SONORA 2007
FIELD CAMPAIGN

A U.S.-Mexico Collaboration on Hydrological Studies of the North American Monsoon

TABLE OF CONTENTS

LIST OF FIGURES/ILLUSTRATIONS....4
LIST OF TABLES....6
EXECUTIVE SUMMARY....7
EXPERIMENTS TIMELINE CHART....9
ITINERARY WITH DAILY SCHEDULE....10
OVERALL MAPS....18
TOWER EXPERIMENT 1: EVAPOTRANSPIRATION FLUX PARTITIONING USING ISOTOPES....21
TOWER EXPERIMENT 2: DAILY SOIL MOISTURE / TEMPERATURE SAMPLING PLOTS....28
TOWER EXPERIMENT 3: MEASUREMENTS OF VEGETATION COVER, LEAF AREA INDEX & VEGETATION REFLECTANCE....34
TOWER EXPERIMENT 4: INSTALLATION OF CONTINUOUS SOIL MOISTURE / TEMPERATURE SENSORS....43
BASIN EXPERIMENT 1: INSTALLATION OF FIVE NEW STATIONS IN SAN MIGUEL BASIN....50
BASIN EXPERIMENT 2: SURFACE SOIL SAMPLING IN THE SIERRA LOS LOCOS BASIN....58
BASIN EXPERIMENT 3: STATIC / DYNAMIC CALIBRATION FOR SIERRA LOS LOCOS TIPPING BUCKET RAIN GAUGES....61
BASIN EXPERIMENT 4: SOIL PIT SAMPLING IN THE SIERRA LOS LOCOS BASIN....66
BASIN EXPERIMENT 5: WATER SOURCE CHARACTERIZATION USING MAJOR ANIONS AND ISOTOPES....87
APPENDIX 1: ECOSYSTEMS AND MAIN PLANT SPECIES OF THE SAN MIGUEL BASIN....89
APPENDIX 2: RELEVANT SECTIONS OF THE CEPTOMETER MANUAL....100
APPENDIX 3: RELEVANT SECTIONS OF THE SPECTRORADIOMETER MANUAL....103
APPENDIX 4: COLLECTING DATA FROM DATALOGGER TO PC FOR THE CONTINUOUS SOIL MOISTURE / TEMPERATURE MEASUREMENTS....128
APPENDIX 5: GRAVIMETRIC SOIL MOISTURE CALCULATION AT THE CONTINUOUS SOIL MOISTURE/TEMPERATURE SENSORS....136
APPENDIX 6: CO-ORDINATES OF SOIL SURFACE SAMPLING LOCATIONS IN THE SIERRA LOS LOCOS BASIN....142
APPENDIX 7: DOWNLOADING DATA FROM THE HOBO DATALOGGER AT TIPPING BUCKET RAIN GAUGE SITES....144
APPENDIX 8: DESERT SURVIVAL PRIMER....149
APPENDIX 9: DRIVING TIPS....158
APPENDIX 10: SAFETY CONSIDERATIONS WHEN DRIVING ON RURAL ROADS....159
APPENDIX 11: FIELD NOTEBOOK SPREADSHEETS....165
APPENDIX 12: EQUIPMENT LISTS....177
APPENDIX 13: LIST OF PARTICIPANTS....180

APPENDIX 14: EARLIER PUBLICATIONS (2) AND POSTERS (2)......................182

LIST OF FIGURES/ILLUSTRATIONS

Figure 1: Overall study site map....18
Figure 2: Overall land cover map....19
Figure 3: Overall topography/hillshade map....20
Figure 4: An example Keeling plot....22
Figure 5: The vapor collection setup....25
Figure 6: Vials of leaves, stems and soils samples....26
Figure 7: Some of the equipment used to estimate soil moisture and soil temperature. This includes thetaprobe, thermometers, compass etc....29
Figure 8: Example of a sampling plot. Plot dimensions are 1 m x 1 m....30
Figure 9: Soil moisture measurements using theta probe. Soil temperature is measured using thermometers at different depths....31
Figure 10: Map of sampling plots....33
Figure 11: Map of approximate location and orientation of transects around the tower in a 250m * 250 m area....37
Figure 12: The tape extended between the transect ends (rope covered by tape and not seen)....38
Figure 13: Correct form in which LAI should be measured.(a) If the vegetation species is a tree, below canopy PAR should be taken at three different randomized heights. (b) For bushes, below canopy PAR should be taken at three different horizontal distances. Compute the average for the three readings and consider this value as below canopy PAR for the sample....40
Figure 14: Example of field spectroradiometer usage. Check the shade projected by the operator. In this case, the measurement is not the optimal because the operator shadow is projected over the creosote bush, thus, can influence the reflectance or radiance readings. 42
Figure 15: The use of an extension pipe can help us to measure radiance/reflectance over relative high canopy....42
Figure 16: An aspect of the tower site shown in the lower right corner of the square. Tentative locations of the sampling points (shown in red points). Green square indicate the fluxes tower as reference....44
Figure 17: Different components inside the enclosure, from top to bottom, battery, datalogger and multiplexer....45
Figure 18: Input connections to datalogger. Check Table 4 in order to identify the terminals and/or ports....46
Figure 19: Connections from the sensors to the multiplexer. Terminals numbers from left to right go from numbers 1 to 6. The soil moisture connectors attached to these terminals are seen above on the multiplexer, while those for soil temperature are inside and not seen....46
Figure 20: Decagon soil moisture sensor model ECH2O EC-20....47
Figure 21: Campbell Scientific temperature sensor model 107....47
Figure 22: Main window for PC400. In order to connect with the software choose the set/up connect tab and the CR10 icon. 48
Figure 23: a) Soil digger recommend for post installation .b) Installation of metal pipes in the field .c) Final result....51

Figure 24: a) Fixation of the enclosure to the post. b) Final result................................51
Figure 25: Solar panel Installation...52
Figure 26: Battery connections...52
Figure 27: Solar panel connection in to the datalogger..53
Figure 28: Wiring connections for Hydra probe SDI-12 at 5cm depth. Remember that blue wire sends the sensor signal to the datalogger, black and clear are ground and red is the source of power for the sensor..55
Figure 29: Wiring connections 6"diameter rain gauge. Remember that black wire sends the sensor signal to the datalogger, white and clear, are ground.........................56
Figure 30: Vertical placement of sensors..56
Figure 31: Location of new stations..57
Figure 32: Surface sampling locations in the Sierra Los Locos basin...........................59
Figure 33: Burette filling a TB rain gauge bucket with water during the static calibration procedure...62
Figure 34: The Texas Electronics model TE525..63
Figure 35: The Hydrological Services model TB3-0.01-P...63
Figure 36: Adjusting the height of the pole under the bucket using an Allen wrench during the static calibration procedure...64
Figure 37: Setup and time measurement during the dynamic calibration procedure. 65
Figure 38: Soil pit locations in the Sierra Los Locos basin..68
Figure 39: Key to the identification of basic sedimentary rocks..................................70
Figure 40: Color/texture identification key for igneous rocks.....................................71
Figure 41: Key to common metamorphic rocks...72
Figure 42: Sample photograph of the soil pit with measuring tape in vertical position 74
Figure 43: Size classification for granular and angular/subangular shapes.................79
Figure 44: Size classification for platy and prismatic/columnar shapes 80
Figure 45: Example of soil plasticity: In this case soil has high plasticity (i.e., vp) and correspondingly clay content...83
Figure 46: Determining soil texture by the 'feel' method...84

LIST OF TABLES

Table 1: Plot coordinates..32
Table 2: Target type...39
Table 3: Shows the proposed coordinates of the six sampling points located around the fluxes tower...44
Table 4: Overview of the cables connected to the CR10 datalogger.........................45
Table 5: Co-ordinates of new stations in San Miguel basin......................................50
Table 6: Master horizon characteristics...75
Table 7: 'A' horizon suffix characteristics..76
Table 8: 'B' and 'C' horizon suffix characteristics..77
Table 9: Textural abbreviations...83

EXECUTIVE SUMMARY

The Sonora 2007 field campaign is an essential component of the research program stemming from the funded proposal 'A US-Mexico Collaboration on Hydrological Studies of the North American Monsoon: A Synthesis of Field Experiments, Remote Sensing, and Hydrological Modeling'. This proposal aims to address the pressing need for binational studies that properly characterize the spatial and temporal variability in hydrologic variables such as precipitation, soil moisture, and streamflow around the Sonora region where the summer monsoon can account for up to 70% of the annual rainfall in the region. This characterization seeks to address an identified gap in our current understanding of monsoon hydrology by integrating ground observations, remote sensing, and hydrologic modeling in a semiarid, mountainous watershed of northern Sonora, México. Hence, the major scientific objectives are to quantify the spatiotemporal variability of hydrologic variables, to estimate the uncertainty of remotely-sensed hydrologic variables such as rainfall and soil moisture through field validation, and to synthesize the observational uncertainty with a hydrologic model. The research program includes various components that are directly addressed by this field campaign: (a) a field program in México for instrument deployment and data collection, (b) research training for undergraduate students prior to and after the field study, and (c) mentoring activities to promote hands-on, team-based learning in a field setting.

The campaign has many participating professors, scientists, and students from different institutions/universities in USA and Mexico (including visiting students from Italy). The 'Experiment Timeline Chart' and the 'Itinerary with Daily Schedule' sections provide an overview and detailed glimpse into the experiments and activities planned during this campaign. The experiments can be separated into two categories: tower experiments and basin experiments, where the basins experiments include the mid-sized 100 km^2 Sierra Los Locos (SLL) basin, and the regional San Miguel basin. The tower experiments are focused around an eddy covariance tower station located in the San Miguel basin with continuous measurements of rain and soil moisture/temperature. Four experiments will be performed in the vicinity of the tower: (a) the daily soil moisture/temperature measurements at multiple depths at the corners and the center of sampling plots located at the 25 grid points of a square grid configuration around the tower, (b) installation of 12 continuous soil moisture and temperature sensors arranged at 6 locations in a hexagonal vertex configuration around the tower, (c) an evapotranspiration flux partitioning experiment at the tower involving isotope measurements on soil, vegetation and evapotranspiration flux samples, and (d) the validation of LANDSAT/MODIS vegetation products like vegetation cover, LAI and vegetation reflectance using transect-based ground measurements around the tower. The basin experiments in the San Miguel basin include installation of five new tipping bucket rain gauge stations with soil moisture/temperature sensors, and basin water characterization of water sources in semi-arid regions using major anion and isotope measurements over groundwater, runoff, precipitation and streamflow components. Basin experiments in the SLL basin include maintenance and dynamic calibration of tipping bucket rain gauges, collecting 50 surface soil samples throughout the basin, and soil profile characterization in the SLL basin through digging of 12 soil pits.

EXECUTIVE SUMMARY (CONTINUED)

The Sonora 2007 has much more diverse experiments than the Sonora 2006 campaign, and would give the participating students the benefit of working in different teams. Day-to-day rotation among these teams will give the students a chance to work with different scientists and get a diversely rich exposure to different aspects of field hydrology. This experience is expected to help all the participants in the future to interact inter-culturally (or in any other framework) in a global scientific context.

EXPERIMENTS TIMELINE CHART

July　　　　　　　　　　　　　　　　　　　　August

	R	F	S	U	M	T	W	R	F	S	U	M	T	W	R	F	S	U	M
	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6

T1	Travel	Meeting	Travel														Finish	Travel	
T2	Travel	Meeting	Travel														Finish	Travel	
T3	Travel	Meeting	Travel														Finish	Travel	
T4	Travel	Meeting	Travel														Finish	Travel	

B1	Travel	Meeting	Travel														Finish	Travel	
B2	Travel	Meeting	Travel														Finish	Travel	
B3	Travel	Meeting	Travel														Finish	Travel	
B4	Travel	Meeting	Travel														Finish	Travel	
B5	Travel	Meeting	Travel														Finish	Travel	

LEGEND

Days:

R, F, S, U, M, T, & W: Thursday to Wednesday

Experiments (T for Tower, B for Basin):

T1: Evapotranspiration partitioning by isotopes
T2: Daily soil moisture/temperature sampling plots
T3: Vegetation sampling
T4: Continuous soil moisture and temperature
B1: Installation of 5 new stations
B2: Soil properties (50 surface samples)
B3: Maintenance/calibration/Installation of SLL watershed stations
B4: Soil properties (12 soil pits)
B5: Groundwater, runoff, precip, streamflow measurements

ITINERARY WITH DAILY SCHEDULE

TOWER EXPERIMENTS at Eddy Covariance Station in San Miguel Watershed

EXPERIMENT	LEADERS
1. Evapotranspiration partitioning by isotopes	Enrico Yepez
2. Daily Soil Temperature/Moisture Sampling Plots	Chris Watts, Julio Rodriguez, Enrique Vivoni
3. Vegetation Sampling - Leaf Area Index, Radiance and Reflectance, Vegetation Cover - Transect	Luis Mendez
4. Continuous Soil Moisture and Soil Temperature	Soni Yatheendradas

BASIN EXPERIMENTS

EXPERIMENT	LOCATION	LEADERS
1. Installation of 5 New Stations	San Miguel Basin	Julio Rodriguez
2. Soil Properties (50 Surface Samples)	Sierra Los Locos Basin	Luis Mendez, Soni Yatheendradas
3. Maintenance/calibration of SLL Watershed Stations/Installation of rain gauges (5) if not already	Sierra Los Locos Basin	Luis Mendez, Soni Yatheendradas
4. Soil Properties (12 Soil Pits)	Sierra Los Locos Basin	Soni Yatheendradas, Luis Mendez
5. Groundwater, Runoff, Precipitation, and Streamflow Measurements	San Miguel Basin	Lissette de La Cruz

TOTAL DAYS FOR EACH EXPERIMENT

Experiment	Total # of days
Evapotranspiration partitioning by isotopes	3 days + 2 days by students
Daily soil moisture/temperature sampling plots	Everyday
Vegetation sampling	3 days: beginning at LANDSAT overpass, mid, end
Continuous soil moisture and temperature	1 day
Installation of 5 new stations	2 days
Soil properties (50 surface samples)	4 days
Maintenance/calibration/Installation of SLL watershed stations	5 days
Soil properties (12 soil pits)	4 days
Groundwater, runoff, precip, streamflow measurements	8 days

DAILY SCHEDULES

FRIDAY, July 20, 2007

9:00 am - 7:30 pm	**Meeting at UNISON** **-Introduction and Overview of Sonora Campaign 2007-**
9:00 am - 9:30 am	Introductions of students/researchers/professors
9:30 am - 1:00 pm	Overview of science and previous campaign work -Enrique Vivoni, Luis Mendez
1:00 pm - 2:00 pm	Lunch
2:00 pm - 5:00 pm	Go over each experiment and basic overview of protocols and purpose (See booklet)
5:00 pm - 7:00 pm	Train students to use equipment. Students would be assigned teams. (keeping in mind factors like tall people needed for some rain gage installations, stronger people assigned to soil pits, Alexis or Whitney in Enrico's team, etc.)
7:00 pm - 7:30 pm	Go over safety issues
7:30 - 8:30 pm	Dinner

SATURDAY, July 21, 2007

8:00 am - 10:00 am	**Group Meeting at UNISON for Last Minute details**		Fill/pick-up nitrogen tanks - Enrico Yepez
10:00 am - 12:00 pm	Lunch, buy groceries/materials, and leave for Rayon.		
12:00 pm - 2:30 pm	Travel to Rayon		
2:30 pm - 4:00pm	Pre-Field Campaign Preparation	Unpack, settle in at house in Rayon	
4:00 pm - 6:00 pm		Tour of area where experiments will be conducted, town, etc.	
6:00 pm - 10:00 pm		Dinner and prepare for field campaign in the morning.	

SUNDAY, July 22, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.			
5:30 am - 6:30 am	Travel to experiment location			
6:30 am - 6:00pm	Field Campaign	**Field Work**		
		<u>Evapotranspiration partitioning by isotopes</u> - Enrico Yepez (+ 2 required)	**<u>Vegetation Sampling - Transect, LAI, Radiance, and Reflectance-</u>** Luis Mendez (+ 1 teams of 3 required + 1 team of 2 required + Soni Yatheendradas)	**<u>Daily Soil Temperature/Moisture Sampling Plots</u>** Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 2 teams of 2 each required)
6:00 pm - 8:00 pm		<u>Organize Data Collected</u> • Transfer data to spreadsheets • GIS mapping	Prepare / organize equipment for following day of experiments	
8:00 pm - 10:00 pm		Dinner		

MONDAY, July 23, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.				
5:30 am - 6:30 am	Travel to experiment location				
6:30 am - 6:00pm	Field Campaign	**Field Work**			
		Evapotranspiration partitioning by isotopes - Enrico Yepez (+ 2 required + 1 extra)	**Setup samplers for stream flow** - Lissette de La Cruz (+ 1 required)	**Continuous Soil Moisture and Soil Temperature** - Soni Yatheendradas (+ 3 required + Luis Mendez)	**Daily Soil Temperature/Moisture Sampling Plots** Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 2 teams of 2 each required)
6:00 pm - 8:00 pm		Organize Data Collected • Transfer data to spreadsheets • GIS mapping		Prepare / organize equipment for following day of experiments	
8:00 pm-10:00 pm		Dinner		Discussion Topic/Presentation: Evapotranspiration flux partitioning, the ecohydrological characteristics that relate to ecosystem productivity - Enrico Yepez	

TUESDAY, July 24, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.				
5:30 am - 6:30 am	Travel to experiment location				
6:30 am - 6:00pm	Field Campaign	**Field Work**			
		Evapotranspiration partitioning by isotopes - Enrico Yepez (+ 2 required)	**Take stream flow samples** - Lissette de La Cruz (+ 1 required)	**Maintenance/Calibration of Sierra Los Locos Watershed Stations/Installation** Luis Mendez, Soni Yatheendradas (+ 2 teams of 2 each required)	**Daily Soil Temperature/Moisture Sampling Plots** Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 2 teams of 2 each required)
6:00 pm - 7:00 pm		Organize Data Collected • Transfer data to spreadsheets • GIS mapping		Prepare / organize equipment for following day of experiments	
7:00 pm - 10:00 pm		Dinner		Discussion Topic/Presentation: Determination of baseflow inputs in riparian areas along a North American Monsoon gradient-Lissette de La Cruz	

WEDNESDAY, July 25, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.					
5:30 am - 6:30 am	Travel to experiment location					
6:30 am - 6:00pm	Field Campaign	**Field Work**				
		Evapotranspiration partitioning by isotopes - Students continue (2 required)	**Take rain and runoff samples** - Lissette de La Cruz (+ 1 required)		**Maintenance/Calibration of Sierra Los Locos Watershed Stations/Installation** Luis Mendez, Soni Yatheendradas (+ 2 teams of 2 each required)	**Daily Soil Temperature/Moisture Sampling Plots** Chris Watts, Julio Rodriguez, Enrique Vivoni **(+ 2 teams of 2 each required)**
6:00 pm - 7:00 pm		Organize Data Collected • Transfer data to spreadsheets • GIS mapping		Prepare / organize equipment for following day of experiments		
7:00 pm - 10:00 pm		Dinner		Discussion Topic/Presentation: Comparison of Remote Sensing and Ground Data of Soil Moisture in Sierra Los Locos - Enrique Vivoni		

THURSDAY, July 26, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.					
5:30 am - 6:30 am	Travel to experiment location					
6:30 am - 6:00pm	Field Campaign	Field Work				
		Evapotranspiration partitioning by isotopes - Students continue (2 required)	**Take groundwater samples** - Lissette de La Cruz (+1 required)		**Maintenance/Calibration of Sierra Los Locos Watershed Stations/Installation** Luis Mendez, Soni Yatheendradas (+ 2 teams of 2 each required)	**Daily Soil Temperature/Moisture Sampling Plots** Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 2 teams of 2 each required)
6:00 pm - 7:00 pm		Organize Data Collected • Transfer data to spreadsheets • GIS mapping		Prepare / organize equipment for following day of experiments		
7:00 pm - 10:00 pm		Dinner		Discussion Topic/Presentation: Calibration and corrections for tipping bucket rain gauges-Chris Watts		

FRIDAY, July 27, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.				
5:30 am - 6:30 am	Travel to experiment location				
6:30 am - 6:00pm	Field Campaign	**Field Work**			
		<u>Soil Properties - 12 Soil Pits</u> - Soni Yatheendradas (+ 2 teams of 2 each required)	**<u>Take groundwater samples</u>** - Lissette de La Cruz	**<u>Maintenance/Calibration of Sierra Los Locos Watershed Stations/Installation</u>** Luis Mendez (+ 2 teams of 2 each required)	**<u>Daily Soil Temperature/Moisture Sampling Plots</u>** Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 1 team of 1 required + 1 team of 2 required)
6:00 pm - 7:00 pm		<u>Organize Data/Samples Collected</u> • Transfer data to spreadsheets • GIS mapping • Organize soil samples		Prepare / organize equipment for following day of experiments	
7:00 pm - 10:00 pm		Dinner		Experiment Results	

SATURDAY, July 28, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.			
5:30 am - 6:30 am	Travel to experiment location			
6:30 am - 6:00pm	Field Campaign	**Field Work**		
		<u>Soil Properties - 12 Soil Pits</u> Luis Mendez (+2 teams of 2 each required)	**<u>Daily Soil Temperature/Moisture Sampling Plots</u>** Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 1 team of 1 required + 1 team of 2 required)	**<u>Maintenance/Calibration of Sierra Los Locos Watershed Stations/Installation</u>** Soni Yatheendradas (+ 2 teams of 2 each required)
6:00 pm - 7:00 pm		<u>Organize Data/Samples Collected</u> • Transfer data to spreadsheets • GIS mapping • Organize soil samples	Prepare / organize equipment for following day of experiments	
7:00 pm - 10:00 pm		Dinner		

SUNDAY, July 29, 2007

DAY OFF!! ☺	***Relax at house or travel to Hermosillo, Bahia Kino, or other plans.***

MONDAY, July 30, 2007

<table>
<tr><td>5:00 am - 5:30 am</td><td colspan="5">Breakfast & prepare, pack, and load vehicles for field experiments.</td></tr>
<tr><td>5:30 am - 6:30 am</td><td colspan="5">Travel to experiment location</td></tr>
<tr><td rowspan="2">6:30 am - 6:00pm</td><td rowspan="4">Field Campaign</td><td colspan="4">Field Work</td></tr>
<tr><td><u>Vegetation Sampling - Transect, LAI, Radiance, and Reflectance</u> Luis Mendez (+ 2 teams of 2 each required)</td><td><u>Take rain and runoff samples</u> - Lissette de La Cruz</td><td><u>Soil Properties - 12 Soil Pits</u> - Soni Yatheendradas (+ 2 teams of 2 each required)</td><td><u>Daily Soil Temperature/Moisture Sampling Plots</u> Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 1 team of 1 required + 1 team of 2 required)</td></tr>
<tr><td>6:00 pm - 7:00 pm</td><td colspan="2"><u>Organize Data/Samples Collected</u>
• Transfer data to spreadsheets
• GIS mapping
• Organize soil samples</td><td colspan="2">Prepare / organize equipment for following day of experiments</td></tr>
<tr><td>7:00 pm - 10:00 pm</td><td colspan="2">Dinner</td><td colspan="2">Discussion Topic/Presentation: Seasonal evolution of Land Surface Conditions in NAM region from MODIS observations-Luis Mendez</td></tr>
</table>

TUESDAY, JULY 31, 2007

<table>
<tr><td>5:00 am - 5:30 am</td><td colspan="5">Breakfast & prepare, pack, and load vehicles for field experiments.</td></tr>
<tr><td>5:30 am - 6:30 am</td><td colspan="5">Travel to experiment location</td></tr>
<tr><td rowspan="2">6:30 am - 6:00pm</td><td rowspan="4">Field Campaign</td><td colspan="4">Field Work</td></tr>
<tr><td><u>Soil Properties - 50 Surface Samples</u> - Luis Mendez, Soni Yatheendradas (+ 2 teams of 2 each required)</td><td><u>Take groundwater samples</u> - Lissette de La Cruz</td><td><u>Installation of New San Miguel Stations</u> - Julio Rodriguez (+ 2 teams of 2 each required)</td><td><u>Daily Soil Temperature/Moisture Sampling Plots</u> Chris Watts, Enrique Vivoni (+ 1 team of 1 required + 1 team of 2 required)</td></tr>
<tr><td>6:00 pm - 7:00 pm</td><td colspan="2"><u>Organize Data/Samples Collected</u>
• Transfer data to spreadsheets
• GIS mapping
• Organize soil samples</td><td colspan="2">Prepare / organize equipment for following day of experiments</td></tr>
<tr><td>7:00 pm - 10:00 pm</td><td colspan="2">Dinner</td><td colspan="2">Presentation/Presentation: Energy Balance and Micrometeorological Measurements-Chris Watts</td></tr>
</table>

WEDNESDAY, August 1, 2007

<table>
<tr><td>5:00 am - 5:30 am</td><td colspan="6">Breakfast & prepare, pack, and load vehicles for field experiments.</td></tr>
<tr><td>5:30 am - 6:30 am</td><td colspan="6">Travel to experiment location</td></tr>
<tr><td rowspan="2">6:30 am - 6:00pm</td><td rowspan="4">Field Campaign</td><td colspan="5">Field Work</td></tr>
<tr><td><u>Soil Properties - 50 Surface Samples</u> - Luis Mendez, Soni Yatheendradas (+ 2 teams of 2 each required)</td><td><u>Take rain and runoff samples</u> - Lissette de La Cruz</td><td colspan="2"><u>Installation of New San Miguel Stations</u> - Julio Rodriguez (+ 2 teams of 2 each required)</td><td><u>Daily Soil Temperature/Moisture Sampling Plots</u> Chris Watts, Enrique Vivoni (+ 1 team of 1 required + 1 team of 2 required)</td></tr>
<tr><td>6:00 pm - 7:00 pm</td><td colspan="2"><u>Organize Data/Samples Collected</u>
• Transfer data to spreadsheets
• GIS mapping
• Organize soil samples</td><td colspan="3">Prepare / organize equipment for following day of experiments</td></tr>
<tr><td></td><td colspan="2">Dinner</td><td colspan="3">Discussion Topic/Presentation: Hydrological Modeling in Sierra Los Locos-Enrique Vivoni</td></tr>
</table>

THURSDAY, August 2, 2007

<table>
<tr><td>5:00 am - 5:30 am</td><td colspan="5">Breakfast & prepare, pack, and load vehicles for field experiments.</td></tr>
<tr><td>5:30 am - 6:30 am</td><td colspan="5">Travel to experiment location</td></tr>
<tr><td rowspan="2">6:30 am - 6:00pm</td><td rowspan="4">Field Campaign</td><td colspan="4">Field Work</td></tr>
<tr><td><u>Soil Properties - 50 Surface Samples</u> - Soni Yatheendradas (+2 teams of 2 required)</td><td colspan="2"><u>Vegetation Sampling - Transect, LAI, Radiance, and Reflectance</u> Luis Mendez (+ 2 teams of 2 each required)</td><td><u>Tower Sampling Plots - Soil Temperature and Moisture</u> Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 1 team of 1 required + 1 team of 2 required)</td></tr>
<tr><td>6:00 pm - 7:00 pm</td><td colspan="2"><u>Organize Data/Samples Collected</u>
• Transfer data to spreadsheets
• GIS mapping
• Organize soil samples</td><td colspan="2">Prepare / organize equipment for following day of experiments</td></tr>
<tr><td>7:00 pm - 10:00 pm</td><td colspan="2">Dinner</td><td colspan="2">Experimental Results</td></tr>
</table>

FRIDAY, August 3, 2007

5:00 am - 5:30 am	Breakfast & prepare, pack, and load vehicles for field experiments.			
5:30 am - 6:30 am	Travel to experiment location			
6:30 am - 6:00pm	Field Campaign	Field Work		
		Soil Properties - 50 Surface Samples - Soni Yatheendradas (+ 2 teams of 2 each required)	**Soil Properties - 12 Soil Pits** - Luis Mendez (+ 2 teams of 2 each required)	**Tower Sampling Plots - Soil Temperature and Moisture** Chris Watts, Julio Rodriguez, Enrique Vivoni (+ 1 team of 1 required + 1 team of 2 required)
6:00 pm - 7:00 pm		Organize Data/Samples Collected • Transfer data to spreadsheets • GIS mapping • Organize soil samples	Prepare / organize equipment for following day of experiments	
7:00 pm - 10:00 pm		Dinner		

SATURDAY, August 4, 2007

6:00 am - 6:00 pm	Wrap - up: • Finish any remaining experiments/tasks • Organize equipment, data • Prepare for departure • Meeting to review sum of results/conclude campaign

Sunday, August 5, 2007

9:00 am - 9:00 pm	End of Campaign, return.

Additional information:

- Excluding the task leaders, 11 students are assigned among the experiments each day.
- Whitney or Alexis would be always in Enrico's experiment
- The vegetation measurements need clear sky. If conditions are cloudy on July 30 and August 2, these experiments will swap with those of the following day: task leaders should co-ordinate.
- Lissette's schedule depends on the rain conditions.

OVERALL MAPS

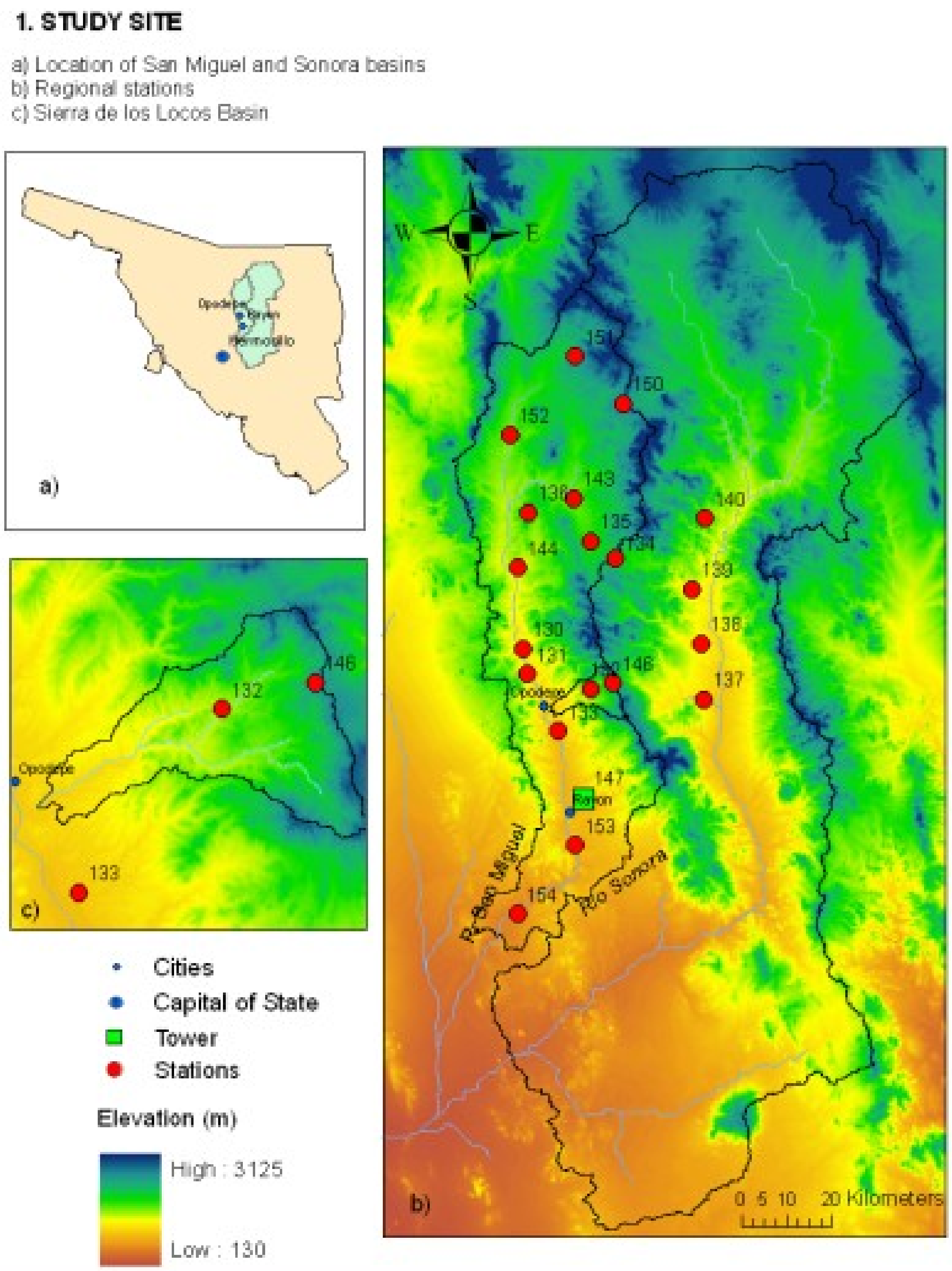


Figure 1: Overall study site map

2. LAND COVER

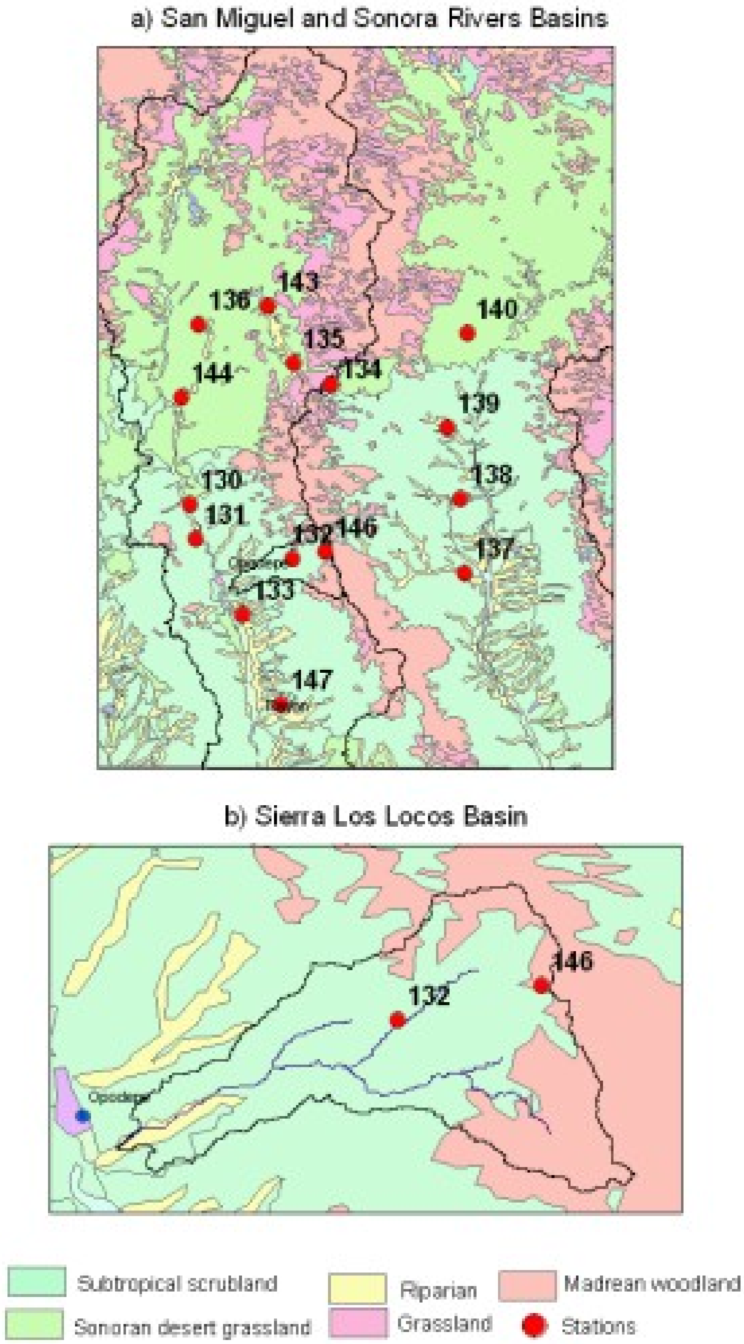
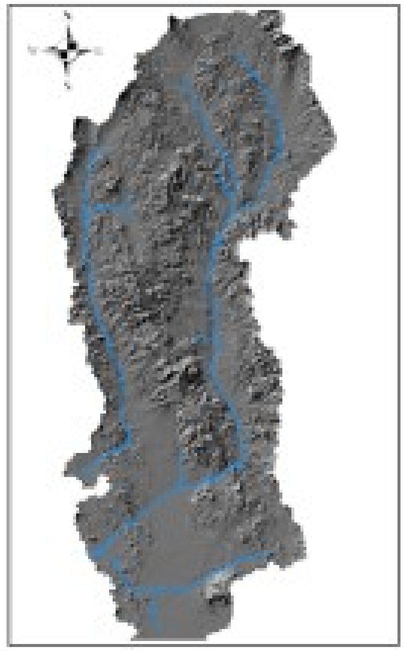


Figure 2: Overall land cover map

3. Topography/Hillshade

Sonora and San Miguel Basins



Sierra de los Locos Basin

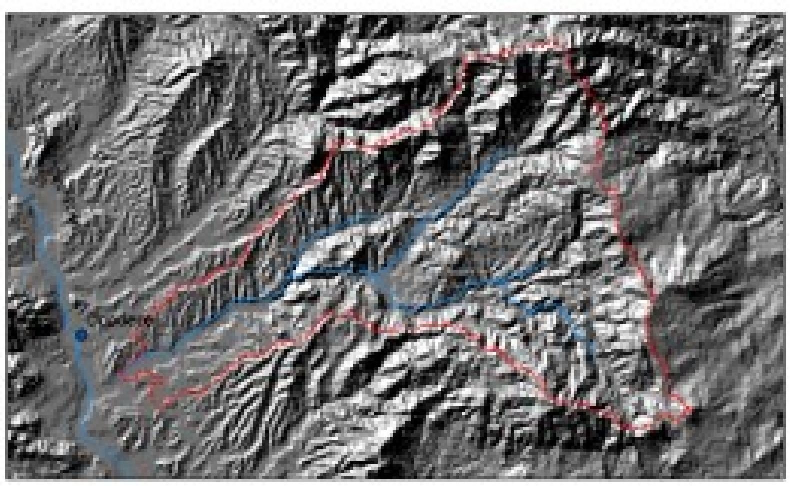


Figure 3: Overall topography/hillshade map

TOWER EXPERIMENT 1: EVAPOTRANSPIRATION FLUX PARTITIONING USING ISOTOPES

Goal

The purpose of this experiment is to collect samples of vapor, soils and transpiring vegetation (stems, leaves) which, through the corresponding isotopic compositions, will help determine the relative proportions of evaporation (E; soil and wet surfaces) and transpiration (T; plant) in the total evapotranspiration flux (ET) measured by eddy covariance in dry shrublands “Matorrales secos” along the Rio San Miguel in Sonora Mexico.

