Machine Learning for policy evaluation: Introduction to remote sensing

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Overview

Introduction to remote sensing

Sensor Overview

Accessing data

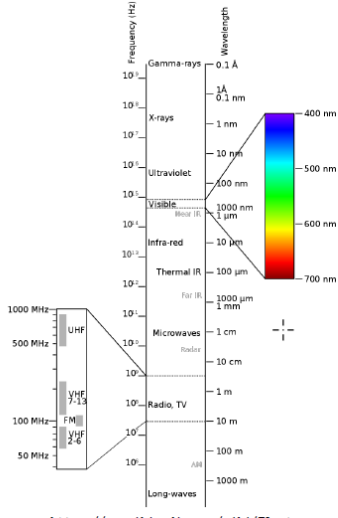
Pitfalls

The electromagnetic spectrum

Sun's energy constantly hits the earth as electromagnetic wave

- Waves are categorized into a wide spectrum
- Only a tiny fraction is visible to the human eyes

We perceive color with specialized cone cells in the retina sensitive to different parts of the spectrum

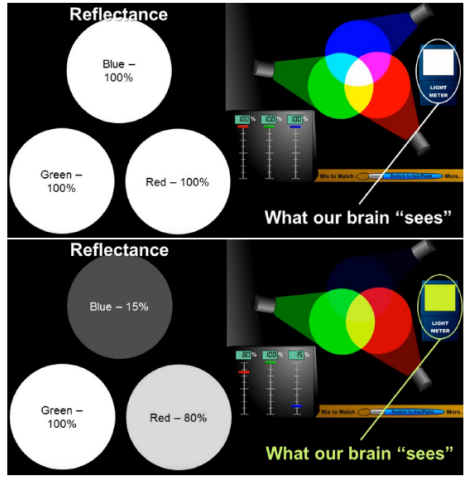


source: https://en.wikipedia.org/wiki/Electromagnetic_spectrum

Human vision

Combining reflectance at different intensities from different parts of the spectrum results in color vision

- Max B,R,G reflectance = white
- Intensity variation leads to color variation

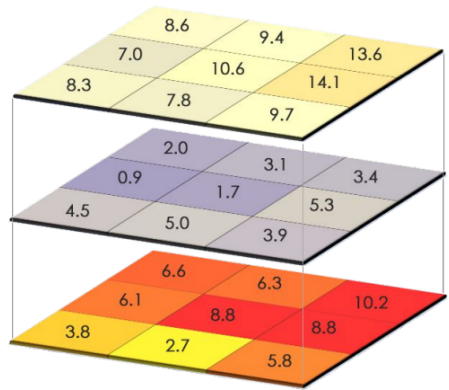


Digital vision

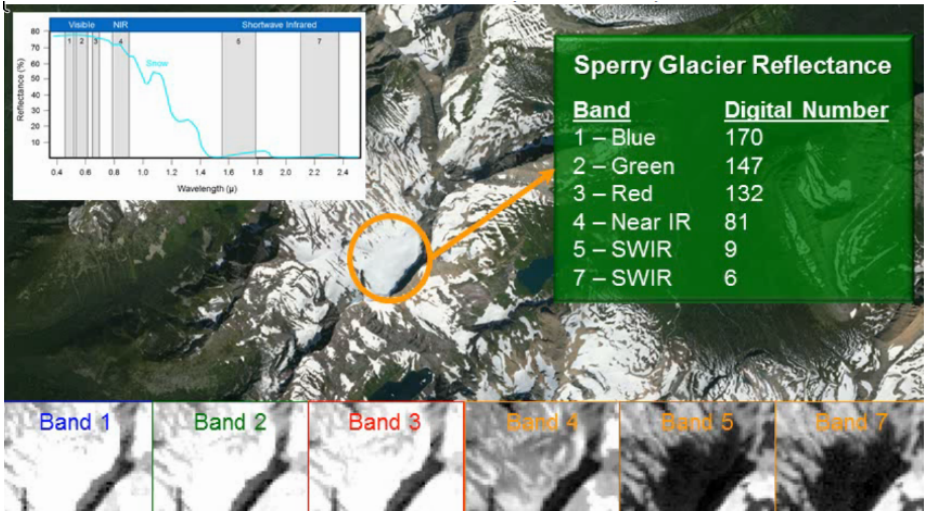
Digital cameras do exactly the same:

