Personalized Itinerary Planner and Abstract Book

2010 AGU Fall Meeting
December 11 - 17, 2010

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<td>G11A-0620. Accuracy Assessment of High-Rate Kinematic GPS Based on Six-Degree-of-Freedom Shake Table Tests G. Wang; F. Blume; C.M. Meertens; P. Ibanez; M. Schulze</td>
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<td>IN11A-1074. Visualization and data sharing of COSMIC radio occultation dataset Y. Ho; W.J. Weber; J. Chastang; D. Murray; J. McWhirter</td>
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<td>8:00 AM-12:20 PM, Poster Hall (Moscone South), IN11B. Interoperability Barriers for Earth Science Data Systems I Posters</td>
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<td>IN11B-1085. The Geodetic Seamless Archive Centers Service Layer: A System Architecture for Federating Geodesy Data Repositories J. McWhirter; F.M. Boler; Y. Bock; P. Jamason; M.B. Squibb; C.E. Noll; G. Blewitt; C.W. Kreemer</td>
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<td>U13A-0019. Gravity Modeling of the Cerro Goden fault zone, NW Puerto Rico G.A. Mattei; K.M. Keranen; E. Asencio</td>
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<td>G13B-04. Comparison of Deep Drill Braced Monument (DDBM) and Borehole Strainmeter (BSM) Wellhead GPS antenna mounts: a Plate Boundary Observatory (PBO) case study from Dinsmore, CA. T.B. Williams; K.E. Austin; A.A. Borsa; K. Feaux; M.E. Jackson; W. Johnson; D. Mencin</td>
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<td>1:40 PM-6:00 PM</td>
<td>Poster Hall (Moscone South), S13C. Seismic Networks and Instrumentation Posters</td>
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<td>S13C-2031. The PBO borehole seismometer network. W. Johnson; O. Fox; D. Mencin; W. Gallaher; M.H. Gottlieb; K.M. Hodgkinson; C. Pyatt; E. Van Boskirk; M.E. Jackson</td>
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<td>IN14A-07. Interoperable Data Systems for Satellite, Airborne, and Terrestrial LIDAR Data. C.M. Meertens; C. Baru; B. Blair; C.J. Crosby; T.M. Haran; D.J. Harding; M.A. Hofton; S.S. Khalsa; J. McWhirter</td>
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Tuesday, December 14, 2010

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<td>8:00-12:20 PM</td>
<td>G21A-0791. The Integration of TLS and Continuous GPS to Study Landslide Deformation: A Case Study at the El Yunque National Forest, Puerto Rico D.A. Phillips; G. Wang; J. Joyce; F.O. Rivera; G. Galan; C.M. Meertens</td>
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<td>G21A-0795. Introducing Terrestrial Laser Scanning (TLS) to Undergraduate Geology Curricula: Insights from the Indiana University G429 Field Course, Summer 2010 B.J. Douglas; D.A. Phillips; C.M. Meertens; W. Simmons</td>
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<td>G21A-0797. 2010 Strainmeter Network Observations Along the Western Coast of North America E. Van Boskirk; M.H. Gottlieb; W. Johnson; D. Mencin; K.M. Hodgkinson; B. Henderson; W. Gallaher; O. Fox; M.E. Jackson</td>
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<td>G23B-0827. Geodetic Seamless Archive Centers Modernization – Information Technology for Exploiting the Data Explosion F.M. Boler; G. Blewitt; C.W. Kreemer; Y. Bock; C.E. Noll; J. McWhirter; P. Jamason; M.B. Squibb</td>
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<td>G23B-0830. The EarthScope Plate Boundary Observatory (PBO) High-rate Real-time Cascadia network K.E. Austin; A.A. Borsa; K. Feaux; M.E. Jackson; T.B. Williams</td>
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Wednesday, December 15, 2010

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<td>B33A-0388. Measuring Above Ground Biomass and Vegetation Structure in the South Florida Everglades Wetland Ecosystem with X-, C-, and L-band SAR data and Ground-based LiDAR E.A. Feliciano; S. Wdowinski; M. Potts; S. Chin; D.A. Phillips</td>
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<td><strong>G33A-0837. Rapid GNSS and Data Communication System Deployments In Chile and Argentina Following the M8.8 Maule Earthquake</strong> F. Blume; C.M. Meertens; B.A. Brooks; M.G. Bevis; R. Smalley; H. Parra; J. Baez</td>
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<td><strong>G33A-0838. CO- AND POST-SEISMIC SURFACE DEFORMATION PRODUCED BY THE MAULE EARTHQUAKE AS OBSERVED BY A DENSE NETWORK OF CONTINUOUS GPS STATIONS</strong> J. Baez; K. Bataille; A. Tassara; M.G. Bevis; E.C. Kendrick; C. Vigny; B.A. Brooks; R. Smalley; I.M. Ryder; H. Parra; M. Moreno; D. Melnick; S.E. Barrientos; F. Blume</td>
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<td><strong>G34A-01. Earth's Elastic Response to Seasonal Cycles in Surface Loading in Greenland and Antarctica.</strong> E.C. Kendrick; M.G. Bevis; A.K. Brown; F. Madsen; S.A. Khan; M.J. Willis; T. vanDam; R. Forsberg; J.E. Box; T.J. Wilson; D. Caccamise II; S.A. Konfal; B. Johns</td>
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<td><strong>G41A-0797. The Plate Boundary Observatory Borehole Network: Combining Geodetic, Seismic and Environmental Data to Understand Plate Boundary Deformation.</strong> K.M. Hodgkinson; D. Mencin; D.B. Henderson; A.A. Borsa; W. Johnson; M.H. Gottlieb; E. Van Boskirk; W. Gallaher; O. Fox; J. Smith; M.E. Jackson</td>
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<td><strong>P53C-1524. THERMAL FORENSICS OF ZIRCONS FROM THE MESOPROTEROZOIC SUDBURY IMPACT STRUCTURE (ONTARIO, CANADA)</strong> D. Prado; S.J. Mojzsis</td>
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<td><strong>T53B-2127. GPS Measurements of crustal motion associated with the 2010 Mw 7.2 Sierra El Mayor-Cucapah Earthquake, Baja California, Mexico</strong> J.C. Spinler; R.A. Bennett; J.J. Gonzalez-Garcia; C.P. Walls; S. Lawrence</td>
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<td><strong>T53B-2128. UNAVCO Response to the M7.2 El Mayor-Cucapah Earthquake</strong> C.P. Walls; S. Lawrence; A. Bassett; D. Mann; A.A. Borsa; M.E. Jackson; K. Feaux</td>
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Over the last decade, 1-Hz kinematic Global Positioning System (GPS) has been applied as a displacement sensor in earthquake observations and structural health monitoring. Many researchers in both seismology and engineering fields have expressed the desire for higher-rate sampled (10-sample-per-second or even higher) GPS data to acquire high-frequency information. Accuracy is the primary concern in developing high-rate kinematic GPS.

With the major purpose of evaluating the accuracy of high-rate kinematic GPS, we performed several shake table tests on GPS on April 29, 2009. We found that the accuracy of high-rate kinematic GPS is independent of sampling rate of the receivers, while it depends on the movements of the GPS antennas. The errors of kinematic GPS measurements during the periods of strong shaking are systematically larger than those during the static periods. We further find that these large errors are coincident with large accelerations and jerks of the shake table motions. We believe that these errors are correlated to weak performance of the GPS equipment in a very dynamic environment and to high-frequency multipaths induced by rapid and periodic changes of the satellite-reflector-antenna geometry. A GPS unit could temporarily lose tracking on some or all satellites and lead to a gap of observations during strong shaking periods. This happened during the 2008 Wenchuan, China (M8.0) and 2010 Maule, Chile (M 8.8) earthquakes. The results obtained from this study have important implications in developing high-rate GPS seismometers.

URL: http://gps1.uprm.edu

Contact Information: Contact Information
Body: In 2005, the L2C signal was introduced to improve the accuracy, tracking and redundancy of the GPS system for civilian users. The L2C signal also provides improved SNR data when compared with the L2P(Y) legacy signal, comparable to that of the L1 C/A-code, which allows for better tracking at lower elevations. With the recent launch of the first block II-F satellite (SVN62/PRN25), there are 8 healthy satellites broadcasting L2C signals, or 25% of the constellation.

However, GNSS network operators such as the UNAVCO Plate Boundary Observatory (PBO) have been hesitant to use the new signal as it is not well determined how tracking and logging L2C could affect the positions derived from L2 carrier phase measurements for a given receiver. The L2C carrier phase is in quadrature (90° out of phase) with the L2P(Y) phase that has been used by high-precision positioning software since the beginning of GPS. To complicate matters further, some receiver manufacturers (e.g. Trimble) correct for this when logging L2C phase while others (e.g. Topcon) do not. The L2C capability of receivers currently in widespread use in permanent networks can depend on firmware as well as hardware; in some cases receivers can simultaneously track L2C and L2P(Y) phases and some can track only one or the other, and the resulting observation files can depend on how individual operators configure the devices. In cases where both L2C and L2P(Y) are logged simultaneously, translation software (such as UNAVCO’s teqc) must be used carefully in order to select which L2 observation is written to RINEX (2.11) and used in positioning. Modifications were recently made to teqc to eliminate potential confusion in that part of the process; if L2C code observations appear in a RINEX (2.11) file produced by teqc, the L2 phase and S2 SNR observations were from the L2C carrier for those satellites. To date L2C analyses have been restricted to special applications such as snow depth and soil moisture using SNR data (Larson et al, 2010).

