CHULA ENGINEERING
Innovation toward Sustainability | ACTNOW

OPTICAL REMOTE SENSING

Geospatial Programming

Modern Integrated Surveying Technologies 2024

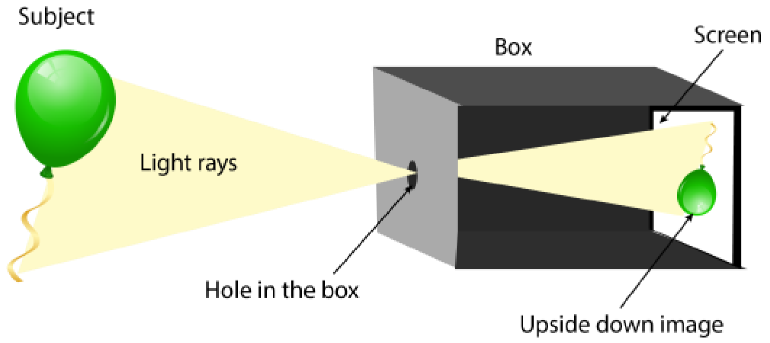
Thepchai Srinoi

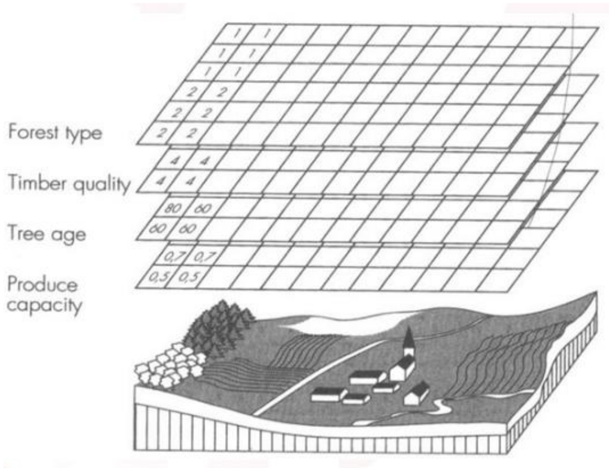
Master Degree Student and Teaching Assistant,

Department of Survey Engineering Chulalongkorn University

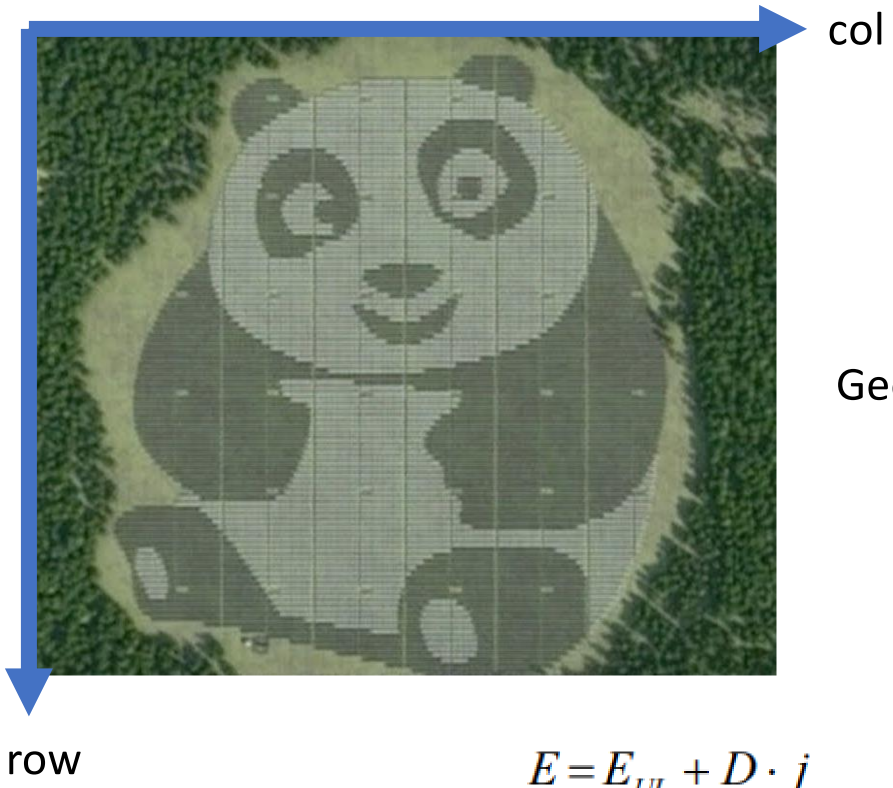
Welcome to Field based data model

A set of locations with properties
(absolute space, existent in itself)





Consists of a matrix of homogeneous grid cells
(usually square in shape)



toporec.bilw :

5

0.0

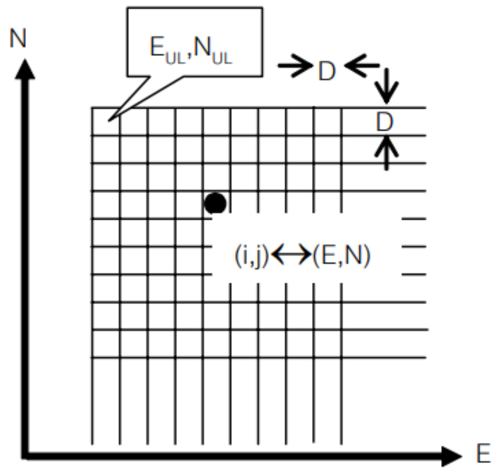
0.0

-5

728187.820000

1585853.890000

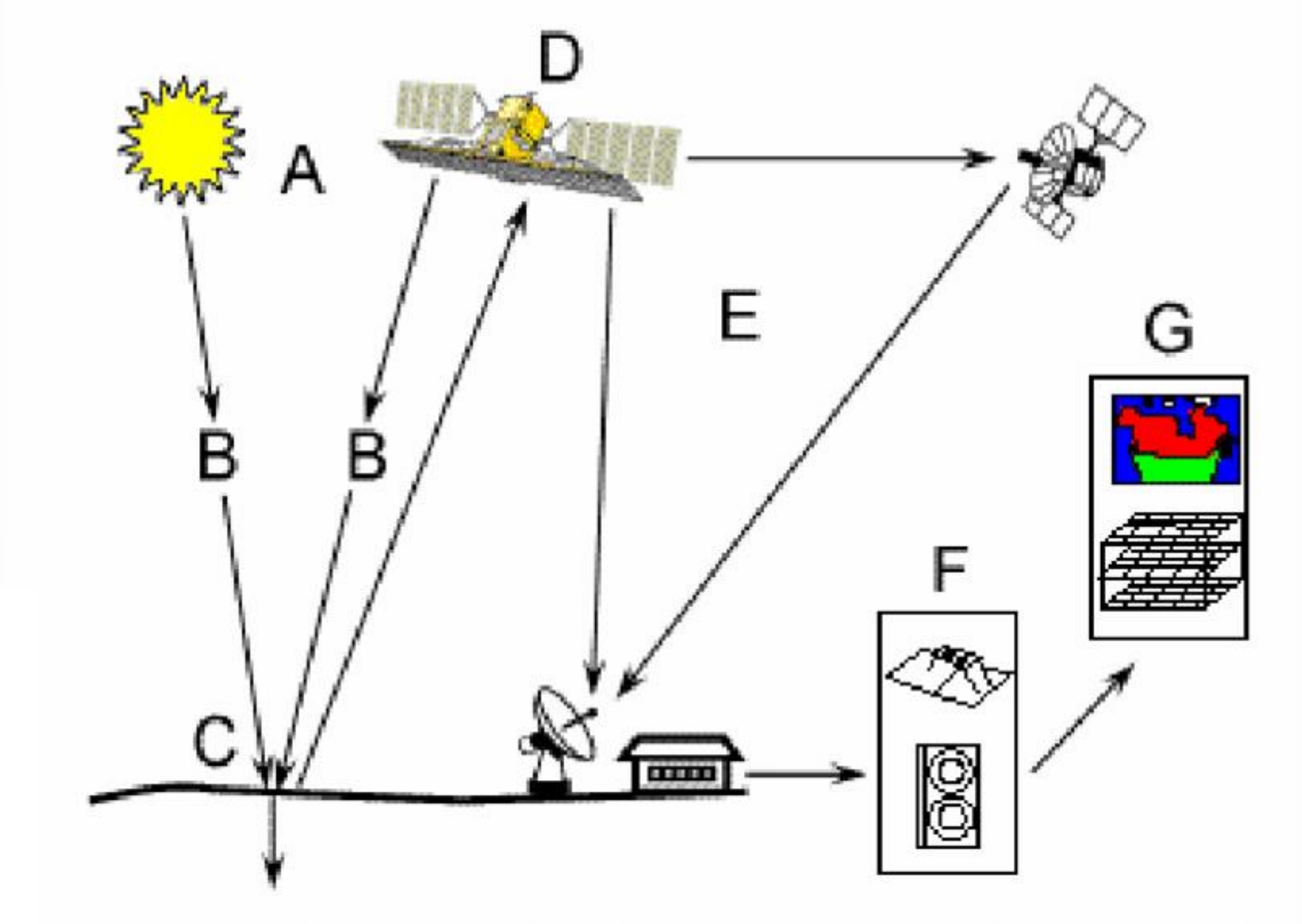
Georeferencing



$$E = E_{UL} + D \cdot j$$

$$N = N_{UL} - D \cdot i$$

Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information.

