Cruise Report
RRS James Cook JC133

VOILA - Volatile recycling in the Lesser Antilles arc

Leg 1

6-17 March 2016

Port of Spain, Trinidad –to– St Johns, Antigua

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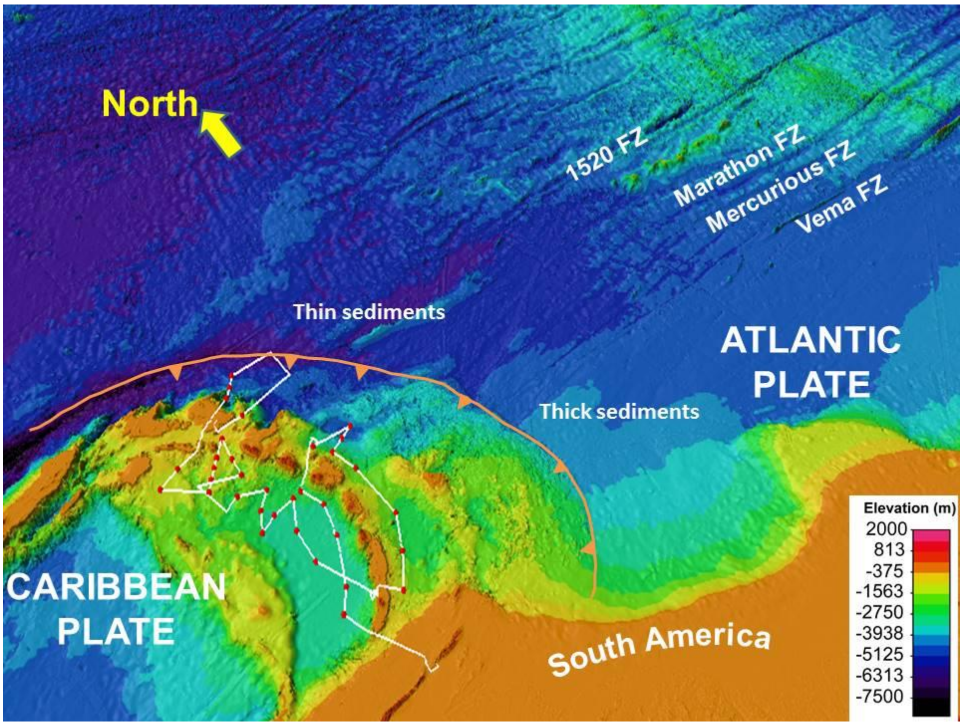

JC133 tracks (white line) and BBOBS deployments (red spheres) on a perspective view of the Lesser Antilles subduction zone

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1 Executive Summary

The VOILA (Volatile recycling in the Lesser Antilles arc: Processes and consequences) research programme will consist of two cruises onboard RRS James Cook. Cruise JC133 forms the first leg. The main aim of the cruise (SME 698) was to deploy 34 broad-band ocean bottom seismometers (BBOBS) sourced from Germany (DEPAS – 24 instruments) and USA (Scripps Institute of Oceanography – 10 instruments). Underway geophysical data (PES, MBES, SBP and gravity) were collected along most transit between stations. Towed magnetic data were also collected along longer transits together with three short dedicated magnetic surveys designed to infill at critical locations (between stations 5&6; 21&22 and 33&34) and give rest periods for the BBOBS teams. A detailed swath survey of *Kick'em Jenny* volcano as requested by host-nation collaborators was also conducted and provided a further rest break for BBOBS personnel. Despite sailing 36 hours late, vessel operations at sea were excellent and there was no subsequent science time lost. As a consequence all scientific work was successfully completed in 9 days between 8 -16 March 2016, starting in Port of Spain, Trinidad and ending in St John's, Antigua (Figure 1). The seabed instruments will be collected during the second leg in May 2017 (SME 697), when an active source OBS experiment will also be conducted.

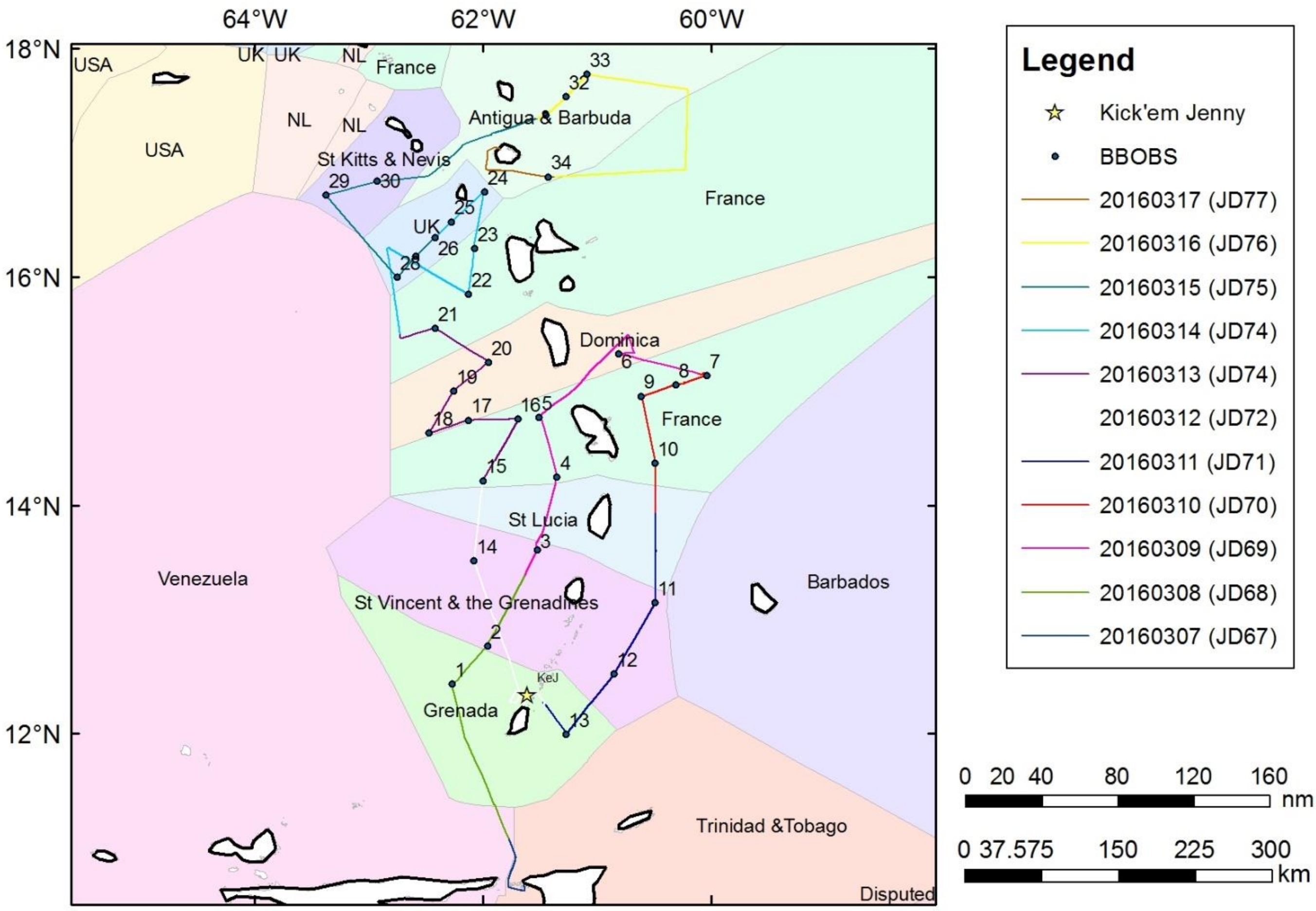

Figure 1 Summary of activity for JC133 showing daily tracks (numbered yyyymmdd and Julian Day), BBOBS stations (numbered) and location of *Kick'em Jenny* (KeJ) MBES survey. The basemap shows political boundaries.

2 Personnel

2.1 Ship's Officers and Crew

John Leask (Captain)
Stewart MacKay (Chief Officer)
Nick Norrish (2^{nd} Officer)
Sam Vargas (3^{rd} Officer)

Robert Brett (Chief Engineer)
Chris Kemp (2^{nd} Engineer)
Noel Doherty (3^{rd} Engineer)
Gary Slater (3^{rd} Engineer)
Paul Damerell (ETO)
Graham Bullimore (Purser)

John Macdonald (Chief PO, Scientific)
Andrew Maclean (Chief PO, Deck)
Steve Duncan (PO, Deck)

Neil Machin (Engine Room PO)

Jarold Welton (Seaman)
Mark Squibb (Seaman)
Nicolas Byrne (Seaman)
William Strudley (Seaman)

John Haughton (Head Chef)
Walter Link (Chef)
Peter Robinson (Steward)
Tommy Docherty (Steward)

Christina Coates (Cadet)
Robert Hoyland (Cadet)

2.2 Science Party

Jenny Collier	(Imperial College London; PSO)
Tim Henstock	(Soton, Watch 12-4; Sub-team leader)
George Cooper	(Durham, Watch 4-8)
Vanessa Hiemer	(Potsdam, Germany, Watch 8-12)
Henning Kirk	(DEPAS BBOBS, AWI, Germany; Sub-team leader)
Aline Plotz	(DEPAS BBOBS, AWI, Germany)
Andreas Rietbrock	(Liverpool, co-opted to DEPAS BBOBS team)
Martin Rapa	(SIO BBOBS, USA; Sub-team leader)
Mark Gibaud	(SIO BBOBS, USA)
Matt Thalio	(NMF; Cruise manager)
Andrew Moore	(NMF; IT and Sea Systems)

JC133 Science Party (LtoR) Aline Plotz, Henning Kirk, Matt Thalio, Tim Henstock, Vanessa Hiemer, Jenny Collier, Andy Moore, Mark Gibaud, George Cooper, Andreas Rietbrock, Martin Rapa

3 Science Objectives (Lay Summary)

Everyone has probably heard of the water cycle at the Earth's surface, where the exchange happens between the sea and the atmosphere via evaporation, cloud formation and rain. However there is also a water cycle *within* the Earth, where the exchange happens between the sea and the solid Earth. The most important step in this lesser-known cycle is when water trapped in the oceanic crust is returned to the deep interior at subduction zones as part of the plate tectonic cycle. As the sinking plate heats up and gets squeezed a large fraction of the incoming water is "sweated off" and added to the overlying mantle where it causes melting. These melts feed volcanoes above which are dangerously explosive. This activity, combined with the earthquakes triggered by the plates scraping past each other and the consequent tsunamis and landslides, makes subduction zones the most hazardous places on Earth. Yet these regions also have benefits: the cocktail of fluids travelling with the melts concentrates valuable metal deposits and the fine ash erupted by the explosive volcanoes produces nutrient-rich, fertile soils.

The aim of VOILA (Volatile cycling in the Lesser Antilles arc) research programme is to take a holistic approach to the cycling of volatiles (water, along with other volatiles such as carbon dioxide and sulphur) into the deep Earth at the Lesser Antilles subduction zone (Figure 2). Here the North American plate, soaked with water from the Atlantic Ocean subducts beneath the Caribbean plate. The project combines a range of Earth scientists with skills in petrology, geochemistry, numerical modelling as well as marine geophysics. We will combine with Caribbean researchers to track the passage of the water as it goes into and out of the subduction zone system and so better understand natural hazards in the region.

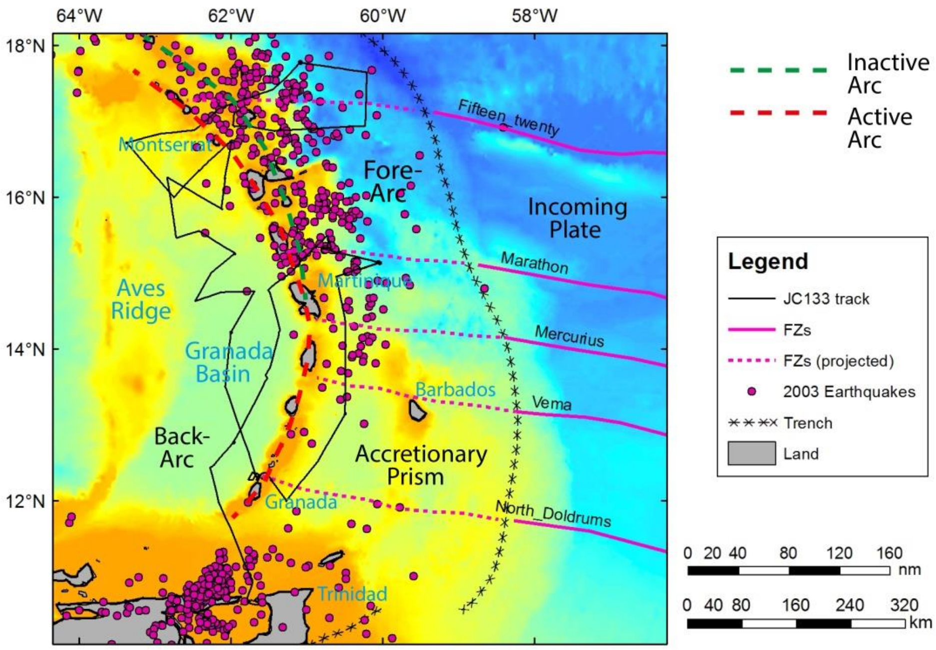

Figure 2 Summary of tectonic features (black text) in the study area together with some geographic place names (blue text).

During cruise JC133 we laid out an array of seismometers on the seabed to record distant earthquakes in order to image the wedge (area between the top of the underlying subducting slab and the seabed, Figure 3). We will use methods similar to medical X-ray imaging to determine the seismic velocity and attenuation structure and hence the pathways of the water and melt as it travels from depth of ~100 km to the surface where is makes the volcanic islands. The seismic array will also record local earthquakes from the scraping of the North American and Caribbean plates which will help regional hazard assessment and answer specific questions such as is there a link between the fluid pathways and the pattern of earthquakes?

The VOILA passive array is the largest of its type ever deployed at an Atlantic subduction zone. The instruments will sit on the seabed for about 15 months, when we will return to pick them (and their precious data recordings) up. We will then conduct further geophysical measurements to determine the pattern of water on the incoming plate in order to complete our understanding of this *interior* water cycle.

4 Background

4.1 Project VOILA

Cruise JC133 forms part of NERC NE/K010743/1 grant, project VOILA (Volatile recycling in the Lesser Antilles arc: Processes and consequences). The project will study a key element of the solid Earth water cycle and in particular the effect on natural hazards and melting at subduction zones. We target the Lesser Antilles Arc as (1) it is one of only two subduction zones that consume lithosphere formed at the slow-spreading mid-Atlantic Ridge and so represents an end member particularly suitable to study the role of the mantle lithosphere in transporting water into the deep Earth (2) the Antilles are a prime candidate for studying along-arc variations, because of large variations in sediment input and structure of the incoming plate, while thermal subduction parameters are almost constant along the arc, and (3) large high-quality data sets (especially geochemical and petrological) are already available from the arc. We will determine the distribution of water in the downgoing plate, how slab dehydration is distributed with depth and along strike, how dehydration affects flow in the subduction mantle wedge, and what controls the location of the volcanic arc.

The VOILA programme is divided into 5 work-packages (Figure 3). Cruise JC133 forms part of *WP2: Pathways* and *WP4: Consequences*. The 15-month passive broad-band ocean-bottom seismometer deployment will record global teleseismic earthquakes for seismic tomography analysis to determine wedge structure and local earthquakes to contribute to the seismicity catalogue of the region.

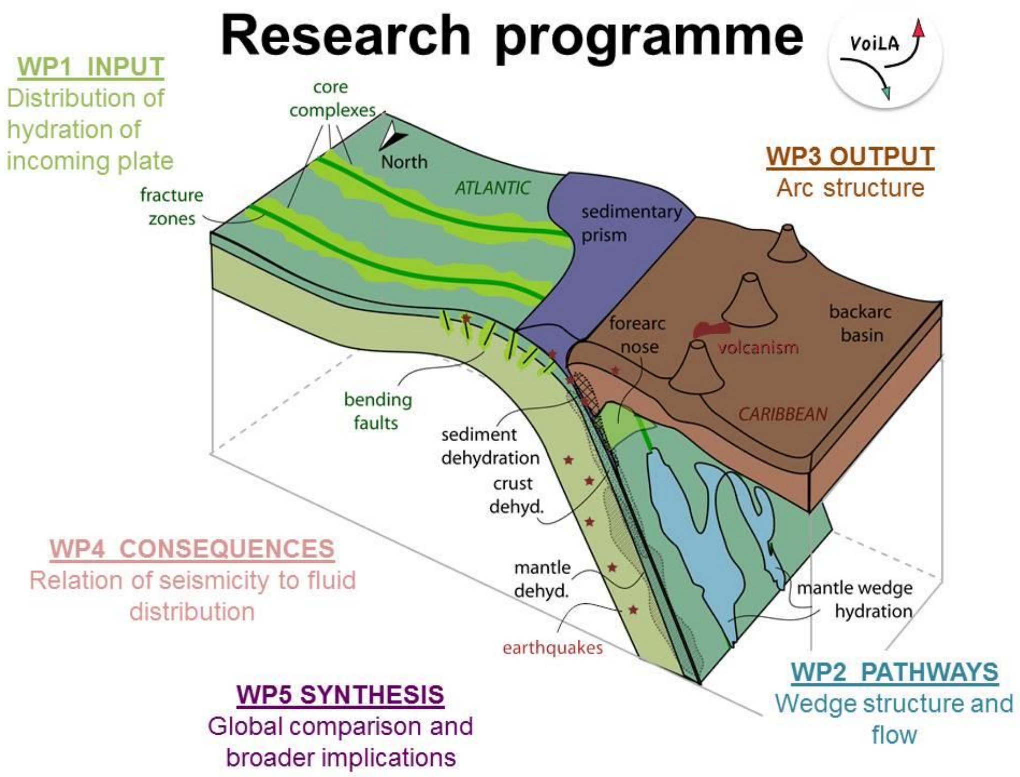

Figure 3 Cartoon of the Antilles subduction zone showing incoming plate with fracture zones, the accretionary prism (wider in the south), fore-arc, arc and back-arc. Also shown is a summary of NERC project VOILA work-packages 1-5.

The overall objectives of each work-package are as follows:

1. The distribution of hydration on the incoming plate, in particular the role of fracture zones and oceanic core complexes, which have been proposed to be key bearers of water in mantle serpentinite.
2. The distribution of water release below the arc (specifically the role of serpentinite dehydration) and the effect of the dehydration distribution on the style of wedge flow
3. The along strike variations in arc structure and its relation to that of the incoming plate and mantle wedge
4. The relation of water pathways to the distribution of seismicity, volcanism and mineralization
5. Compare the hydration and dehydration processes in the end member Antilles subduction zone and its effect on the arc and tectonic hazards with others (especially around the Pacific) to improve our overall understanding of the subduction water cycle.

4.2 Broad-band array design

The broad-band array was designed to cover the central part of the back-arc and fore-arc of the Lesser Antilles subduction zone. It consists of two components:

- Two cross-arc linear sub-arrays with ~30 km station spacing, which, together with the regional distribution of seismicity, will achieve high resolution imaging from fore-arc to back-arc (Figure 4). The northern line (stations 28,27,26,25,24,31,32,33) focuses on the mantle wedge beneath Montserrat. The second line focuses on Martinique (stations 18,17,16,5,9,8,7).

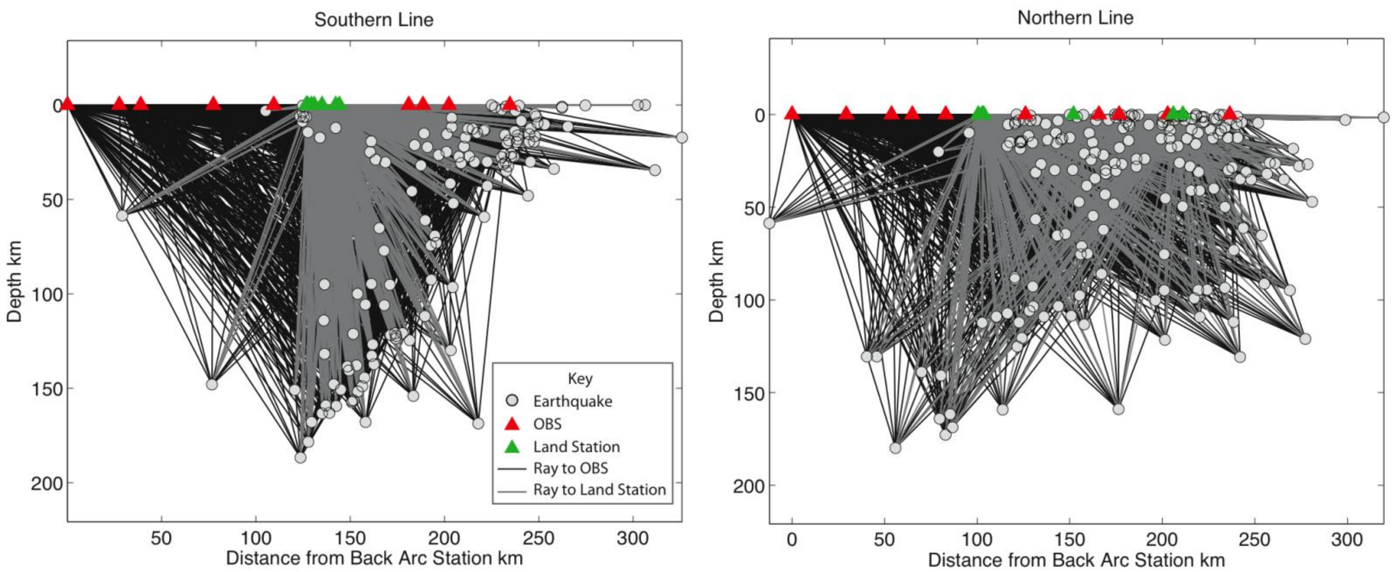

Figure 4 Design of the two linear BBOBS sub-arrays using the 2003 earthquake catalogue.

