NASA Perspective on Earthquake Research

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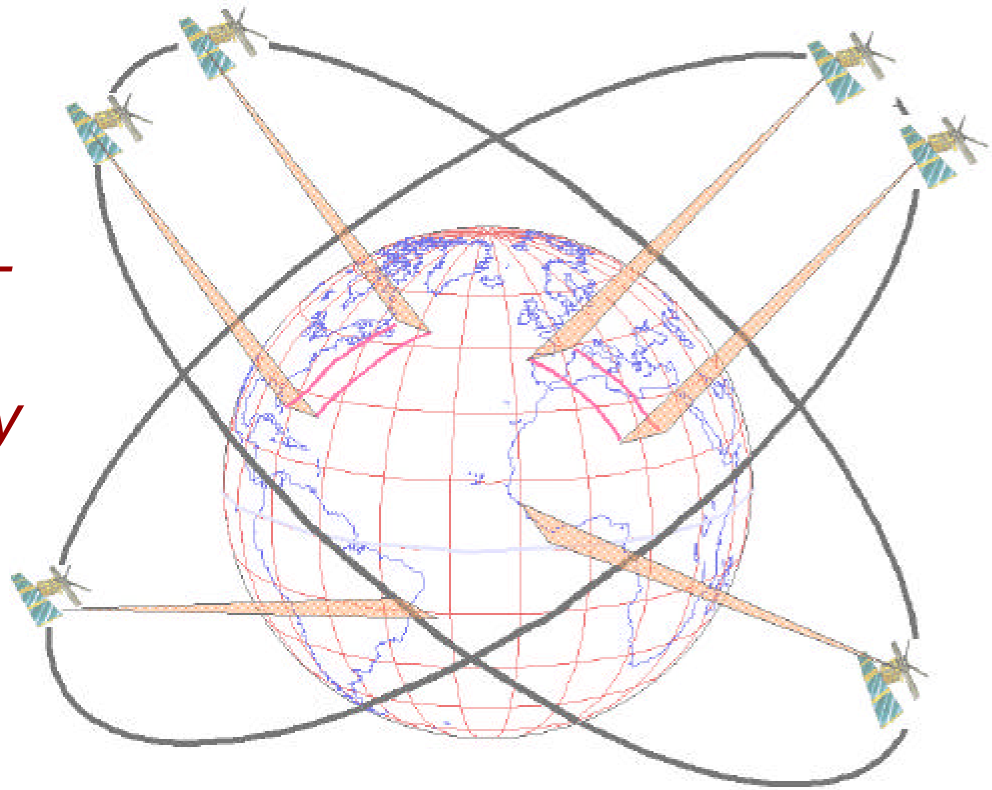
The NASA Vision for Solid Earth Science in 2050

Continuous mapping of dynamic stresses in the Earth's crust, supporting real-time hazard assessments, mitigation planning and policy decision support



Six Key Questions Identified by NASA's Solid Earth Science Working Group

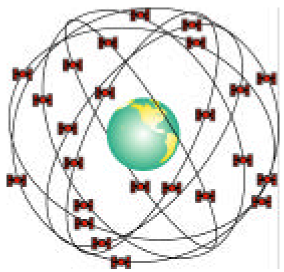
1. What is the nature of deformation at plate boundaries and what are the implications for earthquake hazards?
2. How do tectonics and climate interact to shape the Earth's surface and create natural hazards?
3. What are the interactions among ice masses, oceans, and the solid Earth and their implications 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?

