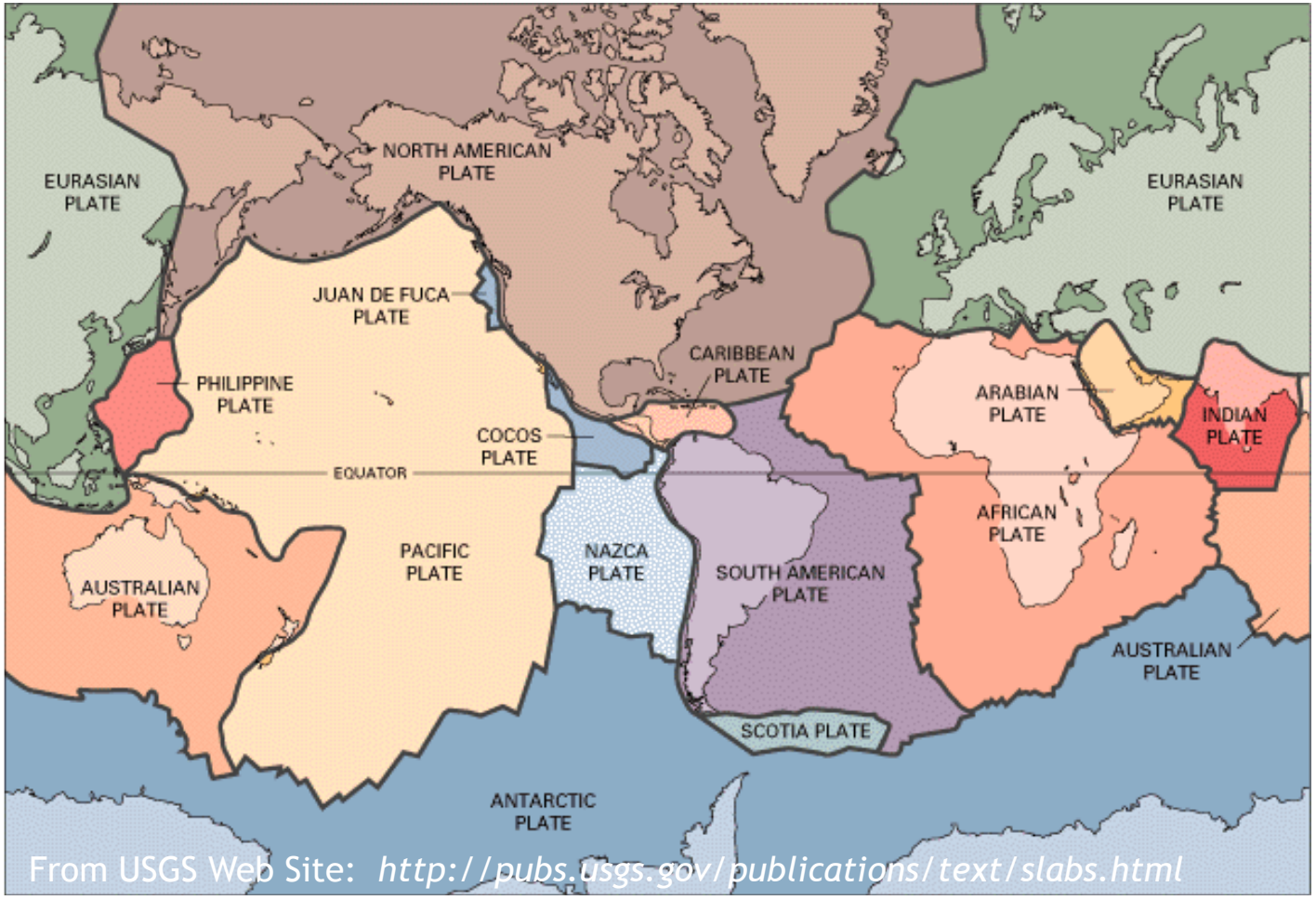
# SLR and GPS

## (and Plate Tectonics and Earthquakes)

# Plate Tectonics



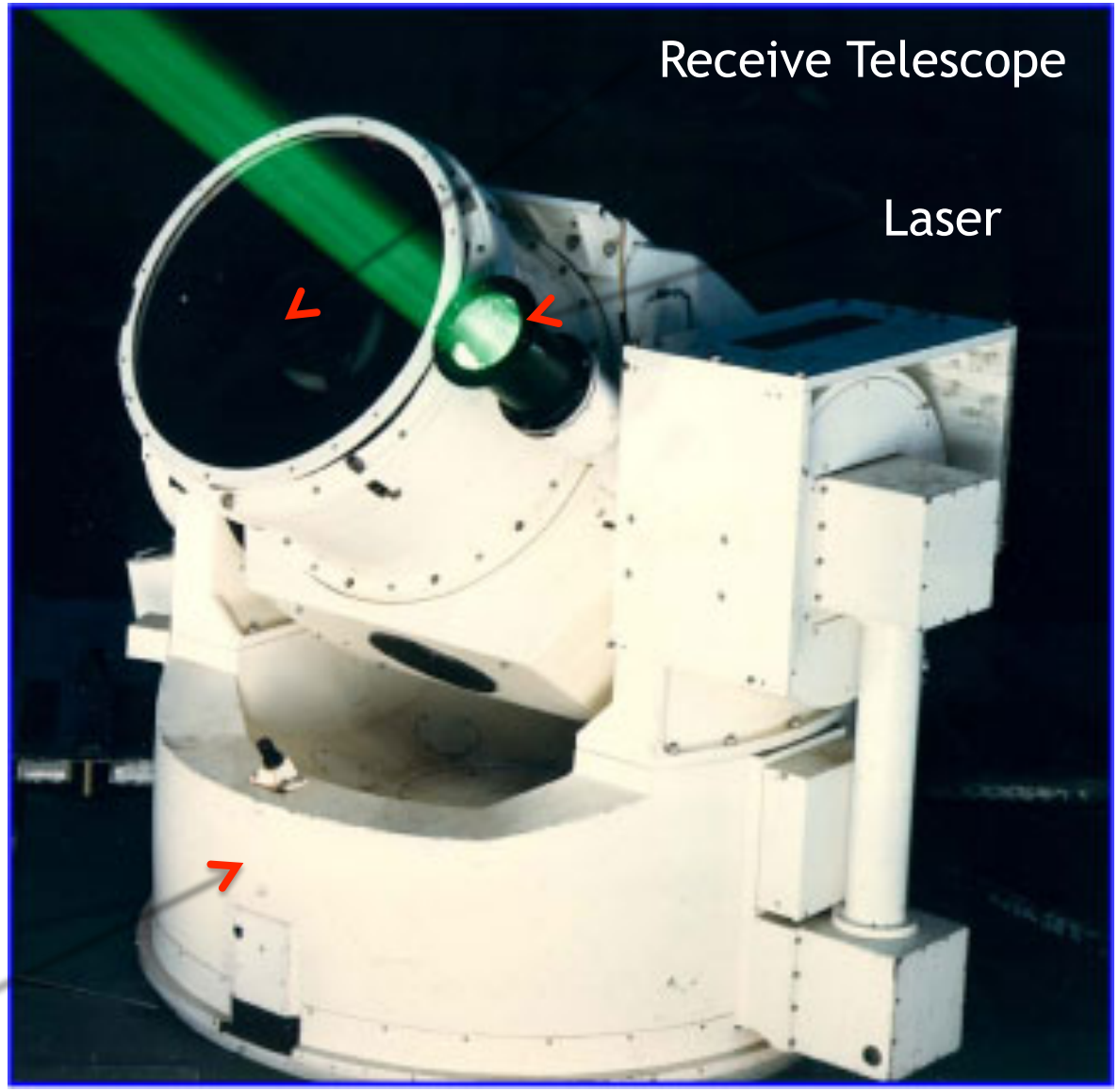

- The different tectonic plates move in different directions and at different speeds
- Because plate motions are global in scale, they are best measured by satellite-based methods

# Satellite Laser Ranging (SLR)

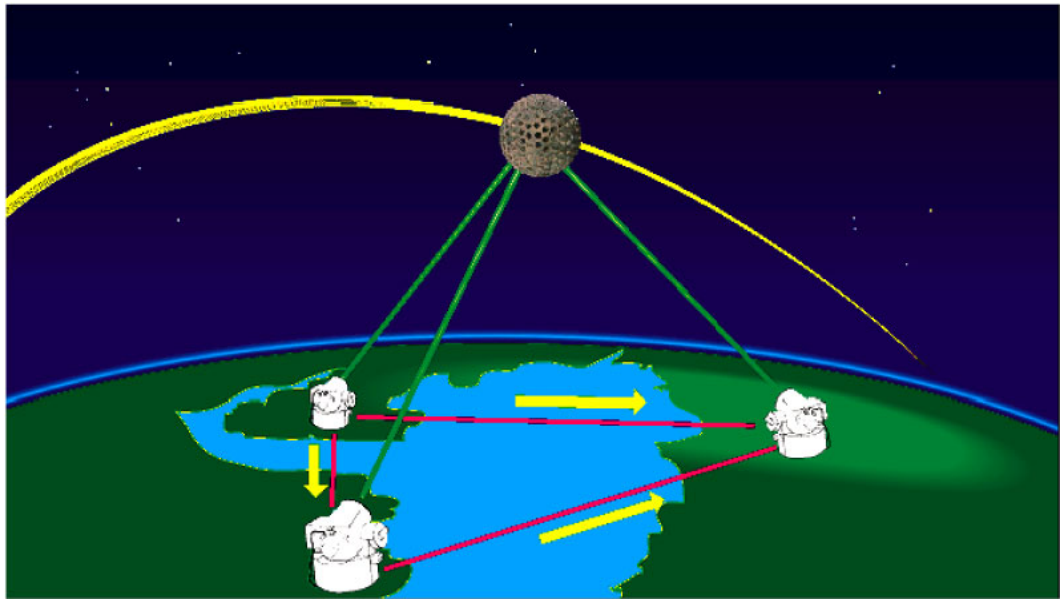
- In Satellite Laser Ranging (SLR), a station fires a laser to an orbiting satellite equipped with special reflectors
- The station then measures the round trip time of flight of the pulses of light
- The orbit of the satellite can then be determined when several stations perform these measurements
- 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

