Preview of Award 1042906 - Annual Project Report

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Federal Agency and Organization Element to Which Report is Submitted:	4900
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Project Title:	Collaborative Instrumentation: COCONet (Continuously Operating Caribbean GPS Observational Network) An Infrastructure Proposal for a Multi-hazard Tectonic and Weather Observatory
PD/PI Name:	Meghan Miller, Principal Investigator Karl F Feaux, Co-Principal Investigator Glen S Mattioli, Co-Principal Investigator Guoquan Wang, Co-Principal Investigator
Recipient Organization:	UNAVCO, Inc.
Project/Grant Period:	09/15/2010 - 08/31/2016
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Submitting Official (if other than PD\PI):	Glen S Mattioli Co-Principal Investigator
Submission Date:	08/27/2015
Signature of Submitting Official (signature shall be submitted in accordance with agency specific instructions)	Glen S Mattioli

Accomplishments

*** What are the major goals of the project?**

This annual report covers COCONet project (EAR-1042906/EAR-1042909) activities for the time period from September 1,

2014 to August 31, 2015. COCONet is a Collaborative Research project between UNAVCO (EAR-1042906) and University Corporation for Atmospheric Research (UCAR) (EAR-1042909) awarded on September 14, 2010. The project is under the direction of M. Meghan Miller, as PI, with Co-PIs Karl Feaux, Glen Mattioli, and Guoquan Wang. Glen Mattioli is acting as Project Director in his role as Director of Geodetic Infrastructure at UNAVCO and John Braun is the UCAR PI. This document is a roll-up of the quarterly reports previously submitted by email on December 23, 2014, March 15, 2015 and June 17, 2015 to the COCONet NSF-EAR-IF Program Officer, Mr. Russ Kelz. Also included in this annual report is a brief summary of activities completed in FY2015-Q4, which also will be submitted as a quarterly report by September 15, 2015.

Major Goals for COCONet (modified from Braun et al., 2012, Eos feature article)

The Caribbean is a region of lush vegetation, beaches, active volcanoes, and significant mountain ranges; an environment that was created through geological, oceanic, and atmospheric processes, which also pose natural hazards for the developing countries in the Caribbean. The rise in population density, migration to coastal areas, and sub-standard building practices make the threat of natural hazards particularly devastating for the region. These demographic and social characteristics are taking place against a backdrop of the threat of an evolving climate, which produces a more vigorous hurricane environment and rising mean sea-level. The January 12, 2010 earthquake in Haiti and Hurricane Ike (2008) both caused widespread destruction and loss of life, illustrating the need for a scientific focus on the underlying natural hazards of the Caribbean. This report highlights a new National Science Foundation funded initiative termed COCONet (Continuously Operating Caribbean Observation Network), which commits ~$7M over five years to a collaborative natural hazard research team including UNAVCO, University of Houston, and the University Corporation for Atmospheric Research (UCAR).

COCONet will infuse geodetic infrastructure into the Caribbean to support a broad range of process-oriented geoscience investigations with direct relevance to geohazards. COCONet will allow for more focused topical geophysics studies and will also be a focal point for leveraging regional infrastructure for international partnerships and capacity building.

COCONet will install 50 new continuous Global Navigation Satellite System (cGNSS) and meteorology stations in the Caribbean and Central America, refurbish an additional 15 stations, and archive data from 62 cGNSS stations that are already or will soon be in operation (Figure 1) by various institutions committed to free and open data access. In addition to raw data, products will include estimates of column integrated tropospheric water vapor, time series of daily positions and component velocities, and high-rate low-latency data from a subset of stations. Data and products will be provided through UNAVCO or in collaboration with a regional center.

The large oceanic extent of the Caribbean and the presence of many offshore active faults make the region a source and a recipient of tsunamis. The Central America and Lesser Antilles subduction zones are associated with explosive volcanoes that pose a direct threat to large population centers. Much of the region’s tectonic context is still relatively poorly constrained, and local risk is not yet quantified. Only a few of the active plate boundary faults have well-determined geodetic slip rates and some key structures are not even considered in current hazard assessments.

Some key tectonic questions that COCONet will address include: What are kinematics, boundaries, and rigidity of the Caribbean plate? What reference frame is appropriate for tectonic studies? More targeted questions include mechanisms of stress release at convergent boundaries and interplate coupling along the leading and trailing edges of the Caribbean plate. Broader questions include how is strain partitioned at convergent margins and how is stress transfered across plate boundaries?

COCONet will also address key processes in the Caribbean region tied to ocean-atmosphere coupling, transport of moisture, and precipitation. Better observations are critical for improved initialization of numerical weather prediction systems and to assess model skill related to precipitation and latent heat transport. The distribution of stations across the Caribbean basin will allow large and small-scale processes to be studied: stations along the boundary of the Caribbean sea will be important for regional moisture studies; North-South transects, on both the eastern and western edges, will measure differences in moisture transport from low level jets into the mid-latitudes; and data collected from small and large landmasses will reveal the interaction between the ocean, land, and atmosphere.

COCONet observations will address key questions including: What are the sources and predictability of climate anomalies in the Caribbean? Are convective parameterizations, originally derived from western Pacific data sets, applicable to a Caribbean atmosphere? How does land heating and island topography influence moisture transport and precipitation?

The most obvious weather hazard that affects the Caribbean region is hurricanes. An emphasis of COCONet will be in determining how continuous and reliable estimates of precipitable water vapor, with temporal resolution of 15 minutes or less, can be applied in understanding of latent heat release in convective towers and synoptic scale moisture transport can fuel the evolution of tropical storms.

Lastly, three broad themes for capacity development have been identified to help ensure the success of COCONet. The first is the need for COCONet to effectively complement and extend regional geodetic infrastructure, and technical capabilities while simultaneously promoting open data policies. COCONet regional partners will play leading roles in transforming data obtained through COCONet investment into concrete benefits for hazards mitigation and scientific advancement. The second is the need to bridge the gap between scientific understanding and the application of that knowledge for public benefit. As COCONet advances science, it should also be used to improve public use of the acquired knowledge. Therefore, primary-school students, teachers, surveyors, emergency managers, policy and decision makers have all been identified as key audiences for COCONet outreach. The third theme is the need for bidirectional scientific partnerships to nurture a new generation of researchers in the region to assure knowledge flow in multiple directions – from and among Caribbean nations as well as between all of the project's international stakeholders. Mechanisms for promoting intellectual exchange include traditional opportunities such as encouraging advanced training or graduate school for Caribbean students as well as fostering the development of Caribbean training centers, bidirectional science exchanges, and field campaigns, which include partners from across the Americas.

Lastly, as part of a supplement approved for this award on 7/31/2012, UNAVCO was authorized to locate, permit and install two (2) cGPS-constrained sea-level tide gauges and augment two (2) existing sea-level tide gauges with cGPS in Caribbean region. UNAVCO has initiated contact with the University of Colorado, University of Hawaii, NOAA and commercial specialists to validate the design and location of these sea-level tide gauges.

*** What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities: **Below FY2015 refers to the project period from September 1, 2014 to August 31, 2015.**

FY2015-Q1:

- Three new cGPS-Met stations were installed in FY2015-Q1 (one GPS-Met station on Dominica, plus two GPS instruments associated with the tide gauge station at Port Royal, Jamaica). The total number of new, refurbished, or co-located stations installed to date is 64.
- Maintenance work was completed to upgrade cellular data communications at CN24 and CN25 (Mexico) and CN19 (Aruba).
- UNAVCO currently archives 112 designated COCONet cGPS stations. This group includes stations that are new, refurbished as well as contributing stations from other networks.
- There are currently 35 COCONet stations delivering high-rate, low-latency (1 Hz, less than 2 s) data streams in real-time via the Networked Transport of RTCM via Internet Protocol (NTRIP). This exceeds the original project goal outlined in the proposal.

FY2015-Q2:

- Seven new and refurbished cGPS-Met stations were installed in FY2015-Q2 (2 GPS-Met stations in Venezuela, one in Antigua, one GPS-Met station installed on the pier at the Bocas del Toro tide gauge station, plus two GPS instruments associated with the new tide gauge station at Puerto Morelos, Mexico. The total number of new, refurbished, or co-located stations installed to date is 71. There are 12 remaining stations to be installed as part of the COCONet installation plan.
- Maintenance work was completed at a number of stations, including:
  - Choke ring antenna were installed at five original COCONet stations.
  - Antenna LNA was upgraded at CN07 in the Dominican Republic.

- Cellular data communications were upgraded at VRAI and VERA.
- UNAVCO currently archives 119 designated COCONet cGPS stations. This group includes stations that are new, refurbished as well as contributing stations from other networks. The UNAVCO Data Archive Interface (DAI) now has two distinct groupings of COCONet sites: 1) COCONet core, which includes all the sites that UNAVCO has installed or upgraded and currently maintains; and COCONet contributing, which includes stations that UNAVCO does not operate, but have been contributed by various regional partners.
- There are currently 37 COCONet stations delivering high-rate, low-latency (1 Hz, less than 2 s) data streams in real-time via the Networked Transport of RTCM via Internet Protocol (NTRIP). This exceeds the original project goal outlined in the proposal.
  - Training of Regional Data Center staff took place in Boulder December 8-10.
  - A few minor changes to server software installation and configuration were completed and the servers have been shipped to Regional Data Centers.