- Record reflectance value for each band at the pixel level (0-255)
- Different layers correspond to different bands

Satellite imagery: stacked pixels with associated coordinate reference system + transform



An illustration: detecting snow



Snow is only "white" in bands 1-4 of the spectrum and abosrbs radition in others

Band Combinations

Red band:

- Absorbed by chlorophyll: little reflectance from healthy vegetation
- Absorbed by water: water bordies apper fairly dark

Green band:

- Better reflected by water
- Strongly reflected by vegetation

Blue band:

- Can use to differential soil, vegetation, and deciduous from coniferous vegetation

Near infrared band:

- Strongly absorbed by healthy vegetation

An example: NDVI

The Normalized Difference Vegetation Index: identify vegetation, measure its health/vitality

- Chlorophyll causes light absorption in the red part of the spectrum
- Plant leaf cells re-emit solar radiation in near-infrated part of the spectrum
- Each plant has its own spectral signature
- When vegetation is less healthy or more sparse: more red and less infrared light gets reflected

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

case healthy vegetation: NDVI close to 1; if unhealthy: NIR smaller, RED larger.

Some definition

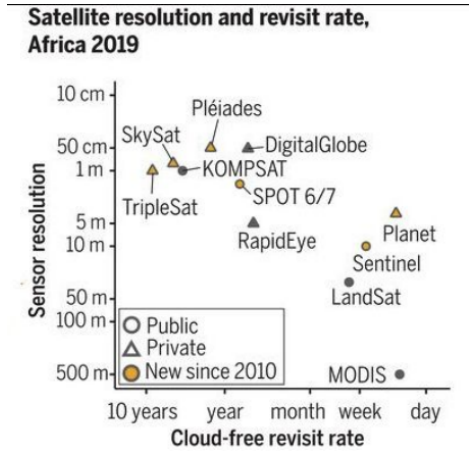
- Coordinate reference system: rule for assigning coordinates to location on Earth. Some distorts distance and can’t be use for distance calculation
- Transform: assigns pixel corners coordinates
- Spatial resolution: size of pixels in space. E.g., Landsat pixels are 30m x 30m
- Revisit rate or temporal resolution: how often a picture is taken

Overview

Sensor overview

Most used in economics:

- Night-time Lights
- Medium resolution multispectral: see Landsat
- High resolution visible spectreum: see Planet

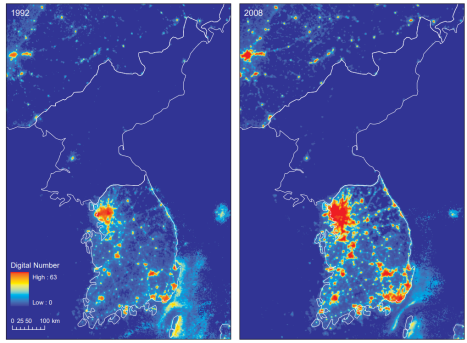


Source: Burke et al. (2021)

Night Lights

Widely used as a proxy for economic output

- 2 sensors: DMSP 1992-2013 and VIIRS 2012-Present
- Cons: does not work well for very developing countries and rural locations

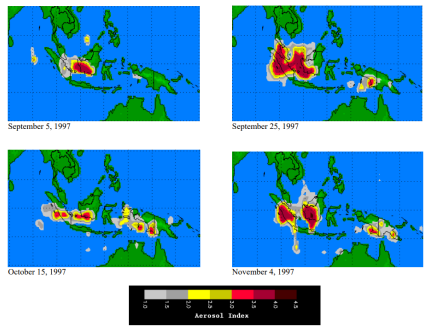


Source: Henderson et al. (2012)

Multispectral Imagery

Imagery with multiple bands, often with some outside of the visible spectrum

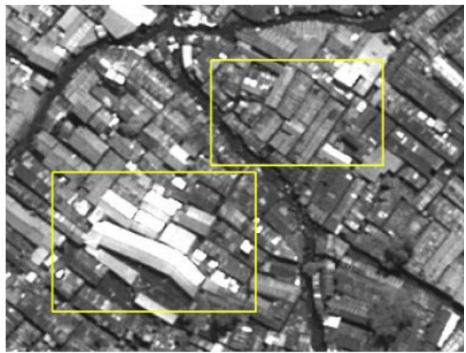
- NDVI: proxy for vegetation cover
- Aerosol Optical Depth (AOD): proxy for air pollution
- Normalized Difference Flood Index (NDFI): measures standing water
- Thermal Anomalies: Used for detecting active fires



