Introduction to Remote Sensing & GIS

Japan Space Systems

Contents

1. What is the remote sensing?
   - Optical Sensor
   - Microwave (Synthetic Aperture Radar/SAR)
   - Digital Elevation Model (DEM)

2. Basic GIS

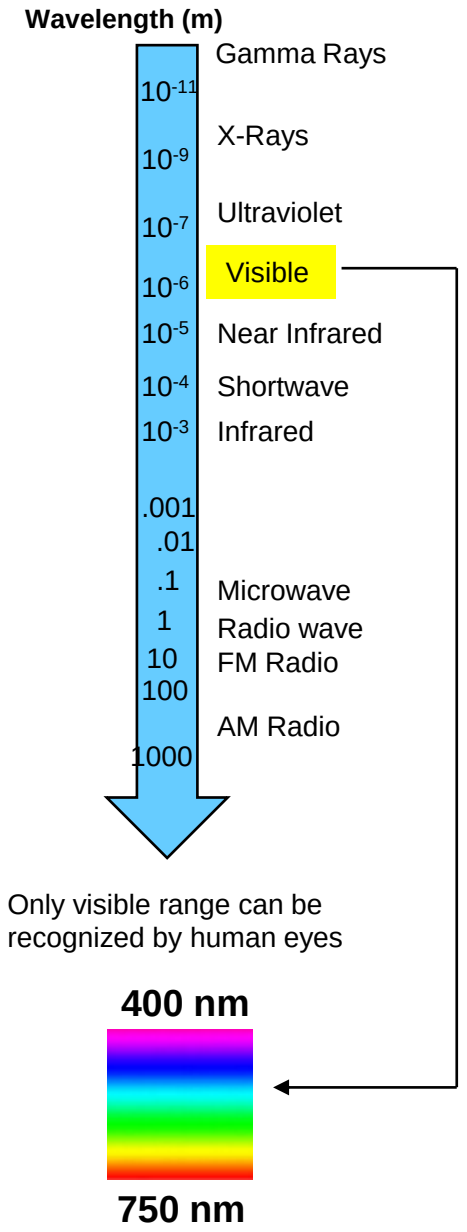
What is remote sensing?

Remote sensing (RS) is a technique obtaining information about a phenomena or object from a distance, without direct contact.

Remote sensing and electromagnetic radiation

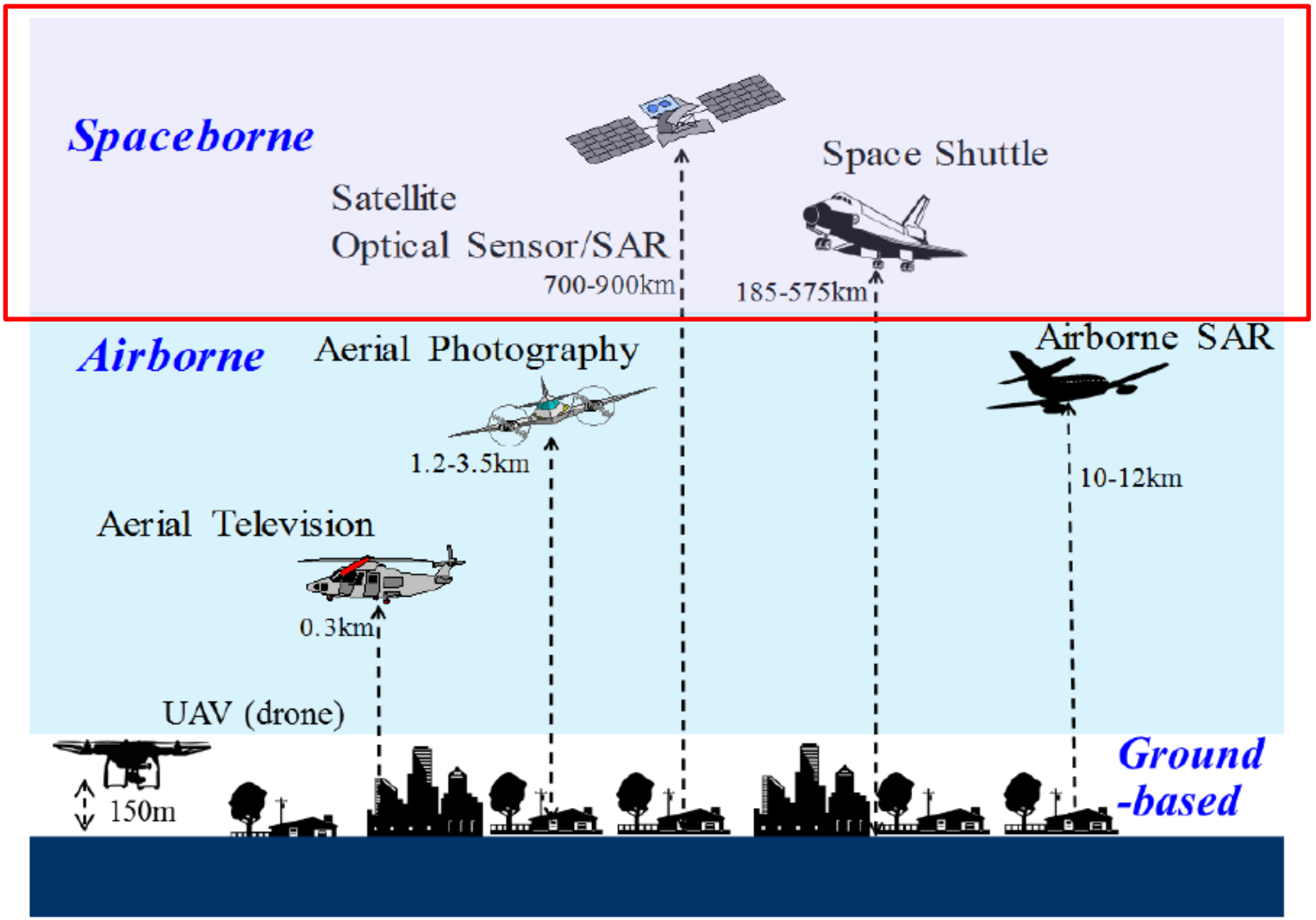
- **Remote sensing** is **a technique** obtaining information about a phenomena or object from a distance, without direct contact.
- **Electromagnetic radiation (EM)** is used for remote sensing. EM is **invisible form of energy** that travel through the universe at various ranges of wavelength.
- **Human eyes** can recognize the narrow range of EM from 400nm to 750nm approximately.
- **Digital camera** is one of tools of remote sensing to capture the objects.

Visible range: 400-750nm



Remote sensing data by different altitude

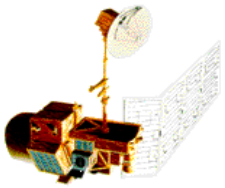
❑ Various platforms and sensors used for remote sensing



Yamazaki and Liu (2016)

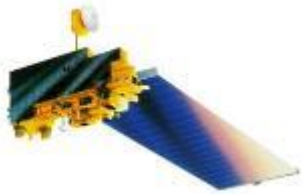
Integration of three types of spaceborne data

(1) Optical Sensor (OPS)



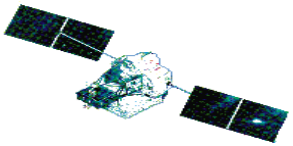
LANDSAT, Sentinel-2

RapidEye, QuickBird, WorldView-2/3, etc.

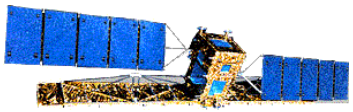


MODIS, ASTER

(2) Microwave (Synthetic Aperture Radar/SAR)



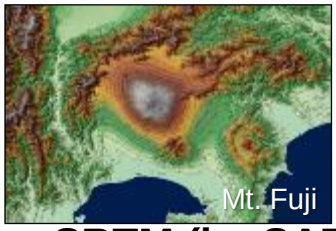
TerraSAR-X (X-band <3cm)



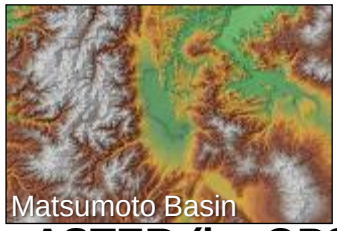
Sentinel-1, RADARSAT (C-band <6cm)

PALSAR, PALSR-2 (L-band <25cm)

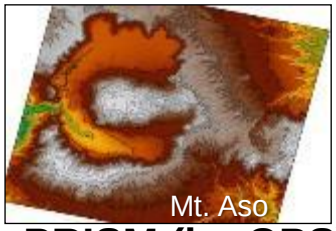
(3) Digital Elevation Model (DEM)



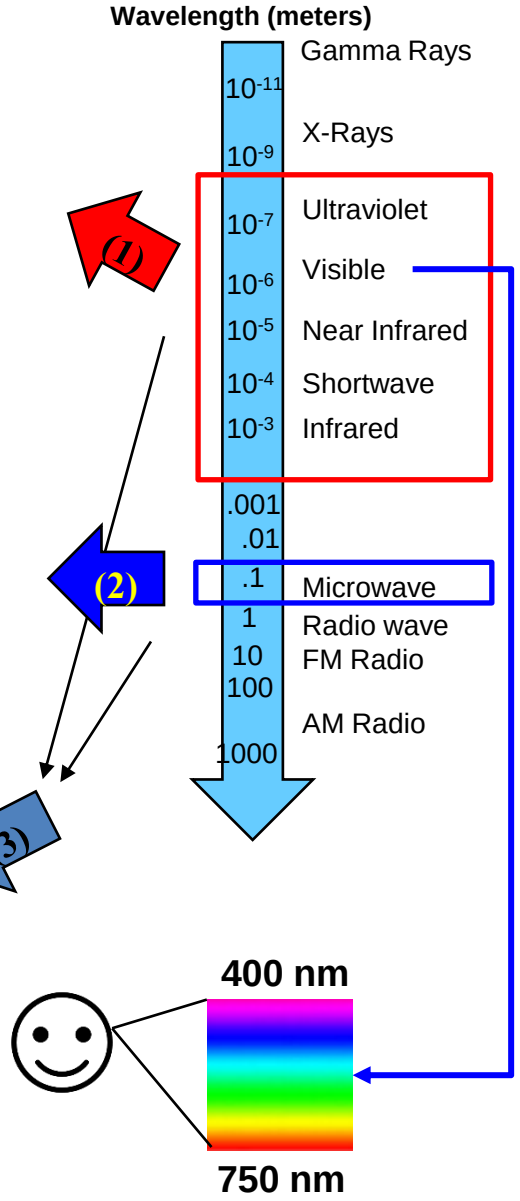
SRTM (by SAR)



ASTER (by OPS)

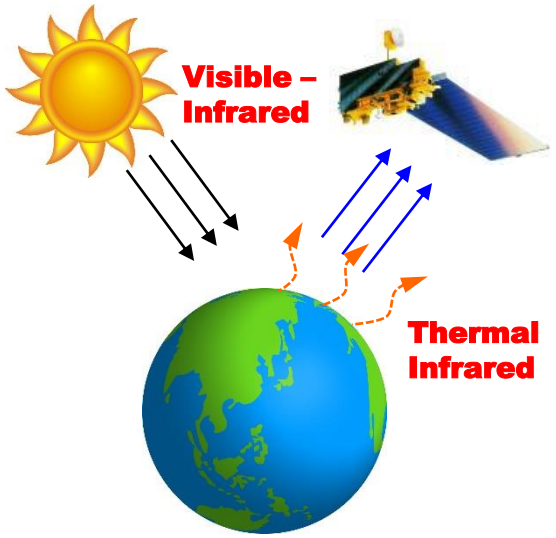


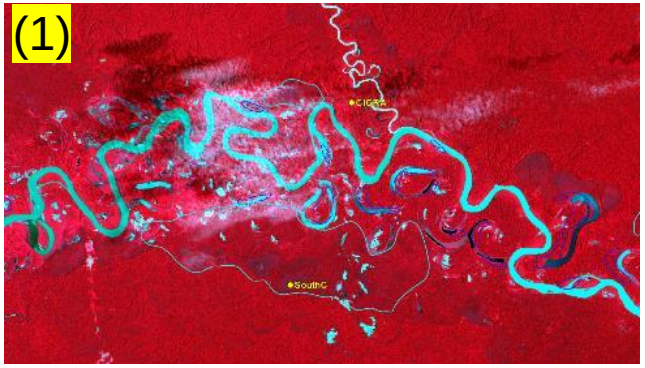
PRISM (by OPS)

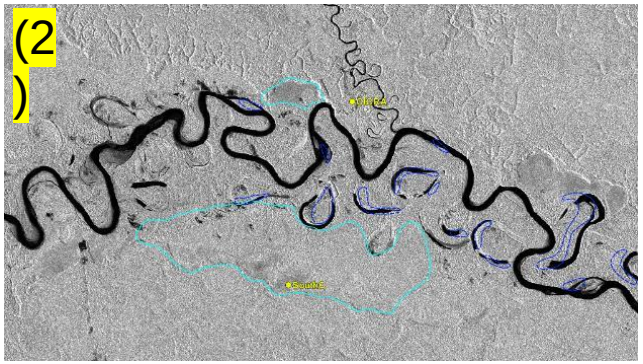


Three types of data by different sensors

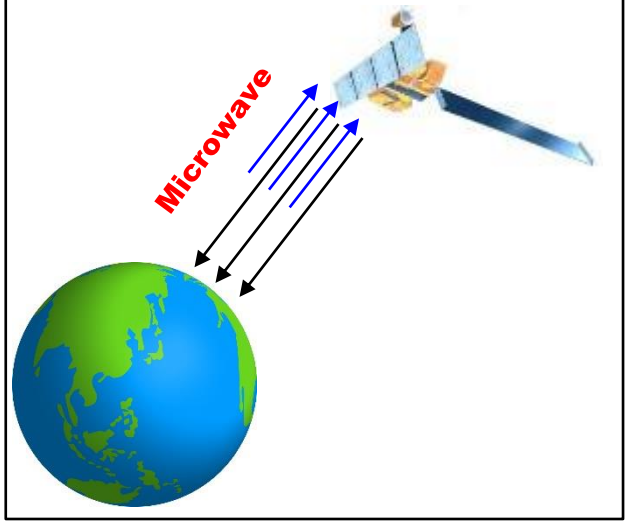
(1) Optical data



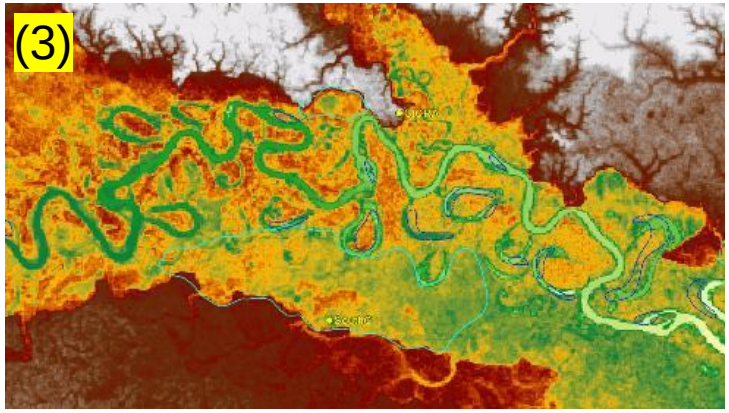




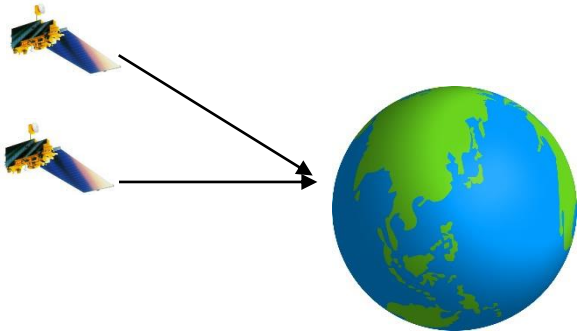
(2) Microwave data



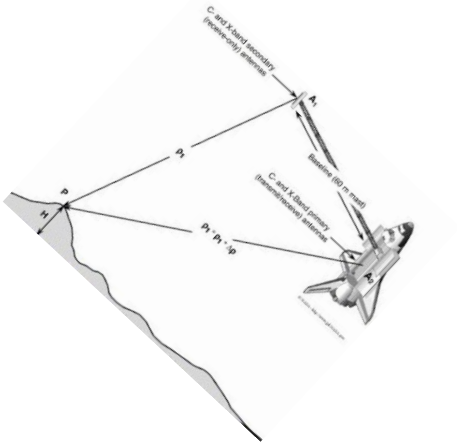
(3) Digital Elevation Model (DEM)



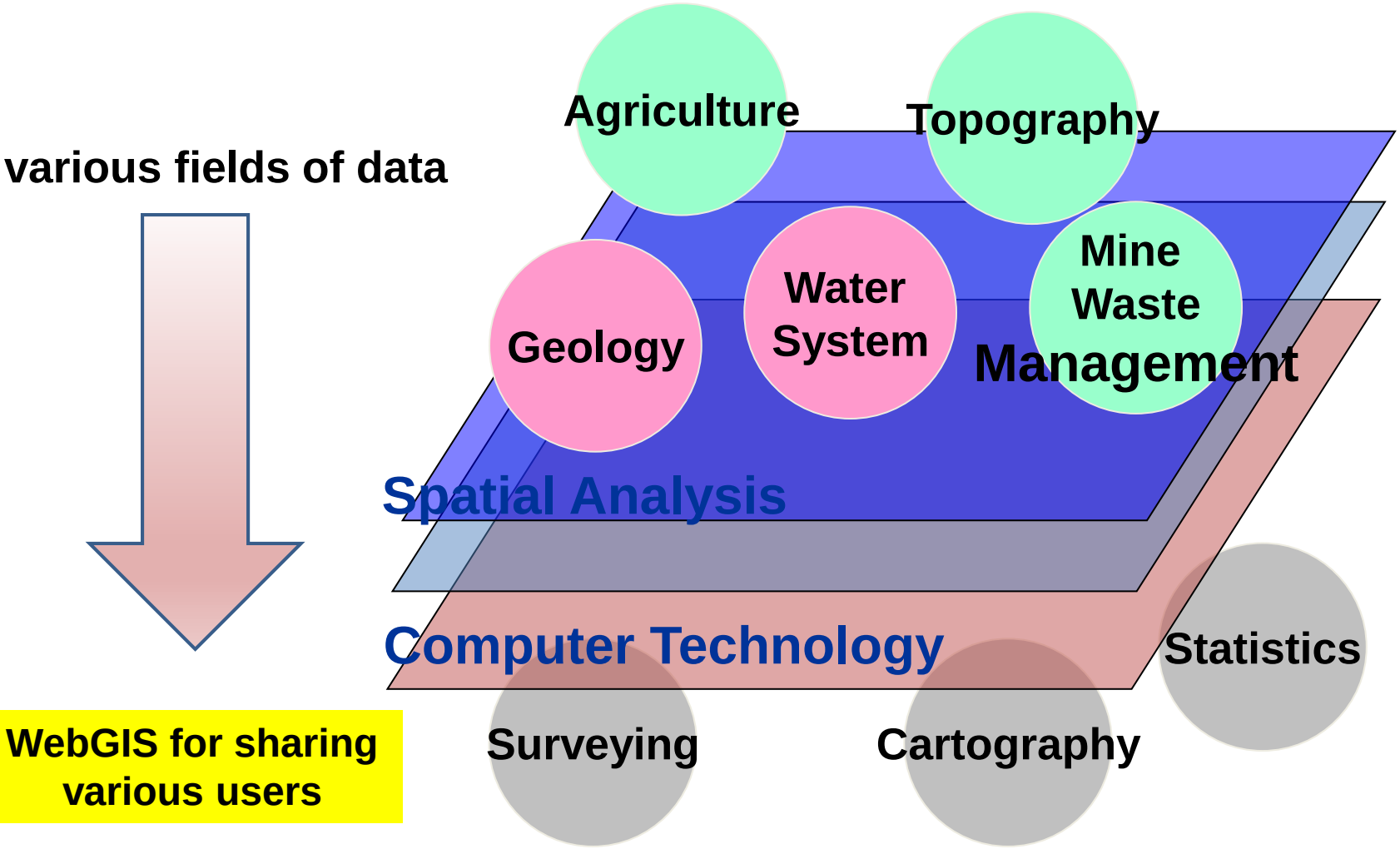
(1)Stereo Method (optical sensor)



(2) Interferometry Method (microwave)



Remote Sensing Data Integration on GIS



Data collection of remote sensing data

How to obtain and use remote sensing data?

(1) Source of energy
- (1-1) Sun
- (1-2) Earth
- (1-3) Microwave

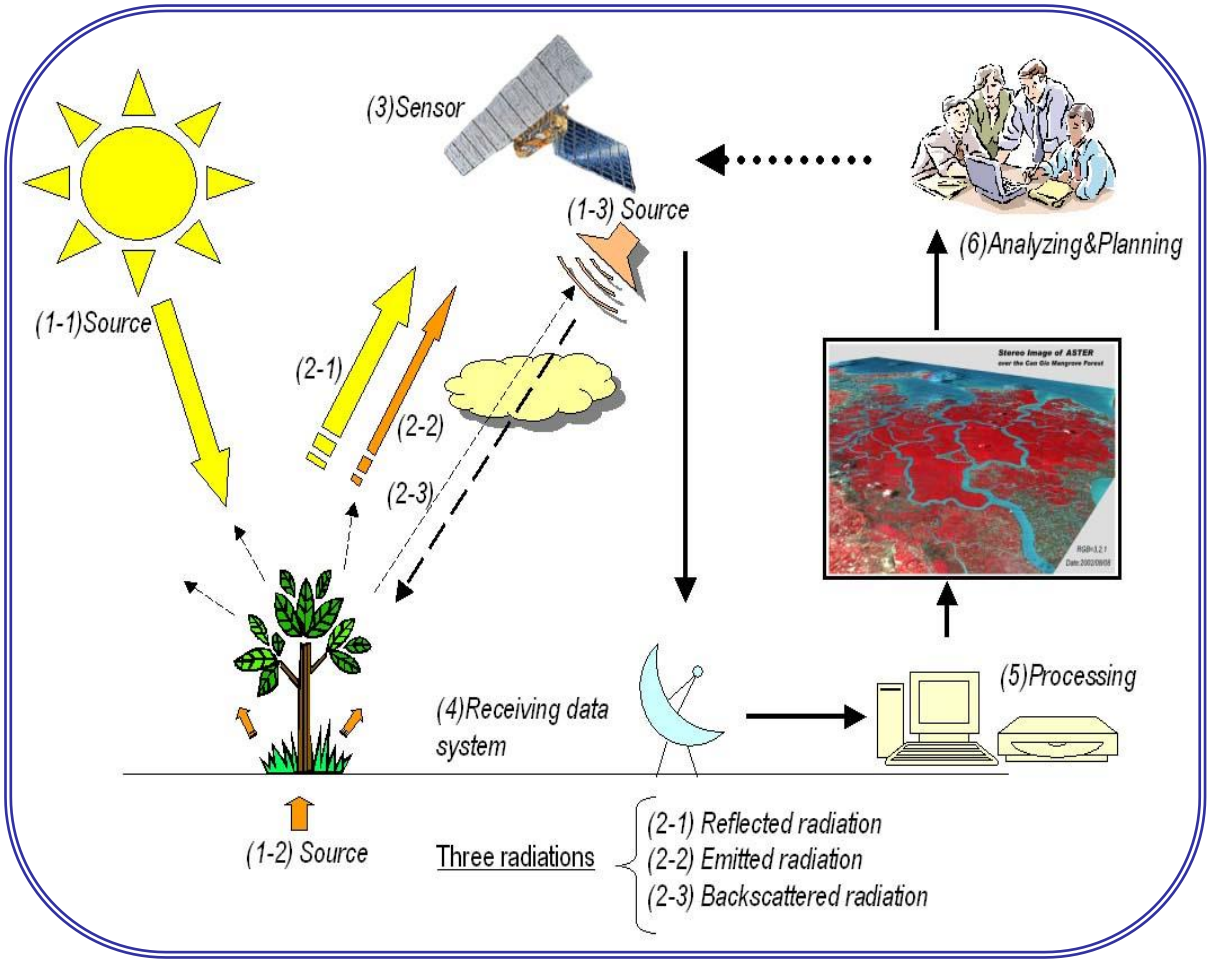
(2) Radiations
- (2-1) Reflected radiation
- (2-2) Emitted radiation
- (2-3) Backscattered radiation

(3) Sensors on satellite/aircraft

(4) Receiving data system

(5) Image Processing

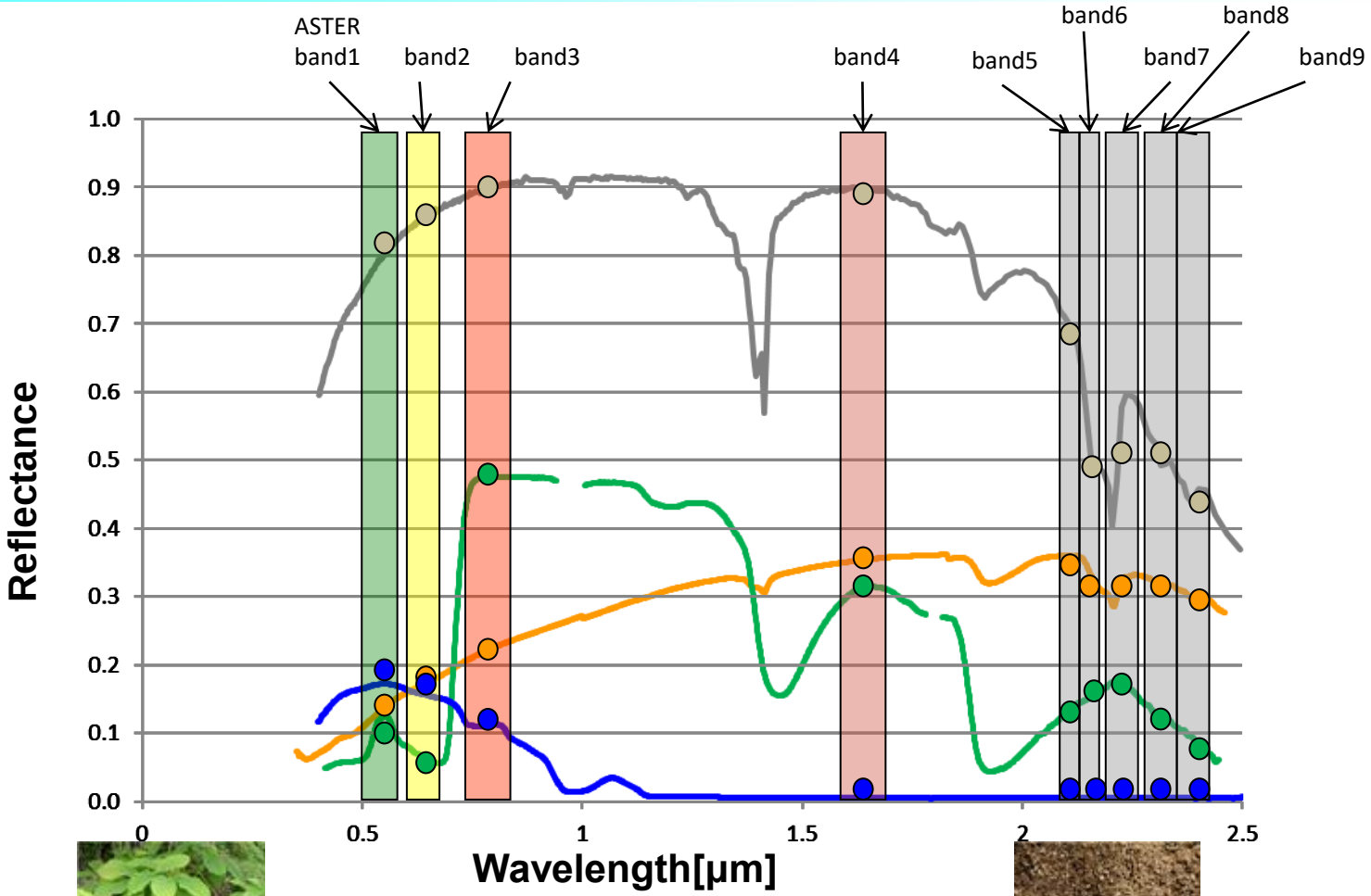
(6) Analyzing & Planning



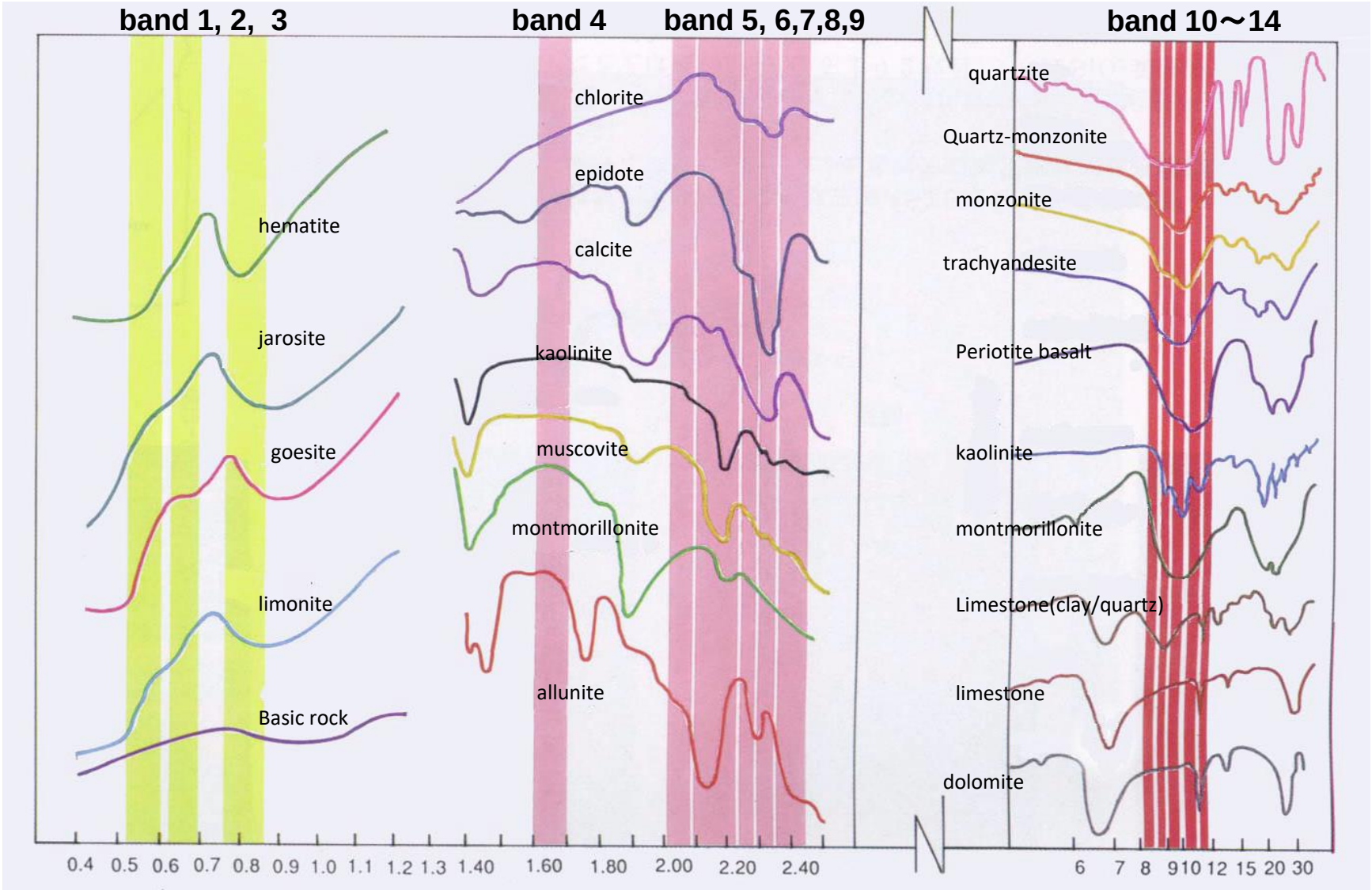
Major sensors:
1)Optical sensors (OPS), 2)Synthetic Aperture Radar (SAR), 3)Digital Elevation Model (DEM)

