

# Geographic Information Systems

ESM 263 - Winter 2023

# Data Collection

- Capture: becomes digital
  - primary: “born digital”
  - secondary: digitized
- Transfer: acquired/digitized by someone else
- Either way, you still may have to
  - Edit and Clean
  - Re-project
  - Generalize

# Data Collection Techniques

## Raster

- Primary
  - digital remote sensing
- Secondary
  - scanned photographs
  - scanned maps
  - DEMs from maps

## Vector

- Primary
  - GPS
  - Surveying
- Secondary
  - topographic surveys
  - toponomy from text

# Raster Primary Data Capture

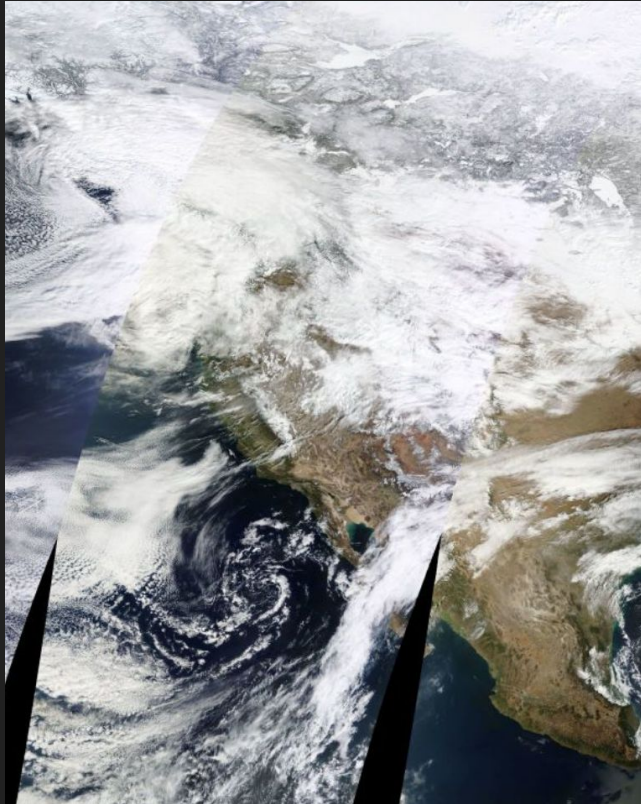
## Remote sensing

- Passive
  - optical scanners
  - microwave radiometers
- Active
  - Radar
  - Lidar

