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Dissolved Oxygen Monitoring Project Final Report 2006

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Friends of Casco Bay

Final Report

2006 Dissolved Oxygen Monitoring Project

Prepared for the

CASCO BAY ESTUARY PARTNERSHIP

By

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Introduction

Quahog Bay has experienced reduced water quality, including low dissolved oxygen (DO), for at least the past twelve years. This embayment is considered one of the most environmentally challenged in Casco Bay. Previous Dissolved Oxygen Monitoring Projects have revealed hypoxic conditions at depth and high organic carbon concentrations in the sediment, suggesting high sediment oxygen demand. These conditions are present regardless of temperature or salinity stratification in the water column (Doan 2005a). Additionally, relatively high sediment oxygen demand has been documented in Quahog Bay (Bridges 2003). In 2005, the Dissolved Oxygen Monitoring Project attempted to determine the underlying causes behind these conditions by looking at how water moves into and out of the bay. Restricted water flow would contribute to increased sedimentation and accumulation of organic matter, resulting in high bacterial respiration and low DO.

Data from the 2005 project indicated that there were three distinct layers of water moving through the mouth of Quahog Bay. The top layer of water was influenced by prevailing winds and exhibited the highest rates of flow. The middle layer was dominated by tidal movement and moved at a lower rate. The bottom layer did not move much at all. These results suggested that poor flushing may be the cause of the heavy organic loading found in the Bay. However, the study was conducted over just a 10-day period in the late fall (Doan 2006).

The 2006 Dissolved Oxygen Monitoring Project was conducted over approximately two months during the late summer and early fall, in order to capture the flow conditions during the time period when bottom water DO has historically been at its lowest. The 2006 project used an acoustic Doppler current profiler (ADCP) to measure flow speed and direction throughout the water column, similar to 2005. The ADCP was deployed on the bottom in a deep channel near the mouth of the Bay. This channel is the principal location of the perennially low DO in Quahog Bay (Doan 2005a, 2005b). Water flow was recorded in one-meter increments from the bottom to the surface every ten minutes.

In addition, a meteorological station was set up on a small island in Quahog Bay (Center Island) to measure wind speed and direction every ten minutes. Water column profile measurements of temperature, salinity, DO, pH and chlorophyll fluorescence were collected just south of the ADCP site location, before, during and after the ADCP deployment.

Collaboration with Bowdoin College allowed for the collection of various types of suspended solids data at the ADCP deployment site, as well as at two reference locations in adjacent Harpswell Sound. Samples for suspended solids were collected at the surface, at mid-depth, and just above the bottom. During the ADCP deployment, Bowdoin College students also collected water temperature data every ten minutes at several depths just south of the ADCP site with HoboTemp dataloggers (Cohen and AbiNader 2006).

Methods

The ADCP unit used during the 2006 Dissolved Oxygen Monitoring Project was a Nortek AquaDopp 600 khz profiler designed for coastal applications. The profiler was fixed to the bottom and set to record current direction and velocity measurements in one-meter increments throughout the water column every ten minutes. The AquaDopp profiler uses the Doppler Effect to determine the direction and velocity of water current. The instrument transmits a short pulse of sound, listens to its echo, and then measures the change in pitch or frequency of the echo. The sound pulse actually reflects from particles suspended in the water, not the water itself. Particles might be zooplankton, suspended sediment, or small bubbles. These particles move at the same speed as the water, so the velocity measured by the instrument is the velocity of the water. Following a similar deployment strategy initiated in 2005, a modified weighted lobster trap was used as the mounting platform, with the ADCP secured to the side of the trap. The unit was attached by seventy five feet of horizontal line to a concrete block, which anchored another eighty feet of vertical line that was buoyed at the surface. The ADCP was deployed on August 1 and checked twice during the deployment on September 5 and September 21. Each time the units were checked, the collected data was uploaded and the unit was cleaned and then redeployed. The batteries in the unit were changed once during the deployment.

The water column profile measurements for temperature, salinity, and dissolved oxygen were conducted by boat. At a site adjacent to the ADCP deployment location, a Yellow Springs Instruments 6600 data sonde was lowered from the surface to the bottom, recording data at the surface, at one meter below the surface, at two meters below the surface, and then at every two meters down to the bottom. The sonde was calibrated against known standards at the start of each monitoring event, and then checked against the standards at the conclusion of each event. Both the ADCP unit and the data sonde were used in accordance with the Friends of Casco Bay, EPA approved, Water Quality Monitoring Program Quality Assurance Project Plan.

The meteorological station was deployed on Center Island through a coordinated effort with Bowdoin College. Wind speed and direction data were recorded every ten minutes.

Bowdoin College students collected water samples for suspended sediment and deployed HoboTemp data loggers to record water temperatures in the water column near the ADCP. Of the various analyses involving suspended sediment conducted by Bowdoin College students, the determination of the amount of organic carbon in the sediment was of particular interest. Water samples were filtered, and the filters were dried for twenty four hours at 100 degrees C. At this point the filters were weighed, then placed in a muffle furnace for two hours at 550 degrees C, then weighed again. The difference in mass before and after placement in the muffle furnace represents the organic carbon lost on ignition. The HoboTemp loggers were deployed vertically along an anchored and buoyed line located just south of the ADCP unit.

Figure 1 shows the locations of the ADCP unit, the suspended sediment sample / water column profile / HoboTemp deployment site, and the meteorological station site.

Figure 1. Map showing the location of Quahog Bay and the placement of the ADCP and meteorological station, as well as the site for the water column profiles, HoboTemp deployment and suspended sediment samples.

Analysis of the ADCP and meteorological data was conducted by ASL Environmental, Inc. The analysis included: Time series plots of the east velocity component, north velocity component, speed, and direction, all of which were edited for spikes; Speed versus direction histogram tables and statistics; Speed versus direction polar plots; Time series current "stick" plots; Time series sensor data plots; Time series wind data; and Progressive vector diagrams. Data from four distinct levels were included in the analysis. The first three levels were at a set distance above bottom, representing the bottom layer, a mid depth, and a surface layer, whereas the fourth level was two meters beneath the (varying) water surface to correct for tides. Direction was reported in degrees true, and the time zone set to Coordinated Universal Time (UTC).

Results and Discussion

The 2006 Dissolved Oxygen Monitoring Project provided a substantial data set on the movement of water into and out of Quahog Bay. Analysis of this data set confirmed some of the findings from the 2005 Project and challenged others. ASL reported that water currents overall were fairly weak. Findings from their analysis included the following: Mean speeds at all levels were about 11 centimeters per second (cm/s), with maximum speeds of about 40 cm/s. The near-bottom flows were found to be of a similar magnitude to those at other levels. The current directions were bi-modal NNE-SSW, along the channel axis. There was a dominant semi-diurnal signal at all levels, flooding NNE into the bay, and ebbing SSW out of the bay. The flood tide flows were stronger in the near-surface layer, whereas the ebb tide flows were stronger near-bottom. This was most evident in the histogram tables and polar plots. Over the length of the record, these flows resulted in a net vector-averaged flow of about 2 cm/s towards the NNE near-surface, and about 3 cm/s towards the SSW near-bottom. This effect was also evident in the progressive vector diagrams, which simulated the movement of a packet of water assuming it was continually forced by the current measured at the site. This is contrary to estuaries with significant river input, as flow of the river water produces a net seaward flow near-surface. ASL presumed (correctly) that there was little if any freshwater input to the bay over the measurement period (Birch 2007).

ASL also noted that there was no wind effect on surface currents observed during the deployment period. Data from the meteorological station revealed a lack of sustained winds during the 2006 project.

Overall, the absence of strong water flow in Quahog Bay was very evident during the 2006 project. This finding corroborates the basic premise that poor water circulation allows sediment organic carbon to build up, with resultant high rates of decomposition at depth. However, there was no real difference in flow between the surface, mid and bottom layers. Additionally, there was not a measured wind effect, as seen during the 2005 project. The wind-dominated surface flow seen during the 2005 project was not repeated during the 2006 season. This may have simply been due to the fact that there were no sustained winds from any direction during the deployment period, which was earlier in the season than the 2005 project. The 2005 project was held during the month of October, when storms and higher wind speeds are more prevalent, rather than the relative calm of August and September when the 2006 project was conducted. The timing of the 2005 project coincided with the high winds typical of late fall. Without the influence of a strong, steady wind during the 2006 project, surface layer water flow was dictated by the tides.

The water column profile data collected in mid-July, prior to the ADCP deployment, showed a pronounced thermocline between two and four meters of depth. This thermocline resulted in a drop of two milligrams per liter (mg/l) of dissolved oxygen. However, bottom DO was still relatively high with a concentration of 7.8 mg/l and a percent saturation of 86.6%. The extremely high percent saturations - in excess of 120% - in the upper two meters (above the thermocline) indicate a phytoplankton bloom.

By late July the thermocline had dropped to a depth of between four and six meters. There was a concomitant drop in DO of 1.5 mg/l and of 25% saturation, from 100.6% to 75.4%. On the bottom, DO had dropped to 6.1 mg/l and the percent saturation to 66.5. This reduction in water quality at depth may be evidence of a crash of the phytoplankton bloom indicated earlier in the month.

In mid-August, there was no pronounced thermocline, but rather a gradual decrease in water temperature throughout the water column of about 7 degrees C over the 17 meters from surface to depth. There was a correspondingly gradual decrease in DO from 8.8 mg/l at the surface to 6.6 mg/l at depth. The 6.6 mg/l concentration at the bottom resulted in a 74.1 percent saturation value.

Late August saw the return of a moderate thermocline between 4 and 6 meters, with a drop in DO concentration of 1.5 mg/l between the two depths. At the bottom, the water quality had become quite reduced. Bottom DO conditions were 5.6 mg/l and only 65.3 percent saturation, typical values for Quahog Bay in the late summer (Doan 2005a, 2005b).

The late September profile data for temperature and salinity showed a well-mixed water column, indicating that the Bay had “turned-over”. However, the DO pattern from surface to depth was identical to that of the previous profile when a thermocline was present. This strengthens the premise that the low bottom oxygen values are the result of high respiration at the sediment water interface, and not due to stratification. DO concentrations around 8.5 mg/l at the surface, dropping to around 6.5 mg/l on the bottom, were seen during both months. The bottom percent saturations for each were around 65%.

The Bowdoin College HoboTemp data collection efforts captured the water column turnover as it occurred. The HoboTemp data revealed a mixing event between September 10 and September 14. Bottom water temperatures increased steadily, becoming well mixed with the surface water by September 14. During this same time period, the ADCP data reflected a downwelling event (Cohen and AbiNader 2006).

The Bowdoin College suspended sediment analysis included a look at the amount of carbon lost on ignition. Data from that analysis revealed that the amount of organic material near the bottom was higher in Quahog Bay than at two reference sites in Harpswell Sound. This neighboring bay does not experience the reduced water quality that Quahog Bay does. The results of the analysis, 4.3% organic carbon in Quahog Bay and 0% and 2.5% at the two reference sites in Harpswell Sound, are indicative of the high sediment load in Quahog Bay. The Quahog Bay results are similar to sediment organic carbon percentages measured previously at that site (Bridges 2004, Doan 2005a). All three sites were similar in depth (15-17 meters MLW).

Conclusion and Recommendations

The goal of this project was to determine if Quahog Bay exhibits poor flushing during the late summer and early fall when water quality in the bay has historically been at its lowest. The results do indicate that there are low flow rates in Quahog Bay. This reduced flow may ultimately lead to the poor water quality by allowing more sedimentation than what might be seen in embayments with higher flow rates. The suspended sediment data certainly suggests that this is the case. In addition, this project reaffirmed that the low DO at depth is present regardless of stratification in the water column. This indicates high respiration rates on the bottom, which would result from the high sedimentation of organic matter. The low water flow is a natural occurrence, and may be due to the bathymetry of the bay, may be the result of the Kennebec River influence at the mouth of the bay, or some combination of the two. Whatever the case, thought should be given to what may happen in the bay if the watershed around it continues to be developed, because shore side development tends to result in higher nutrient loading.

Next steps should include an analysis of the flushing rates and residence time of water in Quahog Bay. The necessary bathymetry has already been accomplished by Bowdoin College (Voinot-Baron 2004). A flushing study would provide more evidence of the poorly flushed nature of the bay, and may provide further evidence for limitations to shore side development. A closer inspection of the influence of the Kennebec River on Quahog Bay flushing rates would also be valuable.

Literature Cited

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Voinot-Baron, W. 2004. Bathymetry of Quahog Bay, Maine. Bowdoin College.

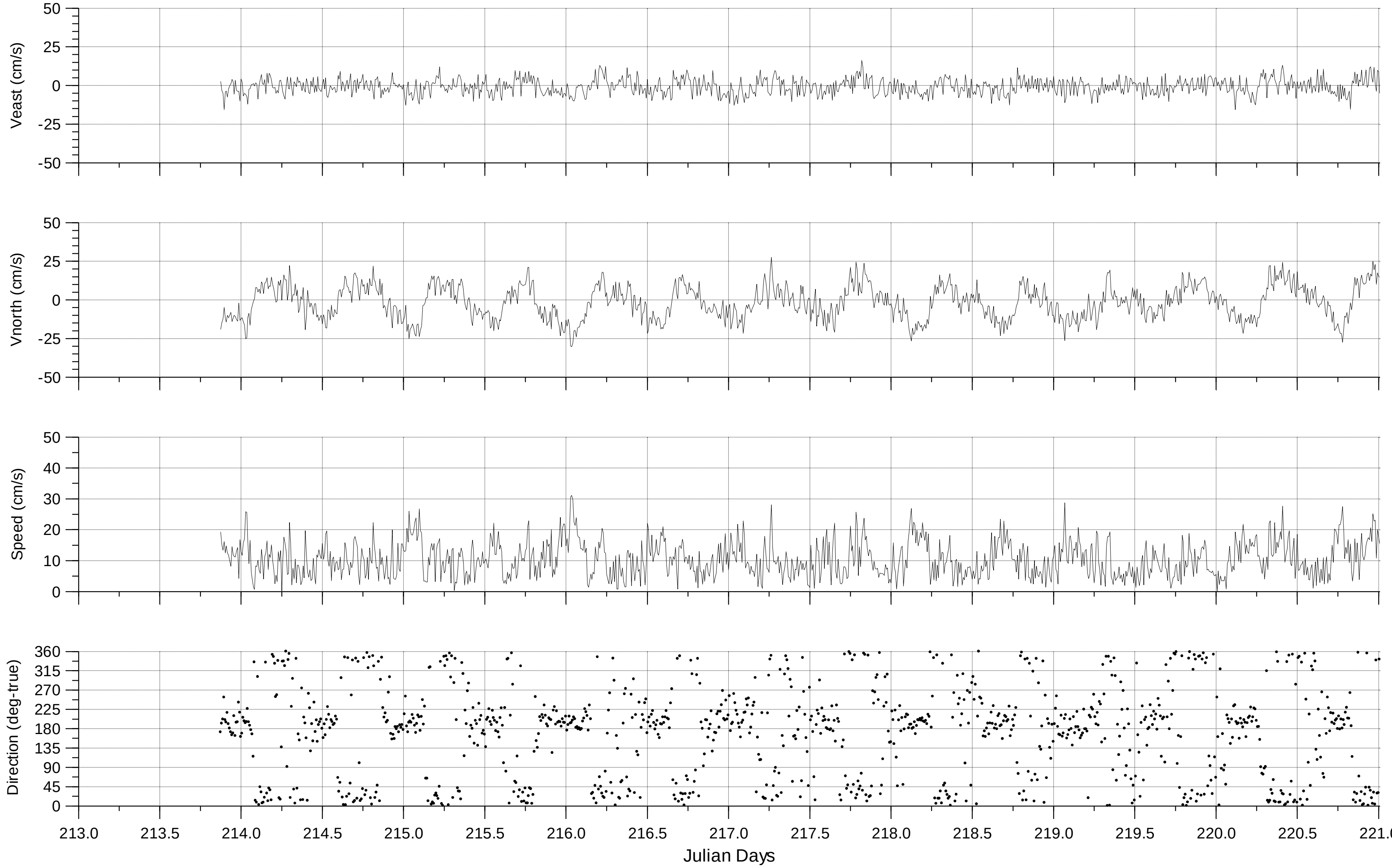
Acknowledgements

This work would not have been possible without the support of Ed Laine and Bowdoin College, Judith and Francis Moriarity, and the Casco Bay Estuary Partnership.

Appendix 1 – Analysis by ASL Environmental, Inc.

Time Series Plots – Veast, Vnorth, Speed, Direction

Bottom Bin



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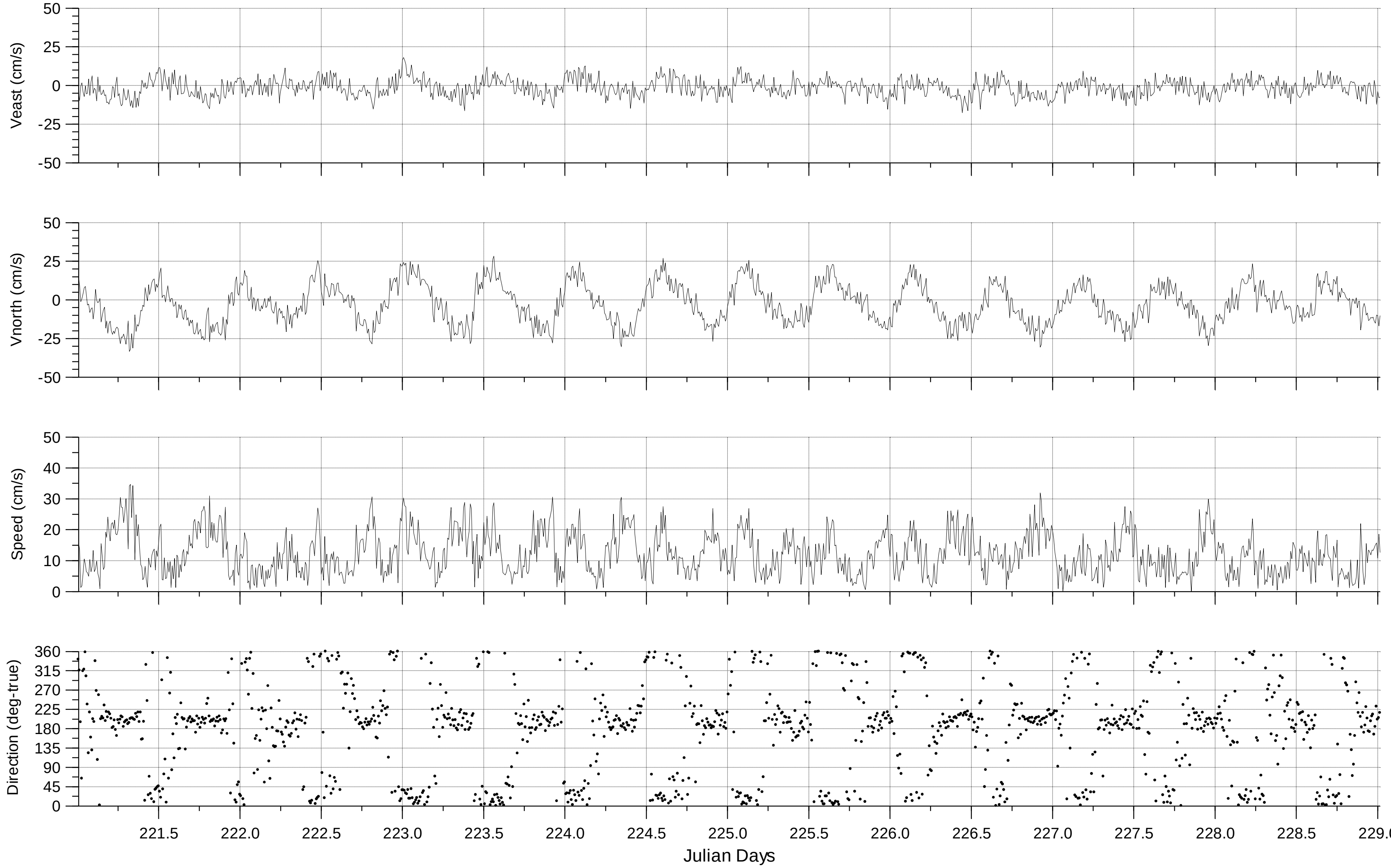

