inSights

the EarthScope newsletter

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Inside this issue...

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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.

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The plenary talks were followed by a panel discussion on the Broader Impacts, Policy, and Future of EarthScope featuring representatives of the NSF (Greg Anderson), NASA (John LaBrecque), NOAA (Juliana Blackwell and Ifikhar Jamil), and USGS (William Leith). Over 300 people attended the talks and the panel discussion. The Decade Symposium also featured an exhibit hall where the EarthScope National Office, IRIS, UNAVCO, and SAFOD displayed geoscientific research equipment and multimedia exhibits from USArray, the Plate Boundary Observatory, and a San Andreas Fault drill core replica.

The Decade Symposium concluded with a reception featuring congratulatory and encouraging remarks from Dr. Cora Marrett, the acting director of NSF (see photo).

Linda Rowan (Director of External affairs, UNAVCO) and Ramon Arrowsmith also put together an entry for AGU's science policy blog The Bridge, to commemorate the event: http://thebridge.agu.org/2014/05/27/earthscope-grand-earth-observing-project-epic-future/.

Right: National Science Foundation Acting Director Dr. Cora Marrett and EarthScope National Office Director Dr. Ramon Arrowsmith at the EarthScope Symposium reception.

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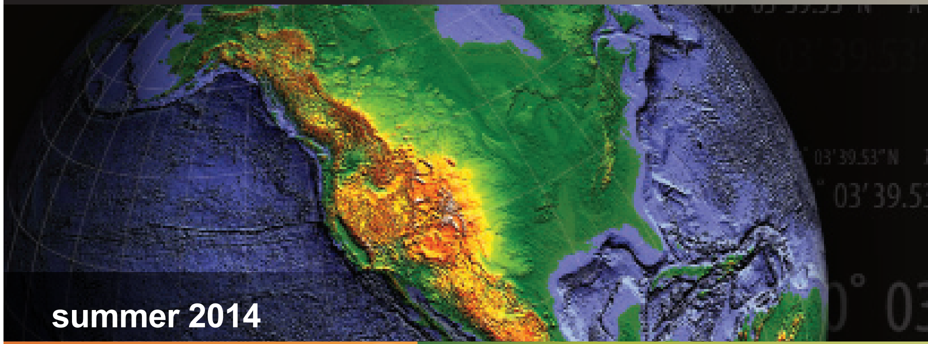
summer 2014



EarthScope News

EarthScope National Meeting 2015

June 8-10, 2015

Save the dates of June 8-10 for the biennial EarthScope National Meeting in Vancouver, Washington. Conference highlights include the opportunity to showcase your research in the poster sessions, hear firsthand results of pioneering EarthScope studies, contribute to the discussion on the future after EarthScope, and participate in a field trip (tentative) with local EarthScope scientists.

More info coming soon at www.earthscope.org

Shakeout 2014!

Get ready to Drop. Cover, and Hold On! The 2014 Great Shakeout will take place October 16 at 10:16 AM! To learn more and sign up visit www.shakeout.org.

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PBO Weighs California's Water Resources

By Donald Argus, Yuning Fu, and Felix Landerer, Jet Propulsion Laboratory, NASA

Approximately 500 sites in California, most of which are part of the Plate Boundary Observatory, are weighing changes in the total mass of snow, soil moisture, and surface water as a function of location across the state. Changes in water storage are inferred from vertical movement of Earth's surface. The seasonal change in surface water thickness in California is about 0.5 meters in the Sierra Nevada and Klamath Mountains and about 0.1 meters east in the Great Basin. The seasonal change (October 1 to April 1) in total water in the Sierra Nevada mountains is estimated with GPS to have been on average about 35 gigatons each year from 2007 to 2013.

GPS is accurately measuring vertical displacements of Earth's surface in elastic response to changes in water storage in California. California's mountains are observed to subside as much as 12 millimeters during the fall and winter due to the load of snow and rain, then rise about the same amount in the spring and summer when the snow melts, rain water runs off, and soil moisture evaporates. Solid Earth deforms in elastic response to the load of water, snow, ice, and atmosphere. ("Elastic" means that strain generated in response to a surface load is fully recovered when the load is removed.) The elastic response to a surface load is specified by well-known Green's functions that are insensitive to Earth's rheological structure (except above thick sedimentary basins).

