KN201 leg 05 16N Sentry Dive Summaries

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1 Introduction

This document summarizes data from the AUV Sentry dives at 16N 46W. This report provides dive narratives and shows basic vehicle performance, sensor performance, and shows representative maps of chemical data. This report does not attempt to fully describe the scientific results or conclusions.

A detailed description of the data files is provided in a separate document, Sentry_data_file_descriptions.pdf.

Sentry was equipped with the following sensors:

1. Reson 7125 400 khz multibeam sonar
2. Edgetech xxx subbottom profiler, SBP
3. Edgetech xxx 120/440 khz sidescan
4. Seabird 49 CTD
5. Seapoint optical backscatter sensor model xxx
6. NOAA ORP sensor
7. Nakamura Eh sensor
8. Digital still camera, 1Mpixel

2 Multibeam processing

Multibeam records were processed using mbsystem software as is the norm for Sentry operations. We made several significant enhancements that greatly increased the speed at which we can process the data. Scripts were generated automatically using matlab to take advantage of the multicore capability of our processing computer, DPB. Initial processing could be performed in a few minutes. Processing was in 9 stages:

1. s7kextract: this step pulls the records needed for bathymetry, reducing the files size by about 97% (1Gbyte to about 28Mbyte), which in turn greatly speeds up all later steps. This process could be made quicker with an approach that utilizes multiple cores.
2. mb7kpreprocess: this step merges the raw s7k data (bathymetric profiles) with the postprocessed navigation (ppl file). list files are generated for each hour to take advantage of the multicore computing capability of DPB, decreasing processing time by about a factor of 10.
3. mbclean: batch editting, also broken up into hourly chunks. Again, this has been sped up considerably and now takes only a few seconds for the entire dive.
4. mbm_multiprocess: applies edits, navigation, attitude, and tidal corrections. Mbm_multiprocess takes full advantage of the multicore capabilities of DPB with no need to break the filelists into hourly segments.
5. mbgrid: grid the files, preliminary check. This process is not amenable to improvement by use of multiple cores without a full rewrite of mbgrid that is parallelized.
6. mbnavadjust pass 1: apply a navigation adjustment using true crossings only
7. mbnavadjust pass 2: apply a navigation adjustment using all crossing with ¿ 25% overlap. The logic for doing the adjustment in two passes is to make the more obvious true-crossing correction before attempting the correction with lower amounts of overlap.
8. regrid with final adjusted records with crossing line removed
9. make postscript and pdf files

3 Navigation upgrades

Our localization scheme for is based on the complimentary nature (in the frequency domain) of the DVL/INS data and the USBL data. This is especially true if we leave the vehicle for extended periods as we did for dredging on this trip. Under our model, the DVL/INS track has long-term drift but otherwise provides reliable tracking. Likewise we assume that the USBL may be noisy but has error statistics that are close to zero-mean. If these conditions are met, then we can place the DVL/INS track in the world and remove the drift. We observed that these conditions were not met in several regards, but by the end of the cruise we had engineered proper solutions.

1. navpp postprocessing improved in a number of ways, including improved automated usbl flyer rejection based on a moving-median filter, moved all post-proccessing parameters to a parameter structure, reduced unnecessary interative queries.
2. post-processing compensation for poor USBL calibration (casius). When the USBl is poorly calibrated, the vehicle appears to move in unexpected ways as the vessel moves or turns. Using the DVL/INS track from the vehicle, we were able to extract attitude offsets that resulted in USBL fixes that were far more consistent as the (see figures xx and xx). Without this capability, we would have had to redo the casius calibration or we would have had poor usbl for the entire cruise.
3. We observed many examples of corrupted DVL data when the vehicle was on steep terrain. In each case, the vehicle's position estimate moved downslope falsely, so the vehicle moved upslope to compensate. In addition to introducing a false downslope motion, this error also caused the vehicle's forward velocity to be underestimated, which in turn caused the vehicle's forward speed controller to saturate and apply

maximum forward thrust force while the vehicle drove uphill. We came up with a reliable mechanism for identifying this problem (high, unrealistic athwartships velocity). With help from our colleagues Whitcomb and Kinsey, we engineered a real-time fix which largely eliminated the problem. The fix was also applicable in post-processing and allowed us to improve results for previous dives.

4. Our real-time navigation program, navest, correctly identifies DVL dropouts, when no proper velocity can be computed. Note this is different from the previous problem when the DVL reports an incorrect velocity which is tagged as being good. Navest not only identifies this condition but substitutes a model-based velocity based on vehicle forward thrust. This model does not account of the effects of induced drag from the vehicle planes. We devised a better interpolation scheme that is suitable for post-processing which improved estimates during dropouts.

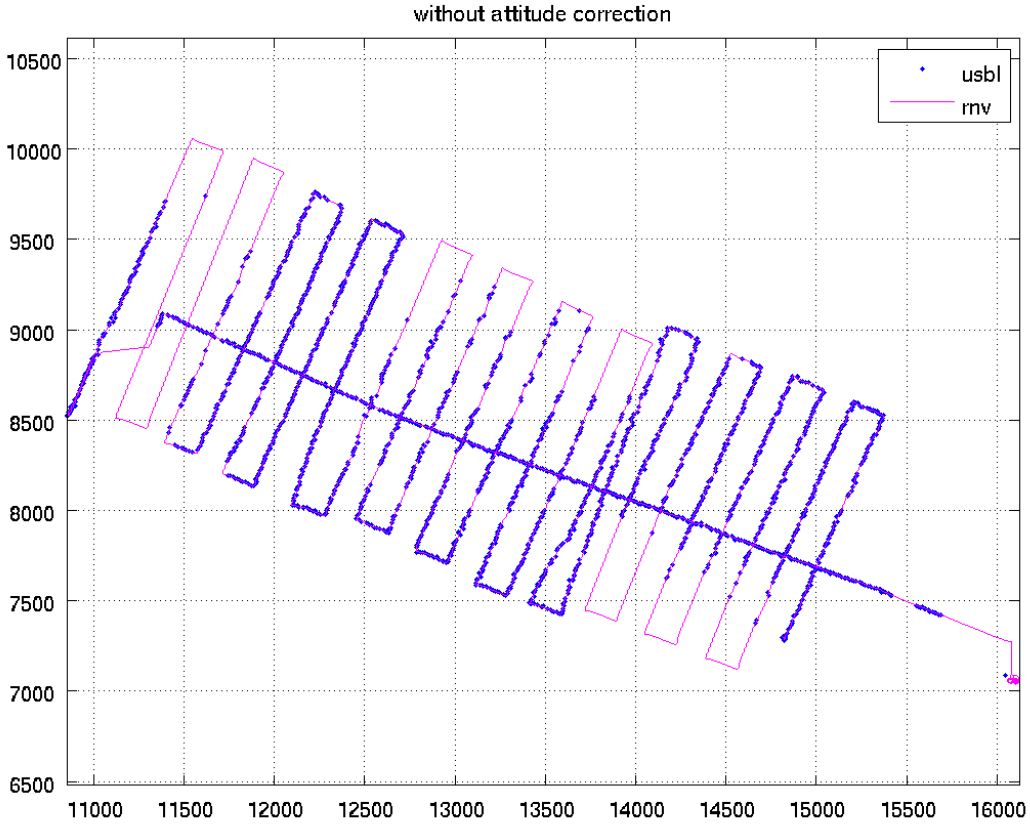

Figure 1: This plot shows the real-time USBL track and the blended USBL/INS/DVL track. The shifts in the USBL data correspond to vessel movement and do not correspond to the straight, uniform lines reported by the DVL/INS. With a high-quality casius calibration or better yet, an integrated INS/USBL head, this would not be a problem. While we certainly should improve our casius calibration skills (Yoerger and Kurras), we will face these problems in the future

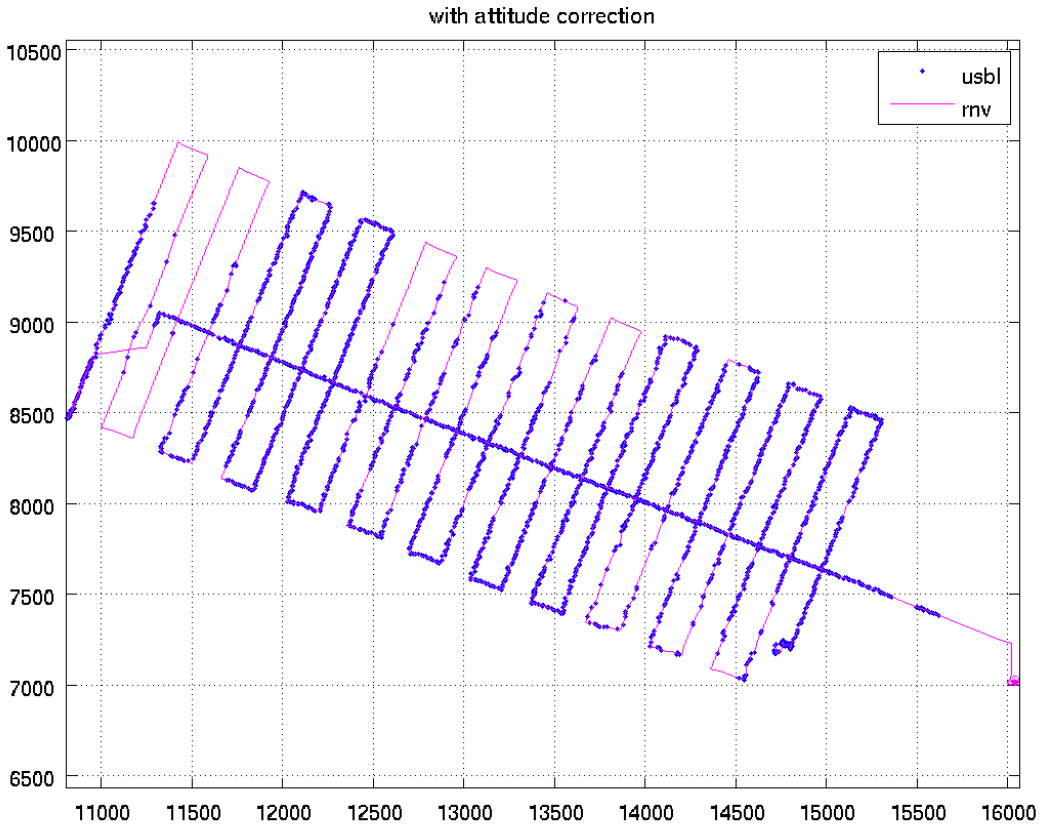

Figure 2: This plot shows the USBL track and the blended USBL/INS/DVL track after correcting the USBL data with the DVL/INS track. The correction, applied in post-processing, restores the complimentary nature of the USBL and the DVL/INS track. We applied this correction to all USBL navigation for all dives

4 Sentry Dive Overview

We mapped two areas with multiple dives and made 5 isolated surveys

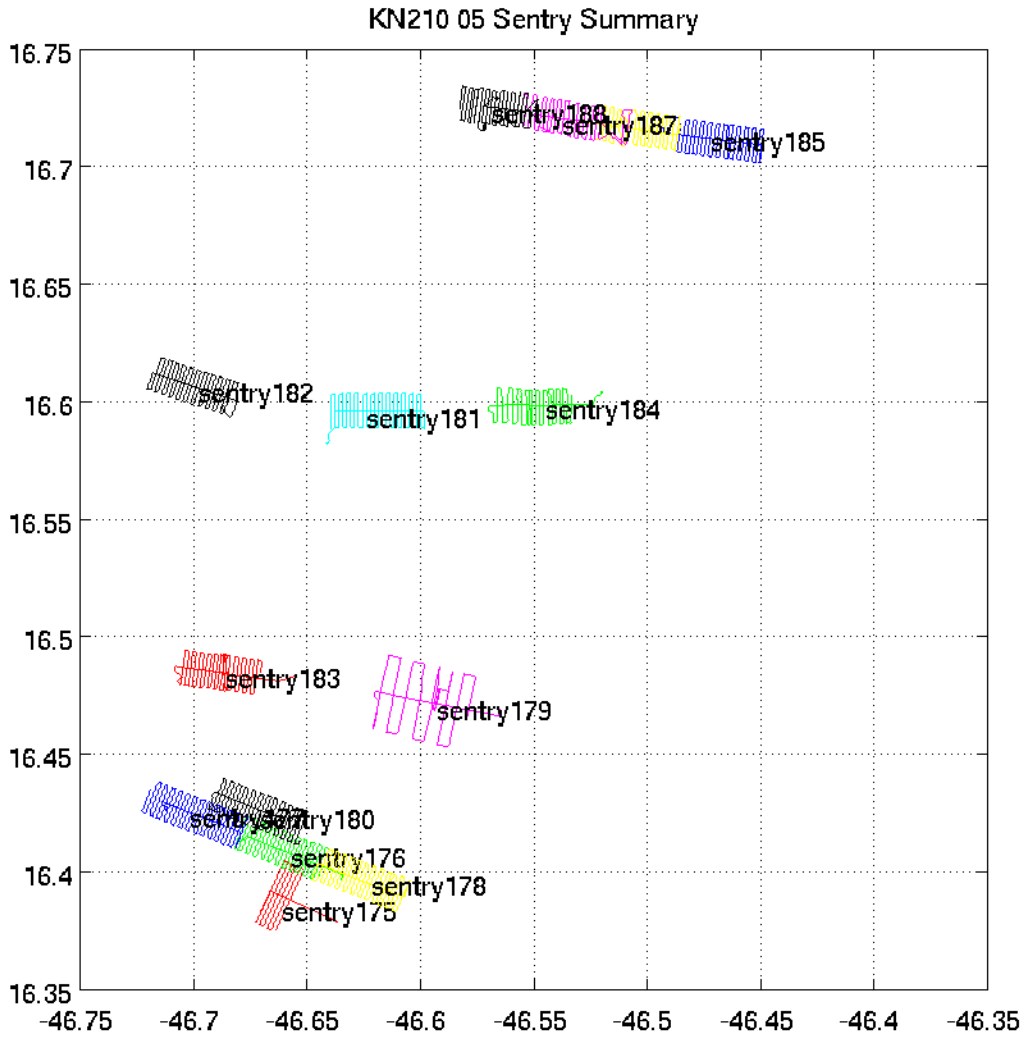

Figure 3: Summary of Sentry dives.

5 Sentry173

The dive plan consisted of a single grid with a full crossing line. This dive ended on the crossing line due to a false emergency condition. The mission controller received a low battery reading and aborted the dive.

The low battery reading was caused by the rov code parsing a corrupted string on the GRD bus. The string contained a non-printing character in the second hex digit of the battery voltage field, and the code parsed on the first character, which equated to a very low voltage. The mission controller was programmed to abort on the first low-battery message. This problem is discussed in more detail in an appendix.

We also had a setup problem with the Reson 7125, which logged no data. We had restarted the 7kcenter before final configuration, but has started the wrong version. We will always use the version that runs automatically, it's the correct one.

