WIND MEASUREMENT LABORATORY

1. Objectives

The objectives of this lab are to familiarize you with wind sensors, to calibrate your weather station Davis wind sensor against a NIST-traceable standard, and to determine the time constant of a two wind sensors. We will use the Venturi wind tunnel in Room 107 Guggenheim Hall.

2. Tasks

2.1 Calibrate the Davis anemometer against the NIST traceable cup anemometer (a cup anemometer made by RM Young) in the wind tunnel. The Young anemometer gives a voltage proportional to wind speed (see appendix for the calibration equation). The wind tunnel should be used to generate at least 5 different wind speeds (e.g., 2, 4, 6, 8, 10 m s\(^{-1}\)) for your calibration of the Davis. Work up and down in wind speeds to check for any hysteresis. The Young anemometer reading is captured to a data-logger, which is time-stamped. Record the wind speed on the Davis manually and make a note of the time so that you can retrieve the data according to the time data in the computer file.

2.2 Determine the time constant (response time) of the Gill and Davis anemometers, i.e. the time for the difference between actual and measured wind speed to fall to \(1/e\) of the initial difference. Do this for three different wind speeds, with a minimum speed of 4 m s\(^{-1}\) to get enough rotation pulses of the Davis. This can be done by blocking the rotation of the Davis cups or Gill propeller until the tunnel wind speed has equilibrated and then releasing the anemometer. The blocking should be done with a rod through the top of the tunnel (to be demonstrated). After release, the anemometer output should asymptotically approach the tunnel windspeed. The output will be recorded to disk as a function of time. It can be analyzed for time response using non-linear regression.

3. Questions to address in the lab report

Write the lab report in the usual format. At appropriate places in the text be sure to address the following issues:

3.1 What is the bias of the Davis anemometer relative to the Young anemometer. Consider slope (gain) and offset biases? A gain bias would result if the slope is different from unity; a zero bias results if the intercept is non-zero. Use linear regression of the form \(U_{\text{YOUNG}} = (a \pm s_a) U_{\text{DAVIS}} + (b \pm s_b)\) to assess the slope \(a\) (and its error) and the offset \(b\) (and its error).
3.2 The Young cup anemometer against which you have calibrated the Davis is a “transfer” standard. Taking into account the uncertainty on the Young relative to the NIST true wind value, what is the total uncertainty on the Davis wind measurement? (This is analogous to the total uncertainty on the temperature measurement in the temperature lab). Use the linear relationship for $U_{\text{YOUNG}}$ in 3.1 to calculate the variance on the Young-Davis measurement ($S_Y^2$) from the general “combination of errors” method. Then also use the linear relationship for the NIST wind ($U_{\text{NIST}} = (c \pm s_c)V_{\text{YOUNG}} + (d \pm s_d)$) to get the variance on the NIST wind ($S_N^2$) from the “combination of errors” method. Calculate a total variance, which is the sum $S_Y^2 + S_N^2$.

3.3 Determine the time constant for the Davis and Gill anemometers for different wind speeds from non-linear regression. Be sure to include the uncertainty on the time constant, which is obtained from the program that calculates the regression. The error will allow you to assess the significance of different response times. Rationalize any differences for the different anemometer response times. Estimate the anemometer distance constant and its uncertainty at the different wind speeds.