Marine Field Group
Florida State University

Dispersion Experiment in the Eastern Gulf of Mexico
RAFOS Float Data Report
May 2012 – May 2013

by
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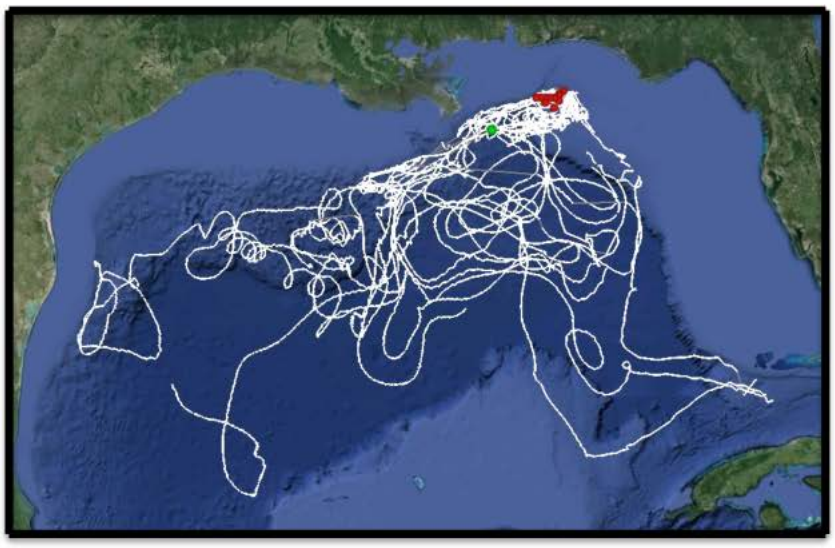
August 2013



Technical Report

Funding was provided by the BP – Gulf of Mexico Research Initiative

Lateral Dispersion in the De Soto Canyon Region, Gulf of Mexico RAFOS Float Data Report May 2012 – May 2013

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Approved for Distribution:

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Abstract

This is the final data report of acoustically tracked RAFOS float data collected by the Marine Field Group, Florida State University, in 2012-2013 during the "GRI Dispersion Experiment in the De Soto Canyon Region, Gulf of Mexico". The experiment was comprised of one RAFOS float deployment in De Soto Canyon, on the R/V Pelican in May 2012. A total of 36 RAFOS floats were deployed, ballasted to drift at 300 meters. The objectives are (1) to determine the mechanisms controlling lateral dispersion, upwelling and downwelling in the De Soto Canyon Region, and (2) to produce physical observations to constrain and calibrate models of the region.

Front Cover Figure Caption: Composite RAFOS float track diagrams. All RAFOS float trajectories are shown. Float launch positions are marked with a red circle. The green circle marks the location of the Deepwater Horizon oil spill. Float tracks are represented as solid white lines.

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1. Introduction

This is the final data report of acoustically tracked RAFOS float data collected during the 2012-2013 "GRI Dispersion Experiment in the De Soto Canyon Region".

In the Deep-C program the physical oceanography effort is directed to the topographic control of oil transport. A preferential location of exchange and transport will occur at the canyon. At the surface and within the water column, the topographic steering of the canyon will control the dominant direction of transport and potentially guide oil onshore. Near the head of the canyon strong vertical motions will combine surface and upwelling waters and inject nutrients into the mixed layer.

This experiment focuses on determining the physical controls on the dispersion and transport of subsurface contaminants exerted by the De Soto Canyon geomorphology. The objectives are (1) to determine the mechanisms controlling lateral dispersion, upwelling and downwelling in the De Soto Canyon region and (2) to produce physical observations to constrain and calibrate models of the region.

36 RAFOS floats were deployed in De Soto Canyon, from the R/V Pelican in May 2012. All of the RAFOS were designed for a one-year deployment. The floats were tracked using numerous sound sources that had been moored by WHOI and FSU for Deep-C and other experiments, as shown in Figure 1. Data was transmitted via IRIDIUM Satellite.

2. Description of the RAFOS Floats

The RAFOS float is an acoustically tracked subsurface Lagrangian drifter (see Rossby et al. (1986) for an complete description of the RAFOS system), which is programmed to listen for signals from moored sound sources. The RAFOS floats record the time-of-arrival (TOA) of these signals, from which, given the speed of sound in seawater, position can be determined by triangulation. The TOA of the acoustic signals, as well as temperature and pressure measurements, are recorded in the float's micro-processor memory. Also stored in the float's memory are correlation heights for each TOA, which indicate the quality of the TOA

signal heard. The sound sources in this experiment were programed to transmit a 90-second-long continuous wave FM modulated tone. The individual sound source broadcast this tone three times a day at different times (see Table 1 for specifics on broadcasting times). The floats in this experiment recorded these signals three times a day.

The floats were ballasted at WHOI, to drift at 300 meters depth.

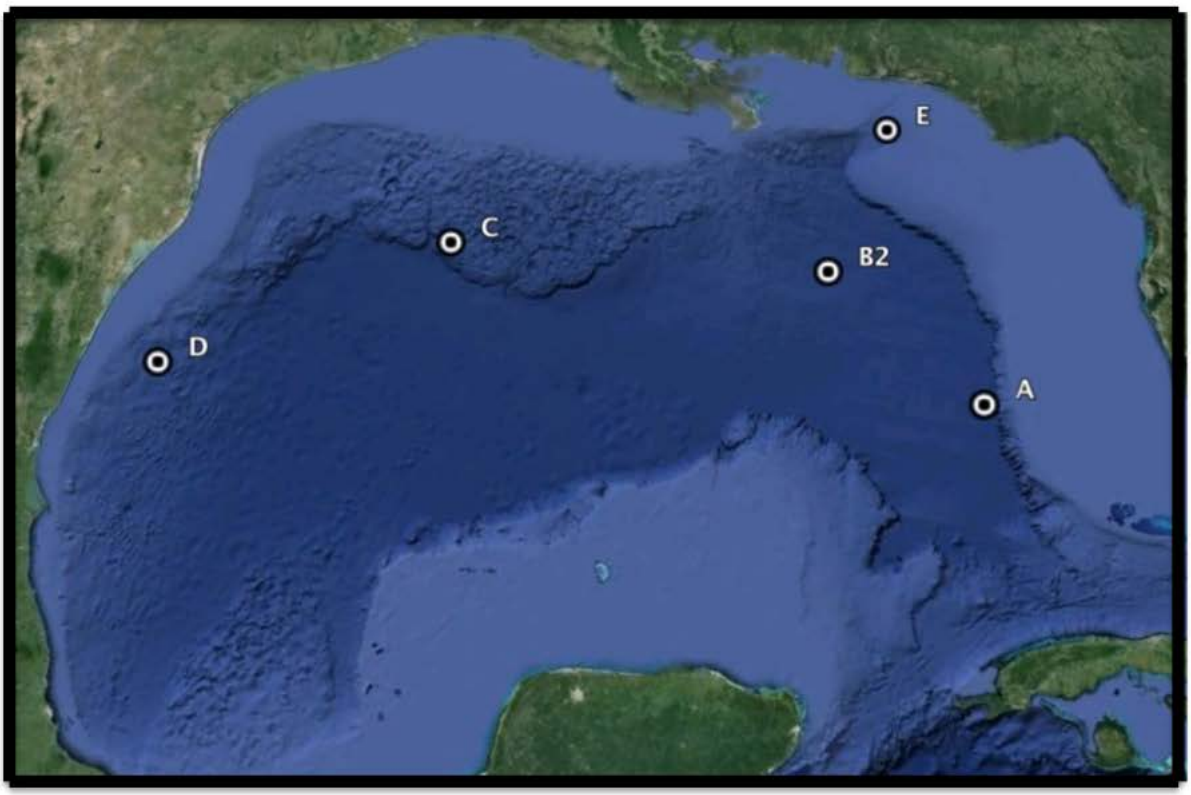

Figure 1: Location of Sound Sources.

3. Sound Sources

In this experiment, five moored sound sources were used (Figure 1 and Table 1). These were moored by WHOI and Florida State University (FSU) and are located in the Gulf of Mexico. A comprehensive list of the sound sources, their locations, and other vital statistics can be found in the Lagrangian Study Cruise Event Summaries from the following cruises: 15th -23rd July 2011 on the R/V Pelican, 11th -17th January 2012 on the R/V Pelican, and 18th -20th February 2013 on the Weatherbird.

Table 1. Sound Source Summary

Sound Source	*Latitude*	*Longitude*	*Depth (m)*	*Type*	*Owner*	*Schedule (hr)*	*Reference Time*
A (1)	25.59895	-84.99668	1000	WEBB	BOEMRE	8	02:15
B (2)	27.00000	-87.50138	1000	URI-WHOI	BOEMRE	8	02:45
B2 (2b)	27.00098	-87.50045	1000	WEBB	FSU	8	02:45
C (3)	26.24982	-93.00012	1000	WEBB	BOEMRE	8	02:02
D (4)	23.67563	-96.53180	1000	WEBB	BOEMRE	8	02:30
E (5)	29.40200	-86.98400	1000	URI-WHOI	BOEMRE	8	03:00

4. Float Deployment

36 RAFOS were deployed from the R/V Pelican in May 2012. Eleven locations in the De Soto Canyon region were picked to deploy all 36 floats. The floats were deployed in 10 groups of three (triplets) and one group of 6 (sextuplet). A summary of the float launch and surface times and locations is found in Table 2 and Figure 2. The strategy for choosing the launch sites was to investigate lateral dispersion, upwelling and downwelling in De Soto Canyon. For more information on float deployment see Deep-C Physical Oceanography Cruise Report, Cruise PE12-26 Speer.

5. Float Performance

Of the 36 RAFOS floats that were deployed, 14 failed, 15 surfaced early, 1 surfaced late and 2 stayed at the surface for their entire mission. Summaries of the float missions are described in Table 2 and Figure 4. The duration chart in Figure 3 describes visually the RAFOS float missions in time (failed floats are not plotted). In total, 56% of the RAFOS floats transmitted data at the end of their mission. Of these, 58% of the planned float mission was accomplished at depth (see Table 3 for individual submerged mission percentages). From this 58%, we ended up with 3663 float days of track data.

Table 2. Float Summary

RAFOS ID	LAUNCH				SURFACE[1]				Days Tracked	Status Code
	Date	Time (GMT)	Lat.	Long.	Date	Time (GMT)	Lat.	Long.		
1164	5/12/12	08:19	29.333	-87.367	1/17/13	-	25.506	-88.797	220	01
1165	5/12/12	08:19	29.333	-87.367	5/5/13	-	25.510	-91.053	310	01
1166	5/12/12	10:09	29.332	-87.091	-	-	-	-	-	03
1167	5/12/12	10:09	29.332	-87.091	-	-	-	-	-	03
1168	5/12/12	07:42	29.336	-87.460	5/16/13	20:42	28.944	-88.933	180	00
1169	5/12/12	07:42	29.336	-87.460	-	-	-	-	-	03
1170	5/12/12	03:50	29.280	-86.999	5/22/12	-	29.19	-86.735	10	01
1171	5/12/12	05:04	29.149	-87.100	-	-	-	-	-	03
1172	5/12/12	06:23	29.241	-87.281	7/26/12	-	28.348	-86.465	75	01
1173	5/12/12	06:23	29.241	-87.281	-	-	-	-	-	03
1174	5/12/12	09:23	29.332	-87.183	12/4/12	-	23.982	-82.915	174	01
1175	5/12/12	09:23	29.332	-87.183	6/6/12	-	29.326	-86.814	23	01
1176	5/12/12	03:50	29.280	-86.999	5/12/12	-	29.280	-86.999	0	02
1177	5/12/12	03:50	29.280	-86.999	4/20/13	-	26.153	-96.32	331	01
1178	5/12/12	08:19	29.333	-87.367	7/6/12	-	29.266	-87.530	55	01
1179	5/12/12	08:56	29.333	-87.274	-	-	-	-	-	03
1180	5/12/12	03:09	29.375	-87.000	-	-	-	-	-	03
1181	5/12/12	03:09	29.375	-87.000	5/5/13	-	24.254	-83.098	252	01
1182	5/11/12	01:27	29.402	-86.985	5/10/13	21:02	28.031	-86.459	329	00
1183	5/11/12	01:27	29.402	-86.985	7/13/12	-	28.297	-87.697	58	01
1184	5/12/12	05:04	29.149	-87.100	-	-	-	-	-	03
1185	5/12/12	05:04	29.149	-87.100	-	-	-	-	-	03
1186	5/12/12	08:56	29.333	-87.274	5/12/12	-	29.333	-87.274	0	02
1187	5/12/12	08:56	29.333	-87.274	-	-	-	-	-	03
1188	5/11/12	01:27	29.402	-86.985	10/24/12	-	28.695	-86.287	145	01
1189	5/11/12	01:27	29.402	-86.985	5/11/13	21:02	24.061	-94.528	332	00
1190	5/12/12	09:32	29.332	-87.183	-	-	-	-	-	03
1191	5/12/12	10:09	29.332	-87.091	-	-	-	-	-	03
1192	5/11/12	01:27	29.402	-86.985	8/15/12	-	28.768	-88.803	91	01
1193	5/12/12	01:27	29.402	-86.985	-	-	-	-	-	03
1194	5/12/12	07:42	29.336	-87.460	10/19/12	-	23.876	-82.768	160	00
1195	5/12/12	06:23	29.241	-87.281	4/6/13	-	26.218	-91.874	311	01
1196	5/12/12	02:07	29.455	-86.908	9/12/12	-	26.298	-86.082	117	01
1197	5/12/12	02:07	29.455	-86.908	10/13/12	-	26.265	-87.111	151	01
1198	5/12/12	02:07	29.455	-86.908	-	-	-	-	-	03
1199	5/12/12	03:09	29.375	-87.000	5/12/13	21:02	26.297	-90.881	336	00

Status Codes: 00: Successful, 01: Surfaced early/late, 02: At surface entire mission, 03: Failed

[1] Only floats that stayed at depth their entire mission have GPS surfacing information, including surfacing time. For floats that surfaced early, surfacing date and position are determined from the pressure record and ARTOA track, respectively. No surfacing time is recorded for early risers.

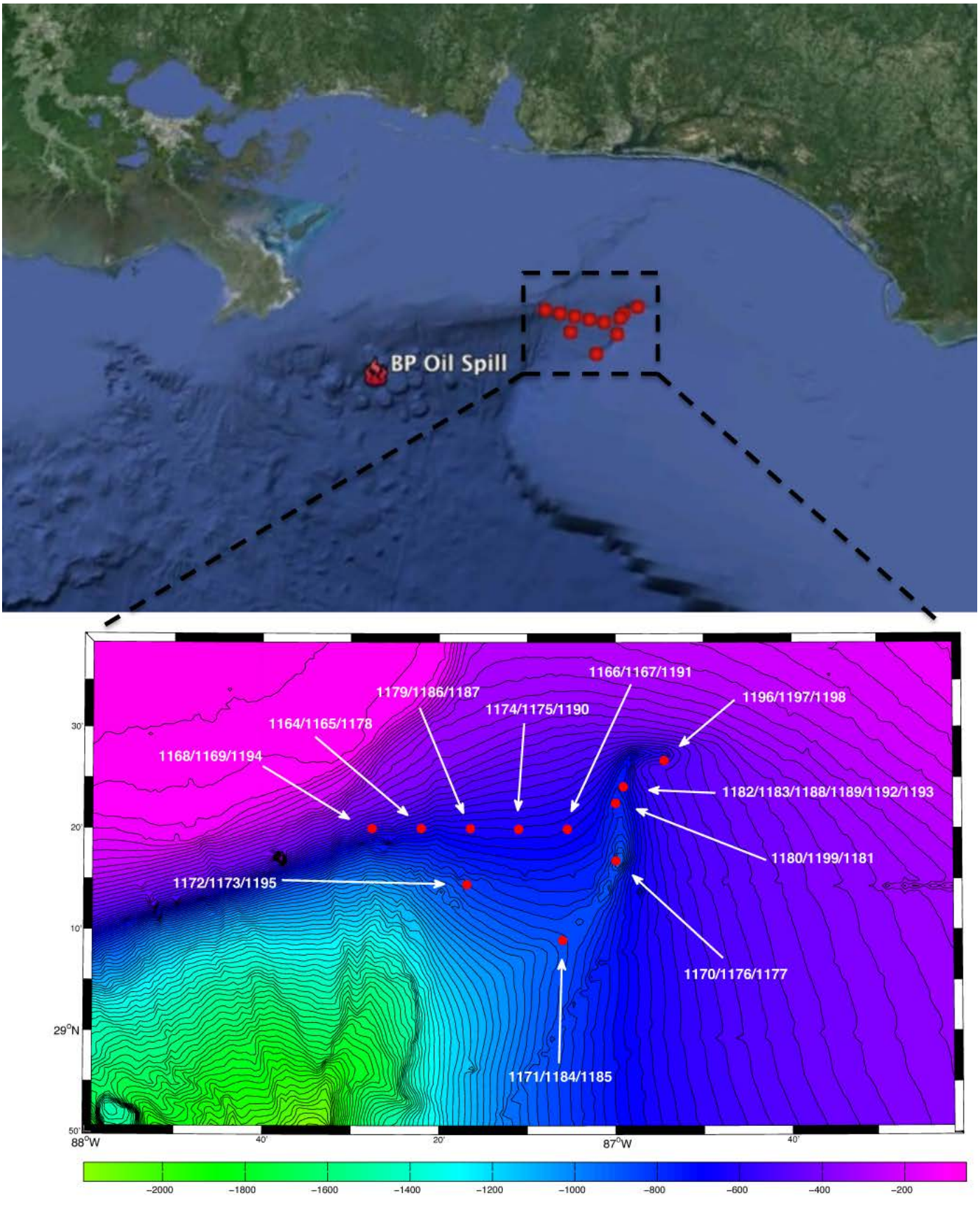

Figure 2. Launch locations for RAFOS floats. Bathymetry is as in Figure 1.

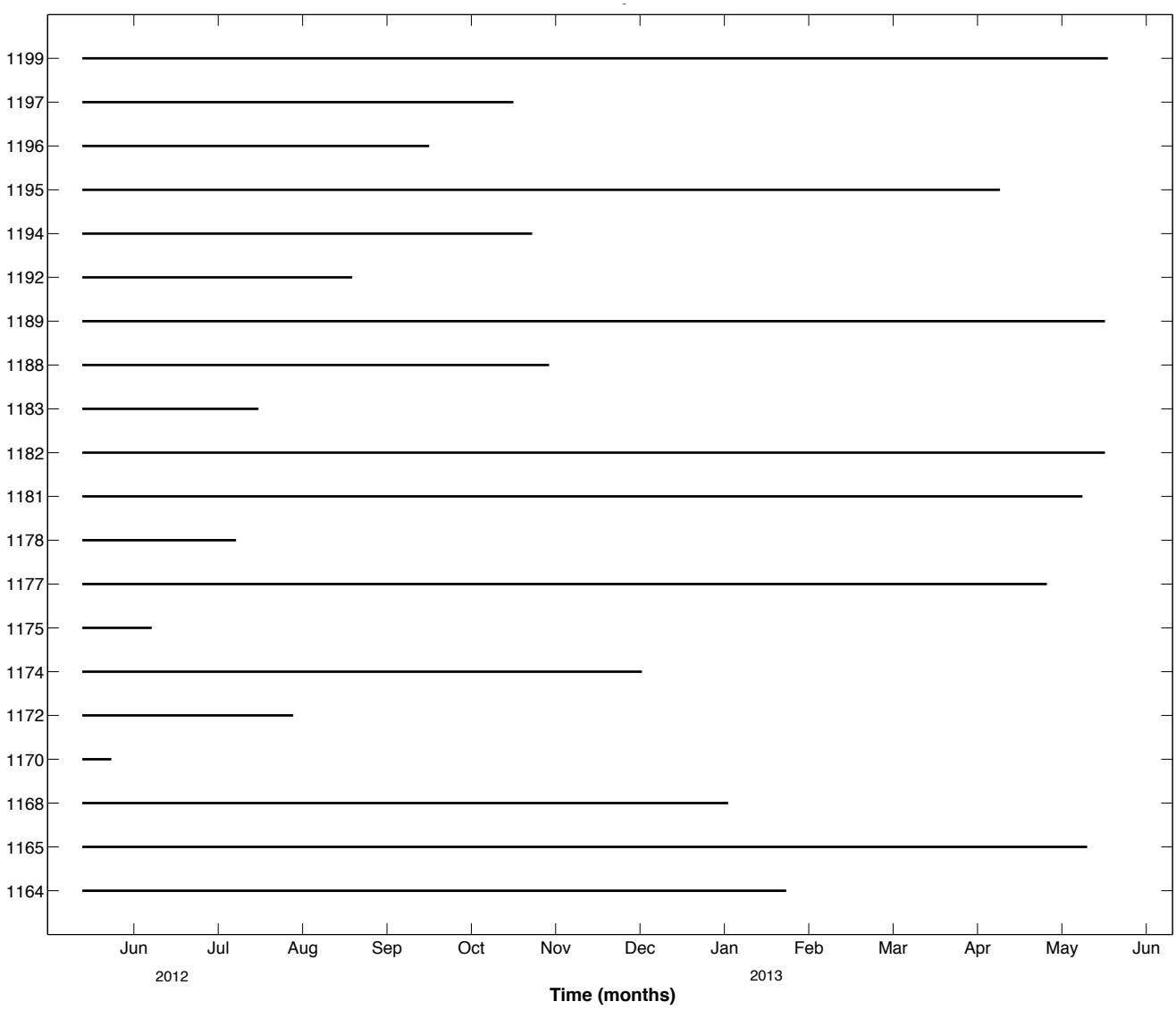

Figure 3. RAFOS float duration chart showing length of each float mission. Floats that failed or stayed at the surface for their entire mission are not plotted.

Of the 14 floats that failed, 6 were from two triplet groups (Figure 2 and Table 2), 2 were from another triplet group, where the third float never sank (1186), and the remaining 6 were single floats from the rest of the groups. De Soto Canyon has complex bathymetry with much vertical structure, which opens for the possibility of floats hitting bottom. In addition, current structure of the water column will have an effect on the likelihood of a bottom-hitting event. Deployment site could therefore be a controlling factor in why some floats hit bottom. This suggests certain float failures could have been due to sinking under the weight of additional ballasting, such as mud and clay (Kim et al., 2004) from such bottom hitting incidents (see Appendix B, along track float depth versus water column depth).

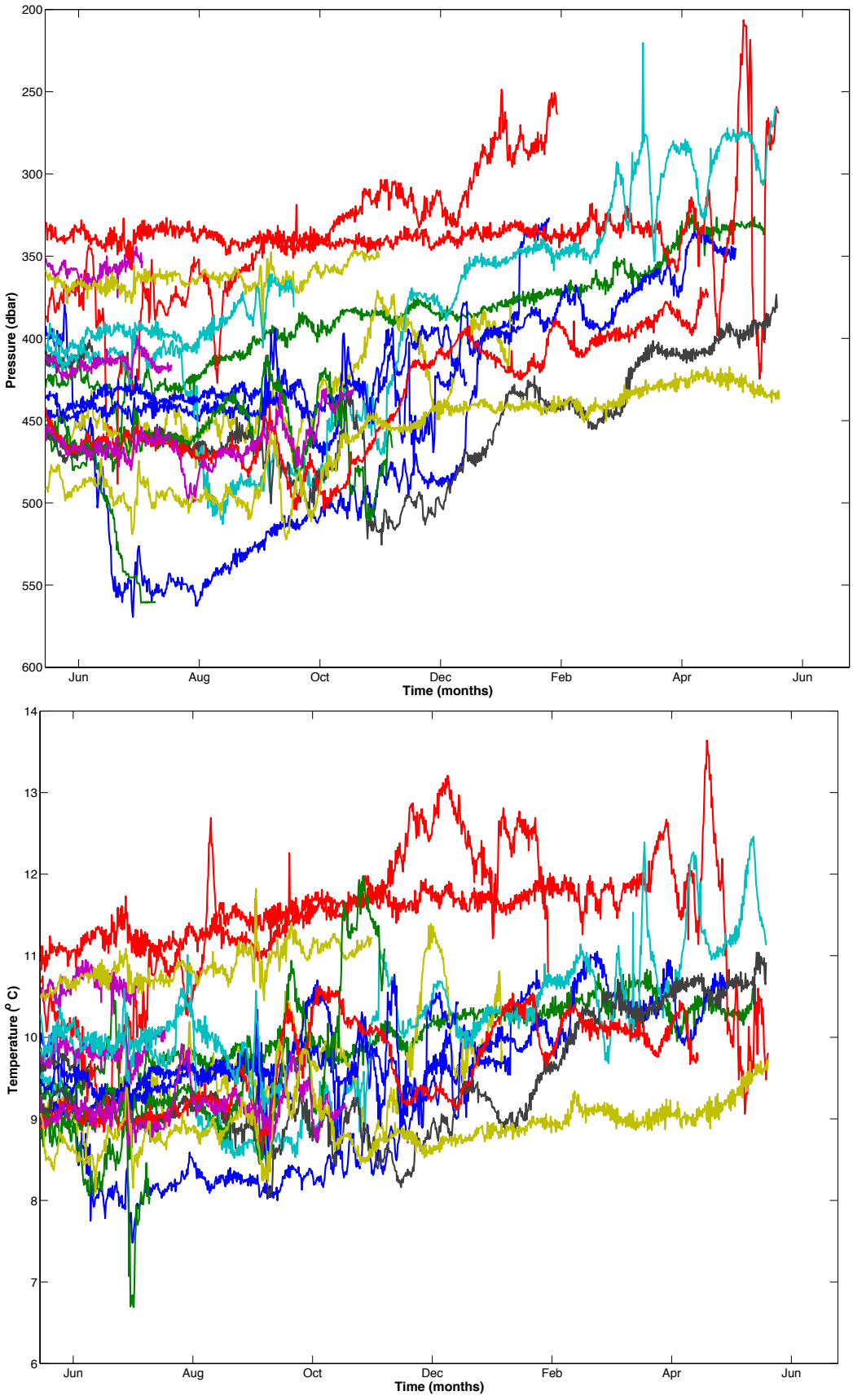

Figure 4. Pressure (top) and temperature (bottom) for all RAFOS floats over the duration of their deployment.

Table 3. Float Median Depth and Tracked Days Summary

Float ID	*Median Depth (m)*	*Days Submerged*	*% of Mission Submerged*	*Days Tracked*	*% of Submerged Mission Tracked*[2]
1164	499	250	68	221	88
1165	385	358	98	310	86
1166	-	-	-	-	-
1167	-	-	-	-	-
1168	344	369	101	180	48
1169	-	-	-	-	-
1170	415	10	3	10	100
1171	-	-	-	-	-
1172	358	75	21	75	100
1173	-	-	-	-	-
1174	448	272	75	174	64
1175	414	25	7	23	92
1176	0	0	0	0	0
1177	420	343	94	331	97
1178	480	55	15	55	100
1179	-	-	-	-	-
1180	-	-	-	-	-
1181	338	358	98	252	70
1182	384	364	99	329	90
1183	415	63	17	58	92
1184	-	-	-	-	-
1185	-	-	-	-	-
1186	0	0	0	0	0
1187	-	-	-	-	-
1188	364	166	45	145	87
1189	460	365	100	332	91
1190	-	-	-	-	-
1191	-	-	-	-	-
1192	435	209	57	91	44
1193	-	-	-	-	-
1194	455	365	100	160	44
1195	451	329	90	311	95
1196	396	123	34	117	95
1197	465	154	42	151	98
1198	-	-	-	-	-
1199	450	365	100	336	92

[2] In this instance 'Submerged Mission' refers to the length of time the float was submerged, and not the actual specified mission length.

If these floats got stuck on the bottom, even the release of the ballast could be insufficient to allow them to rise to the surface. At least one of the floats (1168) showed signs of getting stuck on the bottom, and was the only float to surface late (see Table 2).

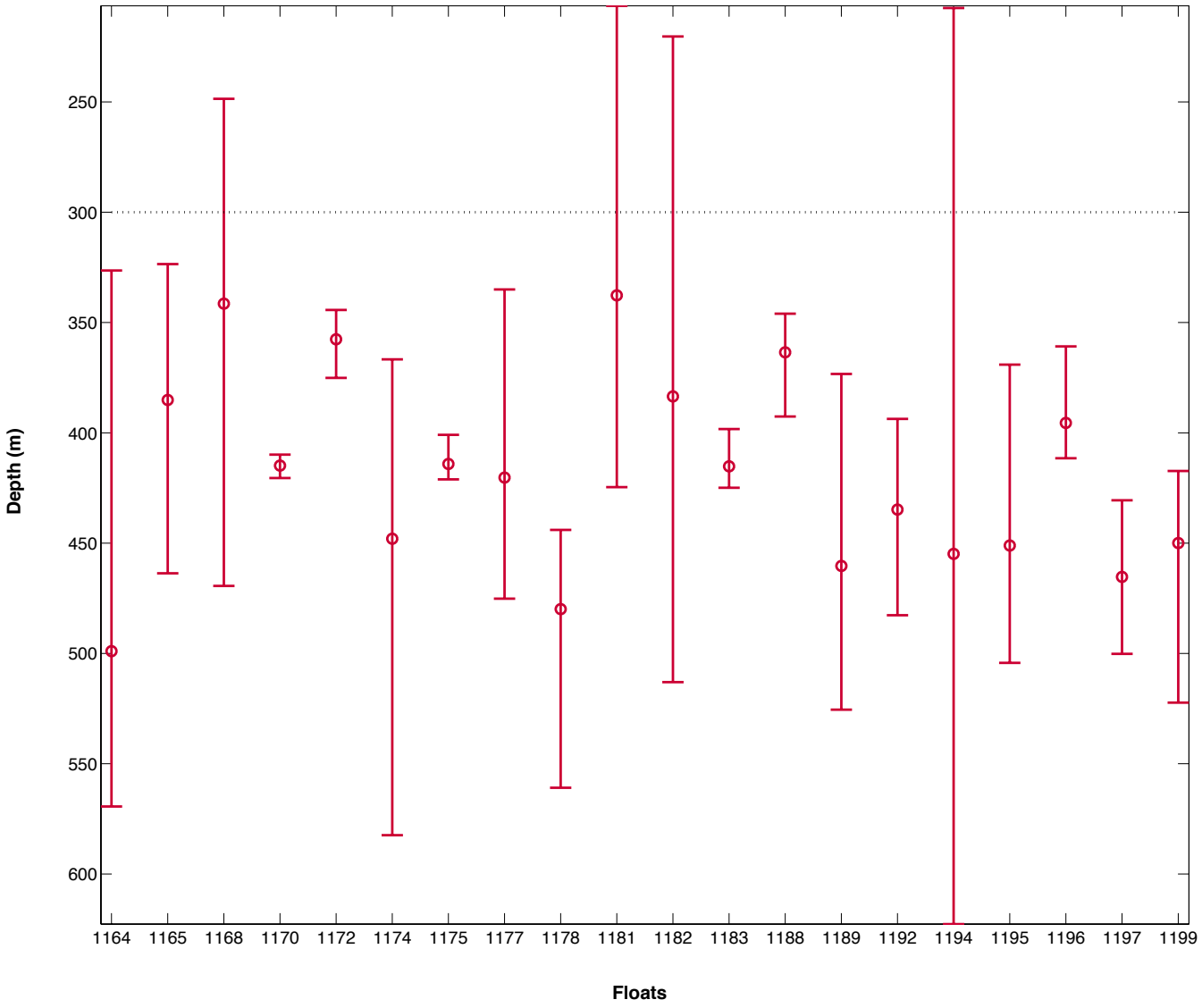

Figure 5. Median depth (red dots), with minimum and maximum values (top and bottom error bars), for each RAFOS float. The average median depth is 419 meters, substantially deeper than the target depth of 300 meters (black dashed line).

In general the floats sank to a median depth of 419 meters, exhibiting average minimum and maximum depths of 343 and 486 meters, respectively (see Table 3 for individual depths). This is substantially deeper than the float target depth of 300 meters. Figure 5 shows median depth, including minimum and maximum values, for each RAFOS float.

Temperature standard deviation was 0.3366 ° C after subtracting a linear trend.

Table 4 describes the performance of the RAFOS floats that surfaced and transmitted data via IRIDIUM, including the initial and final float clock offsets. The success rate of message transmission was 100%.

6. Float Clock Offset

Before deployment, each float clock is checked against GPS time, and any offsets are recorded. At the end of their mission, upon surfacing, the float clock is recorded, as well as GPS time. Based on this, an end clock offset is calculated, correcting for leap seconds due to Earth's rotation. The initial and end offsets for each float can be found in Table 4.

7. Sound Source Offset Calculation

The primary sources used in tracking the floats were A, B2, C, D and E. Clock offsets were estimated using all RAFOS floats that satisfied the following criterion: a 'time of arrival' (TOA) existed for either the first record after launch, or the last record before surface. These were then compared to calculated TOA's based on distance from source (taken as deployment or surfacing position) and a sound speed of 1.5 km/s. The sample size ended up being very small and the results showed general scattering around zero. Based on this, no sound source offsets were used during tracking of the RAFOS floats.

Table 4. RAFOS Float Clock and ARGOS/IRIDIUM Information

Float ID	*Launch Date (yymmdd)*	*Initial Float Clock Offset (s)*	*Surface Due Date (yymmdd)*	*Actual Surface Date (yymmdd)*	*Final Float Clock Offset (s)*	*Msgs Received (%)*	*Status Code*
1164	5/12/2012	0	5/12/2013	1/17/2013	-3	100	01
1165	5/12/2012	0	5/12/2013	5/5/2013	0	100	00
1166	5/12/2012	0	5/12/2013	-	-	-	03
1167	5/12/2012	0	5/12/2013	-	-	-	03
1168	5/12/2012	0	5/12/2013	5/16/2013	1	100	01
1169	5/12/2012	0	5/12/2013	-	-	100	03
1170	5/12/2012	0	5/12/2013	5/22/2012	-	-	01[3]
1171	5/12/2012	0	5/12/2013	-	-	-	03
1172	5/12/2012	0	5/12/2013	7/26/2012	-1	100	01
1173	5/12/2012	0	5/12/2013	-	-	-	03
1174	5/12/2012	0	5/12/2013	2/8/2013	-1	100	01
1175	5/12/2012	0	5/12/2013	6/6/2012	-1	100	01
1176	5/12/2012	0	5/12/2013	5/12/2012	-1	100	02
1177	5/12/2012	0	5/12/2013	4/20/2013	0	100	01
1178	5/12/2012	0	5/12/2013	7/6/2012	0	100	01
1179	5/12/2012	0	5/12/2013	-	-	-	03
1180	5/12/2012	0	5/12/2013	-	-	-	03
1181	5/12/2012	0	5/12/2013	5/5/2013	-1	100	01
1182	5/11/2012	0	5/11/2013	5/10/2013	0	100	00
1183	5/11/2012	0	5/11/2013	7/13/2012	0	100	01
1184	5/12/2012	0	5/12/2013	-	-	-	03
1185	5/12/2012	0	5/12/2013	-	-	-	03
1186	5/12/2012	0	5/12/2013	5/12/2012	-	100	02
1187	5/12/2012	0	5/12/2013	-	-	-	03
1188	5/11/2012	0	5/11/2013	10/24/2012	0	100	01
1189	5/11/2012	0	5/11/2013	5/11/2013	0	100	00
1190	5/12/2012	0	5/12/2013	-	-	-	03
1191	5/12/2012	0	5/12/2013	-	-	-	03
1192	5/11/2012	0	5/11/2013	12/6/2012	-	100	01
1193	5/12/2012	0	5/12/2013	-	-	-	03
1194	5/12/2012	0	5/12/2013	5/12/2013	-1	100	00
1195	5/12/2012	0	5/12/2013	4/6/2013	0	100	01
1196	5/12/2012	0	5/12/2013	9/12/2012	2	100	01
1197	5/12/2012	0	5/12/2013	10/13/2012	0	100	01
1198	5/12/2012	0	5/12/2013	-	-	-	03
1199	5/12/2012	0	5/12/2013	5/12/2013	0	100	00

Status Codes: 00: Successful, 01: Surfaced early/late, 02: At surface entire mission, 03: Failed

[3] 1170 was picked up at sea and data was manually extracted from the float at Seascan. No data was transmitted via Iridium.

Table 5. Distance VS Time Offsets for Deployment Positions

Float ID	*Distance (km)*	*Time (hr)*	*Speed (m/s)*	*Status Code*
1164	10.2	1.7	1.68	0A
1165	19.3	1.7	3.18	0A
1166	-	-	-	0C
1167	-	-	-	0C
1168	0.6	2.3	0.07	0A
1169	-	-	-	0C
1170	24.2	20.2	0.22	0A
1171	-	-	-	0C
1172	4.1	3.6	0.32	0A
1173	-	-	-	0C
1174	5.1	0.6	2.28	0A
1175	3.2	0.6	1.43	0A
1176	-	-	-	0C
1177	9.6	6.2	0.43	0A
1178	3.5	1.7	0.57	0A
1179	-	-	-	0C
1180	-	-	-	0C
1181	3.2	6.9	0.13	0A
1182	17.0	144.5	0.03	0B
1183	12.4	120.5	0.03	0B
1184	-	-	-	0C
1185	-	-	-	0C
1186	-	-	-	0C
1187	-	-	-	0C
1188	1.1	8.5	0.04	0B
1189	13.5	120.5	0.03	0B
1190	-	-	-	0C
1191	-	-	-	0C
1192	12.8	120.5	0.03	0B
1193	-	-	-	0C
1194	1.4	2.3	0.16	0A
1195	4.2	3.6	0.32	0A
1196	6.6	7.9	0.23	0A
1197	8.1	56.0	0.04	0B
1198	-	-	-	0C
1199	3.1	6.9	0.12	0A

Status Codes: 0A: Recorded first TOA after deployment, 0B: Did not record first TOA after deployment, 0C: Did not track in ARTOA.

8. Float Tracking

The floats were tracked using ARTOA software (Wooding et al. (2005) and WHOI (2005)), which originated at the University of Rhode Island and was further developed at IFREMER. ARTOA, which was used to edit the temperature, pressure and TOA data, and to track the floats, is run on MATLAB. The TOA's were corrected for the Doppler shift and difference in transmission time, and then interpolated using a variable width (usually 10-day) cubic spline filter, before tracking. Tracking used a least-squares method if more than two TOA's were available. The final sound velocity chosen for this experiment was 1.5 km/sec.

Tracking was straightforward, with an average of 50% of each successful mission tracked (see Table 3 for individual percentages). Many tracks ended prematurely, due to the float surfacing ahead of schedule. Validation of the tracking is done in two ways. The first method is by comparing GPS deployment position with ARTOA's first tracking point (Table 5 and Figure 6). Four floats show suspicious initial track positions, 1164, 1165, 1174 and 1175. From Table 5, all of these need speeds greater than 1 m/s to travel the calculated distance, which is much greater than that observed in ARTOA (see individual velocity plots in Appendix B). This indicates an initial tracking error within ARTOA. Interestingly, 1164/1165 and 1174/1175 deployed in two triplets (see Figure 2).

Second method is by plotting float depth versus total water depth, calculated from 30 arc second bathymetry of the Gulf of Mexico (courtesy Heather Furey). Nine RAFOS show regions where float depths is greater than the total water depth (Appendix B). Of these nine, only three show regions of substantial magnitude. Common for all three (1164, 1178 and 1197) is the location of these regions, namely the start of their tracks in De Soto Canyon. There can be several reasons for this, (1) the bathymetry is not detailed enough to resolve the complex vertical structure of this area (hence giving smaller water depths than what is actually present), (2) small errors in tracking caused the float to hug the bathymetry too closely (decreasing the speed of sound causes the track to move southwest), (3) three tracking positions in 24 hours cannot resolve the floats behavior in De Soto Canyon, or (4) a combination of the above.

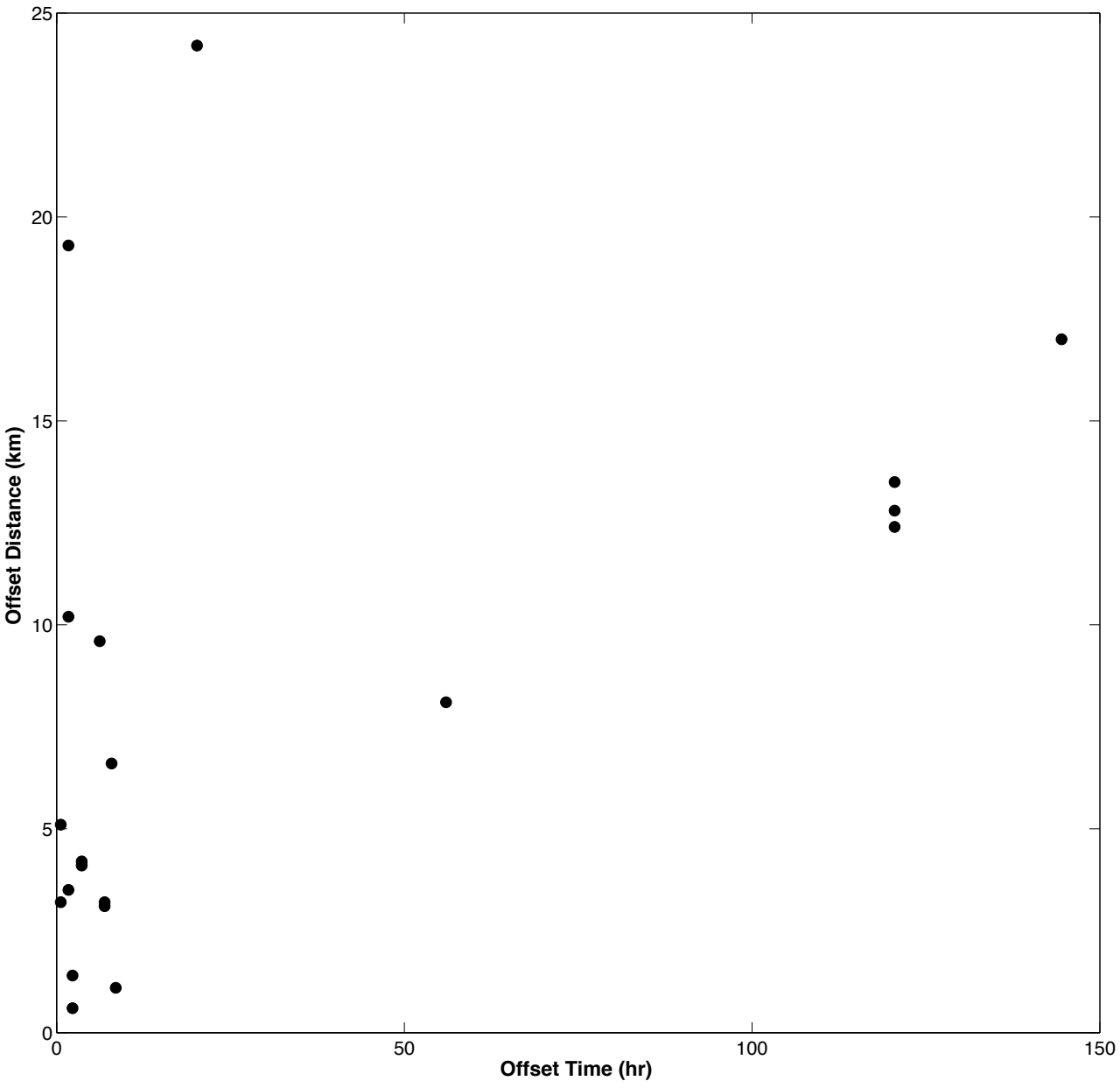

Figure 6. Time (hr) and distance (km) offset between deployment and first point in ARTOAs track.

Several RAFOS have large gaps in their tracks (1164, 1165, 1174, 1177, 1182 and 1189), where only one sound source was heard. As a quality control on these, the distance and time between start and end points of each gap are used to calculate the minimum required velocity. For all six RAFOS, the calculated velocities are well below those seen before and after each gap (not shown here).

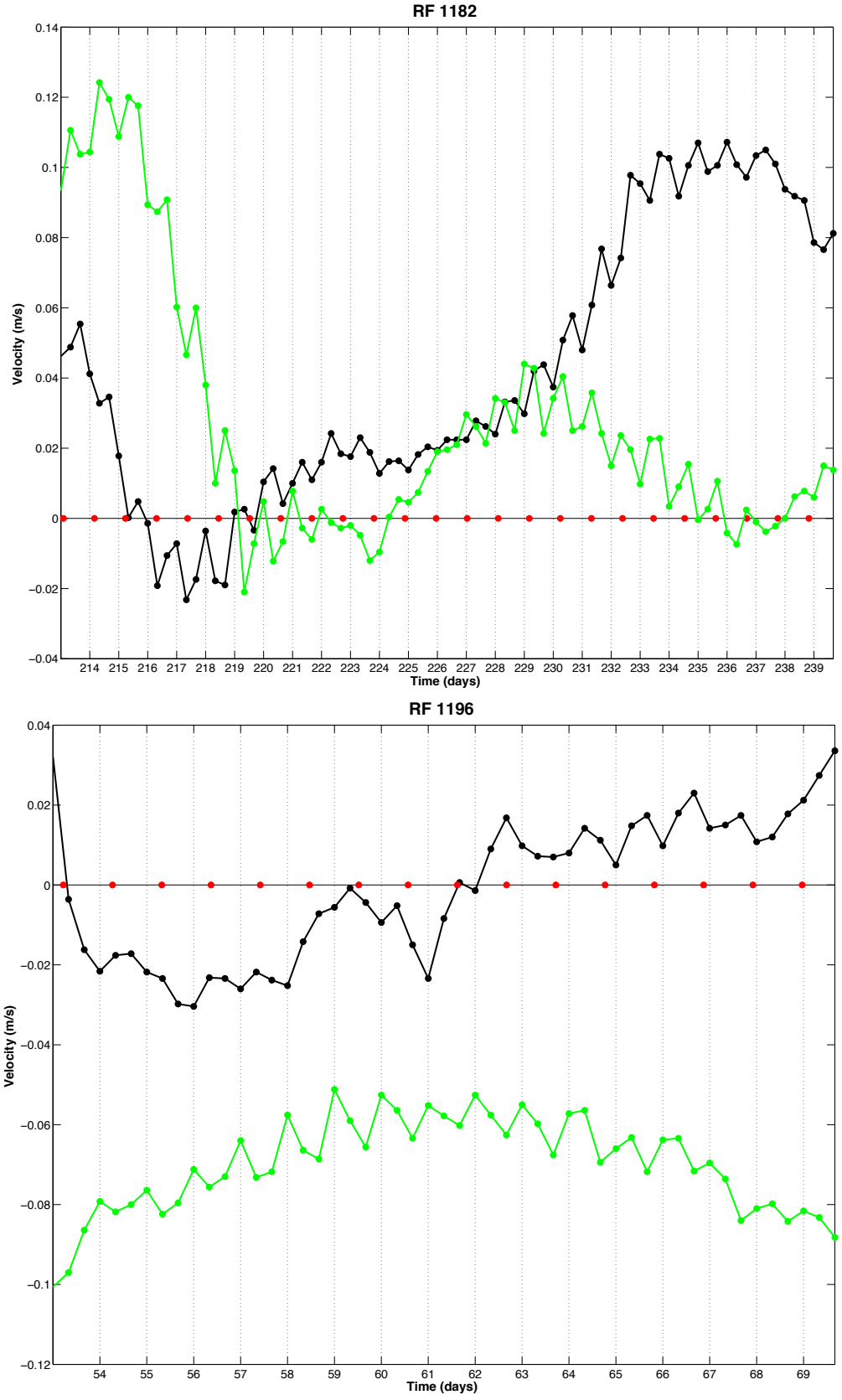

Figure 7. Velocity components u (black) and v (green) as a function of days from deployment, for 1182 (top) and 1196 (bottom). Red dots indicate inertial period.

Some degree of small-scale variability is evident in all of the RAFOS tracks. Superimposing the inertial period onto time series of u and v velocity components, for all RAFOS, suggests them to be partially resolved inertial oscillations. Figure 7 shows two examples (1182 and 1196) of inertial oscillations present in the velocity components.

Appendix A contains composite displacement vector and track diagrams. Appendix B contains each float's track and property plots, including: temperature, pressure, u-velocity, v-velocity, stick plot showing the direction and magnitude of the float's velocity and along track depth of float versus water column depth[4]. In Appendix C, the float tracks are grouped according to deployment location and time. Some temperature and pressure data exists outside the Gulf of Mexico region, as some of the floats made it out into the Gulf Stream. This data has been removed for this report.

9. Acknowledgements

The authors thank the captain and crew of the R/V Pelican for their able assistance in carrying out this sea-going experiment. Nicolas Wienders and Justin Lewis are acknowledged for preparation and deployment of floats. Most sincere thanks to Heather Furey of WHOI for continuous modifications to ARTOA. This research was funded by the BP - Gulf of Mexico Research Initiative.

10. References

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[4] All RAFOS, which showed float depth greater than water depth along their track, have an accompanying map with their location along the track.

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Appendix A

The following figures show composite displacement vector diagrams (Figure 1), composite float track diagram (Figure 2), diagrams showing float track segments of different velocities (Figure 3 and 4), and a float track gallery (Figure 5).

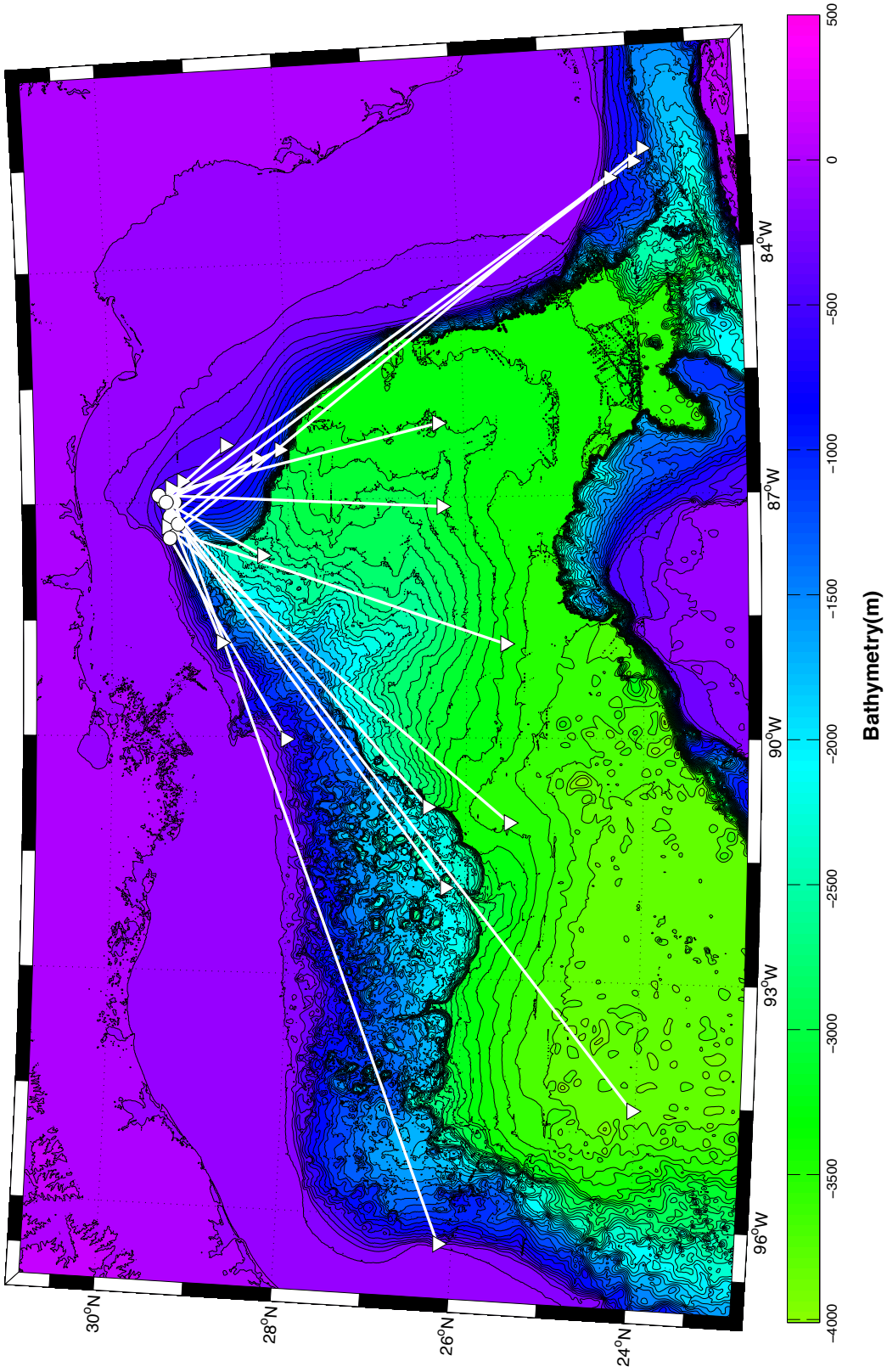


Figure 1. RAFOS float displacement vectors. Circles mark the launch position, and triangles the surface position. Bathymetry is shaded according to the color bar and contour lines are every 100m.

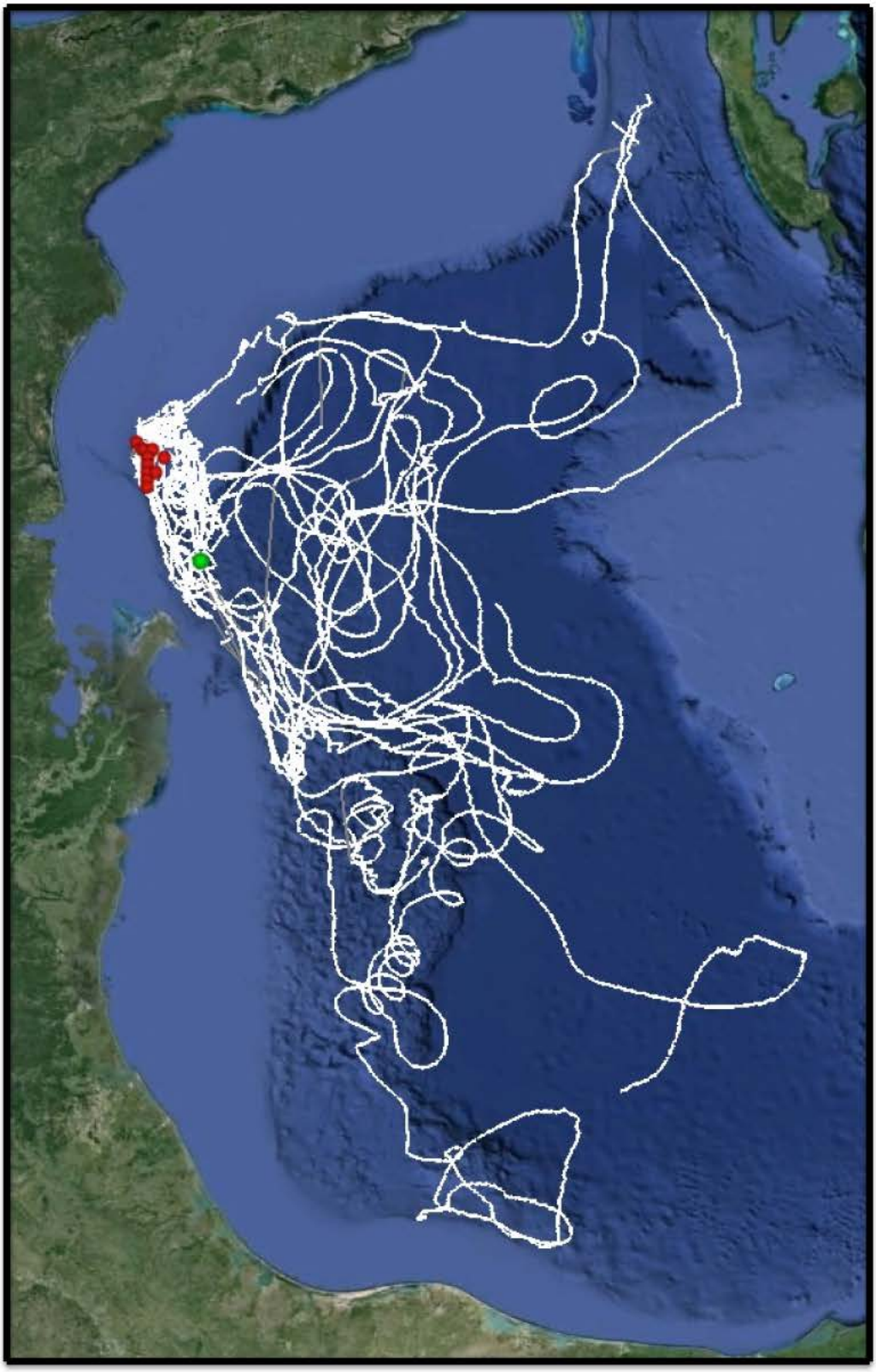
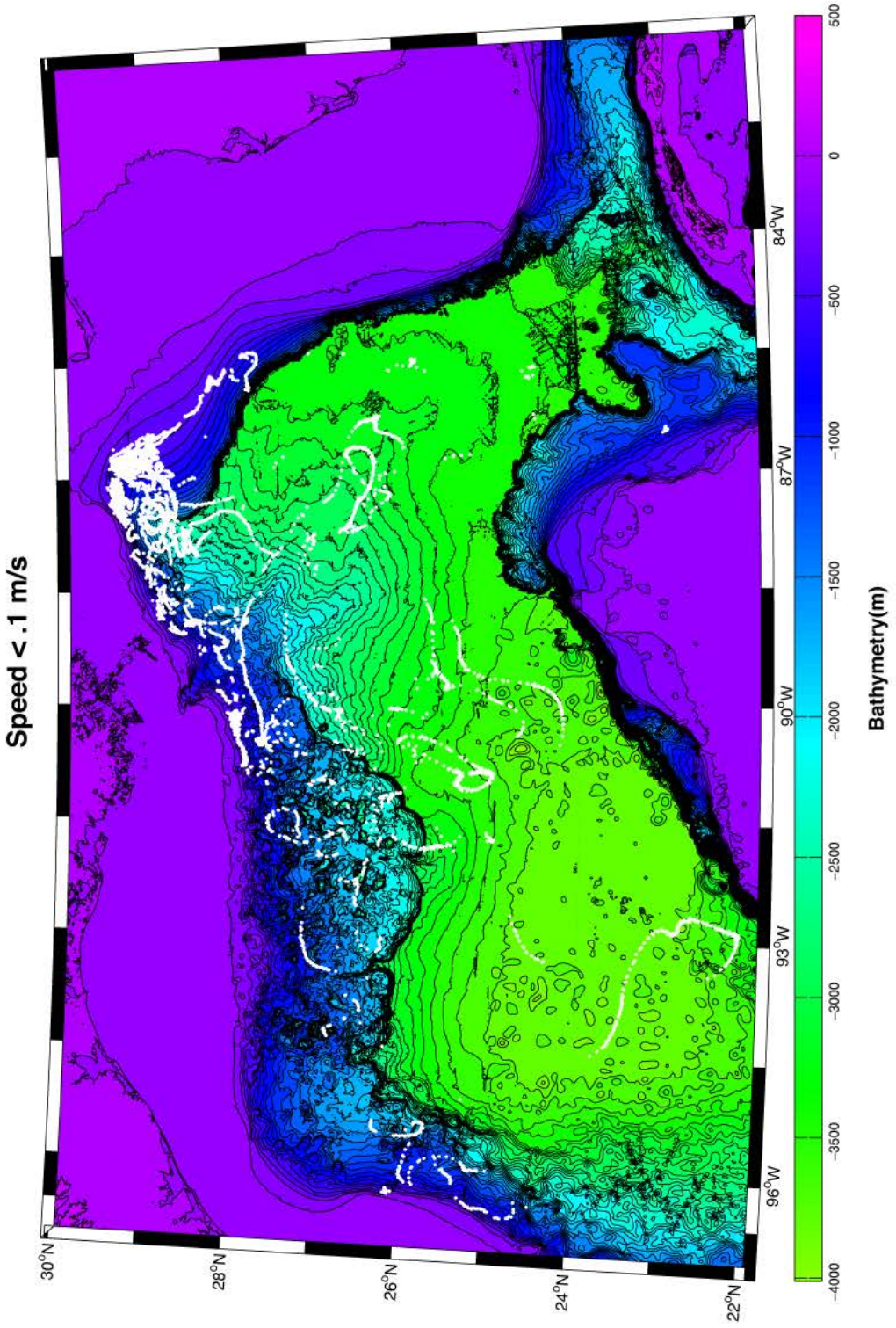
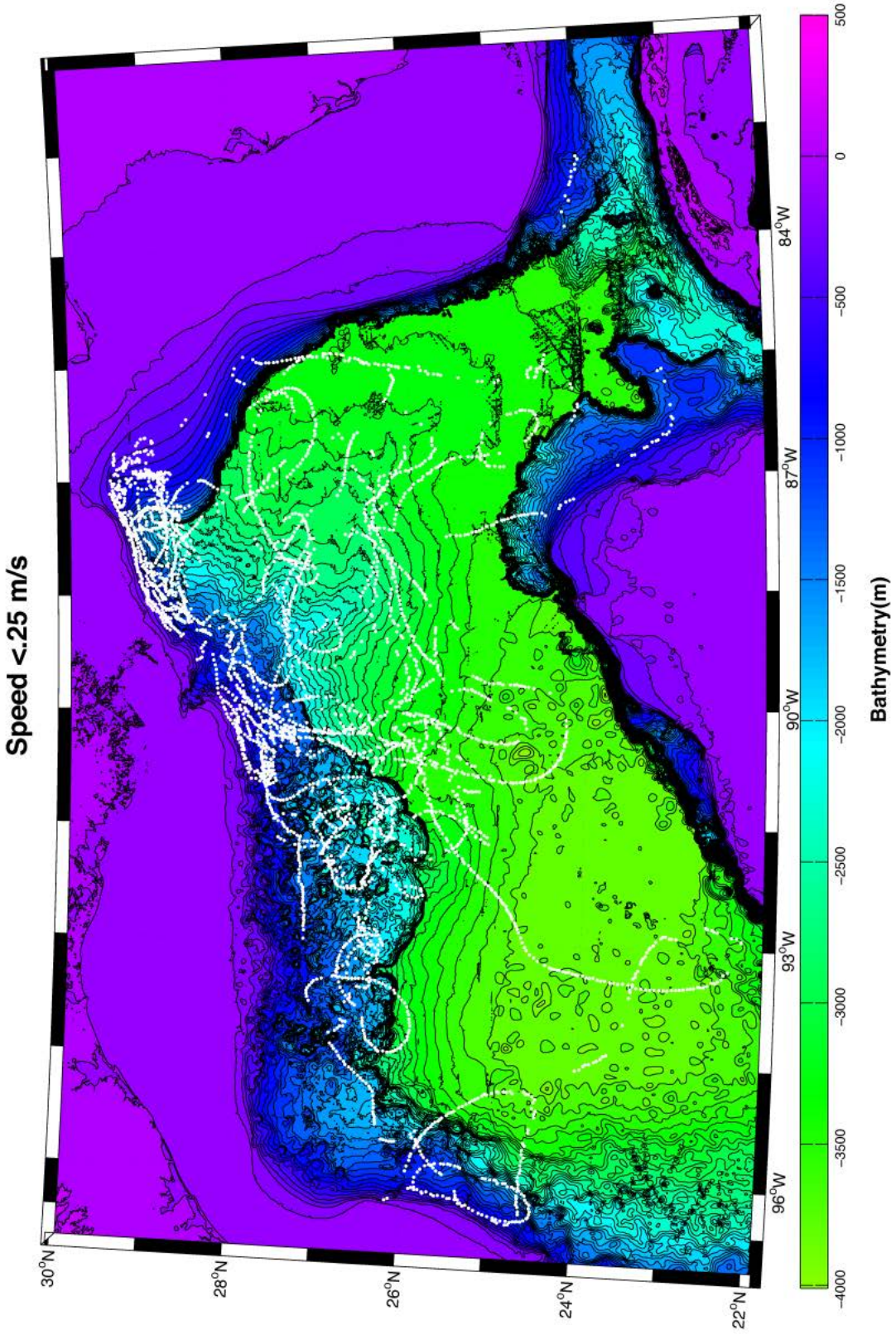


Figure 2. Composite RAFOS float track diagram. All RAFOS float trajectories shown. Float launch positions are shown with a red circle and float tracks are solid white lines. The green circle shows the location of the Horizon Deep Water oil spill. Bathymetry is from Google Earth.

