CIE5401
GIS and Remote Sensing for Water Resources Management

Lecture 4: Visible Remote Sensing
5 March 2018
Susan Steele-Dunne

Course Introduction: Schedule

Lecture Date	**Lecture topic**	**Assignment Due Date**
12 February	Introduction to GIS	19 February
19 February	Spatial Analysis in GIS	26 February
26 February	Watershed delineation	5 March
5 March	Visible RS	12 March
12 March	Thermal IR	19 March
19 March	Microwave remote sensing	26 March

Course Introduction: Schedule

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5 March	**Visible RS (Vera Hollander)**	**12 March**
12 March	Thermal IR (NEO)	19 March
19 March	Microwave remote sensing (VanderSat)	26 March

Acknowledgements

- Prof. Nick van de Giesen
- ESA
- NASA/USGS Landsat

Why?

Why?

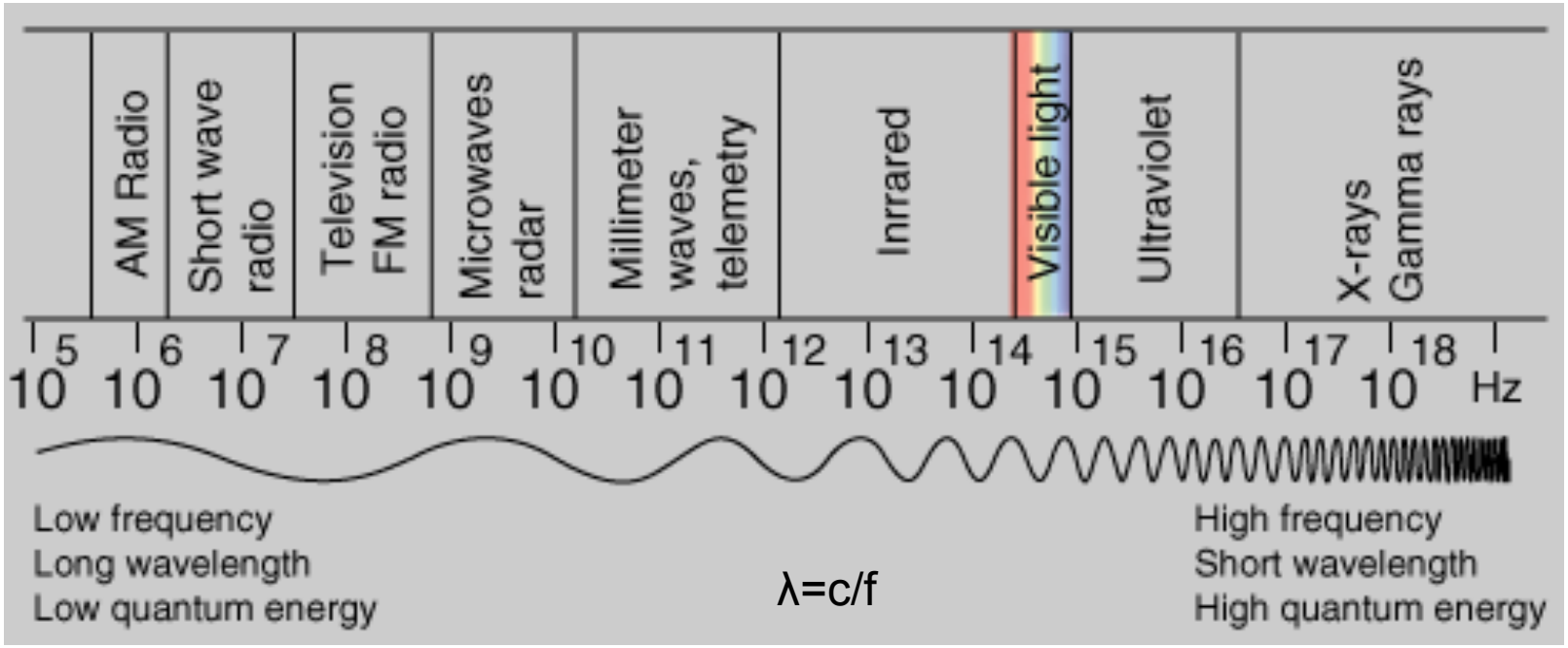
Global coverage

Inexpensive?

Continuous monitoring

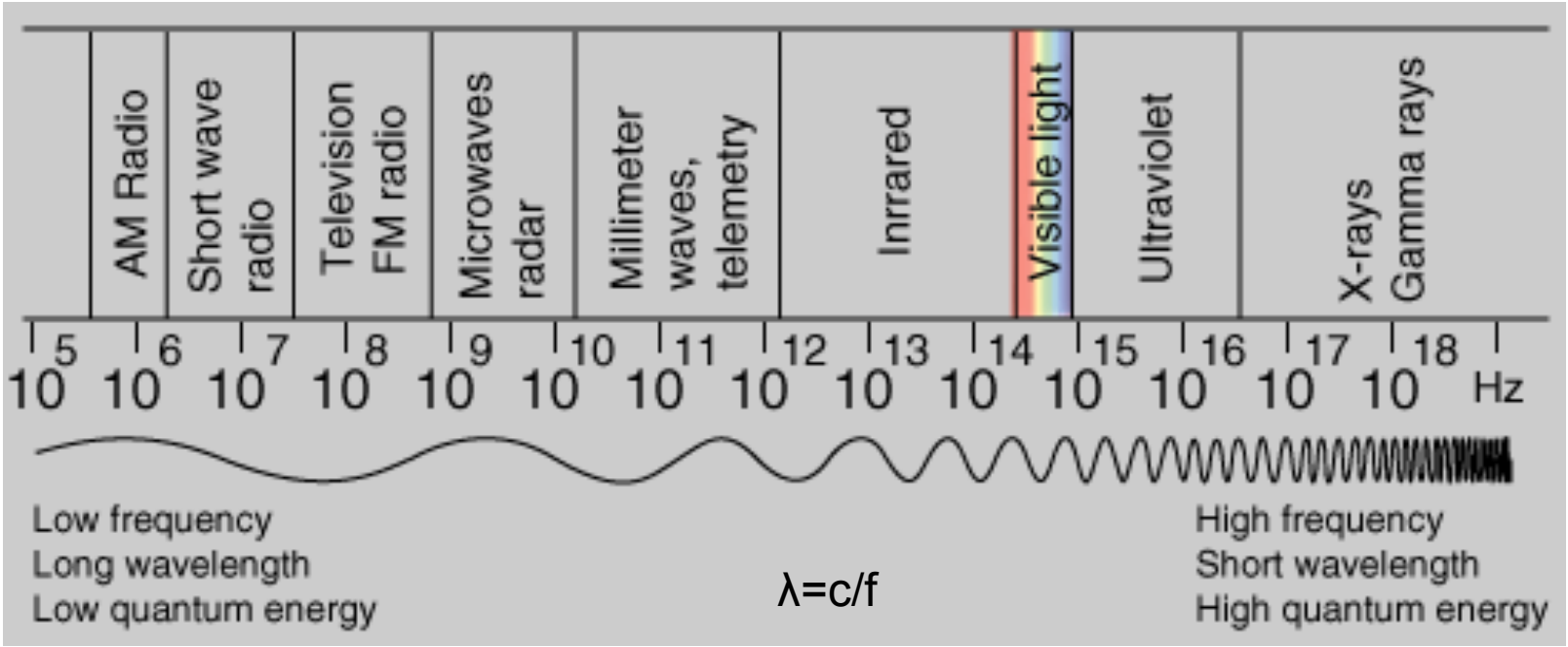
Monitor everywhere ...

Electromagnetic Spectrum



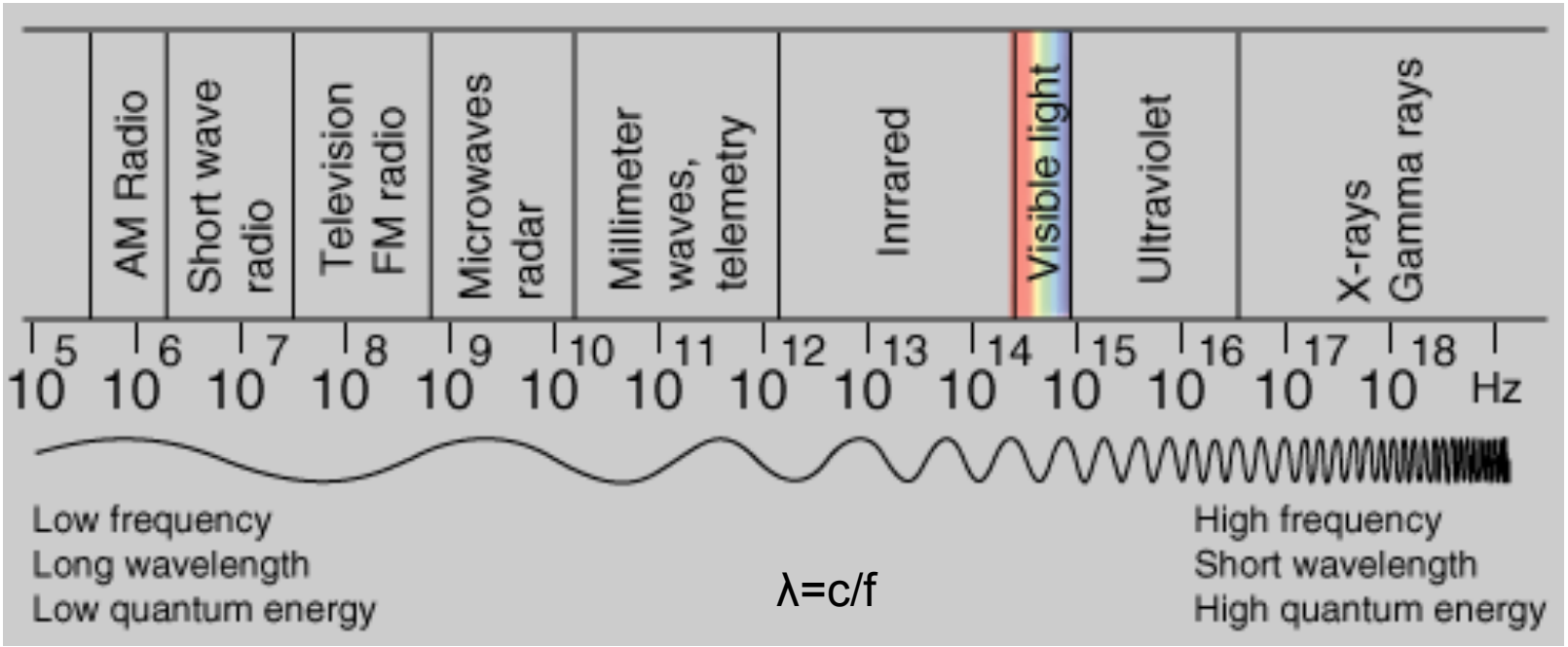
Electromagnetic Spectrum

Visible



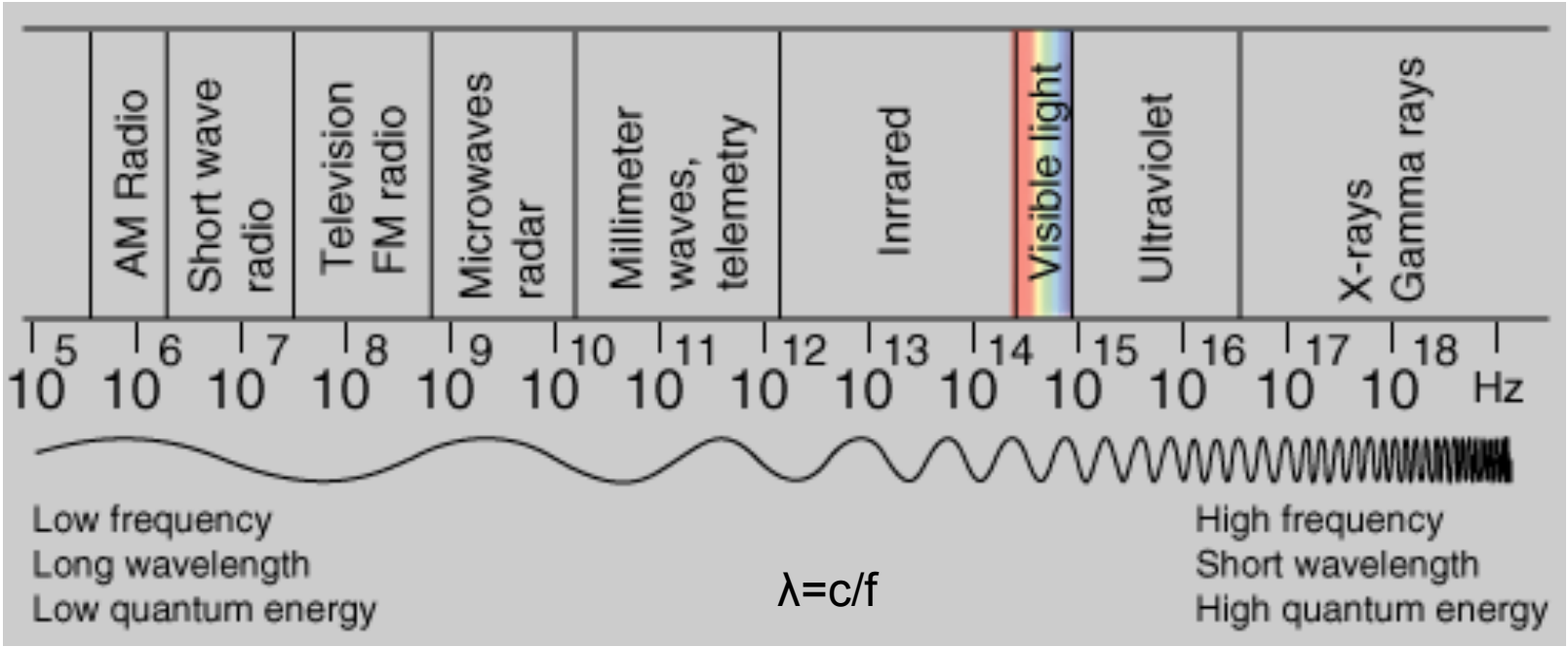
Electromagnetic Spectrum

NIR



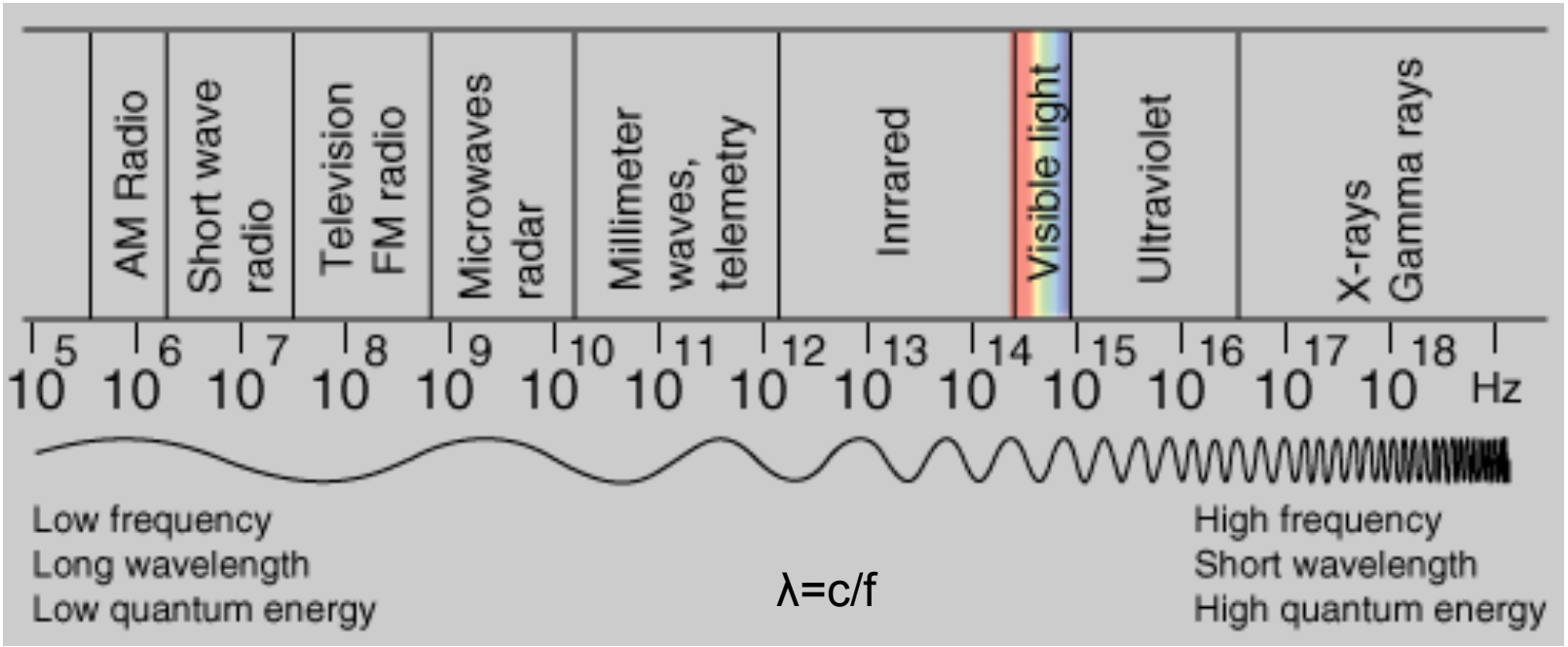
Electromagnetic Spectrum

Thermal



Electromagnetic Spectrum

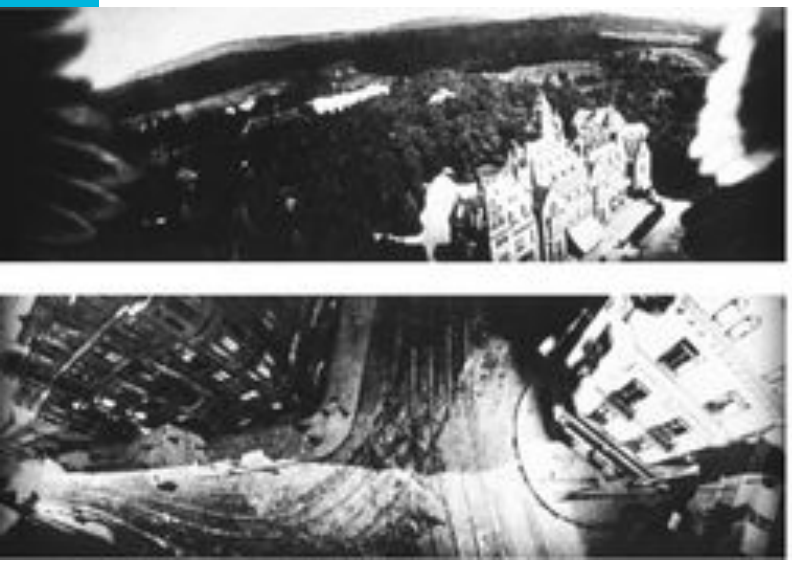
Microwave



Visible: Easy to Interpret

Google Maps!