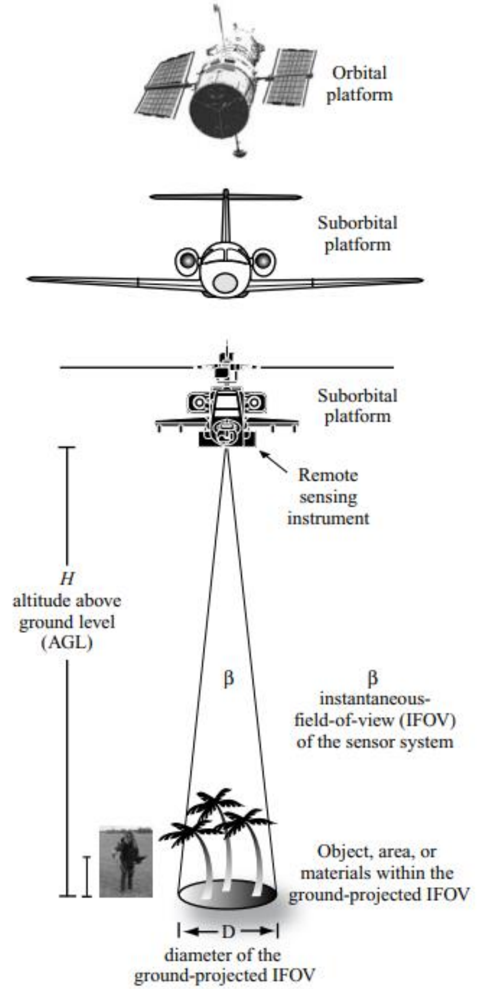


A	Energy Source of Illumination
B	Radiation and the Atmosphere
C	Interaction with the Target
D	Recording of Energy by the Sensor
E	Transmission, Reception and Processing
F	Interpretation and Analysis
G	Application

(modified from Walton, 1989)

The Process of Remote Sensing

Remote Sensing Measurement



The Remote Sensing Process

Statement of the Problem → **Data Collection** → **Data-to-Information Conversion** → **Information Presentation**

Statement of the Problem

- **Formulate Hypothesis** (if appropriate)
- **Select Appropriate Logic**
  - Inductive and/or
  - Deductive
  - Technological
- **Select Appropriate Model**
  - Deterministic
    - Empirical
    - Knowledge-based
    - Process-based
  - Stochastic

Data Collection

- ***In Situ* Measurements**
  - Field (e.g., *x,y,z* from GPS, biomass, reflectance)
  - Laboratory (e.g., reflectance, leaf area index)
- **Collateral Data**
  - Digital elevation models
  - Soil maps
  - Surficial geology maps
  - Population density, etc.
- **Remote Sensing**
  - Passive analog
    - Frame camera
    - Videography
  - Passive digital
    - Frame camera
    - Scanners
      - Multispectral
      - Hyperspectral
    - Linear and area arrays
      - Multispectral
      - Hyperspectral
  - Active
    - Microwave (RADAR)
    - Laser (LIDAR)
    - Acoustic (SONAR)

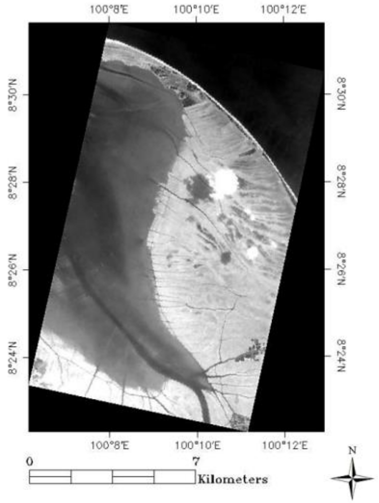
Data-to-Information Conversion

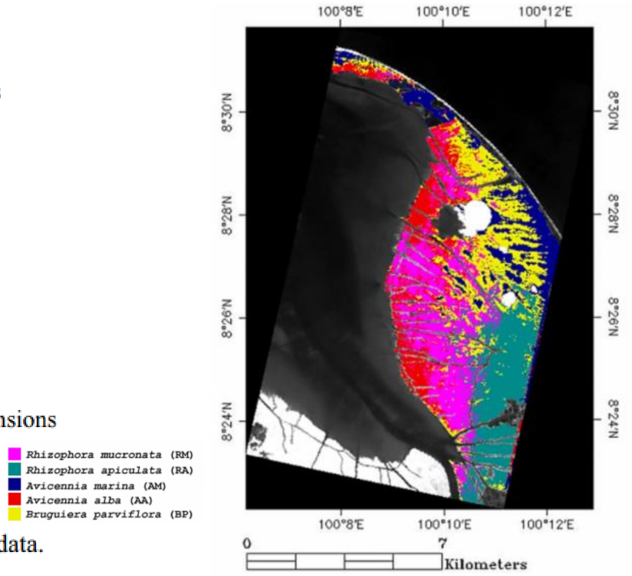
- **Analog (Visual) Image Processing**
  - Using the *Elements of Image Interpretation*
- **Digital Image Processing**
  - Preprocessing
    - Radiometric Correction
    - Geometric Correction
  - Enhancement
  - Photogrammetric analysis
  - Parametric, such as
    - Maximum likelihood
  - Nonparametric, such as
    - Artificial neural networks
  - Nonmetric, such as
    - Expert systems
    - Decision-tree classifiers
    - Machine learning
  - Hyperspectral analysis
  - Change detection
  - Modeling
    - Spatial modeling using GIS data
    - Scene modeling
  - Scientific geovisualization
    - 1, 2, 3, and *n* dimensions
- **Hypothesis Testing**
  - Accept or reject hypothesis

Information Presentation

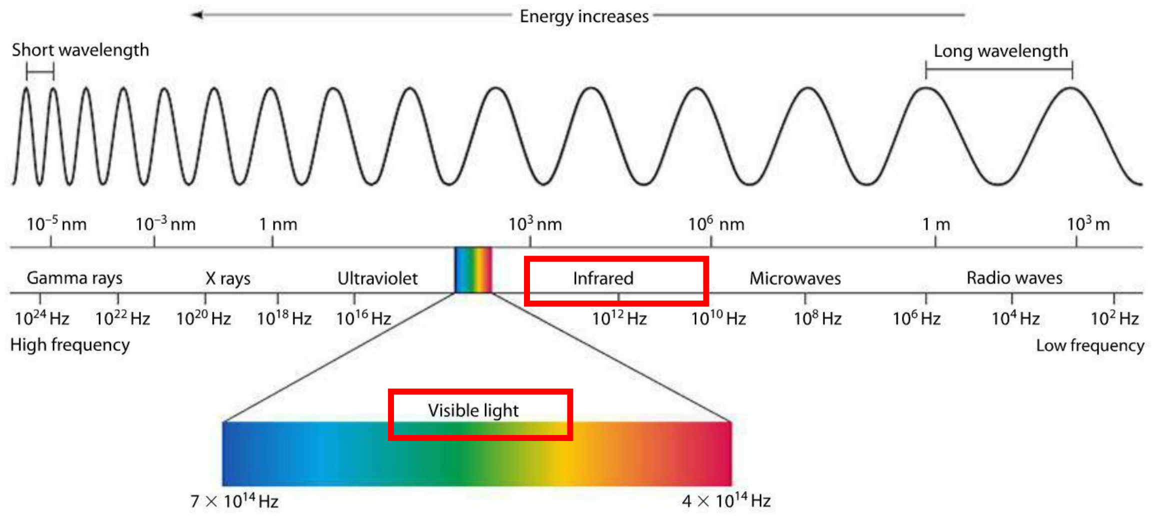
- **Image Metadata**
  - Sources
  - Processing lineage
- **Accuracy Assessment**
  - Geometric
  - Radiometric
  - Thematic
  - Change detection
- **Analog and Digital**
  - Images
    - Unrectified
    - Orthoimages
  - Orthophotomaps
  - Thematic maps
  - GIS databases
  - Animations
  - Simulations
- **Statistics**
  - Univariate
  - Multivariate
- **Graphs**
  - 1, 2, and 3 dimensions

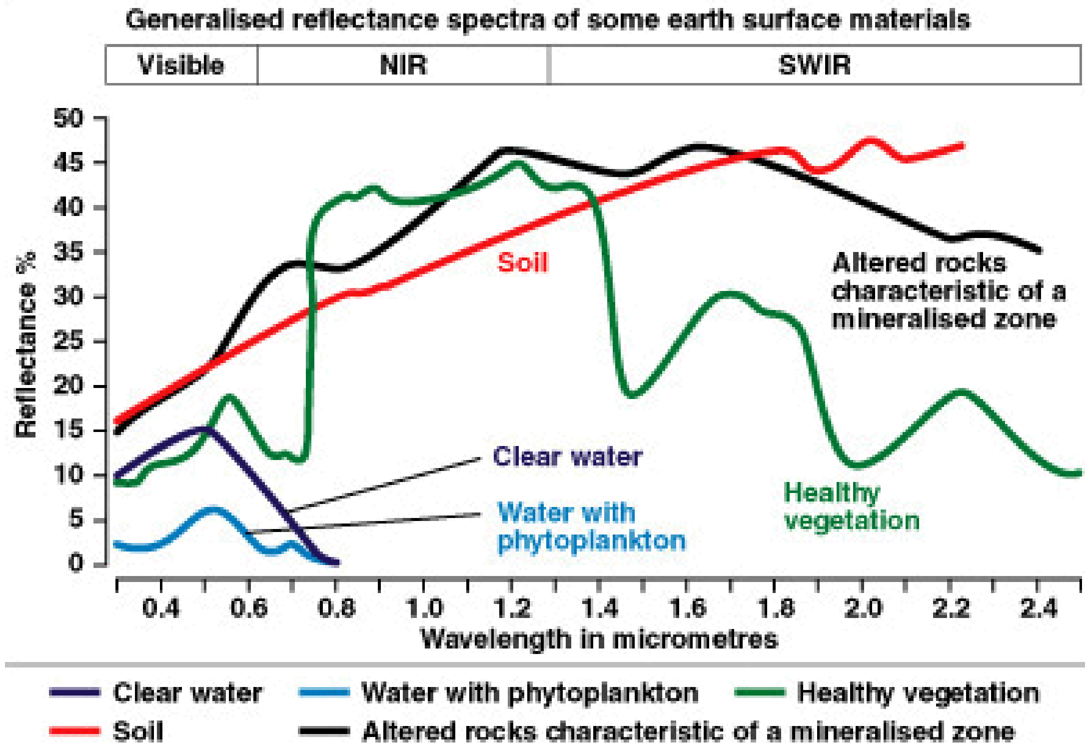
Figure 5 Scientists generally use the remote sensing process when extracting information from remotely sensed data.





Optical remote sensing makes use of visible, near infrared and short-wave infrared sensors to form images of the earth's surface by detecting the solar radiation reflected from targets on the ground.





The reflectance characteristics of earth surface features expressed as the ratio of energy reflected by the surface to the energy incident on the surface, measured as a function of wavelength is called spectral reflectance.