Optical Sensor (OPS) / Passive Sensor

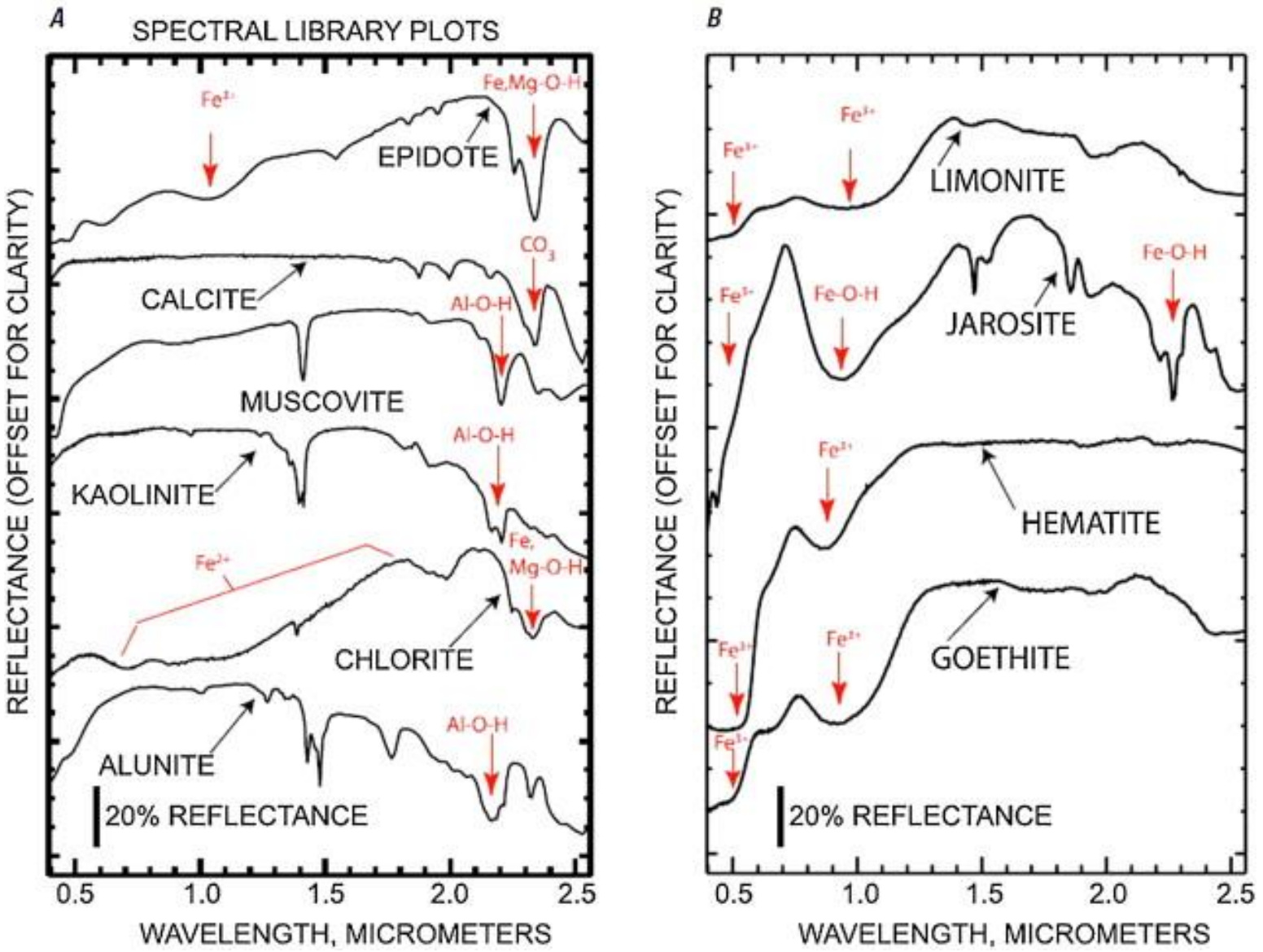
Optical sensor/ASTER



Spectral characterization of minerals and rocks with ASTER bands

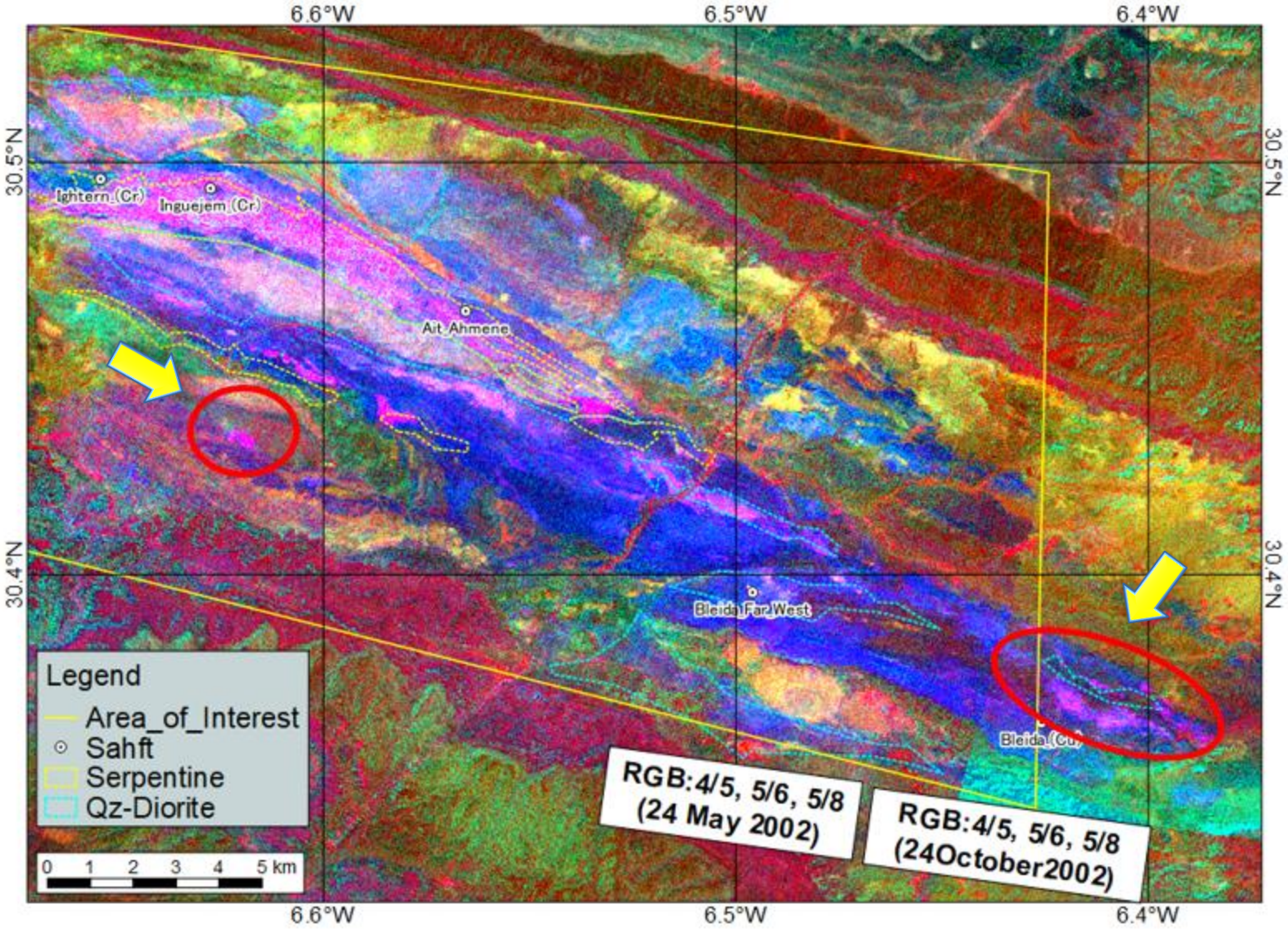


Optical sensor/ iron mineral spectral pattern



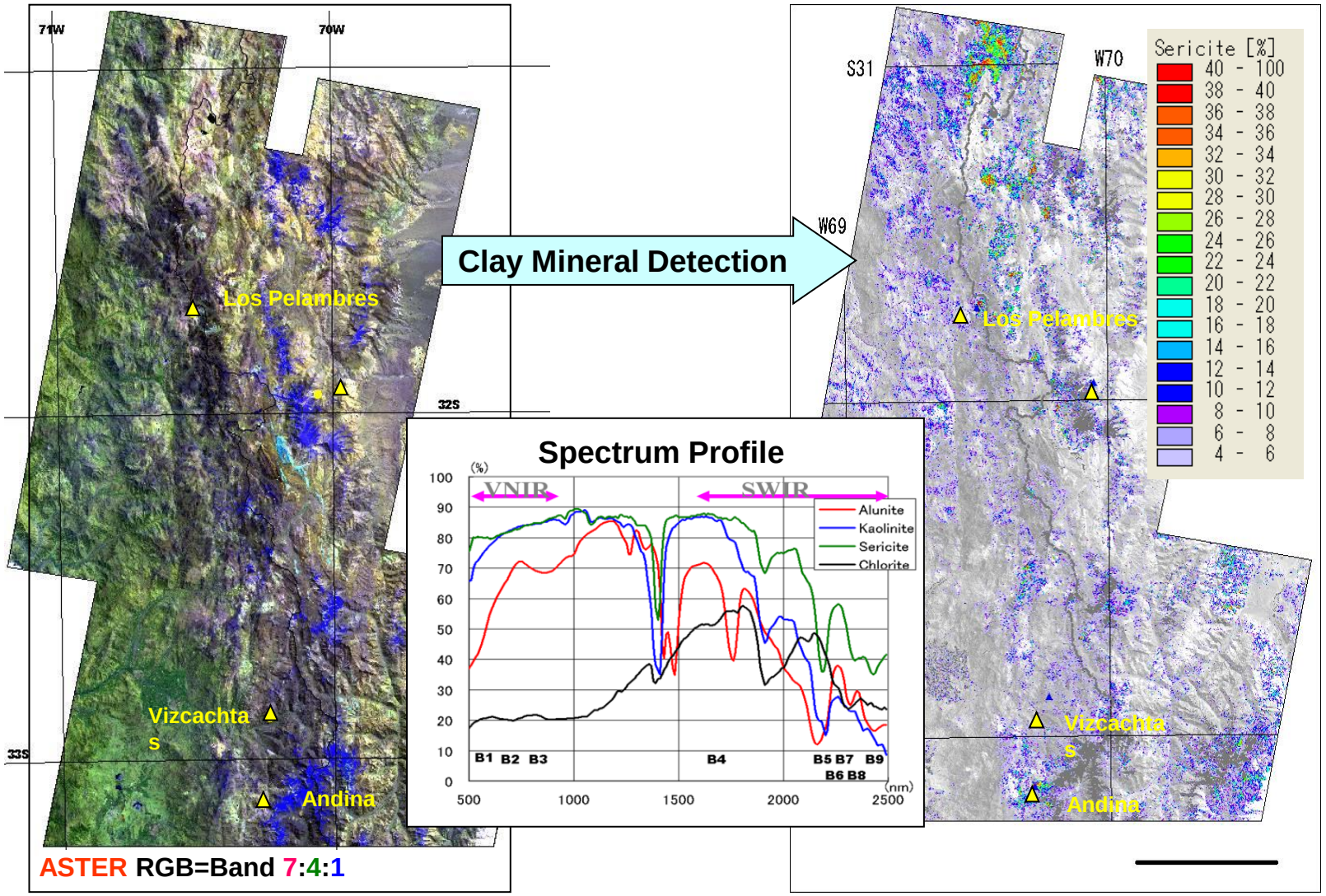
https://www.sciencedirect.com/science/article/pii/S1658365514001290

Optical sensor/ rationing for anomaly detection



Optical sensor/ASTER (Sericite content map)

Clay minerals are detected by spectrum of SWIR data

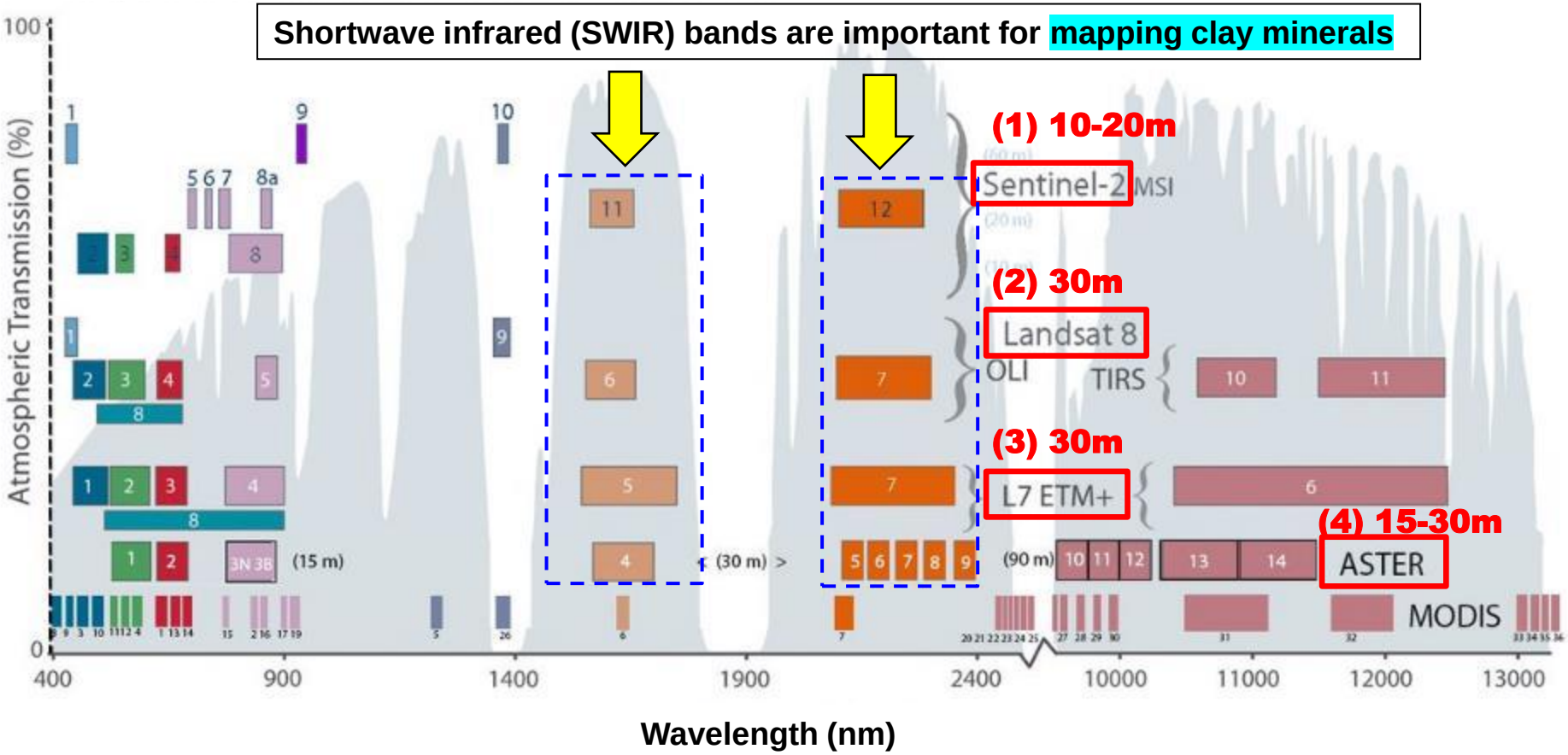


Location: Los Palembres, Northern Chile

Sericite Content Mapping (Phyllic Alteration Zone)

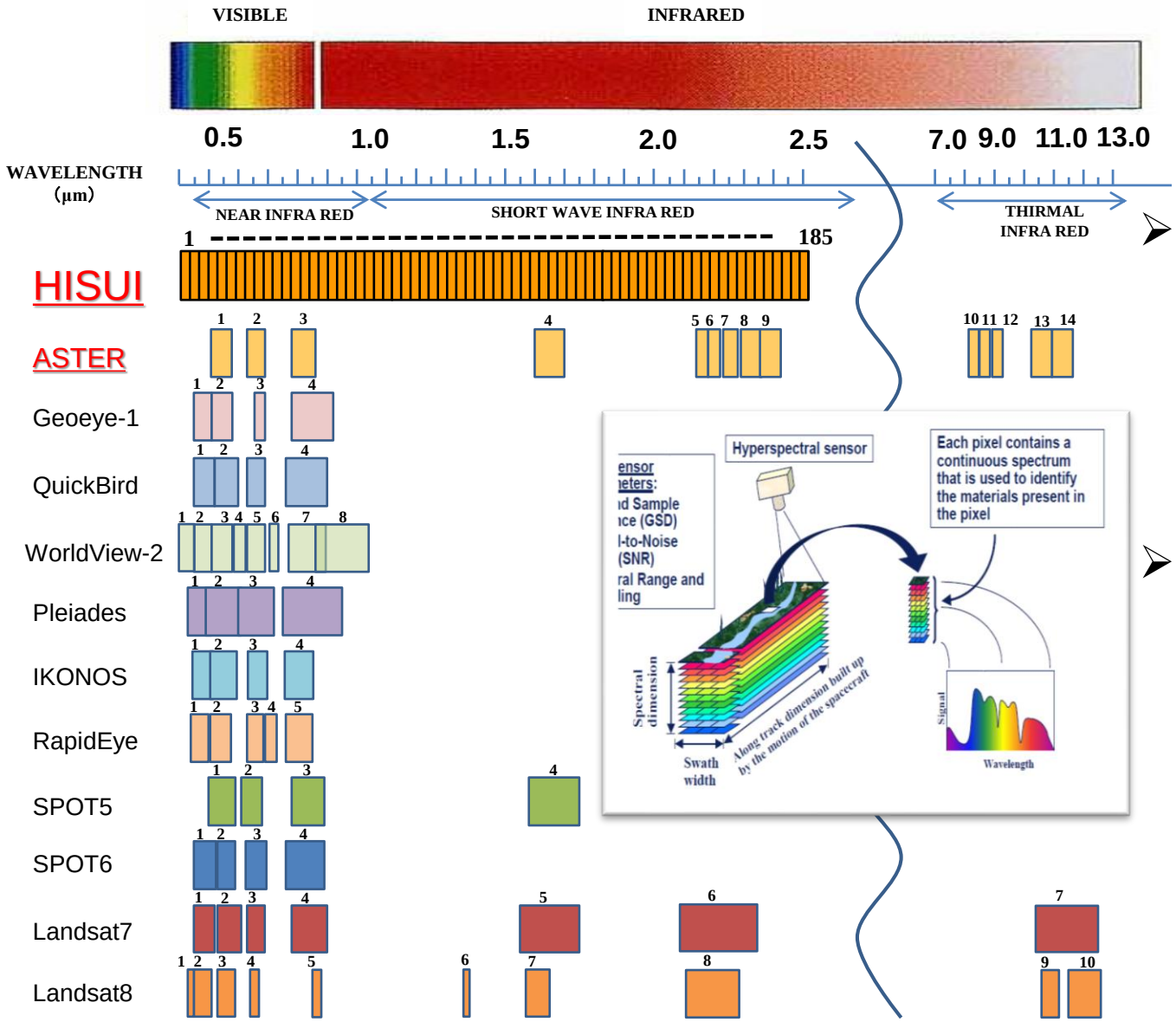
Clay mineral mapping needs more bands in SWIR

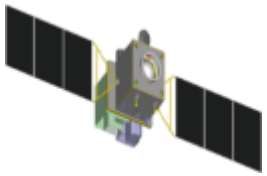
Comparison of bands of ASTER, Landsat 7, 8 and Sentinel-2



https://twitter.com/usgslandsat/status/837696716417687553

Optical sensor/Hyperspectral sensor

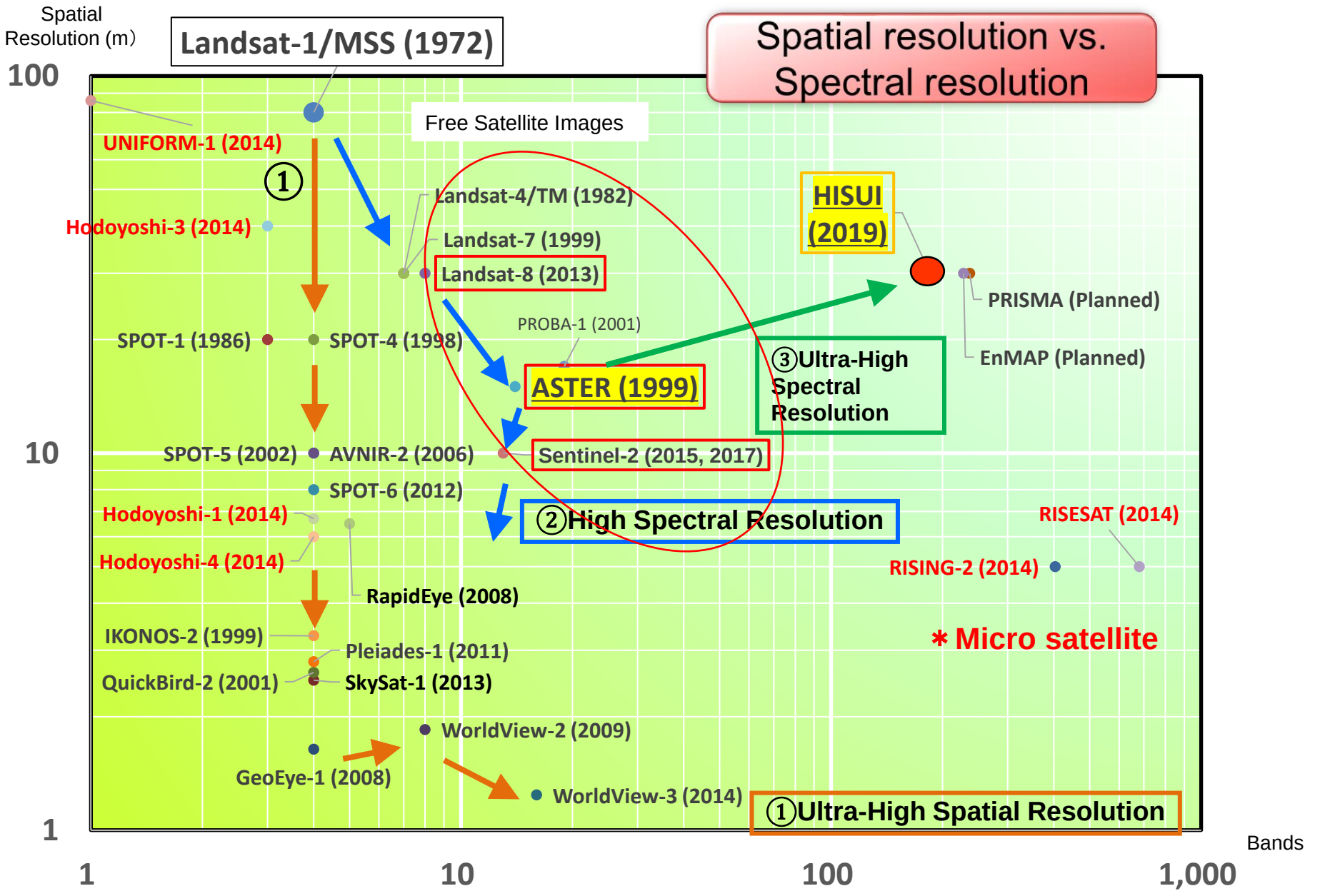




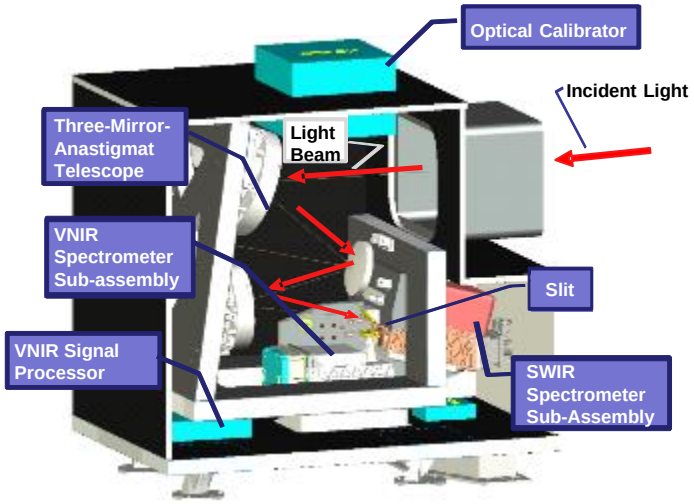
- **Hyperspectral: advanced technologies in the field of remote sensing.**
- **Advantages:**

  ability to extract surface spectral information in detail, much powerful compared with other existing sensors such as Landsat, ASTER and others

Optical sensor/Hyperspectral sensor

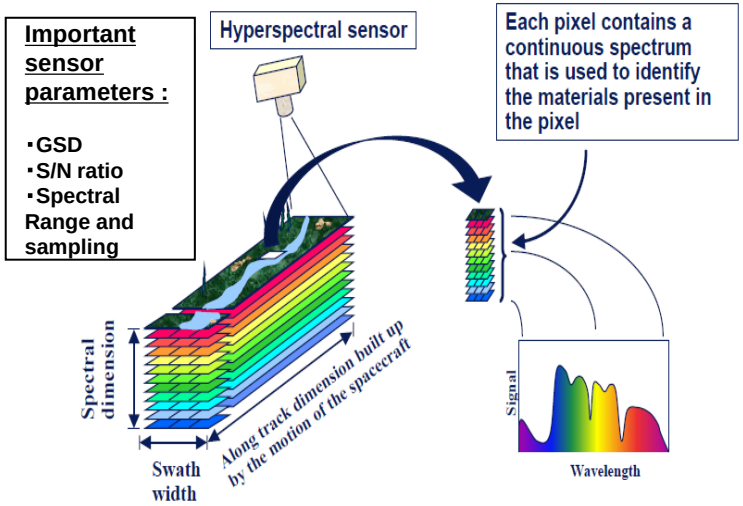


Optical sensor/HISUI Hyperspectral sensor



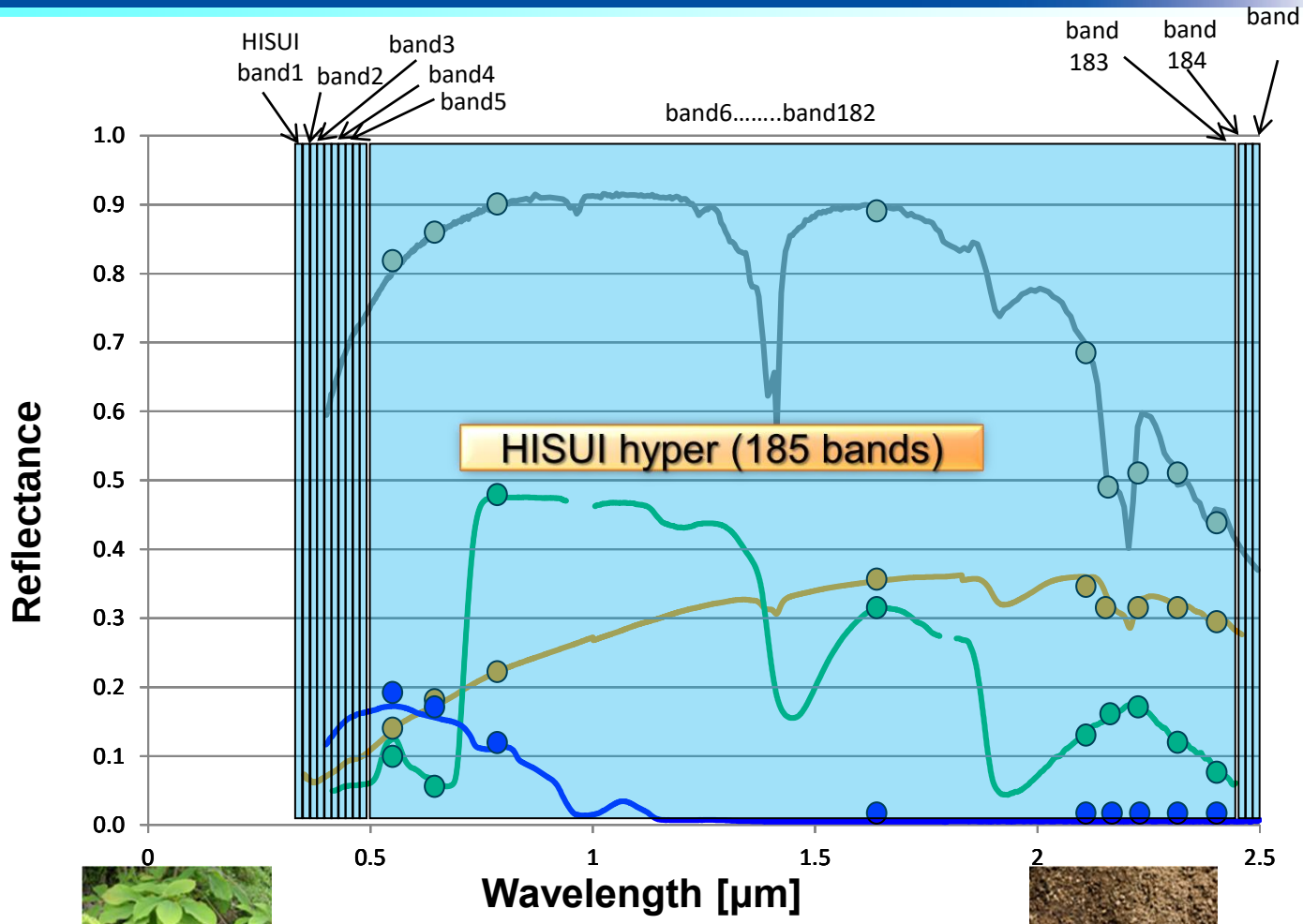
HISUI Hyperspectral Imager

- Ministry of Economy and Trade Industry (METI), Japan has developed a spaceborne hyperspectral imager *HISUI (with Japan Space Systems & Supporting Companies)*
- HISUI has 185 bands and was launched in December 2019

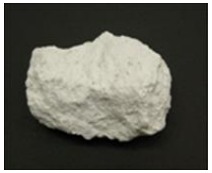


		Hyperspectral Imager
Spatial Resolution		30 m
Swath		30 km
Spectral	#Band	185 VNIR:57 SWIR:128
	Coverage	0.4-2.5 μm
		VNIR: 0.4-0.97 μm SWIR: 0.9-2.5 μm
	Resolution	VNIR: 10 nm SWIR: 12.5 nm
S/N		≥ 450 @ 620 nm ≥ 300 @ 2100 nm
Modulation Transfer Function		≥ 0.2
Dynamic Range		12 bits

Optical sensor/HISUI Hyper



Vegetation (Green leaves)

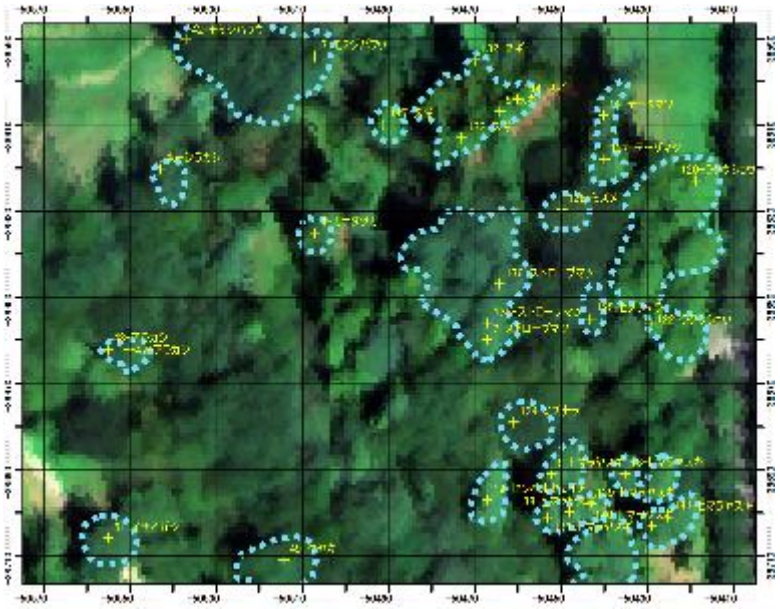


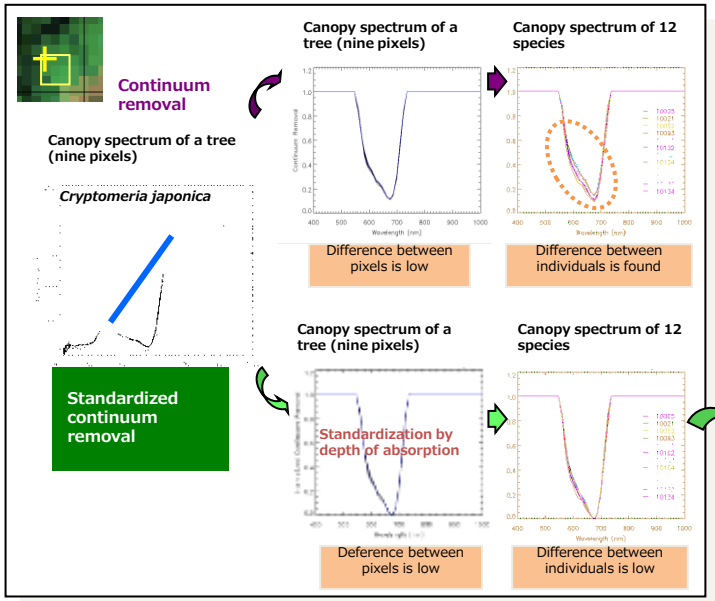
Mineral (Kaolinite)

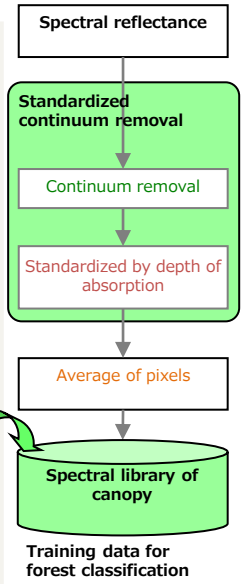
Soil

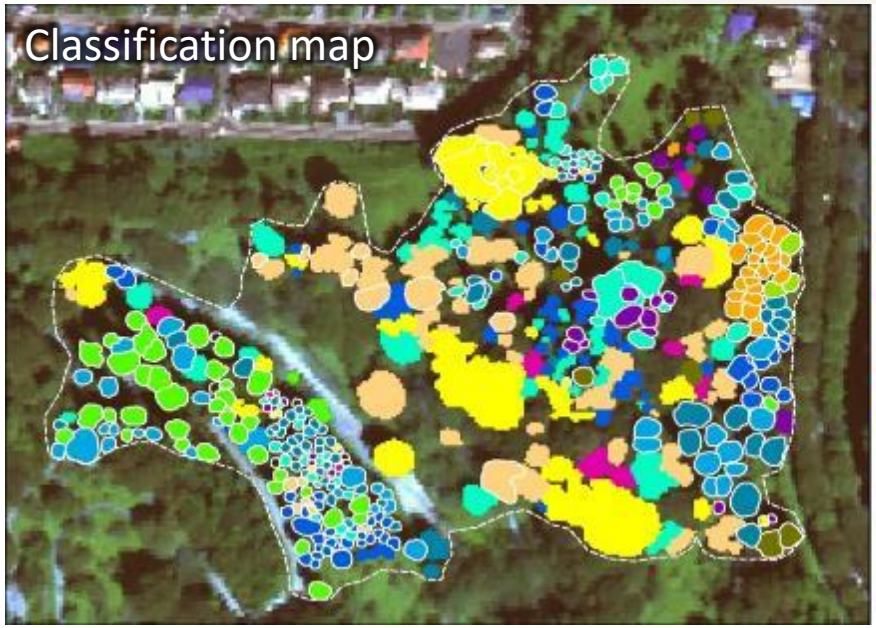
Water (Ocean)

Optical sensor/HISUI Hyperspectral sensor





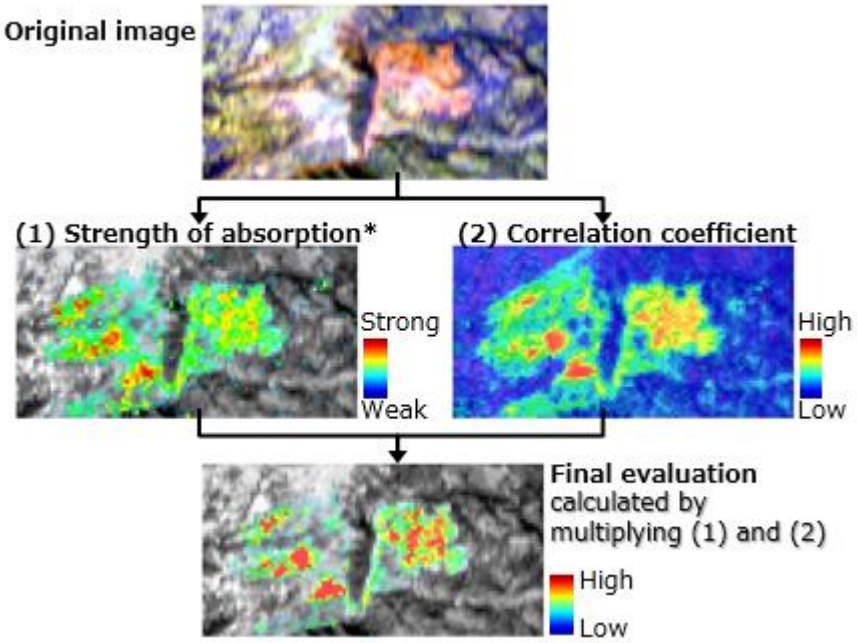




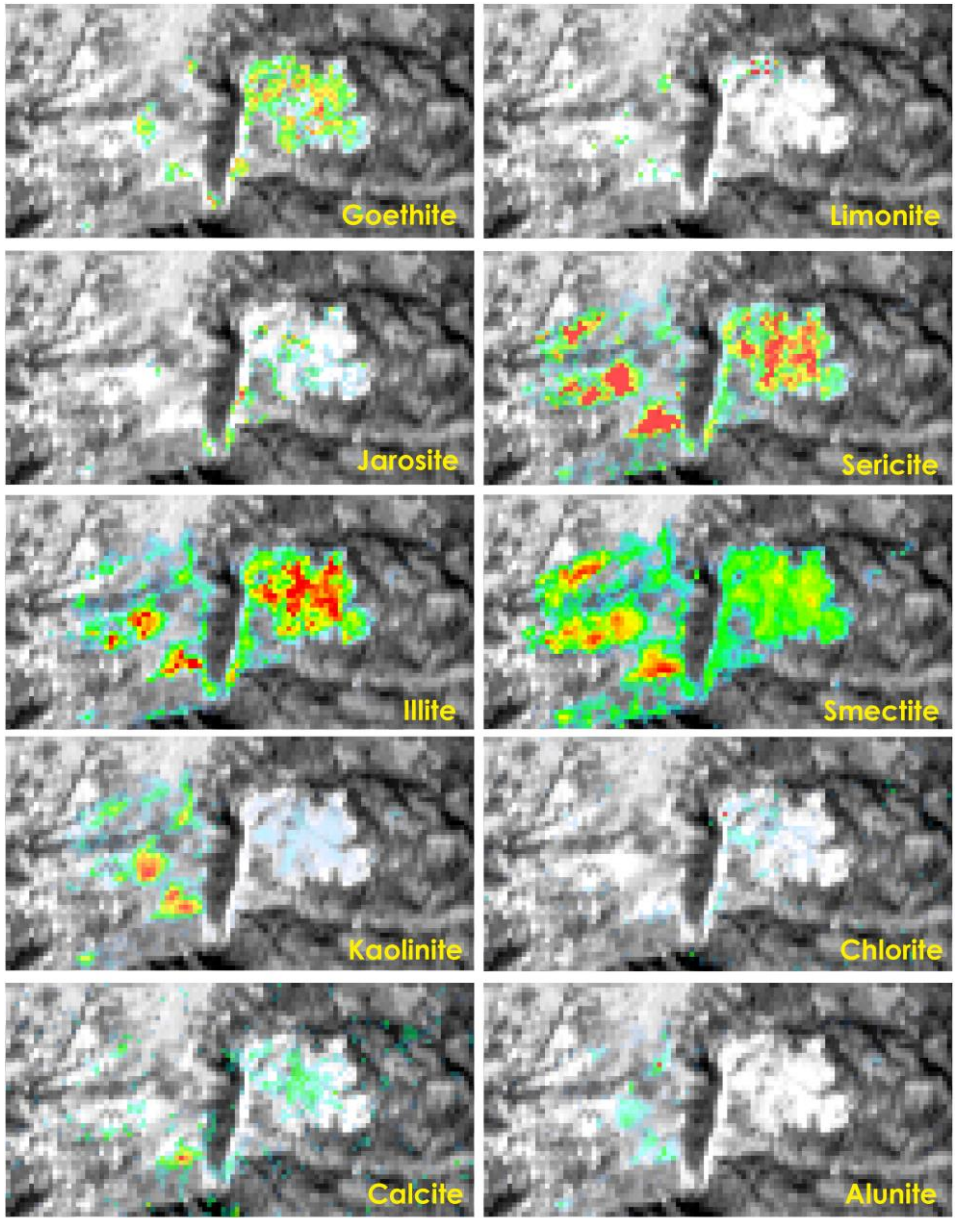
Optical sensor/HISUI Hyperspectral sensor

❑ Hyperspectral Data for Minerals

➢ The results of field validation showed that ten minerals in the study area were successfully mapped by this approach.