We use several different methods to determine the effect that tracking and logging L2C has on carrier phase measurements and positioning for various receiver models and configurations. Our analyses use GAMIT and TRACK to calculate positions and baseline lengths including zero-length baselines, position time series from a subset of 10 PBO stations that have been L2C enabled, phase residual comparisons and direct comparisons of the L2 phase observable. Twenty-four hour zero-length baseline solutions using L2 show sub-millimeter differences in the mean positions for both the horizontal and vertical components. Direct comparisons of the L2 phase observable from RINEX (2.11) files with and without the L2C observable show sub-millicycle differences over a 24 hour mean with variations up to ~±0.06 cycles for satellites that broadcast L2C. Our results show that the magnitude of the variations increased at low elevations. Separate correlation of the L2 and L2C signals may explain this difference. The number of L2 observations increased when the L2C observable was recorded, while the number of cycle slips above 10 degrees in elevation decreased when L2C was recorded. The behavior of the L2P(Y) phase observations or positions from a given receiver was not affected by the enabling of L2C tracking.

Contact Information: Contact Information

Henry Berglund, Boulder, Colorado, USA, 80304, <a href='mailto: henry.berglund@colorado.edu?subject=AGU-FM10: Question regarding G11B-0640'>click here</a> to send an email
Visualization and data sharing of COSMIC radio occultation dataset
Y. Ho; W. J. Weber; J. Chastang; D. Murray; J. McWhirter;
1. Unidata, UCAR, Boulder, CO, United States.
2. ESRL/PSD, NOAA, Boulder, CO, United States.
3. UNAVCO, Boulder, CO, United States.

Body: Visualizing the trajectory and the sounding profile of the COSMIC netCDF dataset, and its evolution through time is developed in Unidata's Integrated data Viewer (IDV). The COSMIC radio occultation data is located in a remote data server called RAMADDA, which is a content management system for earth science data. The combination of these two software packages provides a powerful visualization and analysis tools for sharing real time and archived data for research and education. In this presentation we would like to demonstrate the development and the usage of these two software packages.

Contact Information: Contact Information
Yuan Ho, Boulder, Colorado, USA, 80301, <a href='mailto:yuanho@ucar.edu?subject=AGU-FM10: Question regarding IN11A-1074'>click here</a> to send an email

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The Geodetic Seamless Archive Centers Service Layer: A System Architecture for Federating Geodesy Data Repositories

J. McWhirter;¹ F. M. Boler;¹ Y. Bock;² P. Jamason;² M. B. Squibb;² C. E. Noll;⁴ G. Blewitt;³ C. W. Kreemer;³
1. UNAVCO, Boulder, CO, United States.
2. Institute of Geophysics and Planetary Physics, Scripps Institution of Oceanography, University of California, San Diego, CA, United States.
3. Nevada Geodetic Laboratory, Nevada Bureau of Mines and Geology, University of Nevada, Zurich, Switzerland.

Body: Three geodesy Archive Centers, Scripps Orbit and Permanent Array Center (SOPAC), NASA's Crustal Dynamics Data Information System (CDDIS) and UNAVCO are engaged in a joint effort to define and develop a common Web Service Application Programming Interface (API) for accessing geodetic data holdings. This effort is funded by the NASA ROSES ACCESS Program to modernize the original GPS Seamless Archive Centers (GSAC) technology which was developed in the 1990s. A new web service interface, the GSAC-WS, is being developed to provide uniform and expanded mechanisms through which users can access our data repositories. In total, our respective archives hold tens of millions of files and contain a rich collection of site/station metadata. Though we serve similar user communities, we currently provide a range of different access methods, query services and metadata formats. This leads to a lack of consistency in the user's experience and a duplication of engineering efforts.

The GSAC-WS API and its reference implementation in an underlying Java-based GSAC Service Layer (GSL) supports metadata and data queries into site/station oriented data archives. The general nature of this API makes it applicable to a broad range of data systems. The overall goals of this project include providing consistent and rich query interfaces for end users and client programs, the development of enabling technology to facilitate third party repositories in developing these web service capabilities and to enable the ability to perform data queries across a collection of federated GSAC-WS enabled repositories.

A fundamental challenge faced in this project is to provide a common suite of query services across a heterogeneous collection of data yet enabling each repository to expose their specific metadata holdings. To address this challenge we are developing a "capabilities" based service where a repository can describe its specific query and metadata capabilities. Furthermore, the architecture of the GSL is based on a model-view paradigm that decouples the underlying data model semantics from particular representations of the data model. This will allow for the GSAC-WS enabled repositories to evolve their service offerings to incorporate new metadata definition formats (e.g., ISO-19115, FGDC, JSON, etc.) and new techniques for accessing their holdings. Building on the core GSAC-WS implementations the project is also developing a federated/distributed query service. This service will seamlessly integrate with the GSAC Service Layer and will support data and metadata queries across a collection of federated GSAC repositories.

Contact Information: Contact Information
Jeff McWhirter, Boulder, Colorado, USA, 80301-5554, <a href='mailto: jeff.mcwhirter@gmail.com?subject=AGU-FM10: Question regarding IN11B-1085'>click here</a> to send an email
Gravity Modeling of the Cerro Goden fault zone, NW Puerto Rico

G. A. Mattei; 2 K. M. Keranen; 1 E. Asencio; 2
1. Geology and Geophysics, University of Oklahoma, Norman, OK, United States.
2. Geology, University of Puerto Rico at Mayaguez, Mayaguez, Puerto Rico.

Body: The 2010 M7.0 Haiti earthquake served as a reminder of potential earthquake hazards on upper-crustal fault systems along the northern boundary of the Caribbean plate. In this study we modeled the structure of the Cerro Goden and subparallel fault zones in northwestern Puerto Rico, which cross through densely populated areas, using existing and newly collected gravity data. The fault zone had previously been mapped at the surface, but the details of the fault zone in the subsurface and the detailed structure remain poorly constrained. We used our gravity data to extend surface geologic models to greater depth. Specifically, we modeled and interpreted a north-to-south 2-D model perpendicular to the Cerro Goden fault zone. We used horizontal derivative and residual anomaly maps to emphasize edges of subsurface bodies and shallow structures of interest. Our preliminary 2D model constrains the width and depth extent of serpentinite bodies along the fault zones, the relationship of the faults with the Cerro Goden anticline in central Puerto Rico, and confirms the steep NE dip of the faults extrapolated from surface data. Additional data will be collected in the future across the Cerro Goden fault zone to laterally extend our models of subsurface structural features.

Contact Information
Gabriel A. Mattei, Adjuntas, Puerto Rico, 00601, <a href='mailto:gmatt0711@gmail.com?subject=AGU-FM10: Question regarding U13A-0019'>click here</a> to send an email
Comparison of Deep Drill Braced Monument (DDBM) and Borehole Strainmeter (BSM) Wellhead GPS antenna mounts: a Plate Boundary Observatory (PBO) case study from Dinsmore, CA.

T. B. Williams; 1; K. E. Austin; 1; A. A. Borsa; 1; K. Feaux; 1; M. E. Jackson; 1; W. Johnson; 1; D. Mencin; 1;
1. PBO, UNAVCO, Boulder, CO, United States.

Body: With the 2009 installation of GPS station P793 in Dinsmore, CA, the Plate Boundary Observatory (PBO) created a unique opportunity to directly compare a traditional deep drill braced GPS monument (DDBM) with a borehole strainmeter (BSM) wellhead GPS monument. PBO installed a GPS antenna to the wellhead of BSM B935 to perform a direct comparison to DDBM P327 in an attempt to determine stability and long-term behavior of both. The two adjacent stations share power and communications and are roughly 20 meters apart. The steel BSM casing is cemented ~520ft in meta-sandstone & shale, while the DDBM is anchored ~30ft deep in alluvial river gravels. Both stations are located inside a rural auto wrecking yard, which has potential sources of fixed noise in the form of multipath reflections off large metal objects. Preliminary analysis indicates consistent measurements in the North-South component, and a ~3.3 mm difference in the East-West component that has been detected between the two stations over a 450-day period (~2.7 mm/yr). The analysis utilizes standard PBO data products and differences time series data from each station in the SNARF 1.0 and IGS 2005 reference frames. We estimate the time dependent seasonal variations observed at each station and compare with available temperature and precipitation data to attempt to identify the cause of differential movement between the monuments.

URL: http://pboweb.unavco.org/

Contact Information
Todd B. Williams, Eureka, California, USA, 95503-0000, <a href='mailto: williams@unavco.org?subject=AGU-FM10: Question regarding G13B-04'>click here</a> to send an email
The PBO borehole seismometer network.

