COCONet EAR 1042906/9 Quarterly Report

June 2012 - August 2012 (FY2012-Q4)

SUMMARY

This quarterly report covers the COCONet project (EAR-1042906/EAR-1042909) activities for the time period June 2012 - August 2012. The COCONet grant was awarded to UNAVCO (EAR-1042906) with a collaborative grant (EAR-1042909) awarded to J. Braun, University Corporation for Atmospheric Research on September 14, 2010. The project is under the direction of M. Meghan Miller, as PI, with Co-PIs Eric Calais, Guoquan Wang, John Braun, Glen Mattioli, and Karl Feaux. Glen Mattioli is acting as Project Director in his role as Director of Geodetic Infrastructure at UNAVCO; he was also recently added as a Co-PI, replacing Chuck Meertens, who was the acting GI Director until June 2012.

Most of the of effort during this reporting period included installation and maintenance activities related to the siting plan developed at the Port of Spain siting meeting in June 2011. Specifically, installations in Dominican Republic, Antigua and Barbuda, Belize, and Colombia were the field highlights during the last quarter. Station maintenance was required at previously installed stations in Dominican Republic and Costa Rica. UNAVCO engineering personnel have performed site reconnaissance at 57 locations (one less station from previous report due to the elimination of St. Croix site) in 24 countries, submitted land use permits for 48 sites, permits accepted for 37 sites, and currently have 25 stations installed (Figure 1, yellow dots).

In the last three months, Dr. Alberto Lopez from the University of Puerto Rico, Mayaguez led planning efforts for the 3rd COCONet community workshop, scheduled for October 24-26, 2012. The location of Tulum, Mexico was chosen based on cost, ease of access for all participants, availability, and possible synergies with the TLALOCNet community in Mexico. Other participants will include representatives from COCONet partner organizations, UNAVCO, and the atmospheric science community. The workshop will consist of plenary speakers and breakout sessions for special topics, but will focus on COCONet data, including archiving, distribution, processing, and data analysis.

This summer has been an active hurricane season and COCONet engineers have worked to repair meteorological instruments and to improve data communications at key stations in the region in preparation for atmospheric events. In late August, Hurricane Isaac passed close to COCONet stations recently installed in the Dominican Republic.

In the past month, there have been two strong earthquakes that struck within the COCONet footprint. On August 27, the M 7.3 Puerto El Triunfo, El Salvador earthquake occurred offshore near the subduction zone interface between the Cocos and Caribbean plates. Three installed COCONet stations – SSIA (El Salvador), CN22 and MANA (Nicaragua) - are located within the expected area of displacement, derived from a forward model (Geirsson, personal communication, August 27, 2012) based on the seismically determined moment tensor.

UNAVCO sent four GPS systems to Nicaragua (PI: Pete LaFemina, The Penn State University) to make campaign measurements related to the coseismic displacements.

