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# COCONet EAR 1042906/9 Quarterly Report

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March 2013 - May 2013 (FY2013-Q3)

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## SUMMARY

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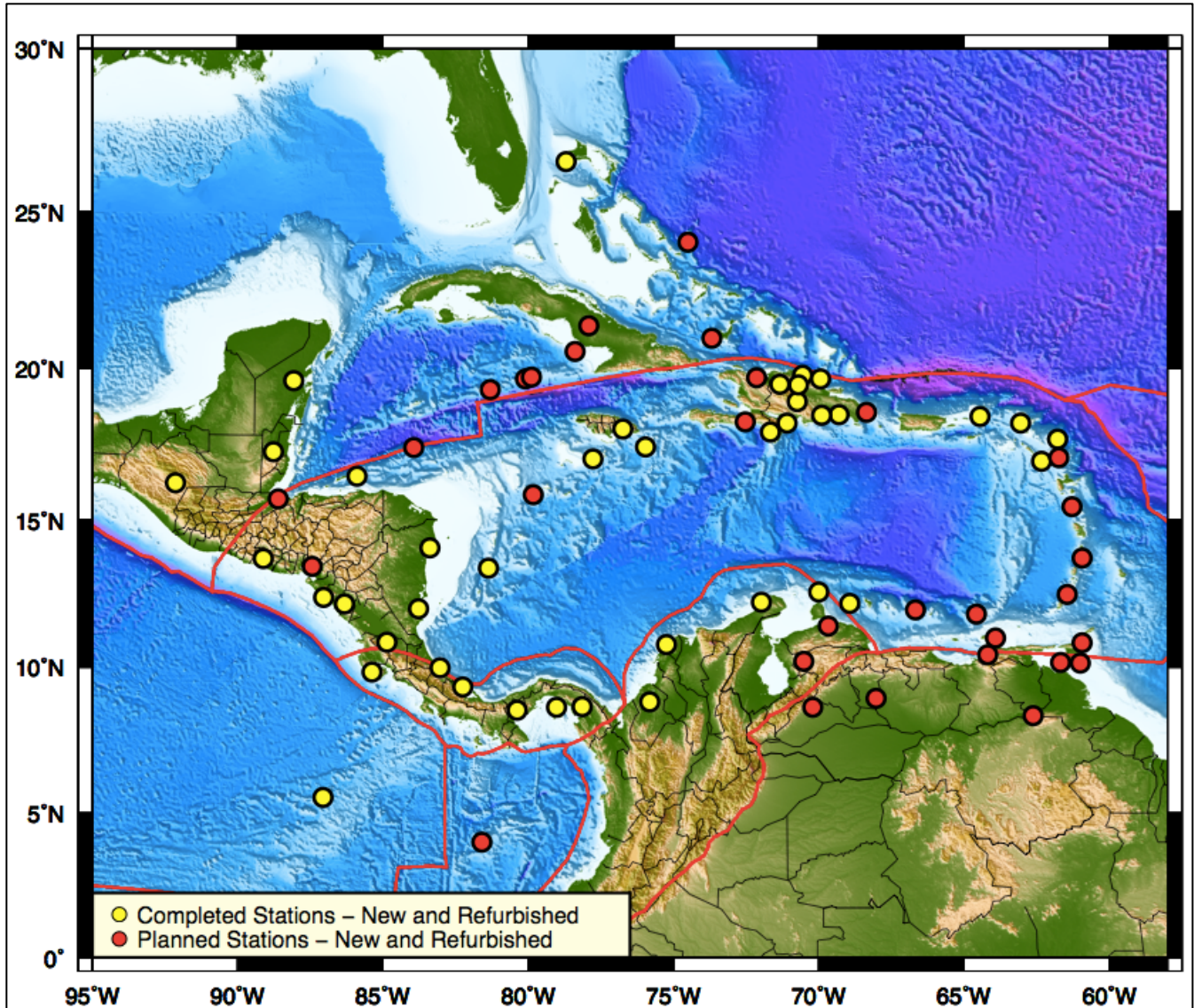
This quarterly report covers COCONet project (EAR-1042906/EAR-1042909) activities for the time period from March 1, 2013 to May 31, 2013. COCONet is a Collaborative Research project between UNAVCO (EAR-1042906) and University Corporation for Atmospheric Research (UCAR) (EAR-1042909) awarded on September 14, 2010. The project is under the direction of M. Meghan Miller, as PI, with Co-PIs Guoquan Wang, Glen Mattioli, and Karl Feaux. Glen Mattioli is acting as Project Director in his role as Director of Geodetic Infrastructure at UNAVCO and John Braun is the UCAR PI.

