P6317 Assignment III

Due, Monday, December 2, 2019

1) [5] Your are calibrating a circular piston source of radius 20 cm over the frequency range from 5 kHz to 50 kHz. How far away from the source should the test hydrophone be placed in order to avoid near-field effects?

2) [5] A typical hydrophone has a sensitivity of about S = -170 dB (re 1 V/μPa). You paid $2000 for the preamplifier and it has a noise level of 20 nV (that means that if a signal is bigger than 20 nV you can see it). At what maximum range can you expect to detect a 100 dB (re 1 μPa), 10 kHz source? (assume spherical spreading and use an absorption value of 0.001 dB/m).

3a) [8] For the 200 kHz echosounding record shown on the following figure, label the bottom, the surface, the location of fish schools and individual fish. If the sound speed is 1475 m/s, what is the minimum depth shown in the echosounding. Explain the cause of the "multiple" bottom expressing where you would expect it in apparent distance (or time) compared to the real bottom. Comment on the accuracy of the depth given that the sound speed has been fixed at an arbitrary value. For a reasonable range of sound speeds, what uncertainty should be assigned to any given depth?

3b) [2] If the vessel making the echosounding is traveling at 3 m/s, what is the maximum bottom slope in this area. How does this slope compare with the apparent slope of the bottom in the echosounding?

4) [10] In a matlab data file *p6317.mat* I will send along to you there is data from a 300 kHz ADCP deployed looking upward from a 150 m depth. The data was collected in a protected inlet: Smith Sound (NL). The instrument was configured to collect 75 1.2 m bins. I have sampled this data so that there is one sample per hour for the first month of 2005. In the file you will find variables: V1_s, V2_s, V3_s, and V4_s which represent the velocities (in mm/s) observed for the four instrument beams (positive velocity is toward the instrument). Take this data and using the instrument heading information (variable Hdg_s which indicates the compass heading of beam 3) convert it into east and north component velocities. You can cheat to see if you got the right answer because there is also Ve_s and Vn_s as computed by the instrument itself (exact agreement will be imposible because of the way I averaged the data). Also of possible interest are the backscatter intensities, I1_s, I2_s, I3_s, and I4_s. The compass direction identifies the +Y direction of the instrument. The beams 1, 2, 3, and 4 are directed in the +X, -X, +Y, -Y directions respectively. The beams are tilted at 20° to the vertical.

Please submit your code along with your results.

1] Circular piston, 20 cm radius frequency range is 5 - 50 kHz, how far away to far field?

Wavelength $= \frac{c}{f}$ $\quad 0.03 < \lambda < 0.3$ m

Near field is $\quad R < \frac{\pi a^2}{\lambda}$

$$0.419 < R < 4.19 \text{ m}$$

Should stay 4.2 m away.

[next time ask for non-logarithm approach!]