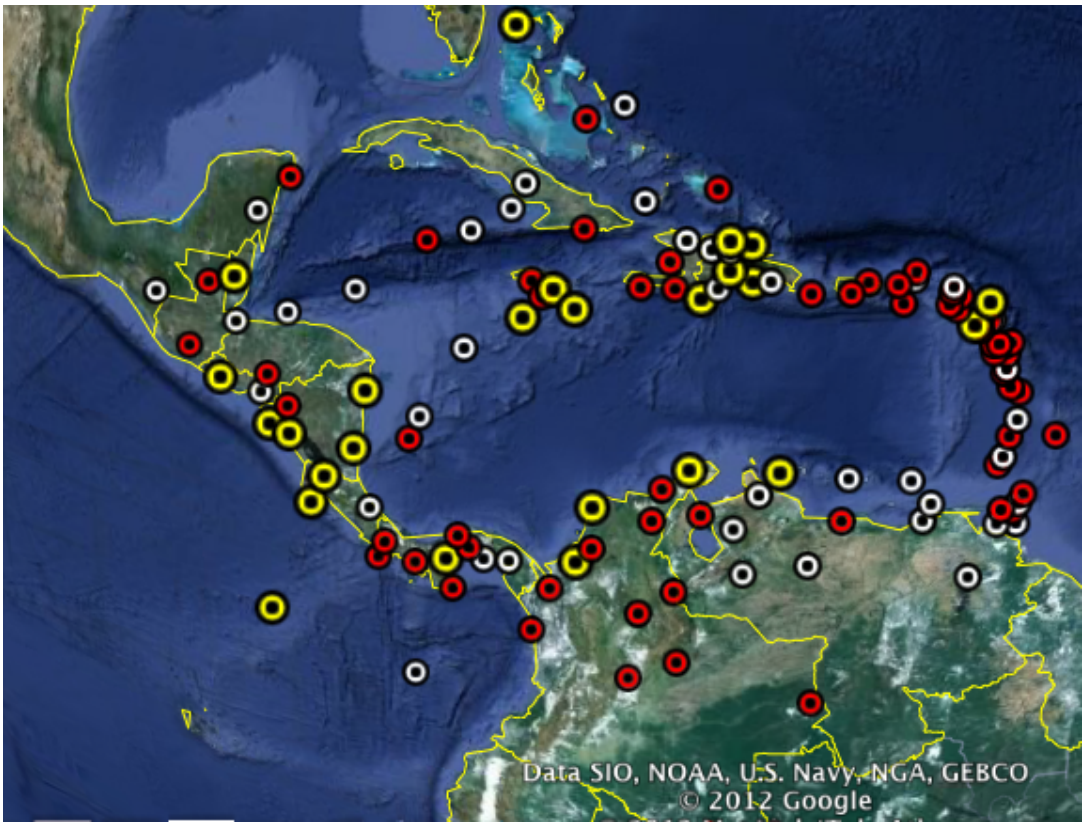

Figure 1. The final COCONet siting plan, the result of siting meetings in Puerto Rico and Trinidad. White dots represent planned new or refurbished stations, yellow dots represent the 25 installed stations, and red dots represent existing stations (61).

On Wednesday, September 5, 2012, at 14:42:07 UTC, a magnitude 7.6 earthquake struck roughly 40 km (25 miles) below the surface of the Earth, 10 km (6.2 miles) ESE of the city of Nicoya, Costa Rica. The Nicoya Peninsula has been well instrumented with continuous GPS installed over the past two decades and funded largely by NSF, thus providing a unique research opportunity for scientists. COCONet engineers will provide support to UNAVCO community scientists by downloading data from GPS receivers in the region currently without data communications. The one COCONet station (QSEC) located on the Nicoya Peninsula was operational during the event. The COCONet QSEC site high-rate (5 Hz) data were processed by G. Mattioli with GIPSY-OASIS-II (v.6.1.2) using *Rapid* orbit, clock, and Earth orientation parameters from JPL while treating the site as a kinematic buoy. The 1 Hz position time series is shown in Figure 2. The coseismic offsets for QSEC are as follows: ΔE = -14.29±7.80 mm, ΔN = -326.28±4.97 mm, ΔV = 379.03±11.54 mm, calculated by averaging over 101 position estimate epochs approximately one minute before and after the main shock at 14:42:07 UTC. Errors are estimated by summing squared standard deviations of position

estimates and assuming that the pre- and post-seismic variance is uncorrelated, which yields the maximum error estimate.

The Nicoya event and the processing of the QSEC high-rate data has sparked an internal discussion within the COCONet project management team about COCONet high-rate and RT-GPS (>1 Hz, < 1 s latency) processing in general and in response to specific geophysical events within the COCONet footprint. The original COCONet proposal called for 10 high-rate, real-time GPS sites distributed throughout the network. The specific sites were to be determined by the COCONet Siting and Oversight committee. COCONet sites are being processed by the PBO Analysis Centers (CWU and NMT) and reviewed placed in the SNARF frame by the Analysis Coordinator at MIT. Recent discussions with PBO ACC T. Herring of MIT confirm that the COCONet sites are being analyzed and that the PBO ACC at MIT routinely calculates coseismic offsets, based on daily solutions, for every significant earthquake (>Mw6) within the PBO footprint. This will be extended to COCONet.

There is no provision for specific event response or high-rate processing for COCONet at this time, but the consensus within the Geodetic Infrastructure program is that we can handle events within the COCONet footprint using established UNAVCO and PBO protocols. While the COCONet high-rate data were not being ingested in the PBO real-time processing system during the Nicoya event, our current build out related to the ARRA Cascadia project will allow us to process all COCONet data that arrives through the Trimble VRS2Net software in real-time going forward.

