2012 LTER Training Workshop Final Report
Acquisition and Management of Data from Remote Locations

Dates: June 10-15, 2012
Hosted by: University of New Mexico Sevilleta Field Station

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Summary:
This training workshop focused on several topics related to the remote acquisition of environmental data typical of LTER sites including basic electronics, photovoltaic systems, wireless networking, Wi-Fi telemetry systems, sensor theory, and Campbell Scientific datalogger wiring and programming. We employed a combination of field demonstrations, lectures, hands-on activities, and discussions to illustrate these concepts. Participants included a diverse group of graduate students, technicians, post-doctoral associates, and faculty members in need of hands-on experience in these areas.

Goals:
The main objectives of this training workshop were to provide participants with a comprehensive and affordable introduction to the major aspects of field-based data acquisition with an emphasis on hands-on learning. No other formal training of this nature is currently available to scientists working in environmental fields. As a result, scientists are often faced with a steep learning curve when first faced with the installation and management of sensors, probes and other instrumentation. Our goal was to present theory and practice as well as to provide a forum for participants to share alternative approaches, successes and failures.

Immediate Outcomes:
We had a total of 26 applications, from which we chose 16 individuals. We narrowed down the list of applicants based on their perceived needs, taking care that participants represented a diverse group of roles, experience levels, and affiliations. As a result, we trained 11 field technicians, 2 graduate students, 2 post-doctoral associates, and 1 early-career faculty member from 11 LTER sites and 2 non-LTER sites. Participant names and affiliations are listed with the group photo at the end of this report.

As shown in the agenda presented below, we provided five days of intense training and discussion. Comments from participants were universally positive. We have included the following comments to illustrate both the range of topics we covered and the success of the exercises and presentations.

"Thank you, for gave us the opportunity to take the Workshop, the information and the practice exercises will be very usefully for our daily work. The logistic for the training was excellent."

"The hands-on exercises with real instruments were really valuable. Also to see working sites applying workshop topics and using the instruments and programs we used in the lab. I appreciate the time and effort it must have taken to get everything together and organized. Not to mention writing a grant to fund it all."

"I wanted to thank you again for the excellent workshop. I learned so much that will help me with up and coming research. Without this workshop I would have continued to be in-the-dark about wireless, power, and Campbell Scientific dataloggers. The class size was perfect and both of you provided an amazing learning environment. I desperately needed the "hands-on" experience that this course offered. I feel honored to have been admitted into the course. Oh, and the food was amazing as well."

"I learnt a lot in the workshop, especially the telemetry and datalogger part, which I will use in the near future. The support from LTER is necessary to me since I could not find other sources of funding. Thank you and Don again for ALL of these in the past week!"

"Thanks again for including me in the workshop. I got a lot out of it and had fun at the same time-- what a great group of people."

"The topics covered were clearly relevant to all of the participants, whose diversity of experience and research sites made for a very constructive week. Everybody contributed some knowledge and took away much new knowledge."

"The Daily Grind did a great job."

"I just wanted to thank both you and Don again for the workshop you put on! I had a great time, and am very grateful for the introduction into remote data acquisition. Thanks also for showing us some of the work that y'all are doing, it was nice to see some real-world application of what we later learned more about in the classroom. For my work, I don't yet access any data remotely, but this workshop has provided me the tools to start some of that up. I now have a better understanding of who to contact, and what sort of instrumentation I'll need to begin accessing our data remotely. This will be hugely helpful, as I'm sure our lab will soon be moving in this direction."

"Overall assessment: A+, extremely useful and well done. I do not remember a week of such good learning and networking in a very long time."

"It was very important that we actually worked with the hardware, thanks for making the effort to make it all available."

"I really liked the solar panel and electrical circuits exercises."

"Field trip to sites was definitely a very important component of the class."

"Doing all wiring to logger, NL 200, etc. ourselves was very important and very useful."

"I can't emphasize enough how well you guys did this and how useful it was for me. Thanks for accepting me into the course and thanks for feeding us some good food there and for the opportunity to spend some time out at Sevilleta. Really cool place with some amazing stars!!!"

"Thanks again, and great idea about the mail list, we'll stay in touch."

"Just wanted to leave a few comments about the workshop. Most importantly, I thought it was fantastic. Going in, I'd say I knew about 20% of what you taught, so I got a ton out of it! I also thought it was great having a mix of techs/graduate students. From the tech's side of thing, it's important that they know how to program, deal with the equipment, as many PIs don't really give a great overview of that sometimes. As a grad student, it was informative to see what systems people are using, and how to implement them, as one day (hopefully) I'll be writing a few research grants."

Longer-term Outcomes:
We have set up a mailing list (rda-2012@sevilleta.unm.edu) to facilitate and promote further discussion among participants and instructors on the topics we covered in the training workshop.

