Physics and Physical Oceanography Data Report 2011-1

Analysis of Physical Oceanographic Data from St. George's Bay, NS

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Introduction

This study is a joint project between scientists at Memorial University, in St. John's, and Dalhousie University, in Halifax. This work is part of a larger national research partnership program, the Canadian Healthy Oceans Network (CHONE). This program is collaborative between scientists at academic institutions across the country and researchers from Fisheries and Oceans Canada. The goal of this particular study is to improve our understanding of the relationship between oceanographic dynamics and larval dispersion and survival. The key larvae to be studied are those of lobster (*Homarus americanus)*, a species which is commercially important throughout Atlantic Canada. Larvae of lobster drift for many tens of days after release before settling on the bottom. For the most part, they drift passively during this period so understanding the water circulation is crucial for determining where they end up and how oceanographic features determine their survival.

A key component in this work is to make measurements of the circulation in St. George's Bay, NS. This relatively small coastal embayment has a large lobster population and a relatively weak coastal circulation and so makes an ideal location in which to study the relation between circulation and lobster larval dispersal. The first step in this work is to make direct measurements of the water characteristics and circulation when lobster larvae are in the water, during the summer. To address this, five moorings were deployed in the summer of 2009. Each mooring had thermistors, located from near the surface to the bottom, to measure temperature, as well as Acoustic Doppler Current Profilers (ADCPs) for current measurement. The ADCPs provide measurements of the horizontal and vertical currents from very near the bottom to just below the surface, at a resolution of about 1 m.

The moorings were deployed from July 10-July 11, 2009 (days 190-191) and retrieved from August 21-August 22, 2009 (days 233-234) for a total of roughly 43 days. All times in this report are represented in year day, with January 1st being day 1. Times are indicated in Universal Time (UT). Both temperature and current velocity measurements were taken every 20 minutes for the entire sampling period. Mooring locations are shown in Figure 1. Further details about their locations and the ADCP specifications are found in Table 1 and Table 2. We provide very little interpretation of the currents in this report. This report is simply to present the data with the intent that these plots and results can be used for further analysis to understand the circulation of St. George's Bay.

Data Processing

Missing or bad data from both the thermistor and ACDP data were dealt with in the same manner: either they were replaced by linearly interpolated values from surrounding points if there was sufficient data, or if there was not, they were removed entirely and omitted from the plots. Only very small gaps in the data were interpolated in this manner, typically just one or two points. Specifically, ADCP current data for M4 were only available from July 10-14 (days 191-195), and the upper 2 m for M1, 1 m for M2, 2m for M3 and M4, and 5 m for M5 were removed due to backscatter effects in the data.

In Figures 2-6, averaged velocity vector data is shown as a time series. The mean magnitude of velocity components were taken over every 3-hour period and plotted with the magnitude of the velocity shown on the vertical axis, and the time represented on the horizontal axis. Wind data from Caribou Point, NS   (45°46' N, 62°41' W) available on the Environment Canada website (http://www.climate.weatheroffice.gc.ca/climateData/canada_e.html) are also shown in these figures.

Progressive vector plots, shown in Figure 8 were created by calculating the distance travelled at each mooring using the unfiltered velocity data for each 20 minute interval. The position after each day is marked with an ‘x’, and the start and end positions are each marked with an unfilled and a filled circle, respectively.

In both the current velocity and the temperature isotherm time series plots (Figures 9-18), data were filtered using a 5th order forward-and-reverse Butterworth low pass digital filter with a cut-off frequency of 30 hours in order to remove high frequency variability. The filtered data were then interpolated into 0.25 m bins in order to plot the isotherms.

Mooring	Latitude (°N)	Longitude (°W)	Water depth	Distance of first ADCP bin from seafloor (m)
M1	45 50.535	61 51.536	26.8	3.21
M2	45 46.977	61 46.66	24.7	2.1
M3	45 43.639	61 45.662	25.9	3.2
M4	45 43.109	61 37.474	24.4	2.11
M5	45 50.24	61 35.66	29.6	3.2

Table 1: 2009 mooring location specifications.

Mooring	Start time:			End time:			ADCP frequency	ADCP serial number
	Day	Hour	Minute	Day	Hour	Minute		
M1	190	20	20	233	15	0	307.2 kHz	2460
M2	191	19	20	234	15	20	614.4 kHz	2069
M3	191	19	0	234	16	0	307.2 kHz	2477
M4	191	17	0	234	1	0	614.4 kHz	3785
M5	191	16	0	234	17	0	307.2 kHz	1316

Table 2: 2009 ADCP specifications.

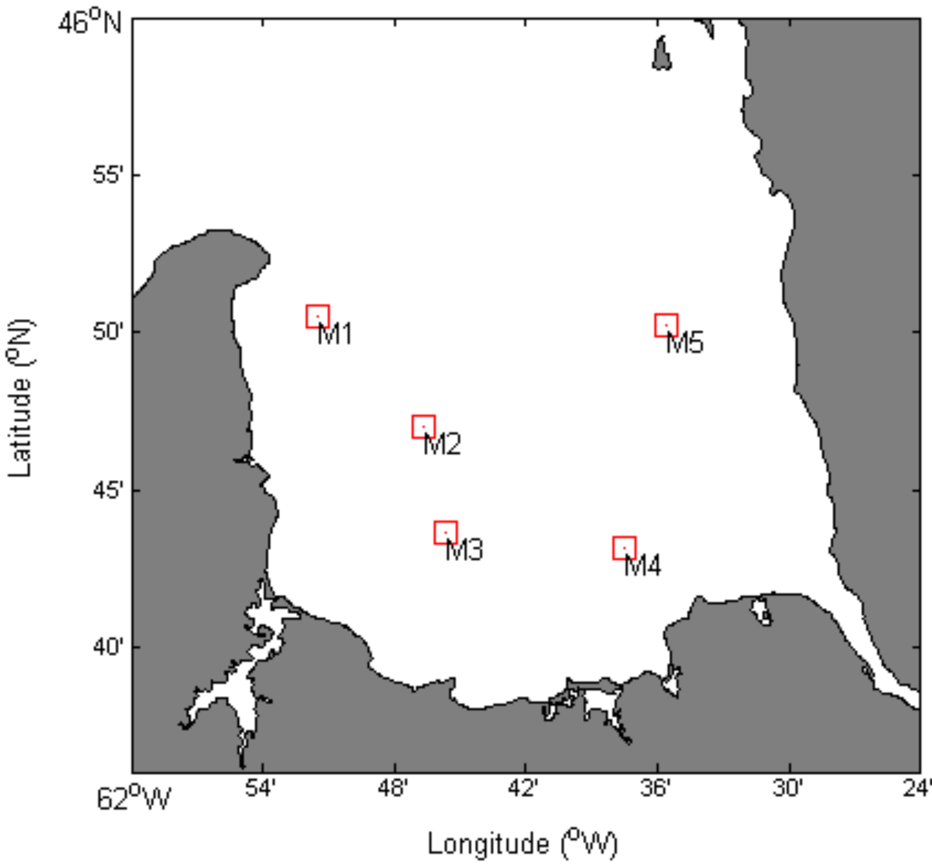
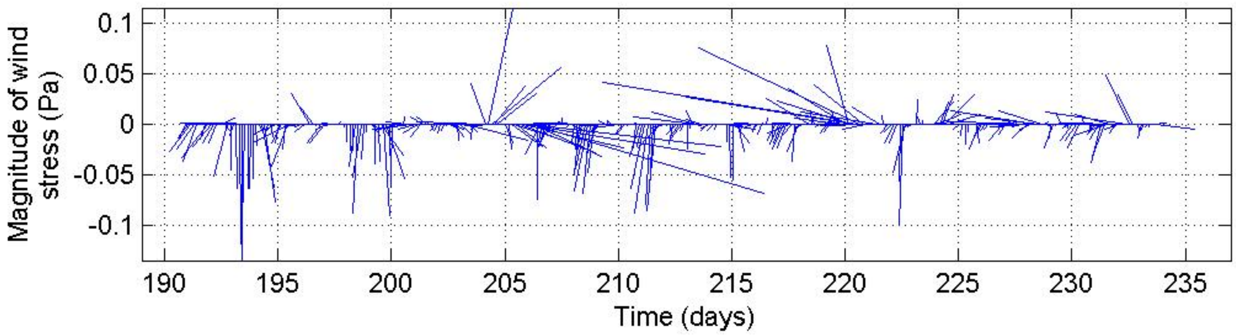


Figure 1: 2009 mooring locations for St. George's Bay, NS.

a)



b)

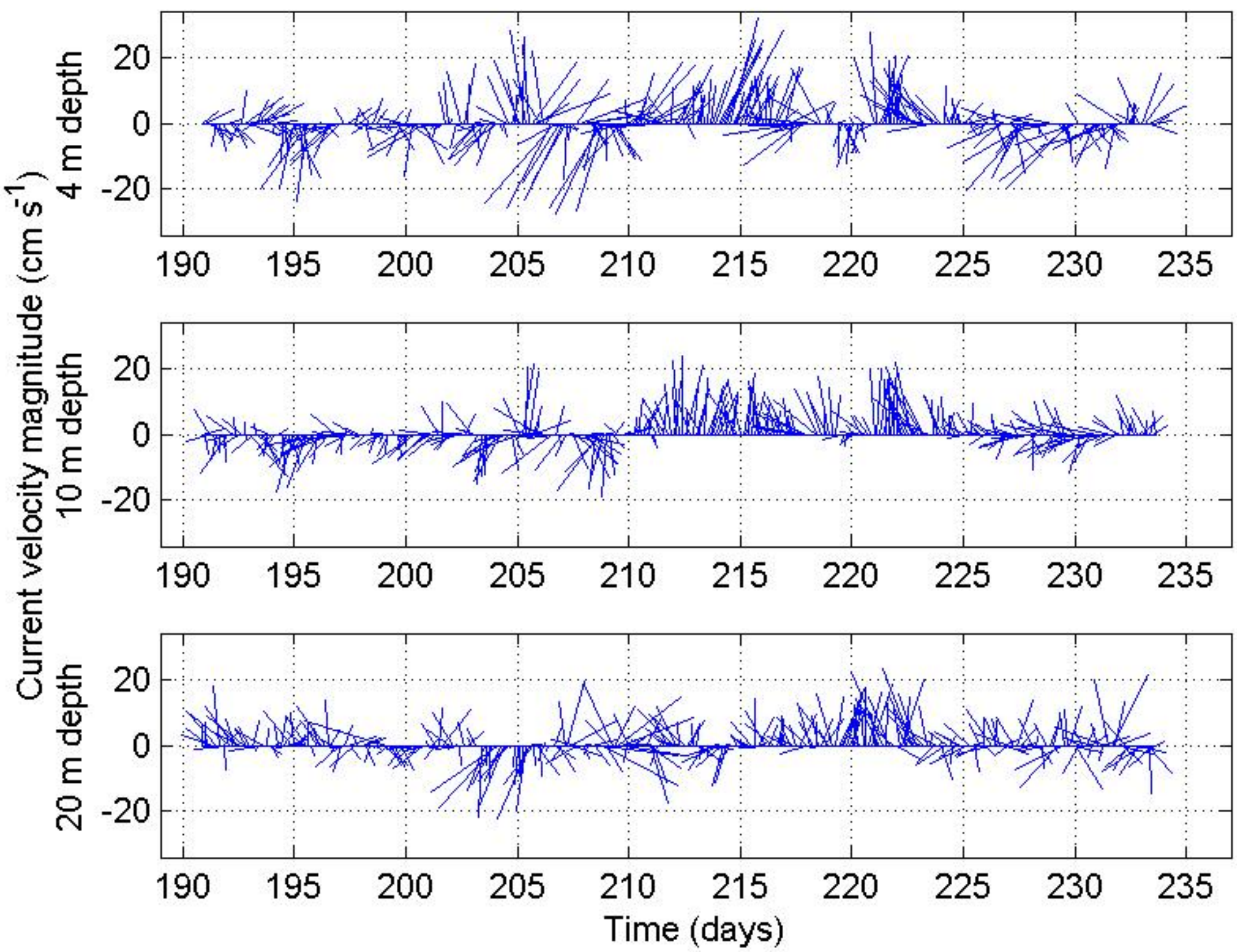
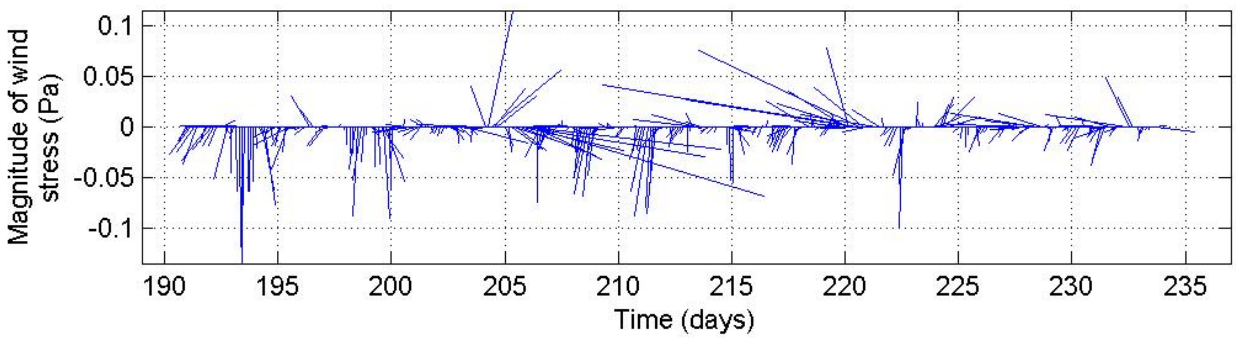


