Contents

PREAMBLE

```
close all;
clear variables;
clc;

set(groot, 'defaultTextInterpreter', 'Latex');
set(groot, 'defaultLegendInterpreter', 'Latex');
set(groot, 'defaultAxesTickLabelInterpreter','latex');
set(groot, 'defaultLegendInterpreter','latex');
set(groot, 'defaultTextFontSize', 12);
set(groot, 'defaultAxesFontSize', 16);
set(groot, 'defaultLineLineWidth', 2);
set(groot, 'defaultFigureColor', 'white');
```

Loading Data

```
%REMEMBER TO CHANGE THIS IF ON WINDOWS cause apples hates me
%fileDir = '/Users/christopherbianco/Desktop/School_Code/Wind Physics/HW1'; %Mac

fileDir = 'C:\Users\Christopher\Desktop\School_Code\Wind Physics\HW1'; %Windows


data = load(fullfile(fileDir, '08_28_2019_22_00_00_000.mat'));
```

Time conversion

```
%Convert UTC datenum to datetime
thyme = data.time_UTC.val;
time = NaT(size(thyme));
for ti = 1 : length(thyme)
    time(ti) = datetime(floor(thyme(ti)), 'ConvertFrom', 'datenum') ...
        + days(rem(thyme(ti),1)); % convert datenum to datetime object
end
time.TimeZone = 'Etc/UTC'; % add TimeZone field (UTC time)
time.TimeZone = 'America/Denver'; % shift to NREL time zone
```

Part a: Horizontal wind speed profile

```
%Initialize measurement height
sonic_heights = [15,41,61, 74, 100, 119];
U_av_sonic = NaN(1, length(sonic_heights));
U_std_sonic = NaN(1, length(sonic_heights));

cup_heights = [3, 10, 30, 38, 55, 80, 87, 105, 122, 130];
U_av_cup = NaN(1, length(cup_heights));
U_std_cup = NaN(1, length(cup_heights));

%Calculate horizontal wind speed from sonic anemometers
for i = 1:length(sonic_heights)
    sonic_height = sonic_heights(i);
    U = sqrt(data.(strcat('Sonic_x_clean_',num2str(sonic_height),'m')).val.^2 + data.(strcat('Sonic_y_clean_',num2str(sonic_height),'m')).val.^2);

    U_av_sonic(i) = mean(U);
    U_std_sonic(i) = std(U);
end

%Extract horizontal wind speed from cup anemometers
for i = 1:length(cup_heights)
    cup_height = cup_heights(i);

    %Now, we need to take into account the naming convention
    fn = fieldnames(data);
    matchIdx = contains(fn, 'Cup_WS_') & contains(fn, strcat(num2str(cup_height),'m'));
    match = fn(matchIdx);

    %Extract U
    U = data.(match{1}).val;

    %Do mean and standard deviation
```

```
    U_av_cup(i) = mean(U);
    U_std_cup(i) = std(U);
end

%Make the figure
figure(1); hold on;
xlabel('Horizontal Wind Speed (m/s)');
ylabel('z (m)');
grid on

%Plot sonic
e1 = errorbar(U_av_sonic, sonic_heights, U_std_sonic, 'horizontal', '*c', 'LineWidth',2);
%Plot cup
e2 = errorbar(U_av_cup, cup_heights, U_std_cup, 'horizontal', '*k', 'LineWidth',2);

% Dummy plots for legend only
h1 = plot(nan, nan, '*c', 'LineWidth', 2);
h2 = plot(nan, nan, '*k', 'LineWidth', 2);

% Legend
legend([h1 h2], {'Sonic','Cup'}, 'Location', 'best')

hold off
```

Part b and c: Temperature readings

```
%Initialize measurement height
sonic_heights = [15,41,61,74,100,119];
temp_av_sonic = NaN(1, length(sonic_heights));
temp_std_sonic = NaN(1, length(sonic_heights));

solo_heights = [3, 38, 87];
temp_av_solo = NaN(1, length(solo_heights));
temp_std_solo = NaN(1, length(solo_heights));

%Extract temp from sonic anemometers
for i = 1:length(sonic_heights)
    sonic_height = sonic_heights(i);
    temp = data.(strcat('Sonic_Temp_clean_', num2str(sonic_height), 'm')).val;

    temp_av_sonic(i) = mean(temp);
    temp_std_sonic(i) = std(temp);
end

%Extract temp from stand alone measurements
for i = 1:length(solo_heights)
    solo_height = solo_heights(i);
    temp = data.(strcat('Air_Temp_', num2str(solo_height), 'm')).val;

    temp_av_solo(i) = mean(temp);
    temp_std_solo(i) = std(temp);
end

%Make figure
figure(2); hold on;
xlabel('Temperature (C)');
ylabel('z (m)');
grid on

%Plot sonic
e1 = errorbar(temp_av_sonic, sonic_heights, temp_std_sonic, 'horizontal', '*c', 'LineWidth',2);
%Plot cup
e2 = errorbar(temp_av_solo, solo_heights, temp_std_solo, 'horizontal', '*b', 'LineWidth',2);

% Dummy plots for legend only
h1 = plot(nan, nan, '*c', 'LineWidth', 2);
h2 = plot(nan, nan, '*k', 'LineWidth', 2);

%Define and plot the adiabatic lapse rate
h = linspace(0,120,1000);
lapse_rate = (-9.8/1000).*h + 30;
h3 = plot(lapse_rate, h);

% Legend
legend([h1 h2 h3], {'Sonic','Stand Alone Measurement', 'Adiabatic Lapse Rate'}, 'Location', 'southwest')

hold off
%Based on these graphs, the temperature readings from the sonic anemometers
%at z = 41m and 74m are quite low, and deviate wildly from all other
%measurements. For that reason, these points look unreliable.
```

