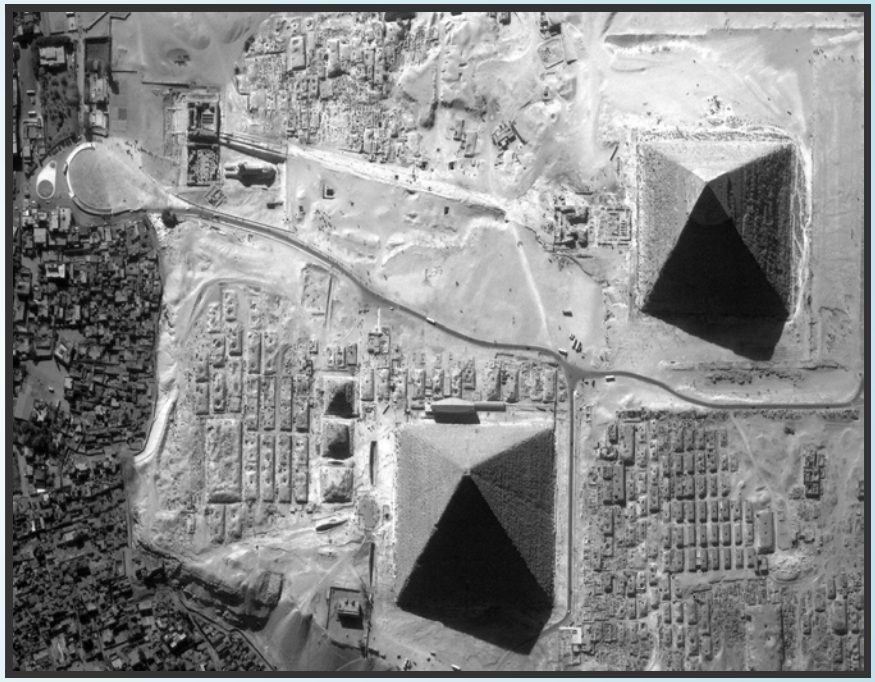
WEEK 6:
AERIAL AND SATELLITE IMAGES

Intro to GIS

Evan Lue, PhD

LARGE EXTENTS, HIGH RESOLUTION



Bolstad 2012, Fig 6.1

WHY WE LIKE IT

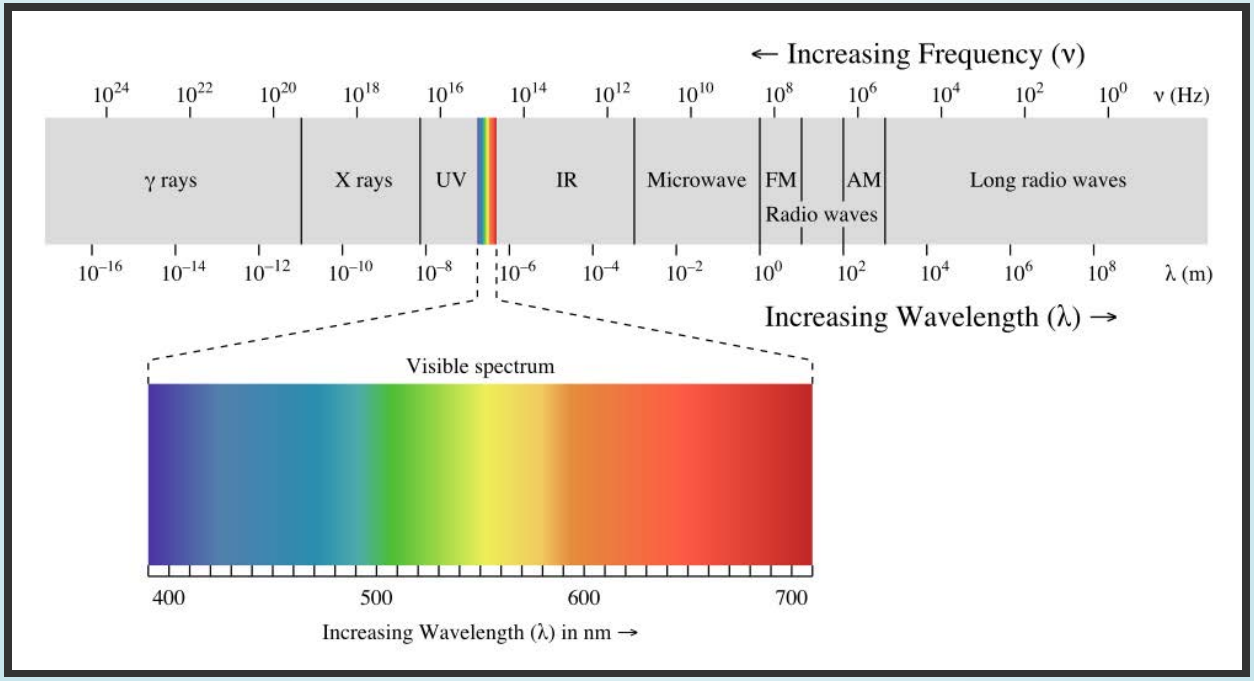
- Land area coverage
- Extended spectral range
- Geometric accuracy
- Permanent record
- Rapid and frequent

IMPORTANT TERMS

- Remote sensing - The acquisition of data using measuring instruments from a distance; typically refers to data collected from aircrafts and satellites
- Aerial image - Taken from aircrafts
- Satellite image - Taken from satellites

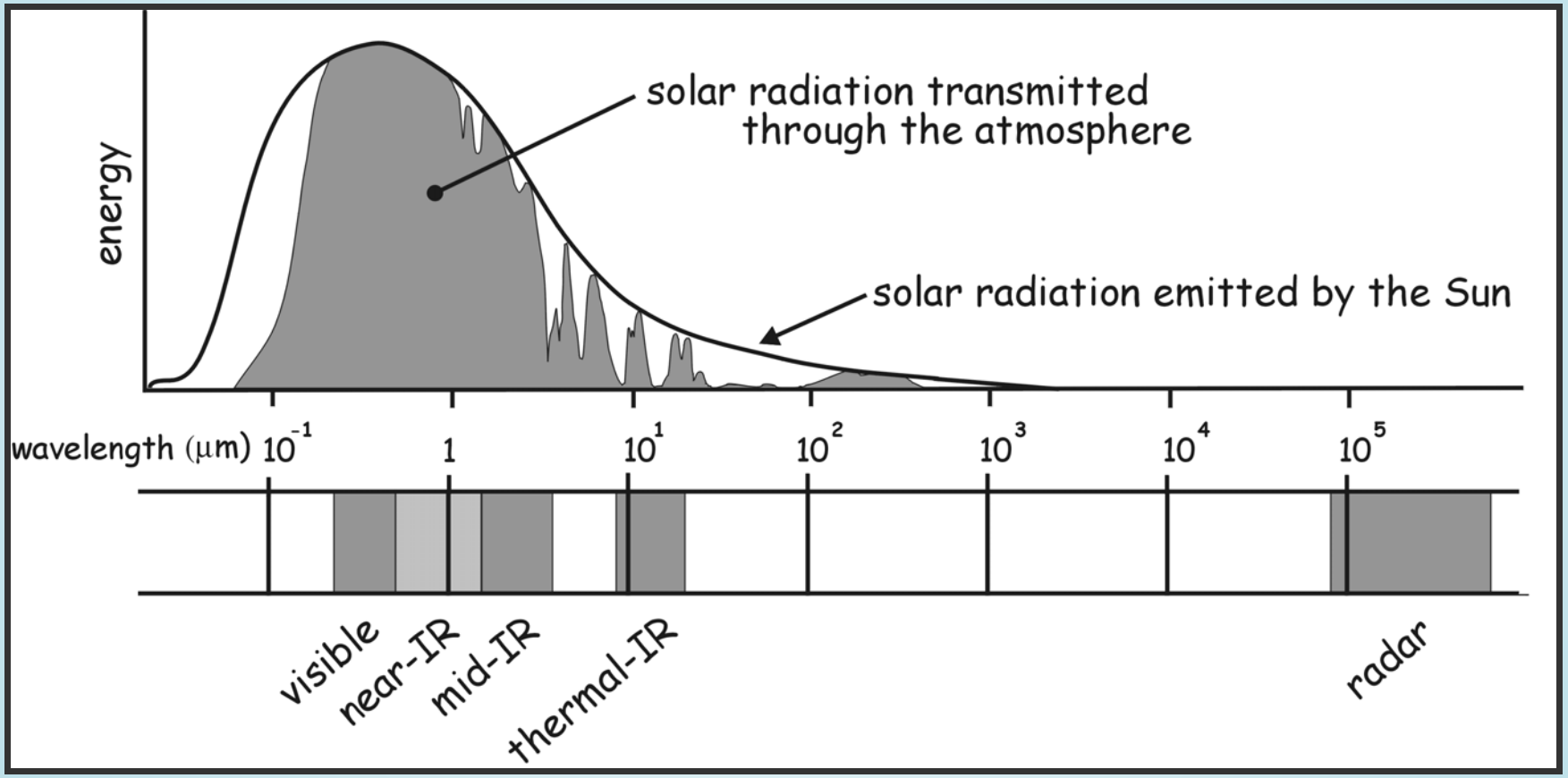
ELECTROMAGNETIC (EM) SPECTRUM

- EM spectrum - The full range of wavelengths of light
- Wavelength - The distance over which the wave's shape repeats; often nm (nanometers), μm (micrometers)