Optical Remote Sensing : Example

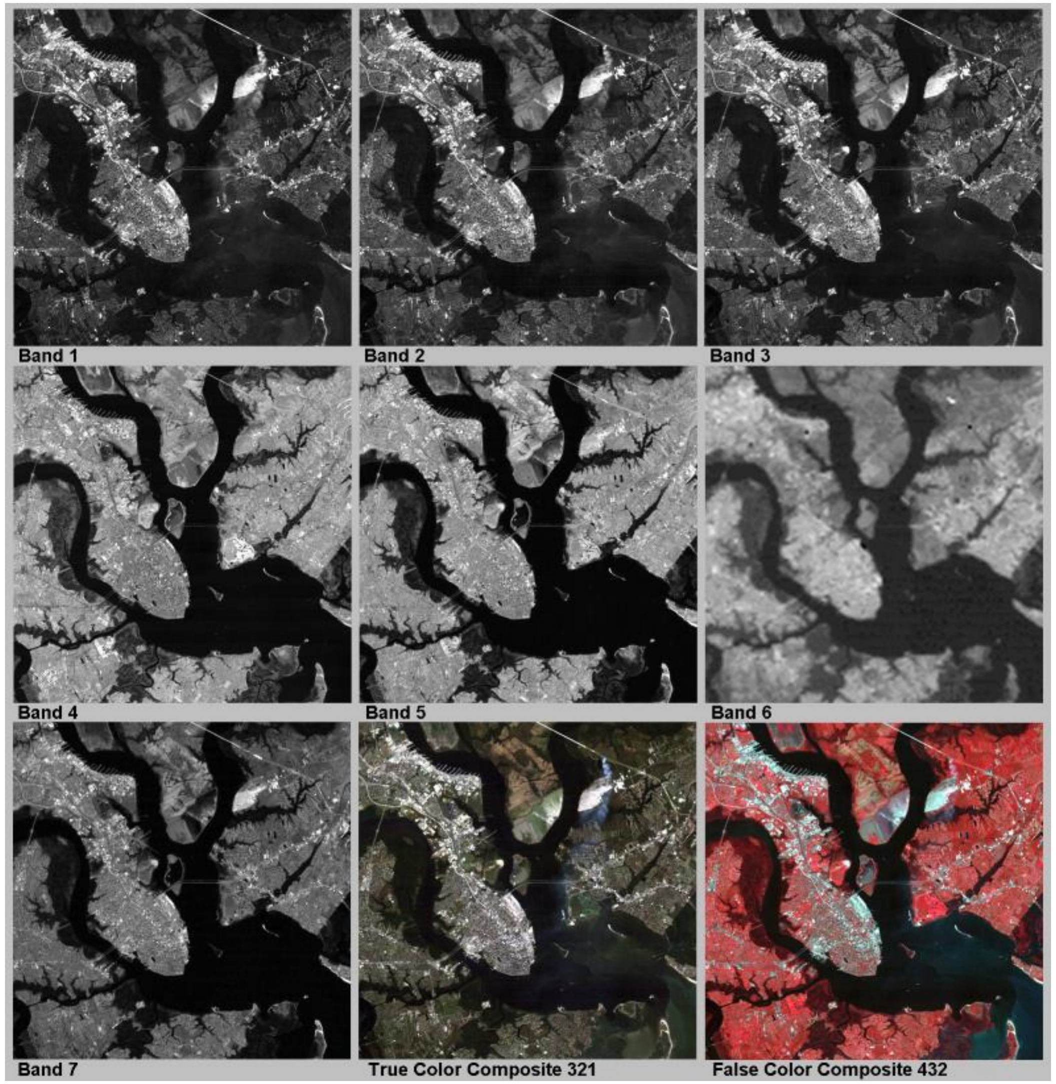
LANDSAT 4

Satellite Orbit Facts

- Orbited the Earth in a sun-synchronous, near-polar orbit (98.2 degrees inclination)
- Reached an altitude of 705 km
- Circled the Earth every 99 minutes
- Had a 16-day repeat cycle with an equatorial crossing time of 9:45 a.m. +/- 15 min.
- Acquired on the Worldwide Reference System-2 (WRS-2) path/row system, with swath overlap (sidelap) varying from 7 percent at the Equator to a maximum of approximately 85 percent at extreme latitudes.

Thematic Mapper (TM)

Band No.	Wavelength Interval (μm)	Spectral Response	Resolution (m)
1	0.45 - 0.52	Blue Green	30
2	0.52 - 0.60	Green	30
3	0.63 - 0.69	Red	30
4	0.76 - 0.90	Near IR	30
5	1.55 - 1.75	Mid-IR	30
6	10.40 - 12.50	Thermal IR	120
7	2.08 - 2.35	Mid-IR	30



Spectral Reflectance of the plant

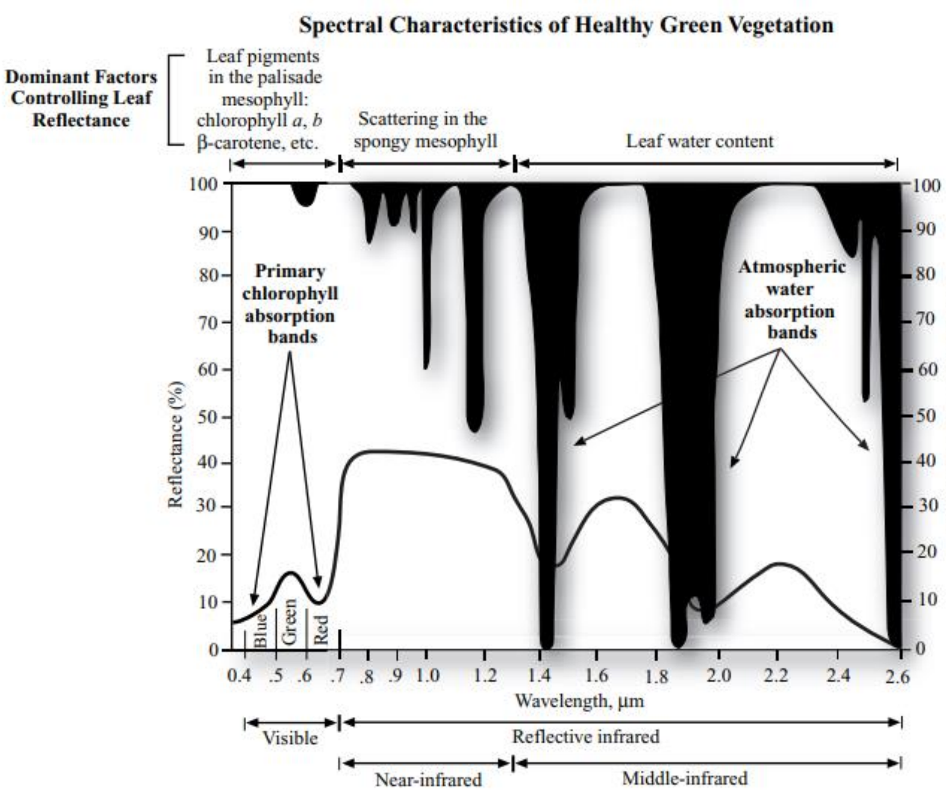
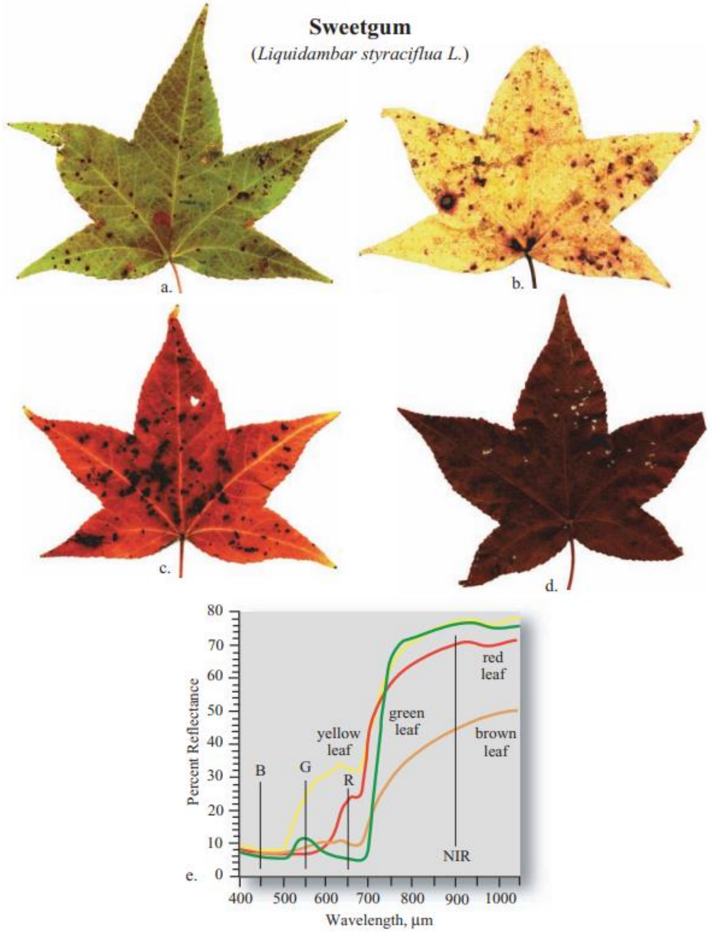


Figure 1 Spectral reflectance characteristics of healthy green vegetation for the wavelength interval 0.4 – 2.6 µm. The dominant factors controlling leaf reflectance are the various leaf pigments in the palisade mesophyll (e.g., chlorophyll *a* and *b*, and β-carotene), the scattering of near-infrared energy in the spongy mesophyll, and the amount of water in the plant. The primary chlorophyll absorption bands occur at 0.43 – 0.45 µm and 0.65 – 0.66 µm in the visible region. The primary water absorption bands occur at 0.97, 1.19, 1.45, 1.94, and 2.7 µm.