2] $SP = SL - TL - AL$

$$SP = SL - 20 \log_{10} R - \alpha R$$

$\mathcal{V}L \equiv$ Voltage level $= S + SP$

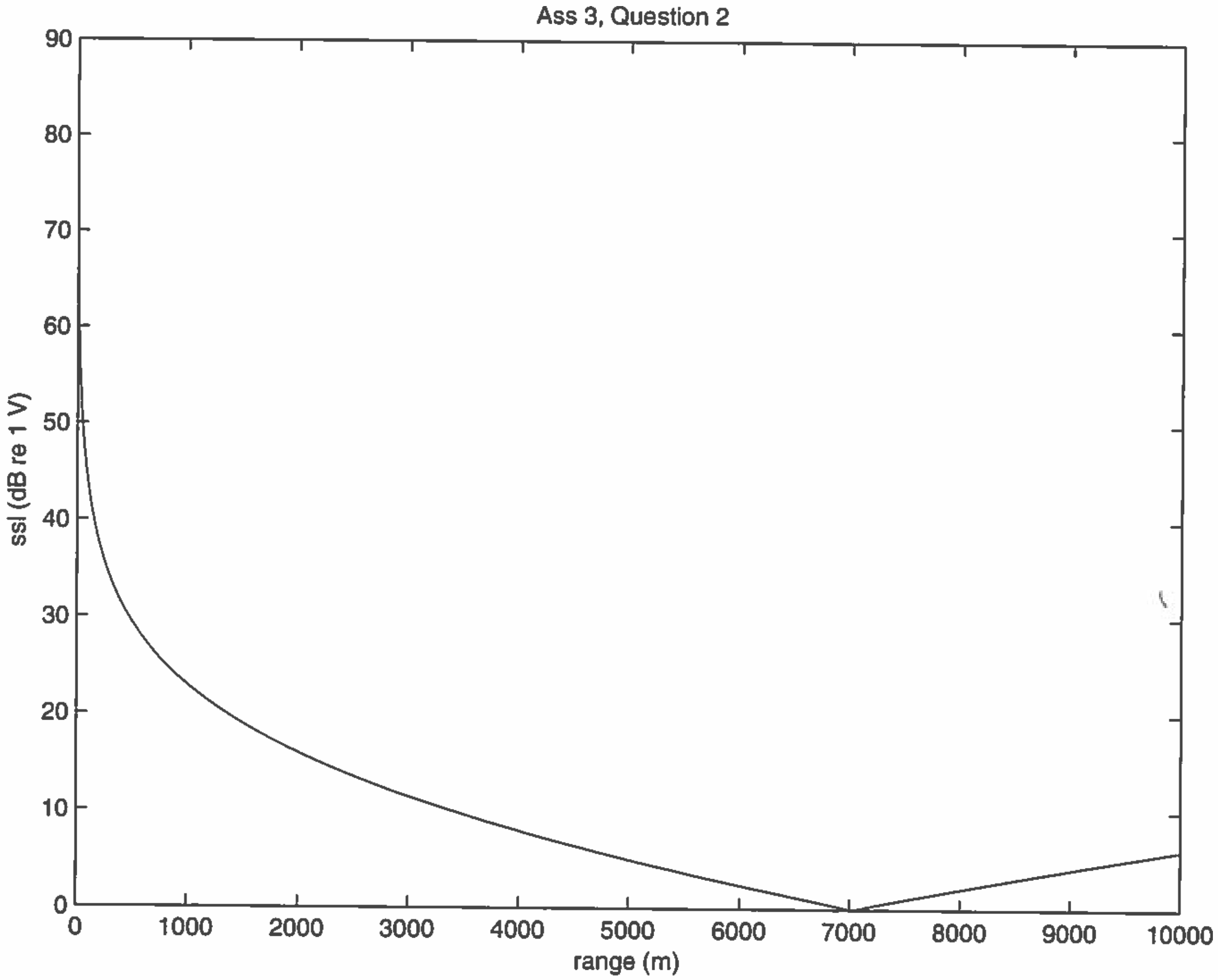
$$\mathcal{V}L = S + SL - 20 \log R - \alpha R$$

$-153{,}9 \quad -170 \quad 100$

I need $\mathcal{V}L = 20 \log_{10} V > 20 \log_{10} (20 \cdot 10^{-9})$

Used matlab .. $R = 7035$ m

```


R = 1:1:10000;

alpha = 0.001;    % db/m
SL = 100;         % source level
S = -170;         % sensitivity V/uPa
SSL = 20*log10(20e-9);

ssl = S + SL - 20*log10(R) - alpha * R;

[ival ibin] = min(abs(ssl-SSL));

DRange = R(ibin);

figure(1)
clf
plot(R,abs(ssl-SSL));
xlabel('range (m)')
ylabel('ssl (dB re 1 V)')
title('Ass 3, Question 2')
```


Ass 3, Question 2
90
80
70
60
50
40
30
20
10
0
ssl (dB re 1 V)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
range (m)

1a 8

Fish schools ($\frac{1}{2}$)
Individual fish ($\frac{1}{2}$)
Surface ($\frac{1}{2}$)