Part b and c short answer

```
%In terms of stability, if we ignore the temperature readings at z = 41m
%and 74m, we can see that the average slope is less steep (more negative)
%than the adiabatic lapse rate of -9.8 K/km. In other words, the lapse rate
%is super adiabatic.This indicates static instability. Given that these
%measurements were taken at 4pm local time, this observation makes sense.
%We would expect an unstable mixing layer at this time. However, there is a
%decent degree of uncertainty. As mentioned previously, we have at least
%two large outliers. Additionally, the temperature reading at z = 119 m
%doesn't fall on the qualitatively observed slope. Finally, the slope
%doesn't appear that much flatter than the adiabatic case, so small
%variations in temperature could change the characterization.
```

Part d: August 2019

```
%Load data
aug_data = load(fullfile(fileDir, '2019_August.mat'));

%Do time conversion
%Convert UTC datenum to datetime
thyme_all = aug_data.all_data.Virtual_Potential_Temperature_3m.date;
time_all = NaT(size(thyme_all));
for ti = 1 : length(thyme_all)
    time_all(ti) = datetime(floor(thyme_all(ti)), 'ConvertFrom', 'datenum') ...
        + days(rem(thyme_all(ti),1)); % convert datenum to datetime object
end
time.TimeZone = 'Etc/UTC'; % add TimeZone field (UTC time)
time.TimeZone = 'America/Denver'; % shift to NREL time zone

%From manual inspection, the entry we want to look at in the large dataset
%is 3986

aug_temp_ave_sonic = NaN(1, length(sonic_heights));
aug_temp_std_sonic = NaN(1, length(sonic_heights));

aug_temp_ave_solo = NaN(1, length(solo_heights));


%Extract air temp from sonic anemometers
for i = 1:length(sonic_heights)
    sonic_height = sonic_heights(i);
    aug_temp_ave_sonic(i) = aug_data.all_data.(strcat('Raw_Sonic_Temp_',num2str(sonic_height),'_mean')).val(3986);
    aug_temp_std_sonic(i) = aug_data.all_data.(strcat('Raw_Sonic_Temp_',num2str(sonic_height),'_sdev')).val(3986);
end

%Extract air temp from stand alone measurements
for i = 1:length(solo_heights)
    solo_height = solo_heights(i);
    aug_temp_ave_solo(i) = aug_data.all_data.(strcat('Air_Temperature_',num2str(solo_height),'m')).val(3986);
end

%Make plot
figure(3)
xlabel('Temperature (C)');
ylabel('z (m)');
title('Average temperature from August 2019 dataset')
grid on
hold on

%Plot temperatures
errorbar(aug_temp_ave_sonic, sonic_heights, aug_temp_std_sonic, 'horizontal', '*c', 'LineWidth',2)
plot(aug_temp_ave_solo -273.15 , solo_heights, '*k', 'LineWidth',2)
legend({'Sonic','Stand Alone Measurement'}, 'Location', 'southwest')

hold off

solo_heights = [3,38,87,122];
%Extract virtual potential temp
aug_vpt = NaN(1, length(solo_heights));
for i = 1:length(solo_heights)
    solo_height = solo_heights(i);
    aug_vpt(i) = aug_data.all_data.(strcat('Virtual_Potential_Temperature_',num2str(solo_height),'m')).val(3986);
end

%Make plot
figure(4)
xlabel('Virtual Potential Temperature');
ylabel('z (m)');
xlim([43 46]);
title('August 2019 dataset')
grid on
hold on

plot(aug_vpt -273, solo_heights, '*r', 'LineWidth',2)
hold off
```

d short response

```
%As can be seen from the temperature data, the virtual potential
%temperature (VPT) is much higher than the raw temperature. The virtual potential
%is also unreasonably high, even for the summer. This is likely because,
%according to the report, a p0 of 100 kpa was used to calculate VPT.
%However, the data was taken at an elevation of 6000 feet. According to
%engineering toolbox, the pressure at 6000 feet is 81.2 kpa, much lower. If
%this value was used, the temperature values would be lower and likely more
%sensical.
```

Part e

We can correct the virtual potential temperature measurements by multiplying them by the factor we get from changing p0 to 82 kpa. To find

```
%This, we take (82/100)^(R/Cp), where R/Cp is given as 0.286. Thus,
%multiplying by 0.94 should give us better temperature measurements.

figure(5)
xlabel('Corrected Virtual Potential Temperature');
ylabel('z (m)');
xlim([24 27])
title('August 2019 dataset')
grid on
hold on

plot(aug_vpt.*0.94 -273, solo_heights, '*r', 'LineWidth',2)
hold off

%As can be seen, this gives us much more reasonable temperature values. The
%slope here is negative, indicating a super-adiabatyic, or unstable,
%bondary layer. This matches up with the conclusions from the temperature
%data from part c. These values are also much closer to the values from
%part c, but don't have the same two values that are much lower than the
%rest, indicating that those two are in fact outliers.
```