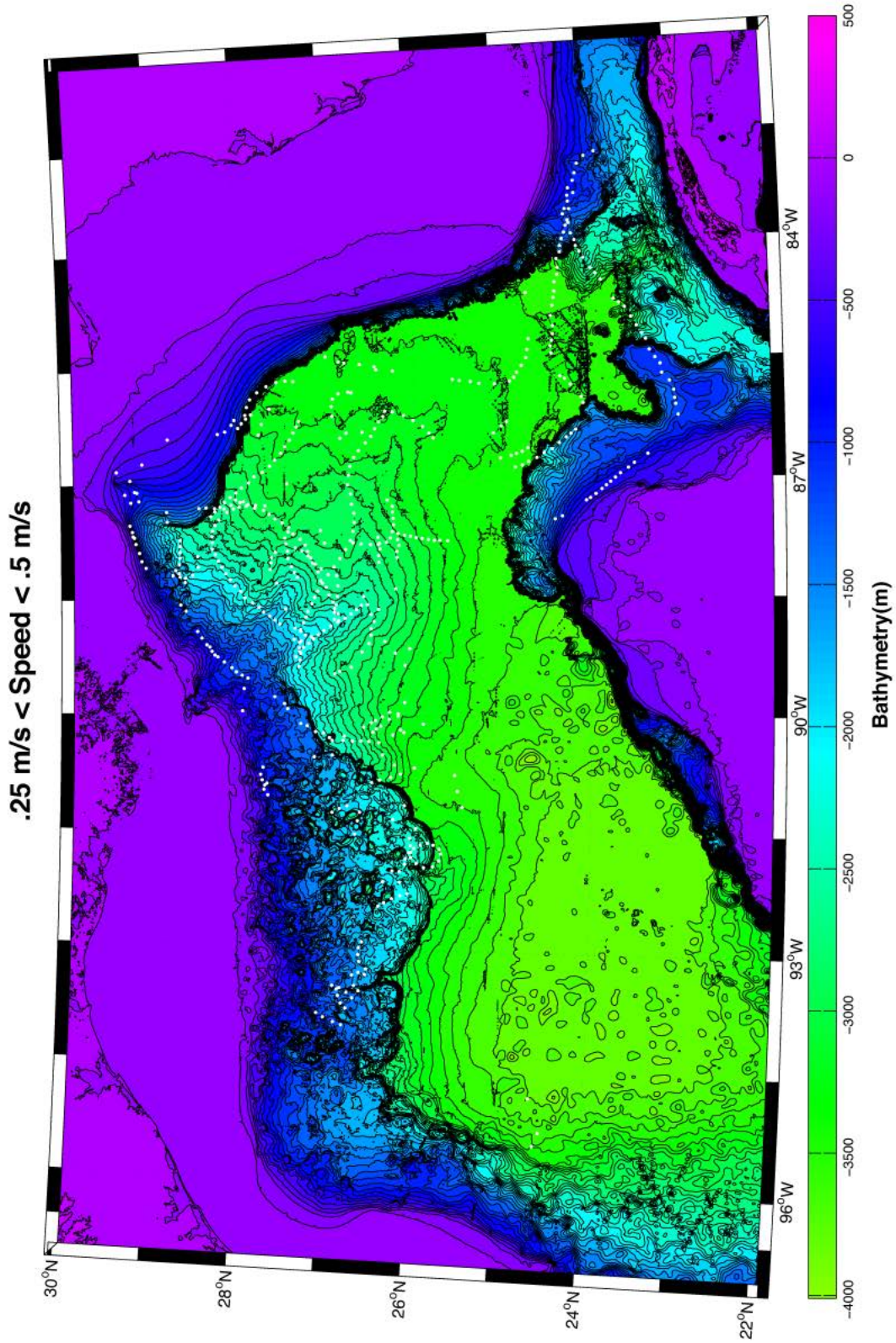


(a)

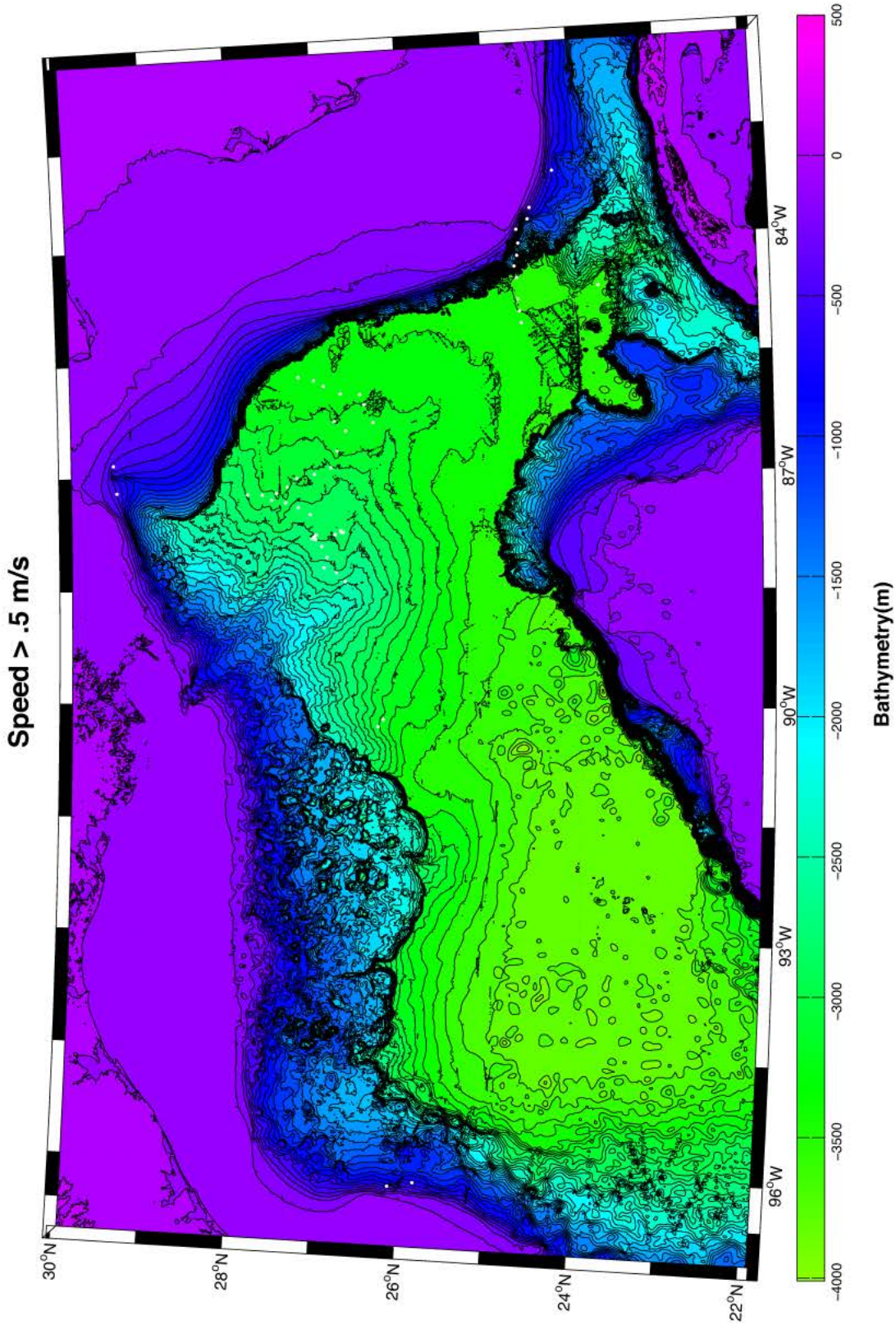
Figure 3. Float track segments with velocities (a) less than 10 cm/s, (b) less than 25 cm/s, (c) between 25 cm/s and 50 cm/s, and (d) greater than 50 cm/s.


Speed <.25 m/s
30°N
28°N
26°N
24°N
22°N
96°W
93°W
90°W
87°W
84°W
Bathymetry(m)
500
0
−500
−1000
−1500
−2000
−2500
−3000
−3500
−4000

(b)


.25 m/s < Speed < .5 m/s
30°N
28°N
26°N
24°N
22°N
96°W
93°W
90°W
87°W
84°W
Bathymetry(m)
500
0
−500
−1000
−1500
−2000
−2500
−3000
−3500
−4000

(c)


Speed > .5 m/s
30°N
28°N
26°N
24°N
22°N
96°W
93°W
90°W
87°W
84°W
Bathymetry(m)
500
0
−500
−1000
−1500
−2000
−2500
−3000
−3500
−4000

(d)

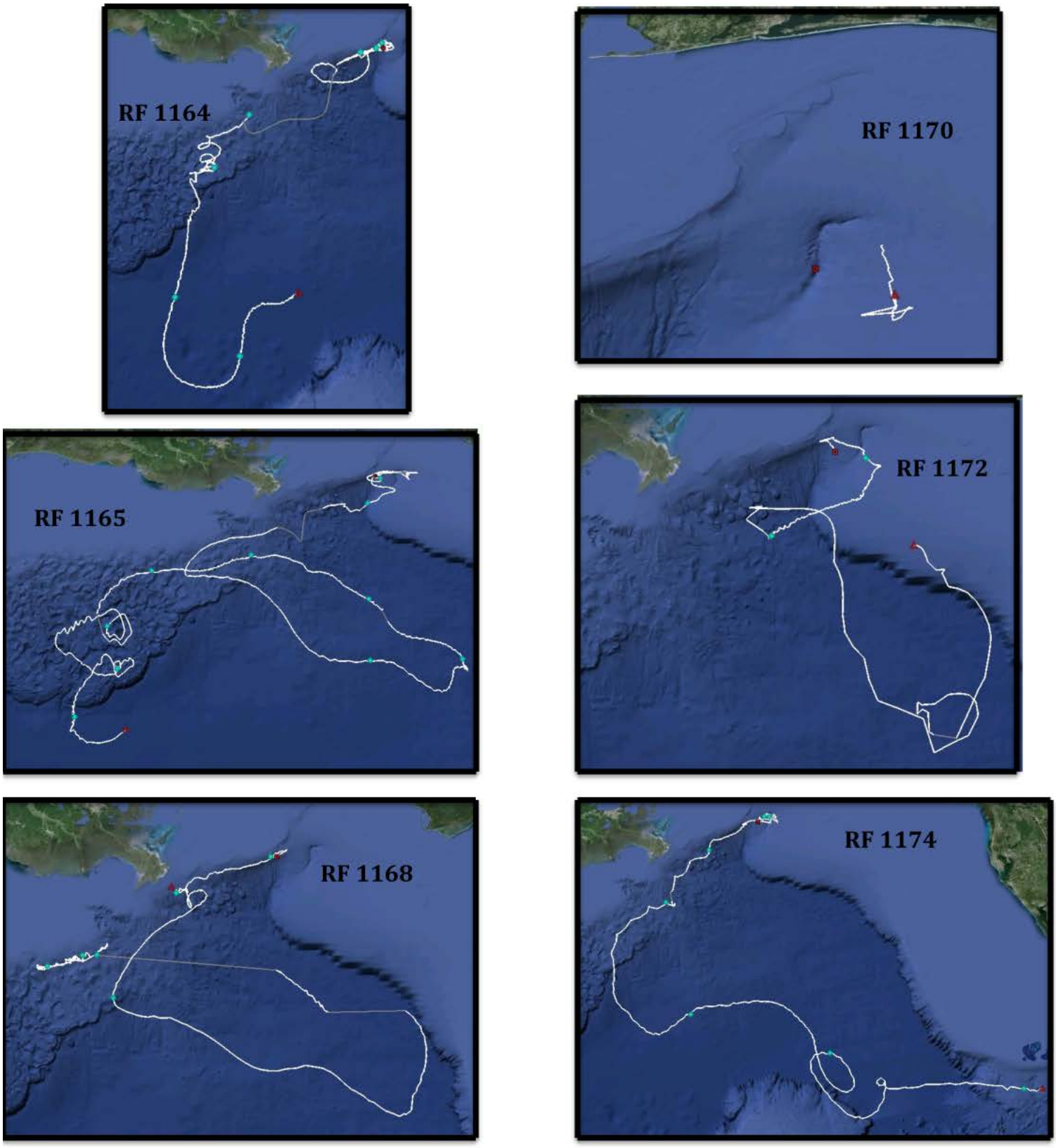


Figure 4. RAFOS float track gallery. Each tracked float is presented with bathymetry from Google Earth. The launch position of each float is marked with a red square. Untrackable segments are drawn with a grey solid line, trackable with white solid line.

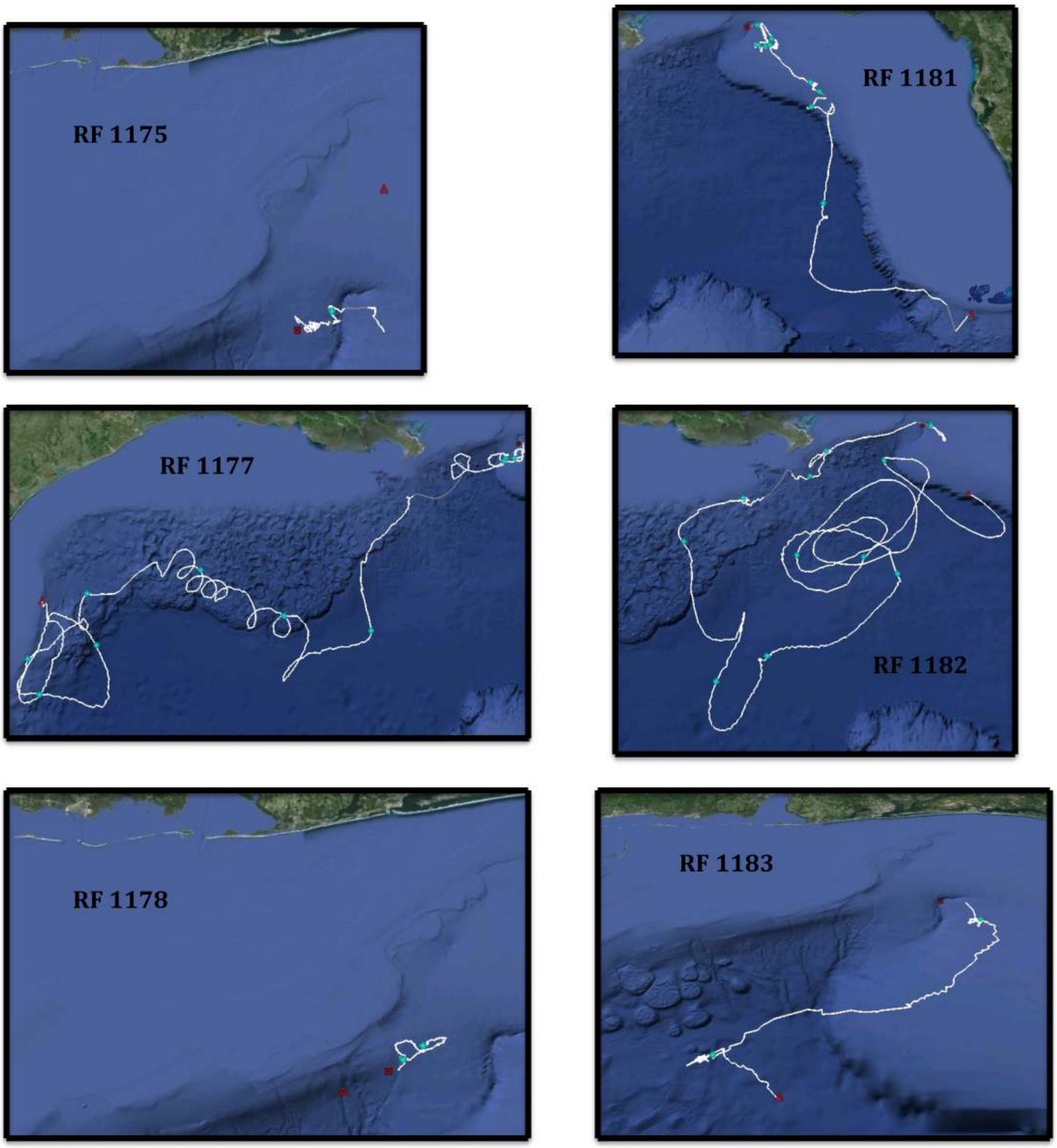
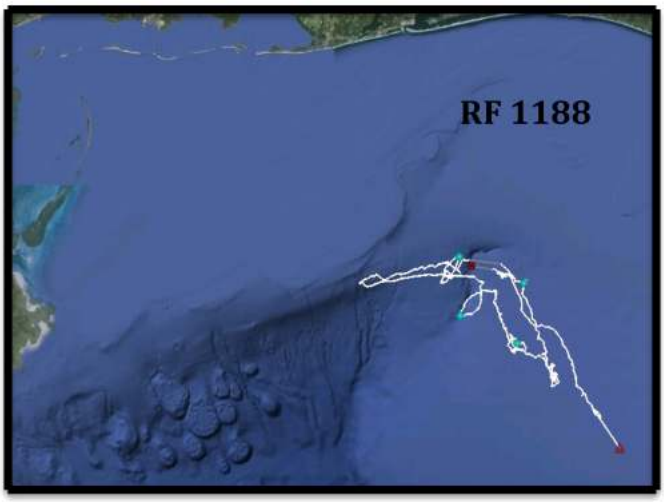
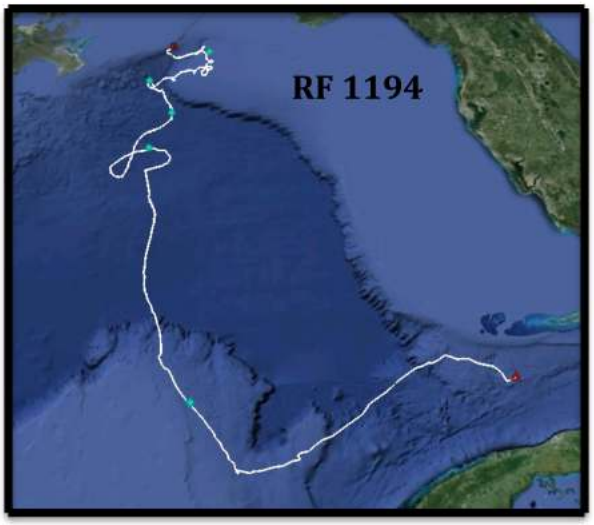
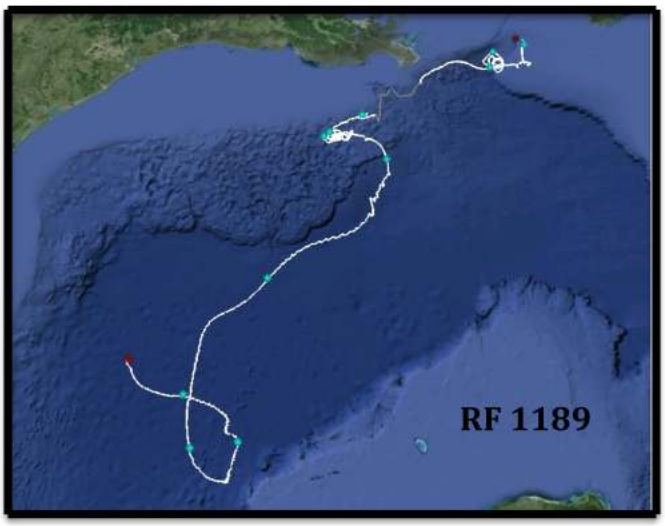
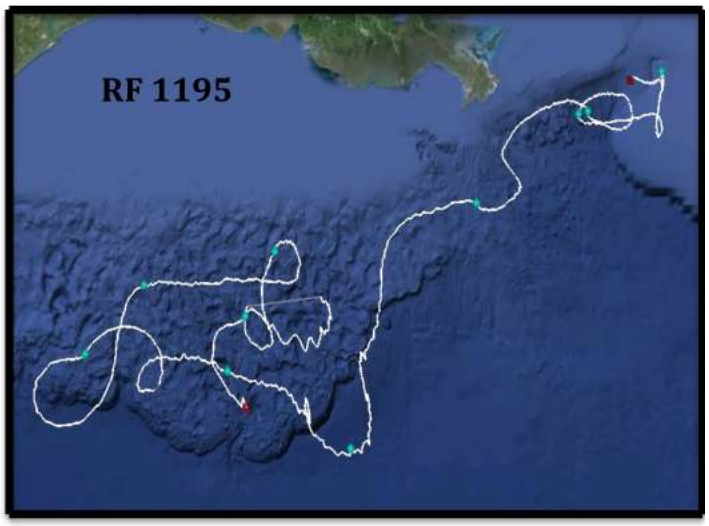


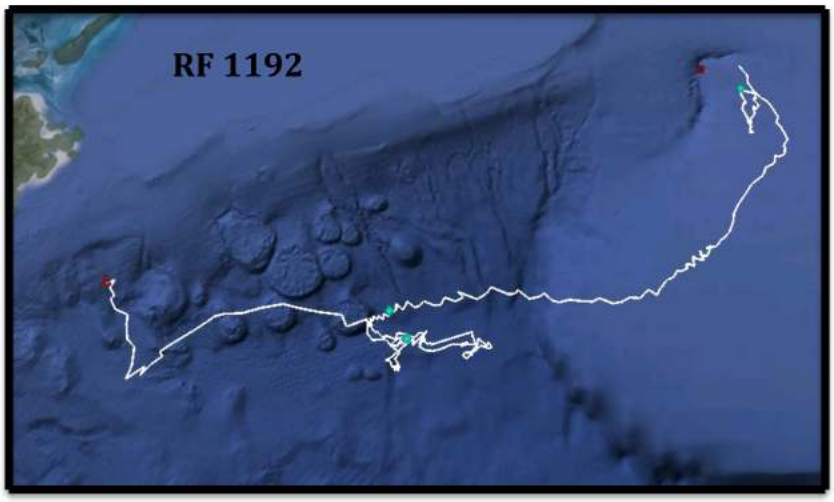
Figure 4, continued.











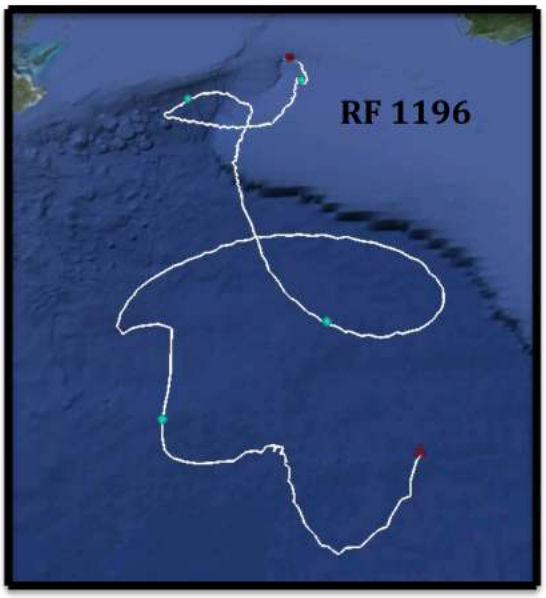
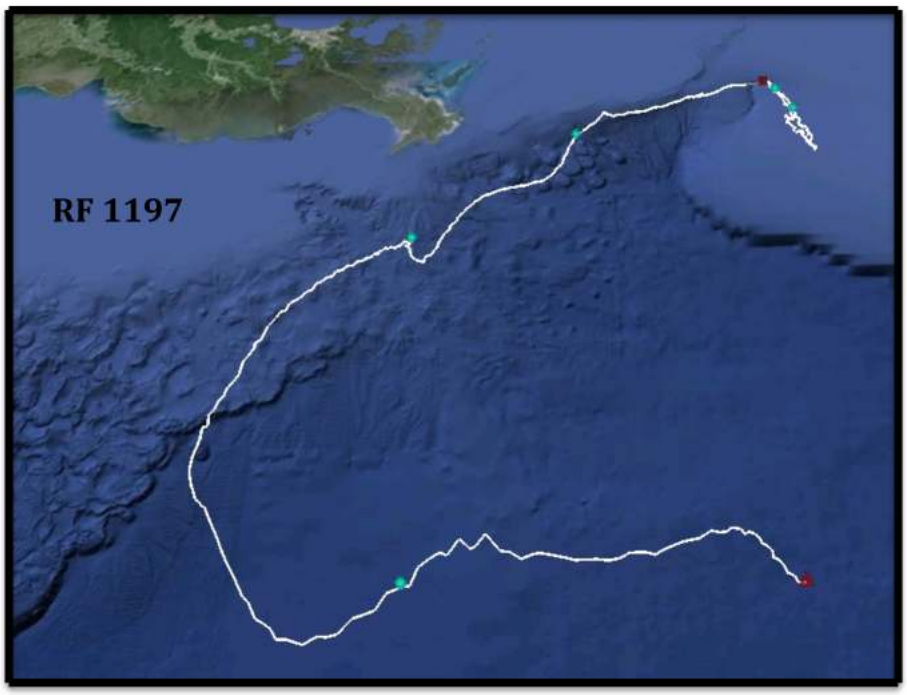


Figure 4, continued.



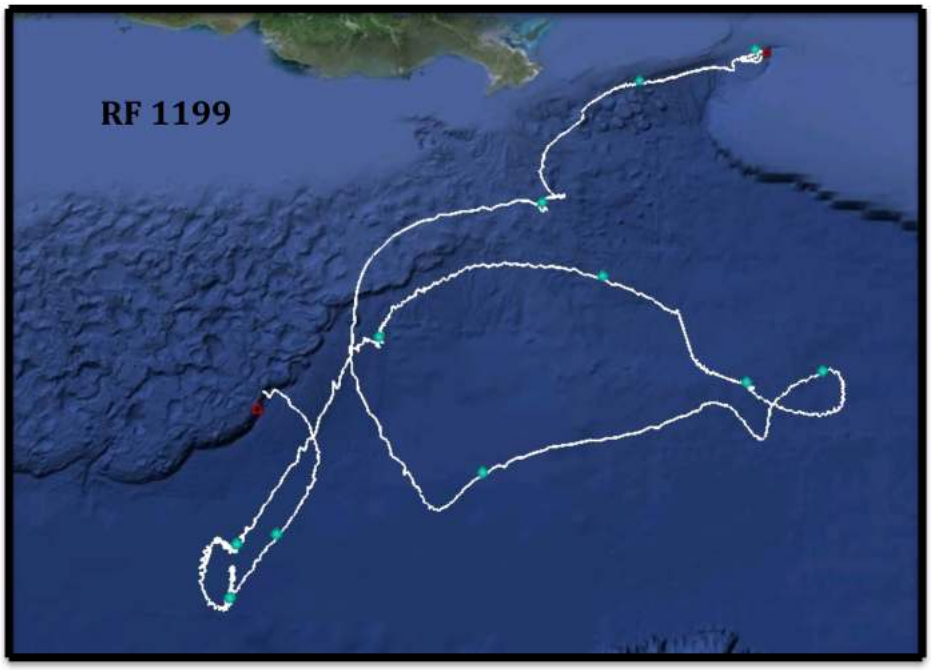
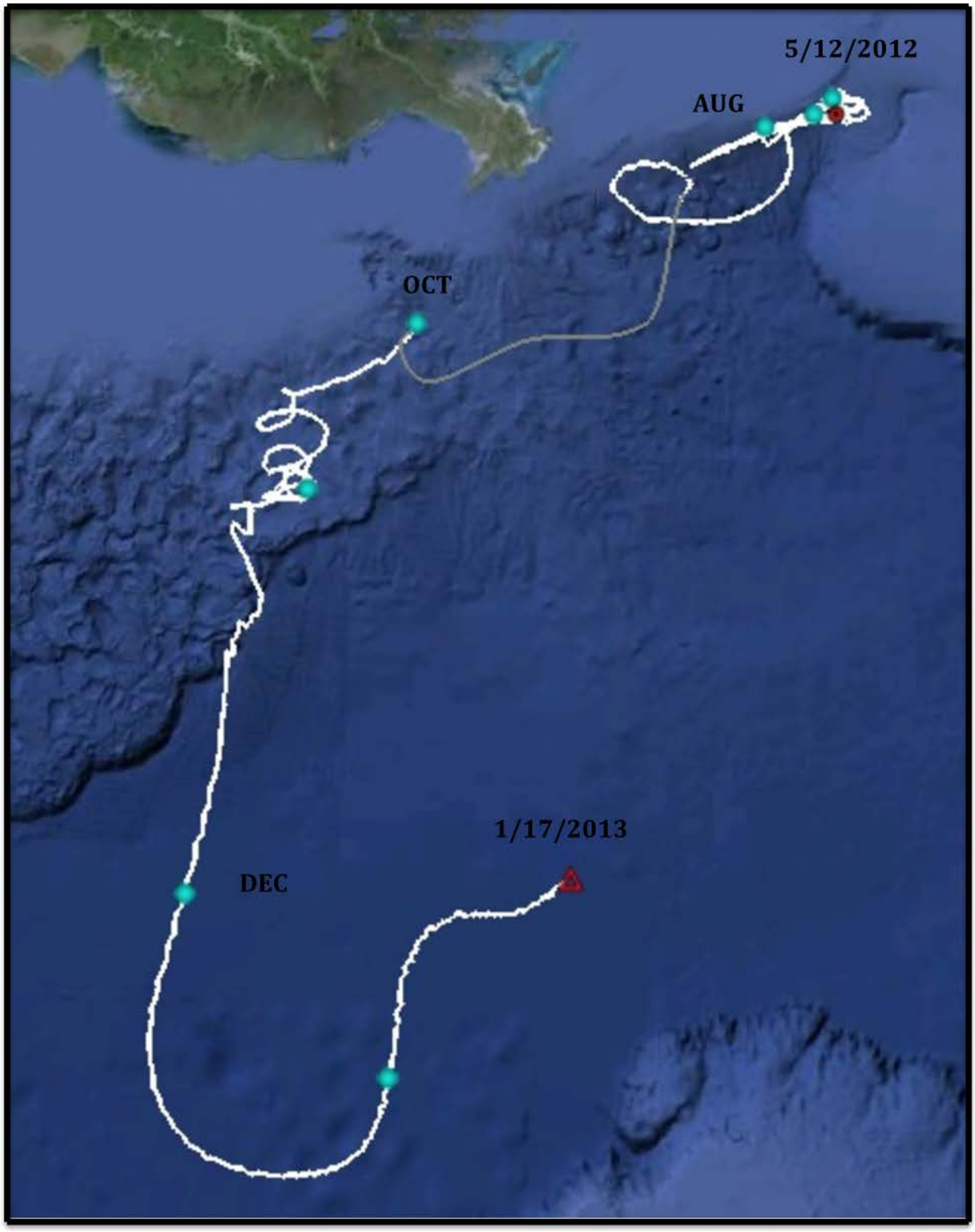


Figure 4, continued.

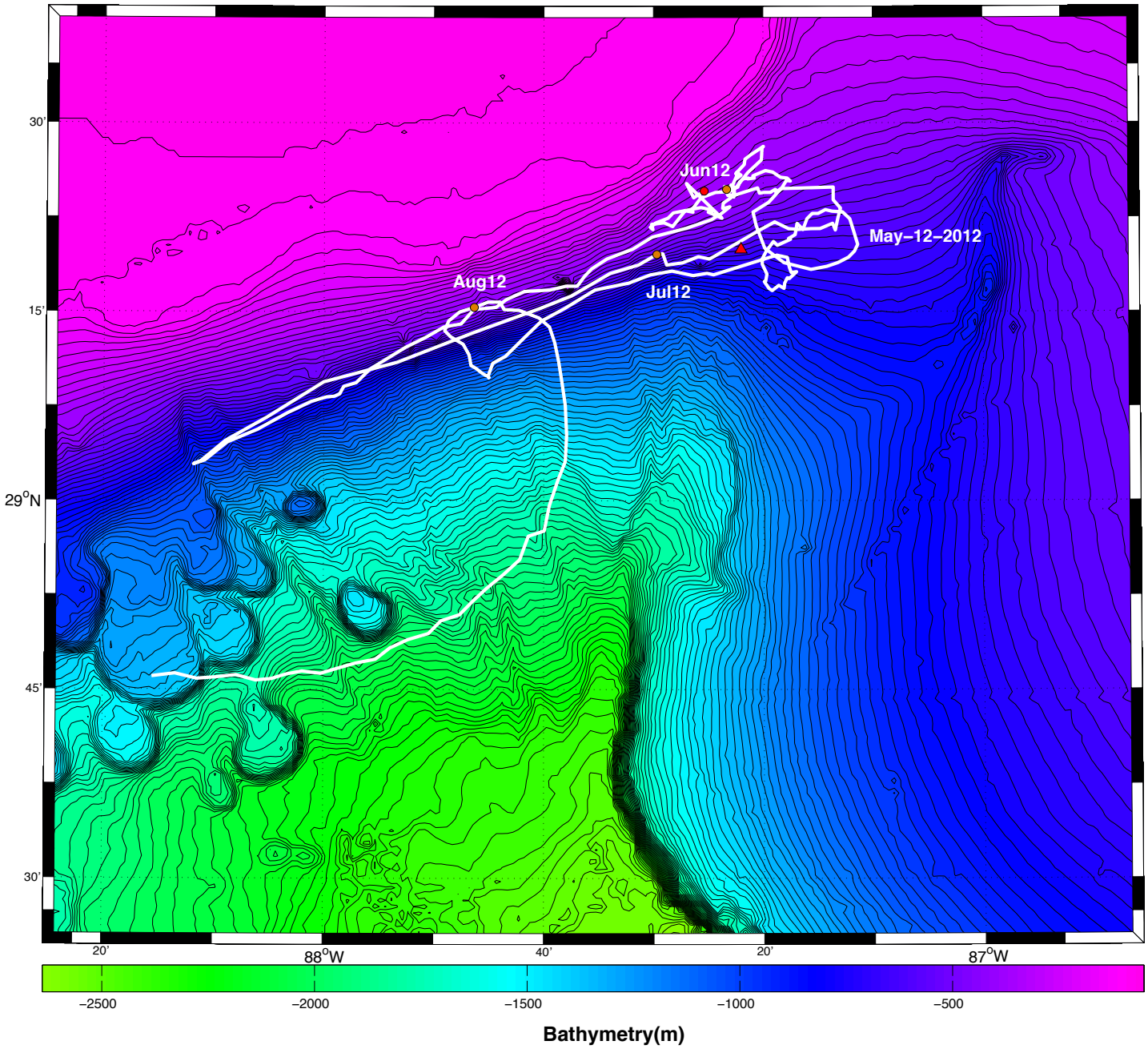
Appendix B

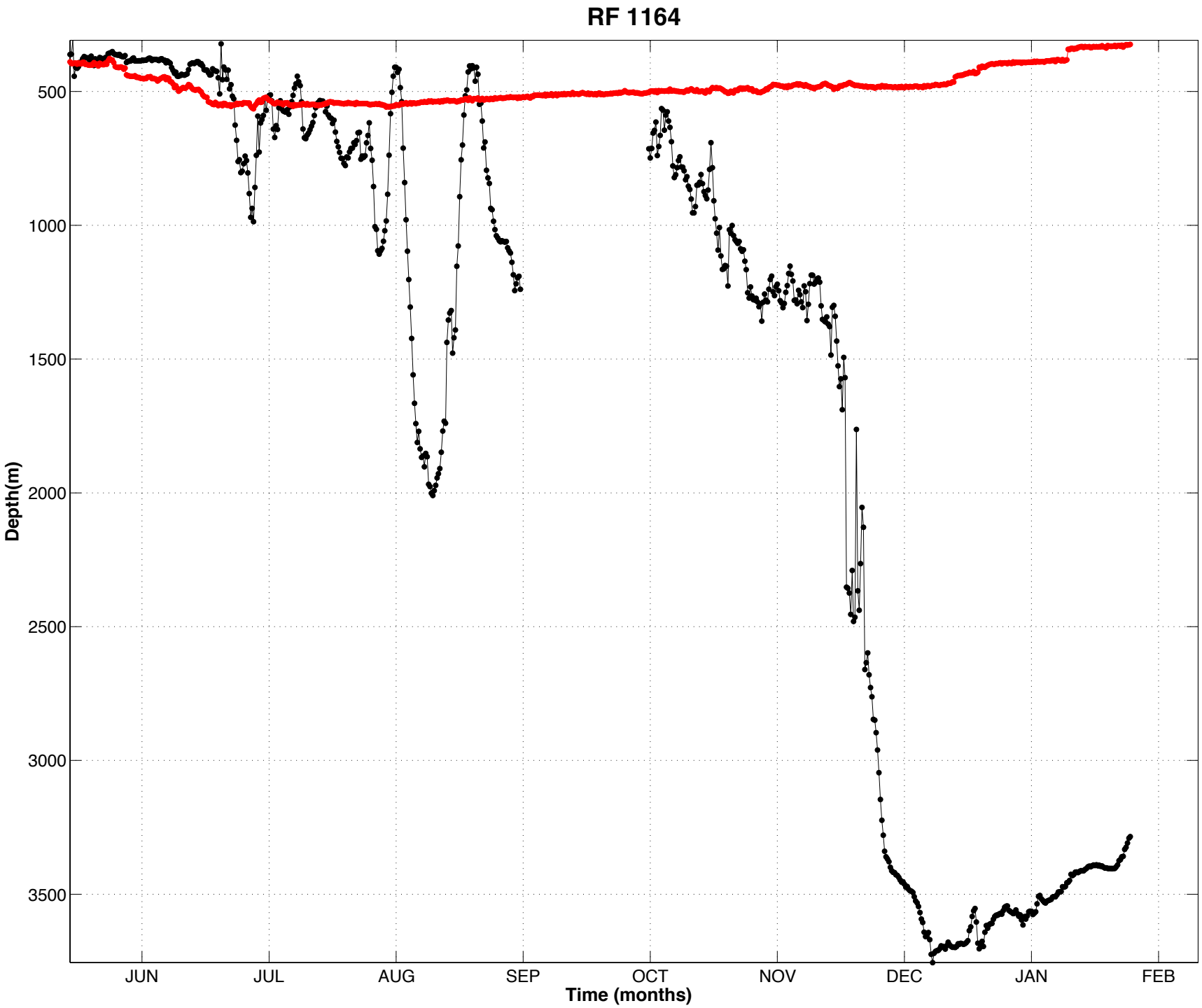
Individual float trajectories and property plots. For each individual float, separate figures show, the entire track, the first 90 days of track, along track depth of float versus water column depth (when appropriate an accompanying map of track locations), and property plots. Track plot bathymetry is from Google Earth or shaded in 25-meter intervals, for the entire or 90 day tracks respectively Monthly positions are marked as turquois or orange dots, for the entire or 90 day tracks respectively. Launch position is marked with a red square and the date in 'ddmmyyyy'. Surface position is marked with a red triangle and the date in 'ddmmyyyyy'. Untrackable segments are drawn with a solid gray line. The title on each trajectory plot includes the float name, the percent of total mission tracked, and the interpolation interval used in tracking. In the along track depth plots, total water depth is shown as black and float depth in red. For RAFOS with regions of float depth greater than water depth, an accompanying map of the track is provided. Here the entire track is plotted in white, with untrackable segments as a dotted white line, and regions where float depth is larger than water depth in red. Bathymetry is shaded in 100-meter intervals. Property plots contain panels depicting temperature, pressure, u-velocity, v-velocity, and stick plots representing velocity magnitude and direction. The x-axis marks the time in months. Launch and surface information for these floats is presented in Table 2. Floats that failed or stayed at the surface for their entire mission are not included.

RF 1164 - 61% tracked, 10-day interpolation

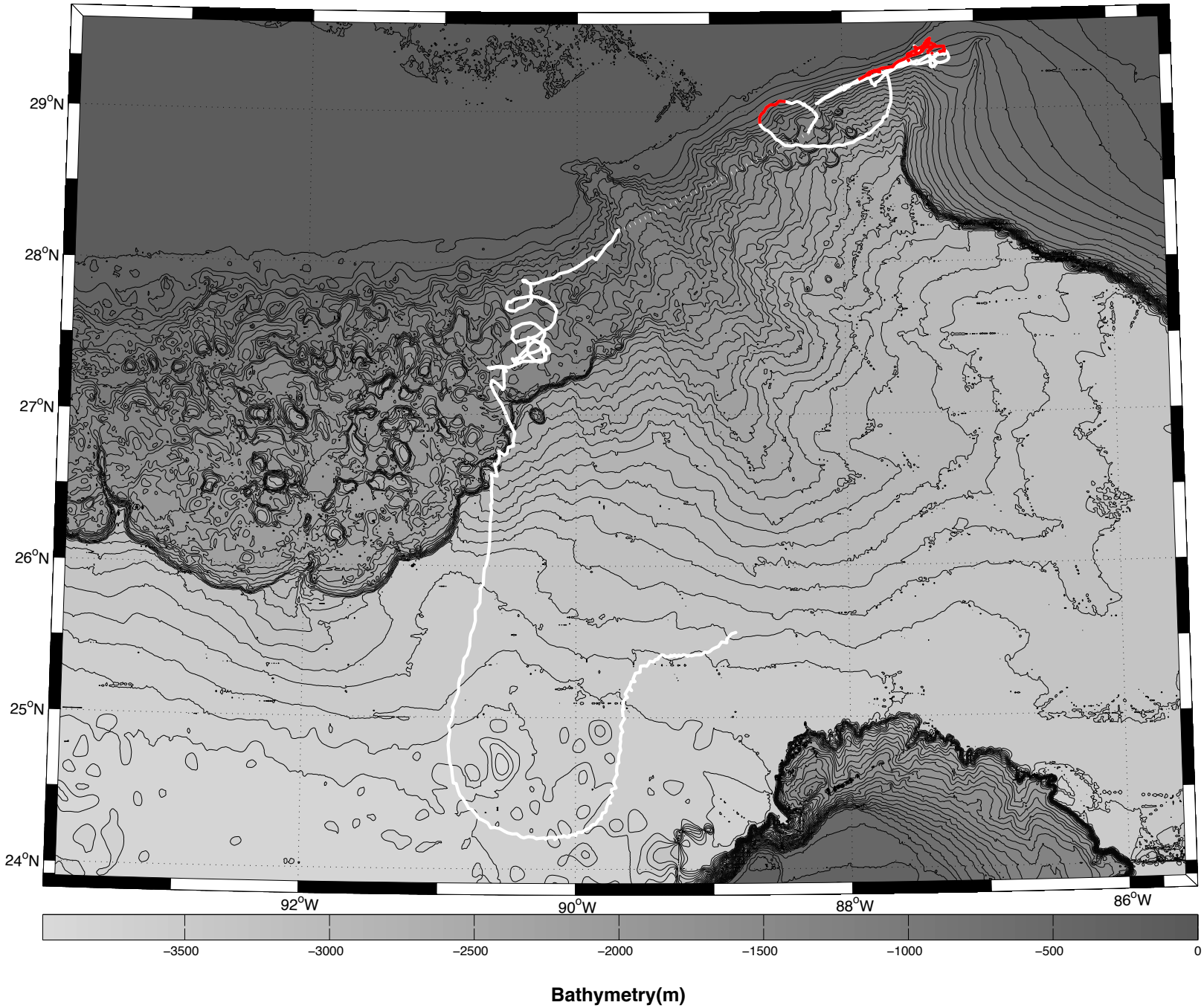


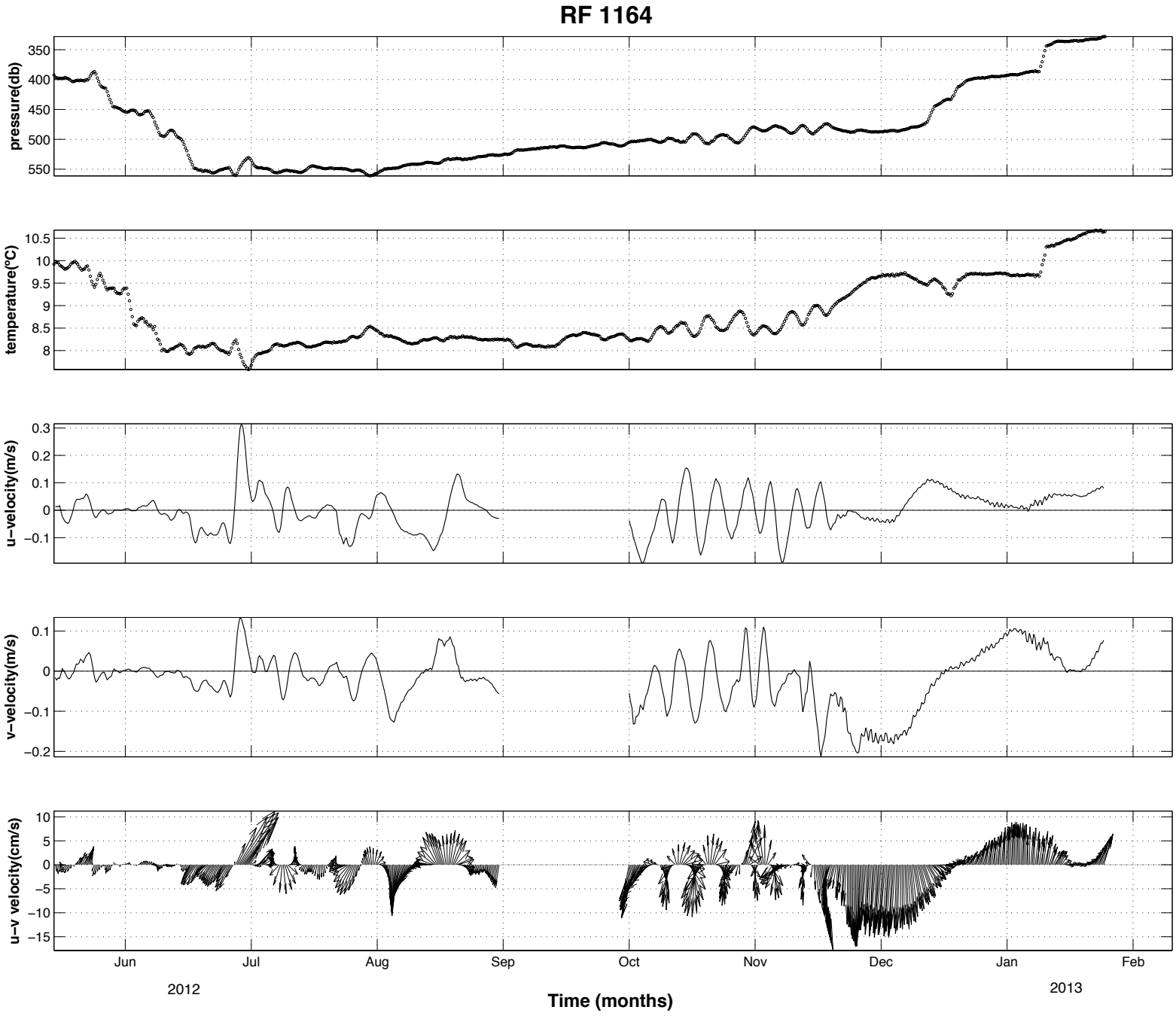
RF 1164 – first 3 months



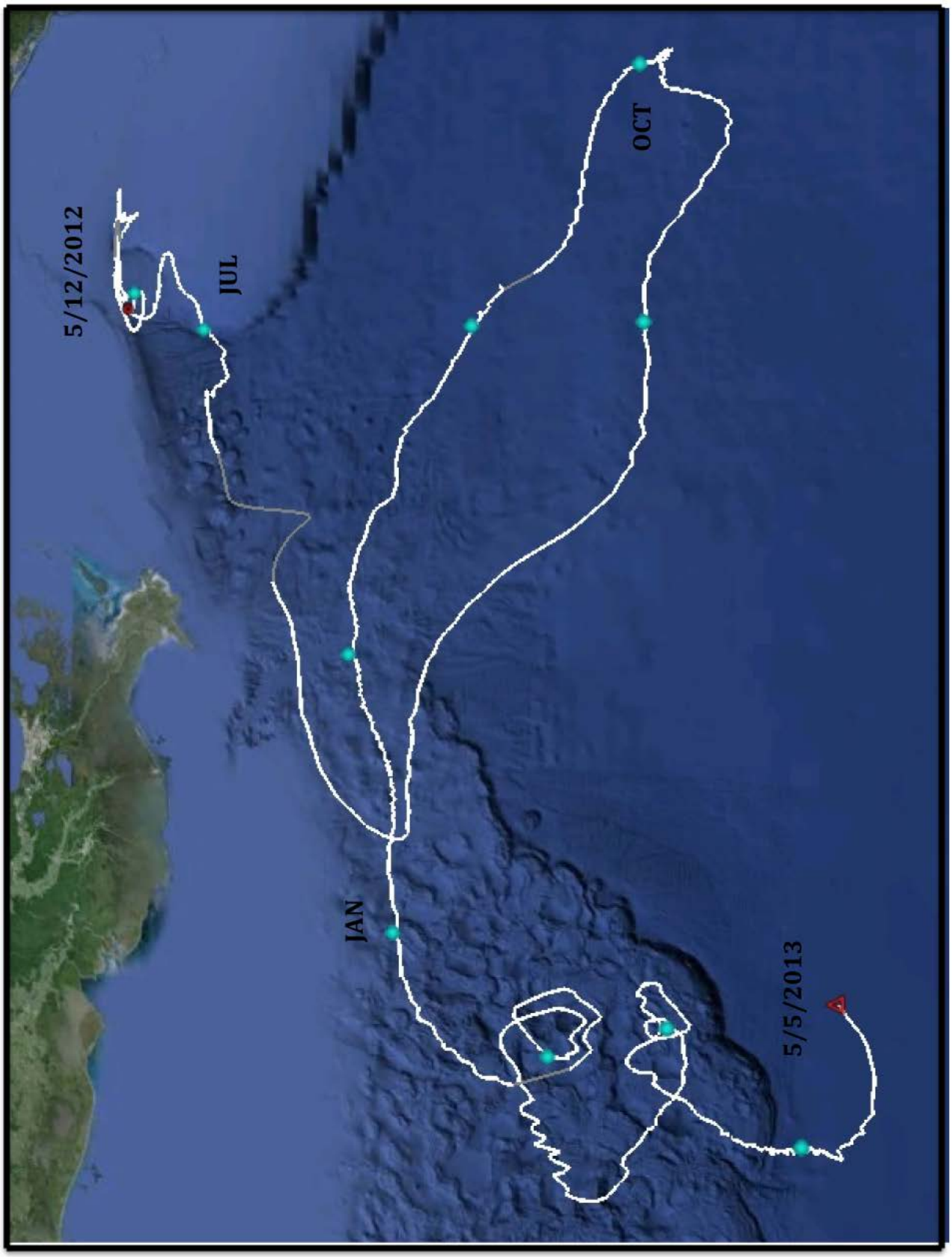

RF 1164
Depth(m)
500
1000
1500
2000
2500
3000
3500
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
Time (months)

RF 1164

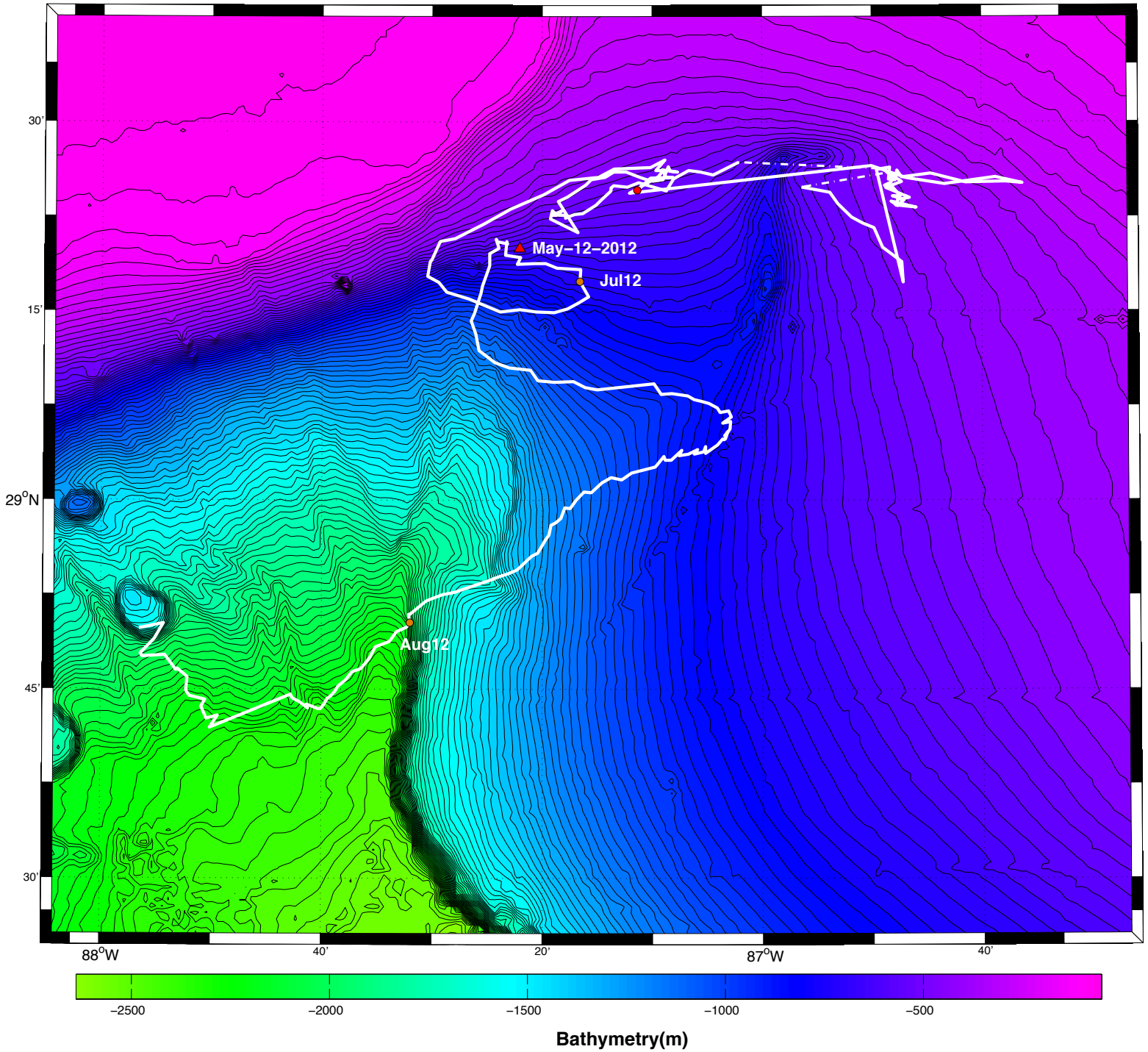

29°N
28°N
27°N
26°N
25°N
24°N
92°W
90°W
88°W
86°W
−3500
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

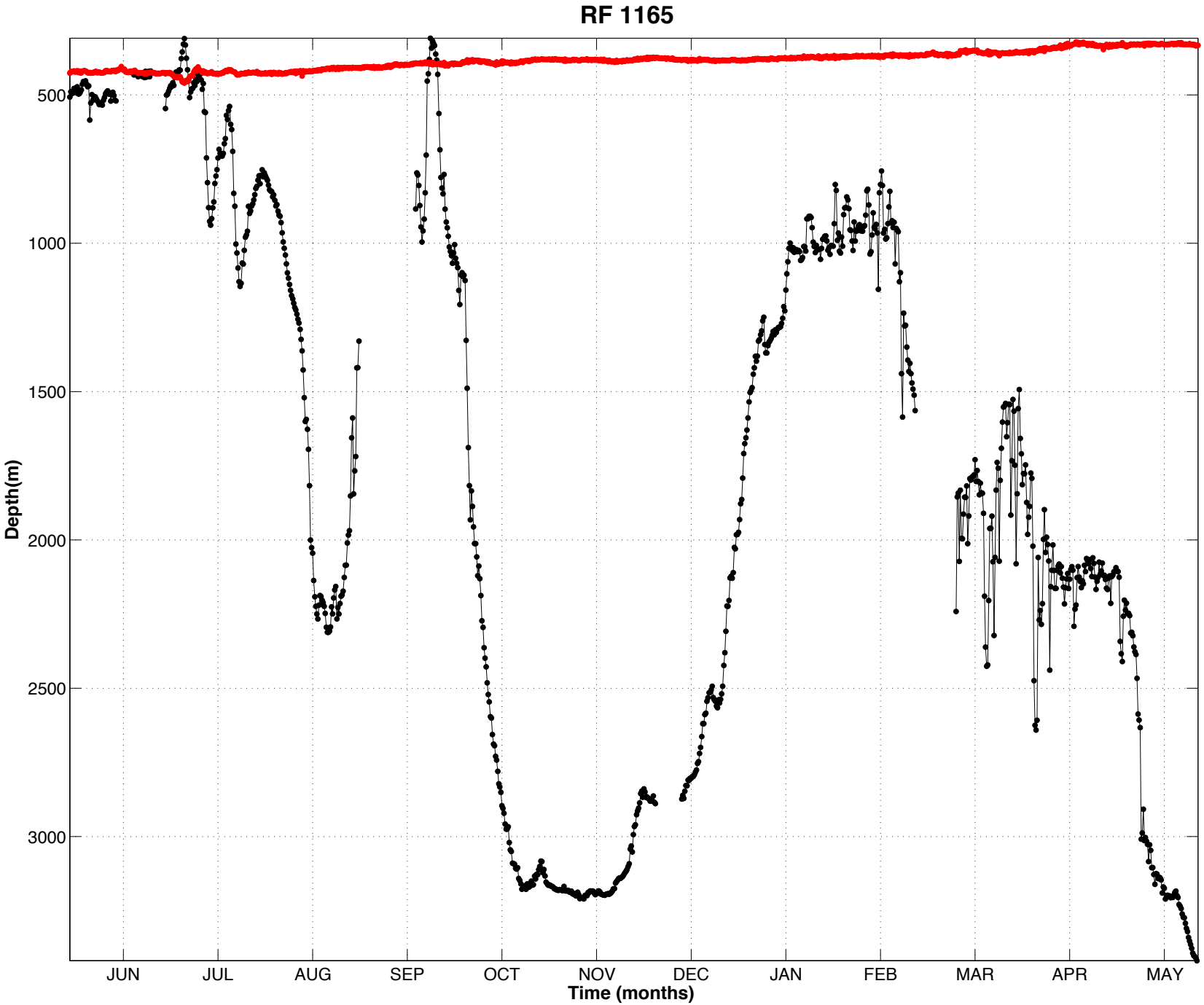

RF 1164
pressure(db)
350
400
450
500
550
temperature(ºC)
10.5
10
9.5
9
8.5
8
u−velocity(m/s)
0.3
0.2
0.1
0
−0.1
v−velocity(m/s)
0.1
0
−0.1
−0.2
u−v velocity(cm/s)
10
5
0
−5
−10
−15
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
2012
2013
Time (months)

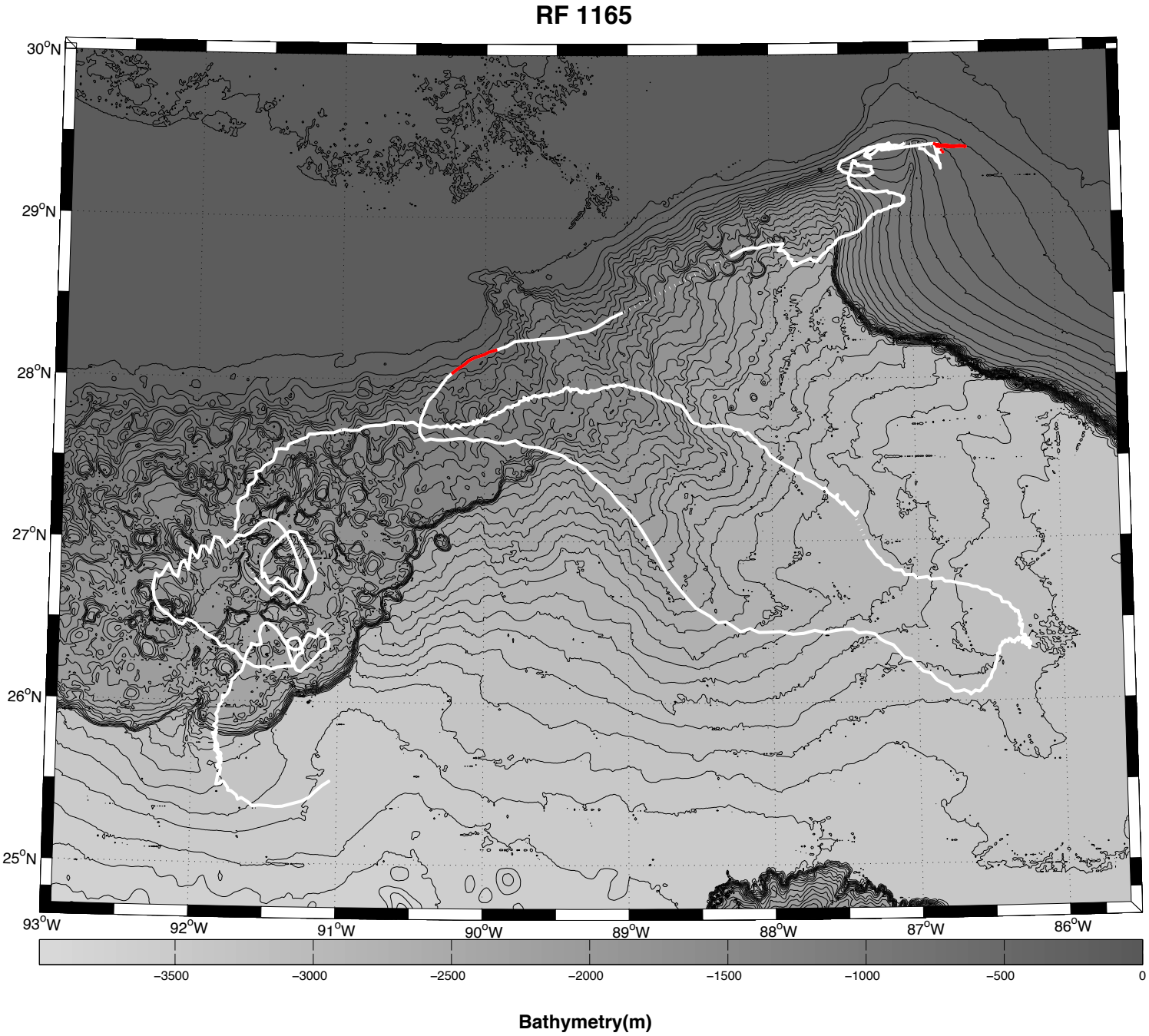
RF 1165 – 85% tracked, 10-day interpolation

