First of all…

- Thanks for your invitation to Krakow!

- And thanks to the Erasmus Programme

Funded by the
Erasmus+ Programme
of the European Union

About myself and **research activities**

Dr. Vahagn Muradyan

PhD in Geography

PhD - Thesis Title:A landscape - ecological assessment of mountain ecosystems applying geographical information system (on the example of the territory of Syunik marz, RA)

-remote sensing data and GIS for assessing and monitoring of landscape-ecological situation of mountain landscapes
-remote sensing data and GIS for Land cover Classification & Change Detection
-remote sensing data for studying and managing urban landscapes, assessment of ecological situation of urban ecosystems and mapping, assessment of biophysical and chemical properties of forests and crops
-remote sensing methods for assessing and mapping soil and crops pollution with heavy metals
-remote sensing data for spatial-temporal ecological monitoring and dynamics of mountain ecosystems
-investigation and assessment of space and time changes of biomass using remote sensing data on mountain ecosystems
-remote sensing data for monitoring and quantitative estimation vegetation and climate condition
-remote sensing data for vegetative drought monitoring and mapping
-remote sensing data for water quality monitoring and mapping
-spatial-analytical data infrastructure for decision making and management

The total number of publications is 75.

International Scientific-Educational Center of the National Academy of Sciences of Republic of Armenia (ISEC)

Center for Ecological-Noosphere Studies National Academy of Sciences of the Republic of Armenia

Republic of Armenia

Location: Southern Caucasus

Area: 29,800 sq.km.

Population: 3.2 million

(urban/rural – 64%/36%)

Capital: Yerevan (1 mil.)

Contents

OPTICAL Remote sensing : preprocessing

RADAR Remote sensing

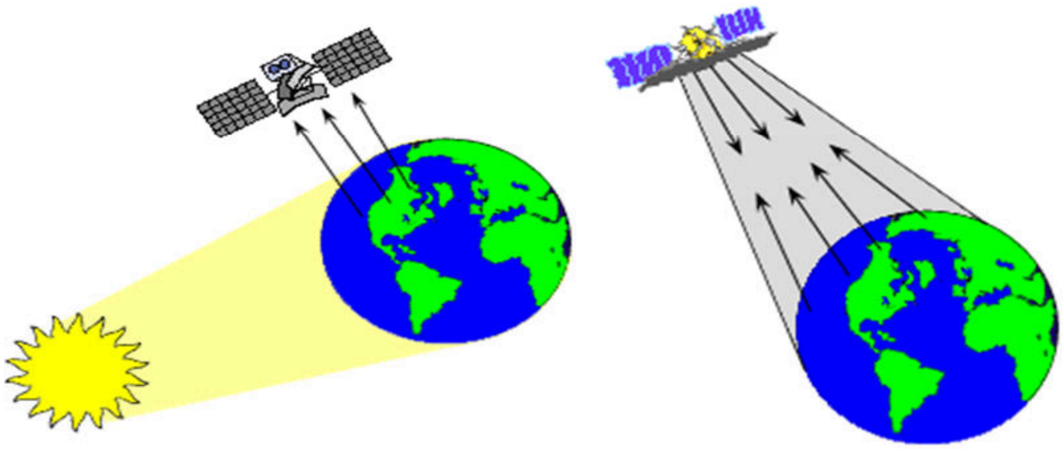
SNAP software

Google Earth Engine: JavaScript,

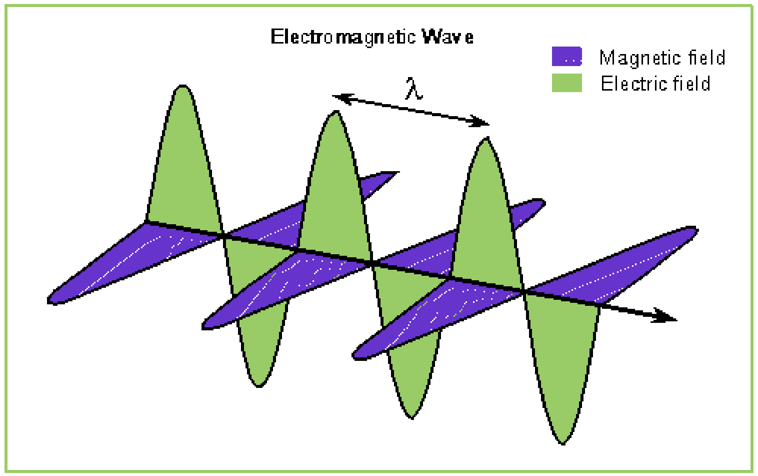
Common types of remote sensing's data source

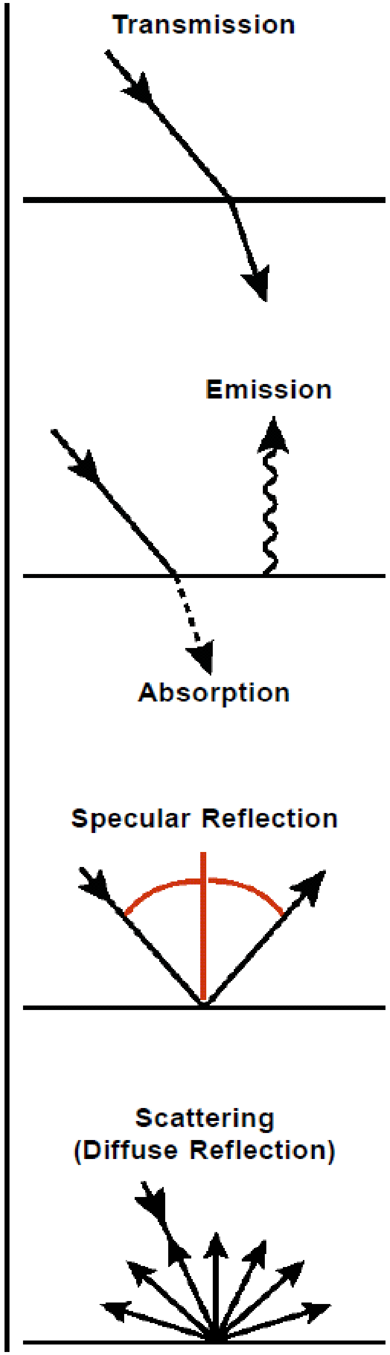
Active system
- Radar
- Lidar
- Sonar

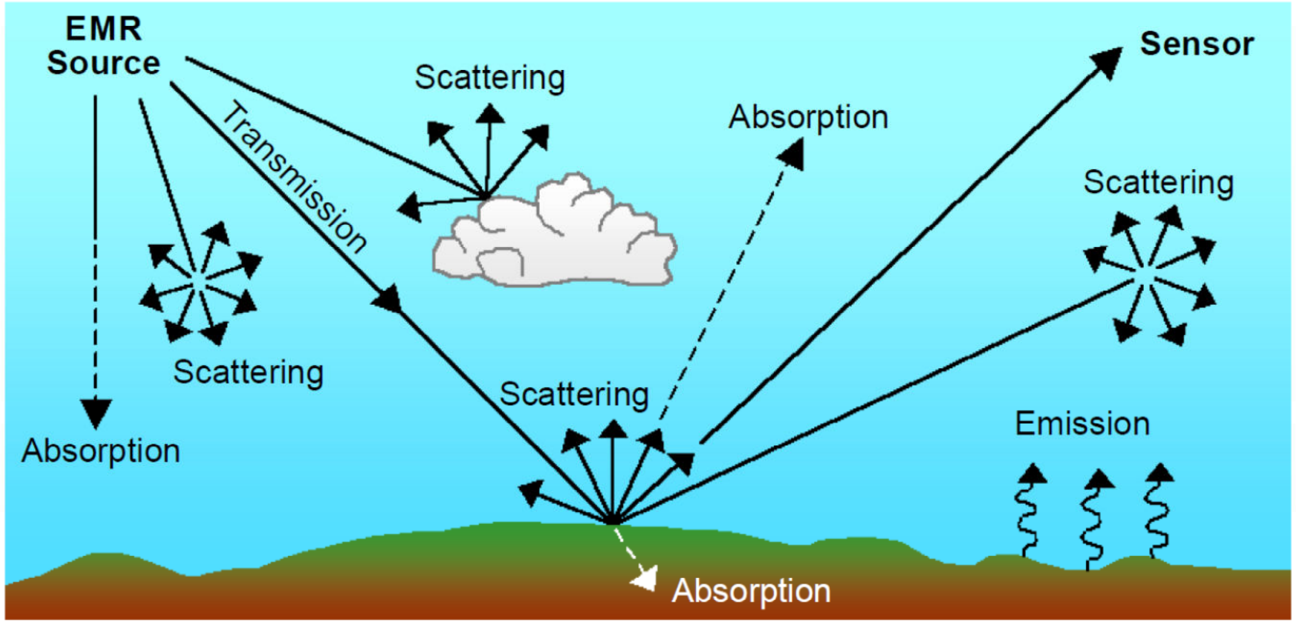
Passive system
- Aerial photo
- Satellite image