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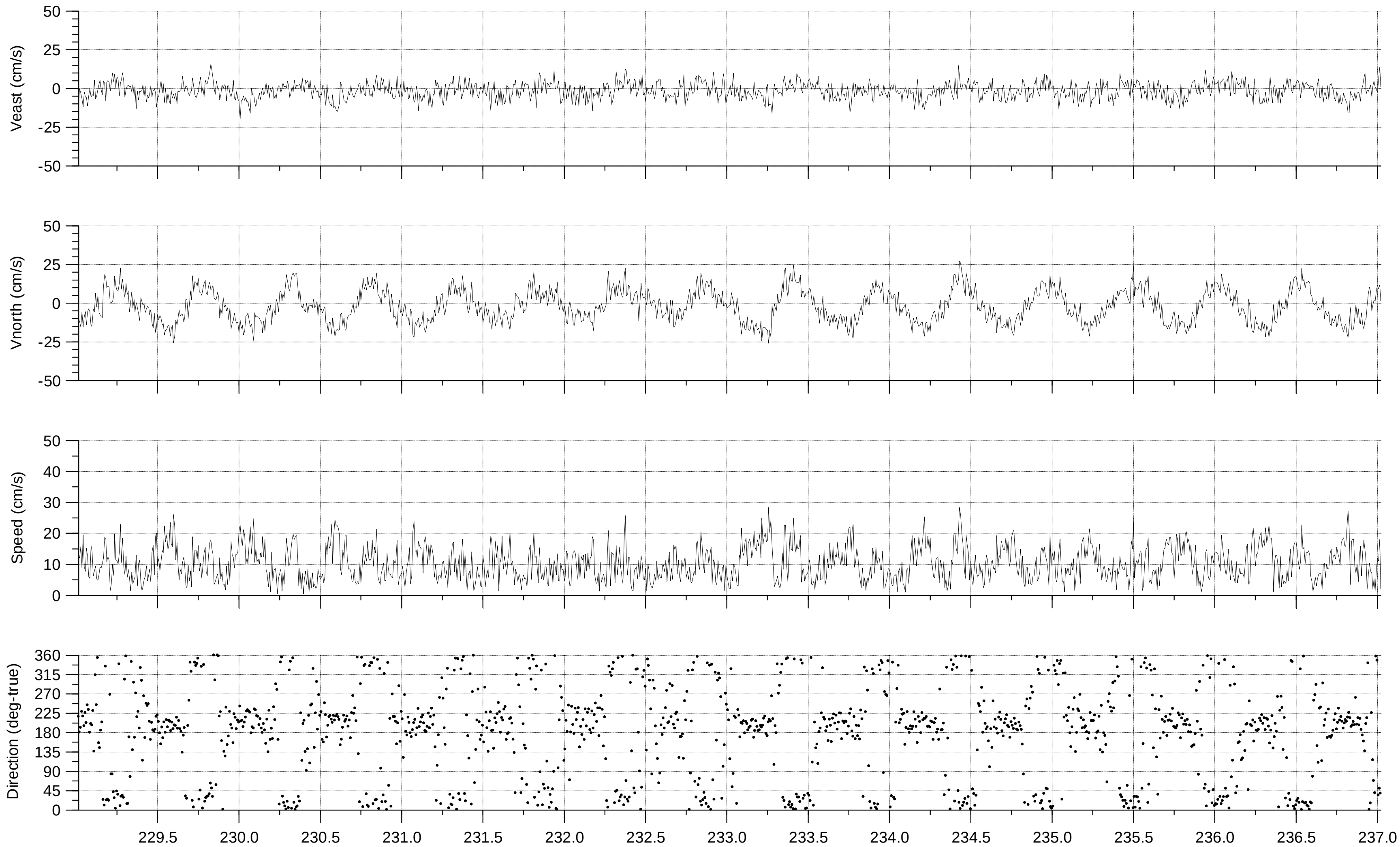

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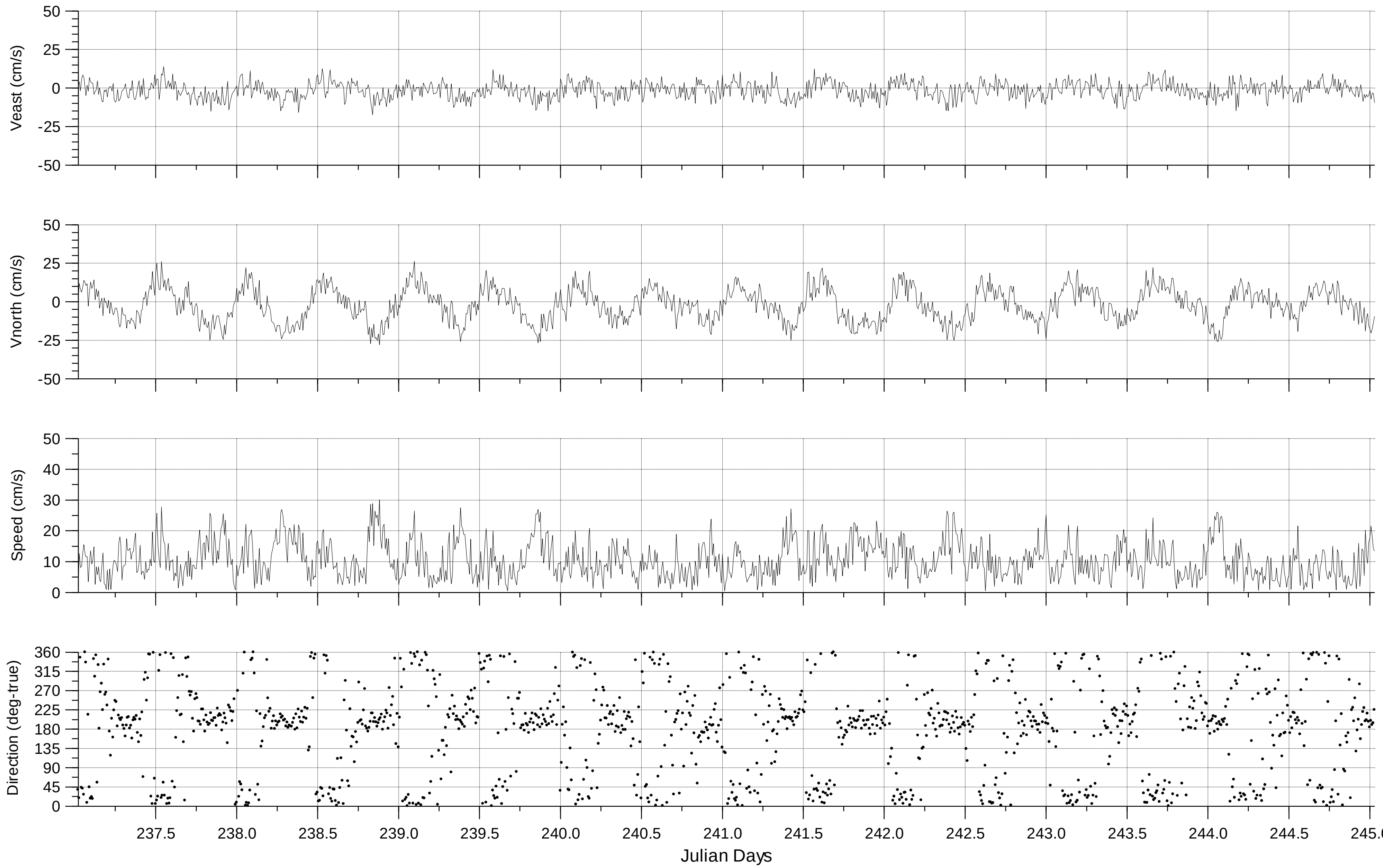

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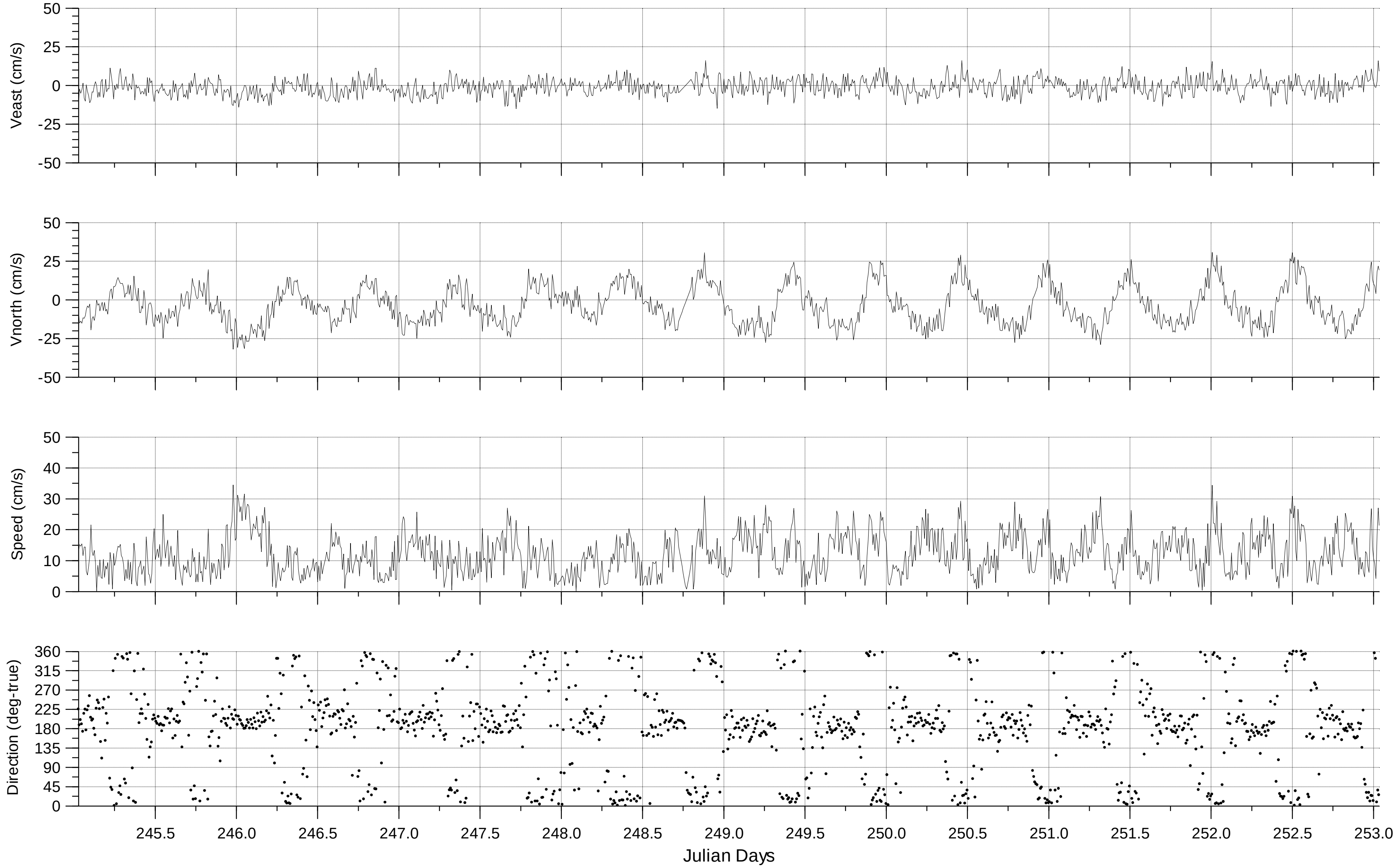

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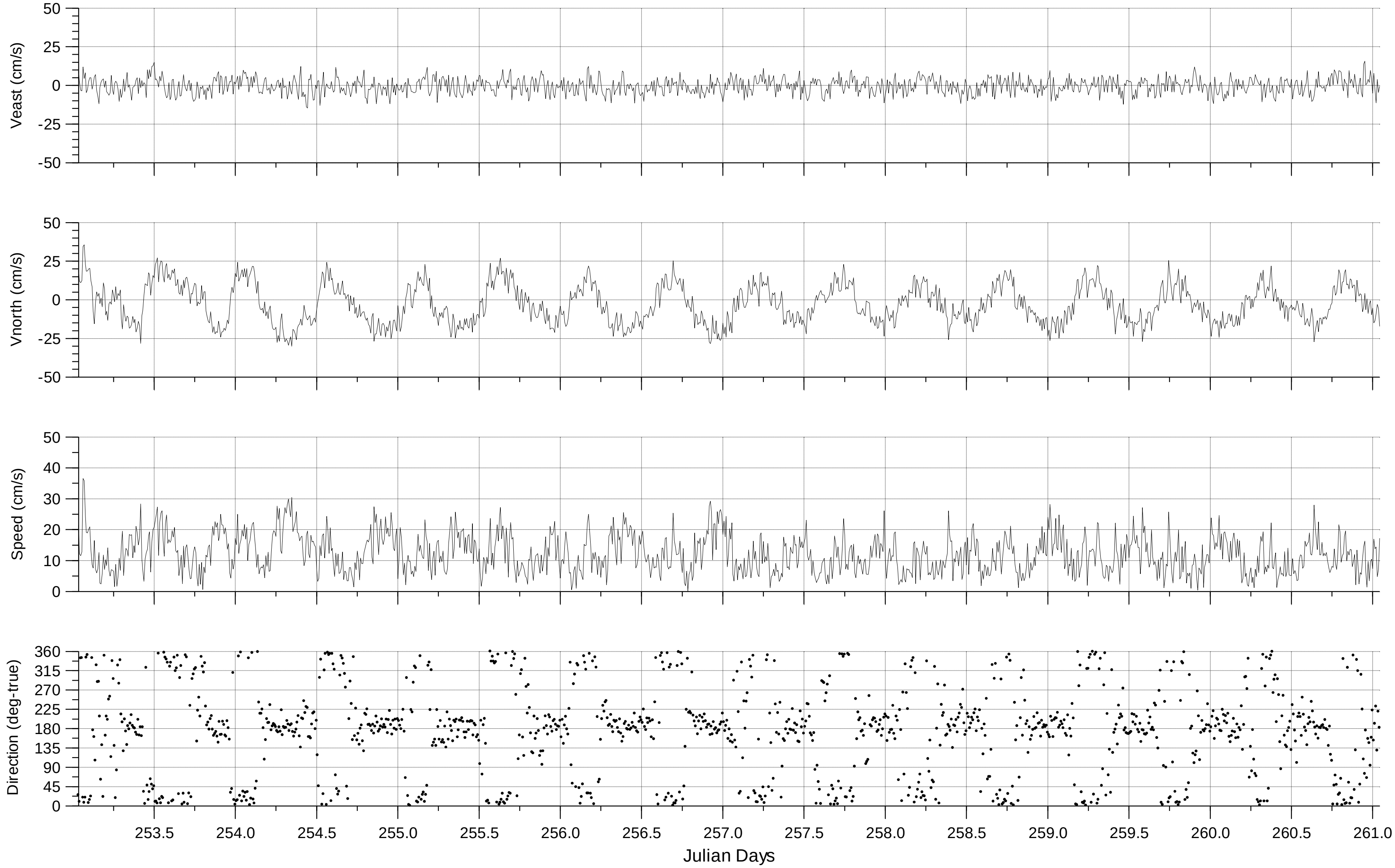

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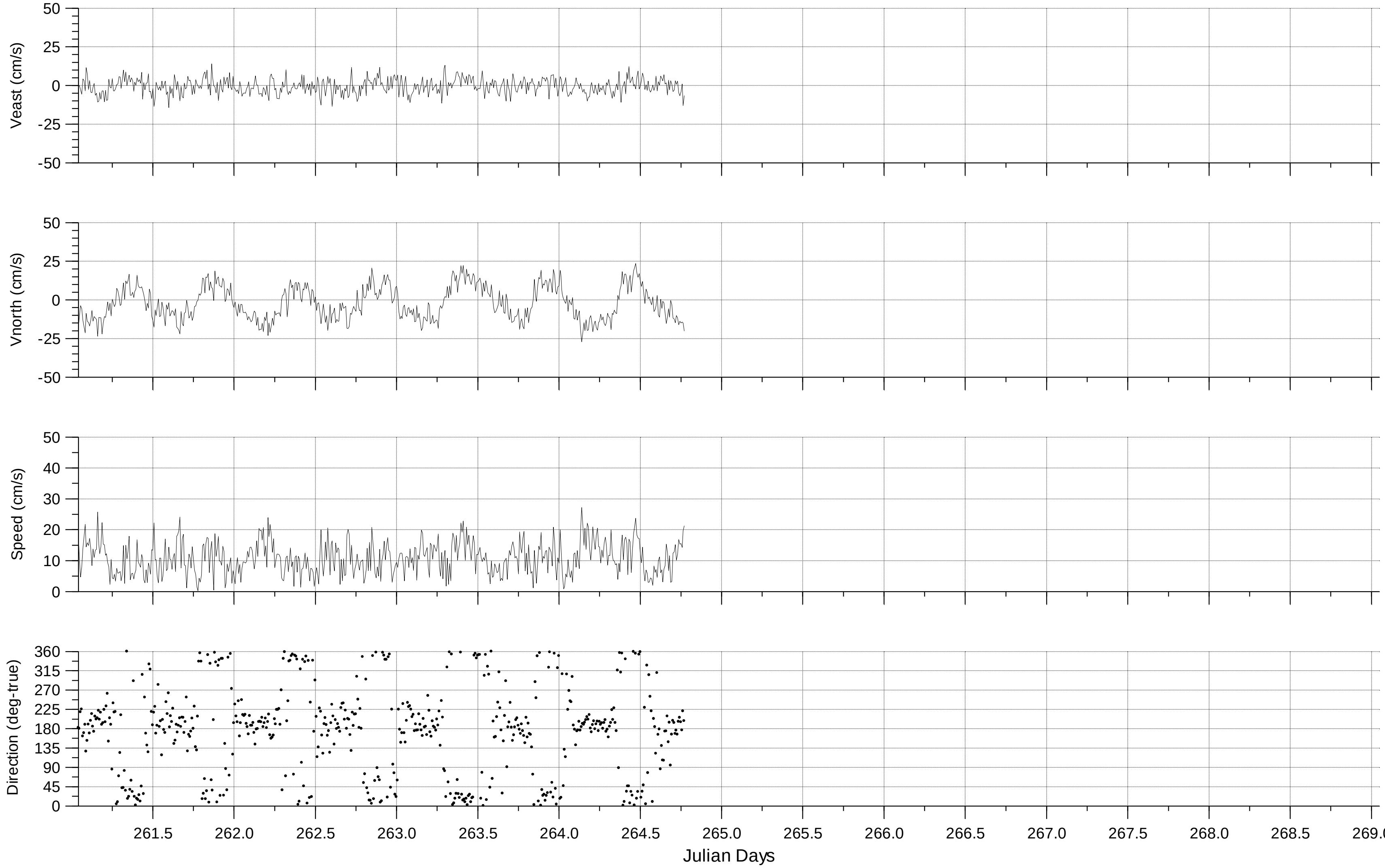

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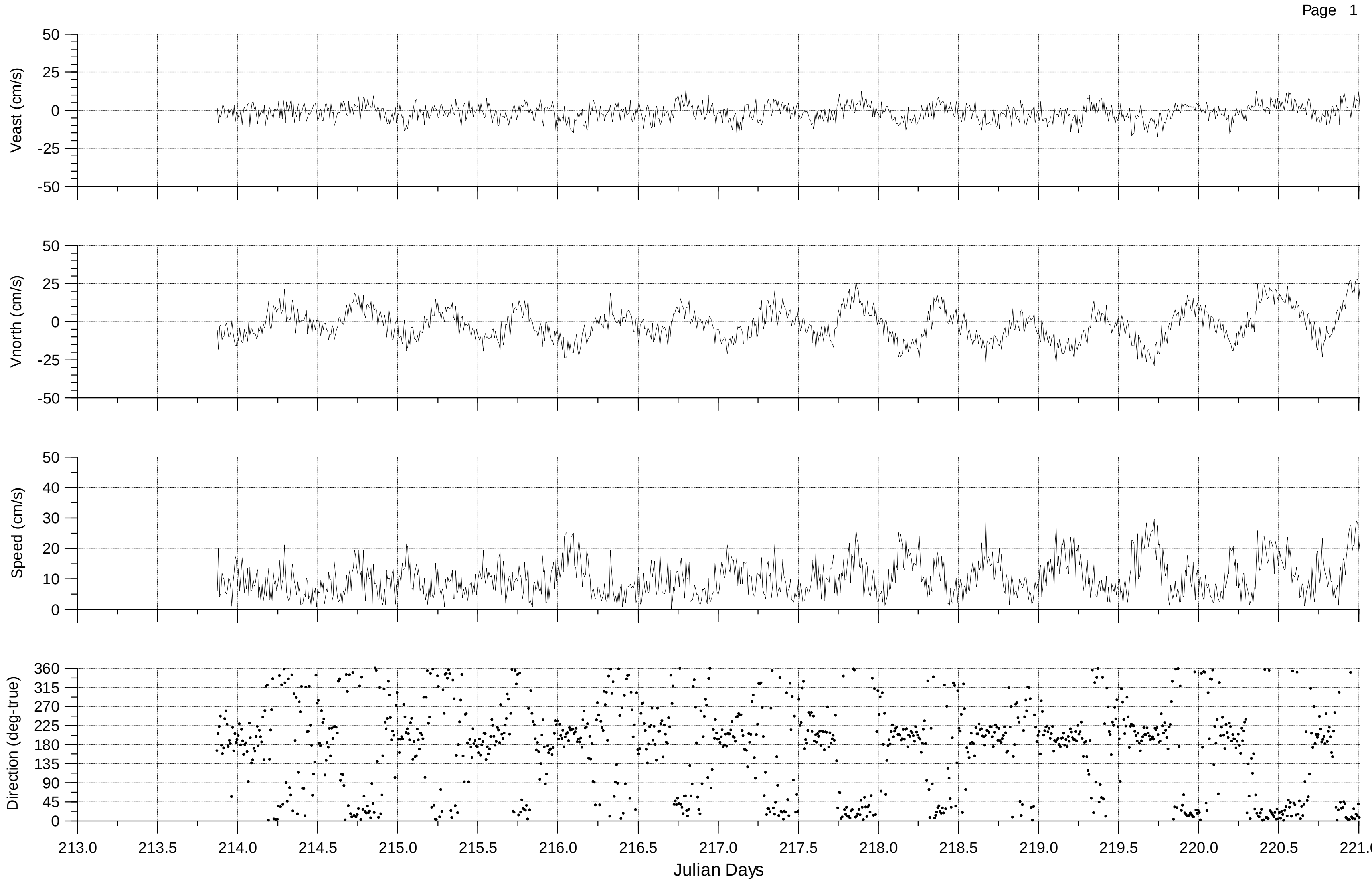
Time Series Plots – Veast, Vnorth, Speed, Direction