Pigeon photography



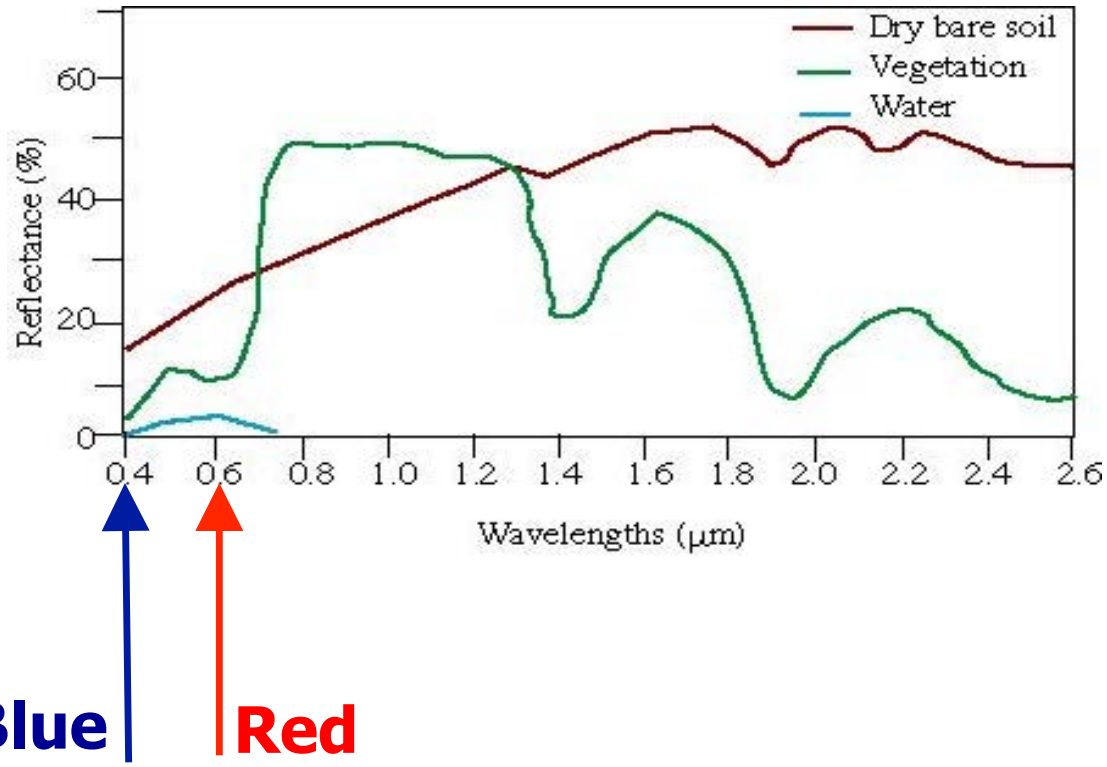
1907 Julius Neubronner
Spy Museum, Washington DC
https://en.wikipedia.org/wiki/Pigeon_photography

Drones

http://dronecameraworld.com/

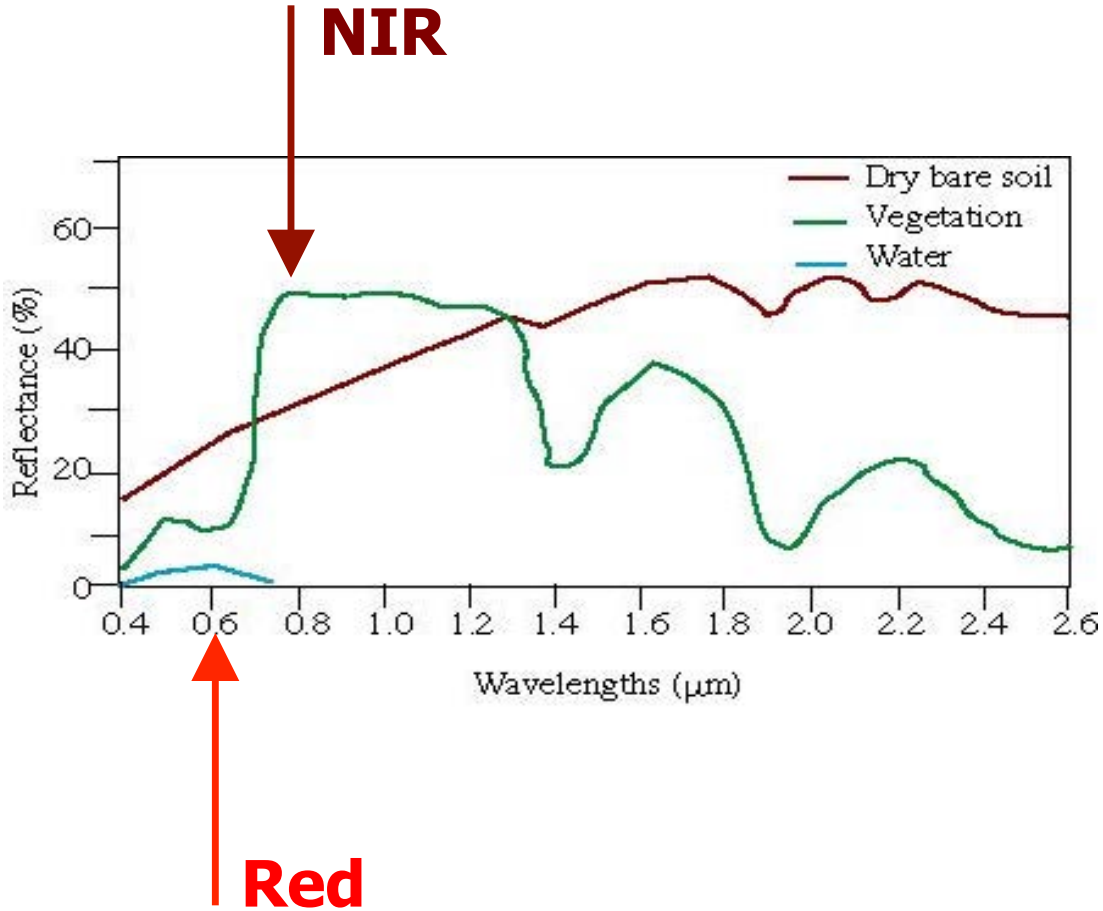
Optical: Sensitive to Water and Vegetation

Vegetation Indices



Vegetation Indices

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



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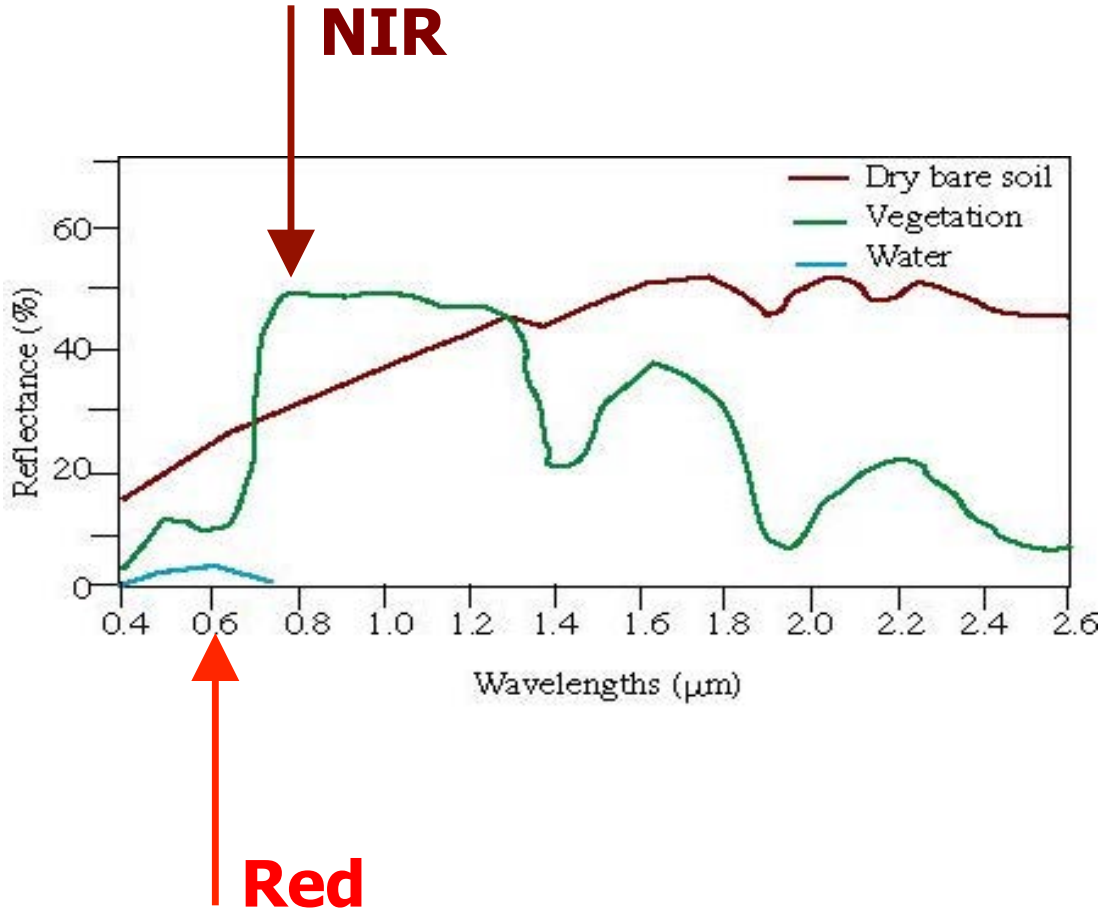
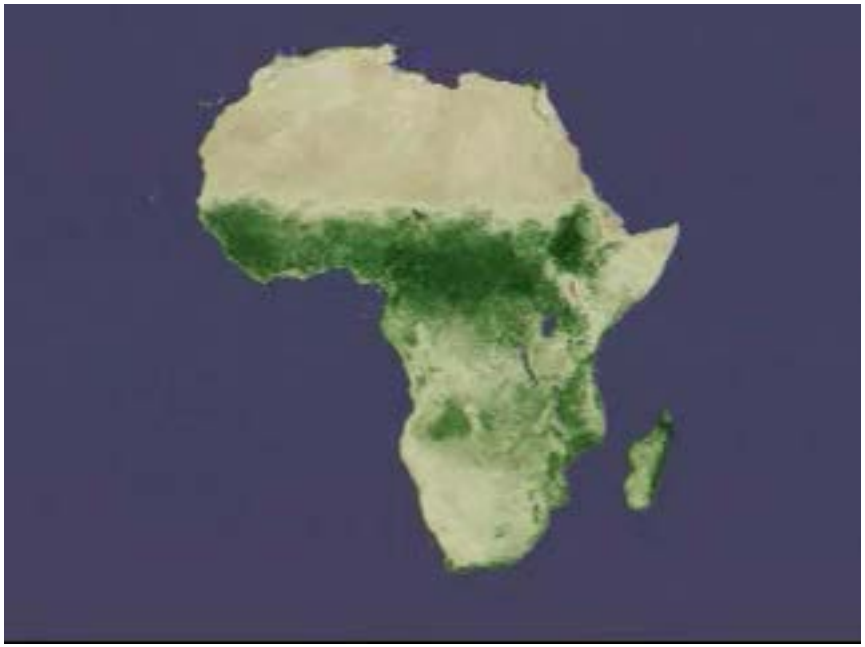


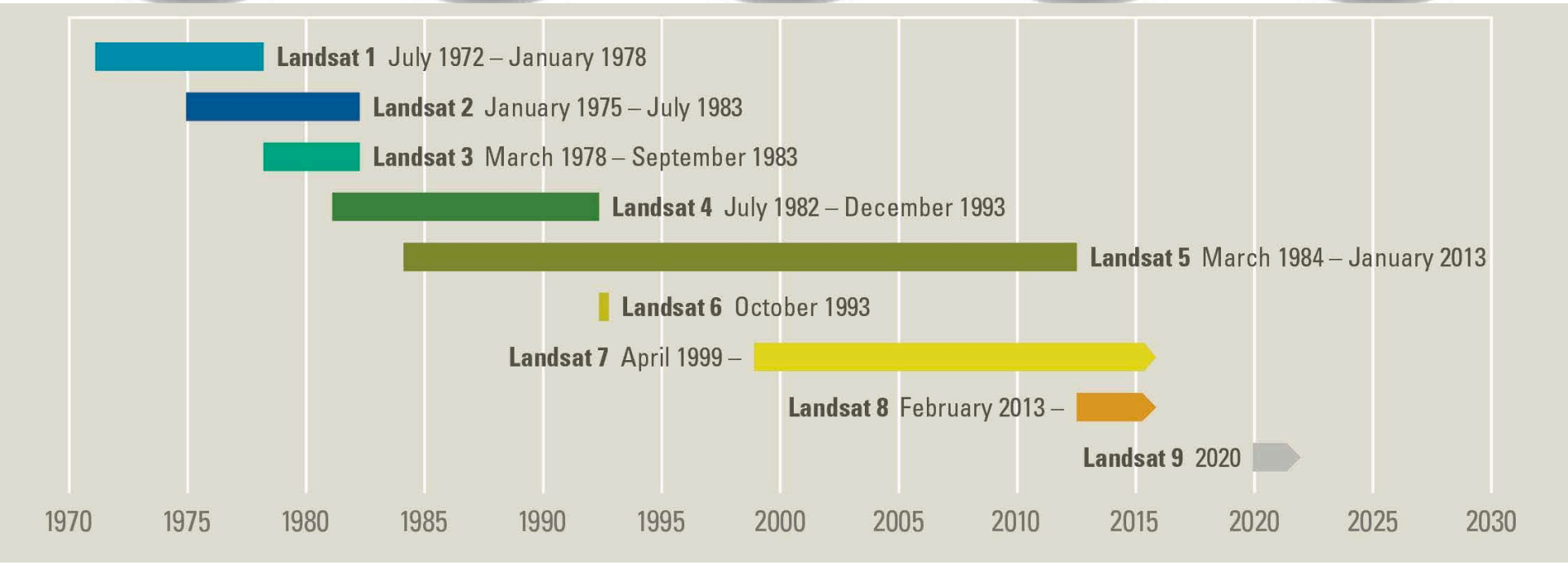
Vegetation Indices



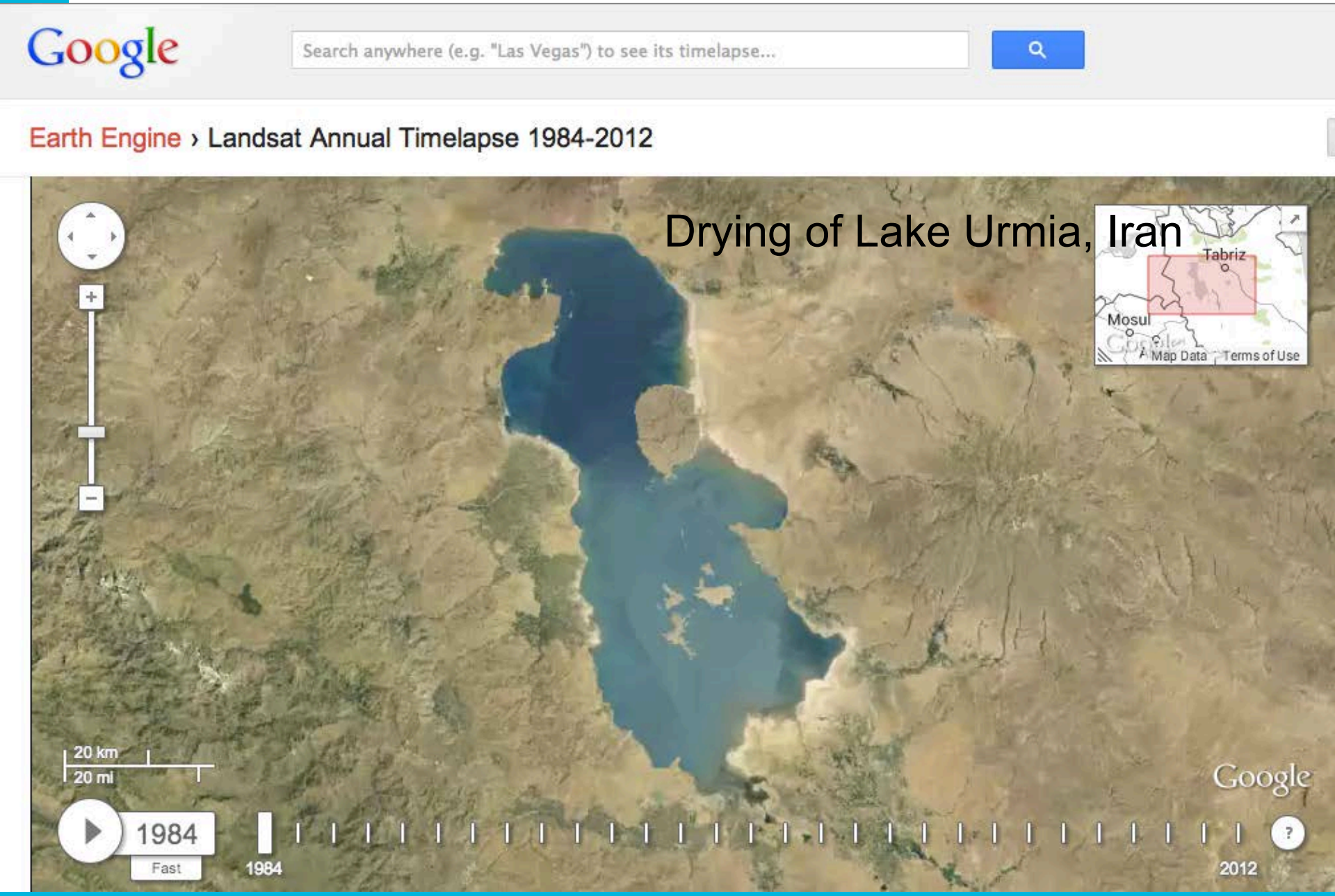
https://www.youtube.com/watch?v=FO6ztYUAvhY

NDVI=(NIR-Red) / (NIR+Red)

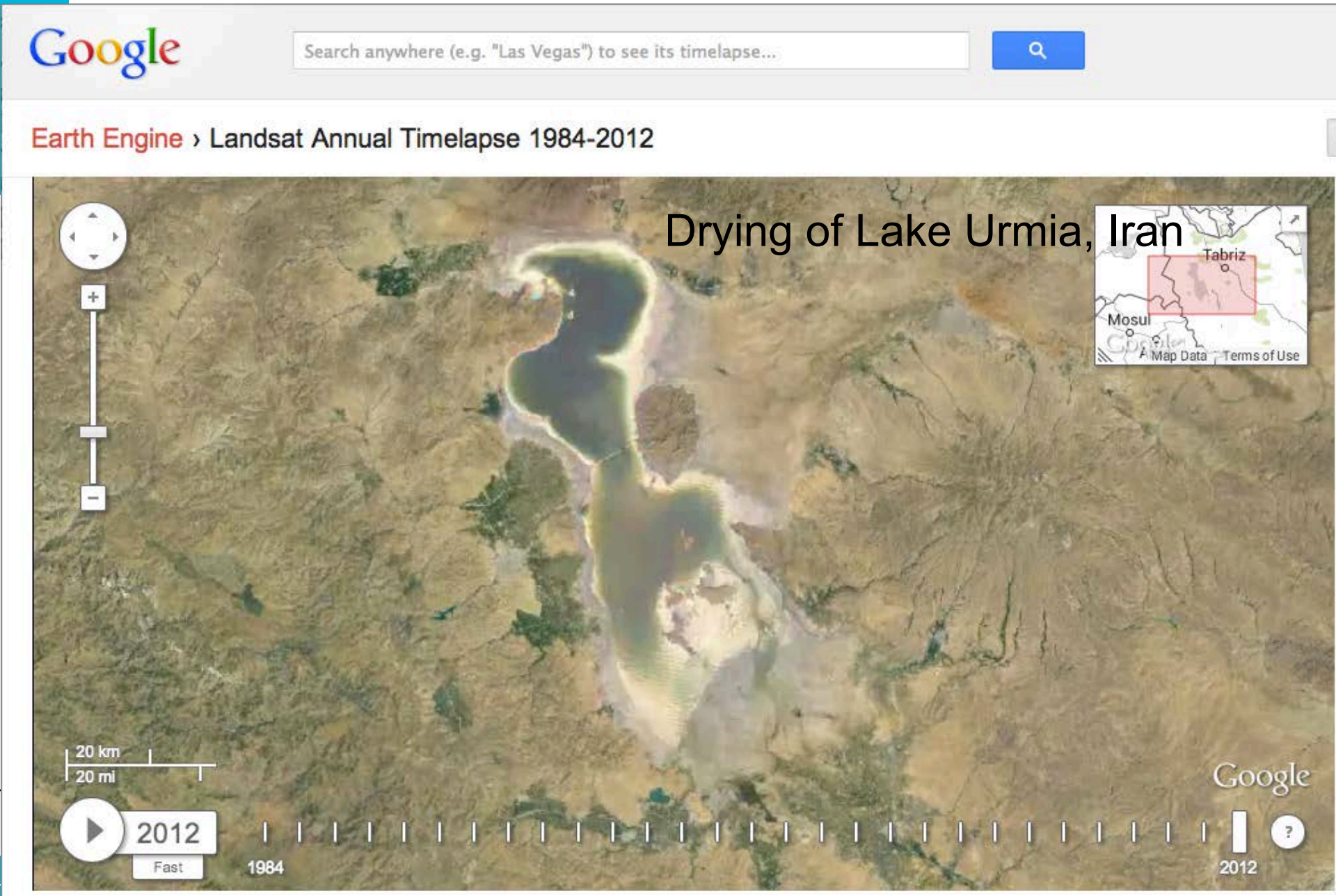
LandSat (1972 -)