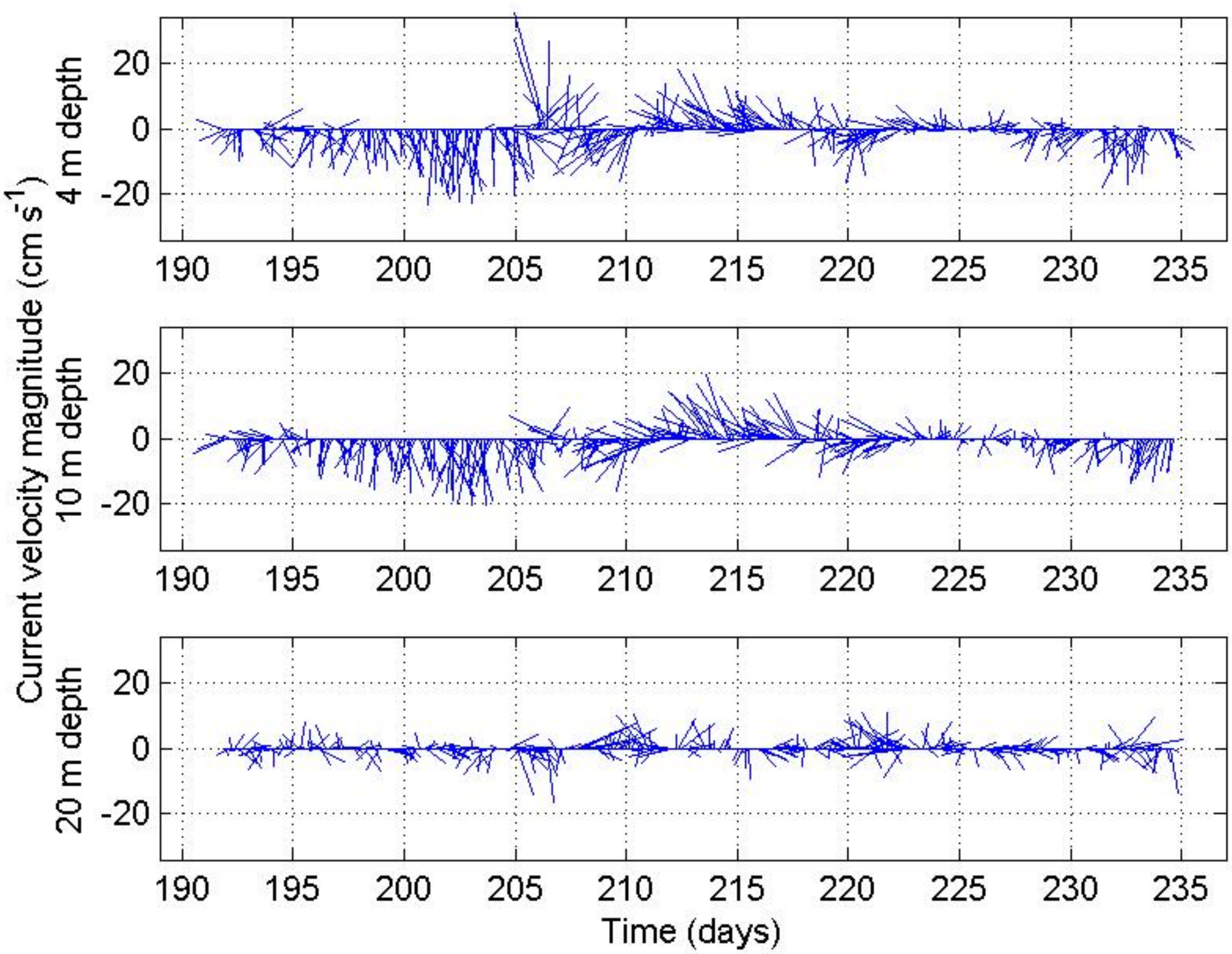
Figure 2: Magnitude and direction for a) wind stress and b) current velocity at surface (4 m), middle (10 m) and bottom (20 m) depths for mooring M1. Vectors shown represent averaged values of each 3 hour segment of the entire sampling period.

a)



0.1
0.05
0
-0.05
-0.1
Magnitude of wind stress (Pa)
190
195
200
205
210
215
220
225
230
235
Time (days)

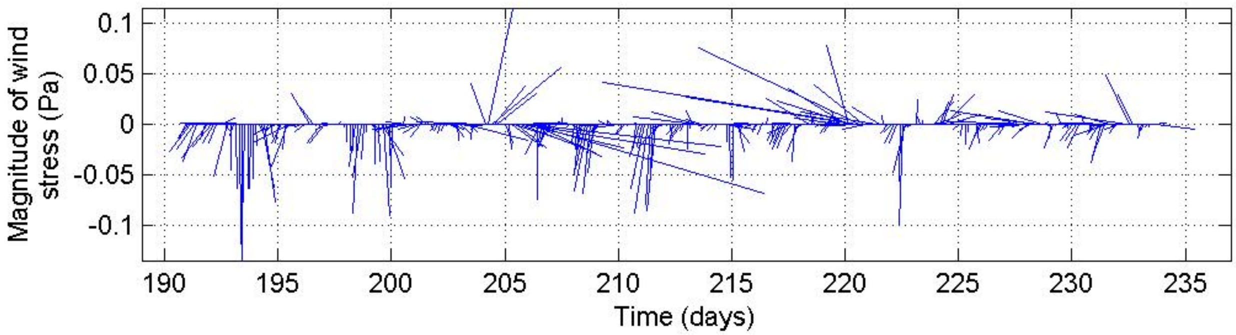
b)



Current velocity magnitude (cm s^{-1})
4 m depth
10 m depth
20 m depth
20
0
-20
190
195
200
205
210
215
220
225
230
235
Time (days)

Figure 3: Magnitude and direction for a) wind stress and b) current velocity at surface (4 m), middle (10 m) and bottom (20 m) depths for mooring M2. Vectors shown represent averaged values of each 3 hour segment of the entire sampling period.

a)



b)

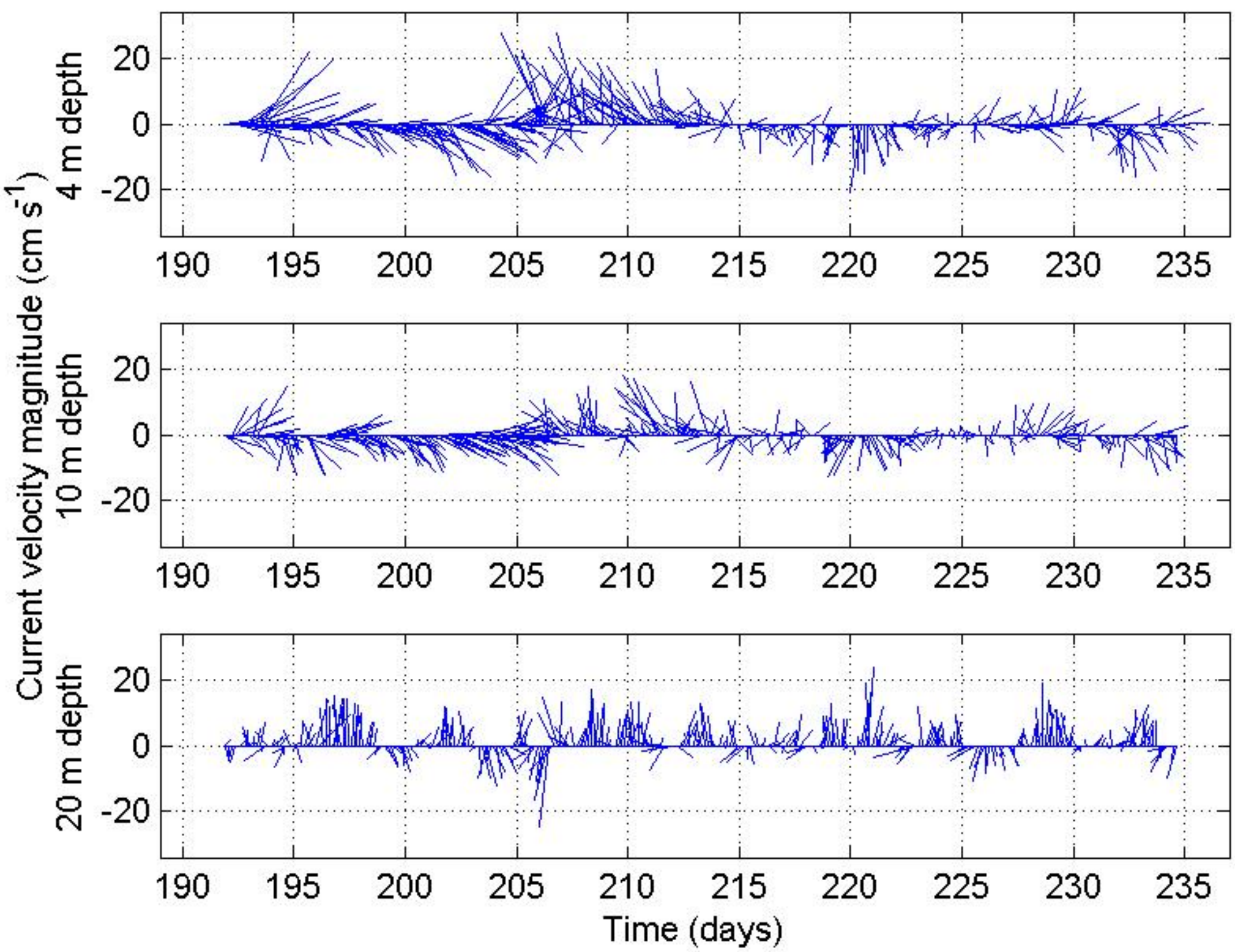
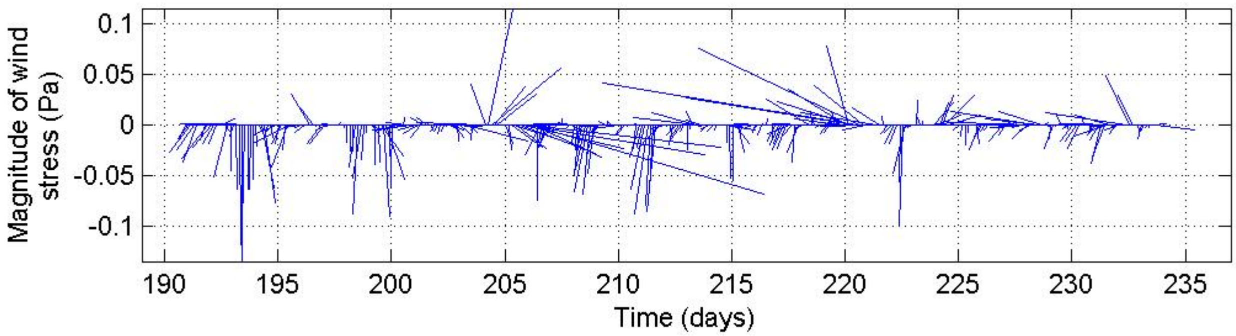


