1. What is the nature of deformation at plate boundaries and what are the implications for earthquake hazards?

2. How do tectonics and climate interact to shape the Earth’s surface and create natural hazards?

3. What are the interactions among ice masses, oceans, and the solid Earth and their implications for sea level change?

4. How do magmatic systems evolve and under what conditions do volcanoes erupt?

5. What are the dynamics of the mantle and crust and how does the Earth’s surface respond?

6. What are the dynamics of the Earth’s magnetic field and its interactions with the Earth system?

**Earth Surface and Interior Focus Area**

**ESI Strategic Goals**

- OMB Performance Metrics
  - Enable 30 Day volcanic eruption forecasts with > 50% confidence by 2014
  - Enable estimation of earthquake likelihood in North American plate boundary with > 50% confidence by 2014

**ESI Component Programs**

- Natural Hazards
  - Predictive Models
  - Remote Sensing
  - Natural Laboratories

- Space Geodesy
  - Celestial Ref Frame
  - Terrestrial Ref Frame
  - Earth Rotation
  - Crustal Dynamics

- Planetary Interior
  - Seismological Models
  - Gravity Models
  - Geodynamic Models

**ESI Achievements in FY05**

- GRACE: 1st Time Variable Gravity & Mass Flux
- SRTM: 1st Uniform Global Topography

**Overview of ESI Focus Area**

- Earthquake Forecasting
- SRTM: 1st Uniform Global Topography
The GRACE Mission

Measuring the Movement of Mass in the Earth System

Earth Surface and Interior Budget Evolution

ESI Budgets FY80-FY06 (2006 Dollars)

Crustal Dynamics Program

Dynamics of the Solid Earth

Solid Earth and Natural Hazards

ESI

The GRACE Mission
GRACE provides global monthly water accumulation with cm accuracy over regions of a few hundred km.

GRACE provides mass-based sea level change, deep currents, with sub centimeter accuracy.

GRACE provides first integrated estimates of polar ice mass changes.

GRACE provided first space borne measurement of earthquake induced mass transport.
GeoFEST uses stress-displacement finite elements to model stress and flow in a realistic model of the Earth's crust and upper mantle in a complex region such as the Los Angeles Basin.

PARK is a boundary element program that determines the stress on every element of the fault surface due to slip on every other element, using a Green's function approach.

Virtual California is a code that utilizes the Monte Carlo method in order to generate simulated, realistic earthquakes on an arbitrary fault surface mesh.
Probing the Earth with Spaceborne GPS

IONOSPHERE
- High resolution 3D ionospheric imaging
- Iono/thermo/atmospheric interactions
- Onset, evolution & prediction of Space storms
- TiDs and global energy transport
- Precise ion cal for OD, SAR, altimetry

OCEANS
- Significant wave height
- Ocean geoid and global circulation
- Short-term eddy scale circulation
- Surface winds and sea state
- Structure, evolution of the deep interior
- Shape of the earth

SOLID EARTH
- Earth rotation
- Polar motion
- Vertical motion of crust & lithosphere
- Location & motion of the geocenter
- Gross mass distribution
- Structure, evolution of the deep interior
- Shape of the earth

ATMOSPHERE
- Climate change & weather modeling
- Global profiles of atmosphere density, pressure, temp, and geopotential height
- Structure, evolution of the tropopause
- Atmospheric winds, waves & turbulence
- Tropospheric water vapor distribution

GNSS Remote Sensing Concept

- Constellation of GNSS satellites
  - GPS
  - GALILEO
  - Others
- Constellation of GNSS receivers in LEO
  - 6 LEO
  - High gain nadir antennas
    - 1-2 meter diameter electronically steerable antenna
- Receivers track phase delay of GNSS signals
  - Direct signals
  - Reflected signals from the ocean
- Continuous acquisition of reflections
  - on an increasingly dense, pseudo-random grid
- Recover ocean surface heights
  - 5 – 25 cm