Mid Depth Bin



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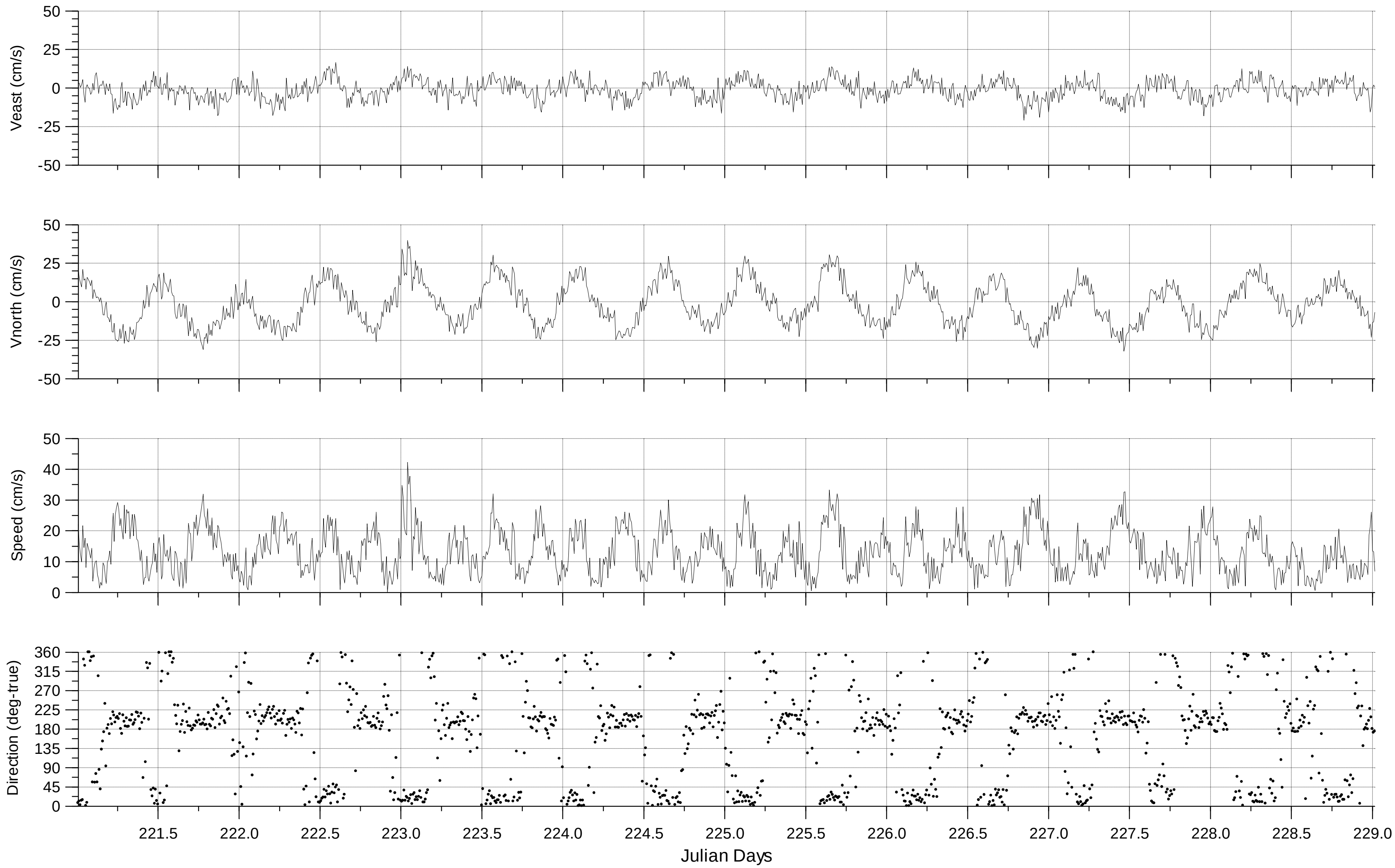

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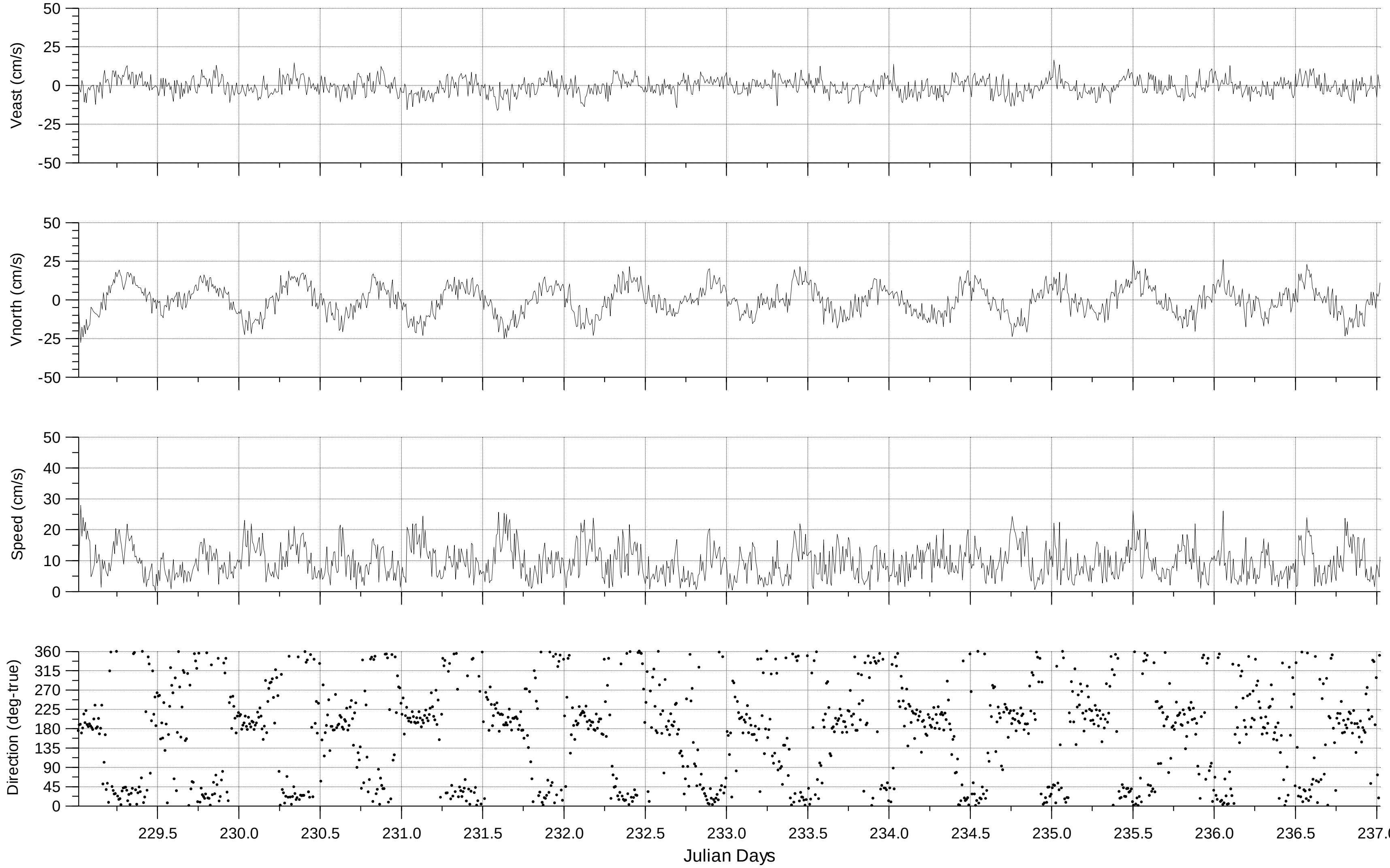

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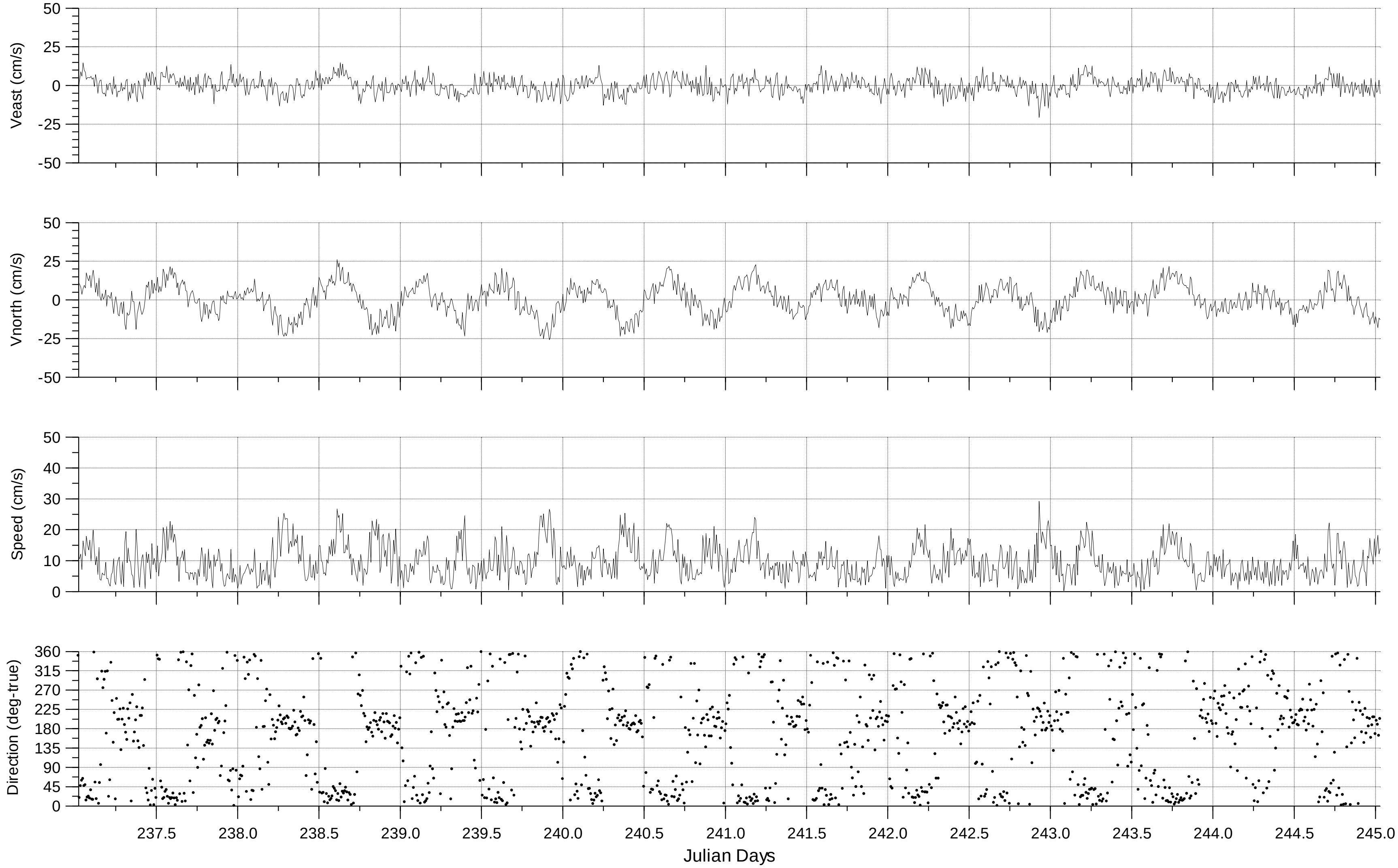

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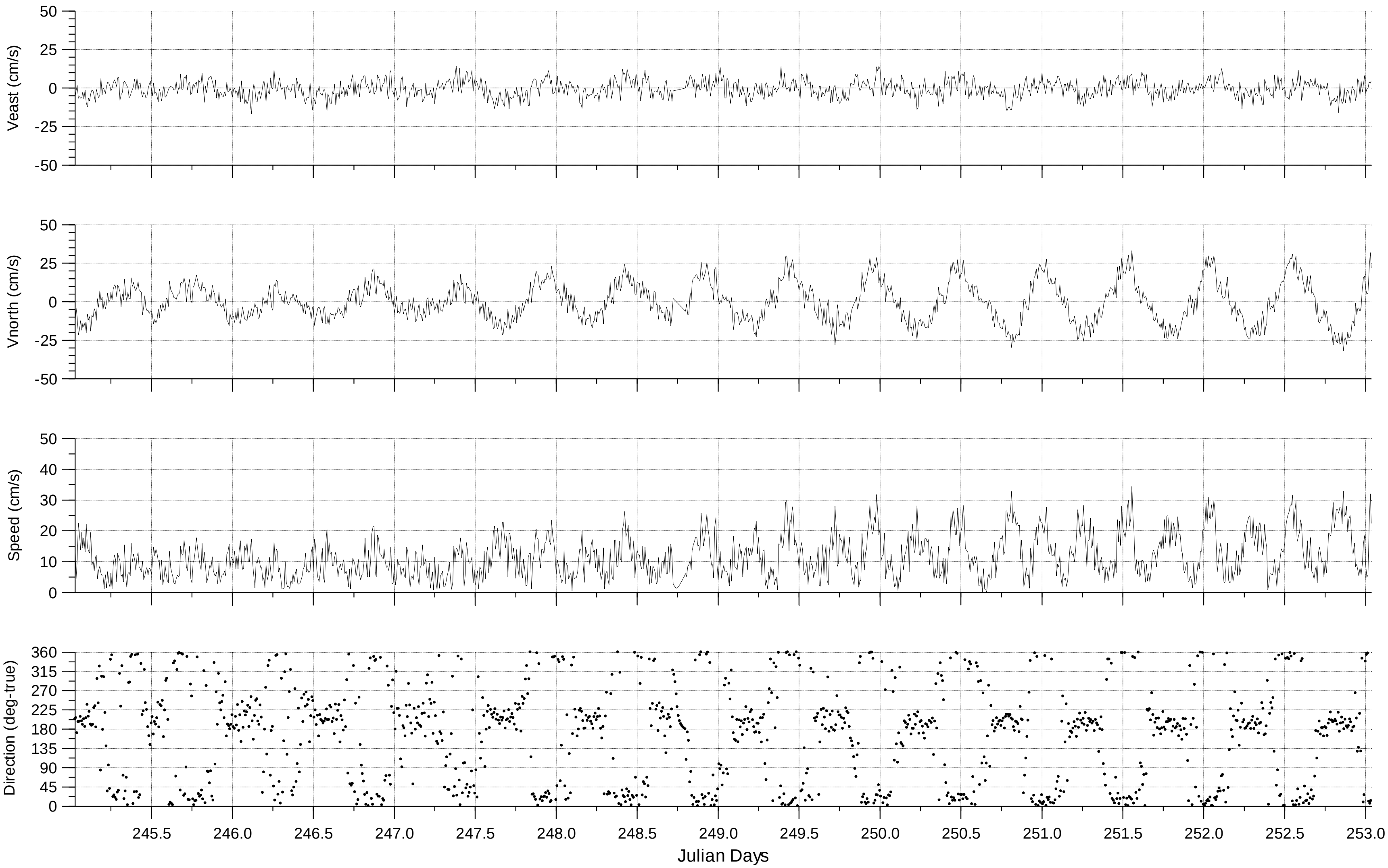

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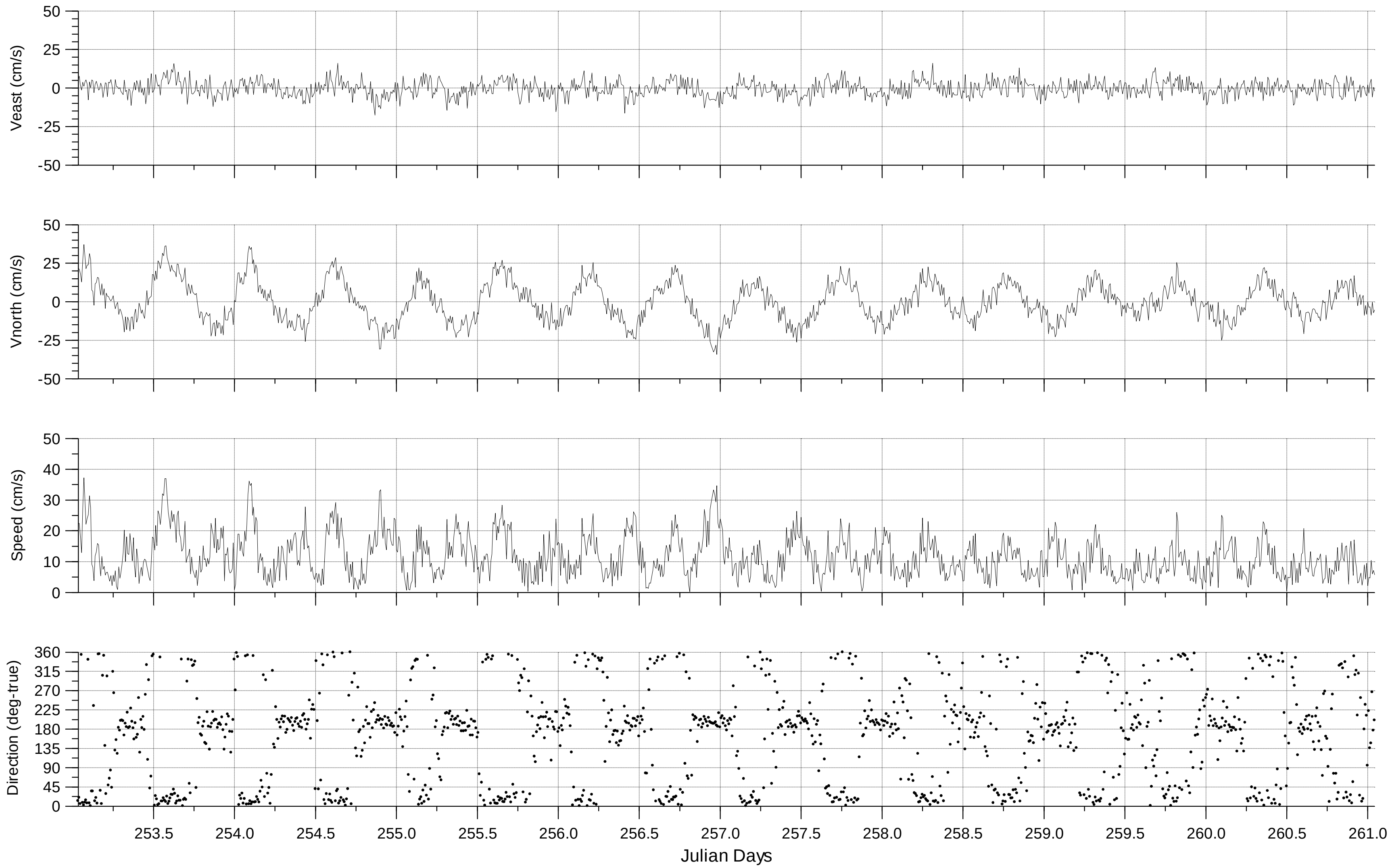

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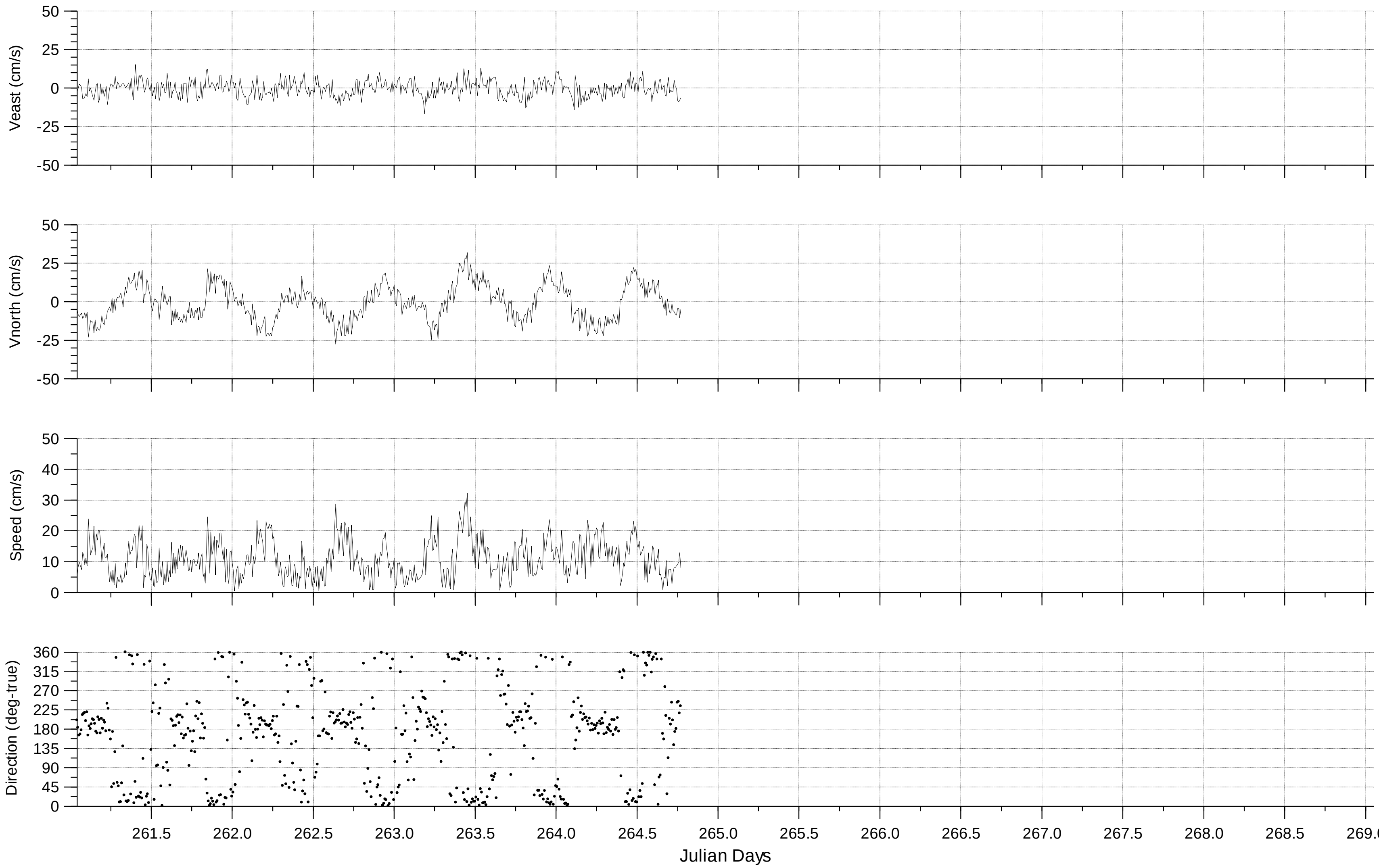