Figure 4: Magnitude and direction for a) wind stress and b) current velocity at surface (4 m), middle (10 m) and bottom (20 m) depths for mooring M3. Vectors shown represent averaged values of each 3 hour segment of the entire sampling period.

a)



b)

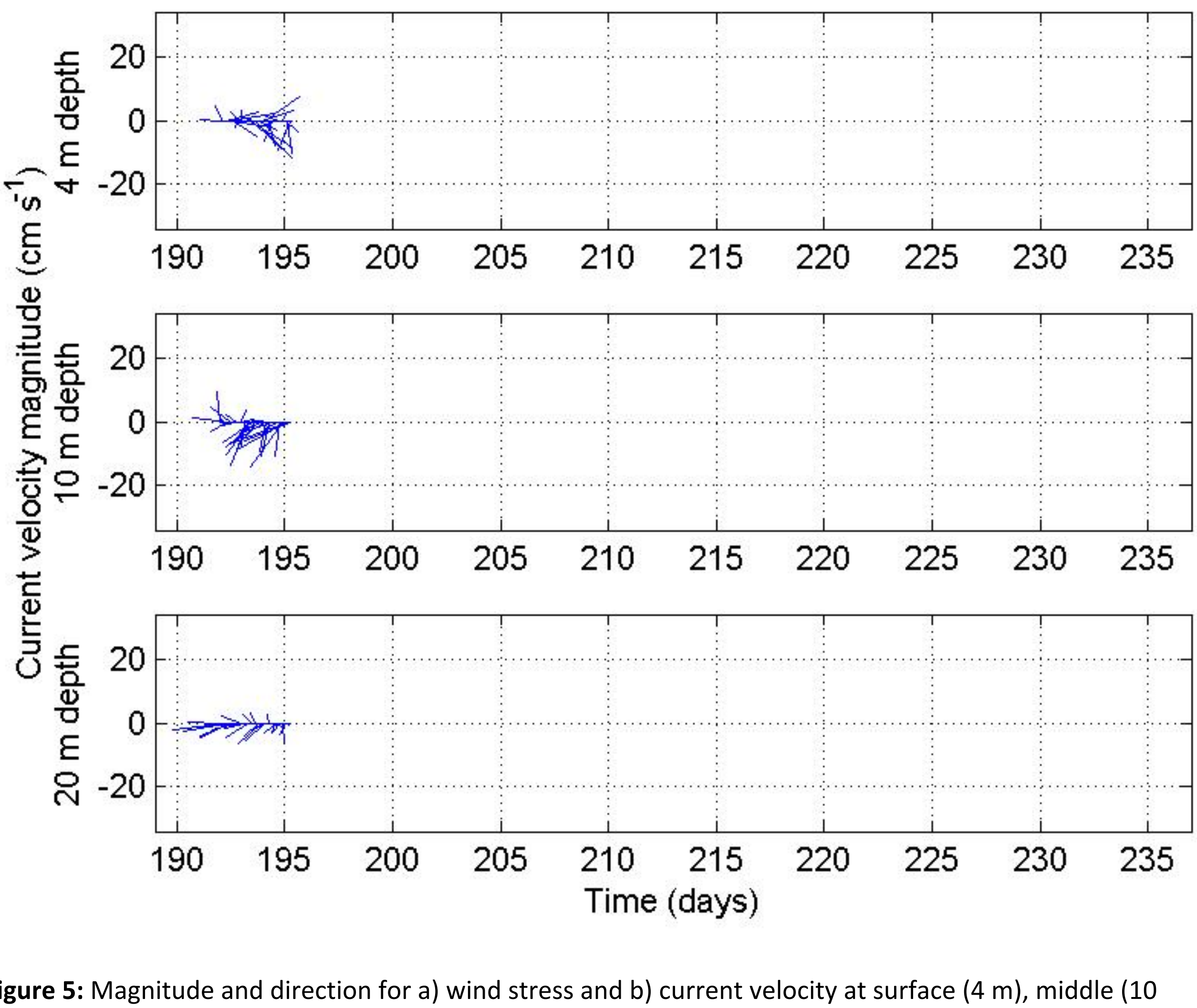
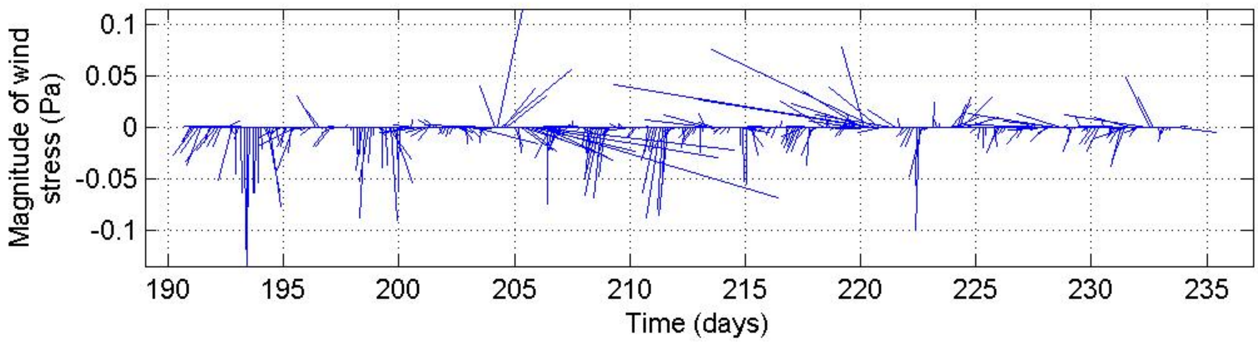


Figure 5: Magnitude and direction for a) wind stress and b) current velocity at surface (4 m), middle (10 m) and bottom (20 m) depths for mooring M4. Vectors shown represent averaged values of each 3 hour segment of the entire sampling period.

a)



b)

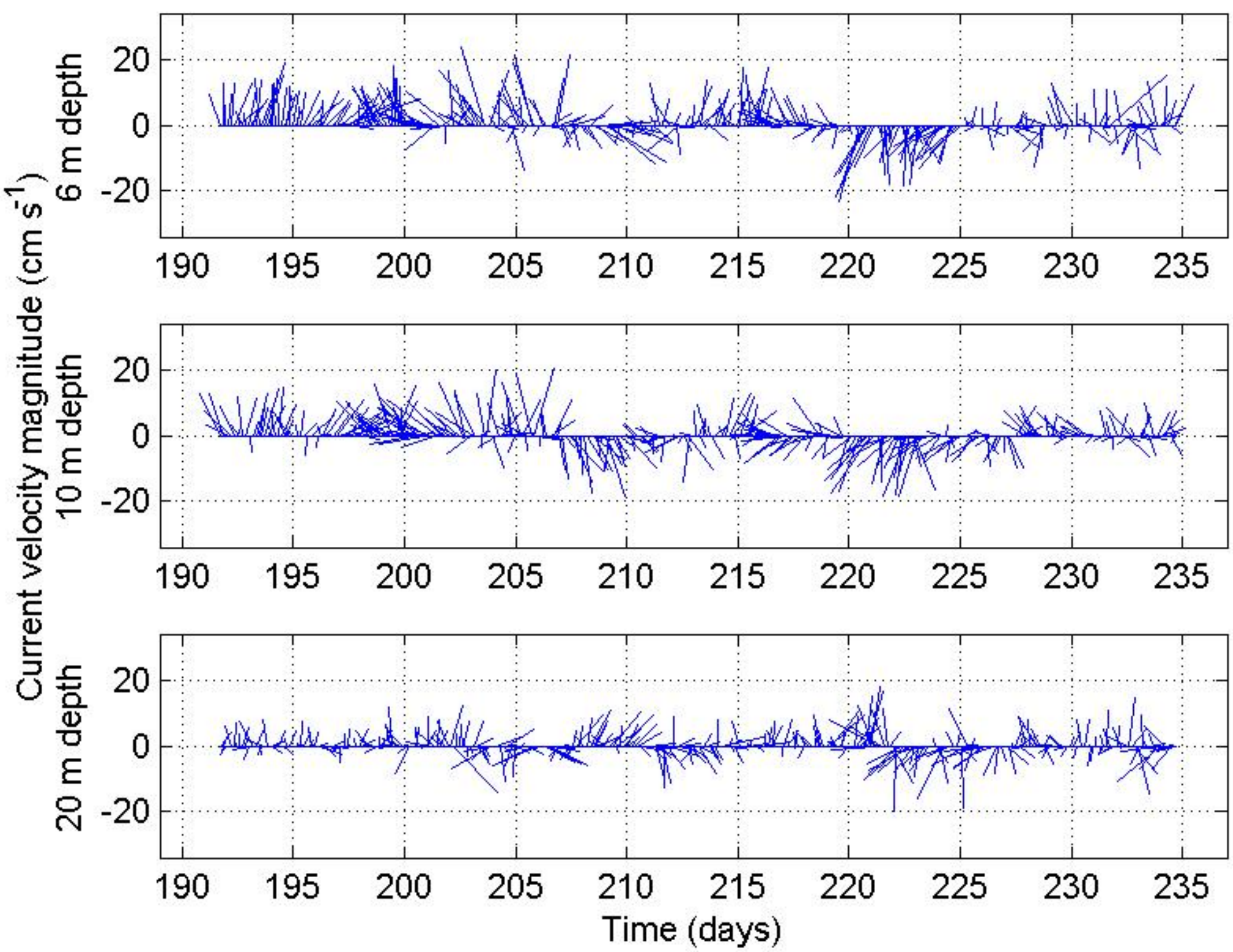
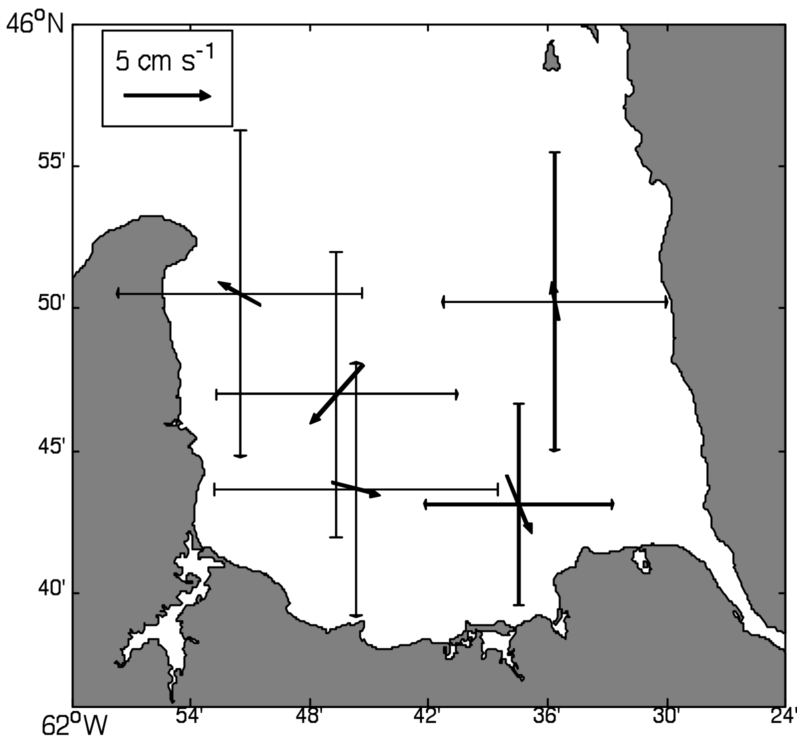
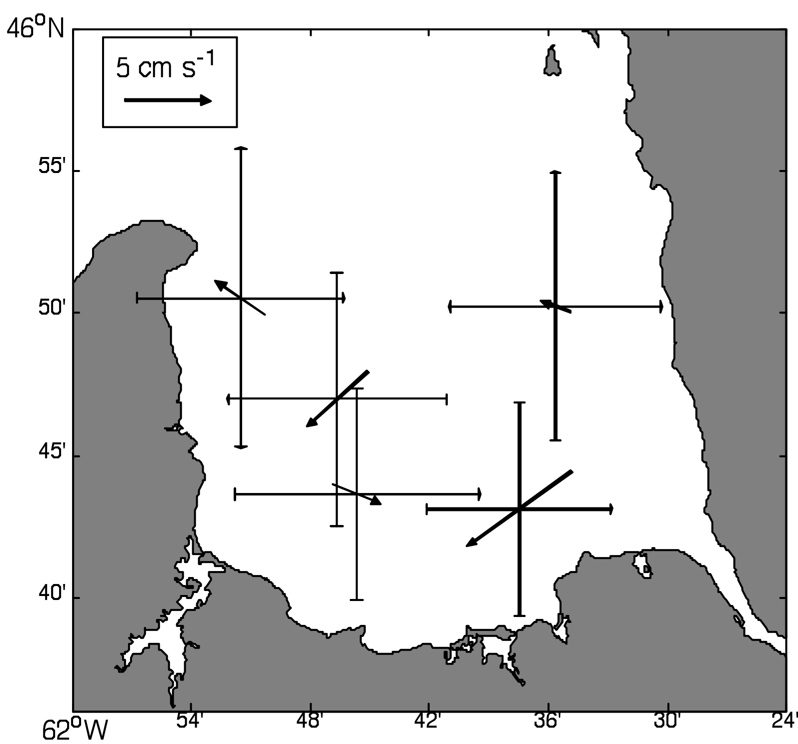