Most of the effort during this reporting period included reconnaissance, permitting, installation and maintenance activities related to the siting plan developed at the June 2011 Port of Spain siting meeting and four siting committee meetings held during the past two years. Specifically, refurbishment of the Roatan station, located on an offshore island of Honduras and new station installations in Panama and Anguilla were among the operations highlights during the last quarter. UNAVCO engineering personnel have performed site reconnaissance at 63 locations in 25 countries, submitted land use permits for 56 sites, received permits for 53 sites, and currently have 40 stations installed (Figure 1, yellow dots).

The Spanish version of the final report for the COCONet Data and Research Workshop, which was held in Tulum, Mexico October 24-26, 2012, was posted to the COCONet website and can be viewed at: <http://coconet.unavco.org/lib/downloads/COCONet-3-Espanol.pdf>. The completion of this document was a critical COCONet project milestone. Efforts are now underway to address the concerns and suggestions provided by the COCONet 3<sup>rd</sup> workshop participants.

In April 2013, Dr. Franck Audemar (La Fundación Venezolana de Investigaciones Sismológicas) and Dr. Omar Perez (Simon Bolivar University) met with UNAVCO staff and Dr. Roger Bilham (University of Colorado) in Boulder, CO to discuss issues related to the upcoming reconnaissance of four refurbished stations and the installation of 5 new stations in Venezuela. Topics for discussion included shipping of equipment to Venezuela, safety considerations related to planned fieldwork, and logistics. In addition, photos from Aves Island were reviewed in detail to assess a potential location and monument type were prior to future reconnaissance at this critical location, which is 210 km west of the Leeward Islands in the Caribbean. This site is critical for both the solid Earth and atmospheric science objectives of COCONet.

June 18, 2013



**Figure 1.** The current COCONet siting plan. This plan results from the siting meetings in Puerto Rico and Trinidad, as well as four siting committee teleconferences held during 2011 and 2012. Yellow dots represent the 40 completed COCONet stations (new and refurbished), red dots represent the 31 planned stations (new and refurbished). The existing stations (61+) that will deliver data to the COCONet archive and the 6 additional cGPS stations (locations TBD) associated with the tide gauge installations are not shown in this map.

### **COCONET HIGHLIGHT: NEW STATION INSTALLED IN ANGUILLA**

In May of 2013, UNAVCO Field Engineers John Sandru and Mike Fend traveled to Anguilla to install a new COCONet station (CN02) near the Anguilla Wallblake Airport. With assistance from the Anguillan government, UNAVCO installed a continuous GPS/MET station on the island, which is one of the most northerly of the Leeward Islands in the Lesser Antilles, lying east of Puerto Rico and the Virgin Islands, and directly north of Saint Martin. The main island

of Anguilla is approximately 16 miles (26 km) long by 3 miles (5 km) wide at its widest point. This is the most northeastern COCONet site to be installed. The Anegada Passage, separates Anguilla from the British Virgin Islands. The 40-mile-wide (65 km) channel connects the Atlantic Ocean with the Caribbean Sea. This site will provide important GPS/Met observations to test tectonic models of the opening of the Anegada Passage and to refine models for secular motion of the Caribbean plate as well as generating new and potentially leveraging observations related to hurricanes and tropical storms that initiate in the Atlantic Ocean and transit into the Caribbean Sea.



**Figure 2.** UNAVCO Field Engineer John Sandru passes CN02 (Anguilla) station key to Anguillan Airport Maintenance Supervisor Edwin Carty. Photo by Mike Fend (UNAVCO).

## FIELD OPERATIONS SUMMARY

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In addition to the CN02 station installation, the following field operation milestones were completed during the last three months:

June 18, 2013

- US State Department issued an export license for installation of UNAVCO GPS equipment in Cuba. The installation will occur as soon as final pre-clearance with Cuban customs officials is finalized.
- In May, Jim Normandeau completed the COCONet upgrade at Roatan in Honduras (ROA0).
- Reconnaissance activities were initiated for 2 tide gauge locations in Anguilla and the Yucatan Peninsula in Mexico (see additional information below).
- In late May-early June, UNAVCO field engineers Abe Morrison and Mike Fend completed the installation of COCONet station CN19 in Aruba.