Bottom ($\frac{1}{2}$)
minimum depth ~44 m ②

— multiples at integral ranges of original depth ②
caused by sound bouncing off the surface
and back to the bottom

— Sound speed is set to 1475 but realistically
could be 1450 – 1550 or 100/1450 ⇒ 7% ! ②

1b 2

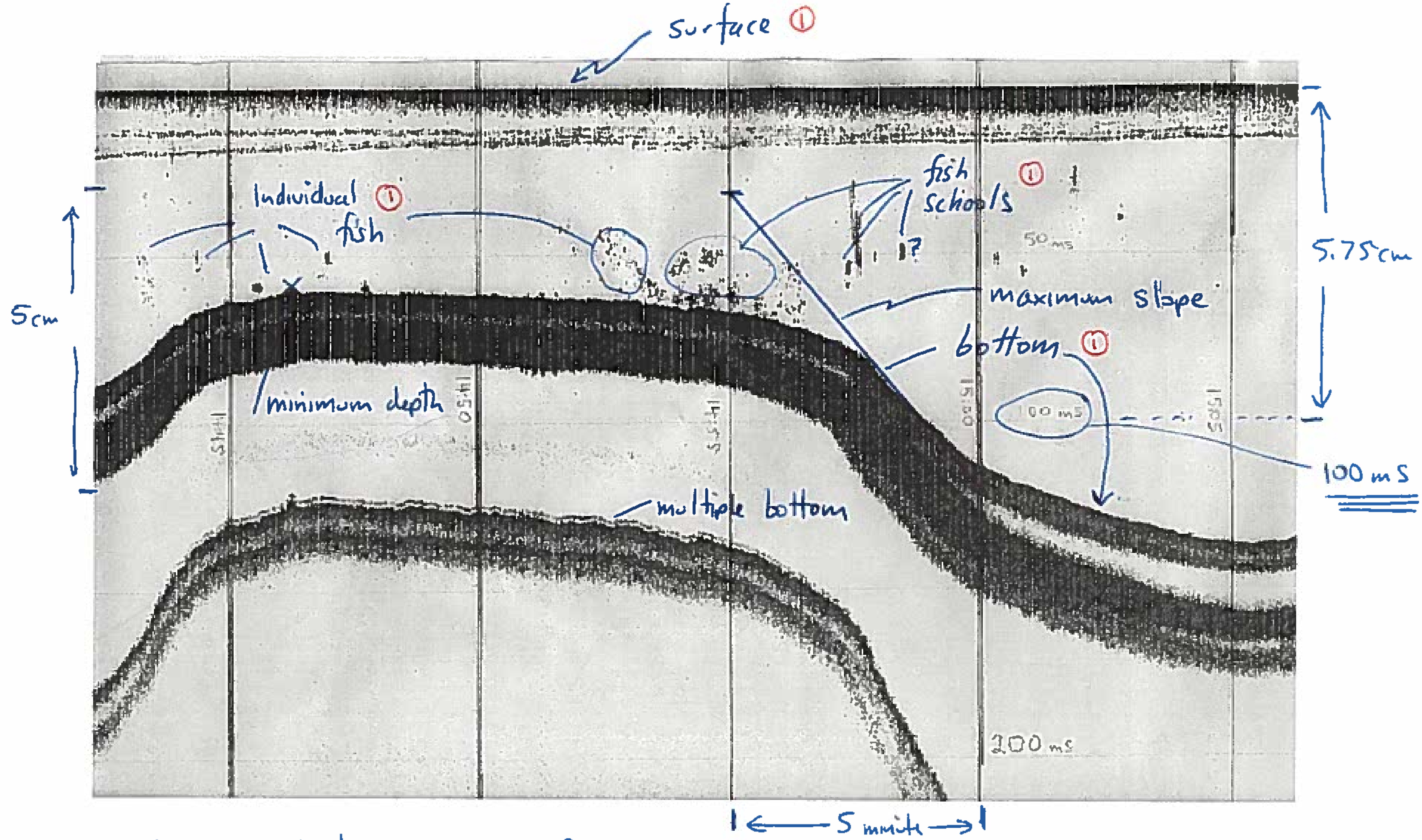
Slope is ~7% ②

Slope: $5\,\text{min} \times 60\,\frac{\text{s}}{\text{min}} \times 3\,\text{m/s} = 900\,\text{m}$