Color Plate 1 a) Photosynthesizing green Sweetgum leaf (*Liquidambar styraciflua* L.) obtained from a tree on November 11, 1998. b-c) Senescing yellow and red Sweetgum leaves obtained from the tree. d) Senesced Sweetgum leaf that was on the ground. e) Spectroradiometer percent reflectance measurements over the wavelength interval 400 – 1050 nm.

field spectroscopy

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Spectral Reflectance of the water

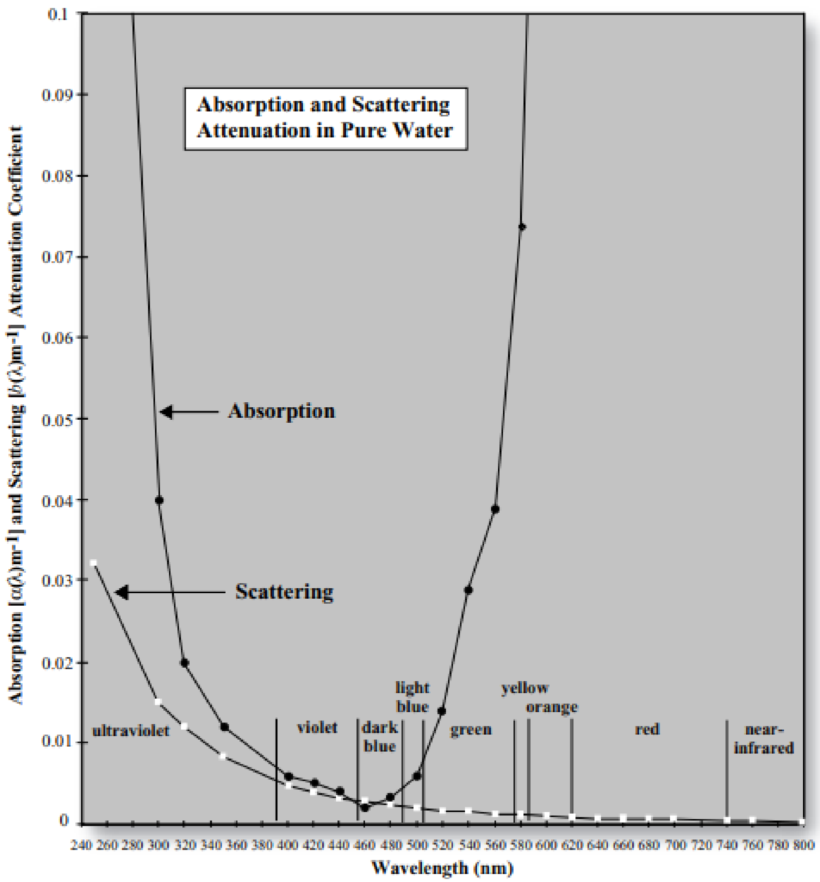
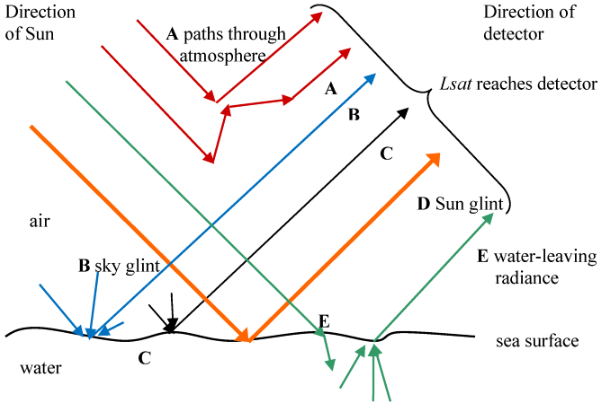
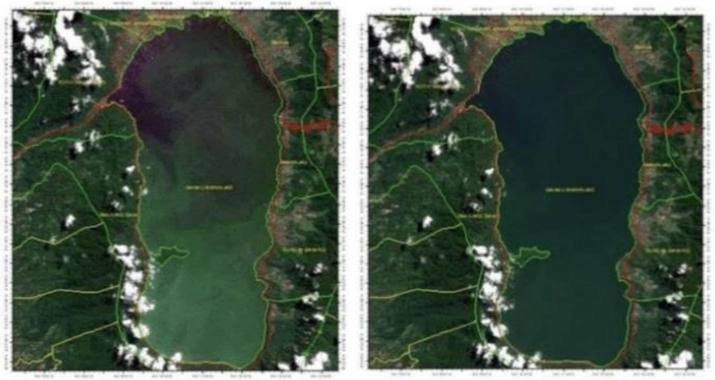


Figure 3 Absorption and scattering of light in pure water. Molecular water absorption dominates in the ultraviolet (< 400 nm) and in the yellow through the near-infrared portion of the spectrum (> 580 nm). Almost all of the incident near- and middle-infrared (740 – 2500 nm) radiant flux entering a pure water body is absorbed with negligible scattering taking place. This is why water is so dark on black-and-white infrared or color-infrared film. Scattering in the water column is especially important in the violet, dark blue, and light blue portions of the spectrum (400 – 500 nm). This is the reason water appears blue to our eyes. These data were derived from a variety of sources by Bukata et al. (1995). The graph truncates the absorption attenuation information in the ultraviolet and in the yellow through near-infrared regions because the attenuation is so great. Refer to Table 1 for absorption attenuation information in these regions.

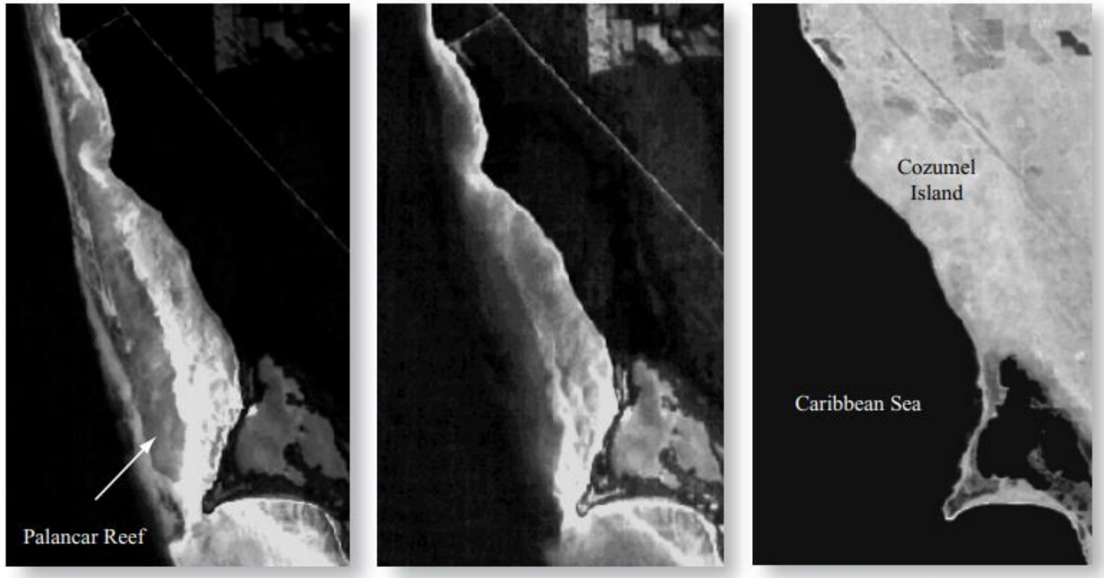




Original Data

Sun Glint Correction

Palancar Reef on Cozumel Island, Quintana Roo, Mexico



a. SPOT Band 1 (0.50 - 0.59 µm).

b. SPOT Band 2 (0.61 - 0.68 µm).

c. SPOT Band 3 (0.791 - 0.89 µm).