Graphic by Philip Ronan

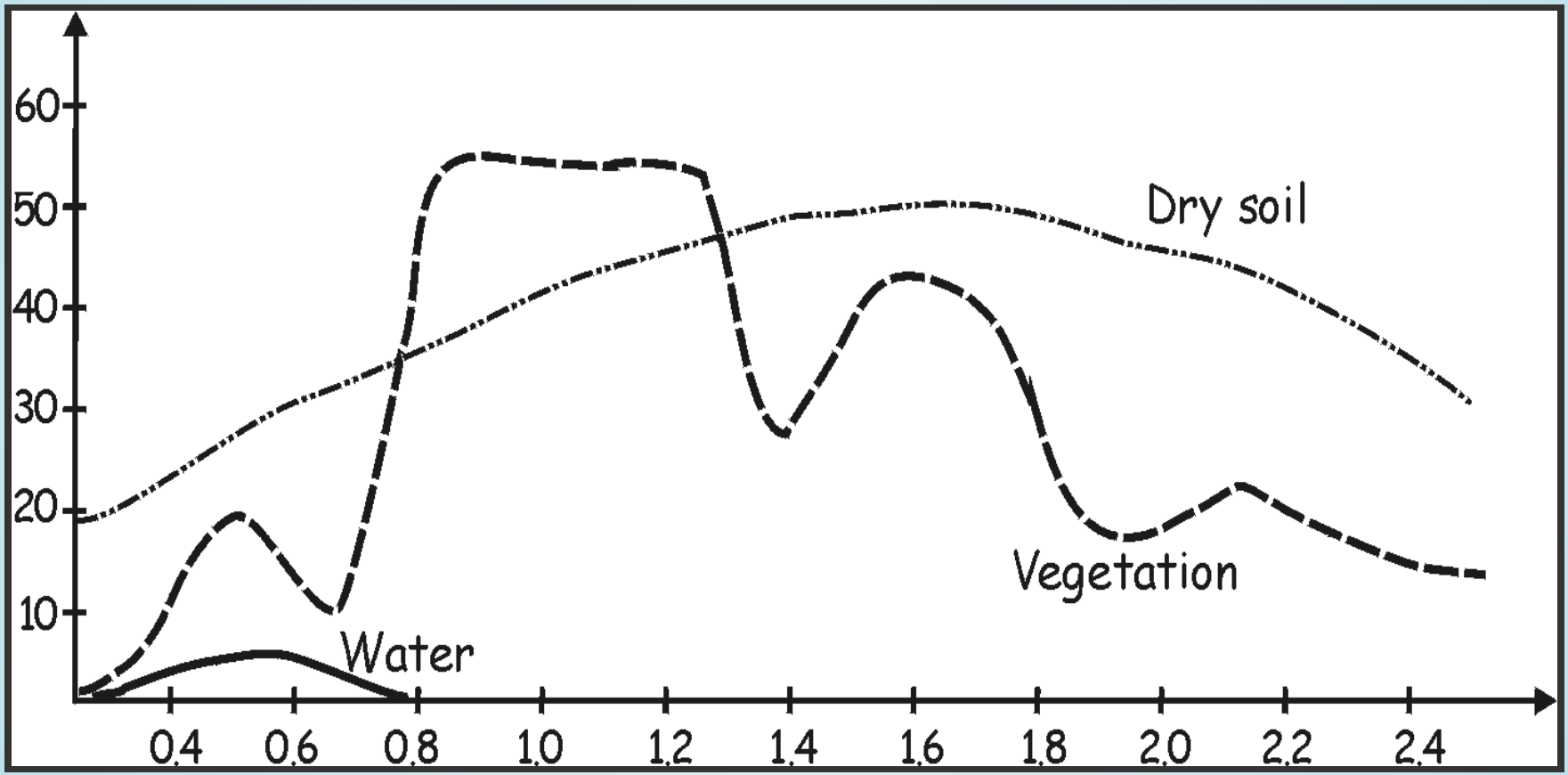
THE EM SPECTRUM AND EARTH'S ATMOSPHERE



Bolstad 2012, Fig 6.2

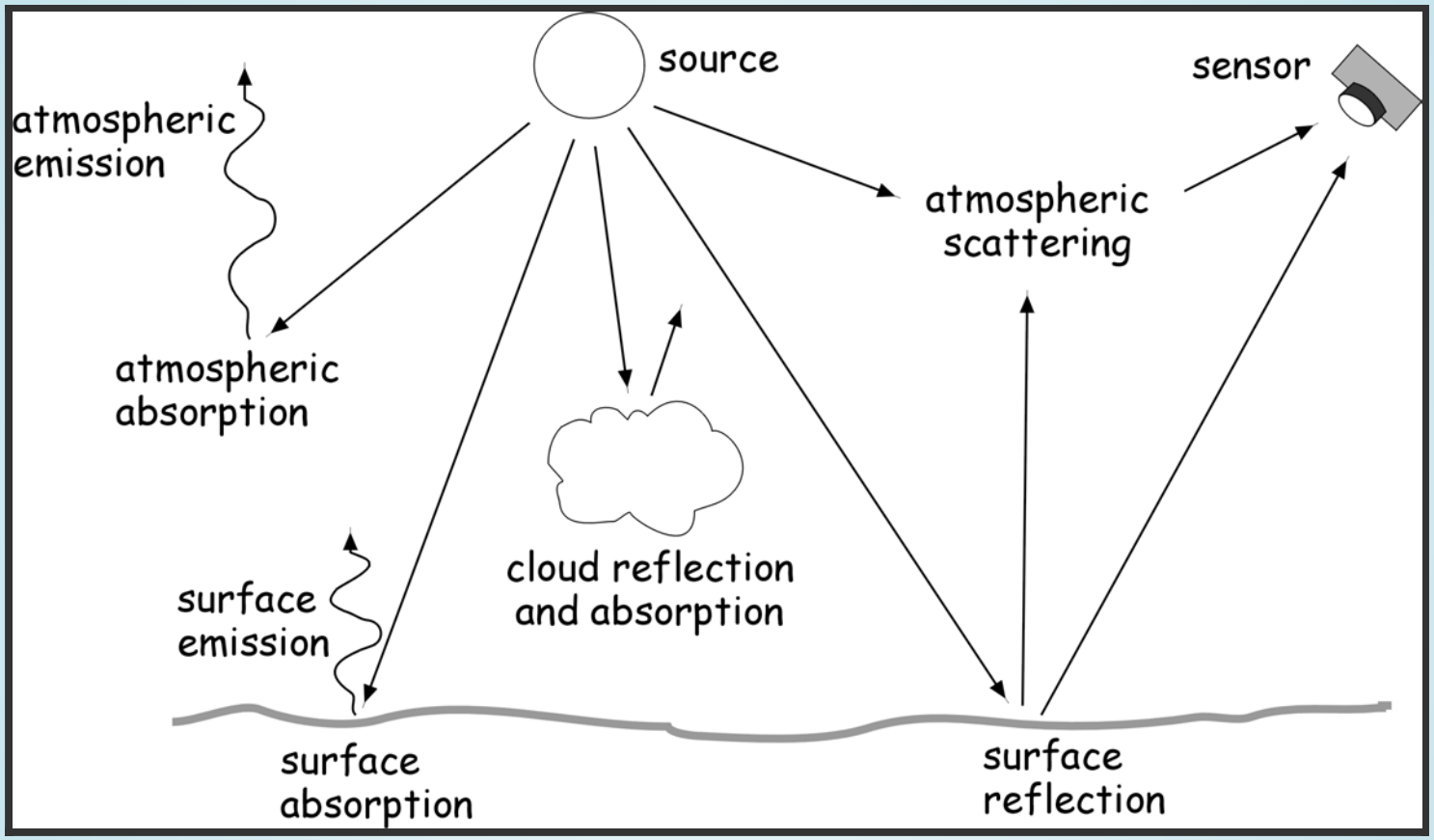
SPECTRAL REFLECTANCE

% reflectance (y-axis) vs wavelength in μm (x-axis)



Bolstad 2012, Fig 6.3

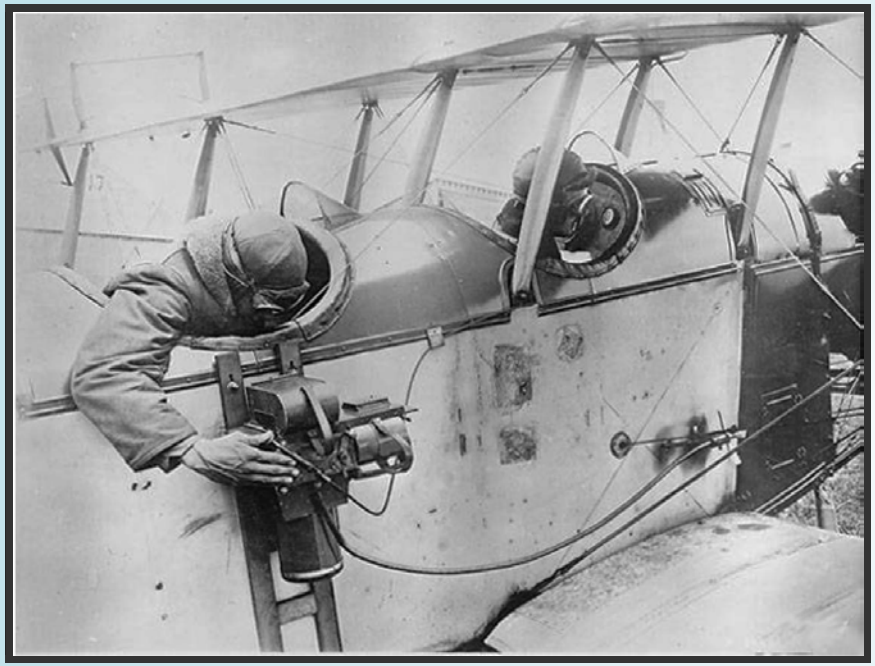
SOURCE TO SENSOR



Bolstad 2012, Fig 6.4

PHOTOGRAMMETRY

The science of measuring geometry from images



Bolstad 2012, Fig 6.5

Bolstad 2012, Fig 6.6

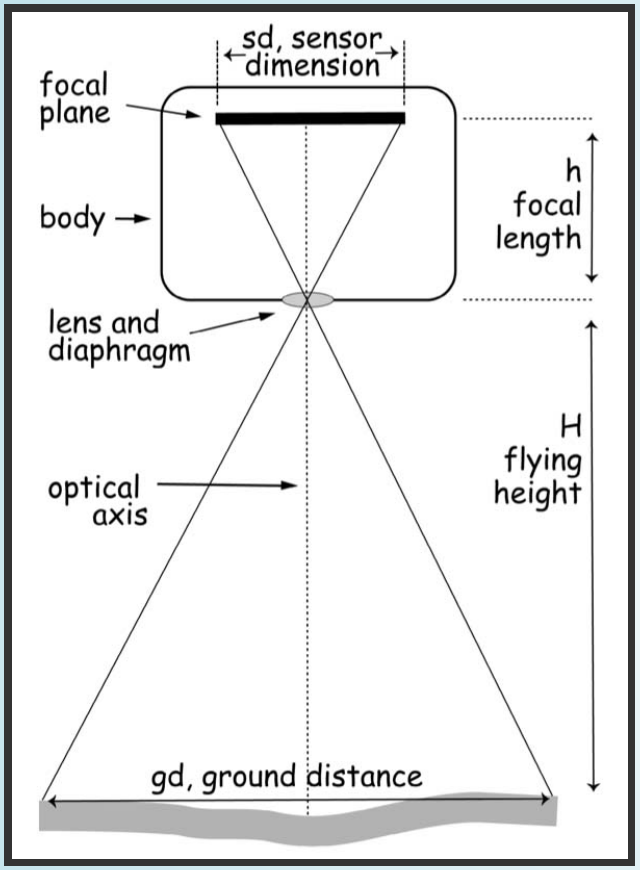
MORE TERMS

- Passive system - Remote sensing that measures energy generated by the sun
- Active system - Remote sensing that measures energy generated by the system
- Sensing media - The digital sensor or film that records light
- Optical axis - The central direction of the incoming image,oriented to intersect the sensor in perpendicular direction
- Focal plane - The flat stage that images are recorded on, perpendicular to the optical axis
- Header (digital) or data strip (film) - Like metadata for time, altitude, and other conditions, but recorded as part of the data

SCALE, EXTENT, AND RESOLUTION

- Image scale - Like map scale; a scale of 1:24,000 means an inch on the image represents 24,000 inches
- Image extent - The area that an image covers
- Image resolution - The smallest object that can be detected on the imagel, typically referred to as pixel size

A SIMPLE CAMERA



Bolstad 2012, Fig 6.7

Calculating image extent:

$$gd = sd * H / h$$

$$0.42m = 7.1 \times 10^{-6} * 3000 / 0.05$$

Bolstad 2012, Eqs 6.1 and 6.2

DIGITAL AERIAL COLLECTION

Bolstad 2012, Fig 6.9

Bolstad 2012, Fig 6.12

A FEW MORE TERMS

- Pixel - Picture element, the smallest physical addressable point in a raster
- Band - Waveband; a raster of a single wavelength
- Co-registration - Alignment of individual raster bands to make a multi-band image
- Format - Not file formats, but rather sizes for images, such as 240 mm; also applies to paper sizes