5.1 sentry173 Summary

sentry173 Summary
Origin: 16 20.0000'N 046 47.0000'W
Launch: 2013/05/20 16:15:55
Survey start: 2013/05/20 17:51:19
Survey end: 2013/05/20 18:32:47
Ascent begins: 2013/05/20 18:33:29
On the surface: 2013/05/20 19:41:56
On deck: 2013/05/20 20:01:29
descent rate: 36.7 m/min
ascent rate: 51.6 m/min
survey time: 0.7 hours
deck-to-deck time 3.8 hours
Mean survey depth: 3505m
Mean survey height: 65m
distance travelled: 3.30km
average speed; 0.75m/s
average speed during photo runs: -0.00 m/s over -0.00 km
average speed during multibeam runs: 0.75 m/s over 1.86 km
total vertical during survey: 440m
Battery energy at launch: 13.8 kwhr
Battery energy at survey end: 12.6 kwhr
Battery energy on deck: 12.1 kwhr

6 Sentry174

The dive plan consisted of a single grid with a full crossing line. This dive ended on the descent due to a false emergency condition on descent. The mission controller received a message that on of the hardware deadman timers had expired. The mechanism was the same as the false low-battery message on the last dive, a corrupted serial message had been parsed, yielding an incorrect result.

7 Sentry175

The dive plan was the same as for the previous two dives. We got a good survey, although the vehicle quit early due to a more subtle false-emergency message. The resulting multibeam map has very good internal consistency following correction with mbnavadjust.

All water column sensors were operational on this dive. We noted no obvious hydothermal signals, only two small hits on the optical backscatter sensor but they did not correspond to any anomalies in orp, temperature, or conductivity.

The DVL/INS navigation looks very solid. We saw none of the lateral shifts that we saw in later dives. The complimentary filter for the navpp post-processing was run with a very low break frequency, 0.0001. We observed no stretches of high dvl velocity error as we did in later dives.

The false emergency was caused by a sequence of incorrect leak detects. The last data field in the HTP string (which reports humidity, temperature, and pressure) in the main housing was truncated due to the insertion of a non-printing character. This caused the level to be misreported. When that happened a sufficient number of times, the dive aborted. Like the battery monitor and deadman timer, we knew that those strings were vulnerable, but elected not the put more filters on the parsing as several additional tests were already performed. They were insufficient so we put stricter checks on each field. Again, we did not want to make changes in the vehicle's safety systems unnecessarily.

7.1 sentry175 Summary

sentry175 Summary
Origin: 16.333333 -46.783333
Launch: 2013/05/21 20:11:59
Survey start: 2013/05/21 21:42:18
Survey end: 2013/05/22 06:35:01
Ascent begins: 2013/05/22 06:36:52
On the surface: 2013/05/22 07:50:36
On deck: 2013/05/22 08:12:24
descent rate: 38.3 m/min
ascent rate: 47.7 m/min
survey time: 8.9 hours
deck-to-deck time 12.0 hours
Mean survey depth: 3429m
Mean survey height: 65m
distance travelled: 24.14km
average speed; 0.78m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.78 m/s over 24.94 km
total vertical during survey: 3120m
Battery energy at launch: 13.1 kwhr
Battery energy at survey end: 6.2 kwhr
Battery energy on deck: 5.7 kwhr

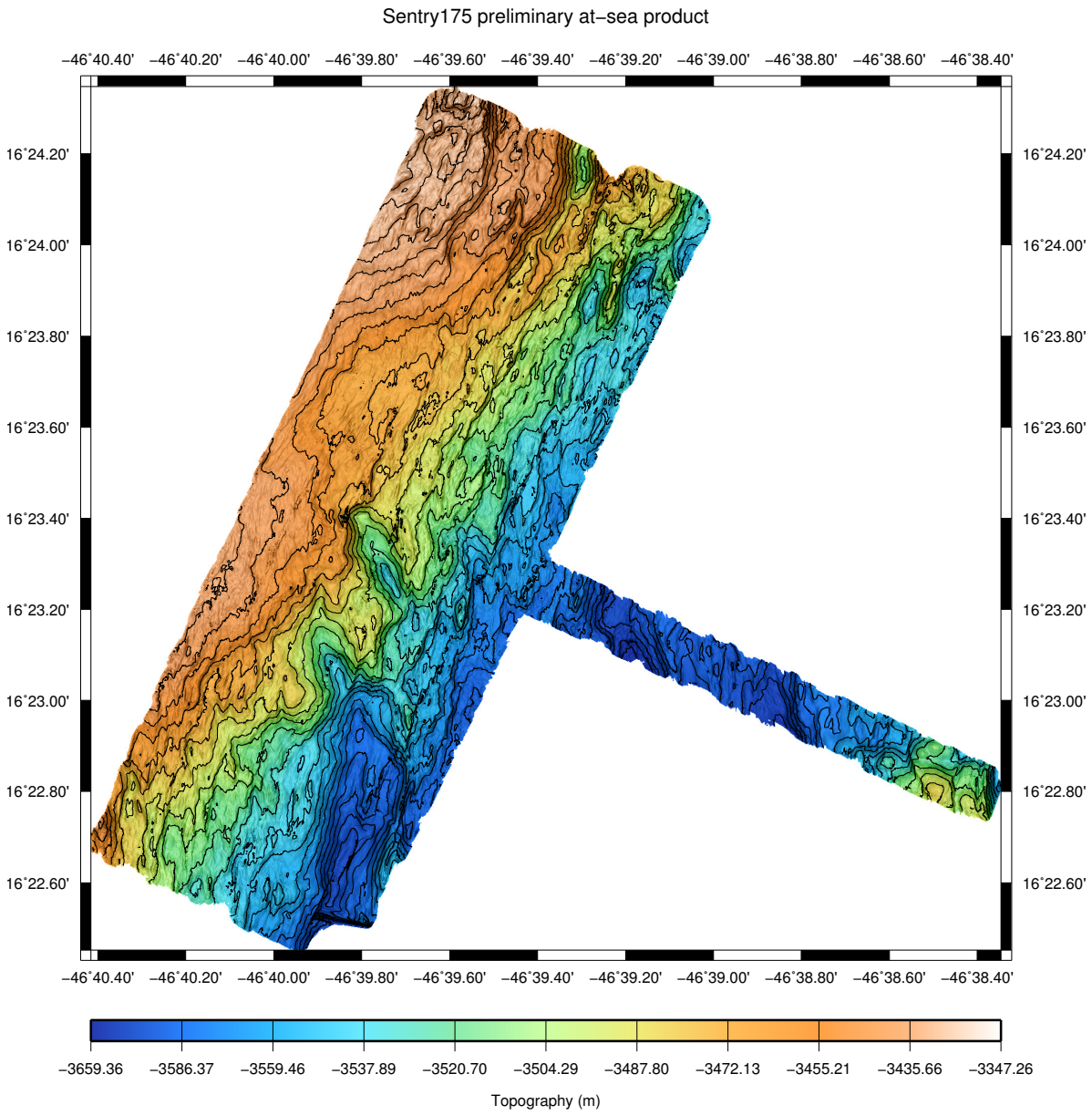

Figure 4: Bathymetry for Sentry175.

8 Sentry176

Sentry 176 was a bathymetry/sidescan dive on a block contiguous to sentry175. This survey went as planned with the vehicle leaving the bottom on low battery (8%).

All water column sensors were operational on this dive. We observed a substantial (100mv) Eh hit at 06:00 in the NW corner of the survey box. But it was a single, isolated hit and did not correlate with any anomalies in optical backscatter, temperature, or conductivity. The science channel assignments are listed in an appendix.

The DVL/INS navigation looks very solid. We saw none of the lateral shifts that we saw in later dives. The complimentary filter for the navpp post-processing was run with a very low break frequency, 0.0001. We observed no stretches of high dvl velocity error as we did in later dives.

The multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossing with over 25% overlap.

8.1 sentry176 Summary

sentry176 Summary
Origin: 16.333333 -46.783333
Launch: 2013/05/23 01:38:23
Survey start: 2013/05/23 03:02:16
Survey end: 2013/05/23 20:26:12
Ascent begins: 2013/05/23 20:26:55
On the surface: 2013/05/23 21:36:00
On deck: 2013/05/23 21:46:03
descent rate: 41.0 m/min
ascent rate: 50.4 m/min
survey time: 17.4 hours
deck-to-deck time 20.1 hours
Mean survey depth: 3279m
Mean survey height: 65m
distance travelled: 46.04km
average speed; 0.78m/s
average speed during photo runs: -0.00 m/s over -0.00 km
average speed during multibeam runs: 0.78 m/s over 48.59 km
total vertical during survey: 7146m
Battery energy at launch: 13.3 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.5 kwhr

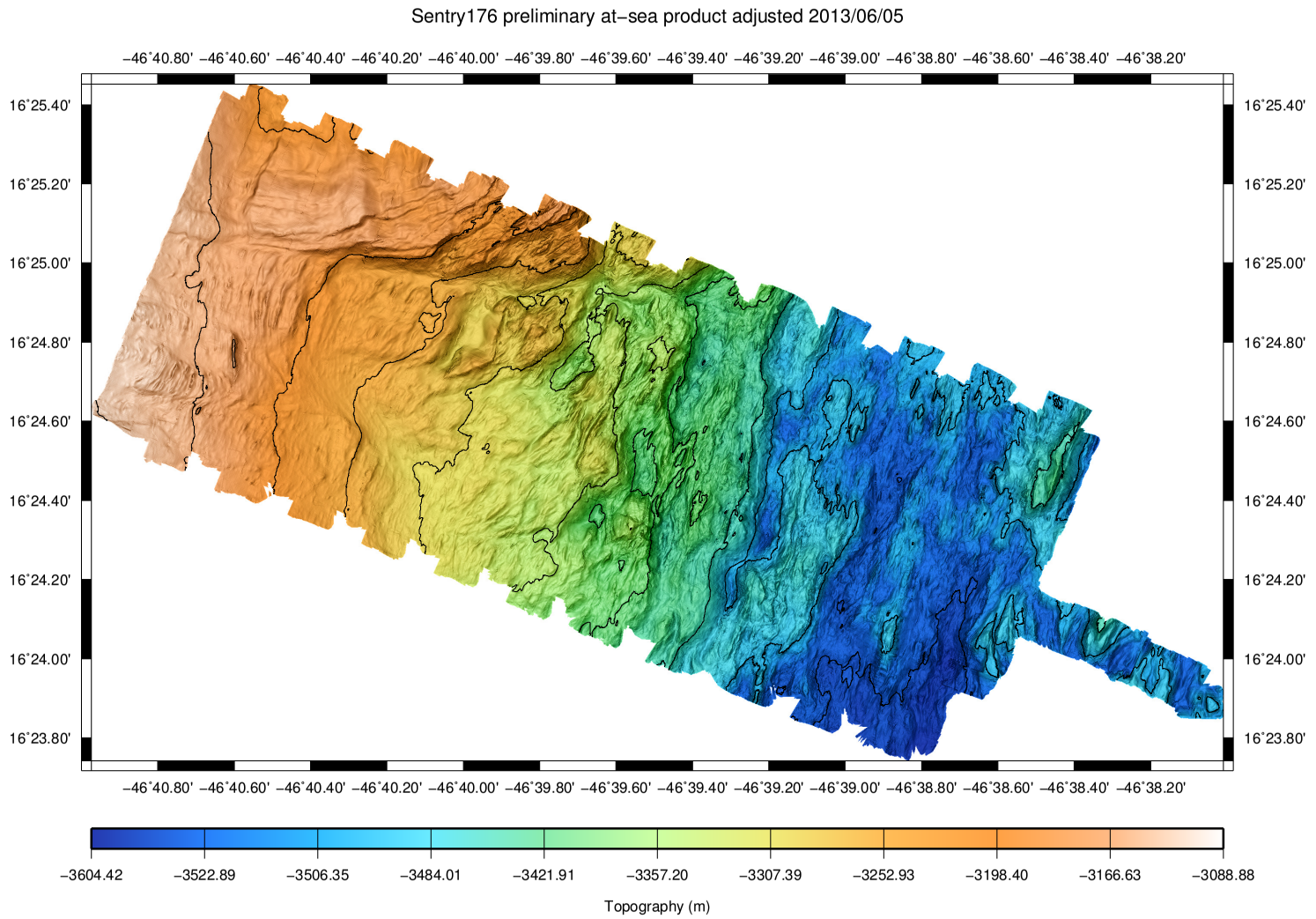

Figure 5: Bathymetry for Sentry176.

9 Sentry177

This survey went as planned from a navigation and control perspective with the vehicle leaving the bottom on low battery (8%). However, the Reson 7125 logging was problematic. The bottom detections were very spotty, mostly consisting of a narrow (+-30m strip) under the vehicle. The remainder of the profile was corrupted by a large acoustic signal appearing at a range of 145m. Even though most of our data was well short of this range, the strong signal corrupted the real-time bottom detection. Fortunately, we had recorded what Reson calls "compressed video" or 7011 records, which is actually a matrix of decimated return amplitudes arranged by beam number. We viewed them on the Reson topside software in replay mode, and we could see the reasonable data had been recorded. The resolution is 1024 samples across the full range (250m in this case). We extracted the range data and did simple bottom detection on each beam. These were then stuffed into a convention bottom-profile record (7006) and processed normally. The results were very satisfactory. We received excellent shore-side support from Carl Kaiser and from Reson in recovering the data. We note that this "save" would be considerably less effective in flatter terrain, in which case the relatively low resolution (0.25m) of the range data would be more significant.

We corrected this on later dives by altering the timing scheme so that all sonars pinged at 500msec intervals.

All water column sensors were operational on this dive, although the optical backscatter sensor measured lots of activity. These anomalies did not correspond to Eh hits. We suspect the optical backscatter sensor was failing.

The DVL/INS navigation looks very solid. We saw none of the lateral shifts that we saw in later dives. The complimentary filter for the navpp post-processing was run with a very low break frequency, 0.0001. We observed no stretches of high dvl velocity error as we did in later dives.

The resulting multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossings with over 25% overlap.