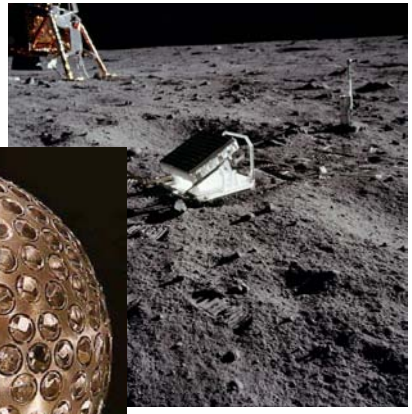
# How SLR Works

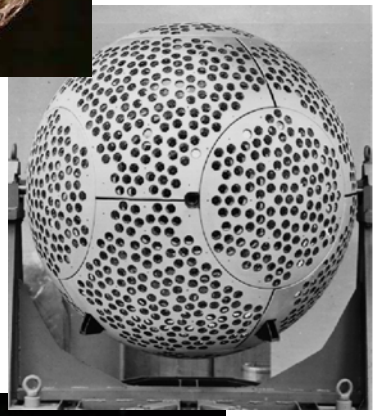
- Laser system sends a laser pulse to satellite with retroreflectors
- Satellite retro reflects beam back to point of origin (the laser system)
- Timing system measures round trip “time of flight”
- System’s computer translates time into distance
- Scientists calculate orbit of satellite from multiple distance (range) measurements