$5\,\text{cm} \times \frac{100\,\text{ms}}{5.75\,\text{cm}} \times \frac{1475}{2}\,\frac{\text{m}}{\text{s}} \times \frac{1}{1000}\,\frac{\text{s}}{\text{ms}} = 64.1\,\text{m}$

$\frac{\Delta y}{\Delta x} = \frac{64.1}{900} = 0{,}071$

$\sim 7\,\%$



Minimum depth 3.45 cm from surface

from chart 5.75 cm ≙ 100 ms

$\frac{3.45}{5.75} \cdot 100 = 60\,\text{ms}$

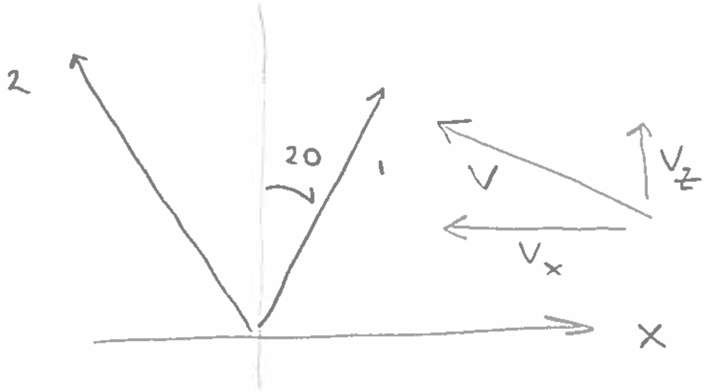
$\text{depth} = \frac{c \cdot t}{2} = \frac{1475\,\frac{\text{m}}{\text{s}} \cdot 60 \cdot 10^{-3}\,\text{s}}{2}$

$= 44\,\text{m}$

②

ADCP data

Consider beam 1, 2



For a horizontal velocity compount V_x, and vertical V_z, V_1 samples $V_1 \cdot \vec{V}$

$$\hat{V}_1 = \sin 20\,\hat{i} + \cos 20\,\hat{k}$$

$$V_1 = \hat{V}_1 \cdot \vec{V} = V_x \sin 20 + V_z \cos 20$$

similarly

$$V_2 = \hat{V}_2 \cdot \vec{V} = -V_x \sin 2 + V_z \cos 20$$

$$\hat{V}_1 \cdot \vec{V} - \hat{V}_2 \cdot \vec{V} = 2 V_x \sin 20 = V_1 - V_2$$

$$\boxed{V_x = \frac{(V_1 - V_2)}{2 \sin 20}}$$

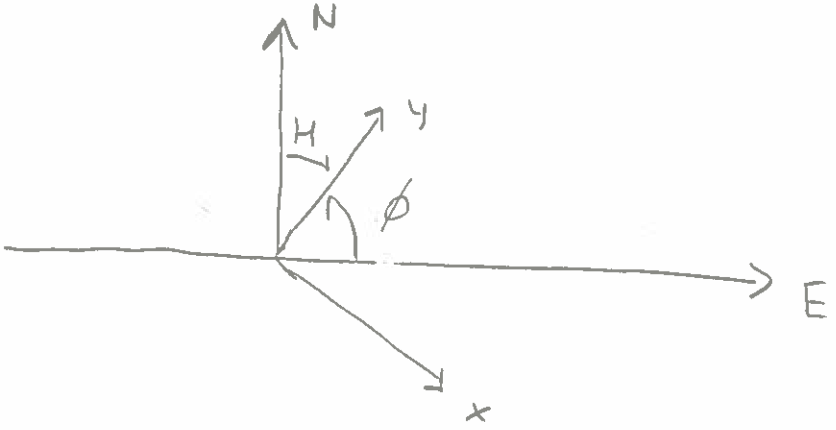
and can also show

$$\boxed{V_z = \frac{(V_1 + V_2 + V_3 + V_4)}{4 \cos 20}}$$

similarly

$$\boxed{V_y = \frac{(V_3 - V_4)}{2 \sin 20}}$$

Now rotate to "earth" coordinate system



It's DANGEROUS working with compass headings what you need to do is convert to angle relative to +ve x ... once you have that all the math works correctly. I'll call that ϕ for Sarah.