9.1 sentry177 Summary

sentry177 Summary
Origin: 16.333333 -46.783333
Launch: 2013/05/24 13:04:45
Survey start: 2013/05/24 13:57:49
Survey end: 2013/05/25 08:36:16
Ascent begins: 2013/05/25 08:36:44
On the surface: 2013/05/25 09:18:23
On deck: 2013/05/25 09:38:49
descent rate: 40.0 m/min
ascent rate: 49.0 m/min
survey time: 18.6 hours
deck-to-deck time 20.6 hours
Mean survey depth: 2532m
Mean survey height: 65m
distance travelled: 50.69km
average speed; 0.79m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.79 m/s over 53.00 km

total vertical during survey: 6073m
Battery energy at launch: 13.7 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.6 kwhr

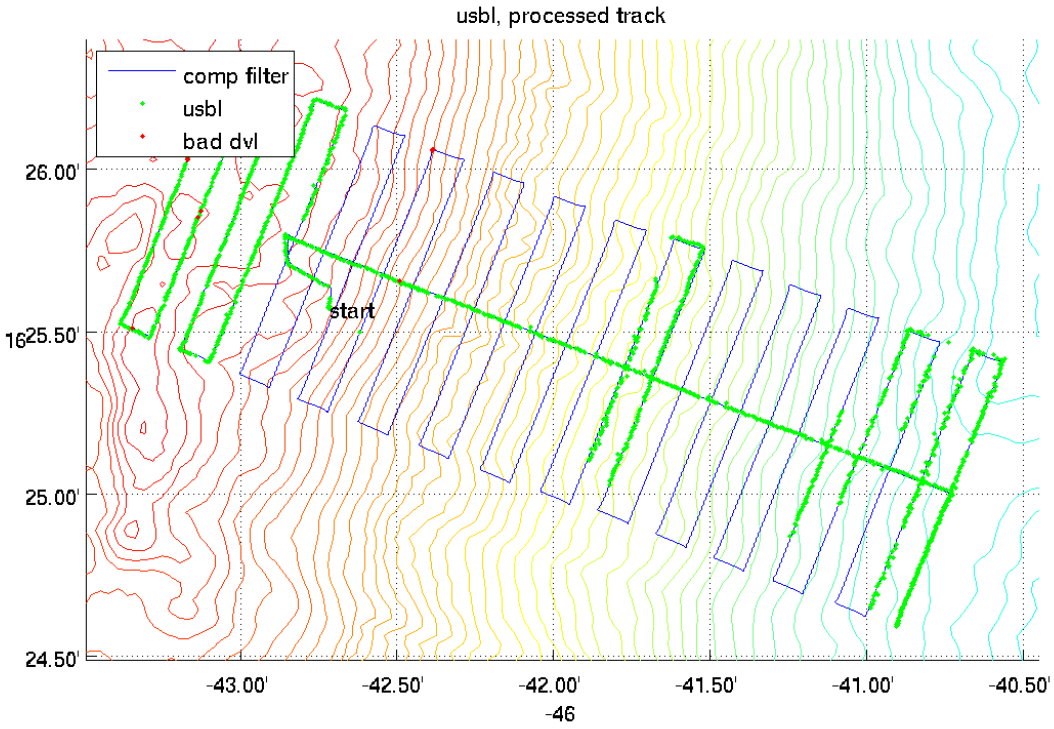

Figure 6: This plot shows the vehicle fixes and processed tracklines for dive 177. The green markers indicate the USBL fixes after transformation and flyer-rejection.

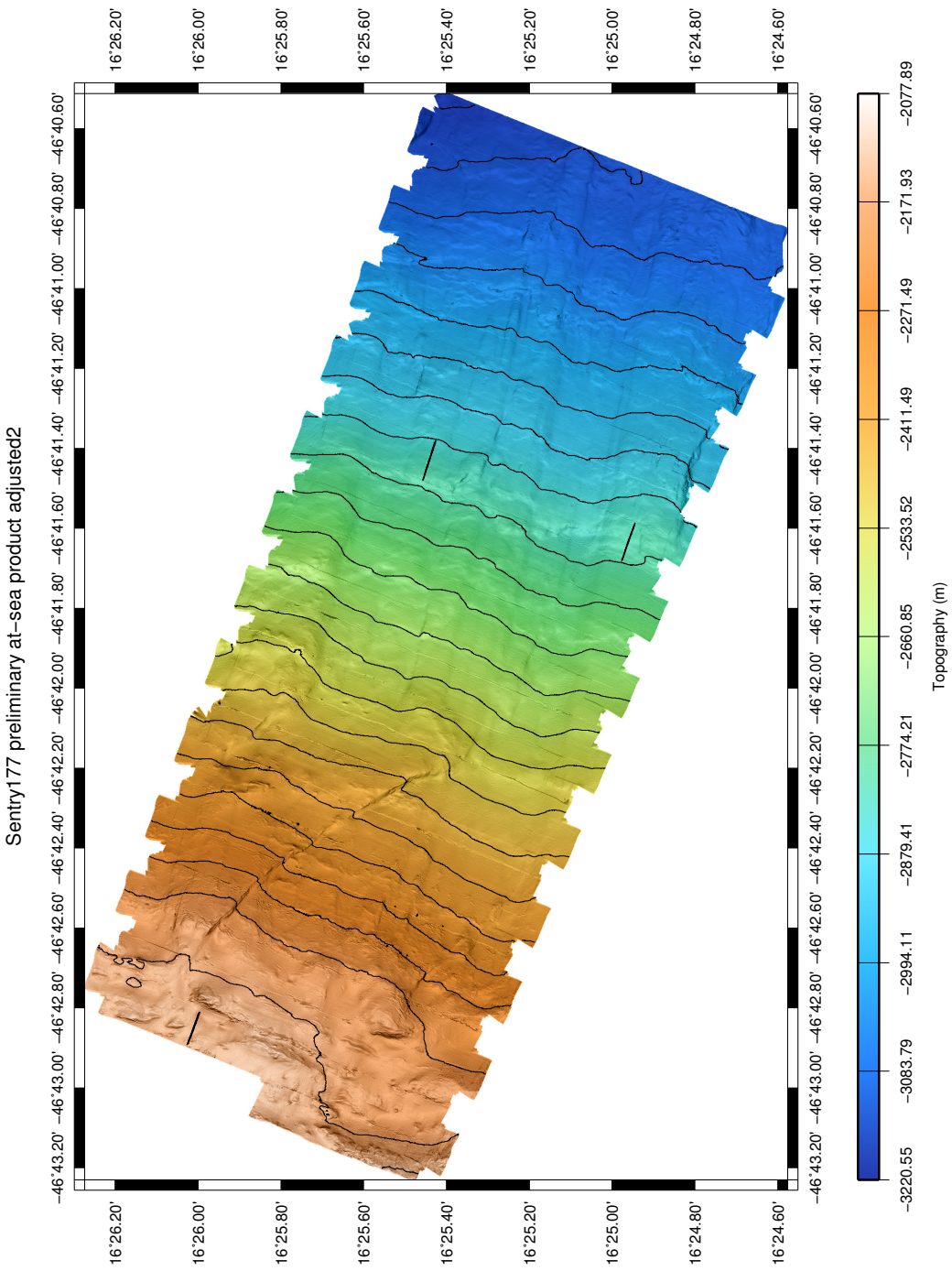

Figure 7: Bathymetry for Sentry177.

10 Sentry178

This survey extended the coverage of Sentry175 through Sentry177. This survey went as planned from a navigation and control perspective with the vehicle leaving the bottom on low battery (8%).

All water column sensors were operational on this dive, although the optical backscatter sensor measured lots of activity that looks suspicious. These anomalies did not correspond to Eh hits. We suspect the optical backscatter sensor was failing. The Eh sensor got a single, isolated hit at 0530, but that did not correlate with other water column activity.

The DVL/INS navigation looks very solid although USBL fixes were spotty, we had decent coverage only at the start and end of the survey. We saw one instance of the lateral shifts that we saw in later dives on the very last line. The complimentary filter for the navpp post-processing was run with a moderately low frequency, 0.0003. This allowed composite estimate to track the usbl motions that did not appear in the dvl record. We observed no stretches of high dvl velocity error as we did in later dives.

The resulting multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossings with over 25% overlap. The map benefited greatly from careful nav postprocessing and the use of mbnavadjust. We saw no sign of the corruption of the multibeam records from the DVL as we saw on Sentry177, so our correction to the timing was effective.

10.1 sentry178 Summary

sentry178 Summary
Origin: 16.333333 -46.783333
Launch: 2013/05/26 02:16:04
Survey start: 2013/05/26 03:39:50
Survey end: 2013/05/26 20:59:35
Ascent begins: 2013/05/26 21:00:03
On the surface: 2013/05/26 22:06:30
On deck: 2013/05/26 22:44:44
descent rate: 39.6 m/min
ascent rate: 50.1 m/min
survey time: 17.3 hours
deck-to-deck time 20.5 hours
Mean survey depth: 3394m
Mean survey height: 65m
distance travelled: 44.60km
average speed; 0.75m/s
average speed during photo runs: -0.00 m/s over -0.00 km
average speed during multibeam runs: 0.75 m/s over 46.56 km
total vertical during survey: 11052m
Battery energy at launch: 13.7 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.4 kwhr

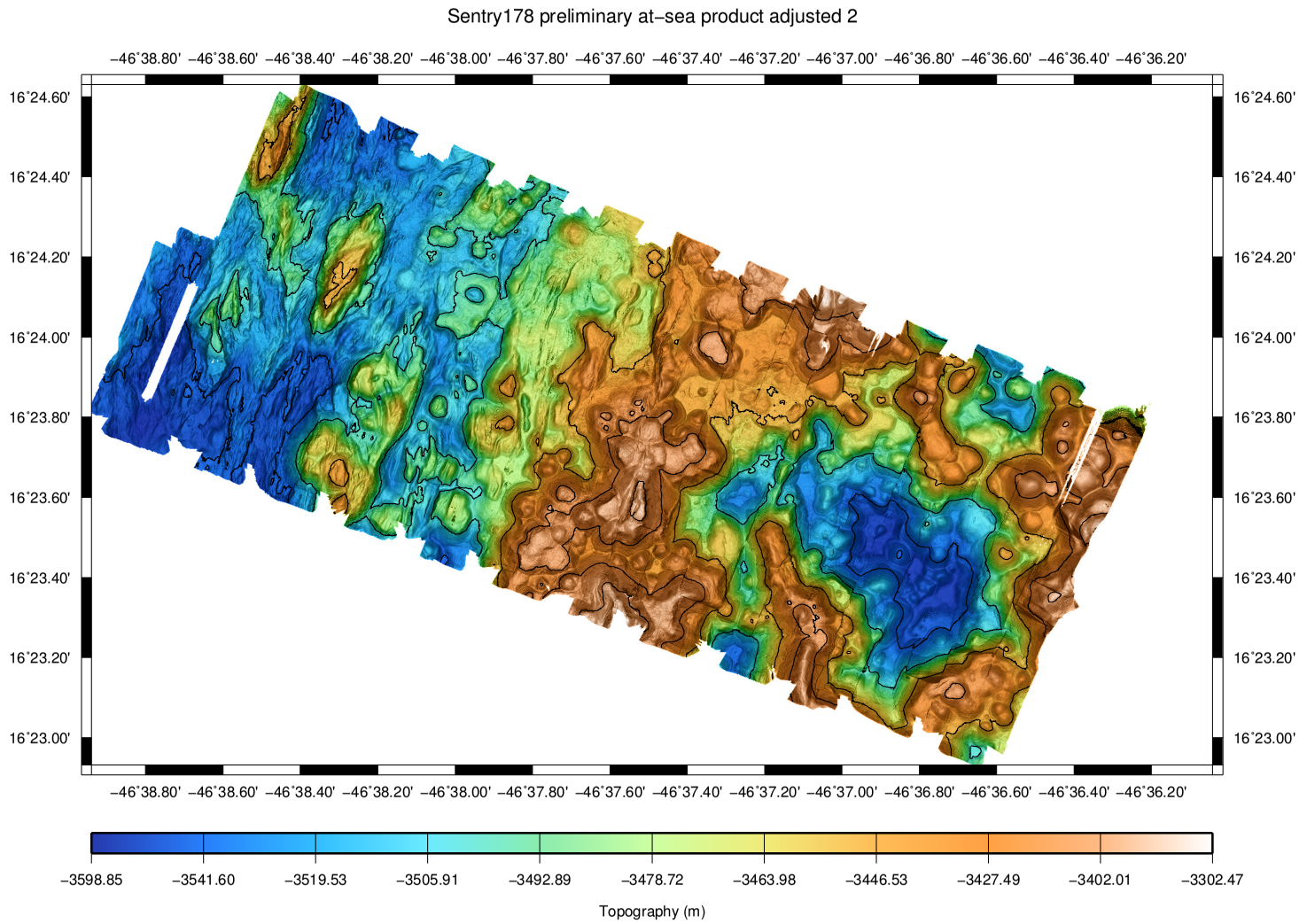

Figure 8: Bathymetry for Sentry178.

11 Sentry179

This survey was primarily a sidescan survey. Lines were spaced at 600m, leaving gaps in the multibeam coverage but producing maximum sidescan coverage. The dive went as planned from a navigation and control perspective with the vehicle leaving the bottom on low battery (8%).

All water column sensors were operational on this dive, although the optical backscatter sensor measured lots of activity that looks suspicious. These anomalies did not correspond to Eh hits. We suspect the optical backscatter sensor was failing. The Eh sensor got a single, isolated hit at 0530, but that did not correlate with other water column activity.

The DVL/INS navigation looks very solid although USBL fixes were spotty, we had decent coverage only at the start and end of the survey. We saw one instance of the lateral shifts that we saw in later dives on the very last line. The complimentary filter for the navpp post-processing was run with a moderately low frequency, 0.0003. This allowed composite estimate to track the usbl motions that did not appear in the dvl record. We observed no stretches of high dvl velocity error as we did in later dives.

The resulting multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossings with over 25% overlap. The map benefited greatly from careful nav postprocessing and the use of mbnavadjust.

11.1 sentry179 Summary

sentry179 Summary
Origin: 16.333333 -46.783333
Launch: 2013/05/27 14:43:45
Survey start: 2013/05/27 16:09:32
Survey end: 2013/05/28 09:36:56
Ascent begins: 2013/05/28 09:37:10
On the surface: 2013/05/28 10:52:49
On deck: 2013/05/28 11:05:23
descent rate: 39.0 m/min
ascent rate: 42.2 m/min
survey time: 17.5 hours
deck-to-deck time 20.4 hours
Mean survey depth: 3636m
Mean survey height: 60m
distance travelled: 39.92km
average speed; 0.70m/s
average speed during photo runs: 0.31 m/s over 2.02 km
average speed during multibeam runs: 0.73 m/s over 42.01 km
total vertical during survey: 9901m
Battery energy at launch: 13.6 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.5 kwhr

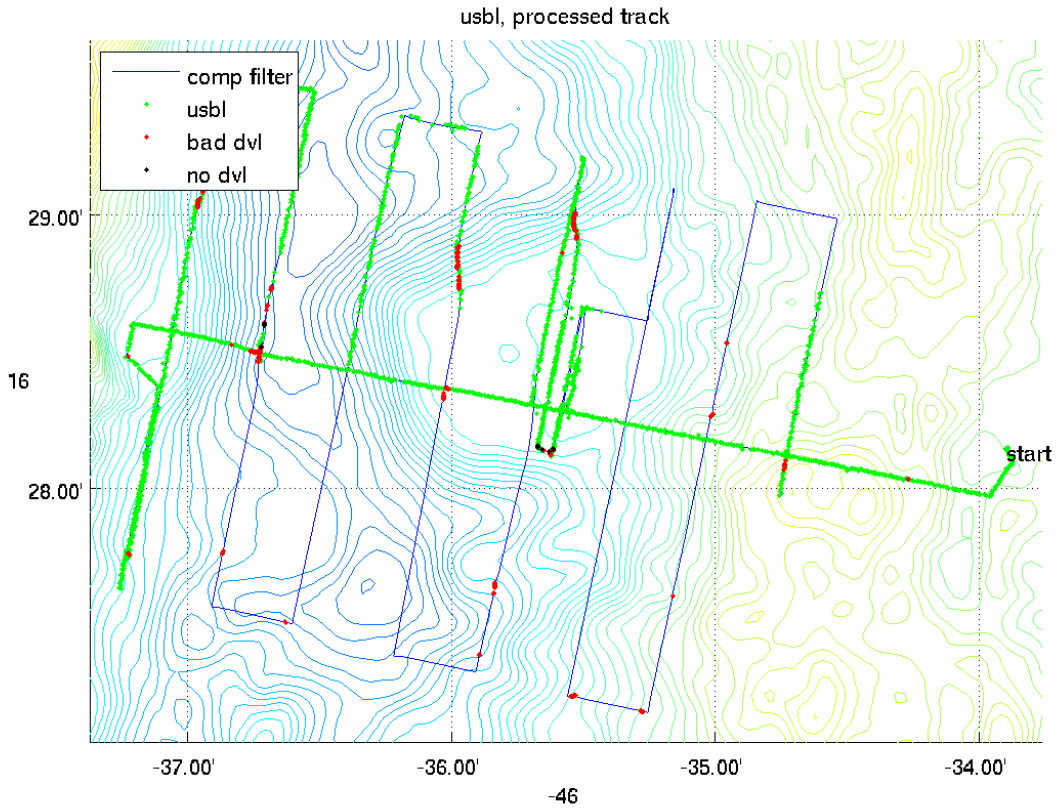

Figure 9: This plot shows the vehicle fixes and processed tracklines for dive 179. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity. On this dive, we see many bad dvl readings with the resulting "wobbles" where the vehicle drives upslope