***Existence of the absorption peak charactering a target mineral is checked. If there is, quantity of the mineral is estimated according to the depth of absorption. If not, regarded as no occurrence.**



Remote sensing technique in mining sector

Contribution of Remote Sensing Technique

Environmental Monitroinsg(High)

1st stage	2nd stage	3rd stage	4st stage	5th stage
High contribution	Moderate	Low	Moderate	M

Exploration/FS

Development/ Operation

Closing

1)Reconnaissance

-Satellite data analysis

-Existing data integration

2)Regional - Detailed Survey

-Satellite/Airborne data analysis

-Geological Survey

-Geophysical Survey

3)Pre-FS/FS

-Drilling

-Core sampling

- Pre-FS/ FS

4)Development/ Operation

-Development (Infrastructure, port, road, EIA…)

-Operation management, Environment monitoring

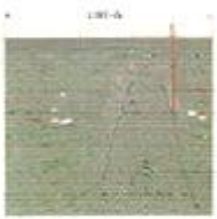
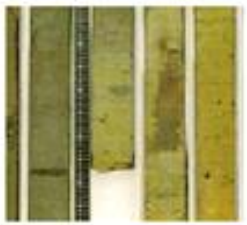
5) Environmental Monitoring





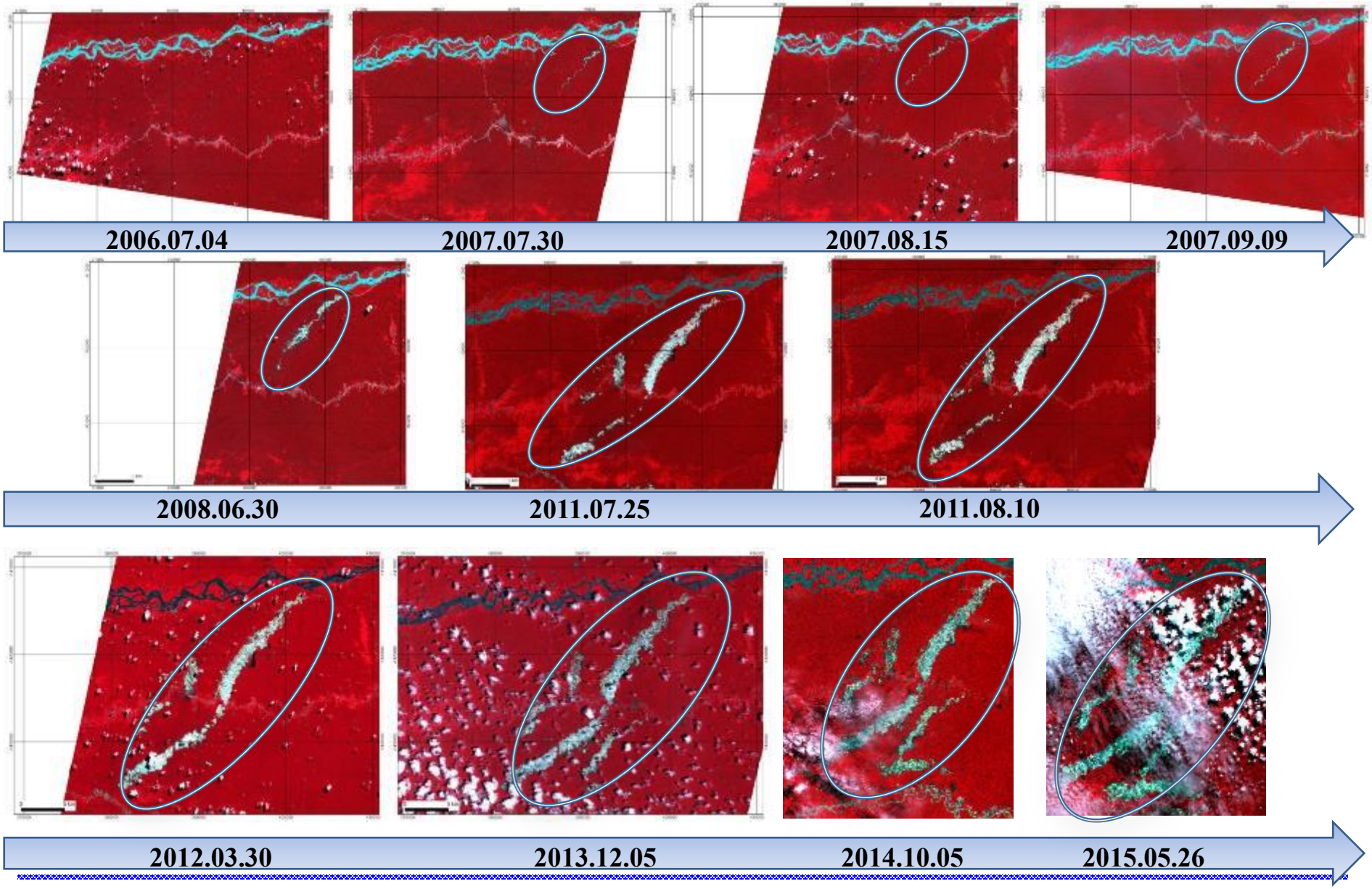




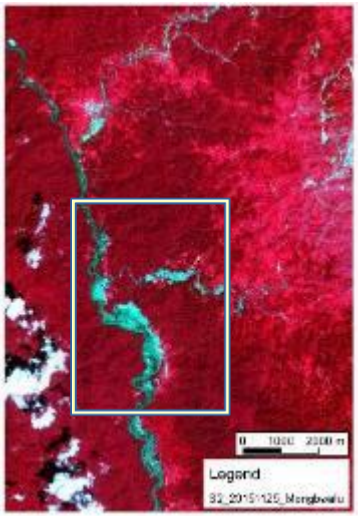



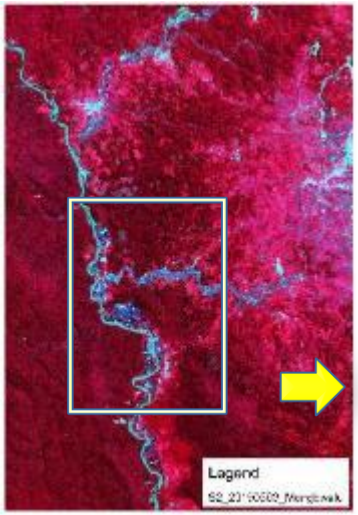
Optical Sensor/ASTER (Illegal mining, Peru)

ASTER Multi temporal images for illegal mining in Peru Amazon



Optical sensor/ Illegal mining, DRC





Free Satellite Images

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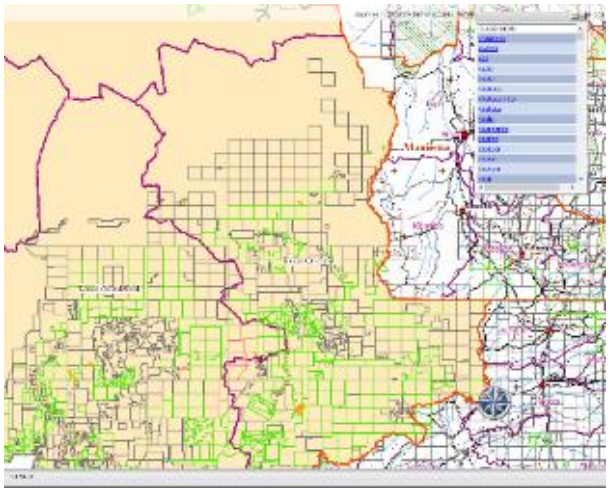
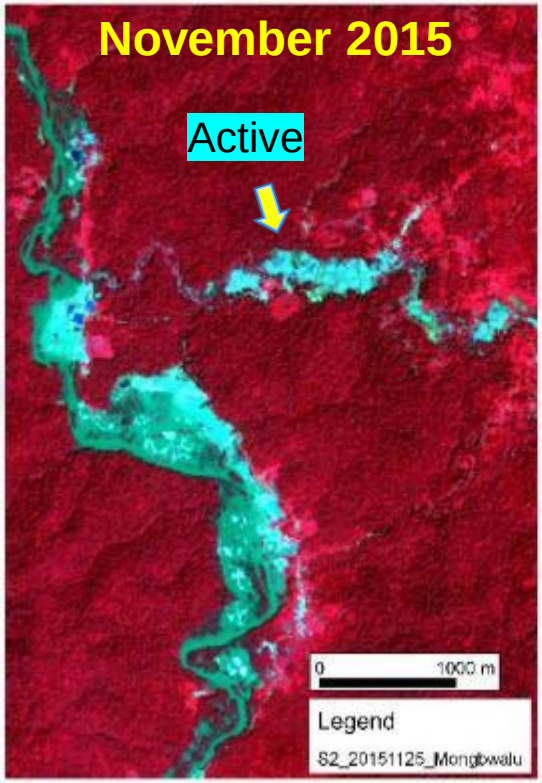
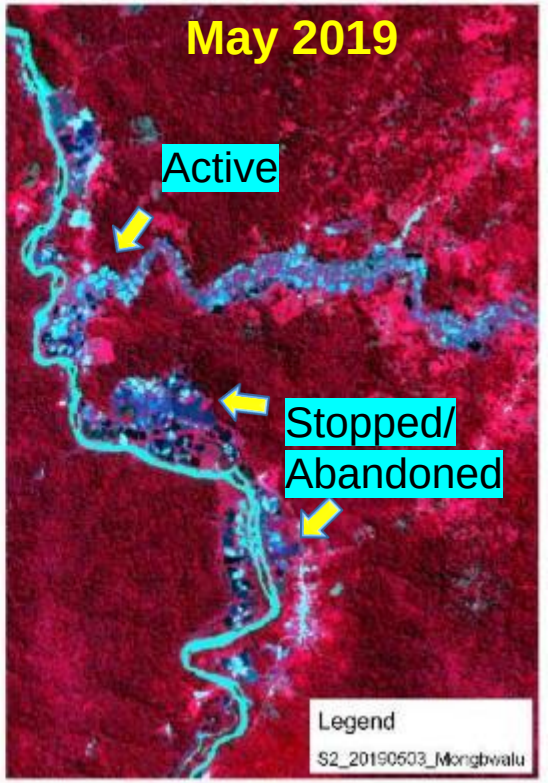
Concession Data on Web



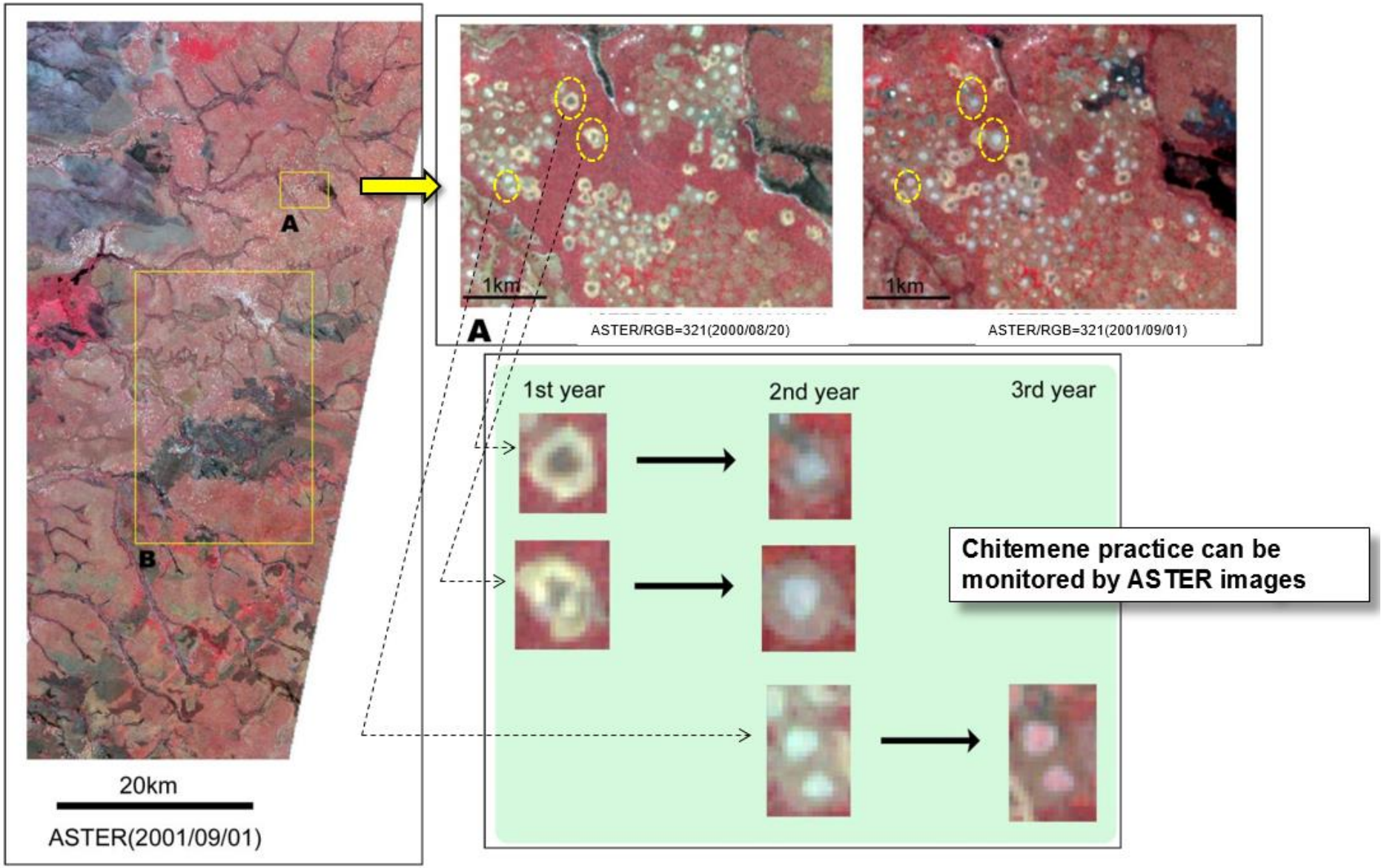




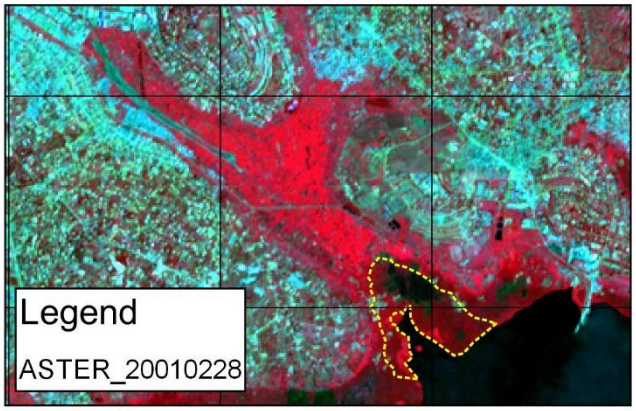
- Mining activity is normally prohibited river side due to the high possibility of environmental risks. Therefore, mining activity near the river is mostly by illegal or small-scale mining

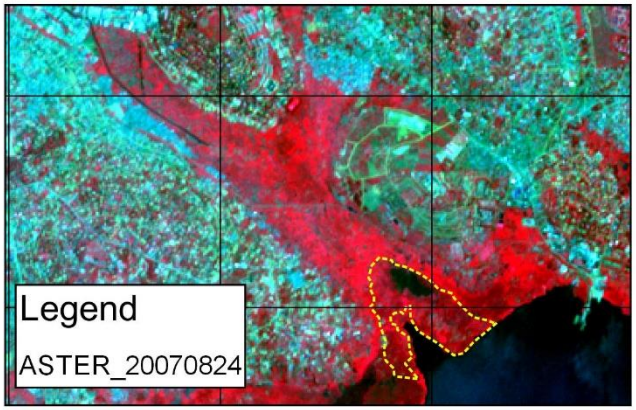
- Estimation of mining status from water colors
  - ❑Clear water: Stopped/abandoned mining sites
  - ❑Water including suspension: Active operation

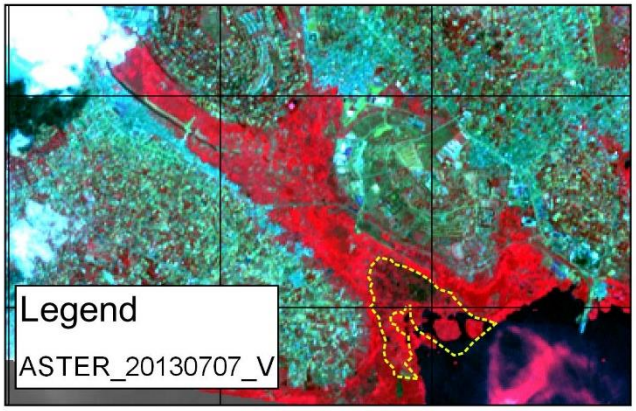
Optical sensor/ASTER (Slash and burn, Zambia)

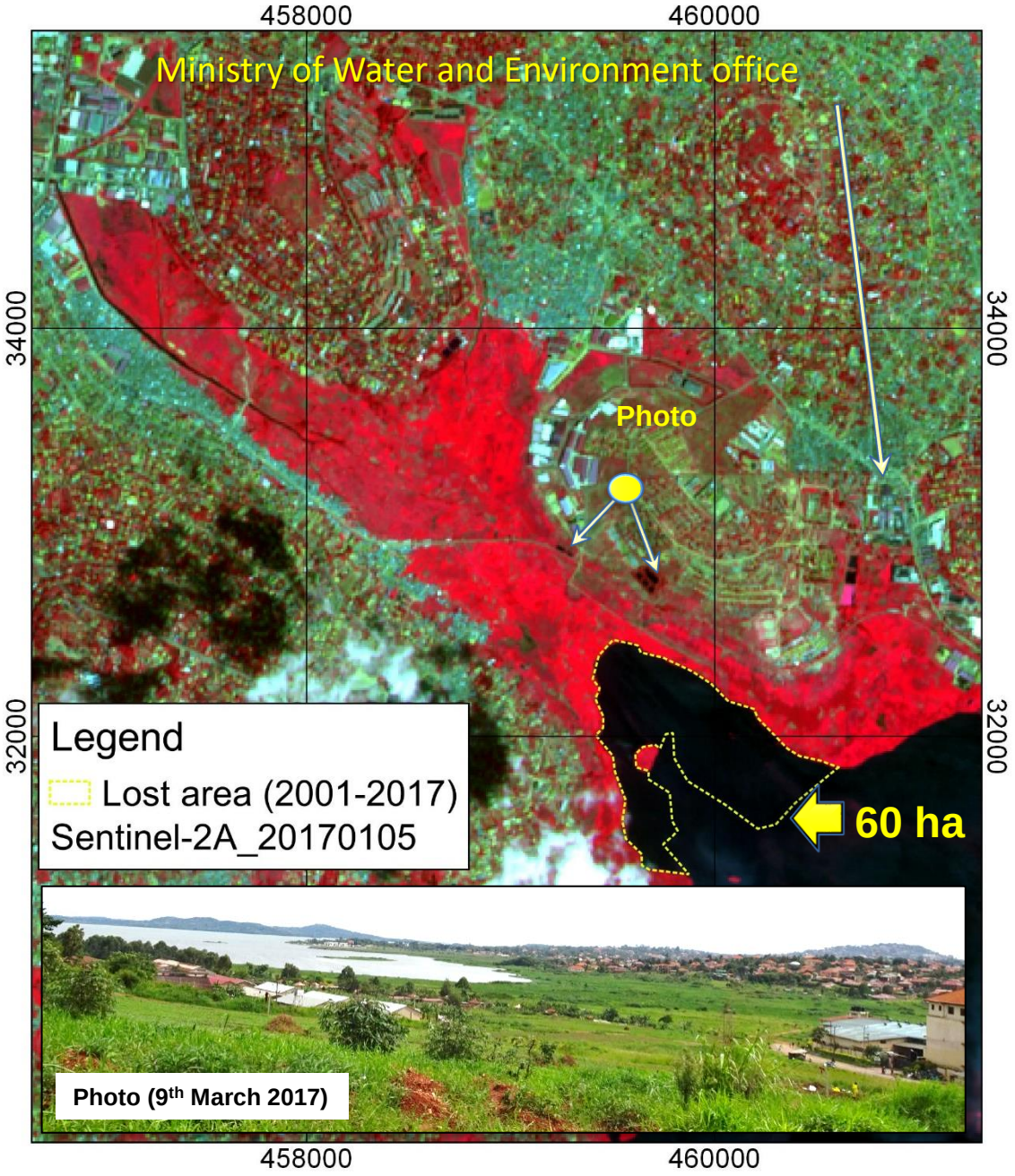


Optical Sensor/ASTER (Wetland change, Uganda)





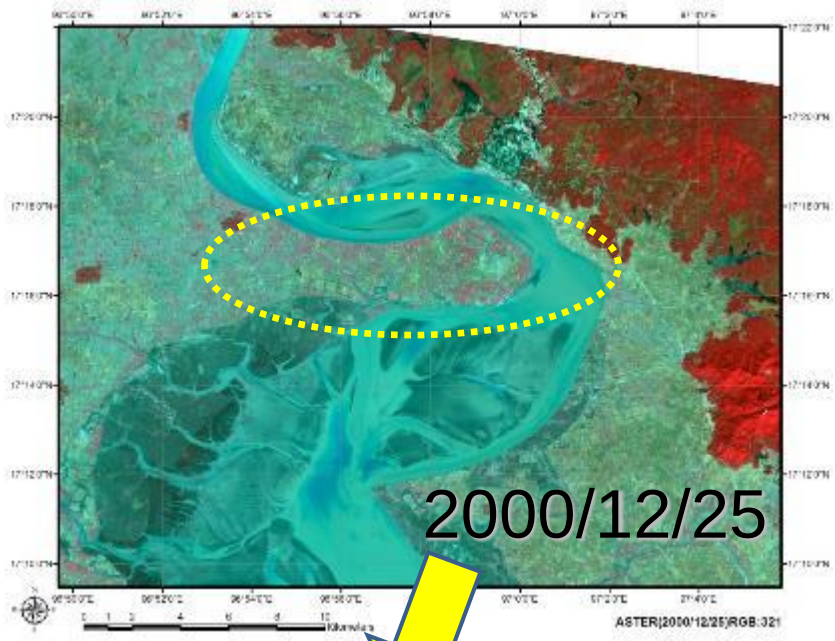


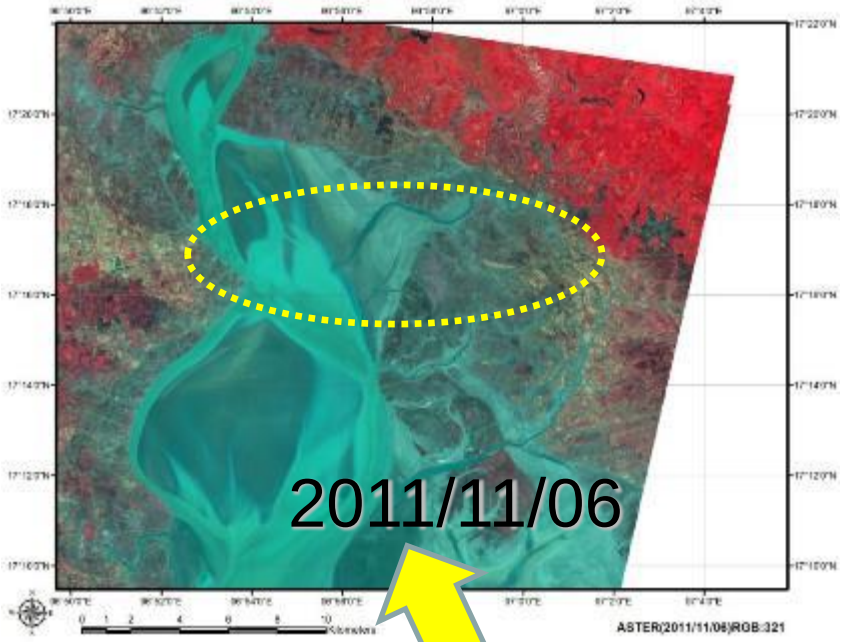


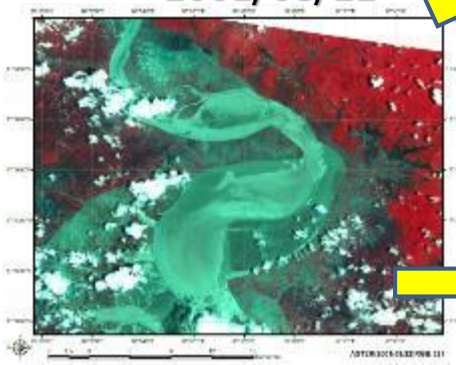
Optical Sensor/ASTER (Myanmar)

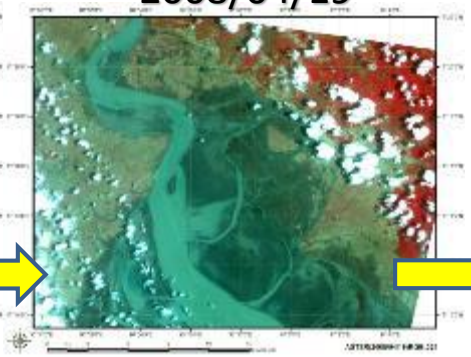
❑ Coastal Erosion in Myanmar

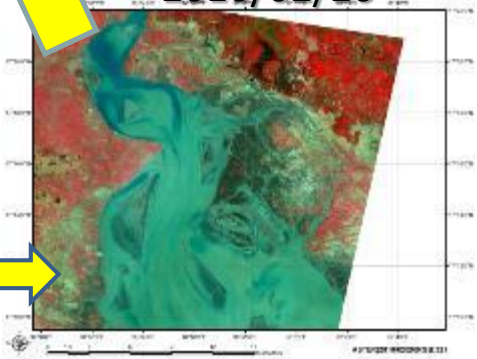
ASTER images showing coastal erosion & sedimentation



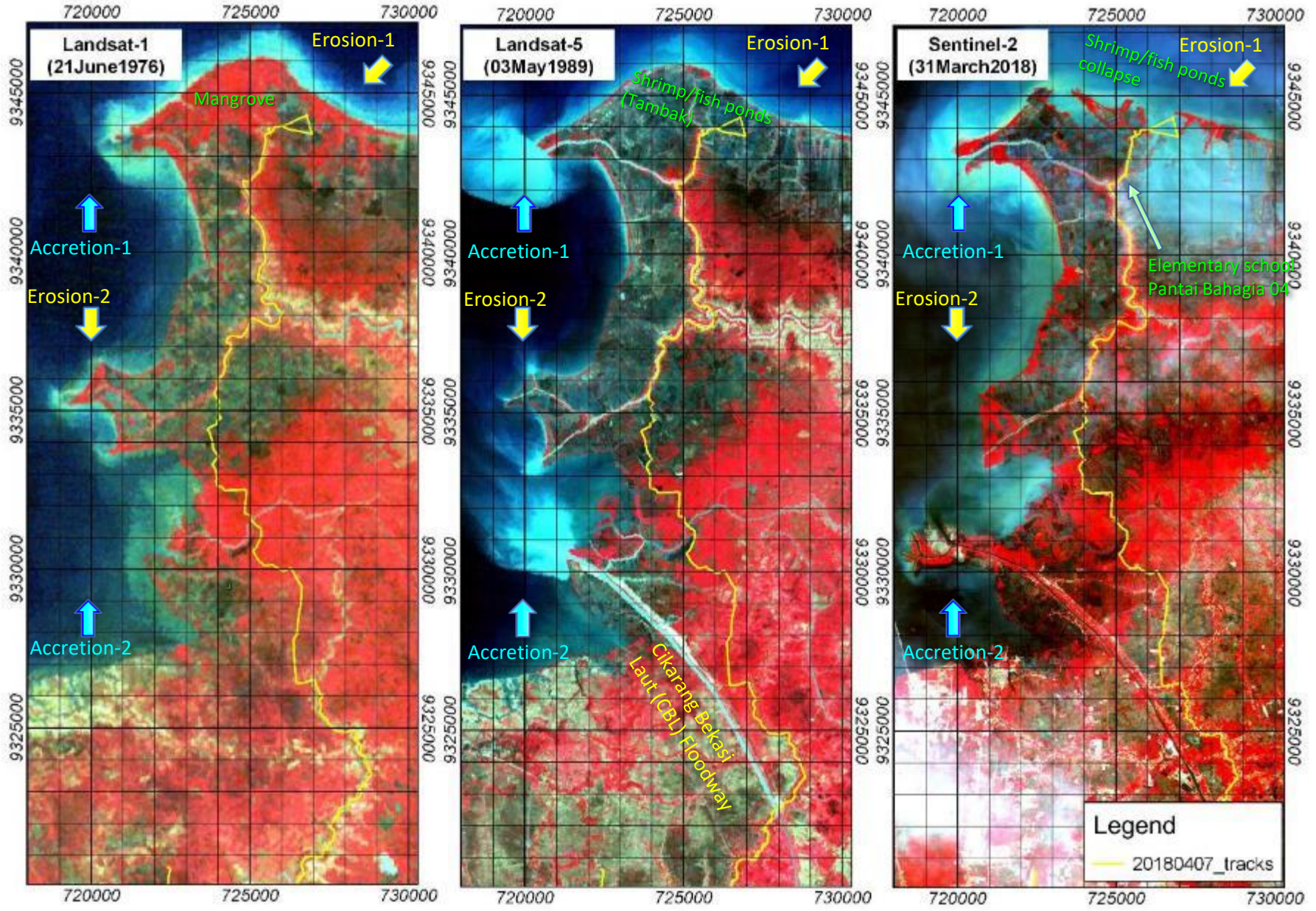




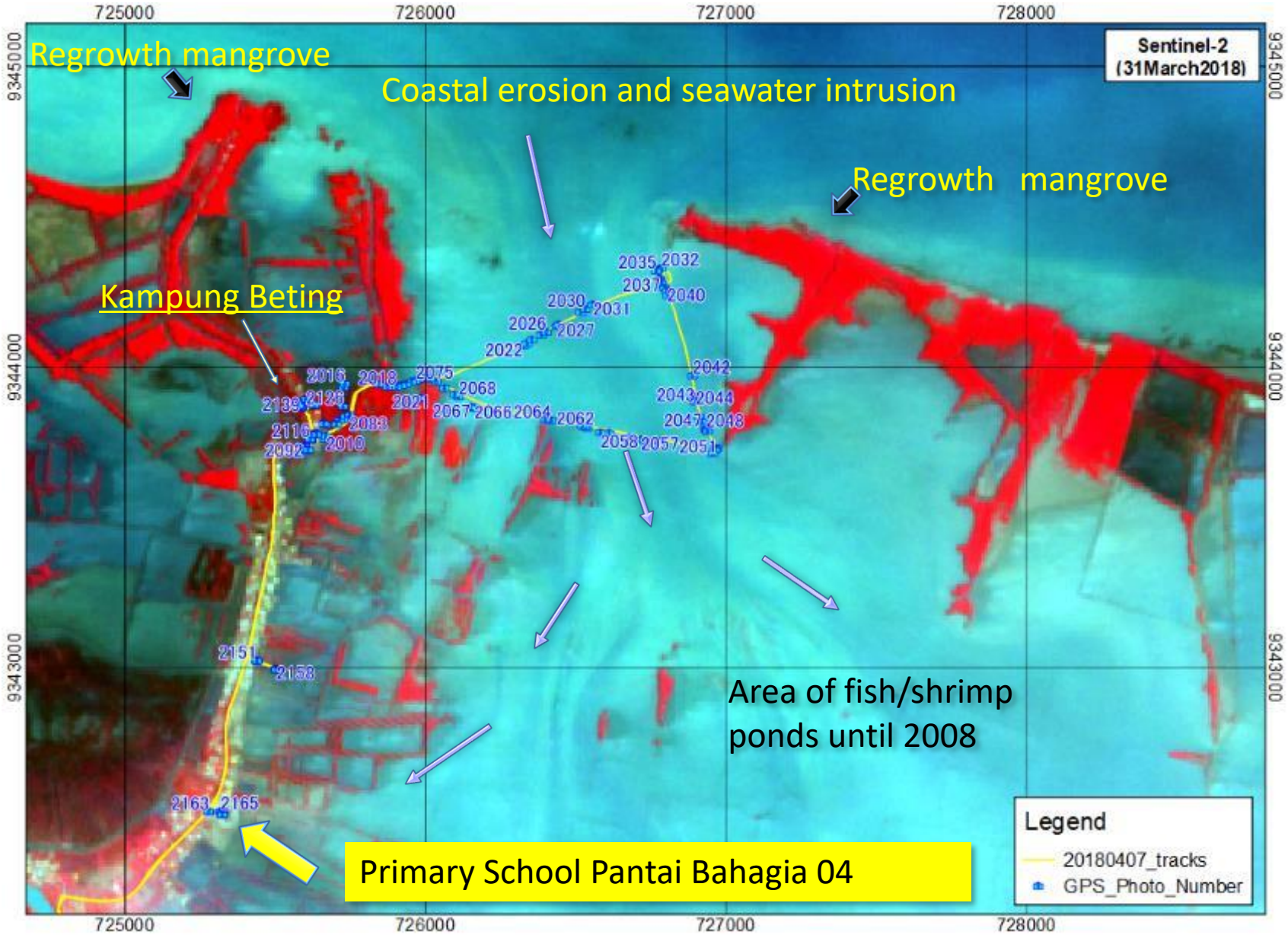




42 Years Coastal Changes in Indonesia (1976-2018)



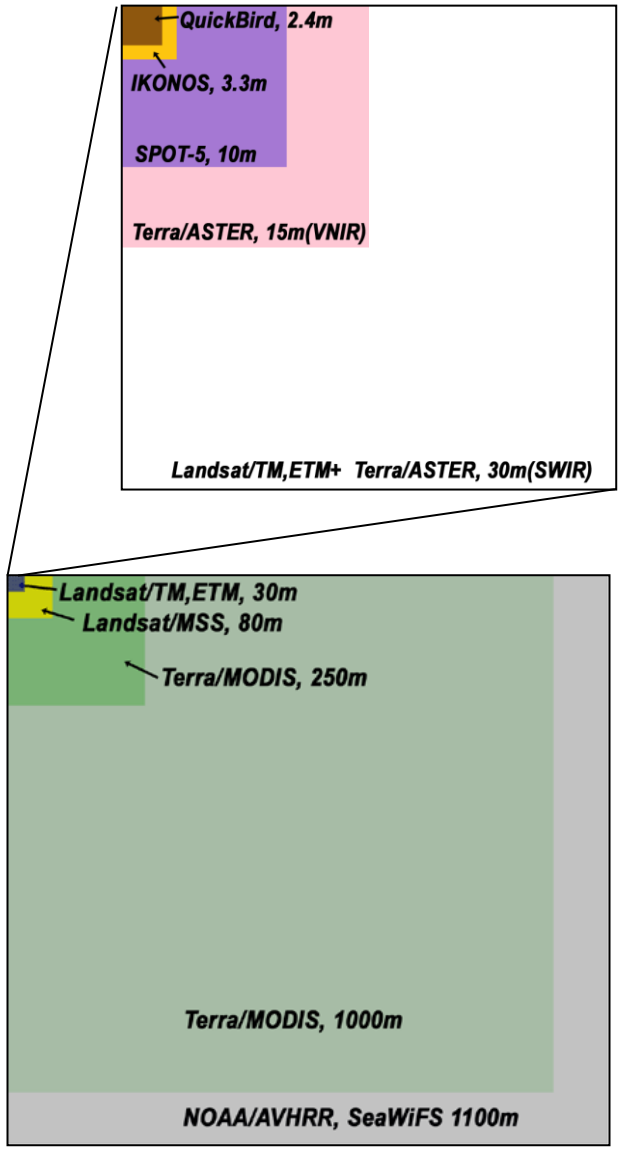
Optical Sensor/ASTER (Coastal Change, Indonesia)