Daily sampling equipment

- Markers for soil and vegetation locations
- GPS unit
- Watch/clock/chronometer
- Field notebook
- Soil auger
- 25 ml screw-capped vials (18 or 36 for leaves, 12 for stems, 15 for soils)
- Labels and pen/pencil for labeling the vial samples
- A set of hand pruners
- Enough pieces of parafilm cut to strips of 1 by 4 inches
- Vapor trapping system (including glassware and liquid nitrogen/alcohol bath)
- Aluminum foil and coolers to keep the vapor samples (collected in glass tubes) cool.
- Ziploc bags to collect the vials of soil, stem and leaf samples
- Metal file (used to help break glass tubes)
- A set of scissors

CHECK with Enrico, Alexis or Whitney if the stem or leaf sampling would be done that day, and if 18 or 36 vials are required for the leaf samples.

For the vapor trapping system:

- Glass tubes
- Liquid Nitrogen
- Ethanol
- Dewar flask with lid (item that holds the liquid nitrogen and ethanol)
- thermometer (one in plastic container)
- Vapor trapping system connected to board and in white plastic container
- Valves
- Tubing

Post-sampling analysis background

Measurements of the stable isotopic compositions of water or water vapor provide a tracer of the sources of ET because water vapor from plant transpiration and soil evaporation each have unique isotopic signatures (Wang and Yakir, 2000). This helps separate the relative contributions of transpiration and evaporation at the ecosystem scale, using a mixing equation:

$$T/ET = \frac{\delta_{ET} - \delta_E}{\delta_T - \delta_E} \qquad \text{(Eq. 1)}$$

where δ_{ET} is the isotopic composition of evapotranspiration,

δ_E is the isotopic composition of soil evaporation, and

δ_T is the isotopic composition of transpiration.

δ_{ET} is estimated using the 'Keeling plot' approach (Yakir and Sternberg 2000).

About isotopic composition of evapotranspiration vapor, δ_{ET}:

Determination of the isotopic composition of the evapotranspiration flux (δ_{ET}) is possible using "Keeling plots" (Figure 4) of water vapor. In this model the y-intercept of a simple linear regression between the isotopic composition of several vapor samples and the inverse of the corresponding absolute moisture concentration indicates δ_{ET}.

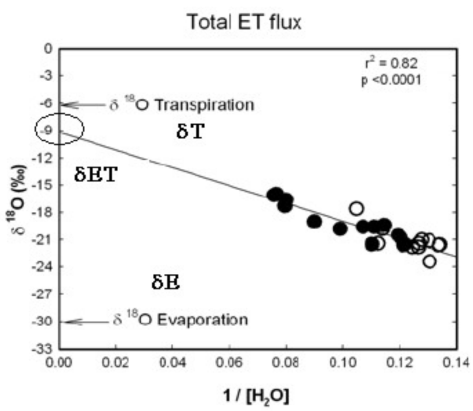


Figure 4: An example Keeling plot

About isotopic composition of vapor from soil evaporation, δ_E

During the process of evaporation, the isotopic composition of water is modified during the diffusion through boundary layers, where fractionation processes act against the heavy isotopes resulting in an evaporation water flux depleted in heavy isotopes relative to the water at the evaporating surface in the soil. The intensity of such depletion is a function of the isotopic composition of the vapor in the atmosphere and soil water, relative humidity and equilibrium and kinetic fractionations associated with a phase change and diffusion and temperature.

About isotopic composition of the transpiration vapor sources, δ_T:

During transpiration, an isotopic steady state (ISS) can be attained, in which the vapor leaving the leaf has the same isotopic composition of water moving into the leaves from the xylem. This because of no isotopic fractionation during water uptake by roots and transport to sites of evaporation in leaves, and despite the common enrichment of heavy isotopes in the leaf water as a product of kinetic and equilibrium fractionations. Hence, the isotopic composition of the stem water could a reliable surrogate for $_T$ (Yakir and Sternberg, 2000). However, field and laboratory experiments investigating factors controlling the isotopic composition of leaf water suggest that, during typical diurnal regimes of atmospheric humidity, leaf water is not always at ISS and that transpiration at ISS occurs only after ambient conditions are relatively stable. Thus, a careful consideration of potential deviations from ISS during transpiration is necessary when using the isotopic mass balance depicted in eq. (1) because failure to account for deviations from ISS can translate in significant errors in the final estimates ofT/ET under certain circumstances.

Experimental Approach

Initial setup

For the vapor collection, the setup would be done under the supervision of Enrico Yepez on the first 3 days. This setup basically consists of air flow generated with a miniature diaphragm pump to exhaust dry air that has passed through a cryogenic vapor trap resting in a cold bath at -80 ∫C (see subplot 2 in Figure 5), where the air flow is regulated with a flow meter to be at 0.5 L min^{-1}. The vapor trap consists of two glass tubes assembled by a gas tight metal tee such that a 6 mm open tube rests inside a 9 mm tube to route the air between the walls of both tubes and then through the inner cavity of the 6mm tube upwards (see subplot 1 in Figure 5; **REMEMBER: when preparing the vapor trap, mark off the radial circumference of the tube with the sharp file so that the tube neatly breaks later along that marking and would not create sharp jagged edges that could bleed your hand**). The air flow aims to simultaneously collect atmospheric vapor from 4 heights within and above the canopy (0.1, 1, 4.5, and 9 m to match the heights where the moisture concentration is being sensed by an infrared gas analyzer) through low-absorption tubing attached to the tower to reach such heights. The cold bath will be maintained at -80ºC by periodic additions of liquid nitrogen to a slush of ethanol (**IMPORTANT**: In any case, strictly keep the temperature lower than -60ºC). At this temperature, all moisture condenses (freeze) in the glass tubes of the trap and dry air is exhausted towards the pump.

For the soil water collection, the setup consists of marking 3 different spots (assign ID labels from 1 to 3) where the soil samples will be extracted at 4 or 5 different depths. Also write down the co-ordinates of these 3 spots into the field notebook using the GPS, along with those assigned IDs.

For the stem and leaves collection, the setup consists of finding 2 plants each from the 3 most representative species (i.e., total of 6 plants) and marking their locations (assign ID labels 1 to 3 from the most representative species to the least if possible, along with the ID suffixes 'a' and 'b' for the 1st and 2nd plant of each species respectively). Also write down into the field notebook the names of these 3 representative species, and the co-ordinates of these 6 plants along with their assigned IDs and ID suffixes. Refer the Appendix on 'Ecosystems and main plant species of the San Miguel basin' for the vegetation classification.

Vapor samples collection (δ_{ET})

IMPORTANT: Periodically check the cold bath temperatures and add liquid nitrogen to a slush of ethanol to maintain them at -80ºC. If the temperatures rise to -70ºC during each 30-minute experiment and even possibly to -60ºC, its okay, but SURELY keep the temperature below -60ºC.

The steps for vapor samples collection are:

1. Start the air flow and check if the experimental setup is okay (see subplots 1 and 2 in Figure 5).
2. Vapor will be collected during **six 30-minute periods distributed during the day (each period starts every 2 hours, so there is a 1.5-hour interval between these experimental periods)** to match the averaging periods used by the eddy covariance tower for the ET measurements. Start to time each period and note it in your field notebook.
3. Depending on the moisture conditions of the atmosphere, after each 30 minute period of maintaining a constant flow, 30 to 50 µL of water would be collected in each trap. **IMPORTANT: This water collection time should be accurate to within 1 min of this 30-min duration (i.e., 30-min ± 1 min).** The inner tubes sticking out from the metal tees then have to break to be able to disassemble the vapor trap. The wet portion of the 6mm glass will drop into the 9mm tube, so that we can cap with few layers of parafilm and secure the vapor (the 1st label/wrapping should be securely fastened) for storage and transport to the lab for the isotope analysis (see subplot 3 in Figure 5).

Important: Be quick on breaking the inner tube and capping the samples when the air flow stops. This is to avoid drastic changes in temperature that can evaporate water from the traps, which might then change the isotopic composition of our water samples.

4. Repeat the above steps for each 30-minute time period.

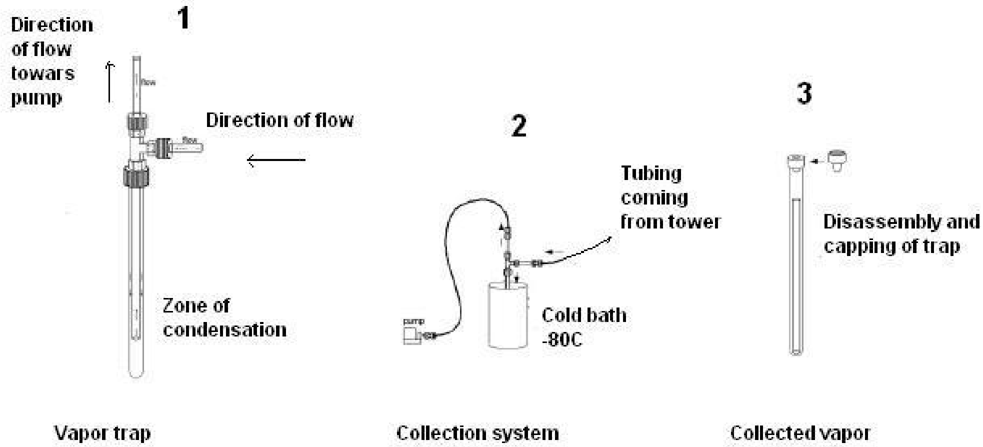


Figure 5: The vapor collection setup

<u>*Soil water samples collection (δ_E).*</u>

The steps for soil water samples collection (**to be done only once daily**) are:

1. For the considered spot, use a hand soil auger as far as possible into the soil to reach the depths needed to obtain the samples. Then, separate the soil sample into sections of 5 cm (should have ideally been 10 cm sections with a deeper soil auger). If the soil sample can not be cut into equal sections of 5 cm, cut the sample so that only the deepest sample is not a full 5 cm. Rapidly put the soil interval sections into separate vials and rapidly cap them to avoid evaporation from the sample (see Figure 6).
2. Label the samples using the spot number first, then the date on the next line, and then the sampling interval section number with the sampling interval in parentheses, for example, section 2 (5-10 cm). The section number is one for the topmost and increases with depth.
3. Repeat above steps for each depth at each spot.

Figure 6: Vials of leaves, stems and soils samples

Stems and leaves samples collection (δ_T).

If the stem samples are supposed to be collected on that day, the steps for stem samples collection **(to be done only once daily**) are:

1. For each of the 6 plants, use a set of hand pruners to rapidly cut 6 to 8 pieces (roughly inch-long) of non-green stems and rapidly all these 6 to 8 pieces into a vial (see Figure 6). Again, rapidly cut another 6 to 8 pieces and put into a duplicate vial. So, we should have 2 vials from each plant.
2. Label with the date, the ID, and the ID suffix (e.g., 'July 22, 2007', followed by '2a' where '2' is the ID and 'a' is the ID suffix).
3. Repeat this for each plant.

The steps for leaves samples collection (**to be done six times daily roughly corresponding to the vapor collection times**) are:

1. For each of the 6 plants, detach several leaves detached from their petioles, and rapidly put into vials (see Figure 6). If we have only 18 vials for the leaves for that day, then mix the leaves from both plants of the representative species sampled into one vial.
2. Label with the date, the ID, and the ID suffix (e.g., 'July 22, 2007', followed by '2a' where '2' is the ID and 'a' is the ID suffix. If only 18 samples are collected, then the ID suffix would be a mix like 'ab').
3. Repeat this for each plant.

References

Yakir D. and Sternberg, L. da S. (2000) The use of stable isotopes to study ecosystem gas exchange. Oecologia 123, 297-311.

Yepez E.A., Williams D.G., Scott R.L. and Lin G. (2003) Partitioning overstory and understory evapotranspiration in a semi-arid woodland ecosystem from the isotopic composition of water vapor. Agrucultural and Forest Meteorology 119, 53-68.

Wang X. F. and Yakir, D. (2000) Using stable isotopes of water in evaporation studies. Hydrological Process 14, 1407-1421.

TOWER EXPERIMENT 2: DAILY SOIL MOISTURE / TEMPERATURE SAMPLING PLOTS

Goal

The purpose of this task is to study the variability of soil moisture/temperature within the 1km^2 area around the fluxes tower. This will be accomplished by taking daily measurements of soil temperature (at four depths: surface with an infrared thermometer, and 1cm, 5cm, and 10cm using a probe thermometer), soil moisture (using a theta probe), and weather data (provided by the weatherstation on the tower).

Materials

The first day

- 4 hand held theta probes (soil moisture probe)
- extra tines
- 1 infrared thermometer (surface temperature instrument)
- 3 soil thermometers
- 200 flags
- 100 1' wooden stakes
- 1 GPS unit
- 1 map and coordinates of station locations
- Field notebook
- Writing utensils (permanent marker, pen, pencil)
- Radios
- Digital Camera (when available)

Subsequent days

- 4 hand held theta probes
- extra tines
- 1 infrared thermometer (surface temperature instrument)
- 3 soil thermometers
- a few extra flags
- a few extra stakes
- 1 GPS unit
- 1 map and coordinates of station locations
- Field notebook
- Writing utensils (permanent marker, pen, pencil)
- Radios
- Digital Camera (when available)

Procedure

Before departing for the field

1. Gather all necessary equipment (see figure 7).

2. Check that all equipment is working (especially GPS and radios).

3. Double-check your equipment.

Figure 7: Some of the equipment used to estimate soil moisture and soil temperature. This includes thetaprobe, thermometers, compass etc.

Plot deployment (first day)

1. Locate sampling location. **(We will be using the same locations as the 2006 campaign.)**

2. Place 4 flags in the ground at this location creating a 1m x 1m square using the flags as corner markers (check figure 8).

   IT IS VERY IMPORTANT THAT YOU DO NOT STEP INSIDE THE BOX AS THIS WILL CHANGE THE SOIL COMPACTION AND WILL ALTER THE DATA

Figure 8: Example of a sampling plot. Plot dimensions are 1 m x 1 m

3. Take an exact GPS reading for the location and record in notebook. Also record operators, date, and time in notebook.

4. Mark on the flag the location ID.

5. Take 5 soil moisture measurements; one at each corner of the box and one at the center of the box. Record measurements in notebook. (figure 9)

6. Note which measurement was taken with which probe.

7. Take surface temperature with the infrared thermometer and record in notebook.

8. Take soil temperatures at 1cm, 5cm, and 10cm, each with different soil thermometers and record in notebook (check figure 9)

9. Make sure to gather all equipments before departing to the next site.

Figure 9: Soil moisture measurements using theta probe. Soil temperature is measured using thermometers at different depths.

Subsequent Days

1. Record location ID, operators, date, and time in notebook.

2. Take 5 soil moisture measurements; one at each corner of the box and one at the center of the box. Record measurements in notebook.

3. Note which measurement was taken with which probe.

4. Take surface temperature with the infrared thermometer and record in notebook.

5. Take soil temperatures at 1cm, 5cm, and 10cm, each with different soil thermometers and record in notebook.

6. Make sure to gather all equipments before departing to the next site.

Table 1: Plot coordinates

Site ID	East *	North*
1,1	544687	3290049
2,1	544750	3290065
3,1	544801	3290058
4,1	544871	3290051
5,1	544933	3290062
1,2	544679	3290113
2,2	544753	3290123
3,2	544815	3290122
4,2	544873	3290115
5,2	544925	3290117
1,3	544684	3290180
2,3	544752	3290183
3,3	544819	3290182
4,3	544870	3290179
5,3	544945	3290183
1,4	544699	3290242
2,4	544749	3290240
3,4	544805	3290238
4,4	544866	3290236
5,4	544934	3290246
1,5	544701	3290310
2,5	544760	3290297
3,5	544808	3290288
4,5	544877	3290277
5,5	544929	3290280
A	544809	3290158
B	544833	3290180
C	544811	3290205
D	544785	3290178

*Projection: UTM-12
Datum: WGS84

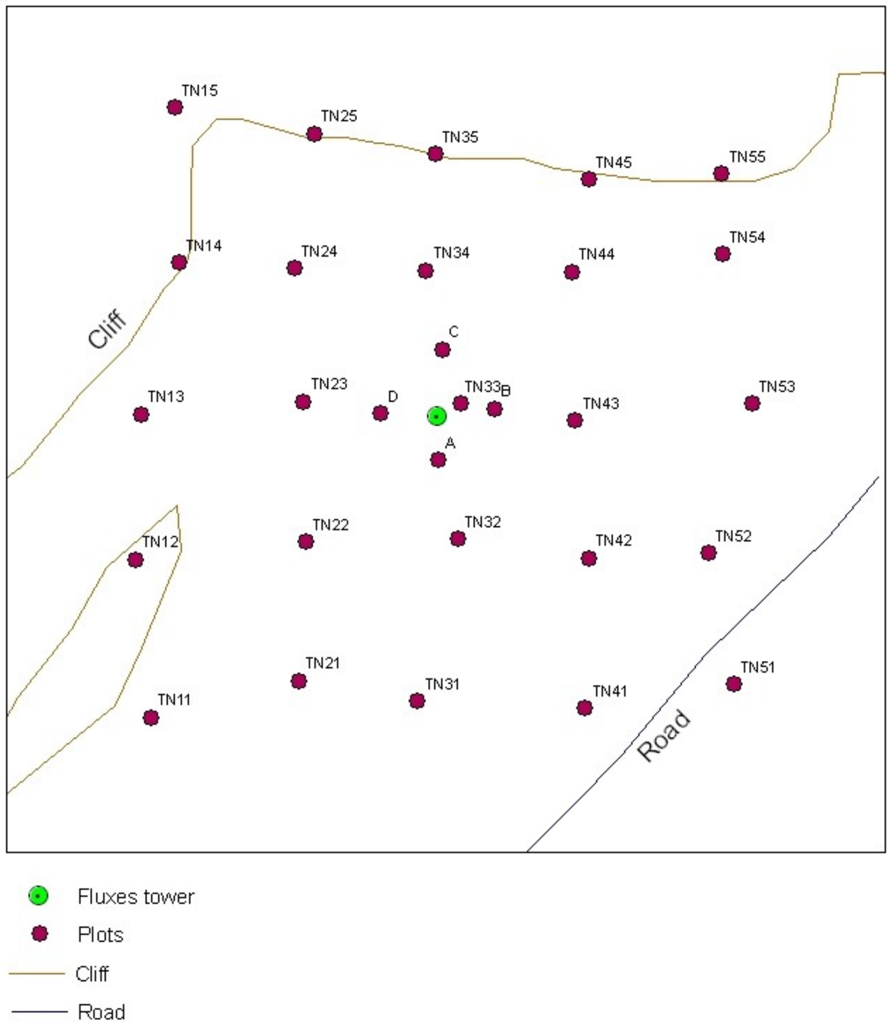


Figure 10: Map of sampling plots

TOWER EXPERIMENT 3: MEASUREMENTS OF VEGETATION COVER, LEAF AREA INDEX & VEGETATION REFLECTANCE

Goal

To validate vegetation-related LAI and reflectance products in MODIS/LANDSAT using ground measurements of vegetation cover (using the line intercept or transect method), of Leaf Area Index or LAI for short (using a ceptometer), and of vegetation reflectance (using a spectroradiometer).

Background

Vegetation cover: The dynamics of plant species of our study sites can be better understood from information about vegetation cover. At a general level of information, dominant species can be identified with their relative ground cover density. At a more specific level, the information of cover density by classes can obtained using the transect method, where the percent of observations of any plant species out of the total number of equi-spaced transect measurements would give the percent vegetation cover for that species. Vegetation cover information is useful both for the experiment on evapotranspiration partitioning using isotopes, and for combining with individual plant species LAI measurements to get a representative MODIS/LANDSAT pixel-scale LAI.

LAI: LAI is defined as a simple ratio of total upper leaf surface area of a plant to surface area of the ground on which the plant grows. In other words, as foliage increases, LAI also increases. Hence, changes in LAI over time can be converted to leaf biomass and used to represent leaf production in forests. In order to estimate the representative value of LAI corresponding to the scale of a MODIS/LANDSAT pixel, the information of the breakdown of the total vegetation cover by vegetation species is combined with the LAI values of the individual vegetation species. The inputs required for LAI measurements using the ceptometer are listed below:

- *Tau (τ)* is the ratio between above and below canopy photosynthetically active radiation (PAR) values. PAR is defined as the radiation between 400 and 700 nm and it is the part of the spectrum that plants needed for photosynthesis.

- *Zenith Angle (z)* is the angle made by the sun with respect to the zenith (i.e., outward normal at the location which points straight up). Hence, the zenith angle of the zenith is 0∞ and of the horizon is 90∞. Zenith angle is thus calculated based on the time of the day and your global position.

Vegetation reflectance: Vegetation reflectance is one of the energy components after solar radiation hits or encounters an object in the field. This reflectance can be expressed as a ratio of the radiance (reflected energy) and the irradiance (incident solar energy).

Materials :

Common to each team:

- Camera
- Stakes
- Rope of at least 100 m length.
- Graduated tape, preferably minimum 100 m length.
- Hammer
- GPS (remember: UTM reference system and datum WGS-1984).
- Labels or felt pens for labeling stakes on the 1st day of measurements.

Vegetation cover measurement:

- Relevant field notebook

LAI measurement:

- Ceptometer
- Relevant field notebook

IMPORTANT: Check if the longitude, latitude, date, and time are correctly set in the set up menu of the ceptometer (model Accupar LP-80 by Decagon) before you leave the house (ask Luis Mendez or Julio Rodriguez). The lat-long coordinates for the tower site are:

Latitude = 29.741

Longitude = -110.537

At the house in Rayon, familiarize yourself with the ceptometer manual for turning on and operating the instrument.

Vegetation reflectance measurement:

- Spectralon white panel (or equivalent)
- Devise to extend spectrabn.
- Spectroradiometer
- Rug (to continuously clean the spectralon white panel)
- Relevant field notebook
- Compass if available

IMPORTANT: Ensure that the spectroradiometer is assembled and that the software is installed at the house in Rayon (ask Luis Mendez or Julio Rodriguez: details are in the spectroradiometer manual). Also, at the house in Rayon, refer to the manual and familiarize yourself with the appropriate use, handling, and procedures for starting the equipment and ending a sampling session. Important considerations to take into account regarding the reflectance readings are:

- Know the spectrometer's field of view (FOV).
- The reference panel fills the FOV. Note the approximate height required above any target.
- Take reading of reference panel.

Procedure :

Since many communities of trees and shrubs with a wide variation in spatial coverage characterize the tower site, hence, it is highly recommended that the length of transect be 100 meters (MODIS pixel is 250 meters along each dimension) and the along-transect measurements be taken every 1-meter. The number of transects increase with the diversity and sparse-ness of the vegetation. For this experiment, the approximate map of transects chosen and along which the vegetation cover, LAI, and vegetation reflectance are measured, is shown in Figure 11.

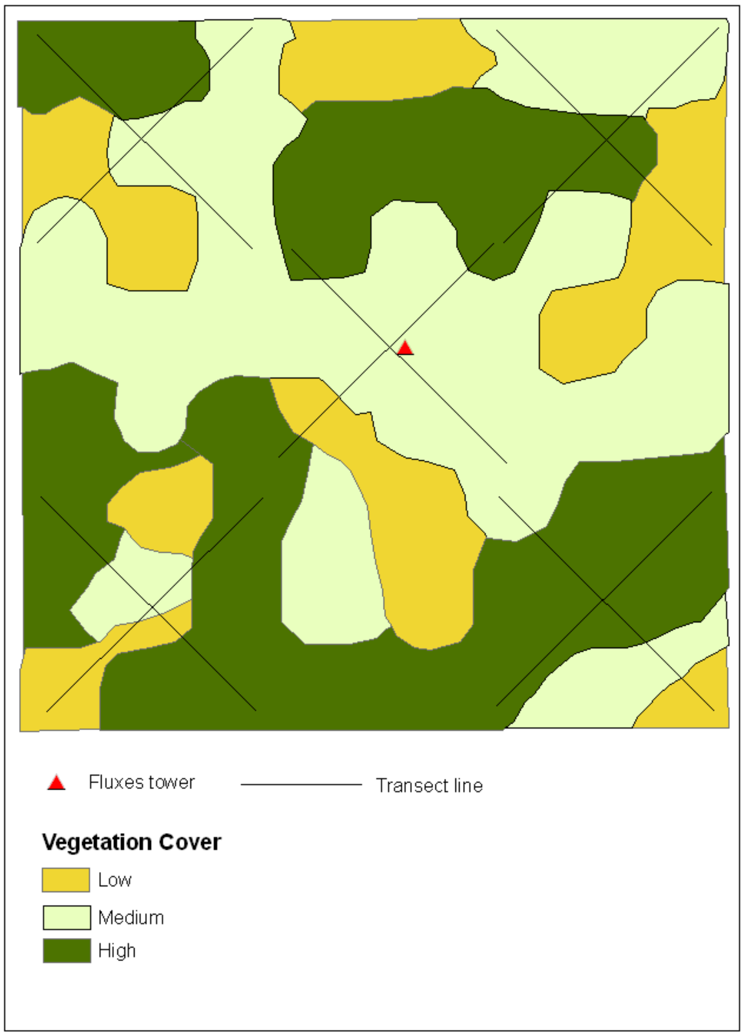


Figure 11: Map of approximate location and orientation of transects around the tower in a 250m * 250 m area.

NOTE:

- Because irradiance is constant, while measuring reflectance and using the reference panel, cloudy days must be avoided. Do not sample LAI or vegetation reflectance if conditions are cloudy (if the clouds hide the sun, then definitely do not take the readings, however, if they do not hide the sun, then you could still go ahead and take the readings).

- If vegetation reflectance sampling is done, one person should be preferably only handling the spectroradiometer. Distribute the writing down of the spectroradiometer measurements, along the vegetation cover and LAI measurement tasks, equally among the remaining persons in the team.

For each transect, repeat the following steps:

1. If this is the first day of these experiments, use the rope and measuring tape to select the transect end-points. Drive stakes into the ground at these end-points using the hammer. Use the GPS to find co-ordinates of these end-points. Allot an ID for this transect (co-ordinate with the other team to avoid duplicate transect IDs), label both transect end-points with this ID. This will be among the transect information recorded in each field notebook:
    - Transect ID
    - Co-ordinates of both end-points of transect
    - Date and time
    - Person performing the respective experiment.
    - Environmental information
2. If this is not the first day of the experiments, locate the transect end-points using the IDs from the labels and/or the GPS, and record all the above transect information into each field notebook except the co-ordinates of both end-points of the transect.
3. Tie the 100m rope connecting the transect ends. Extend the tape along this rope (Tape shown in Figure 12).

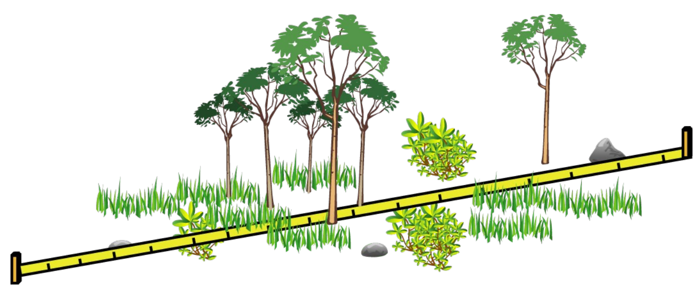


Figure 12: The tape extended between the transect ends (rope covered by tape and not seen)

4. Turn the ceptometer on. Refer to the subsection on 'turning on the ceptometer' in the Appendix on 'Relevant sections of the ceptometer manual': in short, the PAR sampling menu is initially active where the real-time PAR value of the ceptometer surroundings is displayed in the center of the screen (you don't need this), along with a smaller size PAR value to its right and above. This smaller value is measured at the connected sensor and has an above-canopy icon (this is what you need and is an average above-canopy reading; the average below-canopy reading will appear below this when you take those measurements during the course of the experiment).
5. Turn the CT100 power switch on the spectroradiometer on: refer to the subsection on 'Collecting readings' in the subsection on 'Relevant sections of the

spectroradiometer manual'. In short, the screen flashes some diagnostic characteristics for a few seconds, then shows the underscore character in the upper left-hand corner, then press the Enter key 3 times at approximately 1-second intervals. Press enter again and choose 2 to record the average of the sub-samples (i.e, target readings) per plot (i.e. target).

6. Start walking from one end to another, recognizing each stretch of bare soil, litter, rock or individual vegetation species (all team members should agree on the m point beginning and ending for any stretch). To co-ordinate the readings of all team members, the idea is to replicate this information in each m entry of the vegetation cover table in its field notebook for that stretch, and to take measurements only at each individual vegetation species for the LAI and reflectance to be entered into their respective field notebooks for that stretch. At any time along the transect path, take photographs if necessary. The procedures for the vegetation cover, the LAI and the reflectance/radiance to be taken co-ordinatedly then follow in separate subsections:
   - *Vegetation cover*: For every stretch of bare soil, litter, rock or individual vegetation species, find the along-transect span of measurements in whole numbers of m along the transect length covered by that target (e.g., grass from 33-36 m). Use the following main symbols from the Table 2 below (e.g., "V" for "vegetation") for entering this information into the field notebook. Fill the rows corresponding to that stretch in the field notebook (e.g., enter "V" for rows starting at 33m and ending at 36 m). Also enter additional information describing the type of vegetation (tree, shrub, genus, species, grass, etc.) on those rows after checking the Appendix on 'Ecosystems and main plant species of the San Miguel basin' for information about more common species.

Label	**Vegetation Cover**
S	Bare soil
L	Litter
R	Rock
V	Vegetation

Table 2: Target type

   - *LAI*: If the target is a plant, then one above-canopy and 3 below-canopy PAR/LAI measurements are required for each target (**IMPORTANT: When taking any reading, the ceptometer screen should be facing vertically up so that the corresponding sensor gets the correct radiation from above vertically, this can be checked with the bubble level at the upper right corner which needs to be in the center**). Refer to the subsection on 'taking measurements' in the Appendix on 'Relevant sections of the ceptometer manual': in short, press the up-arrow or down-arrow keys for making the above-canopy or below-canopy measurements respectively. Among the two vertically placed value rows oto the right, the screen value to the left side of the up- or the down-arrow is the corresponding average PAR value, and that to the right side is the number of measurements over which the PAR value is averaged. The above-canopy reading is direct to the sunlight without canopy interception, and hence can even be made in direct sunlight just next to the target in case of tall unreachable canopy top targets. The 3 below-canopy readings are at positions along the longer dimension of the target: Figure 13 shows example ways that PAR/LAI should be measured if the target is a tree or a bush. Enter these values on the screen (above-canopy PAR, average below-canopy PAR, and values at the bottom of the screen: T, L, i.e., LAI, Fb, x and z) into the field notebook, along with any other surrounding details you consider relevant. These values would be manually calculated/confirmed at the house later. Press ENTER to electronically save these values; do not press ESC which discards them (both options clear the screen for new data): if ESC is pressed by mistake, remember that we still have those values entered into the field notebook.

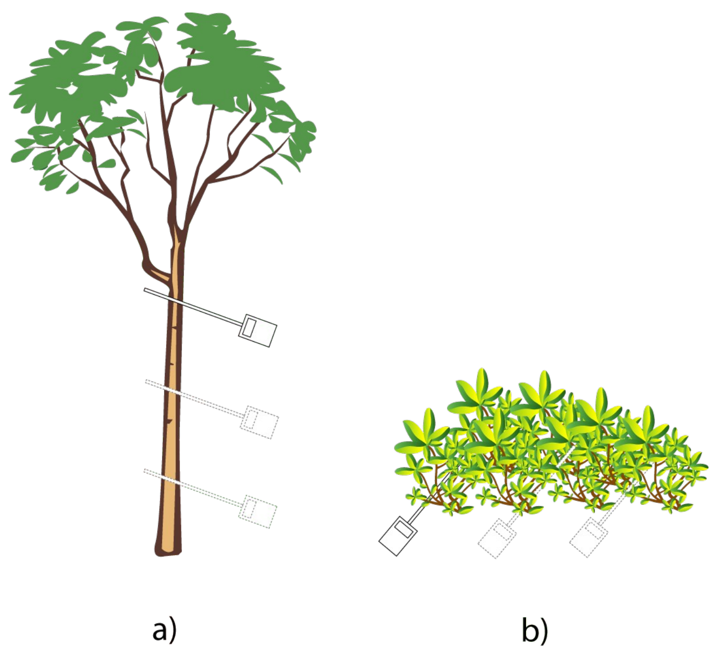


Figure 13: Correct form in which LAI should be measured.(a) If the vegetation species is a tree, below canopy PAR should be taken at three different randomized heights. (b) For bushes, below canopy PAR should be taken at three different horizontal distances. Compute the average for the three readings and consider this value as below canopy PAR for the sample.

- *Vegetation reflectance:* If the target is a plant, then an average of 5 readings above the canopy are required for each target, along with a reference panel reading every 6 targets (REMEMBER to do such reference panel reading every 6 targets unless the illumination is stable). Refer to the subsection on 'Collecting readings' in the Appendix on 'Relevant sections of the spectroradiometer manual': In short, enter the possible plot (target) numbers for each transect, for example, for transect 2, you could enter 2001 to 2999 (This includes the average target and reference panel readings). For taking a reading, maintain a consistent viewing geometry relative to the solar azimuth (e.g., facing the sun always), while avoiding projecting any shade (made by self or objects) on the reference panel or target (IMPORTANT!). Avoid viewing geometries like in Figure 14, for example. One way to do this might be by facing the sun every measurement. Vehicles and persons other than the operator should be kept several meters away from the target during the readings. Any extension pipe should be painted with a dark color in order to avoid any influence on readings. Do not forget to hold the sensor at the approximate height required above any target considering the Field of view (FOV). Use the extension device, if necessary, to take readings of the trees or shrubs, avoiding the shade projected by object (Figure 15). **IMPORTANT: When taking any reading, tilt the pole so that the bubble level is centered and hence the spectroradiometer leveled**. Initiate a reading scan by pushing the space key, and follow the instructions as given in the subsection on 'Collecting readings' in the Appendix on 'Relevant sections of the spectroradiometer manual', including storing the readings while also noting them down into your field notebook: note them down in the same format as appears on the screen, e.g. 'IRR 809 B 10.7' (These would be manually confirmed at the house later). Add also any other surrounding details you consider relevant.