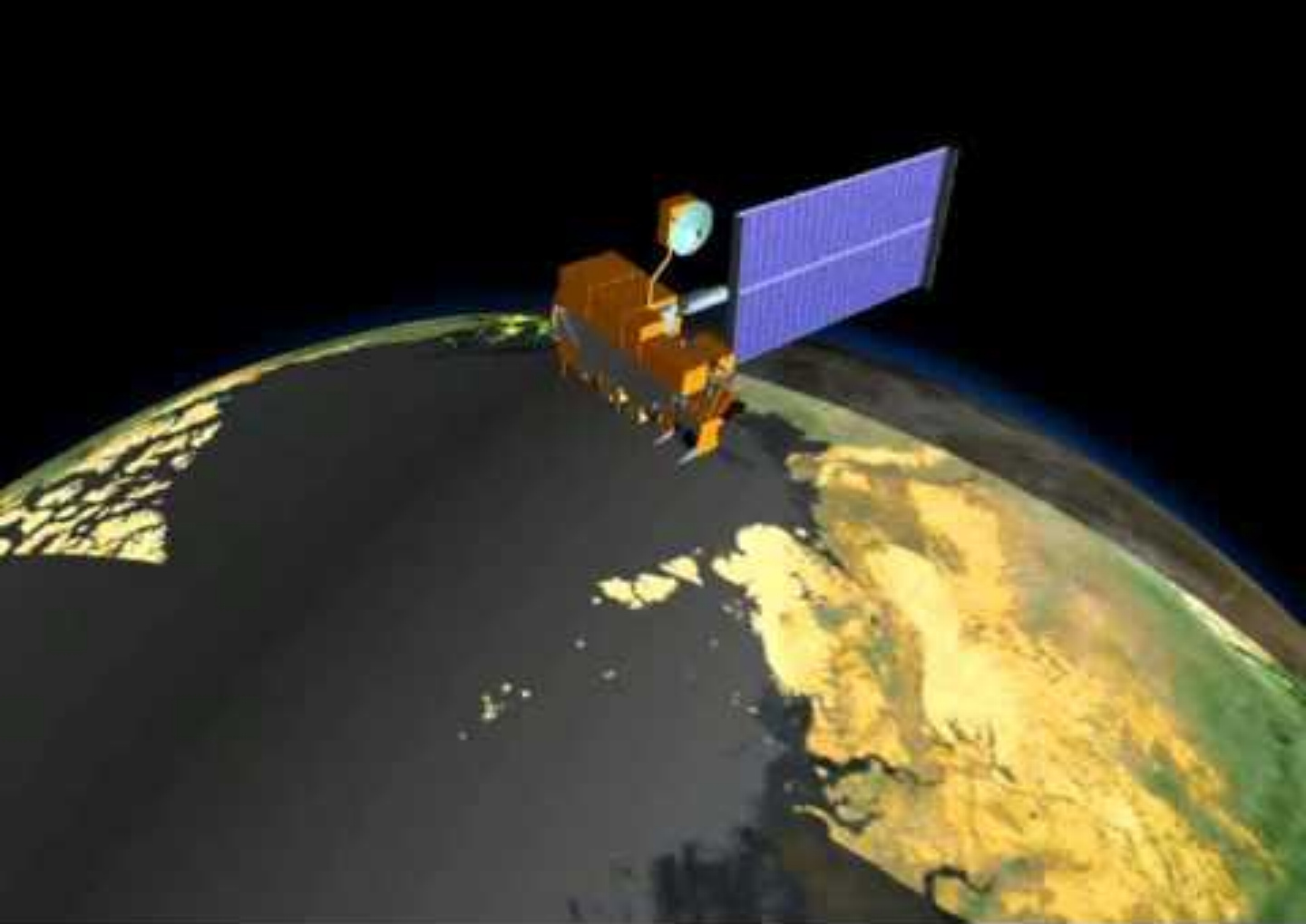
## Resolution

- Spatial
  - cell size
  - swath width
- Spectral
  - Bandwidth
  - #bands
- Temporal
  - repeat cycle
- Radiometric
  - Range
  - precision

# MODIS (MODerate-resolution Imaging Spectrometer)



- Platforms
  - EOS Terra (since Feb 2000)
  - EOS Aqua (since May 2002)
- Spatial resolution
  - 2330 km swath
  - 250 ... 1000 m / pixel
- Spectral bands
  - 36 visible, near-IR, thermal
- Temporal resolution
  - every 1 ... 2 days
  - 100% duty cycle

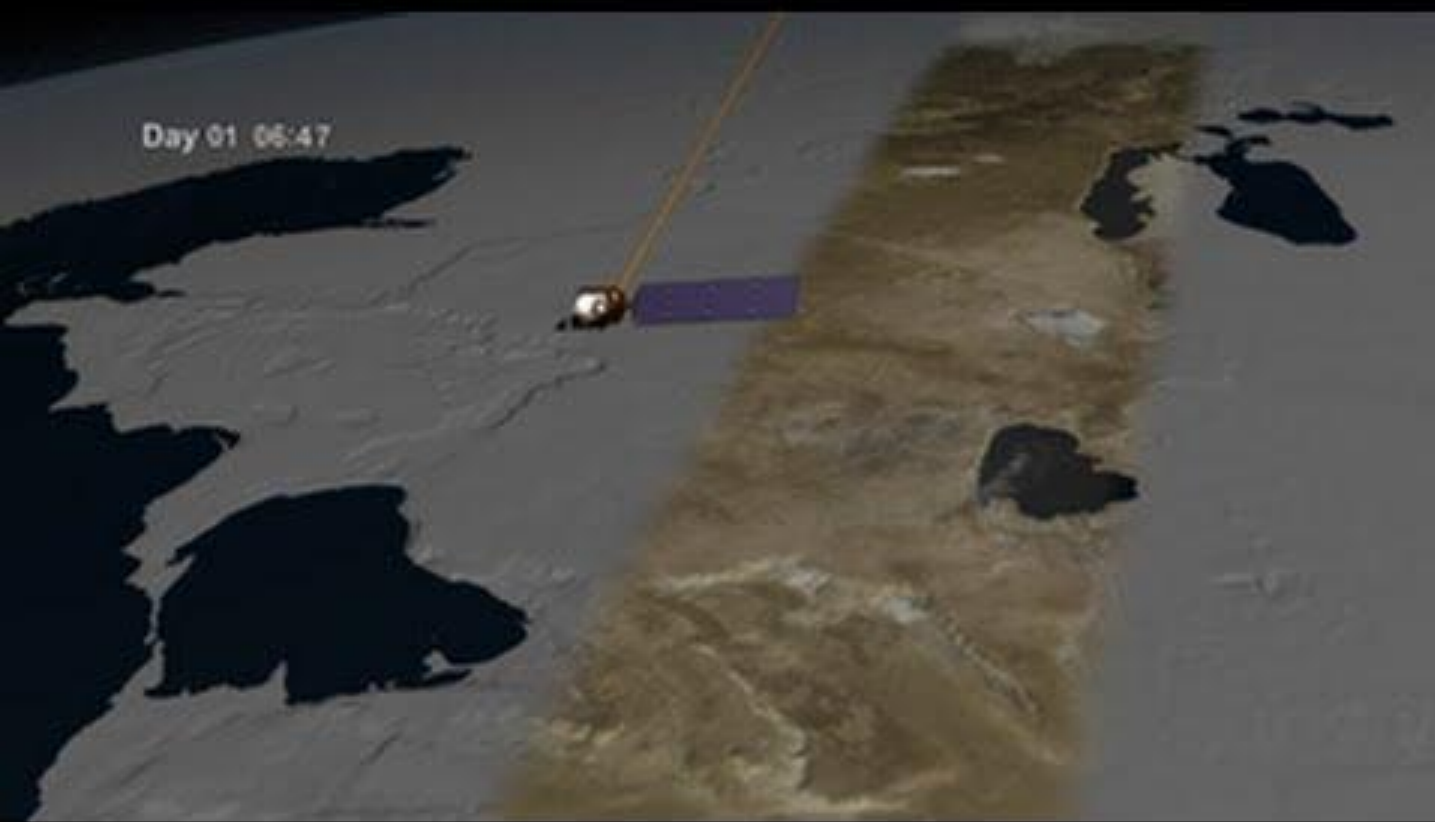


# Landsat Satellites

Sattelite	Sensor	Data Start	Data Stop
Landsat 4	TM	1982	1993
Landsat 5	TM	1984	2011
Landsat 6	ETM+	1993	Partial since 2003
Landsat 8	OLI	2013	ongoing
Landsat 9	OLI	2021	ongoing