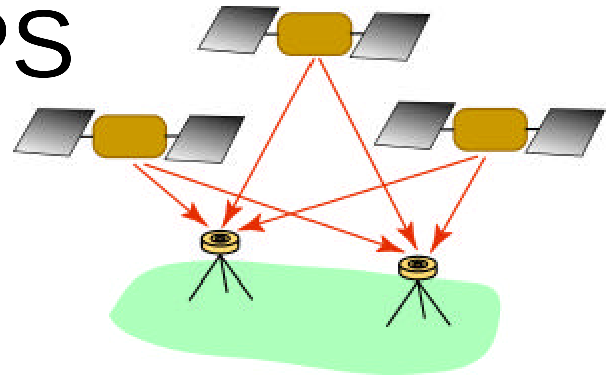
http://solidearth.jpl.nasa.gov

Approach

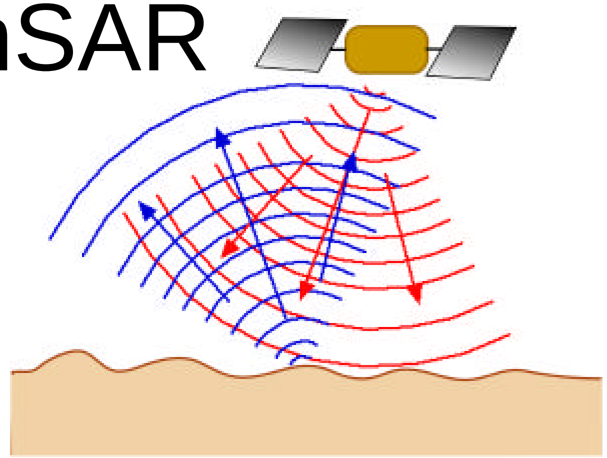
Space-based measurements

GPS





InSAR

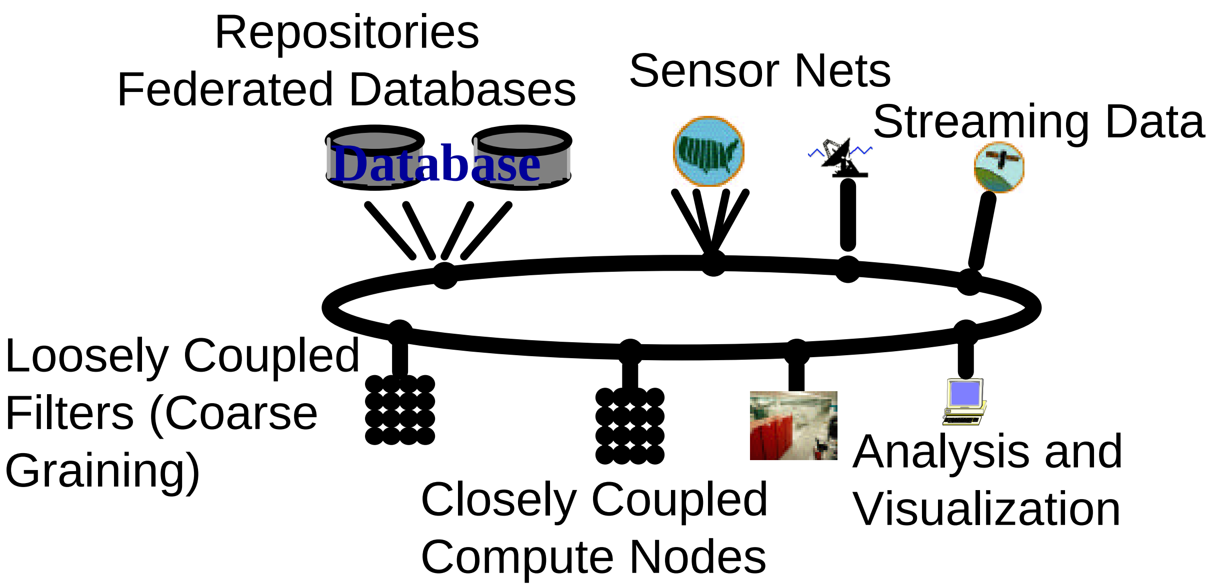


Other spaceborne measurements such as electromagnetic

Approach

Modeling, simulation, and applications of information technology

SERVO Grid – Establishment of a Solid Earth Research Virtual Observatory using grid technologies and high-end computers



Approach

Modeling, simulation, and applications of information technology

- **Development of finite element and other modeling tools in a web services environment.**
- **Data repositories in a web services environment.**
- **Use of pattern recognition techniques to extract subtle information about the data.**

