Annual Report to Southern California Earthquake Center: Piñon Flat Observatory: Continuous Monitoring of Crustal Deformation

3/01/2007 — 2/29/2008

Duncan Carr Agnew (dagnew@ucsd.edu)
Frank K. Wyatt (fwyatt@ucsd.edu)

Institute of Geophysics and Planetary Physics
Scripps Institution of Oceanography
University of California, San Diego
La Jolla, CA 92093-0225

1. Major Goals and Activities

Support from the Southern California Earthquake Center through this grant covers part of the operation of a facility for the continuous measurement of strain changes in southern California: Piñon Flat Observatory (PFO), between the San Jacinto and San Andreas faults. The instruments at PFO (three laser strainmeters and two longbase tiltmeters)measure crustal deformation in Southern California for periods from seconds to years. **Figure 1** shows the locations of these strainmeters, along with the USGS-supported instrument at Durmid Hill (DHL), near the southern end of the San Andreas fault, and the new strainmeters that have been and are being added by the Plate Boundary Observatory project as part of Earthscope. By recording strain over this wide range of frequencies these measurements provide a nearly unique bridge between seismology and geodesy that is rarely available.

This award provides funding for operation of PFO, including support for power distribution, data recording, preliminary data-processing, and data distribution: all fairly basic activities, but all needed if the observatory is to function productively.

2. Accomplishments and Changes Implemented in this Reporting Period

It is the nature of this kind of data collection that there may not be a significant geophysical event in any given year; however, even without events, the accumulation of data can reveal new information. One example of the value of long term recording is provided by recent work on interpreting the time-varying permeability at PFO (Elkhoury *et al.* 2006).

Figure 2 shows the long-term signals for the NWSE strainmeter at PFO, which was (for most of the time shown) the only well-anchored one. The "bump" after 1992.5 is postseismic strain from the Landers earthquake; the apparent offset at the earthquake is actually rapid aseismic strain change, starting immediately after the event, which then reversed and returned to the preseismic rate. Following the 1999 Hector Mine earthquake, the rate seems to have slowly decreased and by 2004 had reversed again, only to abruptly change following the 2005 Anza earthquake. The trend in deformation has persisted to the present. We do not have a full understanding of these variations, which are unprecedented in the previous record of interseismic strain, except to say that they correlate neither with instrument changes nor with the (occasional) groundwater recharge events.