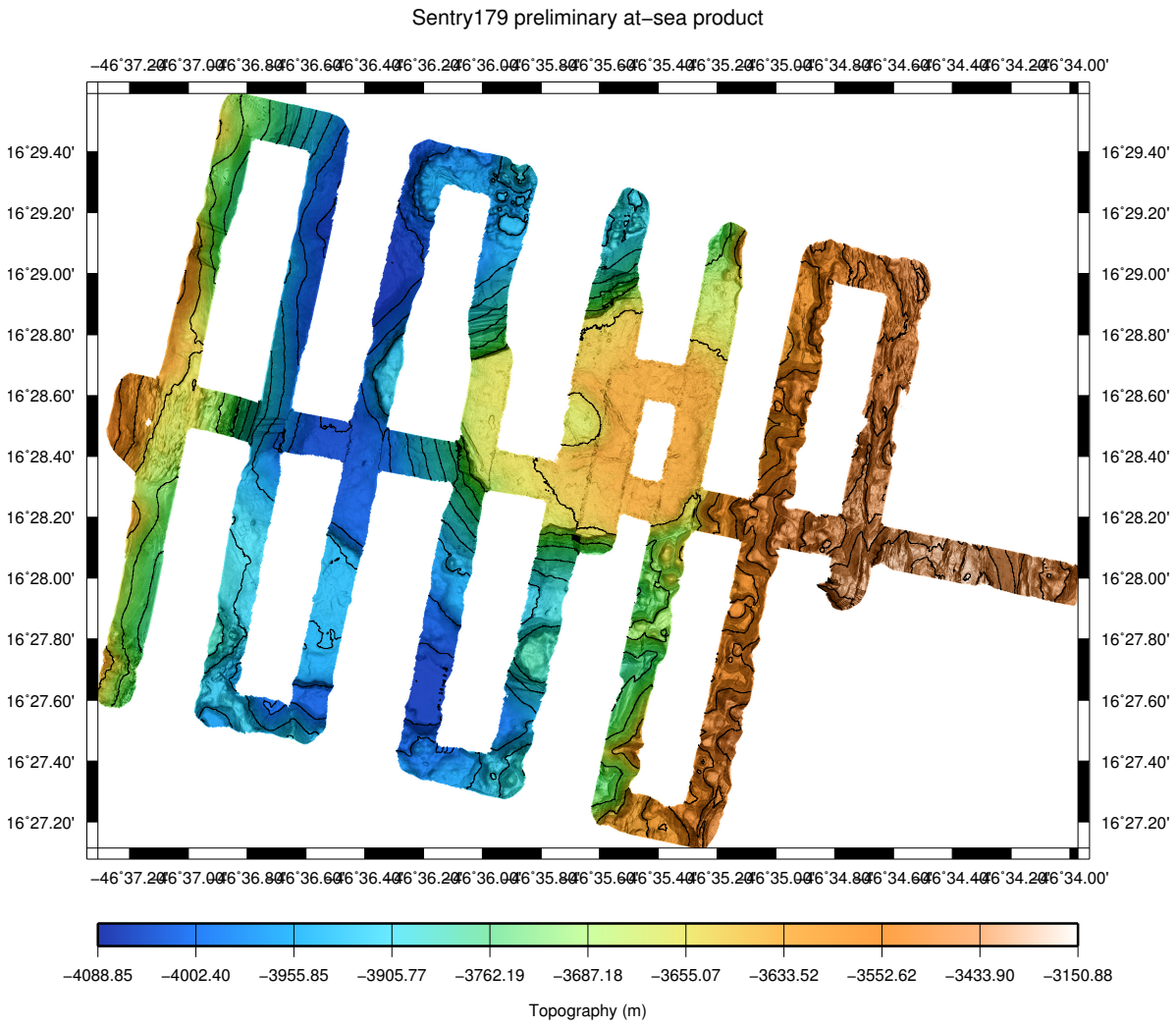

Figure 10: Bathymetry for Sentry179.

12 Sentry180

This survey extended the coverage of Sentry175 through Sentry177 to the north. This survey went as planned from a navigation and control perspective with the vehicle leaving the bottom on low battery (8%).

The optical backscatter sensor failed on this dive, all water column sensors were operational. We noticed no obvious anomalies on the Eh or orp sensors.

The DVL/INS navigation looks very solid although USBL fixes were spotty, we had decent coverage only at the start and end of the survey. We saw one instance of the lateral shifts that we saw in later dives on the very last line. The complimentary filter for the navpp post-processing was run with a moderately low frequency, 0.0003. This allowed composite estimate to track the usbl motions that did not appear in the dvl record. We observed no stretches of high dvl velocity error as we did in later dives.

The resulting multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossings with over 25% overlap.

12.1 sentry180 Summary

sentry180 Summary
Origin: 16.333333 -46.783333
Launch: 2013/05/29 02:06:12
Survey start: 2013/05/29 03:25:35
Survey end: 2013/05/29 20:55:32
Ascent begins: 2013/05/29 20:56:17
On the surface: 2013/05/29 22:04:21
On deck: 2013/05/29 22:28:30
descent rate: 38.9 m/min
ascent rate: 49.7 m/min
survey time: 17.5 hours
deck-to-deck time 20.4 hours
Mean survey depth: 3057m
Mean survey height: 65m
distance travelled: 46.45km
average speed; 0.78m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.78 m/s over 48.85 km
total vertical during survey: 7399m
Battery energy at launch: 13.4 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.4 kwhr

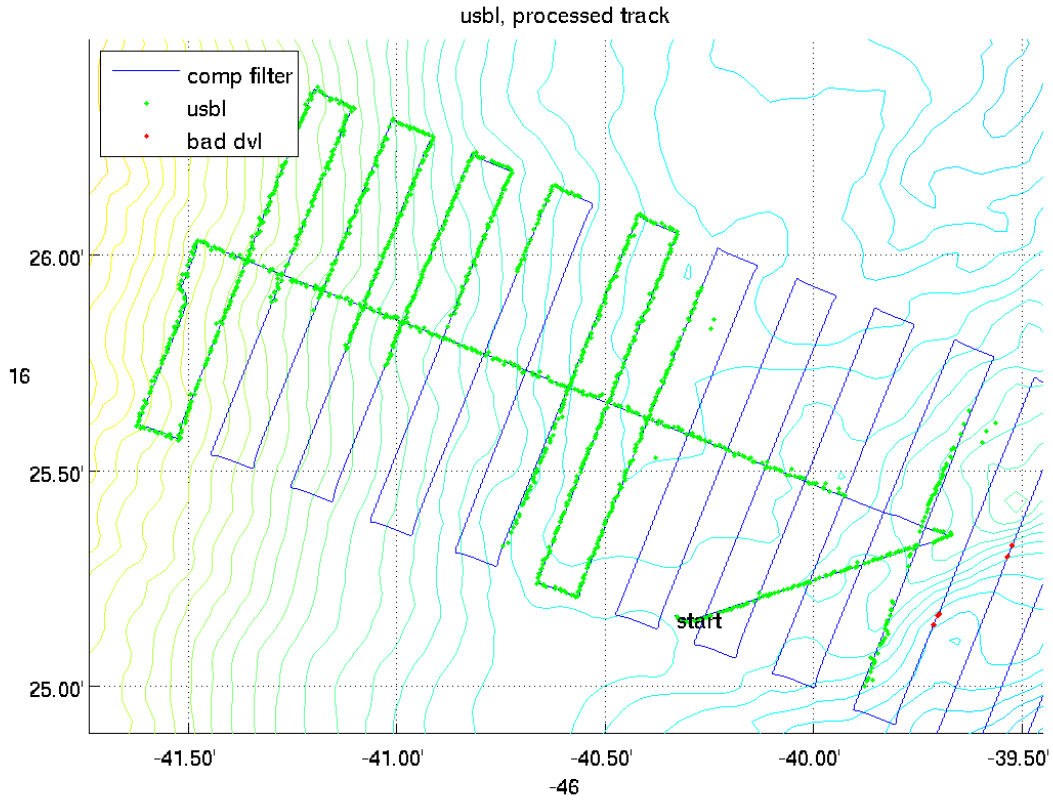

Figure 11: This plot shows the vehicle fixes and processed tracklines for dive 18. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity. On this dive, we see many bad dvl readings with the resulting "wobbles" where the vehicle drives upslope

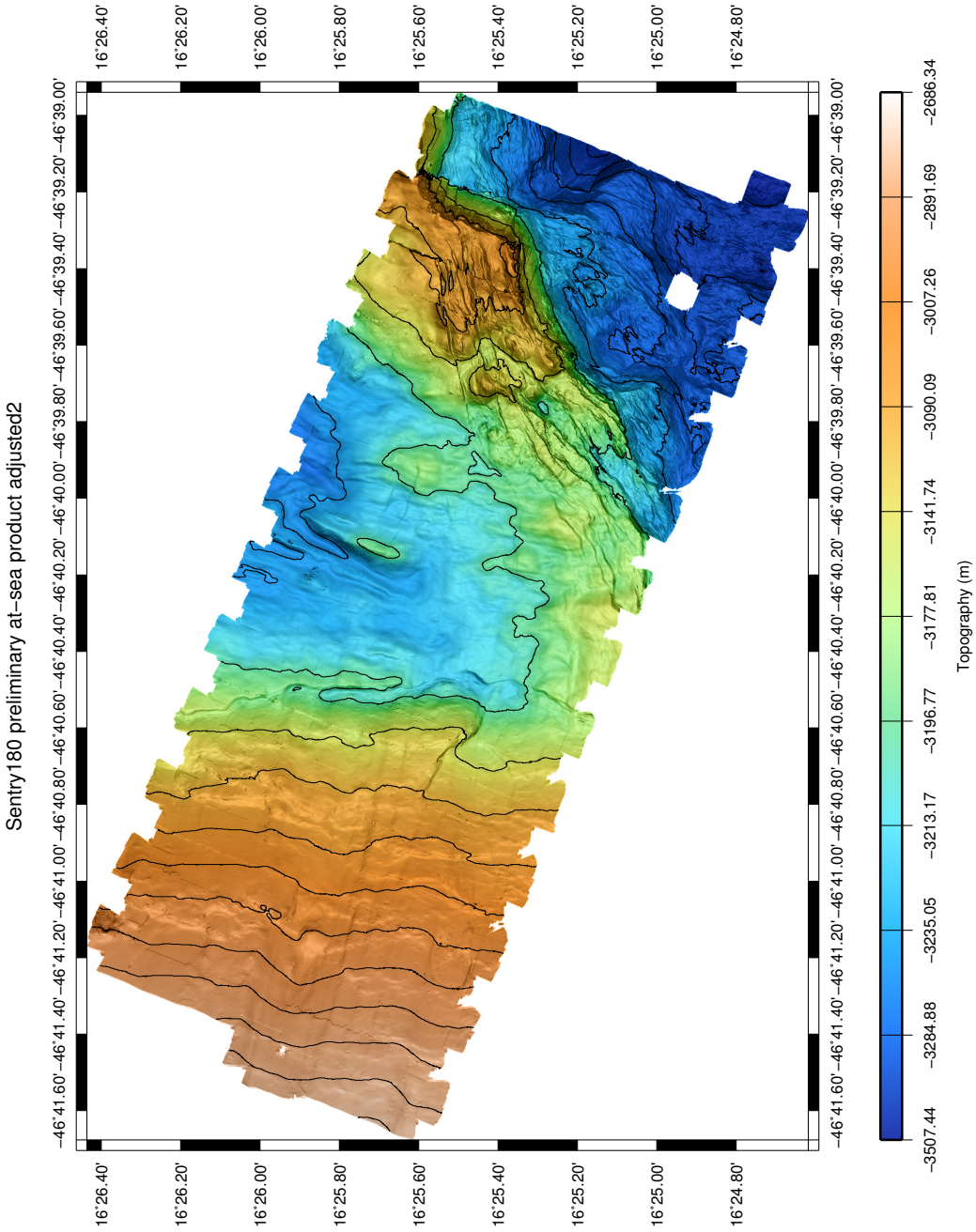

Figure 12: Bathymetry for Sentry180.

13 Sentry181

This survey went as planned from a navigation and control perspective with the vehicle leaving the bottom on low battery (8%).

The optical backscatter sensor failed on this dive, all water column sensors were operational. We noticed no obvious anomalies on the Eh or orp sensors.

The problems with the optical backscatter A/D knocked out the entire SCI bus on this dive, so no optical backscatter, Eh, or orp were recorded on this dive.

The DVL/INS navigation looks very solid although USBL fixes were spotty, we had decent coverage only at the start and end of the survey. We saw one instance of the lateral shifts that we saw in later dives on the very last line. The complimentary filter for the navpp post-processing was run with a moderately low frequency, 0.0003. This allowed composite estimate to track the usbl motions that did not appear in the dvl record. We observed no stretches of high dvl velocity error as we did in later dives.

The resulting multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossings with over 25% overlap.