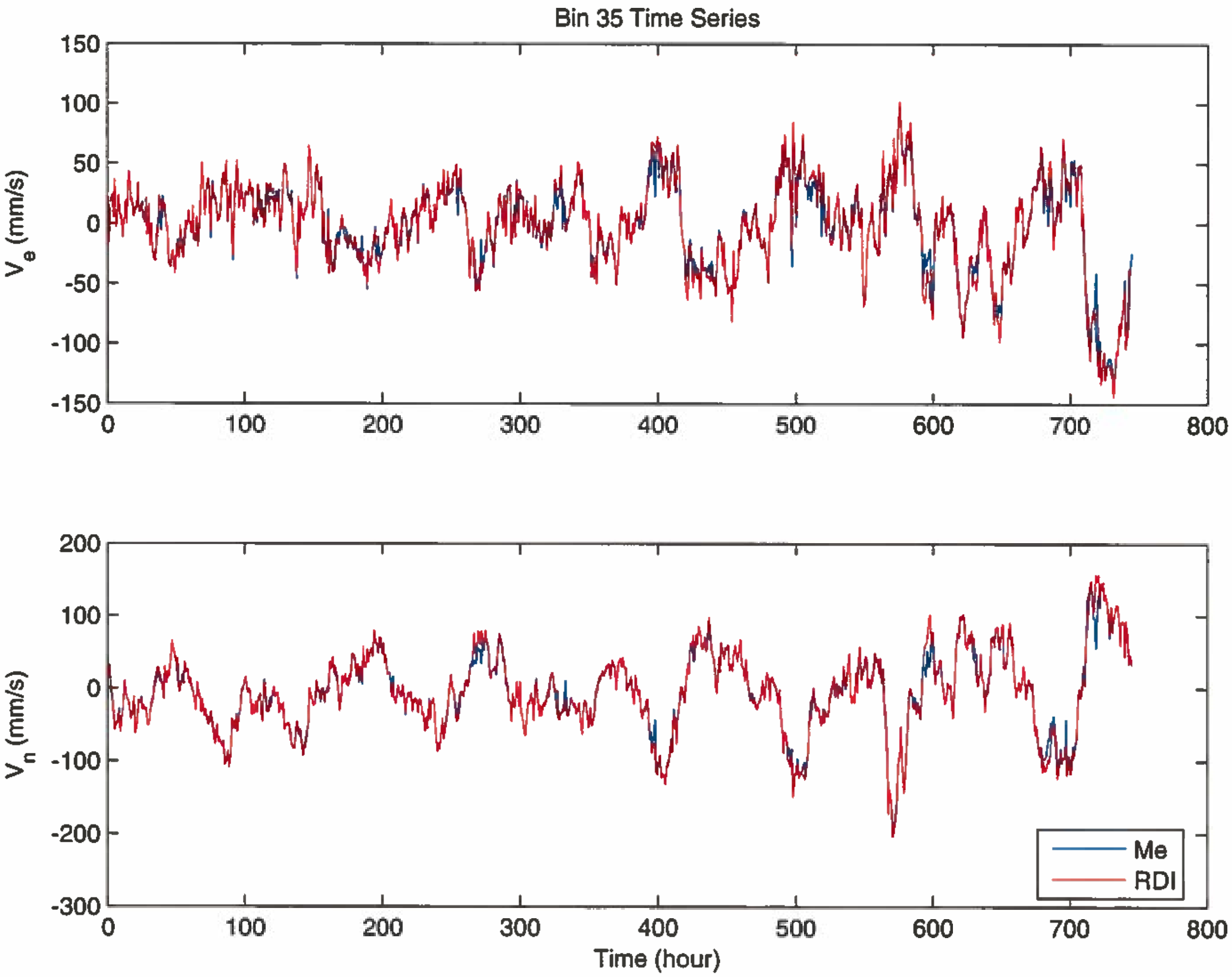
$$\phi = 90 - H$$

solving problem in Q1 translates correctly to Q2, 3, & 4!