Spectral Reflectance of the urban material

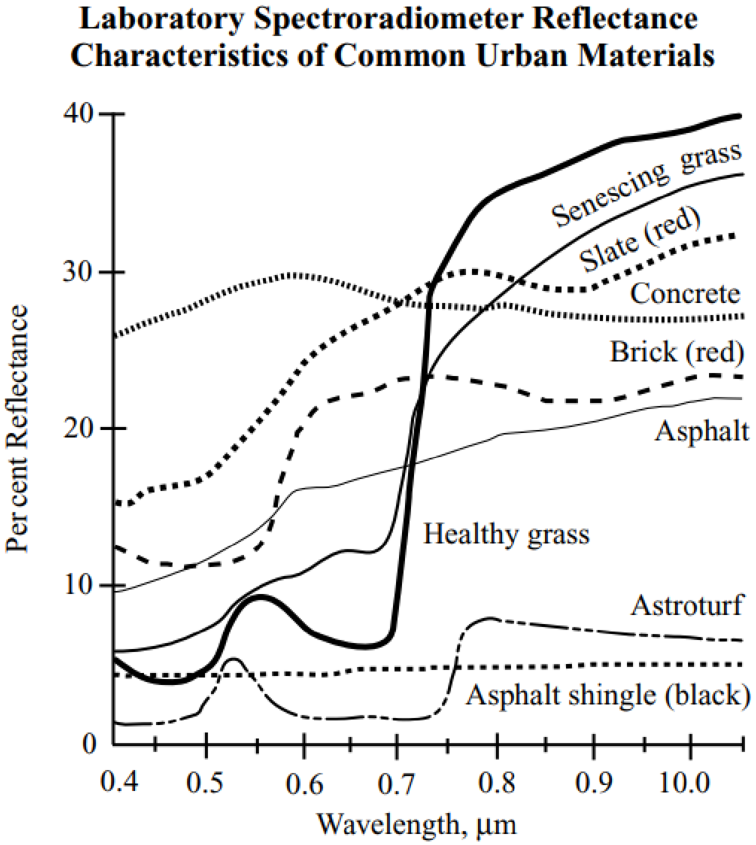
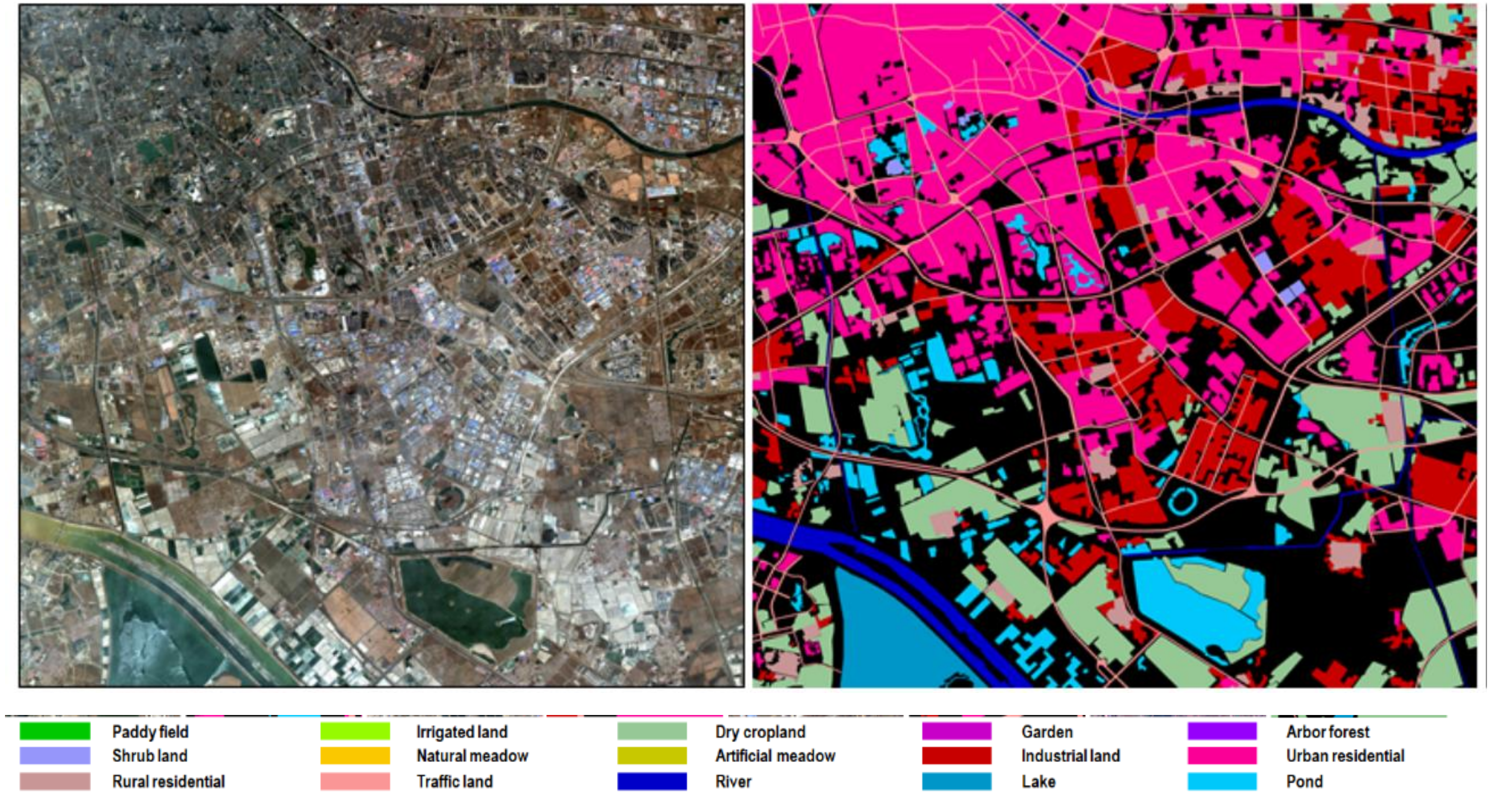
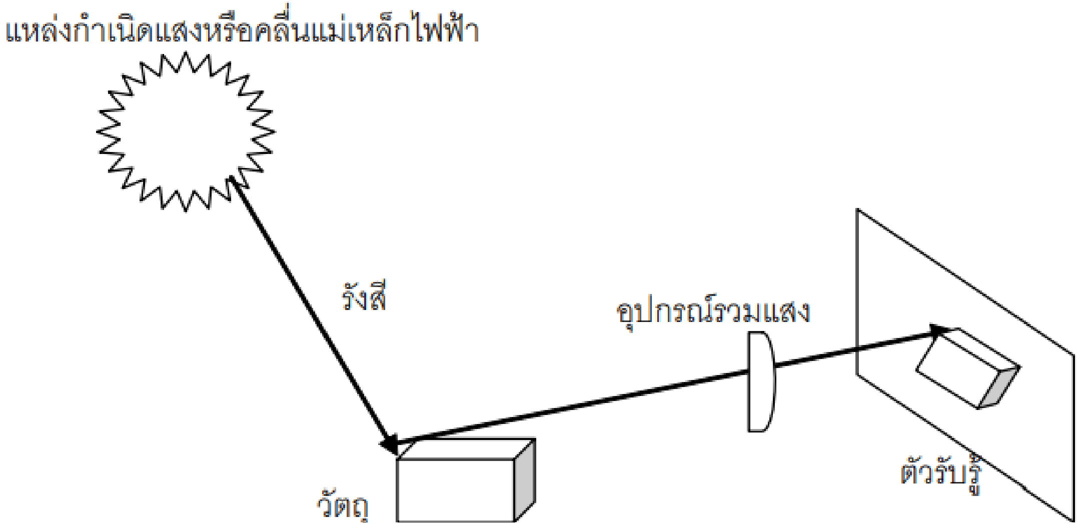


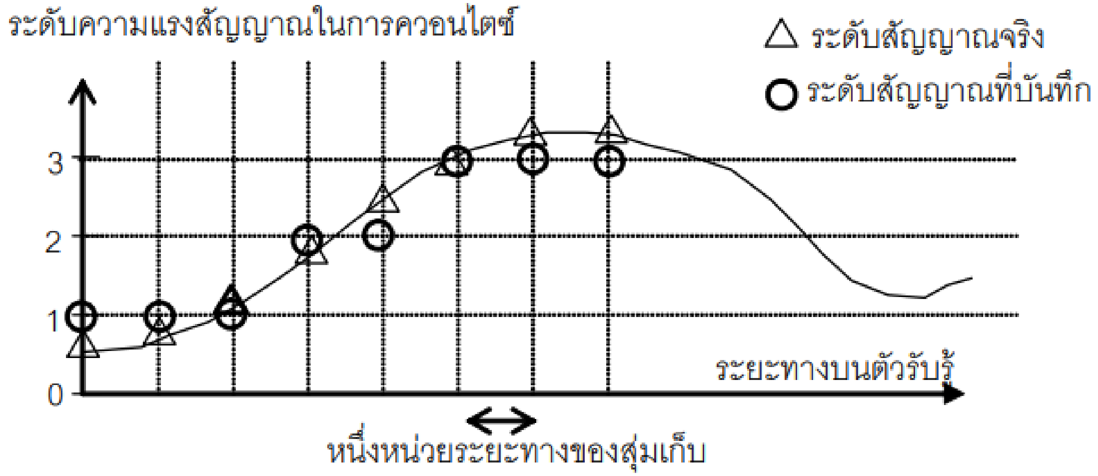
Figure 6 Percent reflectance curves for common materials found in urban environments. The reflectance spectra were obtained in a controlled laboratory environment using a GER 1500 spectroradiometer.



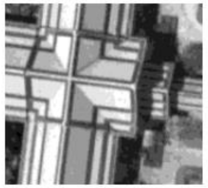
https://captain-whu.github.io/HPS-Net/

Remote Sensing : Digitization

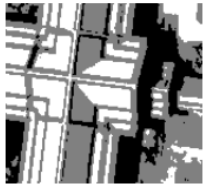




ก) ความละเอียดจุดภาพ 1 เมตร ข) ความละเอียดจุดภาพ 2 เมตร ค) ความละเอียดจุดภาพ 4 เมตร ง) ความละเอียดจุดภาพ 8 เมตร

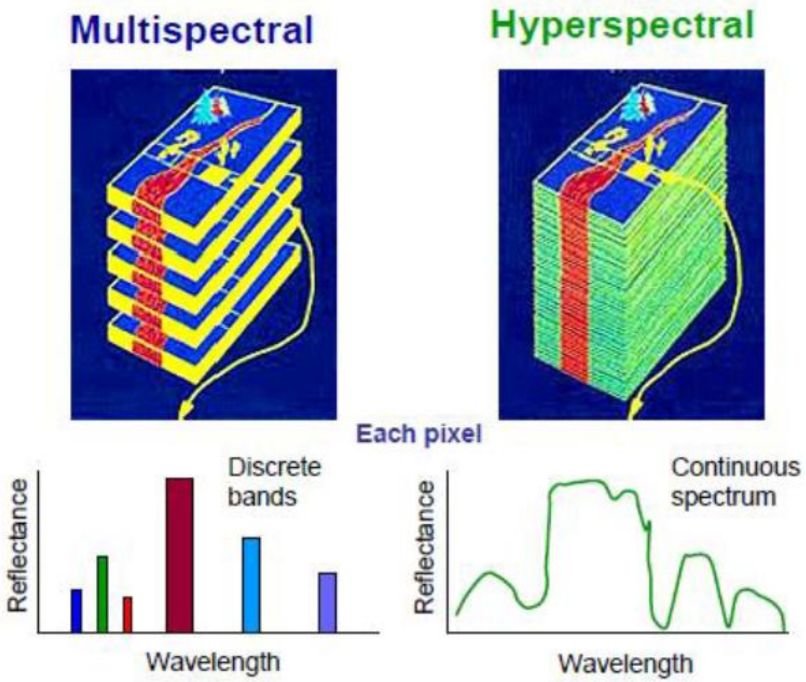


ค) ความลึกของเรดิโอเมตรี 4 บิท (16 ระดับ)