We performed a rigorous inversion of the GPS vertical displacements for equivalent water thickness at 1/4 degree intervals of latitude and longitude (at about every 25 km). A smoothing constraint is imposed to limit change in water thickness between adjacent pixels. Seasonal vertical displacements (Fig. 1, left) are used to infer the seasonal change in water thickness (Fig. 1, right). Earth's surface on top of aquifers responds differently to the addition of water. An aquifer expands as water fills the porous gravel, sand, and silt in the aquifer, causing Earth's surface to rise. Earth's surface rises in the winter when the aquifer is recharged with water and subsides in the summer when groundwater is withdrawn. GPS sites on top of aquifers were not used in this study to infer water changes (in particular in the southern Central Valley shaded gray in Fig. 1, right). GPS resolves seasonal water storage across California's different physiographic provinces well. The average seasonal water thickness change in California is about 0.5 meters in the Sierra Nevada, Klamath, and southern Cascade Mountains and decreases sharply to about 0.1 m eastward into the Great Basin and westward toward the Pacific coast.

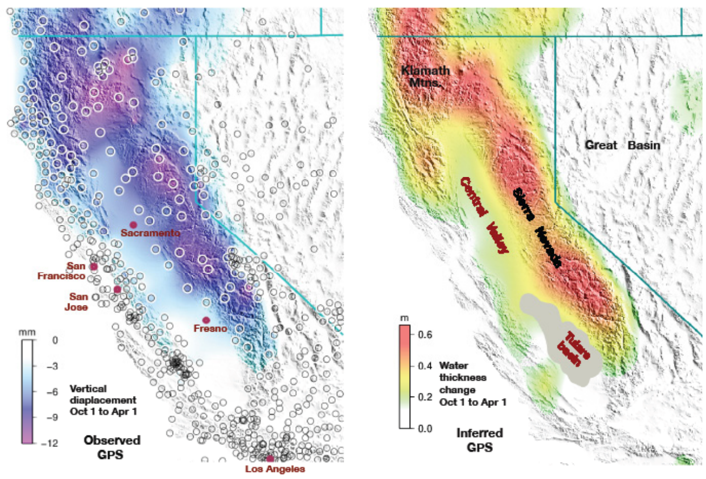


Fig. 1 (Left) Average subsidence in millimeters in the fall and winter used to infer (right) the average increase in equivalent water thickness in meters during the same time period.

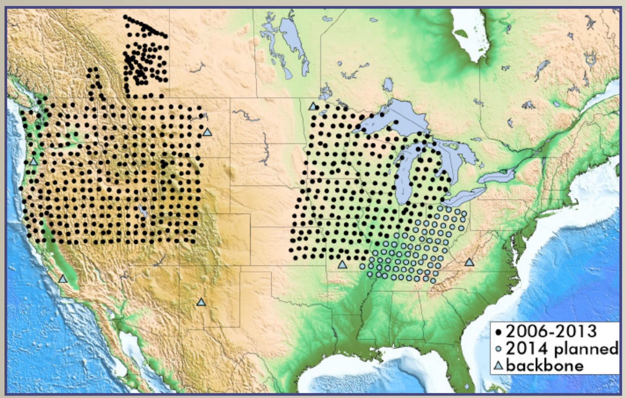
The GPS estimates of seasonal change in water storage in the Sacramento–San Joaquin River basins (containing the Central Valley and Sierras) are consistent with observations from the Gravity Recovery and Climate Experiment (GRACE). The GPS results provide much greater spatial resolution than the satellite data and thus provide more information about water distribution for water resource management. The GPS data are compared to three hydrological models: North American Global Land Assimilation System (NLDAS-Noah), Global Land Data Assimilation System (GLDAS-Noah) and a composite model. The GPS data help to refine hydrological models and the comparison here suggests that NLDAS-Noah underestimates seasonal water storage in the mountains by about 50% while a composite model which includes snow, soil moisture and reservoir water is closer to the GPS results.

California is presently in the third year of drought. Snowpack and reservoir waters are very low. We are now using GPS to estimate the change in the total of snow and soil moisture during the past 36 months of drought given that reservoir water storage is well known and may be removed from the GPS estimate of total water. Developing the capability of estimating changes in surface water in near real time (within 1-2 days) would bring valuable information on water availability to resource managers.