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- Evenly distributed stations between and around the lines. Together with 75 land stations, these 19 stations will allow us to track along-arc variations. Earthquake frequency is higher in the north of the Lesser Antilles Arc (Figure 2) and more stations are located there. The southern BBOBSs will improve the detection of seismicity between Barbados and the main arc, as requested by our host-nation collaborators at the SRC.

5 Cruise Objectives

The aims of the cruise were as follows. All tasks were successfully completed.

1. Deploy 34 Broad-band ocean bottom seismometers in the Lesser Antilles arc.

These instruments will record local and global earthquakes for the next 15 months. The data will be used to

a) improve the seismicity catalogue of the region (in collaboration with international partners at the University of West Indies and Seismological Observatories of Martinique and Guadaloupe).
b) determine the seismic structure of the mantle wedge beneath the Lesser Antilles arc.

The instruments will be collected on cruise JC146 1 May-16 June 2017 (SME 697).

2. Collect magnetic profiles

This data will be combined with earlier surveys sourced from the US NGDC and European SeaNetData to

c) aid the interpretation of the evolution of the back-arc, arc and fore-arc region

Magnetic data were collected along all the longer transects between BBOBS stations and during three specific surveys. The latter were undertaken to provide key infill profiles and to provide the BBOBS technical team sufficient rest breaks.

3. Collect regional gravity, swath bathymetry and sub-bottom profiler data

This data will be combined with earlier surveys sourced from international databases and the published literature to

d) aid the interpretation of the evolution of the back-arc, arc and fore-arc region

4. Conduct an EM710/EM210 swath bathymetry survey of *Kick'em Jenny* volcano offshore Grenada

This data will be combined with earlier surveys (R/V Nautilus 2013 and 2014) and monitoring/sampling work from international partners at the University of West Indies to

a) determine underwater volcanic processes (eruptive and collapse)
b) contribute to hazard assessment

Kick'em Jenny is the only known active underwater volcano in the region and so presents a unique opportunity for study. It presents a potential hazard to local populations due to its proximity to the island of Grenada.

6 Host-nation collaboration and diplomatic clearances

Project VOILA was designed together with collaborators from the region, and in particular the Seismic Research Centre (SRC) of the University of West Indies based in Trinidad and the Volcanic and Seismic Observatories based in Martinique and Guadeloupe. A summary of the proposed broader impact of project VOILA is given in Figure 5.

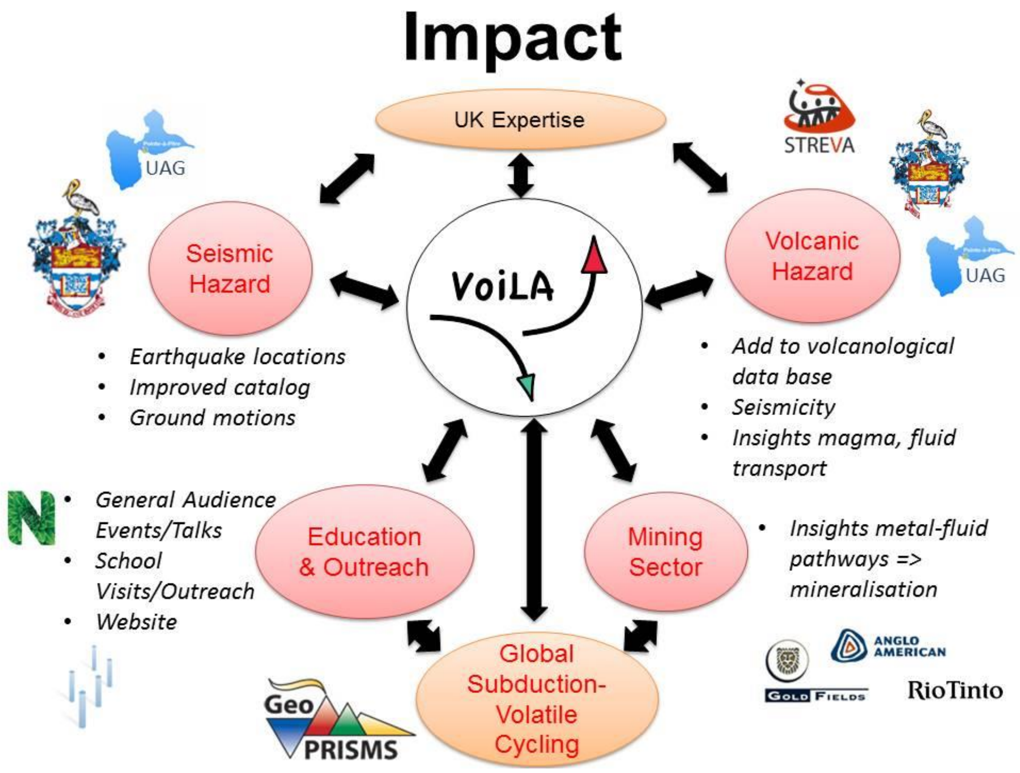


Figure 5 Overview of project VOILA impact.

It was planned to hold a reception onboard the vessel while she was in Port of Spain on Friday 4/3 to which representatives from the Seismic Research Centre and members of the media had been invited. Unfortunately this event had to be cancelled due to the ship's rudder problem and need to relocate to the shipyard at Chaguaramas on Thursday 3/3. Depending on port-call scheduling this idea will be revisited for the second leg of VOILA in May 2017.

Diplomatic clearances were received for the planned work from Trinidad & Tobago (Note No. 61); Grenada (Note No. 690/2015); St Vincent & The Grenadines (Note No. 162/2016); St Lucia (Note No. PE 406/2015); France (2016-138404); Dominica (Ref 242/03-893); Antigua & Barbuda (88/2016) and St Cristopher & Nevis (FA/U11/009). There were no requests to carry observers onboard. No work restrictions were requested apart from the clearance from France to "Limit intensity of noise emissions to 224 decibels". Whilst this request makes little scientific sense as it should be related to a distance of observation, following discussions with representatives from the AGOA sanctuary; scientists from IFREMER and representatives from the Volcanic and Seismic Observatory in Martinique it was decided not to operate any MBES systems whilst in French waters untill the matter has been properly investigated.

7 Cruise Narrative

7.1 Mobilisation (JD62-66) All times are local

The BBOBS shipments were sent from Germany in 2x20’ containers (together with a consignment of air-freight) and from the US in 1x40’ containers. Both BBOBS teams arrived in Port of Spain (PoS) late on Tuesday 1/3. Mobilisation was originally planned to happen in PoS on Friday 4/3, however due to a problem with the ship’s rudder the unstuffing of the containers and secure stowage onboard happened on Wednesday 2/3 before the arrival of the UK team that evening. Despite these issues mobilisation happened without any incident or issues. The ship then transited to the shipyard at Chaguaramas (approximately 2 hours) to await an engineer from Rolls Royce and the Science Party joined the vessel there on the morning of Thursday 3/3.

Sailing was originally scheduled for Sunday 6/3. However, the need to finish the ship’s rudder repair/inspection/certification resulted in a delay, with the ship finally casting off around noon on Monday 7/3. Unfortunately we then needed to hove-to as we waited for permission from the Trinidad authorities to sail. A safety drill was conducted at 16:15, with the ship finally receiving permission to sail around 16:40.

7.2 Science Work At Sea (JD67-77) All times in UTC (=local +4 hrs)

Mon 7/3 JD 67

The MBES and other ship’s logging started at 20:40. The magnetometer was deployed at 21:25 once clearance of the main island of Trinidad had been achieved and transit at a speed of around 10 knots started. Sea conditions were very calm and good progress was made.

Tue 8/3 JD 68

Initially both the EM710 and EM120 were operated, but the EM710 was shut down once water depths reached around 650m. We reached the first scientific station, to the SW of Grenada, around 05:00. The ship slowed to 3-4 knots to allow the magnetometer to be recovered. The DEPAS acoustic release test started at 06:00. The SVP was also attached to the core wire cable. In total 2500m of cable was paid out. All ship’s acoustics were turned off and the release test conducted with the DEPAS over-the-side transducer. All releases responded and the test was completed by 07:25, and the cable was onboard and the ship moving off an hour later.

The ship arrived at Station 1 at 11:20, and the first DEPAS BBOBS was deployed from the starboard side using the starboard stern crane (Figure 6) without incident. We then transited to Station 2 to conduct the SIO acoustic release test. The test started at 14:15 and was completed at 16:25, with the core wire being paid out to 2500m. The SIO BBOBS was then deployed by 17:00 from the starboard mid-ships gantry (Figure 7). The instrument reached the seafloor by 18:27 and the ship then commenced sailing a 1500m radius circle around the drop location at a speed of 5 knots (Figure 8). Good signals from the instrument were received and the survey completed by 19:25. The acoustic systems were then started and the magnetometer deployed before the 10 knot transit to Station 3 commenced.

Wed 9/3 JD 69

The magnetometer was recovered at 01:10 ready for deployment of DEPAS BBOBS #3 at 01:40. The magnetometer was then redeployed at 02:40 and the 10 knot transit to Station 4 started. In general while transiting in the back-arc region a strong NW current was experienced and speed over the ground was typically around 11.5 knots. As we entered French territorial waters just south of Station 4 the EM120 MBES system was switched off. We arrived at Station 4 at 06:20, with the DEPAS BBOBS deployment happening at 06:50. The magnetometer was deployed once more at 07:20 and transit to station 5 started. At 09:50 as we were slowing to recover the magnetometer a series of buoys was seen from the Bridge at the location of the planned DEPAS BBOBS deployment. It was decided to run ~2 nm further along same bearing and deploy the BBOBS there. The instrument was finally deployed at 10:18. The magnetometer was deployed once more and we altered course to a more NE heading and started the transit to Station 6. As the volcanic arc was crossed the swell increased significantly, with the significant wave height increasing to around 4m from earlier values of less than 1.5m. The ships acoustic system performance and especially that of the EM120, deteriorated as a result. The transit to station 6 was extended to form Magnetic Survey 1 to investigate a prominent magnetic low on the outer arc where the split between the single and double arcs happens between Martinique and Dominica (Figure 20) but also to provide sufficient rest for the DEPAS team. In the end the sea-state remained higher than previously experienced and transit speed over the ground fell to 8-9 knots, so this survey was slightly curtailed. The magnetic survey ended at 18:50 and DEPAS BBOBS #6 was deployed at 19:05. It was hoped to collect an XBT at this station, however a problem with the XBT recorder was reported. The system had apparently worked fine on JC132 and so it was not clear what the problem was. Despite stripping the unit down it was not possible to get it working. The magnetometer was deployed once more at 19:35 and transit to BBOBS #7 started.

Thu 10/3 JD 70

The magnetometer was recovered as we approached Station 7 at 00:10. Next the second SIO releaser test and second SVP were deployed on the core wire. The systems were in the water by 01:20 and all ships acoustic systems were switched off. The total wire out of 4000 m was achieved at 02:55 and the acoustic test finished by 03:15. The cable was wound in by 04:40 and SIO BBOBS #7 was deployed at 05:10. The SIO instrument reached the seabed at 07:35 (slant range 4681m) and the circular survey started at 5 knots. This survey was completed by 09:35 and a short transit started to the second DEPAS releaser test which started at 10:55. This time the maximum cable out used was 3200m, which was achieved at 12:15. The test was completed by 12:30 and the cable and releases recovered by 13:40. A short transit to Station 8 followed, where the DEPAS BBOBS was deployed at 14:30, this time from the stern of the ship instead of the side. A short transit to Station 9 followed, where the DEPAS BBOBS was deployed at 16:40. The deployment of this instrument marked the completion of the Martinique Line (Figure 4). The magnetometer was deployed at 17:00 and a more southerly course set for Station 10. The magnetometer was recovered again around 20:30. At this point a technical issue with the releaser for DEPAS BBOBS #10 was discovered. However this was quickly resolved and the instrument was deployed at 21:10. The magnetometer was then deployed and we were underway again by 21:40.

Fri 11/3 JD 71

We arrived at Station 11 at 05:00. The magnetometer was recovered and the ship manoeuvred to the planned drop point. However due to the swell it was difficult to hold station. As the SIO instrument was being deployed the ship rolled and the instrument hit the side of the ship and the titanium frame that holds the trillium seismometer (the frame holding the green sphere shown in Figure 8) broke at the solder. This was considered an unlucky accident as it had not been reported before. The instrument was bought back on deck and the frame replaced. The instrument was finally deployed at 05:55. The instrument reached the seabed at 07:00 and the survey in started. This concluded at 08:40 when the ship acoustic systems were switched back on the magnetometer deployed. While underway the gravity meter started to show high frequency oscillations in both the computed gravity and the cross coupling. We arrived at Station 12 at 13:30 and the DEPAS BBOBS was deployed at 14:00 in ~2000m of water. The magnetometer was then deployed once more and the transit started to Station 13 at 14:30. As we headed south the sea-state gradually improved, with the significant wave height returning to below 2m as experienced at the start of the cruise and the erratic behaviour of the gravimeter started to improve. The magnetometer was recovered at 18:20 and once on deck had its O-rings and connectors serviced as intermittent “magnetic strength warnings” had been flagged by the software. SIO BBOBS #13 was deployed at 18:30 and reached the seabed at 19:10 when the survey started. This work was completed by 19:40 and the transit to the *Kick'em Jenny* MBES site started. Given the lack of XBTs it was decided to conduct a third SVP on in the shallow waters of the east flank arc. This work was started at 20:55 and completed by 21:40 with a total cable out being 650m (Figure 18). On route to the swath site we also took advantage of the seabed morphology to conduct a patch test to calculate roll, pitch and navigation errors for processing the shallow water EM710 data. The ship tracks required are shown in Figure 19 which involved sailing up and down a slope in opposite directions and then across a region of flat seabed. The patch test started at 22:20 and concluded at 00:10.

Sat 12/3 JD 72

We arrived at the *Kick'em Jenny* volcano site at 01:10. Now we had crossed to the west side of the arc the sea-state dropped further, with significant wave heights less than 1.6 m. The MBES survey started at 01:30 and was conducted at 5 knots. The tracks had been planned from earlier surveys in 2013 and 2014 by the RV Nautilus and consisted of six transects in increasingly deep water (Figure 18). Both EM210 and EM710 systems were run initially, with the shallow water system switched off at 05:20. The swath survey finished at 09:30 when a fourth (and final for this cruise) SVP was conducted to a water depth of 1000m. The magnetometer was deployed at 10:45 and transit to Station 14 started at 11:00. The gravity meter had returned to a normal signal, and no action was taken. We arrived on station at 17:55, and once the magnetometer had been recovered the DEPAS BBOBS was deployed at 18:10. The magnetometer was then deployed, the transit to Station 15 commenced and the magnetometer recovered once more at 22:40. The SIO BBOBS was deployed at 23:10.

Sun 13/3 JD 73

The SIO BBOBS reached the seabed at 00:35 and the survey in started at 5 knots. Given the good signals received with the hull transducer the speed of the seabed surveys was increased from 5 to 7 knots from hereon. The survey was therefore completed in good time by 01:30 when the magnetometer was deployed and the transit to Station 16 started. The magnetometer was recovered at 05:00 and the DEPAS BBOBS deployed by 05:30. There then followed an intense day of BBOBS deployments with DEPAS BBOBS #17, #18 and #19 being deployed at 08:40, 10:55 and 13:50 respectively. Due to the short transits between these stations the magnetometer was not deployed. SIO BBOBS # 20 was deployed at 16:30 with the instrument reaching the 2500 m deep seabed at 17:40. The circular survey then started and was completed by 18:25. The magnetometer was then deployed at 18:40 for the transit to Station 21. Finally DEPAS BBOBS # 21 was deployed at 21:55, giving a total of six deployments for this day. Given this intensity of work, magnetic survey 2 was designed to investigate east-west magnetic fabric in the Grenada back-arc basin (Figure 20). The magnetometer was deployed at 22:15.

Mon 14/3 JD 74

The magnetometer was recovered at 09:15 and a second day of intense BBOBS deployments started. DEPAS BBOBS #22 was deployed at 09:50, SIO BBOBS # 23 at 12:30, DEPAS BBOBS #24 at 18:45, DEPAS BBOBS #25 at 21:25 and SIO BBOBS # 26 at 23:10. Of these instruments the only one of note was Station 23 which had a rope cradle for the trillium sensor package to replace the titanium one broken on JD71. However the deployment happened without incident and the data are not expected to be affected. Station 24 is noteworthy as it is on the shallowest seabed (800 m) and marked the start of the Montserrat Line (Figure 3).

Tue 15/3 JD 75

The seabed survey at Station 26 was completed by 00:10 and the transit to Station 27 was completed by 01:30. A DEPAS BBOBS was then deployed at 01:55. The final instrument on the southern side of the Montserrat line was deployed at Station 28 by 03:50. The magnetometer was then deployed at the transit to Station 29 started. The currents started to pick up a little as we headed north, and the speed over the ground dropped to around 9 knots. The quality of the EM120 data also started to degrade. The magnetometer was recovered at 09:00 and the deployment of SIO BBOBS #29 happened at 09:25. This was followed by a seabed survey which finished at 10:20. At this point the ship's engineers took 30 mins while stationary to test the fresh water making equipment. A further 60 min test was conducted between 12:15 and 13:15, and we arrived at Station 30 at 14:30 where a DEPAS BBOBS was deployed at 14:40. The ship then started its transit across the arc to the final stations in the north-east. Due to the shallow bathymetry and uncertainty in the quality of the sounding for navigation it was decided not to deploy the magnetometer as had been originally planned. This was indeed a good decision as the close-approach by a small boat during the transit required the ship to complete a tight avoidance turn at 21:30.

Wed 16/3 JD 76

We arrived at Station 31 at 00:30, and a DEPAS BBOBS was deployed at 00:40. This was followed in quick succession by DEPAS BBOBS #32 at 02:25 and SIO BBOBS # 33 at 04:55. Station 33, which marks the northern end of the Montserrat Line, is notable as having the deepest water at 5050 m. The seabed survey was therefore the longest and was completed by 08:30. A third dedicated magnetometer survey was then started which targeted a potential magnetic anomaly along the subducted FifteenTwenty Fracture Zone (Figure 20). The magnetometer was in the water by 08:35 and the survey was conducted at 10 knots as planned.

Thu 17/3 JD 77

The magnetometer survey finished as we approached Station 34 at 00:34. Once on deck the sensor was found to have picked up a couple of square metres of coarse synthetic netting. This was the only time this happened. The final DEPAS BBOBS was duly deployed at 00:51 which was followed by a seabed survey in a similar manner to that used for the SIO instruments to check decent rates and acoustic communications. This work was finished by 02:00 and marked the end of the ship-science programme.

7.3 Demobilisation (JD77) All times are local

The science party spent the day processing the underway geophysical data and packing up the BBOBS ancillary equipment. Three clearly labelled piles of items were left onboard the RRS James Cook as follows:

DEPAS:

1) Empty boxes, pallets etc (of low commercial value) to be stored at NOC prior to JC146 in May 2017.
2) Deployment-related peripheral equipment and spares (high commercial value) to be shipped back to Germany once RRS James Cook returns to Southampton in May 2016.

SIO

1) Empty boxes, pallets etc (of low commercial value) to be stored at NOC prior to JC146 in May 2017.

(All other peripheral equipment was hand-carried back to USA).
Details are given in Appendix A

The ship docked in St John's Antigua at around 9am on Thursday 17 March. At 10:30 the first gravity readings were made at the quayside next to the ship. The measurements were made at the 4th bollard along at a position approximately parallel with the ship's gravity metre room (see Appendix D for details). Once customs and immigration had been cleared members of the Science Party conducted the gravity basestation tie by taking measurements at the General Post-Office at 13:30. The final set of gravity measurements were taken alongside the vessel at 14:15. Ship's logging was then closed and a final backup to portable disk drives was completed. The science work was completed by 16:00.

All non-NMF members of the Science Party left Antigua on Friday 18 March.

8 Data Acquisition & Equipment Performance

8.1 BBOBS

Due to a lack of broad-band OBS in the UK, instruments were sourced from German (DEPAS, 24) and USA (SIO, 10).

8.1.1 DEPAS

The DEPAS instruments were initially deployed from the starboard side using the stern-starboard crane. However, following concerns about potential drift of the instrument under the ship after release deployments were transferred to the stern using the stern-port crane. There were no further issues with the DEPAS instruments until station 32 when after deployment three large buoys were seen on the starboard side. This was a surprise given the water depth (4000m) and the lack of evidence of fishing activity in general seen throughout the cruise. However the SIO deck unit was used to track the instrument and it was shown that it was sinking normally.

Figure 6 Photograph of a DEPAS BBOBS on deck and during initial deployments.

Under the terms of the hire contract the instruments have been programmed with automatic-release clocks. The instruments will be collected as part of the second leg of Project VOILA in May/June 2017 during cruise JC146 (SME697). The times used are given in Appendix B.

8.1.2 SIO

All 10 SIO instruments were deployed from the starboard mid-ships gantry. There was one incident during deployment of station 12 when the instrument hit the side of the vessel during a roll experienced during the only period of non-flat seas. This resulted in a titanium support strut holding the seismometer breaking at the solder. However this was considered a fluke accident rather than a serious incident. A replacement suspension system was devised using rope and the instrument later deployed at station 23.