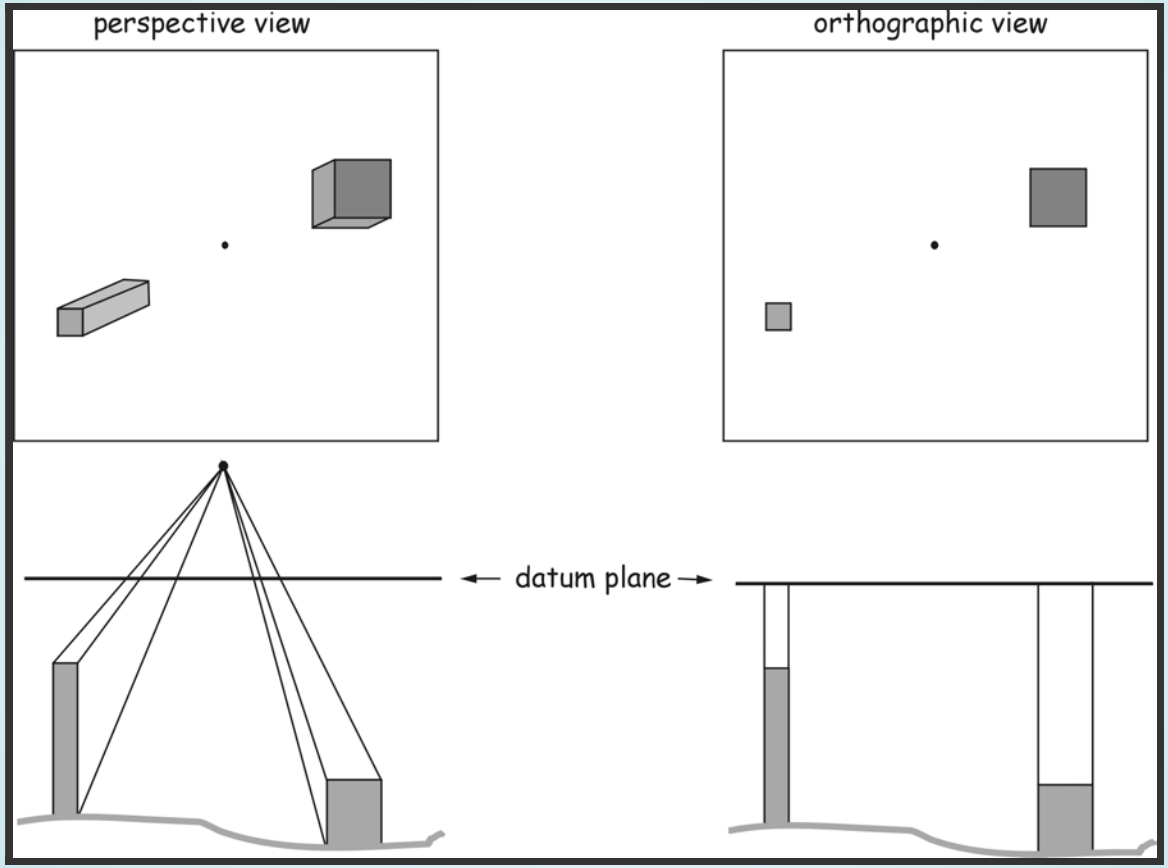
15CM RESOLUTION

Bolstad 2012, Fig 6.8

TYPES OF VIEWS

- Orthogonality - The relation of two lines at right angles to one another (perpendicularity)
- Orthographic view - Projects at right angles to the datum plane
- Perspective or oblique view - A "slanted", non-orthogonal view (perspective and oblique may mean different things in other fields)

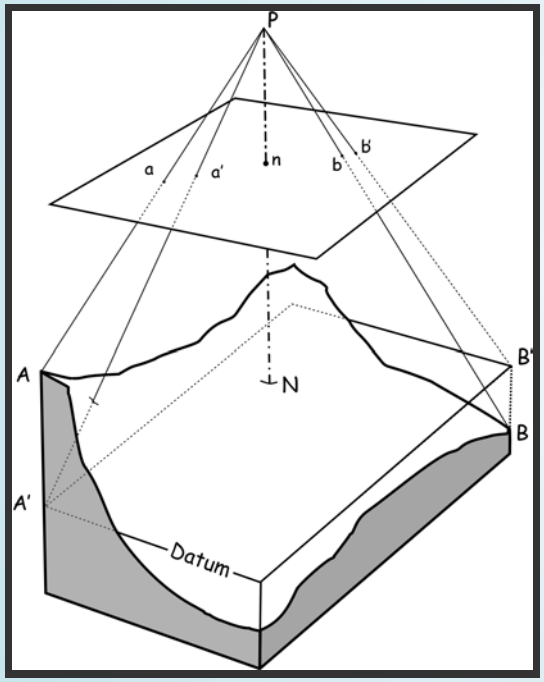
ORTHOGRAPHIC VS. PERSPECTIVE VIEWS



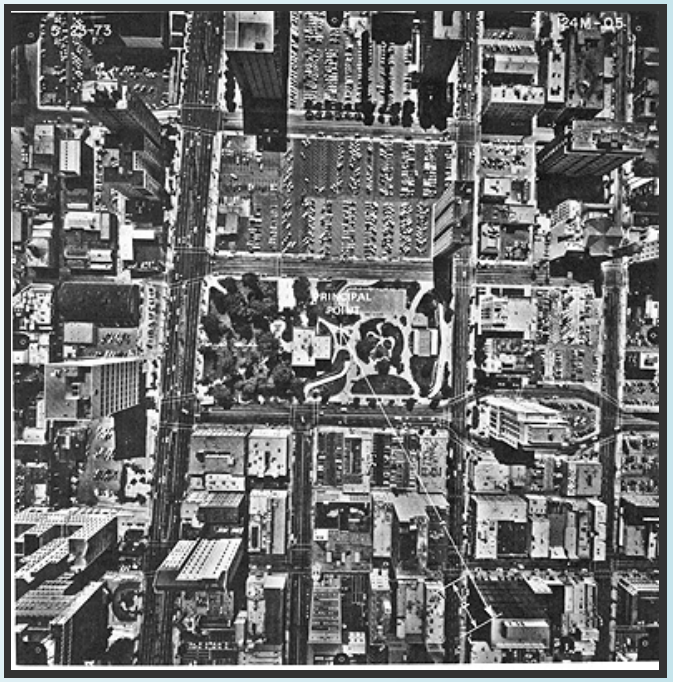
Bolstad 2012, Fig 6.15

RELIEF DISPLACEMENT

- The radial displacement of objects that are at different elevations
- Nadir - The lowest point; contrast with zenith



Bolstad 2012, Fig 6.16



Graphic from
http://www.amesremote.com/section1.htm

COMMON CHARACTERISTICS OF TERRAIN DISTORTION IN VERTICAL AERIAL IMAGES

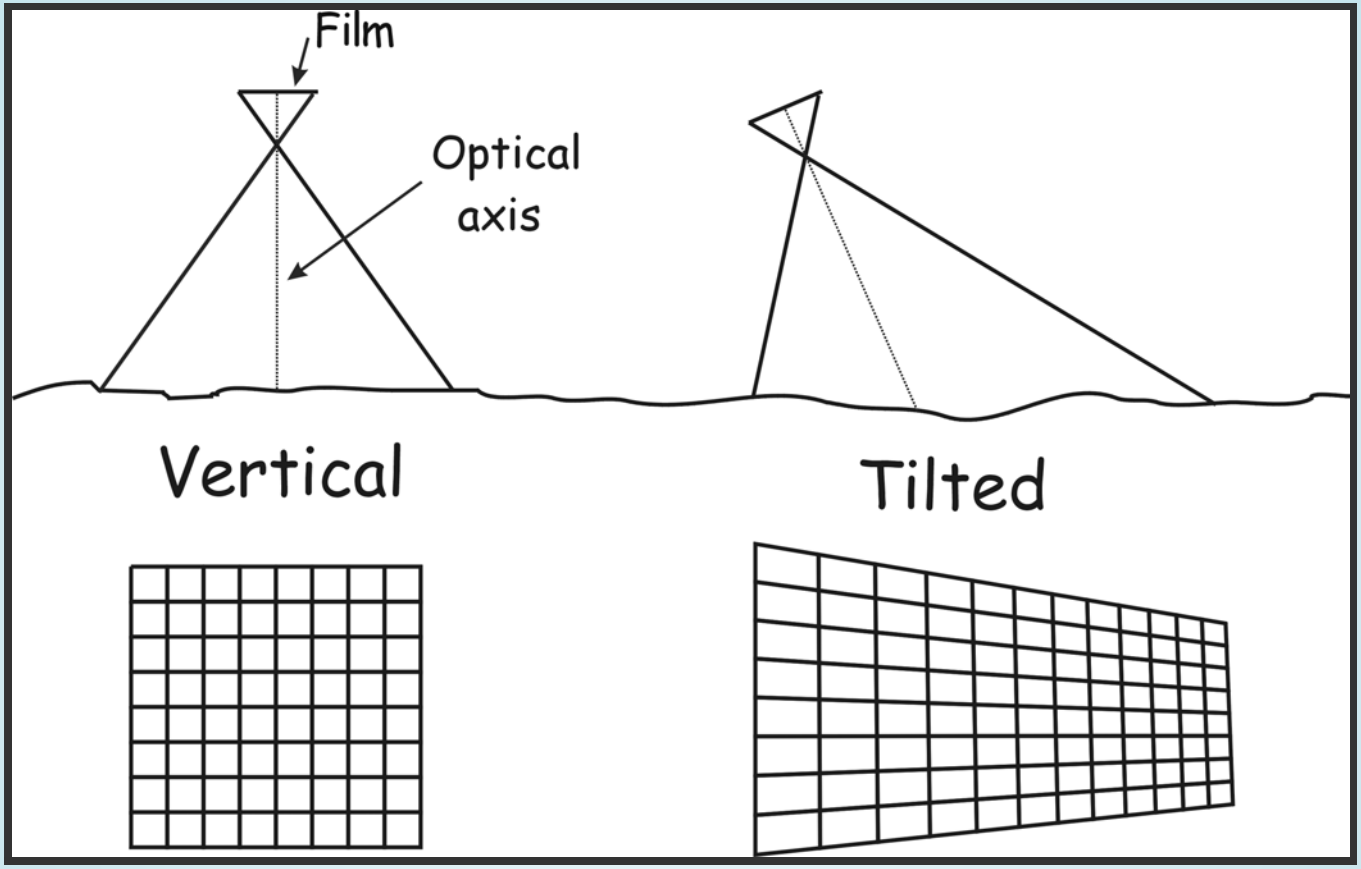
- Terrain distortions are radial
- Angles and distances are affected
- Scale is not constant
- Not orthographic

TILT AND PERSPECTIVE CONVERGENCE

The phenomenon where objects farther away apear closer together than equivalently-spaced near objects