FY2015-Q3:

- One new GPS-Met station was installed in FY2015-Q3 on Sombrero Island (CN51). **The total number of new, refurbished, or co-located stations installed to date is 72.** There are 11 remaining stations to be installed as part of the COCONet installation plan. Permitting issues for two stations in Colombia (Malpelo Island and Seranillo Island) may cause these two stations to be removed from the siting plan. This decision will be made at the next COCONet Working Group teleconference scheduled for FY2015-Q4. The Working Group also will review all installations to date in order to prioritize any remaining fieldwork and develop a plan for a request for a Grantee-approved No Cost Extension, which must be submitted prior to July 15, 2015.
- Maintenance work was completed at a number of stations, including:
  - INEETER engineer visited station CN29 and CN30 in Nicaragua to troubleshoot interference issues and to repair communications links. Both stations were brought back online and currently operating in good health.
  - New cellular modem installed at Virgin Gorda station (CN04).
  - UNAVCO currently archives 121 designated COCONet cGPS stations. This group includes stations that are new and refurbished as well as contributing stations from other networks. The UNAVCO Data Archive Interface (DAI) now has two distinct groupings of COCONet sites: 1) **COCONet core**, which includes all the sites that UNAVCO has installed or upgraded and currently maintains; and 2) **COCONet contributing**, which includes stations that UNAVCO does not operate, but whose data have been contributed by various regional partners. During this reporting period, 85.9% of the stations delivered data to the DAI.
  - There are currently 37 COCONet stations delivering high-rate, low-latency (1 Hz, less than 2 s) data streams in real-time via the Networked Transport of RTCM via Internet Protocol (NTRIP). This exceeds the original project goal outlined in the proposal.
  - The COCONet Regional Data Centers at INETER (Nicaragua), CIMH (Barbados), and SGC (Colombia) are now all operational.

FY2015-Q4:

- One new GPS-Met station was installed in FY2015-Q4 on Aves Island (CN49) and one new cGPS station (TGDR) as part of the tide gauge station in the Dominican Republic. **The total number of new, refurbished, or co-located stations installed to date is 74.** There are 9 remaining stations to be installed as part of the COCONet installation plan.

Specific Objectives:

Significant Results:

Below FY2015 refers to the project period from September 1, 2014 to August 31, 2015.

FY2015-Q1:

Highlight: cGPS-Constrained Tide Gauge Installed in Jamaica

Modern tide gauges provide precise relative sea level data but are greatly influenced by vertical land motion and the stability of the surface (e.g. pier) on which they are built. In addition, tying local, relative sea level to a global reference frame or absolute sea level remains an ongoing challenge. Traditionally, technicians routinely leveled the gauges with respect to various local tide gauge benchmarks. Precise leveling is labor intensive and while accurate, is often inconsistent in recurrence. An NSF supplement to COCONet provided funding for two dual-frequency cGPS stations proximal to newly constructed tide gauges; one cGPS in bedrock or stable ground within five kilometers of the gauge and the second on the tide gauge platform itself with a geodetic baseline tie between them to best constrain vertical motion. In doing so, this experiment provides a near real-time position of the tide gauge instrument, both relative to the changing sea level height as well as the dynamic global reference frame. The supplement also provided funds for the addition of two cGPS stations (on the pier and on nearby bedrock) at two existing, functioning tide gauges, which are considered “upgrades.”

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 1).

UNAVCO opened an ongoing discussion with a panel of experts in the field of GPS constrained tide gauges and sea-level monitoring in order to target specific designs for station engineering as well as to better understand the needs and current assets of the sea-level monitoring community. Instrumentation was selected, purchased, and tested in-house. Additionally, several UNAVCO employees attended the IOC’s Sea Level Operators Workshop in Puerto Rico in November 2014 and taught a short-course on campaign system installations and COCONet data products.

In November of 2014, UNAVCO installed its first complete GPS-constrained tide gauge station in Port Royal, Jamaica. Port Royal is a Jamaican Coast Guard base off the coast of Kingston, Jamaica that previously hosted a tide gauge operated by the Jamaican Meteorological Services (JMS). The JMS station at Port Royal lost funding and the JMS were eager to support UNAVCO’s construction of a new, GPS constrained radar and pressure gauge. A Sutron radar level recorder and submersible pressure gauge were installed on the existing pier (station code: PTRO), along with a Trimble NetR9 receiver and Vaisala meteorological instrument (PRCG). The secondary cGPS (PRML) was constructed on the nearby Marine Research Lab building, which also hosts an ethernet connection for GPS and meteorological instrument dataflow. JMS provided excellent in-country support for the installation and will provide long-term support and maintenance of the tide instruments. Tide data are being transmitted via GOES satellite to the IOC archive (www.ioc-sealevelmonitoring.org). Both cGPS stations and meteorological data will undergo standard COCONet processing and archived at UNAVCO (coconet.unavco.org).

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 2).

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 3).

Finally, using methods developed by Dr. Kristine Larson (*The Accidental Tide Gauge: A GPS Reflection Study from Katchemak Bay, Alaska*, Larson, K. et al.), UNAVCO personnel were able to measure the adjacent ocean tidal signal in the pier-mounted

GPS multipath reflections. Initial results suggest this method may provide a continuous tie between the GPS antenna phase center and the tide instrument datum and could possibly reduce the need for frequent instrument leveling.

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 4).

FY2015-Q2:

Highlight: cGPS Constrained Tide Gauge Installed in Mexico

In February 2015, UNAVCO engineers installed the second COCONet GPS-constrained tide gauge station in Puerto Morelos, Mexico. The installation on the Yucatan coast was another successful collaboration with UNAM, the National Autonomous University of Mexico. The multi-sensor tide gauge station was installed on a concrete pier at the UNAM Institute of Ocean and Limnology Sciences, near the small town of Puerto Morelos. Similar to the station installed last quarter in Jamaica, this station includes a Sutron Radar Level Recorder, an INW pressure sensor, Trimble NetR9 with a Trimble GNSS choke ring antenna, and a Vaisala meteorological instrument. The pier is not an ideal location in terms of sky view and multipath but will allow for a continuous positioning of the tide instruments and help convert relative tide measurements into the global reference frame for measuring global sea level. The receiver at the existing contributing COCONet station, UNPM, was modernized to a Trimble NetR9. UNPM has a 7-year time series and will provide an excellent station to constrain the pier antenna. UNAM staff will assist in long-term maintenance and operation of both the GNSS and tide instrument systems. All tide data are transmitted via GOES satellite and available at UNESCO's IOC (Intergovernmental Oceanographic Commission) tide gauge database, www.iocsealevelmonitoring.org. The tide station is called PUMO2 in the IOC archive. All GNSS and meteorological data for the GNSS station (station code: TGMX) undergo standard COCONet processing and are available at coconet.unavco.org. We are currently in the process of developing a highlight for the UNAVCO website related to this work and also providing links from the UNAVCO website to the UNESCO IOC data archive and viewer.

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 5).

FY2015-Q3:

Highlight: cGPS-Met Installation at Sombrero Island, Anguilla (CN51)

In FY2015-Q3, PBO engineer John Sandru and local collaborator Edwin Carty (Airport Maintenance Manager) installed the remote station CN51 in conjunction with the Government of Anguilla. Sombrero Island is an uninhabited Island northwest of Anguilla that has some existing infrastructure. Permission was granted by the Government of Anguilla to install the station at existing infrastructure on this critical island. This site was recommended for installation at the COCONet Siting Workshop held in Port of Spain, Trinidad in 2011. A helicopter was required for installation. UNAVCO used this opportunity to build relationships with Anguilla Government officials; giving them a tour of the station after the station was completed.

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 6).

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 7).

FY2015-Q4:

Highlight: Continued Progress on Tide Gauges: Installation at Barahona, DR

In FY2015-Q4, UNAVCO with assistance from the Oficina Nacional de Meteorologia (ONAMET) of the Dominican Republic, installed a new cGPS (TGDR) collocated with the Puerto Rican Seismic Network tide gauge (BARA) at the Navy port in Barahona, Domincan Republic. The TGDR station installation includes standard COCONet hardware: Trimble GNSS choke-ring, Trimble NetR9 and a Visalia meteorological instrument. TGDR is a short distance (0.67 km) from the existing COCONet cGPS-Met station BARA and will help constrain existing tidal instruments into a continuous global reference frame. ONAMET facilitated permissions for construction and will provide long-term maintenance support. This installation was another successful opportunity for UNAVCO and ONAMET to exchange knowledge and collaborate on enhancing the Caribbean geodetic network.

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 8).

Key outcomes or Other achievements:

Below FY2015 refers to the project period from September 1, 2014 to August 31, 2015.

FY2015-Q1:

To date, UNAVCO engineering personnel have performed site reconnaissance at 80 locations, submitted land use permits for 78 sites, received permits for 76 sites, and currently have 64 stations installed.

Key accomplishments in the last quarter were the installation of the COCONet cGPS-Met station on Dominica and the installation of the first tide gauge station at Port Royal, Jamaica.