Specifications of sensors

Following specifications are essential for selecting data on image analysis

- Spatial resolution
- Swath width (coverage)
- Spectral range
- Spectral resolution

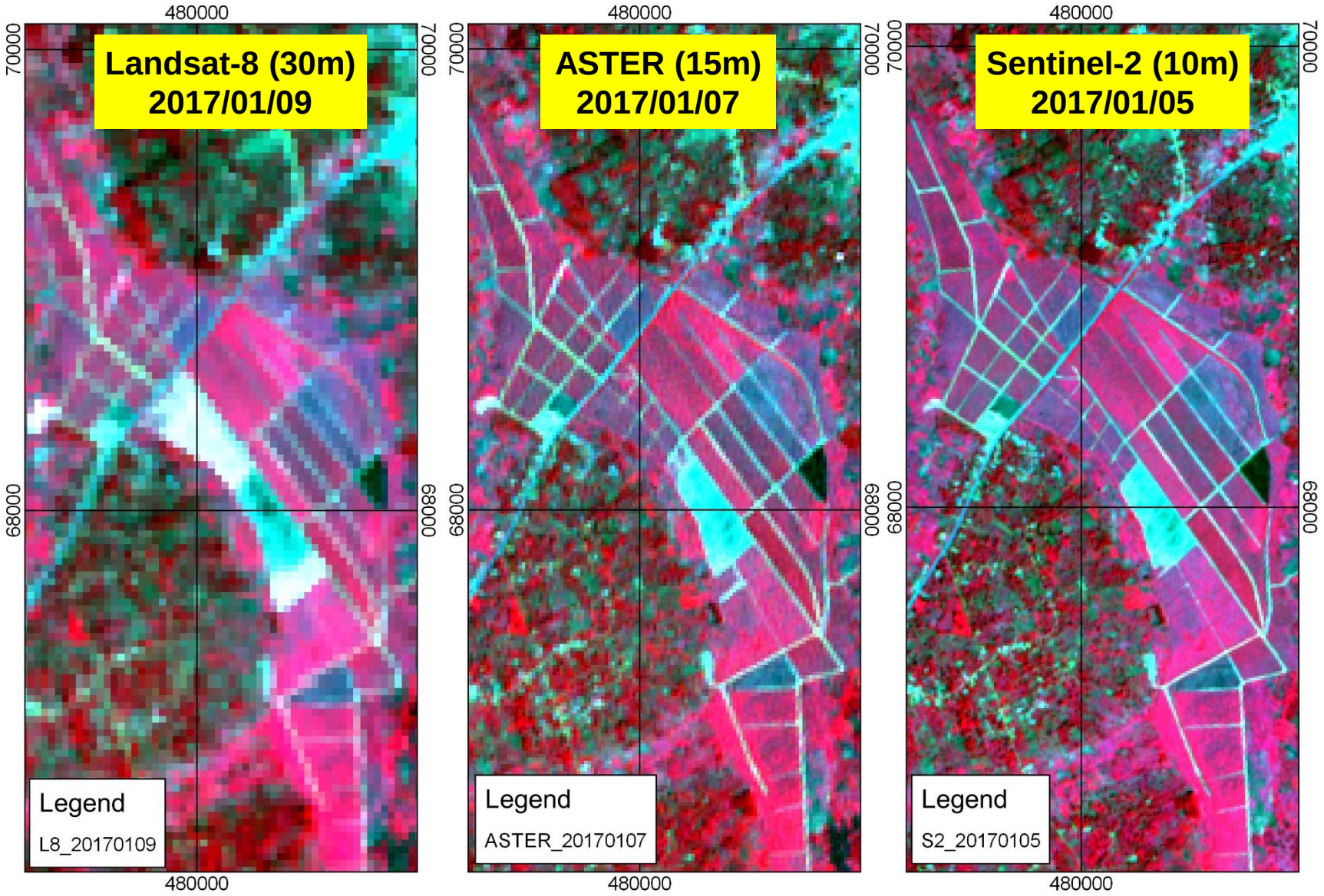


Spatial resolution

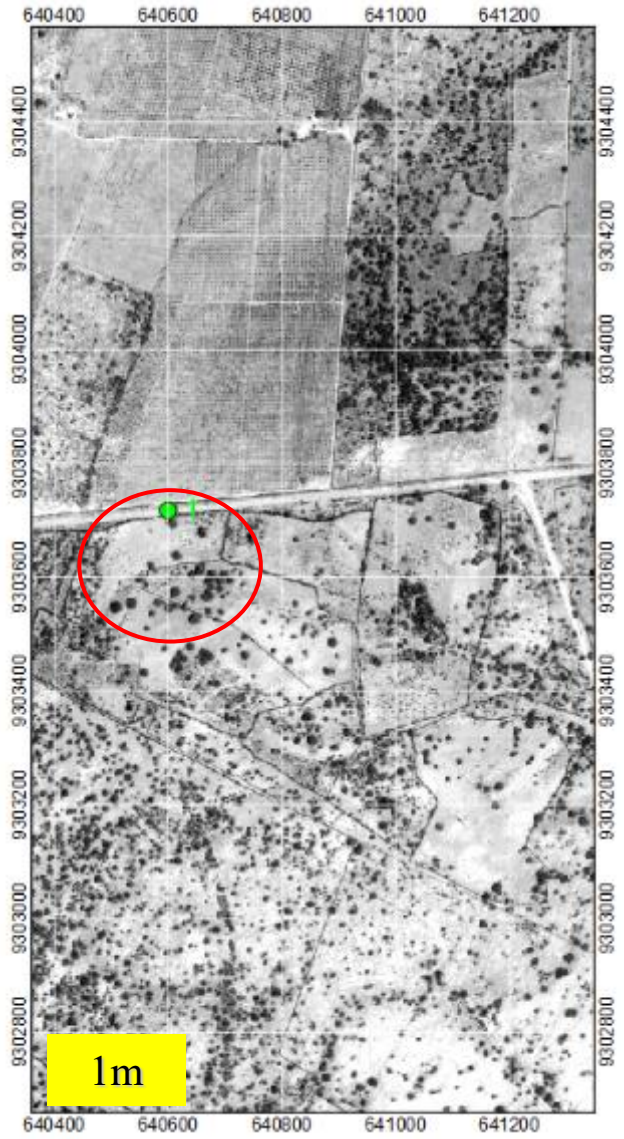
This is the most important element. It can be divided into three levels in general;

- high resolution (< 5m)
- medium resolution (10-30m)
- low resolution (30m <)

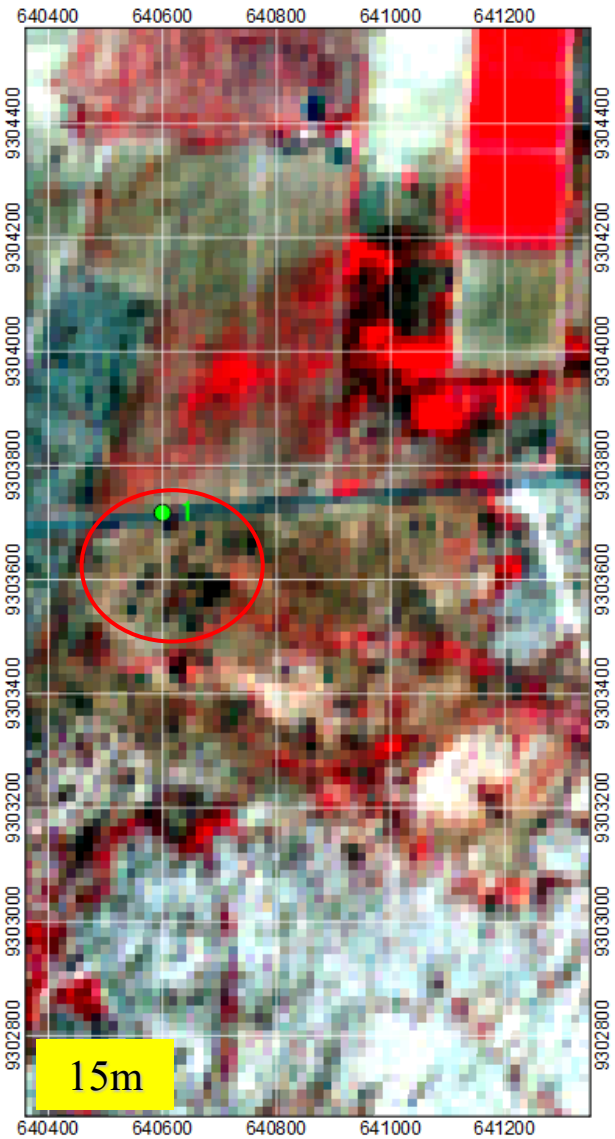
Spatial resolution (optical sensor)



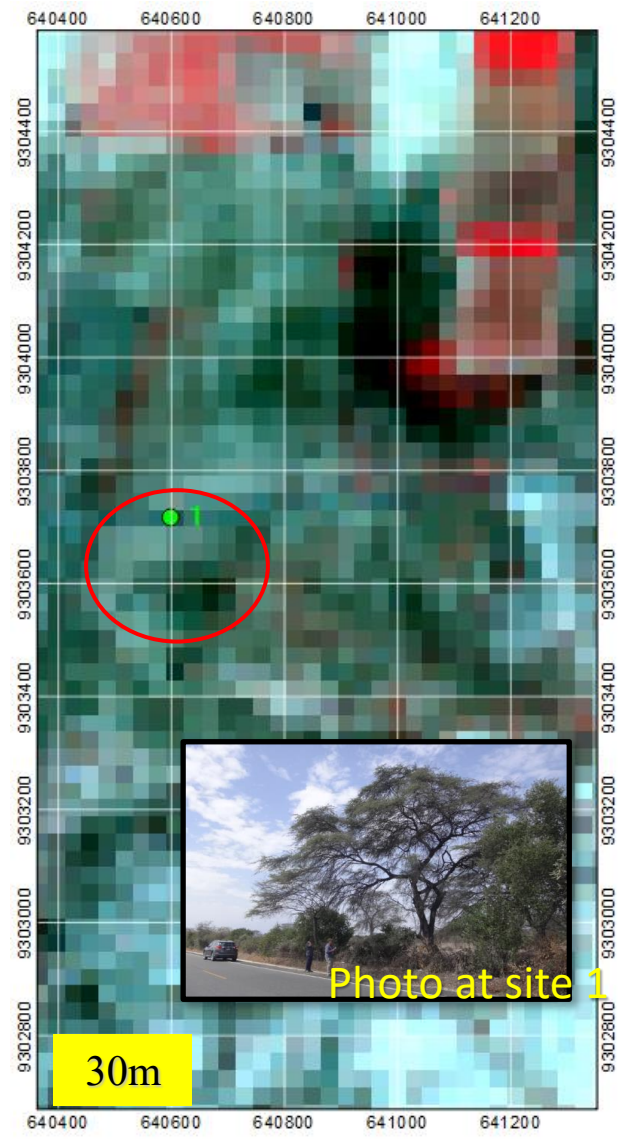
Spatial resolution (optical sensor)



OrbView-3/ 1m
(2005/11/05)



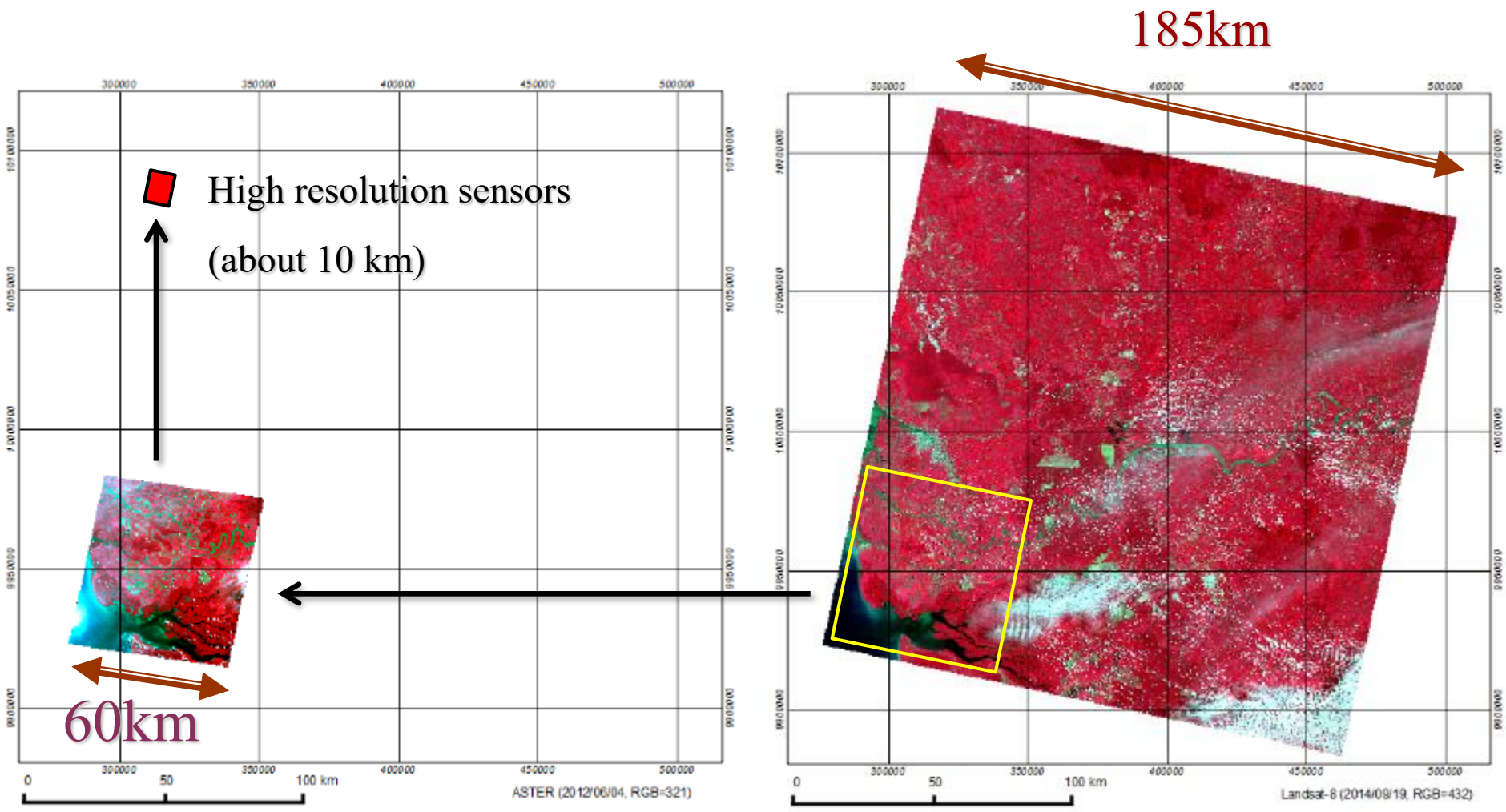
ASTER/ 15m
(2015/08/22)



Landsat-8/ 30m
(2016/05/12)

Swath width/ coverage area (optical sensor)

◆ **Swath width and spatial resolution are in an offset relationship.**



ASTER (Date:2012/06/04)

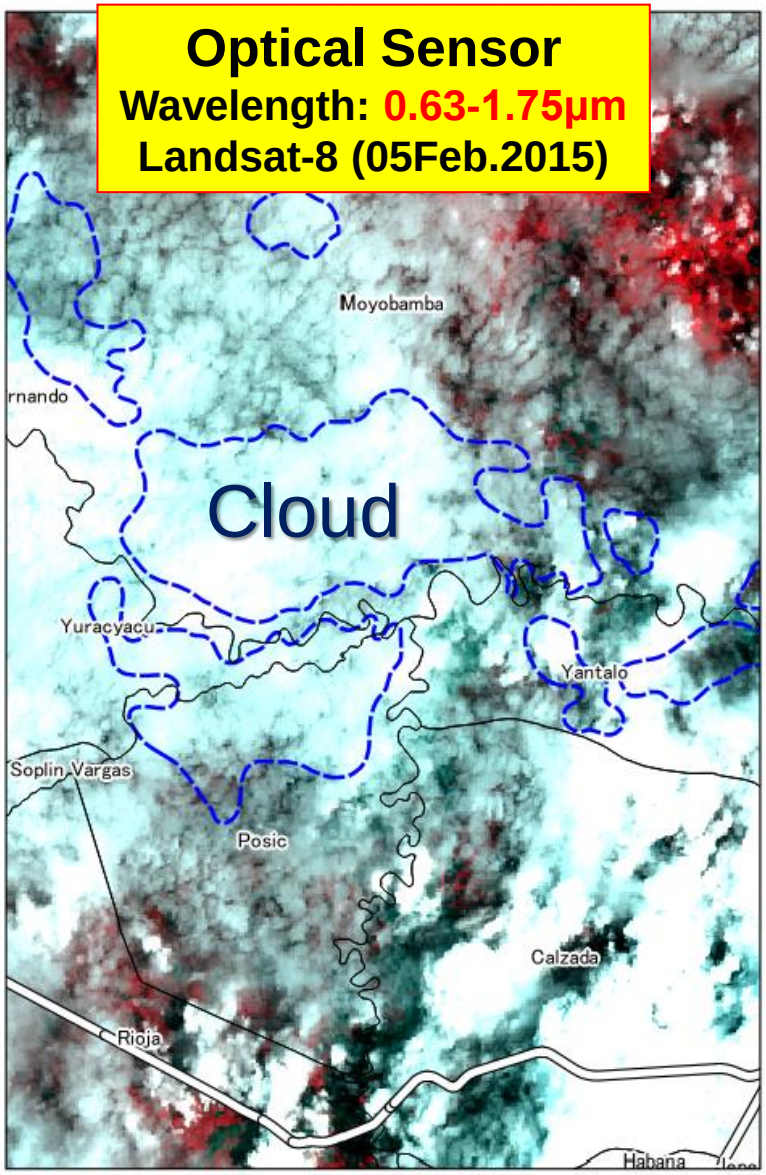
Landsat-8 (Date:2013/09/19)

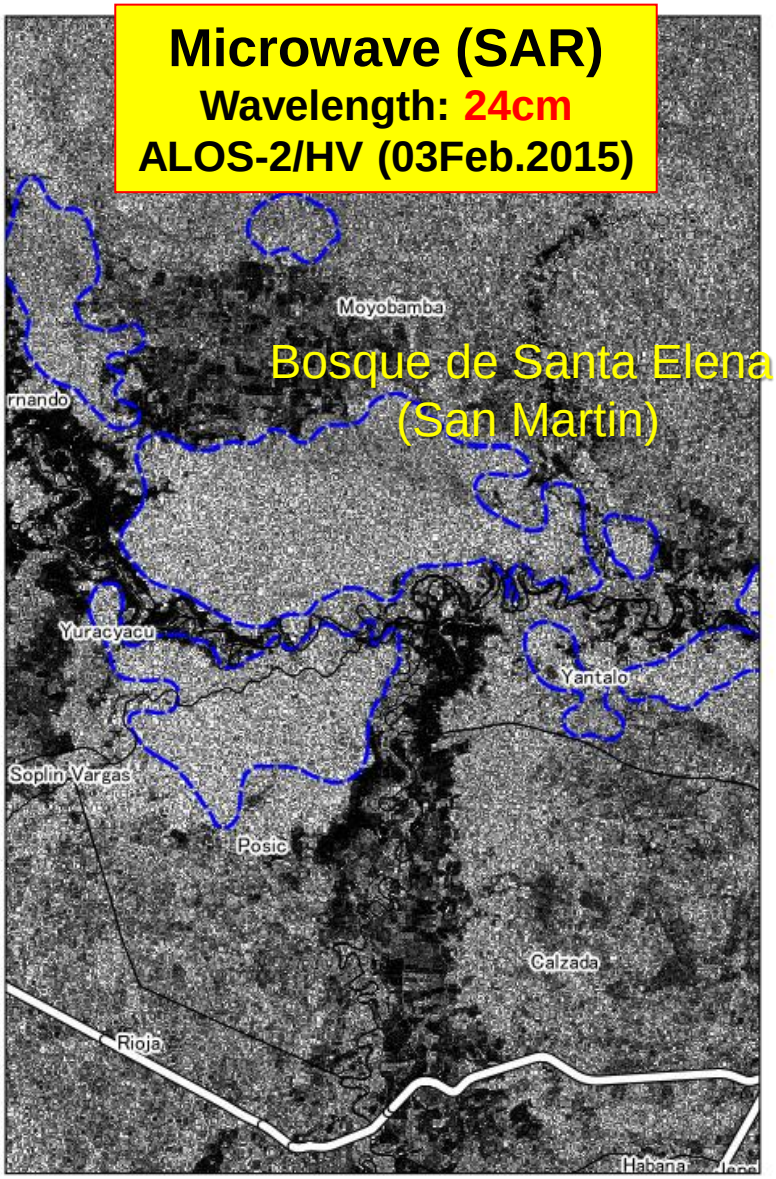
Microwave
(Synthetic Aperture Radar / SAR)

Active Sensor

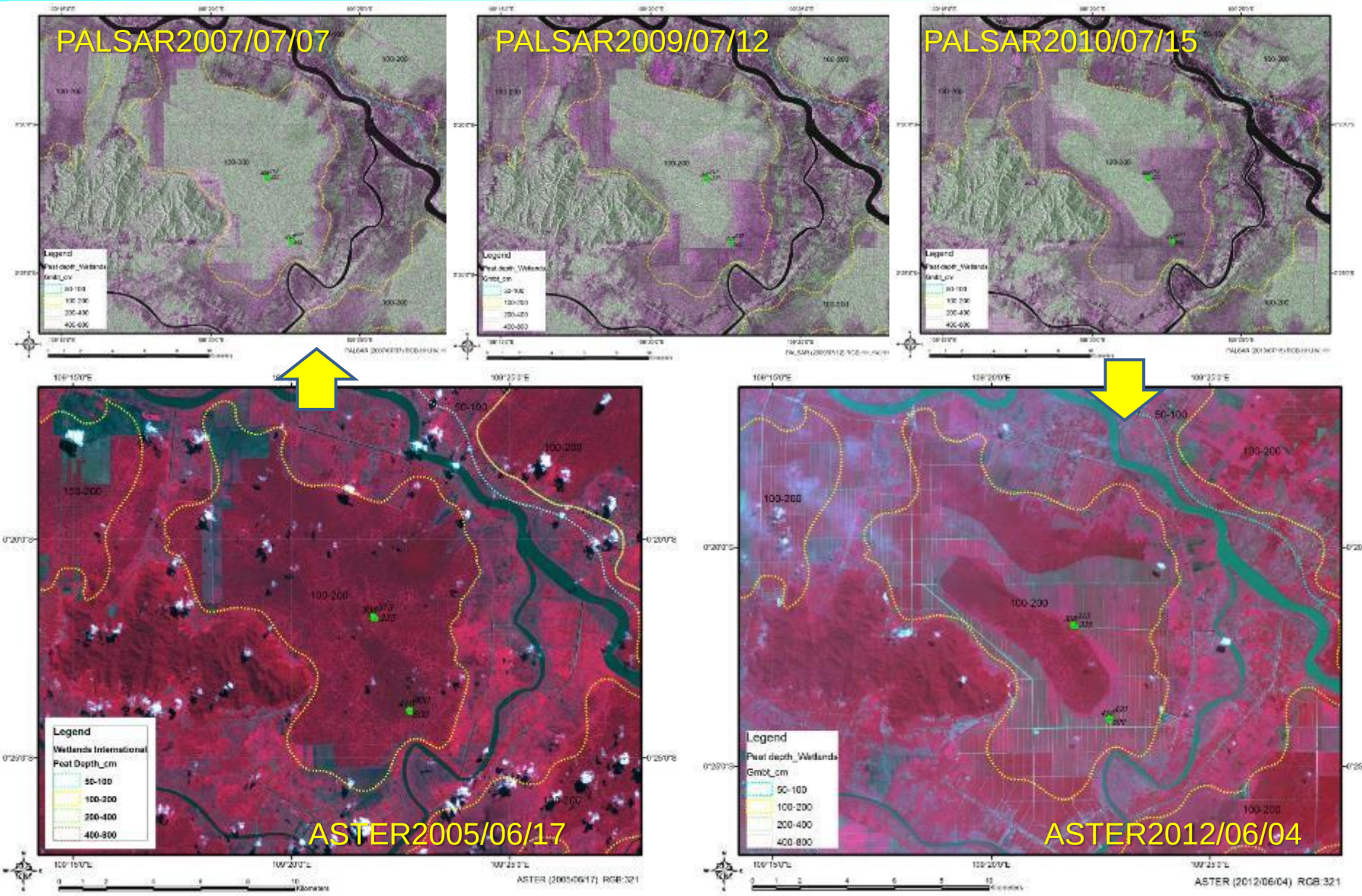
Optical sensor (Landsat-8) vs. SAR (ALOS-2)

Comparison of passive sensor (OPS) and active sensor (SAR) images



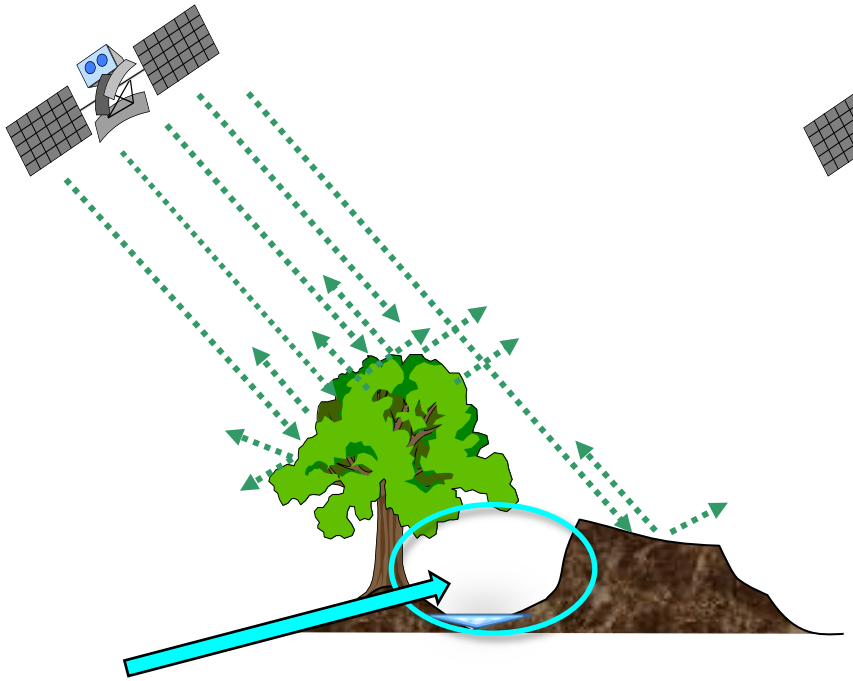


Combination of optical sensor and SAR

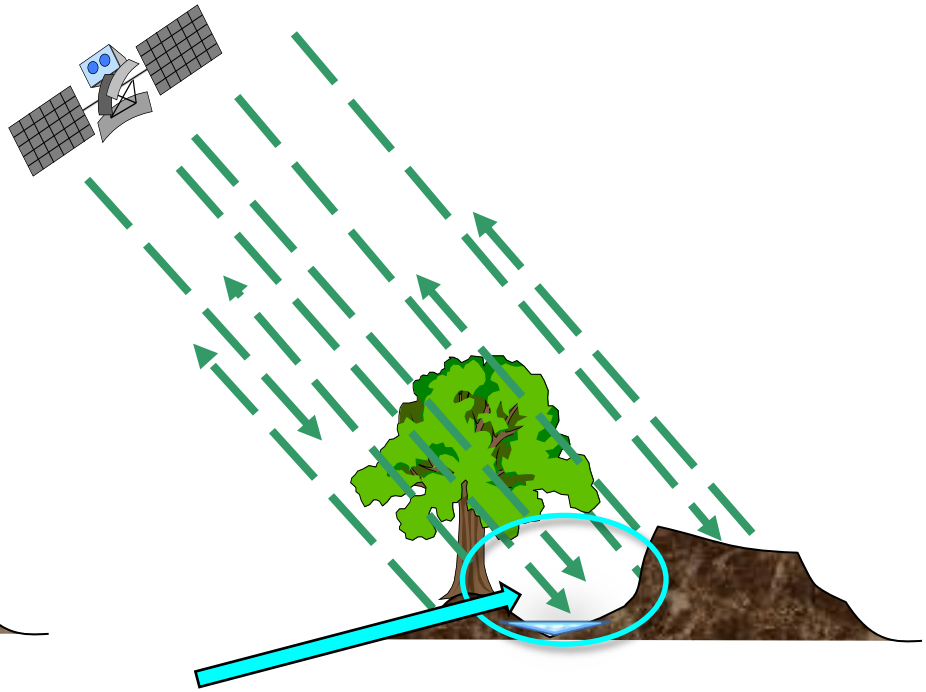


Wavelength of SAR (Microwave/ X, C, L-bands)

- ✓ **L-band penetrates forest and enables to collect information of wetland, river, geologic structure and others which are covered by cloud/ vegetation.**
- ✓ **X-band and C-band cannot penetrate forest. They are not possible to collect those information because of the sensitive signals.**