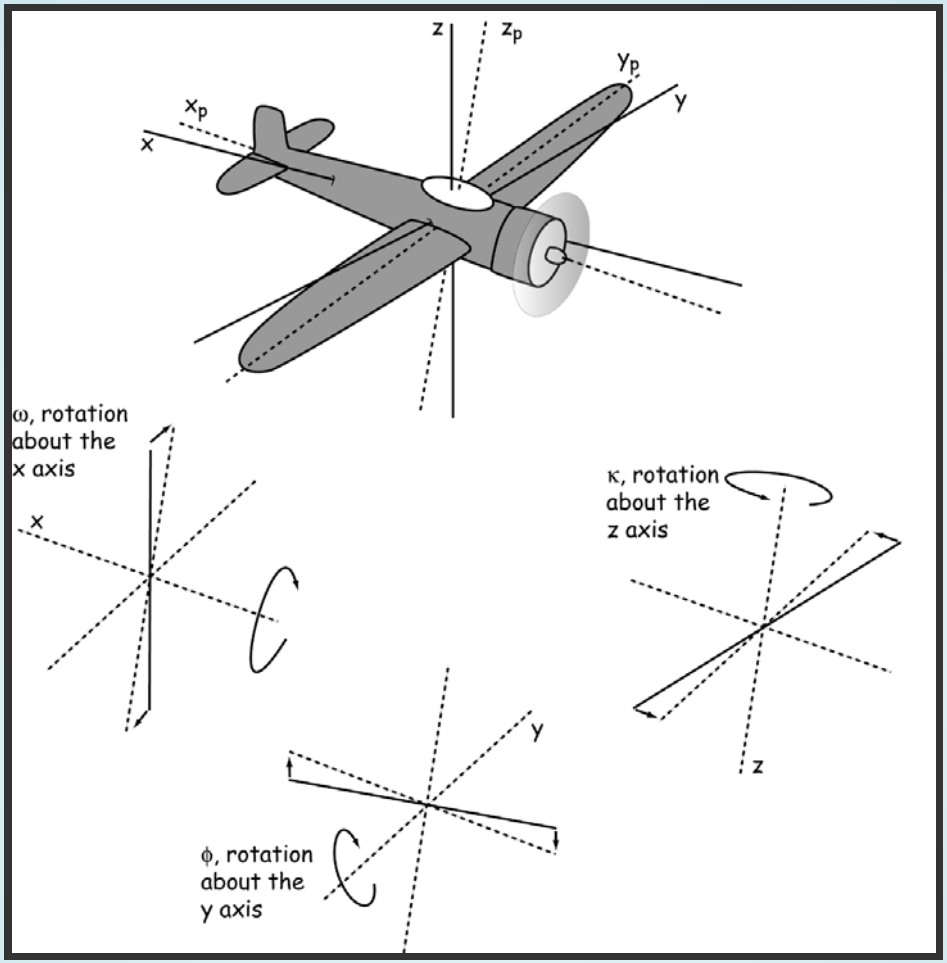
Bolstad 2012, Fig 6.17

TILT CAUSES DISTORTIONS



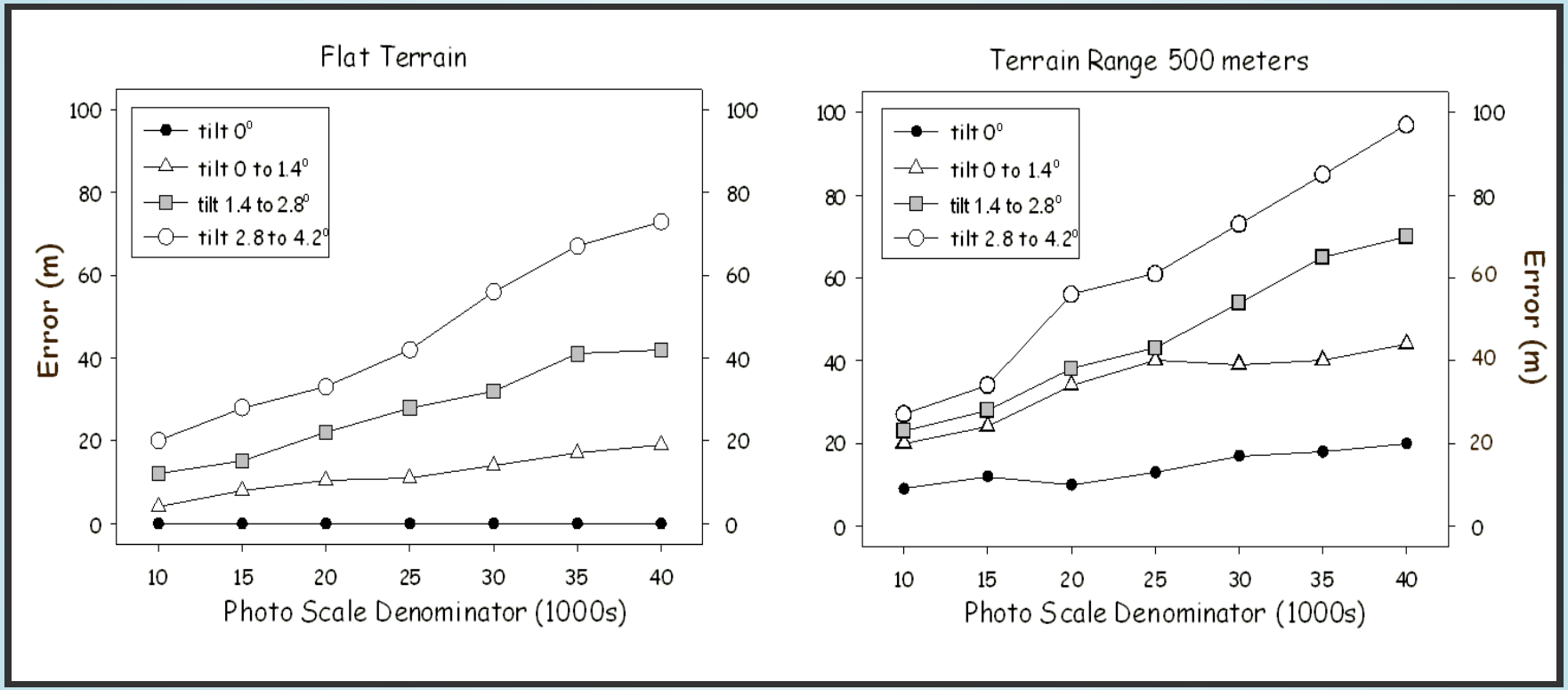
Bolstad 2012, Fig 6.18

IMAGE TILT ANGLES



Bolstad 2012, Fig 6.19

ERROR FROM TILT AND TERRAIN

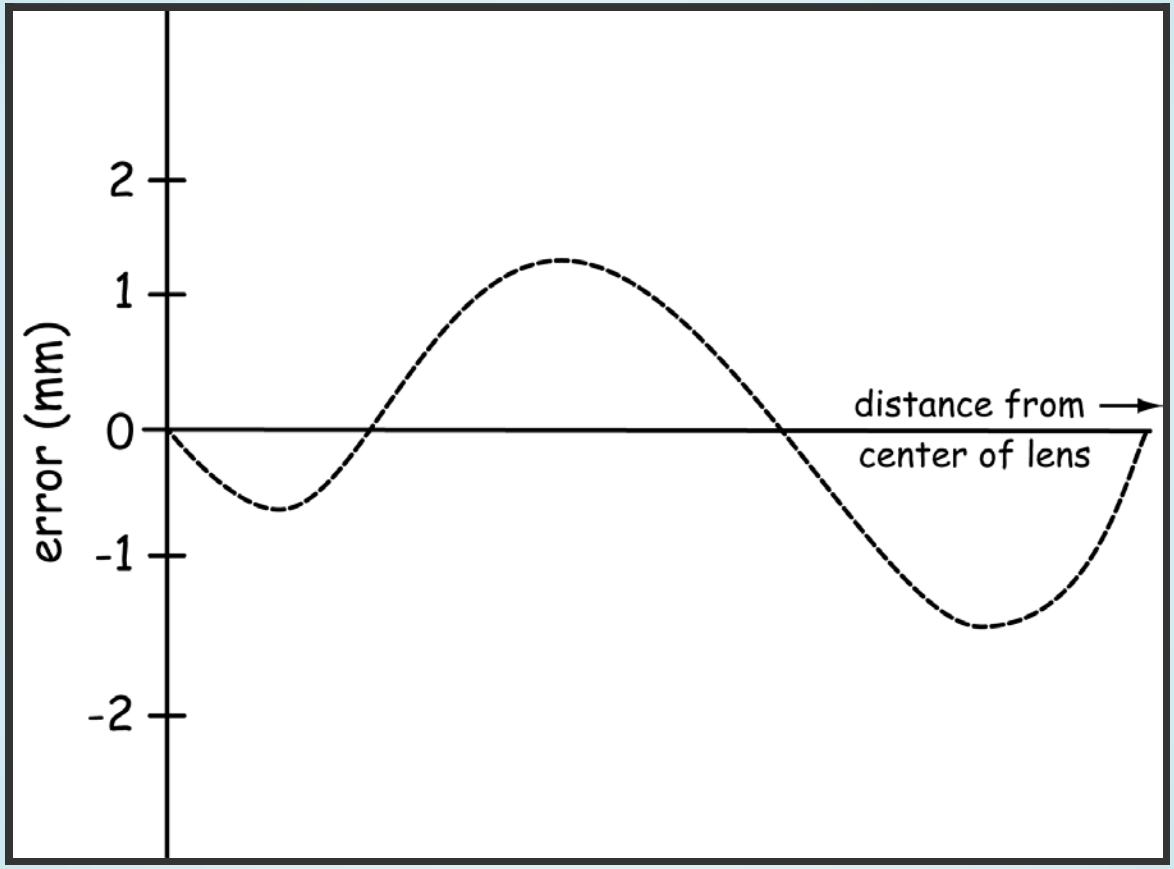


Bolstad 2012, Fig 6.20

OTHER KINDS OF DISTORTION

- Radial lens displacement - Distortion caused by the lens
- Atmospheric distortion - Distortion caused by the atmosphere