USArray Continues Field Activities in 2014

By Perle Dorr, IRIS

Since the completion of the Transportable Array in the Lower 48 during fall 2013, USArray has focused on the creation of the Central and Eastern US Network (CEUSN), moving the Transportable Array to Alaska, and expanding the footprint of EarthScope's magnetotelluric observations.



Magnetotelluric Transportable Array and Backbone Locations

Recordings from the 159-station CEUSN (network code N4) will augment existing seismic station coverage to enable researchers and federal agencies to better understand basic geologic questions, background earthquake rates and distributions, and seismic hazard in the region. Targeted stations will transition from the Transportable Array after the standard two-year recording period. In some key locations, where a Transportable Array station was already decommissioned, seismometers have been re-installed. To date, about 100 stations are officially operated under the CEUSN (http://ceusn.ucsd.edu/deployment/).

Transportable Array activities in Alaska and western Canada have ramped up this year. Site reconnaissance for 2014-2015 installations has been conducted, primarily by helicopter, and permits for selected sites are being prepared and submitted to the appropriate federal or state agency or Native corporation. In addition to several test stations that have been operating for about two years, eight new stations have been installed and upgrades have been made to another six Alaska network stations. It is anticipated that a total of 29 stations will be installed or upgraded by the end of October.

In early June, fieldwork was initiated to deploy 71 temporary magnetotelluric transportable array stations in eastern North America, extending the 2011-2013 Mid-Continent Rift footprint southeastward (see map). More than 22 sites have already been occupied in Arkansas, Illinois, Kentucky, Missouri, and Tennessee. Dozens of magnetotelluric flexible array stations, as well as 85 broadband seismic stations and nearly 2,600 geophones, have also been deployed around Mount St. Helens as part of the PI-led Imaging Magma Under St. Helens (iMUSH) experiment (http://imush.org/), an interdisciplinary investigation of the magmatic plumbing system beneath the volcano.

Helicopter Fieldwork in the PBO Alaska Region Summer 2014

By Ellie Boyce, UNAVCO

With high-elevation GPS stations melting out of the snow and the weather becoming milder, the PBO Alaska region began annual helicopter-based maintenance operations during the last week of May. This year's primary helicopter contract lasted seven weeks and the work plan included stations from Southeast Alaska out west to the Aleutian Arc and up north to Denali National Park and Fairbanks. The helicopter-based UNAVCO field crew made 46 maintenance visits and conducted seven aerial inspections, bringing 29 stations back online by repairing a variety of minor to major problems.

Maintenance on the three PBO Alaska volcano networks is a high priority for our helicopter-based fieldwork each year. This year, we were especially interested in ongoing low-level eruptive activity and an orange or "Watch" alert level at Shishaldin Volcano, Unimak Island (the easternmost of the Aleutian archipelago). Coming into the field season we had two tiltmeter failures on Shishaldin, so repairs were a high priority. Unimak Island is notorious for curious and hungry bears attempting to dig out the edible components from solar panels, GPS monuments, and/or tiltmeter casings. Our Shishaldin Volcano sites AV37 and AV39 tend to be favorite targets. Ryan Bierma (UNAVCO) and Dane Kentner (Alaska Volcano Observatory) made visits to both stations, repaired the bear damage and replaced one tiltmeter to re-enable tilt data collection at both sites. The volcano was pretty quiet as the crew worked nearby, but they did see evidence of recent ash emissions near the summit (see photo).

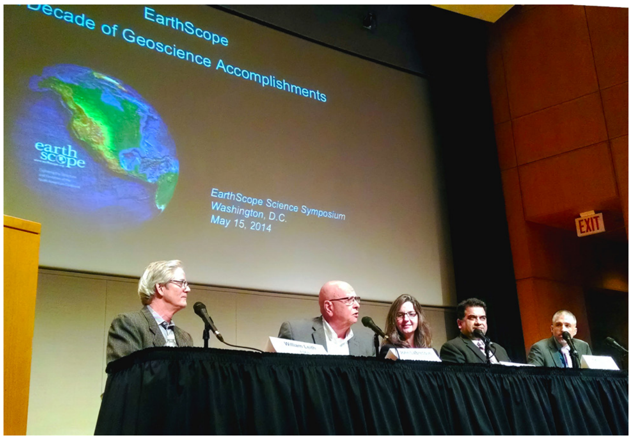
Above: Dark, ash-covered snow near the summit of Shishaldin Volcano in the Aleutians is evidence of ongoing low-level eruptive activity near PBO's AV37 GPS station. (Photo/Ryan Bierma, UNAVCO)