Figure 7 Photograph of a SIO BBOBS on deck and during deployment from the ship's starboard gantry.

During preparation of SIO BBOBS 26, 29 and 33 (the last 3 US instruments) a fault with the sensor package release mechanics was encountered. For safety during deployment reasons the package was further secured with a thin metal wire. It is expected that this additional securing mechanism may take 1-2 weeks to fail at the seabed and so release the sensor package. Given the instrument levelling program does not fall to less than weekly, at most 3 weeks of data recording may be lost from these instruments.

Under the terms of the hire contract the SIO instruments were "surveyed in" once they had reached the seabed by conducting a full to three-quarters circle with a diameter equal to the water depth (image below). The SIO acoustic unit was successfully connected to the ship's hull transducer for this work.

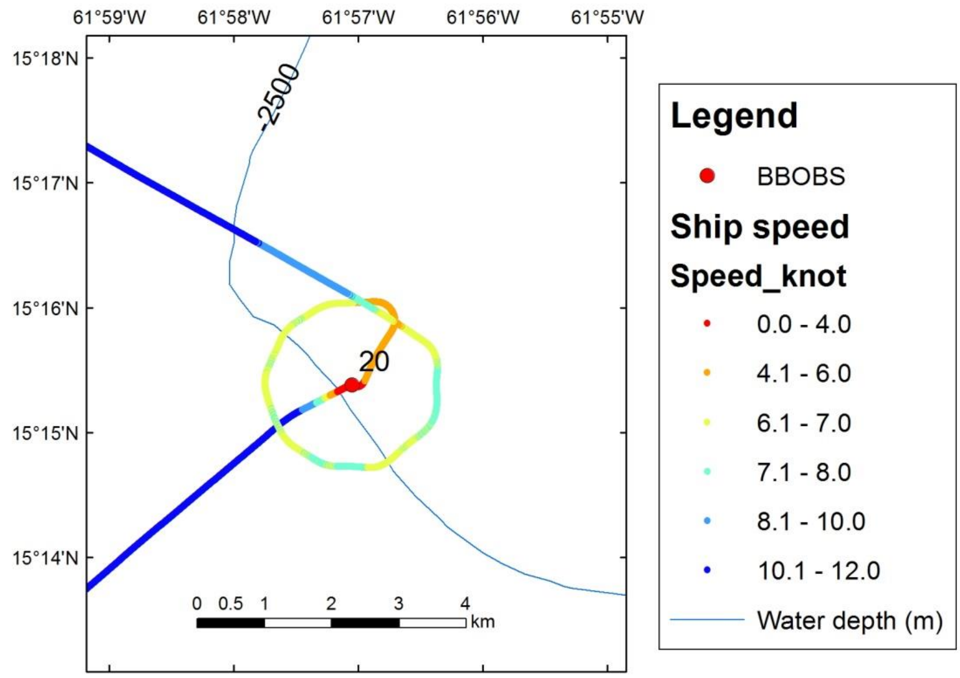


Figure 8 Example of the ship track during a SIO seabed survey.

8.2 Deployments

Overall deployment of the instruments was very efficient. Details are given in the following table.

PLAN			STATION		DEPLOYMENT					DIFFERENCE		RELOCATIONS			
Lat deg	Lon deg	WD m	Station	Type	Day JD	Time UTC	Lat deg	Lon deg	WD m	Position m	WD m	Lat deg	Lon deg	Drift m	Drift az deg
12.44	-62.27	2949	1	DEPAS	68	11:23:10	12.440	-62.270	2948	52	-1				
12.77	-61.96	2962	2	SIO	68	16:58:02	12.770	-61.960	2973	15	11	12.771	-61.960	43	340
13.61	-61.52	2877	3	DEPAS	69	02:08:41	13.611	-61.522	2871	280	-6				
14.25	-61.35	2886	4	DEPAS	69	06:48:57	14.250	-61.350	2887	65	1				
14.77	-61.49	2665	5	DEPAS	69	10:18:41	14.776	-61.509	2707	2174	42				
15.33	-60.81	1441	6	DEPAS	69	19:05:40	15.329	-60.810	1530	61	89				
15.14	-60.04	4725	7	SIO	70	05:08:18	15.140	-60.040	4680	23	-45	15.133	-60.037	865	153
15.06	-60.31	3128	8	DEPAS	70	14:32:24	15.058	-60.309	3107	223	-21				
14.96	-60.61	1394	9	DEPAS	70	16:43:42	14.960	-60.612	1405	269	11				
14.37	-60.49	2035	10	DEPAS	70	21:08:58	14.372	-60.491	2039	203	4				
13.15	-60.49	2311	11	SIO	71	05:54:20	13.150	-60.490	2315	166	4	13.151	-60.491	28	136
12.53	-60.85	1871	12	DEPAS	71	14:00:17	12.530	-60.850	1931	207	60				
12	-61.27	1275	13	SIO	71	18:29:56	12.000	-61.270	1320	161	45	12.000	-61.268	114	80
13.52	-62.08	2986	14	DEPAS	72	18:08:37	13.520	-62.080	2974	597	-12				
14.22	-62	2941	15	SIO	72	23:11:28	14.220	-62.000	2945	197	4	14.219	-62.002	58	303
14.76	-61.69	2753	16	DEPAS	73	05:39:50	14.760	-61.690	2752	502	-1				
14.75	-62.13	2868	17	DEPAS	73	08:42:20	14.750	-62.130	2858	418	-10				
14.64	-62.47	2801	18	DEPAS	73	10:54:54	14.640	-62.470	2842	514	41				
15.01	-62.26	2761	19	DEPAS	73	13:49:12	15.005	-62.258	2754	641	-7				
15.26	-61.95	2479	20	SIO	73	16:28:11	15.256	-61.951	2566	421	87	15.257	-61.950	172	45
15.56	-62.42	2017	21	DEPAS	73	21:55:32	15.555	-62.418	2031	549	14				
15.85	-62.13	1757	22	DEPAS	74	09:47:38	15.852	-62.126	1793	500	36				
16.25	-62.08	1352	23	SIO	74	12:28:24	16.250	-62.075	1396	546	44	16.250	-62.075	3	224
16.75	-61.99	805	24	DEPAS	74	18:45:30	16.749	-61.988	807	287	2				
16.49	-62.28	1120	25	DEPAS	74	21:26:17	16.487	-62.276	1108	562	-12				
16.35	-62.42	1074	26	SIO	74	23:13:36	16.351	-62.419	1071	170	-3	16.351	-62.419	27	282
16.19	-62.59	1777	27	DEPAS	75	01:57:17	16.185	-62.589	1831	593	54				
16	-62.75	1813	28	DEPAS	75	03:51:49	16.001	-62.752	1799	208	-14				
16.72	-63.38	1395	29	SIO	75	09:27:48	16.719	-63.376	1389	393	-6	16.719	-63.378	149	248
16.84	-62.93	1233	30	DEPAS	75	14:40:58	16.840	-62.930	1196	490	-37				
17.42	-61.45	3581	31	DEPAS	76	00:41:42	17.420	-61.450	3822	305	241				
17.58	-61.27	3924	32	DEPAS	75	02:26:19	17.580	-61.270	4015	552	91				
17.78	-61.09	5003	33	SIO	76	04:54:39	17.780	-61.090	5049	652	46	17.775	-61.084	256	91
16.88	-61.43	1134	34	DEPAS	76	00:51:56	16.880	-61.430	1113	667	-21				

Figure 9 Summary of BBOBS deployment positions.

The difference between the planned and actual drop points are shown in the fourth column. The position of BBOBS5 was deliberately repositioned following sightings of buoys near the planned position from the Bridge. Excluding this instrument the mean difference between planned and actual position was 350 +/- 200m (1 stdev). The distribution of the instrument types is shown in Figure 10. The seabed surveys of the SIO allowed the direction and amount of instrument drift as they descended the water column to be calculated. These values are shown in the firth column in the above table and shown graphically in Figure 11.

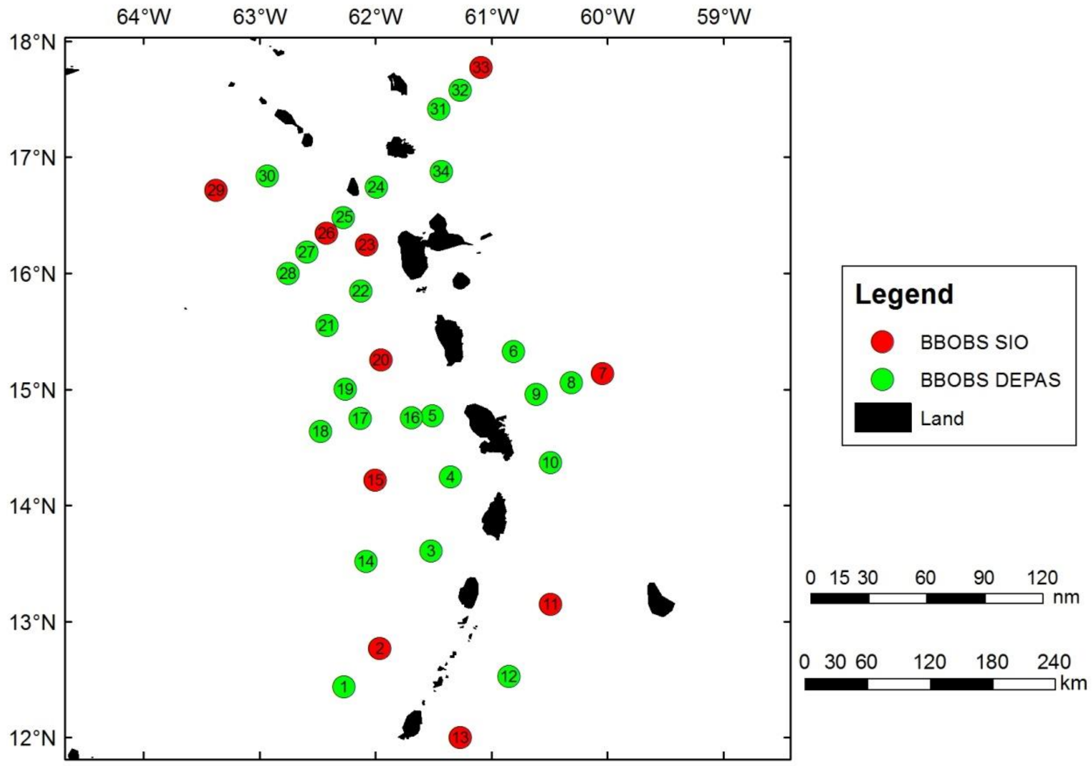


Figure 10 BBOBS deployment by instrument type and station number.

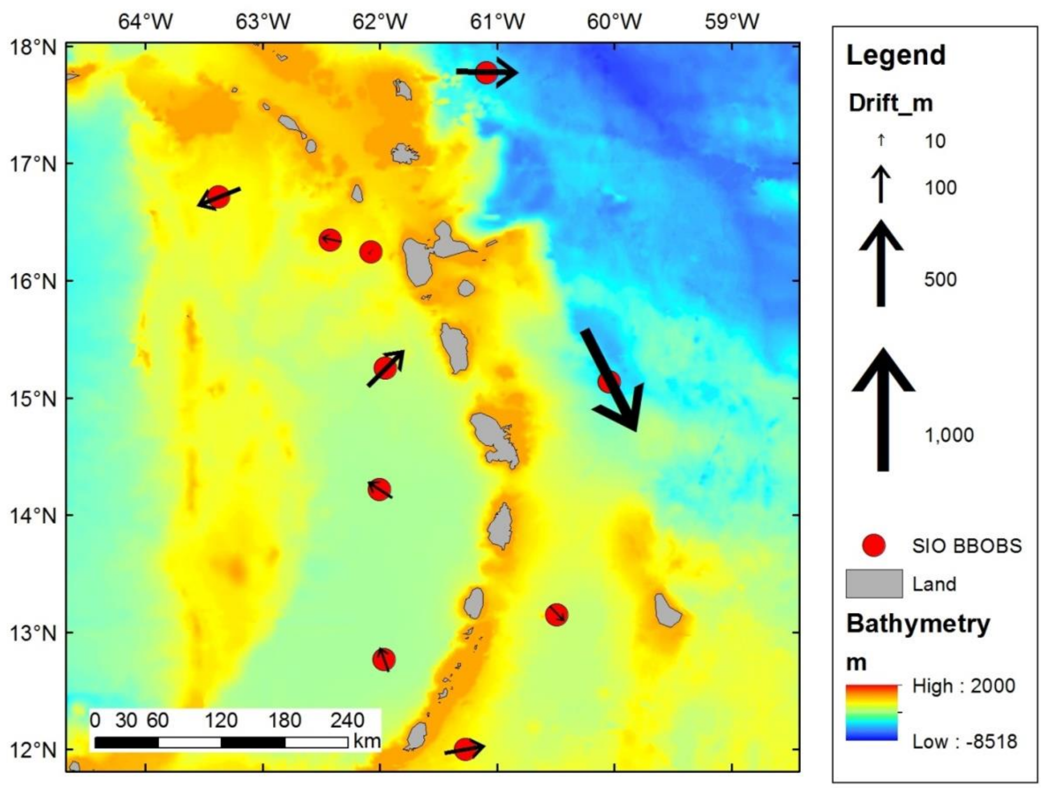


Figure 11 Distance between SIO BBOBS deployment position and relocated position (drift) and direction of drift from north (drift azimuth).

8.3 Ship's fitted equipment

8.3.1 Navigation and data logging

The primary navigation system using during JC133 was an Applanix POS MV 320 Global Positioning System (GPS) which integrates two GPS receivers (Ashtech ADU-5 and C-Nav 3050) with a motion reference unit. This produced a location of the ship's central reference point in the gravity metre room every second. The system also takes differential corrections from a Kongsberg Seatex DPS 116 receiver on the bridge. The positional accuracy is expected to be 0.5-2 m depending on the quality of the differential corrections. The navigation was fed into an Olex 3D chart system and displayed in real-time. The navigation data, together with other ship systems, were logged by the TechSAS version 5.9 in NetCDF time-series format. Further details of logged items are given in Appendix C. One second ASCII versions of the navigation were provided daily for data processing and analysis by the Science Party. No problems with any of the navigational systems were encountered during the cruise.

8.3.2 Meteorology and sea-surface monitoring

The weather and sea-state during JC133 was extremely good. The significant wave height was typically less than 1.5 m, reaching a maximum of 4 m only when east of the arc (stations 6-11). Meteorological data acquired throughout the cruise include sea-surface temperature (around 28^{o}C), air pressure, wind direction and humidity and logged by the NMFSS Surfmet system. Details of the sensors used and calibrations needed are included in Appendix C.

8.3.3 Gravimeter

Gravity data were acquired using a Micro-g-Lacoste AirSea-2 gravimeter (Serial number S40), which was mounted on a gyro-stabilised platform. The sensor is comprised of a highly damped invar beam and changes in g were obtained by time-averaging the beam motions to eliminate accelerations caused by ship motion.

Basestation measurements using a portable Lacoste & Romberg Model G (Serial number G-484) were carried out before and after the cruise in Port of Spain, Trinidad (by the JC132 Science Party) and St Johns, Antigua to calibrate the underway data to absolute gravity and to correct for drift. At Port of Spain a new international standard basestation was installation by Prof. Chris Peirce at the end of JC132 to replace the old one at the airport which is no longer accessible. At the time of writing the final gravity value at the new Trindad basestation was not available so the QC the data the Free-air Anomaly (FAA) was calculated by calibration with respect to Antigua and assuming zero drift (Figure 13). Details of these calibrations are given in Appendix D.

During the moderate seas experienced during JD70-71 the gravity meter was observed to be giving high frequency fluctuations. This behaviour stopped when we crossed the arc back into the Grenada Basin. During the cruise gravity data were supplied in NetCDF format and scripts were written shortly after the cruise in python to convert these binary files to asci and so make the necessary conversion to derive the FAA and so investigate the issue. Plots of the entire gravity time series are included in Appendix D. A detailed plot of the problem is shown in Figure 12. There is clear instability during JD71 showing as high-frequency (~1500 s period) +/- 25 mGal oscillations in the FAA and points to a serious problem with the metre which should be investigated when the vessel returns to port. Overall the longer-frequency trend is well-recorded, and there is a good match on the long-wavelength component of the ship measures FAA to the known Satellite-altimetry derived values (Figure 13).

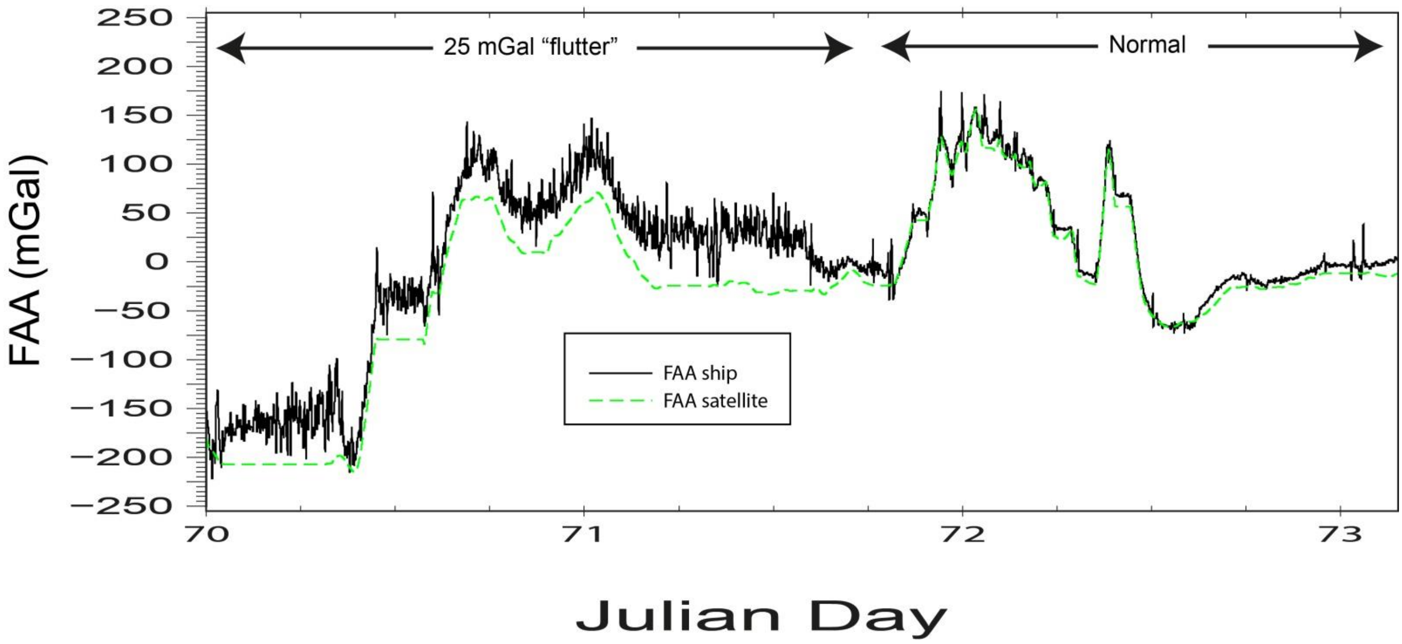


Figure 12 Gravity time series showing noise ("flutter") recorded during moderate sea-states on JD70-71.

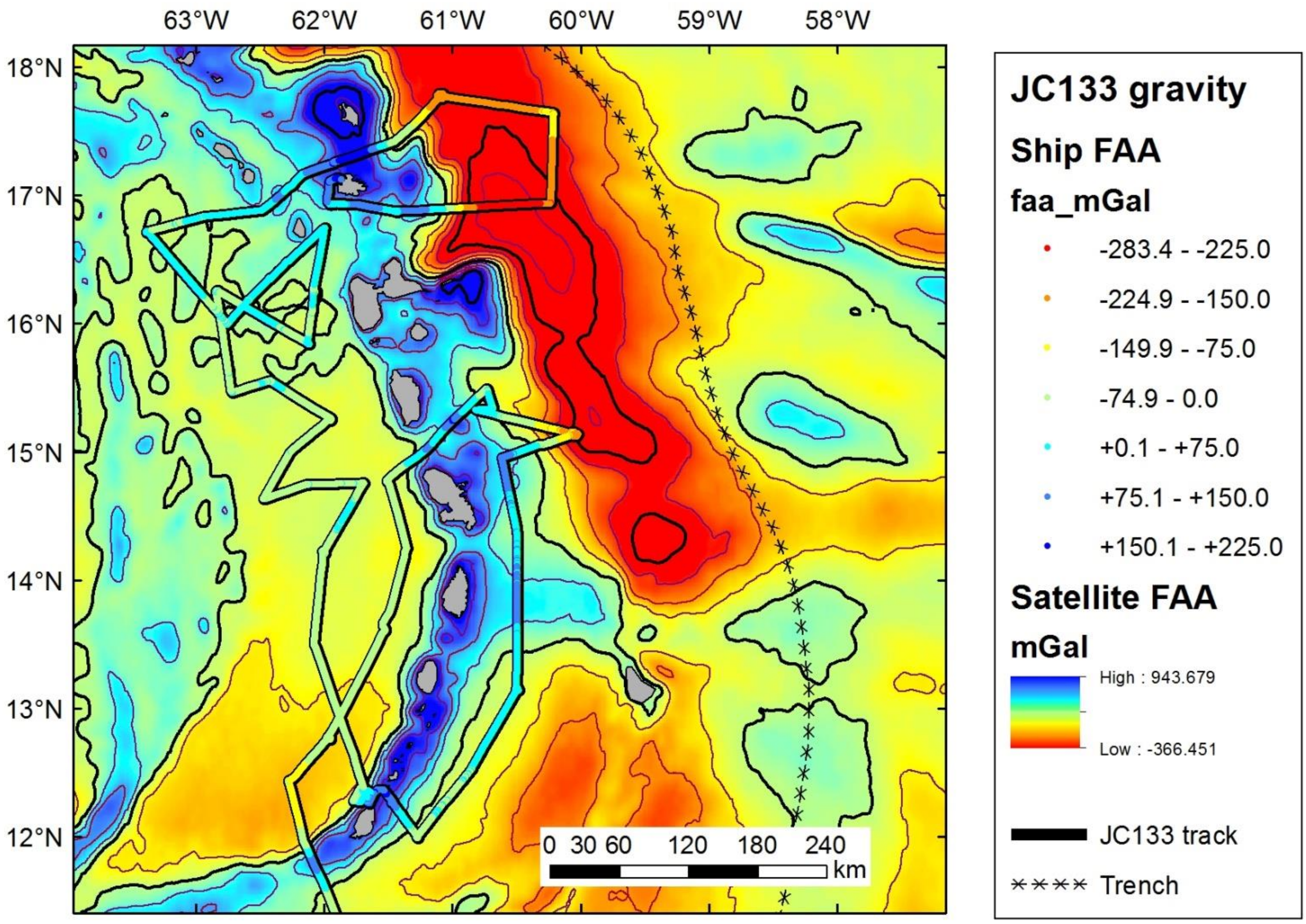


Figure 13 Comparison of preliminarily processed gravity data from JC133 against the v23.1 satellite altimetry grid from Dave Sandwell.