FY2015-Q2:

To date, UNAVCO engineering personnel have performed site reconnaissance at 81 locations, submitted land use permits for 81 sites, received permits for 78 sites, and currently have 71 stations installed.

Key accomplishments in the last quarter were the installation of two COCONet cGPS-Met stations in Venezuela (CN39 and CN40), one station in Antigua (CN01), and the installation of the second tide gauge station at Puerto Morelos, Mexico including cGPS-Met stations TGMX and UNPM.

FY2015-Q3:

To date, UNAVCO engineering personnel have performed site reconnaissance at 81 locations, submitted land use permits for 81 sites, received permits for 79 sites, and currently have 72 stations installed. Key accomplishments in the last quarter were the installation of the COCONet cGPS-Met station on Sombrero Island, Anguilla and maintenance activities in Nicaragua and Virgin Gorda.

Automated transmission of surface meteorology observations from COCONet were deemed suitable for distribution onto the National Weather Service (NWS) Telecommunications Operations Center (TOC) and the Global Telecommunications System (GTS) were finalized on January 7, 2015. These data are now available as NWS data stream under tag SXCA51 KWBC (http://weather.noaa.gov/pub/data/raw/sx/sxca51.kwbc..txt).

FY2015-Q4:

To date, UNAVCO engineering personnel have performed site reconnaissance at 81

locations, submitted land use permits for 81 sites, received permits for 79 sites, and currently have 74 stations installed. Key accomplishments in the last quarter were the installation of the COCONet cGPS-Met station on Aves Island, Venezuela (CN49) and the co-located cGPS-Met station at the sea level station in the Dominican Republic (TGDR).

See COCONet_EAR1042906_FY2015_an_rpt_figs.pdf (Figure 9).

*** What opportunities for training and professional development has the project provided?**

The COCONet project continues to expand and advance outreach activities to achieve the objectives of the project and ensure the broader impacts to science and society. Key highlights of ongoing and new activities related directly to outreach and community engagement include the following:

COCONet Fellowships

The COCONet project provided a second year of funding to the five students who were awarded the first round of COCONet Graduate Fellowships in 2013. The following students were the first recipients of the awards:

- *Steeve Symithe* - a doctoral graduate student in geophysics at Purdue University. Steeve is from Haiti. He has a Bachelor's degree in civil engineering from Universite d'Etat d'Haiti and a Masters degree in geophysics from Purdue University. His doctoral research is focused on understanding the motion between the Caribbean, South American, and North American plates in order to build better kinematic models and improve knowledge of earthquake risks in Hispaniola (Haiti and the Dominican Republic share several dangerous faults that cross national borders) and elsewhere.
- *Roby Douilly* – a doctoral graduate student in geophysics at Purdue University. Roby is from Haiti. He has a Bachelor's degree in civil engineering from Universite d'Etat d'Haiti and a Masters degree in seismology from Purdue University. His doctoral research is focused on understanding and modeling the rupture process of the Enriquillo and Leogane fault zones in Haiti in order to estimate the distribution and strength of future ground shaking to improve risk resiliency in Haiti and other seismic zones.
- *Halldor Geirsson* – a doctoral graduate student in geophysics at Pennsylvania State University. Halldor is from Iceland. He has a Bachelor's degree and a Masters degree in geophysics from the University of Iceland. His doctoral research is focused on understanding the tectonics and deformation related to the subduction of the Cocos plate beneath the Caribbean plate near El Salvador, Nicaragua and Costa Rica. His research will help to assess earthquake hazards (such as the 5 September 2012 magnitude 7.6 Nicoya earthquake) and volcanic hazards (such as the 1999 eruption of Cerro Negro in Nicaragua).
- *Esteban Josue Chaves Sibaja* – a doctoral graduate student in seismology at the University of California, Santa Cruz. Esteban is from Costa Rica. He has a Bachelor's degree in physics from the Universidad Nacional (UNA, Costa Rica) and has worked at the Volcanological and Seismological Observatory of Costa Rica (OVSICORI). His doctoral research is focused on understanding the seismic coupling between the Cocos and Caribbean plates in the subduction zone beneath the Nicoya and Osa Peninsulas of Costa Rica. Both regions have the potential for a very large earthquake and tsunami.
- *Ophelia George* – a doctoral graduate student in geology at the University of South Florida. Ophelia is from the Commonwealth of Dominica, an island nation in the Lesser Antilles region of the Caribbean Sea. She has a Bachelor's degree in geologic sciences from Florida International University and a Masters degree in geophysics from the University of Alaska, Fairbanks. Her doctoral research is focused on changes in plate tectonics affecting volcanism in the Lesser Antilles over the past 40 million years in order to generate a new hazards map for the island arc polygenetic volcanic system.

The COCONet project funded a second round of graduate research fellowships starting in September of 2014 for four additional students. The new COCONet Graduate Fellowships will provide individual awards for a maximum of 2 years to support solid Earth or atmospheric science graduate research projects conducted at a U.S. institution of higher education. The research projects must be within the COCONet footprint or directly use data from the COCONet GPS stations and/or meteorological sensors. The four additional students, receiving a first year fellowship starting September 1, 2014 include:

- Teddy Allen, a doctoral graduate student in meteorology at the University of Miami. He has a Bachelor's degree in physical geography from the University of California, Santa Barbara and a Masters degree in geography from East Carolina University. His research is focused on understanding the origins of the bimodal rainfall signal in the Caribbean

and the onset of the related mid-summer drought. He is a volunteer for the International Environmental Data Rescue Organization and has led workshops on climate data rescue and analysis in Dominica and Jamaica.

- Andria Ellis, a doctoral graduate student in geophysics at the University of Wisconsin, Madison. She has a Bachelor's degree in civil engineering from the University of the Pacific. Her research is focused on understanding plate deformation using GPS measurements, at the western edge of the Caribbean plate, where the Motagua-Polochic fault system, the Middle America subduction zone and other faults have caused destructive earthquakes and volcanic eruptions. She has had valuable geotechnical internships and was a teacher/mentor for a middle school geoscience experience for girls project.

- Hans Lechner, a doctoral graduate student in geology at Michigan Technological University. He has a Bachelor's degree in geography from Humboldt State University and a Masters degree in geology from Michigan Technological University. His research is focused on understanding ground deformation at Pacaya Volcano, Guatemala using GPS and other tools. Hans will model the magma reservoir structure using this data to inform volcano dynamics and eruption warnings for public safety. Hans served in the Peace Corps in El Salvador and Jamaica before pursuing an advanced degree.

- Vashan Wright, a graduate student in Geophysics at Southern Methodist University, Dallas. He has a Bachelor's degree in Geology from Calvin College. In his research, Vashan uses a combination of GPS data, seismic reflection profiles and gravity cores to understand the neotectonic and paleoseismic history of Jamaica. As a native of Jamaica, Vashan is familiar with the environment and his work will help prepare residents for future earthquakes in Jamaica.

*** How have the results been disseminated to communities of interest?**

New Publications by COCONet Fellows

Douilly, R.; H. Aochi; E. Calais; A. M. Freed (2015), 3D Dynamic Rupture Simulations Across Interacting Faults: The Mw7.0, 2010, Haiti Earthquake. J. Geophys. Res. Solid Earth, 120, DOI: 10.1002/2014jb011595 10.1002/2014jb011595.

Ellis, A. P., C. DeMets, P. Briole, E. Molina, O. Flores, J. Rivera, C. Lasserre, H. Lyon-Caen, and N. Lord (2015), Geodetic slip solutions for the Mw = 7.4 Champerico (Guatemala) earthquake of 2012 November 7 and its postseismic deformation, *Geophys. J. Int.*, 201 (2): 856-868 doi:10.1093/gji/ggu484.

Geirsson, H., LaFemina, P. DeMets, C., Hernandez, D., Mattioli, G., Rogers, R., Rodriguez, M., Marroquin, G., and V. Tenorio, 2015, The August 27, 2012 Mw7.3 El Salvador earthquake: Expression of weak coupling on the Middle America subduction zone, *Geophys. J. Int*., v. 202, p 1677-1689, doi: 10.1093/gji/ggv244.

Symithe, S., E. Calais, J. B.de Chabalier, R. Robertson, *and* M. Higgins *(*2015*),* Current block motions and strain accumulation on active faults in the Caribbean, J. Geophys. Res. Solid Earth, 120*, doi: 10.1002/2014JB011779.*

Weber, J. C., **H. Geirsson**, J. L. Latchman, K. Shaw, P. La Femina, S. Wdowinski, M. Higgins, C. Churches, and E. Norabuena (2015), Tectonic inversion in the Caribbean-South American plate boundary: GPS Geodesy, Seismology, and Tectonics of the Mw 6.7 April 22, 1997 Tobago earthquake, *Tectonics*, 34, doi:10.1002/2014TC003665.

Wright V., Hornbach, M., McHugh, C. and P. Mann, (2015). Factors Contributing to the 2005-present Rapid Rise in Lake Levels, Dominican Republic and Haiti (Hispaniola): Special Issue – Natural Disasters and Extreme Weather. Natural Resources.

Meetings Attended by COCONet Fellows

Roby Douilly

Invited talk: Seismological Society of America Annual Meeting 2015 in Pasadena CA.