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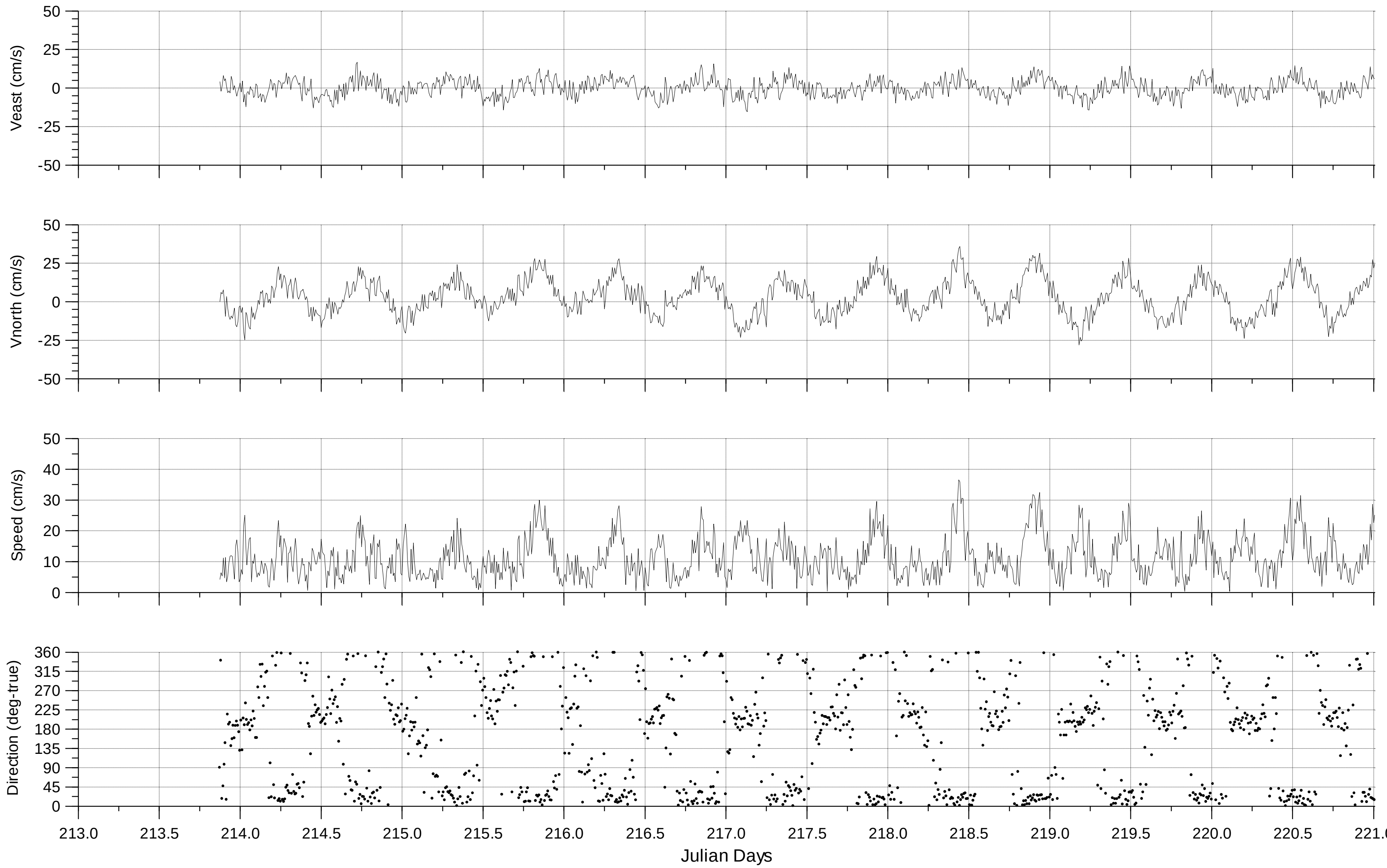
Time Series Plots – Veast, Vnorth, Speed, Direction

Surface Bin (constant height above bottom)



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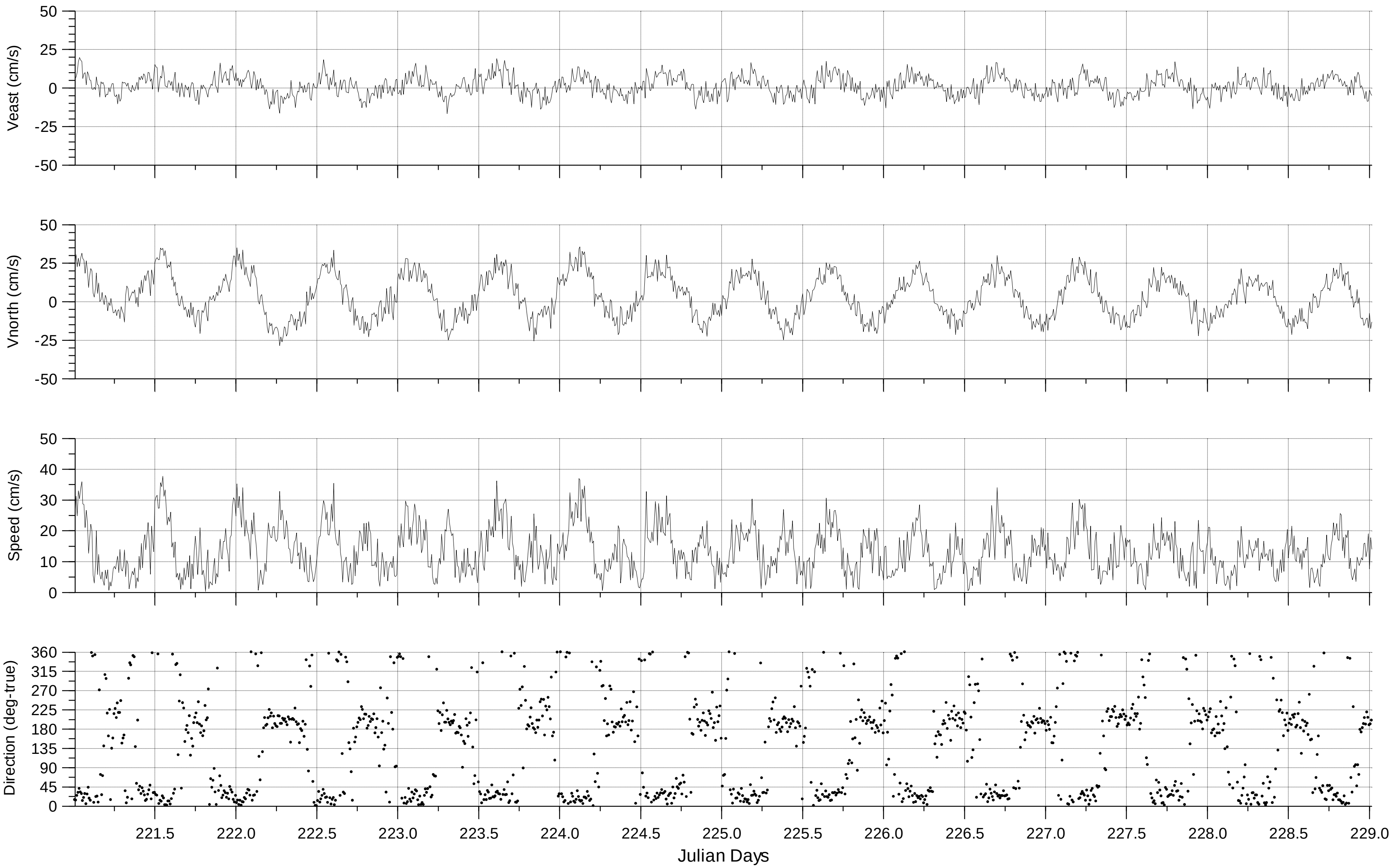

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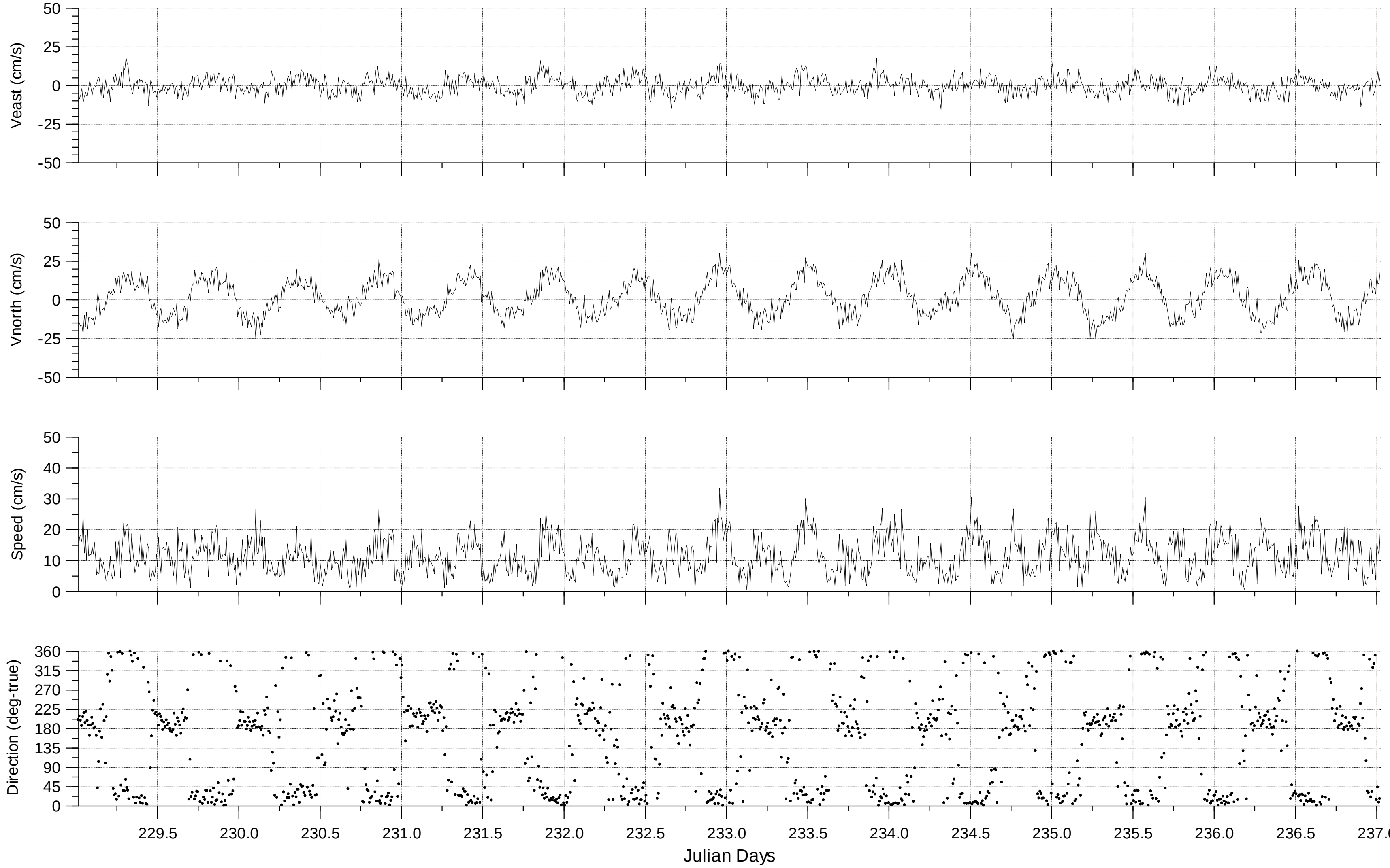

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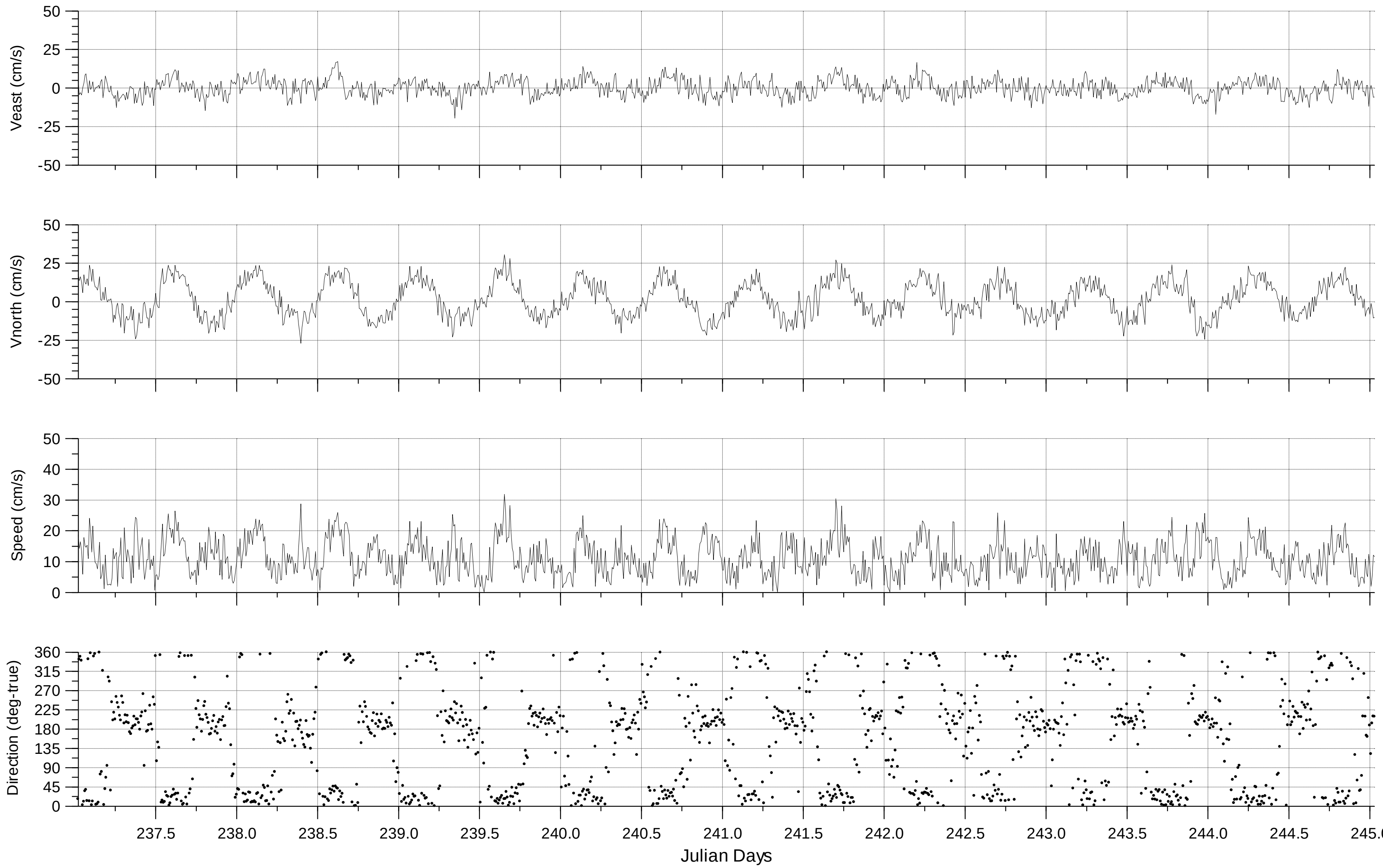

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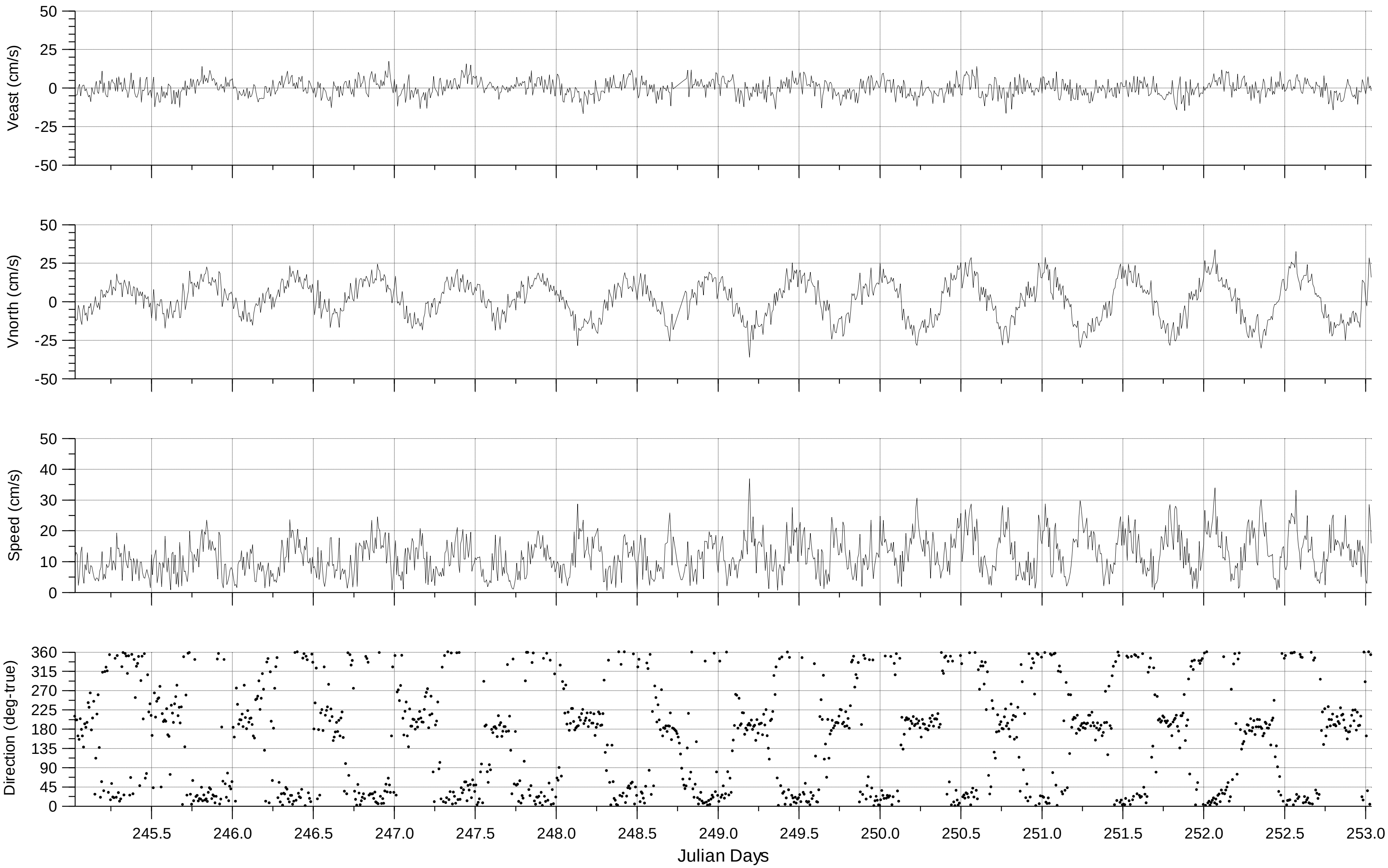

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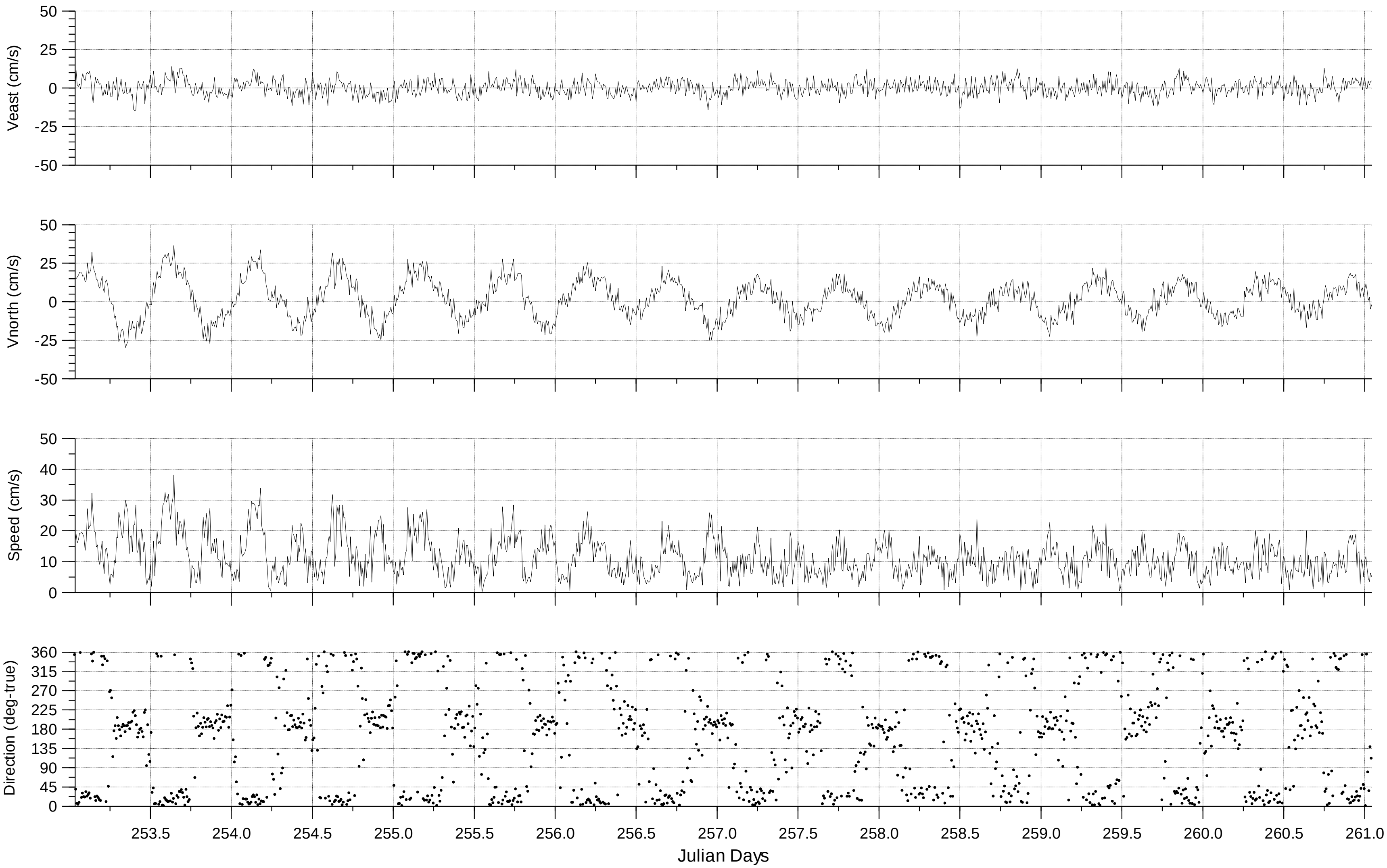