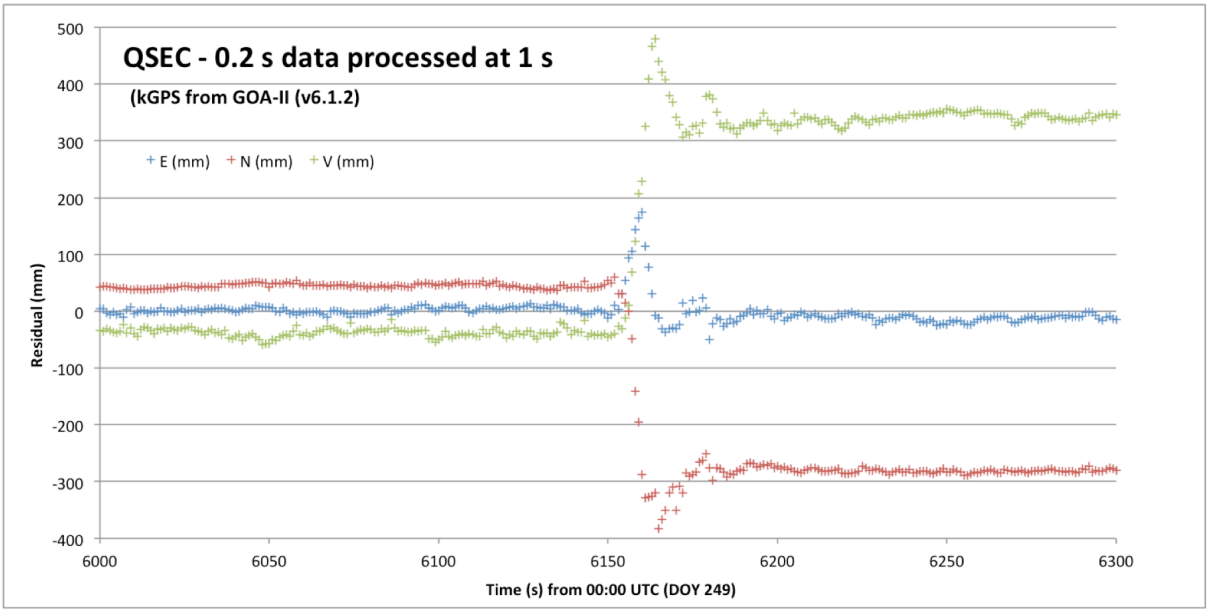

Figure 2. QSEC site high-rate (5 Hz) data for M_w7.6 main shock of the Nicoya Peninsula earthquake on Sept. 5, 2012. Processed by treating the site as a kinematic buoy with GIPSY-OASIS-II (v.6.1.2) using *Rapid* orbit, clock, and Earth orientation parameters from JPL. Note the displacements after the main shock are likely the surface waves.

COCONET HIGHLIGHT: INSTALLATIONS IN COLOMBIA

In August 2012, COCONet engineer Sarah Doelger installed three new stations in Colombia at Monteria, Galerezamba, and Cerrejon. Dr. Hector Mora-Paez, with the Colombian Geological Survey, and members of his field team assisted Ms. Doelger with these installations. Earlier in the year, Dr. Mora and Kyle Bohnenstiehl of UNAVCO completed the reconnaissance at these sites, ensuring the GPS monuments were installed in desirable locations with excellent sky view and excellent security, along with solid cellular data communications options. The Monteria station (CN36) is located at the city airport, behind a guarded gate on land owned by the Colombian Government. An alternative monument type was installed at this station, which consisted of angled legs driven to refusal and a vertical leg anchored and encased in concrete. The Galerazamba station (CN37) is located behind manned security gates on property owned by a local mining facility, with the monument installed into competent limestone bedrock near an existing GPS campaign mark. This station also utilizes cellular data coverage. The third station constructed near Cerrejon (CN38) on the northern tip of Colombia also features excellent security and solid limestone bedrock.

In addition to these station installations, the field team participated in maintenance activities on the island of San Andreas at existing COCONet station SAN0, which had been constructed by UNAVCO and INGEOMINAS engineers in 2007. The final new COCONet station in Colombia is scheduled for installation in early September 2012 on the remote Providencia Island, located 450 miles NW of mainland Colombia. Overall, this was a very successful trip by COCONet field engineers, which clearly strengthened the partnership between UNAVCO and the Colombian Geological Survey.

FIELD OPERATIONS SUMMARY

During the last three months, the following field operation milestones were completed:

- COCONet field crews installed ***seven*** new COCONet stations in the region, including the Dominican Republic, Belize, Colombia, and Antigua and Barbuda (see Table 1 for details). Short-drilled braced monuments were built in the Dominican Republic near the towns of Valle Nuevo (CN06) and Cabo Frances Viejo (CN27). In Belize, a roof mount monument (CN23) was installed at the Ministry of Natural Resources and Environment building in the capital city of Belmopan. Engineers installed a new short-drilled braced monument adjacent to the existing Global Seismic Network station on the island of Barbuda, which is operated by the USGS. The station electronics were housed inside the USGS enclosure and the GPS receiver utilizes the USGS DC power system and satellite data communications. Also, three new stations were built in Colombia with the generous assistance of the Colombian Geological Survey.