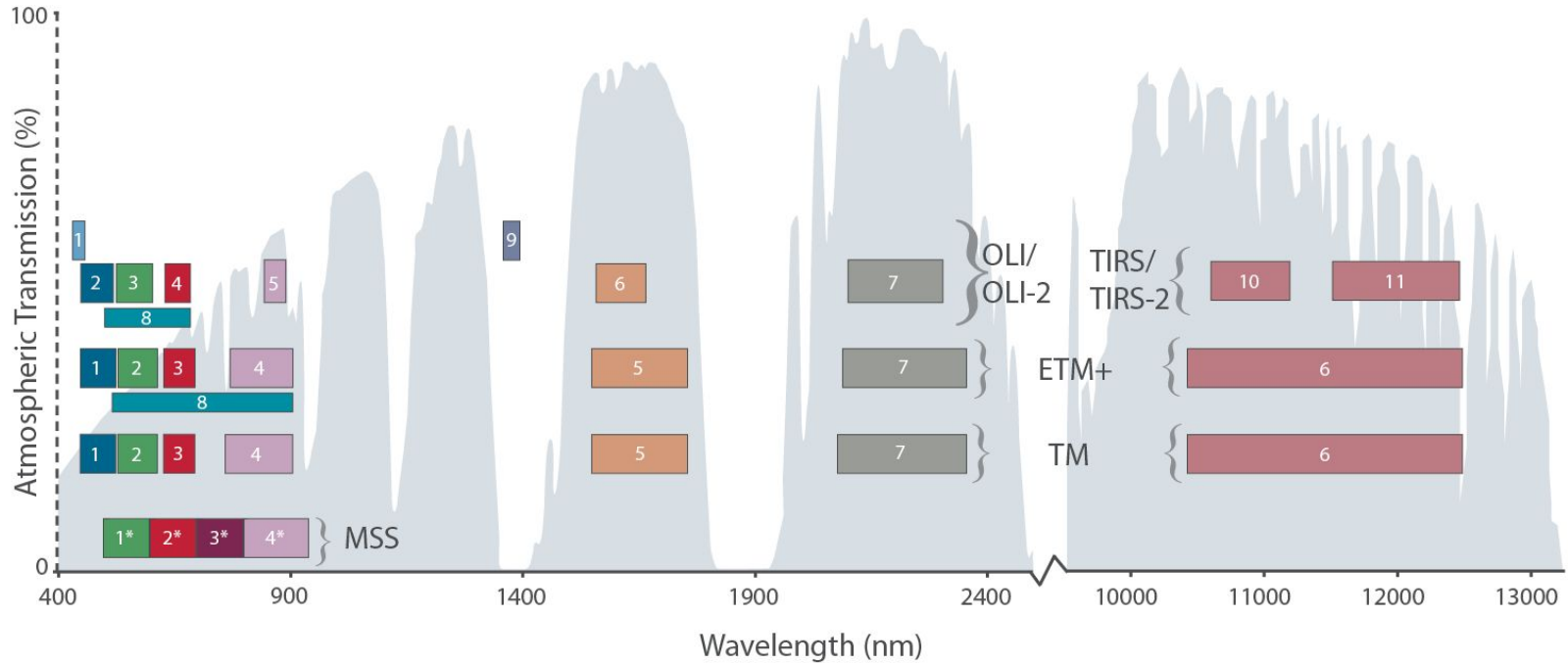
- Spatial Resolution
  - 185 km Swath
  - 30 m / pixel
- Temporal resolution
  - every 16 days
  - every 8 days since 2013: most recent 2 Landsats; 8 days apart

Day 01 06:47





# Landsat Spectral Bands



# Planet Labs

Platform	Spatial Resolution	Spectral Resolution (Bands)	Temporal Resolution
Dove / SuperDove	3.7 m	4/8	Daily
Rapid Eye	5 m	5	Daily
SkySat	<= 1 m	4	Tasked

Also: DigitalGlobe / Maxar Technologies  
<https://en.wikipedia.org/wiki/DigitalGlobe>