Andria Ellis

Invited public lecture: A GPS and modeling study of crustal deformation and regional tectonics in northern Central America, Invited lecture, Universidad de San Carlos de Guatemala, February 17, 2015. Guest speaker for El Centro Estudios Superiores de Energía y Minas.

Andria P Ellis, Charles DeMets, Pierre Briole, Enrique Molina, Omar Flores, Jeffery Rivera, Cecile Lasserre, Helene Lyon-Caen, and Neal Lord. Geodetic Slip Solution for the Mw=7.4 Champerico (Guatemala) Earthquake of 07 November 2012. Poster presented at: American Geophysical Union Fall Meeting; 2014 December 15-19; San Francisco, CA: Session T11C-3171, Abstract ID. 10366.

Vashan Wright

Invited Talk: Assessing Seismic Geohazards near Kingston Jamaica: Earthquakes, Tsunamis, Slope Failures and Liquefaction Events. Calvin College, Grand Rapids, MI. March, 2015

Wright V, Hornbach M, McHugh C and Mann P (presentation) Factors Contributing to the 2005-present Rapid Rise in Lake Levels, Dominican Republic and Haiti (Hispaniola), AAPG/SEG Student's Expo, Houston, Texas, 22-23 September 2014.

Teddy Allen

International Conference on Mesoscale Meteorology and Tropical Cyclones

Boulder, Colorado (15-18 September 2014). Presentation Title: "Flow pattern persistence, Lagrangian diagnostics, and spring subtropical rains".

International Conference Climate Services – 4, Montevideo, Uruguay (10-12, December 2014 **Oral,** "Integrating interviews into climate based research: how Caribbean farmers drive synoptic climatology diagnostic and rainfall prediction activities" and **Poster**, "Examples of free data analysis and visualization tools administered during IEDRO's application workshop".

Invited talk: Caribbean Climate Outlook Forum (CariCOF) in Kingston, Jamaica in May 2015.

Other key highlights by UNAVCO staff and PIs

- *Tenth Session of the Intergovernmental Oceanographic Commission (IOC) Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions*

Representing COCONet, Co-PI Karl Feaux attended this meeting on Tsunami and Coastal hazards on May 13-15, 2015 in Sint Maarten. Karl gave a brief presentation, which introduced the participants to UNAVCO, the Plate Boundary Observatory, and provided an update on the COCONet and TLALOCNet projects. The primary interest of the participants at this meeting was related to the COCONet tide gauge installations and stations capable of high rate data realtime data distribution.

- Continued improvements and updates to the COCONet webpage, such as new or revised content to the main subpages of Project Management, COCONet Science, People & Partnerships, Reports & Publications, Data, and Events & Meetings to keep the community and the public informed of COCONet activities and opportunities. The presentations (in PDF format) from the Pan-American Advanced Studies Institute (PASI) on Magmatic-Tectonic Interactions in the Americas (May 2013 in Managua and Leon, Nicaragua) are available on the COCONet webpage.
- Several UNAVCO staff attended the Tide Gauge Operators Training at the University of Puerto Rico, Mayaguez November 3-7, 2014. This provided an opportunity for face-to-face communications with the key tide gauge stakeholders.
- Continued development and expanding use of the COCONet Facebook page.
- Distribution of the monthly newsletter to inform COCONet partners, collaborators, and other stakeholders of actions, advances, and opportunities.
- COCONet Fellow, Hans Lechner and his colleagues at Michigan Technological University met with INSIVUMEH, CONRED, Pacaya National Park and the city of San Vicente Pacaya in Guatemala to discuss advancing continuous geodetic/seismic infrastructure in the region during a GPS field campaign to Pacaya Volcano in November 2014.
- COCONet Fellow Halldor Geirsson held a GPS training course at INETER in Managua, Nicaragua from October 6-13, 2014. The course covered basic GPS theory, collection of GPS measurements, some UNIX basics, data archiving, and data processing using GAMIT/GLOBK.
- COCONet supported E. Cabral-Cano (TLALOCNet Co-PI) and Paul Jarrin to attend the Latin American Geophysical Networks meeting in Santiago, Chile May 25-30.

- COCONet activities were covered by the media, which informed the public about research and natural hazards. In

particular, there were multiple news stories about GPS installations in Nicaragua for research and to monitor active volcanoes. The local media in Nicaragua reported on the installation of GPS stations and the use of these and other stations for monitoring volcanic hazards in October 2014. Two stories reported in El 19 Digital include the following:
Instalan Sistema de Monitoreo en Laderas del Volcan Masaya

http://www.el19digital.com/articulos/ver/titulo:22838-instalan-sistema-de-monitoreo-en-laderas-del-volcan-masaya

Gobierno Continua En Monitoreo Constante del San Cristobal

http://www.el19digital.com/articulos/ver/titulo:22857-gobierno-continua-en-monitoreo-constante-del-san-cristobal

- *UNAVCO prepared a Science Snapshot about the Douilly et al. paper*

https://www.unavco.org/science/snapshots/solid-earth/2015/douilly.html

- The University Corporation for Atmospheric Research (UCAR) posted a press release about the new COCONet station in Cuba.
- GPS Station Debuts in Cuba, 9 March 2015, *NCAR/UCAR Staff News*
- Other COCONet-related news items posted on the UNAVCO webpage:
- Ineter instala GPS de alta definicion en el volcan Masaya, 2 October 2014, Hope Sevilla, *La Sandino*
- Instalan sistema de monitoreo en laderas del volcan Masaya, 3 October 2014, Tania Ceron Mendez, *El 19 Digital*
- Gobierno continua en monitoreo constante del San Cristobal, 4 October 2014, Tania Ceron Mendez, *El 19 Digital*
- Keeping Watch Over Colombia's Slumbering Volcanoes, 27 February 2015, Ordonez et al. *Eos, 96, doi:10.1029/2015EO025079*

*** What do you plan to do during the next reporting period to accomplish the goals?**

Continue with project plan as per revision to scope and budget as submitted to NSF in April 2013 and approved by NSF in June 2013. Will finish the construction phase of the project, which includes nine cGPS-Met stations.

In addition, we are beginning the evaulation of logistics and funding to support a fourth and final COCONet Science Workshop. At this time, we anticipate that this workshop will occur in the late Spring of 2016. Two locations are currently under consideration: Bridgetown, Barbados and Cartagena, Colombia.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
COCONet_EAR1042906_FY2015_an_rpt_figs_red.pdf	Figures for COCONet Annual Report	Glen Mattioli	08/27/2015

Products

Books

Book Chapters

Conference Papers and Presentations

Inventions

Journals

Licenses

Other Products

Data and Research Materials (e.g. Cell lines, DNA probes, Animal models).

2014-2015 Data Summary

The Port-of-Spain, Trinidad planning meeting resulted in 50 target locations for new stations, 15 targets for refurbished stations, and at least 61 existing stations for integration into the COCONet network. Since the Port-of-Spain workshop, the COCONet siting committee (now the COCONet working group) has rejected the location of three new stations (St. Croix, Cayman Islands, Guanaja) and approved the addition of 2 new (Aruba, Panama-Bocas Island) and 8 refurbished stations to the plan. Also, one of the planned refurbished stations, GOV1, was determined to be unsuitable for construction. Consequently a new station GOV2 was built in its place. Four of the refurbished stations in Venezuela were removed from the Trinidad siting plan. A number of existing stations in Guatemala (in exchange for building a new station there) were upgraded and new stations were approved for installation at Sombrero Island, Anguilla, Aves Island, Venezuela, and St. Lucia. At this time, the current siting plan calls for 54 new stations, 24 refurbished stations, 5 stations as part of the tide gauge support, and at least 61 existing stations to be incorporated into the COCONet data archive. The COCONet data plan also calls for at least 10 stations to provide high-rate, low-latency (1 Hz, <1 ms) or real-time GPS data streams.

UNAVCO currently provides a suite of geodetic data products from COCONet GPS stations. COCONet stations are mostly configured for 15-second hourly downloads, with some exceptions for sites that have BGAN satellite data communications infrastructure in place. Level 1 GPS data products include quality checked RINEX files. At the time of this report, Level 1 GPS data are available from 122 COCONet stations (includes new, refurbished, and existing stations). Level 2 GPS data products include station position solutions, station position time series, station position velocity estimates, and tropospheric delay parameters. Level 2 products are produced by the Plate Boundary Observatory (PBO) Analysis Centers (ACs) in collaboration with the Analysis Center Coordinator (ACC), and are identical in format to corresponding PBO data products. At the time of this report, Level 2 GPS products are available from 122 COCONet stations (includes new, refurbished, and existing stations). Note: data products may not be available from all stations installed at the time of this report due to unresolved communication issues or other reasons, such as the station being recently built and the data not yet being available for archiving or analysis. A comprehensive data re-processing effort by the PBO ACs/ACC, designed to produce IGS08 solutions for all PBO, COCONET and affiliated network stations back through 1996, continued this period and we expect that new Level 2 data products will become available for all available COCONet stations with historic time series sometime during the next quarter.

Currently, 42 COCONet stations are configured to deliver high-rate, low-latency (1 Hz, < 2 s) data streams in real-time via the Networked Transport of RTCM via Internet Protocol (NTRIP). This exceeds a project goal outlined in the project proposal, which called for at least 10 stations to deliver high-rate, low-latency data in real-time.

