inSights
the EarthScope newsletter
Fall 2013

EarthScope News

2013 Great ShakeOut

The EarthScope National Office will participate in this year's Great ShakeOut (http://www.shakeout.org/), a "Drop, Cover and Hold On" earthquake preparedness drill scheduled for October 17th at 10:17 am local time.

In addition to the drill itself, the EarthScope National Office will host a public lecture session at Arizona State University on the evening of October 16. The presentations will be available at our website www.earthscope.org/shakeout.

The Great ShakeOut drills help people in homes, schools, and organizations improve preparedness and safety procedures during earthquakes. The ShakeOut organization currently has nearly 17 million people registered worldwide for the 2013 drills, with over 12 million of these people registered to drill on October 17. Numbers are expected to exceed last year's global participation of 19.5 million. Please visit the Great ShakeOut website to find out how you can get involved.

Monitoring Surface Deformation at Long Valley Caldera, California

Kang Hyeun Ji, The University of Alabama

Continuous monitoring of volcanic activity provides a way to detect changes from usual activity, provide warning impending eruptions, and reduce volcanic risk. We have developed a near real-time monitoring tool for surface deformation: Targeted Projection Operator (TPO). With the Global Positioning System (GPS) data from the Long Valley Caldera (LVC) in eastern California, TPO shows that LVC has experienced a sequence of deformation events including inflation from 2007-2009, slow deflation from 2009-2010, and a rapid inflation since late-2011. The current event is about four times faster than the 2007-2009 event and is ongoing, although starting June 2013 the rate began to slow. Here we briefly introduce how TPO works for continuous monitoring of deformation in LVC.

The TPO method assumes that an event has the same spatial pattern as previous deformation events but with different amplitudes. This assumption is reasonable for the recent relatively quiet phases in LVC because the spatial pattern of the 2007-2009 inflation is similar to that of the 2009-2010 deflation. Under this assumption, a known base pattern or "target" pattern is selected and the varying amplitudes are recovered by projecting the data along the target pattern. Large changes in amplitude imply changes in strength of the event. An anomalous change can be detected by comparing historic amplitudes. The technique is easily applied whenever new data are available. Ji et al. (2013) provides details of the technique.

Operational use of TPO currently relies on GPS data from the EarthScope Plate Boundary Observatory stations around the LVC. The horizontal pattern of the 2009-2010 event was selected as a target pattern (Figure a). Then the horizontal components of the GPS data are projected along the target pattern to obtain the varying amplitudes or TPO time series (Figure b). The TPO time series shows that an inflation event began in late 2011 with brief pauses in during the summer and fall of 2012, continuing to the present time (July 2013). The inflation is consistent with a Mogi source located beneath the resurgent dome at about 6.6 km depth with an inflation rate of 0.009 km^3/yr volume change.

To determine the anomalous amplitude of the TPO time series, we calculate differences between averages from two consecutive time windows (e.g., 60- and 30-day windows in the LVC case) and see if the differences are larger than the root-mean-square (RMS) error from relative quiescence. The recent inflation event is significantly large compared to relatively quiet periods (i.e., three times more than the RMS error, Figure c). In this way, TPO can be a useful tool for continuous monitoring, providing a timely alert of deformation events, and for assessing volcanic hazard in this potentially eruptive volcanic system.