References:

McCoy, Roger M. (2005), Field Methods in Remote Sensing, Guilford Press.

Figure 14: Example of field spectroradiometer usage. Check the shade projected by the operator. In this case, the measurement is not the optimal because the operator shadow is projected over the creosote bush, thus, can influence the reflectanceor radiance readings.

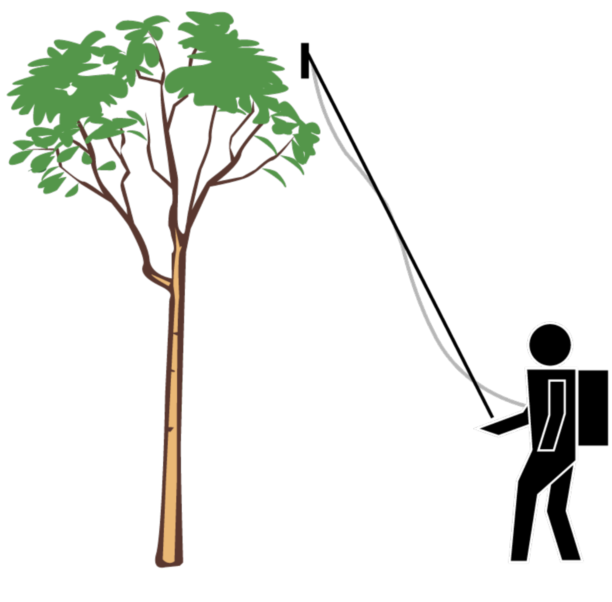


Figure 15: The use of an extension pipe can help us to measure radiance/reflectance over relative high canopy.

TOWER EXPERIMENT 4: INSTALLATION OF CONTINUOUS SOIL MOISTURE / TEMPERATURE SENSORS

Goal:

To deploy two sets of soil moisture and soil temperature sensors around the flux tower in order to infer a moisture footprint that affects the ET reading registered by the tower.

Materials:

- Shovels and picks
- Two datalogger enclosures with sensors
- Laptop computer with PC400 software
- Datalogger program (we can recognize this program with the extension. DLD)
- SC32B optical interface cable
- Set of screwdrivers (flat and cross shape) - be sure that you have the small screwdrivers provided by Campbell scientific
- Set of solar panels
- GPS unit
- Field notebook.

Every enclosure with sensors contains:

- 6 Decagon ECHO soil moisture sensors
- 6 Campbell Scientific soil temperature probes model 107
- 1 Datalogger Model CR10WP*
- 1 battery*
- 1 Campbell Scientific Relay Multiplexer model AM16/32A*

*They are located inside the enclosure

Study site and sampling sites.

The study site will be at the flux tower located about 4 km northeast of Rayón, Sonora. We will deploy 6 sampling locations around the tower (approximately in a radius of 6 meters around the tower because the cable length of each sensor connected to the datalogger is 6 m). Each sampling location will have a soil moisture and a temperature probe at each of the two different depths (5 and 10 cm). Figure 16 shows the tentative locations of the 6 sampling points around the tower. Table 3 also provides the coordinates (UTM, zone 12 N) of the six sampling points proposed.

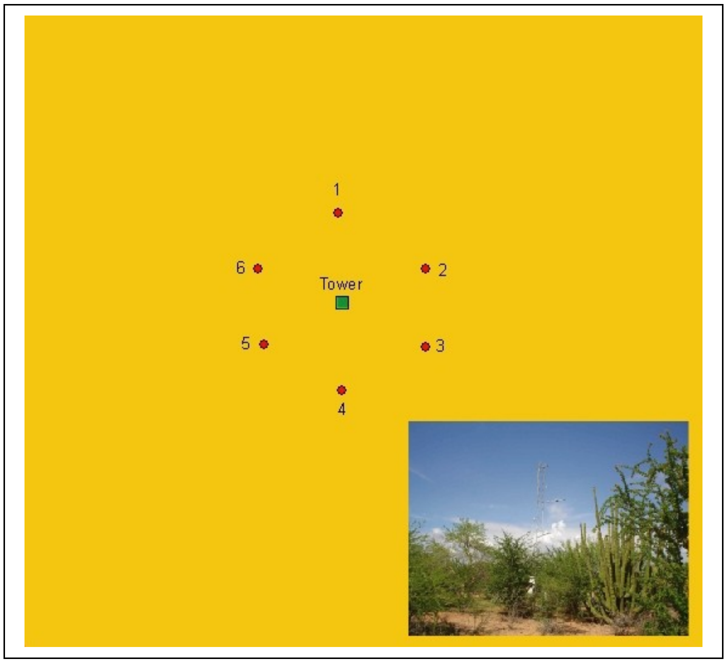


Figure 16: An aspect of the tower site shown in the lower right corner of the square. Tentative locations of the sampling points (shown in red points). Green square indicate the fluxes tower as reference.

Sampling ID	East*	North*
1	544808.69	3290183.36
2	544814.86	3290179.36
3	544814.86	3290173.97
4	544808.95	3290170.93
5	544803.38	3290174.06
6	544802.86	3290179.45

*Coordinates system: UTM-12N
*Datum WGS-84

Table 3: Shows the proposed coordinates of the six sampling points located around the fluxes tower

Procedure:

1. Place the dataloggers and their enclosures at the flux tower (or very close to it).
2. Identify the locations of the sampling points. At each sampling point, dig a small pit in order to insert the soil sensors. Try to make a vertical wall inside the soil pit, be sure that the soil wall is soft enough to allow the inserting of soil sensors. Do not force the sensors, especially the ECH_2O probes, they can break and we only have a limited number of sensors.

3. With a measuring tape please mark the desired depths for the insertion of the sensors (5 and 10 cm). Insert the soil sensors horizontal and perpendicular to the soil wall.

4. The sensors are already connected to the multiplexer and the datalogger. Check all the connections before you start running the system. The next section is an overview of all the connections inside the enclosure.

Connections:

This section provides a brief description of the connections plugged to the datalogger. Every enclosure contains three components: a) battery, b) datalogger and c) multiplexer (see figure 17). Table 4 shows the different connections plugged to the datalogger.

Input	**Wire color**	**Datalogger terminal/port**
Multiplexer	Yellow	C5
	Orange	C4
	Red	12v
	Blue	E1
	Purple	E2
	Brown	3L
	White	3H
	Gray	Ground
Battery	Black	Ground
	Red	12v

Table 4: Overview of the cables connected to the CR10 datalogger

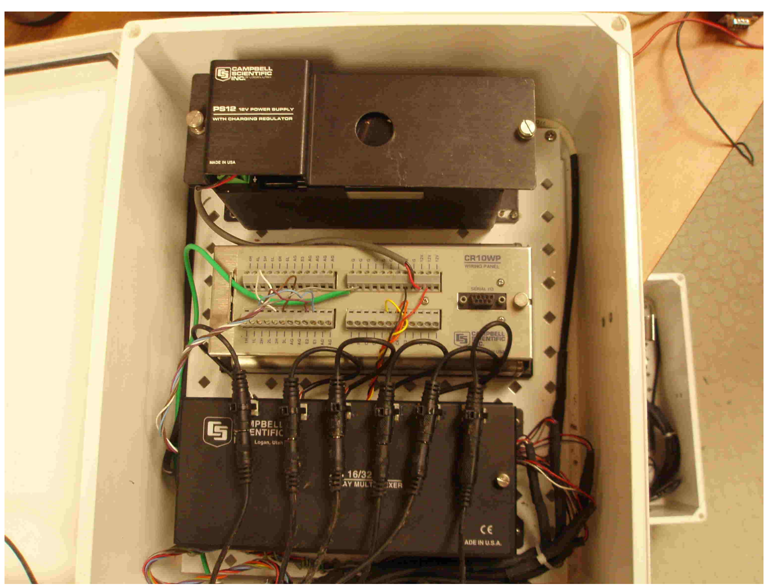


Figure 17: Different components inside the enclosure, from top to bottom, battery, datalogger and multiplexer

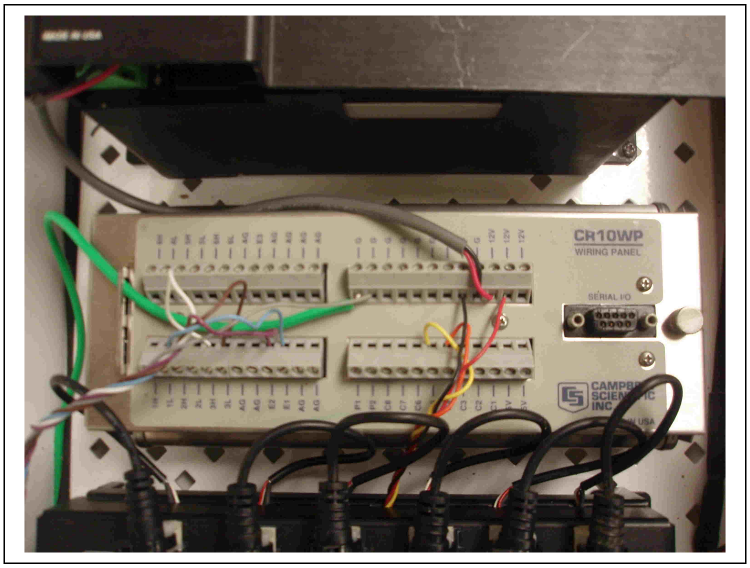


Figure 18: Input connections to datalogger. Check Table 4 in order to identify the terminals and/or ports

Also, Figure 18 provides a guide for the connections that are plugged to the datalogger. An important detail is to identify the input terminals to the multiplexer so you can identify the sensor number in the final output table. In other words, you can identify the location of the sensor in the final output table of results. The terminal number goes from left to right; therefore, the first terminal to the left will be number one and so on. Figure 19 shows the input terminals of the multiplexer.

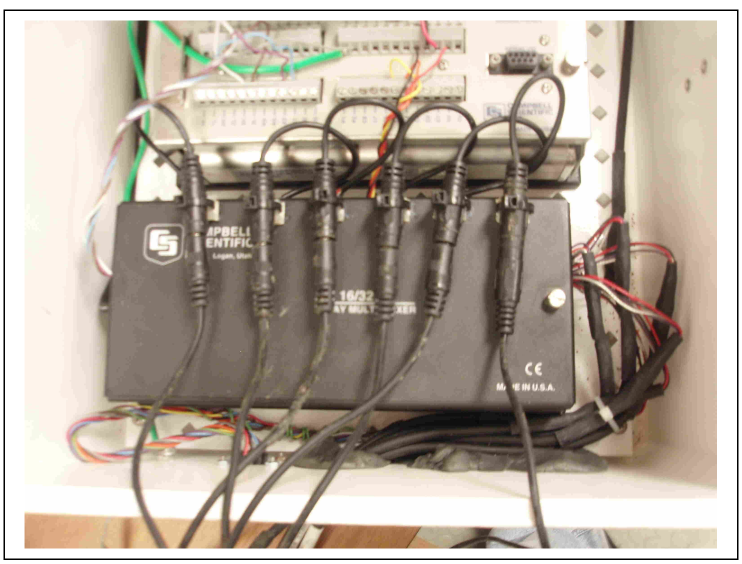


Figure 19: Connections from the sensors to the multiplexer. Terminals numbers from left to right go from numbers 1 to 6. The soil moisture connectors attached to these terminals are seen above on the multiplexer, while those for soil temperature are inside and not seen.

Sensors connected to the multiplexer:

Decagon ECH2O probes: The ECH2O probe measures the dielectric constant of the soil in order to find its volumetric water content. Since the dielectric constant of water is much higher than that of air or soil minerals, the dielectric constant of the soil is a sensitive measure of water content. The ECH2O probe has a very low power requirement and high resolution. This gives you the ability to make as many measurements as you want (even hourly) over a long period of time (like a growing season, for example), with minimal battery usage (see figure 20).

Figure 20: Decagon soil moisture sensor model ECH2O EC-20

Campbell Scientific temperature sensor model 107: The temperature probe 107 (see Figure 21) consists in a thermistor encapsulated in cylindrical aluminum housing. The probe measures temperature from -35∞ to +50∞C and is designed for durability and ease of installation/removal.

Figure 21: Campbell Scientific temperature sensor model 107

5. REMEMBER to switch off the battery before you start. Connect the battery to the datalogger. The red cable that comes from the battery should be connected to a 12v port and the black wire should be connected to a ground port. Also, connect the solar panel to the battery, the red and black wires coming from the solar panel should be connected to the CHG port of the battery. Now you can turn on the battery.
6. Upload the datalogger program using the PC400 software from Campbell. Open the program clicking on the PC400 icon or go to start/all programs/PC400. Then in the setup/connect tab choose the icon for the CR10 datalogger and then connect (shown in figure 22). A green bar in the lower right corner will indicate that the connection was

successful. If the datalogger is not set (i.e., datalogger time is not current), click on “set clock” button. This will automatically set the datalogger clock time to the PC clock time.

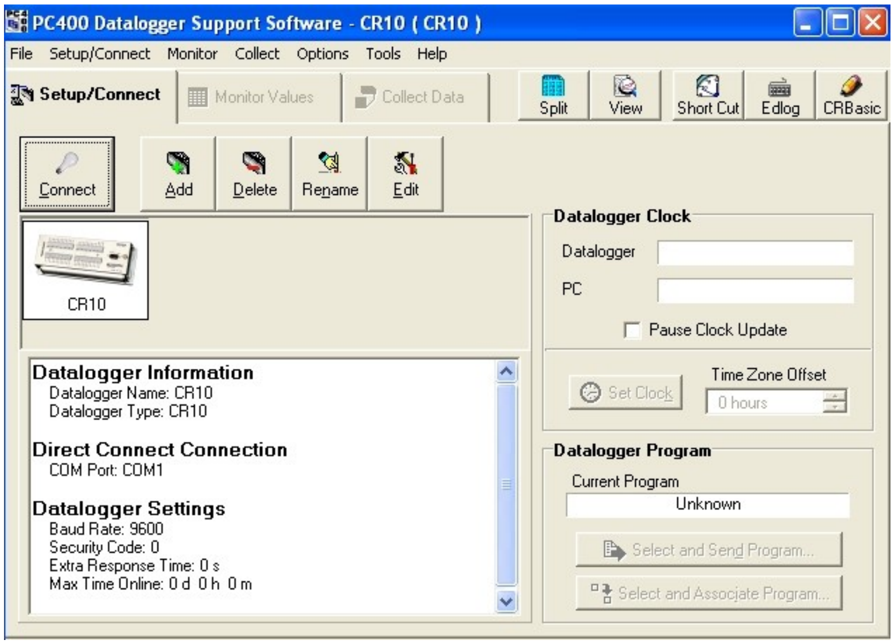


Figure 22: Main window for PC400. In order to connect with the software choose the set/up connect tab and the CR10 icon.

7. Now you can send the program to the datalogger. In the lower right corner of the main window click on “Select and Send program”. The program is located in C:/Programs datalogger CR10/SOILTM.DLD. Now the sensors are working: this can be verified from the clicking sounds that come from the multiplexer.

8. More information about uploading programs to the datalogger and downloading data from the datalogger can be found in the Appendix on ‘Collect Data from Datalogger to PC’.

Output tables:

If you want to check the sensors measurements in real time you need to click on the "monitor values" tab located in the main window of PC400 program. The output fields are:

Year
Julian Day
Time (GMT)
Logger ID
Index
Soil Temp from sensor 1 (C)
Soil Temp from sensor 2(C)
Soil Temp from sensor 3(C)
Soil Temp from sensor 4(C)
Soil Temp from sensor 5(C)
Soil Temp from sensor 6(C)
ECHO sensor 1 Volumetric Water Content (raw data)
ECHO sensor 2 Volumetric Water Content (raw data)
ECHO sensor 3 Volumetric Water Content (raw data)
ECHO sensor 4 Volumetric Water Content (raw data)
ECHO sensor 5 Volumetric Water Content (raw data)
ECHO sensor 6 Volumetric Water Content (raw data)
Battery Voltage

BASIN EXPERIMENT 1: INSTALLATION OF FIVE NEW STATIONS IN SAN MIGUEL BASIN

Stations locations:
We will find the stations location using a GPS unit with the stations coordinates already uploaded in it. This year locations will be:

Site ID	Map ID	*East	*North
155	1	532835	3387410
156	2	543725	3368097
157	3	543725	3337687
158	4	536558	3308621
159	5	552901	3296497

*Projection: UTM Zone 12. Datum: WGS-84

Table 5: Co-ordinates of new stations in San Miguel basin

Once the station is located, a 1.5 inches inner diameter galvanized pipe will be inserted in a small soil pit (figure 23 b,c). For the soil pit we recommend to use a soil digger like the one shown in the figure 1a, shovels and pick will also required. In addition, we need to be sure that the post is properly leveled; we can use a bubble level to reach this. Cement will be needed for appropriate deployment of the station. One extra pole will be inserted in the soil in order to attach the rain gauge. For that reason we will have two posts by site, one for to support the enclosure and the solar panel, and the other for the tipping bucket rain gauge.

Figure 23: a) Soil digger recommend for post installation .b) Installation of metal pipes in the field .c) Final result.

Next step consist in attaching the enclosure to the post. For this purpose we need brackets and ½" wrench. Insert the bracket in to enclosure holes as it is shown in figure 24 and use the wrench to fix it.

Figure 24: a) Fixation of the enclosure to the post. b) Final result

When enclosure installation is done, the solar panel should be installed in the upper part of the post, ½" wrench is required to fix it. The panel must pointing south with 43 degrees of inclination as shown in figure 25.

Figure 25: Solar panel Installation

<u>Solar panel connection to data logger</u>:
The Solar panel needs to be plugged in to the PS100 12V battery. Both cables will be inserted in the CHARGE terminal of the battery (figure 26), IMPORTANT!! Be sure that the battery is **TURNED OFF** when you are connecting the cables. Once connected, then turn it on. The red light will led in approximately 1 hour.

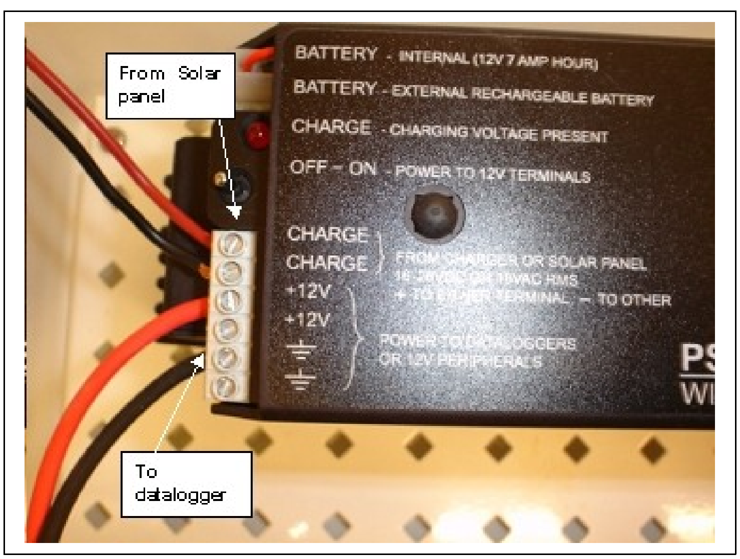


Figure 26: Battery connections

Next step consists on plug the battery to the datalogger. The datalogger model is a CR1000 from Campbell scientific. Figure 4a shows the connections from the battery 12V and ground terminals to the datalogger. Figure 27 shows the appropriate connection of the datalogger with the cables coming from the battery (Remember: red color cable is 12V and black cable is ground).

Figure 27: Solar panel connection in to the datalogger

Sensors:

The sensors that will be connected to the CR1000 datalogger will be:

1) Stevens Hydra probe model SDI-12: Two sensors will be connected to the datalogger. One sensor will be installed at 5cm depth in the soil. The other one will be inserted at 10 cm depth.

2) TR-525 typing bucket rain gauges. In locations 152 and 153 two rain gauges with different funnel diameter will be installed. One funnel diameter is 6"and the other one is 8".

Connections:

The sensors must be connected to the datalogger ports according to the following table:

Sensor	Characteristic	Wiring	Datalogger Port
Hydra probe SDI-12	Depth 0-5 cm	Blue Black Red Clear	C5 Ground (G) 12V Ground
Hydra probe SDI-12	Depth 5-10 cm	Blue Black Red Clear	C6 Ground (G) 12V Ground
Rain gauge TE525	Tipping bucket rain gauge	Black	P1 (pulse port)
		White	Ground
		Clear	Ground

Hydra probe connection: As showed before Hydra probe at depth 0-5 cm. should be connected in with the sequence: Blue wire, port C5. Black and clear wires on ground ports (G), and finally red wire must be inserted in 12V port. Check figure 28 to see the location of the datalogger ports.

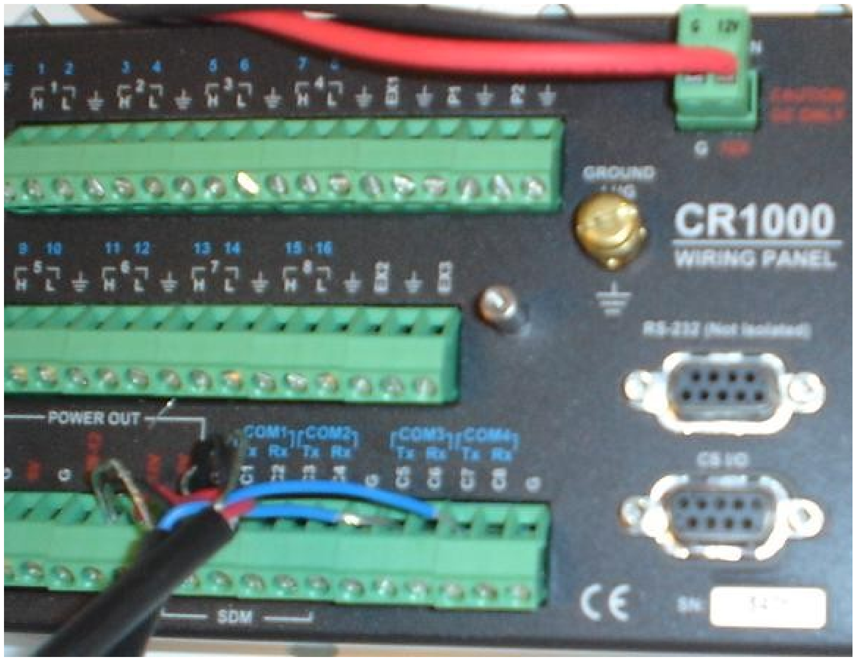


Figure 28: Wiring connections for Hydra probe SDI-12 at 5cm depth. Remember that blue wire sends the sensor signal to the datalogger, black and clear are ground and red is the source of power for the sensor.

For Hydra probe at depth 5-10 cm. should be connected in with the sequence: Blue wire, port C6. Black and clear wires on ground ports (G), and finally red wire must be inserted in 12V port. In addition, 6" rain gauge must be inserted with the following sequence: Black, Port P1, white and clear wires, ground (G) as it is shown in the following figure (29).

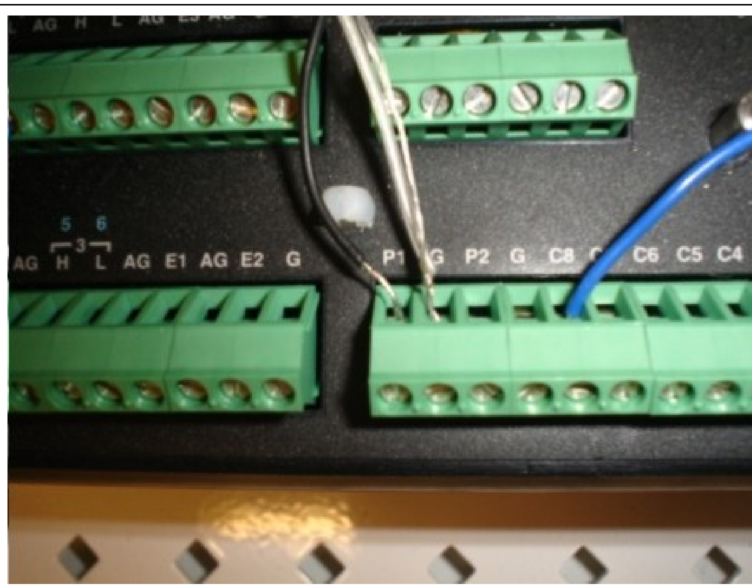
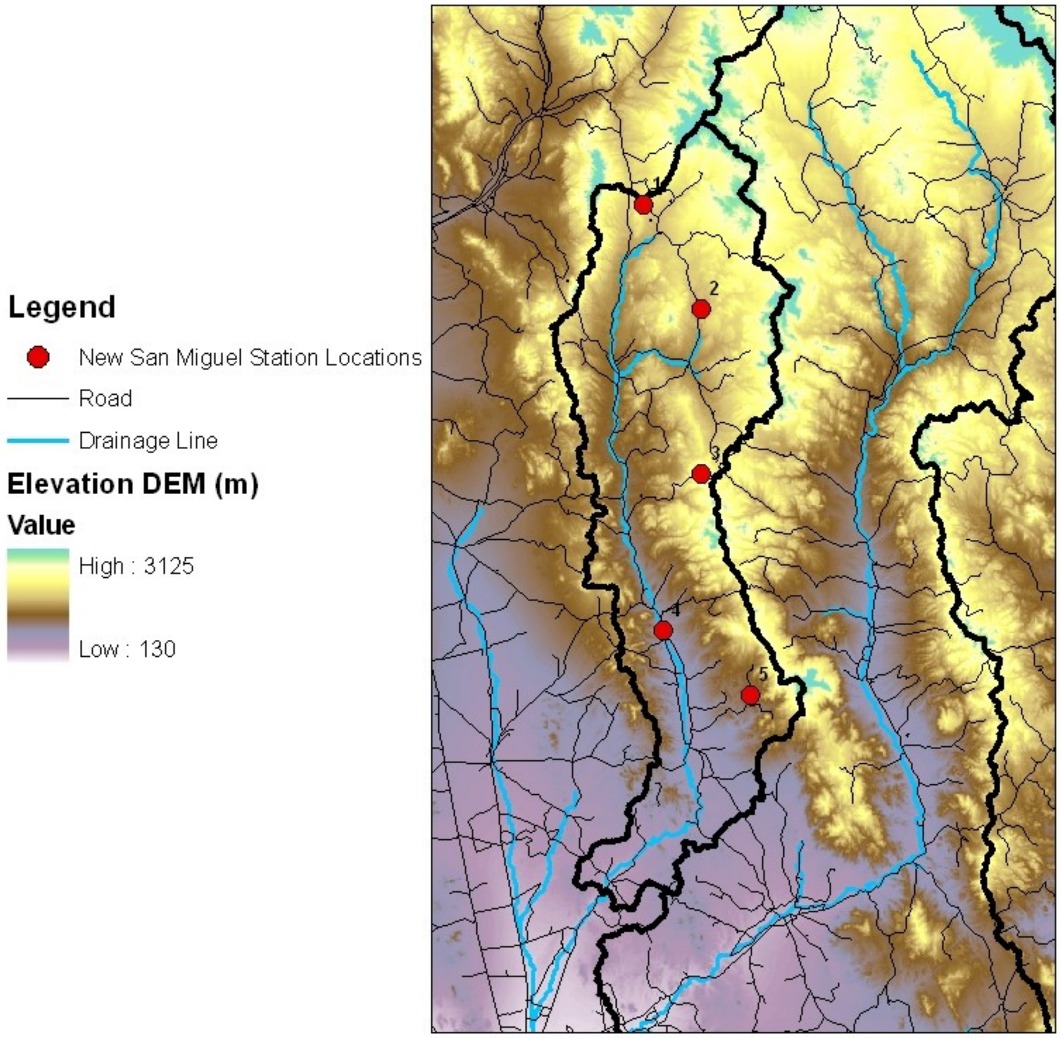


Figure 29: Wiring connections 6”diameter rain gauge. Remember that black wire sends the sensor signal to the datalogger, white and clear, are ground.

Deployment of the soil moisture/soil temperature sensors in the field: You need to dig a hole of approximately 20 cm depth and 50 cm long with a shovel. Use a measuring tape to place the sensors in the vertical face of the soil pit. Check the figure 30 in order to put the sensors in the soil pit.

Figure 30: Vertical placement of sensors



	UTM Coordinates			
Site #	Northing	Easting	Elevation (m)	Distance from the road (m)
1	3387410	532835	1293	983
2	3368097	543725	1020	873
3	3337687	543725	1385	143
4	3308621	536558	660	307
5	3296497	552901	877	351

Figure 31: Location of new stations

BASIN EXPERIMENT 2: SURFACE SOIL SAMPLING IN THE SIERRA LOS LOCOS BASIN

Goal:
To capture the spatial distribution of some soil properties, using 50 locations throughout the basin.

Materials:
- Picks
- Shovels
- Measuring tapes or ruler
- Sieves
- Soil notebook or field spreadsheets
- Digital camera
- GPS device
- 4 mil (mm?) thick soil sample storage bags (1 for each location)
- Clinometer and compass

Procedure:

Fifty surface soil sample locations were chosen based on a reasonably equitable coverage possible across variations of a combination of elevation, vegetation, accessibility, current rain gauge locations in the basin, transect sites from the 2004 campaign, and accessibility. These 50 locations are shown on the map in Figure 32, and the position co-ordinates are listed in Appendix on ‘Co-ordinates of soil surface sampling locations in the Sierra Los Locos basin’.

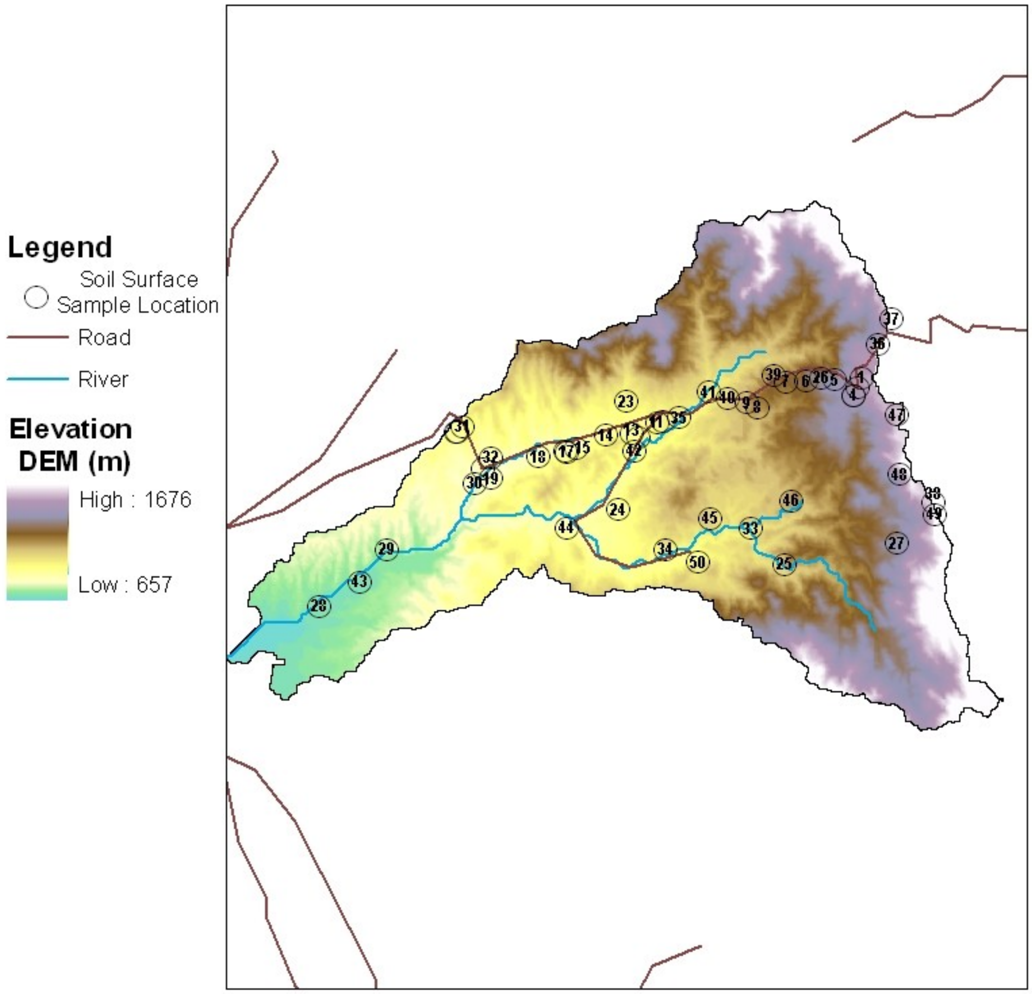


Figure 32: Surface sampling locations in the Sierra Los Locos basin

Start with the first location. For each location, follow the steps below:

1. Use the co-ordinates stored in the GPS to determine the location. If for some reason a different location is decided upon, list that reason and the new co-ordinates against the surface soil sample site number into the soil notebook.

2. Enter a quick description the sampling location into the soil notebook: The site number (Refer the Appendix or GPS), coordinates, location (i.e. qualitative information: e.g., southwest of ranch, etc.), type of vegetation (prominent and others), elevation, slope, and aspect. For describing the type of vegetation, follow the information given in Appendix 1. For the slope, use the clinometer. For the aspect, use the compass.

3. Take about a kilo of the soil surface sample (0-10 cm depth), including stones. Note down into the soil notebook if there is any bedrock within this top 10 cm. Sieve the kilo of this soil surface sample with 2mm sieve, and see if you have a min of 500 grams of < 2mm for the lab analysis. Store the sample in a sample bag and label the

bag with the location number, date and the depth interval, for example, ‘0-10 cm‘. If by any chance you do not have a sieve in the field, remember to sieve the sample in the house in Rayon and put the sample back to its original bag.

BASIN EXPERIMENT 3: STATIC / DYNAMIC CALIBRATION FOR SIERRA LOS LOCOS TIPPING BUCKET RAIN GAUGES

Introduction:

The static calibration approach simply uses a burette to check the water volume that causes the bucket of the tipping bucket (TB) rain gauge to tip. This approach is thus primarily concerned with the accuracy of an individual tip volume in the sense of consistency of the tip volumes between the two buckets of an individual rain gauge.

The dynamic calibration approach employs a calibration kit by Hydrological Services, Inc., which uses a constant flow-constant head-measuring device that dispenses prespecified flow rates to the rain gauge. The dispenser delivers water at five nominal flow rates (50, 100, 200, 300, or 500 mm h^{-1}) using five corresponding calibrated nozzles. This approach is thus concerned with the accuracy of the rain measured over a range of rainfall intensities, particularly for the higher intensities where the fast operation of the tipping mechanism may not be accurately capturing the rain volume.

Goal: To statically and dynamically calibrate tipping bucket rain gauges using a burette and a calibration kit from Hydrological Services, Inc respectively.

Materials:

- Calibration kit
- Burette
- Enough water for calibration
- Chronometer
- Field notebook
- Allen wrench
- Laptop with appropriate software for downloading data.

CHECK with Luis which are the locations where static calibration is required

Procedure

IMPORTANT:

- This experiment should not be done during a rainfall event.

Datalogger data download:

- Switch off the datalogger. This will be switched on later after the entire static/dynamic calibration procedures.

Download the data: the procedure is similar to that in the Appendix on 'Collecting data from datalogger to PC for the continuous soil moisture / temperature measurements'.

Static calibration:

At a rain gauge location where static calibration is required, the steps to be followed are:

1. Check if the buckets are empty. Fill the burette with water and release this water into an empty bucket (Figure 33). Write down the volume that causes the bucket to tip. Do atleast 5 such readings for each bucket (enter into the field notebook), remembering to make sure that the bucket is empty before it is filled with water each time by the burette. Calculate an average of these 5 readings for each bucket, and enter into the field notebook.

Figure 33: Burette filling a TB rain gauge bucket with water during the static calibration procedure

2. There are two models of rain gauges installed in the Sierra Los Locos Basin: the Texas Electronics model TE525 (Figure 34), and the Hydrological Services model TB3-0.01-P (Figure 35). For the TB3-0.01-P model, the static calibration procedure is complete at this point, please proceed to the dynamic calibration procedure section. For the TE525 model, continue to step 3 in this static calibration procedure.