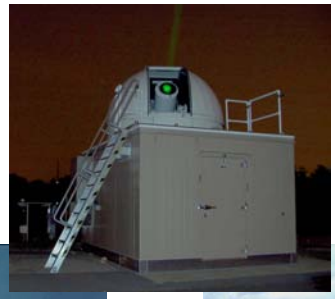


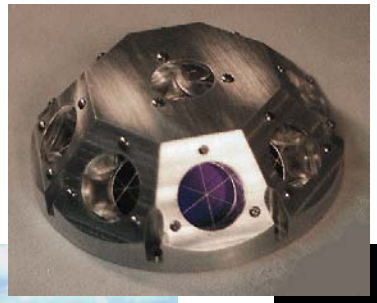
# Satellite Laser Ranging





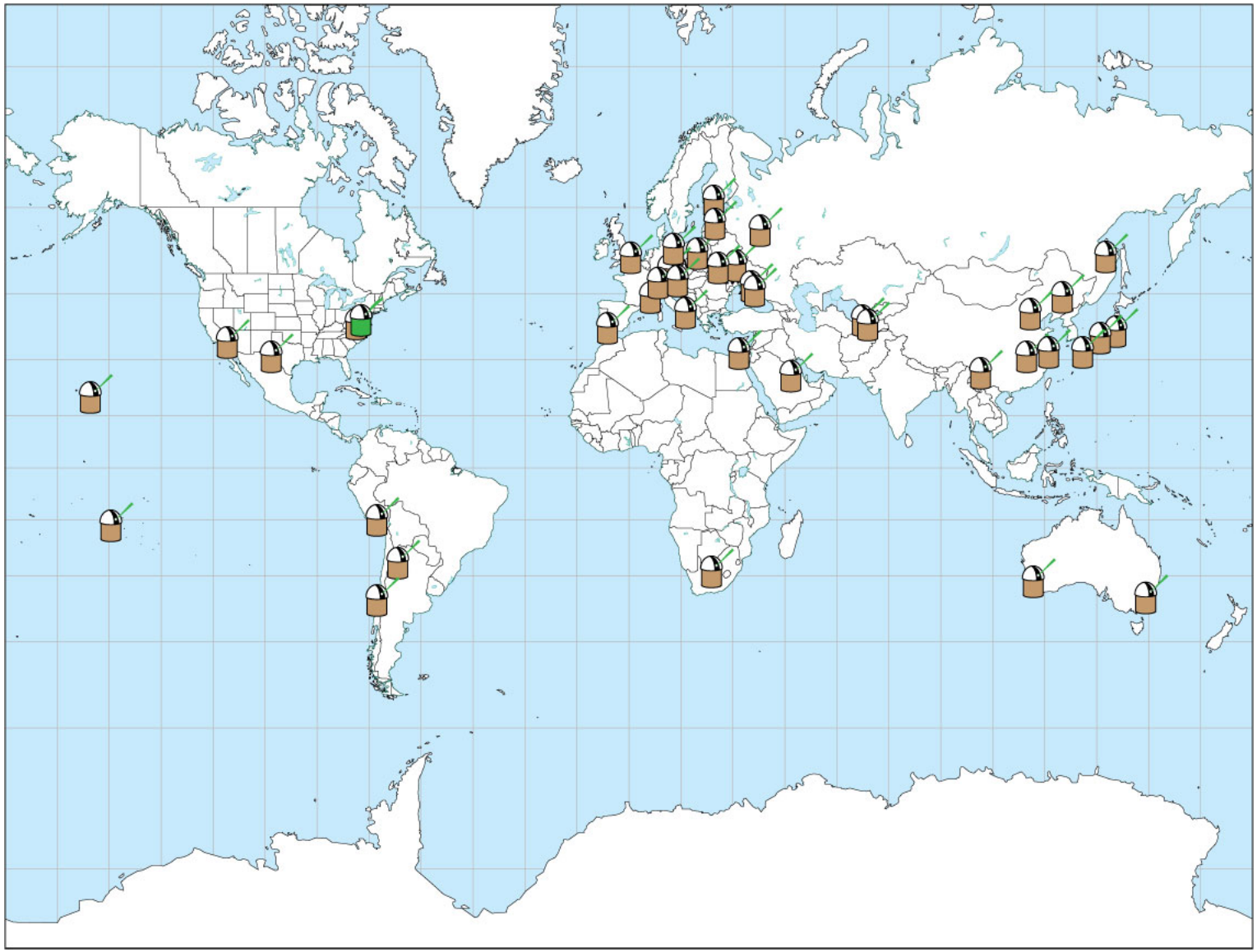






# Laser Ranging in Action

# Global SLR Stations



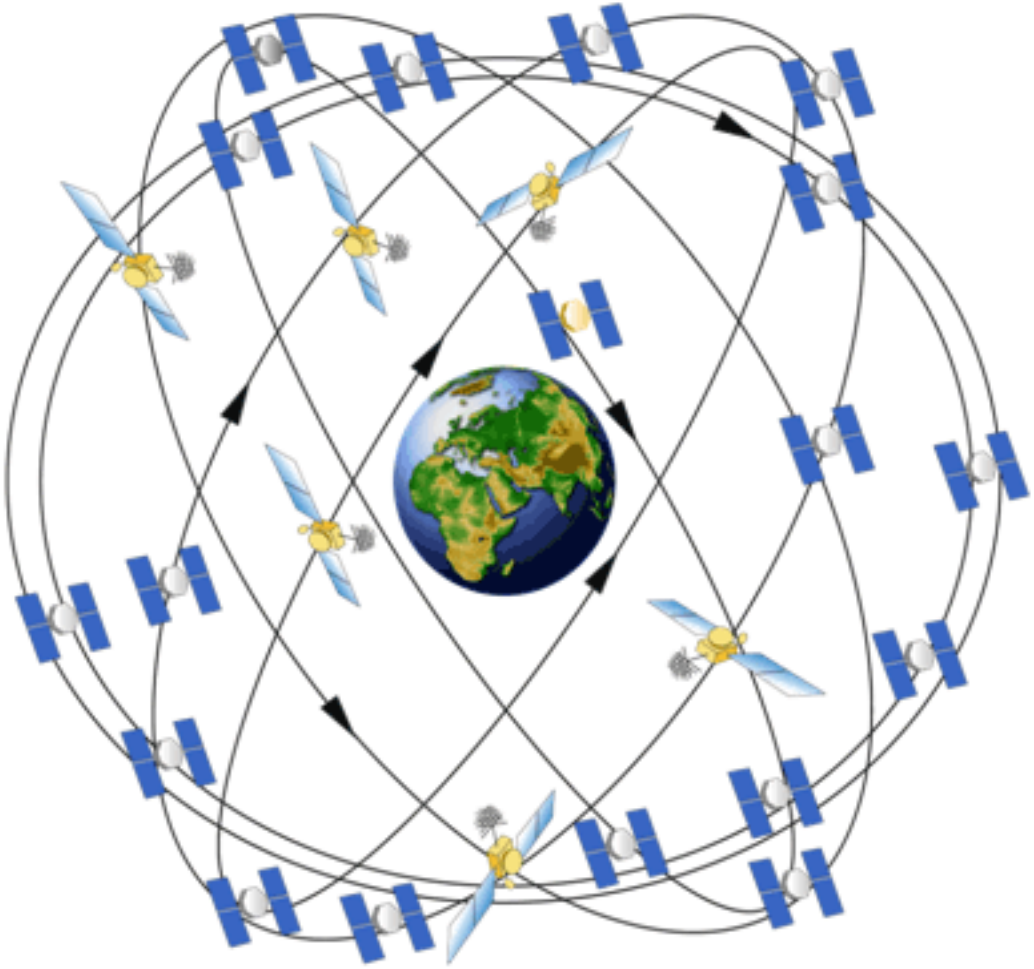
# What is SLR Used For?

- There are laser retro reflectors on over thirty satellites currently orbiting the Earth
- 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 receiver uses these signals to determine its distance from the satellites
- The distance is then translated into a location 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