Then

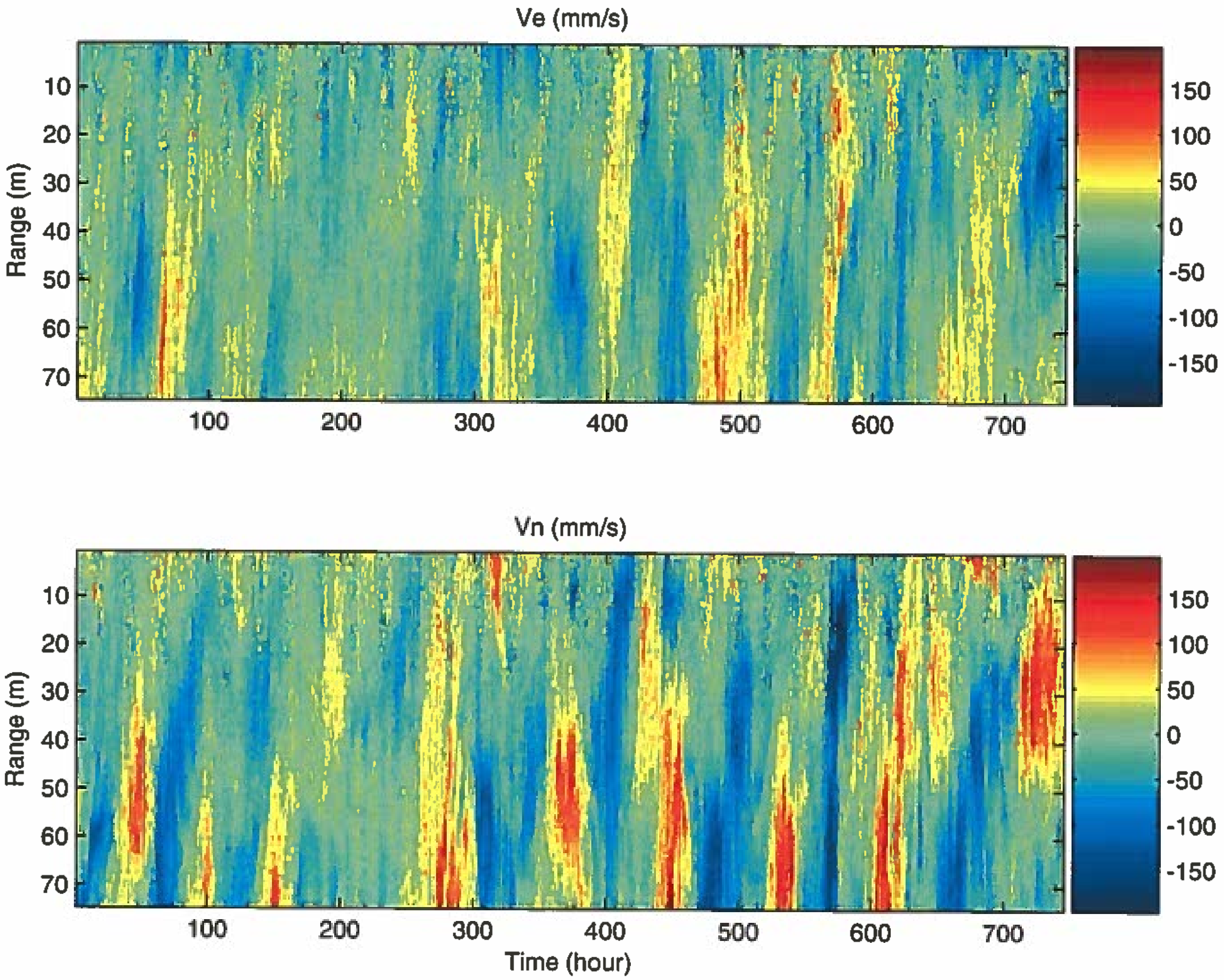
$$V_E = V_x \sin\phi + V_y \cos\phi$$

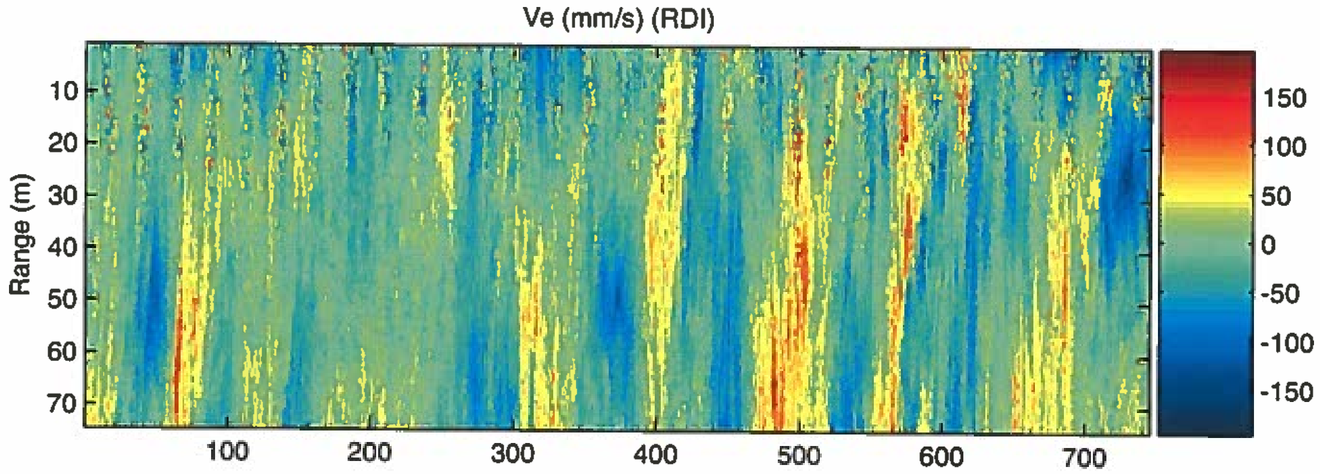
$$V_N = -V_x \cos\phi + V_y \sin\phi$$


Bin 35 Time Series
150
100
50
0
-50
-100
-150
V_e (mm/s)
0
100
200
300
400
500
600
700
800
200
100
0
-100
-200
-300
V_n (mm/s)
Me
RDI
0
100
200
300
400
500
600
700
800
Time (hour)