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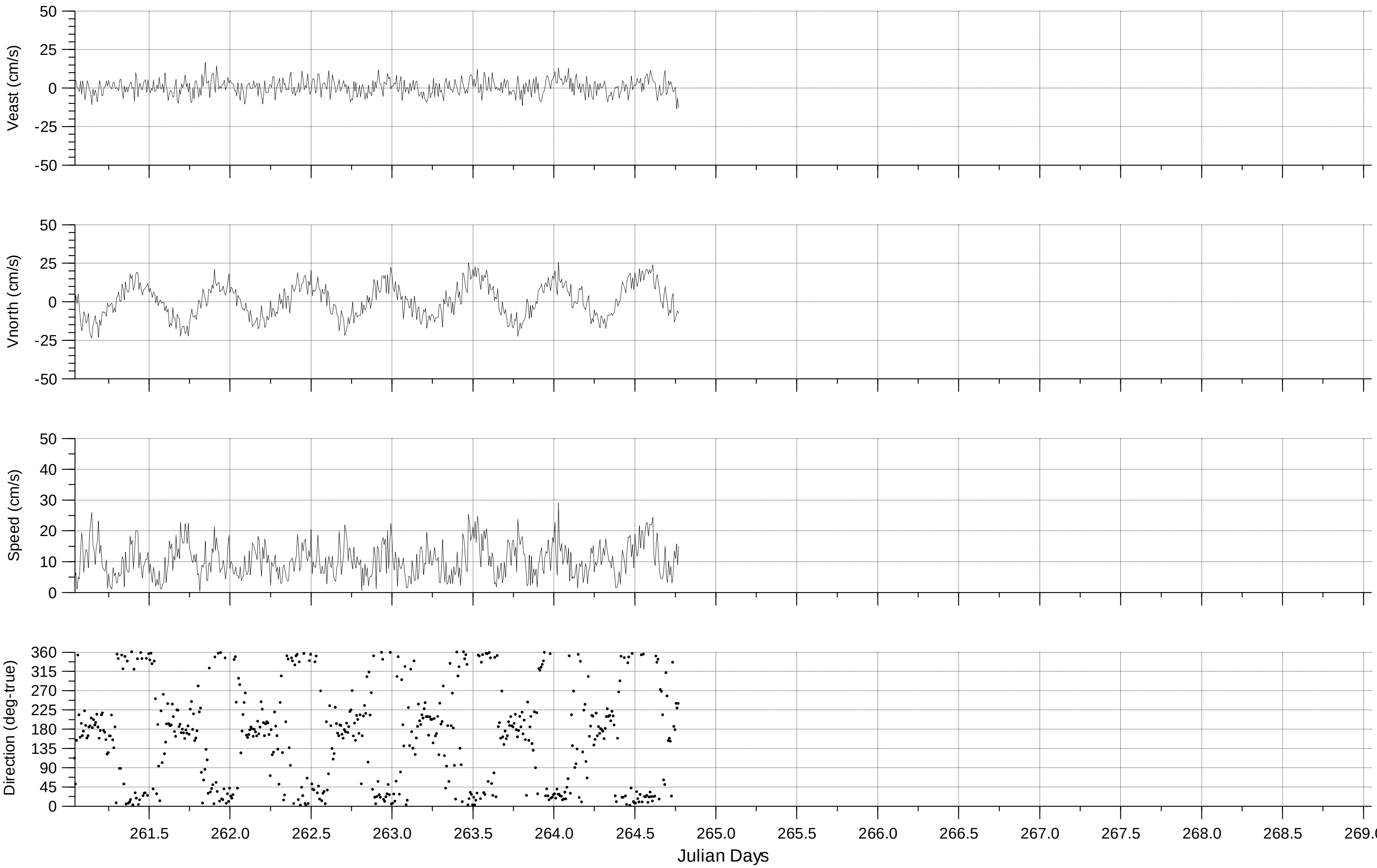

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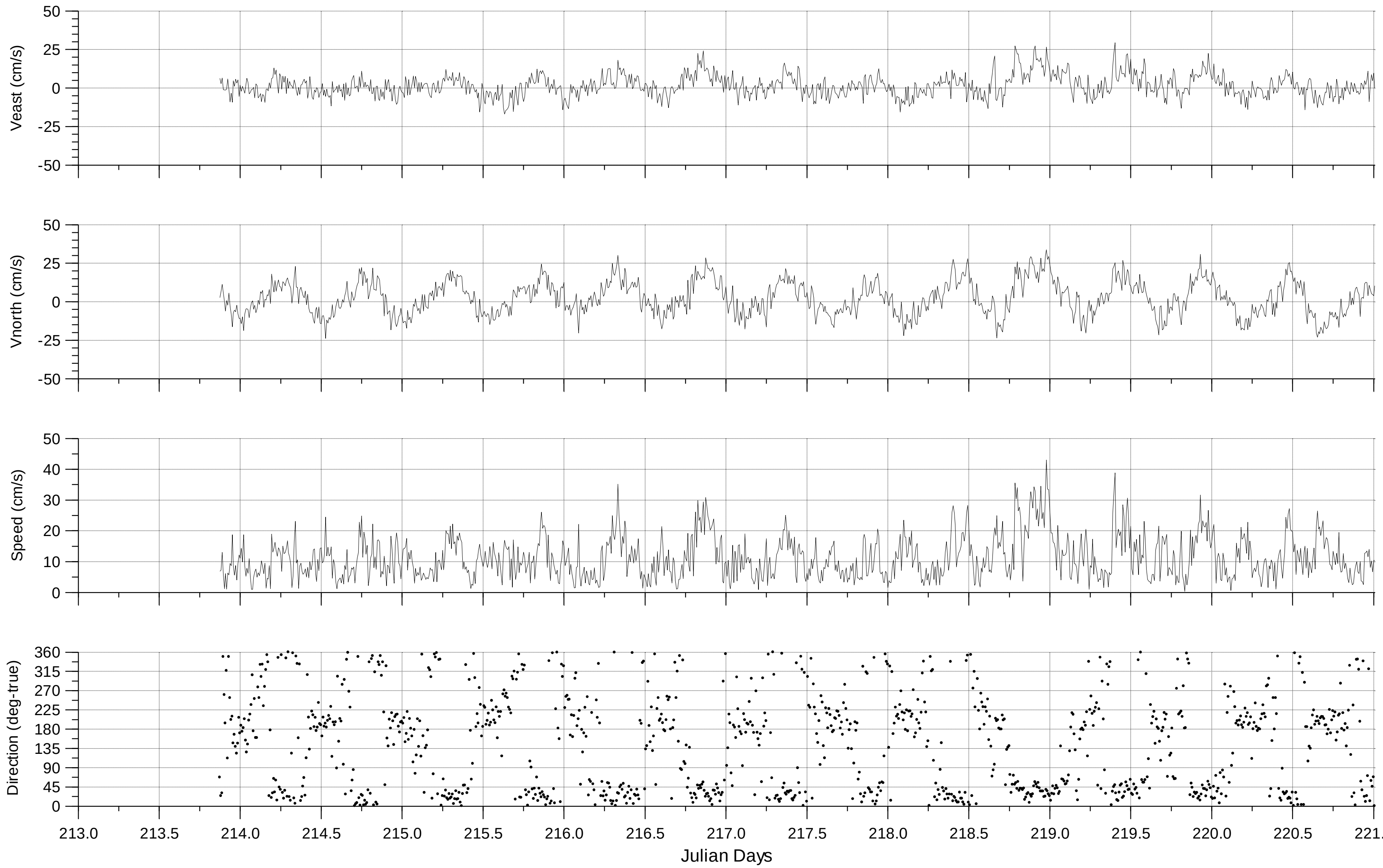
Time Series Plots – Veast, Vnorth, Speed, Direction

Surface Bin (constant depth)



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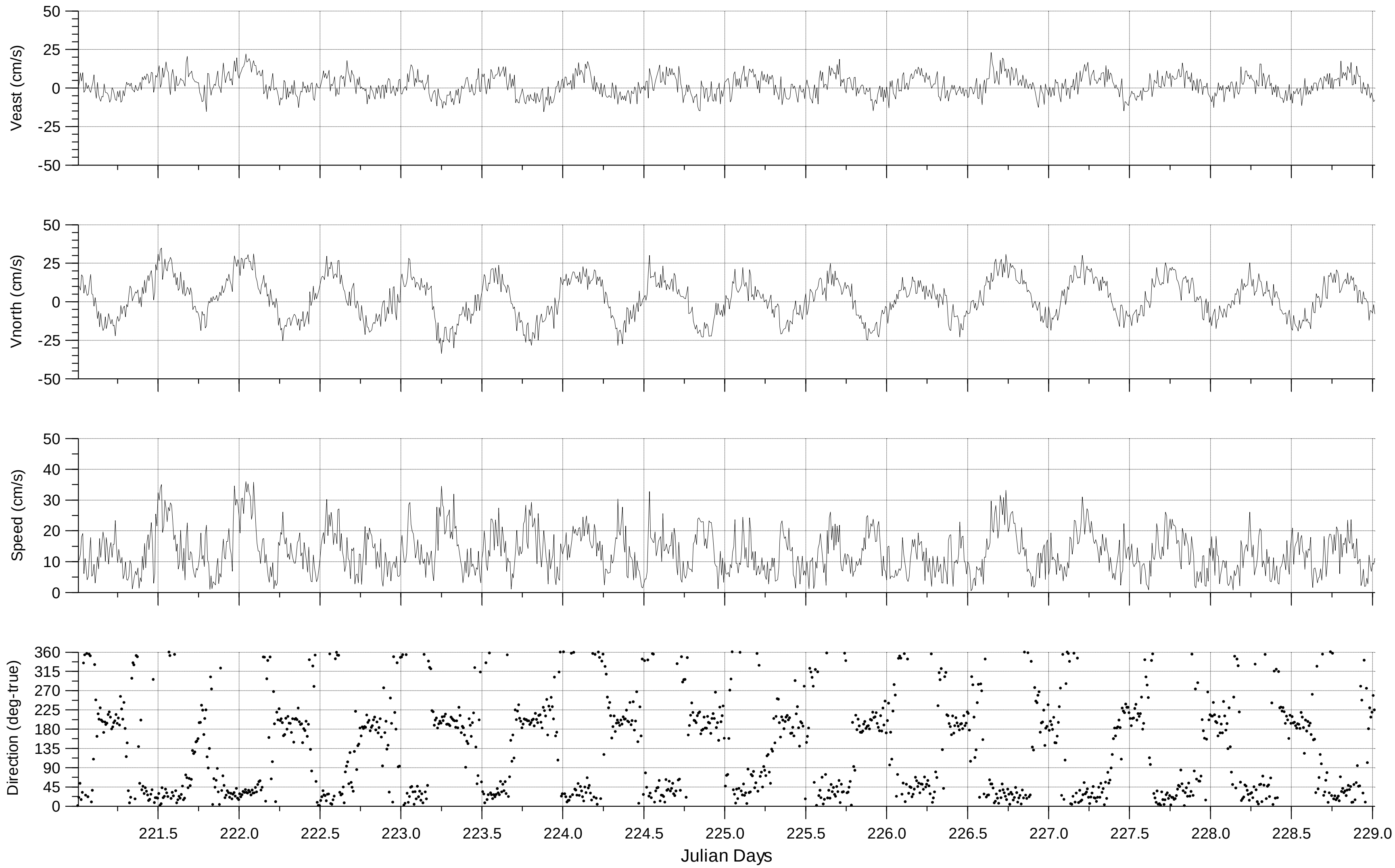

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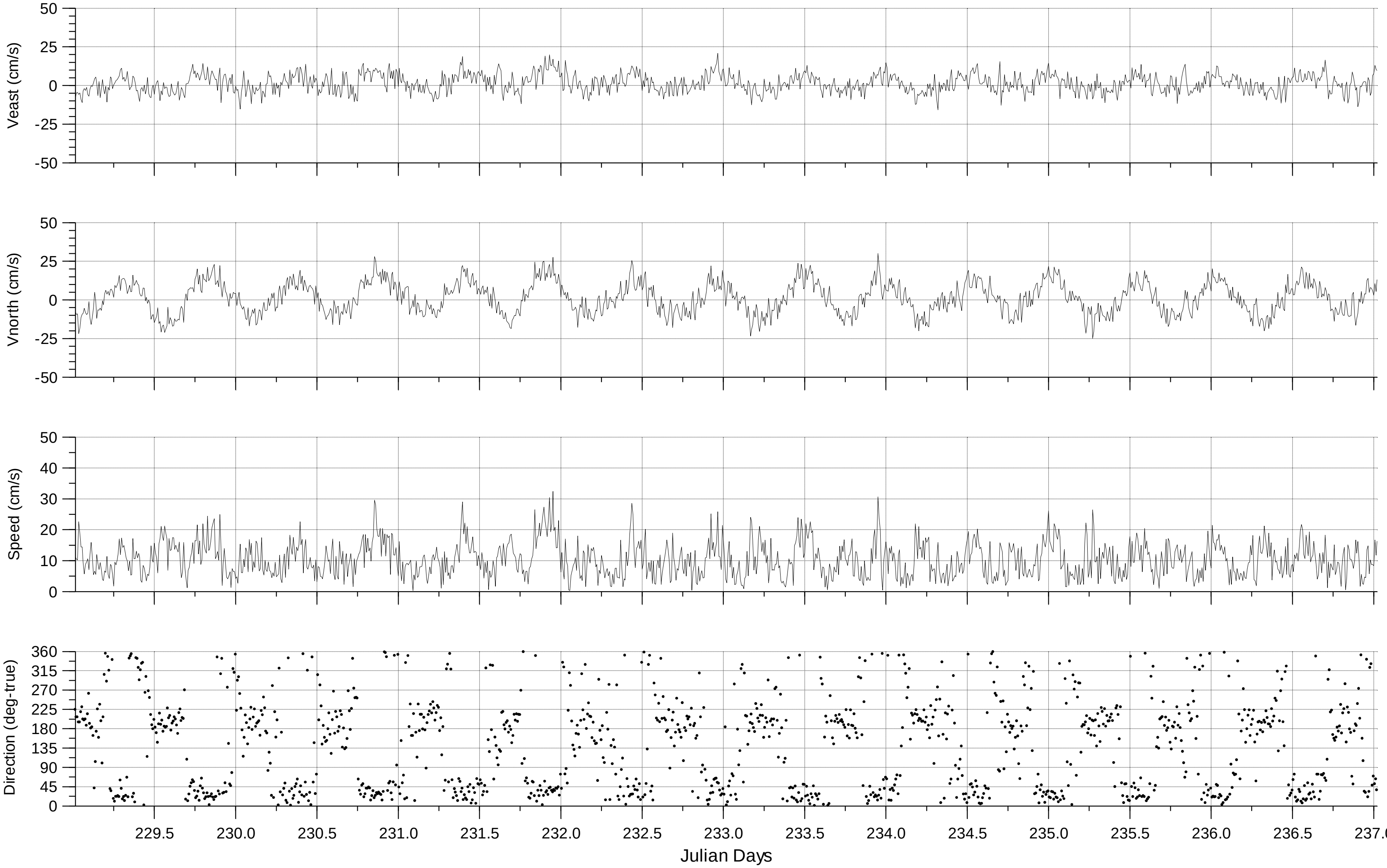

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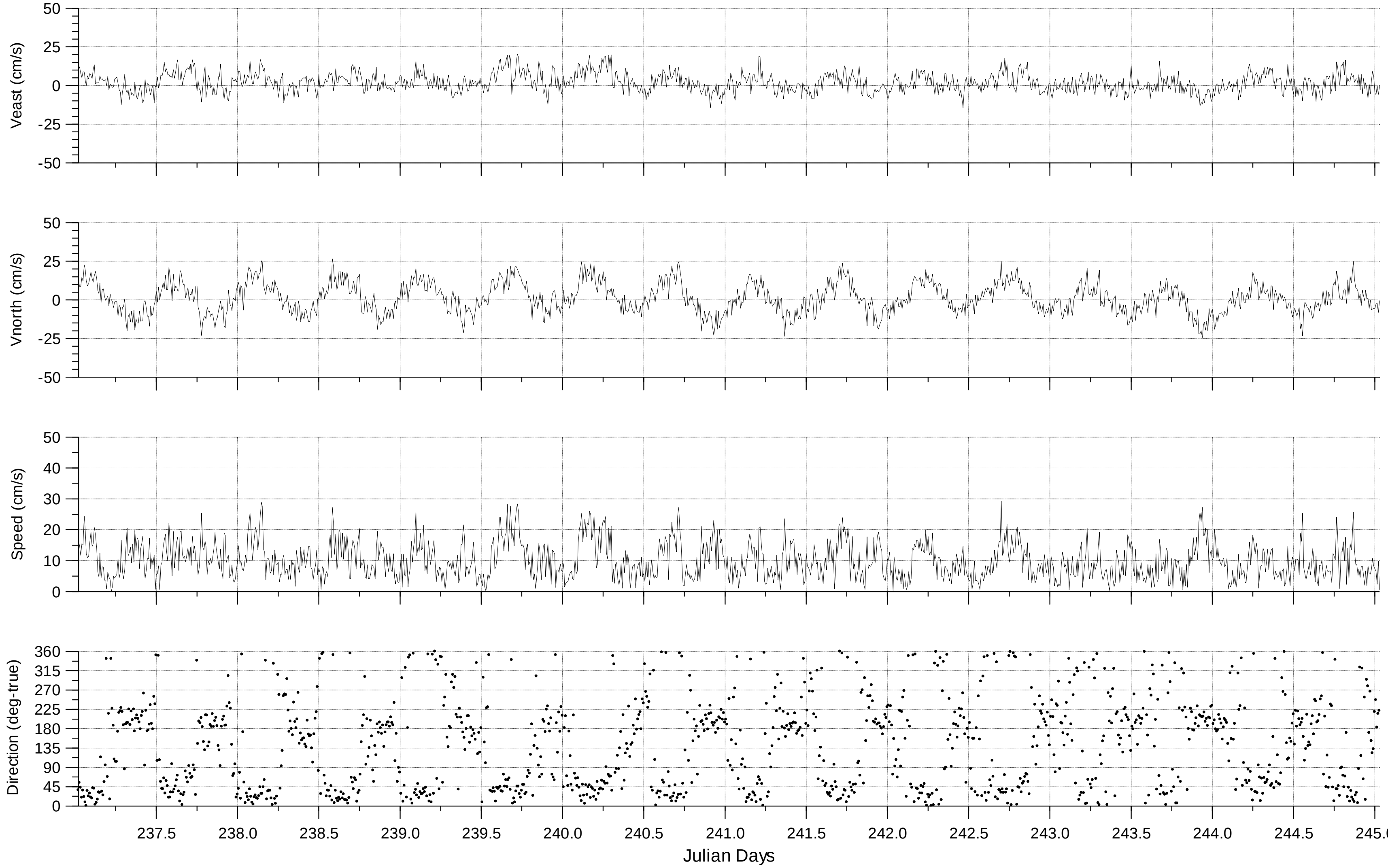
Instrument: 600Khz Profiler   Date: 2006/08/17 00:20:00.00 to 2006/08/25 00:30:00.00 UTC