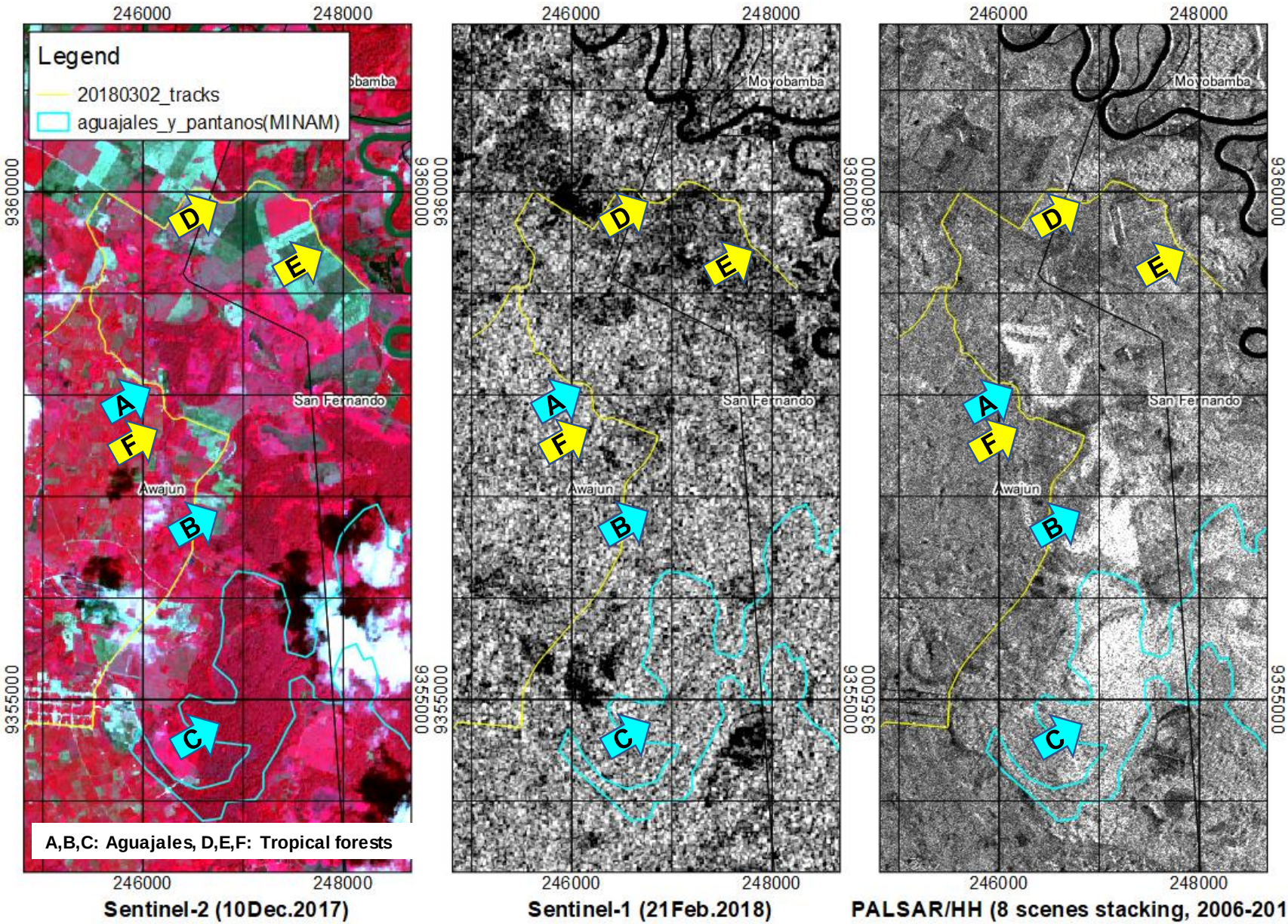


X-band (<3cm), C-band(<6cm)

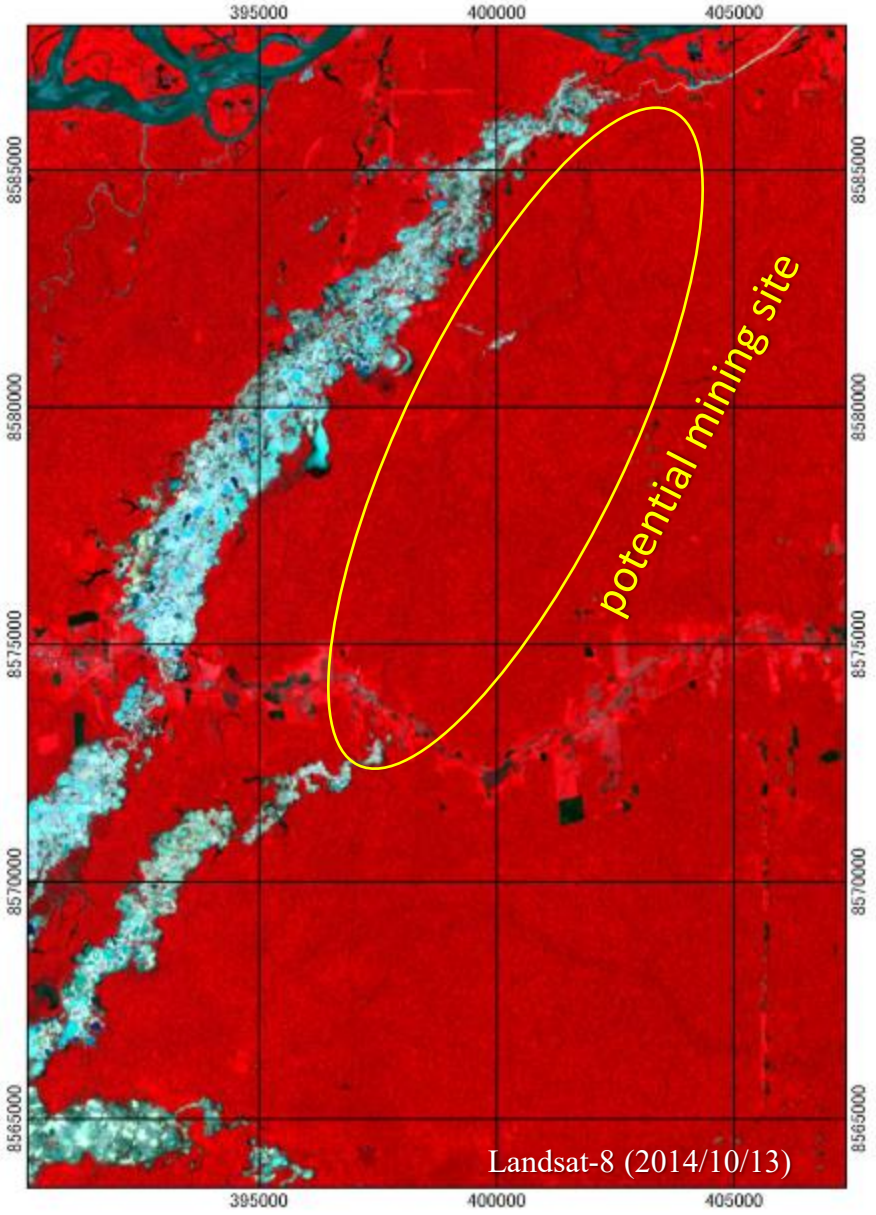


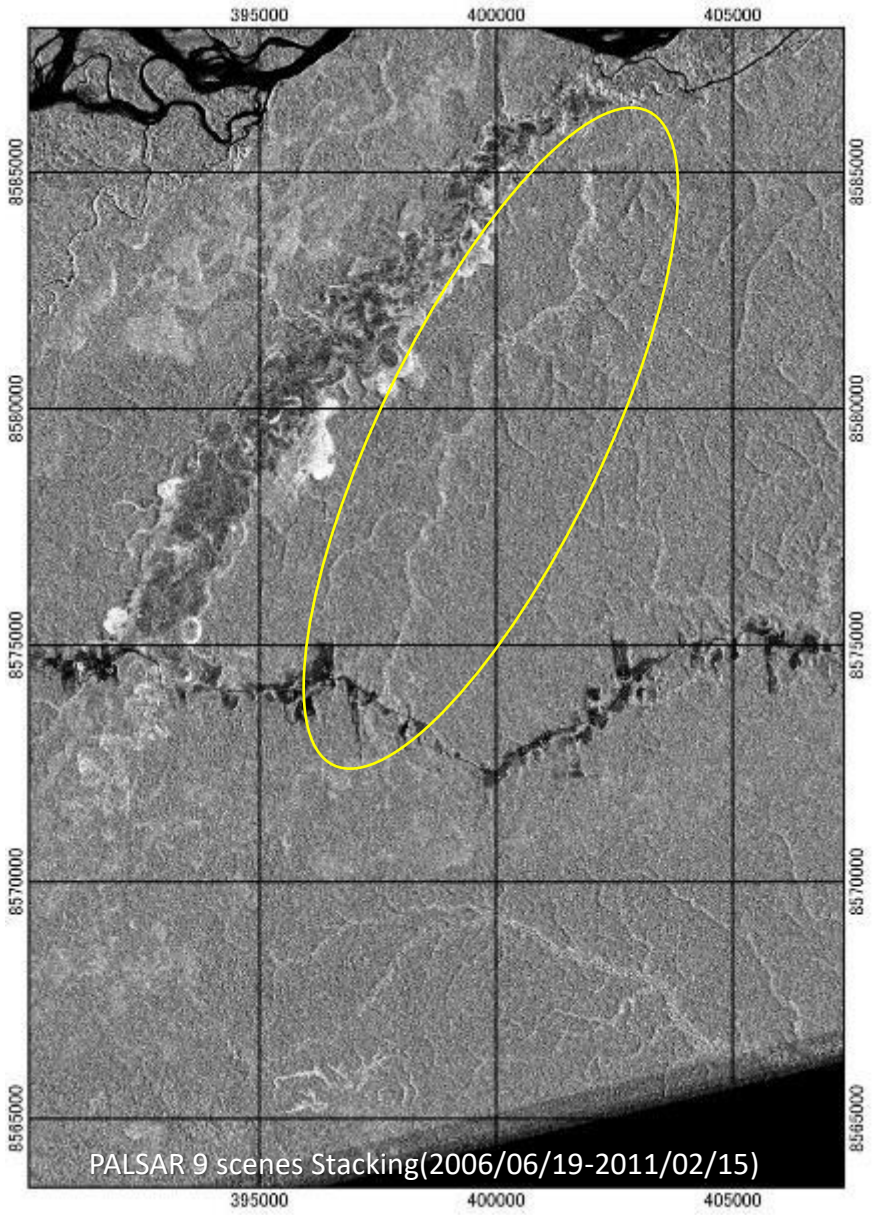
L-band(<25cm)

Wavelength of SAR (Microwave/ X, C, L-bands)



Optical sensor (Landsat-8)vs. SAR (PALSAR)





SAR (JERS-1/PALSAR)

A. Strike and dip.

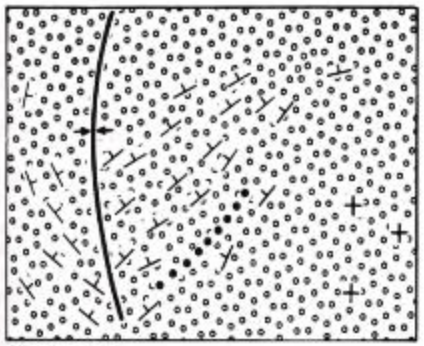
B. Thrust faults.

C. Folds, moderately eroded.

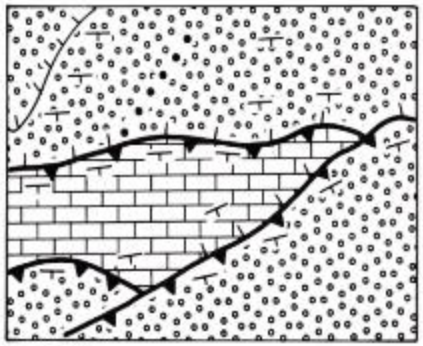
D. Folds, deeply eroded.

E. Lineaments.

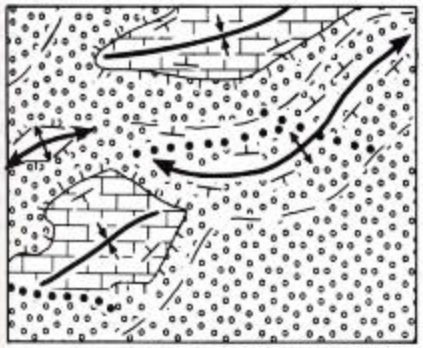
F. Strike-slip fault.



A. Strike and dip.

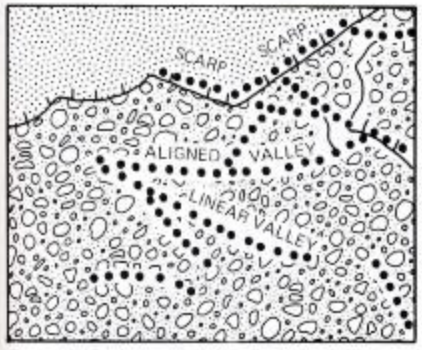


B. Thrust faults.

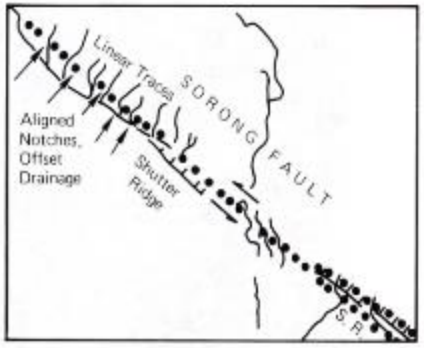


C. Folds, moderately eroded.

D. Folds, deeply eroded.



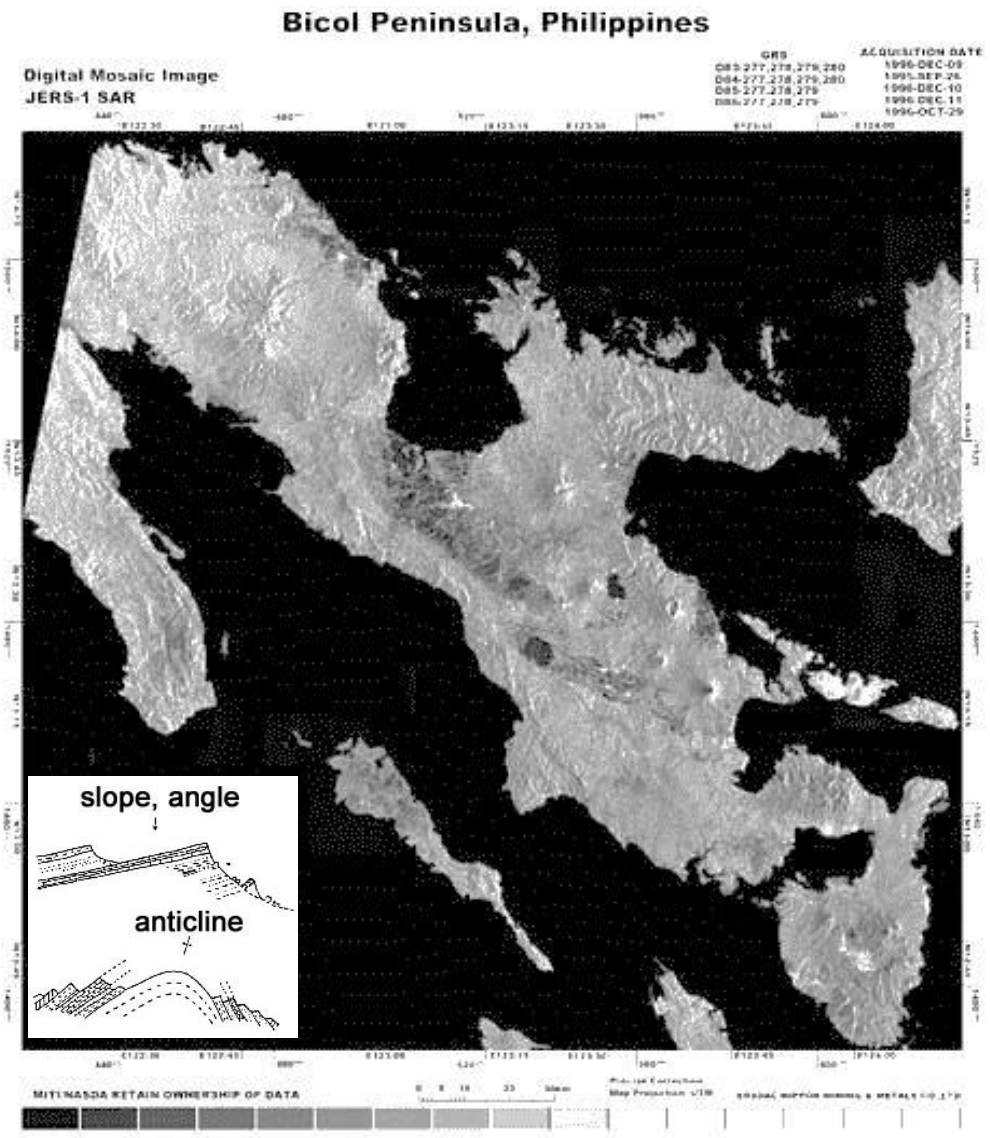
E. Lineaments.

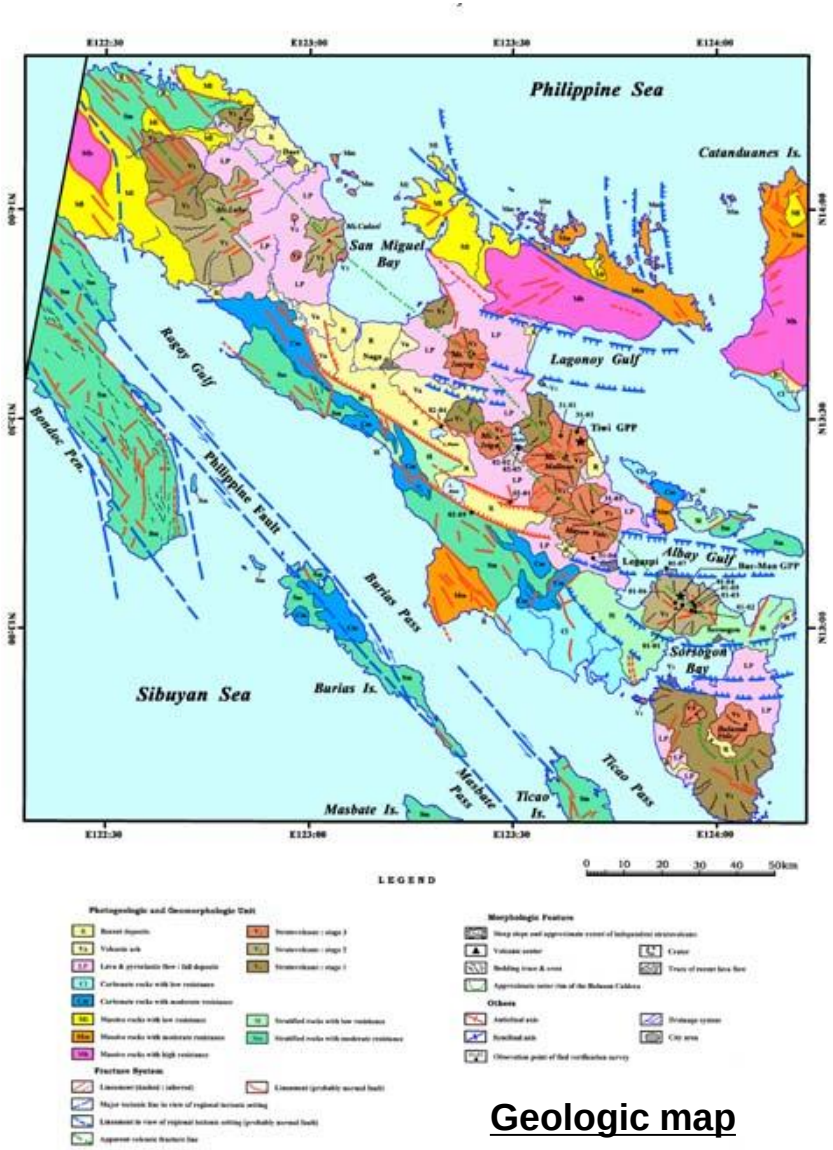


F. Strike-slip fault.

Geological structure on the SAR images → **Image interpretation of geology**

◆ Photogeometric interpretation

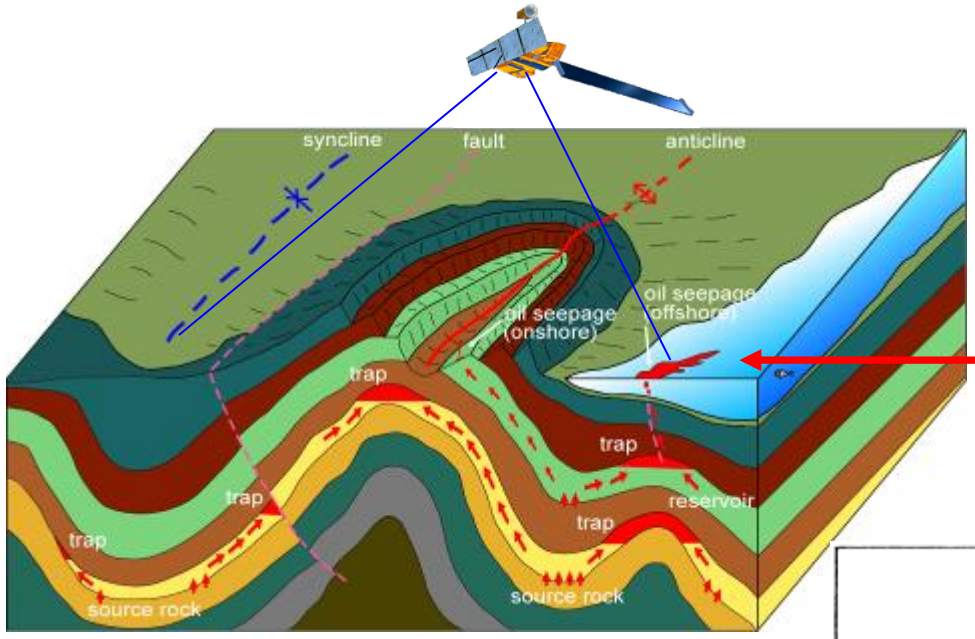


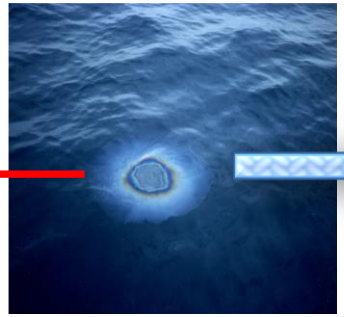


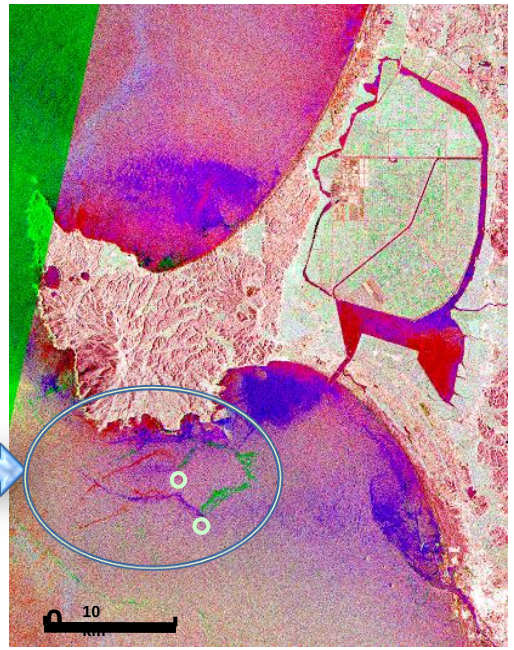
Geologic map

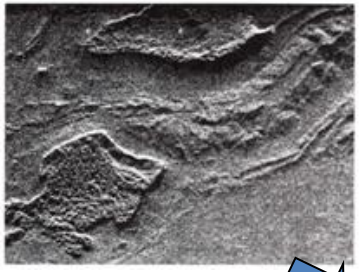
SAR for oil & gas

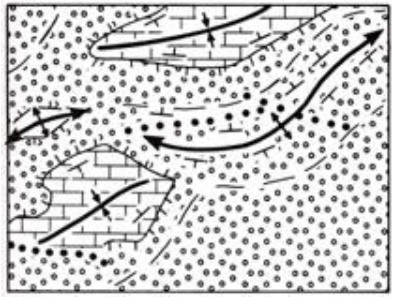
➢**Oil seepage detection and photogeometric interpretation for oil & gas exploration**

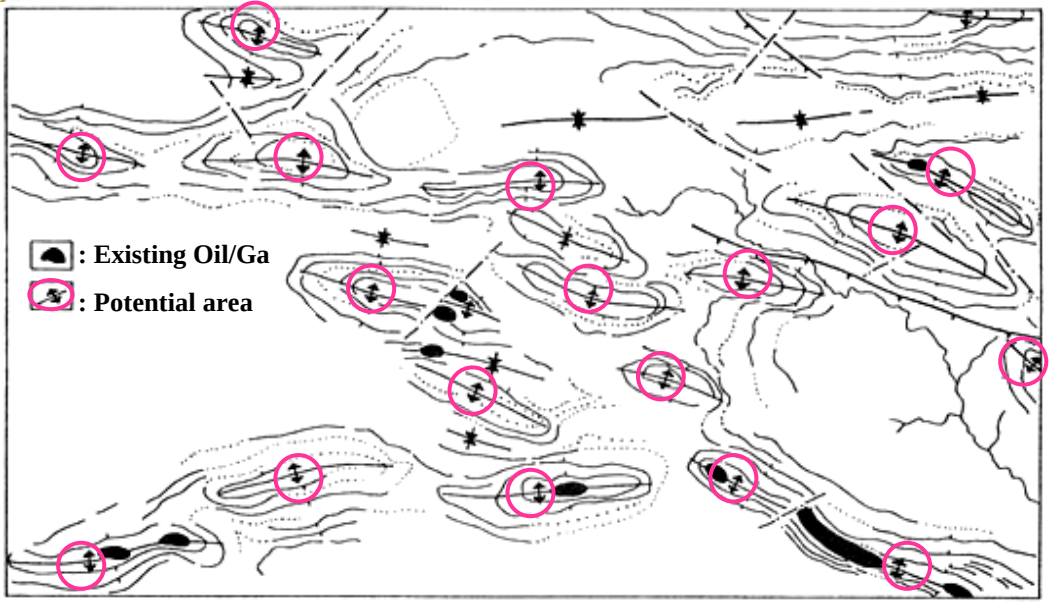












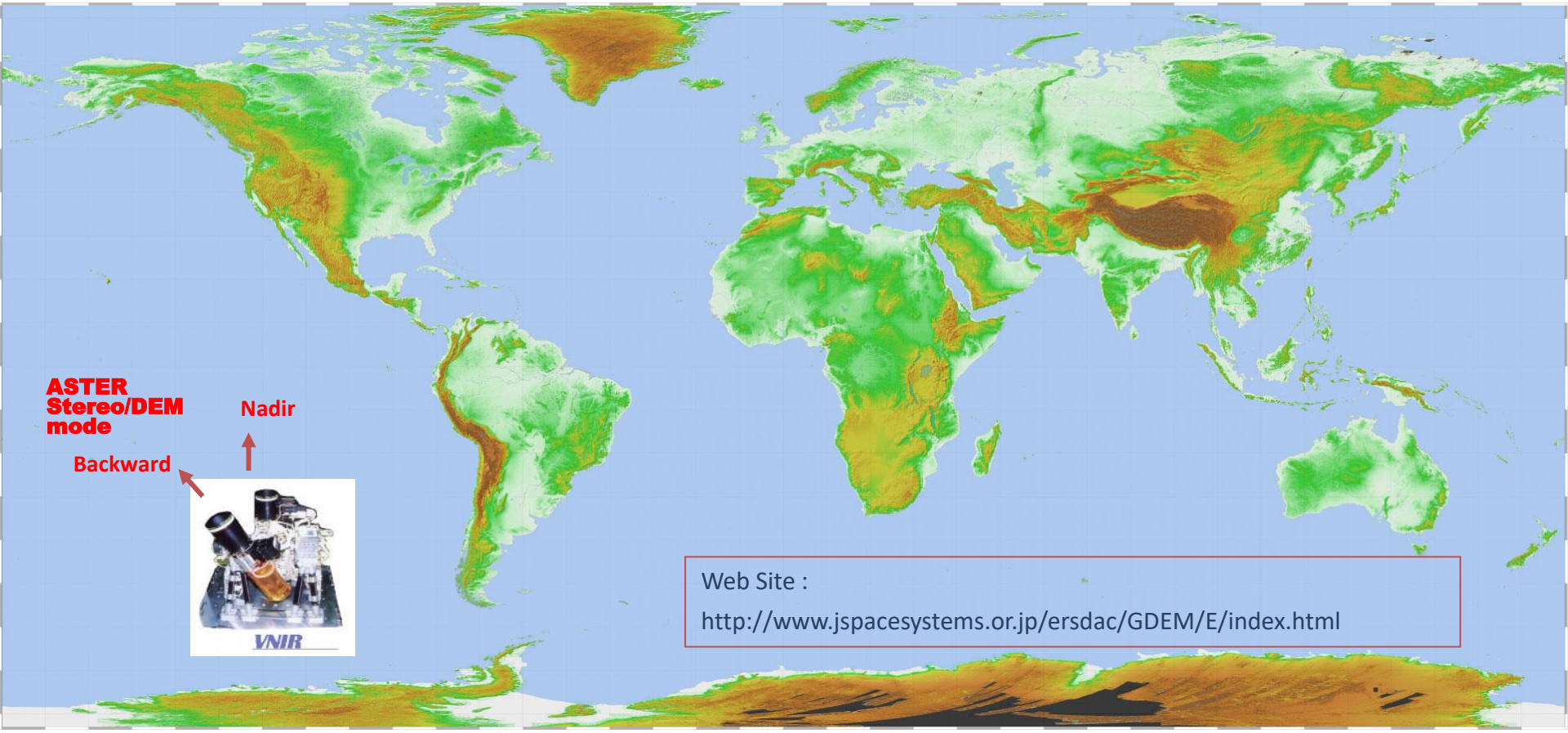
➢**<u>Anticline – Syncline pattern in moderately eroded area</u>**

Digital Elevation Model (DEM)

Digital Elevation Model (DEM)

ASTER GDEM

➢**ASTER GDEM version3 will be released soon!**



What is ASTER GDEM ? (ASTER Global Digital Elevation Model)

- **METI-Japan and NASA/USGS cooperatively prepared it to contribute for GEO's research.**
- **Generation of seamless DEM globally using all of ASTER data (approx. 1.3 million scene).**
- **Available even for high-latitude zone and steep slopes in mountainous areas**
- **Spatial resolution 30m x30m. Free of charge to use.**

Digital Elevation Model (DEM)

NASA conducted Shuttle Radar Topographic Mission (SRTM) in 2000 and 90m mesh DEM are available globally.