8.3.4 Single-beam echo sounding (EA600)

Throughout the cruise, we acquired 12 kHz single-beam echo soundings with a hull-mounted Kongsberg EA-600. There are breaks in the data only during the BBOBS releaser tests and deployment of the SIO BBOBS. The system was run with a constant sound velocity of 1500 m/s for the water column was used for allow it to be corrected for the measured water column sound speed in post-processing. The system performed well and provided essential water depth information for BBOBS deployments in French waters. The bathymetric data are archived as ASCII xyz files and bmp images.

8.3.5 Sub-bottom profiling (SBP120)

Throughout the cruise, we acquired sub-bottom profiling data which yielded useful high resolution images of various tectonic features (such as faulting and folding in the Grenada back-arc) and seabed processes (such as landslides from the volcanic islands). Although this shallow profiling technique was not central to the success of the cruise, it provides very useful ancillary data which will enhance our geological and geophysical interpretations. The source was a linear chirp sweep with frequencies between 2.5 kHz and 6.5 kHz delivered in a 40 ms pulse and a ping interval of 2175 ms. The system was run with a deep water delay that was entered manually by the watchkeeper and a typical record length of 300 ms and 48 micro-s sample rate. Penetration was typically 50-100 ms. The data are archived as both .raw and “processed” .seg (conventional segy format, deconvolved from the source sweep) files named by time-stamp. An example of the processed data collected (filtered and AGC applied) viewed in SeiSee software is shown in Figure 14.

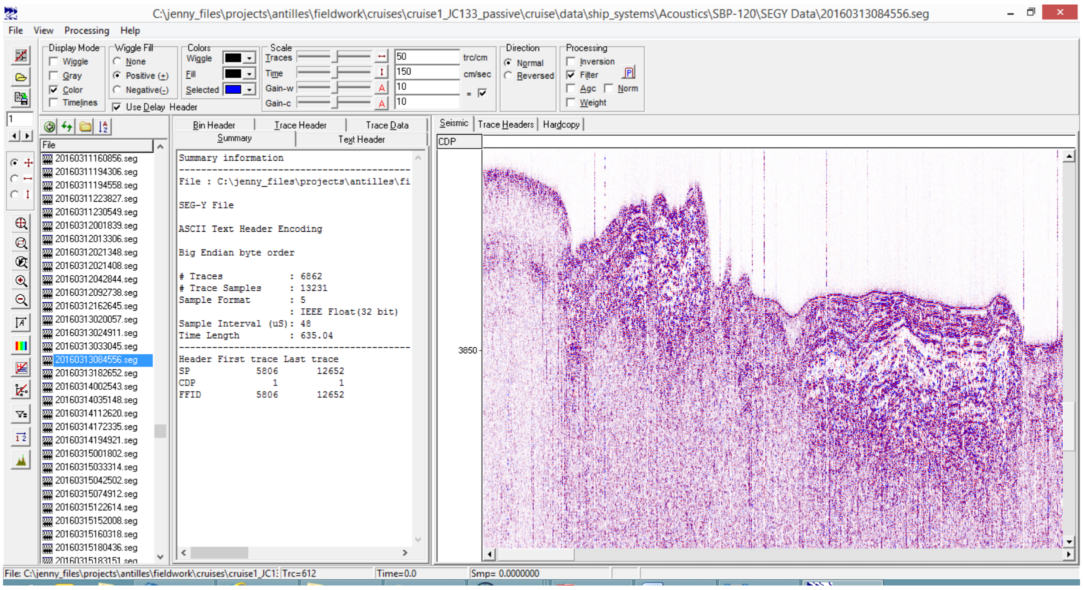


Figure 14 Example Sub-Bottom Profiler segy file viewed in SeiSee software.

8.3.6 Swath bathymetry (EM120 and EM710)

The swath data were primarily acquired using a Kongsberg EM120 multibeam echosounder (MBES), which operates at a frequency of 12 kHz with angular coverage sector of up to 150 degrees and 191 beams per ping. This geometry yields a swath width of six times water depth. Beams are automatically adjusted to be equidistant horizontally. Profiles were recorded in 30 minute segments on the SIS v 4.1.5 interface and archived in .all binary format (water depth and backscatter). In total 309 EM120 .all format files were collected.

For water depths less than about 600 m the EM710 system was also used which operates in the 70-100 kHz range and 200 beams per ping. In total 78 EM170 .all binary files were collected together with 78 water column (.wcd) files. Both systems operated without incident throughout the cruise, and whilst some drop-outs of beams were experienced during the short period of rougher seas and 10 knot speeds, the data quality was in general acceptable.

Due to ambiguity with the French diplomatic permissions it was decided not to collect any swath bathymetry data within their waters. The resulting swath coverage is shown in Figure 15.

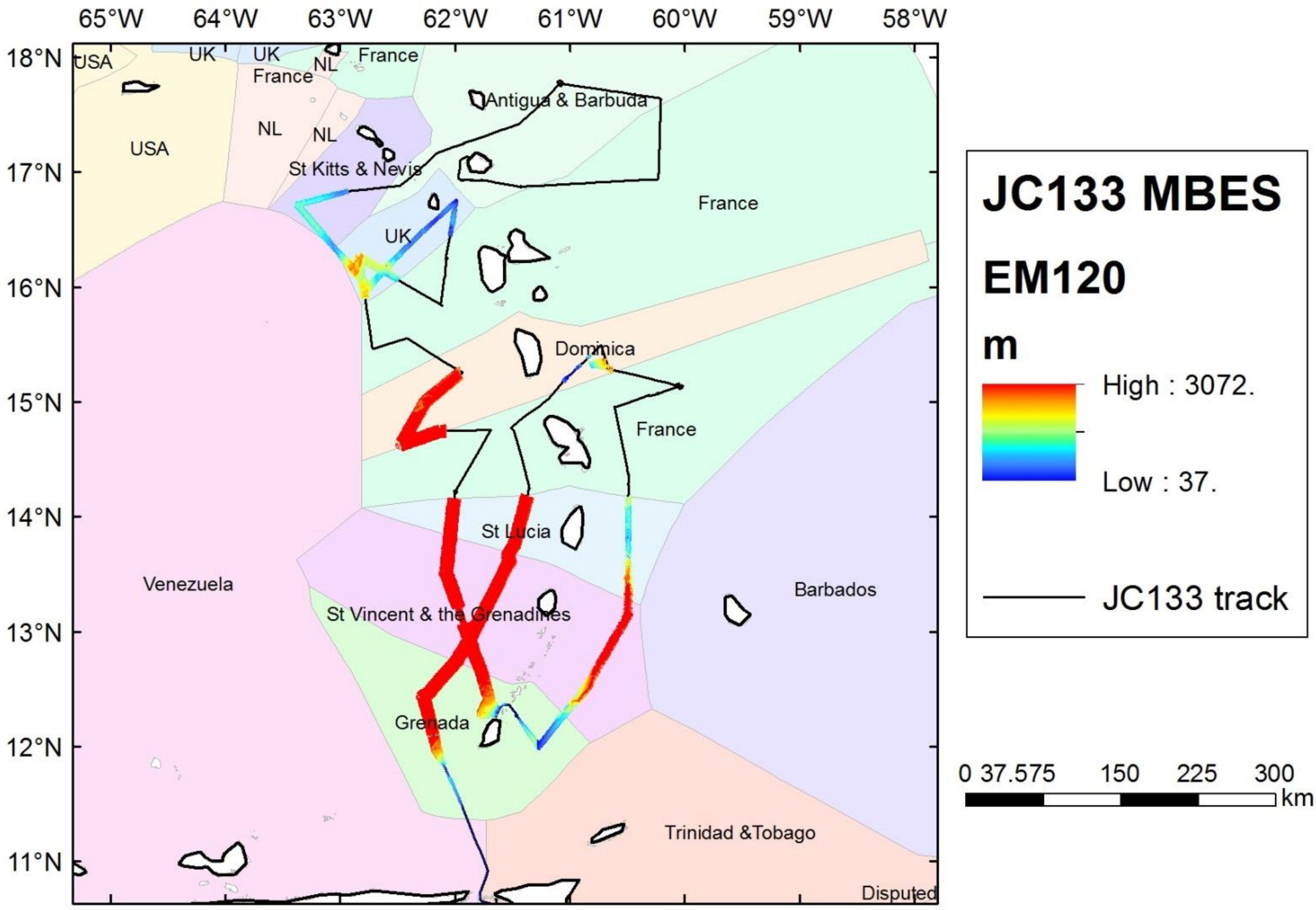


Figure 15 Summary of EM120 MBES collection. No MBES data were collected within French territorial waters. Note that data were also collected within the territorial waters of Antigua and Barbuda on the final two science days but Caris processing of these sections has not been completed at the time of writing this report.

8.3.6.1 Water sound velocity profiles (SVPs)

A total of 4 water column sound velocity profiles using a retrievable Valeport Midas SN 22241 SVP sensor were made for use in swath bathymetry processing (Figure 16). It was originally planned to conduct two SVPs mounted on the core wire during two of the BBOBS acoustic releaser tests (the intermediate and deep water depth ones conducted on 8/3 and 10/3) and nine expendable bathythermographs (XBTs). In the event the latter system was not available due to a technical fault with the onboard hardware. Therefore two additional SVPs were conducted – including one during the patch test of the EM710 (on 11/3) and one after the collection of the *Kick'em Jenny* swath survey (on 12/3). Whilst adding approximately 3 hours to the ship-programme, this was countered by the benefit of obtaining full water column profiles compared to the more rapid XBT method. It is recommended however that the XBT system be repaired, as in general a finer density of water column velocity points would be needed for swath work and it is the only feasible method to collect shallow water column velocity data when combined with multi-channel seismic reflection work.

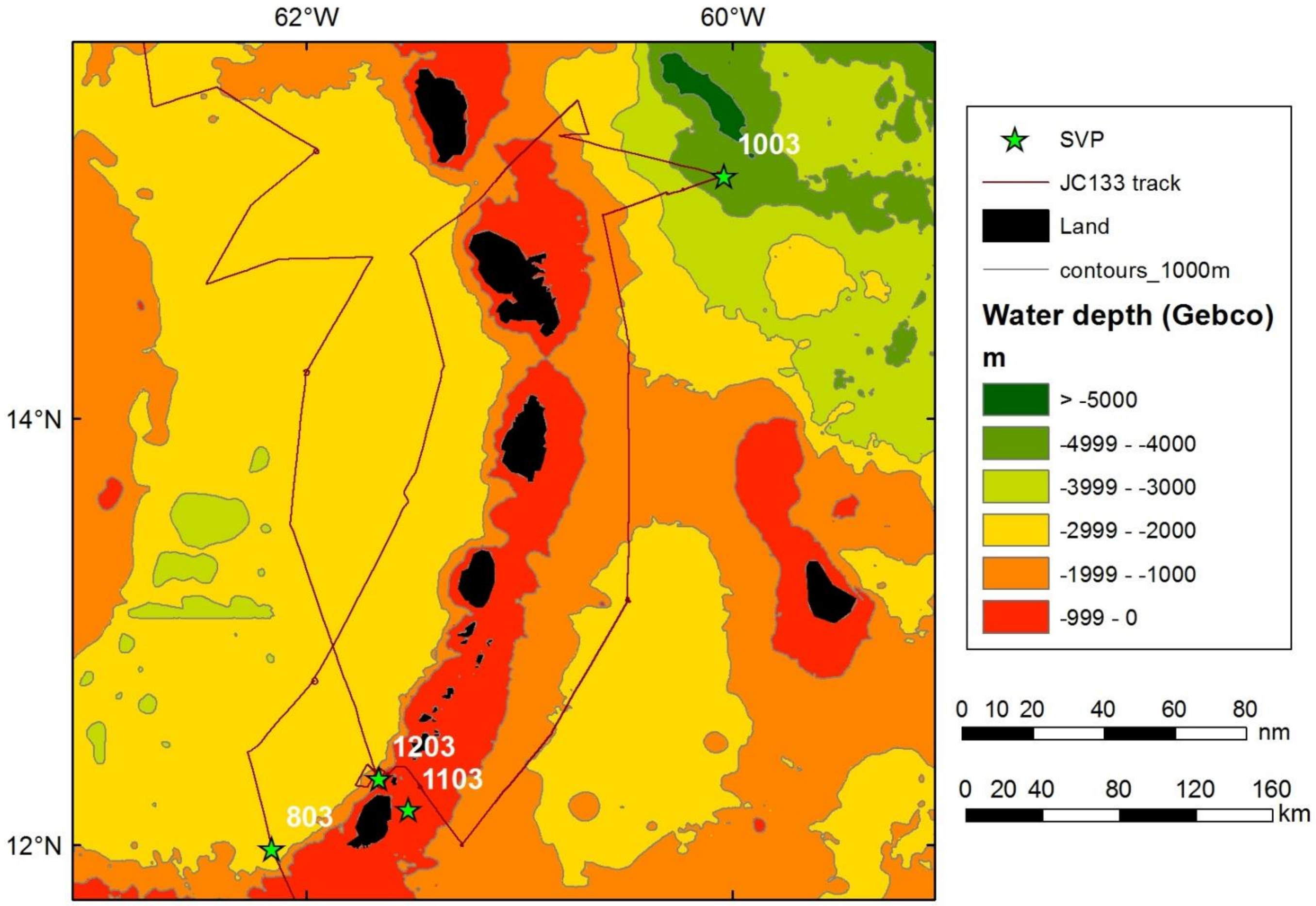


Figure 16 Location of water column sound velocity probe (SVP) dips. The dips are referenced by their calendar date in ddmm.

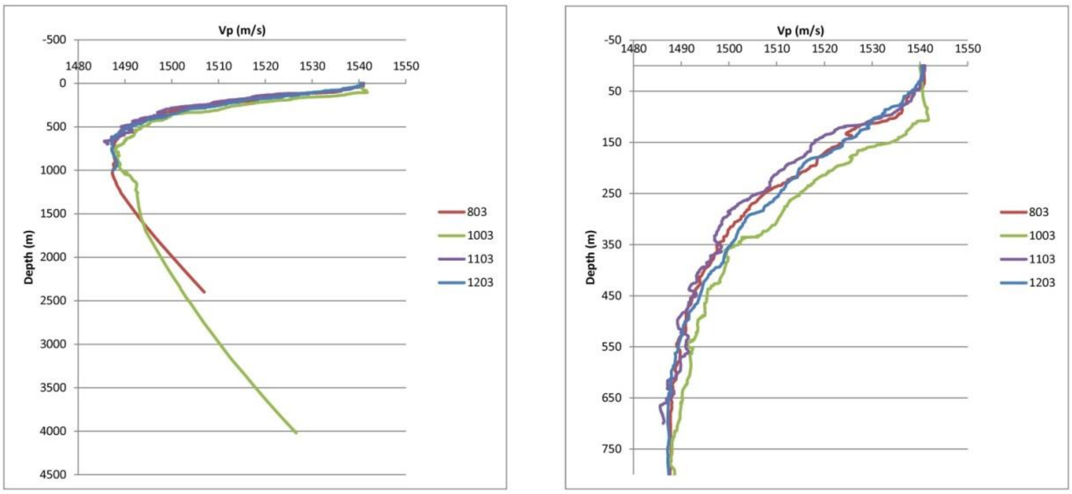


Figure 17 Sound Velocity Probe results. The dips are referenced by their calendar date in ddmm.

8.3.6.2 EM710 Patch test

A calibration patch test was performed for the EM710 on 13/3/16 using the geometry shown below. The ship was sailed in reverse directions up a slope and across an area of relatively flat seabed.

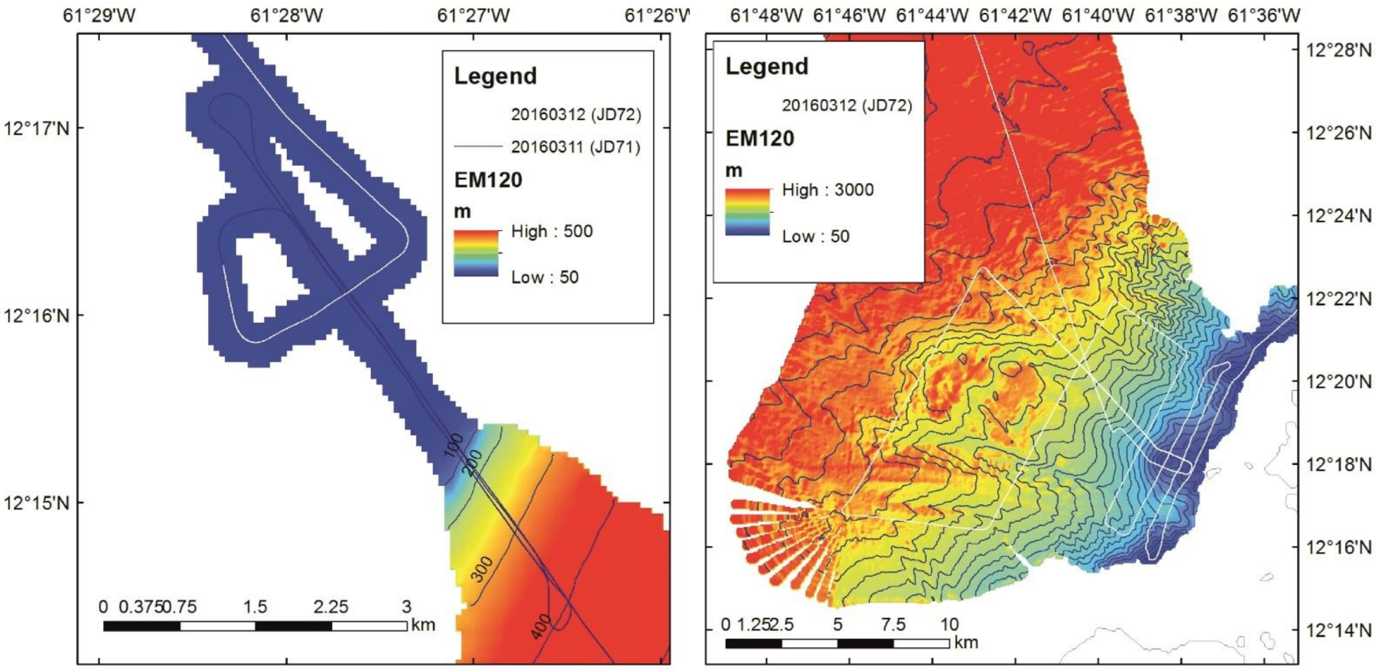


Figure 18 Left: Sail geometry for the EM710 patch test. Numbered contours are water depth in metres. Right: Ship tracks during the Kick'em Jenny survey.

The system was operated without the drop keel throughout. The calibration results were:

Roll error = -0.14; Pitch error = -1.14; Navigation timing = -0.87

and these values were saved to Caris file "James_Cook_EM710_Post_Cal_Seapath.hvf". Further details are given in Appendix E.

8.3.6.3 Processing

Bathymetry data processing was carried out using Caris HIPS software version 8.1 in UTM zone 20N. Firstly, sound velocity corrections were calculated using the recorded velocity profiles nearest in distance to the swath. Next, spurious points were removed by eye from the attitude, navigation and bathymetric data. Next, total propagated uncertainty (TPU) was derived from the combination of all individual error sources and a final manual edit of data points completed. Tidal corrections were not applied as the range in the area surveyed is less than 0.5m. No changes to the configuration files for the EM120 processing were made, so the .hvf vessel file established during JC109 (October 2014) was used. Surfaces gridded at 100-30m and 5-3m were produced for the EM120 and EM710 respectively, and exported as ASCII xyz files for import into IVS Fledermaus, arcgis and gmt software. The drop keel was not used for any EM710 data collection (due to time constraints and doubt as to its likely data quality improvement given the calm sea-state conditions) and an excellent tie with the EM120 data was produced at the *Kick'em Jenny* site following the patch test. Due to the shortness of the cruise the collected backscatter data was not processed or analysed onboard.