Figure 6: Magnitude and direction for a) wind stress and b) current velocity at surface (6 m), middle (10 m) and bottom (20 m) depths for mooring M5. Vectors shown represent averaged values of each 3 hour segment of the entire sampling period.

a)


46°N
5 cm s^{-1}
55'
50'
45'
40'
62°W
54'
48'
42'
36'
30'
24'

b)


46°N
5 cm s^{-1}
55'
50'
45'
40'
62°W
54'
48'
42'
36'
30'
24'

c)

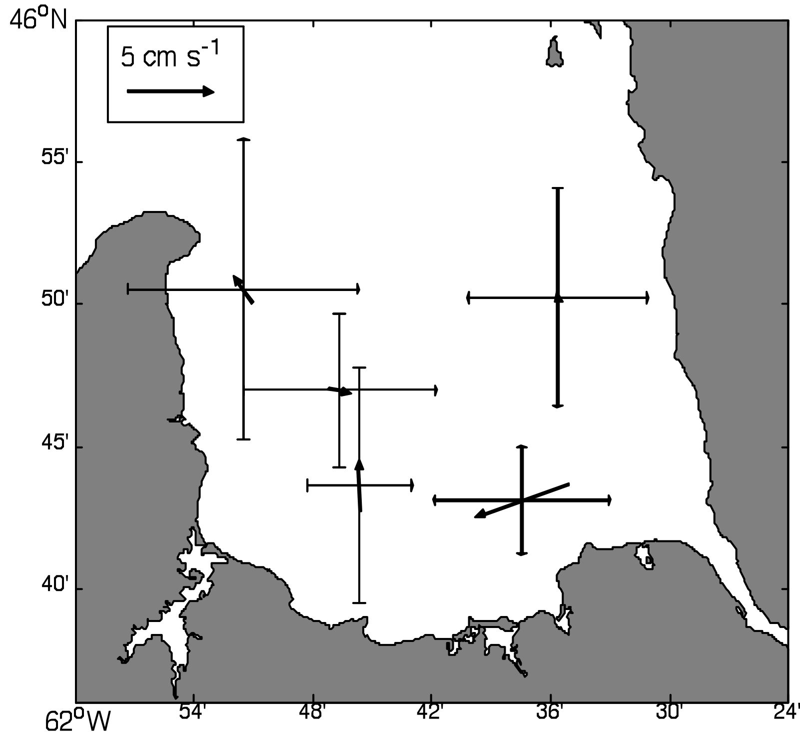
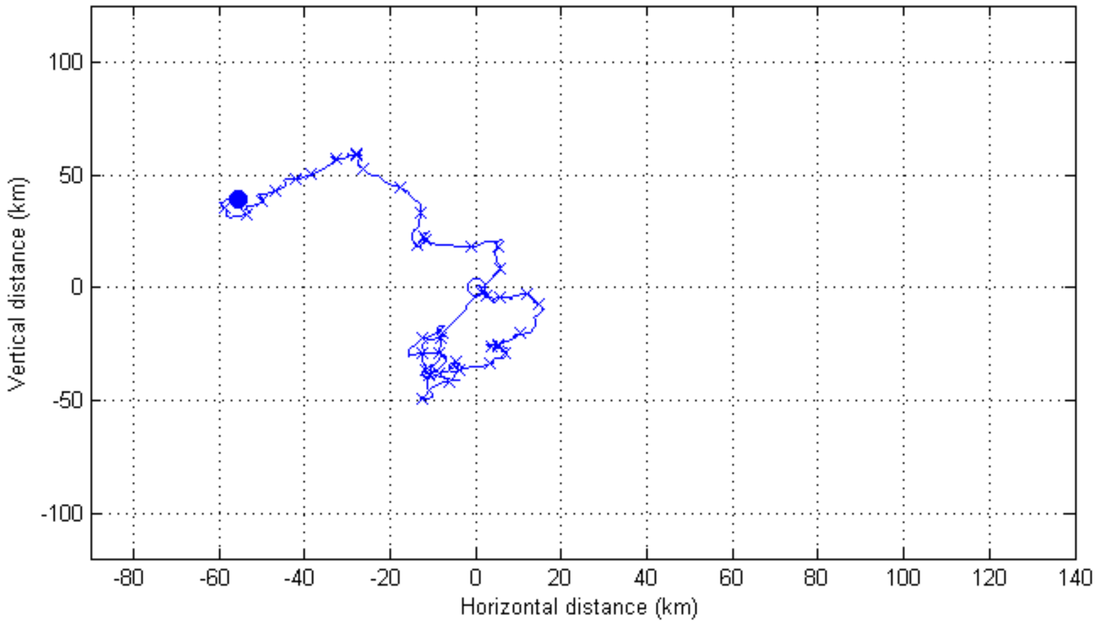


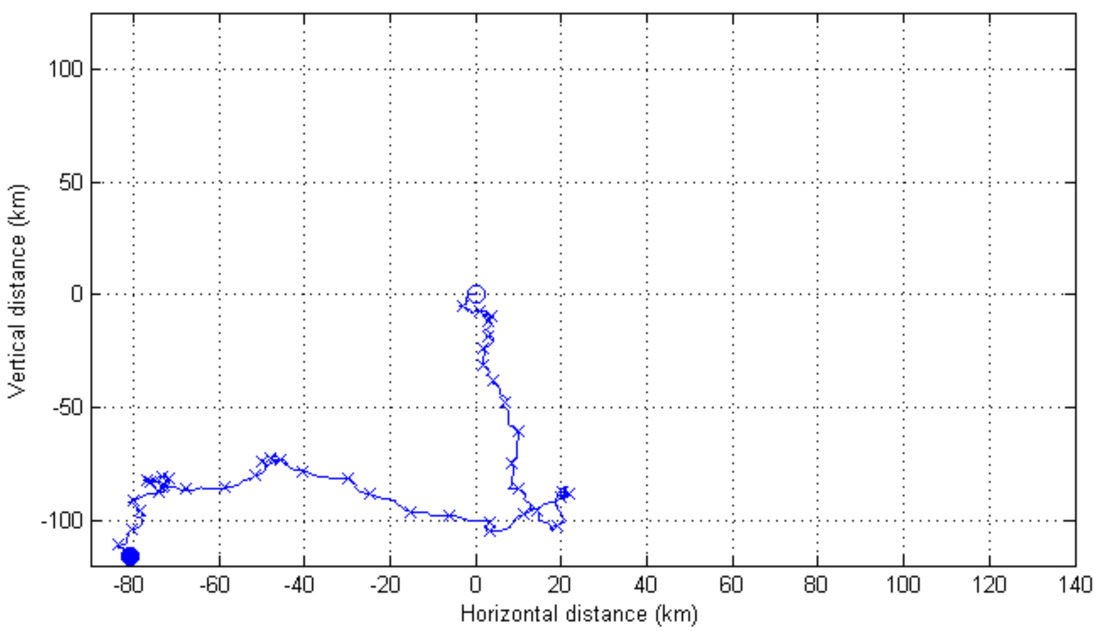
Figure 7: Mean current velocities over the full sampling period for a) 6 m, b) 10m, and c) 20 m depths. One standard deviation in both the N/S and E/W components of the current are shown.

a)



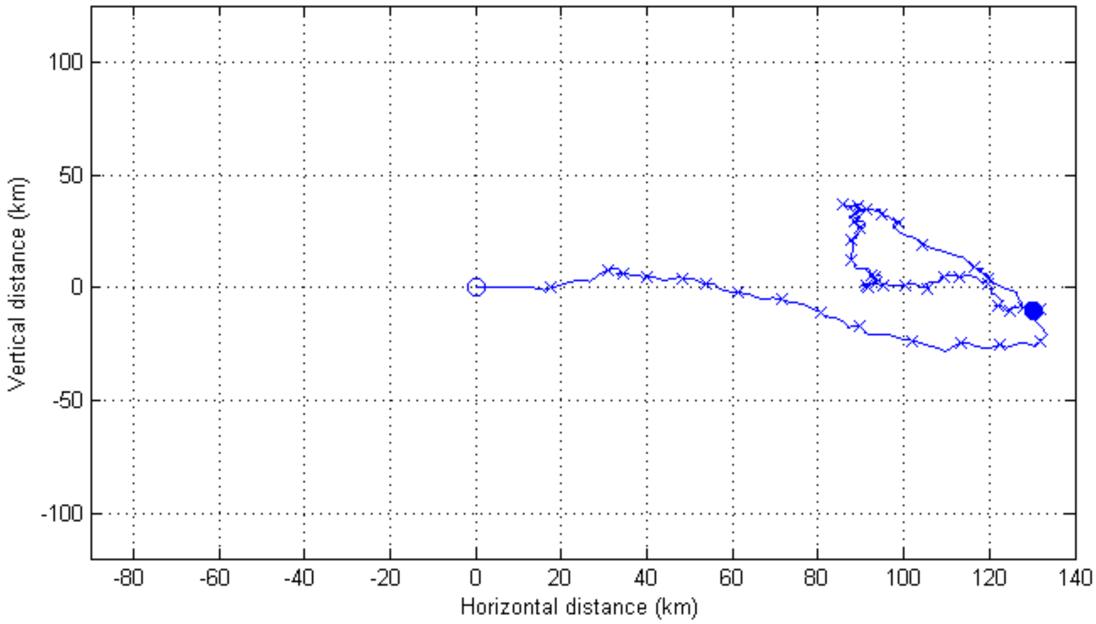
100
50
0
-50
-100
Vertical distance (km)
-80
-60
-40
-20
0
20
40
60
80
100
120
140
Horizontal distance (km)

b)