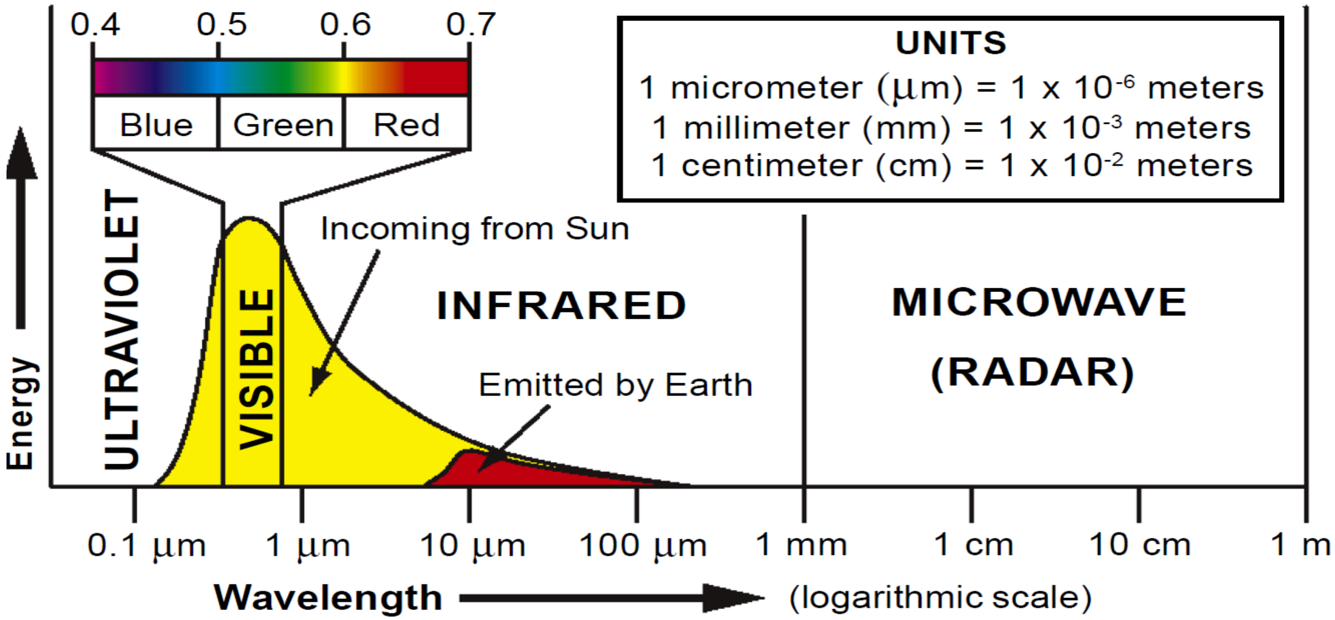
Passive sensors   Active sensors







Typical EMR interactions in the atmosphere and at the Earth's surface.



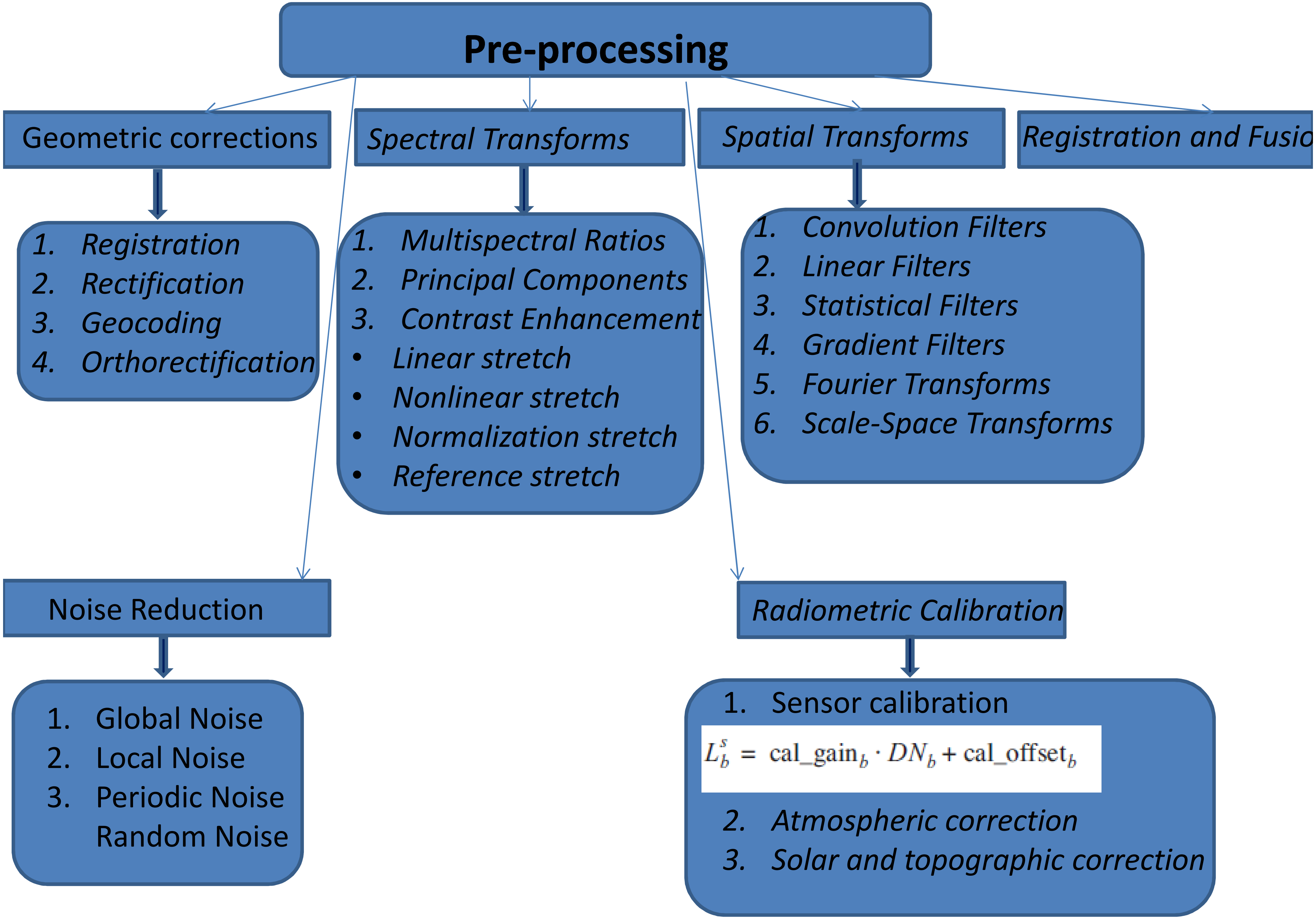
What do we need to know..