O. Fox; 1 W. Johnson; 1 D. Mencin; 1 W. Gallaher; 1 M. H. Gottlieb; 1 K. M. Hodgkinson; 1 C. Pyatt; 1 E. Van Boskirk; 1 M. E. Jackson; 1

1. UNAVCO, Boulder, CO, United States.

Body: During the installation of the Plate Boundary Observatory, UNAVCO installed 79 borehole seismometers from Vancouver Island to Southern California, including Yellowstone. 74 are co-located with borehole strainmeters and five are stand alone installations. The sensors installed are Sonde-2 seismometers. This sensor uses three 2 Hz geophones in a triaxial configuration. Eight sites in the Anza, CA region also have MEMS accelerometers. The data set generated by this network has become an integral component to research being done in regional seismic networks, such as those in Anza, CA and Yellowstone NP. The depth of installation allows for the detection and location of microseisms that can be missed by a surface installation. To improve the data quality of the network UNAVCO is calibrating and orientating the seismometers in the PBO network. Local and regional earthquakes are used in conjunction with a co-located surface seismometer for the orientation process. A birddog is utilized to determine the instrument response for the individual geophones in the seismic package.

URL: pboweb.unavco.org

Contact Information: Contact Information
Wade Johnson, Boulder, Colorado, USA, 80301, <a href='mailto:johnson@unavco.org?subject=AGU-FM10: Question regarding S13C-2031'>click here</a> to send an email
Interoperable Data Systems for Satellite, Airborne, and Terrestrial LiDAR Data

C. M. Meertens; 1; C. Baru; 2; B. Blair; 4; C. J. Crosby; 2; T. M. Haran; 3; D. J. Harding; 4; M. A. Hofton; 5; S. S. Khalsa; 3; J. McWhirter; 1;

1. UNAVCO, Boulder, CO, United States.
2. San Diego Supercomputing Center, University of California, San Diego, San Diego, CA, United States.
3. National Snow and Ice Data Center, University of Colorado, Boulder, CO, United States.
4. Goddard Space Flight Center, Greenbelt, MD, United States.
5. Dept of Geography, University of Maryland College Park, College Park, MD, United States.

Body: LiDAR (Light Detection and Ranging) technology is being widely applied to scientific problems on global to local scales using a range of laser technologies mounted on satellite, low- and high-altitude airborne and terrestrial platforms. Modern laser ranging instruments are increasingly capable of providing full waveform data, multiple detectors, higher sample rates and longer ranges. Accompanying these improvements, however, are rapidly growing data volumes and ever more complex data formats and processing algorithms. This presents significant challenges for existing Earth science data systems serving these data and creates barriers to the efficient use of these data by a growing and diverse community of scientific and other users who are studying deformation of the solid Earth, the cryosphere, vegetation structure, and land form evolution.

To address these challenges, a group of data centers is collaborating under a project funded by the NASA ROSES ACCESS Program to develop interoperable LiDAR data access systems to provide integrated access to data and derived products in common data formats via simple-to-navigate web interfaces. The web service-based systems created by this project, called NLAS, will enhance access to existing laser data sources hosted at the National Snow and Ice Data Center DAAC, Goddard Space Flight Center LVIS Data Center, UNAVCO, and the OpenTopography Facility at the San Diego Supercomputer Center (SDSC). Through the OpenTopography portal, NLAS systems will provide access to satellite laser altimetry data from ICESat and high altitude airborne laser scanning data from LVIS, as well as low altitude airborne LiDAR and terrestrial laser scanning data hosted at OpenTopography and UNAVCO. NLAS will develop new web service interfaces for NASA data archives at GSFC/LVIS and NSIDC in an effort to improve and streamline access to these data archives. The OpenTopography portal will act as a client to the NLAS services and will provide integrated access to the GSFC and NSIDC-hosted datasets along with OpenTopography hosted data. This interoperable system will provide access to LiDAR point data as well as on-demand processing capability for user-specified topographic data products. Web service–based access and integration of these distributed data archives via an easy-to-use web portal will increase usability and enhance exposure for these data.

URL: http://www.opentopography.org/index.php/about/nlas

Contact Information: Contact Information

Charles M. Meertens, Boulder, Colorado, USA, 80301-0000, <a href="mailto: meertens@unavco.org?subject=AGU-FM10: Question regarding IN14A-07">click here</a> to send an email
Identifying sediment sources and quantifying rates of erosion along the North Fork Toutle River near Mount St. Helens, WA

J. Pitlick; 1; C. M. Meertens; 2; J. J. Major; 3; J. Normandeau; 2; K. Spicer; 3;
2. UNAVCO, Boulder, CO, United States.

Body: Traditional methods for measuring surface erosion are labor intensive and subject to large uncertainty due to the spatial variability in topography and stochastic nature of sediment transport processes. High-resolution Terrestrial Laser Scanning (TLS) measurements of surface topography have the potential to shorten the time involved in taking measurements as well as improve the accuracy of the surface change data. In this presentation we describe a pilot project that uses TLS to track erosion and deposition along the North Fork Toutle River (NFTR) near Mount St. Helens, WA. Since the May 1980 eruption of Mount St. Helens, the NFTR has been incising through the deposits of the massive debris avalanche generated at the start of the eruption. These deposits are still largely free of vegetation and present an ideal opportunity to examine erosional processes. In August, 2010, we performed initial surveys of two 0.5-km-long swaths of representative areas of the NFTR valley. Each of the two 250–300-meter diameter survey areas was scanned from multiple positions at cm-level spacing, and the resulting point cloud was georeferenced using co-located GPS. Measurements from this year's campaign will be used to develop a baseline digital elevation model (DEM) to track future changes in side-slope and valley-floor topography. Data from overlapping scans from this initial survey will be used to further evaluate the resolution of surface change measurements. In subsequent campaigns, the same areas will be mapped, and by differencing the scanned surfaces, we hope to identify prominent sediment sources and develop fine-scale quantitative estimates of localized erosion and deposition. In the long term we expect to use these surveys to test hypotheses regarding the relative contributions of sediment eroded from hillslopes versus sediment eroded from the valley floor.

Contact Information: Contact Information
John Pitlick, Boulder, Colorado, USA, 80309-0260, <a href='mailto: pitlick@colorado.edu?subject=AGU-FM10: Question regarding G21A-0789'>click here</a> to send an email
The Integration of TLS and Continuous GPS to Study Landslide Deformation: A Case Study at the El Yunque National Forest, Puerto Rico

G. Wang; 2; D. A. Phillips; 1; J. Joyce; 2; F. O. Rivera; 2; G. Galan; 2; C. M. Meertens; 1;
1. UNAVCO, Boulder, CO, United States.
2. Department of Geology, University of Puerto Rico at Mayaguez, Mayaguez, PR, United States.

Body: Terrestrial Laser Scanning (TLS) and Global Positioning System (GPS) technologies provide comprehensive information of landslide deformation in the both spatial and temporal domains, which are critical to study the dynamics and kinematics of landslides. TLS allows the generation of a precise 3D model of a landslide surface by deriving spatial deformation from consecutive TLS campaigns. Continuous GPS (CGPS) monitoring allows the generation of the displacement time series of single points. Integrated TLS and CGPS datasets were collected at the base of a 500-600 meter long landslide on a steep mountain slope in the El Yunque National Rainforest in Puerto Rico. Major movements of this landslide in 2004 and 2005 caused the closing of one of three remaining access roads to the national forest. A retaining wall was constructed to restrain the landslide and allow the road reopen. Prior to termination of the wall a significant portion of the northwest end of the wall failed. This portion was repaired but prior to final termination in August 2009 significant soil displacements behind the failed section thwarted final grading efforts. Geologic investigation indicated that the landslide extended much further upslope than indicated and involved bedrock as well as overlying residual soils. Striations along flank escarpments indicated displacement of the entire landslide to the northwest but active displacement could only be certified in the lower most portions behind the retaining wall. The northwest portion of the wall continued to show flexural deformation until it finally burst in July 2010. The size and displacement magnitude of the presently moving mass has become a major focus of investigation. To precisely identify the present boundaries and displacement magnitude of the lower portions of the landslide, we performed two TLS campaigns at the landslide site in May and August 2010. A continuous GPS array consisting of 3 stations was also installed at the site, one of which was located outside of the landslide as a stable reference point. Topcon GB-1000 dual frequency receivers and PG-A1 antennas were used to collect the GPS data. GPS data were processed using Topcon software. A Riegl VZ-400 laser scanner, provided by UNAVCO, was used to collect the TLS data. This scanner provides high resolution, high-speed data acquisition using a narrow infrared laser beam and a fast scanning mechanism. Centimeter-level scans from 12 scan positions were performed during each TLS campaign. TLS data acquisition and global registration were performed using RIEGL RiSCAN-PRO software. The Generic Mapping Tools (GMT, http://gmt.soest.hawaii.edu), a software package widely utilized in the geophysical community, was used for data post processing and map plotting. Our TLS and GPS results have clearly identified the boundaries, the rate and direction of displacement, and the volume change of the lower portions of presently sliding mass. Rainfall data from a local USGS weather station were also integrated to this study. Our results indicate close correlation between landslide movements and rainfall.