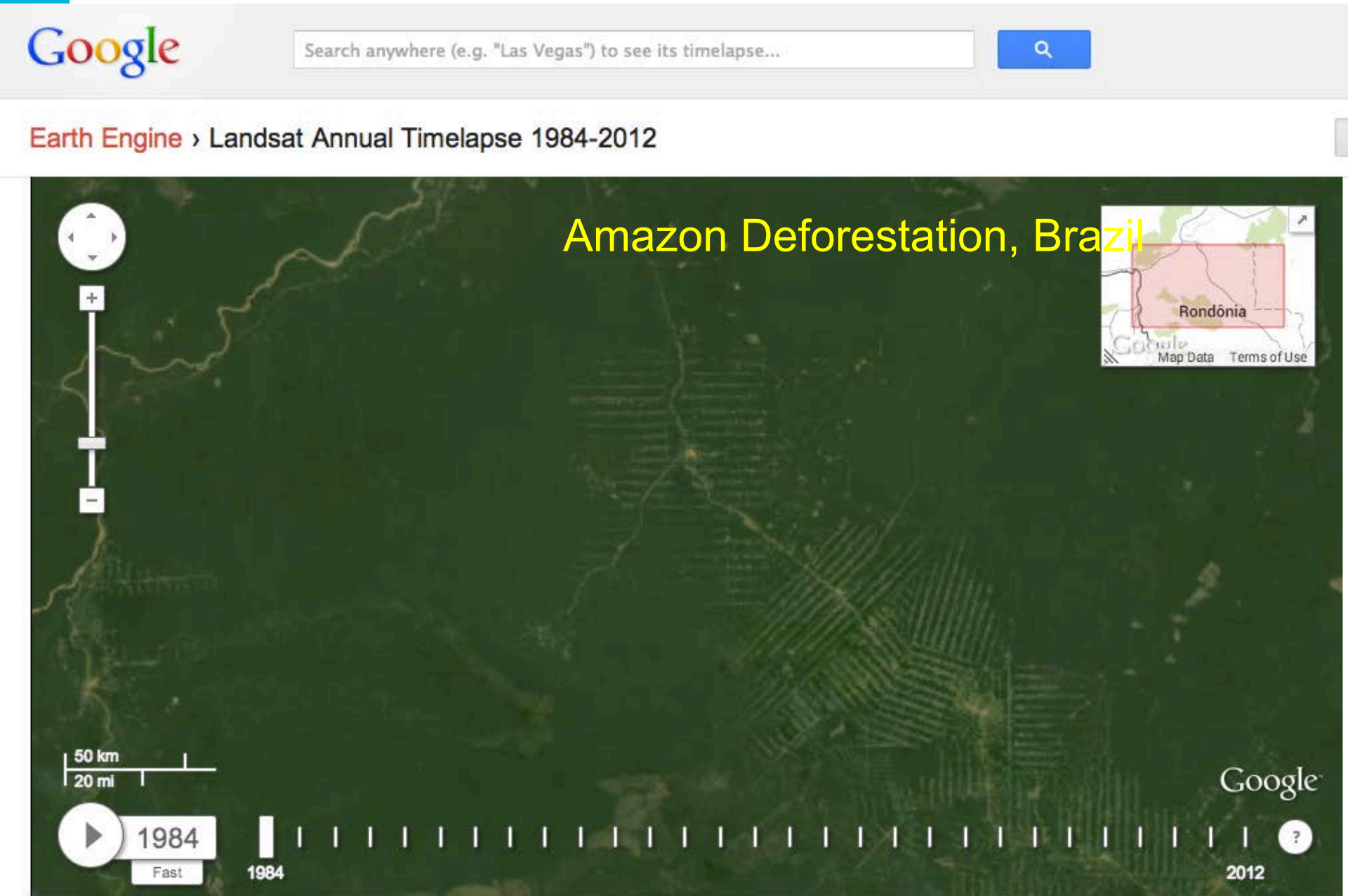
LandSat Archive on Google Earth Engine



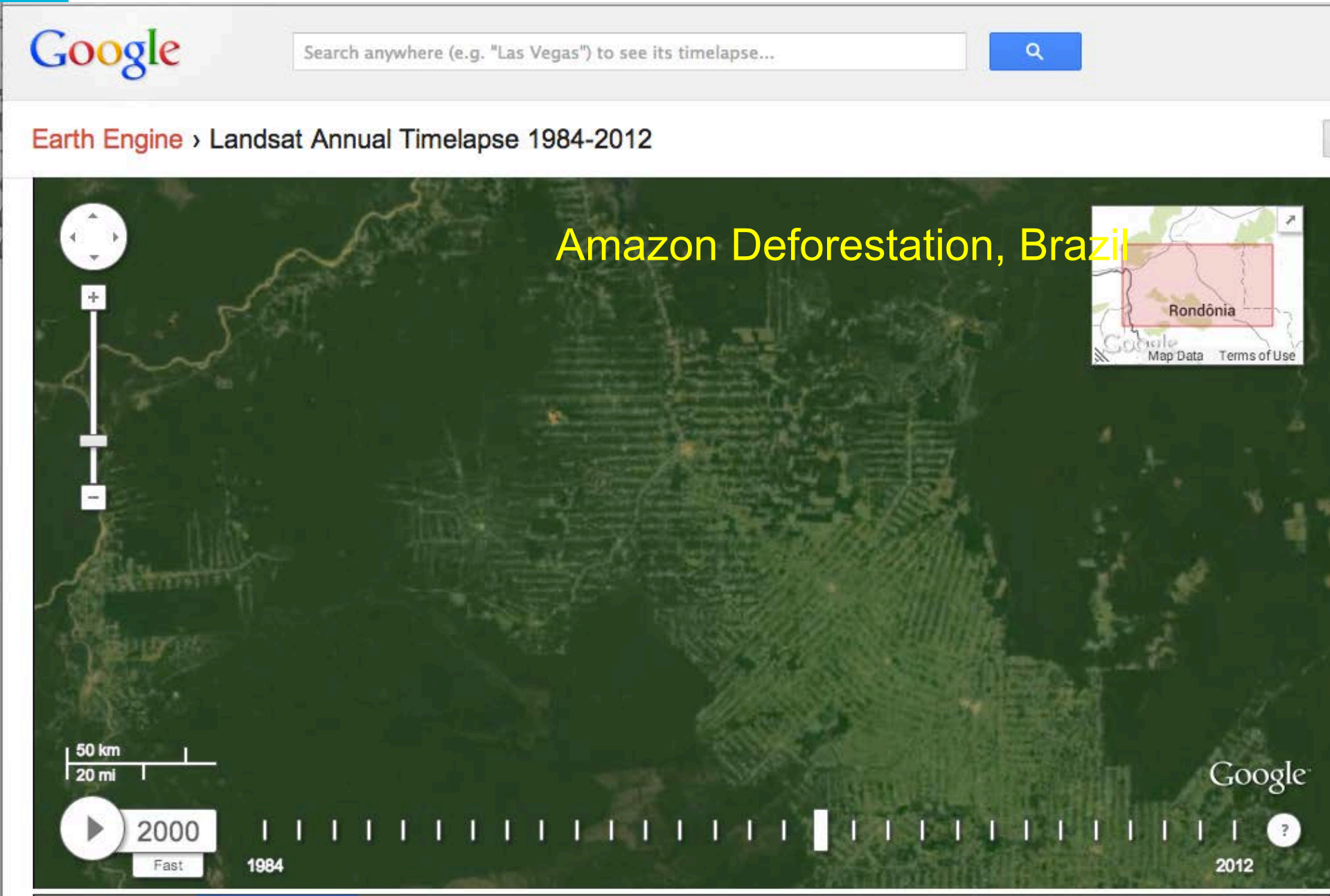
LandSat Archive on Google Earth Engine



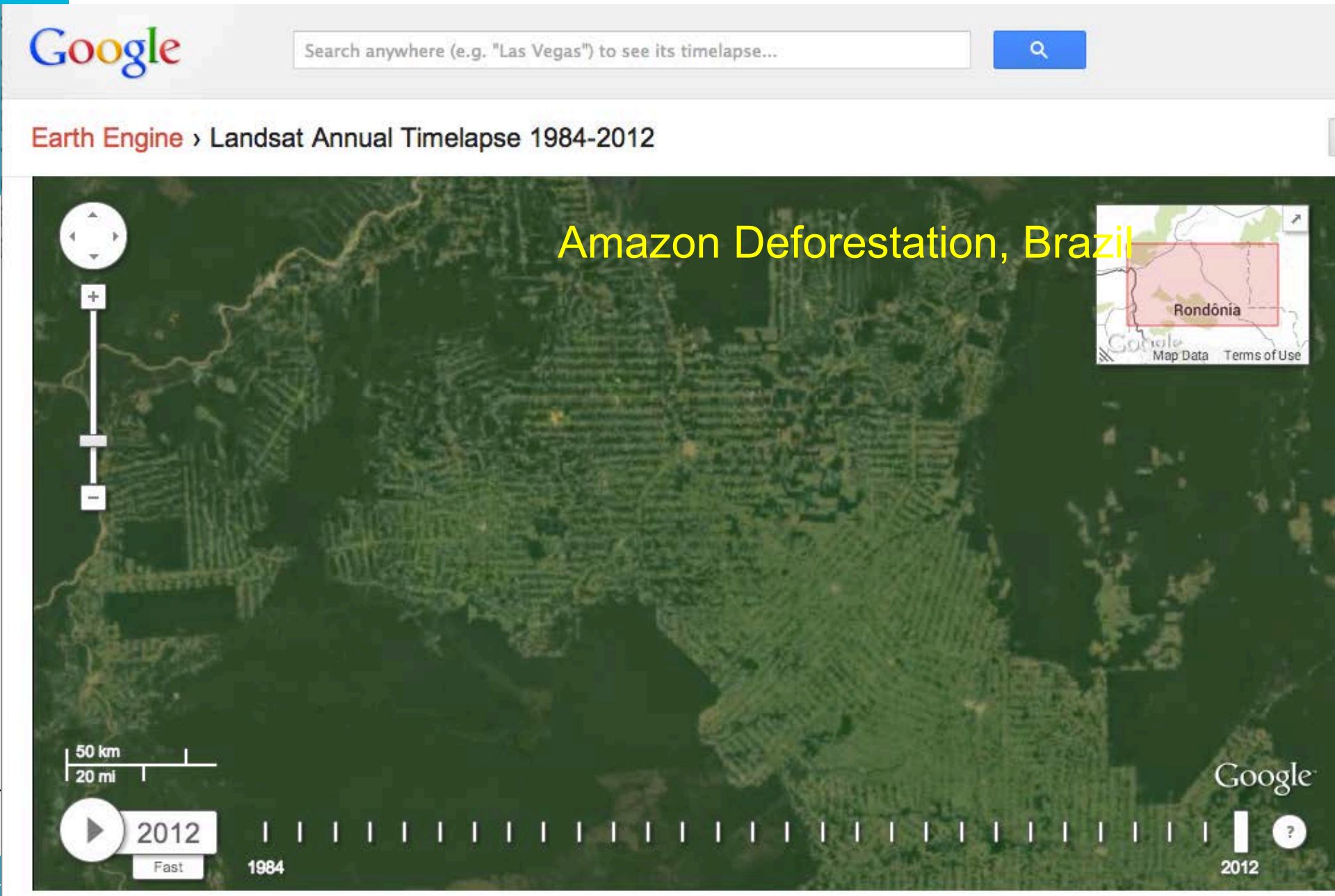
LandSat Archive on Google Earth Engine



LandSat Archive on Google Earth Engine



LandSat Archive on Google Earth Engine



LandSat Archive on Google Earth Engine

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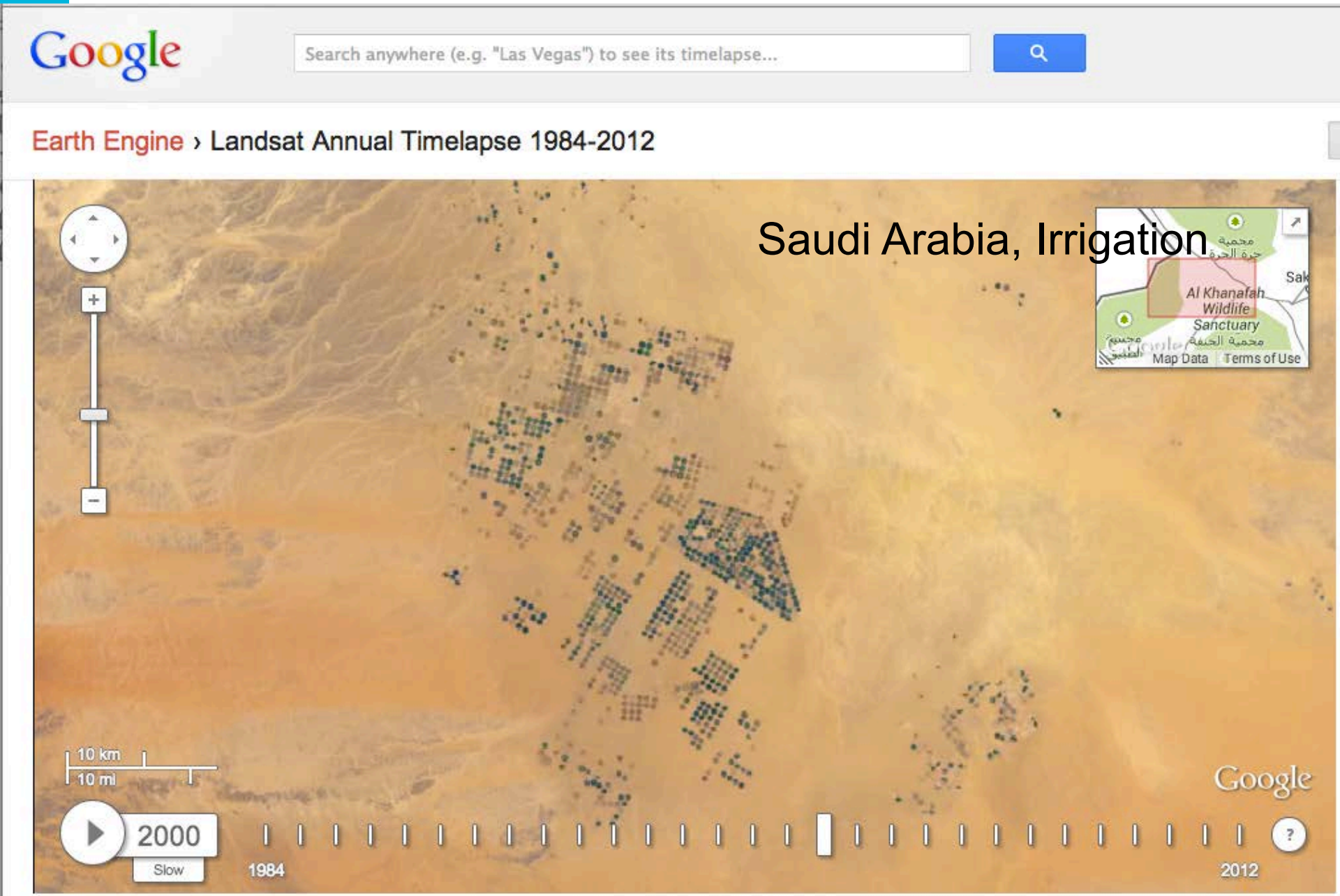
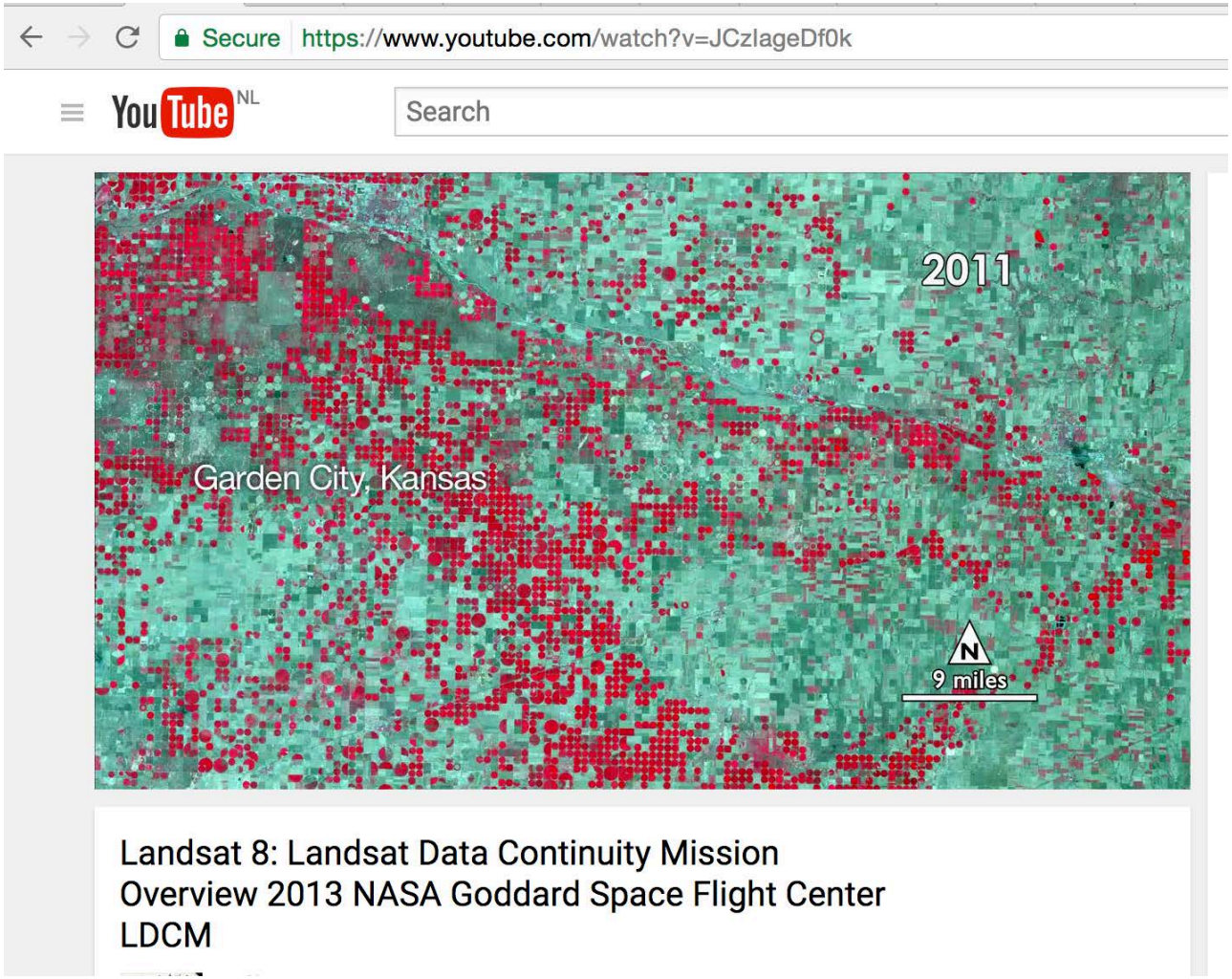