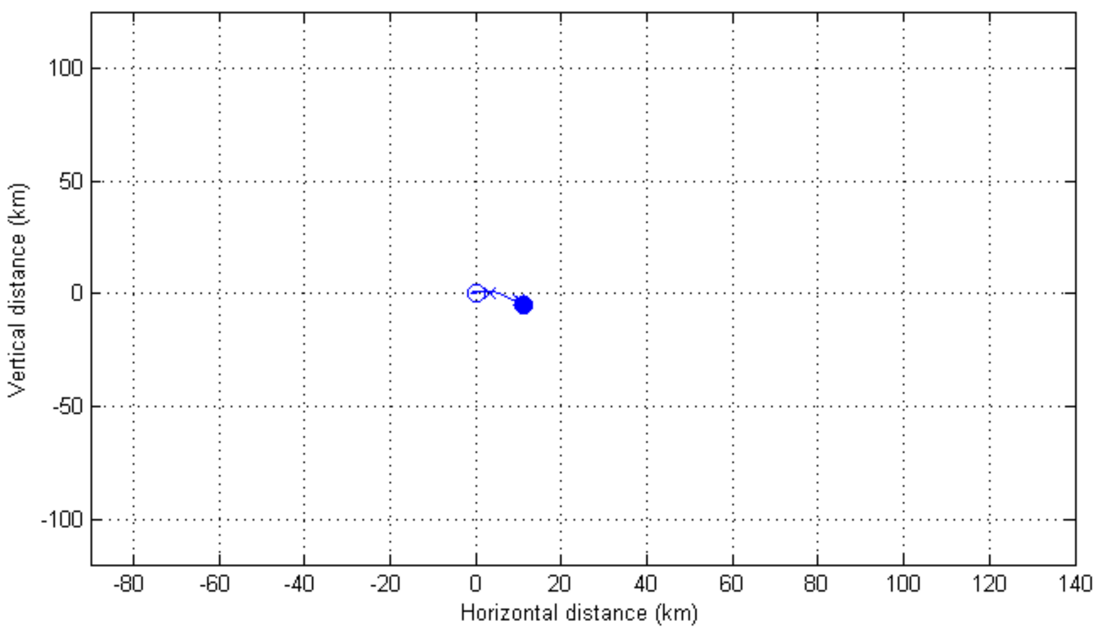


100
50
0
-50
-100
Vertical distance (km)
-80
-60
-40
-20
0
20
40
60
80
100
120
140
Horizontal distance (km)

c)


100
50
0
-50
-100
Vertical distance (km)
-80
-60
-40
-20
0
20
40
60
80
100
120
140
Horizontal distance (km)

d)


100
50
0
-50
-100
Vertical distance (km)
-80
-60
-40
-20
0
20
40
60
80
100
120
140
Horizontal distance (km)

e)

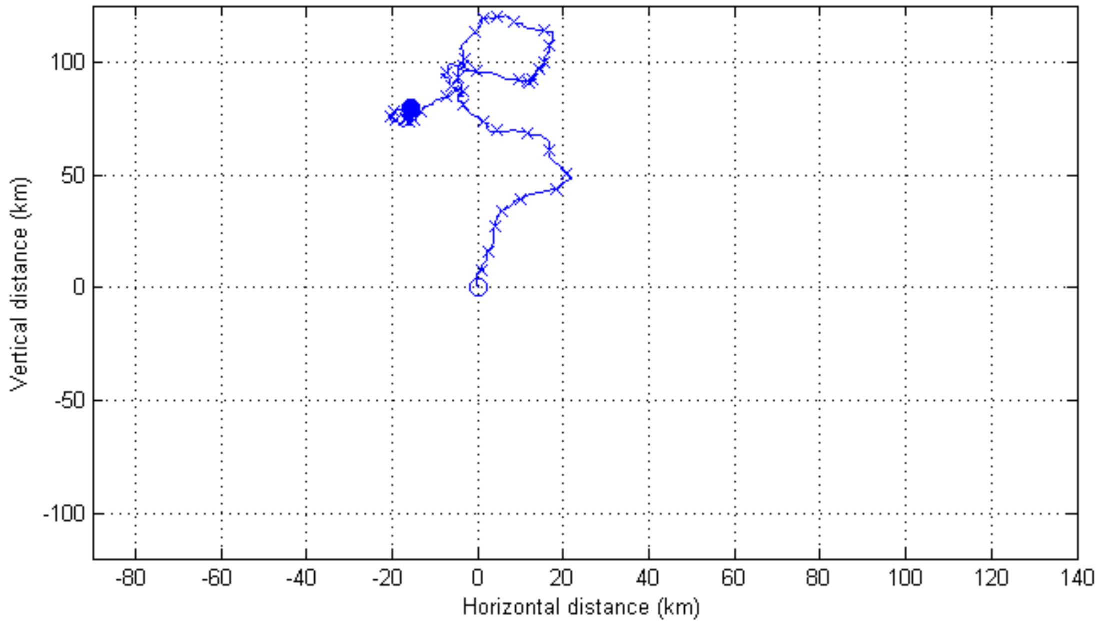
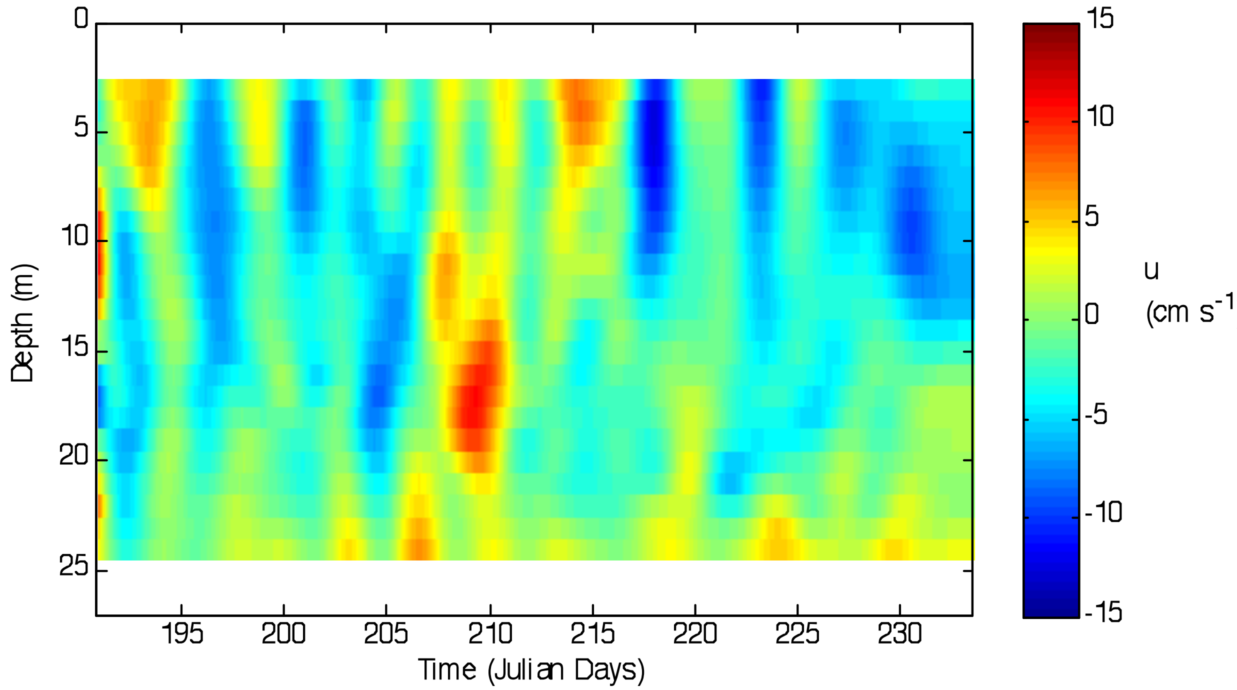


Figure 8: Position of object at 4 m depth for each mooring (6 m depth for M5): a) M1, b) M2, c) M3, d) M4 and e) M5. Starting position is shown as an unfilled circle, end position as a filled circle, and position after each day as an 'x'.

a)



b)

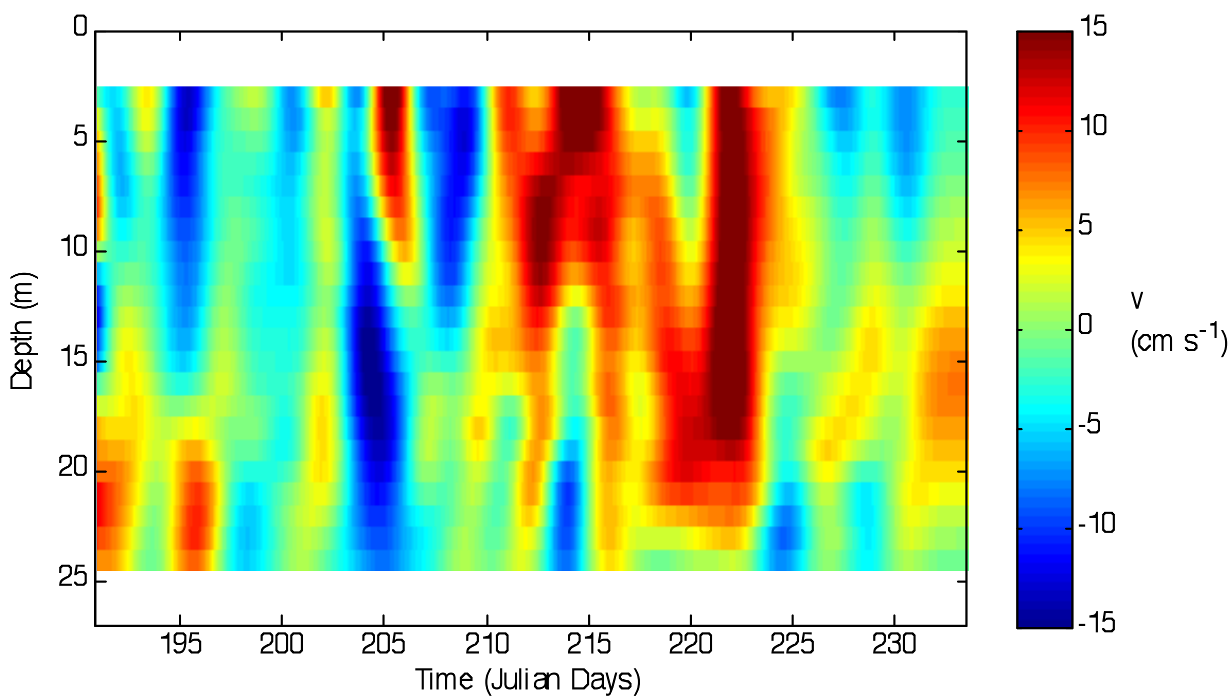
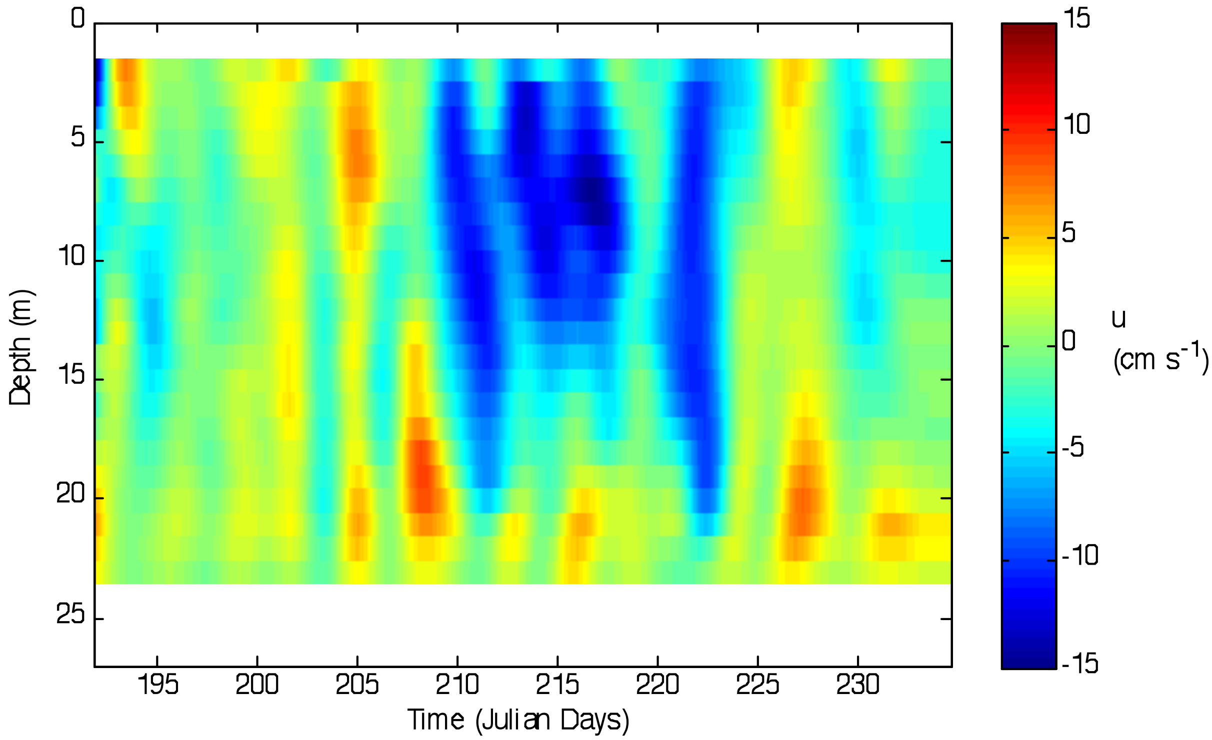