Contact Information: Contact Information

David A. Phillips, Boulder, Colorado, USA, 80301-0000, <a href='mailto: phillips@unavco.org?subject=AGU-FM10: Question regarding G21A-0791'>click here</a> to send an email
Introducing Terrestrial Laser Scanning (TLS) to Undergraduate Geology Curricula: Insights from the Indiana University
G429 Field Course, Summer 2010

B. J. Douglas; 1; D. A. Phillips; 2; C. M. Meertens; 2; W. Simmons; 1;
1. Geological Sciences, Indiana University, Bloomington, IN, United States.
2. UNAVCO, Boulder, CO, United States.

Body: Bruce J. Douglas, Dept. of Geological Sciences, Indiana University, 1001 East 10th Street
Bloomington, IN 47405, douglasb@indiana.edu

David A. Phillips, UNAVCO, 6350 Nautilus Drive, Boulder, CO 80301, phillips@unavco.org

Charles M. Meertens, UNAVCO, meertens@unavco.org

William H. Simmons, Dept. of Geological Sciences, Indiana University, 1001 East 10th Street, Bloomington, IN 47405

During the summer of 2010, a pilot version of a week-long module designed to apply Terrestrial Laser Scanning (TLS) to various problems encountered while conducting field geology applications was embedded within the Indiana University G429 field course. The format followed that of a successful module developed to concentrate on surface and groundwater hydrology known as G429e. The TLS module was implemented with the aid of UNAVCO, which provided both equipment and professional staff to complement the faculty and staff working in G429. The students who participated in the program were all volunteers aware of the experimental nature of the module. The students' backgrounds varied from those with extensive field instrumentation and surveying experience to those with only the prior field experience provided by the first three weeks of the G429 field course. The targets selected for the TLS work were directly related to scientific questions that arose from projects previously completed by the students. This was critical in that the motivation for the work was scientifically driven and not strictly an exercise in instrument use. The activities for the week built from an initial survey in a small highly constrained location to a final project where the students had to design a plan and deploy all of the instruments, collect the various data types, and analyze the data based on a simple set of criteria, to produce a TLS data set that would allow others to explore the Judson Mead Geologic Field Station. The other problems selected included determining the magnitude and type of normal fault displacement recorded in Quaternary sediment, the potential for using a large bedrock fault scarp to determine displacement intervals, and the geometry of the sedimentary architecture of a shoaling carbonate bank. In addition to the data analysis, the students produced a series of field/instrument set up flow charts. Analysis of the variations in these was not always directly correlated to the students' prior experience with field instrumentation and provided insights into what are critical aspects of teaching students how to employ TLS to solve scientific problems. The project also made it clear how important a set of data recording sheets that provide systematic and guided mechanisms for allowing all of the participants involved in all of the decision making steps necessary to successful TLS data acquisition. Examples included such parameters as spot spacing, scan rates, beam divergence and scan geometries. This presentation includes an overview of the curriculum implemented, examples of data collections and analyses produced by the students, discussion of challenges faced, and thoughts on future work.

Contact Information: Contact Information

Bruce J. Douglas, Bloomington, Indiana, USA, 47405-0000, <a href='mailto: douglasb@indiana.edu?subject=AGU-FM10: Question regarding G21A-0795'>click here</a> to send an email
Body: The PBO borehole strainmeter (BSM) network contains 75 sites along the Western Coast of the United States of America and Southern Canada. Each site contains a Gladwin tensor strainmeter, Malin borehole geophone, and in some cases GPS, pore pressure and/or tilt meter. The strainmeters and geophones are at depths between 400 to 800 feet, which is free of most surface noise. There are four additional geophone only sites in Humboldt County, California at depths of 400 feet. All sites in Anza, California also have borehole accelerometers.

Over the course of 2010 the PBO BSM network has observed several tectonic events throughout the network. Along the Juan de Fuca plate episodic tremor and slip (ETS) events have been observed in late March and late August. The January 9, 2010 magnitude 6.5 and the February 4, 2010 magnitude 5.9 earthquakes offshore on the Gorda plate, near the Mendocino Triple Junction, are clearly recorded by the Humboldt CA array. In Parkfield, California, along the San Andreas fault creep events are observed in the southern portion of the BSM network on August 20, 2010. On July 9, 2010 there was a magnitude 5.4 very near the Anza regional network, near the Coyote Creek segment of the San Jacinto fault. These regional strainmeter observations will be presented as well as the ongoing research highlights produced from these instruments.

Large magnitude events, such as the February 27, 2010 Chile magnitude 8.8 earthquake, are observed across the entire BSM network. Smaller events, including the slow slip motions of ETS in the Northwest and creep events in Parkfield, are captured by focused regional arrays in these locations. Geophysical monitoring at depth over a large network of strainmeters provides a window to observe the variety of tectonic observations that accommodate plate boundary deformation.

Contact Information: Contact Information

Elizabeth Van Boskirk, Portland, Oregon, USA, 97202, <a href='mailto: liz.vanboskirk@gmail.com?subject=AGU-FM10: Question regarding G21A-0797'>click here</a> to send an email

J. G. Ryan; 1; S. C. Eriksson; 2;
1. Geology, University of South Florida, Tampa, FL, United States.
2. UNAVCO, Boulder, CO, United States.

Body: Inspired by the recommendations of the NSF report “Fostering Learning in the Networked World: The Cyberlearning Opportunity and Challenge” (NSF08204), the NSF National STEM Digital Learning program funded “Planning for the Future of Geocybereducation” Workshop sought to bring together leaders from the geoscience education community, from major geoscience research initiatives, and from the growing public- and private-sector geoscience information community. The objectives of the workshop were to begin conversations aimed at identifying best practices and tools for geoscience cyber-education, in the context of both the changing nature of learners and of rapidly evolving geo-information platforms, and to provide guidance to the NSF as to necessary future directions and needs for funding.

65 participants met and interacted live for the two-day workshop, with ongoing post-meeting virtual interactions via a collaborative workspace (www.geocybered.ning.com). Topics addressed included the rapidly changing character of learners, the growing capabilities of geoscience information systems and their affiliated tools, and effective models for collaboration among educators, researchers and geoinformation specialists. Discussions at the meeting focused on the implications of changing learners on the educational process, the challenges for teachers and administrators in keeping pace, and on the challenges of communication among these divergent professional communities. Ongoing virtual discussions and collaborations have produced a draft workshop document, and the workshop conveners are maintaining the workshop site as a venue for ongoing discussion and interaction.

Several key challenges were evident from the workshop discussions and subsequent interactions: a) the development of most of the large geoinformatics and geoscience research efforts were not pursued with education as a significant objective, resulting in limited financial support for such activities after the fact; b) the “playing field” of cybertechnologies relevant to geoscience education, research and informatics changes so rapidly that even committed “players” find that staying current is challenging; c) the scholarly languages of geoscience education, geoscience research, and geoinformatics are different, making easy communication about respective needs and constraints surprisingly difficult; and d) the impact of “everyday” cybertechnologies on learner audiences is profound and (so far) not well addressed by educators. Discussions on these issues are ongoing in a number of other venues.

URL: www.geocybered.ning.com

Contact Information: Contact Information
Jeffrey G. Ryan, Tampa, Florida, USA, 33620-5201, <a href='mailto: ryan@shell.cas.usf.edu?subject=AGU-FM10: Question regarding ED23B-0722'>click here</a> to send an email
Body: Space geodetic science and other disciplines using geodetic products have benefited immensely from open sharing of data and metadata from global and regional archives. Ten years ago, Scripps Orbit and Permanent Array Center (SOPAC), the NASA Crustal Dynamics Data Information System (CDDIS), UNAVCO and other archives collaborated to create the GPS Seamless Archive Centers (GSAC) in an effort to further enable research with the expanding collections of GPS data then becoming available. The GSAC partners share metadata to facilitate data discovery and mining across participating archives and distribution of data to users. This effort was pioneering, but was built on technology that has now been rendered obsolete. As the number of geodetic observing technologies has expanded, the variety of data and data products has grown dramatically, exposing limitations in data product sharing.

Through a NASA ROSES project, the three archives (CDDIS, SOPAC and UNAVCO) have been funded to expand the original GSAC capability for multiple geodetic observation types and to simultaneously modernize the underlying technology by implementing web services. The University of Nevada, Reno (UNR) will test the web services implementation by incorporating them into their daily GNSS data processing scheme. The effort will include new methods for quality control of current and legacy data that will be a product of the analysis/testing phase performed by UNR. The quality analysis by UNR will include a report of the stability of the stations coordinates over time that will enable data users to select sites suitable for their application, for example identifying stations with large seasonal effects. This effort will contribute to enhanced ability for very large networks to obtain complete data sets for processing.