*Tide Gauge reconnaissance report:*

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 and will bring this to the COCONet Working Group for recommendations in the next quarter. In addition UNAVCO has performed two reconnaissance activities of existing tide gauges during the course of normal COCONet operations in Cancun Mexico and Anguilla.

Figure 3. UNAVCO staff visited possible tide gauge site in Yucatan while attending the AGU MOA meeting in Cancun, MX in May 2013.

Additional details related to COCONet field activities this quarter may be found in Table 1 below.

	<b>Cumulative</b>	<b>Since Previous Quarter</b>	<b>Details From Current Quarter</b>
Station Recons	63	4	
Permits Submitted	56	0	
Permits Accepted	53	0	
Stations Installed New / Refurbished	30 new 10 refurbished	2 new 1 refurbished (Honduras)	Aruba (CN19-new), Anguilla (CN02-new), Roatan (ROA0-refurb)
Data Flow	New/Refurbished: 36 Existing: 49	New/Refurbished: 3 Existing: 10	
Maintenance Visits	12	0	
Next Quarter Projection	Recons: 4, Permits: 2, New Installs: 6, Refurbishments: 3 Maintenance: 5		

**Table 1.** COCONet Status: Tasks completed to date and in FY2013-Q2.

## 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 has rejected the location of three new stations (St. Croix, Cayman Islands, Guanaja) and approved the addition of 2 new or refurbished sites (Aruba, Panama-Bocas Island) and 7 refurbished stations to the plan. At this time, the current siting plan calls for 49 new stations, 22 refurbished stations 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.

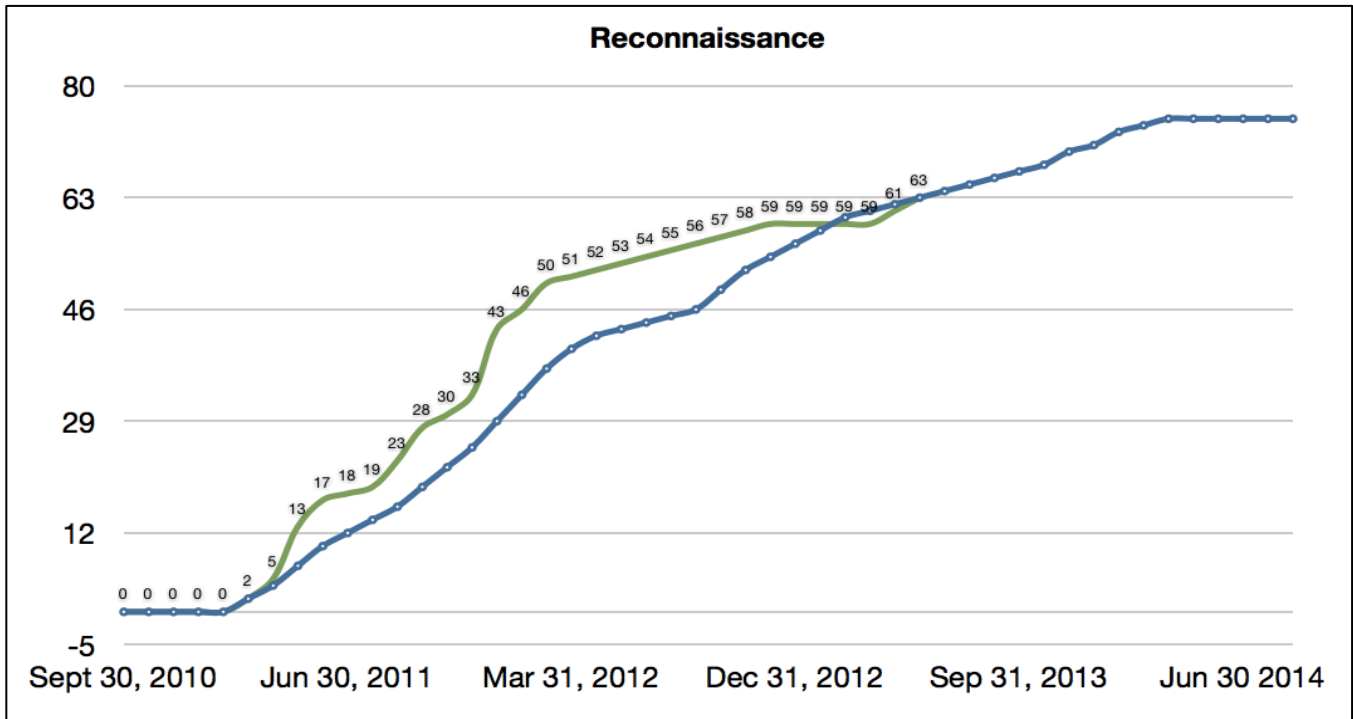
Level 1 GPS data products include quality checked RINEX files. At the time of this report, Level 1 GPS data are available from 85 COCONet stations (Table 1-Data Flow). Level 2 GPS data products include station position solutions, station position time series, station position velocity estimates, and tropospheric delay parameters. Level 2 products are produced by the Plate Boundary Observatory (PBO) Analysis Centers (AC's) and 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 83 COCONet stations. Note: data products may not be available from all stations installed at the time of this report due to communication issues or other reasons, such as the station being recently built and the data not yet being available for archiving or analysis.