1. Image Acquisition

- Spatial and Radiometric Characteristics
- Spectral Characteristics
- Temporal Characteristics
- Multi-Sensor Formation Flying

2. Image Processing

- Pre-processing (CORRECTION, CALIBRATION)
- Processing (INTERPRETATION)
- Post-Processing (ACCURACY ASSESSMENT)


Pre-processing
Geometric corrections
1. Registration
2. Rectification
3. Geocoding
4. Orthorectification
Spectral Transforms
1. Multispectral Ratios
2. Principal Components
3. Contrast Enhancement
• Linear stretch
• Nonlinear stretch
• Normalization stretch
• Reference stretch
Spatial Transforms
1. Convolution Filters
2. Linear Filters
3. Statistical Filters
4. Gradient Filters
5. Fourier Transforms
6. Scale-Space Transforms
Registration and Fusio
Noise Reduction
1. Global Noise
2. Local Noise
3. Periodic Noise
Random Noise
Radiometric Calibration
1. Sensor calibration
$L_b^s = \mathrm{cal\_gain}_b \cdot DN_b + \mathrm{cal\_offset}_b$
2. Atmospheric correction
3. Solar and topographic correction

Statistical Measures of Image Quality

Contrast

Numerical contrast may be defined in several ways, e.g.,

$$C_{ratio} = \frac{DN_{max}}{DN_{min}}, \quad (4\text{-}24)$$

$$C_{range} = DN_{max} - DN_{min} \quad (4\text{-}25)$$

or,

$$C_{std} = \sigma_{DN} \quad (4\text{-}26)$$

Modulation

Another easily measured image property is modulation, M, defined as,

$$M = \frac{DN_{max} - DN_{min}}{DN_{max} + DN_{min}}. \quad (4\text{-}27)$$

Because *DN*s are always positive, this definition insures that modulation is always between zero and one and unitless.

Signal-to-Noise Ratio (SNR)

$$SNR_{amplitude} = \frac{C_{signal}}{C_{noise}}$$

Noise Reduction

Global Noise

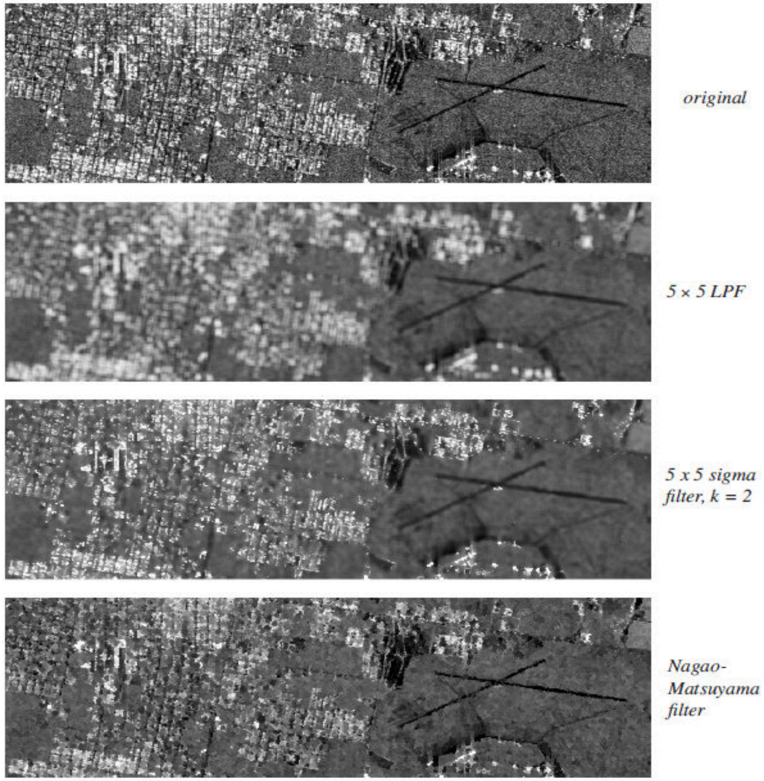


FIGURE 7-25. Speckle noise filtering of a SLAR image of Deming, New Mexico, acquired in the X-band with HH polarization on July 1, 1991, from 22,000 feet altitude. The GSI is about 12 × 12 meters. Metallic objects such as cars, metal roofs, and power lines show a high signal ("return"). (The SLAR image is from the U.S. Geological Survey's Side-Looking Airborne Radar (SLAR) Acquisition Program 1980–1991 and is available on CD-ROM. The processed images are courtesy of Justin Paola, Oasis Research Center.)

Global periodic noise (commonly called *coherent* noise) is a spurious, repetitive pattern that has consistent characteristics throughout an image.

Local Noise (*scanline noise)*

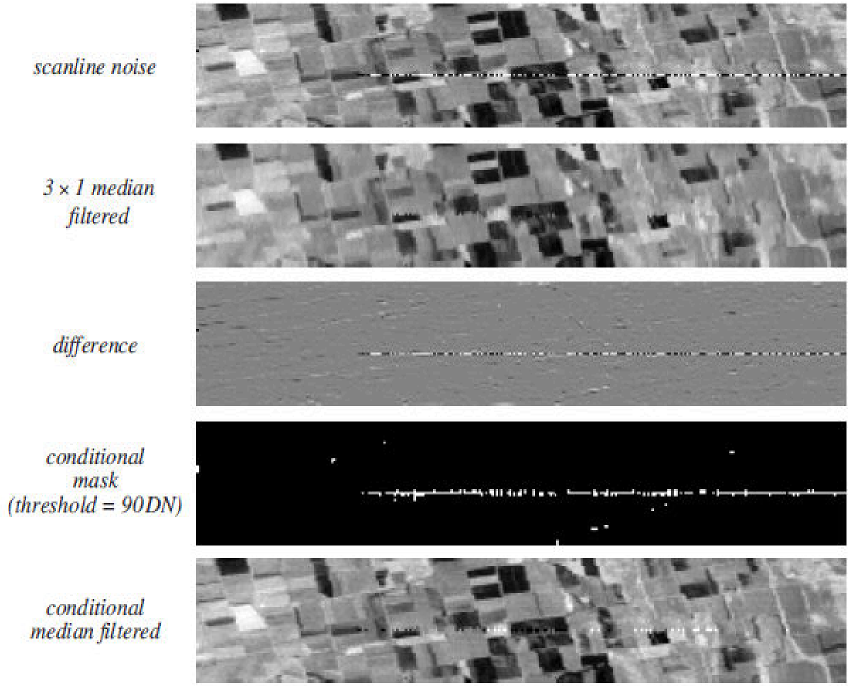
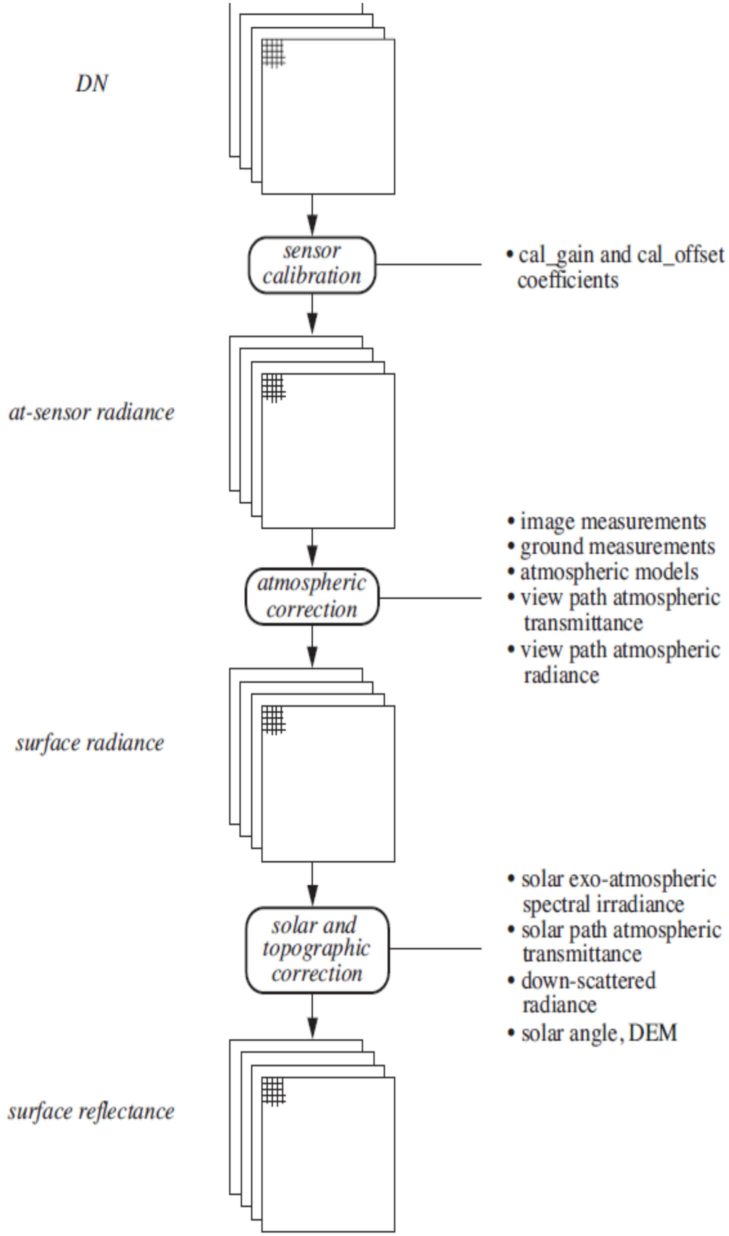