8.4 Magnetometer

Magnetic data were collected with a SeaSPY Overhauser sensor. The sensor was towed 300 m behind the ship from the port side. The total layback from the ship's navigation reference point was 312 m. The instrument contains a pressure sensor which showed the sensor typically towed at 5-7 m depth. Deployment and recovery used a small electronic winch and typically took 30 mins to deploy/recover. Owing to this time overhead magnetic data were only collected on transits that exceeded 2 hours. The magnetometer was also not deployed on the long transit across the arc in the north due to the shallowness and indications of considerable uncertainty in the bathymetry in that region on the Bridge's charts. The system performed well. At two points during the survey "magnetic strength warnings" were shown by the software which prompted a service of the O-rings and connectors once the instrument was on deck.

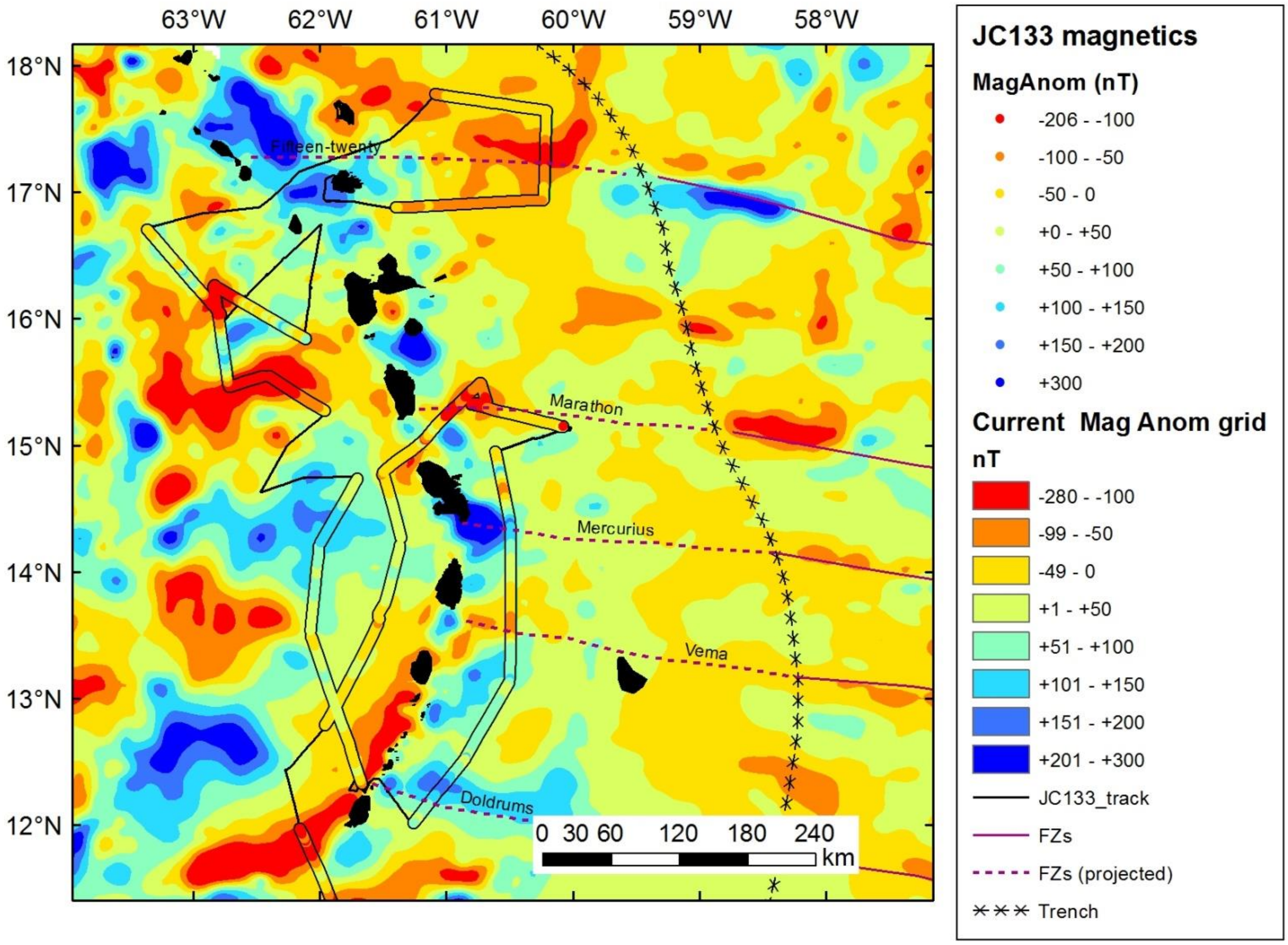


Figure 19 Map showing magnetic anomaly data collected during JC133 plotted on top of a grid of magnetics produced from legacy marine surveys sourced from the US NGDC and European SeaNetData databases. Note that the two datasets have the same plot scale.

At the end of each profile the acquisition software ("BOB") was shut down before sensor recovery and the ASCII files containing the measured total field, instrument depth and quality index with a 2 Hz sample interval archived. These files were then processed by the science party to compute the magnetic anomaly every 10 s. Processing included correcting for the layback and subtracting the 12th generation IGRF (2014 version). A visual comparison of these new data with a grid computed from the historical database is shown in Figure 19. A good general match between the two can be seen. A detail cross-over error analysis will be conducted onshore and is beyond the scope of this cruise report. However several key observations central to the VOILA project can be made. Firstly the existence of strong

Fracture zone parallel magnetic anomalies (e.g. Doldrums and FifteenTwenty), consistent with the presence of serpentinised mantle, can be seen in the fore-arc. Secondly an overall east-west magnetic structure is confirmed in the Grenada back-arc. This, together with the complex tectonic structures seen in the SBP data seems to rule out the possibility of simple east-west back-arc spreading in this region.

9 Recommendations

9.1 Cruise scheduling

The current practice of not releasing the cruise programme until 8 months prior to sailing causes both general and specific difficulties to delivering our science:

- We needed to book instruments from national and international equipment pools. These facilities are heavily used.
- We required 10 diplomatic clearances that need a 6 months lead-in time.
- For the next leg we will need to produce EIA which requires knowledge of the month of acquisition
- We needed to programme automatic backup release clocks for the recovery leg.

9.2 Manning and co-ordination

- Due to the nature of magnetometer deployments interspersed with OBS deployments we needed both NMF staff. If, as we believe was originally planned, there had been only one it would have impacted the work programme.
- Mobilisation happened 2 days earlier than planned due to the rudder issue (need to move ship from PoS to yard at Chaguramas). Whilst both the OBS teams were present the UK team were not. Fortunately this did not cause any major problems.
- At the time of sailing (36 hours late) we lacked diplomatic clearances for 2 states, but these were forthcoming whilst at sea and did not impact the work programme.

9.3 Equipment performance

- The only technical failure was the lack of XBTs. We had planned to deploy 9 which would have provided better constraints on upper water column velocity structure. This is an essential piece of kit especially when towing the hydrophone streamer when it is not possible to stop to deploy SVPs.
- There is clear instability in the S40 gravimeter showing as high-frequency (1500s period) +/- 25 mGal oscillations during moderate sea-states. This points to a serious problem with the metre which should be investigated when the vessel returns to port.
- The bottom-detection accuracy of the swath bathymetry at speeds above 5 knots under even moderate sea-states remains a concern.

We make the following suggestions:

- It would advantageous for all geophysics cruises to re-introduce a standardised method of processing the gravity and magnetic data to allow data QC at sea. This could take the form of a series of linux scripts to read the various logged NetCDF files, apply standard corrections and output a merged ASCII table. Currently there is a lot of duplication of effort by the scientists on different cruises. Members of the science party would be more than happy to advice on this implementation.
- In the current configuration of screens in the main lab it would be very helpful for OBS deployments if the watchkeeper could view the CTV screen and the GPS screen at the same time!

9.4 Internet and ship's intranet

With a Science Party of just 9 people and "double" 256k bandwidth still running from the previous cruise the performance of the internet (RJ45 and wireless) was acceptable. We stress the importance of internet for the research programme. As part of the "pathways to impact" objectives a cruise blog (www.voila.ac.uk) and twitter feed (@Voila_nerc) were maintained throughout the cruise. Modern work life also dictates a high reliance on internet – and probably 80% of the Science Party's use was directly work-related. Improved internet facilities would greatly aid productivity (rather than simply provide entertainment!).

The ship's intranet was also extensively used for ship position, winch control etc away from the Main Lab. It was also used to distribute key documents related to the ship's programme.

10 Acknowledgements

The cruise was highly successful which was greatly aided by the professionalism of the entire ship's complement. We especially thank the Captain, John Leask and our NMF cruise-liaison officer Matt Tailho for their direct contribution to the execution of the science. Andrew Moore is also thanked for his exceptional engagement in the scientific work. The deck crew are especially acknowledged for their work in deploying the BBOBS and magnetometer and the catering staff for looking after us so well. It was a pleasure to sail, and we received nothing but complements from the German and American-members of our party about facilities and conditions onboard.

Back onshore, we also thank Colin Day for his overall assistance and Jane Thompson for her work on the complex diplomatic clearances needed (and good humour at all times!). We are grateful to Valérie Clouard of the Martinique Volcanic Observatory and Walter Roest and Frauke Klingelhoefer of IFREMER for assistance with French permissions; and Richie Robertson of the SRC with help with St Vincent permissions. We also thank Joan Latchman and Frederic Dondin for providing cruise reports from earlier Kick'em Jenny surveys

11 Appendix A: Demobilisation equipment list

12 Appendix B: DEPAS automatic release clocks

13 Appendix C: Ships logging and data formats

14 Appendix D: Gravity basestation ties

15 Appendix E: EM710 patch test results

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

VERSION: AWI_2015_02

FREIGHT LIST

KIND OF EXPEDITION:	OTHER		**PARTICIPANT:**	Andreas Rietbrock/Henning Kirk	**KIND OF FREIGHT:**	DANGEROUS GOODS
CRUISE NO.:	James Cook		**E-MAIL ADDRESS:**	A.Rietbrock@liverpool.ac.uk	**DATE:**	18/03/2016
CRUISE LEG / FLIGHT NO.:	JC133 -Backfreight to AWI		**PHONE NO.:**	+44(0)151 794 5181	**CONTAINER NO.:**	None
COLOUR CODE: YELLOW	YELLOW		**INSTITUTION:**	University of Liverpool, School of Env. Sciences, Jane Herdman Building, Liverpool L69 3GP, United Kingdom	**REQUISITIONER NO.: (ONLY FILLED BY AWI-LOGISTICS)**	

IDENT-NO.	KIND OF PACKING	STOWAGE (ONLY FILLED BY AWI-LOGISTICS)	ITEM (CONTENT - KEYWORDS)	MEASUREMENTS LxWxH (CM)			VALUE (€)	WEIGHT (KG)	VOLUME (CBM)
GPP088	ALUBOX		2 Releaser (SN: 0803168, 051158) 2 Radio Beacons (SN: X10-015, U04-028) 2 Flashlights (SN: T10-056, T10-079) 2 Seismometers (SN:003155, 000101)	80.0	60.0	40.0	29080.00	60.00	0.192
GPP026	ALUBOX		15 MCS Recorder (SN: 050904, 080104, 050912, 060730, 050916, 060701)	80.0	60.0	40.0	36600.00	20.00	0.192
GPP010	ALUBOX		1 Deck Unit, small (SN: 34984) 1 Transducer (SN: 34984) 1 GPS Antenna (SN: 110704) 1 Connector Box (SN: 110702) 1 Direction Finder (SN: 69989) 1 Programming Terminal (SN: 0404127)	80.0	60.0	40.0	8500.00	25.00	0.192
GPP067	ALUBOX		1 Deck Unit, big (SN: 31084) 1 Transducer (SN: 31251) 1 GPS Antenna (SN: 051108) 1 Connector Box (SN: 051205) 1 Direction Finder (SN: 80690) 1 Programming Terminal (SN: 0404110)	80.0	60.0	60.0	9040.00	28.00	0.288
GPP034	ALUBOX		1 Tool Box, 1 Soldering Set, Spare Parts (Seals, Screws), 1 Hot-Air Gun, Cable Straps, Tape	80.0	60.0	40.0	550.00	50.00	0.192
GPP090	ALUBOX		2 Laptops (AWI-SN: 71547; 61106), 1 Drilling Machine, Sprays (UN 1950, LQ, s. DG List)	80.0	60.0	40.0	580.00	40.00	0.192
GPP031	ALUBOX		Working Cloths, Ropes	80.0	60.0	40.0	80.00	30.00	0.192
GPP501	ALUBOX		1 Cable Drum, Office Material, Sockets, Adaptors	80.0	60.0	40.0	100.00	25.00	0.192
GPP031	ALUBOX		Desiccants, Cleaning Material, Spare Parts	80.0	60.0	40.0	150.00	35.00	0.192

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

VERSION: AWI_2015_02

FREIGHT LIST

KIND OF EXPEDITION:	OTHER	**PARTICIPANT:**	Andreas Rietbrock/Henning Kirk	**KIND OF FREIGHT:**	DANGEROUS GOODS
CRUISE NO.:	James Cook	**E-MAIL ADDRESS:**	A.Rietbrock@liverpool.ac.uk	**DATE:**	18/03/2016
CRUISE LEG / FLIGHT NO.:	JC133 -Backfreight to AWI	**PHONE NO.:**	+44(0)151 794 5181	**CONTAINER NO.:**	None
COLOUR CODE: YELLOW	YELLOW	**INSTITUTION:**	University of Liverpool, School of Env. Sciences, Jane Herdman Building, Liverpool L69 3GP, United Kingdom	**REQUISITIONER NO.: (ONLY FILLED BY AWI-LOGISTICS)**	

IDENT-NO.	KIND OF PACKING	STOWAGE (ONLY FILLED BY AWI-LOGISTICS)	ITEM (CONTENT - KEYWORDS)	MEASUREMENTS LxWxH (CM)			VALUE (€)	WEIGHT (KG)	VOLUME (CBM)
	PALLET		Steel-Ankerpallet	110.0	70.0	15.0	40.00	60.00	0.116
GPP098	ALUBOX		1 Fire Extinguisher Class D 12-Kg (UN1044, s. DG List)	80.0	60.0	60.0	220.00	27.00	0.288
GPP620	PALLET		Releaser Test Box	120.0	80.0	120.0	300.00	100.00	1.152
			Total: 10 Aluboxes, 1 Releaser test box, 1 Ankerpallet						
			Collies: 3 Euro-Pallets						
			Back to AWI from Southampton in May 2016						
Signature: **Date:**				**TOTAL:**			**85240.00**	**500.0**	**3.380**

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

VERSION: AWI_2015_02

DANGEROUS GOODS LIST

(PLEASE HAND OVER THE MATERIAL SAFETY DATA SHEET [MSDS] FOR EVERY SINGLE DANGEROUS ITEM TOGETHER WITH THE PACKAGE TO THE AWI-WAREHOUSE. PLEASE ALSO FORWARD A COPY TO THE AWI-LOGISTICS)

KIND OF EXPEDITION:	OTHER	**PARTICIPANT:**	Andreas Rietbrock/Henning Kirk	**DATE:**	18/03/2016
CRUISE NO.:	James Cook, Back to AWI	**E-MAIL ADDRESS:**	A.Rietbrock@liverpool.ac.uk	**CONTAINER NO.:**	None
CRUISE LEG / FLIGHT NO.:	JC133	**PHONE NO.:**	+44(0)151 794 5181		
COLOUR CODE: YELLOW	YELLOW	**INSTITUTION:**	University of Liverpool, School of Env. Sciences, Jane Herdman Building, Liverpool L69 3GP, United Kingdom	**REQUISITIONER NO.: (ONLY FILLED BY AWI-LOGISTICS)**	

IDENT-NO.	QUANTITY & PACKING	PROPER SHIPPING NAME (CORRECT TECHNICAL NAME)	IMO	UN-NO.	PACK. GROUP	WEIGHT (KG) GROSS	NET	MEASUREMENTS (LxWxH) (CM)			VALUE (€)
GPP098	1 12-Kg Fire Ext., Alubox	Fire Extinguisher	2.2	1044	--	27.00	17.000	80.0	60.0	60.0	220.00
GPP090	5 Spray Cans, Alubox	Aerosols (LQ)	2.1	1950	--	24.00	2.500	80.0	60.0	40.0	60.00
Signature: **Date:**				**TOTAL**		**51.00**	**19.500**				**280.00**

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR-
UND MEERESFORSCHUNG

VERSION: AWI_2015_02

FREIGHT LIST

KIND OF EXPEDITION:	OTHER		**PARTICIPANT:**	Andreas Rietbrock/Henning Kirk	**KIND OF FREIGHT:**	NORMAL
CRUISE NO.:	James Cook, Stay in Southh.		**E-MAIL ADDRESS:**	A.Rietbrock@liverpool.ac.uk	**DATE:**	18/03/2016
CRUISE LEG / FLIGHT NO.:	JC133		**PHONE NO.:**	+44(0)151 794 5181	**CONTAINER NO.:**	None
COLOUR CODE: YELLOW	YELLOW		**INSTITUTION:**	University of Liverpool, School of Env. Sciences, Jane Herdman Building, Liverpool L69 3GP, United Kingdom	**REQUISITIONER NO.: (ONLY FILLED BY AWI-LOGISTICS)**	

IDENT-NO.	KIND OF PACKING	STOWAGE (ONLY FILLED BY AWI-LOGISTICS)	ITEM (CONTENT - KEYWORDS)	MEASUREMENTS LxWxH (CM)			VALUE (€)	WEIGHT (KG)	VOLUME (CBM)
	PALLET		7 Zarges-Boxes (Id-No: GPP019, GPP096, GPP012, GPP082, GPP018, GPP083, GPP036)) GPP036 with 23 Tension Belts, 5 Ropes, 2 Tarps GPP019 with 19 empty MCS-Boxes	120.0	80.0	180.0	210.00	80.00	
	PALLET		8 Zarges-Boxes (Id-No: GPP028, GPP013, GPP070, GPP058, GPP068, GPP056, GPP077, GPP085)	120.0	80.0	180.0	240.00	90.00	
	PALLET		10 Euro-Pallets	120.0	80.0	150.0	50.00	100.00	
	PALLET		9 Europallets	120.0	80.0	135.0	45.00	90.00	
	PALLET		6 OBS-Pallets, 2 Bags with Foam Pieces	125.0	130.0	180.0	120.00	300.00	
			Total: 15 Aluboxes, 19 Europallets, 6 OBS-Pallets, 2 Foam Bags						
			Collies: 5 Pallets						
			To Stay in Southhampton till Recovery Cruise in May 2017						
Signature: **Date:**				**TOTAL:**			**665.00**	**660.0**	**0.000**

SIO BBOBS-periferal equipment for storage at NOC between legs

Qty	Description	Dims (feet)	Weight lbs	Comments
1	Wire basket=zarges boxes	4x4x5	1000	Must be inside covered/secure
1	Rosette	3x3x3	400	Stored outside if needed
1	Stack of 10 pallets	4x4x6	400	Outside storage OK
1	Pallet jack		200	Under cover
5	Double stacked sensor boxes	2x2x4	80 ea	Must be inside covered/secure
1	Bik box w/ surface equipment	3x3x3	150	Must be inside covered/secure

The times were calculated with the following parameters:

1) Transit time between stations assume 10 knots
2) Ship arrives at Station 15 mins before instrument surfaces
3) Ship leaves station 60 mins after instrument surfaces
4) Rise rate of 1.1 m/s

Station #	Auto-Release-Time (UTC)					
	yr	mon	day	hr	min	sec
01	2017	6	5	12	0	0
03	2017	6	5	21	33	0
04	2017	6	6	2	45	0
05	2017	6	6	7	17	0
06	2017	6	6	14	2	0
08	2017	6	6	17	46	0
09	2017	6	6	21	42	0
10	2017	6	7	2	23	0
12	2017	6	7	14	55	0
14	2017	6	8	1	13	0
16	2017	6	8	10	18	0
17	2017	6	8	14	5	0
18	2017	6	8	17	25	0
19	2017	6	8	21	13	0
21	2017	6	9	2	5	0
22	2017	6	9	5	49	0
24	2017	6	9	12	46	0
25	2017	6	9	16	13	0
27	2017	6	9	19	50	0
28	2017	6	9	22	33	0
30	2017	6	10	5	5	0
31	2017	6	10	14	55	0
32	2017	6	10	17	29	0
34	2017	6	10	23	44	0

Table of programmed DEPAS automatic release clocks.

Cruise	JC133
Technician	A Moore
Date	6th March 2016 – 17th March 2016

BODC Ship-fitted Systems Information Sheet (James Cook)

Ship-fitted instruments:

The following table lists the logging status of ship-fitted instrumentation and suites.