Mt Dukono  
2016-08-24

Planet Labs  
Dove Sattelites





Mt Dukono  
2016-08-25

Planet Labs  
Dove Sattelites

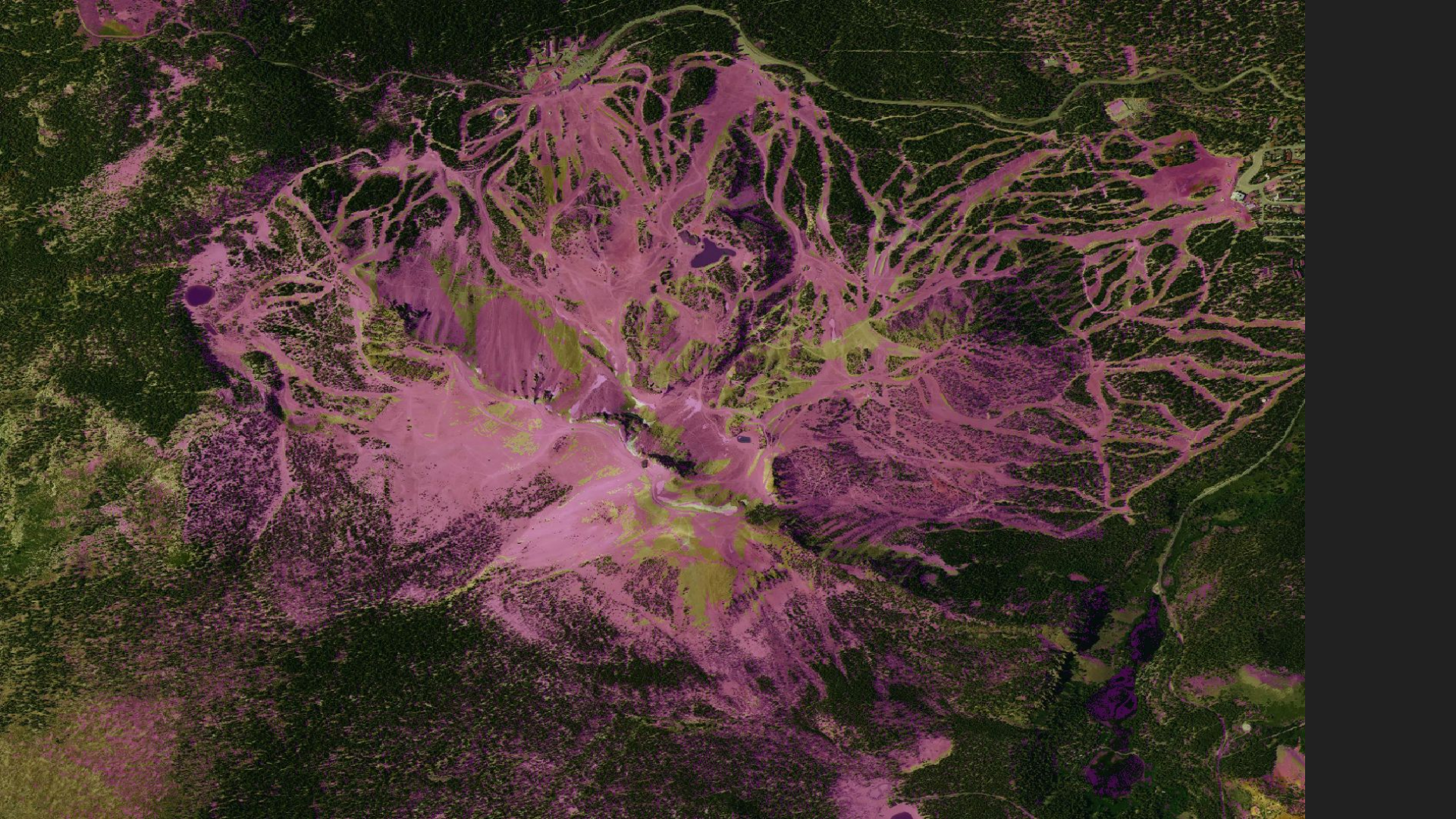




Mt Dukono  
2017-03-29

Planet Labs  
Dove Sattelites









# Vector Primary Data Capture

- Surveying
  - Angle and distance measurements from known locations
  - Expensive field equipment and crews
  - Most accurate method for large scale, small areas
- Global navigation satellite systems (GNSS)
  - Collection of satellites used to fix location re: Earth center
    - GPS (US)
    - GLONASS (Russia)
    - BeiDou (China)
    - Galileo (EU)

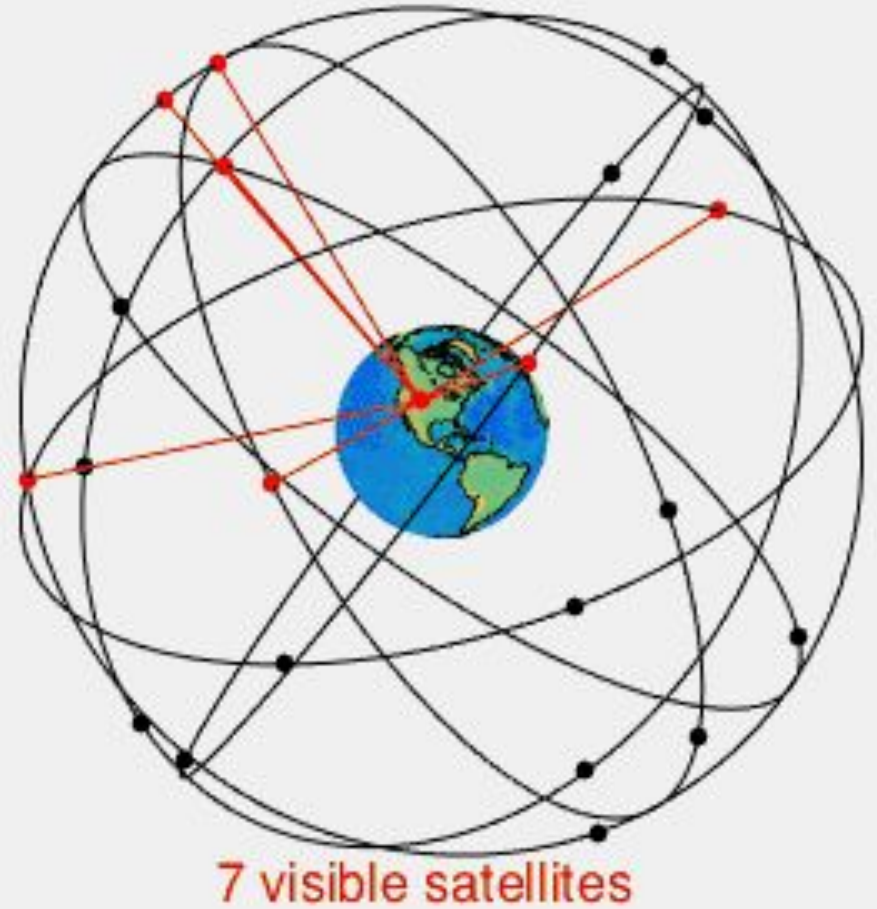


# GPS: Satellites

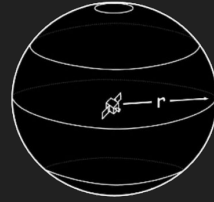
24 satellites

- 4 satellites / orbit
- 6 orbits
  - 26 km
  - 55° inclination

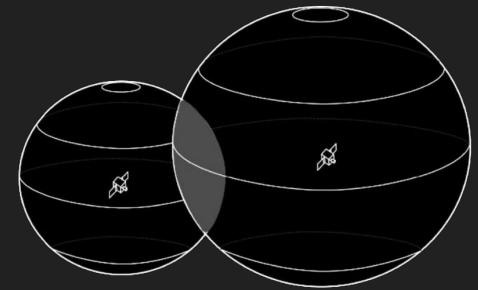
→ Always > 4 satellites visible / above horizon