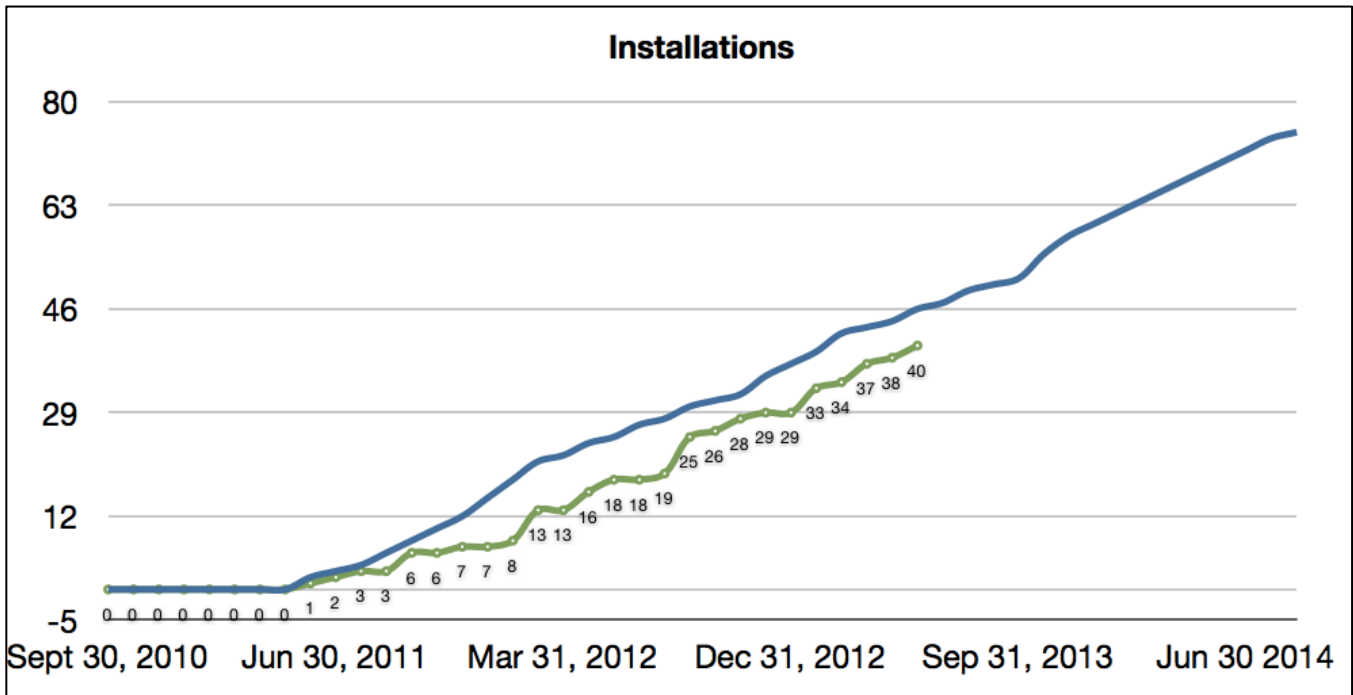
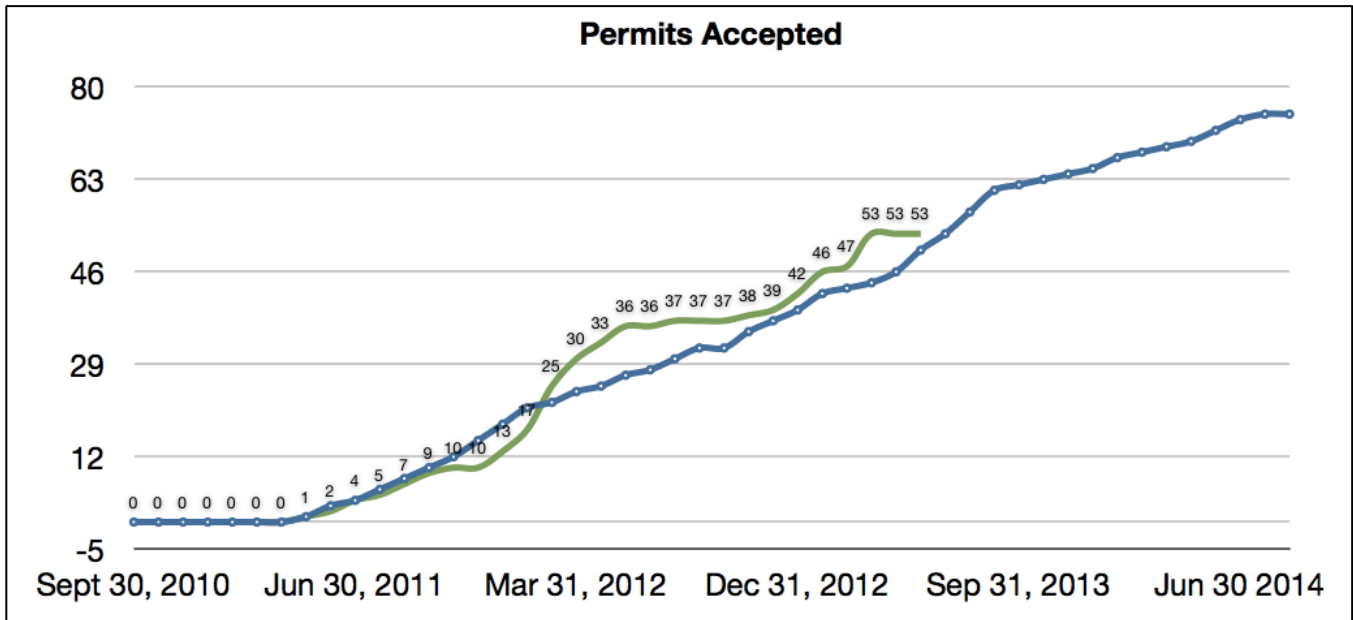
Seven stations are currently configured to deliver high-rate, low-latency (1 Hz, < 2 s) data streams in real-time via the Networked Transport of RTCM via Internet Protocol (NTRIP). These data and derived data products are now being incorporated into the World Meteorological Organization’s (WMO) Global Telecommunications System (GTS).