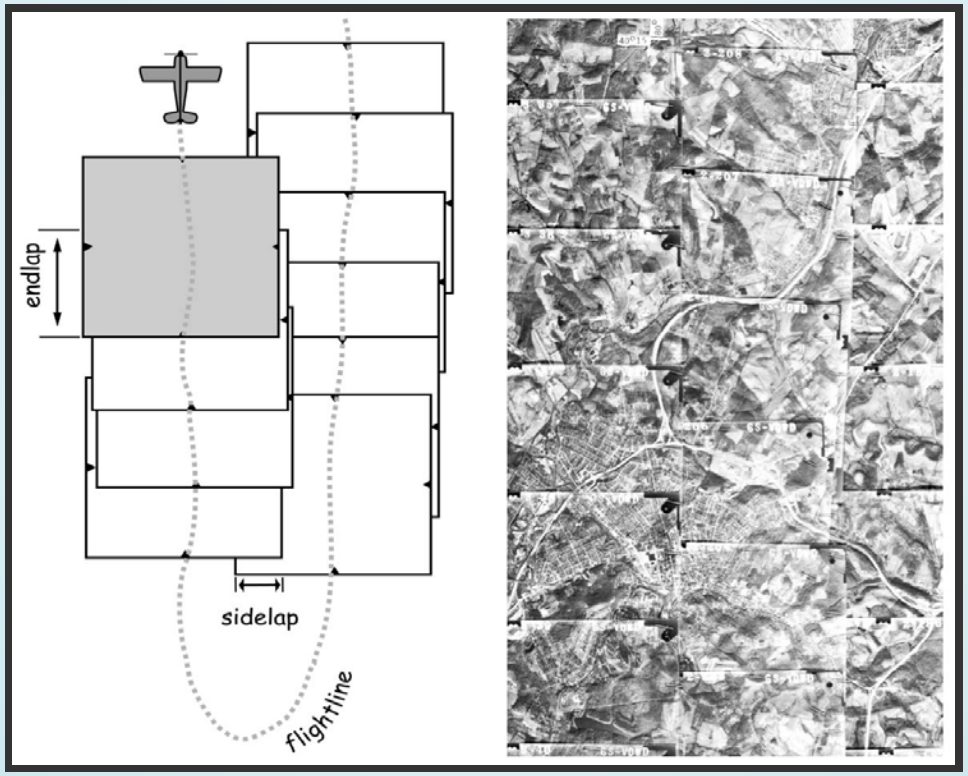
EXAMPLE OF RADIAL LENS DISPLACEMENT



Bolstad 2012, Fig 6.21

STEREO PHOTOGRAPHIC COVERAGE

Sequential photos in a flight line overlap with endlaps and sidelaps



Bolstad 2012, Fig 6.22

STEREOMODEL

The 3D perception of a stereopair, allowing us to observe depth

Image of a stereoscope from http://serc.carleton.edu

3D DEVELOPMENTS TODAY

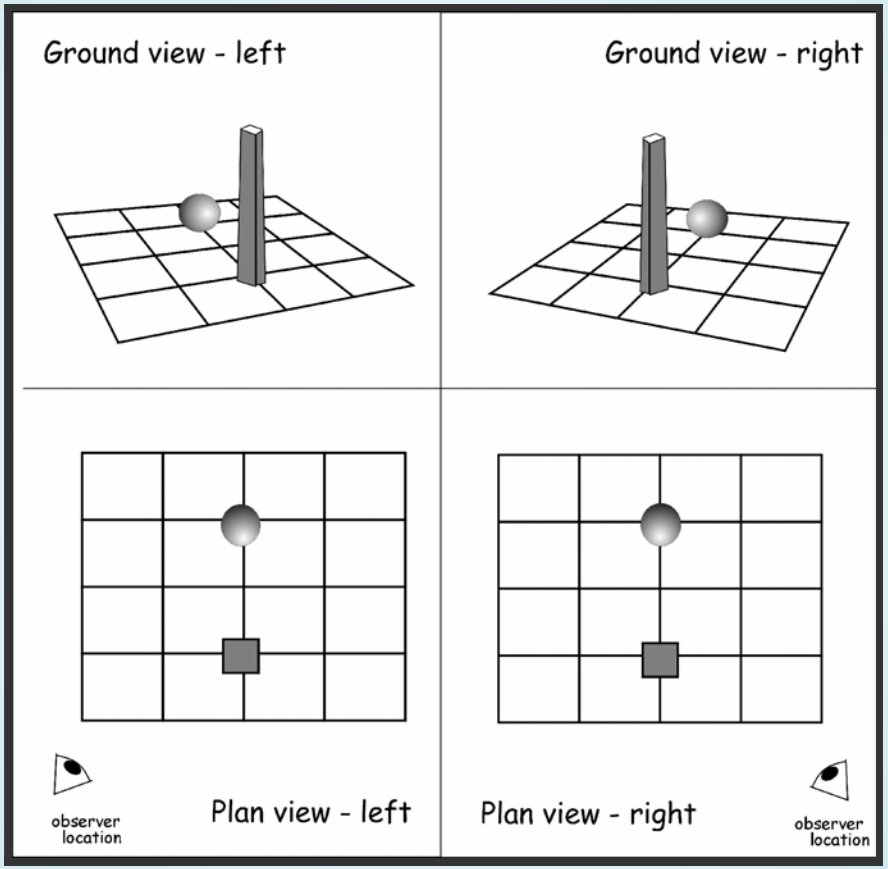
Image from http://serc.carleton.edu

Image from http://venturebeat.com/

Images from http://www.google.com/

PARALLAX

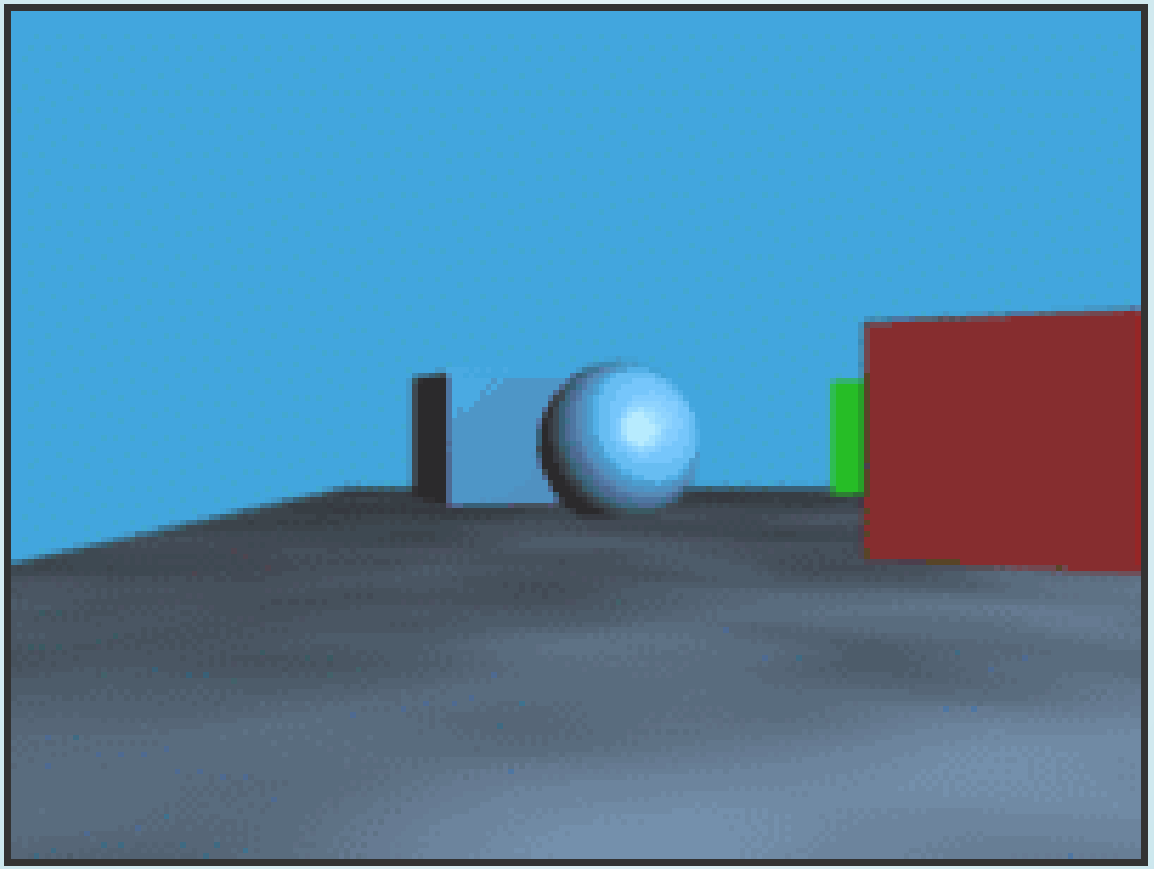
Shift in the relative distances and positions of objects due to a shift in observer location; responsible for stereomodels



Bolstad 2012, Fig 6.23

PARALLAX

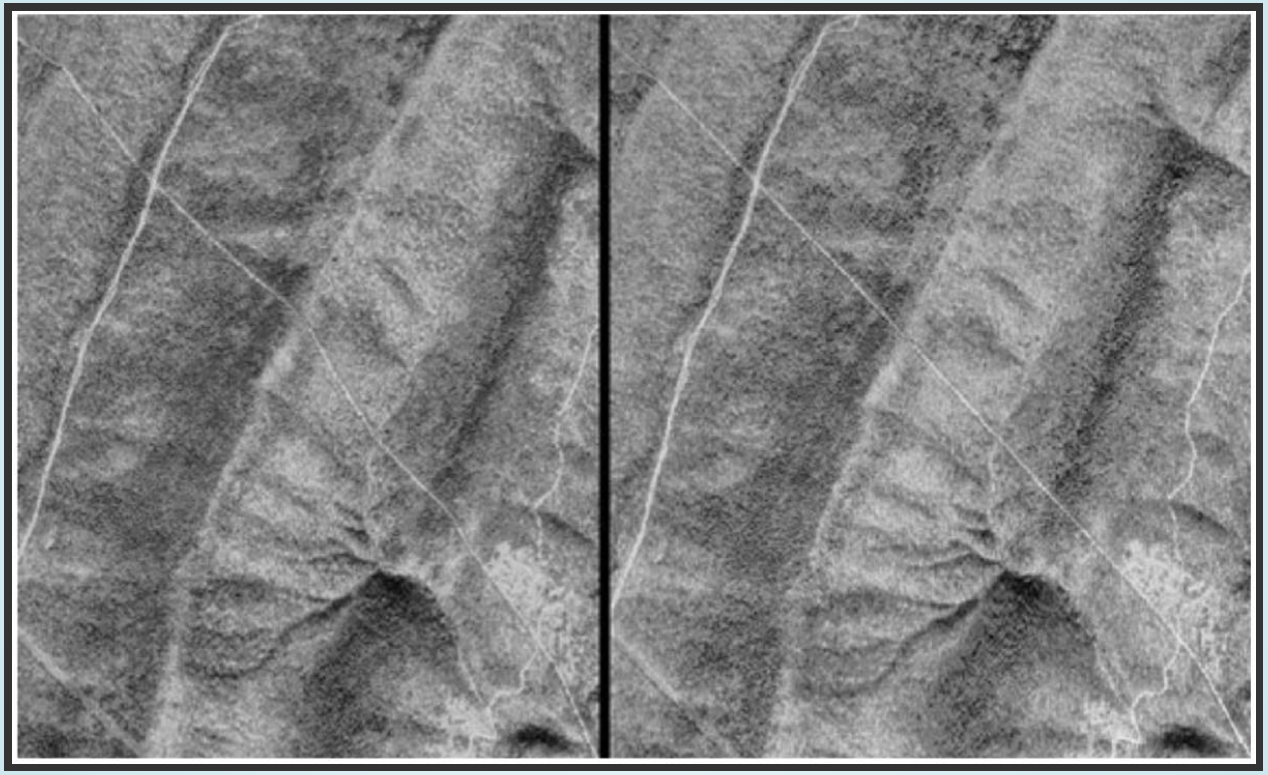
Shift in the relative distances and positions of objects due to a shift in observer location; responsible for stereomodels



Animation by Nathaniel Domek

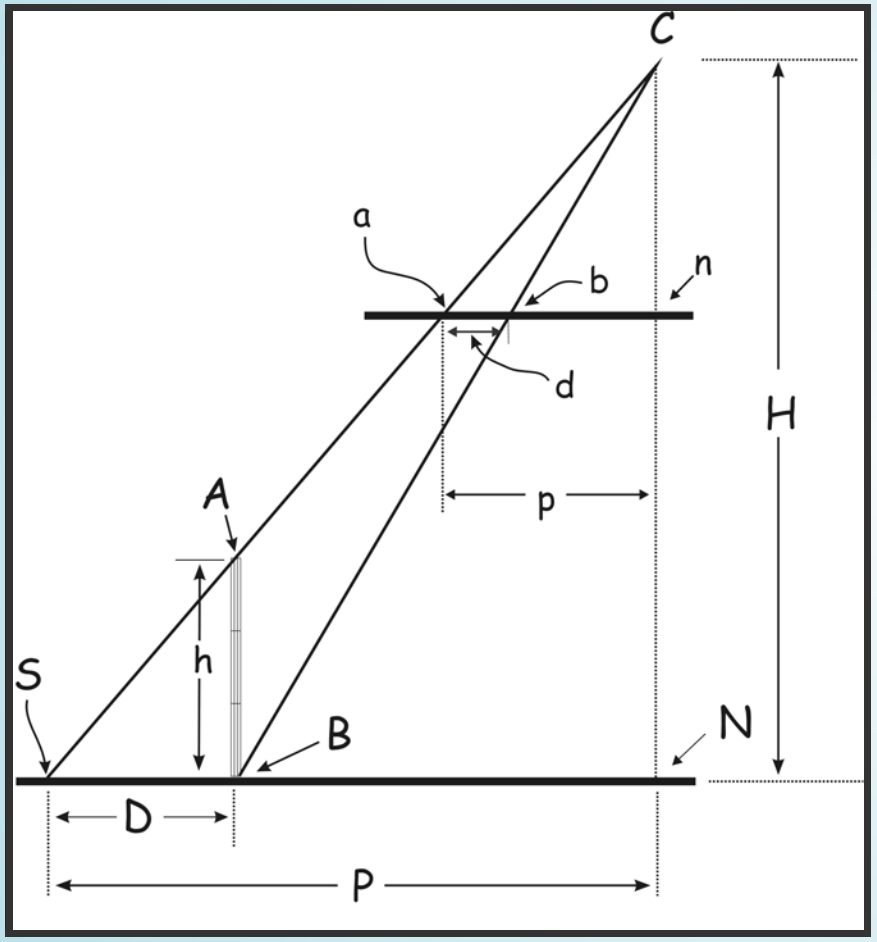
DISTORTION REMOVAL

Orthophotos/images/quads - Aerial images that have uniform scale and true geometry



Bolstad 2012, Fig 6.24

CALCULATING RELIEF DISPLACEMENT



Bolstad 2012, Fig 6.25

$$D/P = h/H \qquad (6.3)$$

$$d/p = D/P \qquad (6.4)$$

$$d/p = h/H \qquad (6.5)$$

$$d = p*h/H \qquad (6.6)$$

where:

d = displacement distance

p = distance from the nadir point, n, on the vertical photo to the imaged point a