FIGURE 7-26. Local line noise in an MSS image. A 3 × 1 median filter removes the noise, but also changes many good pixels, as shown by the difference (scaled to [0, 255]) between the noisy image and the filtered result. A mask can be derived as explained in the text and used to restrict the pixels replaced by the median filter. In this example, the regular median filter replaces 43% of the image pixels, while the conditional median filter replaces only 2%.

Local periodic noise is periodic, but the noise amplitude, phase, or frequency varies across the image. One approach to this problem is to estimate the local amount of noise and remove only that amount at each pixel

Radiometric corrections

Radiometric corrections are made to the raw digital image data to correct for brightness values, of the object on the ground, that have been distorted because of sensor calibration or sensor malfunction problems. The distortion of images is caused by the scattering of reflected electromagnetic light energy due to a constantly changing atmosphere. This is one source of sensor calibration error.



Topografic correction

Topographic effects are caused by differences in illumination due to solar position at the moment of image acquisition and result in a variation in reflectance response for similar terrain features.

- Imaging geometry changes locally causing unwanted brightness changes
- E.g. deciduous forest looks like more bright on the sunny side that the shadow side of the hill
- Reflectance is largest when the slope is perpendicular to the incoming radiation

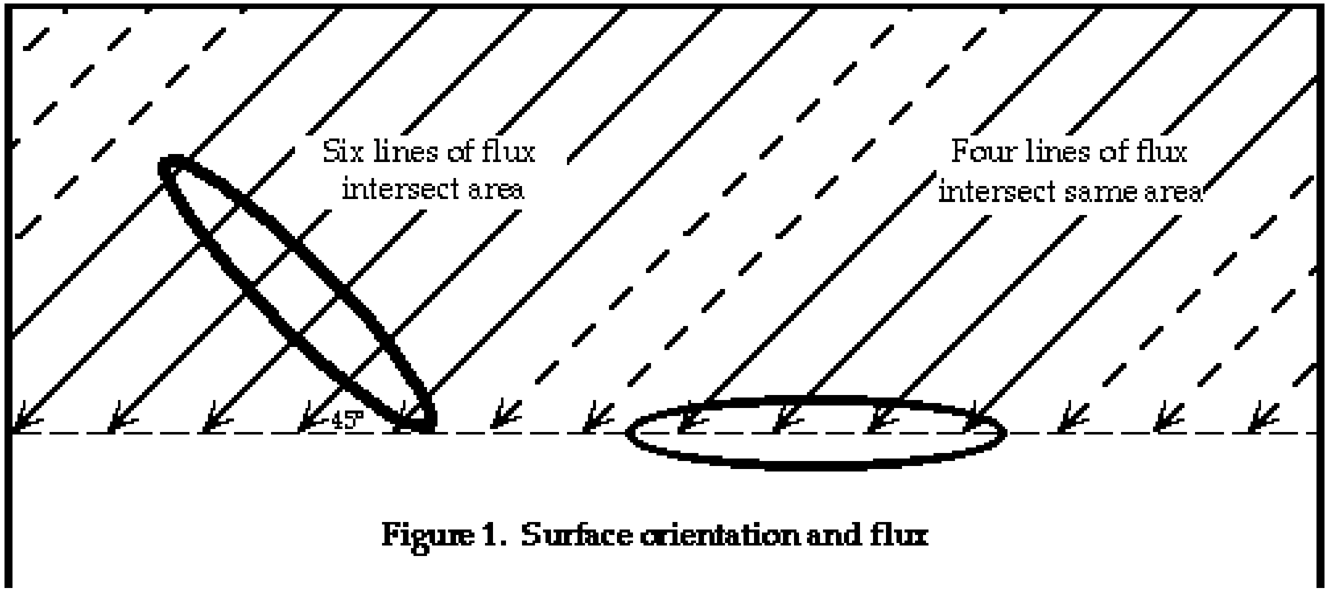


Figure 1. Surface orientation and flux

The first step in the correction of topographic shadows is the computation of the illumination angle, which is based on the following formula.