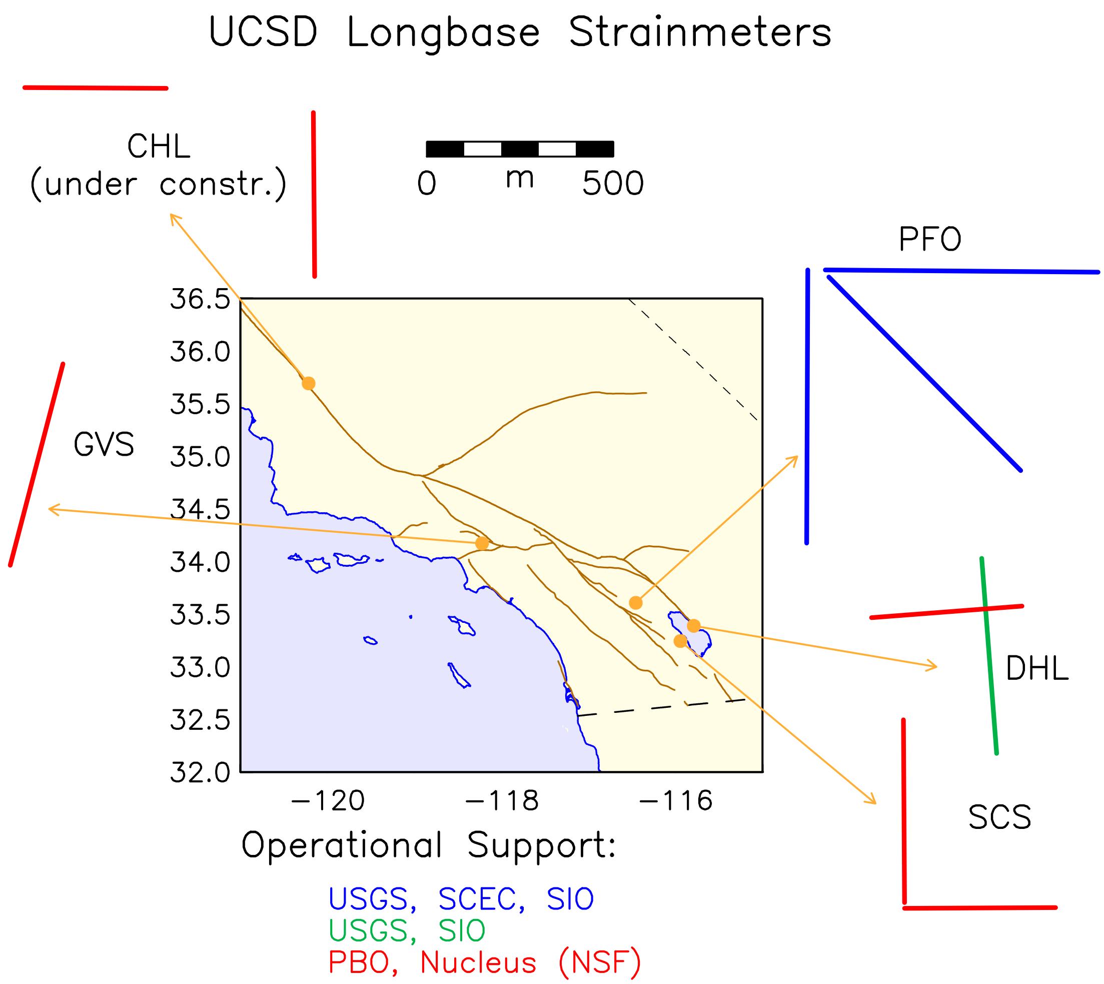

Figure 1: Laser strainmeters in California. All of the systems are telemetered by radio links and Internet to UCSD, with data streamed, and also downloaded daily.

Figure 3 shows the time series from all three long-base strainmeters at PFO, from 120 days before the Anza earthquake to the end of 2005. We have removed the tides, except at the end, for scale. Because of strong ground shaking no coseismic offset was recorded, and we have not tried to show it (available from modeling). All three strain records show a clear rate change after the earthquake. The diversity of responses argues against this being some kind of local response at PFO; if we assume it to be afterslip on the San Jacinto fault, the response is consistent with slip in a region of the fault that showed small earthquakes triggered by the mainshock and outside the aftershock zone, with this aseismic slip then propagating upwards, the total aseismic moment is equivalent to a magnitude (M_w) 5.0 event.

PBO has installed a number of borehole strainmeters (BSM's) in the Anza area, largely in response to this observation of aseismic slip. These instruments will be very useful, but they do not replace the PFO strainmeters. Figure 4 shows a comparison between the two for a year of data, starting at a time far enough after the installation of the PBO instruments that any initial transient had ended; an exponential and trend were also removed from each of the borehole