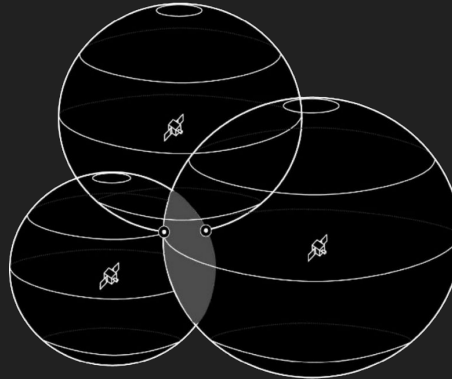
# GNSS: How It Works



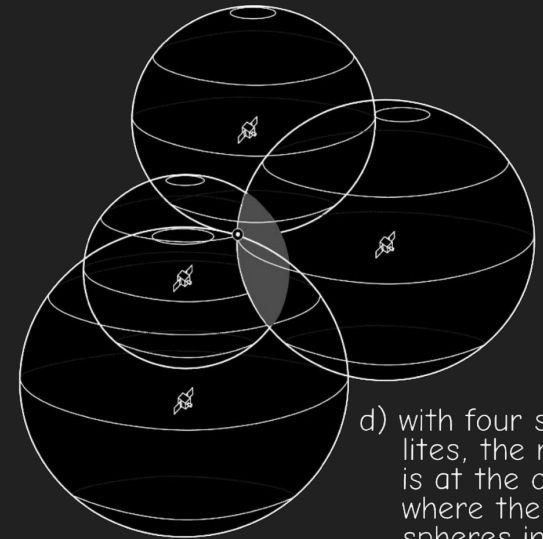
a) with a range measurement from one satellite, the receiver is positioned somewhere on the sphere defined by the satellite position and the range distance,  $r$



b) with two satellites, the receiver is somewhere on a circle where the two spheres intersect



c) with three satellites the receiver is at one of two points where the three spheres intersect



d) with four satellites, the receiver is at the one point where the four spheres intersect.