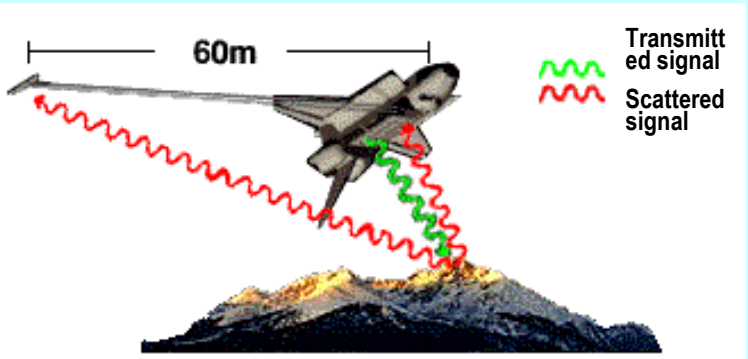
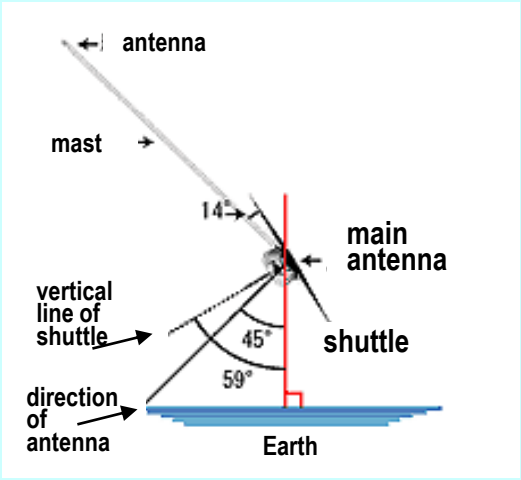
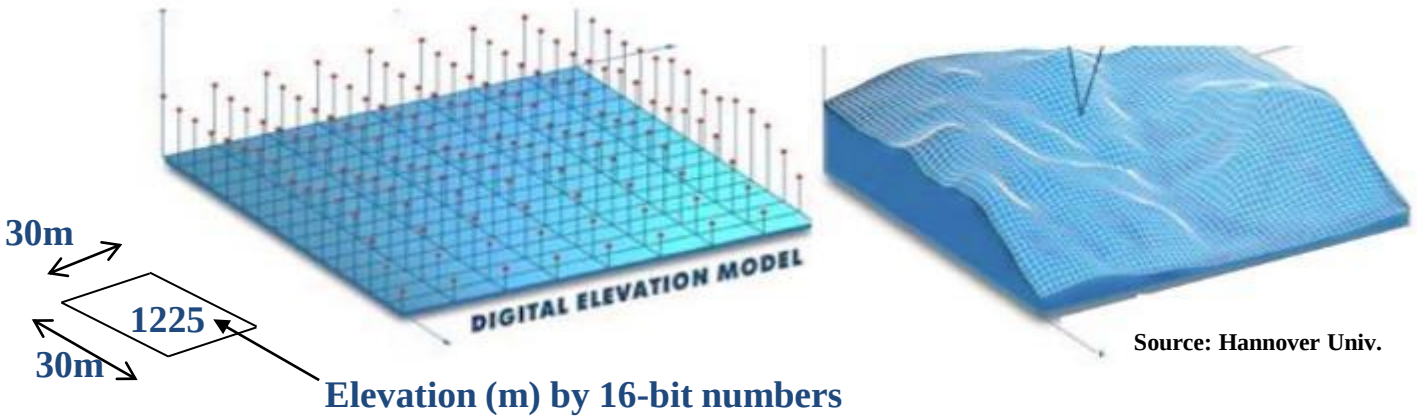


Image of Shuttle Data Acquisition (Interferometry Technique)

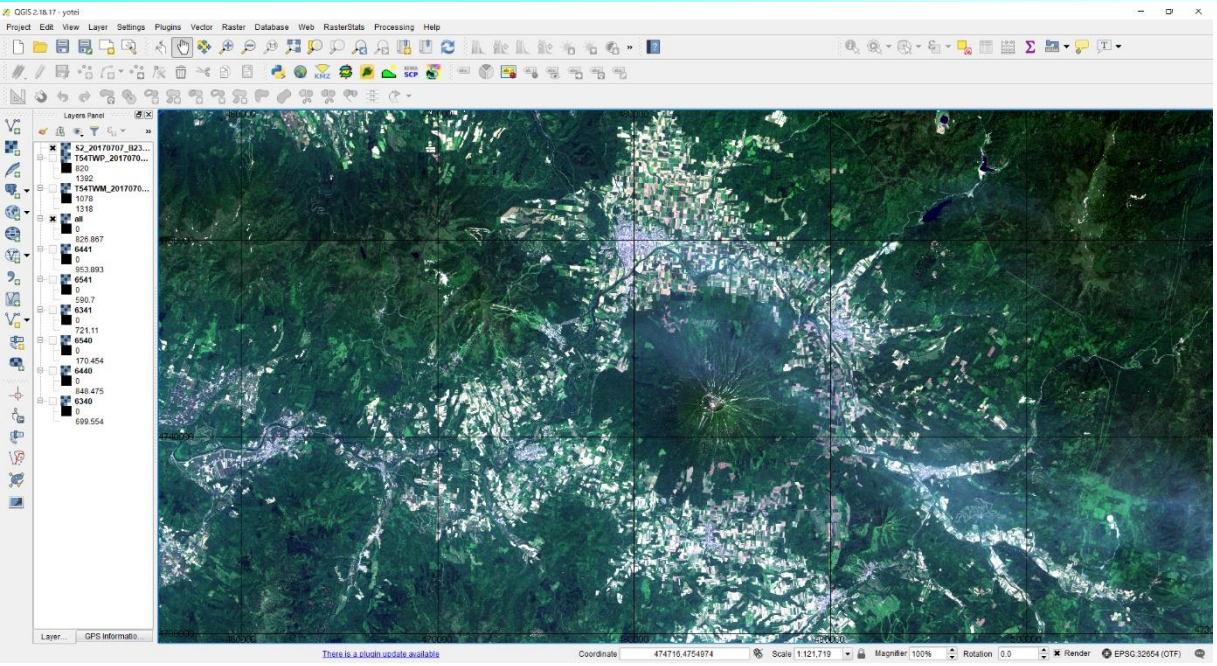


Digital Elevation Models (DEM)

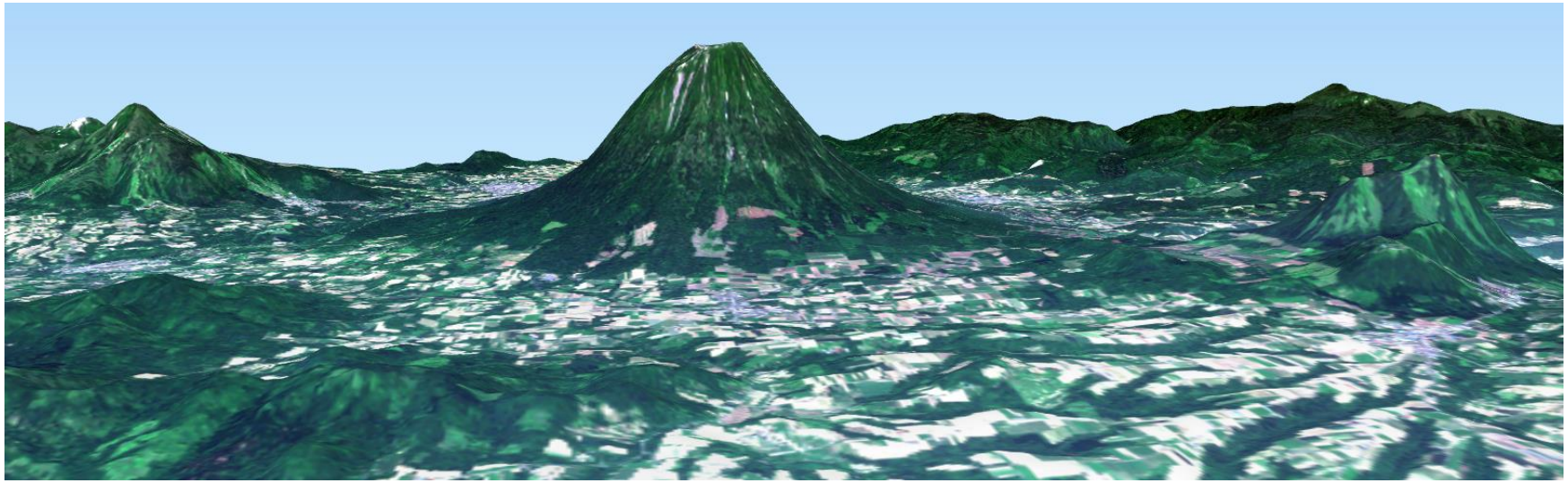


Elevation (m) by 16-bit numbers

Digital Elevation Model (DEM)



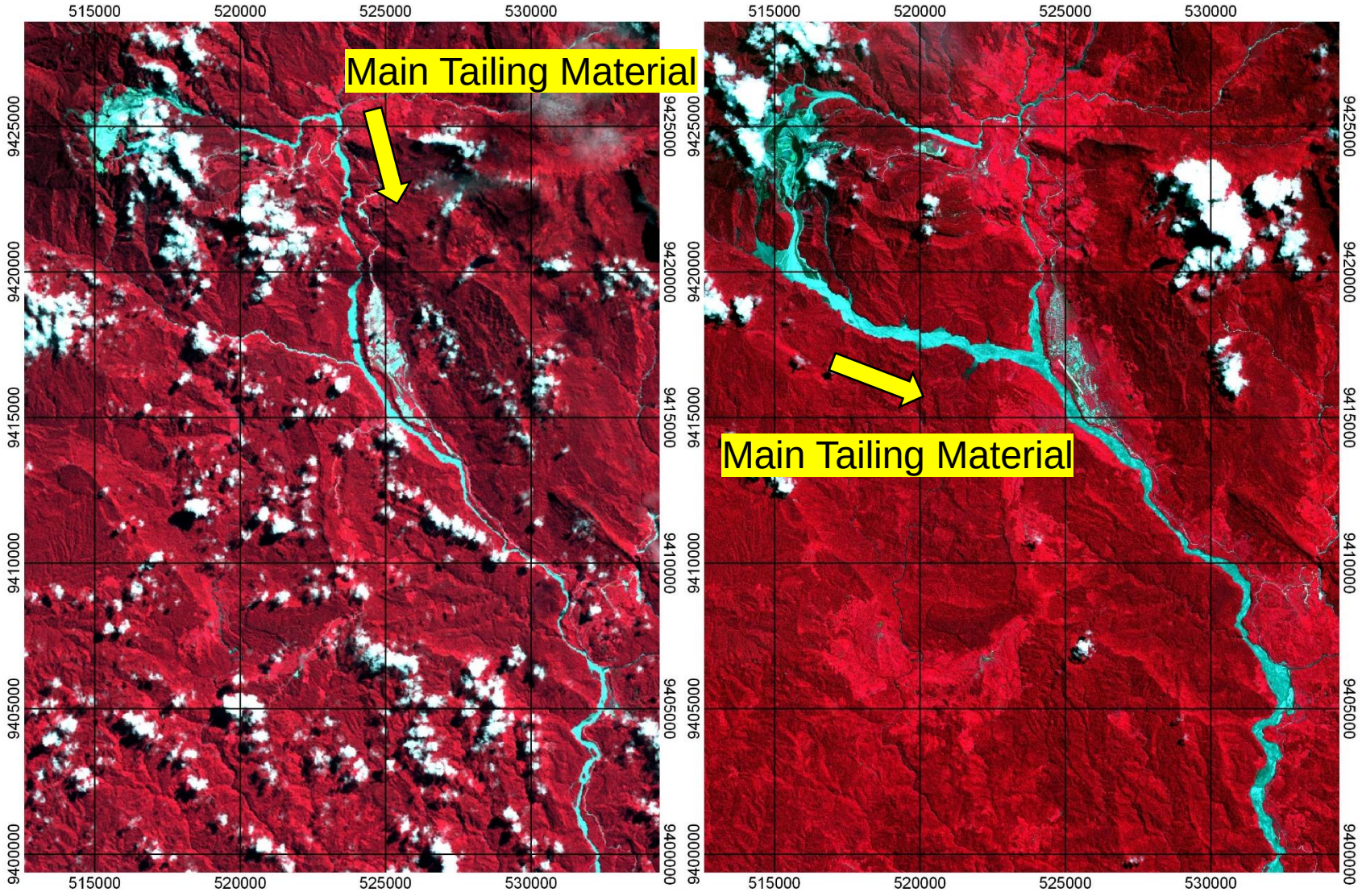
3D image can be created easily



Monitoring Mining Environment (Ok Tedi Mine/ PNG)

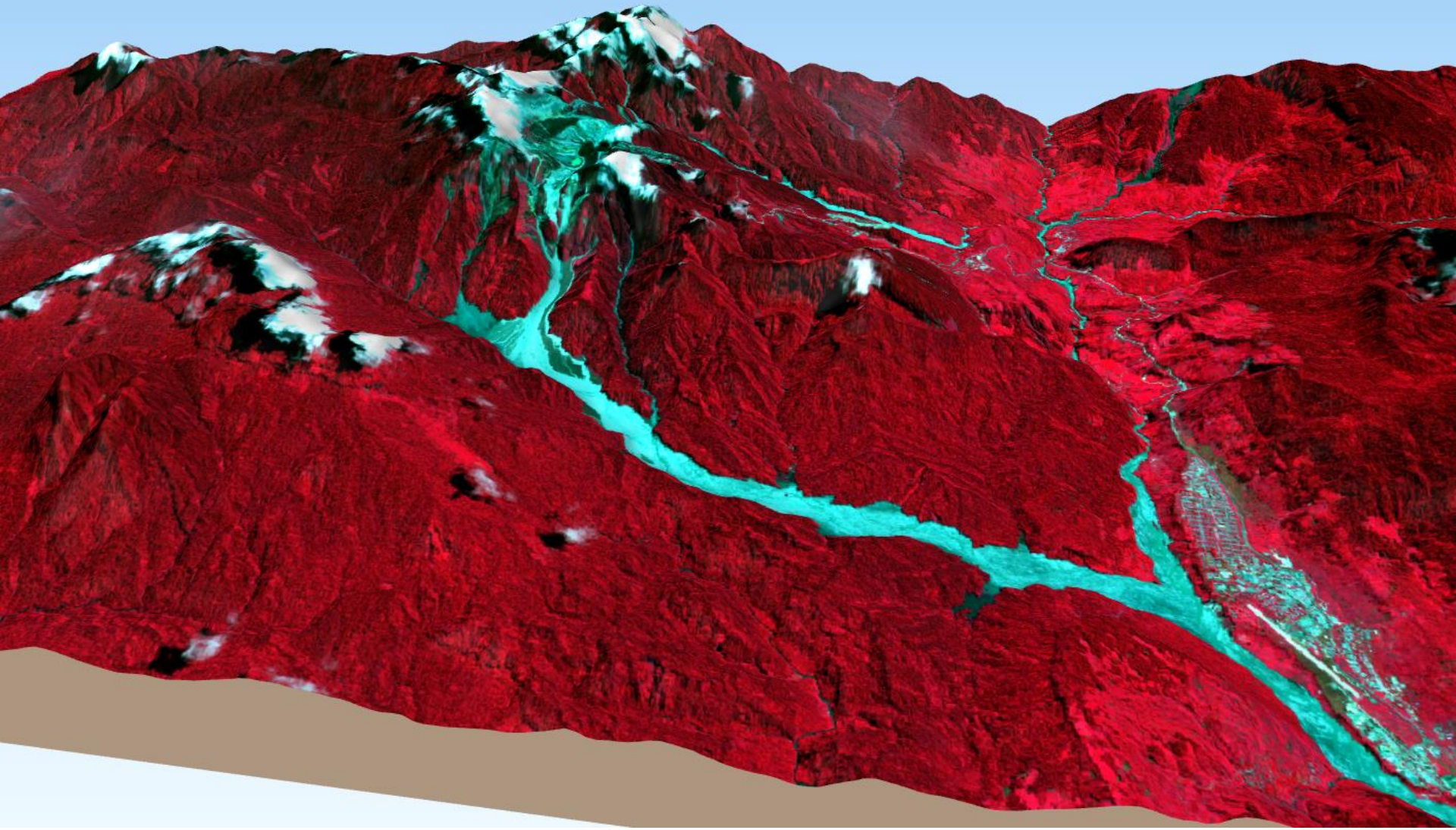
Landsat-5 (5th June 1990)

Sentinel-2 (13th April 2017)

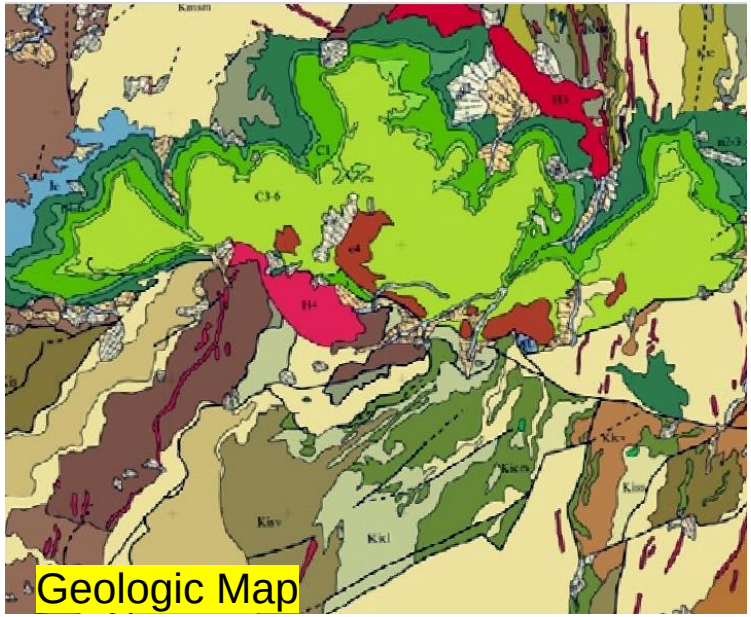


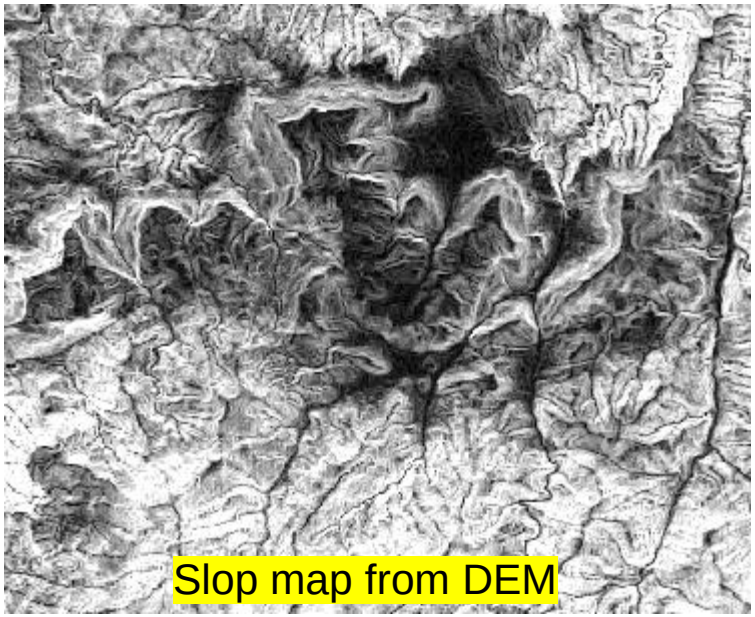
Monitoring Mining Environment (Ok Tedi Mine/ PNG)

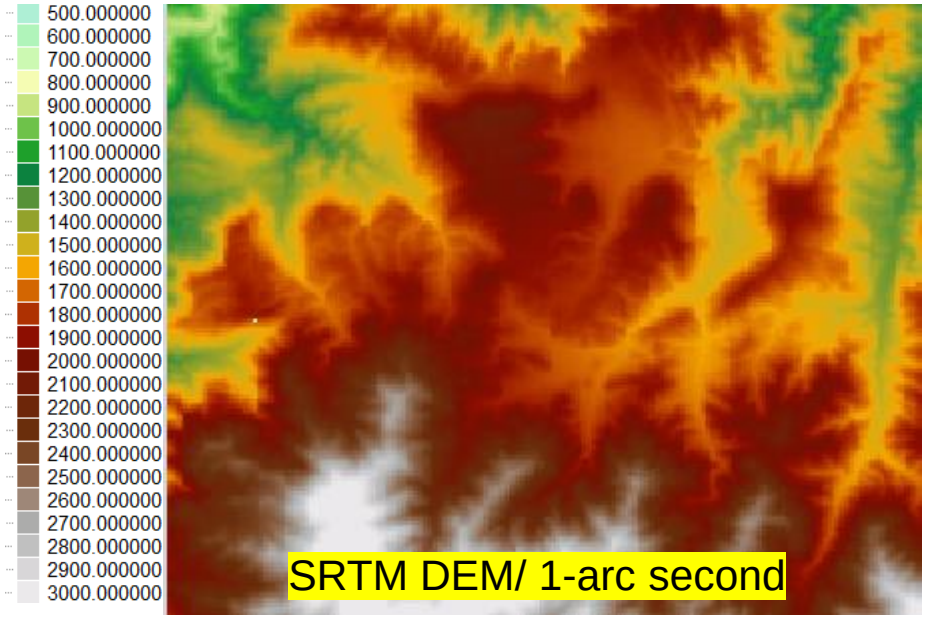
Sentinel-2 (13th April 2017)



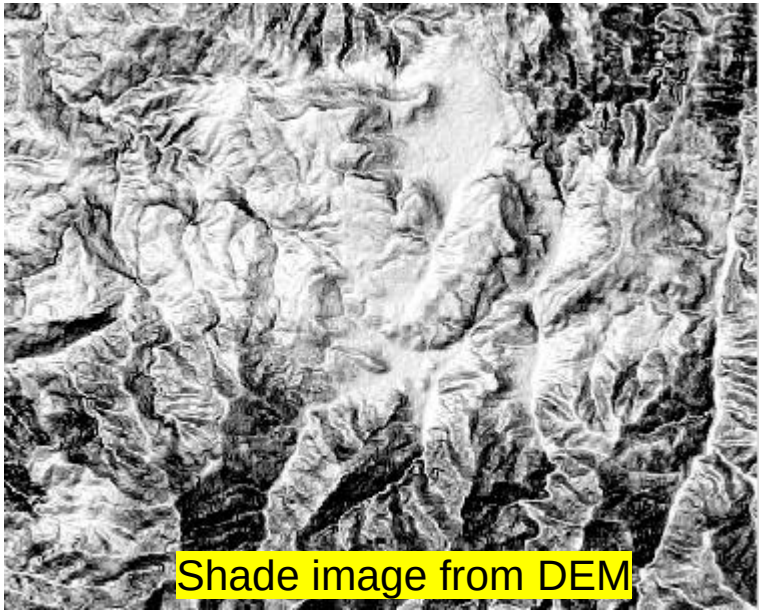
Digital Elevation Model (DEM)


Geologic Map


Slop map from DEM

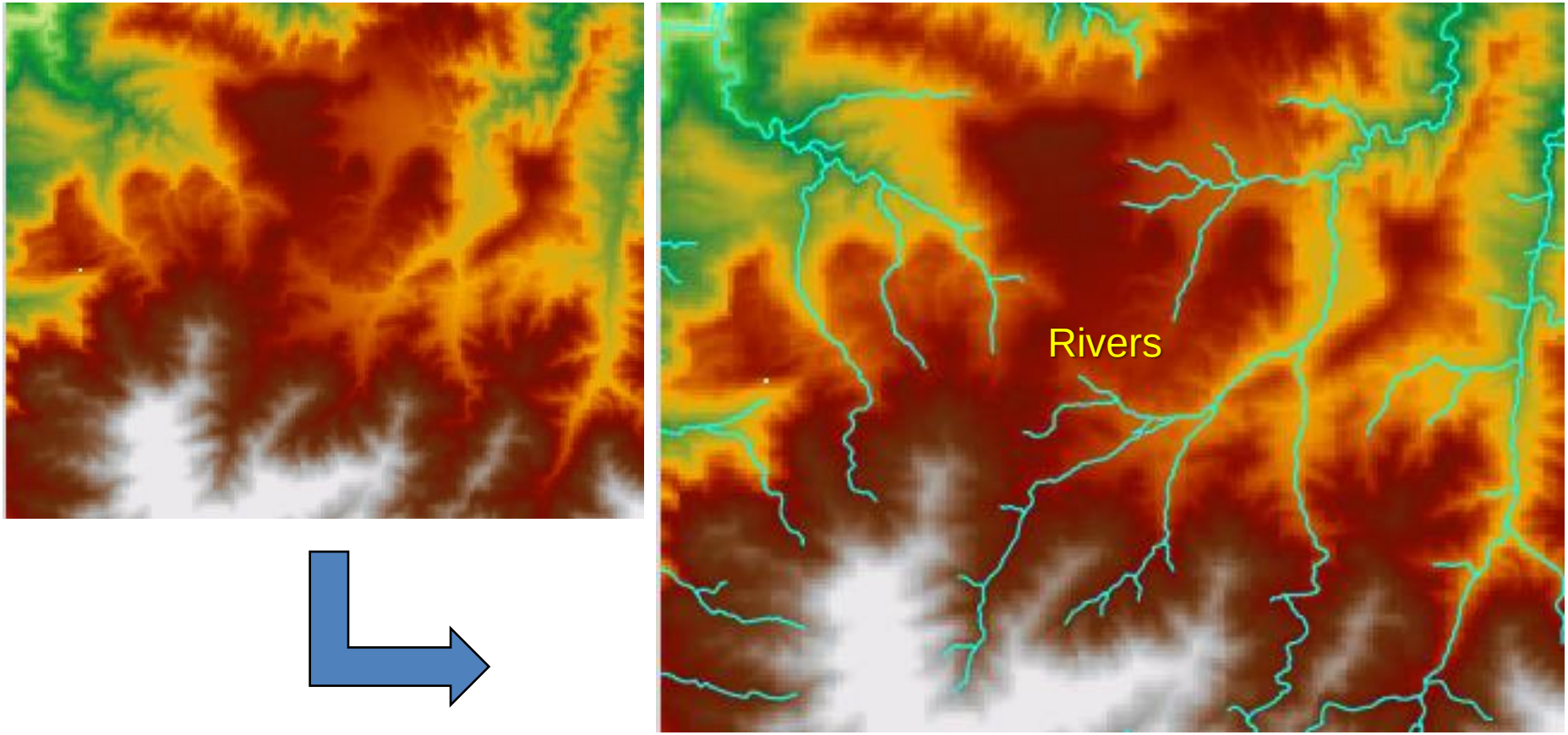


SRTM DEM/ 1-arc second


Shade image from DEM

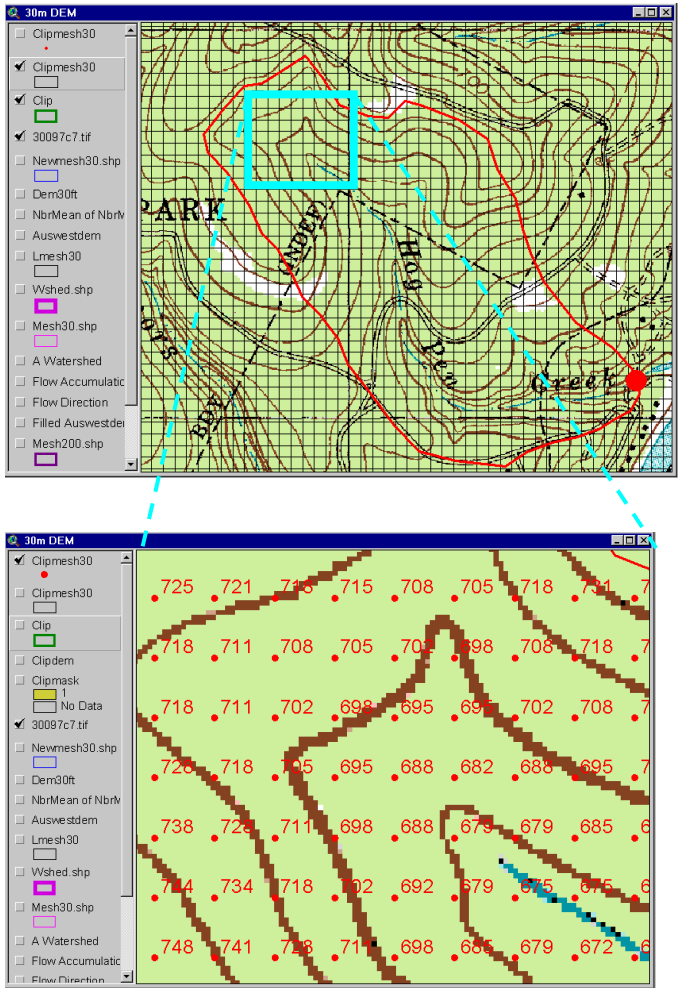
Digital Elevation Model (DEM)

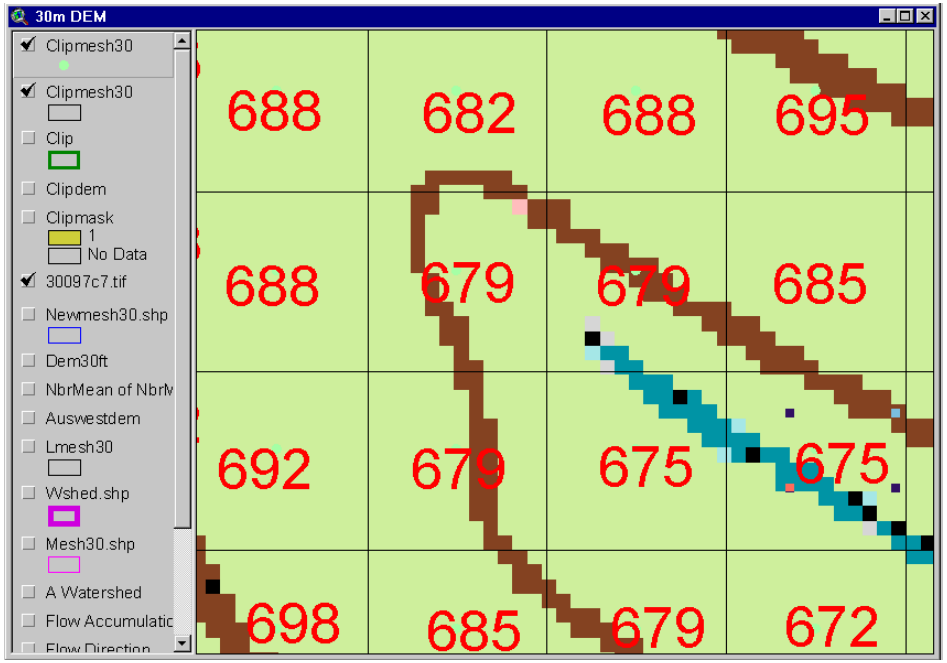
- Stream line detection from DEM



✓ **Rivers can be extracted from DEM**

- Integrated DEM data from satellite data





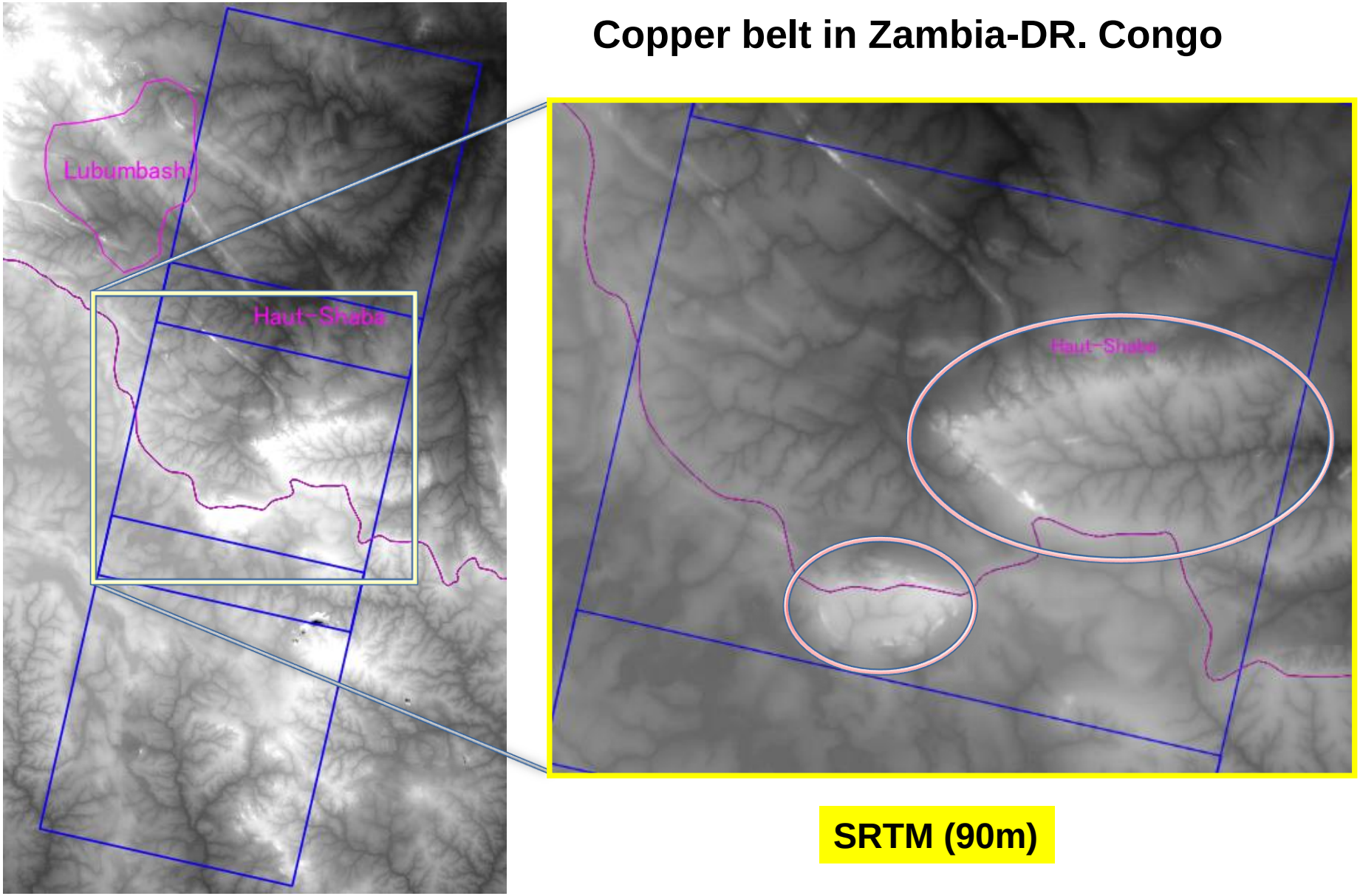
(Source: Hannover Univ.)

Grid size

SRTM: 30m

ASTER:30m

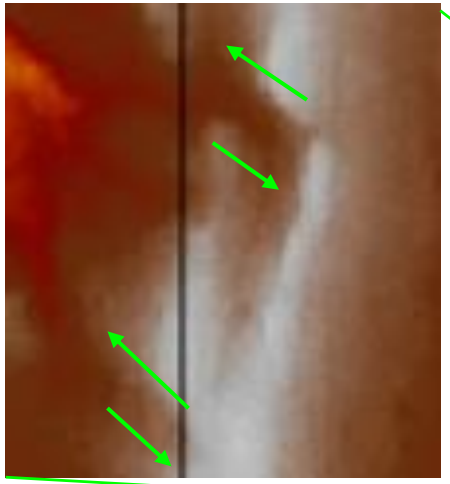
Digital Elevation Model (DEM)



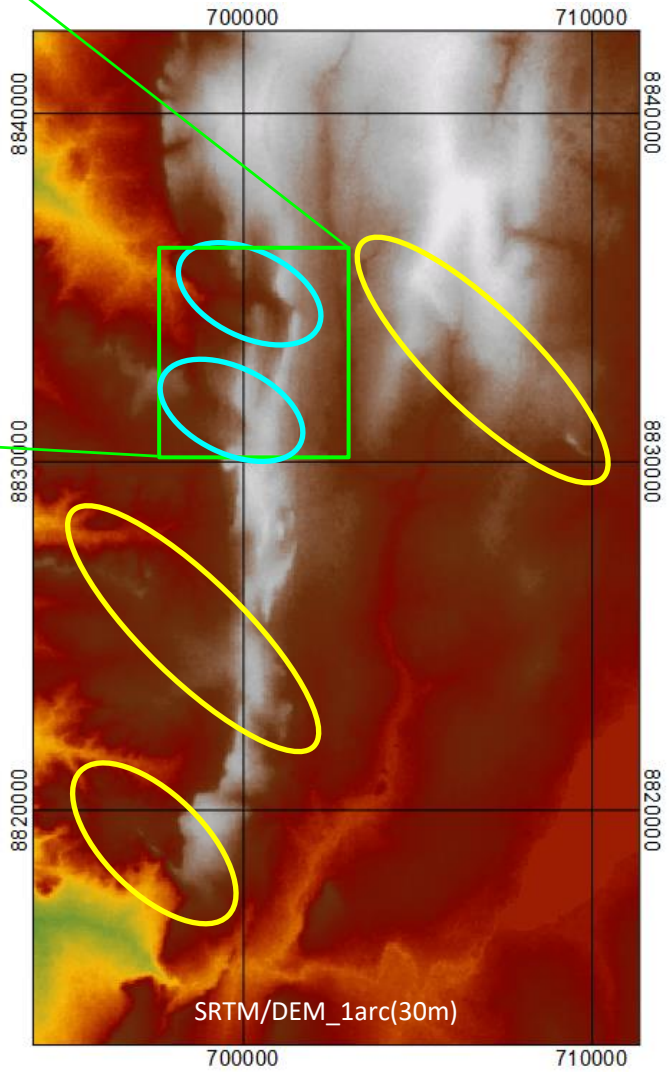
Copper belt in Zambia-DR. Congo

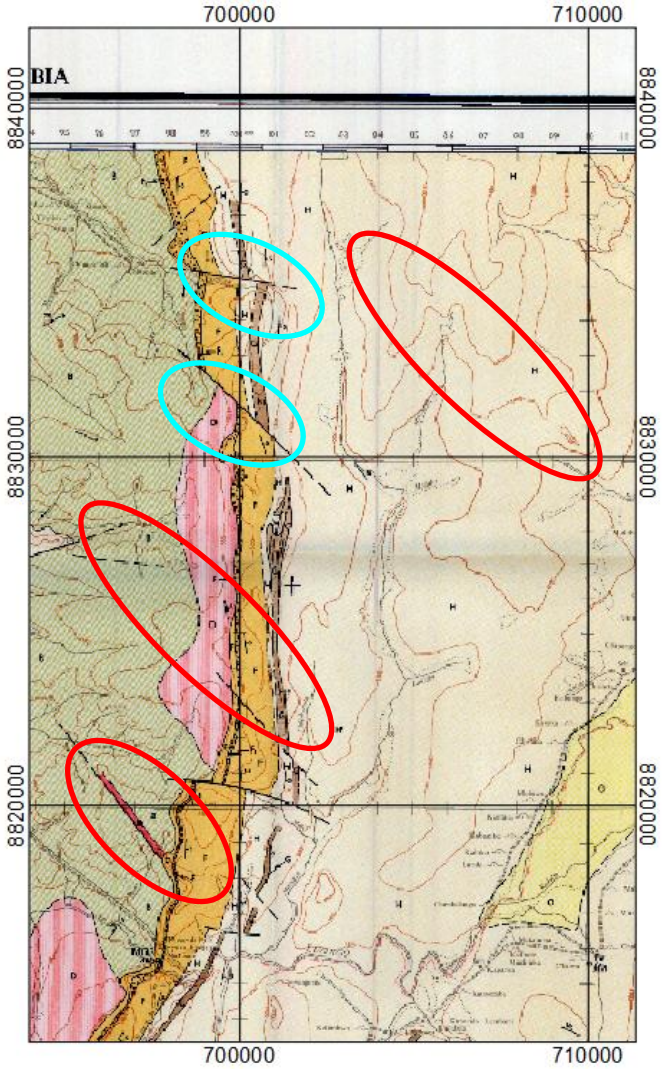
SRTM (90m)

Digital Elevation Model (DEM)



NW-SE Trend





DEM reflects geomorphologic features caused by fault, different rock unit

Digital Elevation Model (DEM)

Drainage can be generated from maximum flow direction intensity (Z) as below.