# Global Positioning System (GPS)

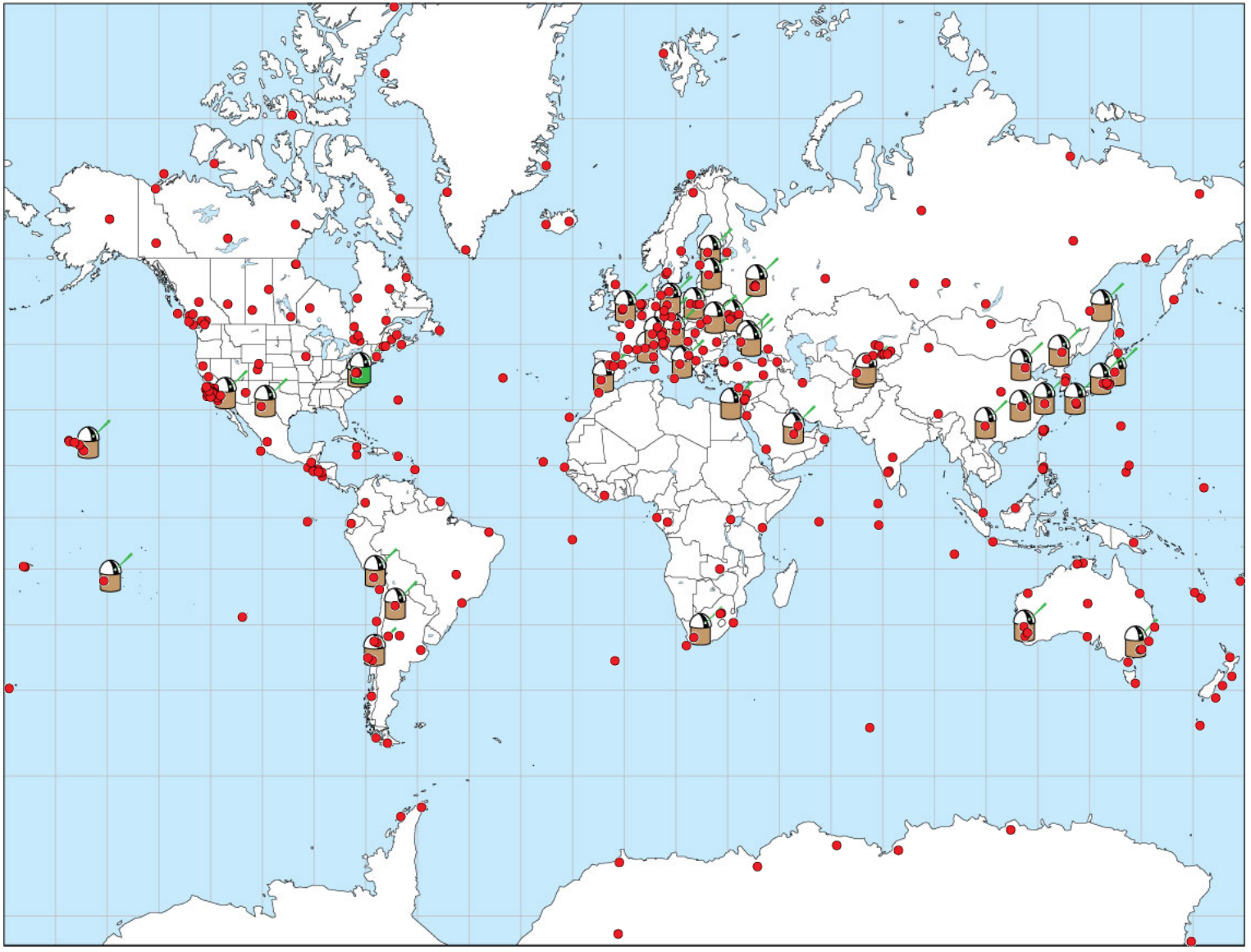



- 24 operational satellites
- Orbit Earth at ~11,000 miles
- Transmit signals to receivers on the Earth
- Receivers obtain signals from at least 4 satellites to calculate position

