COCONet EAR 1042906/9 Quarterly Report

June 2013 - August 2013 (FY2013-Q4)

SUMMARY

This quarterly report covers COCONet project (EAR-1042906/EAR-1042909) activities for the time period from June 1, 2013 to August 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.

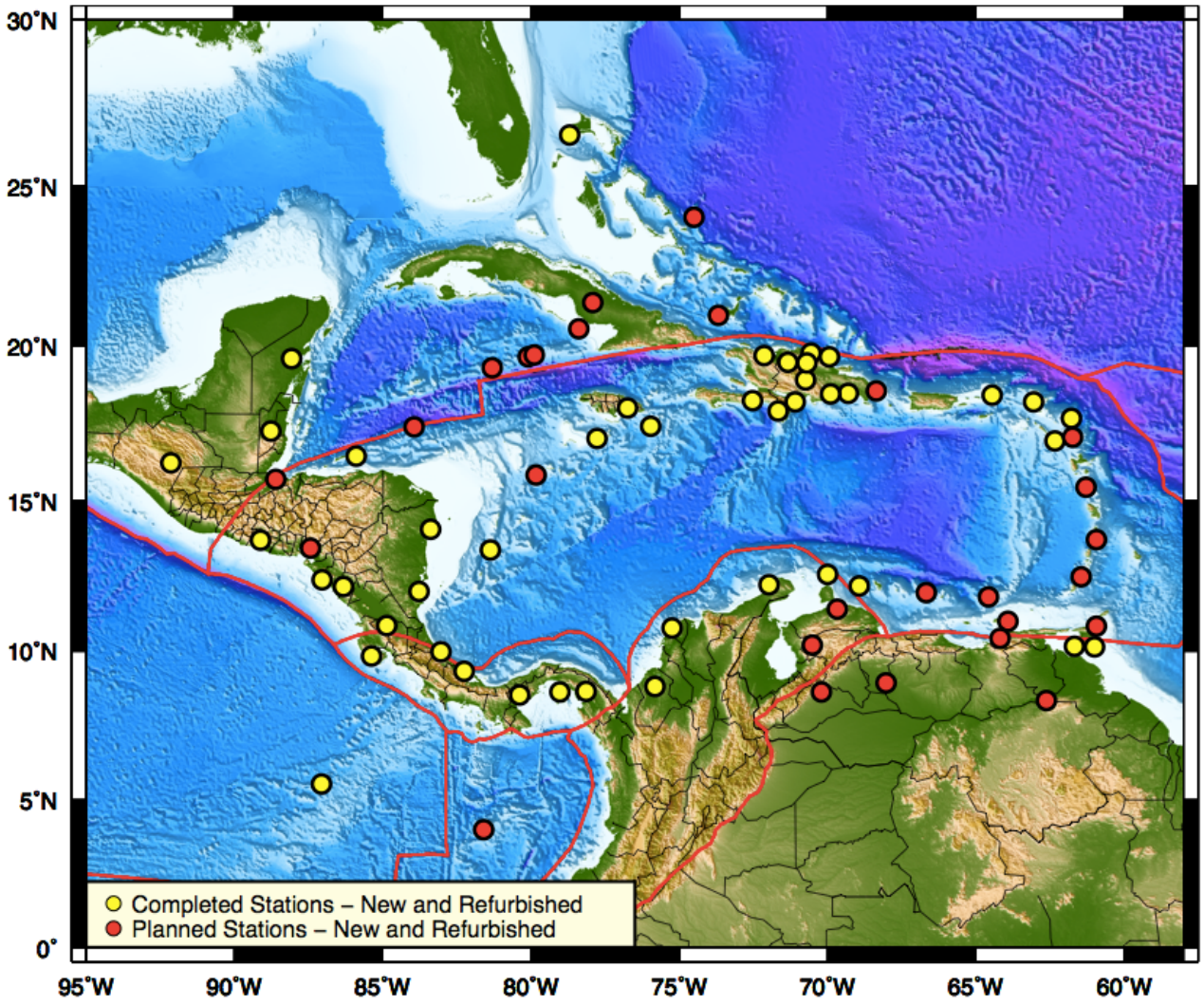

Figure 1. The current COCONet siting plan. Yellow dots represent the 44 completed COCONet stations (new and refurbished) and red dots represent the 27 planned stations (new and refurbished). The existing stations (61+), which deliver data to the COCONet archive and the 6 additional cGPS stations (locations TBD) associated with the tide gauge installations are not shown in this map.