Manufacturer	Model	Function/data types	Logged? (Y/N)	Comments
Steatite	MM3S	GPS network time server (NTP)	N	Not logged but feeds times to other systems
Applanix	POS MV	DGPS and attitude	Y	Primary GPS
Ashtech	ADU-5	DGPS and attitude	N	
C-Nav	3050	DGPS and DGNSS	Y	
Kongsberg Seatex	DPS116	Ship's DGPS	Y	Bridge GPS
Kongsberg Seatex	Seapath 200	DGPS and attitude	Y	Secondary GPS
Sonardyne	Fusion USBL	USBL	N	
Sperry Marine		Ship gyrocompasses x 2	Y	
Chernikeeff Instruments	Aquaprobe Mk5	Electromagnetic speed log	Y	Good above 4 kts
Kongsberg Maritime	Simrad EA600	Single beam echo sounder (hull)	Y	
Kongsberg Maritime	Simrad EA500	Single beam echo sounder (hull)	N	
Kongsberg Maritime	Simrad EM120	Multibeam echo sounder (deep)	Y	
Kongsberg Maritime	Simrad EM710	Multibeam echo sounder (shallow)	Y	
Kongsberg Maritime	Simrad SBP120	Sub bottom profiler	Y	
Kongsberg Maritime	Simrad EK60	Scientific echo sounder (fisheries)	N	
NMFSS	CLAM	CLAM system winch log	Y	
NMFSS	Surfmet	Meteorology suite	Y	
NMFSS	Surfmet	Surface hydrography suite	Y	
		Skipper log (ship's velocity)	Y	
OceanWaveS GmbH	WaMoS II	Wave Radar	Y	Display Purposes Only
Teledyne RD Instruments	Ocean Observer 75 kHz	VM-ADCP	N	
Teledyne RD Instruments	Ocean Observer 150 kHz	VM-ADCP	N	
Microg Lacoste	Air-Sea System II	Gravity	Y	

Bestnav hierarchal ordering:

The following table lists the order of navigational systems in the *bestnav* process for positional fix.

Rank	Order of positional fixes	Comment
1	POS MV	
2	CNAV	
3	DPS116	

Units of dist_run: nautical miles

Relmov source:

The following table lists the navigational systems that are used in the *relmov* process for ship's motion.

Navigational source of ship's motion	Comment
Ship's Gyro	
Chernikeeff EM log	

RVS data processing:

The following table lists the RVS Level-C processing programs that were run.

Program	Was it run?	Comments
bestnav	Y	
*prodep***	Y	
protsg	N	
relmov	Y	
satnav	N	
windcalc	Y	

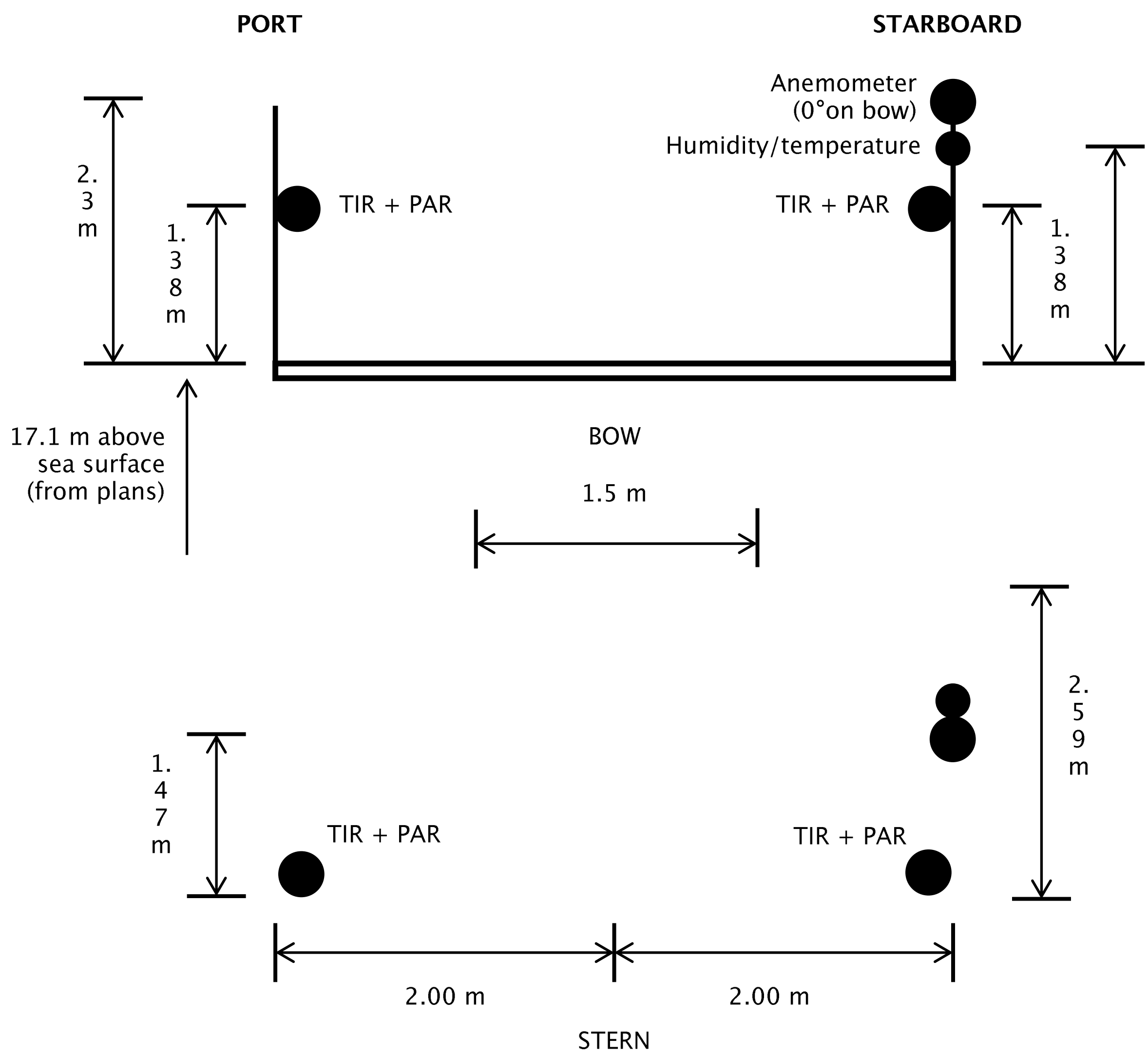
**Please state if sound velocity probes used for depth correction instead of *prodep*.

Surfmet Sensor Information Sheet (James Cook)

Cruise	JC133
Technician	Andrew Moore
Date	06/03/2016 - 17/03/2016

Meteorology platform (Foremast)

JAMES COOK MET PLATFORM



Pumped seawater flow rates (ml/min):	1500
Anemometer orientation on bow (deg):	0
Seawater intake depth (m):	5.5

Fitted Sensors:

Manufacturer	**Sensor**	**Serial No.**	**Comments (eg. Port)**	**Calibration applied?**	**Last calibration date**
AML	Smart SV	5124	(High data rate)	No	16/07/2015
Skye	PAR	28557	Starboard	No	30/04/2015
Skye	PAR	28559	Port	No	11/09/2015
Kipp & Zonen	TIR	047463	Starboard	No	15/06/2015
Kipp & Zonen	TIR	047462	Port	No	01/06/2015
Gill	Windsonic	064537		No	No cal
Vaisala	HMP45 Temp./Hum.	E1055002		No	15/06/2015
Vaisala	PTB110 Air Pres.	L2240581		No	28/05/2015
Wet Labs	WS3S Fluorimeter	WS3S-134		No	19/05/2015
Wet Labs	CST Transmissometer	CST-114		No	26/09/2014
Sea-Bird	SBE38 Temperature	386825-0689		No	24/06/2015
Sea-Bird	SBE45 TSG	4548881-0230	Good from install (27/12/2015) to **27/12/2016**	No	11/09/2015
Valeport	MIDAS SVP	22355			23/09/2015
Valeport	MIDAS SVP	22241			31/07/2014

Spare Sensors on-board not fitted:

Manufacturer	**Sensor**	**Serial No.**	**Comments (eg. Port)**	**Calibration applied?**	**Last calibration date**
AML	Smart SV	5444	-	-	22/09/2015
Skye	PAR	38884	-	-	16/07/2014
Skye	PAR	-	-	-	-
Kipp & Zonen	TIR	994133	-	-	23/07/2014
Kipp & Zonen	TIR	994132			23/07/2014
Gill	Windsonic	064538	-	-	No cal
Vaisala	HMP45 Temp./Hum.	B4950011	1 degree low (JC125)	-	(10/06/2015)
Vaisala	HMP45 Temp./Hum.	B4950010	-	-	12/08/2015
Vaisala	HMP45 Temp./Hum.	C1320001	-	-	12/08/2015
Vaisala	PTB110 Air Pres.	J0710002	-	-	06/08/2015
Wet Labs	WS3S Fluorimeter	WS3S-351P	-	-	19/05/2015
Wet Labs	CST Transmissometer	CST-113R		-	03/09/2015
Sea-Bird	SBE38 Temperature	0476	-	-	24/06/2015
Sea-Bird	SBE45 TSG	4548881-0232	Up to 1yr of operation from install date (within 2yrs of calibration date)	-	09/11/2015

National Marine Facilities – RRS James Cook NetCDF Description Version 2.10 – March 2016

This document describes how the variables logged by the National Marine Facilities Sea System's Techsas version 5.9 data logging system are recorded and processed on RRS James Cook. There is a similar set-up on RRS Discovery, but the NetCDF filenames are different; a similar document is available for RRS Discovery. If you have any questions then please contact the Scientific Ship Systems Group via email at: nocs_nmfss_shipsys@noc.ac.uk or via the head of the group, Gareth Knight on 023 8059 6281.

The following list of variables is arranged by the NetCDF files in which each variable occurs, with the RVS Level-C stream name afterwards in round brackets. The NetCDF files are arranged into sub-directories and the directory name is given before the filename, separated by a forward slash. The variable name in round brackets is the variable name from the RVS Level-C data file. The units are given in square brackets.

The **time** variable in the NetCDF files is a floating point number giving the number of days since 30th December 1899 00:00:00 UTC. The decimal part gives the time of day. The **Time** variable in the RVS Level-C files when they are presented in an ASCII format varies depending upon the program used to generate the ASCII file, but is commonly YY DDD HH:MM:SS where YY is the last two digits of the year, DDD is the Julian day of the year and the remainder is the UTC time.

Variables in the Level-C files have a status flag associated with them. The value of these status flags indicates the following:

Flag	Meaning
60	Accept
55	Correct
50	Good (default)
45	Uncorrected
40	Interpolated
35	Restart
30	Suspect
20	Reject
10	Test
0	Not written

Changes

Version 1.10: an error was found in YYYYMMDD-hhmmss-MET-JC-SM_JC1.SURFMETv2 (surfmet). In version 1.00 the anemometer was described as having an RS232 output, when in fact it had an analogue output. This has been corrected in this version. The error was solely in this document; no changes have been made to the hardware.
Version 1.11: added the post-processed Level-C data streams relmov, bestnav, bestdrf, pro_wind and prodep. Added the RVS Level-C statuses and a complete description of the USBL data for the first time.

Version 1.12: a bug was discovered in the CNAV NetCDF data. All NetCDF data logged since the GPS was fitted to the vessel on cruise JC052 in September 2010 was logged in the format described in version 1.12 of this document.
Version 1.13: added in details about the CLAM cable types and a bug that occurred in the CLAM cable type prior to cruise JC68.
Version 1.14: improved the description of the USBL accuracy.
Version 1.15: updated after changes were made to Techsas and Level-C. A bug was found in the Level-C winch data recorded prior to 25th July 2012. Details are on the winch page. The CNAV module was fixed to remove the bug in position. The CNAV page has been updated to describe when this bug was present in the data. The POSMV and DPS116 modules prior to 25th July 2012 did not record data in the gndcourse or gndspeed variables. The Seapath 200 still does not record data in gndcourse or gndspeed.
Version 1.16: fixed three errors in this document. The unit for dist_run in the Level-C had been given as degree when it should have been nautical miles. In the satellite info files for the POSMV, Seapath 200 and DPS116 GPSs the descriptions for VDOP and PDOP had been swapped over. The page for the CNAV satellite info file had been omitted from previous versions.
Version 1.17: included a numerical example of how to apply the calibration to TIR data as the units of light intensity are given in an unusual format.

Version 2.0: a new version for Techsas 5.9, which began to be used on the James Cook on cruise JC108 on 23rd September 2014. Details of bugs that occurred in the older Techsas 2.35 have been removed from this document. If you are working with data prior to JC108 then you should consult version 1.17 of this document.

Version 2.1: 'SURFMETv2/YYYYMMDD-hhmmss-Light-JC-SM_JC1.SURFMETv2 (surfmet)' page 9 – Added second pressure equation for converting PTB110 voltage to hPa. This only applies to PTB110 S/N:L2240581, L2240582 (as of 03/2016).

Table of Contents

AIRSEAII/YYYYMMDD-hhmmss-AirSeaII-S84_JC1.AirSeaII (gravity)

This file contains data from the Micro-g Lacoste gravity meter.

grav_av (grav_av) [counter units] is the filtered gravity value.

springt (springt) [counter units] is the spring tension.

beam (beam) [volt × 750000] is the beam position.

vc (vc) [see manual] VCC data field.

al (al) [see manual] AL data field.

ax (ax) [see manual] AX data field.

ve (ve) [see manual] VE data field.

ax2 (ax2) [see manual] AX2 data field.

xac2 (xac2) [see manual] XACC2 data field.

lac2 (lac2) [see manual] LACC2 data field.

xac (xac) [Gal] Cross acceleration.

lac (lac) [Gal] Longitudinal acceleration.

eotcor (eotcor) [milliGal] EOTVOS correction.

lat (lat) [degree] is the latitude that the gravity value was taken at.

lon (lon) [degree] is the longitude that the gravity value was taken at.

heading (heading) [degree] is the course made good from the GPS data.

velocity (vel) [knot] is the vessel’s velocity from the GPS data.

not logged (xcup) [] a constant value of zero.

time (Time) []

CLAM/YYYYMMDD-hhmmss-CLAM-CLAM_JC1.CLAM (winch)

The CLAM system records data from the ship's permanently fitted winches.

cabltype (cabltype) [] is the type of cable in operation.

The cable types are shown below:

Numeric Value	Cable Type
0	No winch selected
1	CTD1
2	CTD2
3	Core Warp
4	Trawl
5	Fibre Optic Deep Tow
6	Plasma

cablout (cablout) [metre] is the length of cable deployed.

rate (rate) [metre per minute] is the rate of cable deployment. A positive rate indicates that the cable is being paid out (veered) and a negative rate indicates that the cable is being hauled in.

tension (tension) [tonne] is the cable tension.

btension (btension) [tonne] is the cable back tension.

angle (angle) [degree] is no longer be measured by the winch system, but was probably the vessel heel (roll) angle.

time (Time) []

EA600/YYYYMMDD-hhmmss-EA600-EA600_JC1.EA600 (ea600m)

The EA600 echo sounder outputs the depth that it measures from the sea bed to the ship's waterline, (i.e. compensating for the depth of the sensor below the waterline). The compensation factor is set in the software. The sensor is mounted on the drop keel. The sonar user should modify the compensation factor when the drop keel is moved. The depth is output in various units, all of which are logged to the NetCDF file. Only the depth in metres is recorded in the RVS data files. No compensation is made for the current tidal height. No information about the sound velocity correction applied is contained in the file and the cruise report should be consulted for further information.

depthft (not logged) [feet]

depthm (depth) [metre]

depthF (not logged) [fathom]

time (Time) []

LOG/YYYYMMDD-hhmmss-vmvbw-log_chf_JC1.log (log_chf)

The Chernikeef Electromagnetic dual-axis log measures the ship's velocity through the water.

speedfa (speedfa) [knot] is the speed of the vessel through the water in a fore and aft direction. Forward motion results in a positive speed.

speedps (speedps) [knot] is the speed of the vessel through the water sideways. Starboard motion results in a positive speed.

time (Time) []

ATT/YYYYMMDD-hhmmss-gppat-GPPAT_JC1.att (adu5pat)

This data file contains data from the Ashtech ADU5 GPS-based attitude-measuring system.

measureTS (measureT) [days] is the time stamp applied to the data by the GPS unit.

lat (lat) [degree] is the latitude.

long (lon) [degree] is the longitude.

alt (alt) [metre] is the measured altitude.

heading (heading) [degree] is the true heading of the ship.

pitch (pitch) [degree] is the pitch of the ship. A bow up rotation gives a positive pitch value.

roll (roll) [degree] is the roll of the ship. A rotation of the ship's superstructure to starboard gives a positive roll value.

mrms (mrms) [metre] attitude phase measurement RMS error.

brms (brms) [metre] attitude baseline length RMS error.

time (Time) []

SURFMETv2/YYYYMMDD-hhmmss-Light-JC-SM_JC1.SURFMETv2 (surfmet)

This NetCDF file gives the voltages recorded by the four light sensors and also the air pressure (it is unknown why air pressure is included in this file rather than the met file). The voltages recorded by the light sensors must be converted to an intensity using the calibration factor given on each sensor's latest data sheet. The units for the voltage do not use a standard SI prefix and care must be taken when converting them to light intensity. The following example shows how the conversion should be performed:

A typical maximum value for a TIR in a Techsas or Level-C file is 1108.7. This is 1108.7×10^{-5} V. From the data sheet for this TIR the calibration to be applied is 11.94 µVolts/W/m^2. So the actual TIR light intensity is 0.011087 / 0.00001194 = 928.5 W/m^2.

pres (press) [hectopascal] is the atmospheric pressure. The voltage measured by the Nudam ADC is converted to hPa in the Surfmet program by the equation:

$pres = 800 + (52\times voltage)$

where *voltage* is the measured voltage in volts.

[Version 2.1 Change] For fitted PTB110 sensors S/N: L2240581, L2240582 the voltage measured by the Nudam is converted to hPa in the Surfmet program by the equation:

$pres = 500 + (120*voltage)$

ppar (ppar) [volt × 10^{-5}] is the voltage measured by the Nudam ADC in millivolts multiplied in the Surfmet software by 100, from the Photosynthetically Active Radiation (PAR) sensor on the port side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet, paying attention to the fact that the calibration factor typically has units of microvolt per watt per metre squared and this value has units of $\times10^{-5}$ volts.

spar (spar) [volt × 10^{-5}] is the voltage measured by the Nudam ADC in millivolts multiplied in the Surfmet software by 100, from the PAR sensor on the starboard side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet.

ptir (ptir) [volt × 10^{-5}] is the voltage measured by the Nudam ADC in millivolts multiplied in the Surfmet software by 100, from the Total Irradiance (TIR) sensor on the port side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet.

stir (stir) [volt × 10^{-5}] is the voltage measured by the Nudam ADC in millivolts multiplied in the Surfmet software by 100, from the TIR sensor on the starboard side of the ship's meteorological platform. To convert this value to a light intensity, it should be divided by the calibration factor specified on each sensor's data sheet.

time (Time) []

SURFMETV2/YYYYMMDD-hhmmss-MET-JC-SM_JC1.SURFMETv2 (surfmet)

speed (speed) [metre per second] is the relative wind velocity. The wind speed and direction are at the height of the anemometer on the met platform, approximately 18.7 metres above the sea surface depending upon the trim of the ship. The sensor outputs a voltage between 0 and 5 volts corresponding to 0 and 50 ms^{-1}. These voltages are measured by a Nudam ADC. The Surfmet software converts this voltage to a speed using the equation:

$$speed = (50/5) \times voltage$$

The units attribute of the speed variable in the NetCDF file say that the units are knot, but this is incorrect and the units are meter per second.

direct (direct) [degree] is the wind direction relative to the vessel that the wind is blowing from. 0° is at the bow. The sensor outputs a voltage between 0 and 5 volts corresponding to 0 and 360°. The Surfmet software converts this voltage to a direction using the equation:

$$direct = (360/5) \times voltage$$

airtemp (airtemp) [degree Celsius] is the air temperature. The sensor outputs a voltage between 0 and 1 volt, corresponding to -40°C to +60°C. This voltage is measured by a Nudam ADC and is converted to a temperature in the Surfmet software using the equation:

$$airtemp = (100 \times voltage) - 40$$

where *voltage* is the measured voltage in volts.

humid (humidity) [percent] is the relative humidity of the air. The sensor outputs a voltage between 0 and 1 volt, corresponding to 0% and 100% relative humidity respectively. The voltage is measured by a Nudam ADC and is converted to relative humidity in the Surfmet software using the equation:

$$humid = 100 \times voltage$$

where *voltage* is the measured voltage in volts.

time (Time) []

GPS/YYYYMMDD-hhmmss-ADUPOS-ADUPOS_JC1.gps (adu5pos)

This data file contains position data from the Ashtech ADU5 GPS-based attitude-measuring system.

type (type) [] specifies the position type. 0 indicates a raw position and 2 specifies a differentially corrected position.

svc (svc) [] is number of satellites used to compute the position.

measureTS (measureT) [] is the time stamp applied to the data by the ADU5 GPS.

lat (lat) [degree] is the latitude.

long (lon) [degree] is the longitude.

alt (alt) [metre] is the altitude.

cmg (cmg) [degree true] is the course made good, or course over the ground.

smg (smg) [knot] is the speed over the ground, or speed made good.

vvel (vvel) [metre per second] is the vertical velocity with a positive value indicating motion upwards.

pdop (pdop) [] is the GPS positional dilution of precision.

hdop (hdop) [] is the GPS horizontal dilution of precision.

vdop (vdop) [] is the GPS vertical dilution of precision.

tdop (tdop) [] is the GPS time dilution of precision.

time (Time) []

TSG/YYYYMMDD-hhmmss-SBE45-SBE45_JC1.TSG (sbe45)

The Sea-Bird Electronics SBE45 Thermosalinograph's (TSG) data is logged directly by the Techsas data acquisition system. Techsas rebroadcasts the data and it is logged for a second time in the Surfmet data files.

temp_h (temp_h) [degree Celsius] is the water temperature measured in the SBE45 housing. The SBE45 contains its own calibration coefficients and outputs over RS232 the calibrated temperature.

cond (cond) [siemen per metre] is the conductivity measured by the SBE45. It is the calibrated conductivity output via RS232.