URL: http://facility.unavco.org/data/gsacws/index.html

Contact Information: Contact Information
Frances M. Boler, Boulder, Colorado, USA, 80301-5554, <a href='mailto:boler@unavco.org?subject=AGU-FM10: Question regarding G23B-0827'>click here</a> to send an email
Body: As part of the 2009 American Recovery and Reinvestment Act (ARRA), NSF is investing in onshore-offshore instrumentaion to support studies of the Cascadia margin. EarthScope's Plate Boundary Observatory (PBO) is upgrading 232 of its GPS stations in the Pacific Northwest to high-rate sampling and real-time telemetry and providing streaming data from this network to the public for scientific research, education, and hazard monitoring. This effort expands UNAVCO's real-time GPS operations beyond its original pilot project of 100 stations to include a comprehensive regional network that spans the states of Washington and Oregon, and extends south into California to the Mendocino triple junction. By blanketing the Pacific Northwest with real-time GPS coverage, the NSF is hoping to create a natural laboratory in an area of great scientific interest and high geophysical hazard in order to spur new volcano and earthquake research opportunities. Streaming high-rate data in real-time will enable researchers to routinely analyze for strong ground motion monitoring and earthquake hazards mitigation. At stations with collocated meteorological instruments, met data is being streamed as well, opening the possibility for combined GPS/met processing in real time by the atmospheric community. Funding for field upgrades provide for the installation of 3G capable modems or high speed data radios, as well as for updating the power at each location. Finally, the new funding also expands opportunities for research using high-rate GPS data from a large-aperture network, since 1 Hz streams will be permanently archived and freely available via FTP. PBO deployed new data distribution software in June 2010, to which stations being added soon after field upgrades have been completed. PBO is currently providing 1Hz-streaming data in BINEX, RTCM2.3 and RTCM 3.0 formats via the NTrip protocol, from servers located at UNAVCO headquarters in Boulder, CO. Data latency varies according to the telemetry deployed at each station, but typically ranges from 0.5~2.0 seconds given recent improvements in PBO's real-time streaming capabilities and advances in the communications infrastructure.

URL: http://pboweb.unavco.org

Contact Information: Contact Information

Kenneth E. Austin, Ellensburg, Washington, USA, 98926-7418, <a href="mailto: austin@unavco.org?subject=AGU-FM10: Question regarding G23B-0830">click here</a> to send an email
Body: The number of Ph.D.s from underrepresented populations graduating each year in the geosciences lags behind all other sciences including physics. This results in a dearth of minorities acting as role models in higher education. Overall, African Americans, Native Americans, and Hispanics comprised a total of 6% of the Ph.D. graduates in 2005 compared to about 27% of the general population. African Americans were the most poorly represented relative to their proportion in the U.S. population, comprising only 1% of Ph.D.s in the geosciences compared to 12% of the population. Only one African American woman Ph.D. graduated in the geosciences in the U.S. in each of 2004 and 2005, while proportionally one would expect 28 to obtain a Ph.D. each year. Our multiyear internship program, RESESS helps to carry students from underrepresented minority populations through to graduate programs by preparing them for graduate school. Our interns experience an authentic summer research experience at a university, the USGS, or UNAVCO, while doing an intensive writing course and working closely with a science and writing mentor. We continue mentoring during the academic year, as students apply for graduate school and scholarships, and present their research results at professional conferences. RESESS focuses on the Earth sciences and partners with SOARS, which focuses on atmospheric and related sciences. Our future goals include developing more RESESS pods elsewhere in the country, making it possible for students to do community-driven research, and increasing the diversity of support for the program through new and stronger partnerships with organizations such as the U.S.G.S., the National Parks Service, and other universities. In this paper, we will present current statistics on diversity in higher education in the geoscience, details of our program, and conclusions about effective means of supporting minority students in the bridge to graduate school. When the numbers are this low, every student counts.

URL: reess.unavco.org

Contact Information: Contact Information
Valerie Sloan, Boulder, Colorado, USA, 80301-5554, <a href="mailto: sloan@unavco.org?subject=AGU-FM10: Question regarding ED31B-0628">click here</a> to send an email

Diana Prado Garzon at work in summer of 2010.
Improving Slab 1.0 Subduction Zone Models Using Regional Constraints from the Eastern Pacific

F. A. Martinez-Torres; 1, 2; G. P. Hayes; 3

1. Geology, University of Puerto Rico at Mayaguez, Mayaguez, PR, United States.
2. RESESS, UNAVCO, Boulder, CO, United States.
3. NEIC, USGS, Golden, CO, United States.

Body: Knowledge of the geometry of subduction zones is essential for understanding the rupture processes of great (magnitude >8) earthquakes and is a key constraint for many others calculations, including the inference of subduction zone mechanics, interpretations of seismic structure and some types of geodynamic modeling. Estimates of plate geometry are usually made based on seismicity; the hypocenters of subduction zone earthquakes provide our best estimates of the location of the slab, so is important to obtain well-resolved hypocentral locations.

In this study we work with Slab 1.0, a global three-dimensional model of subduction zone geometries. These models are compiled primarily using teleseismic data, which can be less accurate than regional data because they use global observations, rather than local and regional seismic networks. In this study, we compare Slab 1.0 models with contours of subduction zone geometry compiled from regional studies, digitized from Geoscience literature. After digitization these regional studies can be quantitatively compared to Slab 1.0 models covering the same region, generating difference maps of their vertical offset. We also analyze the methodology and data sets used by each study to verify the accuracy of the regional models. By quantifying the differences between models and by assessing the reasons for those differences we can identify areas where Slab 1.0 can be improved.

Contact Information: Contact Information

Subduction zone interface models in South America. Panels (A) and (B) show modeled depth to the subducting interface from (A) Slab 1.0, a new global subduction zone model, and (B) Bevis & Isacks (1984), a model built from regional data. (C) shows the vertical difference between (A) and (B). All panels are contoured at 20 km intervals.
A Comparison of Regional 3-D Subduction Models in the Western Pacific to Subduction Models from Slab1.0

A. Lopez; 1, 2; G. P. Hayes; 2;
1. University of Texas at El Paso, El Paso, TX, United States.
2. USGS, Golden, CO, United States.

Body: Globally, the largest earthquakes occur in subduction zones, regions where one tectonic plate slides beneath another. To assess which subduction zones may be most susceptible to future, great, earthquakes, it is critical to accurately understand the rupture process of past seismic events – to do this, we must characterize the details of the geometry of the rupture plane. For this purpose we use Slab1.0, a three-dimensional model of global subduction zone geometries created using teleseismic data, and regional data when available. Here we assess the accuracy of Slab1.0, by comparing a selection of these models to models derived from previous regional studies. By digitizing models of subduction zone geometries collected from the geoscience literature and quantitatively comparing these models to Slab1.0, we identify discrepancies in slab interface depth. Plausible reasons for such discrepancies include differences in data coverage and bias in the location of the earthquake epicenters within regional and teleseismic catalogs. We show comparisons between subduction zone models in Japan, Sumatra and the Tonga trench, all well-defined in Slab1.0. In Japan, where we have collected several regional models, we find that the Slab1.0 models are consistently shallower than their regional counterparts in the shallow sections of the subduction zone. We explore whether these discrepancies are due to well-known biases in teleseismic earthquake locations within subduction zones, and/or whether the regional data are biased because of poor azimuthal coverage in recordings of offshore events.

Contact Information: Contact Information
Andrew Lopez, El Paso, Texas, USA, 79936-0000, <a href='mailto:aplopez6@miners.utep.edu?subject=AGU-FM10: Question regarding DI31A-1957'>click here</a> to send an email
Measuring Above Ground Biomass and Vegetation Structure in the South Florida Everglades Wetland Ecosystem with X-, C-, and L-band SAR data and Ground-based LiDAR

E. A. Feliciano; S. Wdowinski; M. Potts; S. Chin; D. A. Phillips;
1. University of Miami - RSMAS, Miami, FL, United States.
2. University of California, Berkeley, Berkeley, CA, United States.
3. UNAVCO, Boulder, CO, United States.

Body: Worldwide, anthropogenic activities are disturbing and disrupting nutrient rich bio-diverse wetland ecosystems. Disturbance of the South Florida Everglades has been particularly acute, but difficult to quantify given its limited accessibility. Successful ecosystem monitoring requires the use of remote sensing. We used space-based Synthetic Aperture Radar (SAR) observations to estimate vegetation structure and above-ground biomass and track their changes over time. Our study leveraged three different SAR wavelengths that interact with different aspects of the vegetation. The short wavelength X-band (3.2 cm) signal interacts mainly with canopies; the intermediate wavelength C-band (5.6 cm) signal interacts with both canopies and branches; and the long wavelength L-band (24 cm) signal interacts with both the surface and lower portion of the vegetation. We used dual- and quadruple-polarization observations acquired from the TerraSAR-X, RadarSAT-2, and ALOS satellites. Different polarization data reflect radar signal interaction with different sections of the vegetation due to different scattering mechanisms.

In order to calibrate the multi-wavelength and multi-polarization SAR observations, we conducted field measurement in three vegetation communities: hammock, pine and cypress. Our ground measurements included both traditional forestry surveys and state-of-the-art Terrestrial Laser Scanning (TLS), a.k.a. ground based LiDAR surveys. A week long TLS survey was conducted in the Everglades National Park in the three calibrations sites using a Leica ScanStation C10 TLS instrument which utilizes a narrow, green (532 nm) laser beam. During this week we collected a total of 29 scans (33 GB of data). The TLS surveys provided centimeter resolution 3-D point clouds of the ground surface and below-canopy vegetation. Initial analysis of the data has provided detailed 3-D estimates of the vegetation structure and above ground biomass. A comparative analysis of the ability of the three bands of SAR to quantify above ground biomass in the different communities is presented. We also determine the essential bands needed to most efficiently estimate biomass. We find that the performance of SAR differs by community types. More rigorous data processing will provide important quantitative measures that will allow careful calibration of the remote sensing SAR data.