Fig. 5-7, p. 199  
Bolstad 7th Edition

# GNSS: It's Not Perfect

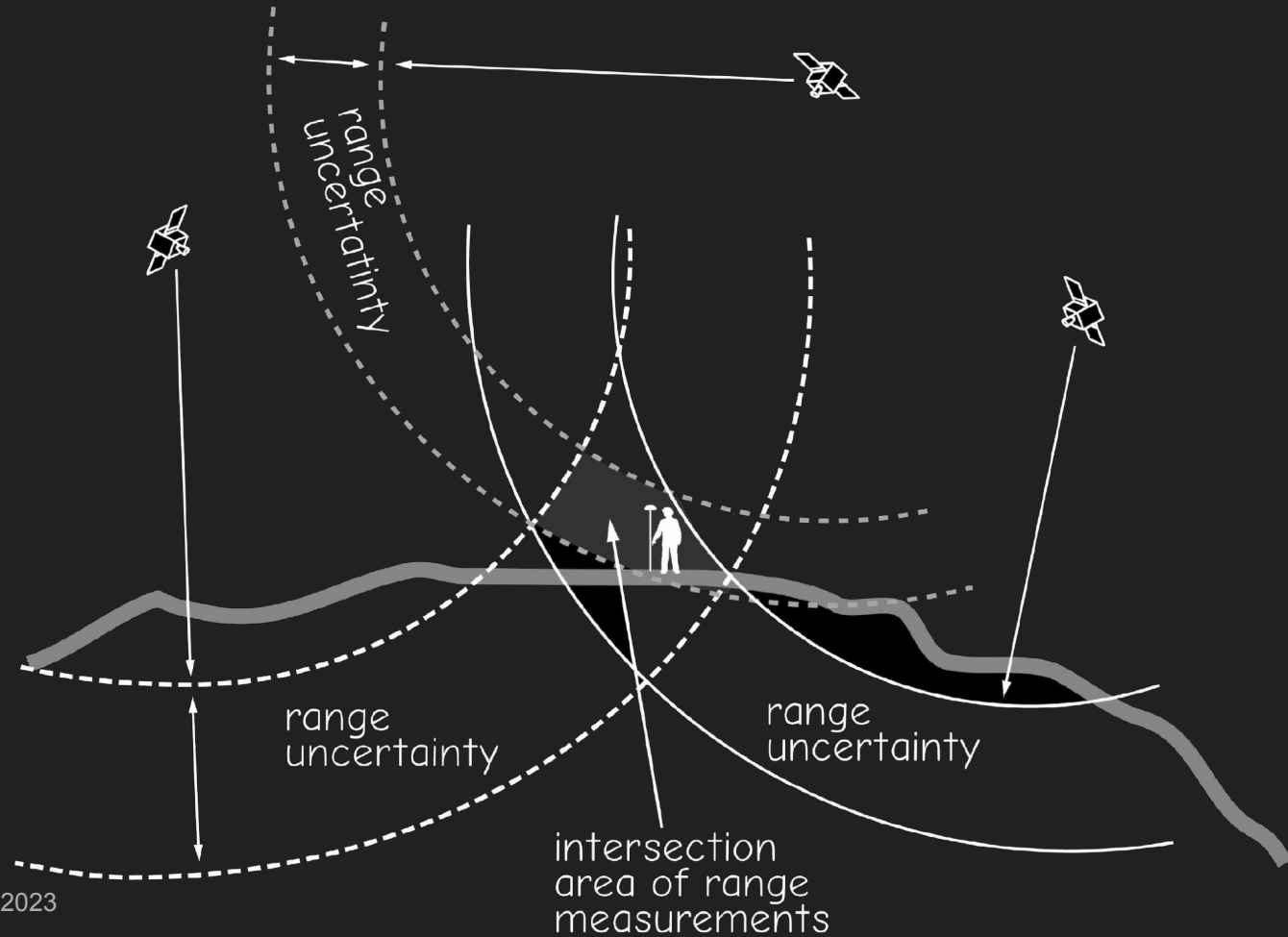


Fig. 5-10, p. 201  
Bolstad 7th Edition

# Differential GNSS

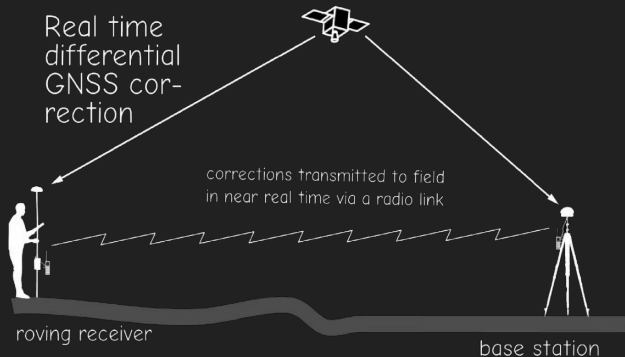