$$\cos i = \cos E \cos Z + \sin E \sin Z \cos\left(A_0 - A_S\right)$$

i = incidence angle with respect to surface normal

E = slope inclination

Z = solar zenith angle

A_0 = solar azimuth

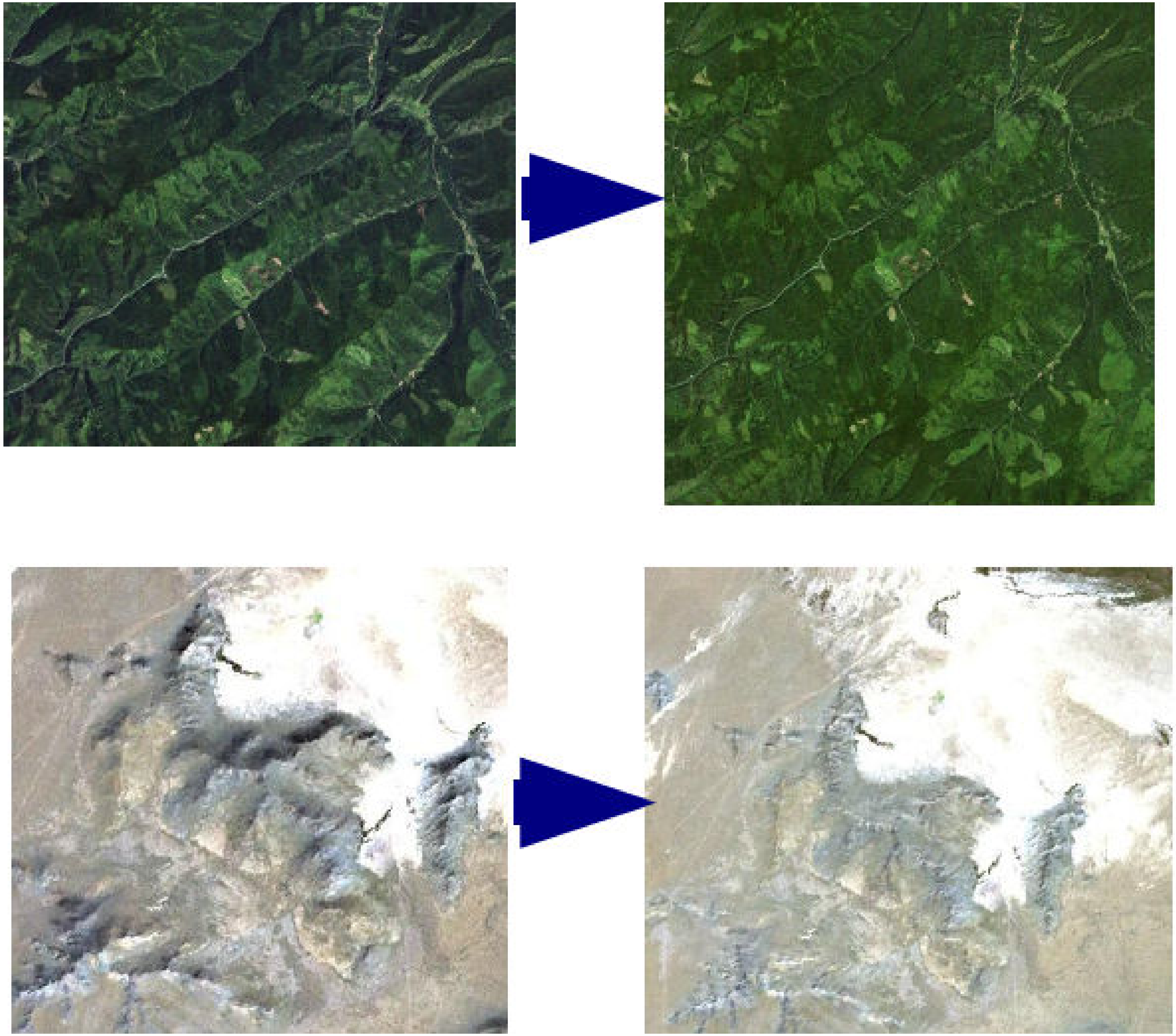
A_S = surface aspect of the slope angle

Shadowed pixel , when $\cos(i)<0.3$

Different Topographic Correction Techniques

1. Lambertian cosine correction
2. Minnaert
3. Modified Minnaert (Minnaert Colby, Jansa-Minnaert, Minnaert- Stratified)
4. C-correction
5. Statistical-Empirical
6. Semi-Empirical
7. Ekstrand
8. 2-stage normalization
9. Modified – Normalization
10. Band Ratio (Bands relation)
11. Lambertian SCS (Sun-Canopy-Sensor) Correction
12. Modified SCS Correction

Landsta before and after correction



C-correction

- C-correction is modification of the cosine correction by a factor *C* which should model the diffuse sky radiation.

$$L_C = L_O \left[\left(\cos(sz) + C \right) / \left(\cos(i) + C \right) \right]$$

- $C = b/m$ (Correction parameter)
- b and m are the regression coefficients of statistical-empirical correction method ($L_O = m \cos(i) + b$)

(*b* – point of intersection of the regression line *m* – slope of regression line)

Conclusions

Tree height

- Statistical-Empirical best
- Stratification decreases the correlation a little

Tree crown cover

- Cosine and C-correction best
- Stratification decreases the correlation a little

Vegetation cover

- C- and Minnaert correction best

Classification methods

Nonparametric Classification (Rule)

- Level-Slice Classifier (*box* or *parallelepiped classifier*)
- Histogram Estimation Classifier
- Nearest-Neighbors Classifier
- Artificial Neural Network (ANN) Classifier

Parametric Classification (Rule)

- The Nearest-Mean Classifier
- (Minimum Distance)
- Maximum-likelihood

Unsupervised

- *K-means clustering algorithm*
- The *ISODATA* algorithm (Ball and Hall, 1967)
- is a common modification of the
- *K*-means algorithm
- Indices (NDVI, EVI, SAVI)

Supervised

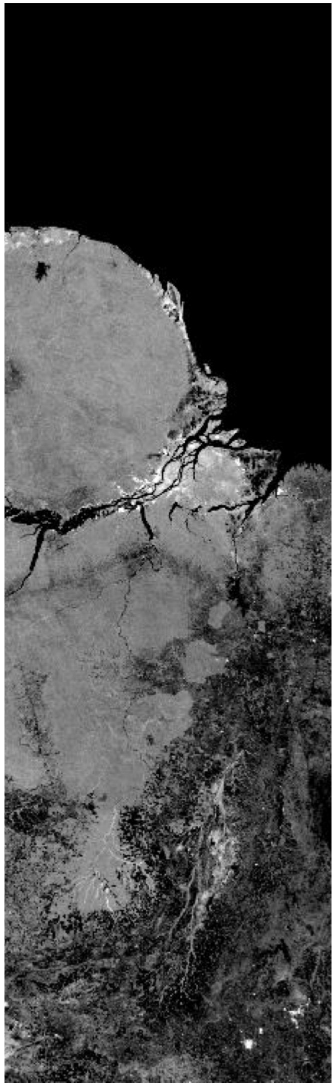
- Level-Slice Classifier (*box* or *parallelepiped classifier*)
- The Nearest-Mean Classifier (Minimum Distance)
- Maximum-likelihood
- Artificial Neural Network (ANN) Classifier