Other Publications

Patents

Technologies or Techniques

Thesis/Dissertations

Websites

COCONet: Continuously Operating Caribbean GPS Observational Network
http://coconet.unavco.org/coconet.html

COCONet main website. All reports, personnel, data, status, etc. are provided to the public through this website.

Supporting Files

Filename	Description	Uploaded By	Uploaded On
COCONet_EAR1042906_publications_aug_2015.pdf	COCONet publications with	Glen	08/27/2015

	update for 2015	Mattioli

Participants/Organizations

What individuals have worked on the project?

Name	Most Senior Project Role	Nearest Person Month Worked
Miller, Meghan	PD/PI	0
Feaux, Karl	Co PD/PI	1
Mattioli, Glen	Co PD/PI	1
Wang, Guoquan	Co PD/PI	0

Full details of individuals who have worked on the project:

Meghan Miller
Email: Meghan@unavco.org
Most Senior Project Role: PD/PI
Nearest Person Month Worked: 0

Contribution to the Project: UNAVCO President and COCONet PI. Responsible for oversight of entire project.

Funding Support: GAGE Facility Cooperative Agreement

International Collaboration: No
International Travel: No

Karl F Feaux
Email: feaux@unavco.org
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: PBO and related networks Operations Manager and Co-PI. Oversight of budget and scope. Preparation of draft quarterly and annual reports. Presentation of talks at national and international meeting. Fieldwork as needed.

Funding Support: This award and GAGE Facility Cooperative Agreement

International Collaboration: No
International Travel: Yes, Sint Maarten (Dutch Part) - 0 years, 0 months, 4 days; Mexico - 0 years, 0 months, 5 days

Glen S Mattioli
Email: gmattioli@uta.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 1

Contribution to the Project: Co-PI and Project Director by virtue of position as UNAVCO Director of Geodetic Infrastructure. Review of all documents transmitted to the NSF and direct supervision of UNAVCO staff supporting all field

operations.

Funding Support: This award and GAGE Facility Cooperative Agreement.

International Collaboration: No
International Travel: Yes, Cuba - 0 years, 0 months, 4 days

Guoquan Wang
Email: gwang@uh.edu
Most Senior Project Role: Co PD/PI
Nearest Person Month Worked: 0

Contribution to the Project: Co-PI and member of the COCONet Working Group.

Funding Support: Other NSF.

International Collaboration: No
International Travel: No

What other organizations have been involved as partners?
Nothing to report.

What other collaborators or contacts have been involved?
Nothing to report

Impacts

What is the impact on the development of the principal discipline(s) of the project?

COCONet was the impetus for the development of TLALOCNet - another multihazard cGPS/Met network in Mexico. UNAVCO submitted an MRI proposal in February 2013 to request funding to develop a combined atmospheric and tectonic cGPS-MET network in Mexico, named TLALOCNet, for interrogation of climate, atmosphere, the earthquake cycle, and tectonic processes of Mexico and environs. TLALOCNet will span all of Mexico and link existing GPS infrastructure in North America and the Caribbean. We propose new cGPS stations at locations of high scientific value in Mexico and adjacent islands, in parallel with the upgrade of existing cGPS stations previously established by NSF-funded collaborations. The resulting 25 stations will operate to the high standard of the EarthScope Plate Boundary Observatory (PBO) and the Continuously Operating Caribbean GPS Observational Network (COCONet), and complement additional cGPS-MET stations to be installed by our Mexican partners, including National Meteorological Service (SMN) and the Universidad Nacional Autonoma de Mexico (UNAM) over the next three years. This $2.14M request to the NSF MRI program, which builds on decades of NSF investments in Mexico and is supported by several years of preparation, community workshops, and planning by multiple institutions and individuals, is tailored to achieve the highest and broadest impact for the most efficient and appropriate investment. TLALOCNet is greatly leveraged Mexico's formal cost-share of $643K (13 stations) and SMN's anticipated further substantial investment in cGPS-MET across Mexico. Collectively, the developed infrastructure and capabilities will provide the basis for a unique class of interdisciplinary observations and science applications that meet the criteria for MRI instrument development. Design and construction rely on design work and engineered solutions for system integration. Risks associated with development of the unique observing system will be managed by benchmarking against established scope and schedule, in close coordination with the sponsor and the scientifically diverse user community.

What is the impact on other disciplines?
Nothing to report.

What is the impact on the development of human resources?

See section on COCONet Science Fellows above.

What is the impact on physical resources that form infrastructure?

See section on COCONet sites already constructed with COCONet and the PDF file that contains the figures, including a map of all the sites.

What is the impact on institutional resources that form infrastructure?

Nothing to report.

What is the impact on information resources that form infrastructure?

Regional Data Centers

In FY2014, UNAVCO Contracts staff worked to finalize the formal agreements between UNAVCO and each of the Regional and Regional Mirror Data Centers (SGC in Colombia, and CIMH in Barbados and INETER in Nicaragua) and to finalize the statements of work and budgets related to the data center. The agreements were signed by SGC and are ready to be signed by the other parties. The purchase of the computer server hardware was delayed until the agreements were signed. In the meantime, progress continued on software components that will make up the data centers. In addition, to test the various components of the Regional Mirror Data Centers software without the intended hardware in-house, UNAVCO proceeded with configuring the virtual machine (VM).

For three days in early December 2014 in Boulder, UNAVCO, Data Services staff trained future COCONet (and TLALOCNet) Regional Data Center (RDC) operators in a GSAC and Dataworks software. In February 2015, UNAVCO staff delivered the Regional Data Center systems to each country. The system consists of a virtual machine (VM) that has been provisioned with the Linux operating system and systems software including web server, web application server, ftp server, Java, Perl, Python, Dataworks, and MySQL, plus the GSAC database, GSAC software, and required synchronization scripts. The following two COCONet mirror centers and data centers are considered operational:

Caribbean Institute for Meteorology and Hydrology **–** The Caribbean Institute for Meteorology and Hydrology (CIMH) received a grant to develop a mirror data center to host and serve COCONet data and metadata from UNAVCO and serve as a geodetic seamless archive center through web services (GSAC-WS). CIMH, headquartered in Husbands, St. James, Barbados will serve the eastern circum-Caribbean region. Dr. Andrea M. Sealy is the principal investigator for the mirror data center award. CIMH is a Regional Meteorological Training Centre for the World Meteorological Organization (WMO) and part of the Caribbean Meteorological Organization (representing 16 countries in the Caribbean). The institute is well placed to serve as a mirror data center and to expand collaborations and integration of geodetic data for atmospheric and solid Earth sciences applications.

Instituto Nicaraguense De Estudios Territoriales **–** The Nicaraguan Institute for Terrestrial Studies (Instituto Nicaraguense De Estudios Territoriales, INETER) received a grant to develop a mirror data center to host and serve COCONet data and metadata from UNAVCO and serve as a geodetic seamless archive center through web services (GSAC-WS). INETER, headquartered in Managua, Nicaragua will serve the western circum-Caribbean region. Dr. Jose Armando Saballos is the principal investigator for the mirror data center award. INETER provides research, data, education, and support for all hazards in Nicaragua, especially volcanic unrest, earthquakes, and severe weather. Their diverse talents in all fields of geoscience research and observations and their established data services make the INETER an excellent site for a mirror data center.

Colombian Geological Survey – The Colombian Geological Survey, Center for Processing and Analysis of Geodetic Data received a grant to develop a regional data center (RDC) headquartered in Bogota, Colombia and serve the entire circum-Caribbean community. The RDC functions as a mirror for COCONet data and metadata with capabilities for local data and metadata management, such as downloading stations and archiving GNSS data. Dr. Hector Mora-Paez serves as the principal investigator for the RDC award. Dr. Mora-Paez directs the GNSS GEORED Project at the Colombian Geological Survey. The project, the institution, and the investigators are well suited to host a regional data center with capabilities to support longer-term integration and dissemination of geodetic data for research and broader impacts.

UNAVCO will continue to provide hardware, software, and training as needed to operate these sites. The centers will support open access to data, data integration, high impact research and graduate-level training in the Earth sciences in the circum-Caribbean region where there is a significant need for more expertise and study to meet immediate concerns and provide longer-term benefits to the COCONet community. The benefits include but are not limited to, educational advancement; professional workforce development; hazards preparedness, response and mitigation; development and planning; and understanding and living with Earth processes.

What is the impact on technology transfer?

See above.

What is the impact on society beyond science and technology?
Nothing to report.

Changes/Problems

Changes in approach and reason for change
Nothing to report.

Actual or Anticipated problems or delays and actions or plans to resolve them

Currently in grantee-approved NCE to complete scope as originally planned.

Changes that have a significant impact on expenditures
Nothing to report.

Significant changes in use or care of human subjects
Nothing to report.

Significant changes in use or care of vertebrate animals
Nothing to report.

Significant changes in use or care of biohazards
Nothing to report.