Figure 34: The Texas Electronics model TE525

Figure 35: The Hydrological Services model TB3-0.01-P

3. If the average tipping volumes from above step 1 for each of the two buckets are different by more than a chosen value of 0.2 mm, then the Allen wrench must be inserted on the underside of the tipping bucket to raise the pole (raising or lowering the pole would decrease or increase the tip volume respectively of that individual bucket). See Figure 36.

Figure 36: Adjusting the height of the pole under the bucket using an Allen wrench during the static calibration procedure

4. Repeat steps 1 & 3 till the difference between the average tipping volumes for each of the two buckets in the Texas Electronics model TE525 is less than a chosen value of 0.2 mm, recording all the values into your field notebook.

<u>Dynamic Calibration:</u>
First, the flow rates of the dispenser are required to be tested in timed tests using a graduated accumulation in the rain gauge. The actual flow rates measured during this procedure may differ from the design flow rates of the nozzles (50, 100, 200, 300, or 500 mm h^{-1}). These measured flow rates from the flow device calibration tests can then be used for subsequent calibration of the TB rain gauges. These flow rate values have already been obtained in the lab, and would be used in the analysis after the field dynamic calibration. The dynamic calibration steps in the field are:

1. Place the holding plate so that it sits on the catch of the TB rain gauge, and the central hollow of this holding plate is right above the bucket (refer Figure xx where it sits on the rain gauge and would hold the column of the calibration kit to be described in the next few steps).
2. Start with the lowest nozzle size of 50 mm h^{-1}.
3. Ensure that the valve at the top of the column of the calibration kit is closed.
4. Remove (by unscrewing) the base cap or the nozzle (whichever is present) at the base of the column.

5. If this is the first nozzle used, invert and fill the column with water (This filled volume is approximately 653 ml). Otherwise, the remaining water from the previous nozzle uses should be sufficient for this nozzle size used.
6. Screw the selected nozzle size at the same location from where the base cap or the earlier nozzle was removed, invert the column to its earlier upright position, and place it so that its base fits into the central hollow of on the holding plate.
7. The earlier closed position of the valve entrapped some air inside the cylinder. Open this valve so that the created vacuum maintains constant head while releasing water through the nozzle and into the TB rain gauge.
8. Calculate the time taken using the chronometer (see Figure xx) for a prespecified number of total bucket tips: 10, 20, 40, 40 and 50 tips for the 50, 100, 200, 300, and 500 mm h^{-1} nozzles respectively)..

Note: It is very important that the nozzle is *very clean* to allow for a constant flow

Figure 37: Setup and time measurement during the dynamic calibration procedure.

9. Repeat step 8 to confirm the value obtained in step 8. Enter this value into the field notebook.
10. Repeat steps 3-9 for each increasing nozzle size.

REMINDER: Switch on the datalogger before leaving the location!

BASIN EXPERIMENT 4: SOIL PIT SAMPLING IN THE SIERRA LOS LOCOS BASIN

Goal: At different locations in the SLL basin, soil samples collected by digging soil pits would be used to identify soil horizons, and to determine soil parameters for each horizon like percent of gravel, color, structure, consistence, and texture, and also the type of boundaries between the horizons. The determined soil characteristics are useful for modeling purposes.

Materials:

- Picks
- Shovels
- Measuring tape
- Munsell color chart
- Sieves
- Soil notebook or field spreadsheets
- Digital camera
- Knife
- Bottle with HCl
- Bottle with water
- GPS device
- Compass and clinometers
- 4 mil (mm?) thick soil sample storage bags (atleast 13 for each pit: 8 layers max. + 5 possible horizons)
- Pedon storage containers (15 pedons for each pit: 5 possible horizons * 3 each horizon).
- Glass to scratch for parent material test
- parafilm

Check with Soni, Luis or Enrique if the soil pits are supposed to be filled back up the same day.

Procedure:

Twelve soil pit locations were chosen based on a reasonably equitable coverage possible across variations of a combination of elevation, aspect, slope, and vegetation throughout the SLL basin. Utilizing the raster calculator in ArcMap, areas in the basin which had the following characteristics were displayed and used to select the locations:

- Flat, desert
- Flat, riparian
- Flat, subtropical
- Flat, oak

- North facing, with a slope between 20 and 30 degrees, subtropical
- North facing, with a slope between 20 and 30 degrees, oak

- South facing, with a slope between 20 and 30 degrees, subtropical
- South facing, with a slope between 20 and 30 degrees, oak

In addition, areas with a higher elevation were preferred in selecting the locations.

These 12 tentative locations are shown on the map in Figure 38.

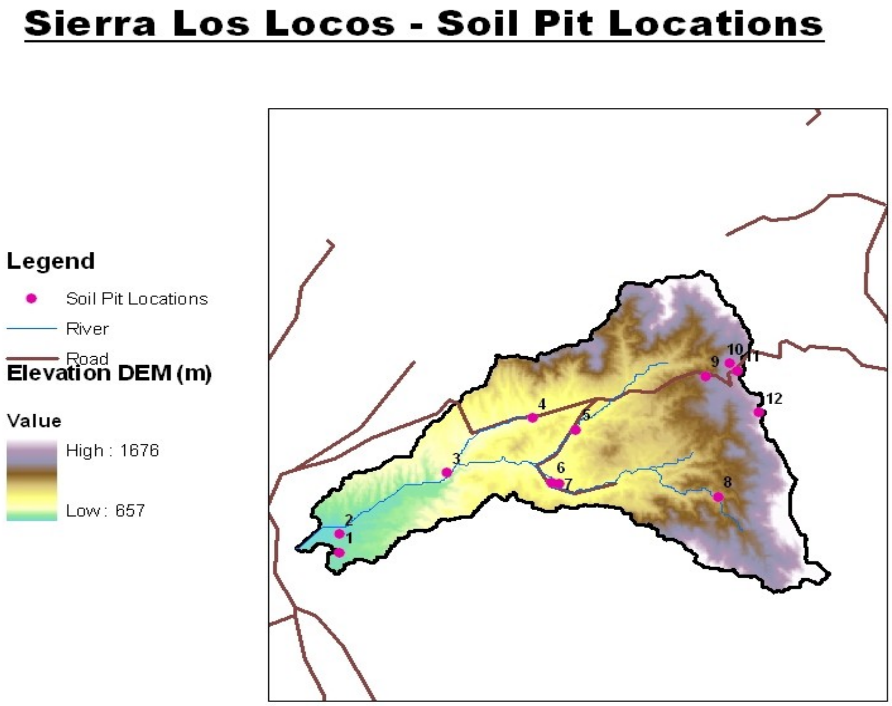


Figure 1.

Site #	UTM Coordinates Northing	Easting	Description	Elevation (m)
1	3309276	538412	Flat, desert	680
2	3309944	538404	Flat, riparian	657
3	3312188	541886	South facing, slope between 20 and 30, subtropical	784
4	3314176	544640	Flat, riparian	835
5	3313763	546048	Flat, subtropical	877
6	3311837	545257	South facing, slope between 20 and 30, subtropical	840
7	3311795	545506	North facing, slope between 20 and 30, subtropical	878
8	3311313	550640	South facing, slope between 20 and 30, subtropical	1062
9	3315717	550226	North facing, slope between 20 and 30, subtropical	1189
10	3316189	551028	North facing, slope between 20 and 30, oak	1359
11	3315920	551271	Flat, oak	1380
12	3314398	551959	Flat, oak	1460

Figure 38: Soil pit locations in the Sierra Los Locos basin

Start with the first location. For each location, follow the steps below:

1. Use the co-ordinates stored in the GPS to determine the location. If for some reason a different location is decided upon, list that reason and the new co-ordinates against the soil pit site number into the soil notebook.
2. Before digging the soil pit, a description of the sampling site is required. This description includes: The site number (Refer Figure 38 or GPS), coordinates, location (i.e. qualitative information: e.g., southwest of ranch, etc.), type of vegetation (prominent and others), elevation, slope, aspect and parent material (types of minerals/rocks in soil). For describing the type of vegetation, follow the information given in Appendix on 'Ecosystems and main plant species of the San Miguel basin'. For the slope, use the clinometer. For the aspect, use the compass. For the parent material, use the following information, and the classification charts given in Figures 39,40 and 41.

   Parent Materials

   Soil forms from different parent materials; one such parent material is bedrock. As rocks become exposed at Earth's surface they erode and become chemically altered. The type of soil that forms depends on the type of rocks available, the minerals in rocks, and how minerals react to temperature, pressure, and erosive forces. Temperatures inside the Earth are very hot and melt rock (lithosphere) that moves by tectonic forces below Earth's surface. Melted rock flows away from the source of heat and eventually cools and hardens.

   Igneous rocks are formed when minerals crystallize during this cooling process, and the original parent material from which rocks are formed on the earth. Under the right environmental conditions, these can change into sedimentary and metamorphic rocks. Volcanoes produce igneous rocks such as granite, pumice, and obsidian.

   Sedimentary rocks are formed when older rocks are broken apart by plant roots, ice wedges, and earth movements and become transported by glaciers, waves, currents, and wind. The transported particles then become bound together (cemented) as secondary minerals grow in the spaces between the loose particles and create a new, solid, sedimentary rock. Sandstone, limestone, and shale are types of sedimentary rocks that contain quartz sand, lime, and clay, respectively.

   Metamorphic/Crystalline rocks form when pressure and temperature, below Earth's surface, are great enough to change the chemical composition of sedimentary and igneous rocks. Metamorphic rocks, such as quartzite, marble, and slate form under intense temperature and pressure but were originally quartz sandstone, limestone, and shale.

   Recent Cover Deposits are another types of parent material that mineral soils form from and include alluvium, colluvium, eolian deposits, glacial deposits, lacustrine (lake) deposits, loess deposits, marine deposits, and volcanic ash deposits.

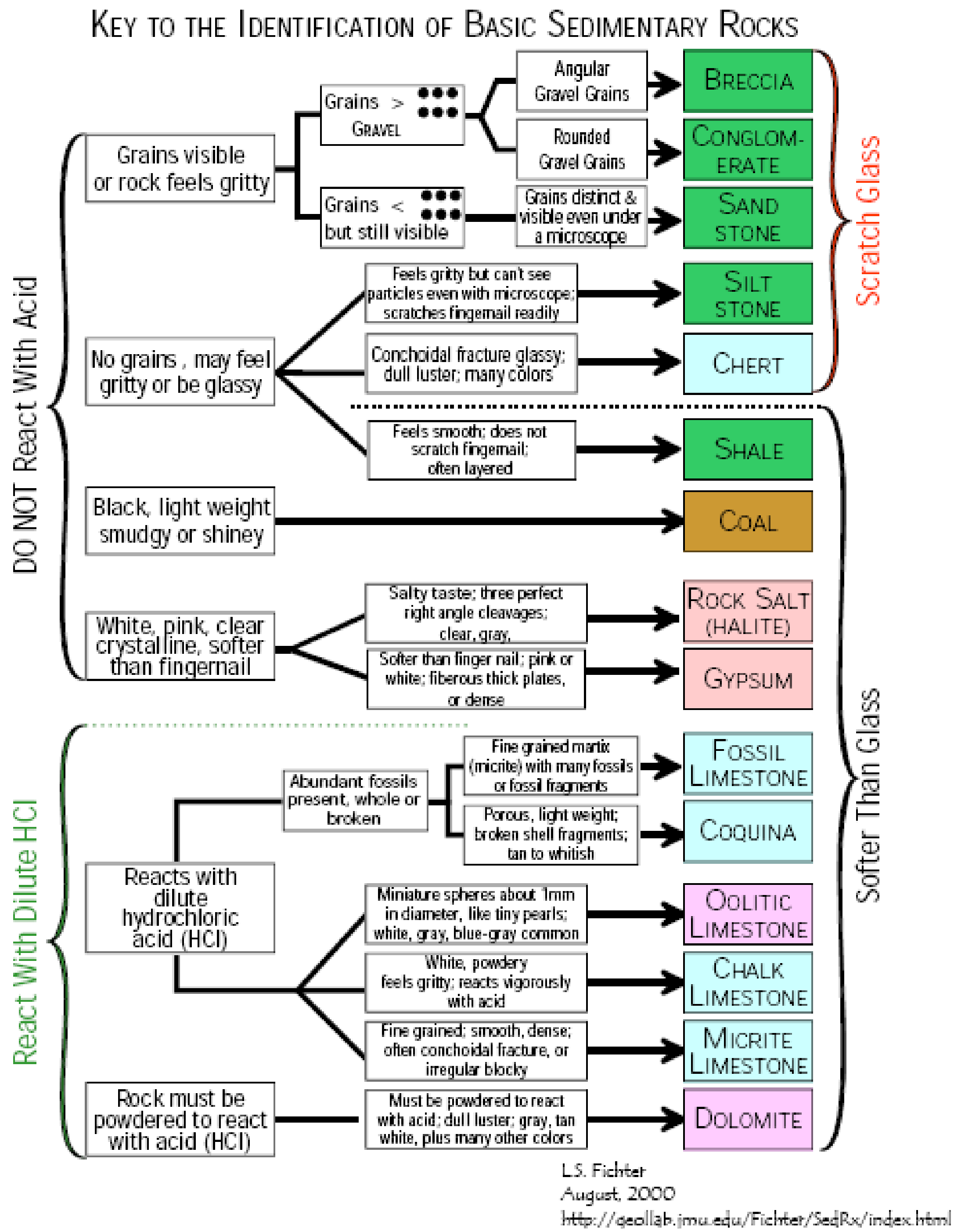


Figure 39: Key to the identification of basic sedimentary rocks

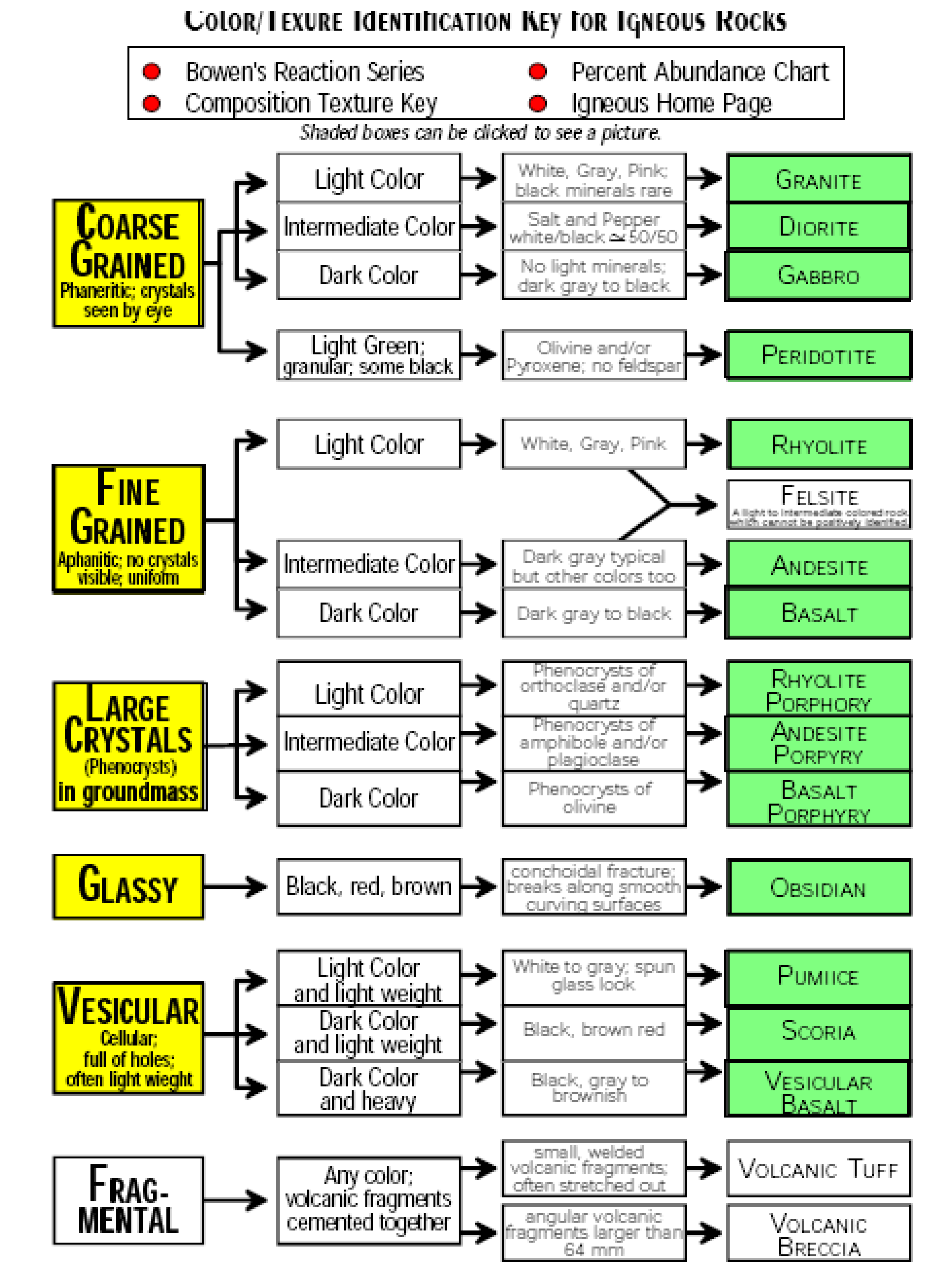


Figure 40: Color/texture identification key for igneous rocks

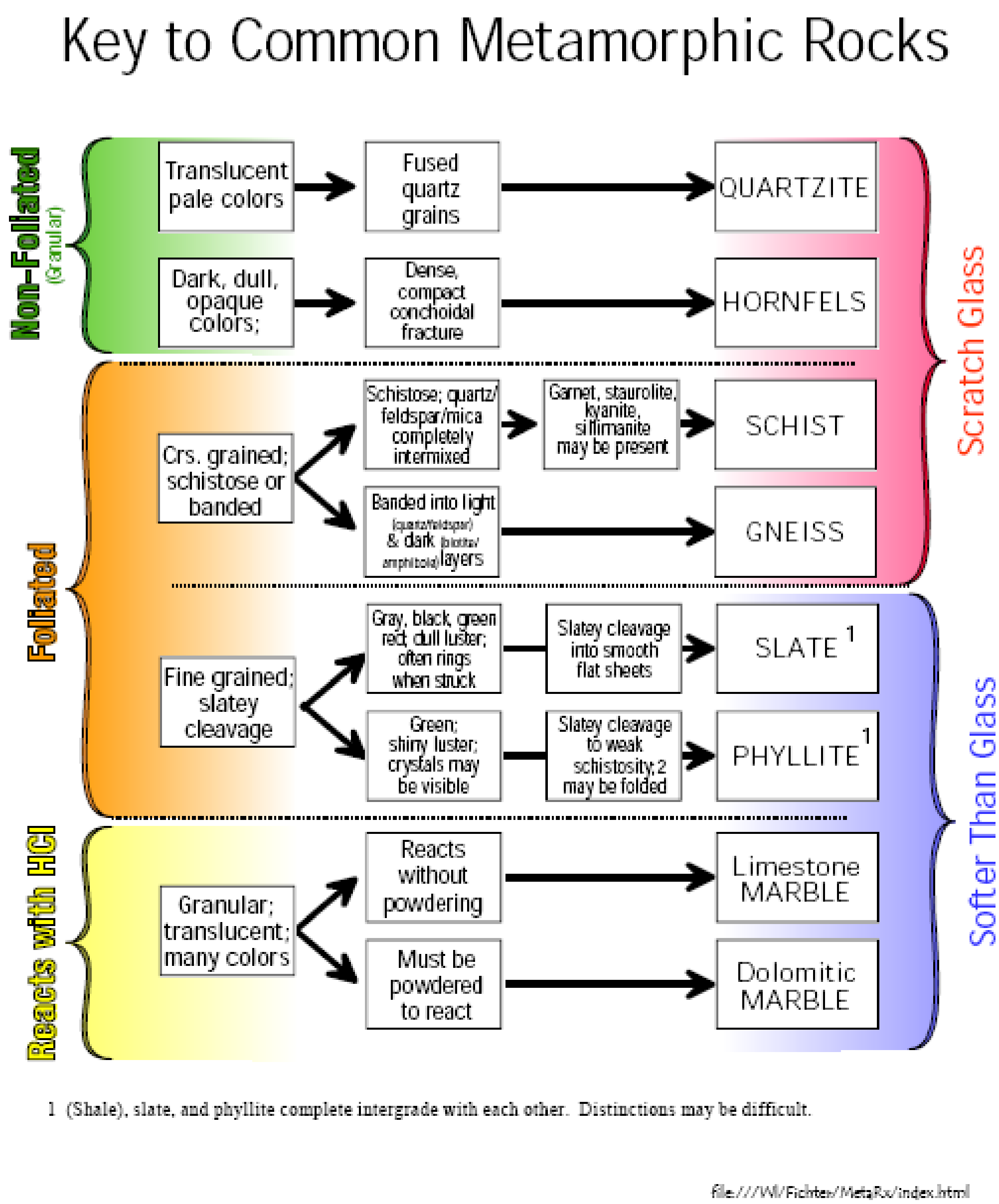


Figure 41: Key to common metamorphic rocks

3. In addition to the above description, also take good pictures of the soil pit site, showing position on hill slope, nature of vegetation, soil surface conditions (e.g., humid), etc. For the position on the hill slope, you may have to move far away from the location to capture the location relative to and inside the hillslope area (remember to leave any item like picks, shovels etc. at the location that is visible in the picture to see the location).

4. Dig a soil pit until bedrock is hit (typically on hillslopes) or up to a depth of 1.5 m (typically in valleys), or which ever is smaller. The horizontal pit dimensions should be atleast 1 m by 1 m. The larger these dimensions, the easier it is to dig deeper. Note down whether the bedrock is hit, and the dug depth of the soil pit in the soil notebook.

5. Remember to clean up the face of the soil pit so that it is not too rough. NOTE: This cleaning is for photographing and soil horizon identification, both of which need direct sunlight on that cleaned face, so take the movement of the sun into account during digging and cleaning. Once the soil pit is dug and cleaned, take a photograph of the soil pit with a measuring tape run vertically along the wall at the side of the pit (not in the center, refer Figure 42): the measuring tape zero should be at the soil surface level. You are photographing the soil, not the tape. Photographing soils usually means low light (the soils absorb some of the light), so you have a wide aperture and you lose depth of field of the photo. Make sure that the pit has consistent light across the face: if it is totally shaded, then take one photo with flash, and the other under natural light.

Figure 42: Sample photograph of the soil pit with measuring tape in vertical position

6. Identify and write down the depth (using the measuring tape) and type of every recognized soil horizon into the soil notebook (soil horizon description section follows below). Remember that the face of the soil pit described should be vertical and also remember that it must receive direct sunlight at the time the hole is completed.

Type of soil horizons

Soil horizons will generally form within unconsolidated material on stable horizontal surfaces that have been sub aerially exposed for a sufficient length of time, as material is added to or removed from parent material. These sets of processes tend to form distinct layers within the upper mantle of unconsolidated materials.

Master horizons

Master Horizons are designated with uppercase letters and are divided in horizons: O, A, E, B, C, R and also sometimes the horizon D is considered. The following Table 6 describes some characteristics of the soil master horizons.

Master horizon	Characteristics
O	Layers dominated by organic material (litter, humus) in several stages of decomposition
A	Mineral horizons formed at the surface or below an O horizon. Characterized by accumulation of humified organic matter intimately mixed with mineral fraction
E	Light colored mineral horizons in which the main feature is loss of weatherable materials, silicate clays, iron, and aluminum, leaving a concentration of uncoated quartz or other resistant material.
B	Subsurface mineral horizons dominated by illuvial (i.e., washed in) accumulations of clay, iron, aluminum and humus. Removal of primary carbonates. Residual concentration of sesquioxides. Brittleness
C	Mineral horizons, excluding hard bedrock, that have been little affected by pedogenic processes and lack of properties of the previous horizons. Retain some rock structure or sedimentary structure.
D	Deep horizons that show virtually no evidence of pedogenic alteration, such as leaching of carbonates or oxidation. D horizons retain geologic structure and are often dense and slowly permeable. D horizons are formed of unconsolidated materials.
R	Hard continuous bedrock that is sufficient coherent to make digging by hand impractical.

Table 6: Master horizon characteristics

Master horizon suffixes

Master horizons have suffixes that provide additional information about the characteristics, such as the presence of an illuviated (washed in) substance, its degree of decomposition or its density among others. Suffixes are written in lowercase letters. Following tables provide some of the most common suffixes that describe soil master horizons characteristics.

"A" horizons suffixes

Suffix	*Characteristics*
p	Plowed, tilled or otherwise disturbed surface layer
v	Porous, vesicular horizon common in deserts regions

Table 7: 'A' horizon suffix characteristics

"B" and "C" horizons suffixes

Suffix	*Characteristics*
c	Presence of concretions or hard non-concretionary nodules, usually of Fe, Al, Mn or Ti
h	Dark, illuvial accumulations of organic matter and humus. The moist Munsell value and chroma of the horizon must be 3 or less
j	Accumulation of jarosite, either as ped coatings or nodules.
k	Accumulation of pedogenic carbonates, commonly $CaCO_3$, as ped coatings, filaments or nodules.
n	Accumulation of pedogenic carbonates, exchangeable sodium (Na), commonly as sodium salts.
q	Accumulation of pedogenic, secondary silica (quartz)

s	Accumulation of sesquioxides of Fe and Al
t	Accumulation of silicate clay, as evidence by argillans on ped faces or lamellae (clay bands).
y	Accumulation of pedogenic gypsum.
z	Accumulation of pedogenic salt more soluble than gypsum

Table 8: 'B' and 'C' horizon suffix characteristics

7. Estimate the percent of gravel for every soil horizon (using the coarse soil sieve) and write it down.

8. For each soil horizon, sieve the soil with the 2 mm sieve, identify the color of the soil using the Munsell soil color chart in direct sunlight, and write it down. List dominant color, both moist and dry, in the soil notebook, if feasible (NOTE that if soil is wet due to rains, then dry color cannot be estimated). The color should be written down similar to the example format '7.5YR 6/4' (7.5YR for the page, and 6 and 4 for the horizontal row and vertical column on the page respectively)

9. For each soil horizon, describe the structure (grade, size and shape) and write down into the soil notebook. Note that the structure size classification depends on the structure shape, and the size charts are given in Figures 43 and 44. Use the following nomenclature for the structural properties:

<u>Structure grade:</u>

0 **Structureless:**

- **m** **Massive:** Enough aggregation to maintain a vertical face but not formation of structure type.
- **sg** **Single grain:** No aggregation (structure). Loose grains of sand dune are good example.

1 **Weak.** Peds barely observable in place. When disturbed, few entire peds are observed; much of the material is unaggregated.

2 **Moderate.** Peds easily observable in place. When disturbed, there is a mixture of whole peds, broken peds, and some material not organized into peds.

3 **Strong**. Peds are distinctly visible in place, and when disturbed, nearly the entire mass consists of whole peds.

<u>Structure shape:</u>

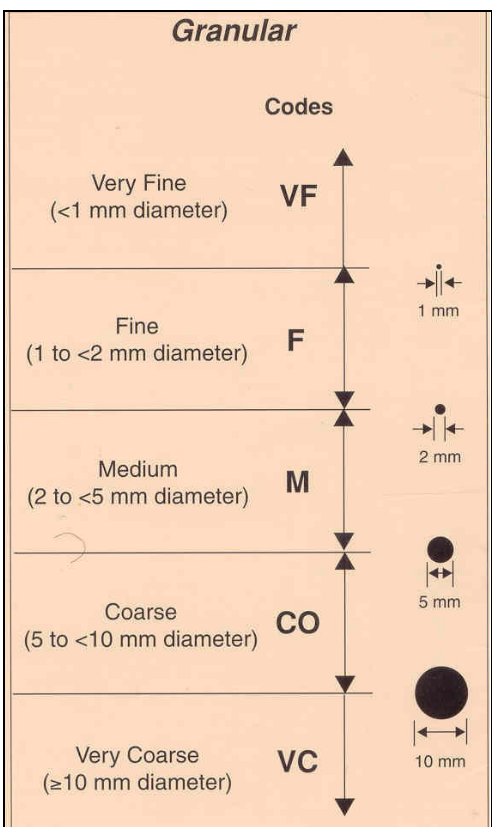
gr Granular (1-5mm diameter)

pl Platy. Consists on thin (<4 mm thick) plate-like peds.

pr	Prismatic. Typical of the lower B structure and C.
abk	Angular blocky. Common in horizon B
sbk	Subangular blocky. Common in horizon B
cpr	Columnar prismatic

Structure size:

vf	Very fine
f	Fine
m	Medium
c	Coarse
vc	Very coarse.



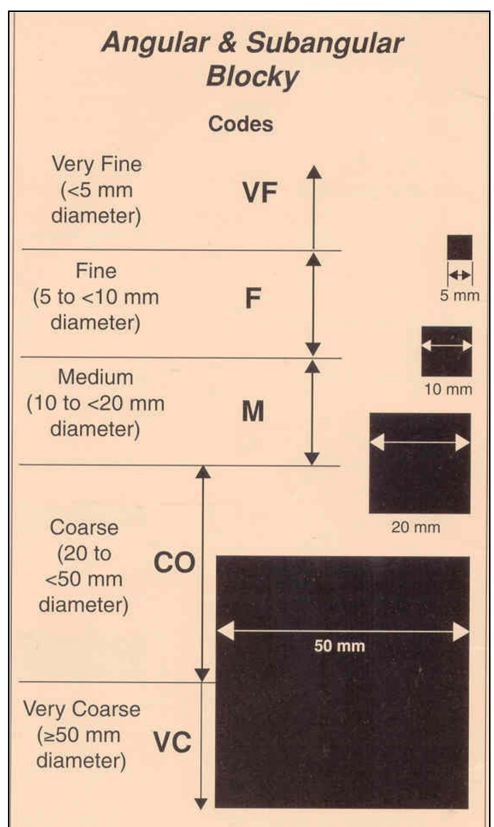


Figure 43: Size classification for granular and angular/subangular shapes

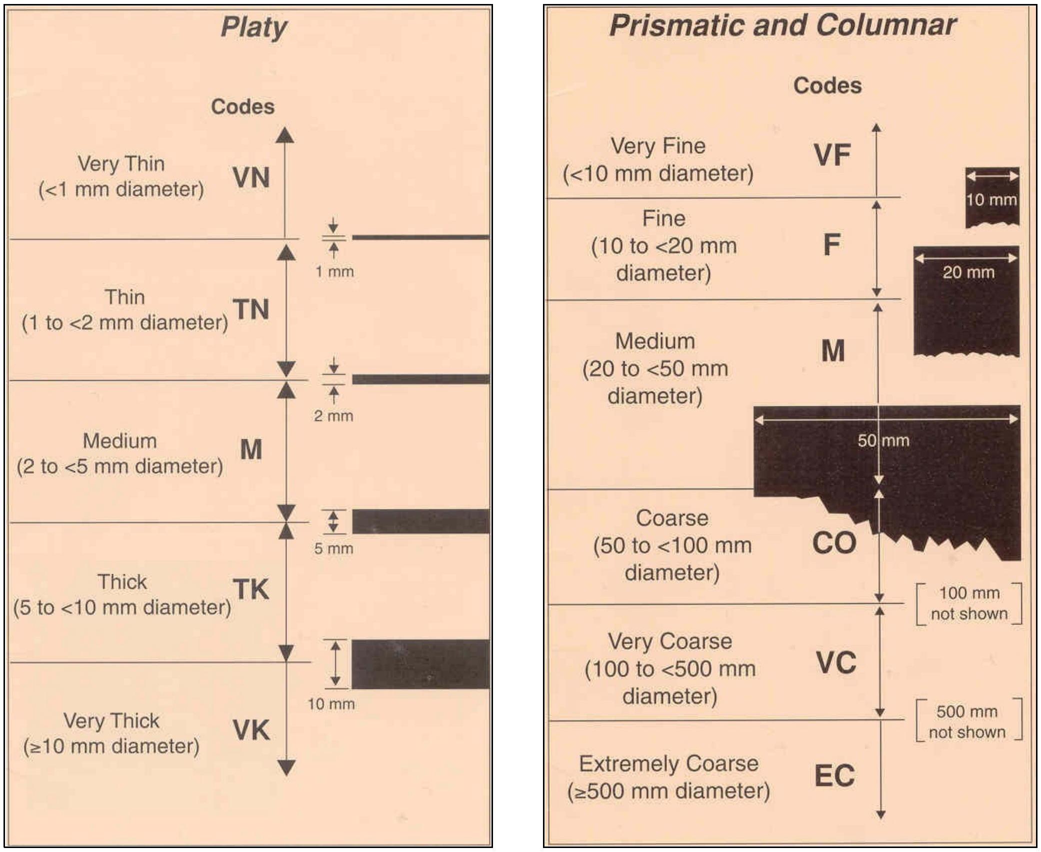


Figure 44: Size classification for platy and prismatic/columnar shapes

10. For every soil horizon, estimate consistence and write down into the soil notebook. The consistence is a measure of the adherence of the soil particles to the fingers, the cohesion of soil particles to one another and the resistance to soil mass to deformation. This property varies with moisture content, therefore, it is important to estimate consistence with dry and wet conditions. (IMPORTANT: Wet consistence and plasticity tests are to be done only for the fine soil particles after using the 2 mm sieve)

Dry consistence (NOTE that if soil is wet due to rains, then dry consistence cannot be estimated):

- **lo** **Loose:** Non coherent, such as grains of a sand dune
- **so** **Soft:** Easily fails to powder or single grain. With very slight force between thumb and forefinger
- **sh** **Slightly hard:** Easily fails under slight force between thumb and forefinger.
- **h** **Hard:** Fails in the hands without difficulty, requires strong force to fail between forefinger and thumb.
- **vh** **Very hard:** Fails in hands with difficulty, but not between thumb and forefinger
- **eh** **Extremely hard:** Cannot be failed in hands.

Wet Consistence: (Usually wetted artificially using the water from the bottle). Stickiness is measured by pressing the soil between the forefinger and the thumb.

- **so** **Non sticky:** Practically non adherent to thumb and forefinger when pressured released.
- **ss** **Slightly sticky:** After release of pressure, soil adheres to both thumb and forefinger, but comes off one or the other rather cleanly.
- **s** **Sticky:** After release of pressure, soil adheres to both forefinger and thumb .
- **vs** **Very sticky:** After release of pressure, soil adheres strongly to both digits and is markedly stretched when they are separated.

Plasticity: Measured by rolling the wet soil between the thumb and forefinger and observing whether a roll can be formed and maintained. Plasticity directly relates to clay content.

- **po** **Non plastic:** No roll can be formed
- **ps** **Slightly plastic:** A roll 4 cm long and 6 mm thick can be formed.
- **p** **Plastic:** A roll 4cm long and 4mm thick can be formed .

vp **Very plastic:** A roll 4 cm long and 2 mm thick can be formed and support its own weight. Figure 45 shows an example of the plasticity test.

Figure 45: Example of soil plasticity: In this case soil has high plasticity (i.e., vp) and correspondingly clay content

11. For each horizon, estimate texture with the “feel method” (Figure 46) after sieving. Write down the textural abbreviation as per Table 9.