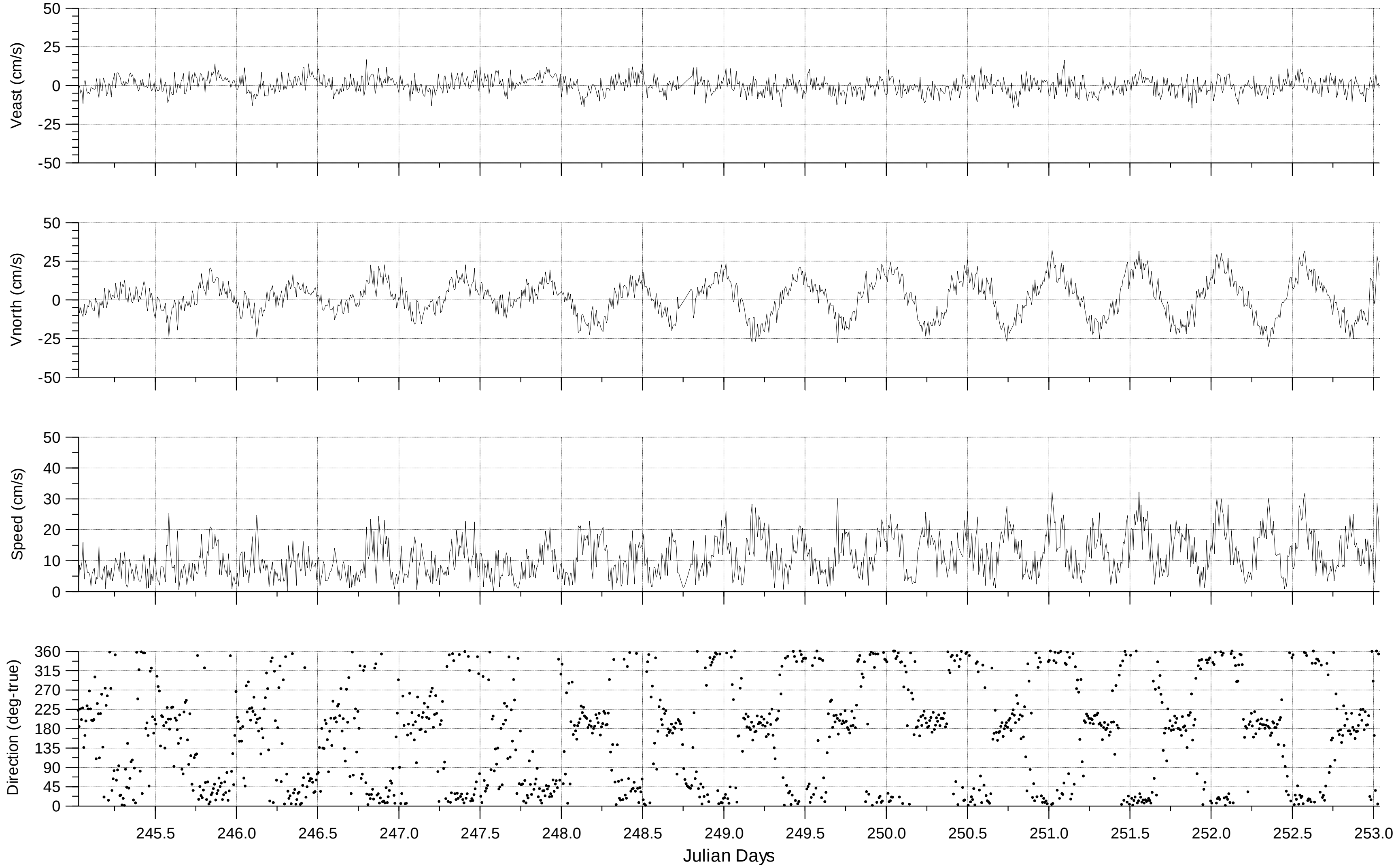
Filename: surface_constdepth_ed2.dat



Experiment: Quahog Bay ADCP   Site : Surface Bin - Two datasets combined (2 m depth)

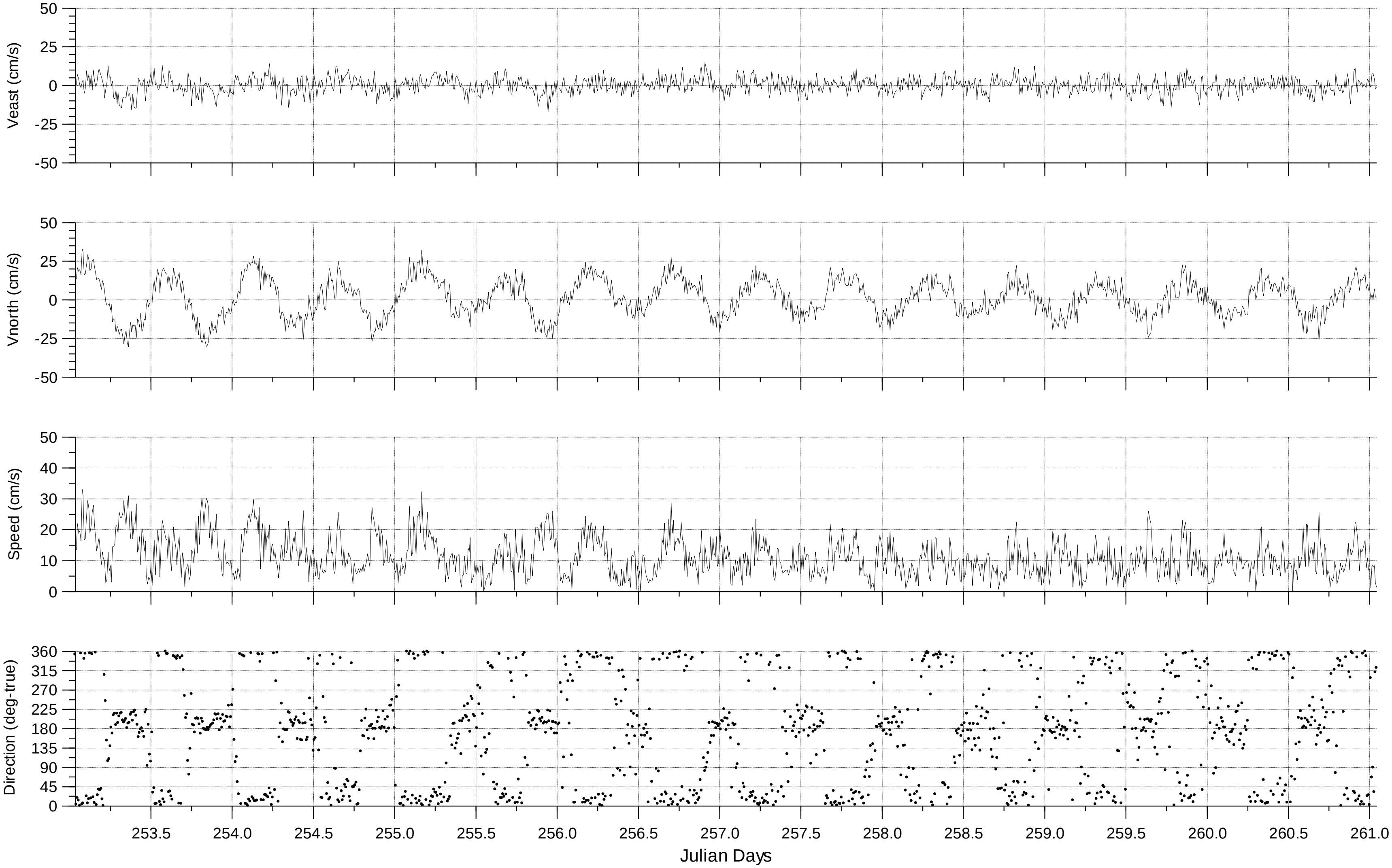
Instrument: 600Khz Profiler   Date: 2006/08/25 00:30:00.00 to 2006/09/02 00:40:00.00 UTC

Filename: surface_constdepth_ed2.dat



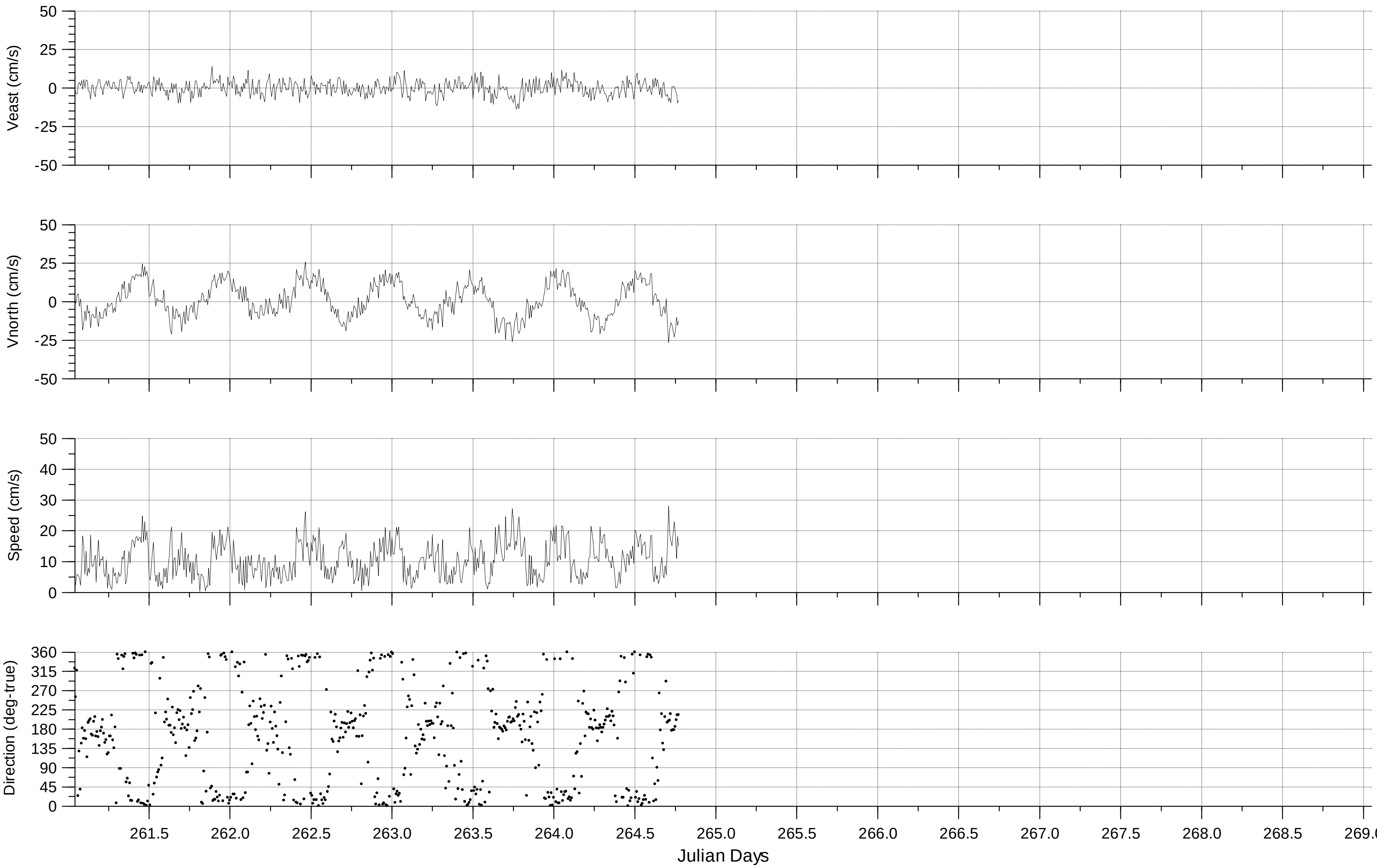
Experiment: Quahog Bay ADCP   Site : Surface Bin - Two datasets combined (2 m depth)
Instrument: 600Khz Profiler   Date: 2006/09/02 00:40:00.00 to 2006/09/10 00:50:00.00 UTC

Filename: surface_constdepth_ed2.dat



Experiment: Quahog Bay ADCP Site : Surface Bin - Two datasets combined (2 m depth)
Instrument: 600Khz Profiler Date: 2006/09/10 00:50:00.00 to 2006/09/18 01:00:00.00 UTC

Filename: surface_constdepth_ed2.dat



Experiment: Quahog Bay ADCP Site : Surface Bin - Two datasets combined (2 m depth)

Instrument: 600Khz Profiler Date: 2006/09/18 01:00:00.00 to 2006/09/21 18:30:00.00 UTC

Filename: surface_constdepth_ed2.dat

Speed-Direction Histogram Tables

Location: Quahog Bay - Bottom Bin
Instrument: 600Khz Profiler
For period: 2006/08/01 21:00:00 to 2006/09/21 18:30:00 UTC
Sample interval: 10 min

Direction (deg true)			Speed (cm/s)										Row Total (%)
			0.00 to 5.00	5.00 to 10.00	10.00 to 15.00	15.00 to 20.00	20.00 to 25.00	25.00 to 30.00	30.00 to 35.00	35.00 to 40.00	40.00 to 45.00	45.00 to 50.00	
11.25	**33.75**	**NNE**	1.06	2.52	3.57	2.03	0.87	0.25	0.01	0.01			**10.34**
33.75	**56.25**	**NE**	0.89	1.83	1.31	0.55	0.11	0.04	0.01				**4.73**
56.25	**78.75**	**ENE**	0.90	1.17	0.44	0.05							**2.56**
78.75	**101.25**	**E**	0.82	0.70	0.11								**1.62**
101.25	**123.75**	**ESE**	0.76	0.86	0.08								**1.71**
123.75	**146.25**	**SE**	0.95	1.08	0.42	0.04	0.01						**2.51**
146.25	**168.75**	**SSE**	1.16	2.44	1.75	1.04	0.30	0.07					**6.75**
168.75	**191.25**	**S**	1.16	3.11	4.43	3.83	1.79	0.59	0.05				**14.97**
191.25	**213.75**	**SSW**	1.21	3.48	5.29	4.98	2.44	0.85	0.19				**18.44**
213.75	**236.25**	**SW**	1.11	2.95	2.73	1.46	0.41	0.10					**8.74**
236.25	**258.75**	**WSW**	1.04	1.77	0.75	0.08	0.01						**3.66**
258.75	**281.25**	**W**	0.98	1.38	0.18	0.03							**2.56**
281.25	**303.75**	**WNW**	0.95	1.02	0.26	0.03							**2.26**
303.75	**326.25**	**NW**	0.78	1.24	0.56	0.18							**2.76**
326.25	**348.75**	**NNW**	0.93	2.24	1.72	0.56	0.16	0.01					**5.62**
348.75	**11.25**	**N**	1.02	2.76	3.49	2.17	1.02	0.25	0.03	0.01			**10.75**
Column Total (%)			**15.73**	**30.55**	**27.09**	**17.03**	**7.14**	**2.14**	**0.30**	**0.03**	**0.00**	**0.00**	

Filename: bottom_ed2.dat
Max Speed: 36.50 cm/s
Mean Speed: 11.34 cm/s
non-flagged records: 7330
flagged records: 0
Vector-averaged Speed: 2.70 cm/s at 203.13 deg

Location: Quahog Bay - Mid Depth Bin
Instrument: 600Khz Profiler
For period: 2006/08/01 21:00:00 to 2006/09/21 18:30:00 UTC
Sample interval: 10 min

Direction (deg true)			Speed (cm/s)										Row Total (%)
			0.00 to 5.00	5.00 to 10.00	10.00 to 15.00	15.00 to 20.00	20.00 to 25.00	25.00 to 30.00	30.00 to 35.00	35.00 to 40.00	40.00 to 45.00	45.00 to 50.00	
11.25	**33.75**	**NNE**	1.20	3.14	3.92	2.80	1.61	0.49	0.15	0.03	0.01		**13.34**
33.75	**56.25**	**NE**	0.94	2.26	1.84	0.76	0.19	0.03					**6.03**
56.25	**78.75**	**ENE**	1.05	1.38	0.56	0.05							**3.04**
78.75	**101.25**	**E**	1.11	0.95	0.22								**2.28**
101.25	**123.75**	**ESE**	0.87	0.79	0.10								**1.76**
123.75	**146.25**	**SE**	1.04	1.04	0.23	0.01							**2.32**
146.25	**168.75**	**SSE**	1.06	1.86	1.24	0.40	0.11						**4.67**
168.75	**191.25**	**S**	1.42	3.55	3.40	2.62	1.31	0.27	0.04				**12.61**
191.25	**213.75**	**SSW**	1.34	3.45	4.94	3.77	2.03	0.79	0.14				**16.45**
213.75	**236.25**	**SW**	1.24	2.73	2.31	1.23	0.60	0.15	0.01				**8.27**
236.25	**258.75**	**WSW**	1.27	1.90	0.78	0.20	0.01						**4.16**
258.75	**281.25**	**W**	1.00	1.30	0.27	0.01							**2.58**
281.25	**303.75**	**WNW**	1.16	1.19	0.23								**2.58**
303.75	**326.25**	**NW**	1.04	1.20	0.42	0.04							**2.70**
326.25	**348.75**	**NNW**	1.34	2.32	1.30	0.38	0.20	0.07					**5.61**
348.75	**11.25**	**N**	1.16	2.77	3.56	2.11	1.31	0.50	0.12	0.07			**11.61**
Column Total (%)			**18.23**	**31.81**	**25.31**	**14.39**	**7.38**	**2.31**	**0.46**	**0.10**	**0.01**	**0.00**	

Filename: mid_ed2.dat
Max Speed: 42.26 cm/s
Mean Speed: 11.00 cm/s
non-flagged records: 7330
flagged records: 0
Vector-averaged Speed: 0.88 cm/s at 226.58 deg

Location: Quahog Bay - Surface Bin (constant height above bottom)
Instrument: 600Khz Profiler
For period: 2006/08/01 21:00:00 to 2006/09/21 18:30:00 UTC
Sample interval: 10 min

			Speed (cm/s)										
Direction (deg true)			**0.00 to 5.00**	**5.00 to 10.00**	**10.00 to 15.00**	**15.00 to 20.00**	**20.00 to 25.00**	**25.00 to 30.00**	**30.00 to 35.00**	**35.00 to 40.00**	**40.00 to 45.00**	**45.00 to 50.00**	**Row Total (%)**
11.25	**33.75**	**NNE**	1.05	3.18	5.29	4.54	2.77	1.15	0.41	0.12			**18.51**
33.75	**56.25**	**NE**	1.00	1.96	2.25	1.19	0.48	0.07	0.03				**6.97**
56.25	**78.75**	**ENE**	0.91	1.24	0.38	0.10	0.01						**2.65**
78.75	**101.25**	**E**	0.82	0.95	0.05	0.01							**1.84**
101.25	**123.75**	**ESE**	0.93	0.85	0.04								**1.81**
123.75	**146.25**	**SE**	0.75	1.09	0.23	0.01							**2.09**
146.25	**168.75**	**SSE**	0.95	1.79	1.19	0.48	0.07						**4.47**
168.75	**191.25**	**S**	0.97	2.97	3.48	2.29	0.79	0.33	0.01				**10.85**
191.25	**213.75**	**SSW**	1.04	3.12	4.46	3.07	1.15	0.27	0.03	0.01			**13.15**
213.75	**236.25**	**SW**	0.93	2.74	2.29	0.91	0.19	0.01					**7.08**
236.25	**258.75**	**WSW**	0.98	1.47	0.64	0.14	0.01						**3.25**
258.75	**281.25**	**W**	0.74	1.02	0.34	0.01							**2.11**
281.25	**303.75**	**WNW**	0.87	0.79	0.14								**1.80**
303.75	**326.25**	**NW**	0.71	1.28	0.41	0.04							**2.44**
326.25	**348.75**	**NNW**	1.04	1.98	1.62	0.67	0.22	0.05					**5.58**
348.75	**11.25**	**N**	0.95	3.38	3.96	4.02	2.14	0.70	0.20	0.03			**15.39**
Column Total (%)			**14.64**	**29.84**	**26.78**	**17.49**	**7.83**	**2.58**	**0.68**	**0.16**	**0.00**	**0.00**	

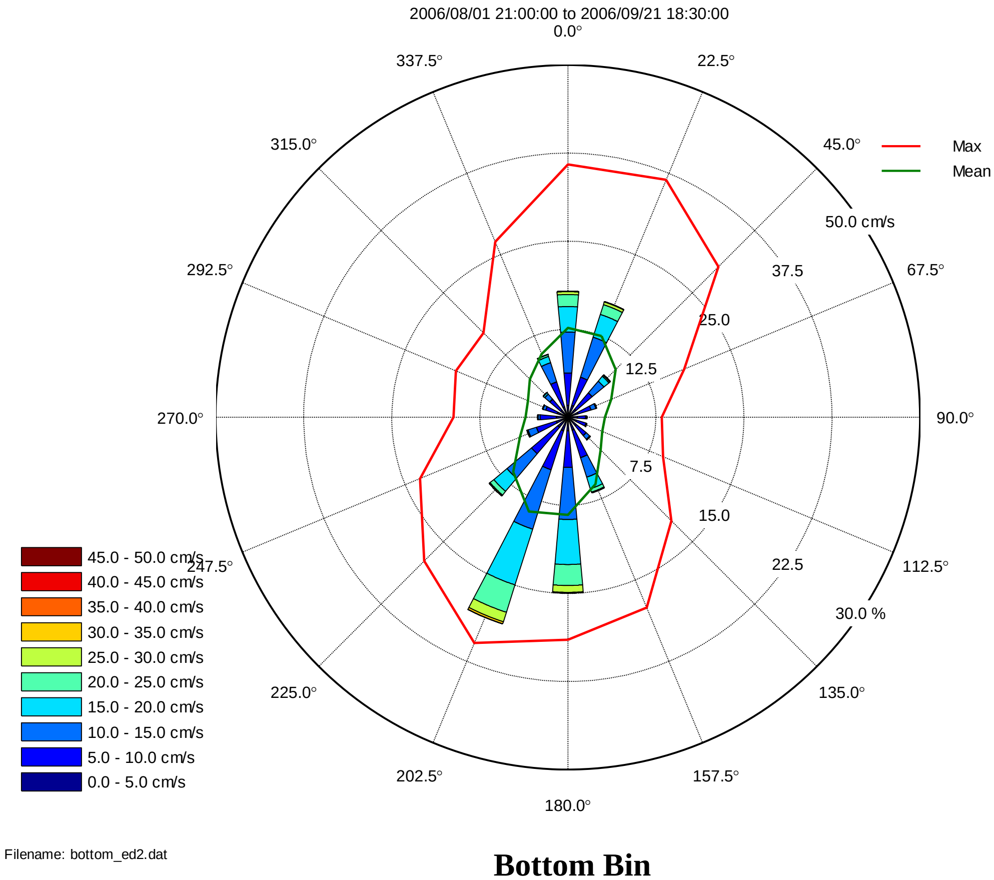
Filename: surface_ed2.dat
Max Speed: 38.16 cm/s
Mean Speed: 11.77 cm/s
non-flagged records: 7330
flagged records: 0
Vector-averaged Speed: 2.12 cm/s at 7.87 deg