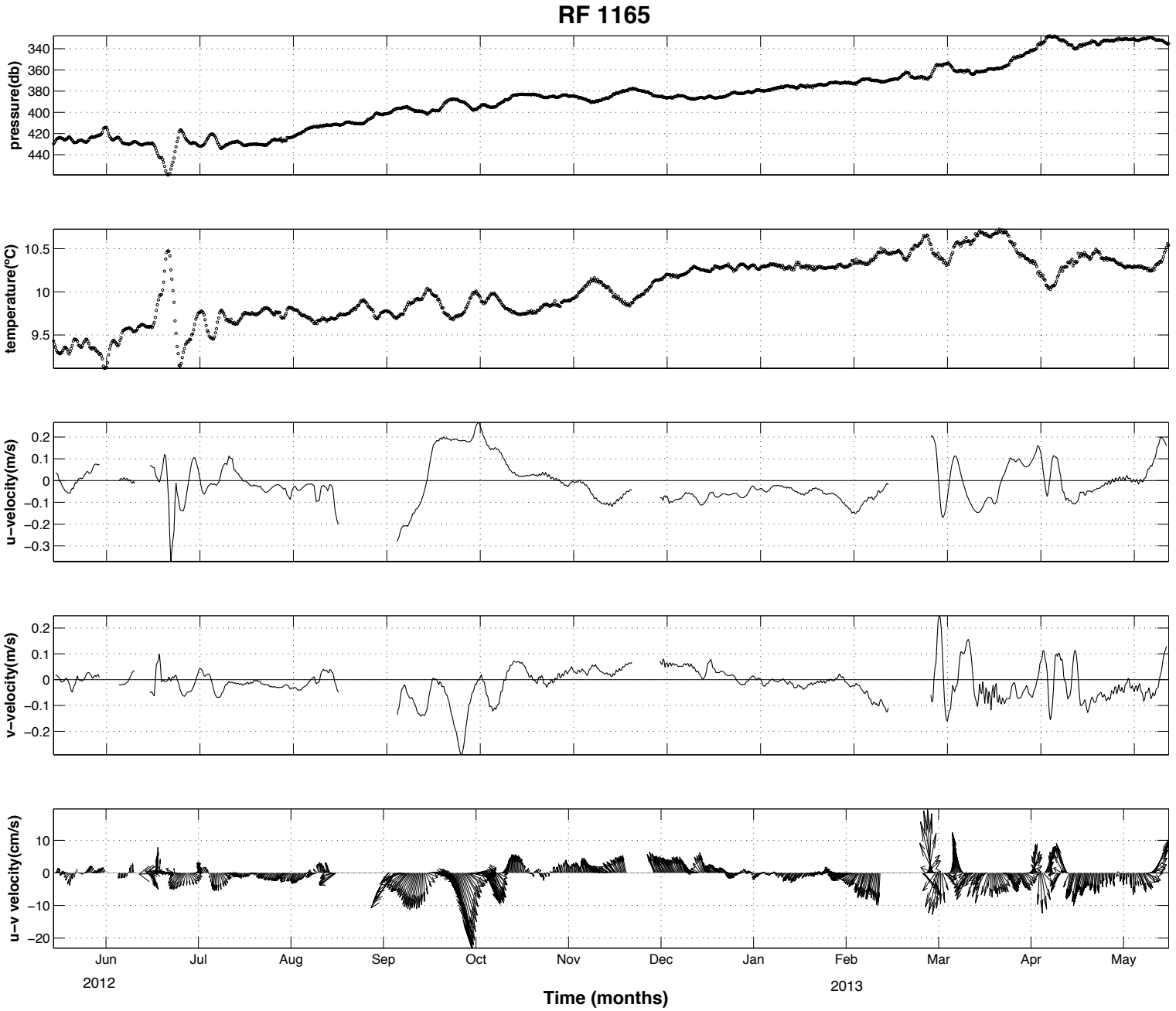


RF1165 – 3 month track

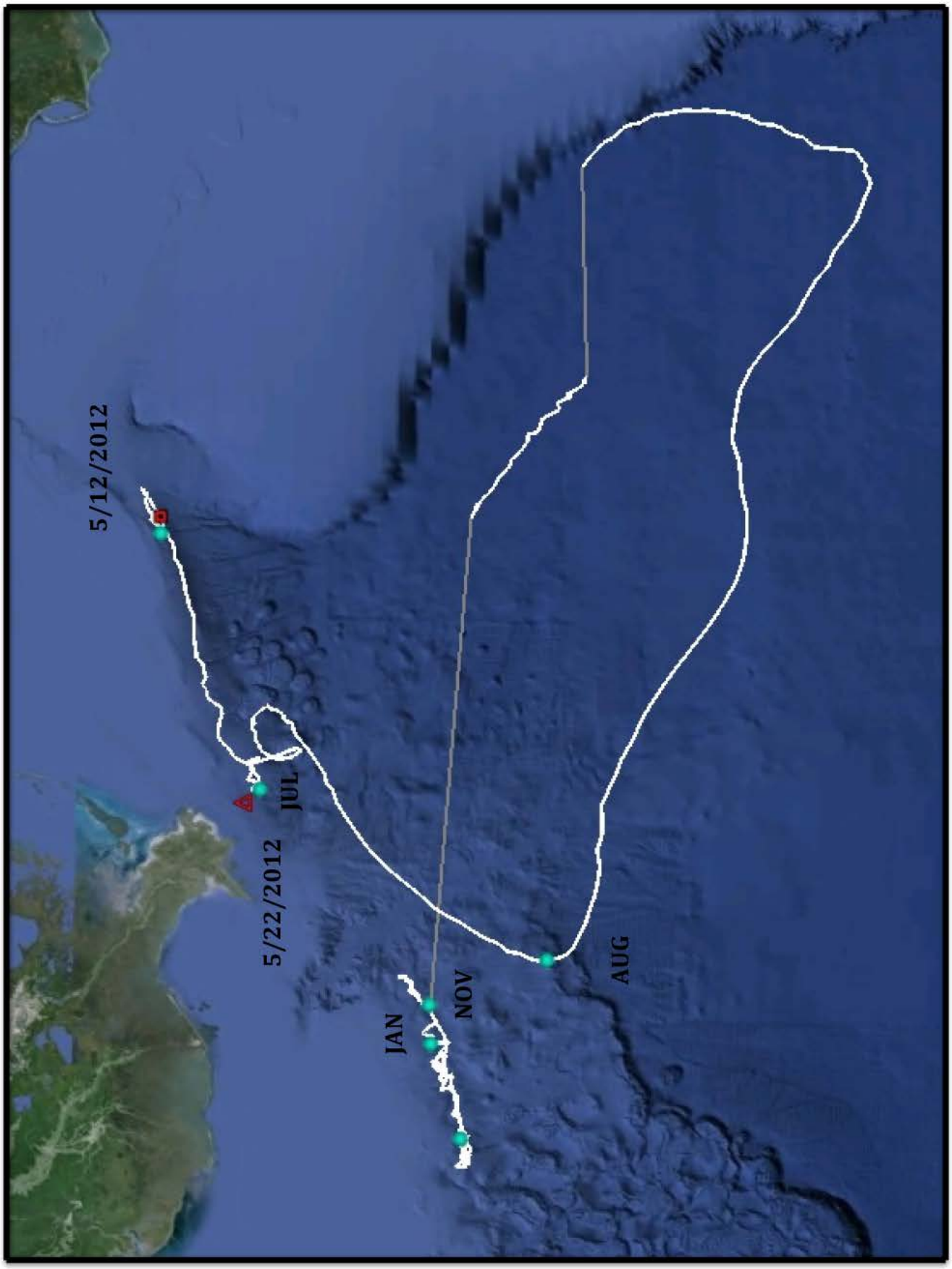


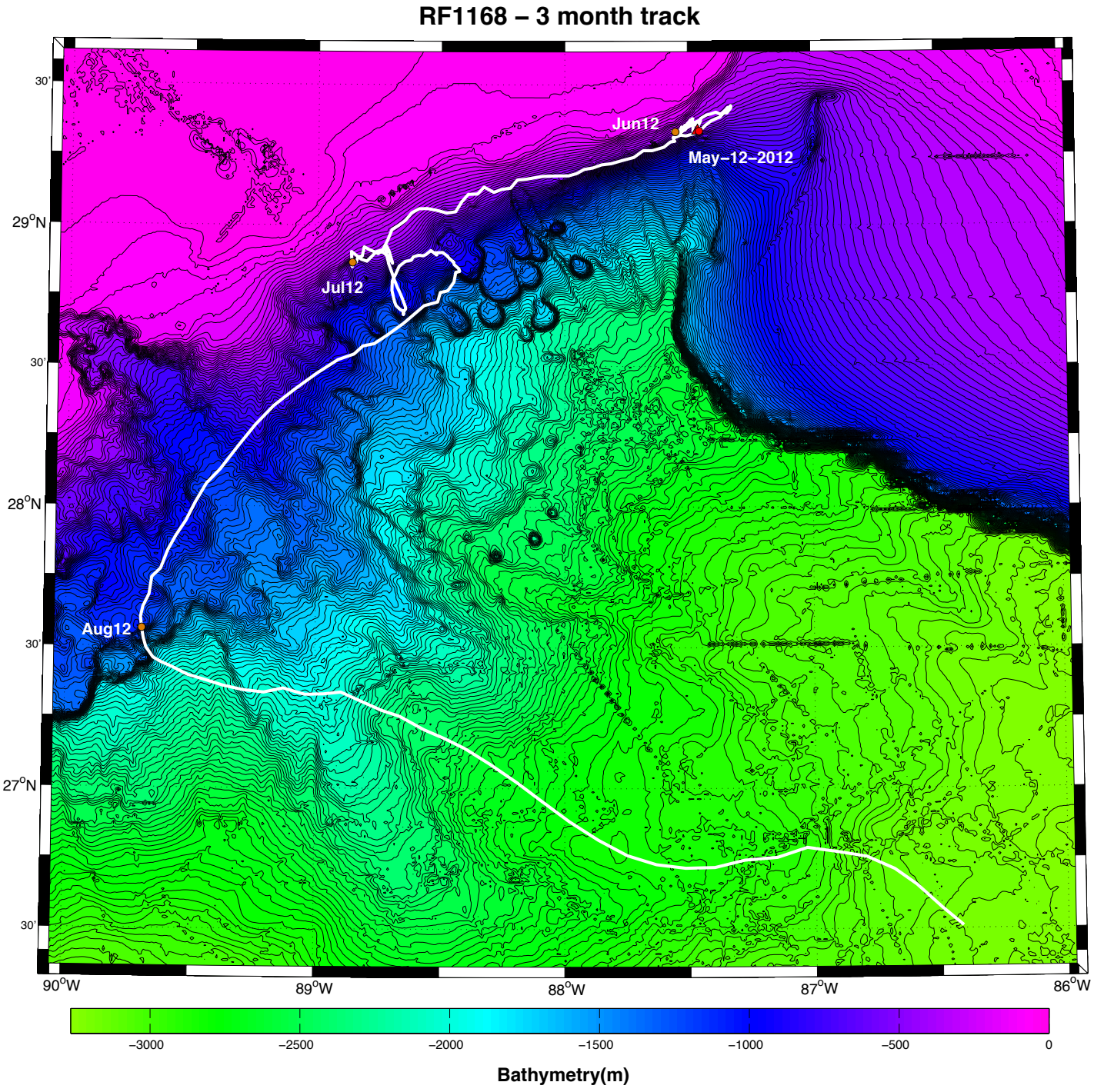

RF 1165
Depth(m)
500
1000
1500
2000
2500
3000
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)

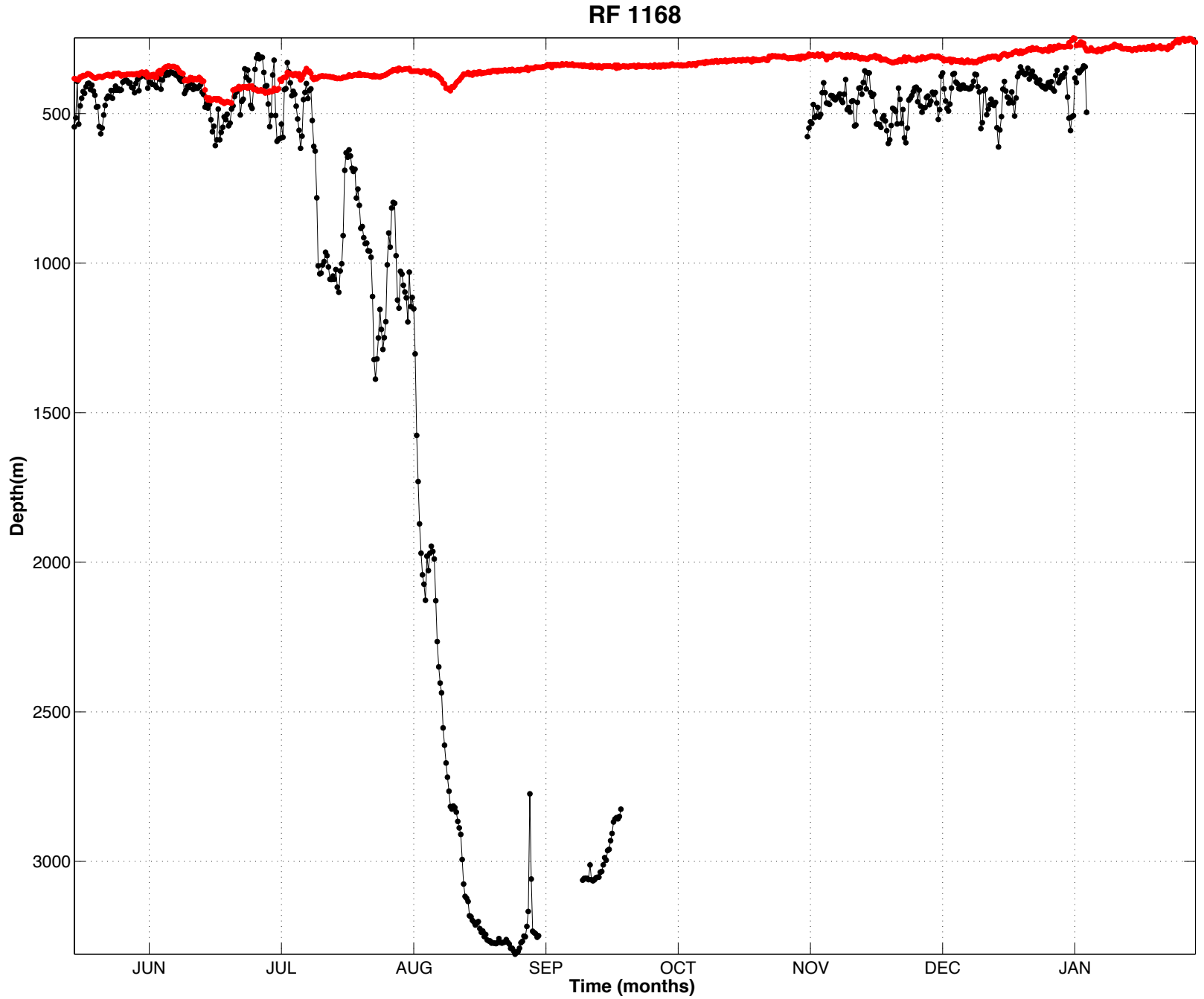

RF 1165
30°N
29°N
28°N
27°N
26°N
25°N
93°W
92°W
91°W
90°W
89°W
88°W
87°W
86°W
−3500
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

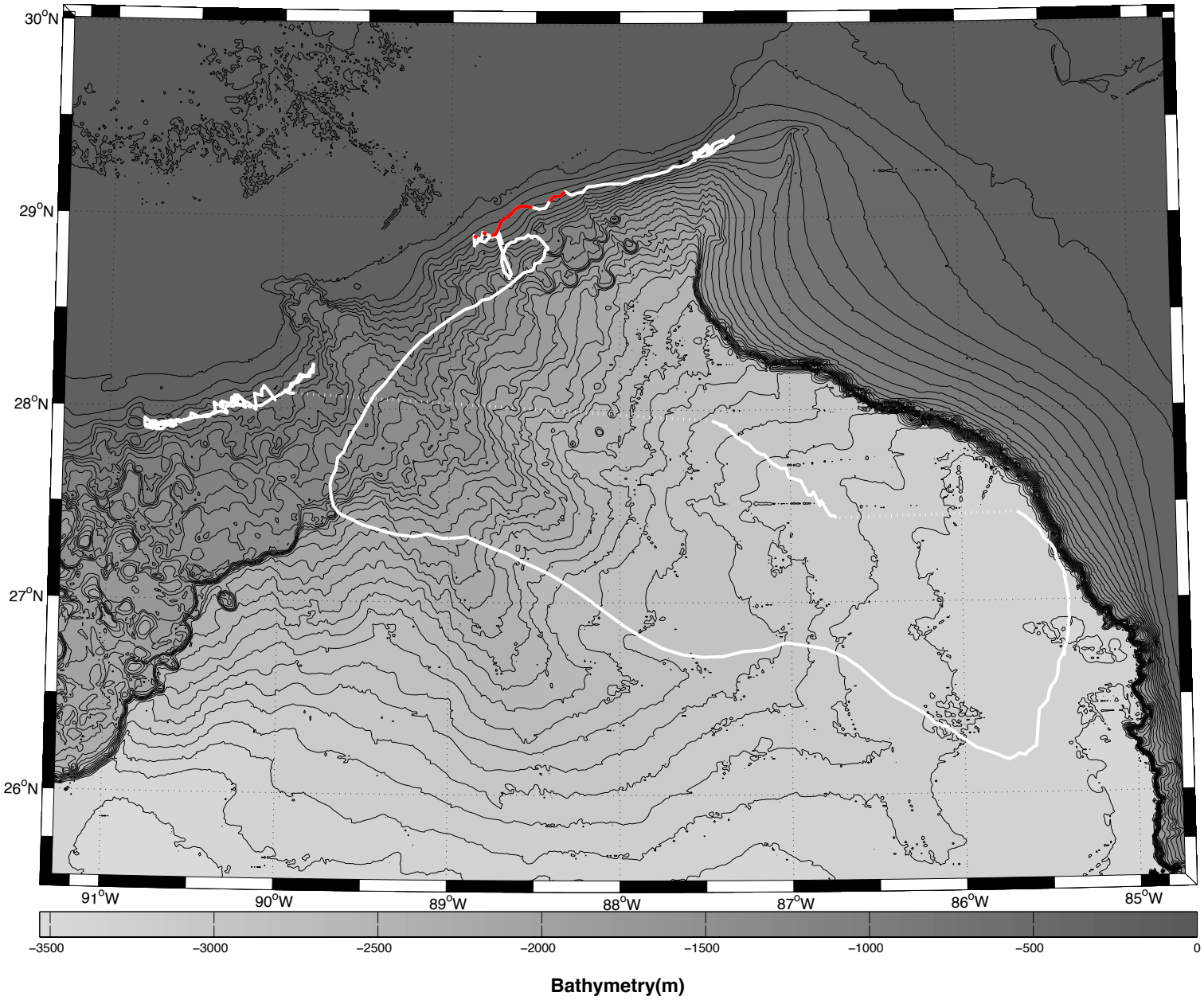

RF 1165
pressure(db)
340
360
380
400
420
440
temperature(°C)
10.5
10
9.5
u−velocity(m/s)
0.2
0.1
0
−0.1
−0.2
−0.3
v−velocity(m/s)
0.2
0.1
0
−0.1
−0.2
u−v velocity(cm/s)
10
0
−10
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2012
2013
Time (months)

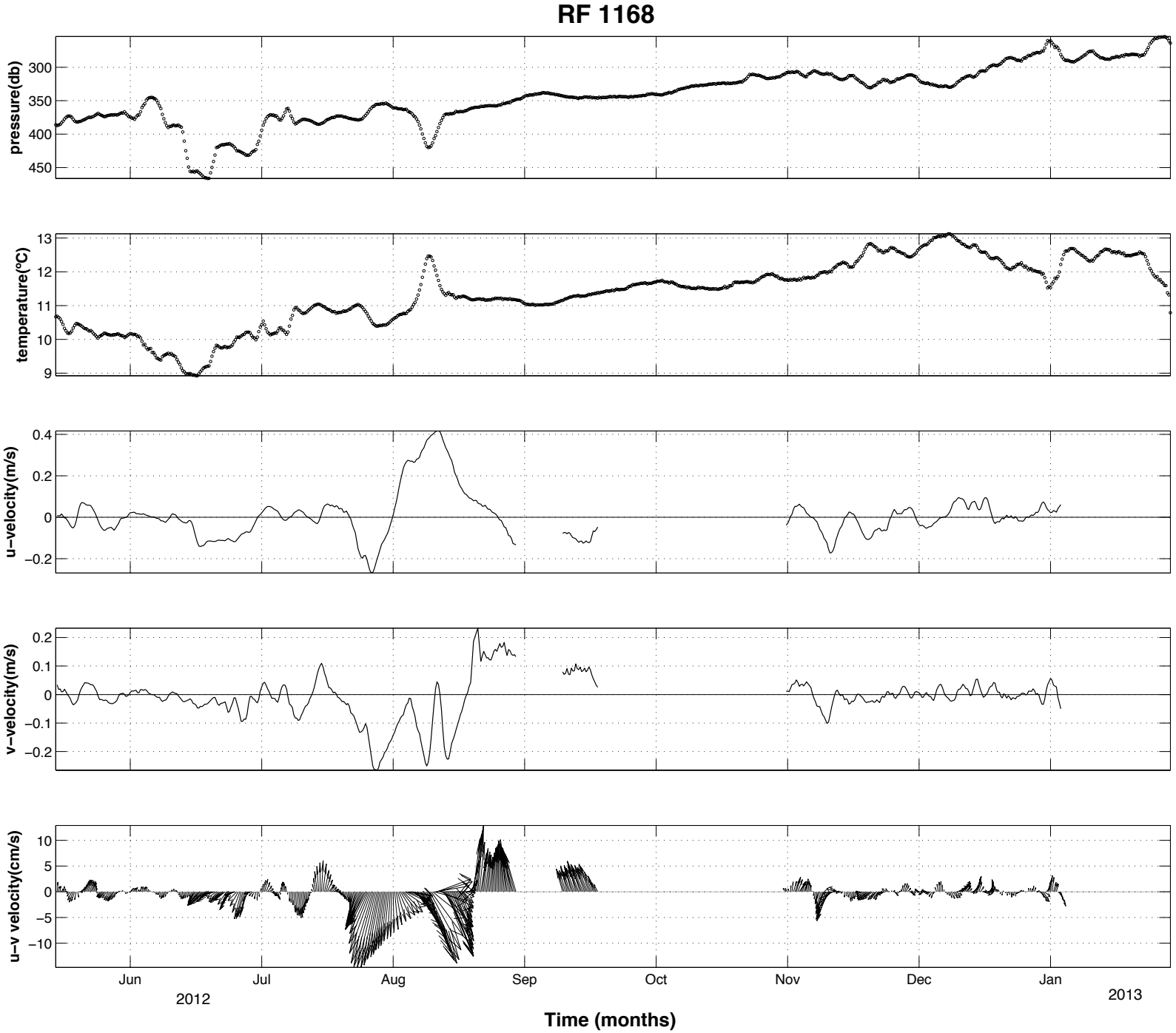
RF 1168 – 49% tracked, 10-day interpolation



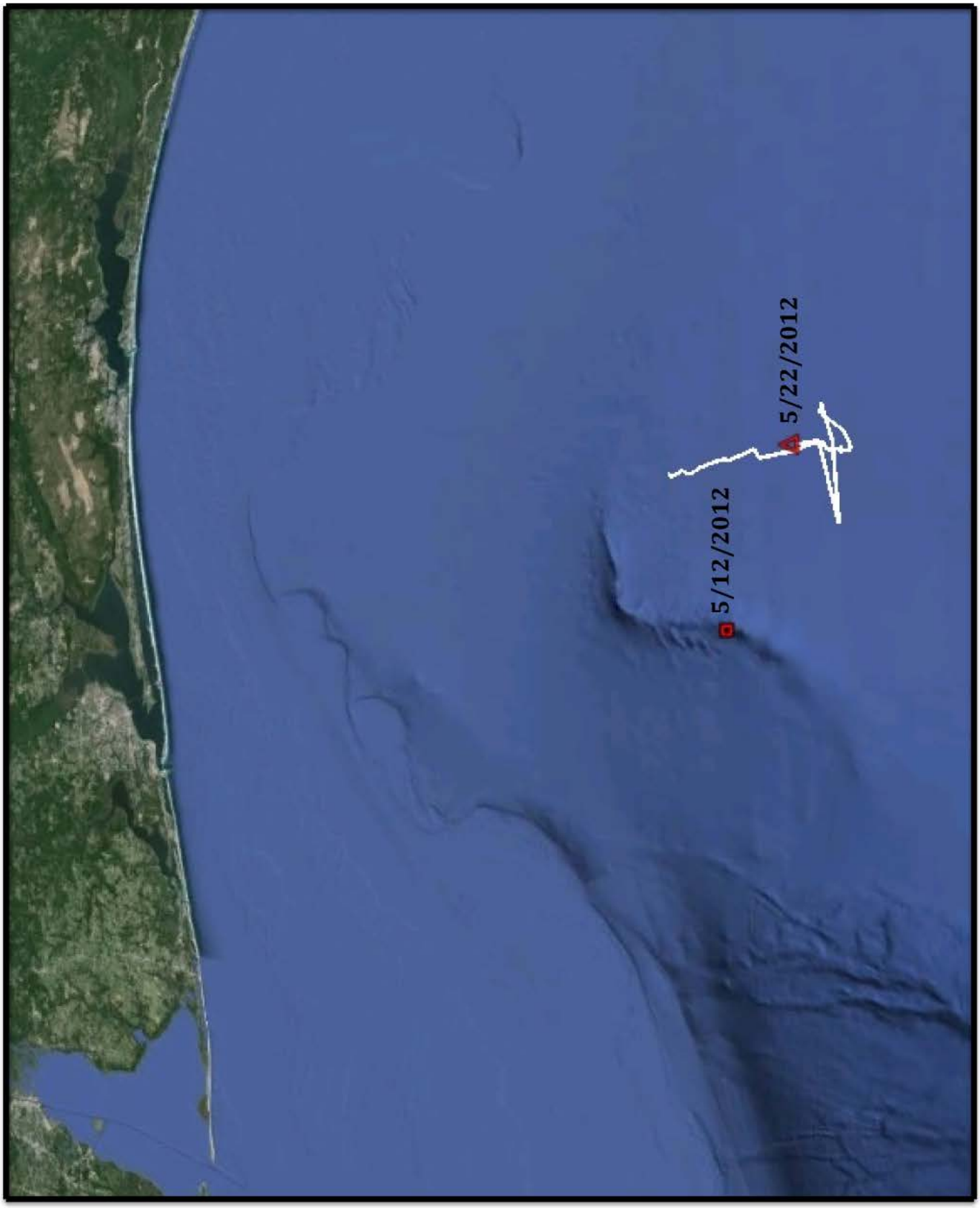

RF1168 – 3 month track
Jun12
May–12–2012
Jul12
Aug12
30'
29°N
30'
28°N
30'
27°N
30'
90°W
89°W
88°W
87°W
86°W
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)


RF 1168
Depth(m)
500
1000
1500
2000
2500
3000
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
Time (months)

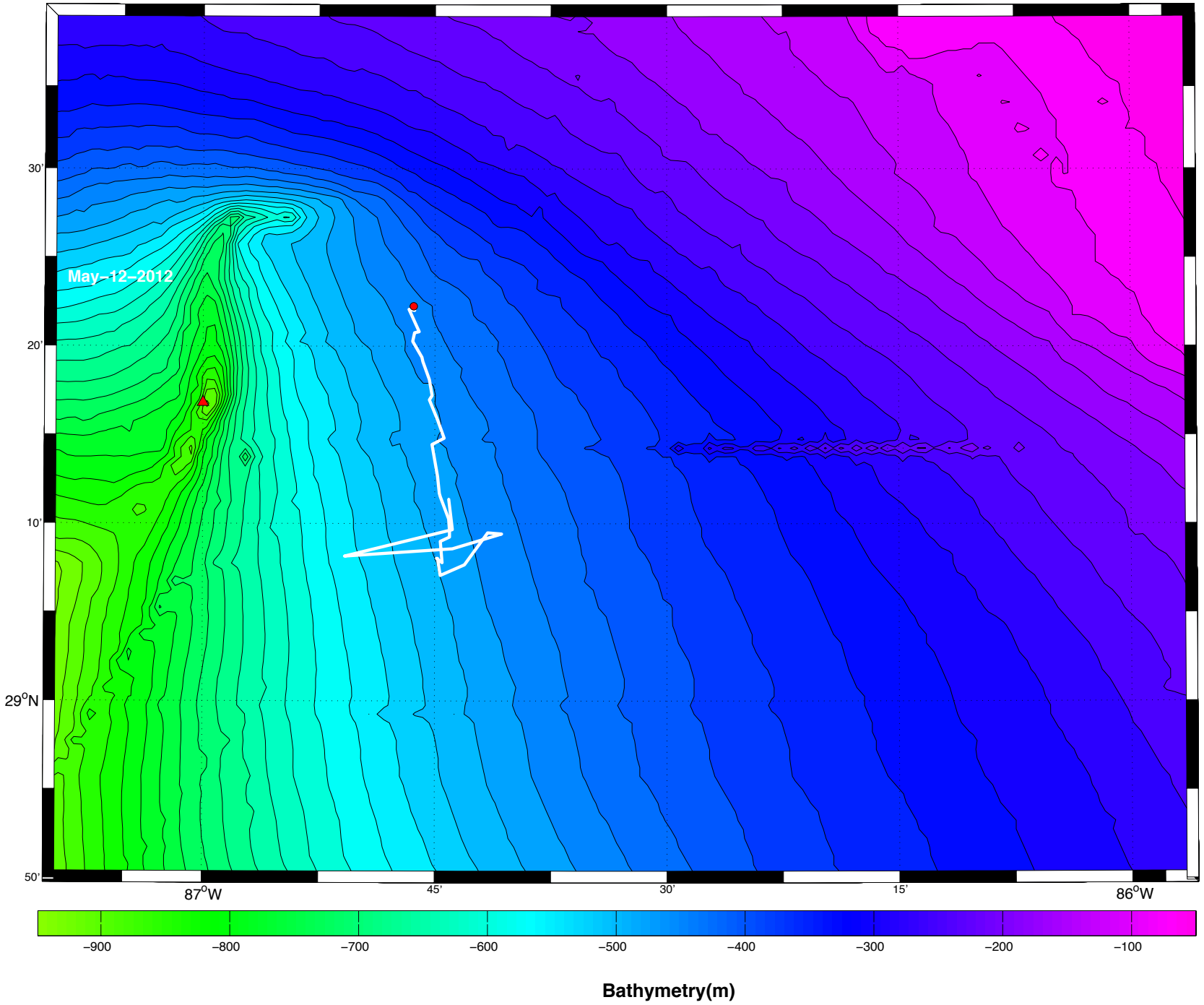

RF 1168
30°N
29°N
28°N
27°N
26°N
91°W
90°W
89°W
88°W
87°W
86°W
85°W
−3500
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

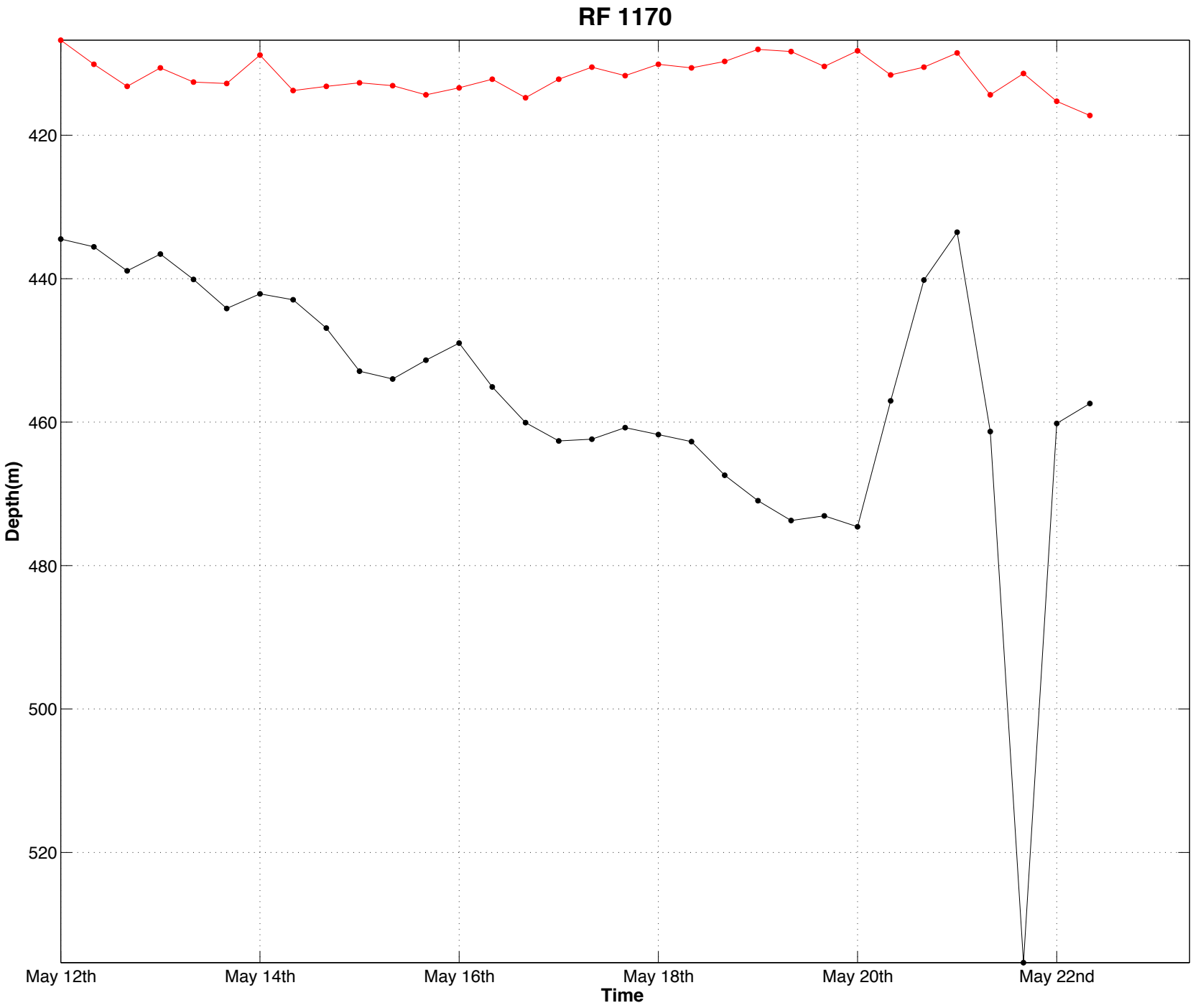

RF 1168
pressure(db)
300
350
400
450
temperature(°C)
13
12
11
10
9
u−velocity(m/s)
0.4
0.2
0
−0.2
v−velocity(m/s)
0.2
0.1
0
−0.1
−0.2
u−v velocity(cm/s)
10
5
0
−5
−10
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
2012
2013
Time (months)

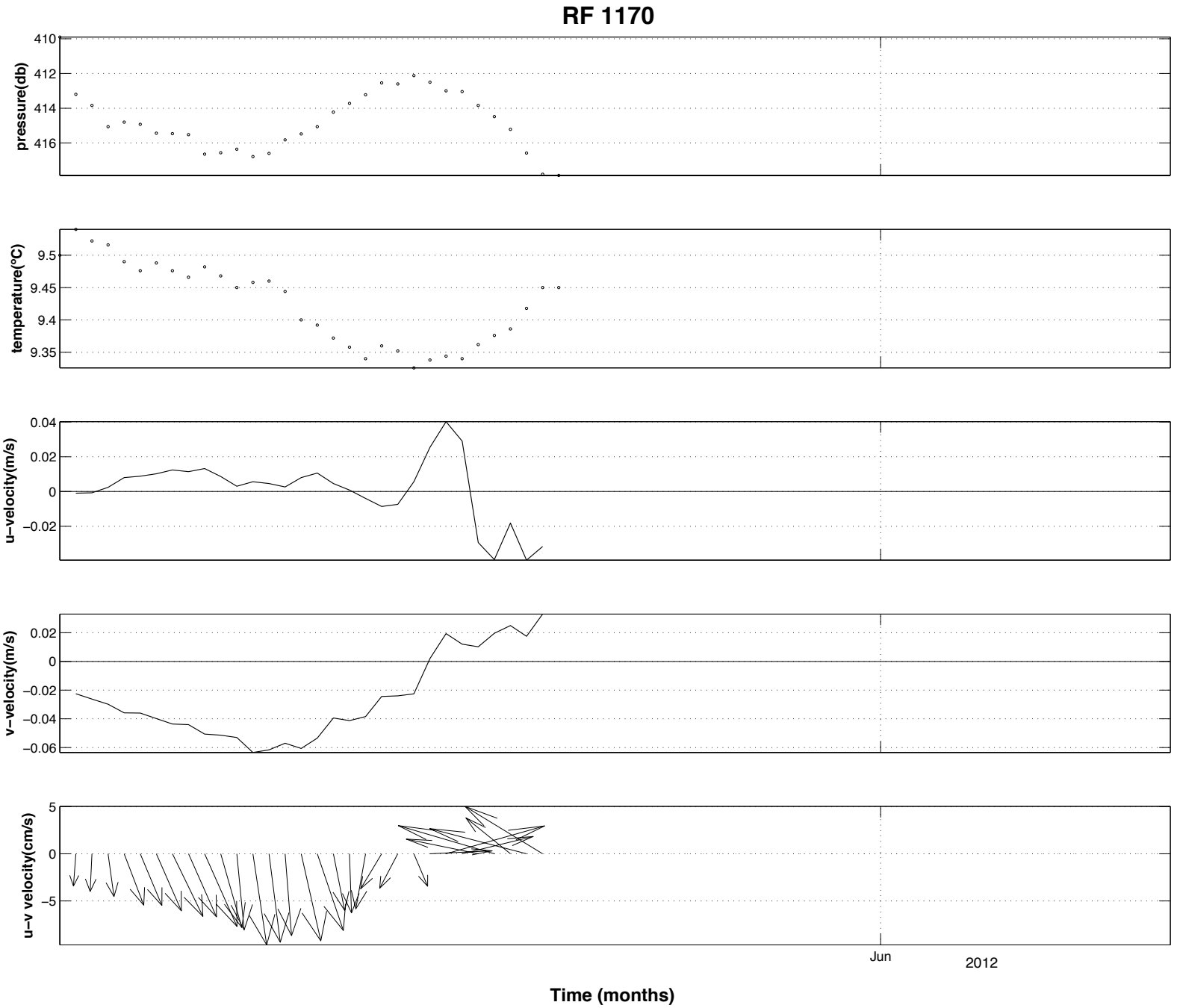
RF 1170 – 3% tracked, 10-day interpolation



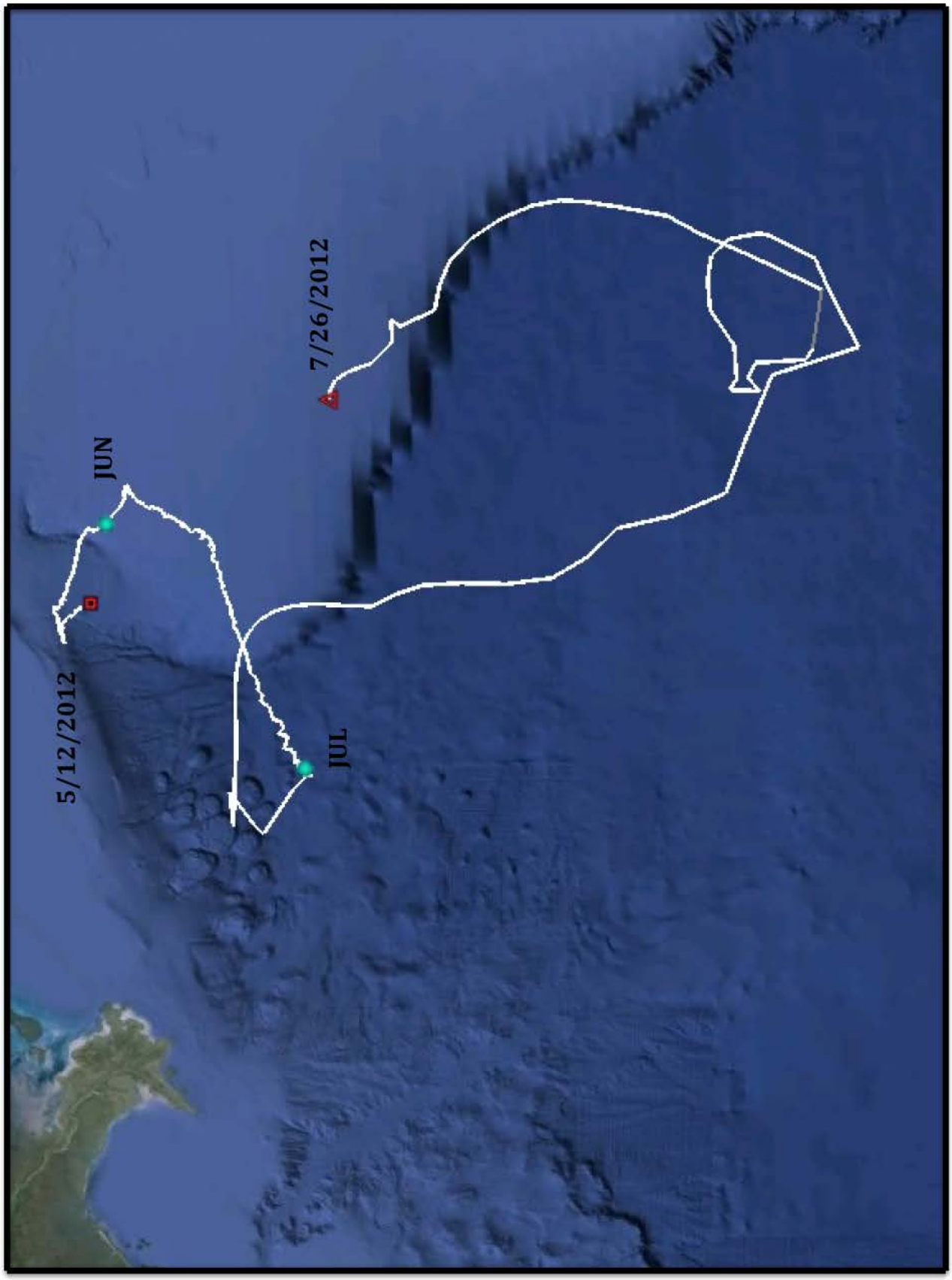
RF1170 – 3 month track



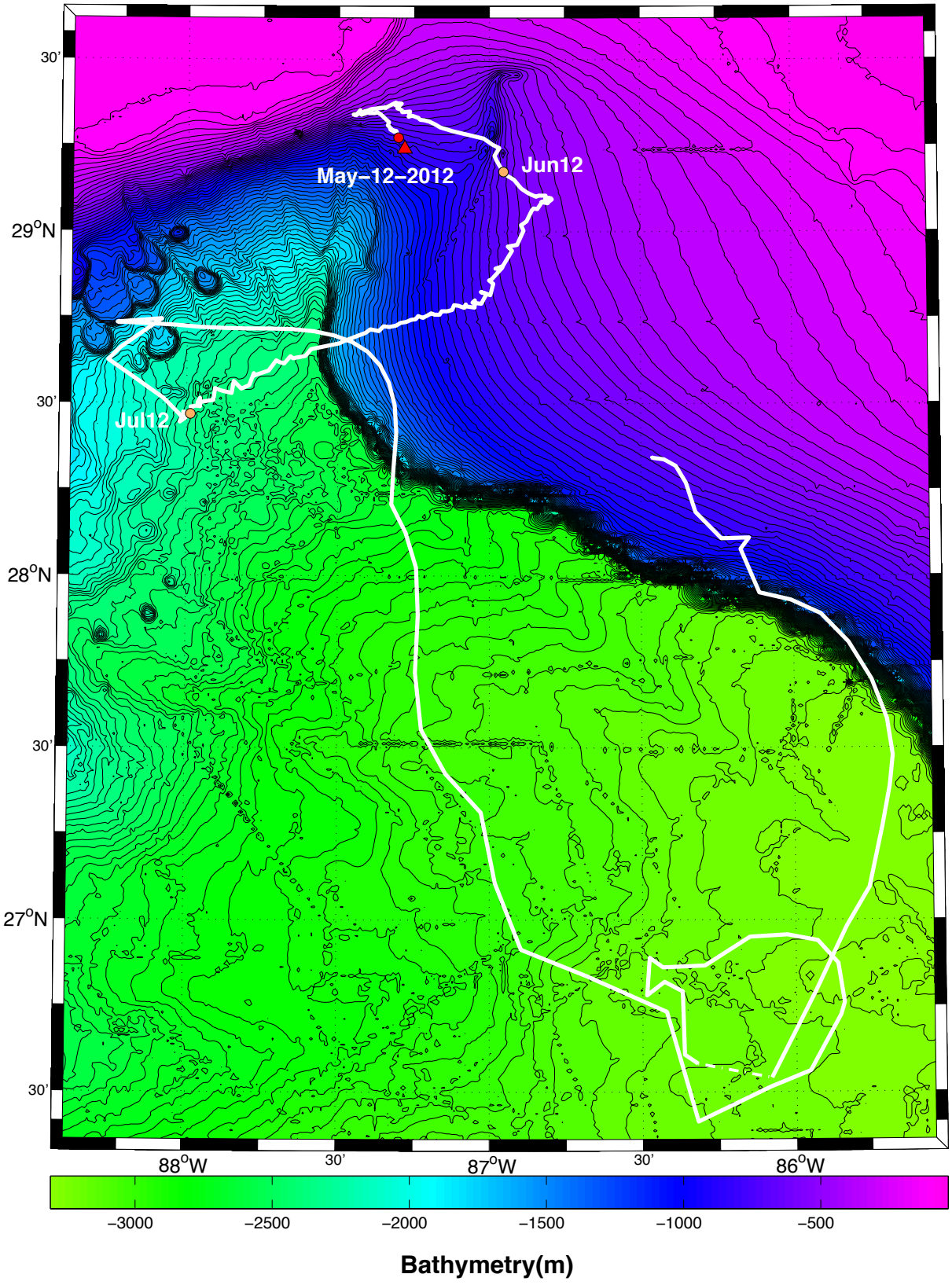

RF 1170
Depth(m)
420
440
460
480
500
520
May 12th
May 14th
May 16th
May 18th
May 20th
May 22nd
Time

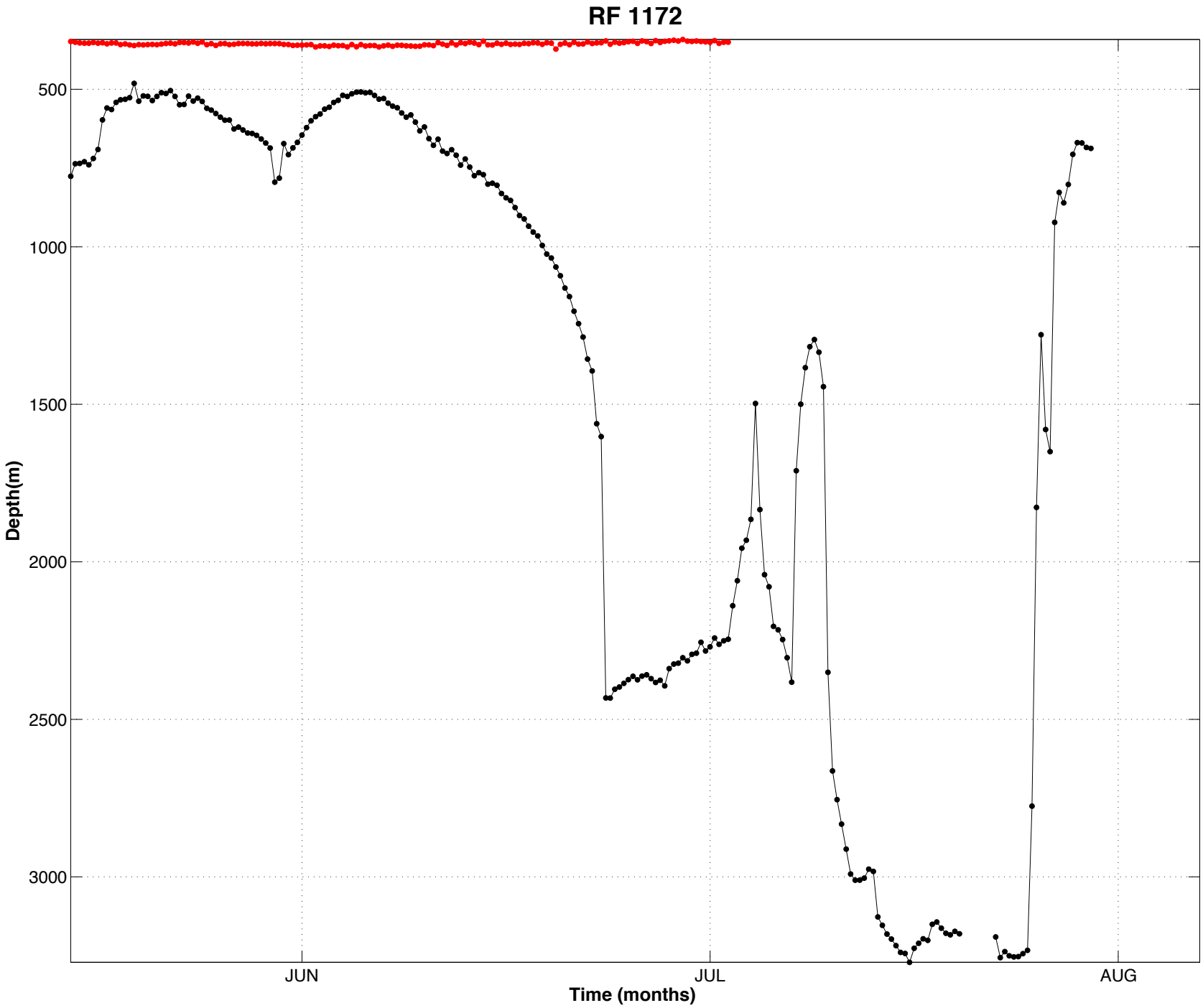

RF 1170
pressure(db)
410
412
414
416
temperature(°C)
9.5
9.45
9.4
9.35
u−velocity(m/s)
0.04
0.02
0
−0.02
v−velocity(m/s)
0.02
0
−0.02
−0.04
−0.06
u−v velocity(cm/s)
5
0
−5
Jun
2012
Time (months)

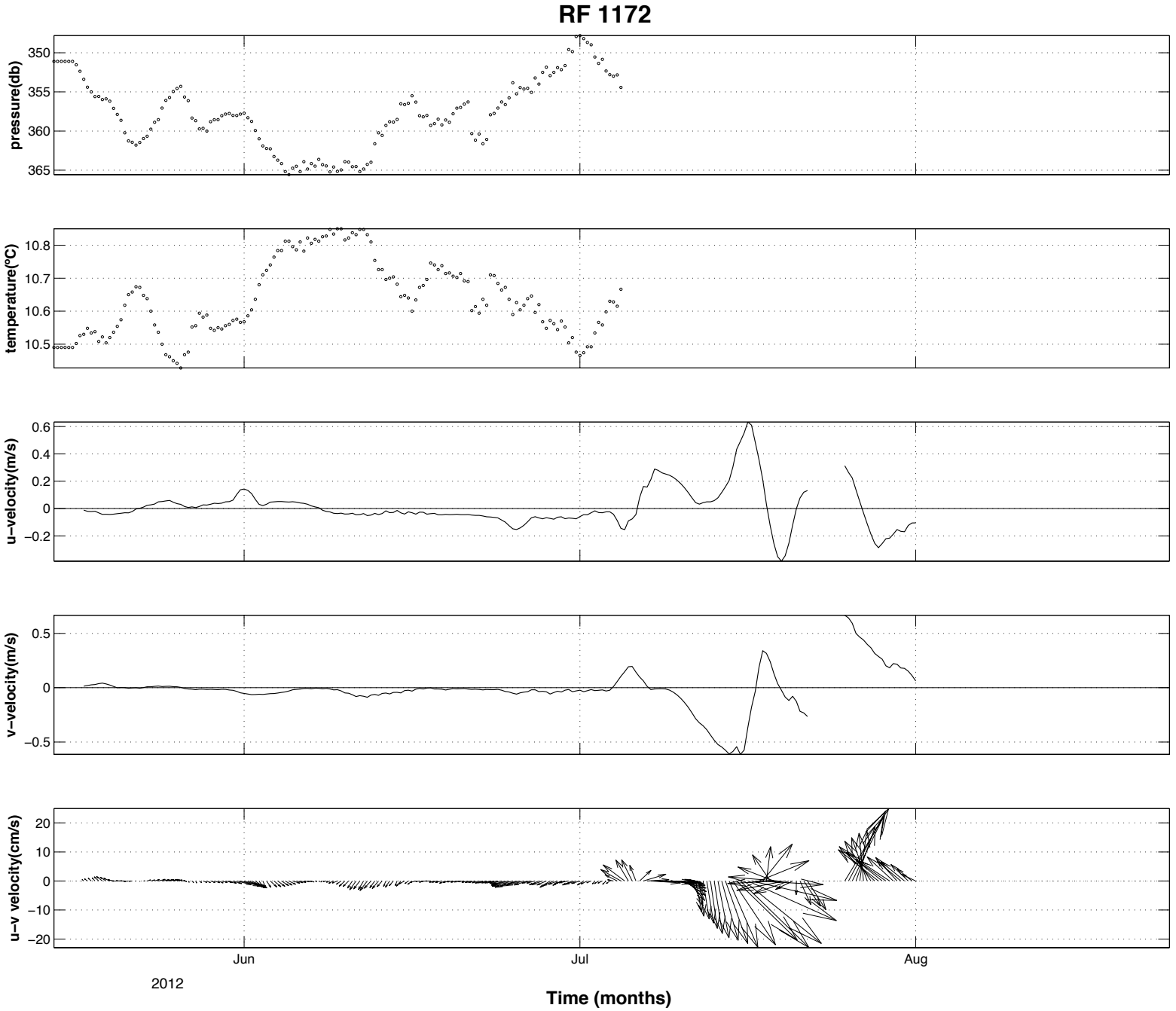
RF 1172 – 21% tracked, 10-day interpolation



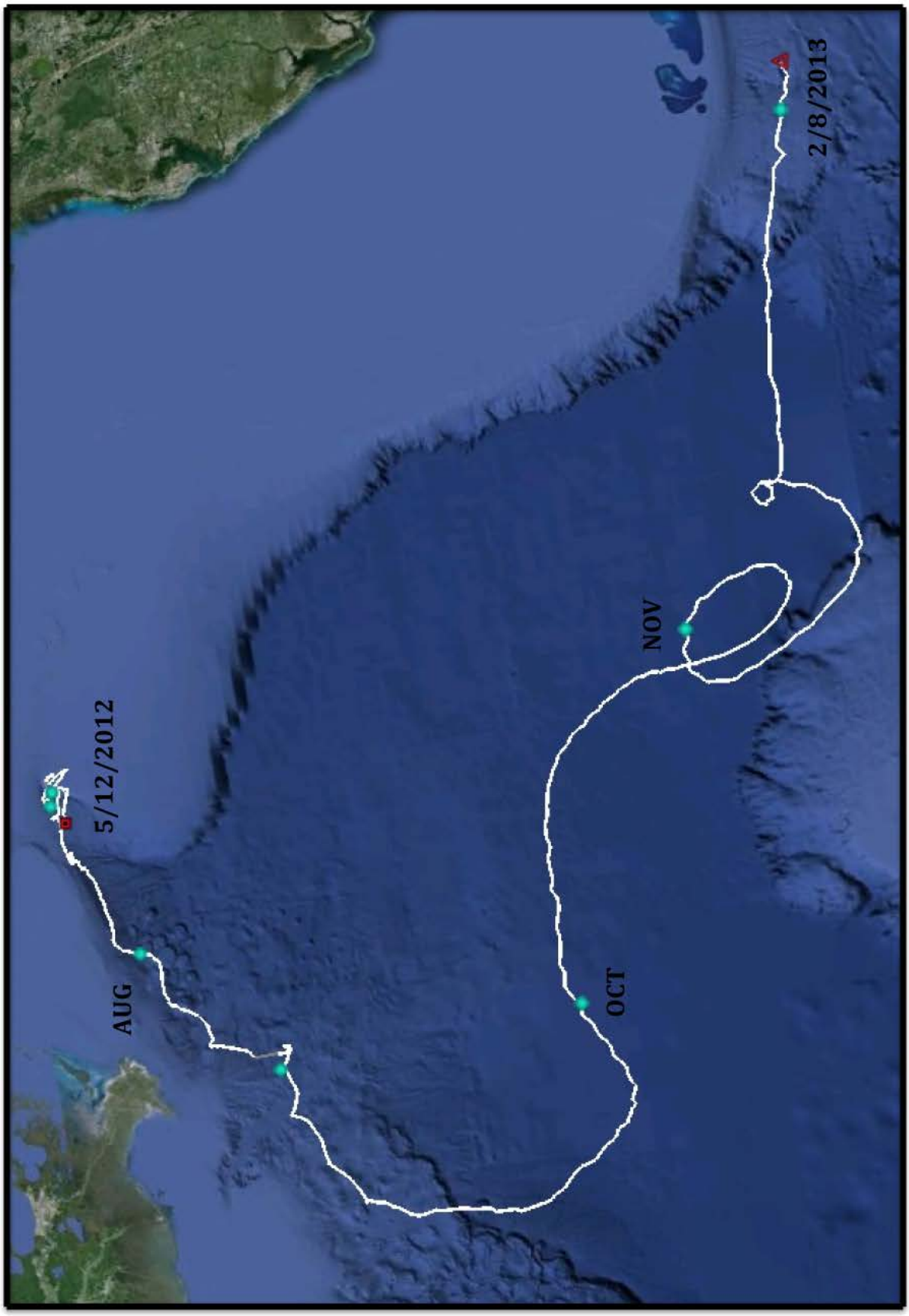
RF1172 – 3 month track

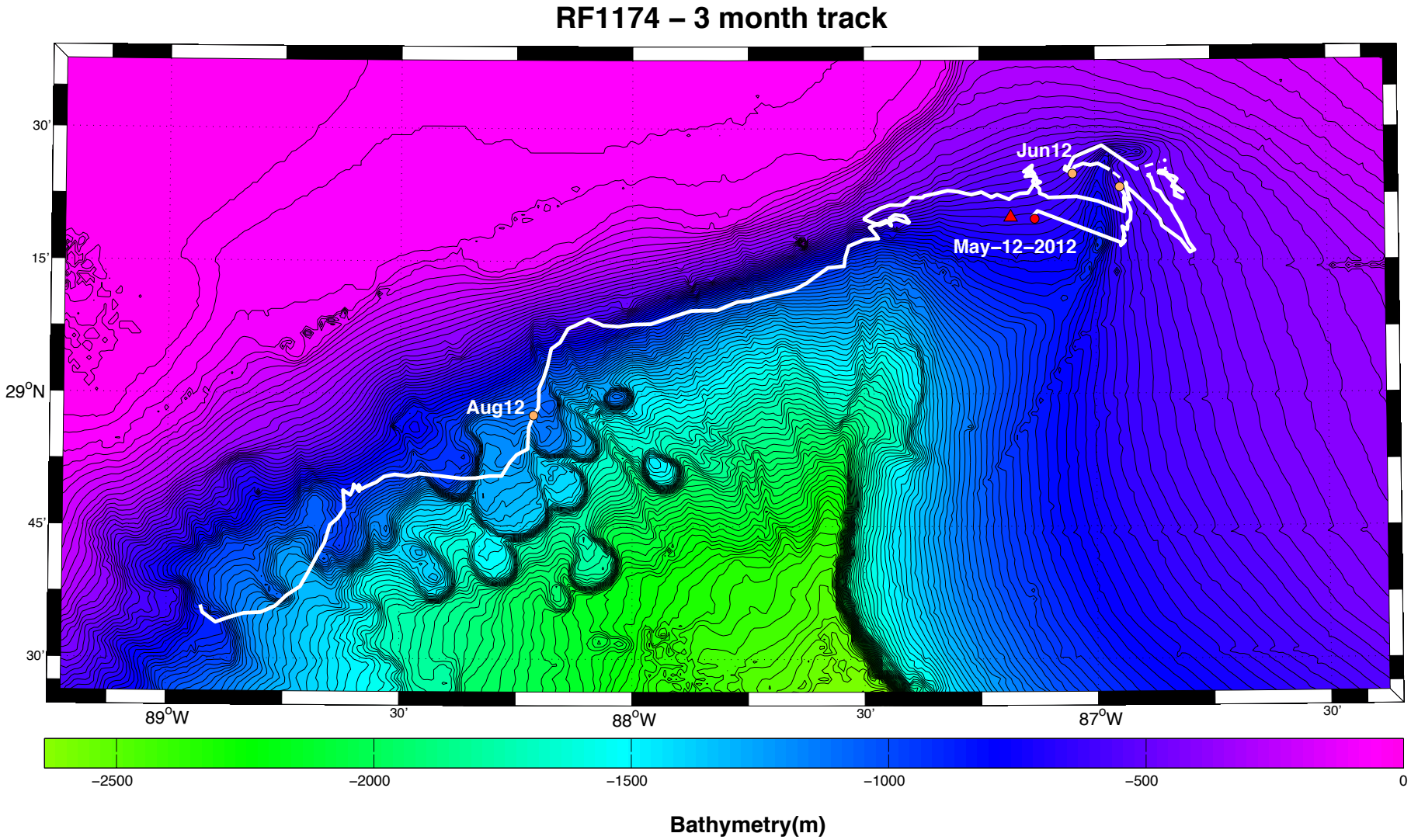


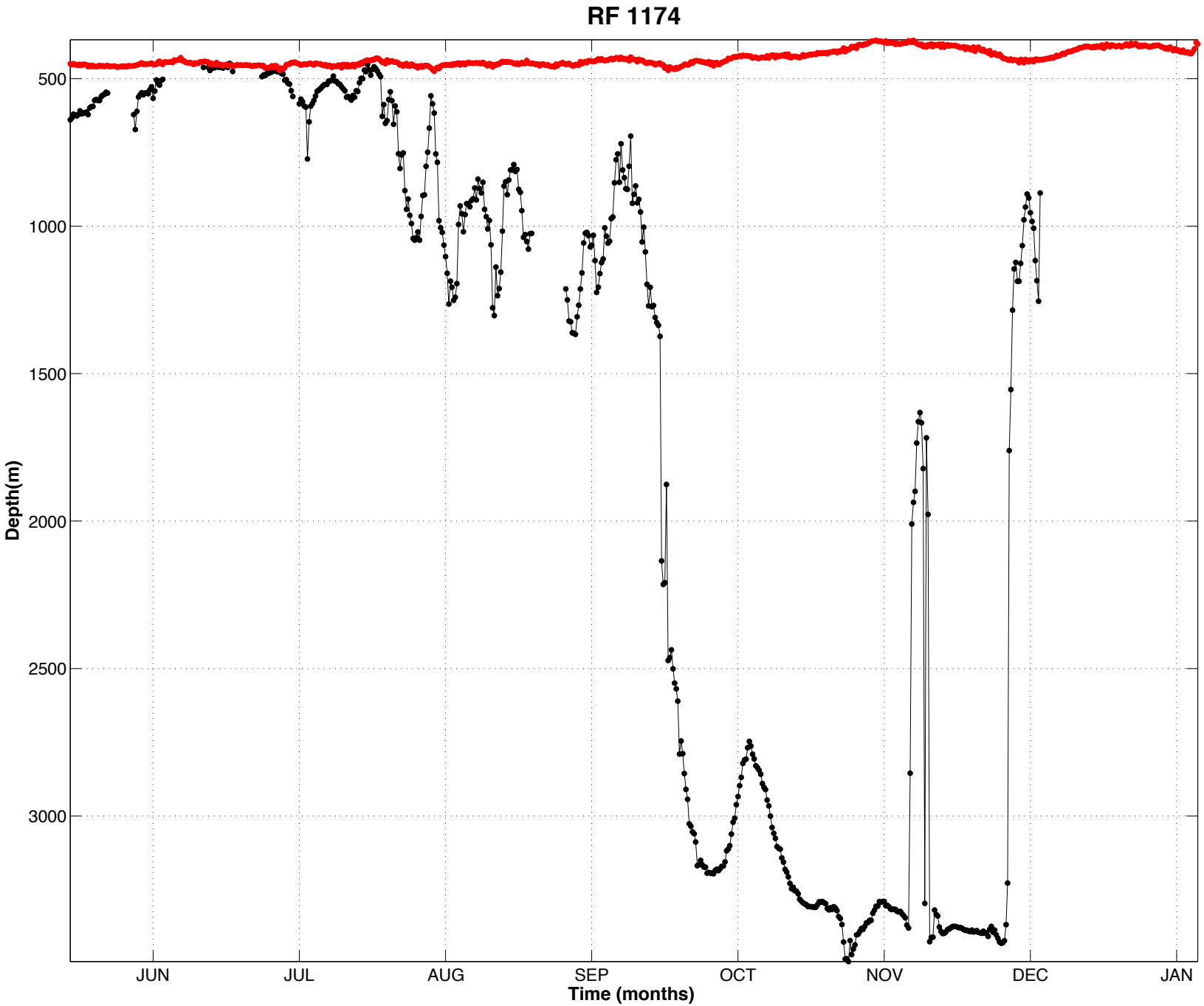

RF 1172
Depth(m)
500
1000
1500
2000
2500
3000
JUN
JUL
AUG
Time (months)

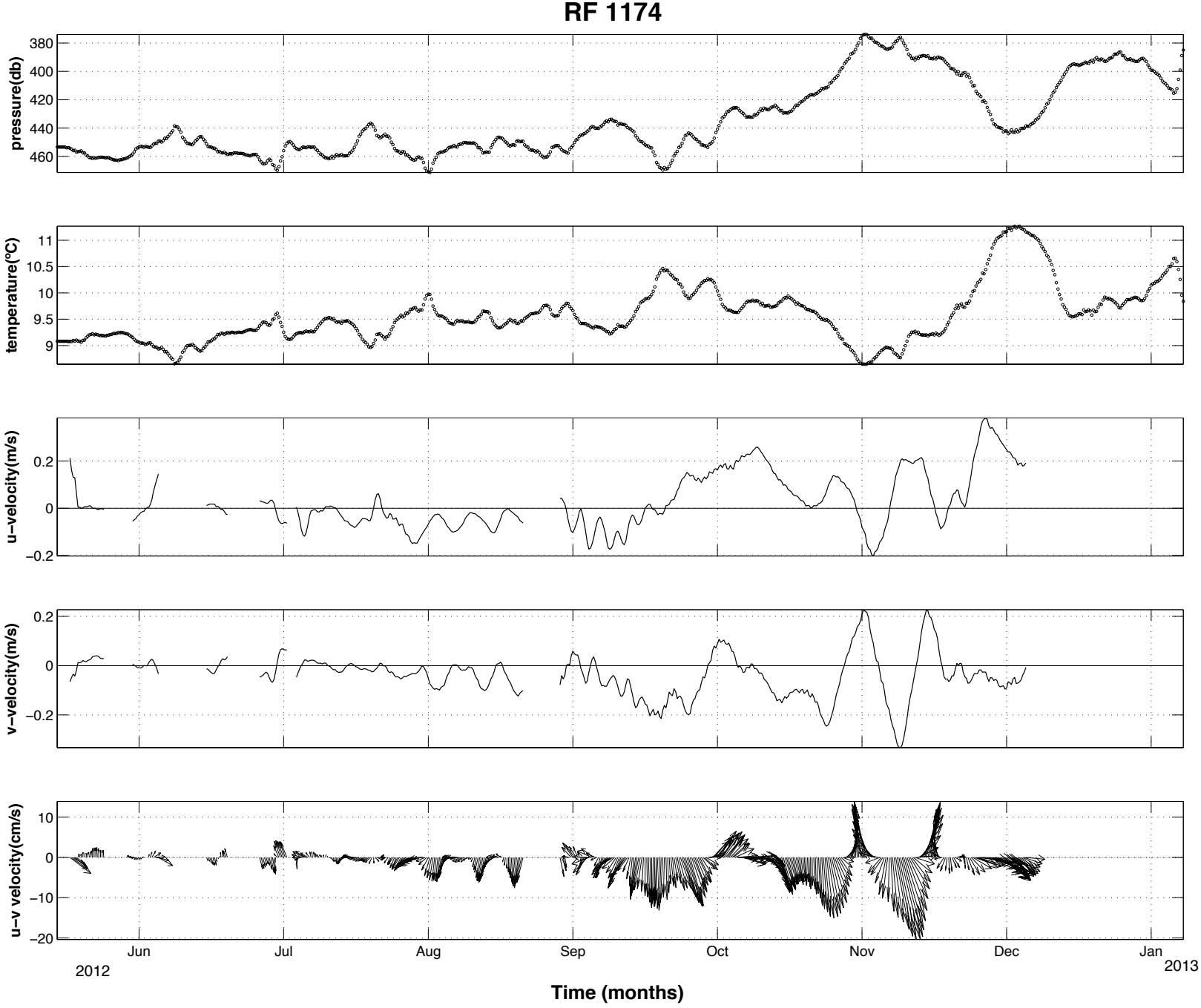

RF 1172
pressure(db)
350
355
360
365
temperature(°C)
10.8
10.7
10.6
10.5
u−velocity(m/s)
0.6
0.4
0.2
0
−0.2
v−velocity(m/s)
0.5
0
−0.5
u−v velocity(cm/s)
20
10
0
−10
−20
Jun
Jul
Aug
2012
Time (months)