The success of this and other sensor-oriented LTER training workshops over the past year indicate the need for further resources on these topics. This has led to the formation of SensorNIS, a collaborative effort initiated by several LTER affiliated personnel for the purposes of developing resources to aide the environmental sensor user community. The first of these efforts is the development of an online resource guide that will include topics related to all aspects of using environmental sensors, from field deployments to data management. Renee Brown was involved in co-organizing a working group at this year's LTER All Scientist's Meeting to promote and garner further support for SensorNIS. The working group was a success and development of these resources is proceeding. The SensorNIS resource guide outline is located at http://im.lternet.edu/resources/im_practices/sensor_data.

Budget:
With the award from LNO we were able to fund the travel ($14,693.63), food ($4,948.71), and lodging ($3,596.14) expenses of all 16 participants. Use of UNM Sevilleta Field Station classroom and dining facilities amounted to $730. In order to provide hands-on training, we purchased 8 Campbell Scientific CR1000 dataloggers, 8 licenses of LoggerNet 4.1, 8 thermocouple sensors, 4 NL200 serial-to-ethernet converters, and one 12v power supply for powering the dataloggers ($16,237.91). We also purchased 16 multimeters ($336.24) and other miscellaneous small equipment items ($645.16). **Total** $37,279.81

The equipment purchased for this workshop is stored in the Electronics Laboratory at the Sevilleta Field Station in anticipation of offering a similar training workshop on an annual basis. We have just received a new award from the Field Station and Marine Laboratories program at NSF that will allow us to purchase new computers and furniture for the classroom in which most of the workshop activities take place. These upgrades will speed up computer exercises, improve transitions across workshop sections, help with logistics of workshop preparation and increase participant comfort.

Additional Support:
The UNM Sevilleta Field Station provided 8 Wi-Fi radios and antennas, Ethernet switches, cabling, and other miscellaneous equipment, shuttle transportation to and from the Albuquerque International Sunport, field trip vehicles, and it staffed logistical support for meals, snacks, and laboratory setup. The Sevilleta LTER loaned additional sensors and other miscellaneous equipment for use during training exercises and the UNM Department of Biology loaned 14 laptop computers.

AGENDA

Sunday, June 10, 2012

6:00 – 7:00 PM   **Opening Remarks, Introductions, and Sevilleta LTER Overview Presentation** (*SERF, Room 203*)

7:00 – 9:00 PM   BBQ & Social Mixer (*Patio*)

Monday, June 11, 2012

7:30 – 8:00 AM   Breakfast (*Patio*)

8:00 – 6:00 PM   **Field Trip** (*Depart from Main Parking Lot*)**:**

8:45 – 9:30 AM   - Met Station: Deep Well
                              - Nighttime Warming Experiment

10:00 – 11:00 AM   - Monsoon Rainfall Manipulation Experiment
                              - Rainout Shelters: Black Grama (*Michell Thomey*)

11:00 – 12:15 PM   - McKenzie Flats Grassland Loop (*lunch en route*)
                              - Los Piños Mountains Wireless Backhaul

12:15 – 1:00 PM   - Piñon-Juniper Rainfall Manipulation Experiment (*Rob Pangle*)

2:15 – 3:00 PM   - New Mexico Upland Flux Network: Piñon-Juniper Control (*Skyler Hackley*)

4:15 – 5:00 PM   - Middle Rio Grande Flux Network: Sevilleta site (*Jim Thibault*)

5:00 – 6:00 PM   - Optional supply run to Socorro, NM

6:30 – 7:30 PM   Dinner (*Patio*)

Tuesday, June 12, 2012

7:30 – 8:30 AM   Breakfast (*Patio*)

8:30 – 12:00 PM   **Basic Electronics** (*SERF, Room 206*)**:**
- Low voltage DC systems
- Introductory circuit theory
- Ohm's Law & Watt's Law
- Multimeter skills for checking and troubleshooting circuits

- *Hands-on exercise: using a multimeter to measure voltage, current, resistance, and continuity*

12:00 – 1:00 PM   Lunch (*Patio*)

1:00 – 5:30 PM   **Photovoltaic Systems** (*SERF, Room 206*)**:**
- Components of photovoltaic systems: solar panels, charge controllers, batteries, wiring, inverters, fuses, & grounding
- Solar panel mounting: construction options & tilt angles
- Sizing photovoltaic systems
- *Hands-on exercise: using MS Excel to calculate power budgets and size photovoltaic systems*

6:30 – 7:30 PM   Dinner (*Patio*)

Wednesday, June 13, 2012

7:30 – 8:30 AM   Breakfast (*Patio*)