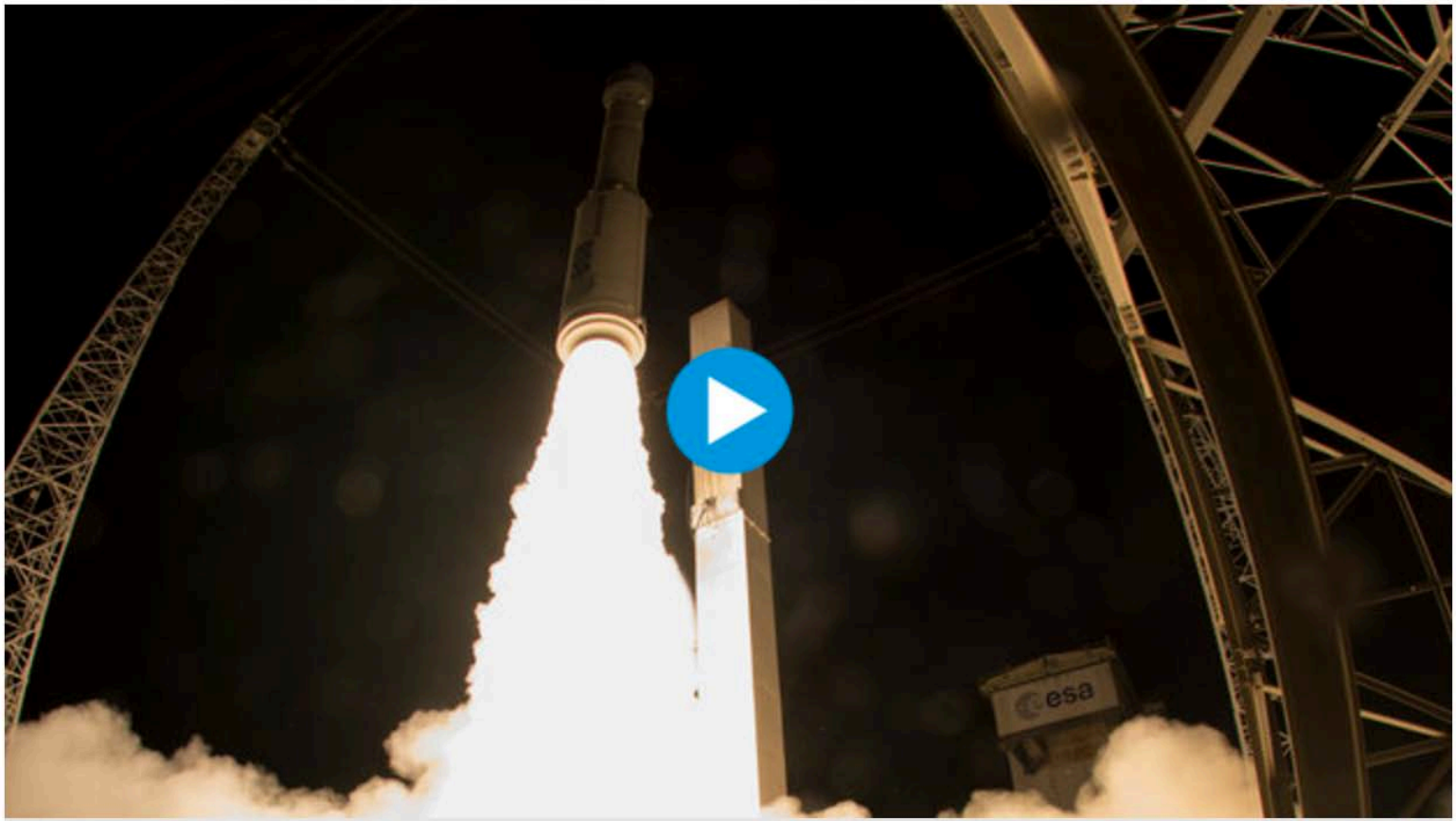
LandSat Archive on Google Earth Engine

LandSat8



https://www.youtube.com/watch?v=JCzIageDf0k

ESA's Sentinel-2

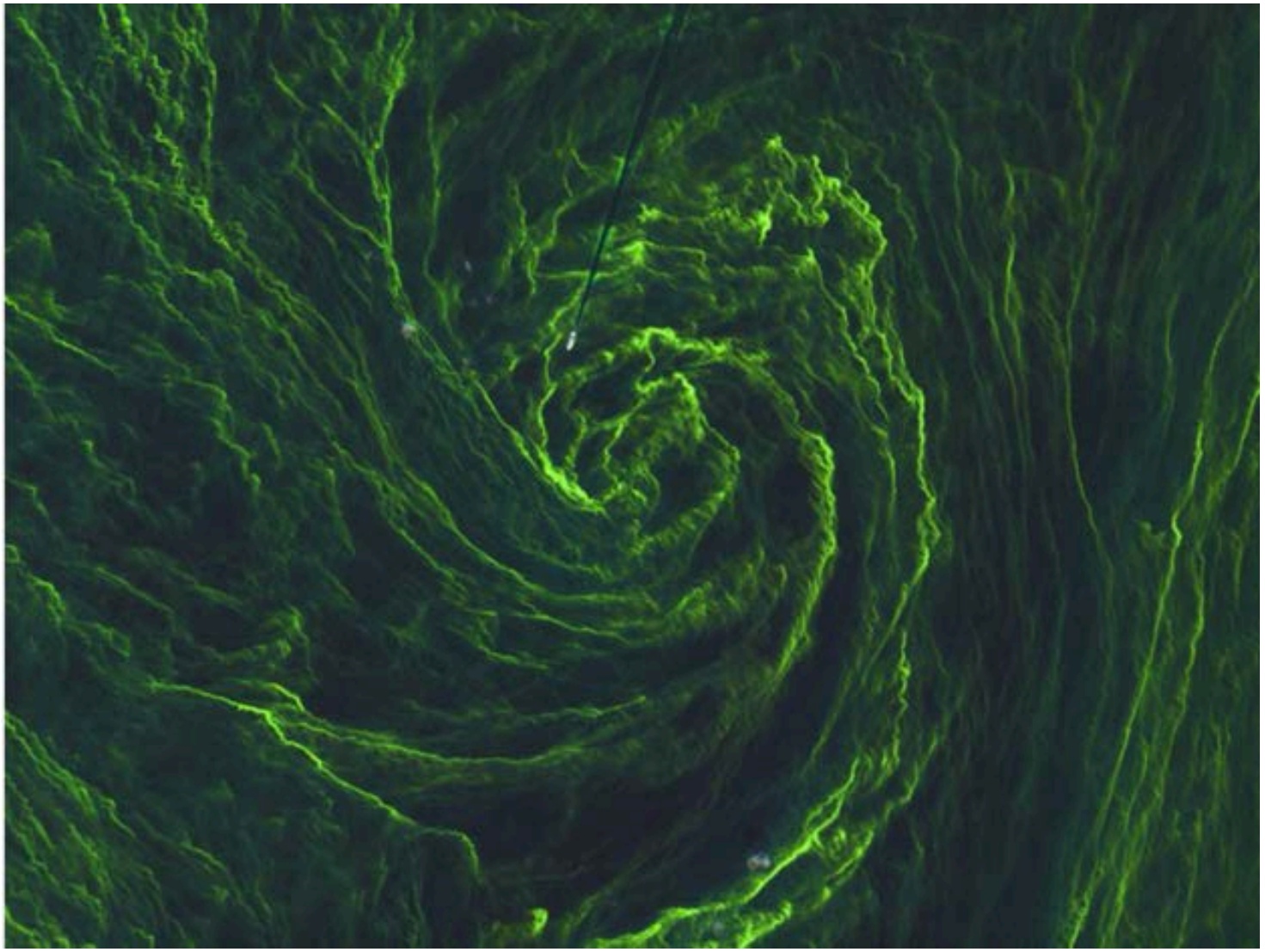


Sentinel-2B liftoff

Access the video

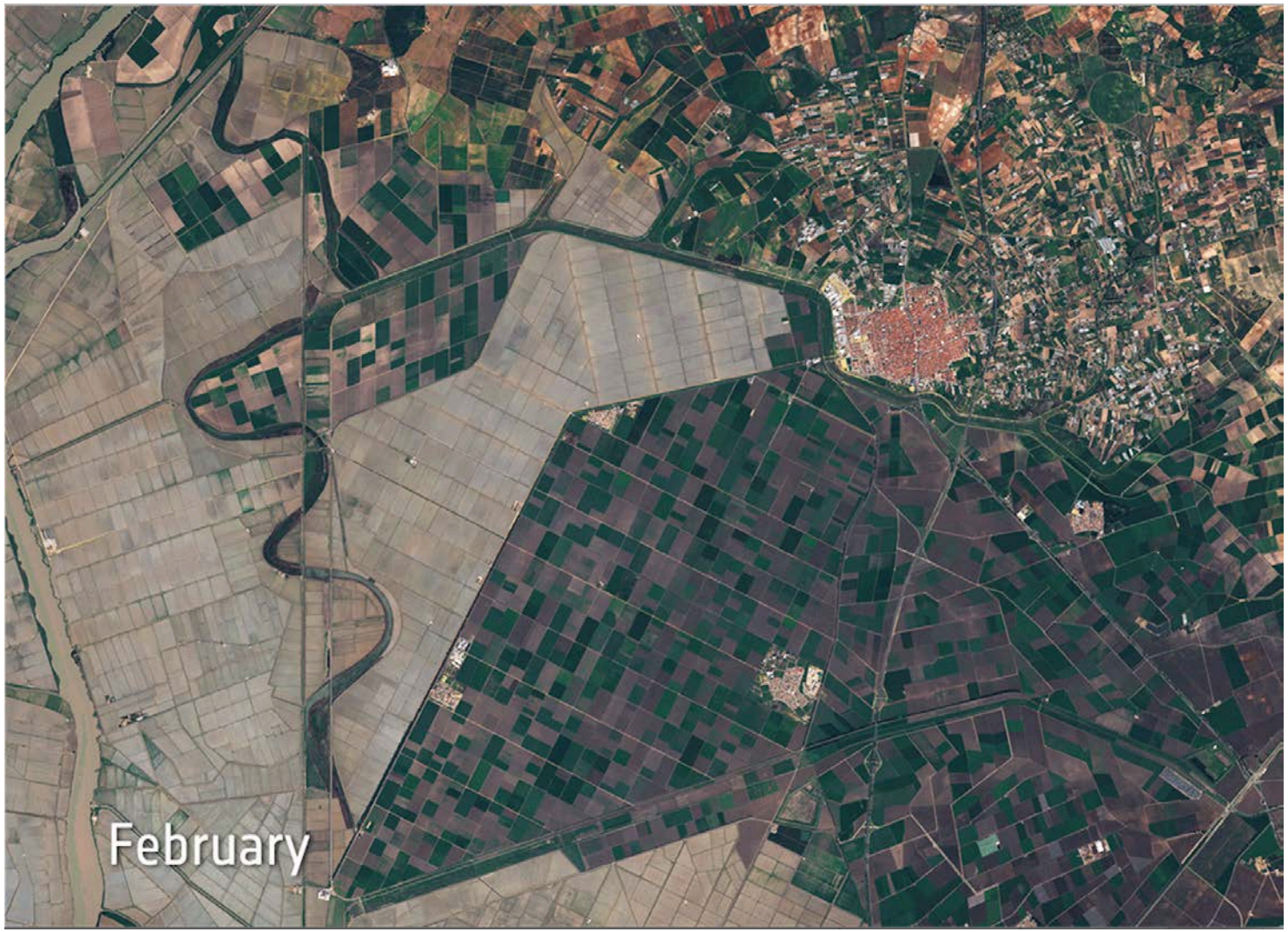
SECOND 'COLOUR VISION' SATELLITE FOR COPERNICUS LAUNCHED

ESA's Sentinel-2 catches eye of algal storm



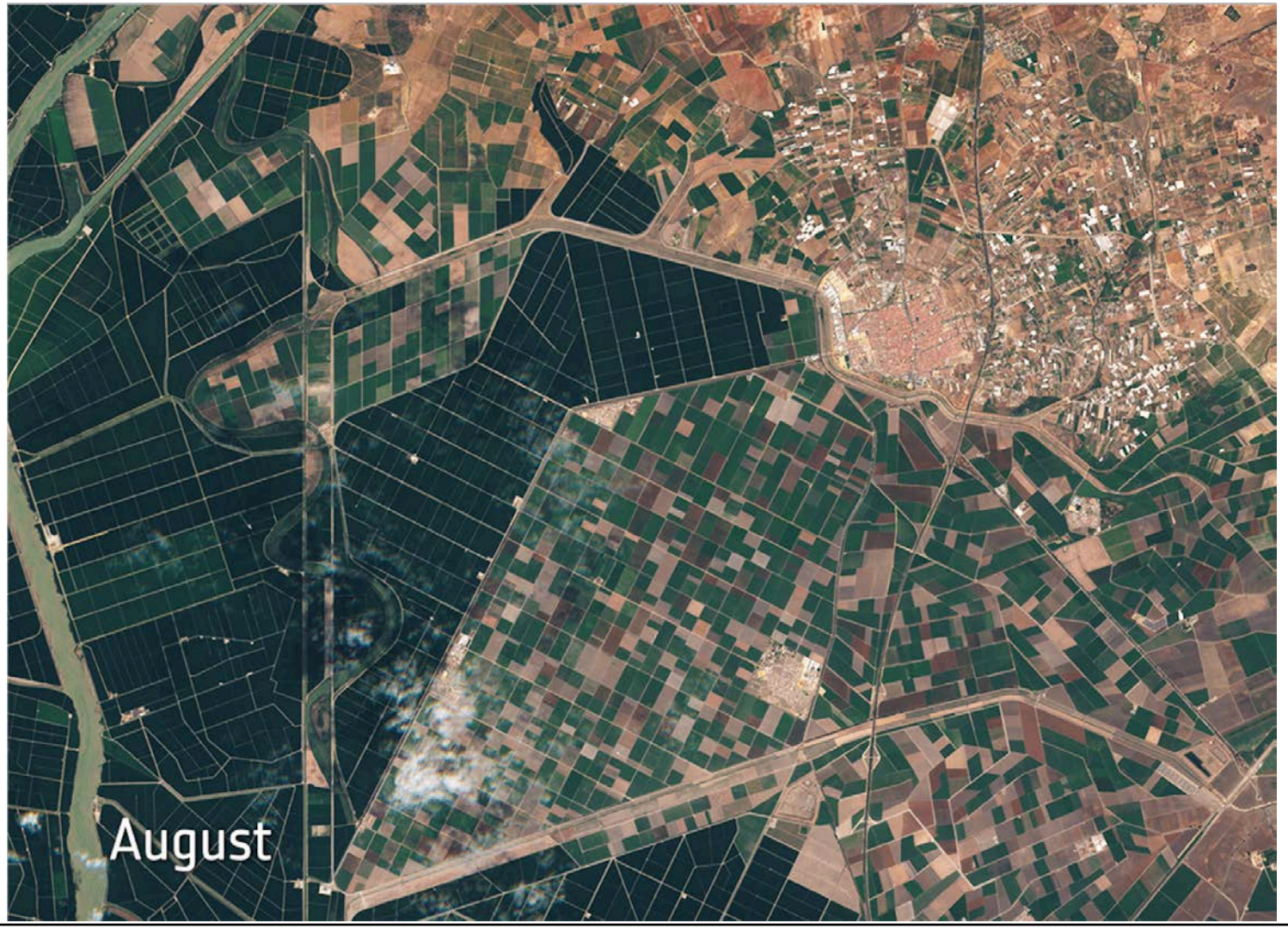
http://www.esa.int/Our_Activities/Observing_the_Earth/Copernicus/Sentinel-2/Sentinel-2_catches_eye_of_algal_storm

ESA's Sentinel-2 Agricultural Monitoring in Spain



ESA's Sentinel-2 Agricultural Monitoring in Spain

ESA's Sentinel-2 Agricultural Monitoring in Spain



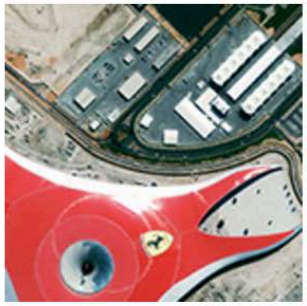
Commercial data

High Resolution Satellite Images (0.31m - 2m)

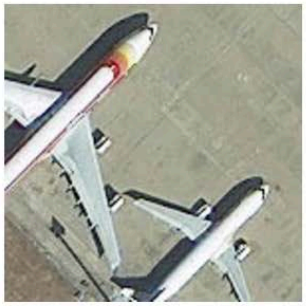
2016

Click on any of the following satellite images to view their galleries.

GeoEye-1 (0.5m)



WorldView-3 (0.31m)

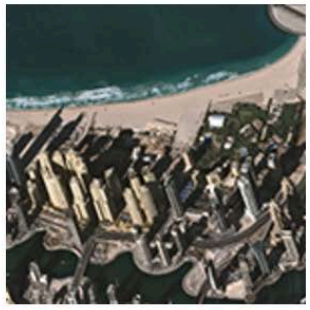


WorldView-2 (0.5m)

WorldView-1 (0.5m)

Pleiades-1A (0.5m)

Pleiades-1B (0.5m)



http://www.satimagingcorp.com/gallery/

Satellite Data Portal from NSO

Image Analysis

Image Analysis

Image Analysis

Image => Matrix

Row => Horizontal line

Column => Vertical line

Entry => Picture element (pixel)

Image Analysis

Pre-processing:

- Georeferencing
- Atmospheric correction
- Image enhancement

Processing

- NDVI
- Surface temperature
- Classification

Image Analysis: Color composite

Pixel => Number (DN), greyscale

Image Analysis: Color composite

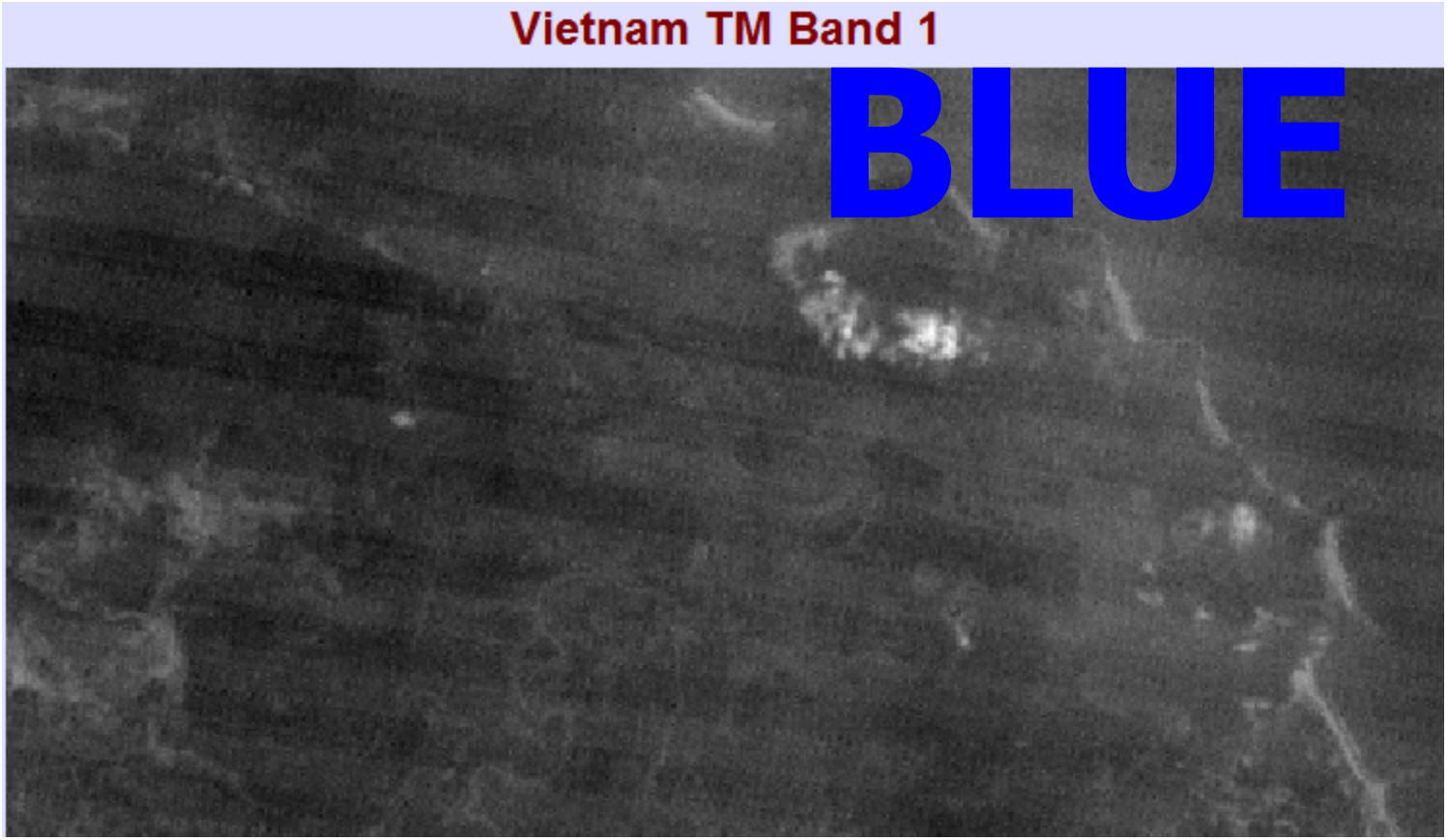


Image Analysis: Color composite

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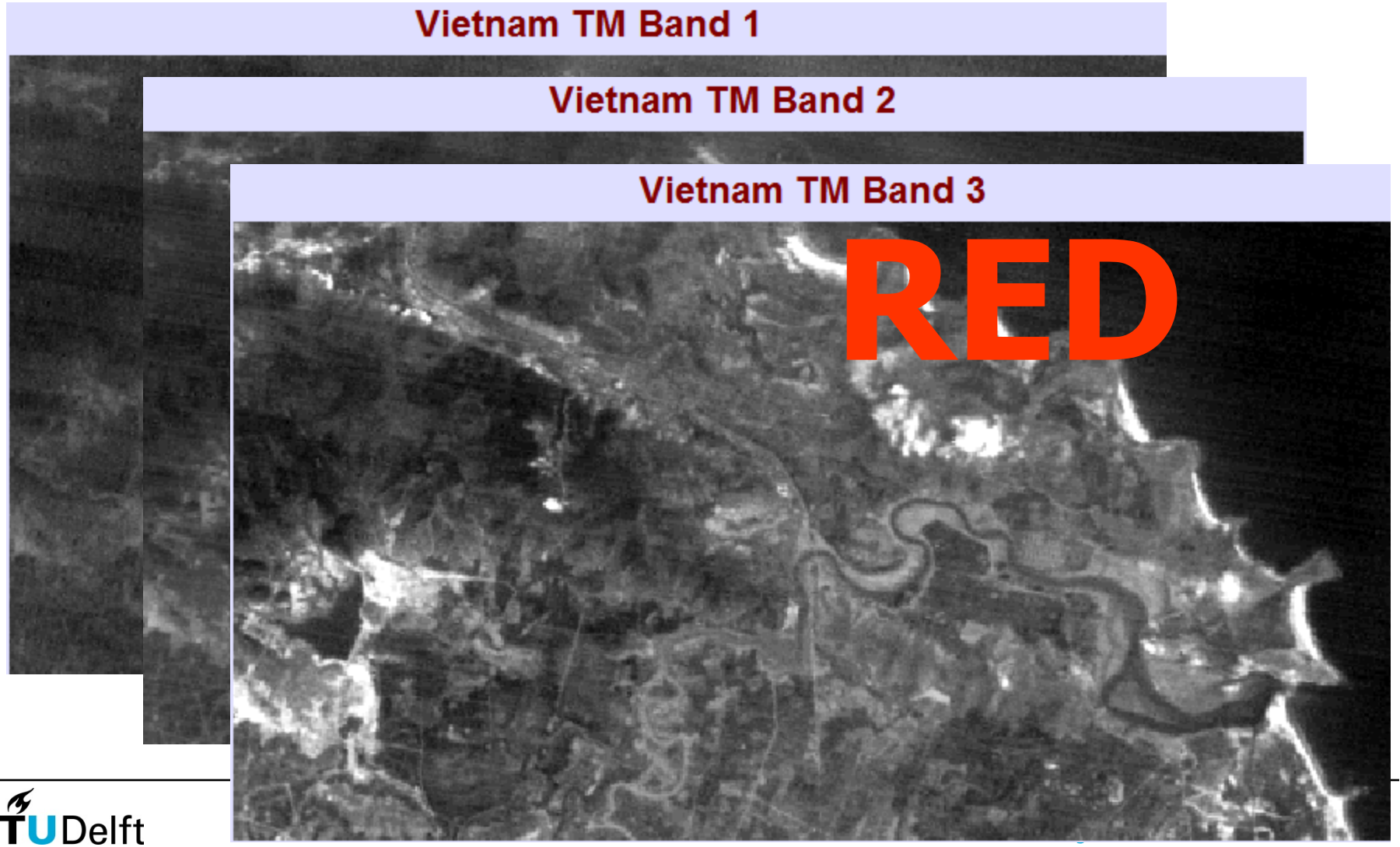