H = flying height

h = height of the imaged point

Bolstad 2012 Equations

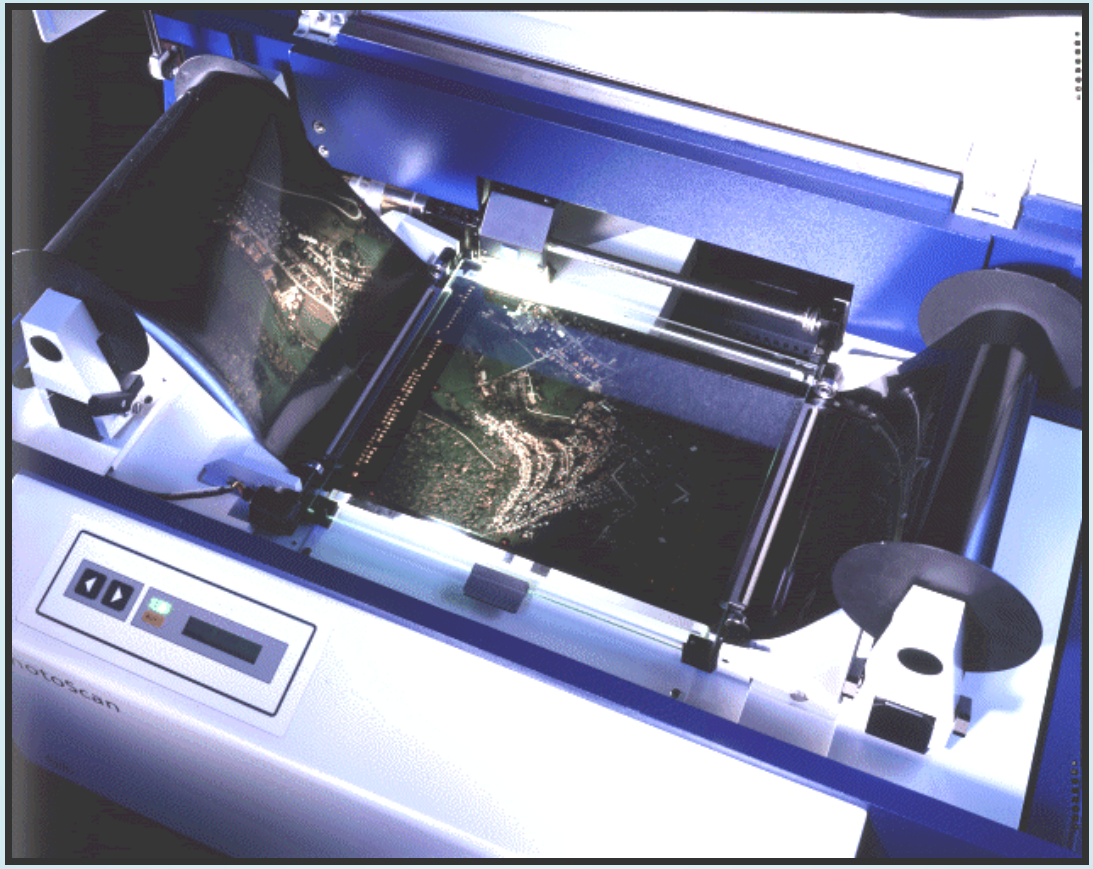
SOFTCOPY PHOTOGRAMMETERY

The practice of creating orthophotos by removing distortion from aerial images

Bolstad 2012, Fig 6.26

CREATING ORTHOPHOTOS

Scanning/Digitizing



Bolstad 2012, Fig 6.27a

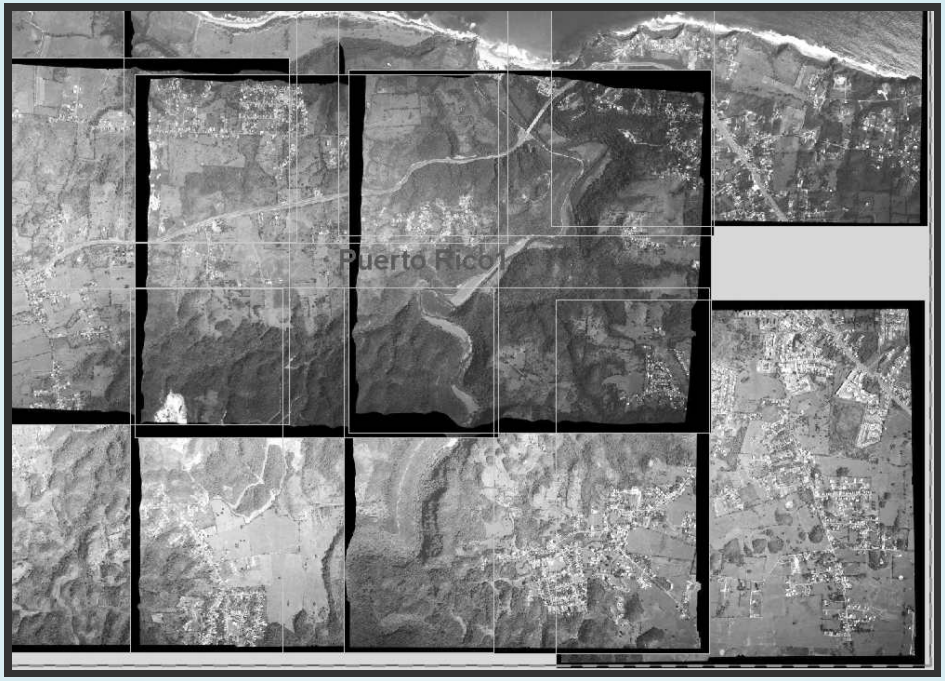
CREATING ORTHOPHOTOS

Control Points

Bolstad 2012, Fig 6.27b

CREATING ORTHOPHOTOS

Mosaic - Images with overlap that are stitched together to create a single image



Bolstad 2012, Fig 6.27c

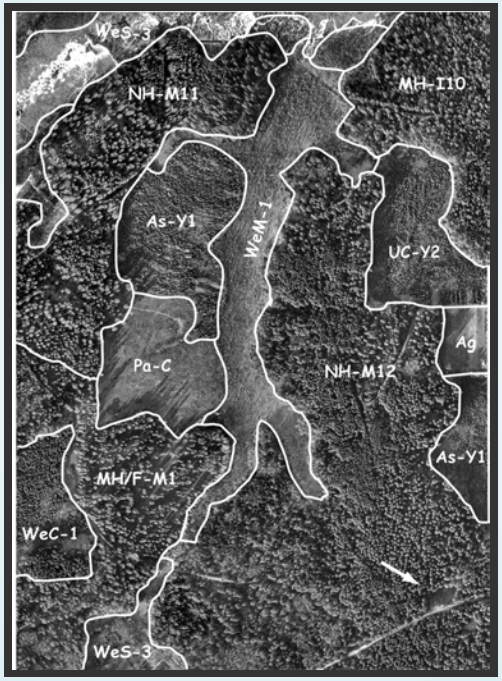
CREATING ORTHOPHOTOS

Final Product

Bolstad 2012, Fig 6.27d

PHOTOINTERPRETATION

- Converting images to information
- Minimum mapping unit - Defines the lower limit on what is considered significant



Bolstad 2012, Fig 6.28

SATELLITES

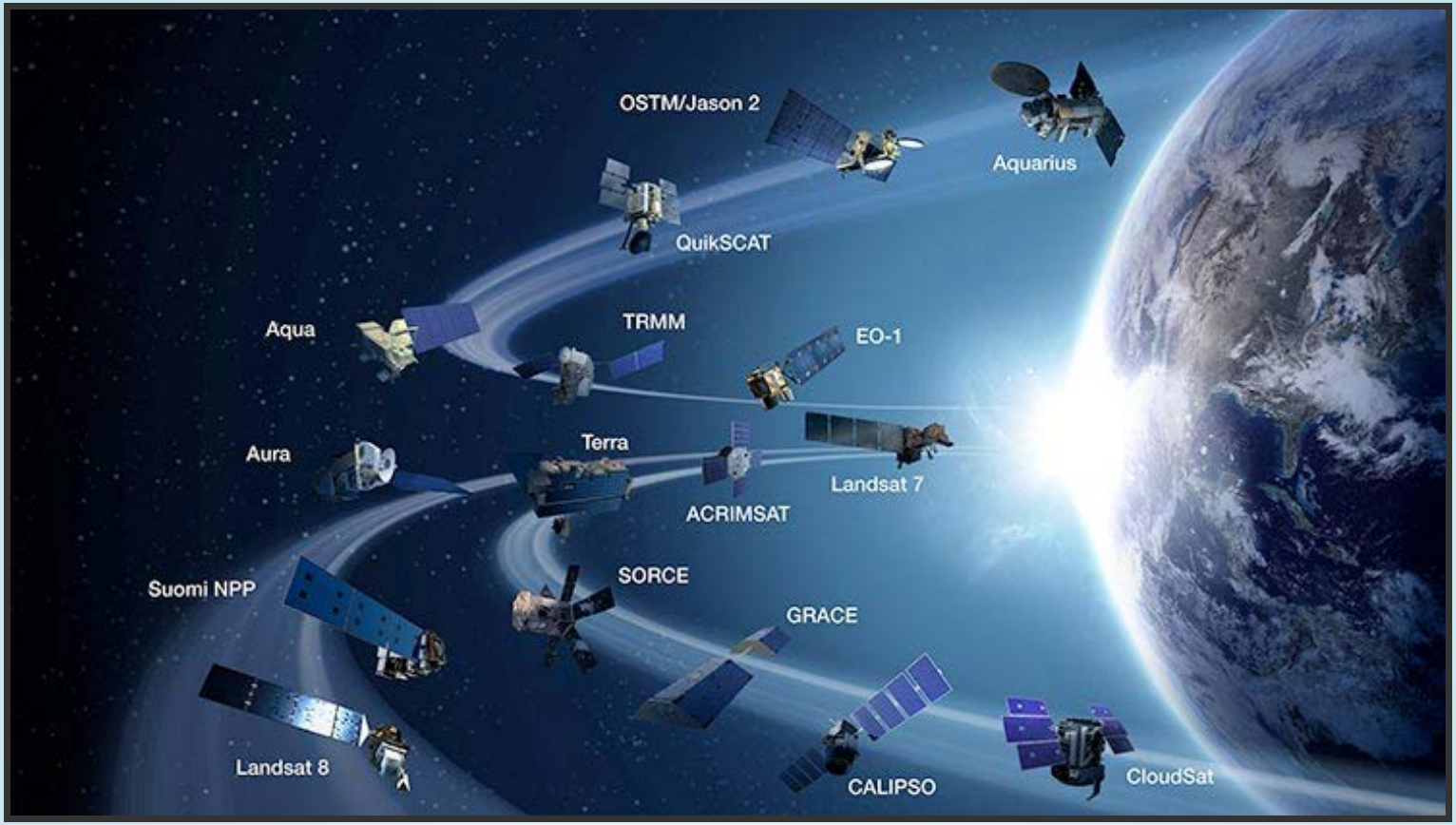
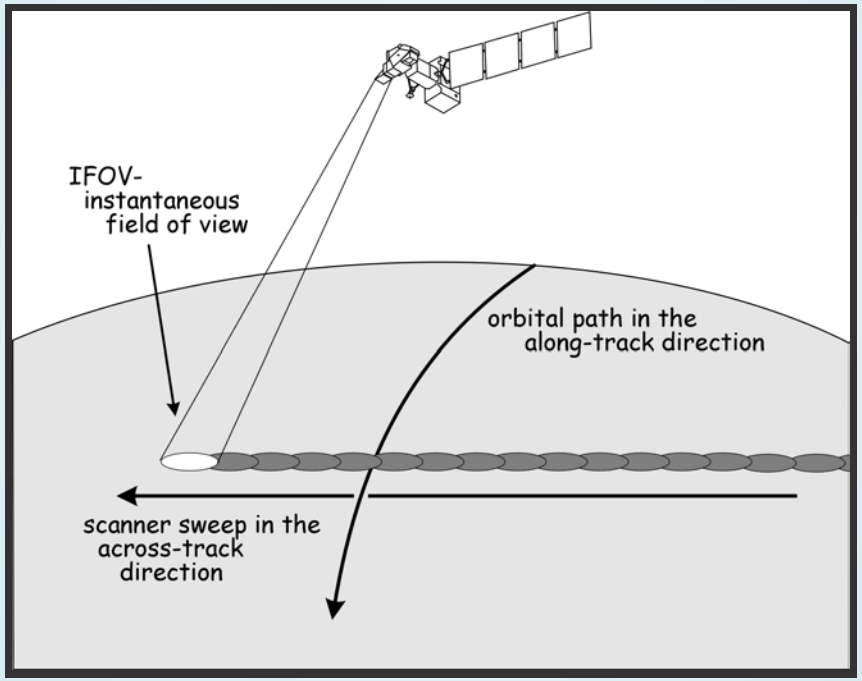