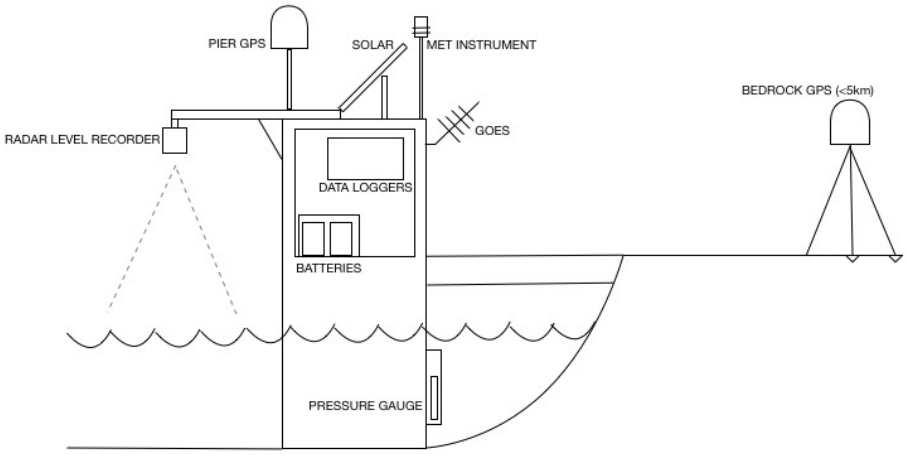

Figure 1: Schematic of COCONet GPS-constrained Tide Station.

Figure 2: UNAVCO engineer Keith Williams installing the GOES satellite antenna.

Figure 3: Final layout of Port Royal Tide Gauge Pier.

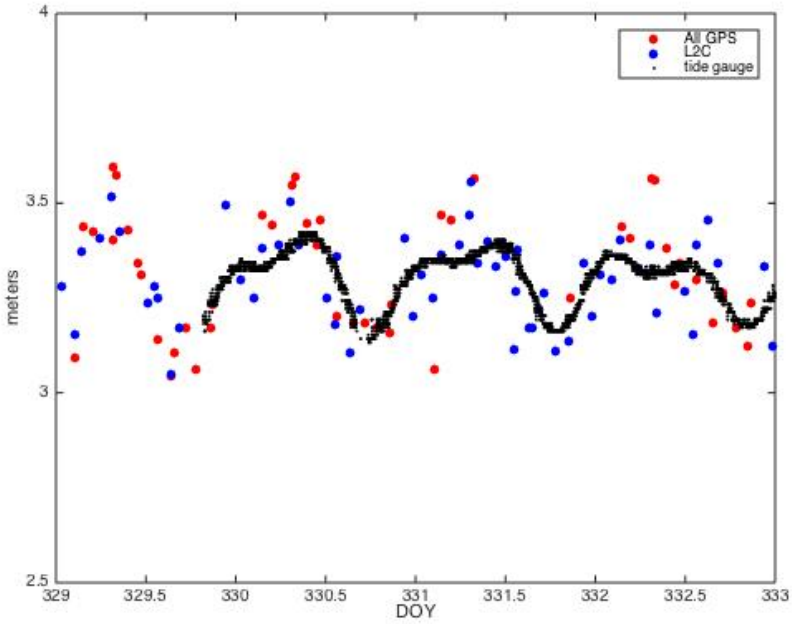

Figure 4: Measured reflection heights using1-Hz data from cGPS PRCG compared to 1 min radar gauge measurements at co-located PRTO.

Figure 5. UNAVCO engineer Korey Dausz installing radar level recorder mount.

Figure 6. Aerial view of Sombrero Island.

Figure 7. CN51 installed on top of the former barracks for the lighthouse staff.

Figure 8. Overview of TGDR cGPS station co-located with tide gauge.

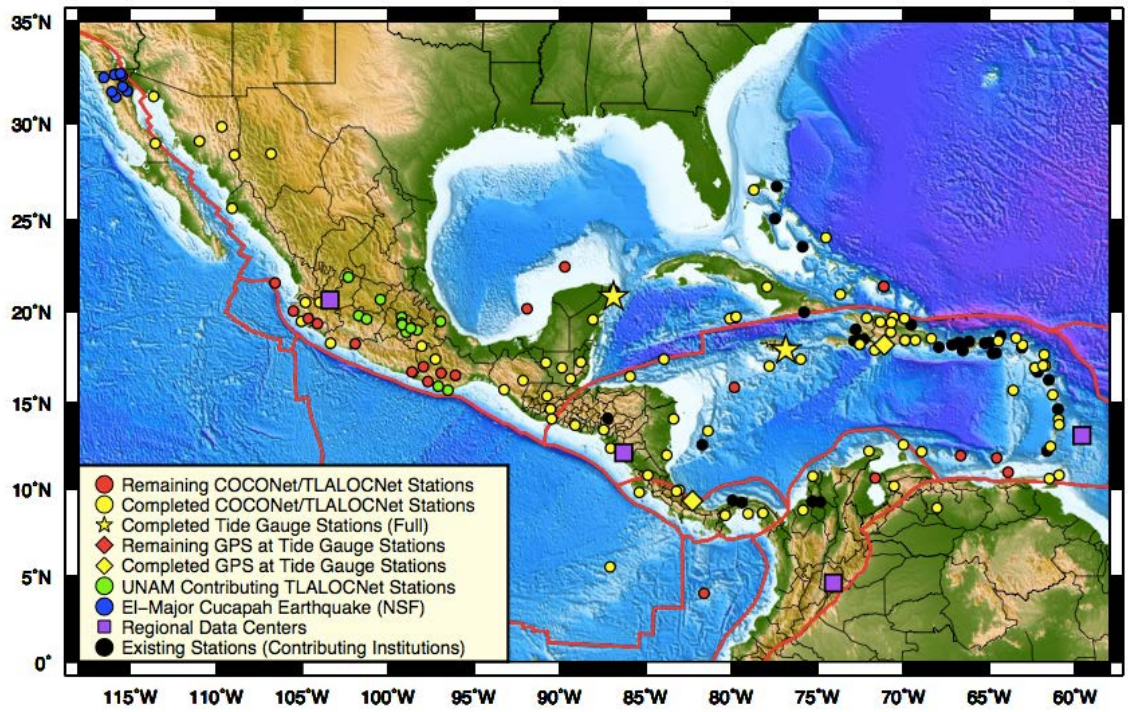

Figure 9. The current combined COCONet and TLALOCNet siting plan. Yellow dots represent the 74 completed COCONet stations (new and refurbished) and 13 completed stations from the TLALOCNet network. Red dots represent the 9 remaining planned COCONet stations (new and refurbished) and 12 planned TLALOCNet stations. The yellow stars represent the completed, full-tide gauge locations (with 2 additional GPS sites per location). The yellow diamonds represent existing tide gauge stations where 1 GPS station will be added to constrain the motion of the pier. The existing "contributing" GPS stations (n=41), which either already or are soon to be delivering data to the COCONet archive, are shown as black dots. The four regional data centers or mirrors are shown as purple squares (Mexico (TLN), and Nicaragua, Colombia, Barbados (CCN).

COCONet EAR 1042906/9 Annual Report

September 1, 2014 – August 31, 2015 (FY2015)

COCONET RELATED PUBLICATIONS FOR PROJECT YEAR 2015

The following publications and associated presentations at national and international meetings were completed (presenters in bold; student authors are underlined) were completed in FY2015-Q1 through FY2015-Q4:

Boler, F., Meertens, S. Wier, M. Rost, and J. Matykiewicz, 2015, Dataworks for GNSS – Data Management Software for Regional Networks, oral presentation at National Geophysical Workshops in Latin America Workshop, May 25-30, 2015, Santiago, Chile.

Boler, F., C. Meertens, S. Wier, M. Rost, and J. Matykiewicz, 2015, Dataworks for GNSS – Software Modules for Rapidly Standing Up Data Acquisition, Management, and Distribution for Local and Regional Scale Data Centers, poster presentation at National Geophysical Workshops in Latin America Workshop, May 25-30, 2015, Santiago, Chile.

Braun, J., ***Miller, M.M.***, ***Mattioli, G.***, ***Wang, G.***, ***Feaux, K.***, Rowan, L., and P. LeFemina, 2014, The Continuously Operating Caribbean Observational Network (COCONet): Supporting Regional Development of Geoscience Research Across the Circum-Caribbean, abstract PA23C-03 presented at the 2014 Annual Meeting of the AGU, San Francisco, CA, 15-19 December 2014.

Braun, J. and T. Van Hove, 2014, The Relationship between Sea Surface Temperature and Total Column Precipitable Water Vapor Across the Broader Caribbean (A41L-04), Session A41: Advances in Weather and Climate Science Enabled by Atmospheric Profilers and Ground-Based GNSS/GPS Techniques II, Fall AGU Meeting, Thursday, Dec 18, 2014.

Braun, J. and T. Van Hove, 2015, The Assessment and Validation of Atmospheric Water Vapor in Global Analysis and Forecasts Accross the Broader Caribbean (13B.6), 19th Conference on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS), American Meteorological Society Annual Meeting, Thursday, Jan 8, 2015.

Dausz, K., Dittmann, S., ***Feaux, K.***, von Hillebrandt-Andrade, C., ***Mattioli, G.***, and J. Normandeau, 2014, COCONet enhancements to circum-Caribbean tsunami warning, tidal, and sea-level monitoring: update on tide gauge installations, abstract OS33C-1082 presented at the 2014 Annual Meeting of the AGU, San Francisco, CA, 15-19 December 2014.