Image Analysis: Color composite

"Natural color"

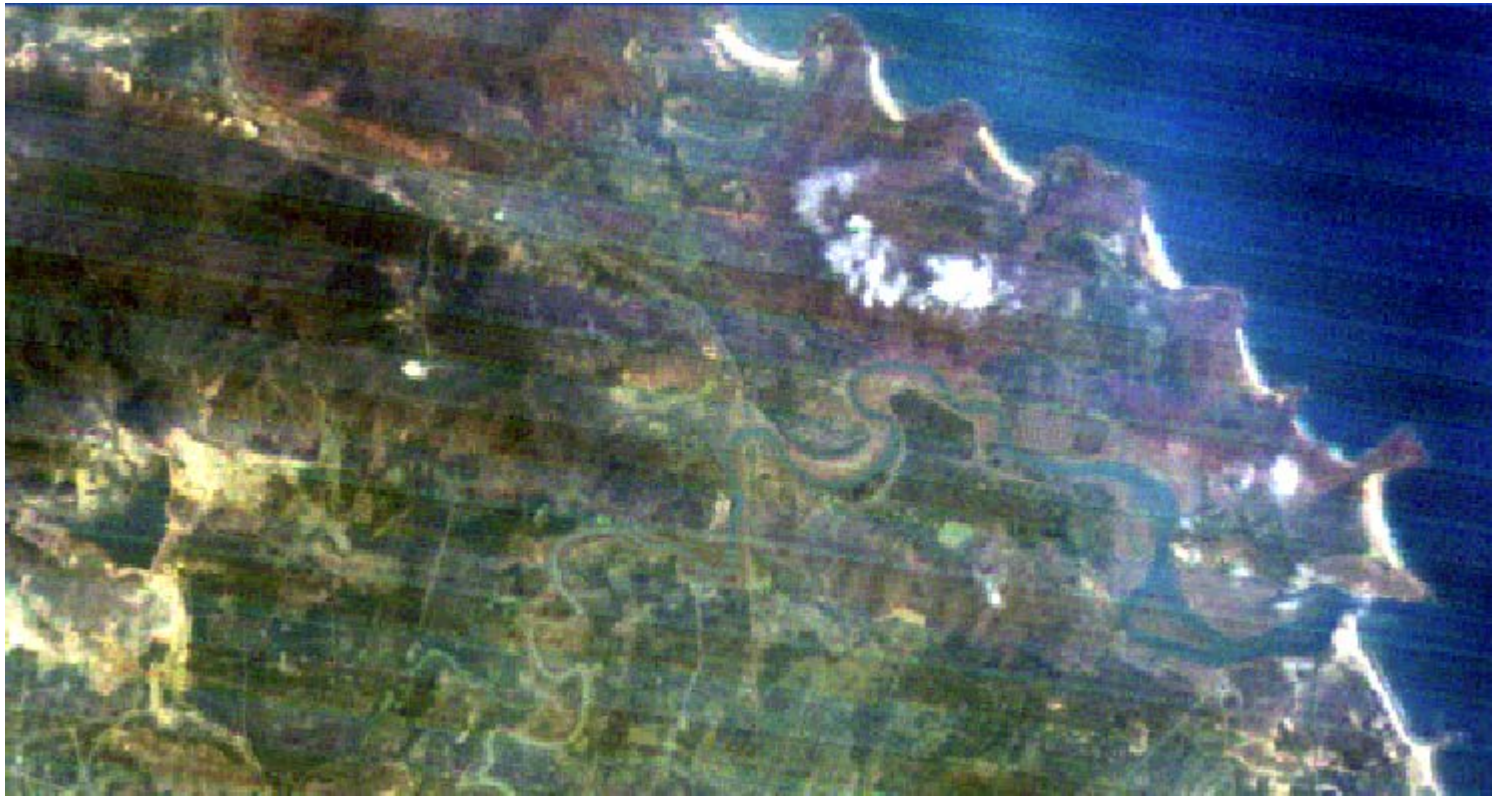

Image Analysis: Color composite

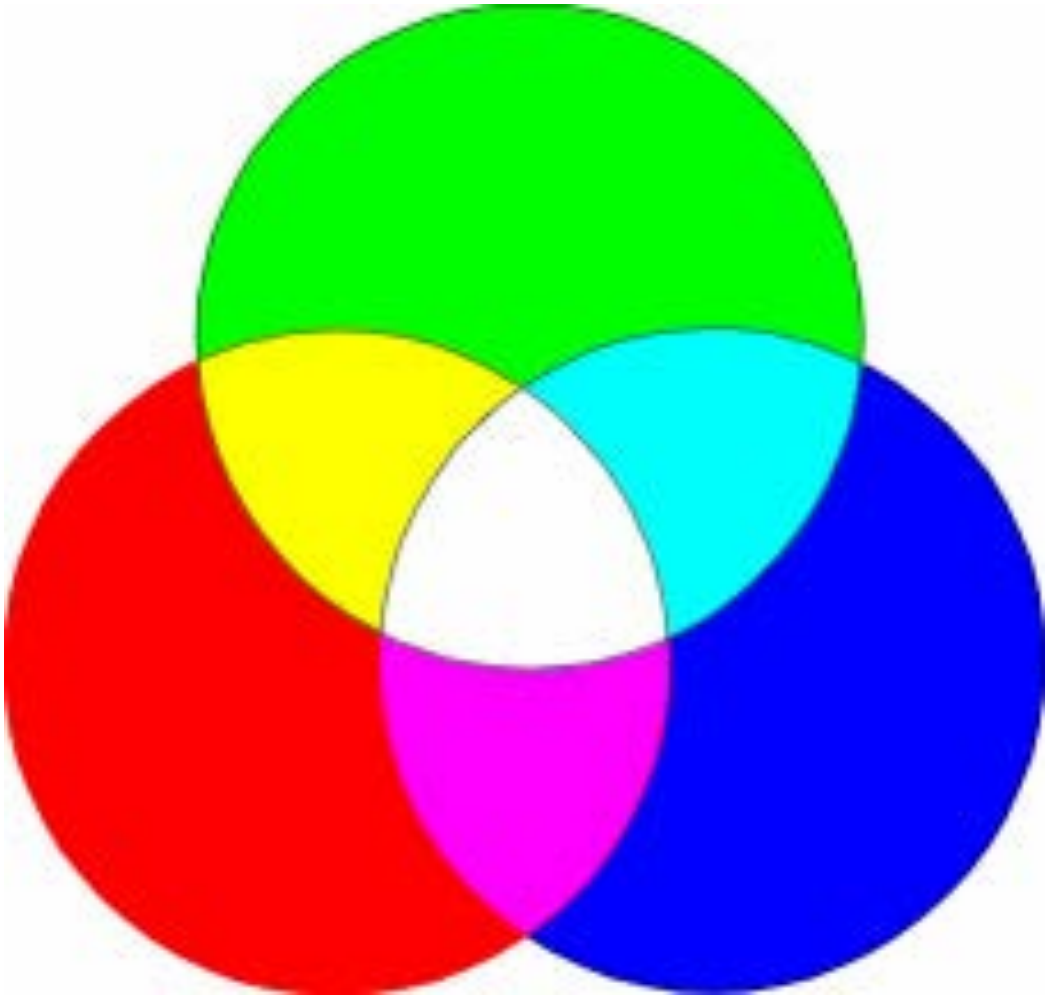

Image Analysis: Color composite

Image Analysis: Color composite

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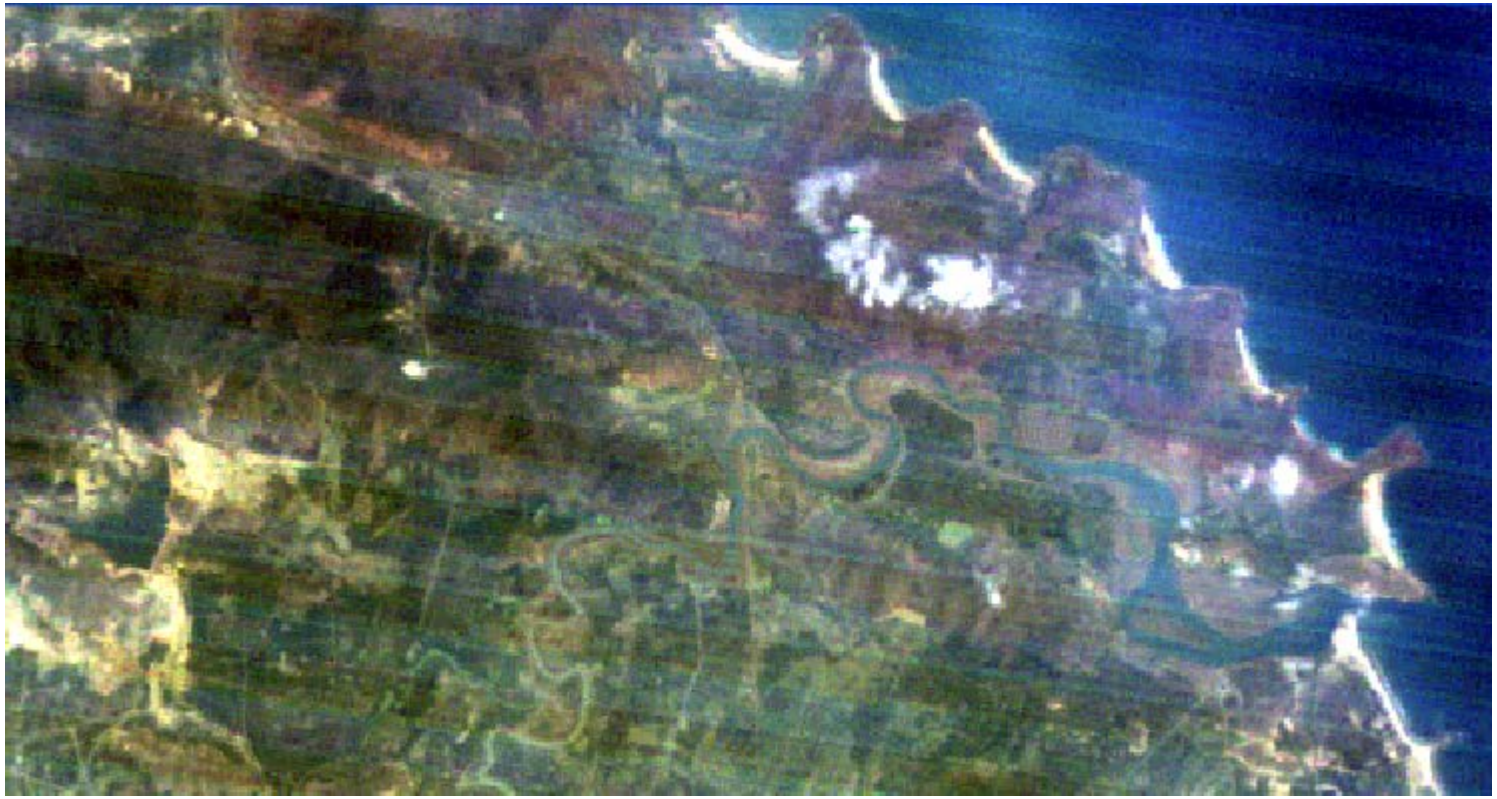

Image Analysis: Color Composites

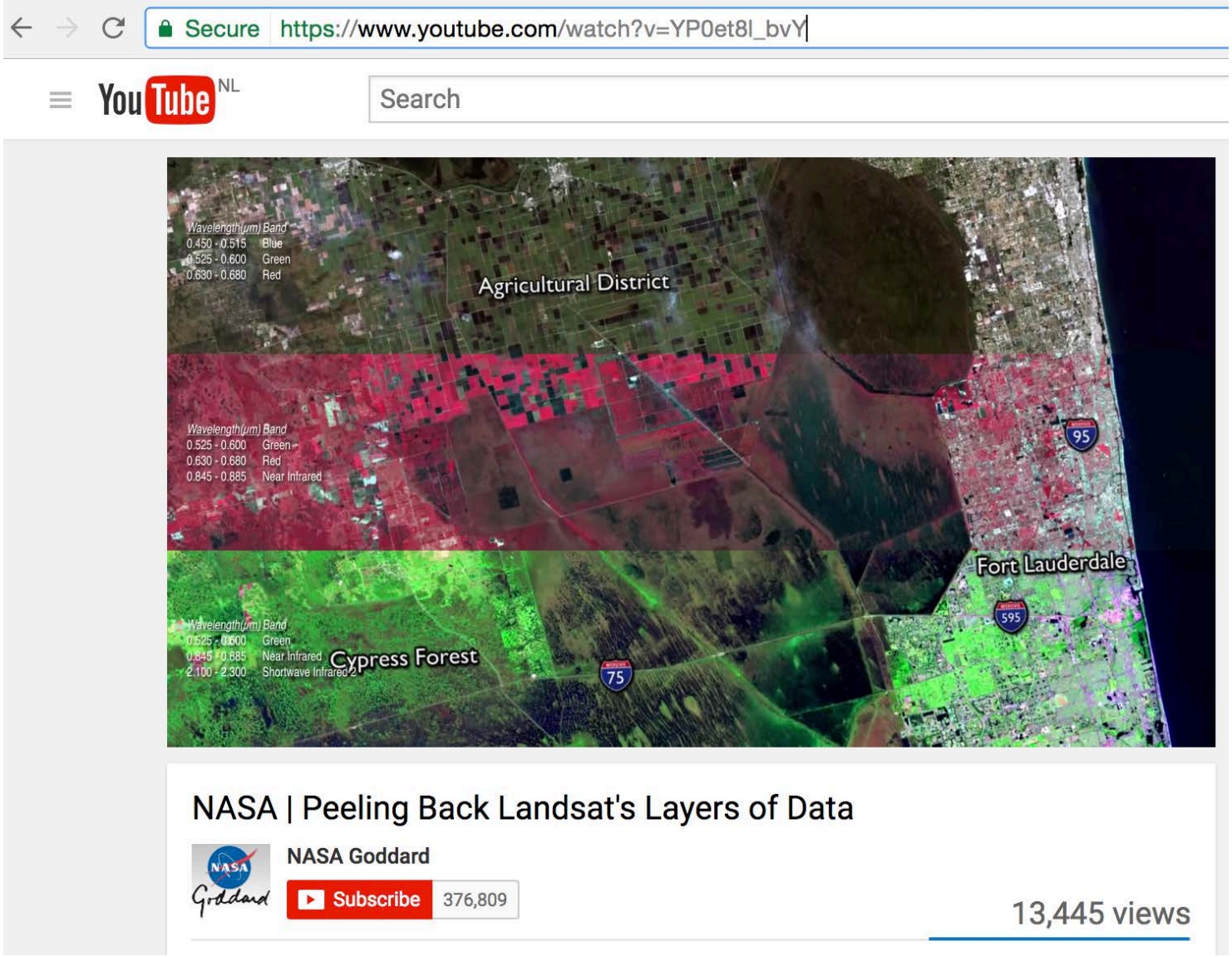

Image Analysis: Color Composites

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Image Analysis: Color Composites

Landsat 7 (ETM+) bands
(wavelengths in micrometers)

Band 1	0.45-0.52	Blue-Green
Band 2	0.53-0.61	Green (often mapped to Blue)
Band 3	0.63-0.69	Red (often mapped to Green)
Band 4	0.75-0.90	Near IR (often mapped to Red)
Band 5	1.55-1.75	Mid-IR
Band 6	10.4-12.5	Thermal IR
Band 7	2.09-2.35	Short Wave IR
Band 8	0.52-0.90	Panchromatic

Image Analysis: Map Algebra

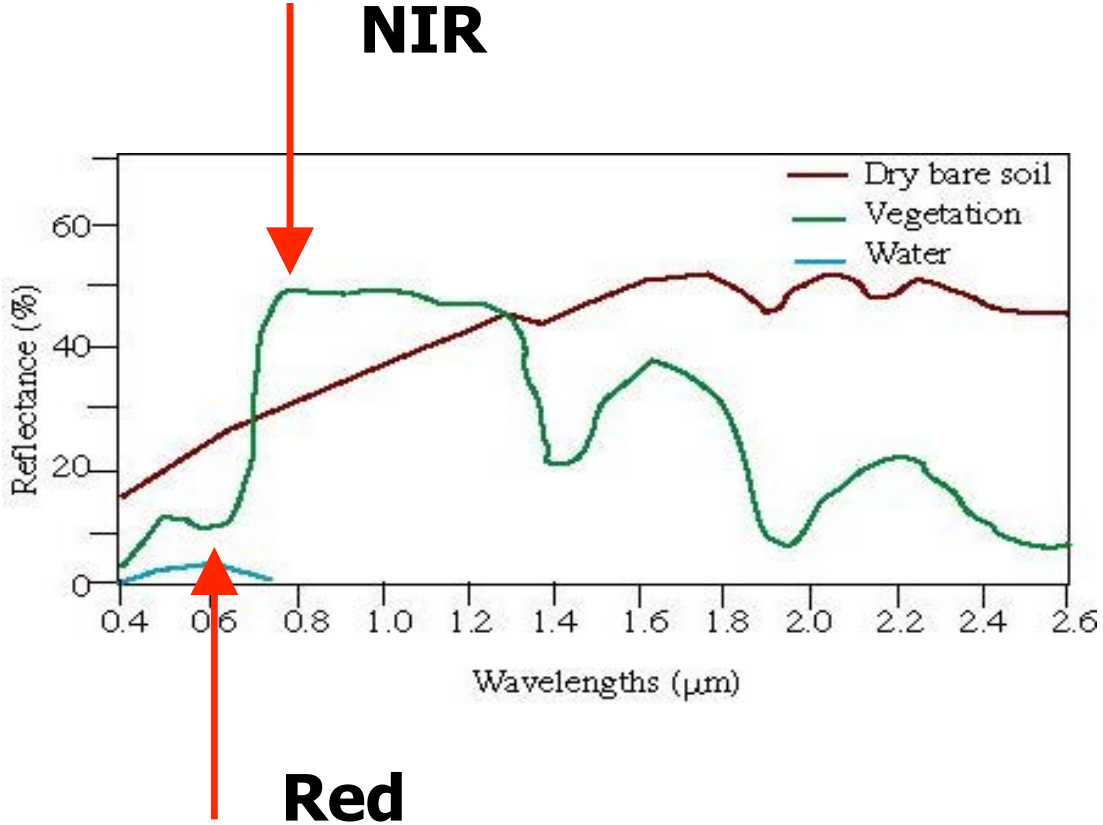
Operators

Multiply, add, subtract, …

If …, then … (Boolean)

Convolution / filters

Image Analysis: Map Algebra



NDVI=(NIR-Red) / (NIR+Red)

Image Analysis: Map Algebra

Red

Vietnam TM Band 3

Image Analysis: Map Algebra

Near Infrared (NIR)