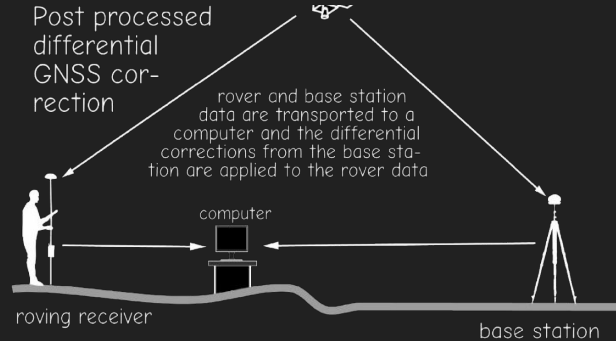
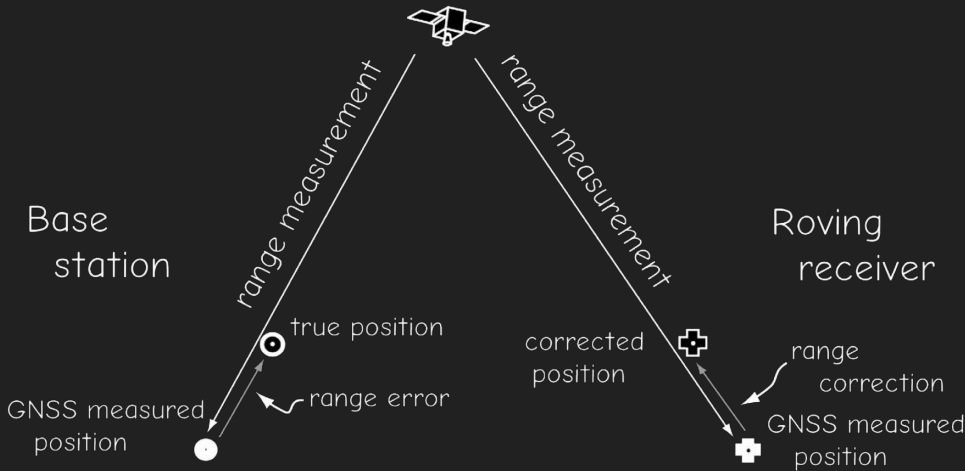
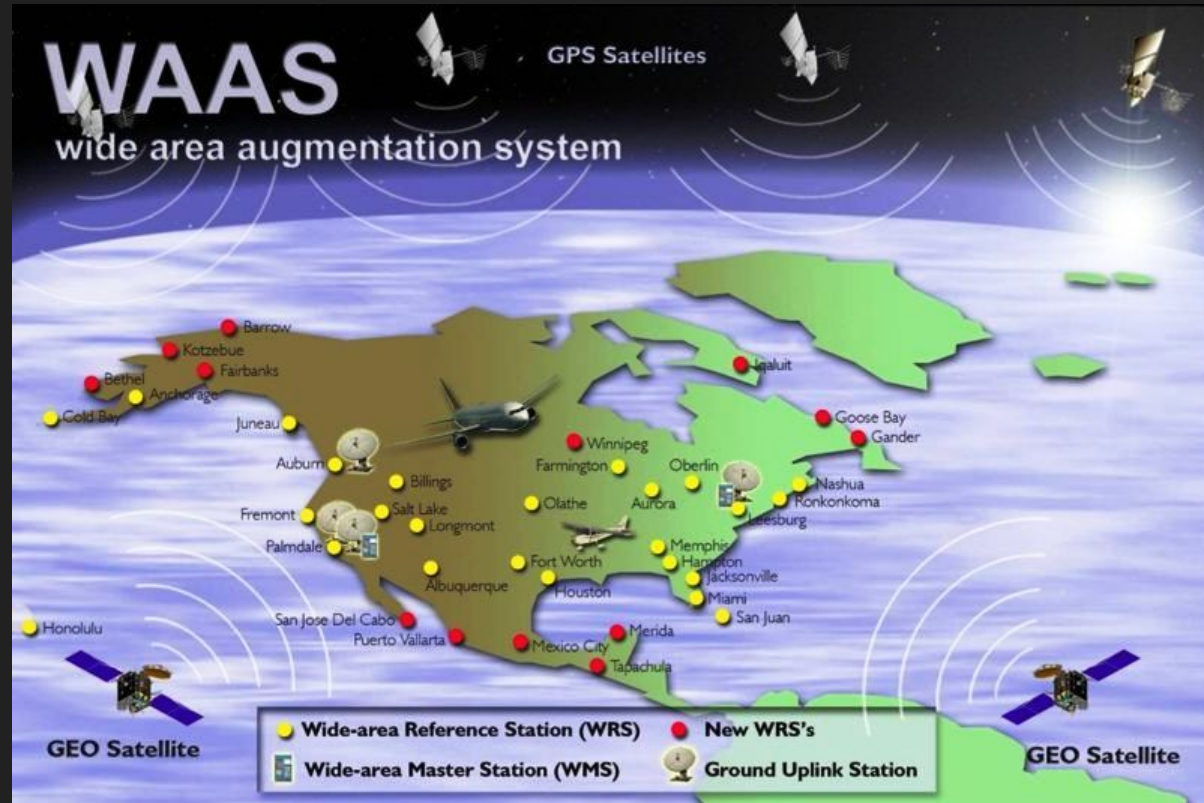
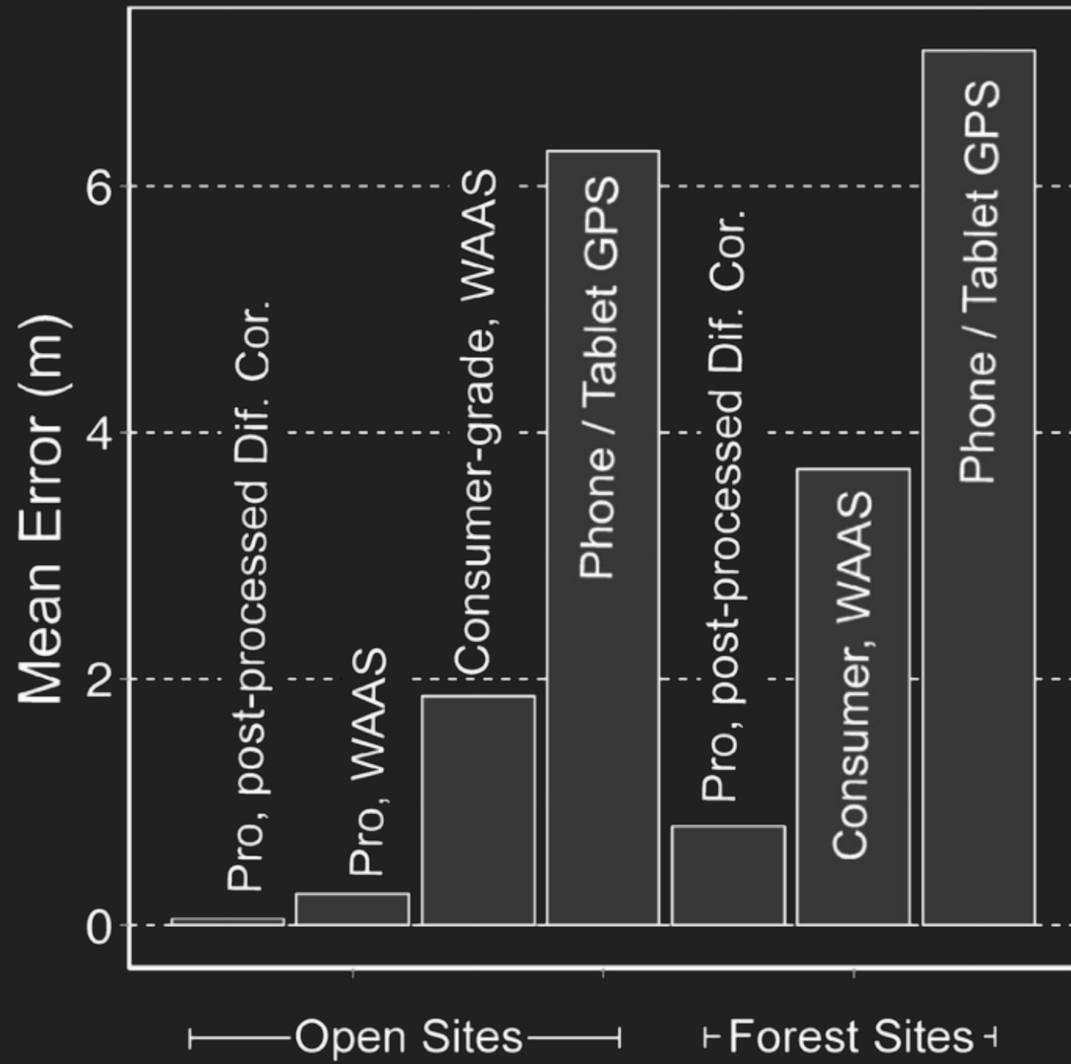