Source: Jayachandran (2009)

High Resolution Visible Spectrum or Panchromatic Imagery

- Visible Spectrum: Red, Blue, and Green bands used to make imagery similar to that displayed by our computers
- Panchromatic: greyscale
- Used for object detection
- For instance planet



Source: Marx et al. (2019)

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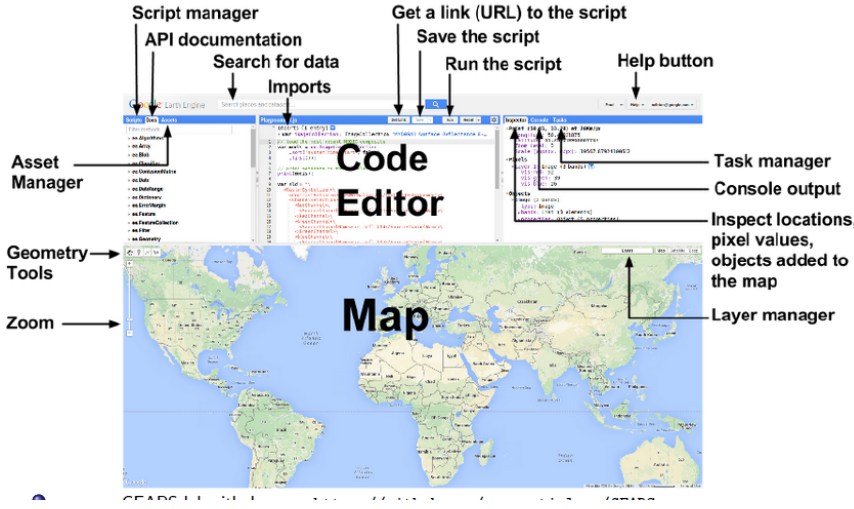
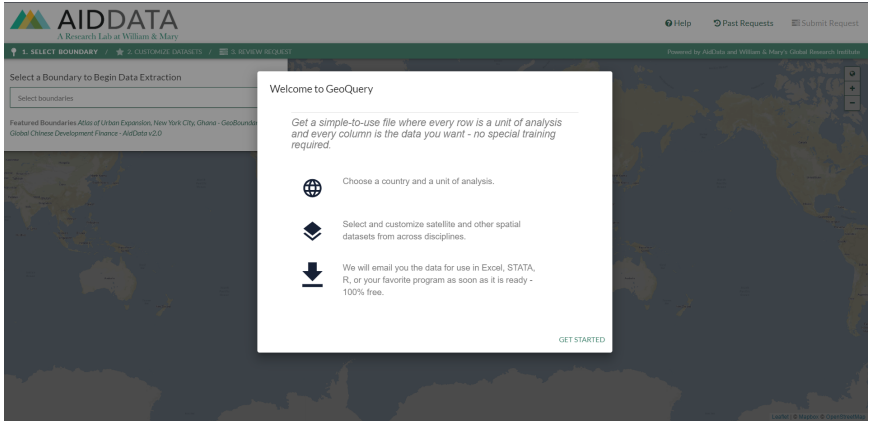
Google Earth Engine



Rely on javascript but a python API exists. Lot of data freely accessible. Quite fast.

AidData: geoquery



Good solution to start, lot of data available. But spatial limitation.

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Main limitations

- Clouds:
  - Yield to measurement error
  - Hard to filter
  - Issue for cloudiest locations
- Time limitation:
  - Tradeoff between granularity and revisit rate
  - Higher-resolution images for recent satellites
  - Can have access to granular images but .. quite expensive 15k for Planet
- Non classical measurement error

References I

Marshall Burke, Anne Driscoll, David B Lobell, and Stefano Ermon. Using satellite imagery to understand and promote sustainable development. *Science*, 371(6535):eabe8628, 2021.

J Vernon Henderson, Adam Storeygard, and David N Weil. Measuring economic growth from outer space. *American economic review*, 102(2):994–1028, 2012.

Seema Jayachandran. Air quality and early-life mortality: Evidence from indonesia's wildfires. *Journal of Human resources*, 44(4):916–954, 2009.

Benjamin Marx, Thomas M Stoker, and Tavneet Suri. There is no free house: Ethnic patronage in a kenyan slum. *American Economic Journal: Applied Economics*, 11(4):36–70, 2019.