13.1 sentry181 Summary

sentry181 Summary
Origin: 16.550000 -46.700000
Launch: 2013/05/30 17:27:46
Survey start: 2013/05/30 18:36:19
Survey end: 2013/05/31 12:14:52
Ascent begins: 2013/05/31 12:15:32
On the surface: 2013/05/31 13:11:53
On deck: 2013/05/31 13:25:51
descent rate: 39.0 m/min
ascent rate: 48.5 m/min
survey time: 17.6 hours
deck-to-deck time 20.0 hours
Mean survey depth: 3180m
Mean survey height: 65m
distance travelled: 42.41km
average speed; 0.78m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.78 m/s over 49.68 km
total vertical during survey: 7409m
Battery energy at launch: 13.6 kwhr
Battery energy at survey end: 1.4 kwhr
Battery energy on deck: 1.0 kwhr

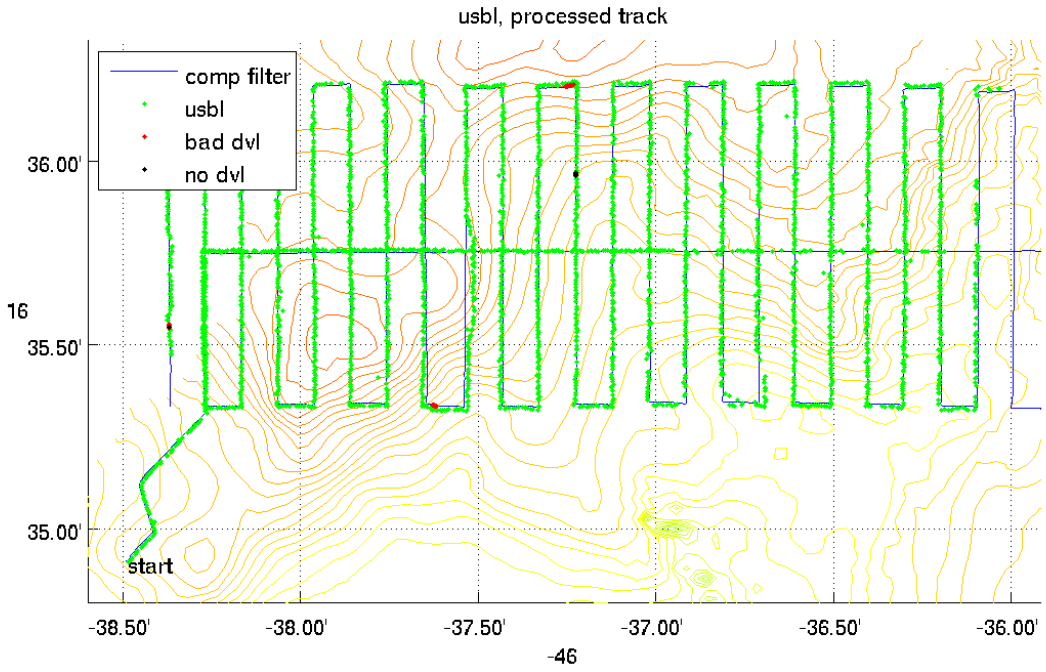

Figure 13: This plot shows the vehicle fixes and processed tracklines for dive 181. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity. On this dive, we see many bad dvl readings with the resulting "wobbles" where the vehicle drives upslope

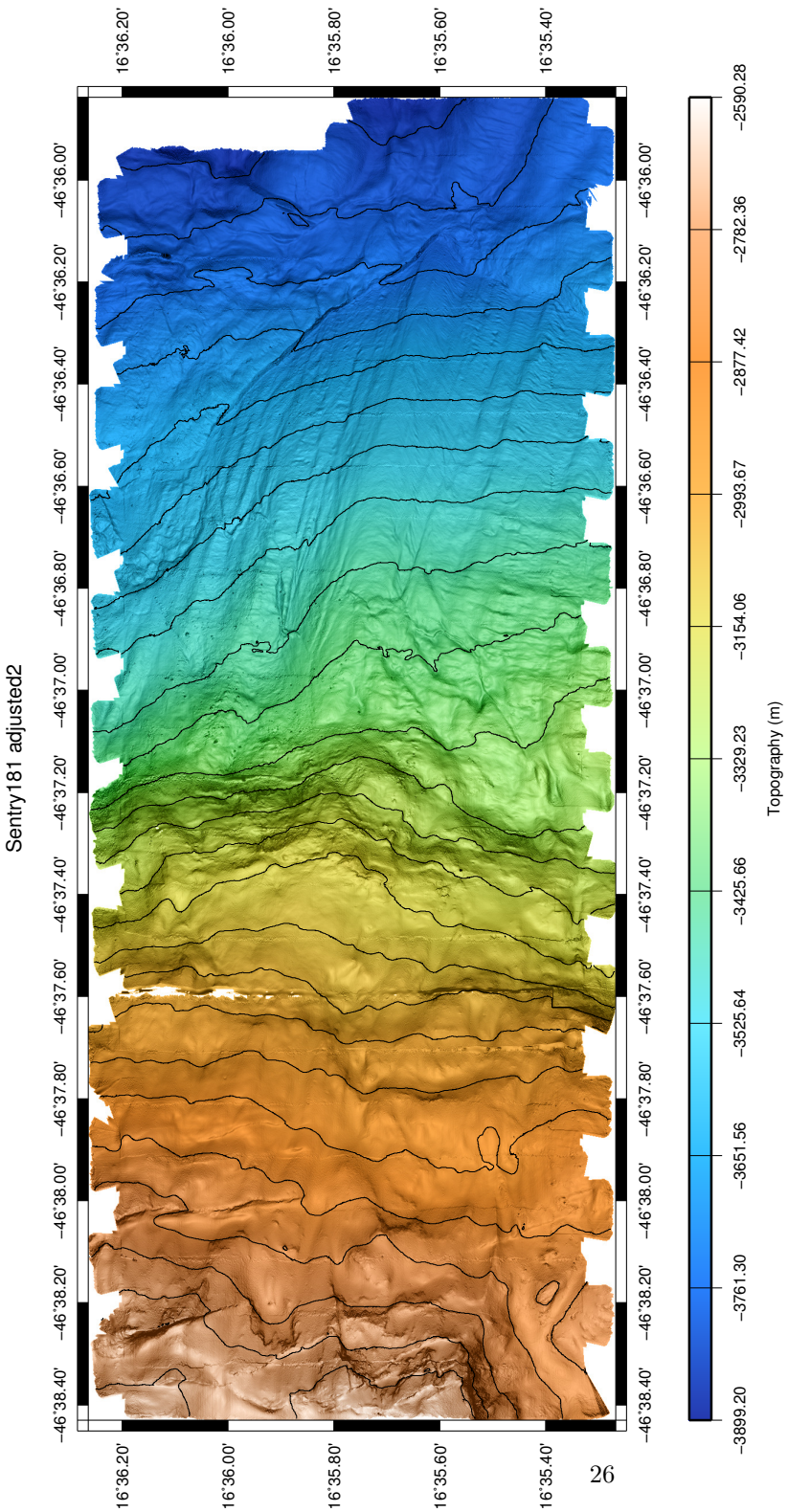

Figure 14: Bathymetry for Sentry181.

14 Sentry182

This survey went as planned from a navigation and control perspective with the vehicle leaving the bottom on low battery (8%).

The optical backscatter sensor failed on this dive, all water column sensors were operational. We noticed no obvious anomalies on the Eh or orp sensors.

The problems with the optical backscatter A/D knocked out the entire SCI bus on this dive, so no optical backscatter, Eh, or orp were recorded on this dive.

The DVL/INS navigation looks very solid although USBL fixes were spotty, we had decent coverage only at the start and end of the survey. We saw one instance of the lateral shifts that we saw in later dives on the very last line. The complimentary filter for the navpp post-processing was run with a moderately low frequency, 0.0003. This allowed composite estimate to track the usbl motions that did not appear in the dvl record. We observed no stretches of high dvl velocity error as we did in later dives.

The resulting multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossings with over 25% overlap.

14.1 sentry182 Summary

sentry182 Summary
Origin: 16.550000 -46.833333
Launch: 2013/06/01 00:42:33
Survey start: 2013/06/01 01:47:34
Survey end: 2013/06/01 17:36:19
Ascent begins: 2013/06/01 17:36:23
On the surface: 2013/06/01 18:27:22
On deck: 2013/06/01 18:38:26
descent rate: 39.8 m/min
ascent rate: 50.1 m/min
survey time: 15.8 hours
deck-to-deck time 17.9 hours
Mean survey depth: 2496m
Mean survey height: 65m
distance travelled: 41.92km
average speed; 0.78m/s
average speed during photo runs: -0.00 m/s over -0.00 km
average speed during multibeam runs: 0.78 m/s over 44.61 km
total vertical during survey: 5948m
Battery energy at launch: 11.7 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.6 kwhr

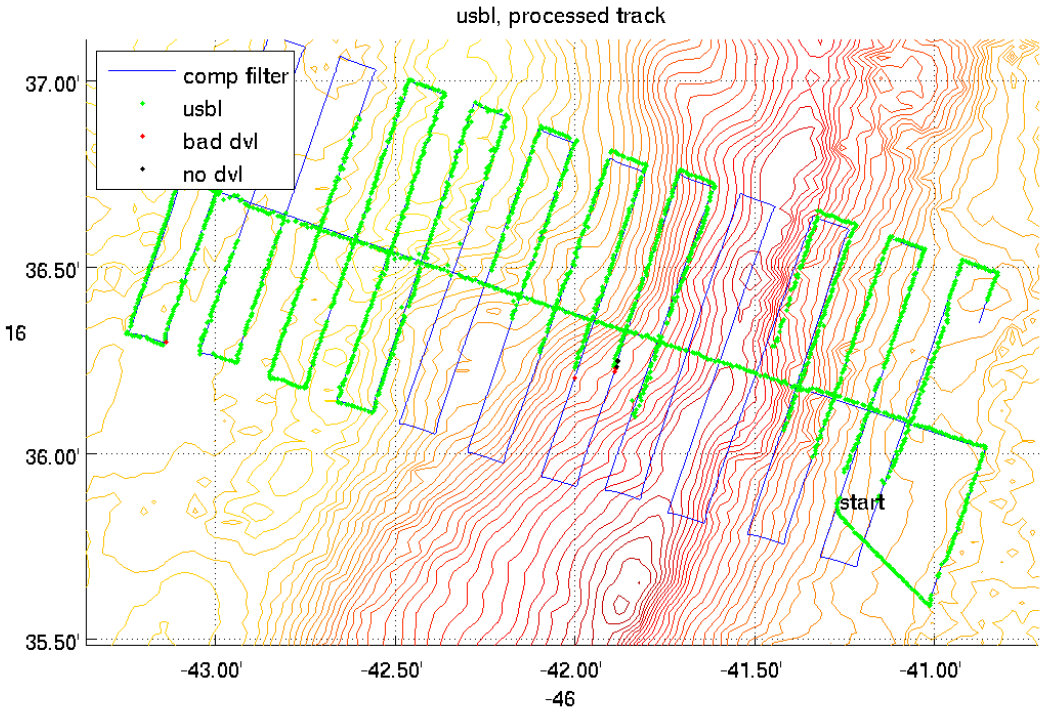

Figure 15: This plot shows the vehicle fixes and processed tracklines for dive 182. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity. On this dive, we see many bad dvl readings with the resulting "wobbles" where the vehicle drives upslope

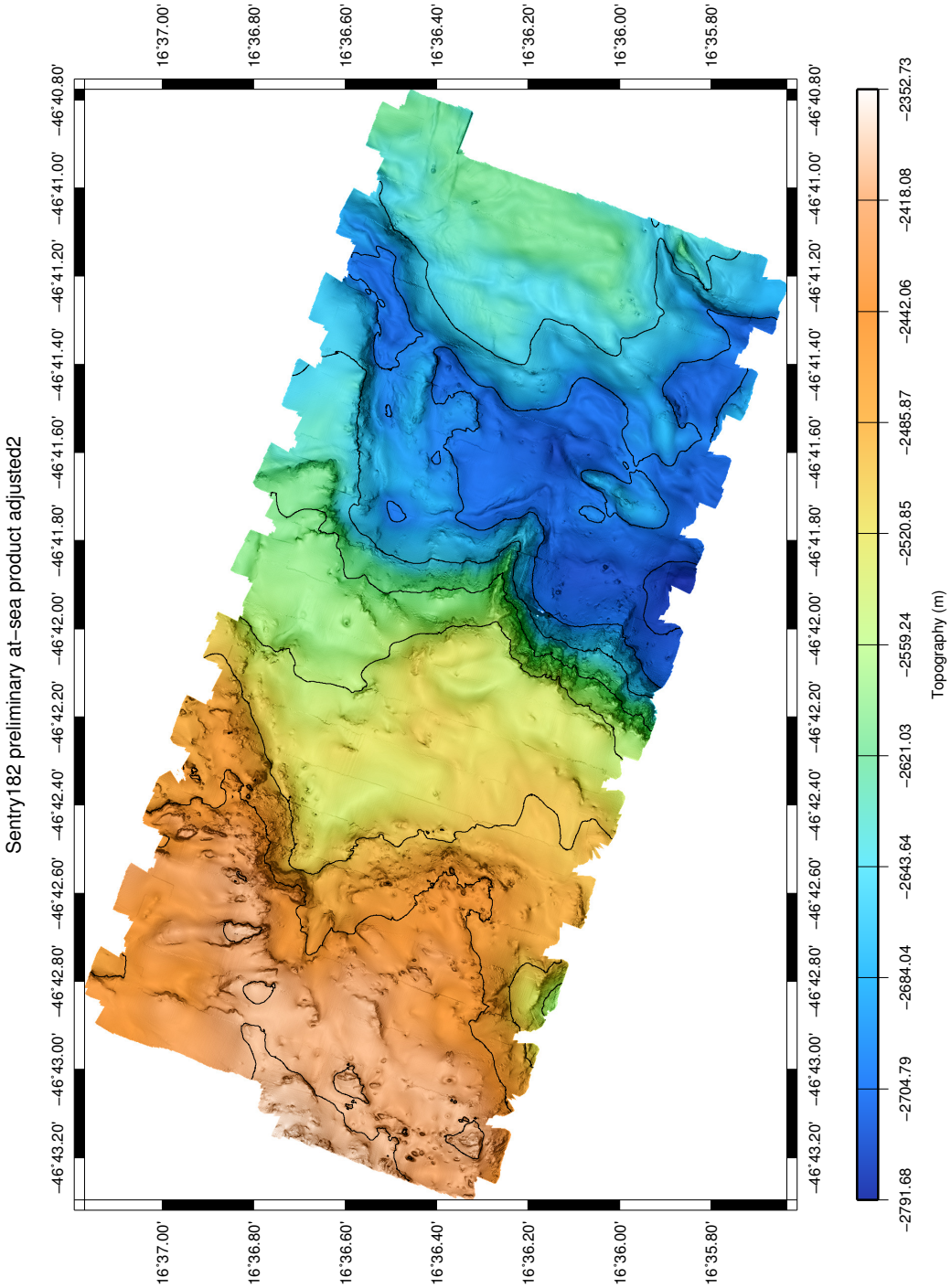

Figure 16: Bathymetry for Sentry182.

15 Sentry183

This survey went as planned from a navigation and control perspective with the vehicle leaving the bottom on low battery (8%).

The optical backscatter sensor failed on this dive, all water column sensors were operational. We noticed no obvious anomalies on the Eh or orp sensors.

The problems with the optical backscatter A/D knocked out the entire SCI bus on this dive, so no optical backscatter, Eh, or orp were recorded on this dive.

The DVL/INS navigation looks very solid although USBL fixes were spotty, we had decent coverage only at the start and end of the survey. We saw one instance of the lateral shifts that we saw in later dives on the very last line. The complimentary filter for the navpp post-processing was run with a moderately low frequency, 0.0003. This allowed composite estimate to track the usbl motions that did not appear in the dvl record. We observed no stretches of high dvl velocity error as we did in later dives.

The resulting multibeam map looks very good with high internal integrity. We ran mbnavadjust first with true crossings, then with all crossings with over 25% overlap.