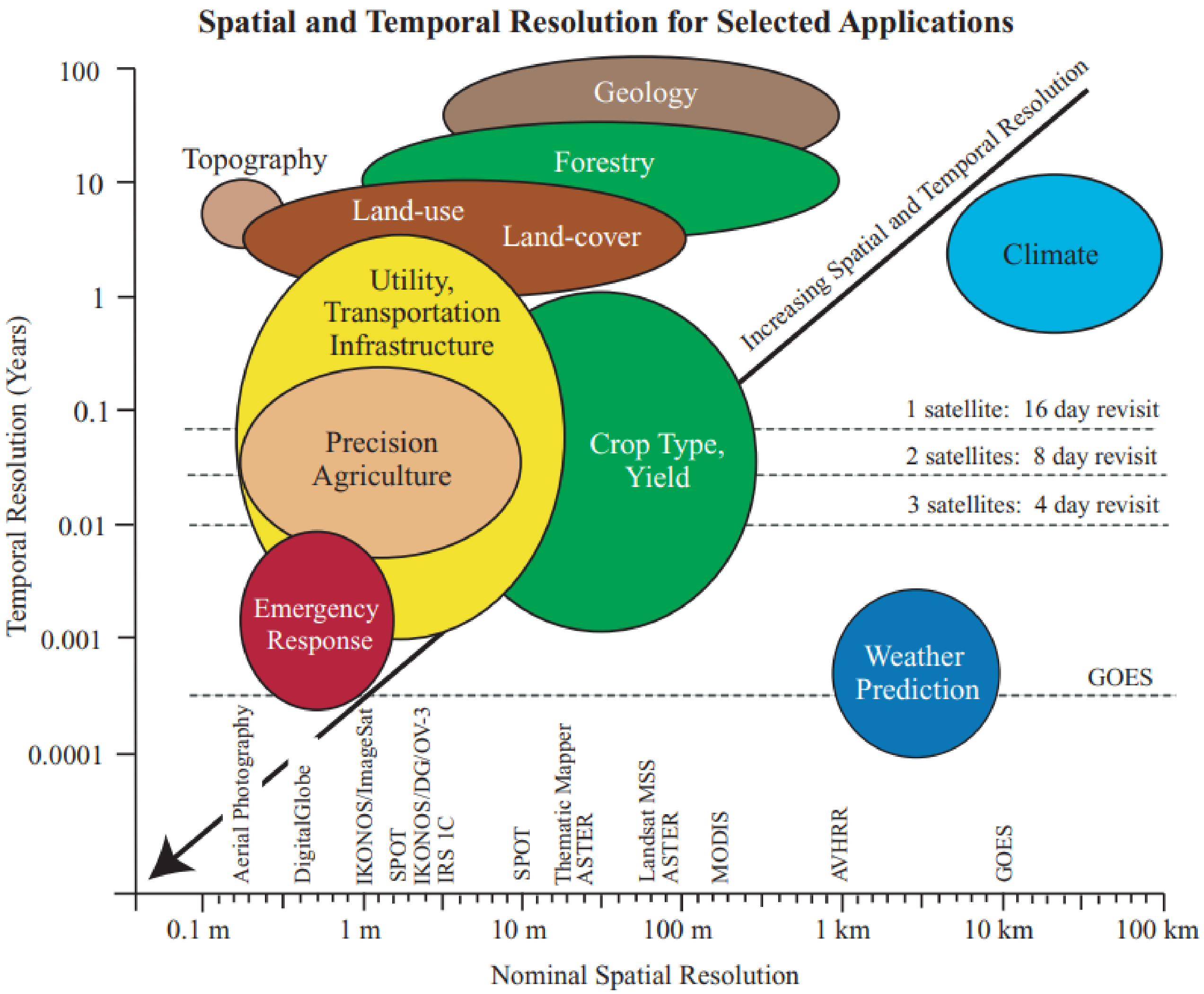
ง) ความลึกของเรดิโอเมตรี 2 บิท (4 ระดับ)

จ) ความลึกของเรดิโอเมตรี 1 บิท (2 ระดับ)



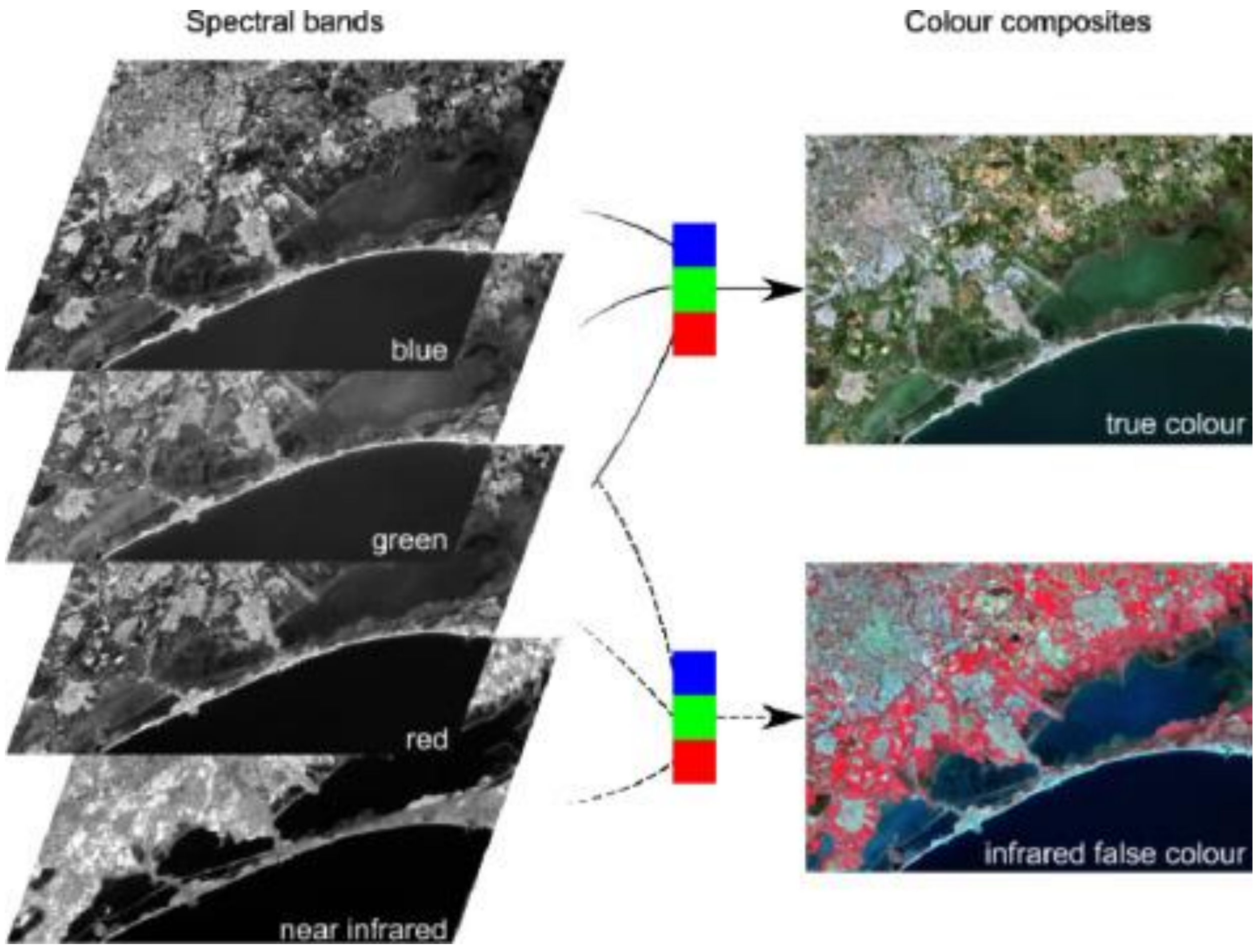
Remote Sensing : Resolution

Remote Sensing Systems	Resolution: Spectral: Blue	Green	Red	Near-infrared	Middle-infrared (SWIR)	Thermal infrared	Microwave	Spatial (m)	Temporal (days)
Suborbital Sensors									
Panchromatic film (black & white)		0.5 — 0.7 µm						Variable	Variable
Color film	0.4 — 0.7 µm							Variable	Variable
Color-infrared film		0.5 — 0.9 µm						Variable	Variable
Digital Frame Cameras (CCD)	1	1	1	1				0.25 – 5	Variable
CASI - 1500	0.40 — 288 bands — 1.0 µm							variable	Variable
AVIRIS - Airborne Visible Infrared Imaging Spectrometer	0.40 — 224 bands — 2.5 µm							2.5 or 20	Variable
Intermap Star-3*i* X-band radar							1	Variable	Variable
Satellite Sensors									
NOAA-9 AVHRR LAC			1	1		3		1100	14.5/day
NOAA- K, L, M			1	1	2	2		1100	14.5/day
Landsat Multispectral Scanner (MSS)		1	1	2				79	16 – 18
Landsat 4 and 5 Thematic Mappers (TM)	1	1	1	1	2	1		30 and 120	16
Landsat 7 Enhanced TM (ETM^+) — Multispectral	1	1	1	1	2	1		30 and 60	16
— Panchromatic		0.52 — 0.9 µm						15	16
SPOT 4 HRV — Multispectral		1	1	1				20	Pointable
— Panchromatic		0.51 — 0.73 µm						10	Pointable
GOES Series (East and West)		0.52 — 0.72 µm				4		700	0.5/hr
European Remote Sensing Satellite (ERS-1 and 2)	VV polarization C-band (5.3 GHz)						1	26 – 28	—
Canadian RADARSAT (several modes)	HH polarization C-band (5.3 GHz)						1	9 – 100	1 – 6 days
Shuttle Imaging Radar (SIR-C)							3	30	Variable
Sea-Viewing Wide Field-of-View Sensor (SeaWiFS)	3	2	1	2				1130	1
MODIS - Moderate Resolution Imaging Spectrometer	0.405 — 36 bands — 14.385 µm							250, 500, 1000	1 – 2
ASTER - Advanced Spaceborne Thermal Emission and Reflection Radiometer		0.52 — 3 bands — 0.86 µm						15	5
					1.6 — 6 bands — 2.43 µm			30	16
					8.12 — 5 bands — 11.6 µm			90	16
MISR - Multiangle Imaging SpectroRadiometer	Nine CCD cameras in four bands (440, 550, 670, 860 nm)							275 and 1100	1 – 2
NASA Topex/Poseidon — TOPEX radar altimeter	(18, 21, 37 GHz)							315,000	10
— POSEIDON single-frequency radiometer	(13.65 GHz)								
Space Imaging IKONOS — Multispectral	1	1	1	1				4	Pointable
— Panchromatic	0.45 — 0.9 µm							1	
Digital Globe QuickBird — Multispectral	1	1	1	1				2.44	Pointable
— Panchromatic	0.45 — 0.9 µm							0.61	

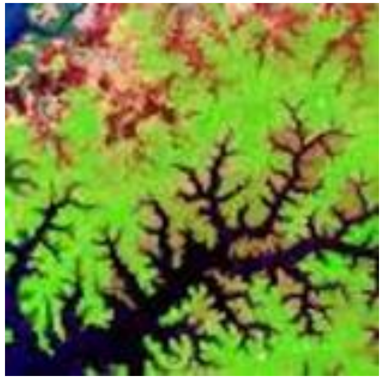


Remote Sensing : Color Composite

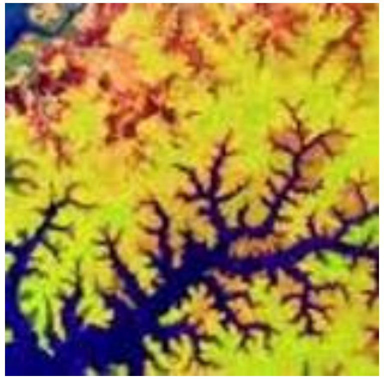
https://custom-scripts.sentinel-hub.com/custom-scripts/sentinel-2/composites/