RF 1174 – 48% tracked, 10-day interpolation

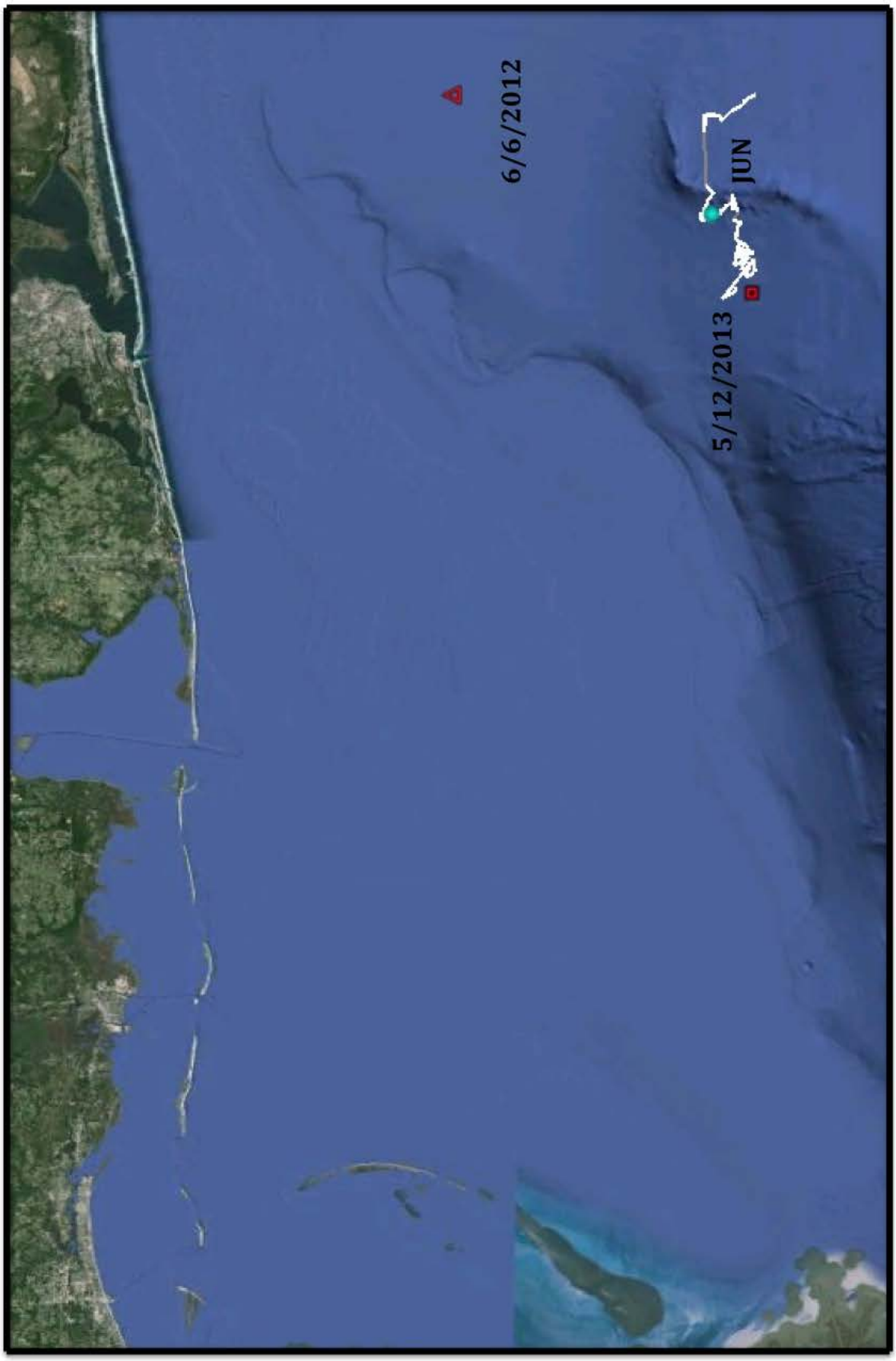



RF1174 – 3 month track
Jun12
May–12–2012
Aug12
30'
15'
29°N
45'
30'
89°W
30'
88°W
30'
87°W
30'
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

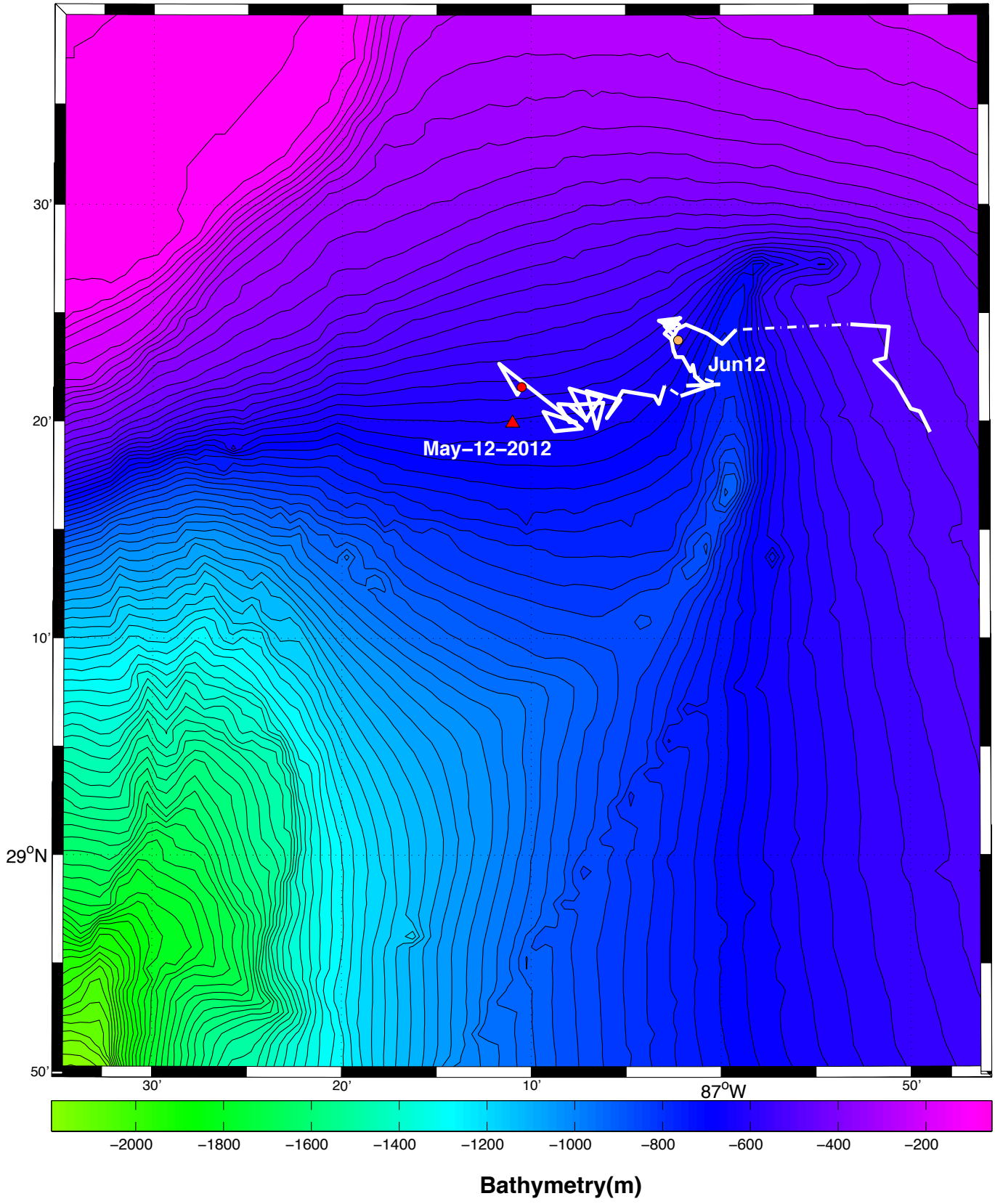

RF 1174
Depth(m)
500
1000
1500
2000
2500
3000
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
Time (months)

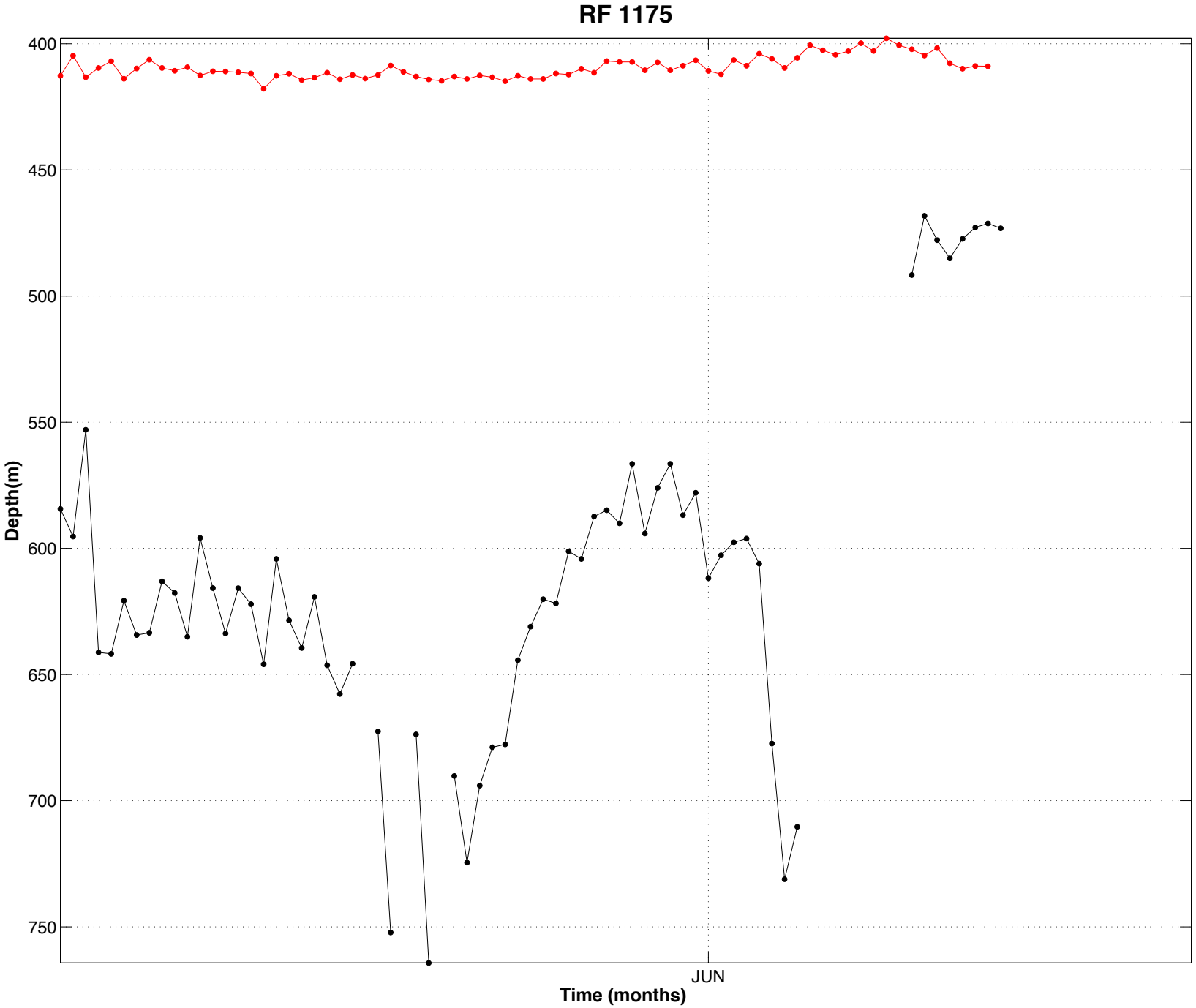

RF 1174
pressure(db)
380
400
420
440
460
temperature(°C)
11
10.5
10
9.5
9
u−velocity(m/s)
0.2
0
−0.2
v−velocity(m/s)
0.2
0
−0.2
u−v velocity(cm/s)
10
0
−10
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
2012
2013
Time (months)

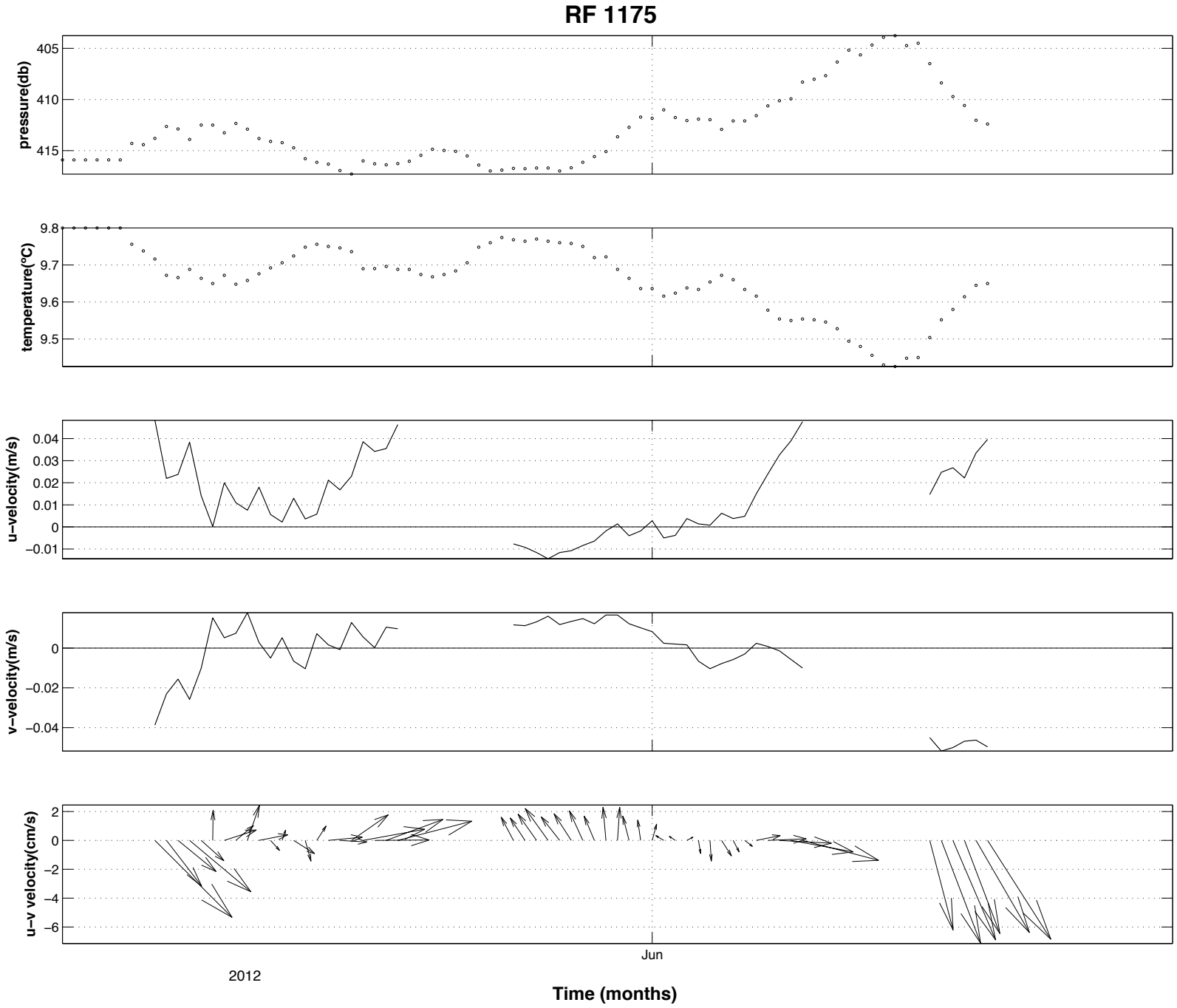
RF 1175 – 6% tracked, 10-day interpolation



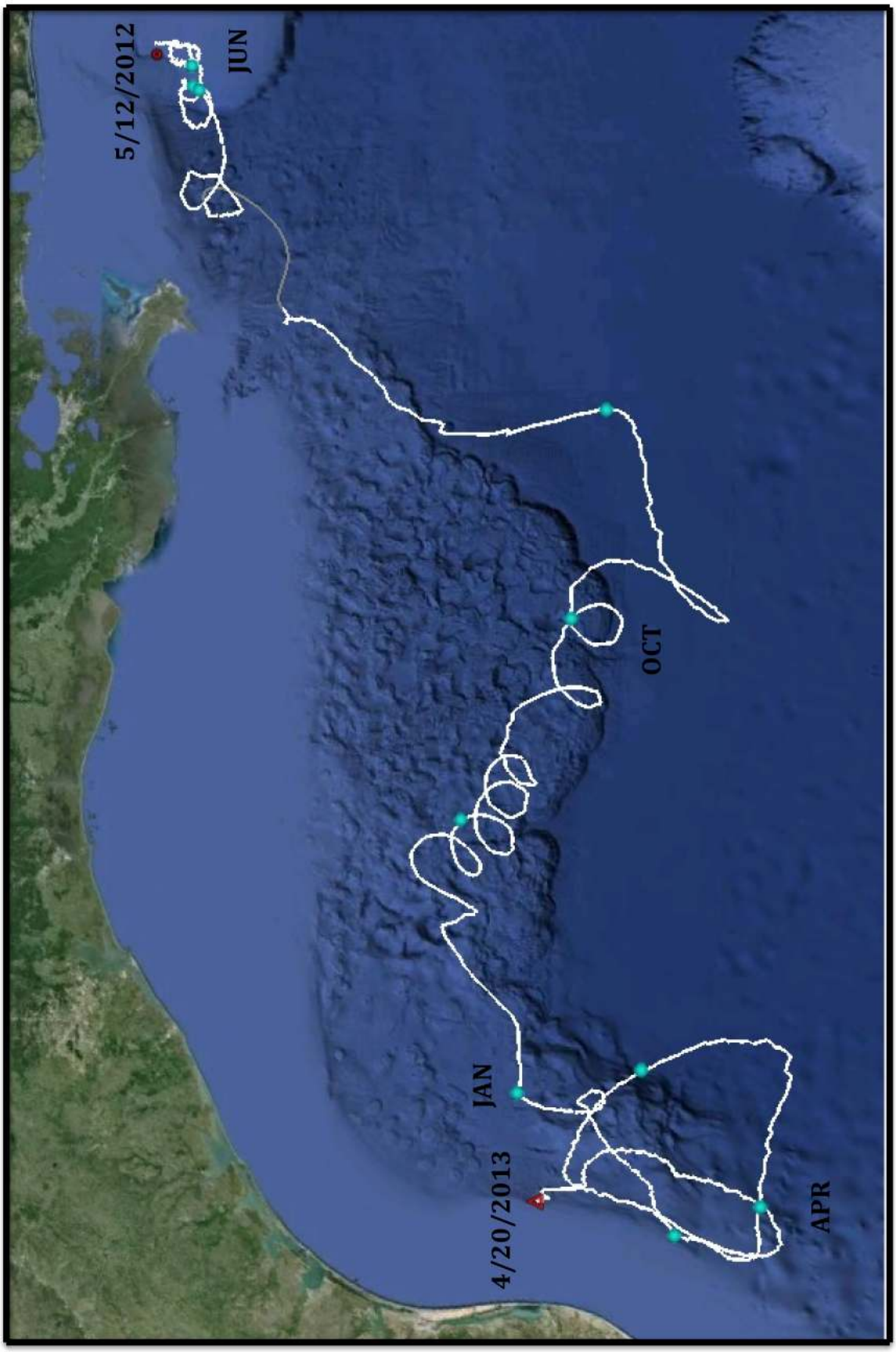
RF1175 – 3 month track



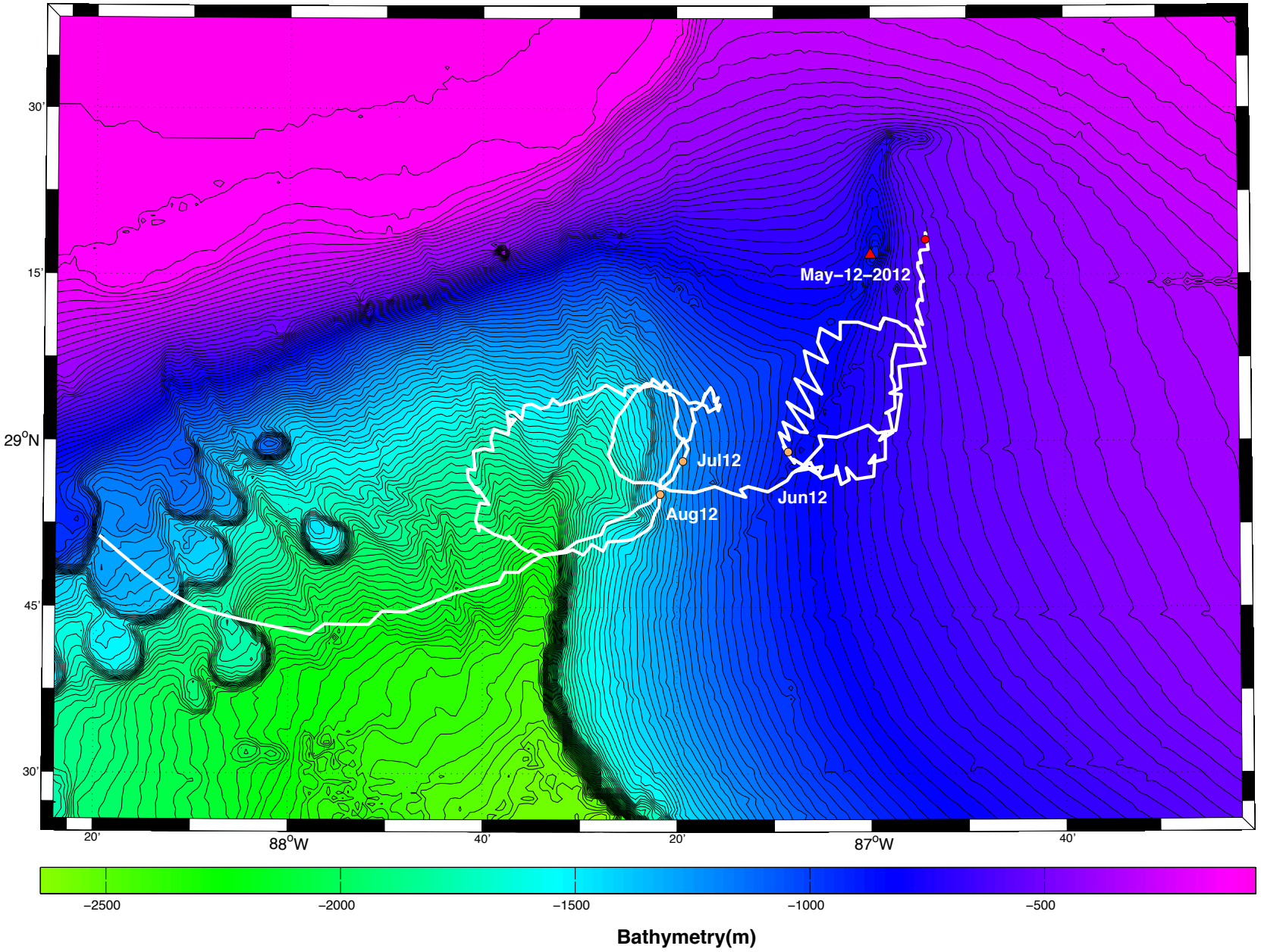

RF 1175
400
450
500
550
600
650
700
750
Depth(m)
JUN
Time (months)

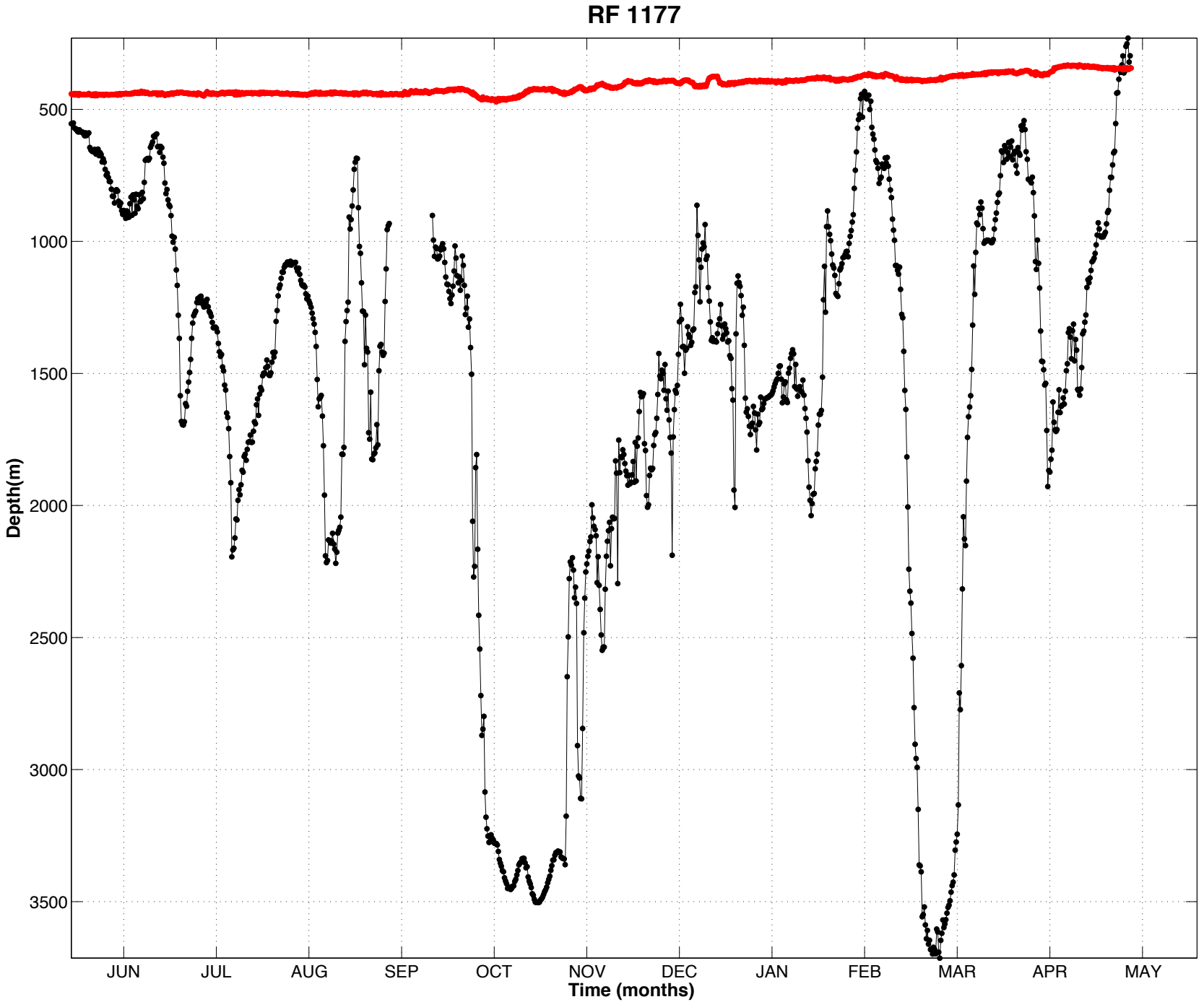

RF 1175
pressure(db)
405
410
415
temperature(°C)
9.8
9.7
9.6
9.5
u−velocity(m/s)
0.04
0.03
0.02
0.01
0
−0.01
v−velocity(m/s)
0
−0.02
−0.04
u−v velocity(cm/s)
2
0
−2
−4
−6
Jun
2012
Time (months)

RF 1177 – 91% tracked, 10-day interpolation

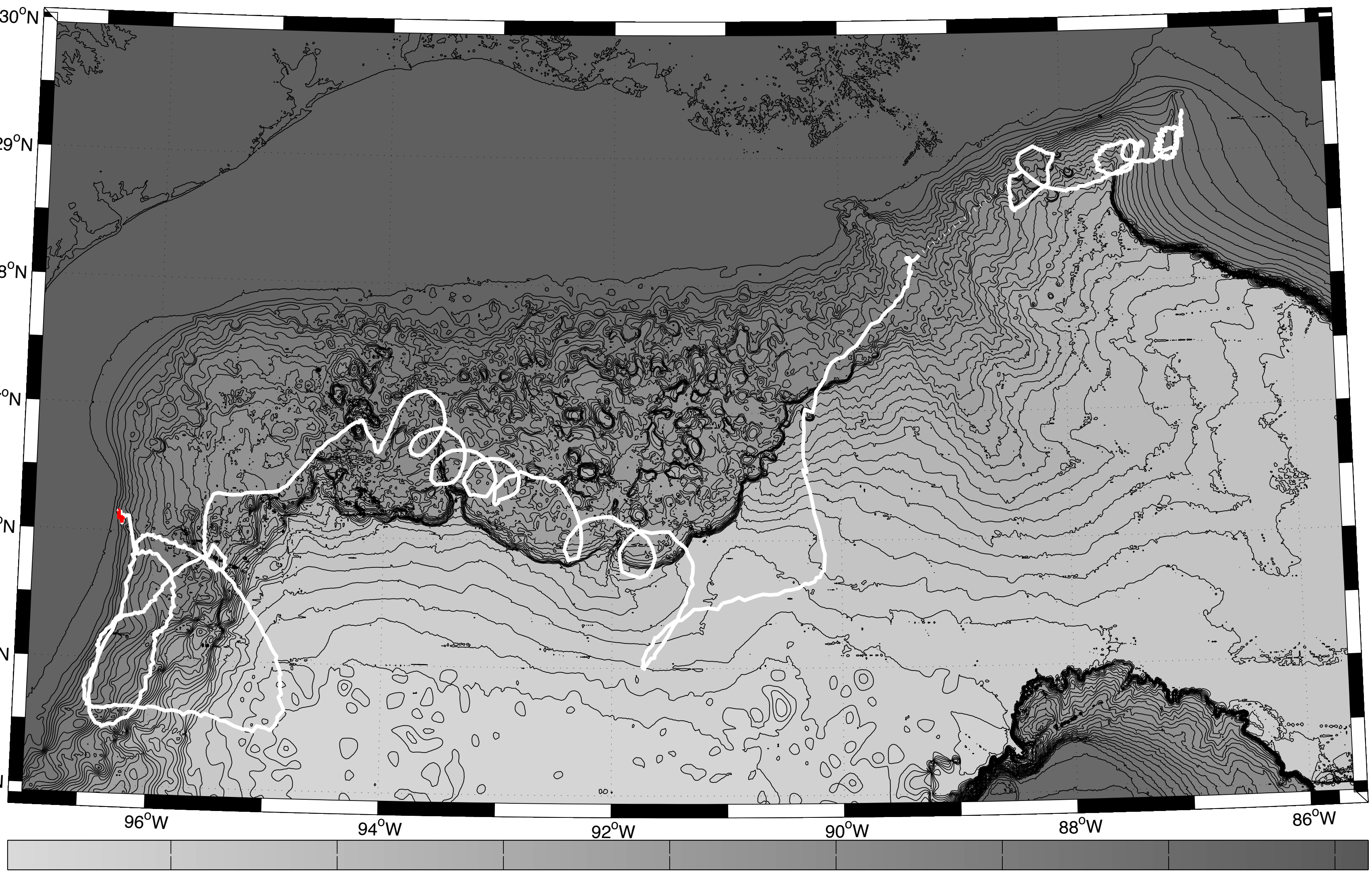


RF1177 – 3 month track

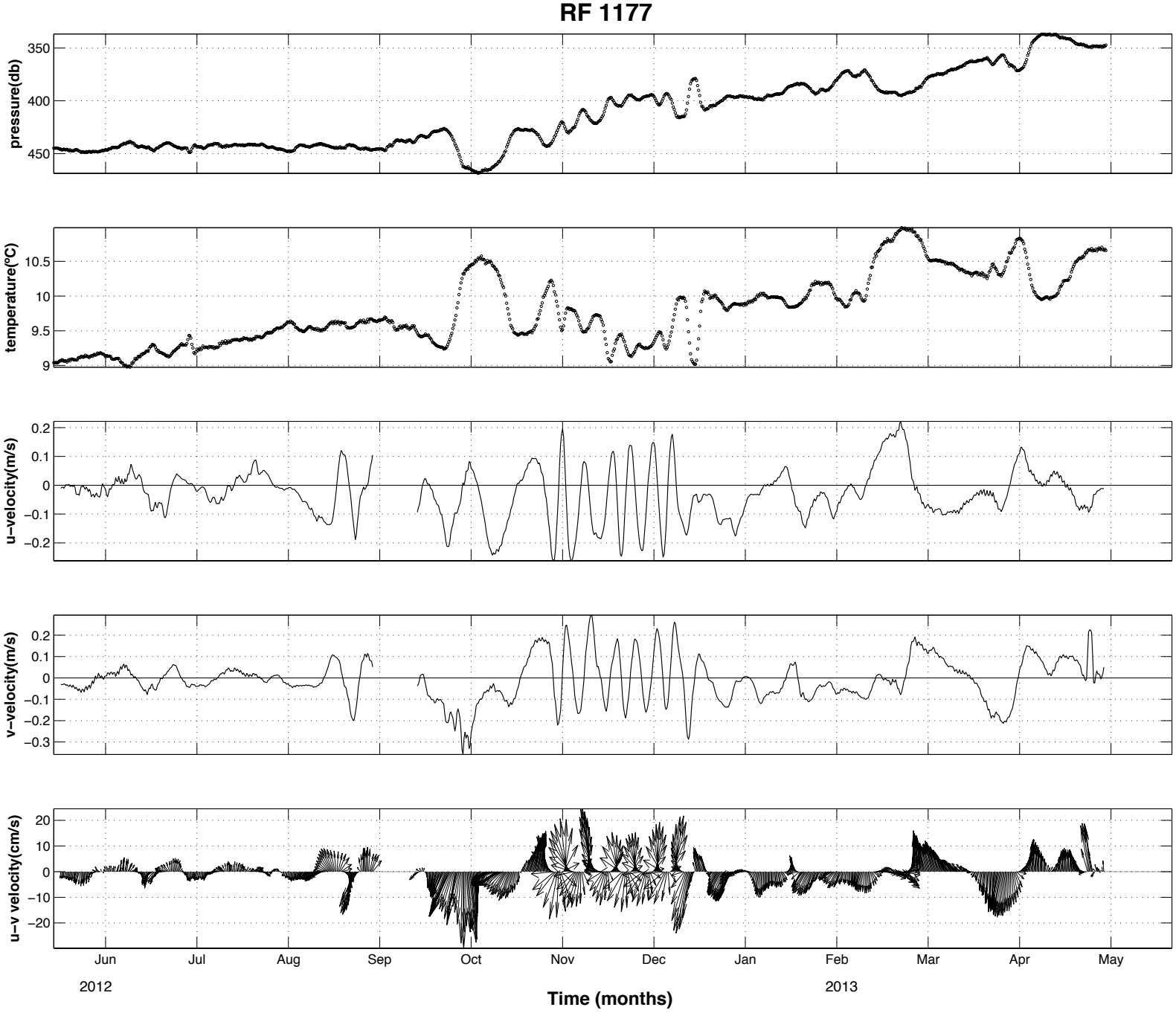



RF 1177
Depth(m)
500
1000
1500
2000
2500
3000
3500
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)

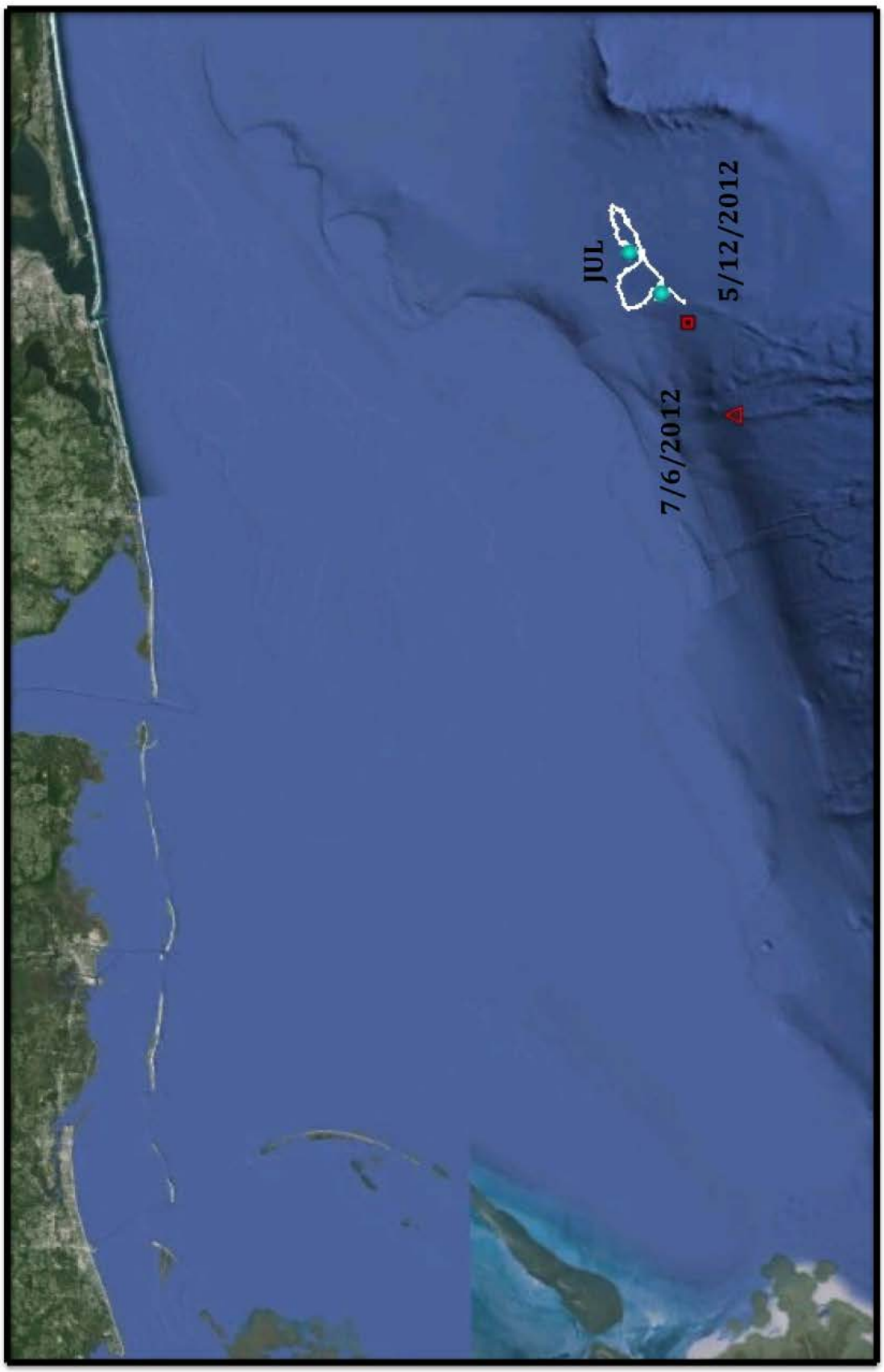
RF 1177



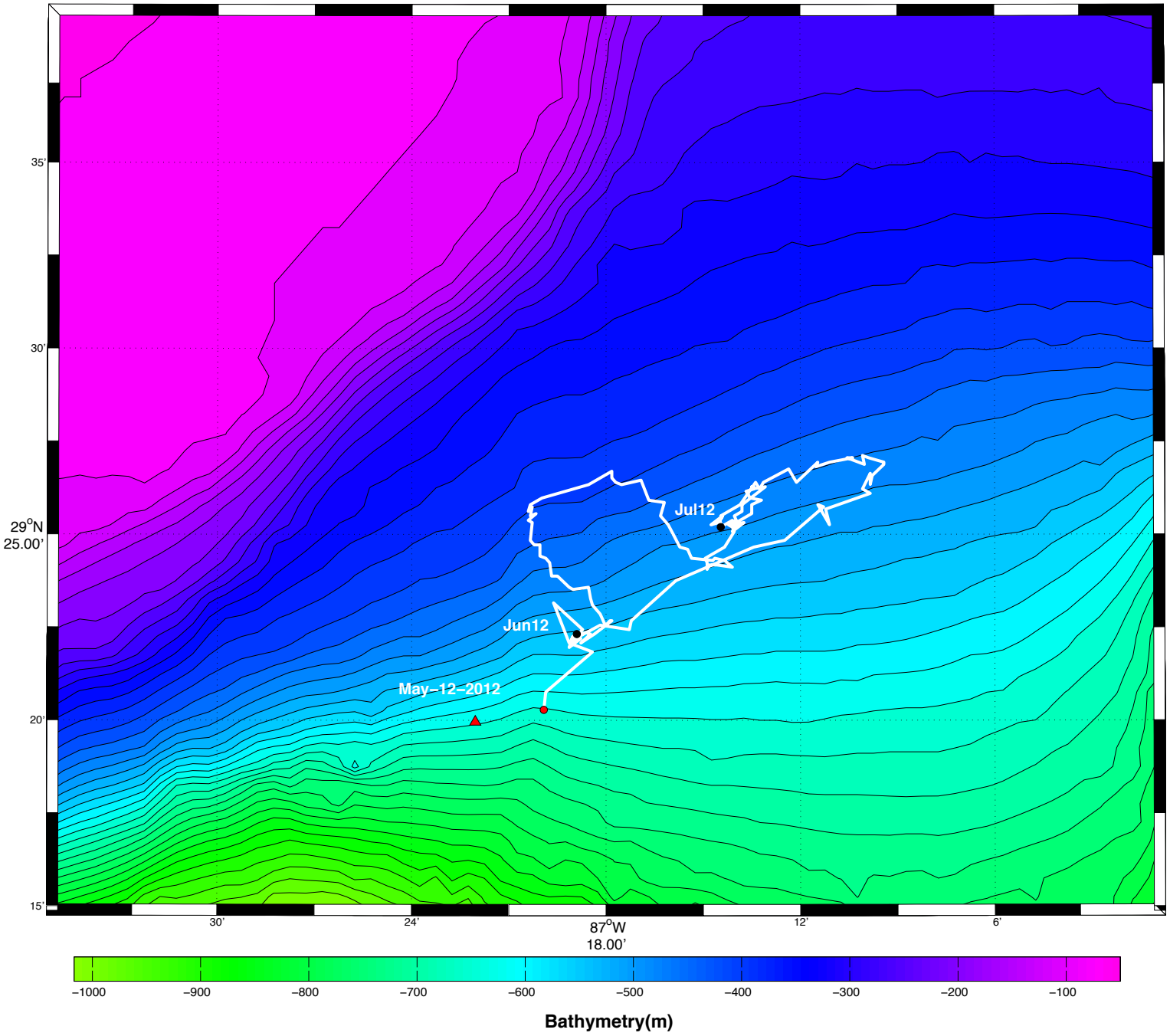
Bathymetry(m)

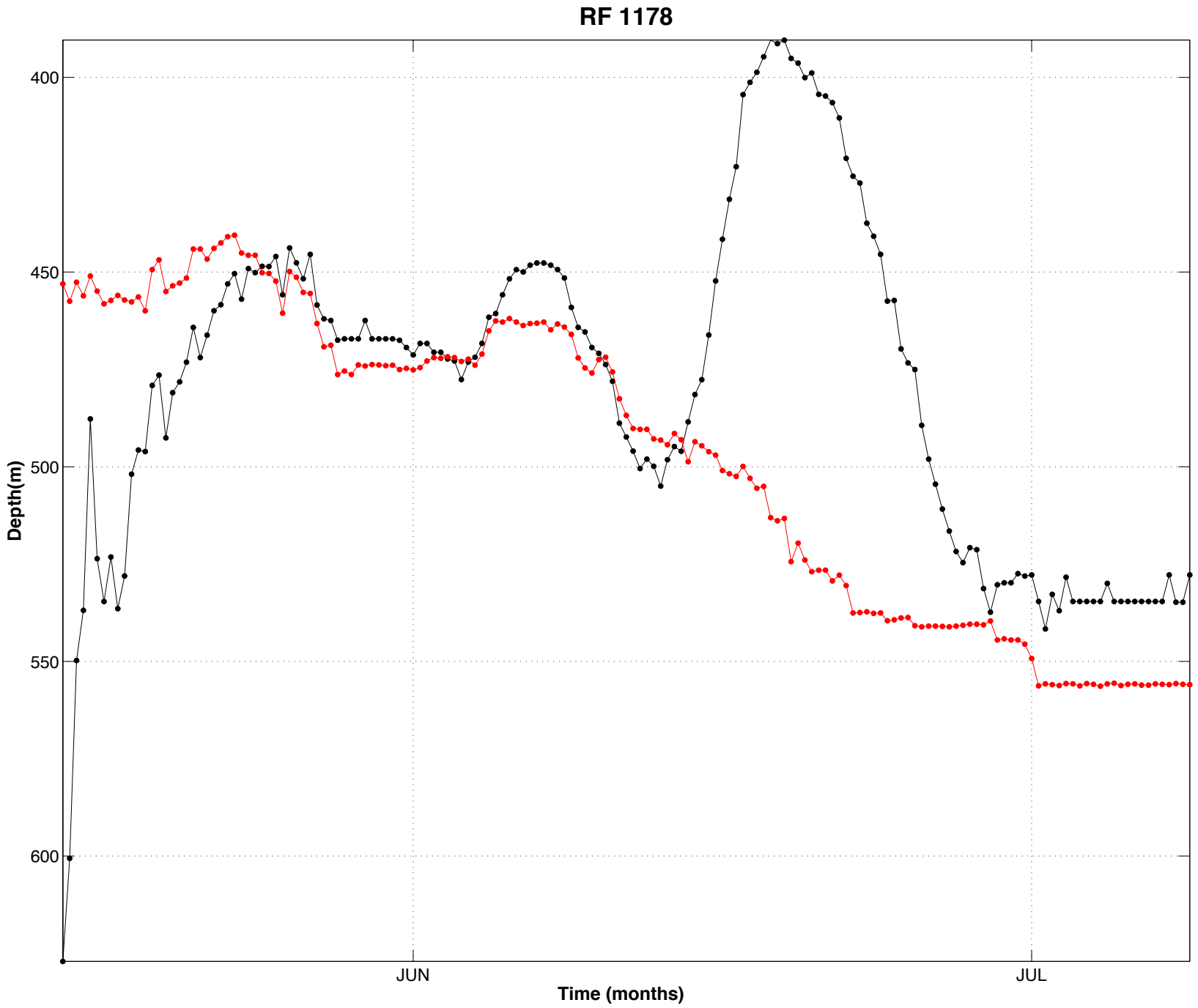

RF 1177
pressure(db)
350
400
450
temperature(°C)
10.5
10
9.5
9
u−velocity(m/s)
0.2
0.1
0
−0.1
−0.2
v−velocity(m/s)
0.2
0.1
0
−0.1
−0.2
−0.3
u−v velocity(cm/s)
20
10
0
−10
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2012
2013
Time (months)

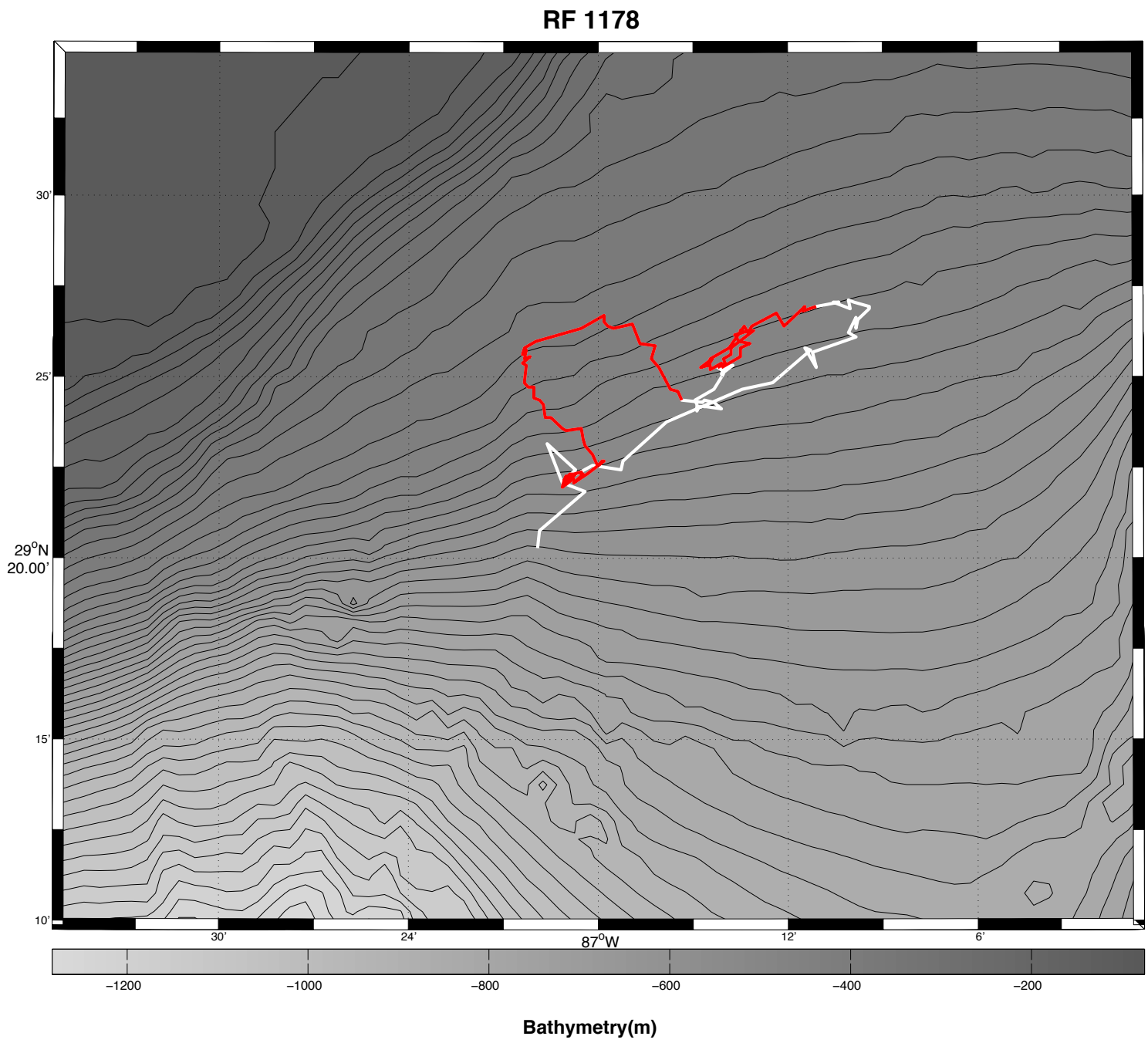
RF 1178 – 16% tracked, 10-day interpolation

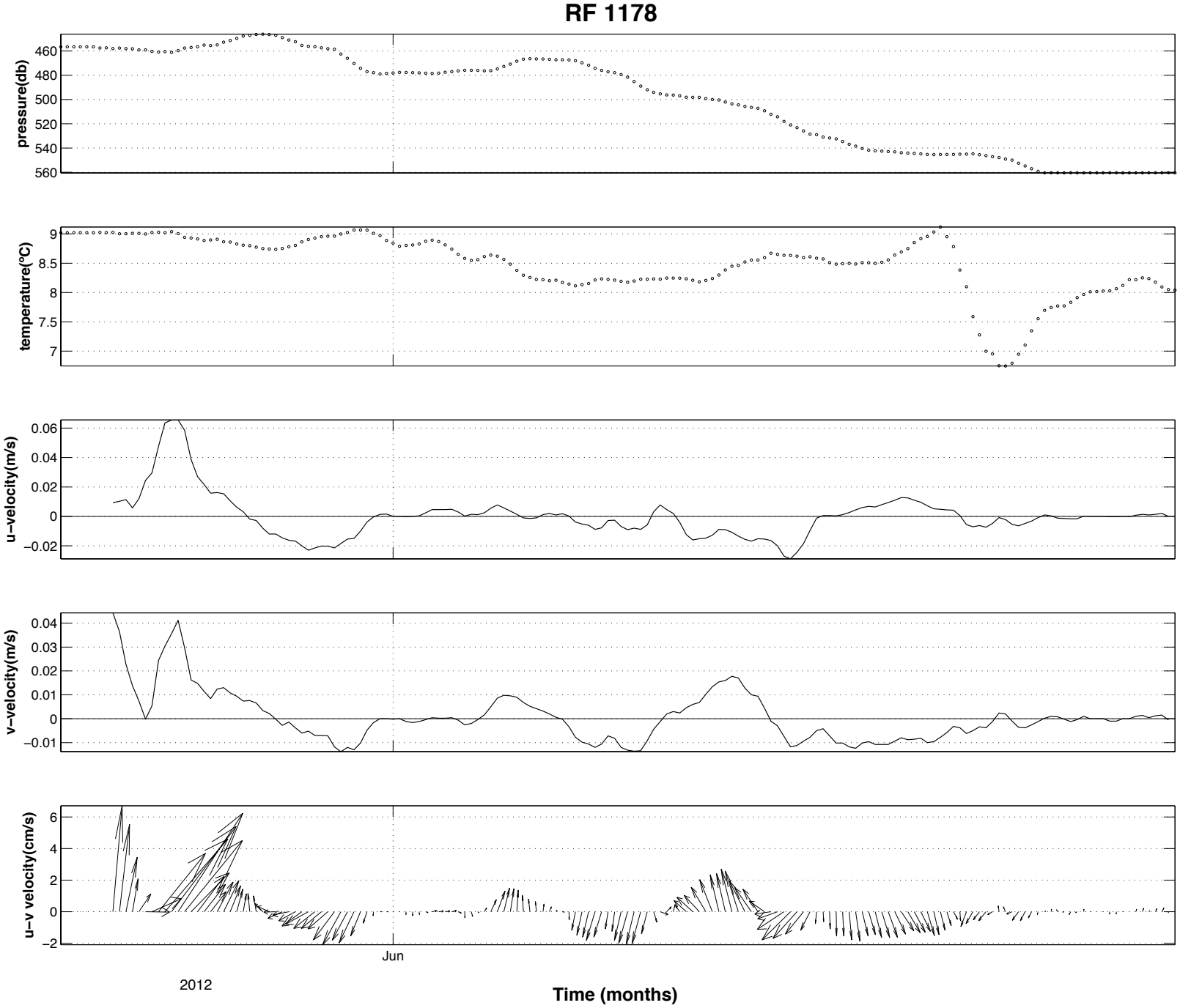


RF1178 – 3 month track

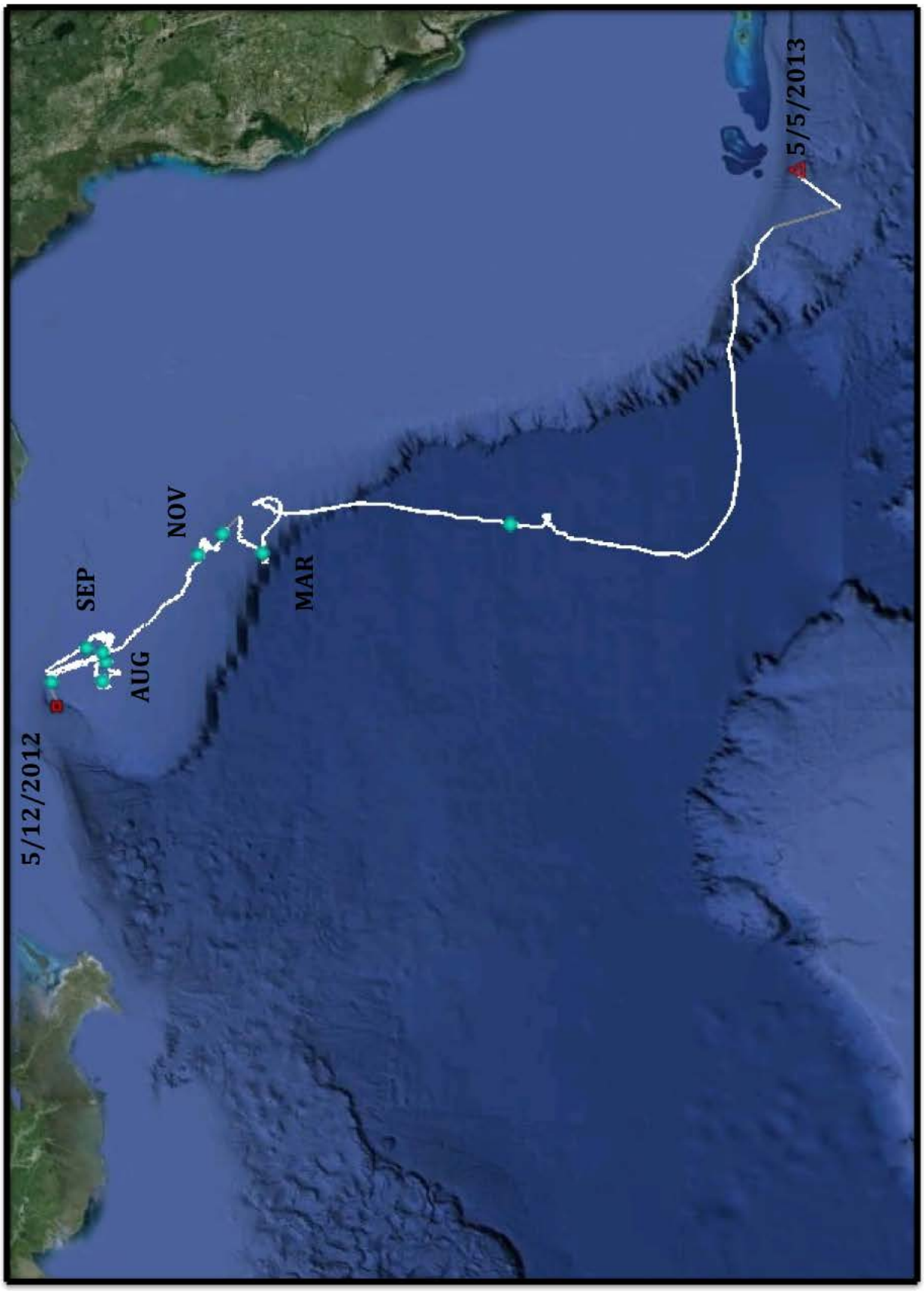



RF 1178
400
450
500
550
600
Depth(m)
JUN
JUL
Time (months)

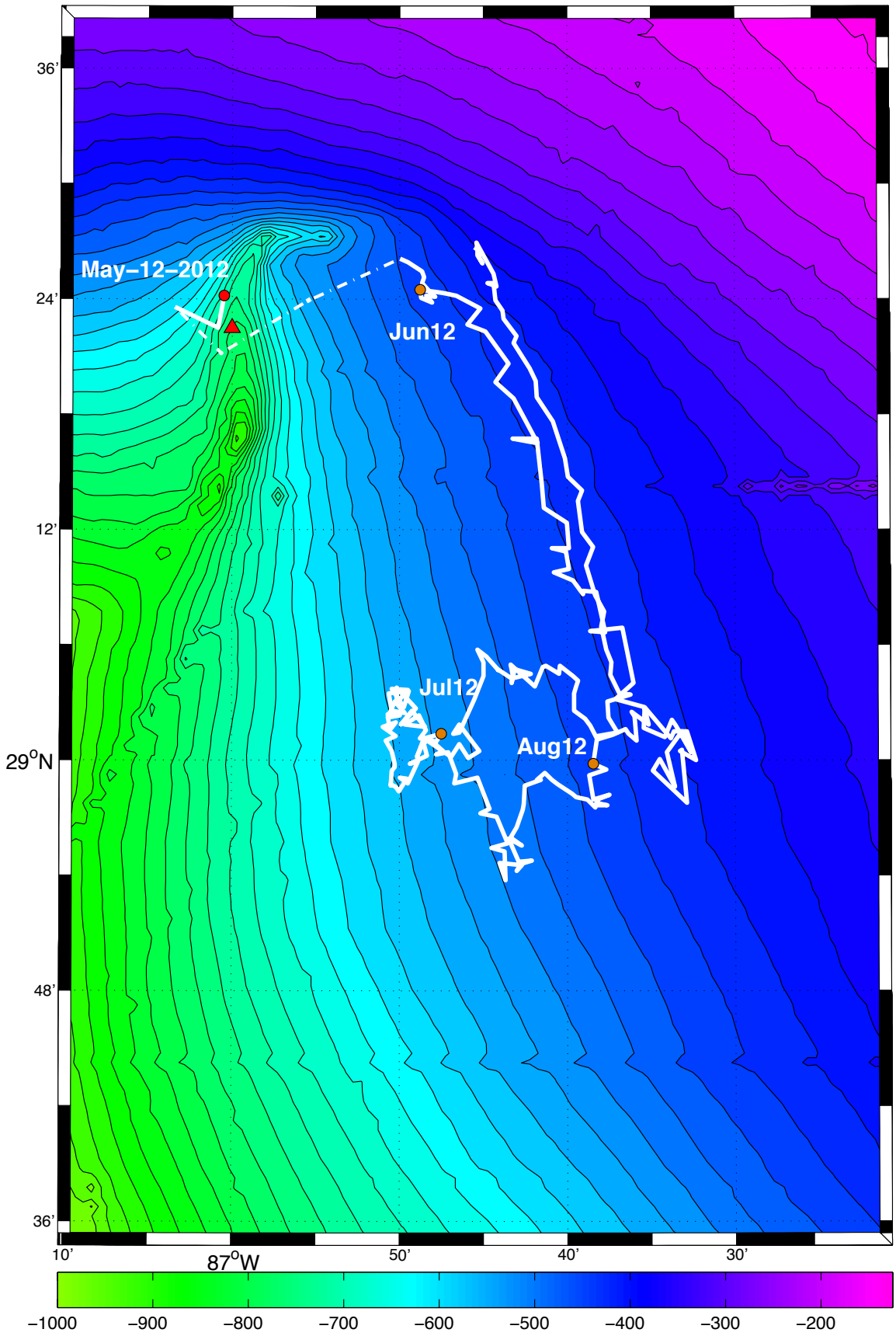

RF 1178
30'
25'
29°N
20.00'
15'
10'
30'
24'
87°W
12'
6'
−1200
−1000
−800
−600
−400
−200
Bathymetry(m)

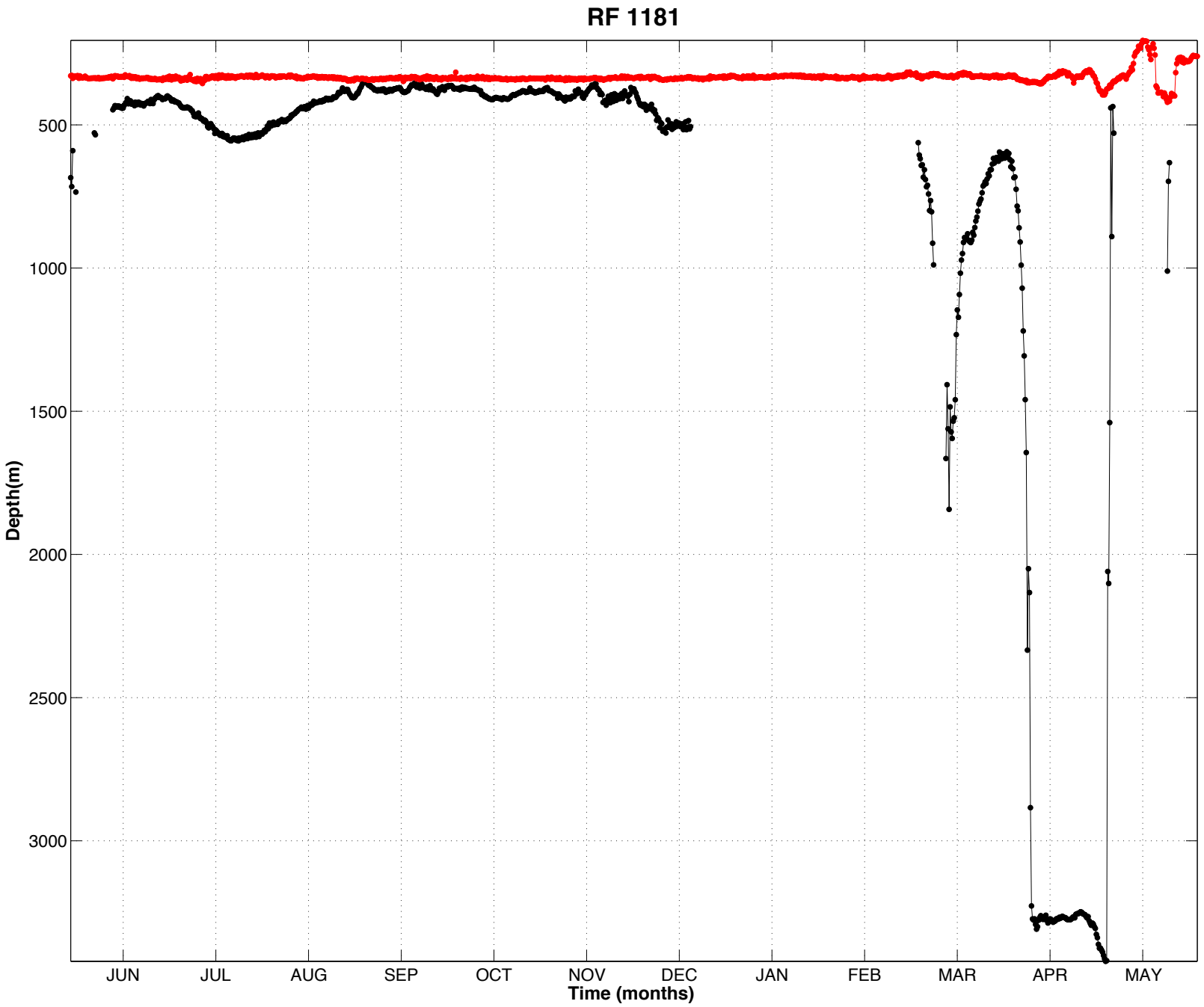

RF 1178
pressure(db)
460
480
500
520
540
560
temperature(°C)
9
8.5
8
7.5
7
u−velocity(m/s)
0.06
0.04
0.02
0
−0.02
v−velocity(m/s)
0.04
0.03
0.02
0.01
0
−0.01
u−v velocity(cm/s)
6
4
2
0
−2
Jun
2012
Time (months)