15.1 sentry183 Summary

sentry183 Summary
Origin: 16.333333 -46.783333
Launch: 2013/06/02 16:53:55
Survey start: 2013/06/02 18:34:28
Survey end: 2013/06/03 12:34:55
Ascent begins: 2013/06/03 12:35:24
On the surface: 2013/06/03 13:47:21
On deck: 2013/06/03 14:03:12
descent rate: 36.8 m/min
ascent rate: 49.0 m/min
survey time: 18.0 hours
deck-to-deck time 21.2 hours
Mean survey depth: 2843m
Mean survey height: 65m
distance travelled: 43.07km
average speed; 0.74m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.74 m/s over 48.09 km
total vertical during survey: 10984m
Battery energy at launch: 13.8 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.5 kwhr

15.2 sentry183 Summary

sentry183 Summary
Origin: 16.333333 -46.783333

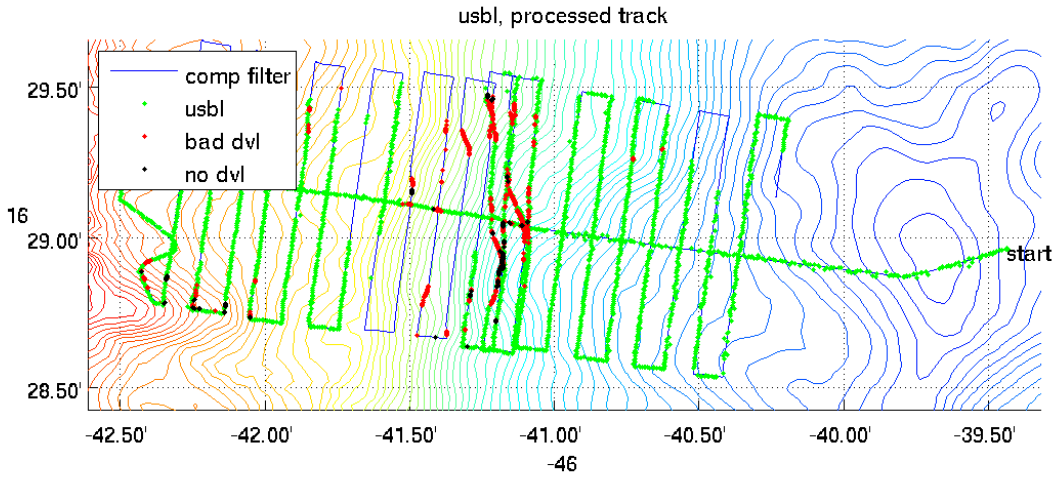

Figure 17: This plot shows the vehicle fixes and processed tracklines for dive 183. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity. On this dive, we see many bad dvl readings with the resulting "wobbles" where the vehicle drives upslope

Launch: 2013/06/02 16:53:55
Survey start: 2013/06/02 18:34:28
Survey end: 2013/06/03 12:34:55
Ascent begins: 2013/06/03 12:35:24
On the surface: 2013/06/03 13:47:21
On deck: 2013/06/03 14:03:12
descent rate: 36.8 m/min
ascent rate: 49.0 m/min
survey time: 18.0 hours

deck-to-deck time 21.2 hours
Mean survey depth: 2843m
Mean survey height: 65m
distance travelled: 43.07km
average speed; 0.74m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.74 m/s over 48.09 km
total vertical during survey: 10984m
Battery energy at launch: 13.8 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.5 kwhr

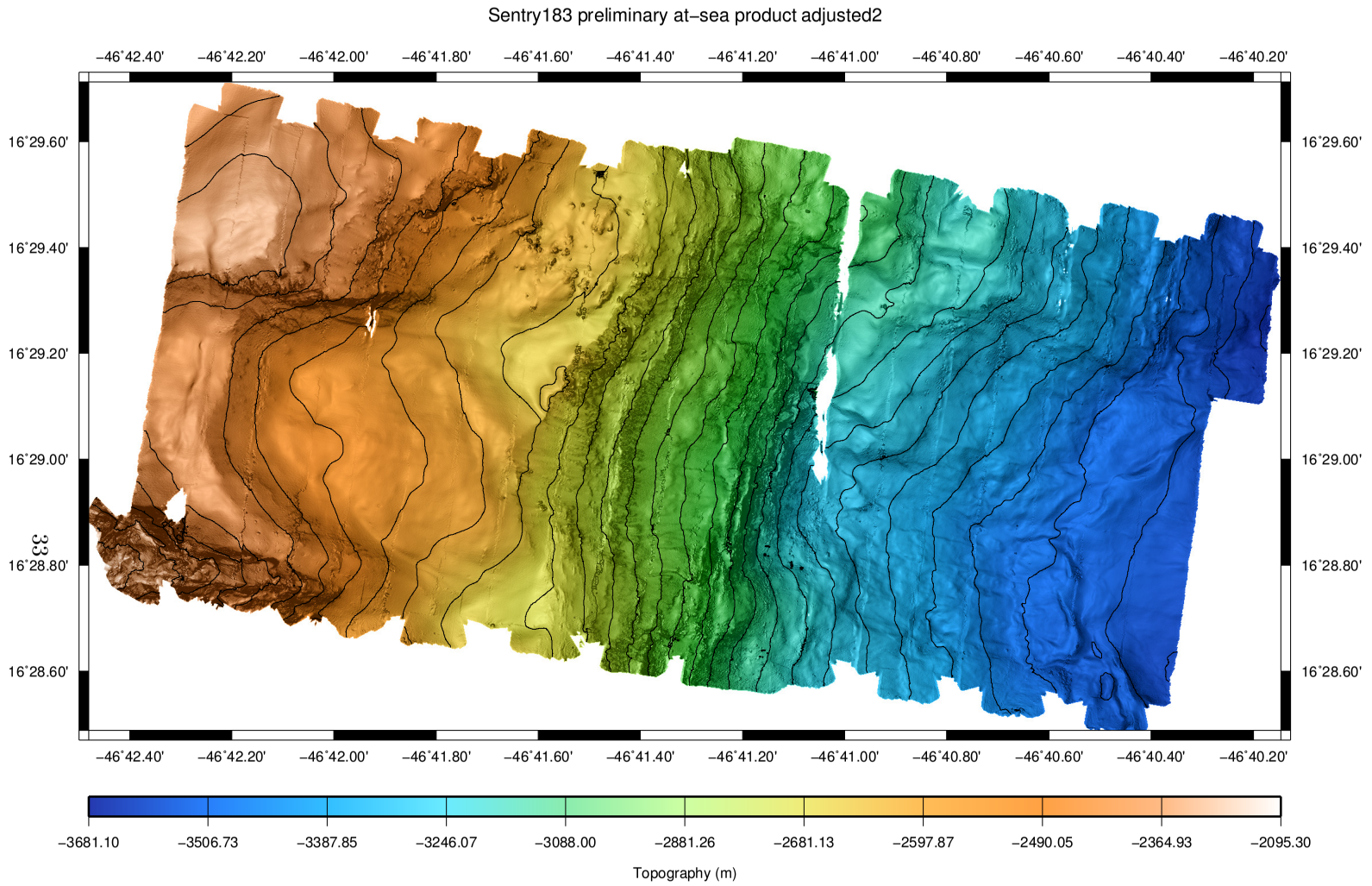

Figure 18: Bathymetry for Sentry183.

16 Sentry184

Sentry184 mapped an area at the latitude of Sentry181 and Sentry182 but did not connect to them. The terrain was rough and the navigation suffered significantly with numerous "wobbles" resulting in gaps and poor matches between swaths. Processing to improve the map is ongoing as of this writing (2013/06/17).

All water column sensors with the exception of the optical backscatter sensor were operational on this dive. We noted no obvious water column anomolies on the Eh or ORP sensors. The optical backscatter most likely had an electrical problem.

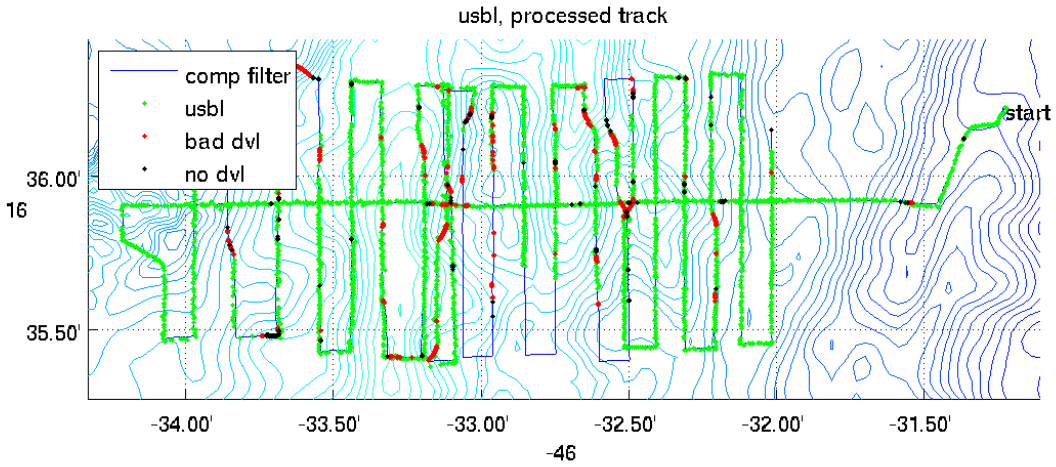

Figure 19: This plot shows the vehicle fixes and processed tracklines for dive 184. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity. On this dive, we see many bad dvl readings with the resulting "wobbles" where the vehicle drives upslope

16.1 sentry184 Summary

sentry184 Summary
Origin: 16.550000 -46.800000
Launch: 2013/06/04 02:59:32
Survey start: 2013/06/04 04:46:30
Survey end: 2013/06/04 21:42:13
Ascent begins: 2013/06/04 21:42:28
On the surface: 2013/06/04 22:59:17
On deck: 2013/06/04 23:16:06
descent rate: 38.5 m/min
ascent rate: 49.3 m/min
survey time: 16.9 hours
deck-to-deck time 20.3 hours
Mean survey depth: 3641m
Mean survey height: 66m
distance travelled: 38.12km
average speed; 0.71m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.71 m/s over 43.51 km
total vertical during survey: 12129m
Battery energy at launch: 13.3 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.4 kwhr

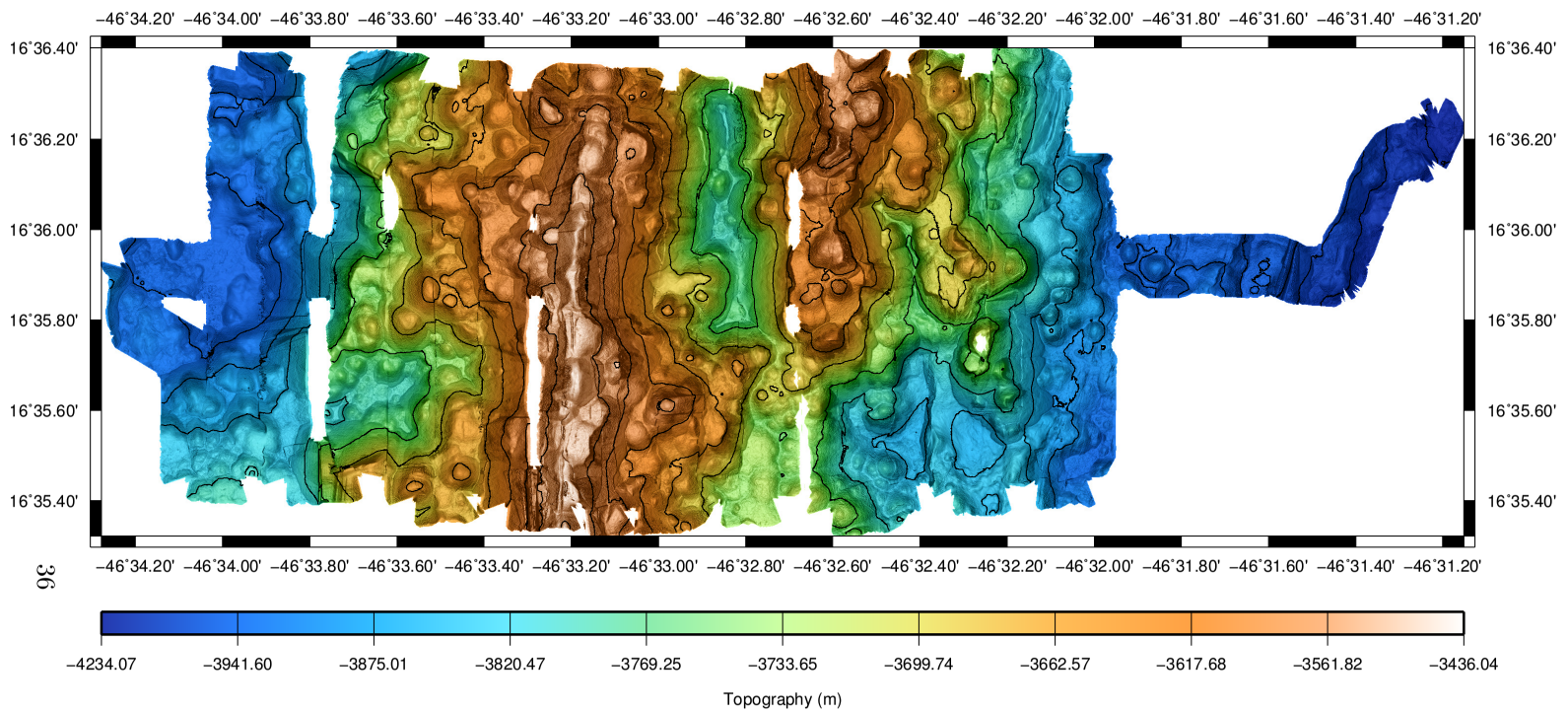

Figure 20: Bathymetry for Sentry184.

17 Sentry185

Sentry185 was the first, eastern-most block in the 16 44' area. It included a crossing line. The terrain was relatively benign and navigation was very good with minimal DVL problems except at the end of the last trackline where a significant "wobble" was noted.

All water column sensors were operational on this dive. We noted no obvious water column anomolies on the Eh or ORP sensors. Some mild elevation of the optical backscatter was noted.

The main part of the map has good coverage and internal consistency with the exception of gaps caused by DVL errors. The bathymetry was processed using the standard method for this cruise with two passes of navigation adjustment.