RGB (8,4,3)



RGB (12,8,4)



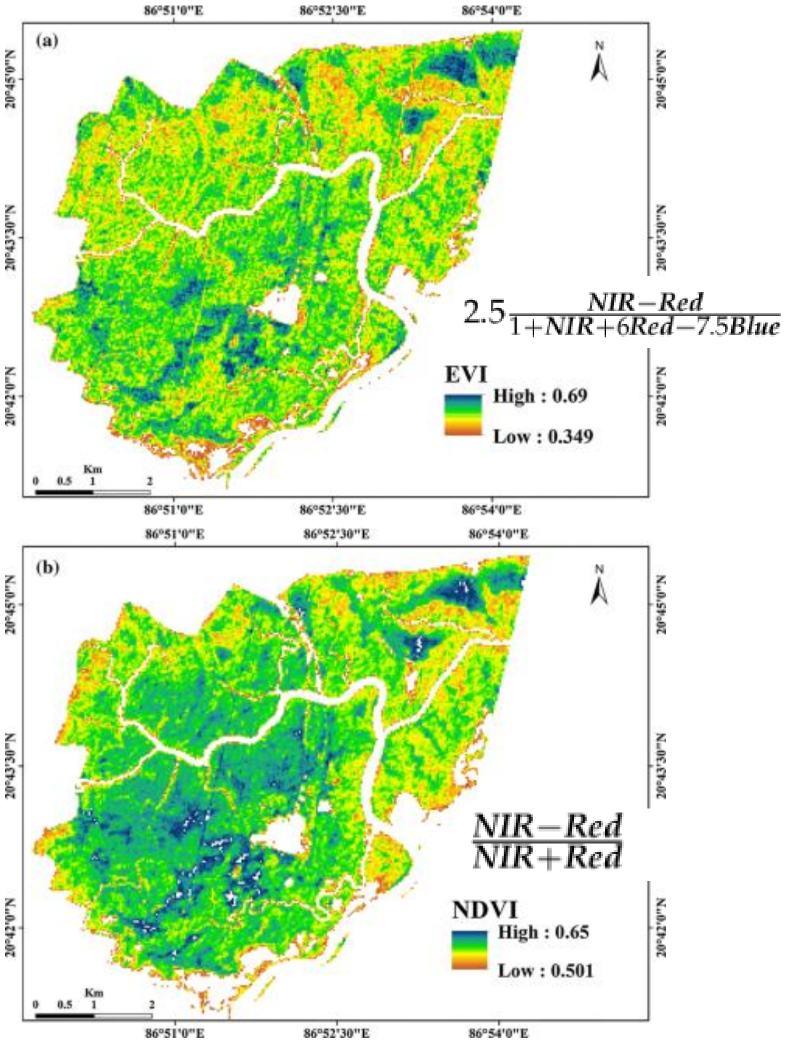
RGB (11,8,2)

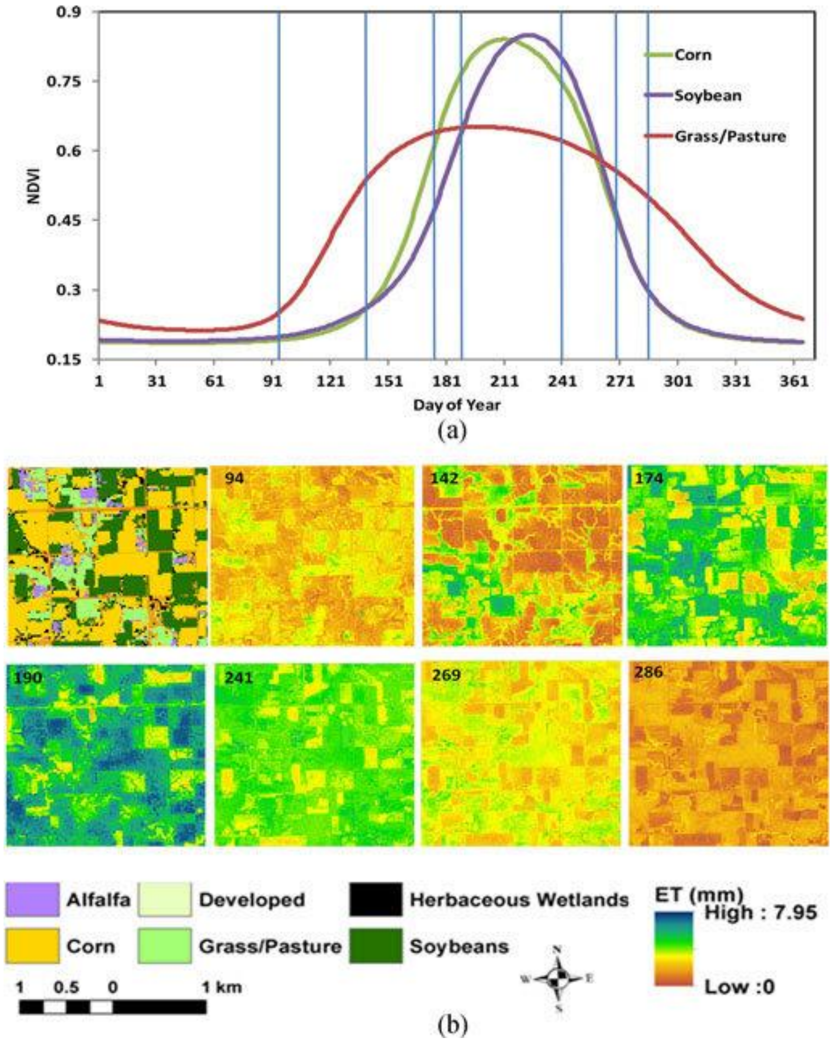
RGB (12,11,2)

Remote Sensing : Band Indices

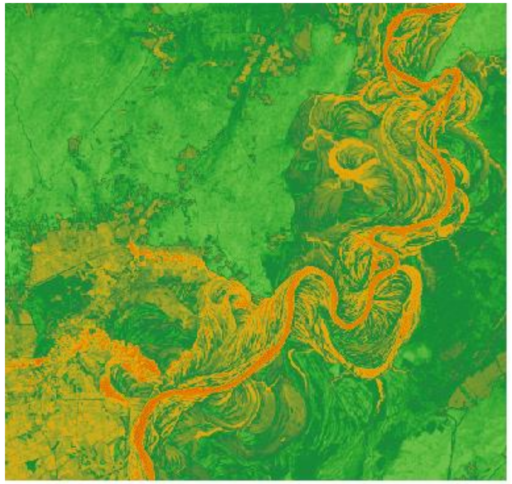
$$EVI = 2.5\frac{NIR - Red}{1 + NIR + 6Red - 7.5Blue}$$