Vietnam TM Band 4

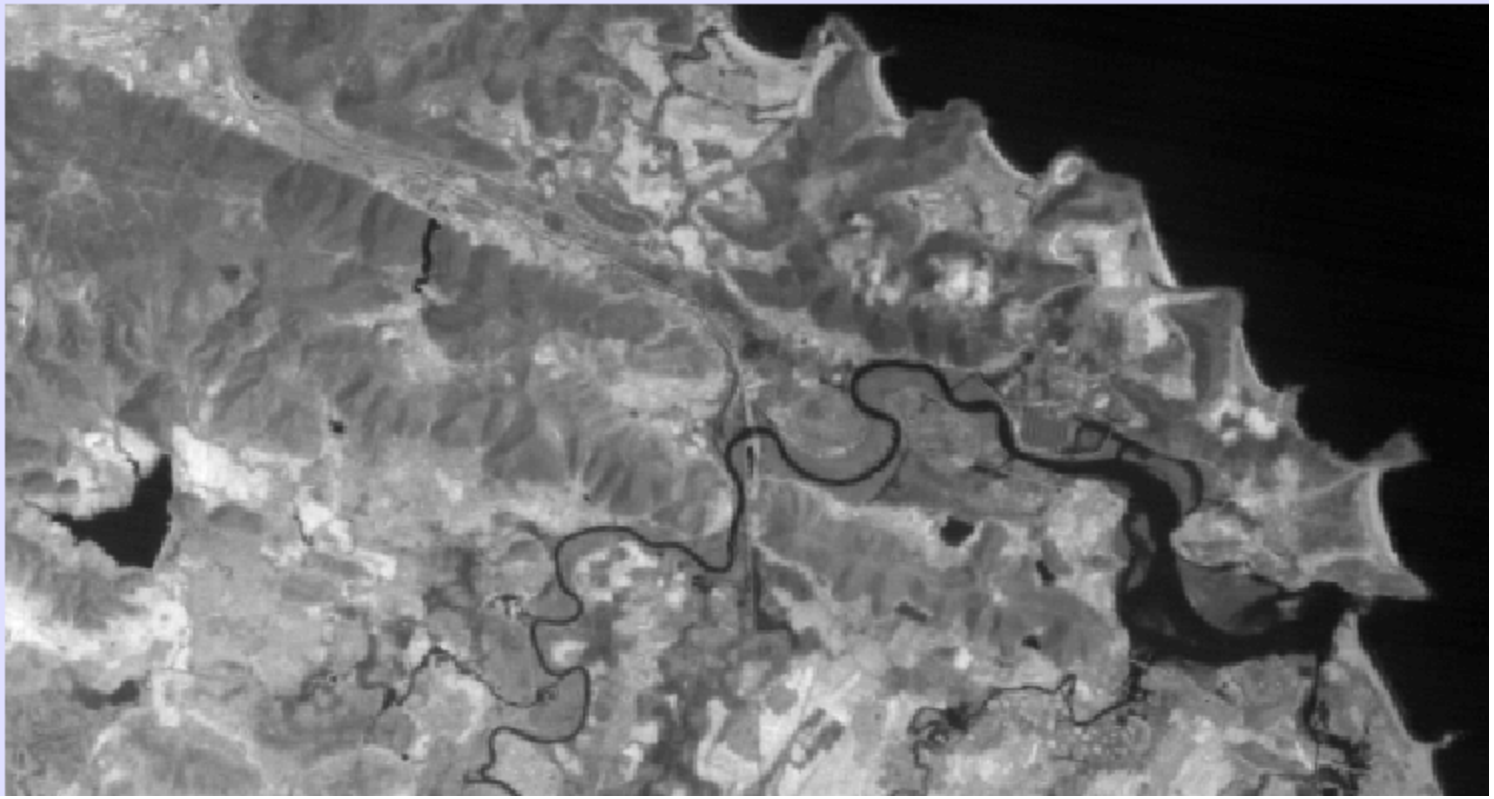


Image Analysis: Map Algebra

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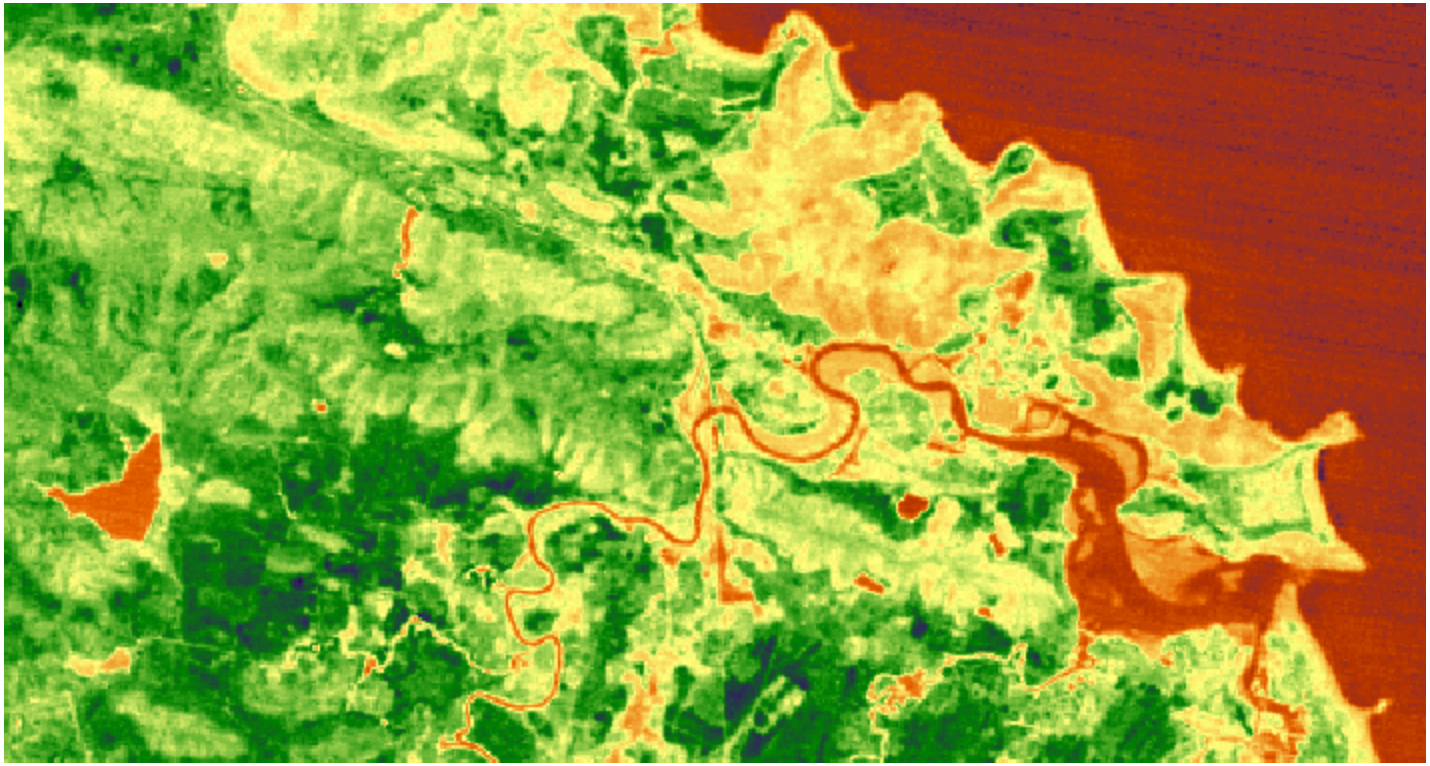


Image Analysis: Map Algebra

Density Slice Classification

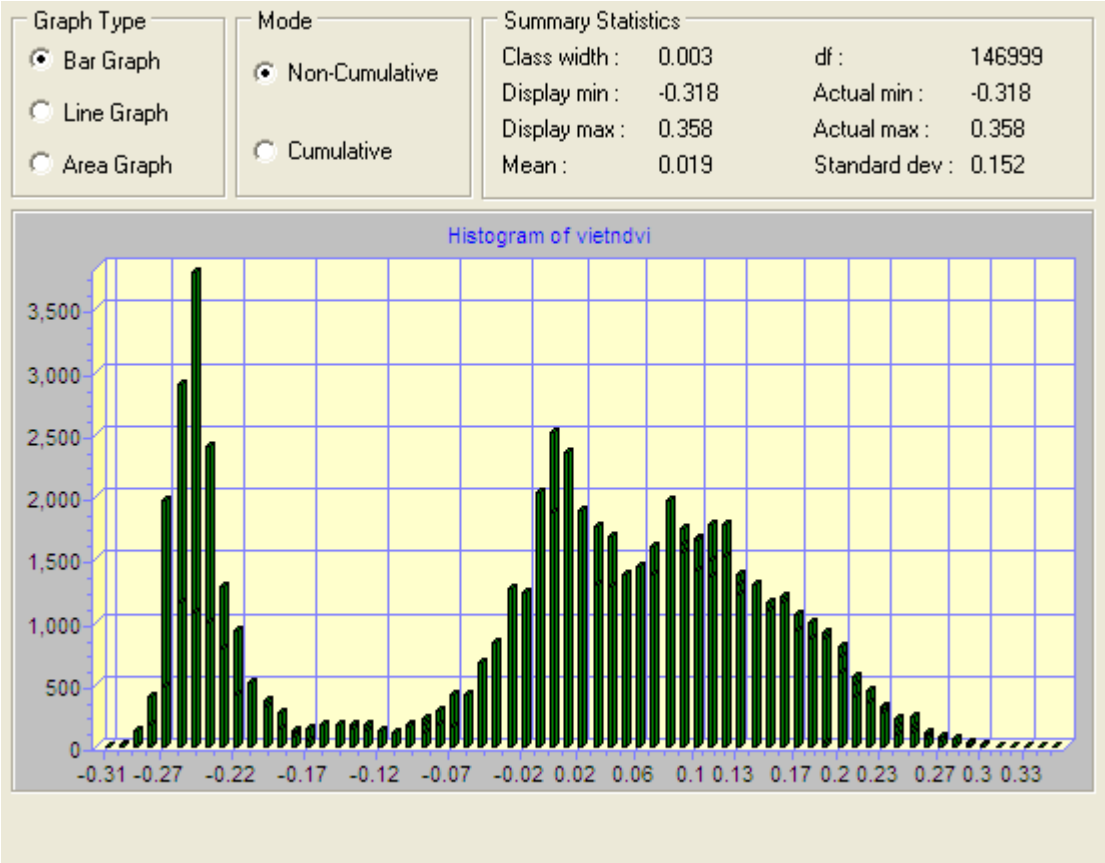


Image Analysis: Map Algebra

Density Slice Classification

NDVI<-0.15 => Water

NDVI>-0.15 => Other

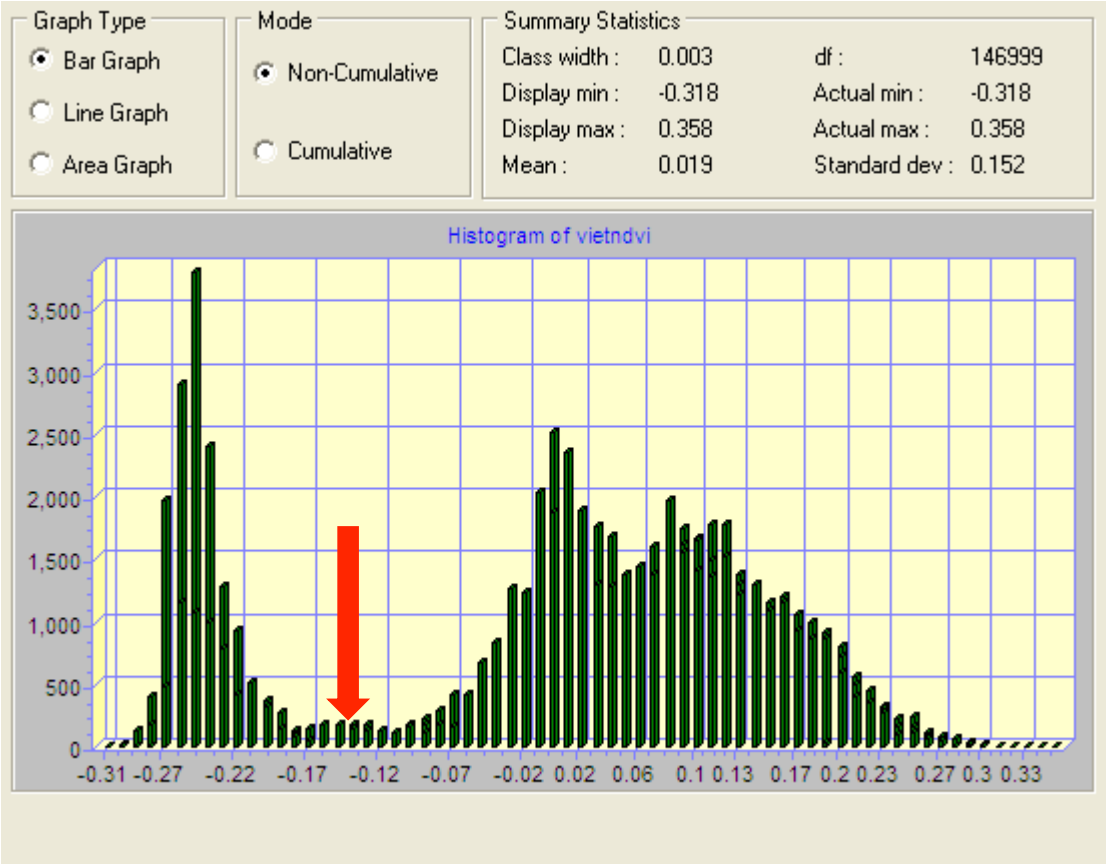


Image Analysis: Map Algebra

Density Slice Classification

NDVI<-0.15 => Water (Red)

NDVI>-0.15 => Other(Black)

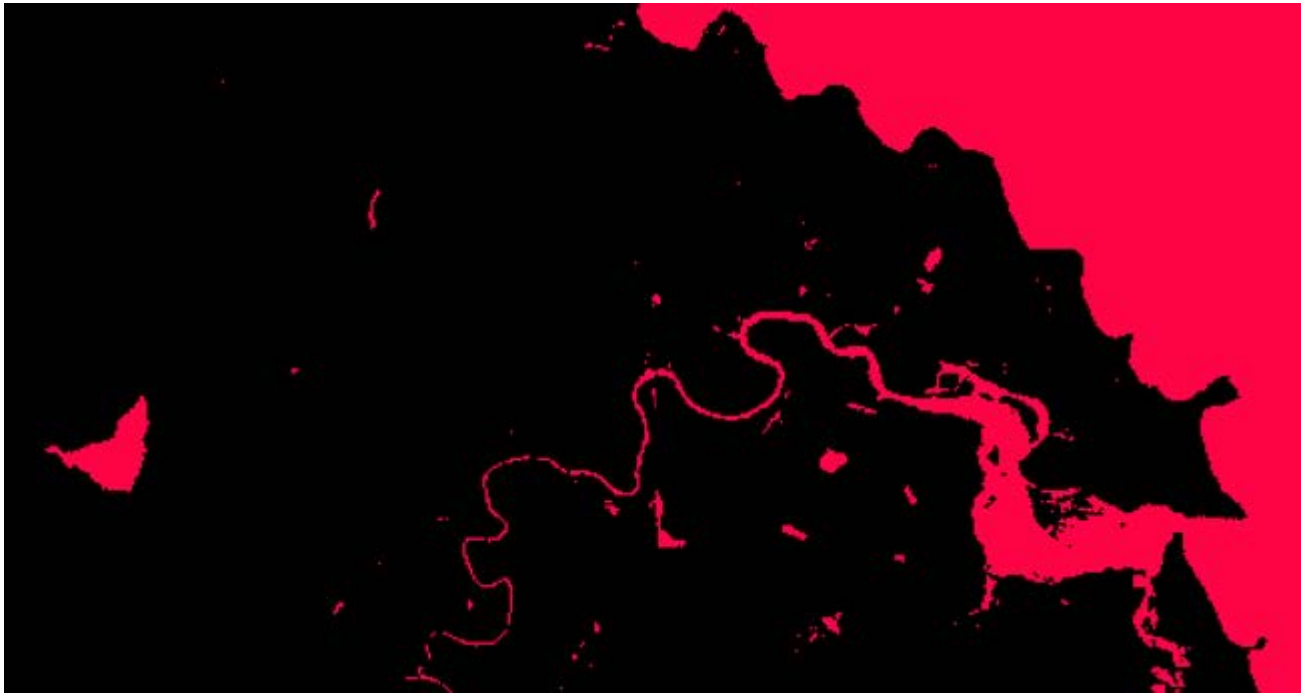


Image Analysis: Classification

- Automatic (cluster analysis)
- **Supervised**
  - Parallelepiped
  - Minimum distance
  - **Maximum Likelihood**

Image Analysis: Classification

Maximum Likelihood Classification

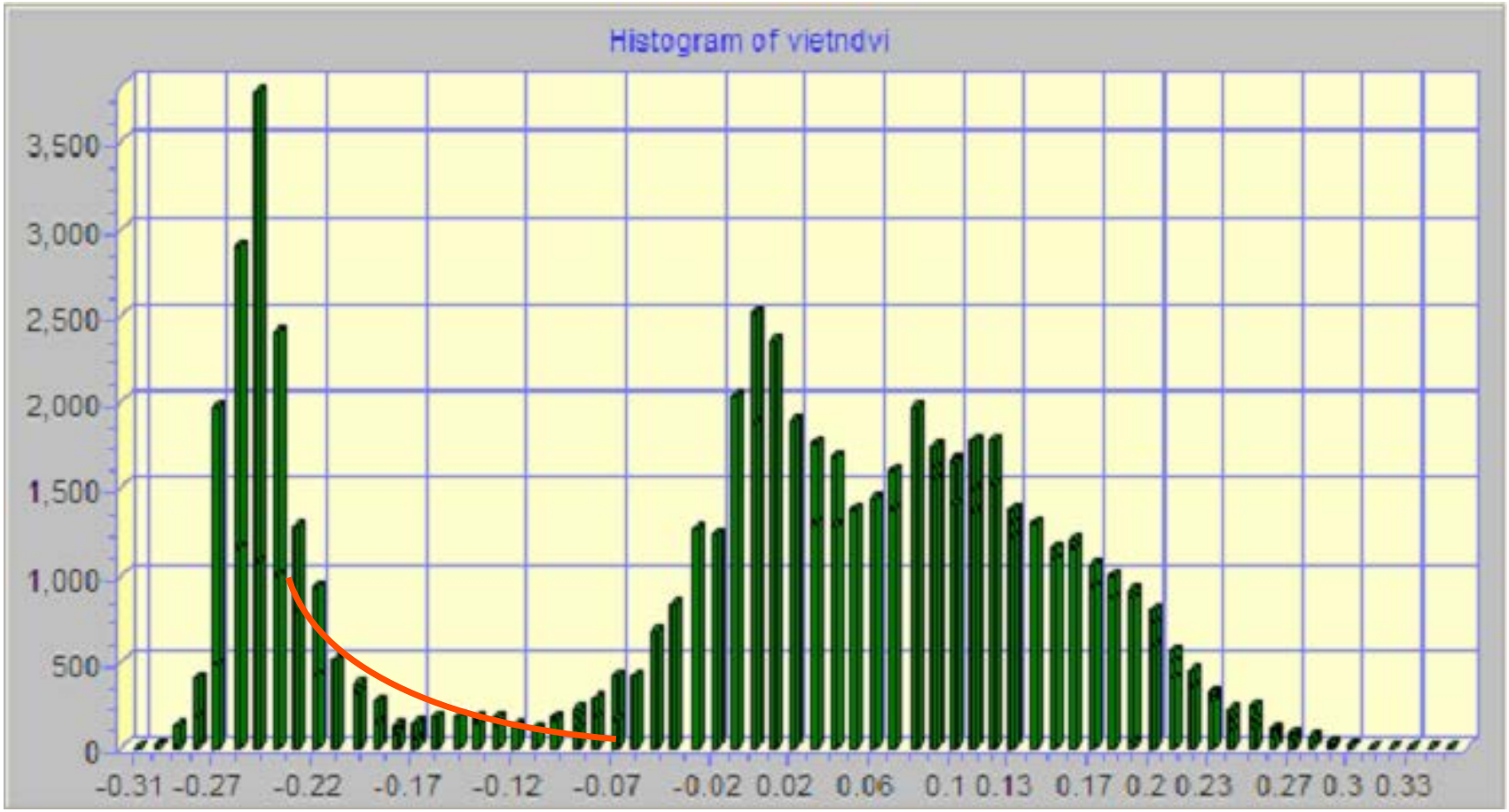


Image Analysis: Classification

Maximum Likelihood Classification

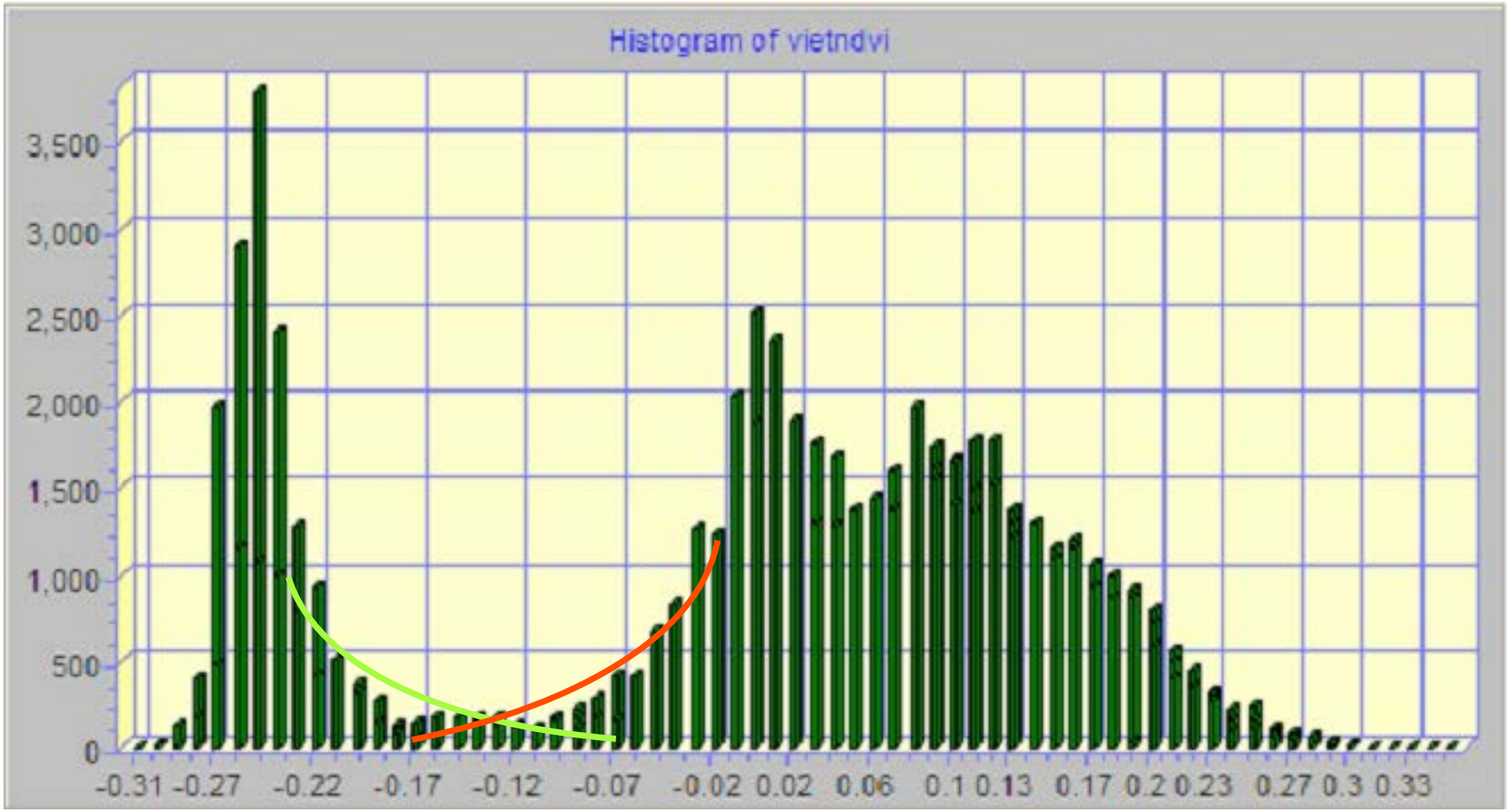


Image Analysis: Classification

Maximum Likelihood Classification

- Multi-band analysis
- Assume normal distribution
- Use training sets => avg, sd, cov
- Determine likelihoods per class (take max)
- Some pixels may remain undetermined