C: Clay	**CL:** Clay loam	**Loam:** Loam
LS: Loamy Sand	**S:** Sand	**SC:** Sandy clay
SCL: Sandy clay loam	**SL:** Sandy loam	**Si:** Silt
SiC : Silty clay	**SiCL:** Silty clay loam	**SiL:** Silt loam

Table 9: Textural abbreviations

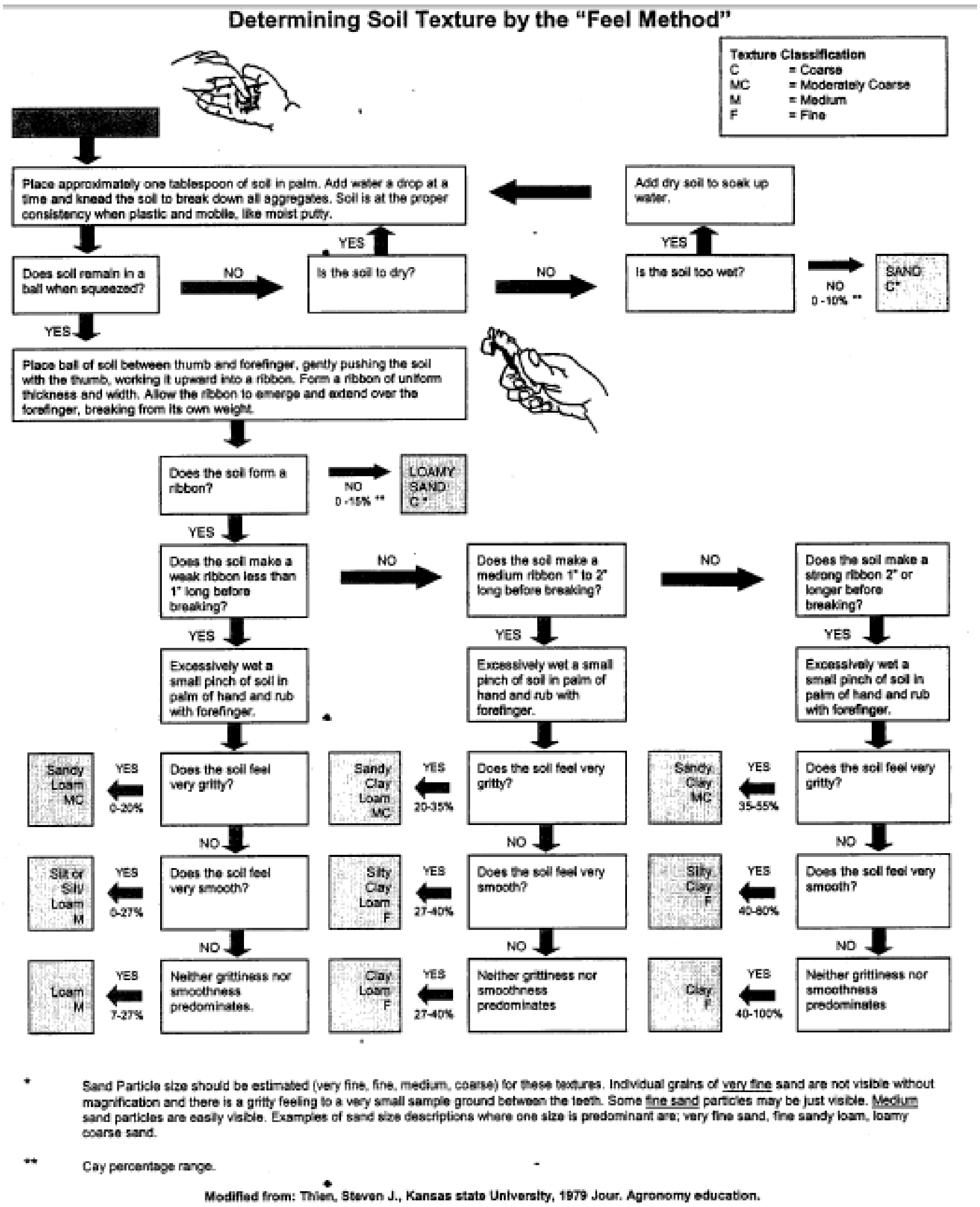


Figure 46: Determining soil texture by the 'feel' method

12. Describe the boundaries between horizons, indicating distinctness and general topography.

    Distinctness:

    a **Abrupt:** Transition less than 2cm.
    c **Clear:** Transition is 2-5 cm thick
    g **Gradual:** Transition is 5-15 cm thick
    d **Diffuse:** Transition is more than 15 cm.

    Topography: refers to the nature of the surface that separates the horizons. You can use the adjectives "slightly" and "very" in combination with the following abbreviations.

    s **Smooth:** Boundary is planar or parallel to the geomorphic surface
    w **Wavy:** Undulating surface with pockets wider than they are deep.
    i **Irregular:** If pockets are deeper than their width.
    b **Broken:** If one or both of the horizons separated by the boundary are discontinuous, so the boundary is interrupted.

13. Remember to apply some drops of HCl on the soil of every soil horizon. Carbonates react with acid and produce effervescence, its intensity is close related with the amount of carbonates. This step is hence very useful to identify the presence of carbonates; note this down for each horizon into the soil notebook.

14. If the soil pit is dug till bedrock, and the depth to bedrock is less than or equal to 60 cm, then the soil samples are to be taken at the intervals of 0-10, 10-20, 20-30, 30-40, and 40-60 (all in centimeters), stopping obviously at the interval where bedrock is hit. For example, if the bedrock is at 35 centimeters, then obviously that interval will span 30-35 cm and is the bottom-most interval. However, if the depth to bedrock is more than 60 cm, or if the soil pit depth is 1.5 meters, then sample at the intervals of 0-10, 10-20, 20-40, 40-60, 60-80, 80-100, 100-120, 120-150 (all in centimeters), stopping again obviously at the interval where bedrock is hit. If one of any sampling intervals occurs across a horizon boundary, then you need to sub-sample so that you don't sample two horizons in the same soil sample. You should take about a kilo of each sample including stones. Sieve each sample with 2mm sieve, and see if you have a min of 500 grams of < 2mm for the lab analysis. Store each such sample in a sample bag and label the bag with the location (pit number), date and layer number with the depth interval in parentheses, for example, 'Layer 3 (20-30 cm)'. For the layer number, note that '1' is for the surface 0-10 cm, and so on it increases downwards. If there is sub-sampling because of a

sampling interval across a horizon boundary, then add suffix ‘a’, ‘b’ etc. increasing downwards to the layer number (do not forget to add the depth interval infomation in parentheses).

15. Extract 3 intact pedons (big soil peds) from each horizon. Wrap these peds with parafilm, label them, and put them in some containers. For labeling, note down the pit number, the date, then the soil horizon number (0 for the ‘A’ horizon, 1 for the next topmost horizon and so on increasing downwards), then the pedon number at that depth. With these samples, bulk density will be estimated in the laboratory.

16. Note down any depth of roots and the corresponding vegetation (Appendix on ‘Ecosystems and main plant species of the San Miguel basin’) into the soil notebook. Take photographs if possible.

17. If the soil pits are supposed to be filled back up the same day, DO NOT FORGET to do so before leaving the location, to avoid trapping cattle in the pits and getting into trouble with the local ranchers!

BASIN EXPERIMENT 5: WATER SOURCE CHARACTERIZATION USING MAJOR ANIONS AND ISOTOPES

Goal: To determine water source to rivers in semi-arid regions by collecting samples of groundwater, runoff, precipitation, and stream flow and analyzing major anions and isotopes.

Materials:

GeoPump
125 ml. Plastic bottles
10 ml. Plastic vials
pH and EC meter
Labeling tape
Markers
Cooler
Buckets
Screen
Wire
Screen scissors
Mineral Oil
Syringes
Samplers
1 lt. Plastic Bottles
Autosamplers

Procedure:

- First Day of Work (this can be done either the first or the second day of work)
  1. If not already, get in touch with the person in charge of the "El Cajon" stream gauge station to get permit to set up autosampler. (Lissette will try to do this on Friday, while in Hermosillo)
  2. Install stream flow autosampler at station .
     - This sampler will be located close to the "El cajon" stream gauge.
     - The sampler will collect every 4 hours for 4 days.
  3. Possibly set up precipitation collector in the "Torre", where the eddy covariance station is located. More collectors will be added if some other place is seen where more could be set up.
  4. Also, set up the device for collecting precipitation samples at Summer 2006 stations 132 and 146. Further, set up sampling devise at the upper part of the basin in Cucurpe (Lissette might stop on her way to Hermosillo to set up this, and might need to come back at some point to

get a sample and once she is heading back to Tucson, she will stop again), Meresichic, etc.

- Second Day of Work

1. Collect stream flow samples one or a few of the perennials reaches, which are usually around towns such as San Miguel de Horcasitas, Rayon, Opodepe, Meresichic, and Cucurpe
   - These Samples will be collected every 500m.
   - At each site 3 samples will be taken.

- Third Day of Work

1. Set up sampler for capturing runoff near rain gauges. (These will be set up once, I'll see how they work, and I'll keep collecting samples every time it rains)
2. Collect runoff captured by Samplers.
3. Collect precipitation sample (These samples will be collected every day after a rain event).

- Fourth Day of Work

These will be done the days Lissette gets free from other activities (i.e. seting up samplers, collecting rain, runoff and stream sampling)

1. If not already, get permits to access wells. (The wells to be sampled will depend on the accessibility. Lissette already talked to people about it, and also needs to talk individually to the owners. These wells are all the located in the San Miguel basin)
2. Collect 3 samples from each of the wells located at San Miguel Basin
   - For wells that are pumping at the time, just collect discharge samples
   - For wells that are not working at the time, use geopump
     - Before taking sample, pump 3 case volumes because that's the protocol established to make sure the water sampled is coming from the aquifer and hasn't been sitting in there for months, hence changing the composition.

- Fifth Day of Work

1. Take ground water samples .

- Next day of work

1. collect rain and runoff samples .

- Next day of work

1. collect ground water samples.

- Next day of work

1. take rain and runoff samples

APPENDIX 1: ECOSYSTEMS AND MAIN PLANT SPECIES OF THE SAN MIGUEL BASIN

The San Miguel watershed is located about 70 kilometers northeastward of Hermosillo, the capital of the Mexican state of Sonora. The San Miguel watershed is around 3,798 km^2 and ranges in elevation from 370 to 2440 meters above sea level. A close coupled relationship exists between elevation and plant communities, especially in this area. In the san Miguel basin we can find three main ecosystems: Subtropical scrubland, Desert scrubland, and Madrean evergreen woodland.

Subtropical Scrubland

These drought deciduous communities occupy a moisture gradient transitional between desert scrub and woodland or forest. Canopy heights tends to be from 2 to 8 m and are typically composed of spinose, microphyllous, and succulent plat life-forms. In Sonora it is usually positioned between the sonoran desertscrub and either tropical deciduous forest or madrean evergreen forest. Dominant plant species have their center of distribution and abundance here, eg. Ocotillo tree (*Fouquieria macdougalii),* see picture 1, we can can also find the appearance and often heavy representation of tropical species not found in the desert scrubland like huinolo (*Acacia cochliacantha*) , see picture 2, or *Acacia cymbispiana.* It is primary resident of low hills, bajadas, mesas and mountains slopes , although we can find it in low valleys where has invaded former savanna grassland. Precipitation range goes from 300-500 mm per year. Cacti are also found with two main species: pithaya (*Stenocereus thurberi*), see figure, Hecho or etcho (*Pachycereus pectin-aboriginum*), and also nopales (*Opuntia sp*).

Picture 1. Ocotillo macho, torote verde or ocotillo tree (*Fouquieria macdougalii).* Dominant specie of subtropical scrubland. Found in hill slopes, mesas and arroyo rims. Shrub or tree 5-8 m high. Trunk usually very short, Blooms mainly in rain periods showing a bright red flower. In our experiment sites, it is usually found around the tower experiment and low hills.

Picture 2. Huinolo (*Acacia cochliacantha).* Found in mesas, valleys, and hill slopes, common between 30-900 m above sea level. It is very aggressive and quickly captures areas abandoned from cultivation; it is used as index specie for deforested zones. Normally 6-8 m of height with a short trunk.


Picture 3. Palo verde o Palo brea (*Cercidium praecox*) Found in roadsides, valleys, volcanic slopes . Common tree in lowlands, sometimes exude a sweet and odorous excretion highly attractive to insects. Flower is bright yellow.


Picture 4. Pithaya (*Stenocereus thurberi*). Found from coastal plains to barrancas in a elevation from sea to 1000 m. It is a large columnar cactus to more than 10 m in height .It is a very valuable resource in rural Sonora.

Picture 5. Tavachin (*Caesalpinia pulcherrinia*), Found in arroyos margins and roadsides. Elevation of 150-1500 above sea level. Bushy-shrub 1 to 3 meters height. It blooms during rainy season. Flowers during youth are yellow turning to red when they are mature.

Picture 6. Guayacan (*Guaiacum coulteri*). Found in canyons, arid hillslopes, roadsides, stabilized dunes. From coastline to 400 m above sea level. Small sturdy tree, closely and complexly branched. In drought season (may to june) it throws out a beautiful bright blue abundance of flowers. It responds quickly to rain.

Picture 7. Reina de la noche (*Peniocereus striatus*). Found in foothills elevation 100-250 m above sea level. A pencil stemmed cactus, sprawling in thickets of other shrubs and closely resembling their leafless, woody branches. The root system bears numerous succulent swellings, shaped like potato tubers.

<u>Sonora Desert scrub</u>

The sonoran desert differs markedly from the other North American desert biomes, which are dominated by low shrubs, in its arboreal elements and its truly large cacti and succulent constituents. Even in its most arid parts, the sonoran desert exhibits tree, tall shrubs and succulent life forms along drainages and in other favored habitats.

One division of the sonoran desert is known as palo verde-cacti desert. This subdivision is found from Arizona to south of Magdalena, Sonora. The lower elevation contact may be as low as 300 m to 650 m. Precipitation range goes from 200 mm to 425 mm. The most common species are saguaro (*Carnegiea gigantean*), see picture, oldman cactus (*mammillaria sp.*) ,see picture, barrel cactus (*ferocactus wislizenii*) , palo verde (*Cercidium mycrophillum*) and ocotillo (*Fouquieria splendens*).

Picture 8. Saguaro (*Carnegiea gigantean).* Rocky , rugged slopes of volcanic slopes. Elevation from 50-500 m.

Picture 9. Ocotillo (*Fouquieria splendens*). Found from southwest USA to Sonora, Mexico. We can find ocotillo until 1500 m above sea level. Leaves are in axils of thorns; simple, in clusters, round, to 1in tall, bright green; plant is generally leafless for most of the year; in years with good rainfall leaves will persist, turning showy colors of yellow and red in the fall. 1.5 to 8 meters in height. Stems/Trunks are long slender stems rise from a common base; stems covered with 1in thorns which are gray or sometimes greenish. Flowers are bright red.

Picture 10. Biznaguita or pithayita (*Mammillaria grahamii*.) Found in rocky slides , cliff crevices, foothills and slopes. Elevation 150-600 m. One of the smallest and more abundant species of mammillaria found in Sonora. It blooms abundantly in July, with bright to pale pink flowers; fruits ripen in the fall.

<u>Madrean evergreen woodland</u>

In the foothills, bajadas and barrancas and mountains ranges of the Sierra Madre Occidental and its outlaying ranges in Mexico, a large variety of oaks participate in both encinal and oak-pine woodlands that covers hundreds of squares miles of western Chihuahua and eastern Sonora. In both states, Chihuahuan oak (*Quercus chihuahensis*) , see picture, is commonly the first oak encountered at the woodlands's lower edge. Other commonly found oaks found in the region are encino prieto o Encino cusi comestible (Quercus alboncita) and Encino cusi prieto (Quercus durifolia).

This biome community generally makes contact with grasslands, however, grass provide the major woodland under canopy coverage. Many of the cacti and leaf succulents of the semi desert grassland extend very well to the madrean evergreen woodland. Main species can include nopal (Opuntia robusta, shown in picture , Opuntia spinosor) and agaves. Precipitation goes within a range from 400-1200 mm, being 400 the mean annual precipitation.

Picture 11. Encino roble o chihuahuan oak (*Quercus chihuahensis*). Found in rocky slopes, ridges and streams sides and altered soils. Elevation from 300 to 1900 m above sea level. Small spreading oak, with light gray, siffured bark reaching at least 10 m in height. Leaves greenish-gray, flowering May-August and producing acorns from October to December.

Picture 12. Nopal o tuna tapon (*Opuntia robusta*). Found in rocks and open places. Between 1500-1800 m above sea level. Prickly pear with massive pads, fruits barrel shaped or globose, reddish to purple. Limited to and common in high elevations, common in mountains of Sonora and Chihuahua.

Picture 12. Leghugilla verde (*Agave bovicornuta*) . Found in rocky slopes, between 500-1900 m above sea level. It is the most common of the uplands agaves and is quickly recognized by its large size and bright green leaves. It flowers from February to May.

All photographs shown in this section were taken by 2004 field campaign participants.

APPENDIX 2: RELEVANT SECTIONS OF THE CEPTOMETER MANUAL

AccuPAR
PAR/LAI ceptometer

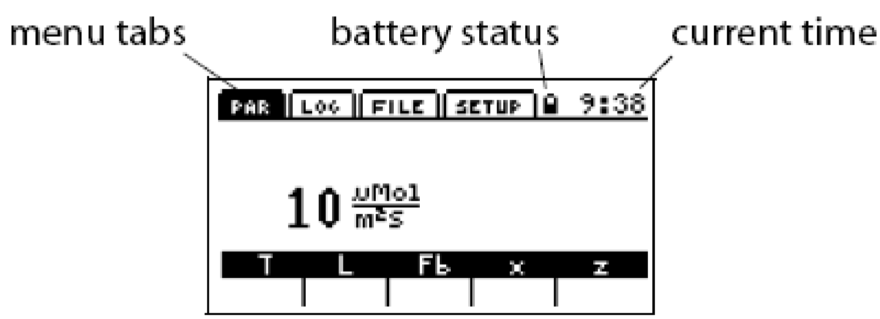
model ***LP-80***

Operator's Manual
Version 1.2

Decagon Devices, Inc.

Turning on the instrument

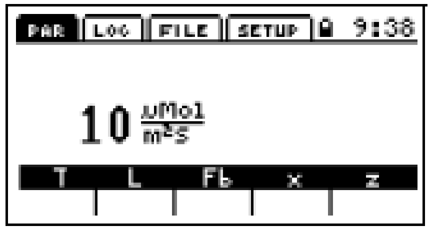
When you first turn on the instrument, it will be in the PAR sampling menu, in which you will see real-time PAR data displayed in the center portion of the screen. If you have the external PAR sensor connected, you will also see its real-time PAR data displayed, and indicated by an above-canopy icon.



At any time, you can cycle between the four menus by pressing the MENU key. The menus are indicated by the tabs on the top of the screen, with the active menu highlighted in black. To the right of the menu tabs is the current battery status and the time. Later chapters discuss each menu in detail and how to use the features that each provides.

Taking measurements:

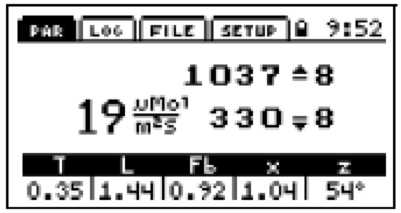
The first menu option is the PAR/LAI sampling menu, which is used for all measurements with the AccuPAR. The default screen is one similar to this:



This screen example indicates that the current real-time PAR level is 10 µmols/m^2/s (this example was taken indoors), and that no above or below PAR measurements have been taken. If the external sensor is attached, the real-time PAR value measured by the external sensor will be also displayed above the real-time probe PAR data.

Taking Measurements

To make an above-canopy PAR measurement, press the up-arrow key in this menu. The resulting value will be displayed in the upper right section of the screen. To make measurements below the canopy, press the down-arrow key or the green circular key in the upper right corner of the keypad. When at least one of both an above and below canopy measurement have been taken, other relevant data is displayed at the bottom of the screen, as shown in this example:



The current calculated Tau (T), LAI value (L) beam fraction (F_b), leaf distribution parameter (x) and zenith angle (z) values are updated and displayed at the bottom of the screen with each subsequent PAR measurement. If the external sensor is attached, both above and below values will be summed each time the down arrow is pressed. Pressing ENTER saves these values to memory. Pressing ESC discards the values. Both options clear the screen for new data. The values displayed at the bottom of the screen are dependent on how you have set up your instrument in the Setup menu. For a more detailed description of these variables and their definitions, please refer to chapter 3 (Definitions) or chapter 8 (Theory).

With each above or below canopy measurement, a number appears to the left of the PAR value, indicating the number of measurements taken. The displayed PAR value reflects the average of the samples taken. Therefore, in the above sample screen, eight above and below canopy measurements have been made, so the average of the eight above-canopy PAR values is 1037 µmols, while the average of the eight below-canopy value is 330 µmols

APPENDIX 3: RELEVANT SECTIONS OF THE SPECTRORADIOMETER MANUAL

1. Assembling The MSR System

The Multispectral Radiometer (MSR) System is shipped partially assembled. The MSR program is pre-installed and pre-configured in the Data Logger Controller (DLC). The following instructions and pictures show how to complete the assembly and the installation of the MSR Software.

After removing the equipment from the shipping containers,

1. Attach the MSR Mounting Bracket (MSRMB) on the pole.

   Pull the detent knob (at right in picture below) and extend the inner pole section:

   Position the MSR Mounting Bracket (MSRMB) over the end of the pole:

Insert the carriage bolt, turn on the wing nut, but do not tighten yet. This makes aligning and inserting the screw easier, in the next step:

Insert the bracket position retaining screw in the desired mounting bracket position hole. The position shown is probably the most likely used position, but will depend on your particular application:

Tighten both the position retaining screw and the wing nut on the carriage bolt. Be sure the square part of the carriage bolt fits into the square hole of the MSR mounting bracket:

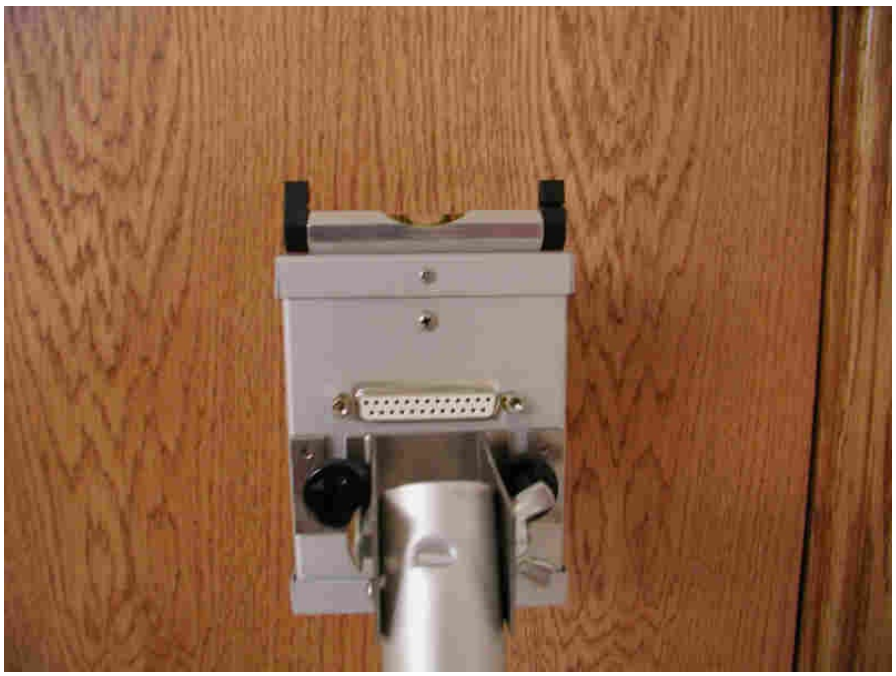
2. Attach the MSR Spirit Level Attachment (MSRSLA), CT100 Mounting Bracket (CT100B), and Radiometer on the pole.

It is suggested that the CT100B be positioned just above where you would likely hold the pole, allowing you to both hold the pole and operate the CT100 hand terminal, to initiate scans, with the same hand. It is suggested to mount the MSRSLA at approximately knee height such that you can look nearly straight down at it to par level the radiometer prior to initiating a scan, during normal operation.

Loosen the two black-knurled thumb knobs on the Radiometer, slip into the two slots on MSR Mounting Bracket and then hand tighten (see below).

3. Par level adjusts the Radiometer and the MSR Spirit Level Attachment.

Position the Radiometer and pole up against a vertical wall or door as shown above, with the Radiometer flush against the wall. Place the line level on top of the radiometer, as shown below, and reposition the pole, as necessary, to position the bubble in the center of the line level:



Adjust the MSRSLA on the pole and then position of the L-bracket to center the bubble in the center of the spirit level circle. When in position, fully tighten both wing nuts:

1. Attach the Radiometer cable.

Attach the Radiometer cable, MSR87C-9 to the radiometer and tighten the two retaining screws, either by hand or with a small screwdriver. Note: The Radiometer cable color and connector design may vary from that pictured:

Slip the cable into the white nylon cable retention clip near pole extension adjustment knob near the upper left corner of the CT100 (in picture below). The other end of the MSR87C-9 cable should already be attached to either an MSR Cable Adapter (MSRCA) or MSR Cable Adapter Box (MSRCAB), depending on the particular MSR system ordered.

2. Attach the CT100.

Attach the CT9M9M-5 cable (end labeled CT100, with gender changer attached to it) to the CT100 Hand Terminal and attach the CT100 to the CT100 mounting bracket already on the pole:

Attach the other end of the CT9M9M-5 cable (labeled DLC) to the DLC RS232 connector (on front panel of DLC).

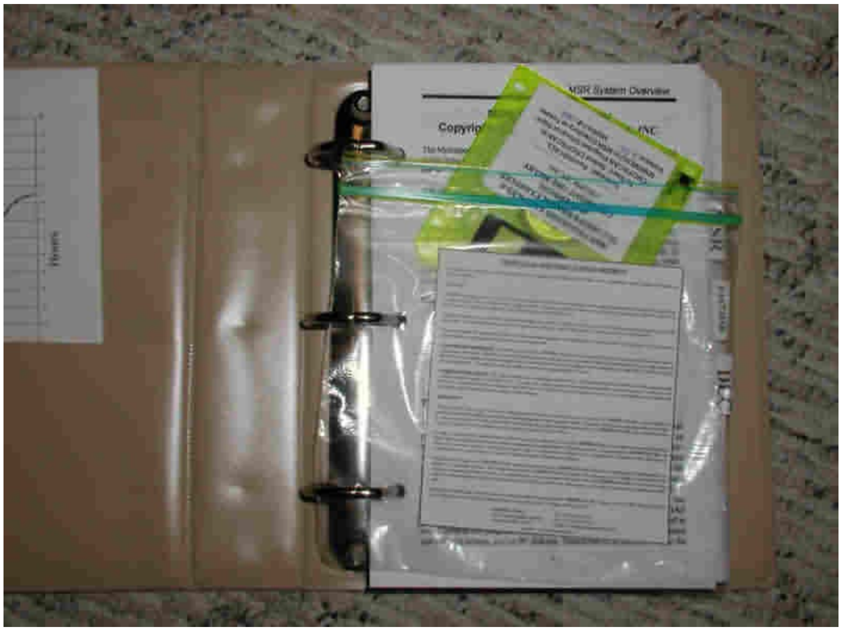
3. Check completed assembly.

Completed MSR system assembly should appear as follows:

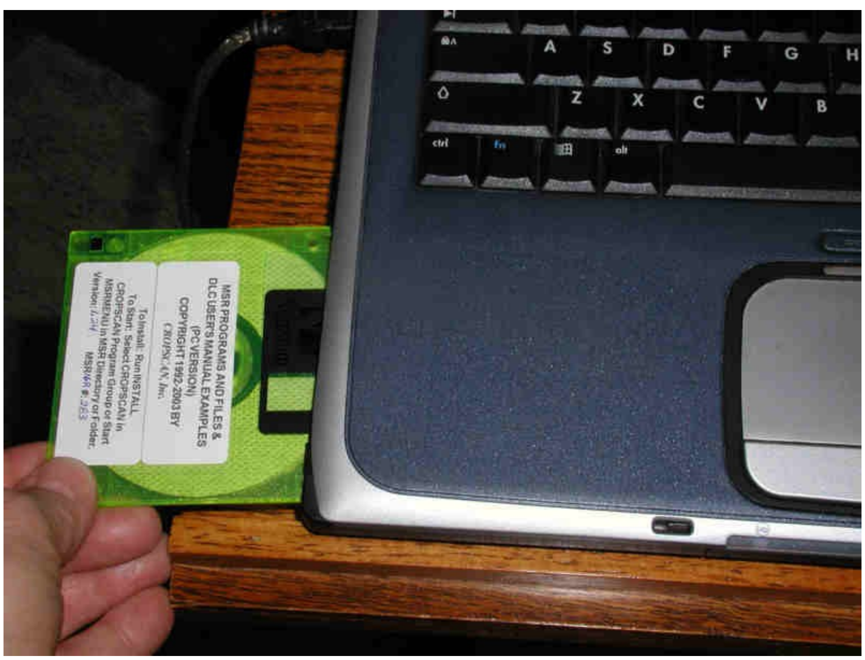
2. ***Installing The MSR Software***

1. Remove the MSR Software Diskette from the plastic pouch inside the User's Manual.

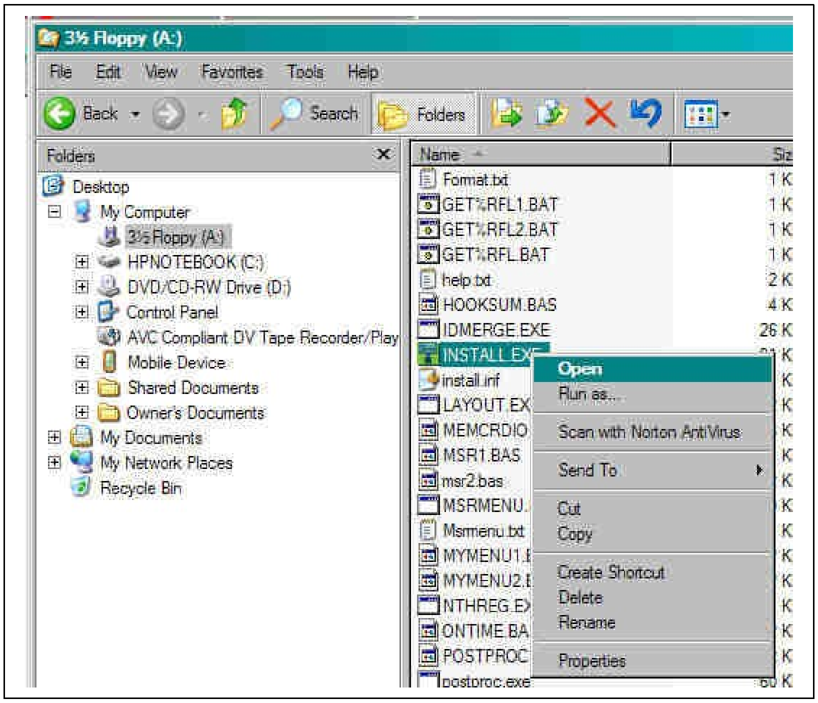
Read the *CROPSCAN, Inc.* Software License Agreement:



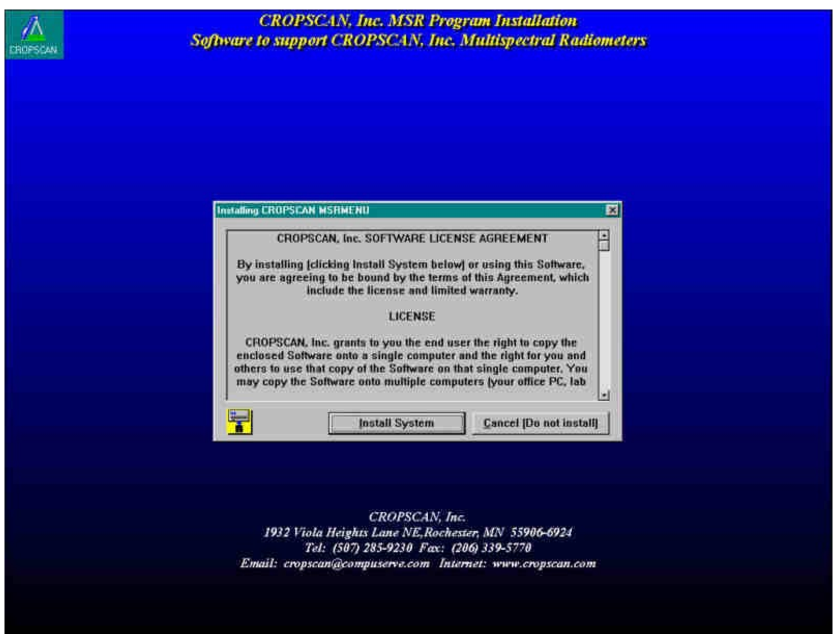
2. Insert the MSR Software Diskette into your PC.



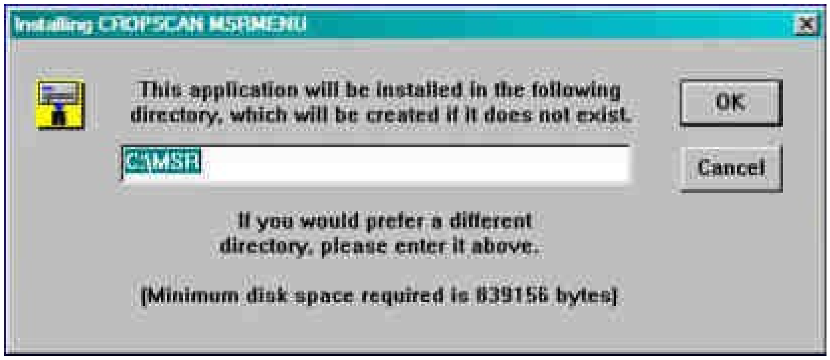
Locate the INSTALL program on the Diskette and Run (Open) it:



3. If you did not read the License Agreement above, read and scroll through it at this window. When done, Click the Install System button:

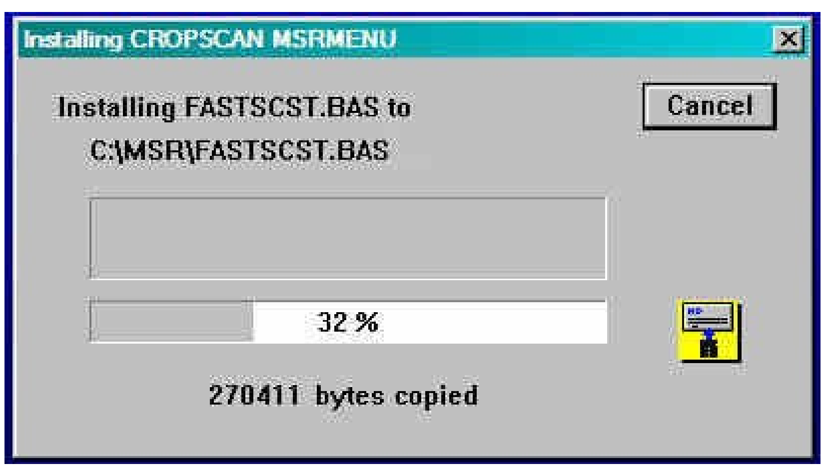


4. Click the OK button to install the MSR Software to the MSR folder:



5. Click the 'OK - Install in above Group' button to create a ***CROPSCAN*** Program Manager Group:

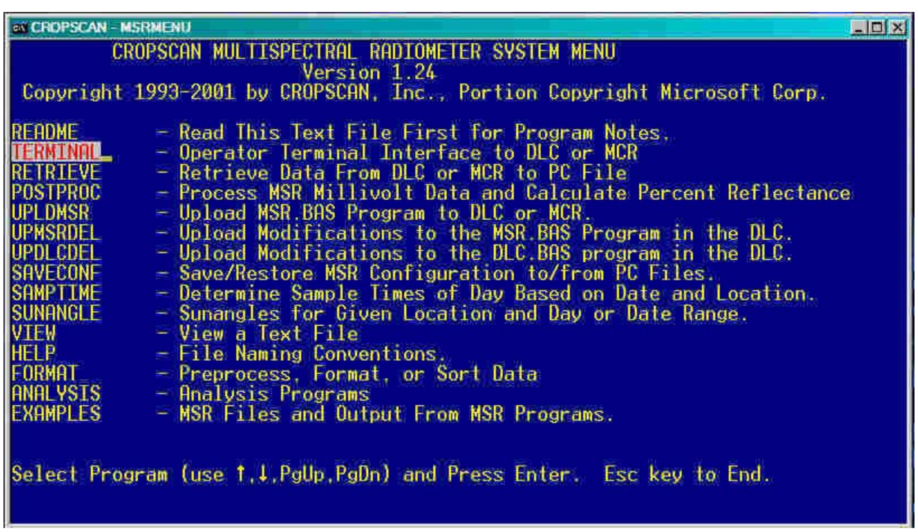
A progress bar window will display progress of the install:



6. Click the OK button at the following window:

7. The Installation Complete message will appear.
   Click the 'Yes - execute' button:

8. The CROPSCAN MULTISPECTRAL RADIOMETER SYSTEM MENU will appear:



Proceed to page 5 of the MSR User's Manual and ignore the copying of the program diskette and typing of MSRMENU instructions in step 3 when you get to step 3. Also, skip the entry of the RECORD command settings on page 8, step 3 and on page 9, step 4, because the items to be recorded were pre-configured prior to the MSRsystem being shipped.