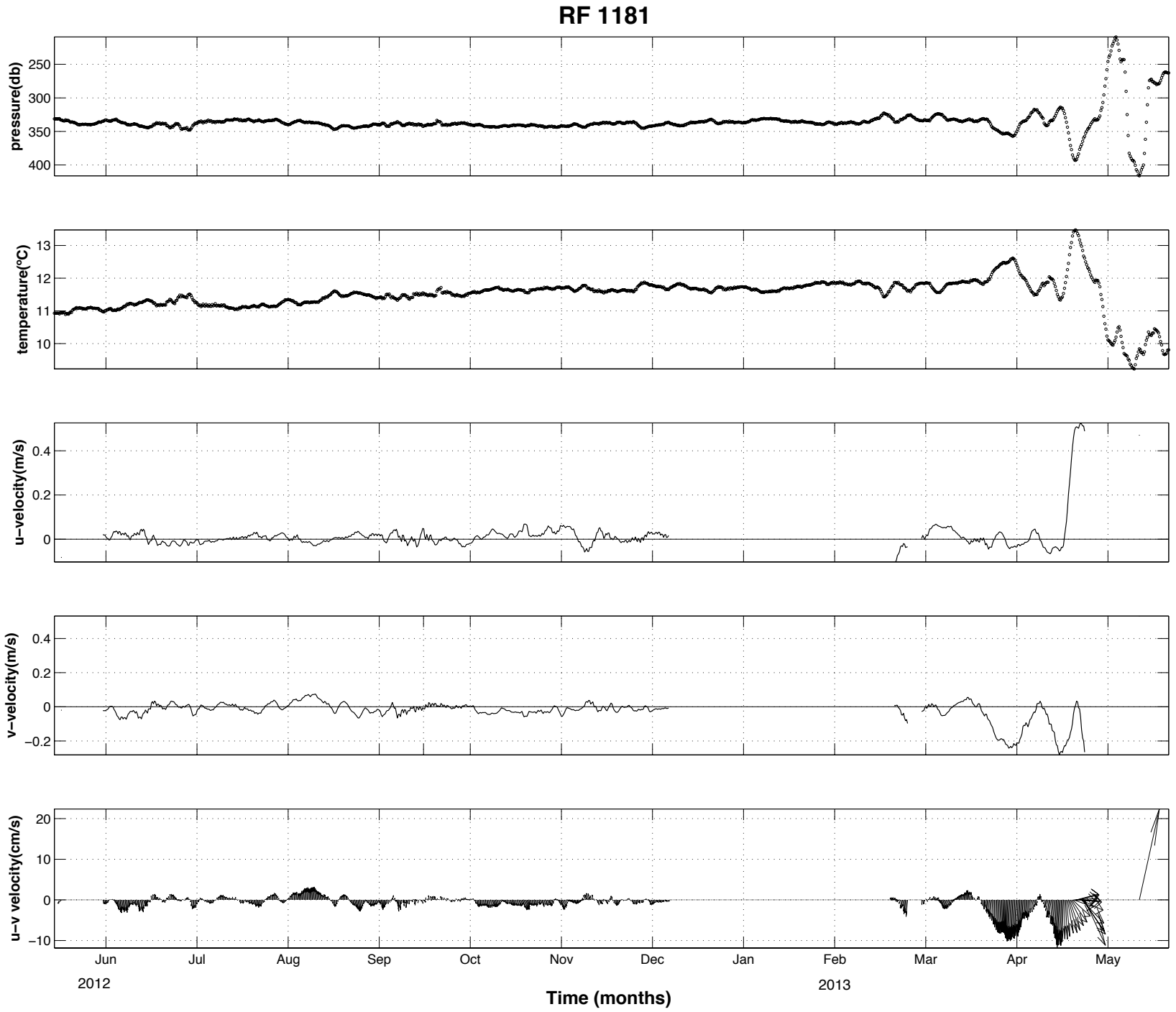
RF 1181 – 69% tracked, 10-day interpolation



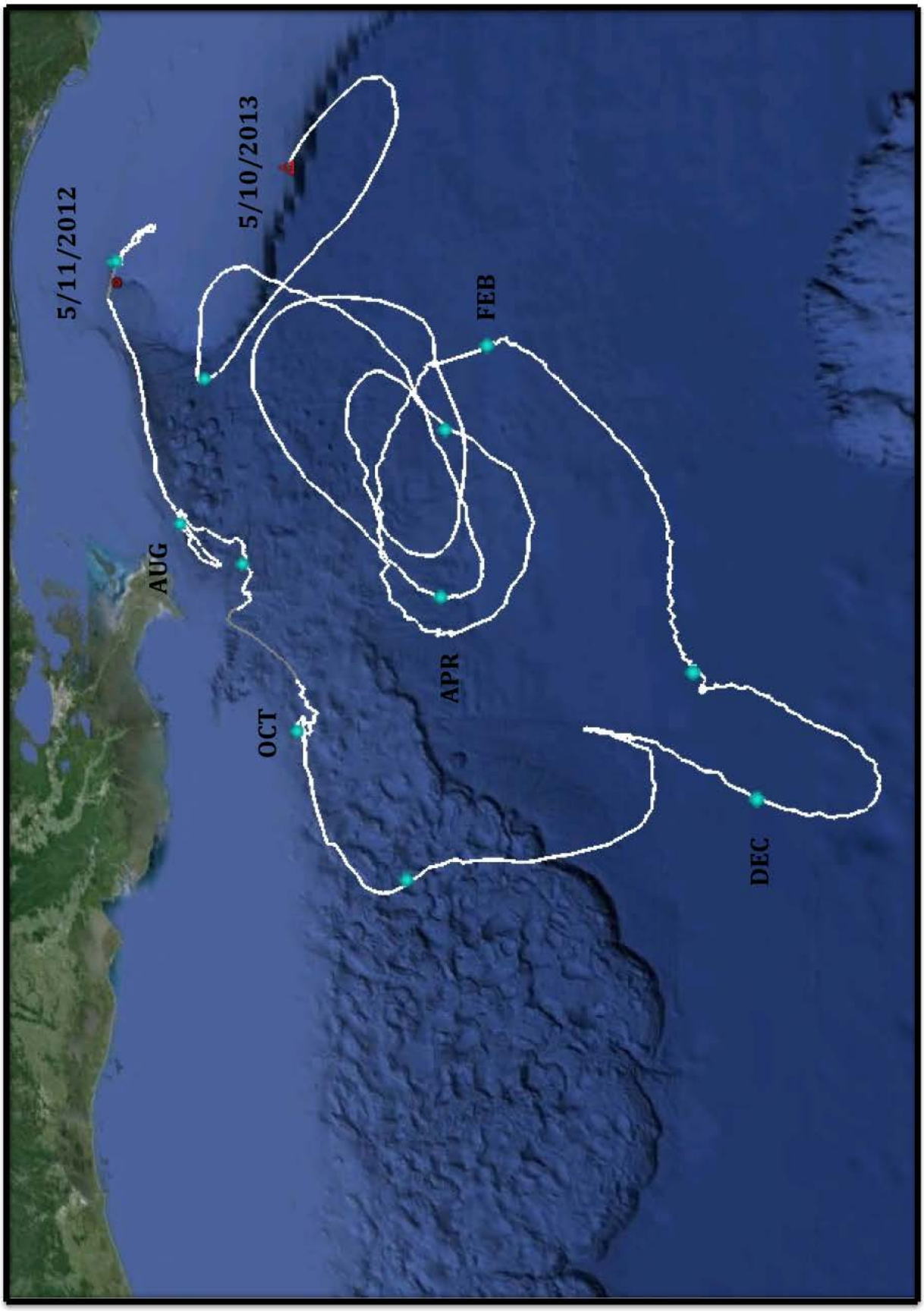
RF1181 – 3 month track

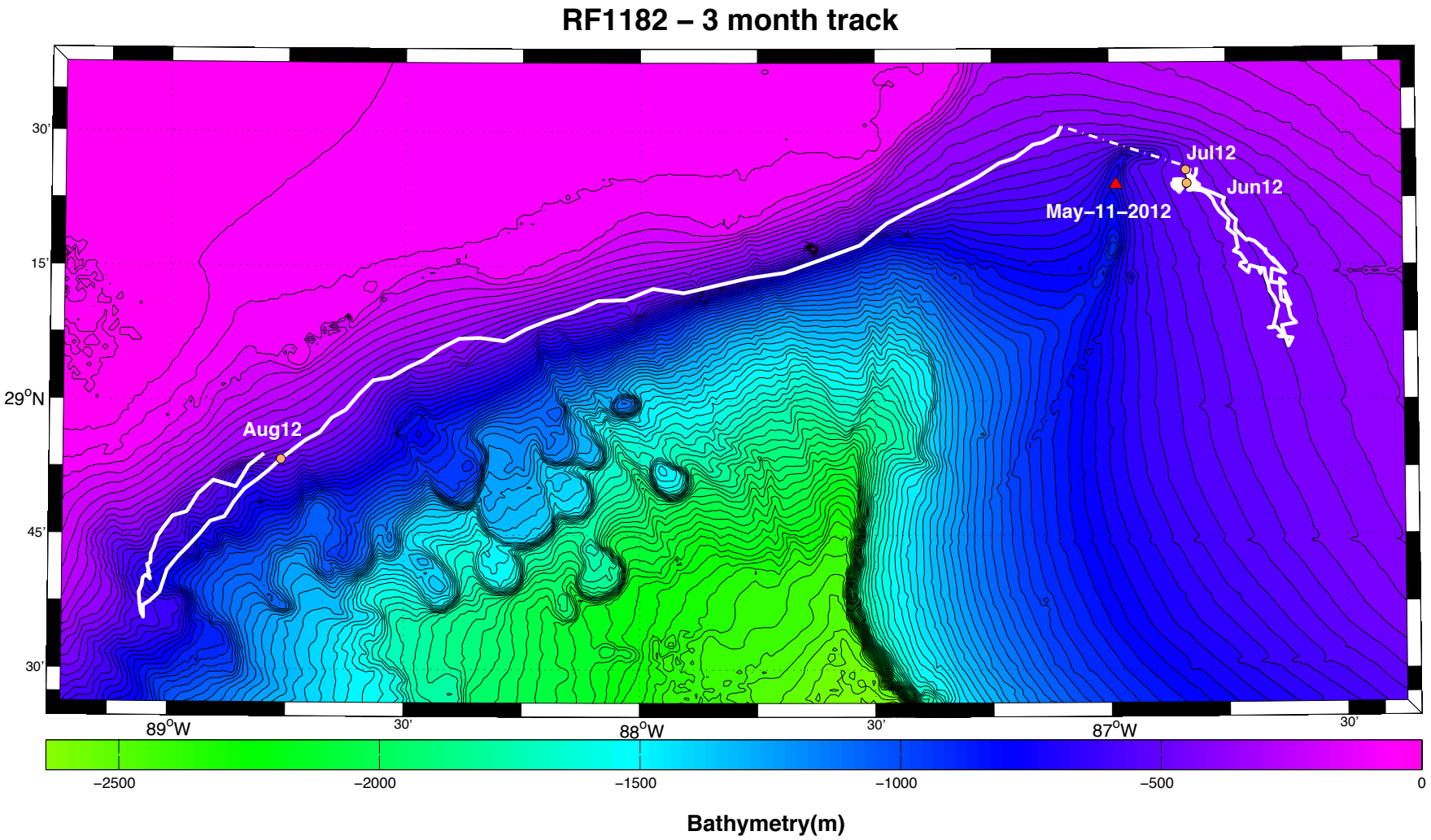


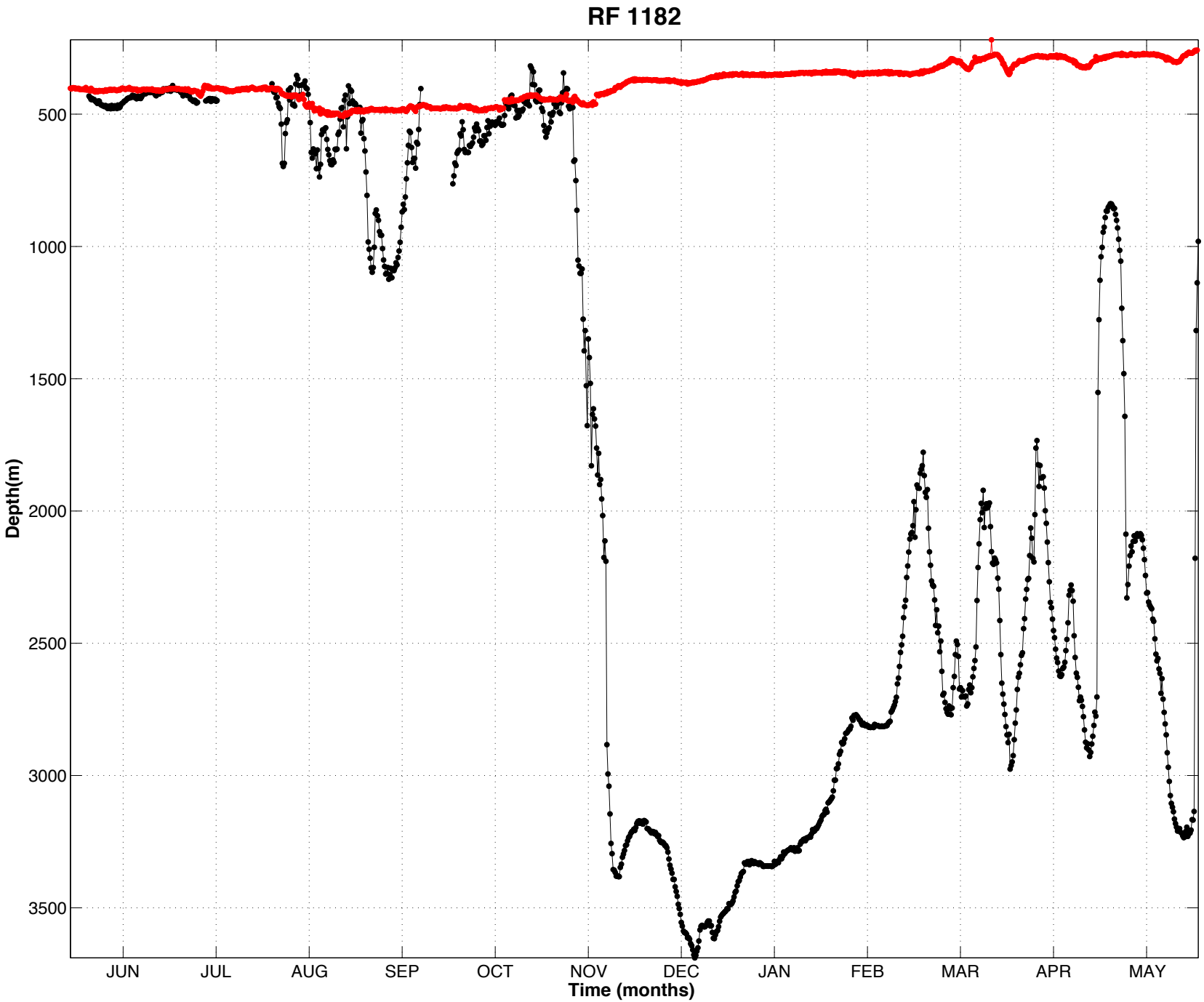

RF 1181
Depth(m)
500
1000
1500
2000
2500
3000
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)


RF 1181
pressure(db)
250
300
350
400
temperature(°C)
13
12
11
10
u−velocity(m/s)
0.4
0.2
0
v−velocity(m/s)
0.4
0.2
0
−0.2
u−v velocity(cm/s)
20
10
0
−10
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2012
2013
Time (months)

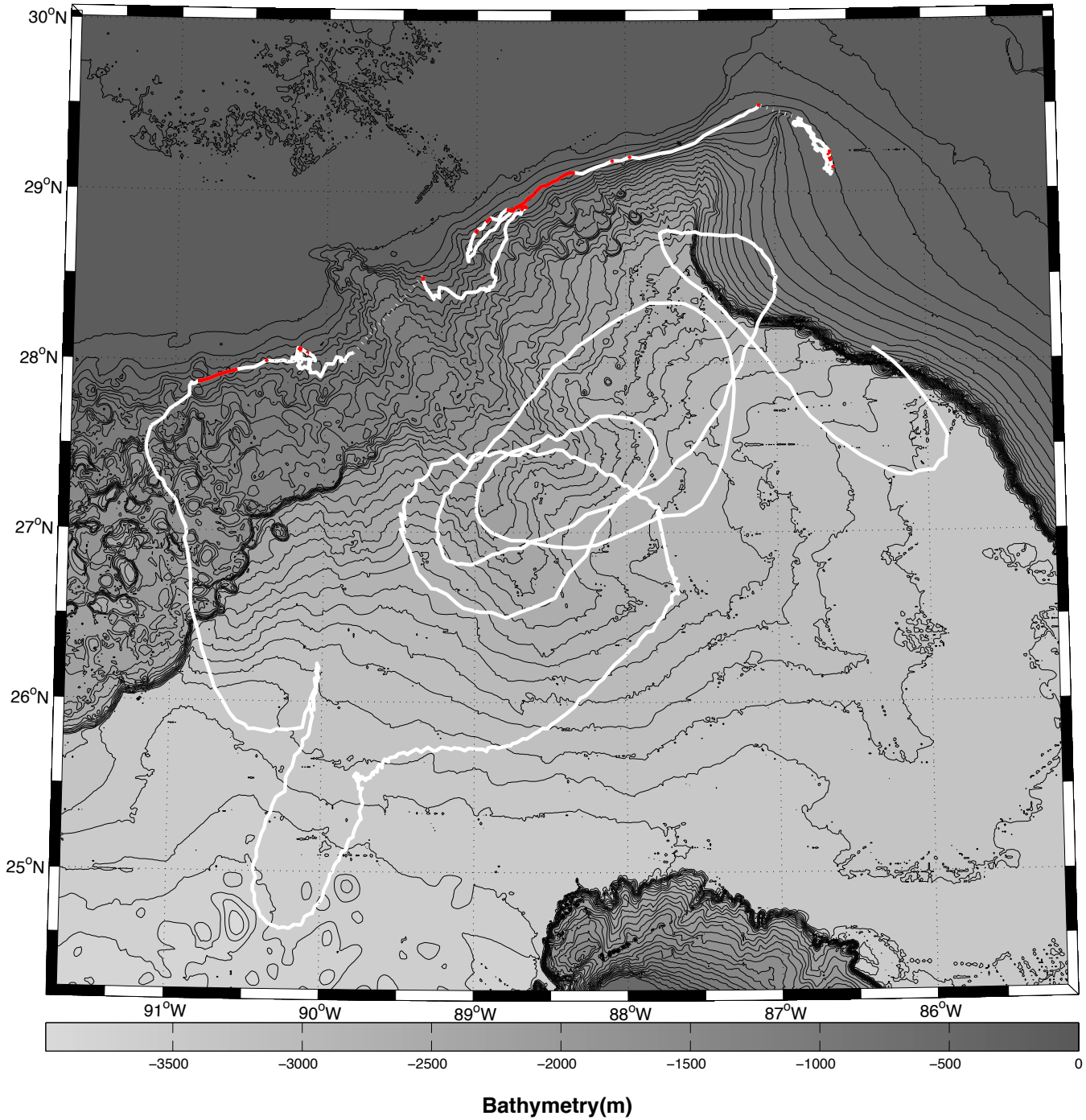
RF 1182 – 90% tracked, 10-day interpolation

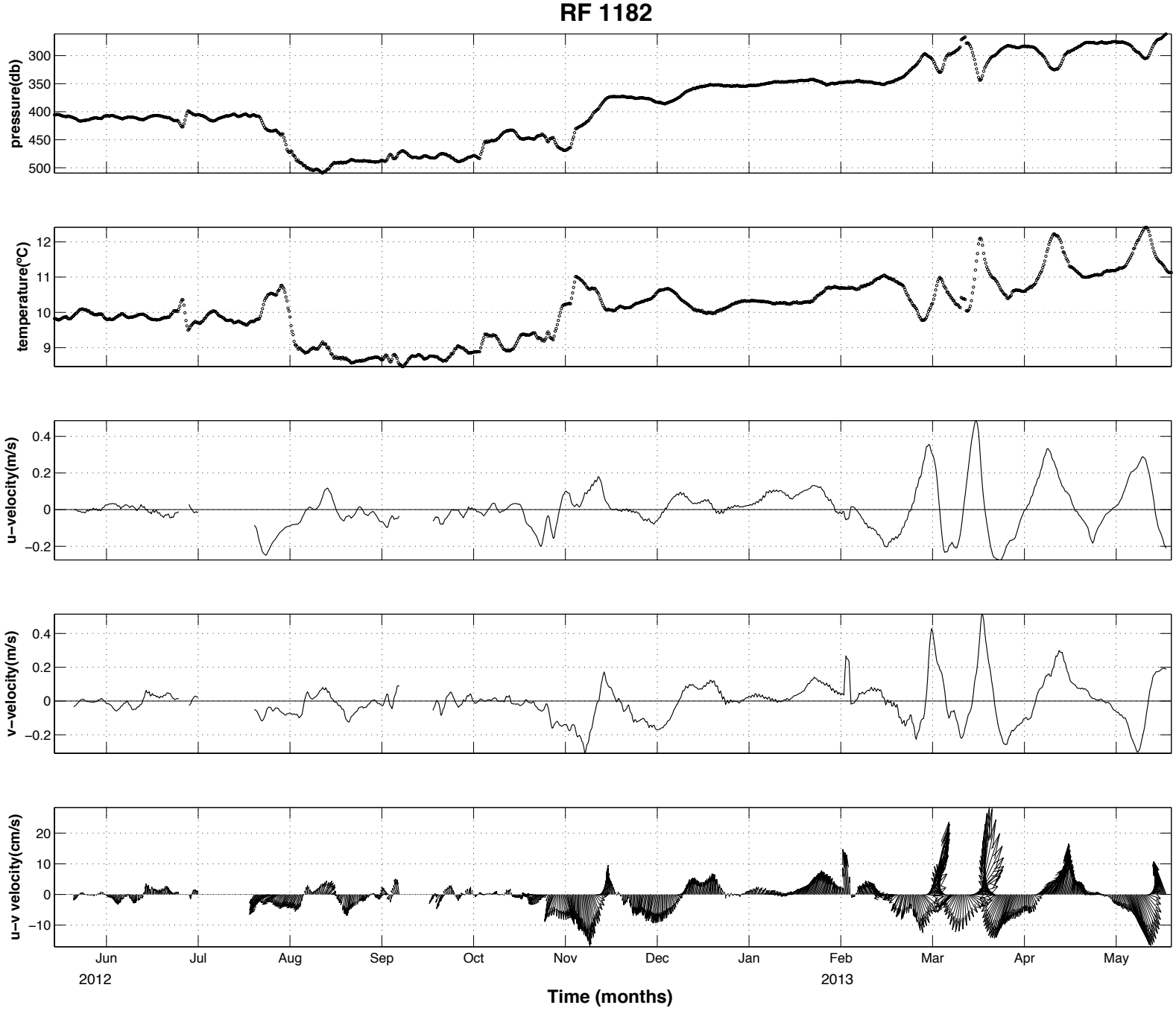



RF1182 – 3 month track
30'
15'
29°N
45'
30'
Aug12
Jul12
Jun12
May–11–2012
89°W
30'
88°W
30'
87°W
30'
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

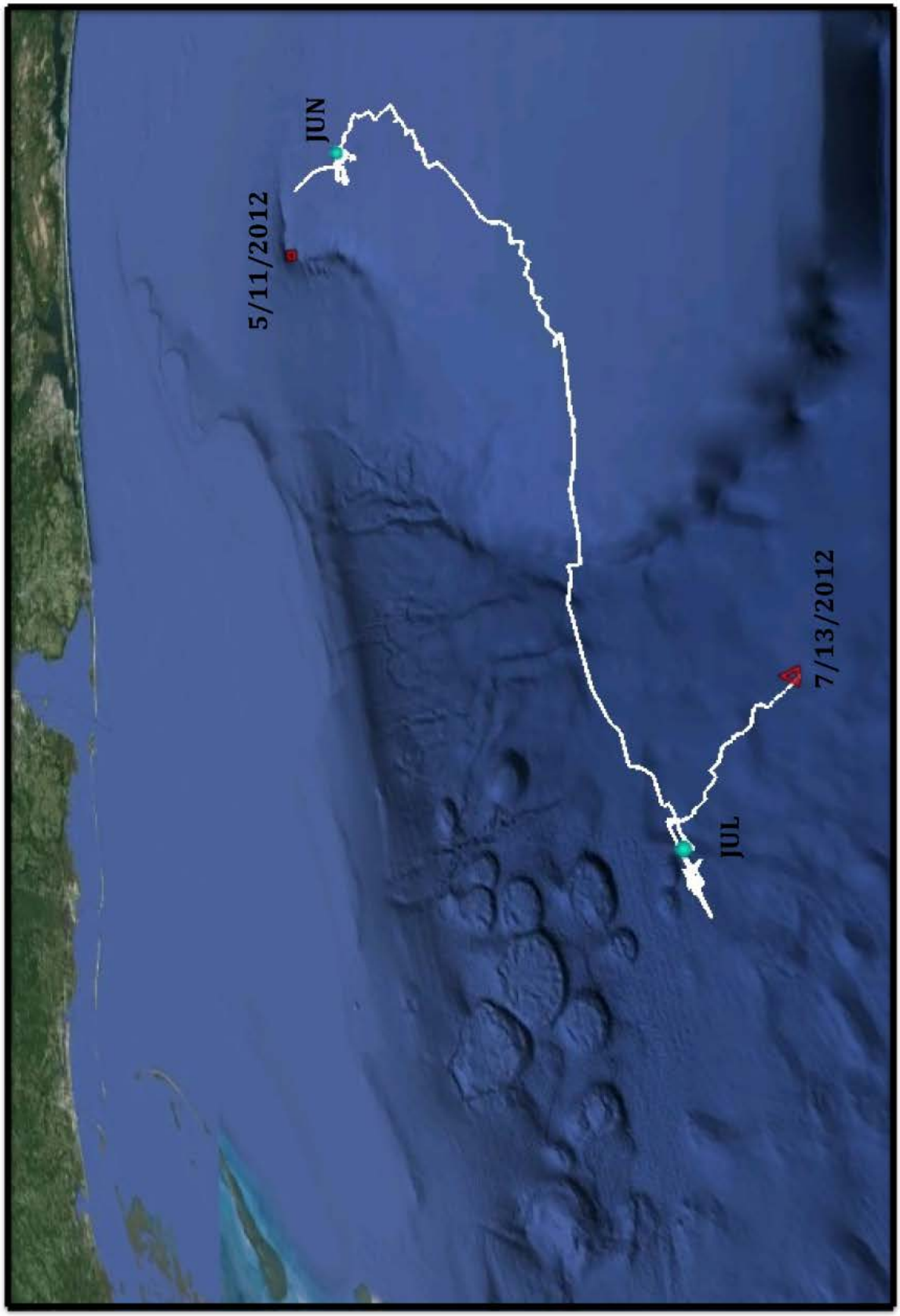

RF 1182
Depth(m)
500
1000
1500
2000
2500
3000
3500
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)

RF 1182

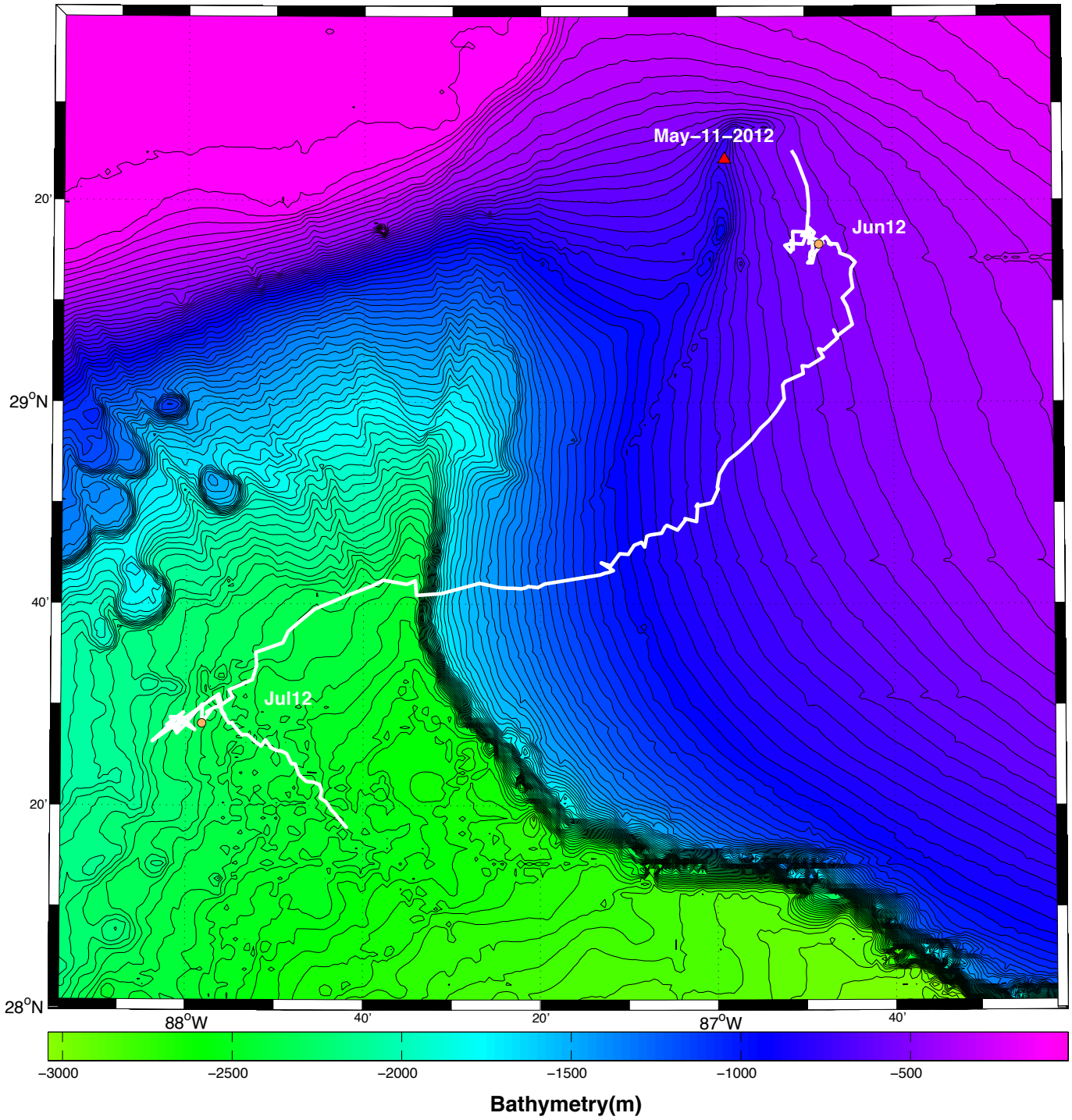

30°N
29°N
28°N
27°N
26°N
25°N
91°W
90°W
89°W
88°W
87°W
86°W
−3500
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

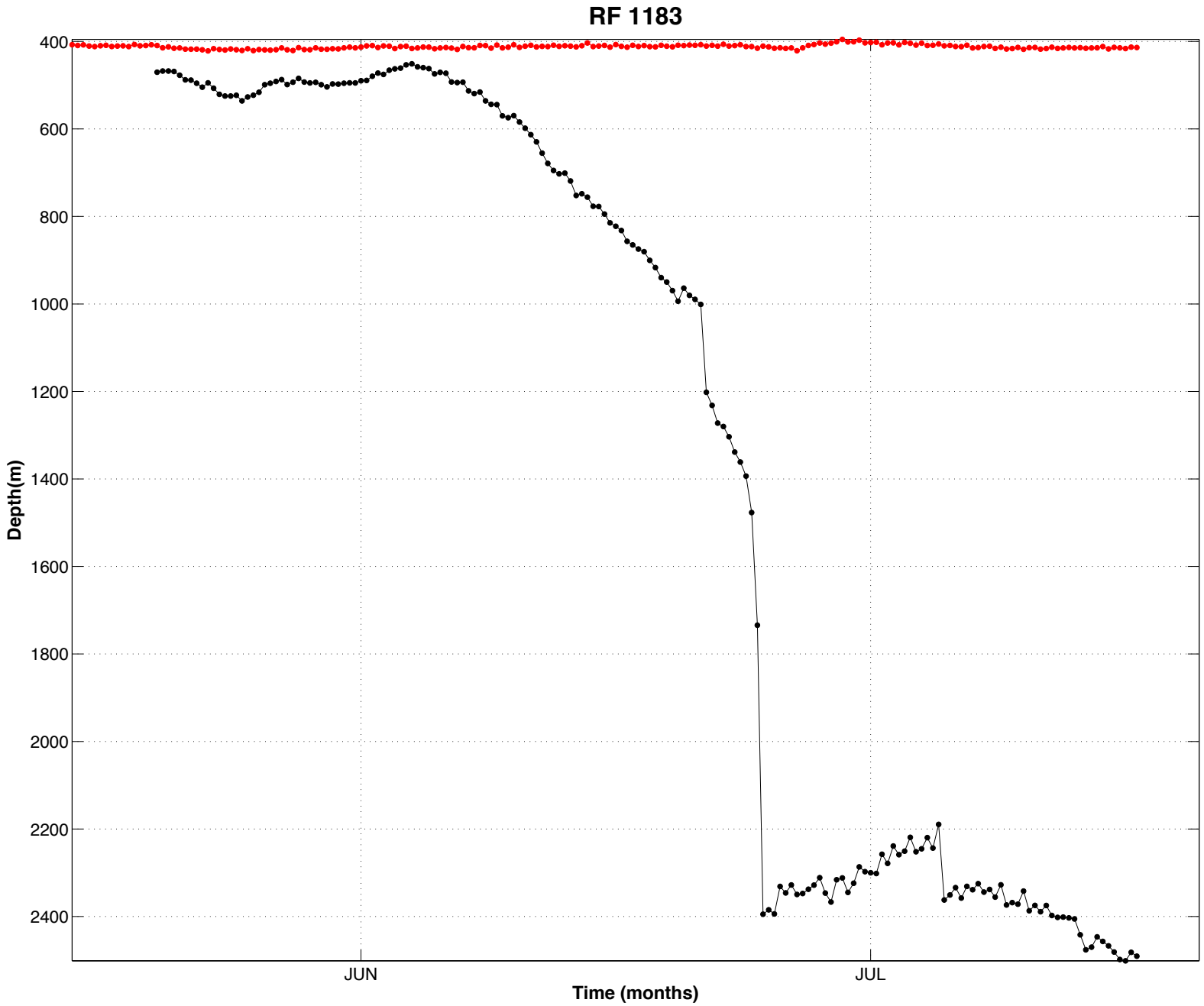

RF 1182
pressure(db)
300
350
400
450
500
temperature(°C)
12
11
10
9
u−velocity(m/s)
0.4
0.2
0
−0.2
v−velocity(m/s)
0.4
0.2
0
−0.2
u−v velocity(cm/s)
20
10
0
−10
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2012
2013
Time (months)

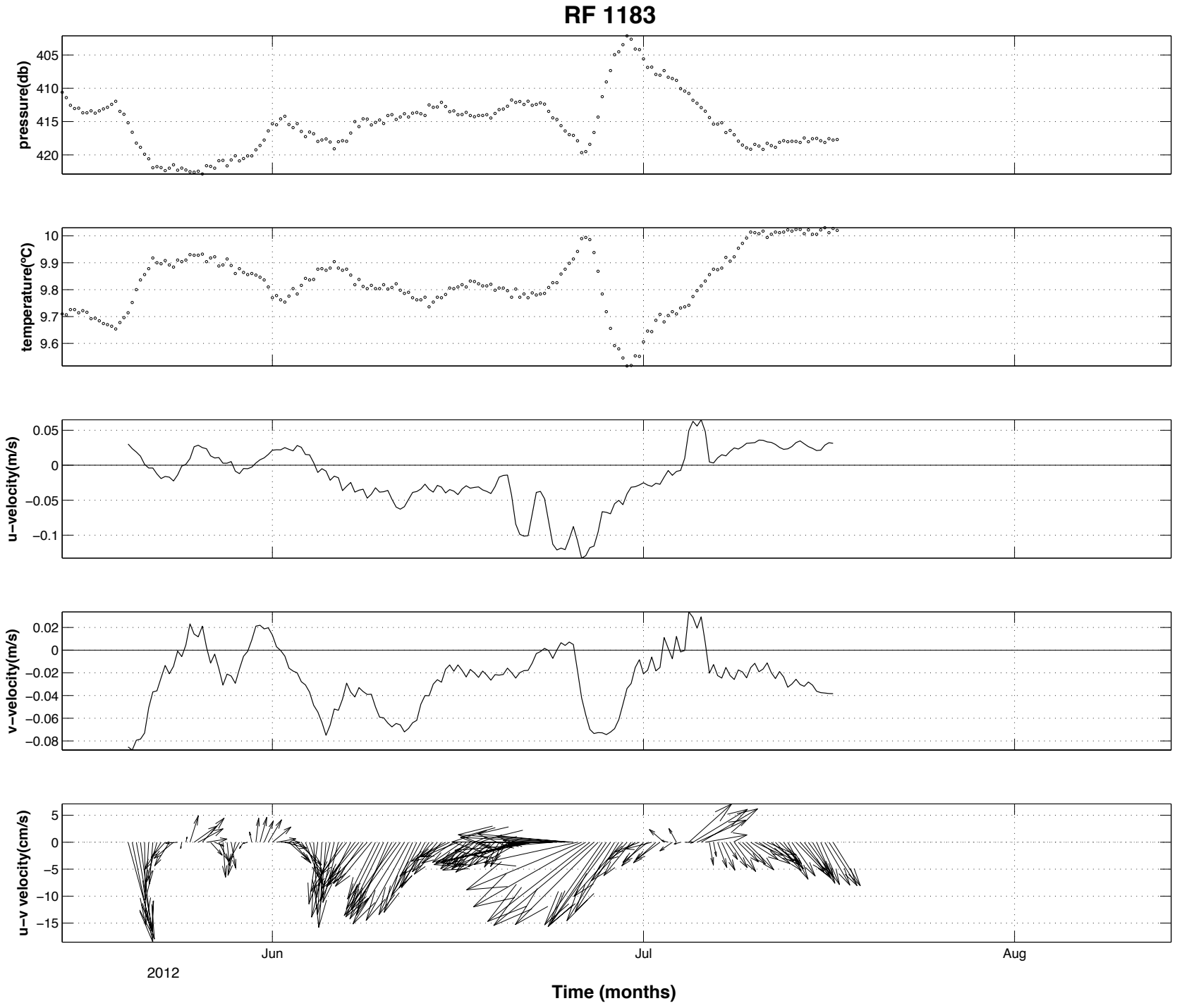
RF 1183 – 16% tracked, 10-day interpolated



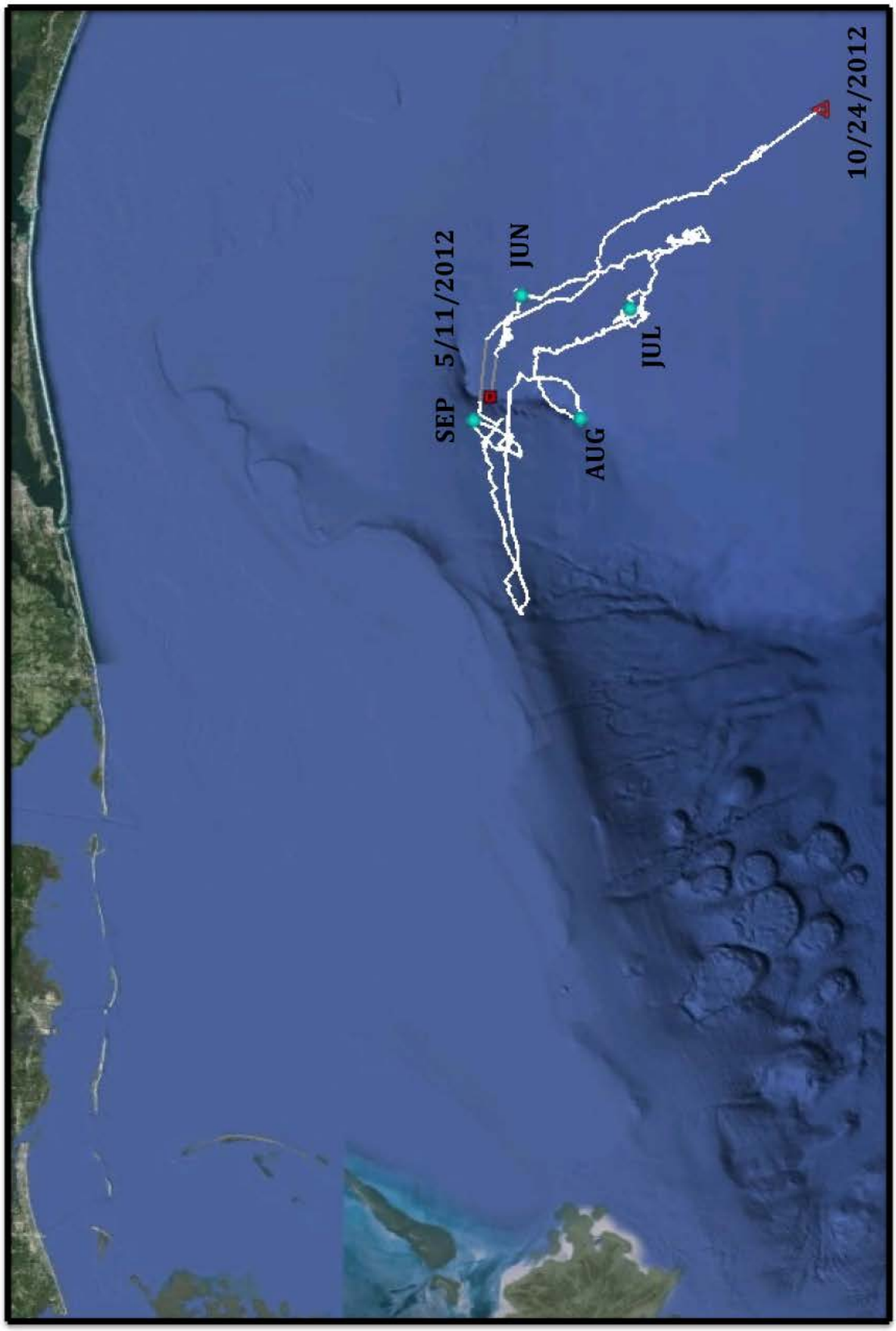
RF1183 – 3 month track



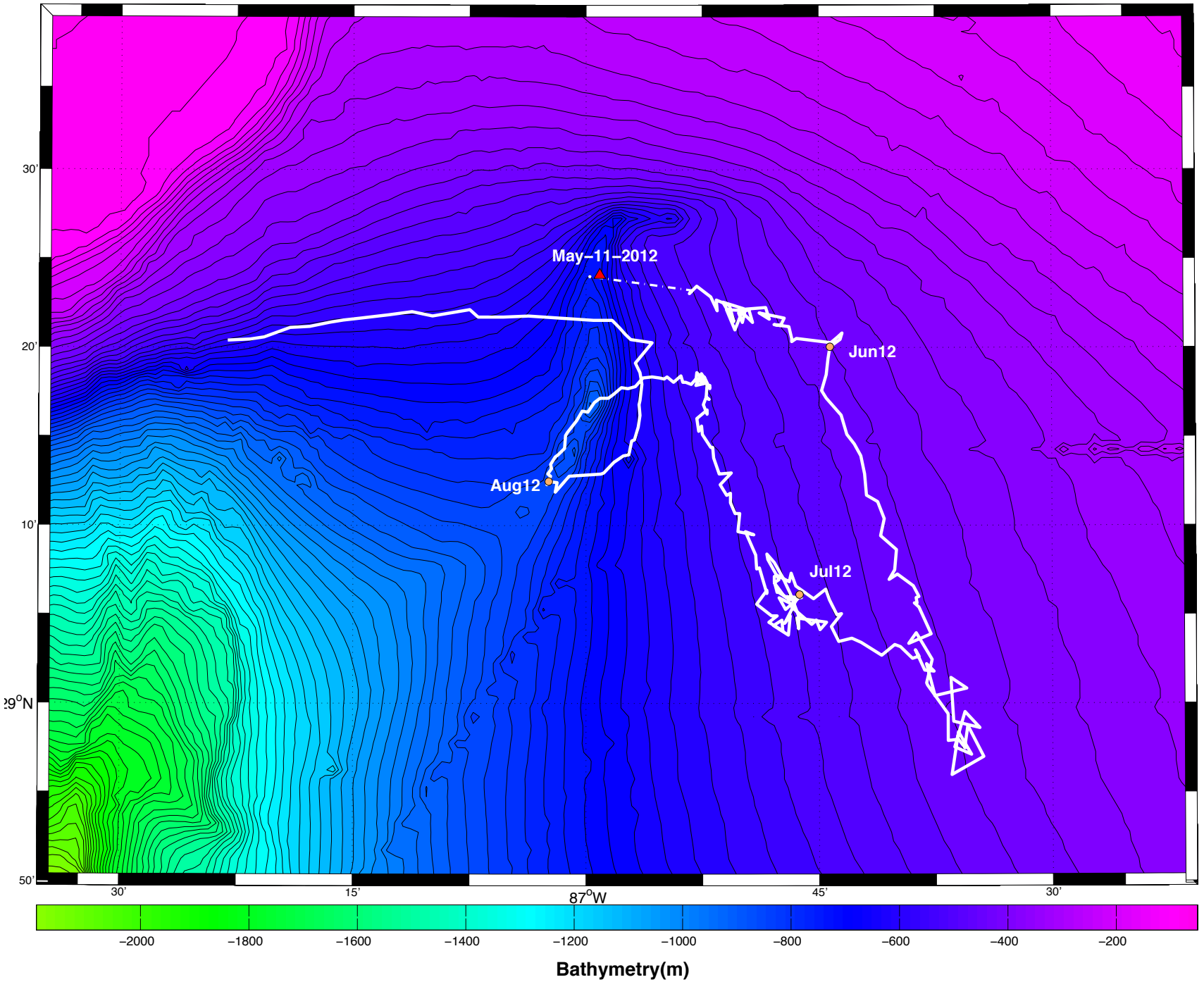

RF 1183
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
Depth(m)
JUN
JUL
Time (months)

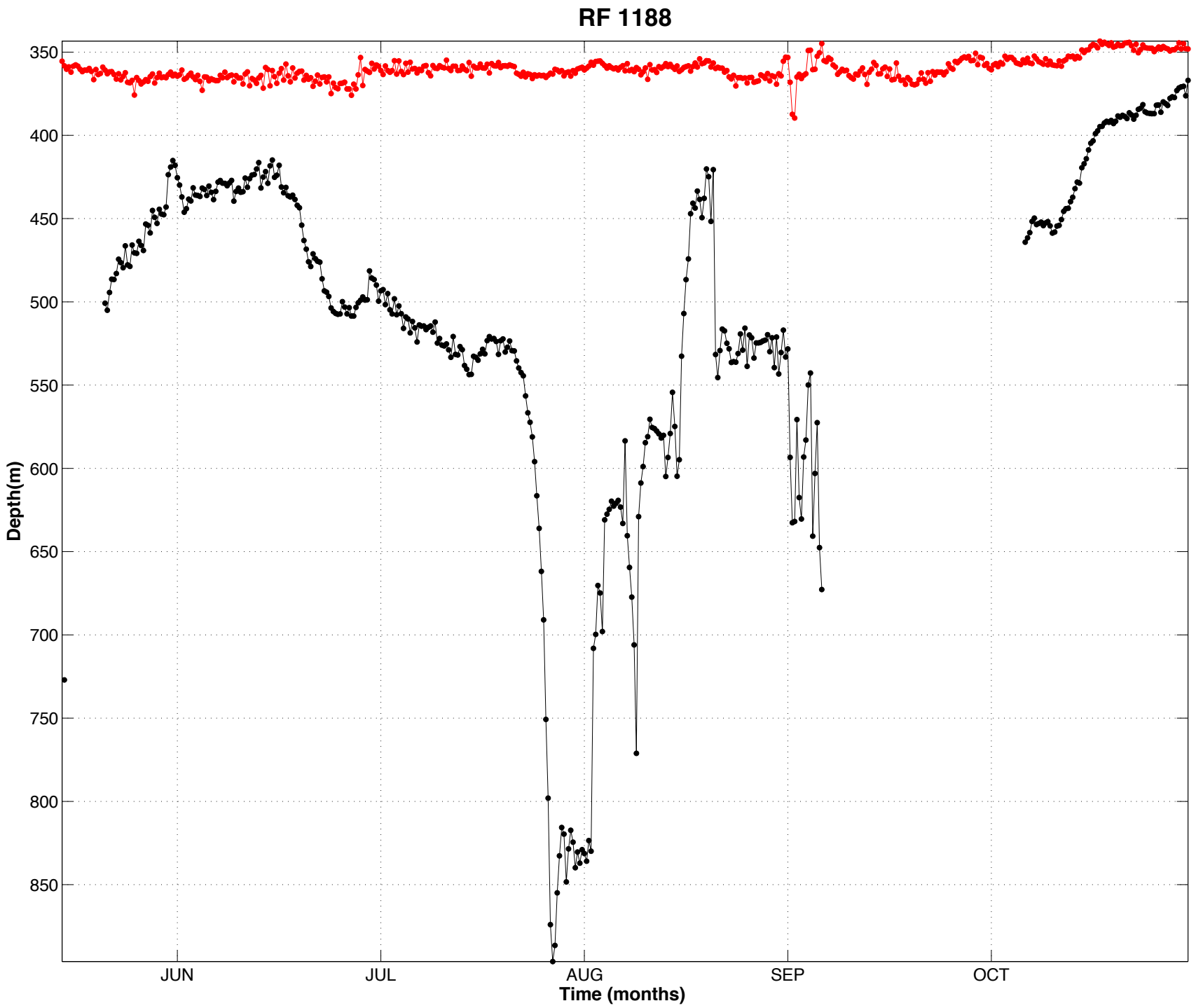

RF 1183
pressure(db)
405
410
415
420
temperature(°C)
10
9.9
9.8
9.7
9.6
u−velocity(m/s)
0.05
0
−0.05
−0.1
v−velocity(m/s)
0.02
0
−0.02
−0.04
−0.06
−0.08
u−v velocity(cm/s)
5
0
−5
−10
−15
Jun
Jul
Aug
2012
Time (months)

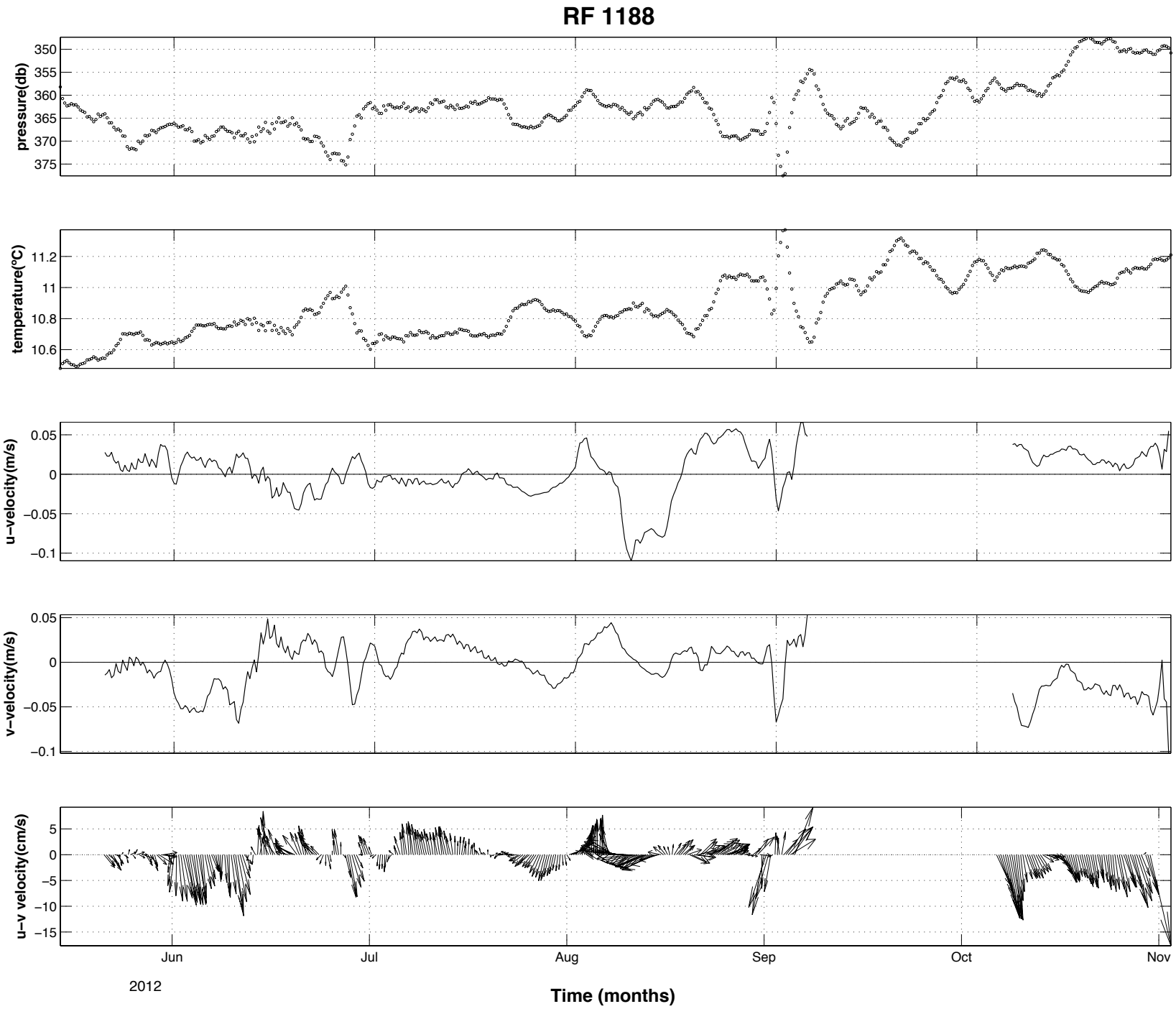
RF 1188 – 40% tracked, 10-day interpolation



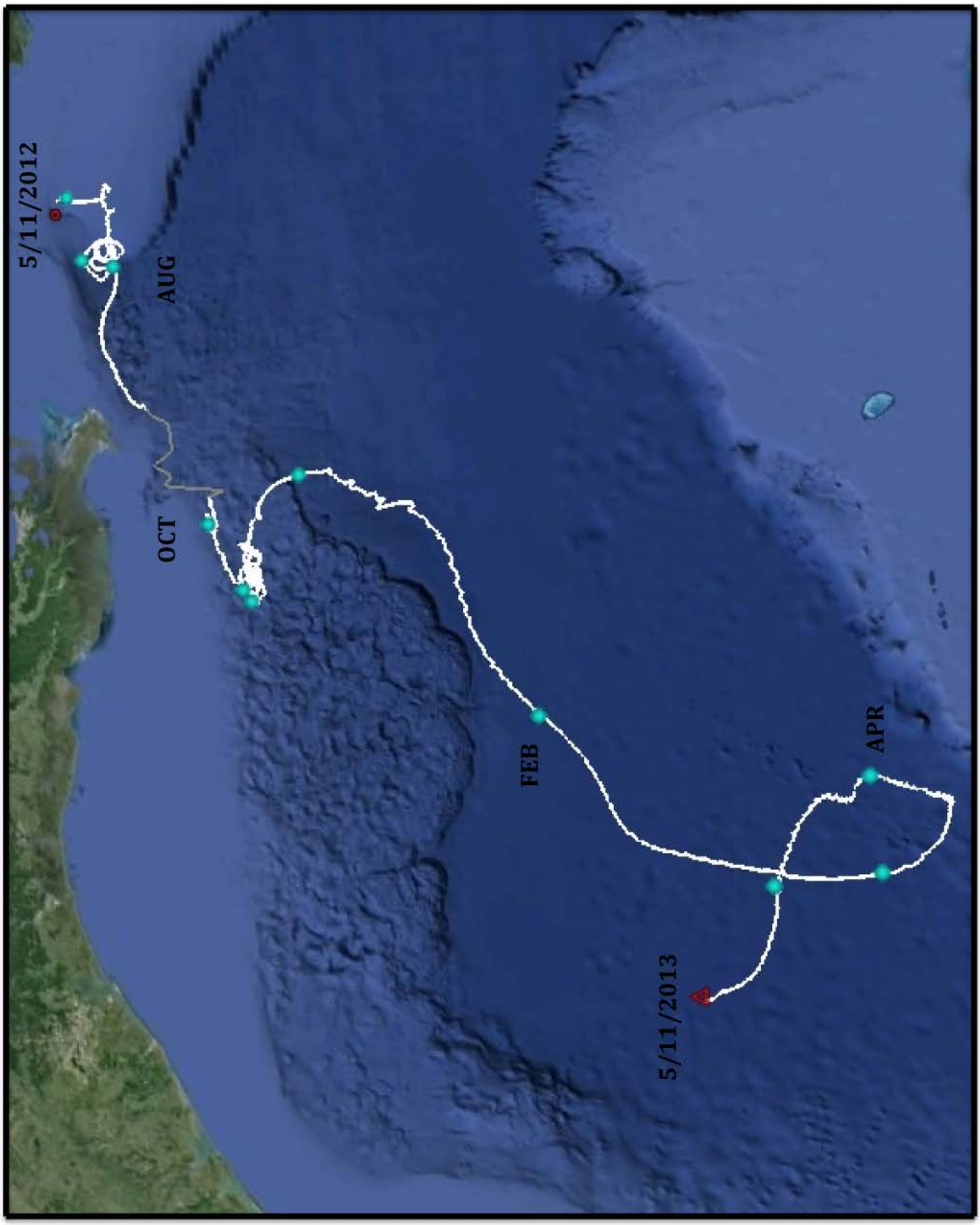
RF1188 – 3 month track

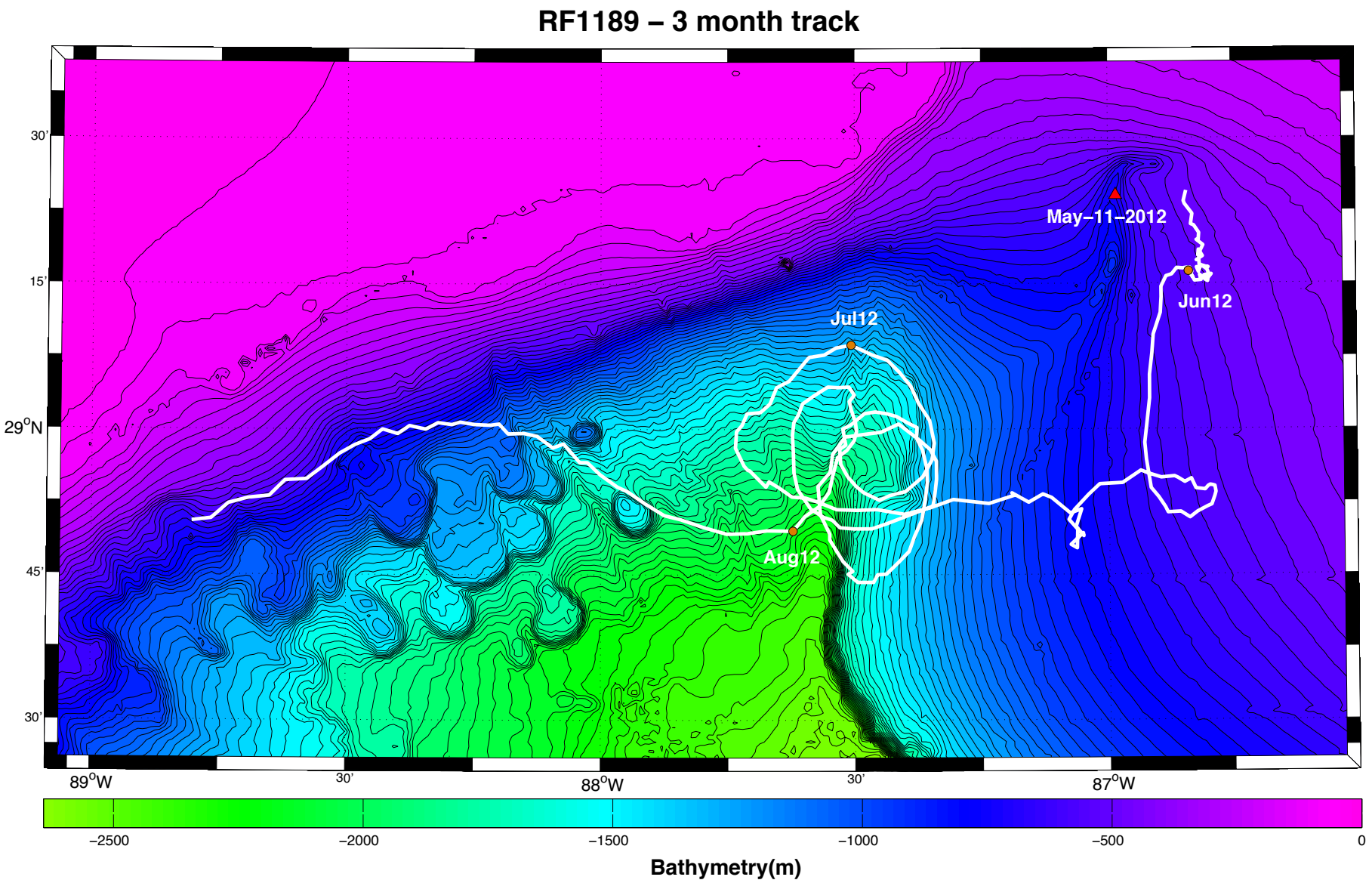



RF 1188
Depth(m)
350
400
450
500
550
600
650
700
750
800
850
JUN
JUL
AUG
SEP
OCT
Time (months)


RF 1188
pressure(db)
350
355
360
365
370
375
temperature(°C)
11.2
11
10.8
10.6
u−velocity(m/s)
0.05
0
−0.05
−0.1
v−velocity(m/s)
0.05
0
−0.05
−0.1
u−v velocity(cm/s)
5
0
−5
−10
−15
Jun
Jul
Aug
Sep
Oct
Nov
2012
Time (months)

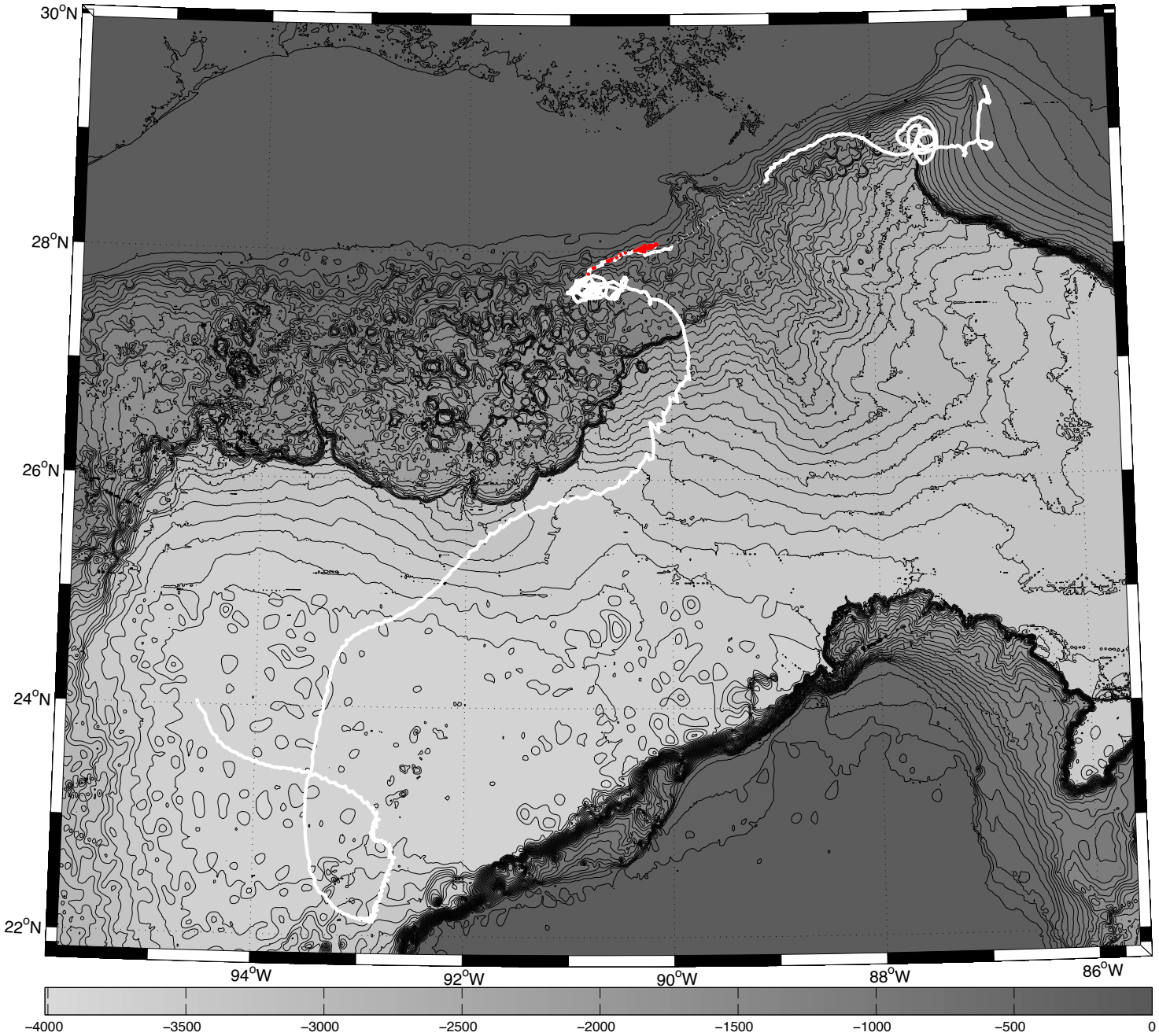
RF 1189 – 91% tracked, 10-day interpolation