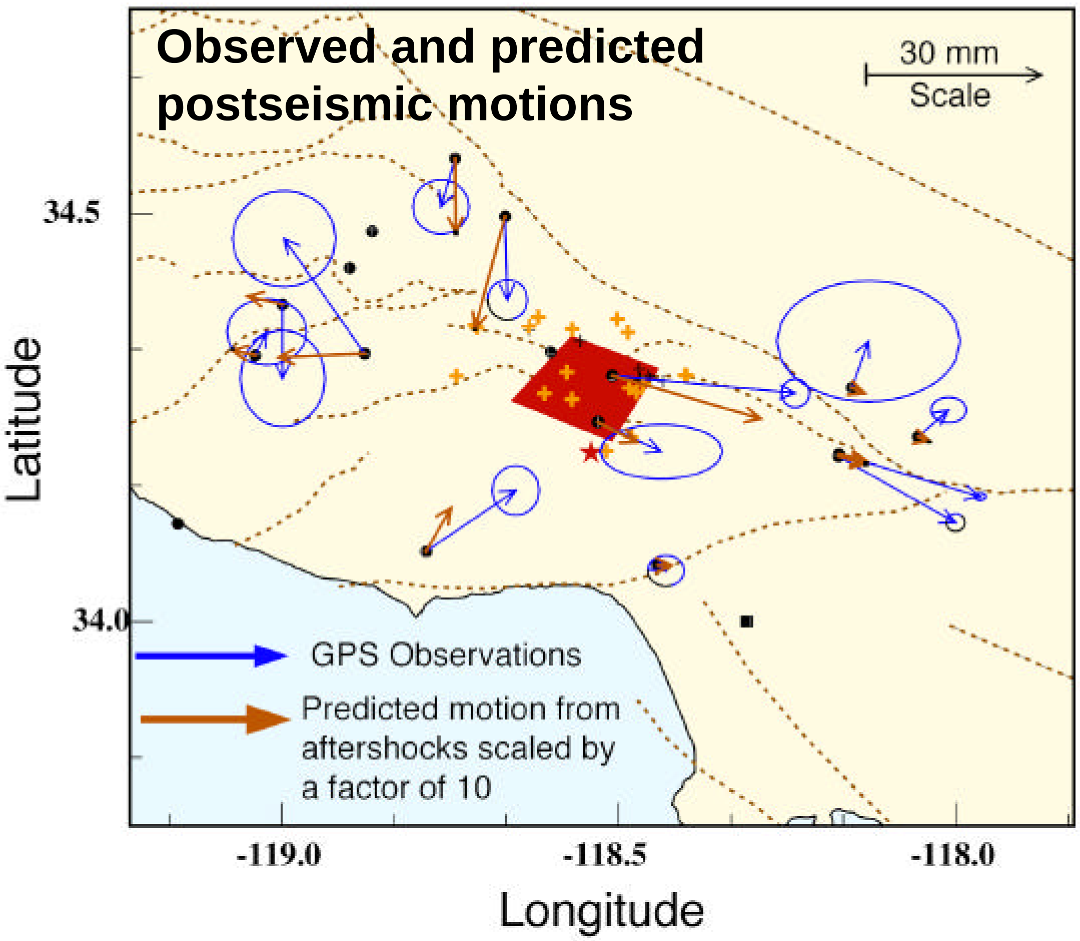
Objectives

- **New missions and ground based measurements to support science objectives**
- **Integrate multiple scales into computer simulations (IT approaches)**
- **Simplified access to data, simulation codes and flow between simulations of varying types (Web services)**
- **<u>Promote open cooperation and data exchange</u>**