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

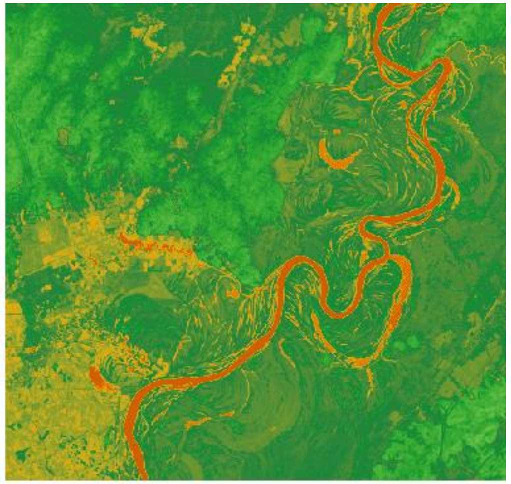




$$NDWI = \frac{Green - NIR}{Green + NIR}$$



NDWI in 2013

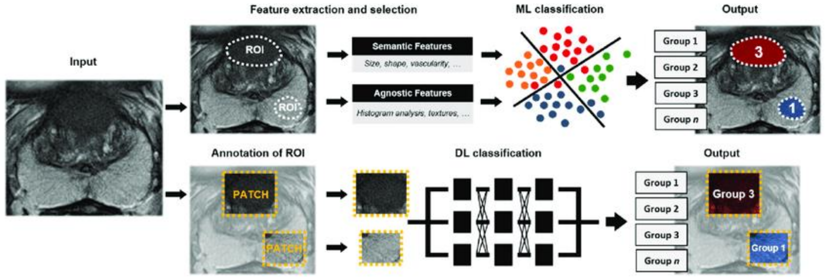


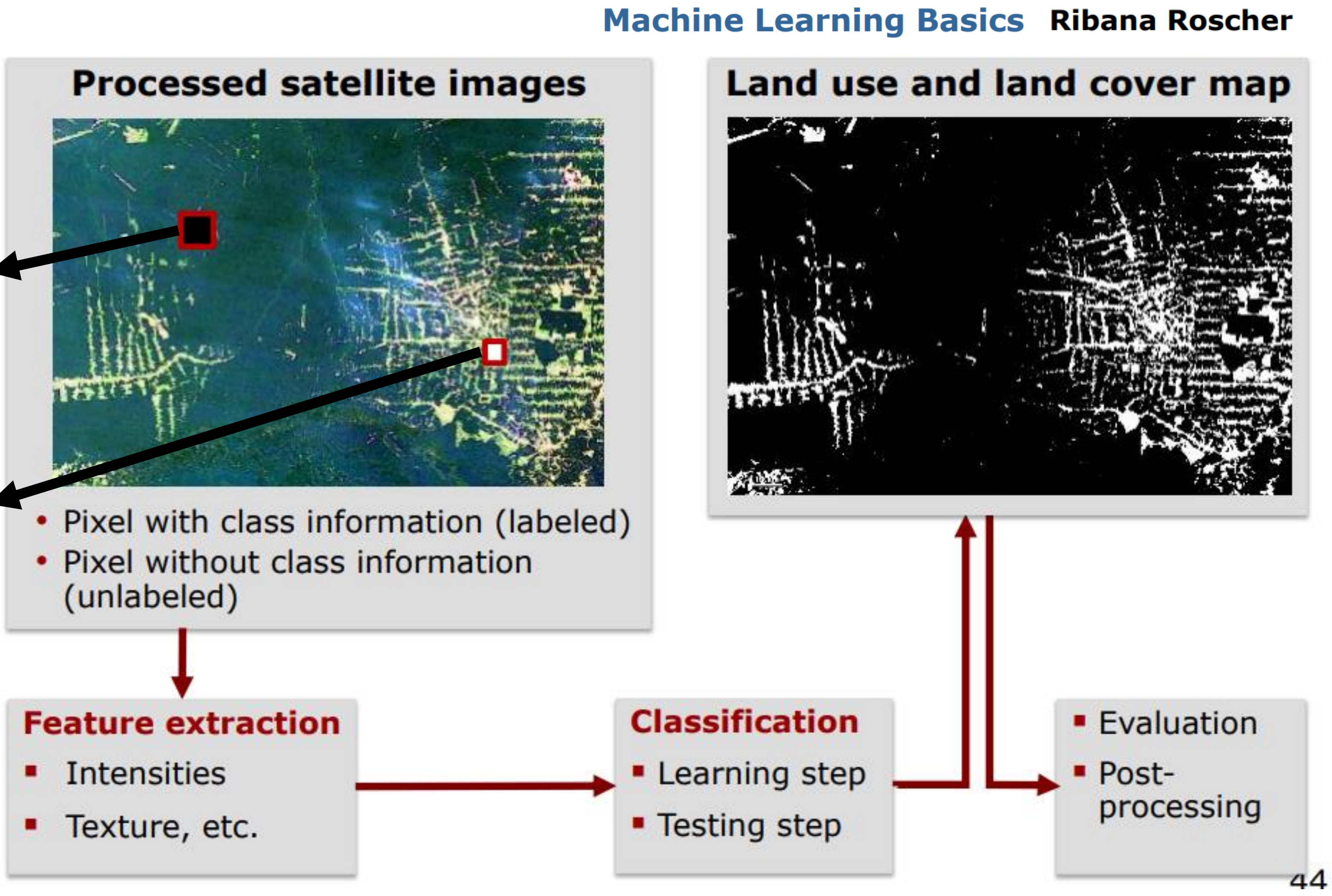
NDWI in 2018

Remote Sensing : Image Classification

FEATURE **CLASS**

B1	B2	…	B11	B12	label
0.10	0.05	…	0.23	0.09	A
0.20	0.2	…	0.03	0.12	B
0.12	0.14	…	0.10	0.15	A
…	…	…	…	…	
0.50	0.21	…	0.22	0.15	B

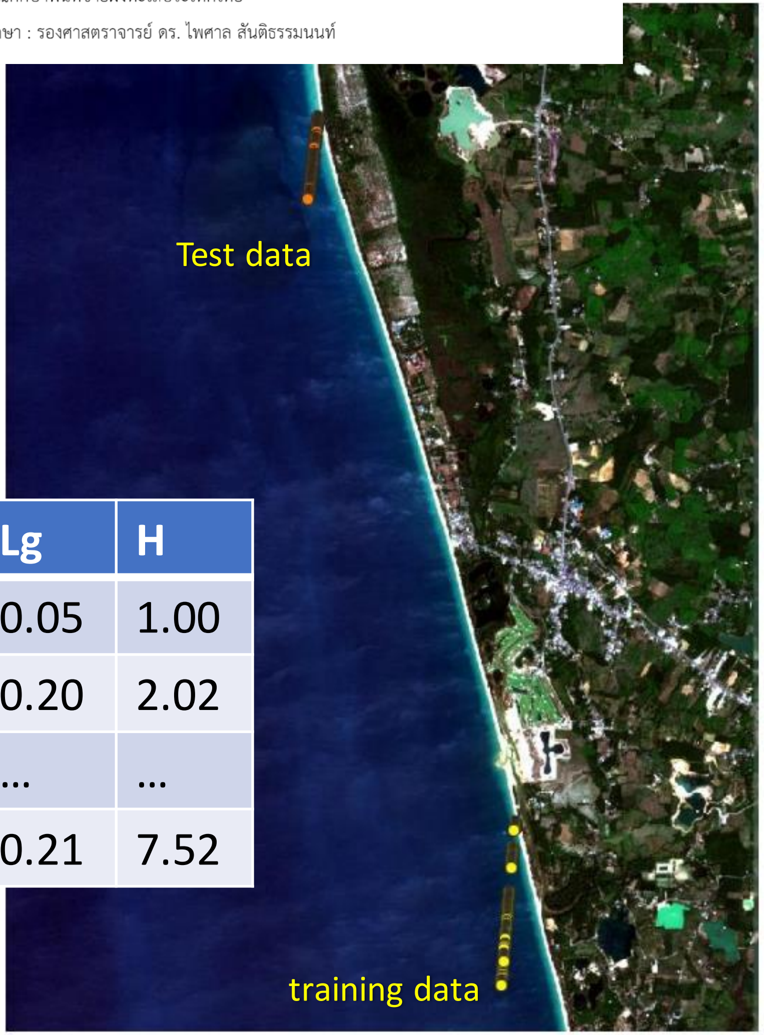




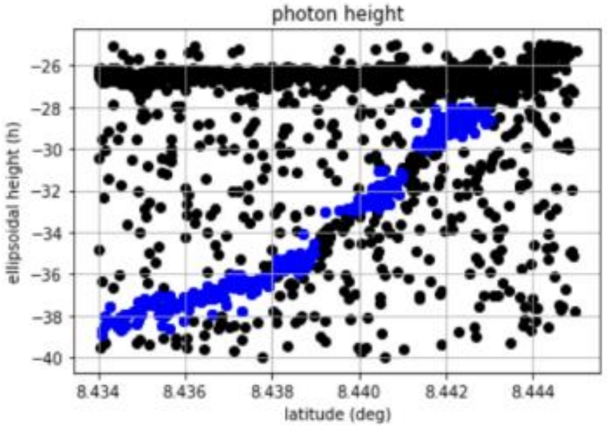
Remote Sensing : Image Regression

เทพชัย ศรีน้อย : การทำแบบจำลองความลึกท้องน้ำตื้นจากภาพถ่ายดาวเทียมและค่าระดับจากไลดาร์บนดาวเทียม กรณีศึกษาพื้นที่ชายฝั่งทะเลประเทศไทย

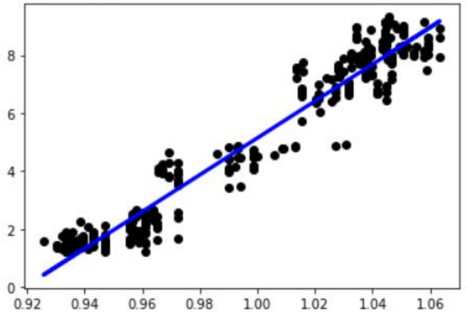
อาจารย์ที่ปรึกษา : รองศาสตราจารย์ ดร. ไพศาล สันติธรรมนนท์



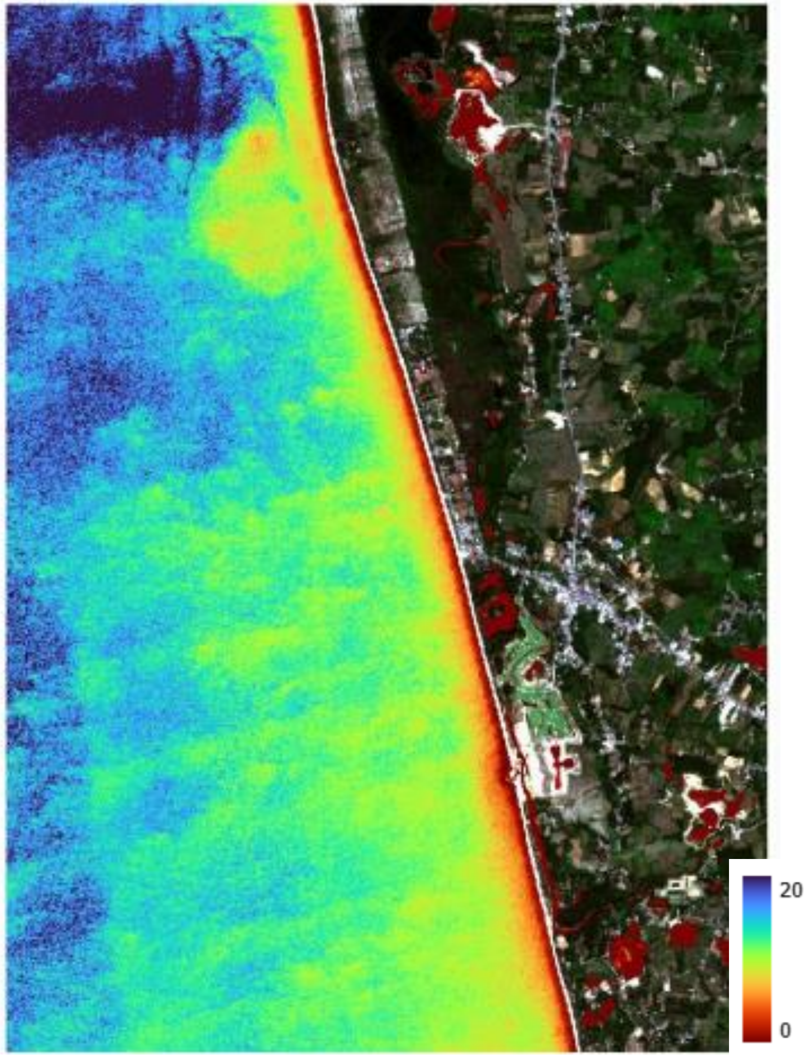
Lb	Lg	H
0.10	0.05	1.00
0.20	0.20	2.02
…	…	…
0.50	0.21	7.52



Stumpf 0.9385333644211409 [-58.4011162] 63.54646932495212



$$H = m_{1S}\frac{\ln(1000L_B)}{\ln(1000L_G)} + m_{0S}$$



CHULA ΣNGINEERING

Innovation toward Sustainability | ACTNOW

THE END ....

Geospatial Programming

Modern Integrated Surveying Technologies 2024

Thepchai Srinoi

Master Degree Student and Teaching Assistant,

Department of Survey Engineering Chulalongkorn University