Contact Information: Contact Information
Emanuelle A. Feliciano, Coral Gables, Florida, USA, 33134, <a href='mailto:emanuelle_f@hotmail.com?subject=AGU-FM10: Question regarding B33A-0388'>click here</a> to send an email
Body: Because the signal is so big, great earthquakes allow us to make quantum leaps in our understanding of Earth deformation process and material properties. The Maule earthquake, with its occurrence near a large subaerial landmass and the large numbers of instruments available to study it, will surely become one of the most important geophysical events in modern memory. Much of the important signal, however, decays and changes rapidly in the short-term following the event and so a rapid response is necessary. Actually delivering the data from the CGPS response stations, however, represents an intellectual challenge in terms of properly matching the engineering realities with the scientific desiderata.

We expect multiple major science advances to come from these data:

(1) Understanding earthquake and tsunami-genesis via use of the coseismic displacement field to create the most well-constrained fault slip and tsunami-genesis models. (2) The role of stress loading on both the principal thrust plane and subsidiary planes. (3) The relationship between fault afterslip to the main event as well as to the distribution of aftershocks (4) Study of large aftershocks jointly using conventional seismology and high-rate GPS coseismic displacement seismogram. (5) Rheological behavior of the fault interface. (6) The mechanical response of the bulk earth to large stress perturbations.

Within 10 days of the earthquake 20 complete GPS systems were delivered by UNAVCO personnel to IGM and OSU staff in Santiago, and 5 were shipped via diplomatic pouch to Argentina. Consisting of of 10 Trimble NetRS and 15 Topcon GB-1000 receivers, the units were deployed throughout the affected area during the following three weeks, using welded-in-place steel tripod monuments driven into soil or drilled into bedrock, or steel masts. Additional GPS hardware was procured from cooperating institutions and donated by GPS manufacturers, and a total of 43 post-earthquake GPS stations are continuously operating in the epicentral area.

UNAVCO has developed and deployed standalone data communications systems at 25 of the stations: (1) the satellite-based Inmarsat Broad Global Area Service (BGAN), (2) ground based cellular internet services provided by a number of telecom companies in Chile and Argentina. Cellular service is economical but prone to disruptions following earthquakes and coverage is limited. BGAN is expensive but robust and globally available. This communication plan has allowed for daily downloads of 15 sec. data and of 1 sec. data recorded during aftershocks of M6.5 and greater. RINEX files from these stations are publicly available at the UNAVCO Facility Archive immediately after data are downloaded, a first for Event Response GPS data.

This effort will serve as the type example in the geodetic community for rapid CGPS data communications following a
destructive earthquake. The communications system hardware purchased during this response will become part of the UNAVCO pool after one year and will be available for future PI projects and event responses.

**Contact Information:**
Frederick Blume, Boulder, Colorado, USA, 80301-5554, <a href='mailto: blume@unavco.org?subject=AGU-FM10: Question regarding G33A-0837'>click here</a> to send an email
Body: The amount of continuous GPS (cGPS) stations deployed in southern South America (0°-54°S) was largely increased over the decade before the 27 February 2010 Maule earthquake to reach a total of 25 stations. 43 new cGPS have been installed after such event, near and around the ruptured area. This is by far the best geodetically-observed megathrust earthquake, and data from this large cGPS network provides unprecedented information related to the pre-, co-, and post-seismic deformation of the Earth's surface. We process simultaneously all these data using Bernese GPS Software, including a large number of stations from the International GNSS Service (IGS), especially those included in the global polyhedron weekly combinations of IGS, what is used here to perform the daily datum definitions. All observations are reduced to antenna phase center and precise orbit and EOP from IGS are used during the processes. We estimate daily solutions and prepare time series to derive GPS vectors that sheds light about surface movements associated with the co-, and post-seismic phases related to this massive event, particularly those recorded by the large network installed after the earthquake. Preliminary models of deformation within the crust, consistent with observations will be presented.

Contact Information: Contact Information
Juan Carlos Baez, Los Angeles, Chile, 4451032, <a href='mailto: jbaez@udec.cl?subject=AGU-FM10: Question regarding G33A-0838'>click here</a> to send an email
Earth’s Elastic Response to Seasonal Cycles in Surface Loading in Greenland and Antarctica.

M. G. Bevis; 1; E. C. Kendrick; 1; A. K. Brown; 1; F. Madsen; 2; S. A. Khan; 2; M. J. Willis; 3; T. vanDam; 6; R. Forsberg; 2; J. E. Box; 4; T. J. Wilson; 1; D. Caccamise II; 1; S. A. Konfal; 1; B. Johns; 5;
1. School of Earth Sciences, Ohio State University, Columbus, OH, United States.
2. Danish National Space Center, Copenhagen, Denmark.
3. Earth and Atmospheric Sciences, Cornell University, Ithaca, NY, United States.
4. Byrd Polar Research Center, Ohio State University, Columbus, OH, United States.
5. UNAVCO, Boulder, CO, United States.
6. University of Luxembourg, Luxembourg, Luxembourg.

Body: Newly installed polar geodetic networks such as the Greenland GPS Network (GNET) and the Antarctic GPS Network (ANET) provide a means to determine the movement of the Earth’s crust in response to past and present changes in ice mass.

It is possible to distinguish between bedrock motions driven by glacial isostatic adjustment (GIA) - the response of the crust and mantle to past changes in ice mass, and those caused by the contemporary steady or time-linear component of the Earth's instantaneous elastic response to present day changes in ice mass, by focusing on accelerations in secular rebound rates, which can only be due to accelerating trends in modern ice mass change.

Seasonal cycles in crustal motion, which manifest Earth’s purely elastic response to cycles in surface loads, are completely distinguishable from GIA. However, we shall show that in many cases the seasonal displacement cycles recorded by GPS stations in Greenland and Antarctica manifest Earth’s elastic response to seasonal variations in atmospheric pressure as well as seasonal cycles in ice mass. Fortunately the atmospheric pressure cycles can be modeled quite well using data from existing meteorology stations, allowing the ice mass signal to be isolated – especially in the case of Greenland. In most situations when the pressure signal is removed, the seasonal elastic signal can be accounted for by seasonal variations in ice surface mass balance. Where this is not the case, it seems likely that variations in local ice dynamics that cause changes in local loads will be manifest.

In addition to the investigation of the interplay between the cryosphere and the solid Earth the new polar geodetic networks are used for water vapor meteorology studies, analysis of ionospheric
phenomena and space weather, and enhanced navigational support for
airborne LIDAR surveys.

**Contact Information**
Eric C. Kendrick, Columbus, Ohio, USA, 43210-1308, <a href='mailto:kendrick.42@osu.edu?subject=AGU-FM10: Question regarding G34A-01'>click here</a> to send an email
Discovering and measuring a layered Earth: A foundational laboratory for developing students' understanding of Earth's interior structure

M. Hubenthal; 1; L. W. Braile; 2; S. E. Olds; 3; J. Taber; 1;
1. IRIS Consortium, Washington, DC, United States.
2. Department of Earth & Atmospheric Sciences, Purdue University, West Lafayette, IN, United States.
3. UNAVCO, Boulder, CO, United States.

Body: Geophysics research is continuously revealing new insights about Earth's interior structure. Before students can grasp these new complexities, they first must internalize the 1st order layered structure of Earth and comprehend how seismology contributes to the development of such models. Earth structure is of course covered in most introductory geoscience courses, though all too often instruction of this content is limited to didactic methods that make little effort to inspire or engage the minds of students. In the process, students are expected to blindly accept our understanding of the unseen and abstract. Thus, it is not surprising then that many students can draw a layered Earth diagram, yet not know that knowledge of Earth's interior is based on information from earthquakes. Cognitive learning theory would suggest that what has been missing from instruction of Earth structure is a feasible method to present students with seismic evidence in a manner that allows students to become minds-on with the content; discovering or dispelling the presence of a layered Earth for themselves.

Recent advances in serving seismic data to a non-seismologist audience have made the development of such laboratory investigations possible. In this exercise students use an inquiry approach to examine seismic evidence and determine that the Earth cannot have a homogeneous composition. Further they use the data to estimate the dimensions of Earth's outer core. To reach these conclusions, students are divided into two teams, theoreticians and seismologists, to test the simplest hypothesis for Earth's internal structure; a homogeneous Earth. The theoreticians create a scale model of a homogeneous Earth and predict when seismic waves should arrive at various points on the model. Simultaneously, seismologists interpret a seismic record section from a recent earthquake noting when seismic waves arrive at various points around Earth. The two groups of students then compare the modeled arrivals to the observed data, and when plotted, a notable discrepancy is found. To help interpret the implications of this anomaly the students transfer the data to a second scale model. By extrapolating their data for additional earthquakes students are able to define and measure a boundary for Earth's outer core. After completing this exercise, not only do students have an understanding of how we know about the structure of Earth, students are more prepared to understand the basics of seismic tomography and the interpretation and limitations of tomographic models.