Hybrid Supervised/Unsupervised

Spatial-Spectral Segmentation

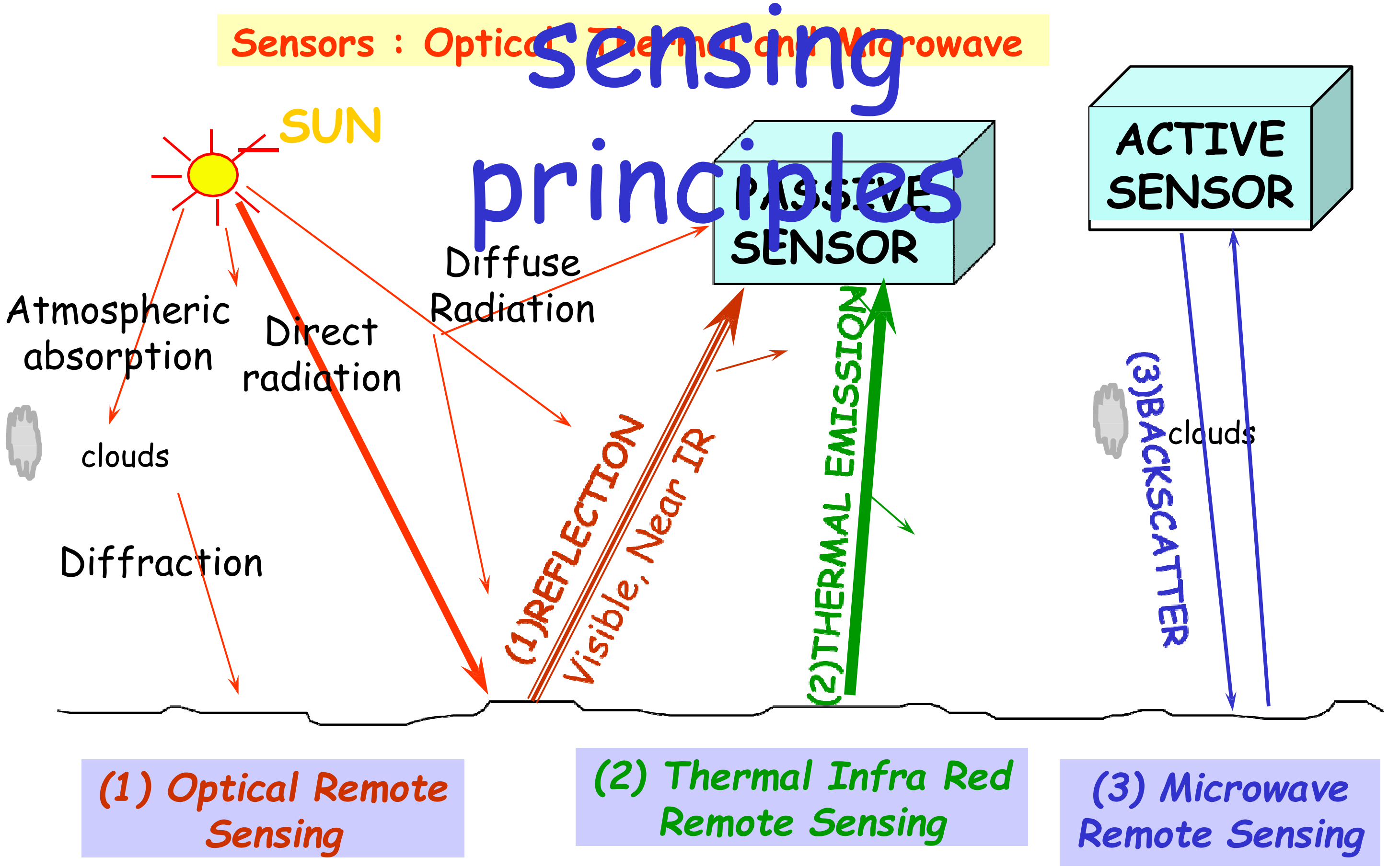
Subpixel Classification

- Linear /nonlinear unmixing
- Fuzzy Set Classification



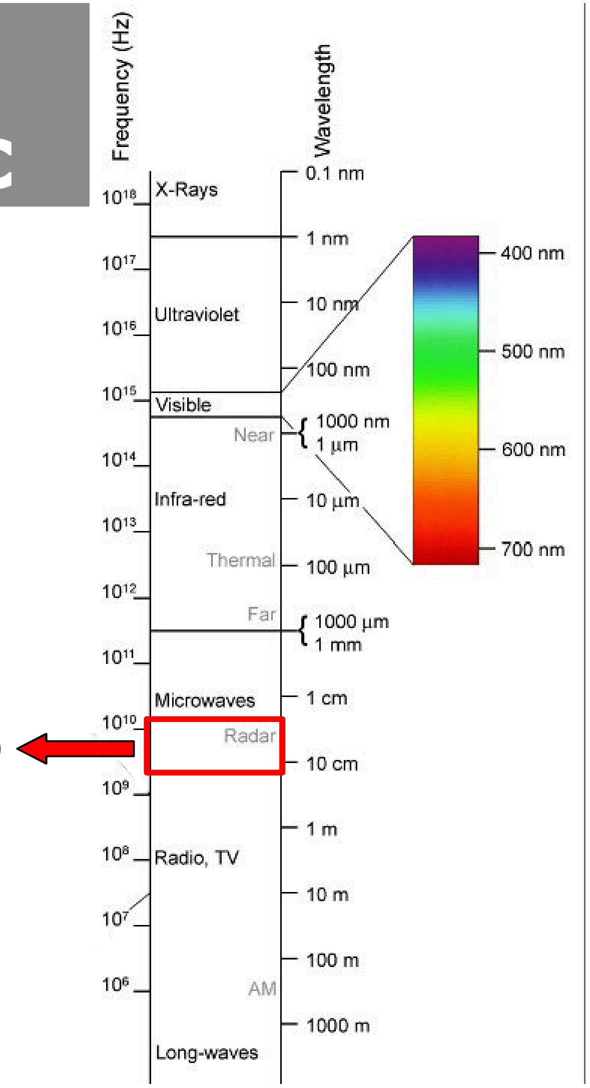
Basics of Synthetic Aperture Radar

General remote sensing principles

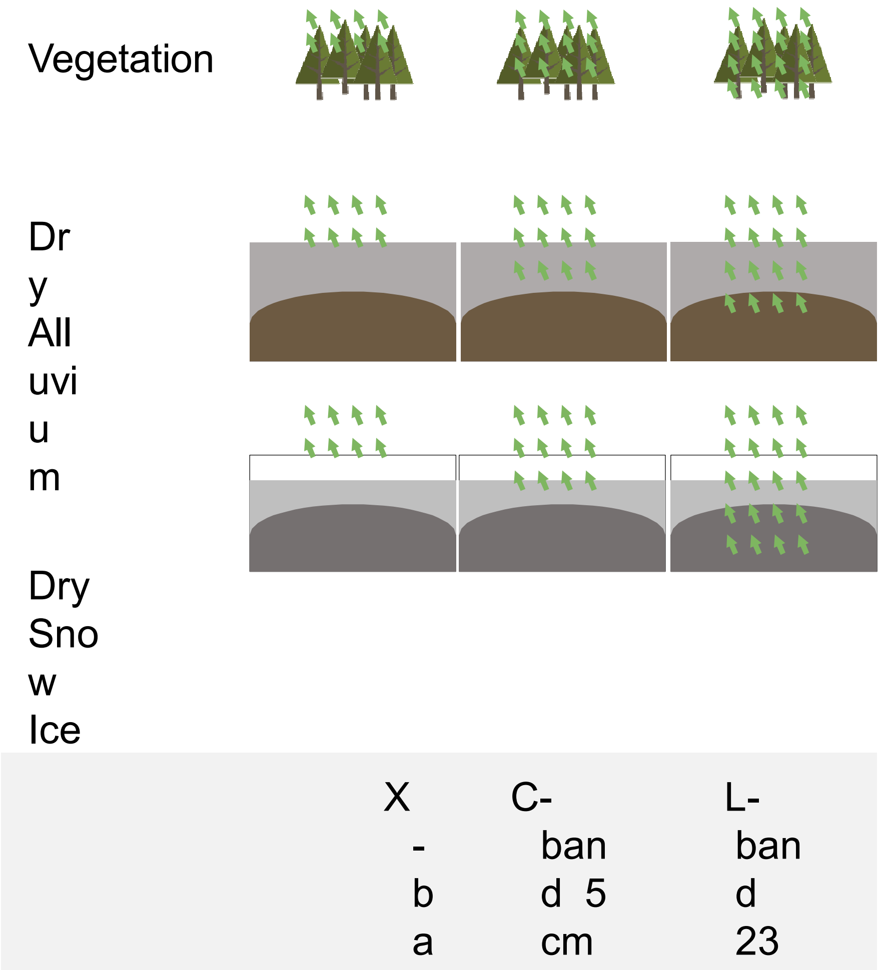


The **electromagnetic**

Synthetic Aperture Radar (SAR)



Penetration as a Function of Wavelength

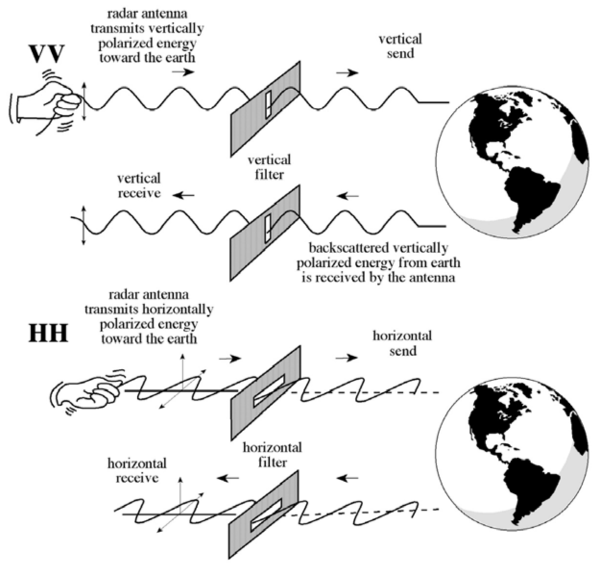


- Waves can penetrate into vegetatio n and (in dry conditions) soil
- Generally

Image based on ESA [Radar Course 2]

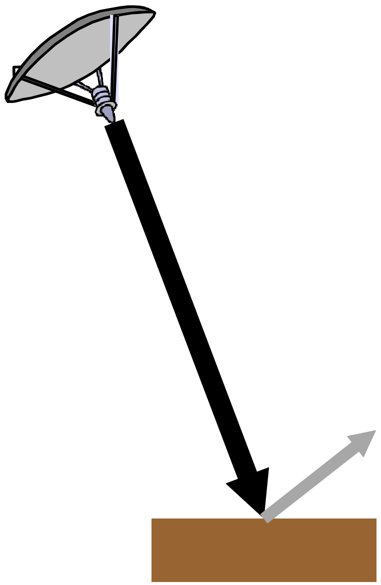
Radar Parameters: Polarization

- The radar signal is polarized
- The polarizations are usually controlled between H and V:
  - HH: Horizontal Transmit, Horizontal Receive
  - HV: Horizontal Transmit, Vertical Receive
  - VH: Vertical Transmit, Horizontal Receive
  - VV: Vertical Transmit, Vertical Receive
- Quad-Pol Mode: when all four polarizations are measured
- Different polarizations can determine physical properties of the object observed