8:30 – 12:00 PM   **Wi-Fi Telemetry Systems** (*SERF, Room 206*)**:**
- Antenna fundamentals: gain, frequency, directionality, polarization, cabling, line-of-sight (LOS), and Fresnel zones
- Tools for designing physical telemetry network infrastructure: LOS calculators, topographic maps, GPS devices, and ground truthing
- *Hands-on exercise: using online tools to calculate LOS*
- Wi-Fi radio fundamentals: 802.11 protocols, access points (AP), clients, bandwidth, frequency, channels, interference, security, and advanced features
- Lightning protection and grounding

12:00 – 1:00 PM   Lunch (*Patio*)

1:00 – 5:30 PM   **Wi-Fi Telemetry Systems** (*SERF, Room 206*)**:**
- Fundamentals of Internet Protocol (IP) networking: IP address, gateway, subnet mask, domain name server (DNS), public vs. private networks, network address translation (NAT), static vs. dynamic (DHCP) addressing, and routing
- Ethernet cabling: types, tools for making and testing
- *Hands-on exercise: making Ethernet cables*
- *Hands-on exercise: configuring AP and client Wi-Fi radios to create classroom network*
- *Hands-on exercise: testing and troubleshooting Wi-Fi networks using ping and speed tests*

6:30 – 7:30 PM   Dinner (*Patio*)

Thursday, June 14, 2012

7:30 – 8:30 AM   Breakfast (*Patio*)

8:30 – 12:00 PM   **Dataloggers, Sensors, and Software** (*SERF, Room 206*)**:**
- Introduction to the Campbell Scientific CR1000 datalogger
- Sensors: types, measurement, Campbell vs. non-Campbell, specifications, extending, field installation, and labeling
- Other data acquisition equipment: multiplexers, wiring, conduit, enclosures, hardware, and tools
- Wiring planners and documentation
- *Hands-on exercise: using MS Excel to develop a wiring plan*
- Introduction to LoggerNet 4.1: setup and connect screens
- *Hands-on exercise: using LoggerNet to setup and connect to a CR1000 datalogger*
- Overview of Short Cut Programming Wizard

12:00 – 1:00 PM   Lunch (*Patio*)

1:00 – 5:30 PM   **Datalogger Programming** (*SERF, Room 206*)**:**
- CRBasic Editor: layout, menus, and help
- Components of a typical datalogger program: variable declarations, data tables, subroutines, main program
- Programming fundamentals: data types, conditional statements, repetition using for loops
- Style and readability: comments, indentation, and spacing
- *Hands-on exercise: programming for control*
- *Hands-on exercise: write a program to measure and collect data from temperature and soil moisture sensors*

6:00 – 7:00 PM   Sevilleta LTER REU Program Summer Seminar Series: Research talk by Dr. Steven Poe, http://biology.unm.edu/core-faculty/poe.shtml, (*Old Conference Room, attendance optional*)

7:00 –   Dinner (*Patio*)

Friday, June 15, 2012

7:30 – 8:30 AM   Breakfast (*Patio*)

8:30 – 12:00 PM   **Data Acquisition and Management** (*SERF, Room 206*)**:**
- Overview of Sevilleta LTER data acquisition system

- Using serial-to-ethernet converters to provide real-time data access: configuration, Campbell vs. non-Campbell
- *Hands-on exercise: configuring Campbell NL200 serial-to-ethernet converters and connecting all classroom CR1000s to classroom Wi-Fi network we set up on Wednesday*
- Data visualization: LoggerNet ViewPro and RTMC, third-party alternatives

12:00 – 1:00 PM	Lunch (*Patio*)
1:00 – 2:30 PM	**Group Discussion & Final Remarks** (*SERF, Room 206*)
5:00 – 7:00 PM	Dinner at Socorro Springs Brewing Company in Socorro, NM

2012 Workshop Participants (from left): Nicholas Grant (Hubbard Brook LTER), Don Natvig (Sevilleta LTER), Trevor Hebert (Jasper Ridge Biological Preserve), Geoffrey Millard (Hubbard Brook LTER), Michell Thomey (Sevilleta LTER), Albert Wolff (Desert Research Institute), Juan F. Blanco (Luquillo LTER), Joseph Davis (Coweeta LTER), Hilary Dugan (McMurdo Dry Valleys LTER), Thihomir Kostadinov (Andrews LTER), Jim Thibault (Sevilleta LTER), Jennifer Morse (Niwot Ridge LTER), Abram DaSilva (Florida Coastal Everglades LTER), Renee Brown (Sevilleta LTER), Michael Bernard (Baltimore Ecosystem Study LTER), Brian Charlton (Bonanza Creek LTER), Samuel Moya (Luquillo LTER), Xi Yang (Harvard Forest LTER).