Location: Quahog Bay - Surface Bin (constant depth)
Instrument: 600Khz Profiler
For period: 2006/08/01 21:00:00 to 2006/09/21 18:30:00 UTC
Sample interval: 10 min

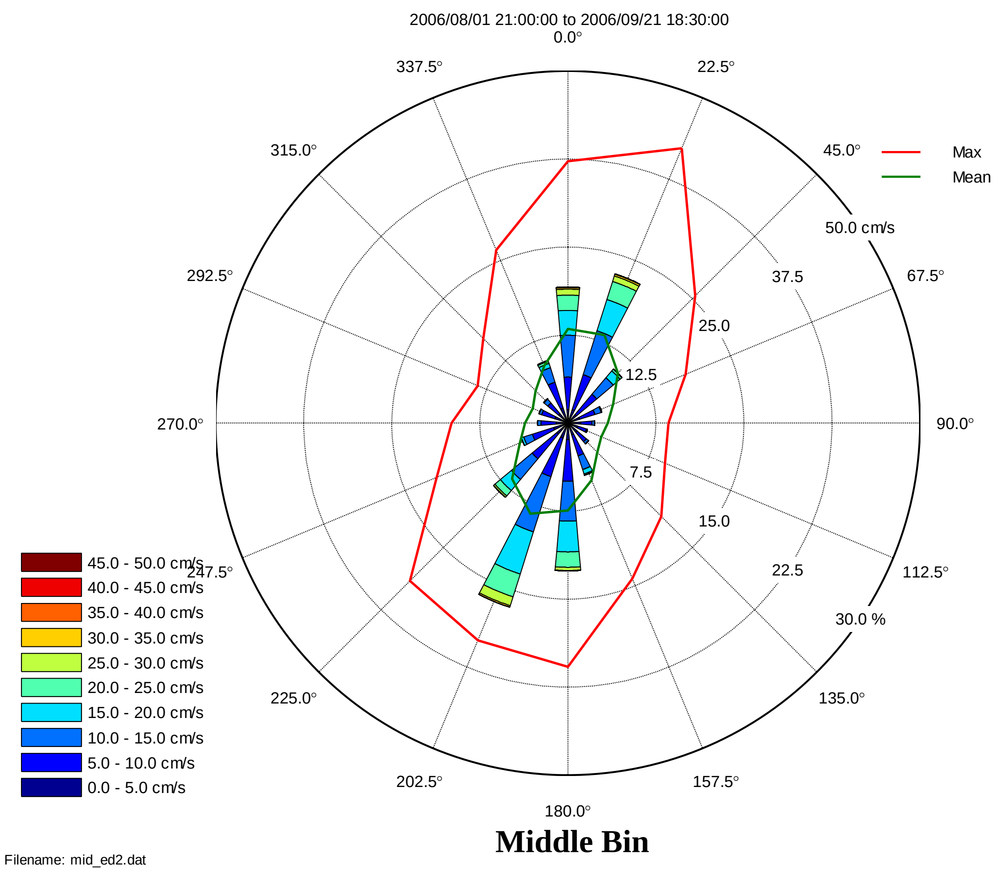
			Speed (cm/s)										
Direction (deg true)			**0.00 to 5.00**	**5.00 to 10.00**	**10.00 to 15.00**	**15.00 to 20.00**	**20.00 to 25.00**	**25.00 to 30.00**	**30.00 to 35.00**	**35.00 to 40.00**	**40.00 to 45.00**	**45.00 to 50.00**	**Row Total (%)**
11.25	**33.75**	**NNE**	1.17	3.15	4.68	4.07	2.29	0.85	0.27	0.04			**16.52**
33.75	**56.25**	**NE**	1.23	2.69	2.91	2.02	0.79	0.31	0.18	0.04	0.01		**10.18**
56.25	**78.75**	**ENE**	1.08	1.71	1.13	0.49	0.14	0.03					**4.57**
78.75	**101.25**	**E**	0.85	1.31	0.33	0.05	0.01						**2.55**
101.25	**123.75**	**ESE**	1.00	1.00	0.23								**2.22**
123.75	**146.25**	**SE**	1.04	1.66	0.37	0.04							**3.11**
146.25	**168.75**	**SSE**	1.26	2.21	1.32	0.27	0.08	0.01					**5.16**
168.75	**191.25**	**S**	1.13	2.93	3.38	2.20	0.78	0.19	0.03				**10.64**
191.25	**213.75**	**SSW**	1.27	3.18	3.74	2.54	1.15	0.42	0.08				**12.37**
213.75	**236.25**	**SW**	1.20	2.32	1.96	0.86	0.23	0.03					**6.60**
236.25	**258.75**	**WSW**	0.95	1.34	0.45	0.10							**2.84**
258.75	**281.25**	**W**	0.85	0.94	0.26	0.05							**2.10**
281.25	**303.75**	**WNW**	1.09	0.76	0.19	0.04							**2.09**
303.75	**326.25**	**NW**	0.89	1.17	0.46	0.05							**2.58**
326.25	**348.75**	**NNW**	1.05	1.98	1.16	0.70	0.14	0.01					**5.03**
348.75	**11.25**	**N**	1.12	2.84	3.21	2.55	1.21	0.38	0.11	0.01			**11.43**
Column Total (%)			**17.16**	**31.19**	**25.78**	**16.03**	**6.82**	**2.24**	**0.67**	**0.10**	**0.01**	**0.00**	

Filename: surface_constdepth_ed2.dat
Max Speed: 43.03 cm/s
Mean Speed: 11.19 cm/s
non-flagged records: 7330
flagged records: 0
Vector-averaged Speed: 1.86 cm/s at 34.25 deg

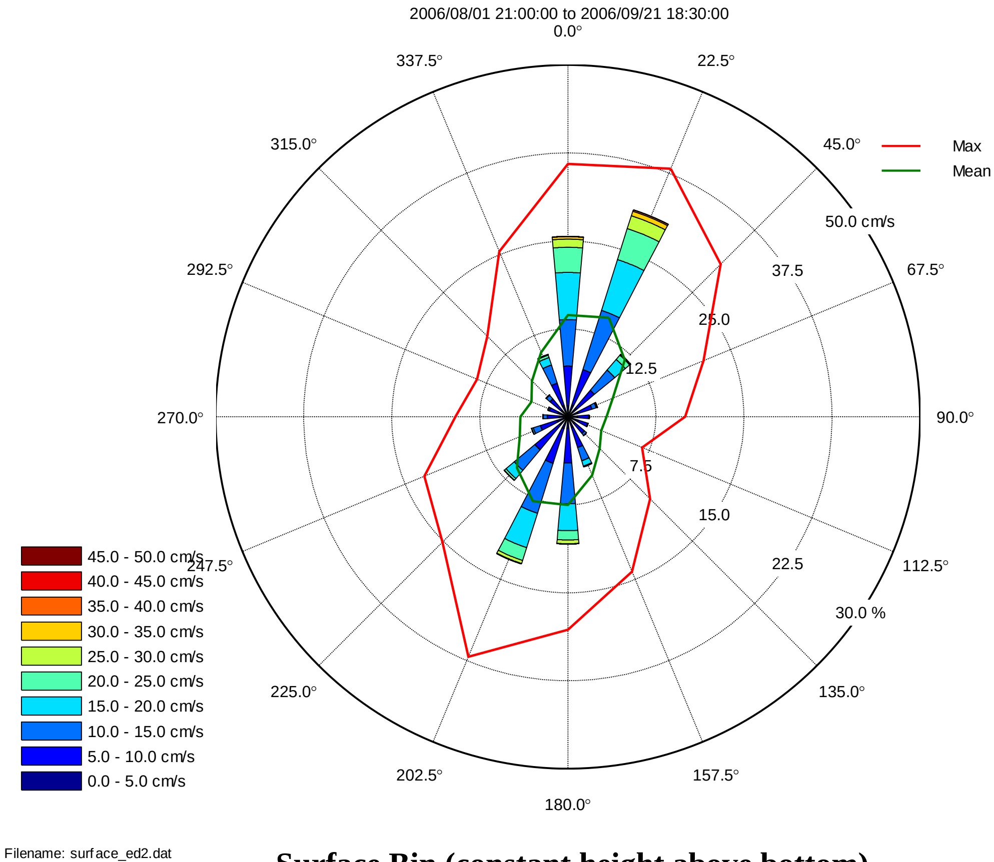
Speed-Direction Histogram Tables



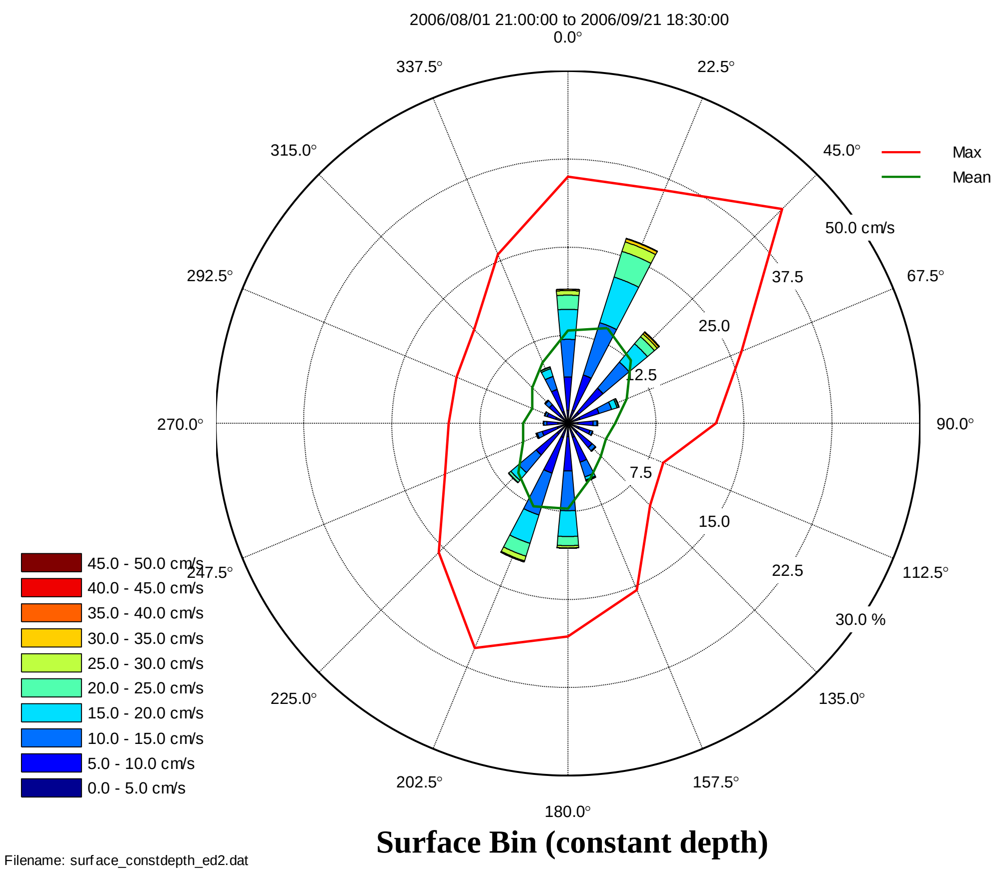
Bottom Bin



Middle Bin

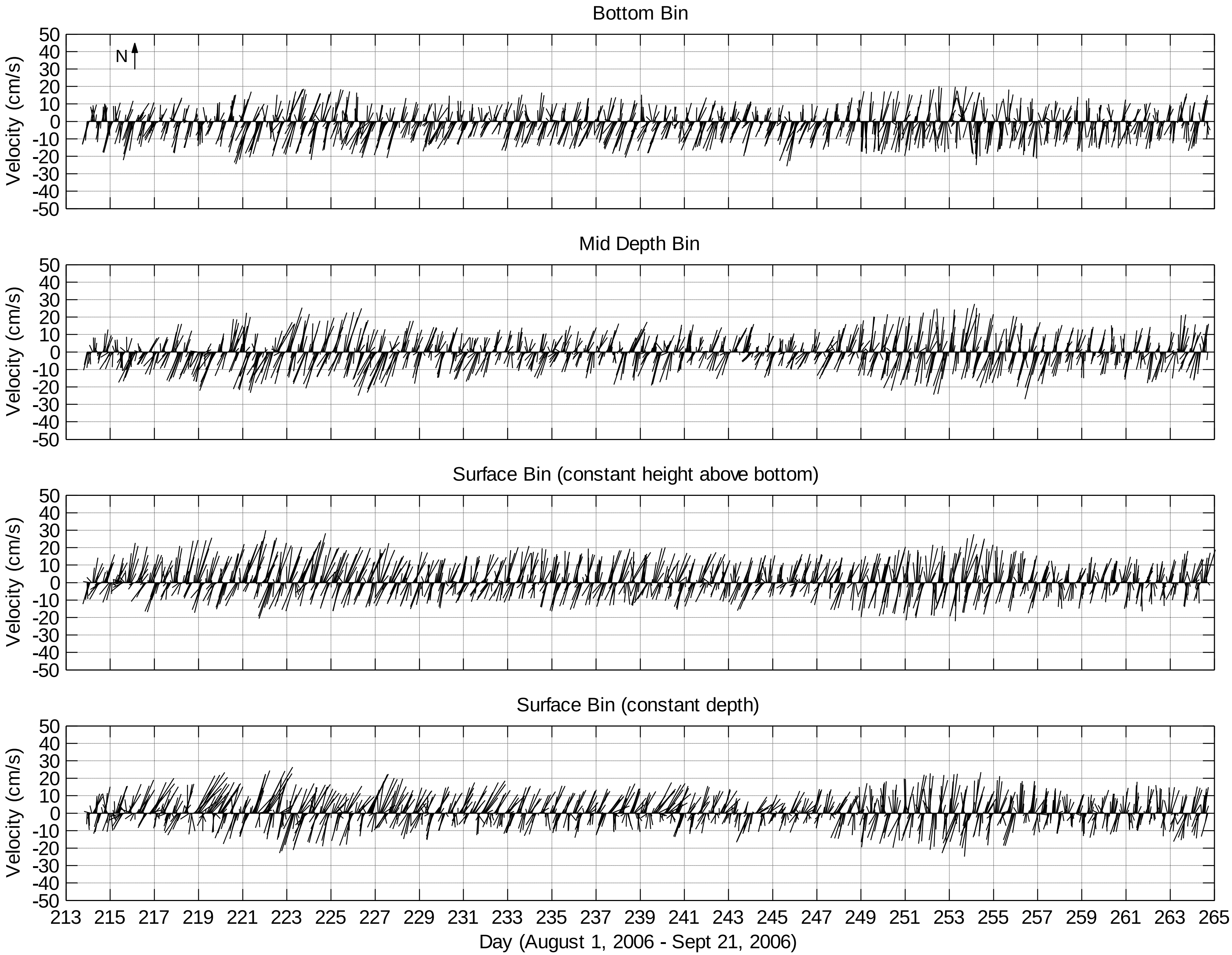


Surface Bin (constant height above bottom)

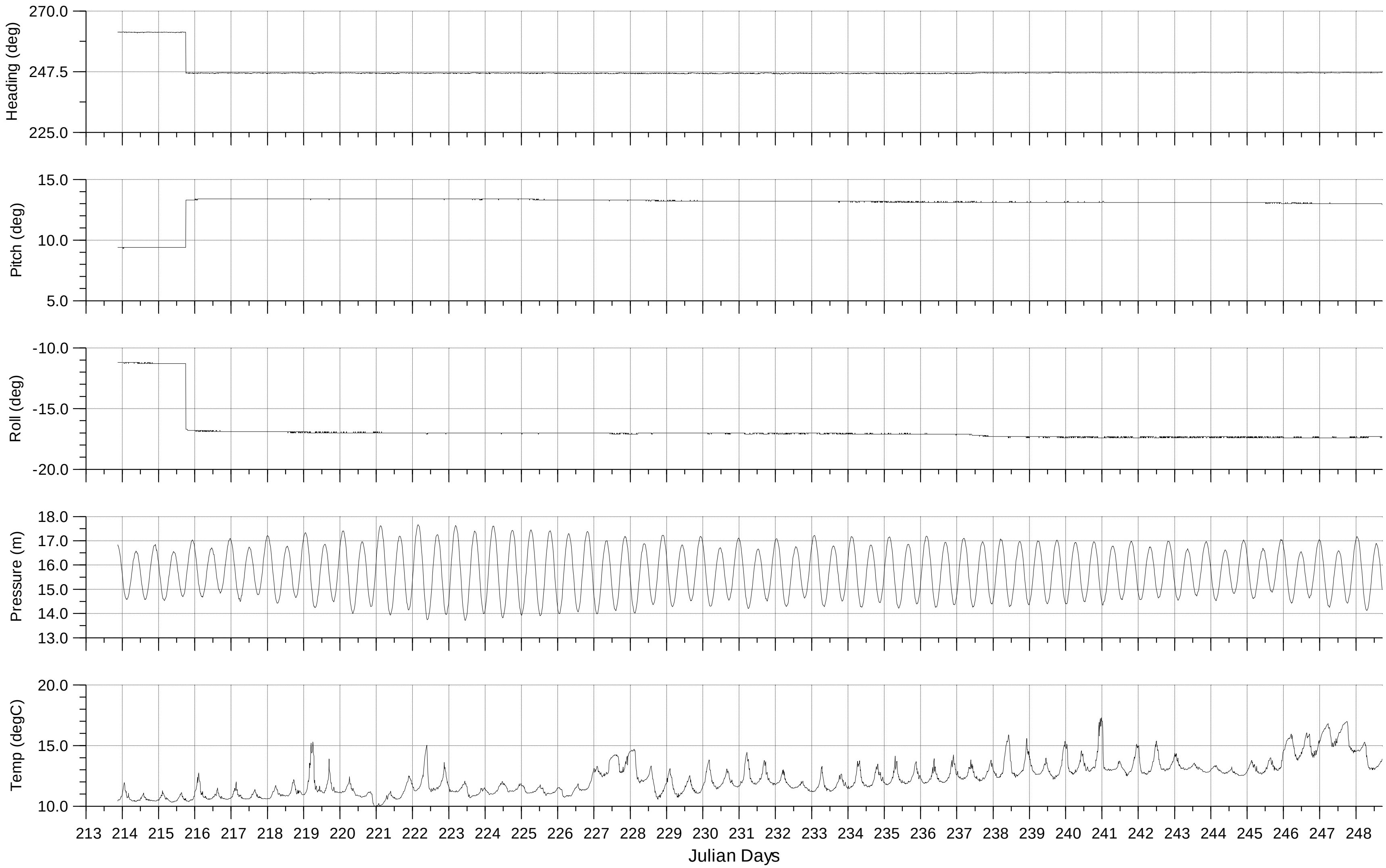


Surface Bin (constant depth)

Current Stick Plots


Bottom Bin
Mid Depth Bin
Surface Bin (constant height above bottom)
Surface Bin (constant depth)
N
Velocity (cm/s)
50
40
30
20
10
0
-10
-20
-30
-40
-50
213
215
217
219
221
223
225
227
229
231
233
235
237
239
241
243
245
247
249
251
253
255
257
259
261
263
265
Day (August 1, 2006 - Sept 21, 2006)

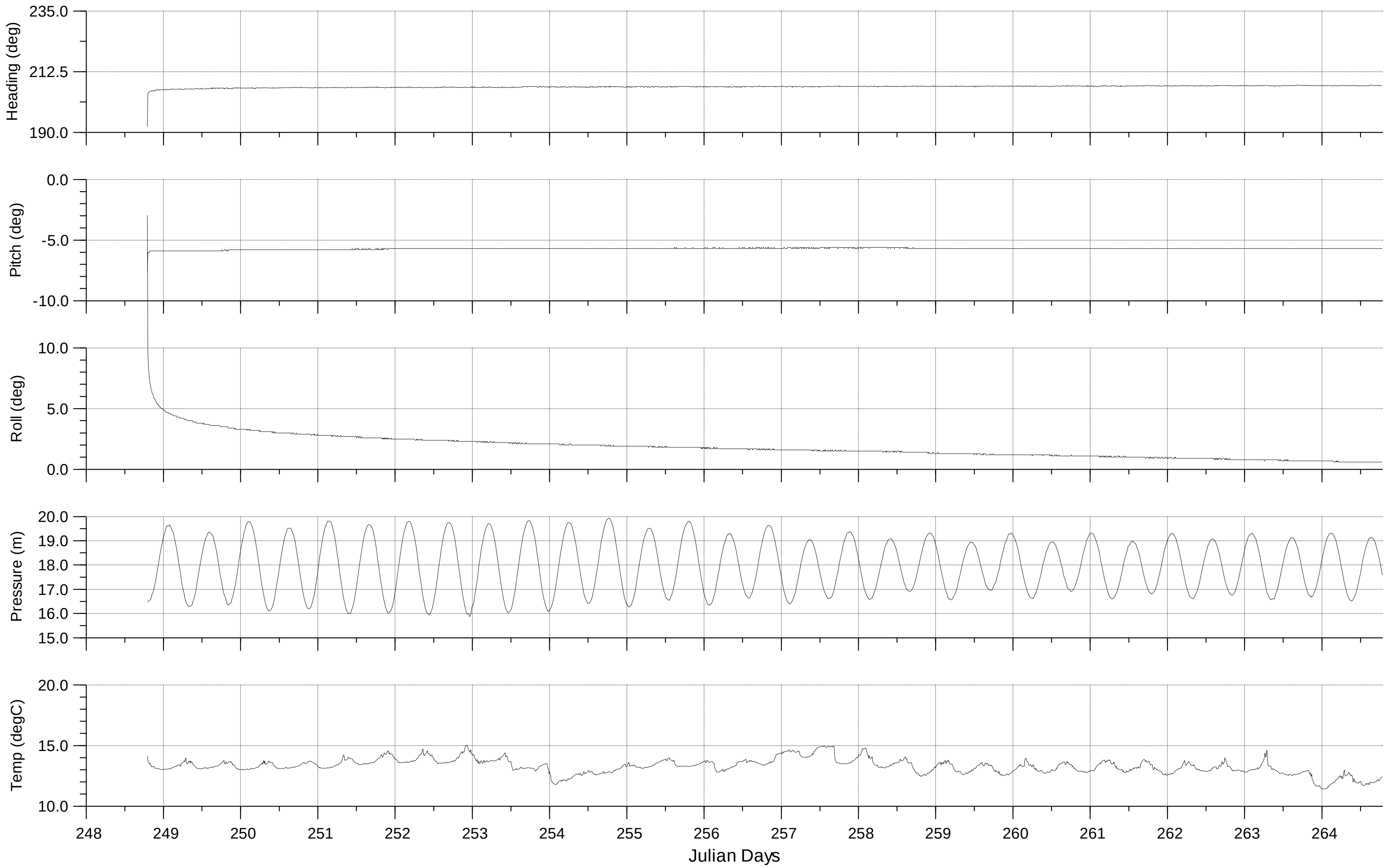
Time Series Plots – Heading, Pitch, Roll, Pressure, Temperature