3. ***Collecting Readings***

Readings are best made in clear sky or lightly cloudy (cirrus type) conditions. Useful readings can be obtained in irradiance levels down to about 300 watts per square meter or just before shadows disappear.

Before going to the field to take readings, it is suggested that you check the MSR configuration, in particular Date, Time, Latitude, Longitude, and GMT Difference, for the location where you will be obtaining readings. This is more easily done using the TERMINAL program on a PC rather than using the smaller display of the CT100 Hand Terminal. Additional information and detail is available in the Operation section of the MSR User's Manual.

What follows below are the steps to obtain field plot readings.

1. Slide the CT100 Power switch to the ON position. The CT100 will flash some diagnostics characters on its display for a few seconds. When complete, the underscore character will be displayed in the upper left-hand corner of the display.

2. Press the Enter key 3 times at approximately 1 second intervals. The following will appear and scroll upwards on the display:

```
DATA LOGGER CONTROLLER (DLC)
Copyright 1992-2002 by CROPSCAN, Inc.

MULTISPECTRAL RADIOMETER (MSR)
Copyright 1992-2001 by CROPSCAN, Inc.
```

```
MSR PROGRAM
 16 WAVELENGTHS
Enter or M-Menu
```

The number of wavelengths shown depends on the radiometer model and how many channels are configured for RECORDing.

3. Press Enter to proceed with the program.

```
RECORD:
1 EVERY SS.

2 AVERAGE SS.1
```

Choose 1 to record every Sub-Sample per plot or choose 2 to record the average of the Sub-Samples.

```
AUTO PLOT #s
BEGIN PLOT#:1

END PLOT#:80
```

If automatic sequential plot numbering is configured. Any plot number may be chosen for the beginning plot number but the ending plot number cannot exceed 99999999. If manual plot numbering is configured, any plot number up to 99999999 may be entered. Spaces are ignored. After entering the beginning and ending plot numbers, the following information is displayed.

```
PRESS SPACE OR
MANUAL SWITCH
TO SCAN
R-Repeat scan
P-repeat Plot
S-Suspend
M-Menu
W-WhiteStandard
D-Dark Reading

PLOT   1 SAMP  1
IRR  810 B 10.9
```

The present plot and sample numbers are then displayed on the first line. On the second line the real-time solar irradiance, IRR, and battery voltage, B, are displayed.

4. Facing the sun, so as not to cast a shadow on the radiometer plot view area, position the pole to the desired spot over the first plot, tilting the pole so the bubble is centered and hence the radiometer leveled.


5. Initiate a scan by pushing the space key or space bar or by pressing the hand-held manual scan push-button switch (optional accessory) momentarily.

```
PLOT   1 SAMP  1

Scanning...
```

The message ‘scanning...’ will appear on the screen. Simultaneously, an audible beep will be heard. When the scan is complete (about two seconds) two asterisks ‘**’ will be displayed and simultaneously, two beeps will be heard.

```
PLOT   1 SAMP  1

Scanning...**
```

At this time, you can move to the next plot during which time the data is recorded and the word ‘Done’ appears. Simultaneously, three beeps will be heard.

```
PLOT   1 SAMP  1

Done
```

After the scan is done, the next plot number or sample will be displayed to indicate that the system is ready for the next scan.

```
PLOT   2 SAMP  1

IRR  809 B 10.7
```

Continue with step 4 above.

To suspend operations after the plot number has been displayed (auto mode), or manually entered (manual mode), press the S key. The DLC will go to sleep and resume operations exactly where you left off upon a restart by pressing the Enter key three times. If you use the CT100 hand terminal, switch the power to OFF to reduce power drain until you are ready to resume operations.

6. After the last plot scan has completed, press the 'M' key to return to the MSR Main Menu:

```
MSR MAIN MENU
 1 Config-Status
 2 ReConfigure      7 Memory Card
 3 Retrieve Data    8 MSR Program
 4 Clear Data       9 Exit MENU
 5 View            10 BYE
Enter Selection/Command
*10
```

7. Type 10 and press Enter to put the DLC to sleep:

```
Returning to SLEEP... BYE!
```

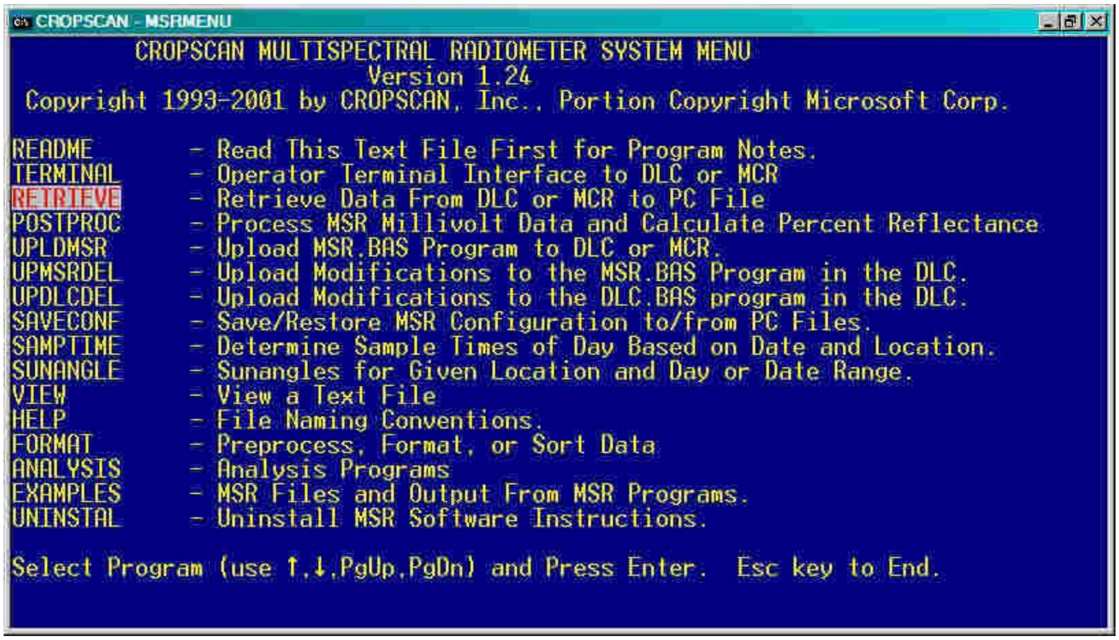
At this point, the plot readings have been made and the sensor millivolt readings logged in the DLC. The next step would be to RETRIEVE the data from the DLC to a PC file.

4. *Retrieving Data to a PC File*

MSR sensor plot data logged in the DLC can be retrieved to a PC by using the RETRIEVE program.

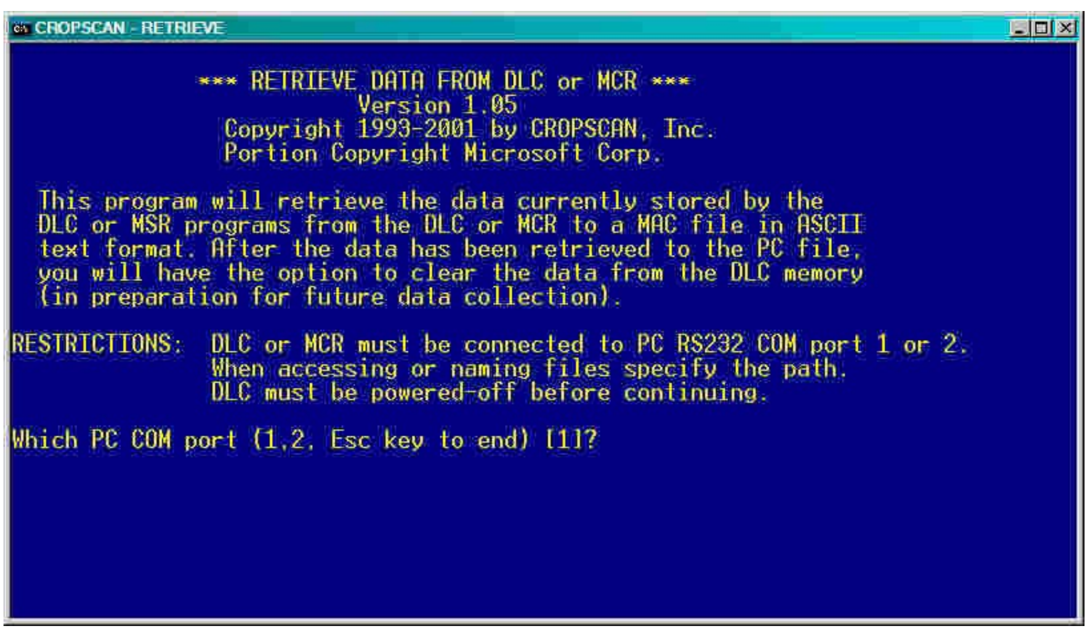
1. Connect the DLC to your PC using the RS9M9F-5 cable. Connect the male end of the cable to the RS232 connector on the DLC front panel and the female end to the 9-pin RS232 serial connector on your PC. If your PC does not have a serial connector (some newer PCs do not) but instead has a USB connector you will need to use a USB to Serial converter. Refer to Configuring a USB to Serial Converter for additional information in setting it up.

2. Start the *CROPSCAN* MSR Software on your PC.

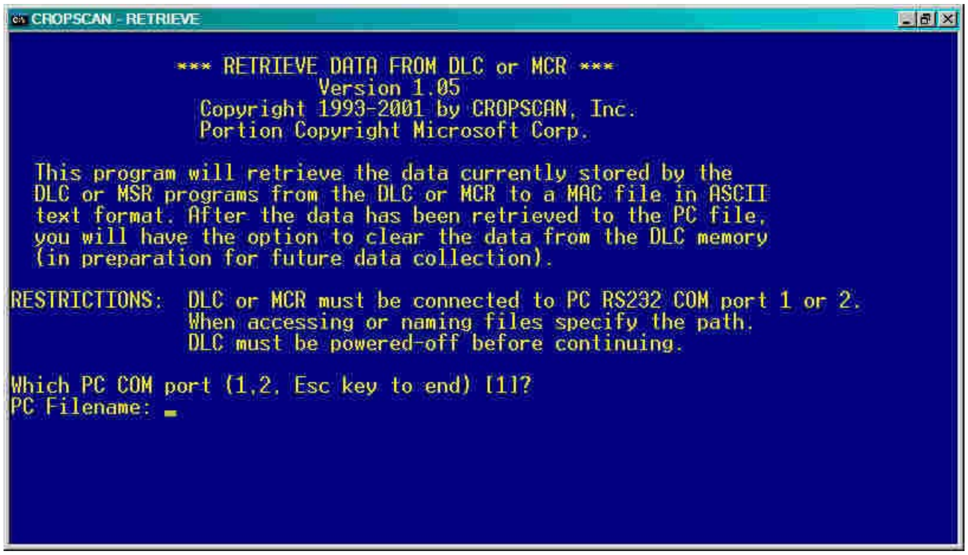


3. Select RETRIEVE and press Enter.

If the correct COM port number is not shown in the brackets, type the correct number.



4. Press Enter. The following should appear:



5. Type a file name [eight (8) characters maximum] with the .MV extension and press Enter.Example: mydata.mv

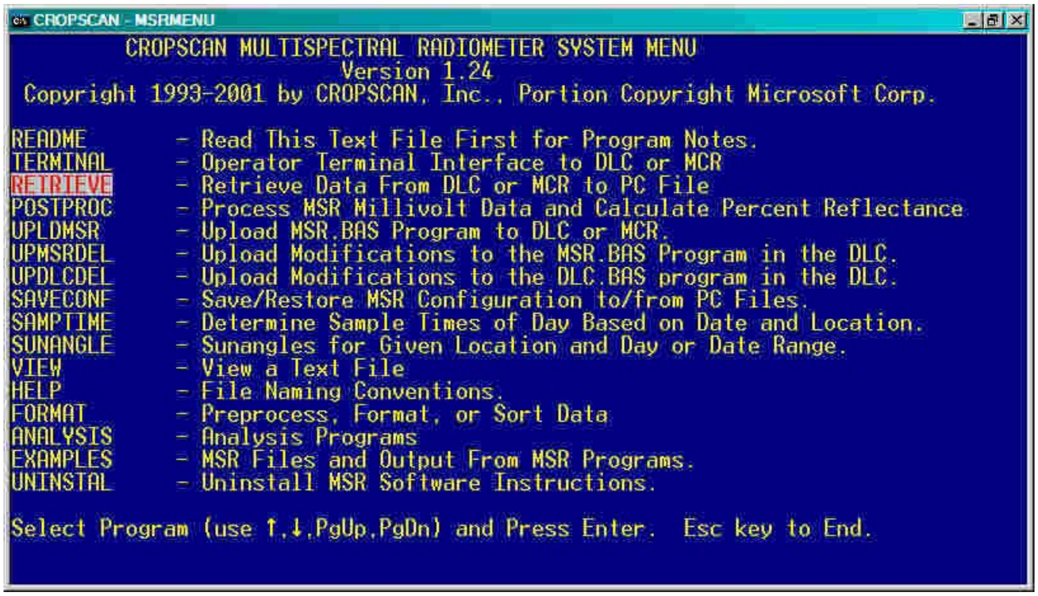
   The RETRIEVE program will automatically wake the DLC and pass various commands to the DLC to cause it to present its configuration and logged data. The various commands will be displayed followed by the configuration and data scrollng upwards on the display. The RETIEVE program captures this configuration information and data to the PC file.

   When the last of the data has been presented and stored to the PC file, the following will be displayed:

   `CLEAR DATA FROM DLC MEMORY (Y/N)?:`

6. Unless you have other reasons to save keep the data logged in the DLC, type Y and press Enter. The RETRIEVE program will then instruct the DLC to clear its data memory and will put the DLC back to sleep. The DLC will then be ready for the next field plot scanning session.

After the DLC is back to sleep, control returns to the main *CROPSCAN* MSR Software Menu:



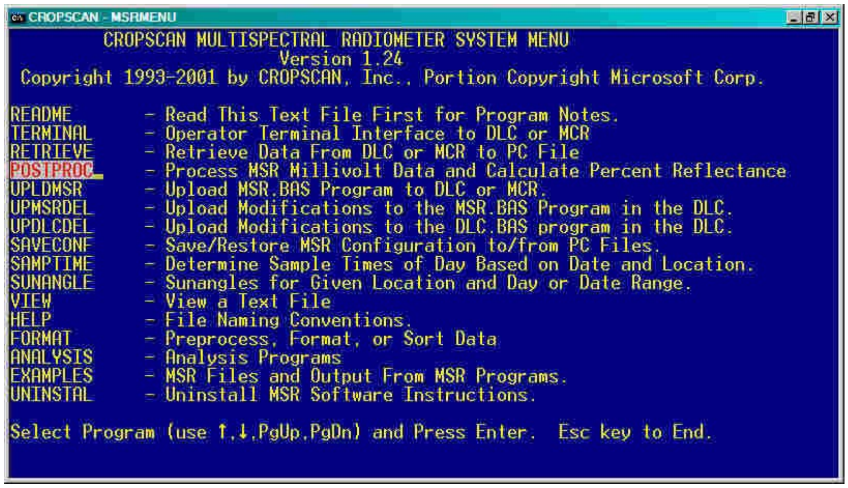
This completes the RETRIEVE operation. At this point, Post-Processing of the data may be done.

5. ***Post-Process MSR millivolt (.mV) File [create Reflectance (.RFL) file]***

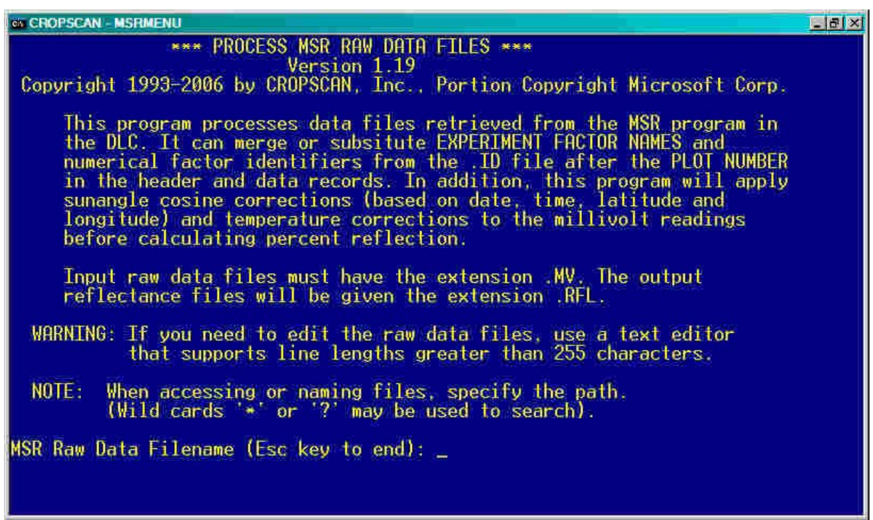
Retrieved MSR sensor data millivolt files can be processed by the POSTPROC program to calculate the corresponding percent reflectance values by applying temperature sensitivity corrections, up-sensor cosine response corrections, and calibration constants.

To POSTPROC an MSR .MV file, do the following:

1. Start the *CROPSCAN* MSR Software on your PC.

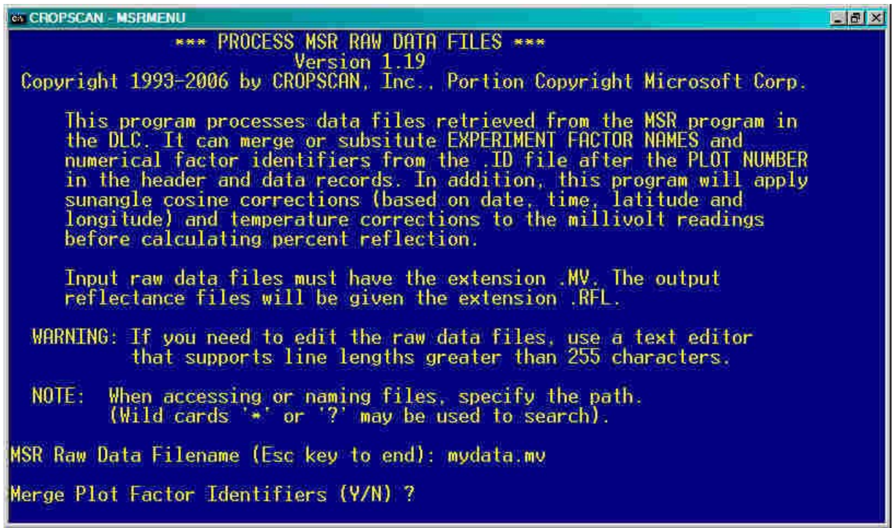


2. Select POSTPROC and press Enter.



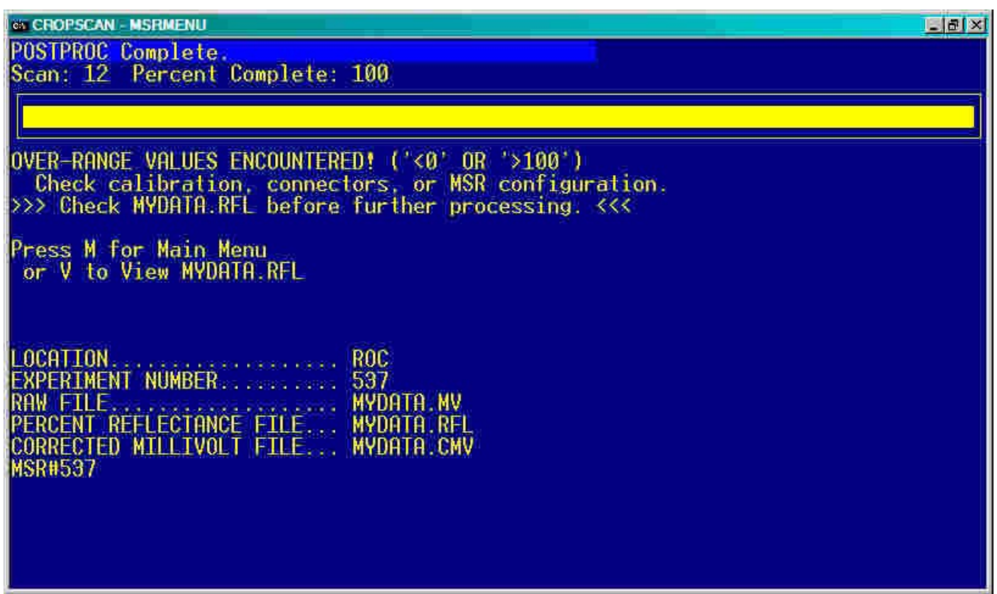
3. Type a file name [eight (8) characters maximum]. If no extension is entered, .MV will be assumed. Press Enter.

Example file name: mydata.mv



The POSTPROC program supports merging plot experimental factor identifiers into the output reflectance file. This can help subsequent statistical analysis by having the factor identifiers in the same file as the reflectance data. Merging plot factors is optional. Mergeable plot factor files can be created using the FACTORID program. Refer to the MSR User's Manual and programhelp text for additional information. For this example, merging plot factors will not be done.

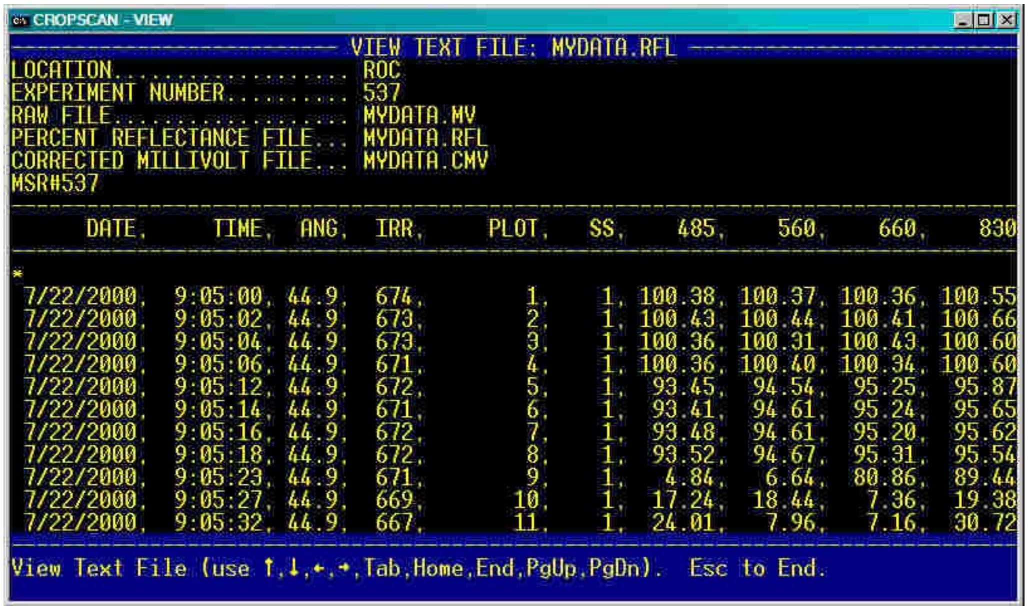
1. Type N and press Enter. Something similar to the following will be displayed



A progress bar is display to display the progression of processing. Being a data calculation intensive program, large MSR data files can cause POSTPROC to take several seconds to process, depending on the PC CPU speed.

Any error condition detected will result in a message display, such as the over- range value message displayed above.

2. Press V to view the percent reflectance output file, mydata.rfl in this case.



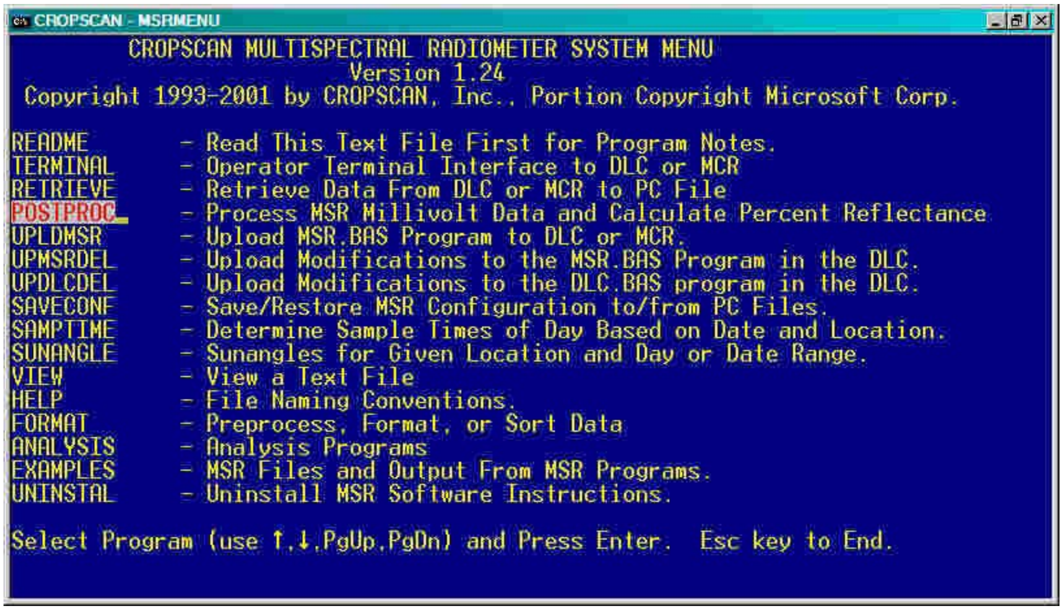
```
CROPSCAN - VIEW
-------------------- VIEW TEXT FILE: MYDATA.RFL --------------------
LOCATION.................. ROC
EXPERIMENT NUMBER......... 537
RAW FILE.................. MYDATA.MV
PERCENT REFLECTANCE FILE... MYDATA.RFL
CORRECTED MILLIVOLT FILE... MYDATA.CMV
MSR#537
------------------------------------------------------------------------
      DATE,     TIME,  ANG,  IRR,      PLOT,   SS,    485,     560,     660,    830
------------------------------------------------------------------------
*
 7/22/2000,  9:05:00, 44.9,  674,        1,     1, 100.38, 100.37, 100.36, 100.55
 7/22/2000,  9:05:02, 44.9,  673,        2,     1, 100.43, 100.44, 100.41, 100.66
 7/22/2000,  9:05:04, 44.9,  673,        3,     1, 100.36, 100.31, 100.43, 100.60
 7/22/2000,  9:05:06, 44.9,  671,        4,     1, 100.36, 100.40, 100.34, 100.60
 7/22/2000,  9:05:12, 44.9,  672,        5,     1,  93.45,  94.54,  95.25,  95.87
 7/22/2000,  9:05:14, 44.9,  671,        6,     1,  93.41,  94.61,  95.24,  95.65
 7/22/2000,  9:05:16, 44.9,  672,        7,     1,  93.48,  94.61,  95.20,  95.62
 7/22/2000,  9:05:18, 44.9,  672,        8,     1,  93.52,  94.67,  95.31,  95.54
 7/22/2000,  9:05:23, 44.9,  671,        9,     1,   4.84,   6.64,  80.86,  89.44
 7/22/2000,  9:05:27, 44.9,  669,       10,     1,  17.24,  18.44,   7.36,  19.38
 7/22/2000,  9:05:32, 44.9,  667,       11,     1,  24.01,   7.96,   7.16,  30.72
------------------------------------------------------------------------
View Text File (use ↑,↓,←,→,Tab,Home,End,PgUp,PgDn).  Esc to End.
```

The navigational keys shown can be used to scroll up and down or left and right to view the entire output reflectance file.

```
LOCATION.................. ROC
EXPERIMENT NUMBER......... 537
RAW FILE.................. MYDATA.MV
PERCENT REFLECTANCE FILE... MYDATA.RFL
CORRECTED MILLIVOLT FILE... MYDATA.CMV
MSR#537
---------------------------------------------------------------------------------------
      DATE, TIME,  ANG,  IRR,     PLOT,   SS,    485,    560,    660,    830,   1650
---------------------------------------------------------------------------------------
*
  7/22/2000, 9:05:00, 44.9, 674,        1,     1, 100.38, 100.37, 100.36, 100.55, 100.36
  7/22/2000, 9:05:02, 44.9, 673,        2,     1, 100.43, 100.44, 100.41, 100.66, 100.38
  7/22/2000, 9:05:04, 44.9, 673,        3,     1, 100.36, 100.31, 100.43, 100.60, 100.28
  7/22/2000, 9:05:06, 44.9, 671,        4,     1, 100.36, 100.40, 100.34, 100.60, 100.22
  7/22/2000, 9:05:12, 44.9, 672,        5,     1,  93.45,  94.54,  95.25,  95.87,  92.69
  7/22/2000, 9:05:14, 44.9, 671,        6,     1,  93.41,  94.61,  95.24,  95.65,  92.48
  7/22/2000, 9:05:16, 44.9, 672,        7,     1,  93.48,  94.61,  95.20,  95.62,  92.48
  7/22/2000, 9:05:18, 44.9, 672,        8,     1,  93.52,  94.67,  95.31,  95.54,  92.39
  7/22/2000, 9:05:23, 44.9, 671,        9,     1,   4.84,   6.64,  80.86,  89.44,  72.74
  7/22/2000, 9:05:27, 44.9, 669,       10,     1,  17.24,  18.44,   7.36,  19.38,  74.59
  7/22/2000, 9:05:32, 44.9, 667,       11,     1,  24.01,   7.96,   7.16,  30.72,  55.13
  7/22/2000, 9:05:37, 44.9, 665,       12,     1,  10.54,  11.20,  12.21,  15.75,  18.92
                                          END
```

The values displayed under the radiometer center-wavelength headers are the percent reflectance values.

When finished viewing the reflectance values, press the Esc key to return to the main ***CROPSCAN*** MSR Software Menu:

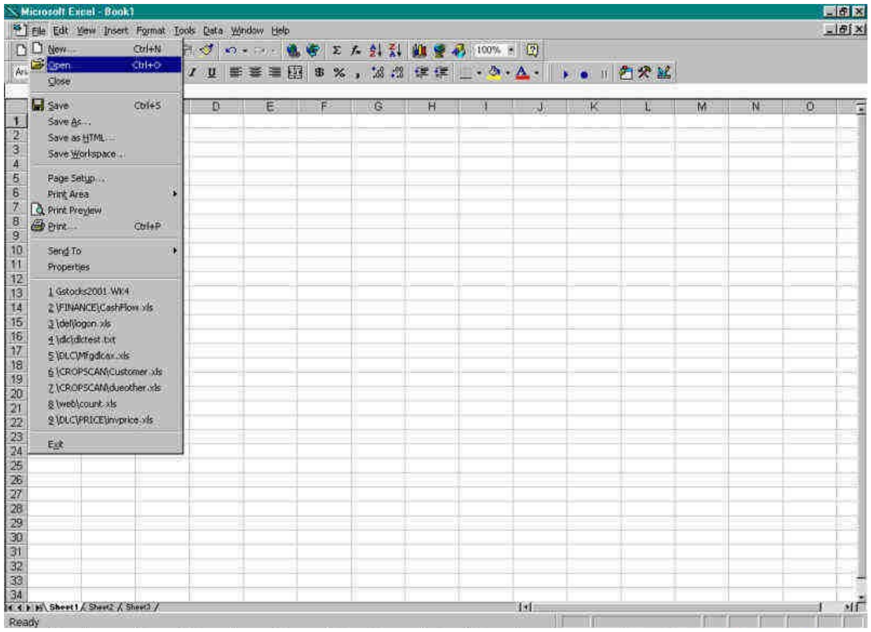


This completes the POSTPROC operation. At this point, the reflectance can be graphed or analyzed by importing the reflectance file into a spreadsheet program or processing it with other statistical analysis programs.