URL: http://www.iris.edu/hq/resource/determining_internal_structure

Contact Information: Contact Information
Michael Hubenthal, Washington, District of Columbia, USA, 20005-0000, <a href='mailto:hubenth@iris.edu?subject=AGU-FM10: Question regarding ED41B-0635'>click here</a> to send an email
Jules Verne Voyager, Jr: An Interactive Map Tool for Teaching Plate Tectonics

M. W. Hamburger; 1; C. M. Meertens; 2;
1. Dept of Geological Sciences, Indiana University , Bloomington, IN, United States.
2. UNAVCO, Inc., Boulder, CO, United States.

Body: We present an interactive, web-based map utility that can make new geological and geophysical results accessible to a large number and variety of users. The tool provides a user-friendly interface that allows users to access a variety of maps, satellite images, and geophysical data at a range of spatial scales. The map tool, dubbed 'Jules Verne Voyager, Jr.', allows users to interactively create maps of a variety of study areas around the world. The utility was developed in collaboration with the UNAVCO Consortium for study of global-scale tectonic processes. Users can choose from a variety of base maps (including "Face of the Earth" and "Earth at Night" satellite imagery mosaics, global topography, geoid, sea-floor age, strain rate and seismic hazard maps, and others), add a number of geographic and geophysical overlays (coastlines, political boundaries, rivers and lakes, earthquake and volcano locations, stress axes, etc.), and then superimpose both observed and model velocity vectors representing a compilation of 2933 GPS geodetic measurements from around the world. A remarkable characteristic of the geodetic compilation is that users can select from some 21 plates' frames of reference, allowing a visual representation of both 'absolute' plate motion (in a no-net rotation reference frame) and relative motion along all of the world's plate boundaries. The tool allows users to zoom among at least three map scales. The map tool can be viewed at http://jules.unavco.org/VoyagerJr/Earth. A more detailed version of the map utility, developed in conjunction with the EarthScope initiative, focuses on North America geodynamics, and provides more detailed geophysical and geographic information for the United States, Canada, and Mexico. The 'EarthScope Voyager' can be accessed at http://jules.unavco.org/VoyagerJr/EarthScope.

Because the system uses pre-constructed gif images and overlays, the system can rapidly create and display maps to a large number of users simultaneously and does not require any special software installation on users' systems. In addition, a javascript-based educational interface, dubbed "Exploring our Dynamic Planet", incorporates the map tool, explanatory material, background scientific material, and curricular activities that encourage users to explore Earth processes using the Jules Verne Voyager, Jr. tool. Exploring our Dynamic Planet can be viewed at http://www.dpc.ucar.edu/VoyagerJr/.

Because of its flexibility, the map utilities can be used for hands-on exercises exploring plate interaction in a range of academic settings, from high school science classes to entry-level undergraduate to graduate-level tectonics courses.

URL: http://jules.unavco.org/VoyagerJr/Earth

Contact Information: Contact Information
Michael W. Hamburger, Bloomington, Indiana, USA, 47405-1405, <a href='mailto:hamburg@indiana.edu?subject=AGU-FM10: Question regarding ED41B-0640'>click here</a> to send an email
Discovering plate boundaries: Laboratory and classroom exercises using geodetic data to develop students’ understanding of plate motion

S. E. Olds; 1

1. Education and Outreach, UNAVCO, Boulder, CO, United States.

Body: To introduce the concept of plate boundaries, typical introductory geology exercises include students observing and plotting the location of earthquakes and volcanoes on a map to visually demarcate plate boundaries. Accompanying these exercises, students are often exposed to animations depicting the movement of Earth’s tectonic plates over time. Both of these teaching techniques are very useful for describing where the tectonics plates have been in the past, their shapes, and where the plates are now. With the integration of data from current geodetic techniques such as GPS, InSAR, LiDAR, students can learn that not only have the tectonic plates moved in the past, but they are moving, deforming, and changing shape right now. Additionally, GPS data can be visualized using time scales of days to weeks and on the scale of millimeters to centimeters per year. The familiar temporal and spatial scales of GPS data also help students understand that plate tectonics is a process that is happening in the present and can ease the transition to thinking about processes that are typically described using deep time, a very difficult concept for students to grasp.

To provide a more robust learning environment, UNAVCO has been incorporating high-precision GPS data into free, place-based, data-rich learning modules for educators and students in introductory Earth science courses at secondary and undergraduate levels. These modules integrate new scientific discoveries related to crustal deformation and explore applications of GPS, LiDAR, and InSAR techniques to research. They also provide students with case studies highlighting the process of scientific discovery, providing context and meaning. Concurrent to these efforts, tools to visualize the inter-relationships of geophysical and geologic processes, structures, and measurements including high-precision GPS velocity data are an essential part of the learning materials. Among the suite of visualization tools that UNAVCO has made available, the Jules Verne Voyager (JVV) interactive map tools are available online and are very well received by educators in introductory Earth science courses. In response to requests for easily accessible and usable data, UNAVCO built the Data for Educators webpage, incorporating an embedded Google Map with GPS locations and providing current GPS time series plots and downloadable data from the Plate Boundary Observatory. To extend and update the datasets available to our community, UNAVCO has developed a GPS velocity viewer using Google Maps technology and provides a learning- focused KMZ combining geophysical data sets for Google-Earth.

By combining near real-time geodetic data with modern visualization tools into inquiry-based learning resources, students are deepening their understanding about the active nature of plate margins and gain a solid foundation for learning future concepts.

UNAVCO is a non-profit, membership-governed consortium funded by the National Science Foundation and NASA. URL: www.unavco.org

Contact Information: Contact Information
Shelley E. Olds, Nederland, Colorado, USA, 80466-0000, <a href='mailto: olds@unavco.org?subject=AGU-FM10: Question regarding ED41B-0641'>click here</a> to send an email
The Plate Boundary Observatory Borehole Network: Combining Geodetic, Seismic and Environmental Data to Understand Plate Boundary Deformation.

K. M. Hodgkinson; D. Mencin; D. B. Henderson; A. A. Borsa; W. Johnson; M. H. Gottlieb; E. Van Borkirk; W. Gallaher; O. Fox; J. Smith; M. E. Jackson.

1. PBO, UNAVCO, Boulder, CO, United States.
2. PBO, UNAVCO, Socorro, NM, United States.

The Plate Boundary Observatory (PBO), the geodetic component of the NSF-funded Earthscope program, is designed to capture the continuous three-dimensional deformation field across the western US plate boundary. Installed and maintained by UNAVCO, the observatory currently consists of over 1100 continuously operating GPS stations and 79 borehole installations. PBO boreholes are multi-instrumented sites containing a combination of strainmeters, seismometers, pore pressure sensors, tiltmeters, barometric pressure sensors, and rainfall and temperature sensors. Measurements include 100-sps seismic data, 20-sps strain, 1-sps pore, barometric and tilt data plus low frequency rainfall and temperature measurements. The sites are built in targeted arrays with spacing between boreholes ranging from a few hundred meters to several kilometers. Combining the different geophysical measurements over this range of sample rates and instrument spacing improves both the temporal and spatial resolution of tectonic signals, creating a rich data set that can yield better understanding of the tectonic processes involved in plate boundary deformation. In this presentation we will highlight some of the unique signals recorded by the borehole network in the past 12 months, including the evolution of strain transients associated with the summer 2010 Cascadia Episodic Tremor and Slip event, recordings of tsunamis-generated strain signals as they arrived along the North American coastline and aseismic slip events along the creeping section of the San Andreas in Parkfield. Between 50 and 60 separate channels of data are collected from most of the PBO boreholes. The majority of the data are made available to the scientific community within one to two hours of download, the exception being the seismic data, which are available in near-real time. Providing the scientific community with an easily-accessible, rapidly available data set plus all the associated metadata presents challenges of its own. We will outline how PBO monitors data quality for several data streams and data products available to the scientific community via the PBO web page (http://pboweb.unavco.org/), the Northern California Earthquake Data Center and the IRIS DMC.

Contact Information: Contact Information

Kathleen M. Hodgkinson, Socorro, New Mexico, USA, 87801-0000, hodgkinson@unavco.org?subject=AGU-FM10: Question regarding G41A-0797" to send an email
Identification of Geomorphic Conditions Favoring Preservation of Multiple Individual Displacements Across Transform Faults

P. L. Williams; 1 D. A. Phillips; 2 E. Bowles-martinez; 1 E. Masana; 3 P. Stepancikova; 4

2. UNAVCO, Boulder, CO, United States.
3. RISKNAT Group, Univ. of Barcelona, Barcelona, Spain.
4. Inst. of Rock Structure and Mechanics, Academy of Sciences, Prague, Czech Republic.

