ATMOS 5910-2/6910-1 Environmental Instrumentation. Spring 2010

Lab Assignment 4. Measuring Precipitation

Objective: Become familiar with the operation of tipping bucket, weighing precipitation, and snow depth sensors.

Before the Lab Session. YOU MUST TURN YOUR ANSWERS IN TO QUESTIONS 1-7 AT THE BEGINNING OF THE LAB OR YOU WILL NOT BE ALLOWED TO START!!!

- Read through Chapter 9 on measuring precipitation rate.
- Refer to the information on the Texas Electronic 525 tipping bucket rain gauge http://www.campbellsci.com/documents/manuals/te525.pdf.
- *Question 1.* Complete the following information from the manual and basic reasoning. Show your calculations

Rainfall per tip (in and cm)	Accuracy for rain rate up to 1 in per hour	Accuracy for rain rate > 2 in per hour	Diameter of gauge (in)	Area of gauge opening (cm^2)	Volume of precipitation with depth of .01 in (cm^3/ml)	Number of tips for 750 ml	Time (min)required for 750 ml at 4 in/hr rate
.01in/.0254cm	+-1%	-5%	6 in	182.41cm^2	4.63ml	162	24 min

- *Question 2.* Describe in a paragraph how the TE525 works, including how the tip of the bucket is converted into something measurable by the datalogger.
- Refer to the information on the NOAH II total precipitation gauge http://www.eol.ucar.edu/isf/facilities/isff/sensors/eti-noahii.pdf and some info here: http://www.etisensors.com/noah_ii.htm
- *Question 3.* Complete the following information from the information and basic reasoning. Show your calculations

Rainfall per tip (resolution) (in and cm)	Accuracy	Diameter of gauge (in)	Area of gauge opening (cm^2)	Volume of precipitation with depth of .01 in (cm^3/ml)	Volume of precipitation with depth of .05 in (cm^3/ml)	Number of tips for 250 ml
.01in/.0254cm	+-1%	12 in	729.64 cm^2	18.5 ml	92.5 ml	13.5

- *Question 4.* Describe in a paragraph how the NOAH II works, including how snow falling into the gauge is converted into something measurable by the datalogger.
- Refer to the information on the Judd communication snow depth sensor: http://www.juddcom.com/ds2manual.pdf
- *Question 5.* Complete the following from the manual and basic reasoning. Show your calculations

Range (cm)	Accuracy (cm)	Beam Width (degrees) and half width	Radius (cm) of surface area for sensor beam height 1.5 m	Surface area (cm^2) for sensor beam height 1.5 m	For snow density of 10% and snow depth of 1cm and sensor beam height of 1.5 m, amount of snow water equivalent (ml)
.01in/.0254cm	+-1cm	22/11 deg	29 cm	2642 cm^2	264 ml

- *Question 6.* Describe in a paragraph how the Judd snow depth sensor works, including how the measurement depends on temperature.
- Participants in each lab section will be broken into 3 groups. The groups will rotate through the three areas: tipping bucket; NOAH II total precipitation gauge; Judd Communications depth sensor.

- The same program is used for all three sensors. Look at the code on the class web page: precip_lab_2010.cr1
- *Question 7.* What is the scan rate (in seconds)? What is the interval over which the data will be stored in Table 1?

1. **Area 1. TE 525 Tipping Bucket**
    - Reboot the laptop for this area. Create a folder on the netbook using your team number (M-T, groups 1-3), e.g., M_1, etc.
    - Copy the precip_lab_2010.cr1 from the class web page into the folder on the laptop.
    - Check battery voltage.
    - Use Loggernet to connect to the CR1000 and send the program.
    - Click on the Custom download option. Change the Collect Mode to "All the Data"
    - Change the File Mode to "Overwrite Existing File"
    - Select Change File Name and create a file in your folder
    - Select "Start Collection"
    - You should now be able to go and open that file with Wordpad or Notepad. Do so.
    - From LoggerNet, select from the Data tab: View Pro
    - From the File menu, select open and open the file you created
    - Highlight the Rain column and select Line graph. You'll come back later and monitor your output.
    - At this point, you are ready to assess the accuracy of the tipping bucket rain gauge
    - Fill the bottle with 750 ml of tap water. Insert the 1/32" tip into the base. Connect the bottle to the base.
    - Practice taking data. One person will be timing the beginning (to the end), while another will turn the bottle assembly over. According to your answer to Question 1, how long will it take for all of the water to run through the tipping bucket? Monitor the data for a few tips, looking at the data, etc.
    - For your final calibration run, the bottle must be **turned over quickly and smoothly** to avoid splashing water out of the slots in the top of the water dispenser. Hold the orifice and dispenser over the rain gauge funnel as the bottle is turned over so any spilled water will be caught and counted in the total amount of water. At the end of the test, lift the bottle slightly to observe the stream of water from the orifice. The water may still be dripping out of the nozzle. Keep the calibration bottle over the funnel until the water flow stops. The stream will stop abruptly at the end of the flow. Note the time elapsed from the outset.
    - Some water may remain in the water dispenser part of the calibrator- remove the bottle and base from the gauge and dribble the remaining water into the graduated cylinder. Subtract that amount from your original 750 ml.
    - Upon completing the calibration procedure, carefully remove the funnel. If there is still water left in the bucket, use the syringe to determine how many additional milliliters of water are needed to produce another tip of the bucket. In many cases, the amount of water needed will be two or three milliliters. Add the water slowly from the syringe, one milliliter at a time, allowing time for the water to drop into the bucket before adding the next milliliter of water. Count the number of milliliters of water as they are added, until the bucket tips. From your results from Question 1, you should then be able to determine how many milliliters were left in that final bucket.
    - *Question 8.* From the total volume run through the gauge and the elapsed time, how did your flow rate compare to your estimate in Question 1?
    - *Question 9.* How does the number of tips compare to that expected from your calculations in Question 1?
    - *Question 10.* What might explain any discrepancies between the expected values and what was observed? Compare your results to those from the other groups.