17.1 sentry185 Summary

sentry185 Summary
Origin: 16.666667 -46.666667
Launch: 2013/06/05 16:32:45
Survey start: 2013/06/05 18:19:28
Survey end: 2013/06/06 11:59:54
Ascent begins: 2013/06/06 12:00:39
On the surface: 2013/06/06 13:20:58
On deck: 2013/06/06 13:33:29
descent rate: 38.2 m/min
ascent rate: 50.4 m/min
survey time: 17.7 hours
deck-to-deck time 21.0 hours
Mean survey depth: 4355m
Mean survey height: 65m
distance travelled: 40.77km
average speed; 0.74m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.74 m/s over 47.18 km
total vertical during survey: 10378m
Battery energy at launch: 13.8 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.5 kwhr

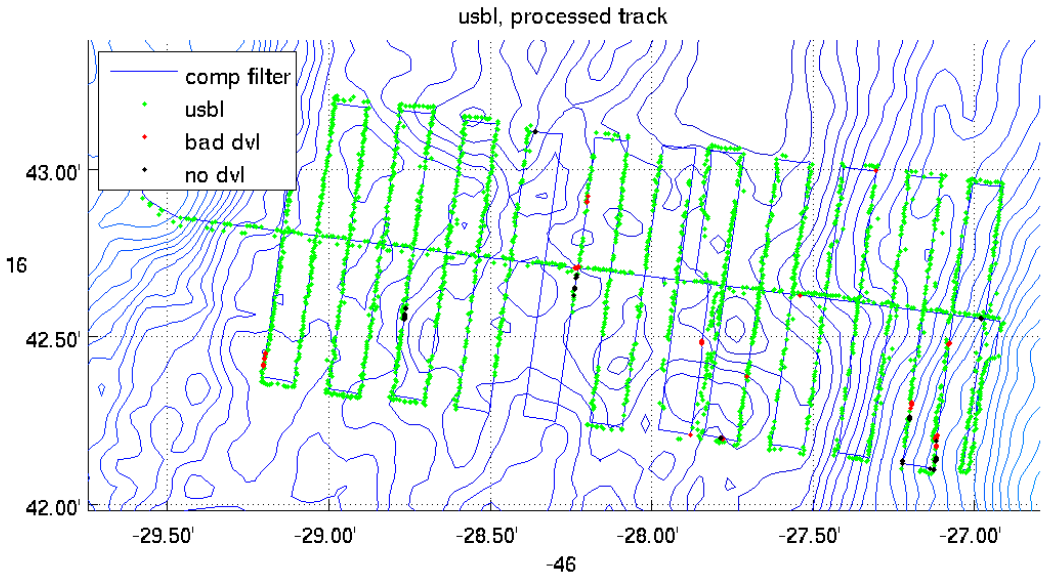

Figure 21: This plot shows the vehicle fixes and processed tracklines for dive 185. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity. The USBL coverage was consistent and the DVL problems were minimal. We noted on large DVL "wobble" at the end of the last trackline

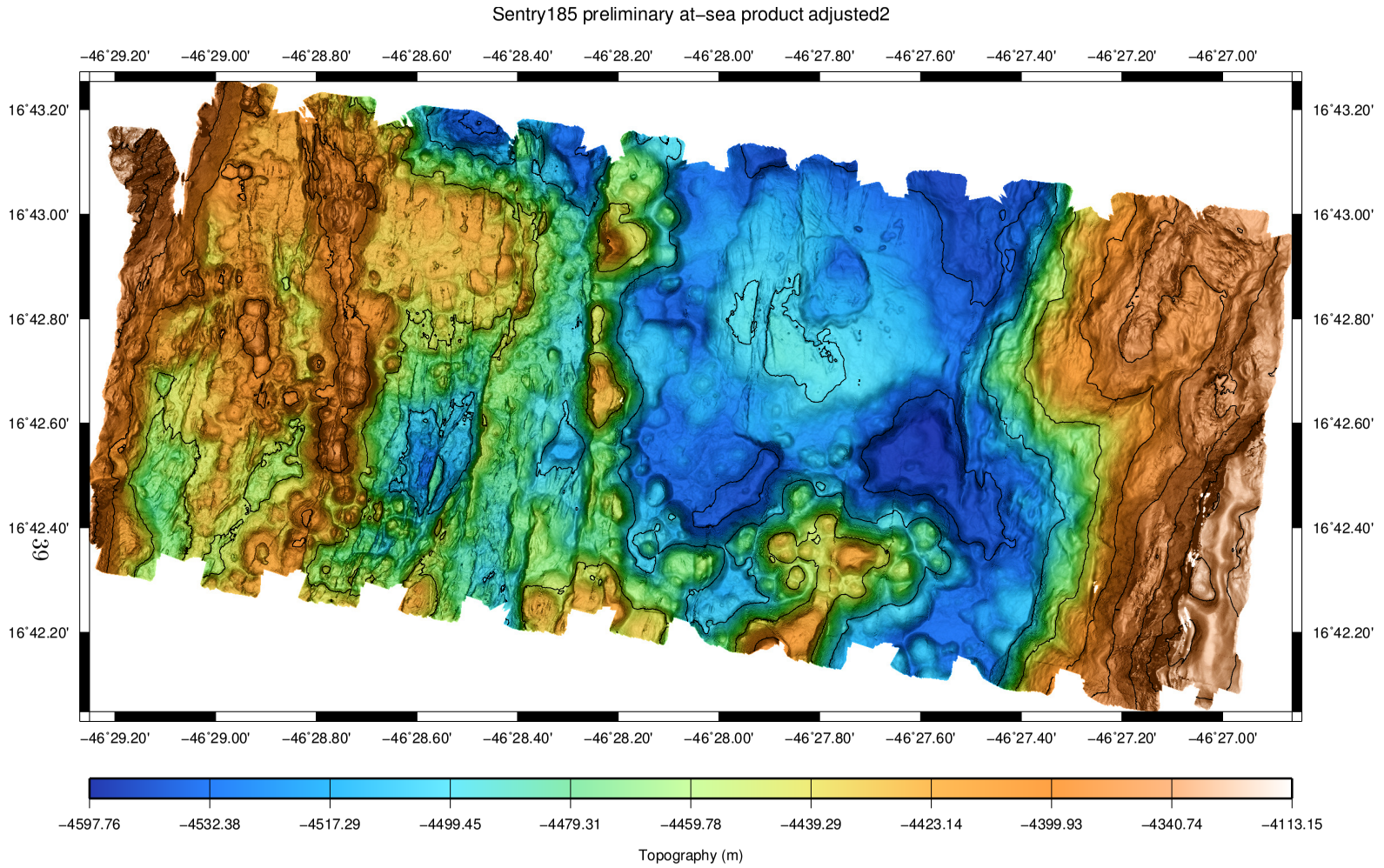

Figure 22: Bathymetry for Sentry185.

18 Sentry186

Sentry186 was the second block in the 16 44' area. It included a crossing line. The vehicle navigation experienced several shifts on the steep terrain, which included a scarp over 200m high. These shifts correspond to the identified problem DVL pings based on our v-velocity and missing fixes.

All water column sensors were operational on this dive. We noted no obvious water column anomolies on the Eh or ORP sensors. Some mild elevation of the optical backscatter was noted.

The main part of the map has good coverage and internal consistency with the exception of gaps caused by DVL errors. The bathymetry was processed using the standard method for this cruise with two passes of navigation adjustment.

18.1 sentry186 Summary

sentry186 Summary
Origin: 16.666667 -46.666667
Launch: 2013/06/07 03:29:30
Survey start: 2013/06/07 04:59:18
Survey end: 2013/06/07 20:48:26
Ascent begins: 2013/06/07 20:48:50
On the surface: 2013/06/07 22:00:13
On deck: 2013/06/07 23:48:46
descent rate: 39.0 m/min
ascent rate: 49.2 m/min
survey time: 15.8 hours
deck-to-deck time 20.3 hours
Mean survey depth: 3780m
Mean survey height: 66m
distance travelled: 36.23km
average speed; 0.71m/s
average speed during photo runs: 0.00 m/s over 0.00 km
average speed during multibeam runs: 0.71 m/s over 40.31 km
total vertical during survey: 11014m
Battery energy at launch: 12.4 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.6 kwhr

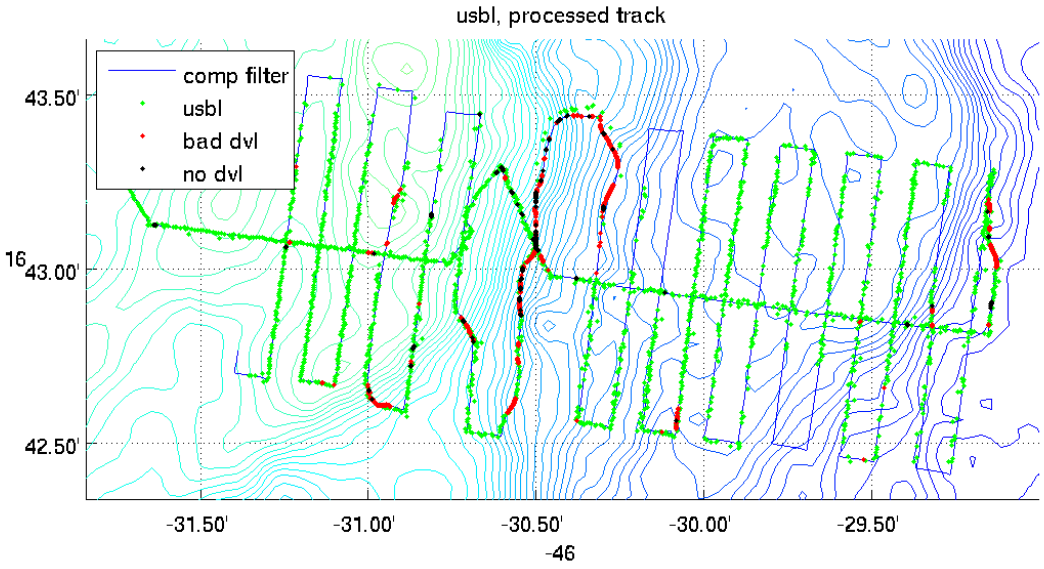

Figure 23: This plot shows the vehicle fixes and processed tracklines for dive 186. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity.The dive plan included a crossing line, then several fill-in lines to the east to patch missing sections from the previous dive. The vehicle encountered many dvl "wobbles" on the steep terrain as indicated by the black and red markers. We had very sparse USBL coverage in the eastern main block, as the vessel was out of range for dredging.

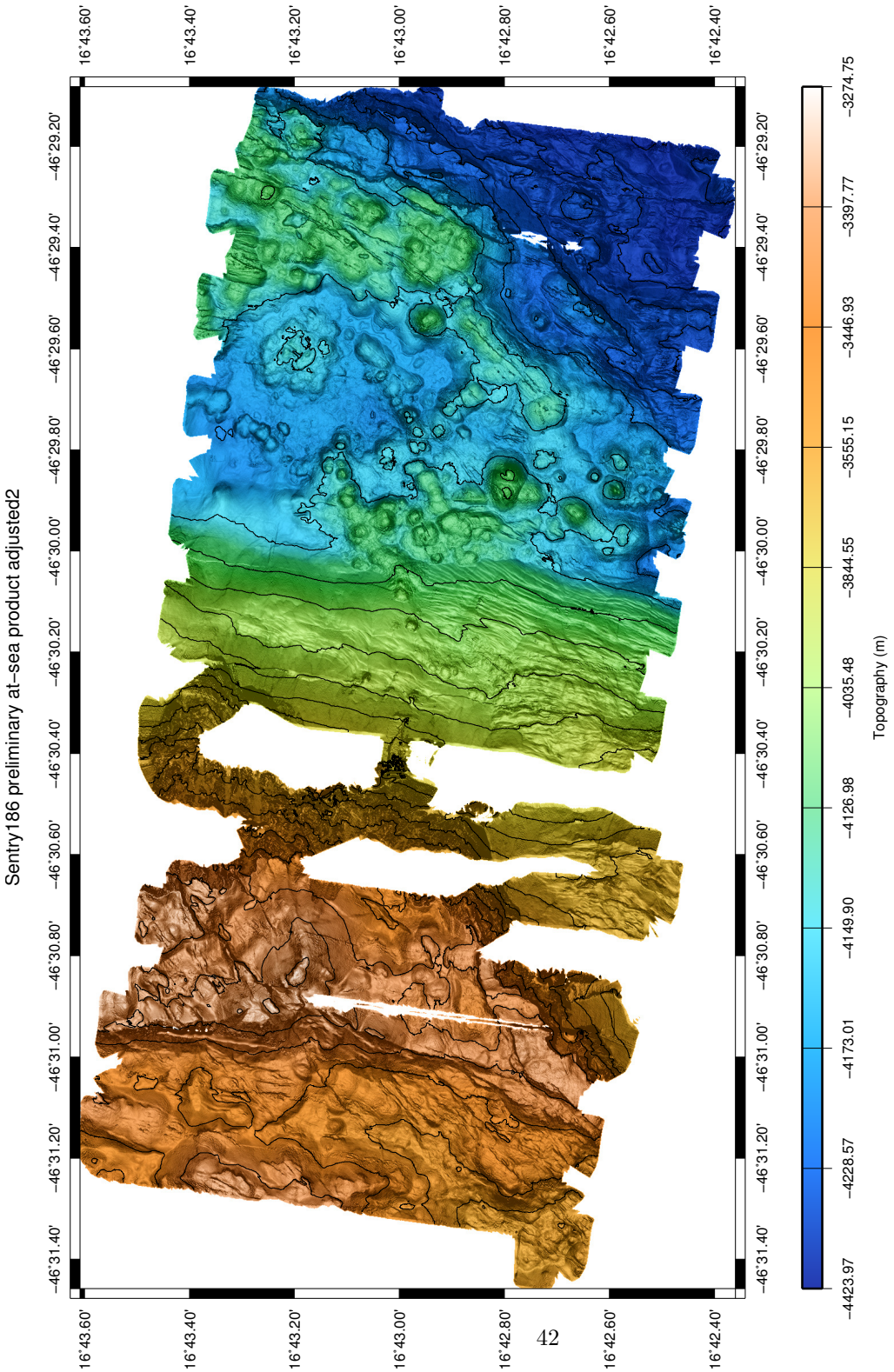

Figure 24: Bathymetry for Sentry186. The DVL "wobbles" resulted in gaps on the steep terrain

19 Sentry187

Sentry187 included a crossing line and two fill-in lines for areas missed on the previous survey due to DVL "wobbles" on steep terrain. We were mostly successful in filling those holes, although the vehicle "wobbled" often on the same terrain. In all cases, each "wobble" corresponds to a period (sometimes short) that meets the high-v-velocity criteria, and in each case the vehicle drove upslope as the vehicle's internal estimate falsely moved downslope.

All water column sensors were operational on this dive except for the optode. It would not start properly and we chose not to delay the dive.

The main part of the map has good coverage and internal consistency with the exception of two gaps caused by DVL errors.

19.1 sentry187 Summary

sentry187 Summary
Origin: 16.666667 -46.666667
Launch: 2013/06/08 17:58:32
Survey start: 2013/06/08 19:24:38
Survey end: 2013/06/09 13:02:54
Ascent begins: 2013/06/09 13:03:33
On the surface: 2013/06/09 14:02:42
On deck: 2013/06/09 14:16:56
descent rate: 39.3 m/min
ascent rate: 49.3 m/min
survey time: 17.6 hours
deck-to-deck time 20.3 hours
Mean survey depth: 3328m
Mean survey height: 66m
distance travelled: 40.16km
average speed; 0.71m/s
average speed during photo runs: -0.00 m/s over -0.00 km
average speed during multibeam runs: 0.71 m/s over 45.17 km
total vertical during survey: 12152m
Battery energy at launch: 13.7 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.6 kwhr

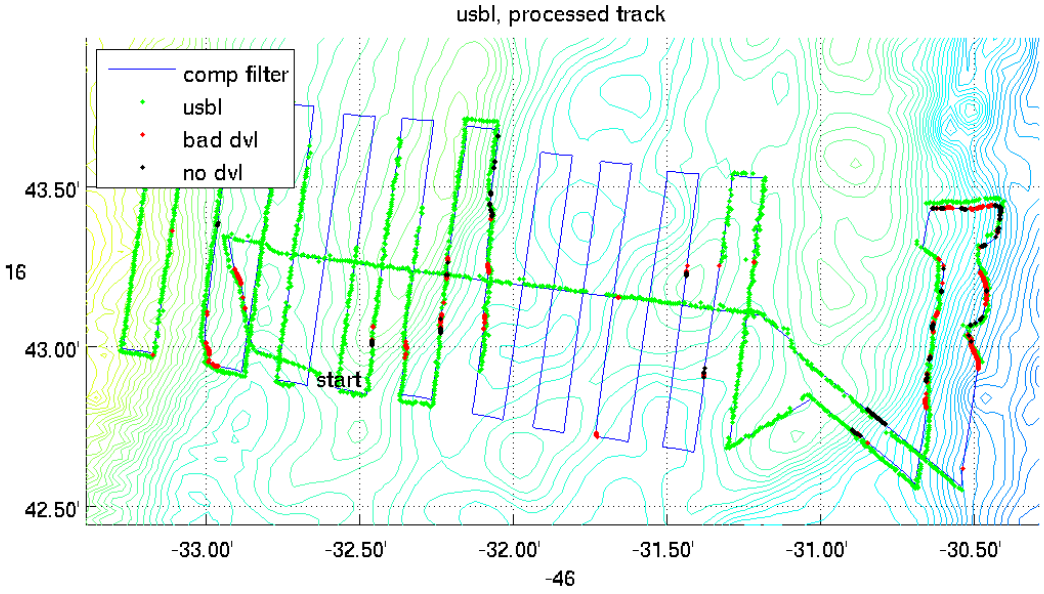

Figure 25: This plot shows the vehicle fixes and processed tracklines for dive 187. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity.The dive plan included a crossing line, then several fill-in lines to the east to patch missing sections from the previous dive. The vehicle encountered many dvl "wobbles" on the steep terrain as indicated by the black and red markers. We had very sparse USBL coverage in the eastern main block, as the vessel was out of range for dredging.