Body: Terrestrial and airborne LiDAR data, and low altitude aerial photography have been utilized in conjunction with field work to identify and map single and multiple-event stream-offsets along all strands of the San Andreas fault in the Coachella Valley. Goals of the work are characterizing the range of displacements associated with the fault's prehistoric surface ruptures, evaluating patterns of along-fault displacement, and disclosing processes associated with the prominent Banning-Mission Creek fault junction. Preservation offsets is associated with landscape conditions including: (1) well-confined and widely spaced source streams up-slope of the fault; (2) persistent geomorphic surfaces below the fault; (3) slope directions oriented approximately perpendicular to the fault. Notably, a pair of multiple-event offset sites have been recognized in coarse fan deposits below the Mission Creek fault near 1000 Palms oasis. Each of these sites is associated with a single source drainage oriented approximately perpendicular to the fault, and preserves a record of individual fault displacements affecting the southern portion of the Mission Creek branch of the San Andreas fault. The two sites individually record long (>10 event) slip-per-event histories. Documentation of the sites indicates a prevalence of moderate displacements and a small number of large offsets. This is consistent with evidence developed in systematic mapping of individual and multiple event stream offsets in the area extending 70 km south to Durmid Hill. Challenges to site interpretation include the presence of closely spaced en echelon fault branches and indications of stream avulsion in the area of the modern fault crossing. Conversely, strong bar and swale topography produce high quality offset indicators that can be identified across en echelon branches in most cases. To accomplish the detailed mapping needed to fully recover the complex yet well-preserved geomorphic features under investigation, a program of terrestrial laser scanning (TLS) was conducted at the 1000 Palms oasis stream offset sites. Data products and map interpretations will be presented along with initial applications of the study to characterizing San Andreas fault rupture hazard. Continuing work will seek to more fully populate the dataset of larger offsets, evaluate means to objectively date the larger offsets, and, as completely as possible, to characterize magnitudes of past surface ruptures of the San Andreas fault in the Coachella Valley.

Contact Information: Contact Information

Patrick L. Williams, West Tisbury, Massachusetts, USA, 02575-1492, <a href='mailto:plw3@earthlink.net?subject=AGU-FM10: Question regarding T43D-03'>click here</a> to send an email
Analysis of Three Real-Time Dst Indices

T. L. Carranza-fulmer; 1, 2; J. L. Gannon; 3; J. J. Love; 3

1. Physics, The City College of New York, New York, NY, United States.

Body: The Dst is commonly used to specify geomagnetic disturbance periods and characterize the resulting ring current enhancements from ground-based horizontal magnetic field intensity measurements. Real-time versions of the Dst index are produced for operational purposes, and are of interest to many users, including the US military, airline industry, and power companies. USGS Real time Dst, Kyoto Quicklook Dst, and Space Environment Corporation RDst use preliminary data and use a variety of contributing observatories and processing methods. Both USGS and RDst use a combined time-and-frequency domain method and Kyoto uses a time domain only method in creating the Dst index. We perform an analysis of these three real time Dst indices for the time period of October 1, 2009 to May 31, 2010. The USGS 3, using three observatories instead of the standard four, and the Kyoto Sym-H index, are introduced in the analysis for comparison of observatory location with the three main Dst indices. We present a statistical study of the differences due to algorithm, output time resolution, and location of contributing observatories. Higher time resolution shows higher frequency fluctuations during disturbances and more defined storm features. There were small differences in mid- to low-latitude observatories during quiet to moderate storm time periods. The average impact on the index due to the different algorithms used was approximately 9 nT, and greater for individual storms.

Contact Information: Contact Information

Theresa L. Carranza-fulmer, Bronx, New York, USA, 10469-0000, <a href='mailto:tcarranza.fulmer@gmail.com?subject=AGU-FM10: Question regarding SM51A-1742'>click here</a> to send an email
Body: The Sudbury Igneous Complex (SIC) forms the central part of the Mesoproterozoic (ca. 1.85 Ga) Sudbury impact structure and comprises three lithological units: norite (bottom), quartz gabbro, and granophyre (top). To determine the precise timing of the impact and the subsequent thermal behavior of the crust to this impact, an experimental approach was formulated to directly assess the associated impact energies by exploiting the crystallo-chemical response of zircon (Zr(SiO4)). The differential (slow) diffusional response of constituent elements (e.g. U, Th, Pb, REEs, Ti) in zircon at different temperatures and time-scales of the thermal pulse associated with impact makes this mineral an ideal recorder of the timing and condition of impact energies. Because titanium concentration in zircon is a function of temperature, we can also use this relationship a useful thermometer to probe time vs. temperature during the impact and its aftermath. Here, we report our studies of individual zircon grains extracted from SIC norite and granophyre drill core samples via standard heavy-mineral techniques (no zircons were found in the quartz gabbro unit). Grains were both hand-picked under an optical microscope and cast in epoxy, or entire heavy-mineral aliquots were cast without bias that arises from hand-picking. Electron imaging was used to identify individual zircons; many of the norite zircons displayed sets of planar deformation features (PDFs) attributable to shock wave deformation from impact, but none of the granophyre zircons displayed such structures. The largest and least altered grains from the sample aliquot we prepared were removed from their mounts and recast in epoxy with standard zircon AS-3 in anticipation of titanium thermometry and uranium-lead geochronology by high-resolution ion microprobe in depth-profile mode. Depth profiling reveals relationships between zircon growth time and the geochemical environment during crystallization and cooling after impact. We report our results to quantify the conditions for secondary zircon growth and recrystallization after a large (and in this case very well-characterized) impact and outline a quantitative means to better define impact conditions and timing for ancient terrestrial and lunar samples.

Contact Information: Contact Information
GPS Measurements of crustal motion associated with the 2010 Mw 7.2 Sierra El Mayor-Cucapah Earthquake, Baja California, Mexico

J. C. Spinler; 1; R. A. Bennett; 1; J. J. Gonzalez-Garcia; 2; C. P. Walls; 3; S. Lawrence; 3;

1. Dept. of Geosciences, University of Arizona, Tucson, AZ, United States.
2. CICESE, Ensenada, Mexico.
3. UNAVCO PBO, Boulder, CO, United States.

Body: We present crustal motion data obtained from an analysis of continuous and campaign GPS data for southern California and northern Baja Mexico, including the first results from a new six-station extension of the NSF EarthScope PBO network across the international border into northern Baja California, Mexico. This PBO extension was constructed in late Summer and early Fall 2010 in response to the April 4, 2010, Mw7.2 Sierra El Mayor-Cucapah earthquake. The locations of the six new PBO sites were selected in order to complement the dense existing continuous and campaign GPS networks in southern California, as well as providing needed continuous data for northern Mexico. Coseismic displacements for sites located nearest to the earthquake exceed 20 cm. In addition to allowing precise estimates of coseismic displacements, the ~17 years of pre-earthquake data for northern Baja California and southern California obtained from the archives at SCEC, UNAVCO, SOPAC, the University of Miami, and other sources, provides an opportunity to assess the evolution of postseismic deformation over the coming years. We will present updated results for pre- and post-seismic velocity for an assessment of post-seismic perturbations to the secular velocity field.

Contact Information: Contact Information
Joshua C. Spinler, Tucson, Arizona, USA, 85721-0000, <a href='mailto:jspinler@email.arizona.edu?subject=AGU-FM10: Question regarding T53B-2127'>click here</a> to send an email
UNAVCO Response to the M7.2 El Mayor-Cucapah Earthquake

C. P. Walls; ¹; S. Lawrence; ¹; A. Bassett; ¹; D. Mann; ¹; A. A. Borsa; ¹; M. E. Jackson; ¹; K. Feaux; ¹;
¹. Plate Boundary Observatory, UNAVCO, Boulder, CO, United States.

Body: The El Mayor – Cucapah earthquake occurred close to the Mexico – U.S. border, at the edge of the EarthScope – Plate Boundary Observatory (PBO’s) footprint. UNAVCO was one of several community organizations to support event response, providing co-seismic observations from PBO’s CGPS stations, borehole strainmeters and seismometers, the shipment of a Terrestrial LiDAR Scanner, and the acquisition of InSAR data through the UNAVCO-hosted WiNSAR consortium. PBO standard 15 second GPS data spanning the event for sites throughout southern California were recorded at 100% data completeness and were used to establish co-seismic displacement hours to days following the earthquake. High-rate (1-5 Hz) GPS downloads were completed with a 97% data return and used by community members to plot co-seismic displacement waveforms. In the months following the event 1Hz GPS data has been collected a disseminated for multiple airborne lidar and photography missions.

CGPS station P796, a deep-drilled braced monument, was constructed in San Luis, AZ along the border within 5 weeks of the event. In addition, UNAVCO participated in a successful University of Arizona-led proposal for the deployment of six continuous GPS stations for post-seismic observations. These stations will be installed, maintained and data analyzed by UNAVCO/PBO in coordination with CICESE, an Associate Member institution in Mexico. At present two stations (ALAX, SITX) are installed with 4 remaining permits in process.

Contact Information: Contact Information
Christian P. Walls, Boulder, Colorado, USA, 80301, <a href='mailto:walls@unavco.org?subject=AGU-FM10: Question regarding T53B-2128'>click here</a> to send an email