Image Analysis: Classification

Maximum Likelihood Classification

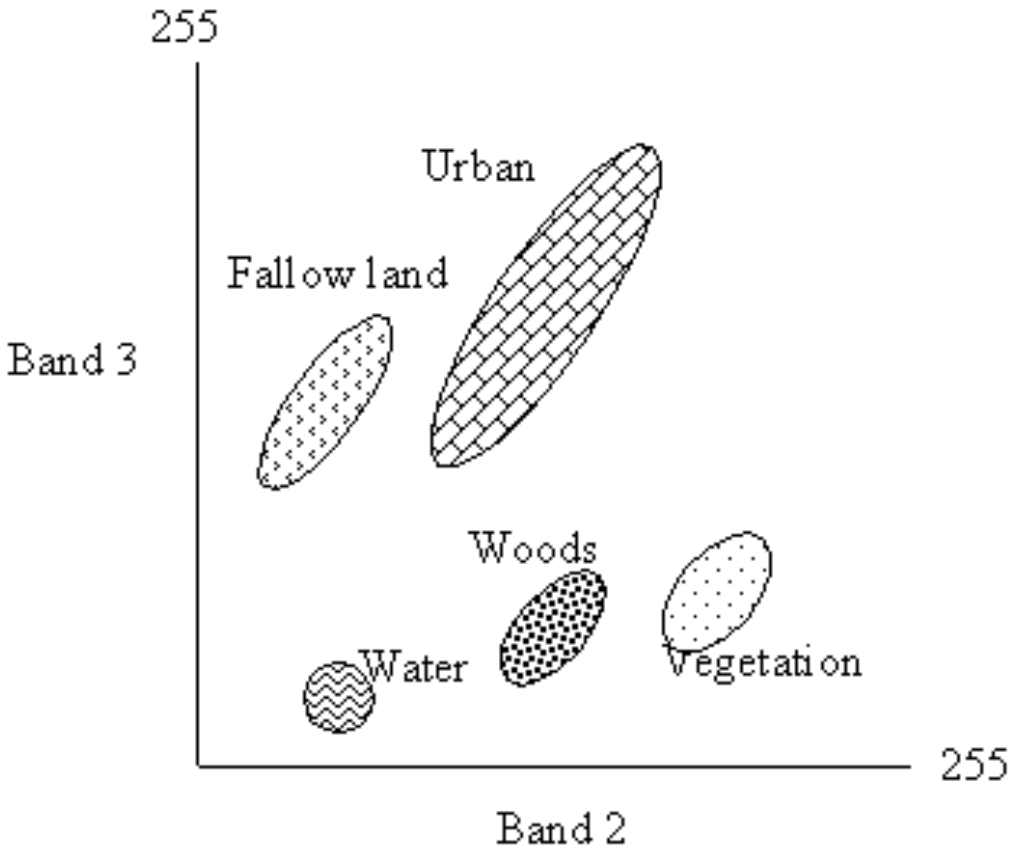
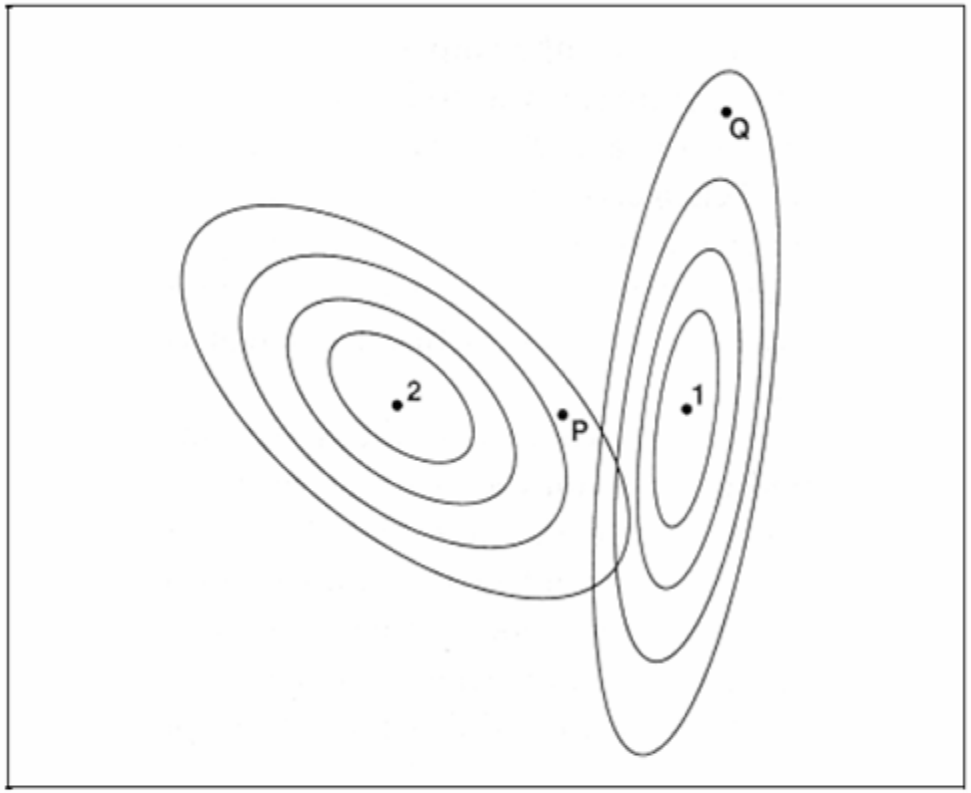


Image Analysis: Classification

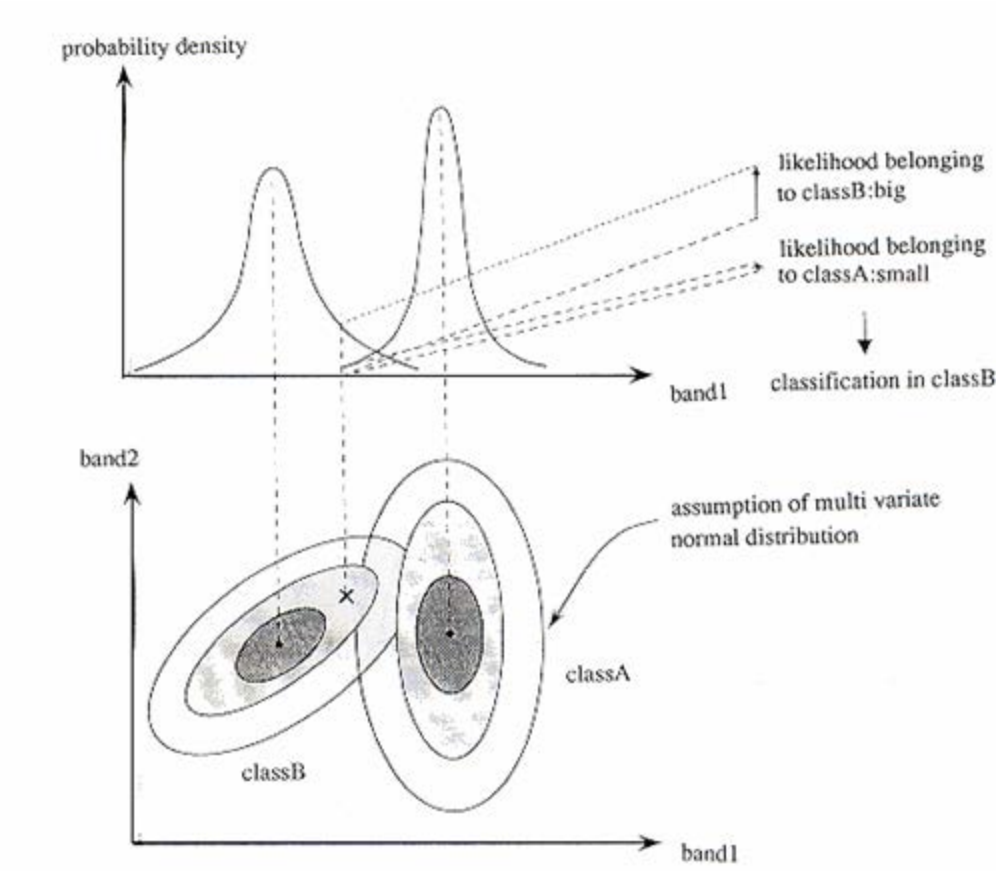
Maximum Likelihood Classification



Equi-probability contours as used in Maximum Likelihood classification

Image Analysis: Classification

Maximum Likelihood Classification



Concept of Maximum Likelihood Method

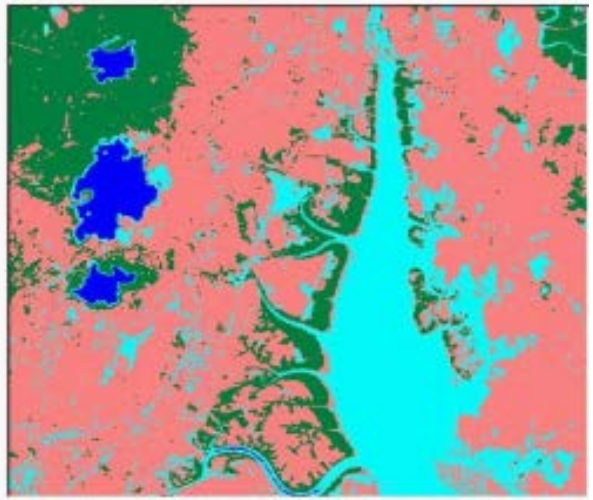
Image Analysis: Classification

Maximum Likelihood Classification

Steps:

1. Select test sets
2. Determine statistics
3. Classify complete image

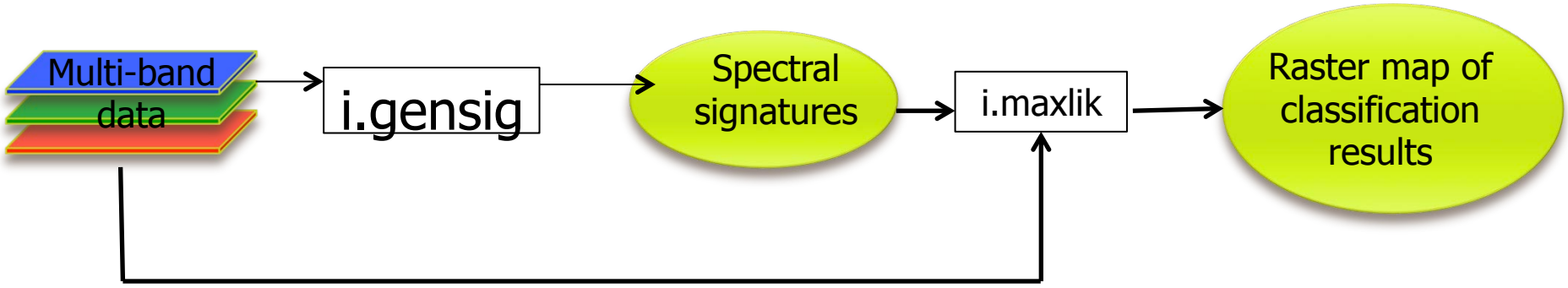
Original Image

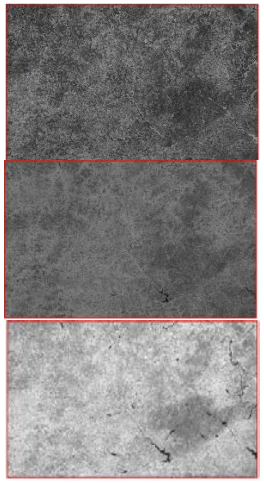


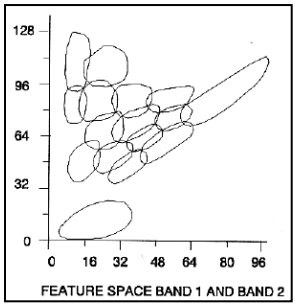
Classified Image

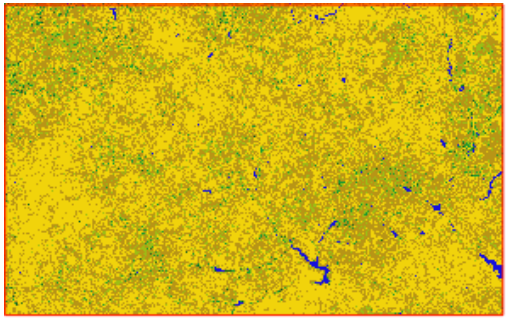
Classification using GRASS

i.gensig is a non-interactive tool for supervised classification, which is just what we need!