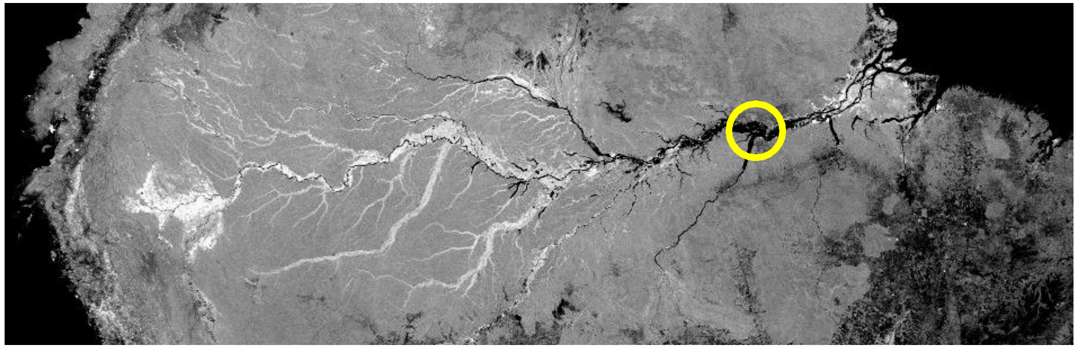
Examples of Radar Interaction

Smooth Surface Reflection (Specular Reflection)



Smooth, level surface
(open water, road)

SMAP Radar Mosaic of the Amazon Basin
April 2015 (L-band, HH, 3 km)



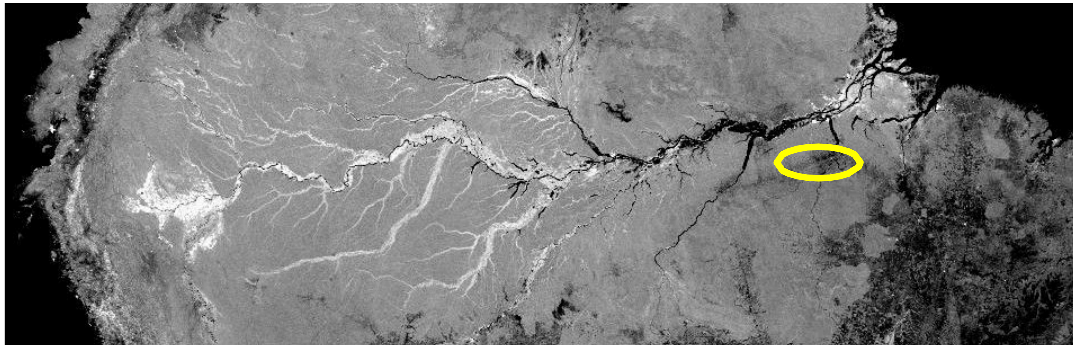
Pixel Color

Examples of Radar Interaction

Rough Surface Reflection

rough bare surface
(deforested areas, tilled agricultural fields)

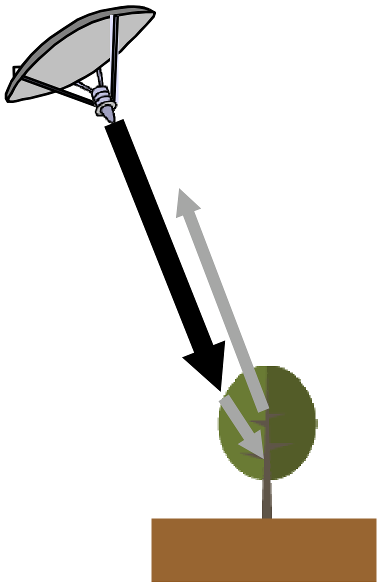
SMAP Radar Mosaic of the Amazon Basin
April 2015 (L-band, HH, 3 km)



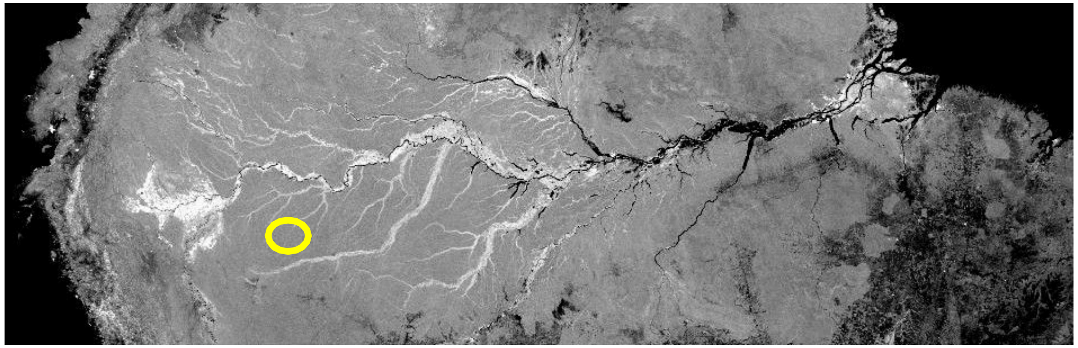
Pixel Color

Examples of Radar Interaction

Volume Scattering by Vegetation

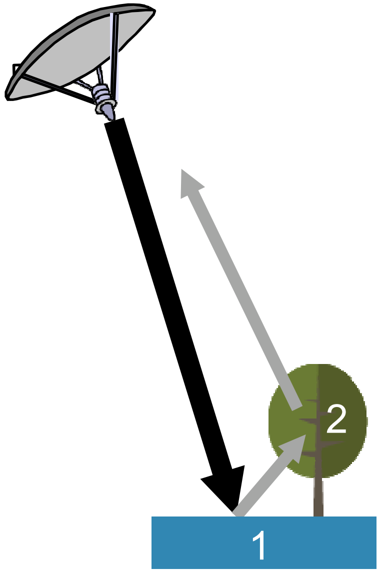


SMAP Radar Mosaic of the Amazon Basin April 2015 (L-band, HH, 3 km)



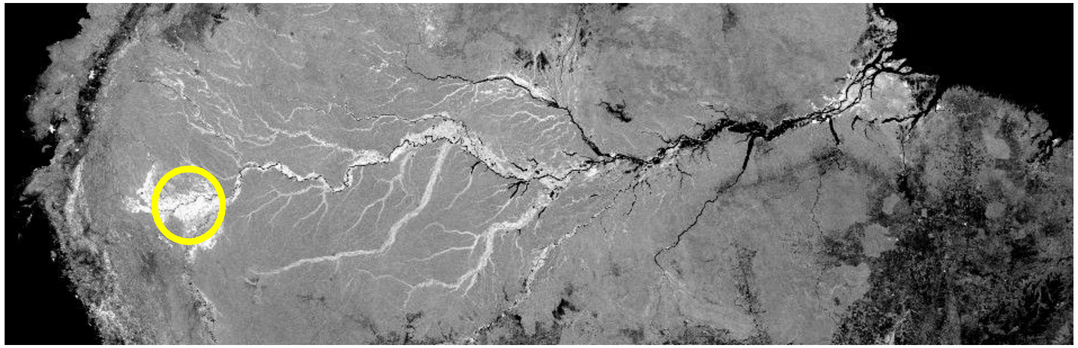
Examples of Radar Interaction

Double Bounce

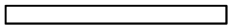


Inundated Vegetation

SMAP Radar Mosaic of the Amazon Basin
April 2015 (L-band, HH, 3 km)