salin (salin) [] is the water salinity calculated by SBE45. It is measured using the Practical Salinity Scale and hence is unit less.

sndspeed (sndspeed) [metre per second] is the velocity of sound in the sampled water calculated by the SBE45 using the Chen-Millero equation.

temp_r (temp_r) [degree Celsius] is the water temperature measured by the SBE38 remote thermometer at the raw water inlet to the ship. The SBE38 contains its own calibration coefficients and outputs over RS232 the calibrated temperature.

time (Time) []

SURFMETV2/YYYYMMDD-hhmmss-Surf-JC-SM_JC1.SURFMETv2 (surfmet)

This file contains the underway water sampling data. The transmissometer and fluorimeter data has been recorded directly by Techsas. The SBE45 data is first logged by the Techsas, which then broadcasts the data across the network. The Surfmet software then logs these broadcasted values. Occasionally Surfmet can be delayed in logging values and data will be buffered in the software. Comparing salinity or temperature data from the SBE45 file with the delayed data in this file will allow the length of the delay to be found.

temp_h (temp_h) [degree Celsius] is the SBE45 housing water temperature.

temp_m (temp_r) [degree Celsius] is the SBE38 remote temperature at the ship's raw water inlet.

cond (cond) [siemen per metre] is the conductivity measured by the SBE45.

fluo (fluo) [volt] is the voltage measured by the Nudam Analogue to Digital Converter (ADC) from the Wet Labs WS3S Fluorimeter. Each fluorimeter's data sheet should be consulted for the equation and calibration factors to convert from voltage to chlorophyll concentration.

trans (trans) [volt] is the raw voltage measured by the Nudam ADC from the Wet Labs C-Star Transmissometer. Each transmissometer's data sheet should be consulted for the equation and calibration factors to convert from voltage to transmittance.

time (Time) []

LOG/YYYYMMDD-hhmmss-vdvhw-log_skip_JC1.Log (log_skip)

The Skipper single-axis log measures the vessel's speed through the water. It is primarily intended for bridge navigation purposes but is also logged by Techsas and Level-C.

heading (heading) [degree true] is the true heading of the vessel. This field may not contain any data.

headMag (headMag) [degree magnetic] is the magnetic heading of the vessel. This field may not contain any data.

speed (speed) [knot] is the speed of the vessel through the water.

speedKPH (speedKPH) [kilometre per hour] is the speed of the vessel through the water.

time (Time) []

GPS/YYYYMMDD-hhmmss-cnav-CNAV.GPS (gps_cnav)

This data file contains data from the CNAV GPS unit. The CNAV GPS data is not motion compensated and so the positions are the position of the antenna at the top of the mast.

measureTS (measureT) [] is the time stamp applied to the data by the GPS unit.

lat (lat) [degree] is the latitude of the CNAV GPS antenna in the format described above.

long (lon) [degree] is the longitude of the CNAV GPS antenna in the format described above.

alt (not logged) [metre] is the height of the CNAV GPS antenna above the reference ellipsoid.

prec (not logged) [] is the horizontal position precision code. It is defined by the following table:

prec	HDOP
0	HDOP < 0.3
1	0.3≤HDOP<1.0
2	1.0≤HDOP<3.0
3	3.0≤HDOP<10.0
4	10.0≤HDOP<30.0
5	30.0≤HDOP<100
6	100≤HDOP<300
7	300≤HDOP<1000
8	1000≤HDOP<3000
9	3000≤HDOP

mode (prec) [] is the mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix.

not logged (pdop) [] this is a null value that is only logged in the RVS data file.

gndcourse (cmg) [degree true] is the course made good, or course over the ground.

gndspeed (smg) [knot] is the speed over the ground, or speed made good.

time (Time) []

GYR/YYYYMMDD-hhmmss-gyro-GYRO1_JC1.gyr (gyropmv)

heading (heading) [degree true] is the true heading of the ship in degrees from the POSMV gyro.

time (Time) []

GYR/YYYYMMDD-hhmmss-gyro-SGYRO_JC1.gyr (gyro_s)

heading (heading) [degree true] is the true heading of the ship in degrees from the ship's gyro compass.

time (Time) []

GPS/YYYYMMDD-hhmmss-position-Applanix_GPS_JC1.gps (posmvpos)

This data file contains data from the POSMV GPS unit. The POSMV outputs the position of the vessel's common reference point, the cross on top of the POSMV Motion Reference Unit (MRU) in the gyro and gravity meter room.

measureTS (measureT) [] is the time stamp applied to the data by the GPS unit.

lat (lat) [degree] is the latitude of the vessel's common reference.

long (lon) [degree] is the longitude of the vessel's common reference point.

alt (alt) [metre] is the height of the surveyed reference point above the reference ellipsoid.

prec (prec) [] is the horizontal position precision code. It is defined by the following table:

prec	HDOP
0	HDOP < 0.3
1	0.3≤HDOP<1.0
2	1.0≤HDOP<3.0
3	3.0≤HDOP<10.0
4	10.0≤HDOP<30.0
5	30.0≤HDOP<100
6	100≤HDOP<300
7	300≤HDOP<1000
8	1000≤HDOP<3000
9	3000≤HDOP

mode (mode) [] is the mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix.

gndcourse (cmg) [degree true] is the course made good, or course over the ground.

gndspeed (smg) [knot] is the speed over the ground, or speed made good.

heading (not logged) [degree true] is the direction that the vessel's bow is pointing towards calculated from the POSMV's motion reference unit.

time (Time) []

GPS/YYYYMMDD-hhmmss-position-DPS-116_JC1.gps (dps116)

This data file contains data from the DPS116 GPS unit. The DPS116 outputs the position of the DPS116 antenna at the top of the main mast.

measureTS (not logged) [] is the time stamp applied to the data by the GPS unit.

lat (lat) [degree] is the latitude of the DPS116 antenna.

long (lon) [degree] is the longitude of the DPS116 antenna.

alt (alt) [not logged] is the height of the DPS116 antenna above the reference ellipsoid.

prec (not logged) [] is the horizontal position precision code. It is defined by the following table:

prec	HDOP
0	HDOP < 0.3
1	0.3≤HDOP<1.0
2	1.0≤HDOP<3.0
3	3.0≤HDOP<10.0
4	10.0≤HDOP<30.0
5	30.0≤HDOP<100
6	100≤HDOP<300
7	300≤HDOP<1000
8	1000≤HDOP<3000
9	3000≤HDOP

mode (not logged) [] is the mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix.

gndcourse (not logged) [degree true] is the course made good, or course over the ground, which is not available for the DPS116.

gndspeed (not logged) [knot] is the speed over the ground, or speed made good, which is not available for the DPS116.

heading (not logged) [degree true] is the direction that the vessel’s bow is pointing towards but is not available for the DPS116.

time (Time) []

GPS/YYYYMMDD-hhmmss-position-Seapath200_JC1.gps (sb-pos)

This data file contains data from the Seapath 200 GPS unit. The Seapath 200 outputs positions at the vessel's common reference point.

measureTS (measureT) [] is the time stamp applied to the data by the GPS unit.

lat (lat) [degree] is the latitude of the common reference point (the cross on the top of the POSMV MRU).

long (lon) [degree] is the longitude of the common reference point.

alt (not logged) [metre] is the height of the surveyed reference point above the reference ellipsoid.

prec (not logged) [] is the horizontal position precision code. It is defined by the following table:

prec	HDOP
0	HDOP < 0.3
1	0.3≤HDOP<1.0
2	1.0≤HDOP<3.0
3	3.0≤HDOP<10.0
4	10.0≤HDOP<30.0
5	30.0≤HDOP<100
6	100≤HDOP<300
7	300≤HDOP<1000
8	1000≤HDOP<3000
9	3000≤HDOP

mode (not logged) [] is the mode that the GPS was operating in. 0 indicates an invalid fix, 1 a GPS fix and 2 a DGPS fix.

gndcourse (not logged) [degree true] is the course made good, or course over the ground, which is not available for the Seapath 200.

gndspeed (not logged) [knot] is the speed over the ground, or speed made good, which is not available for the Seapath 200.

heading (not logged) [degree true] is the direction that the vessel's bow is pointing towards but is not available for the Seapath 200.

time (Time) []

GPS/YYYYMMDD-hhmmss-position-usbl_JC1.gps (usblpos)

This data file contains the positions of beacons being tracked by the USBL system. It is generated from the NMEA GGA stream output by the Sonardyne USBL software and uses a GPS data logging module to record the data and so there are additional fields logged that do not contain any meaningful data. The name of the beacon being tracked is not logged and so if multiple beacons are being tracked, the data from all of the beacons will be logged with no way of telling which beacon the position logged refers to.

measureTS (measureT) [] is the time stamp applied to the data by the GPS unit.

lat (lat) [degree] is the latitude of the object being tracked.

long (lon) [degree] is the longitude of the object being tracked.

alt (alt) [metre] is the depth relative to the water surface of the object being tracked. A negative value is depth below the water and a positive value is a depth above the water and so is not valid.

prec (prec) [] contains no meaningful data.

mode (mode) [] contains no meaningful data and is always 2.

gndcourse (cmg) [degree true] contains no meaningful data.

gndspeed (smg) [knot] contains no meaningful data.

heading (not logged) [degree true] contains no meaningful data.

time (Time) []

GPS/YYYYMMDD-hhmmss-satelliteinfo-Applanix_GPS_JC1.gps (not logged)

Additional information from the Applanix POSMV regarding the GPS position fix quality.

nbseen (not logged) [] is the number of satellites that can theoretically be seen from the current position.

nbused (not logged) [] is the number of satellites actually used to compute the position.

HDOP (not logged) [] is the GPS horizontal dilution of precision.

VDOP (not logged) [] is the GPS vertical dilution of precision.

PDOP (not logged) [] is the GPS positional dilution of precision.

time (not logged) []

GPS/YYYYMMDD-hhmmss-satelliteinfo-DPS-116_JC1.gps (not logged by Level-C)

Additional information from the DPS116 regarding the GPS position fix quality.

nbseen (not logged) [] is the number of satellites that can theoretically be seen from the current position.

nbused (not logged) [] is the number of satellites actually used to compute the position.

HDOP (not logged) [] is the GPS horizontal dilution of precision.

VDOP (not logged) [] is the GPS vertical dilution of precision.

PDOP (not logged) [] is the GPS positional dilution of precision.

time (not logged) []

GPS/YYYYMMDD-hhmmss-satelliteinfo-Seapath200_JC1.gps (not logged by Level-C)

Additional information from the Seapath 200 regarding the GPS position fix quality.

nbseen (not logged) [] is the number of satellites that can theoretically be seen from the current position.

nbused (not logged) [] is the number of satellites actually used to compute the position.

HDOP (not logged) [] is the GPS horizontal dilution of precision.

VDOP (not logged) [] is the GPS vertical dilution of precision.

PDOP (not logged) [] is the GPS positional dilution of precision.

time (not logged) []

GPS/YYYYMMDD-hhmmss-satelliteinfo-CNAV.gps (not logged by Level-C)

Additional information from the CNAV regarding the GPS position fix quality.

nbseen (not logged) [] is the number of satellites that can theoretically be seen from the current position.

nbused (not logged) [] is the number of satellites actually used to compute the position.

HDOP (not logged) [] is the GPS horizontal dilution of precision.

VDOP (not logged) [] is the GPS vertical dilution of precision.

PDOP (not logged) [] is the GPS positional dilution of precision.

time (not logged) []

GPS/YYYYMMDD-hhmmss-satelliteinfo-usbl_JC1.gps (not logged by Level-C)

Additional information from the Fusion USBL system regarding the GPS position fix quality. None of this data does not contain meaningful information and is generated because the default GPS logging module is used to log the USBL NMEA GGA output.

nbseen (not logged) [] contains no meaningful data.

nbused (not logged) [] contains no meaningful data and is always 12.

HDOP (not logged) [] is the semi-major axis value for the fix of the beacon's position in metres.

VDOP (not logged) [] contains no meaningful data.

PDOP (not logged) [] contains no meaningful data.

time (not logged) []

DEPTH/YYYYMMDD-hhmmss-sb_depth-EM120_JC1.depth (em120cb)

This data file contains the depths logged by the centre beam of the EM120 multi-beam echo sounder. The data has been corrected for sound velocity and the cruise report should be consulted for details of the corrections applied. The depths have not been corrected for tidal height.

snd (depth) [metre] is the depth measured by the EM120 multi-beam sonar from the sea bed to the sea surface. No compensation is made for the current tidal height.

freq (not logged) [kilohertz] is the sound frequency used to make the depth measurement. -1 indicates that the frequency was not included in the telegram from the echo sounder.

time (not logged) []

ATT/YYYYMMDD-hhmmss-shipattitude-Aplanix_TSS_JC1.att (posmvtss)

This data file contains data from the Applanix POSMV system's Motion Reference Unit (MRU).

measureTS (not logged) [] is the time stamp applied to the data by the POSMV.

head (heading) [degree] is the true bearing that the bow of the vessel is pointing at.

roll (roll) [degree] is the roll angle of the vessel. A positive angle indicates that the port side of the vessel is above the starboard side.

pitch (pitch) [degree] is the pitch of the ship. A bow up rotation gives a positive pitch value.

heave (heave) [metre] is the vertical variation in height of the reference point on top of the POSMV MRU. Positive values indicate the reference point has risen above its stationary position. Please see the POSMV documentation for details of the filtering applied to the MRU data to calculate this value.

mode (not logged) [] is a quality indicator of the heading data. 0 indicates that the calculation of the heading was performed without any GPS aid, 1 indicates the heading calculation was aided by the GPS and 2 that it was aided by GPS and GAMS.

time (Time) []

ATT/YYYYMMDD-hhmmss-shipattitude-Seapath200AT_JC1.att (sb-att)

This data file contains data from the Seapath 200 system's Motion Reference Unit (MRU).

measureTS (not logged) [] is the time stamp applied to the data by the Seapath 200.

head (heading) [degree] is the true bearing that the bow of the vessel is pointing at.

roll (roll) [degree] is the roll angle of the vessel. A positive angle indicates that the port side of the vessel is above the starboard side.

pitch (pitch) [degree] is the pitch of the ship. A bow up rotation gives a positive pitch value.

heave (heave) [metre] is the vertical variation in height of the reference point on top of the POSMV MRU (the Seapath's data is referenced to the POSMV MRU). Positive values indicate the reference point has risen above its stationary position. Please see the Seapath 200 documentation for details of the filtering applied to the MRU data to calculate this value. This variable in the RVS data stream may have every value as 0.

mode (not logged) [] is a quality indicator of the heading data. 0 indicates that the calculation of the heading was performed without any GPS aid, 1 indicates the heading calculation was aided by the GPS and 2 that it was aided by GPS and GAMS.

time (Time) []

ATT/YYYYMMDD-hhmmss-shipattitude_aux-Aplanix_TSS_JC1.att (posmvtss)

This data file contains data from the Applanix POSMV system's Motion Reference Unit (MRU).

acX (not logged) [] is not valid data.

acY (not logged) [] is not valid data.

acZ (not logged) [] is not valid data.

hunc (acc_hdg) [degree] is the heading uncertainty determined by the POSMV MRU.

runc (acc_roll) [degree] is the roll uncertainty determined by the POSMV MRU.

punc (acc_ptch) [degree] is the pitch uncertainty determined by the POSMV MRU.

time (Time) []

ATT/YYYYMMDD-hhmmss-shipattitude_aux-Seapath200AT_JC1.att (sb-att)

The logging module for the Seapath 200 system is based upon the POSMV's data logging module. This file is generated automatically but does not contain any valid data. The **accroll**, **accpitch** and **acchdg** variables do exist in the RVS Level-C stream, but every value is set to 0.0.

Not logged by Techsas (relmov)

This RVS Level-C post processed file contains details of the motion of the vessel and is used by other Level-C post-processing streams. This file is generated from a gyro and log. The cruise documentation should be consulted to find which log and gyro source were used.

not logged (vn) [knot] is the north component of the vessel's velocity.

not logged (ve) [knot] is the east component of the vessel's velocity.

not logged (pfa) [knot] is the vessel's speed in the fore direction.

not logged (pps) [knot] is the vessel's speed in the port direction.

not logged (pgyro) [degree true] is the vessel's average heading.

time (Time) []

Not logged by Techsas (bestnav)

This RVS Level-C post processed file was written when satellite positioning was in its infancy and there could be long periods of time between fixes. The program bestnav reads position fixes from up to three RVS data files along with the ship's motion as calculated by relmov and generates a series of positions at time intervals of the navigation window. The cruise report should be consulted to find the source of the three position fixes used.

The basis for the program's calculations is a series of position fixes. The input fix files are given in order and a timeout given for each file. Fixes will be taken from the first file until a data gap longer than that file's timeout is encountered. Fixes will then be taken from the second file until either the first file resumes or the second file also times out. In the latter case the third file will be used.

The gaps in the series of fixes are next filled using dead-reckoning based on the ship's motion relative to the water. When the end of each gap is reached the position obtained by dead-reckoning is compared with the fix position and the difference between the positions attributed to drift, caused either by wind or water currents. The drift in position is used to calculate an average drift velocity during the fix gap whose magnitude is compared with the known drift and maximum allowable drift entered on the menu. If the drift is greater than the limit then the fix is assumed to be in error and processing is halted. If this occurs the user should either correct (or delete) the fix or increase the allowed drift and re-run the program.

If an acceptable drift velocity is found this is added to the dead reckoned positions. This completes the calculation of the ship's track. For each navigation window a position is interpolated from the calculated track and a record written to the output fixes file. Each record also contains the calculated velocity represented as north and east components and as speed made good and course made good. The average heading of the ship is calculated along with a cumulative distance since the start of the file. If the output file contains a variable stream this will be set to 1, 2 or 3 to indicate which of the fix files the current fix was taken from. The status of the calculated values will either be good, if there was a fix at the time of the output record, or interp otherwise.

not logged (lat) [degree] is the vessel’s calculated latitude.

not logged (lon) [degree] is the vessel’s calculated longitude.

not logged (vn) [knot] is the north component of the vessel’s velocity.

not logged (ve) [knot] is the east component of the vessel’s velocity.

not logged (cmg) [degree] is the vessel’s course made good.

not logged (smg) [knot] is the vessel’s speed made good.

not logged (dist_run) [nautical miles] is the distance that the vessel has run since the start of this bestnav file. Bestnav can also output this value in km. The BODC documentation produced for each cruise should be consulted for the units for cruises after December 2012.

not logged (heading) [degree] is the vessel's heading.

time (Time) []

Not logged by Techsas (bestdrf)

The drift velocities calculated by the bestnav program are also written to the bestdrf file. This contains either one record per navigation window (if there is more than one fix in the window) or one record per fix. The file contains the north and east calculated drift velocities as well as the known and limit drift speeds entered on the menu.

not logged (vn) [knot] is the north component of the vessel's drift.

not logged (ve) [knot] is the east component of the vessel's drift.

not logged (kvn) [knot] is the known north velocity entered in the relmov menu.

not logged (kve) [knot] is the known east velocity entered in the relmov menu.

time (Time) []

Not logged by Techsas (prodep)

The prodep post-processing file takes echo sounder depths that have been logged with a fixed sound velocity of 1500 ms-1 and corrects them for typical sound velocities for that geographical area using Carter's tables by the Hydrographic Office.

not logged (uncdepth) [metre] is the uncorrected depth.

not logged (cordepth) [metre] is the corrected depth.

not logged (cartarea) [] is the number of the Carter area used for the correction.

time (Time) []

Not logged by Techsas (pro_wind)

The Level-C windcalc post-processing program takes the bestnav and surfmet Level-C files and calculates the absolute wind speed and direction.

not logged (abswpsd) [knot] is the absolute wind speed at the height of the anemometer.

not logged (abswdir) [degree true] is the absolute wind direction.

time (Time) []

JC133 Gravity basestation ties

	Location	Day/UTC time of measurement	Latitude (N)		Longitude (W)		Absolute gravity (mGal)
Trinidad	Port of Spain dock Bollard 37/38	JD56/12:30 & 12:55 &15:55	10	39.15	61	31.28	
	Port of Spain Customs Warehouse SE corner (relative basestation used in JC102 and JC109)	JD56/12:40	10	39.12	61	31.182	TBC
	Ministry of Agriculture, Land & Fisheries (new absolute basestation established Feb 2016)	JD56/15:20	10	39.14	61	31.006	TBC
Antigua	St Johns dock 4th bollard along in commercial port	JD77/14:30 & 17:30	17	7.52	61	51.43	
	St Johns Post Office	JD77/18:15	17	5	61	50	978652.72

Calibration of Ship's metre

Antigua (basestation established 1970)

Absolute gravity at ship's metre	978651.47	mGal	15/03/2016
Potsdam correction +14 mGal	978665.47	mGal	
Ship metre reading	6899.5	CU	15/03/2016
Offset to add to ship readings	971765.97	mGal	

NMFD Gravitymeter Port Tie In Form

Ship: *JAMES COOK* **Cruise:** *Post JC133*

Principle Scientist: Collier

Details of Ship Fitted Gravity Meter:

Make: *Micro-g-Lacoste*
Type: *AirSea 2*
Serial No: *S40*

Details of Land Gravity meter used for the tie in readings:

Make: *Lacoste & Romberg*
Type: *Model G*
Serial No: *G-484*
Calibration factor (microgals / div): Factor for interval *1.02212*

Location where Tie In needs to be calculated:

Port: *St. Johns Antigua*
Berth No:
Coordinates (Lat / Long): *17 7.52'N 061 51.43'W*

Location of Known Gravity Base Station:

ISGN Station No: St Johns Post Office (ACIC 2223-1/ IGB 04371B)
Address:

Contact Person (If any):
Tel no. / e-mail:
Coordinates (Lat / Long):

Absolute gravity value in milliGals: *978652.72*

Comments:
ALL TIMES IN GMT

Readings Page

Date: *17/03/2016* **Julian Day No:** *77*

First set of readings on quay wall adjacent to ship: TIMES GMT

Counter Reading 1:	*2090.370*	**@ time:**	*14:26*
Counter Reading 2:	*2090.340*	**@ time:**	*14:28*
Counter Reading 3:	*2090.390*	**@ time:**	*14:30*
Counter Reading 4:		**@ time:**	
Counter Reading 5:		**@ time:**	

Height of Gravity Meter above water level (h1): *2.6* **meters**

Set of readings at the known base station:

Counter Reading 1:	*2091.870*	**@ time:**	*17:24*
Counter Reading 2:	*2091.880*	**@ time:**	*17:25*
Counter Reading 3:	*2091.890*	**@ time:**	*17:27*
Counter Reading 4:	*2091.950*	**@ time:**	*17:28*
Counter Reading 5:		**@ time:**	

Second set of readings on quay wall adjacent to ship:

Counter Reading 1:	*2090.320*	**@ time:**	*18:12*
Counter Reading 2:	*2090.340*	**@ time:**	*18:13*
Counter Reading 3:	*2090.310*	**@ time:**	*18:14*
Counter Reading 4:		**@ time:**	
Counter Reading 5:		**@ time:**	

Height of Gravity Meter above water level (h2): *2.65* **meters**

Height of ships GM above static water line (h3): *1.79* **metres**

	ST (cu)	*6899.6*
Digital Gravity Reading shown on ships GM display	*Gravity(cu)*	*6899.60*
	QC Grav (mGal)	*6842.10*
	(Reading taken at	**18:33**

Calculations page

Tidal Calculations: (Obtain (a),(b) and (d) below from UK Hydrographic tables)

Height of last Low Water (a):	*0.40*	metres
Height of next High Water (b):	*0.50*	metres
Tidal Range (c):	*0.10*	metres
Height of tide above LW at average time of readings (d):	*0.45*	metres
Height of tide above mean sea level ((d-c/2) =e):	*0.40*	metres
Average height of Land GM above waterline ((h1+h2)/2=f):	*2.63*	metres
Average height of Land GM above mean sea level (e + f =g):	*3.03*	metres
Difference in height between Land GM and Ship GM (f - h3):	*0.84*	metres
Free Air corrected value for height difference (0.31 x (f-h3)):	*0.26*	metres

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Average of the first set of quay wall readings (S1);	*2090.367*	Counter divs
Average of the second set of quay wall readings (S2):	*2090.323*	Counter divs
Average of the Known base station readings (S3):	*2091.880*	Counter divs
Difference in minutes between first and second sets of quay wall readings (ST2 - ST1):	*224.0*	Mins
Drift of Land GM ((S1-S2)/ST2-ST1 = k):	*0.0002*	divs/min
Difference in minutes between Known Base station readings and first quay wall readings (ST3):	*178.0*	Mins
Corrected quay wall reading at the time of Base station reading: (S1 + (ST3 x k)=m):	*2090.4*	Counter divs
Difference between quay wall reading and known base (S2-m-S3 =N):	*-1.479*	Counter divs
Converted value (calibration factor x N):	*-1.5*	milliGals

Absolute value at the quay wall (Known value + converted value):	***978651.21***	**milliGals**
Absolute value at ships GM (abs. quay wall value + free air corrected value):	***978651.47***	**milliGals**

St John's Post Office (High Street)

Alongside (Commercial Port)

View from Measurement Point

Measurement Point

Antigua Gravity Basestation Ties (JD 77/2016)

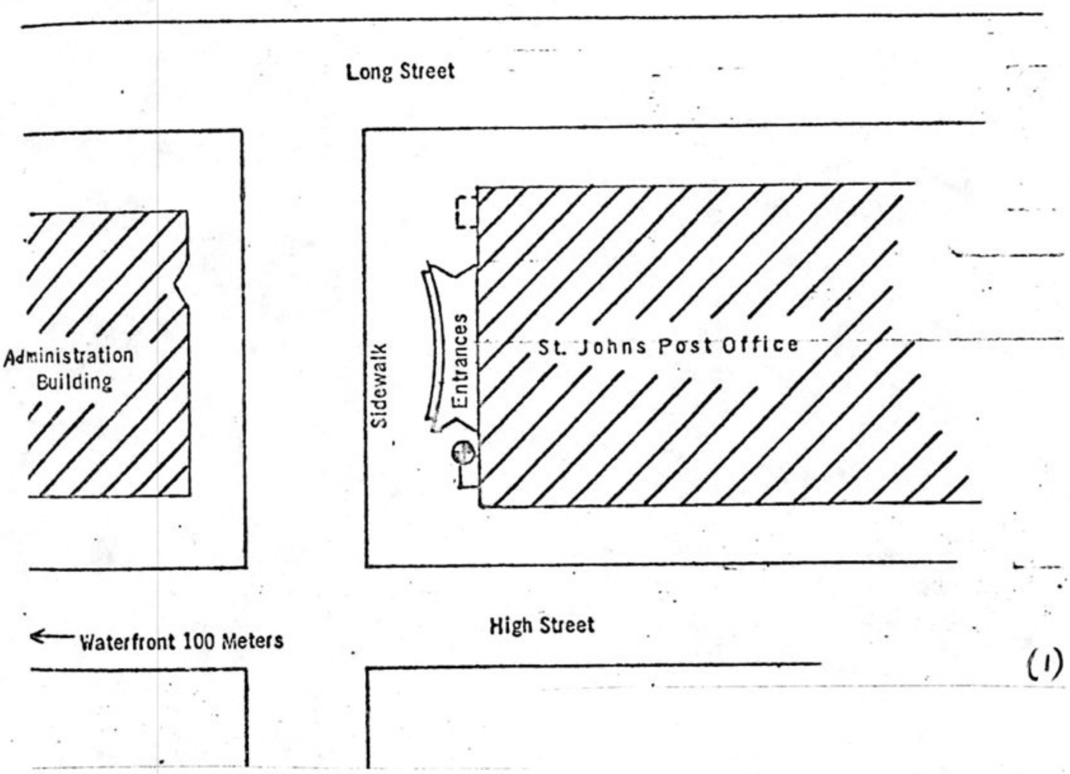
GRAVITY BASE STATION

LATITUDE: 17° 05'N (1)	STATION DESIGNATION: ANTIGUA
LONGITUDE: 61° 50'W (1)	
ELEVATION: 2 METERS (1)	COUNTRY/STATE: Antigua

REFERENCE CODE NUMBERS		ADOPTED GRAVITY VALUE	
ACIC 2223-1		g = 978 652.72 mgals	
IGB 04371B			
		ESTIMATED ACCURACY	DATE MONTH/YEAR
		± 0.2 mgals	8/70

DESCRIPTION AND/OR SKETCH

The gravity station is in St Johns, Antigua (approximately 5 miles west of Coolidge Airport). Station is at the city Post Office between High Street and Long Street near the water front. Station is in a corner, one meter east of the southwest entrance to the building, on a concrete surface. Station is approximately 6 meters north of the southwest corner of the building. (1)

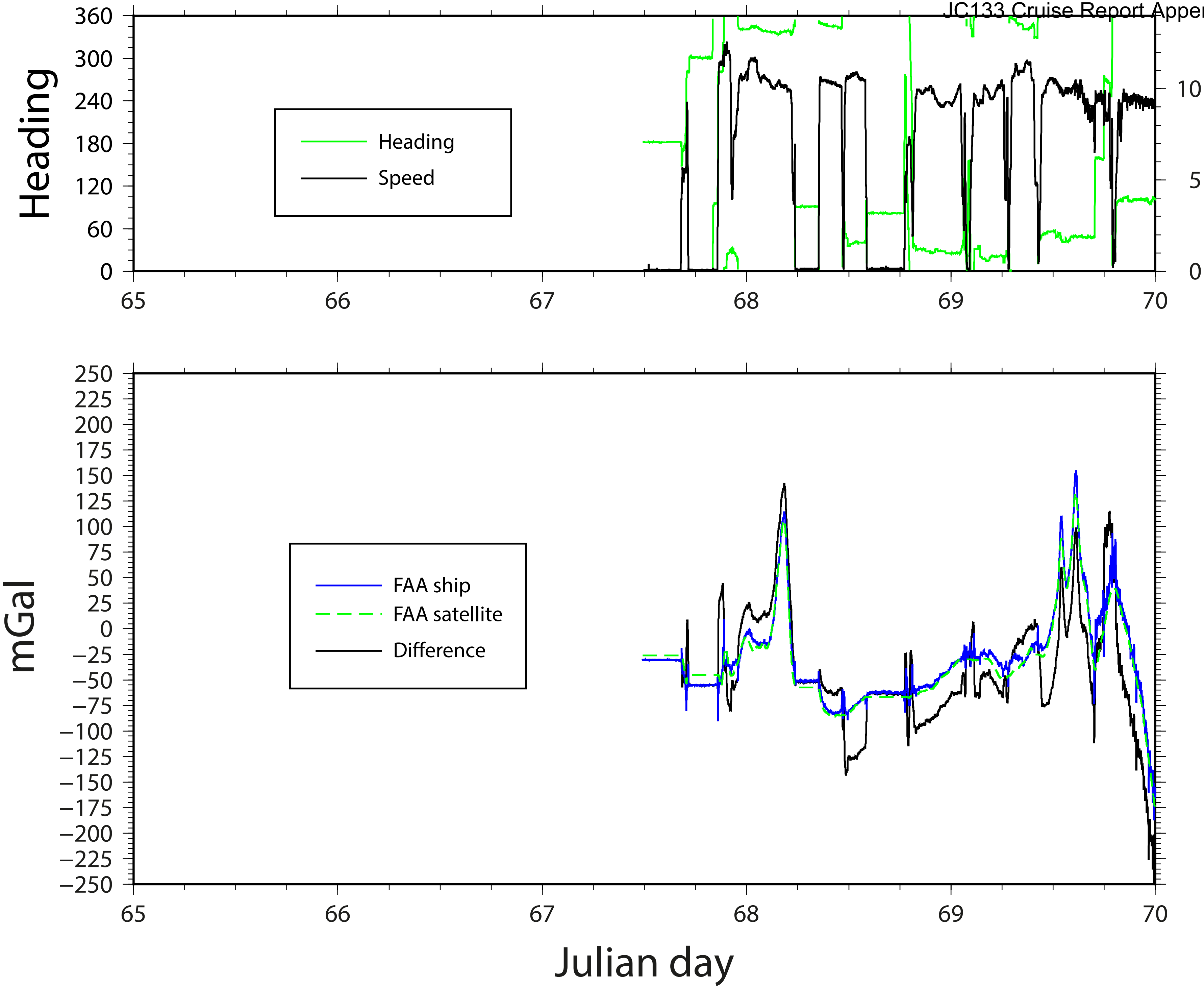


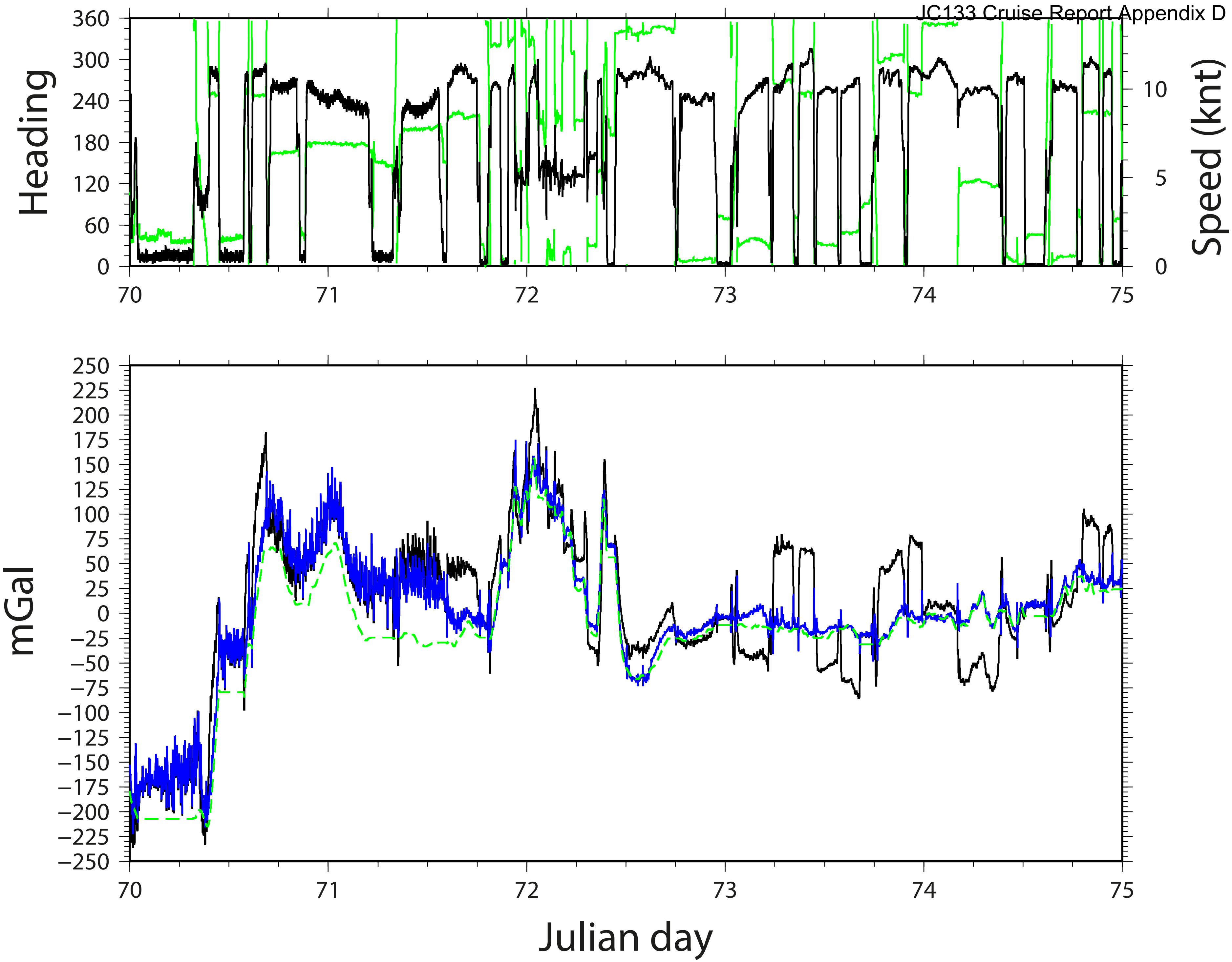
REFERENCE SOURCE

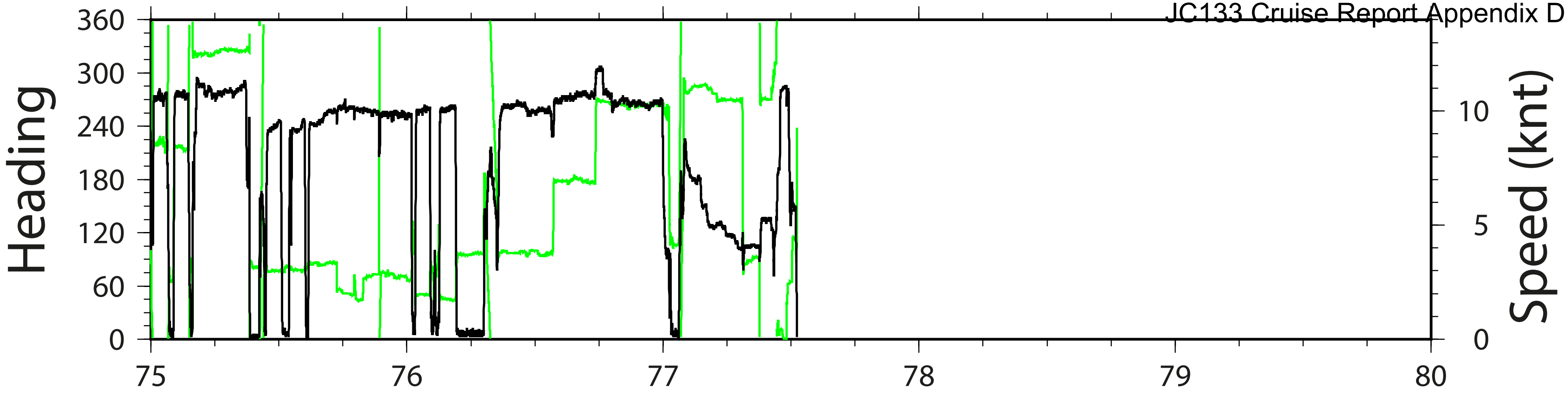
(1) 02752

36

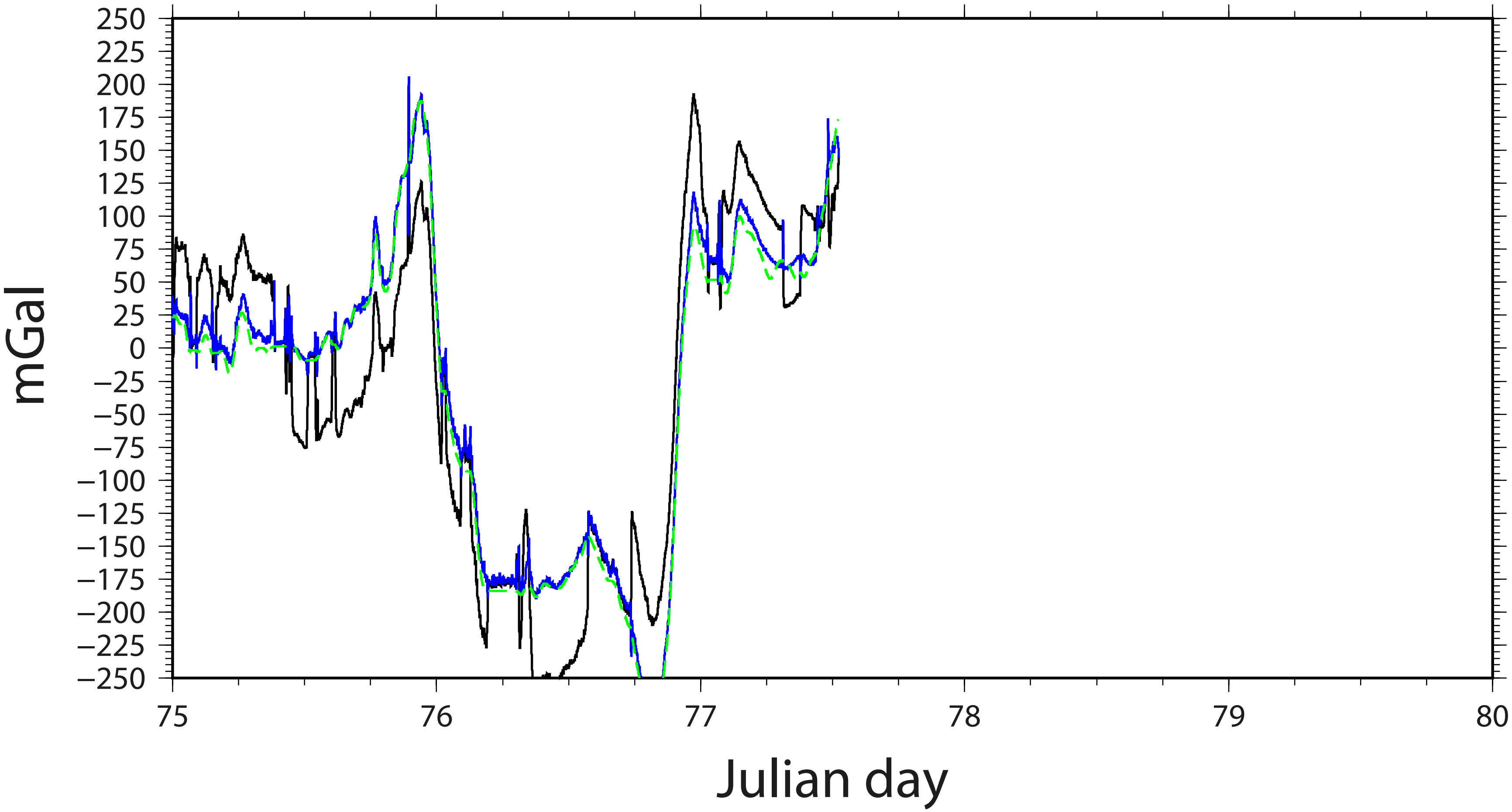
ACIC HQ FORM FEB 69 0-415


Heading
Speed
Heading
Speed (knt)
360
300
240
180
120
60
0
10
5
0
65
66
67
68
69
70
FAA ship
FAA satellite
Difference
mGal
250
225
200
175
150
125
100
75
50
25
0
−25
−50
−75
−100
−125
−150
−175
−200
−225
−250
Julian day


Heading
Speed (knt)
mGal
Julian day
360
300
240
180
120
60
0
10
5
0
70
71
72
73
74
75
250
225
200
175
150
125
100
75
50
25
0
−25
−50
−75
−100
−125
−150
−175
−200
−225
−250



Heading
Speed (knt)
360
300
240
180
120
60
0
10
5
0
75
76
77
78
79
80



mGal
250
225
200
175
150
125
100
75
50
25
0
−25
−50
−75
−100
−125
−150
−175
−200
−225
−250
75
76
77
78
79
80
Julian day

Appendix E: EM710 Patch test results