Fig. 5-14, 5-15, p. 205, 206  
Bolstad 7th Edition

# Wide Area Augmentation System



# GNSS: Accuracy



# Secondary Data Capture

- Data collected for other purposes can be converted for use in GIS
- Raster conversion
  - Scanning of maps, aerial photographs, documents, etc.
  - Important parameters:
    - spatial resolution (dots per inch)
    - radiometric resolution (bits per pixel)

# Scanning Example: US Topo

- USGS topo maps in PDF / GeoTIF
  - “GeoPDF” metadata
- New & historical
  - new: multi layers
  - old: single scan
- Mix of projections and scan methods

USGS science for a changing world

TNM Download (v2.0) Help Custom Views Share Link Contact Us New: topoBuilder

Datasets Products Cart

Other Format (PDF)

	USGS 1:24000-scale Quadrangle for Santa Barbara, CA 1952 <b>Published Date:</b> 1952-01-01 <b>Metadata Updated:</b> 2018-02-18 <b>Format:</b> GeoPDF, GeoTIFF <b>Extent:</b> 7.5 x 7.5 minute	Footprint Thumbnail Zoom To Info/Metadata Vendor Metadata Download Link (TIF) Other Format (PDF)
	USGS 1:24000-scale Quadrangle for Santa Barbara, CA 1976 <b>Published Date:</b> 1976-01-01 <b>Metadata Updated:</b> 2018-02-18 <b>Format:</b> GeoPDF, GeoTIFF <b>Extent:</b> 7.5 x 7.5 minute	Footprint Thumbnail Zoom To Info/Metadata Vendor Metadata Download Link (TIF) Other Format (PDF)
	USGS 1:24000-scale Quadrangle for Santa Barbara, CA 1995 <b>Published Date:</b> 1995-01-01 <b>Metadata Updated:</b> 2018-02-18 <b>Format:</b> GeoPDF, GeoTIFF <b>Extent:</b> 7.5 x 7.5 minute	Footprint Thumbnail Zoom To Info/Metadata Vendor Metadata Download Link (TIF) Other Format (PDF)
	USGS 1:31680-scale Quadrangle for Santa Barbara, CA 1944 <b>Published Date:</b> 1944-01-01 <b>Metadata Updated:</b> 2018-02-18 <b>Format:</b> GeoPDF, GeoTIFF <b>Extent:</b> 7.5 x 7.5 minute	Footprint Thumbnail Zoom To Info/Metadata Vendor Metadata Download Link (TIF) Other Format (PDF)

<< Previous 1 Next >>

Expand View US Topo (3 results) txt csv Show All Footprints Show All Thumbnails

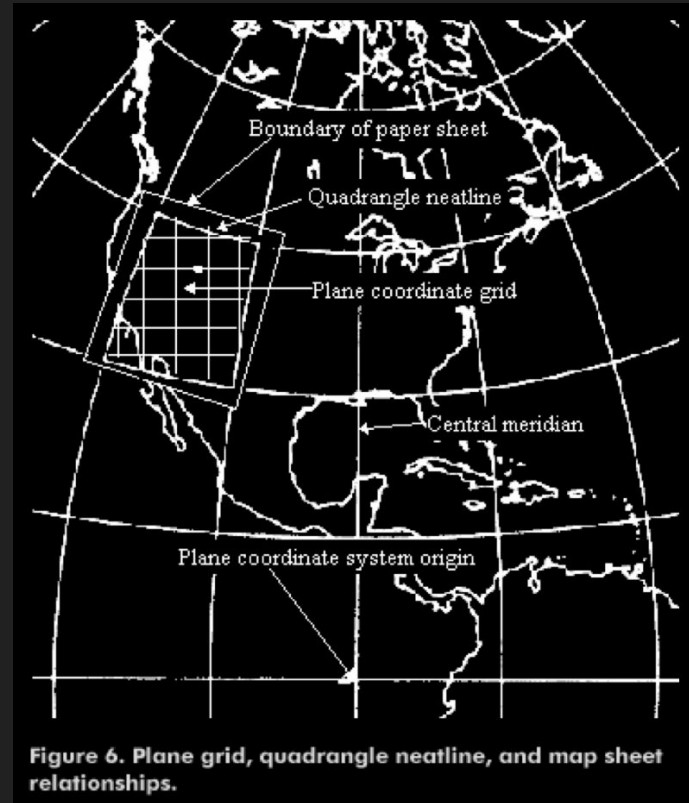
First three results

Map showing topographic data for Santa Barbara, CA, including features like Lake Cachuma, San Marcos Pass, and Santa Barbara. The map is overlaid with a grid and includes a search bar and navigation controls.



# Scanning maps: orientation issues

- Boundaries
  - meridians and parallels
- Projection
  - conformal conic (older)
  - UTM (newer)
  - meridians pinch; parallels curve
- Map sheet
  - quad bounding rectangle
  - not projection-aligned



# Vector Secondary Data Capture

## Manual

- Keyboard
- Transcription
- "heads-up" digitizing
  - see also Bolstad ch. 4
- Coordinate digitizer
  - Point
  - Stream

## Automatic

- Scan
  - `vector = line_detect(raster)`
- OCR
  - extract placenames or coordinates from scanned text

# Figure Credits

- GIS Fundamentals, 6th ed.
  - ISBN 978-1-59399-552-2
- Geographic Information Systems and Science, 2nd ed.
  - ISBN 978-0470870013
- Introduction to Geographic Information Systems, 4th ed.
  - ISBN 978-0-07-305115-2
- Using ArcGIS Spatial Analyst
- Wikimedia Commons
- NASA Landsat Science