Recent Results

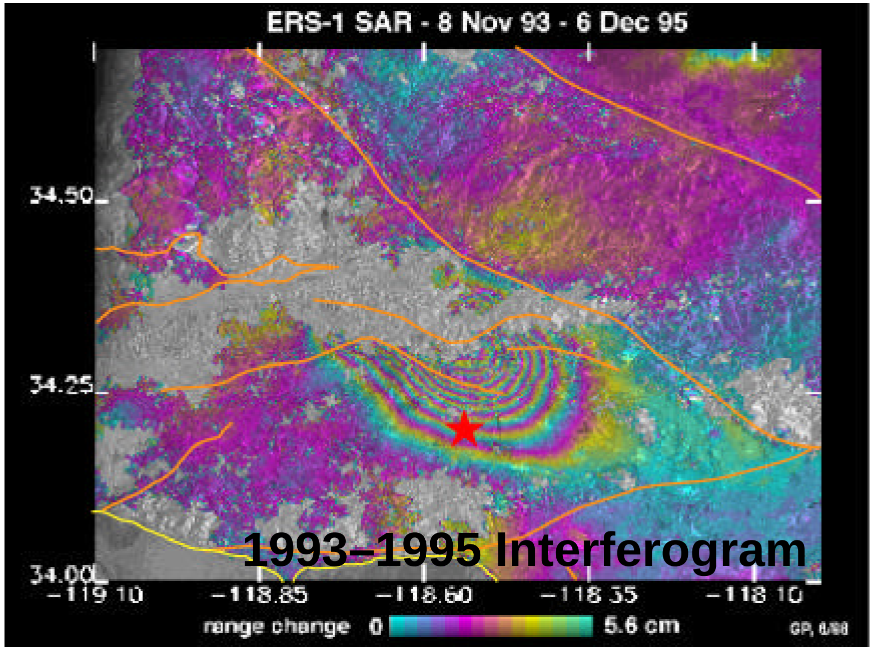
- GPS and InSAR show substantial aseismic deformation following earthquakes.
- Deformation is dependent on local crustal properties.
- Earthquakes can affect faults many fault dimensions away and act as a fault system.
- GPS and InSAR anomalies appear to coincided with anomalies of seismicity and microseismicity identified through pattern recognition.

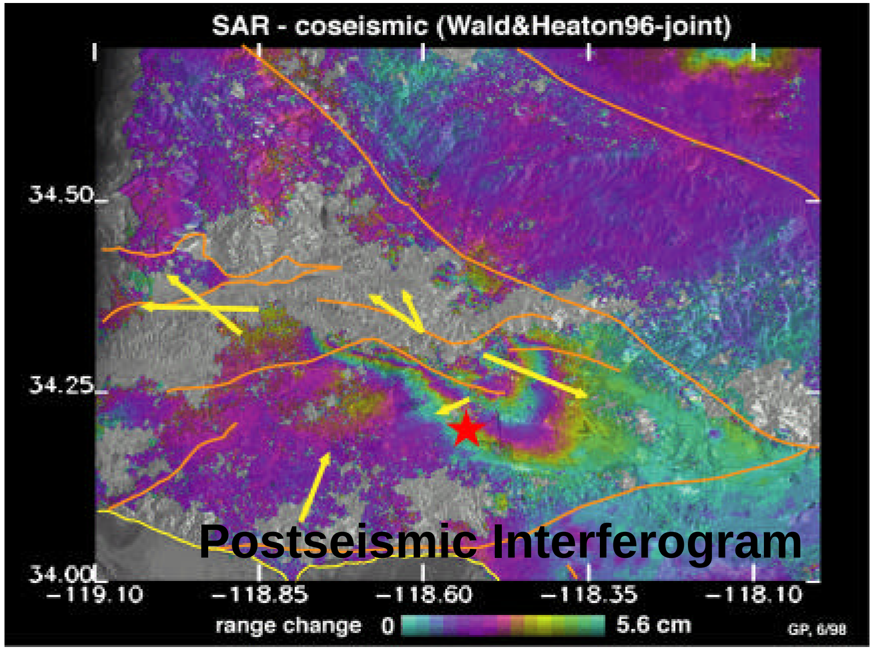
GPS and InSAR show substantial aseismic deformation following earthquakes



- 90% of the motion that occurred after the earthquake was aseismic
- Can not be attributed to aftershocks.
- Must be measured using techniques other than seismology.
- Can be measured with space geodesy.