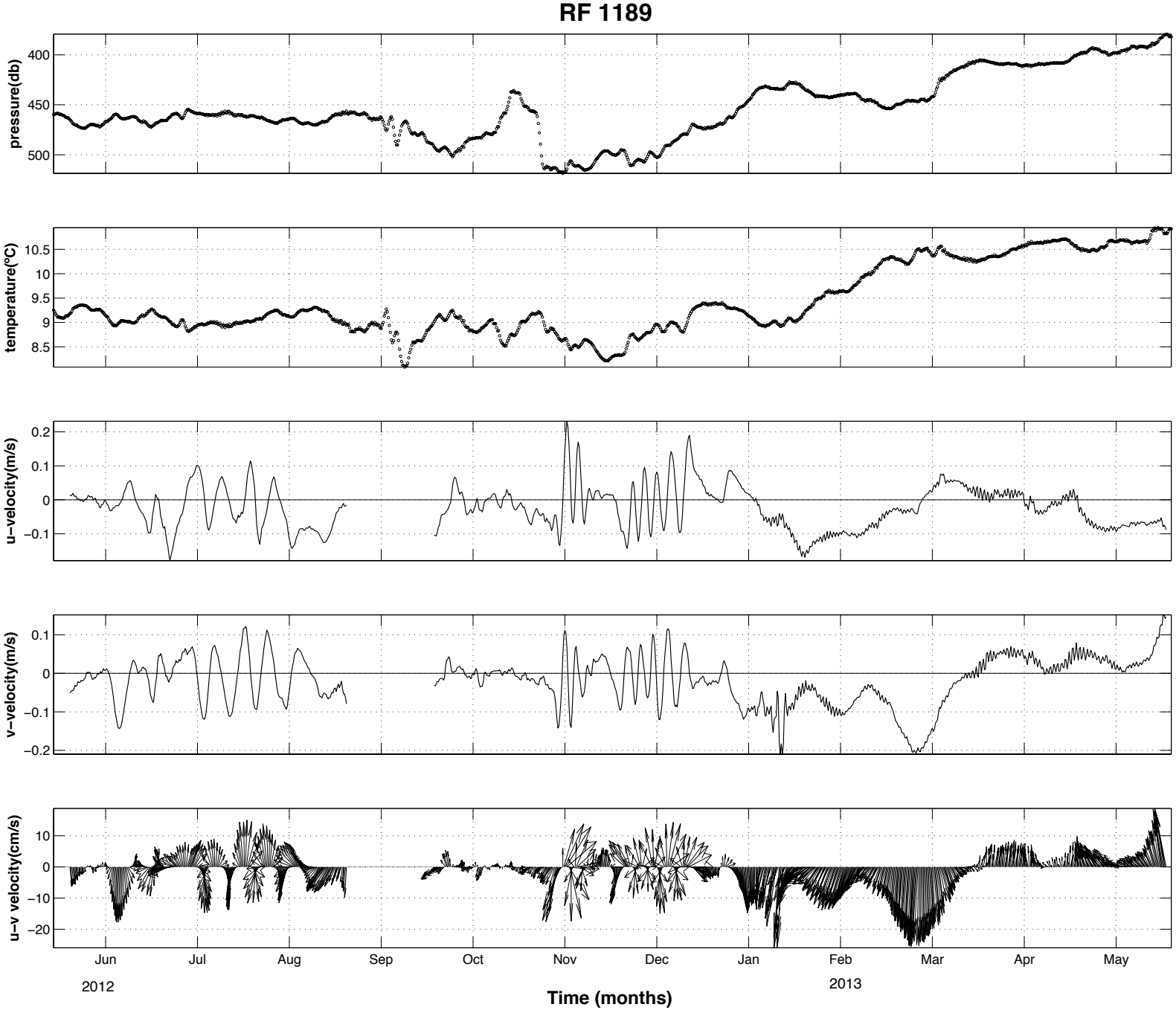



RF1189 – 3 month track
May–11–2012
Jun12
Jul12
Aug12
30'
15'
45'
30'
29°N
89°W
30'
88°W
30'
87°W
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

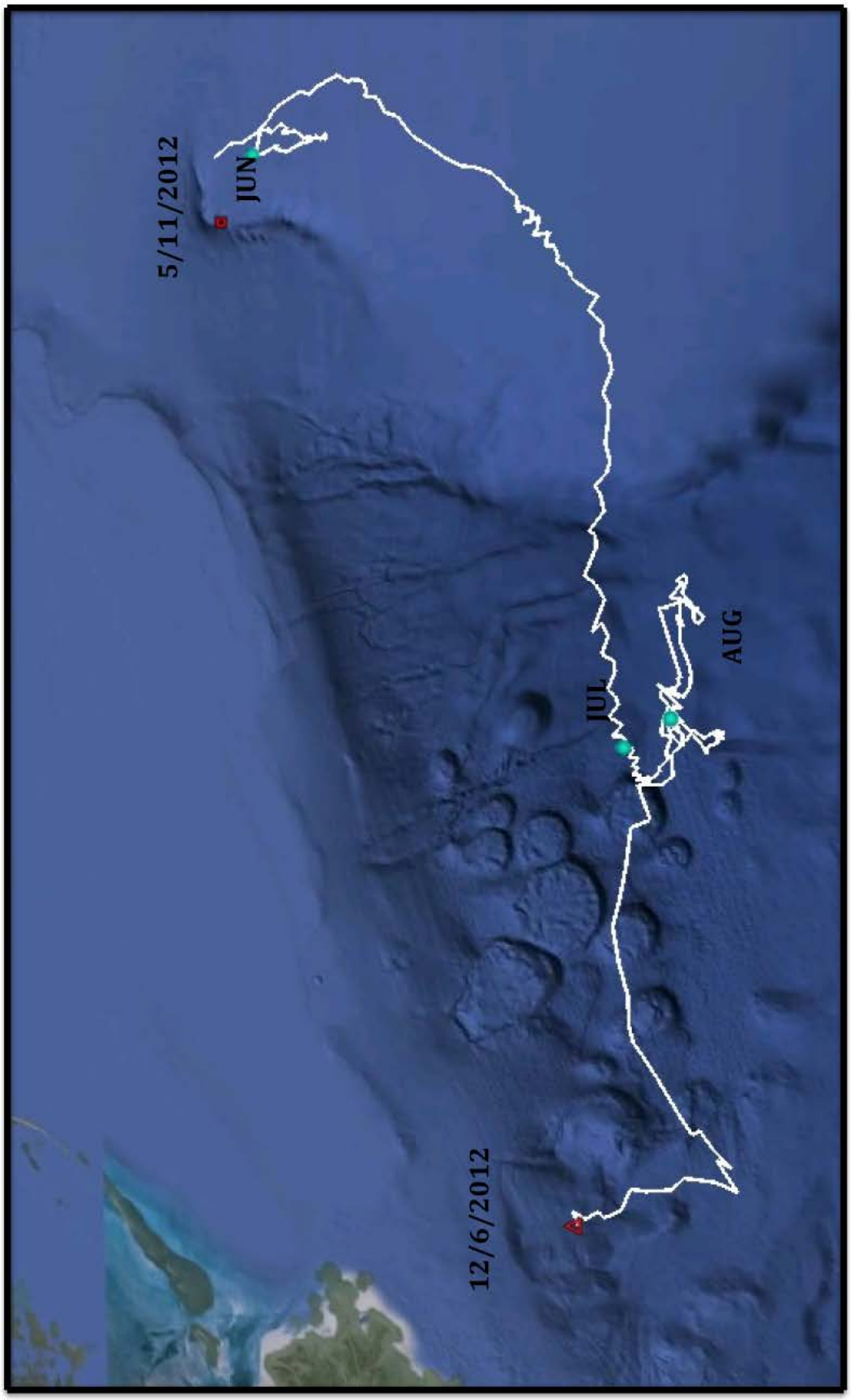

RF 1189
Depth(m)
500
1000
1500
2000
2500
3000
3500
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)

RF 1189

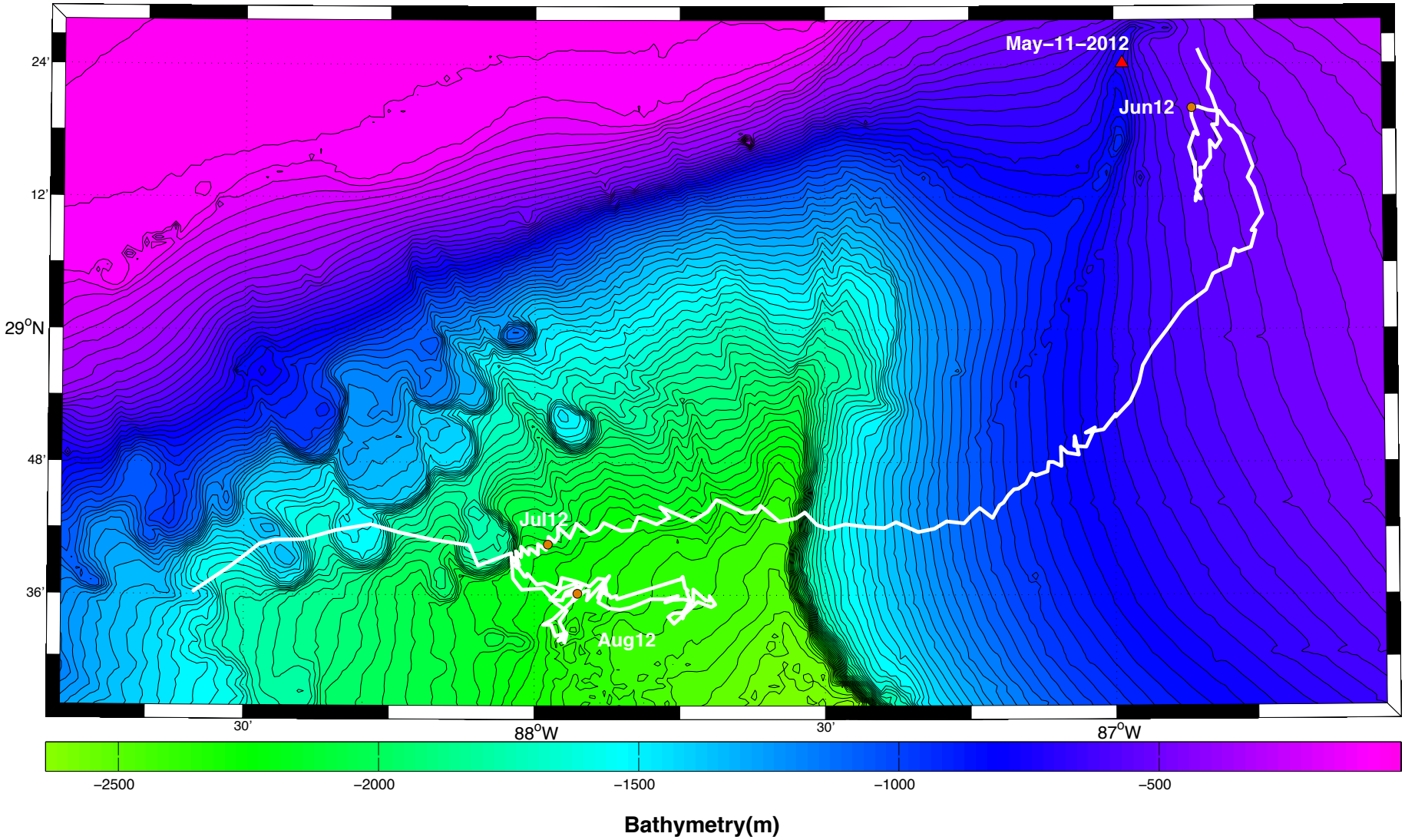

30°N
28°N
26°N
24°N
22°N
94°W
92°W
90°W
88°W
86°W
−4000
−3500
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

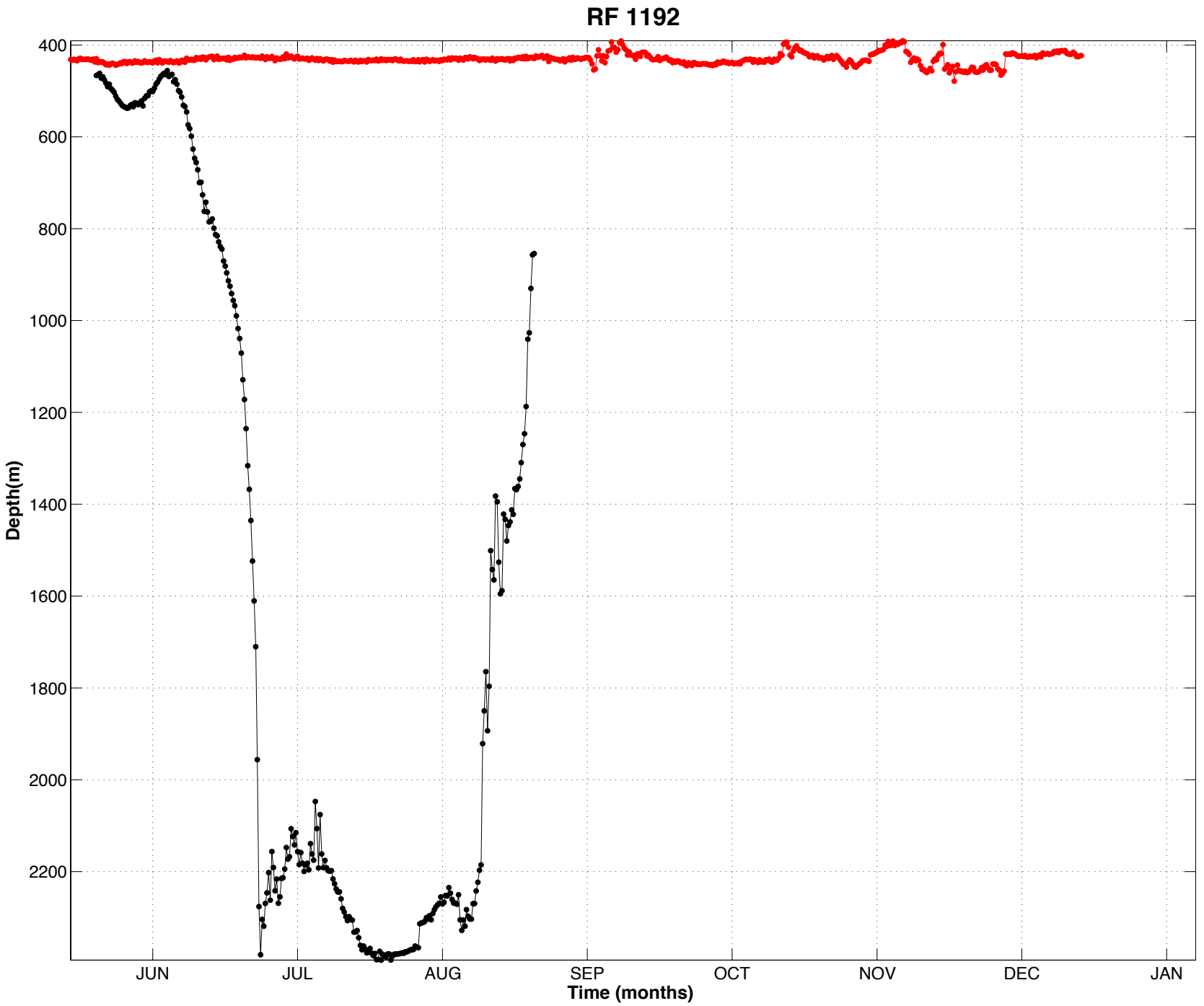

RF 1189
pressure(db)
400
450
500
temperature(°C)
10.5
10
9.5
9
8.5
u−velocity(m/s)
0.2
0.1
0
−0.1
v−velocity(m/s)
0.1
0
−0.1
−0.2
u−v velocity(cm/s)
10
0
−10
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2012
2013
Time (months)

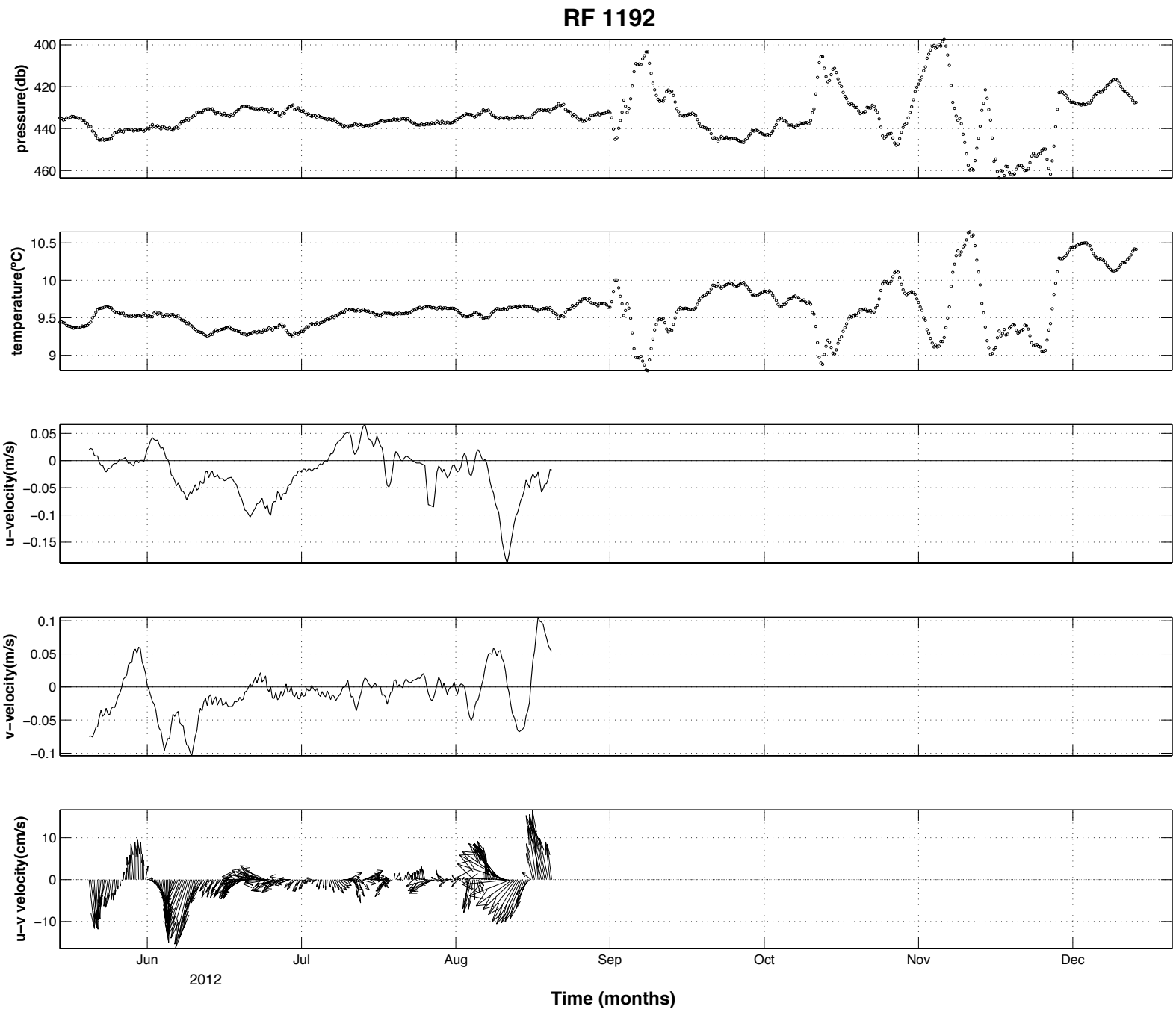
RF 1192 – 25% tracked, 10-day interpolation



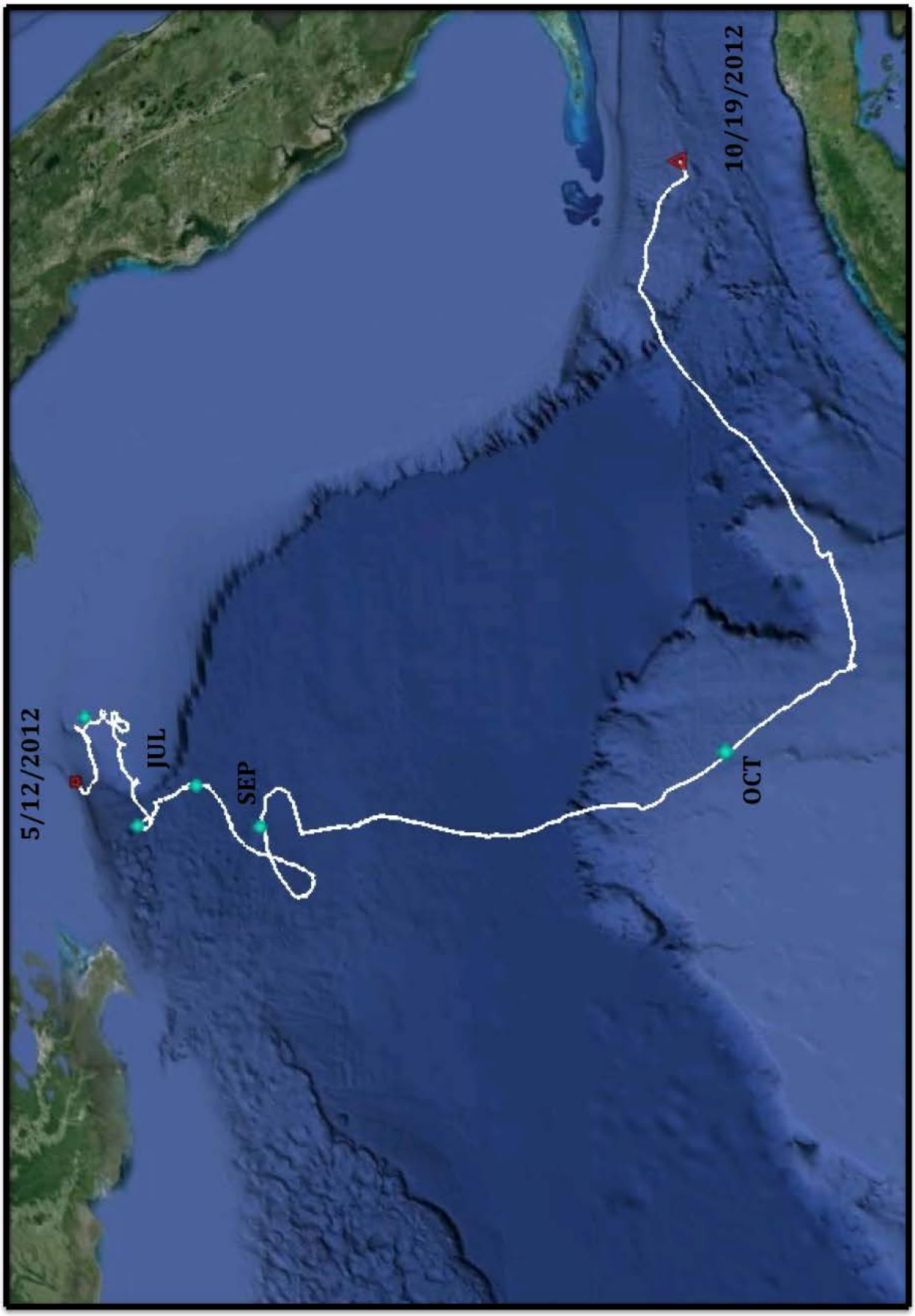
RF1192 – 3 month track



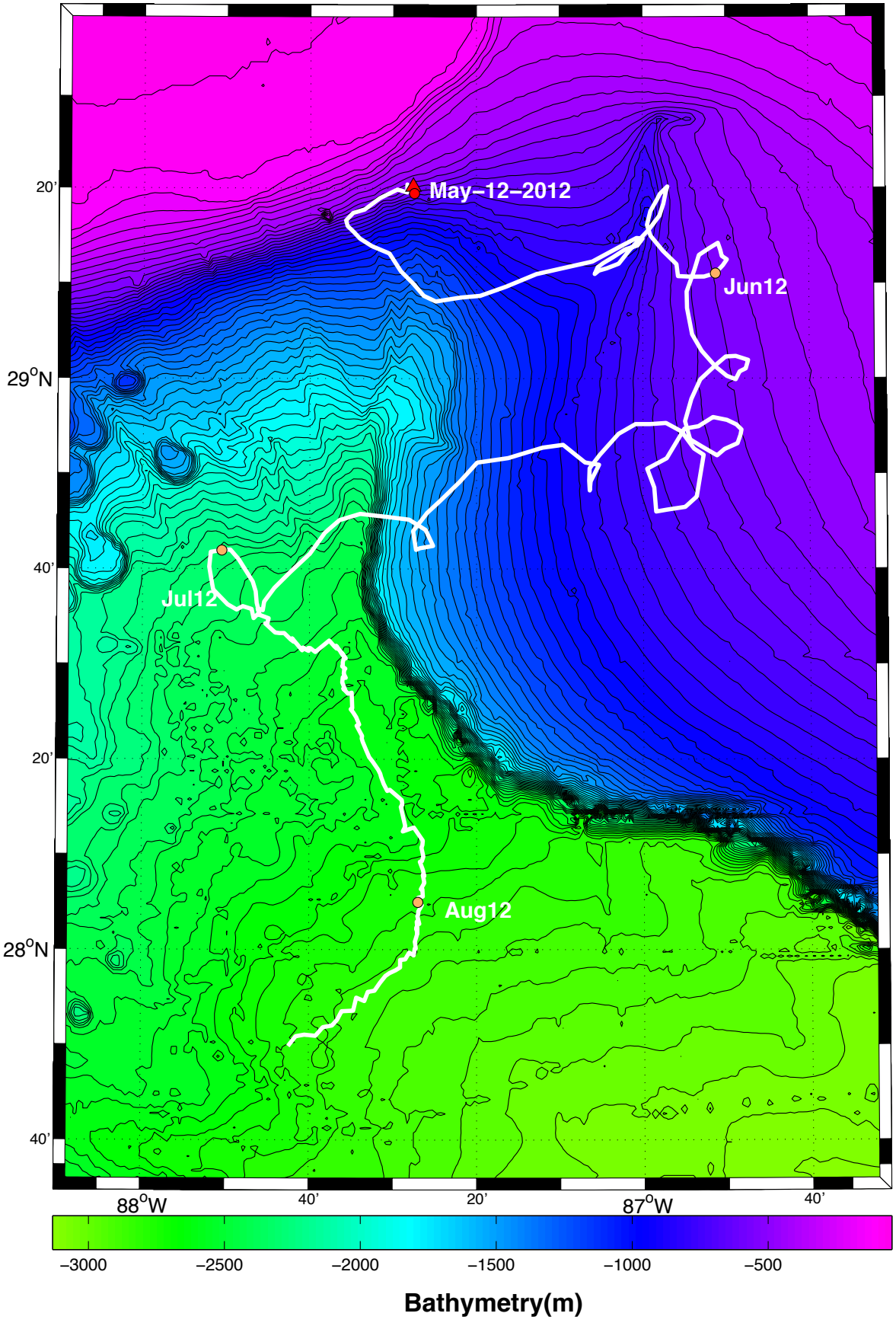

RF 1192
400
600
800
1000
1200
1400
1600
1800
2000
2200
Depth(m)
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
Time (months)

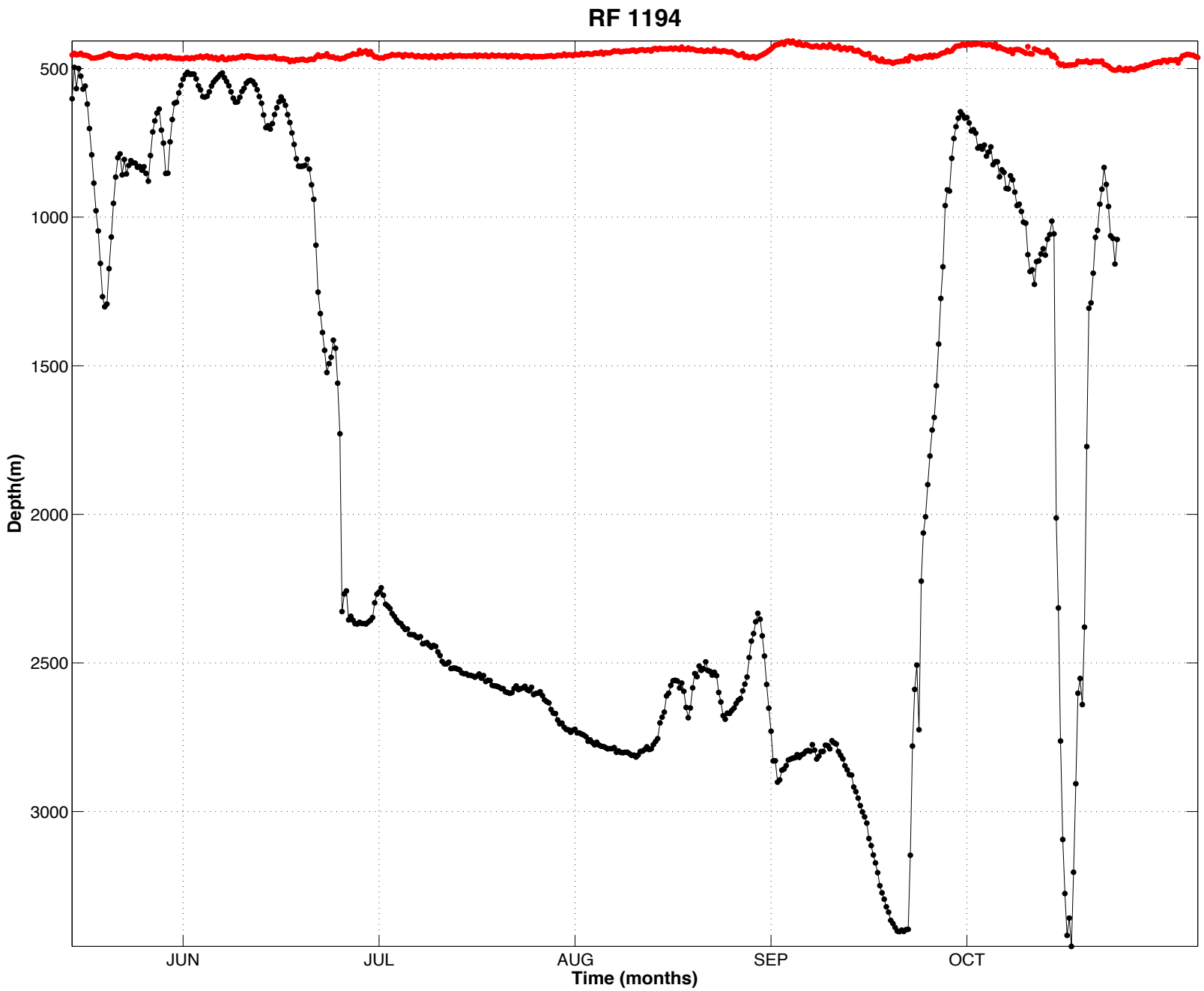

RF 1192
pressure(db)
400
420
440
460
temperature(ºC)
10.5
10
9.5
9
u−velocity(m/s)
0.05
0
−0.05
−0.1
−0.15
v−velocity(m/s)
0.1
0.05
0
−0.05
−0.1
u−v velocity(cm/s)
10
0
−10
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2012
Time (months)

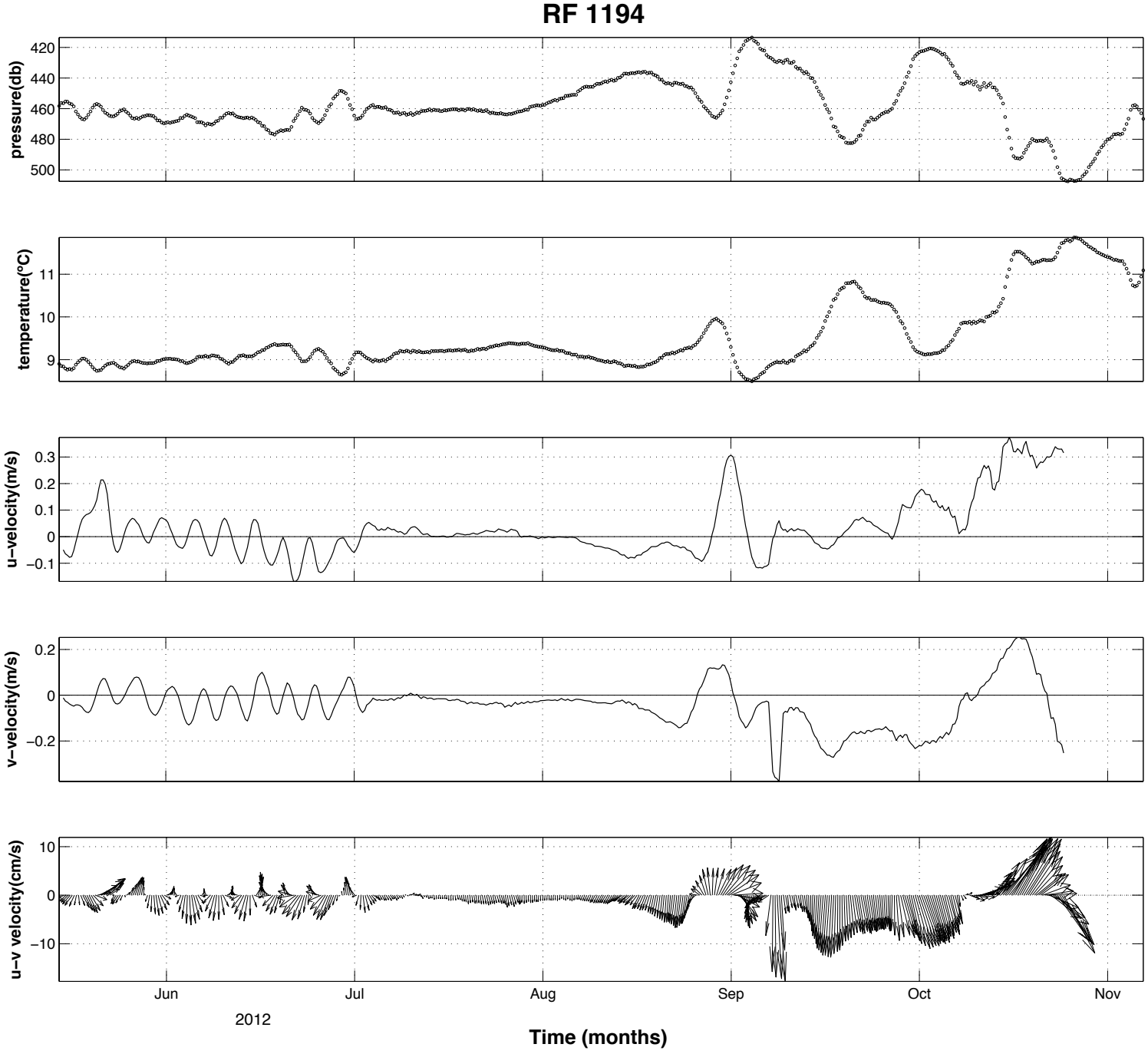
RF 1194 – 44% tracked, 10-day interpolation



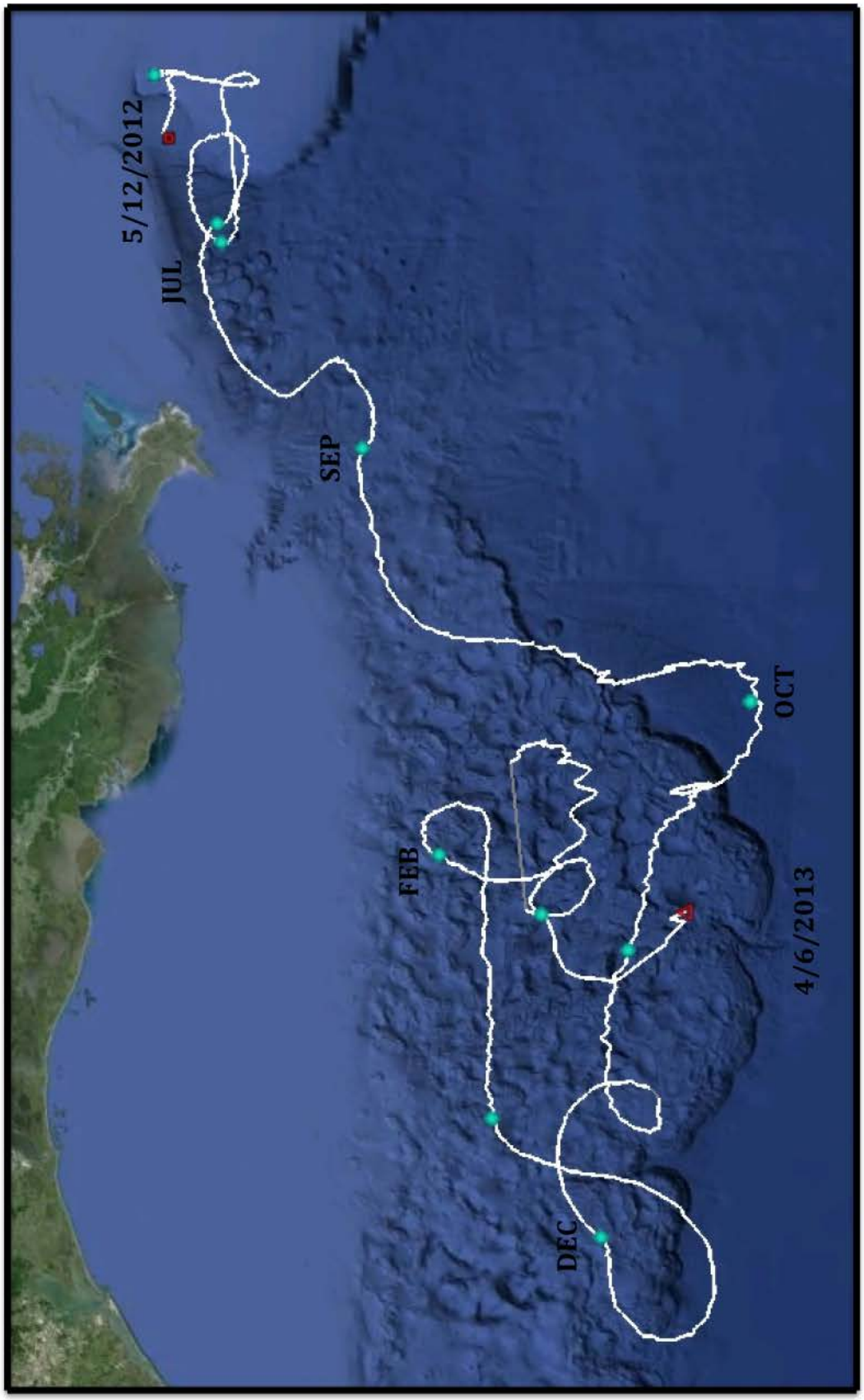
RF1194 – 3 month track

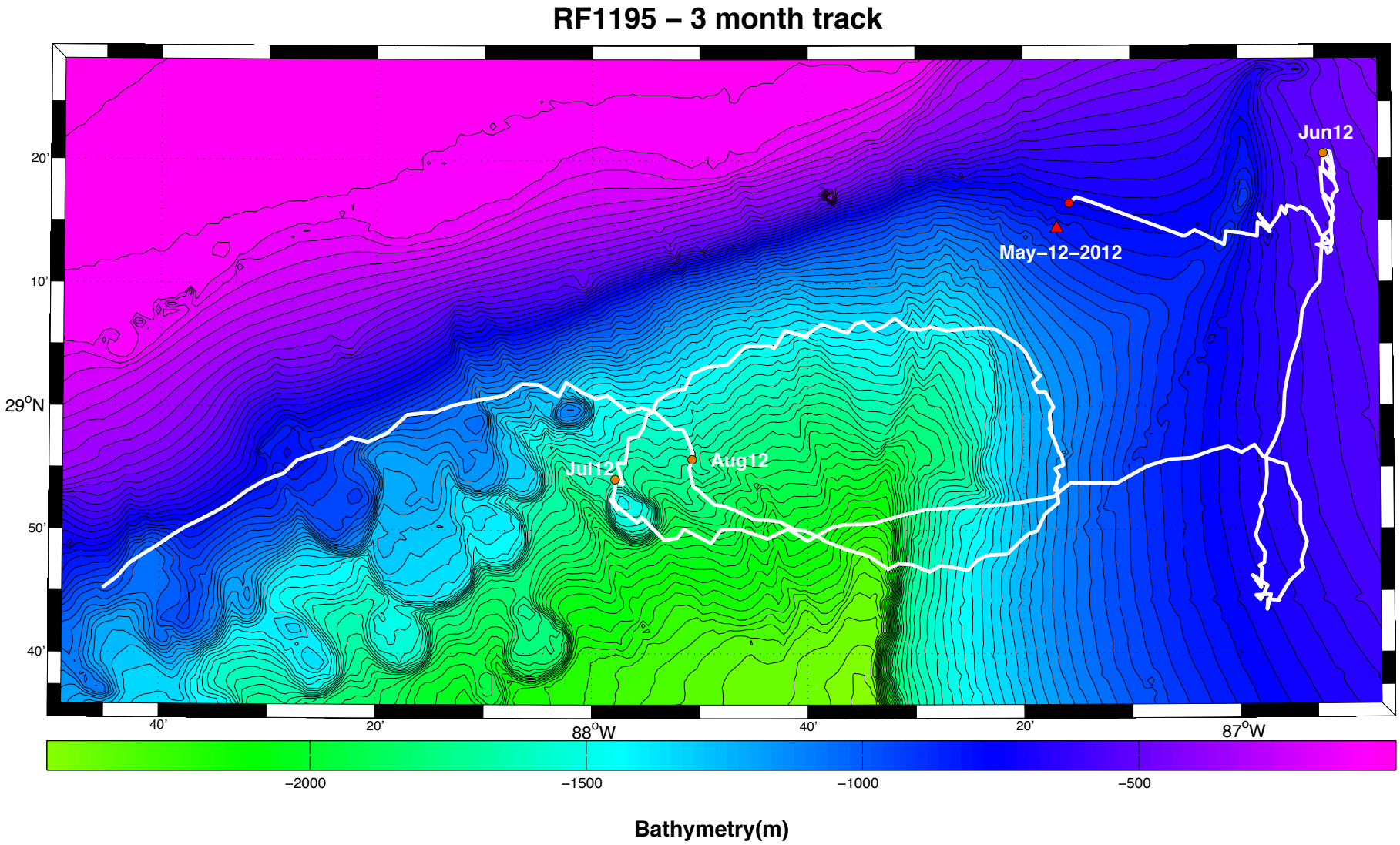


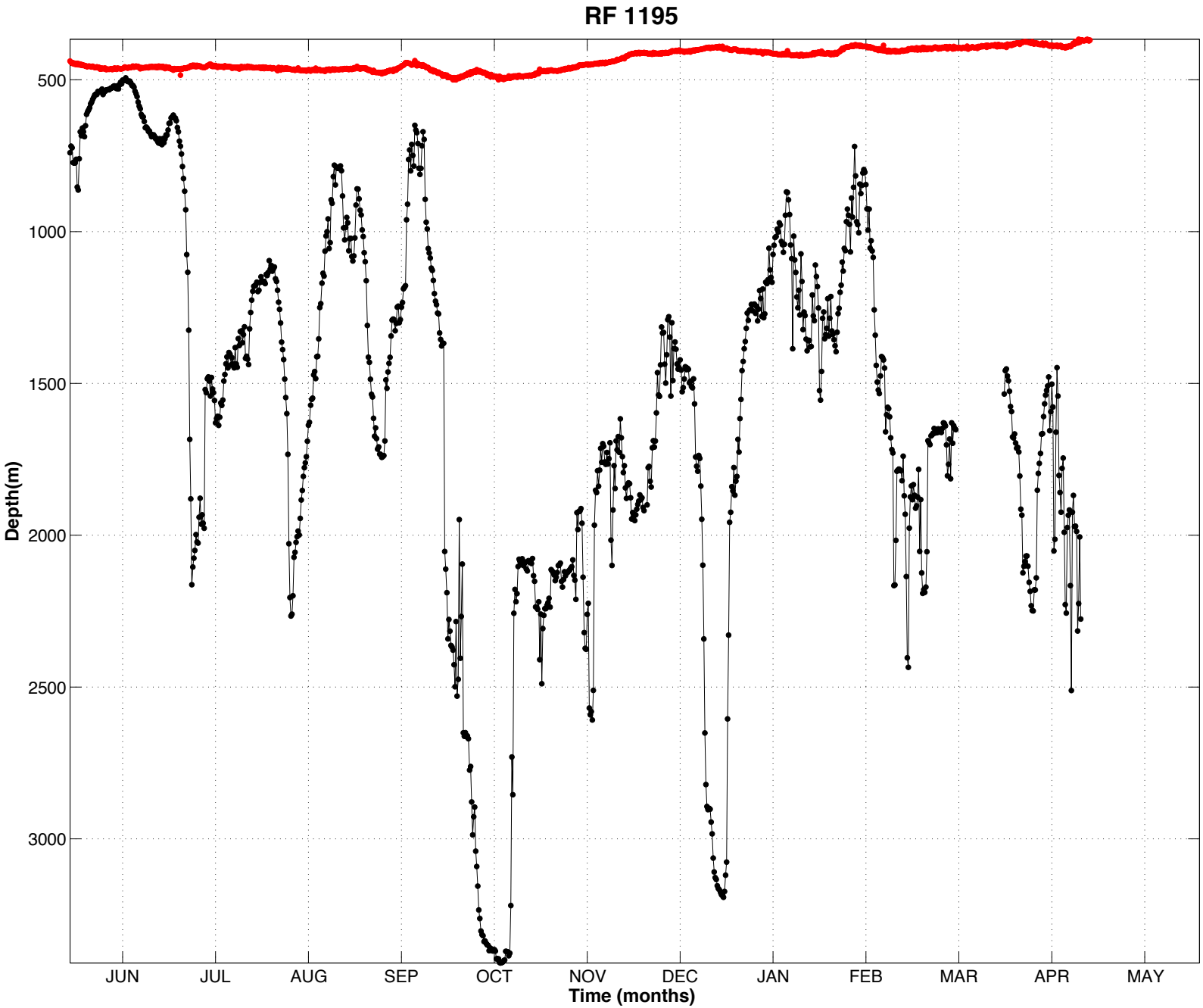

RF 1194
500
1000
1500
2000
2500
3000
Depth(m)
JUN
JUL
AUG
SEP
OCT
Time (months)

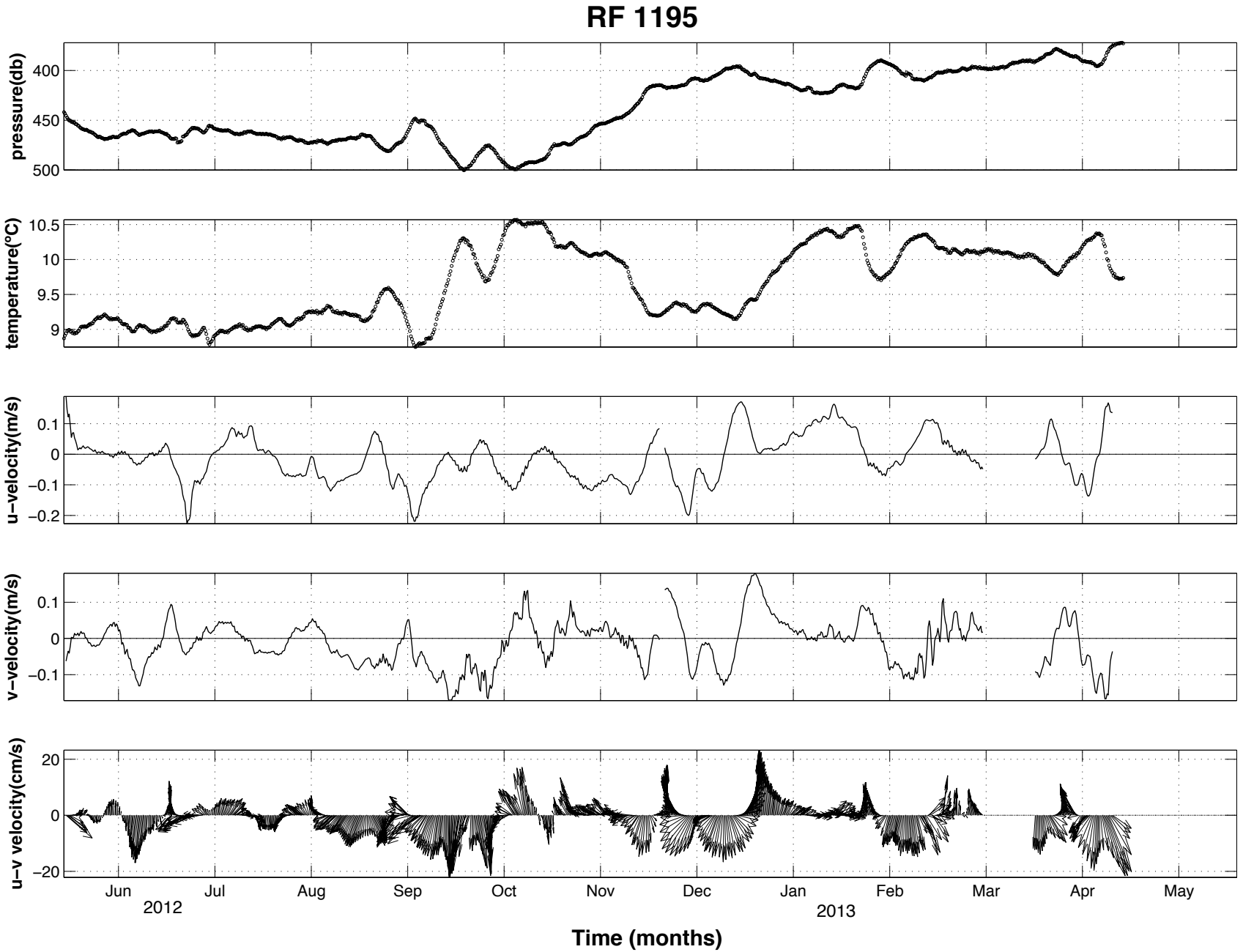

RF 1194
pressure(db)
420
440
460
480
500
temperature(°C)
11
10
9
u−velocity(m/s)
0.3
0.2
0.1
0
−0.1
v−velocity(m/s)
0.2
0
−0.2
u−v velocity(cm/s)
10
0
−10
Jun
Jul
Aug
Sep
Oct
Nov
2012
Time (months)

RF 1195 – 85% tracked, 10-day interpolation

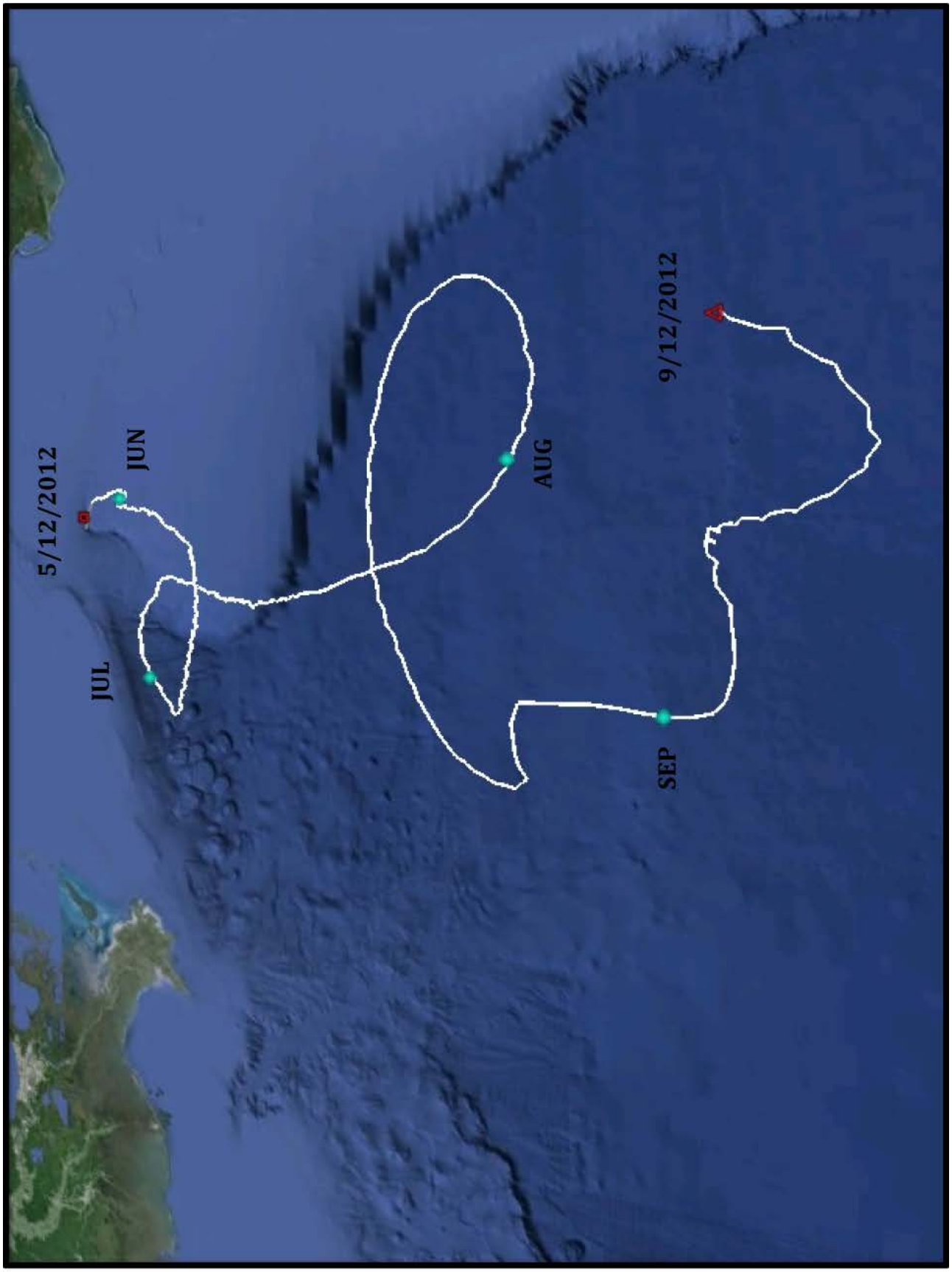



RF1195 – 3 month track
Jun12
May–12–2012
Jul12
Aug12
20'
10'
29°N
50'
40'
40'
20'
88°W
40'
20'
87°W
−2000
−1500
−1000
−500
Bathymetry(m)

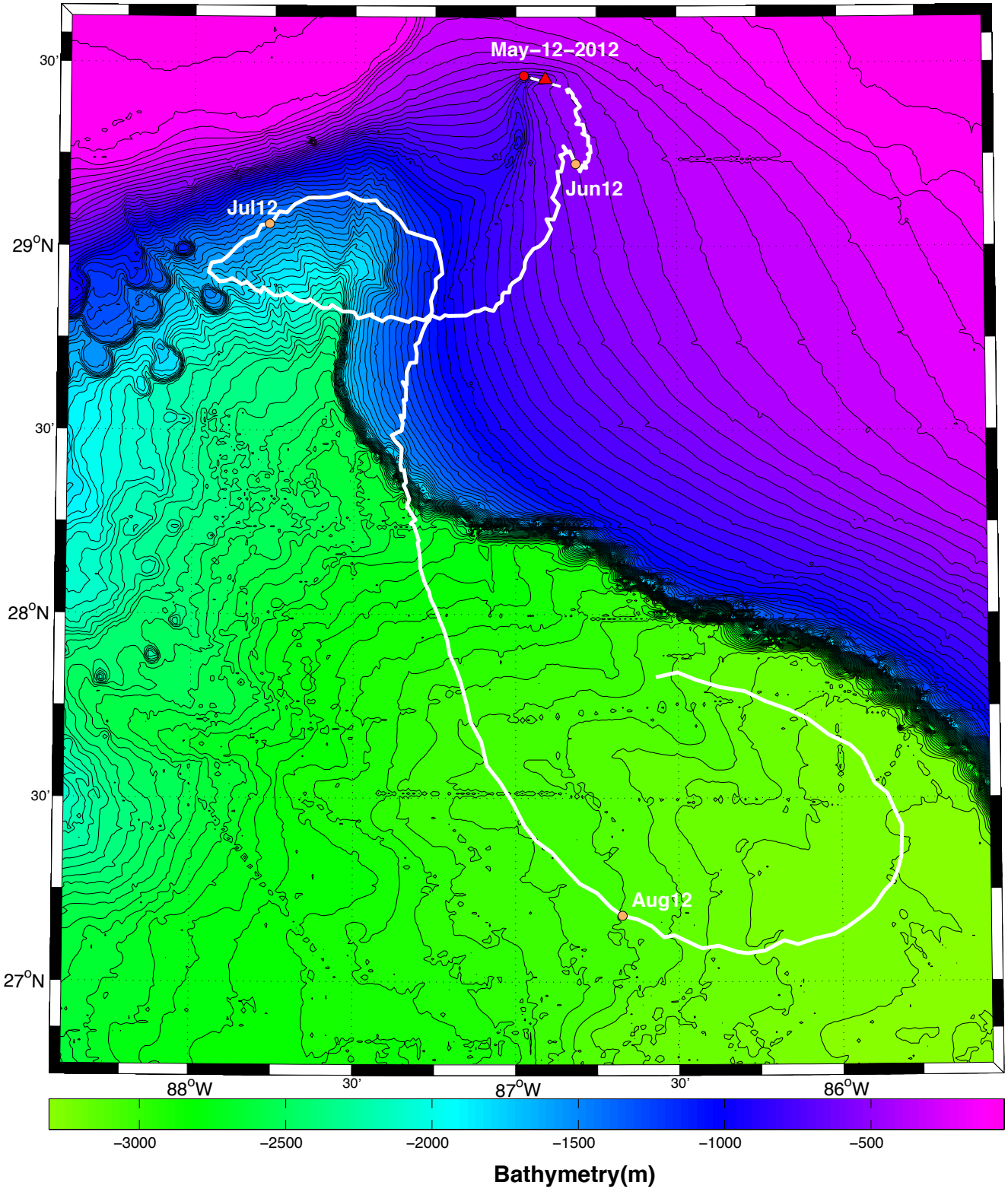

RF 1195
500
1000
1500
2000
2500
3000
Depth(m)
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)

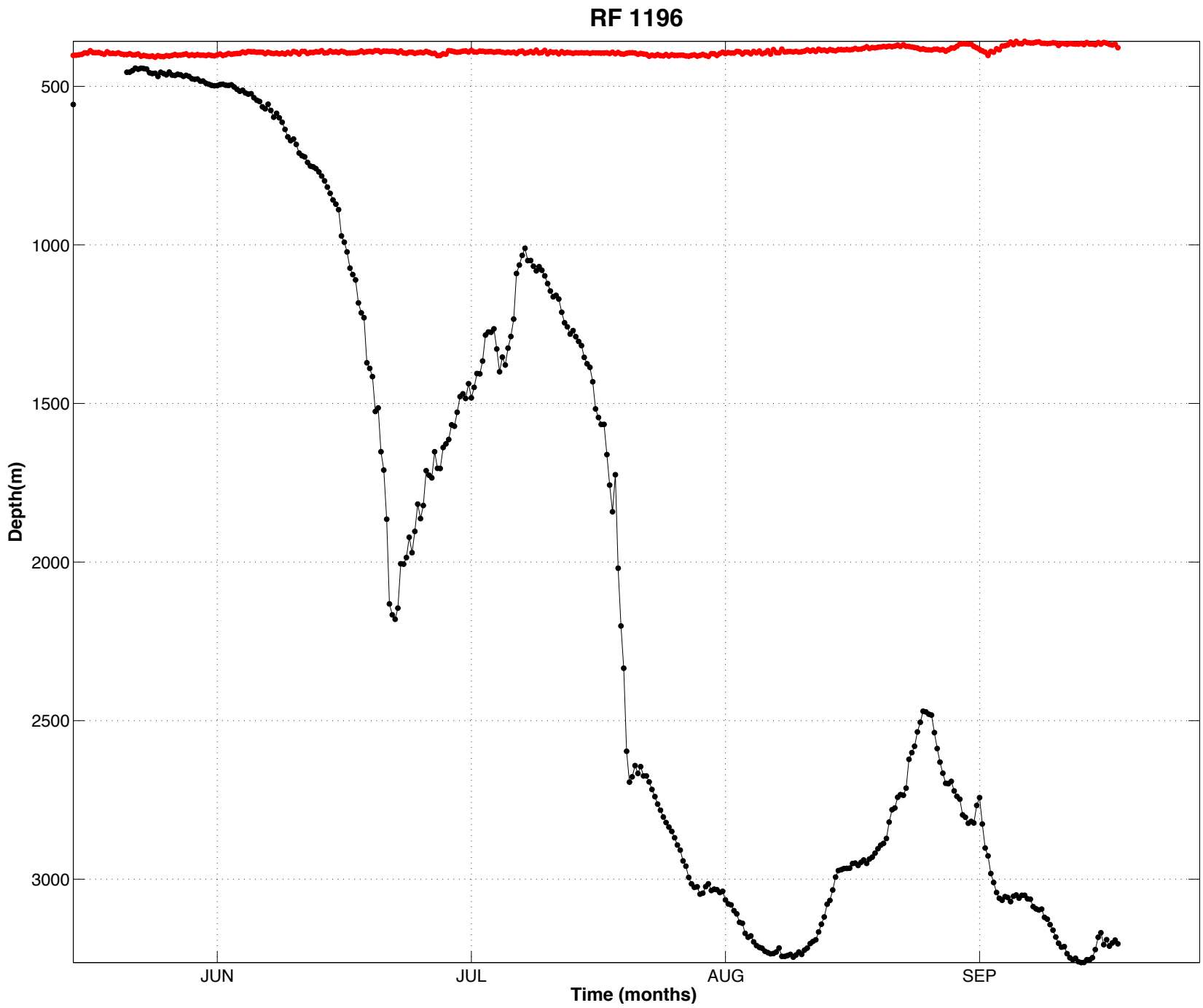

RF 1195
pressure(db)
400
450
500
temperature(°C)
10.5
10
9.5
9
u−velocity(m/s)
0.1
0
−0.1
−0.2
v−velocity(m/s)
0.1
0
−0.1
u−v velocity(cm/s)
20
0
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2012
2013
Time (months)

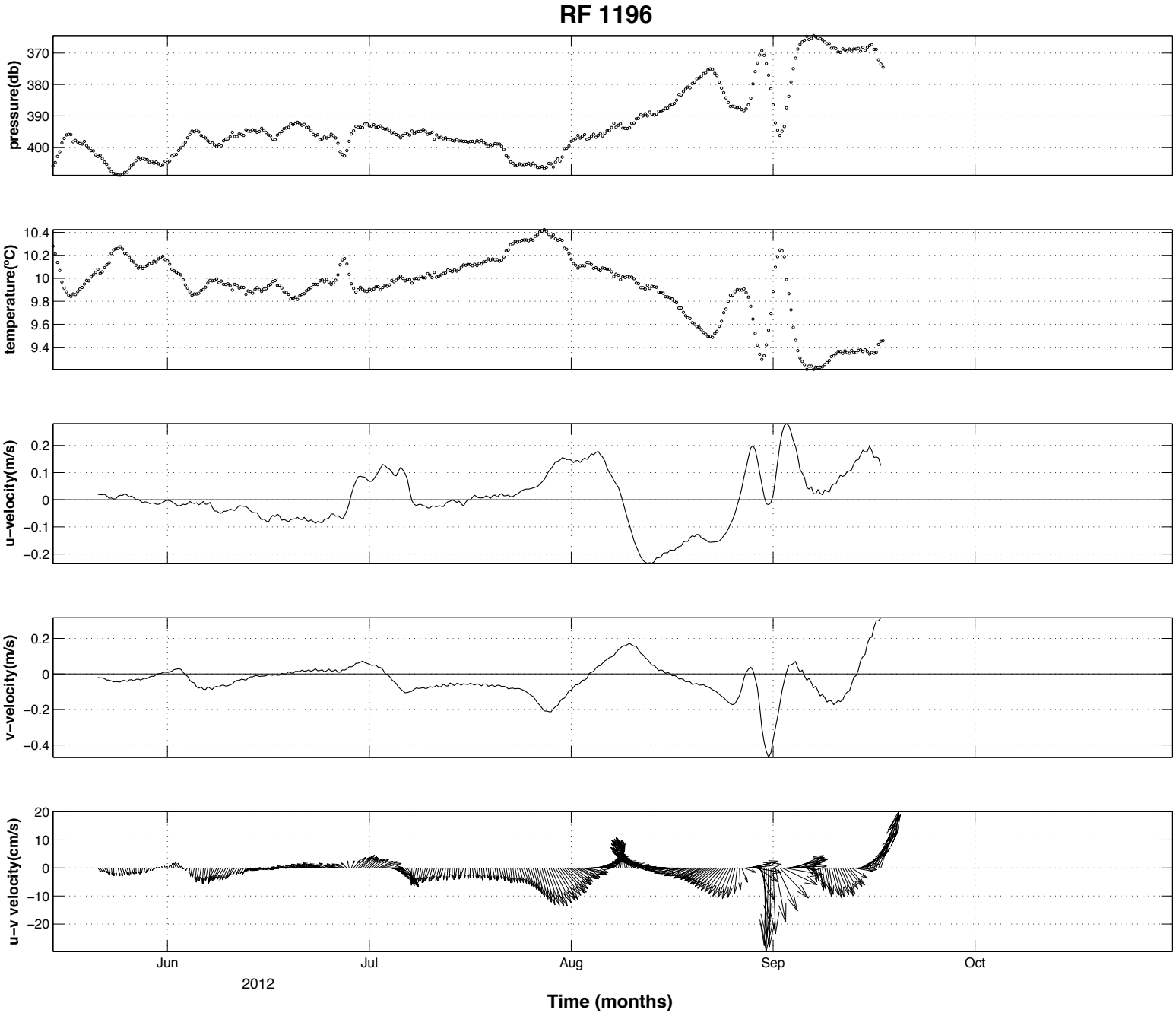
RF 1196 – 32% tracked, 10-day interpolation