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, four siting committee meetings, and two COCONet Working Group meetings held during the past three years. Specifically, UNAVCO field engineers focused on station installations in Haiti and Trinidad as well as permitting and logistics efforts for upcoming work in Cuba, Jamaica, Colombia, Venezuela, and St. Lucia. UNAVCO engineering personnel have performed site reconnaissance at 63 locations in 25 countries, submitted land use permits for 59 sites, received permits for 56 sites, and currently have 44 stations installed (Figure 1, yellow dots). Other significant activities included: 1) the review of applications and awarding of the 2013 COCONet Graduate Fellowships to five outstanding students at four US institutions (http://coconet.unavco.org/science/coconetfellowship2013.html); and 2) the development and announcement of the request for proposals for the COCONet Regional Data Centers (http://coconet.unavco.org/lib/downloads/COCONet-Regional-Data-Center-RFP_final.pdf). The review of the applications is underway and the plan is to announce the initial COCONet RDCs by the end of September 2013.

COCONET HIGHLIGHT: NEW STATION INSTALLED IN TRINIDAD

COCONet field engineers recently installed a new GPS station on the island of Trinidad. This island is the lowest latitude landform of the Lesser Antilles arc, and the new station now marks the most eastern boundary of COCONet. Two additional existing GPS sites on Trinidad, operated by the University of the West Indies (UWI), are slated for incorporation into the COCONet data flow this fall and the incorporation of these sites will push the boundary of the network in Trinidad even farther to the south.

UNAVCO worked in collaboration with personnel at UWI, both in the seismic and surveys and lands departments, to complete the new GPS site at Toco, a small town situated along the remote north east coast of Trinidad. The geography surrounding Toco is densely vegetated, with few available outcrops, yielding sparse options for bedrock sites. The station infrastructure was installed on the rooftop of the local public health center, one of the few reinforced concrete buildings available in the region. The data will be telemetered via a co-located UWI seismic station at the health center.

Data from the Toco station will be part of COCONet's large-scale geodetic and meteorologic Caribbean plate monitoring backbone. Similar to the other sites in COCONet, the new site at Toco will provide raw GPS data, GPS-PWV, surface meteorology measurements, time series of daily positions, as well as a station velocity field to support a broad range of geoscience investigations. Previous GPS monitoring of the Caribbean plate has been limited due to the fact that much of the plate's extent lies under water.

Figure 2. GPS monument located at the Health Center building in Toco, Trinidad.

OPERATIONS SUMMARY

In addition to the Toco, Trinidad station installation, the following operations milestones were completed during the last three months:

- In FY2013-Q4, there were two meetings of the newly formed COCONet Working Group, which replaced the COCONet Siting Committee. This working group, comprised of the same individuals from the original COCONet Siting Committee, will provide scientific recommendations to the project PIs and to UNAVCO project managers related to siting priorities for the GNSS/meteorological stations as well as the tide gauge network. The initiation of the new working group was prompted by the restructuring of all community governance committees as part of UNAVCO's reorganization into Geodetic Infrastructure, Geodetic Data Services, and Education and Community Engagement directorates and the recently funded GAGE Facility. John Braun was appointed as the chair of this new working group by the UNAVCO president and approved by the UNAVCO board.
- An MOU is being established with the Guatemala IGN. This agreement will provide COCONet access to the Guatemalan national cGPS network. COCONet will provide 6

meteorological instruments, which will be installed at selected sites to provide a met-data profile across the country.