**BUDGET AND SCHEDULE**

The revised schedule includes at least 49 new station installations, 22 refurbished stations, and contribution of data from at least 61 existing stations. Refurbished stations are defined as stations that were operated by a regional partner and were working previously, but now require some equipment upgrades to become compatible with COCONet standards. Existing stations are assumed to require no additional hardware to be compatible with the COCONet network. The installation schedule was extended to four years, given the delay in starting the field component of the project, because of the need to refine the siting plan in light of new information that was not available at the time that the proposal was developed and submitted to NSF in 2010.

Overall the project is ahead of schedule in reconnaissance and permitting while slightly behind schedule in station installations (Figures 3-5). The projection for the next quarter is to install or upgrade at least 9 new/refurbished stations, which would put the project back on schedule for installations.

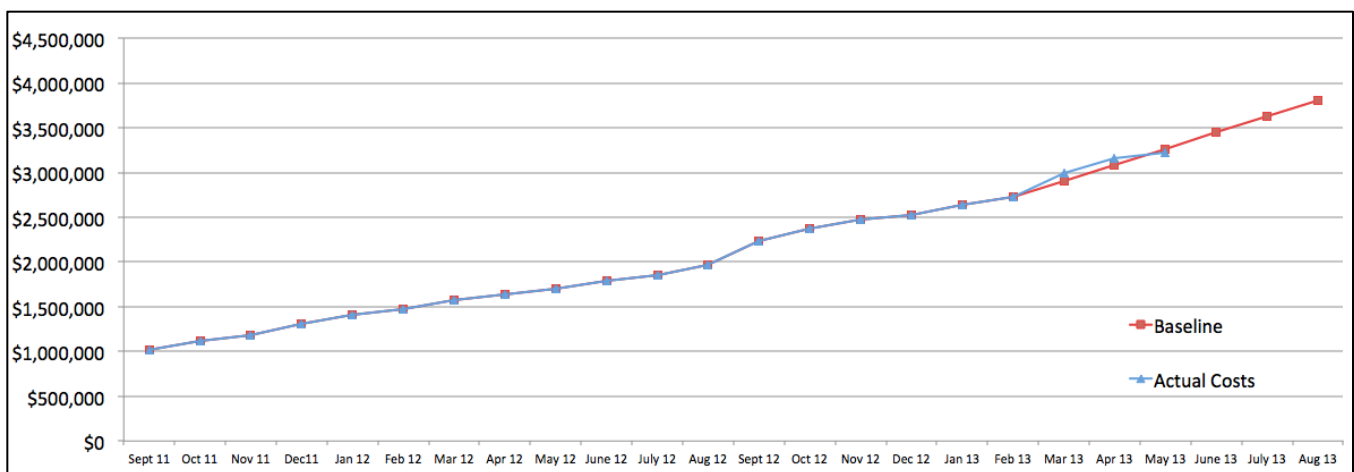




Figures 4-6. COCONet Reconnaissance, Permitting, and Installations: Plan (blue line) vs. Actual (green line).

COCONet expenditures are over \$3.2M through the end of May 2013 (Figure 7). During the last quarter, a schedule and budget re-baseline of the original project plan was developed which includes the following proposed changes: 1) the addition of modest support for the Project Director, G. Mattioli, at 0.3 calendar months/year; 2) placement of costs associated with K. Feaux's Project Management from the Other Professionals category to Senior Personnel to reflect his appointment as Co-PI; 3) inclusion of revised scope to install two

platinum-grade tide gauge sites within the COCONet footprint for sea level monitoring and for tsunami hazard mitigation; 4) a revised plan to rescope the remaining \$350K of unused funds originally budgeted for a subaward from UNAVCO to Purdue University. The revised plan for re-scoping the Purdue subaward includes: a) funding for at least 2 COCONet Science Fellows, with one focused on solid Earth and the other focused on atmospheric processes, the selection of which will be completed through a community-wide, open competition; b) support for funding face to face meetings in FY2014 and FY2015 for the four newly constituted COCONet working groups; c) modest additional funding to allow additional community participation for the two COCONet-related PASIs, which occur in May 2013; and d) funding to support enhanced skills development through a visitor program at UNAVCO in Boulder for COCONet regional partner or stakeholder staff engineers or technicians; 5) a revision of expected costs for field engineering travel, equipment and material shipments, and data communications for the new and refurbished COCONet sites, which is consistent with the current installation schedule and approved siting plan; and 6) the allotment of \$100K for 1-2 regional data centers, as per the recommendations from the COCONet 3rd Workshop report.



**Figure 7.** Total project actual costs vs. budget from September 30, 2011 – May 31, 2013, reflecting the project re-baseline. Red line is the re-baseline budget and blue line is actual UNAVCO expenditures.

## EDUCATION, OUTREACH, AND COMMUNITY ENGAGEMENT

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:

- Completion of two successful Pan American Advanced Studies Institute (PASI) short courses involving COCONet facilities, data, and partners. The May 2013 PASI in Leon, Nicaragua, covered Magma-Tectonic Interactions in the Americas. The June 2013 PASI in Cartagena, Colombia, covered Atmospheric Processes in Latin America and the Caribbean: Observations, Analysis, and Impacts (see UCAR report below). Both short courses were oversubscribed and included researchers from more than 10 different countries. The atmospheric course was able to leverage virtual meeting services and



accessible online content to allow additional researchers who could not attend the course in person to participate in segments of the course. Both courses will be archived online at the COCONet website in the near future and interested researchers can access the training on their own time.