Experiment: Friends of Casco Bay Site : Quahog Bay

Instrument: 600Khz Profiler Date: 2006/08/01 21:00:00.00 to 2006/09/05 17:20:00.00 EST

Filename: QBay1D01_sen_ed1.dat

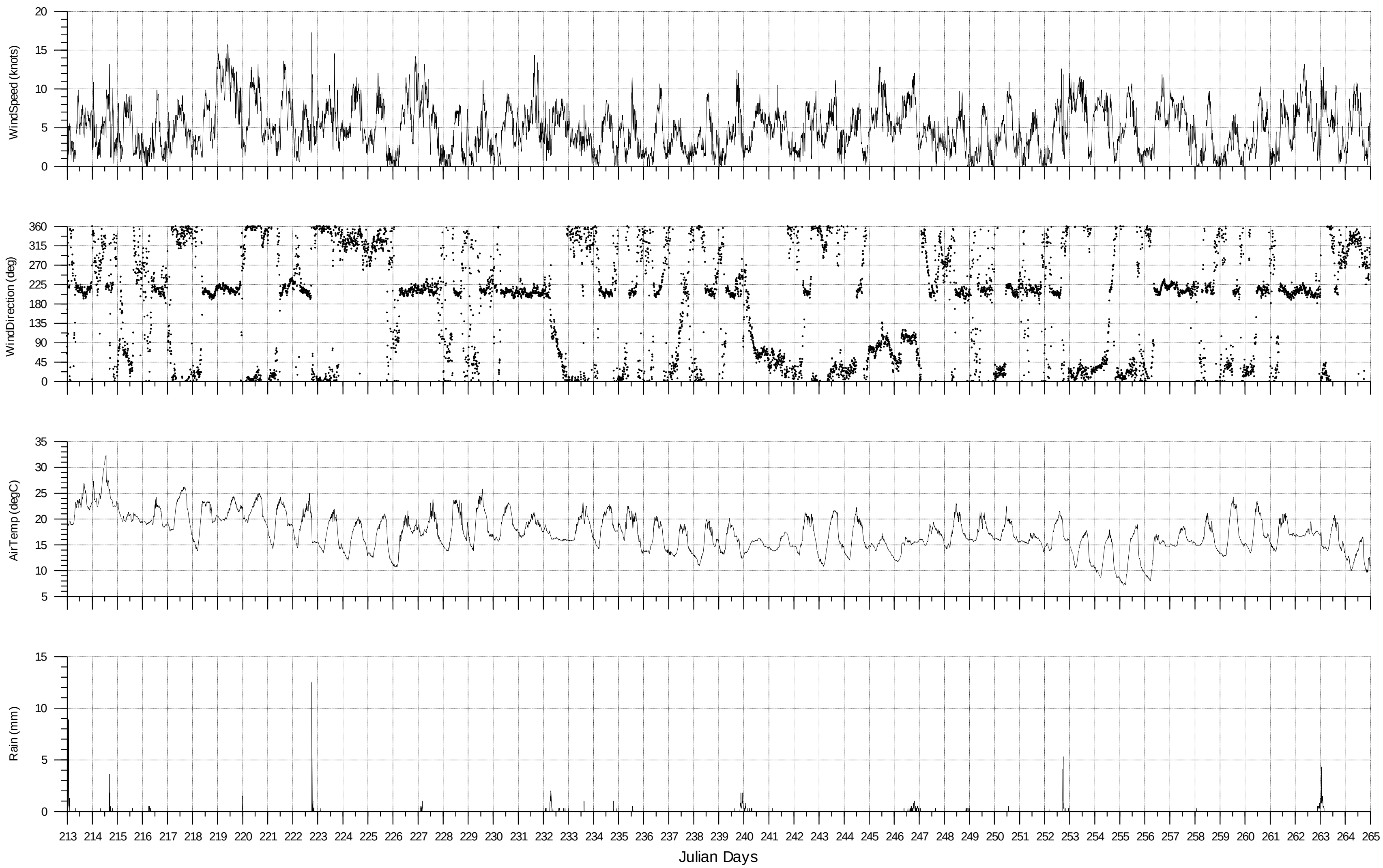


Experiment: Friends of Casco Bay Site : Quahog Bay

Instrument: 600Khz Profiler Date: 2006/09/05 19:00:00.00 to 2006/09/21 18:49:60.00 EST

Filename: QB1D0201_sen_ed1.dat

Time Series Plots – Met Data

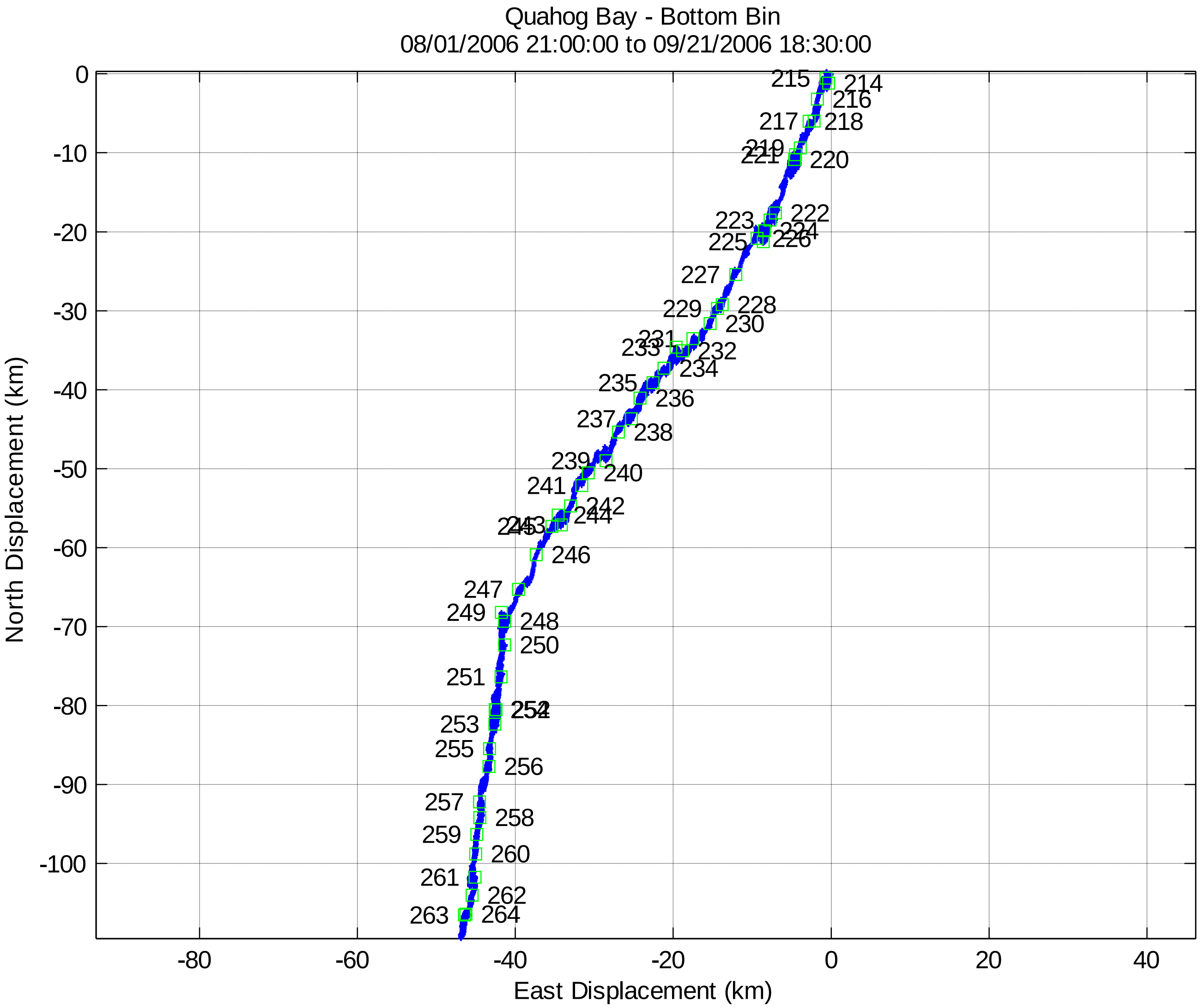


Experiment: Friends of Casco Bay Site : Quahog Bay Met Data

Instrument: Met Station Date: 2006/08/01 00:00:00.00 to 2006/09/22 00:00:00.00 EST

Filename: QuahogMet_ed2.dat

Progressive Vector Diagrams


Quahog Bay - Bottom Bin
08/01/2006 21:00:00 to 09/21/2006 18:30:00
North Displacement (km)
East Displacement (km)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-80
-60
-40
-20
0
20
40
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
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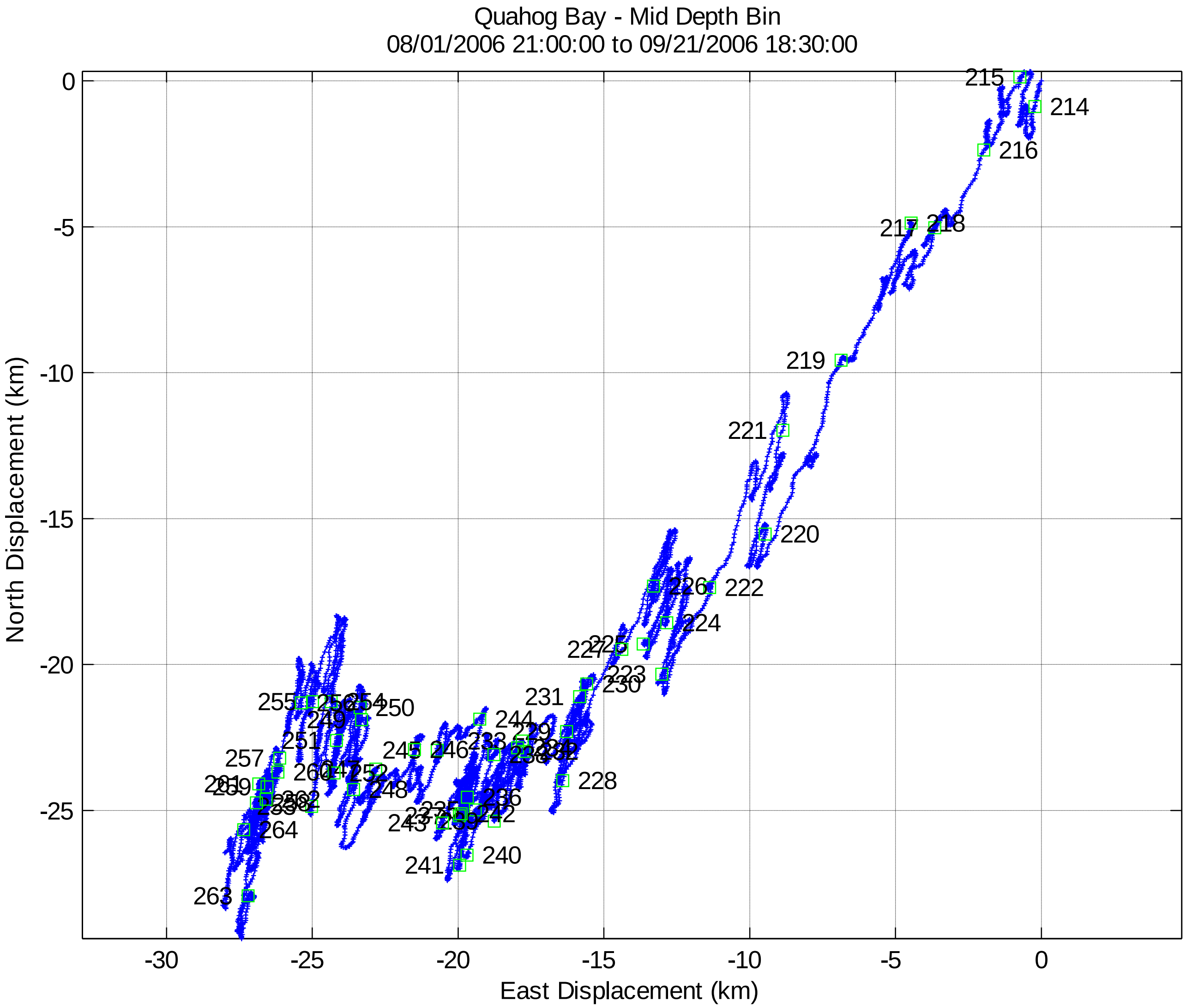
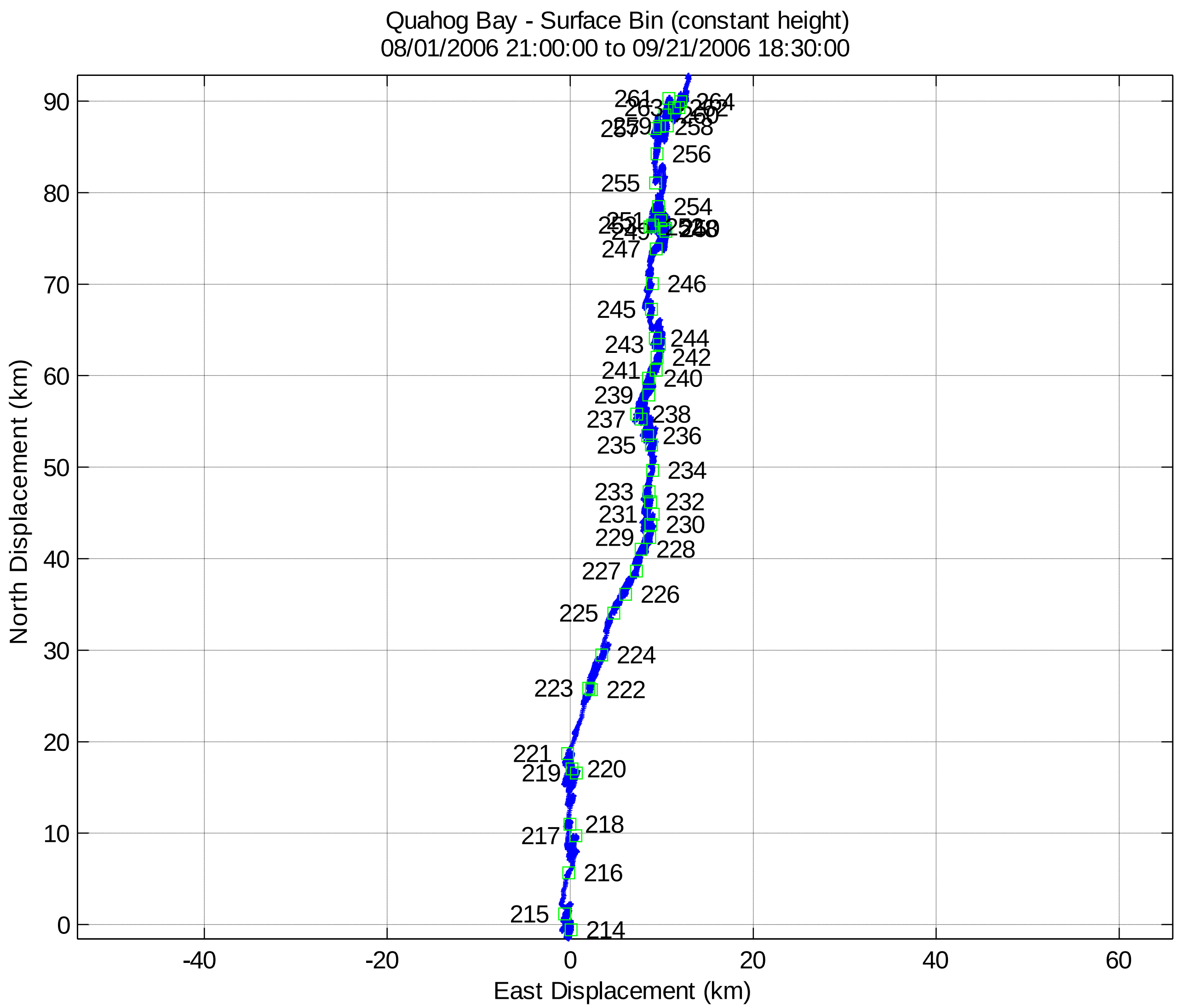
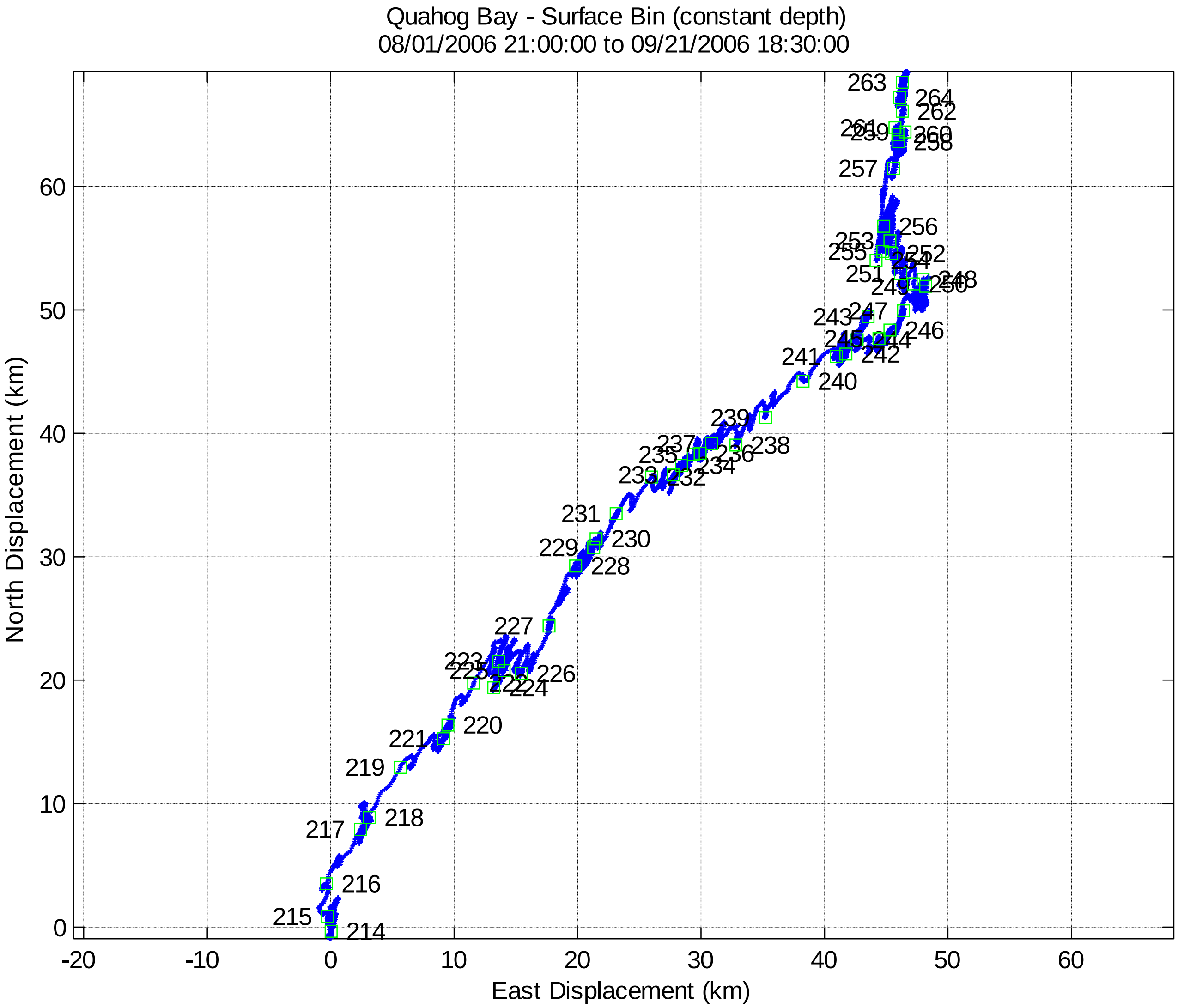
260
261
262
263
264



Quahog Bay - Mid Depth Bin
08/01/2006 21:00:00 to 09/21/2006 18:30:00
North Displacement (km)
East Displacement (km)
0
-5
-10
-15
-20
-25
-30
-25
-20
-15
-10
-5
0
215
214
216
218
219
221
220
226
222
224
227
225
223
230
231
228
244
255
250
249
251
257
245
246
240
241
263
264


Quahog Bay - Surface Bin (constant height)
08/01/2006 21:00:00 to 09/21/2006 18:30:00
North Displacement (km)
East Displacement (km)


Quahog Bay - Surface Bin (constant depth)
08/01/2006 21:00:00 to 09/21/2006 18:30:00
North Displacement (km)
East Displacement (km)
214
215
216
217
218
219
220
221
226
227
228
229
230
231
238
239
240
241
242
246
256
257
263
264
262