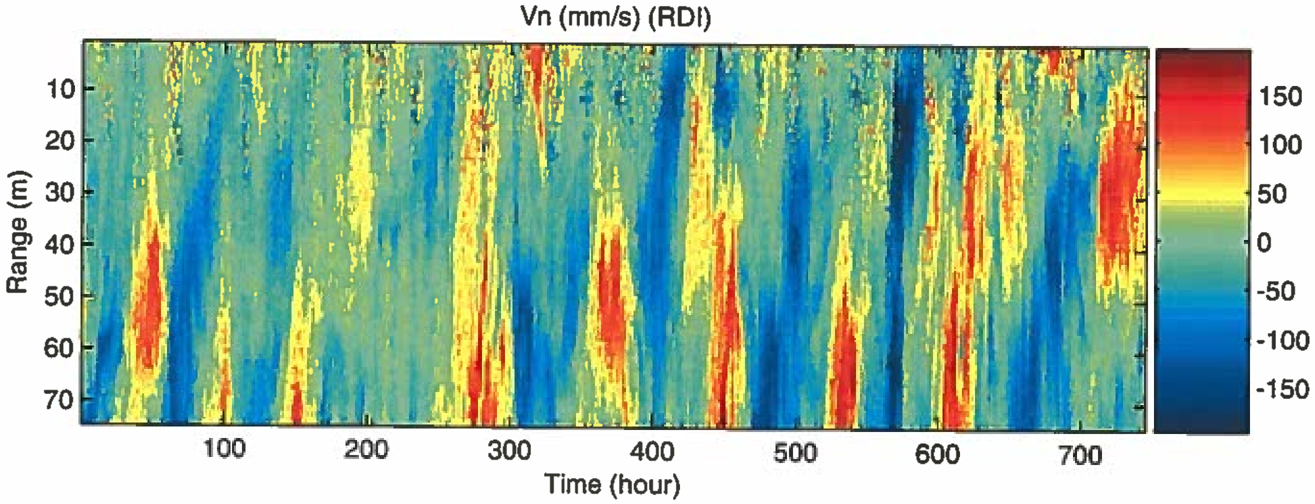
```matlab

%  Assignment 3, Question 4

load p6317

V1_s = -V1_s;      % make positive "away from" transducer
V2_s = -V2_s;
V3_s = -V3_s;
V4_s = -V4_s;

%
%  solve for x, y, and z components wrt instrument
%


Vx = (V1_s - V2_s)./(2*sin(20/180*pi));
Vy = (V3_s - V4_s)./(2*sin(20/180*pi));
Vz = (V1_s + V2_s + V3_s + V4_s) ./ (4 * cos(20/180*pi));

%
% convert heading into radians wrt +ve x axis
%

[idim ilen] = size(Vx);
phi = 90 - Hdg_s;
phi_r = ((phi/180*pi)' * ones(1,idim))';    % manipulate array into
                                             % matrix size of Vx


%
%  Rotate Vx and Vz to Vn and Ve
%

Ve = Vx .* sin(phi_r) + Vy .* cos(phi_r);
Vn = -Vx.* cos(phi_r) + Vy .* sin(phi_r);

%
% scaling information for axes
%

range = 1.2 * 1:idim;
hour = 1:ilen;

%
% colour images of entire data
% figure 1 for my velocities, figure 2 for RDI
%


figure(1)
clf
subplot(211)
imagesc(hour,range,Ve,[-200 200]);
```

```
ylabel('Range (m)')
title('Ve (mm/s)')
colorbar
subplot(212)
imagesc(hour,range,Vn,[-200 200]);
ylabel('Range (m)')
xlabel('Time (hour)')
title('Vn (mm/s)')
colorbar

figure(2)
clf
subplot(211)
imagesc(hour,range,Ve_s,[-200 200]);
ylabel('Range (m)')
title('Ve (mm/s) (RDI)')
colorbar
subplot(212)
imagesc(hour,range,Vn_s,[-200 200]);
ylabel('Range (m)')
xlabel('Time (hour)')
title('Vn (mm/s) (RDI)')
colorbar

%
% plot single depth time series, much clearer comparison
%


figure(3)
subplot(211)
plot(hour,Ve(30,:))
hold on
plot(hour,Ve_s(30,:),'r')
hold off
ylabel('V_e (mm/s)')
title('Bin 35 Time Series')

subplot(212)
plot(hour,Vn(30,:))
hold on
plot(hour,Vn_s(30,:),'r')
hold off
ylabel('V_n (mm/s)')
legend('Me','RDI',4)
xlabel('Time (hour)')
```


Ve (mm/s)
Range (m)
10
20
30
40
50
60
70
100
200
300
400
500
600
700
150
100
50
0
-50
-100
-150
Vn (mm/s)
Range (m)
10
20
30
40
50
60
70
100
200
300
400
500
600
700
Time (hour)
150
100
50
0
-50
-100
-150



Ve (mm/s) (RDI)



Vn (mm/s) (RDI)