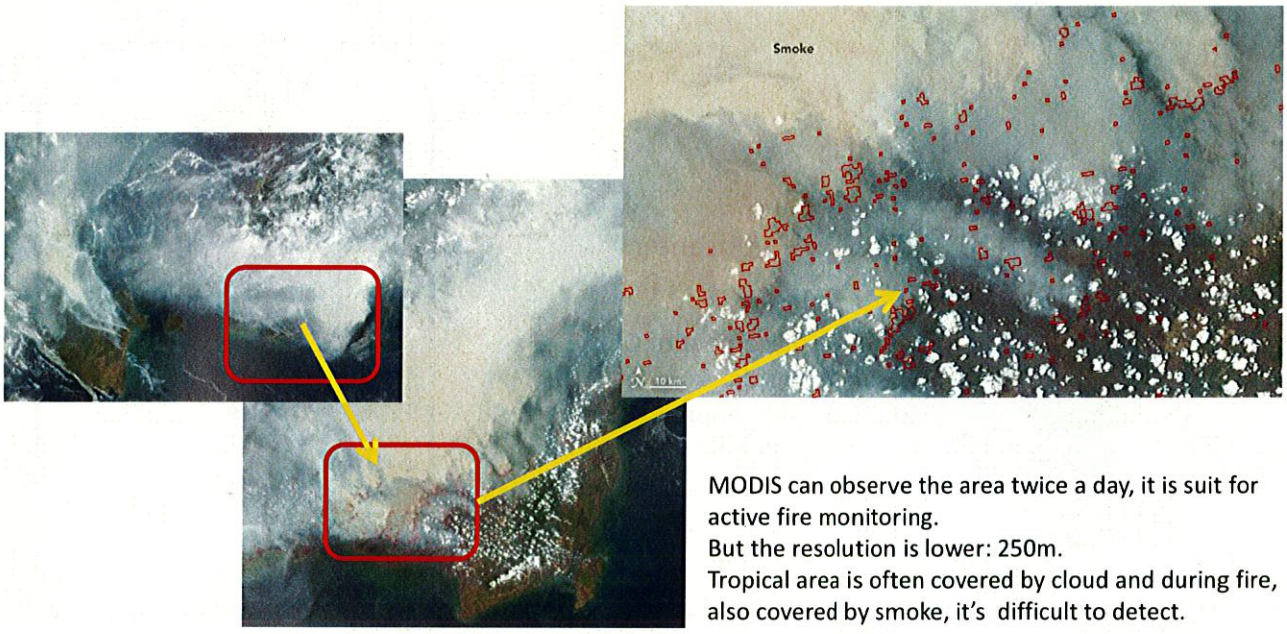
Land Subsidence analyzed by DInSAR technique



Forest Fire



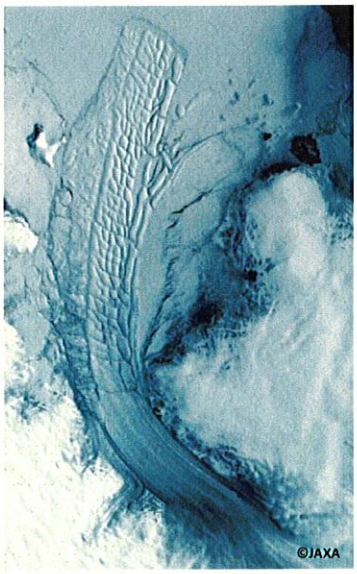
MODIS can observe the area twice a day, it is suit for active fire monitoring.
But the resolution is lower: 250m.
Tropical area is often covered by cloud and during fire, also covered by smoke, it's difficult to detect.

Borneo, Indonesia
2015/10/19 MODIS

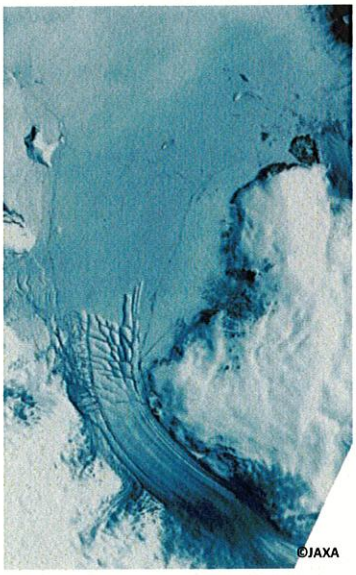
https://earthobservatory.nasa.gov/IOTD/view.php?id=86681
https://earthobservatory.nasa.gov/IOTD/view.php?id=86847&eocn=image&eoci=related_image

Oil spill

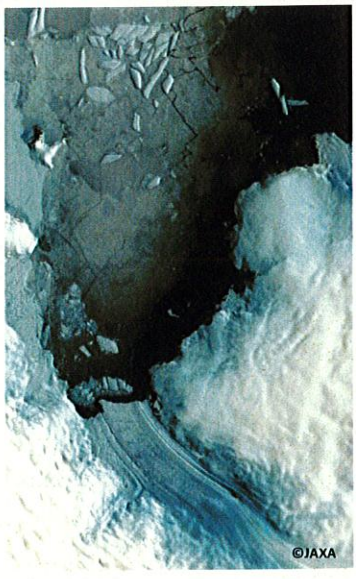
Glacier Monitoring in Antarctica



1973



1984



1988

These images taken by Landsat show the collapse and reduction of a glacier.

The satellite can take an image of the same area constantly, and it's suitable for the comparison of time series changes.

Thank you for your attention