- 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.
- 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. Initial feedback on the newsletter has been positive.
- COCONet partners organized a well-attended full day session on COCONet research at the AGU Meeting of the Americas in Cancun, Mexico in May 2013. In addition, COCONet sponsored 8 students to present their COCONet-related research at AGU-MOA.
- COCONet support for Research Experiences in Solid Earth Science for Students (RESESS) intern Rachel Medina for the summer semester of 2013 will allow her to learn more about processing GPS data while conducting research on the apparent large vertical displacement at Soufriere Hills Volcano, Montserrat after a major dome collapse in 2003. Rachel will work with Dr. Glen Mattioli and Dr. John Braun (research advisors) plus Dr. Norgaard Rolf (RESESS Writing Workshop Instructor), Dr. Aisha Morris (RESESS Director), and Dr. Linda Rowan (writing mentor).
- Development of a prestigious COCONet Fellowship Award that will support two graduate students to conduct research toward an advanced degree at a U.S. institution using COCONet resources starting as early as August 2013. The fellowships will help to develop the next generation of geodesists with a focus on building human capacity among the more than 30 nations that are part of the COCONet community.
- COCONet Working Group 4: Community Engagement and Outreach has been organized and approved by the COCONet Steering Committee. The volunteer members of Working Group 4 include Franck Audemard, Venezuelan Foundation for Seismological Research, Carlos Fuller, Caribbean Community Climate Change Centre, Leslie Jason Hodge, Department of Lands and Surveys, Anguilla, Peter Dare, University of New Brunswick and Daniel Lao Davila, Oklahoma State University. The Working Group will promote COCONet in scientific and non-scientific communities.

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

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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; Mizaël 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*

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**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*

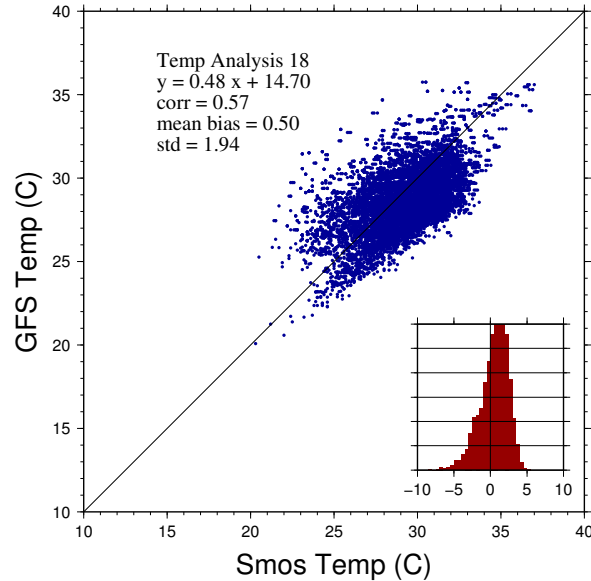
## UCAR UPDATE

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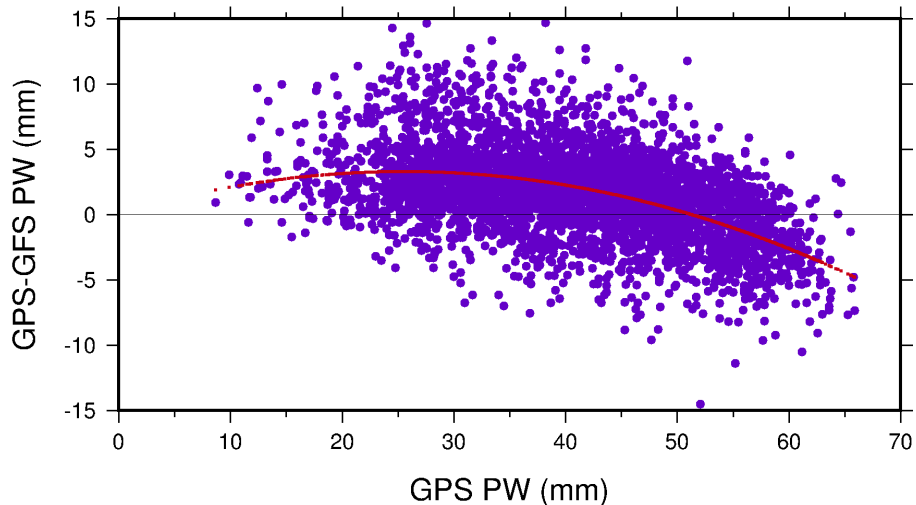
The UCAR/COSMIC program is participating in COCONet under support from NSF grant (EAR- 1042909). UCAR/COSMIC produces continuous estimates of atmospheric precipitable water vapor (PW) using a heterogeneous network of GNSS stations, including those stations that are part of COCONet. These data are produced and distributed through the Suominet ([www.suominet.ucar.edu](http://www.suominet.ucar.edu)) web portal as well as with the local data management (LDM) system. In an effort to make COCONet met data more widely available to the global atmospheric science and numerical weather modeling communities, COCONet data and derived data products are now being incorporated into the World Meteorological Organization's (WMO) Global Telecommunications System (GTS). The COSMIC group at UCAR has the ability to create 'BUFR' files, which would include PI Braun's estimates of PWV and temporally averaged surface met data (over the same epoch as the PWV), for delivery to the WMO GTS. Braun is currently in negotiations with appropriate NOAA staff to provide PWV products for all COCONet sites.