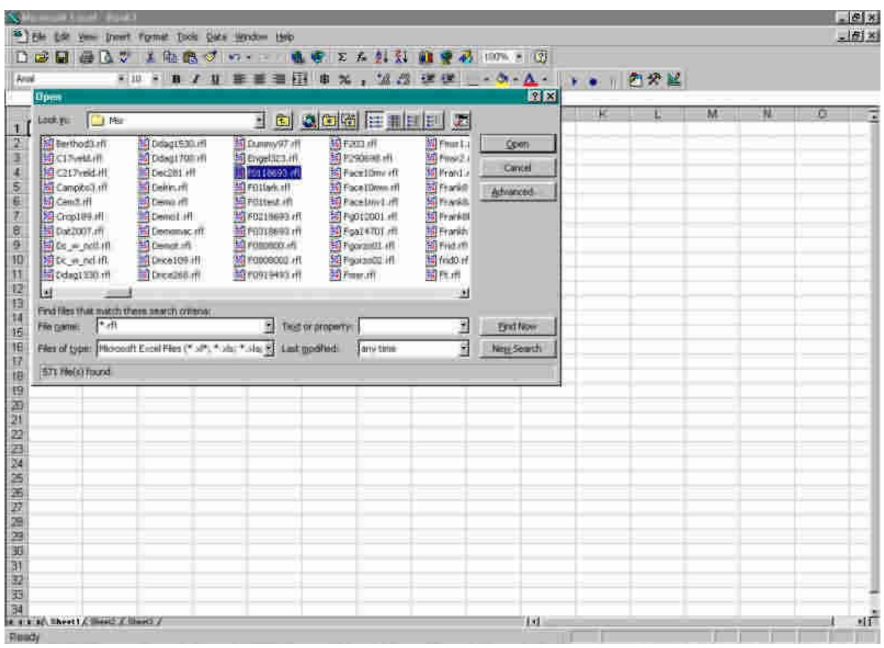
6. *Import Reflectance File Into Excel*

To import an MSR .rfl reflectance file into an Excel spreadsheet do the folowing:

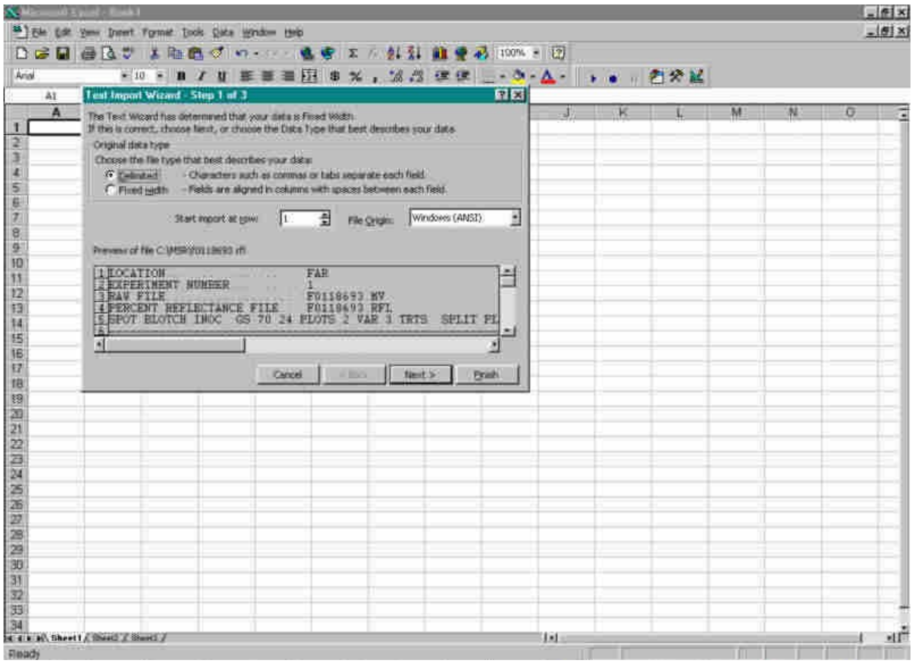
Select File pull-down and click on Open:



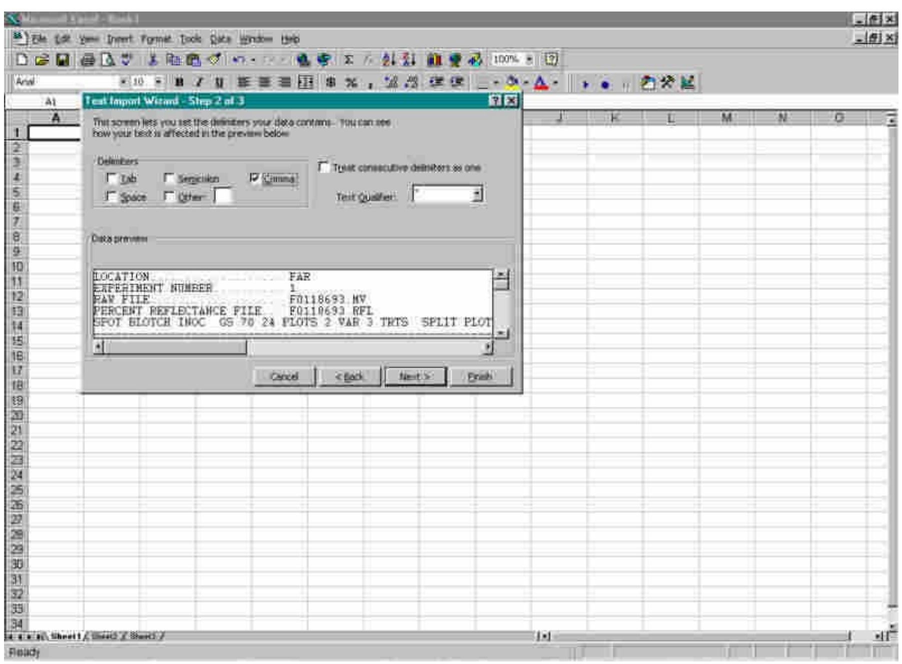
Navigate to MSR folder, select desired .rfl file and click the Open button:



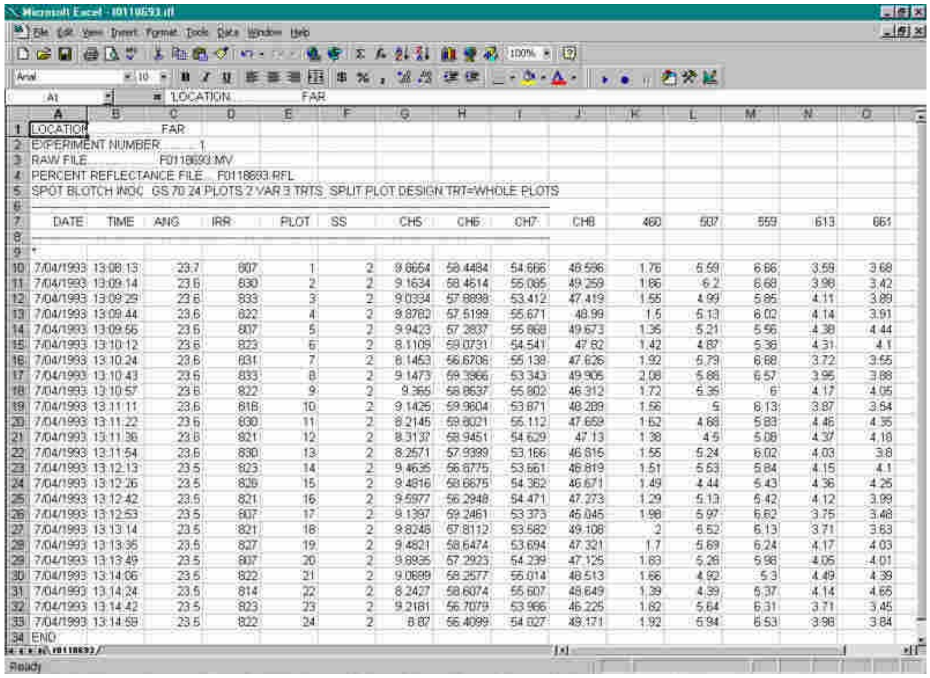
Select Delimited and click on the Next button:



Select Comma (delimited), unselect all other delimitings, and click the Finish button:



The .rfl file should appear with data in columns, as follows:



LOCATION FAR
EXPERIMENT NUMBER 1
RAW FILE F0118693.MV
PERCENT REFLECTANCE FILE F0118693.RFL
SPOT BLOTCH INOC GS 70 24 PLOTS 2 VAR 3 TRTS SPLIT PLOT DESIGN TRT=WHOLE PLOTS

DATE	TIME	ANG	IRR	PLOT	SS	CH5	CH6	CH7	CH8	460	507	559	613	661
7/04/1993	13:08:13	23.7	807	1	2	9.8664	58.4484	54.666	48.596	1.76	5.59	6.66	3.59	3.68
7/04/1993	13:09:14	23.6	830	2	2	9.1634	58.4614	55.085	49.259	1.86	6.2	6.68	3.98	3.42
7/04/1993	13:09:29	23.6	833	3	2	9.0334	57.8898	53.412	47.419	1.55	4.99	5.85	4.11	3.89
7/04/1993	13:09:44	23.6	822	4	2	9.8782	57.5199	55.671	48.99	1.5	5.13	6.02	4.14	3.91
7/04/1993	13:09:56	23.6	807	5	2	9.9423	57.2837	55.868	49.673	1.36	5.21	5.56	4.38	4.44
7/04/1993	13:10:12	23.6	823	6	2	8.1109	59.0731	54.541	47.82	1.42	4.87	5.38	4.31	4.1
7/04/1993	13:10:24	23.6	831	7	2	8.1453	56.6706	55.138	47.626	1.92	5.79	6.88	3.72	3.55
7/04/1993	13:10:43	23.6	833	8	2	9.1473	59.3966	53.343	49.906	2.08	5.88	6.57	3.95	3.88
7/04/1993	13:10:57	23.6	822	9	2	9.365	58.8637	55.802	46.312	1.72	5.35	6	4.17	4.05
7/04/1993	13:11:11	23.6	818	10	2	9.1425	59.9604	53.871	48.289	1.56	5	6.13	3.87	3.54
7/04/1993	13:11:22	23.6	830	11	2	8.2145	59.8021	55.112	47.659	1.62	4.68	5.83	4.46	4.35
7/04/1993	13:11:36	23.8	821	12	2	8.3137	58.9451	54.629	47.13	1.38	4.5	5.08	4.37	4.18
7/04/1993	13:11:54	23.6	830	13	2	8.2571	57.9399	53.166	46.816	1.55	5.24	6.02	4.03	3.8
7/04/1993	13:12:13	23.5	823	14	2	9.4635	56.6775	53.661	46.819	1.51	5.63	5.84	4.15	4.1
7/04/1993	13:12:26	23.5	826	15	2	9.4816	58.6675	54.362	46.671	1.49	4.44	5.43	4.36	4.25
7/04/1993	13:12:42	23.5	821	16	2	9.5977	56.2948	54.471	47.273	1.29	5.13	6.42	4.12	3.99
7/04/1993	13:12:53	23.5	807	17	2	9.1397	59.2461	53.373	45.045	1.98	5.97	6.62	3.75	3.48
7/04/1993	13:13:14	23.5	821	18	2	9.8248	67.8112	53.582	49.108	2	6.52	6.13	3.71	3.63
7/04/1993	13:13:36	23.5	827	19	2	9.4821	58.6474	53.694	47.321	1.7	5.69	6.24	4.17	4.03
7/04/1993	13:13:49	23.5	807	20	2	9.8935	57.2923	54.239	47.125	1.63	5.28	5.98	4.05	4.01
7/04/1993	13:14:06	23.5	822	21	2	9.0889	58.2577	55.014	48.513	1.66	4.92	5.3	4.49	4.39
7/04/1993	13:14:24	23.5	814	22	2	8.2427	58.6074	55.607	48.649	1.39	4.39	6.37	4.14	4.65
7/04/1993	13:14:42	23.5	823	23	2	9.2181	56.7079	53.986	46.225	1.82	5.64	6.31	3.71	3.45
7/04/1993	13:14:59	23.5	822	24	2	8.87	56.4099	54.027	49.171	1.92	5.94	6.53	3.98	3.84

END

APPENDIX 4: COLLECTING DATA FROM DATALOGGER TO PC FOR THE CONTINUOUS SOIL MOISTURE / TEMPERATURE MEASUREMENTS

There will be three different models of Campbell Scientific dataloggers used in this field campaign. The models CR10X and CR1000 are and will be used for the continuous Rain Gauge stations. The Model CR10WP will be used for the continuous Soil Moisture and Soil Temperature station at the Tower. The following information will help you collect data from the differing models.

In order to download the data stored in the datalogger, PC400 software or Loggernet software needs to be installed in the computer. However, PC400 is the preferred software and thus following instructions apply only to PC400. If PC400 software is not installed use the installation disc distributed by Campbell scientific. Before trying to connect the datalogger to the PC, we need to plug a SC32B cable (figure 1) from the CSI/O port to the PC COM1 port.

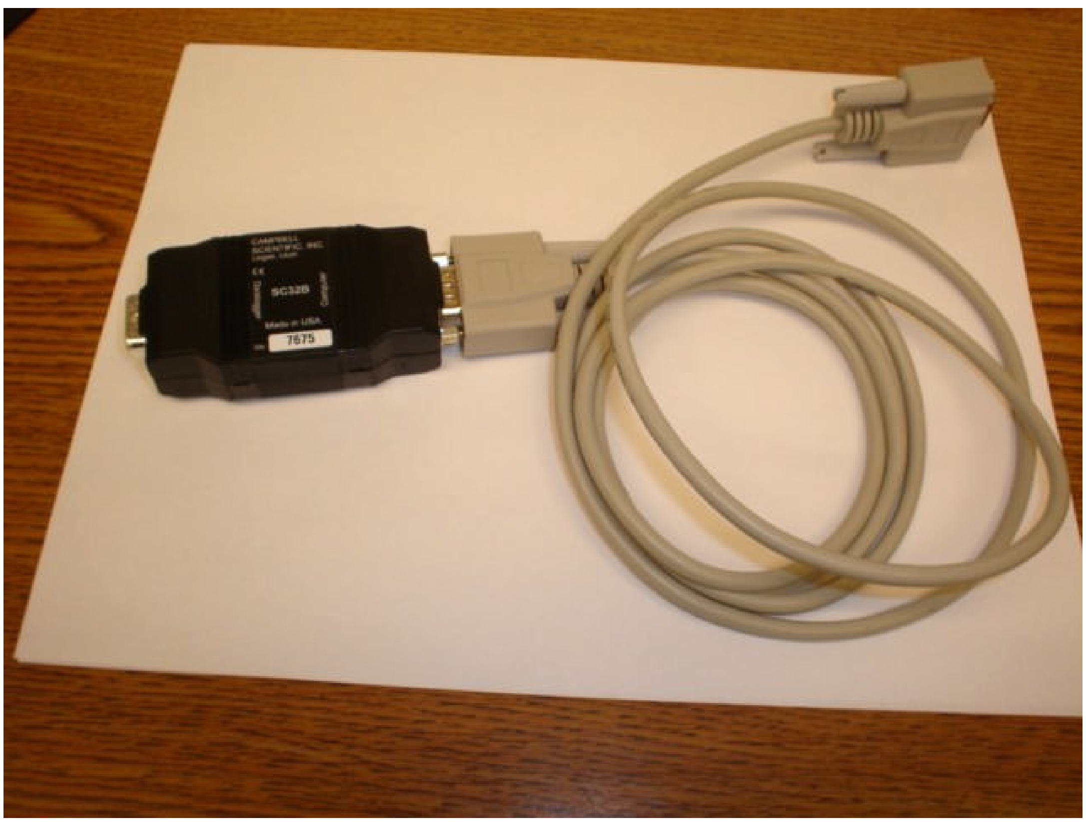


Figure 1. SC32B cable. This cable and the optically isolated devise are necessary to establish a connection between PC and the datalogger

The first step is to open the PC400 software clicking on its Icon located on the desktop (figure 2) the pathway start/all programs/PC400/PC400.

Figure 2. PC400 icon

Determine datalogger model of the datalogger you are using.
If either CR10X, CR1000, or CR10 (which will be used for CR10WP) is not a default datalogger set up, you need to establish a new connection. If CR10X, CR1000, or CR10 is already an installed data logger, you can skip to the step after Figure 7. One thing to note, if the CR10WP is turned off, the program has to re-downloaded on to the datalogger. Click on Add and the EZ setup wizard dialog box will appear on the screen (figure 3). This process will help you to set up the proper datalogger configuration. Click on Next

Figure 3. EZset up wizard. This process will guide you to establish a new datalogger set up

The following dialog box will show you different models of Campbell Scientific dataloggers. You need to choose the correct model, and also, you can type a name for the connection if you want (figure 4). Click on next to continue.

Figure 4. Datalogger models from Campbell Scientific. You need to choose CR10X, CR1000, or CR10 as the default Model

Select Direct Connect as the mode of communication between the datalogger and the PC as shown in figure 5.

Figure 5. This dialog box shows the different modes of connection. Click on Direct connect as Default

Next, Select the Computer port where the SC32B cable is connected. Select COM 1 if the cable is plugged in this port (figure 6).

Figure 6. Ports where SC32B port can be connected, choose the desired port dependng on the port used.

Once the communication set up is complete, the datalogger settings dialog box will appear. Keep the default values as Baud rate: 9600, Security code: 0, Extra response time: 00

seconds, Max time on line: 000. Click on Next to continue. The following dialog box is a summary of the datalogger communication set up. Please check if everything looks reasonable and is as you selected. Click Next to continue. After this, a Dialog box will ask you if you want to perform a communication test. Please check on YES and click on Next to continue. When the communication between the datalogger and the PC is reached, there will be a message indicating COMMUNICATION TEST SUCEEDED, click next.

The next step is to set up the datalogger clock with the PC clock. A window will show you the time in the datalogger and PC clocks. If you need to make a change go to set up datalogger clock button and set the correct time. If not, click on Next to continue.

The following window will ask you for the datalogger program. You must click on Select and Associate Program button, because the datalogger already has a program uploaded. In our case we have two programs depending on the number of sensors connected to the datalogger. The programs files created are listed on table 1, table 2, and table 3. Remember, if the CR10WP is turned off, the program has to be re-downloaded onto the datalogger.

Name of the Datalogger Program file for CR10X	**Description**
Ask Juan	Configured for two STEVENS Hydra Probes (two different depths) and one TR-525 rain gauge (6 inches funnel diameter).
Ask Juan	Configured for two STEVENS Hydra Probes (two different depthisand two TR 525 rain gauges (6and 8 inches funnel diameters).

Table 1. Programs files associated with CR10X dataloggers and the Current Continuous Rain Gauge Stations.

Name of the Datalogger Program File in CR1000	**Description**
Test.dld	Configured for two STEVENS Hydra Probes (two different depths) and one TR-525 rain gauge (6 inches or 8 inches funnel diameter)

Table 2. Programs files associated with CR1000 dataloggers and the New Continuous Rain Gauge Stations.

Name of the Datalogger Program File in CR10WP (CR10)	Description
SOILTM.dld	Configured for six ECH2O Soil Moisture Sensors and six soil temperature probes.

Table 3. Programs files associated with CR10WP dataloggers and The Continuous Soil Moisture and Soil Temperature Experiment.

Once selected you will see the program name in the Current Program space, as shown in the following figure. Click on Next to continue.

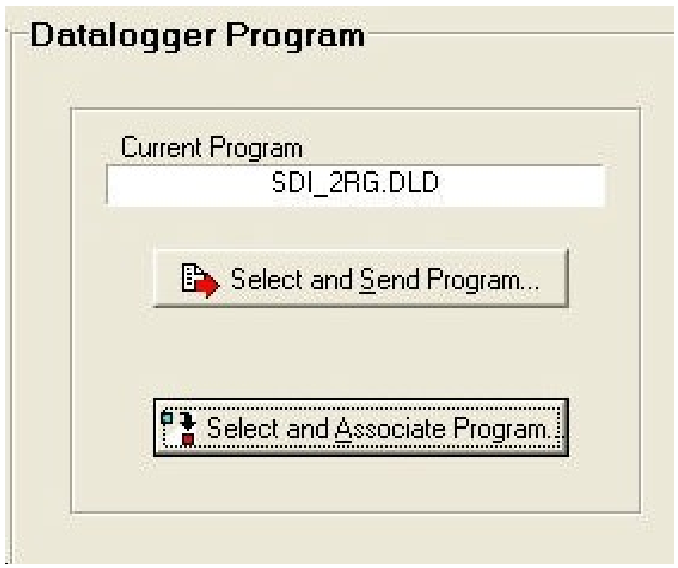


Figure 7. Program associated with data collection

A message will indicate that the set up wizard is complete. Click on Finish to start the downloading process. With the connection already established, go to Collect data tab located in the upper right side of the main window of PC400 software (figure 8) and click on it. After this, the collect data window will appear. Depending of your needs you can choose New data from datalogger or all data. Main information is contained in final storage area 1, therefore, select this location. In the collect data space, type a filename and folder of your choice. Finally, click on Collect button to download the data.

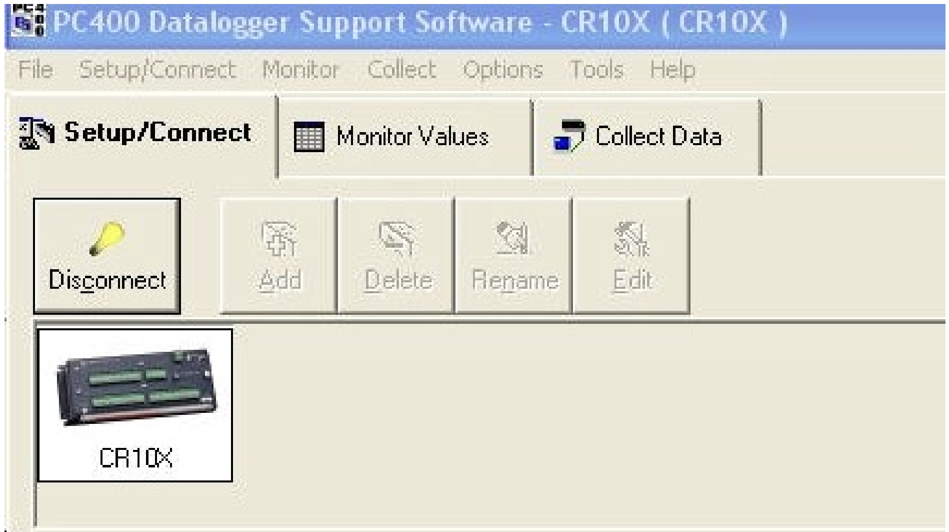


Figure 8. Collect data tab located in the mainPC400 window. There should be a different icon for the CR1000 model.

Opening Output readings from Stations

The output file has a .dat extension and can be opened in Microsoft Excel. This file contains 38 columns for those dataloggers with two rain gauges and 37 for all those that have only one rain gauge. The following table shows the file headers. The values in the file correspond to an average of the variables with a time step of 30 minutes.

Output Readings for CR10X:

Header	Description	Units
ID	Station ID	-
Year	Year	-
DOY	Day of the year	-
Time	Hour an minute of the average readings	-
V1_5	Voltage 1 at 5 cm depth soil moisture sensor	Volts
ST_V1_5	Voltage 1 5 cm depth standard deviation	-
V2_5	Voltage 2 at 5 cm depth soil moisture sensor	Volts
ST_V2_5	Voltage 2 5 cm depth standard deviation	-
V3_5	Voltage 3 at 5 cm depth soil moisture sensor	Volts
ST_V3_5	Voltage 3 5 cm depth standard deviation	-
V4_5	Voltage 4 at 5 cm depth soil moisture sensor	Volts
ST_V4_5	Voltage 4 5 cm depth standard deviation	-
STMP	Soil Temperature at 5 cm depth	Celsius
ST_STMP_5	Standard deviation of 5 cm depth soil temperature	-
SM_5	Soil moisture at 5 cm depth	Water fraction by volume
ST_SM_5	Standard deviation of 5 cm depth soil moisture	-
NaCl_5	Salinity at 5 cm depth	Grams NaCl / liter
ST_NaCl	Standard deviation of 5 cm depth salinity	-
Cond_5	Soil Conductivity (temperature corrected at 5 cm depth)	Siemens/meter
ST_Cond_5	Standard deviation of soil conductivity at 5 cm	-
V1_10	Voltage 1 at 10 cm depth soil moisture sensor	Volts
ST_V1_10	Voltage 1 10 cm depth standard deviation	-
V2_10	Voltage 2 at 10 cm depth soil moisture sensor	Volts
ST_V2_10	Voltage 2 10 cm depth standard deviation	-
V3_10	Voltage 3 at 10 cm depth soil moisture sensor	Volts
ST_V3_10	Voltage 3 10 cm depth standard deviation	-
V4_10	Voltage 4 at 10 cm depth soil moisture sensor	Volts
ST_V4_10	Voltage 4 10 cm depth standard deviation	-
STMP_10	Soil Temperature at 10 cm depth	Celsius
ST_STMP_10	Standard deviation at 10 cm soil temperature	-
SM_10	Soil Moisture at 10 cm depth	Water function by volume
ST_SM_10	Standard deviation of 10 cm depth soil moisture	-
Cond_10	Soil conductivity (temperature corrected) at 10 cm depth	Siemens/meter
ST_Cond_10	Standard deviation of soil conductivity at 10 cm	-
Rain_mm	Precipitation (6”funnel diameter)	millimeters
Rain_mm_2	Precipitation (8”funnel diameter) only stations 153 and 154	millimeters
Battery_voltage	Battery voltage	Volts

Output Readings for CR1000:

Header	Description	Units
ID	Station ID	-
Year	Year	-
DOY	Day of the year	-
Time	Hour an minute of the average readings	-
V1_5	Voltage 1 at 5 cm depth soil moisture sensor	Volts
V2_5	Voltage 2 at 5 cm depth soil moisture sensor	Volts
V3_5	Voltage 3 at 5 cm depth soil moisture sensor	Volts
V4_5	Voltage 4 at 5 cm depth soil moisture sensor	Volts
STMP	Soil Temperature at 5 cm depth	Celsius
SM_5	Soil moisture at 5 cm depth	Water fraction by volume
NaCl_5	Salinity at 5 cm depth	Grams NaCl / liter
Cond_5	Soil Conductivity (temperature corrected at 5 cm depth)	Siemens/meter
V1_10	Voltage 1 at 10 cm depth soil moisture sensor	Volts
V2_10	Voltage 2 at 10 cm depth soil moisture sensor	Volts
V3_10	Voltage 3 at 10 cm depth soil moisture sensor	Volts
V4_10	Voltage 4 at 10 cm depth soil moisture sensor	Volts
STMP_10	Soil Temperature at 10 cm depth	Celsius
SM_10	Soil Moisture at 10 cm depth	Water function by volume
Cond_10	Soil conductivity (temperature corrected) at 10 cm depth	Siemens/meter
Rain_mm	Precipitation (6"funnel diameter)	millimeters
Rain_mm_2	Precipitation (8"funnel diameter) only stations 153 and 154	millimeters
Battery_voltage	Battery voltage	Volts

APPENDIX 5: GRAVIMETRIC SOIL MOISTURE CALCULATION AT THE CONTINUOUS SOIL MOISTURE/TEMPERATURE SENSORS

Materials:
Can
Ring
Hammer
Piece of Wood
Scraper

Procedure:
1. Weigh the empty can that will be used to put the soil sample in.
2. Insert the ring onto the top of the soil to be sampled.
3. Place piece of wood on top of the ring to provide a platform for hammering ring into the ground.

4. Hammer the ring into the ground and sweep away soil on outside of ring to allow for the top of the ring to become flush with the ground.

5. Slide the scraper underneath the bottom of soil sample and remove ring and sample from ground by lifting scraper, ring, and soil out of the ground.

6. Put the soil sample into can.

7. Weigh the can + soil sample, record weight.
8. Remove lid and put the can in the oven at 105°C for 48 hrs.
9. Weigh the dry can + soil sample, record weight.

<u>Calculation of Soil Constituents:</u>

<u>Dry Bulk Density (ρ_b)</u>

$\rho_b = M_s/(V_s+V_a+V_w)$

M_s = Mass of solids
V_s = Volume of solid
V_w = Volume of water
V_a = Volume of air

$\rho_b = M_s/(V_t)$

M_s = Mass of solids
$V_t = 326.96\ cm^3$ ($V=\pi r^2 h$, r=4.2, h=5.9cm)

<u>Mass Wetness *w*</u>

$w = M_w / M_s$

M_w = Mass of water = (Mass of wet sample – Mass of dry sample)
M_s = Mass of dry soil particles

<u>Relation between Mass Wetness *w* and Volume Wetness θ</u>

$\theta = w\,\rho_b / \rho_w$

w = wetness
ρ_b = bulk density
ρ_w = density of water (1000 kg/m^3)

APPENDIX 6: CO-ORDINATES OF SOIL SURFACE SAMPLING LOCATIONS IN THE SIERRA LOS LOCOS BASIN

Site #	Easting (m)	Northing (m)	Elevation (m)
1	551096	3315640	1371
2	550991	3315414	1331
3	550920	3315235	1304
4	550901	3315250	1301
5	550492	3315597	1246
6	549863	3315565	1201
7	549401	3315551	1123
8	548768	3314978	1098
9	548539	3315080	1067
10	546672	3314664	925
11	546552	3314641	914
12	546134	3314314	904
13	545976	3314409	869
14	545434	3314357	845
15	544759	3314081	826
16	544530	3313993	822
17	544549	3313984	822
18	543909	3313874	802
19	542882	3313419	778
20	542686	3313627	807
21	542128	3314437	885
22	542096	3314417	886
23	545860	3315109	928
24	545676	3312715	864
25	549392	3311498	1043
26	550173	3315638	1237
27	551879	3311961	1271
28	539060	3310571	663
29	540564	3311828	720
30	542503	3313298	779
31	542246	3314558	888
32	542871	3313864	806
33	548617	3312298	935
34	546732	3311823	926
35	547050	3314751	942
36	551445	3316386	1357
37	551733	3316932	1411

Site #	Easting (m)	Northing (m)	Elevation (m)
38	552685	3312875	1450
39	549123	3315695	1160
40	548131	3315187	1014
41	547710	3315330	931
42	546061	3314016	890
43	539953	3311108	681
44	544549	3312311	831
45	547721	3312519	998
46	549518	3312903	1061
47	551870	3314811	1437
48	551922	3313499	1353
49	552713	3312607	1467
50	547471	3311536	901

APPENDIX 7: DOWNLOADING DATA FROM THE HOBO DATALOGGER AT TIPPING BUCKET RAIN GAUGE SITES

Introduction:
There are two types (possibly three) models of HOBO Dataloggers being used in the 2007 Summer Campaign. Ten of the tipping bucket rain gauges, not the David Gochis rain gauges, contain Hobo Pendant Event Dataloggers that are also able to record temperature. The David Gochis rain gauges are coupled with a temperature and relative humidity sensor called HOBO Pro v2 Temp / RH Datalogger. This relative humidity sensor sits inside a solar radiation shield (looks like a bee hive). It is possible that a HOBO logger called HOBO Event logger is out in the field, but I am not quite sure.

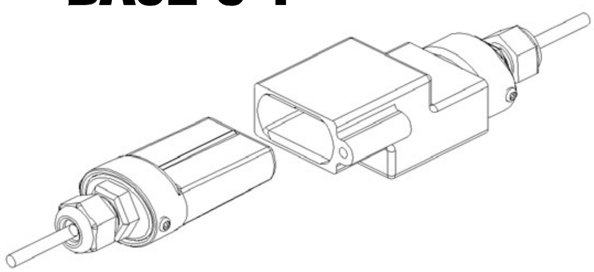
Inorder to download the data from the HOBO Pendant Event Dataloggers and the HOBO Pro v2 / RH Datalogger it requires an optic base station and a coupler used to correctly configure the connection between the optic base station and the HOBO Datalogger. With the correct coupler, one can download the date form the HOBO Pendant Event Datalogger with an Optic USB Base Station for Pendant or an Optic USB Base Station. The HOBO Pendant Event requires a pendant coupler. The data from the HOBO Pro v2 / RH Datalogger can only be downloaded through the Universal Optic USB Base Station and its HOBO Waterproof Shuttle counterpart. The HOBO Pro v2 Temp / RH Datalogger requires a particular coupler (I think it has a red label).

Connecting HOBO Pendant Event Datalogger to Optic Base Stations and to PC:

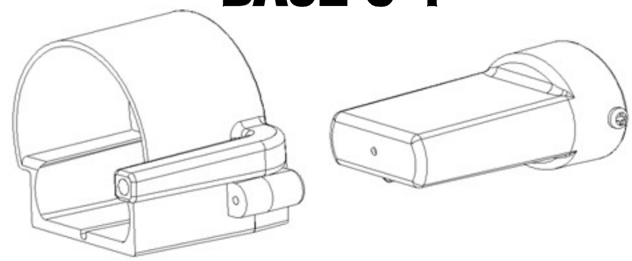
The HOBO Pendant logger requires either of the following to connect to the computer:
Pendant Optic USB Base Station & Coupler (part # BASE-U-1); HOBOware 2.1 or later
OR
Optic USB Base Station (part # BASE-U-4) or HOBO Waterproof Shuttle (part # U-DTW-1); coupler (part # COUPLER2-A); HOBOware 2.2 or later

1. Turn on and log into laptop.
2. Log into Hobo software.(If possible, avoid connecting at temperatures below 0∞C (32∞F) or above 50∞C (122∞F)).
3. Plug the USB connector on the base station into an available USB port on your computer.
4. Insert the logger and the base station into the coupler, as shown in the following diagrams. For BASE-U-1, make sure that the logger is inserted in the end of the coupler that has the magnet, and that the ridges on the base station and logger are aligned with the grooves in the coupler. For BASE-U-4 or the HOBO Waterproof Shuttle, firmly insert the optical end of the base station into the D-shaped end of the coupler, and make sure that the ridge on the logger is aligned with the groove in the coupler.

BASE-U-1



BASE-U-4

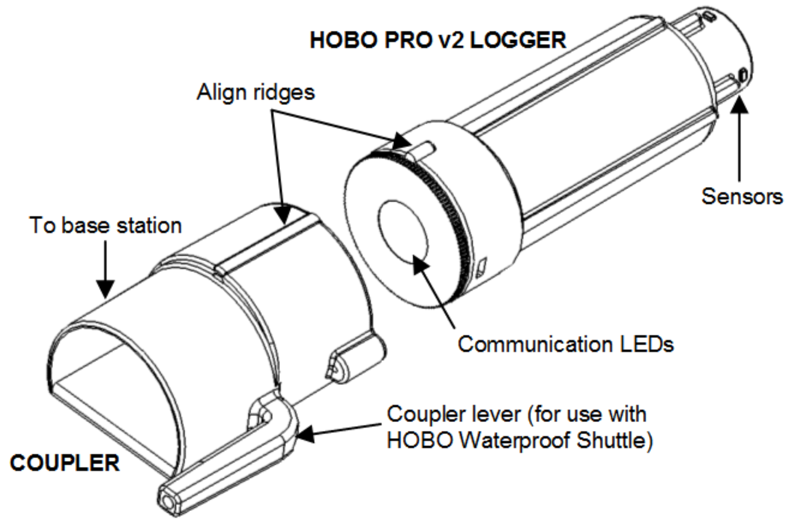


5. If you are using the HOBO Waterproof Shuttle, briefly press the coupler lever to put the shuttle into base station mode.
6. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected.
7. Use the logger software to launch and read out the logger.

Connecting HOBO v2 Temp / RH Datalogger to Optic Base Station and to PC:

The HOBO Pro v2 requires a coupler (Part # COUPLER2-E) and USB-Optic Base Station (Part # BASE-U-4) or HOBO Waterproof Shuttle (Part # U-DTW-1) to connect to the computer.

1. Install the logger software on your computer before proceeding.
2. Connect the base station or shuttle to a USB port on the computer.
3. Make sure the logger's communications window is clean and dry. (Use a clean, nonabrasive cloth, if necessary.) If the logger is damp, wipe off excess moisture.
4. Attach the coupler to the basestation or shuttle, then insert the logger into the coupler with the ridge on the logger aligned with the ridge on the coupler.



5. If you are using the HOBO Waterproof Shuttle, briefly press the coupler lever to put the shuttle into base station mode.
6. If the logger has never been connected to the computer before, it may take a few seconds for the new hardware to be detected by the computer.
7. Use the logger software to launch the logger, check the logger's status, read it out, stop it manually with the software, or let it continue to record data until the memory is full. Or, use the HOBO Waterproof Shuttle to read out and relaunch the logger in the field.

   Important: USB communications may not function properly at temperatures below 0°C (32°F) or above 50°C (122°F).
   Note: The first time you launch the logger, the deployment number will be greater than zero. Onset launches the loggers to test them prior to shipping.

Launching Data:

1. After connecting the HOBO Datalogger to the Optical USB Base Station and the Base Station to the PC (the Hobo Pro software should already be active and up), a small screen will pop up labeled "Select Device". Select the image and description that fits the HOBO logger being used and press "OK". If the correct HOBO logger is not present, there might be a problem with the connection.
2. Next, select the launch icon on the tool bar. The "Launch Logger" Window will appear.
3. Depending on the Datalogger, the Launching Window will give you several options. All the Dataloggers' Launch window will display the "Logger Type", the "Serial Number", "Deployment Number", "Battery Level", and "Description". The Description is available for editing, but it should remain as is, with the serial number of the logger as the description. The Channels to Log option depends on which HOBO logger being used.

The HOBO Pendant Event loggers have the following Channel to Log options:

i. Battery Level
ii. Temperature
iii. External Event

The HOBO v2 Temp / RH loggers have the following Channel to Log options:

i. Battery Level
ii. Temperature
iii. Relative Humidity

After "Channels to Log" option is the "Logging Interval". Depending on how many Channels are chosen to log and the duration time the Logging Duration increases or decreases. As one would expect, the more channels being logged and the smaller the duration time, thus the more measurements logged in a particular amount of time, decreases the Logging duration. The Logging Duration is limited by the amount of memory the HOBO logger contains.

At this moment we suggest only choosing "External Event" for the HOBO Pendant Event. However, it depends on the person in charge's opinion. Overall, What we really have to make that the HOBO logger does not run out of memory space before some one comes back to download data.

The last option in the Launch Logger window is "Launch Options". This option allows you to choose how and when the logger will be launched.

We recommend choosing the "Now" option, though a delayed start can also be chosen (as long as you do not delay it for too long!!! Pay attention!!). We do not suggest using the "Trigger" option, because we have not instructed you how to do so.

Before pushing "launch", look over the launch window and make sure every chosen option is correct.

4. After pressing launch, wait until the logger is no longer being launched to disconnect the HOBO Logger.

Downloading Data:

1. Connect the HOBO logger to the USB Optical Base Station and then the PC as instructed before.
2. Select the correct HOBO logger in the "LoggerDevice' window.
3. Select the Readout icon on the toolbar. Click Stop when HOBOware Pro asks if you want to stop the logger before reading out.

4. After reading out the logger, HOBOware Pro prompts you to save the datafile. Choose a file name – we recommend something related to the HOBO Serial Number and the date. If you download more than one time in a day from the same datalogger, add a number signifying the number of the download.
5. If you would like to review the readings, on the “Plot Setup” window, select the series and/or events you would like to plot. Select “Plot”.
6. After download, make sure to re-launch the HOBO datalogger.

APPENDIX 8: DESERT SURVIVAL PRIMER

Desert Survival Primer: Safety from the Heat

Prevention of Heat Stroke and Dehydration in Desert Conditions:

- Loose-fitting and light colored clothing
- Long-sleeves shirts and pants
- Sunglasses
- Sunscreen
- Large brimmed hat
- Sufficient water!!! (at least a gallon of water for ea. person) and Gatorade – or some other way of replacing electrolytes
- Avoid tea, coffee, soda and alcohol as these can lead to dehydration
- Schedule vigorous activity and sports for cooler times of the day
- First aid / survival kit
- Sharp knife

Hot Weather Conditions

During hot weather, walk through the desert slowly and rest for 10 minutes every hour. Begin early in the morning or late in the day. Water and body temperature are critical to survival. A person requires about a gallon of water each day. Be sure extra drinking water is available as it may be the difference between life and death.

To reduce water loss, keep the mouth closed, breathe through the nose and avoid conversation. Do not drink alcohol. It causes dehydration. Digestion consumes water so don't eat food if there is not a sufficient amount of water available. Don't ration water in hot weather. When you are thirsty, drink. Conserve water as best as possible and look for more.

In the summer, ground temperatures can be 30 degrees hotter than the surrounding air temperature, so, when resting, sit at least 12 inches above the ground on a stool or a branch.

Body temperature is absorbed in three ways: from direct sunlight, hot air and heat reflected from the ground. Stay in the shade and wear clothing, including shirt, hat and sunglasses. Clothing helps ration sweat by slowing evaporation and prolonging the cooling effect. Travel at night or early in the day if possible.