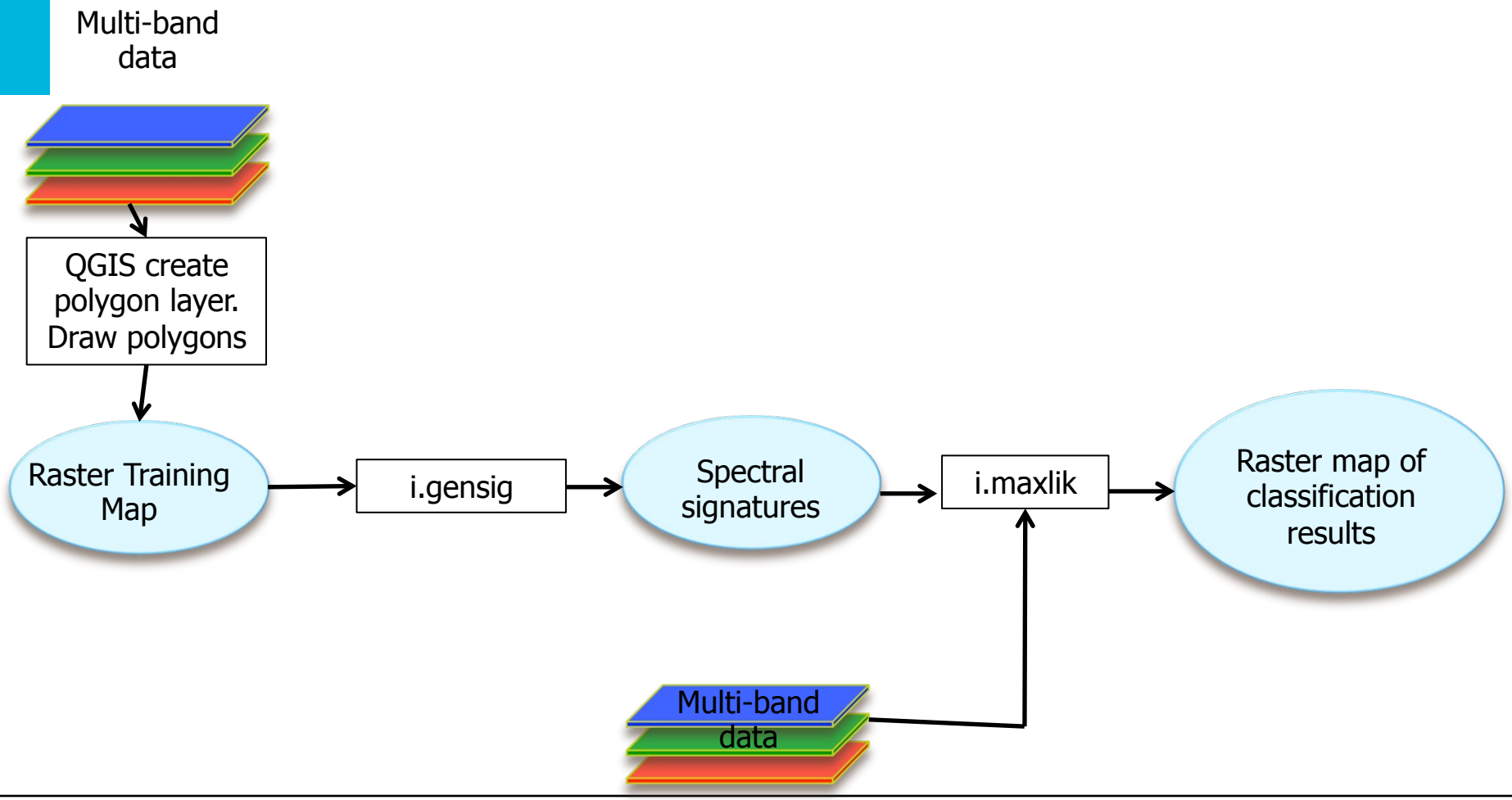






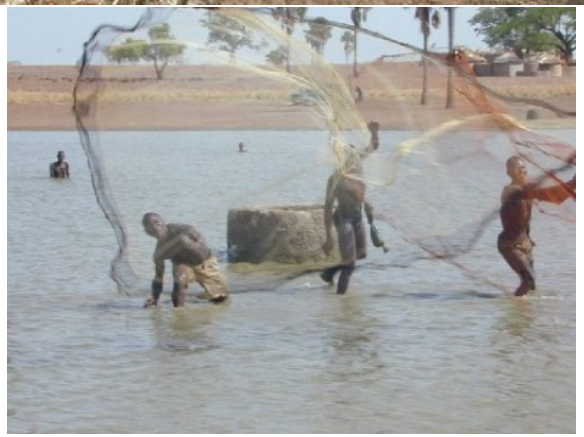


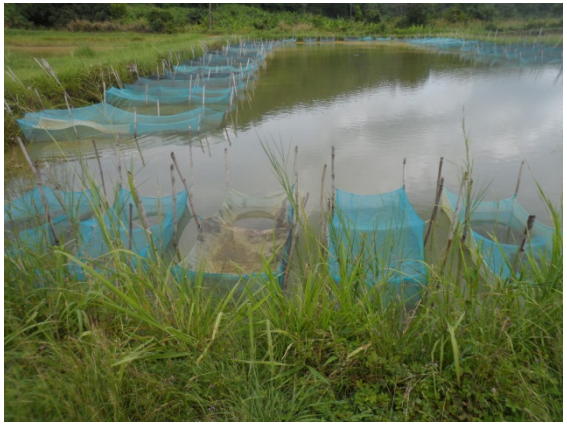
Classification using GRASS Step-by-step



Assignment 4: Small Reservoirs

www.smallreservoirs.org





Assignment 4: Small Reservoirs

Small Reservoirs in Burkina Faso

Reading: Jens Liebe's Thesis

Assignment 4: Small Reservoirs

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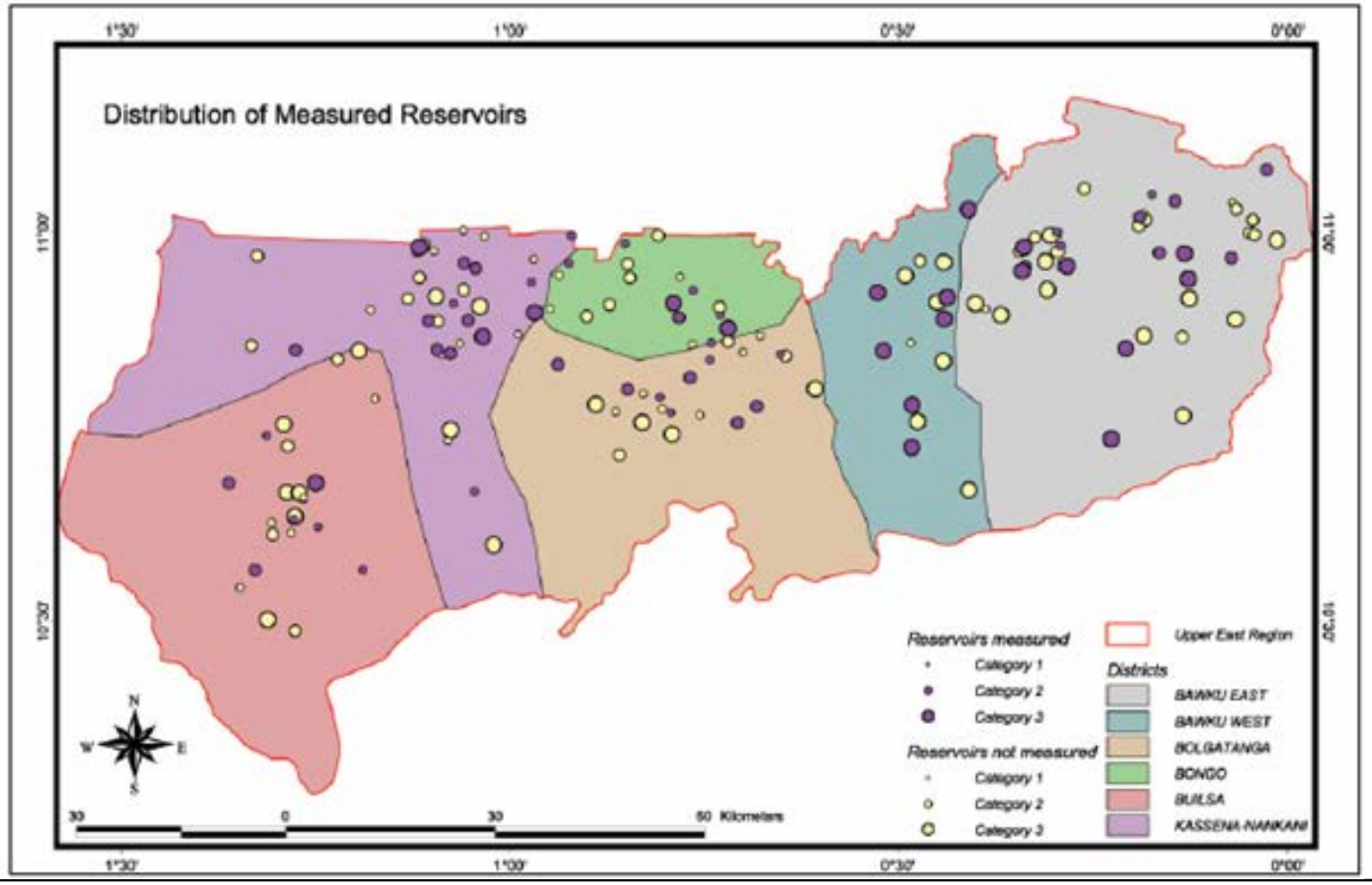
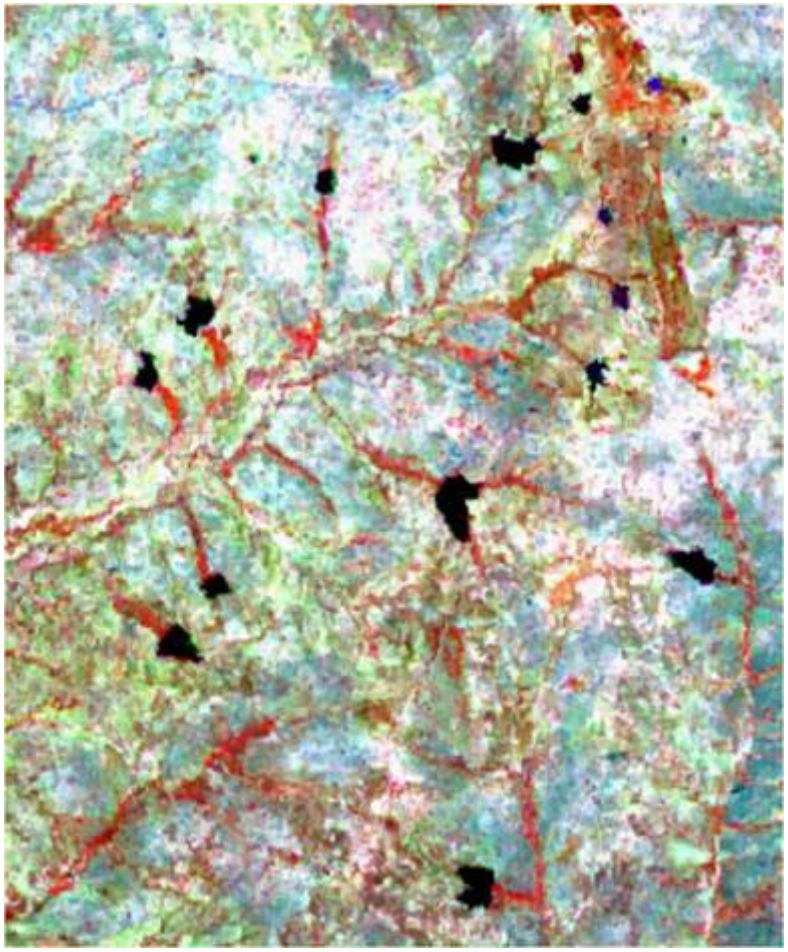


Assignment 4: Small Reservoirs

Lots of shapes and sizes!

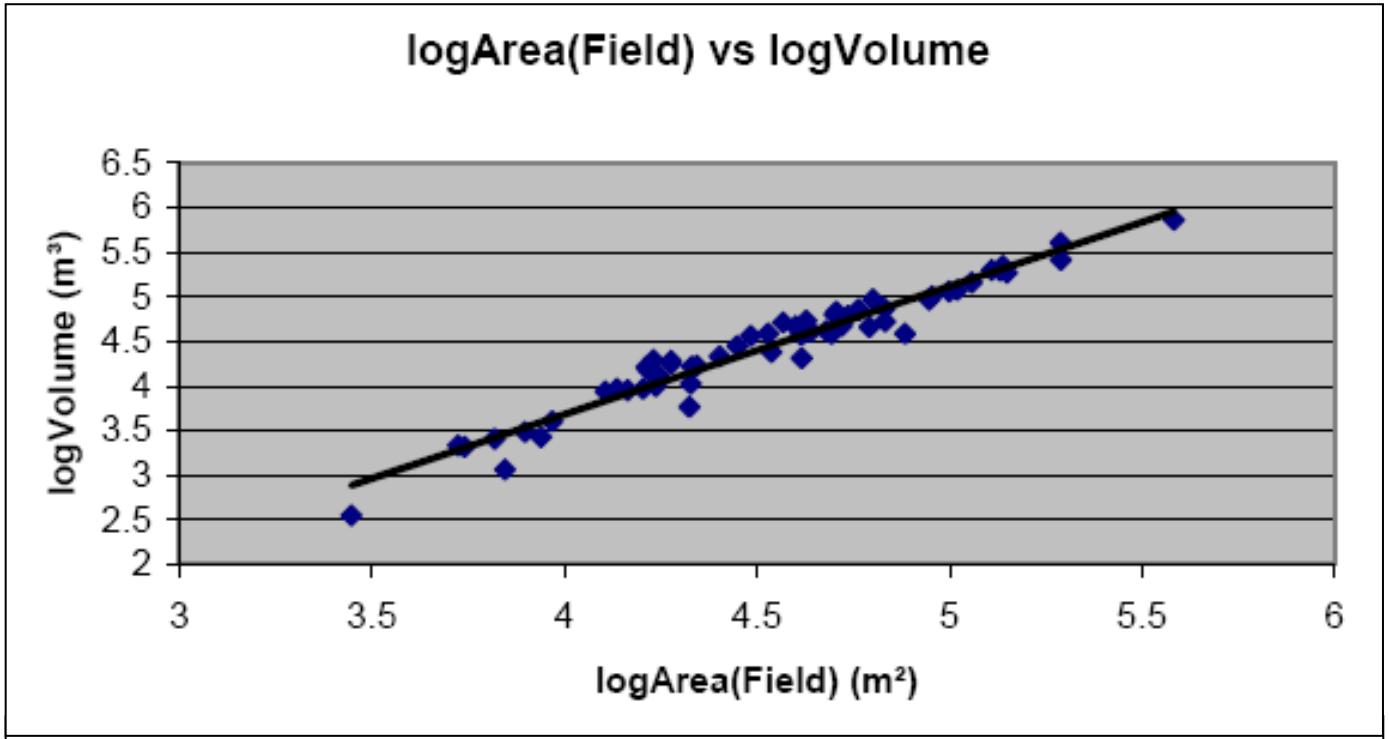


Assignment 4: Small Reservoirs

Bathymetric survey of sixty reservoirs

Assignment 4: Small Reservoirs

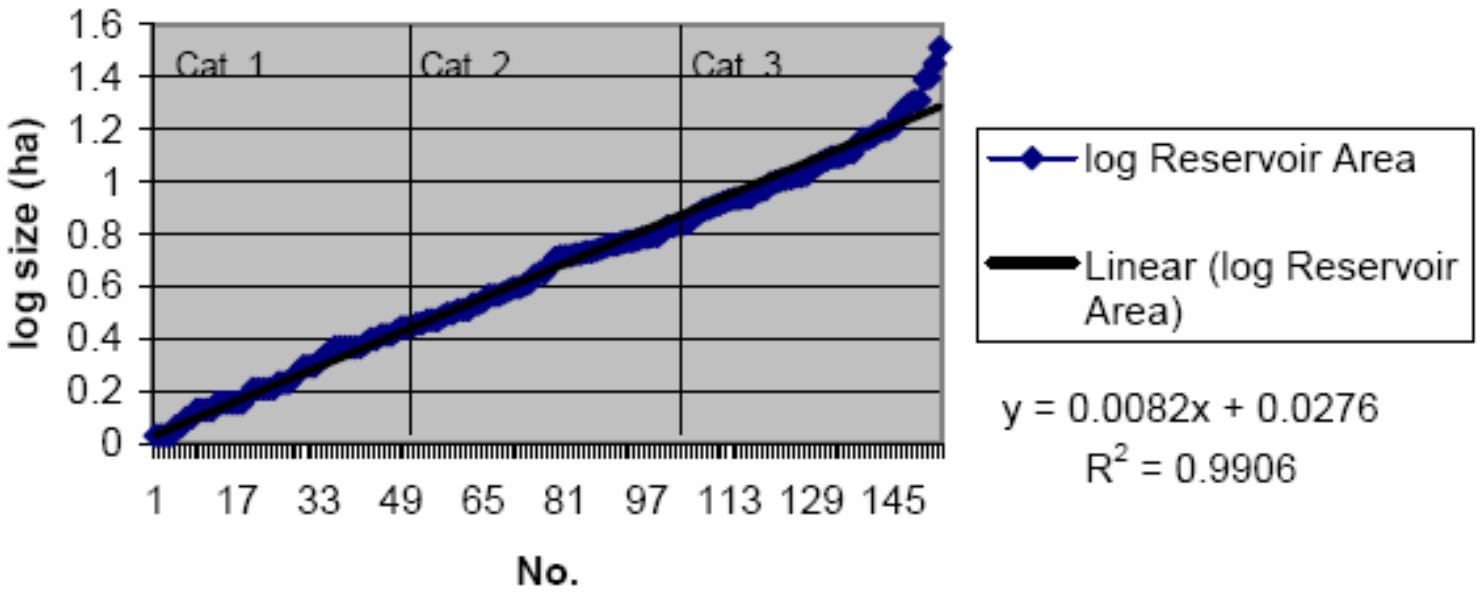
Many shapes… one equation!



$$\text{Volume} = 0.00857 * \text{Area}^{1.4367} \ [\text{m}^3]$$

Exercise

Mapping small reservoirs in Burkina Faso



Assignment 4: Small Reservoirs

How to map open water?

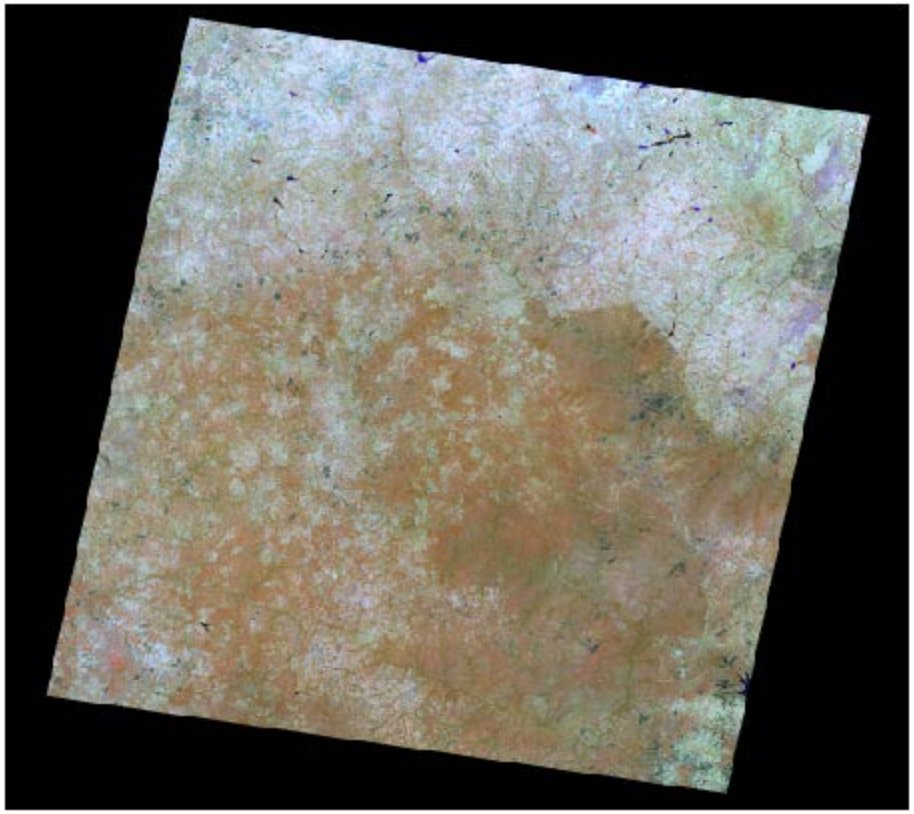
- **Color composite**
- **Training map (many classes!)**
- **Maximimum Likelihood**
- **Contiguity**
- **Hand check…**

Exercise

How to map open water?

Color composite

- Band 4 => Blue
- Band 5 => Green
- Band 3 => Red



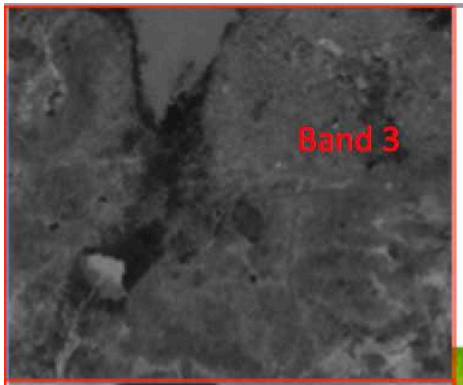
(Windows)

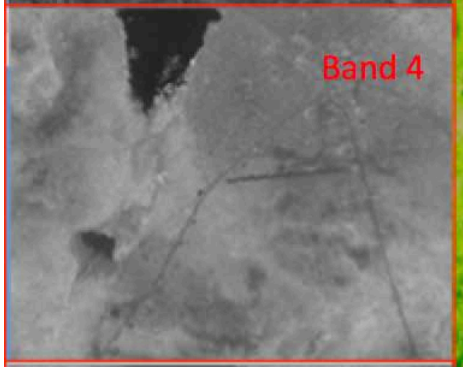
Assignment 4: Small Reservoirs

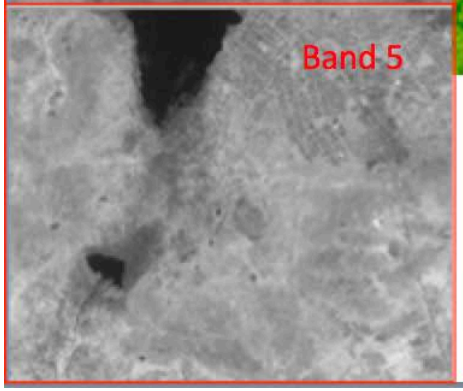
Training map:

- Sediment
- Clear water
- Non-water!
- Shades & burn scars

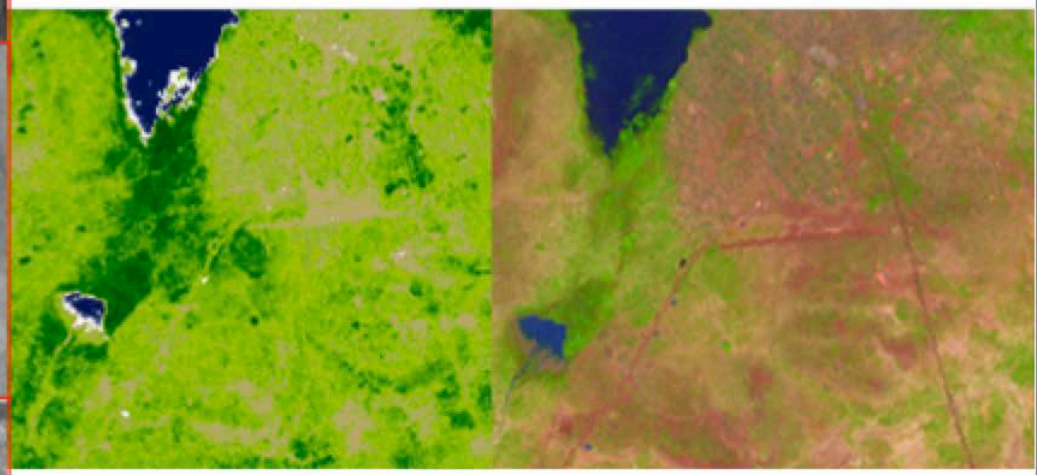
Assignment 4: Small Reservoirs







Use NDVI, individual bands and composite to identify classes:

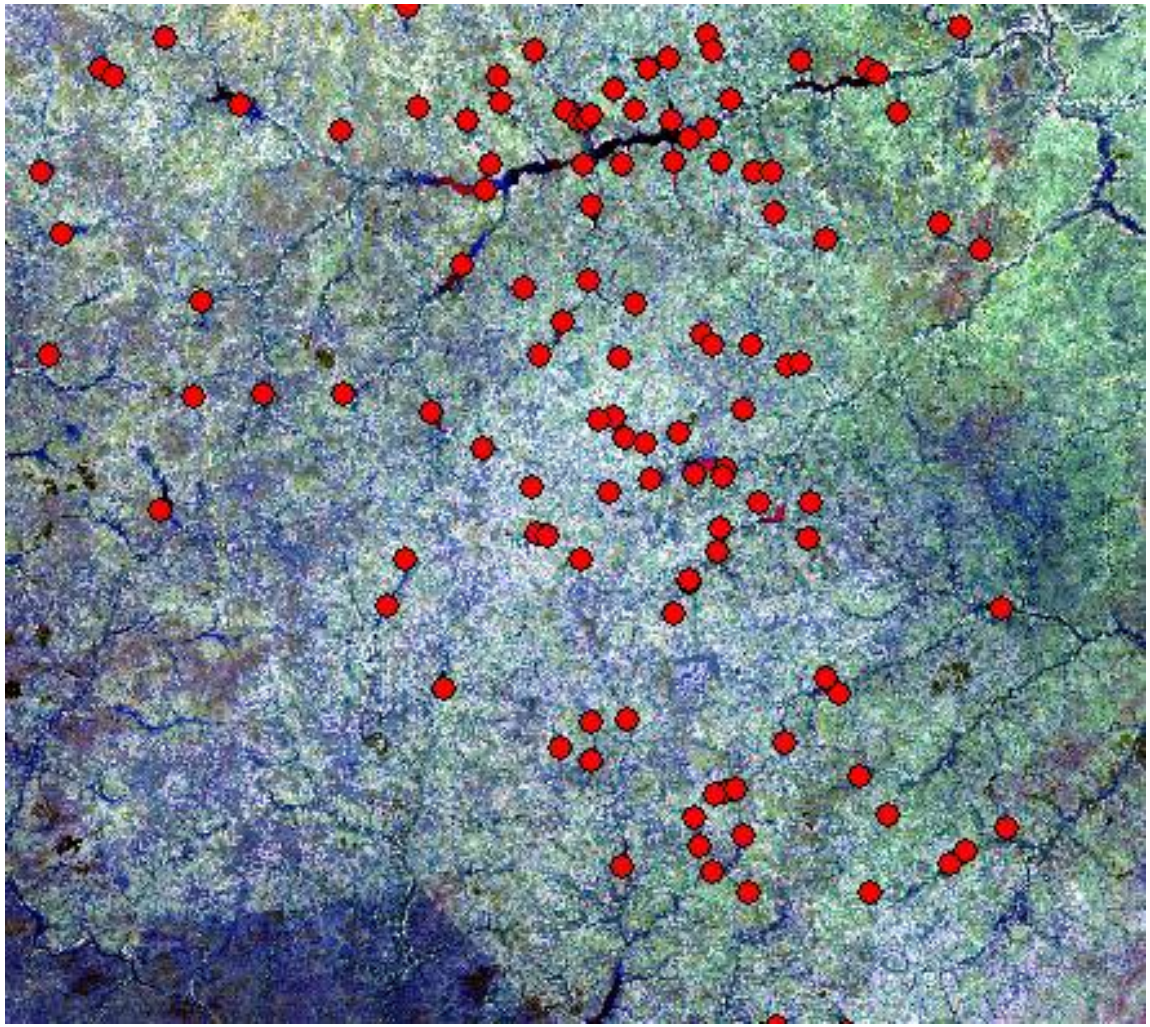


Some features are clearer looking at one of the bands than the composite or NDVI!

Assignment 4: Small Reservoirs

Check against ground data:

reservoirs.shp



Assignment 4: Small Reservoirs

1) Maximum Likelihood classification

2) Identify real small reservoirs:

   Find contiguous sets of water pixels and group them into single objects

3) Hand check results:

   i.e. check that the “reservoirs” you’ve identified really look like reservoirs.

   A single pixel reservoir? => Noise => remove!

   River classified as reservoir => remove!

   Reservoirs “cut” in two? => Make them a single object

   Check that your reservoir is not a burn scar (dark objects)