- An MOU is being established with the St. Lucia Ministry of Physical Development to establish CN47 and to relocate an existing site on the National Emergency Management Organization (NEMO) building.
- Equipment for Honduran stations CN18 and CN21 are in-country awaiting final clearance through customs. UNAVCO is identifying a pilot to fly the installation team to Swan Island.
- The NSF-funded Haitian cGPS network that was installed after the 2010 Haiti earthquake was upgraded with new GNSS receivers donated by Trimble. These stations provide data to COCONet.
- Dave Mencin continued discussions with Doug Wilson, affiliated with the Global Ocean Observing System, and others at NOAA in regards to the tide gauge instrumentation and possible locations for installation. A report on hardware and possible sites for tide gauge/cGPS installations is expected to be presented at the next COCONet working group meeting, scheduled for early October 2013.

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

	Cumulative	**Since Previous Quarter**	**Details From Current Quarter**
Station Recons	63	0	
Permits Submitted	59	3	
Permits Accepted	56	3	
Stations Installed New / Refurbished	34 new 10 refurbished	4 new 0 refurbished	Cap Haitien (CN09-new) Petit Goave, Haiti (GOV2-new) Toco, Trinidad (CN45-new) UWI, Trinidad (UWI1-new)
Data Flow	New/Refurbished: 36 Existing: 49	New/Refurbished: 0 Existing: 0	
Maintenance Visits	19	7	Jamaica, Panama, Bahamas
Next Quarter Projection	Recons: 9, Permits: 2, New Installs: 4, Refurbishments: 3 Maintenance: 5		

Table 1. COCONet Status: Tasks completed to date and in FY2013-Q4.

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 or refurbished sites (Aruba, Panama-Bocas Island) and 7 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. At this time, the current siting plan calls for 50 new stations, 21 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 83 COCONet 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 80 COCONet 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. Due to a large scale data re-processing effort currently underway by the PBO ACs/ACC, designed to produce IGS08 solutions for all existing PBO data back through 1996 and funded independently as part of the PBO/SAFOD cooperative agreement with NSF, we expect that new Level 2 data products will become available for all COCONet stations with historic time series sometime during the next quarter.

Currently, 12 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.

BUDGET AND SCHEDULE

The revised schedule includes at least 50 new station installations, 21 refurbished stations, and contribution of data from at least 61 existing stations. Refurbished stations are defined as stations that are 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

and therefore can provide data directly to the COCONet project at minimal additional cost (for data archiving and processing). 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 slightly behind schedule in station installations (Figure 3). The projection for the next quarter is to install or upgrade at least 7 new/refurbished stations, which would put the project back on schedule.