Water sources can be located at the base of rock cliffs or in the gravel wash from mountain valleys, especially after a recent rain. Water may be found by digging three to six feet at the outside edge of a sharp bend in a dry stream bed. If wet sand is found, dig down into it to find seeping water. Green vegetation, tree clusters and other "indicator" shrubbery, such as cottonwood, sycamore, willow or tamarisk trees, may indicate the presence of water. Animal paths and flocks of birds also may lead you to water.

Cactus fruit and flowers may be eaten when food or water is scarce. Split open the base of cactus stalks and chew on the pith...but don't swallow it. Carry chunks of pith to alleviate thirst while walking. Other desert plants are not edible

Heat Exhaustion

Heat exhaustion is a milder form of heat-related illness that can develop after several days of exposure to high temperatures and inadequate or unbalanced replacement of fluids. Those most prone to heat exhaustion are elderly people, people with high blood pressure, and people working or exercising in ahot environment.

Signs of Heat Exhaustion

Warning signs of heat exhaustion include:

- heavy sweating
- paleness
- muscle cramps
- tiredness
- weakness
- dizziness
- headache
- nausea or vomiting
- fainting

The skin may be cool and moist. The victim's pulse rate will be fast and weak, and breathing will be fast and shallow. If heat exhaustion is untreated, it may progress to heat stroke. Seek medical attention immediately if:

- symptoms are severe, or
- the victim has heart problems or high blood pressure.

Otherwise, help the victim to cool off, and seek medical attention if symptoms worsen or last longer than 1 hour.

Heat Exhaustion: What to Do

Cooling measures that may be effective include:

- cool, non-alcoholic beverages, as directed by your physician
- rest
- cool shower, bath, or sponge bath
- an air-conditioned environment
- Lightweight clothing

Dehydration can be a serious heat-related disease, as well as being a dangerous side-effect of diarrhea, vomiting and fever. Children and persons over the age of 60 are particularly susceptible to dehydration.

Dehydration

Under normal conditions, we all lose body water daily through sweat, tears, urine and stool. In a healthy person, this water is replaced by drinking fluids and eating foods that contain water. When a person becomes so sick with fever, diarrhea, or vomiting or if an individual is overexposed to the sun, dehydration occurs. This is caused when the body loses water content and essential body salts such as sodium, potassium, calcium bicarbonate and phosphate. Occasionally, dehydration can be caused by drugs, such as diuretics, which deplete body fluids and electrolytes. Whatever the cause, dehydration should be treated as soon as possible.

Symptoms of Dehydration

The following are the most common symptoms of dehydration, although each individual may experience symptoms differently. Symptoms may include:

- thirst
- less-frequent urination
- dry skin
- fatigue
- light-headedness
- dizziness
- confusion
- dry mouth and mucous membranes
- increased heart rate and breathing

In children, additional symptoms may include:

- dry mouth and tongue
- no tears when crying
- no wet diapers for more than 3 hours
- sunken abdomen, eyes or cheeks

- high fever
- listlessness
- irritability
- skin that does not flatten when pinched and released

Dehydration: What to do

If caught early, dehydration can often be treated at home under a physician's guidance. In children, directions for giving food and fluids will differ according to the cause of the dehydration, so it is important to consult your pediatrician.
In cases of mild dehydration, simple rehydration is recommended by drinking fluids. Many sports drinks on the market effectively restore body fluids, electrolytes, and salt balance. For moderate dehydration, intravenous fluids may be required, although if caught early enough, simple rehydration may be effective. Cases of serious dehydration should be treated as a medical emergency, and hospitalization, along with intravenous fluids, is necessary. Immediate action should be taken.

Heat Stroke

Our bodies produce a tremendous amount of internal heat and we normally cool ourselves by sweating and radiating heat through the skin. However, in certain circumstances, such as extreme heat, high humidity or vigorous activity in the hot sun, this cooling system may begin to fail, allowing heat to build up to dangerous levels. If a person becomes dehydrated and cannot sweat enough to cool their body, their internal temperature may rise to dangerously high levels, causing heat stroke.

Symptoms of Heat Stroke

The following are the most common symptoms of heat stroke, although each individual may experience symptoms differently. Symptoms may include:

- headache
- agitation
- strange behavior
- difficulty breathing
- high body temperature
- dizziness
- disorientation, agitation or confusion
- sluggishness or fatigue
- seizure
- coma
- dry skin that is flushed but not sweaty
- a high body temperature
- loss of consciousness
- rapid heart beat
- hallucinations

Heat Stroke: What to do

It is important for the person to be treated immediately as heat stroke can cause permanent damage (organ damage) or death. There are some immediate first aid measures you can take while waiting for help to arrive.

- ***First and foremost, cool the victim.*** Get the victim to a shady area or indoors.
- Get the person indoors.
- Remove clothing and gently apply cool water to the skin followed by fanning to stimulate sweating (for example you may spray the victim with cool water from a garden hose).
- Apply ice packs to the groin and armpits.
- Have the person lie down in a cool area with their feet slightly elevated
- Monitor body temperature with a thermometer and continue cooling efforts until the body temperature drops to 101-102 degrees.
- Always notify emergency services (such as - 911) immediately. If their arrival is delayed, they can give you further instructions for treatment of the victim.

Intravenous fluids are often necessary to compensate for fluid or electrolyte loss. Bed rest is generally advised and body temperature may fluctuate abnormally for weeks after heat stroke.

References:
http://www.medicinenet.com/heat_exhaustion/article.htm
http://www.medicinenet.com/dehydration/article.htm
http://www.medicinenet.com/heat_stroke/article.htm

Desert Survival Primer: Emergency Situations

In an emergency situation follow ABC's:

- **A**ccept the situation. Do not blame yourself or others.
- "**B**rew a cup of tea." As in start a fire, complete something familiar, a calming chore.
- **C**onsider options. Take stock of items on hand, i.e., water reserves, first-aid kit, etc.
- **D**ecide on a plan that best ensures safety.
- **E**xecute the plan and stick with it unless new conditions warrant.

Desert Survival Priorities

Water

Learn to locate water through areas of green vegetation, flights of birds, converging animal trails and digging in the outside bends of dry creek beds. Burros and other animals are excellent at finding water and digging it up in creek.

Fire

Fire can be used to signal, cook food and purify water. Fire also provides psychological comfort.

Shelter

Aside from your clothes, additional shelter may be needed. In desert areas, shelter from the sun is usually the main consideration, but cold, rain, hail, even snow can also be factors. It is important to keep the skin temperature under 92 degrees F, to keep from sweating away precious water. Draping a sleeping bag over a bush for shade, while allowing for breezes, may be the best bet. Try not to sit on the hot ground, even if it means tearing the seats out of your brand new 4x4. Try to make shelter visible to searchers. Build shelter in a safe place, such as out of creek beds which can flash flood.

Food

In hot climates, however, food is not as important as other factors. If water is in short supply it is important not to eat *anything* because it increases your water needs to digest

Text by David Alloway from http://www.desertusa.com/mag99/mar/stories/desertsur.html

Other

IF YOU BECOME LOST

If you become lost while hiking on foot or traveling by vehicle, stay put! Sit down for a while and take stock of the situation. Stay with your vehicle if you came in one. Most lost or stranded victims would be rescued sooner if they resisted the urge to walk for help. It is better to conserve energy and prepare distress signals.

If you feel you can retrace your steps, mark your spot and leave a note. Then backtrack by following footprints or vehicle tracks. Consult a map and try to identify landmarks and other surroundings. Don't take shortcuts. Go to a high point and look around. Always move downstream or down country, but travel the ridges instead of washes or valleys.

Move with a purpose. Don't wander aimlessly. If you aren't absolutely sure you can follow your tracks or prints, stay put!

Reference:

http://www.phoenix.gov/fire/desert.html

Desert Survival Primer: Snake Bites

Snake Bites

The danger of snake bites:

Each year, nearly 8,000 people receive poisonous snake bites in the United States. Even a bite from a so-called "harmless" snake can cause infection or allergic reaction in some people. People who frequent wilderness areas, camp, hike, picnic, or live in snake-inhabited areas should be aware of the potential dangers posed by venomous snakes.

What snakes cause poisonous bites?

Any of the following snakes cause poisonous bites:

- Rattlesnake
- Copperhead
- Cottonmouth Water Moccasin
- Coral Snake

What are the symptoms of poisonous bites?

While each individual may experience symptoms differently, the following are the most common symptoms of poisonous snake bites:

- bloody wound discharge
- fang marks in the skin and swelling at the site of the bite
- severe localized pain
- diarrhea
- burning
- convulsions
- fainting
- dizziness
- weakness
- blurred vision
- excessive sweating

- fever
- increased thirst
- loss of muscle coordination
- nausea and vomiting
- numbness and tingling
- rapid pulse

How are snake bites treated?

Call for emergency assistance immediately if someone has been bitten by a snake. Responding quickly in this type of emergency is crucial. While waiting for emergency assistance:

- Wash the bite with soap and water.

- Immobilize the bitten area and keep it lower than the heart.

- Cover the area with a clean, cool compress or a moist dressing to minimize swelling and discomfort.

- Monitor vital signs.

If a victim is unable to reach medical care within 30 minutes, the American Red Cross recommends:

- Apply a bandage, wrapped two to four inches above the bite, to help slow the venom. This should not cut off the flow of blood from a vein or artery - the band should be loose enough to slip a finger under it.

- A suction device can be placed over the bite to help draw venom out of the wound without making cuts. These devices are often included in commercial snake bite kits.

Most often, physicians use antivenin -- an antidote to snake venom -- to treat serious snake bites. Antivenin is derived from antibodies created in a horse's blood serum when the animal is injected with snake venom. Because antivenin is obtained from horses, snake bite victims sensitive to horse products must be carefully managed.

Preventing snake bites:

Some bites, such as those inflicted when you accidentally step on a snake in the woods, are nearly impossible to prevent. However, there are precautions that can reduce your chances of being bitten by a snake. These include:

- Leave snakes alone. Many people are bitten because they try to kill a snake or get too close to it.
- Stay out of tall grass unless you wear thick leather boots and remain on hiking paths as much as possible.
- Keep hands and feet out of areas you cannot see. Do not pick up rocks or firewood unless you are out of a snake's striking distance.
- Be cautious and alert when climbing rocks.

References:

http://www.umm.edu/non_trauma/snake.htm

APPENDIX 9: DRIVING TIPS

Among the many vehicle types, Sports utility vehicles or SUVs are more prone to rolling over. In fact, SUVs are three times more likely to roll over compared to passenger cars. Moreover, 36% of rollover accidents involving SUVs result in fatalities. This is actually the highest rate in all vehicle categories. To curb this alarming rate, JD Power and Associates offered some helpful safety tips that SUV drivers will find useful.

Drive at safe speed, especially on curved roads; keep steering smooth, avoid sudden turns.

Allow extra distance for braking, be cautious of wet pavement

Secure interior cargo behind rear seat when possible, store on roof only when necessary

Keep tires properly inflated, check tire pressure at least monthly

Use caution when towing, avoid sudden turns

Check around vehicle for low-lying objects before entering

SEAT BELTS!!

APPENDIX 10: SAFETY CONSIDERATIONS WHEN DRIVING ON RURAL ROADS

Introduction

Secondary roads in remote and/or rural areas may present hazards that drivers accustomed to travel on urban and suburban roadways may not be aware of. This document describes hazards particular to unpaved and rural roads and recommends safety procedures to follow

Characteristics of rural or forest roads
Extra caution is required when driving on "country roads" because they are often not designed for efficient high-speed travel like urban roadways. The following safety hazards are more likely to be found on rural roads:

- Lack of signs or accurate maps
- Blind curves
- Narrow width (not sufficient for vehicles to pass safely)
- No shoulder or guard rails
- Soft surface (uncompacted gravel or dirt)
- Rough or damaged road surface
- Obstacles on road (slow-moving vehicles, animals, debris)
- Unusually steep hills or sharp curves

Since help may often be difficult to reach or unavailable in the event of an accident, it is particularly important to exercise caution when driving in remote areas. Never exceed posted speed limits and remember that some circumstances require driving well below the posted speed.
Beyond exercising normal driver safety, travel on rural roads may also warrant specific additional precautions due to the hazards listed above. These hazards and the recommended ways to deal with them are listed below.

Navigation
Description: Rural roads may not be clearly signed. New or unmapped roads are common in areas where logging or mining activities occur.

Hazard: One can easily become lost and possibly end up on difficult or dangerous roads when traveling in rural areas.

Cautions:
- Carry a compass and/or GPS when traveling to remote areas on rural roads.
- Obtain the most current USFS or BLM maps if traveling on federal lands.
- Always double check directions or maps before venturing onto rough or little-used dirt roads.

- Fill fuel tank before leaving populated areas. Fuel stations may be unavailable for long distances. Carry extra fuel in an approved gas can if you will be a long way from populated areas.
- Check the air in the spare before you go. Be sure you have a jack and usable flashlight.
- Carry water, food, and emergency supplies.
- Don't count on cell phone service. Be sure someone knows where you have gone and when you are expected back so they can notify authorities if you don't return or check in within a reasonable amount of time after your expected return time.

Blind curves and dips
Description: Mountain roads are often too narrow for 2 vehicles to pass easily and have many sharp curves that prevent seeing approaching traffic. Rural and desert roads may follow the topography of the landscape, resulting in many dips and rises that create blind spots in the road ahead. Agricultural or prescribed forest burning may produce smoke on roads.

Hazard: Approaching vehicles, livestock or wild animals on the road, or slow-moving vehicles may be encountered without warning. Visibility may be suddenly reduced due to smoke.

Cautions:

- When approaching a blind curve or dip/rise on a narrow road, slow down and keep to the right. Watch for dust indicating on-coming traffic and sound your horn to warn approaching vehicles if lack of visibility warrants.
- Stay as far right as possible when entering a blind curve.
- Dips in the road may be due to creeks where animals congregate on or near the road. Approach carefully if in a free-range area, or in twilight or darkness.
- If you see smoke plumes crossing the road ahead, slow down when approaching because visibility can decrease rapidly and there may be workers or vehicles along the road.

Obstacles
Description: Off-road vehicles such as tractors or bulldozers may drive on rural roads or be left parked on forest roads. Livestock or wildlife may be encountered on roads. Fallen trees or landslide debris may not be removed quickly from rural or forest roads.

Hazard: Slow moving vehicles or stationary obstacles may require sudden stops. Animals may move onto road unexpectedly, or block it entirely. Collisions with large animals (deer, cows, sheep) can result in major vehicle damage and serious injury.

Cautions:

- Reduce speed on roads with blind curves or dips in case you need to stop suddenly.
- Be aware that farm vehicles and construction equipment may be wider than passenger vehicles. Pass with extra caution unless they pull over.

- When driving in free-range areas, on forest roads near dawn or dusk, or if you see wildlife near the road, slow down and watch carefully for animals on or approaching the road. *Note: in some free-range areas livestock owners are not legally liable for any damage caused by their animals on a roadway.*
- If a small animal (e.g. rabbit, coyote) runs out into the road in front of you, do not try to swerve around it or slam on the brakes. Animals move rapidly and unpredictably and may be confused by any changes in your approach.
- When passing large animals near the edge of the road, go slowly as they may suddenly move onto the road. If a group of animals is crossing the road, wait until they have all moved to a safe distance before proceeding. For example, don't try to creep through a slow moving flock of sheep or between a group of indecisive deer crossing the road because they may become startled and run right into your vehicle.

Passing other vehicles
Description: Some roads may be too narrow to pass oncoming vehides safely.

Hazard: Trying to pass oncoming vehicles at speed could result in a collision or one vehicle being forced off the road.

Cautions:
- When an oncoming vehicle is encountered, pull over to give adequate passing room. Watch out for steep drop offs or loose surface on the shoulder. If no safe shoulder is available at your location, stop and wait for the other vehicle to pull over.
- When there is no shoulder available for either vehicle to pull over safely, stop. One vehicle should back up until a safe spot is reached. By custom the vehicle closest to the safe shoulder will reverse or, on a steep hill, the vehicle traveling downhill.
- Do not expect logging trucks, cars with trailers, or other large vehicles to make room for you. Pull over early when you see them coming.

Steep grades
Description: the steepness of most roads is limited for safety, however, rural or logging roads may exceed this limit putting unusual demands on vehicle brakes.

Hazard: Excessive use of brakes can result in overheating and eventual failure. Skidding may occur more easily, especially when towing.

Cautions:
- When descending a long or particularly steep grade shift the vehicle into a low gear to reduce the need to use the brakes. This applies to both manual and automatic transmission vehicles.
- On more level stretches of a long grade, avoid using brakes to let them cool.
- If towing, or if the road may have sharp curves, maintain a lower speed than normal to allow stopping without skidding.

Washboards

Description: these corrugations in the road surface are commonly found on hills or curves, but may occur anywhere on dirt or gravel surface roads that have not been regularly maintained.

Hazard: Due to the reduced traction created by the rough surface, washboards make it difficult to steer and may result in sudden loss of control or drifting sideways. Many drivers have skidded into roadside ditches or rolled their vehicles over after losing control on washboards.

Cautions:

- SLOW DOWN! Although the vehicle may appear to handle more smoothly at higher speeds when driving on washboards, this is due to reduced contact with the road surface and therefore less control.
- Brake BEFORE entering curves, downhills, or other potentially washboarded stretches of road. Once you are on the washboards, braking may reduce your ability to control the vehicle. Shifting into a lower gear than normal will help reduce the need to brake suddenly.
- Putting your vehicle in 4WD (if available) before going uphill on a washboarded road can help with navigation.
- Steer gently when on washboards. Trying to make sharp turns or corrections will be ineffective and may result in loss of control.

Loose surface

Description: unpaved roads may range from hard-packed dirt or gravel that is as solid as asphalt to soft sand, fine dust, or deep uncompacted gravel.

Hazard: The primary hazard is loss of traction which may result in getting stuck or losing control of the vehicle. Secondary hazards are reduced visibility and/or engine damage due to heavy dust, windshield damage due to flying stones, and damage to the vehicle's undercarriage.

Cautions:

- Reduce speed and avoid sharp turns, to avoid skidding. If your vehicle starts to skid, brake gently and keep the steering wheel straight as you would on wet or icy roads. Engage four wheel drive (4WD) if available, even if the road is level.
- Leave extra distance between your vehicle and those ahead of you to avoid dust and flying rocks. Slow down when approaching oncoming vehicles in preparation for a loss of visibility.
- Be aware of changing road surface. If you enter an area of soft sand or gravel, steer gently and avoid braking or accelerating suddenly. Remember that if you drive down a hill with loose surface you may have trouble climbing back up.
- Stay off of shoulders which may be less compacted than the road. Use extra caution when pulling off the road.
- If your vehicle has low clearance, watch for rocks or other obstacles protruding from the road surface.

- Air and oil filters can clog rapidly due to excessive road dust, causing reduced performance and eventual engine damage. Have them changed more often when traveling on unpaved roads. If you experience a rapid loss of power when driving in very dusty conditions, try cleaning the air filter by shaking surface dust off of it. Dirt and debris can also clog the radiator surface, resulting in overheating. Brush or hose off the radiator surface (after letting engine cool) as needed.
- Watch the weather closely before setting off on dirt roads. Even a few drops of rain can turn some surfaces, such as clays, from hard packed dirt to impassable slippery mud.

Ruts
Description: Unpaved roads often develop deepruts due to tire wear or erosion.

Hazard: Lower clearance vehicles may become "high-centered" when the wheels go into ruts. This can cause the vehicle to become stuck or damage the undercarriage.

Cautions:

- Try to keep one or both tires out of wheel ruts by driving on edge or in center of road.
- When crossing ruts, approach at an angle (not perpendicular) to reduce the effective steepness of the rut.
- If vehicle undercarriage makes contact with the road, stop and check underneath for fluid leaks or damage before proceeding. If vehicle becomes stuck, have all passengers get out and remove any heavy cargo before trying to reverse (or possibly go forward if you have 4WD) slowly.

Washouts/Flooding
Description: Unmaintained roads may become partially damaged during floods or heavy rainstorms. Damaged areas may or may not be signed. Flood waters may cross roads at low points.

Hazard: Attempting to cross damaged or flooded sections of road may run risk of getting stuck or sliding off road down a steep slope.

Cautions:

- If undamaged portion of road is not clearly wide enough for vehicle to pass, have someone get out and watch or, if alone, pull vehicle close to washout and compare wheelbase width before crossing.
- If it is necessary to cross the washed-out area, first check how solid the surface is before attempting.
- Do not attempt to cross a wash-out if a sideways slide could result in the vehicle slipping down a steep slope. Be extra cautious if there is running water present.
- Never enter running water unless you can tell how deep it is and you are sure it is not rising. Always avoid crossing moving water that is deep enough to touch the vehicle's body. If you get stuck, exit the vehicle on the upstreamside only.

Don’t stop while crossing a washout or flooded area.

Reference:
http://safety.dri.edu/FieldSafety/Guidelines/DrivingRuralRoads.doc
http://www.jdpower.com/articles/article.aspx?ID=109

APPENDIX 11: FIELD NOTEBOOK SPREADSHEETS

Tower Experiment 1:

Vapor Trap for Evapotranspiration Partitioning					
Date	Time	Collection Heights - Labels			
		1	2	3	4

Tower Experiment 1:

Evapotranspiration Partitioning				
Type of Sample	Date	Time	Label Name	Detail

Tower experiment 2:

Daily Soil Moisture and Soil Temperature								
DATE:			Temperature °C				Soil Moisture	
Site ID	Point	Time	IR	1 cm	5 cm	10 cm	%	Mv
1 1	A							
	B							
	C							
	D							
	Cen							
2 1	A							
	B							
	C							
	D							
	Cen							
3 1	A							
	B							
	C							
	D							
	Cen							
4 1	A							
	B							
	C							
	D							
	Cen							
5 1	A							
	B							
	C							
	D							
	Cen							
1 2	A							
	B							
	C							
	D							
	Cen							
2 2	A							
	B							
	C							
	D							
	Cen							
3 2	A							
	B							
	C							
	D							
	Cen							
4 2	A							
	B							
	C							
	D							

		Cen							
5	2	A							
		B							
		C							
		D							
		Cen							
1	3	A							
		B							
		C							
		D							
		Cen							
2	3	A							
		B							
		C							
		D							
		Cen							
3	3	A							
		B							
		C							
		D							
		Cen							
4	3	A							
		B							
		C							
		D							
		Cen							
5	3	A							
		B							
		C							
		D							
		Cen							
1	4	A							
		B							
		C							
		D							
		Cen							
2	4	A							
		B							
		C							
		D							
		Cen							
3	4	A							
		B							
		C							
		D							
		Cen							
4	4	A							

	B							
	C							
	D							
	Cen							
5 4	A							
	B							
	C							
	D							
	Cen							
1 5	A							
	B							
	C							
	D							
	Cen							
2 5	A							
	B							
	C							
	D							
	Cen							
3 5	A							
	B							
	C							
	D							
	Cen							
4 5	A							
	B							
	C							
	D							
	Cen							
5 5	A							
	B							
	C							
	D							
	Cen							

Tower Experiment 3: Vegetation cover:

Date:	Time Started:	
Transect Location		
Transect #		
	UTM	
	Northing	Easting
Starting Point		
Ending Point		
List of Experimenters:		
Environmental Information:		

Meter #	Target Type	Meter #	Target Type	Meter #	Target Type
1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
10		20		30	

Meter #	Target Type	Meter #	Target Type	Meter #	Target Type
31		41		51	
32		42		52	
33		43		53	
34		44		54	
35		45		55	
36		46		56	
37		47		57	
38		48		58	
39		49		59	
40		50		60	

Meter #	Target Type	Meter #	Target Type	Meter #	Target Type
61		71		81	
62		72		82	
63		73		83	
64		74		84	
65		75		85	
66		76		86	
67		77		87	
68		78		88	
69		79		89	

	70		80		90	

Meter #	Target Type
91	
92	
93	
94	
95	
96	
97	
98	
99	
100	

Species	%	Species	%	Species	%
Species	**%**	**Species**	**%**	**Species**	**%**

Tower experiment 3: LAI:

LAI Spreadsheet				
Tramsect #		Coordinates (UTM):		
Date:				
Name of Operators:				
Time	Target (species)	PAR Readings		Environmental Conditions (topo., veg.cvr, prox. Of features, weather) and/or Details
		Above Canopy Reading	Average 3 Below Canopy Readings	

Tower experiment 3: Vegetation reflectance:

Field Spectroscopy / Vegetation Reflectance Spreadsheet

Date:		Name of Operators:		
Transect#			Coordinates (UTM):	
Target ID	Time	Reading Average	Type of Target	Environmental conditions (topo., veg.cvr, prox.of features, weather) and/or Details
Reference Reading				
Reference Reading				
Reference Reading				
Reference Reading				

Tower Experiment 4:

Continuous Soil Moisture and Soil Temperature Download		
Date	Time	File Name

Basin Experiment 4: Change in co-ordinates of soil pits:

Soil Properites Change in Coordinates					
	Original Coordinates UTM		New Coordinates UTM		
Soil Pit ID:	Easting	Northing	Easting	Northing	Reason for Changing Location:

Date:__/__/____ Time:____:_____ Site No.___________ Vegetation Type:___________________________________ Elevation:_______________

Location:_____________________ Parent Material:_______________________________ Slope:_________________

Described by:_________________________ Geomorphic Surface:__________________________ Aspect:_________________

Bag Label	Depth (cm)	Horizon	Color		Structure			Gravel	Consistence			Texture	pH	Clay films	Boundaries	Notes
			moist	dry	grade	size	structure	%	wet	moist	dry					
					m	vf	gr	<10	so po	lo	lo	S SiCL		v1 f pf	a s	
					sg	f	pl	10	ss ps	vfr	so	LS SiL		1 po	c w	
					1	m	pr	25	s p	fr	sh	SL Si		2 d br	g I	
					2	c	cpr	50	vs vp	fi	h	SCL SiC		3 co	d b	
					3	vc	abk	75		vfi	vh	L C		p cobr		
							sbk	>75		efi	eh	CL SC				
					m	vf	gr	<10	so po	lo	lo	S SiCL		v1 f pf	a s	
					sg	f	pl	10	ss ps	vfr	so	LS SiL		1 po	c w	
					1	m	pr	25	s p	fr	sh	SL Si		2 d br	g I	
					2	c	cpr	50	vs vp	fi	h	SCL SiC		3 co	d b	
					3	vc	abk	75		vfi	vh	L C		p cobr		
							sbk	>75		efi	eh	CL SC				
					m	vf	gr	<10	so po	lo	lo	S SiCL		v1 f pf	a s	
					sg	f	pl	10	ss ps	vfr	so	LS SiL		1 po	c w	
					1	m	pr	25	s p	fr	sh	SL Si		2 d br	g I	
					2	c	cpr	50	vs vp	fi	h	SCL SiC		3 co	d b	
					3	vc	abk	75		vfi	vh	L C		p cobr		
							sbk	>75		efi	eh	CL SC				
					m	vf	gr	<10	so po	lo	lo	S SiCL		v1 f pf	a s	
					sg	f	pl	10	ss ps	vfr	so	LS SiL		1 po	c w	
					1	m	pr	25	s p	fr	sh	SL Si		2 d br	g I	
					2	c	cpr	50	vs vp	fi	h	SCL SiC		3 co	d b	
					3	vc	abk	75		vfi	vh	L C		p cobr		
							sbk	>75		efi	eh	CL SC				

Basin Experiment 4: Properties of soil pits

APPENDIX 12: EQUIPMENT LISTS

EQUIPMENT LISTS

PERSONAL EQUIPMENT

Travel Documents / Cards
- Passport
- Health Insurance Card
- Credit Cards
- Driver's License
- Phone Card
- Money
- Letters from NMT
- Soil Permits

Clothes
- Hiking Boots
- Tennis Shoes
- Flip-flops/Sandals
- Socks
- Pants
- Shorts
- Underwear
- Shirts
- Long-Sleeve Shirts

Accessories
- Hat
- Bandana
- Sunglasses
- Watch
- Belt

Toiletries
- Sunscreen
- Bug Repellent
- Lip Balm
- Shampoo/Conditioner
- Body Soap
- Deodorant
- Toothpaste/Toothbrush
- Toilet Paper
- Shaving Kit
- Medicine – pain / upset stomach relief
- Laundry Detergent
- Towel

Field Gear
- Water Bottle
- Emergency Whistle
- Mirror – small
- Pocketknife
- Work gloves

Other
- Bedding (sleeping bag/pillow)
- Entertainment (books, cards, cd players, etc.)
- Lunch Box/Utensils (knife/fork/spoon, cup)
- Camera

FIRST AIDE KIT

Pre-made kit	2
Snakebite kits	4
Large Home Kit	1
Bactine	1 btl
Alcohol	1btl
Peroxide	1 btl
Iodine	1 btl
Aspirin	1 btl
Various gauze	
Various bandages	
Immodium	1 box
Benedryl	1 box
Pepto Bismol	1 btl
Tumms	1 btl
Tweezers	1
Ace Bandages	3
Thermometer	1
Eye Wash	1
Antibiotic Ointment	
Butterfly Clips	
Ice packs	3
Tape	1
Gloves	1 box

VEHICLE EQUIPMENT

Tools
- Phillips
- Flathead
- Axe
- Saw
- Pliers
- Wrenches and sockets
- Hammer
- Duct tape
- Bailing wire

Vehicle Repair
- Vehicle water
- Oil
- Fix-a-flat
- Battery charger cables
- Hand wrench
- Roadside emergency kit
- Shovel
- Towrope
- First Aide Kit
- Radio

NOTE: Equipment Listed in italics, are repeated in different experiments and are tabulated at the end for total quantity.

EQUIPMENT LISTS

RESEARCH EQUIPMENT

1. **Isotopic partitioning of Evapotranspiration**

- *Markers/pens/pencils*
- Watch (1)
- Extra veg. vials (144)
- *Field notebook (1)*
- Soil auger (1)
- 25ml screw-capped vials (65)
- Labeling tape (roll)
- Primers (3 in set)
- *Parafilm (box)*
- Scissors (1)
- Vapor trapping apparatus (including glassware and liquid nitrogen/alcohol bath) (1)
- Aluminum foil (box)
- *Cooler (1 medium)*
- *GPS (1)*
- Ziploc bags (box)
- Metal file (1)
- Glass tubes (50)
- Liquid nitrogen (40 l)
- Ethanol
- Dewar Flask w/lid (1)
- Thermometer (1)
- Valves (several)
- Tubing
- 6V batteries (3)

2. **Sampling Plots- Daily Soil Moisture / Temperature**

- Hand held theta probes (soil moisture probe) (4)
- extra tines (2 bags)
- Infrared thermometer (surface temperature instrument) (2)
- *Soil thermometers (3)*
- Flags (200)
- *Wooden stakes (100)*
- *GPS (1)*
- map and coordinates of station locations (1)
- *Field notebook (2)*
- *Markers/pens/pencils*
- *Radios*
- *Digital Camera*
- Mulitmeter
- *Hammer (2)*
- AA batteries (20)
- 9V batteries (20)
- Hand held weather instrument (4)

3. **Vegetation Sampling**

- *Digital Camera*
- *Stakes (20)*
- Rope (100 m)
- Measuring tape (100m & 50m)
- *Hammer (2)*
- *GPS (2)*
- Labels or marker
- *Field notebook (2)*
- Ceptometer (2) *Mexico
- Spectralon white panel (or equivalent)
- Spectroradiometer w/ device to extend spectralon
- Rug (1)
- *Compass + case (2)*

4. **Soil Profile Properties**

- Picks (2)
- Shovels (lrg 2, shrt 1)
- Hand Shovels (2)
- Measuring tape (2)
- Munsell color chart (3)
- 2 mm Sieves (2)
- *Field notebook (2)*
- *Digital camera*
- Knife (2)
- Bottle with HCl (3)
- Bottle with water (3)
- *GPS device (2)*
- *Compass + case (2)*
- Clinometers (1)
- Sample storage bags (225)
- Pedon storage containers (24 containers of 12)
- Small pick/hammer (1)

5. **Calibration for Tipping Bucket**

- Allen wrench (2)
- *Laptop (2)*
- Calibration kits (1)
- Burette (2)
- Enough water for calibration
- Chronometer (1)
- *Field notebook (2)*

6. **Gravimetric Soil Moisture**

- Small Tin Cans (30)
- Small Ring (4)
- Rubber Mallet (2)
- Piece of Wood (2)
- Scrapers (3)
- Oven (1) *in Mexico

7. **Continuous Soil Moisture/Temperature**

- Datalogger (2)
- Datalogger box (2)
- Multiplexor (2)
- 12V Battery (2)
- ECH2O probes (12)
- Temperature probes (12)
- Solar panels (2)

8. **New Station Installation (5)**

- Data loggers
- Tipping Bucket Rain Gauges
- Solar Panels
- Soil Digger (1)
- Wrench (1)
- Soil Moisture Hydro probes (10)

OTHER SUPPLIES:

- CR-2032 Batteries (10)
- 76A batteries (10)
- Tent/Tarp (1)
- BBQ grill (1)
- 6" bubble level (1)
- Duct tape (2 rolls)
- Data Logger Posts (8") *in Mex
- Red gas cans (2)
- Electrical tape (2 rolls)
- Moisture Meter User Manual
- Moisture Meter Data Link
- Flathead screwdriver (1)
- Phillips screw driver (1)
- Data Logger Spare Equipment
- Data Logger Mounting Brackets (10)
- Data Logger Boxes (7)
- Rain Gauge Manual (1)
- Rain gauge mounting brackets
- Rain Gauge Posts 7' (5) *in Mexico
- Topographic Maps (Large)
- Soil Permits
- HOBO Base Stations (USB)
- Cable SC32B for laptop
- Tables (2)
- Chairs (4)
- AC/DC converter (1)
- Battery charger (1)
- Water bottles (2)
- Toolbox (1)
- Ziploc bag (several boxes)

TOTAL OF REPEATED ITEMS:

- *Coolers (4 chests, 1 jug)*
- *Spreadsheets for data recording*
- *Pens/pencils/markers*
- *Field notebooks (12)*
- *Compass + case (2)*
- *eTrex GPS (8)*
- *Laptop computer (2)*
- *Parafilm (2 boxes)*
- *Digital Camera (personal)*
- *Wooden Stakes (120)*
- *Hammer (4)*
- *Soil Thermometers (15)*

APPENDIX 13: LIST OF PARTICIPANTS

New Mexico Institute of Mining and Technology - Socorro, NM

Enrique Vivoni
Associate Professor of Hydrology
Research Hydrologist

Soni Yatheendradas
Post-doctoral Research Associate in Hydrology

Lorena Liuzzo
PHd student
Visiting Researcher in Hydrology from
University of Palermo, Italy

Luca Martini
Graduate Student
Visiting Researcher in Hydrology from
University of Rome La Sapienza

Luis Mendez
Graduate Student of Hydrology

Alexis Martinez
Undergraduate Student of Environmental Engineering

Whitney DeFoor
Undergraduate Student in Environmental Science

University of New Mexico – Albuquerque, NM

Enrico Yepez
Post-doctoral Research Associate in Biology

University of Arizona – Tucson, AZ

Tom Meixner
Associate Professor, Hydrochemistry
Department of Hydrology and Water Resources

Lissette De La Cruz
Graduate Student in Hydrology
Department of Hydrology and Water Resources

Universidad de Sonora, Hermosillo, MX

Christopher Watts
Professor of Physics

Juan Sainz
Professor of Civil Engineering

Danira Adriana MartÌnez GarcÌa
Undergraduate Student in Civil Engineering

Javier Navarro Estupiñán
Undergraduate Student in Civil Engineering

Fátima Beatriz Félix Salas
Undergraduate Student in Civil Engineering

Instituto Tecnológico de Sonora, Ciudad Obregón, Sonora, MX

Jaime Garatuza
Professor of Hydrology

Tonantzin Tarín Terrazas
Undergraduate Student in Environmental Engineering

José María Esquer Vizcarra
Undergraduate Student in Environmental Engineering

Elí Rafael Pérez
Undergraduate Student in Environmental Engineering

Universidad Autónoma de Chihuahua – Chihuahua, Chihuahua, MX

Karina Yazmin Gutierrez Jurado
Undergraduate Student in Hydrdogy

APPENDIX 14: EARLIER PUBLICATIONS (2) AND POSTERS (2)