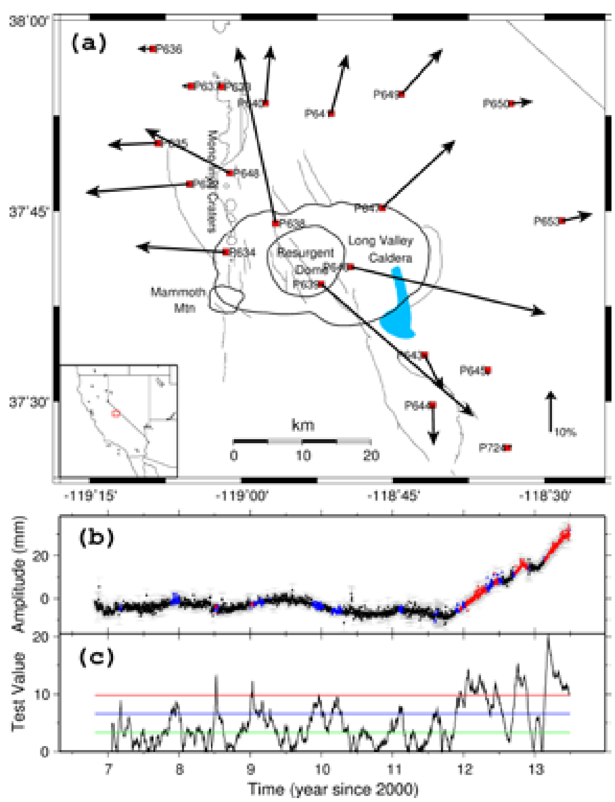


Figure (A) Map of the Long Valley Caldera region and the horizontal pattern of the 2009-2010 event (arrows) Figure (B) TPO time series (dots) and 1-sigma uncertainties (gray error bars). Colors correspond to those appeared in Figure C. (C) Differences between averages from two consecutive timewindows and RMS values from relatively quiet time periods (green: 1-sigma, blue: 2-sigma, and red: 3-sigma).

Ji, K. H., T. A. Herring, and A. L. Llenos (2013), Near real-time monitoring of volcanic surface deformation from GPS measurements at Long Valley Caldera, California, *Geophys. Res. Lett.*, 40, 1054–1058

USArray Looks Back as it Looks Ahead

Ten years ago, the construction of USArray observatories officially began. This followed numerous community meetings, countless hours of meticulous planning, and some healthy skepticism that perhaps USArray was too ambitious to even be possible. However, the USArray observatories have exceeded expectations for the quality and quantity of data delivered and have provided observations of unprecedented scale:

• The Reference Network, designed to provide a long-term reference frame for the Transportable Array, was completed in September 2006. It consists of more than 100 stations at approximately 300-km spacing across the conterminous United States and 10 stations in Alaska. Developed in close collaboration with the USGS to augment the Advanced National Seismic System, USArray installed or upgraded 39 of these stations. To improve the uniformity of the Reference Network coverage, the Transportable Array also installed an additional 20 stations that are operating for the duration of USArray.