- COCONet engineers completed planning and preparation for six refurbishment projects in

the Dominican Republic and Trinidad. GPS receivers and meteorological instruments were readied for shipment to these countries.

	Cumulative	Since Previous Quarter	Details From Current Quarter
Station Recons	57	0	All recons complete except Cuba
Permits Submitted	48	0	
Permits Accepted	37	0	
Stations Installed New / Refurbished	20 new 5 refurbished	7 new 0 refurbished	Belize, Antigua and Barbuda, Dominican Republic, Colombia
Data Flow	22	6	Belize, Antigua and Barbuda, Dominican Republic, Colombia
Maintenance Visits	9	3	Costa Rica, Dominican Republic
Next Quarter Projection	Recons: 0, Permits Submit: 5, Installs: 6, Refurbishments: 6		

Table 1. COCONet Status: Tasks completed to date and in FY2012-Q4.

• COCONet engineers conducted station maintenance at ISCO in Costa Rica and CN07 and CN08 in Dominican Republic. The maintenance at ISCO was related to an IP change from the satellite Internet provider, whereas the maintenance completed in the Dominican Republic was related to the cellular and radio data communications at these stations.

	New Stations	Refurbished Stations	Existing Stations	Notes
Standard data archived at UNAVCO	15 of 20 stations installed currently archiving 15-sec data 2 of 20 stations installed currently archiving 30-sec data (BGAN stations)	4 of 5 refurbished stations currently archiving 15 or 30-sec data	UNAVCO has received data from 38 existing stations. 32 currently online and operational	Known communicatio ns problems at CN06, CN22, CN29
Stations Streaming 1-Hz Data	(4) CN15, CN40, ISCO, CN12	(1) MANA	(3) NWBL, RCHY, P780	

Table 2. COCONet data and archive summary.

DATA SUMMARY

The Port-of-Spain planning meeting resulted in 50 target locations for new stations, 15 targets for refurbished stations, and 61 existing stations for integration into the COCONet network. The COCONet data plan calls for 10 stations to provide high-rate real-time GPS data streams.

COCONet is currently downloading mostly 15-second data (some exceptions for BGAN sites) and processing daily time series from 21 of the 25 new and refurbished COCONet stations.

Processing of station data by the PBO GPS Analysis Centers is yielding high-quality time series. Table 2 shows the current data summary for stations identified as belonging to the COCONet network. See the discussion above related to the current status of PBO AC data processing and the plans for RT-GPS ingest and analysis at UNAVCO.

UCAR UPDATE

The UCAR/COSMIC program is participating in COCONet under support from NSF grant (EAR- 1042909). UCAR 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. As of September 1, 2012 UCAR was including data from 38 new and existing COCONet sites into its processing system, and was preparing to ingest data from eight other sites that had recently begun producing sub-daily data streams for near real time analysis. In an effort to maximize the availability of COCONet data, UCAR/COSMIC program is developing a software library to distribute PW data products in the Binary Universal Form for the Representation of meteorological data (BUFR) version 4 format. This format is the data standard for operational numerical weather prediction centers around the world. The completion of this software task is expected to be finished before the upcoming COCONet data users workshop in October. The production of atmospheric COCONet data products in BUFR format, and the distribution of this data through the Global Telecommunications System (GTS), should provide the operational meteorological community with broad access to COCONet data products.

COCONet PW data are shown in Figure 3 as Hurricane Isaac passed through the eastern Caribbean Sea. Isaac represents an opportunity to assess the distribution of water vapor in atmospheric analysis fields within and around hurricane systems. UCAR/COSMIC is now evaluating the differences in the Global Forecast System (GFS) analysis fields that are used to initialize numerical weather prediction models for forecasting.

UCAR/COSMIC has received notification that the proposed short course titled “Pan American Advanced Studies Institute on Atmospheric Process of Latin American and the Caribbean: Observations, Analysis, and Impacts” has been recommended for funding from NSF (solicitation NSF 12-535). This short course is intended to foster a community of early career

scientists who are interested in regional atmospheric processes, and as a way of introducing these researchers to the COCONet project. The proposed time window for the course will be sometime in May or June of 2013, in Cartagena, Colombia.