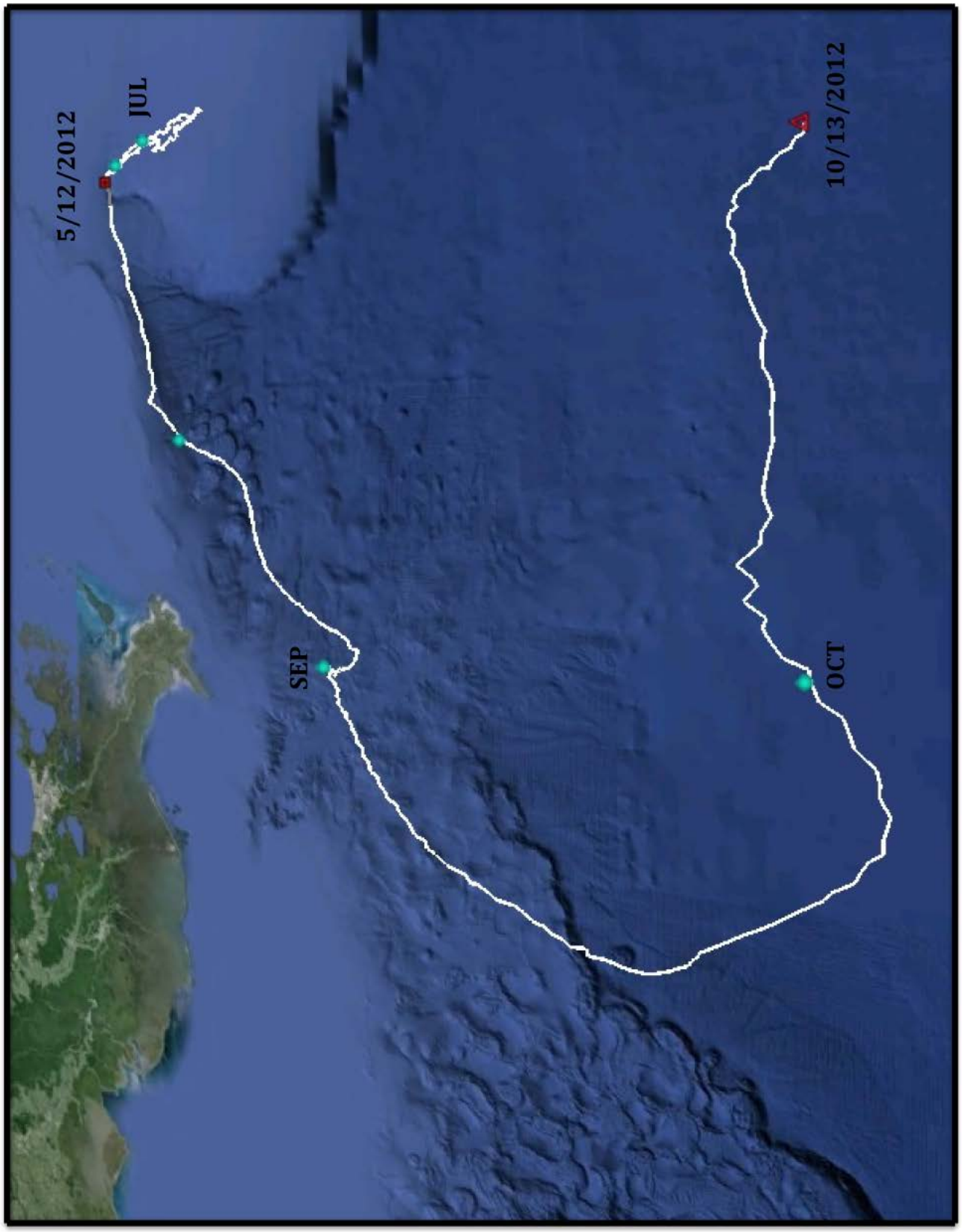
RF1196 – 3 month track

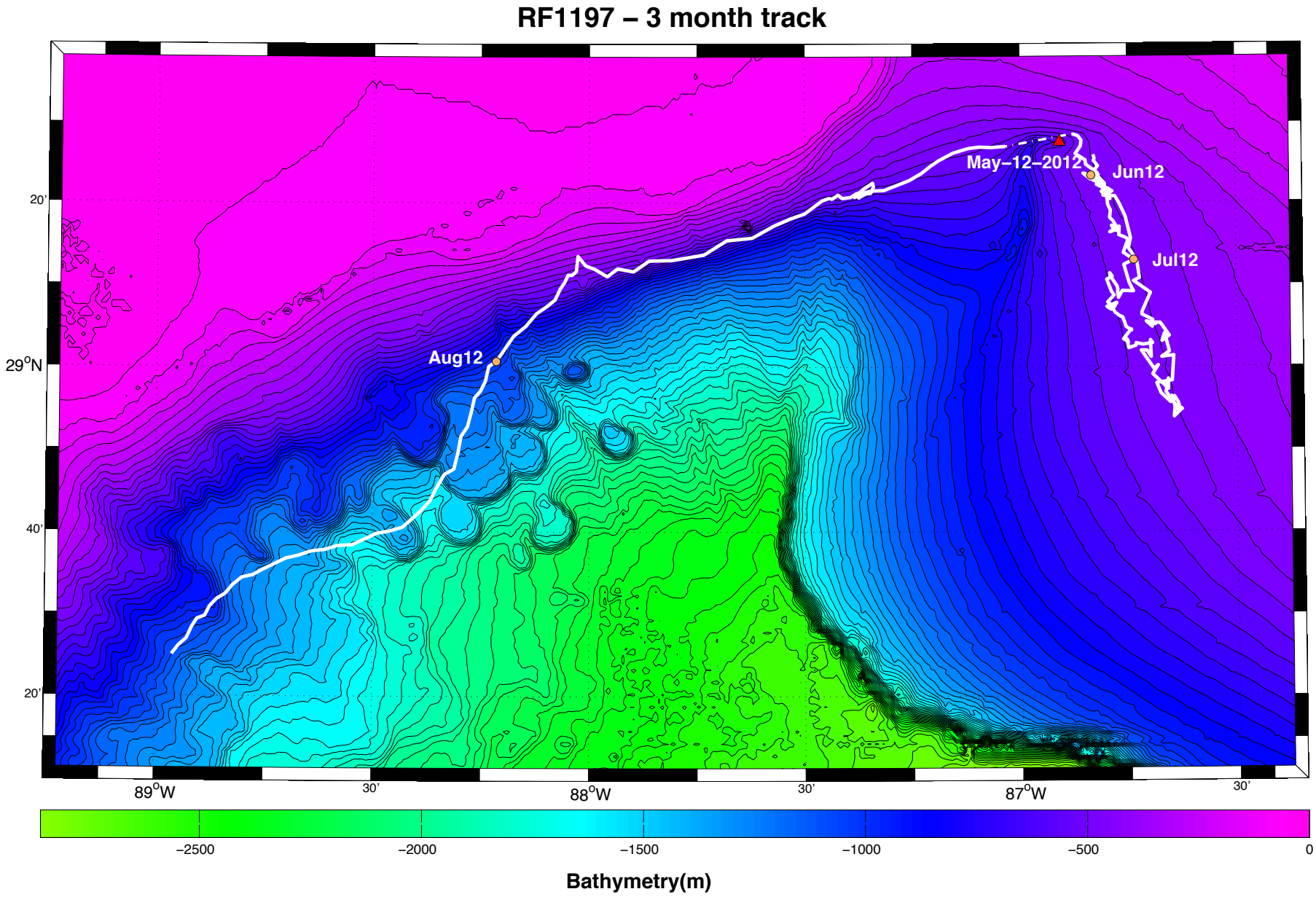



RF 1196
500
1000
1500
2000
2500
3000
Depth(m)
JUN
JUL
AUG
SEP
Time (months)

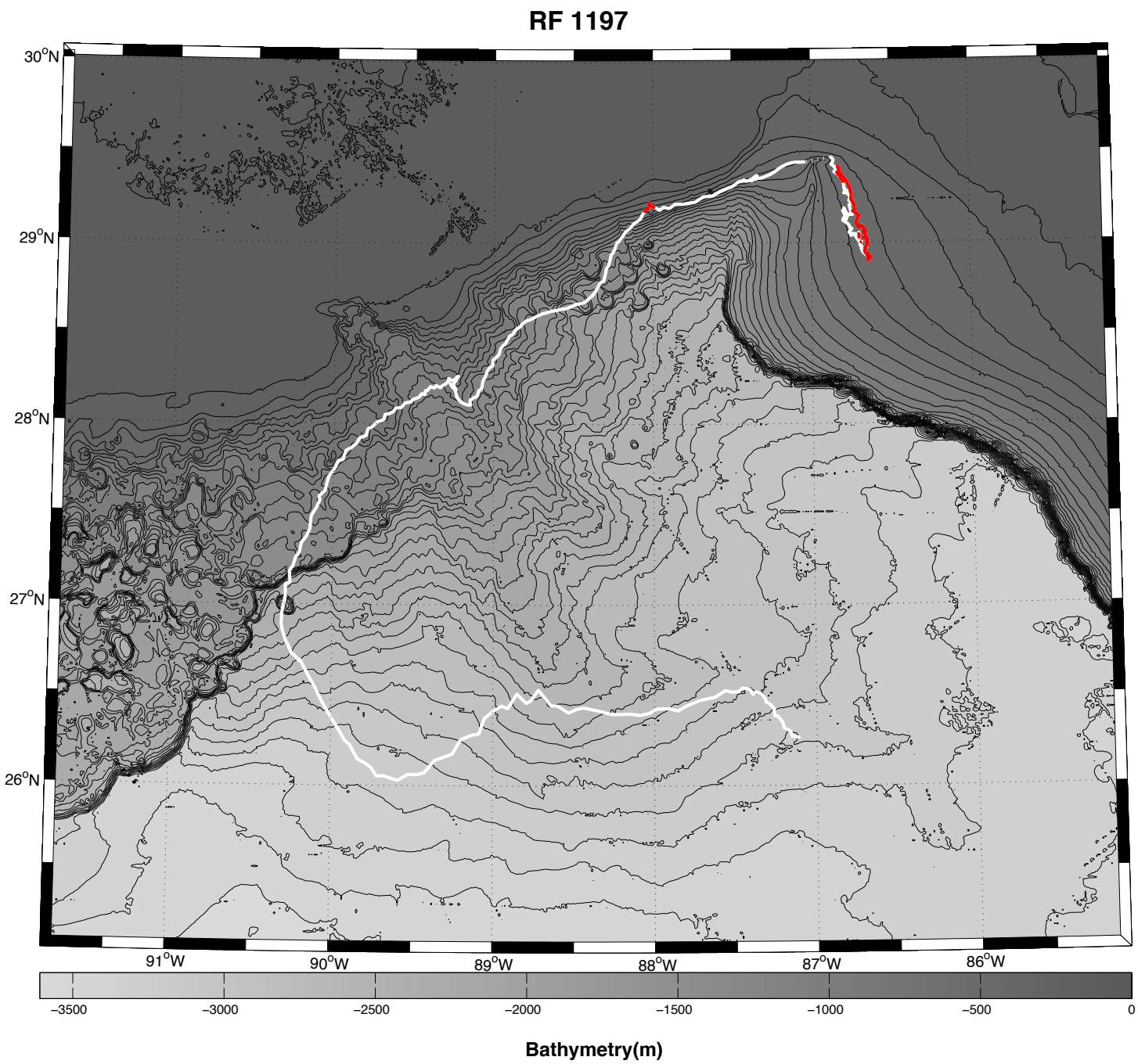

RF 1196
pressure(db)
370
380
390
400
temperature(°C)
10.4
10.2
10
9.8
9.6
9.4
u−velocity(m/s)
0.2
0.1
0
−0.1
−0.2
v−velocity(m/s)
0.2
0
−0.2
−0.4
u−v velocity(cm/s)
20
10
0
−10
−20
Jun
Jul
Aug
Sep
Oct
2012
Time (months)

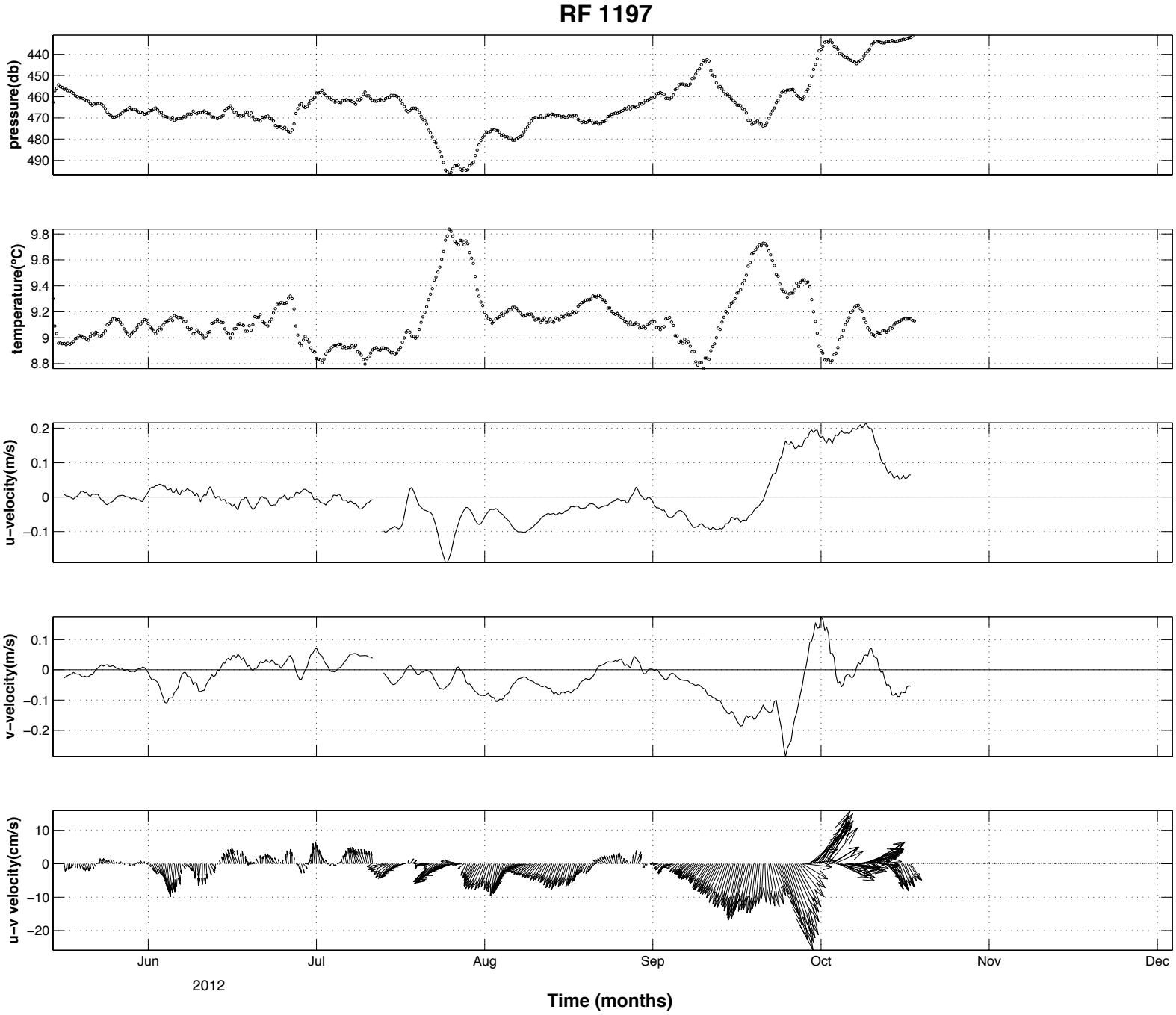
RF 1197 – 41% tracked, 10-day interpolation



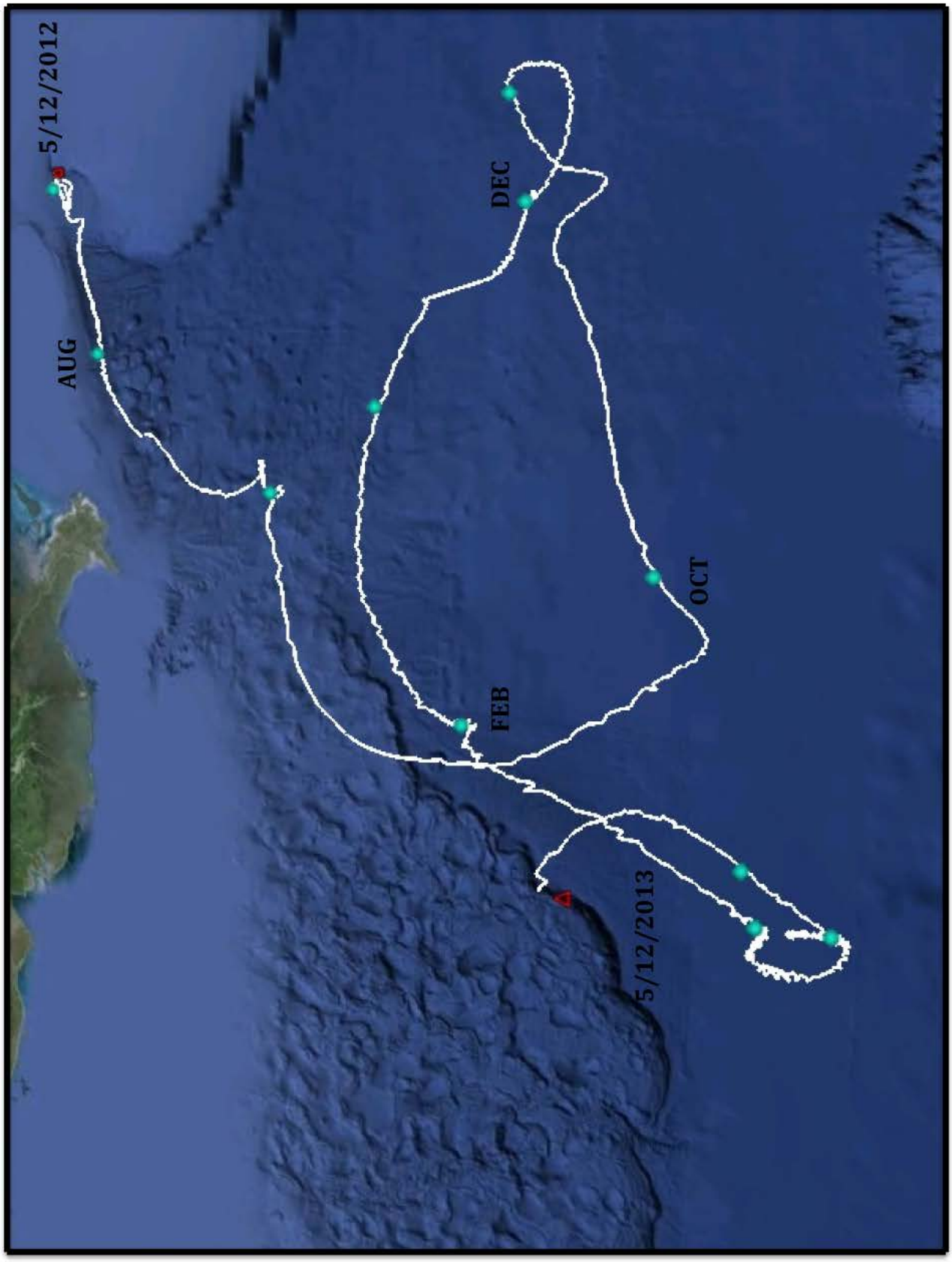

RF1197 – 3 month track
May–12–2012
Jun12
Jul12
Aug12
20'
29°N
40'
20'
89°W
30'
88°W
30'
87°W
30'
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

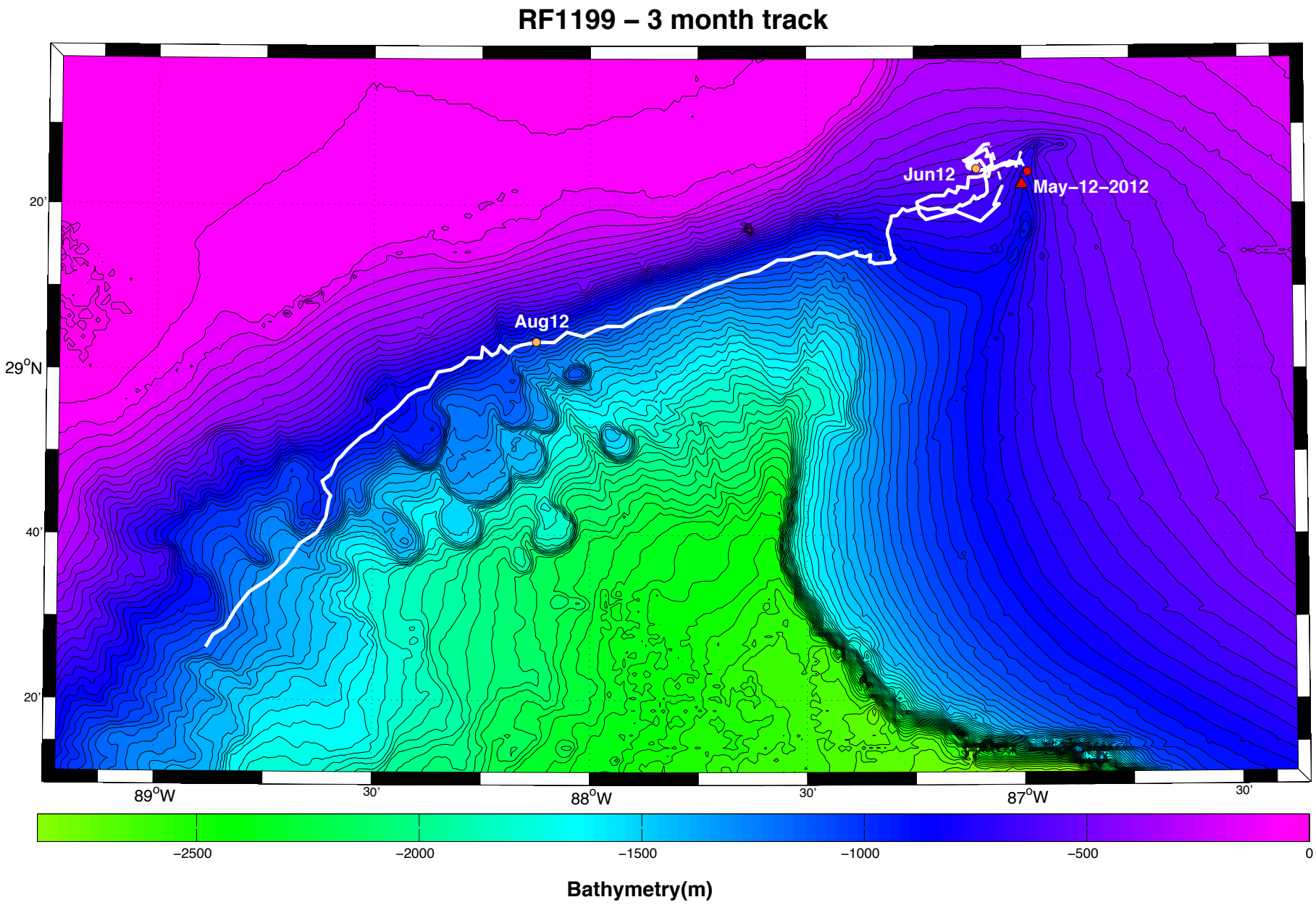

RF 1199
500
1000
1500
2000
2500
3000
3500
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)

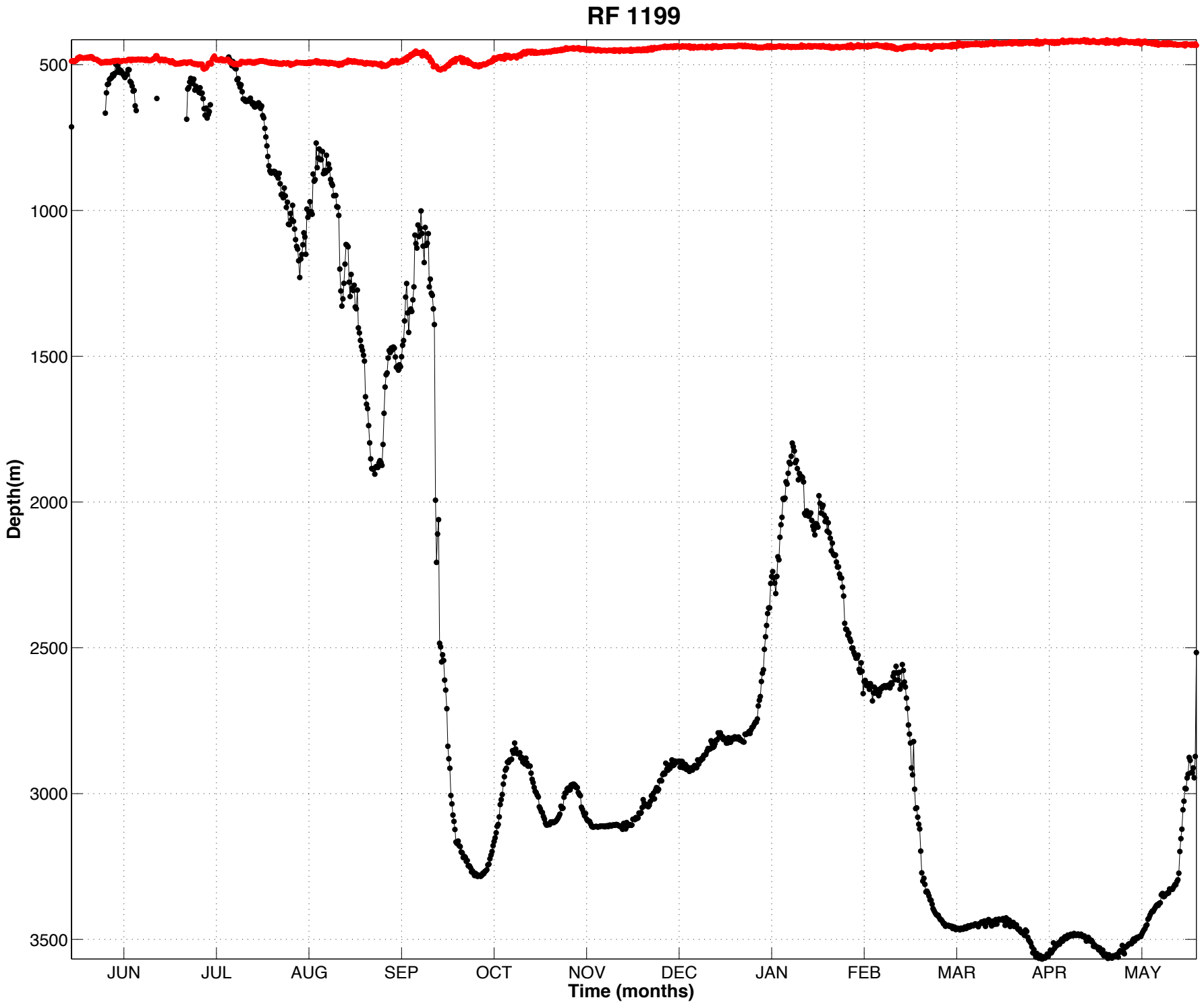

RF 1197
30°N
29°N
28°N
27°N
26°N
91°W
90°W
89°W
88°W
87°W
86°W
−3500
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)


RF 1197
pressure(db)
440
450
460
470
480
490
temperature(°C)
9.8
9.6
9.4
9.2
9
8.8
u−velocity(m/s)
0.2
0.1
0
−0.1
v−velocity(m/s)
0.1
0
−0.1
−0.2
u−v velocity(cm/s)
10
0
−10
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
2012
Time (months)

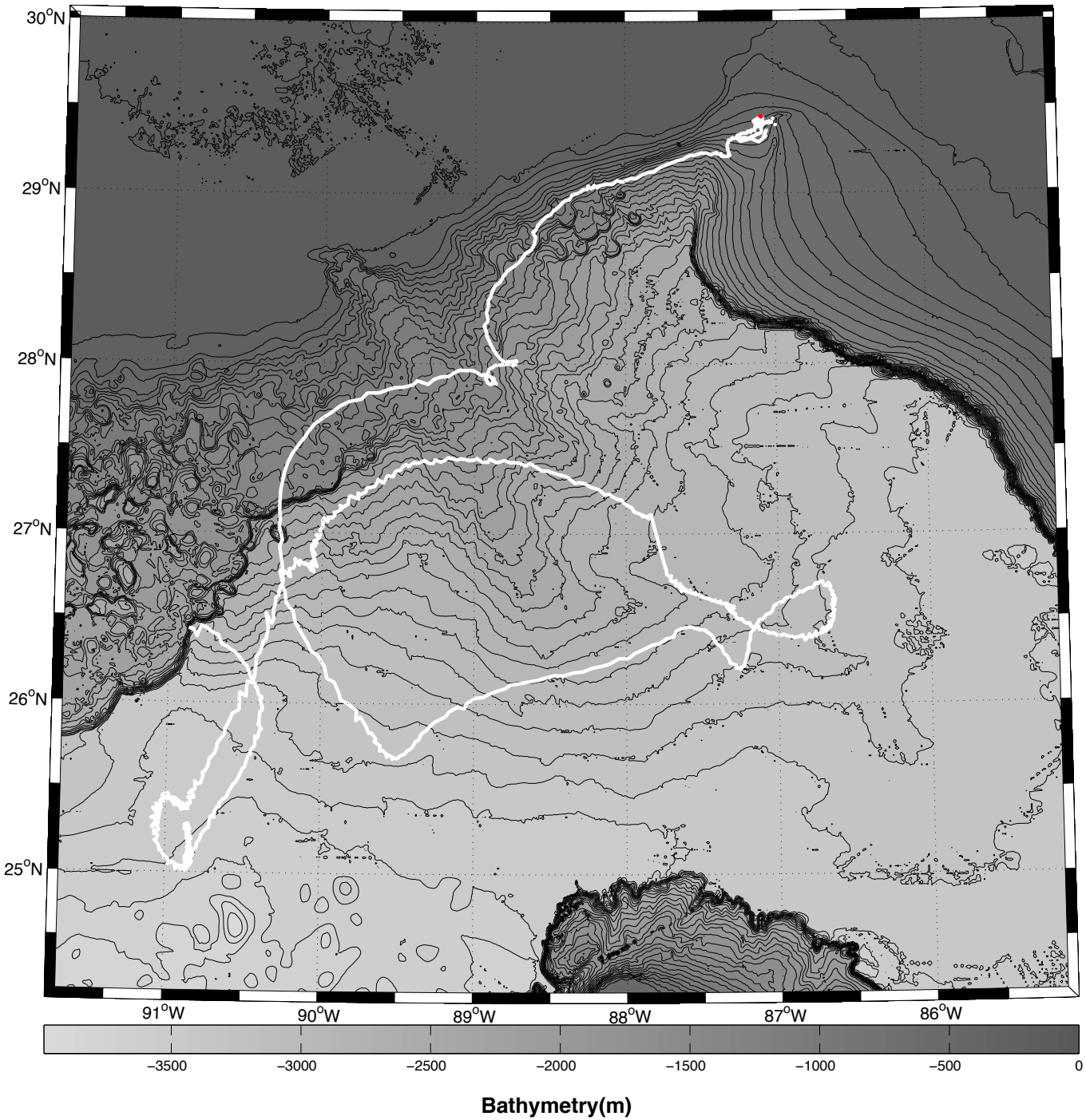
RF 1199 – 92% tracked, 10-day interpolation

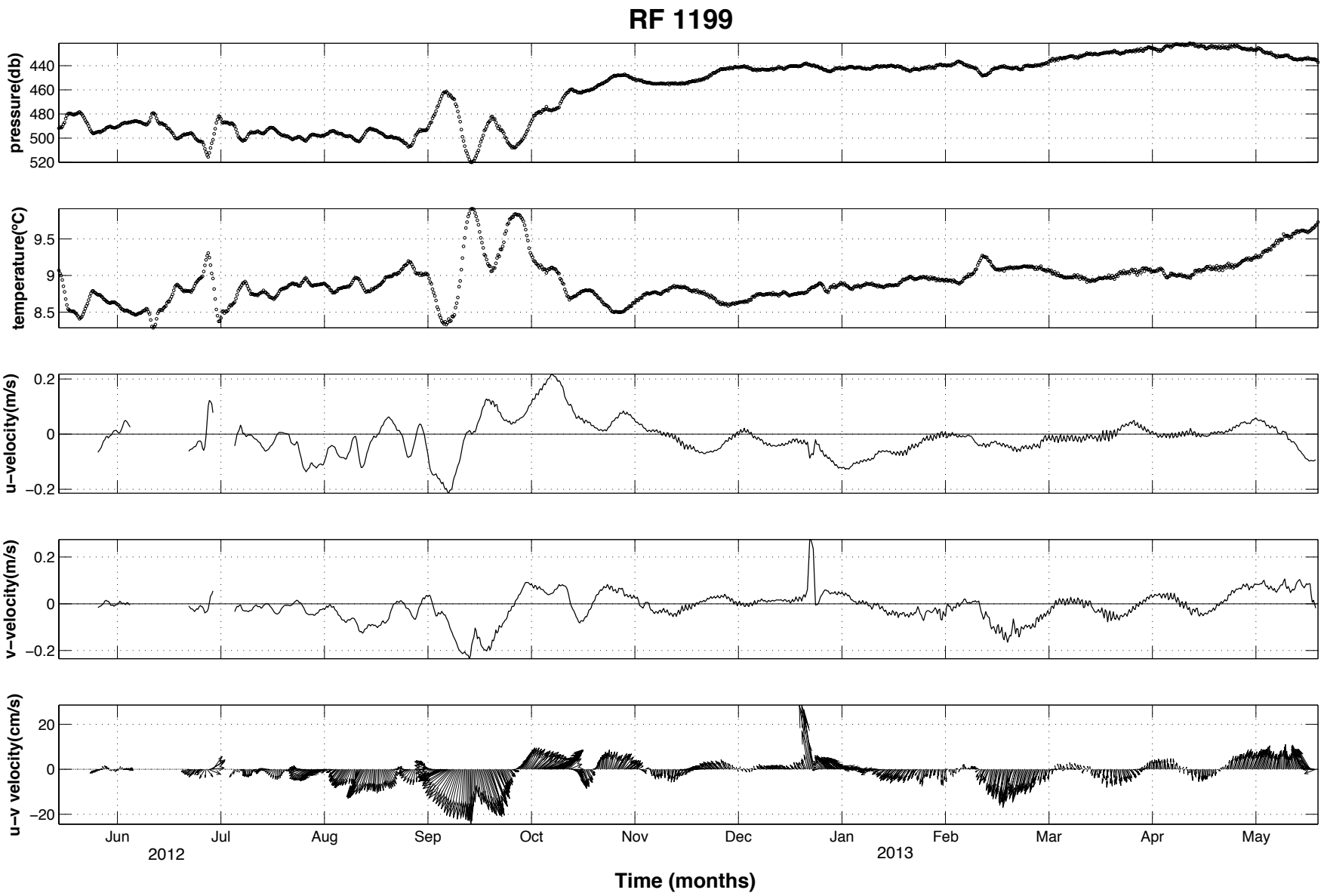



RF1199 – 3 month track
Jun12
May–12–2012
Aug12
20'
29°N
40'
20'
89°W
30'
88°W
30'
87°W
30'
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)


RF 1199
Depth(m)
500
1000
1500
2000
2500
3000
3500
JUN
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
Time (months)

RF 1199


30°N
29°N
28°N
27°N
26°N
25°N
91°W
90°W
89°W
88°W
87°W
86°W
−3500
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

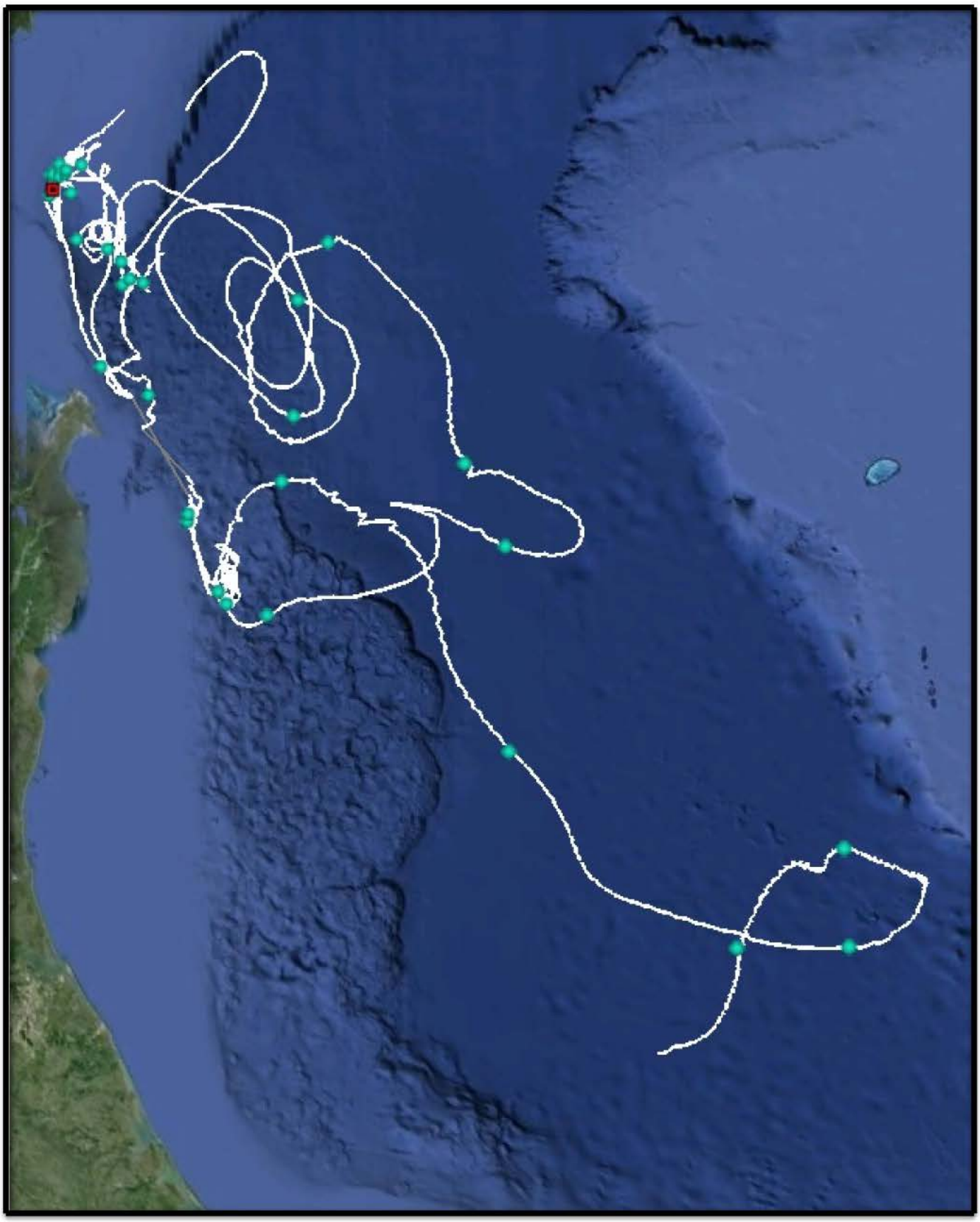

RF 1199
pressure(db)
440
460
480
500
520
temperature(°C)
9.5
9
8.5
u−velocity(m/s)
0.2
0
−0.2
v−velocity(m/s)
0.2
0
−0.2
u−v velocity(cm/s)
20
0
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2012
2013
Time (months)

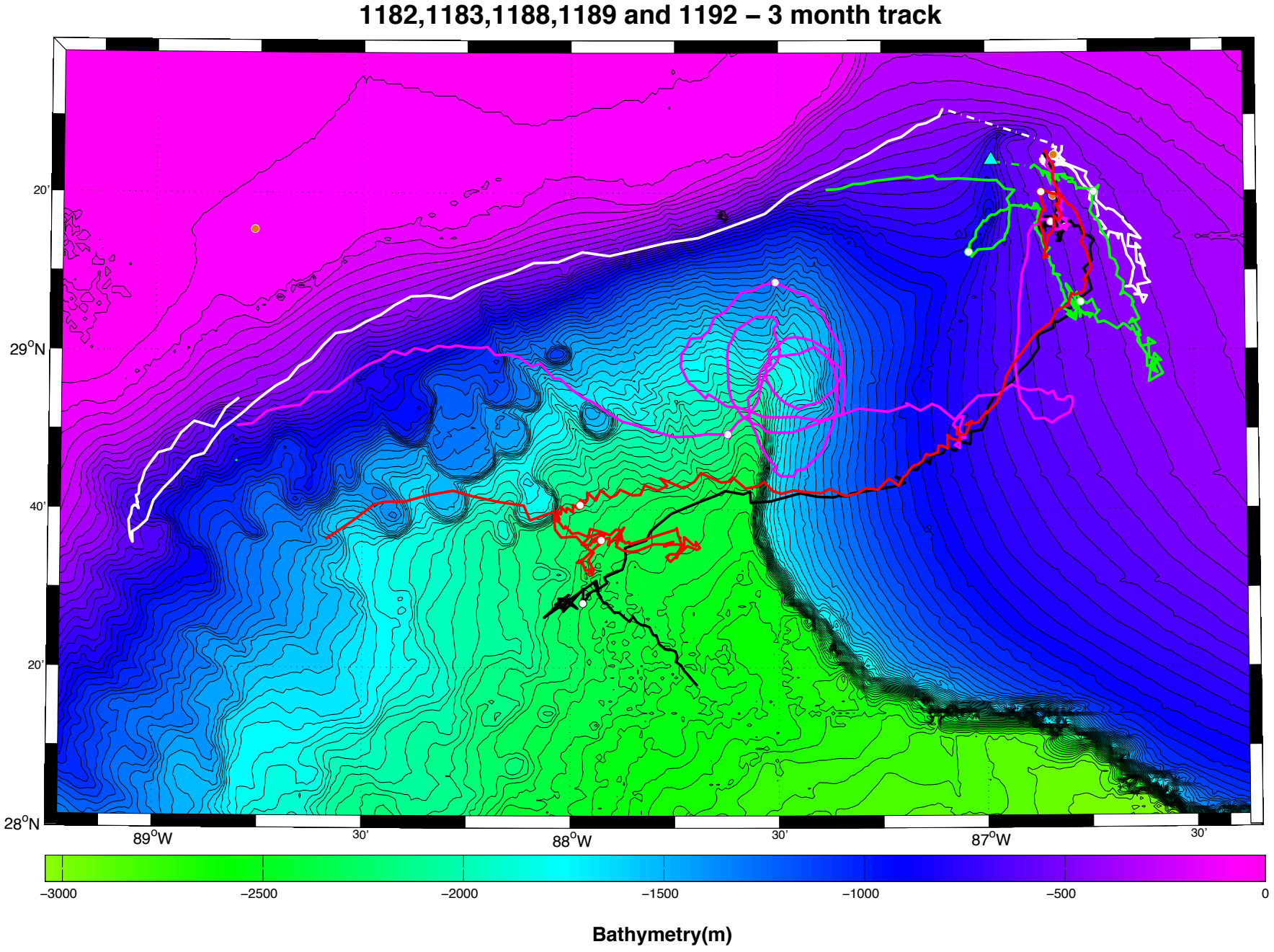
Appendix C

Floats are grouped based on deployment location and time. For each grouping, the entire track, the first 90 days of track, the first 30 days of track[5] and velocity vectors are shown in individual figures. Track plot bathymetry is from Google Earth or shaded in 25-meter intervals, for entire track or 90 day track respectively. Monthly positions are marked as dots, colors varying with plots. Launch position is marked with a red square, turquois triangle or black triangle. The title on each trajectory plot includes the float in each group. Floats that failed or that stayed at the surface for their entire mission are not included.

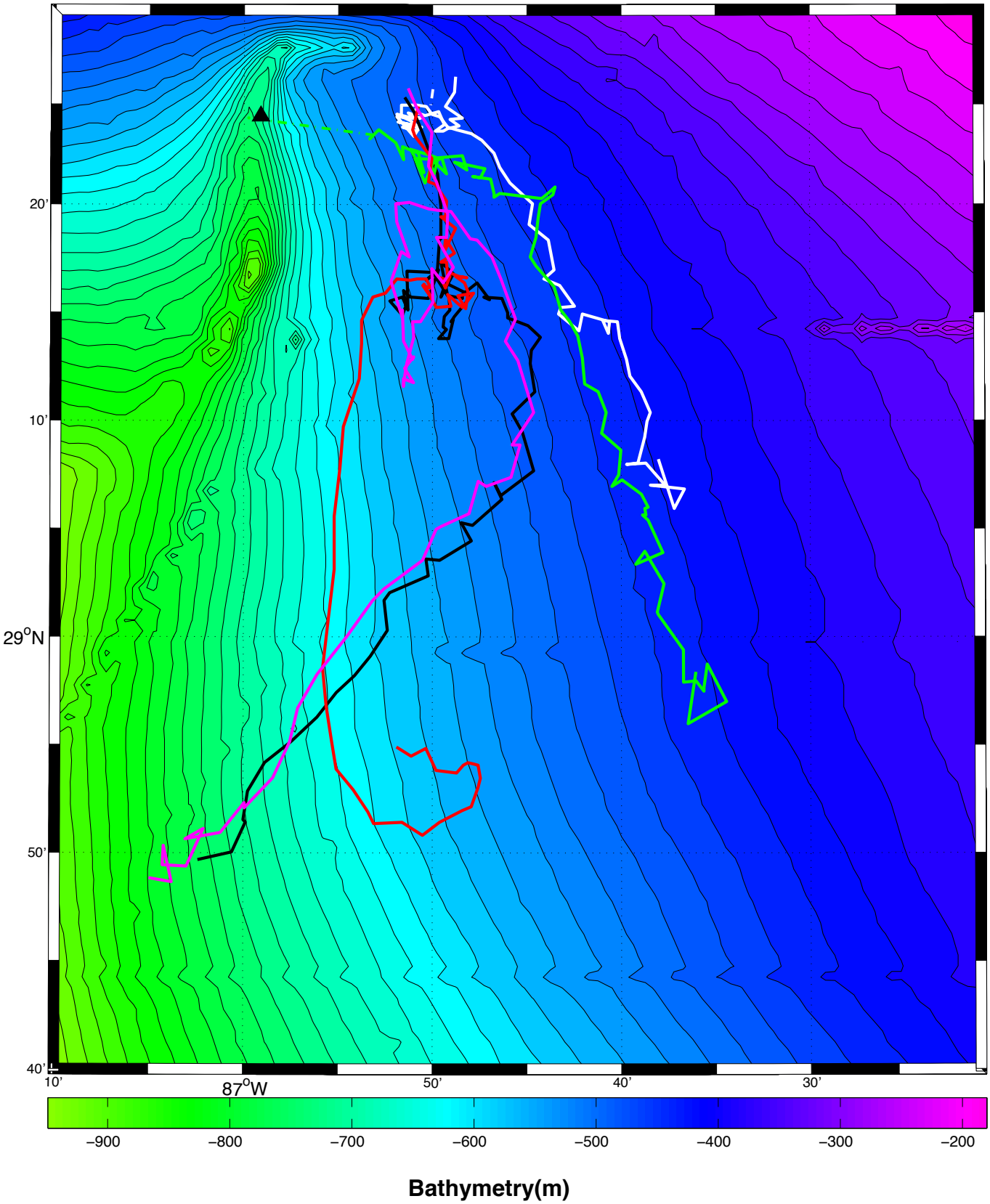
[5] A plot of the first 30 days of track is only available for the quintuplet group.

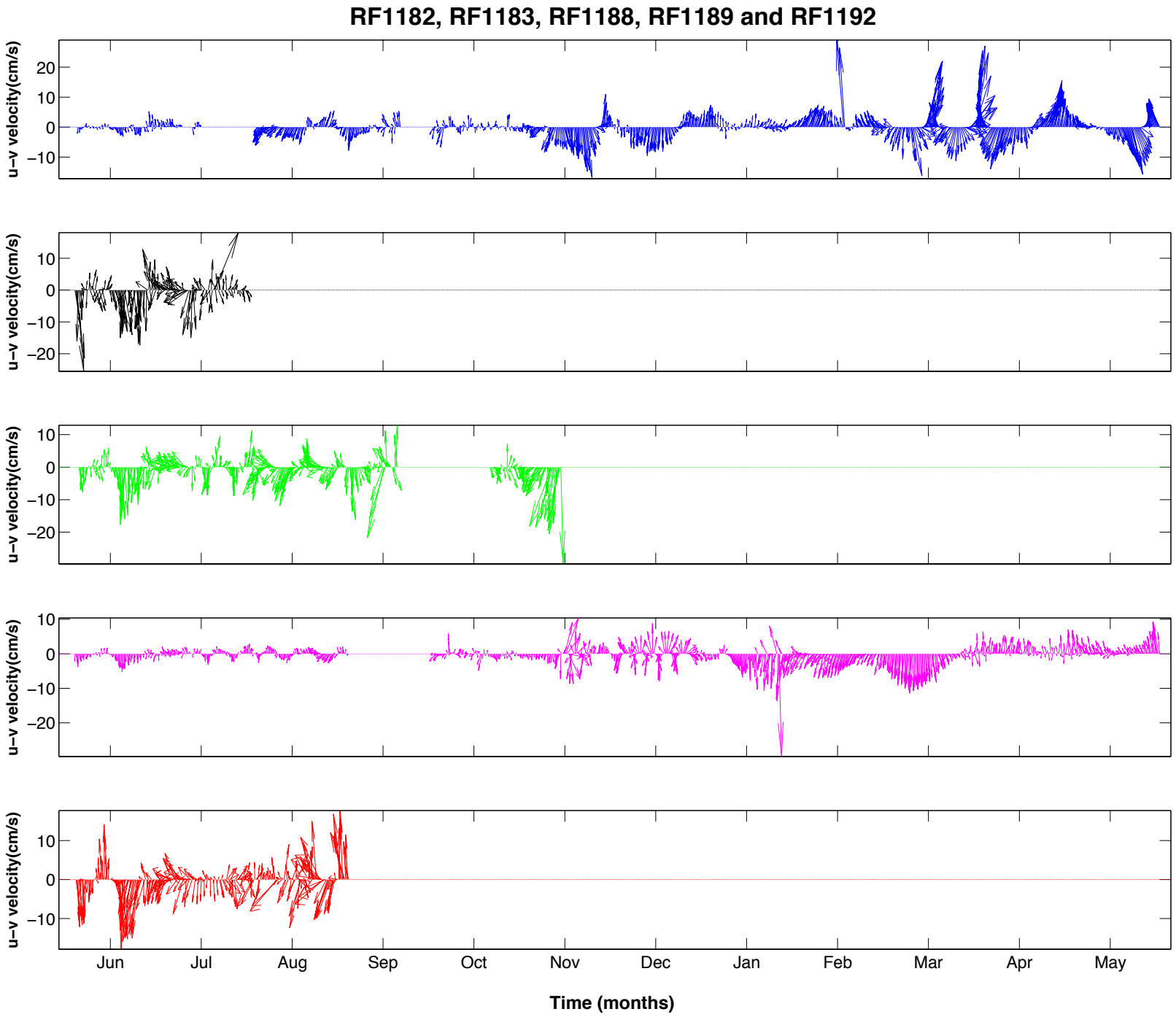
RF 1182, RF 1183, RF 1188, RF 1189, and RF 1192



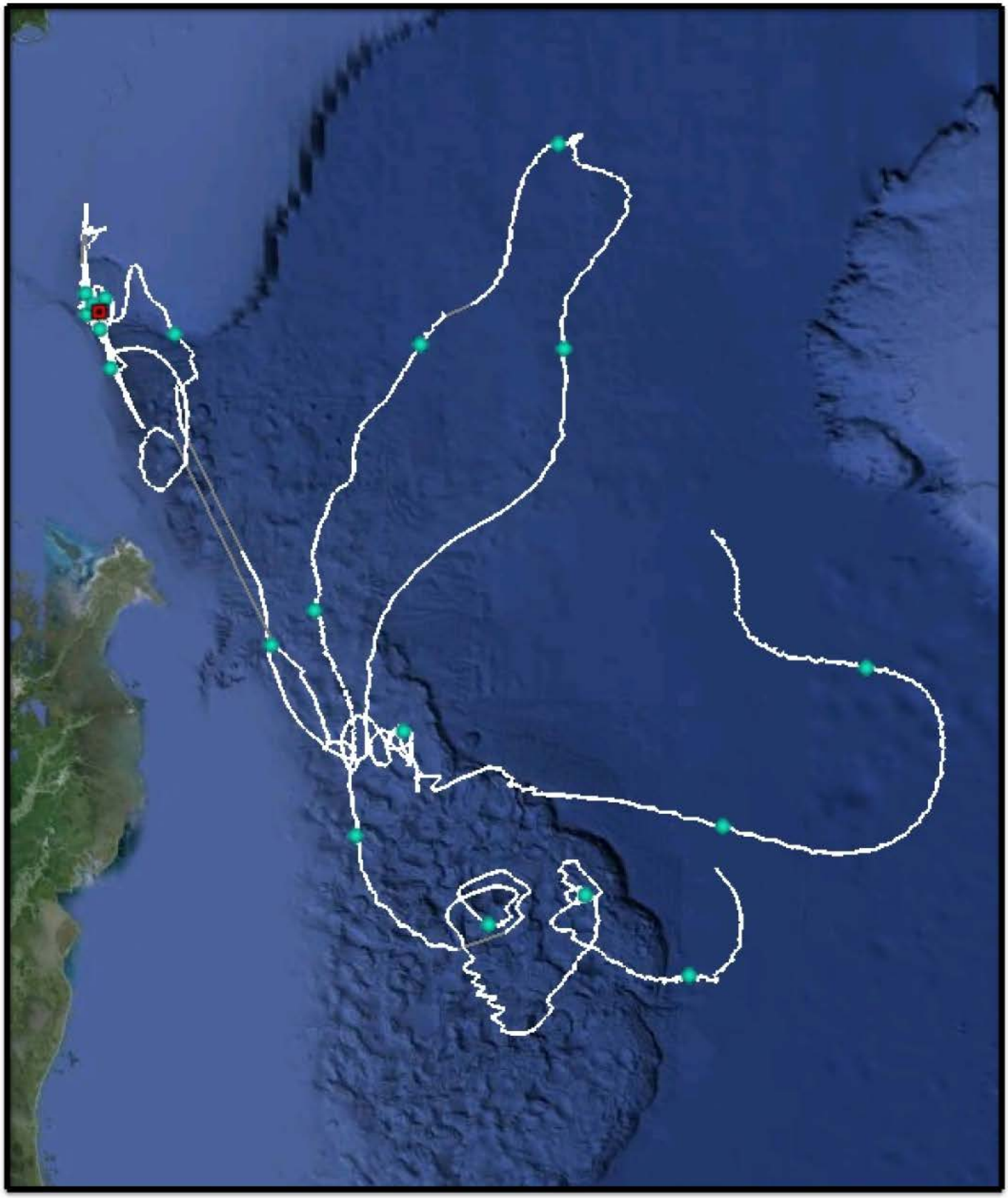

1182,1183,1188,1189 and 1192 – 3 month track
20'
29°N
40'
20'
28°N
89°W
30'
88°W
30'
87°W
30'
−3000
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

1182,1183,1188,1189 and 1192 – 1 month track

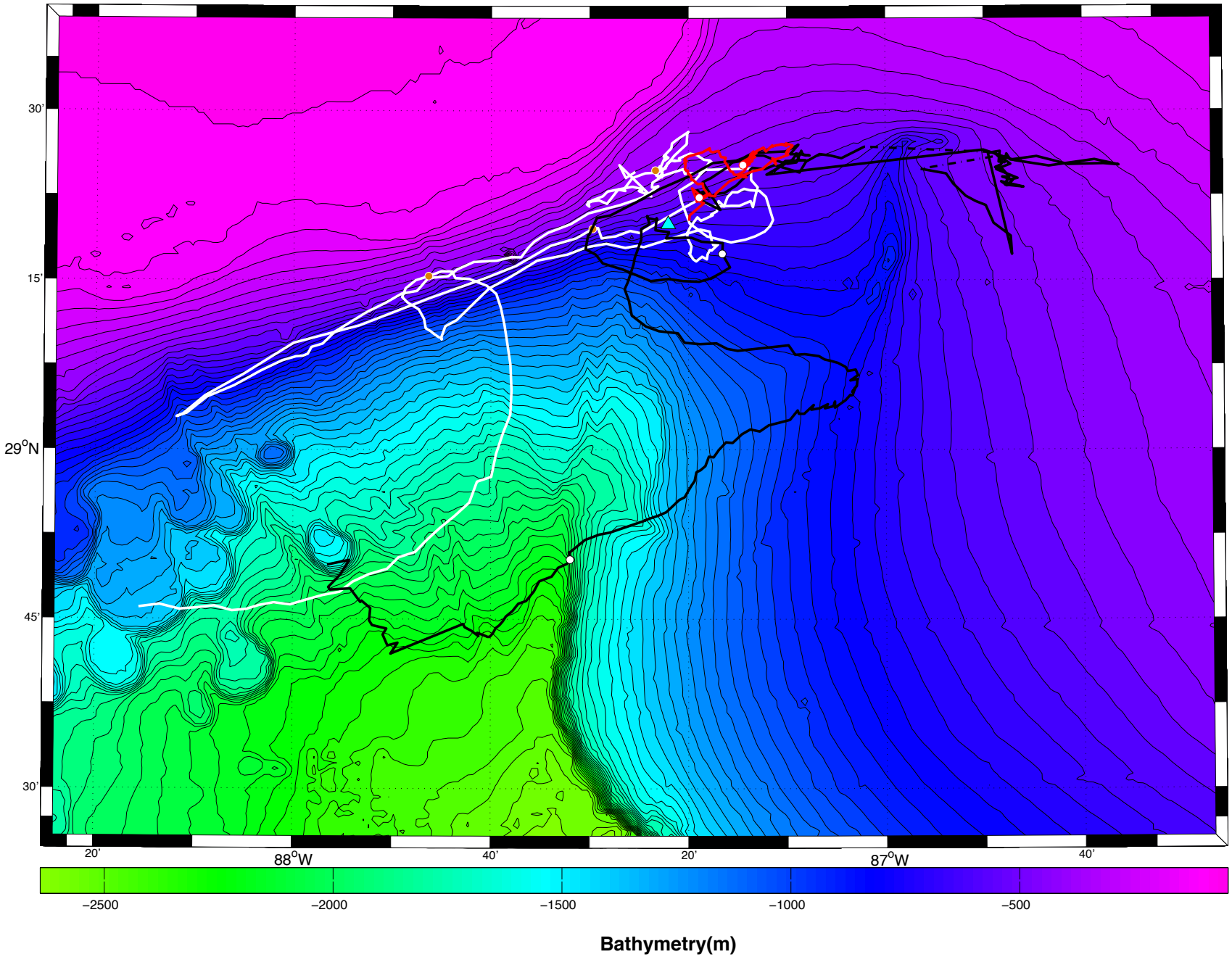


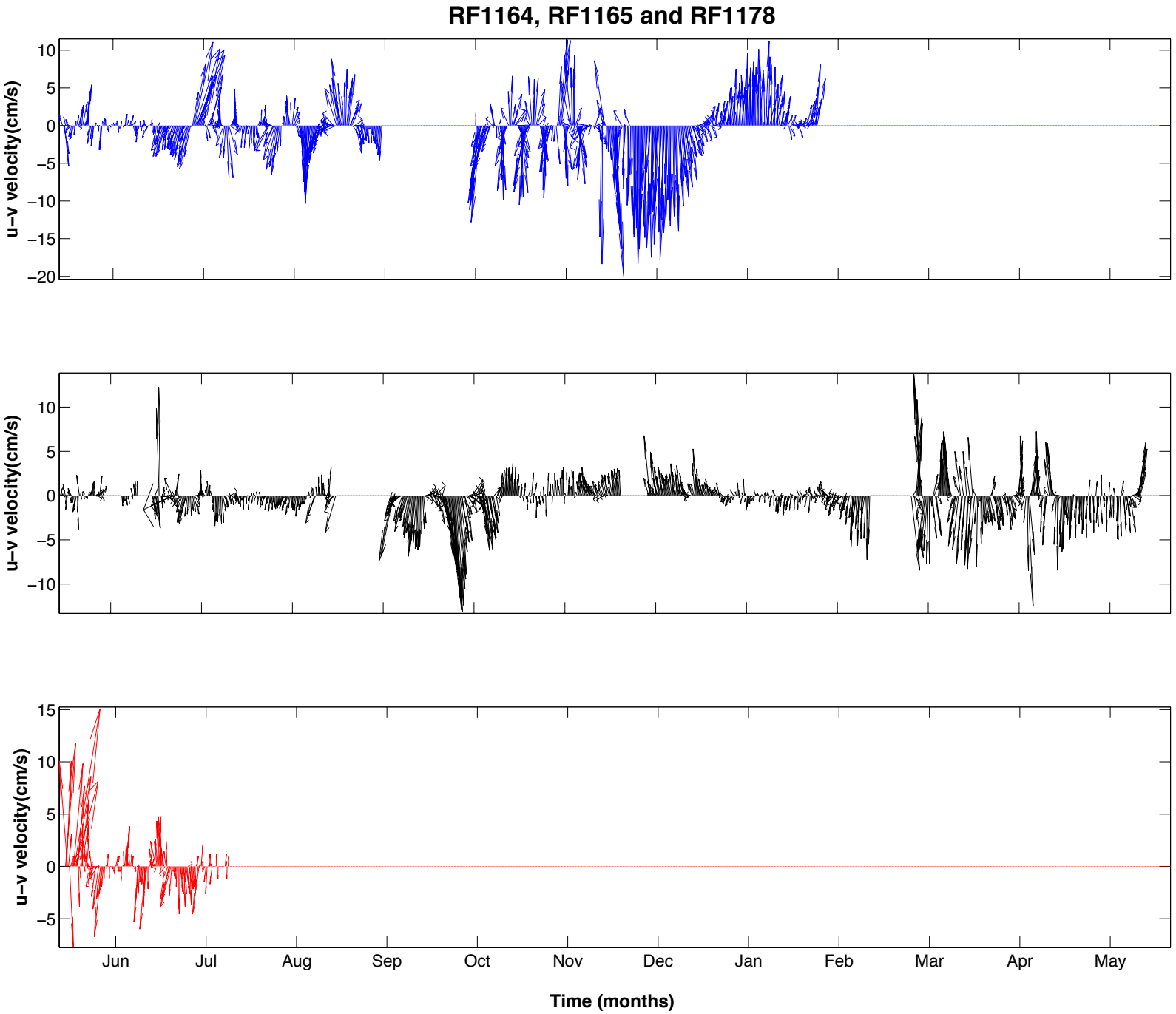

RF1182, RF1183, RF1188, RF1189 and RF1192
u–v velocity(cm/s)
20
10
0
−10
u–v velocity(cm/s)
10
0
−10
−20
u–v velocity(cm/s)
10
0
−10
−20
u–v velocity(cm/s)
10
0
−10
−20
u–v velocity(cm/s)
10
0
−10
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)