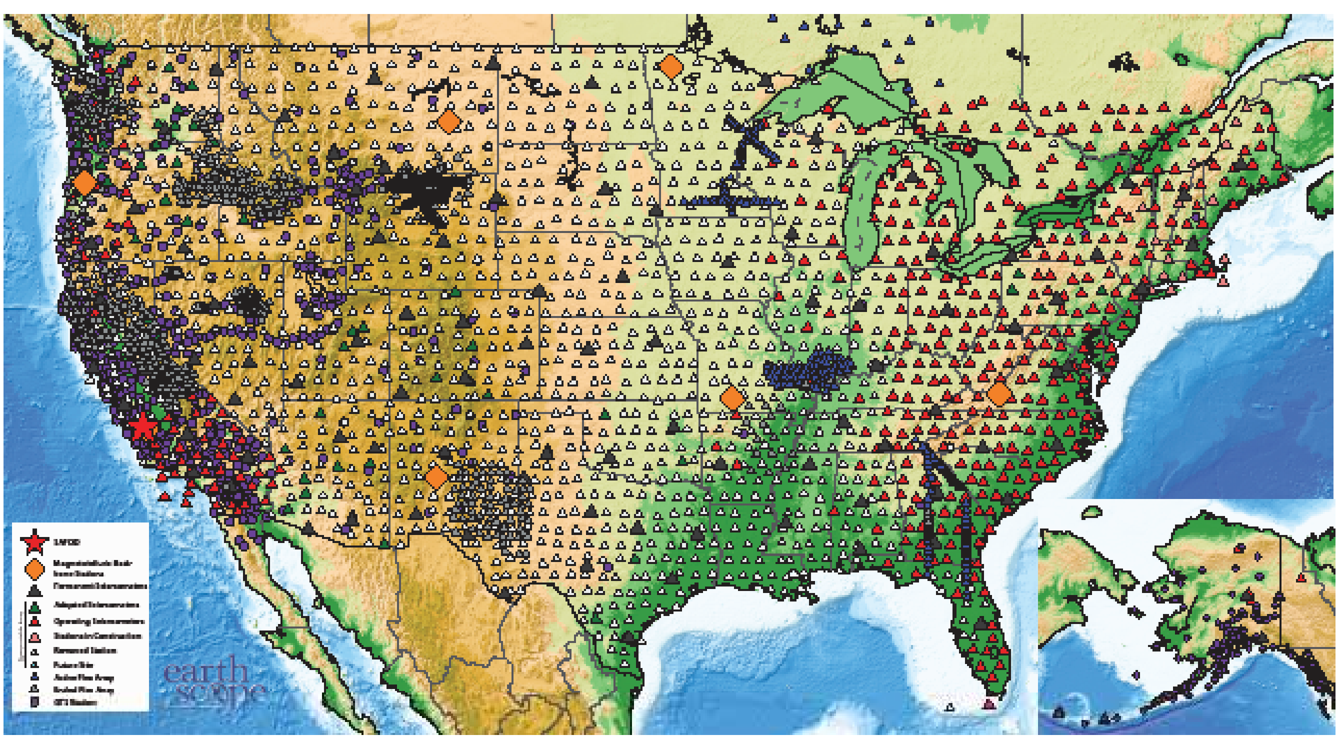
• The Transportable Array's network of 400 broadband stations, each about 70 km apart, has slowly rolled across the country from west to east, recording data at each site for about two years. In August 2007, the first 400-station footprint was established, stretching from Canada to Mexico in the westernmost United States. The entire observatory has now occupied more than 1700 temporary sites, including 58 sites in southern Ontario and Quebec. The station design has been relatively consistent from site to site, with some additions and improvements, most notably the inclusion of atmospheric sensors starting in 2009, the introduction of rotomolded vaults, and the use of a water-tight box for electronic components. Identification of nearly 85% of the locations was conducted with assistance from about 150 students from more than 50 universities.

• The Flexible Array, consisting of a pool of portable seismic instruments, was established to support focused investigations requiring higher-resolution images embedded within the context of the Transportable Array. Thus far, more than 20 major PI-driven Flexible Array experiments have been supported. The pool has 326 broadband, 120 short period, and 1700 active source instruments.

• In 2008, a Magnetotelluric backbone observatory was completed with seven stations installed within the United States. Twenty additional systems are in use for Transportable Array deployments with 70-km spacing. During the last seven field seasons, nearly 500 sites have been occupied in the Pacific Northwest and in the Midcontinent Rift. Two magnetotelluric Flexible Array experiments got underway earlier this year.

With more than 54 TB of freely available seismic and magnetotelluric data, USArray observatories have already enabled significant discoveries that have contributed to a better understanding of the structure and evolution of the North American continent. As EarthScope embarks on the next five years, some USArray activities are continuing in the contiguous United States. It is with much anticipation that the Transportable Array will focus on deploying stations on an 85-km grid in Alaska and western Canada. The rugged terrain, the extreme yet fragile environment, and the scarcity of paved roads are among some of the challenges ahead, but with advance planning and ingenuity, all appear surmountable. The scientific community anxiously awaits the arrival of these new data.

EarthScope Stations Status as of October 2013



EarthScope at GSA and AGU Annual Meetings

EarthScope will have a significant presence at the GSA and AGU annual meetings both in sessions and in the exhibit hall. EarthScope scientists, researchers, and educators are asked to volunteer some time at the booth. If you are interested in volunteering, please contact the national office at earthscope@asu.edu.