Deformation is dependent on local crustal properties

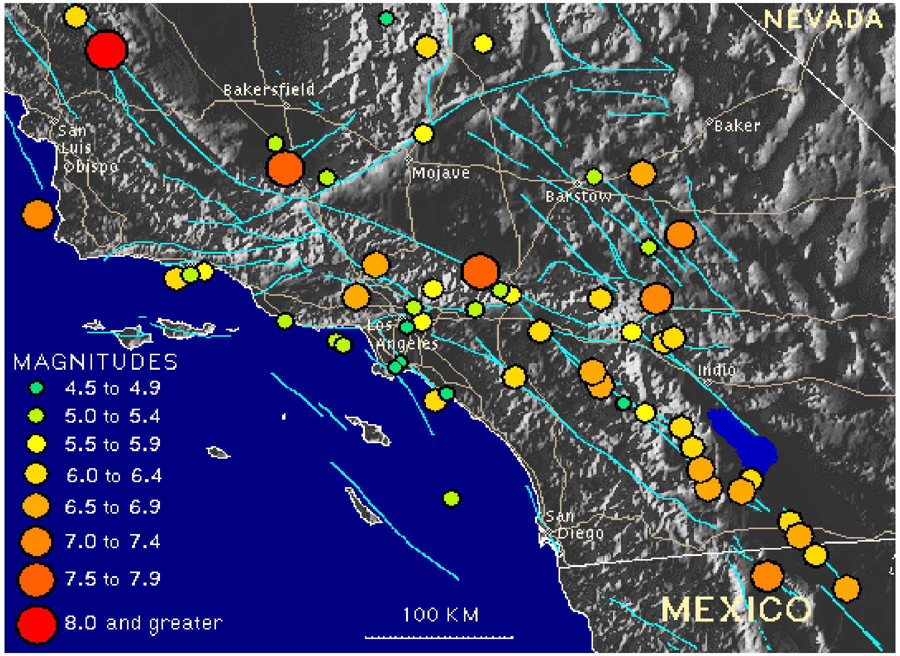




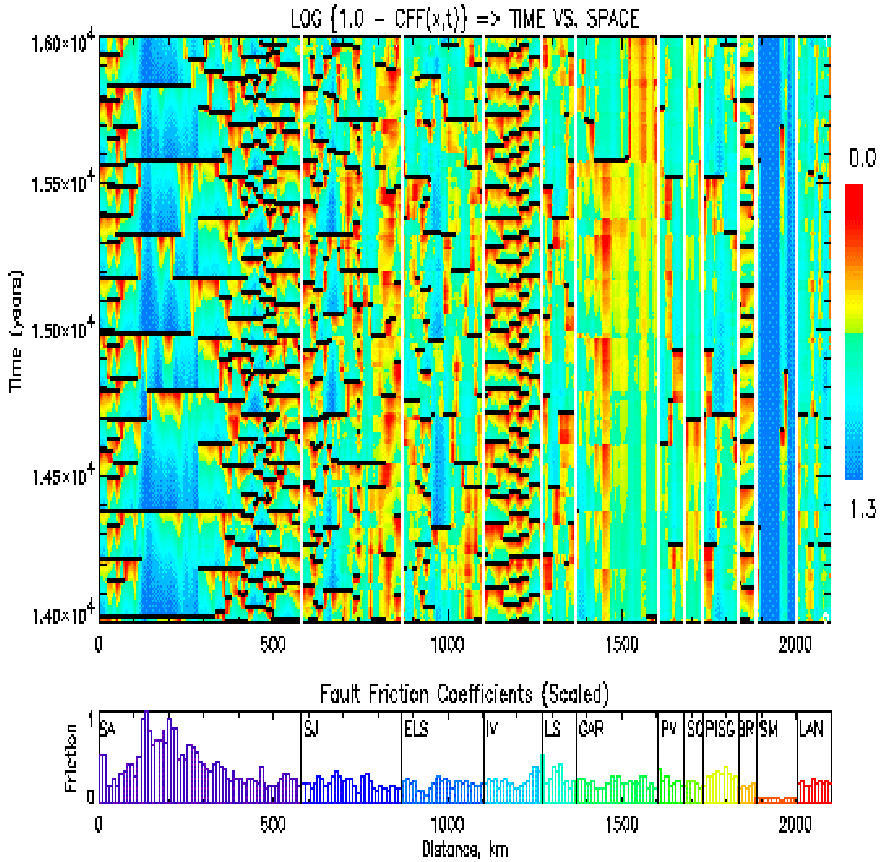
- The mountains grew an additional 12 cm in the two years following the earthquake.
- Consistent with fault afterslip.
- Not consistent with lower crustal relaxation.
- Recent deformation is similar to pre-seismic velocity field, particularly near the source.