Figure 9: Magnitude of filtered a) u velocity and b) v velocity for mooring M1.

a)



b)

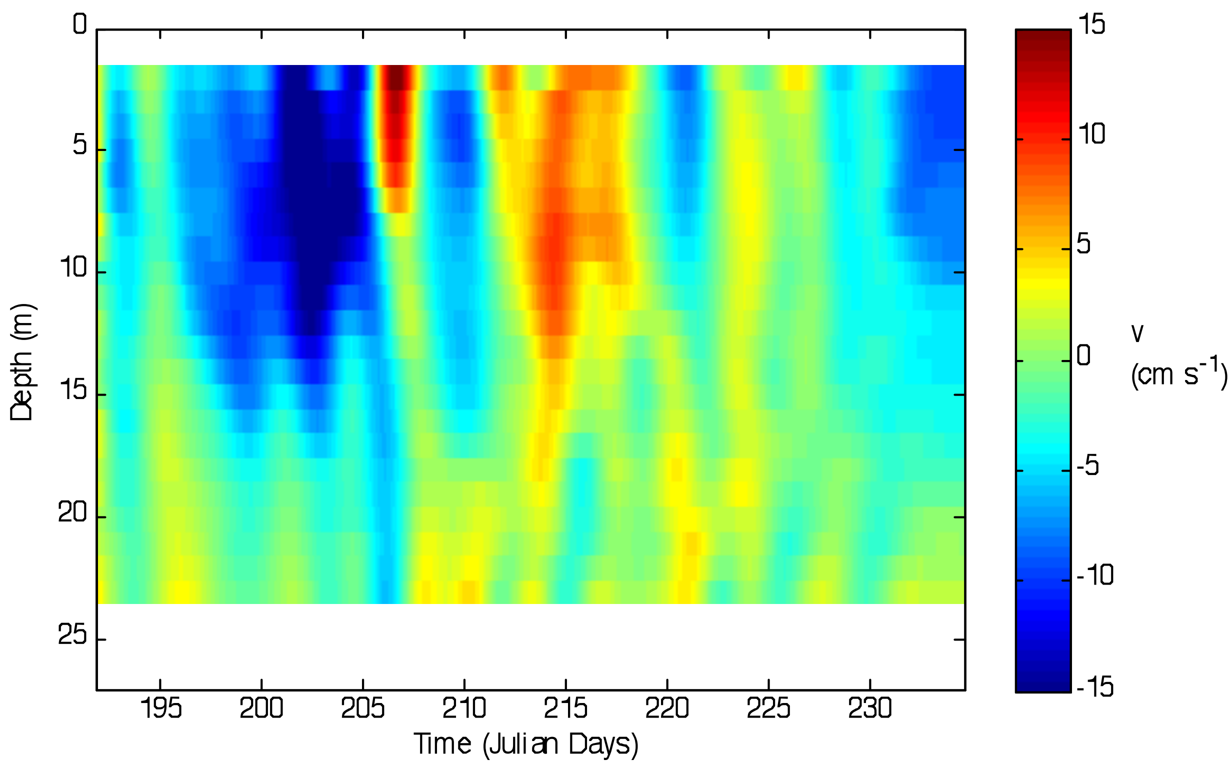
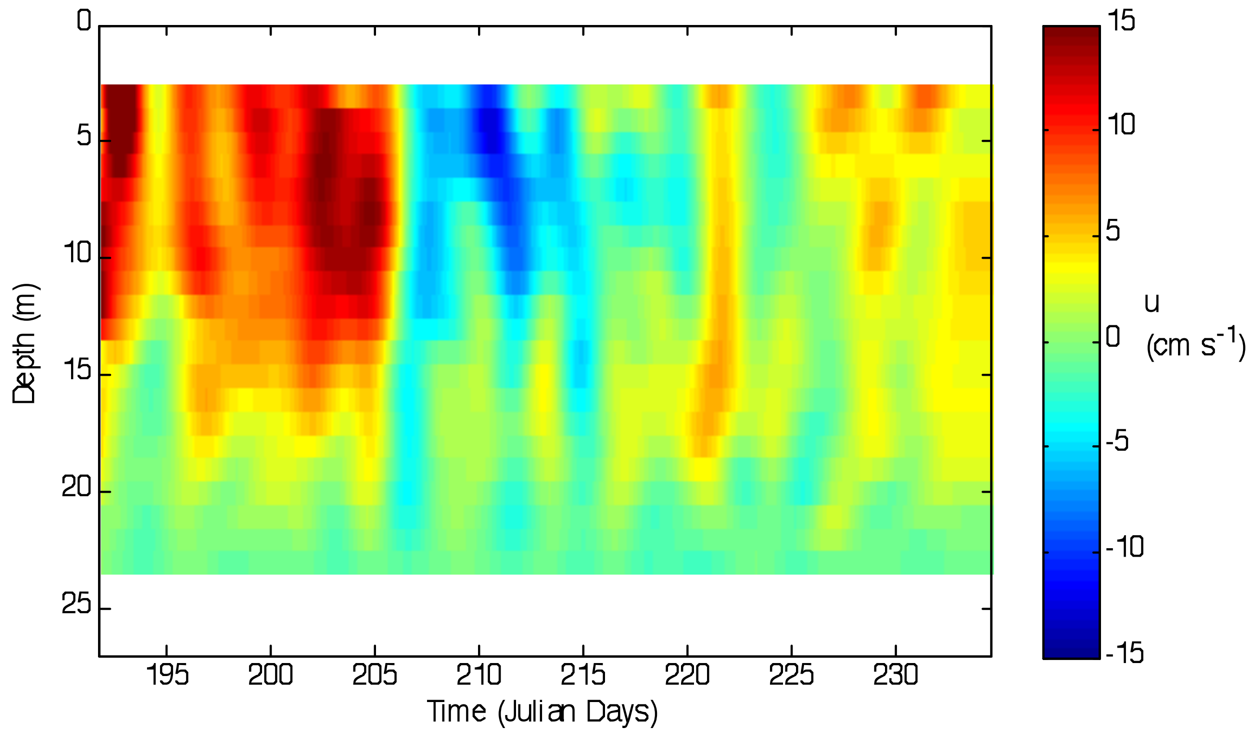


Figure 10: Magnitude of filtered a) u velocity and b) v velocity for mooring M2.

a)



b)

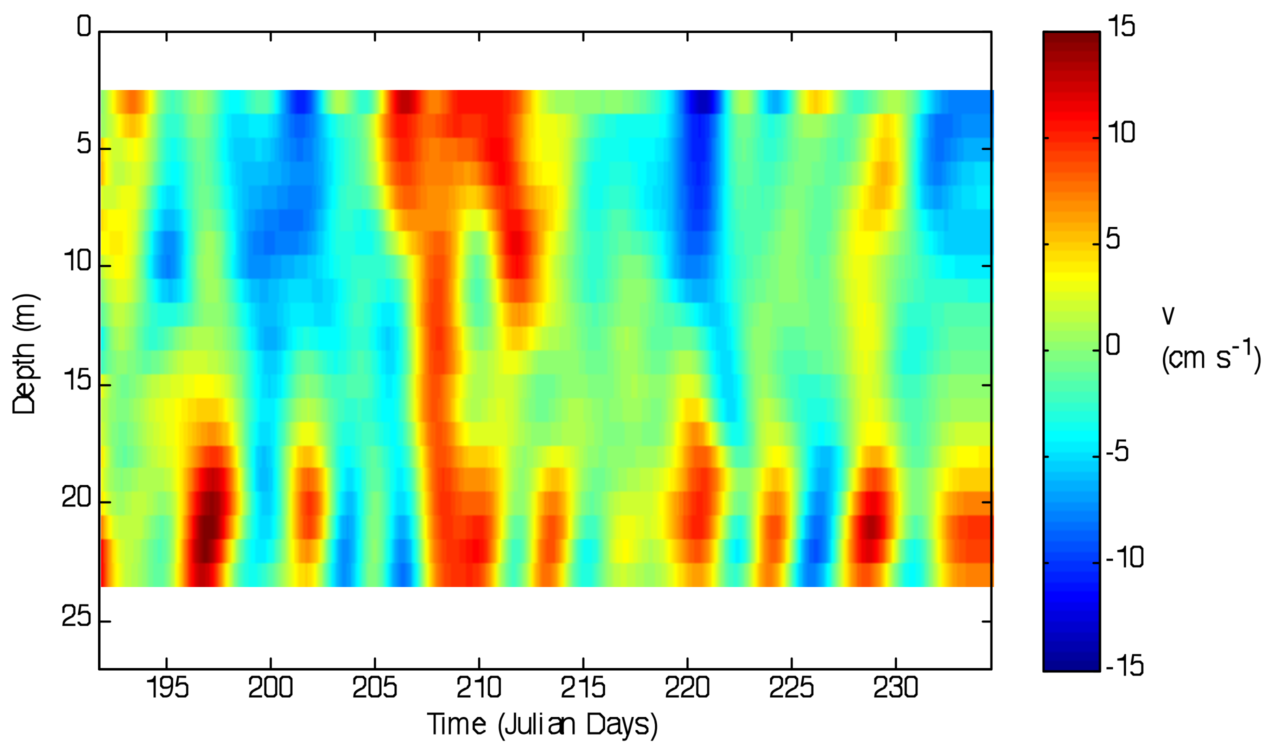
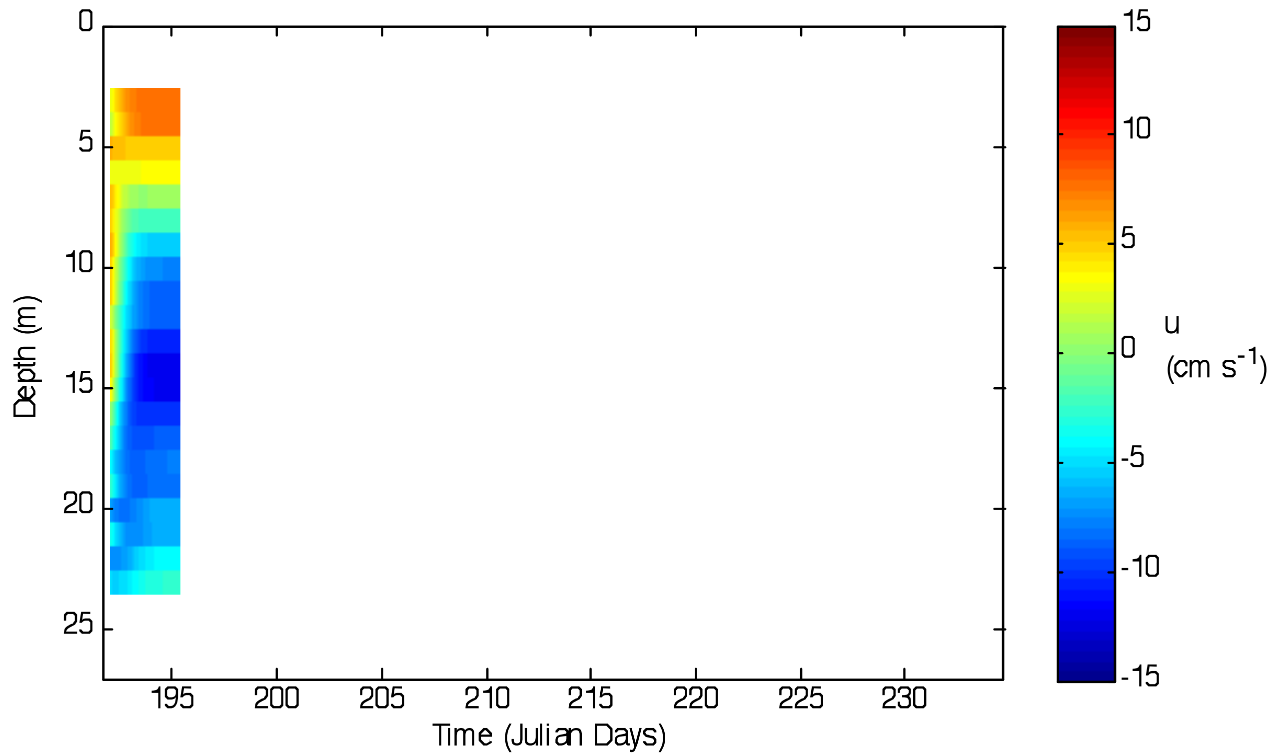