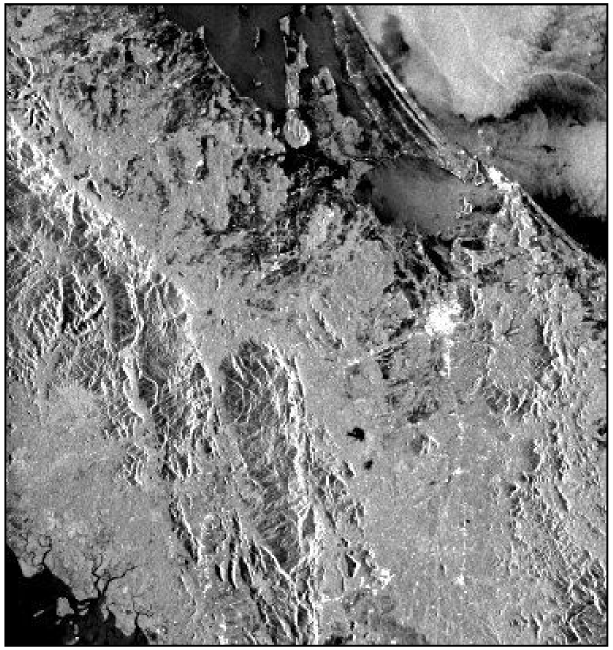


Pixel Color



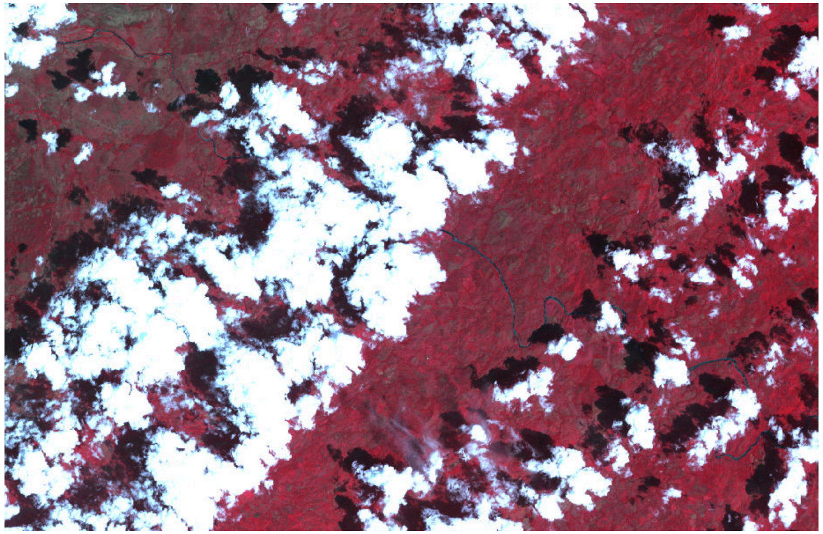
Speckle Filtering

Before

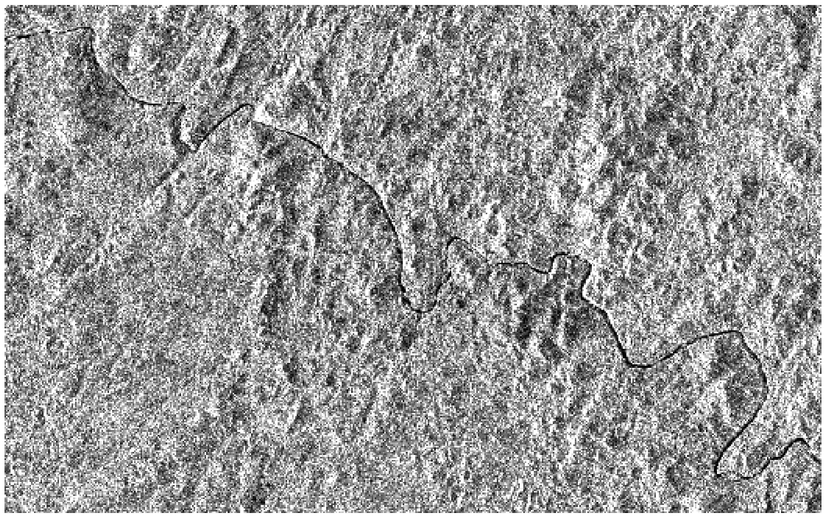


After

ASTER



RADARSAT



Google Earth Engine

What is Google Earth Engine?

What Is Earth Engine?

"Big Data" analysis and visualiza

- Inherently **parallel** system
- Designed for scientists, not s
- Goals: make it easy, **enable**

The Earth Engine Public Data Catalog

Landsat and Sentinel
Raw, TOA, SR, ...

MODIS
Daily, NBAR, LST, ...

Terrain
SRTM, GTOPO, NED, ...

Land Cover
GlobCover, NLCD, ...

Atmospheric
NOAA NCEP, OMI, ...

... and many more, updating daily!

> 200 public datasets

> 4000 new images every day

> 5 million images

> 5 petabytes of data

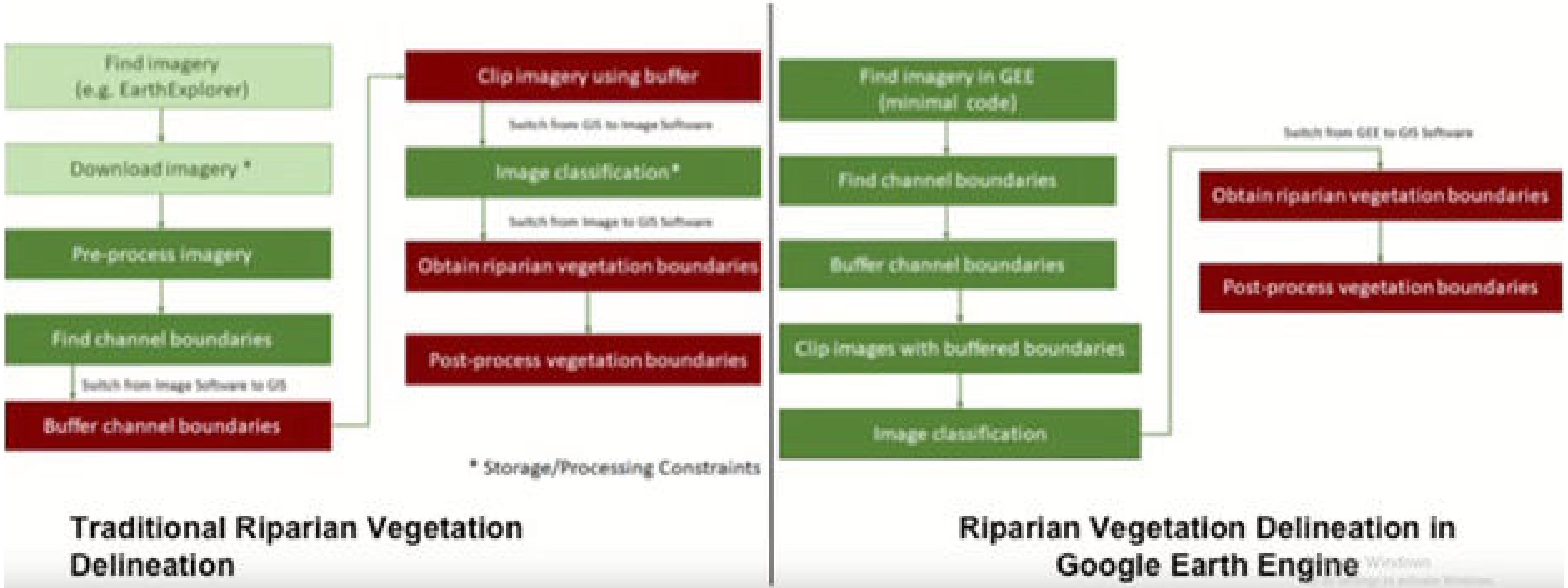

1984

Data Types and Geospatial Processing Functions

- **Image** - band math, clip, convolution, neighborhood, selection ...
- **Image Collection** - map, aggregate, filter, mosaic, sort ...
- **Feature** - buffer, centroid, intersection, union, transform ...
- **Feature Collection** - aggregate, filter, flatten, merge, sort …
- **Filter** - by bounds, within distance, date, day-of-year, metadata ...
- **Reducer** - mean, linearRegression, percentile, histogram ….
- **Join** - simple, inner, outer, inverted ...
- **Kernel** - square, circle, gaussian, sobel, kirsch …
- **Machine Learning -** CART, random forests, bayes, SVM, kmeans, cobweb …
- **Projection** - transform, translate, scale …

over 1000 data types and operators, and growing!

Opportunities



Google Earth Engine

earthengine.google.com/signup