2. NOAH II Total Precipitation Gauge

- Reboot the laptop for this area. Create a folder on the netbook using your team number (M-T, groups 1-3), e.g., M_1, etc.
- Copy the precip_lab_2010.cr1 from the class web page into the folder on the laptop.
- Check battery voltage.
- Use Loggernet to connect to the CR1000 and send the program.
- Click on the Custom download option. Change the Collect Mode to "All the Data"
- Change the File Mode to "Overwrite Existing File"
- Select Change File Name and create a file in your folder
- Select "Start Collection"
- You should now be able to go and open that file with Wordpad or Notepad. Do so.
- From LoggerNet, select from the Data tab: View Pro
- From the File menu, select open and open the file you created
- Highlight the Rain_Noah column and select Line graph. You'll come back later and monitor your output.
- At this point, you are ready to assess the accuracy of the Noah II gauge to varying amounts of precipitation.
- Use the graduated cylinders to pour the equivalent of .05 inches of precipitation into the gauge. Repeat three times. Repeat three times pouring in 250 ml. Repeat 3 times pouring in 18.5 ml. Repeat two more times selecting 2 other volumes.
- *Question 11.* Fill in the following table

Trial	0.05 in	250 ml	18.5 ml	Your choice	Your choice
1					
2					
3					

- *Question 12.* Plot the expected values vs. the observed values. Determine the linear best fit to the observed data.
- *Question 13.* Estimate the accuracy (in %) of the Noah II gauge based on the root-mean squared differences about the linear best fit.

3. Judd Communications depth sensor

- Reboot the laptop for this area. Create a folder on the netbook using your team number (M-T, groups 1-3), e.g., M_1, etc.
- Copy the precip_lab_2010.cr1 from the class web page into the folder on the laptop.
- Check battery voltage.
- Use Loggernet to connect to the CR1000 and send the program.
- Click on the Custom download option. Change the Collect Mode to "All the Data"
- Change the File Mode to "Overwrite Existing File"
- Select Change File Name and create a file in your folder
- Select "Start Collection"
- You should now be able to go and open that file with Wordpad or Notepad. Do so.
- From LoggerNet, select from the Data tab: View Pro
- From the File menu, select open and open the file you created
- Highlight the Depth column and select Line graph. You'll come back later and monitor your output.
- At this point, you are ready to assess the accuracy of the depth sensor under varying conditions.
- Measure the distance from the sensor to the floor. Mark with tape the location immediately below the sensor. Using your results from Question 5, mark with tape the boundaries of the sensors viewing area based on the

beamwidth of the sensor. Fill in the following table based on results collected from at least 3-4 observations for each case.

- *Question 14.* Fill in the following table assessing the accuracy of the sensor

Observations	No objects in field of view	Large Cylinder directly under sensor	Large Cylinder halfway from sensor to beam width bounds	Large Cylinder at beam width bounds	Your choice
1					
2					
3					
4					

- *Question 15.* Fill in the following table assessing the accuracy of the sensor under windy conditions. Place the fan at distances/angles from the sensor to generate light, moderate, and strong winds. Use the Kestrel to estimate the wind speed experienced by the sensor. Graph the data (x axis wind speed, y axis depth)

Observations	Temperature (C) from Judd sensor	Light wind (XX m/s)	Moderate wind (YY m/s)	Strong wind (ZZ m/s)
1				
2				
3				
4				

- *Question 16.* Loosen the depth sensor mount from the tower and measure the distance from the sensor to the floor for various depths. Collect several observations at each depth. Graph the data (x axis expected depth , y axis observed depth)

Observations	Temperature (C) from Judd sensor	Depth 1	Depth 2	Depth 3	Depth 4
1					
2					
3					
4					

- *Question 17.* Summarize the data collected on the accuracy of the depth sensor as a function of varying expected depth, wind speed, and different obstacles within the field of view.

4. Final Steps

a. **Create a lab report with all of your answers to Questions 1-17 . This must be typed.**
b. **Turn your lab report in by the following lecture.**