Faults Can Be Modeled as Interacting Systems

Southern California Seismicity

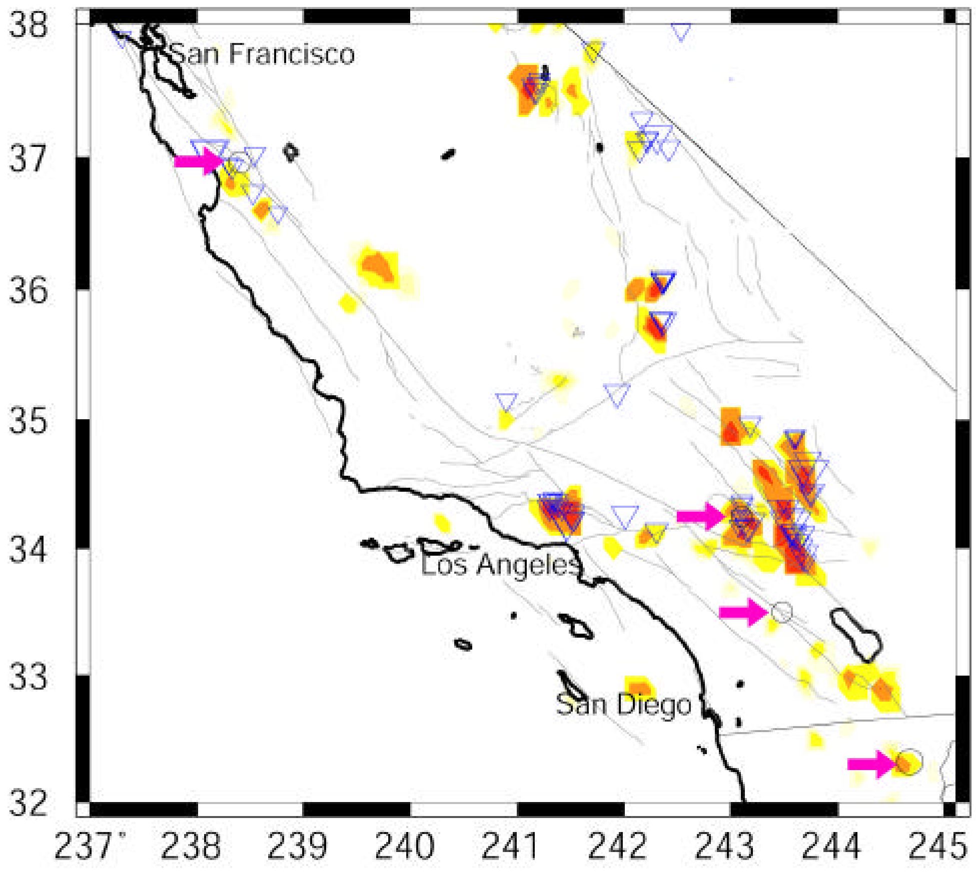


Space-time Stress Diagram



Courtesy John Rundle

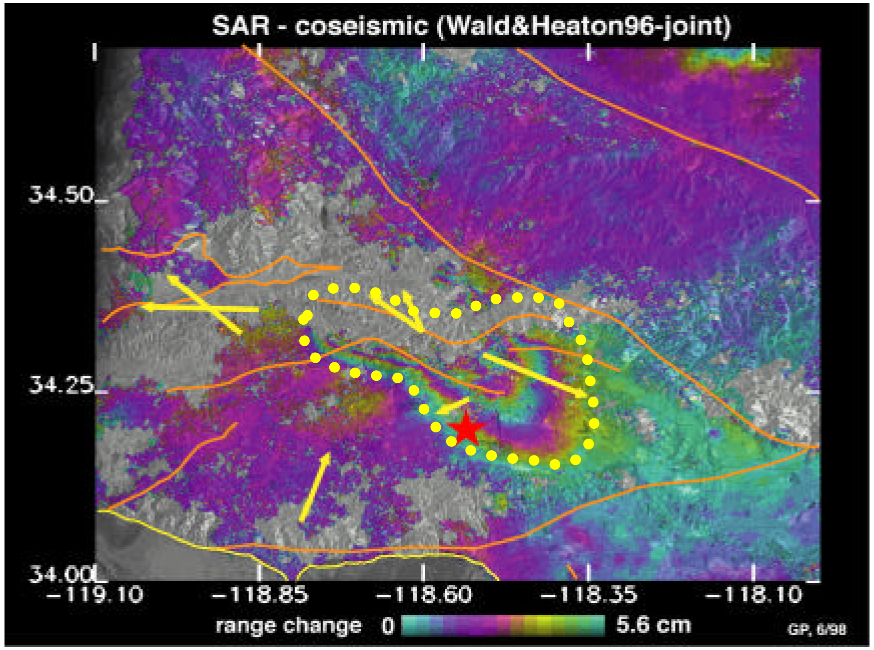
Application of Pattern Recognition

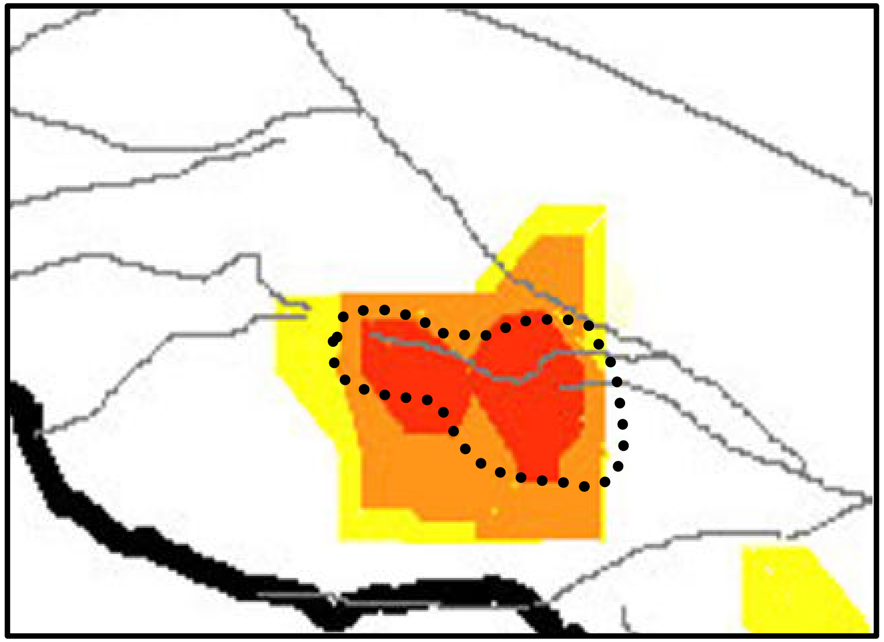


- Red regions indicate anomalies detected through Principal Component Analysis.
- Blue triangles and circles are earthquakes
- Recent earthquakes have occurred in the anomalous regions.

Courtesy John Rundle

Correlation Between Geodetic and Seismic Anomalies





- Similar anomaly shows up in both the postseismic deformation indicated by GPS and InSAR (Donnellan et al) and seismic anomalies identified using Principal Component Analysis (Rundle and Tiampo).
- Mojave desert shows a similar correlation near Barstow and the Blackwater Fault (Rundle and Tiampo; Peltzer).

Collaboration

- **NASA intends to continually strengthen collaborations and advocates open access to data.**
- **Open access is critical for exploration and discovery of new phenomenon.**
- **Recent collaborations include:**
  - **Southern California Integrated GPS Network (SCIGN)**
  - **APEC Cooperation on Earthquake Simulations (ACES)**
  - **International GPS Service (IGS)**