THE GEOLOGICAL SOCIETY OF AMERICA®

Geologic Society of America
October 27-30, 2013 in Denver, CO

EarthScope scientific research and broader impacts are quite diverse, so there are many topical and special sessions of potential interest. We would like to bring your attention to two Pardee sessions in particular which focus on EarthScope scientific results. For additional information on sessions please visit http://community.geosociety.org/2013AnnualMeeting/Sessions or our blog at http://earthscope.org/blog/gsa2013

P2. 125 Anniversary Pardee Symposium: Advances in Understanding Earth

P5. Evolution of the North American Cordilleran Lithosphere

AGU American Geophysical Union

American Geophysical Union
December 9-13, 2013 in San Francisco, CA

There are many EarthScope relevant sessions planned for the AGU meeting. The following EarthScope-related sessions may be of particular interest. For additional session related information please visit http://fallmeeting.agu.org/2013/scientificprogram/ or our blog at http://earthscope.org/blog/agu2013

S005. A Decade of EarthScope Discoveries Advancing Earth Science Research and Education

T011. Deep Exploration into the Lithosphere

ED003. Broader Impacts of EarthScope: Geoscience Education and Outreach Activities

EarthScope Town Hall: Thursday December 12 at lunch. Please join us!

Hot New Science

In each *inSights,* we highlight a few recent EarthScope-related publications. Please submit your latest publications to earthscope@asu.edu

Bohon, W., Robinson, S., Arrowsmith, R., Semken, S. (2013). Building an Effective Social Media Strategy for Science Programs. Eos, 94, 237–244.

Chao, K., Peng, Z., Gonzalez-Huizar, H., Aiken, C., Enescu, B., Kao, H., … Matsuzawa, T. (2013). A Global Search for Triggered Tremor Following the 2011 Mw 9.0 Tohoku Earthquake. Bulletin of the Seismological Society of America, 103(2B), 1551–1571. doi:10.1785/0120120171

Colombelli, S., Allen, R., & Zollo, A. (2013). Application of real-time GPS to earthquake early warning in subduction and strike-slip environments. Journal of Geophysical Research: Solid Earth, Retrieved from http://doi.wiley.com/10.1002/jgrb.50242.

Frederiksen, A. W., Bollmann, T., Darbyshire, F., van der Lee, S., & Sciences, P. (2013). Modification of Continental lithosphere by tectonic processes: a tomographic image of central North America. Journal of Geophysical Research: Solid Earth. doi:10.1002/jgrb.50060

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inSights is a quarterly publication showcasing exciting scientific findings, developments, and news relevant to the EarthScope program. Contact earthscope@asu.edu to be added or deleted from the hardcopy mailing list; electronic copies are available at www.earthscope.org. Editor: Devon Baumback ASU/EarthScope National Office.

EarthScope Northeastern Interpretive Workshop

Twenty-six interpretive professionals listened intently as Park Ranger Stephanie Kyriazis (photo) relayed the glacial history of Acadia National Park. She explained how the landforms and rocks seen today tell a story of glaciers moving the rocks and shaping the land thousands of years ago. The workshop, held September 16-18, was ninth in a series of workshops hosted by the EarthScope National Office for park rangers, museum staff, and other interpretive professionals. Participants learned geology basics and EarthScope science through expert lectures and small group collaboration.

The highlight was the field trip where they visited a newly installed EarthScope Transportable Array station and hiked through Acadia National Park as Ranger Kyriazis discussed the geologic history of the region. At the end of the workshop, participants (and facilitators) presented what they learned throughout the week. These presentations and activities were designed for use in their own interpretive environments as a way to illustrate both EarthScope science and the northeastern regional geologic history. The next EarthScope interpretive workshop will be in Alaska, with the same goal of educating interpretive professionals, who in turn educate the public on geologic concepts and EarthScope science.