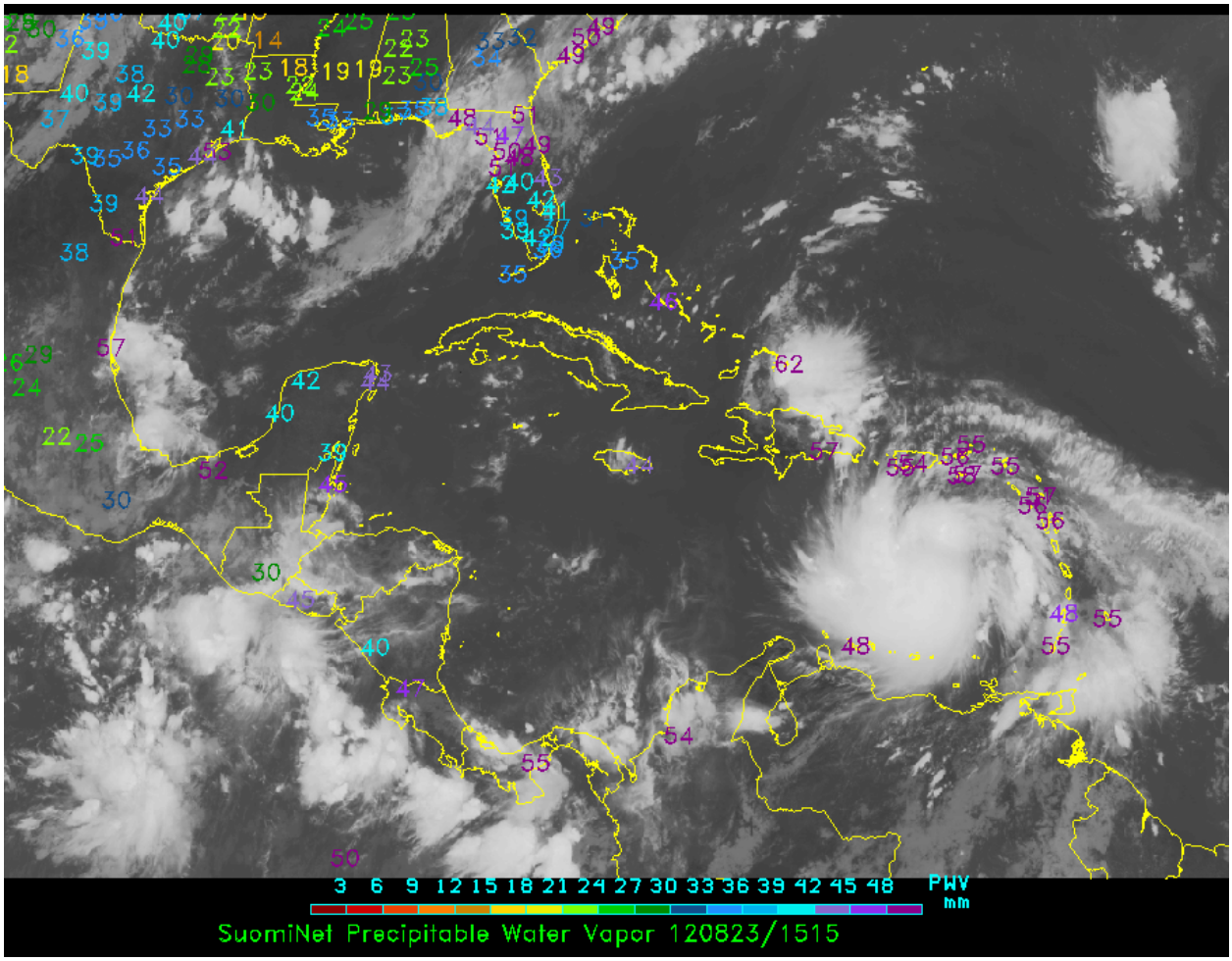

Figure 3. COCONet derived precipitable water vapor (PW) are overlaid upon a GOES-IR image taken on August 23, 2012 at 15:15 UTC. Hurricane Issac is visible in the Eastern Caribbean.

Education and Outreach Highlight: Diverse Workforce Development Supported by COCONet Through RESESS

RESESS, or Research Experiences in the Solid Earth Sciences for Students, is a summer research internship program dedicated to increasing the diversity of undergraduate students entering the geoscience workforce. This program is supported by the National Science Foundation through Grant No. 0917474 GEO-OEDG. To date, the program has supported 37 undergraduates. Of those who have graduated from college, 70% are currently in graduate school.

