SLR and GPS
(and Plate Tectonics and Earthquakes)

- Overview of geodesy from space
- What is SLR?
- What is GPS?
- Introduction to GGAO
• The different tectonic plates move in different directions and at different speeds
• Because plate motions are global in scale, they are best measured by satellite-based methods
Satellite Laser Ranging (SLR)

- In Satellite Laser Ranging (SLR), a station fires a laser to an orbiting satellite equipped with special reflectors.

- The station then measures the round trip time of flight of the pulses of light.

- The orbit of the satellite can then be determined when several stations perform these measurements.

- Once a scientist knows the orbit of the satellite, he can precisely determine the location of the station on the Earth.

- Positions of SLR stations change as the plates move.

- If we take measurements over many years, we can determine how the stations move over time.
How SLR Works

• Laser system sends a laser pulse to satellite with retroreflectors
• Satellite retro reflects beam back to point of origin (the laser system)
• Timing system measures round trip “time of flight”
• System’s computer translates time into distance
• Scientists calculate orbit of satellite from multiple distance (range) measurements
Laser Ranging in Action
Laser Ranging in Action
Global SLR Stations
What is SLR Used For?

- There are laser retro reflectors on many satellites currently orbiting the Earth; about 30 satellites are tracked regularly by NASA and other international partners.
- Scientists can use SLR to compute a very precise orbit of these satellites.
- Precise station locations can be used to study plate tectonics.
- Scientists use the orbit produced by SLR on some satellites to improve the measurements coming from other scientific instruments onboard the satellites.
Global Positioning System (GPS)

- The Global Positioning System (GPS) is a series of satellites that transmit signals to receivers on the Earth.
- The GPS satellite system was built by the U.S. Department of Defense for military uses.
- The system is now used for many commercial, scientific, and recreational activities.
- The receiver uses these signals to determine its distance from the satellites.
- The distance is then translated into a location on the Earth.
Global Positioning System (GPS)

- 24 operational satellites
- Orbit Earth at ~11,000 miles
- Transmit signals to receivers on the Earth
- Receivers obtain signals from at least 4 satellites to calculate position
What is GPS Used For?

• Military Uses
  – Troop deployment
  – Weapons control

• Commercial Uses
  – Airline navigation
  – Ship navigation
  – Freight tracking
  – Surveying
  – Farming

• Scientific Uses
  – Plate motion studies
  – Earthquake displacement
  – Volcano monitoring
  – Weather forecasting

• Recreational Uses
  – Automobile navigation
  – Hiking
  – Boating
GPS and Earthquake Studies

- 1000’s of GPS receivers around the globe
- Positions of GPS stations also change as the plates move
- Scientists use GPS as an accurate method to survey station positions and measure tectonic motions during and between earthquakes
- When an earthquake occurs, the ground on either side of the fault moves
- GPS can measure the size of an earthquake by determining how much the station has moved before and after the event (displacement)
Plate Motion as Seen by GPS

Map showing plate motion vectors with GPS data. The vectors indicate the direction and rate of movement of tectonic plates. Map credits include Heflin et al., 2007.9. For more information, visit http://sideshow.jpl.nasa.gov/tmbh/series.html.
• Plots show daily GPS position determinations from 1992-2007 for a site at JPL in Pasadena, located on Pacific Plate

• JPL is moving north about 1.4 cm/year and west about 3.6 cm/year
GGAO Tour
MOBLAS-7 (MOBile LASer) at GSFC
Laser System Innards
Interesting Links

• NASA:
  – http://www.nasa.gov

• Goddard Space Flight Center, GGAO:
  – http://www.nasa.gov/centers/goddard/visitor/home/index.html
  – http://cddis.gsfc.nasa.gov/ggao/

• Plate tectonics, Earthquakes:
  – http://pubs.usgs.gov/gip/dynamic/

• GPS:
  – http://www.gps.gov