Feaux, ***K.***, 2015, PBO, COCONet and TLALOCNet: Multi-hazard observatories, enhancing geodetic infrastructure in the Caribbean and the Americas, Tenth Session of the Intergovernmental Oceanographic Commission (IOC) Intergovernmental Coordination Group for the Tsunami and other Coastal Hazards Warning System for the Caribbean and Adjacent Regions, May 13-15, 2015 in St Maarten

Herring, T., Floyd, M., King, R., Melbourne, T., Szeliga, W., Murray, M., Phillips, D., Puskas, C., Boler, F., Meertens, C., and ***G. Mattioli***, 2014, GPS data analysis and results from the Geodesy Advancing Geosciences and EarthScope (GAGE), abstract G13A-0511 presented at the 2014 Annual Meeting of the AGU, San Francisco, CA, 15-19 December 2014.

Mattioli, G.S., 2014, Using GPS Observations to Understand The Earth: Examples From PBO, COCONet, and TLALOCNet, Geological Society of America Abstracts with Programs. Vol. 46, No. 6, p. 442.

Meertens, C., F. Boler and ***M. Miller***, 2015, New Developments in Geodetic Data Management Systems forFostering International Collaborations in the Geosciences, PICO presentation by F. Boler at European Geosciences Union Meeting, April 13-17, 2015, Vienna, Austria.

Meertens, C., F. Boler, and ***M. Miller***, 2014, International Collaborations Fostering Data Discovery and Access of Geodetic Data for the Geosciences, AGU Fall Meeting, San Francisco, CA, 15-19 December 2014.

Meertens, C. and F. Boler, 2015, EarthCube International: Extending Geodetic Data Management Systems to Foster Global Collaborations in the Geosciences, paper presented at the EarthCube All-hands-meeting, Arlington, VA, 27-29 May 2015.

Mencin, D., K. Hodgkinson, ***J. Braun***, C. Meertens, ***G. Mattioli***, D. Phillips, F. Blume, H. Berglund, O. Fox, and ***K. Feaux***, On the Development of Multi-Hazard Early Warning Networks: Practical experiences from North and Central America, EGU General Assembly 2015 (17256): HS4.6/NH1.2, Vienna, Austria, April 2015.

Miller, M. , 2015, New geodetic tools for observing global variations in relative and absolute sea level rise, Proceedings of the Asia Oceania Geosciences Society, 2 to 7 August 2015, Singapore, OS05-IG07-D4-PM2-P-011 (OS05-IG07-A017).

Miller, M., Boler, F., and C. Meertens, 2015, Network of Geodetic Networks for the Western Americas, oral presentation at National Geophysical Workshops in Latin America Workshop, May 25-30, 2015, Santiago, Chile.

Phillips, D.A., K. Hodgkinson, D. Mencin, K. Austin, O. Fox, H. Berglund, F. Blume, and ***G. Mattioli***, 2015, Real-Time GPS Data from the EarthScope Plate Boundary Observatory (PBO) and Related Networks, presented at 2015 EarthScope National Meeting, Stowe, VT, June 14-17, 2015.

Russell, J.B., ***Braun, J.J.***, and ***G.S. Mattioli***, 2014, Using GPS Signal-To-Noise Ratio (SNR) Observations to Detect and Characterize the Volcanic Plume Associated with the 2003 Soufrière Hills Volcano Dome Collapse, Geological Society of America Abstracts with Programs. Vol. 46, No. 6, p. 141.

Journal Articles published:

Douilly, R., H. Aochi, E. Calais; A. M. Freed, 2015, 3D Dynamic Rupture Simulations Across Interacting Faults: The Mw7.0, 2010, Haiti Earthquake. J. Geophys. Res. Solid Earth, 120, DOI: 10.1002/2014jb011595 10.1002/2014jb011595.

Ellis, A. P., C. DeMets, P. Briole, E. Molina, O. Flores, J. Rivera, C. Lasserre, H. Lyon-Caen, and N. Lord, 2015, Geodetic slip solutions for the Mw = 7.4 Champerico (Guatemala) earthquake of 2012 November 7 and its postseismic deformation, Geophys. J. Int., 201 (2): 856-868 doi:10.1093/gji/ggu484.

Geirsson, H., LaFemina, P. DeMets, C., Hernandez, D., ***Mattioli, G.***, Rogers, R., Rodriguez, M., Marroquin, G., and V. Tenorio, 2015, The August 27, 2012 Mw7.3 El Salvador earthquake: Expression of weak coupling on the Middle America subduction zone, *Geophys. J. Int*., v. 202, p 1677-1689, doi: 10.1093/gji/ggv244.

Symithe, S., E. Calais, J. B.de Chabalier, R. Robertson, and M. Higgins, 2015, Current block motions and strain accumulation on active faults in the Caribbean, J. Geophys. Res. Solid Earth, 120, doi: 10.1002/2014JB011779.

Weber, J. C., H. Geirsson, J. L. Latchman, K. Shaw, P. La Femina, S. Wdowinski, M. Higgins, C. Churches, and E. Norabuena, 2015, Tectonic inversion in the Caribbean-South American plate boundary: GPS Geodesy, Seismology, and Tectonics of the Mw 6.7 April 22, 1997 Tobago earthquake, Tectonics, 34, doi:10.1002/2014TC003665

Wright V, Hornbach M, McHugh C and Mann P, in review. Factors Contributing to the 2005-present Rapid Rise in Lake Levels, Dominican Republic and Haiti (Hispaniola). Journal of Natural Hazards.

^Uses data from cGPS sites that are now supported in part by COCONet award

COCONet PIs shown in ***bold italics***

COCONET RELATED PUBLICATIONS FOR PROJECT YEAR 2014

The following publications and associated presentations at national and international meetings were completed (presenters in bold; student authors are underlined) were completed in FY2013-Q4 through FY2014-Q3:

Medina, R.B., G.S. Mattioli, and J.J. Braun, 2013, Optimization of kinematic GPS data analysis for large surface deformation from the July 2003 dome collapse at Soufrière Hills volcano, Montserrat, Geological Society of America Abstracts with Programs. Vol. 45, No. 7, p. 564.

Geirsson, H., P.C. La Femina, C. DeMets, D.A. Hernandez, G.S. Mattioli, R. Rogers, and M. Rodriguez, 2013, Geodetically resolved slip distribution of the 27 August 2012 Mw=7.3 El Salvador earthquake , Abstract G23B-0793 presented at the 2013 Annual Meeting of the AGU, San Francisco, CA, 9-13 December 2013.

Stamps, D.S., D.J. Charlevoix, E. Calais, A. Freed, E. Chaussard, and G.S. Mattioli, 2014, Education and Community Engagement in Response to the 2010 Haiti Earthquake from a Young Investigator's Perspective, 2014 UNAVCO Science Workshop, Broomfield, CO, March 4-6, 2014.

Mattioli, G.S., J. Miller, C. DeMets, and P. Jansma, 2014, Rigidity and definition of Caribbean plate motion from COCONet and campaign GPS observations, EGU General Assembly 2014 (14546): GD6.6/GMPV25/TS7.12, Vienna, Austria, April 2014.

Journal Articles published:

Adams, Dave, K., C. Minjarez, Y. Serra, A. Quintanar, L. Alatorre, A. Granados, E. Vazquez, ***J. Braun***, 2014, Mexican GPS Tracks Convection from North American Monsoon, EOS Trans. AGU, DOI:10.1002/2014EO070001.

^Elsworth, D, R. Foroozan, J. Taron, ***G.S. Mattioli***, and Barry Voight, 2014, Geodetic Imaging of Magma Migration at Soufrière Hills Volcano 1995-2008, *Chapter 12: The Eruption of Soufiere Hills Volcano, 15 years on*, (G. Wadge, ed.), Geological Society, London, Memoirs 2014, v.39; p219-227, doi: 10.1144/M39.12.

^Odbert, H.M., G.A. Ryan, ***G.S. Mattioli***, S. Hautmann, J. Gottsmann, N. Fournier, R. Herd, and A. Linde, 2014, Volcano geodesy at Soufrière Hills Volcano: a review, *Chapter 11: The Eruption of Soufiere Hills Volcano, 15 years on*, (G. Wadge, ed.), Geological Society, London, Memoirs 2014, v.39; p195-217, doi: 10.1144/M39.11.

^Uses data from cGPS sites that are now supported in part by COCONet award

COCONet PIs shown in ***bold italics***

COCONET RELATED PUBLICATIONS FOR PROJECT YEAR 2013 (PREVIOUSLY REPORTED)

The following publications and associated presentations at national and international meetings were completed:

Feaux, K. F. and Normandeau, J., J. J. Braun, E. Calais, K. Dausz, B.T. Friesen, G.S. Mattioli, M. M. Miller, E. Seider, and G. Wang (2012), COCONet (Continuously Operating Caribbean GPS Observational Network): Network Status and Project Highlights, Abstract T41A-2556 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec.