In summer of 2012, RESESS intern Rachel Medina (Figure 4) was supported by the COCONet project. Rachel is a senior in geology at Fort Lewis College in Durango, Colorado, President of the college's chapter for Engineers Without Borders, and is interested in geophysics, hazards,

and human impacts of those events. Rachel worked with mentors Dr. Glen Mattioli of UNAVCO and Dr. John Braun of UCAR to determine whether the tremendous vertical displacement (~2m) at Soufrière Hills Volcano, Montserrat, observed following the July 2003 volcano collapse can be explained in part by tropospheric interference by ash plumes. The title of her poster was "An Analysis of GPS and Remote Sensing Data of Soufrière Hills Volcano, Montserrat, During the July 2003 Collapse: Implications for Ash Plume Signals versus Vertical Deformation." From their results, Rachel and her mentors inferred that moisture content associated with the ash plume cannot solely account for the apparent vertical displacement observed at the HERM site on Montserrat, and that a significant portion of the displacement is related to actual crustal motion during the collapse event.

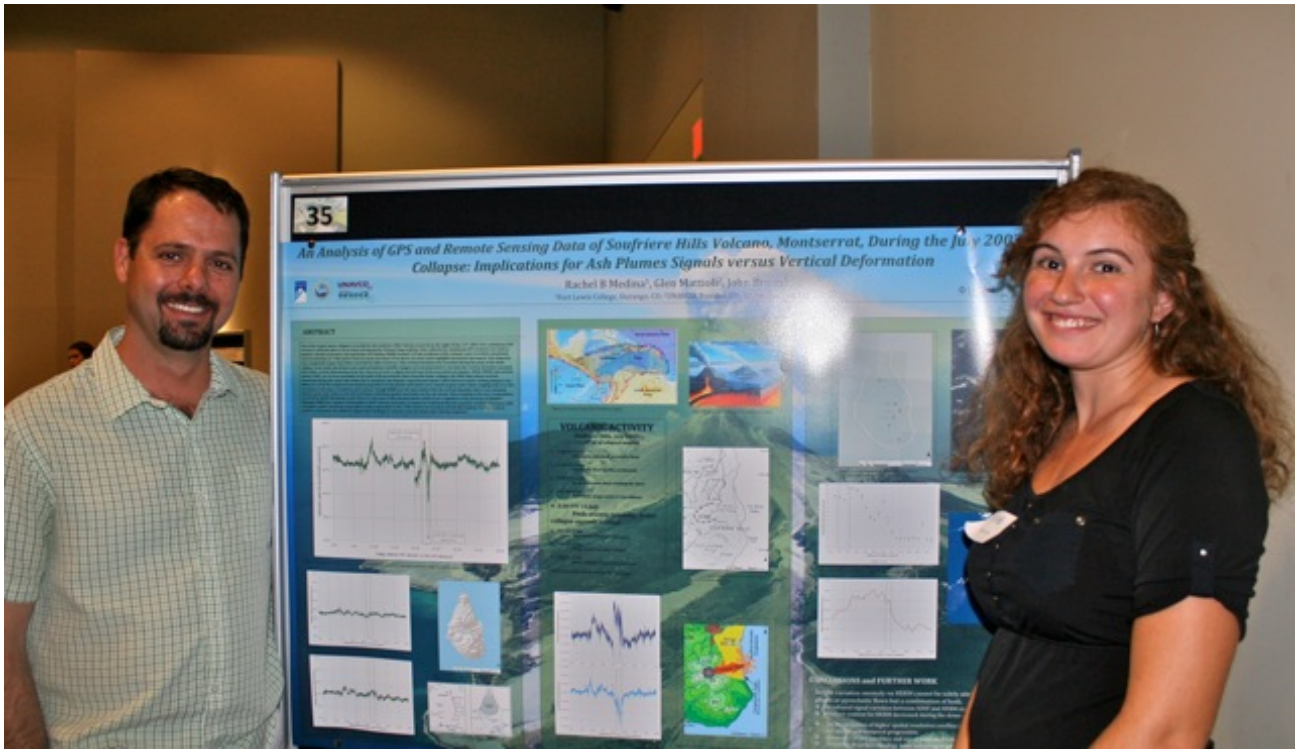

Figure 4. RESESS intern, Rachel Medina, and one of her mentors, Dr. John Braun of UCAR, standing by her poster at the 2012 RESESS Poster Session.