13	12	11
11	10	9
11	9	8

13	12	11	10	10
11	10	9	8	9
11	9	8	7	6
11	10	9	9	8

-0.024	-0.022	-0.008
-0.011		0.011
-0.008	0.011	0.016

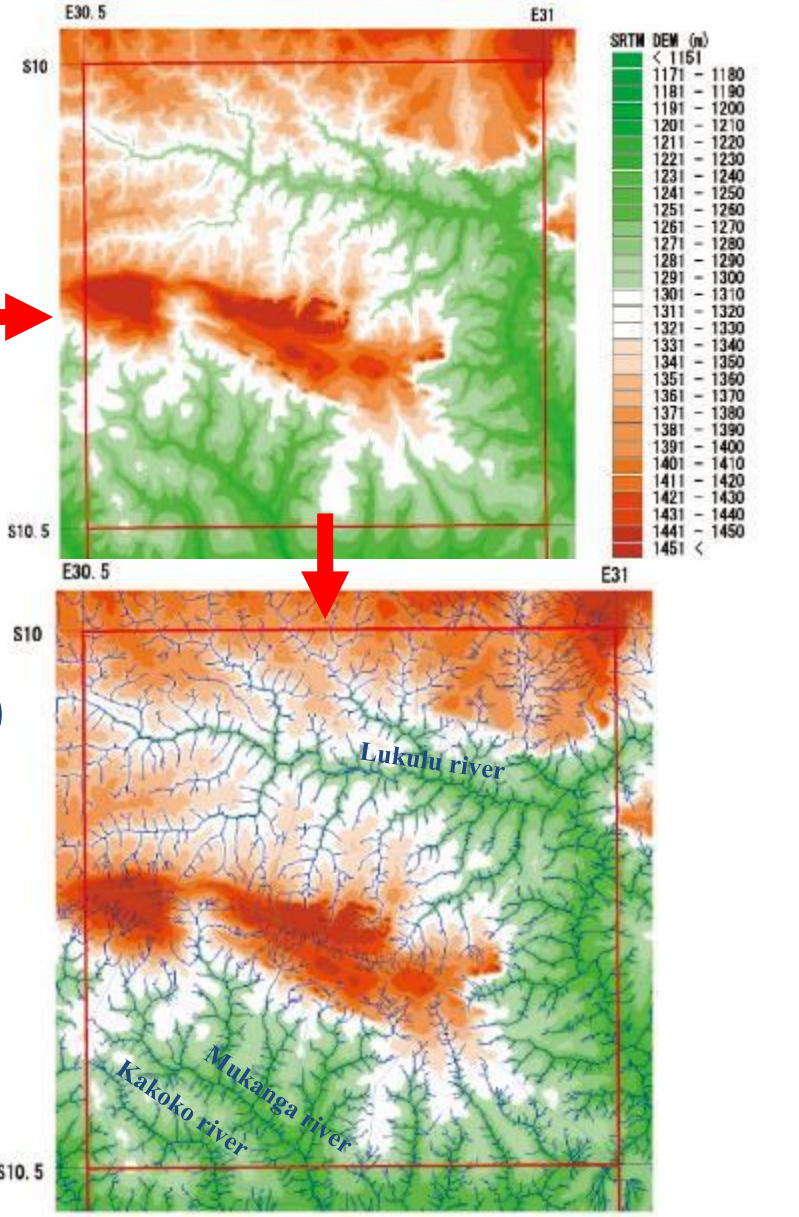
$$Z=(Pi-Pj)/\sqrt{(Pi-Pj)^2+D^2}$$

Z: Maximum flow direction intensity

Pi: DEM value of center pixel

Pj: DEM value of neighbor pixel

D: Distance from Pi to Pj



Digital Elevation Model (DEM)

Sampling points of stream sediment can be determined with the result of stream line analysis using SRTM DEM.

(Left image)

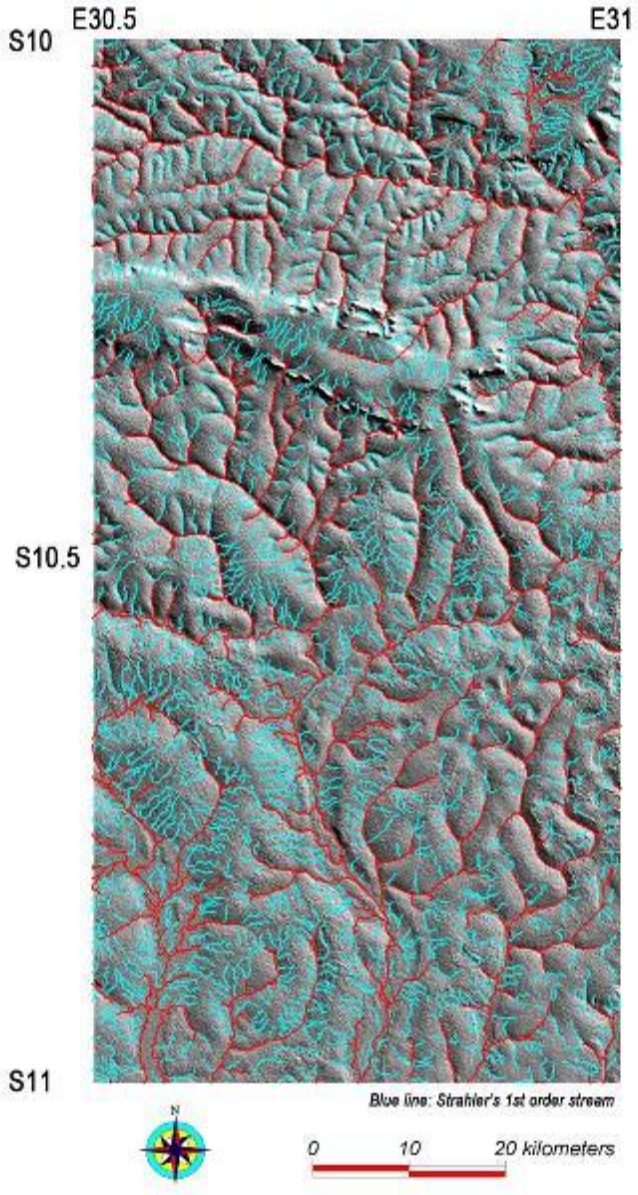
Blue: 1st order stream

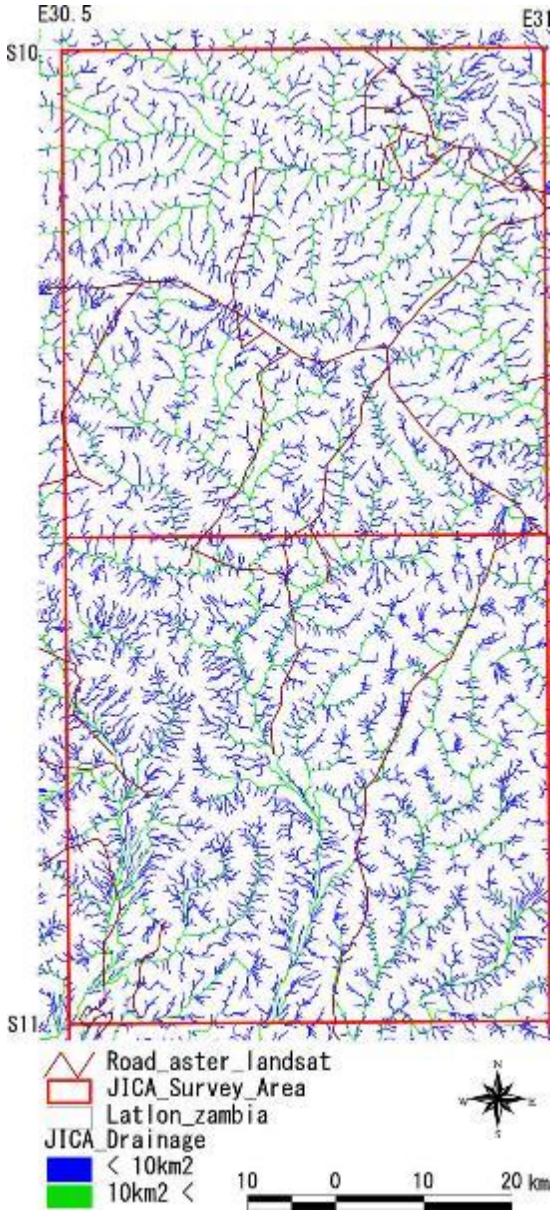
Red : > 1st order stream

(Right image)

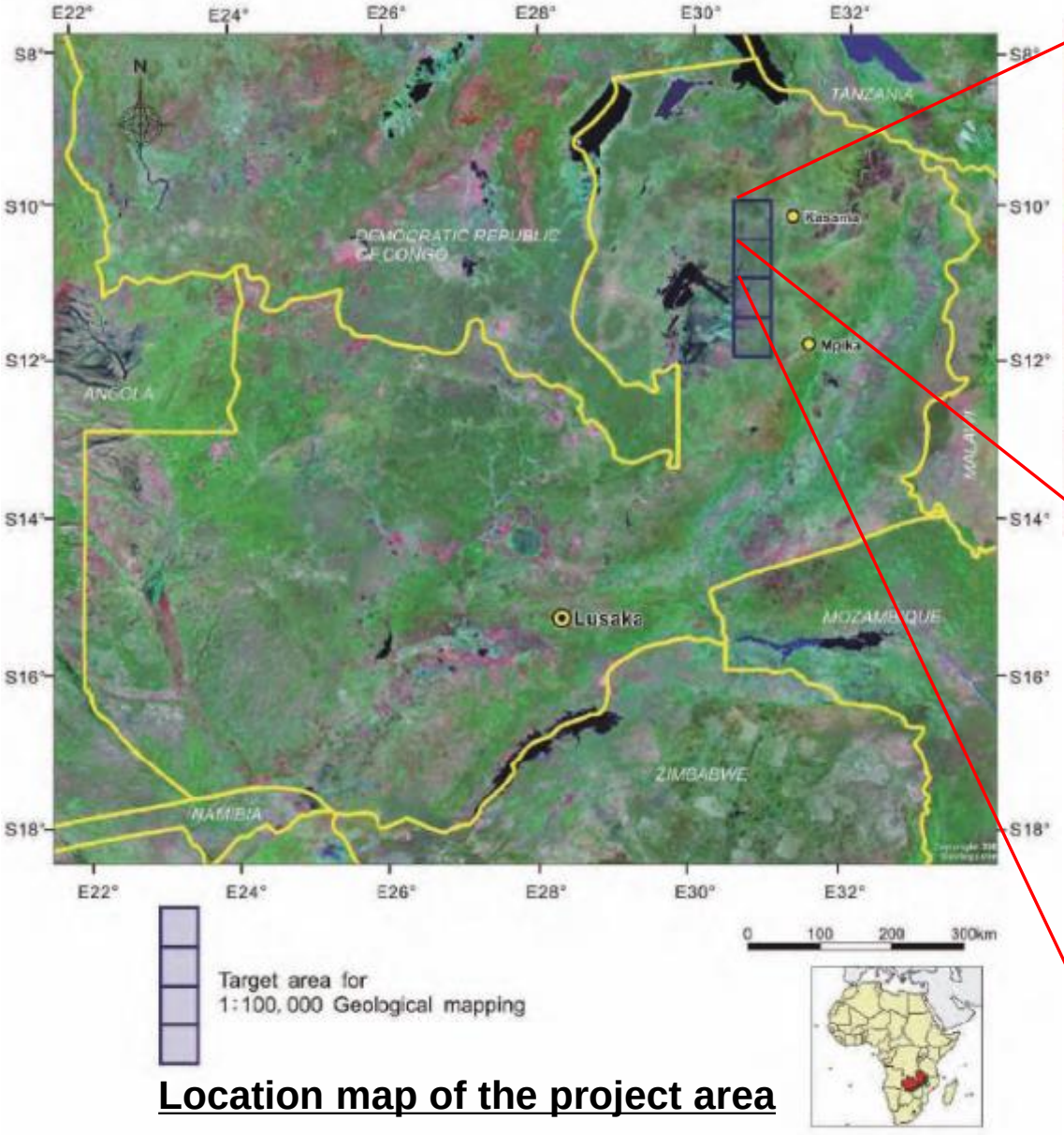
Blue: catchment < 10km²

Green: catchment > 10km²

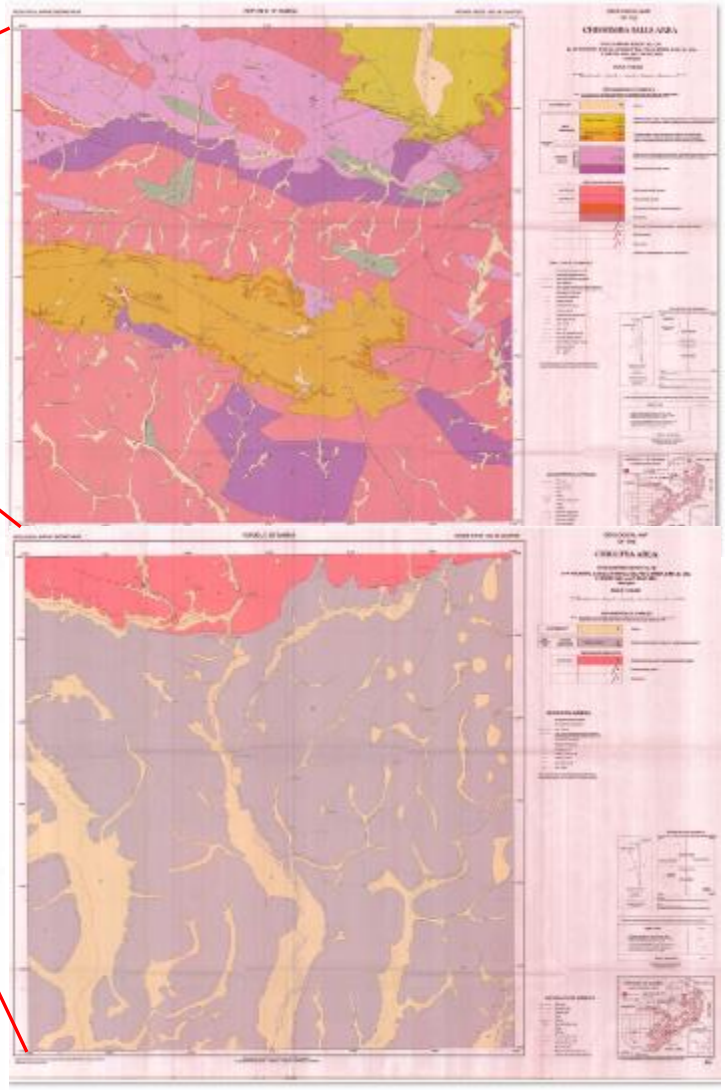




Combination of ASTER, PALSAR, GDEM/SRTM (Zambia)

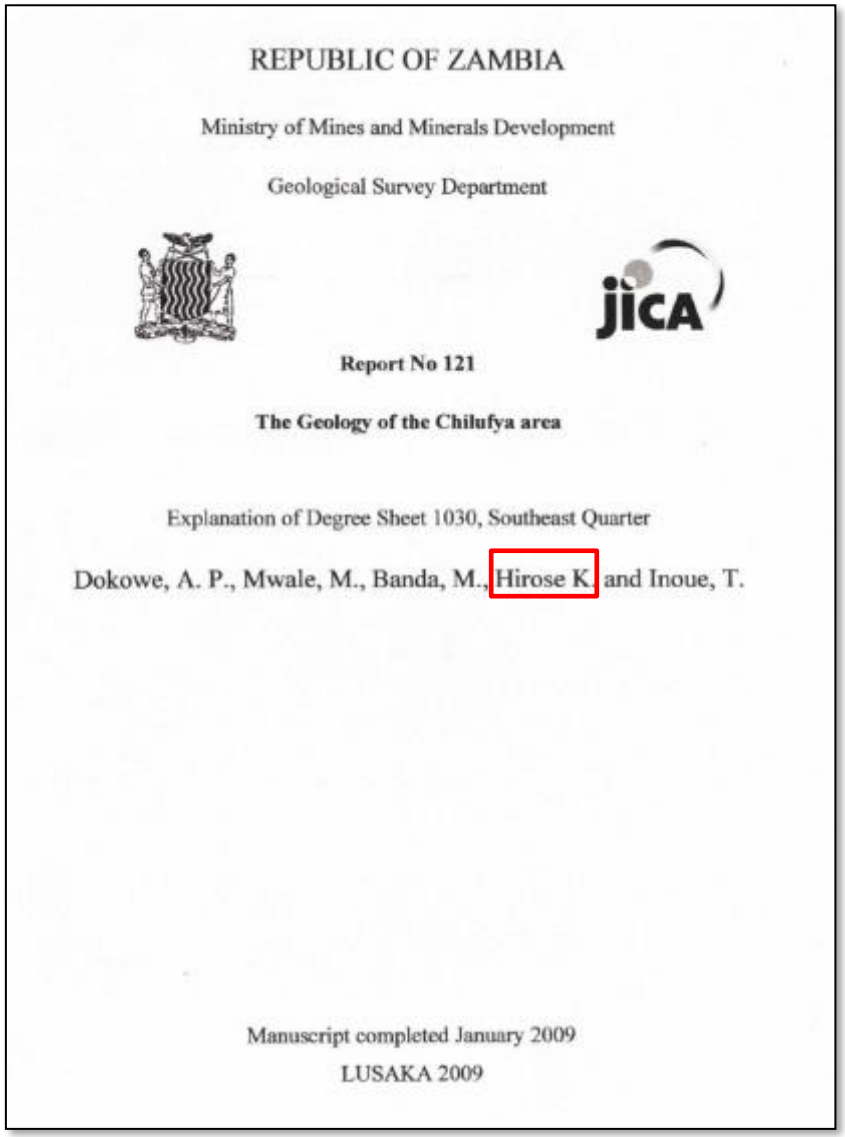


Location map of the project area



(published by Geological Survey of Zambia in 2009)

Combination of ASTER, PALSAR, GDEM/SRTM (Zambia)



REPUBLIC OF ZAMBIA

Ministry of Mines and Minerals Development

Geological Survey Department

JICA

Report No 121

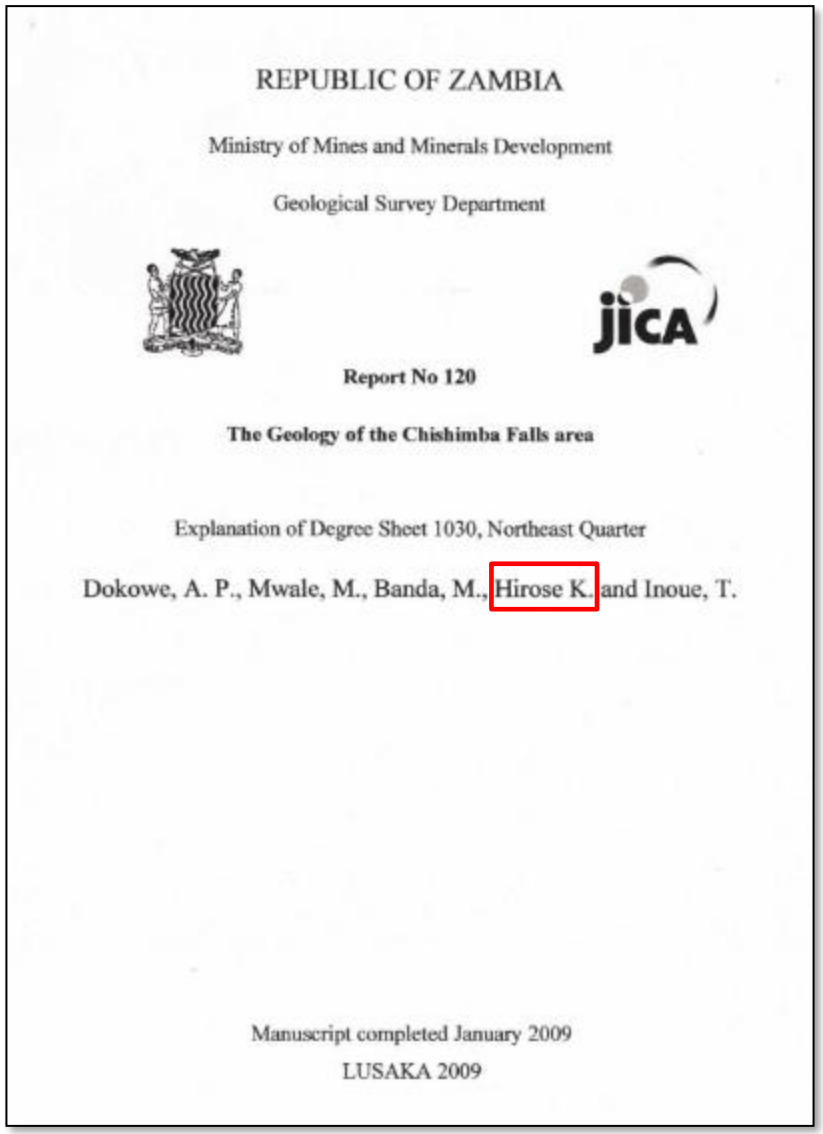
The Geology of the Chilufya area

Explanation of Degree Sheet 1030, Southeast Quarter

Dokowe, A. P., Mwale, M., Banda, M., Hirose K. and Inoue, T.

Manuscript completed January 2009

LUSAKA 2009



REPUBLIC OF ZAMBIA

Ministry of Mines and Minerals Development

Geological Survey Department

JICA

Report No 120

The Geology of the Chishimba Falls area

Explanation of Degree Sheet 1030, Northeast Quarter

Dokowe, A. P., Mwale, M., Banda, M., Hirose K. and Inoue, T.

Manuscript completed January 2009

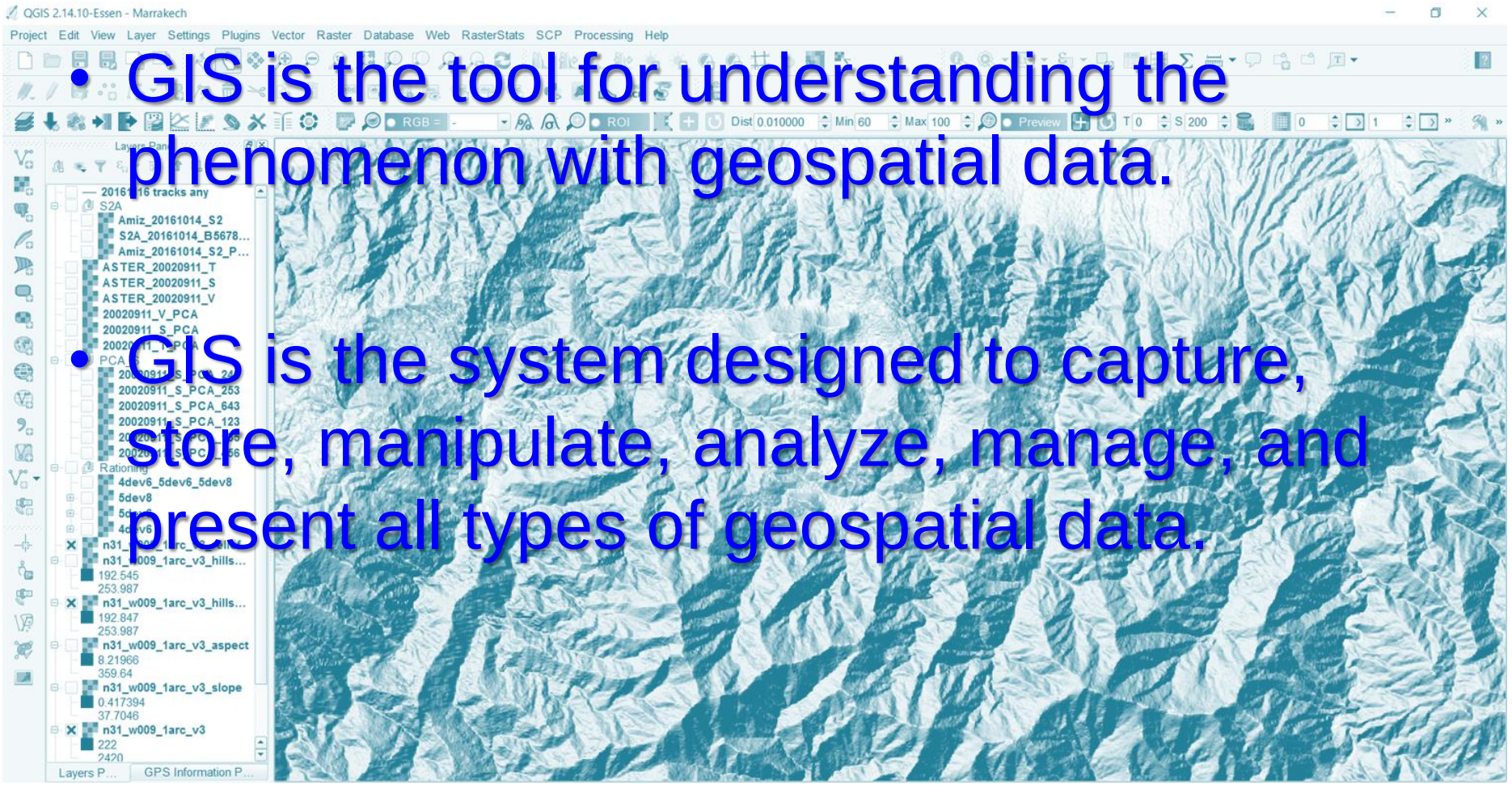
LUSAKA 2009

Prepared by Zambia-Japan/JICA Project

Basic GIS

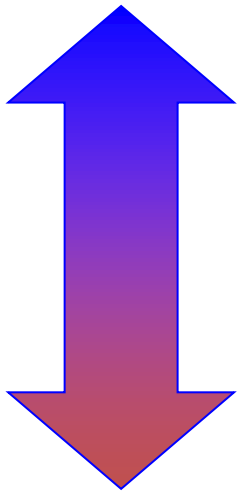
What is the GIS?

- GIS is the tool for understanding the phenomenon with geospatial data.
- GIS is the system designed to capture, store, manipulate, analyze, manage, and present all types of geospatial data.

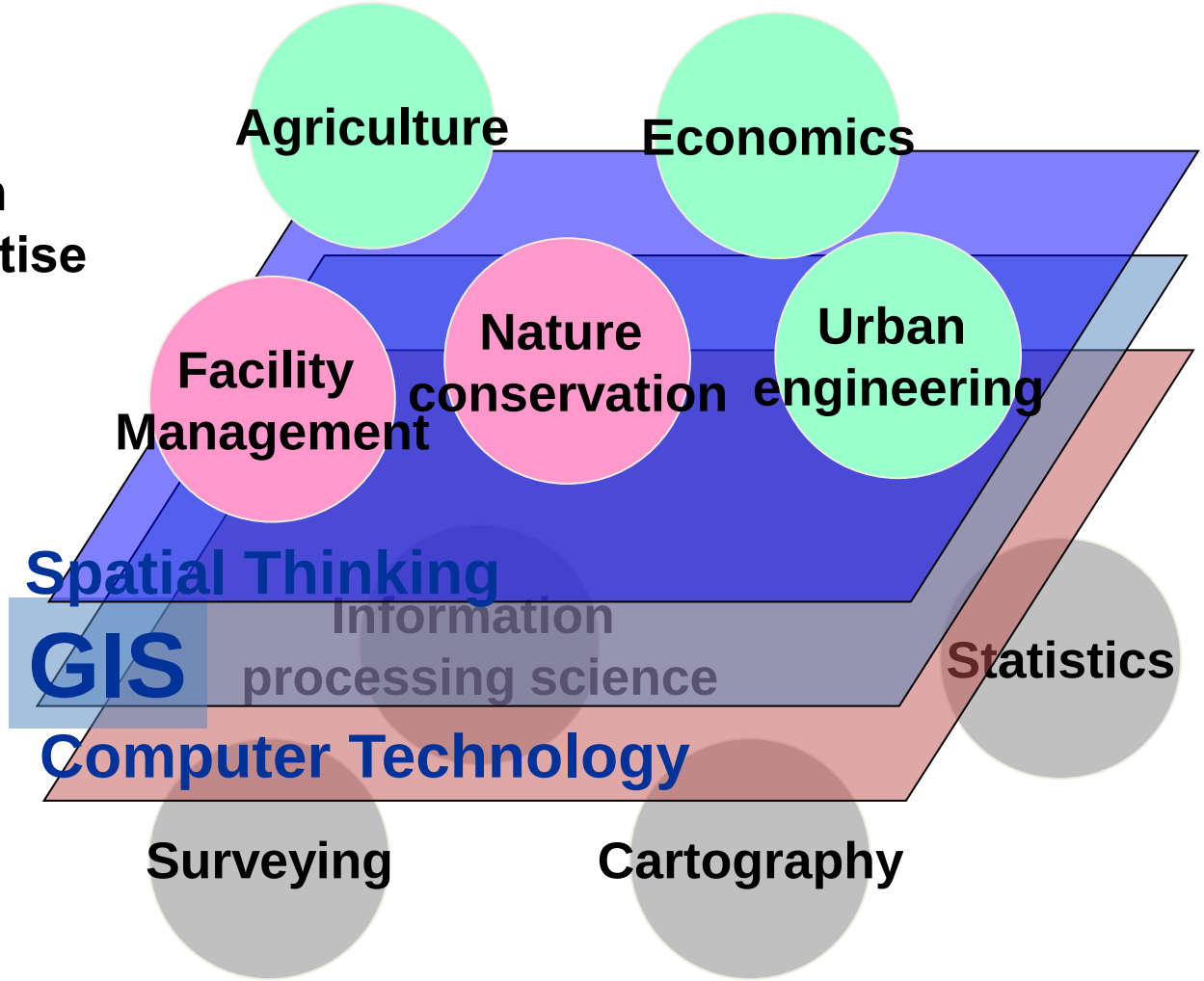


Configuration of the GIS data

GIS as seen from the area of expertise

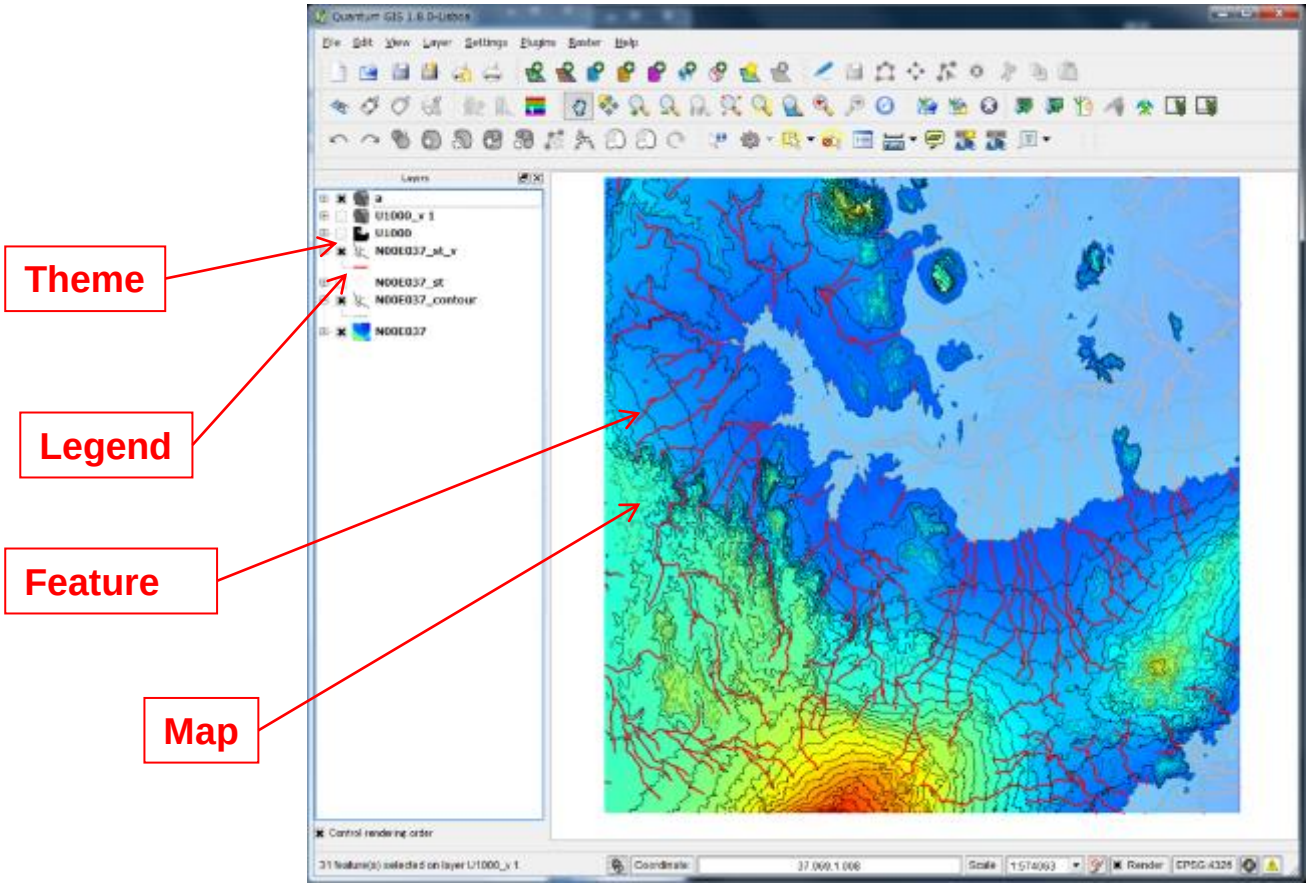


GIS as seen from the basic study

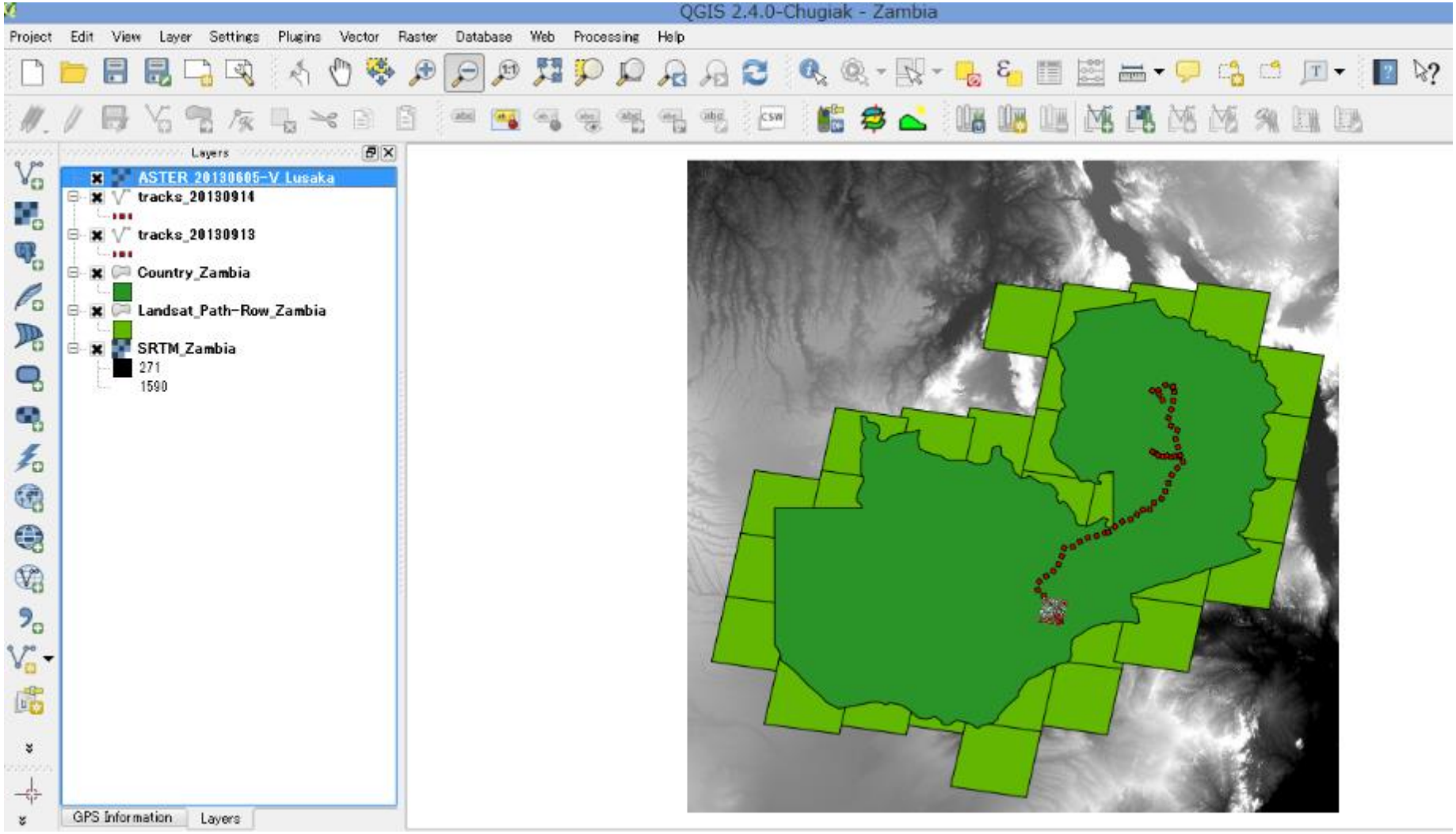


Map information & Feature

- Form that has shown on the map for real-world objects, and location.