An initial assessment of atmospheric data products was presented at the 2013 Meeting of the Americas in Cancun, Mexico. This assessment included both surface meteorological observations and GPS derived precipitable water vapor (PWV) products. Comparisons were made using analysis fields from the National Oceanic and Atmospheric Administration (NOAA) Global Forecast System (GFS) modeling system. Scatter plots of surface temperature are shown in Figure 8 for the 18 UTC analysis time. The standard deviation of temperature for this local afternoon time period is 1.9°, but the histogram of the temperature differences shows a distinct non-gaussian distribution. This may indicate that the GFS analysis field is not able to sufficiently resolve the diurnal variation in temperature across the Caribbean. Differences in PWV between GPS derived estimates and GFS analysis values are plotted as function of total PWV in Figure 9. This comparison indicates that the GFS analysis is slightly moist with respect

to the COCONet derived GPS estimates for PWV amounts of less than 50 mm. Conversely, for PWV values greater than 50 mm, the GFS is dry with respect to GPS. Further investigation is needed to determine what impact these differences have on the overall performance of the GFS model.



**Figure 8:** Scatterplots of surface temperature from COCONet stations and GFS 2-meter temperatures at 18 UTC.



**Figure 9:** Differences in PWV from COCONet derived GPS estimates and GFS analysis fields are plotted as a function of PWV amount.

The 2013 Pan American Advanced Studies Institute (PASI) on Atmospheric Processes of Latin American and the Caribbean: Observations, Analysis, and Impacts was held at the Almirante Padilla Naval Academy in Cartagena, Colombia from May 27 – June 7, 2013. This two-week workshop focused on the most significant atmospheric and ocean processes of the Intra Americas Seas (IAS) region and how data products from COCONet can be used to investigate these processes. It included lectures, computer labs, and a group research project. Thirty-five

participants from twelve countries attended the workshop (Figure 10). Based on preliminary feedback from the PASI participants, the course was successful in introducing early career scientists to many of the important elements of the regional atmospheric system as well as fostering an environment of international cooperation and open data. A meeting summary of this workshop is being proposed to the Bulletin of the American Meteorological Society.



**Figure 10:** PASI participants, lecturers, and Colombian Naval officers all attended the opening ceremonies for the 2013 PASI on Atmospheric Processes of Latin America and the Caribbean: Observations, Analysis, and Impacts in Cartagena, Colombia.

## PROJECT CONCERNS

**Project Staffing** – Until there is more certainty in the status of the new GAGE Cooperative Agreement, UNAVCO senior management is limiting the hiring of some positions within UNAVCO, including one vacant COCONet field-engineering position, which puts some constraints on field operations. In lieu of a dedicated project manager, J. Normandeau is now handling the field operations management component of the project. **Risk mitigation:** Field-engineering staff from the PBO GPS Operations group and the Engineering Support, GLC, and Global Networks group in the Geodetic Infrastructure directorate at UNAVCO have been made available for temporary assignments to the COCONet project. When UNAVCO staff members, normally assigned to other projects are used to support COCONet installations or site operations and maintenance, their time, travel, and field expenses are charged directly to the COCONet award and not to UNAVCO core CAs (PBO and Bridge).