Image from http://nasaesw.strategies.org/

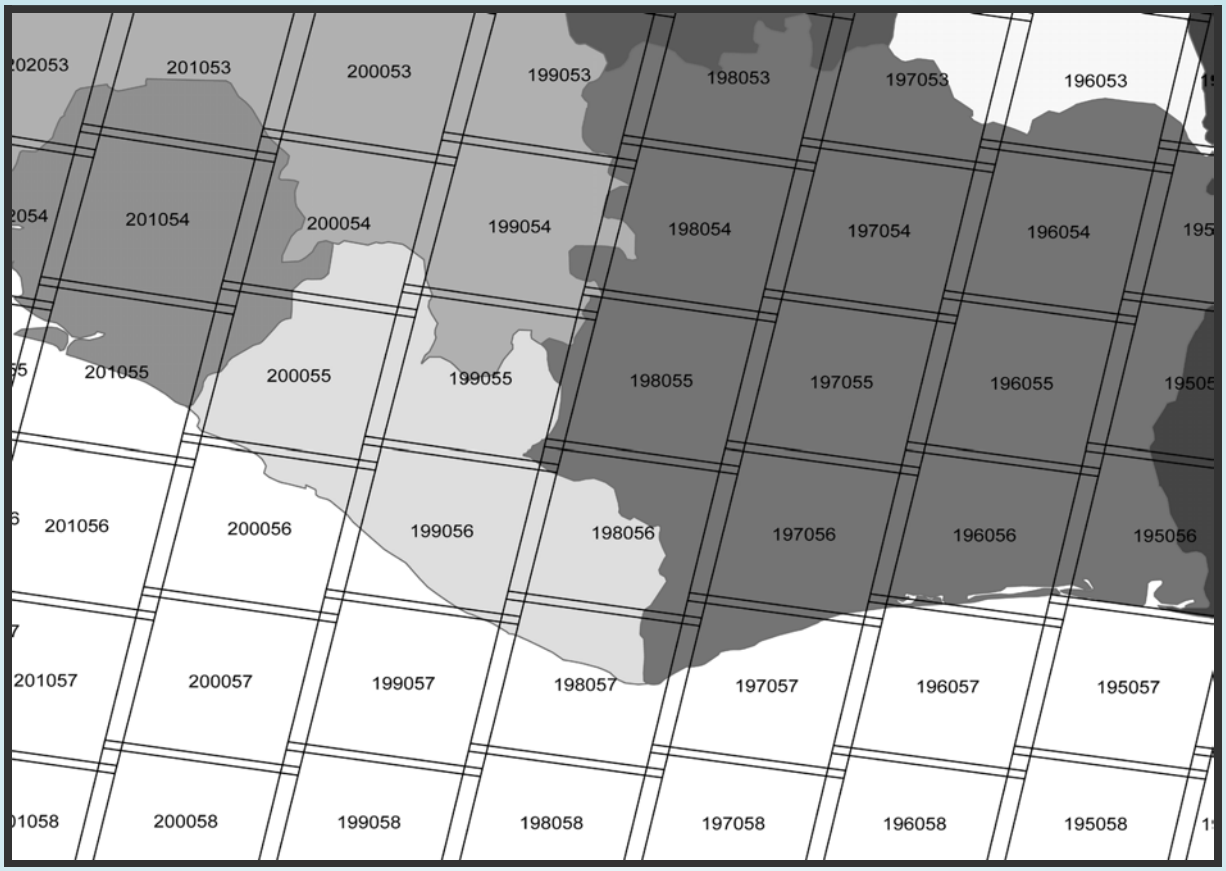
INSTANTANEOUS FIELD OF VIEW (IFOV)

The size of the area that is viewed by each detector; related to resolved pixel size



Bolstad 2012, Fig 6.29

PATH/ROW SYSTEM



Bolstad 2012, Fig 6.30

1-METER BY THE IKONOS SATELLITE SYSTEM

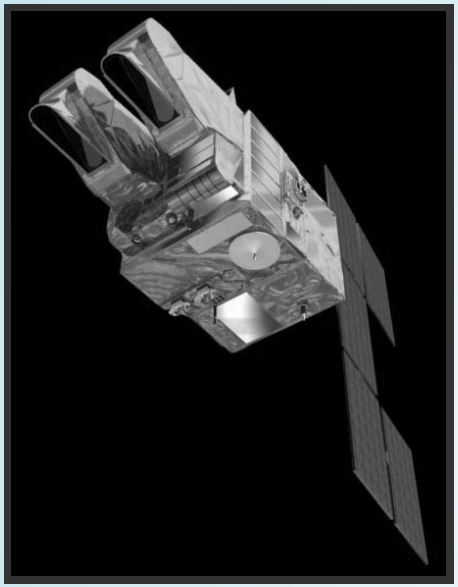
Bolstad 2012, Fig 6.31

0.5-METER BY THE WORLDVIEW-2 SATELLITE

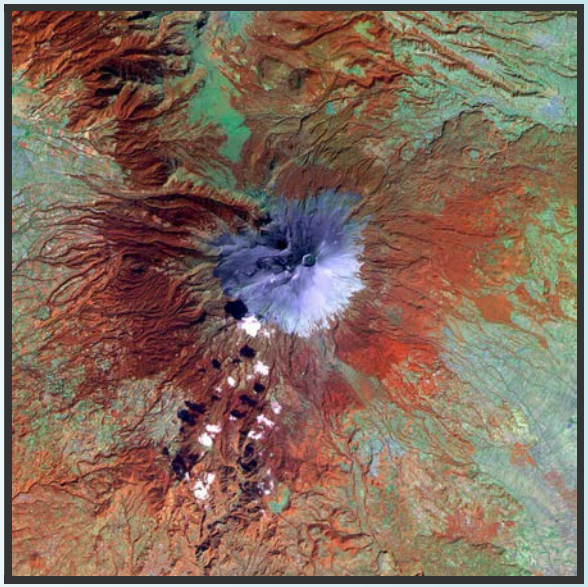
Bolstad 2012, Fig 6.32

SPOT SATELLITES

- Satellite Pour l'Observation de la Terre
- Centre national d'études spatiales (CNES)



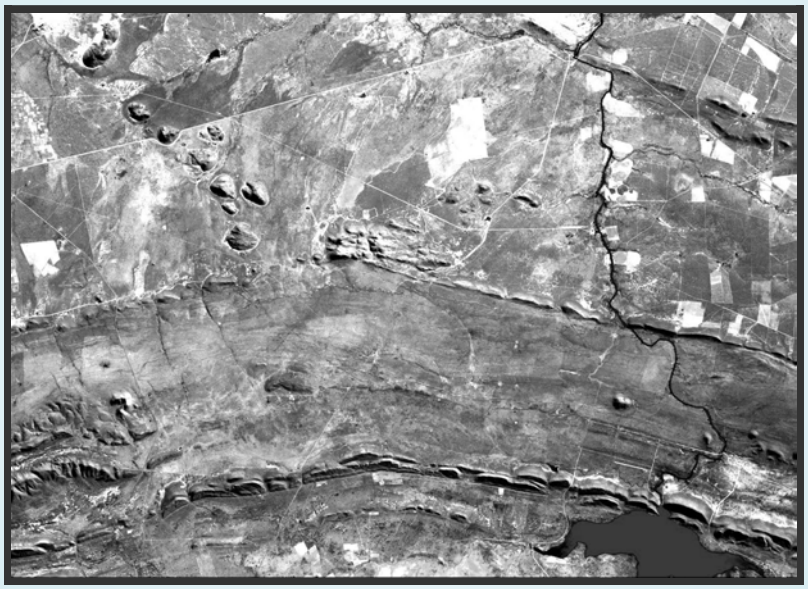
Bolstad 2012, Fig 6.33



Bolstad 2012, Fig 6.34

LANDSAT SATELLITES

- NASA - National Aeronautics and Space Administration
- MSS - Multispectral Scanner
- TM - Thematic Mapper
- ETM+ - Enhanced Thematic Mapper



Bolstad 2012, Fig 6.35

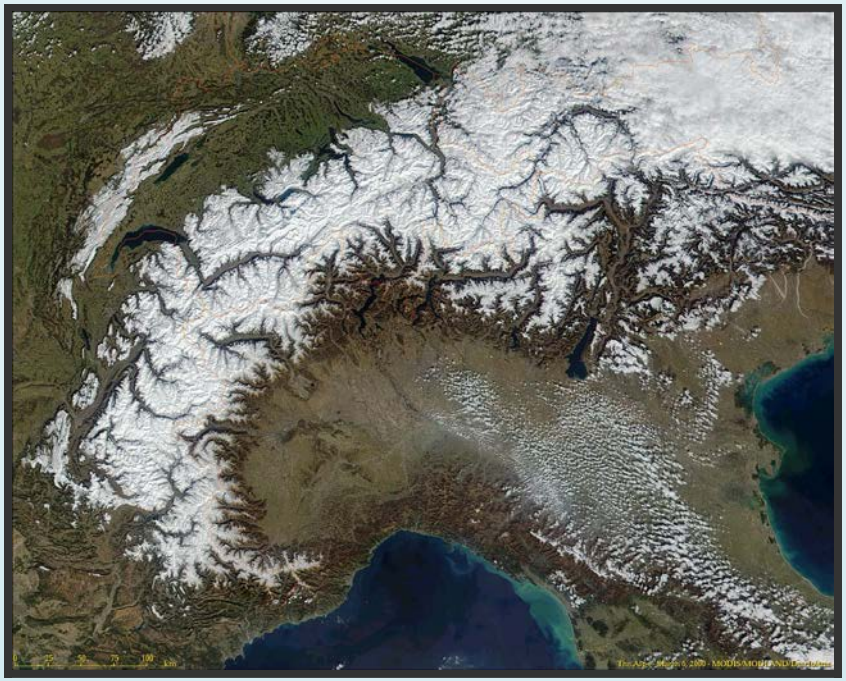
NUMBER OF BANDS

- Multispectral - A few
- Superspectral - A few dozen
- Hyperspectral - Hundreds

MODIS SENSOR

Moderate Resolution Imaging Sensor (NASA)

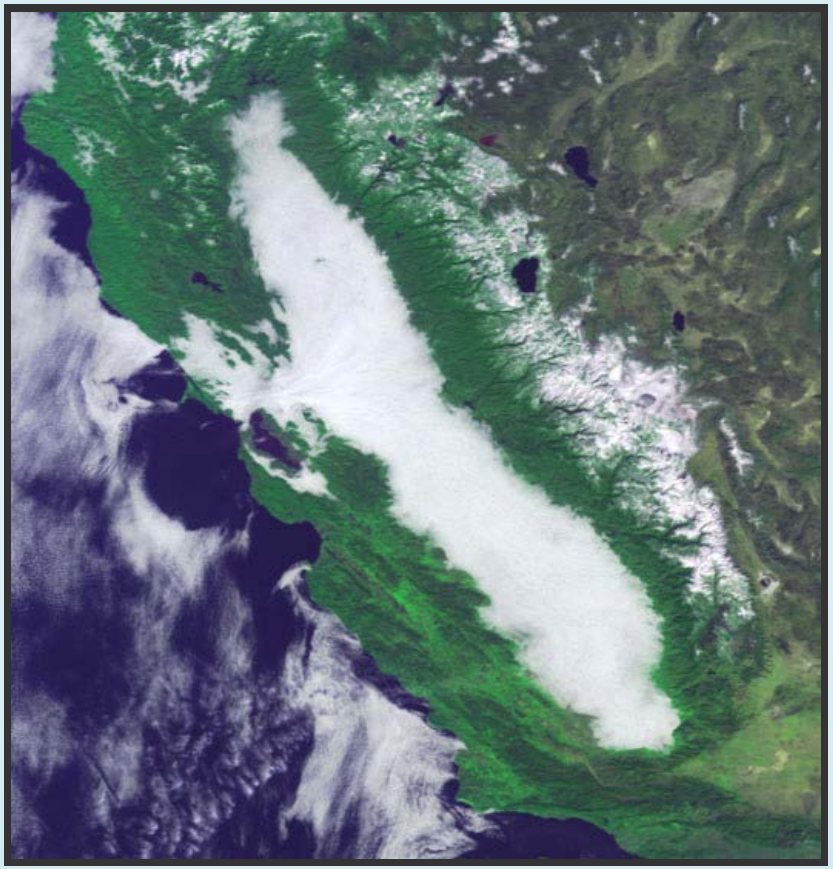
Note that there is a difference between satellites and sensors



