HUMIDITY AND PRECIPITATION LABORATORY

1. Objectives

The objectives of this lab are to familiarize you with a few of the ways in which two common meteorological variables (humidity and precipitation amount) are measured, and to assess the errors implicit in the measurements.

2. Humidity

2.1: Home weather stations have relatively accurate capacitance humidity sensors. However, to a meteorologist these are of limited utility because they can only give the indoor relative humidity (*RH*). Nevertheless, by assuming that the mixing ratio is the same both inside and outside of the building, and by measuring the *RH* inside and the temperatures (*T*) outside and inside, we can use the inside *RH* to estimate the outside *RH*. Part of the lab will be to assess the validity of this assumption.

2.2: Specific tasks

- Compare the RHs of room air from the Vaisala Humicaps and the psychrometers. Take repeat readings to assess reproducibility.
- Calibrate the Vaisala against the four saturated salt solutions.
- Test the hypothesis of conservation of water vapor by measuring the *RH* and *T* inside, with the Vaisala, and then measuring the outside *RH* and *T* with the Vaisala.

3. Precipitation

The Davis gauge is designed to measure increments of 0.01 inches of rainfall. It would therefore be wise to work in inches in this case and convert to millimeters in your analysis because the digitization works better on the Davis using inches.

3.1: Calibrate a Davis tipping bucket rain gauge by determining the volume that each bucket of the gauge holds. You can do this by using a pipette apparatus and slowly pouring a certain amount of water into each bucket until it tips. Try at least 3 trials in each of the two buckets so that you can calculate simple statistics. Also measure the diameter of the collection funnel for use in later calculations.

3.2 For the Davis tipping bucket gauge, determine the relationship between the true and measured (Davis) rain rate, and to determine whether the measurement error changes with rain rate. Do this by pouring measured volumes of water per unit time, using the buret, into the gauge. Use at least four different pouring rates. Make sure to record the measured volume and the amount indicated on the Davis. The lowest rate should be equivalent to ~10 mm hr^{-1} and the rates should be separated by at least a factor of two. Without making a mess, try pouring in a measured amount of rain using a graduated beaker to simulate rain at a very high rate to determine if the Davis gauge would see a tropical downpour.

Humidity and Precipitation Lab Worksheet

Complete the following activities and turn your results as though you would a typical problem set (i.e. no formal write-up required).

1) **Capacitance Humidity (Vaisala) vs Psychrometer:** Provide the mean and standard deviation of your RH measurements using the Vaisala and the psychrometer. Are RH values measured by each significantly different?

2) **Calibration of the Vaisala RH Probes vs Salt Solutions:** Produce a well-labeled calibration figure, a linear regression, and total uncertainty in the Vaisala RH measurements based on the results of that regression of calibration data. Comment on the time response of the sensor.

3) **Conservation of Water Vapor Test:** Compare the measured outside *RH* with that estimated from the inside measurements assuming conservation of mixing ratio. Is there a bias? Give some reasoning for a bias if one is observed. In other words, what might cause the assumption of constant water vapor concentration inside and outside to be invalid?

4) **Tipping Bucket Volume Determinations**: From 3.1 of the lab procedure, you can calculate the mean and standard deviation of your bucket volumes. Assuming a normal distribution, a value within three standard deviations has almost 100% probability of occurrence. Using this information, deduce the lowest amount of rain (in millimeters) measurable for each bucket of the Davis rain gauge.

5) **Error in the Davis Tipping Bucket Gauge as a Function of Rain Rate:** Convert the volume of water that you measured in a given time into equivalent millimeters per hour using knowledge of the collection area of the funnel. Use a linear regression to determine the functional relationship between rain rate and observed rate from the Davis. Produce a well-labeled calibration figure along with the linear regression and uncertainty analysis results.