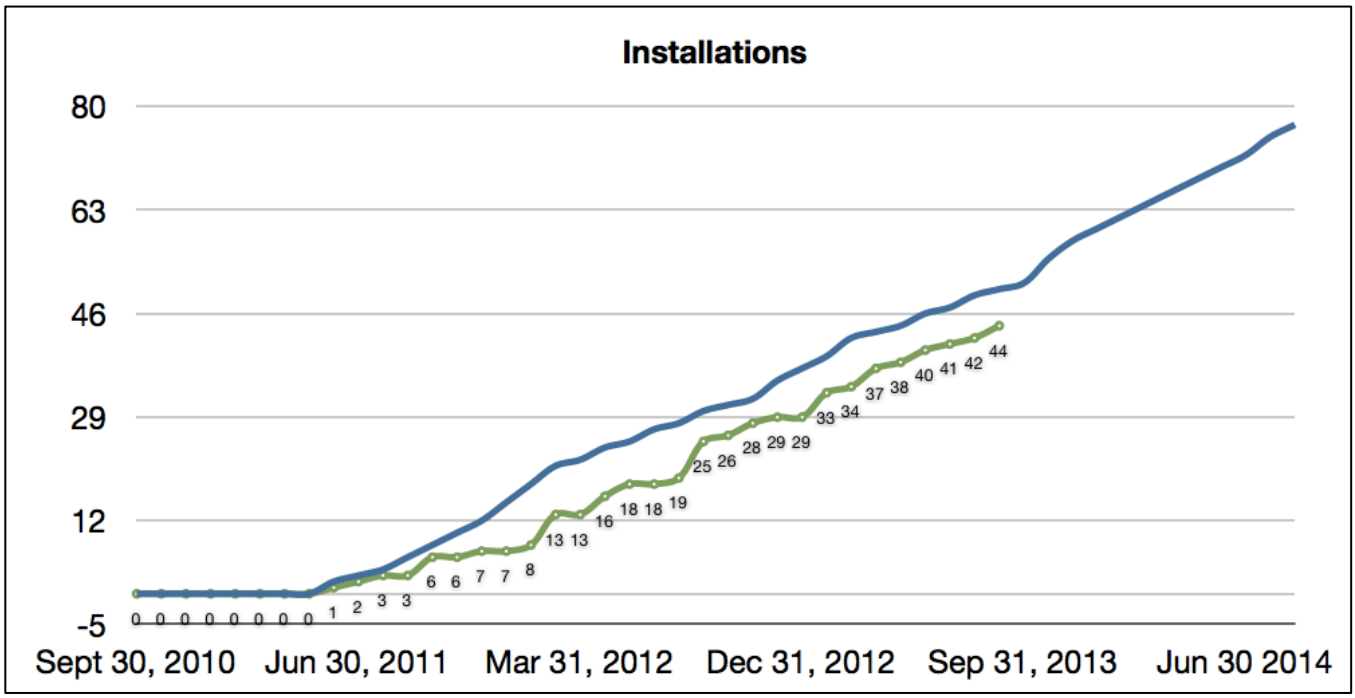

Figure 3. COCONet Installations: Plan (blue line) vs. Actual (green line).

COCONet expenditures are over $3.5M through the end of August 2013 (Figure 4), giving the project an overall slight budget under run to date. There are a number of financial commitments that will hit the books in the next quarter, including the costs associated with the visiting engineers from Venezuela, the COCONet Graduate Fellowships, and the implementation of the regional data centers. Also, some of the expensive sites in Venezuela, Swan Island, and Cuba are scheduled for visits in the next quarter. With these expenditures, the project actual costs should approach the planned budget closely.

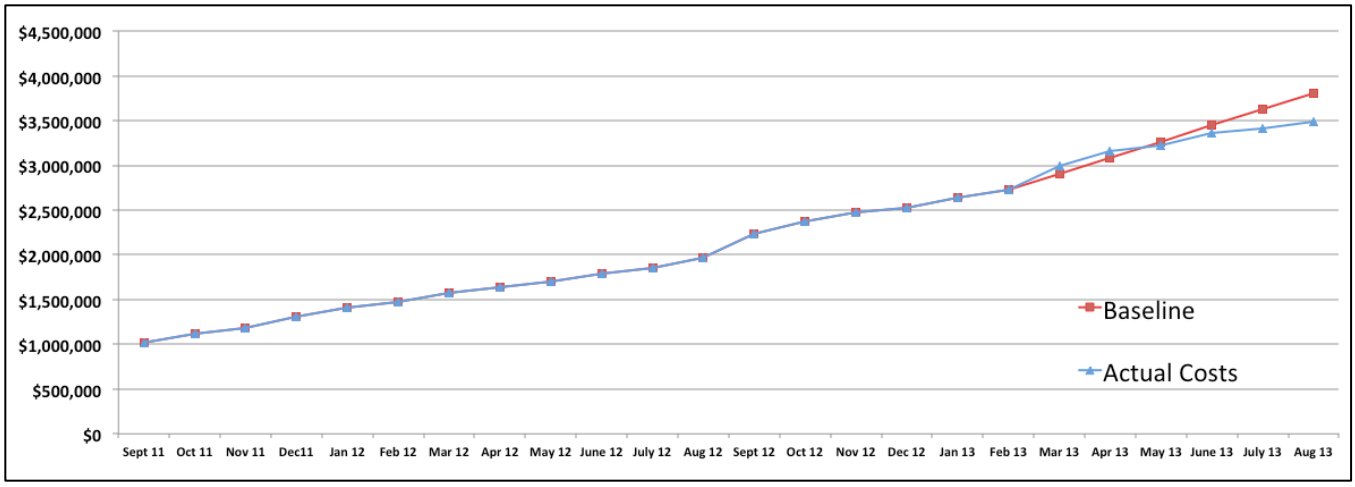

Figure 4. Total project actual costs vs. budget from September 30, 2011 – August 31, 2013, reflecting the project re-baseline. The red line is the re-baseline budget and the blue line is actual UNAVCO expenditures.