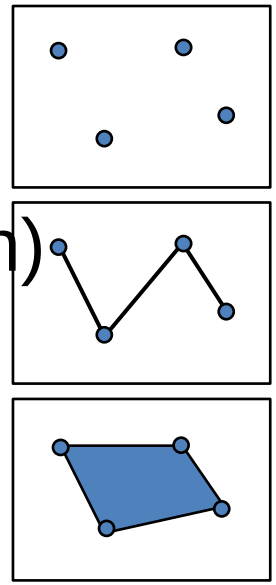


What is the GIS (Example: Zambia)



Data type : Vector

- Vector data used in the GIS, which represents the position coordinates. specified in the y and x.



◆Point : consists of x, y.

◆Line : More than one point (p1, p2, p3, ... pn) which are connected by a line

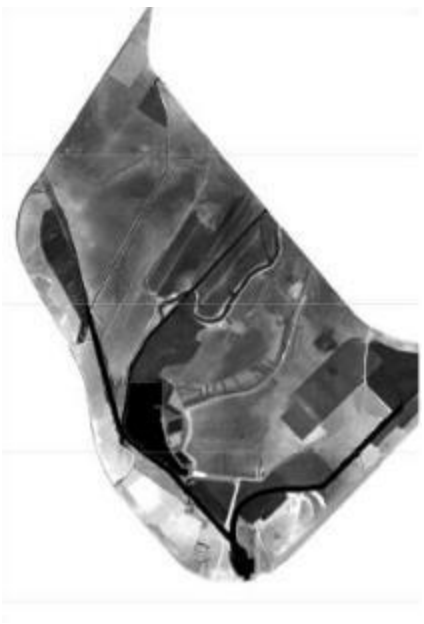
◆Polygon : Some areas inside the circle or ellipse

Data type : Raster

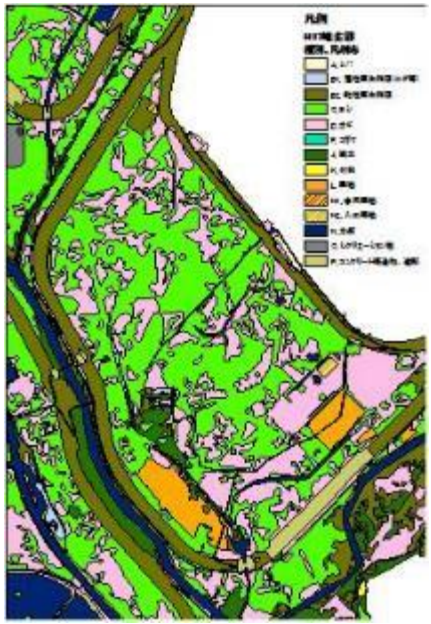
- Data image formed by pixels.

  Aerial photo, satellite image and other.

Aerial photo & Satellite image



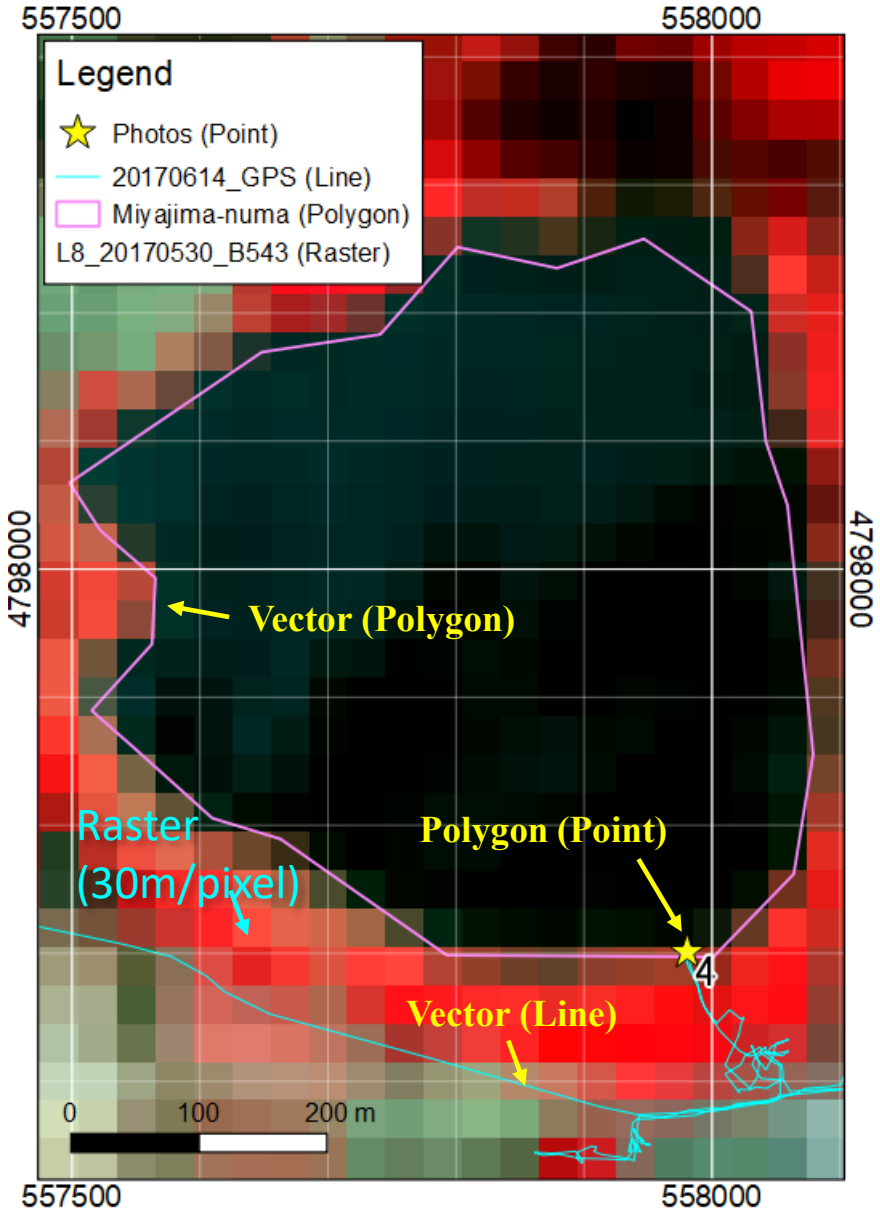
DEM

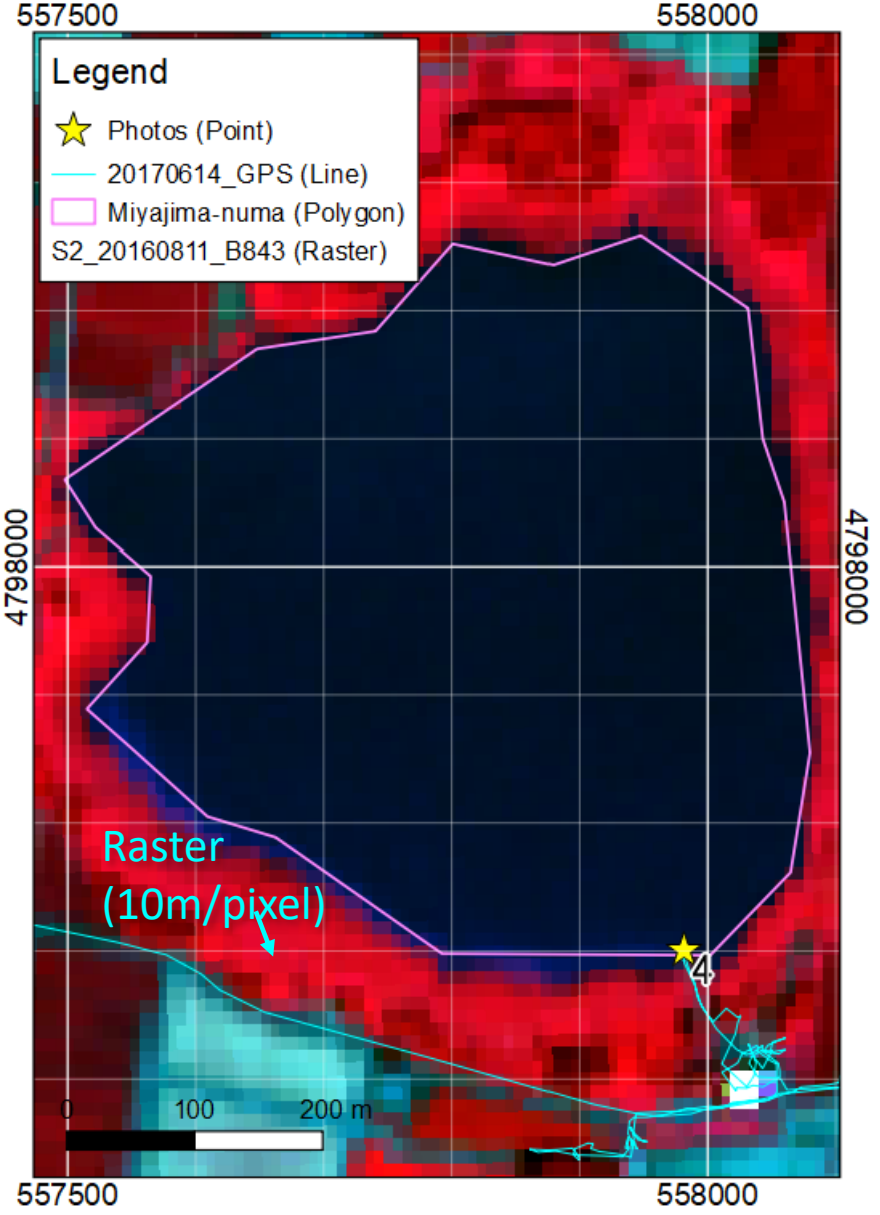


Thematic map (ex. Vegetation map)

Topographic map

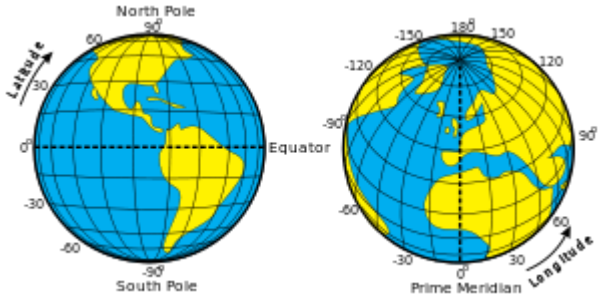
Basic knowledge of GIS (Vector vs Raster)



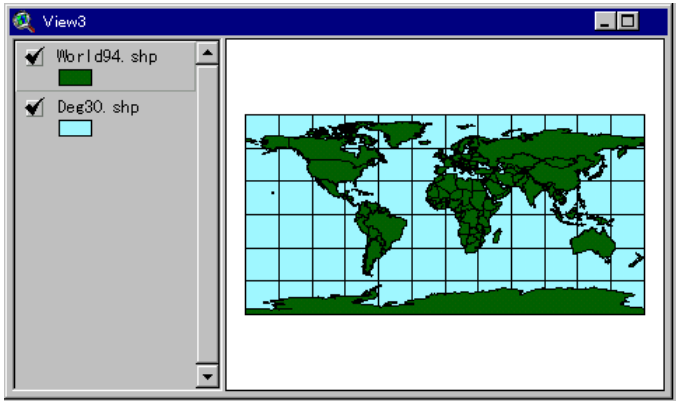


Projection

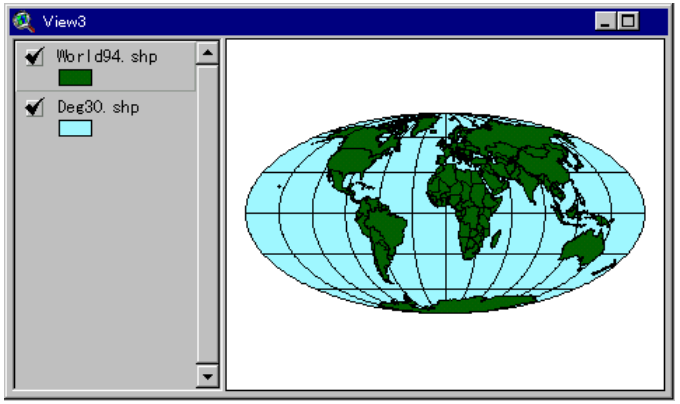
- Projection is performed in order to deal with the various spatial data on the spherical plane such as earth.
  - ◆Area
  - ◆Shape
  - ◆Distance
  - ◆Direction



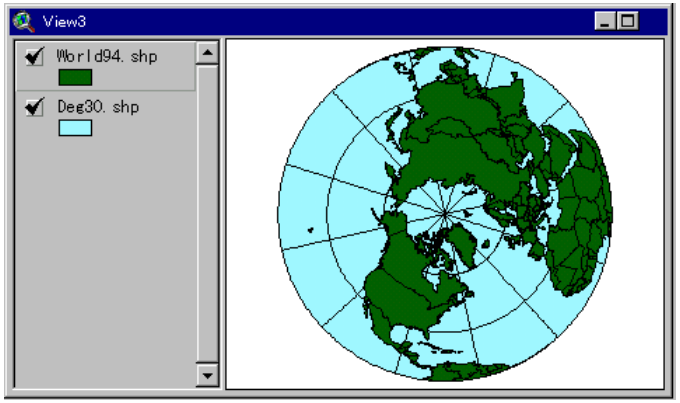
Display cases with a variety of projection method



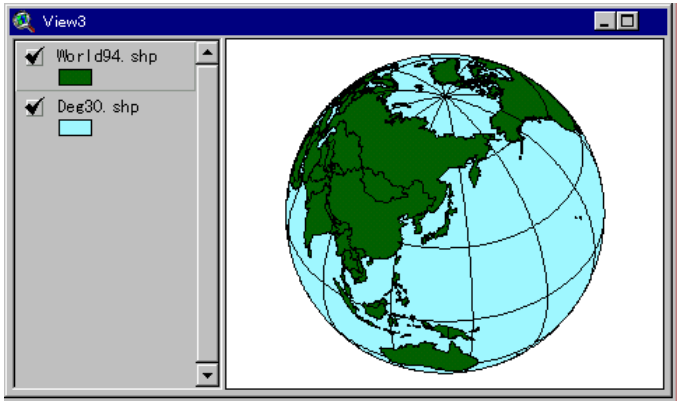
Geographic
-Display X, Y as the latitude and longitude-



Moruwaide projection
Area ratio is correct, but distortion is large near pole



Lambert azimuthal equal-area projection
Direction from the center of the map and the area be displayed properly.

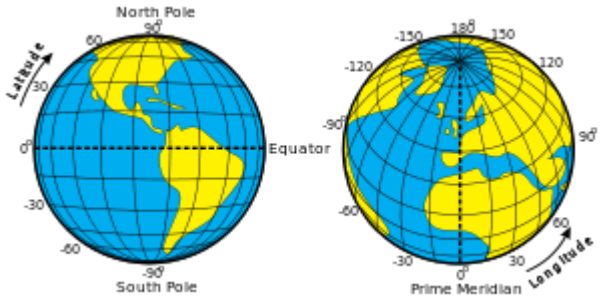


Orthographic projection
Match the image viewed from a distance the Earth

Popular coordinate systems

1. Geographic coordinate system

   By latitude and longitude coordinates.
   Suitable to display at the national level

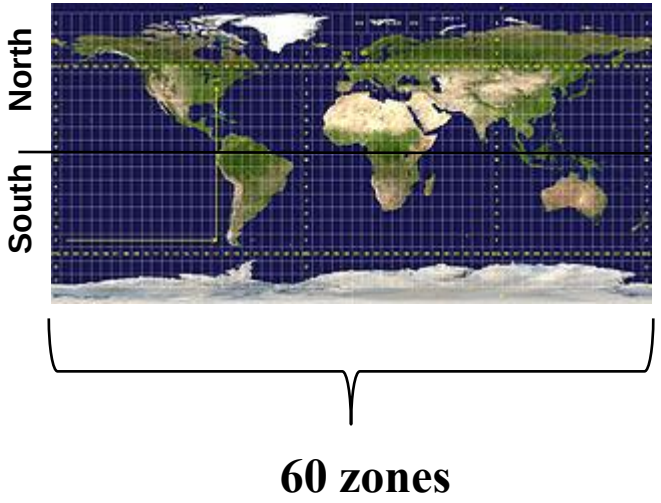


2. Universal Transverse Mercator (UTM)

   Projected coordinate system:

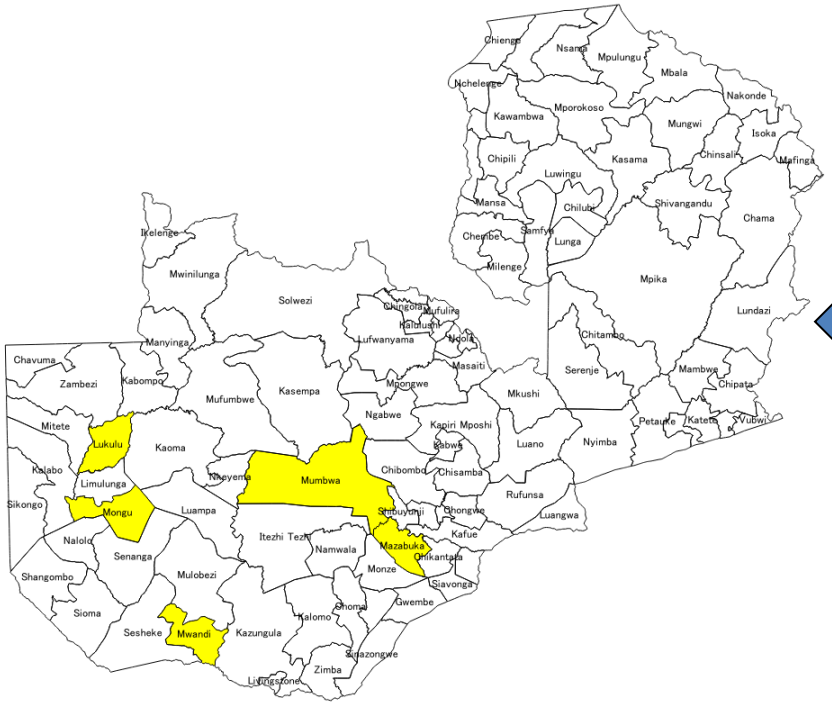
   The UTM projection and grid were adopted by the U.S. Army in 1947 for designating rectangular coordinates on large-scale maps for the entire world.

   https://topomaps.usgs.gov/drg/mercproj/

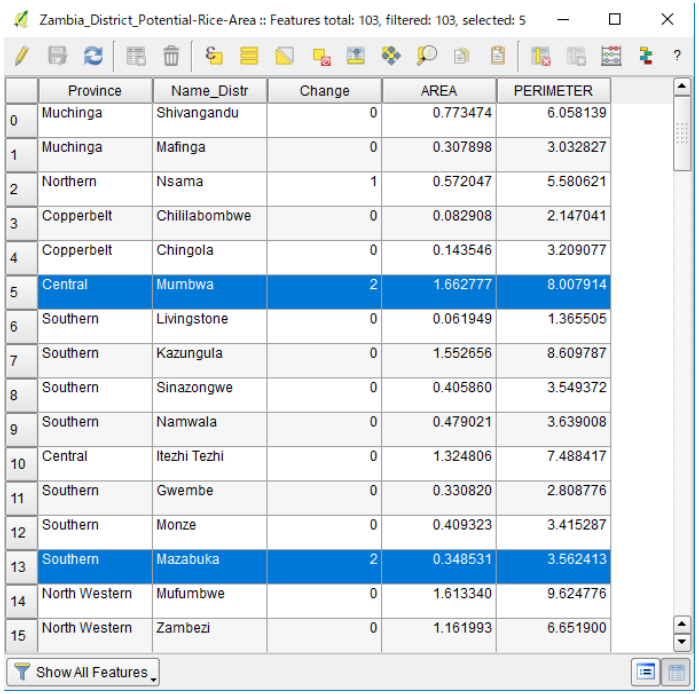


UTM unite is suitable for large scale than provincial level.

View map and database relationships



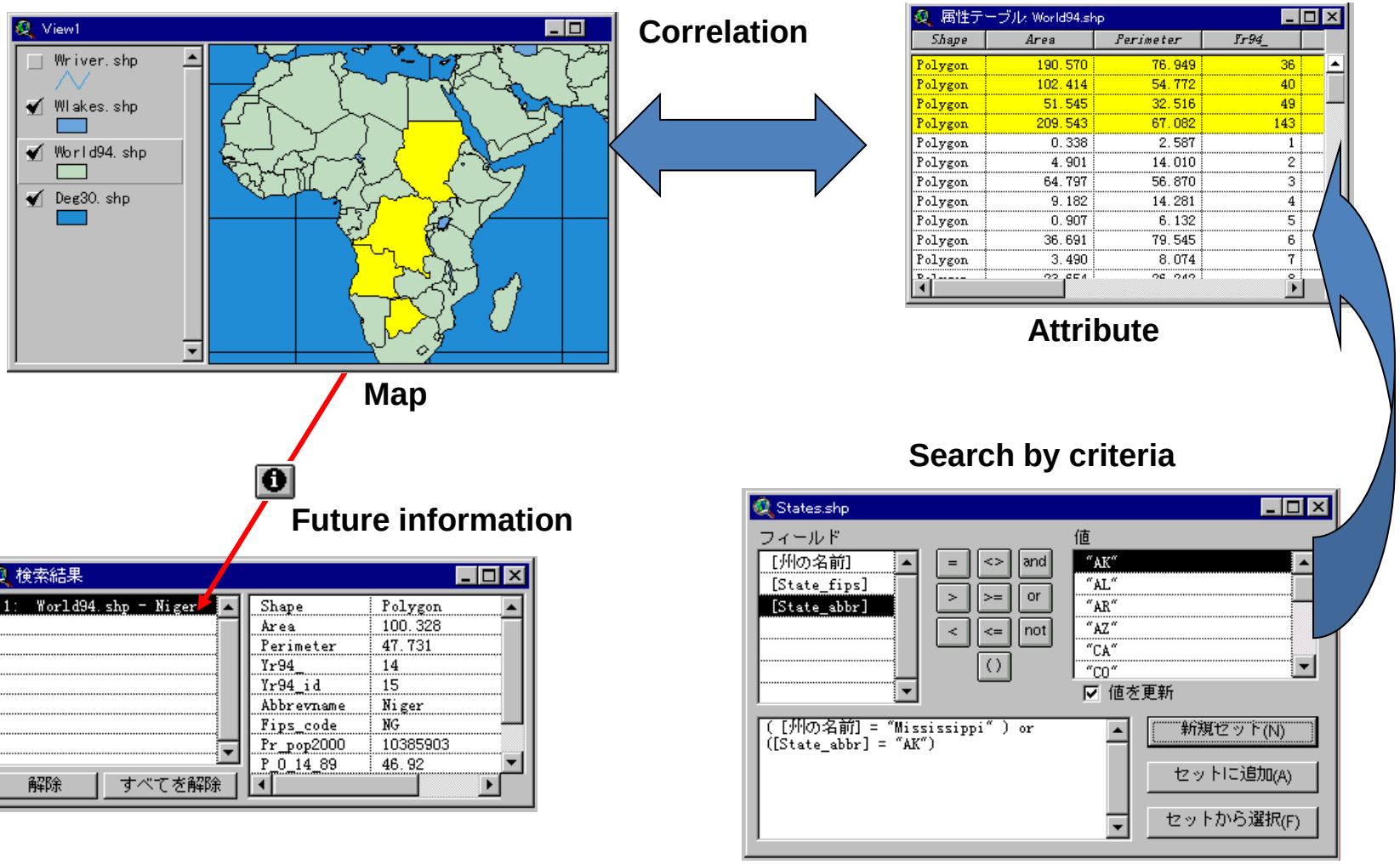
Correlation



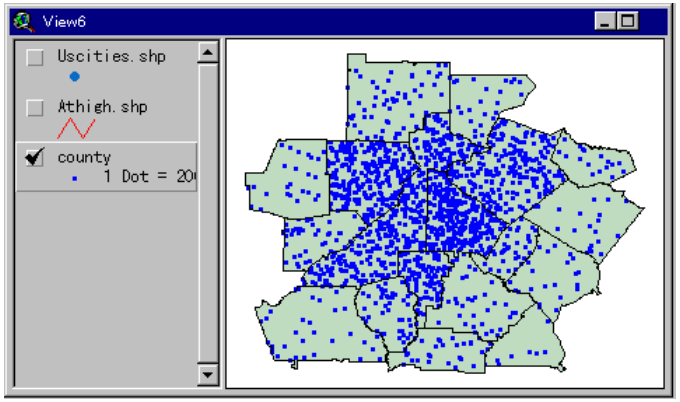
	Province	Name_Distr	Change	AREA	PERIMETER
0	Muchinga	Shivangandu	0	0.773474	6.058139
1	Muchinga	Mafinga	0	0.307898	3.032827
2	Northern	Nsama	1	0.572047	5.580621
3	Copperbelt	Chililabombwe	0	0.082908	2.147041
4	Copperbelt	Chingola	0	0.143546	3.209077
5	Central	Mumbwa	2	1.662777	8.007914
6	Southern	Livingstone	0	0.061949	1.365505
7	Southern	Kazungula	0	1.552656	8.609787
8	Southern	Sinazongwe	0	0.405860	3.549372
9	Southern	Namwala	0	0.479021	3.639008
10	Central	Itezhi Tezhi	0	1.324806	7.488417
11	Southern	Gwembe	0	0.330820	2.808776
12	Southern	Monze	0	0.409323	3.415287
13	Southern	Mazabuka	2	0.348531	3.562413
14	North Western	Mufumbwe	0	1.613340	9.624776
15	North Western	Zambezi	0	1.161993	6.651900

You can manage the display image of the map with modification of the attribute table information (database).

Attribute Search



Effective display of map



Dot Density map

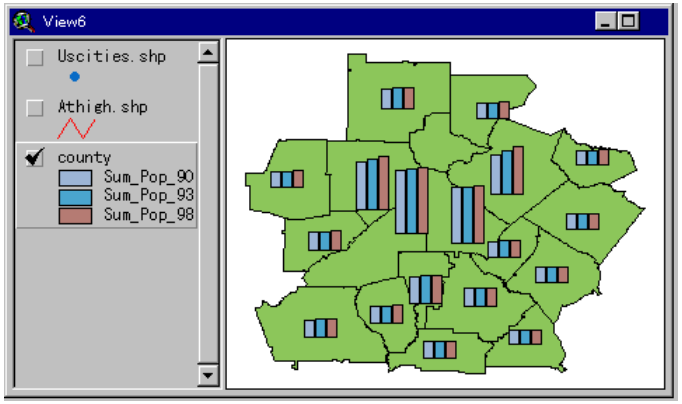
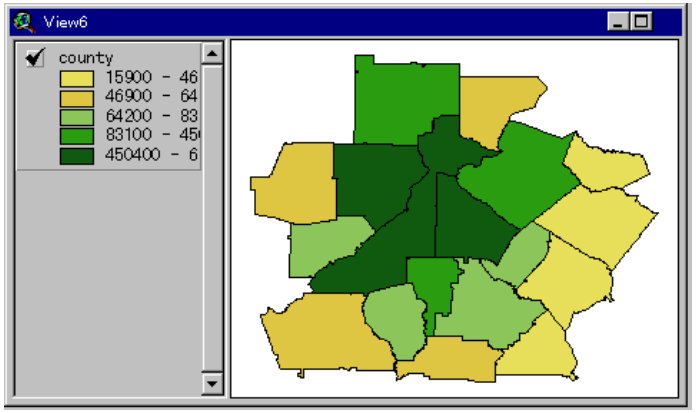
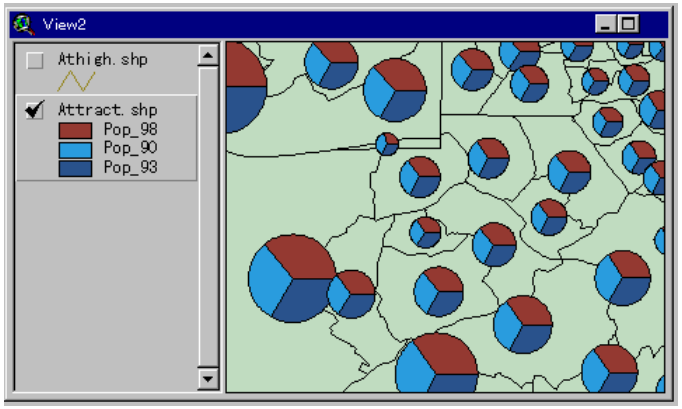


Chart map



Gradient map



Variable symbol map

1000 GIS apprications

1000 GIS Applications & Uses – How GIS Is Changing the World

1000 GIS Applications From Over 50 Industries - How GIS is Changing Our World

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Last Updated: Aug 30, 2017

Superpower Your Data with these 1000 GIS Applications & Uses

Struggling to find GIS projects for you or your students? Read the list.

Paralyzed when someone asks what GIS can really do? Read the list.

Looking to diversify your business and services? Read the list.

One year in the making, these are some of your favorite GIS applications you haven't heard of yet:

GIS student project ideas, GIS case studies, GIS projects, GIS uses – From over 50 industries, this jam-packed guide of 1000 GIS applications will open your mind to our amazing planet and its inter-connectivity.

1 Agriculture GIS Applications

1. **Precision Farming** – Harvesting more bushels per acre while spending less on fertilizer using precision farming and software. (How to win the farm using GIS)

2. **Disease Control** – Combating the spread of pests through by identifying critical intervention areas and efficient targeting control interventions.
3. **Swiss Alps Farming** – Cultivating south-facing slopes in the Swiss Alps using aspect data because it shelters from cold and dry winds which is critical to successful crop growth.
4. **3D Scanners for Biomass** – Measuring with laser accuracy 3D biomass using the FARO scanner.
5. **Real-time Crop Yields** – Shifting to real-time crop monitoring and targeted, automated responses with drones and precision watering sensors.
6. **Current Food Security** – Safeguarding food insecure populations by establishing underlying causes through satellite, mobile-collected and GIS data storage.
7. **Agri-tourism** – Navigating through crop mazes with GPS receivers in the developing field of agri-tourism.
8. **Plant Hardiness** – Defining distinct boundaries in which plants are capable of growing as defined by climatic conditions.
9. **Machine Performance** – Logging geographic coordinates of agricultural machinery in a farm field to better understand the spatially variability cost of field operation and machinery performance.
10. **Future Food Demand** – Diagnosing the future food demand and planning how to fulfill the needs of a growing and increasingly affluent population.
11. **Crop Assimilation Model** – Simulating soil, water and crop processes to better understand crop productivity and monitoring using the Crop Assimilation Model tool in GRASS GIS.
12. **Water Stress** – Balancing the ratio of local withdrawal (demand) over the available water (supply).
13. **Historical Agricultural Land** – Plotting the historical and future farming trends served.
14. **Hunger Map** – Raising awareness about global hunger and places that are in need.
15. **Agromap** – Breaking down primary food crops by sub-national administrative districts and aggregating by crop production, area harvested and crop yields.
16. **Crop Resilience to Climate Change** – Adapting to climate change and shifting weather patterns by promote the continued health of your fields.
17. **Crop Productivity** – Calibrating crop productivity using indices like Normalized Difference Vegetation Index (NDVI) to estimate global crop productivity. (Satellite Image Corporation

http://gisgeography.com/gis-applications-uses/