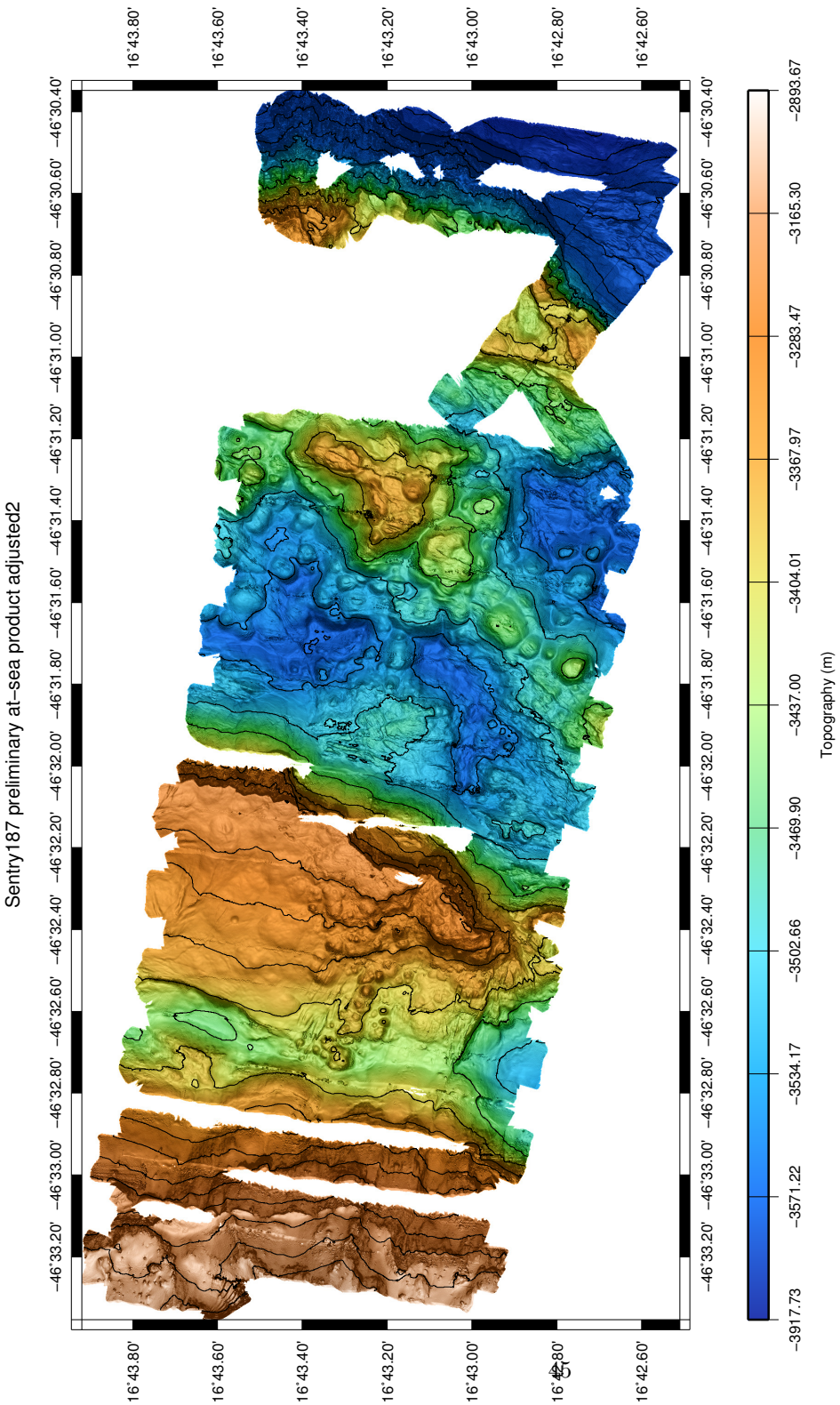

Figure 26: Bathymetry for Sentry187. The DVL "wobbles" resulted in gaps on the steep terrain

20 Sentry188

On Sentry188, we planned a crossing line, then did a fill line to close a gap in the coverage from Sentry187. We put in a fix for the dvl "wobbles" seen while ascending steep terrain in previous runs. These errors resulted in the vehicle shifting upslope, as the position estimate would drift downslope. We demonstrated a functional, real-time fix to this problem on this dive.

We also included a short photo run in this dive. We chose the area based on the available Seabeam data. In hindsight, this was a mistake. We had unknowingly sent the vehicle into some of the most difficult terrain in the entire survey area. Very quickly into the photo run, the vehicle got stuck against a very tall scarp. We sent acoustic commands to increase the bottom-following height to 50 m, which freed the vehicle. We decided to let the photo survey complete at the 50 m height. As the vehicle had already taken some good photos that characterized the terrain, this was the correct call, more photos would have been interesting but were not needed.

The vehicle ran its full dive plan until the battery level reached the assigned level of 8%.

All water column sensors functioned properly. We saw one large optical backscatter hit, but that was associated with the vehicle hitting the bottom on the photo run.

The real-time fix for the doppler problem worked well. In post-processing, we ran the correction algorithm that identified segments where normally we might expect the DVL to produce an upslope offset in the trackline. Those did not occur and the compensation in the real-time navigation software was largely successful.

20.1 sentry188 Summary

sentry188 Summary
Origin: 16.666667 -46.666667
Launch: 2013/06/10 04:11:44
Survey start: 2013/06/10 05:14:45
Survey end: 2013/06/10 23:00:56
Ascent begins: 2013/06/10 23:01:19
On the surface: 2013/06/10 23:59:03
On deck: 2013/06/11 00:14:02
descent rate: 40.2 m/min
ascent rate: 49.0 m/min
survey time: 17.8 hours
deck-to-deck time 20.0 hours
Mean survey depth: 2627m
Mean survey height: 74m
distance travelled: 41.55km
average speed; 0.73m/s
average speed during photo runs: 0.08 m/s over 0.14 km
average speed during multibeam runs: 0.73 m/s over 46.29 km
total vertical during survey: 10830m
Battery energy at launch: 13.7 kwhr
Battery energy at survey end: 1.0 kwhr
Battery energy on deck: 0.6 kwhr

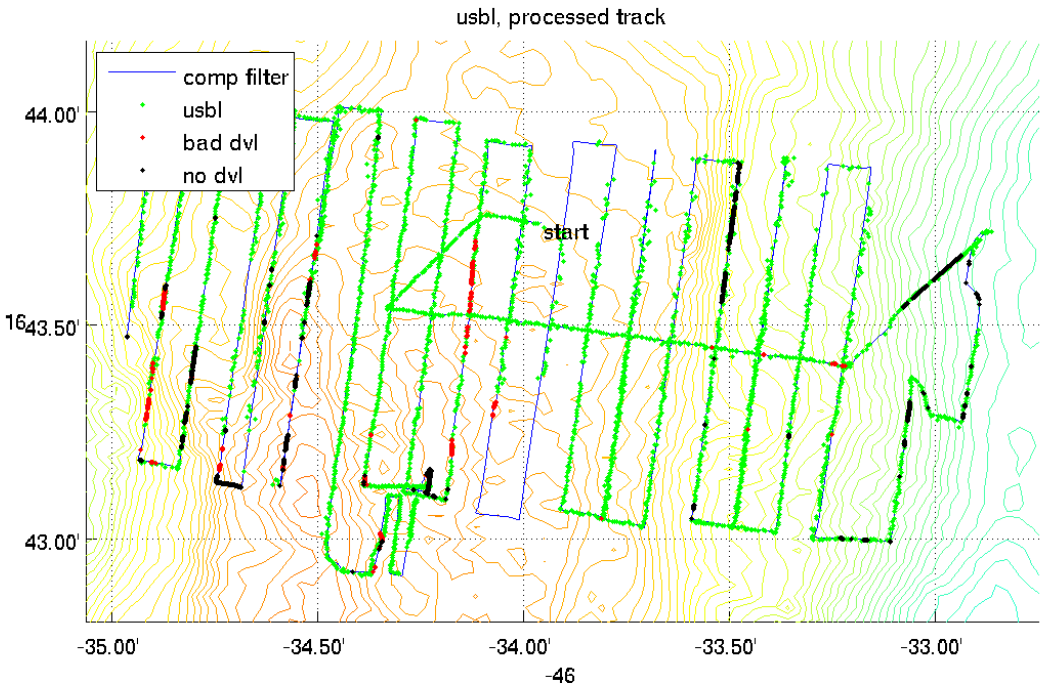

Figure 27: This plot shows the vehicle fixes and processed tracklines for dive 188. The green markers indicate the USBL fixes after transformation and flyer-rejection. The blue trace indicates the final track with blends the USBL fixes and the DVL/INS track. The black markers indicate missing DVL readings and the red markers indicate where DVL readings were received but were judged bad based on high v velocity.

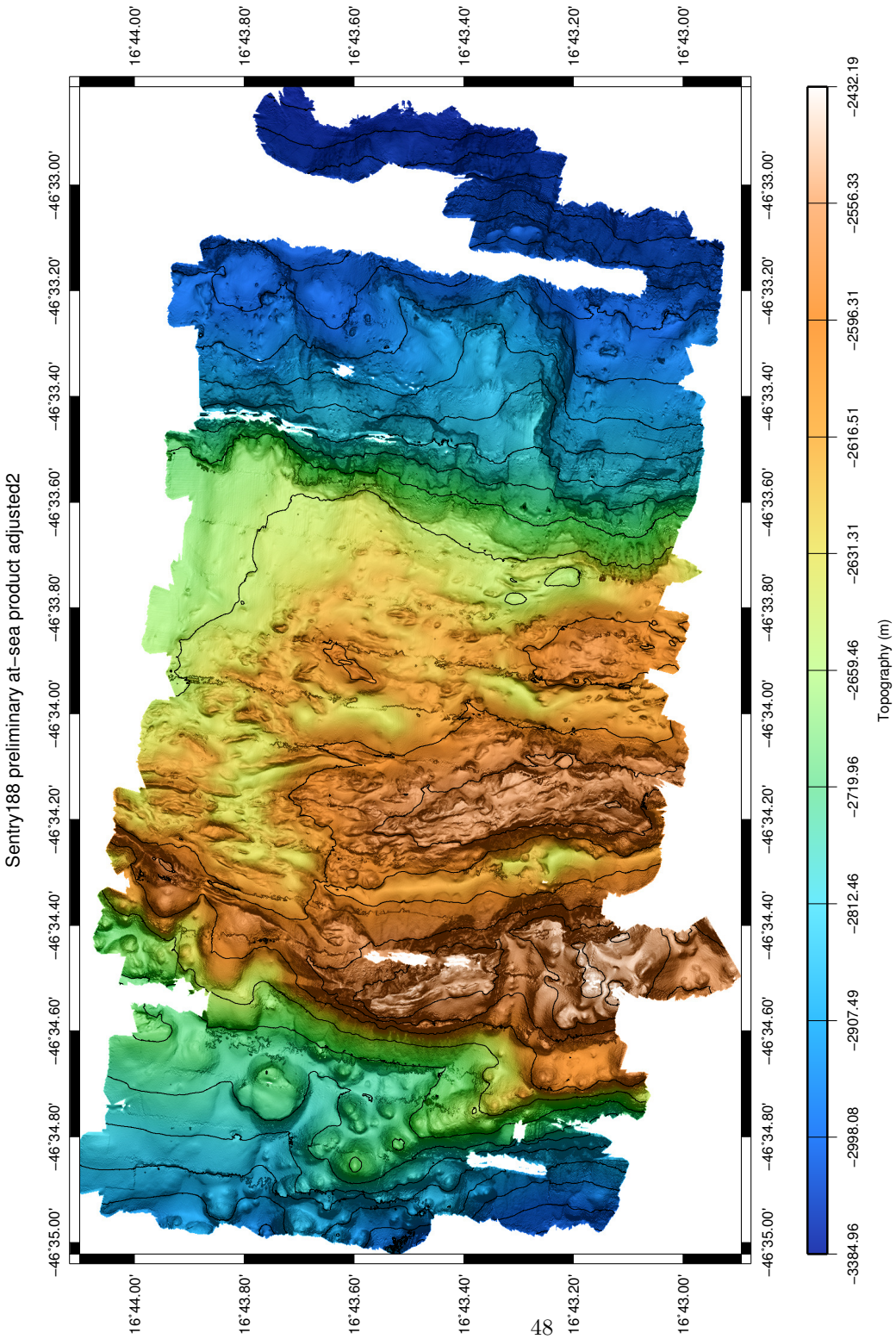

Figure 28: Bathymetry for Sentry188. The DVL "wobbles" were absent even on steep terrain. The gaps on the east side were intentional, the eastern-most lines were fill-in lines for gaps in Sentry187

21 Coordinate origins

The vehicle's control system uses simple mercator coordinates. This system uses an origin, defined in terms of latitude and longitude (WGS84), and a fixed scaling between meters displacement from the origin. We use the identical routines that have been used by the NDSF assets Alvin and Jason for decades. These simple coordinates have several advantages for realtime control of a vehicle. Unlike UTM grid coordinates, the x and y axes intersect at right angles and align with true east and north respectively at the origin. These coordinates distort quickly as one moves away from the origin, but we solve that problem by putting the origin close to the operating area. We almost always report our results in latitude/longitude, so most users need not be aware of these details.

The origin for this cruise were:
Sentry 173: 16N.org 16° 20' −46° -47'
Sentry 174: 16N.org 16° 20' −46° -47'
Sentry 175: 16N.org 16° 20' −46° -47'
Sentry 176: 16N.org 16° 20' −46° -47'
Sentry 177: 16N.org 16° 20' −46° -47'
Sentry 178: 16N.org 16° 20' −46° -47'
Sentry 179: 16N.org 16° 20' −46° -47'
Sentry 181: 1633N.org 16° 33' −46° -48'
Sentry 182: 16N332.org 16° 33' −46° -50'

22 Acknowledgments

1. NSF
2. WHOI Marine Operations

23 Science channel assignments

sentry 173- 17?: sci1: obs, sci2 Eh, sci4 orp

24 Technical issues

1. first item
2. second item