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:

- In August 2013, two students from Venezuela, Ricardo Lopez (La Fundación Venezolana de Investigaciones Sismológicas) and Julio Marquez (Simon Bolivar University) worked with PBO engineers in the Pacific Northwest to learn how to install PBO-style GNSS stations. This training will be beneficial for reconnaissance, installation, and maintenance of the 9 new and refurbished stations in Venezuela scheduled for installation in FY2014.

Figure 5. From left to right: Ken Austin (UNAVCO), Julio Marquez (Simon Bolivar University), Chad Pyatt (UNAVCO), and Ricardo Lopez (FUNVISIS) finish the construction of a single-mast monument that will be used as part of a monument comparison investigation funded by NSF-EarthScope through the PBO multi-monument change order.

- The COCONet Regional Data Center Request for Proposals (RFP) was announced in August 2013. As part of the COCONet project, UNAVCO will provide startup funding for up to four host institutions to operate Regional Data Centers. As many as three institutions will be selected to host a **Regional Mirror Data Center**. One institution will be selected to host the more advanced **Regional Data Center**. Each institution selected will be eligible for up to two years of funding. Each institution will receive all required hardware and software from UNAVCO. Onsite installation and training support from UNAVCO will be provided during the first year of funding; ongoing operations support via phone and e-mail will be provided during the second year. Proposing institutions will be expected to provide Information Technology infrastructure (power, cooling, internet, networking) as an in-kind contribution to the Data Center.

  Proposal Deadline for 2014 Funding: September 13, 2013
  Funding Levels, Regional Mirror: Up to $10K/yr for 2 years
  Regional Data Center: Up to $20K/yr for 2 years
  Start Date for Funding: 2014 funding starts October 15, 2013; 2015 funding starts October 15, 2014

  Additional information regarding the RFP can be found here:
  http://coconet.unavco.org/lib/downloads/COCONet-Regional-Data-Center-RFP_final.pdf

- The selection of the winners of the prestigious COCONet Fellowship Award that will support five graduate students to conduct research toward an advanced degree at a U.S. institution using COCONet was completed in July 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. The following recipients of these awards were announced:

  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.

- 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) were recently made available on the COCONet webpage.

- 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 support for Research Experiences in Solid Earth Science for Students (RESESS) intern Rachel Medina for the summer semester of 2013. Rachel continued her 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). In August 2013, Rachel presented her research at the RESESS annual colloquium and poster session. Her research involved

the apparent large vertical displacement at Soufriere Hills Volcano, Montserrat after a major dome collapse in 2003. This was Rachel's second summer as a RESESS intern at UNAVCO/UCAR. Her research results are described below in the UCAR update.

UCAR UPDATE

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) 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.

Much of the effort at UCAR this past quarter was spent mentoring RESESS intern Rachel Medina in collaboration with G. Mattioli at UNAVCO. This was Ms. Medina's second year in the RECESS program. Her project continued her efforts focused on analyzing 30 s cGPS data acquired during the massive dome collapse of July 2013 on SHV (COCONet contributing sites from CALIPSO). She will be presenting her results at the 2013 GSA Annual Meeting in Denver, CO and the Fall 2013 AGU Annual Meeting in San Francisco, CA.

Ms. Medina was given access to the UT Arlington computing resources along with an office at UCAR in the COSMIC group. The Geodesy Lab at UTA recently upgraded to GOA-II (v. 6.2) and updated its processing procedures, including the use of VMF1 grid files and APCs for the antenna/radome combinations, and newly released IGS08 data products from JPL.