# 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

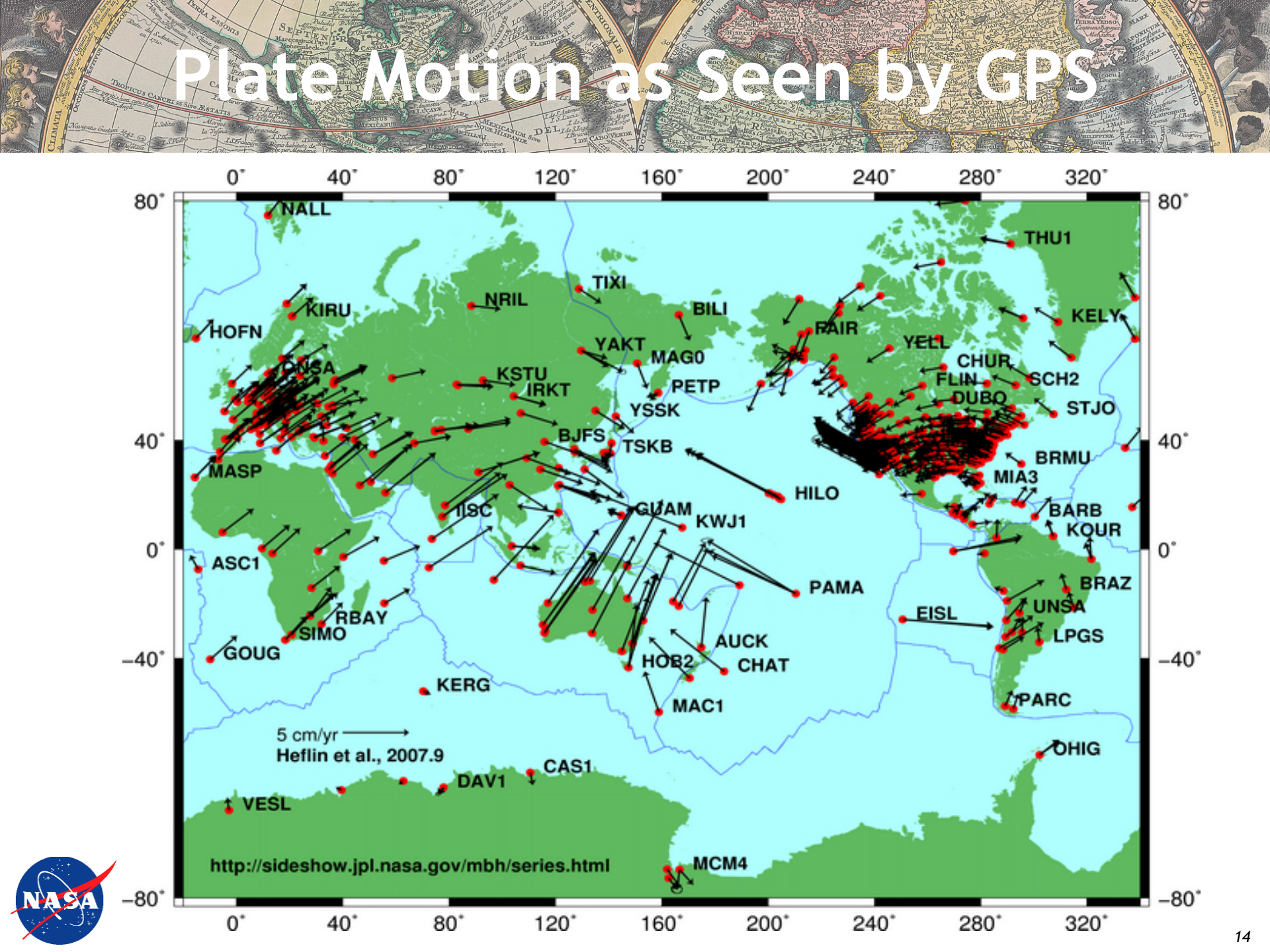
# Global GPS Sites



# GPS and Earthquake Studies

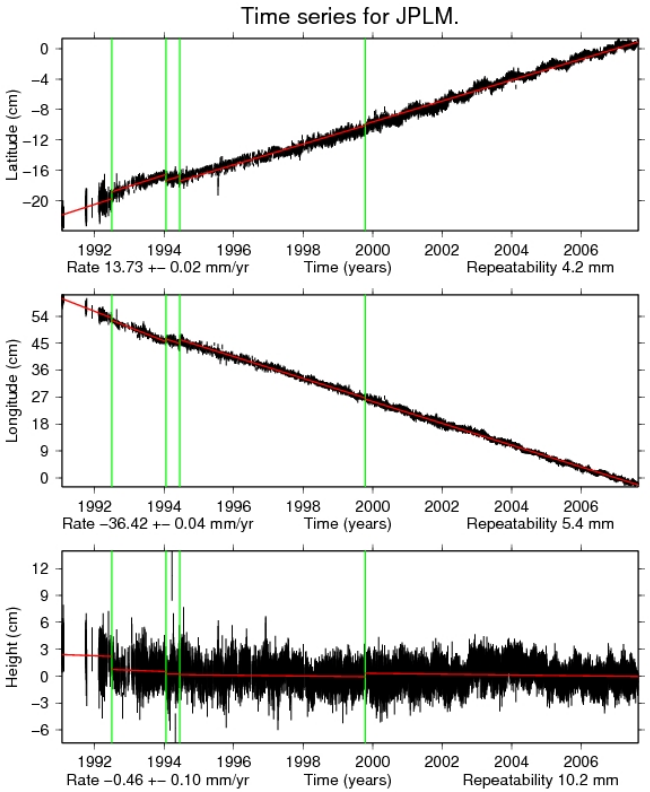
- 1000's of GPS receivers around the globe
- Positions of GPS stations also change as the plates move
- Scientists use GPS as an accurate method to survey station positions and measure tectonic motions during and between earthquakes
- When an earthquake occurs, the ground on either side of the fault moves
- GPS can measure the 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

