Statement of Current Research Interests
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I use crustal geodetic velocities, together with the style and distribution of faulting, and the distribution of gravitational potential energy to infer the properties of the lithosphere, and to unravel the contributions from the driving forces that cause these motions. My principle tool is the Global Positioning System (GPS), which I use to perform surveys that elucidate crustal deformation on the scale of the entire western United States diffuse plate boundary. I enjoy being involved in every component of this process, i.e., data collection, data processing, and interpretation through modeling.

SCIENTIFIC DIRECTIONS

Broad-Scale Crustal Kinematics

The major objective of my current work is to develop GPS velocity and deformation fields for the entire western United States. To that end I have combined and reprocessed all of the campaign GPS data in the USGS archive in order to clarify western U.S. deformation. In addition I have installed and surveyed new long-baseline geodetic networks for the purpose of characterizing strain rates across the northern-most Basin and Range of Idaho, Oregon, Montana, Utah, Washington, and Wyoming where previous coverage was poor. Future measurements on these networks will provide data that will contribute to our understanding of the strain rate field throughout the western United States.

To infer deformation from GPS velocity data, I have employed various improvements in the analytical methods for determining a self-consistent crustal strain field from sparsely, or irregularly spaced geodetic benchmarks. These include both an iterative strain rate inversion method that I have developed and also several finite element approaches. Using a variety of techniques allows me to address geodynamic problems on multiple scales. For example, one finite element technique allows the strain rate field to be continuous or perforated by faults, and allows the model resolution to vary with the station spacing. This is useful in regional studies where the tectonic style or lithospheric structure is heterogeneous. For smaller scale fault zone studies, I have used a different method that is better adapted for unraveling the relative contributions of secular motion and post-seismic processes such as visco-elastic, poro-elastic relaxation or creep. I have also improved the estimation of uncertainties in GPS velocity and reference frame, which has improved my ability to infer the patterns and meaning of tectonic motion.

Continental Dynamics

I use several different approaches to address dynamic issues with GPS, gravity and fault slip data. In a recently completed study with a paper now in review, I interpreted data that I collected in a September 2002 re-survey of a network spanning the Basin and Range at 39°N latitude. I interpreted the results by comparing the spatial characteristics of the deformation to those of a simplified model of the Basin and Range represented by a Newtonian thin viscous sheet under gravitational collapse. Using this comparison I was able to infer that the Walker Lane lithosphere is most likely rheologically weaker than the rest of the Basin and Range. Research of this kind will help us understand the mechanics of tectonic interaction at diffuse plate boundaries, and to shed light on the role of crustal faulting in the deformation of the continental lithosphere. Questions that may be addressed in the near future include:

- *How do Pacific/North America plate boundary tractions influence Great Basin deformation?*
- *How is stress transferred across the San Andreas fault into California and the Great Basin?*
- *What is the role of gravity in deformation of the western United States?*

The Seismic Cycle

In a recent study of Basin and Range deformation, I compared GPS crustal velocities to expectations based on what is known of the faulting mechanisms for earthquakes in the Central Nevada Seismic Zone. I contrasted the rate of fault slip estimated from GPS-derived contemporary deformation to slip rates estimated from paleoseismic studies. The result was that strain accumulation rates, as measured by GPS, are much greater than would be expected from the offsets and frequency of ground rupture in the region. Furthermore, the excess GPS velocity (with respect to paleoseismology) is likely too great to be explained by visco-elastic post-seismic relaxation. This mismatch is representative of a central problem in modern tectonic geodesy: Why do paleoseismology and geodesy disagree? Contributions to the GPS-derived strain rate field may include elastic strain accumulation, creep on faults, co-seismic offsets, relaxation following earthquakes, and ground water or magmatic influences. Each crustal velocity vector has potential contributions from each of these phenomena. Thus, more must be learned about these effects before we can universally extract long-term motion from GPS velocity.

Upper Mantle Flow and Melt Generation
Seismic and geochemical observations bear strongly on the inferred rheological properties of the mantle lithosphere and asthenosphere. My dissertation studies focused on methods for detecting the characteristics of mantle flow using teleseismic body waves, specifically partial melt and anisotropy. These products of mantle flow derive from upwelling and strain in the mantle, respectively, and each possesses a characteristic seismic signature. I used body wave delay times and shear wave splitting delay times to identify melt and anisotropy in the upper mantle, and infer the properties of the mantle flow regime beneath the Southern East Pacific Rise mid-oceanic spreading center. I found that melt may be present at surprisingly great depths, up to 200 km, and that mantle flow produces less vertically oriented anisotropy than expected, implying a relatively shallow and quick-turning asthenospheric return flow.

FIELD STUDIES

A significant portion of my current activities is the management of field campaigns to measure crustal motions with GPS. I have designed and installed six long-baseline geodetic networks that span the northern Basin and Range in Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming. These networks will help quantify seismic hazard in parts of the western United States where currently very little is known. I have led groups of up to 17 observers to collect data in survey-mode campaigns for up to several weeks to occupy these and previously existing networks. These surveys have often been collaborative efforts with university, volunteer or other government groups, requiring me to direct the activities of people with diverse backgrounds and qualifications to achieve results.

Fortunately, visiting the actively deforming part of western North America is usually enjoyable. This type of field work offers opportunities to see large transects of the West, and helps develop a broad and integrated picture of western U.S. tectonics. Thus, doing field work in the Northwest and Great Basin has been particularly rewarding and promises to be an ongoing part of my research activities for years to come.

DATA PROCESSING

Once GPS data is collected, solving for crustal motion has been accomplished by processing the raw data in conjunction with data from nearby continuously recording GPS stations using the GIPSY/OASIS II software package. With the goal of developing western U.S. models in mind, I have moved forward to reprocess the entire USGS archive of GPS data in large meta-campaigns to obtain hundreds of velocities, and I intend to use them as a constraint on dynamic models of western U.S. deformation. Because the rates of deformation in most of the continental United States are very low (the eastern Great Basin, Intermountain Seismic Belt and eastern Oregon move at between zero and 5 mm/yr with respect to stable North America), I've paid careful attention to reference frame and uncertainty issues. This has led me to explore a number of data processing and post-processing techniques. Improved methods are still being developed, and these are the subject of ongoing research.