Ms. Medina reprocessed all available cGPS from the July 2003 dome collapse event on SHV using a grid-search method to examine the appropriate stochastic atmosphere and position parameters to increase the precision of GPS position estimates during the eruption. BGGY, a station located 48 km northeast on Antigua, was used as a control to optimize the parameters for modeling the atmospheric variations more accurately for this type of environment, since BGGY is subjected to the similar weather patterns but was unaffected by volcanic activity at SHV (Figure 6). The final stochastic parameters were selected to yield the lowest variance in the kinematic position time-series at BGGY, then, HERM was reprocessed using the same parameters. The apparent vertical movement at HERM has been reduced substantially, and now has a maximum of 2.5 cm with a variation of 30 cm in the zenith wet troposphere estimate. We conclude that the original default parameters used to process that GPS observations over-constrained possible atmospheric variation for this tropical environment,

producing apparently large dynamic position changes. Our new results now reflect actual dynamic ground deformation during the massive dome collapse and may be used to develop improved models for volcanic processes that occur over time scales of minutes to hours at SHV and other tropical volcanoes.

In order for Ms. Medina to evaluate the appropriate kinematic processing parameters for use with GOA-II, she examined GPS data from Boggy Peak (BGGY), a COCONet contributing site located on a the nearby island of Antigua, which is ~50 northeast of the SHV on Montserrat. While the CALIPSO sites on SHV clearly were effected by the massive dome collapse of July 12-13, 2003, the BGGY was not; yet the SHV sites and the BGGY site experience the atmospheric conditions because of their close proximity. Thus BGGY was used as a standard to obtain the optimal parameters for modeling the tropospheric delay in concert with the apparent change in kinematic position. In the figures below, the tradeoff between the variance in the zenith wet delay and the variance in the horizontal position components are shown for different assumed values of the random walk parameter for the ZWD spanning 4 orders of magnitude and the a priori sigma of the position component spanning 1 order of magnitude.

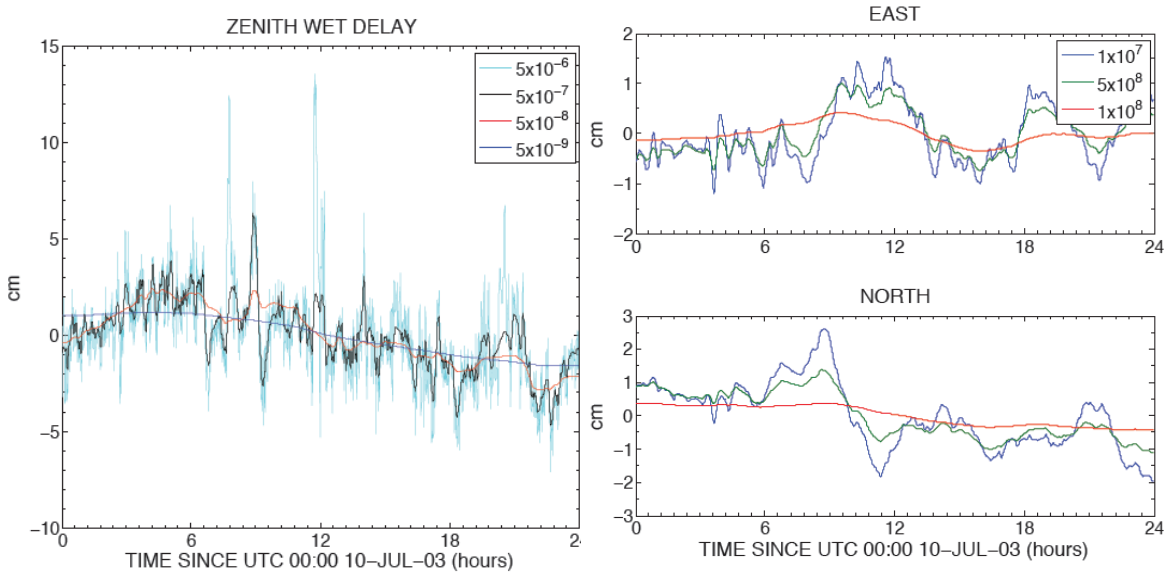

Figure 6. Reprocessed BGGY GPS time series. Figure on left shows the effect of changing the random walk parameter for the zenith wet delay in kinematic position determination using GOA-II. Note that if the ZWD is strongly "damped" then the corresponding apparent kinematic position is highly variable. Figure on right shows the effect of changing the a priori sigma for the position estimate at each 30 s epoch during kGPS analysis.