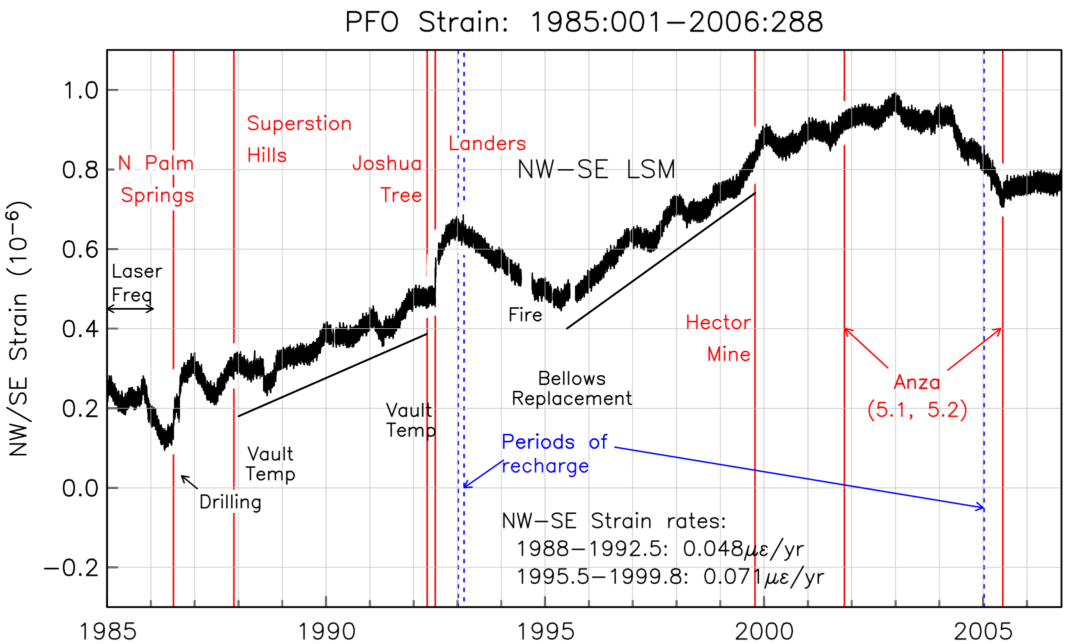

Figure 2

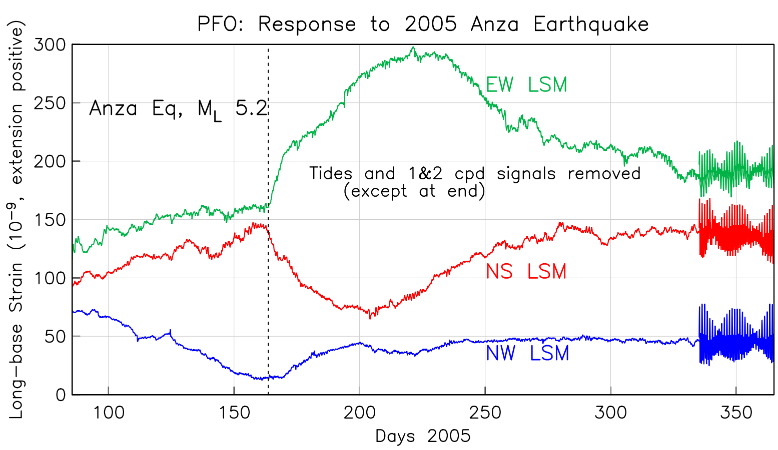

Figure 3

sensors (“gauges”) individually. For periods longer than a few days, and increasingly at longer periods, the laser strainmeters give much quieter results — a better measure of the deformation.

In the past year we have also made significant progress on several specific items related to observatory operation. Of course, there is also maintenance of many items; over the course of the year, we average 1–2 trips per month both to introduce new equipment and to fix problems. Typically the latter involves work on the facility and the laser strainmeters (lasers and vacuum systems). Much of the work reflects the age of some of the equipment at PFO; we have been using recently granted NSF I&F funds, and capital funds from the Green Foundation (Dallas) and from the SIO Director’s Office to purchase some much needed new equipment. The DHL facility also required some preventive maintenance to strengthen the steel vaults the ends are

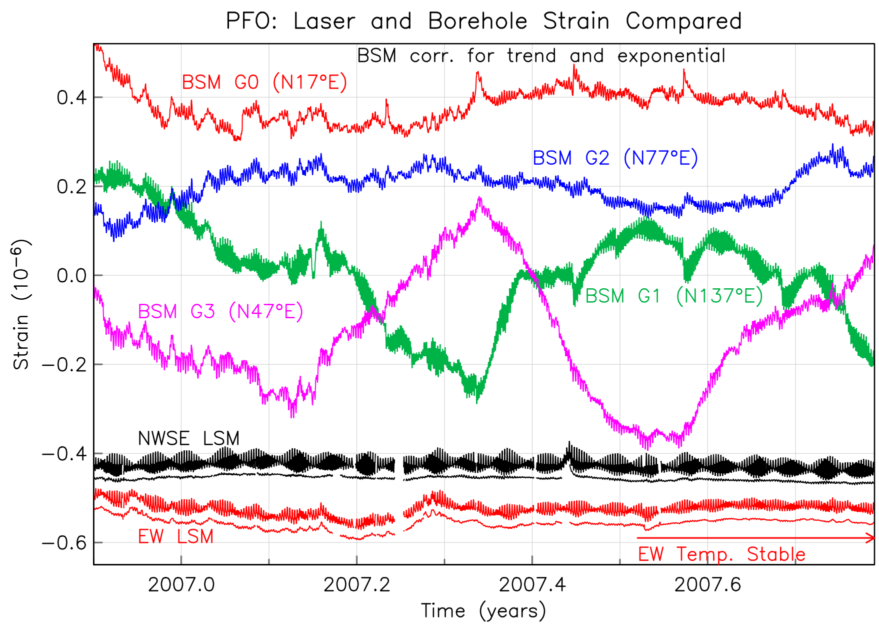

Figure 4

housed in. We spent considerable effort building and testing individual datalogger/controllers to be used in the PFO laser strainmeters, permitting greater remote control and overall improved operation. Another improvement was to install our two-stage temperature control system (standard on the newer instruments) on the EW instrument at PFO; the resulting improved performance (Figure 4) is now equal to that of the NWSE, since both systems are also fully anchored.

3. Data Management Practices

Thanks to various upgrades, and even more to our being able to employ a dedicated person for data processing (needed to meet PBO requirements), we are able to make realistic plans for prompt public access to PFO data. Plots of raw data from PFO and DHL will continue to be available in real time through the Anza RoadNet system; a full description of this is provided at `http://pfostrain.ucsd.edu`. In addition, we are making fully-corrected and edited data available at this location, using the XML format developed by PBO; these data have a latency of no more than six months. Eventually these data will be archived in parallel with the PBO data at the NCEDC; we have been delayed in setting up this transfer because of personnel changes in the PBO group at UNAVCO, who are setting up the system that will make the PFO and DHL data parallel to that used by PBO. We continue to make older data available on request.

4. Continuity of Operations and Response Planning

All our instruments include hold-down clamps so that no damage will be caused by shaking; however, in systems of this size, continous operation through large nearby events is unlikely. PFO has a backup generator; and the strainmeter systems, including the new temperature controllers, are all on uninterruptible power supplies, so power outages up to 1 hour will not affect the operation (for PFO, many days). All data is telemetered and stored onsite; the PC datalogger can easily store several years of data.

References

Elkhoury, J. E., E. E. Brodsky, and D. C. Agnew (2006). Seismic waves increase permeability, *Nature*, **441**, 1135-1138.