Figure 11: Magnitude of filtered a) u velocity and b) v velocity for mooring M3.

a)



b)

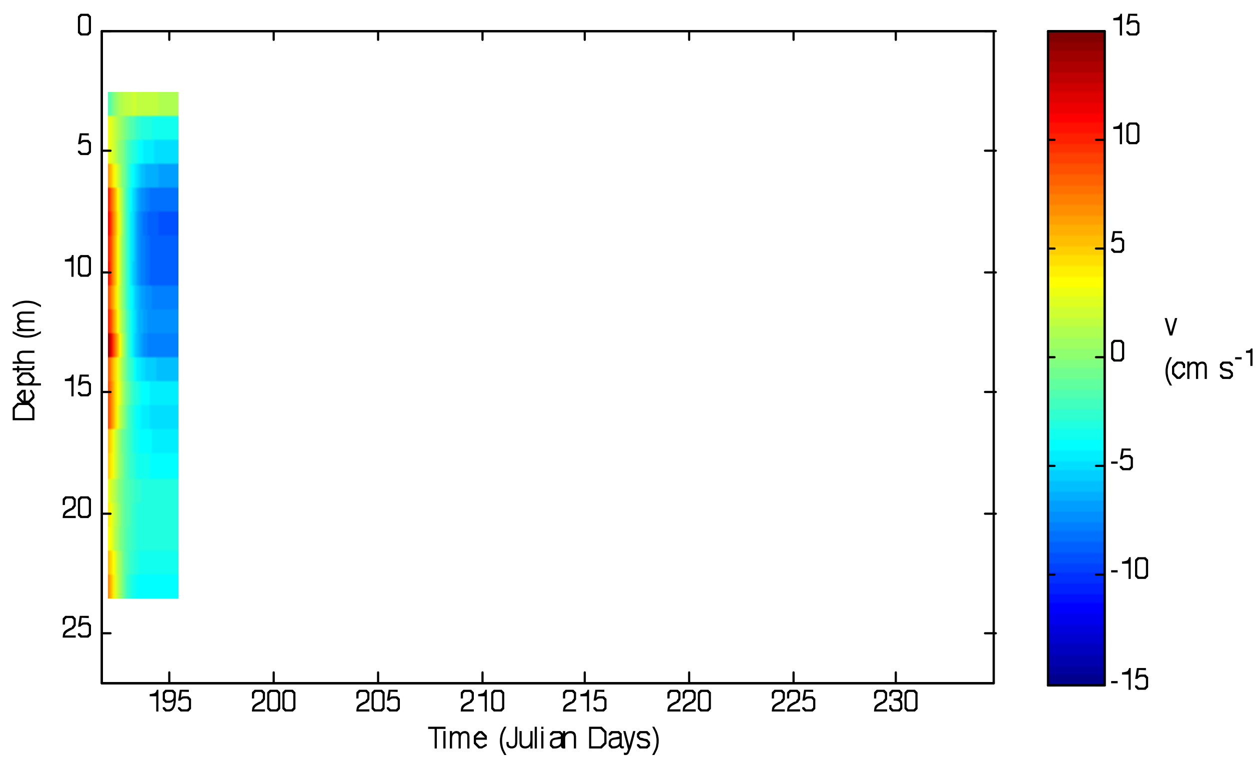
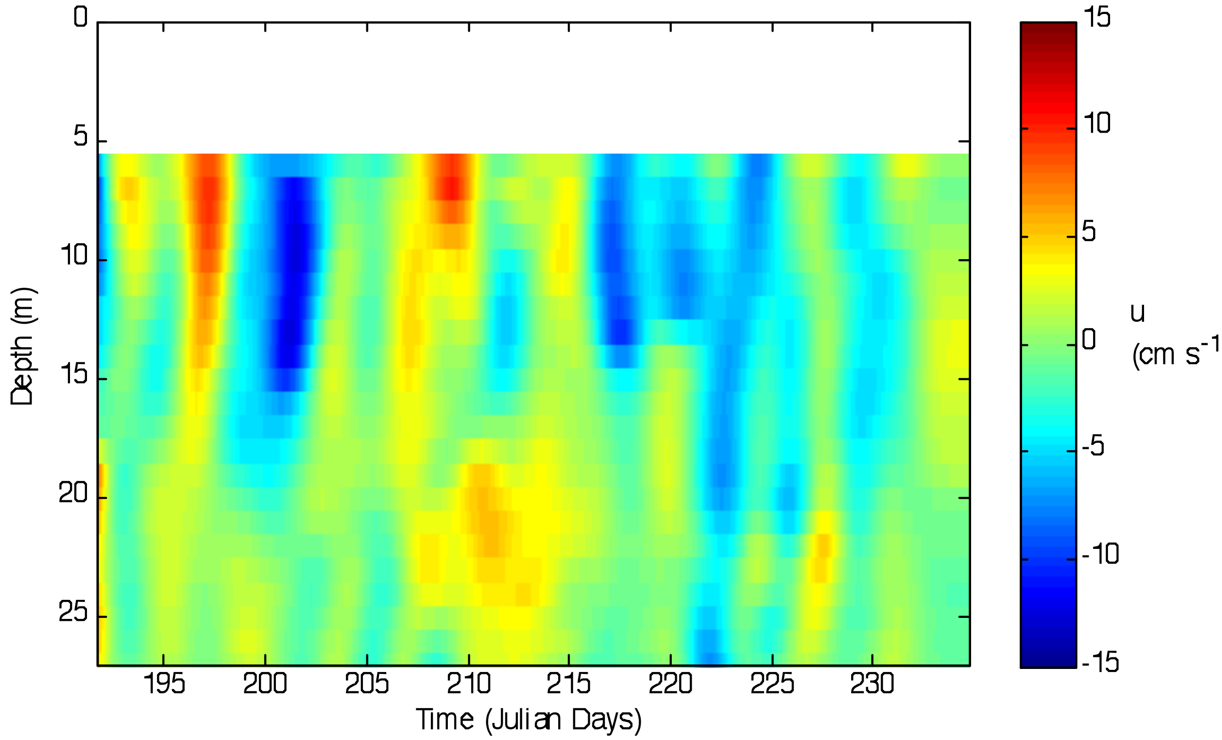


Figure 12: Magnitude of filtered a) u velocity and b) v velocity for mooring M4.

a)



b)

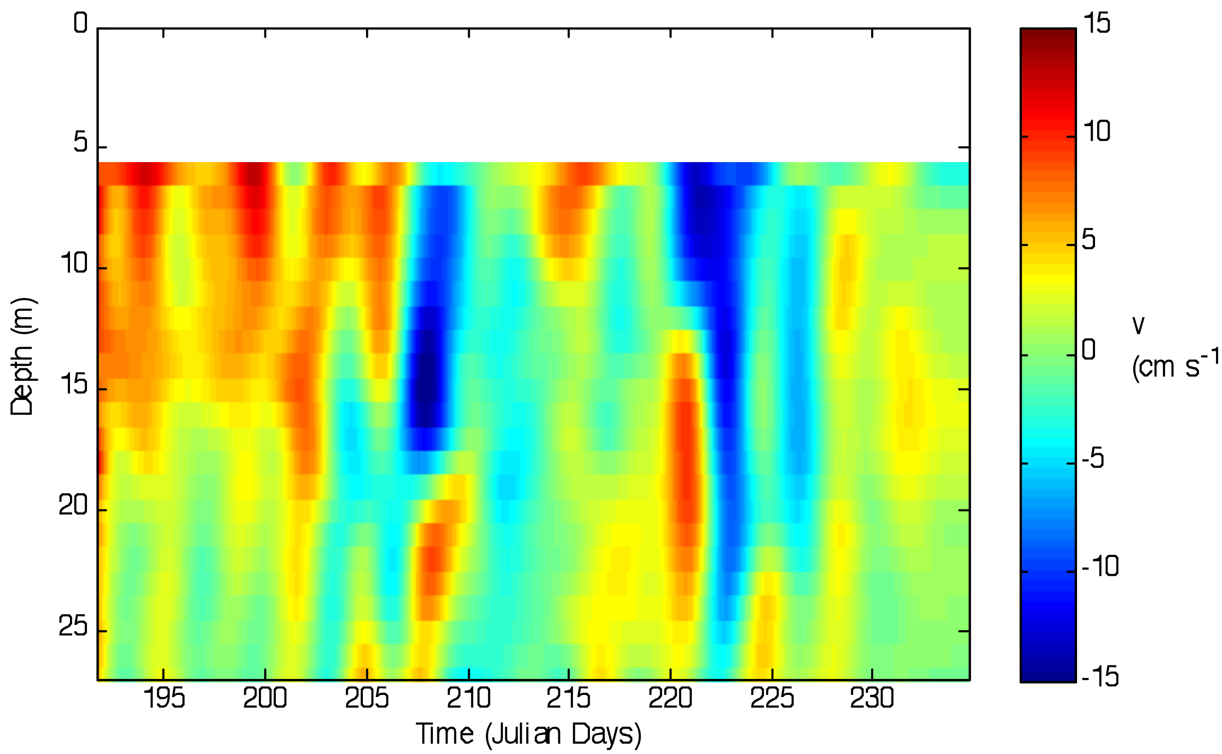


Figure 13: Magnitude of filtred a) u velocity and b) v velocity for mooring M5.