The assumption that drives this is that the BGGY site should not actually be moving significantly over this 24 h time period. As you can see in the figure above, the red line corresponds to an apparent position variation of less than 0.5 cm in the horizontal components. After finding the optimal parameters that yielded reasonable values for the apparent change in position for BGGY, the SHV GPS were reprocessed using the same parameters. The results for MVO1 (located ~7.6 km radially from dome and vent) and HERM (located ~1.6 km radially from dome and vent) are shown in the Figure 7 below. Compared to the previous analysis using an older version of GOA-II and the default parameters suggested

by JPL for kinematic positioning, the variation in the HERM position has been reduced by approximately 1 order of magnitude from ~2 m to ~0.2 m. Additional tests need to be completed prior to publication, but these revised kinematic time-series during the dome collapse are now much closer to simple elastic models of surface unloading from mass redistribution during the dome collapse coupled with a deep crustal Mogi source (at ~6 km depth).

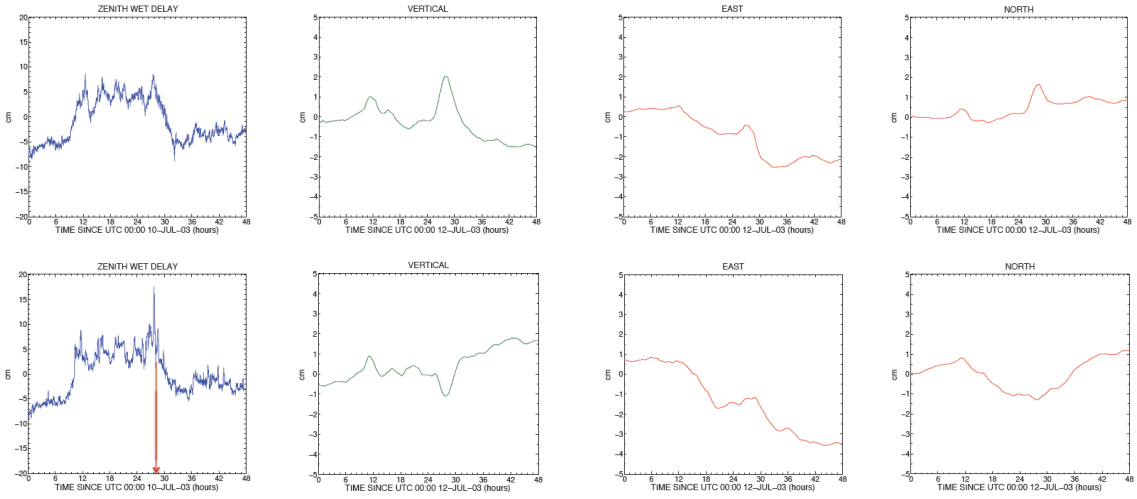

Figure 7. Reprocessed MVO1 (top) and HERM (bottom) GPS time series. Panel on left shows the ZWD time series. The three panels to the right are the vertical, east, and north components of the position time-series, respectively. The parameters used 30 s kinematic GPS analysis are those derived as optimal from the analysis of the BGGY site (shown above). NB that the apparent position changes are on the order of decimeters rather than meters

PROJECT CONCERNS

Project Staffing – The COCONet proposal assumed that field-engineering resources would be used from throughout UNAVCO, not just from engineers funded by COCONet. The recent UNAVCO reduction in force resulted in four fewer field engineers who can be used for the COCONet project. This reduction in force will put some constraints on COCONet field operations because the remaining engineering resources may not be available for COCONet. **Risk mitigation**: Recognition that with a reduced staff, priorities must be set and managed. The GAGE Geodetic Infrastructure Director will set and manage these priorities. 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, Bridge).

Project control: Much of the remaining work, especially in the West Indies, Venezuela, and Cuba relies heavily on local collaborators. **Risk mitigation**: COCONet management will make these stations a priority in the next quarter. Collaborations will be developed and strengthened in order to continue to make progress in the installation of these stations.