Bolstad 2012, Fig 6.37

VEGETATION SENSOR

CNES



Bolstad 2012, Fig 6.38

RESOURCESAT-1

The Indian Space Research Organization

Bolstad 2012, Fig 6.36

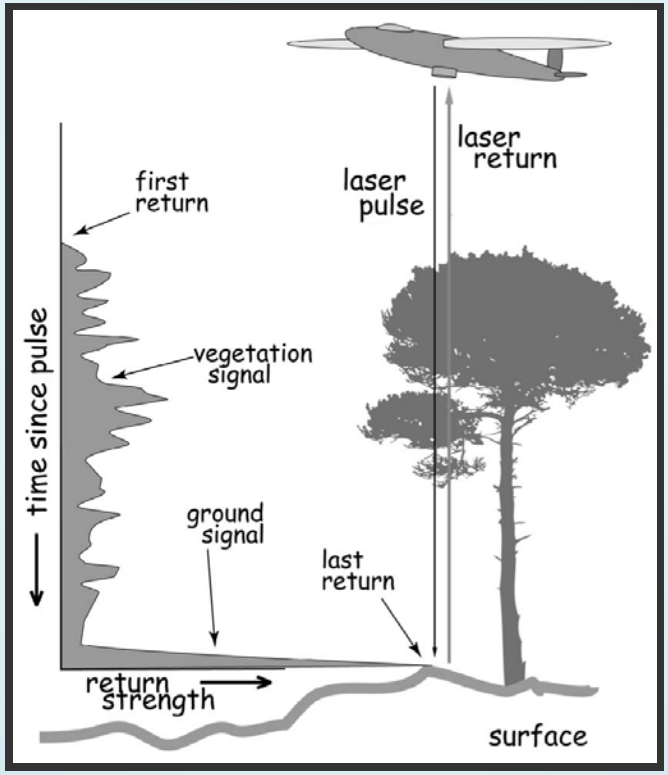
MERIS

European Space Agency (ESA)

Bolstad 2012, Fig 6.39

LIGHT DETECTION AND RANGING (LIDAR)

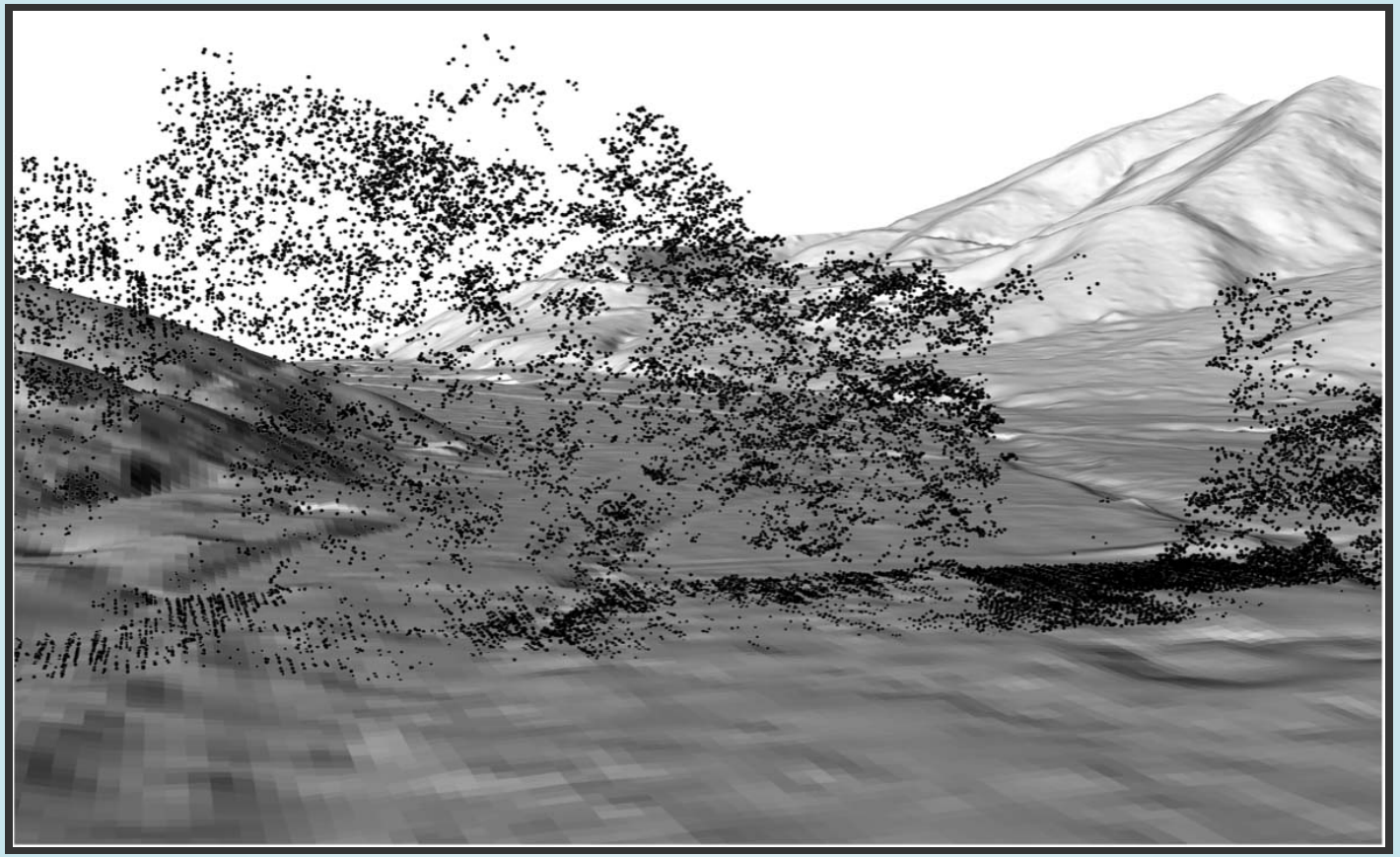
Waveform LiDAR



Bolstad 2012, Fig 6.40

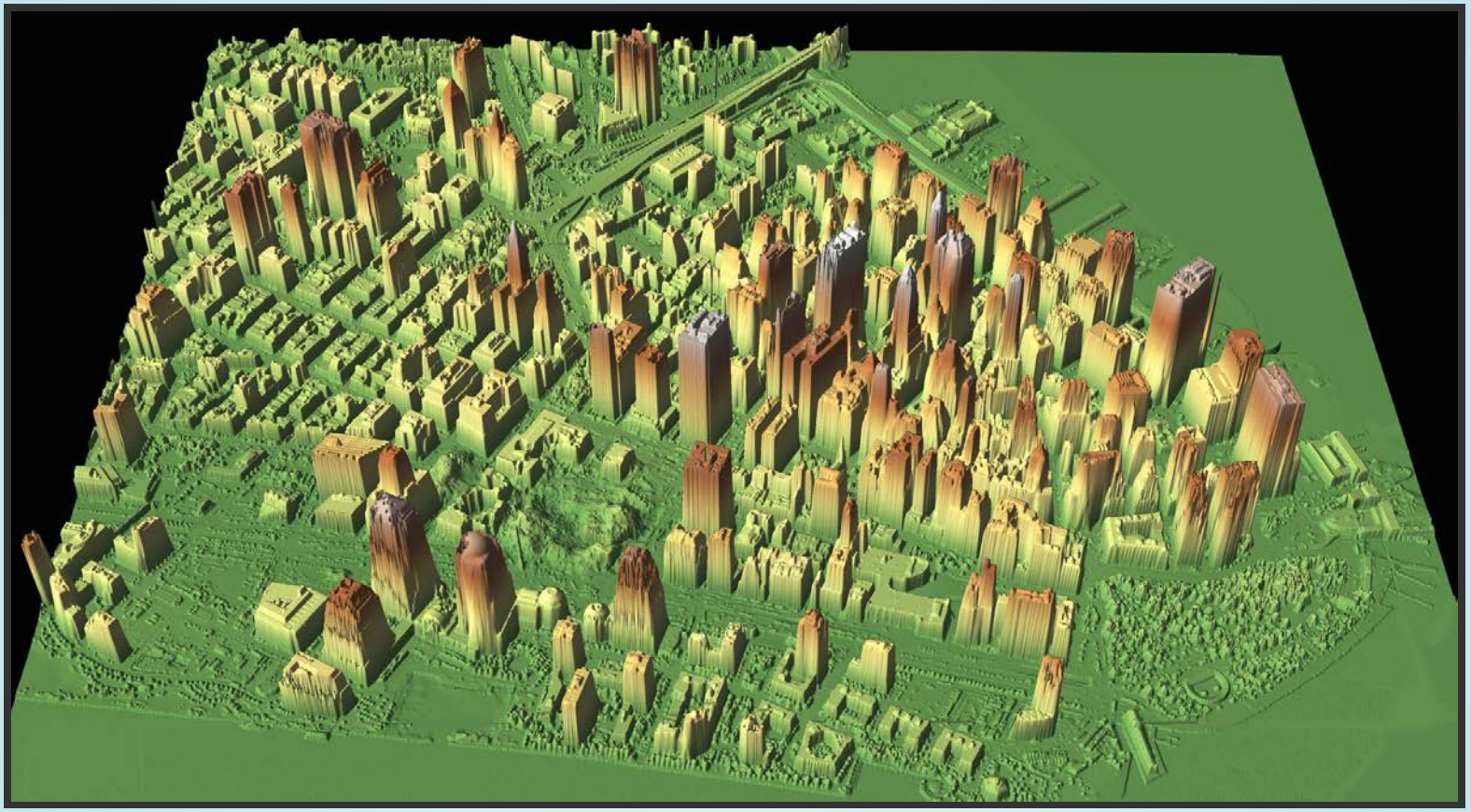
DISCRETE-RETURN LIDAR

Point clouds



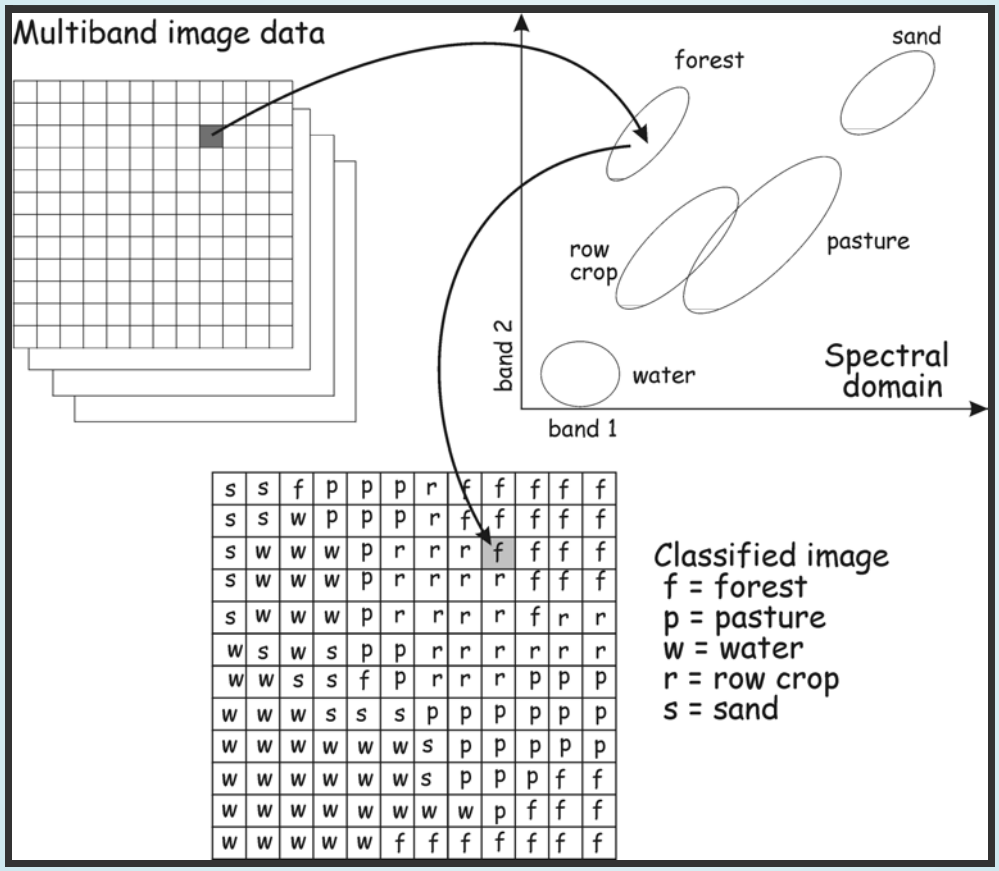
Bolstad 2012, Fig 6.41

LIDAR FOR ELEVATION DATA



Bolstad 2012, Fig 6.42

LAND COVER/USE CLASSIFICATION



Bolstad 2012, Fig 6.43

SOME MORE SATELLITES

Planet Labs

Image from http://www.satmagazine.com

Skybox Imaging

Image from http://www.skybox.com