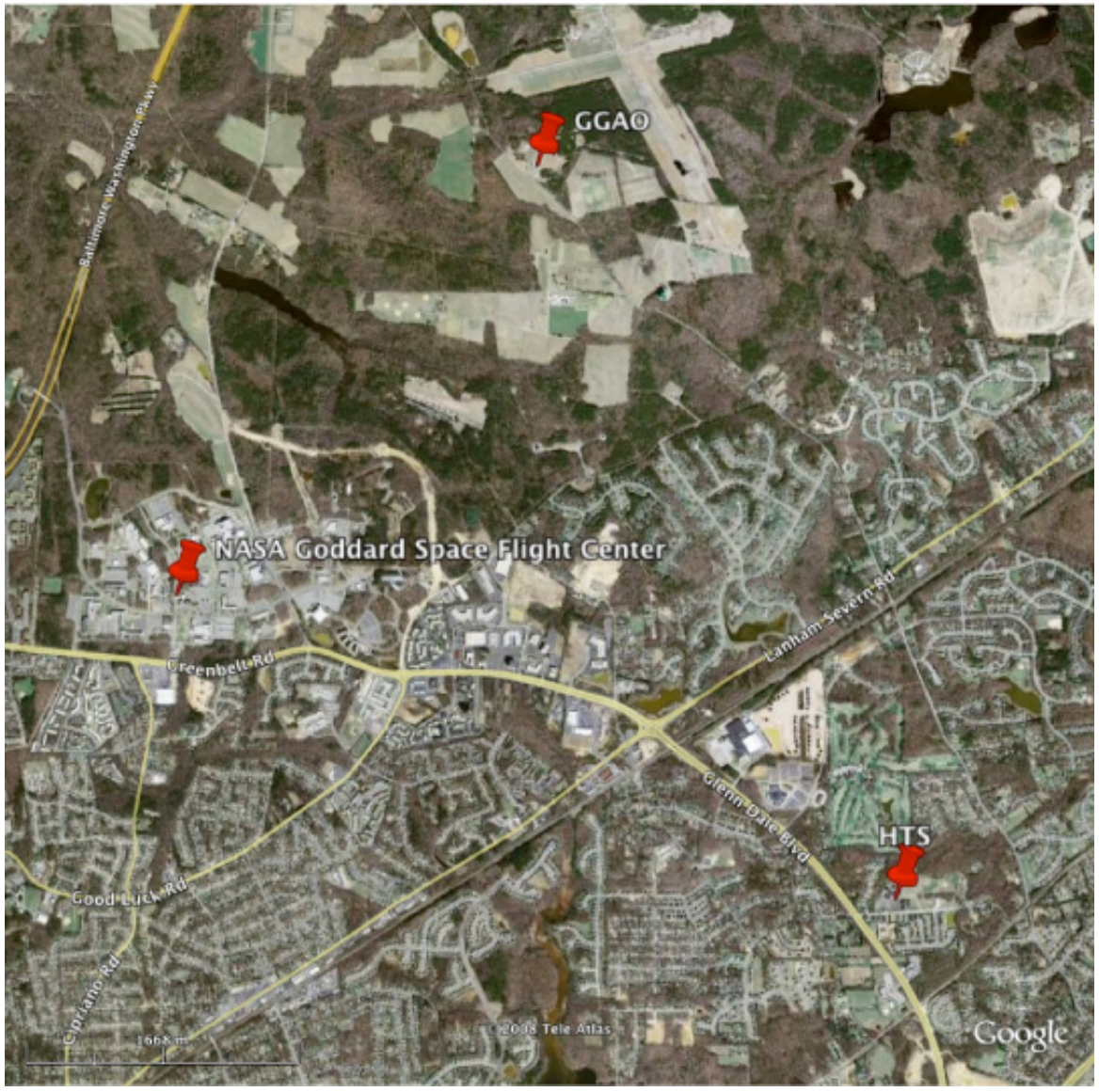


# Example: Pasadena California

- 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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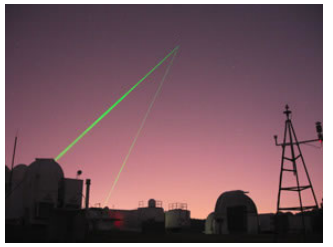
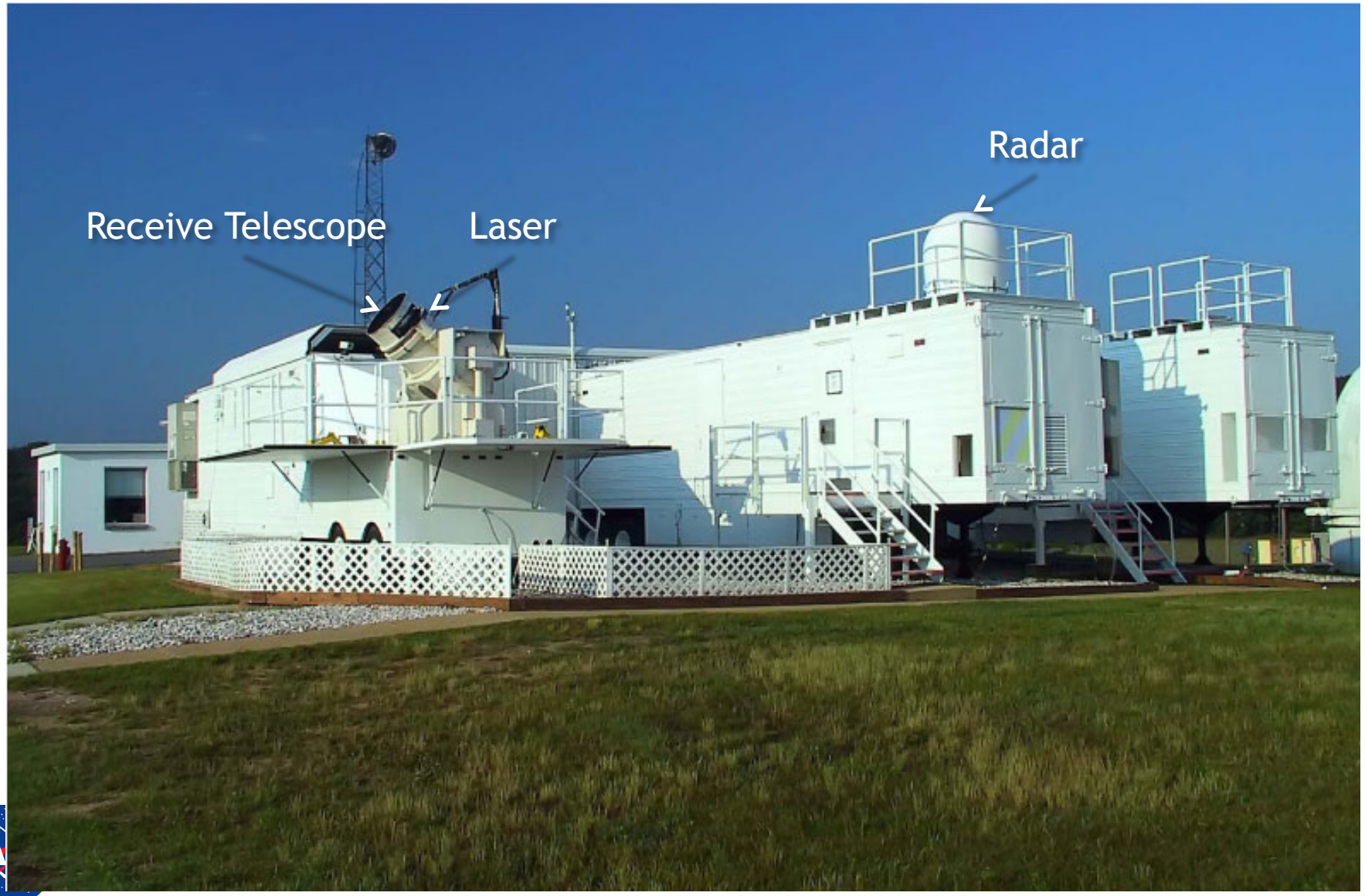
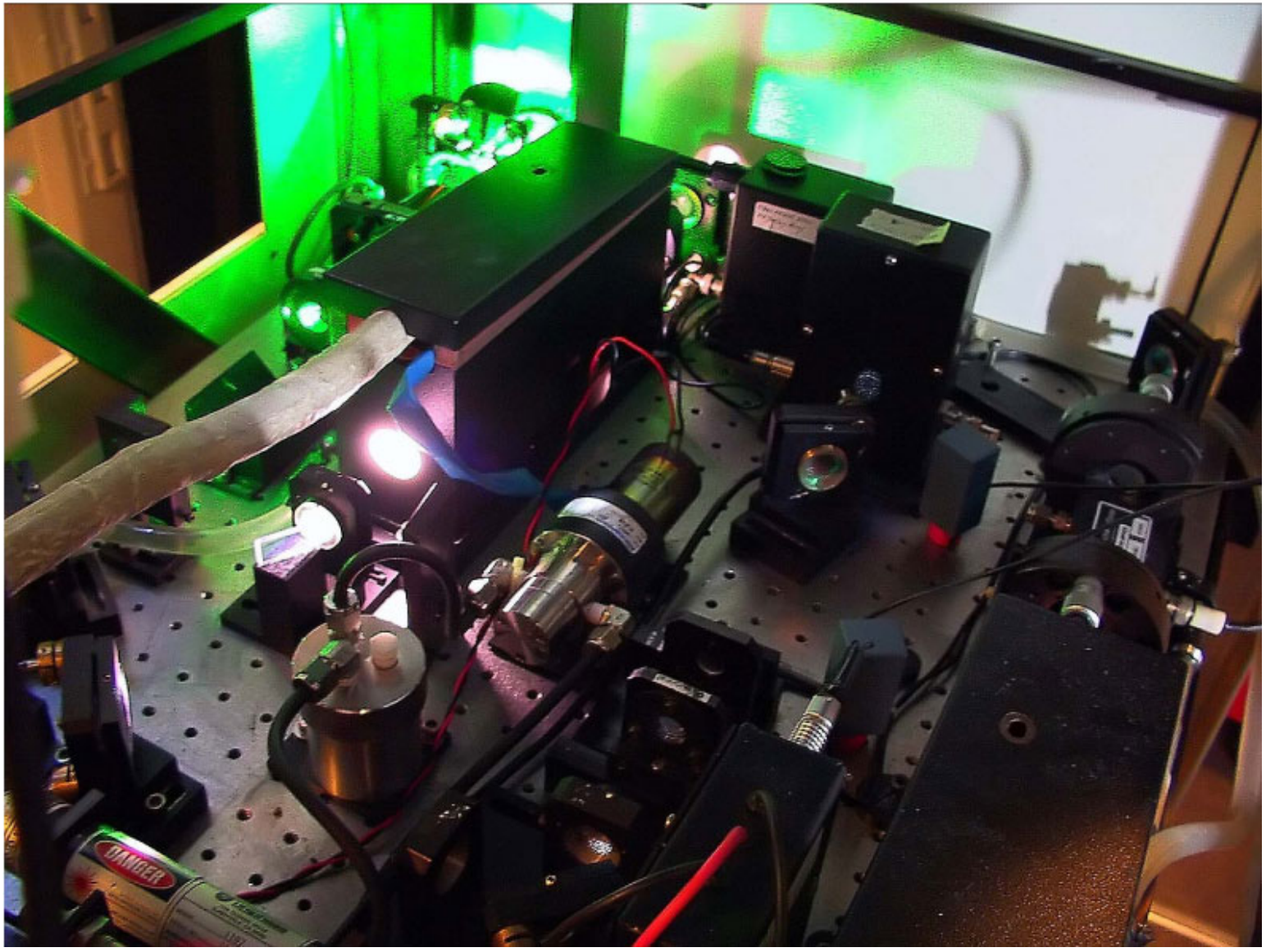
NASA Goddard Space Flight Center
Greenbelt Rd
Lanham-Severn Rd
Good Luck Rd
Cipriano Rd
HTS
Google



# MOBLAS-7 (MOBile LASer) at GSFC



# Laser System Innards



# Interesting Links

- NASA:
  - *http://www.nasa.gov*
  - *http://www.nasa.gov/audience/forstudents/index.html*
- 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/*
  - *http://scign.jpl.nasa.gov/learn/index.html*
- GPS:
  - *http://www.gps.gov*
  - *http://www.science.org.au/nova/066/066act.htm*
  - *http://cfa-www.harvard.edu/space_geodesy/ATLAS/gps.html*