As of July 30, 2014, 134 PBO GPS sites are operational in Alaska, along with 11 tiltmeters. Four of these GPS sites broadcast data in real-time for surveying and potential use in earthquake or eruption early warning systems.

The EarthScope Decade Symposium: Celebrating Ten Years of Geoscience Accomplishments

In 2004, the epic undertaking of the EarthScope program became a reality. Over the next ten years, revolutionary scientific results have helped researchers better understand the geologic structure and evolution of North America, the dynamics of the North American-Pacific plate boundary, and the processes that drive earthquakes and volcanoes. Numerous unexpected discoveries and applications of the high quality and open data have also been made. This past May, several hundred individuals, representing a broad cross-section of EarthScope researchers, educators, leaders, and stakeholders, gathered in Washington, D.C. to celebrate a decade of accomplishment by the EarthScope program.

The two-day event included briefings to members of the House and Senate and a Decade Symposium that was hosted at the headquarters of the American Association for the Advancement of Science.



Above L to R: William Leith, USGS; John LaBrecque, NASA; Juliana Blackwell, NOAA-NGS; Iftikhar Jamil, NOAA-NWS; Greg Anderson, NSF

Jeffrey Freymueller (UAF) kicked things off with an Earthscope overview presentation to the House Research and Development Caucus sponsored by the Coalition for National Science Funding. House and Senate briefings included presentations on the EarthScope Program overall, and specific information on the EarthScope facilities from Ramon Arrowsmith (ESNO/ASU), Rowena Lohman (Cornell), Meghan S. Miller (USC), Hersh Gilbert (Purdue), and Mark Simons (Caltech). The briefings were moderated by William Leith (USGS). Various Congressional and Senate staff members attended these presentations.

The Decade Symposium began with plenary presentations on the evolution of the EarthScope facilities along with their current status, scientific accomplishments made possible by the collaborative nature of EarthScope, and on EarthScope's extensive education and outreach activities. Presenters included M. Meghan Miller (UNAVCO), Robert Detrick (IRIS), Roger Wakimoto (NSF), Ramon Arrowsmith, Steven Semken (ESNO/ASU), Jeffrey Freymueller, Mark Simons, Meghan S. Miller, Hersh Gilbert, and Heather Savage (Lamont-Doherty Earth Observatory).

Continued on back page

Hot New Science

In each inSights, we will highlight a few recent publications of EarthScope results. Please submit your latest publications to earthscope@asu.edu

Amos, C. B., Audet, P., Hammond, W. C., Bürgmann, R., Johanson, I. a, & Blewitt, G. (2014). Uplift and seismicity driven by groundwater depletion in central California. Nature, 509(7501), 483–6.

Verdon, J. P. (2014). Significance for secure CO_2 storage of earthquakes induced by fluid injection. Environmental Research Letters, 9(6), 064022.

Tong, Xiaopeng; Smith-Konter, Bridget; Sandwell, D. T. (2014). Is there a discrepancy between geological and geodetic slip rates along the San Andreas Fault System? Journal of Geophysical Research : Solid Earth, 119.

Stein, C. A., Stein, S., Merino, M., Keller, G. R., Flesch, L. M., & Jurdy, D. M. (2014). Was the Mid-Continent Rift part of a successful seafloor-spreading episode? Geophysical Research Letters.

Porter, Ryan C.; Fouch, Matthew J.; and Schmerr, N. C. (2014). Dynamic lithosphere within the Great Basin. Geochemistry, Geophysics, Geosystems, 1–19.

Jean, M. M., Hanan, B. B., & Shervais, J. W. (2014). Yellowstone hotspot–continental lithosphere interaction. Earth and Planetary Science Letters, 389, 119–131.