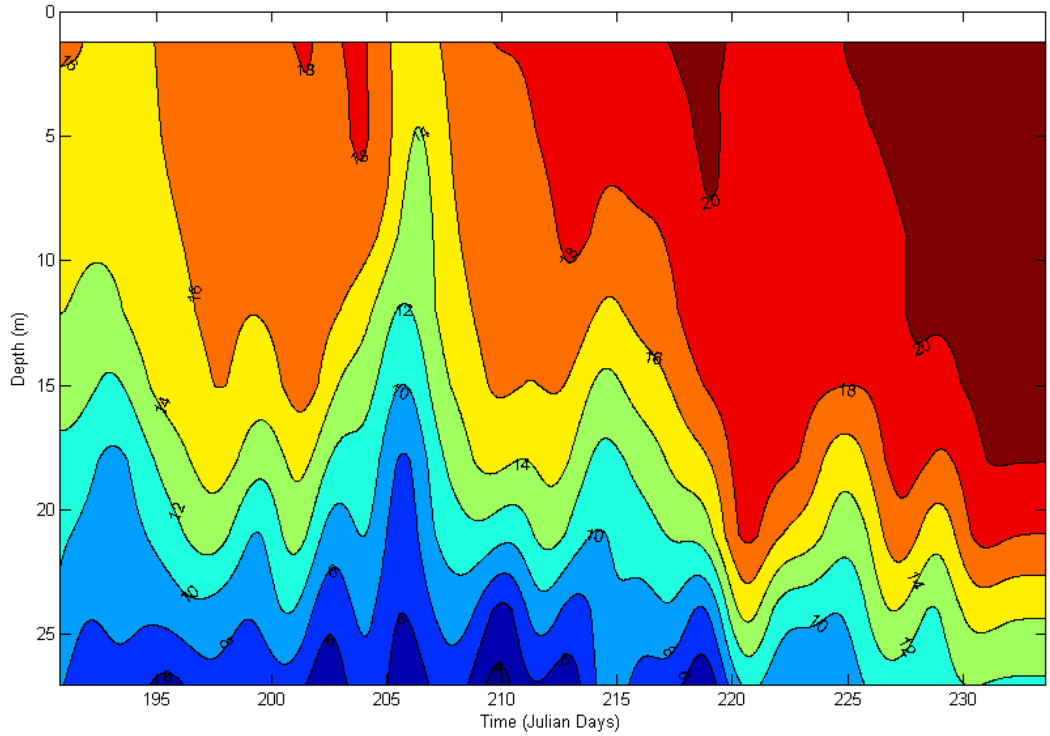


Figure 14: Isotherms for mooring M1.

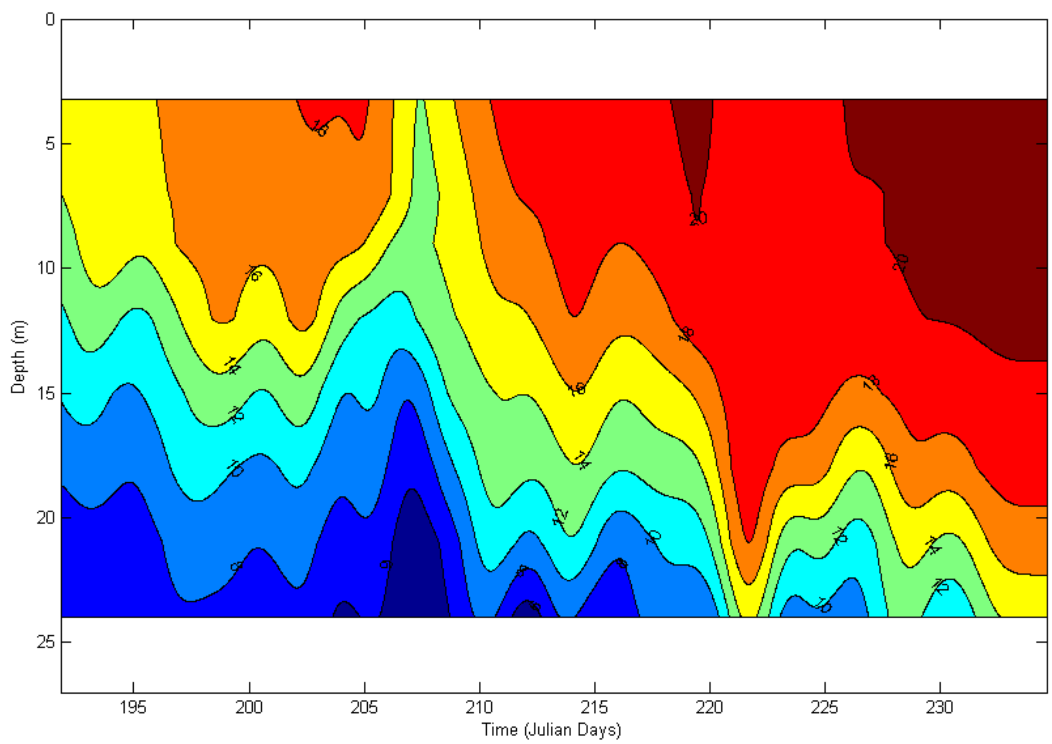


Figure 15: Filtered isotherms for mooring M2.

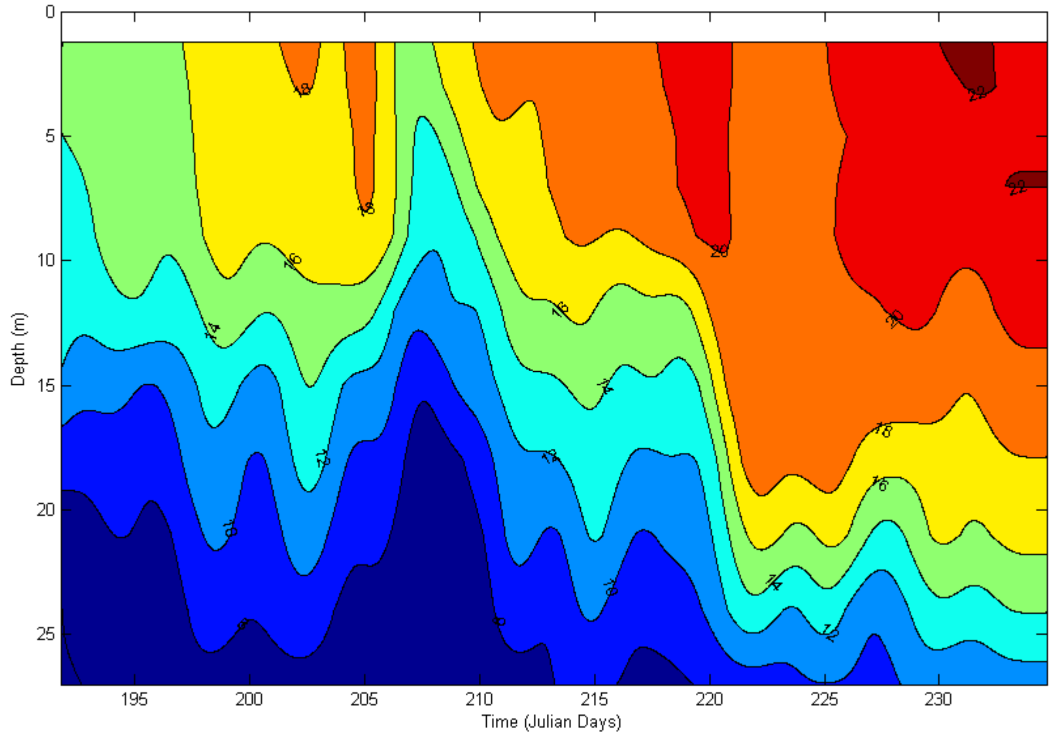


Figure 16: Filtered isotherms for mooring M3.

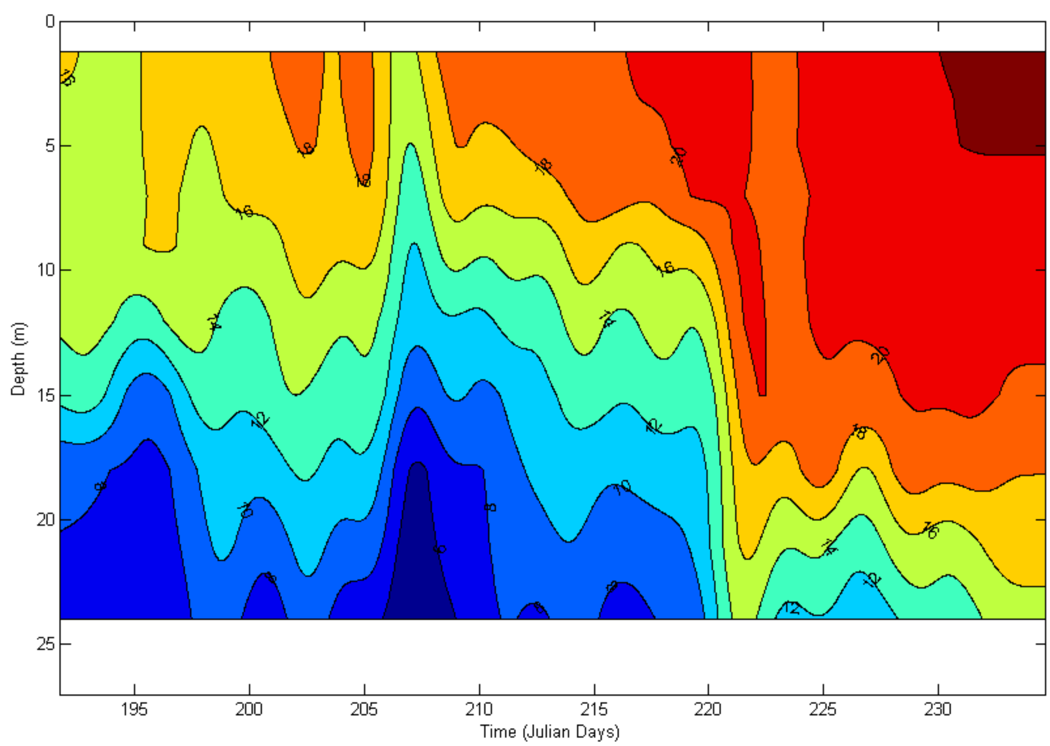


Figure 17: Filtered isotherms for mooring M4.

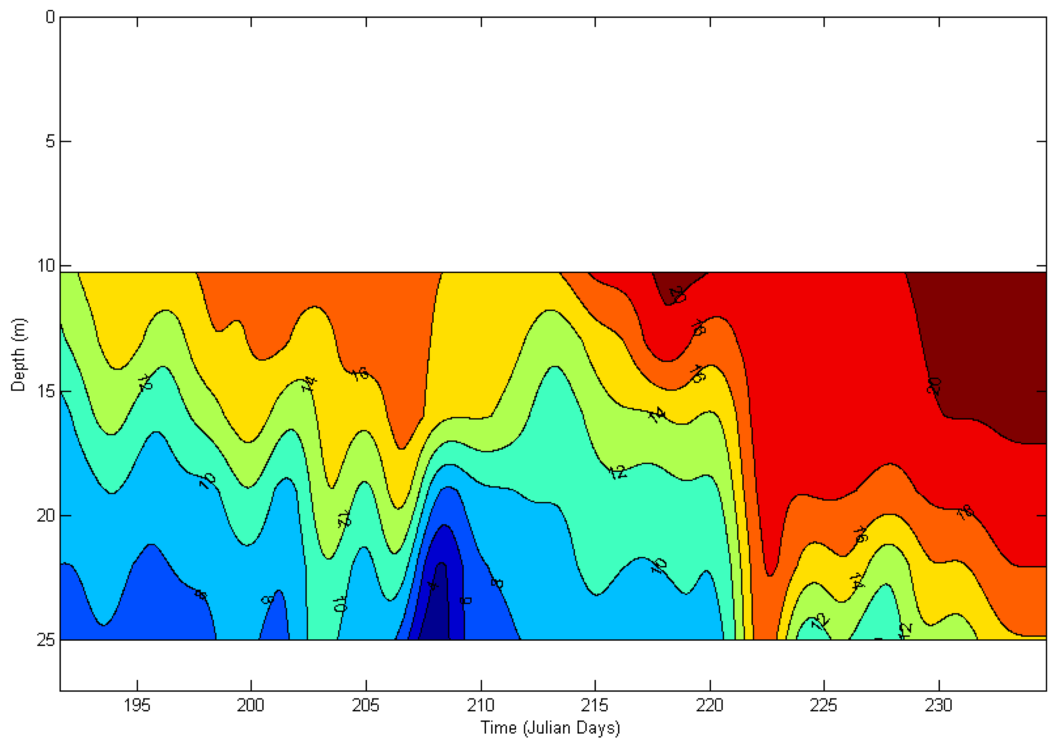


Figure 18: Filtered isotherms for mooring M5.