Puskas, C. M., D.A. Phillips, G.S. Mattioli, C.M. Meertens, T. Herring, M.H. Murray, T. Melbourne, F.M. Boler, G. Blewitt, K. Larson, K. Feaux, J. Braun, E.E. Small (2012), UNAVCO Enhanced data products for the EarthScope Plate Boundary Observatory, COCONet, and other regional networks, Abstract G23B-0916 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec.

Miller, J.A., G.S. Mattioli, and S.A. James, 2012, 2011-2012 Campaign GPS Geodetic Monitoring of Surface Deformation, Dominica, Lesser Antilles, Abstract G41A-0892 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec. 2012.

Braun, J. J., T. Van Hove, The Application of COCONet to Determine Water Vapor Variability in the Caribbean; Poster, 93 Annual AMS Meeting, Austin, TX, AMS, Jan 8, 2013.

Braun, J.J., T.M. Van Hove (2012), The Application of COCONet to Determine Water Vapor Variability in the Caribbean (Invited), Abstract A53S-06 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec.

Medina, R.B., G.S. Mattioli, and J.J. Braun, 2012, An Analysis of GPS and Remote Sensing Data of Soufrière Hills Volcano, Montserrat, during the July 2003 Dome

Collapse: Implications for Detection of Ash Plumes and Vertical Deformation, Abstract V33E-07 presented at 2012 Fall Meeting, AGU, San Francisco, Calif., 3-7 Dec. 2012.

The following publications, presentations, and/or meetings were either completed, submitted, or accepted for publication in FY2013-Q1:

Mattioli, G. S., J. J. Braun, E. Calais, K. Dausz, K. Feaux, B. T. Friesen, M. M Miller, J. Normandeau, E. Seider, and G. Wang, 2012, COCONet (Continuously Operating Caribbean GPS Observational Network): Goals, Network Status, Revised Scope, and Project Highlights, SIRGAS2012, Abstracts and Program SIRGAS Annual Mtg., Concepcion, Chile, Oct. 2012.

Braun, J. J., K. Feaux, B. Friesen, G.S. Mattioli, M. M. Miller, J. Normandeau, E. Seider, and G. Wang, 2012, COCOnet (Continuously Operating Caribbean GPS Observational Network): Infrastructure Enhancements To Improve Sea Level Monitoring, Paper No. 212178, Geological Society of America Abstracts with Programs. Vol. 44, No. 7, p.229.

Protti, M., V. Gonzalez, J. Freymueller, S. Doelger, 2012, Isla del Coco, on Cocos Plate, converges with Isla de San Andrés, on the Caribbean Plate, at 78mm/yr, Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN--0034--7744) Vol. 60 (Suppl. 3): 33--41.

Third Quarter Report

The following student presentations (with student authors underlined below) at the AGU Meeting of the Americas in May 2013 were supported in part by COCONet resources in FY2013-Q3:

A model of short-term surface deformation of Soufriere Hills Volcano, Montserrat, constrained by GPS geodesy, Erin E. McPherson; Glen S. Mattioli

Updated velocity field for the Caribbean plate from COCONet GPS observations, *Jamie A. Miller; Glen S. Mattioli; Pamela E. Jansma*

On the motion of the Caribbean relative to South-America: New results from GPS geodesy 1999-2012, *Roberto De La Rosa; Julio Marquez; Mizael Bravo; Yuleika Madriz; David Mencin; Steven G. Wesnousky; Peter H. Molnar; Roger Bilham; Omar J. Perez*

Asymmetrical and heterogeneous elasto-static deformation along the El Pilar Fault in Northeastern Venezuela, *Carlos Reinoza; François Jouanne; Franck A. Audemard; Christian Beck*

Coseismic Coastal Uplift from the 2012 Mw7.6 Nicoya Earthquake, Costa Rica: Implications of Megathrust Rupture for Fore Arc Morphotectonics, *Jeffrey Marshall; Shawn Morrish; Andrew V. Newman; Marino Protti*

Geomorphologic Features and Age Estimation of Submarine Landslides in the Southwestern Colombian Caribbean*, Javier Idarraga Garcia; Carlos A. Vargas-Jimenez*

Flexural Thickness Variations of the Maracaibo Block, *Mariano S. Arnaiz-Rodriguez; Franck A. Audemard*

Passive Tomography of the Caribbean Using Surface Waves Extracted from Ambient Noise, *Francisco J. Hernandez; Alberto M. Lopez; Eugenio Asencio*

The Contributions of Seismogeodesy to Earthquake and Tsunami Early Warning *Diego Melgar; Brendan W. Crowell; Jianghui Geng; Yehuda Bock; Jennifer S. Haase*

The following additional presentations (presenters in bold; student authors are underlined) were completed in FY2013-Q3:

Geological Society of America Southeastern Section March 2013

COCONet (Continuously Operating Caribbean GPS Observational Network): Status of the Network to Support Geodetic and Atmospheric Investigations and Sea Level Monitoring, *J. J. Braun, Eric Calais, Karl Feaux,* ***Glen Mattioli****, M. Meghan Miller, J. Normandeau, John Sandru and Guoquan Wang*

European Geosciences Union Meeting April 2013

UNAVCO GPS High-Rate and Real-Time Products and Services: Building a Next Generation Geodetic Network, ***David Mencin****, Charles Meertens, Glen Mattioli, Karl Feaux, Sara Looney, Charles Sievers, and Ken Austin*

AGU Meeting of the Americas May 2013

Co-seismic deformation of the August 27, 2012 Mw 7.3 El Salvador and September 5, 2012 Mw 7.6 Costa Rica earthquakes, ***Halldor Geirsson****; Peter C. La Femina; Charles DeMets; Glen S. Mattioli; Douglas Antonio Hernández*

A Stable Reference Frame for Landslides Study in the Puerto Rico and Virgin Islands Region, ***Guoquan Wang***

COCONet (Continuously Operating Caribbean GPS Observational Network) - A multihazard GPS/Met observatory: Enhancing geodetic infrastructure and the scientific community in the Caribbean, ***Karl Feaux****; John J. Braun; Eric Calais; Glen S. Mattioli; M Meghan M. Miller; James Normandeau; John Sandru; Guoquan Wang*

Early implications of the COCONet GPS velocity field for studies of plate and microplate motions in the Caribbean, ***Charles DeMets***

GPS-derived slip rates of active faults in eastern Venezuela, along the southeastern Caribbean PBZ, ***Franck A. Audemard****; Christian Beck; Francois Jouanne; Carlos E. Reinoza*

Co- and Post-seismic deformation after the 2012 Mw 7.6 Costa Rica Earthquake from Continuous GPS observations, ***Rocco Malservisi****; Timothy H. Dixon; Marino Protti; Victor Gonzales; Susan Y. Schwartz; Andrew V. Newman; Stephen R. McNutt*

Isla del Coco, on Cocos Plate, Converges with Isla de San Andrés, on the Caribbean Plate, at 78 mm/yr, ***Marino Protti****; Victor M. Gonzalez; Jeffrey T. Freymueller; Sarah Doelger*

COCONet Atmospheric Data Products: An Initial Assessment, ***John J. Braun****; Teresa M. Van Hove; Glen S. Mattioli; Karl Feaux; James Normandeau*

The UNAVCO role in planning, building, and maintaining geodetic infrastructure across the Americas: update on PBO, COCONet, and TLALOCNet, ***Glen S. Mattioli***; *John J. Braun; Enrique Cabral; Eric Calais; Charles DeMets; Karl Feaux; David Mencin; M Meghan M. Miller; James Normandeau; Yolande Serra; Guoquan Wang*

An update on UNAVCO/COCONet High Frequency Real-Time Products: Towards a next generation multi-hazard network, ***David Mencin***; *Glen S. Mattioli; Karl Feaux; Sara Looney; Charles Sievers; Charles M. Meertens*

Seventeen Years of Geodynamic Monitoring of a Seismic Gap that was Partially Filled by the Nicoya, Costa Rica, Mw=7.6 Earthquake of September 5th, 2012, ***Marino Protti***; *Victor M. Gonzalez; Susan Y. Schwartz; Timothy H. Dixon; Andrew V. Newman; Paul Lundgren; Yoshi-Yuki Kaneda; Teruyuki Kato*

Static and Dynamic Rupture-History of the Nicoya (Mw=7.6) Earthquake, Costa Rica: An approach using high frequency rate GPS and seismological recordings in the near field, ***Victor Gonzales Salas***; *Marino Protti; Esteban J. Chaves Sibaja; Floribeth Vega; Walter Jimenez*

Slow Slip Event and Interseismic Strain Accumulation in the Nicoya Peninsula, Costa Rica, ***Yan Jiang***; *Robert McCaffrey; Timothy H. Dixon; Shimon Wdowinski; Marino Protti; Victor M. Gonzalez*

Source rupture process of the 5 September 2012 Costa Rica Mw=7.6 thrust event from joint inversion of high-rate GPS, strong motion, and teleseismic P wave data, ***Thorne Lay***; *Han Yue; Luis A. Rivera; Susan Y. Schwartz; Marino Protti*

Delineating and Defining the Boundaries of an Active Landslide in the Rainforest of Puerto Rico Using a Combination of Airborne and Terrestrial LIDAR Data, ***Guoquan Wang***; *James Joyce; David A. Phillips; Ramesh L. Shrestha; William E. Carter*