RF 1164, RF 1165 and RF 1178

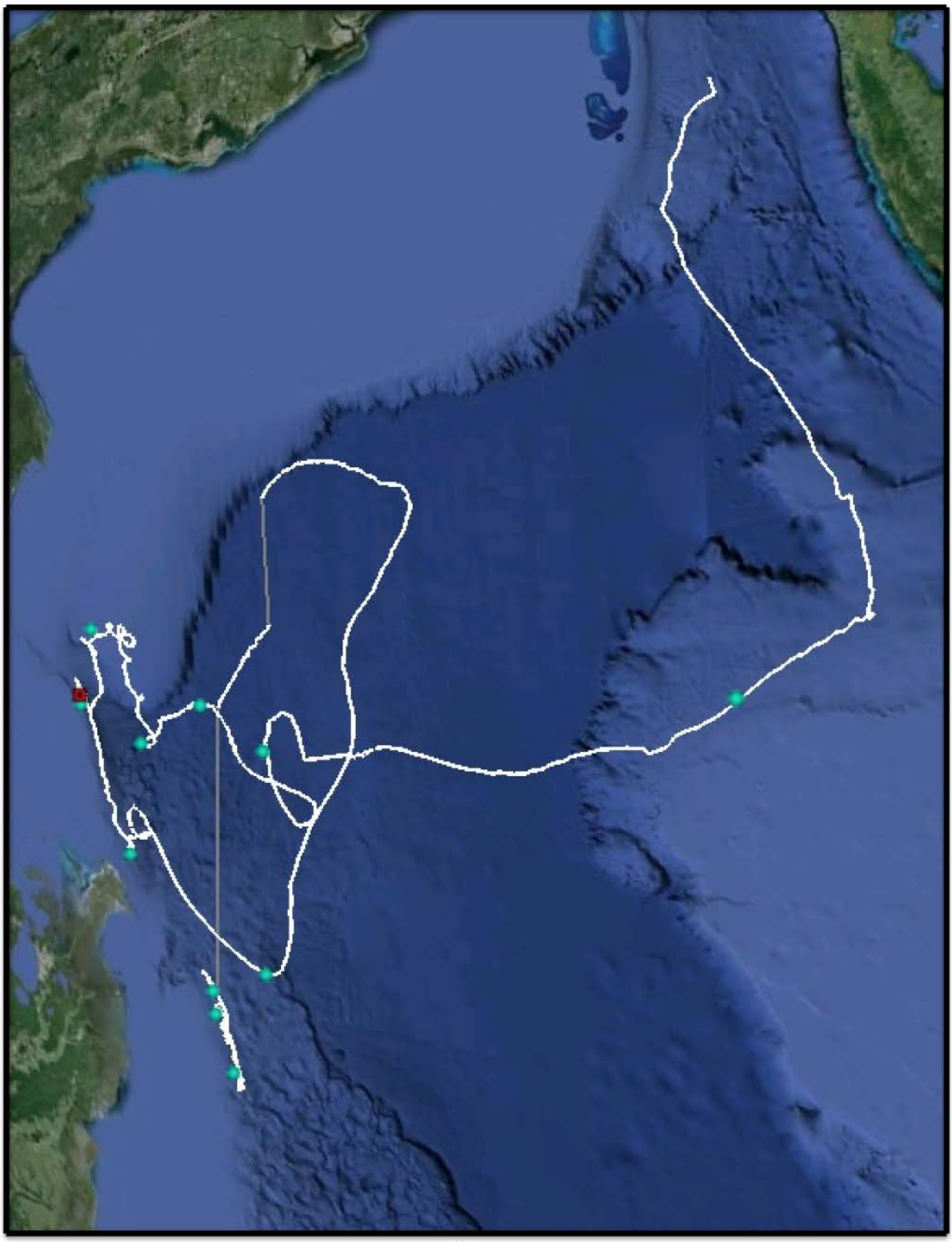


1164, 1165 and 1178 – 3 month track

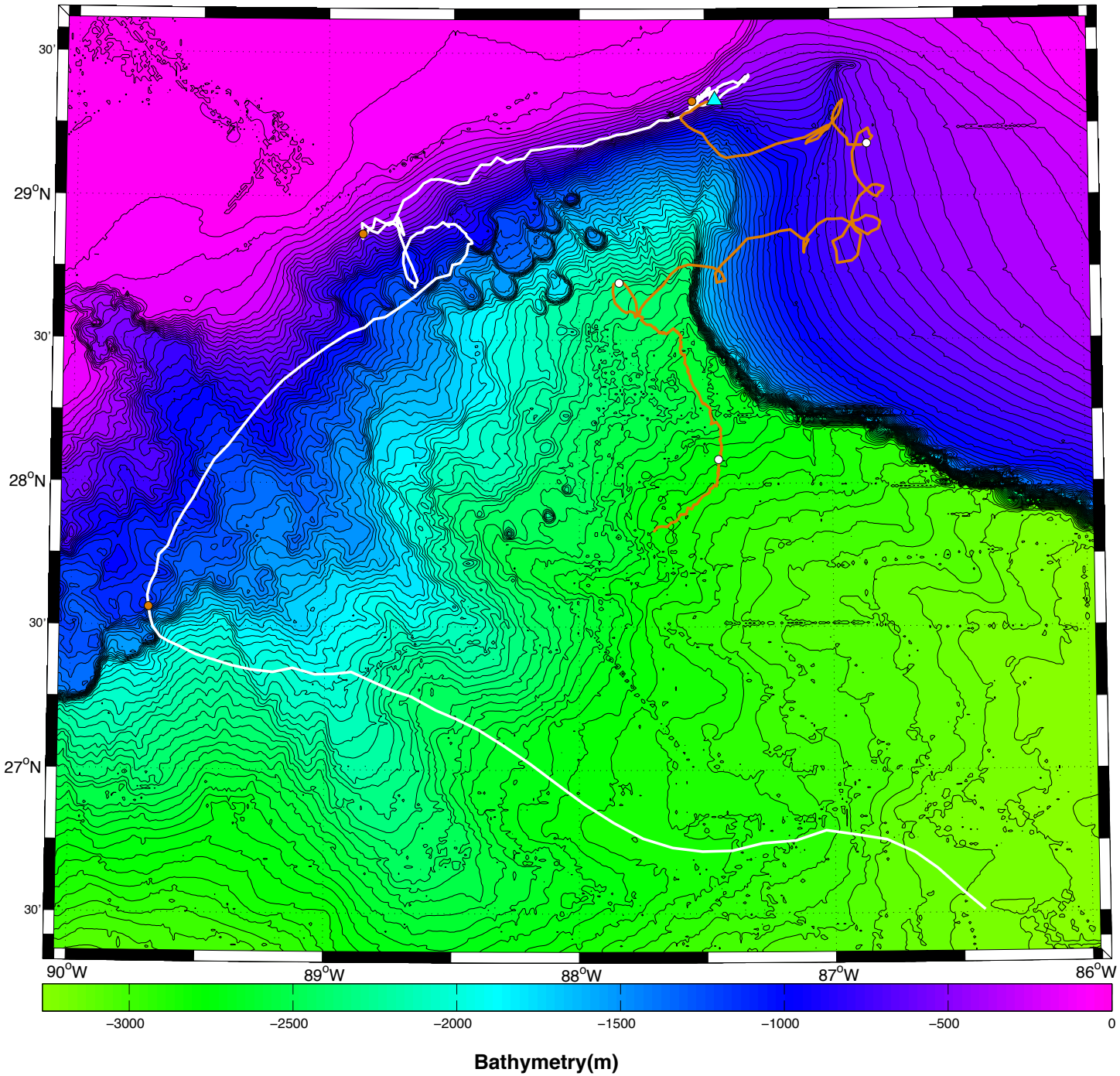


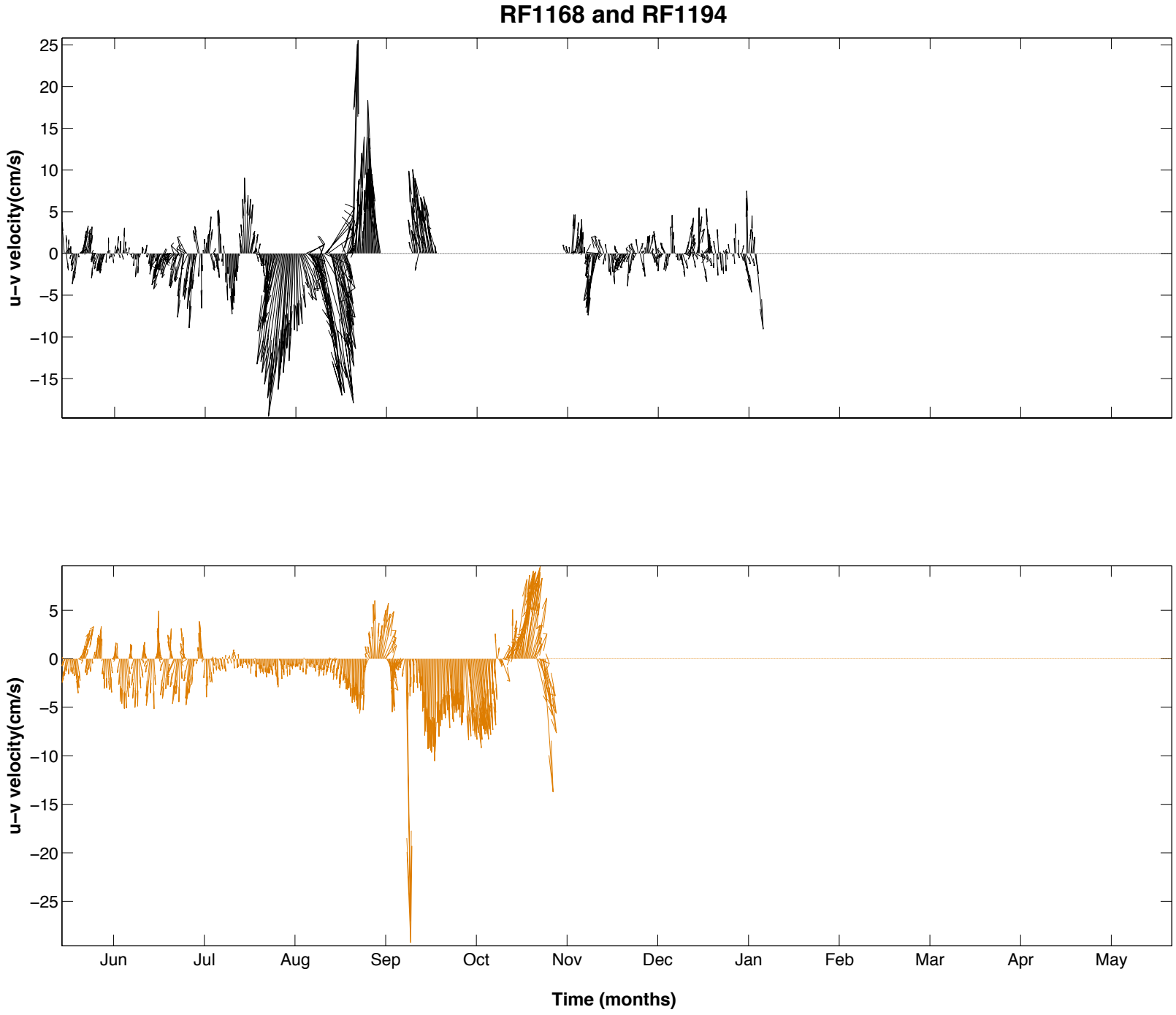

RF1164, RF1165 and RF1178
u–v velocity(cm/s)
10
5
0
−5
−10
−15
−20
u–v velocity(cm/s)
10
5
0
−5
−10
u–v velocity(cm/s)
15
10
5
0
−5
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)

RF 1168 and 1194

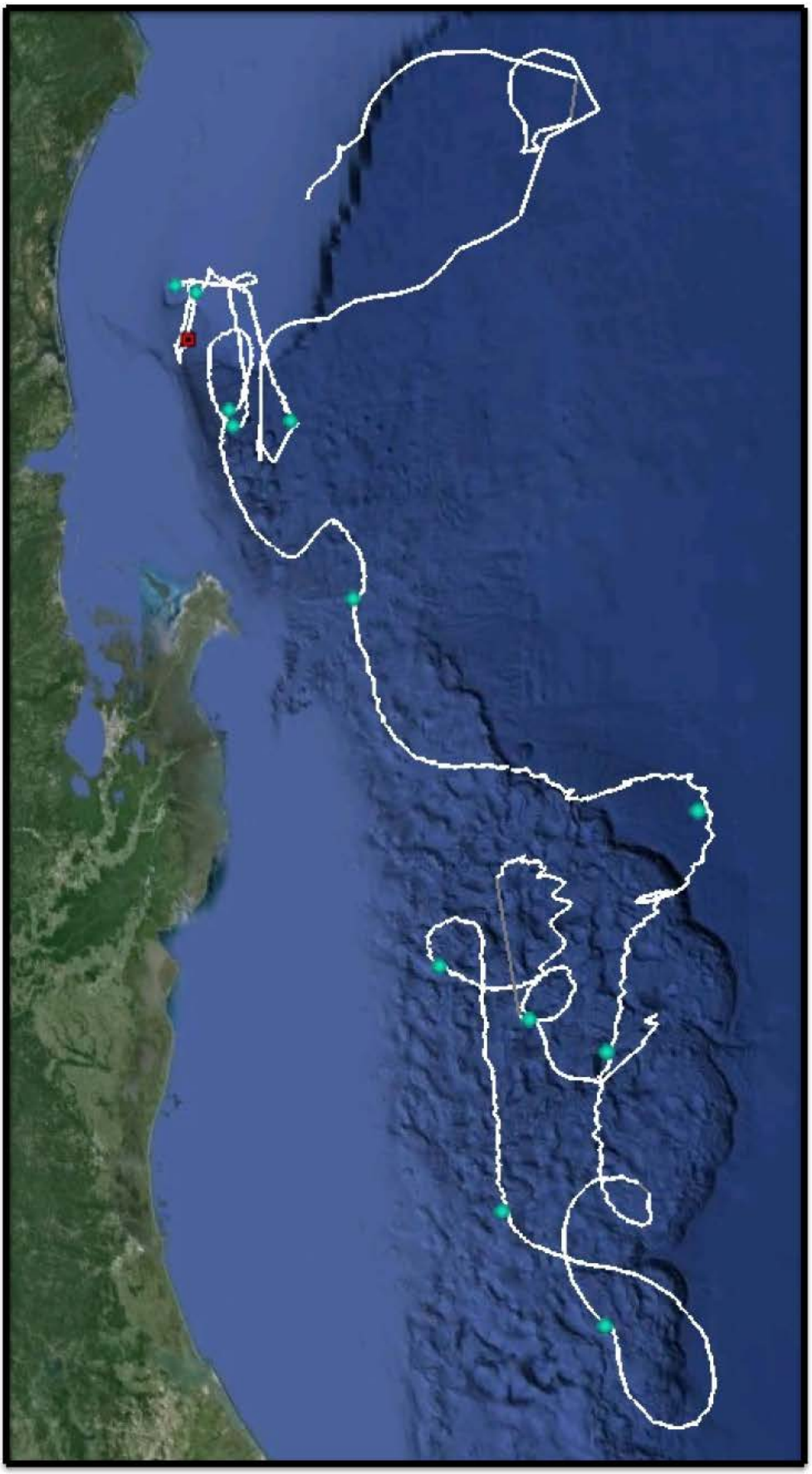


1168 and 1194 – 3 month track

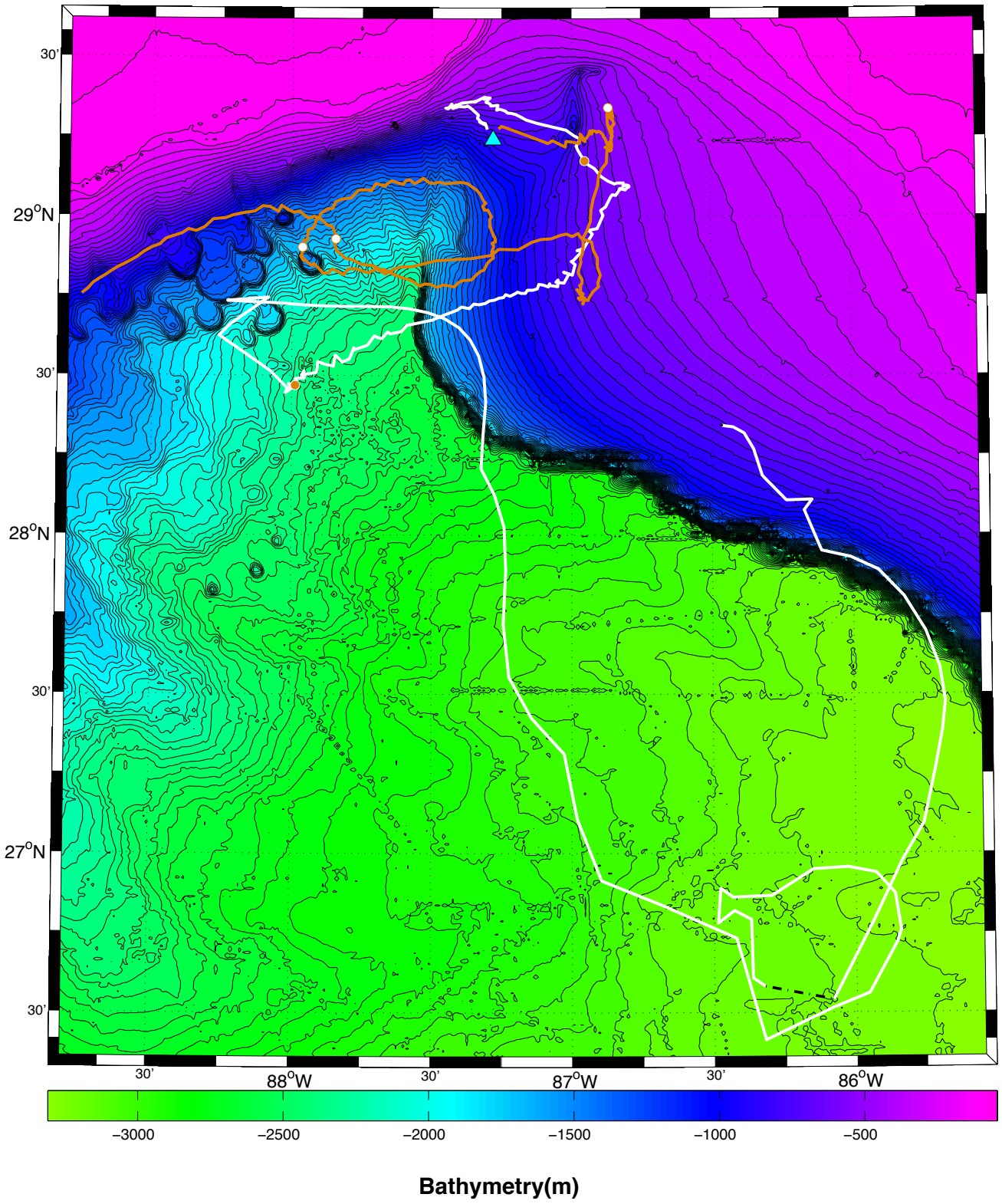


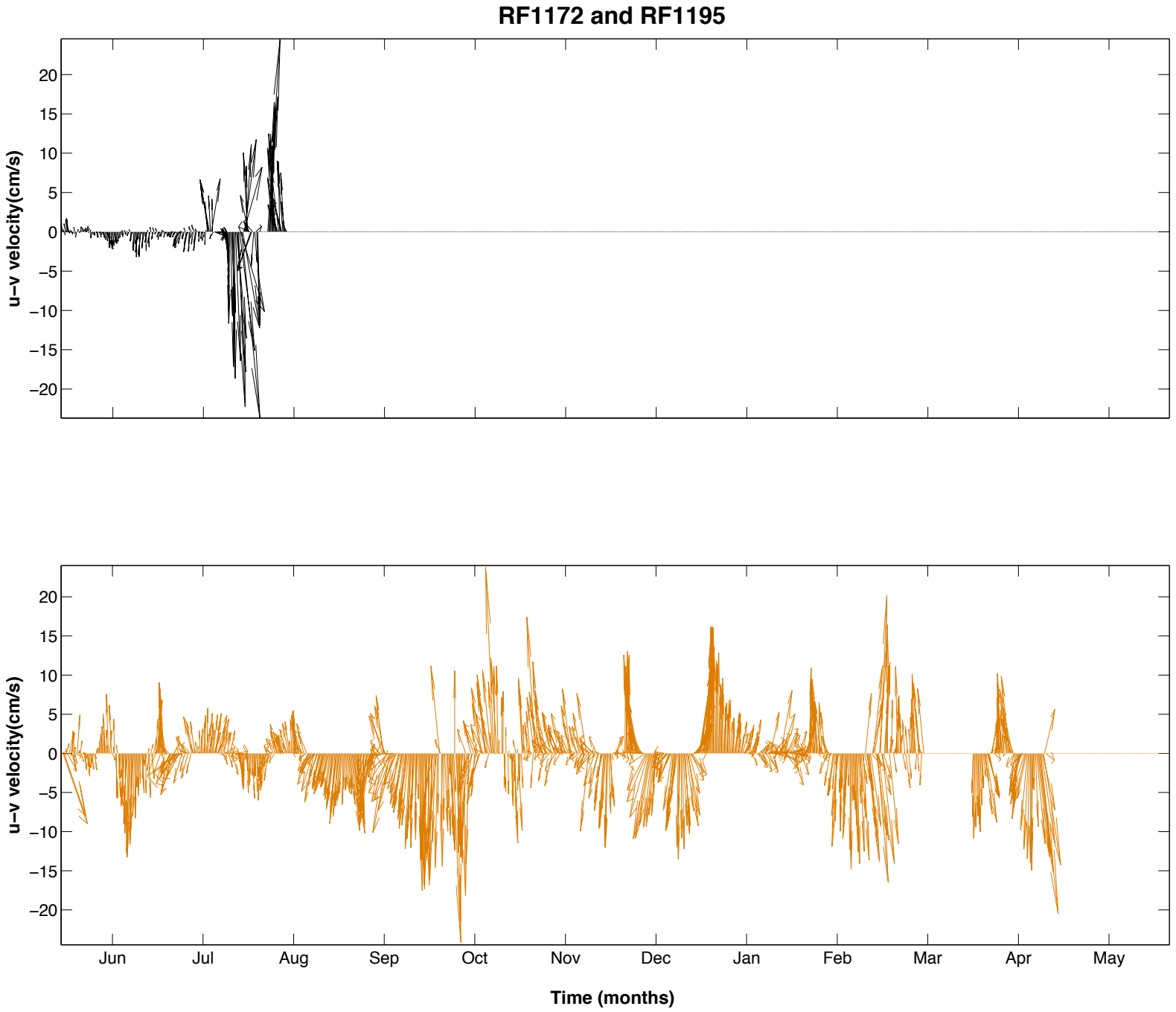

RF1168 and RF1194
u–v velocity(cm/s)
25
20
15
10
5
0
−5
−10
−15
u–v velocity(cm/s)
5
0
−5
−10
−15
−20
−25
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)

RF 1172 and RF 1195

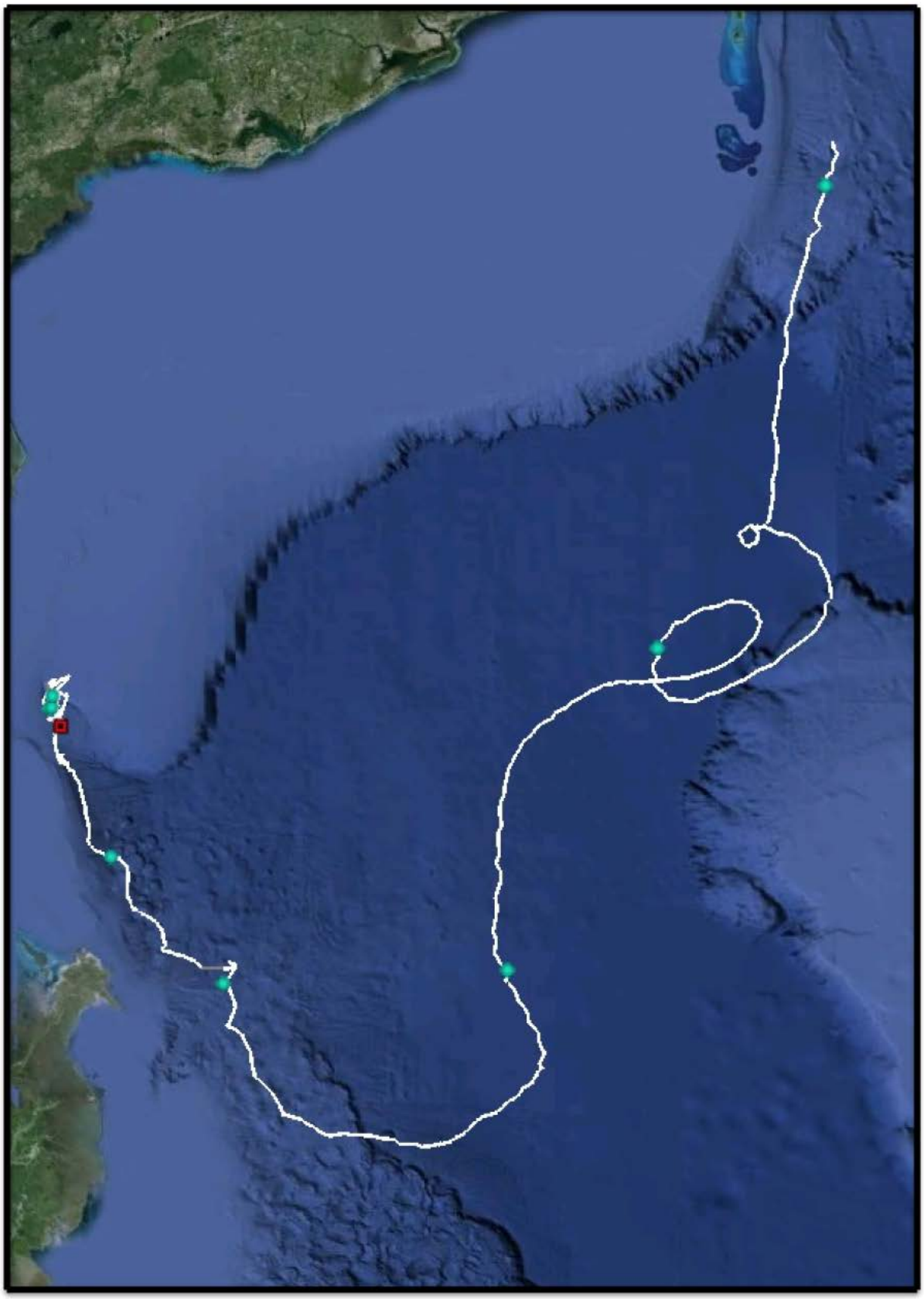


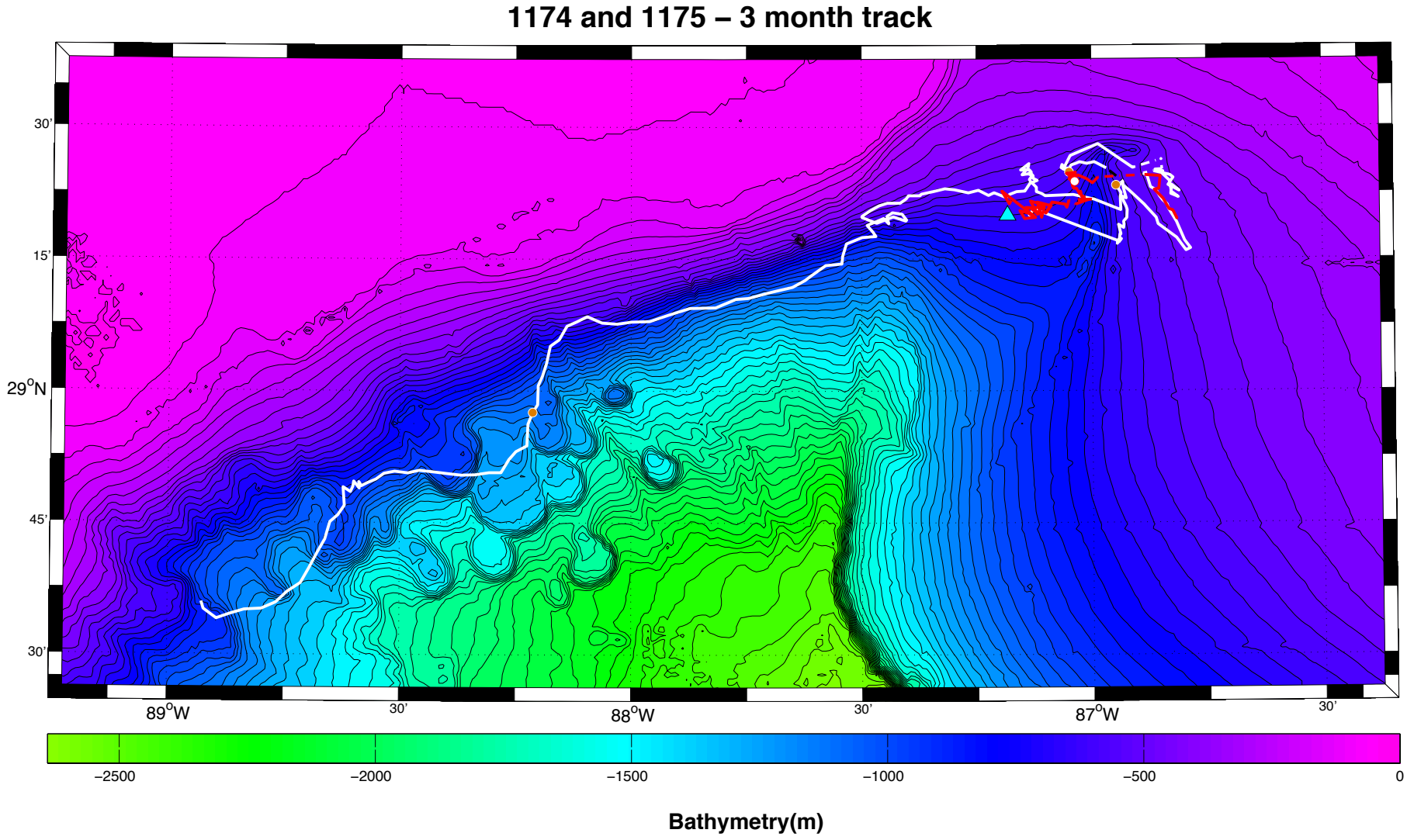
1172 and 1195 – 3 month track

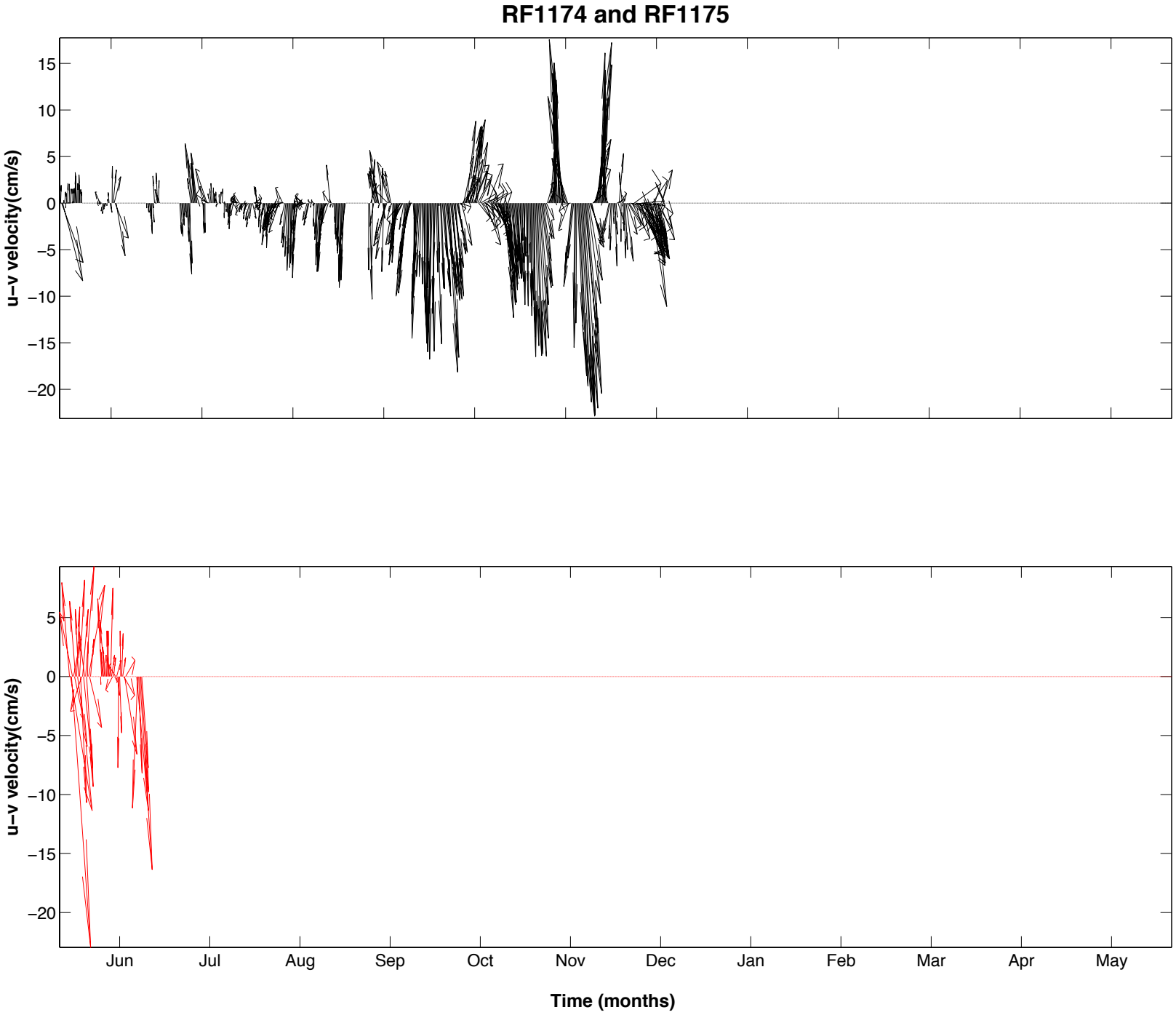



RF1172 and RF1195
u–v velocity(cm/s)
20
15
10
5
0
−5
−10
−15
−20
u–v velocity(cm/s)
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)

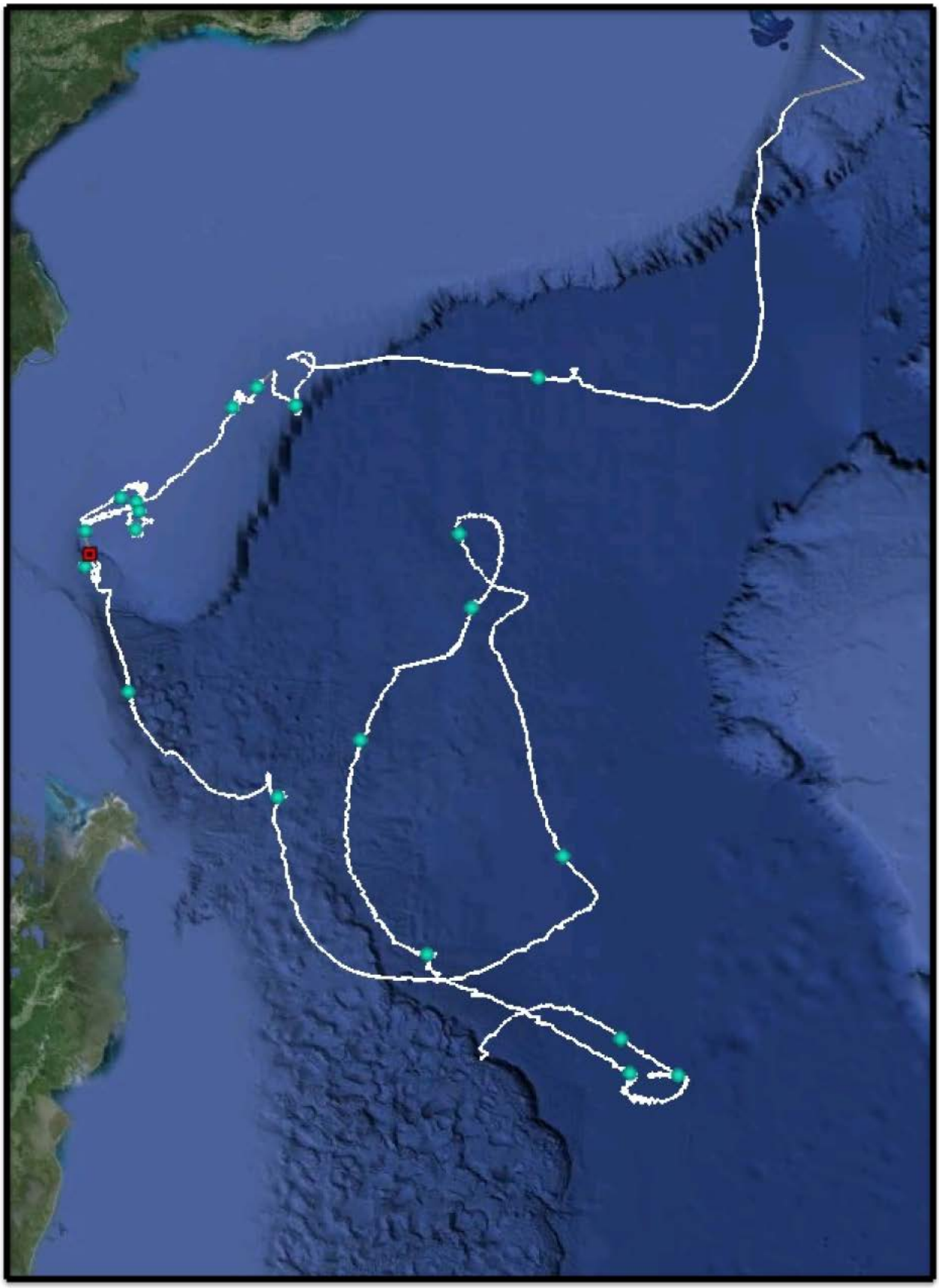
RF 1174 and RF 1175

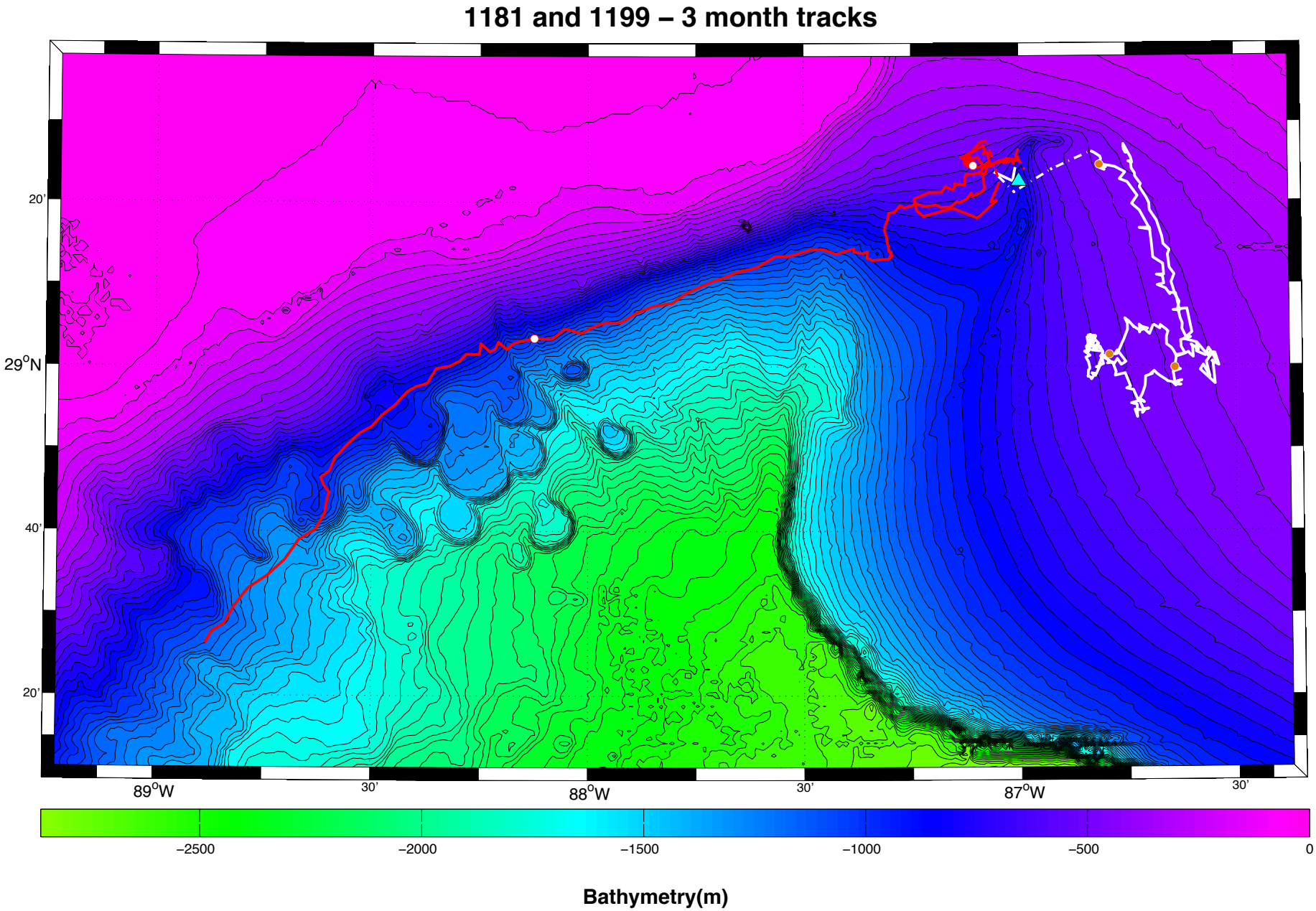


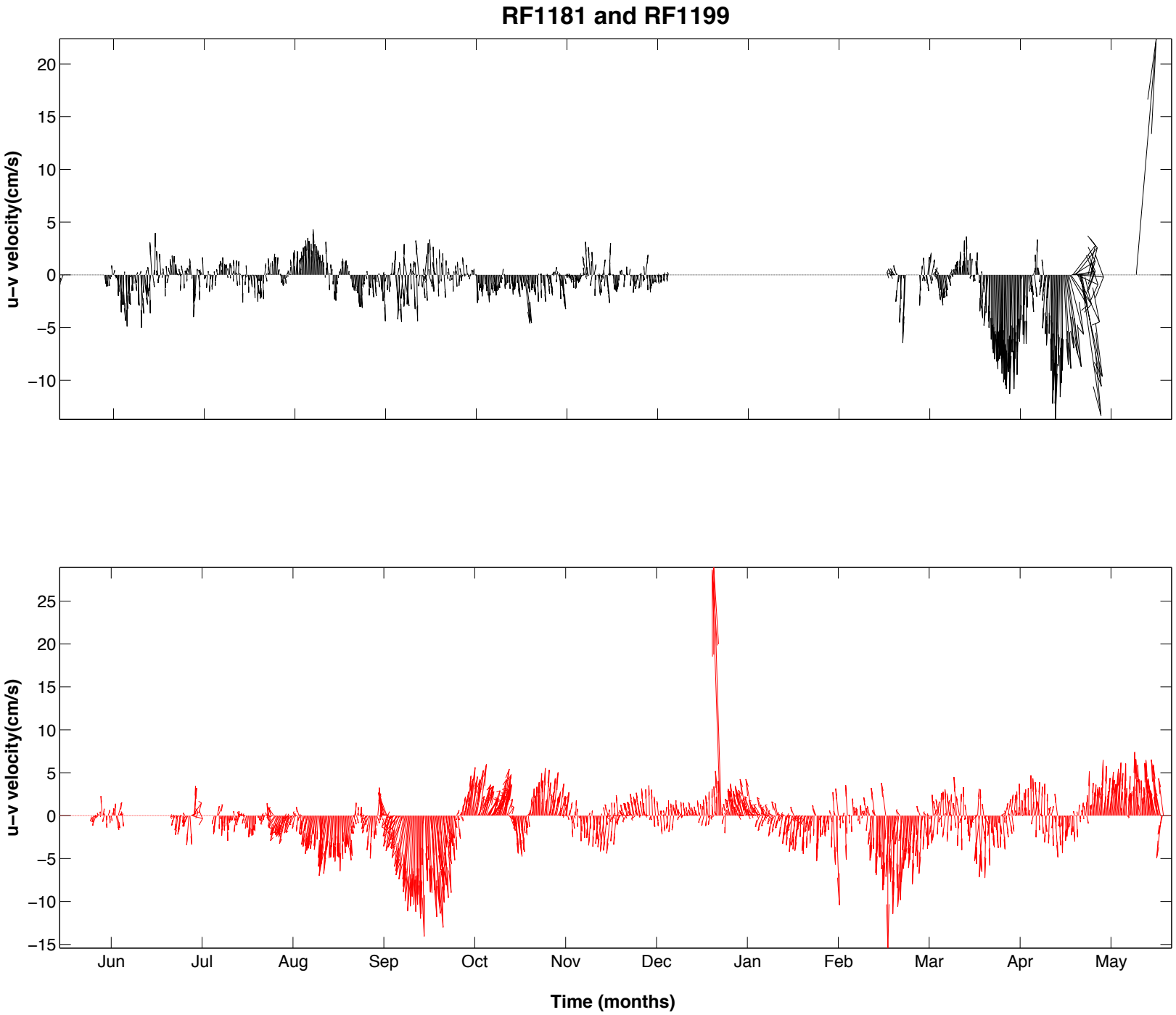

1174 and 1175 – 3 month track
30'
15'
29°N
45'
30'
89°W
30'
88°W
30'
87°W
30'
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)


RF1174 and RF1175
u–v velocity(cm/s)
15
10
5
0
−5
−10
−15
−20
u–v velocity(cm/s)
5
0
−5
−10
−15
−20
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)

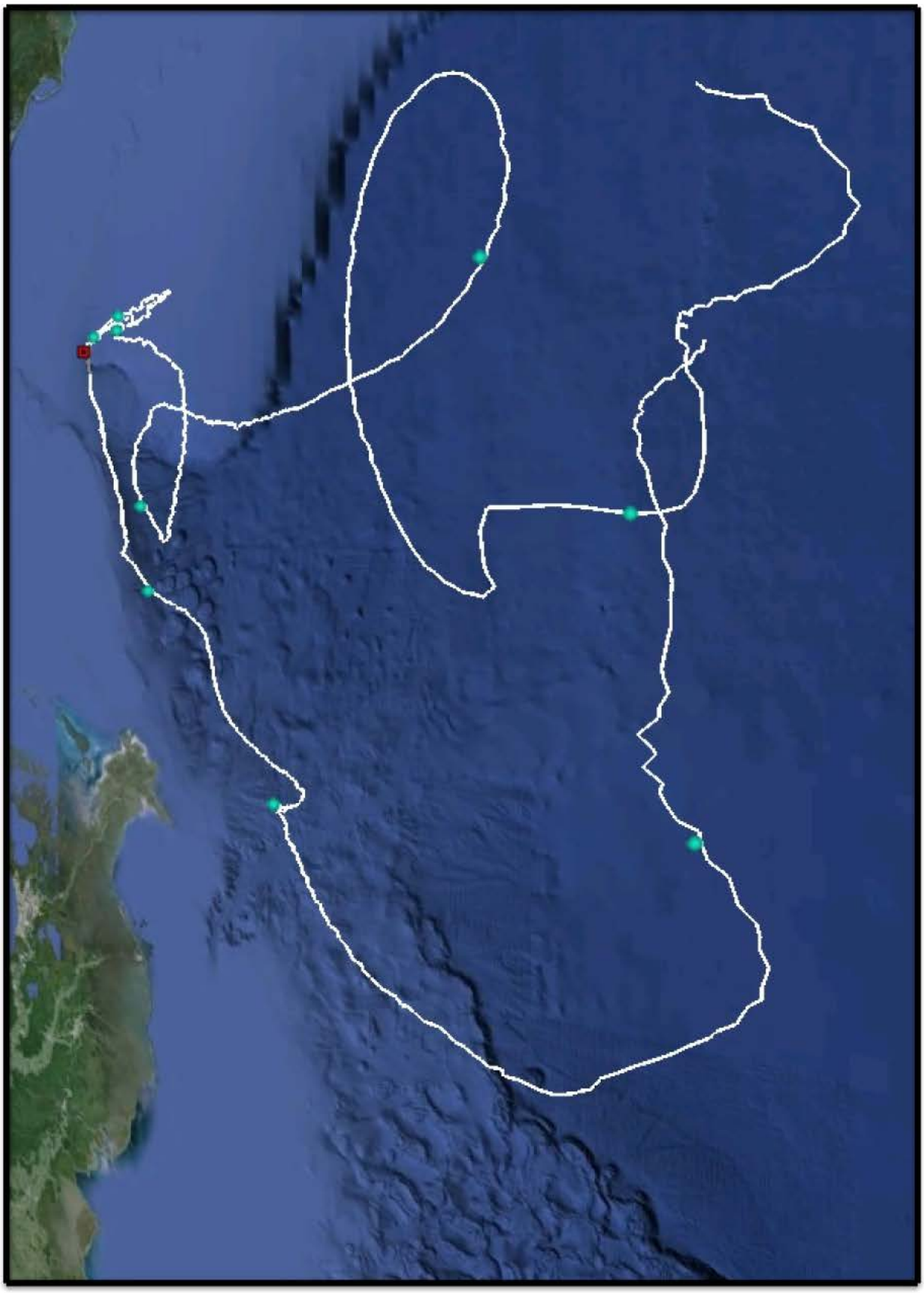
RF 1181 and RF 1199



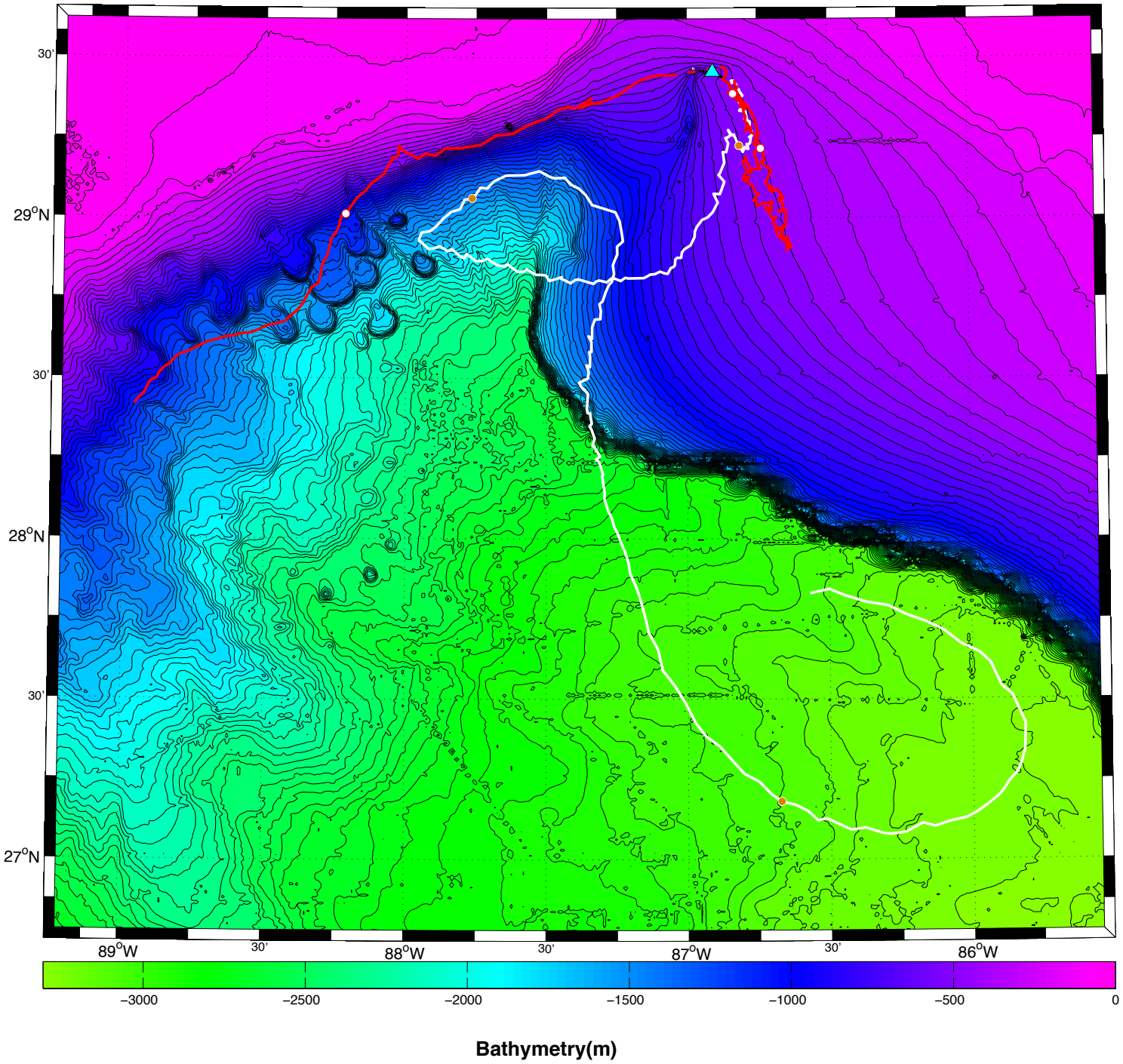

1181 and 1199 – 3 month tracks
20'
29°N
40'
20'
89°W
30'
88°W
30'
87°W
30'
−2500
−2000
−1500
−1000
−500
0
Bathymetry(m)

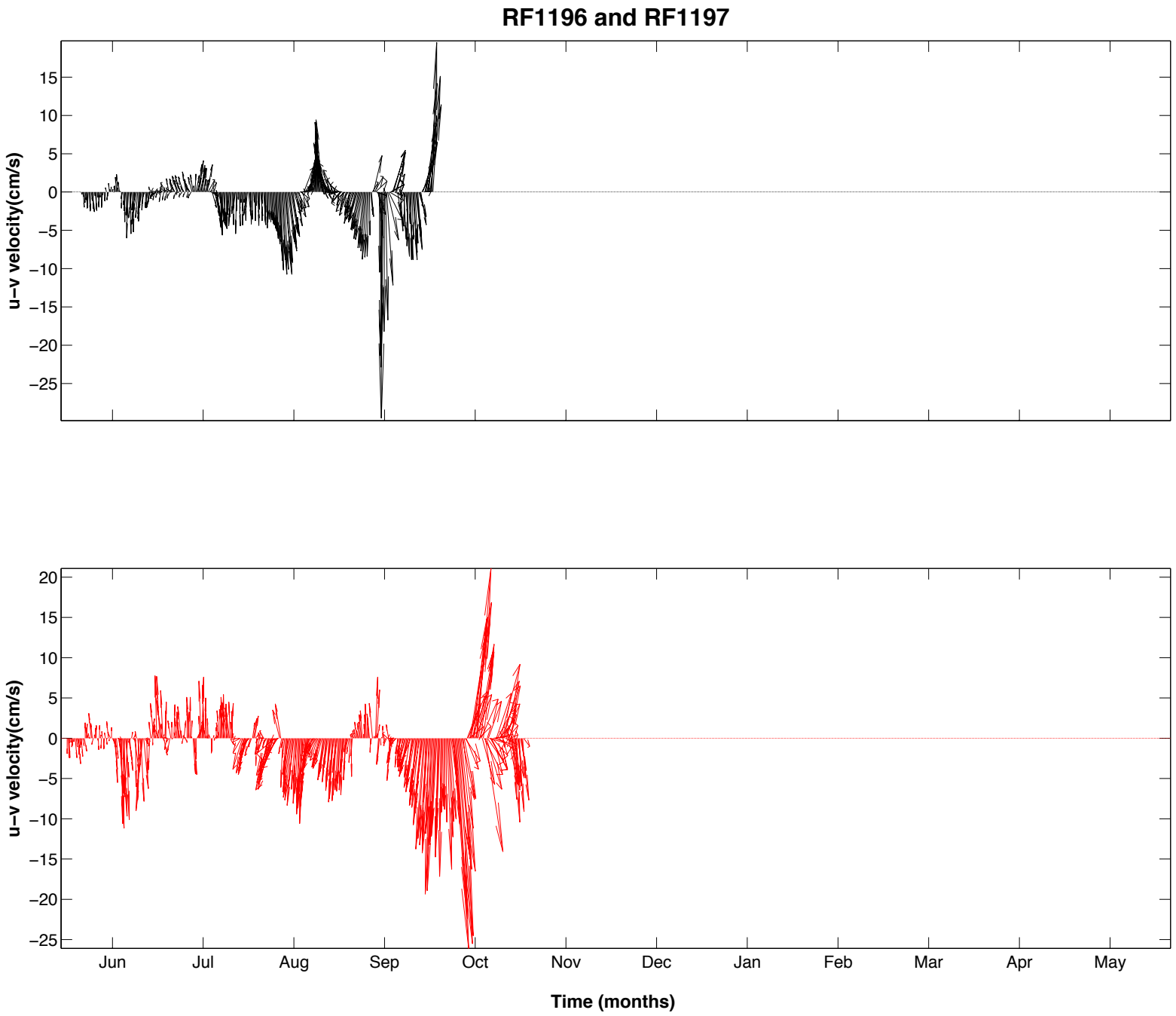

RF1181 and RF1199
u–v velocity(cm/s)
20
15
10
5
0
−5
−10
u–v velocity(cm/s)
25
20
15
10
5
0
−5
−10
−15
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)

RF 1196 and RF 1197

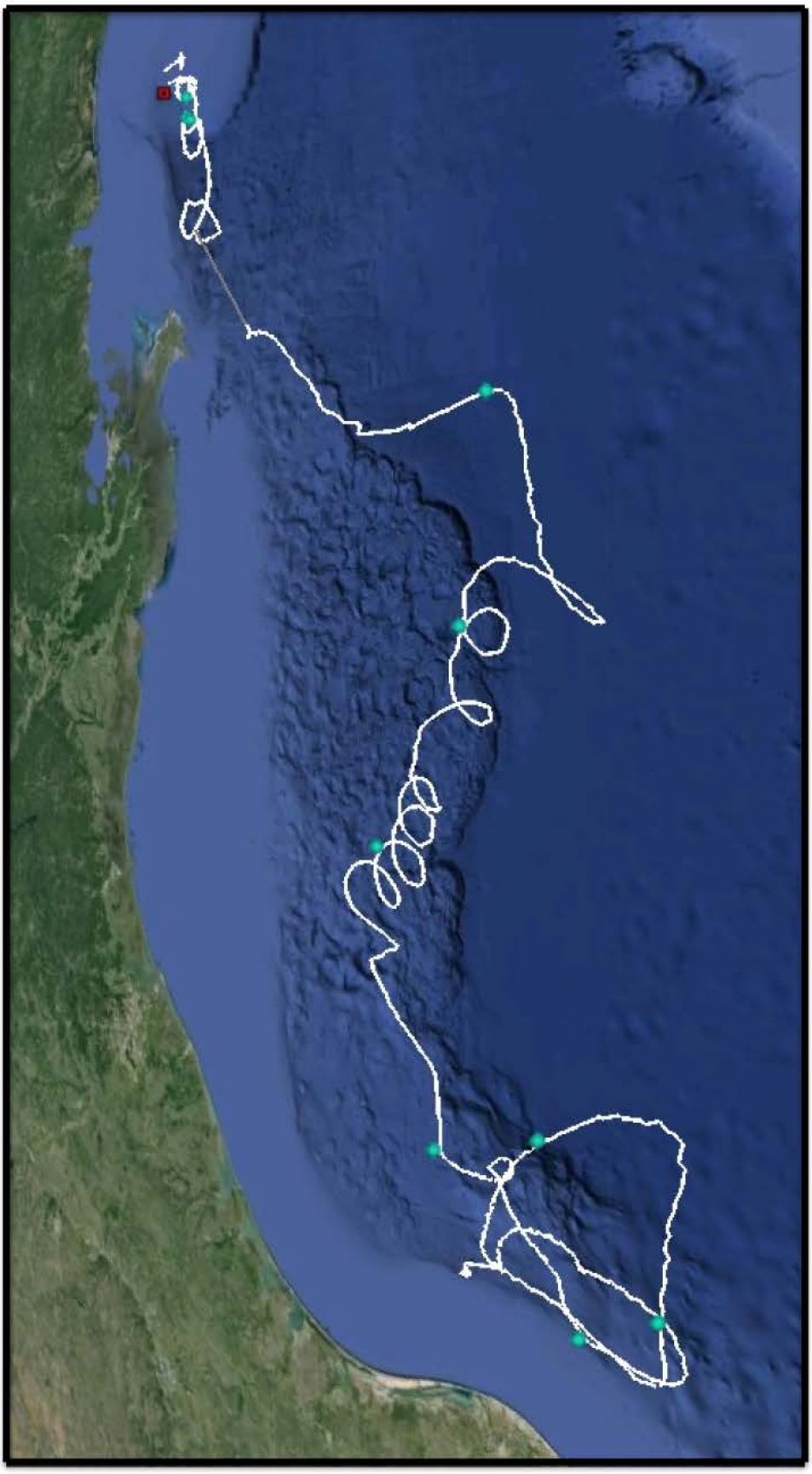


1196 and 1197 – 3 month track

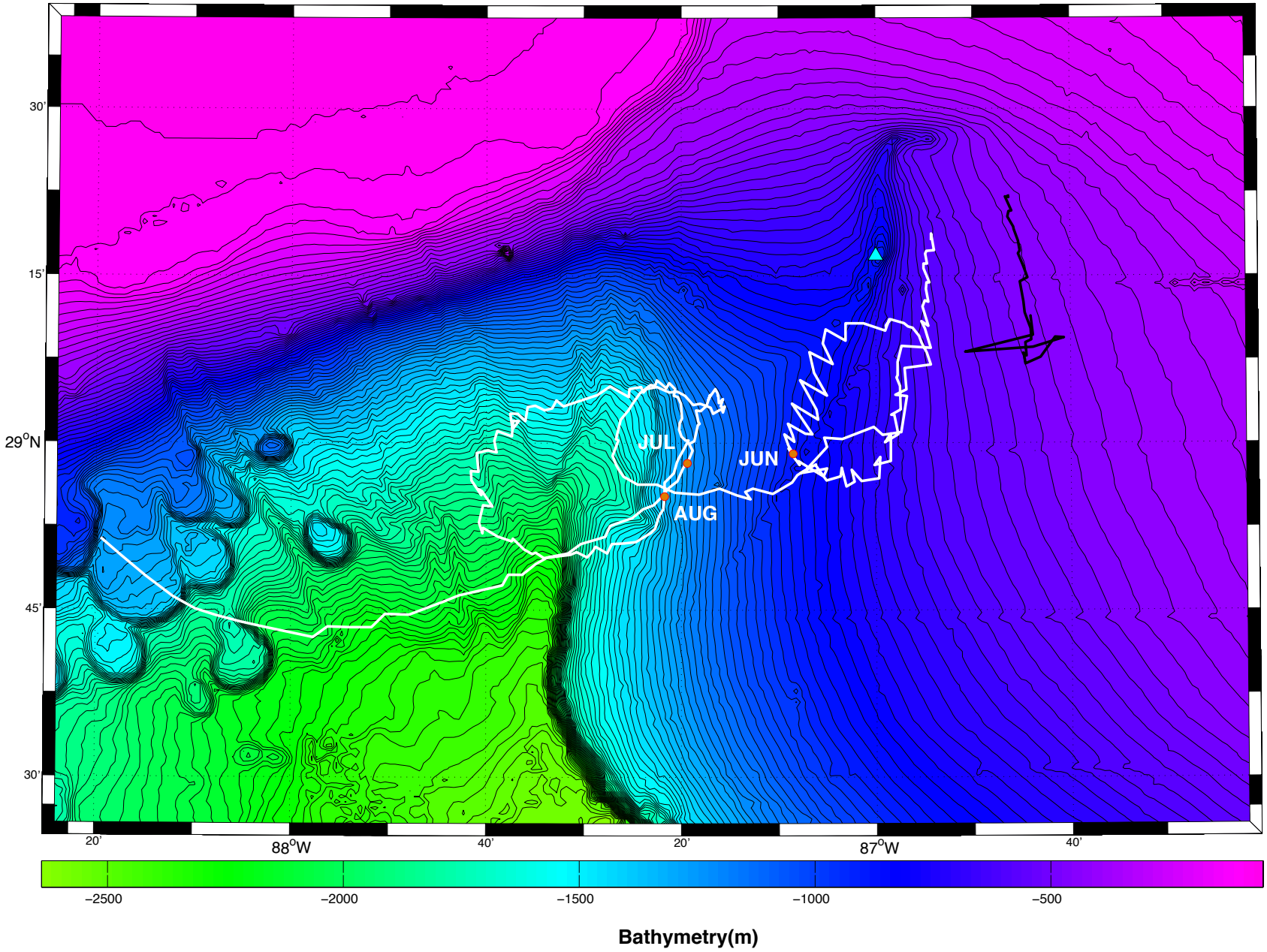


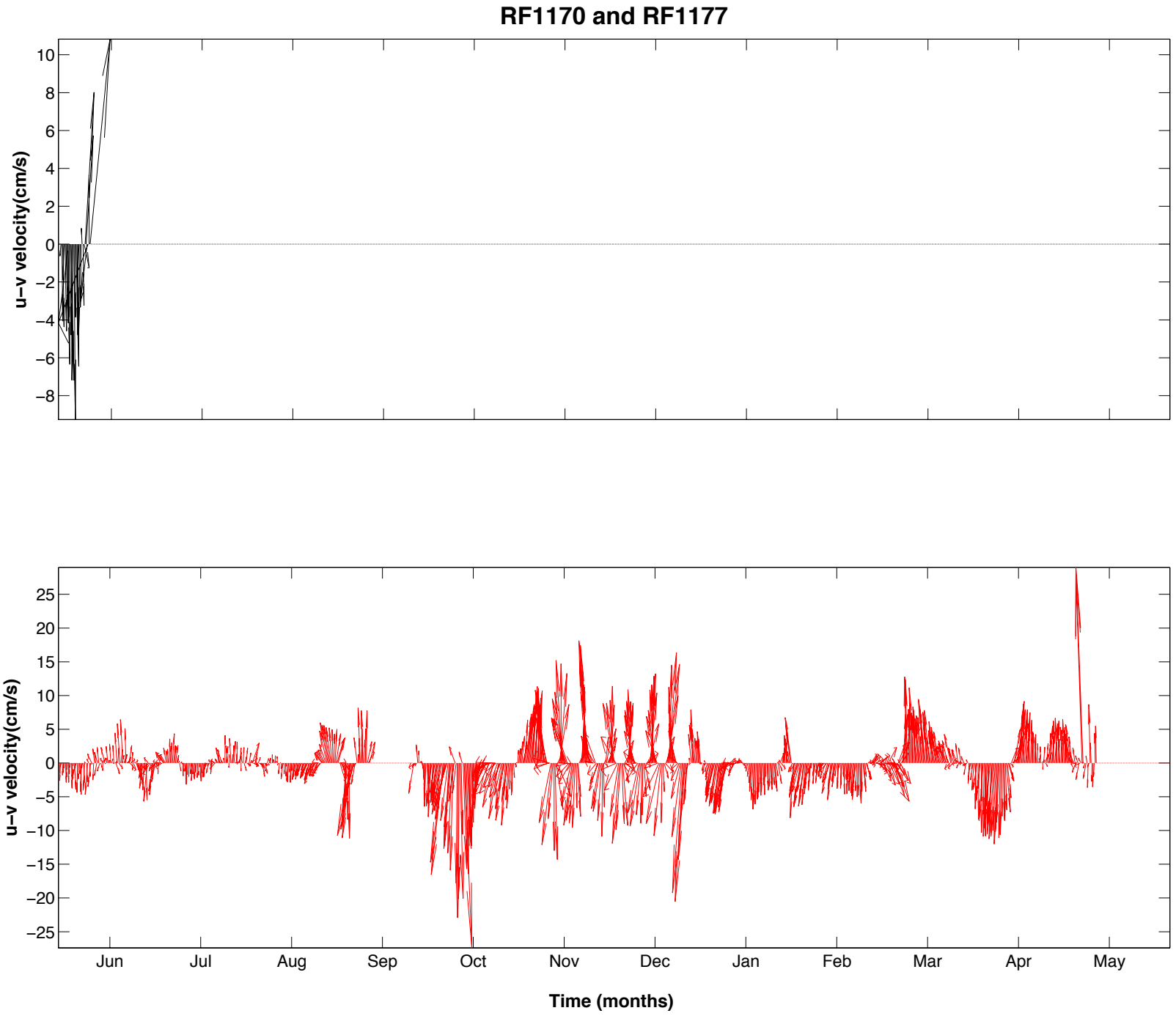

RF1196 and RF1197
u–v velocity(cm/s)
15
10
5
0
−5
−10
−15
−20
−25
u–v velocity(cm/s)
20
15
10
5
0
−5
−10
−15
−20
−25
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)

RF 1170 and RF 1177



1170 and 1177 – 3 month track




RF1170 and RF1177
u–v velocity(cm/s)
10
8
6
4
2
0
−2
−4
−6
−8
u–v velocity(cm/s)
25
20
15
10
5
0
−5
−10
−15
−20
−25
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Time (months)